Determination of purity and efficiency of the clustering algorithm of neutron reconstruction with the HGND at the BM@N experiment

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Outline

- BM@N
- **H**ighly **G**ranular **N**eutron **D**etector
- Reconstruction of neutrons
  - Cluster recognition
  - Selection of neutron clusters
- Determination of efficiency and purity
- Energy reconstruction
- Conclusions

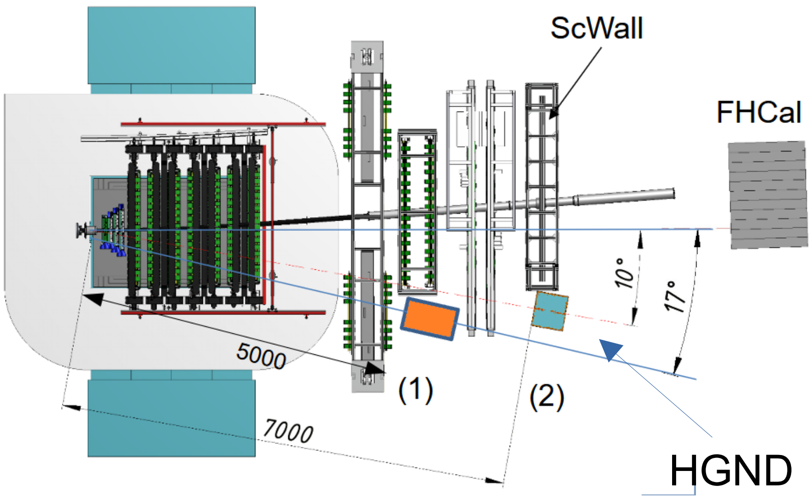
BM@N experiment

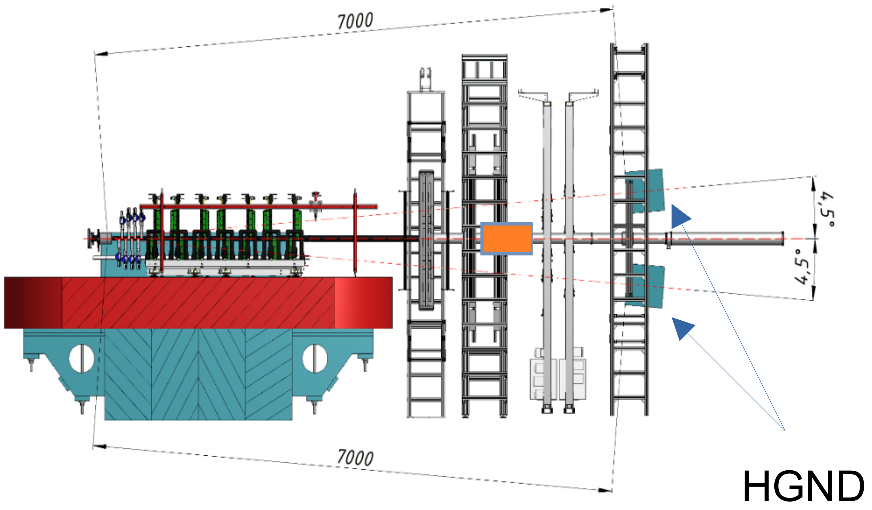
Baryonic Matter at Nuclotron – fixed target experiment in JINR (Dubna, Russia), aimed at studying of baryonic matter at high densities and relatively low temperatures.

- Ion beams from p to Au
- Kinetic energies 1-6 A GeV
- Data accuisition rate ~$5\cdot10^4$ events/s

Highly **G**ranular **N**eutron **D**etector (HGND)

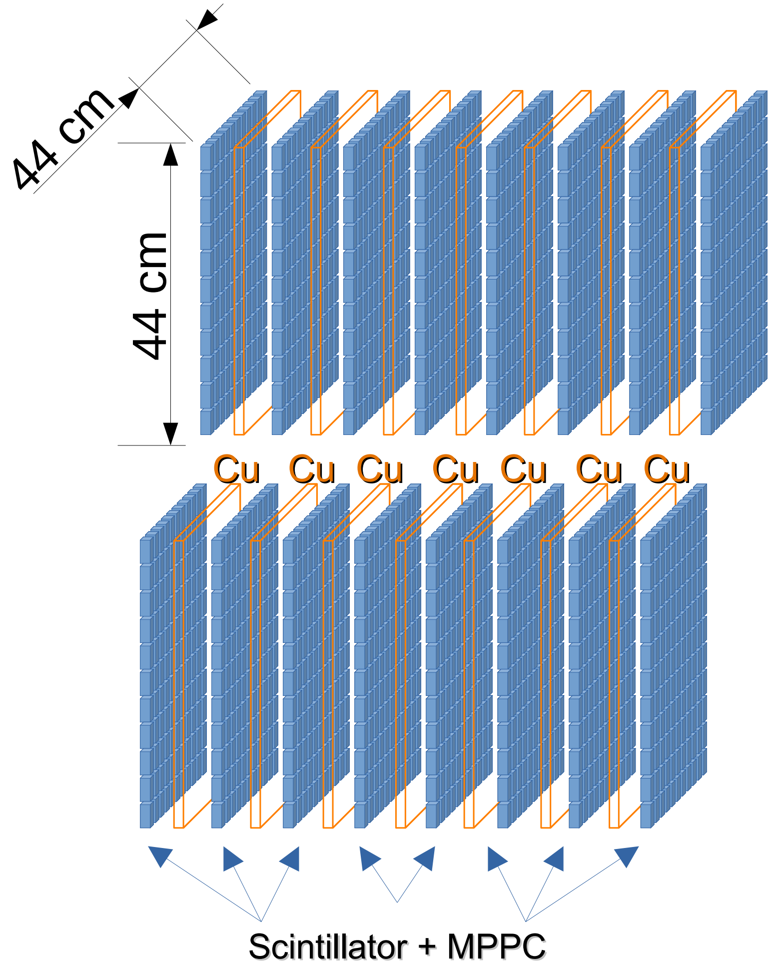
The new detector is being constructed to extend BM@N capabilities in measurement of neutrons





