GATE activities @ IPHC

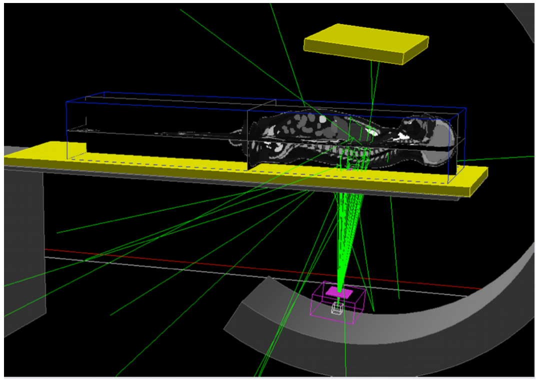
GATE technical meeting – Jan. 2020

Speaker : Clément Corneille

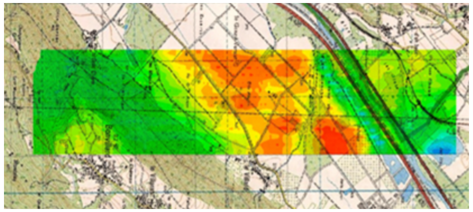
Summary

I. GATE activites @ IPHC

- **Organ dose calculations in interventional radiology**
- How accurate are organ dose softwares / measurements?
- How sensitive are dose calculations to different parameters?



- **Airborne gamma spectrometry**
- Development of a drone-borne gamma spectrometry system
- Data analysis based on machine learning and Monte Carlo simulations (GATE)



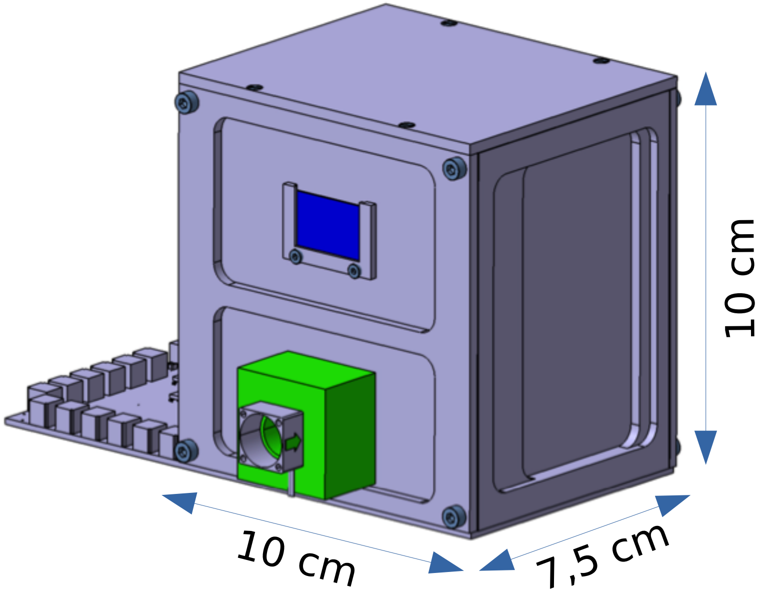
II. Proton recoil telescope

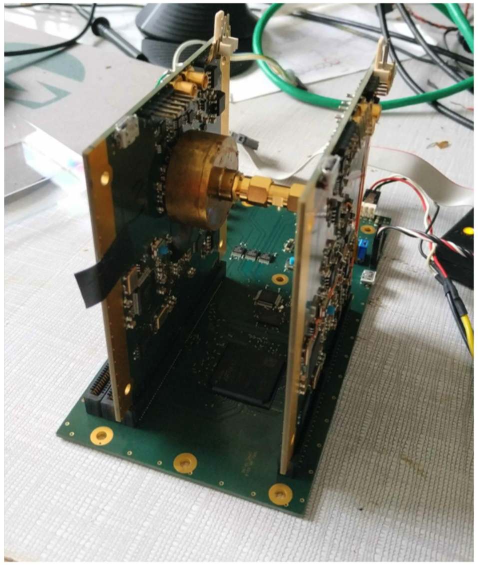
1. Characteristics

→ **neutron** detector produced in collaboration with IRSN

→ goal : measurement of neutrons energy from 5 to 20 MeV

Compact device !





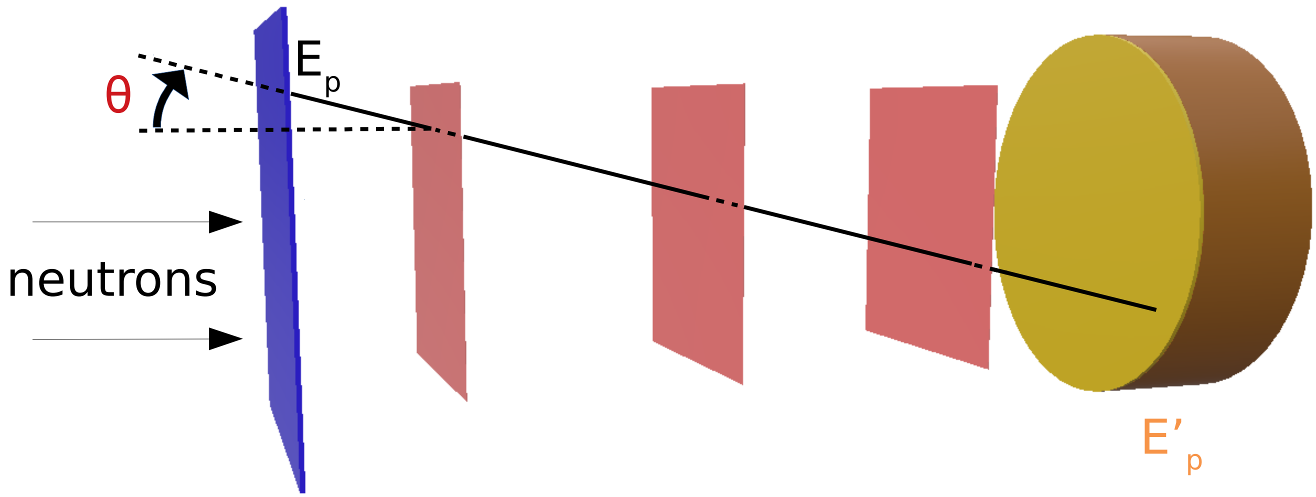
II. Proton recoil telescope

1. Characteristics

→ detection principle : convert the neutron into a proton

Elastic collision → $$E_n = \frac{E_p}{\cos^2 \theta}$$

⚠ Assumption that neutrons direction is known ⚠



- converter $(CH_2)_n$
- 3 pixelated CMOS (FastPixN) → angle θ
- diode → energy E'_p

This PRT is able to measure neutrons energy in the 5-30 MeV range

II. Proton recoil telescope

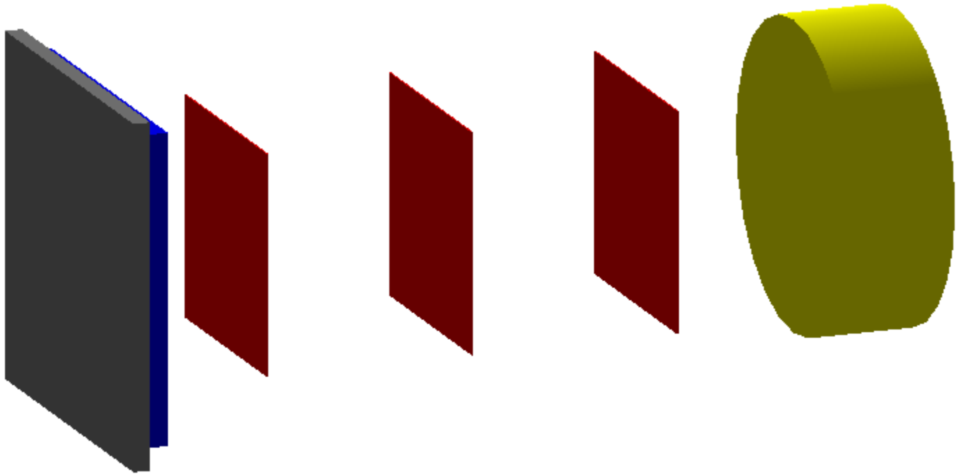
2. GATE modelization

→ **GATE simulation** of the detector to :

- validate the analysis code

- evaluate its performances

- test its response to various spectra of neutrons (energy resolution, efficiency correction, background, ...) and to different parameters (converter thickness, material choice, ...)

