Development of neutron reconstruction procedure with the HGND at the BM@N experiment

Arseniy Shabanov, INR RAS

for the HGND team

arseniy.shabanov@phystech.edu

ICPPA-2024

25.10.2024

Outline

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

BM@N experiment

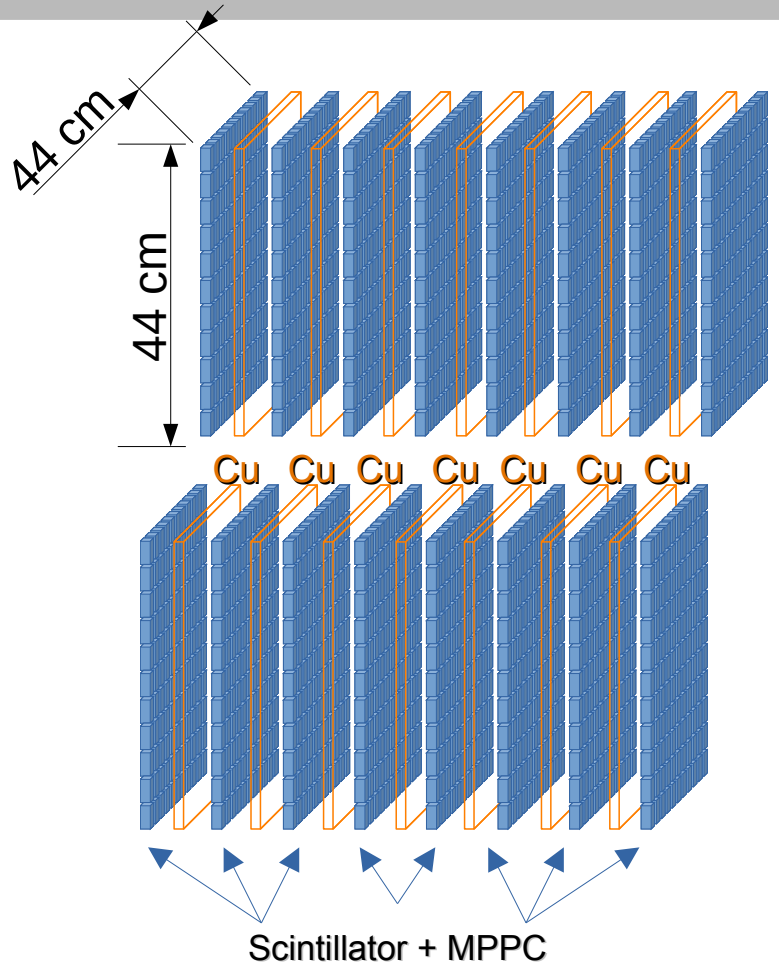
Baryonic Matter at Nuclotron – fixed target experiment in JINR (Dubna, Russia), aimed at studying of baryonic matter at high densities and relatively low temperatures.

- Ion beams from p to Au
- Kinetic energies 1-6 A GeV
- Data accuisition rate ~$5 \cdot 10^4$ events/s.

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

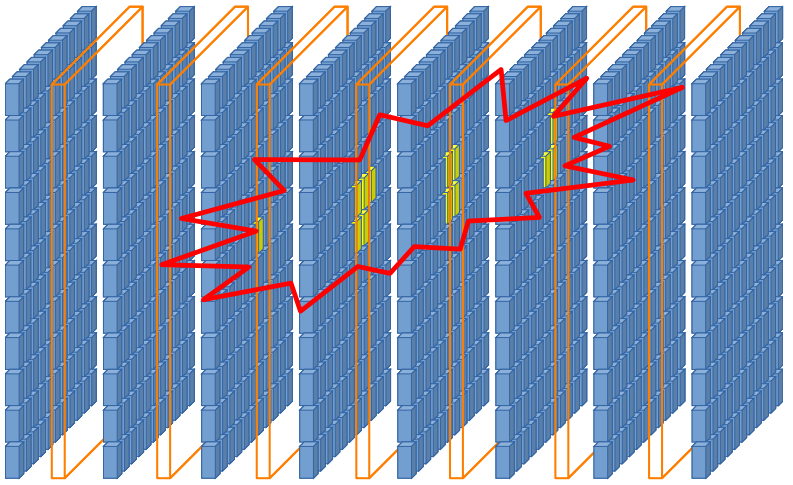
The new detector is being constructed to extend BM@N capabilities in measurement of neutrons

- 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



Cluster recognition

- The particles traversing HGND can fire many cells in one event
- Analysis of data starts from combination of fired cells into clusters
- **Cluster** is a set of neighbouring fired cells with close timestamps
- **BmnNdetClusterFinder::FindClusters()**



