Test of the ECAL modules as gamma protection for a neutron detector.

Afanasiev S.V.

for BN@M collaboration.

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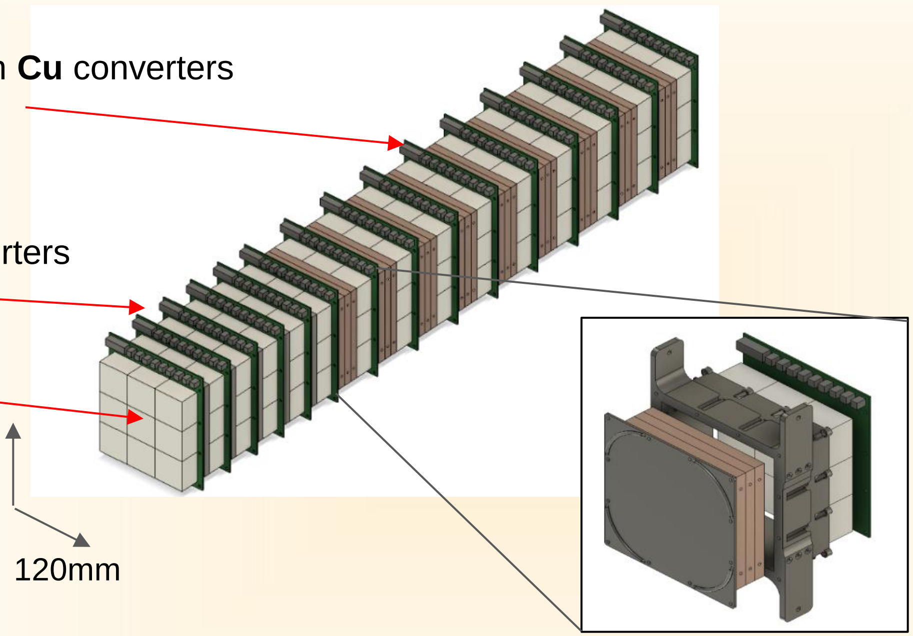
HGNd prototype layout



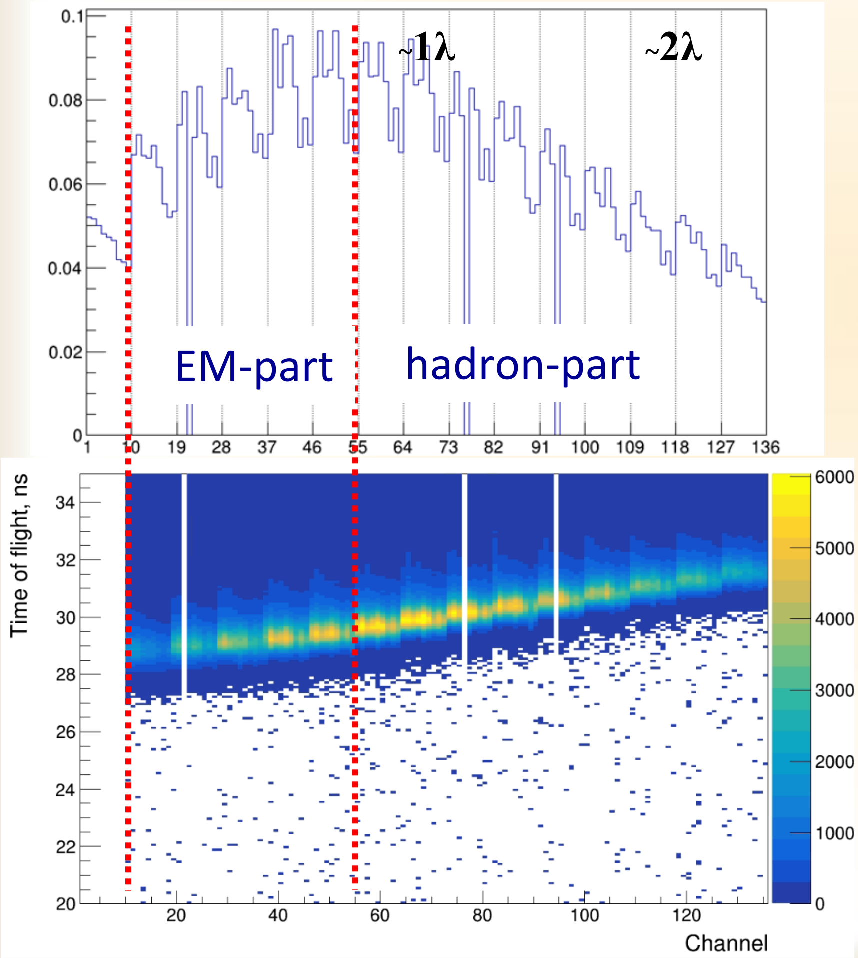
- 3D-printed detector casings
- Light-tight assembly
- Options for Pb, Cu and no converter

One layer 3x3 cells
Scintillator cell – 40 x 40 x 25 mm^3
Total readout channels 9+45+81 = 135
Total size – 120 x 120 x 825 cm^3
Total nuclear interaction length ~ 2

Granulation of the first layers is optimized for the effective suppression of gamma quanta from the target. Granulation of the detector second part is optimized to obtain maximum efficiency of neutron registration with an energy of up to 4 GeV.

