Measurement of the ^{235}U(n,f) cross section relative to n-p scattering up to 1 GeV at n_TOF

A. Manna on behalf of the n_TOF Collaboration

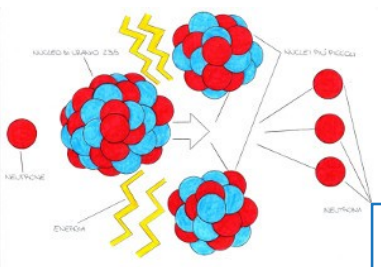
Quarto Incontro Nazionale di Fisica Nucleare INFN 2018

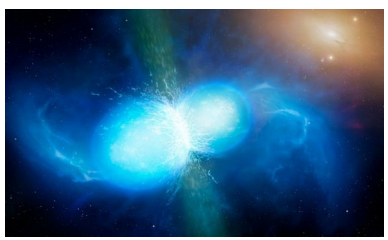
LNS, November 7th – 9th, 2018

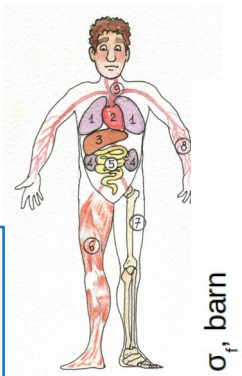
Motivations

INDC International Nuclear Data Commitee

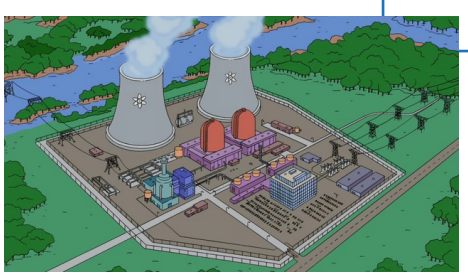
*"...Our analysis indicates that the <u>new absolute measurements of the neutron induced fission cross section</u> (e.g. **<u>relative</u>** **<u>to</u>** **<u>n-p</u>** **<u>scattering</u>**) on **<u>Uranium</u>**, Bismuth, Lead and Plutonium have the highest priority in establishing neutron induced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

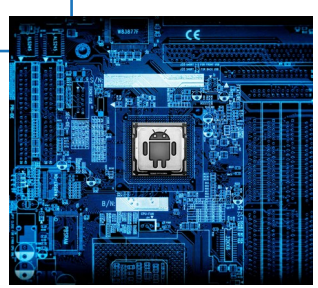


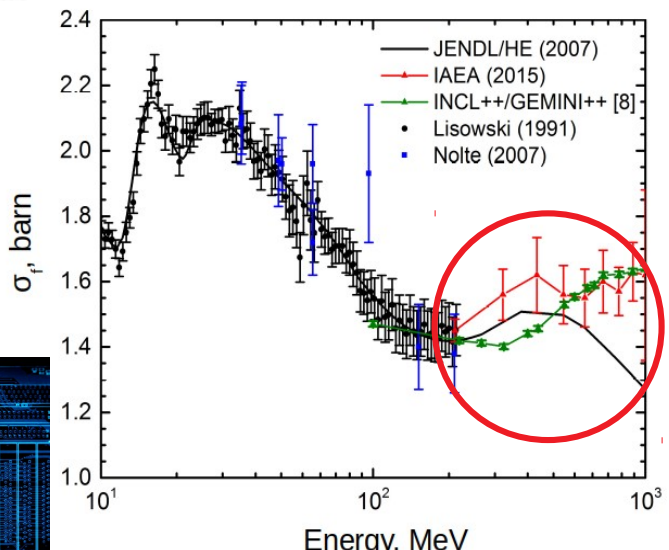




^{235}U(n,f) is one of the most significant cross-section standards at 0.025 eV and [0.15-200] MeV **<u>BUT</u>** there are **<u>no experimental data above 200 MeV</u>**, despite its importance

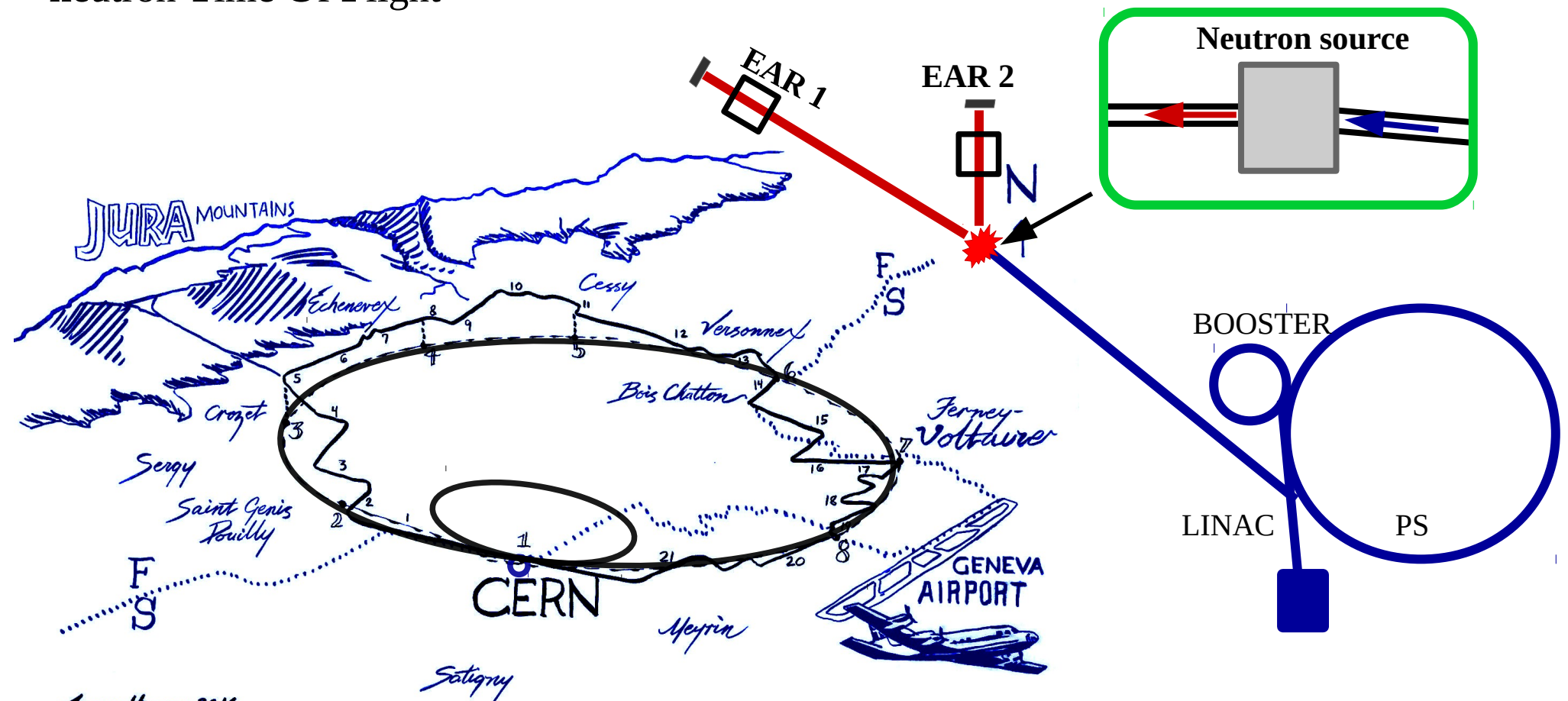






The n_TOF facility

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



The n_TOF facility

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

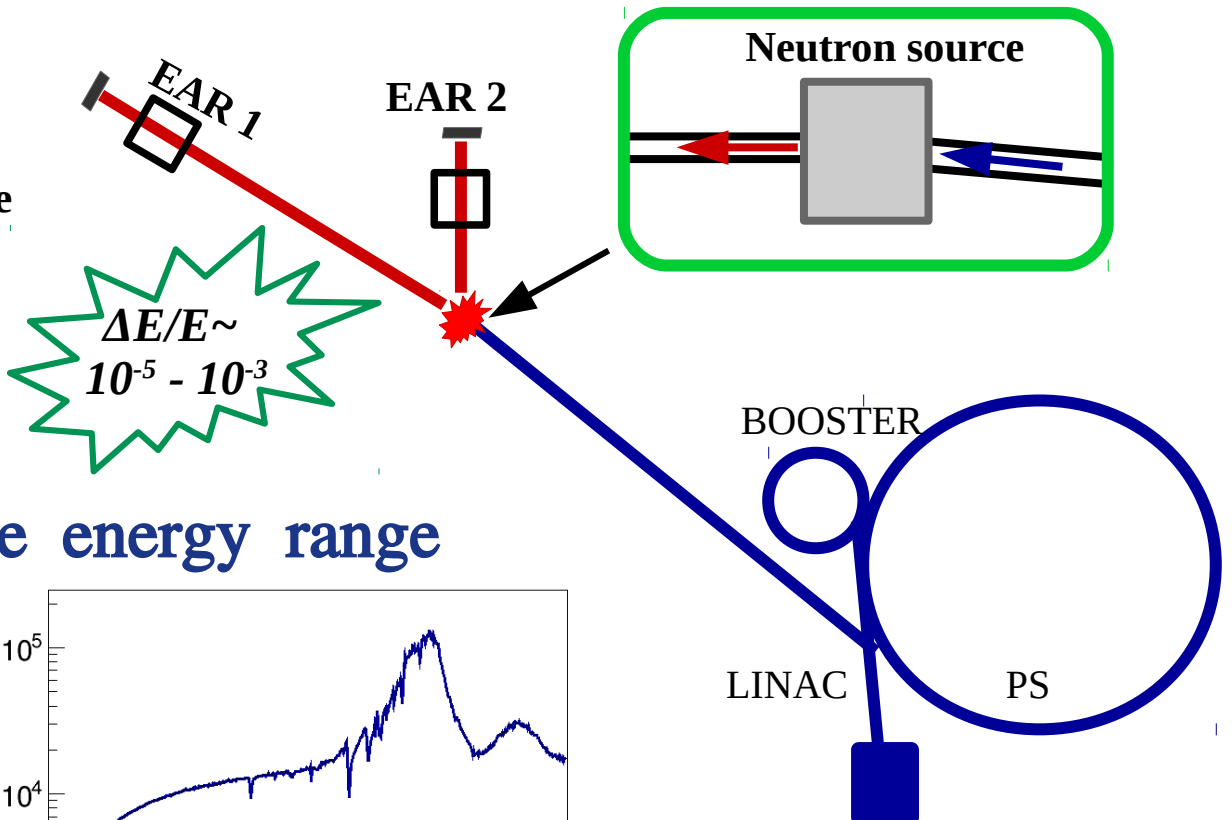
High energy resolution

Time of Flight (ToF) technique

with a long flight path:

185 m @ EAR 1

20 m @ EAR 2



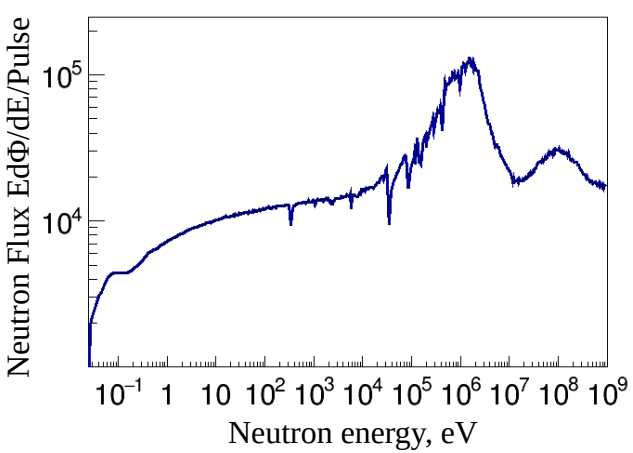
High neutron flux & wide energy range

Spallation reaction

$7 \cdot 10^{12}$ protons,
20 GeV/c momentum

+

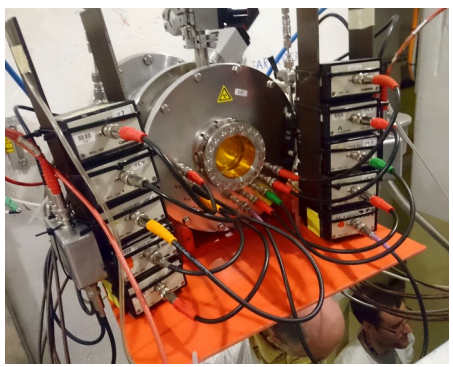
1.3 ton Pb Target



Experimental setup

^{235}U fission reaction

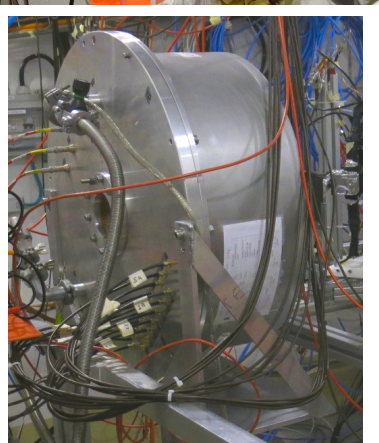
Fission fragment



Parallel Plate Ionization Chamber (**IC**)

→ Ambient gas pressure

Neutron energy: (10-200) MeV



Parallel Plate Avalanche Counter (**PPAC**)

→ Low gas pressure ~ 4 mbar

Neutron energy: (100-1000) MeV

Neutron flux

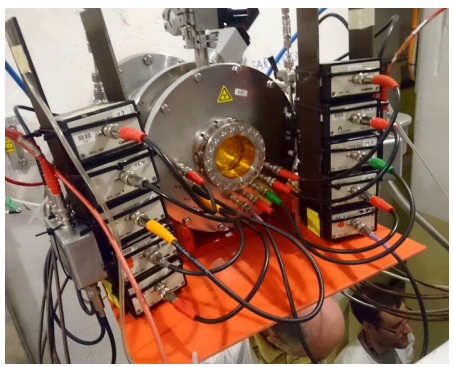
Elastic scattering

n + H → n + p

Experimental setup

^{235}U fission reaction

Fission fragment



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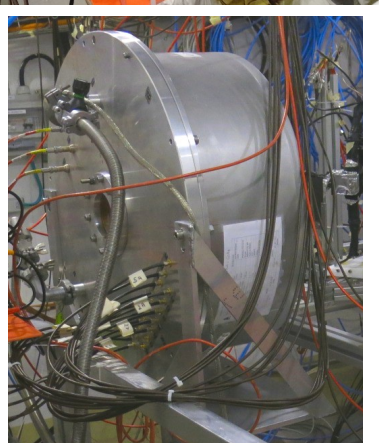

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Neutron flux

Elastic scattering

$$n + \cancel{H}\ (C_2H_4) \rightarrow n + p$$

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

From n+C → Background

A **P**roton **R**ecoil **T**elescope

can discriminate the different emitted particles

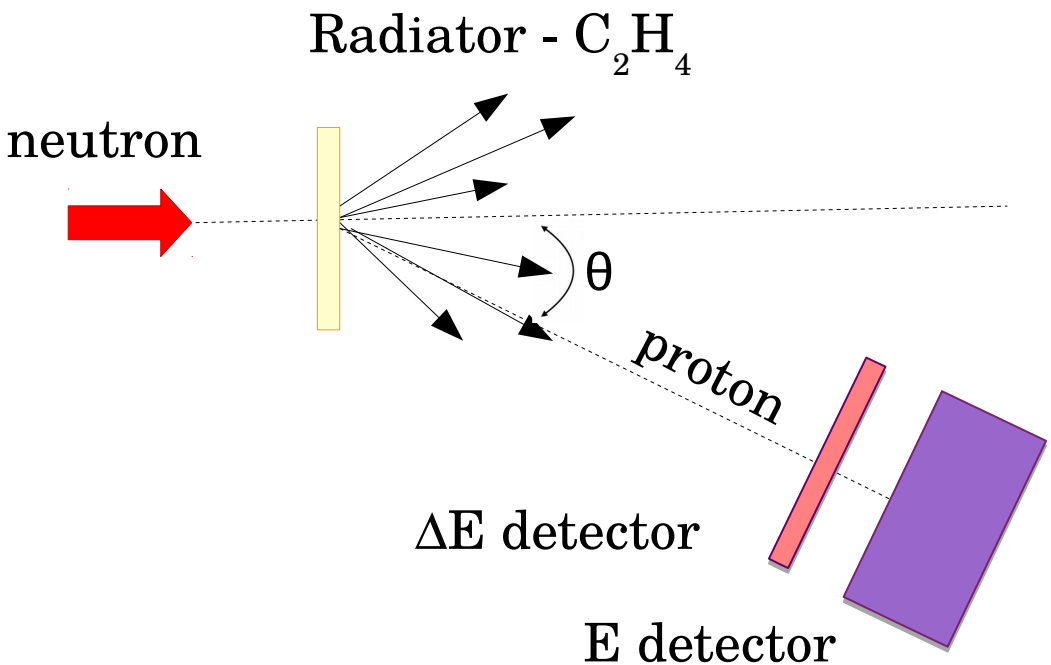
ΔE - E Matrix

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

k: material absorption properties

M, *E*, *z*: interacting particle properties

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



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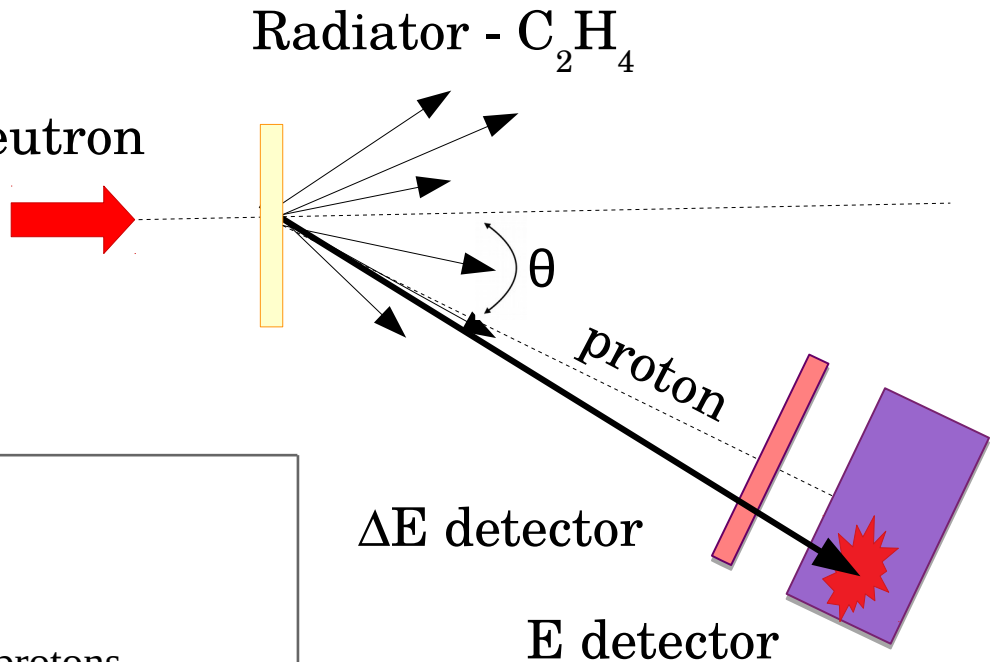
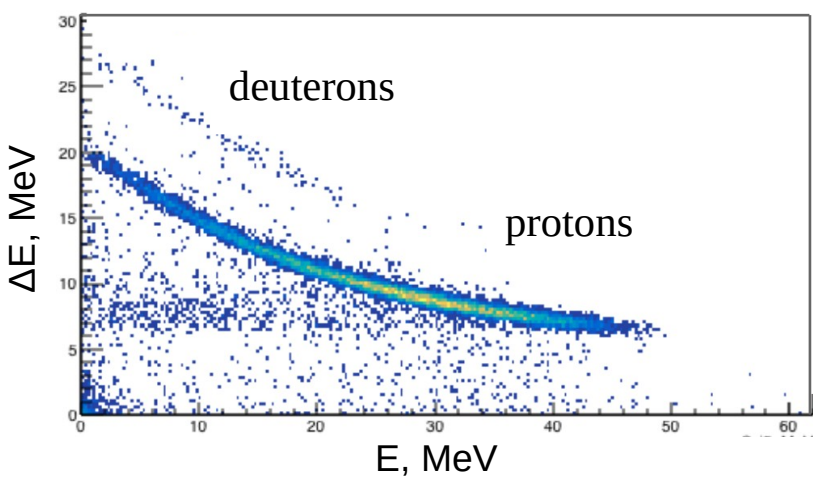