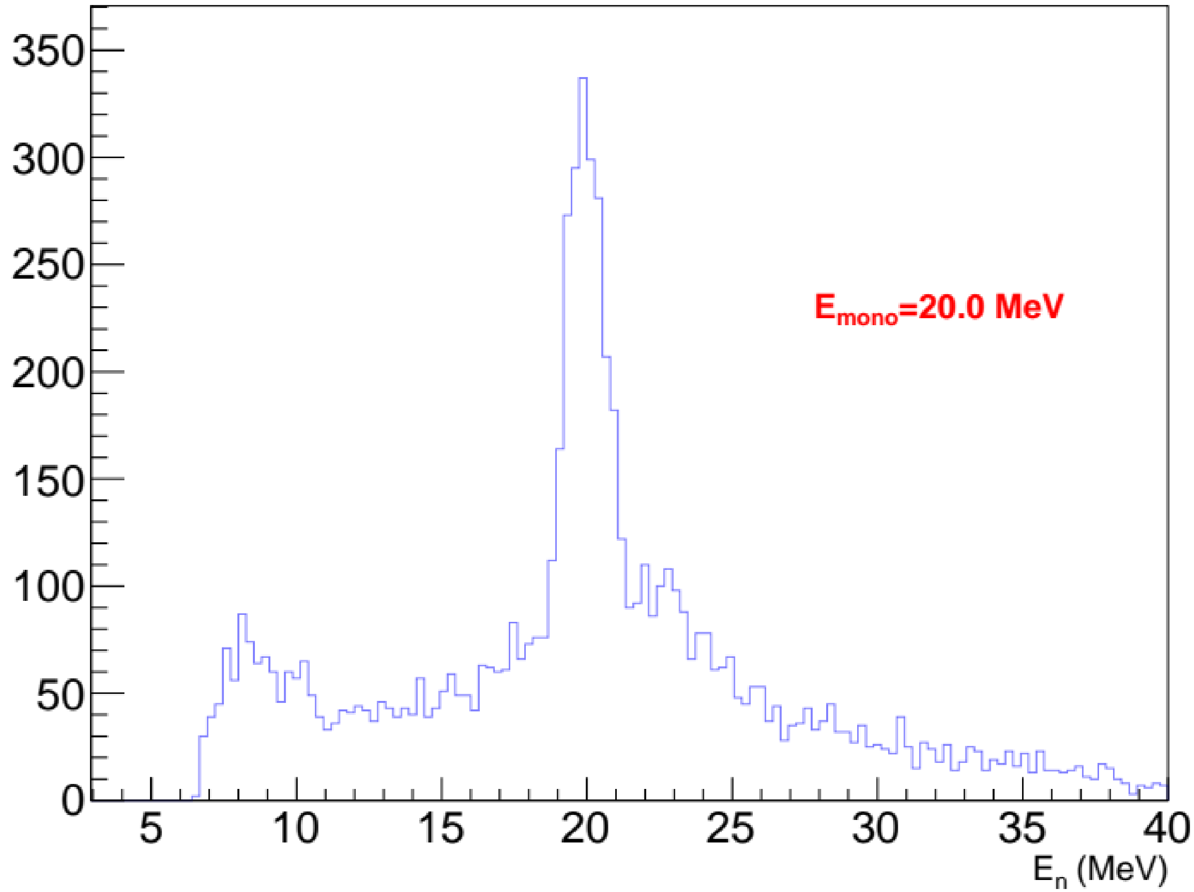


GATE simulation (PCBs and Aluminium box not displayed)

II. Proton recoil telescope

3. Spectrum example

Raw spectrum of a GATE simulated mono-energetic neutron beam of 20 MeV
$\Phi = 10^7$ n.cm^{-2}.s^{-1} → 60 n.frame^{-1}



