Aza Eleni - ESR 1

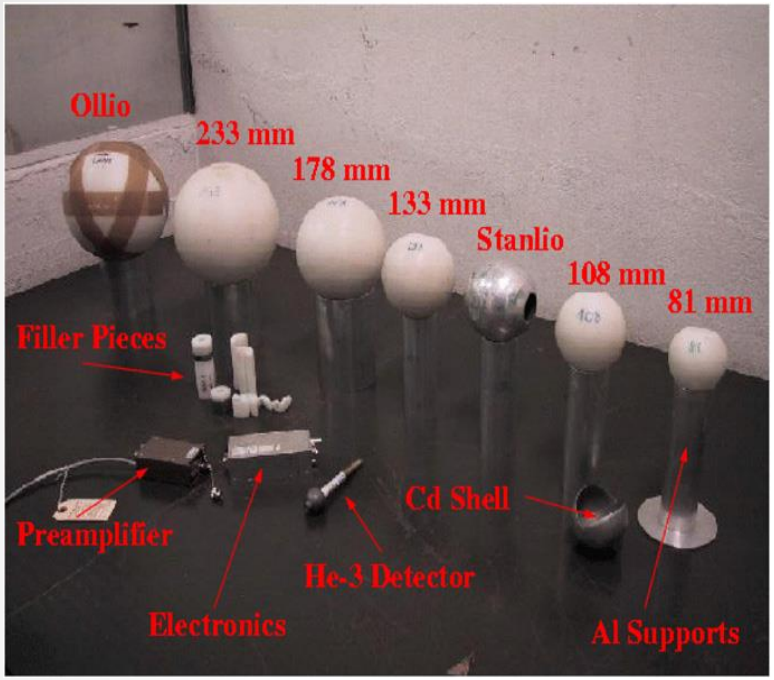
3rd ARDENT Workshop
29.09.14

Simulations & Experimental activities

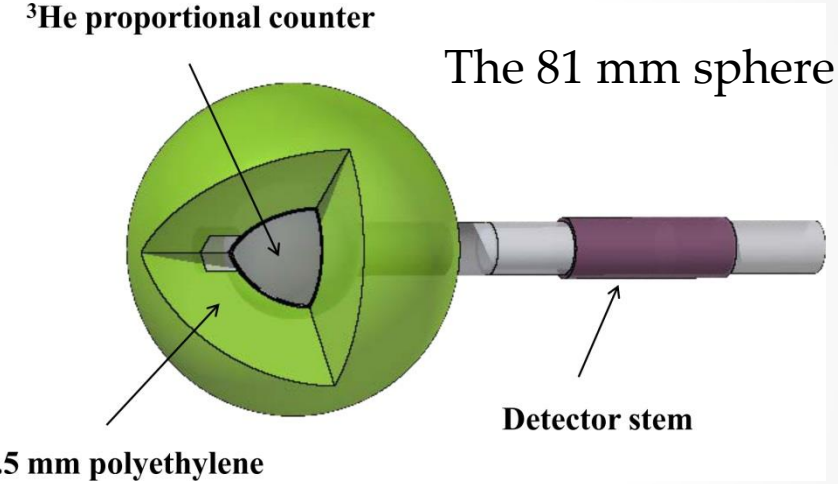
1. Monte Carlo simulation of the BSS response functions & Data unfolding

