brightness

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Tagging Neutrons at the Source Testing Facility

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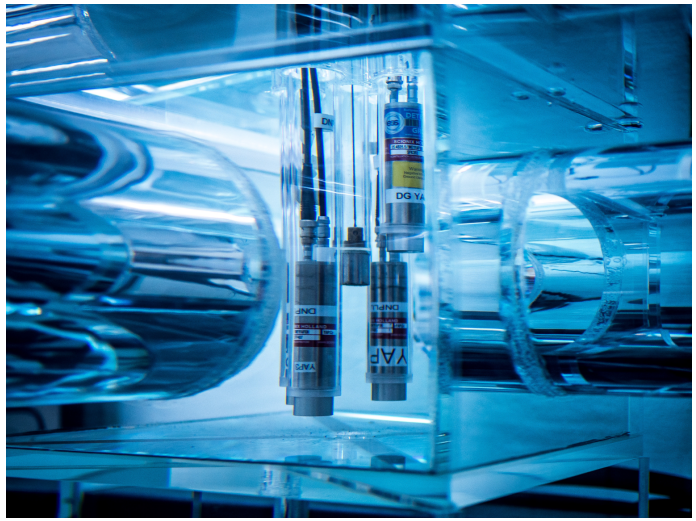


Overview

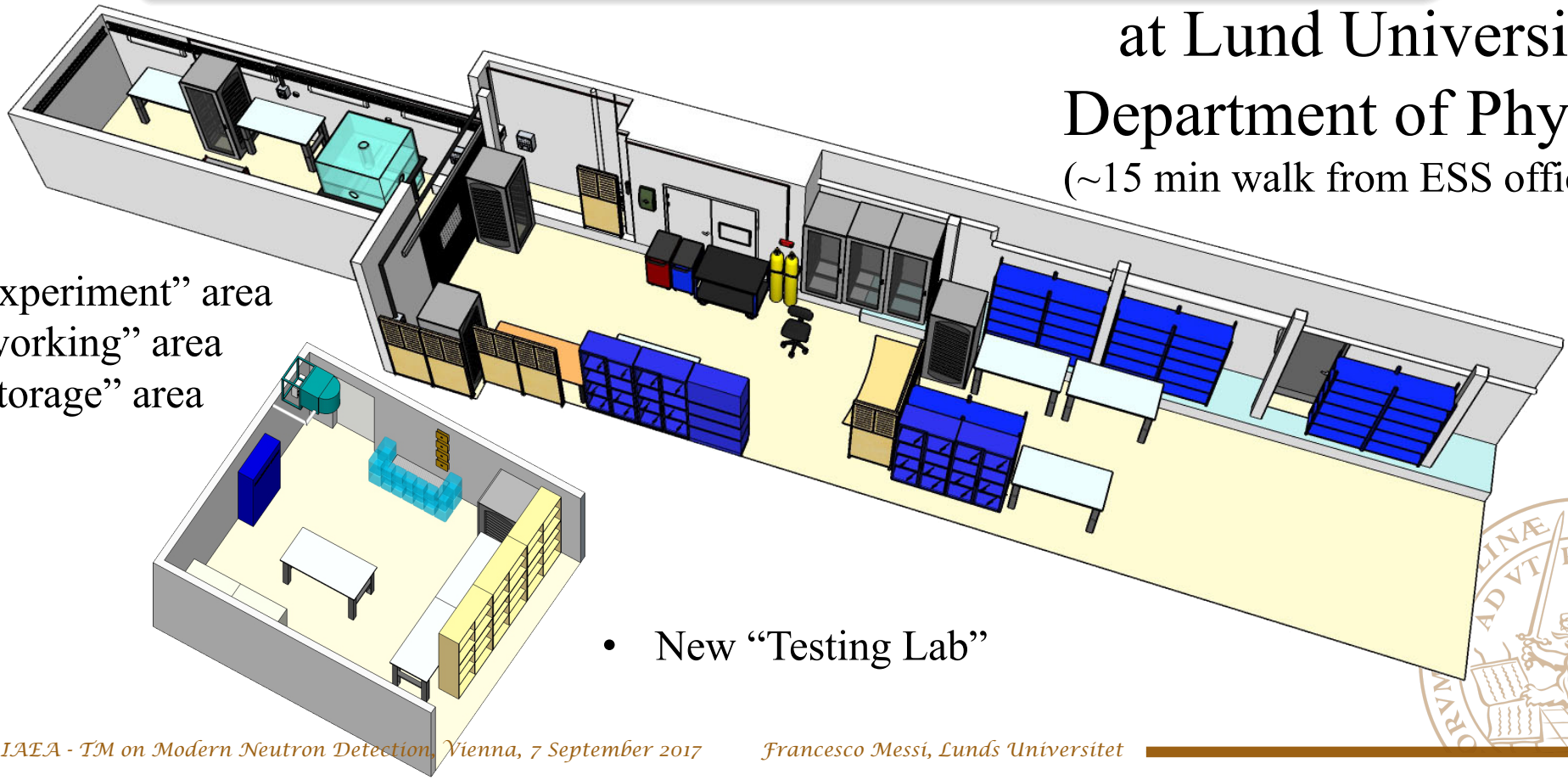
- The Source Testing Facility (STF)
- Tagging technique
- Planned upgrade
- Example of usage

The Source-Testing Facility

Aim of the Source Testing Facility (STF):

Provide neutrons for tests of prototypes and final instruments for ESS and in-kind partners in Lund

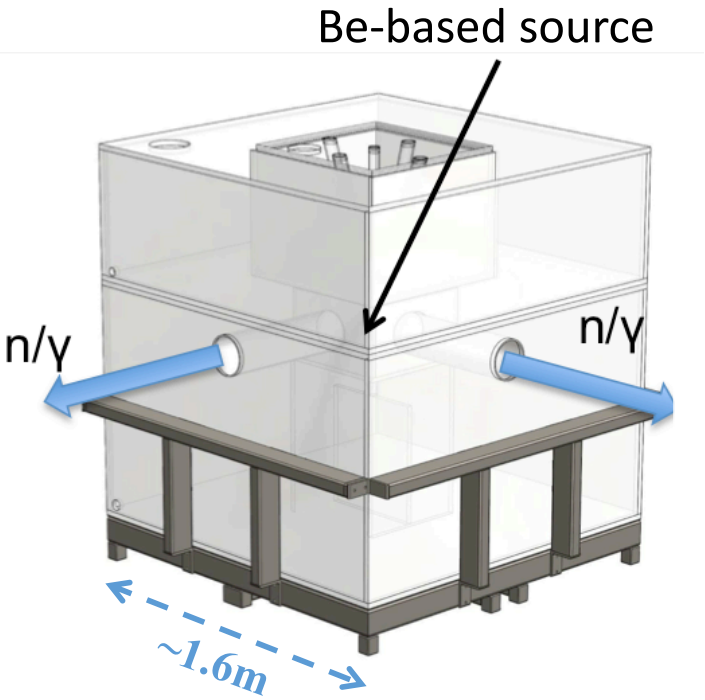
at Lund University
Department of Physics
(~15 min walk from ESS offices)



