

MIMAC-FASTⁿ :
A mobile and directional fast neutron spectrometer
[10 keV - 600 MeV]



Nadine Sauzet, Daniel Santos, Olivier Guillaudin

Laboratoire de Physique Subatomique et de Cosmologie
(Université Grenoble-Alpes -CNRS/IN2P3)



CONTEXT OF MIMAC-FASTn : a valorisation project

Root of the project : MIMAC



- Instrumentation dedicated to directional dark matter detection
- Valorisation in a fast neutron spectrometer

Funding by Enigmass labex,
prematuration of CNRS, and
SATT/LINKSIUM

Since september 2014

Collaboration with IRSN/LMDN
(Laboratory of Neutron Metrology
and Dosimetry)

Since 2010

SPECIFICITY OF MIMAC-FAST_n

NOT JUST NEUTRON
COUNTING !

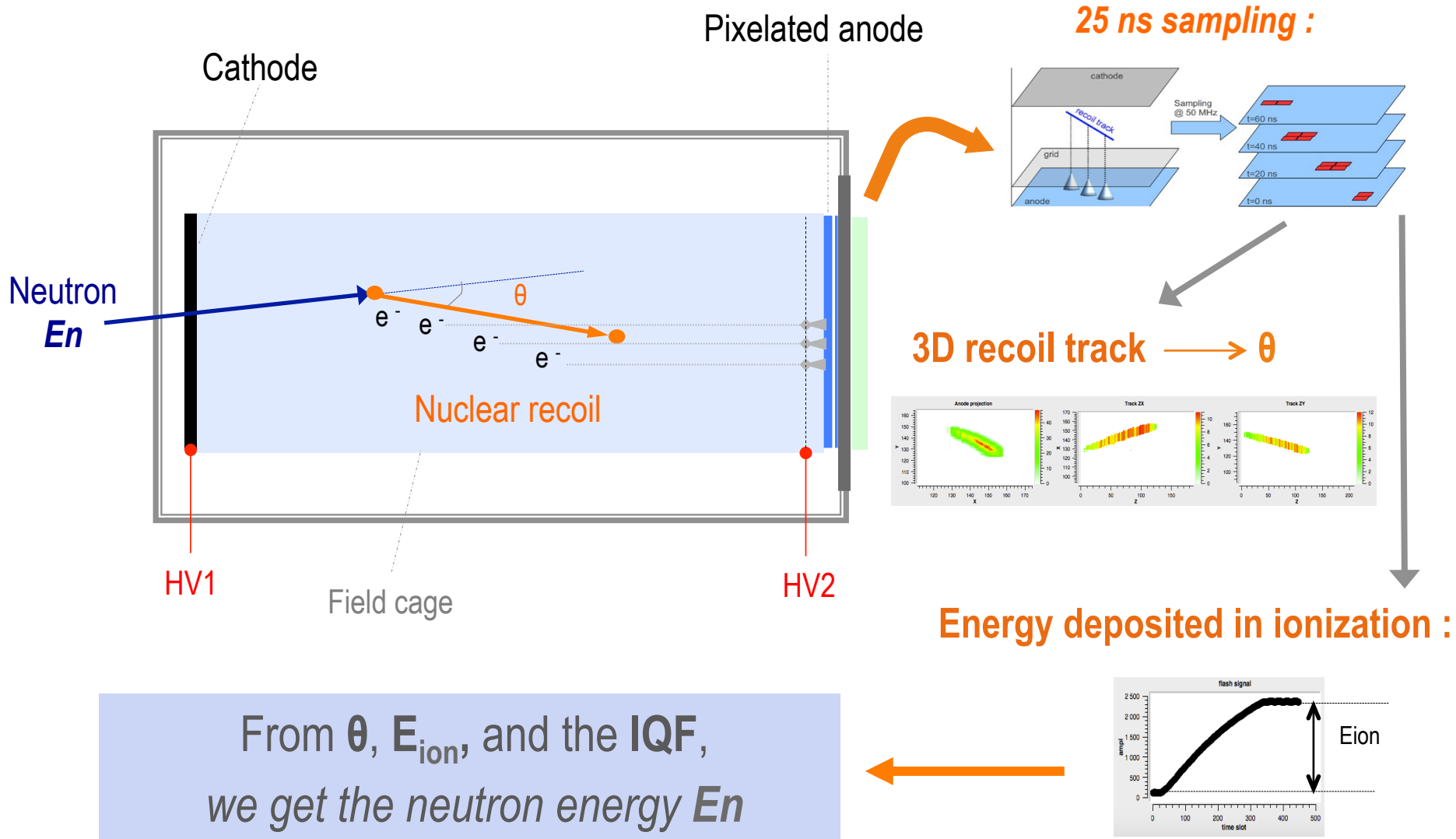
A 3D DETECTION

No moderation
No ³He
No ⁶Li



Adjustable range :
[10 keV ; 600 MeV]

