Physics of fundamental Symmetries and Interactions - PSI2013

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Book of Abstracts

Contents

We - 1 / 1

Precision Penning-trap mass measurements and fundamental constants

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Recently, high-precision mass measurements of atoms have reached a new quality as far as accuracy, sensitivity and a wide application is concerned. This is due to the development and the use of efficient storage devices, effective cooling methods, sensitive detection techniques and new methods of calibration. This contribution provides a survey over recent high-precision mass measurements on stable as well as short-lived species. The applications range from nuclear structure studies to contributions to the modeling of element formation till the examination of the Standard Model as well as contributions to the determination of fundamental constants. Questions will be addressed like: "Why is iron much more abundant on earth than all other elements? How are elements formed in the universe? What is the weight of an electron?"

Tu - 3 / 2

Muon Capture: Status and Prospects

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The MuCap experiment at PSI has published its final result on g_P, the weak-pseudoscalar coupling of the proton.
A novel ultra-pure hydrogen TPC served as an imaging stopping volume. In gas, the μp capture rate is relatively
immune to the poorly known molecular physics complications that plagued previous efforts by others.
The result, $g_P = 8.06 \pm 0.55$ is in excellent agreement with chiral perturbation theory predictions and
provides a unambiguous and stringent test of low energy QCD. After summarizing the technique and the main results, the status
and prospects of this field will be reviewed.

Tu - 3 / 3

Muon Capture on the Deuteron : The MuSun Experiment

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Basic few-body nuclear systems are increasingly understood in terms of QCD-based effective field theories (EFT). These calculations precisely predict electro-weak observables and establish rigorous

relations between muon capture and fundamental astrophysical processes like p-p fusion and neutrino break-up of the deuteron. Experimentally, the muon capture rate on the deuteron tests this modern EFT description and determines the single, poorly known low-energy constant appearing in the two-nucleon sector. The MuSun experiment will achieve an order of magnitude improvement over previous measurements with the use of a cryogenic deuterium TPC target designed to be insensitive to muon atomic kinetics. The capture rate is measured via the lifetime of negative muons in deuterium, so it is critical to avoid decay-time-dependent event selection cuts. Data collected at the Paul Scherrer Institute in 2011 is being analyzed and the MuSun collaboration is implementing detector upgrades for a beam period in the fall of 2013.

Summary:

A presentation of the progress of the MuSun collaboration's analysis of data collected at PSI in 2011 and the experimental upgrades leading up to the upcoming beam period in fall 2013.

Th - 1 / 4

Limit on Lorentz and CPT Violation of the Bound Neutron Using a Free Precession 3He/129Xe Co-magnetometer

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We report on the search for Lorentz violating sidereal variations of the frequency difference of co-located spin-species while the Earth and hence the laboratory reference frame rotates with respect to a relic background field. The co-magnetometer used is based on the detection of freely precessing nuclear spins from polarized 3He and 129Xe gas samples using SQUIDs as low-noise magnetic flux detectors. As result we can determine the limit for the equatorial component of the background field interacting with the spin of the bound neutron to be b_n < 1 ·10−33 GeV (95% C.L.). This new result sets the tightest contrain on SME parameters for the bound neutron.

Th - 1 / 5

Tests of Lorentz symmetry in neutron decay

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Lorentz invariance is a cornerstone of modern physics. As the spacetime symmetry of special relativity, Lorentz symmetry is a basic component of the standard model of particle physics and general relativity, which to date constitute our most successful descriptions of nature. In this talk, I will describe how Lorentz invariance can be tested in the decay of polarized and unpolarized neutrons.

We - 2 / 6

Octupole enhanced EDMs: Recent progress on the Radon-EDM program

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A permanent electric dipole moment (EDM) of a particle or system would arise due to breaking of time-reversal (T), or equivalently charge-conjugation/parity (CP) symmetry. Over the past five decades, a number of experiments on the neutron, atoms and molecules have only set upper limits on EDMs, and the search continues, motivated in large part by the expectation that beyond Standard-Model physics CP violation is required to explain the baryon asymmetry of the universe. In addition, new techniques and access to systems in which the effects of CP violation would be greatly enhanced are driving the field forward. Systems that may be favorable for significant advances include the isotopes 225Ra and 221/223Rn, where the combination of significant octupole collectivity and relatively closely spaced opposite parity levels would increase the nuclear Schiff moment by orders of magnitude compared to other diamagnetic atoms, i.e. 199Hg. A number of technical and nuclear-structure issues must be addressed in order to assess the prospects for an experiment of significant impact. Among the technical challenges for the Radon-EDM program are developing an on-line EDM experiment at an isotope-production facility that will collect and make measurements on the short-lived species (half lives are approximately 25 min). We have developed and tested a system for high-efficiency collection and spin-exchange polarization of noble-gas isotopes that has been tested at the TRIUMF ISAC facility (experiment S929). Radon polarization techniques were studied at ISOLDE and Stony Brook, and spin-precession detection techniques are under development. Nuclear-structure issues include determining the octupole collectivity as well as the spacing of opposite parity levels. A series of experiments at ISOLDE (IS475 and IS552) have recently directly measured octupole collectivity in 220Rn and 224Ra leading to strengthened confidence in conclusions about the octupole enhancements. Additionally, experiments are underway at NSCL at Michigan State University (experiments 11502 and 12006) and ISAC (S929) to study the nuclear structure of isotopes in this mass region. I will report on progress on all these fronts and discuss recent developments in our studies of how we learn about the basic physical parameters of CP violation from the suite of EDM measurements.

Th - 2 / 7

The Neutron Lifetime Experiment at LANL

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We report a new experiment to measure the beta decay rate of the free neutron. The apparatus is based on the asymmetric magneto-gravitational trap for ultracold neutrons (UCNs) proposed by Walstrom et al. [NIMA 599 (2008) pp. 82-92]. A permanent-magnet Halbach array creates the levitating field for "low-field-seeking" UCNs, while external holding field coils eliminate field zeros inside the trap. A significant modification to the original concept is an in-situ UCN detector comprising a vanadium-51 sheet, which is lowered into the trap after defined storage periods to quickly absorb remaining UCNs, and a coincidence detector for the beta and gamma emitted in the decay of 52V.

This year we completed a prototype trap and performed initial studies with UCN from the LANL UCN source. Preliminary results from a few days of beam time indicate a long storage time consistent with the PDG value for the neutron lifetime. A number of upgrades are planned that will allow us to fully evaluate the prototype apparatus and develop a next-generation experiment with sub-1 second precision.

Th - 3 / 8

Searching for the lepton flavor violating decay mu->egamma with the MEG experiment: results and perspectives

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Charged lepton flavor violating (cLFV) processes are strongly suppressed in the Standard Model, therefore their observation would be a clear indication of New Physics. Most New Physics models predict cLFV at an observable level.
The MEG experiment, at the Paul Scherrer Institute, searches for the cLFV mu ->egamma decay, down to a Branching Ratio of a few 10ˆ(-13), exploiting the most intense continuous muon beam in the word. The most recent results from MEG will be presented, together with the plan for an upgrade of the experiment, aiming at an improvement of the sensitivity by one order of magnitude within this decade.

We - 4 / 9

New method for checking a neutron electroneutrality by spin interferometry technique

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New approach for checking neutron electroneutrality is proposed. The main idea is to use the spin interferometry technique SESANS (Spin Echo Small Angle Neutron Scattering).
This technique provide a spatial splitting of neutron on two eigenstates with different projection of spin to the magnetic field. After passing through the working area these two eigenstates are coupled back by the opposite magnetic field. So, the phase of the interference pattern, i.e. azimuthal spin direction, is defined by phase difference of two neutron eigenstates, accumulated in working area.
If such system is placed into uniform electric field E, then two neutron eigenstates, due to their spatial splitting, will be under different electric potentials. With presence of electric charge of neutron qn results in the energy splitting ΔEe=q_n E Δz and, respectively, will give additional phase shift Δφe=ΔEe τ/ħ, where Δz –value of spatial splitting, τ –time of neutron staying in electric field.
A simple test of possibility to measure a small phase shift by the SESANS technique was done at the WWR-M reactor (PNPI, Gatchina). The good agreement of the theoretical and experimental dependencies was obtained.
Furthermore, we propose an improvement of this technique using neutron Laue diffraction in perfect crystal. It based on a well known effect of diffraction enhancement when a small variation of the incident neutron beam direction leads to a considerable deflection of a neutron trajectory inside a crystal. A gain factor for the value of splitting Δz can reach more than 10ˆ5 in comparison with the standard SESANS. The prototype variant of setup is now under construction.

Preliminary estimations have show the using of technique mentioned above can improve the recent constraint on a neutron electric charge on two order of magnitude and reach the value about σ(q_n)˜10ˆ{-23}e.
This work supported by the Russian Foundation for Basic Research (Grant Nos. 12-02-00441-a) and by the Ministry of Education and Science of the Russian Federation (project nos. 2012-1.2.1-12-000-1012-016).

We - 4 / 10

The limits on tensor-type weak currents and the beta-neutrino correlation of 6He

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Precision measurements in nuclear and neutron beta decays are a powerful tool in search for non V-A components in the weak interaction. Such a chirality-violating scalar or tensor interaction is predicted by several theories beyond Standard Model (e.g. [1][2]). We will present a new evaluation of the limits on time-reversal invariant tensor-type weak currents [3], taking into account most recent experimental data in nuclear and neutron beta decays (e.g. [4][5]), including the 5 sigma shift in the PDG2012 recommended value for the neutron lifetime. The effective field theory framework of ref [6] enables a comparison with the limits from pion decay. In addition, the sensitivity of a future 0.1% measurement of a correlation coefficient in beta decays is investigated.
Such precision is currently pursued at the University of Washington on the beta-neutrino correlation in the pure Gamow-Teller decay of 6He. The high-intensity 6He source at the local accelerator [7] makes it possible to simultaneously trap several thousand 6He atoms in a magneto-optical trap (MOT). These atoms are then transferred to a second, back-ground free, MOT. The beta-neutrino correlation is derived from the time-of-flight spectrum of the recoil 6Li ions. The beta particle which serves as a trigger is detected by a position sensitive hodoscope, the recoil ions are guided by an electrostatic field towards a multi-channel plate detector. All detector systems and both atom traps have been successfully commissioned. A first physics run is planned for this summer, aiming for a precision of 1% on the beta-neutrino correlation.

[1] P. Herczeg, Progress in Particle and Nuclear Physics 46, 413 (2001).
[2] S. Profumo, M. J. Ramsey-Musolf, and S. Tulin, Phys. Rev. D 75, 075017 (2007).
[3] F. Wauters, A. Garcia, and R. Hong, arXiv:1306.2608 [nucl-ex] (2013).
[4] M.P. Medenhall et al. (UCNA Collaboration), Phys. Rev. C 87, 032501 (2013).
[5] F. Wauters et al., Phys. Rev. C 82, 055502 (2010).
[6] T. Bhattacharya et al., Phys. Rev. D 85, 054512 (2012).
[7] A. Knecht et al., Nucl. Instrum. Methods Phys. Res. Sect. A 660, 43-47 (2011).

Summary:

Precision data in nuclear and neutron beta decays provide strong limits on tensor-type weak currents. To further increase the discovery potential of such experiments, a precision of 0.1% has to be reached. The ongoing experiment at the University of Washington to measure the beta-neutrino correlation in

the decay 6He is pursuing such accuracy.

We - 2 / 11

The electron EDM from polar molecules

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It is well known that the existence of a permanent electric dipole moment (EDM) of a fundamental particle such as the neutron or electron violates both parity and time reversal symmetries. Many theories of physics beyond the standard model predict EDMs which should be observable by a new generation of experiments. For the electron, this new generation almost entirely involves measurements using paramagnetic molecules. I will review recent work and discuss the prospects for future measurements of the electron EDM. I will illustrate the talk with examples from the experiment using YbF at Imperial College London.

Th - 2 / 12

Big Gravitational Trap for neutron lifetime measurements

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Improvement of accuracy of neutron lifetime measurements is of great importance for physics of elementary particles and cosmology. At present the best accuracy of measurements is reached in PNPI experiment with a gravitational trap of ultracold neutrons (UCN) [Phys. Lett. B 605, 72 (2005)]. Now at PNPI a new installation with a big UCN gravitational trap is made. The planned accuracy of measurements 0.2 s is 4 times better than present level of accuracy. The specified accuracy will be reached because of considerable improvement of statistical accuracy of measurements due to increase in volume of UCN trap and decrease in UCN transport losses. The systematic is planned to be reduced due to improvement of working vacuum and use of insert that allows to carry out UCN storage measurements with an increased frequency of collisions without an installation disassembling.

The Monte-Carlo model of experiment is made. In it there is a possibility to set concrete value of neutron lifetime, then to repeat experimental procedure and to see whether there is a difference between the set and measured value. As a result of simulation the systematic uncertainty connected with a method of calculation of effective frequency of UCN collisions in the trap is defined. It has made 0.1 s. Also simulation of various constructive elements of setup is made.

Th - 3 / 13

The Mu3e Experiment at PSI

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The lepton flavor violation decay muon -> eee provides an excellent testing ground for physics beyond the SM. This process being experimentally excluded with Br(mu->eee) < 10ˆ-12 (90% CL), the Mu3e collaboration aims at improving the sensitivity of the former SINDRUM experiment by four orders of magnitude down to 10ˆ-16 by exploiting novel detector technologies.
The physics motivation for a dedicated LFV search in the mu->eee channel is given and the status of the Mu3e experiment is reported. Emphasis will be put on new detector developments like the HV-MAPS silicon pixel technology which offers many new opportunities for high rate experiments at low energy.

Mo - 3 / 14

Kaon experiments at CERN: recent results and prospects

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The NA62 experiment at CERN collected a large sample of charged kaon decays with a low intensity beam and minimum bias trigger conditions in 2007. This allowed measurements of a number of rare decays that are difficult to address in conventional experiments with selective triggers. Recent results based on this data sample is presented. The status of the next stage of the NA62 experiment aiming a measurement of the ultra-rare decays K+ –> pi+ nu anti-nu to a record 10% precision is also discussed.