R&D High Granularity Neutron detector – first run results.

Occupancy and time of flight in the each cell HGNd obtained in the Run 8.



The are 15 layers in HGNd.
1-st layer – veto
2-6 layers – γ-detection EM-part
7-15 layer – n-detection hadron-part
Detector has thickness more than two nuclear length.

EM-part properties

Nucl.inter.length λ_I **= 0.4**

Rad.length X_0**= 7.4**

Hadron-part properties

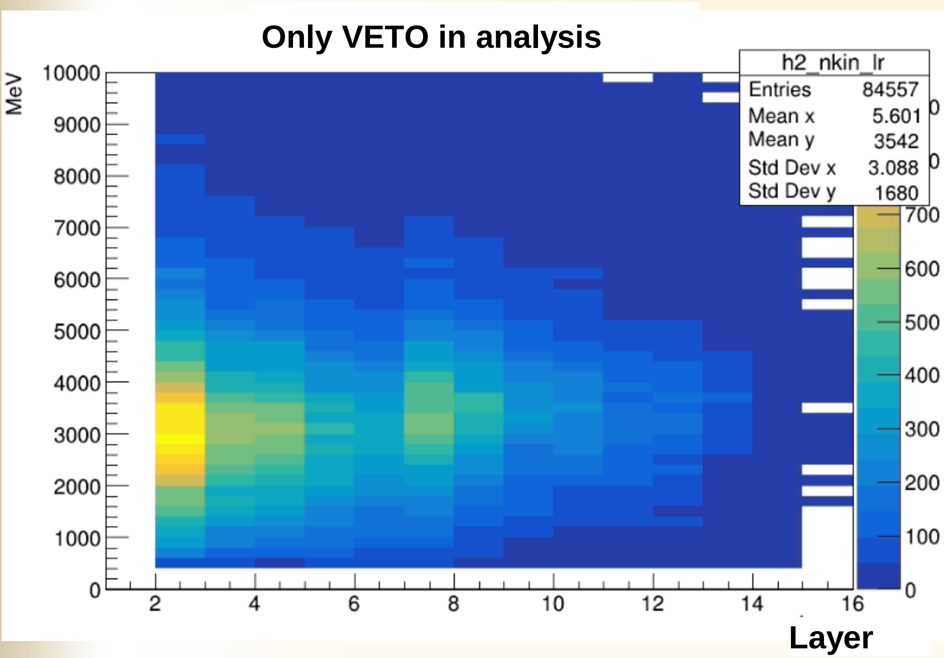
Nucl.inter.length λ_I **= 2.0**

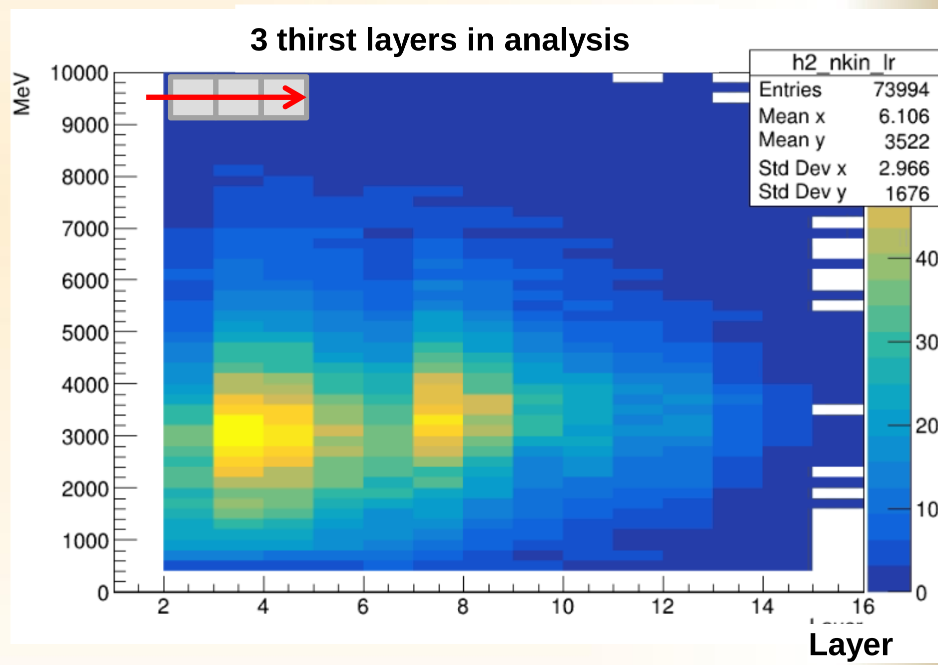
Rad.length X_0**= 19.3**

Suppression of gamma quants in the electromagnetic part of the detector.