2. Measurements with the GEM detector at nTOF, CERN

The BSS – multisphere neutron spectrometer

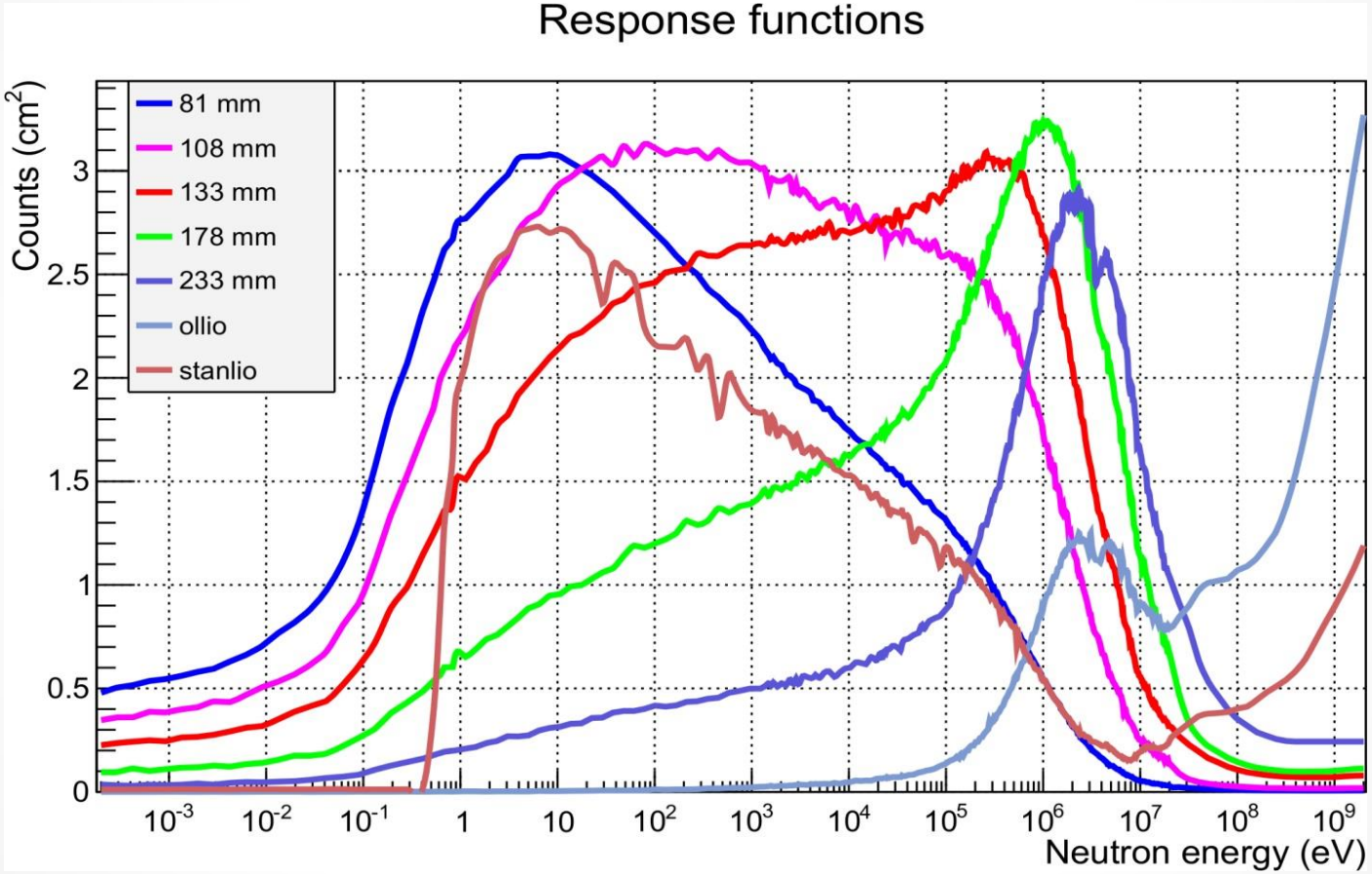


Seven spheres of different diameter composed of moderating material



Charged particles from **^{3}He(n,p)^{3}H reaction** are detected with the ^{3}He proportional counter.
Every sphere is sensitive to a different neutron energy, depending on the moderating material.

The Response functions
Simulated with new FLUKA version



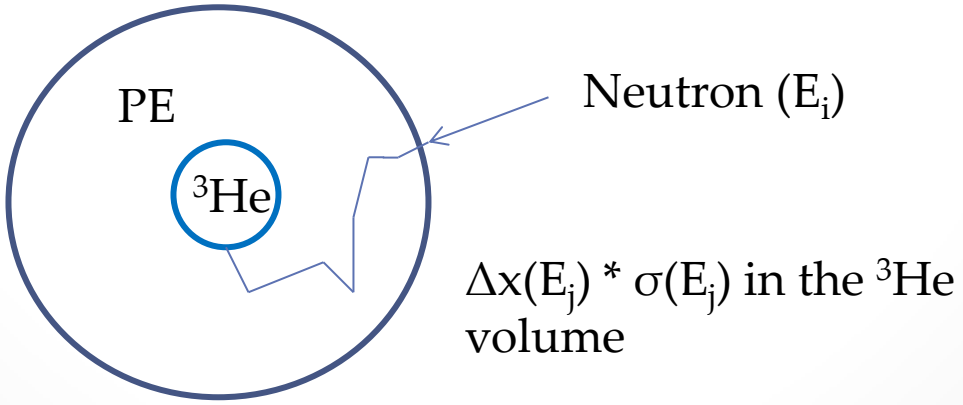
Overlapping of response functions

The Response functions

Simulated with new FLUKA version

$$R(E_i) = \frac{N_{atom} \cdot \sum_{E_j=0eV}^{E_j=\infty} \Delta x(E_j) \cdot \sigma(E_j)}{F_u} \quad (cm^2) \qquad i = 280 \text{ bins}$$

- N_{atom}: the ^3He atomic density (cm^{-3})
- Δx: track length of neutrons in the counter (cm)
- $\sigma(E)$: cross section of the reaction $^3He(n,p)^3H$ (cm^2)
- F_u: normalization quantity, i.e. the neutron fluence impinging on the sphere surface (cm^{-2})



The Unfolding method

Count rate measured

Neutron fluence unknown

$$C_j = \int_{E_{\min}}^{E_{\max}} R_j(E)\Phi(E)dE \qquad j = 1,2,\ldots,M \ \ spheres$$

Response function simulated

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Response function simulated

Solving a system of 7 linear equations with 280 unknown variables

Simulated

$$\textbf{Measured} \begin{bmatrix} C_1 \\ C_2 \\ \ldots \\ C_7 \end{bmatrix} = \begin{bmatrix} R_{1,1} & R_{1,2} & \ldots & R_{1,280} \\ R_{2,1} & R_{2,2} & \ldots & R_{2,280} \\ \ldots\ldots & & & \\ R_{7,1} & R_{7,2} & \ldots & R_{7,280} \end{bmatrix} \begin{bmatrix} \Phi_1 \\ \Phi_2 \\ \ldots \\ \Phi_{280} \end{bmatrix} \quad \textbf{Unknown}$$

Problem is under-defined; **A guess spectrum is needed (simulation)**

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Count rate measured

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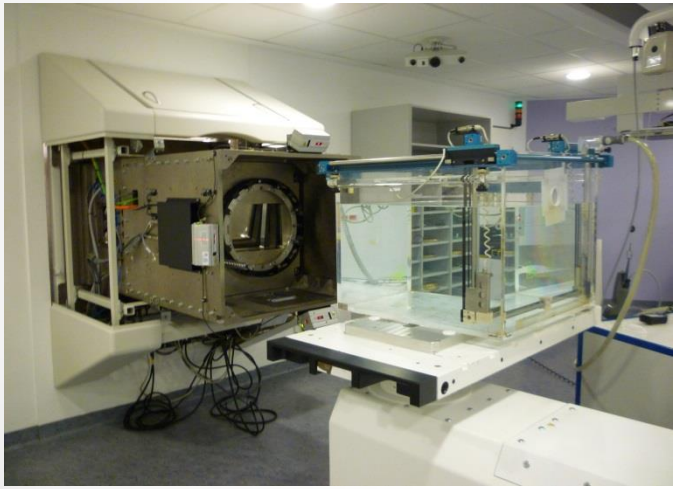
Common unfolding codes: MAXED, GRAVEL, FRUIT