Poster, BBQ & Drinks / 15

Search for LFV and rare decays at the NA62 experiment at CERN

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The decay K+ -> pi+ nu nu-bar is highly suppressed in the Standard Model (SM), while its rate can be predicted with minimal theoretical uncertainty. The branching ratio for this decay is thus a sensitive probe of the flavor sector of the SM.; however, the smallness of this BR (8 x 10ˆ-11) and challenging experimental signature make it very difficult to measure. The primary goal of the NA62 experiment at the CERN SPS is to measure BR(K+ -> pi+ nu nu-bar) with ˜10% precision. This will require the observation of 10ˆ13 K+ decays in the experiment's fiducial volume, as well as the use of high-performance systems for precision tracking, particle identification, and photon vetoing. These aspects of the experiment will also allow NA62 to carry out a rich program of searches for lepton flavor and/or number violating Kˆ+ decays. Such searches can probe new physics scenarios involving, for example, heavy Majorana neutrinos or R-parity violating SUSY. Part of the experimental apparatus was commissioned during a technical run in 2012; installation continues and data taking is expected to begin in late 2014. The physics prospects and the status of the NA62 experiment will be reviewed.

Poster, BBQ & Drinks / 16

Atomic cesium magnetometers in the search for neutron EDM

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Atomic magnetometers are high precision detectors used for magnetic field measurement in many applications, including experiments testing fundamental symmetries in which knowledge of the magnetic field is essential. One such experiment is the search for the electric dipole moment of the neutron, a version of which is located at the new ultracold neutron source of the Paul Scherrer Institut in Villigen. In this experiment, an array of 16 optically-pumped double resonance atomic magnetometers based on cesium atoms is used to measure the spatial and temporal magnetic field distribution with a 10ˆ-7 relative precision. In this contribution we show the magnetometer technology and present the results of magnetic field measurements made under operating conditions of the nEDM experiment.

Mo - 4 / 17

A nEDM measurement by using a spallation UCN source of He-II

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We are studying a new nEDM measurement in the region of < 10-27 e cm, which can be a clue to understand baryogenesis in the universe. For improving counting statistics, we are increasing UCN density by means of a superthermal method [1]. We have placed a He-II bottle at a temperature below 1 K in a spallation neutron source, where UCN production rate is optimized. The UCN transport is improved so that higher UCN density is obtained in an EDM cell. The systematic error, in the previous nEDM measurement, was dominated by a geometric phase effect (GPE) on atomic spin precession, which was used as a magnetometer. The GPE arises from particle motion in a magnetic field gradient. We are studying a 129Xe spin magnetometer. The mean free path for 129Xe interatomic collisions can be short. The motion of the 129Xe atom is suppressed so that the GPE becomes small [2]. In this workshop, we will discuss the present status of our experiment.

[1] Phys. Rev. Lett. 108, 134801(2012).
[2] Phys. Lett. A 376, 1347(2012).

Tu - 3 / 18

Theoretical study of muon capture in light nuclei

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In this talk we review the theoretical calculations of muon capture reactions in light nuclei performed within the chiral effective field theory (EFT). In this approach the pions and nucleons are retained as degrees of freedom, but their mutual interactions, and their interactions with an external electroweak current, are constrained by the the symmetries of QCD, in particular its (spontaneously broken) chiral symmetry. In this way it is possible to construct in a consistent way both the nuclear strong-interaction potentials and the charge-changing weak currents. The unknown parameters entering the Lagrangian have been fixed to reproduce pion-nucleon scattering data,
nucleon-nucleon (NN) scattering data, the A=2 and 3 binding energies, and the triton Gamow-Teller matrix element, allowing for parameter-free predictions of the muon capture rates. We will present the results obtained in this approach for the muon capture on 2H and 3He nuclei. We will also present the results obtained for p-p fusion at energies of astrophysical interest.

We - 2 / 19

Experimental search for atomic EDM in 129Xe using active nuclear spin maser

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Since the electric dipole moment (EDM) in diamagnetic atoms strongly depends on nuclear structure, the EDM searches for various species are meaningful. We aim to measure the EDM in ^{129}Xe to a size of 10^{-28} $e$cm, stepping into a domain below the present upper limit by one order of magnitude. Such the EDM search requires an improvement in the frequency precision down to 1 nHz. In this study, an active nuclear spin maser, which enables us to sustain the spin precession of ^{129}Xe in a long measurement duration, is employed. A comagnetometer using ^{3}He has been incorporated to the system in order to cancel out a long-term drift in the external magnetic field. The developments in the frequency precision using the active spin maser and the current status of the EDM measurement will be presented.

Mo - 2 / 20

Light muonic atoms in search of new interactions at the Compton wavelength scale

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Assuming validity of electronic and muonic hydrogen experiments and assuming universality of lepton interactions, it is plausible to expect an unknown yet interaction at the range of the electron Compton wavelength. There are accurate measurements in search for such forces at larger distances, like that with the molecular hydrogen, H_2^+ or antiprotonic helium, but muonic hydrogen is the first accurate test of fundamental interactions at a few hundreds fm scale.

I will critically review solutions of the proton charge radius puzzle proposed in the literature and emphasize the importance of μHe measurement.

Poster, BBQ & Drinks / 21

Magnetic field environment for the CryoEDM experiment

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The CryoEDM experiment will carry out a precision measurement of the neutron electric dipole moment (EDM) at the ILL reactor facility in Grenoble. Neutron EDM is a parameter sensitive to a wide range of BSM theories addressing CP symmetry in the strong sector. EDM measurement on ultra-cold neutrons (UCN) is conditional on stringent magnetic field conditions, which present a range of hardware challenges, to be met in this case within a superthermal UCN source and Ramsey cell operating at a temperature of 0.5 K. The CryoEDM experiment aims to measure neutron EDM with a sensitivity better than ˜5E-27 ecm and is currently in a commissioning phase; hardware development and improvements to the magnetic field environment are discussed.

We - 1 / 22

A single trapped Ra+ion to measure Atomic Parity Violation

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Atomic Parity Violation (APV) arises from the exchange of Zˆ0 bosons between electrons atomic shell and the quarks within the nucleons of the nucleus. The size of APV effects is strongly enhanced in heavy atoms, even stronger than Zˆ3 [1]. A single trapped Ra+ ion (Z = 88), which is the heaviest available alkaline earth ion, is a superior system for measuring APV; the effects in Ra+ are some

20 times larger than in Ba+ and even 50 times larger than in Cs [1]. From the APVmeasurements one can expect to extract the Weinberg angle at low energies with some 5 times higher accuracy in about one week of measurement time. At that level of accuracy there is sensitivity to Z0' bosons and leptoquarks at mass scales beyond the possibilities of LHC.On the road towards precise APV experiments, on-line laser spectroscopy and atomic lifetime measurements have been performed in a linear Paul trap. The hyperfine structure (HFS) of the 6dˆ2D_{3/2} states [3] and isotope Shift of the 6dˆ2D_{3/2}-7pˆ2P_{1/2} transition have been measured [4] in order to provide benchmarks for the required atomic theory, in particular to probe atomic wave functions. Whereas the hyperfine structure measurements probe the electronic wave functions at the origin, lifetimes probe them at long distances and isotope shifts probe the size and shape of the nuclei [5]. An APV measurement requires the localization of the ion within a fraction of an optical wavelength. To achieve this, current experiments are focused on trapping and laser cooling of Ba+ ions as a precursor for Ra+. Work towards single ion trapping of Ra+, including an offline ˆ{223}Ra source, is in progress [6]. The setup which is used for a competitive APV measurement is also well suited for the realization of a single ion optical clock based on Ra+ [7], where the sensitivity to certain systematic shifts such as the electric quadrupole shift are minimal. Whereas for the APV measurement the light shift needs to be measured as a function of laser intensity very accurately, a clock requires stable control of the S-D transition. A stability of 10ˆ{-18} or beyond appears feasible for a ˆ{223}Ra+ clock.

[1] L. W. Wansbeek et al., Phys. Rev. A 78, 050501 (2008).
[2] O. O. Versolato et. al., Phys. Rev. A 82, 010501 (2010).
[3] O. O. Versolato et al., Phys. Lett. A 375, 3130-3133 (2011).
[4] G. S. Giri et al., Phys. Rev. A 84, 020503(R) (2011).
[5] L. W. Wansbeek et al., Phys. Rev. C 86, 015503 (2012).
[6] M. Nu˜nez Portela et al., Hyperne Interact. 214, 57-162 (2013).
[7] O. O. Versolato et al., Phys. Rev. A 83, 043829 (2011).

Summary:

A measurement of atomic parity violation in a single Ra+ ion promises an improved value for the Weinberg angle at low energies. The experiment has sensitivity, e.g., to extra Z0 bosons and leptoquarks.

Poster, BBQ & Drinks / **23**

A deep ultra-violet frequency-quadrupled diode laser system for the mercury co-magnetometer in the nEDM experiment

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e present a frequency lock for a DUV frequency-quadrupled diode laser system based on the sub-Doppler DAVLL (dichroic atomic vapor laser lock) technique applied to the \SI{253.7}{\nano\meter} transition in mercury. The laser system is part of a free induction decay magnetometer based on the optical detection of nuclear magnetic resonance (ODMR) in a spin polarized ensemble of ^{199}Hg atoms. The magnetometer is employed in the neutron electric dipole moment (nEDM) experiment at the Paul Scherrer Institute, Switzerland (PSI). The Standard Model (SM) of Particle Physics predicts a nEDM, breaking time reversal (T) and parity (P) symmetry, several orders of magnitude below the current best experimental limit $d_\mathrm{n} <$ \SI{2.9E-26}{\ecm} (\SI{90}{\percent} CL, [1]). However many theories beyond the SM predict values for a nEDM on the level of the current experimental sensitivities. Thus, neglecting the QCD θ-term, the search for a nEDM probes the parameter space of the SM extensions free from SM background. The experiment at the new UCN source at PSI aims at a factor five improved sensitivity and will place a limit of $d_\mathrm{n} <$\SI{5E-27}{\ecm} at \SI{95}{\percent} CL [2] in case no nEDM is found. In the next step the sensitivity will be improved by another order of magnitude, $d_\mathrm{n} <$ \SI{5E-28}{\ecm} at \SI{95}{\percent} CL in case no nEDM is found.\newline
The nEDM experiment uses Ramsey's method of separated oscillatory fields to detect a shift of the Larmor frequency of stored ultra-cold neutrons (UCN) in a parallel and an anti-parallel configuration

of magnetic and electric fields. To extract and survey the time stability ($\approx$ $numE-8$ over \SI{100}{\second}) of the magnetic field ($\approx$ $SI1microtesla$) a spin polarized ensemble of ^{199}Hg atoms is added to the UCN storage chamber and acts as a co-magnetometer. The free spin precession of the ^{199}Hg atoms after a $\pi/2$ flip is detected as amplitude modulation of a circularly polarized DUV light beam traversing the UCN/Hg storage volume in the spin precession plane. With the new laser system we have achieved a six fold increase of the modulation signal compared to the light from a ^{204}Hg discharge lamp used so far. Furthermore we have an improved control of vector light shift effects that could induce systematic frequency shifts on the level of the nEDM sensitivity correlated to necessary polarity reversals of the magnetic/electric fields. This project is supported by the Swiss National Science Foundation under contract number 200021_126562.

Poster, BBQ & Drinks / 25

Design of a Simultaneous Spin Analyser for the nEDM experiment at PSI

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The Standard Model (SM) of Particle Physics predicts a neutron Electric Dipole Moment (nEDM) several orders of magnitude below the current best experimental limit $d_n < 2.9\times10^{-26}$ e.cm (90% CL \cite{Baker}). The nEDM breaks both Time Reversal and Parity symmetry. Many extensions of the SM predict nEDM values at the level of the current experimental sensitivity. Thus, the nEDM search is a probe for physics beyond the SM. The nEDM is measured via the Larmor frequency shift of ultracold neutrons (UCN) in parallel and anti-parallel magnetic and electric fields. This frequency shift is measured using the Ramsey's separated oscillating fields method. At the new UCN source at the Paul Scherrer Institute (Switzerland), the collaboration aims to improve the sensitivity to the nEDM to 5×10^{-27} e.cm at 95% CL in a first step.In a second step, we aim to improve the sensitivity by another order of magnitude in a new spectrometer.

We will present a new neutron spin analyser designed to detect the two neutron spin states at the same time after the Ramsey precession. Currently, the two UCN spin states are detected one after the other, limiting the statistic because of neutron losses. The aim of building a simultaneous spin analyser is to improve the neutron detection efficiency and the spin analysis power of the setup in order to increase the nEDM statistical precision during the second phase of the nEDM project. This work is supported by Agence Nationale pour la Recherche, grant ANR-09-BLAN-0046.

Poster, BBQ & Drinks / 26

High electric field development for the SNS nEDM experiment

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The SNS nEDM collaboration is developing an experiment to search for the neutron's electric dipole moment (EDM), using ultracold neutrons (UCNs) stored in superfluid liquid helium, to be run at the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory. In this experiment, being able to achieve a strong and stable electric field in superfluid liquid helium in the region where UCNs are stored is of critical importance, because in EDM searches in general the sensitivity depends linearly on the strength of the applied electric field. However, the phenomenon of electric breakdown in liquid helium is poorly understood, and as such a major R&D effort is under way. The SNS nEDM collaboration has developed an apparatus to study electrical breakdown in liquid helium at temperatures as low as 0.4 K at pressures between the saturated vapor pressure and 1 atm for electrodes 12 cm in diameter with a gap size of a few cm. In this talk, the current status of the high electric field R&D and the implications of the findings on the SNS EDM experiment will be discussed.

Tu - 2 / 27

Test of Time-Reversal Invariance at COSY (TRIC)

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At the Cooler Synchrotron COSY a novel (P-even, T-odd) true null test of time-reversal invariance is planned as an internal target transmission experiment, which is not sensitive to final state interactions. The parity conserving time-reversal violating observable, the total cross-section asymmetry Ay,xz, will be measured to an accuracy of 10-6. This quantity is determined using a 135 MeV polarized proton beam and an internal tensor polarized deuteron target from the PAX atomic beam source. The reaction rate shall be measured by means of an integrated beam transformer (ICT). Thus, the cooler ring serves as ideal forward spectrometer, as a detector, and an accelerator.

Poster, BBQ & Drinks / 28

First application of an improved neutron optical force meter

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We aim to probe the electric charge of the free neutron at a level of 10ˆ-22 times the elementary charge. A possible neutron charge is related to the question of electric charge quantisation, which still remains unanswered by the standard model. Therefor, we developped a neutron optical system, based on a similar experiment in the late 80's (Borisov et al. 1987). This new setup is designed to detect forces of approx. 10ˆ-36N. We will test it via gravitational interaction this summer at the ILL, Grenoble, with a 7t movable attractor. We would like to present our first results at the PSI workshop.