MIMAC-FASTn operation principle

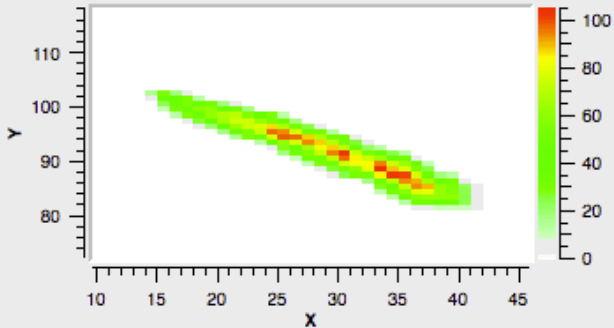


A ^4He NUCLEAR RECOIL TRACK

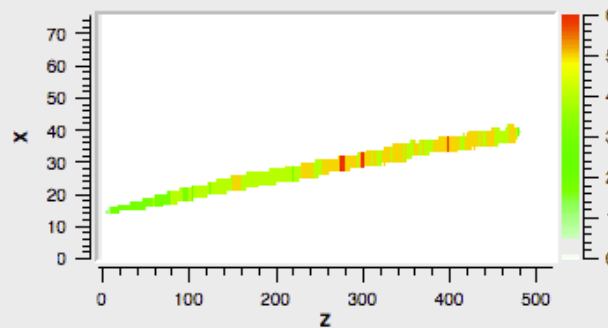
2.9 MeV kinetic

Theta angle = 10°

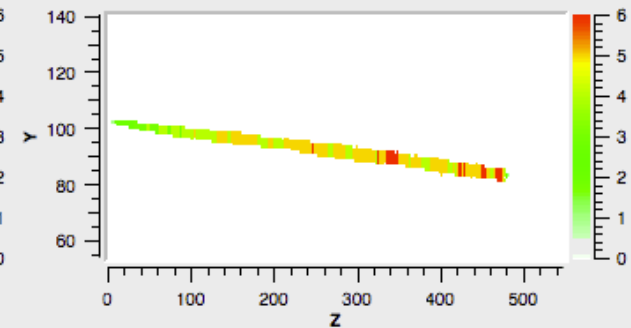
Anode projection



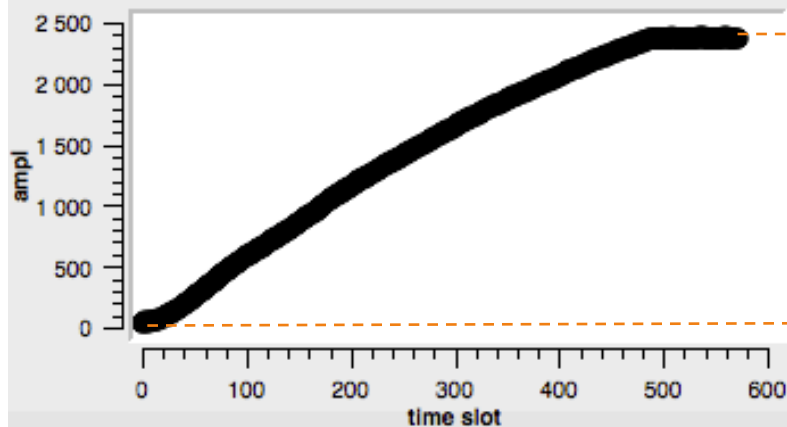
Track ZX



Track ZY



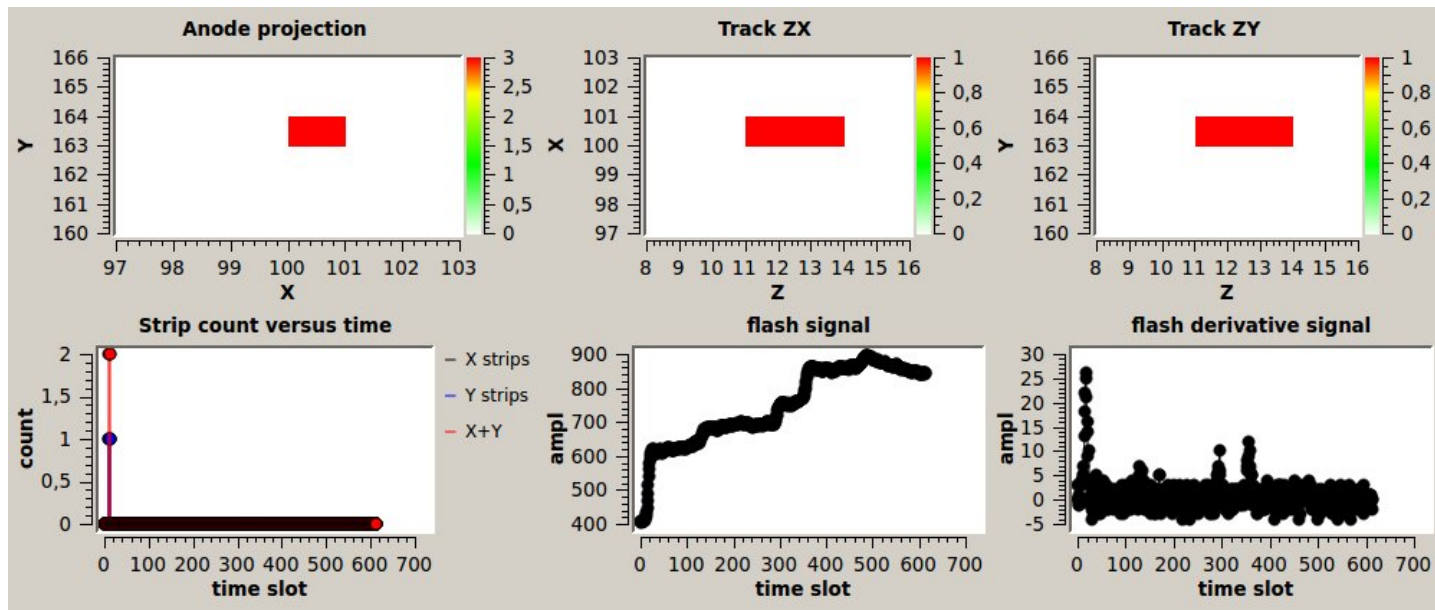
flash signal



Ionization energy

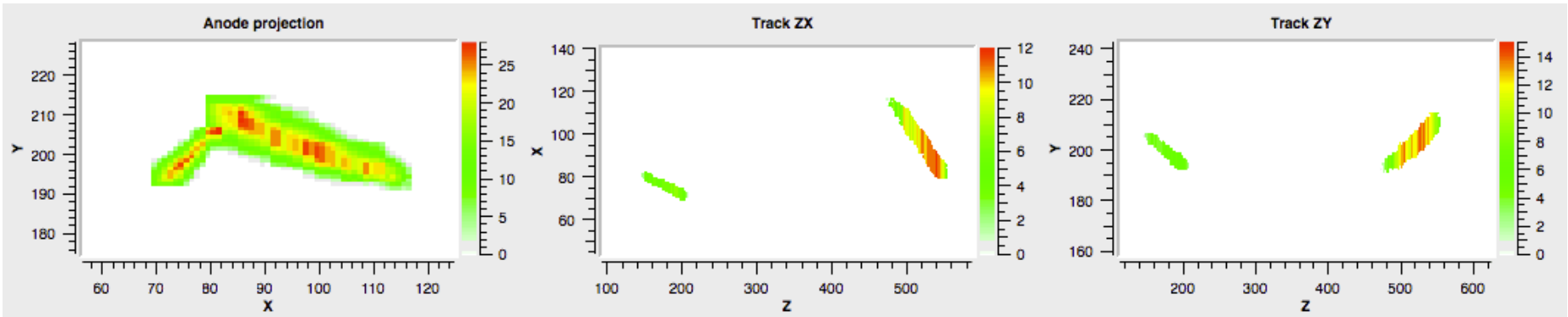
AN EXAMPLE OF ELECTRON EVENT

Electron event :

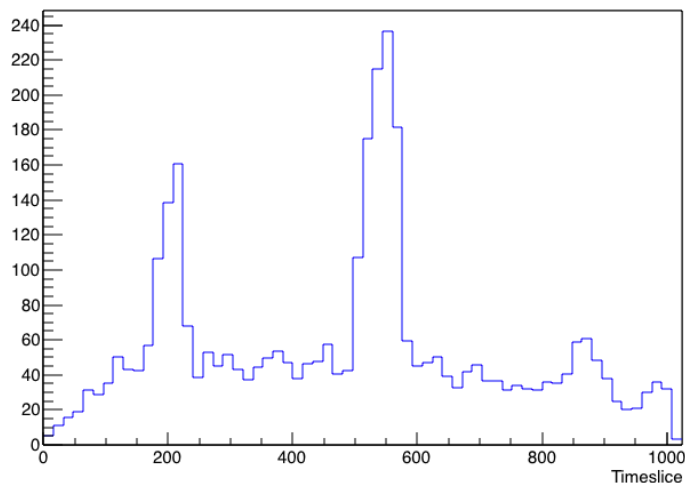


IN HIGH NEUTRON FLUX, IN A WINDOW OF 25 MICROSECOND

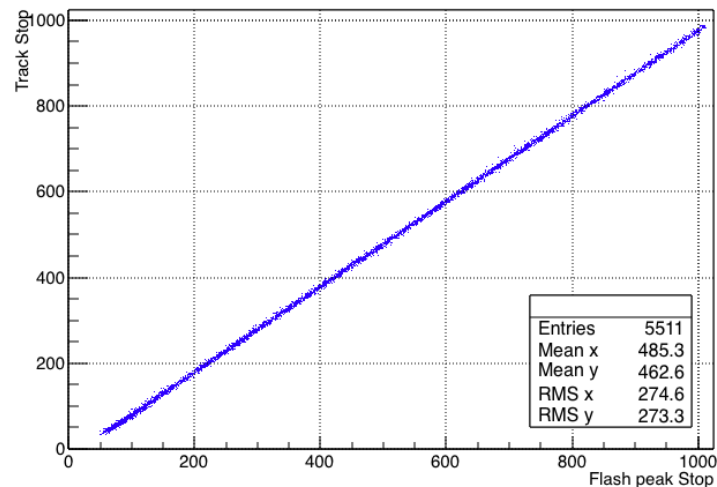
Multiple ^4He recoil tracks :



Flash profile derivative



Flash ADC – anode synchronization



MIMAC (Modane)

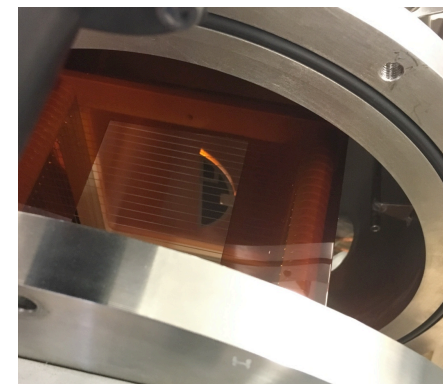
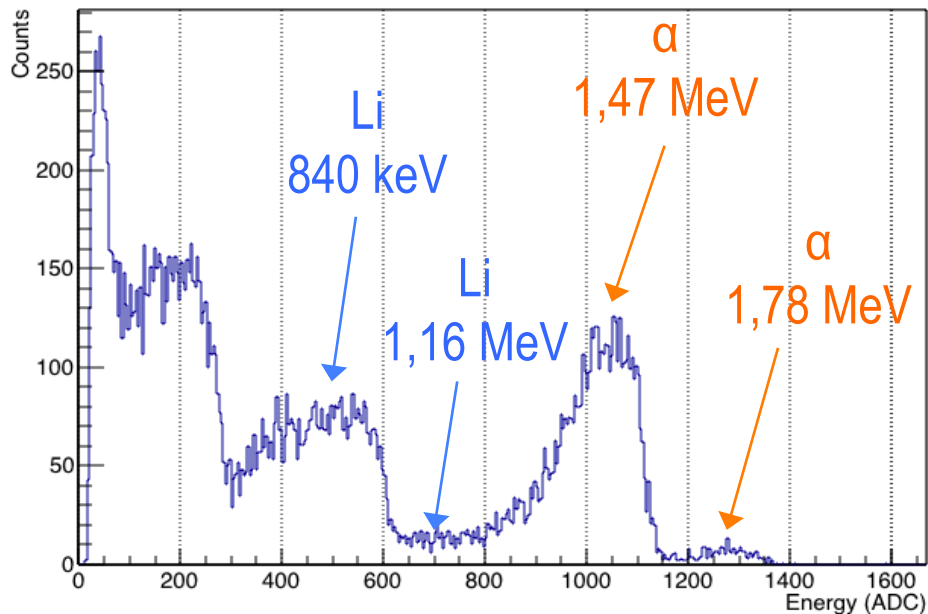


