First year Ph.D. research activity

Lucia Anna Damone

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Collegio docenti XXXI ciclo, Università degli studi di Bari Aldo Moro, 17 novembre 2016

Main topics

- ***^{7}Be (n,p) cross section measurement*** for the Cosmological Lithium Problem in the second experimental area of the n_TOF (neutron time of flight) facility at CERN

- Test for the ***^{7}Be (n,α) cross section measurement***

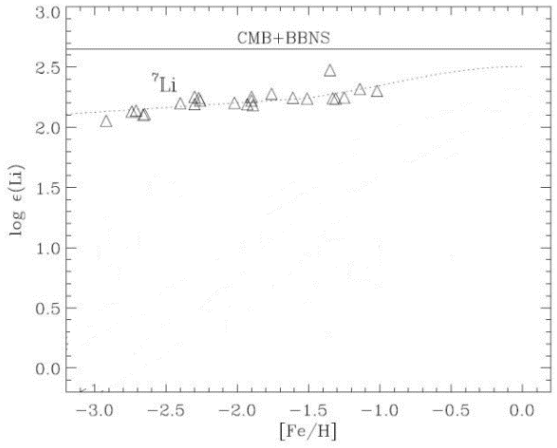
- ***Simulations*** for the measurement of the ***^{235}U(n,f) cross section*** from 200 MeV to 1 GeV at n_TOF

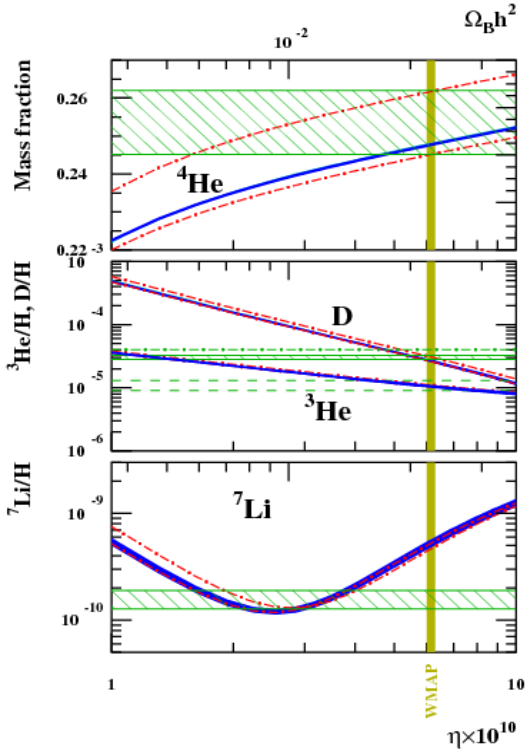
The Cosmological Lithium Problem

^{2}H ^{4}He ^{3}He VERY GOOD AGREEMENT between predicted and observed primordial abundances

WMAP $\left(\frac{Li}{H}\right)_{BBN} \cong 5.12 \times 10^{-10}$

Plank $\left(\frac{Li}{H}\right)_{BBN} \cong 4.89 \times 10^{-10}$





$$\eta \equiv \frac{N_b}{N_\gamma} = 2.74 \times 10^{-8} \Omega_b h^2$$

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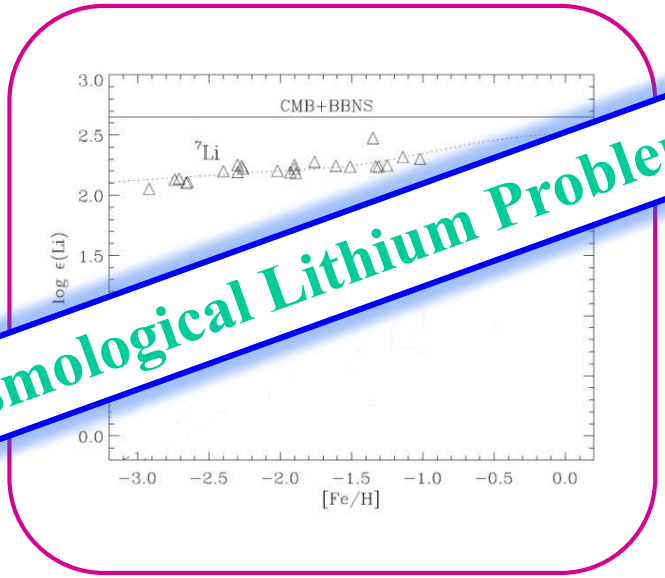
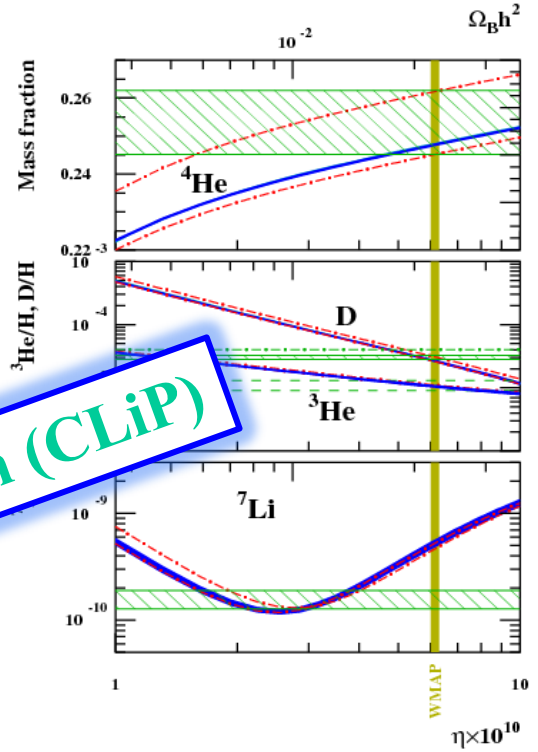


The Cosmological Lithium Problem (CLiP)



$$\eta \equiv \frac{N_b}{N_\gamma} = 2.74 \times 10^{-8} \Omega_b h^2$$

The Cosmological Lithium Problem

In the BBN 95% of the primordial ^{7}Li is produced by the electron capture decay of ^{7}Be

→

The abundance of ^{7}Li is essentially determined by the production and destruction of ^{7}Be

↓ ↓

A higher destruction rate of ^{7}Be can solve or at least partially explain the CLiP

Reaction induced by p, d, t,... Didn't solve the problem.

