$^{12}C(n,3\alpha)$: test di fattibilità con PPAC

Meeting n_TOF Italia, 9 Novembre 2023 - Trieste

Motivation

- Neutron irradiation of Fusion reactor materials will produce residual H and He atoms

  H and He concentration can affect material performance:

  - **Steels**
  - other possible fusion material such as **Silicon Carbide:**

    Alternative material for the first wall of the fusion reactor

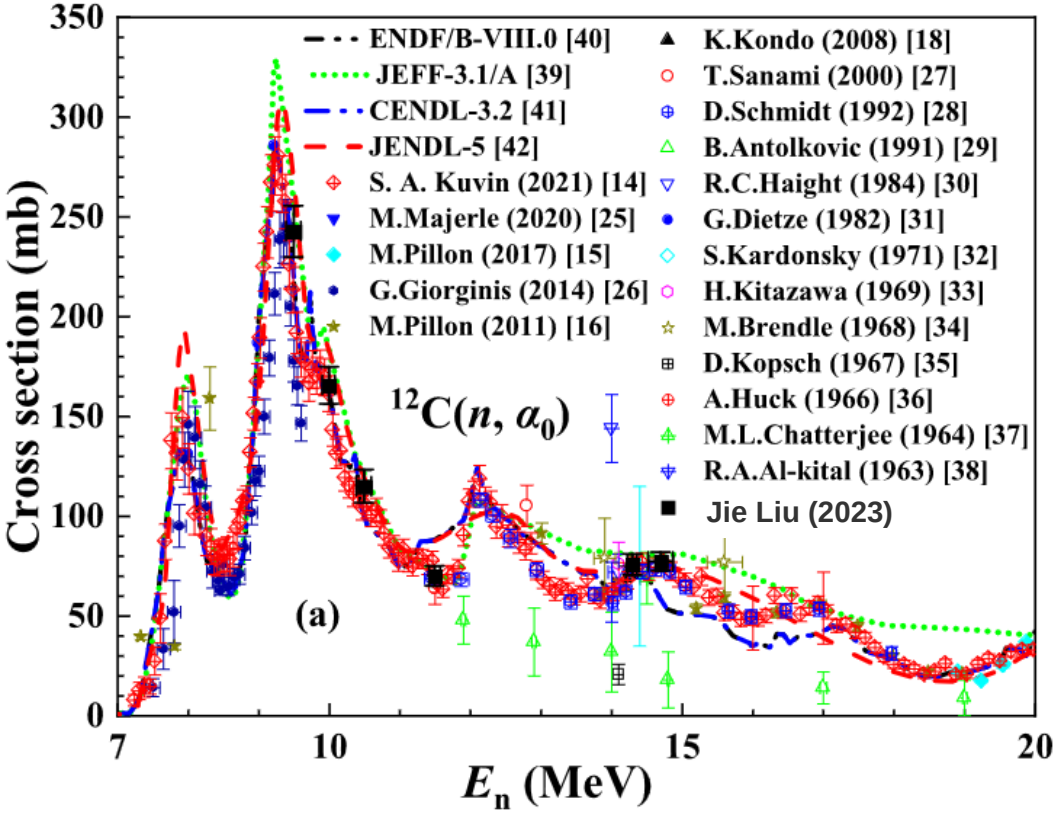
- Carbon-based neutron spectrometers are widely used in neutron detections and diagnoses

In order to predict material performance accurately nuclear data for reactions which produce gas residuals are required

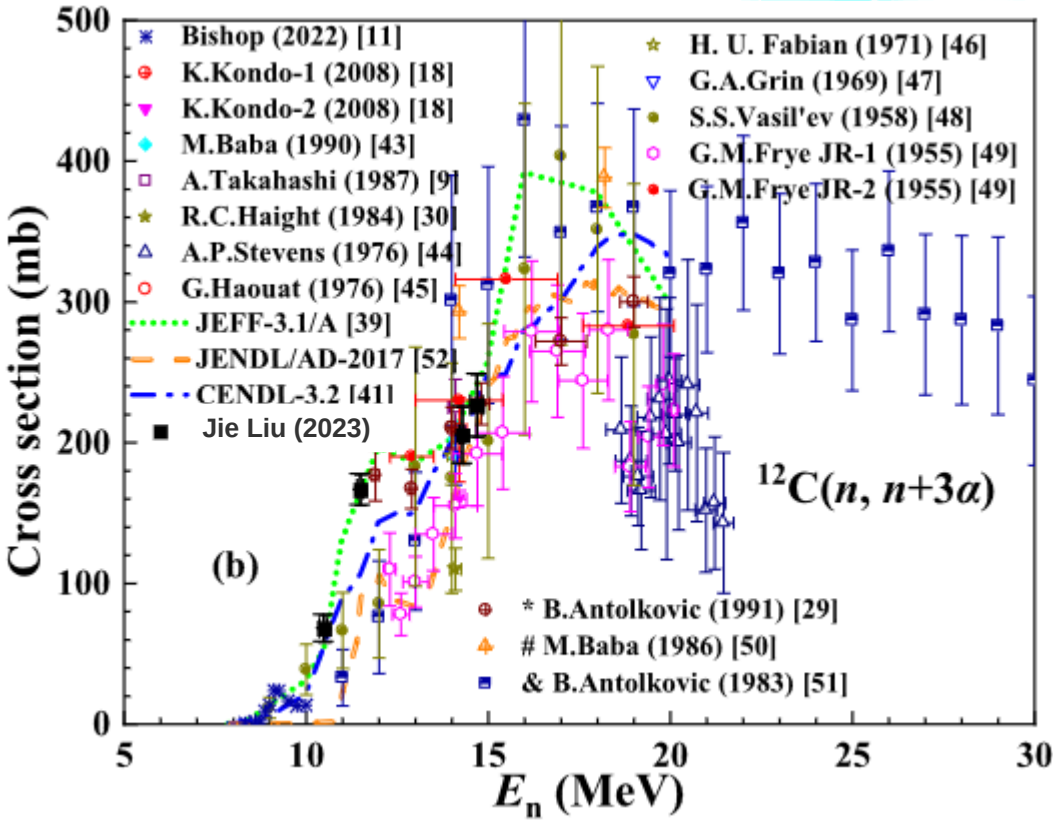
all H and He residuals must be accounted for