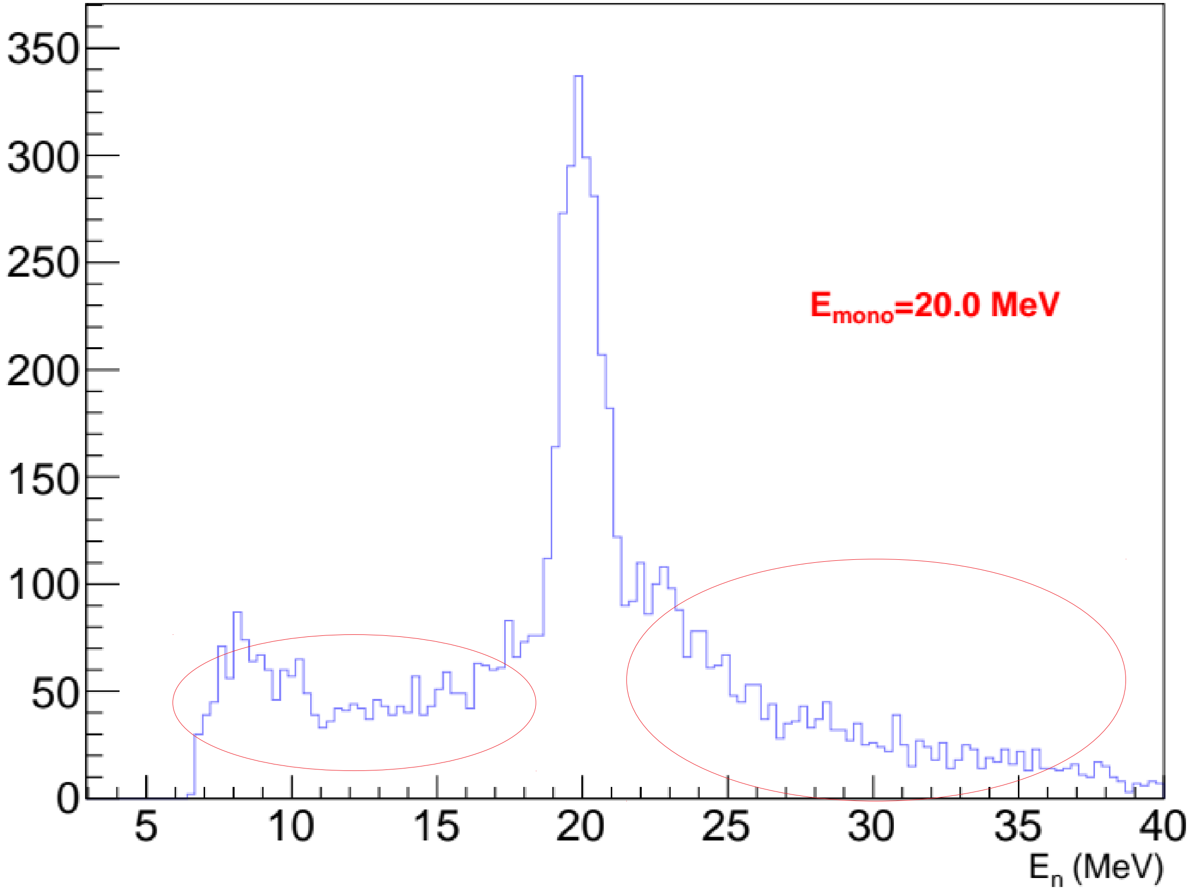
- peak reconstructed at 20 MeV

- relative energy resolution : 7,4 %

II. Proton recoil telescope

3. Spectrum example

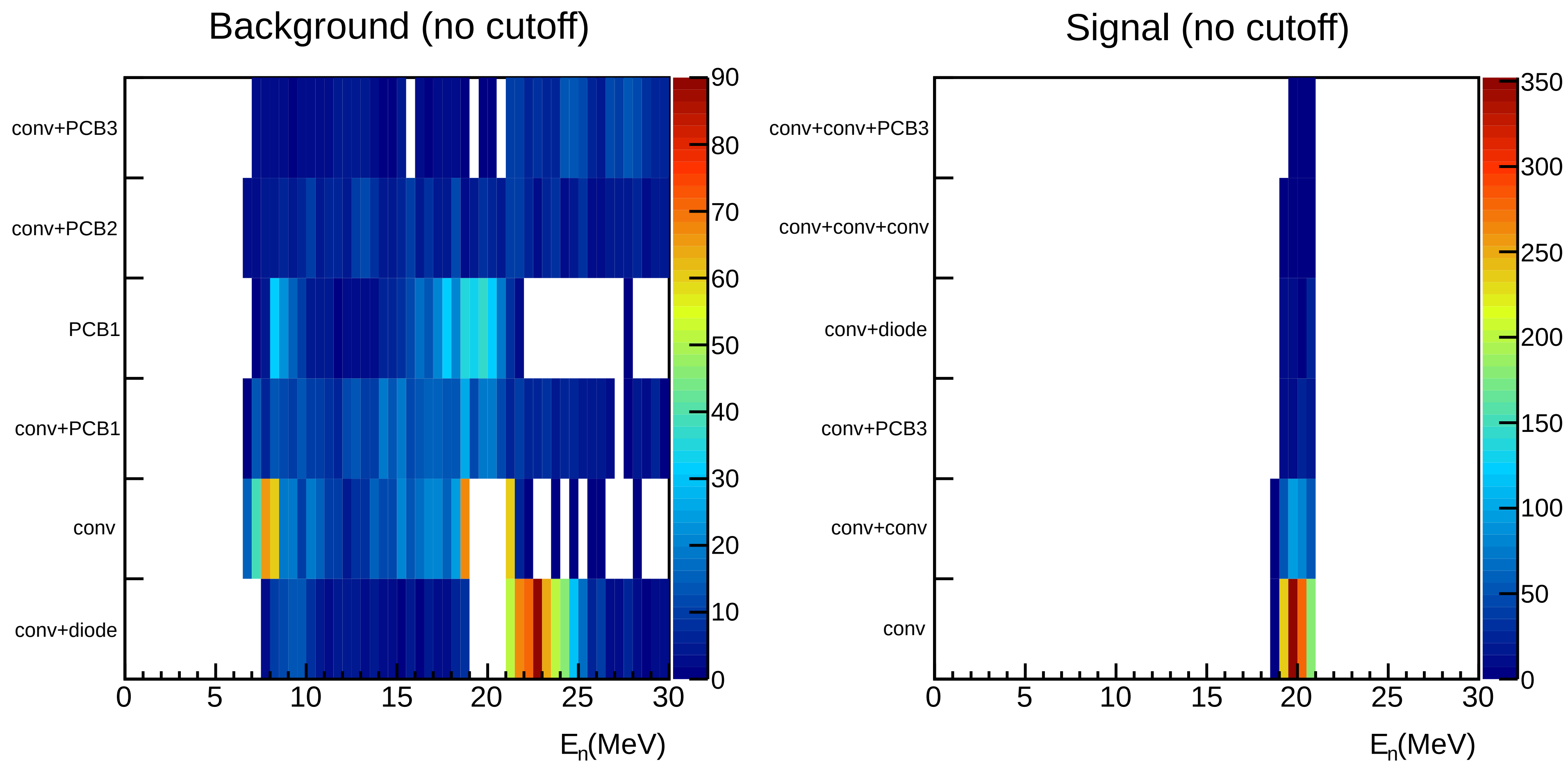
Raw spectrum of a mono-energetic neutron beam of 20 MeV ($\Phi = 10^7$ n.cm^{-2}.s^{-1})



- peak reconstructed at 20 MeV
- relative energy resolution : 7.4 %
- background before and after the peak

