Development of cluster method for neutron identification and energy determination with the HGND

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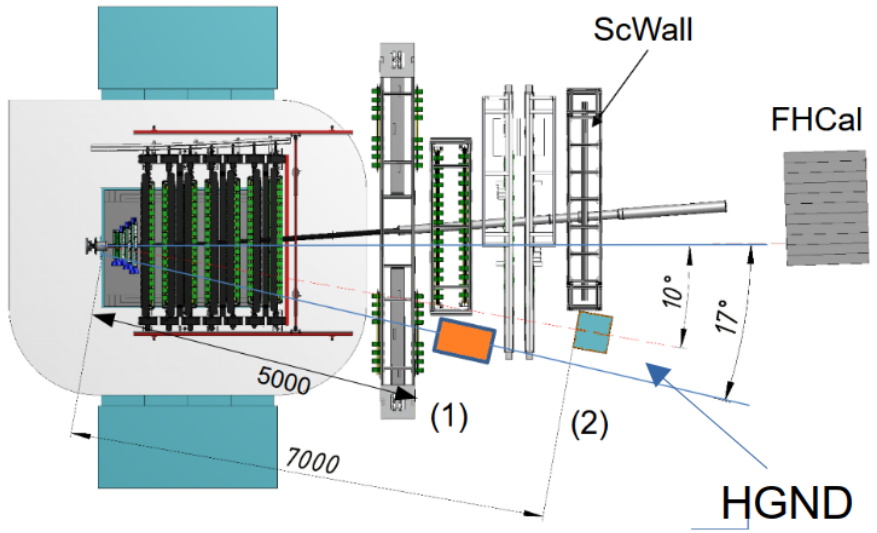
15.05.2025

