Efficiency study of the ECal detector of the HADES experiment

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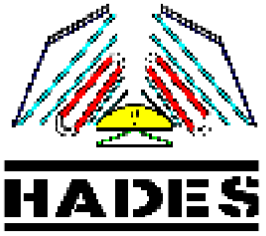


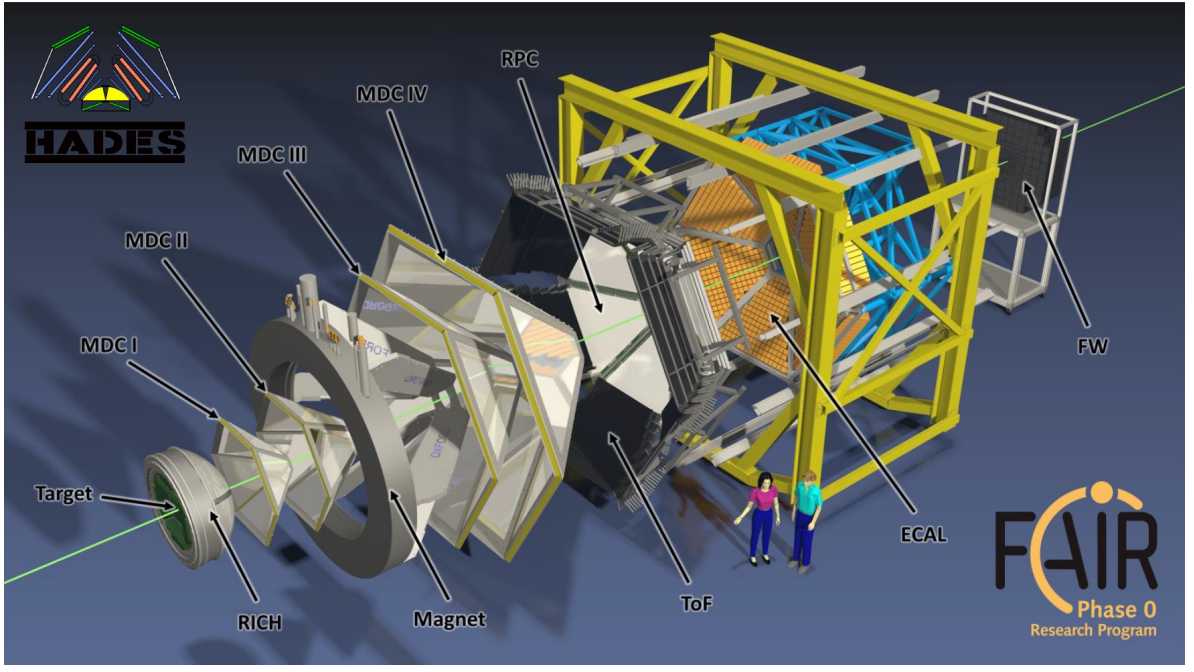
Motivation

- Goal: measurement of $\pi^0 \rightarrow \gamma\gamma$ decay
- All spectra need efficiency & acceptance corrections
- Acceptance can be calculated from simulation
- Efficiency of photon detection can be measured with e+ or e-
- Efficiency is one of key characteristics of the detector

HADES experiment

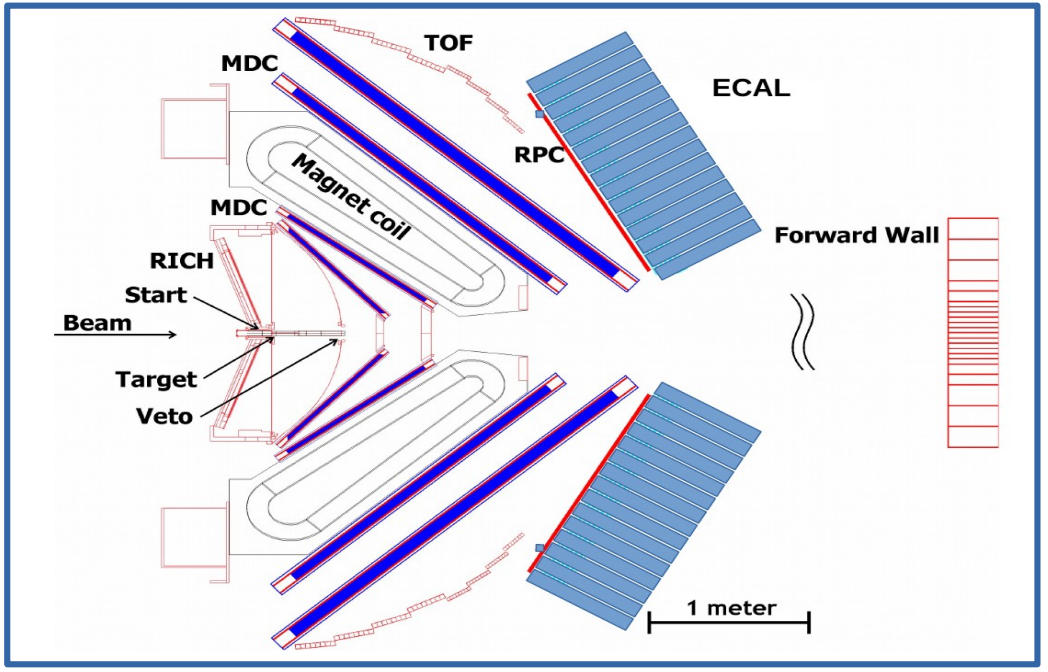
Fixed target experiment at SIS18, Darmstadt

- Beam energy 1-2 A GeV;
- π, p, heavy nuclei beams
- Covers full azimutal angle and $18° < \theta < 85°$ polar angle



HADES detector

- Tracking system
- Time-of-flight system
- Ring imaging Cherenkov detector
- Electromagnetic calorimeter ECal
- Forward hodoscope