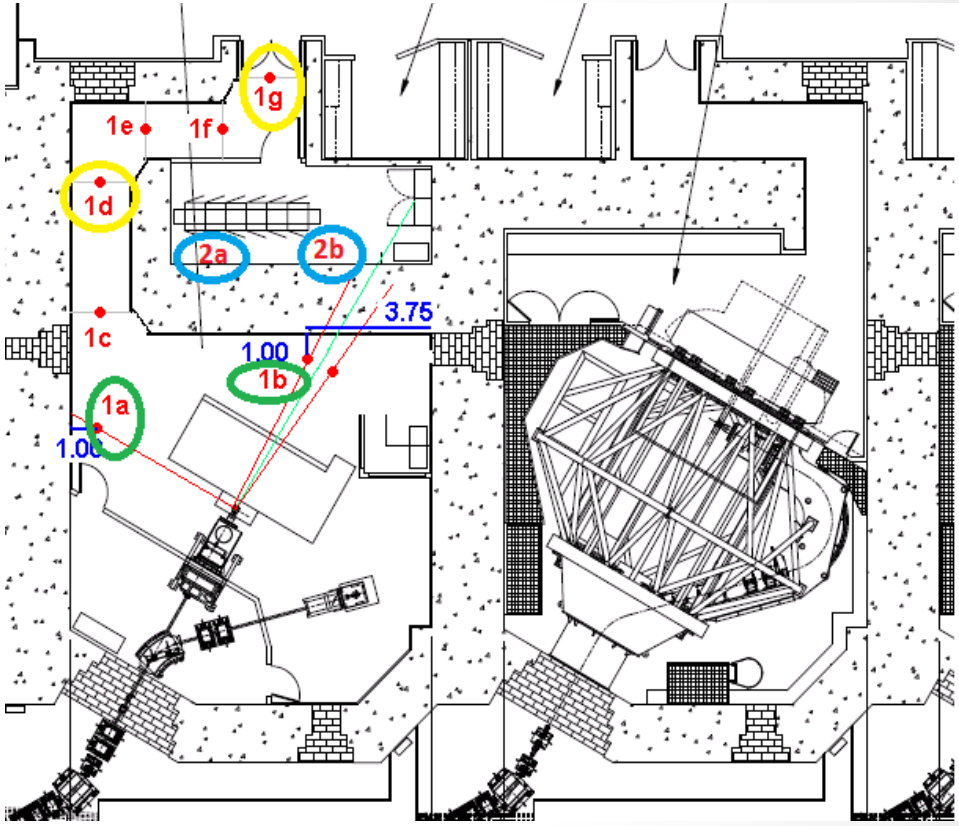
MAXED: Maximum entropy, GRAVEL: Least squares, FRUIT: Physical models

Measurements with the BSS at Essen

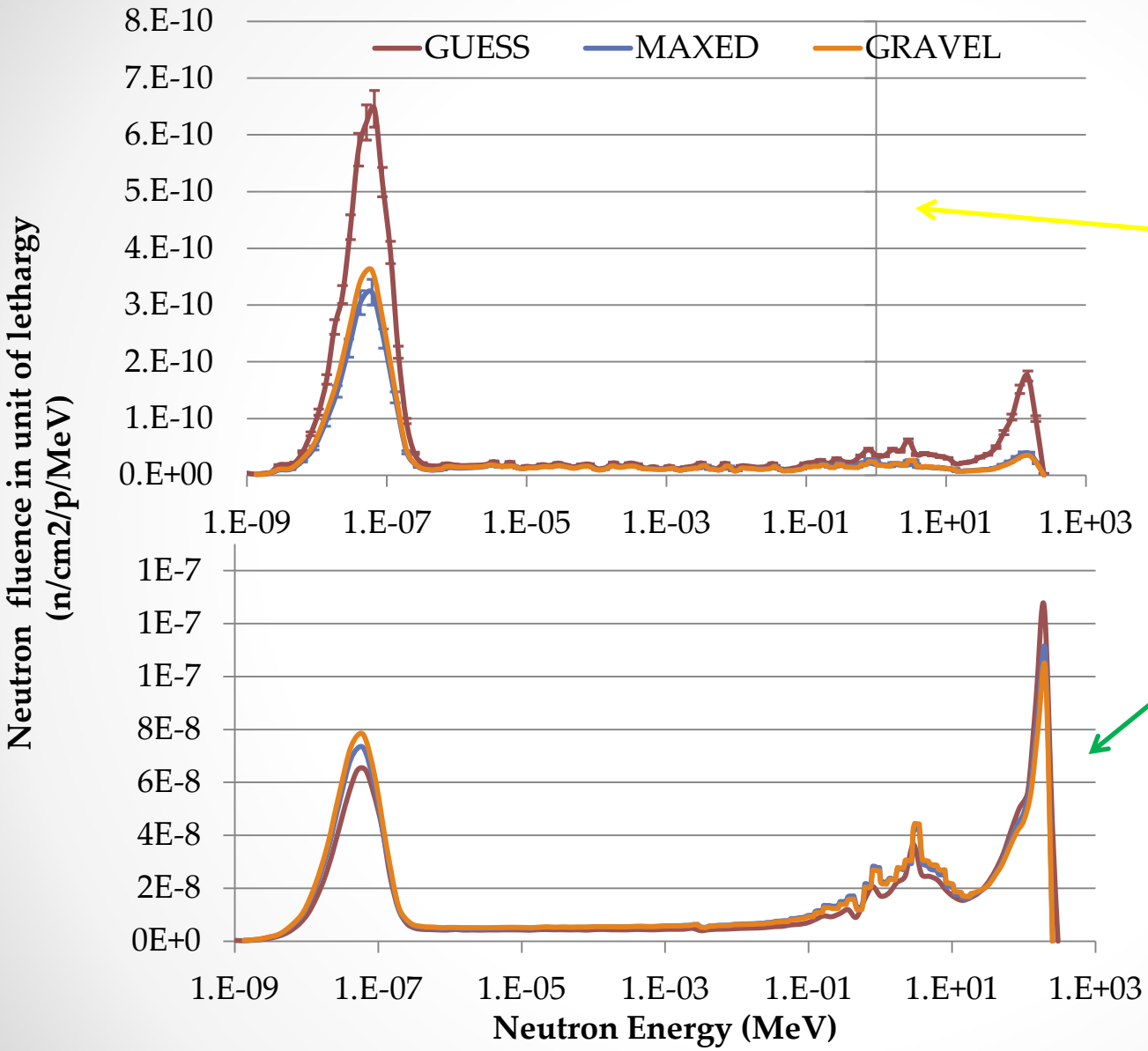
Measurements inside a treatment room in the Proton Therapy Centre of Essen