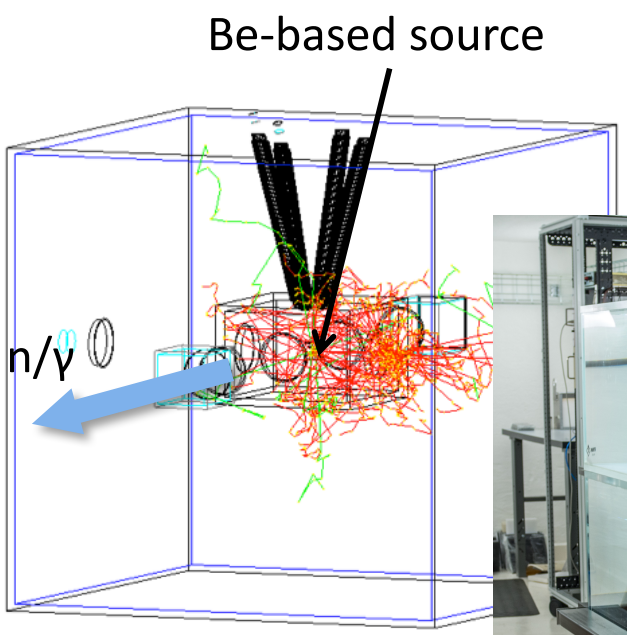
- "experiment" area
- "working" area
- "storage" area

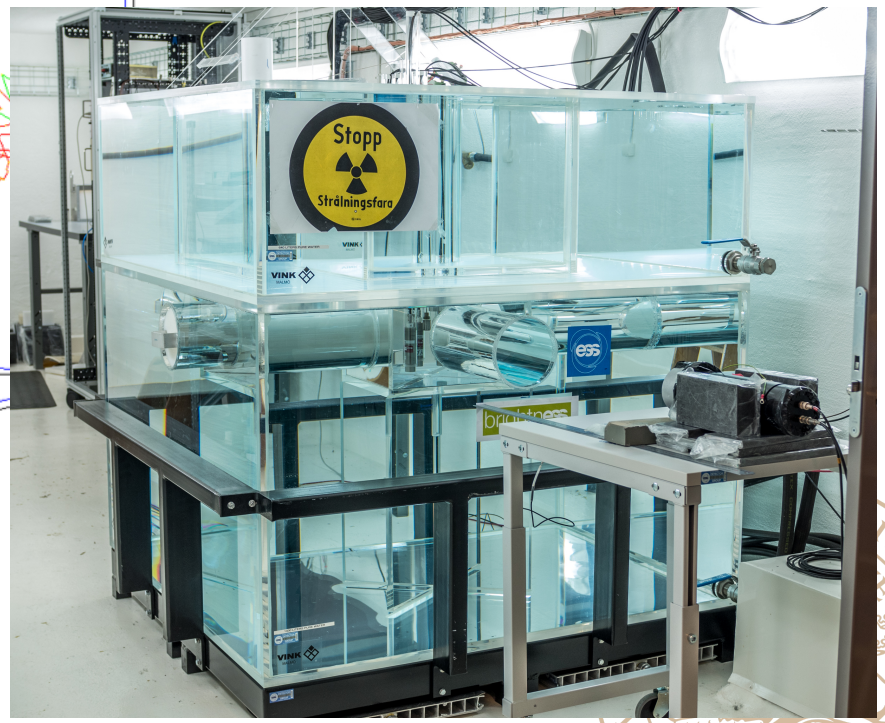
- New "Testing Lab"

The Source-Testing Facility



The Aquarium



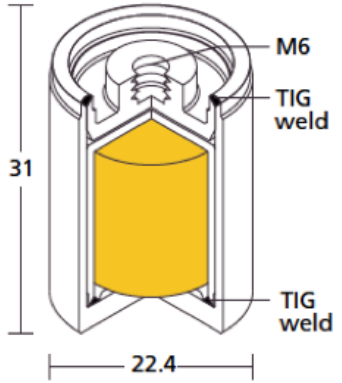


<0.5 μSv/h exterior surface dose

The Source-Testing Facility

- Use of radiative sources:
  - One-time investment!
  - Available round the clock! (no babysitting)
  - Provides fast neutrons (*1…11 MeV*)
    - Neutrons can be moderated/thermalized

- Difficult to increase/control rates
- Broad energy spectrum
- Mixed gamma/neutron fields



Tagging Neutrons

Broad energy spectrum → Energy response of the detector

Mixed γ / *n* fields → TAGGING

Tagging = assign a time and an energy to the neutron!

↳ "physics chopper"

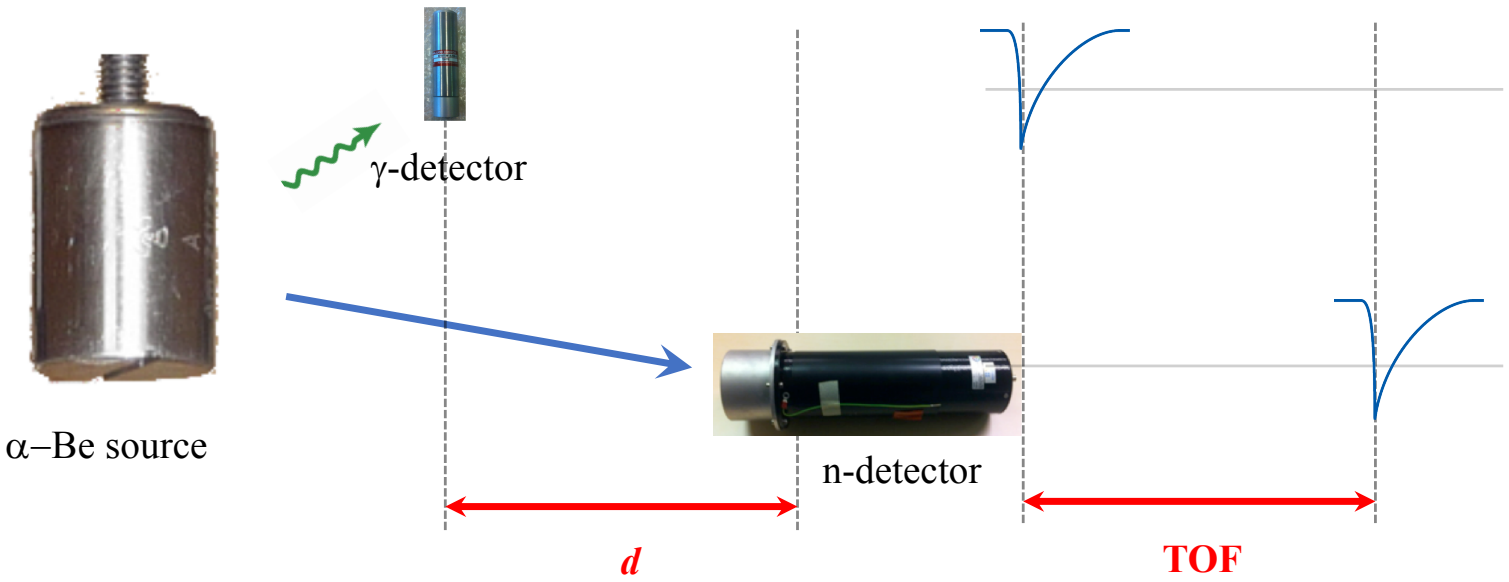
Event_by_Event

Tagging Neutrons

How can we tag our neutrons?