Selection of clusters

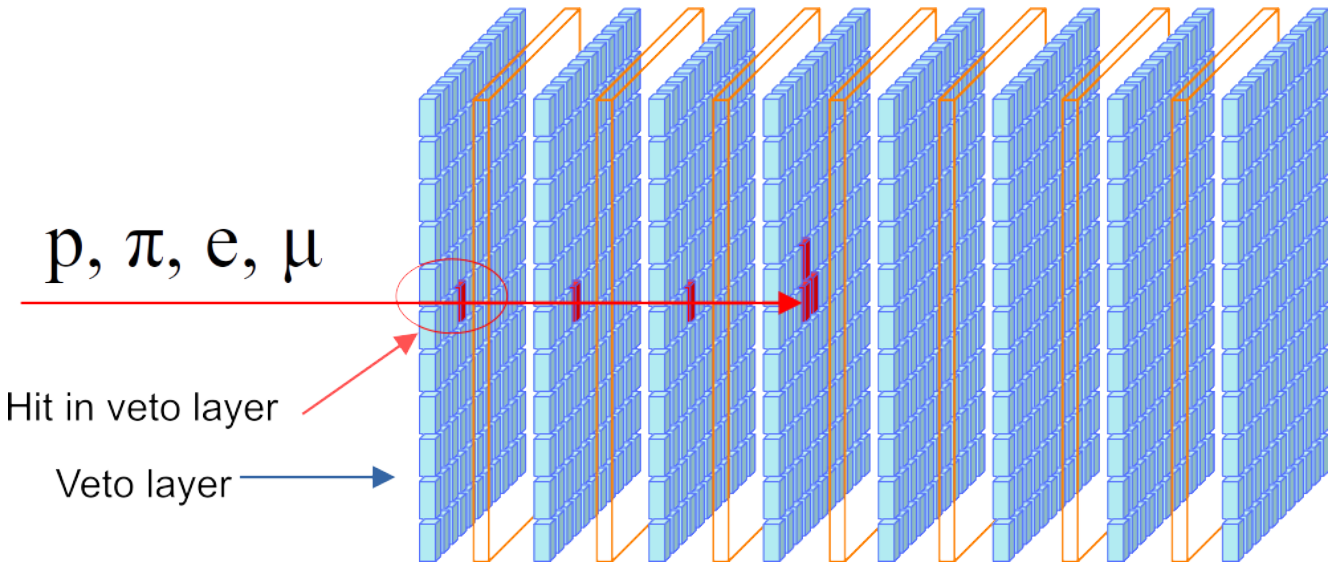
- Rejection of noise: deposited energy > 3 MeV
- Rejection of charged particles with veto on 1st layer
- Rejection of gammas with veto on 2nd layer
- Rejection of light particles (γ, e) with β<1 cut