Motivation

$^{12}C(n, \alpha_0)^{9}Be$



$^{12}C(n, n+3\alpha)$



^{12}C is unstable with respect to α-decay from 7.27 MeV (α-decay threshold)

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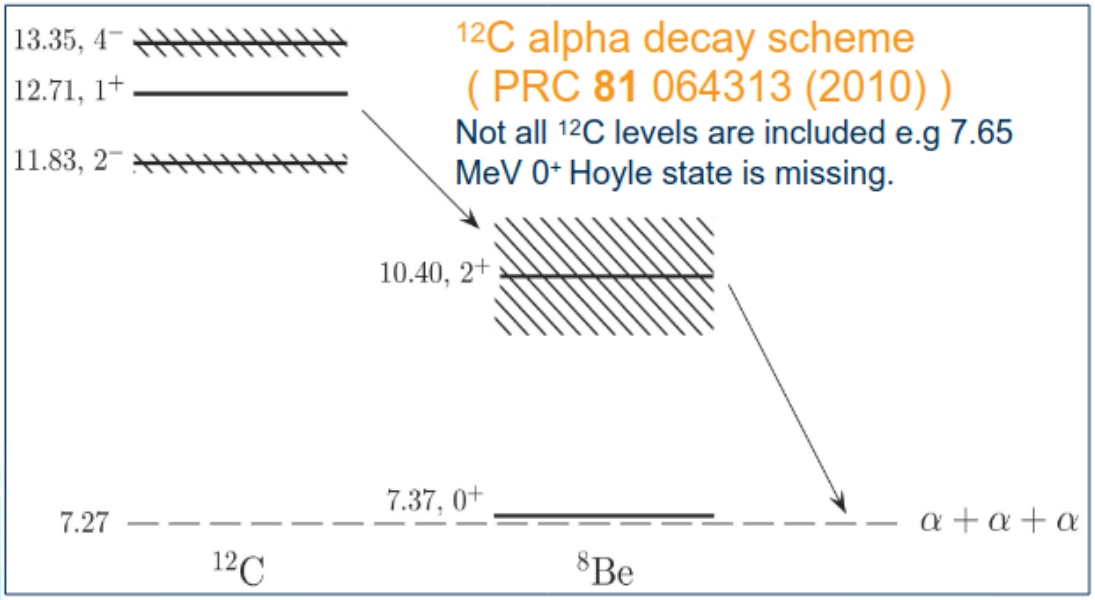
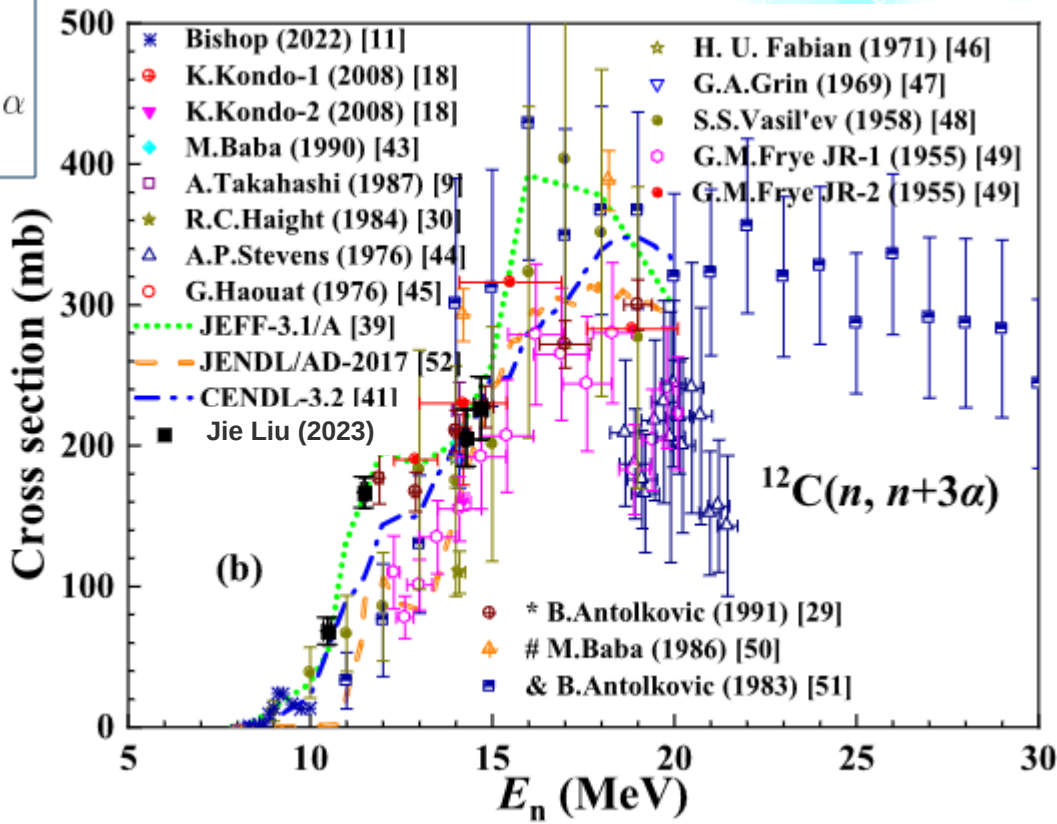


¹²C alpha decay scheme
(PRC **81** 064313 (2010))
Not all ¹²C levels are included e.g 7.65 MeV 0⁺ Hoyle state is missing.