$$\alpha + {}^{9}Be \rightarrow n + {}^{12}C^{*} \quad (BR = \sim 55\%)$$

$${}^{12}C^{*} \rightarrow {}^{12}C + \gamma\ (4.4\,MeV)$$

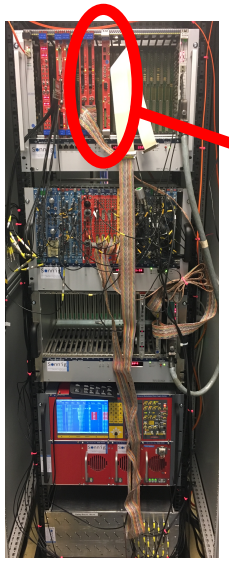


$$T_n = \frac{1}{2} m_n \left(\frac{d}{TOF}\right)^2$$

Tagging Fast Neutrons

- Actual setup:
  - Analogue modules (VME + NIM, very good for didactic)
  - Needed of “analogue gates” and delay lines
  - Long cables for delay lines *(~ 50/60 m* of RG58)

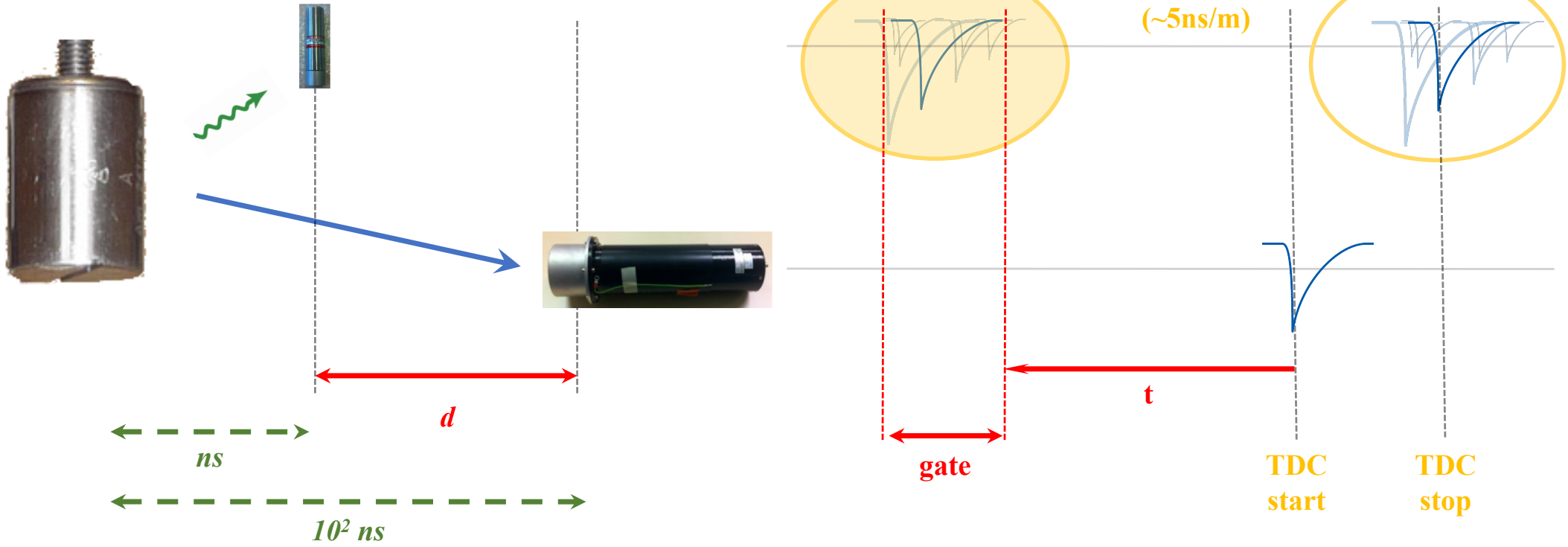
I generation



II generation

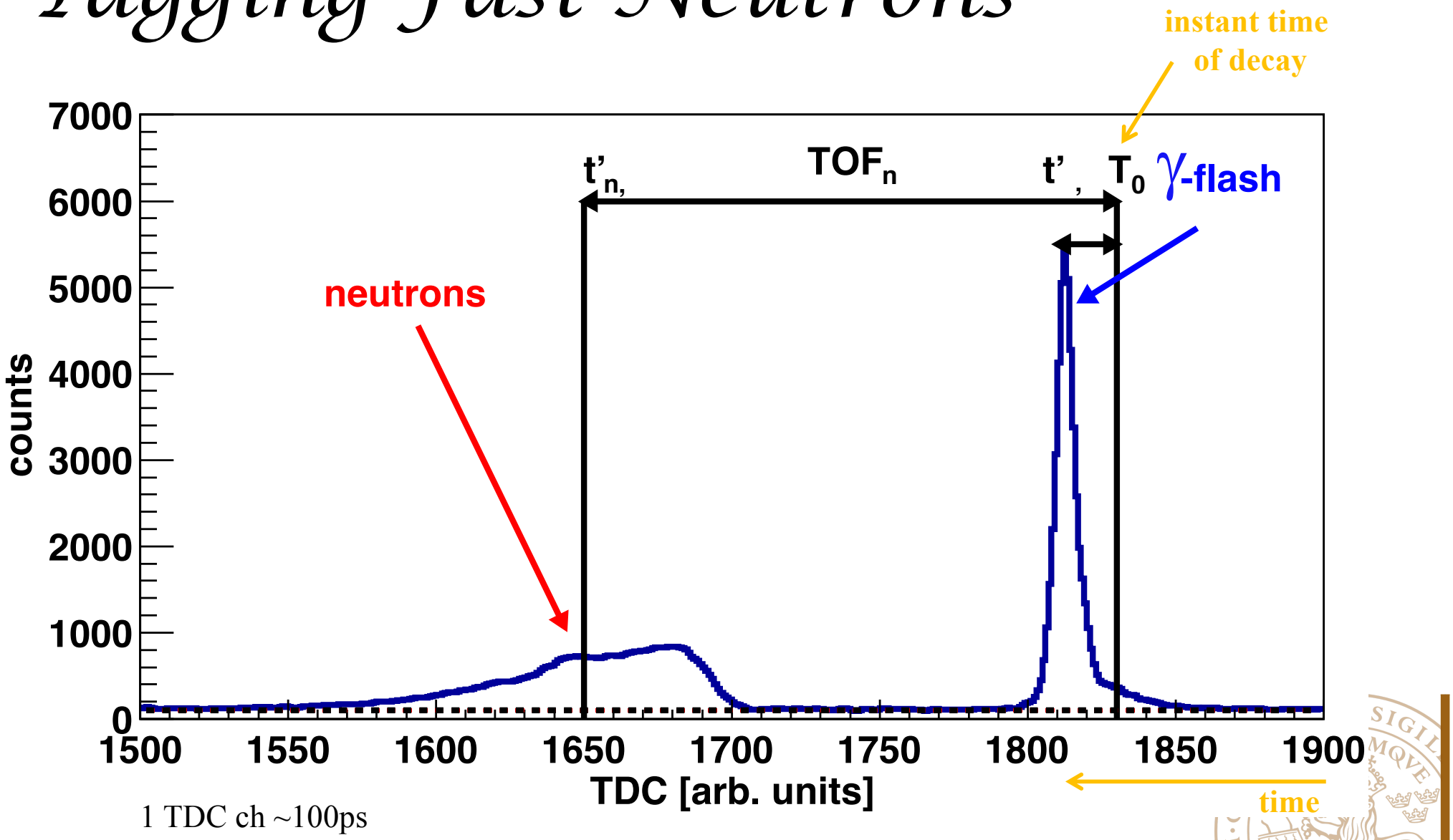
III generation

Tagging Fast Neutrons



Not possible to go "back in time" with an "analogue setup"
use ~*50 m* of cables (RG58) to delay the "gamma signal"