MIMAC-FAST_n

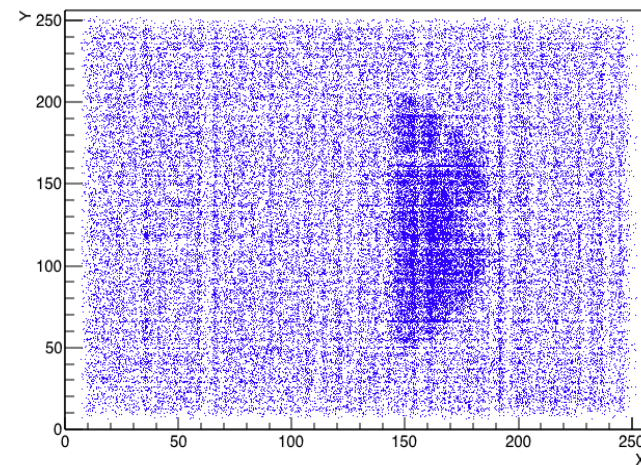


ENERGY CALIBRATION OF THE FLASH-ADC

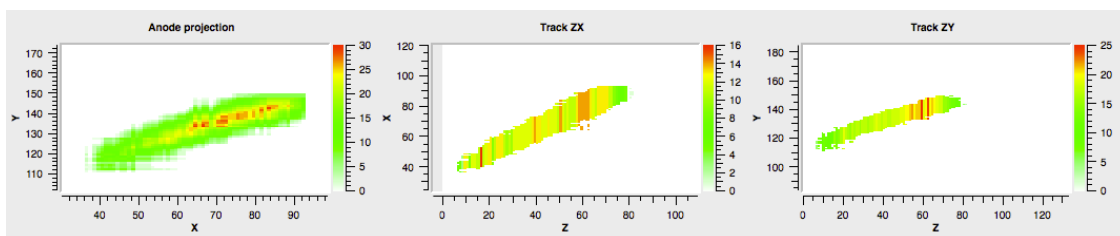
Detection of α and ${}^7\text{Li}$, resulting from thermal neutron capture on a B_4C layer



Projection sur l'anode : debut de la trace

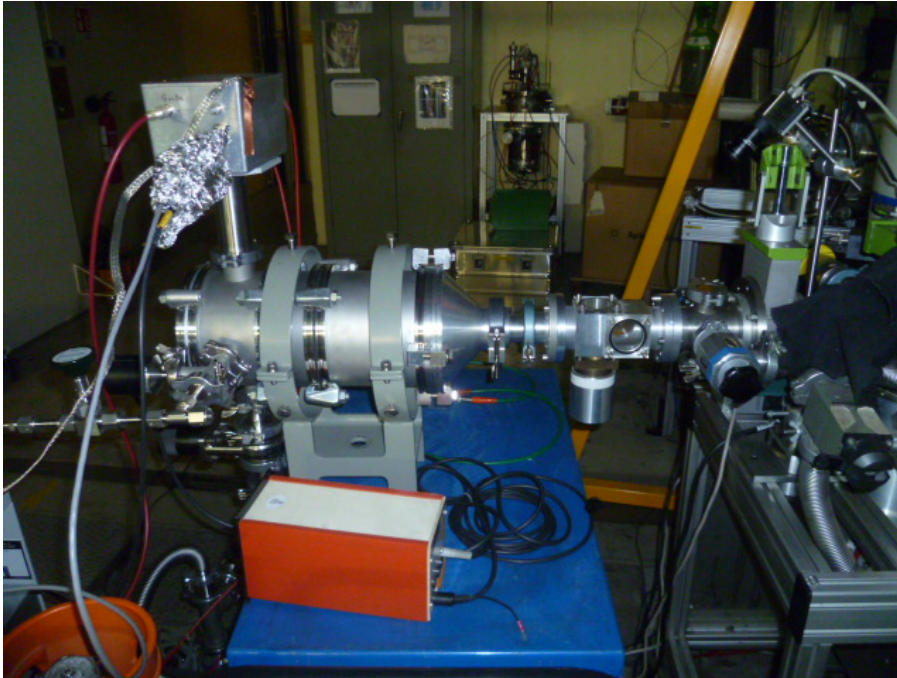


Alpha track

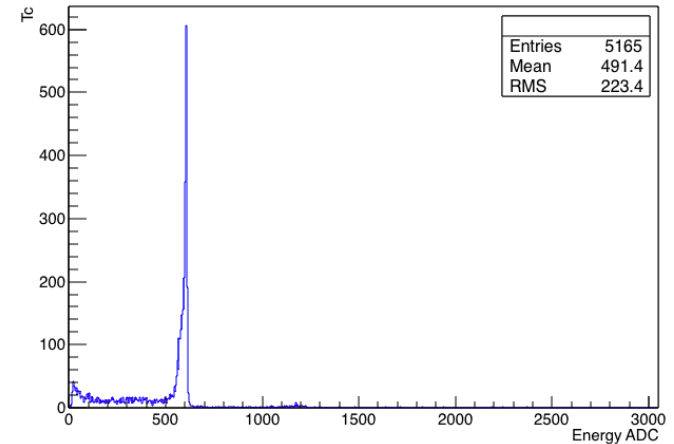


IONIZATION QUENCHING FACTOR MEASURE OF ^4He

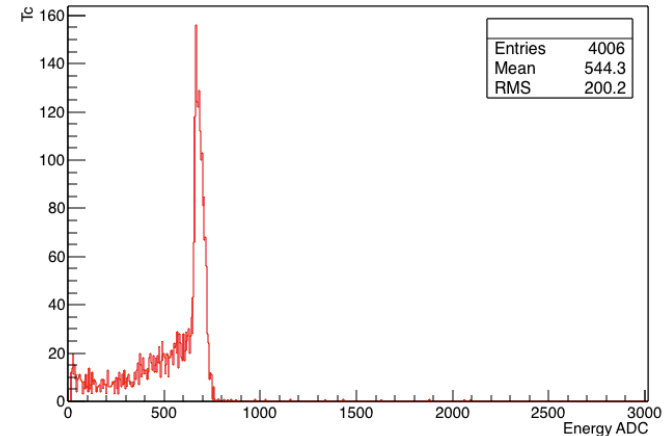
An IQF measure relative to protons



1 MeV kinetic alpha



1 MeV kinetic proton

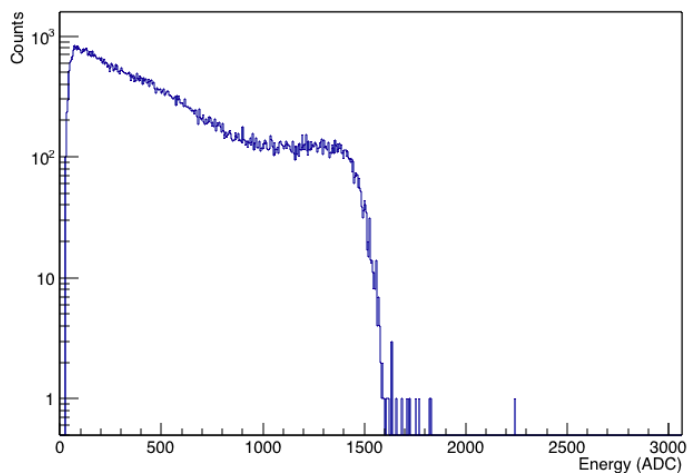


IPNL beam line coupled to a drift space of 25 cm and a 512 μm Micromegas through a 1 μm hole interface