^{7}Be can be destroyed also via:

$$n + {}^{7}Be \rightarrow p + {}^{7}Li \quad Q = 1.644\ MeV\ (\sim 95\%)$$

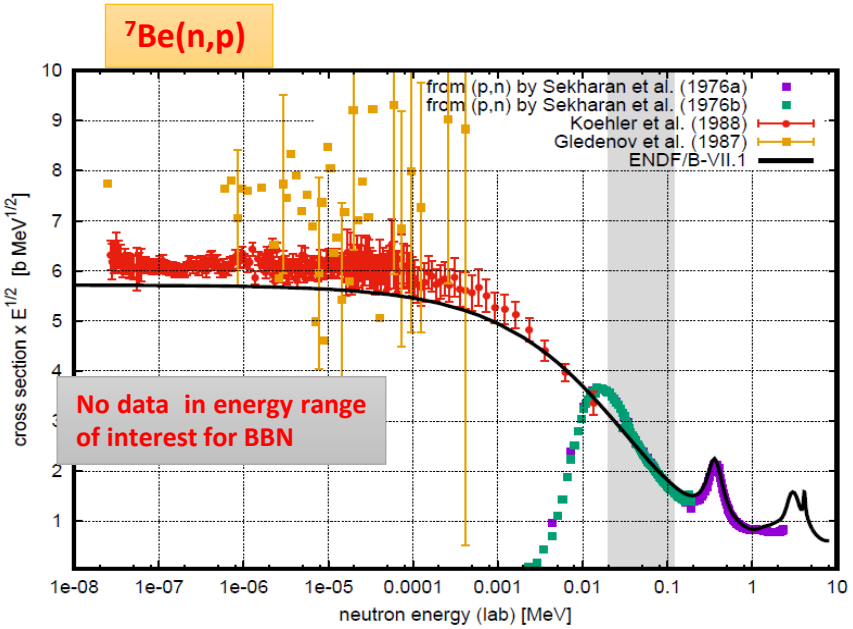
$$n + {}^{7}Be \rightarrow \alpha + \alpha \quad Q = 16.6\ MeV\ (\sim 2.5\%)$$

Data avaliable for these reactions

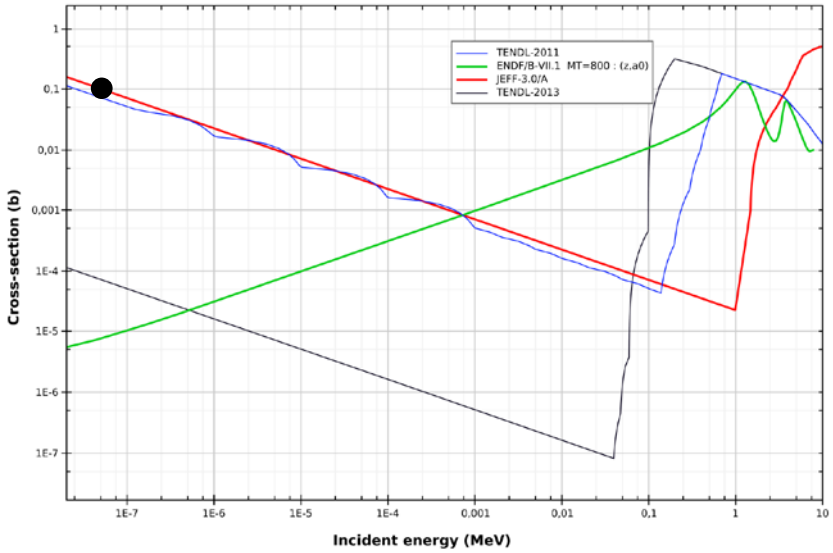
Only one direct measurement (**Koehler at al.**, 1988, **0.025 eV-13.5 keV**)

Only one direct measurement (**P. Bassi et al.**, 1963), at **thermal energy**.