^{12}C(n, n+3α)



Several reaction mechanisms, such as:

- Inelastic scattering

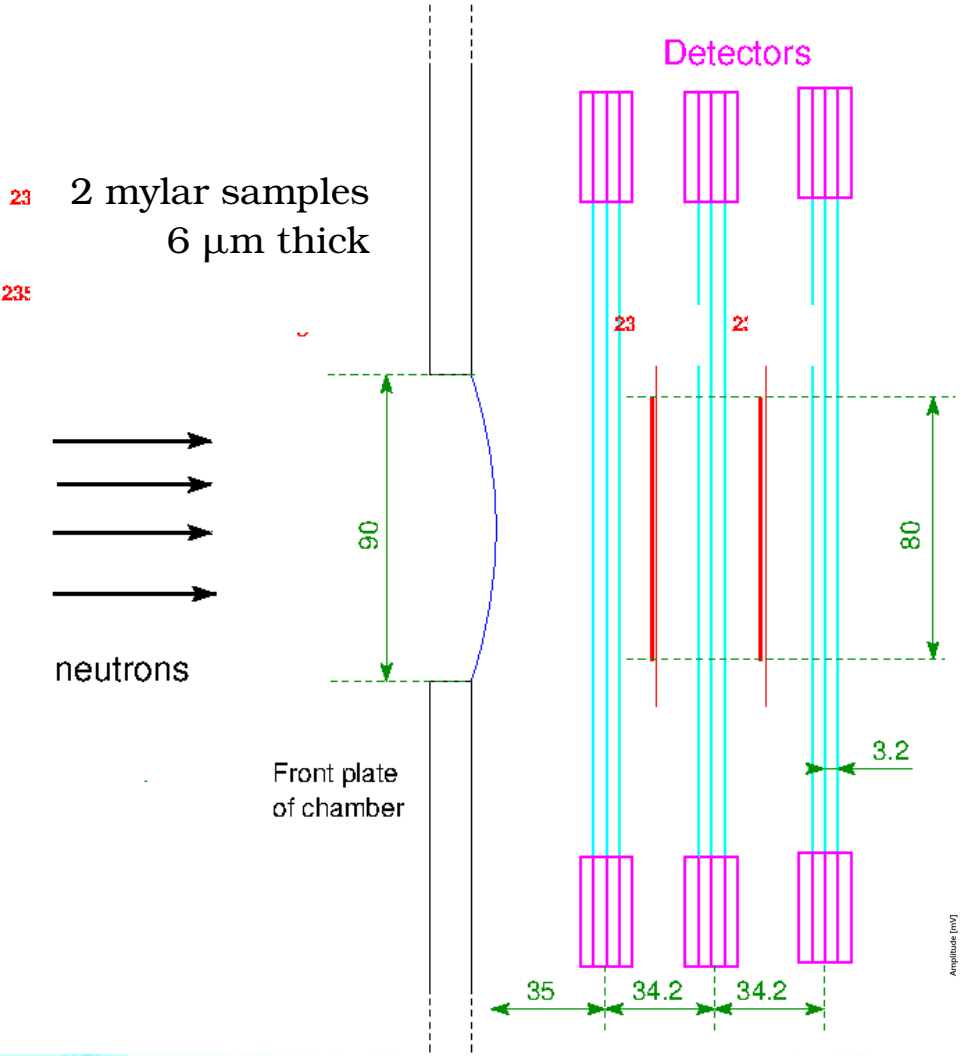
$$n + {}^{12}C \rightarrow {}^{12}C^{*} \rightarrow {}^{8}Be + \alpha \rightarrow 3\alpha$$

