NuESS, a new opportunity for CEνNS at the ESS

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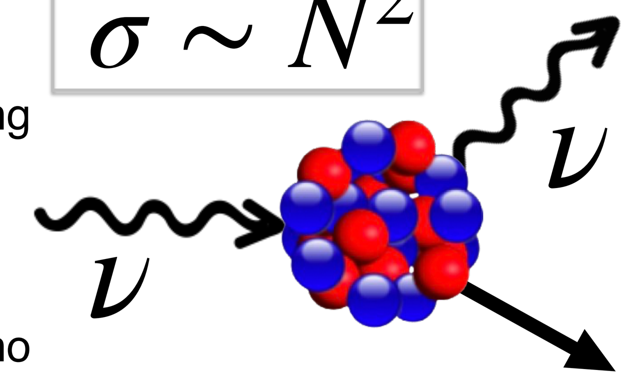
CEνNS interaction signature:

- The neutrino sees the nucleus as a whole -

The single observable from CEνNS is a recoiling nucleus with a very low recoil energy of few keV.

- $E_\nu \lesssim 10$ MeV.
- Large cross section (σ), compared to other neutrino interactions.

$$\sigma \sim N^2$$



CEνNS sources:

- Intense in yield
- Low in neutrino energy (E_ν)

Coherence condition

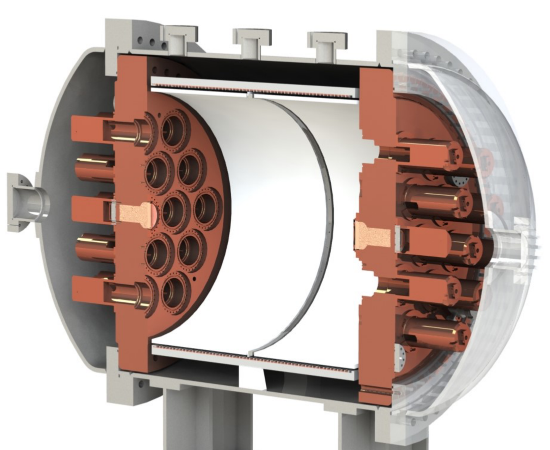
|Q| < 1/R, where |Q| is the momentum transfer and R is the radius of the nucleus.

Spallation sources produce nuclear recoils as energetic as allowed by the coherence condition, facilitating its detection. **Nuclear reactors** are excellent candidates too.

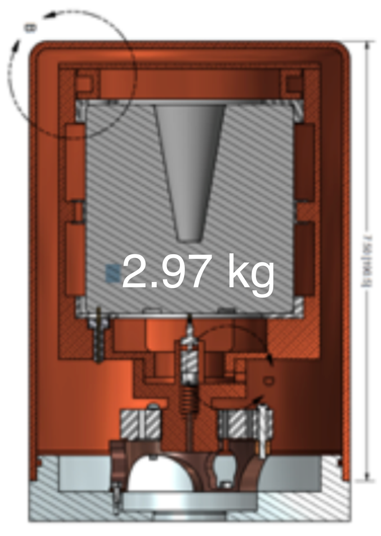
The NuESS detector team @ DIPC

It will overtake the sensitivities of much larger detectors in current spallation sources

