The Source Testing Facility

A cost-effective and highly-available source-based testbed for novel neutron detectors

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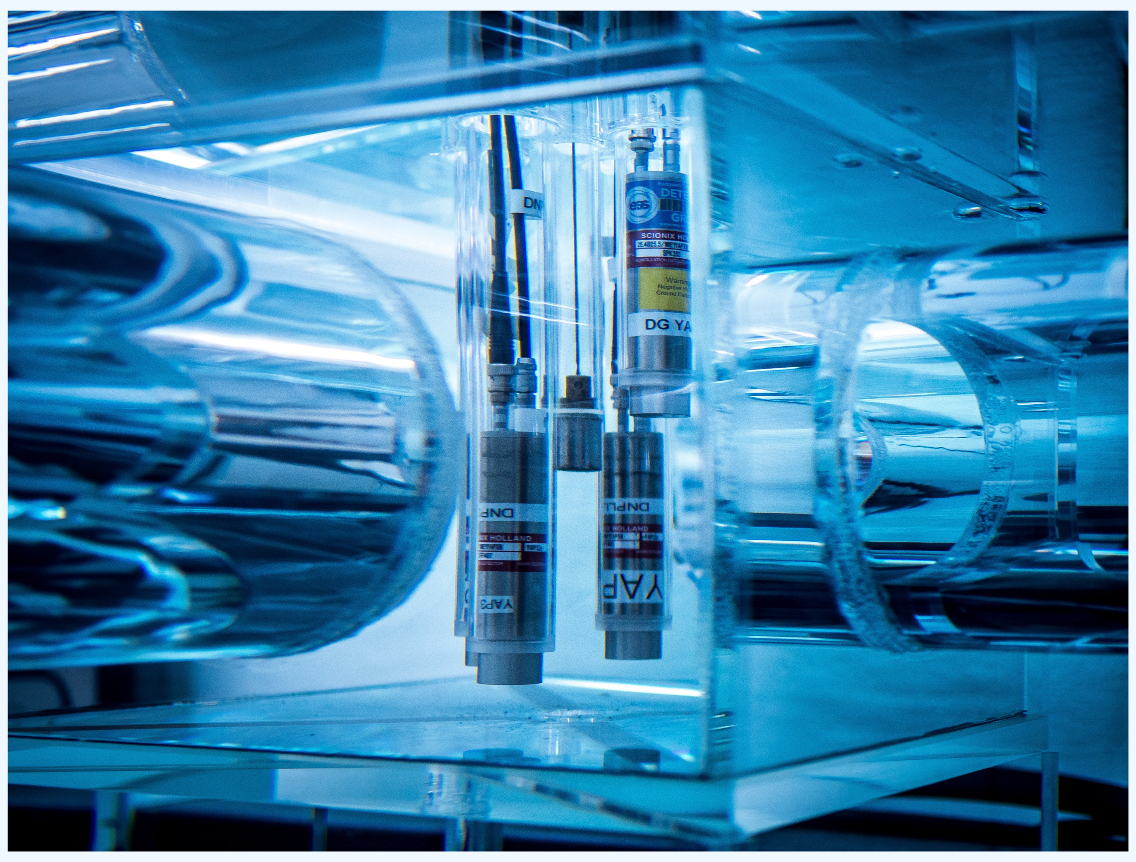
on behalf of the SONNIG group for ICANS 2017