- 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**



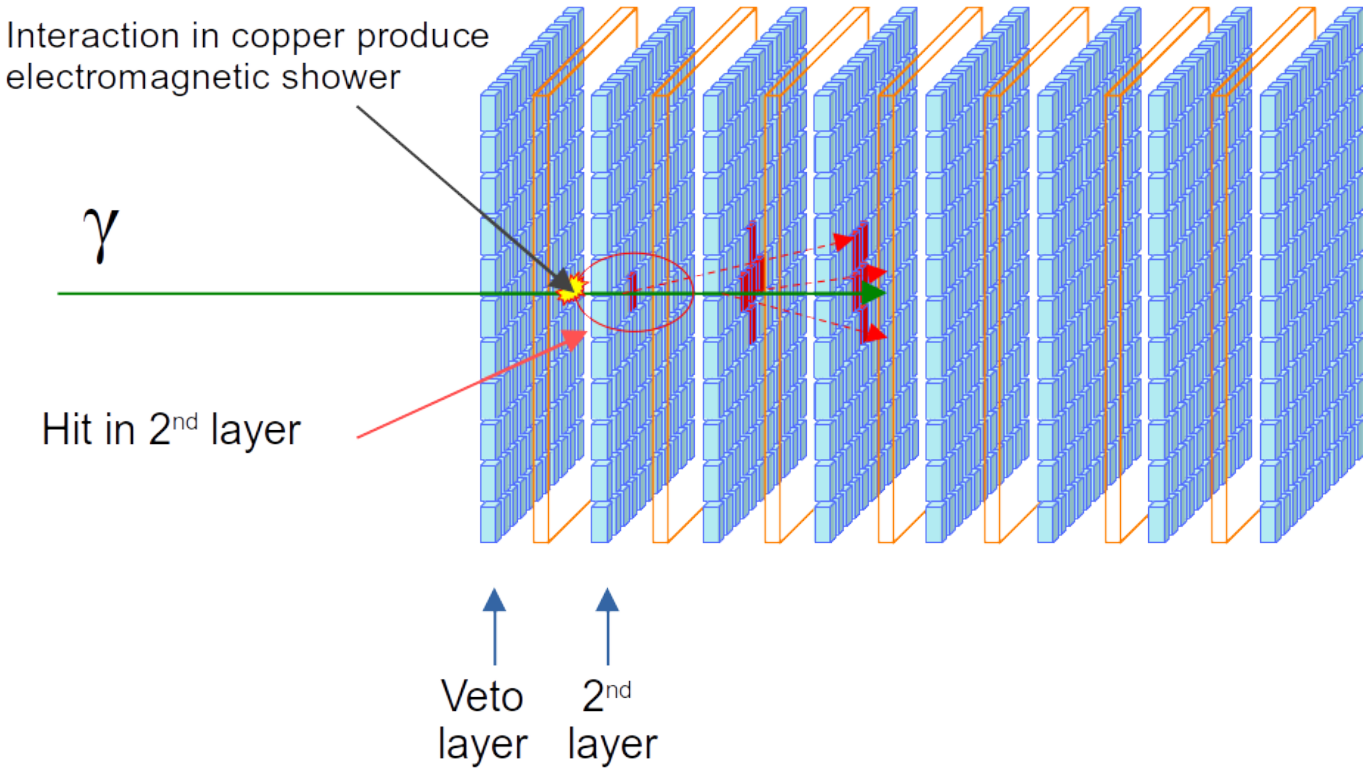
Rejection of γ - quanta

γ-quanta

don’t fire 1st layer,

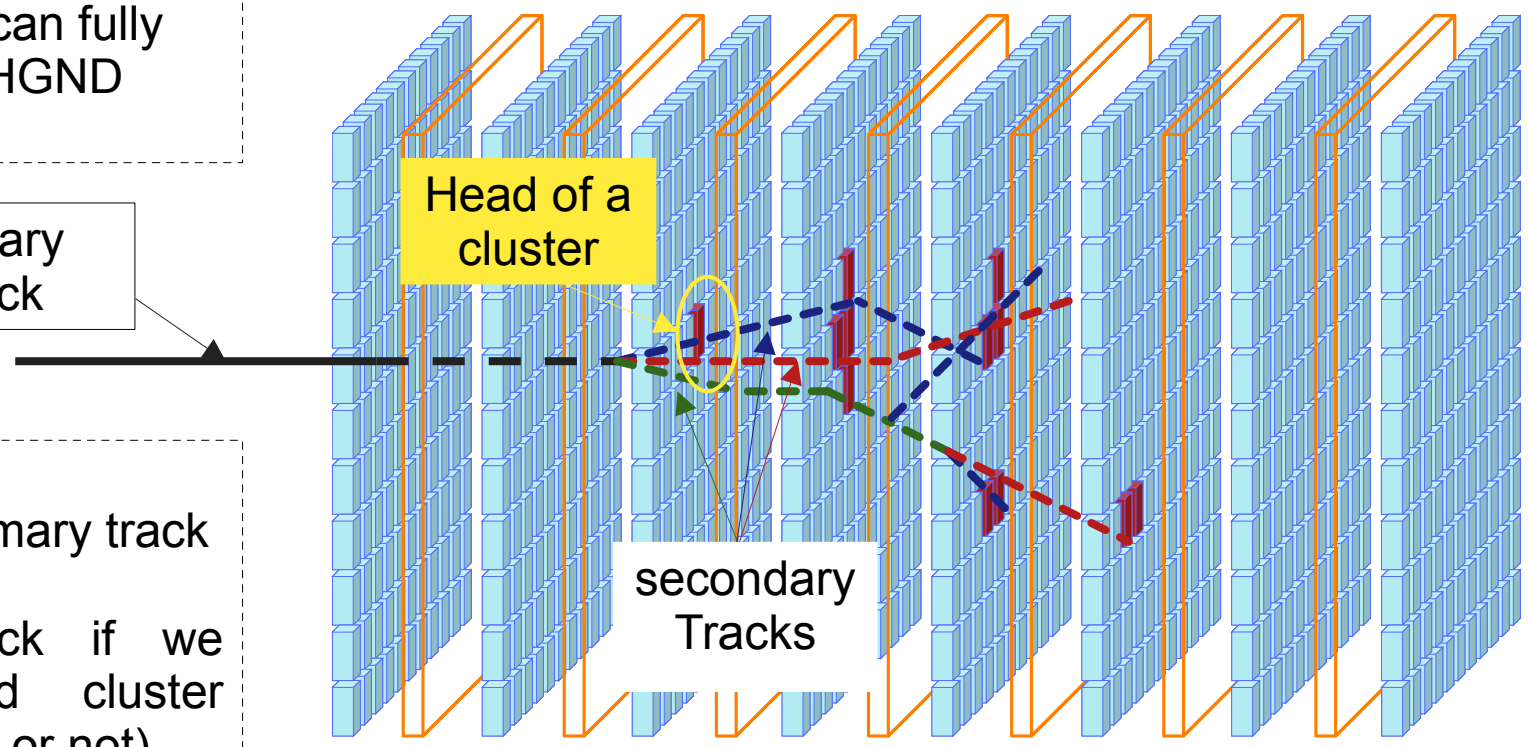
do fire 2nd layer

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



Disentanglement of an event

In MC simulation we can fully disentangle event in HGND



correspondance
head of cluster ↔ primary track

Now we can check if we correctly recognized cluster (produced by neutron or not)