$^{7}\mathbf{Be(n,p)}$



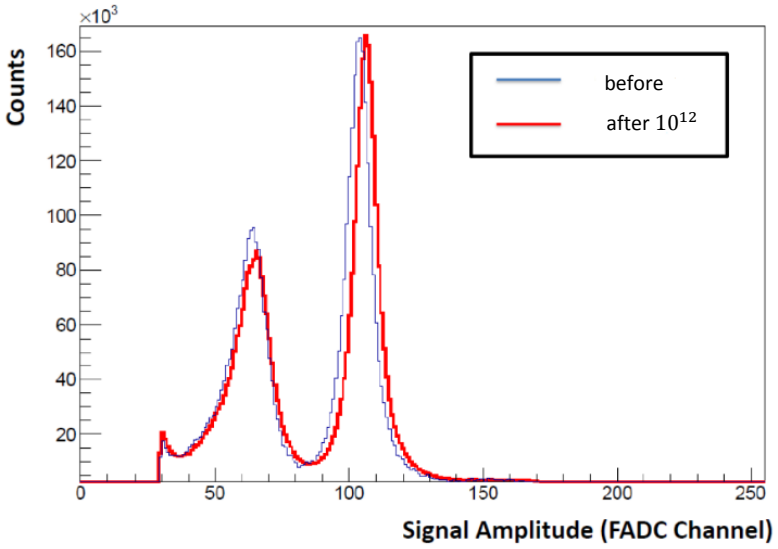
$^{7}\mathbf{Be\ (n,\alpha)}$

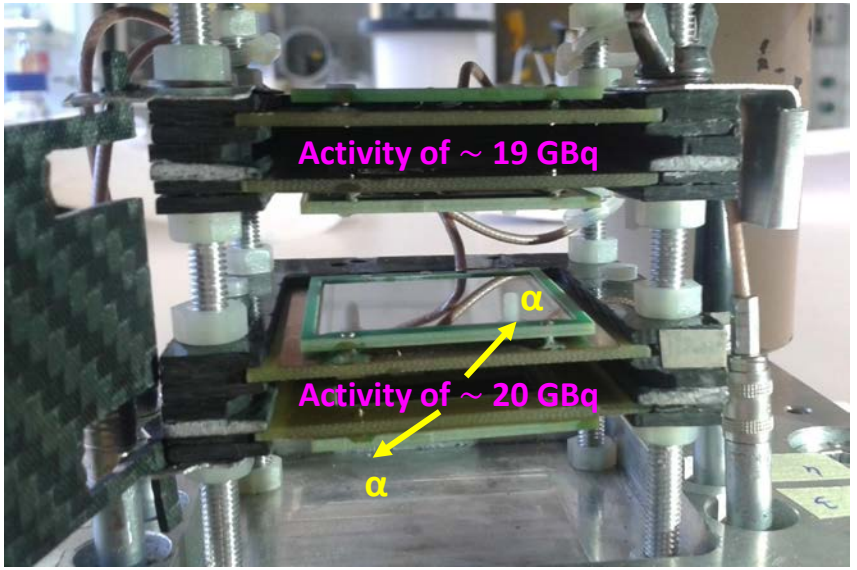


$^{7}Be(n,\alpha)$ cross section measurement

Test study the behavior of the detectors

Silicon detectors directly inserted in the beam

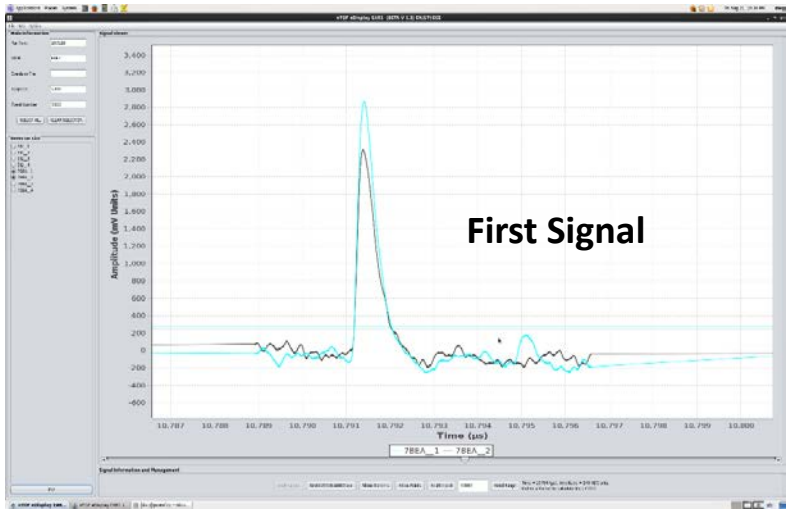


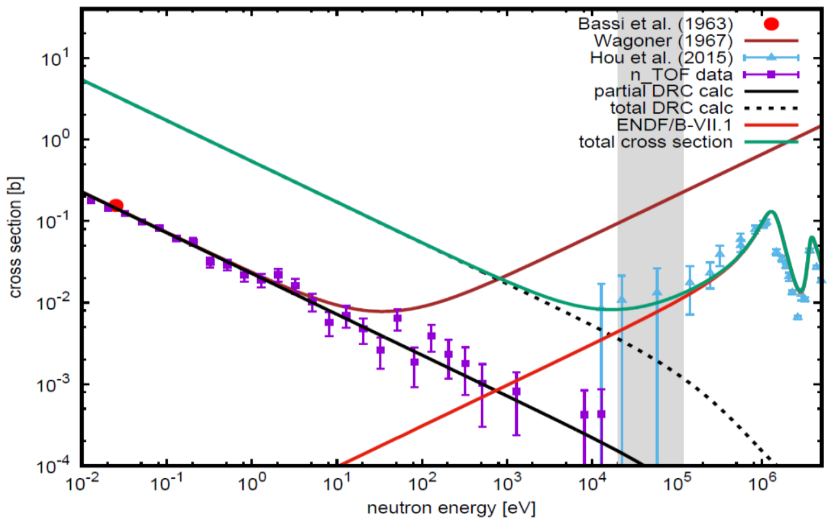


No damage from radiation and consequent degradation in the performance of the detectors with increasing absorbed dose

$^{7}\mathrm{Be}(n,\alpha)$ cross section measurement

Coincidences of two α particles coming from $^{7}\mathrm{Be}(n,\alpha)\ ^{4}\mathrm{He}$ reaction have been observed for the first time above 0.025 eV





1/v behaviour of the $^{7}\mathrm{Be}(n,\alpha)\ ^{4}\mathrm{He}$ reaction cross section.
Good agreement with the only previous measurement (@0.025 eV). The n_TOF cross section is (respect to the predictions) a factor 20 higher at thermal energy, but a factor 10 lower in the BBN region.

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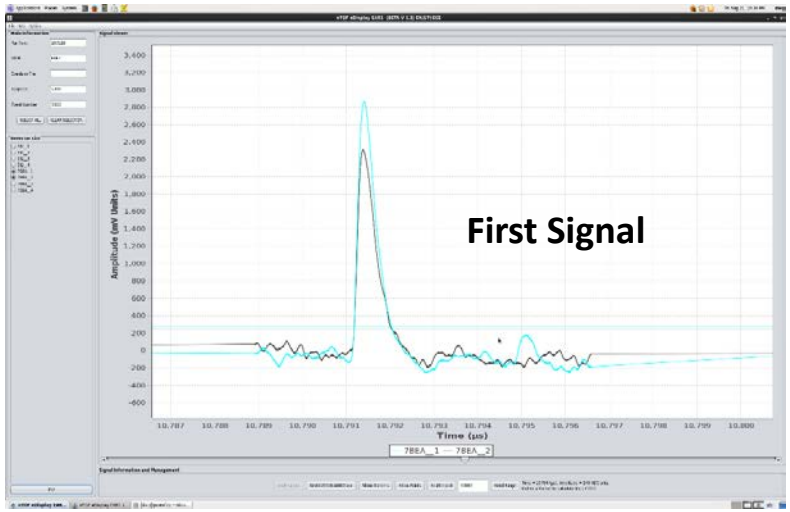

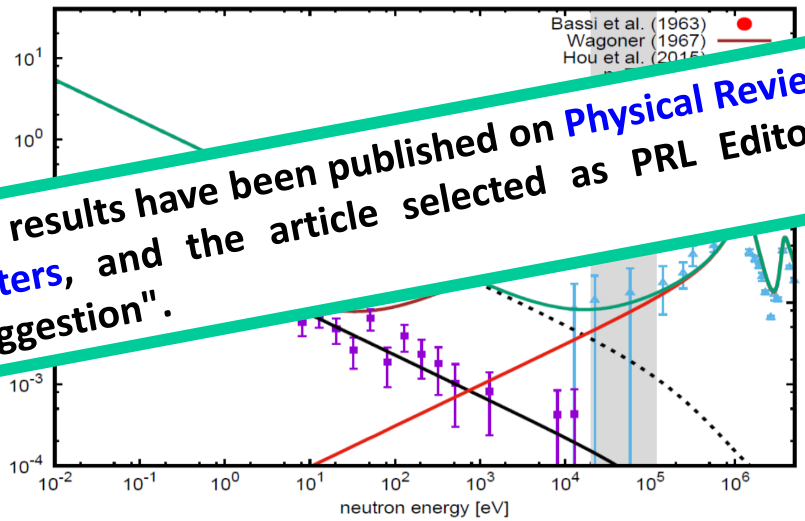

The results have been published on Physical Review Letters, and the article selected as PRL Editors' Suggestion".

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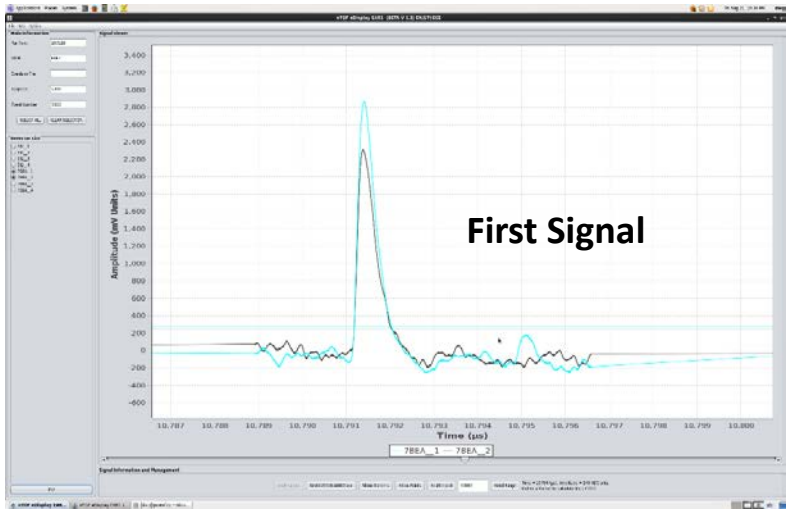