GanESS

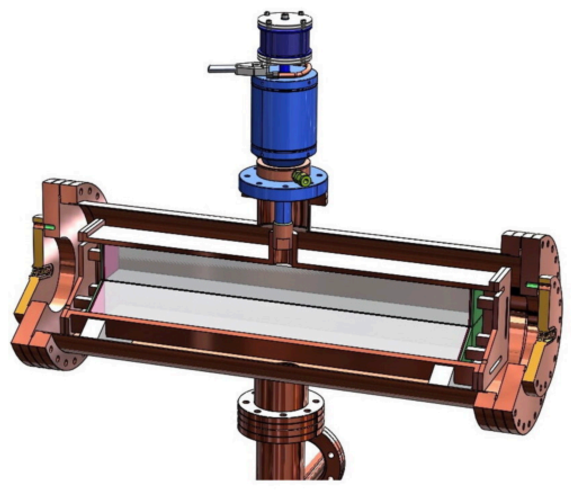


High pressure gas TPC



p-type point contact Ge

C°SI

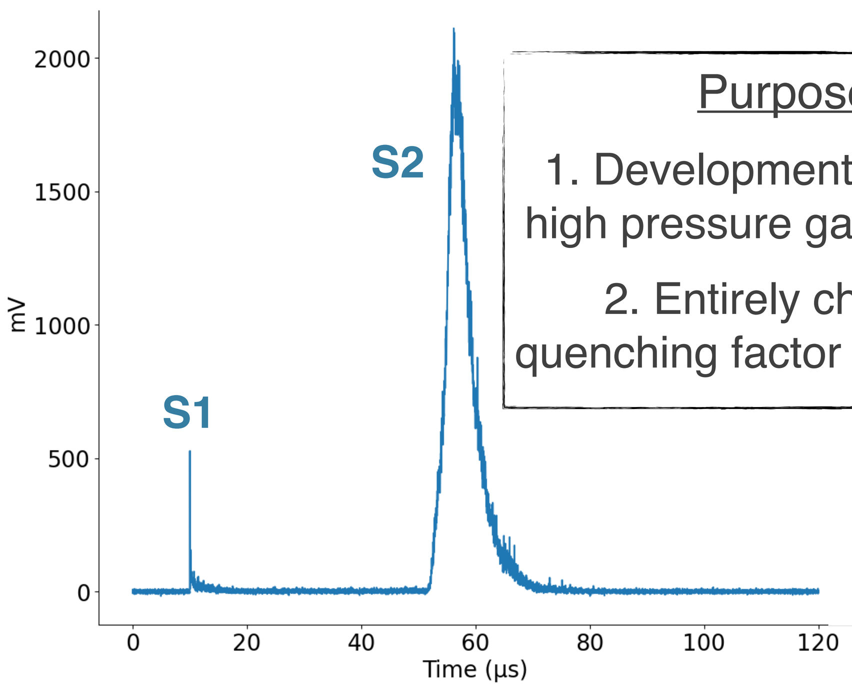


Cryogenic undoped CsI

Development of a small scale gaseous detector (GaP) ongoing @ DIPC

Detector compatible with different nuclei - xenon, argon, krypton -

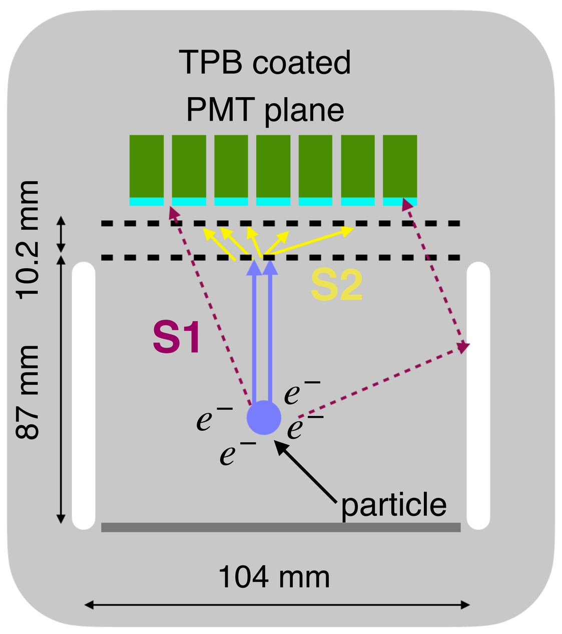
Alpha emission from 241Am source



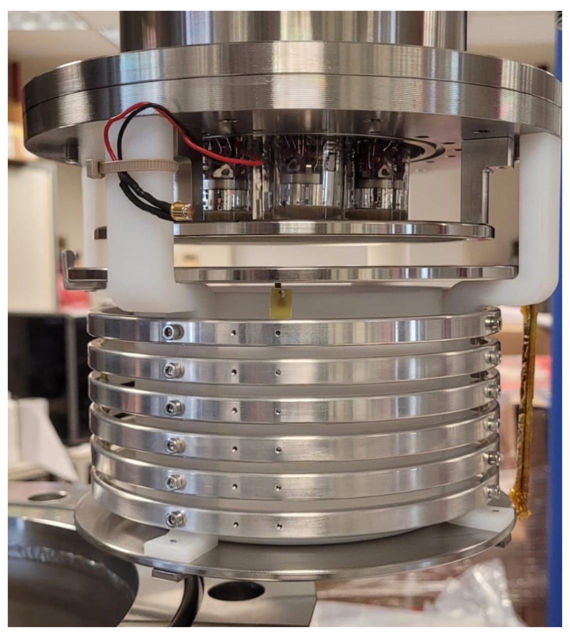
Purpose of GaP

1. Development and validation of high pressure gaseous technology.