Poster, BBQ & Drinks / 29

A new perfluorinated Polymers at liquid Nitrogen Temperature as a UCN Storage Material

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The uncertainty of the value of the neutron lifetime was raised from 0.8 seconds to 1.1 seconds due to three new wall storage experiments whose results were taken into account. To support solving this "Puzzle of Neutron Lifetime"we are preparing an UCN-wall storage experiment with a novel wall coating. We were able to obtain and analyze a perfluorinated polymer as proposed by Pokotilovski in 2002. It fulfills both a hydrogen free wall material and a very low melting point (about -155°C) whereby the neutron losses by inelastic scattering can be further reduced. Currently we are performing first storage experiments at the ILL, Grenoble to determine the UCN loss coefficient eta for this coating material. We expect this to be lower than the loss coefficient of the so far used Fomblin. We present first results and a perspective of using this polymer as a wall Coating Material

Mo - 4 / 30

New Searches for the Neutron Electric Dipole Moment

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A number of exciting technologies are under development that should allow for significant improvements in the sensitivity to neutron electric dipole moments. We will discuss the techniques and experiments that are underway and the status of the various efforts that plan to improve the sensitivity by a factors of 10 - 100.

Summary:

New Searches for the Neutron Electric Dipole Moment

31

UCNA and UCNB: Using ultracold neutrons to measure the beta-asymmetry and neutrino-asymmetry at LANSCE

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The Ultracold Neutron (UCN) program at the Los Alamos Neutron Science Center has developed one of the highest density sources of UCN in the world to perform precision measurements of neutron decay observables. The UCNA collaboration has recently published a sub-percent measurement of the beta-asymmetry, $A_0 = -0.11954(55)_{stat}(98)_{sys}$, used to extract $\lambda = g_A/g_V = -1.2756(30)$,

the ratio of the axial-vector and vector coupling constants. We are now analyzing data from the latest run cycles which implemented significant improvements to reduce all major systematic effects. The UCNB experiment will use thick, large-area, highly segmented silicon detectors installed in the existing UCNA spectrometer to detect protons and electrons in coincidence in order to extract the antineutrino-asymmetry B, used to place limits on non-Standard Model scalar and tensor interactions. UCNB has demonstrated the capability for very low noise operation at 20˜kV bias voltage and 1˜T magnetic field. We expect to observe the first electron-proton coincidences from neutron decay in the 2013 run cycle with up to 24 pixel segments instrumented on each detector, and begin to characterize systematic effects to achieve our preliminary goal of a 0.1% uncertainty measurement. We will present progress on the development of these experiments and the latest updates from the beginning of the 2013 beam cycle.

Summary:

We will present an overview of and results from the UCNA and UCNB experiments.

Mo - 4 / 32

Probing CP violation with EDMs

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I will review the impact of searches for electric dipole moments of nucleons, atoms and molecules on our knowledge of fundamental sources of CP (or T) violation in nature. The talk will focus on the use of effective field theory to disentangle the constraints on different fundamental CP-odd sources, and the recent interplay with direct LHC exclusion limits on possible models of new physics.

Mo - 3 / 33

Search for lepton universality violation in kaon two-body decays

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An experiment (E36) to search for lepton universality violation is planned at J-PARC. The ratio of decay widths of K_{e2} and K_{mu2} will be measured precisely using a high-intensity low-momentum kaon beam. In contrast to NA62 experiment at CERN the stopped beam technique is employed. The TREK detector, originally designed for T-violation search in K_{mu3} decays, will be used. The ratio may deviate from the standard model prediction due to contributions from new physics such as lepton flavor violating SUSY. E36 looks for such effects with a sensitivity of better than 0.25% in the decay width ratio. Beam time is scheduled in 2014 and 2015, and the preparation of the detector is now going on. Several detector R&Ds and test measurements have already been done. In this paper we present 1) the physics background of the lepton universality violation, 2) the detector system, 3) methods of systematic error suppression, and 4) the aimed sensitivity of the experiment.

Poster, BBQ & Drinks / 34

Probing sub-eV particles with 3He

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Many proposed extensions of the Standard Model of particle physics predict the existence of weakly interacting slim (sub-eV) particles (WISP). As WISPs are naturally Dark Matter candidate, they are actively search for using a great variety of experimental methods. Since WISPs are light particles, they could mediate a new interaction between ordinary particles with a macroscopic range. If the new interaction is spin-dependent, as in the case of Axion-like particles, it would generate pseudo-magnetic effects at short range. A new sensitive method has been recently developed in Grenoble to probe such a short-range pseudo-magnetic interaction, using hyperpolarized 3He gas. The pseudo-magnetic field possibly generated by the surface of a 3He cell would induce an anomalous depolarization of the 3He nuclei. The anomalous effect could be separated from the usual depolarization mechanisms by studying the longitudinal depolarization rate as a function of an applied magnetic field. The enhancement of sensitivity, as compared to other techniques, comes from the very long relaxation time (several days under certain conditions) of the polarized gaz.

A test experiment performed in 2010 at the Institut Laue Langevin (ILL) is already competitive in the search for exotic spin-dependent short-range interactions [A. K. Petukhov, G. Pignol, D. Jullien, K. H. Andersen, Phys. Rev. Lett 105 170401 (2010)]. A collaboration was then initiated between the LPSC and the ILL to set up a dedicated magnetic facility in order to improve the sensitivity of the method by a factor 50.

Tu - 1 / 35

Phase diffraction gratings for the transformation of neutron energy

Author: Alexander Frank[1]

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The review concerning the application of moving grating for the transformation of neutron energy spectrum will be presented. It was predicted theoretically almost 20 years ago [1] and experimentally demonstrated [2] that a diffraction grating moving across the neutron wave propagation acts as non-stationary quantum device. Later a moving phase grating with variable spatial frequency was successfully used for the first observation of the neutron focusing in time [3]. The comparing of energy transferred at diffraction of UCN by a moving grating with the energy change due to free falling of neutron was successfully used for experimental test of the weak equivalence principle for neutron [4]. The same approach is a base of the new gravity experiment [5] which is now in progress.

The qualitative consideration and experimental data which are indicates that diffraction efficiency decreases remarkably at the grating velocity increasing will be presented. More rigorous theoretical analysis of the problem which was made recently is in qualitative agreement with experimental results [6] . Some possibilities of the solution of this problem will be discussed.

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Th - 2 / 36

Improved Determination of the Neutron Lifetime

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The most precise determination of the neutron lifetime using the beam method reported a result of $\tau_n = (886.3 \pm 1.2\,[\text{stat}] \pm 3.2\,[\text{sys}])$ s. The dominant uncertainties were attributed to the absolute determination of the fluence of the neutron beam (2.7 s). The neutron beam fluence was determined with a monitor that counted the neutron-induced charged particles from absorption in a thin, well-characterized ^{6}Li deposit. The detection efficiency of the monitor was calculated from the areal density of the deposit, the detector solid angle, and the ENDF/B-VI ^{6}Li(n,t)^{4}He thermal neutron cross section. We have used a second, totally-absorbing neutron detector to directly measure the neutron detection efficiency of this monitor on a monochromatic neutron beam of precisely known wavelength. This method does not rely on the ^{6}Li(n,t)^{4}He cross section or any other nuclear data. The monitor detection efficiency was measured to an uncertainty of 0.06\,\%, which represents a five-fold improvement in uncertainty. We have verified the temporal stability of the neutron monitor through ancillary measurements, which allows us to use the measured neutron monitor efficiency to improve the fluence determination from the 2005 experiment. An updated neutron lifetime based on the improved fluence determination will be presented.

Poster, BBQ & Drinks / 37

Development of a novel muon beam line for next generation precision experiments

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Several next generation precision measurements like muonium (Mu=μ^+e^-) spectroscopy, (g-2)$_\mu$, searches for Mu-$\overline{\text{Mu}}$ oscillations and muon (μ^+) electric dipole moment can be conceived with improved μ^+ and Mu beams.

The principle of the novel μ^+ beam line proposed in PRL \textbf{97}, 194801 (2006) is to stop a standard μ^+ beam in He gas at cryogenic temperatures, and to compress the μ^+ swarm using electric and magnetic fields and gradients of gas densities. Results of the longitudinal compression measured at πE1 beam line of PSI together with the proposed test of transverse compression will be presented.

We - 4 / 38

Low-energy precision measurements at the intensity frontier

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Measurements of observables in nuclear beta decay and neutron decay continue to provide important information on the structure and symmetries of the weak interaction at low energy. Here the focus will be on state-of-the-art precision measurements in nuclear beta decay using a variety of techniques, many of which are based on ion and atom traps. A large number of experiments is currently ongoing or being set up at radioactive ion beam facilities worldwide. Comparing experimental results with the standard model expected values allows testing the standard model or searching for physics beyond.
An update and overview of this field will be presented. With the precision of these measurements reaching the per mille level small standard model effects now have to be included as well. The understanding of some of these requires additional measurements be performed in order to maintain optimal sensitivity to weak interaction properties. Prospects and future of this type of low-energy weak interaction studies in the era of the Large Hadron Collider will be discussed briefly as well.

Th - 3 / 39

Mu2e at Fermilab: a search for charged lepton flavor violation in muon to electron conversion

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The Mu2e experiment will search for coherent, neutrino-less conversion of muons into electrons in the field of a nucleus to a few parts in 10^{-17}. This lepton flavor violating process is sensitive to a range of new physics models inaccessible through other searches. The ambitious 4 order of magnitude sensitivity improvement over existing limits will probe mass scales up to O(10^4) TeV, far beyond the direct reach of colliders, providing ample opportunities for a discovery.
The design and status of the experiment will be presented.

Poster, BBQ & Drinks / 40

Measuring The Neutron Lifetime to One Second Using in Beam Techniques

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The decay of the free neutron is the simplest nuclear beta decay and is the prototype for charged current semi-leptonic weak interactions. A precise value for the neutron lifetime is required for consistency tests of the Standard Model and is an essential parameter in the theory of Big Bang Nucleosynthesis. A new measurement of the neutron lifetime using the in-beam method is planned at the National Institute of Standards and Technology Center for Neutron Research. The systematic effects associated with the in-beam method are markedly different than those found in storage experiments utilizing ultracold neutrons. Experimental improvements, specifically recent advances in the determination of absolute neutron fluence, should permit an overall uncertainty of 1 second on the neutron lifetime. The technical improvements in the in-beam technique, and the path toward improving the precision of the new measurement will be discussed.

Mo - 3 / 41

Rare pion and kaon decays

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The present status of pion and kaon decay experiments will be discussed. The focus will be on precision measurements of the decay modes allowed and cleanly caluculated in the Standard Model (SM) but suppressed by some mechanisms that enable a sensitive test of physics beyond the SM.

Tu - 1 / 42

New Results from the NPDGamma Parity Violation Experiment at the Spallation Neutron Source

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The Hadronic Weak Interaction (HWI) is a complementary probe of nuclonic structure. Although this interaction is dominated by several orders of magnitude by the strong nuclear interaction, it can be isolated through parity violating observables. The HWI can be classified in chiral effective field theory in terms of the spin and isospin dependence of transition amplitudes involving S and P waves. There is an active program to determine the EFT parameters by measuring hadronic PV using cold neutron beams at the Spallation Neutron Source (ORNL) and the NCNR reactor (NIST). These experiment use only few-body observables, for which nuclear wave functions are calculable. The NPDGamma experiment, currently running at the SNS, will measure the gamma asymmetry relative to the neutron spin in the reaction n + p -> d + gamma. This asymmetry is only sensitive to the 3S1->3P1 isovector transition amplitude, usually modeled in terms of weak pion exchange. We will present preliminary first results from this experiment, and show how they will be used with existing data and future experiments to characterize the four major couplings of the HWI.

Poster, BBQ & Drinks / 43

Precision Magnetic Fields for Fundamental Neutron Symmetries

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Because the neutron has only a single static moment–the magnetic dipole, virtually every fundamental neutron physics experiment relies on static and/or oscillating magnetic fields to manipulate the neutron spin and/or kinematics. The level of precision required for modern experiments places stringent constraints on field uniformity, fringes, geometry, magnetic materials, and shielding, which impose formidable challenges on magnet coil design. We describe new techniques being developed to design precision coils and construct them with an industrial robotic arm. These techniques allow direct calculation of coil windings subject to geometric and field constraints. The techniques are based on a new physical interpretation of the magnetic scalar potential, which lends itself to elegant illustrations of the mixed symmetry between electric and magnetic fields.

We - 4 / 44

Gravitational four-fermion interaction and dynamics of the early Universe

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If torsion exists, it generates gravitational four-fermion interaction (GFFI), essential on the Planck scale. We analyze the influence of this interaction on the Friedmann-Lemaitre-Robertson-Walker cosmology. Explicit analytical solution is derived for the problem where both the energy-momentum tensor generated by GFFI and the common ultrarelativistic energy-momentum tensor are included. We demonstrate that GFFI does not result in Big Bounce.

Tu - 2 / 45

Present status of crystal diffraction nEDM experiment and related neutron optics phenomena

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Here we discuss a modern status of crystal diffraction experiment for searching the electric dipole moment of a neutron (nEDM) with the sensitivity comparable or exceeding that for the most sensitive now magnetic resonance method using ultra cold neutrons (the current best limit is D_n < 3x10^{-26} e cm at 90% C.L. obtained at the ILL reactor in Grenoble resulted the long-term efforts of PNPI and ILL groups). The new limits on the nEDM value would be of great importance for understanding the nature of the CP violation as well as of the Universe baryon asymmetry.
Also series of experiments on neutron optics was carried out in Gatchina at PNPI reactor WWR-M to study the features of the neutron propagation through a crystal at nearly Bragg energies. The time of passage of the neutron through the crystal has been studied as a function of the deviation from the Bragg condition. The anomalous behavior of the dispersion of the neutron, i.e., the energy

dependence of its average velocity, has been observed. It has been shown that the derivative dv/dE for the diffracting neutron at nearly Bragg energies can be three or four orders of magnitude larger than this derivative for a free neutron. This important fact should be taken into account in nEDM experiment, as well it opens new possibilities in precision neutron spectroscopy.
For example a method for measuring small changes in the neutron energy has been proposed on the basis of this anomalous dispersion behavior for the neutron in the crystal near Bragg "resonance." A high sensitivity of the method allows the observation of the acceleration of the neutron in the alternating magnetic field. It has been found that the small difference between the energies of two spin states of the neutron (parallel and antiparallel to the magnetic field) leads to significant spatial splitting of wave packets and, correspondingly, to the depolarization of the neutron beam.

Mo - 2 / 46

Kaonic atoms –high precision studies on the low-energy antikaon interaction

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The antikaon interaction on nucleons and nuclei in the low-energy regime is a challenging research field in experiment and theory. Now new precise data are available from x-ray spectroscopy of the lightest hadronic atoms with strangeness, i.e. kaonic hydrogen and helium isotopes. From the measurement of the x-ray transitions to low-lying levels by SIDDHARTA at DAFNE/Frascati the up-to-now most precise values for hadronic shifts and widths were extracted. The new precision data are essential input for the theoretical description. Therefore, SIDDHARTA is a key experiment for the understanding of low-energy QCD with strangeness. The experimental method, the final results and the implications as well as future opportunities will be presented.