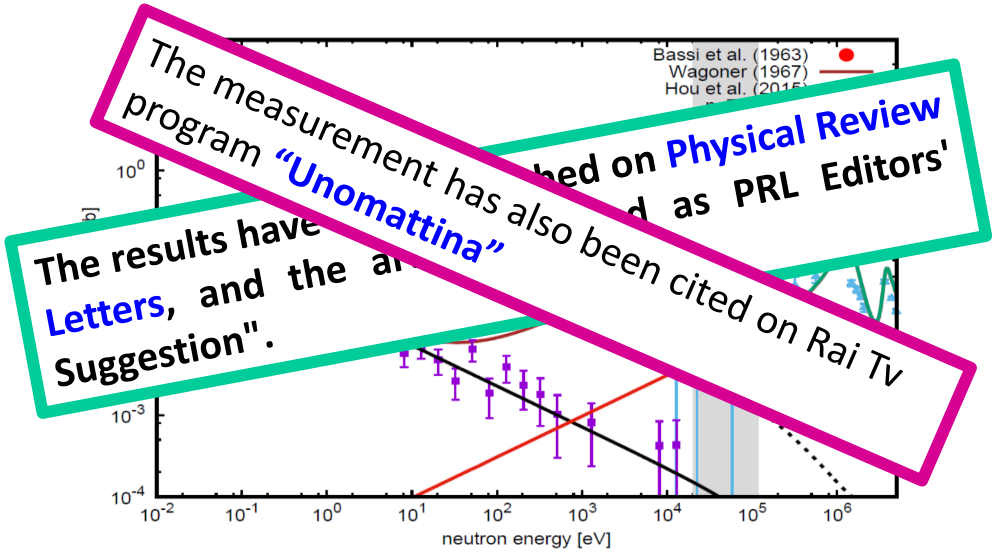

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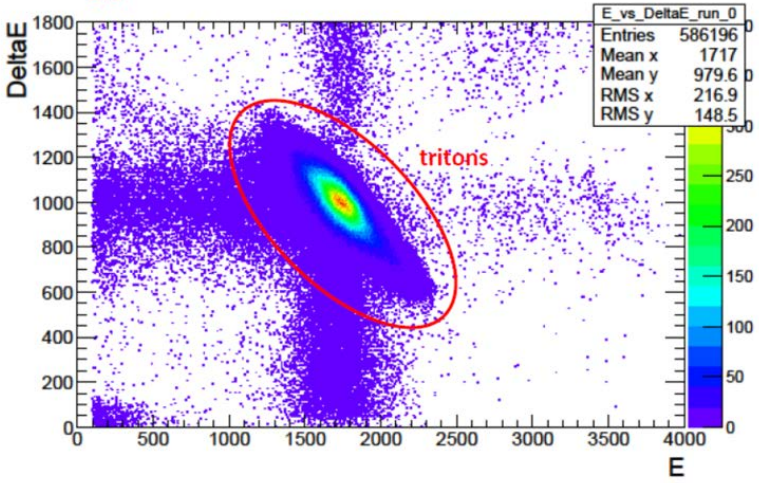
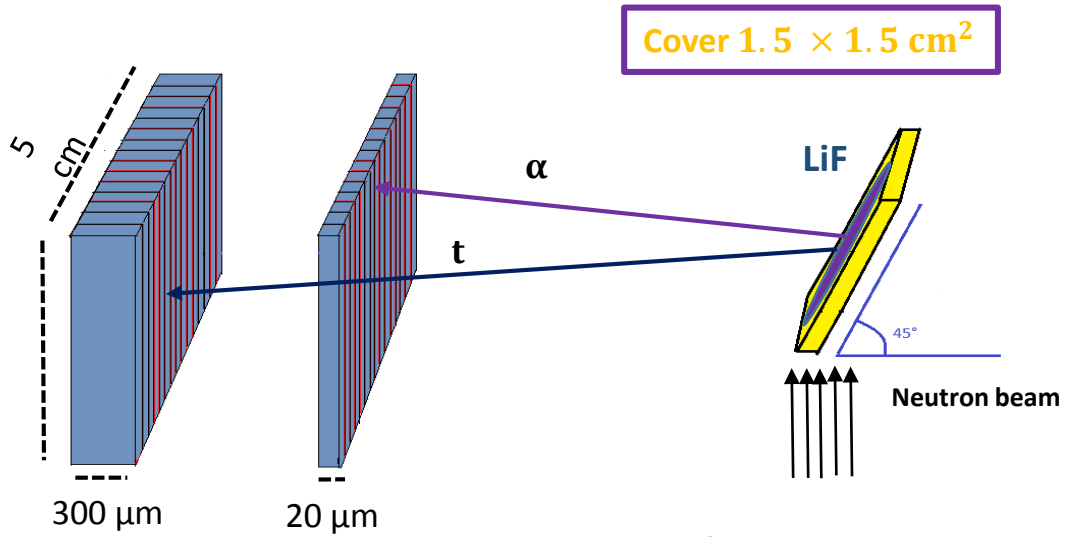
$^{7}Be(n,p)$ cross section measurement