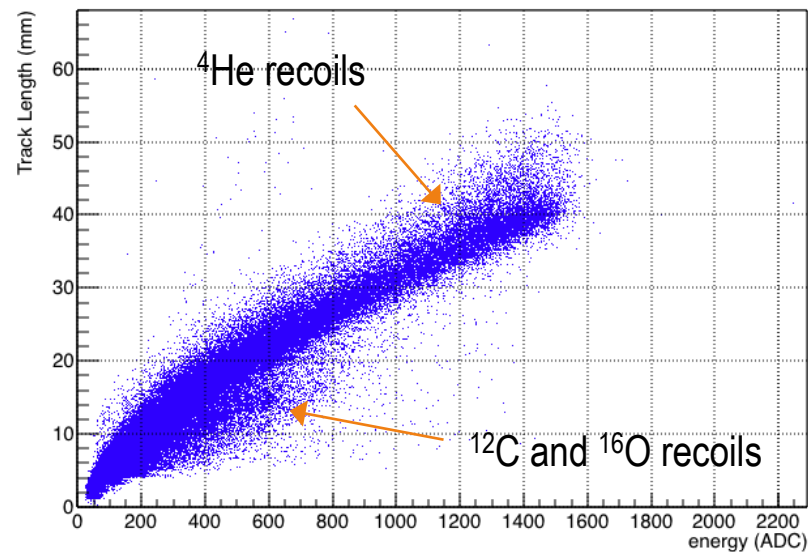
Mixture of $^4\text{He}/\text{CO}_2$ 700 mbar

MONOENERGETIC NEUTRON MEASURE : $^3\text{H}(p(3357 \text{ keV}),n)$

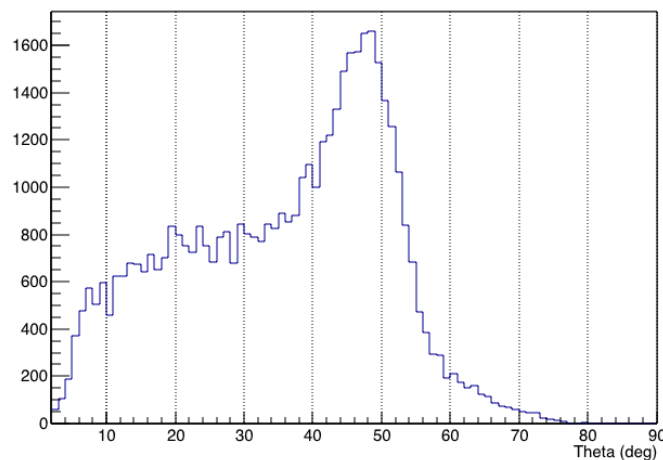
Ionization energy spectrum :



Track length = (energy) :



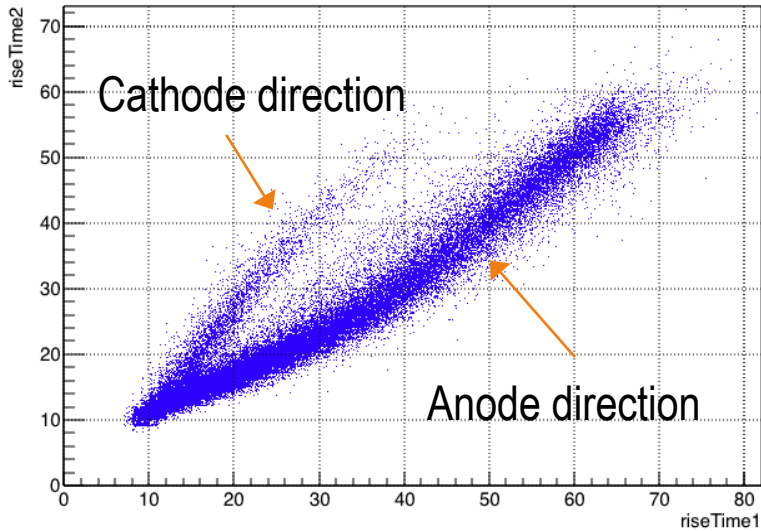
Theta angle distribution :



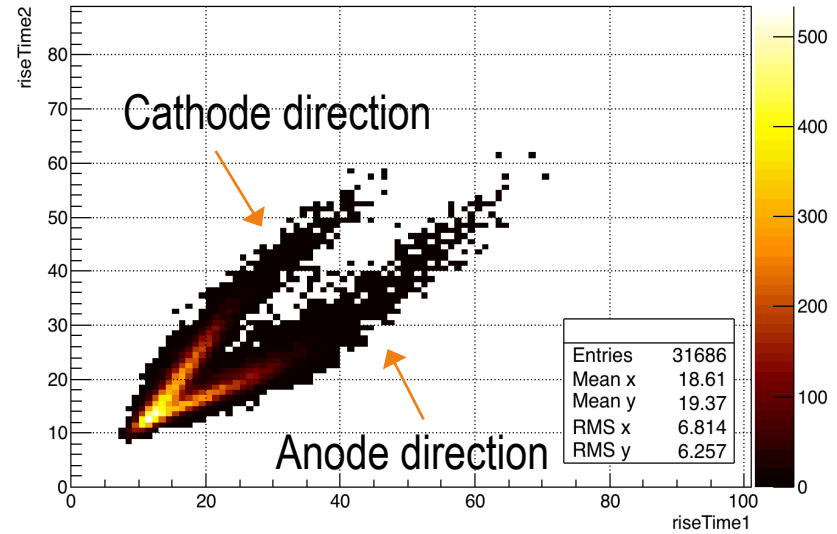
MONOENERGETIC NEUTRON MEASURE : ${}^3\text{H}(p(3357 \text{ keV}),n)$