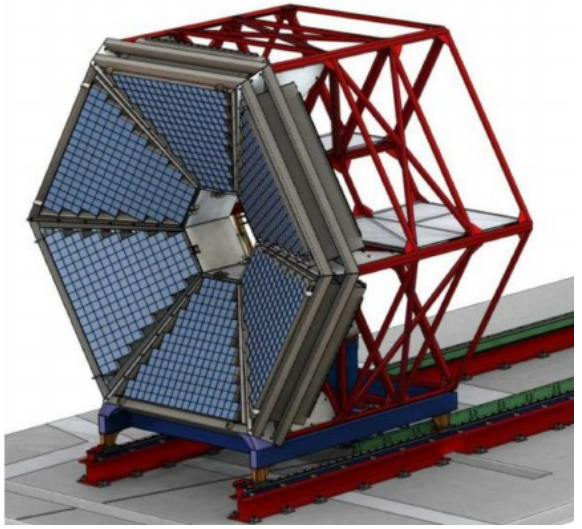


Electromagnetic calorimeter ECal

- Added to the setup in 2019
- Measure photons
- Improve e/π separation

- Energy resolution $\frac{\sigma_E}{E} = \frac{5\,\%}{\sqrt{E\,[GeV]}}$

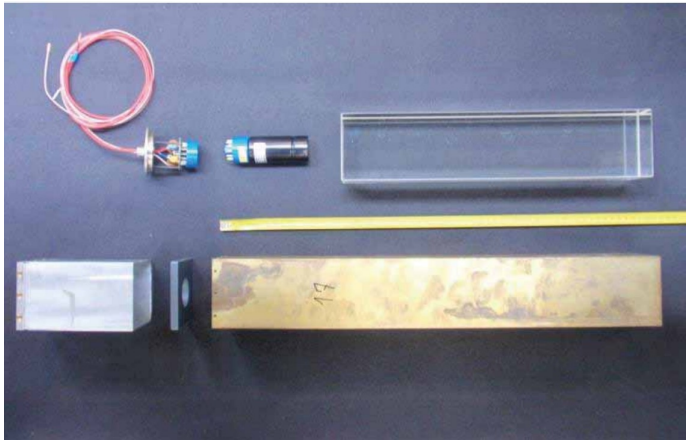
- Time resolution < 300 ps

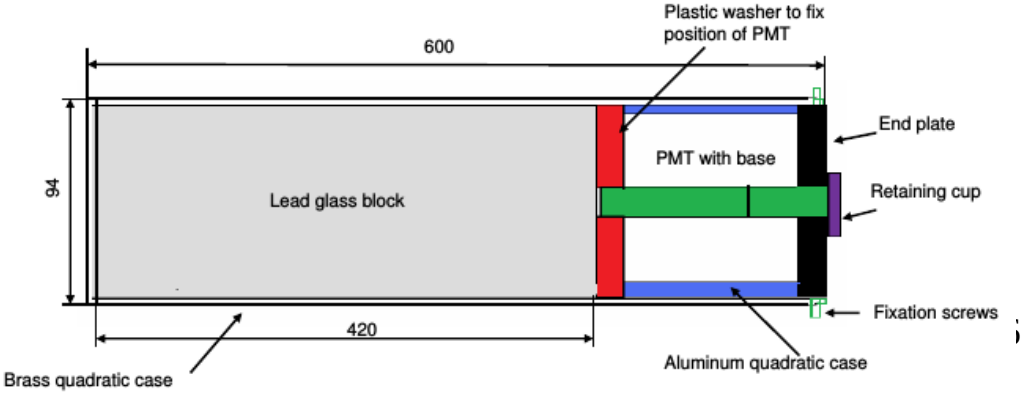


6 sectors covering
$12^\circ < \theta < 45^\circ$

The module of the ECal detector

- Cherenkov radiator made of lead glass (CEREN25), 16.7 radiation lengths
- PMT
  - 1.5 inch EMI 9903KB
  - 3 inch Hamamatsu R6091





Efficiency

- **<u>Efficiency</u>** is one of the key characteristics of the detector to measure yields of particles

  It can be measured using electrons/positrons

$$effifciency = \frac{N\ detected\ particles}{N\ particles\ crossed\ the\ detector}$$

energy	↔	measured momentum
time	↔	time measured by RPC
coordinate	↔	coordinate of RPC hit

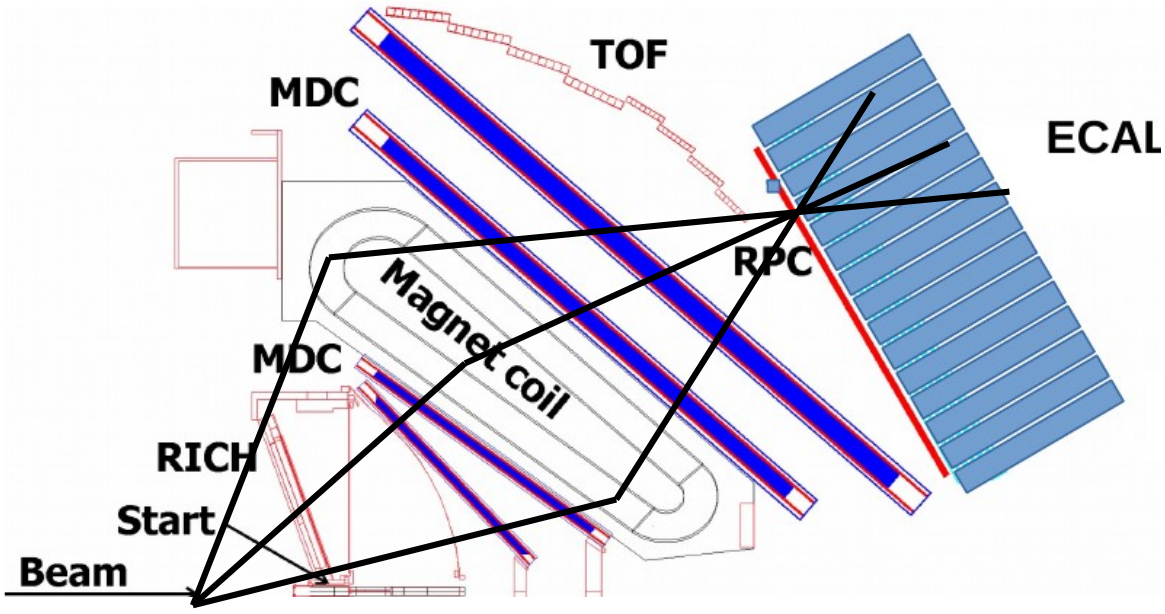
Must be predicted using information from other detectors