We - 4 / 48

Probing the Standard Model via 35Ar beta decay with the WITCH spectrometer

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High-precision measurements of weak-interaction observables offer a powerful probe of physics beyond the Standard Model complementary to that provided by direct searches at colliders like the LHC. In particular, beta-decay kinematic correlation measurements can be sensitive to the presence of scalar and tensor current interactions, which are assumed to be absent in the standard electroweak model.

The WITCH spectrometer is a unique apparatus designed to determine the beta-neutrino angular correlation coefficient via the shape of the recoil-ion energy distribution. It consists of a double Penning trap system for the preparation and storage of a scattering-free source, coupled with a MAC-E type retardation spectrometer and large position-sensitive MCP detector to detect the recoiling daughter ions.

The commissioning phase of the apparatus has come to a close and the first physics results for the beta-neutrino angular correlation coefficient in the decay of 35^Ar have been obtained at the end of 2011. Many upgrades to the system have been implemented in the interim, culminating in the first

high-statistics data taking run, which was performed in November 2012. Details of the analysis of this new data set, including preliminary results, will be presented.

Poster, BBQ & Drinks / 49

Electric Fields in Cryogenic nEDM Experiments

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In the CryoEDM experiment at ILL, magnetic resonance is performed on ultra-cold neutrons stored in superfluid helium at 0.6K. The sensitivity to an electric dipole moment is directly proportional to the strength of the E-field applied across the resonance cell. It has been suggested that the dielectric properties of liquid helium should permit the use of fields much higher than the ˜10kV/cm obtainable to date in room temperature nEDM experiments. We report data showing that ˜400kV/cm can be maintained in small (˜1mm separation) test cells containing helium at 1.3K and 1.5bar. We discuss some of the factors which are expected to limit the E-field in a large (˜4cm separation) CryoEDM cell and the implications for systematic effects.

Poster, BBQ & Drinks / 50

Search for the MUonium annihilation inTO Neutrinos (MUTON)

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In the Standard Model (SM) there are several canonical examples of purely leptonic processes involving the muon, the electron and the corresponding neutrinos which are connected by the crossing symmetry: i) the decay of muon, ii) the inverse muon decay and iii) the annihilation of a muon and an electron into two neutrinos.
Although the first two reactions have been observed and measured since long ago, the third process, resulting in the invisible final state, has never been experimentally tested.
It may go either directly, or, at low energies, via the annihilation of a muon and an electron from an atomic bound state, called muonium (Mu).
The Mu annihilation into two neutrinos is expected to be a very rare process, with the branching fraction predicted to be 6.6 x 10ˆ-12 with respect to the ordinary muon decay rate.

In this talk, we will present our proposal for an experiment (MUTON) dedicated to the sensitive search for this process with a primary goal to observe it for the first time.
A feasibility study of the experimental setup shows that the sensitivity of the search in branching fraction at the level of 10ˆ-12 could be achieved.
The Mu annihilation rate could be enhanced by non-SM contributions, e.g. due the muonium transition into a hidden sector.
This may occur in the mirror matter model due to muonium-mirror muonium conversion. The current indirect limit < 5.7 x 10ˆ-6 (90\%C.L.) is quite modest, still leaving a big gap of about 6 orders of magnitude between this bound and the predictions.
The experiment is also sensitive to an exotic decay mode muon->invisible. This leptonic charge-non conserving process may hold in four-dimensional world in models with infinite extra dimensions, thus making its search complementary to colliders experiments probing new physics.

We - 1 / 51

Positronium 1S-2S measurement

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We report the progress of the ongoing project at ETH Zurich aiming to improve the current accuracy in the measurement of the energy interval of positronium (Ps) from its ground state (1S) to the first excited state (2S) by a factor of 5. This will result in a very stringent test of QED and will provide the best determination of the positron-electron mass ratio.
If the accuracy of the measurement could be further increased by a factor 5, this would lead to a model independent test of the effect of gravity on anti-matter. The gravitational redshift predicted by general relativity was one of the great implications of Einstein's theory that was demonstrated experimentally. The pace of two identical clocks placed at different gravitational potentials is different. If gravity would act differently on antimatter, a shift between Ps and a reference clock made of matter (e.g. a cesium clock) should be observed in the different gravitational potential created by the large variation of 5 millions km of the earth's orbit around the sun during the year.

Poster, BBQ & Drinks / 52

The GRANIT experiment

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The GRANIT instrument is designed to study quantum states of Ultra Cold Neutrons (UCNs) bouncing over a mirror in the gravitational field.
The UCNs are produced by a dedicated superthermal helium source installed at the ILL reactor.
The storage time in the source and the velocity spectrum of extracted neutrons have been recently measured, the source is now connected to the GRANIT spectrometer.
Commissioning is underway and the very first results have been obtained.
The next step will consist in inducing resonant transitions between quantum states in a flow through mode using an oscillating magnetic field gradient.
Searching for deviations of the expected resonant frequencies we can test the weak equivalence principle in a quantum context and/or probe the existence of a new force such as the Chameleon field, a candidate to explain the Dark Energy.

Poster, BBQ & Drinks / 53

HOPE –a magnetic UCN trap to measure the neutron lifetime

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The lifetime of the free neutron is a key quantity for primordial nucleosynthesis, calculation of experimentally inaccessible weak cross sections and for tests of the standard model of particle physics. During past decades, continuous efforts have been made to measure its value with increasing precision, predominantly using cold neutron beams or by trapping ultra cold neutrons (UCN) in material bottles. A new generation of neutron lifetime experiments will confine UCN in a magneto-gravitational potential. In contrast to material bottles neutron interactions with material walls are avoided, which represented a major source of systematic uncertainty.
HOPE employs a combination of a permanent magnet octupol system and several superconducting coils for confinement. It will be installed on the new UCN source SUN2 that is currently commissioned at the ILL in Grenoble. First systematic measurements are currently in preparation and will focus on the main sources of systematic uncertainties of magnetic UCN traps, neutron depolarization and marginally trapped neutrons. While first measurements will employ the classical "fill and empty"method, in a later stage a charged particle detector will enable us to perform also online measurements of the neutron decay products.

Poster, BBQ & Drinks / 54

MC simulations for RT-nEDM systematics

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One important aspect of the study of systematic effects in room-temperature (RT) nEDM is the center of mass offset of the stored ultracold neutrons (UCN) due to gravity and the Larmor frequency shift connected to it.
We will present simulation results on such a shift and on the transversal depolarization time (T2) of the UCN (affecting sensitivity) as a function of realistic magnetic fields which were parametrized from offline mapping measurements.
We show that the fraction of diffuse reflections and the energy spectrum of the UCN play a major role, and will also compare to theoretical predictions for simple magnetic field configurations serving as bench-marks for the realistic field calculations.

We - 2 / 55

The Electron and Its Dipole Moments: Most Stringent Tests of the Standard Model

Author: Gerald Gabrielse[1]

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The most precise measurement of the properties of an elementary particle is the magnetic dipole of the electron which we have been able to measure to 3 parts in 10ˆ13. Perhaps the greatest triumph of the Standard Model of particle physics is a prediction of the measured value to nearly this precision. The electron's electric dipole moment provides an important constraint on extensions to the Standard Model such as supersymmetric models. Our ACME collaboration is closing in on a more sensitive measurement of this moment, profiting from the huge electric field within the ThO molecule.

Tu - 4 / 56

Neutron Polarimetry On the 10ˆ-4 Level

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Correlation coefficients of the polarized neutron beta decay offer a way to test the standard model by precision measurements. One of the currently leading systematic errors is the neutron polarization. State-of-the-art polarizing super mirrors in the X-SM geometry deliver about 99.7(1)% polarization.
We present recent developments in cold neutron polarization, based on the opaque test bench of 3He spin filters: We have shown experimentally that the accuracy of polarization analysis with opaque 3He spin filters is better than 10ˆ-4. By optimizing the operating conditions of supermirrors and selecting the materials, we have achieved a polarization of 99.97(1) % with the X-SM geometry for a divergent 5.3 Å beam (monochromatized by a velocity selector). These results solve the issue of neutron beam polarization for the next generation of neutron beta decay correlation experiments which aim for accuracies of 10ˆ-4.

Poster, BBQ & Drinks / 57

A Measurement of the Total Cross Section of Liquid Parahydrogen for Cold Neutrons

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Liquid hydrogen is commonly used as a neutron moderator and accurate knowledge of the scattering cross section is critical for the design of cold sources. The total cross section for cold neutrons with wavelengths between 2.3 and 14A has been measured for liquid hydrogen at 15.7K. Provided that the orthohydrogen concentration in the target vessel is at the thermodynamic equilibrium limit and using the known hydrogen absorption cross section, we can extract the parahydrogen scattering cross section from our measurement. Our result does not agree with the Seiffert[1] measurement and this disagreement cannot be due to orthohydrogen contamination in our measurement. The measurement was performed on the Fundamental Neutron Physics Beamline at the Spallation Neutron Source at Oak Ridge National Laboratory. The experiment and data analysis will be described.

[1] W. D. Seiffert. Euratom Report No. EUR 4455d, 1970.
Submitted for the NPDGamma Collaboration.

We - 1 / 58

A new mass of the electron

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The g factor of an electron bound to a nucleus depends on the frequency ratio between the Larmor frequency of the electron and the cyclotron frequency of the ion, the ion mass and the electron mass. The high precision g factor measurement on hydrogen-like silicon 28Si13+ with a relative uncertainty of 8.5*10^-10 perfectly agrees with the bound-state quantum electrodynamical calculations (BS-QED) [1]. The uncertainty on the theoretically predicted g factor is dominated by not yet calculated higher order contributions in (Z alpha)^n. Due to the relatively small Z of carbon the g factor of hydrogen-like carbon 12C5+ can be predicted with a relative uncertainty of at least 1.5*10^-11. Improvements in our measurement principle [2] enabled the determination of the frequency ratio between Larmor- and cyclotron frequency of 12C5+ to so far unrivalled precision. Trusting in the theoretically predicted g factor this measurement determines the electron mass in atomic units, which is at least one order of magnitude more precise than the current CODATA value.
The experimental setup with two different Penning traps, the measurement principle and preliminary results are presented.

[1] S. Sturm et al., Phys.Rev.Lett., 107, 023002 (2011)
[2] S. Sturm et al., Phys.Rev.Lett., 107, 143003 (2011)

Poster, BBQ & Drinks / 59

Progress towards a next generation UCN source at TRIUMF

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Most (if not even all) experiments with ultra-cold neutrons (UCN)
currently under development need higher UCN densities than presently available. There are multiple efforts world wide to achieve an increase of up to three orders of magnitude in the storable number of UCNs. Different combinations of neutron source and UCN convertor are used by the various groups.
Neutrons either come from a research reactor or an accelerator-driven spallation source; superfluid helium or frozen deuterium are used as converter material.
The UCN source at TRIUMF in Canada will use the 480-MeV proton beam
from the cyclotron impinging on a tungsten target to create spallation neutrons. A combination of lead, graphite, light and heavy water and possibly liquid deuterium and Be will moderate the

neutrons; the superthermal converter He-II scatters the neutrons down to the ultra-cold regime. With a beam current of 40 muA, a density of > 1e4/cc should be achievable.

The progress towards the dedicated UCN beamline at TRIUMF, the optimization of the moderator design and development of the neutron electric dipole moment experiment will be presented.

We - 3 / 60

Antihydrogen and Antiproton Physics in the LHC era

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With the discovery of the Higgs particle at the LHC, particle physics is entering a new era, where low energy precision experiments are expected to play increasingly important roles. In this context, I will try to motivate experiments using antiprotons and antihydrogen, and argue how they may provide unique insight into fundamental physics, in a manner complementary to other precision experiments. I will then give some recent experimental highlights in the field, and also discuss the future prospects.

Mo - 4 / 61

Present status and future prospects of nEDM experiment (PNPI-ILL-PTI)

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Results of the current measurements of neutron EDM in ILL will be presented. Prospects of increase in sensitivity of experiment due to UCN density increasing and the new scheme of UCN traps of EDM spectrometer will be discussed. The second part of the report will be devoted to preparation of UCN source with superfluid helium in PNPI.

Poster, BBQ & Drinks / 62

Experiment NEUTRINO-4 search for sterile neutrino at WWR-M reactor and SM-3 reactor.

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The project of experiment search for sterile neutrino will be presented. Results of preparations of the experiment at WWR-M reactor and plans of realization of the main experiment on the SM-3 reactor are discussed.

Tu - 4 / 63

Precision measurement of muonium hyperfine splitting at J-PARC

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Muonium is the bound state of a positive muon and an electron. In the standard model of particle physics, muonium is considered as the two-body system of structureless leptons. There is no severe strong interaction effects as in a hydrogen atom, or annihilation effects and intensive recoil effects as in a positronium. Therefore, muonium is the appropriate system for precision test of fundamental interactions.

At J-PARC(Japan Proton Accelerator Research Complex), we are going to measure muonium's hyperfine splitting precisely. Our experiment has three major objectives; test of QED with the highest accuracy, precision measurement of the ratio of muon's magnetic moment to proton's one, and search for CPT violation via the sidereal oscillation.

The uncertainty of latest experimental result[1] is mostly statistical uncertainty(more than 90% of total uncertainty). Hence, higher statistics is essential to the higher precision of measurement. Our goal is more than 10 times accuracy with 200 times of statistics relative to the latest experiment. For improvement of precision, we use the J-PARC's highest intensity pulsed muon beam and highly segmented positron detector with SiPM(Silicon PhotoMultiplier). After the improvement of statistical precision, it becomes more important to reduce systematic uncertainty. Thus, we reduce systematic uncertainty by using longer cavity, high precision magnet, and online/offline beam profile monitor. In this talk, we discuss the experimental overview and R&D status of each components.

[1] : W. Liu et al.,PRL. 82, 711 (1999).

Summary:

Experimental overview and R&D status of the precision measurement of muonium hyperfine splitting in J-PARC.

Poster, BBQ & Drinks / 64

Nuclear fragmentation studies with antiproton-nucleus annihilations

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This work aims at collecting experimental data on low energy antiproton-nucleus annihilation - especially on nuclear fragmentation - by using emulsion detectors.

In spite of their importance in many fields such as nuclear physics, astronomy and radiology, the properties of stopping antiprotons, in particular the energy distributions, the multiplicities and the particle types emitted by the annihilation on nuclei are not well known.