2. Entirely characterise the quenching factor for different nuclei.

Electroluminescence (EL)



GaP can operate up to 50 bar pressure



European Spallation Source

- An optimal CEνNS source -

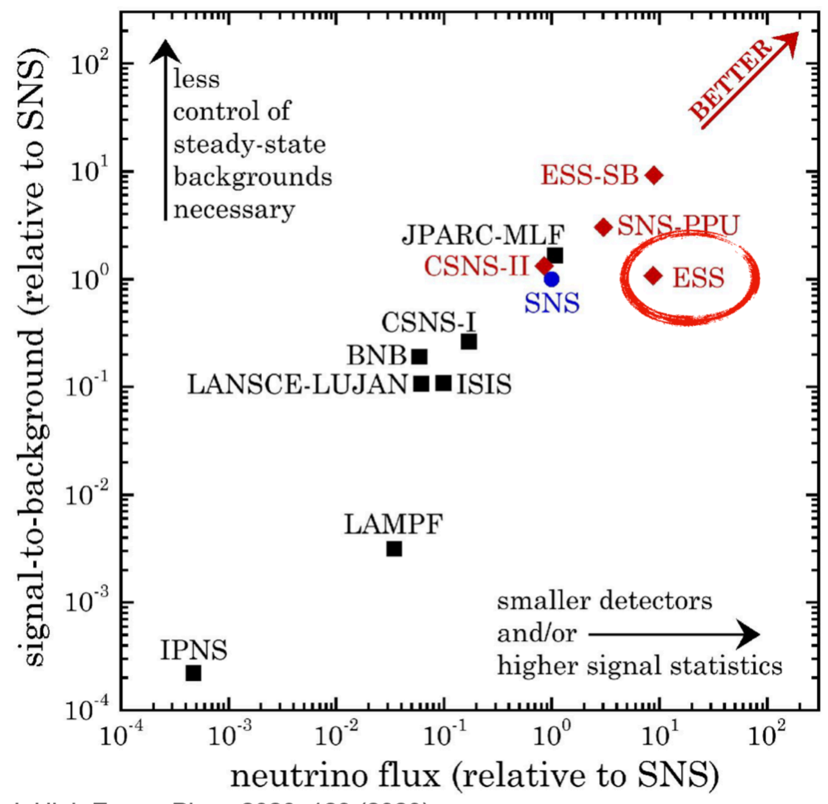
Generation of the most intense neutron beams for multi-disciplinary science. In the process:

Neutrinos are produced too!

- The largest low energy neutrino flux of the next generation facilities.
- ν production @ ESS is x9.2 @ SNS.
- Steady-state background can be subtracted. (Great advantage)