Tagging Fast Neutrons



1 TDC ch ~100ps

Picture from J. Scherzinger, PhD thesis: "Neutron Irradiation Techniques", 2016

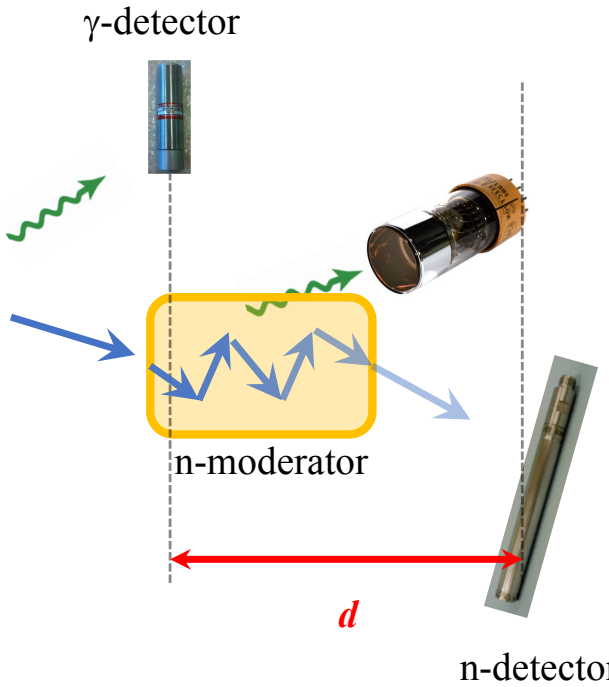
Tagging Fast Neutrons

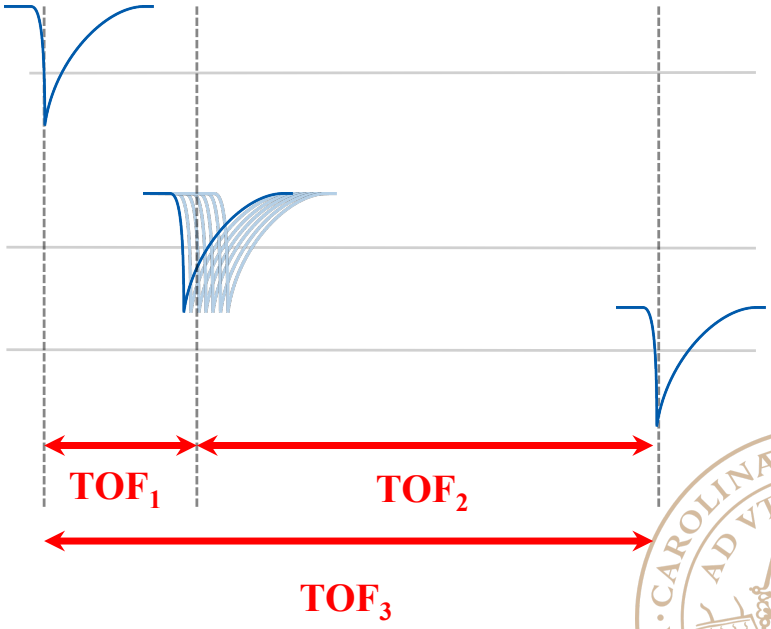
- Excellent results with Fast Neutrons:
  - J. Scherzinger et al., "Tagging fast neutrons from an 241Am/9Be source", App. Rad. and Iso., 98 (2015) 74-79
  - R. Jebali et al., "A First Comparison of the responses of a 4He-based fast-neutron detector and a NE-213 liquid-scintillator reference detector", Nucl. Inst. and Meth. A, 794 (2015) 102-108.
  - J. Scherzinger et al., "The light-yield response of a NE-213 liquid- scintillator detector measured using 2 - 6 MeV tagged neutron", Nucl. Inst. and Meth. A 840 (2016) 121-127.
  - J. Scherzinger et al., "A comparison of untagged gamma-ray and tagged-neutron yields from 241AmBe and 238PuBe sources", App. Rad. and Iso., 127 (2017) 98-102
  - J. Scherzinger et al., "Tagging fast neutrons from a 252Cf fission-fragment source", App. Rad. and Iso., 128 (2017) 270-274
  - D.D. DiJulio et al., "A polyethylene-B4C based concrete for enhanced neutron shielding at neutron research facilities", Nucl. Inst. and Meth. A, 859 (2017) 41–46
  - S. Koufigar, "The Radiological Footprint of a Be-based Neutron Source", Lund University, 2015
  - H. Söderhielm, "Two-Dimensional Radiation Field Map of a Be-based Source", Lund University, 2017
  - M. Meshkian, "Construction and Testing of a Liquid-Scintillator Neutron Detector Using Photoneutrons", Lund University, 2013
  - E. Rofors, "Fast Photoneutron Detection", Lund University, 2016
  - N. Mauritzson, "Design, Construction and Characterization of a Portable Fast-Neutron Detector", Lund University, 2017
  - J. Scherzinger, "A Source-Based Test-Bed for Fast-Neutron Irradiation", Lund University, 2015
  - J. Scherzinger, "Neutron Irradiation Techniques", Lund University, 2016

Can we tag Thermal Neutrons?

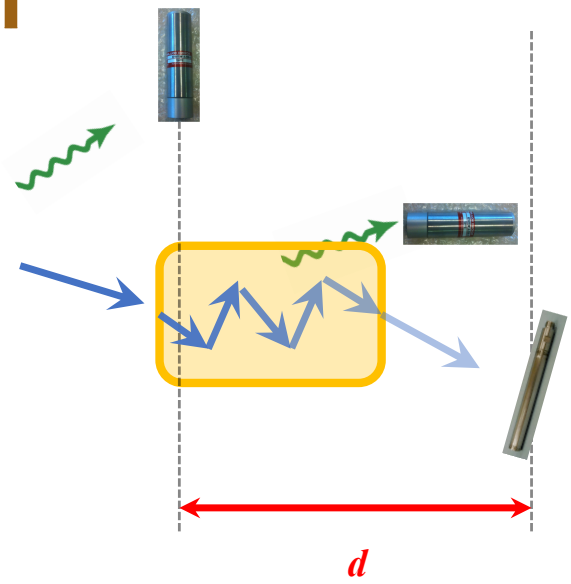
- The principle is the same, but…
  - Thermal Neutrons much slower: "analogue setup" not feasible
    - Prohibitive for cost and signal integrity
    - Huge dead-time