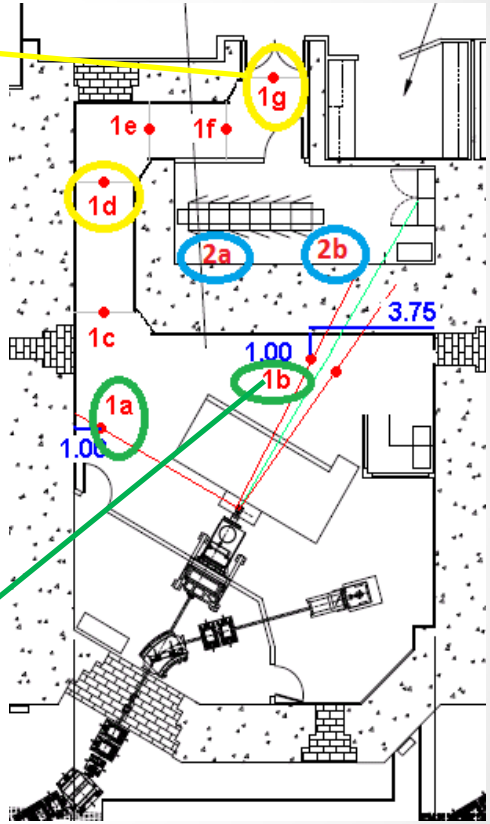
230 MeV/c protons on water phantom
$3*10^9$ protons/s





