DETECTING NEUTRONS using MEDEA BaF_2 array

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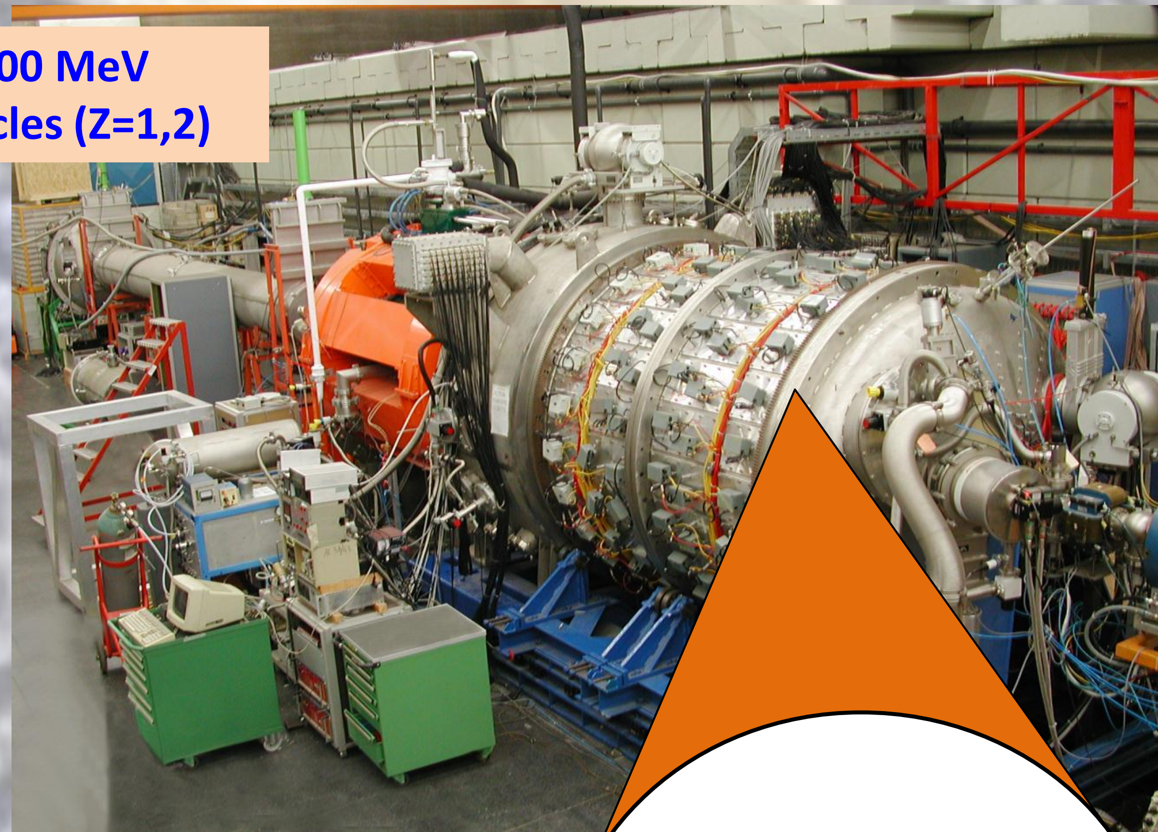
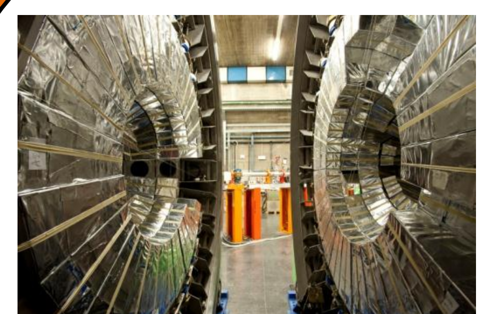
MEDEA APPARATUS

gamma-rays up to 200 MeV and light charged particles (Z=1,2)