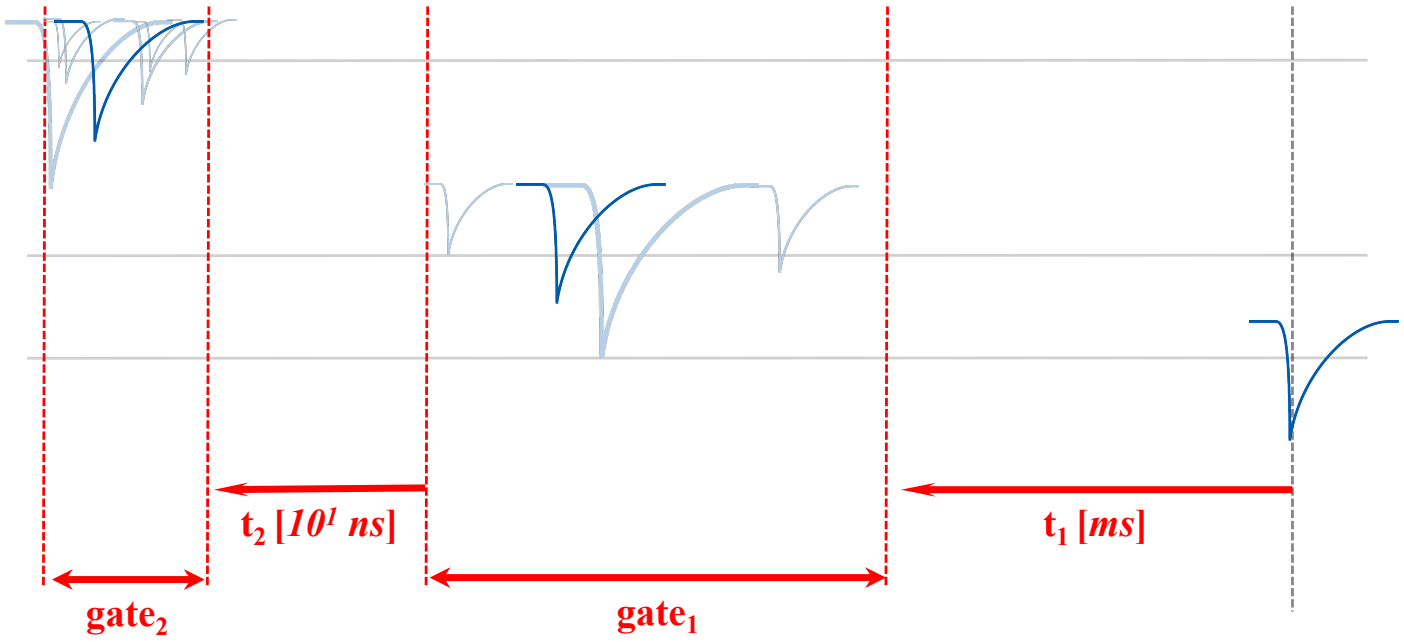
α–Be source





Can we tag Thermal Neutrons?