Comparison between unfolded and guess spectrum in 2 positions



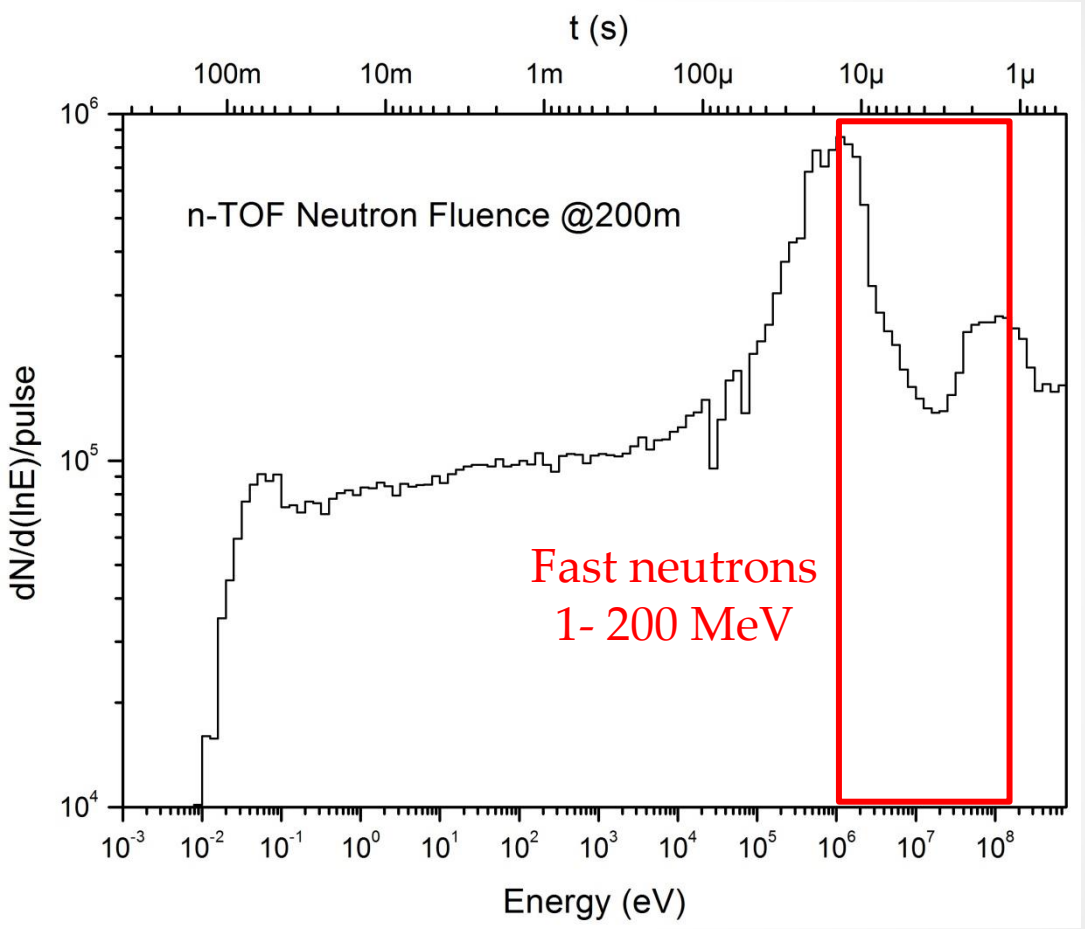


Measurements with the GEM at nTOF, CERN

Neutron production from spallation reactions

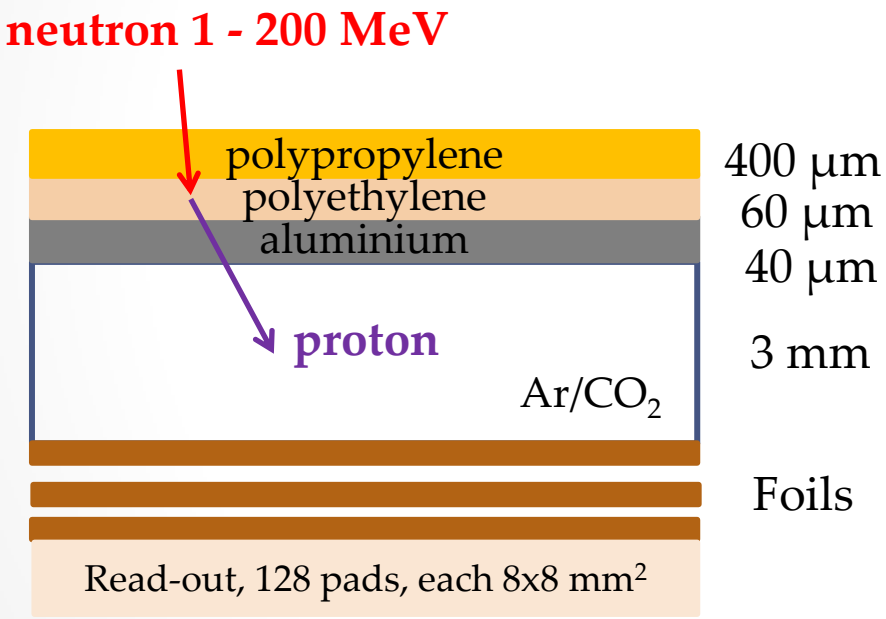
Measurements were performed at the beam dump, 200 m from the target

Neutron energy is measured from their time-of-flight.