If the particle stops inside the telescope



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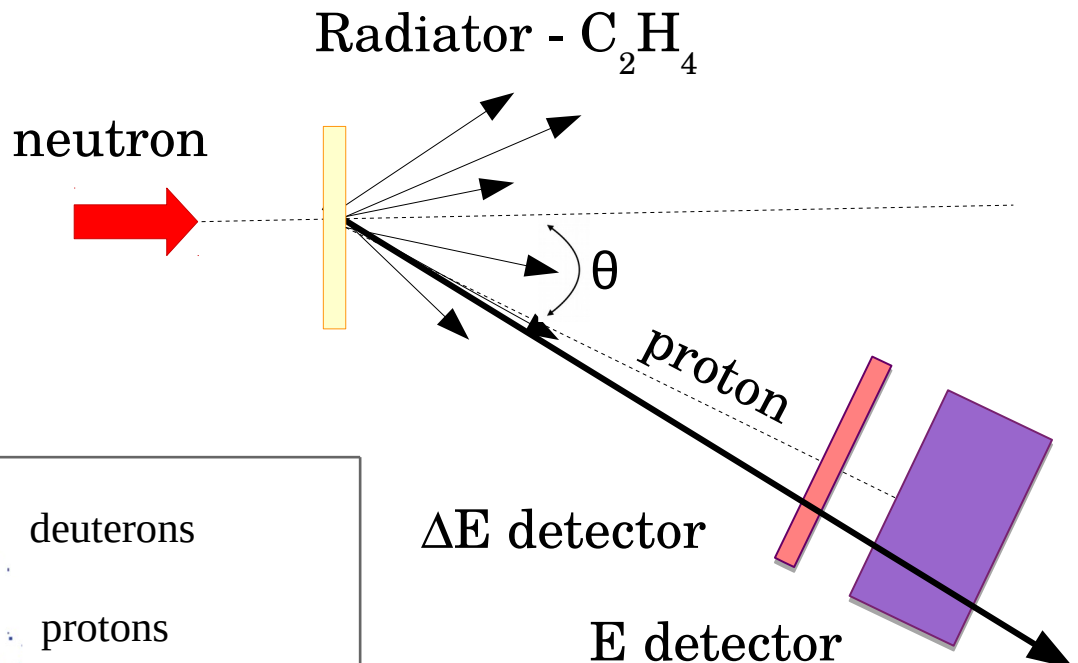
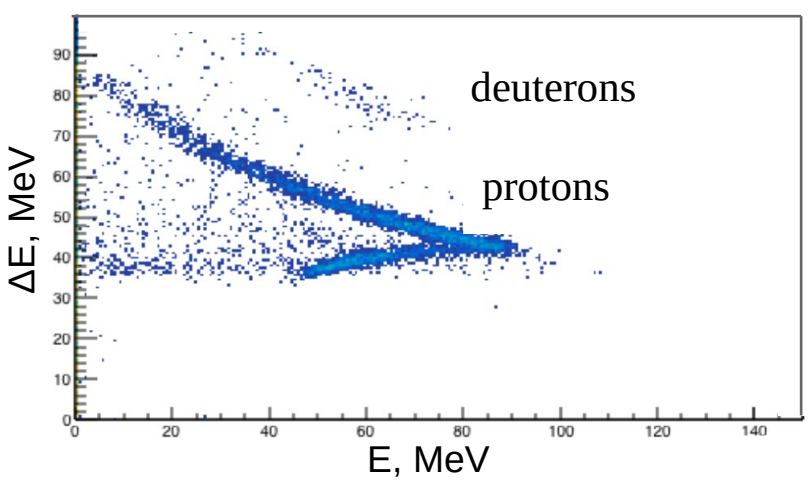
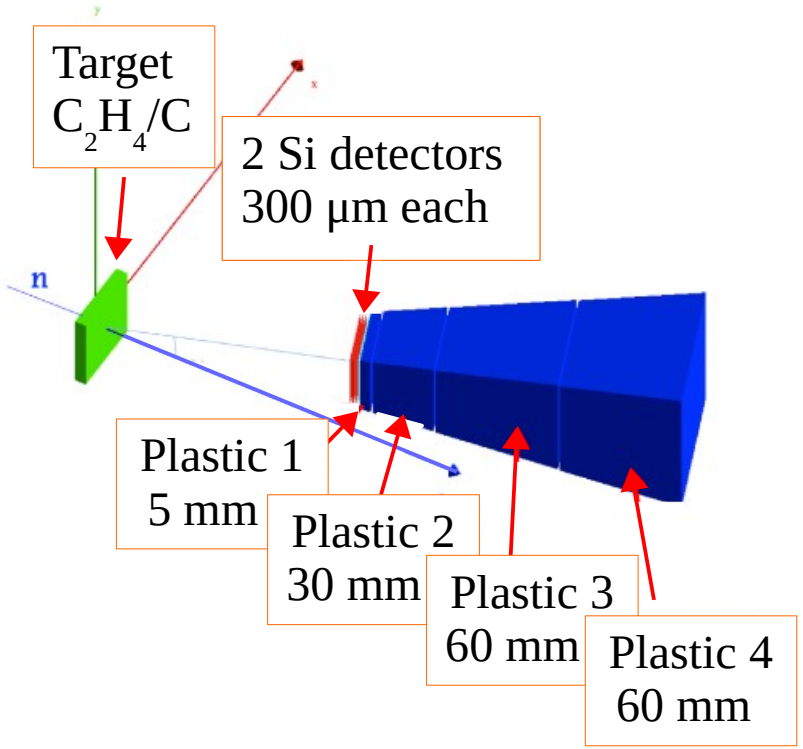


If the particle crosses the telescope



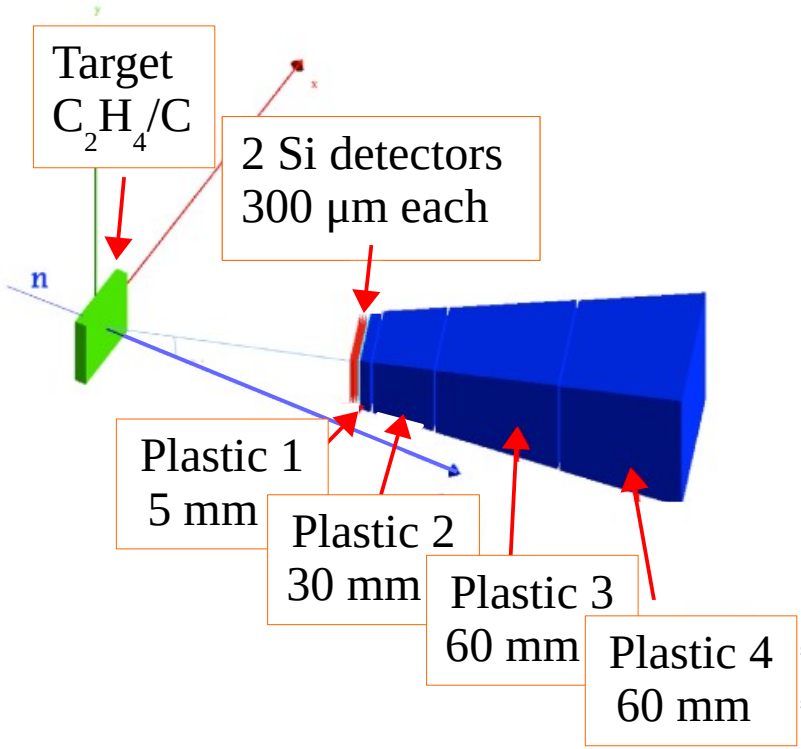
The INFN Proton Recoil Telescope



= 5 Telescopes

Coincidences		Neutron energy
1. 1st & 2nd Silicon	→	< 15 MeV
2. + 1st Plastic	→	15 – 35 MeV
3. + 2nd Plastic	→	35 – 70 MeV
4. + 3rd Plastic	→	70 – 130 MeV
5. + 4th Plastic	→	> 130 MeV

The INFN Proton Recoil Telescope



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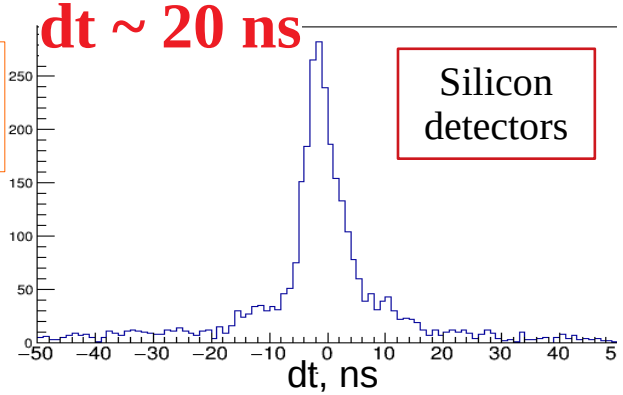
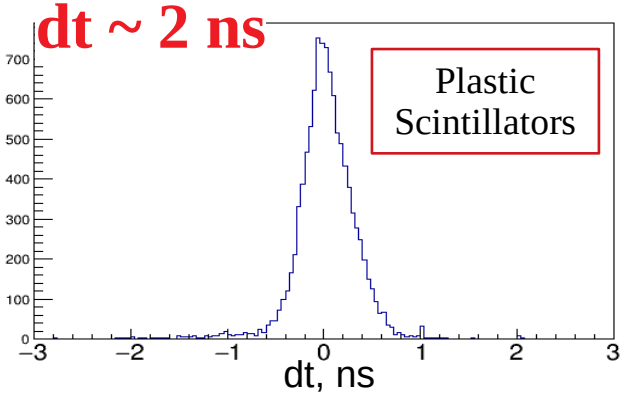
5.	+ 4th Plastic	→	> 130 MeV