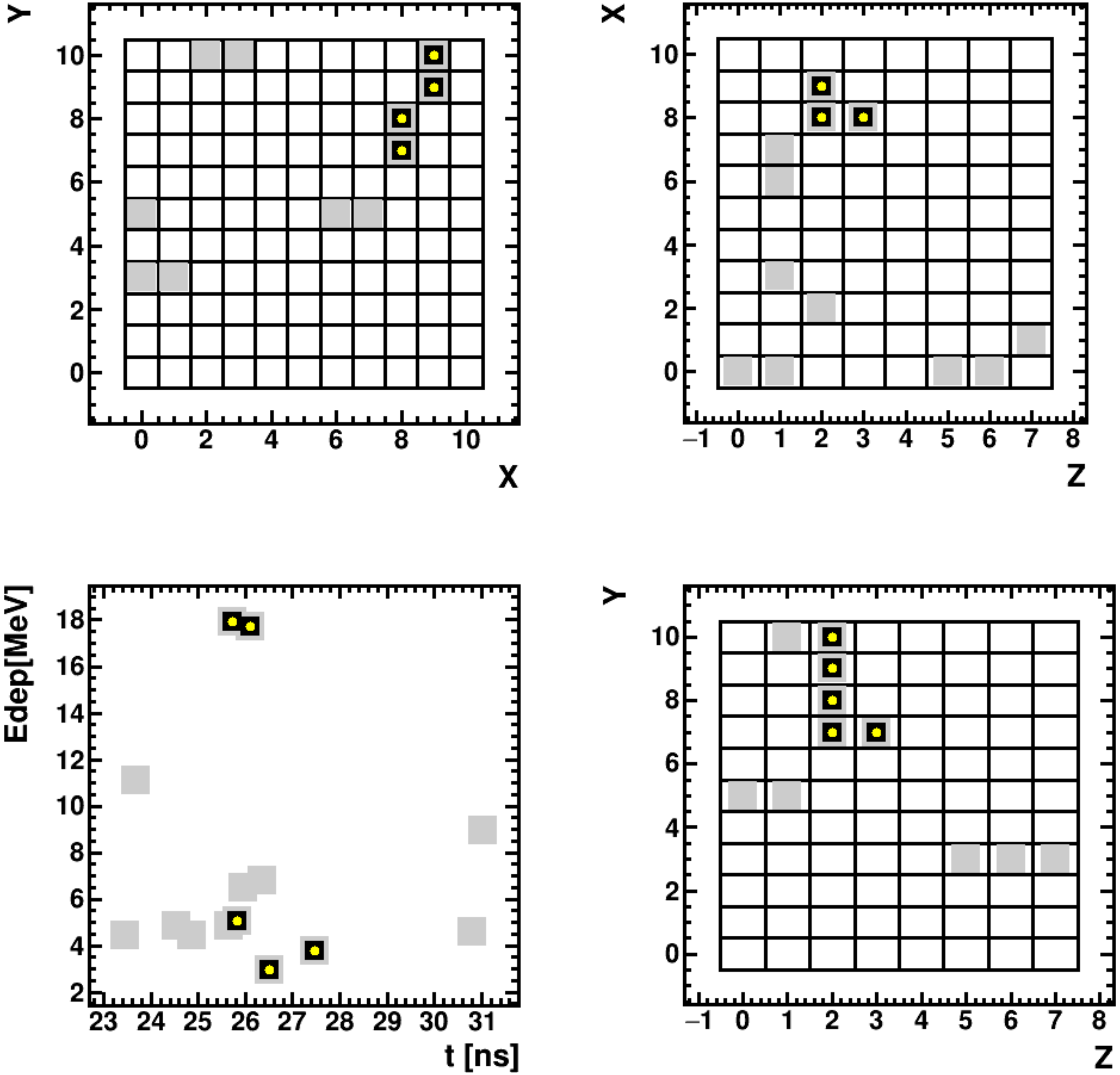
Structure of HGND

- 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



Reconstruction of neutrons

- The particles traversing HGND can fire many cells in one event → need to merge fired cells into **clusters**
- Presence of background (charged, photons) → need to **select** neutron clusters
- Energy and direction reconstruction → search for the cell closest to initial neutron hit ("**head** of cluster")
- Implementation of the algorithm into BmnRoot: **BmnNdetClusterFinder::FindClusters()**