$$n + {}^{6}Li \rightarrow \alpha + t$$

LiF



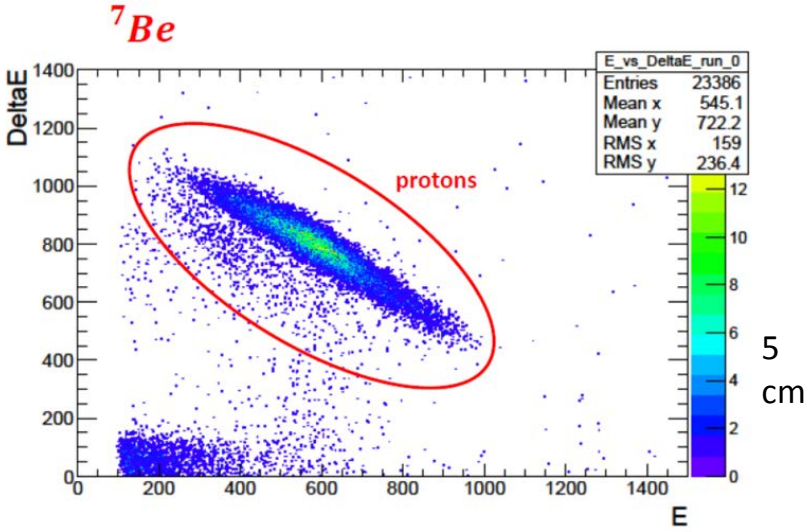


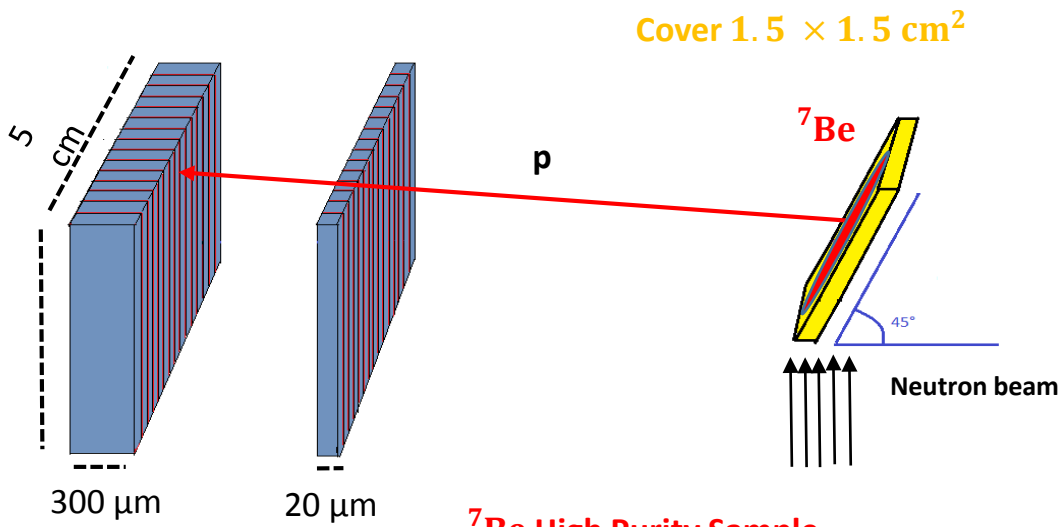
LiF Sample

xy	$5 \times 5\ cm^2$
z	1.8 µm

$^{7}Be(n,p)$ cross section measurement

$$n + {}^{7}Be \rightarrow p + {}^{6}Li$$

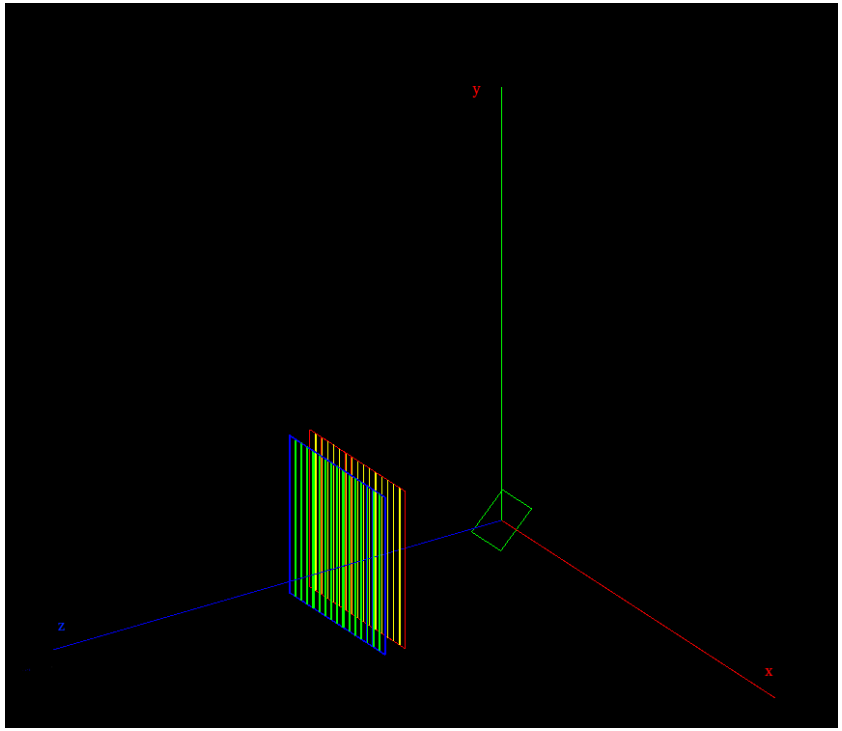


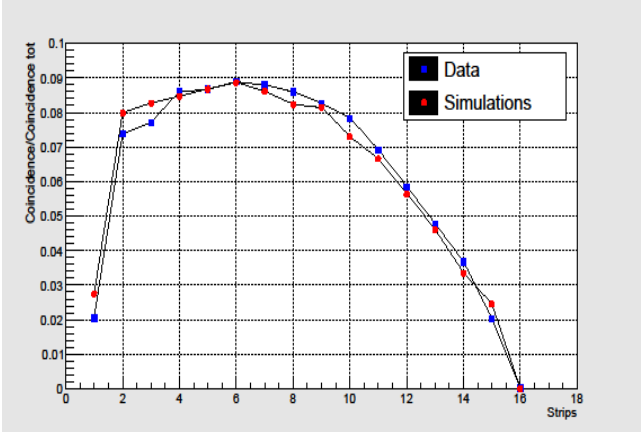


^{7}Be High Purity Sample

Activity	1.1 GBq
Radius	2.5 mm

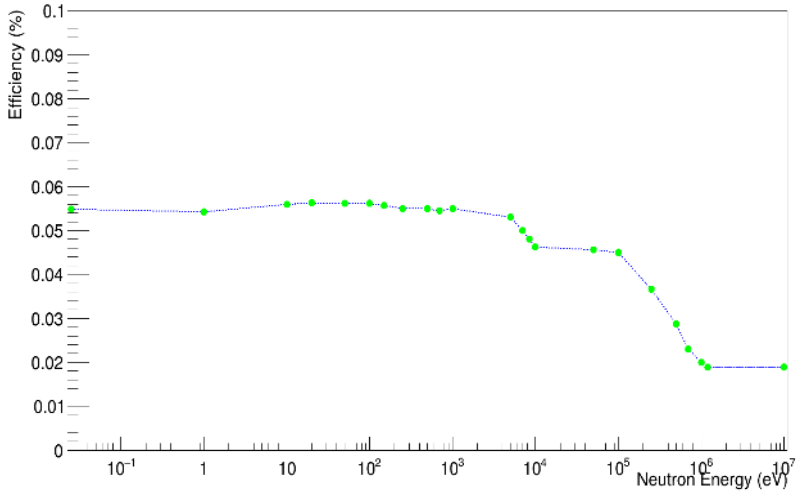
Geant4 simulations





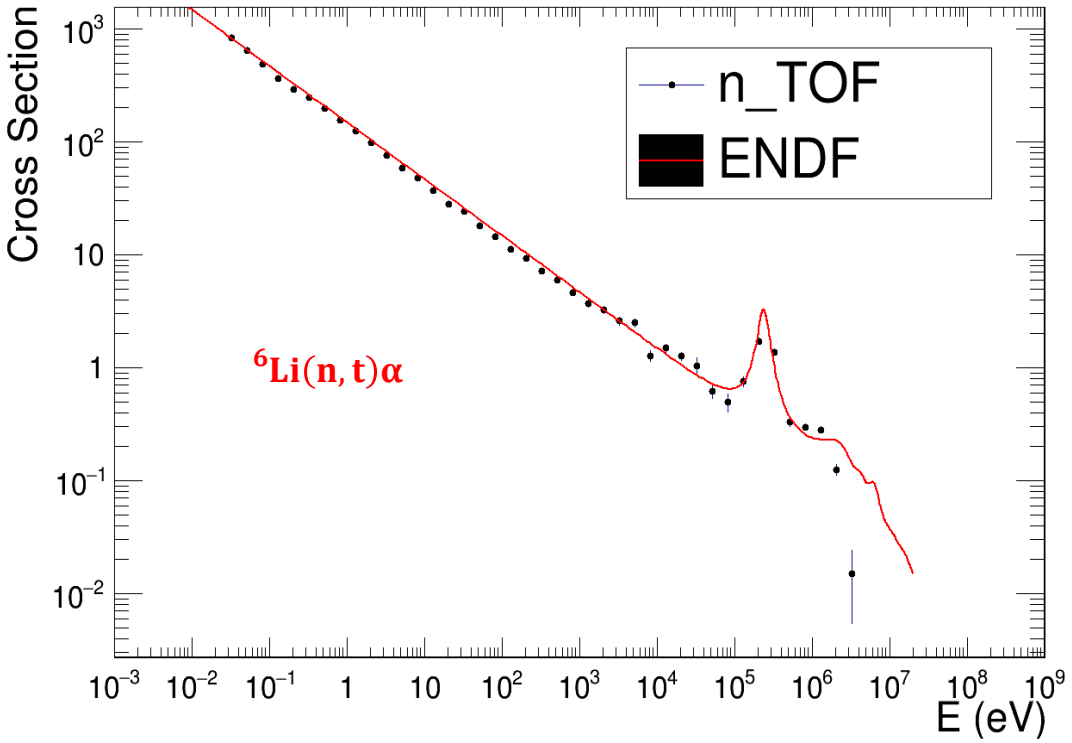
Very good agreement!

After few keV the products emission is not isotropy anymore



