# The Fundamental Physics Beamline @ ESS


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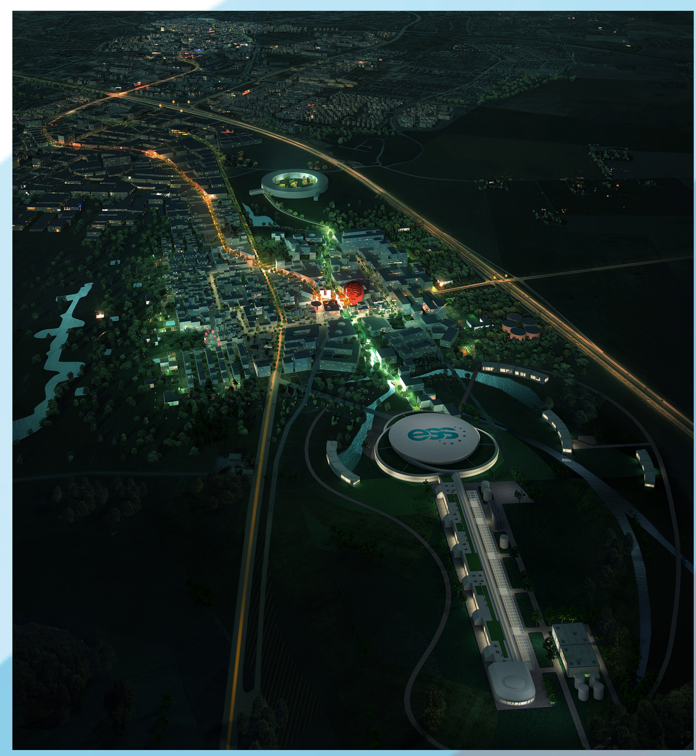
## The European Spallation Source : ESS

The European Spallation Source (ESS) is a facility that 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.

| Parameters | Value |
|---|---|
| Average beam power | 5 MW |
| Number of target stations | 1 |
| Number of instruments in construction budget | 22 |
| Number of beam ports | 48 |
| Number of moderators | 2 |
| Separation of ports | 5° |
| Proton kinetic energy | 2.5 GeV |
| Average macro-pulse current | 50 mA |
| Macro-pulse length | 2.86 ms |
| Pulse repetition rate | 14 Hz |
| Annual operating period | 5000 h |
| Reliability | 95% |



## The Fundamental Physics Beamline project

| Instrument Parameters | Value |
|---|---|
| Moderator | Cold |
| Distance to moderator | to be defined |
| Wavelength Range | ~ 3- 30 Å |
| Energy Resolution | to be defined |
| Beam size at the sample | ~ 100*120 mm2 |
| Divergence at the sample | ~ 2° |
| Size of the experimental area | Up to 30 m X 6 m X 6 m |
| Detectors | 3He, Semiconductor, Scintillator … |
| Infrastructure | High accuracy polarization |

The pulsed time structure of the ESS requires a careful optimization of the beamline parameters

**PROPOSAL FOR THE FUNDAMENTAL PHYSICS BEAMLINE ~ END 2014**

## Advantages of long-pulsed spallation sources for Fundamental Physics

The ESS will be the first pulsed source that provides the same averaged flux as the ILL.

| Advantages | Example |
|---|---|
| Time structure of the beam → separation of neutron velocity dependent systematic effects | Neutron spin rotation in magnetic fields |
| Time structure of the beam → Wavelength-resolved polarization for free, beam-related background, pulsed measurements to investigate spatial dependence of spectrometer response | Asymmetry measurements with polarized neutron |
| Pulse structure → increased signal/ background during pulse, measurement of spectrometer background between pulses | Experiments with intrinsic spectrometer background |

Ultra Cold Neutron case

For He sources: Improve production rate by efficient mono-chromatization. Optimized extraction of cold neutrons from primary moderator.