In the AEgIS experiment (AD6) at CERN (designed to measure the gravitational acceleration of antihydrogen) we exposed several thin targets (Al, Si, Ti, Cu, Ag, Au and Pb) to antiprotons with mean kinetic energies of 100 keV, which were obtained by degrading the extracted beam from the Antiproton Decelerator.

Emulsion detectors have excellent position resolutions (of the order of 1 micron) to detect the nuclear fragments one by one, and the ability to distinguish between highly ionizing particles, such as nuclear fragments or protons,
and other annihilation products products, such as pions and kaons.

This talk will present the results of our nuclear fragmentation study and offer a comparison with simulation models.

Available reference: arxiv.org/abs/1306.5602

Poster, BBQ & Drinks / 65

Investigation of systematic uncertainties of the aSPECT experiment

Author: Alexander Wunderle[1]

Co-authors: Christian Schmidt [2]; Christine Klauser [3]; Ferenc Glück [4]; Gertrud Konrad [5]; Jacqueline Erhart [5]; Marcus Beck [6]; Martin Simson [7]; Michael Klopf [5]; Oliver Zimmer [3]; Romain Maisonobe [3]; Romain Virot [3]; Stefan Baeßler [8]; Torsten Soldner [3]; Werner Heil [9]

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With the retardation spectrometer aSPECT we aim to determine the beta-neutrino angular coefficient a in free neutron decay with high precision. Using this measurement the weak coupling constants gA/gV can be determined and therefore the Standard Model can be tested. To reach this high precision, the systematic uncertainties have also to be known with high precision.
In the past years several systematic investigations to determine these uncertainties have been performed and major improvements were achieved..
This poster gives an overview of the systematic uncertainties, as well as the employed methods to investigate them and the improvements to the spectrometer to minimise these uncertainties.

Poster, BBQ & Drinks / 66

Background investigations on the neutron β-decay spectrometer aSPECT

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The retardation spectrometer aSPECT measures the proton recoil spectrum in free neutron β-decay with high precision. From this spectrum the electron-antineutrino angular correlation coefficient a can be extracted and used to derive the ratio λ = gA / gV of the weak coupling constants. For this high precision measurement, a good understanding of the background is indispensable.

In 2012 the spectrometer was operated without neutron beam, allowing to thoroughly investigate the background. Measurements were performed to evaluate the background behavior for different electrode voltage settings and vacuum conditions. In order to simulate the rest-gas ionization by electrons from neutron decay a beta source (activated gold foil) was used. This study was continued under beamtime conditions, at the neutron beam PF1b at the Institut Laue-Langevin in 2013.

We present results and first conclusions of these investigations.

Tu - 2 / 67

Measurement of Electric Dipole Moments in Storage Rings

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The existence of permanent electric dipole moments (EDMs)
of elementary particles violates
two fundamental symmetries, time reversal, $\mathcal{T}$,
and parity $\mathcal{P}$.
Assuming that the combined symmetry transformation $\mathcal{CPT}$,
where $\mathcal{C}$ is the charge conjugation,
is conserved by all interactions, $\mathcal{T}$ violation is equivalent
to $\mathcal{CP}$ violation.

$\mathcal{CP}$ violation is of particular interest since it is required to
explain the dominance of matter over anti–matter in our universe.
The Standard Model (SM) predictions are several orders of magnitude
too small to account for this dominance.
Additional $\mathcal{CP}$ violating interactions are needed.

These could show up in permanent electric dipole moments of elementary particles.

Up to now, EDM searches focused on neutral particles, for example neutron, atoms and molecules, because charged particles are accelerated in large electric fields and therefore cannot be kept in small volumes.
Storage rings with diameters $>$10m have to be operated to allow for charged particle EDM measurements.
Such EDM storage ring projects for proton, deuteron and light nuc\-lei are pursued at Brookhaven National Laboratory and at Forschungszentrum J\"ulich with the ultimate goal to reach a sensitivity of $10^{-29} e$·cm.

Poster, BBQ & Drinks / 68

Accuracy before sensitivity: Magnetically-silent vector magnetometer as a new tool for nEDM search

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For many years the central focus of atomic magnetometer development has been towards an increase in sensitivity while the aspect of absolute accuracy in the field measurement has received less attention. Here we present measurements made with a novel atomic magnetometry scheme based on the detection of the free induction decay of a spin-oriented Cs vapour which, together with a three beam readout, yields an accurate and sensitive determination of the three components of the magnetic field at the sensor's location.

Summary:

The precision measurement and control of magnetic fields in nEDM experiments is a major prerequisite for controlling systematic errors. Over the past decade, the Fribourg atomic physics group has contributed to this task by two generations of laser-pumped atomic magnetometers (LPM). We are currently working on a third generation of LPMs that shall overcome major identified limitations of the methods deployed in the past. Our previous generation of Mx magnetometers has demonstrated a remarkable sensitivity and robustness in vacuum and high electric field environment. The weakest point of Mx-magnetometers based on phase-locked loops is their lack of absolute accuracy: in order to yield identical readings of a 1 microT field with 10 fT precision, the internal phases of two nominally identical sensors have to be adjusted with a precision of better than 5 microrad, which is rendered impractical, if not impossible, by both mechanical construction and electrical signal treatment considerations. Moreover, the currently deployed Mx-technique magnetometers require a weak oscillating magnetic field to be applied to the sensor to drive the resonance condition. Stray fields from one sensor influence its neighbors, yielding sensor cross talk, another potential source for systematic readout errors.

Here we propose a magnetometer scheme based on the free induction decay (FID) of a spin-oriented Cs vapour. The feedback-free nature of the free precession makes it possible to measure the absolute value of the magnetic field.

We will present details our progress toward a magnetically silent (all-optical) vector magnetometer. Spin orientation is produced by optical pumping with amplitude-modulated light (Bell-Bloom pumping) in an anti-relaxation coated vacuum cell, followed by a recording of the resulting FID using light of significantly lower intensity. The direction and amplitude of the magnetic field are reconstructed by monitoring the transmitted light intensity of three nonparallel beams traversing the vapour cell. The sensitivity and the limitations of the method will be addressed. The pulsed mode of operation of such magnetometers reduces their sensitivity yet yields the benefits of a significantly increased accuracy and vector information, both features of primordial importance for nEDM experiments.

Poster, BBQ & Drinks / 69

Digital pulse processing of proton detector signals for the spectrometer aSPECT

Author: Romain Virot[1]

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The retardation spectrometer aSPECT was designed to measure the electron-antineutrino angular correlation a in free-neutron decay with high accuracy. This coefficient allows to determine the ratio of the weak coupling constants. In aSPECT, it is extracted from the proton recoil spectrum. After selection by a retardation potential, protons are accelerated to typically ˜15keV and deposit up to 10keV in the active volume of a silicon drift detector. The threshold for proton detection must be as low as possible in order to detect also protons depositing very little energy. One challenge is the presence of decay electrons with energies of several hundreds of keV. They can precede coincident protons by a few microseconds only. The quite different energy ranges have to be handled by the same acquisition system, with good resolution for the proton signal and without saturation for the electron signal and proton loss.

We have employed two solutions: a non-linear analog shaper with digital pulse processing of the shaped signal and direct digital pulse processing of the preamplifier signal. The non-linear shaper reduces the amplification for higher signals. Therefore, a moderate resolution in the ADC is sufficient. However, spectra are more difficult to calibrate and saturation effects in the preamplifier may be invisible. Direct processing of the preamplifier signal requires a much higher resolution of the pulse processing ADC which became available only recently. In the 2013 beamtime at the Institut Laue-Langevin, a 14 bit ADC has been tested.

We present and compare both solutions.

Th - 1 / 70

Low-energy precision tests of spacetime symmetries

Author: Ralf Lehnert[1]

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Recent experimental advances have opened an avenue for the study of spacetime symmetries at distance scales beyond the Planck length. This talk provides some theoretical motivations for such investigations, discusses the prediction of experimental effects, and reviews some low-energy tests in this research field.

Mo - 3 / 71

Standard Model Tests with Coherent Neutrino Scattering

Author: Robert Cooper[1]

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Neutrinos with sufficiently low energy (E < 50 MeV) have a wavelength that is larger than its scattering target nuclei, and the neutrino can engage in pure coherent elastic neutrino-nucleus scattering with very low neutral current momentum transfer. At these energies, the coherent scattering cross section dominates, but because it deposits very little energy, low detection thresholds (˜10 keV) are required for observation. Recent progress in direct WIMP dark matter searches has led to detector technologies that are capable of a first direct measurement with accelerator and reactor neutrino sources. Future, precision, coherent neutrino scattering measurements are important in the understanding of supernovae dynamics and detection, as a probe of weak nuclear form factors at low Q^2, measuring the weak mixing angle, and searching for non-standard interactions and neutrino magnetic moments. Furthermore, coherent scattering of atmospheric and solar neutrinos will be an irreducible background for direct WIMP dark matter searches with 10-ton scale detectors. The list of candidate detector technologies to search for coherent neutrino scattering is nearly as diverse as that used to directly search for WIMP dark matter, because their detection signal is very similar. Ambient neutron backgrounds and those correlated with the neutrino source are considered to be the most difficult impediments to a first coherent scattering measurement. Minimizing the correlated neutron flux drives the shielding and source selection requirements for these measurements. In this talk, I will give a broad overview of the unique physics that is accessible with coherent neutrino scattering, review the most prominent detector technologies being developed, and discuss ongoing efforts to measure neutron backgrounds at low-energy neutrino sources.

Poster, BBQ & Drinks / 72

Development of a simulation for measuring neutron electric dipole moment

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The neutron electric dipole moment (nEDM) is sensitive to new physics beyond the standard model, and could provide a new source of CP violation. Several experiments are being planned around the world for its high precision measurement. In the measurement of the nEDM, the systematic uncertainties are due to the motion of the ultracold neutrons (UCNs), the geometry of measurement systems, and the distortions in the magnetic field. Therefore, it is essential to qualitatively understand these effects so that they can be reduced. However, so far there does not exist a simulation framework for UCNs which properly take these effects into account. In this presentation, using the newly developed simulation framework adapted to work with Geant4-UCN, which properly simulate the motion of the UCNs taking into account their spin, we report on the result of optimizing the measurement systems.

We - 1 / 74

Sub-THz Spectroscopy of the Ground State Hyperfine Splitting of Positronium

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Positronium (Ps), a bound state of an electron and a positron, is a purely leptonic system and is a good target to study Quantum Electrodynamics (QED) in bound state. We plan to directly measure the hyperfine structure of the ground-state positronium (Ps-HFS), which is about 203 GHz. Precise measurements of Ps-HFS have been performed in 1970s and 1980s, but all of them are indirect measurements using Zeeman splitting of about 3GHz cause by a static magnetic field of about 1T. In order to measure Ps-HFS with a different method free from systematic uncertainty of the static magnetic field, we develop a new optical system to accumulate about 20 kW power using a gyrotron and high finesse Fabry-Pérot resonator. We report the current status of our experiment.

Poster, BBQ & Drinks / 75

Ultracold Sr experiment toward the search for the electron-EDM using ultracold FrSr molecules

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Exploring an electron's electric dipole moment (e-EDM) is one of the most fundamental problems in physics. Sensitivity of EDM measurement can be enhanced using heavy polar molecules which has the stronger electric field inside the molecules than that achieved in laboratory. We suggested an alternative approach to prepare the ultracold molecules produced by associating laser cooled two-species atoms at the vicinity of a Feshbach resonance. Associating a diamagnetic atom and a paramagnetic Fr atom results in producing a paramagnetic molecule with an electron spin which enables us to measure e-EDM. Producing paramagnetic molecules from ultracold Fr and Sr atoms should be expected to elongate the interaction time, and to dramatically enhance effective electric field compared with conventional Fr atomic experiments and molecular beam experiments.
We report the theoretical results of the polarization factor for the FrSr molecule under external electric field, the development of the apparatus for laser cooling of Sr, and the observation of simultaneous magneto-optical trapping (MOT) of Rb and Sr, which is a proof-of-principle experiment for realizing MOT of Fr and Sr.

Tu - 1 / 76

Parity-odd Neutron Spin Rotation

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The current experimental upper limit on the parity violating neutron spin rotation angle in liquid ^{4}He, ϕ_{PV}, is 10^{-6}~rad/m, consistent with the current theoretical expectation of 10^{-7} to 10^{-6}~rad/m. With the parity violating hadronic weak interaction experiment NPDGamma close to completion, plans for a n^{3}He experiment complementary to neutron spin rotation underway, and in light of advances in quantum chromodynamic computations on the lattice, obtaining a value for ϕ_{PV} is an increasingly important goal. The neutron spin rotation collaboration is mounting an experiment to provide such a measurement. This new experiment is based on the previous effort which provided the current limit on ϕ_{PV}, but leverages the flux available on the new NG-C fundamental physics beamline at the National Institute of Standards and Technology (NIST) Center for Neutron Research, new cryogenics technology and techniques, and enhanced magnetic shielding to improve the sensitivity to ϕ_{PV} by an order of magnitude. The current theoretical and experimental status of ϕ_{PV} will be reviewed in light of other hadronic weak interaction measurements, and the design of our new spin rotation apparatus will be discussed in relation to its application in placing constraints on the existence of short-range spin dependent fifth forces as well as in a measurement of ϕ_{PV}.

Th - 1 / 77

Search for axion like pseudo scalar spin interaction with a 3He-129Xe clock comparison experiment.

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We search for a spin-dependent P- and T-violating nucleon-nucleon interaction mediated by light pseudoscalar bosons such as axions or axion-like particles. While axions are originally invented to solve the strong CP-problem, nowadays interest in axions is boosted by the fact, the axion is a candidate for dark matter. We performed an ultra-sensitive clock comparison experiment based on the detection of free precession of co-located 3He and 129Xe nuclear spins using SQUIDs as low-noise magnetic flux detectors. The precession frequency shift in the presence of an unpolarized mass was measured to determine the coupling of pseudoscalar particles to the spin of the bound neutron. For boson masses between 2 μeV and 500 μeV (force ranges between 3x10ˆ-4 m –10ˆ-1 m) we improved the laboratory upper bounds by up to 4 orders of magnitude.

Tu - 4 / 78

A new source for ultracold neutrons at TRIGA Mainz: latest results

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Ultracold neutrons (UCN) are a powerful tool for addressing many fascinating questions in particle physics, nuclear physics, and astronomy.
UCNs offer unique opportunities for investigating the properties of the free neutron, such as its lifetime, with exceptionally high precision. In order to tackle the obvious count rate limitations, super-thermal UCN sources are now under construction at different places worldwide.
Within PRISMA cluster of excellence the existing UCN source at
TRIGA Mainz will be upgraded in its performance to reach very high
UCN number densities. The talk gives an overview on the present optimization work at the pulsable UCN source at beamport D, measures
to improve the UCN yield and future plans to establish a user facility at TRIGA Mainz.