Large cross section & large neutrino flux: small detectors are allowed

Neutrino production at different facilities



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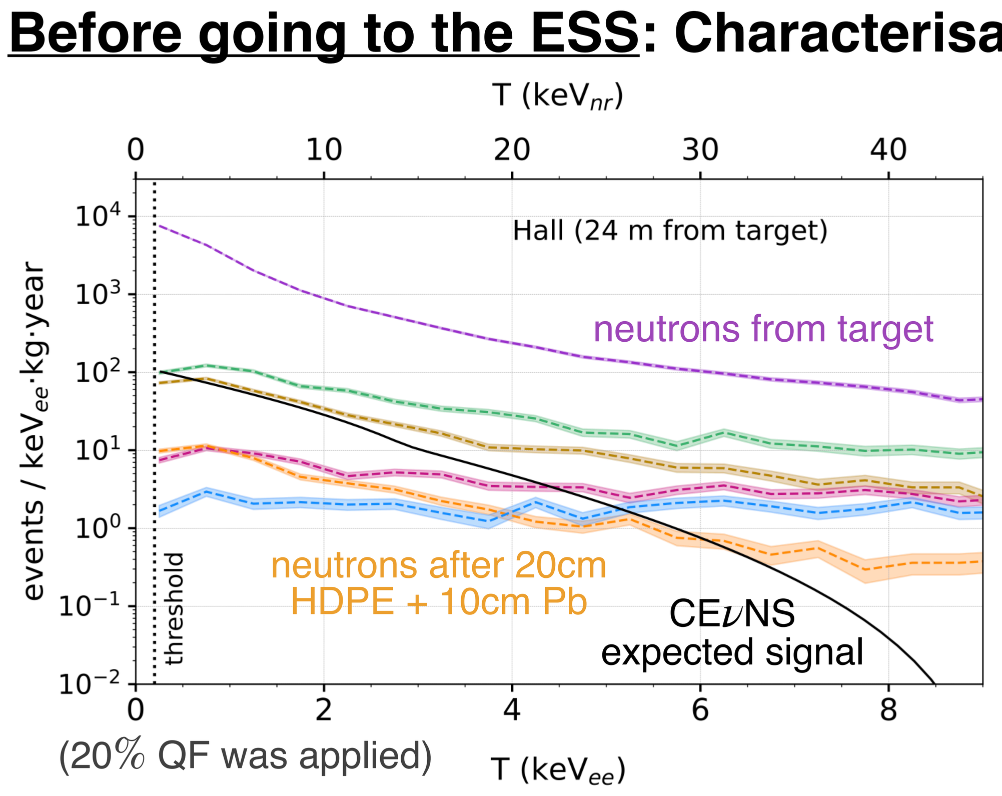
The best source deserves an effort to operate the best possible detectors.

Before going to the ESS: Characterisation of neutron background



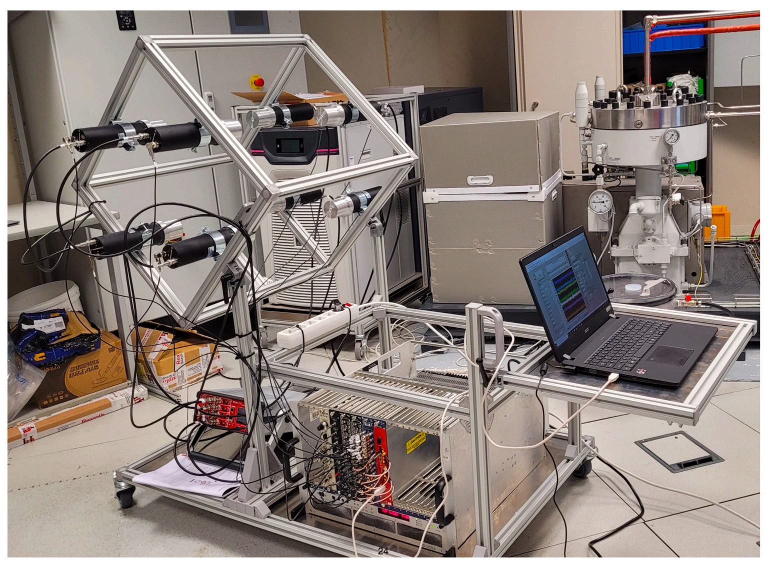
(20% QF was applied)