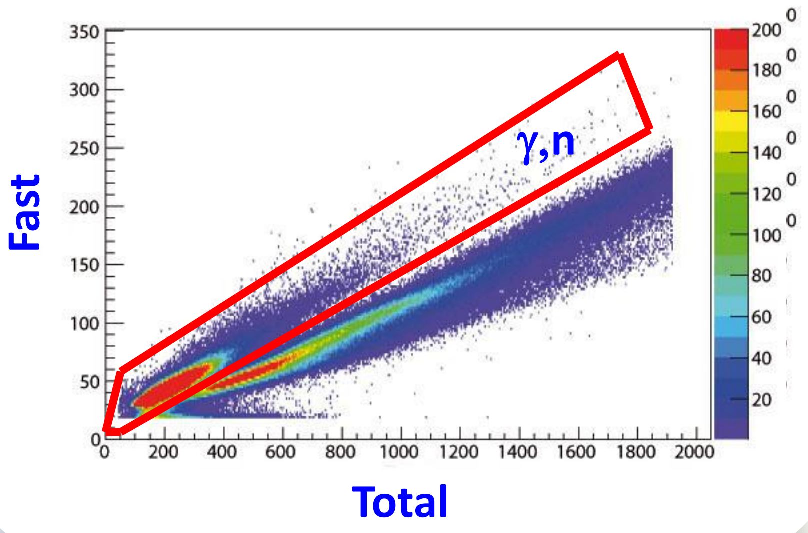


180 BaF_2 scintillators, 20 cm thick, arranged from 30° to 170° in a spherical geometry (radius 22 cm)

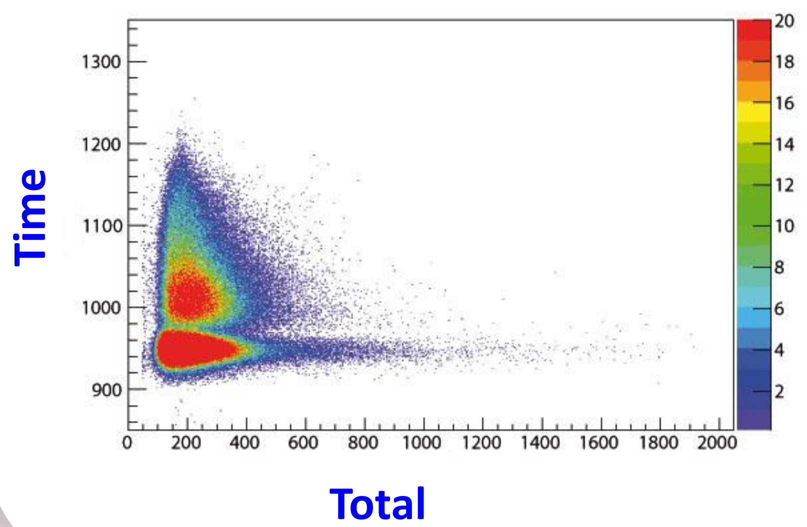


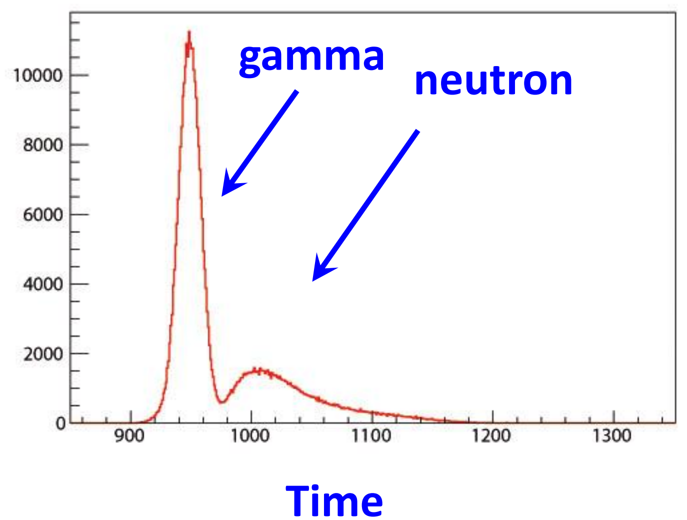
MEDEA

Identification of gammas and particles through pulse shape analysis

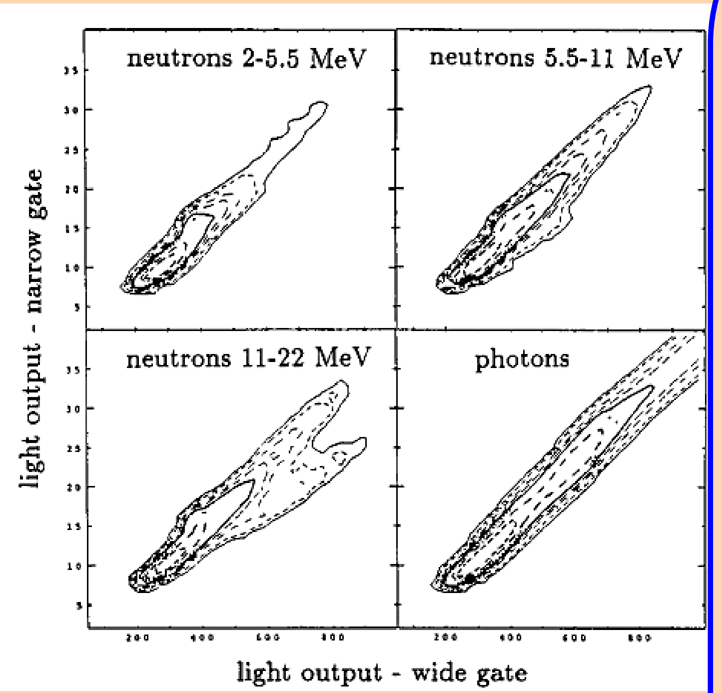


The two-dimensional correlation spectra of the fast component versus the total light yield of the BaF_2 scintillator allow for a clear separation of the signals caused by photons and charged hadrons



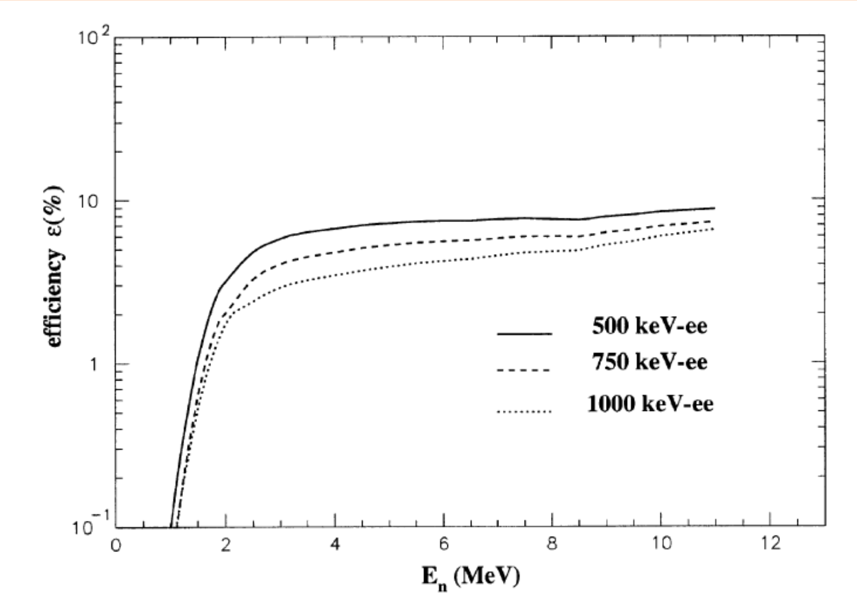


Previous studies on neutron detection using BaF_2 crystals



Matulewicz et al.
NIMA274 (1989) 501

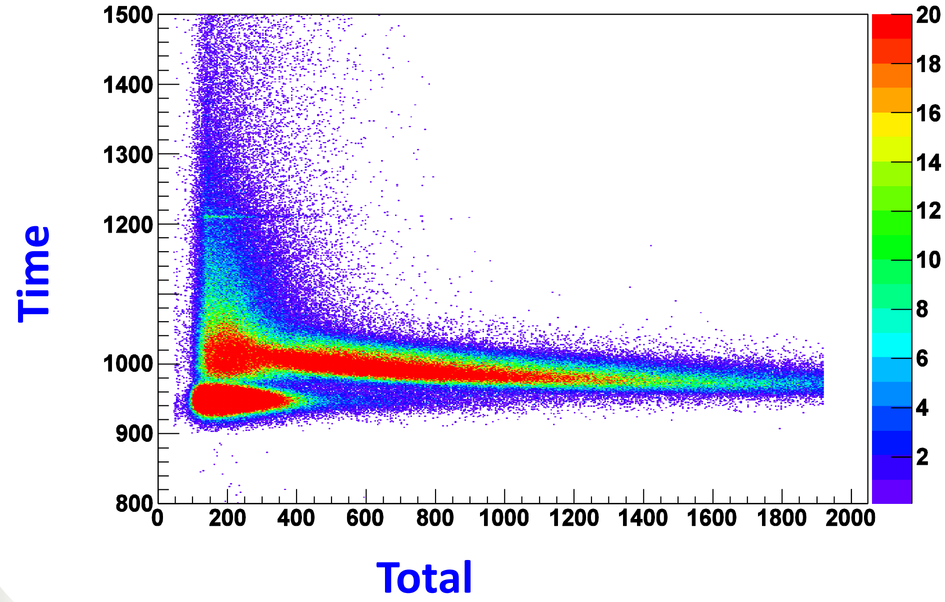
Lanzano detector 25 cm^2
hexagonal surface 5 cm thick

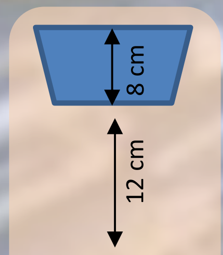


Lanzanò et al.
Nuovo Cimento A110 (1997) 505

Removing the front part of some MEDEA module

The shortened detector allows for a better separation between gammas and neutrons. Indetermination in impact point is reduced to 8 cm while flight path is 34 cm.

