Update on DEI Committee Activities

Omar Beesley on behalf of the DEI committee

DEI Committee and Resources in Twiki

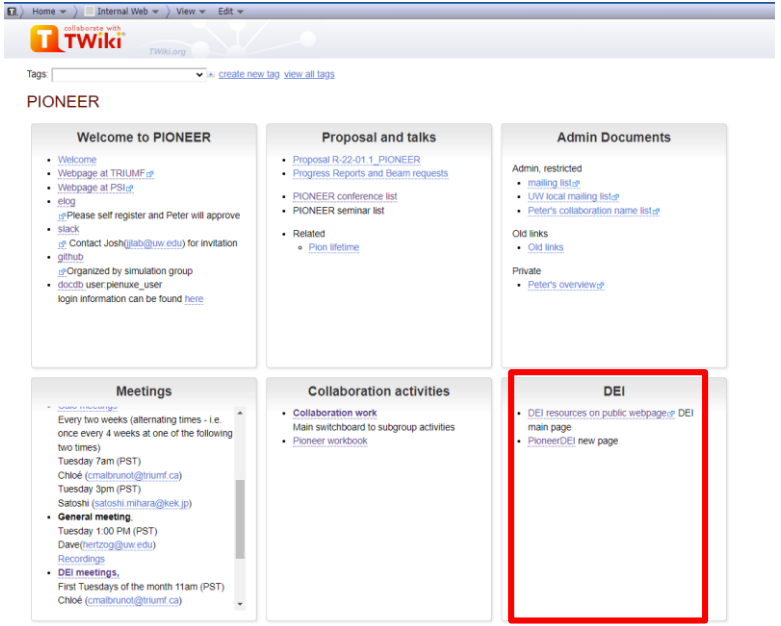
Meet 1st Tuesday of every month

Chairs: Chloé/Omar

Members: Adam, Ben, Bob, Doug, Jaydeep, Jenni, Josh, Svende, Simone

Former Member: Claire (long-term co-op)

Link to Twiki DEI Page: https://pioneer.npl.washington.edu/do/view/Internal/PioneerDEI



DEI subcommittees

- **Climate**
  - Recent work has focused on design and distribution of demographics survey
  - Survey will be administered during the last 15 minutes of today's DEI session
- **Physics onboarding**
  - Develop onboarding documents relating to physics of PIONEER
- **Non-Physics onboarding**
  - Develop instructions/checklist for new members (mailing lists, elogs, docdb, etc.)
  - Develop documentation for preparing computer for simulation and updating example analysis scripts

Climate Subcommittee

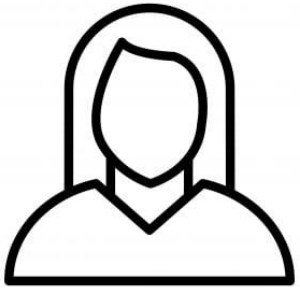
- Understand the composition of our collaboration and track over time through annual brief **demographics surveys**
  - Aggregate data will be analyzed and plotted for internal use
  - Public plots for conferences, funding, etc. will be prepared for internal approval
  - 1st survey today! - dedicated (quick) session after invited speaker
- Create, administer and analyze a **climate survey** to assess the needs of our collaboration, what has worked well so far and what can be improved
  - Example - meetings: number and type, frequency, effectiveness
- Invited speaker, Dr. Alexandra Pedersen, will speak to the importance of these types of surveys (directly following this talk)

Onboarding goal

Develop documentation and a support system where new members of PIONEER can get involved ***regardless of previous experience and background,*** as seamlessly as possible.

Bridging the gap between new members and the physics of PIONEER

New member



Can be a big gap…

68 pages

PSI Ring Cyclotron Proposal R-22-01.1
PIONEER: Studies of Rare Pion Decays

W. Altmannshofer,[1] H. Binney,[2] E. Blucher,[3] D. Bryman,[4,5] L. Caminada,[6] S. Chen,[7] V. Cirigliano,[8] S. Corrodi,[9] A. Crivellin,[6,10,11] S. Cuen-Rochin,[12] A. DiCanto,[13] L. Doria,[14] A. Gaponenko,[15] A. Garcia,[2] L. Gibbons,[16] C. Glaser,[17] M. Escobar Godoy,[1] D. Göldi,[18] S. Gori,[1] T. Gorringe,[19] D. Hertzog,[2] Z. Hodge,[2] M. Hoferichter,[20] S. Ito,[21] T. Iwamoto,[22] P. Kammel,[2] B. Kiburg,[15] K. Labe,[16] J. LaBounty,[2] U. Langenegger,[6] C. Malbrunot,[5] S.M. Mazza,[1] S. Mihara,[21] R. Mischke,[5] T. Mori,[22] J. Mott,[15] T. Numao,[5] W. Ootani,[22] J. Ott,[1] K. Pachal,[5] C. Polly,[15] D. Počanić,[17] X. Qian,[13] D. Ries,[23] R. Roehnelt,[2] B. Schumm,[1] P. Schwendimann,[2] A. Seiden,[1] A. Sher,[5] R. Shrock,[24] A. Soter,[18] T. Sullivan,[25] M. Tarka,[1] V. Tischenko,[13] A. Tricoli,[13] B. Velghe,[5] V. Wong,[5] E. Worcester,[13] M. Worcester,[26] and C. Zhang[13]

