π^0 production in Ag+Ag collisions at 1.23 A GeV beam energy

Arseniy Shabanov

for the HADES collaboration

arseniy.shabanov@phystech.edu

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Outline

- HADES experiment
- ECal detector
- Reconstruction of neutral pions
- Preliminary results
- Summary

Motivation

- π^0 is an important part of hadronic coctail
- Other methods to determine π^0 yield
  - conversion method
  - Dalitz decay

  have large systematic unsertainties and low statistics

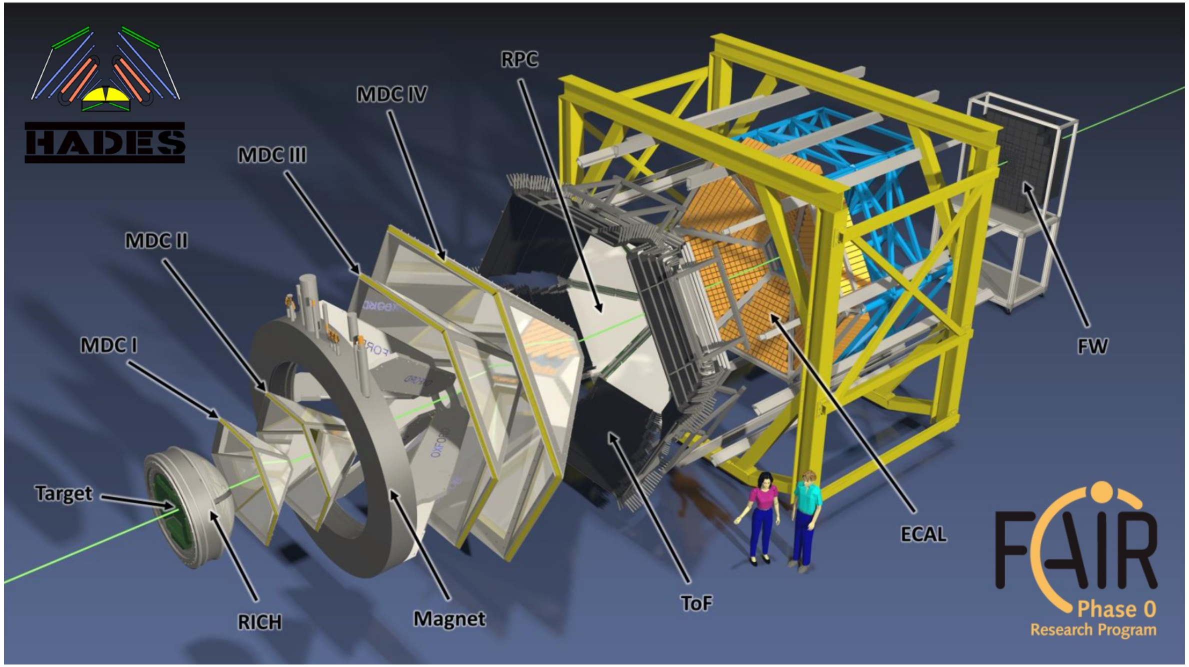
- Direct measurement of decay $\pi^0 \rightarrow \gamma\gamma$ allows to cross check with charged pions production

HADES experiment

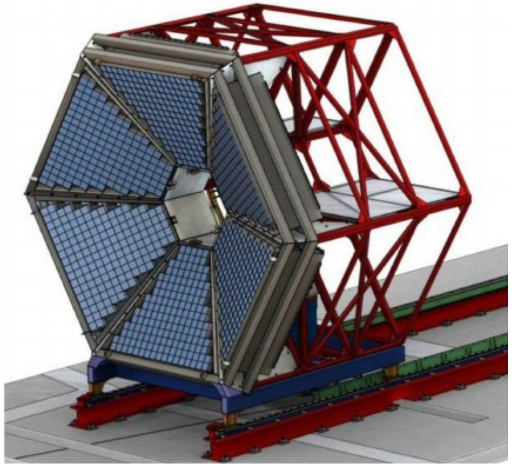
Fixed target experiment at SIS18, Darmstadt

