A Proton Recoil Telescope for the characterisation of the neutron beam at the n_TOF facility at CERN

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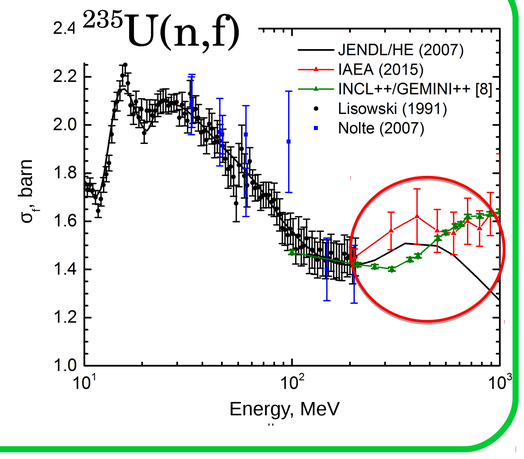
Motivation

*"...Our analysis indicates that the new absolute measurements of the neutron induced fission cross section (e.g. **relative to n-p scattering**) on Uranium, Bismuth, Lead and Plutonium have the highest priority in establishing neutron induced fission reaction standard above 200 MeV..."* (INDC(NDS)-0681 Distr. ST/J/G/NM, IAEA 2015)

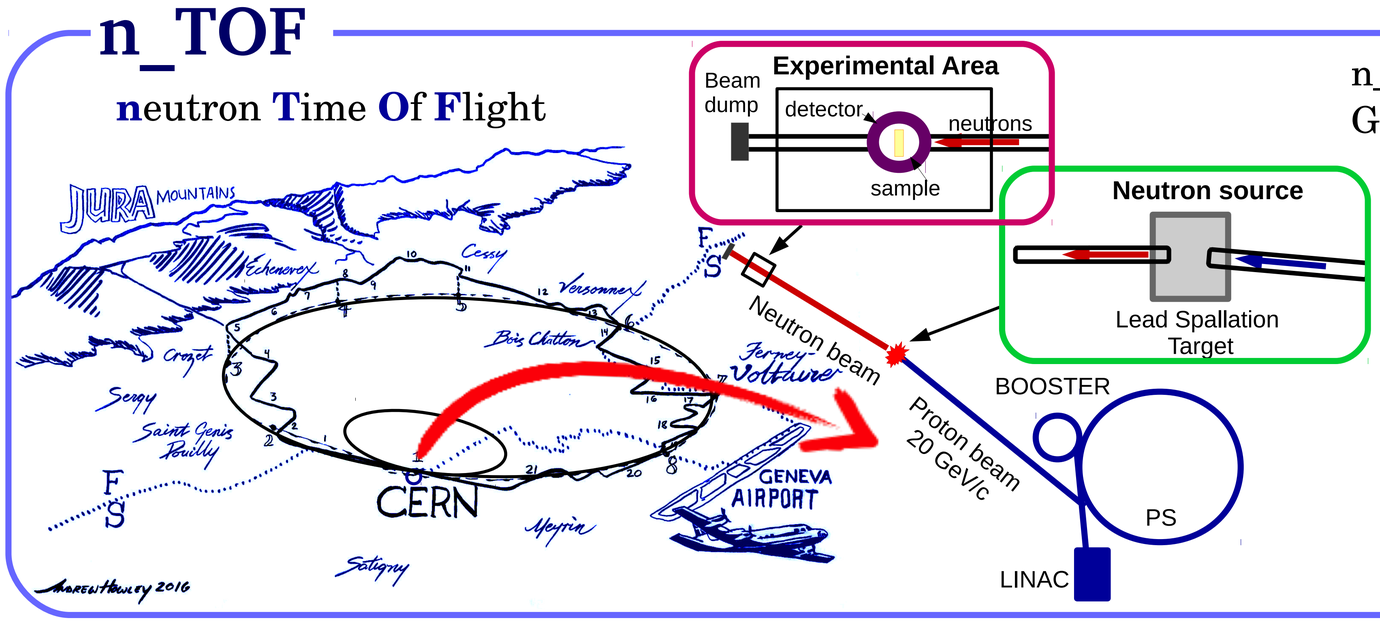
^{235}U(n,f) is one of the most significant cross-section standards at 0.025 eV and [0.15-200] MeV; but there are no experimental data above 200 MeV, despite its importance for:

- Fundamental nuclear physics
- ^{235}U samples are used for the measurement of the neutron fluence
- Effectiveness of high energy neutrons in experimental components and biological tissues
- Nuclear technology: ADS and waste trasmutation
- r-process nucleosynthesis



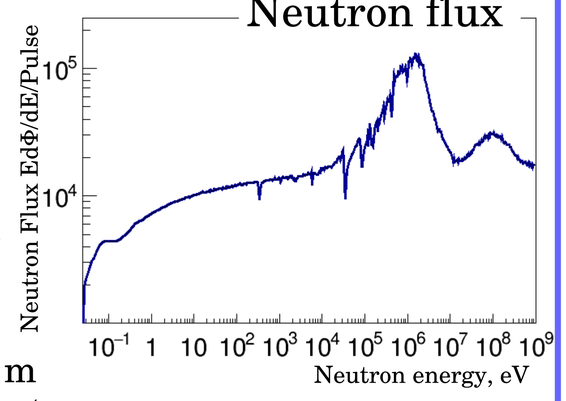
n_TOF

neutron **T**ime **O**f **F**light



n_TOF is a spallation neutron source based on the 20 GeV/c protons impinging on a Pb block.

- Wide energy range: 25 meV – 1 GeV
- High instantaneous neutron flux: 10^5 n/cm^2/pulse
- High energy resolution (185 m flight path): $\Delta E/E \sim 10^{-5}$-10^{-4}



n-p scattering detector

$n + p \rightarrow n + p$

Hydrogen is a perfect target but its density is too low
→ a Polyethylene target has to be used

$n + C_2H_4$ →
- $n + p$ elastic + inelastic — **From n+H**
- $^{9}Be + \alpha$
- $^{11}B + d$
- $^{12}B + p$
- $^{10}B + t$
- ...

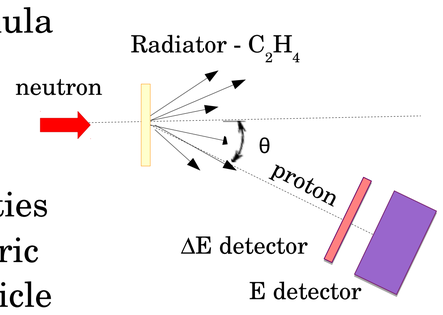
From n+C = Bkg

A Proton Recoil Telescope can discriminate the different emitted particles

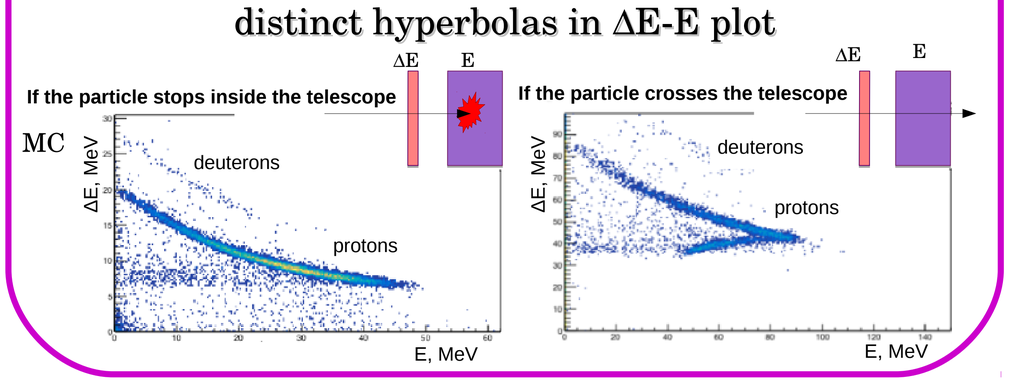
From the stopping power formula for charged particle:

$$\Delta E \cdot E \propto k \cdot z^2 \cdot M$$

k: material absorption properties
M, E, z: mass, energy and electric charge of the interacting particle