II. Proton recoil telescope

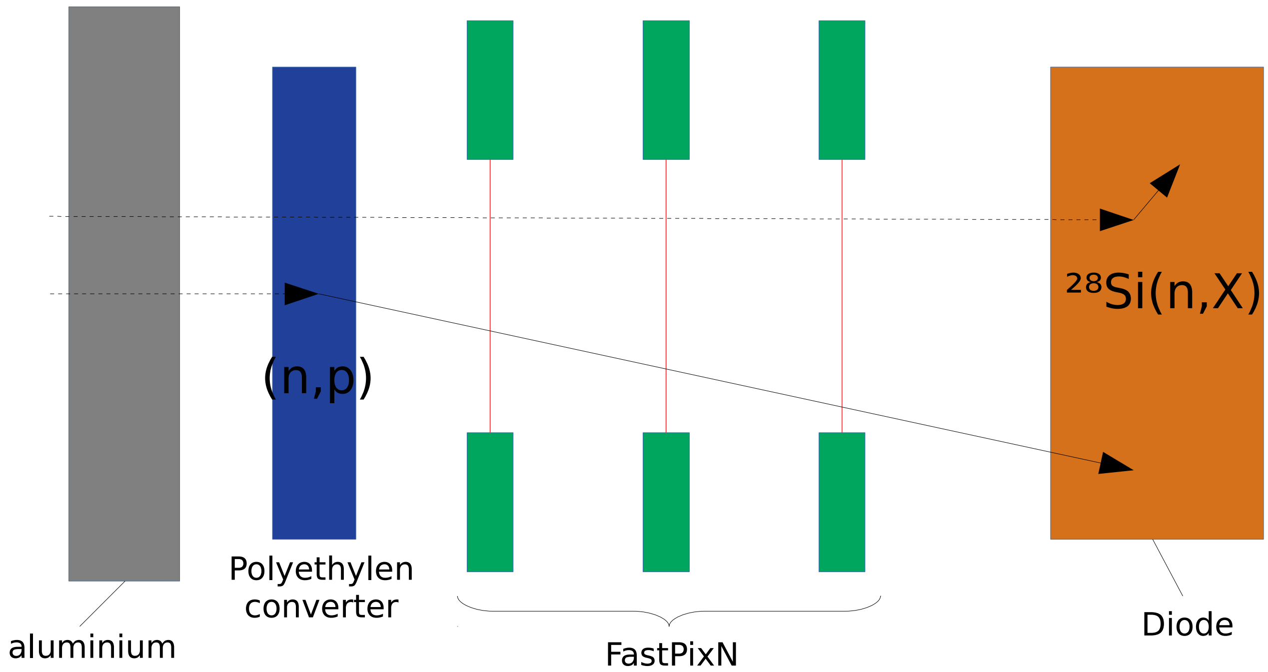
4. Background study



II. Proton recoil telescope

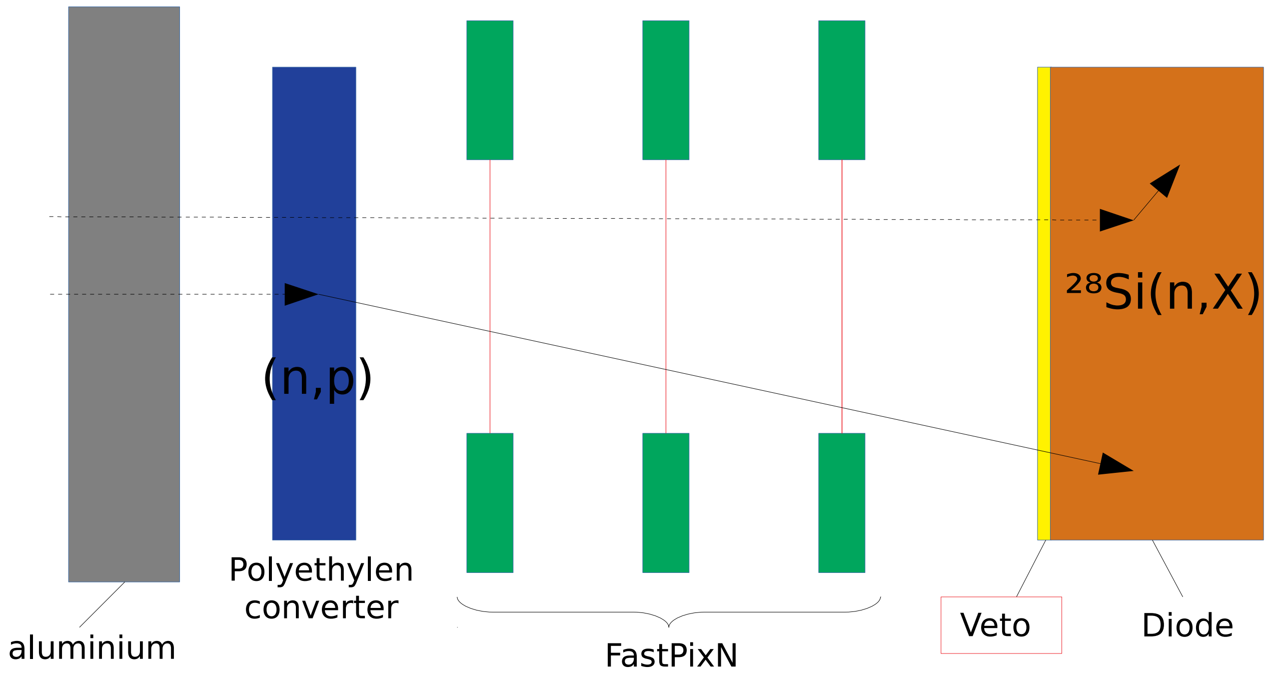
4. Background study

→ Background after the peak : simultaneous collision of a neutron in the diode



→ Background after the peak : simultaneous collision of a neutron in the diode

→ Easily suppressed by the mean of a second Si-diode called « veto »



Veto cutoff :

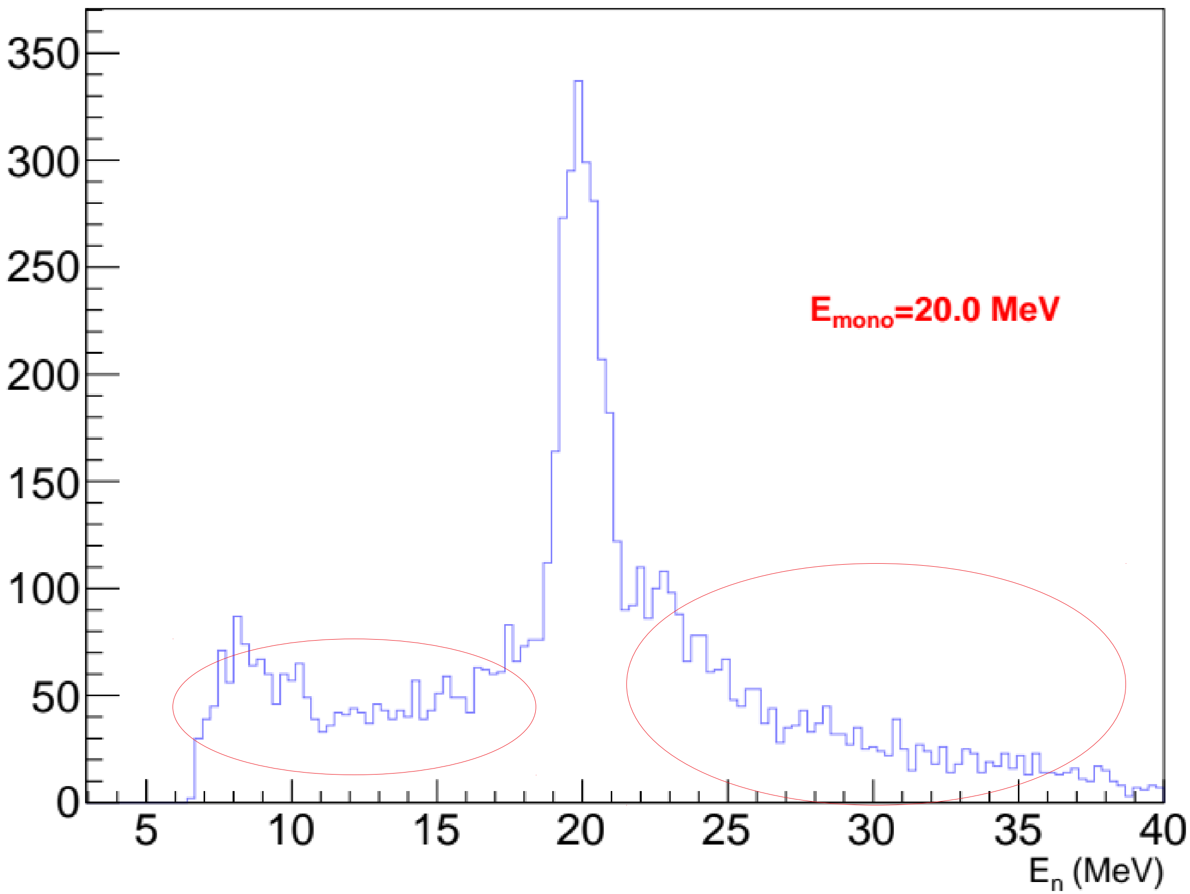
→ comparison E_{th} vs E_{meas}

$$\frac{|E_{th} - E_{meas}|}{E_{meas}} < 20\,\%$$

II. Proton recoil telescope

4. Background study

Raw spectrum of a monoenergetic neutron beam of 20 MeV ($\Phi = 10^7$ n.cm^{-2}.s^{-1})