HEAD-TAIL OF THE ${}^4\text{He}$ TRACKS

Detector in the beam direction

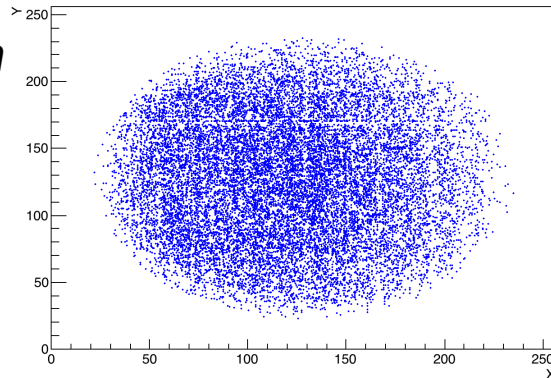


Detector perpendicular to the beam direction

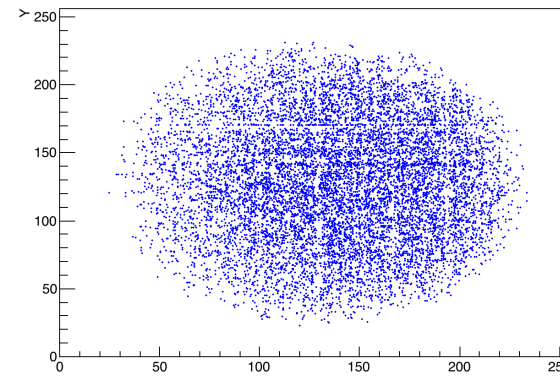


Anode projection

Cathode direction 1st timeslice

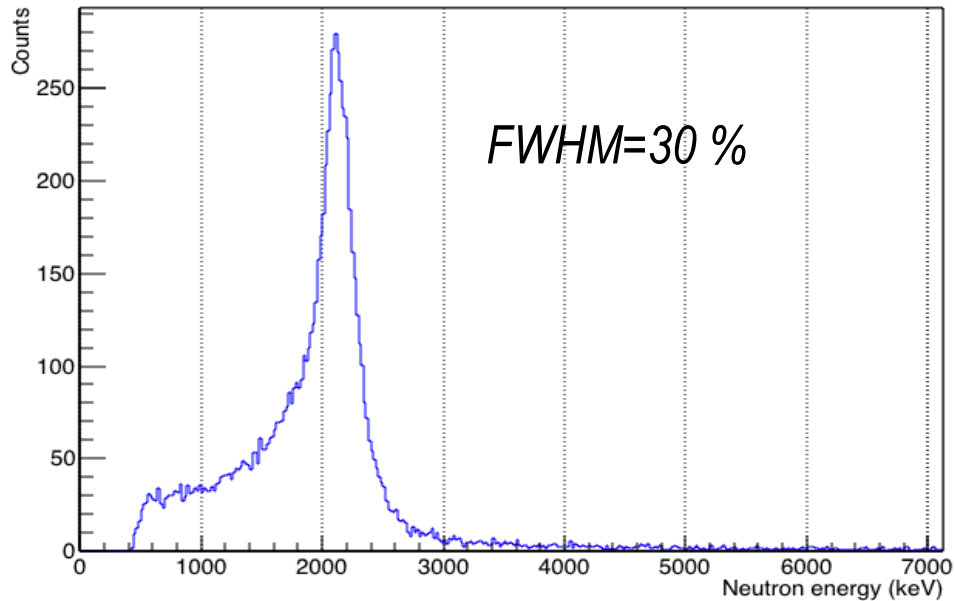


Anode direction 1st timeslice



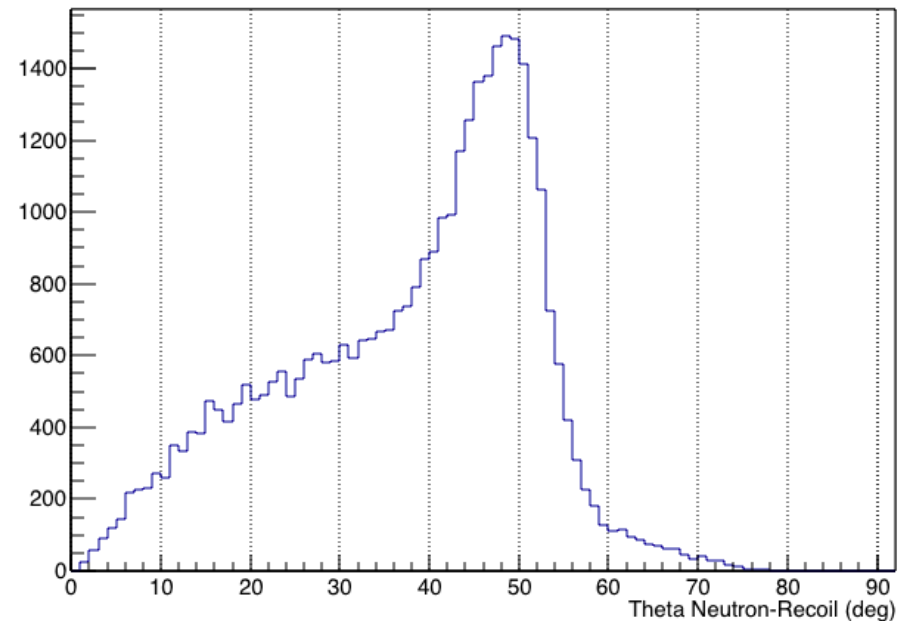
MONOENERGETIC NEUTRON MEASURE : ${}^3\text{H}(p(3357 \text{ keV}),n)$

NEUTRON SPECTRUM



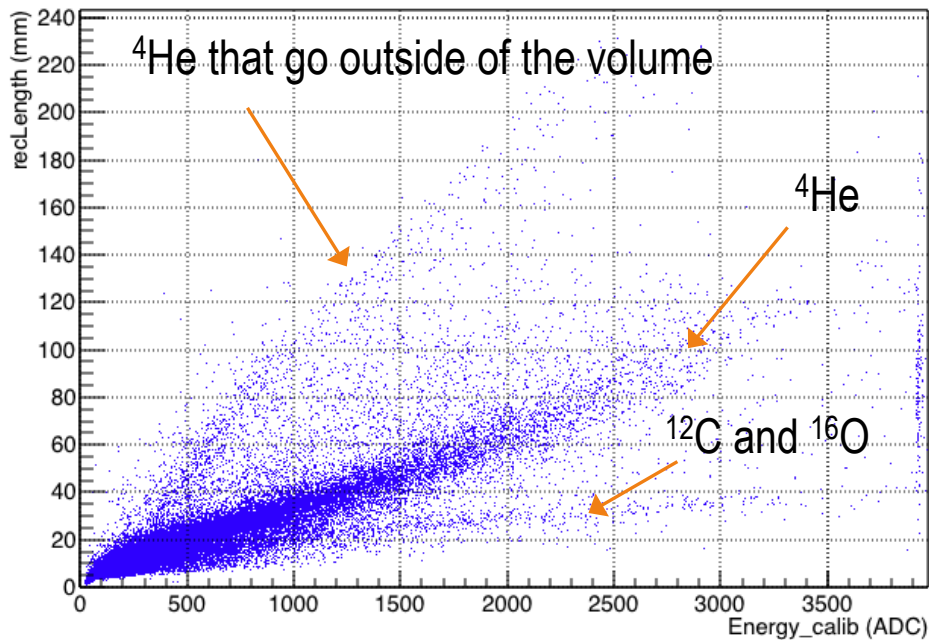
IRSN/AMANDE
(Cadarache)

Elastic diffusion theta distribution



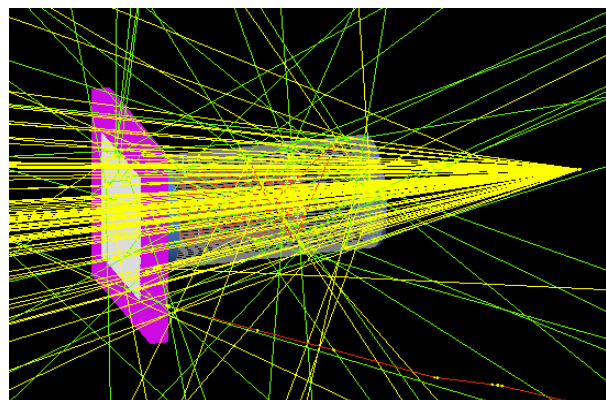
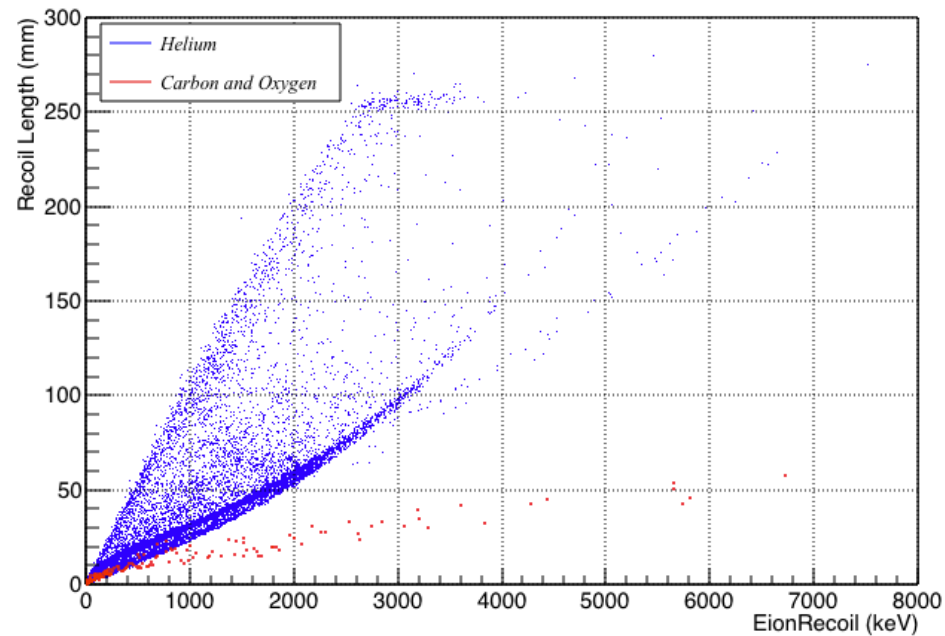
SIMULATIONS WITH GEANT4