Prediction of the ECal module which is hit by e^+

RPC is the closest detector to ECal

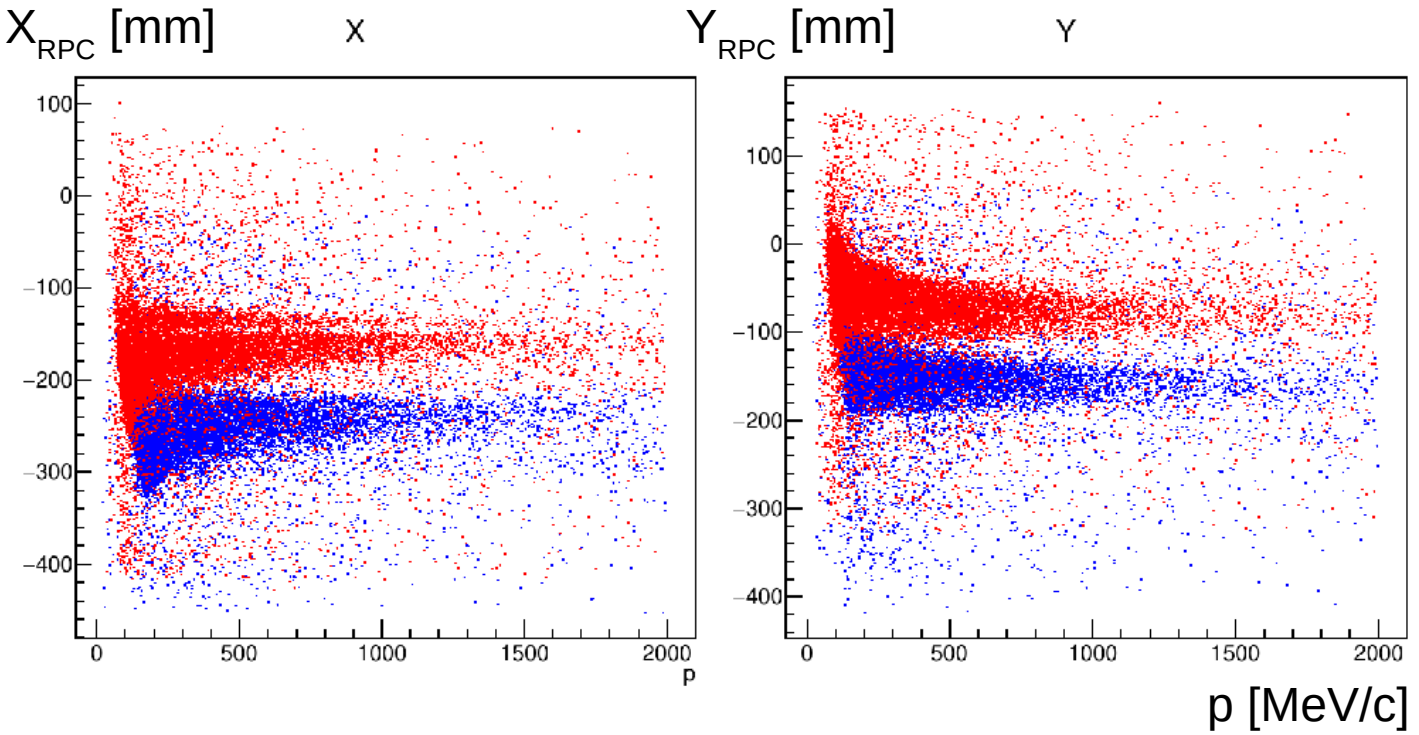
Particles which hit the **same** point in **RPC** can go to **different modules** depending on their momentum and charge

For better estimation we need to take into account momentum of the particle



Separation of the neighbouring modules of ECal

Coordinates of RPC hit
vs momentum
of positrons which fired
ECal module 1
ECal module 2

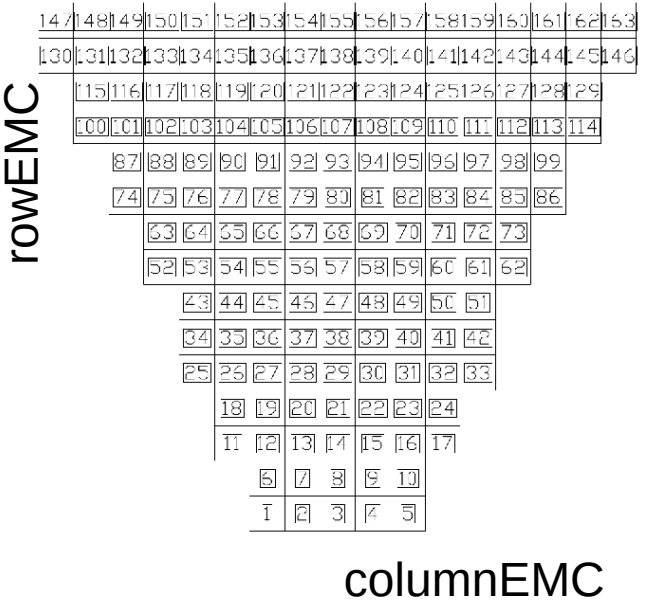


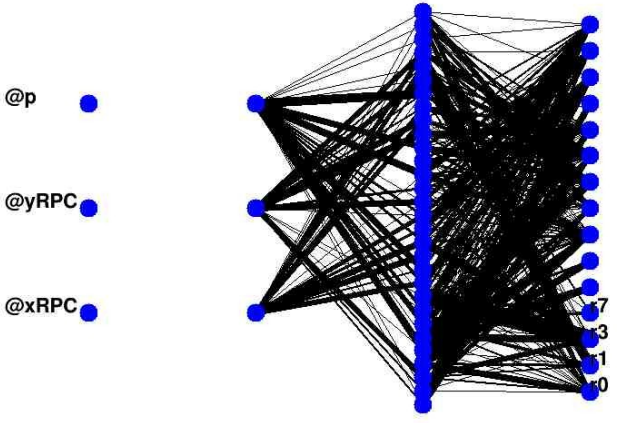
Prediction of ECal module with MLP

- To predict the ECal module we need to learn the machine
- Separate the task into two (for better accuracy):

  (xRPC, yRPC,p) -> rowECal

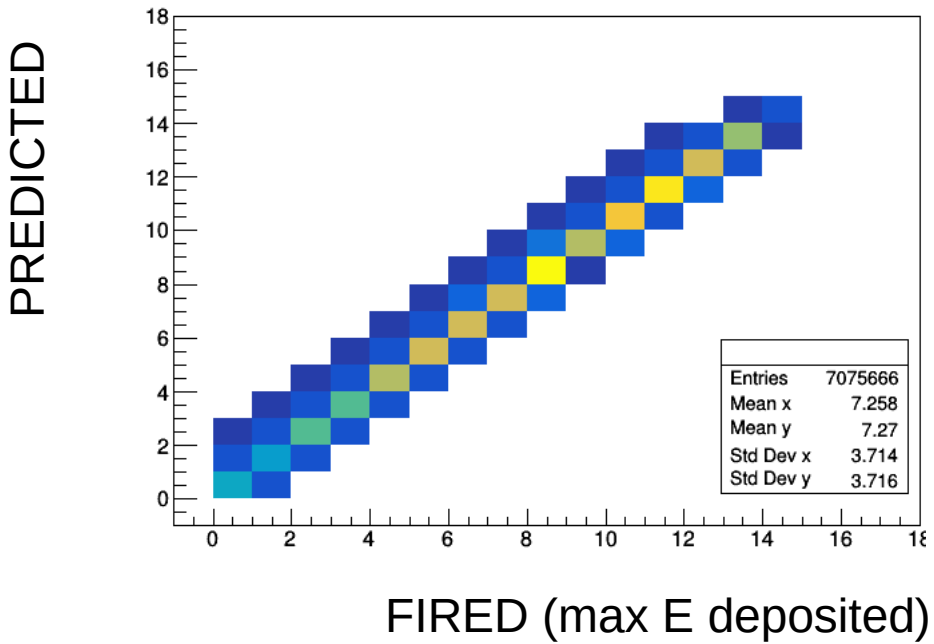
  (xRPC, yRPC,p) -> columnECal
- For each task we learn multilayer perceptron (MLP)