- peak reconstructed at 20 MeV

- relative energy resolution : 7,4 %

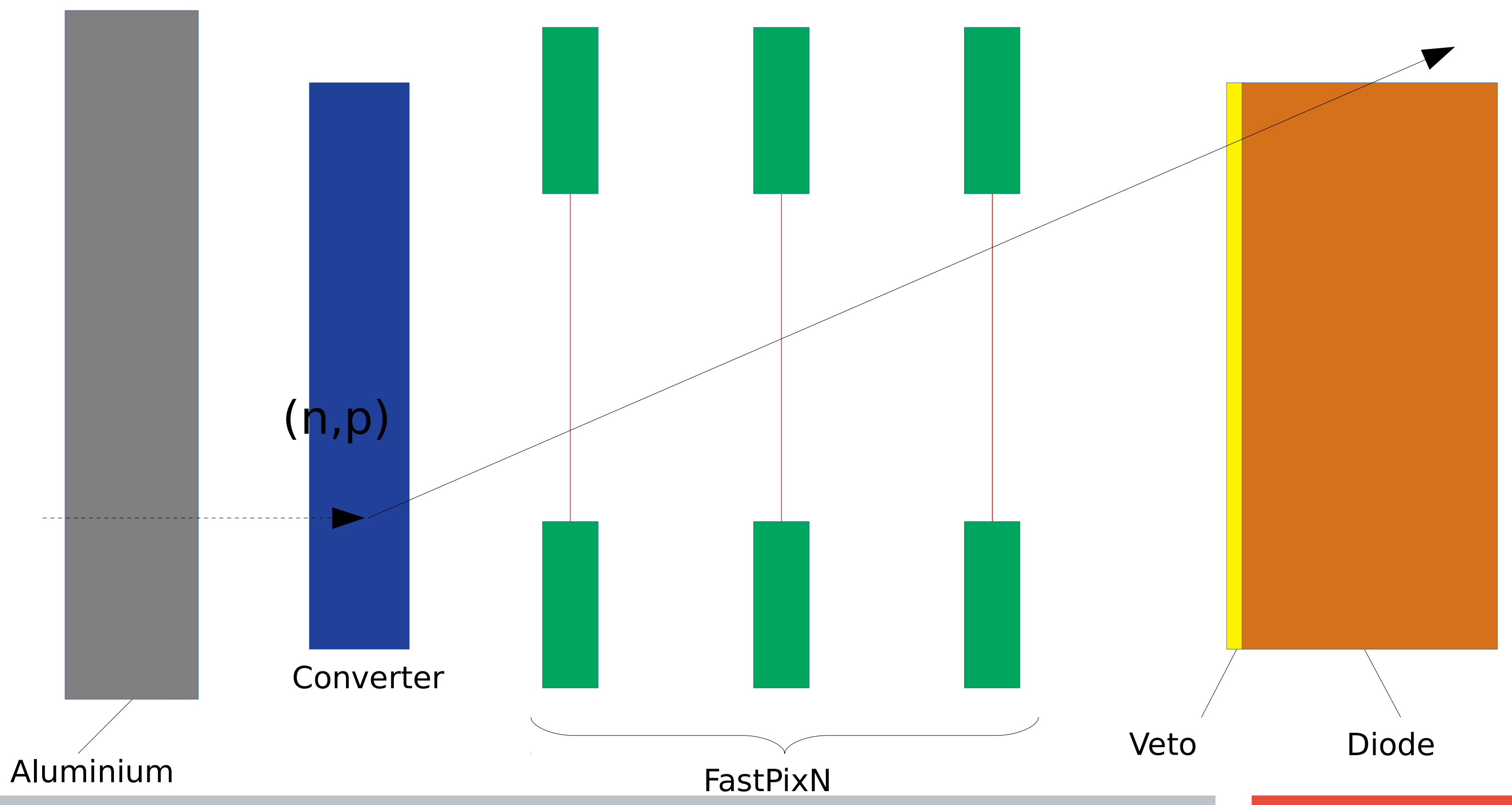
- background before and after the peak

II. Proton recoil telescope

4. Background study

→ background before the peak : proton escapes by the side of the diode, leaving only a fraction of its energy (=lower energy reconstructed)

→ eliminated partially by veto. Completed with track projection



II. Proton recoil telescope

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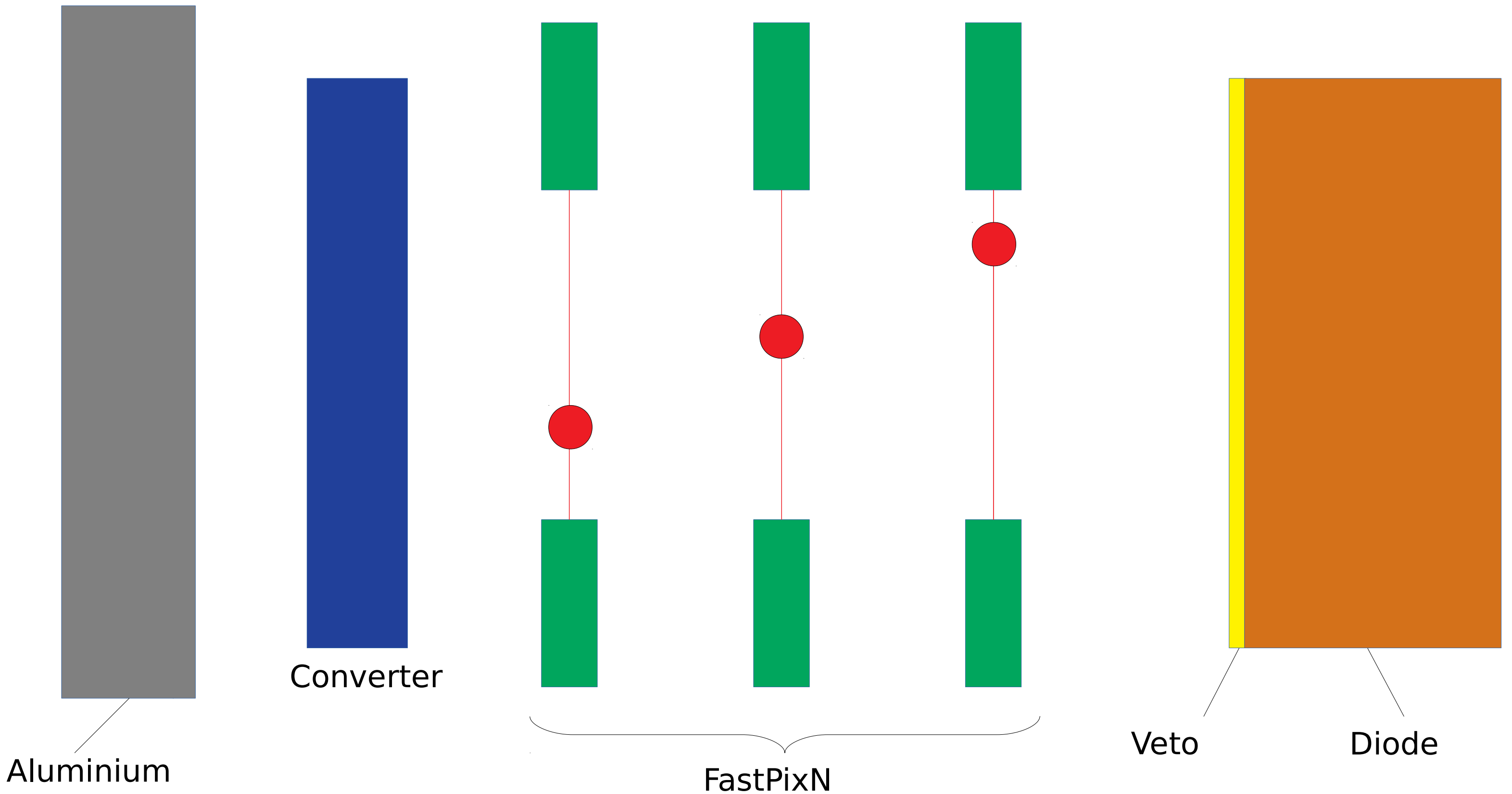