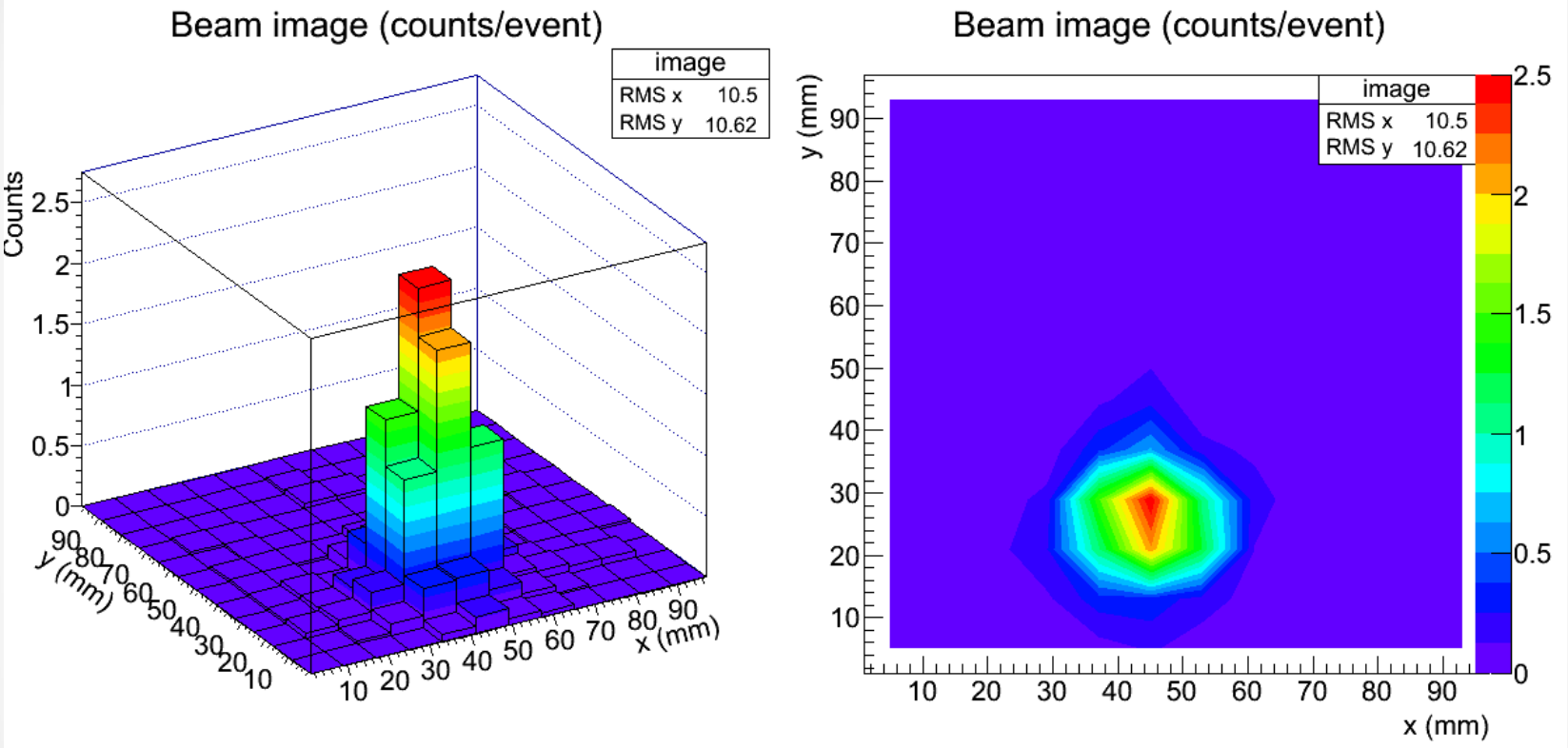
Experimental set-up at the beam dump

Triple GEM for fast neutrons



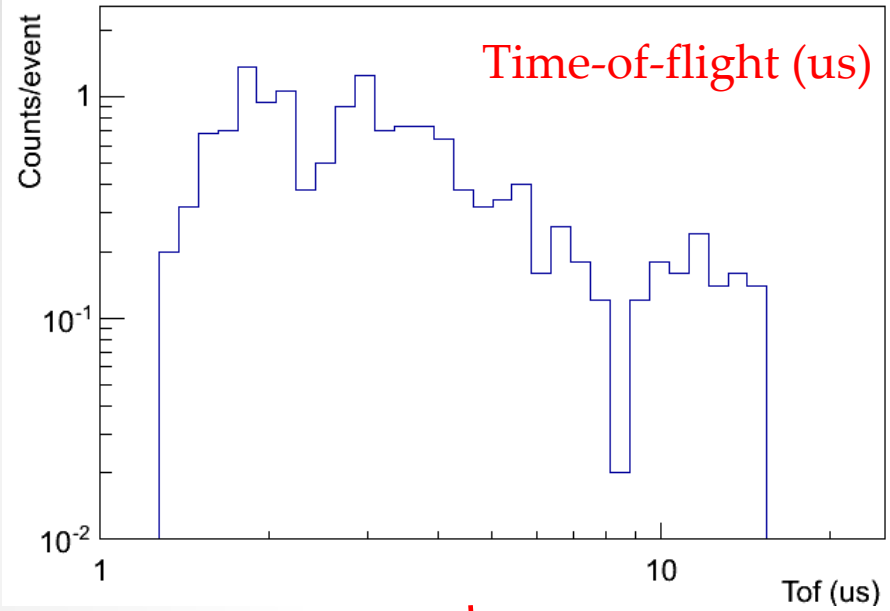
Beam profile

For the entire neutron energy range (1 – 200 MeV)



RMSx = 10.5 mm
RMSy = 10.6 mm

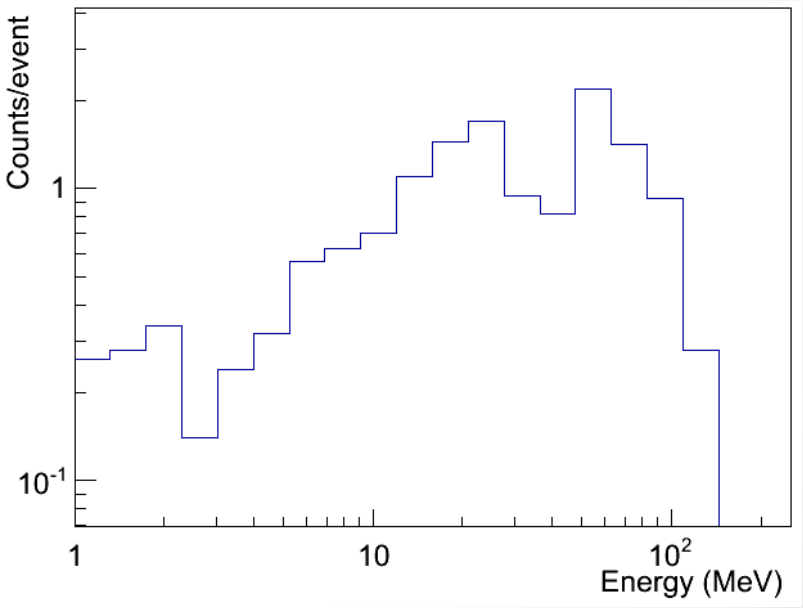
Time-of-flight and neutron spectrum



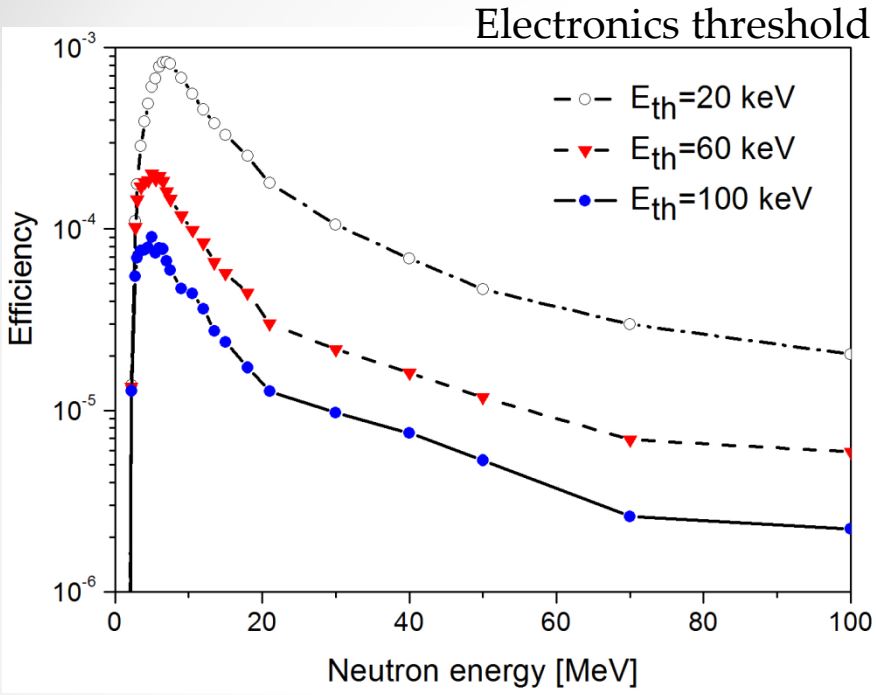
Trigger from the PS
(Proton Synchrotron)