Definition of efficiency and purity

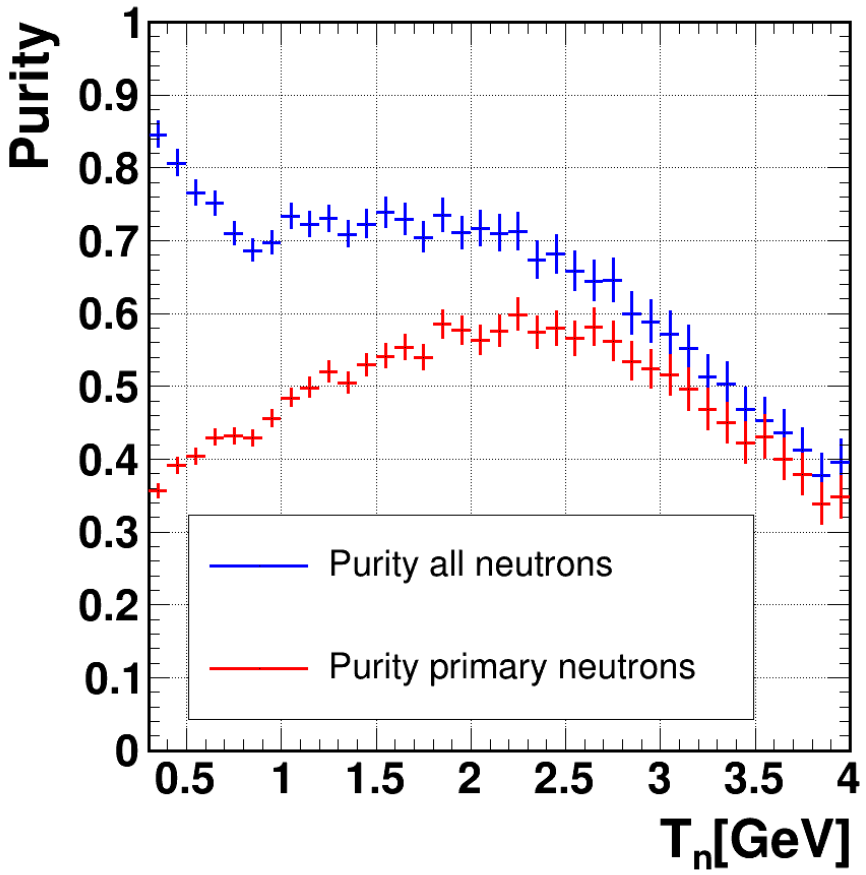
$$eff = \frac{N_{match}}{N_{simulated}} \qquad pur = \frac{N_{match}}{N_{reconstructed}}$$

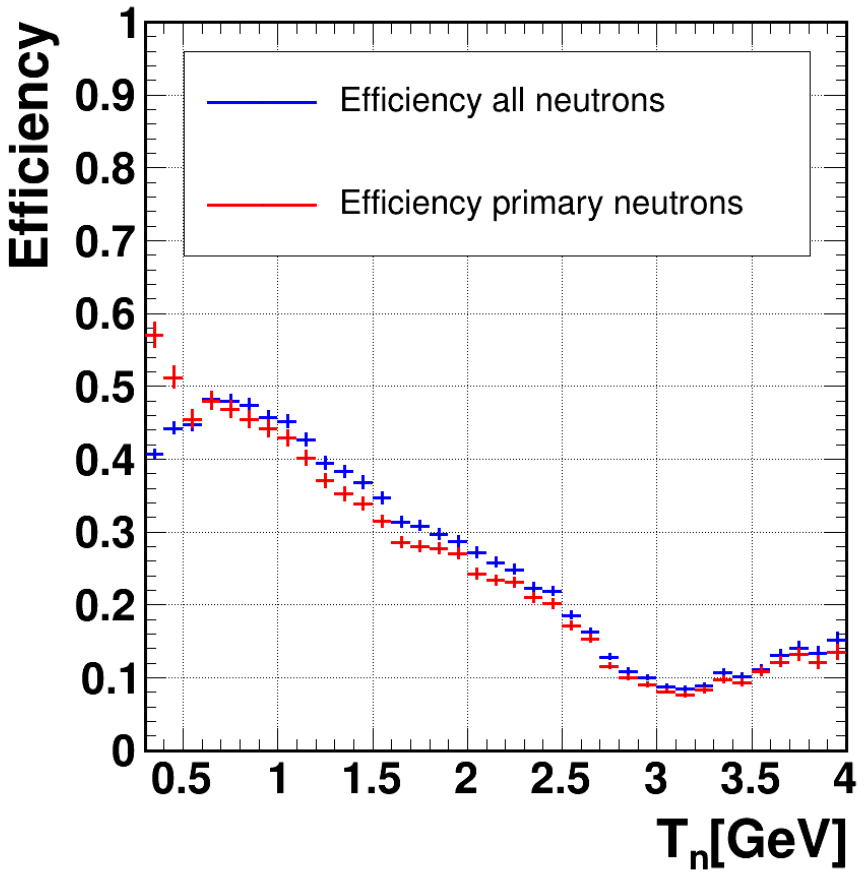
- **N match** – number of clusters which head cell is fired by a particle produced by a neutron
- **N simulated** – number of neutrons crossing HGND volume
- **N reconstructed** – number of clusters recognized as neutrons