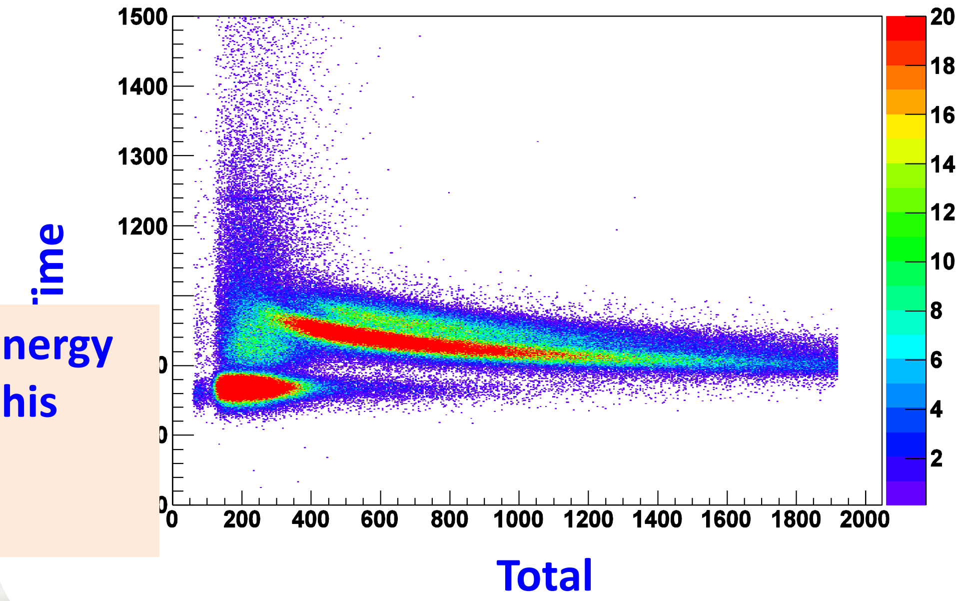




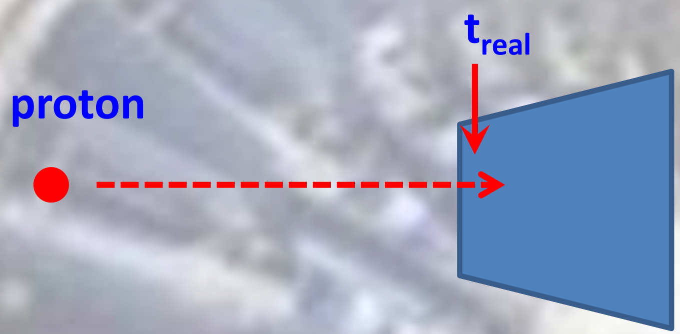
Few modules already modified

Can we have reliable information on energy deduced from the time of flight in this condition?

How to test this point?



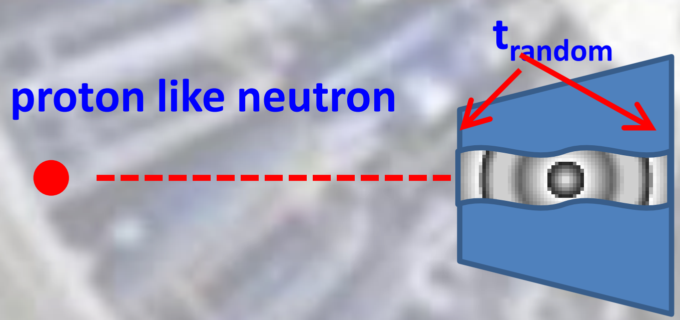
Testing the reliability of the energy calculation from time of flight using protons of known energies



a proton realeases all its energy in a few centimeters unlike a neutron that can interacts inside all the crystal volume

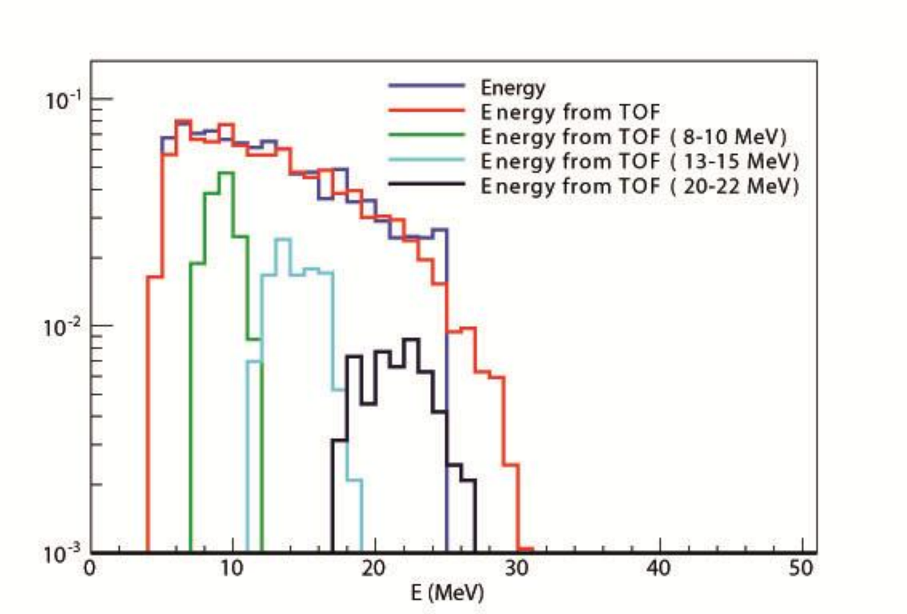
The energy deposited by the proton is obtained by well known calibration procedure

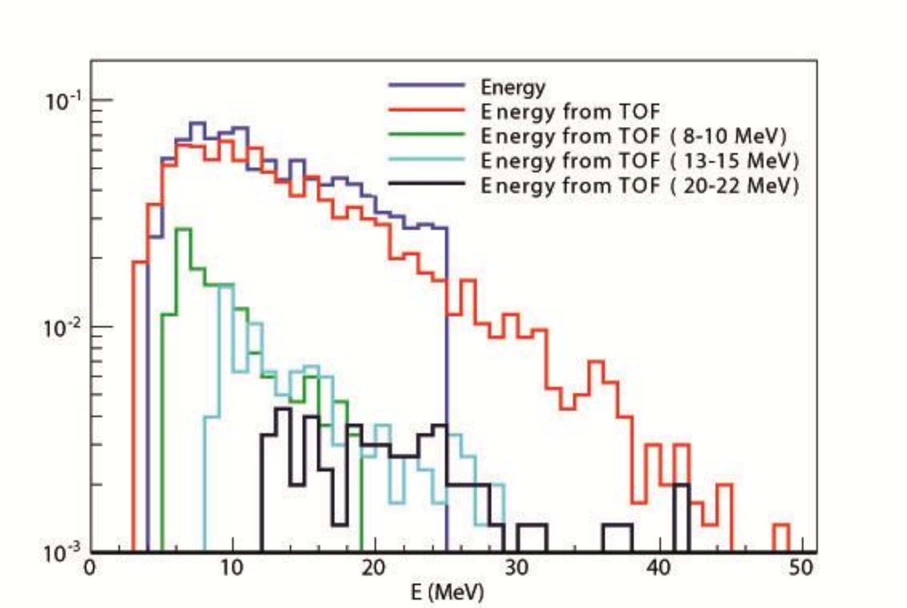
This energy can be compared to the energy calculated from the time of flight forcing a proton to have the same behaviour of a neutron…



…that is adding to proton time a time randomly chosen inside the crystal transit time

Simulating a neutron using a proton….