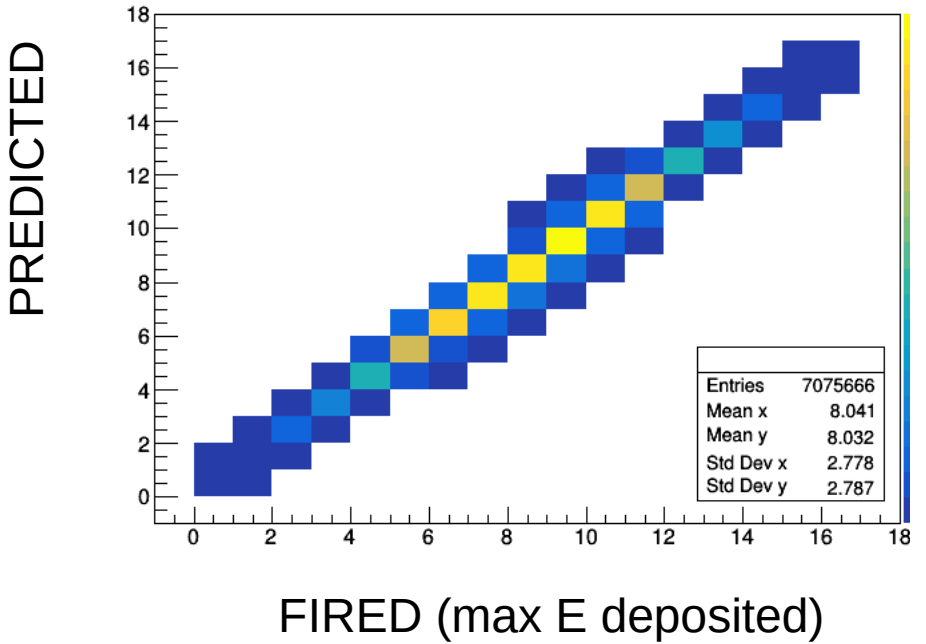


Quality of the prediction

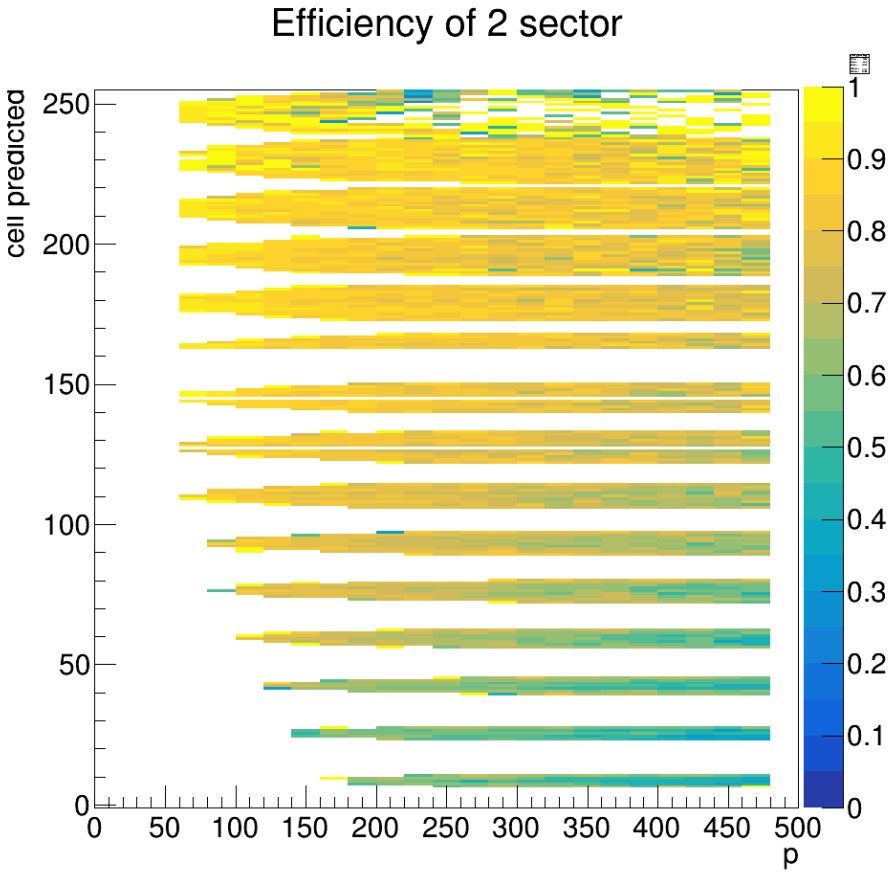
ROWS



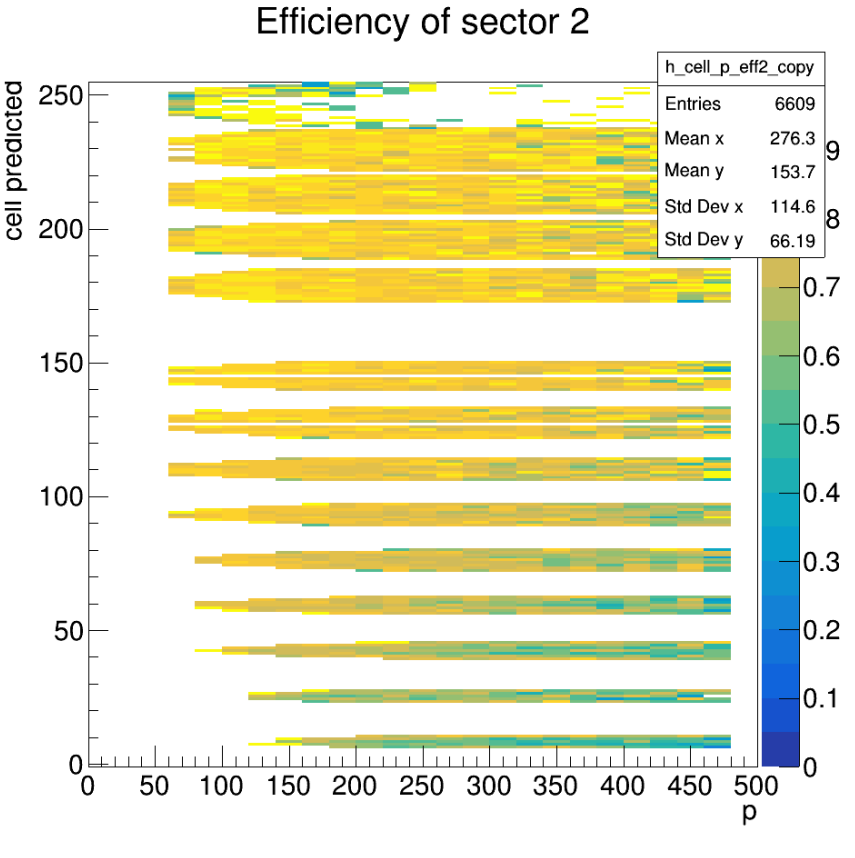
COLUMNS



Efficiency depending on momentum

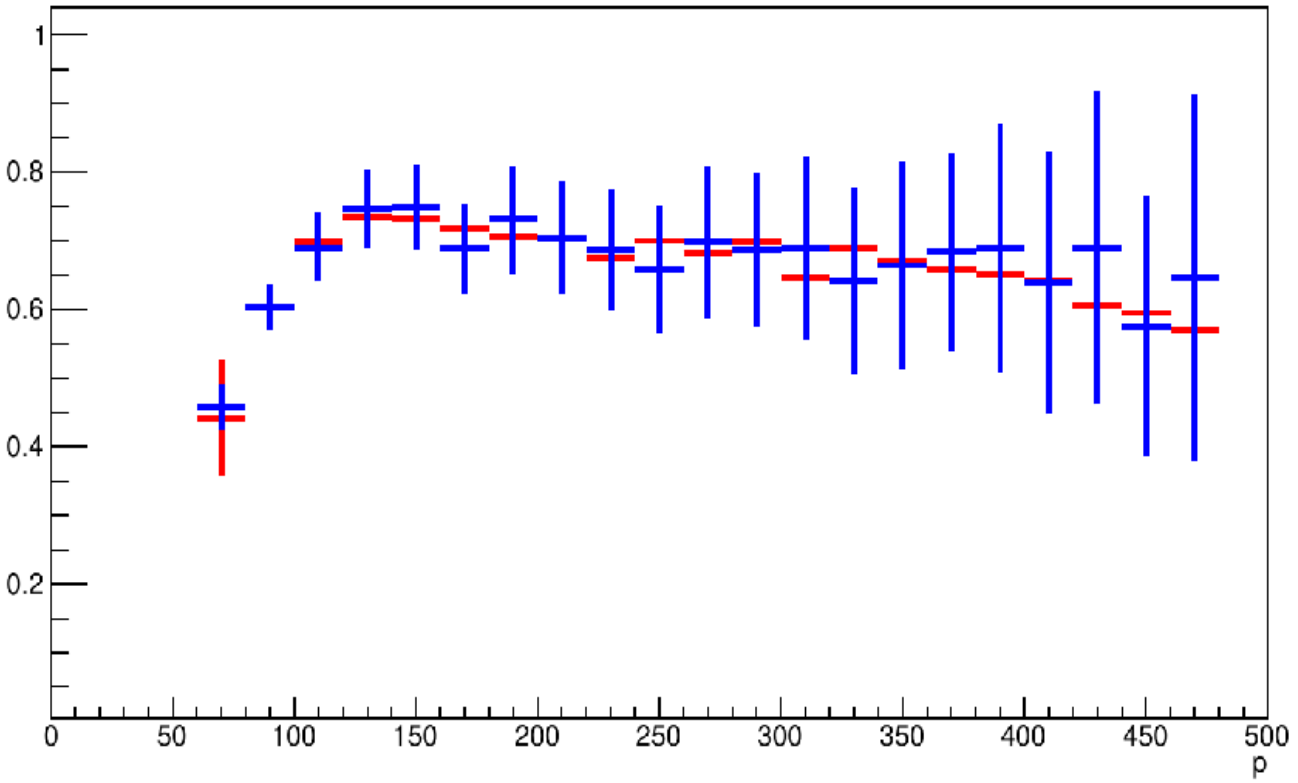


data, taken at 3200 A, 1.58 AGeV



data, taken at 2500 A, 1.23 AGeV

Efficiency of cell 149, sector 4



3200 A,

1.58 AGeV

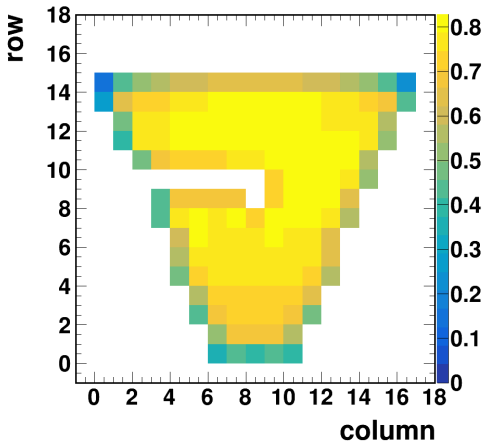
2500 A,

1.23 AGeV

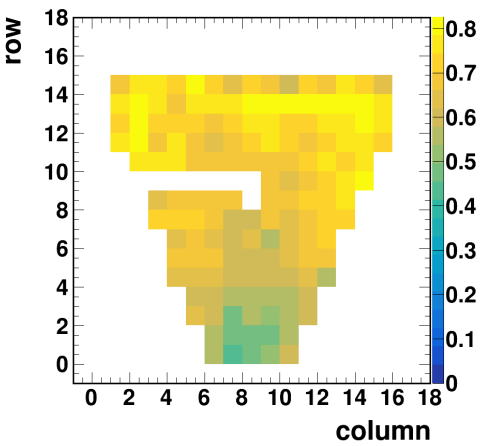