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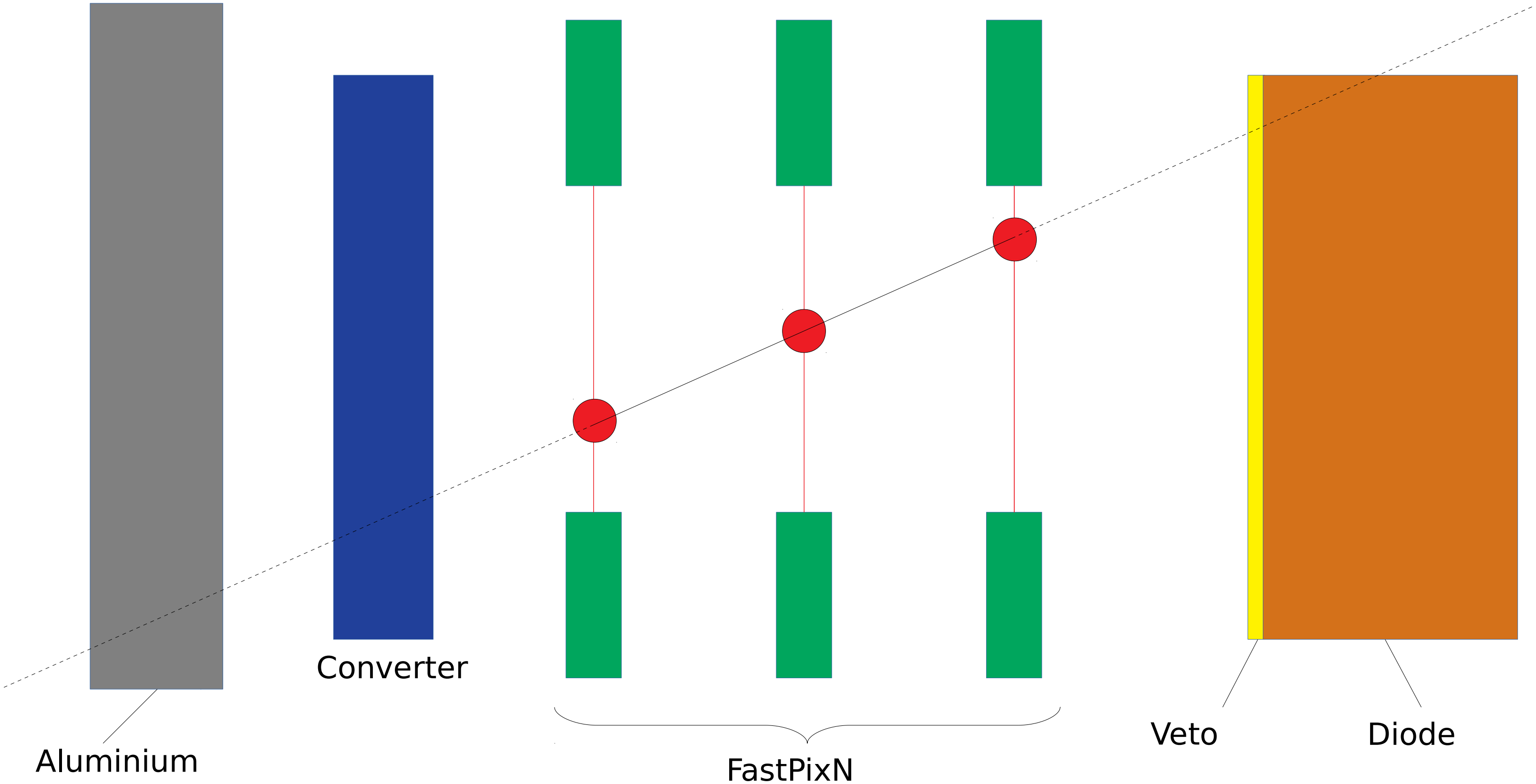
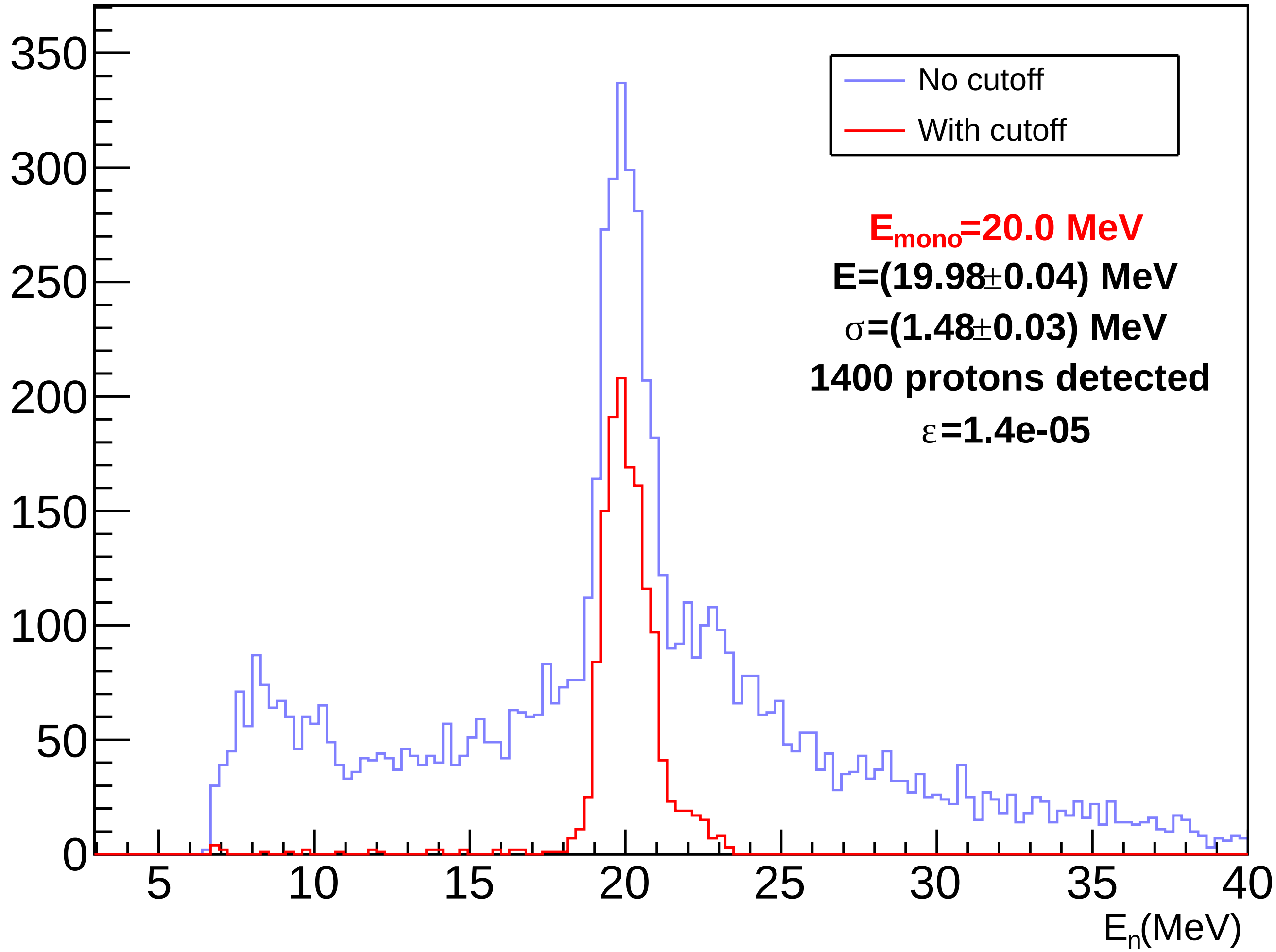