The veto layer suppresses events from charged particles, but essentially does not affect the detection of gamma rays.

The condition was applied in the analysis of the first 3 layers activation simultaneously.



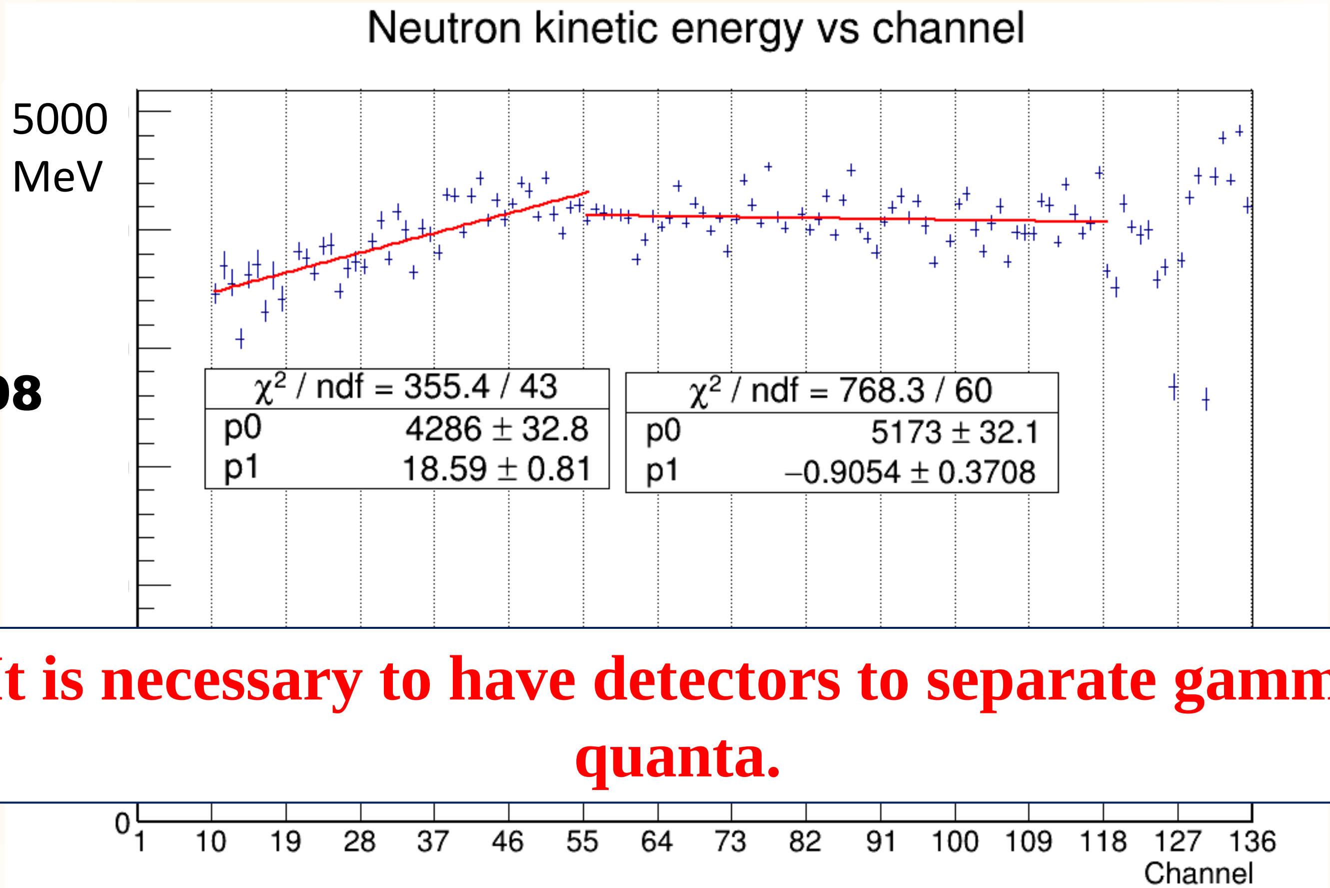


Events associated with gamma quanta are 12% of the total number of events.

The second negative point is the understatement of the reconstructed kinetic energy of neutrons for the first layers as a result of the influence of gamma quanta on the determination of time calibration constants.