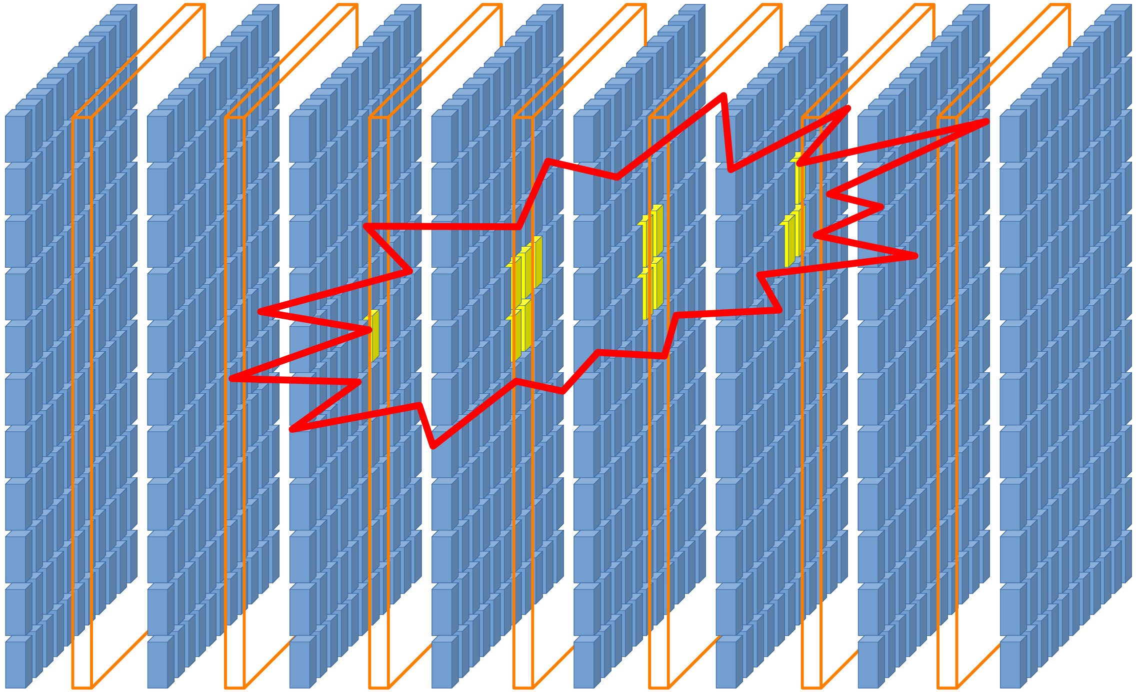


Example of an event in HGND

- all fired cells
- cells fired by the products of neutron hit
- cells recognized as neutron cluster

Cluster recognition

- **Cluster** is a set of neighbouring fired cells with close timestamps
- Algorithm loops over fired cells and checks if there are fired cells nearby
- **BmnNdetClusterFinder::FindClusters()**



Selection of clusters

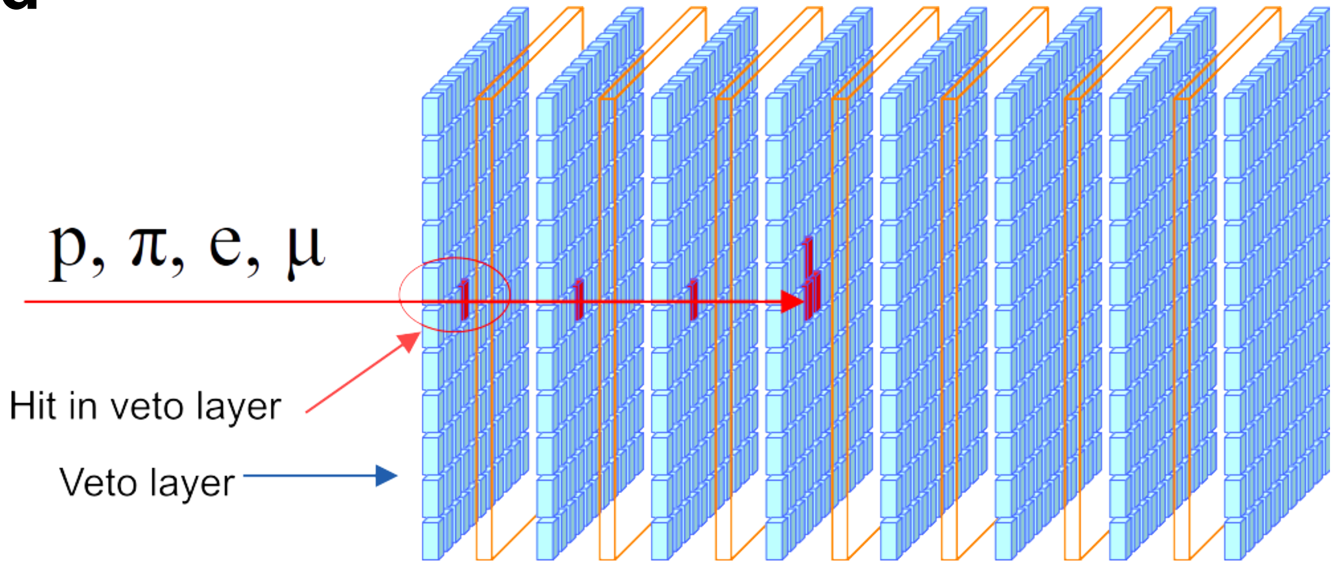
- Rejection of noise: deposited energy > 3 MeV
- Rejection of charged particles with veto on 1st layer
- Rejection of gammas with veto on 2nd layer
- Rejection of light particles (γ, e) with β<1 cut

- The clusters are combined into larger clusters if they have close timestamps (within time resolution of HGND)