The Need for Neutrons

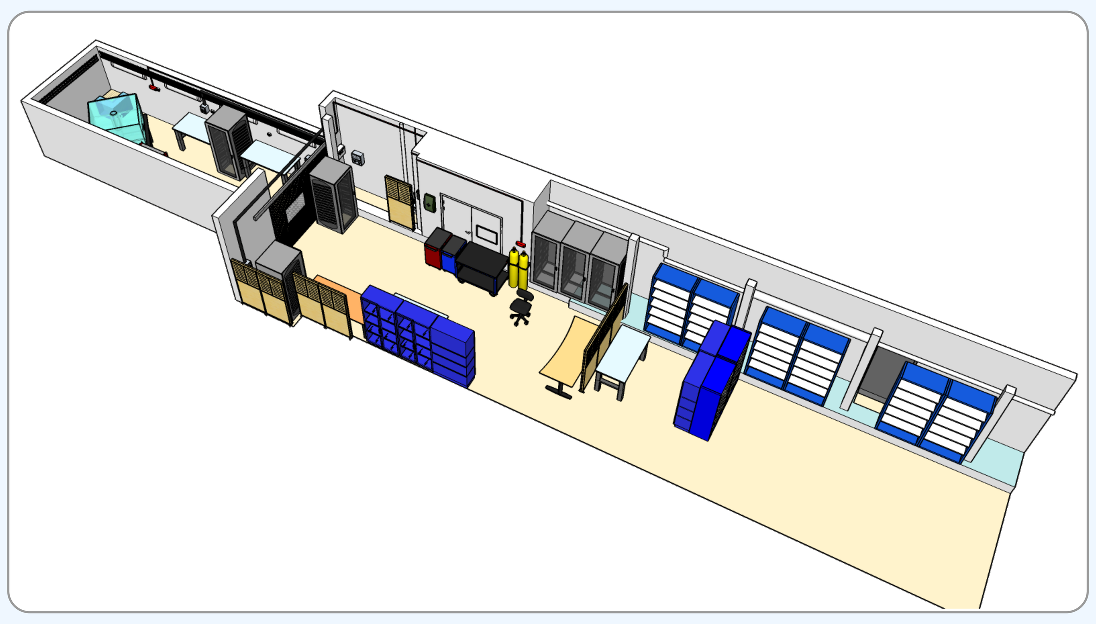


Let's say you have come up with a novel detection technology for neutrons or want to commission a neutron instrument or study a material under neutron irradiation… you will have to demonstrate/test it early on!
There are a few places for such tests:

- reactor and accelerator beam lines
  ⇨ increasingly difficult to get beam-time;
- neutron generators
  ⇨ expensive and can be hard to get;
- neutron source in the basement
  ⇨ cost-effective but know-how trickier to come by.

⇨ Access to neutrons is crucial during entire R&D process.
⇨ Source Testing Facility (STF): Lund-based lab with access to neutrons for ESS instrument development, combining radioactive sources and evolved nuclear physics techniques!

The STF as User Facility



The Source Testing Facility (STF) is more than just a shared lab space, offering its users:

- infrastructure: sources, detectors, moderators, gases, shielding (and a lot more: safety gear, racks, electronic modules, oscilloscopes, tools, soldering kit, computers, network, VPN, DAQs, …);
- organization: measurement slots are scheduled, area is kept tidy and well-sorted, and access and safety procedures are in place;
- support: SONNIG group offers assistance and its decades of experience in nuclear physics techniques.

⇨ everything one needs to get *first neutrons* in a detector [1] or study background sensitivity [2] – and more, *see next section*!