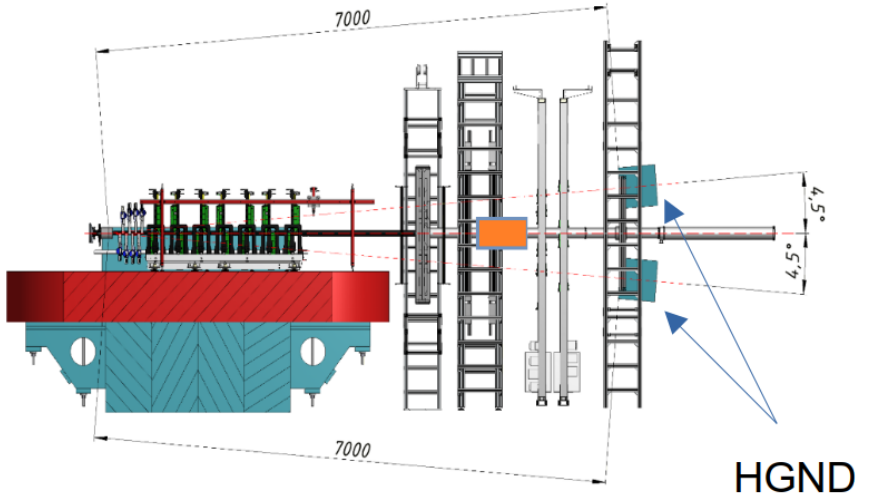
Outlook

1. Simulation
2. Cluster method
3. Background sources
   - Front side
   - Lateral side
   - Secondary clusters

Simulation

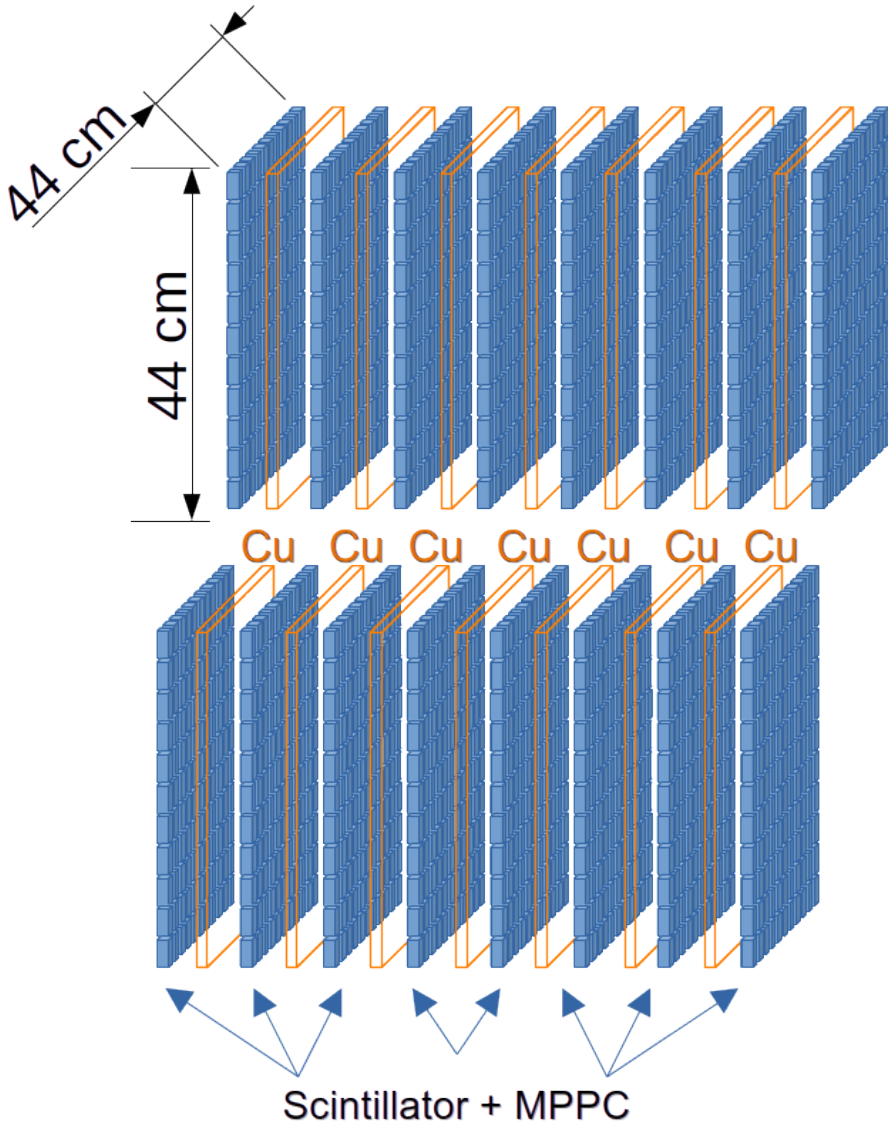
- Bi+Bi at 3 A GeV
- 183 000 events
- DCM-QGSM-SMM model
- Full BM@N geometry





HGND configuration

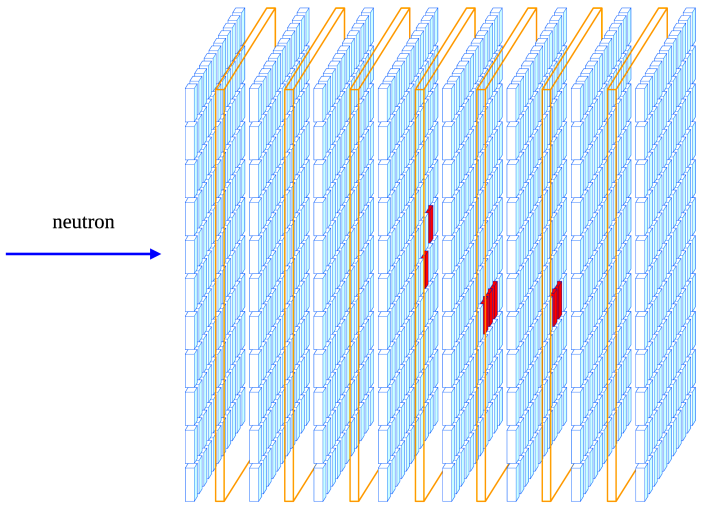
- Two parts
- 8 layers of scintillator 11x11 cells
- 7 layers of Cu convertor in between of scintillator layers
- MPPC connected directly to scintillator
- Time resolution 130 ps