dt ~ 20 ns

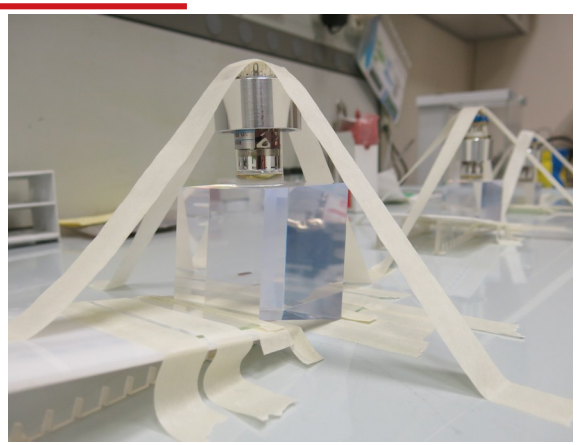


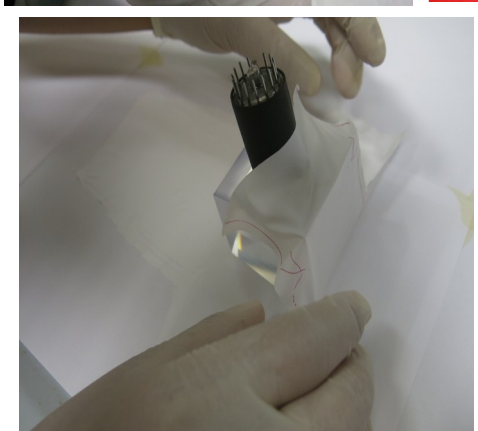
dt ~ 2 ns

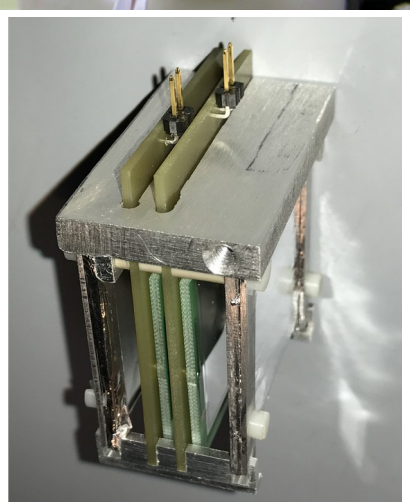


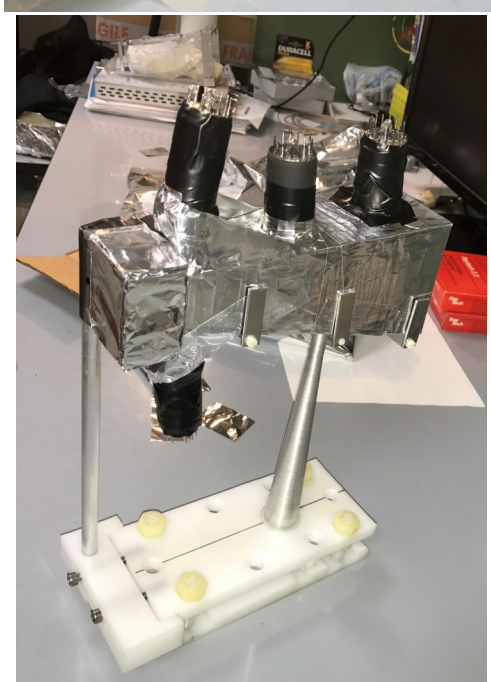
The INFN Proton Recoil Telescope

@LNS







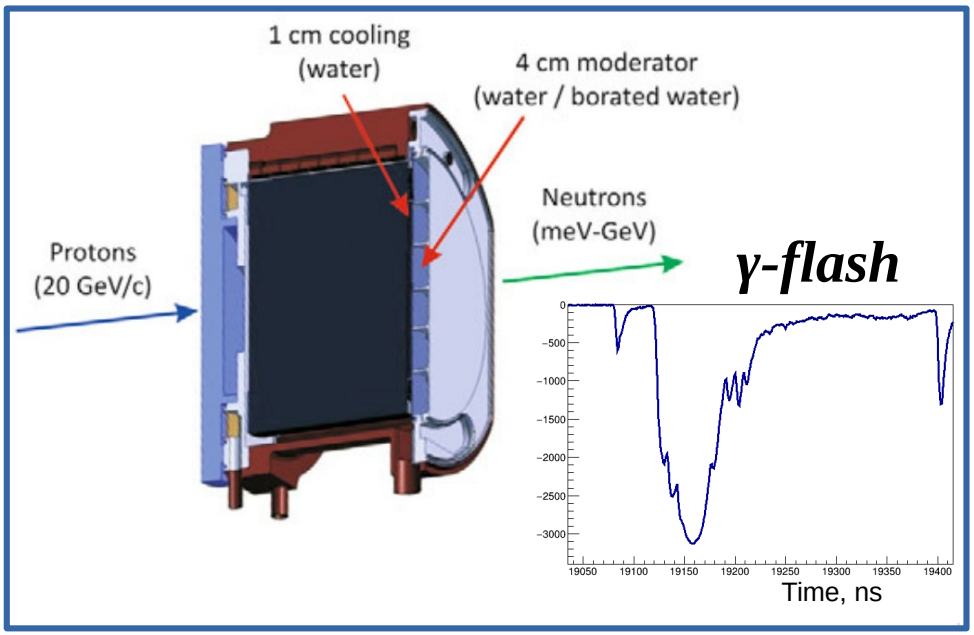


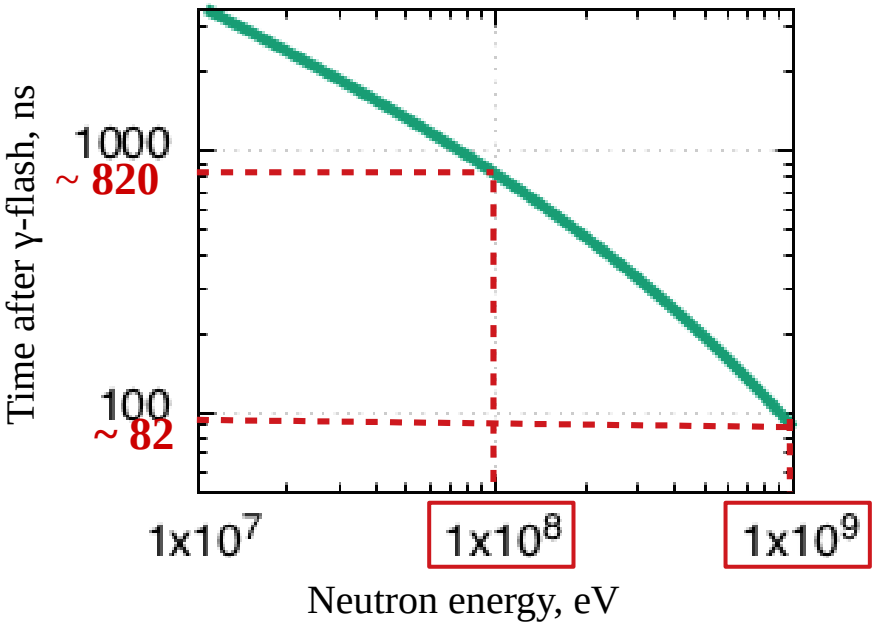
The INFN Proton Recoil Telescope

@n_TOF

The PRT has been tested in EAR1 to prove the performances

Results: PRT response to the γ-flash





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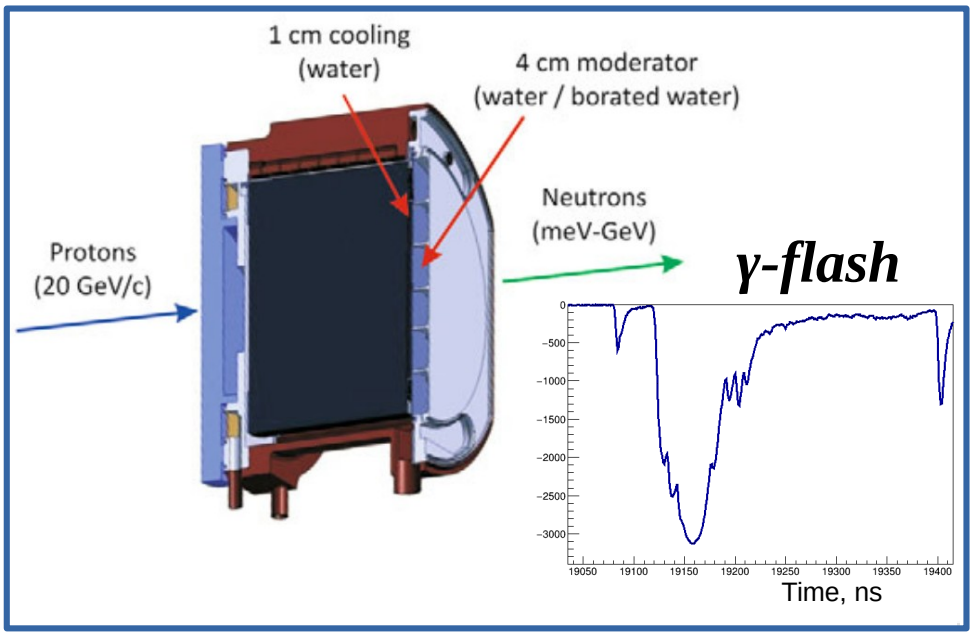
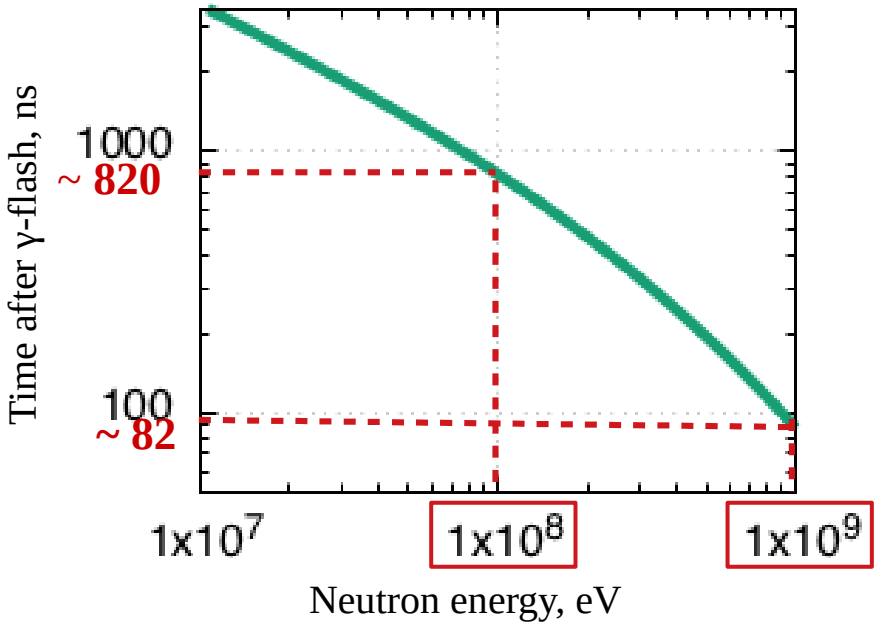
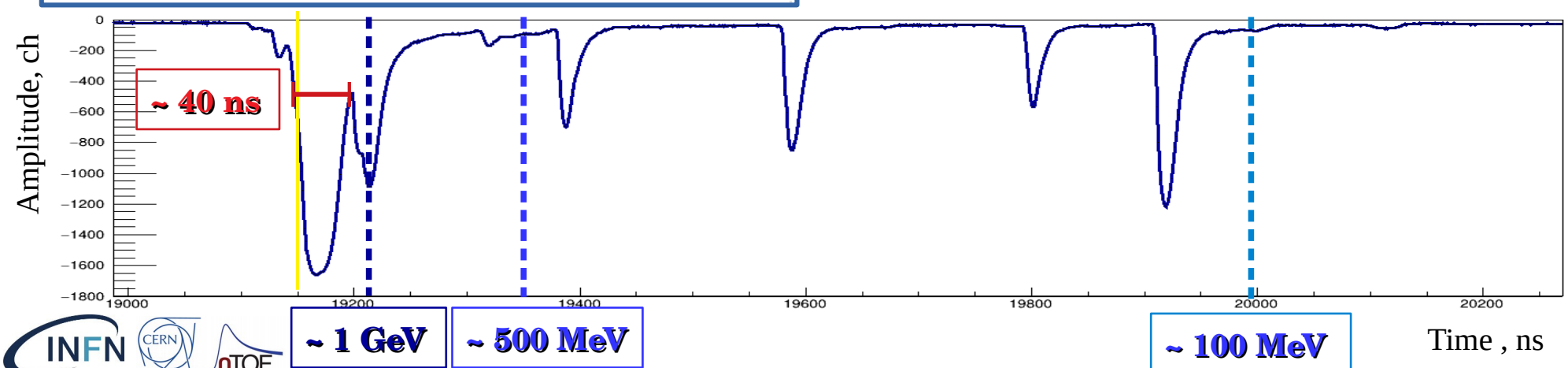