Tu - 4 / 79

Latest results from the superfluid-helium UCNs source SUN2 at ILL

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A current research and development program at the ILL has the goal to bring production of ultracold neutrons (UCN) in superfluid helium to maturity for applications in experiments at room

temperature. While experiments with a first prototype had resulted in a UCN density of 55 per ccm, significant progress was made with an improved, second apparatus.
SUN2 is composed of a 4 liters UCNs converter, full of He4, isotopically pure, cool down with a He3 evaporation refrigerator. The UCNs converter is traversed by monochromatic neutrons provided at a new, dedicated beam line. Thanks to a modular setup, a short cooldown time and a converter preparation of only two days, a series of experiments on UCN production, accumulation and determination of characteristic time constants could be performed in several converter vessels. Tested configurations include supermirrors on aluminium and glass substrates used to guide the cold beam, with a top layer of beryllium, Ni/Mo or fluorinated grease for UCNs reflection. In particular, this talk will report new results on achieved UCN densities.

Poster, BBQ & Drinks / 80

Investigation of the work function fluctuations for high precision experiments

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Low energy, high precision experiments have become an important branch for the investigation and the search for physics beyond the Standard Model of particle physics. Two examples of such experiments are aSPECT, which is designed to determine the electron antineutrino angular correlation coefficient a in free neutron beta-decay, and KATRIN, which will determine or set a significantly improved upper limit for the neutrino mass by investigating the endpoint energy of the beta energy spectrum in tritium beta-decay.
Both experiments utilize a electrostatic filter of MAC-E type. To reach the final sensitivities the retardation potential of the spectrometers have to be known with an accuracy of < 10 mV for aSPECT and < 20 mV for KATRIN. But, however, the potentials are directly influenced by the work function of the electrodes, which can show fluctuations of several 100 meV.
Therefore we commissioned and studied a scanning Kelvin probe system to investigate the work function fluctuations of different gold surfaces on different substrates. The work functions of the surfaces were also tested for their stability in time and under a standard vacuum cleaning procedure and a bake out. This poster will present the results of the measurements.

Poster, BBQ & Drinks / 81

The Fundamental Physics beamline @ ESS

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The European Spallation Source (ESS) will provide to the scientific community new opportunities of research using neutrons. Indeed, the unique capabilities of the ESS, namely the high peak flux of the neutron beam and the inherent time structure of the beam, will permit to push the frontiers of neutron sciences.

These properties will be very useful for many fundamental physics experiments. Therefore we are preparing a proposal for a fundamental physcis beamline. The pulsed time structure of the ESS requires a careful optimisation of the beamline parameters.

As example, we have studied two state-of-the-art high precision neutron beta decay experiments which test the Standard Model with cold neutrons : PERC and aSPECT. Both experiments would profit from the time structure of the beam in terms of signal to background ratio, effectively lowering systematics. We discuss the impact of a pulsed beam and derive first beamline parameters for an installation at ESS. We determine also the gain factor compared to a research reactor.

Tu - 2 / 82

Status of the aSPECT experiment

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The aSPECT experiment aims to determine the beta-neutrino angular correlation in the decay of the free neutron to determine the ratio of the weak coupling constants gA/gV. The past years have been used to optimize the set-up and to investigate and minimize systematic effects. A new beam-time to determine the beta-neutrino angular correlation with an uncertainty of ˜1% has taken place with this improved set-up at the cold neutron beam of PF1b at the Institut Laue Langevin from May to August 2013.

The focus of this talk will be the major improvements and investigations leading to the beamtime in 2013. These include a modified detector electronics to avoid saturation effects and an improved electrode system to suppress field emission and optimized with respect to fluctuations of the work function.

Summary:

The improvements of the aSPECT experiment with which a proton recoil measurement was performed at the ILL in 2013 will be presente.

Th - 2 / 83

Ultracold neutrons from superfluid helium for a neutron lifetime experiment at ILL

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Conversion of cold to ultracold neutrons (UCN) via single-phonon emission in superfluid helium provides a viable mechanism to achieve high densities of UCN at the end of a neutron guide. In a current development at the ILL new sources based on this mechanism have been implemented at two monochromatic neutron beam lines. The first beam feeds an upgraded prototype source with characterized performance which will be used for neutron gravity experiments. Studies with a new source cryostat are underway at the second beam with the goal to further improve the technique of UCN accumulation and extraction. In first place this source will feed the neutron lifetime experiment HOPE which employs a magneto-gravitational UCN trap made of a vertical array of Halbach octupole permanent magnets with superconducting axial-field coils. With its simple, open geometry all necessary systematic checks can be performed in a transparent way. Perspectives to boost the performance of the UCN source to make it useful also for a neutron EDM experiment will be presented as well.

We - 3 / 84

Towards the Production of a Polarized Antihydrogen Beam

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The ASACUSA CUSP collaboration developed a unique scheme for the precision measurement of the ground state hyperfine splitting of antihydrogen. A polarized antihydrogen beam is produced by
using a so-called CUSP magnetic field, which is provided by a superconducting anti-Helmoltz coil assembly. Antihydrogen atoms in high field seeking states which transmit the unique magnetic field configuration are de-focussed, while low field seeking states are focussed. The so produced polarized antihydrogen beam will be used to perform classical Rabi spectroscopy of the ground state hyperfine splitting.
In 2010 we reported on the first production of antihydrogen atoms upstream to the CUSP polarizer [1]. This was achieved by injecting a large number of cryogenic antiprotons, accumulated in the MUSASHI antiproton trap, into a compressed positron plasma stored in a nested Penning trap upstream to the CUSP. Although this was a major step towards our physics goal, experimental cycles were slow, limited by the used positron accumulation scheme. In addition in these experiments the antihydrogen formation rate was rather low. Meanwhile both numbers were significantly increased. A new positron accumulation scheme was developed which enables faster experimental cycles at much higher accumulation rates. By improving the antiproton/positron mixing techniques the antihydrogen formation-rate was increased as well. In the talk an overview on the current setup and status is given, and recent results are presented.

[1] Y. Enomoto et al., Phys. Rev. Lett. 105, 243401 (2010).

Th - 2 / 85

Neutron Lifetime Measurement by storing ultracold neutrons and simultaneously measuring inelastically scattered neutrons

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We present estimations and experimental studies of systematic effects in the neutron lifetime experiment carried out in 2008-2010 at ILL. Taking into account these corrections, we reduce the data of three independent measurements carried out with different energy spectra of ultracold neutrons at different temperatures to the averaged neutron lifetime value equal to xxx(1.1) s.

Poster, BBQ & Drinks / 86

An absolute, high-precision 3He / Cs combined magnetometer

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Many experiments in fundamental science, such as the search for the neutron electric dipole moment (nEDM) at PSI, Switzerland, demand an accurate measurement and control of an applied magnetic field. Here, we describe a combined 3He-Cs magnetometer for the absolute measurement of a µT magnetic field with a precision of better than 10ˆ-6. The magnetometer detects the weak oscillating magnetic field produced by the precession of nuclear spin-polarized 3He atoms with phase-feedback driven Cs magnetometers. We will report on measurements in the magnetically shielded room of PTB, Berlin, investigating the performance and intrinsic sensitivity of the combined device.

Mo - 1 / 87

Laser spectroscopy of muonic atoms

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The measurement of the Lamb shift in muonic hydrogen has resulted in a tenfold improved value of the RMS charge radius of the proton, compared to previous determinations from elastic electron-proton scattering and hydrogen spectroscopy. The muonic and the electronic values of the proton radius differ, however, by more than 7 standard deviations.
Laser spectroscopy of muonic deuterium and muonic helium ions is expected to shed new light on this so-called "proton radius puzzle".

Mo - 2 / 88

First Determination of the Proton's Weak Charge –Early results from Qweak

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The Qweak experiment was designed to exploit the small parity violating asymmetry in elastic ep scattering to make the first direct measurement of the proton's weak charge, Q^p_W, and measure the running of the weak mixing angle, $sin^2 q_w$, at low Q^2. The Standard Model predicts the proton's weak charge, based on the running of the weak mixing angle from the Z_0 pole to low energies. The predicted change in $sin^2 q_w$ corresponds to a 10 s effect in the experiment, thus testing the internal consistency of the Standard Model more rigorously than complementary experiments on the weak charge of Cesium (APV) and the electron Q^e_W. The goals of the experiment were to measure Q^p_W to 4.1%, which will yield a measure of $sin^2 q_w$ to 0.3%, and to provide a tight constraint on a combination of the weak vector quark charges C_{1u} and C_{1d}.

The experiment used a 180 μA longitudinally polarized 1.16 GeV/c electron beam on a 35 cm long liquid hydrogen target. Scattered electrons in the angular range 6° < θ < 12° corresponding to Qˆ2 ≈ 0.026 (GeV/c)ˆ2 were detected in an array of eight Cerenkov detectors arranged symmetrically about the beam axis. The experiment completed its last data taking campaign in May 2012. The results from the commissioning run will be presented.

Poster, BBQ & Drinks / 89

ATLAS Upgrades Towards the High Luminosity LHC: extending the discovery potential

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After successful LHC operation at the center-of-mass energy of 7 and 8 TeV in 2011 and 2012, plans are actively advancing for a series of upgrades, culminating roughly 10 years from now in the high luminosity LHC (HL-LHC) project, delivering of order five times the LHC nominal instantaneous luminosity along with luminosity levelling. The final goal is to extend the data set from about few hundred fb-1 expected for LHC running to 3000 fb-1 by around 2030. Current planning in ATLAS also has significant upgrades to the detector during the consolidation of the LHC to reach full LHC energy and further upgrades to accommodate running already beyond nominal luminosity this decade. The challenge of coping with HL-LHC instantaneous and integrated luminosity, along with the associated radiation levels, requires further major changes to the ATLAS detector. The designs are developing rapidly for an all-new inner-tracker, significant upgrades in the calorimeter and muon systems, as well as improved triggers and data acquisition. This presentation summarises the various improvements to the ATLAS detector required to cope with the anticipated evolution of the LHC instantaneous luminosity during this decade and the next.

Th - 3 / 90

Project X

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"Project-X"is a US led initiative at Fermilab with strong international participation that aims to realize a next generation proton accelerator that will dramatically extend the reach of Intensity Frontier research. The state of the art in Super Conducting RF accelerator technology has advanced to a point where it can be considered and implemented as the core enabling technology for a next generation multi-megawatt proton source. The base Super-Conducting RF technology also supports flexible beam-timing configurations among simultaneous experiments, allowing a broad range of experiments to develop and operate in parallel. The US Department Of Energy Office of High Energy Physics and its advisory bodies have recognized this potential and are supporting R&D for Project-X that could lead to a construction start later this decade.
Project-X will provide multi-megawatt proton beams from the Fermilab Main Injector over the energy range 60-120 GeV simultaneous with multi-megawatt protons beams 1-3 GeV (kinetic) with very flexible beam-timing characteristics as well as substantial beam power at 8 GeV. The Project-X particle physics research program includes world leading sensitivity in long-baseline and short-baseline neutrino experiments, a rich program of ultra-rare muon and kaon decays and opportunities for next-generation electric dipole moment experiments and other nuclear/particle physics probes that reach far beyond the Standard Model. Project X also provides an opportunity to advance energy research and material science studies. These research opportunities and the potential for collaboration will be presented and discussed."

Tu - 1 / 91

High Precision Experiments with Cold and Ultra-Cold Neutrons

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The talk addresses some questions of particle and nuclear physics and concerns the search for possible deviations from the Standard Model (SM) of particle physics with cold and ultra-cold neutrons. The deviations are expected to be the phenomenological outcome of more fundamental theories, unifying all forces induced shortly after the Big Bang.
Precise symmetry tests of various kinds are coming within reach with proposed neutron facilities, where count rates of neutron decay products are increased by a factor 100 compared to best experiments. The goal is neutron beta-decay spectroscopy, where the spectra and angular distributions of the emerging decay particles will be distortion-free on the level of 10−4.
Next, we present a novel direct search strategy with neutrons based on a quantum bouncing ball in the gravity potential of the earth. The aim is a test of Newton's gravity law with a quantum interference technique, providing a constraint on any possible new interactions on the level of accuracy. Many extensions to the standard model naturally predict deviations from Newton's law at short distances that should be detectable. If the reason is that some undiscovered dark matter or dark energy particles interact with a neutron, this should result in a measurable energy shift of the observed quantum states. The experiment has the potential to find or exclude these hypothetical particles in full parameter space.

Poster, BBQ & Drinks / 92

Novel Detection System for Electron and Proton Momentum Spectroscopy with PERC

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Experiments with neutrons address important questions in nuclear and particle physics, astrophysics and cosmology, as well as gravitation. These experiments include precision measurements of the parameters describing the beta decay of free neutrons. Here, the main emphasis is on the search for evidence of possible extensions of the Standard Model of elementary particles and fields. Such extensions require new symmetry concepts like leptoquarks, supersymmetry, or many more. In high energy physics with colliders, one directly searches for new particles, complementary to low energy physics with neutrons, where we indirectly probe their existence.
With the new instrument PERC, several symmetry tests based on neutron beta decay data become competitive. At its exit, PERC delivers neutron decay products under well-defined and precisely variable conditions. Depending on the parameters studied, the analysis of the extracted decay particles is performed with different and specialized detectors. For the measurement of the Fierz term b, we propose a novel detection system for electron and proton momentum spectroscopy based on the RxB drift effect. In the RxB spectrometer, the charged decay particles are dispersed in a uniformly curved magnetic field, and then measured with large phase space acceptance and high resolution.
The Fierz term b is measurable in decays of unpolarized neutrons, as a distortion of the beta spectrum. A non-zero value for b would be an indication of the existence of scalar or tensor interactions. Scalar or tensor couplings in turn would occur if yet unknown charged Higgs bosons or leptoquarks were exchanged instead of a W boson.
We present a design of the RxB spectrometer which can be used with PERC. Its momentum resolution can reach 14.4 keV/c, if the position sensitive detectors have a spatial resolution of 1 mm.