II. Proton recoil telescope

4. Background study

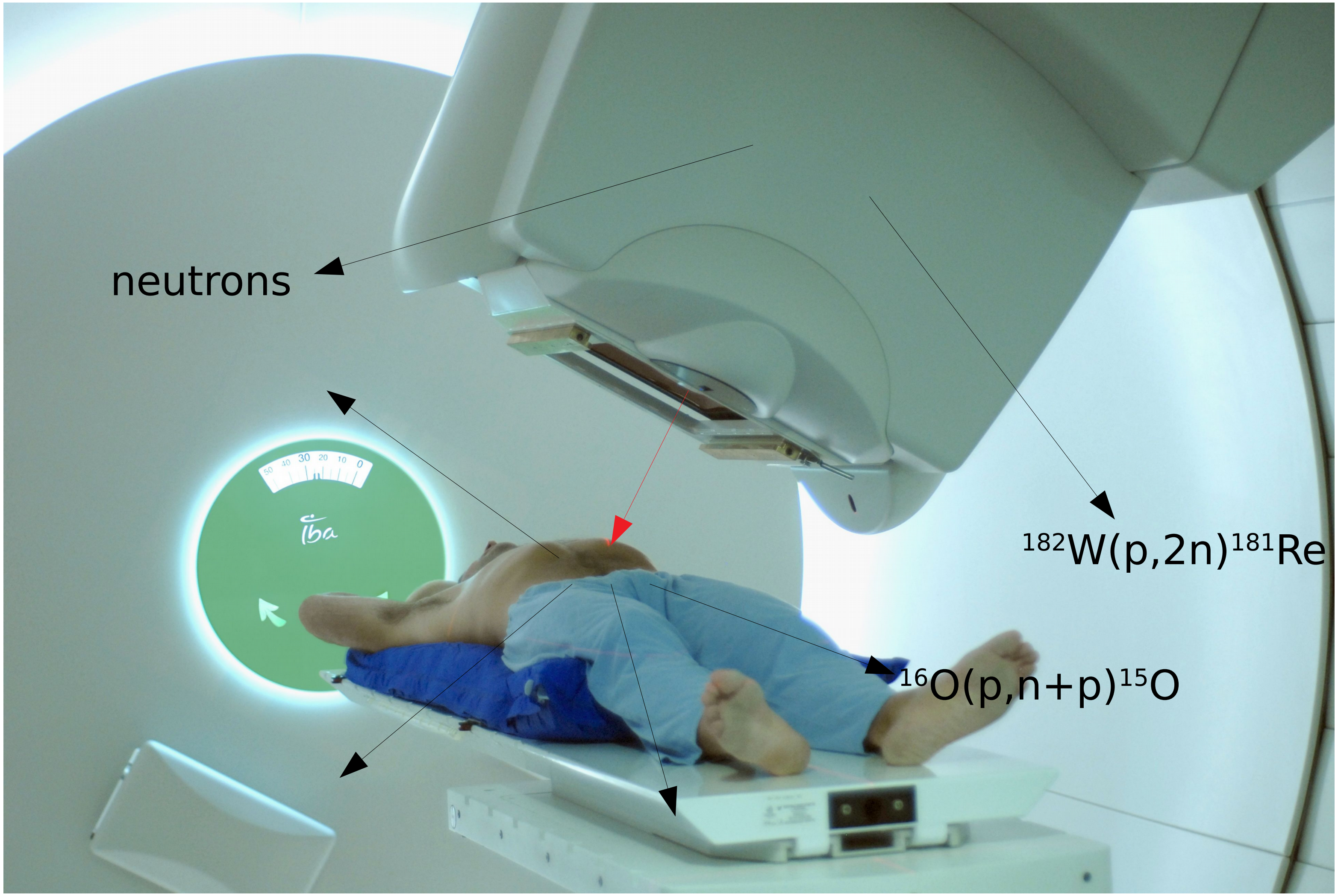
→ 4 cutoffs : track projection + veto + X² test + increasing dE/dX



