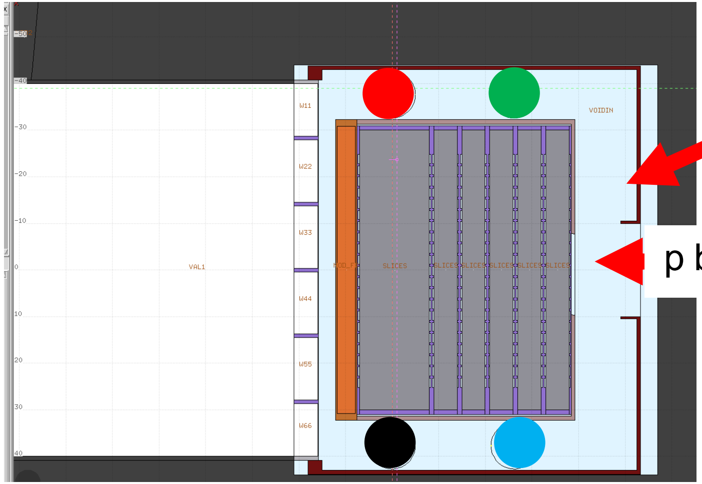
Neutron flux monitoring on Target #3 with Self Powered Detectors

n_TOF Italia - March 26, 2021

S. Fiore

Expected neutron flux on n_TOF target#3

- **integral flux 10^{11} n/cm^{2}s**
- slight differences between possible positions



p beam

FLUKA simulations by Lucianna (2018)
New simulations ready, TBD with Massimo

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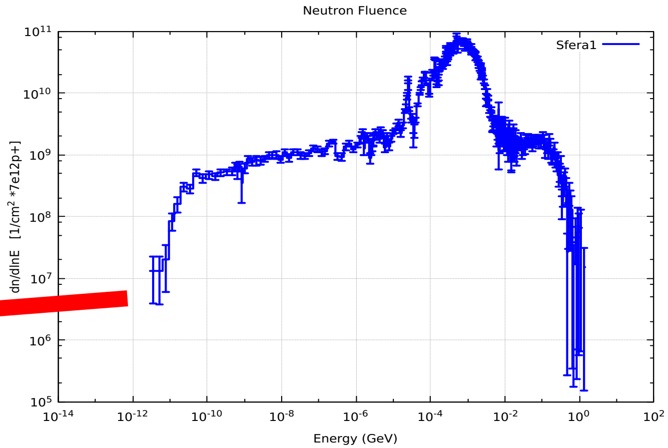