Acknowledgments

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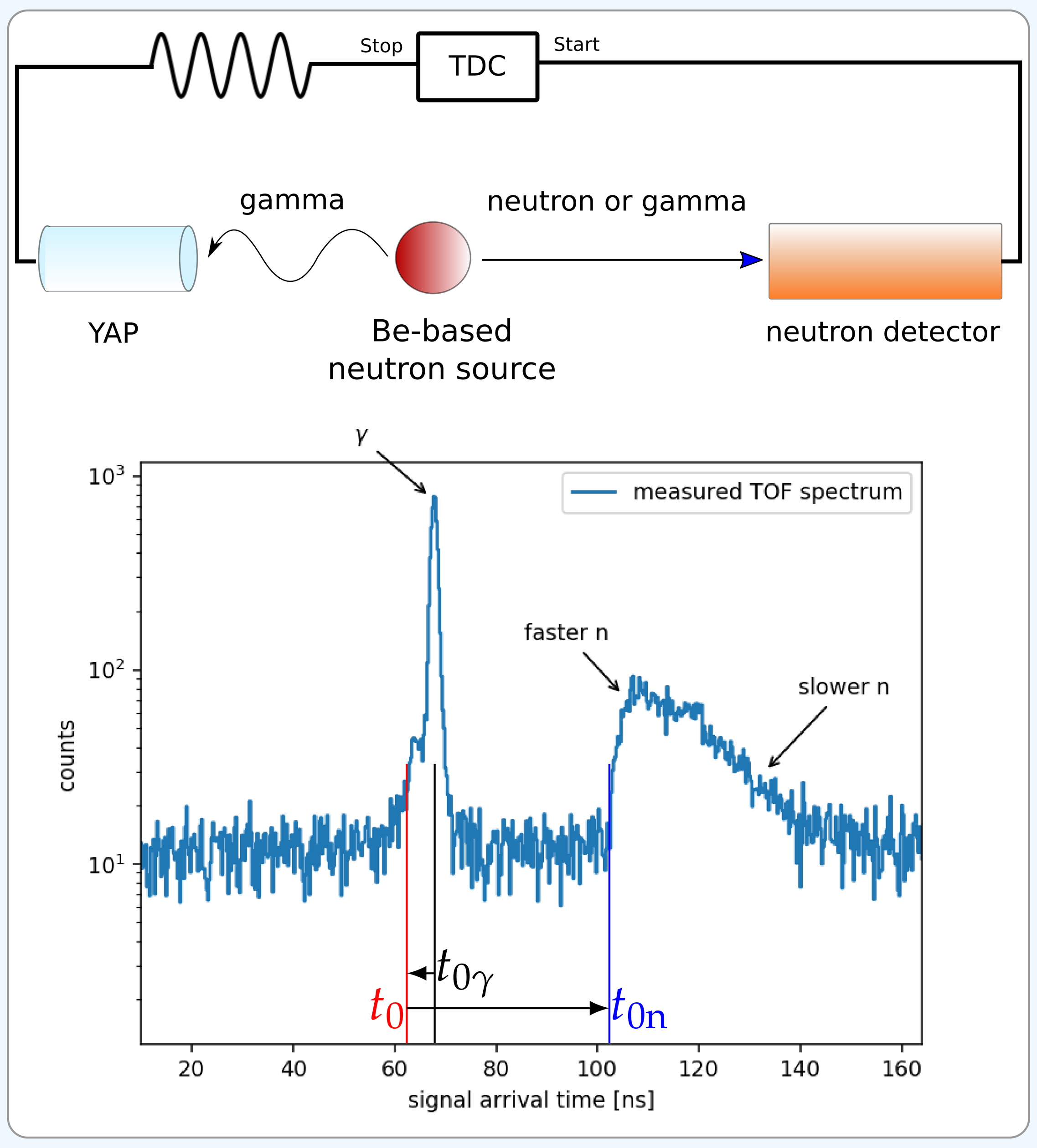
Tagging Neutrons: Energy-Differential Studies with a Source!