Rejection of charged particles

Charged particles fire 1st layer

If cluster contains any cells of **1st layer**, the cluster is **rejected**

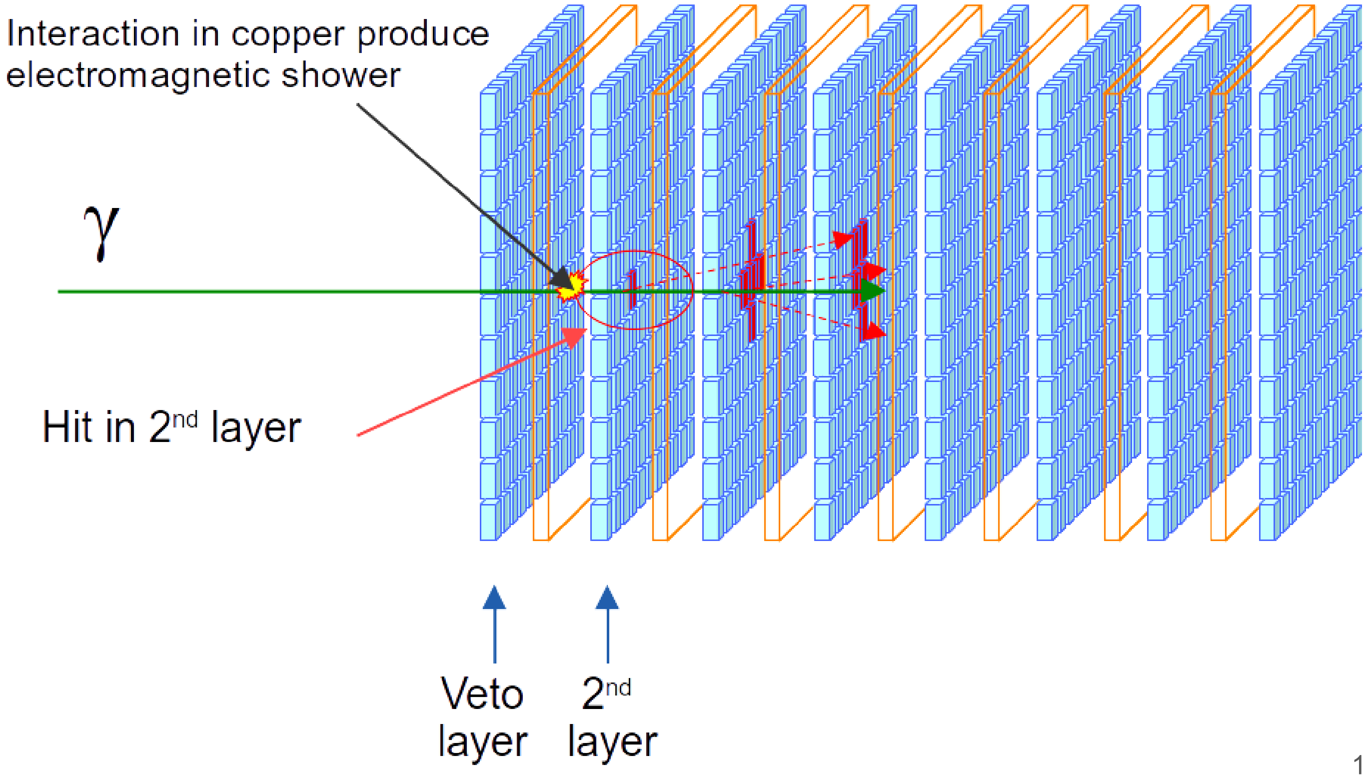


Rejection of photons

don’t fire 1st layer,

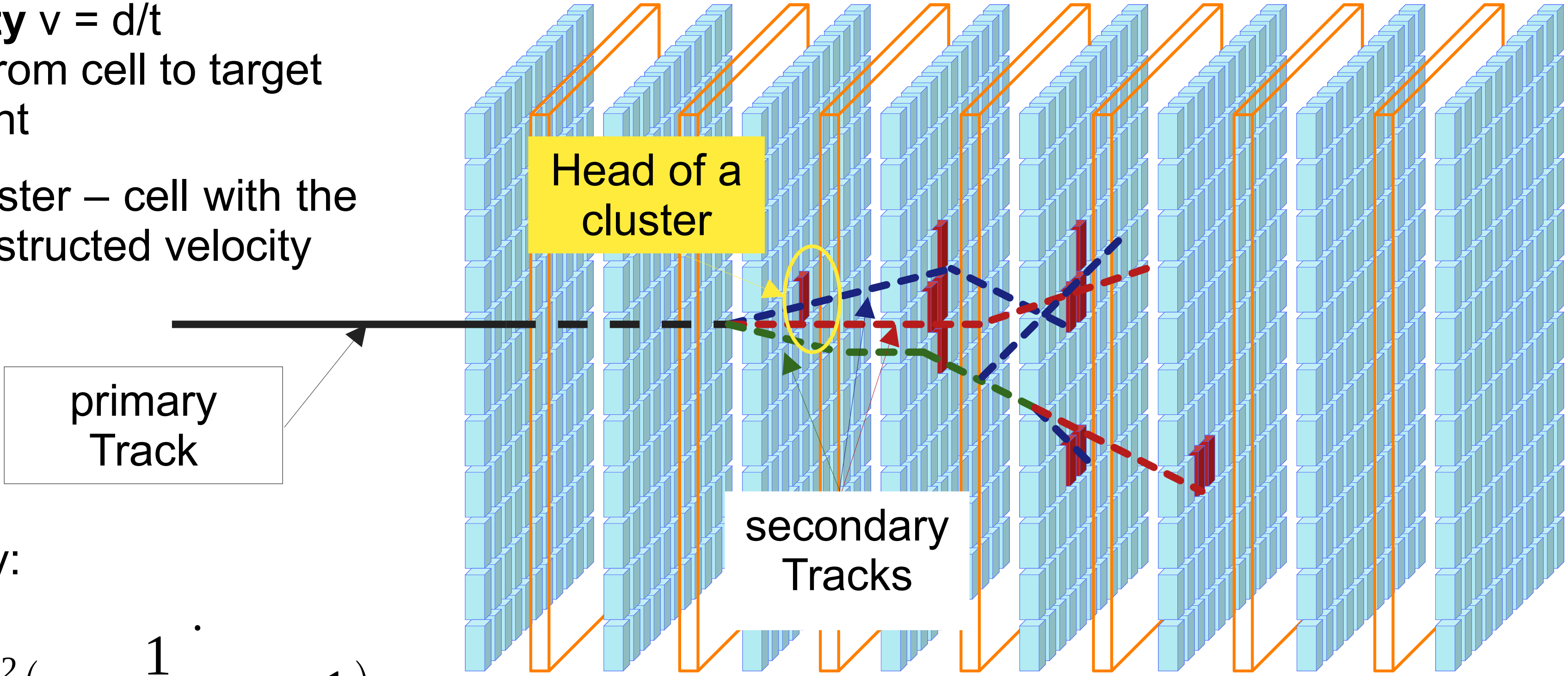
do fire 2nd layer

If cluster contains any cells of **2nd layer**, the cluster is **rejected**