- Covers full azimutal angle and 18° < θ < 85° polar angle

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

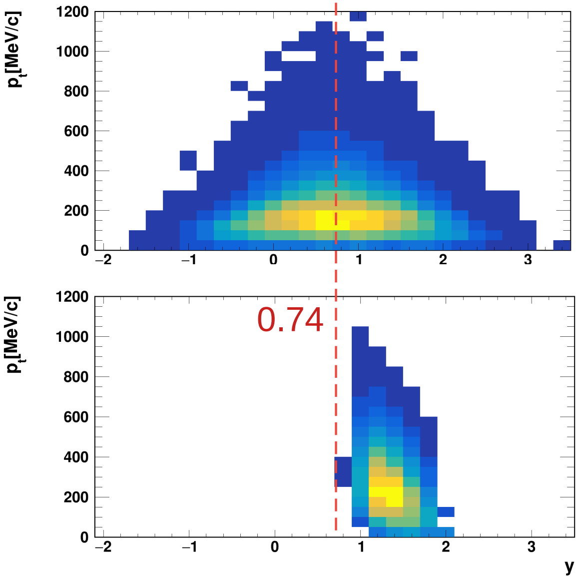


Electromagnetic calorimeter ECal



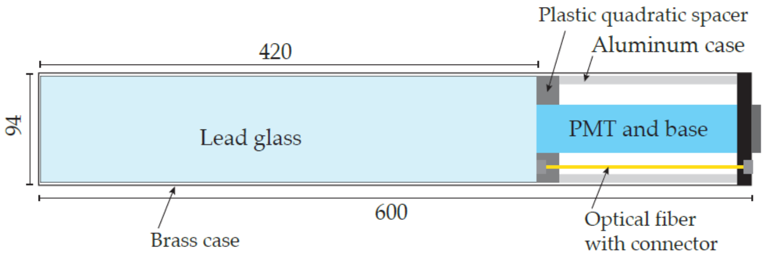
6 sectors covering
12° < θ < 45 °

phase space of π^0 in
Ag+Ag 1.23 A GeV



acceptance of ECal
(3 sectors out of 6
were in operation)

- 978 modules
- Homogeneous Cherenkov radiator is made of CEREN25 lead glass (16.7 radiation length long)
- PMT:
  EMI 9903kB (1.5”) or
  Hamamatsu R6091 (3”)