Simulation

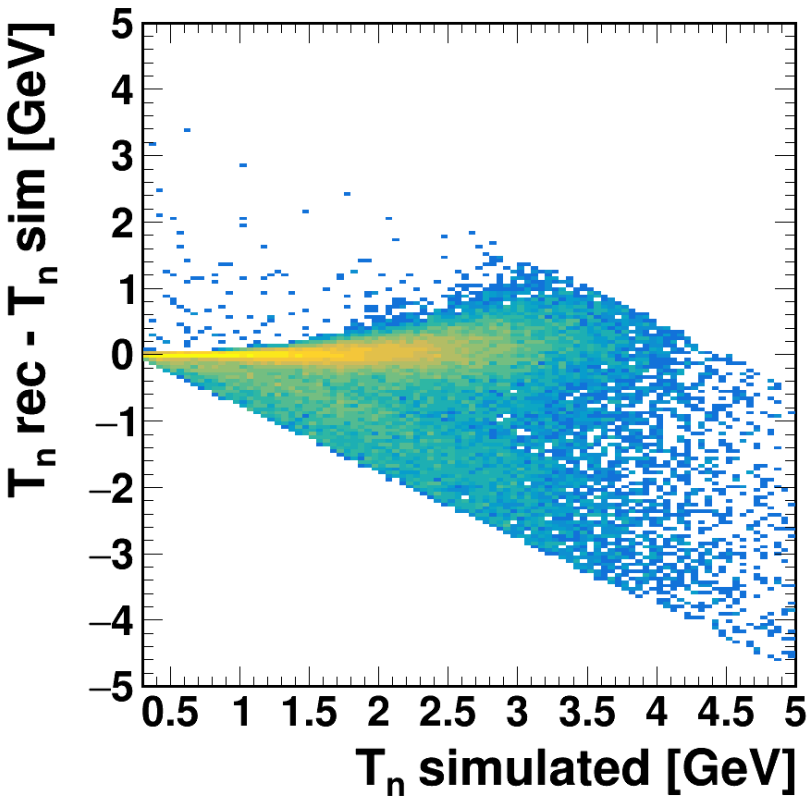
- DCM – QGSM – SMM generator
- Bi+Bi at $\sqrt{s_{NN}}$ = 3.03 AGeV (3.0 AGeV beam energy)
- Full BM@N geometry
- $2*10^5$ events
- Distance from target to HGND 700cm
- Time resolution of HGND cells 130 ps