$\beta_\gamma = 1$

$\beta_n = 0.98$



It is necessary to have detectors to separate gamma quanta.

Test of the ECAL modules as gamma protection for a neutron detector in RUN 8..

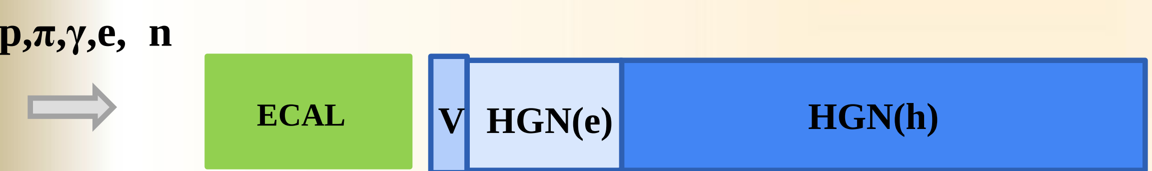
The ECAL module is a lead-scintillator sandwich with wavelength fibers for readout ***«Shashlyk type»***. It include of 220 layers of Pb(0.3mm) and plastic scintillator(1.5mm).

properties

Nucl.inter.length $\boldsymbol{\lambda_I = 0.8}$

Rad.length $\boldsymbol{X_0 = 12.6}$

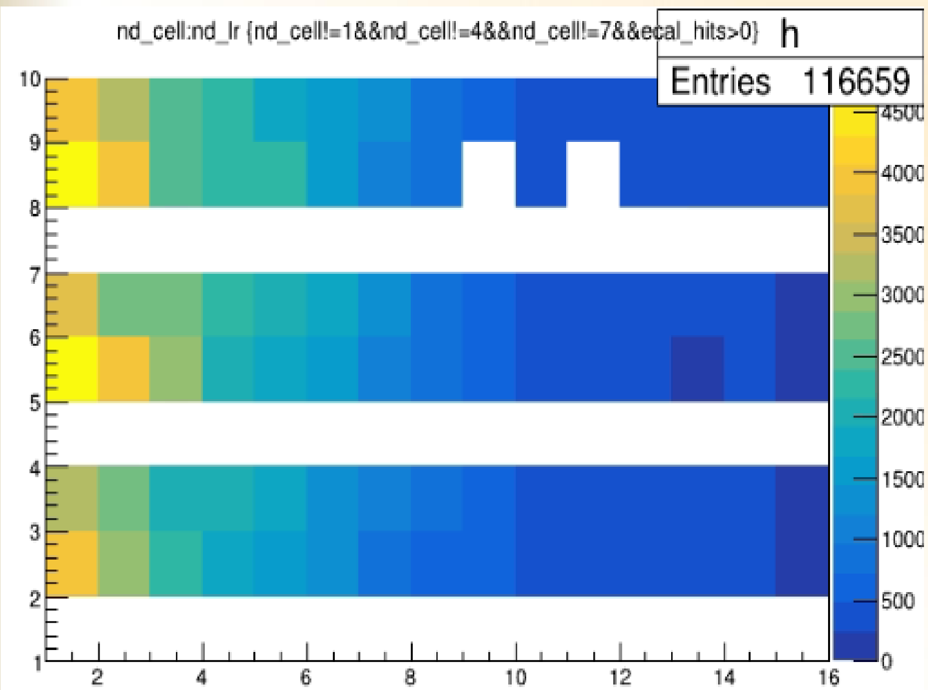
Length $\boldsymbol{L_0 = 42\text{cm}}$