for each cell of a cluster we can define **velocity** v = d/t
d – distance from cell to target
t – time of flight

Head of a cluster – cell with the highest reconstructed velocity



Kinetic energy:

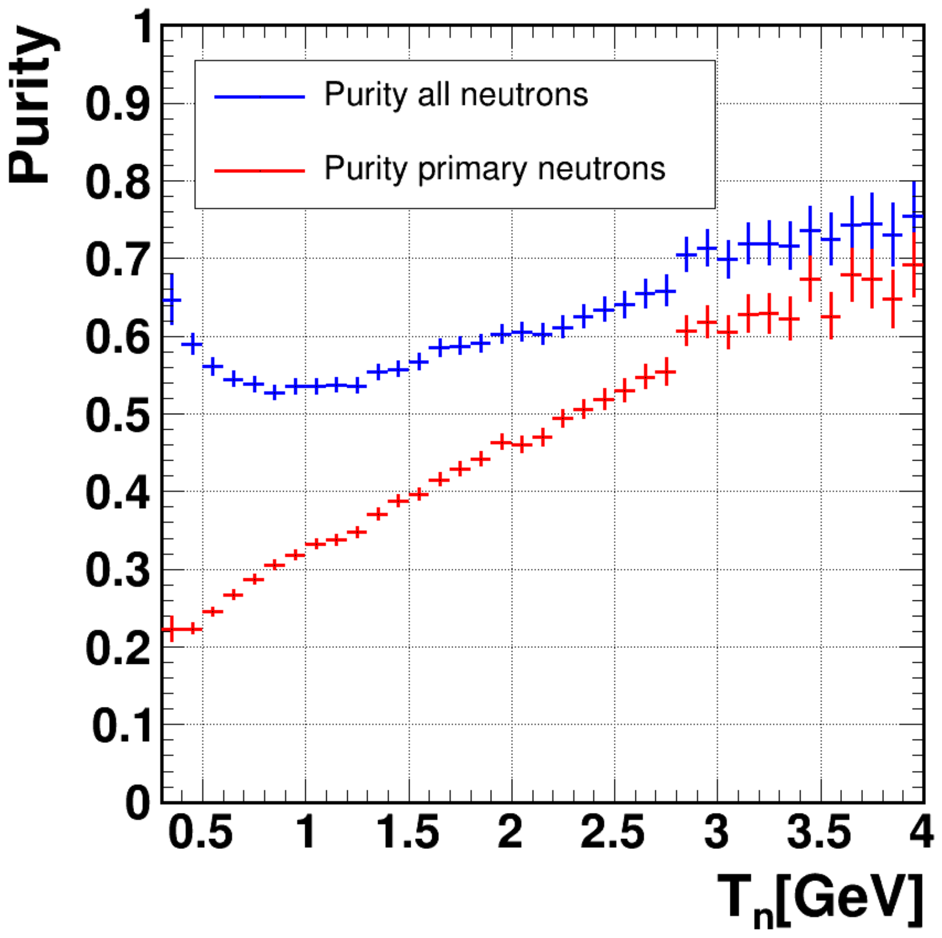
$$T_n = m_n c^2 \left(\frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}} - 1 \right)$$