Poster, BBQ & Drinks / 93

Development of a systematic studies apparatus at North Carolina State University for the nEDM collaboration

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A test apparatus is being developed for use at the ultracold neutron (UCN) source located at the 1 MW NCSU PULSTAR reactor. The goal is to study several critical aspects of the Spallation Neutron Source (SNS) neutron electric dipole moment (nEDM) experiment without the electric field. Detailed studies of the interactions between the 3He and the UCNs, measurements of the correlation functions determining the geometric phase systematic effect, optimization of the parameters for critical dressing, and the pseudomagnetic field caused by neutron scattering from polarized 3He will be

made. Because of the extremely long turn around times, these would be almost impossible with the SNS apparatus. In this setup, polarized UCNs and 3He will be repeatedly loaded into a single full-sized measurement cell made from acrylic and coated with deuterated TPB and polystyrene on the inner walls. The coating will act as both the UCN reflector and the wavelength shifter for the scintillation light emitted from charged particles ionizing the superfluid 4He that is also in the cell. This light is will be detected using two photomultiplier tubes in coincidence and the signal from spin-dependent capture of UCNs on 3He can be used to measure the Larmor precession frequency difference between the two species in the presence of an external magnetic field. Presently, the apparatus is in the final design stages. An overview of the status of the UCN source, the design of the apparatus, and the physics goals to be addressed will be presented.

Mo - 1 / 94

Fundamental physics with muons

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I will review applications of the muon as a probe for new phenomena.
Topics to be discussed include the free muon decay and the
determination of the Fermi constant; using muonic atoms to measure
nuclear form factors and radii, through spectroscopy and capture; the
anomalous magnetic moment of the muon; and searches for charged lepton flavor violation such as mu->e+gamma, mu->3e, and the muon-electron conversion.

Poster, BBQ & Drinks / 95

A new muon beam line for fundamental physics study in J-PARC

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Since the first beam in 2008, Muon Facility, J-PARC (MUSE) has been operated, and the beam intensity reached at the 3E+6/s, the most intense pulsed muon beam in the world, under 200-kW proton beam.
From the 2-cm thick graphite target, four secondary muon beam lines are able to be extracted to the experimental areas.
A new beam line is planed to be constructed.
This beamline is designed to have a large acceptance, momentum tunablity, and ability of kicker-device and wien filter use.
This beam line will provide an intense beam for fundamental physics which will occupy the experimental area for a long time in comparison with material-science programs.
The design work and the schedule be presented.

Summary:

A new beam line, which will be constracted in Muon Facility, J-PARC, is dedicated to fundamental physics study.

Details of this new beam line will be presented.

Th - 2 / 96

The science program at the Los Alamos ultra-cold neutron source

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In this talk, we present an overview of the science program at the Los Alamos spallation-driven solid-deuterium ultra-cold neutron (UCN) source and describe the performance of the source. Experiments in operation or development include the UCNA beta correlation measurements, the UCNTau neutron lifetime experiment, nEDM storage cell performance tests, and detector development for UCN and cold neutron measurements of the a, b, and B parameters in neutron beta decay (Nab, UCNB, and UCNb). The status of the experimental efforts and of the operation of the source will be presented. The source performance, including cold neutron density in the converter region, internal UCN density, and extracted UCN density, will be compared to Monte Carlo models and shown to perform as expected. The maximum delivered UCN density at the exit from the biological shield is 52(9) UCN/cc with a solid deuterium converter volume of 1500 cm3.

Mo - 2 / 97

The Muon g-2 Experiment at Fermilab

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The Muon g-2 experiment at Fermilab will build upon the work of its predecessors at CERN and Brookhaven to measure the anomalous magnetic moment of the muon, a_mu, to 0.14 ppm. With this factor of four improvement in precision over the statistically-limited Brookhaven E821 experiment, we will test the 3.6 σ discrepancy between the Standard Model (SM) theory prediction and experimental results. The SM prediction and potential Beyond SM contributions will be briefly summarized. The experimental upgrades will be discussed, including the outcome of the storage ring's cross-country transport from Brookhaven to Fermilab this summer .

We - 2 / 98

Search for a permanent EDM with radioactive atoms

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To explore the mechanism responsible for the generation of observed matter-antimatter asymmetry in the Universe, the experimental study on the violation of the fundamental symmetry using the laser cooled and trapped atoms is being promoted. One such phenomenon of our interest is the intrinsic electric dipole moment (EDM) of either elementary or composite systems. The non-zero observation of EDM provides the direct and conclusive signatures of the violation of time-reversal symmetry and under the CPT invariance it means the CP violation.
In paramagnetic atoms, an electron EDM results in an atomic EDM enhanced by the factor of the 3rd power of the charge of the nucleus due the relativistic effects. A heaviest alkali element francium (Fr), which is the radioactive atom, has the largest enhancement factor K ˜ 895, and other heavy radioactive elements such as Ra and other atoms are also powerful candidates to search for the EDM. In the world, there are many activities to overcome the current accuracy limit of the EDM using different techniques such as the fountain, optical dipole trap, optical lattice and others to reduce the systematic error due to the motional magnetic field and inhomogeneous applied field.
The present status of the EDM search in the world using the radioactive atoms with extreme quantum states at the low-energy scales will be presented.

Th - 1 / 99

CP violation and precision measurement of CKM parameters at LHCb

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Heavy-flavour hadrons allow the study of discrete symmetries, most notably of CP violation, but also T, CPT, as well as lepton and hadron flavour symmetries. The LHCb experiment is a general purpose forward spectrometer operating at the Large Hadron Collider, optimised for the study of B and D hadrons. LHCb has collected an integrated luminosity of 3fb-1, which provides an unprecedented large sample of heavy-flavour hadrons. These data allow many complementary precision measurements of CP violation and CKM parameters, as well as searches for lepton-flavour violating processes. An overview of these results and prospects for future improvements will be presented.

Tu - 4 / 100

Status of the source for ultracold neutrons (UCN) at the Paul Scherrer Institute

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The UCN source at the Paul Scherrer Institute is being successfully operated since 2011 and provides UCN at three beam ports, most importantly to the nEDM experiment.
We will explain the operation principle of the source and the way of UCN production.
The current status of the source and the progress made since start-up,
will be presented, together with ongoing optimisations and measurements to characterize individual subsystems.
In addition, comparisons between Monte Carlo Simulations of the full source setup and recent measurements will be shown.

This work is supported by the Swiss National Science Foundation under
grant number 200020_137664.

Summary:

Operation principle and status of the PSI source for ultracold neutrons will be presented.

Mo - 2 / 101

Cosmic Ray Radiography

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Abstract Transmission radiography using cosmic ray muons is a technique first used in the 1950's by E.P.George[1] to measure the overburden of mine shafts, and most famously by Alvarez[2] to search for hidden chambers in the second pyramid of Chephren in Gaza. The high penetrating power of near horizontal cosmic ray muons has even been utilized in radiographing volcanoes.[3] The high penetration of cosmic ray muons is not suited to radiography of more conventional objects because of the low flux and high penetration. A new technique that uses the scatter of muons to infer path length densities[4] has been developed in Los Alamos and is being applied to a range of practical problems from home land security[5] to reactor imaging [6-8]. The current status of the Los Alamos muon scattering radiography program will be presented.

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Tu - 2 / 102

Measurements of Neutron Decay Correlation Coefficients with PERKEO and PERC

Author: Bastian Märkisch[1]

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Precision measurements of angular correlation coefficients in neutron beta decay provide unique information about the weak interaction and contribute significantly to precision tests of the standard model of particle physics. In particular, measuring the beta asymmetry A in polarized neutron decay is the most precise way to determine the ratio of axialvector and vector coupling constants. Measurements of A and the neutron lifetime are used to determine the element Vud of the CKM-matrix from neutron decay data alone.

The neutron decay spectrometer PERKEO III was installed at the PF1B cold neutron beam site at the Institut Laue-Langevin to measure the beta asymmetry A. A pulsed neutron beam was used to effectively eliminate major sources of systematic uncertainties, such as neutron beam related background and edge effects. All systematic uncertainties of this measurement are smaller than 10ˆ-3 on A and the error on the axial vector coupling constant is thus reduced to a level of 5x10ˆ-4.

The next generation instrument PERC (Proton Electron Radiation Channel), which is currently under construction at the FRM-II, Garching, realizes a novel concept in this field: as a beam station it delivers not neutrons, but neutron decay products. Electrons and protons are extracted from a long neutron guide by a strong magnetic field. Specialized spectrometers will use PERC as source to measure spectra and correlation coefficients with an improved accuracy by more than one order of magnitude.

In this talk I will present results on the beta asymmetry by the PERKEO instruments, and the design of PERC and its current status.

Poster, BBQ & Drinks / 103

A pixelated Scintillator Positron Timing Counter with SiPM readout for the MEG Experiment Upgrade

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The MEG experiment recently improved the upper limit on the Branching Ratio of the of $\mu \to e\gamma$ decay to BR<5.7×10ˆ(-13). Now we are upgrading the MEG experiment with the goal of one order of magnitude improvement of the sensitivity by improving the detector resolution and increasing its efficiency.

An improved resolution in positron time measurement will result in a reduced combinatorial background.
To this goal, we are developing a pixelated timing counter composed of many small plastic scintillator pixels with SiPM readout.
By using positron impact times averaged over multiple pixels, a good overall resolution in positron timing is expected.
We obtain single pixel resolution of 50-55 ps. Combining this result with a full Monte-Carlo simulation, an ultimate positron time resolution of 35 ps is expected.
In addition, due to its finer segmentation, this new timing counter can reduce ambiguity on hit position, and the effects of pileup.

Single pixel R&D is almost complete and a beam test has just been performed.
The status and prospects of the R&D studies on the new timing counter are presented.

Poster, BBQ & Drinks / 104

Ultracold neutron detectors based on Boron-10 converters used in the qBounce experiments

Author: Tobias Jenke[1]

Co-authors: Gunther Cronenberg [2]; Hanno Filter [2]; Hartmut Abele [3]; Heiko Saul [4]; Kevin Mitsch [2]; Martin Thalhammer [2]

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Newton's Inverse Square Law of Gravity may be tested at micron distances deeply into the theoretically interesting regime by quantum interference with ultracold neutrons. Our newly developed method is based on a resonance spectroscopy technique related to Rabi spectroscopy, which has been adapted to gravitationally bound quantum systems: By coupling such a quantum system to mechanical vibrations, we observe resonant transitions, devoid of electromagnetic perturbations. The experiment is sensitive to any hypothetical short-ranged interactions, as Newtonian gravity and hypothetical Fifth Forces evolve with different phase information. One of the main challenges to achieve sufficient results is the development of dedicated detectors that are well-adapted to very low neutron fluxes of approx. 10 counts/1000s. Here, we present two detector concepts based on Boron-10 neutron converters. The first one allows measurements with a spatial resolution better than 2 μm and a detection efficiency of approx. 61%. The second one provides integral measurement with a total efficiency of 77% and an overall background rate of 0.65 counts/1000s.

Poster, BBQ & Drinks / 105

qBounce: Gravity Resonance Spectroscopy to test Dark Energy and Dark Matter models

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We present observations of transitions between quantum states of gravitationally bound neutrons using a three-part Rabi resonance spectroscopy setup.
In our experiments, ultra-cold neutrons are trapped in the gravitational field of the Earth. Quantum interferences between different states are observed by inducing transitions by mechanical vibration. The latest improvement, omitting the upper confining mirror, allows the shift from a frequency reference to a frequency standard, where the transition frequency depends solely on the neutrons mass, Plancks constant and Earth's gravity.
This tests Newton's Inverse Square Law of Gravity in the micrometer range, which is sensitive to hypothetical Fifth Forces, the origin of the cosmological constant, as well as potential large extra dimensions of submillimetre size of space-time. Our experimental results agrees with Newton's Inverse Square Law at the present sensitivity of ΔE = 10ˆ−14 eV.

Poster, BBQ & Drinks / 106

Preparing a Measurement of the Charge of the free Neutron within qBounce

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The electric charge of the Neutron is one of the last parameters in the standard model of particle physics, that can‘t be derived out of the accepted theoretical framework. Thus for refining the existing model and to exclude extensions to the same, it is necessary to measure the value of the electric charge to an high precision and accuracy.
With our Gravity Resonance Spectroscopy technique we plan to measure the charge of the Neutron by mimicking Ramsey‘s Method of separated oscillating fields. This approach has the prospect of improving the existing limit on the neutrality of the Neutron [1].

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Poster, BBQ & Drinks / 107

R&D status of the COMET experiment to search for a mu-e conversion at J-PARC

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The COMET Experiment at J-PARC aims to search for a lepton-flavour violating process of muon to electron conversion in a muonic atom with a branching-ratio sensitivity of better than 10^{−16} in order to explore the parameter region predicted by most of well-motivated theoretical models beyond the Standard Model. The need for this sensitivity places several stringent requirements on both the beam-line and detector systems. The current R&D status on detector development and accelerator studies both will be presented in addition to the experimental overview.

Tu - 2 / 108

Fundamental Physics at Free Electron Lasers

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Worldwide a number of new X-ray free electron lasers are operating or being constructed currently. In this overview presentation we will consider their potential application for fundamental physics, in particular for non-linear and non-perturbative QED and for searches for very weakly interacting slim particles beyond the Standard Model, such as axion-like particles or hidden photons.

Poster, BBQ & Drinks / 109

NUMERICAL AND EXPERIMENTAL STUDY FOR THE CHARACTERIZATION OF THE SPALLATION TARGET PERFORMANCE OF THE ULTRACOLD NEUTRON SOURCE AT THE PAUL SCHERRER INSTITUT

Authors: Michael Wohlmuther[1]; Vadim Talanov[2]

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Results of numerical calculations and the experimental characterization of the neutron flux profile at the ultracold neutron (UCN) source of the Paul Scherrer Institut (PSI) are presented. At first, the MCNPX-based model of the Monte-Carlo simulation with its detailed description of the so-called "Cannelloni"-type spallation target assembly and the realistic proton beam profile modeling is described. Thereafter the experimental determination of the thermal neutron flux profile using gold foil activation, along the height of the UCN tank, starting from the proton beam plane, is presented. Both calculations and measurements were performed for standard beam parameters, with the full proton beam on target. Finally, a comparison of simulation and experimental result is discussed.

Poster, BBQ & Drinks / 110

Beta-asymmetry parameter of 67Cu for tensor current search

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The β-asymmetry parameter A for the pure Gamow-Teller decay of 67Cu was measured by the low temperature nuclear orientation method. A 3He-4He dilution refrigerator cooled down to milliKelvin temperatures an iron sample foil into which the radioactive nuclei were implanted. An external magnetic field of 0.1 T in combination with the internal hyperfine magnetic field oriented the nuclei. The anisotropic β radiation was observed with planar high purity germanium detectors

operating at a temperature of about 10 K. An on-line measurement of the β-asymmetry of 68Cu was also performed for normalization purposes. Systematic effects were investigated using Geant4 simulations. The result, A = 0.584(13) is in agreement with the Standard Model value of 0.5998(2) and is interpreted in terms of physics beyond the Standard Model. The limits obtained on possible tensor type charged currents in the weak interaction hamiltonian are -0.020 < (CT + CT)/CA < 0.167 (90% C.L.). Combined results of recent measurements employing the same technique will also be presented.