Analyzed data

- March 2019
- Ag + Ag at 1.23 A GeV
- 7 * 10^8 events

Selection of events

- centrality 0-30%

- February-March 2019
- Ag + Ag at 1.58 A GeV
- 14*10^9 events

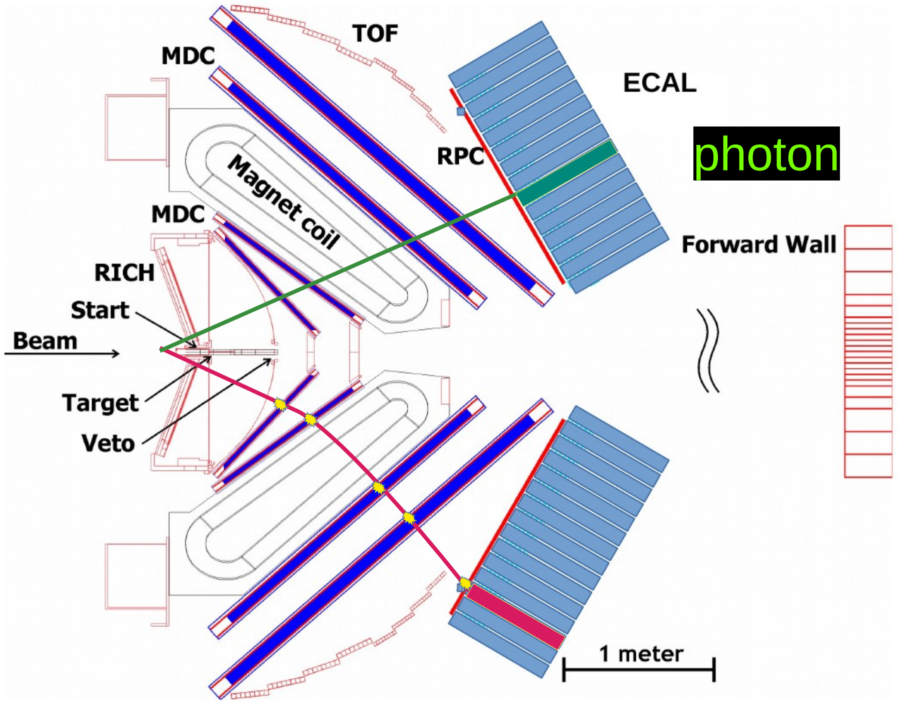
Selection criteria

Photon:

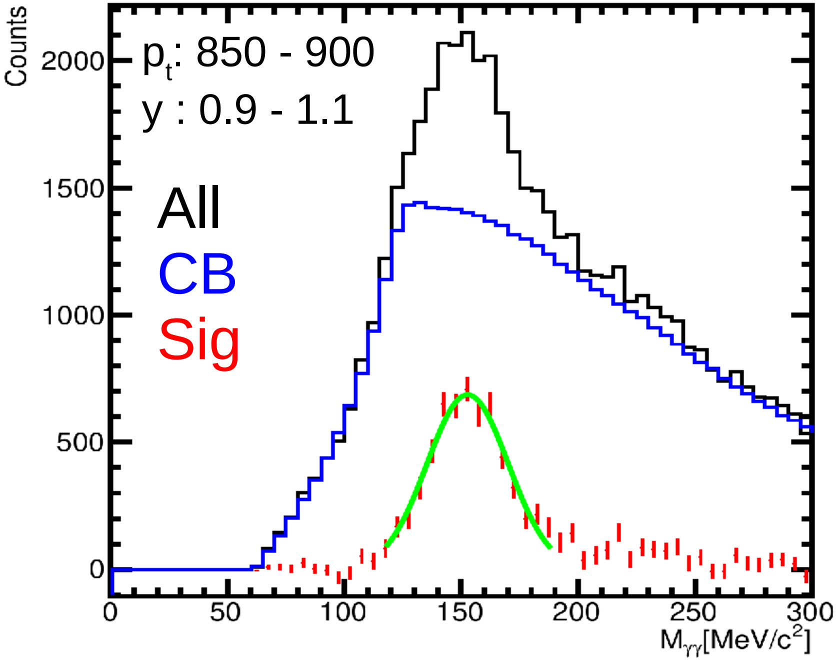
- No hit in RPC (closest detector to ECal)
- No match with any track
- $0.9 < \beta < 1.1$
- E > 100 MeV (reject neutrons)

Diphoton:

- Opening angle > 10°

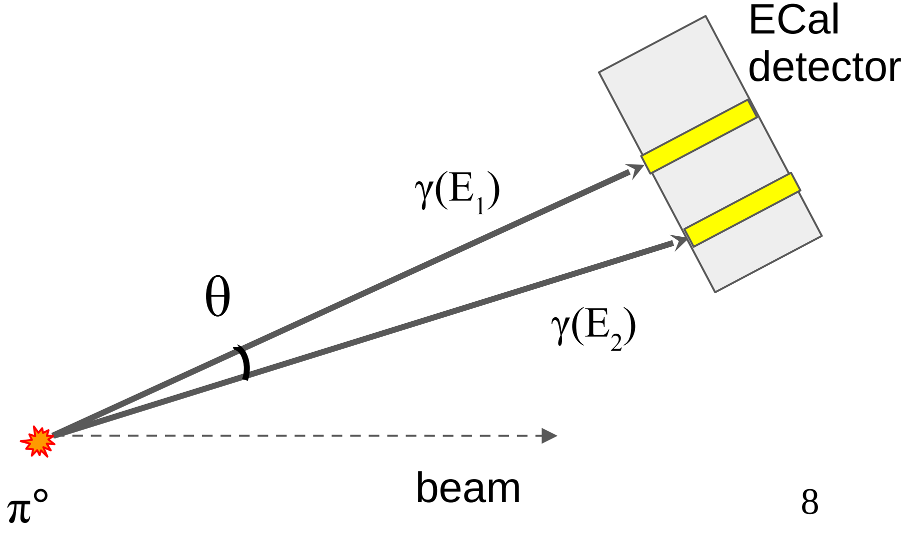


Reconstruction of π^0-mesons

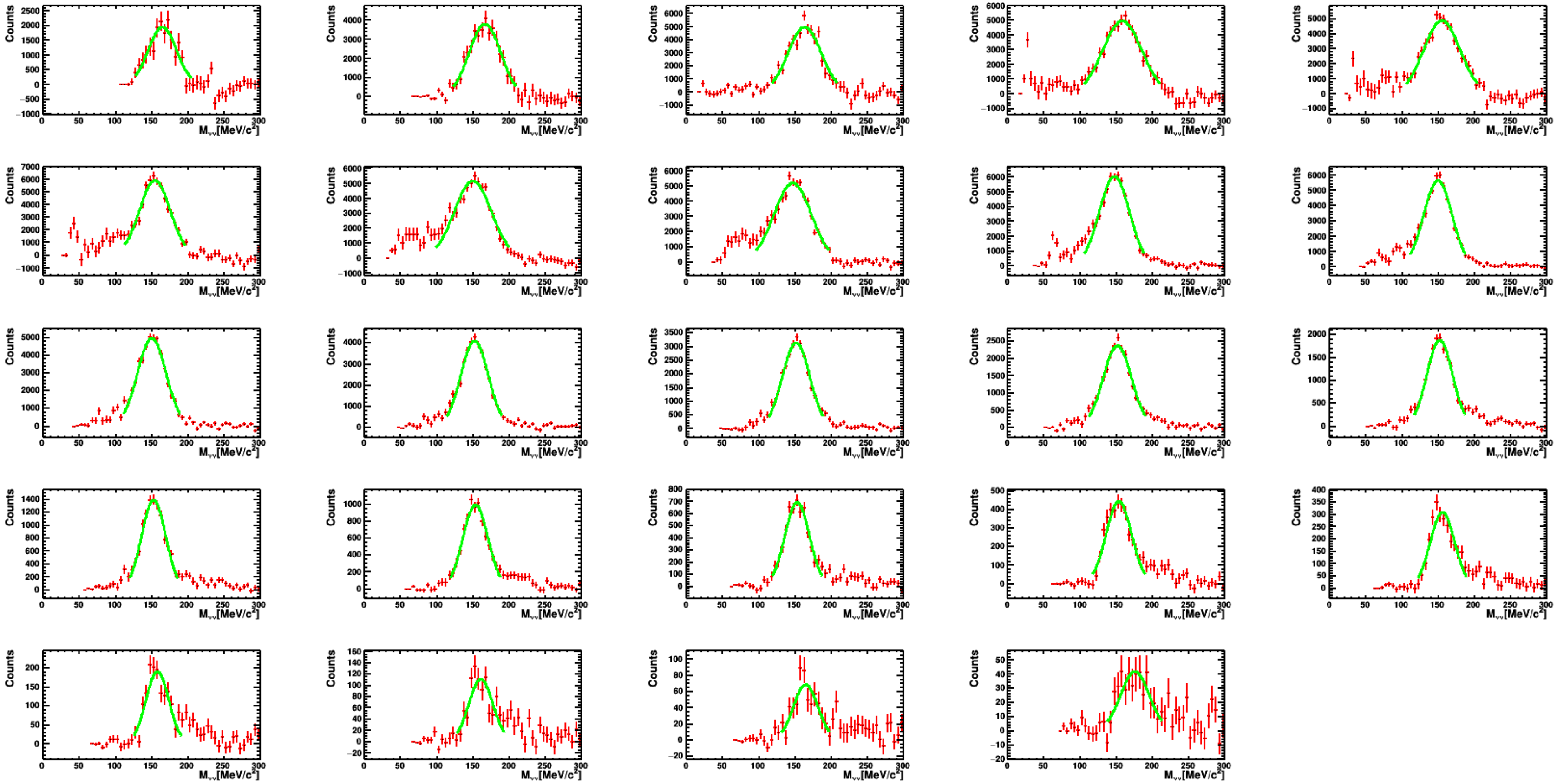


All – experimental data
CB – mixed-event combinatorial background
Sig – signal
Signal is fitted with Gauss