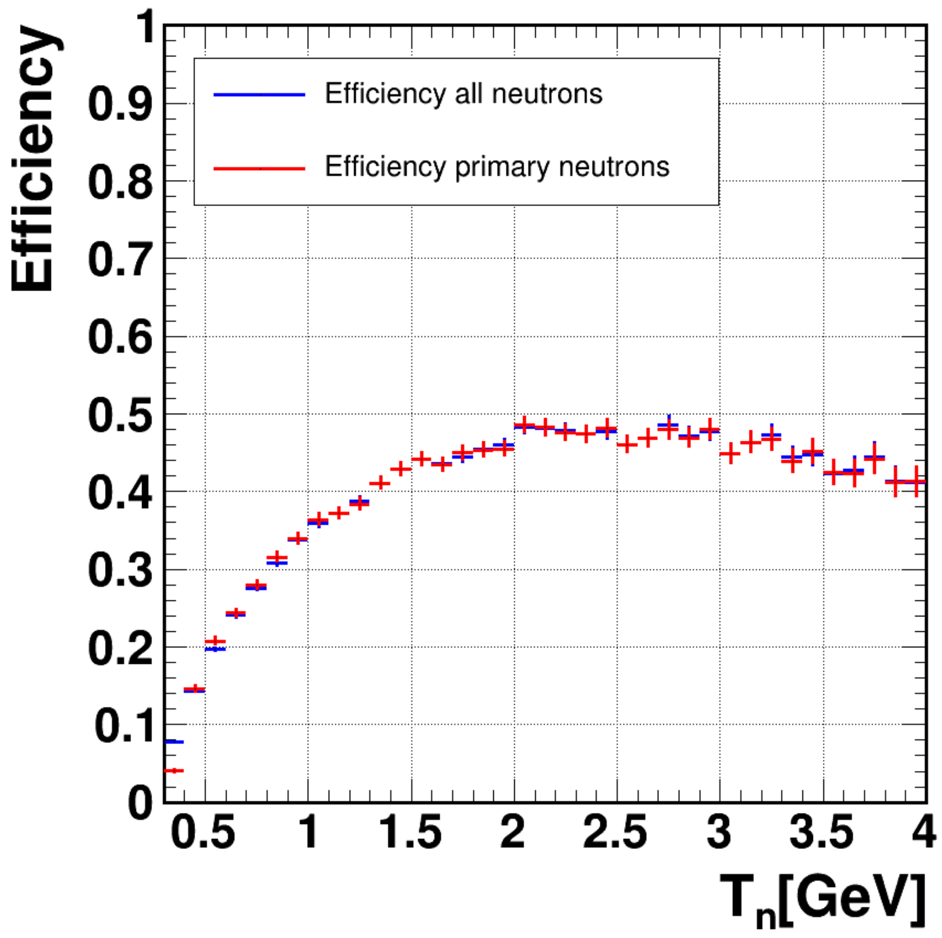
Efficiency and purity

$$eff = \frac{N_{match}}{N_{simulated}} \qquad pur = \frac{N_{match}}{N_{reconstructed}}$$

- **N match** – number of clusters which head cell is fired by a particle produced by a neutron
- **N simulated** – number of neutrons crossing HGND volume
- **N reconstructed** – number of clusters recognized as neutrons

- DCM – QGSM – SMM generator
- Bi+Bi at $\sqrt{s_{NN}}$ = 3.26 AGeV (3.8 AGeV beam energy)
- Full BM@N geometry
- Distance from target to HGND 700cm
- 10^6 events
- Time resolution of HGND cells 130 ps


Purity
Purity all neutrons
Purity primary neutrons
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.5
1
1.5
2
2.5
3
3.5
4
T_n[GeV]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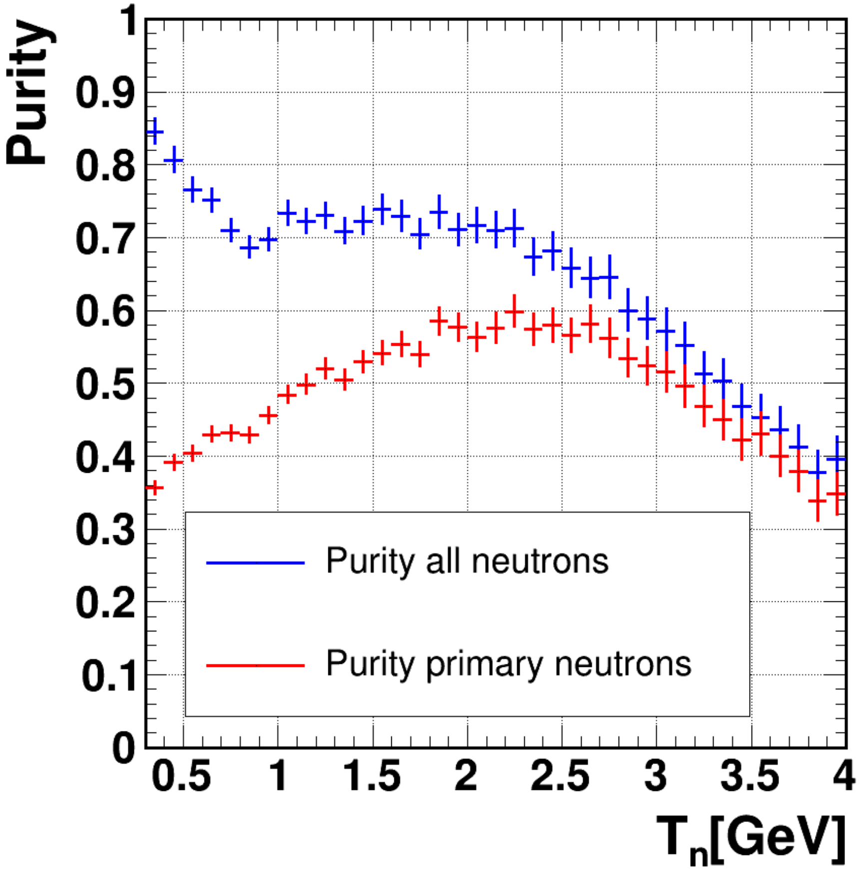
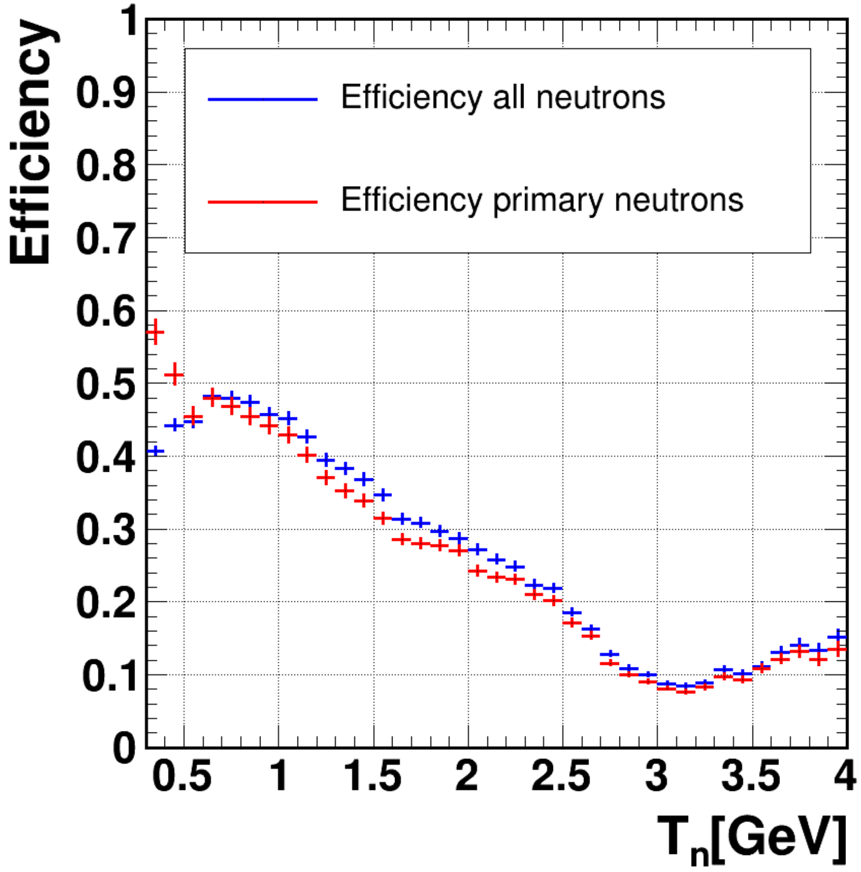
Alternative algorithm