Poster, BBQ & Drinks / 111

The miniBETA spectrometer for the determination of weak magnetism and the Fierz interference term

Author: Gergelj Soti[1]

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Precision correlation measurements in nuclear beta decay searching for new types of weak interactions, have now reached precisions of the order of 1 % and better [Sev2013, Nav2013]. At this level of precision Standard Model higher-order effects in the vector and axial-vector weak currents should be taken into account. The most significant of these is the so-called weak magnetism originating from the hadronic structure of the nucleons and affecting the values of correlation coefficients typically at the level of 0.1 % to 0.5 % [Hol74]. Whereas the weak magnetism form factor can, due to the Conserved Vector Current hypothesis, often be obtained from electromagnetic properties, this is not the case for transitions between non-analog states.

Recent comparisons [Cir2013, Nav2013] of limits for scalar and/or tensor type weak interactions from precision experiments in beta decay with results from direct searches at the Large Hadron Collider showed that both approaches are compatible in sensitivity for the currently available data sets. However, it was also shown that for low energy experiments to remain competitive also with the 14 TeV phase of the LHC, precisions of the order of 0.1 % for the Fierz interference term [Jac57] should be reached. For higher precisions such experiments could even outperform the LHC.

We have developed a new, compact beta spectrometer, miniBETA, for precision beta spectrum shape measurements. As the weak magnetism contribution to the beta spectrum is proportional to the beta-particle energy E, whereas the contribution from the Fierz interference term is proportional to 1/E, both topics discussed above can be addressed with this spectrometer, provided that beta decays with appropriate endpoint energies are selected. The miniBETA spectrometer combines two multiwire drift chambers [Loj2009] for beta particle tracking, with plastic scintillators providing the trigger but also the beta particle energy. In addition, this energy can also be obtained from the curvature of the beta particle trajectories in a magnetic field. The construction of the miniBETA spectrometer was recently finished and commissioning is ongoing. An overview of the technical aspects and physics possibilities of this new beta spectrometer will be presented.

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113

Welcome Reception

Poster, BBQ & Drinks / 114

A g-2 experiment with the PSI high quality muon beam in development

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As presented in another contribution to this workshop an intense low energy positive muon source is being investigated at PSI. With a transverse extension of a a few tenths of a mm and an average energy of 1 eV it should provide after acceleration a precisely timed beam with an ultimate intensity near 10ˆ6 muons/sec. Its application to a precise g-2 experiment makes use of a novel concept where the beam
is injected at around a MeV energy in a very high field solenoid
(> 20 T) in such a way that it gets fully erected into a spiraling trajectory that advances along the solenoid axis by only a few cm in a microsecond.Silicon drift detectors placed around an inside the spiral measure the angle of emission of the decay electron relative to the muon direction providing a precise determination of the precession frequency.

Poster, BBQ & Drinks / 116

Development of UV-sensitive MPPC for the upgrade of liquid xenon detector in MEG experiment

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A major upgrade of the MEG experiment is planned. The liquid xenon gamma-ray detector will be upgraded by replacing a part of the current 2-inch PMTs by smaller photosensors such as silicon photomultipliers (SiPMs). The energy and position resolutions are expected to be improved due to better granularity, especially for the events where gamma-ray converts near the incident face.

An MPPC which is sensitive to the scintillation of liquid xenon and has large active area of 12x12mmˆ2 is being developed in collaboration with Hamamatsu Photonics.
It is found in prototyping tests that sufficiently good performance is already achieved such as a high photon detection efficiency (PDE) of 17% and single photon counting capability, and that the long tail of large-area MPPC can be shortened by subdividing the sensor area and connect them in series in order to reduce the overall capacitance.
Recently Hamamatsu Photonics has improved basic MPPC structure. This will be applied to the UV-sensitive MPPC too, and thus the performance is expected to be further improved.

In this presentation, the performances of the UV-sensitive MPPC is presented.
A development of the MPPC-related items such assembly techniques, high-density vacuum feedthrough and readout electronics is also presented.

Th - 4 / 117

HV CMOS Technology

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High-voltage CMOS detector technology relies on the use of HVCMOS processes for the design of monolithic pixel sensors.
The HVCMOS detectors have several good properties: a fast charge collection by drift, a high radiation tolerance, CMOS in-pixel electronics, the compatibility with commercial processes and the possibility to produce thin detectors. The sensor element is a deep-n-well diode in a p-type substrate.
HVCMOS detectors are the main technology option for the tracking detector of Mu3e experiment at PSI and the luminosity monitor of PANDA detector at GSI.
We are also exploring a HV-CMOS detector as a replacement for the traditional pixel- and strip sensors at ATLAS.
In this talk, we will present the status of our development and possible improvements.

Th - 4 / 118

Waveform digitzing in the Giga-sample Range with Switched Capacitor Arrays

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Switched Capacitor Arrays (SCA) are an attractive alternative to flash ADCs, being able to sample signals up to 10 GSPS and 12 bits with minimal power requirements. The talk gives an overview of the principle of SCAs and summarizes the features of various available chips and their applications in particle physics, including time measurements down to 3 pico seconds.

We - 3 / 119

Antiproton and Antihydrogen Studies at ATRAP

Author: Stephan Malbrunot-Ettenauer[1]

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When compared to their matter counterparts, precision measurements of antiprotons such as the one of their charge-to-mass ratio [1] or of antihydrogen provide very stringent tests of the CPT symmetry (charge conjugation, parity and time reversal) that is fundamental to our formulation of the Standard Model of particle physics in terms of Lorentz invariant, local quantum field theories.

At ATRAP, this type of research is currently pursued along two aspects. One goal is to perform precise spectroscopy of antihydrogen in a magnetic atom trap. Here, a milestone has recently been accomplished by simultaneously trapping 5 antihydrogen atoms on average with confinement times of 15 to 1000 s- long enough to ensure that they have reached their ground state [2]. A second goal is to precisely determine the antiproton's magnetic moment μp. By utilizing one-particle methods in a Penning trap [3,4,5] ATRAP has performed the first direct measurement of μp with a precision of 4.4 parts per million [6], a 680-fold improvement over the previous values [7]. These techniques that can be applied to both, proton and antiproton, ultimately promise a gain in experimental precision of μp by at least a factor of 1000 in addition to the present measurement.

This talk will present recent progress in ATRAP's anti-hydrogen efforts as well as the first direct measurement of the anti-proton's magnetic moment.

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Th - 4 / 120

SiPM - status and propects.

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Silicon photomultipliers (also known as G-APDs, SSPMs, MRS APDs, MAPDs, MPPCs, etc.) have been developed during recent years and promise to be an alternative to photomultiplier tubes. During the last decade, a variety of new SiPMs appeared on the market and interest in these devices increased regarding their application in high energy physics experiments and positron emission tomography. This presentation reviews the latest developments in SiPMs, discusses the SiPM properties and problems and gives a speculative outlook on their future evolution.

121

Welcome Reception

Workshop Dinner / 123

Concert

Mo - 4 / 124

A Next-Generation Neutron-Antineutron Oscillations Experiment at Fermilab

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Neutron-antineutron oscillations provide an extremely sensitive probe for new interactions that change baryon number by 2 units. The discovery of oscillations would have broad impact in particle physics and cosmology: it would imply all matter containing neutrons is ultimately unstable and could inform our understanding of the matter-antimatter asymmetry in the universe. A next-generation neutron-antineutron oscillations experiment, NNbarX, is being planned as a part of Project X at Fermilab. This experiment would utilize a cold-neutron source situated at a 1 MW spallation target dedicated to particle physics experiments. When coupled to an optimized, elliptical neutron reflector in a horizontal geometry, a sensitivity improvement of roughly two orders of magnitude (for one year of running) is expected over the previous limit for the free neutron.
We present an overview of the conceptual approach, the expected sensitivity, and ongoing research and development on aspects of the experimental layout, neutronics design, and components of the annihilation detector.

Poster, BBQ & Drinks / 125

Feasibility study for a new high-intensity muon beam line (HiMB) at PSI

Author: Andreas Knecht[1]

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Muons are an excellent tool for answering both fundamental and applied questions concerning the structure and properties of matter and consequently are in high demand at accelerator facilities. For material sciences, muon spin resonance techniques (muSR) are used to probe the magnetic structures of novel materials. In particle physics a number of fundamental measurements rely on the availability of large numbers of muons such as those of the searches for lepton number violating decays, the precise measurements of the muon decay properties and studies of muonic atoms.
At the Paul Scherrer Institut (PSI) muon rates of up to 4x10ˆ8 mu/s are available, produced by its 1.3 MW proton accelerator complex HIPA. While these are currently the highest muon rates available worldwide, projects in the US and Japan are underway that will be able to surpass these intensities by several orders of magnitude.

In order to maintain PSI's position at the intensity frontier in muon physics and to utilize the unique DC machine structure with its great advantage for coincidence-type experiments, a feasibility study has just started to assess the possibility of creating a next-generation muon beam from pions produced in the neutron spallation target of the SINQ facility and stopped in its beam entrance window. Potentially, muon rates of the order of 10ˆ10 mu/s could be achieved in this way. Such rates are necessary for the successful operation of improved and novel beams for muSR applications and for the proposed search for the lepton number violating decay mu -> eee.
This poster presents the concept of the feasibility study.

Mo - 1 / 126

PSI's high intensity proton accelerator –performance highlights and prospects

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The cyclotron based proton accelerator at PSI generates one of the most powerful beams in the world. The presentation reviews capabilities and performance figures of the facility. These include the overall layout and key parameters, the control of beam losses, energy efficiency, and a brief introduction of the high power targets in use for neutron and muon production. Finally an ongoing improvement program will be presented.

Poster, BBQ & Drinks / 127

PSI Secondary Beam Lines Customized to New Experiments

Authors: Davide Reggiani[1]; Konrad Deiters[1]; Manuel Schwarz[None]; Thomas Rauber[1]

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During the last 2 years we customized the PiE1 and the PiE3 beam lines. The PiE1 beam line is used by the μSR and the particle physics community. The reorganization from one user to another was a time and labor consuming process. We installed an additional bending magnet and additional quadruples. Thus we can now switch within a few days between different users. PiE3 was completely rebuilt to transfer it into a μSR facility for experiments with high magnetic field. This included also the construction of 2 Wien filters. At other beam lines like PiM1 and PiE5 we support a large user community during preparation of new experiments as well as detector tests.

Poster, BBQ & Drinks / 128

The Uncompensated Field Drift Studies in Electric Dipole Moment of neutron (nEDM) Experiment.

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In order to reach in the neutron EDM experiment using ultra cold neutrons at the Paul Scherrer Institute (PSI) the desired sensitivity goal of 5 x 10^(-27)e.cm (95 % C.L.), the systematic uncertainties must be smaller than 1.3 x 10^(-27)e.cm . A crucial requirement is the control of the fluctuations of a magnetic field on a level of better than hundred fT. Optically pumped cesium magnetometers (CsM) are used to reach the resolution of about sub-pT level. The so-called uncompensated field drift [Baker et al. (2006)] is one of the major sources of systematic error [Altarev et al. 2010)]. The mechanism probably is that the charging current of electric field (E) reversal causes a change in the magnetic field (B). This uncontrolled B-field change interacting with the neutron magnetic moment results in a false EDM signal. If this mechanism is sufficiently close to causing the trouble to the sensitivity of the measurement one must consider them carefully. The CsM are placed in a gradiometer configuration to measure the change in the vertical magnetic field gradients.

In December 2012 measurements were performed to estimate a systematic effect correlated with the change of a vertical field gradient correlated with the charging current polarity. Data was taken for 20 days and utilized few thousand electric field reversals. Here, the analysis technique, the result obtained and its implications on the current sensitivity of the experiment will be presented and discussed.

References
[Baker et al(2006)] C. A. Baker et al, Phys.Rev.Lett. 97, 131801 (2006).
[Altarev et al. 2010)] I. Altarev et al., Nucl. Phys. A 844, 47 (2010).

Th - 4 / 129

Silicon tracking detectors in Particle Physics

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Silicon trackers are included to every major HEP experiment since the LEP era in the early 1990s. In the meanwhile several hundred square meters of silicon detectors have been commissioned.
The requirements to these devices in terms of costs, radiation hardness and rate capability became more and more demanding.
This talk gives an overview on the sensors used in past and present HEP experiments, discusses their limitations and gives some perspective for possible future developments.

130

Welcome

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Th - 4 / 131

Welcome

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Tu - 3 / 132

Fundamental Physics at J-PARC

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Japan Proton Accelerator Research Complex (J-PARC) is the high intensity proton driver for particle, nuclear physics as well as material and life science, built in Tokai, Japan . The facility has been in operation since 2008 and in the process of achieving its design power of about 1 MW. We are exploring the flavor physics with neutrino, kaon, and muon beams, as well as the hadron physics with primary and secondary beams.
In this talk, the current status of the facility, including recovery from the recent accident in our hadron facility, and results of fundamental physics are presented. In addition, the newly starting projects such as mu-e conversion experiment, COMET and muon g-2/EDM measurements are described.

Mo - 1 / 133

Welcome

Mo - 1 / 134

Welcome

136

A CP-violating Two-Higgs-Doublet Model and the Proton Radius Problem

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We consider the impact of a CP-violating Two-Higgs-Doublet Model Type-II on the proton radius puzzle and the anomalous magnetic moment of the muon. We show that a light scalar with a certain amount of CP-violation produces an energy shift that alleviates the observed $7-\sigma$ discrepancy in the muonic Lamb Shift $\Delta E_{(2S-2P)}$. Moreover, such a scalar contributes to the anomalous magnetic moment of the muon. We show that in a remarkable region of the parameter space the presence of the aforementioned scalar alleviates both discrepancies down to $1-\sigma$. Thereafter, we discuss constraints on the parameter space coming from high and low energy particle physics experiments, i.e. precision tests at LEP, B-physics, Electric Dipole Moment of the electron. Finally, we discuss the limits of our approach in the context of atomic physics.

Poster, BBQ & Drinks / 137

Precision Magnetometry For Neutron Electric Dipole Moment Experiments

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Accurate monitoring of magnetic fields is crucial for neutron electric dipole experiments to reach limits of d˜10-27ecm and below. The requirements of precision magnetometers in such experiments is discussed, with particular emphasis on the SQUID-based magnetometer developed for CryoEDM. A description of this 12-SQUID system, designed to track fields at the 0.1pT level, and the technical challenges involved in its construction are provided.

Workshop Dinner / 138

Workshop dinner