## How to define the best configuration ?

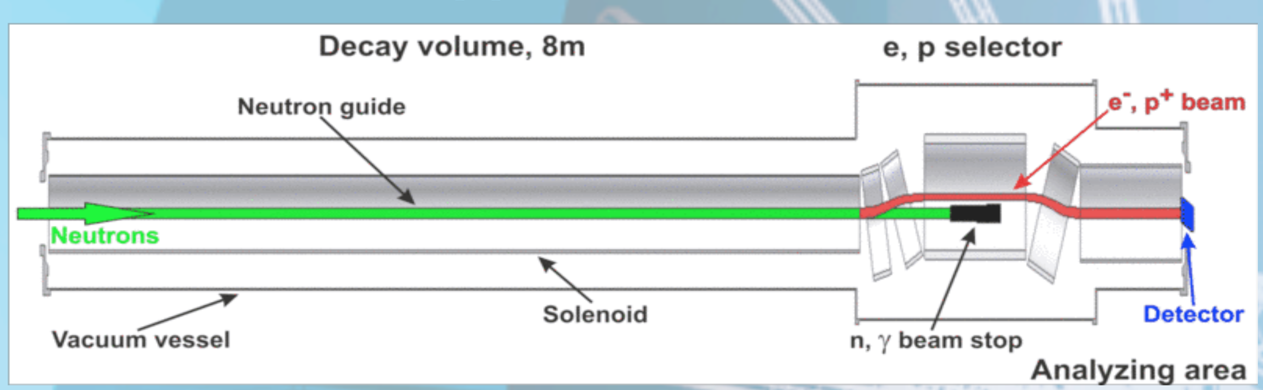
- Collect state-of-the-art fundamental physics experiments at cold neutrons beams.
- Interact with the fundamental physics community to clarify their scientific priorities.
- Define different candidate experiments for ESS
- Perform simulations/calculations

**maximum flexibility for new scientific opportunities**

## An example of an experiment @ ESS : PERC

As example, we are studying the possibility to perform a state-of-the-art high precision neutron beta decay experiment which tests the Standard Model with cold neutrons : PERC, at ESS to determine the gain factor compared to the ILL research reactor.

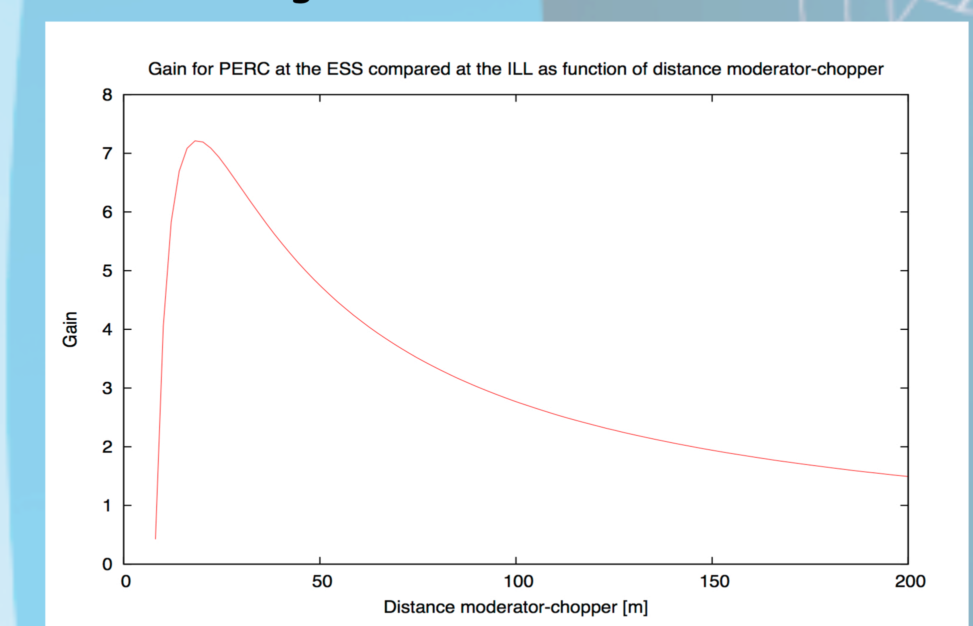
The **P**roton **E**lectron **R**adiation **C**hannel PERC is a new instrument designed to measure correlation coefficients in neutron decay. For that, a strong longitudinal magnetic field is used along a neutron guide to extract charged neutron decay products. With this new experimental set-up, all systematic effects could be controlled at least on the $10^{-4}$ level [1].