- Coincidence of efficiency calculated for different datasets confirms this method

Comparison with simulation

Simulation



Experiment



$$efficiency_{\gamma} = efficiency_{\gamma simulation} \cdot \frac{efficiency_{e\ experiment}}{efficiency_{e\ simulation}}$$

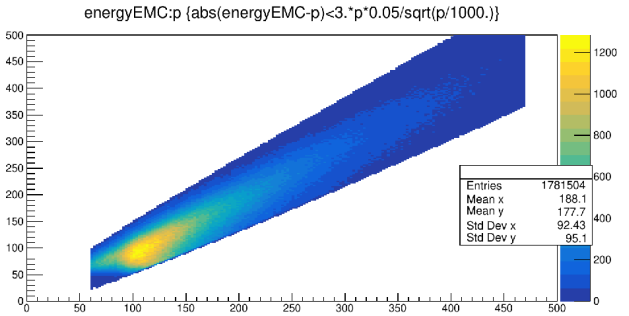
Summary

- Efficiency of the ECal detector is ~85%
- The method of efficiency determination gives reliable results

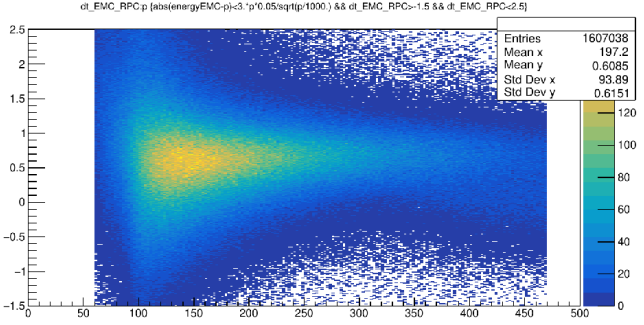
Thank you for your attention!