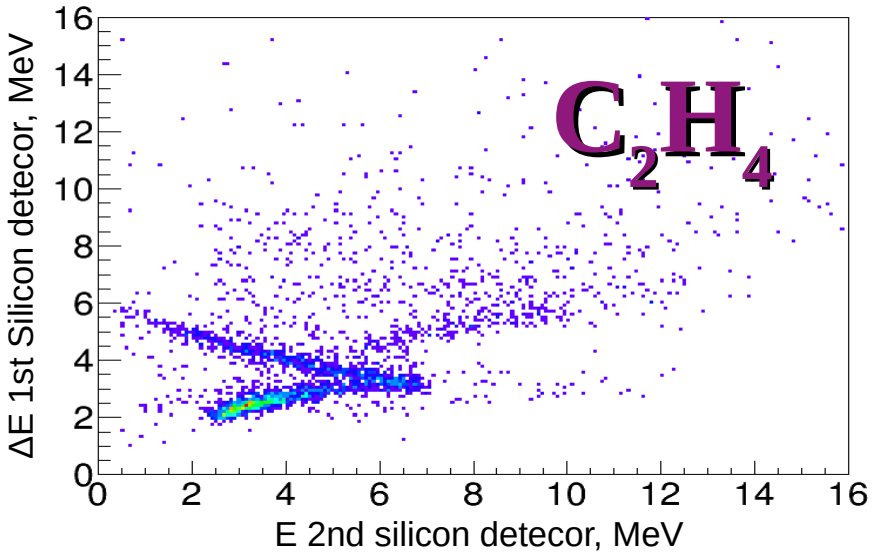


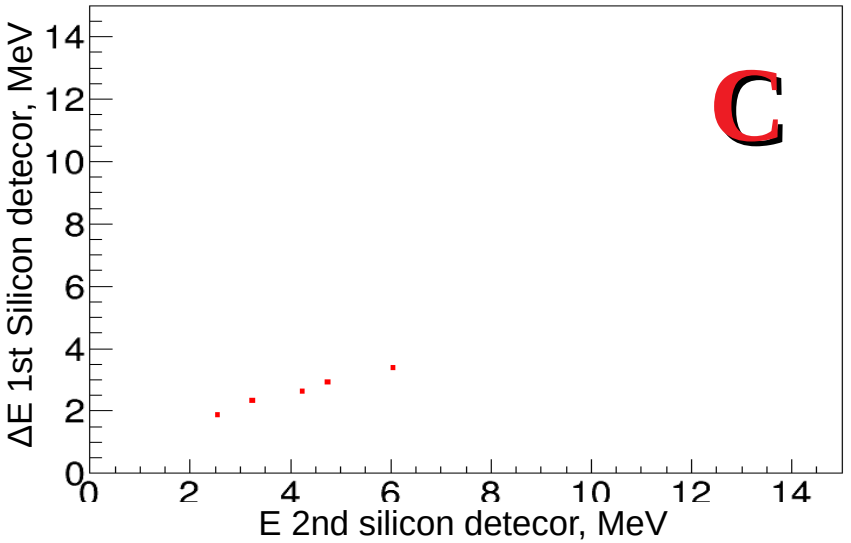
Results: ΔE - E Matrix

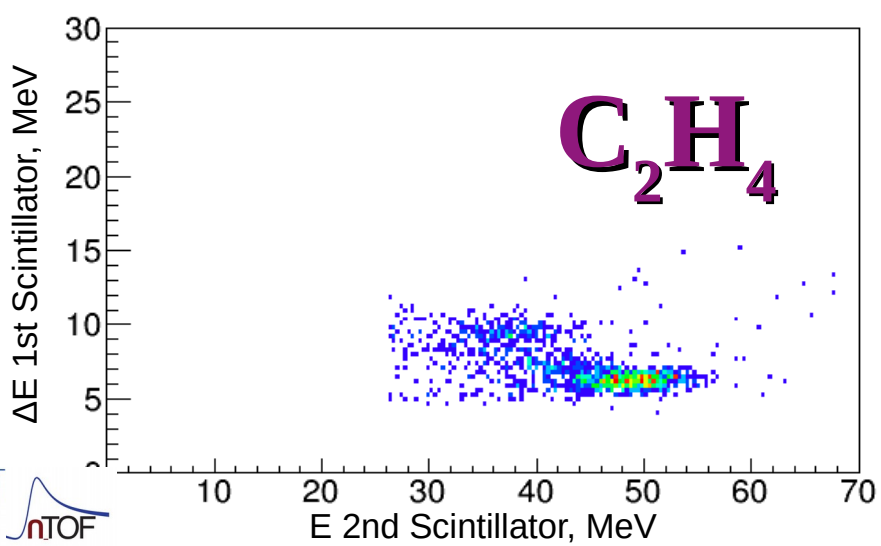
15 MeV

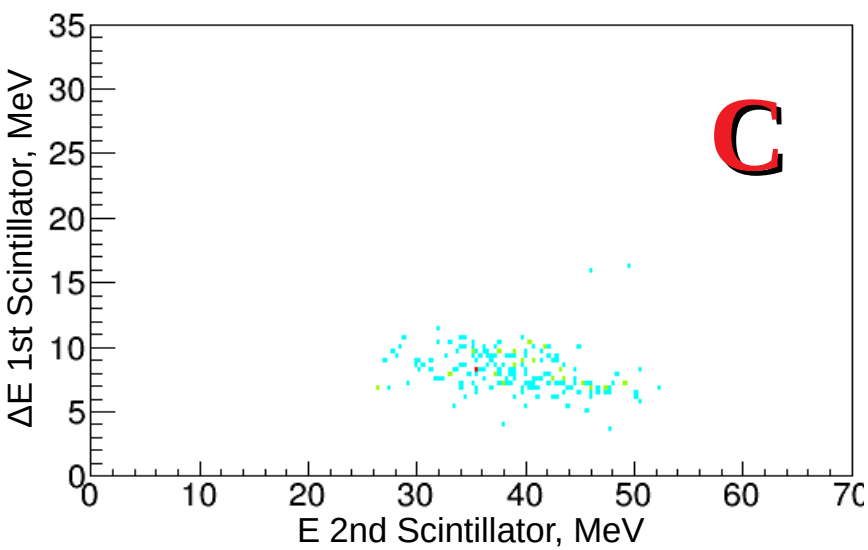
Neutron energy

70 MeV

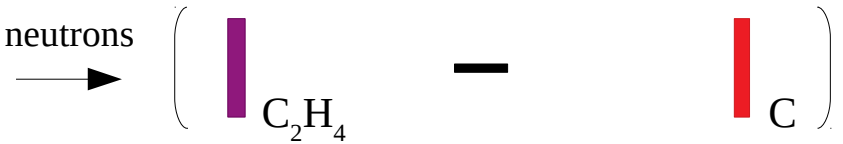




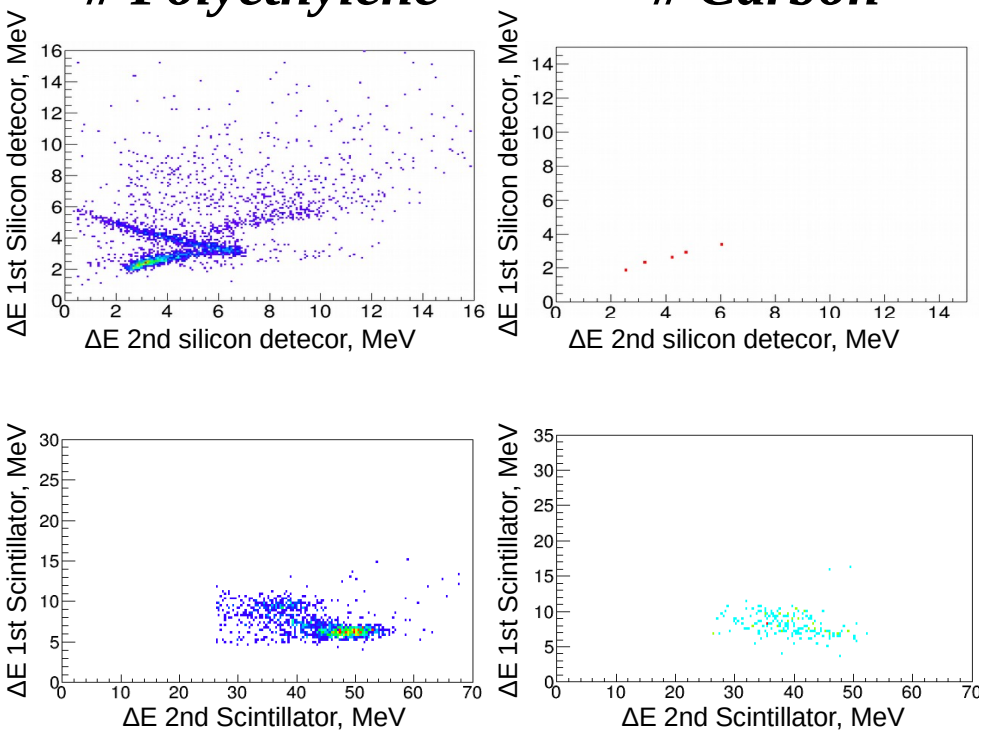


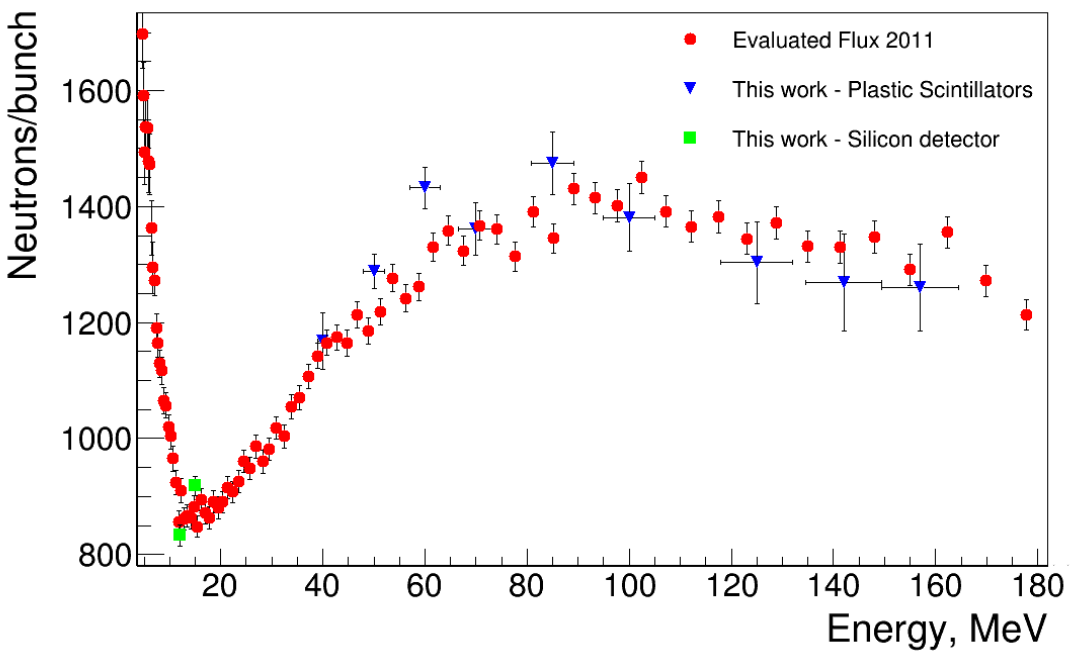


Results: Neutron Flux

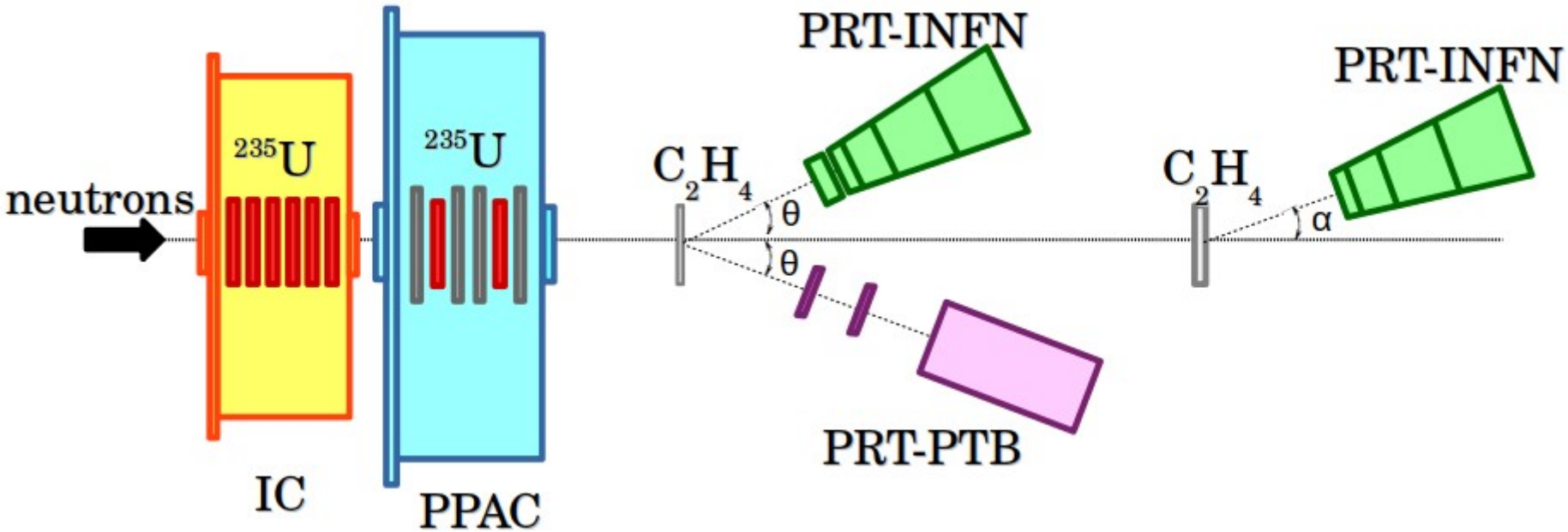