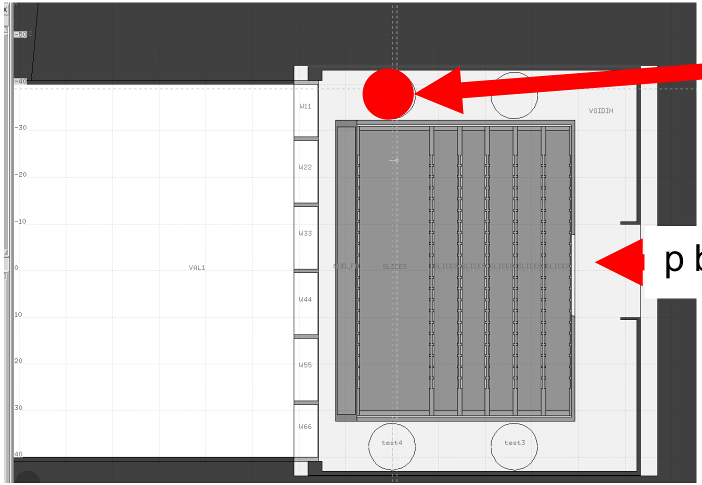

p beam

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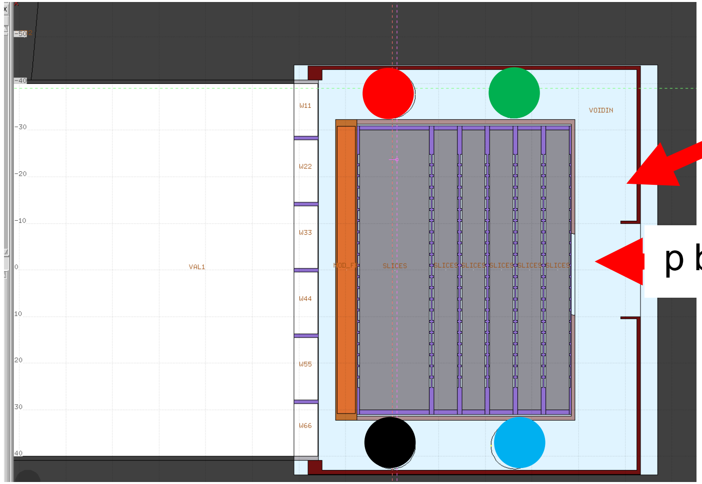
Expected gamma flux on n_TOF target#3

gamma flux one order of magnitude lower

mainly 100 keV-10 MeV

four scoring positions



p beam

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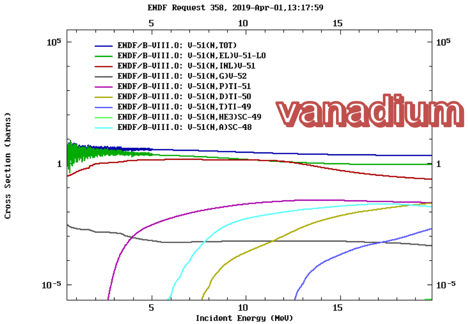
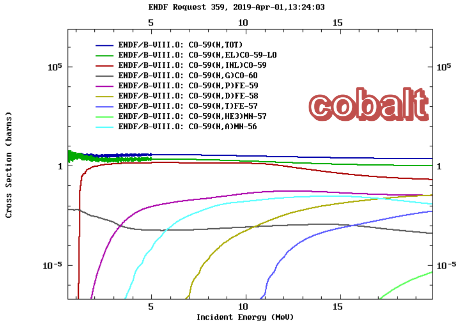
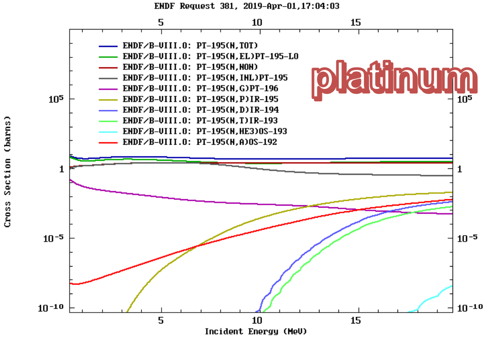
Materials for SPNDs at n_TOF

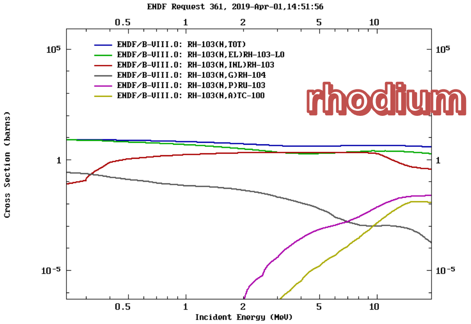
Short **half life** of the daughter nuclei for delayed SPNDs