*Scheme of PERC instrument.*

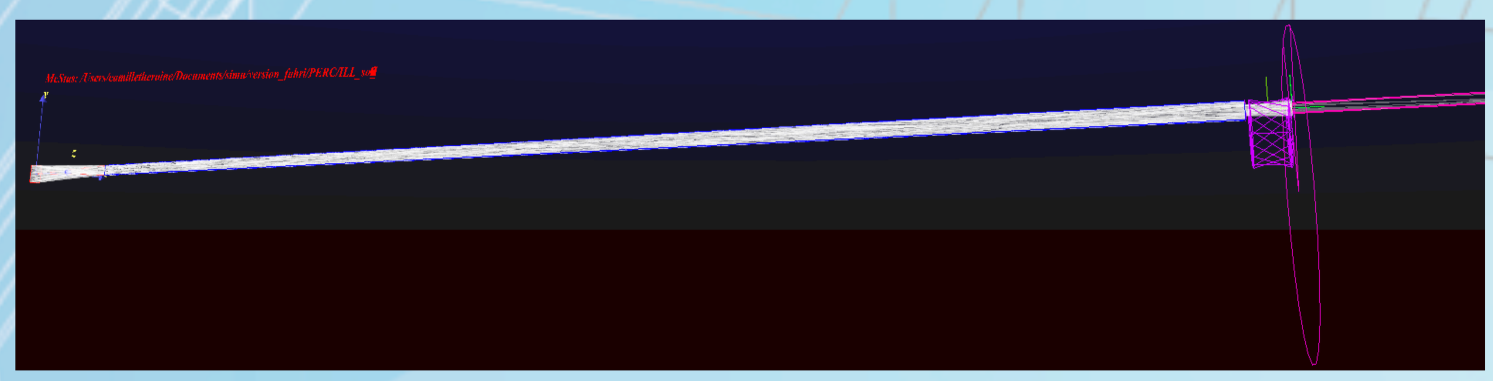
Klauser et al. show analytically in [2] that it is possible to obtain up to a gain factor of 7 for a distance of 19 m between the moderator and the chopper for PERC at ESS compared to the ILL. The main hypotheses used here are :

- The peak flux of ESS is about 30x the continuous flux of the ILL.
- The ESS pulse length is 2.86 ms [3].
- The ESS pulse frequency is 14 Hz [3].
- The reference wavelength is 5 Å.