 # Polyethylene - # Carbon = Extracted neutron flux

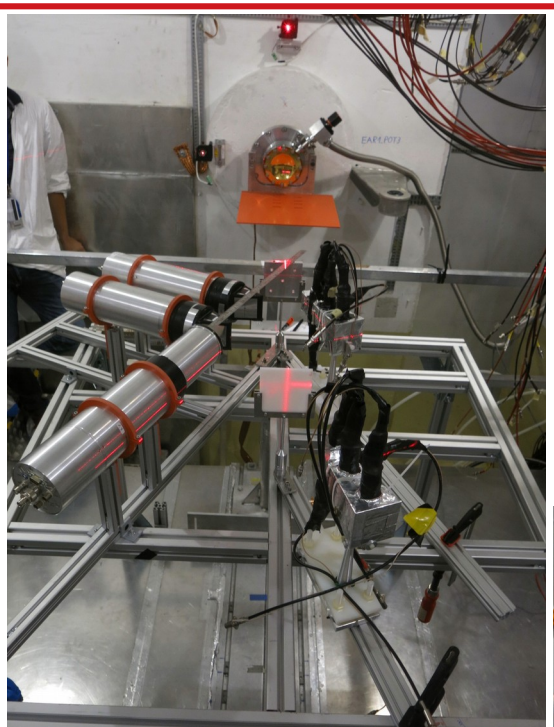


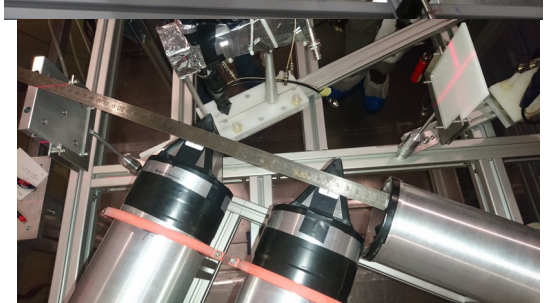


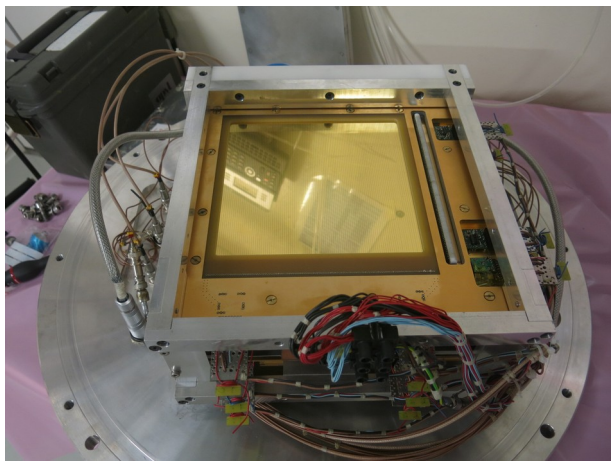
Results: final experimental setup

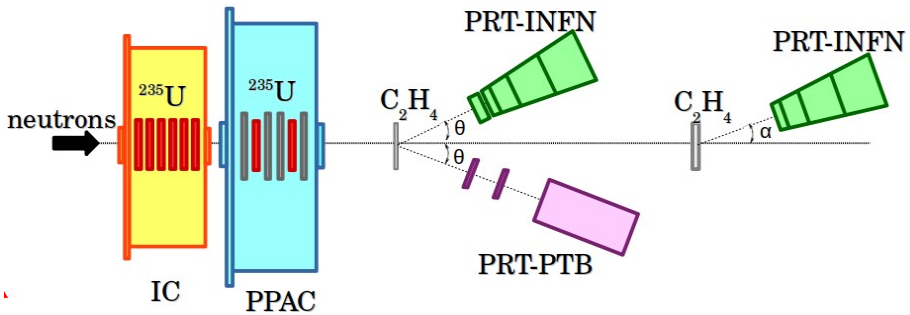


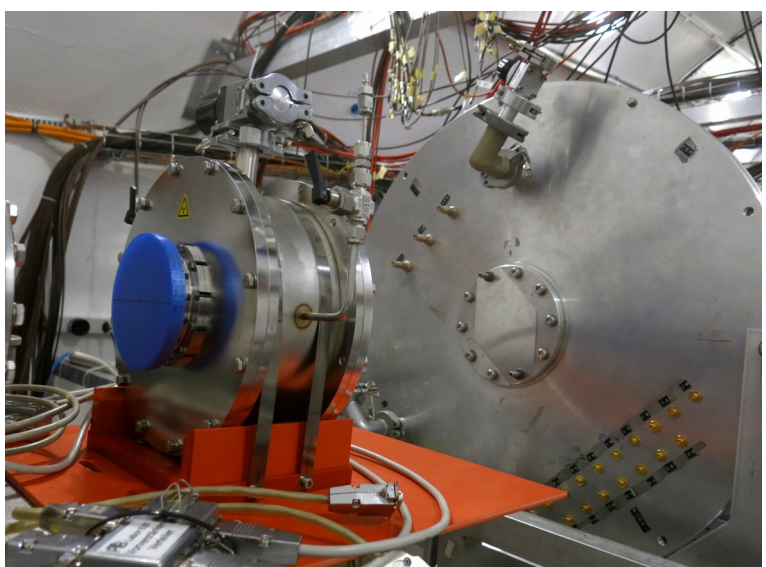
Mounting @ n_TOF

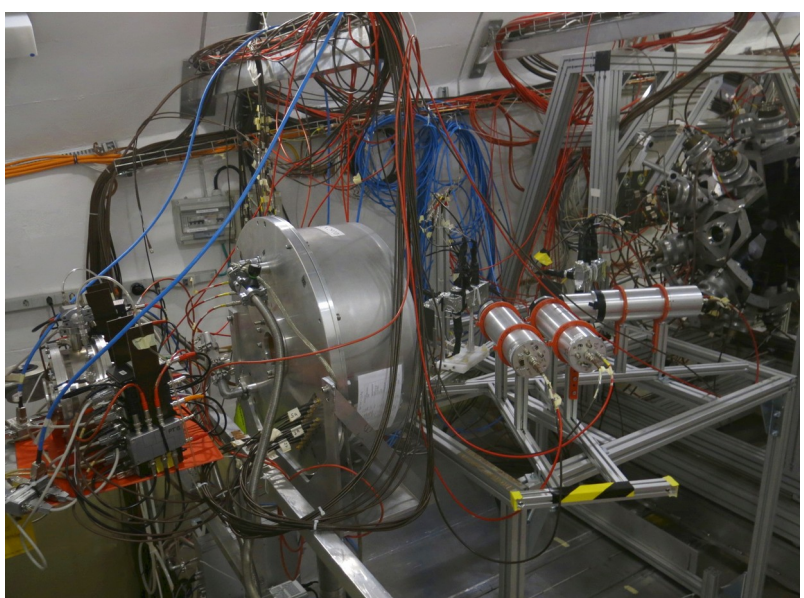