Conclusions

- The method of reconstruction of neutrons in HGND has been developed
- Efficiency and purity are determined with Monte-Carlo simulation
- Efficiency is equal for primary and secondary neutrons
- Purity is lower for primary neutrons at low Tn
- Algorithm can be optimized to increase either **Efficiency** or **Purity**

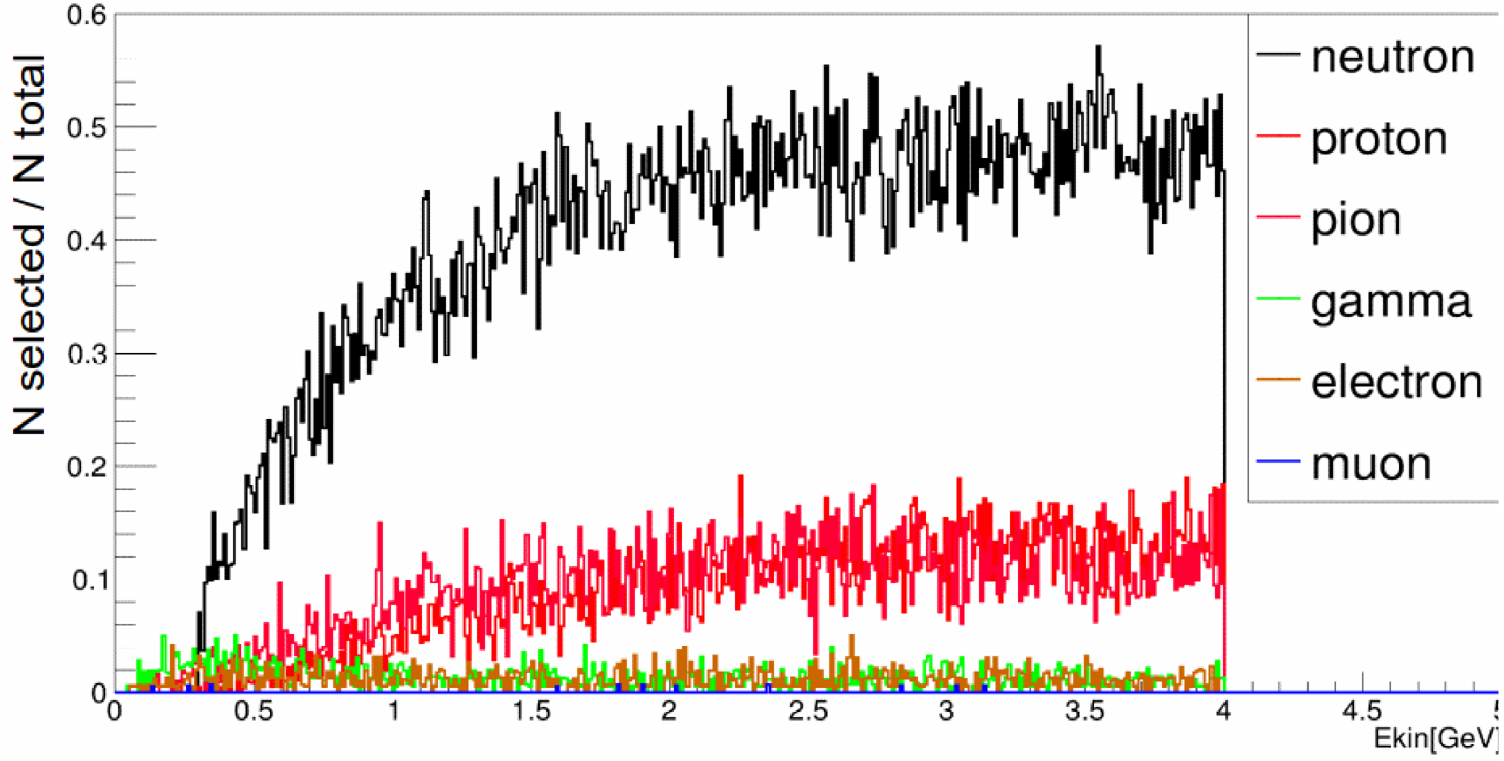