Clustering algorithm

Cells with $E_{kin} > 3$ MeV are selected (noise rejection). Neighbouring cells are combined into clusters. $\beta = \frac{1}{c}d/t$ is calculated for each cell. Cell with highest β is "head" of cluster. The clusters are selected as follows:

- No hit in layer 0 (rejection of charged particles)
- No hit in layer 1 (rejection of γ)
- $\beta < 0.9$ (rejection of fast e^+, e^-, γ)
- $T_{reconstructed} > 300 MeV$
- $N_{cells} \geq 2$ in cluster

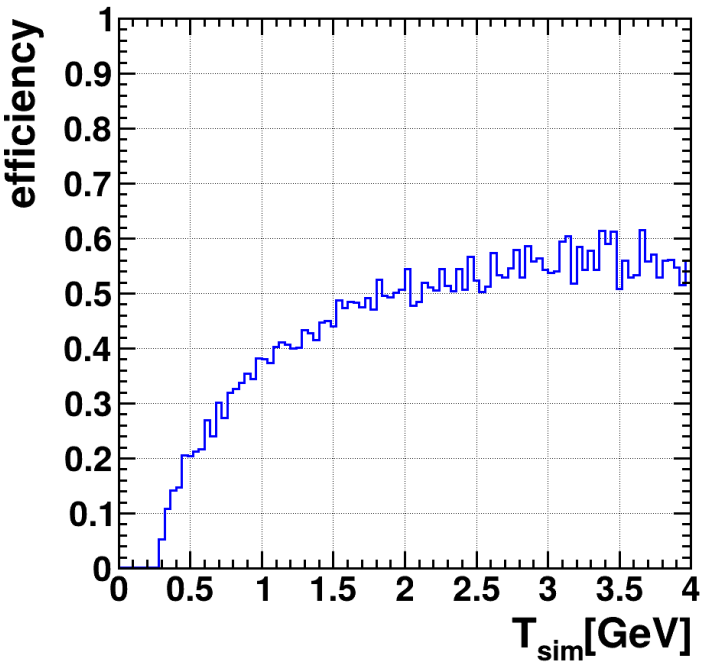


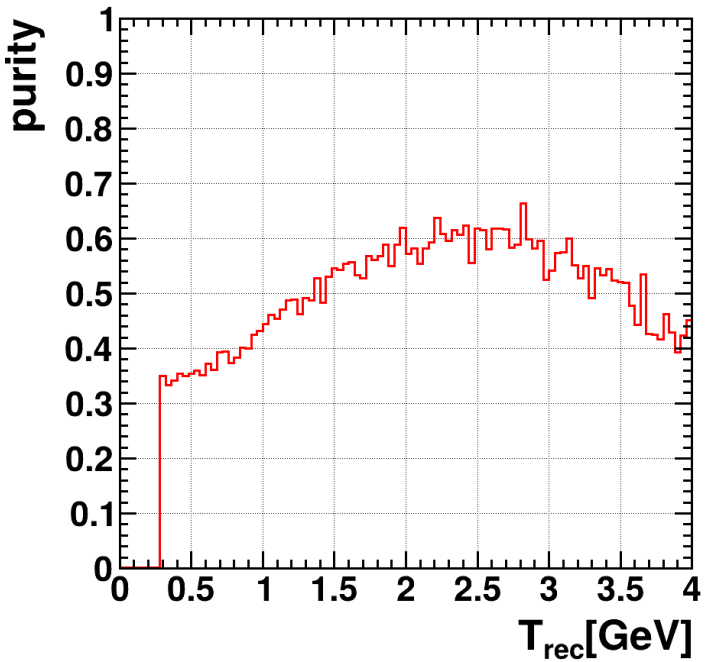
Quality of neutron reconstruction

Every "good" cluster is supposed to be a neutron. In simulation we can check if the "head" of cluster was fired by products of primary neutron interaction ("match" between neutrons and clusters).