Efficiency

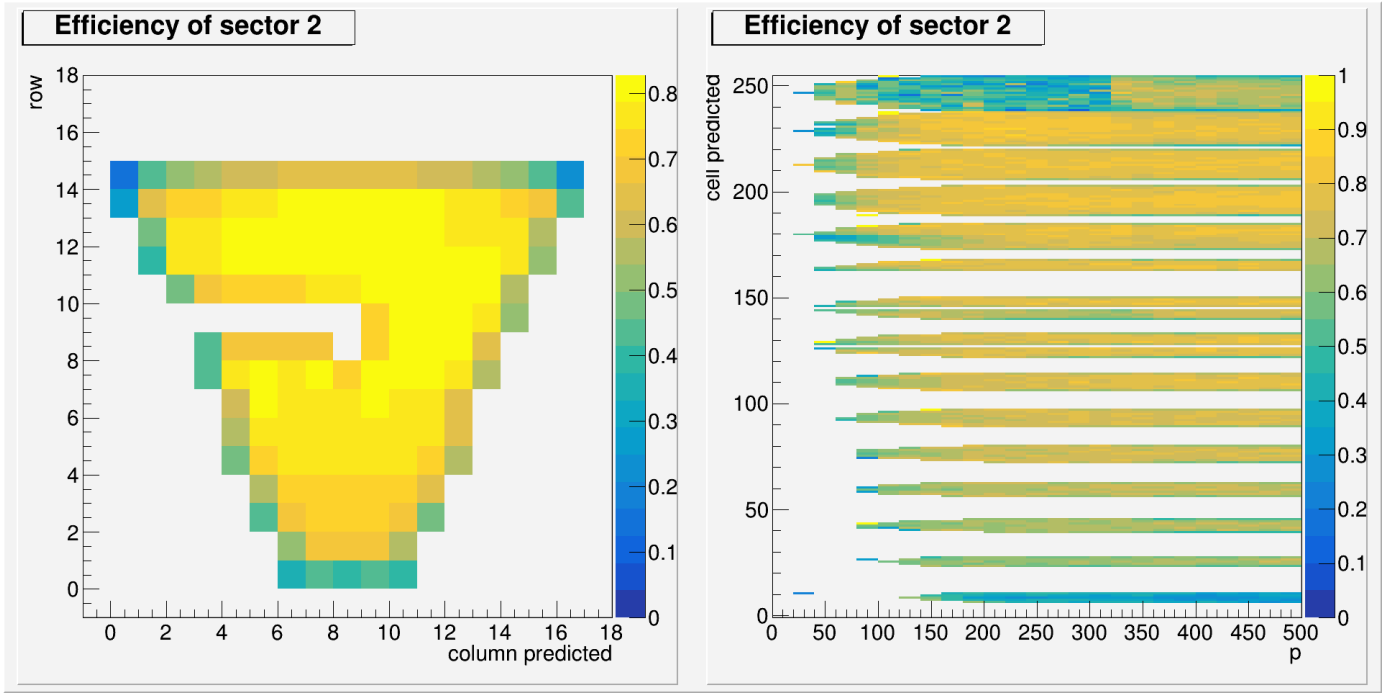
Energy cut



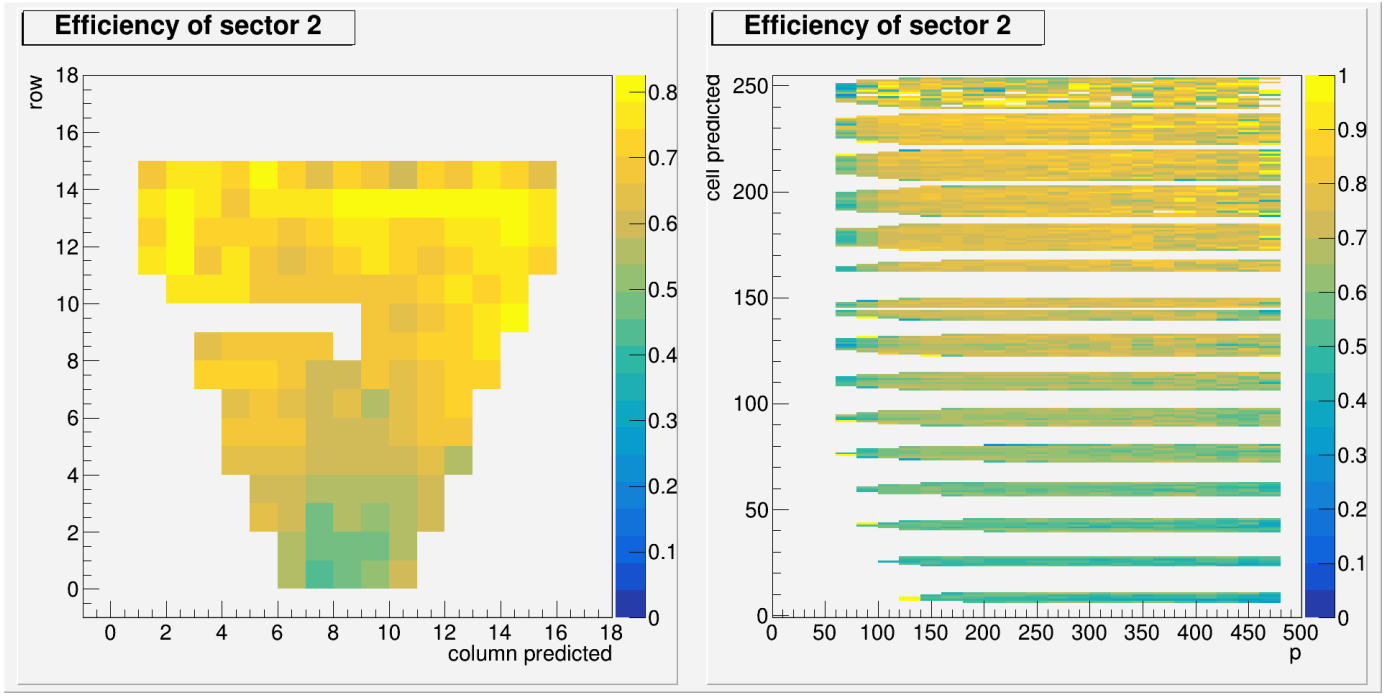
Time cut



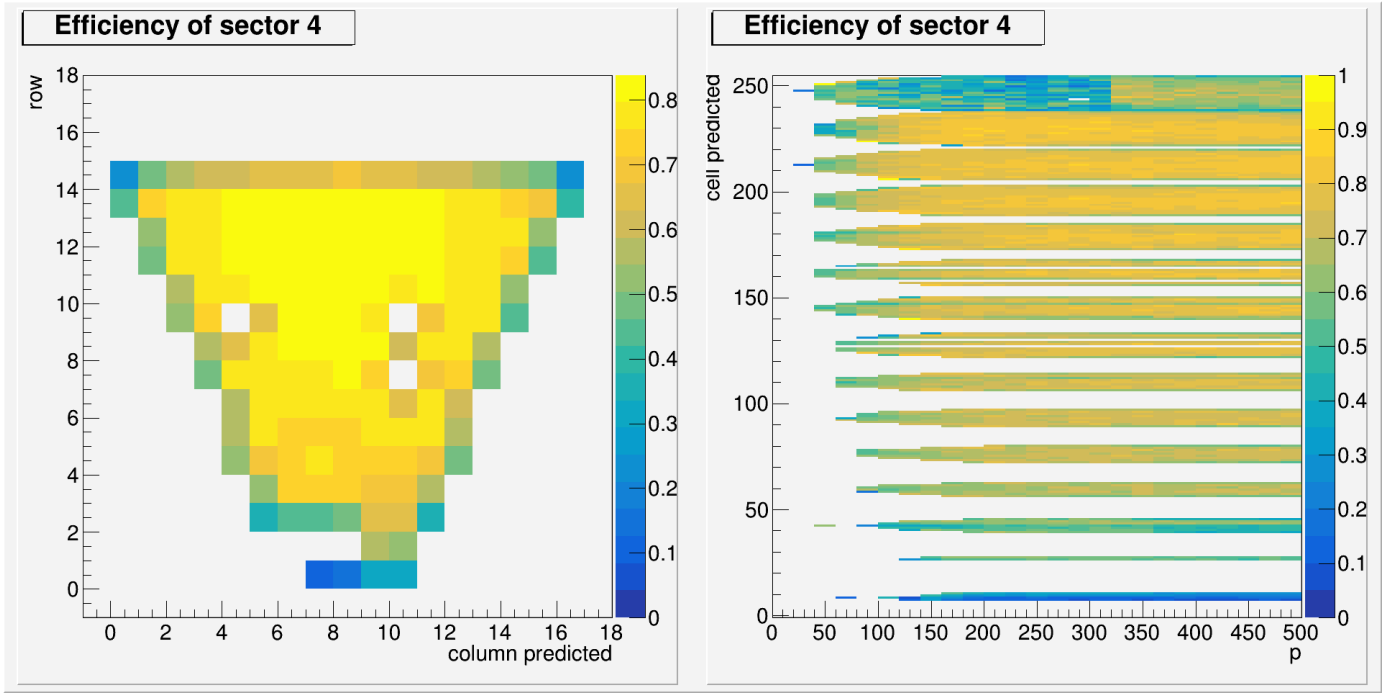
2 sector simulation