Predominant (n,gamma) cross section for prompt SPNDs





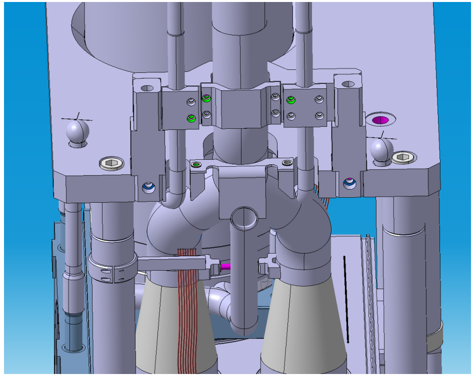


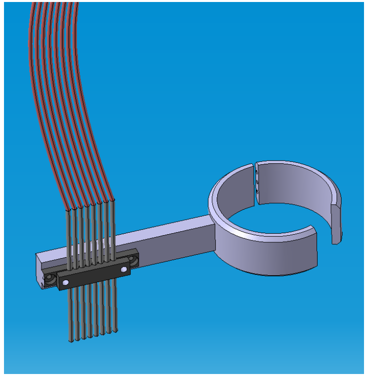


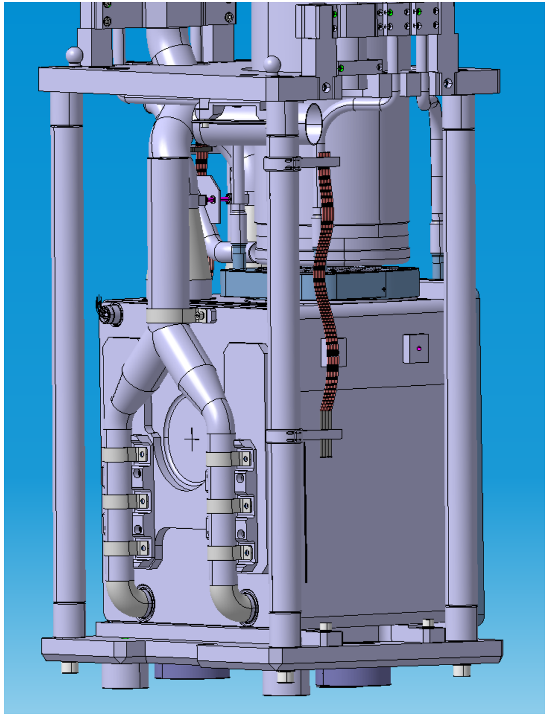
Detectors setup on target container

Given the outcome of the simulations, and integration constraints, two positions on the target have been chosen:

- on both sides of the target vessel
- on the beam horizontal plane
- detectors held by supports
- mineral cables used on target



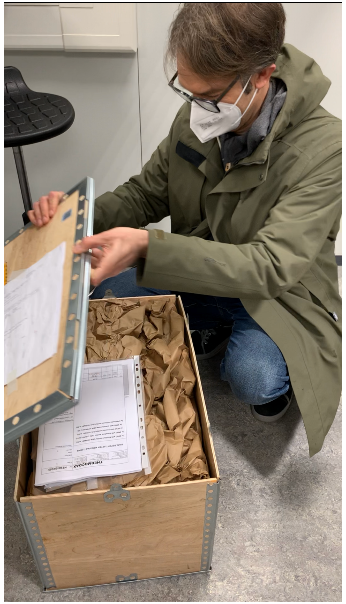


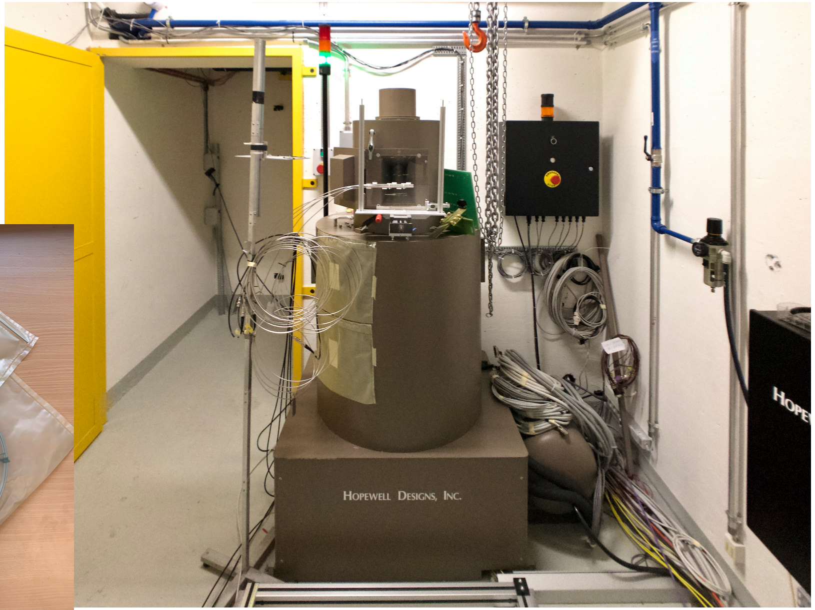


SPNDs preliminary tests

SPNDs arrived at CERN on March 15, just before the target is moved to the pit

Quick functionality test at CC60 Cobalt source and short dose rate range calibration