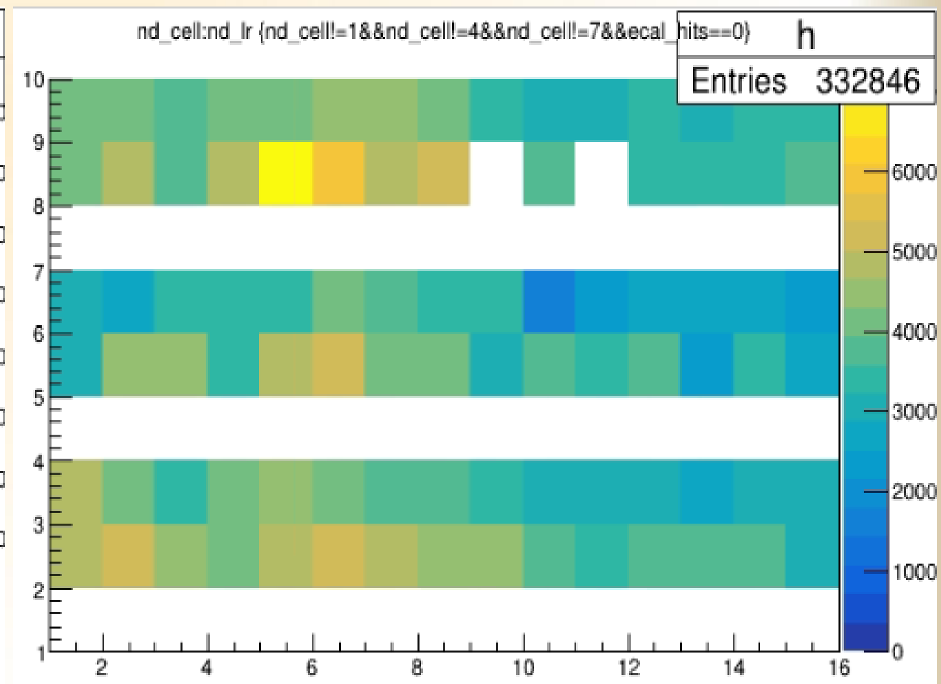


The location of the modules during the test in RUN 8. All detectors are placed under a light-protection material. Position is at 27 degrees.

Cells occupancy in HGNd.
The energy deposited in **ECAL >0**.
Infiltrate charged particles and electromagnetic shower.

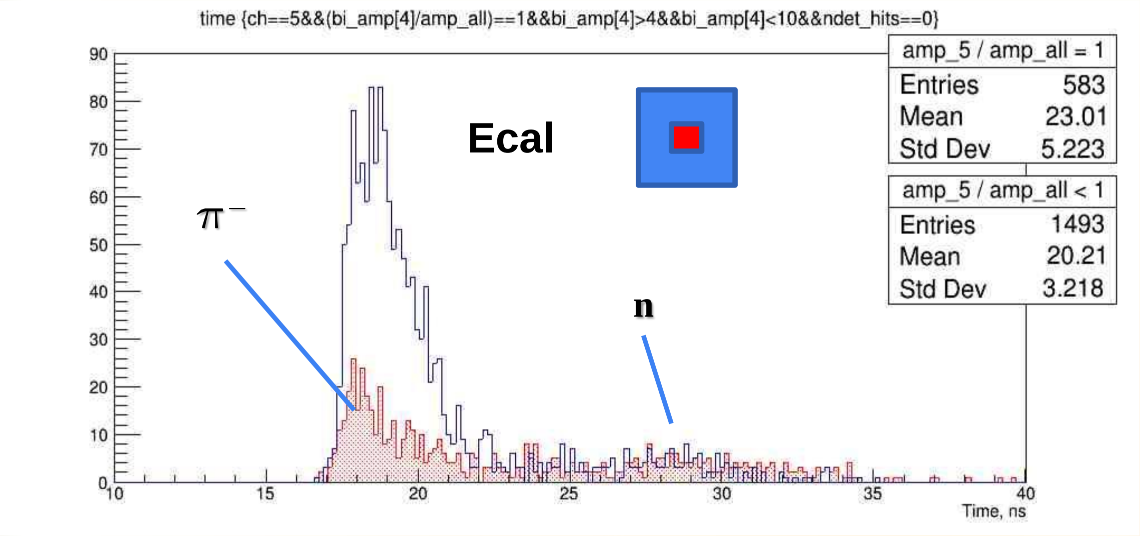
Cells occupancy in HGNd.
The **energy NOT** deposited in ECAL.
Only neutrons penetrate into HGNd.

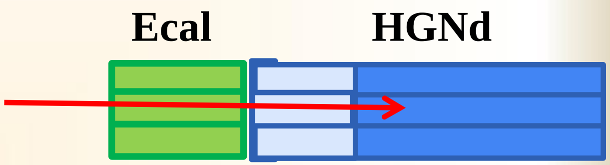




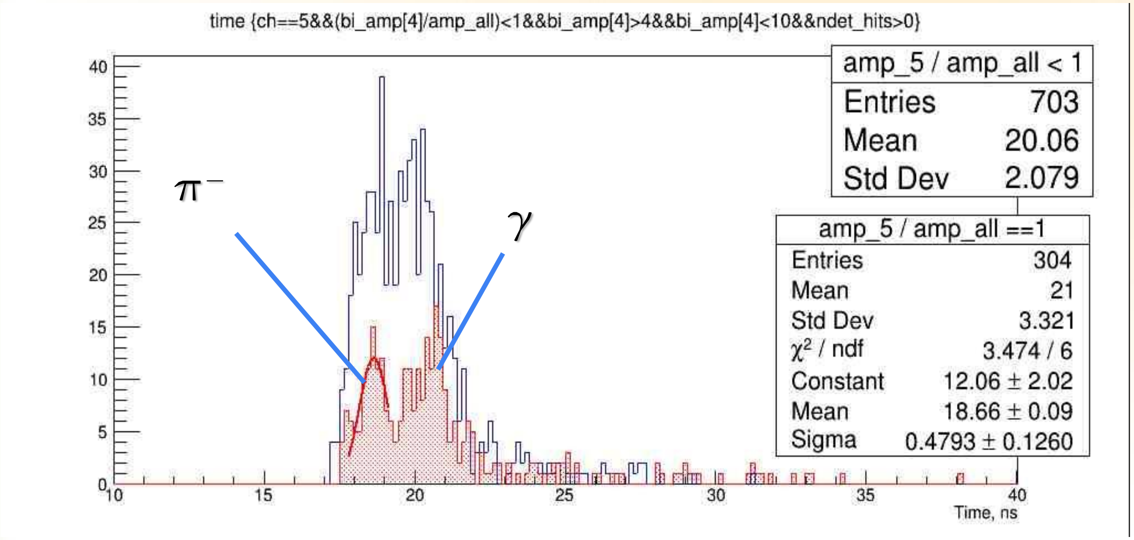
Time analysis in central sell of ECAL.