Backup slides

Veto on 1st, 2nd layers, cut β<1

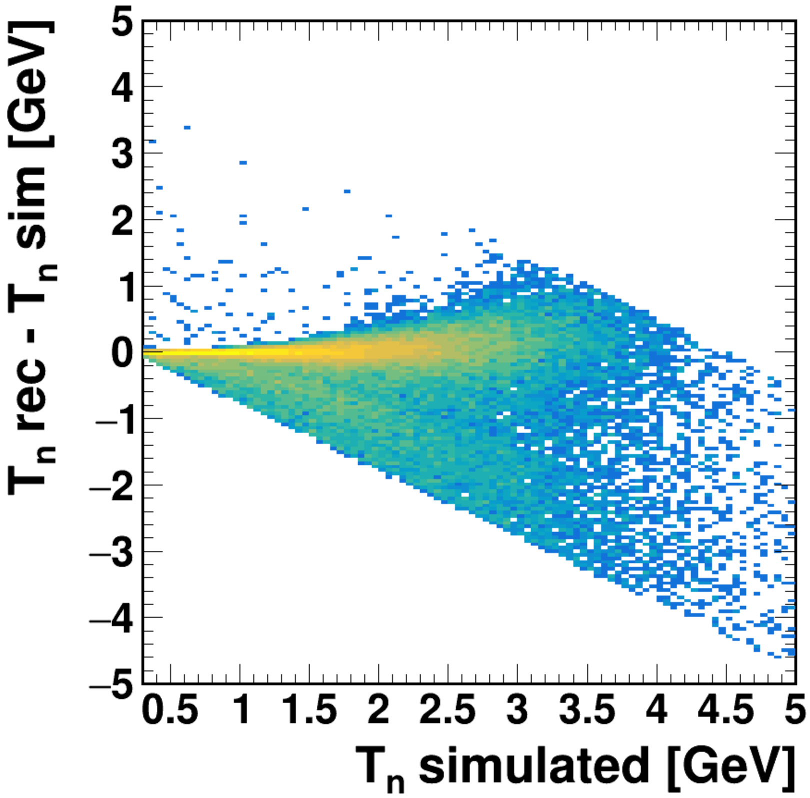
All clusters containing cells of 1 or 2 layer or β=1 are rejected

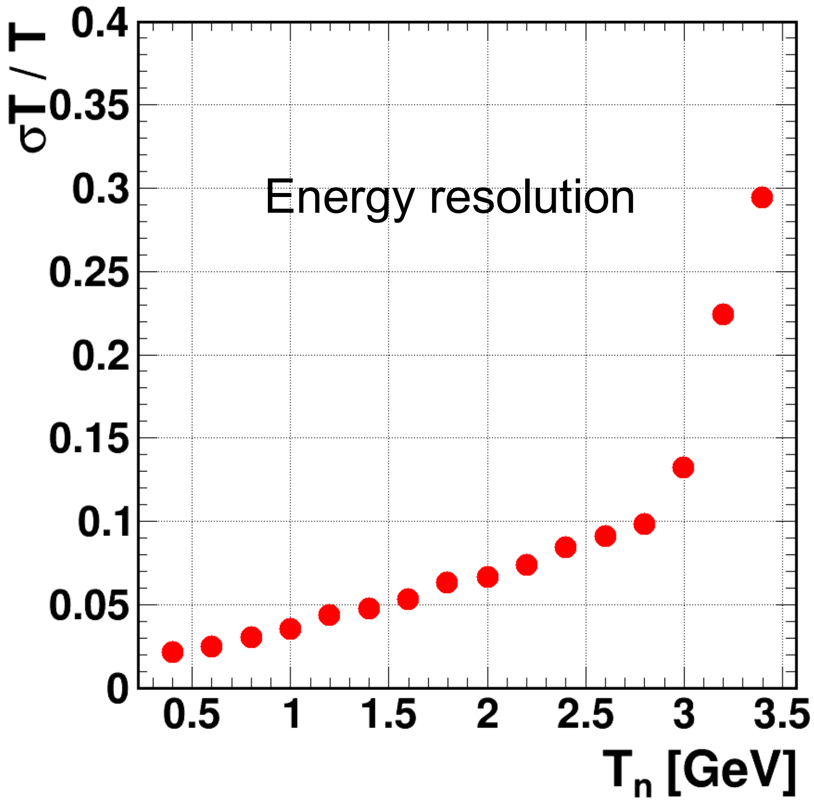
If at least 1 cluster evade rejection, the histogram is filled

γ-quanta, electrons are suppressed



Kinetic energy reconstruction for primary neutrons





Number of neutrons in event