25 pages

R-22-01.1 PIONEER Progress Report 2024

A. Adelmann,[1] W. Altmannshofer,[2] S. Ban,[3] O. Beesley,[4] A. Bolotnikov,[5] S. Braun,[4] T. Brunner,[6] D. Bryman,[7,8] Q. Buat,[4] L. Caminada,[1] J. Carlton,[9] S. Chen,[10] M. Chiu,[5] V. Cirigliano,[4] S. Corrodi,[11] A. Crivellin,[1,12] S. Cuen-Rochin,[13] J. Datta,[14] B. Davis-Purcell,[8] K. Dehmelt,[14] A. Deshpande,[14,5] A. Di Canto,[5] L. Doria,[15] J. Dror,[16] P. Fischer,[17] S. Foster,[9] K. Frahm,[17] P. Garg,[14] G. Giacomini,[5] L. Gibbons,[18] C. Glaser,[19] D. Goeldi,[17] S. Gori,[2] T. Gorringe,[9] C. Hamilton,[8] S. Heinekamp,[1,17] C. Hempel,[8] D. Hertzog,[4] S. Hochrein,[17] M. Hoferichter,[20] S. Ito,[21] T. Iwamoto,[3] P. Kammel,[4] E. Klemets,[8,7] K. Labe,[18] J. Labounty,[4] U. Langenegger,[1] Y. Li,[5] C. Malbrunot,[8,6] A. Matsushita,[3] S. M. Mazza,[2] S. Mehrotra,[14] S. Mihara,[22] R. Mischke,[8] A. Molnar,[2] T. Mori,[3] T. Numao,[8] W. Ootani,[3] J. Ott,[2] K. Pachal,[8] D. Pocanic,[19] X. Qian,[5] D. Ries,[1] R. Roehnelt,[4] T. Rostomyan,[1] B. Schumm,[2] P. Schwendimann,[4] A. Seiden,[2] A. Sher,[8] R. Shrock,[14] A. Soter,[17] T. Sullivan,[23] E. Swanson,[4] V. Tishchenko,[5] A. Tricoli,[5] T. Tsang,[5] B. Velghe,[8] V. Wong,[8] M. Worcester,[5] E. Worcester,[5] C. Zhang,[5] and Y. Zhang[5]

[1] *Paul Scherrer Institute* [2] *University of California Santa Cruz* [3] *The University of Tokyo* [4] *University of Washington* [5] *Brookhaven National Laboratory* [6] *McGill University* [7] *University of British Columbia* [8] *TRIUMF* [9] *University of Kentucky* [10] *Tsinghua University* [11] *Argonne National Laboratory* [12] *University Zurich* [13] *Tecnologico de Monterrey* [14] *Stony Brook University* [15] *Johannes Gutenberg University* [16] *University of Florida* [17] *ETH Zurich* [18] *Cornell University* [19] *University of Virginia* [20] *University of Bern* [21] *Kitakyushu College* [22] *KEK* [23] *University of Victoria*

(Dated: January 22, 2024)

Physics onboarding document

Overview of Technical Design Choices for PIONEER

This document provides an overview of the technical design choices made for the PIONEER physics collaboration, aimed at assisting early career members in understanding the rationale behind these choices and the current research and development (R&D) efforts in implementing them. See here for a longer and more detailed paper on PIONEER.

Physics:

The goal of PIONEER is to measure with unmatched precision the charged-pion branching ratio to electrons vs muons, $R_{e/\mu}$, and the pion beta decay ratio $\pi^+ \to \pi^0 e^+ \nu(\gamma)$. $R_{e/\mu}$ is the ratio of Pion decay to electron or muon, but the probability of decay is not 50-50%. Due to helicity (the spin of the almost zero mass neutrino really likes to be polarized in a certain way with the direction of motion, forcing the other particle in an unnatural helicity state that is easier for the muon since it has more mass; see here for more details) constraints the muon decay is 10^3 more likely to happen than the electron/positron decay.