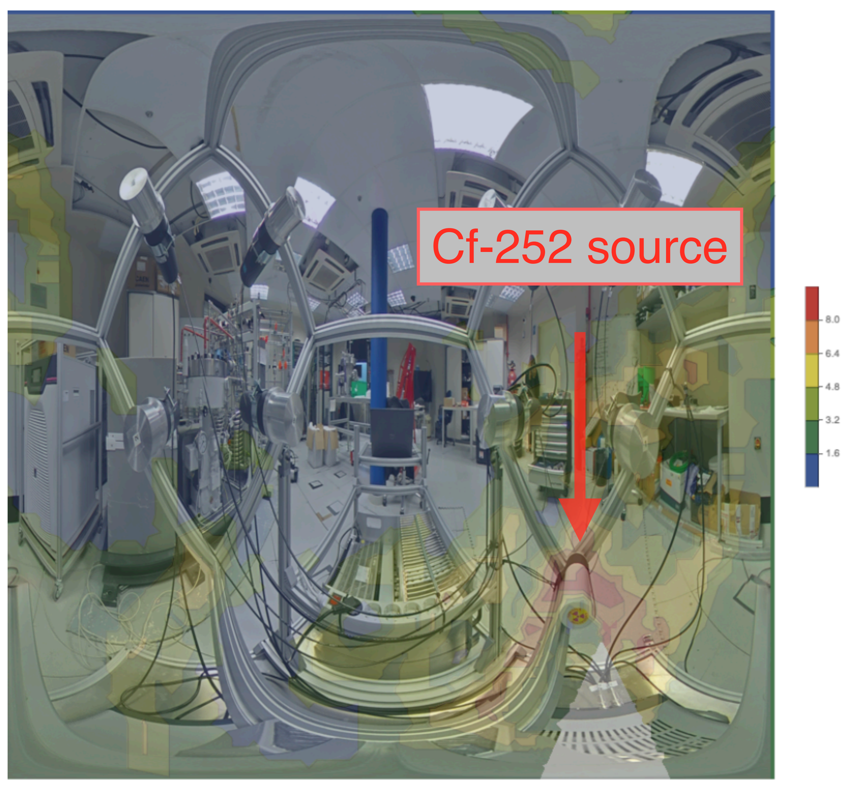
- Simulations of neutron's (and other particles') propagation through ESS.
- Complemented with neutron data provided by the neutron camera.

Shielding study

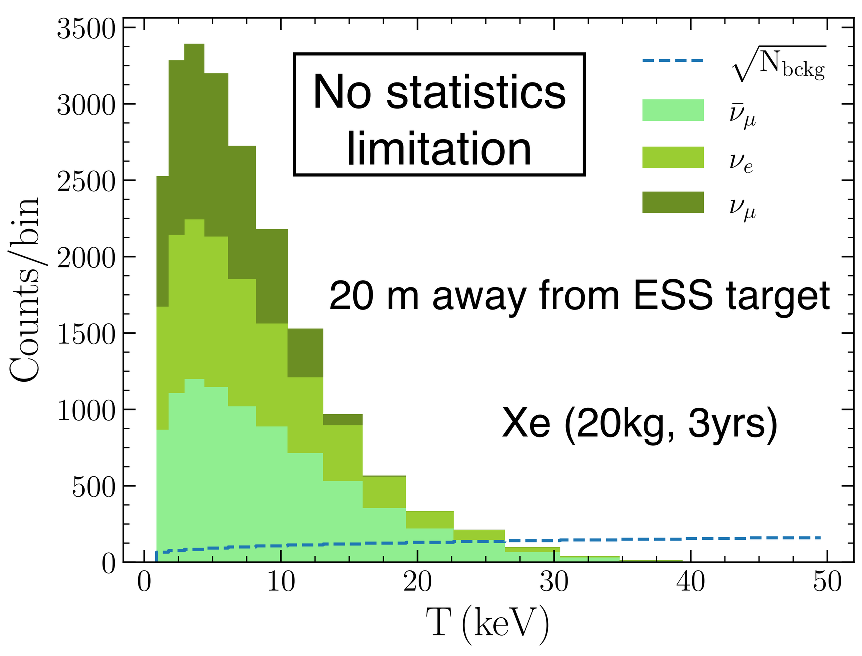
Assuming 20 bar Xe detector operating 1 year