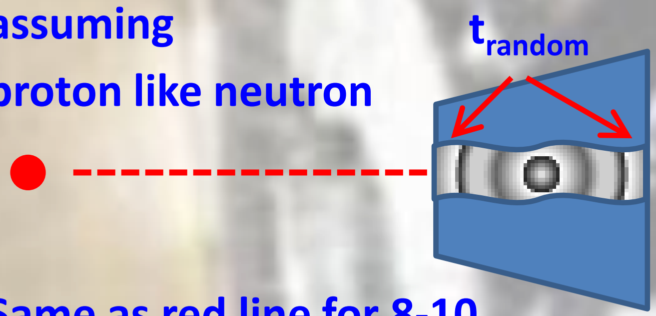




Calibrated proton energy

Energy from time of flight assuming

proton like neutron



Same as red line for 8-10 MeV of deposited proton energy

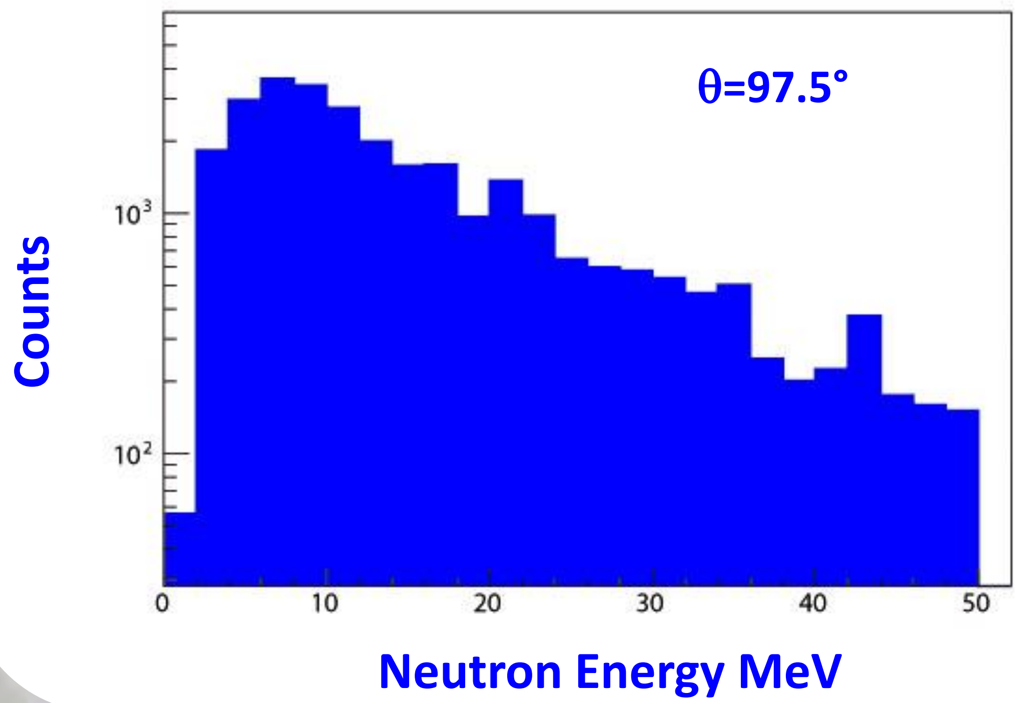
Same as red line for 13-15 MeV of deposited proton energy

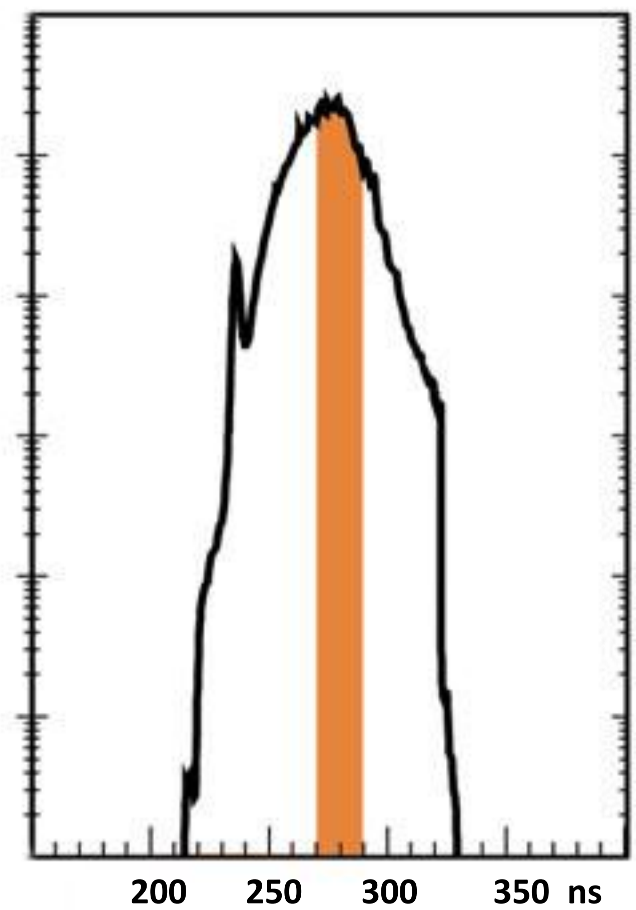
Same as red line for 20-22 MeV of deposited proton energy