π^+ DECAY MODES

π^- modes are charge conjugates of the modes below.

For decay limits to particles which are not established, see the section on Searches for Axions and Other Very Light Bosons.

	Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1	$\mu^+\nu_\mu$	[a] (99.98770 ±0.00004) %	
Γ_2	$\mu^+\nu_\mu\gamma$	[b] (2.00 ±0.25) × 10^{-4}	
Γ_3	$e^+\nu_e$	[a] (1.230 ±0.004) × 10^{-4}	
Γ_4	$e^+\nu_e\gamma$	[b] (7.39 ±0.05) × 10^{-7}	
Γ_5	$e^+\nu_e\pi^0$	(1.036 ±0.006) × 10^{-8}	
Γ_6	$e^+\nu_e e^+e^-$	(3.2 ±0.5) × 10^{-9}	
Γ_7	$e^+\nu_e\nu\overline{\nu}$	< 5 × 10^{-6}	90%

Fig: Pion decay modes, source PDG

The two decays are particularly easy to recognize at first order, looking at the exiting positron: the $\pi \to e\nu$ decay is a two-body decay, meaning that both particles will have around 70 MeV (pion mass is around 140MeV). The $\pi \to \mu\nu \to e\nu\nu$ is a three-body decay of the muon (mass around 105 MeV), so the maximum energy the positron will have (case back-to-back with the two neutrinos) is around 53 MeV. The positron coming from muon decay is what we call 'The Michel spectrum'.

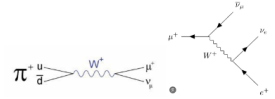


Fig: Pion decay to muon and then muon decay

A Measurement of the two spectra done by simply counting the amount of positrons out of the decay over (e.g.) 55 MeV is already quite an effective measurement of $R_{e/\mu}$.

Particle	Mass	Path length at decay energy	Half-life	Calorimeter positron energy
Pion	139 MeV	-	26 ns	-
Muon	105 MeV	1 mm	1 us	0-55 MeV
Positron	0.5 MeV	Long (MIP)	75 s	70 MeV

Tab. Details of the particles

This was made by the previous generation of experiments (PiENU, PEN) but is limited in precision. That is because a number of events are migrating between the two spectra due to:

- Limited calorimeter energy resolution (usually a few %)
- Positron energy loss in inactive material between decay and energy measurements
- Pion and Muon decay in flight introduce positrons with wildly different moments depending on the position emission direction and flight direction of the decaying particle.
- Pileup and other experimental systematic errors (e.g., muons coming with the beam)

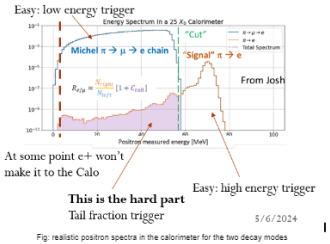


Fig: realistic positron spectra in the calorimeter for the two decay modes

All of these effects limited the precision of previous experiments that mostly relied on Calorimeter positron detection for the count. PIONEER's goal is to improve the measurement to reach the same level as the theory calculation using a new 'active target' idea: the ATAR.

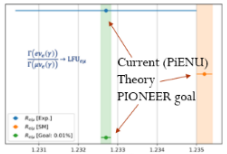


Fig: Current measurement of $R_{e/\mu}$ theory calculation and PIONEER's goal

With measurements at the 0.01% level in precision, new physics up to the PeV scale may be revealed. Such precision would contribute to stringent tests of LFU in a context where several intriguing hints of LFU violation (LFUV) have emerged. In addition, it will allow extended searches for exotics such as heavy neutral leptons and dark sector processes. The ATAR will be a high-granularity, fast-timing, and fully active Silicon target. The temporal and spatial precision will allow the detection of the path of the muon decay (about 1mm in length), permitting the disambiguation of between $\pi \to e\nu$ and $\pi \to \mu\nu$ decays. The ATAR, combined with an improved, large solid angle (3π) and radiation length ($20X_0$) calorimeter, will provide the best measurement of $R_{e/\mu}$ to date.