Preliminary results

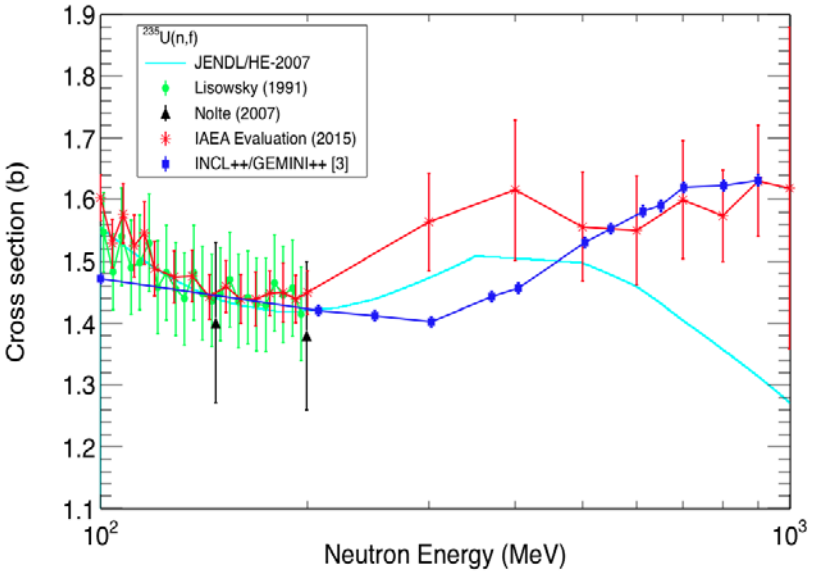
normalizing the cross section of ^{6}Li at thermal energy…

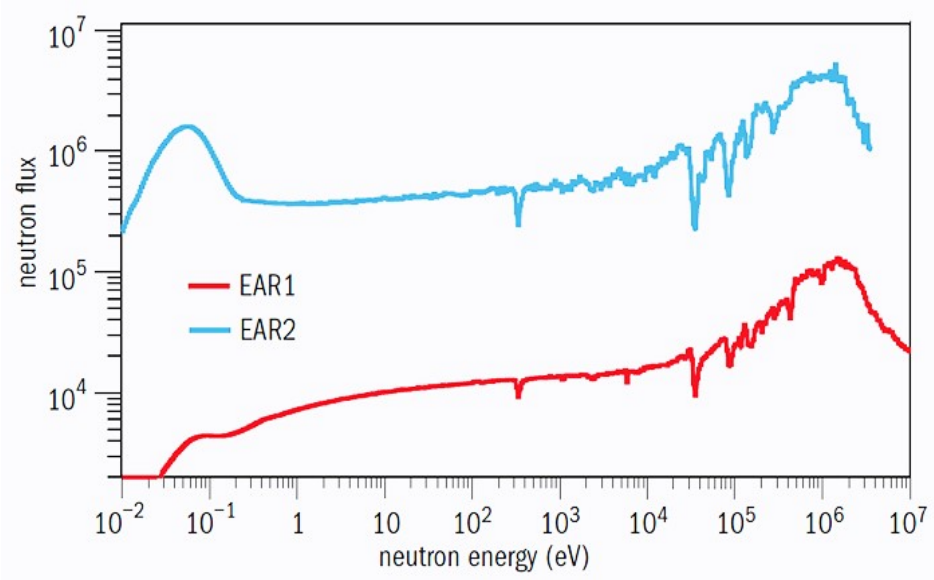


The ^{235}U(n,f) cross section

No data exist on the ^{235}U(n,f) reaction above 200 MeV, and one has to rely on highly uncertain theoretical estimates

^{235}U(n,f) cross section standard at 25 meV and between 0.15 MeV and 200 MeV. Used as **reference in many fields**. In particular to measure the neutron flux in various neutron facilities worldwide, including n_TOF.