360 coverage Neutron Scatter Camera



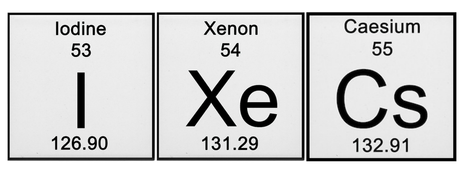


- More than 7000 CEνNS events per year -

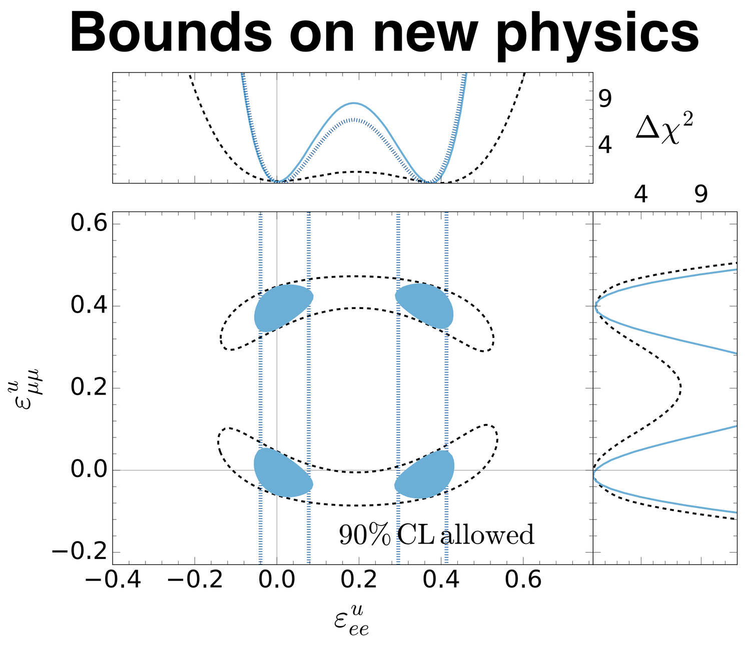


Interesting CsI/Xe overlap

- Same response
- Different systematics

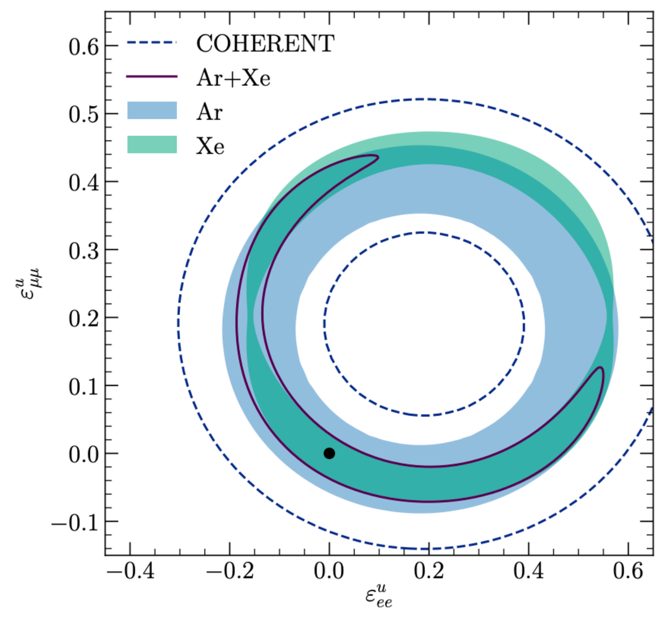


Bounds on new physics



The combination of neutrino sources and different nuclei breaks degeneracies

Sensitivity to non-standard interaction (NSI) combining different neutrino sources and detection technologies [1].



Sensitivity to NSI for a detector running with Xe only, Ar only, and a combination of both at 90%CL for 2 dof. [2].

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[1] Coloma, P., Esteban, I., Gonzalez-Garcia, M. C., Larizgoitia, L. *et al.* "Bounds on new physics with data of the Dresden-II reactor experiment and COHERENT." J. High Energ. Phys. **2022,** 37.
[2] Baxter, D., Collar, J.I., Coloma, P. *et al.* "Coherent elastic neutrino-nucleus scattering at the European Spallation Source." J. High Energ. Phys. **2020,** 123.