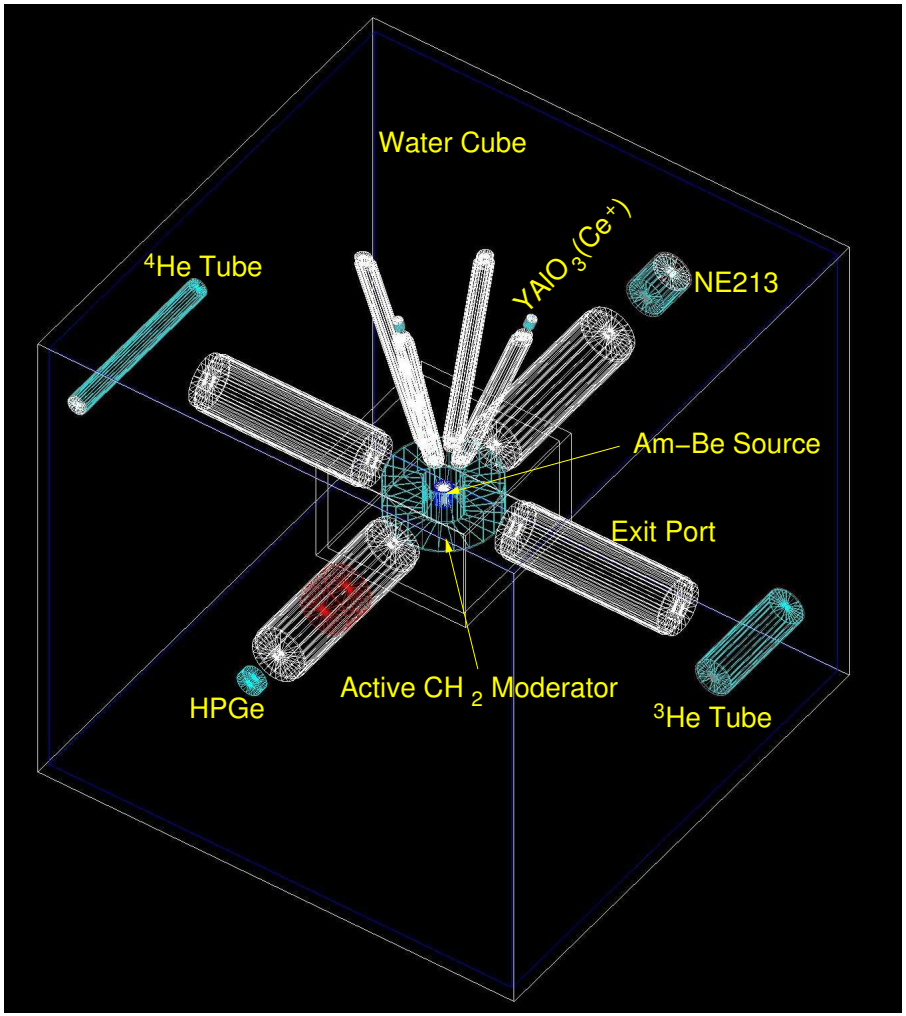


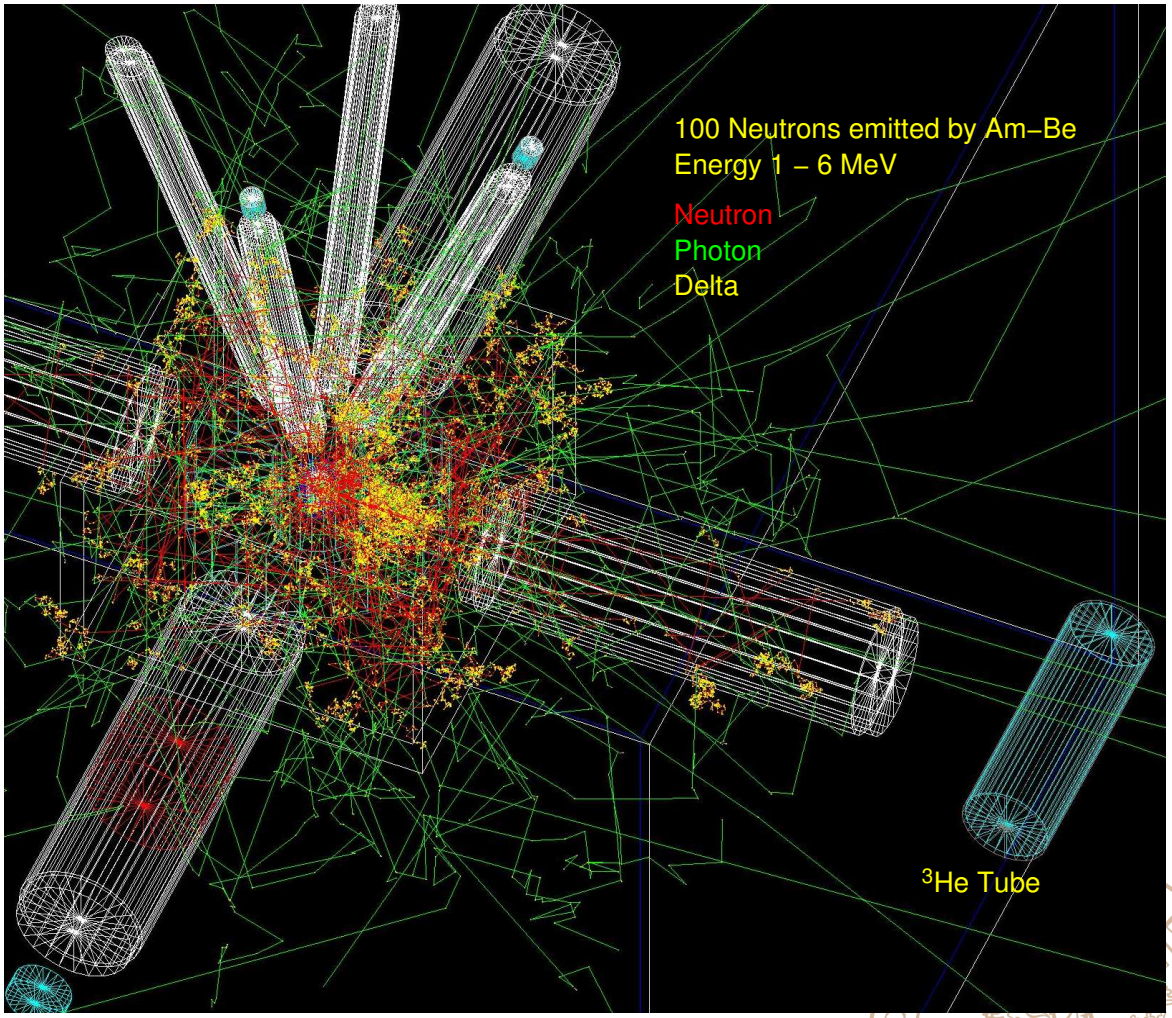


4.4 MeV γ ← compatible signature of thermalisation ← thermal **n** candidate

Would require ~*200 km* of RG58 cables with the "analogue setup" and will results in a huge dead-time