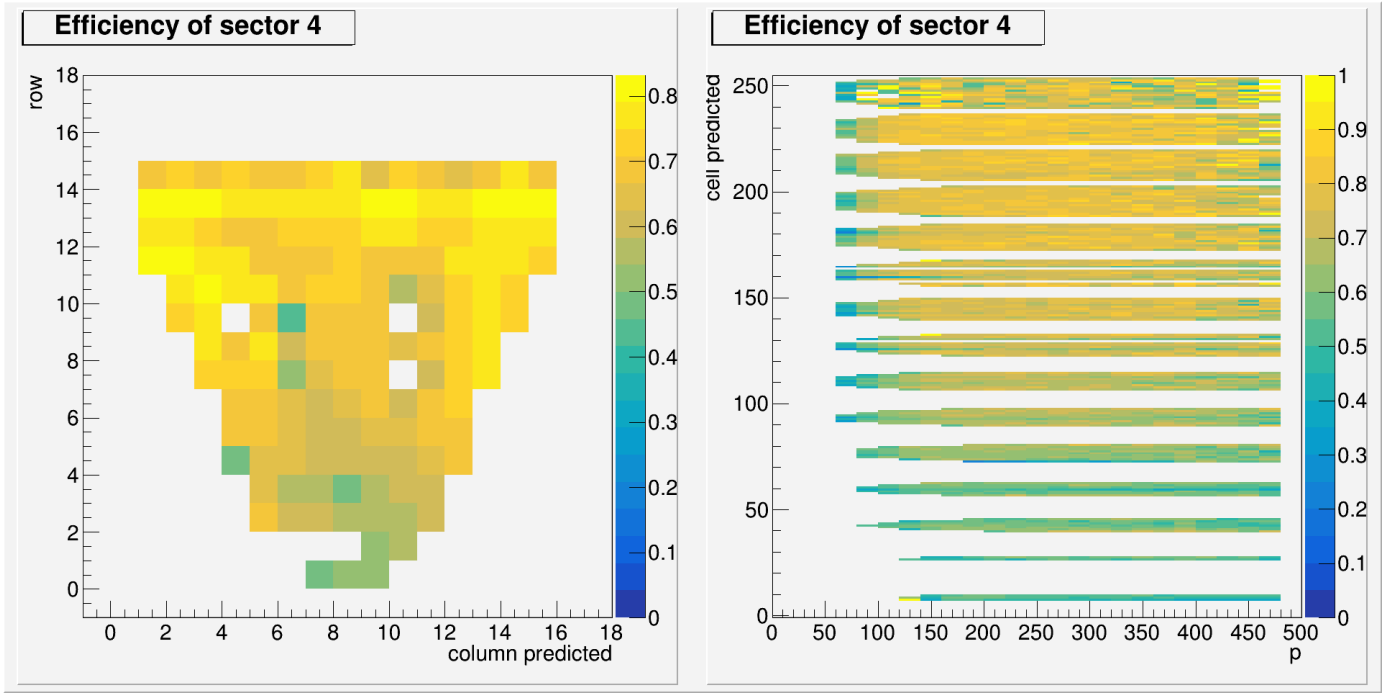
2 sector experiment



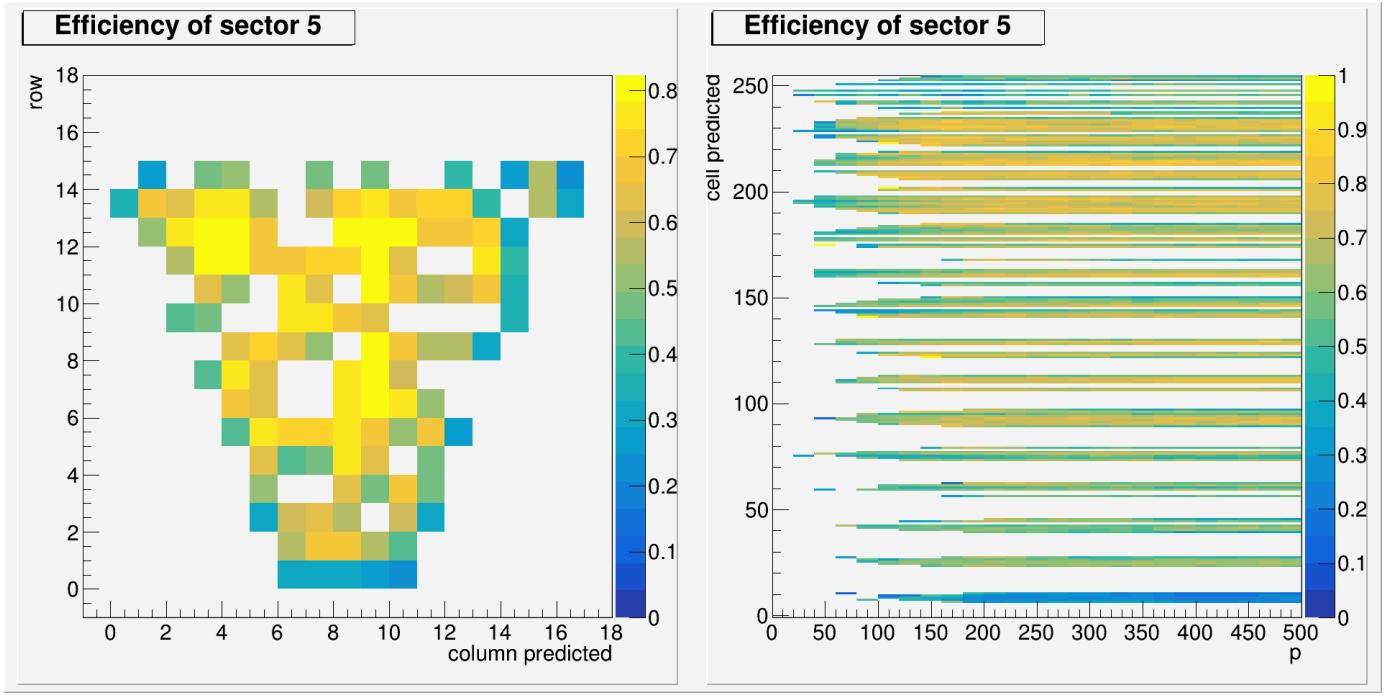
4 sector simulation



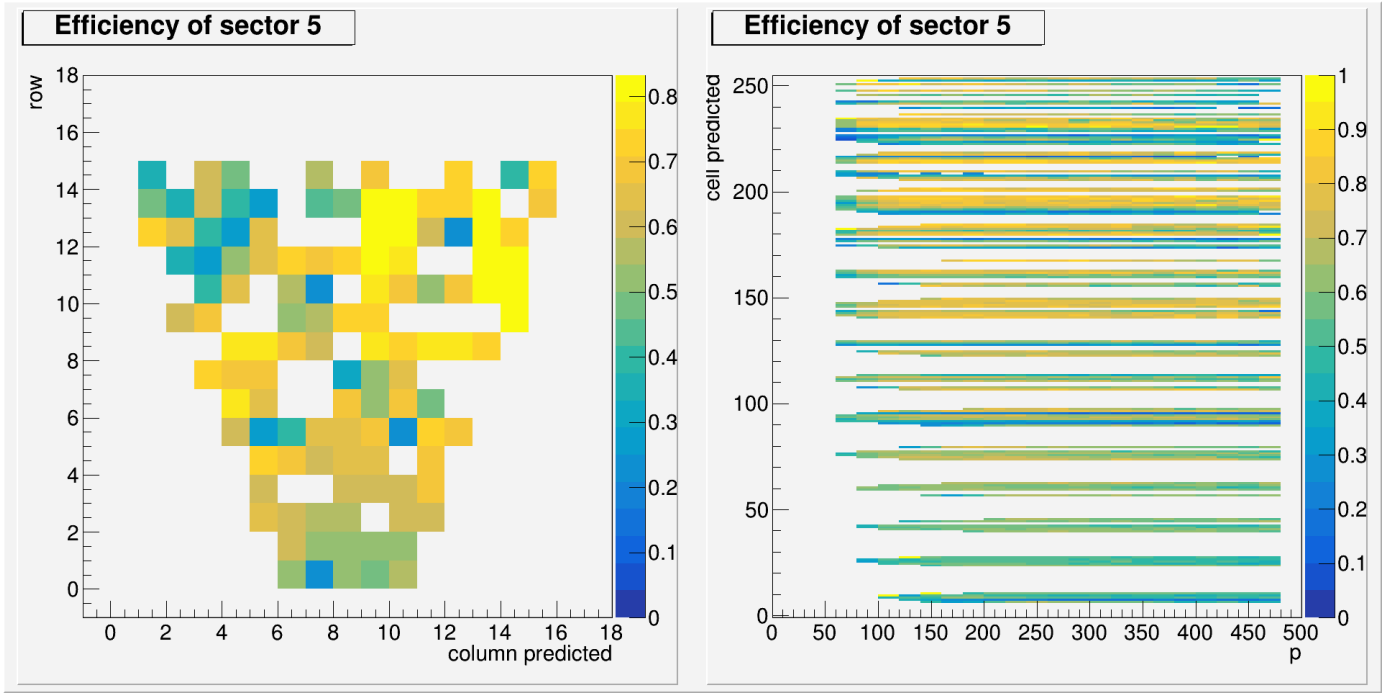
4 sector experiment