Measure $D(d(1.8 \text{ MeV}, n))$



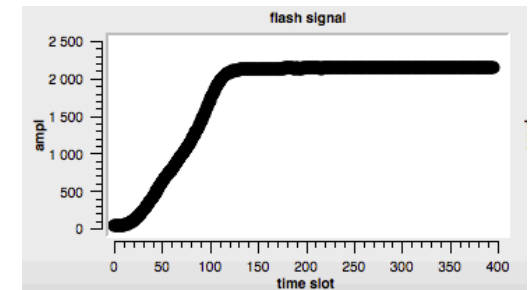
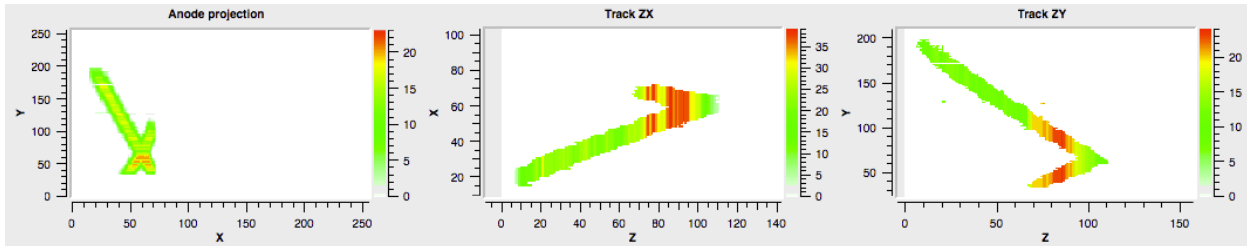
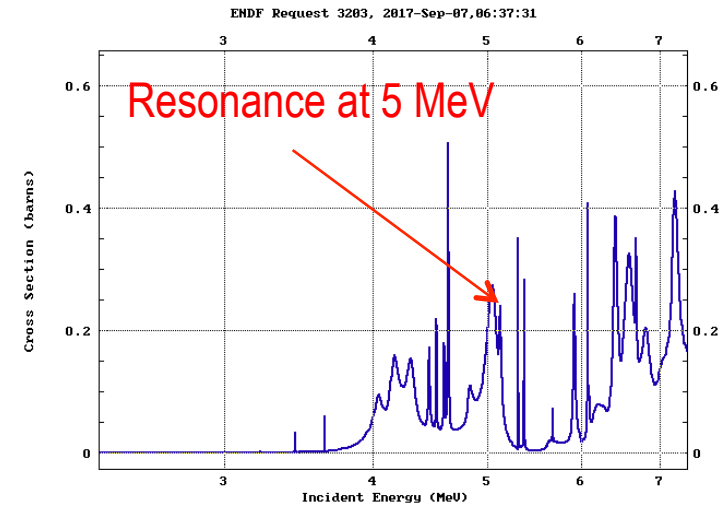
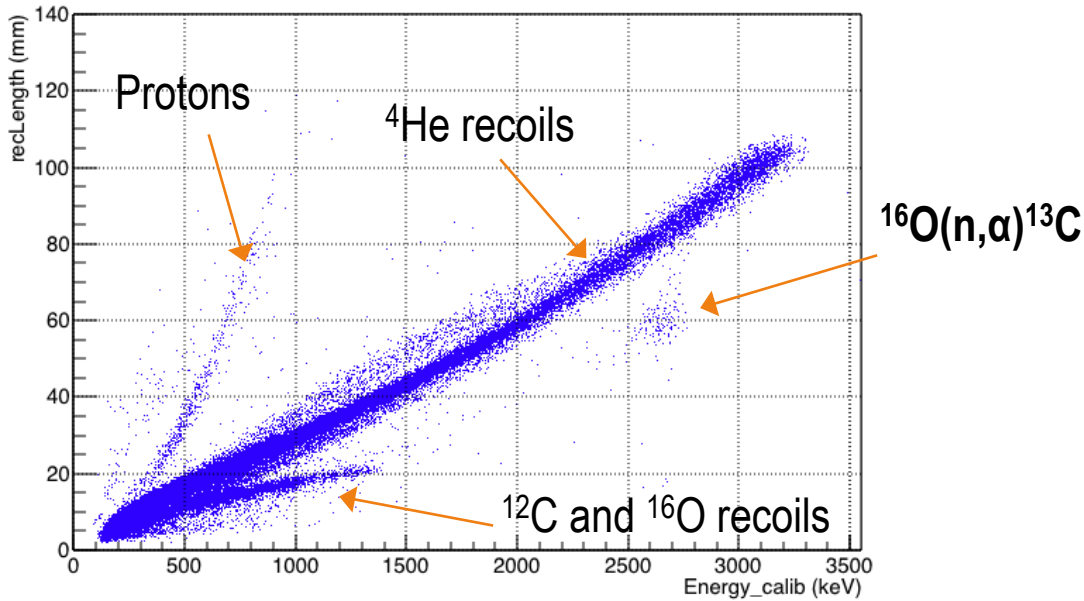
GEANT4 simulation with 5 MeV neutrons

Length= $\tau(E_{\text{recoil}})$



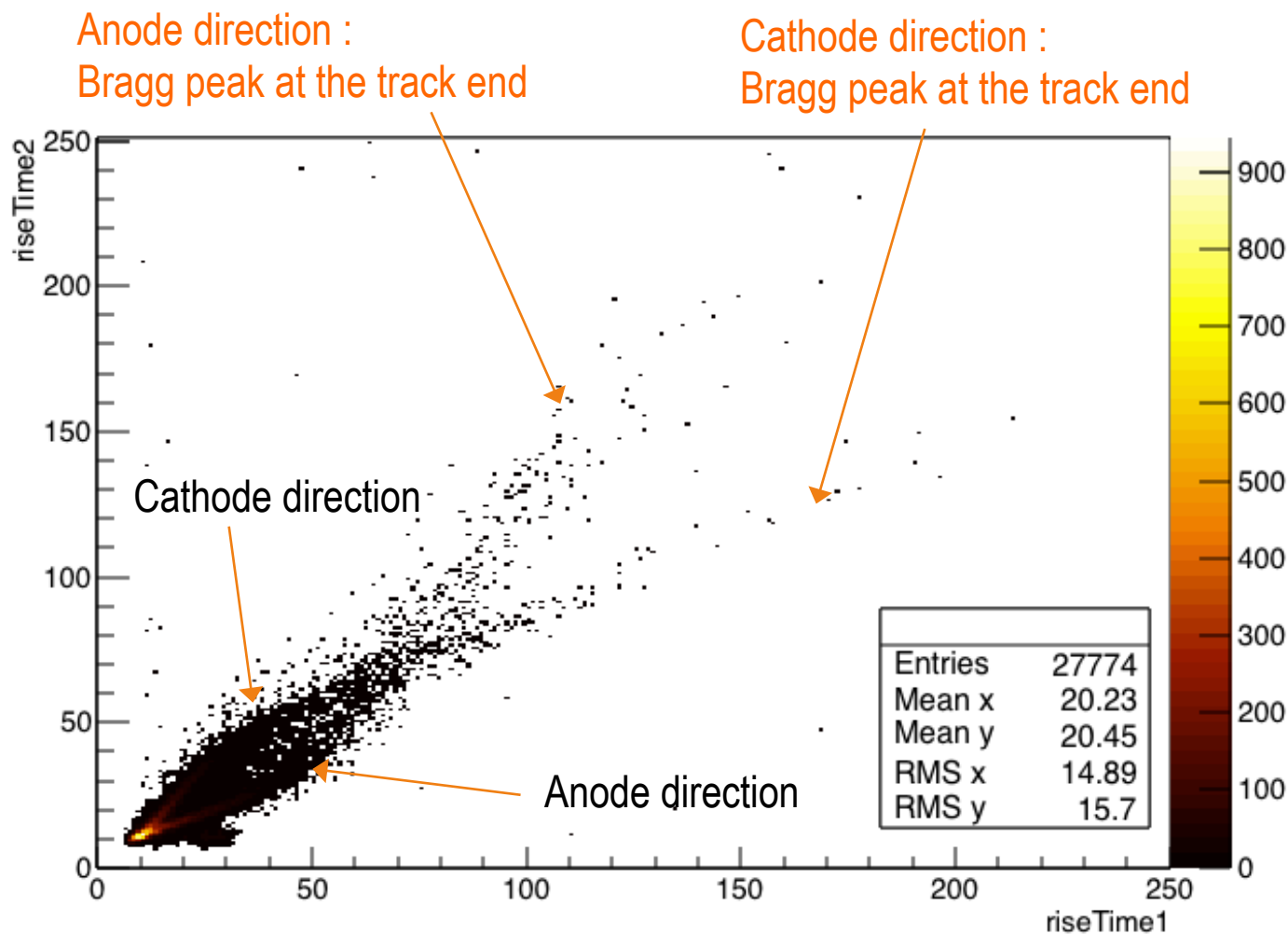
MONOENERGETIC NEUTRON MEASURE : D(d(1.8 MeV),n)

An energy reference through a (n, α) reaction



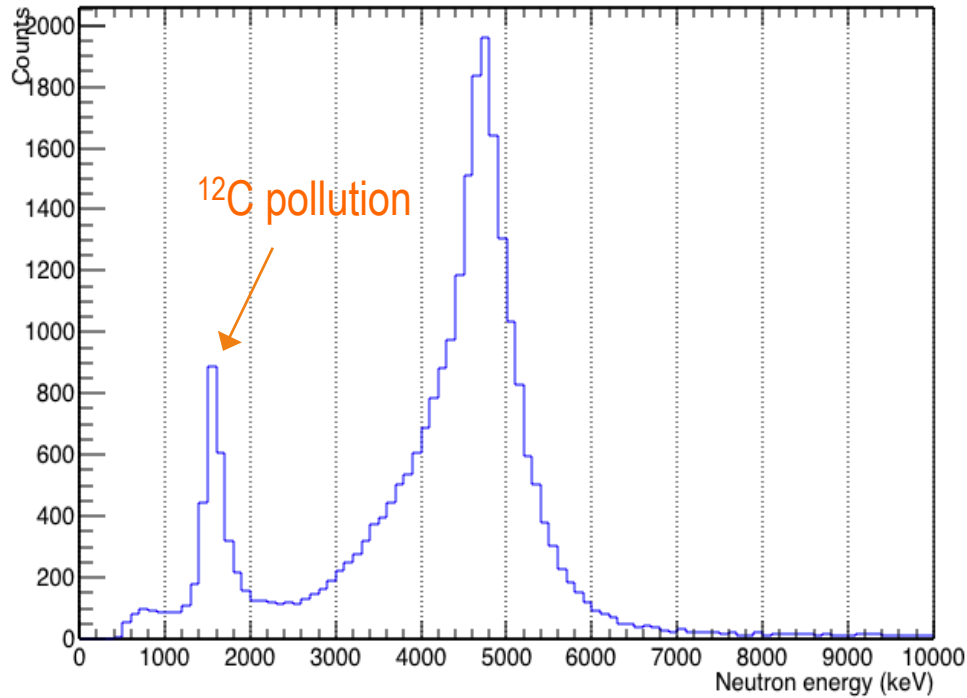
MONOENERGETIC NEUTRON MEASURE : D(d(1.8 MeV),n)