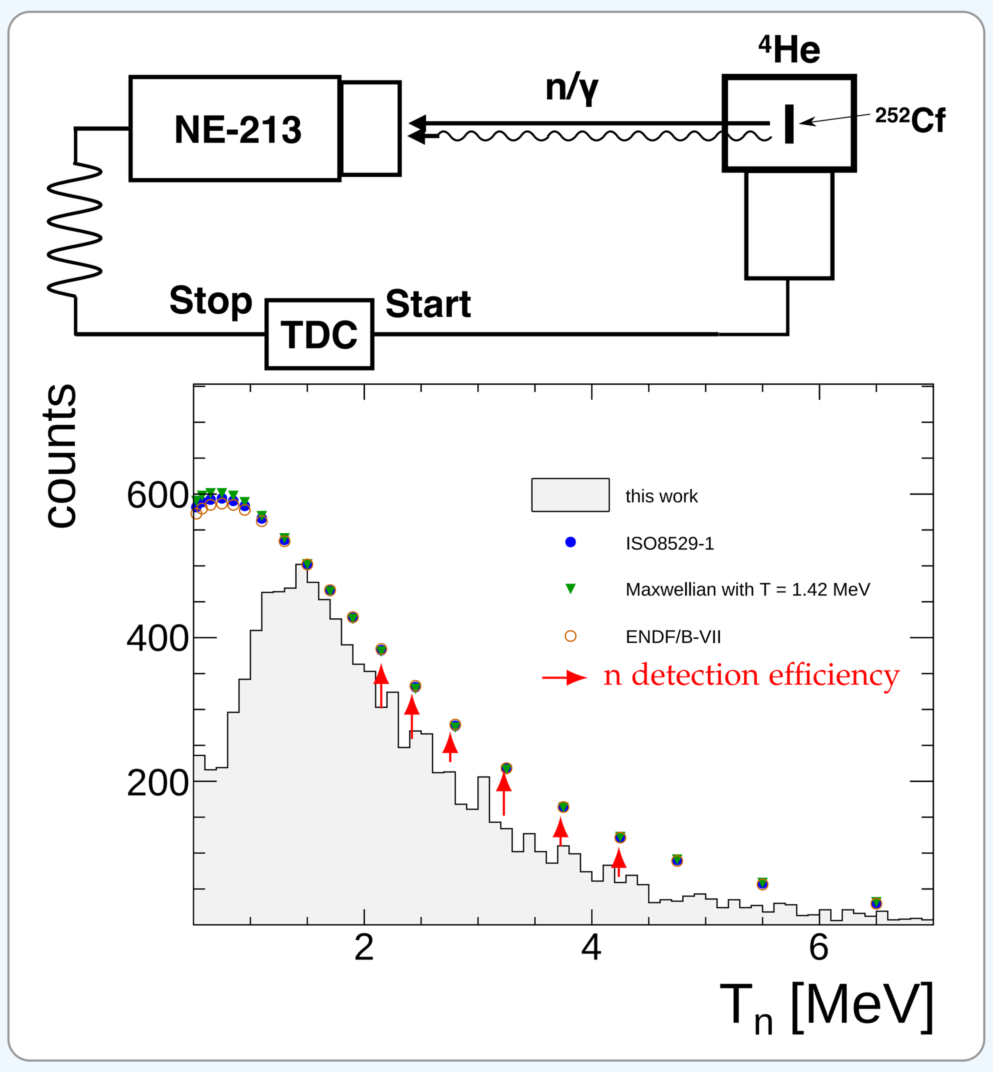
Be-based radioactive sources provide a mixed gamma and neutron field through the reaction $\alpha + ^9\text{Be} \rightarrow \text{n} + ^{12}\text{C}$ with neutron energies between 1…11 MeV.

With a little trick, the energy of a neutron emitted by the source can be determined event-by-event:

- when ^{12}C is left in its first exited state, the neutron is accompanied by a prompt emission of a 4.4 MeV γ;
- measuring the relative timing of this γ detection by a YAP detector and the neutron detection by e.g. a liquid-scintillator detector with a time-to-digital converter (TDC) results in the spectrum to the right;
- using events with two emitted γs (and the resulting *gamma flash* in the TDC spectrum) for calibration, one has all that is needed for determining the time-of-flight of the neutron – thus its kinetic energy – on an event-by-event basis;
- this technique is already established for fast neutrons from different Be-based sources [3, 4] and has recently been extended to a fission-fragment source [5] (*see below*).