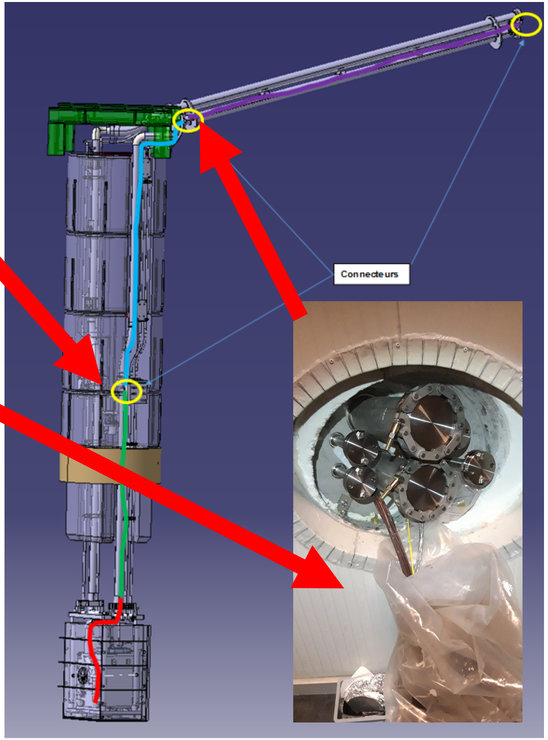
SPNDs are on on Target#3

After the Co tests, SPNDs have been installed on the designed positions on March 18

Two sets of 5 different emitter materials, data cross-check between two identical ones

Next steps

- connection to standard coaxial cables on top of the first cooling pipes section to be performed by SY-STI group during installation
- coaxial cables already in position: will be unrolled during target installation



- Integration of the DAQ in NXCALS in collaboration with BE-CEM-MRO (Jerome Lendaro, Mario Di castro)

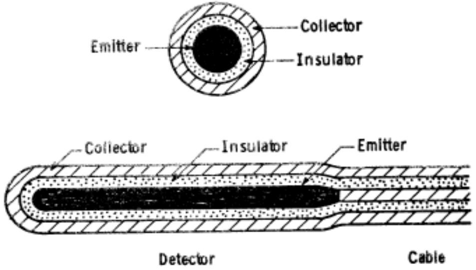
Thank you

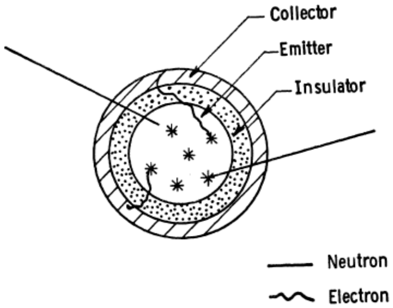
Self Powered Neutron Detectors for Fast Neutrons

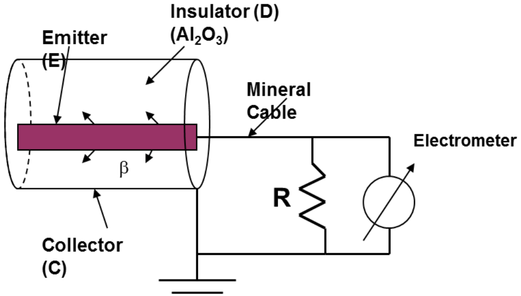
Self Powered (Neutron) Detectors (SPNDs) are **rugged miniature** devices, commonly used for **fixed in-core reactor monitoring** both for safety purposes and neutron and gamma flux mapping.

operate **without any bias voltage**

usually constructed in a **coaxial configuration** with a **central emitter characteristic of each device** type. The other electrode or metallic sheath is called collector and the two are separated by a coaxial insulator. Typical **diameter is 3mm**