Metrics

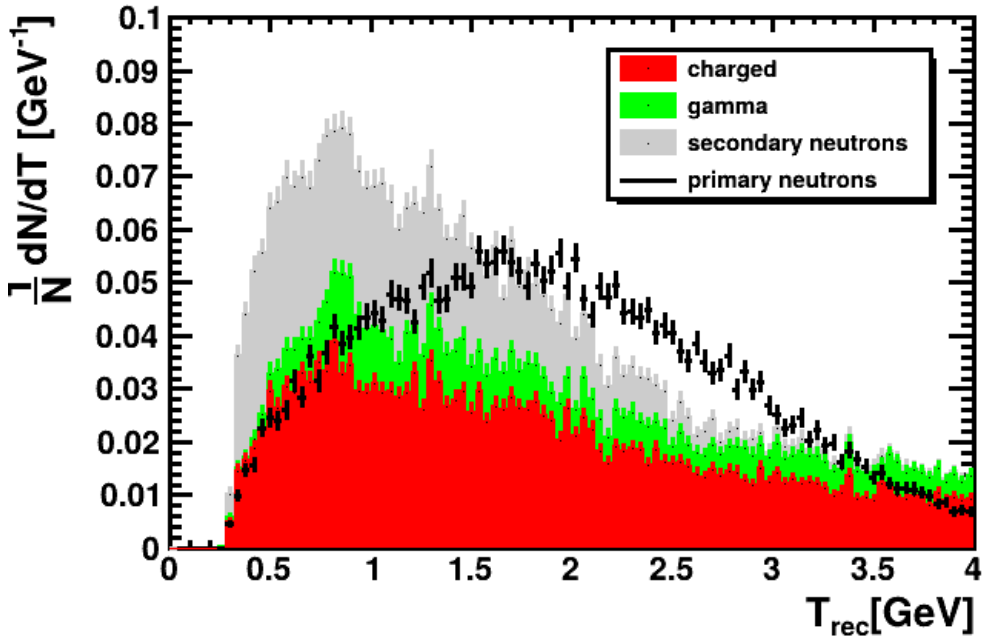
$$\text{Efficiency} = \frac{N_{\text{neutron match}}}{N_{\text{neutrons}}} \qquad \text{Purity} = \frac{N_{\text{cluster match}}}{N_{\text{clusters}}}$$



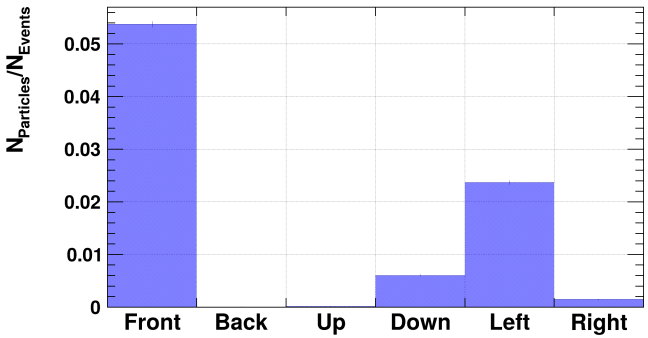


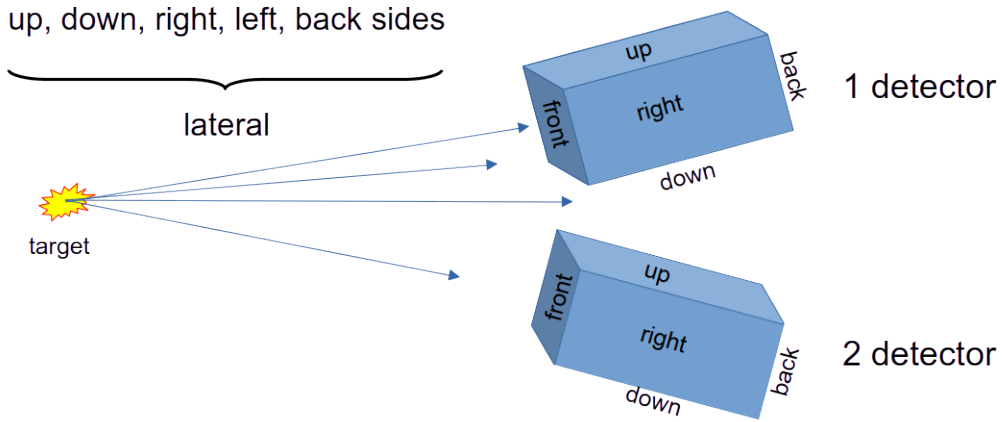
Background particles

Charged particles produce clusters despite veto applied. Where do they come from?