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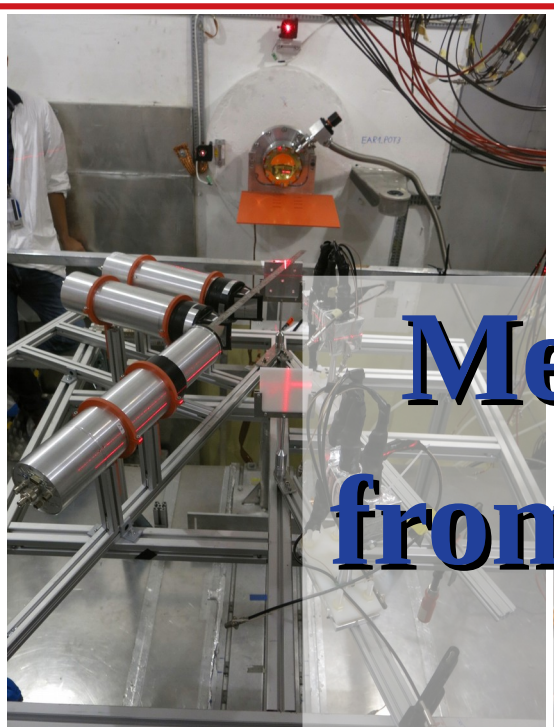
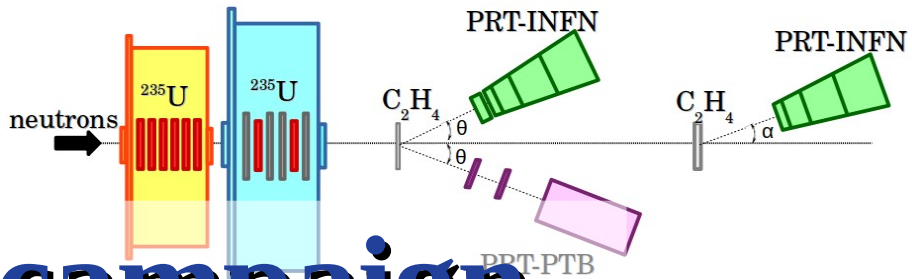
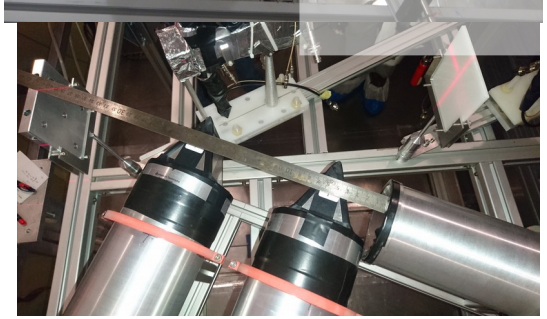




Measurement campaign from Sept 17th to Oct 29th

$3.8 \cdot 10^{18}$ pot



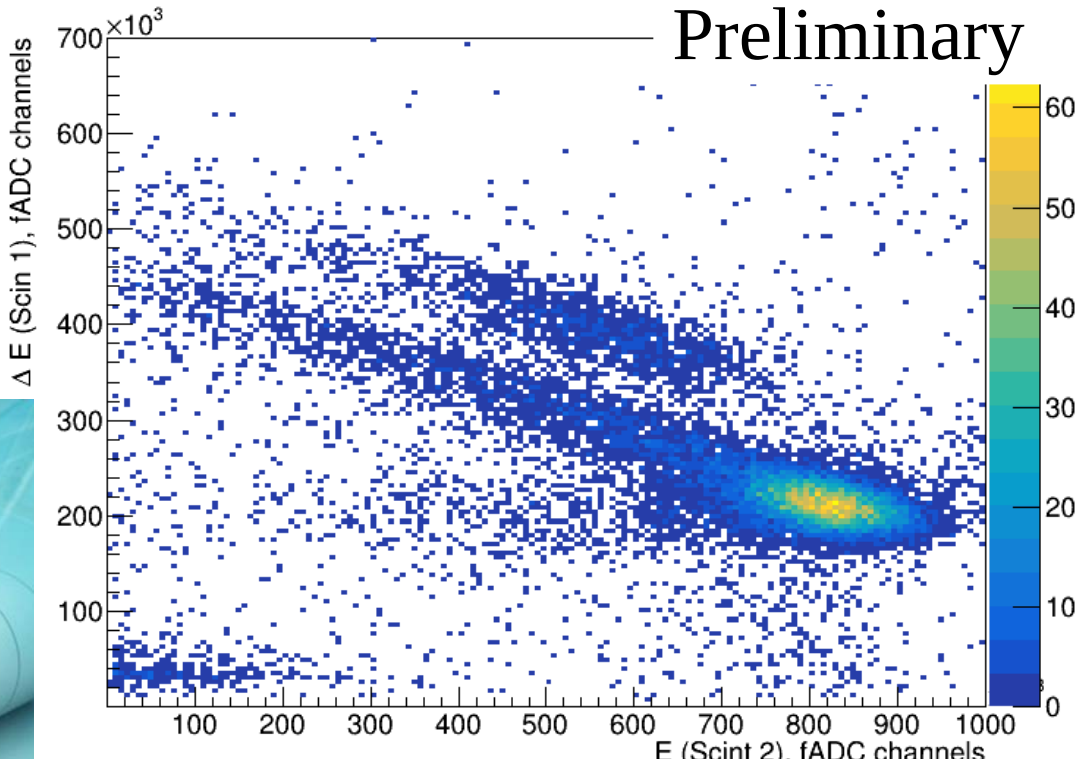
Conclusions

The measurement campaign ended last week

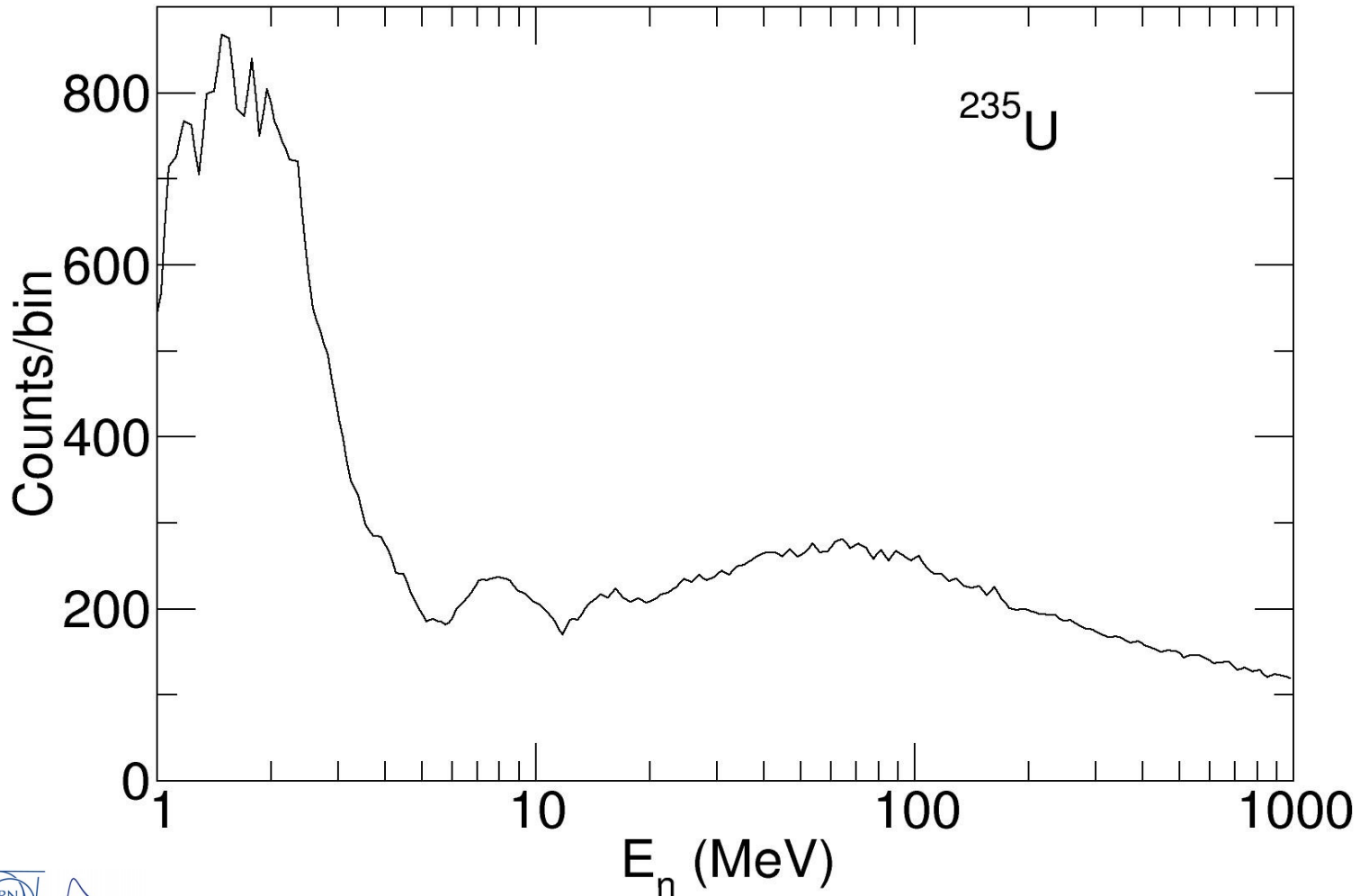
First results indicate VERY NICE DATA from PRT detector!!