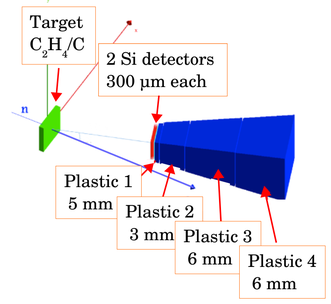


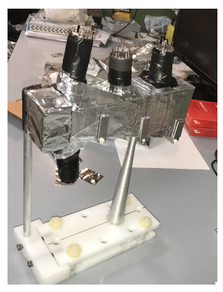
Particles with different z and M produce distinct hyperbolas in ΔE-E plot



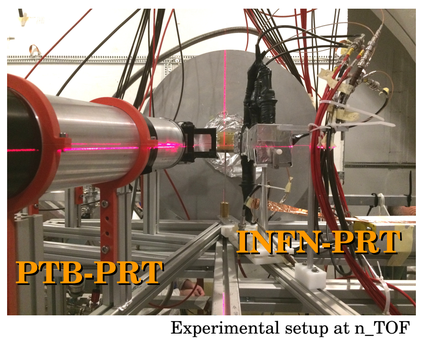
Test

The **INFN-PRT** is composed by 6 layers: 2 Silicon Detectors and 4 Plastic Scintillators





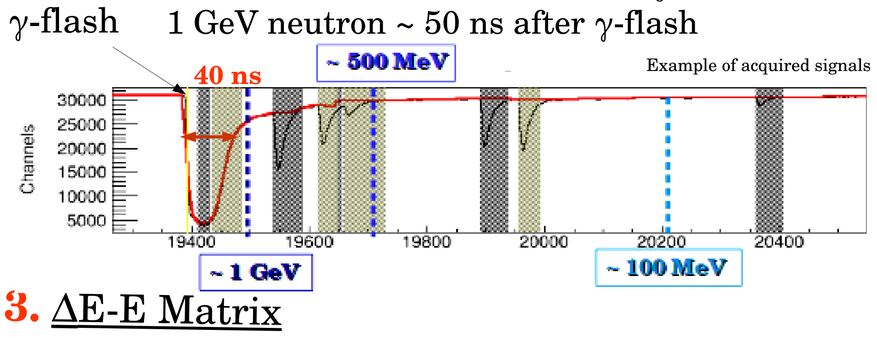
Second PRT (from PTB*) to cover full energy range
*https://www.ptb.de/cms/



Experimental setup at n_TOF

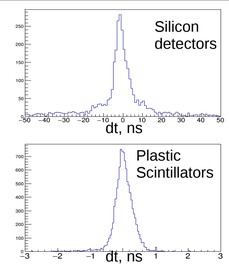
1. The recovery time after γ-flash (t_0)