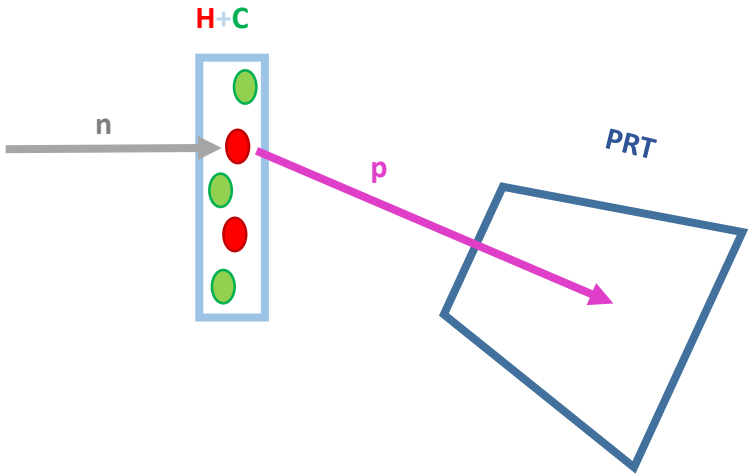




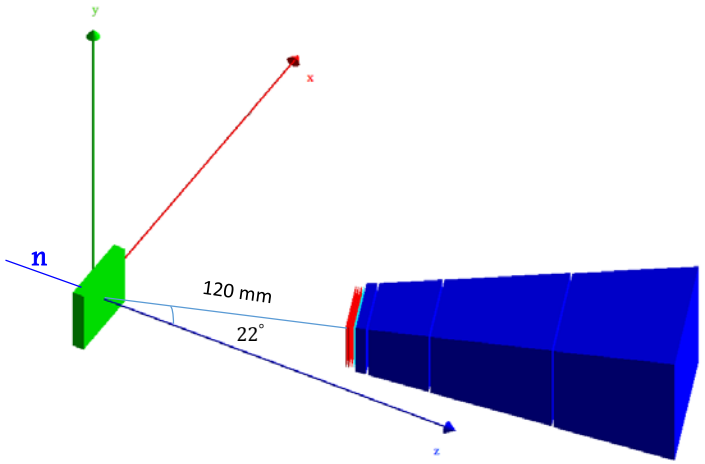
Set-up

• **Measurement** of the ^{235}**U(n,f) cross section** above 200 MeV, relative to the **H(n,n)H** elastic scattering reaction.

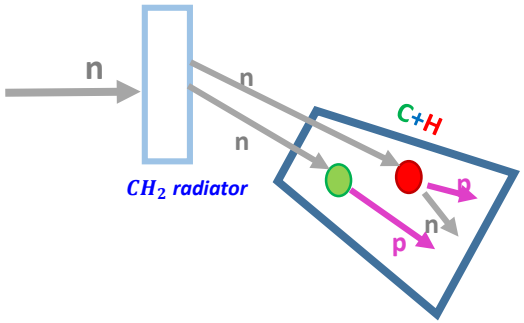
• $\Delta E - E$ **method** to identify **protons**

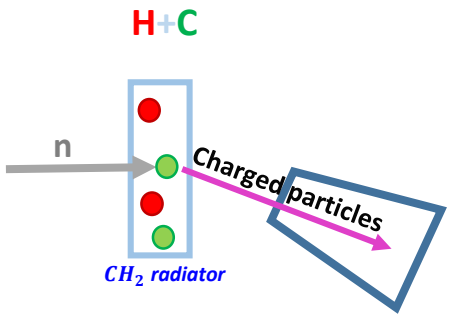


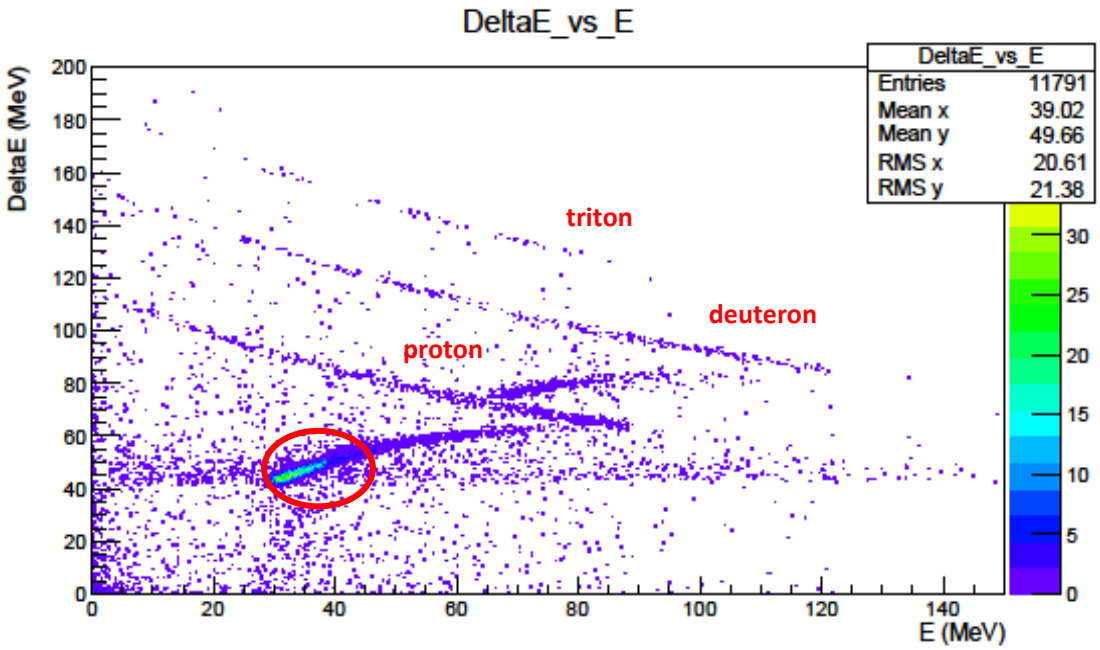
Geant4 simulations



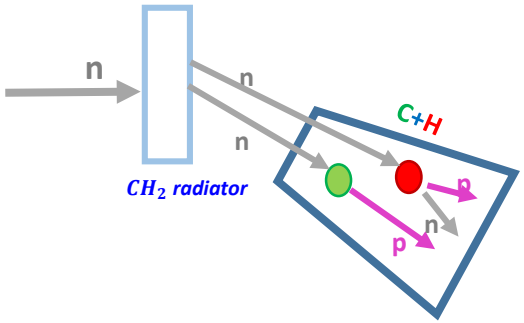
Background

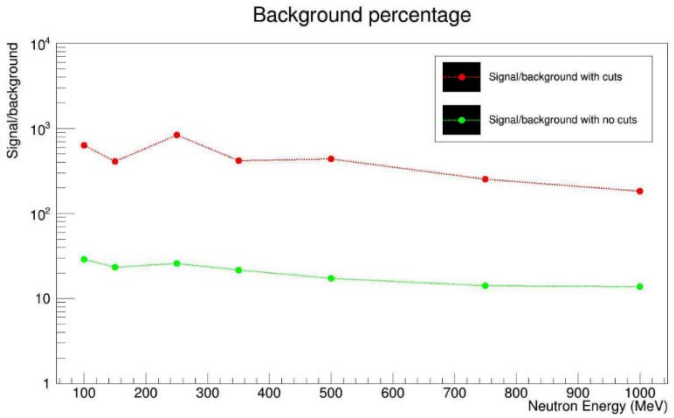

n
n
n
C+H
CH_2 radiator
p
p
n


H+C
n
Charged particles
CH_2 radiator

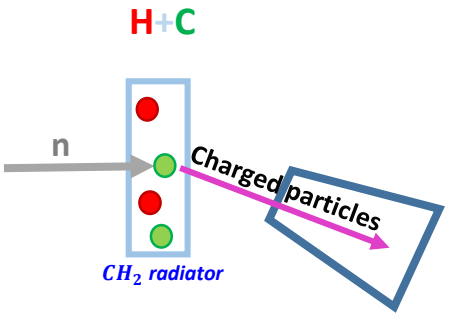

DeltaE_vs_E
DeltaE_vs_E
Entries 11791
Mean x 39.02
Mean y 49.66
RMS x 20.61
RMS y 21.38
DeltaE (MeV)
E (MeV)
triton
deuteron
proton