$$m_{\pi^0} = \sqrt{E_1 \cdot E_2 \cdot (1 - \cos\theta)}$$

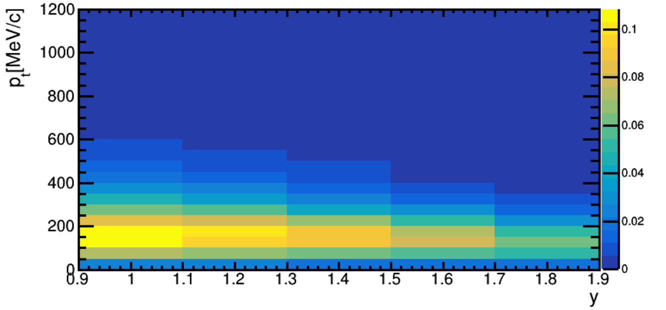


0.9 < y < 1.1

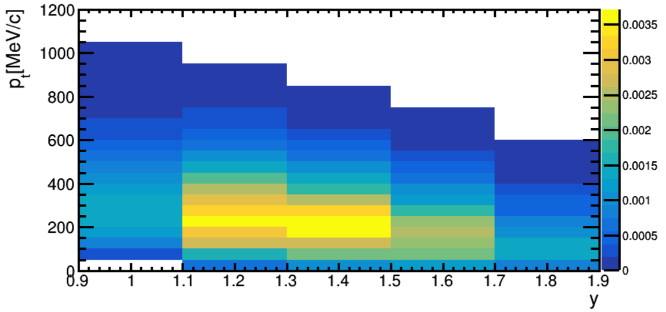


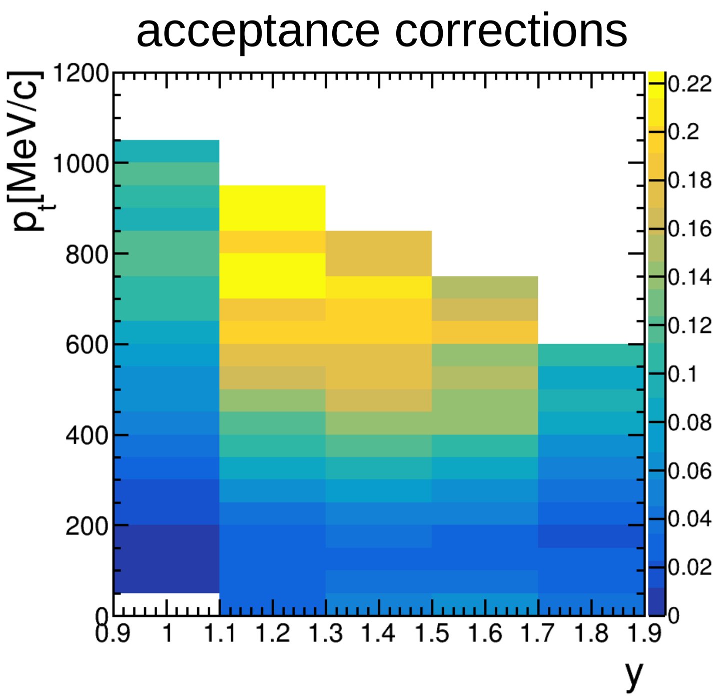
Acceptance corrections

UrQMD generated
number of pions
within pt-y bin
per event



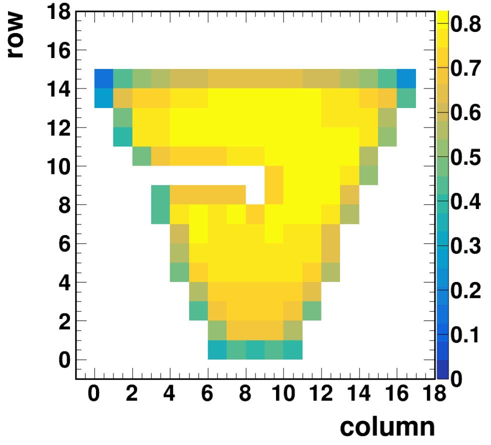
Reconstructed from
simulation number of
pions
within pt-y bin
per event



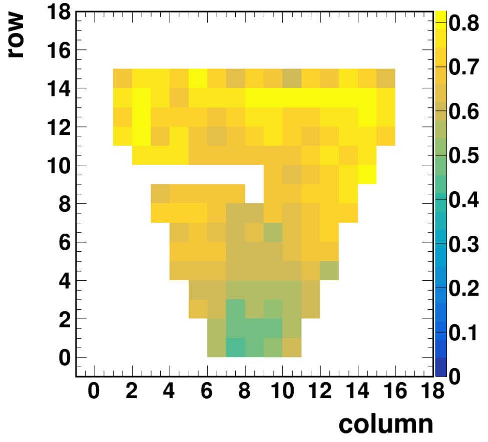


Efficiency corrections

efficiency of detection
of positrons
(simulation)



efficiency of detection
of positrons
(experiment)