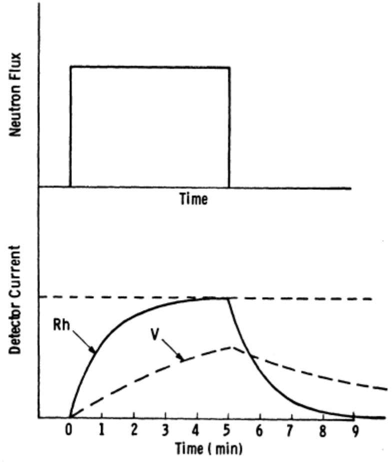




V, Co, Rh are common elements used as emitter in the thermal neutron SPNDs. Their sensitivity for fast neutron is rather low due to limited cross section of these elements. Alternative materials should be used to cover fast neutron energy range.

Contributions to signal formation

Different reactions can take place in the electrodes and the insulator, inducing a current through the emission of electrons



- (n,γ, β): the nuclei of the emitter are activated by a neutron capture and decay with β electron emission
  $\rightarrow$ **delayed** response
- (n,γ): photons from a radiative capture interact within the detector through Compton and photoelectric effect
  $\rightarrow$ **prompt** response
- (γ,e^-): external photons interact within the detector through Compton and photoelectric effect
  $\rightarrow$ **prompt** response

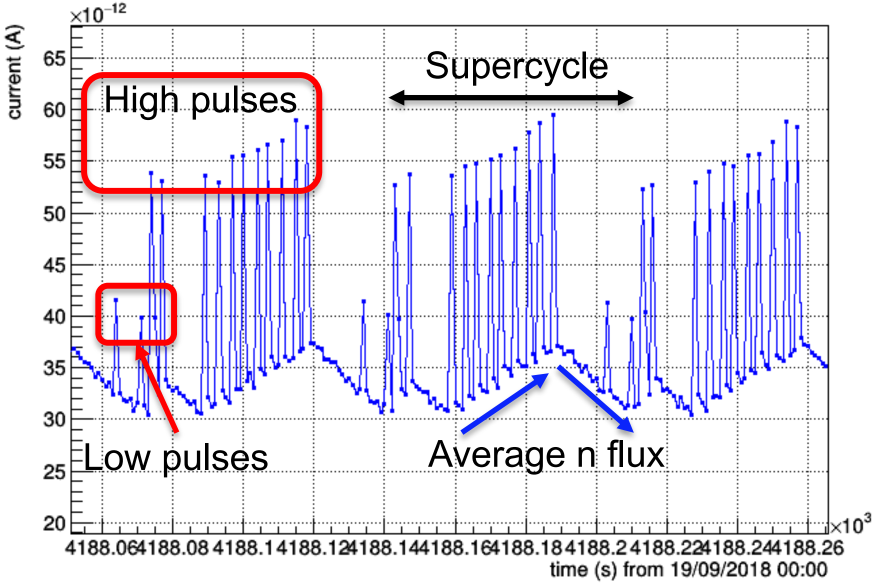
Note that electrons coming from the emitter that stop in the collector give a **positive** signal; electrons coming from the collector that stop in the emitter give a **negative** signal

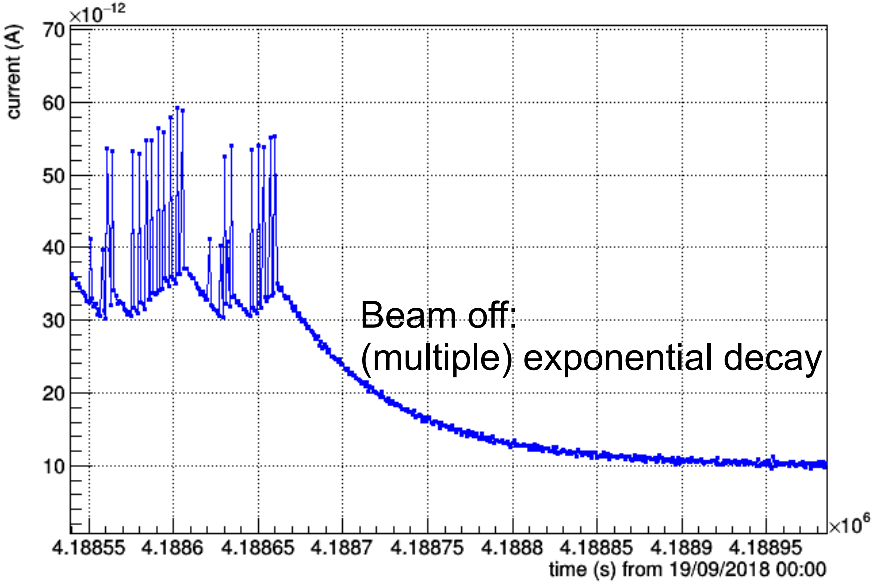
$\rightarrow$ The **net current is the algebraic sum of all the contributions**