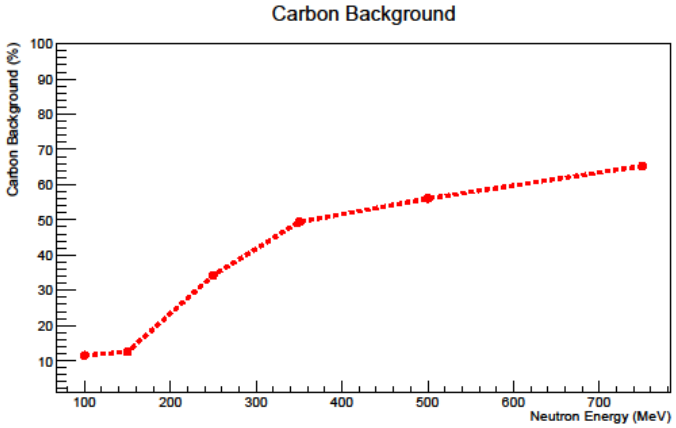
Background





Neutron beam and **proton beam** impinging directly on the PRT



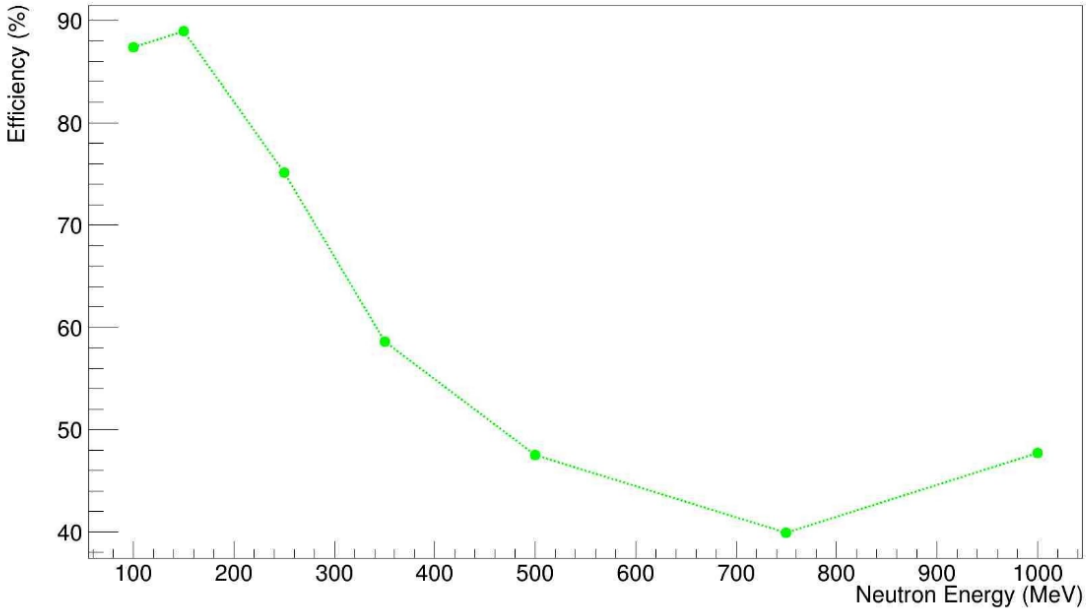


Neutron beam of 250 MeV impinging on a **C** radiator and on a CH_2 radiator

Efficiency

Neutron beam impinging on a H_2 radiator to study the multiple scattering in the detectors

Efficiency: ratio between the protons in the peak and total incident protons on the PRT



Pubblications, Schools and Conferences

- L. Cosentino et al., **"*Experimental setup and procedure for the measurement of the ^{7}Be(n,α)α reaction at n_TOF*"**, *NIM A 830 (2016) 197-205*

- M. Barbagallo et al.,***The ^{7}Be(n,α)^{4}He reaction and the Cosmological Lithium Problem: measurement of the cross section in a wide energy range at n TOF (CERN)*.** **Physical Review Letters** 117, 152701 (2016). Article "Selected as PRL Editors' Suggestion".

- **Russbach Nuclear Astrophysics School** (6-12 March 2016);
- **XXVIII seminario nazionale di Fisica nucleare e subnucleare "Francesco Romano"** (Otranto, 3-10 June 2016); where I presented a talk on: "Simulazioni con Geant4 di un proton recoil Telescope per la misura ad n_TOF del flusso di neutroni tra 100 MeV e 1 GeV«;
- **The XII Torino workshop and IV CSFK Astromineralogy workshop** (Budapest, 31 July-5 August 2016); where I presented a talk on: "^{7}Be(n,α) and ^{7}Be(n,p) cross section measurement for the Cosmological Lithium Problem at n_TOF-EAR2";
- **102° Congresso della Società Italiana di Fisica** (Padova, 26-30 September 2016); where I presented a talk on: "Geant4 simulations of a Proton Recoil Telescope for the measurement of the n_TOF neutron flux between 100 MeV and 1 GeV";
- **Terzo Incontro Nazionale di Fisica Nucleare INFN 2016** (14-16 November 2016); where I presented a poster on: " Geant4 simulation of a Proton Recoil Telescope for the measurement of the ^{235}U(n,f) cross section up to 1 GeV at n_TOF ";

Exams and Teaching activity

ESAME E DOCENTE	ESITO
"Inglese", C. White	SUPERATO
"Progetto Europeo", A. D'orazio	SUPERATO
"Introduction to C++ programming", F. Cafagna	SUPERATO
"Advanced C++ programming", F. Cafagna	SUPERATO
"Rivelatori al Silicio", D. Creanza	SUPERATO
"Analisi dati sperimentali", A. Pompili	CONSEGNATO
"Rivelatori a gas e scintillatori", V. Peskov	15-December
"Astrofisica Nucleare", G. Tagliente	SUPERATO

Teaching Activity

Training for electronic engineering students.
Professor of the course: ***Giuseppe Iaselli***

Goals for the second year of Ph.D

- I will complete the **analysis of the ^{7}Be(n,p) reaction**
- I will be responsible for the measurement of the ^{235}U(n,f) cross section relative to the n-p scattering, with the Proton Recoil Telescope. For this last subject, I have been appointed a **fellowship as "CERN Associate"** (also called "simil fellow"), which will allow me to spend the whole year (2017) at CERN.
- I will also participate in all **other measurements** that will be performed at n_TOF, helping with the experimental apparatus, the data taking and analysis.
- In 2017 I plan to attend a few **conferences** where to present my results, and a **school in Nuclear Astrophysics**.

THANK YOU FOR YOUR KIND ATTENTION!