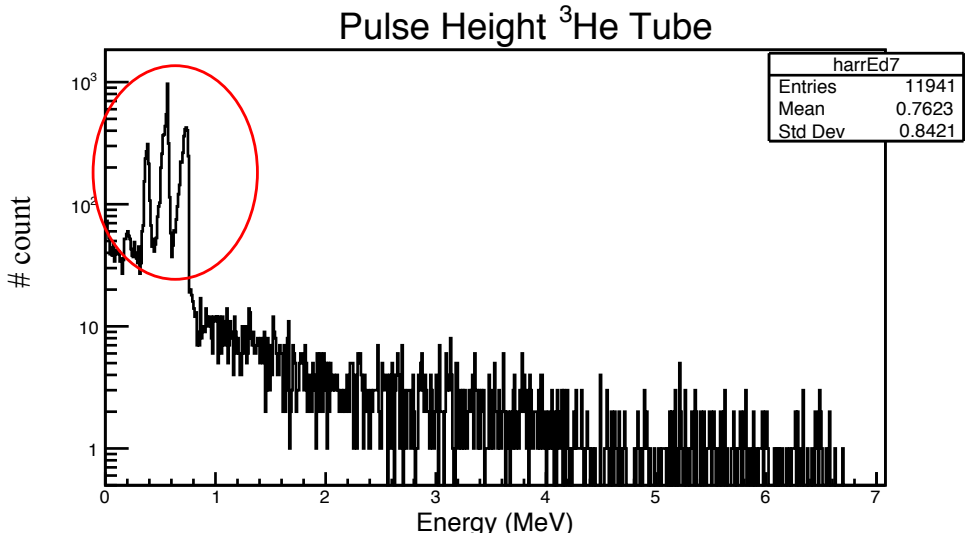
Simulation

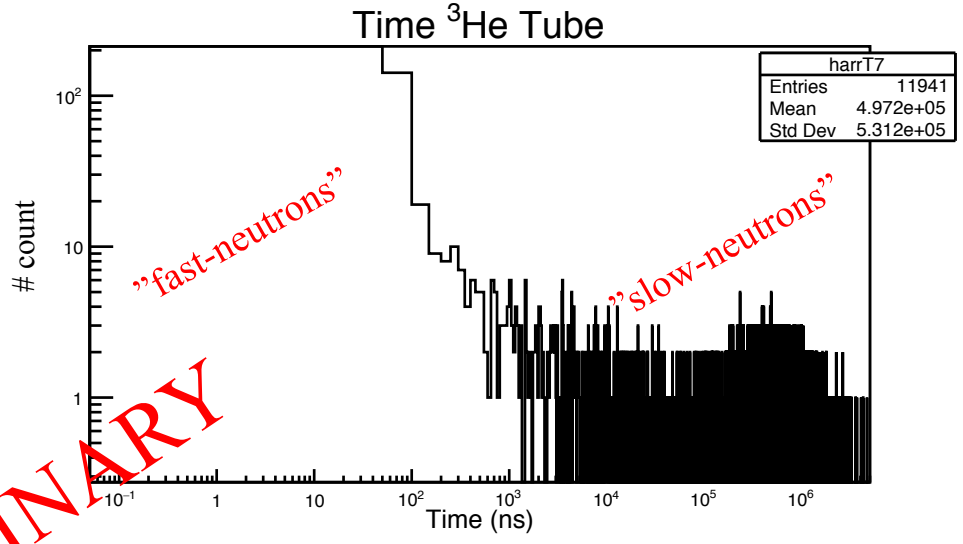




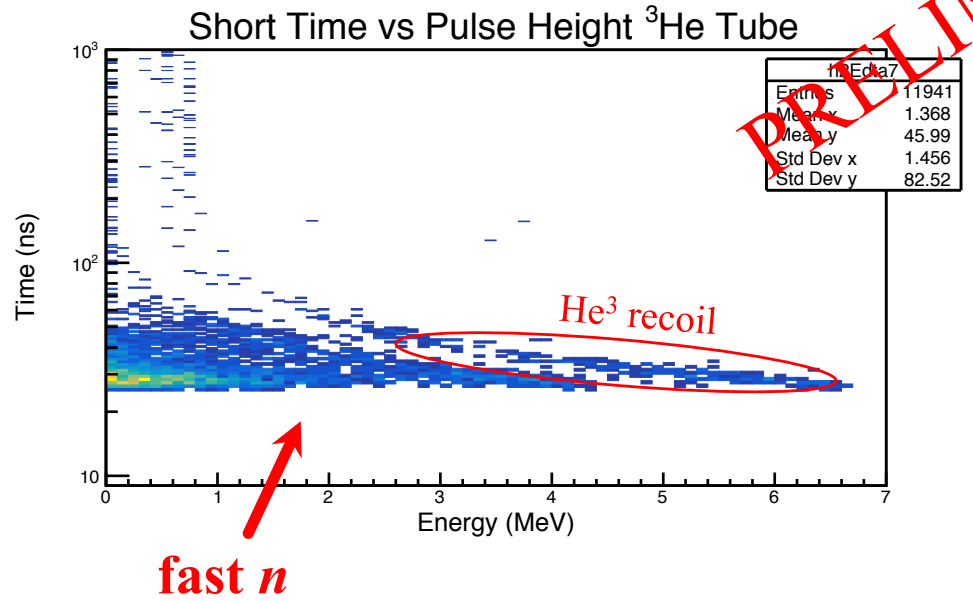
Simulation from John R.M. Annand, University of Glasgow

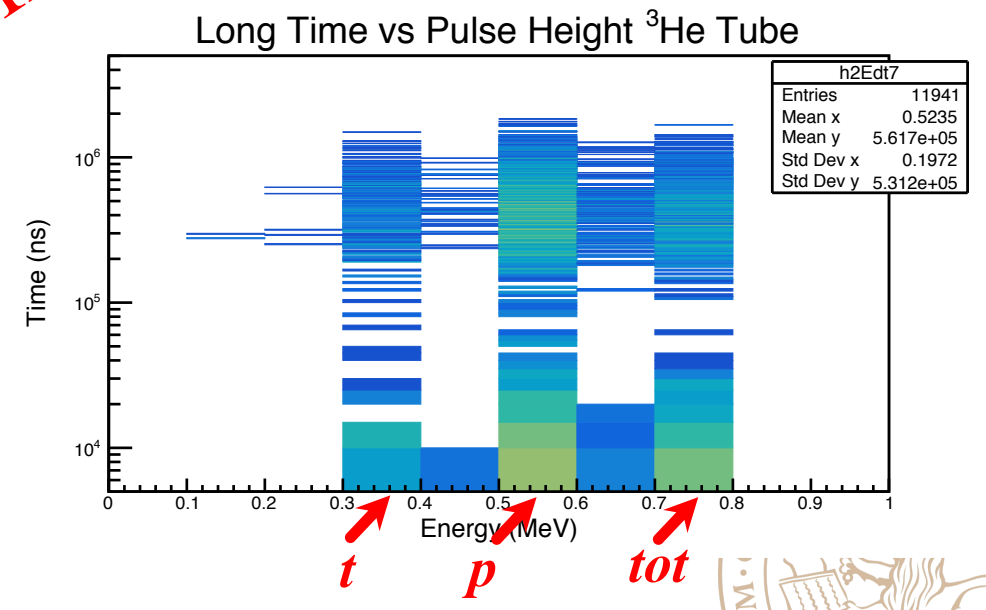
Simulation





PRELIMINARY



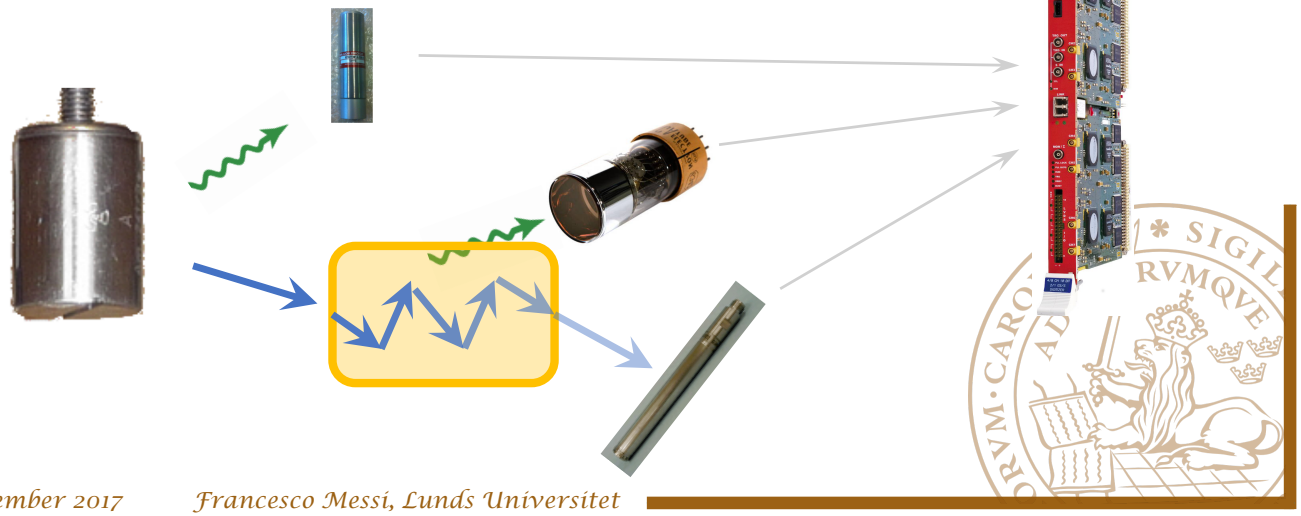


Simulation from John R.M. Annand, University of Glasgow

What do we have / need…

- Neutron source — Am-Be
- Gamma detector — YAP
- Thermal Neutron detector — He3-tube
- Digitiser set-up — VX1751
- Active moderator — Oil (EJ321) /// NE-213
- …time…

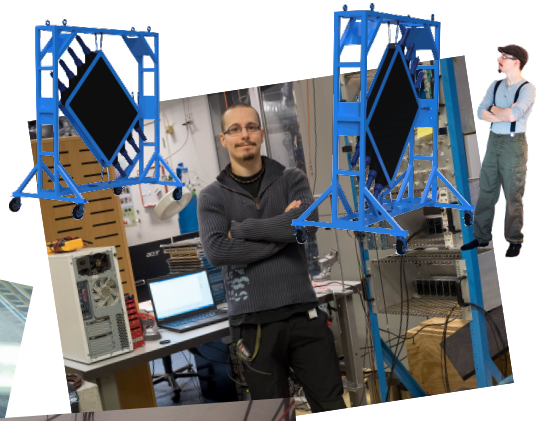
Looking for students!!!