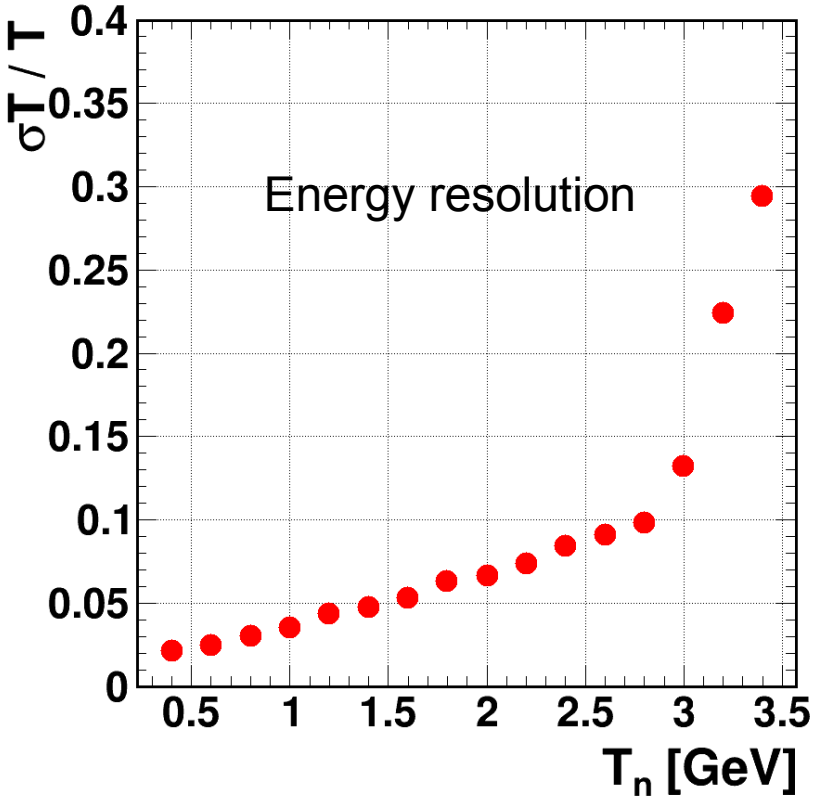
Efficiency and Purity



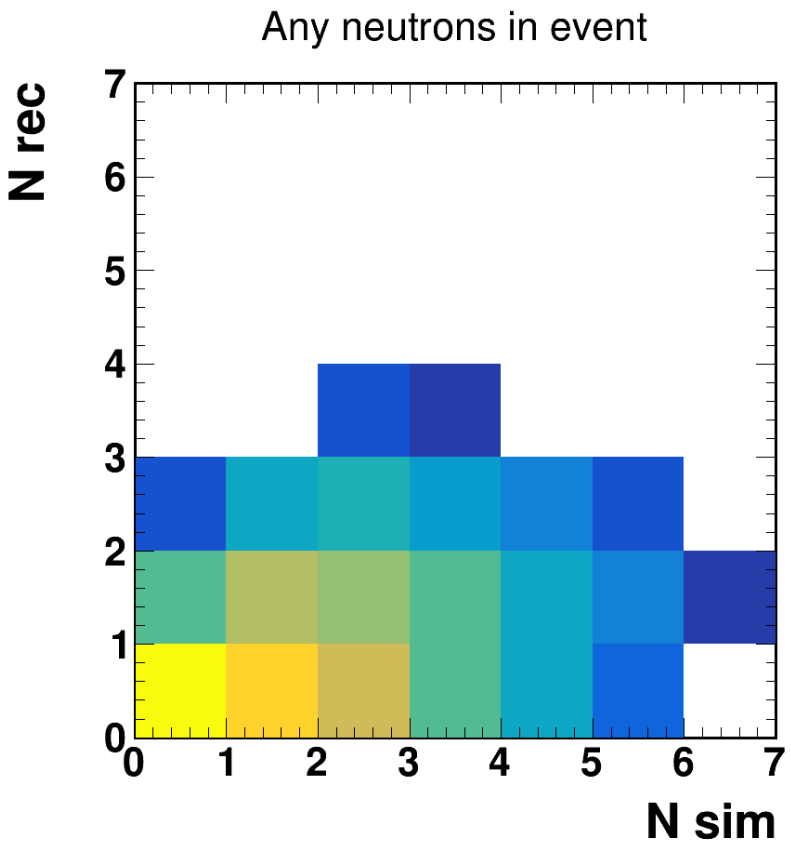


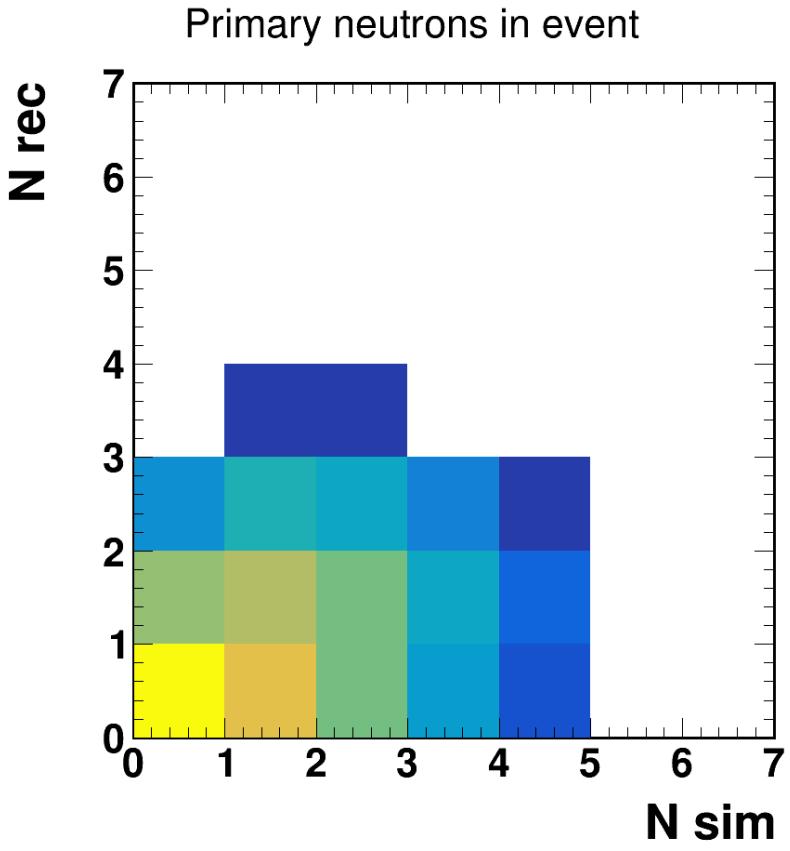
Kinetic energy reconstruction for primary neutrons