- α knock-out

$$n + {}^{12}C \rightarrow {}^{8}Be + \alpha \rightarrow 3\alpha$$

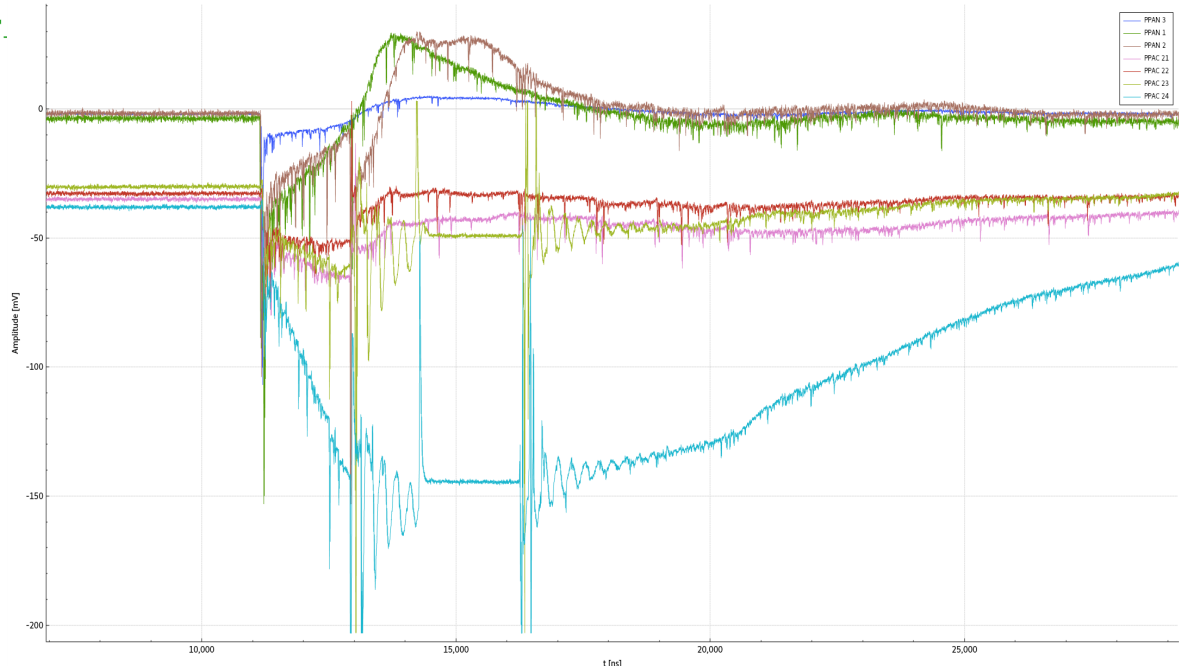
- Complete spallation into 3α's.

PPAC test

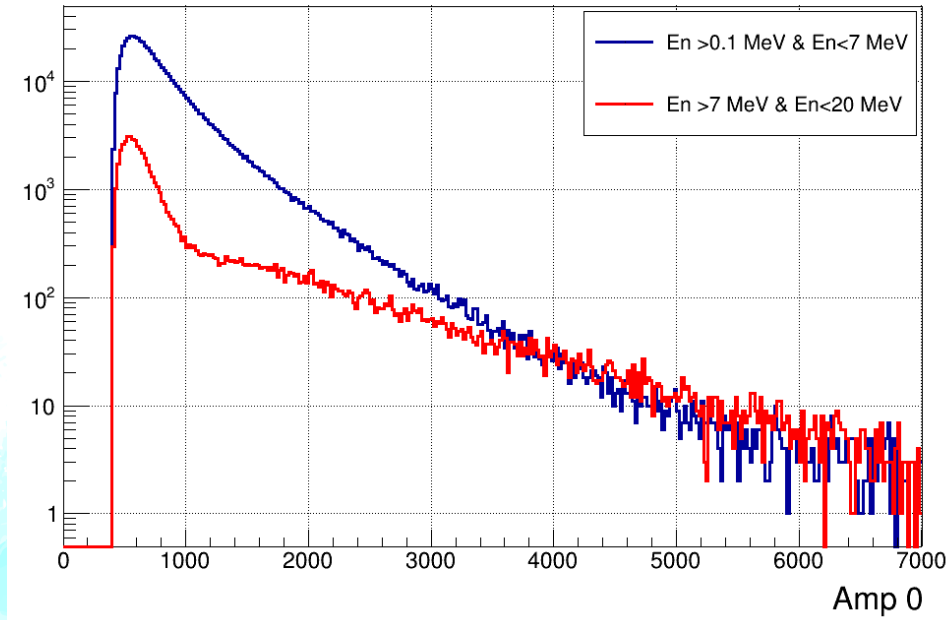


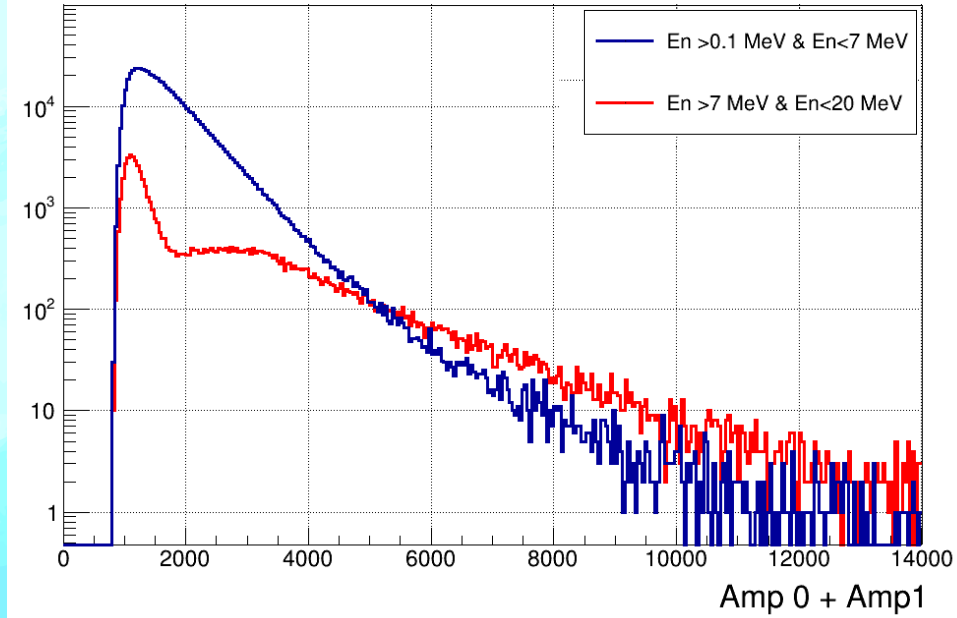
Used configuration:

- C_3F_8 @ 25 mbar
- C_3F_8 @ 10 mbar w/o Pb filter
- C_3F_8 @ 15 mbar w/o Pb filter



Coincidence Events





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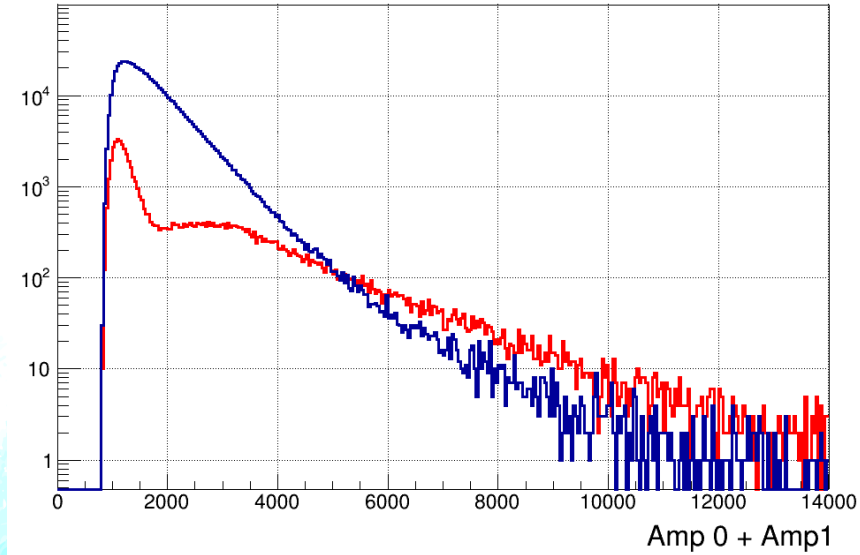
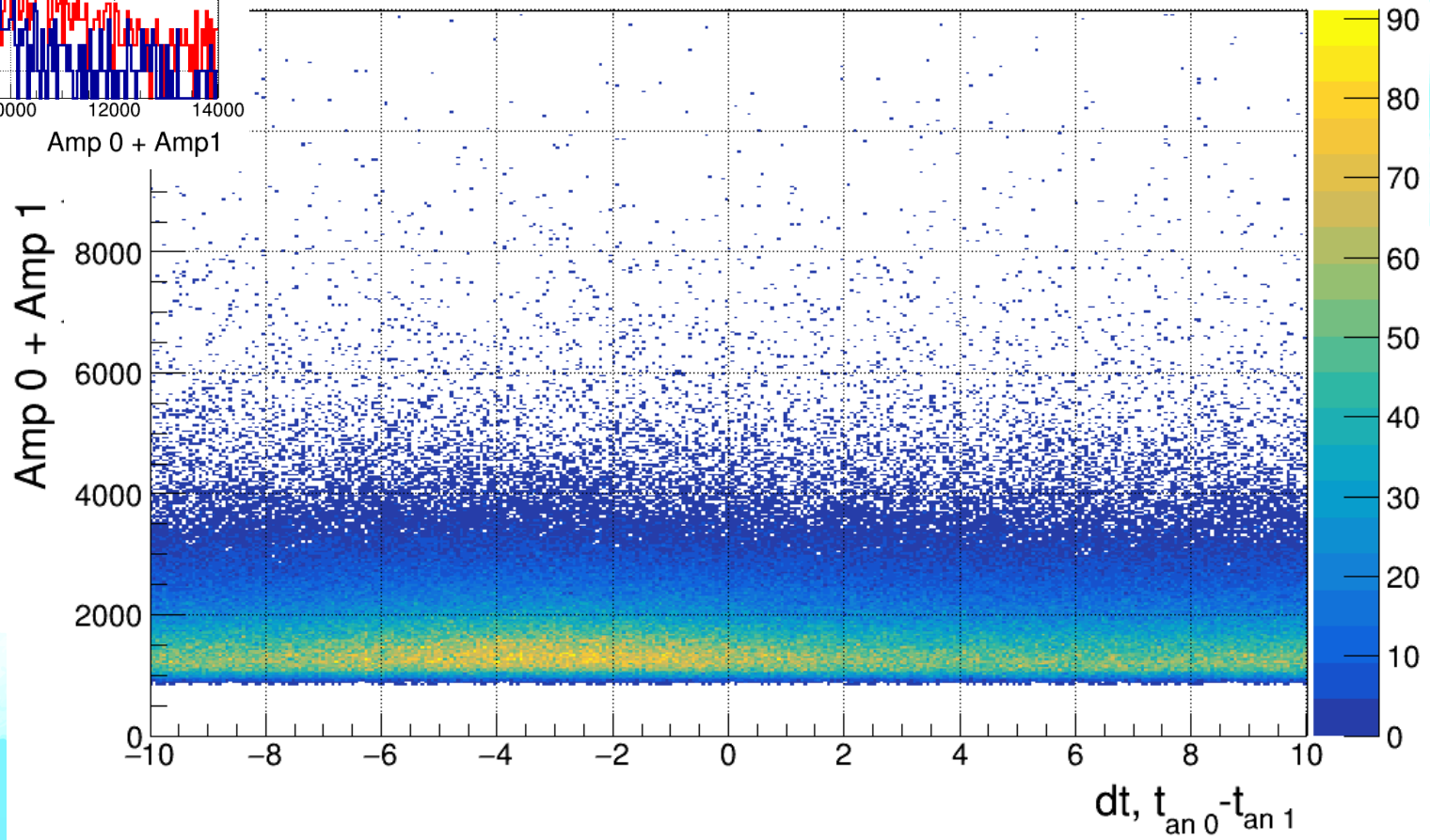
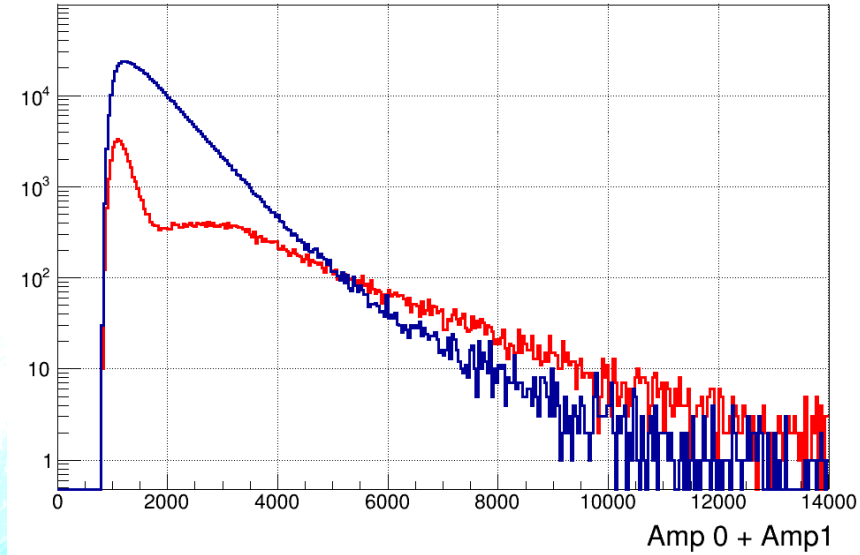