More on SPND signal shape

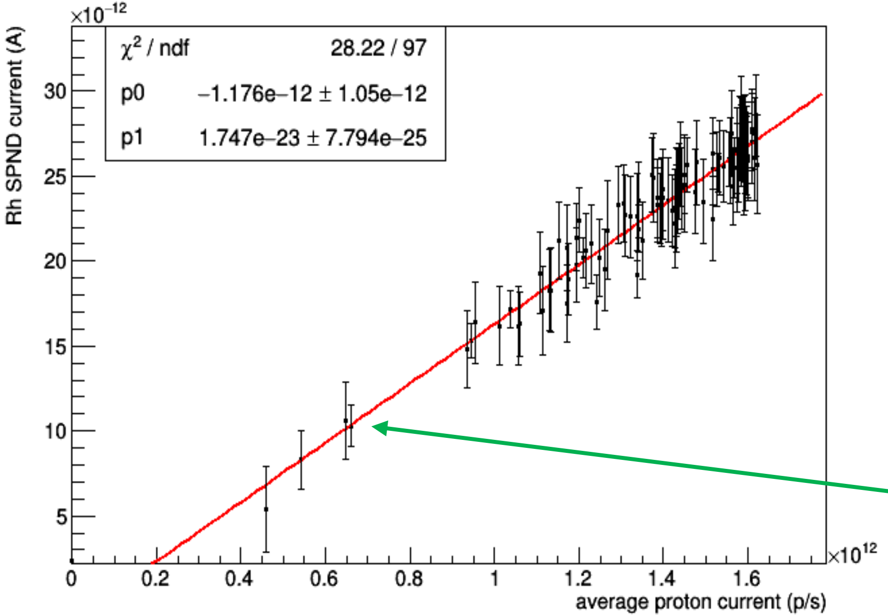
Looking in more detail the Rh, effect of the neutron production by proton pulses is clear:

SPND response has a sharp peak due to prompt target emission, proportional to pulse intensity, and a **slow drift of the baseline due to neutron activation** of the emitter



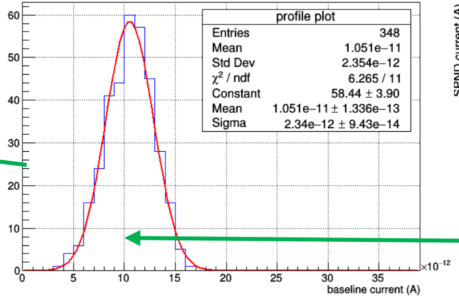


Rh SPND signal vs neutron flux

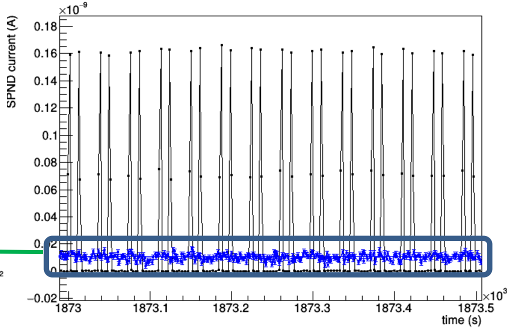


The intensity of the baseline current of Rh SPND is proportional to the average proton current on target → it's **proportional to the neutron flux** on the detector

The points sample a time window of ~49 days



profile plot is fit with gaussian function and central value is added to the linearity plot



baseline is isolated from the prompt signal

Consistent also with Warren analytical model which predicts 10^{-11} A in this flux range