Charged particles

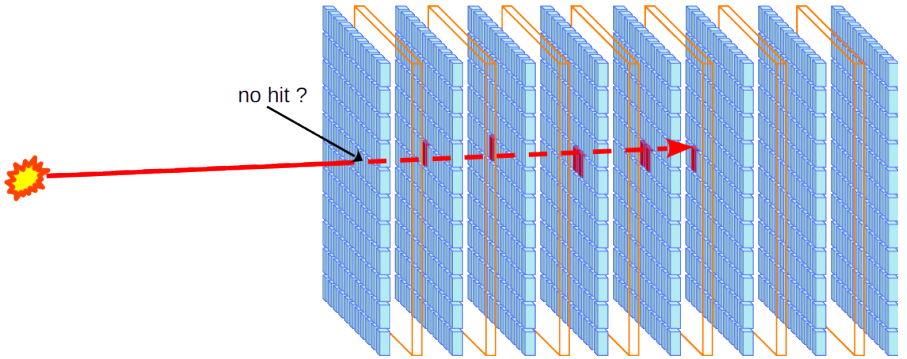




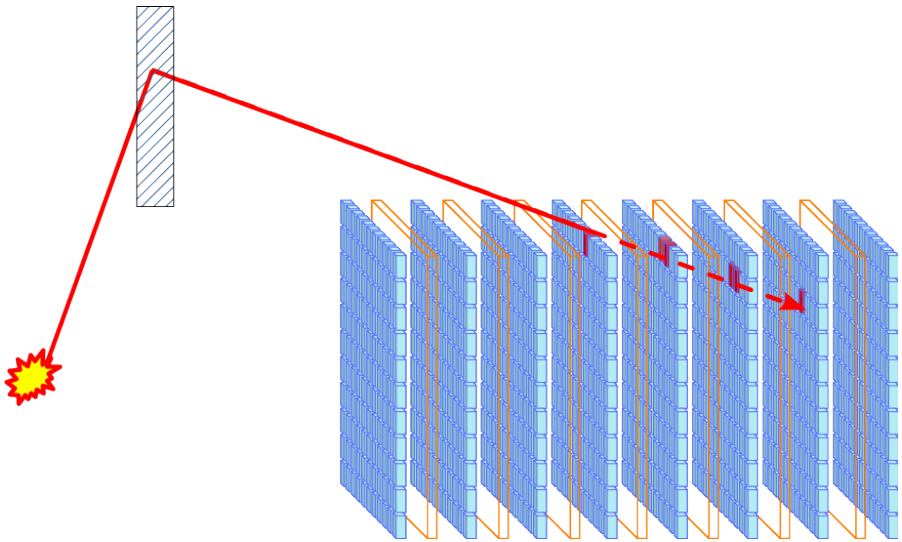
1. Charged particles pass through front surface without firing veto cells
2. Charged particles come through lateral sides
3. Charged particles produce secondary clusters