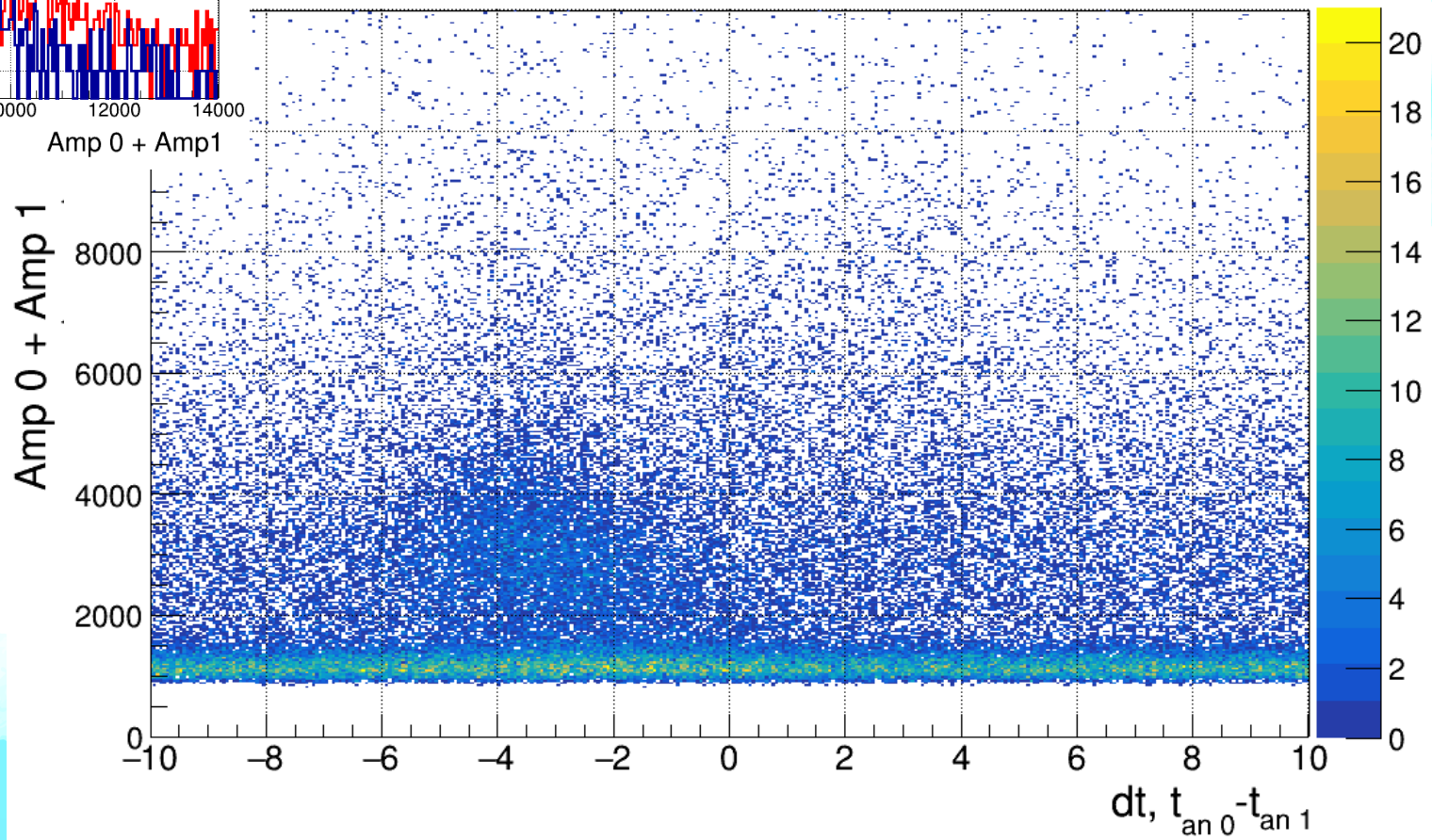
En > 0.1 MeV and En < 7 MeV



Coincidence Events



En > 7 MeV and En < 20 MeV



PPAC test

Background component & limitations

- The same material for Sample and detector
  Sample = 6 μm mylar
  PPAC = 3 electrodes of 1.7 μm mylar each one