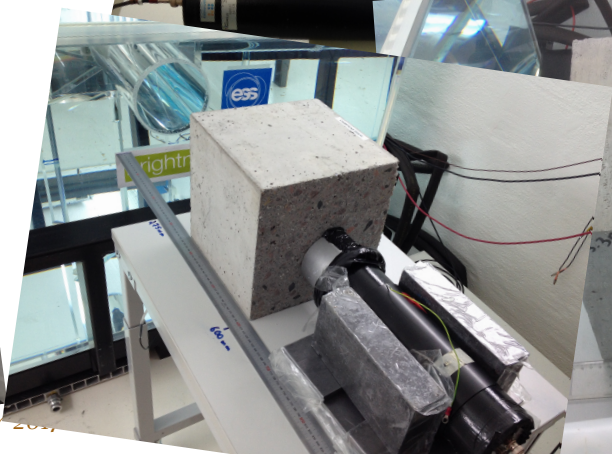


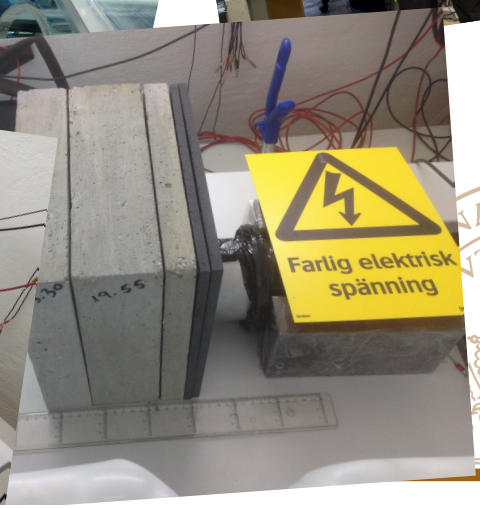
Looking forward to the next upgrade!!!

In the mean time…

Example of usage



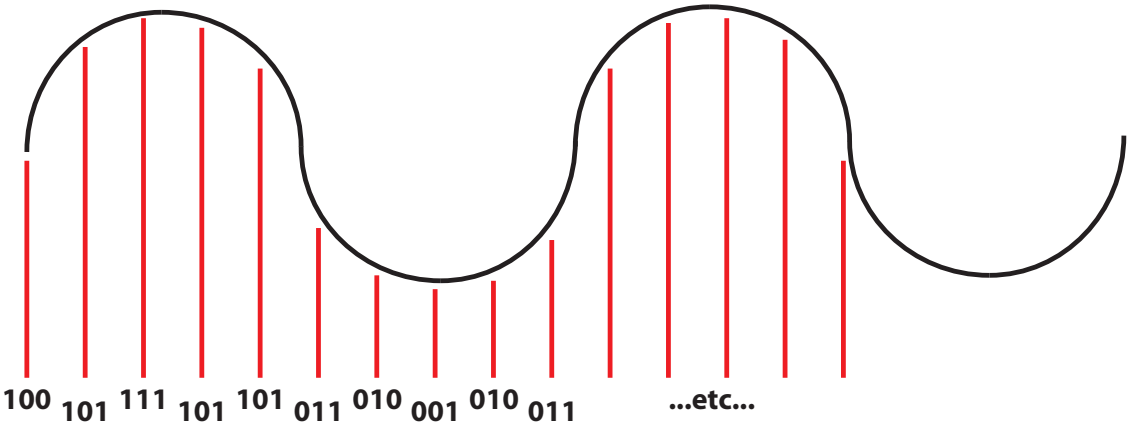




The Source-Testing Facility

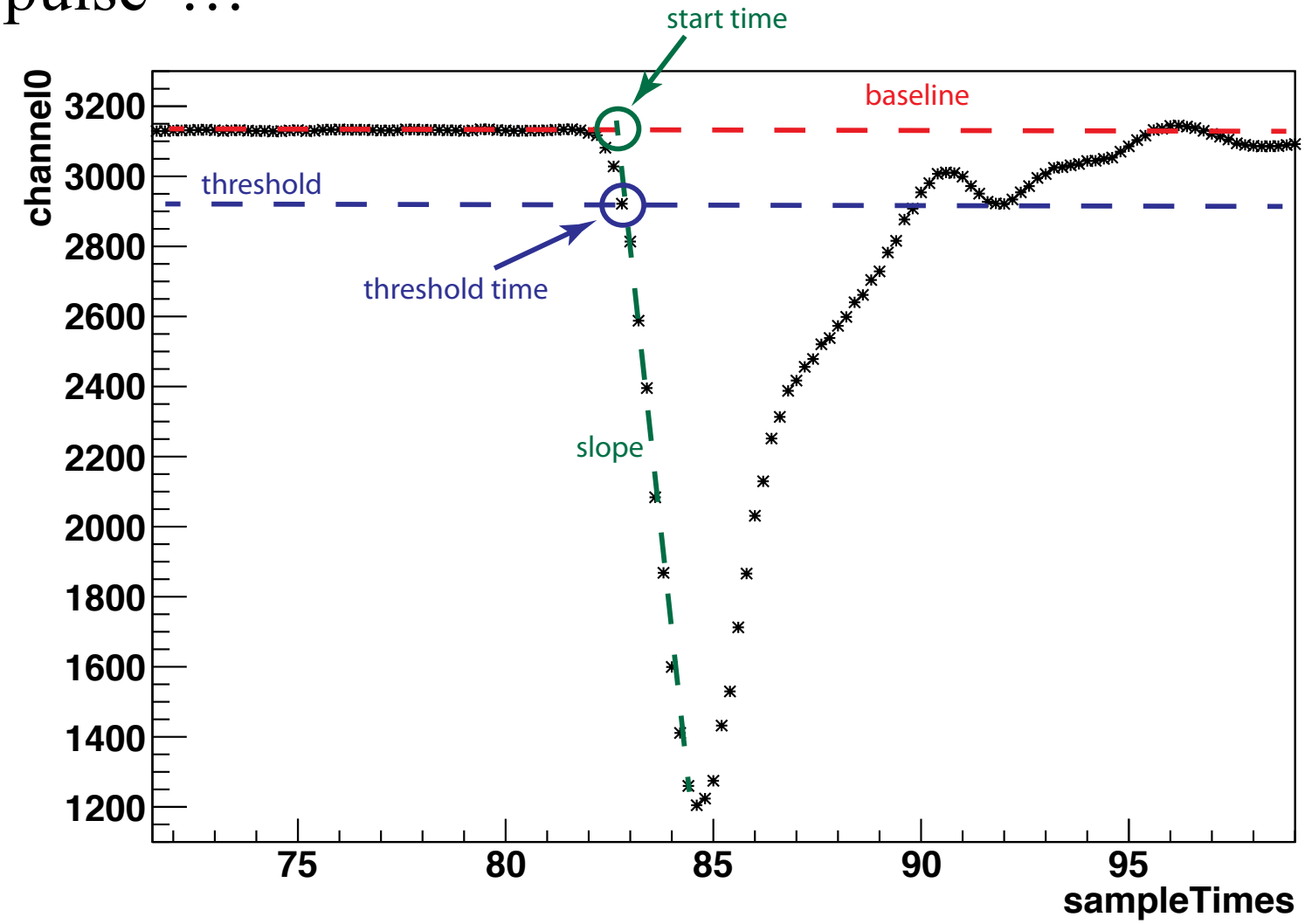
Using digitisers

- How does it work
  - Continuous sampling of the analogue signal (sADC)
  - Digital representation



Using digitisers

- On a “real pulse”…



OFF-LINE

Using digitisers

- Nice! But…

Only a representation of the analogue signal

CLK deepness compatible with rate

Needed of considerable computing power

Needed of huge data storage