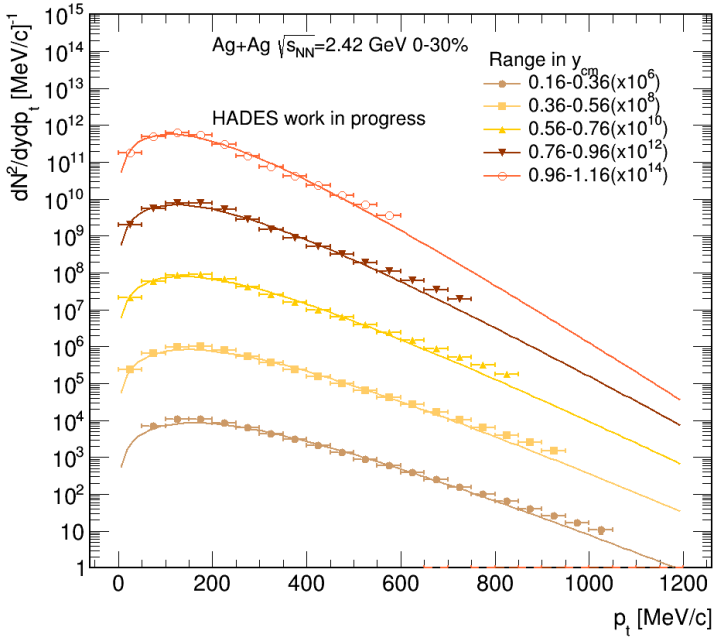
5 sector simulation



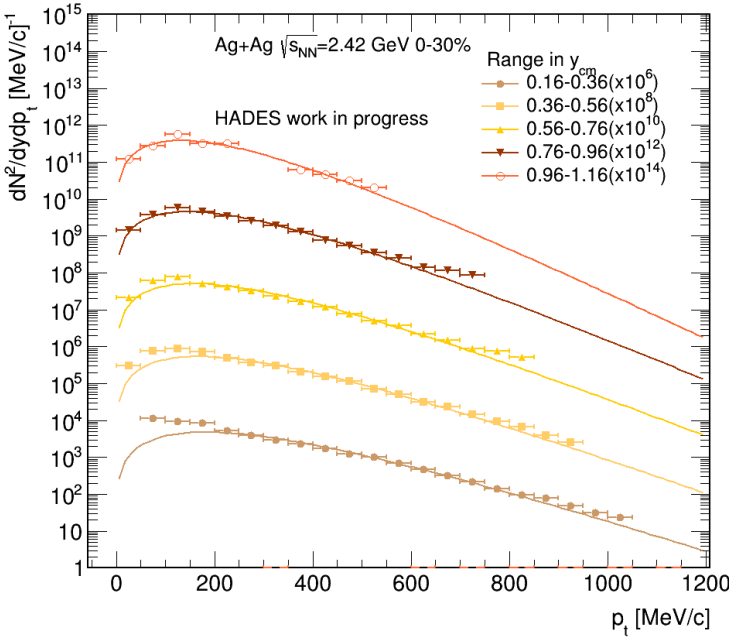
5 sector experiment



Preliminary results



Simulation



Experiment