Number of neutrons in event

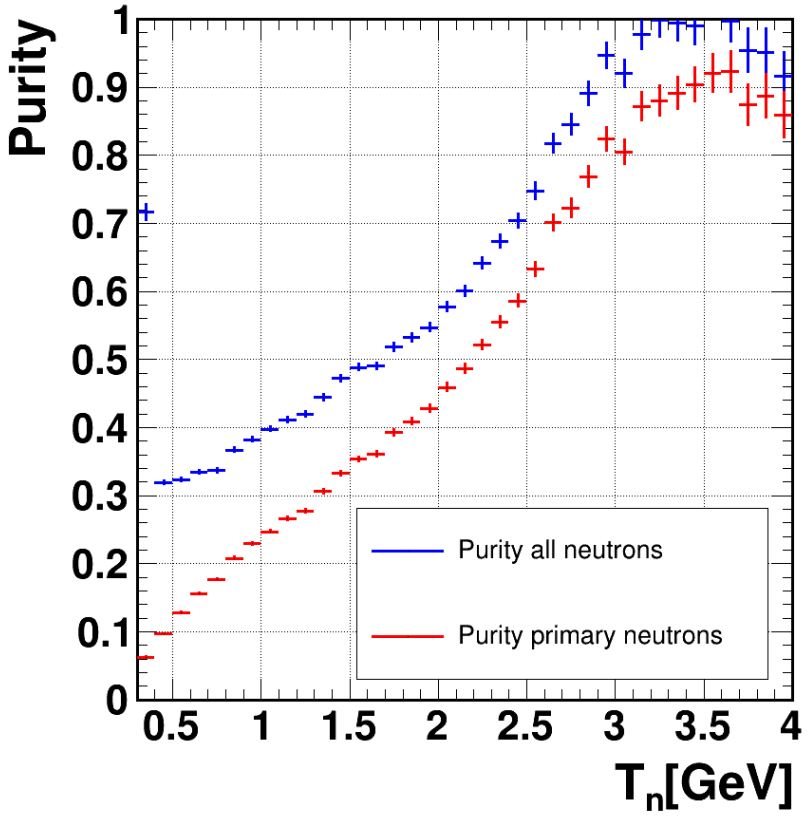


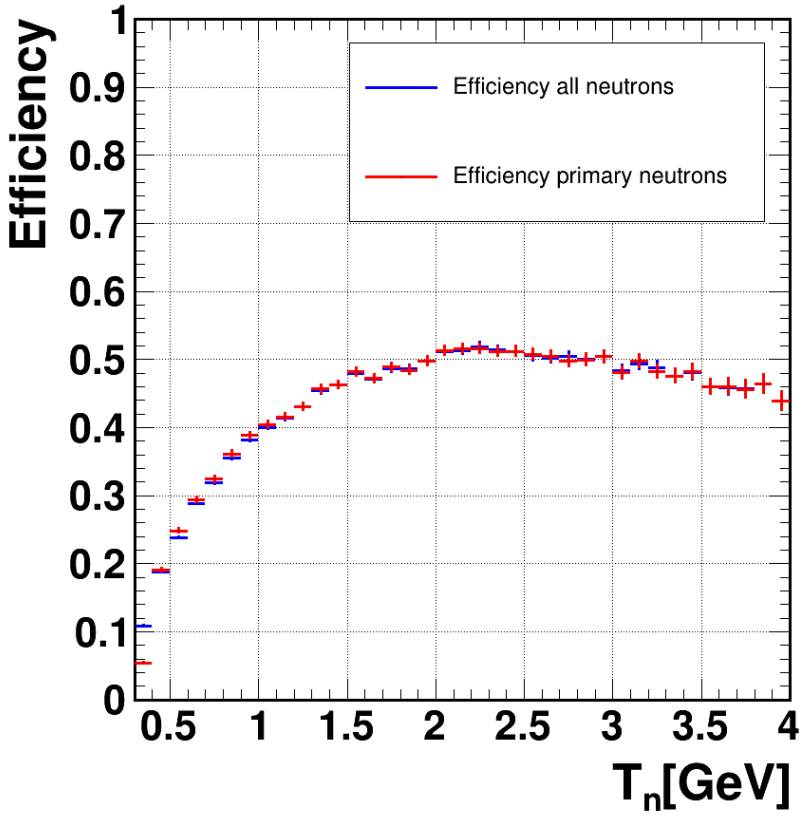


One more simulation, changed cuts in algorithm...