Extending the Tagging Technique

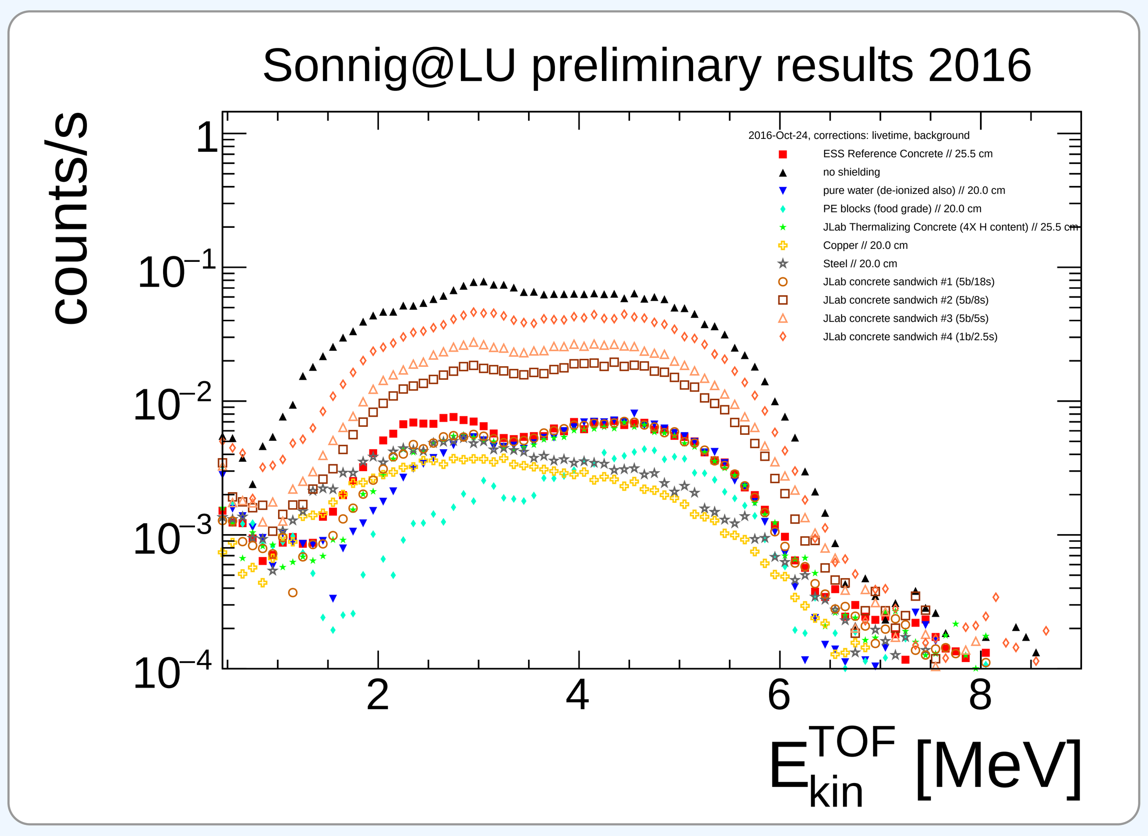


Neutrons from a spontaneous fission source provide a cost-effective means for the characterization of neutron-detector efficiency:

- the source is positioned within a gaseous ^{4}He scintillator detector in which light and heavy fission fragments are detected;
- the fragments enable the corresponding fission neutrons detected in a NE-213 liquid-scintillator detector to be tagged;
- the resulting continuous polychromatic beam of tagged neutrons (shown for ^{252}Cf) has an energy dependence agreeing qualitatively with expectations;
- the known spectrum provides an excellent benchmark from which it will be possible to evaluate the neutron-detection efficiency (indicated by red arrows in the figure).

Studying Neutron Transmission Through Shielding Materials

- In the setup described above, steel, copper, PE and both regular and PE/B_4C-enriched concrete samples are placed directly in front of the liquid-scintillator detector;
- the measured transmission spectra of tagged neutrons through the various materials is shown to the right;
- from time-of-flight information and comparison to reference measurements the energy-differential neutron absorption of the material can be determined;
- the data were found to agree well with GEANT4 simulations [6].



Further Information and References

[1] Francesco Piscitelli et al. "The Multi-Blade Boron-10-based Neutron Detector for high intensity Neutron Reflectometry at ESS". In: *JINST* 12 (2017), P03013.

[2] F. Issa et al. "Characterization of Thermal Neutron Beam Monitors". In: (submitted to journal).

[3] J. Scherzinger et al. "The light-yield response of a NE-213 liquid-scintillator detector measured using 2–6 MeV tagged neutrons". In: *NIM A* 840 (2016), pp. 121–127.

[4] Julius Scherzinger et al. "A comparison of untagged gamma-ray and tagged-neutron yields from ^{241}AmBe and ^{238}PuBe sources". In: *Applied Radiation and Isotopes* (submitted).

[5] Julius Scherzinger et al. "Tagging fast neutrons from a ^{252}Cf fission-fragment source". In: *Applied Radiation and Isotopes* (submitted).

[6] Douglas DiJulio et al. "A Polyethylene-B4C based concrete for enhanced neutron shielding at neutron research facilities". In: *NIM A* (submitted).