$E = mc^2 (\gamma\text{-}1)$

Energy (1 – 200 MeV)

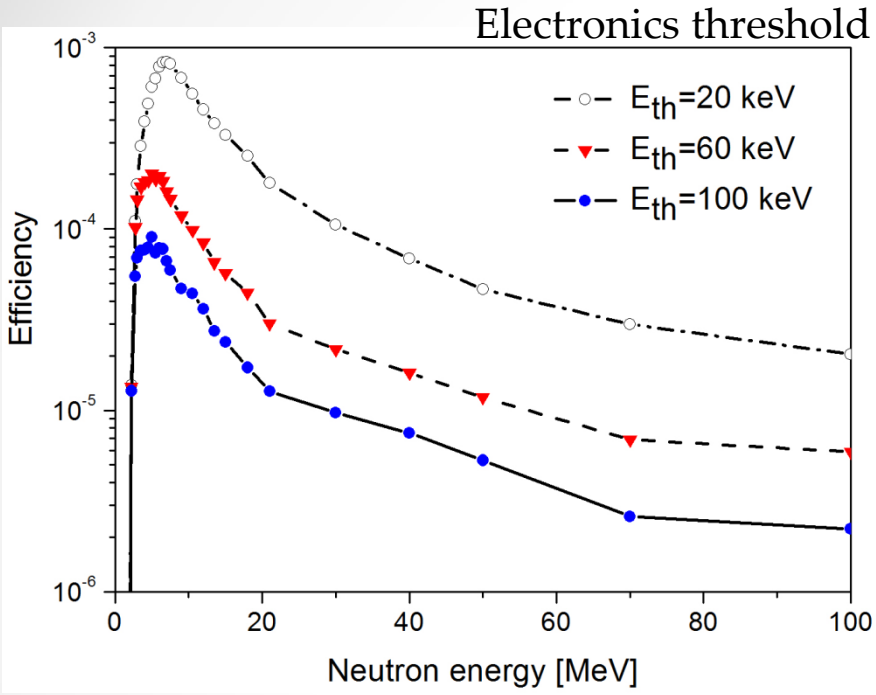


Efficiency simulation and measurement



Simulation with MCNP, JINST 7 P07021

Efficiency simulation and measurement



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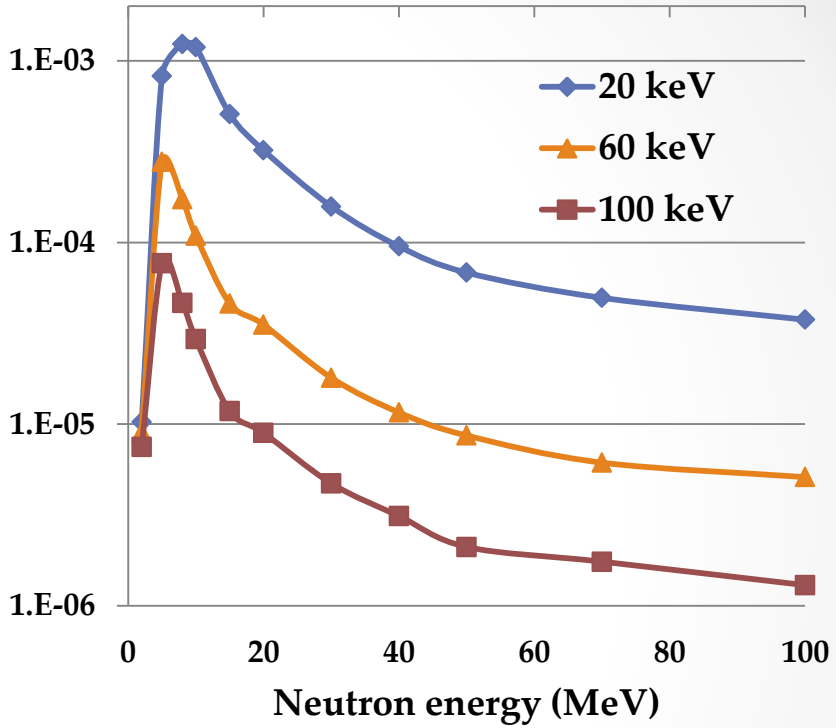
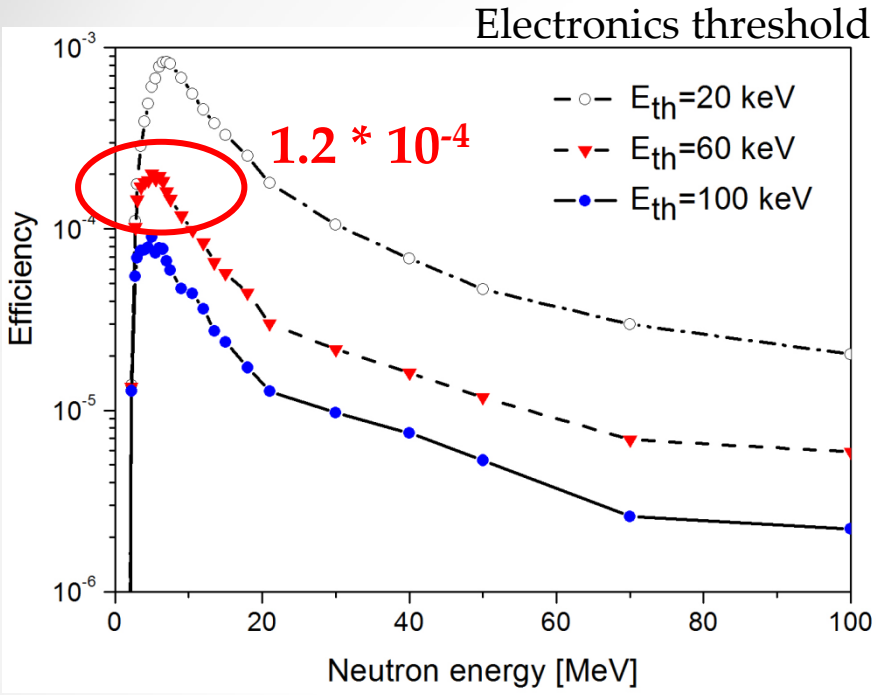
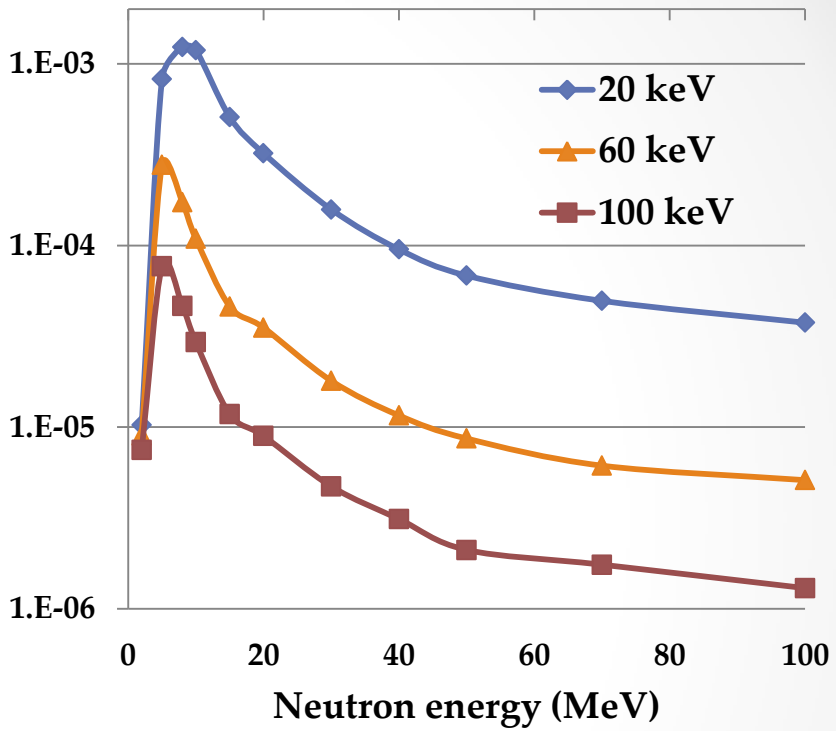


Simulation with FLUKA

Efficiency simulation and measurement



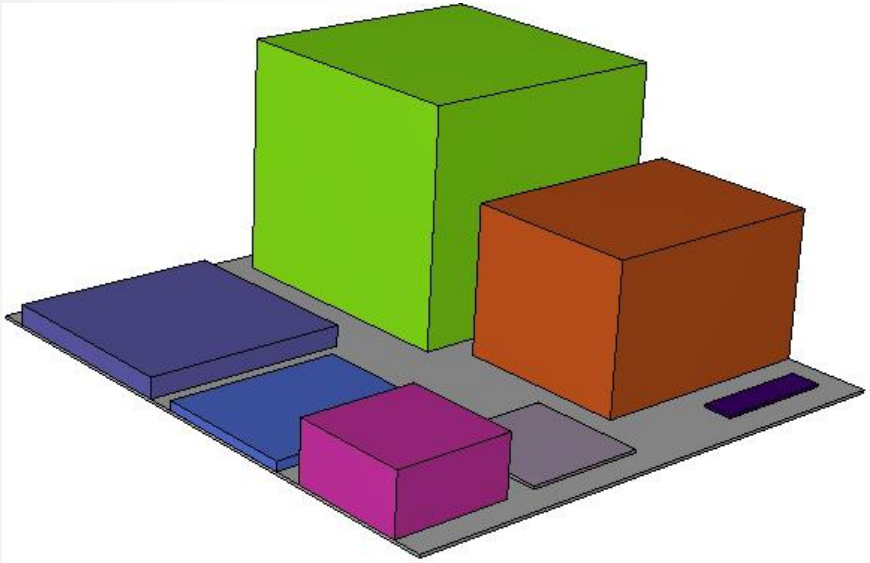


Simulation with MCNP, JINST 7 P07021

Simulation with FLUKA

From our measurements: **1.4 * 10^{-4}** in the same range

Design of a GEM-based neutron spectrometer



For more details visit my poster!

Each section measures in a different energy range, depending on the material used

The charged particles produced are read-out by a GEM attached to the board

Detection methods:

1. Thermal neutron conversion
2. Moderation and thermal neutron conversion
3. Recoil protons from fast neutrons

Publications

1. E. Aza et al., "**Instrument intercomparison in the pulsed neutron fields at the CERN HiRadMat facility**", Radiation Measurements 61, 2014

HiRadMat facility, end of TA7 tunnel (CERN)

Intercomparison of detectors

2. E. Aza et al., "**The Triple GEM detector as beam monitor for relativistic hadron beams**", JINST 9 P06006, 2014

CERF, North Area (CERN)

Beam monitor

Thank you!