- Cathodes pre-amp → gain not well suited for light particles

- α passing through 2 PPAC from the 2nd sample

PPAC test

Background component & limitations

- The same material for Sample and detector
  Sample = 6 μm mylar
  PPAC = 3 electrodes of 1.7 μm mylar each one

  → PPAC not directly in beam and/or PPAC far → events selection by time properties

- Cathodes pre-amp → gain not well suited for light particles

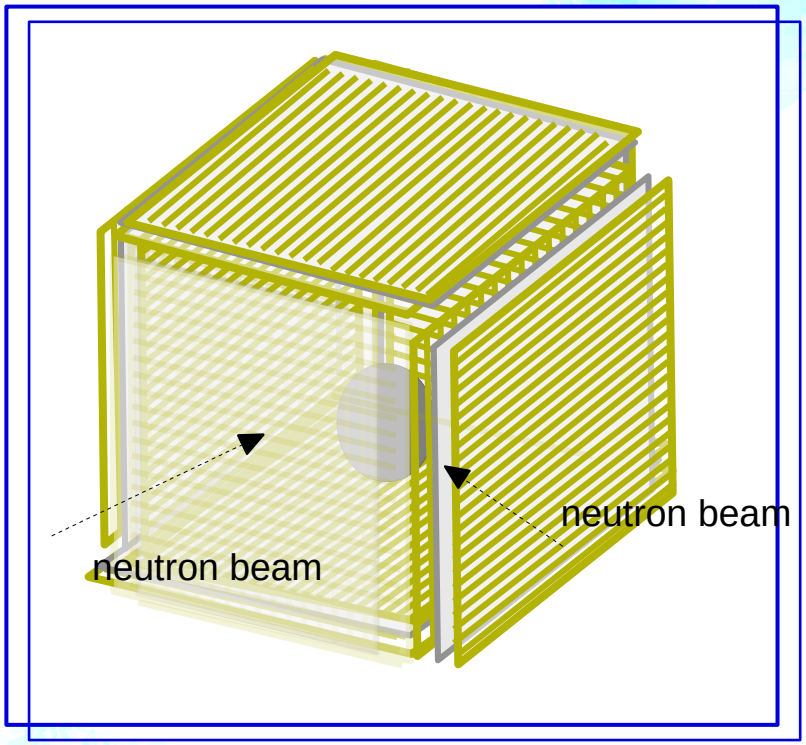
  → already planned a change in the cathodes electronics (probably before the Ce measurement)

- α passing through 2 PPAC from the 2nd sample

Solution

System for CAlorimetry with Parallel Plate Avalanche counters

SCAPPA



Extension of the 235U(n,f) cross section above 420 MeV

Technical papers:

- A. Manna, E. Pirovano et al. on behalf of the n_TOF collaboration, "*Recoil proton telescopes and parallel plate avalanche counters for the ^{235}U(n,f) cross section measurement relative to H(n,n)H between 10 and 500 MeV neutron energy*", Journal of Instrumentation 18 (04), P04024

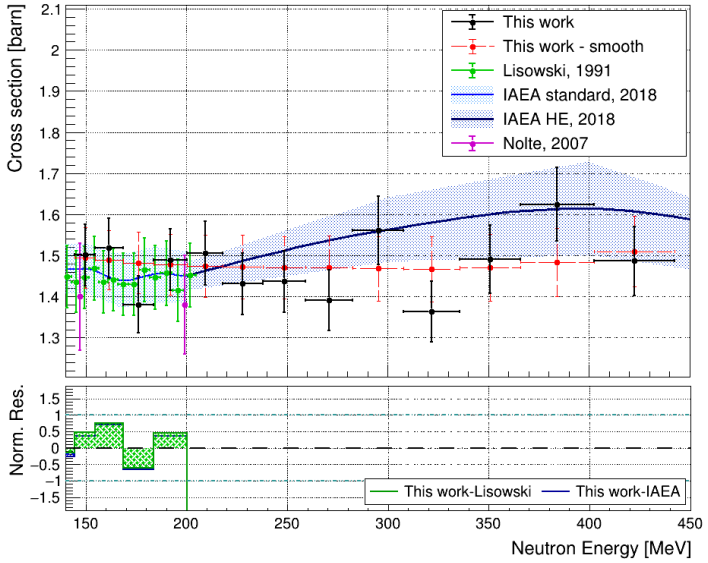
- E. Pirovano, A. Manna et al. on behalf of the n_TOF collaboration, "*A detector system for 'absolute' measurements of fission cross sections at n_TOF in the energy range below 200 MeV*", Journal of Instrumentation, in press