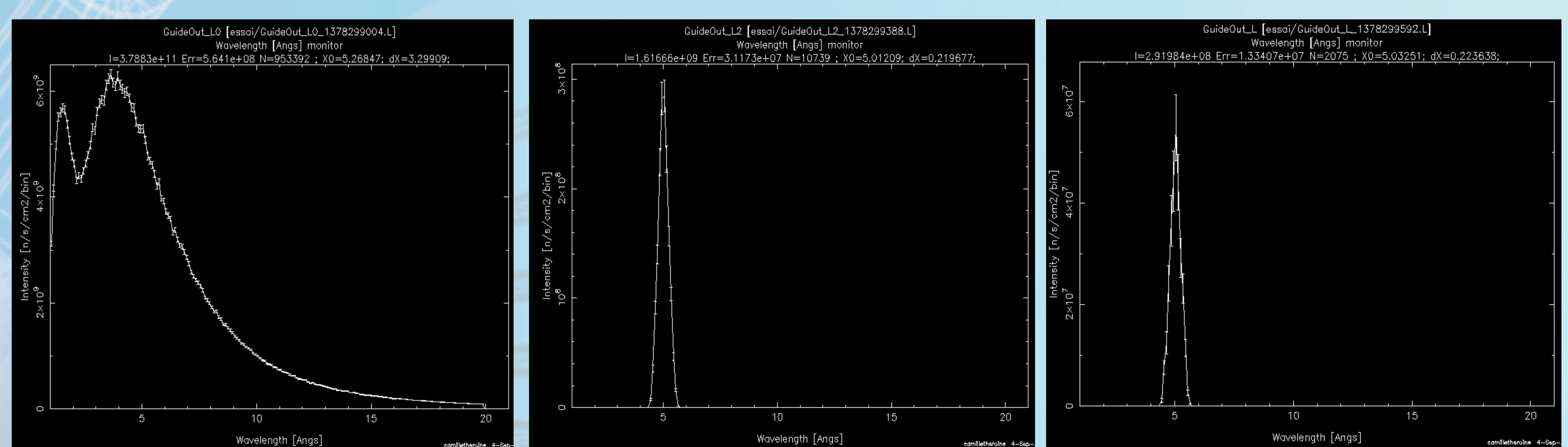



*Gain for PERC at the ESS compared to the ILL calculated by [2].*

Currently, the analytical calculations and claims are tested with simulations from Monte-Carlo code McStas [4]. Preliminary simulations are shown.

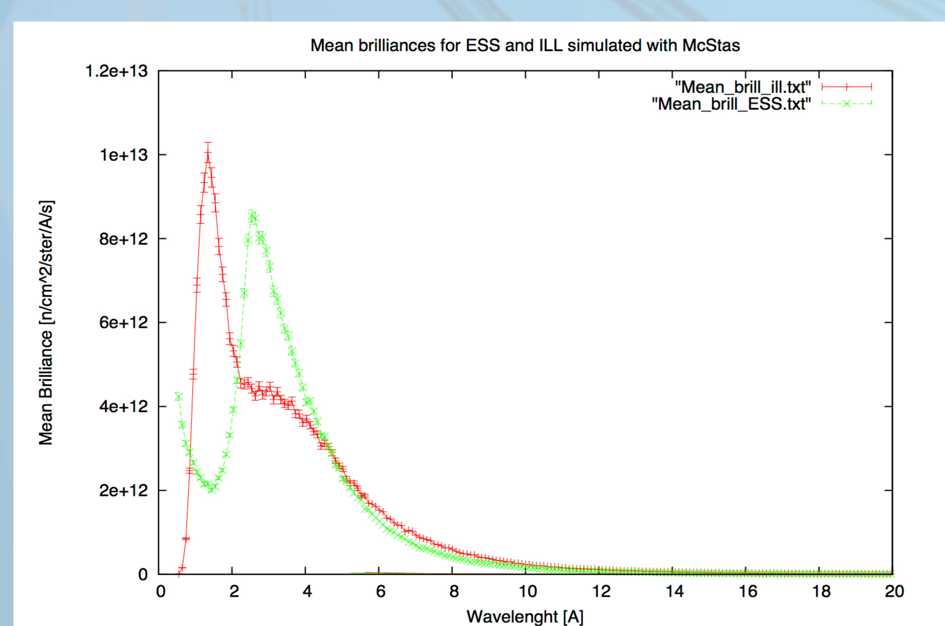


*Simulation of PERC at the ILL with McStas.*



*Simulation of the capture flux in PERC at the ILL with McStas. Left : at 2m from the source, Middle : after the 5 Å selector, Right : after the chopper.*

*McStas simulation results for the mean brilliance between 0.5 and 20Å :*
*for ESS ~ 2.45e+10 n/cm^2/ster/Å/s*
*for ILL ~ 2.60e+10 n/cm^2/ster/Å/s*




**After checking the simulated set-up with McStas at the ILL and ESS, the next step of this work will be the determination of the gain factor**


References :

[1] : D. Dubbers et al., Nucl. Instr. Meth. A **596**, 238 (2008) or **arXiv:0709.4440**.
[2] : C. Klauser et al., submitted in Physics Procedia (NPPatLPS 2013).
[3] : S. Peggs, ESS Technical Design Report (2013), http://esss.se/documents/tdr/TDR_final.pdf
[4] : P. Willendrup et al., McStas manual (2012), http://mcstas.org/.