Analysis ongoing

Preliminary

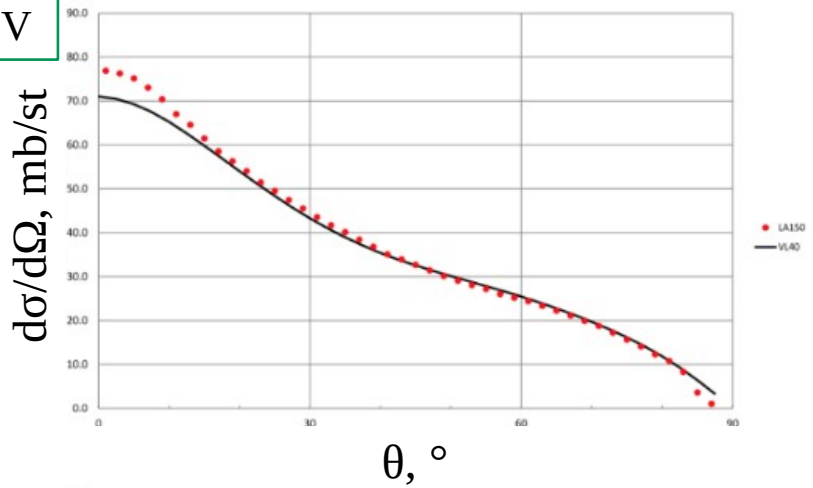


^{235}U(n,f) counts

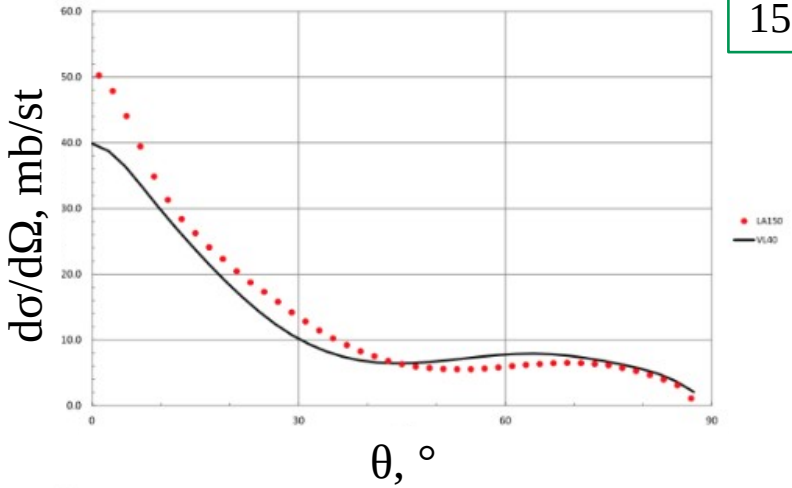


n-p scattering cross section

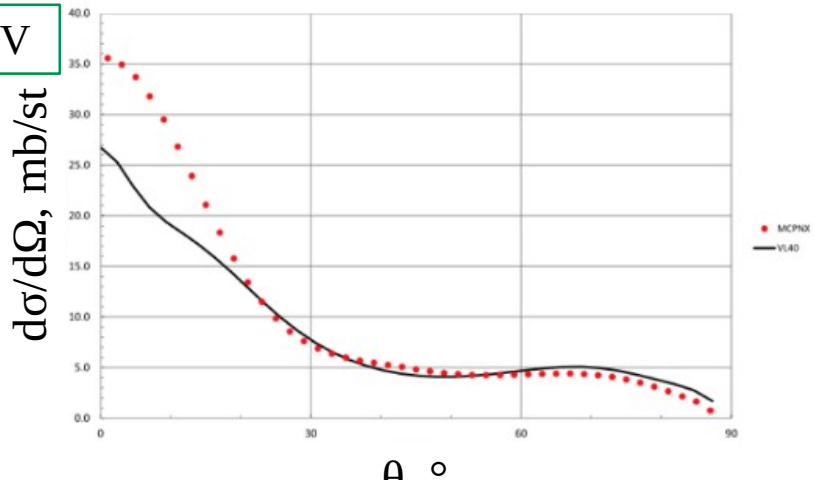
50 MeV



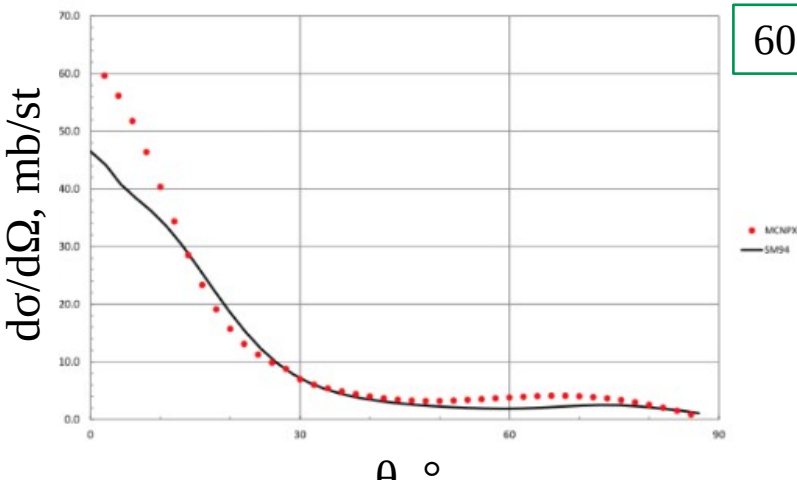
150 MeV



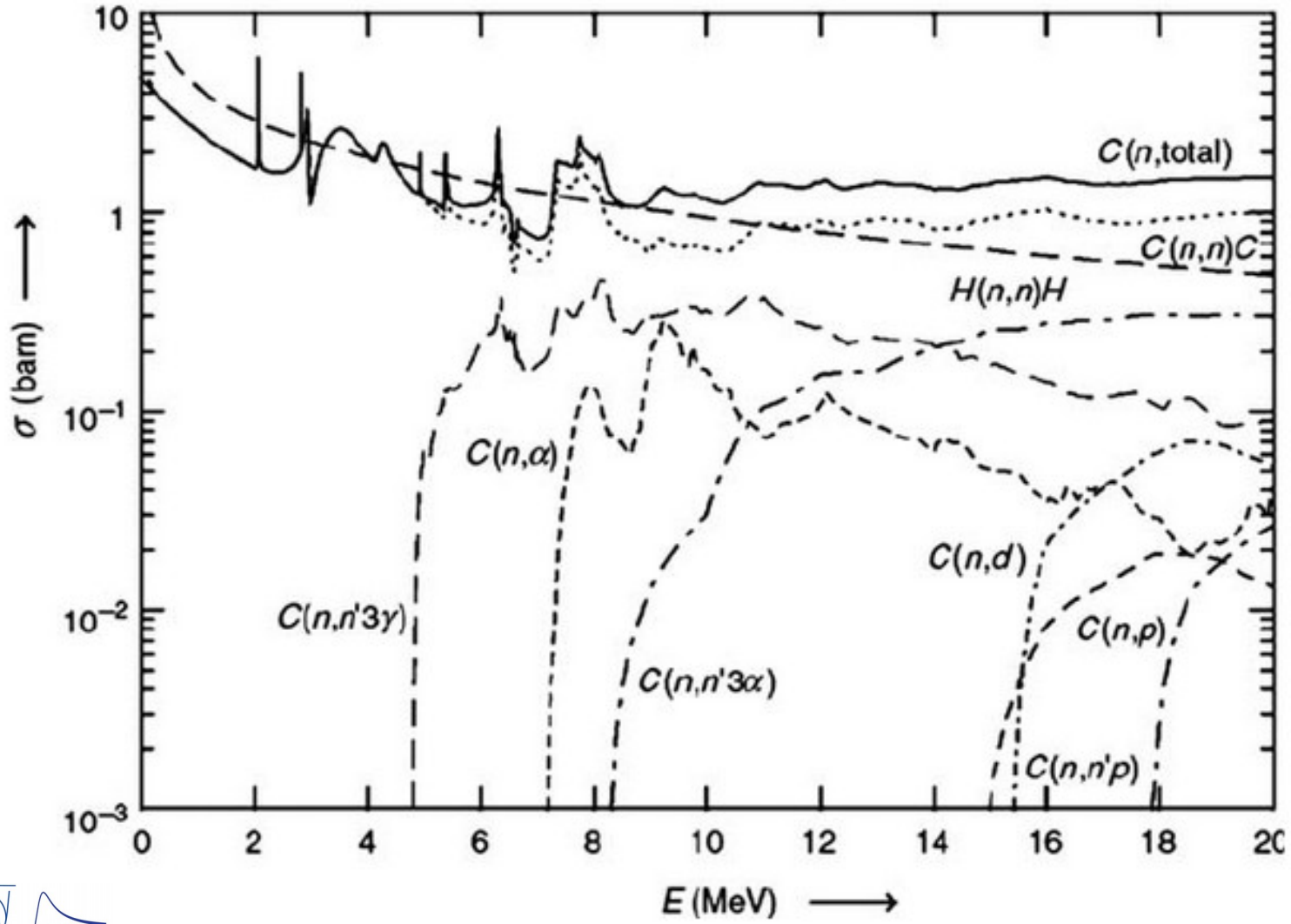
300 MeV



600 MeV



n-p scattering cross section



n-p scattering cross section