Experimental neutron spectrum

$^{116}Sn+^{24}Mg$ @ 23 MeV/A

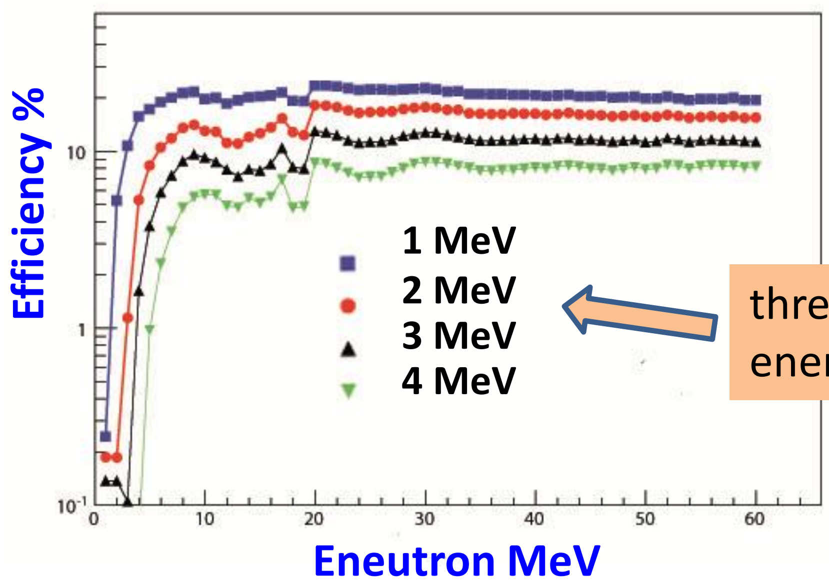
In coincidence with Sn residues





without efficiency correction

Efficiency simulated with Geant4

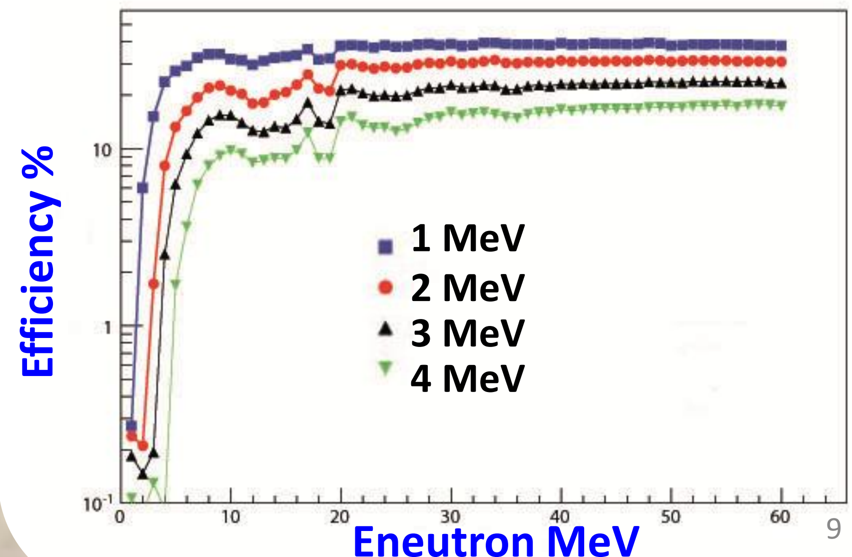


threshold on deposited energy

The last version used Geant4.9.5

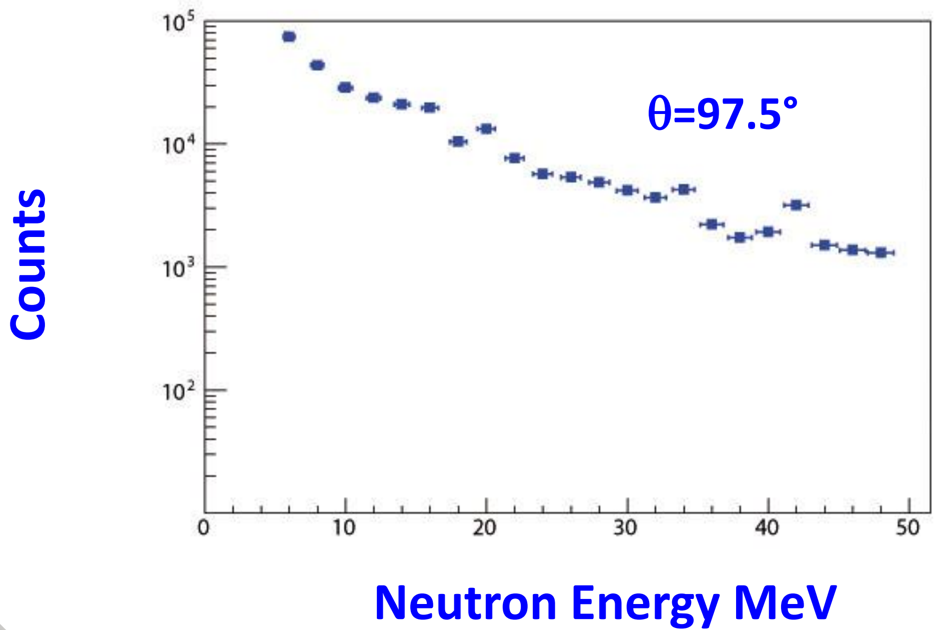
Physics list
QGSP_BIC_HP below 20 MeV
QGSP_BIC_above 20 MeV

for comparison the standard MEDEA detector



Experimental neutron spectrum

^{116}Sn+^{24}Mg @ 23 MeV/A



With efficiency correction

In intermediate energy heavy ion collisions experimental spectra are generally reproduced with a fit assuming emission from multiple sources of Maxwellian type

Proton spectra in $^{116}Sn+^{24}Mg$ @ 23 MeV/A

Experimental proton
reproduced with a fit assu
from two Maxwellian typ
Fast source: compou
Intermediate source: pre-e