γ-flash — 1 GeV neutron ~ 50 ns after γ-flash



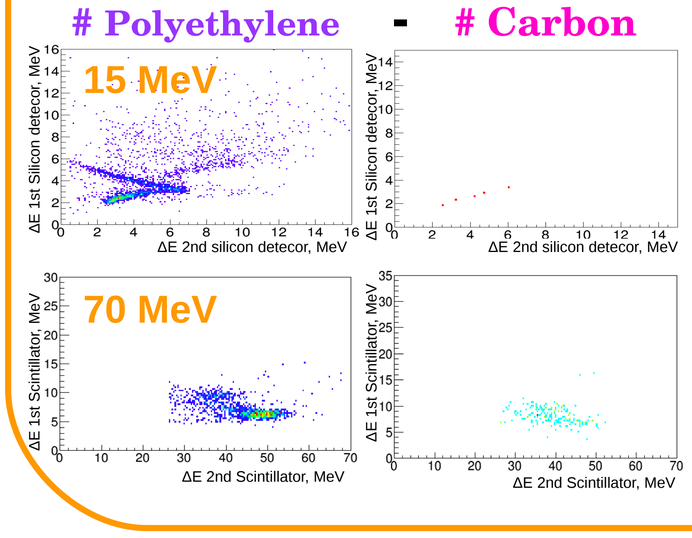
2. Signals time difference

Time difference distribution of events in coincidence in two adjacent detectors

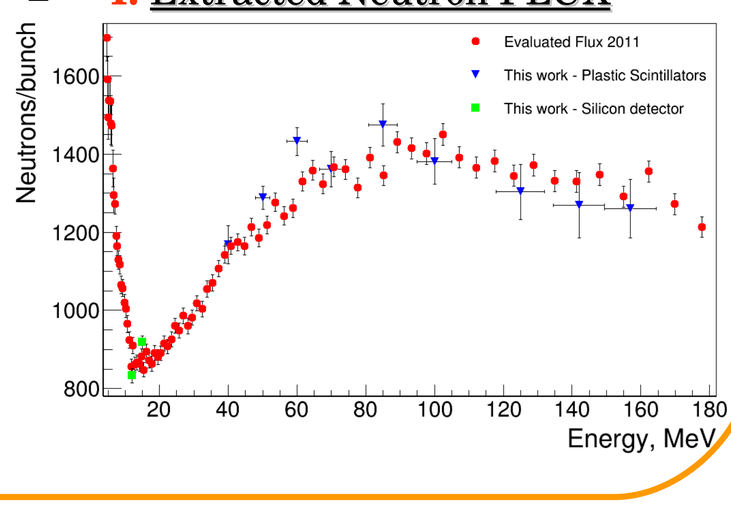


3. ΔE-E Matrix

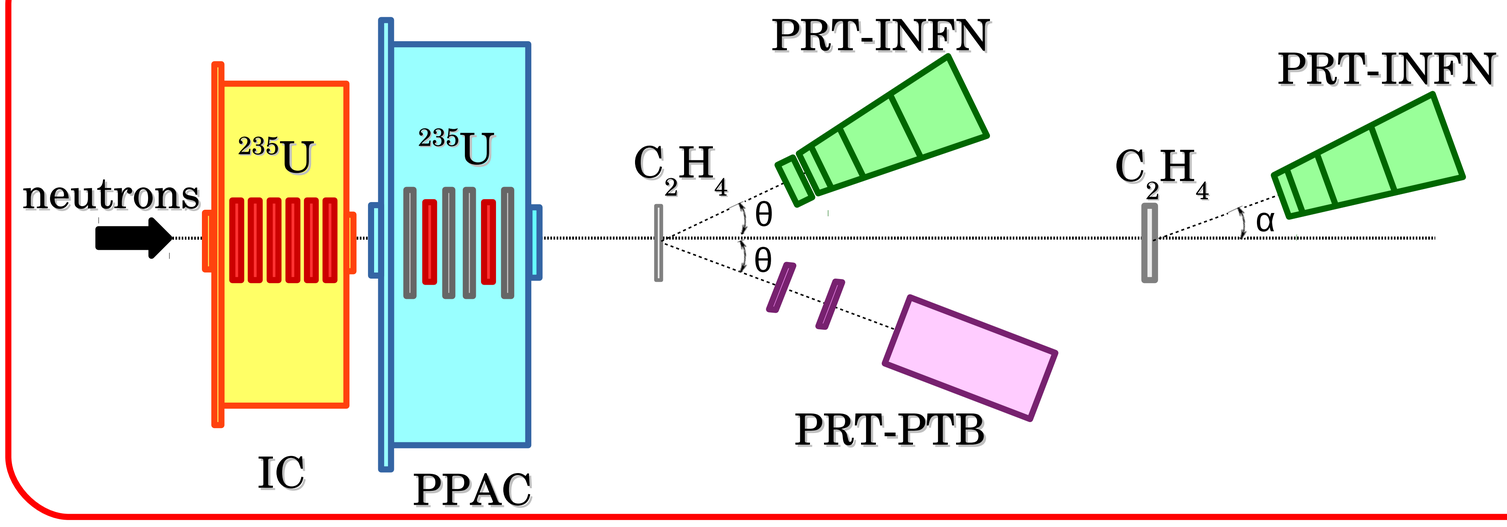
 # Polyethylene - # Carbon



= 4. Extracted Neutron FLUX



Final experimental setup



The measurement of fission cross section of ^{235}U at n_TOF will start on September 17th.

The final confuguration, decided after the PRT test, is:

- 2 Fission chambers:
  - 1 Ionization – IC
  - 1 Avalanche – PPAC
- 3 Telescopes – for n-p scattering:
  - 2 pointing at a thin target
  - 1 pointing at the thick target