- 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

Efficiency and Purity





Conclusions

- The method of reconstruction of neutrons in HGND has been developed
  - Algorithm can be optimized to increase either **Efficiency** or **Purity**
  - Energy of neutrons is reconstructed with a presision < 10%
- Many neutrons in event can be reconstructed, but due to inefficiency and impurity this information cannot be used yet
- Algorithm is continuously being improved

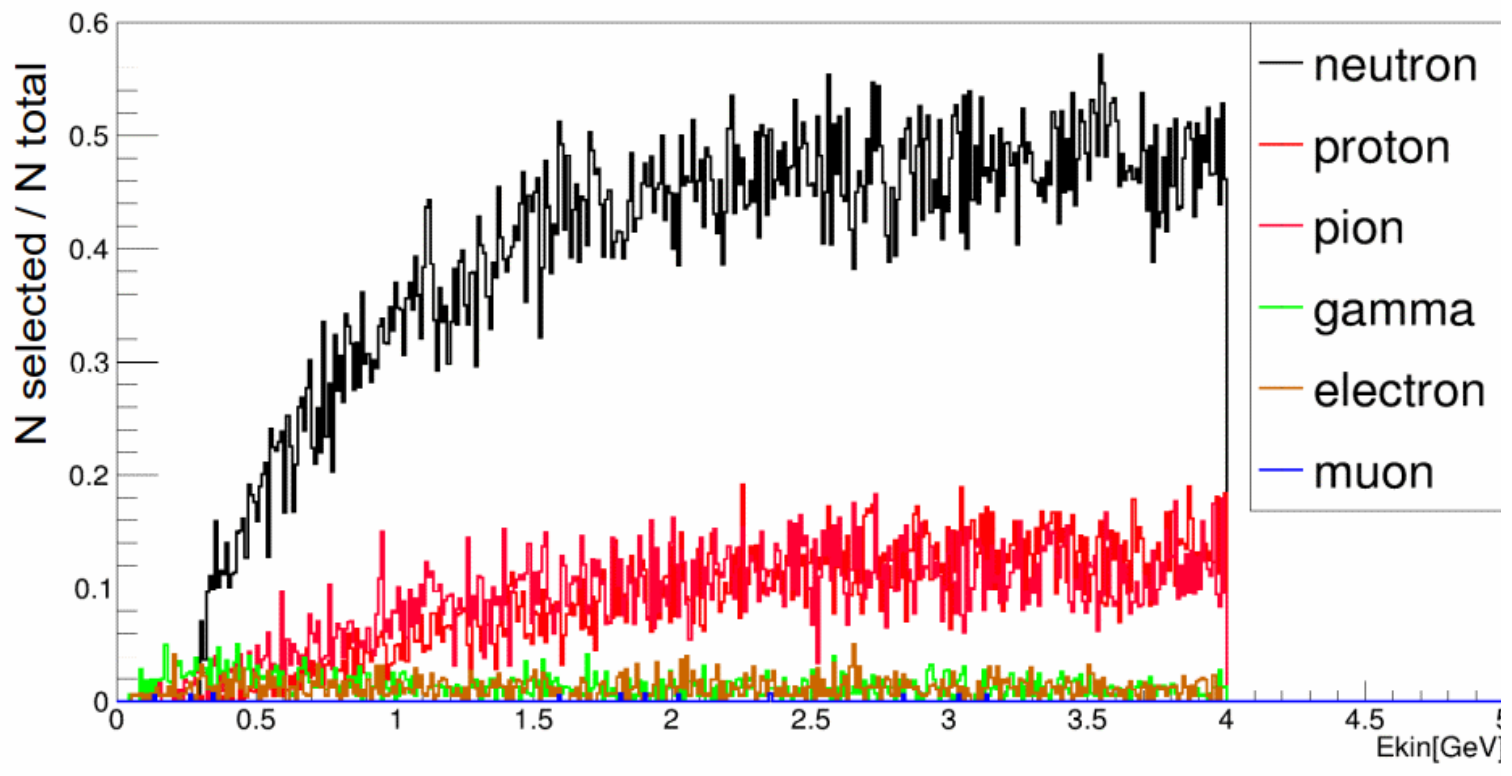
Backup slides

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



Cut on number of cells