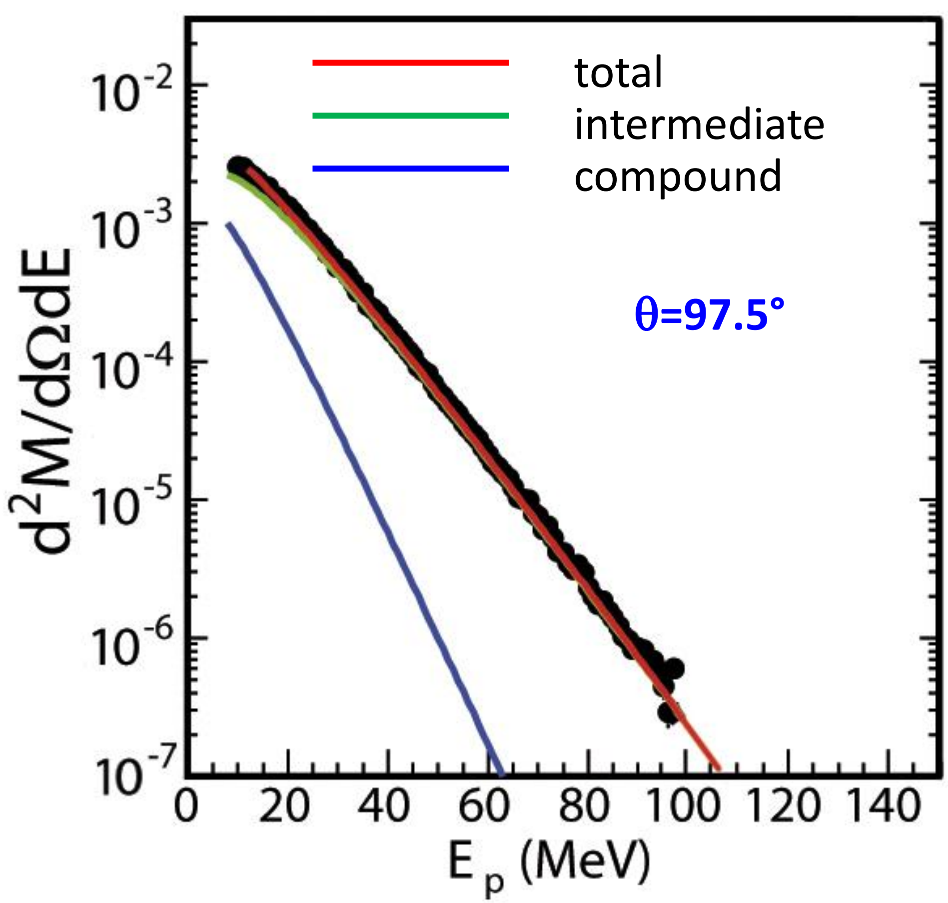
Fast source

M_{fast}	T_{fast}(MeV)	v_{fast} (cm/ns)
2.2	5.5	5.5

Intermediate source

M_{int}	T_{int}(MeV)	v_{int} (cm/ns)
1.1	8.4	3.4

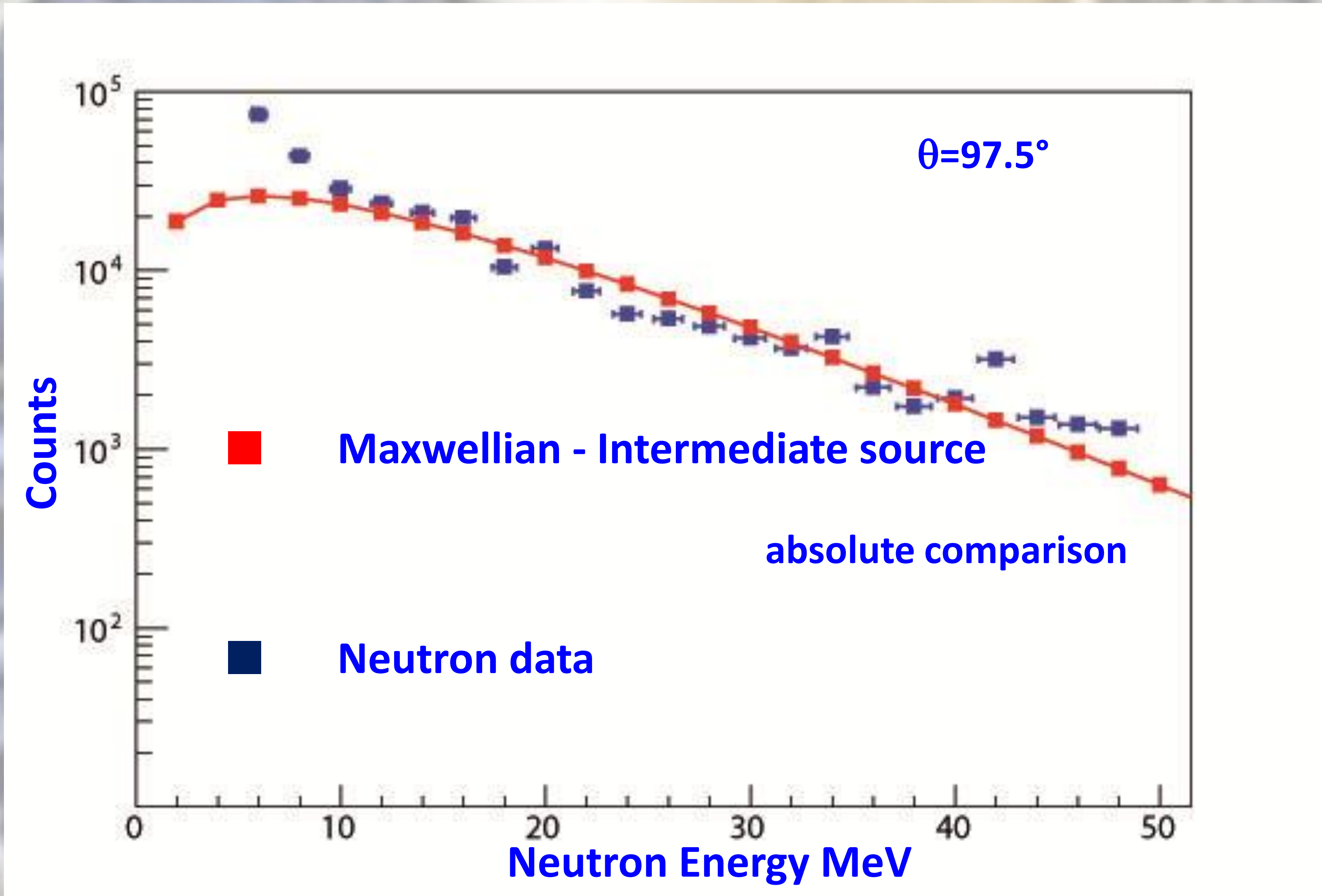
$$T_{int} = \frac{E_{beam}}{8\,A_p} + 6\text{ MeV}$$