Conditions:
E5/Eall=1 Single track
Hits(HGNd)=0

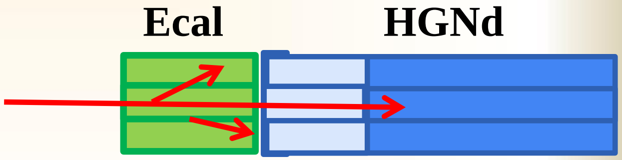




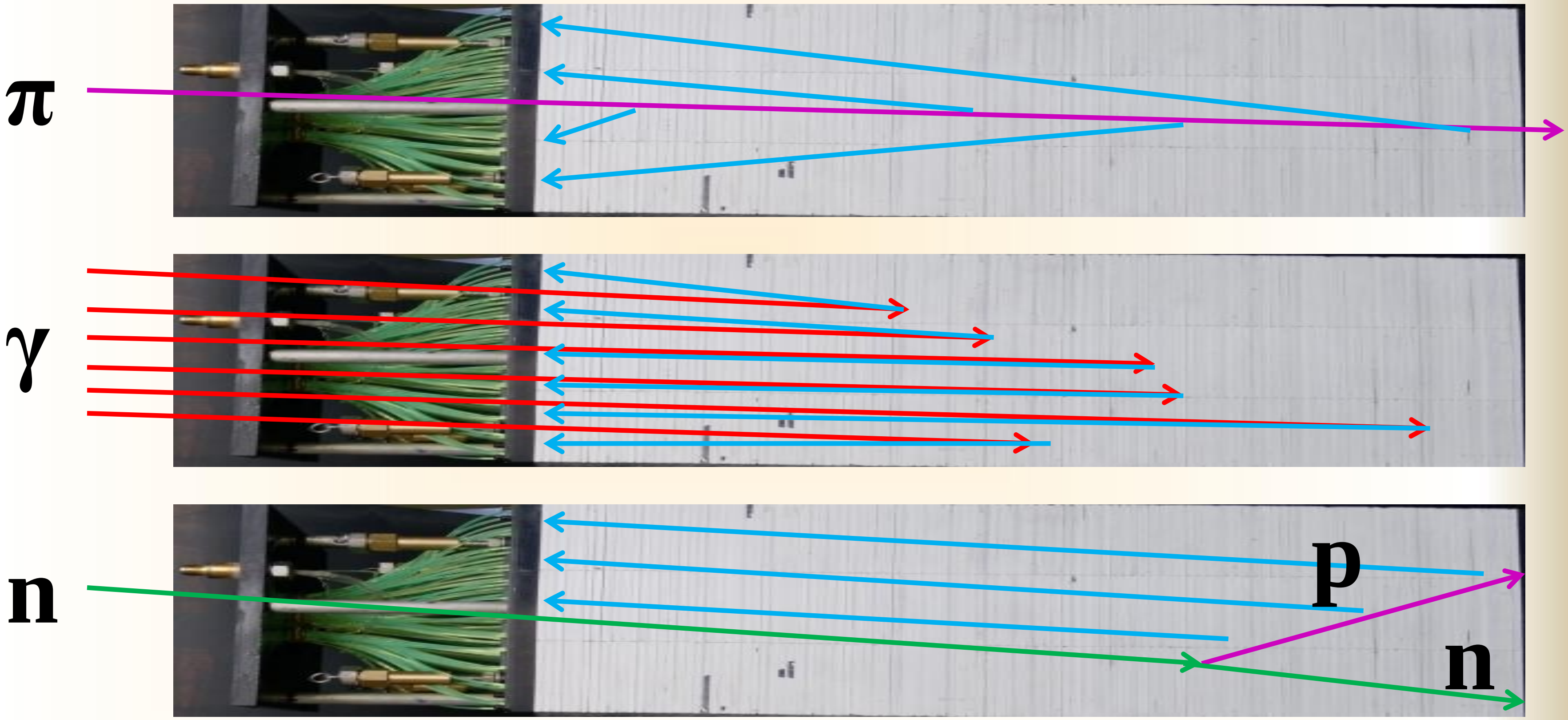
En= 1GeV β=0.87 t(6m)=23.0ns
En= 4GeV β=0.98 t(6m)=20,4ns
En=0.4GeV β=0.7 t(6m)=28.0ns