HEAD-TAIL OF THE ^4He TRACKS

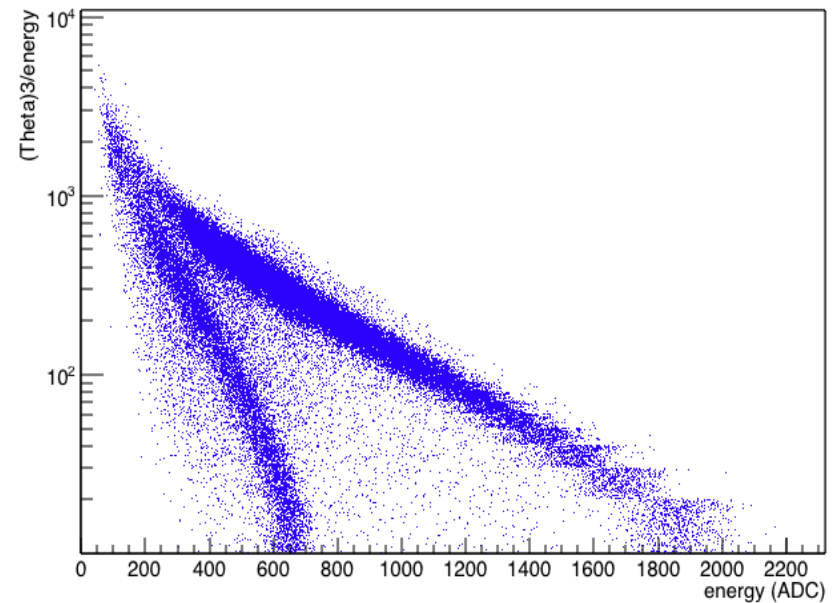


MONOENERGETIC NEUTRON MEASURE : D(d(1.8 MeV),n)

AWAITED NEUTRON ENERGY = 5 MeV

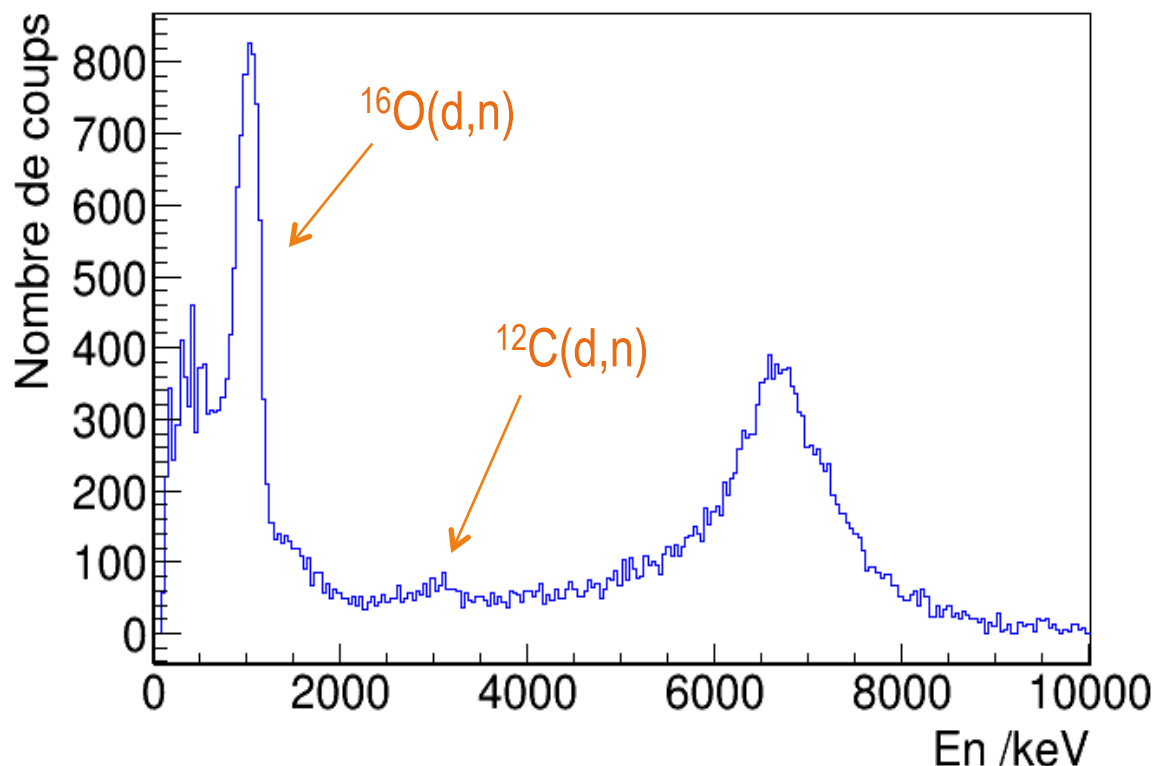


$$\text{Theta}^3/\text{Energy} = f(\text{Energy})$$



MONOENERGETIC NEUTRON MEASURE : D(d(3.2 MeV),n)

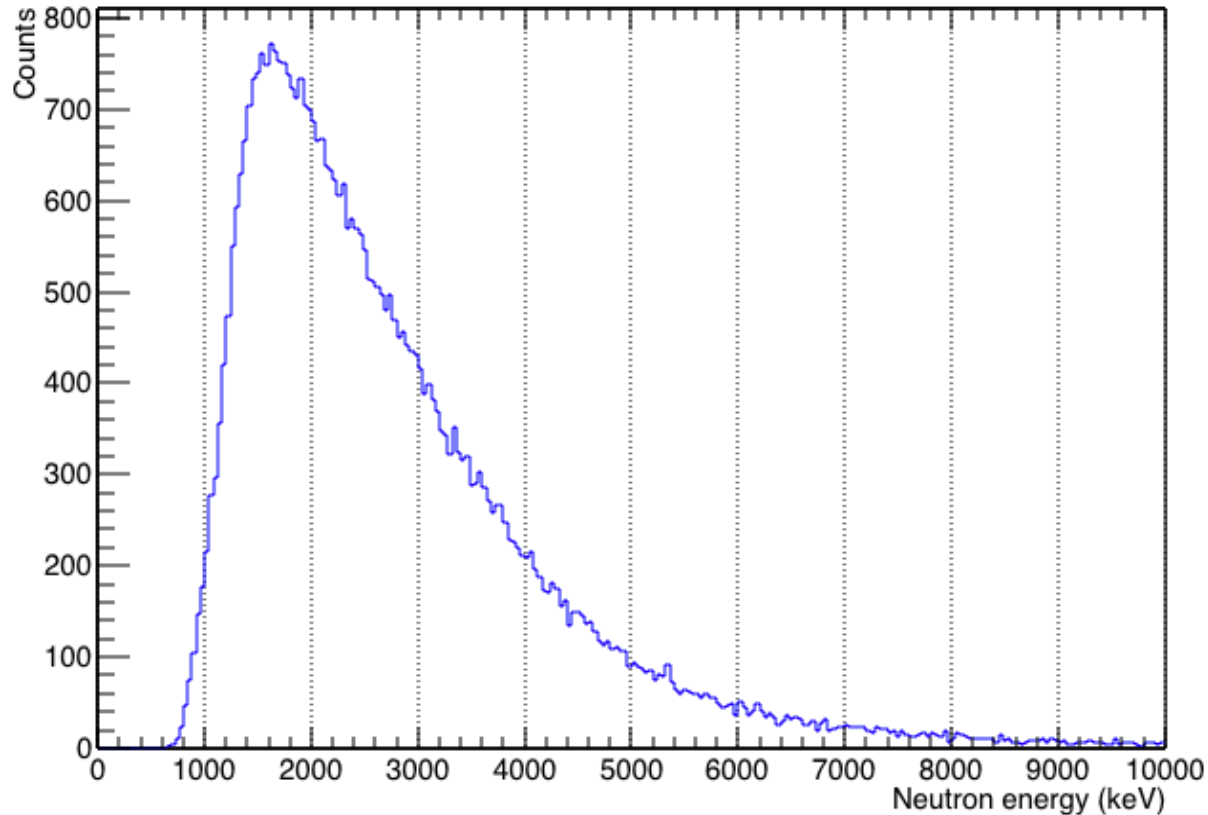
AWAITED NEUTRON ENERGY = 6.5 MeV



IRSN/AMANDE
(Cadarache)