- Up to 95 % background elimination

- Around 20 % of true signal eliminated

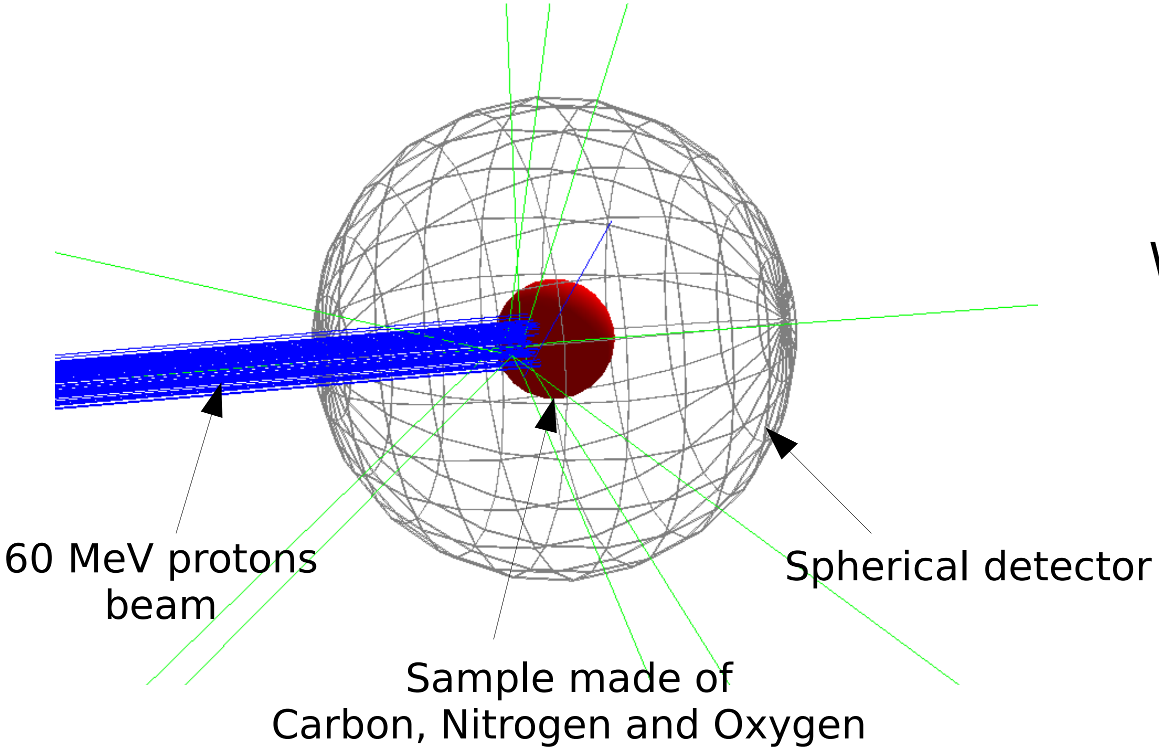
III. Applications & prospect



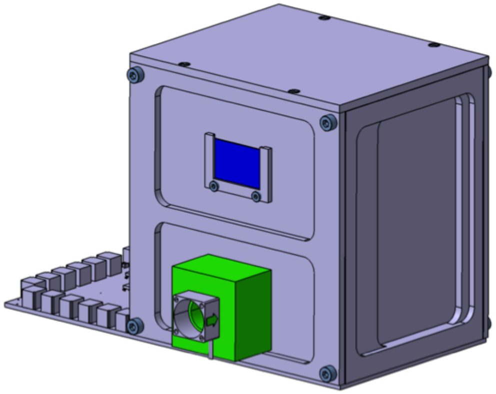
III. Applications & prospect

→ protontherapy : simulation to estimate secondaries neutrons dose to tissues

→ ≠ models → ≠ results : **experimental validation necessary**



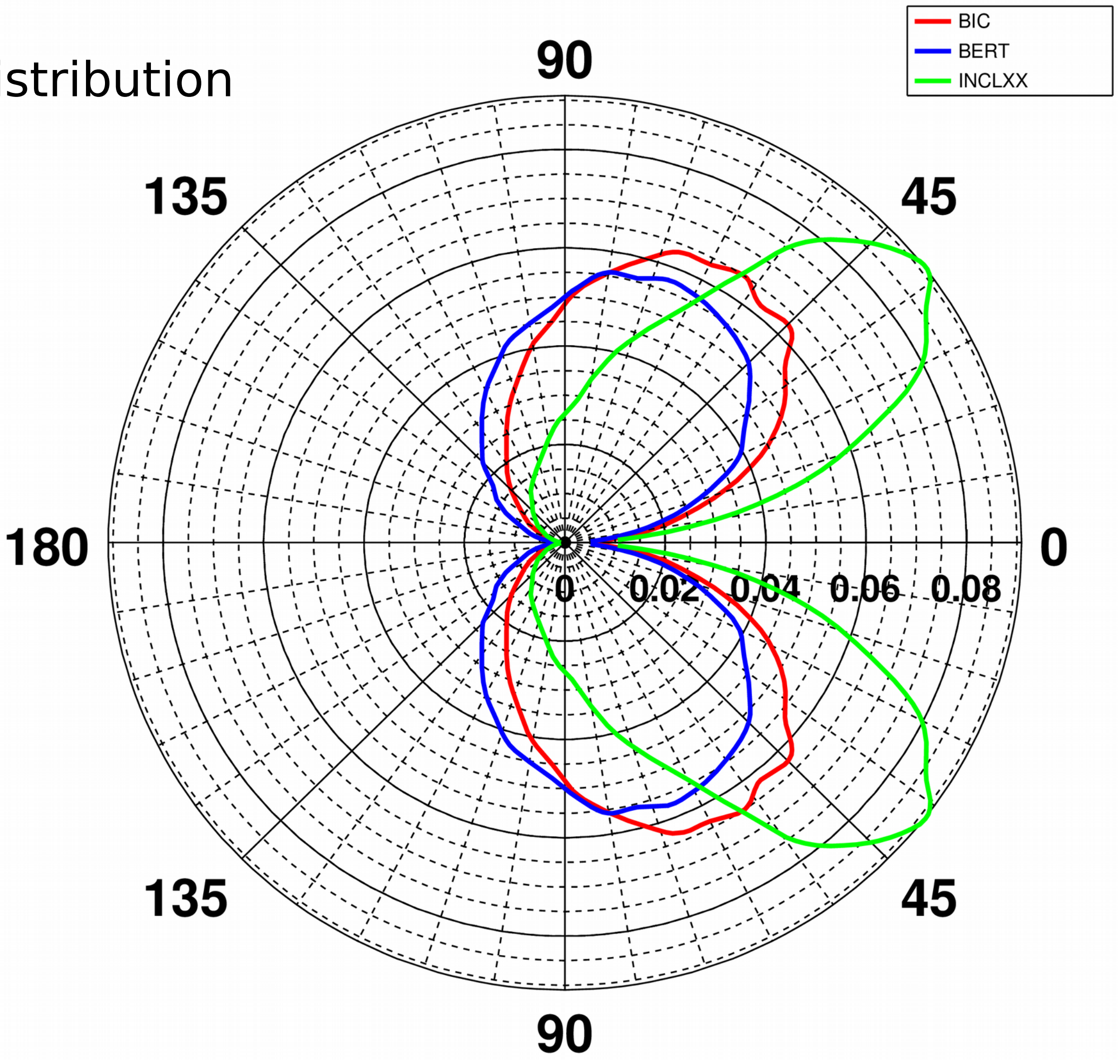
With proton recoil telescope ?



III. Applications & prospect

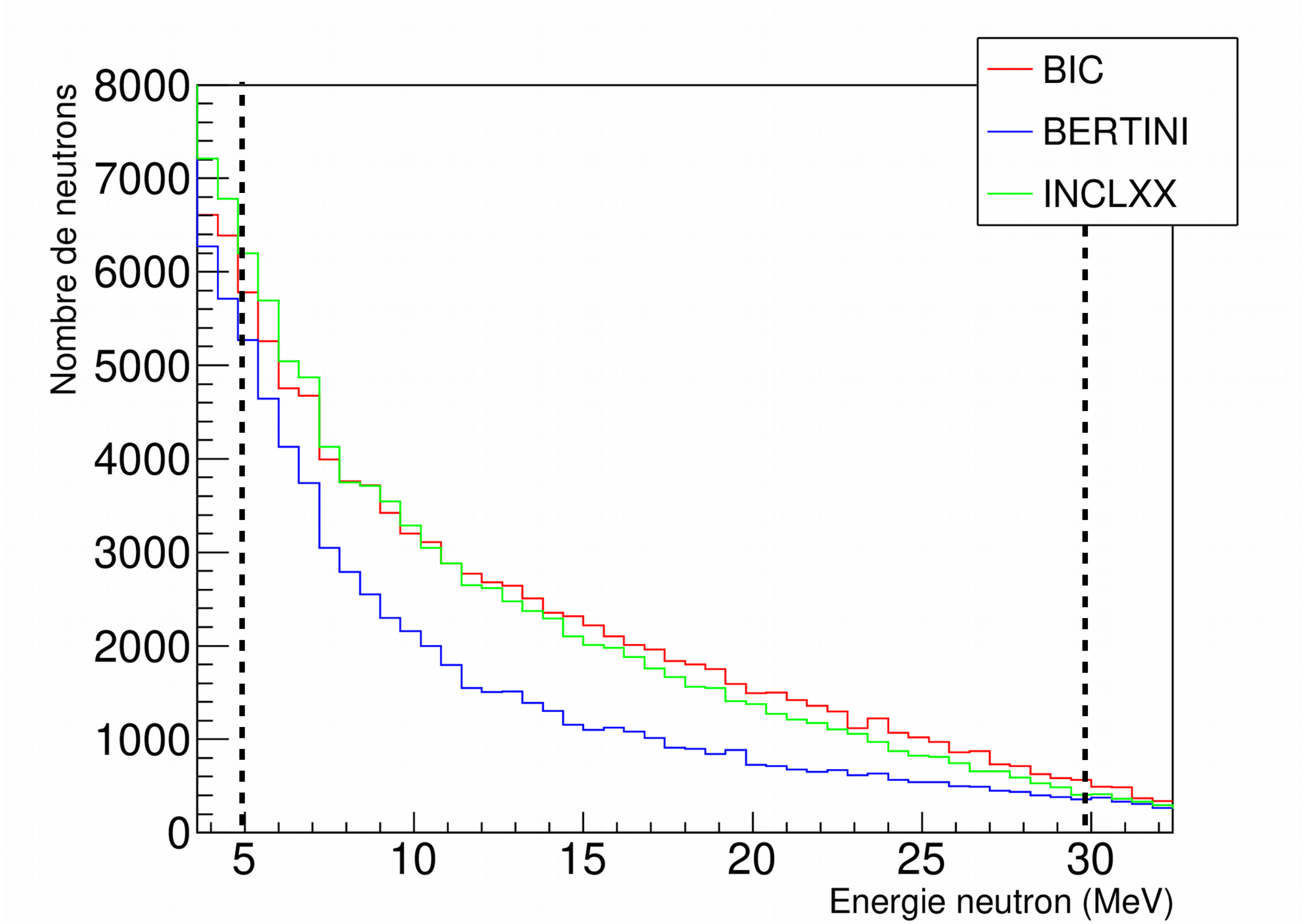
Normalized angular distribution of neutrons :

Incoming 60 MeV protons



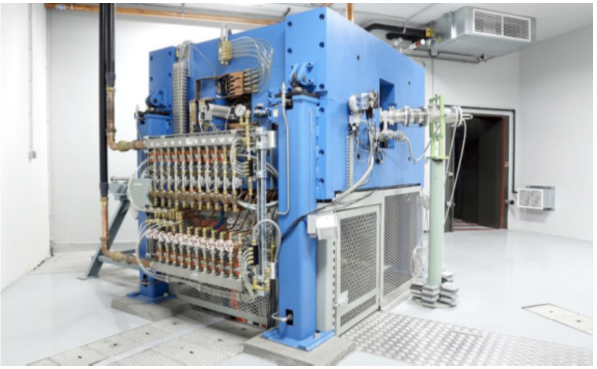
III. Applications & prospect

Energy spectrum :



→ PRT should allow us to differenciate these models

III. Applications & prospect



Prospect :

- test at CYRCÉ proton cyclotron @ 5-24 MeV (IPHC)

- measurement at IPHC Am-Be source

- measurement at AMANDE facility (IRSN) : neutron field from 2 keV to 20.5 MeV

- measurement at protontherapy center (contact with Centre Antoine Lacassagne, Nice @ 65, 235 MeV)
  → looking forward for more centers to make more measurements

- other applications to investigate : industrial sterilization, cross section measurement, etc.

- new ideas to improve performances for future versions :
  - replace $(CH_2)_n$ converter by a scintillator to improve resolution at thicker converter sizes
  - extend energy range by adding more CMOS, modifying angle between CMOS and converter, etc.

Thank you for your attention !