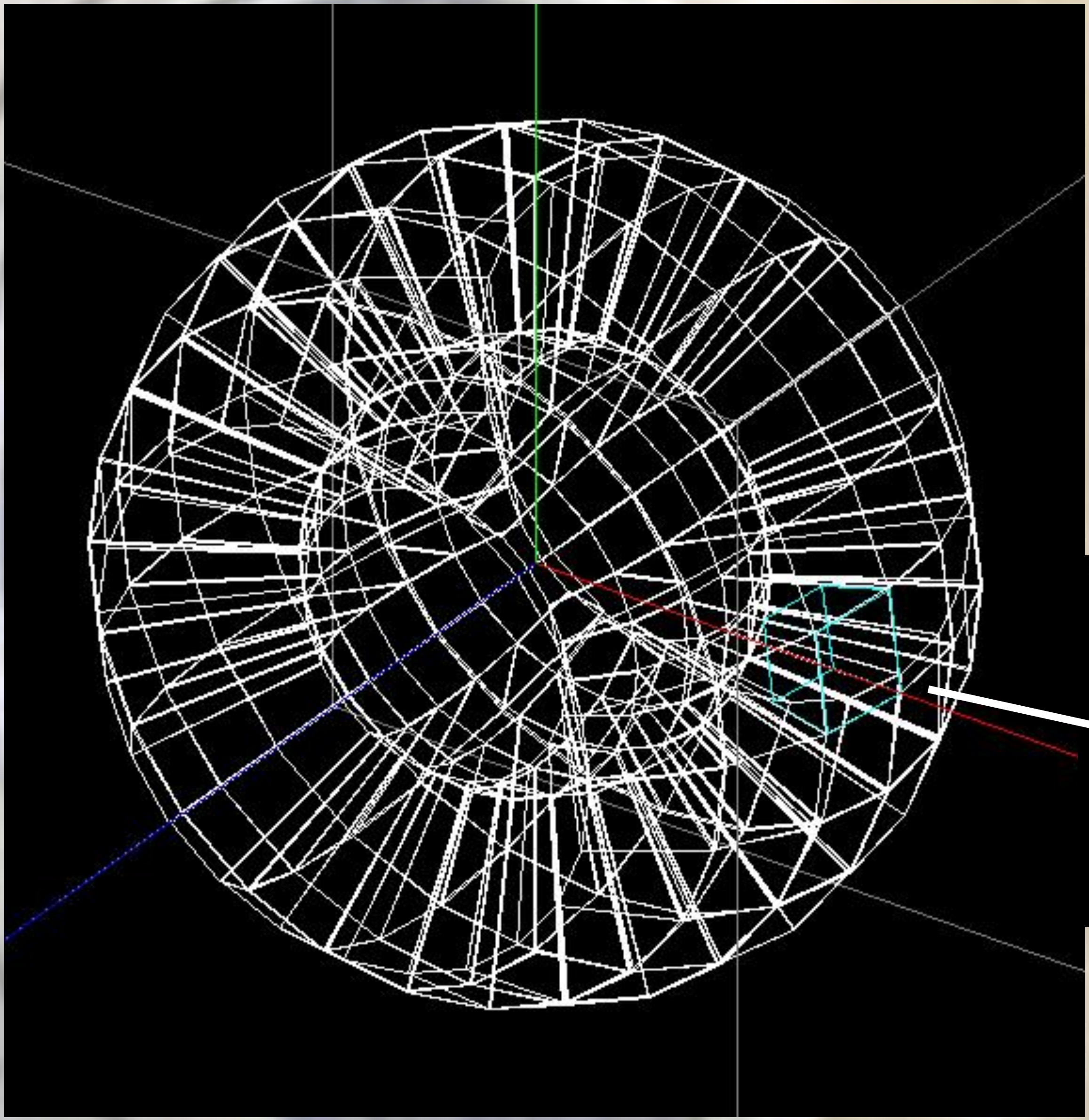
$V_{beam\ (23\ MeV/A)}$ = 6.6 cm/ns

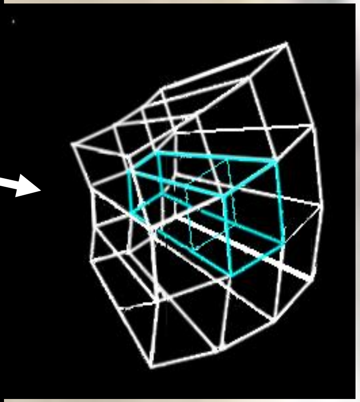
v_{int} near half beam velocity

$^{116}Sn+^{24}Mg$ @ 23 MeV/A



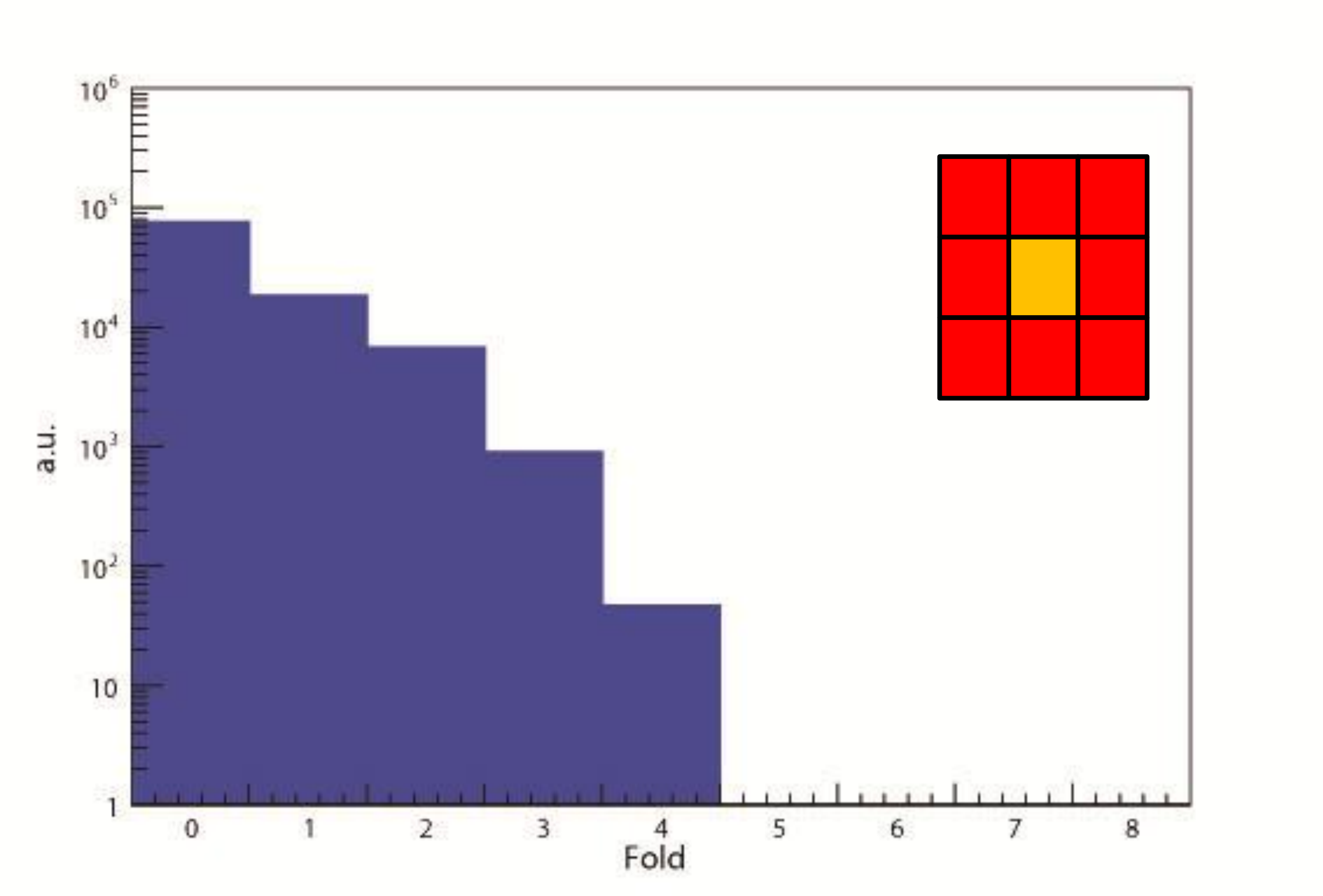
MEDEA GEOMETRY





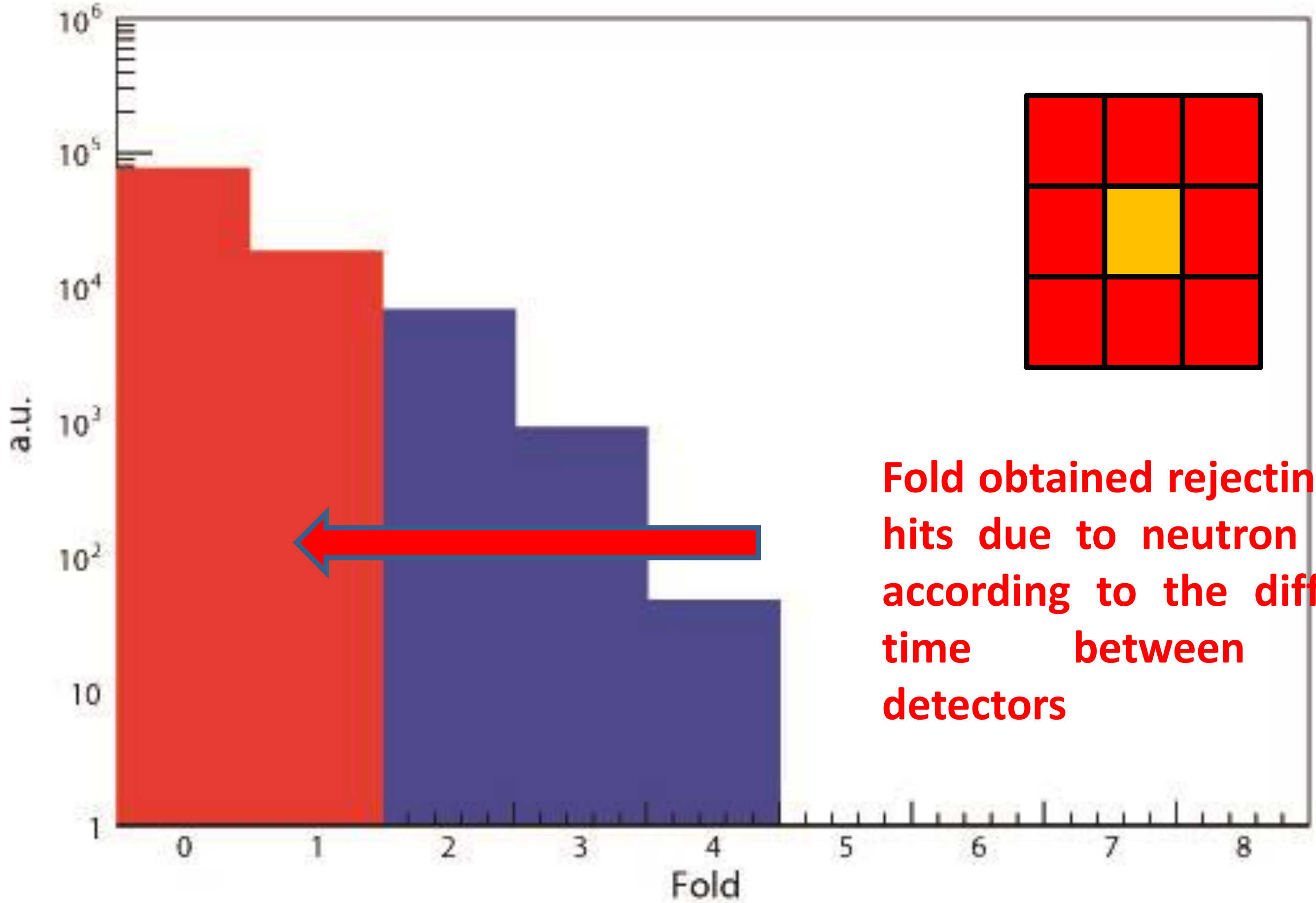
IMPLEMENTED IN GEANT4

SIMULATION



Fold distribution in events where 1 neutron of 14 MeV has been sent randomly in MEDEA

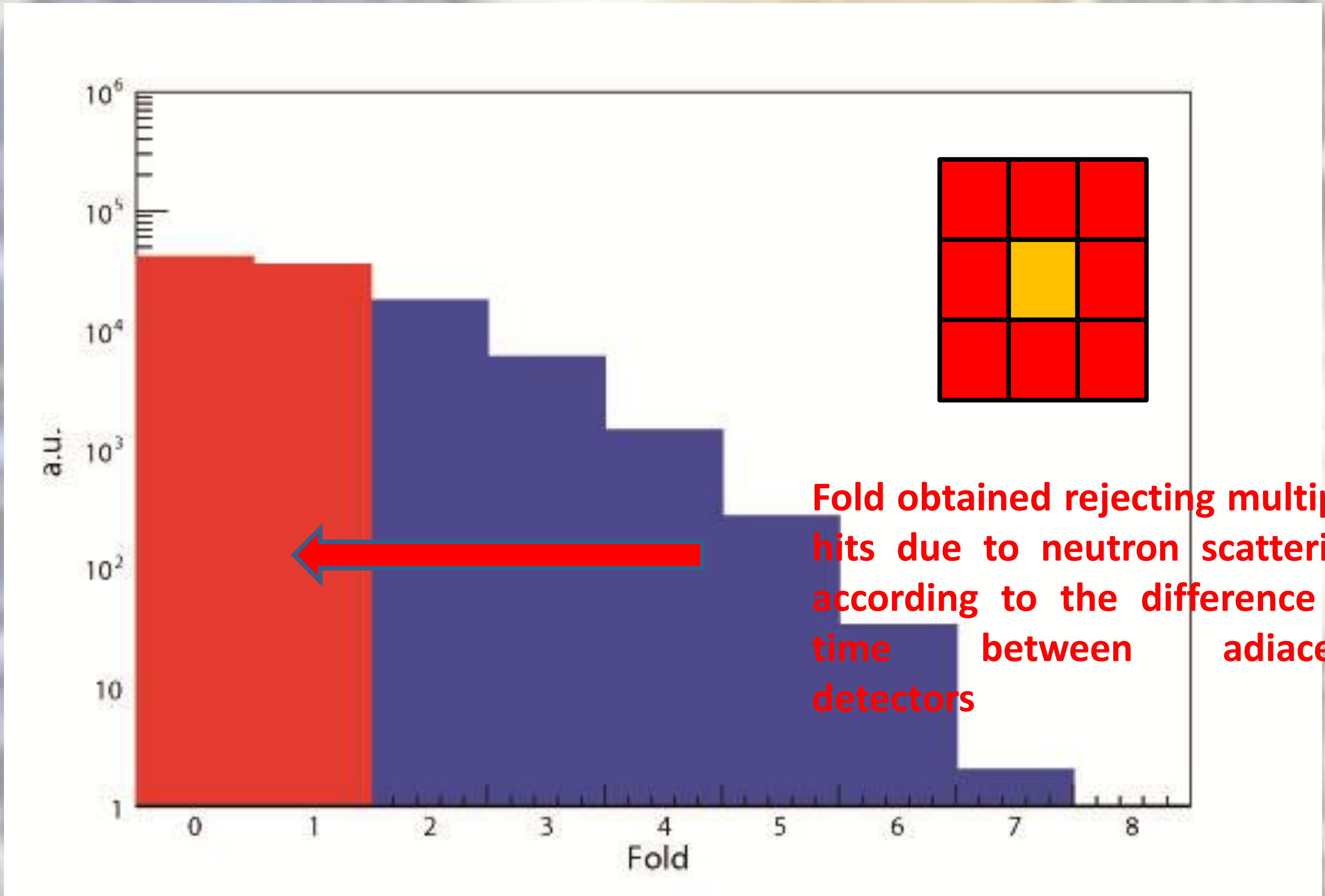
SIMULATION



Fold obtained rejecting multiple hits due to neutron scattering according to the difference in time between adiacent detectors

Fold distribution in events where 1 neutron of 14 MeV has been sent randomly in MEDEA

SIMULATION



Fold distribution in events where 3 neutrons of 7,11,14 MeV have been sent randomly in MEDEA

Summary

Few modules of MEDEA have been modified in order to retrieve information about neutrons

The agreement between experimental neutron spectra and proton spectra obtained in a previous experiment looks promising

Other modules have been modified in view of the next GDR experiment scheduled before july 2013

Of course MEDEA is not a neutron detector but…

…we are confident that in this configuration we can collect some complementary information on the reaction mechanism and improve the excitation energy determination of the hot system populated in the reactions.

Perhaps a migration towards a digital pulse shape analysis could help in this path