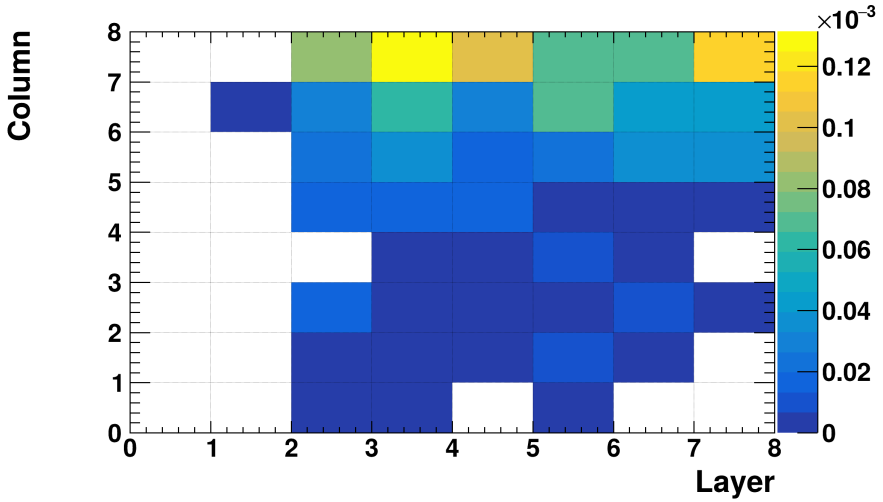
1. Front side

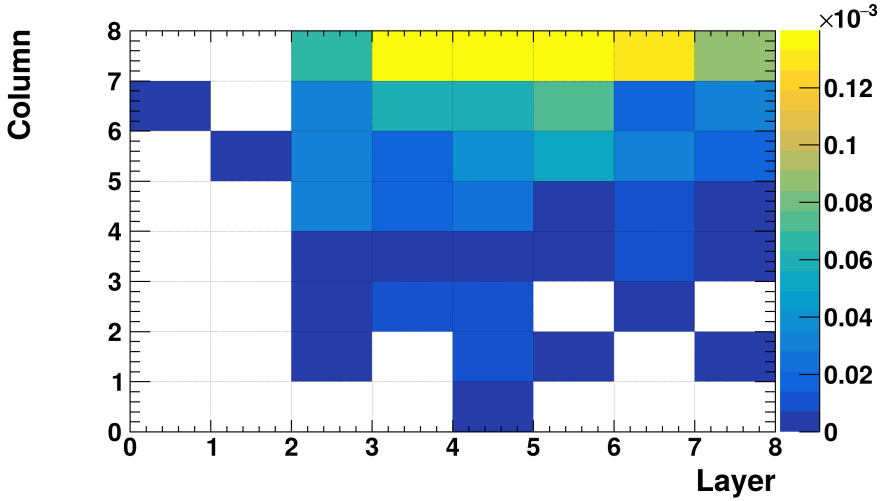
- Deposited energy below threshold (3 MeV)
- Particle pass in between cells, too low energy deposited in each cell
- Charged particle can't avoid hit in both veto and 1st layers, probability is negligible



2. Lateral



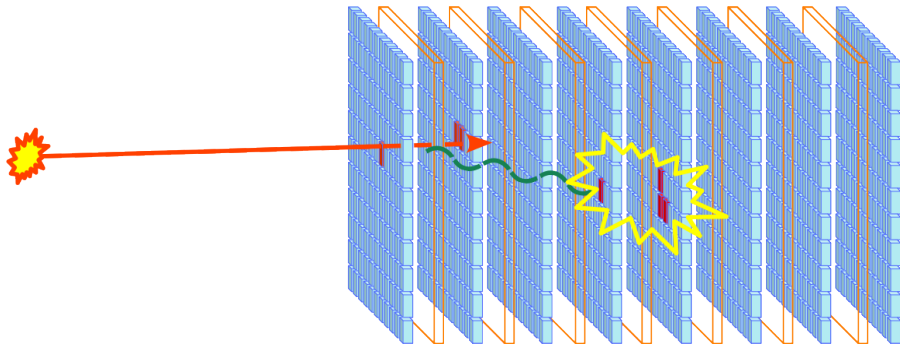




- The particle comes to the HGND through lateral surface
- First cell in cluster lies on border of HGND
- If cluster starts on border, we can reject it

3. Secondary clusters

- p, π^+, π^- produce γ, n
- γ, n produce secondary clusters deep inside HGND
- There is a gap between primary and secondary clusters
- Secondary cluster is wrongly recognized as neutron
- The secondary cluster starts in the same (row, column) as hit in veto.
- We can reject such clusters



Quality after new cuts