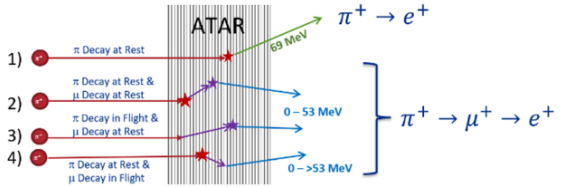


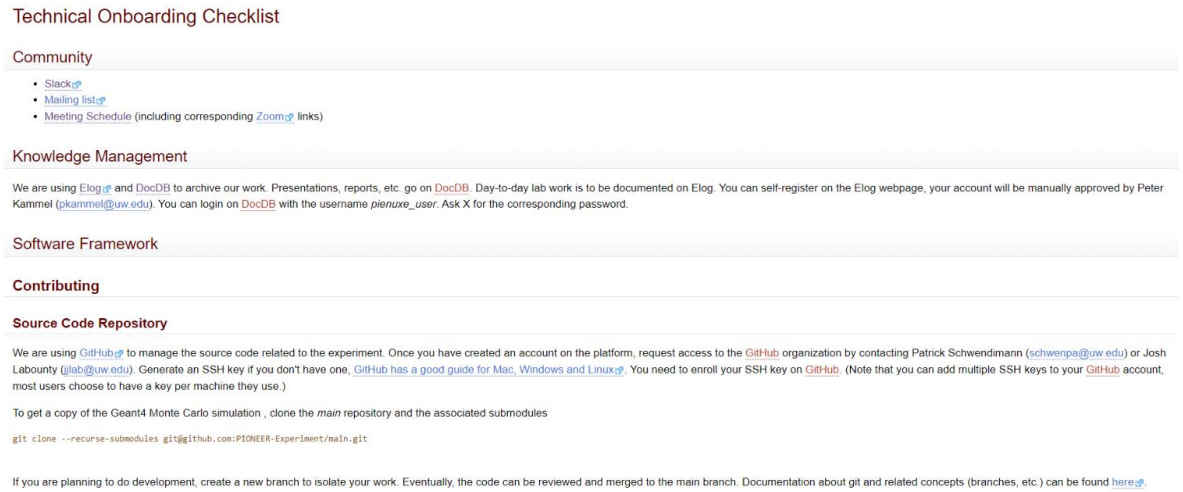
Fig. ATAR decay detection, lines are the ATAR planes.

In the second and third Phases, PIONEER will study the pion beta decay $\pi^+ \to \pi^0 e^+ \nu(\gamma)$, ultimately aiming at an order of magnitude improvement in precision to determine Vud in a theoretically pristine manner and test CKM unitarity, for which there is presently a 3σ tension.

This is just a small part of the document being prepared!

- Gives brief overview of each detector at a level accessible by those not familiar with the detector
- Explains current design choices with pros/cons/development status

Onboarding checklist



Technical Onboarding Checklist

Community

- Slack
- Mailing list
- Meeting Schedule (including corresponding Zoom links)

Knowledge Management

We are using Elog and DocDB to archive our work. Presentations, reports, etc. go on DocDB. Day-to-day lab work is to be documented on Elog. You can self-register on the Elog webpage, your account will be manually approved by Peter Kammel (pkammel@uw.edu). You can login on DocDB with the username *pienuxe_user*. Ask X for the corresponding password.

Software Framework

Contributing

Source Code Repository

We are using GitHub to manage the source code related to the experiment. Once you have created an account on the platform, request access to the GitHub organization by contacting Patrick Schwendimann (schwenpa@uw.edu) or Josh Labounty (jjlab@uw.edu). Generate an SSH key if you don't have one, GitHub has a good guide for Mac, Windows and Linux. You need to enroll your SSH key on GitHub. (Note that you can add multiple SSH keys to your GitHub account, most users choose to have a key per machine they use.)

To get a copy of the Geant4 Monte Carlo simulation , clone the *main* repository and the associated submodules

```
git clone --recurse-submodules git@github.com:PIONEER-Experiment/main.git
```

If you are planning to do development, create a new branch to isolate your work. Eventually, the code can be reviewed and merged to the main branch. Documentation about git and related concepts (branches, etc.) can be found here.

- Onboarding checklist – centralized location where new members can get into the PIONEER slack, get on docdb, mailing lists, elogs etc.

Simulation/Analysis documentation in progress

We want to assume as little prior coding experience as possible when documenting our simulation/analysis scripts

1. Provide additional documentation for setting up the simulation (undergraduate who knows how to open up a terminal can compile simulation with minimal additional help, regardless of OS)
2. Update analysis scripts to provide skeleton with extensive documentation to help new members get to physics studies more quickly

Concluding remarks

- We will update as onboarding documentation is completed – it is all currently visible on the DEI Twiki page, but not finished yet
- We are preparing DEI-related document to assist with funding proposals and checkpoints - results from demographics survey are one aspect of this
- Code of Conduct (CoC) not yet approved by the IB – we should get that done soon
- CoC evolved from DEI committee discussions that included mandate and scope - we will revisit these to make clear descriptions now that CoC is complete