MEASURE WITH A ^{252}Cf SOURCE

NEUTRON SPECTRUM

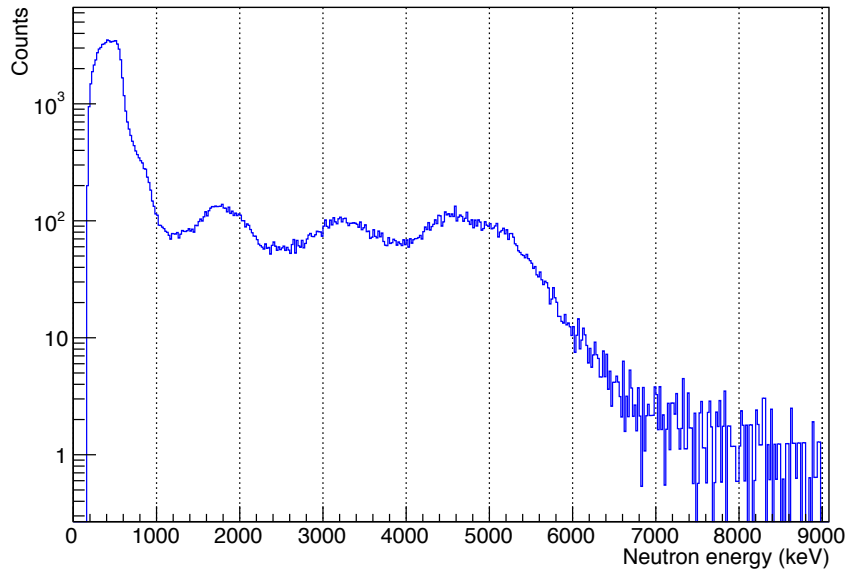


NPL (UK)

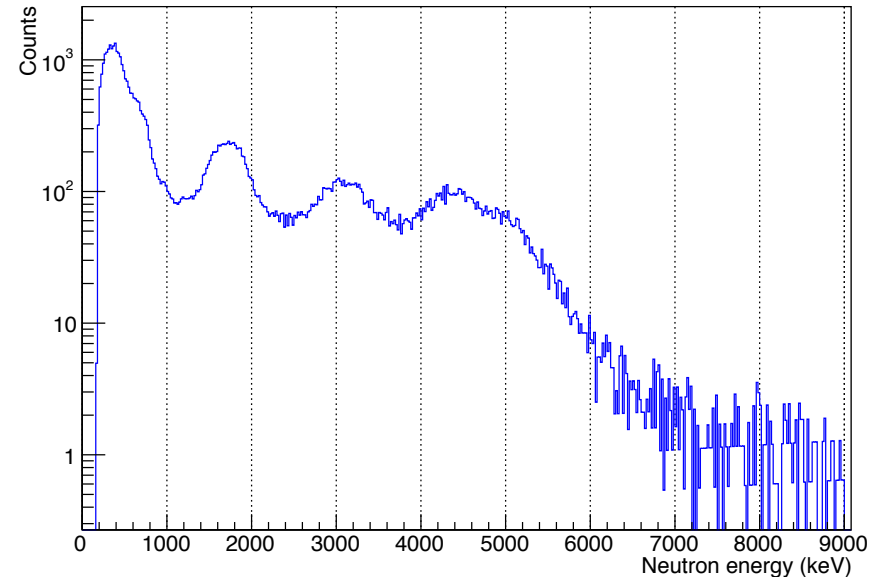
NEUTRON SPECTRA FROM A NUCLEAR REACTION

Angular distribution of ${}^9\text{Be}(d(1.45\text{ MeV}),n)$

Spectrum measured at **0 deg**



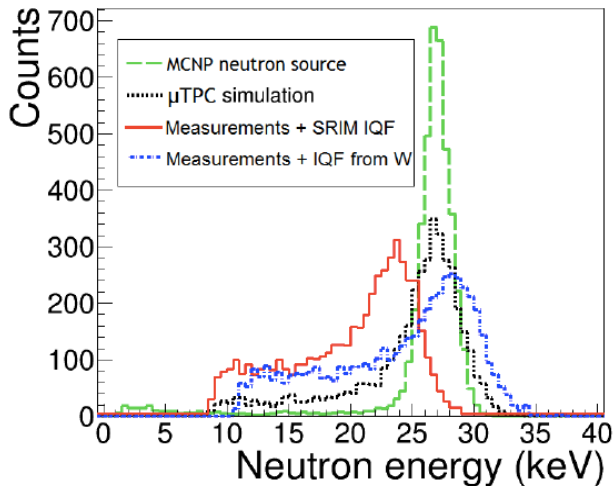
Spectrum measured at **60 deg**



Legnaro (Italy)

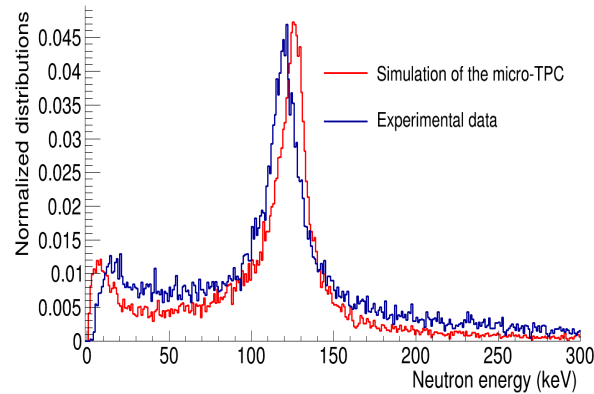
ENERGY ADJUSTABLE RANGE

50% C₄H₁₀ 50% CHF₃
30 mbar



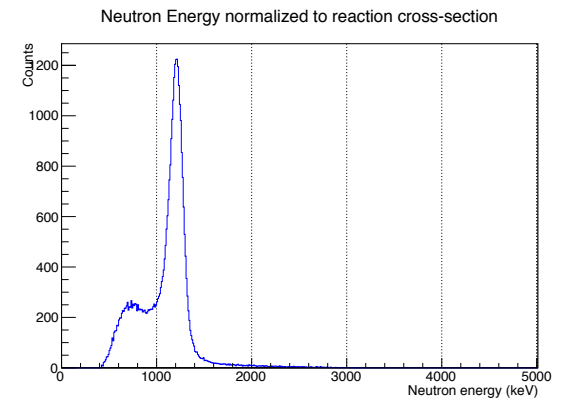
27 keV

60% C₄H₁₀ 40% CHF₃
50 mbar



127 keV

95% ⁴He 5% CO₂
700 mbar



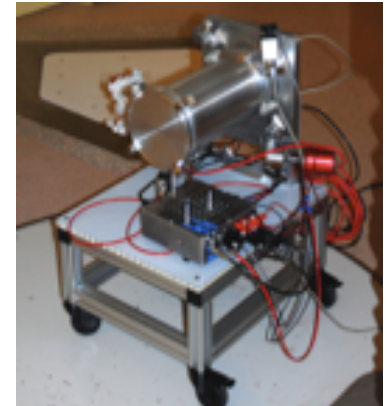
1.2 MeV

CONCLUSION

A NEW NEUTRON
SPECTROMETER WITH A
LARGE ADJUSTABLE RANGE

A MOBILE DEVICE, WITH A GOOD
ENERGY RESOLUTION

OPENING TO NEW
MEASUREMENTS AND
APPLICATION FIELDS



CONTACTS

- Daniel Santos, 04 76 28 40 21
 - daniel.santos@lpsc.in2p3.fr
- Nadine Sauzet, 04 56 80 45 13
 - nadine.sauzet@lpsc.in2p3.fr
- Olivier Guillaudin, 04 76 28 40 31
 - olivier.guillaudin@lpsc.in2p3.fr