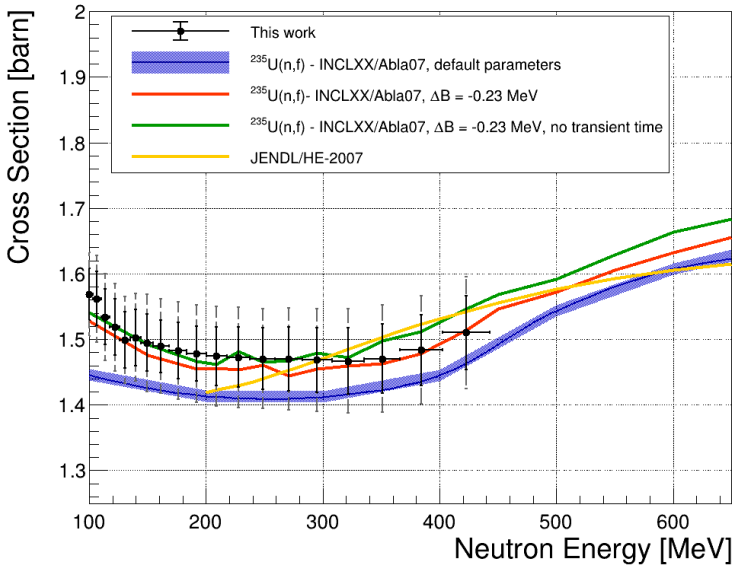
PRC:

a draft ready, in distribution soon

PRL:

a draft ready, in distribution soon



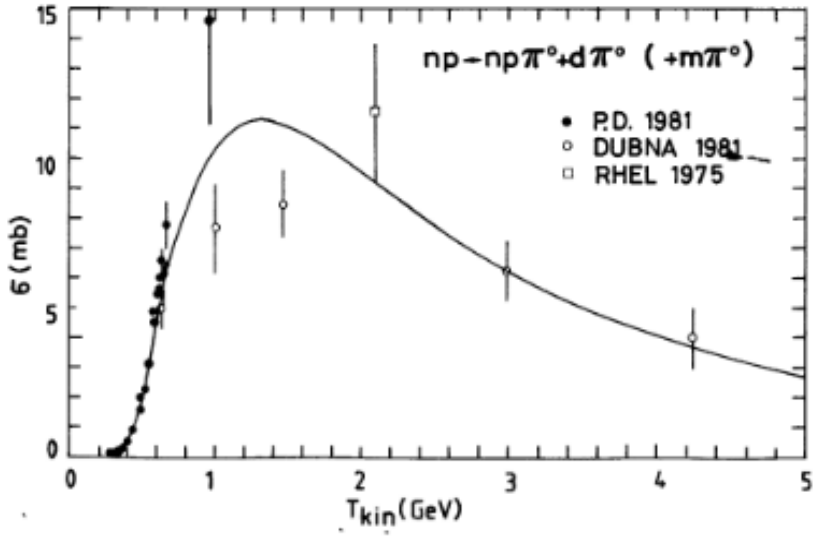


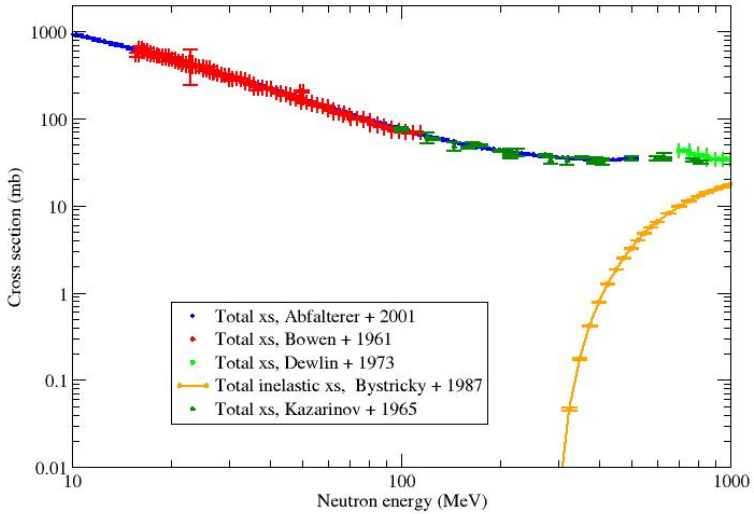
Extension of the 235U(n,f) cross section above 420 MeV

High energy limit in our measurement: opening of the first inelastic channel in the n-p reaction - excitation of the Δ resonance

1) $np \Rightarrow pn\pi^{\circ} + d\pi^{\circ} (+ m\pi^{\circ}$
2) $pp\pi^{-}$ or $nn\pi^{+}$
3) $np\pi^{+}\pi^{-}$
4) $pp\pi^{-}\pi^{\circ}(+ m\pi^{\circ})$
5) $d\pi^{+}\pi^{-}$
6) $nn\pi^{+}(+ m\pi^{\circ})$
7) $np\,2\pi^{+}2\pi^{-}$
8) $np\pi^{+}\pi^{-}\pi^{\circ}$
9) $pp\pi^{+}2\pi^{-}$.

$m(\pi) = 140\ MeV/c^2$





Development of a new detector able to measure the high-energy neutron based in the TOF of the protons from the n-p elastic scattering

Additional fission cross section measurement

Experimental data requested in the last IAEA neutron standard meeting

The idea...

Measurement feasible with our standard PPAC setup
(9 samples + 10 detectors)
in EAR-1 with fission collimator

Preliminary “ok” for the preparation of the samples from Orsay

Anyone is welcome to contribute to the preparation of the proposal and perform the experiment

^{239}Pu(n,f) xs/^{235}U(n,f) xs