Conditions:
E5/Eall<1 - Shower in ECAL



$V_{light}=0.6V_C$ Delay of signal up to 2.3ns



The standard module ECAL is too thick. For the test we have produced a more short module with parameters close to the HGNd prototype.

ECAL(R&D) properties

Nucl.inter.length $\lambda_I = 0.4$

Rad.length $X_0 = 6.3$

Length $L = 20cm$

EM-part HGNd properties

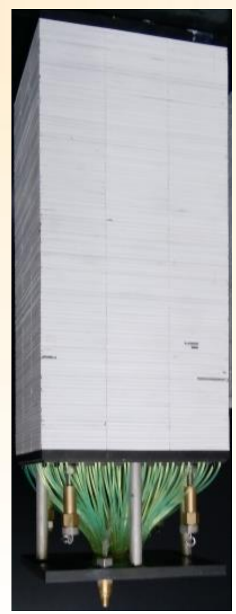
Nucl.inter.length $\lambda_I = 0.4$

Rad.length $X_0 = 7.4$

Length $L = 19cm$

Direction 1

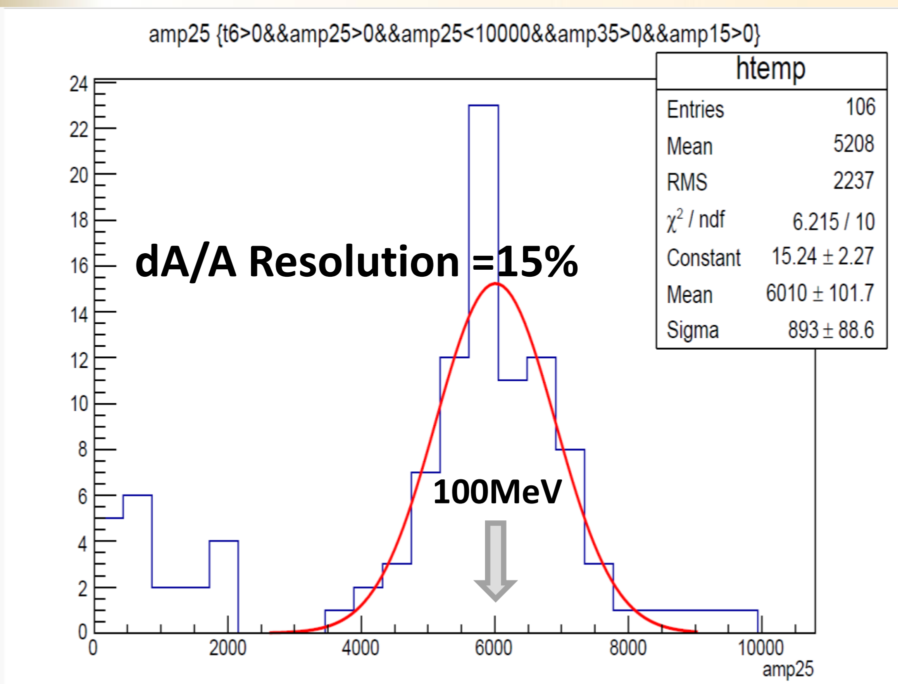
Direction 2

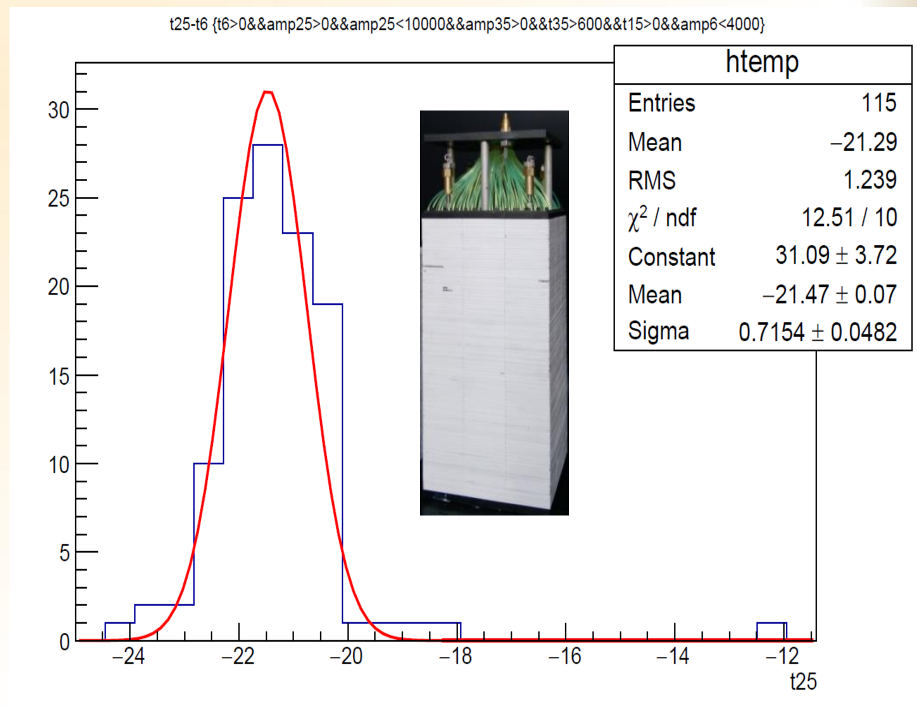


μ,e

Both configurations showed the similar results as for energy resolution as for time resolution . The total time resolution for the start counter and the tested module is 720ps. The ECAL time resolution is estimated at 360 ps.

The obtained energy resolution makes it possible to effectively separate signals from gamma quanta and neutrons.

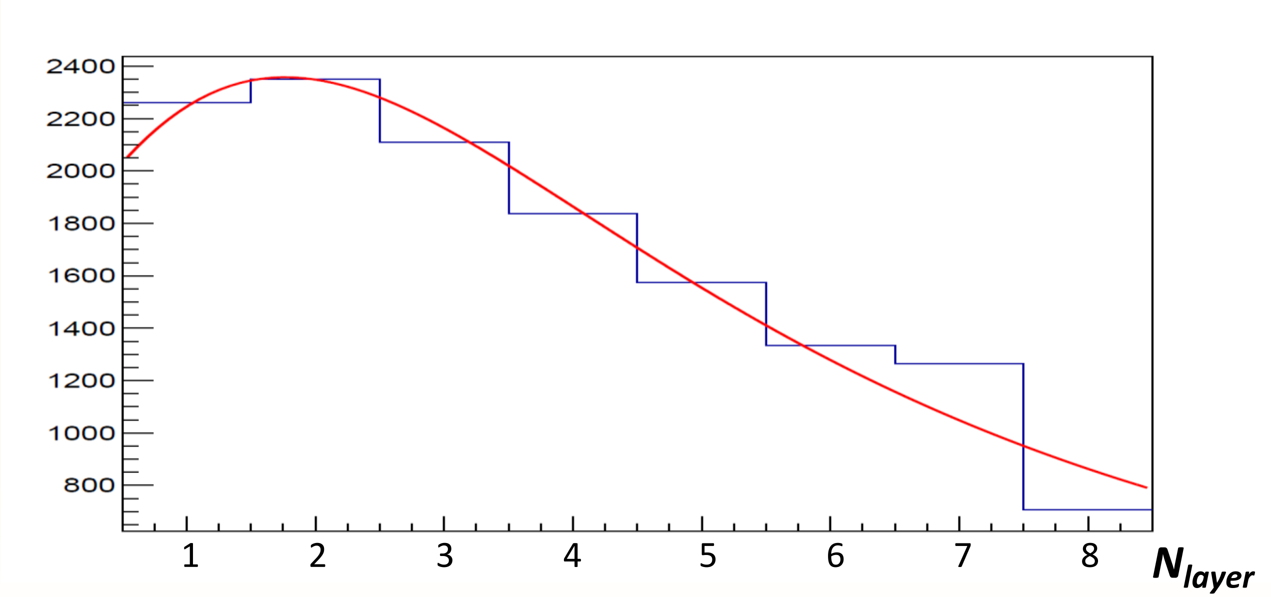




It is more relevant to use ECAL for a neutron detector in a 2x8 layer configuration. In this case, the first 2 layers will give overestimated neutron energy as a consequence of gammas background.

The percentage of events with distorted energy can be large in case to used the fastest cell to determine the neutron energy.

For example, the picture shows distribution of fastest cell as layer function. First 2 layers are have 35% of such hits. The neutron energy is 1000MeV.



Conclusions

- It is important to provide shield for neutron detector in 2-arms modification.
- The colorimeter allows you to effectively suppress gamma rays and charged particles.
- Modification of the calorimeter modules does not require significant effort.
- There are 32 modules need to be modified to protect 2 arms of the neutron detector.

Plans

- To provide Monte-carlo simulation for finding optimal module length .
- To provide test modified modules on gamma and neutrons beams.

Thank you for attention