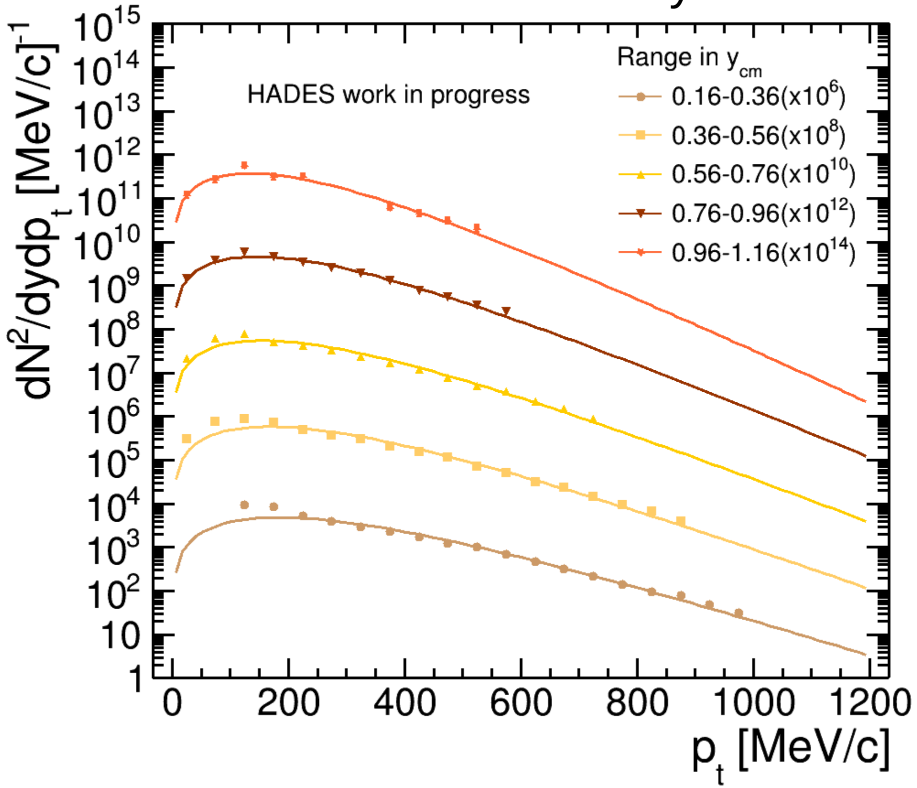


$$efficiency_{\gamma} = efficiency_{\gamma simulation} \cdot \frac{efficiency_{e\ experiment}}{efficiency_{e\ simulation}}$$

Extraction of π^0 yield

$$Ag + Ag \; \sqrt{s_{NN}} = 2.42\, A\, GeV$$

0-30% centrality



Extrapolation to p_t range which is not covered by acceptance of ECal:

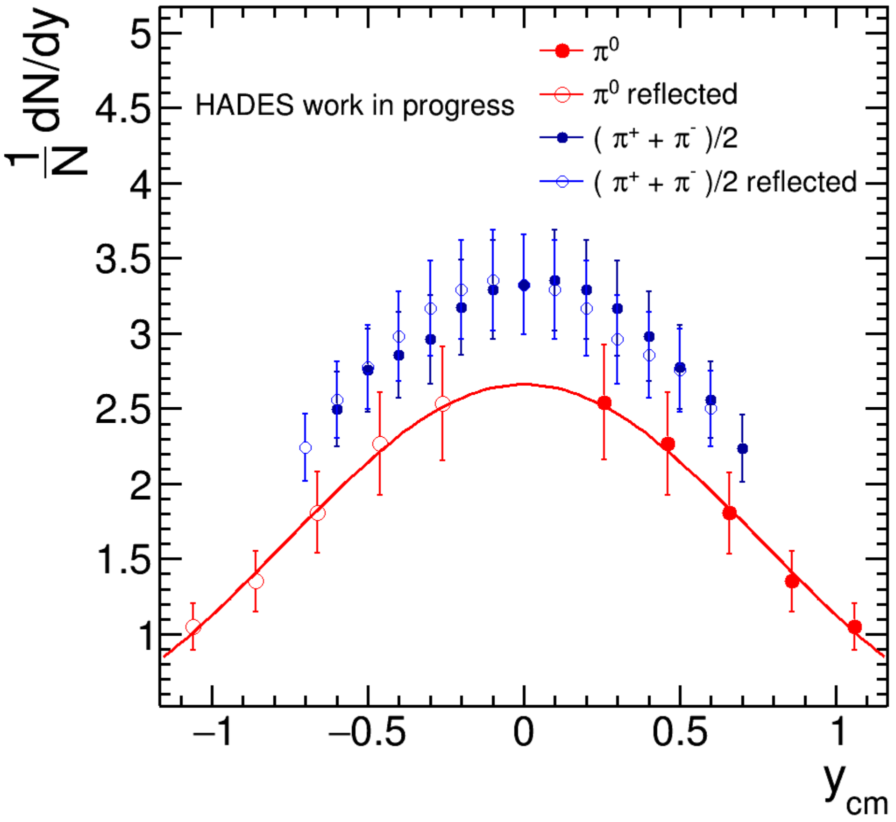
$$\frac{dN}{dp_t} = C\, p_t\, m_t e^{-\frac{m_t}{T}}$$

(Boltzmann fit)

Full π^0 yield per event

$$Ag + Ag\ \sqrt{s_{NN}} = 2.42\ A\,GeV$$

0-30% centrality



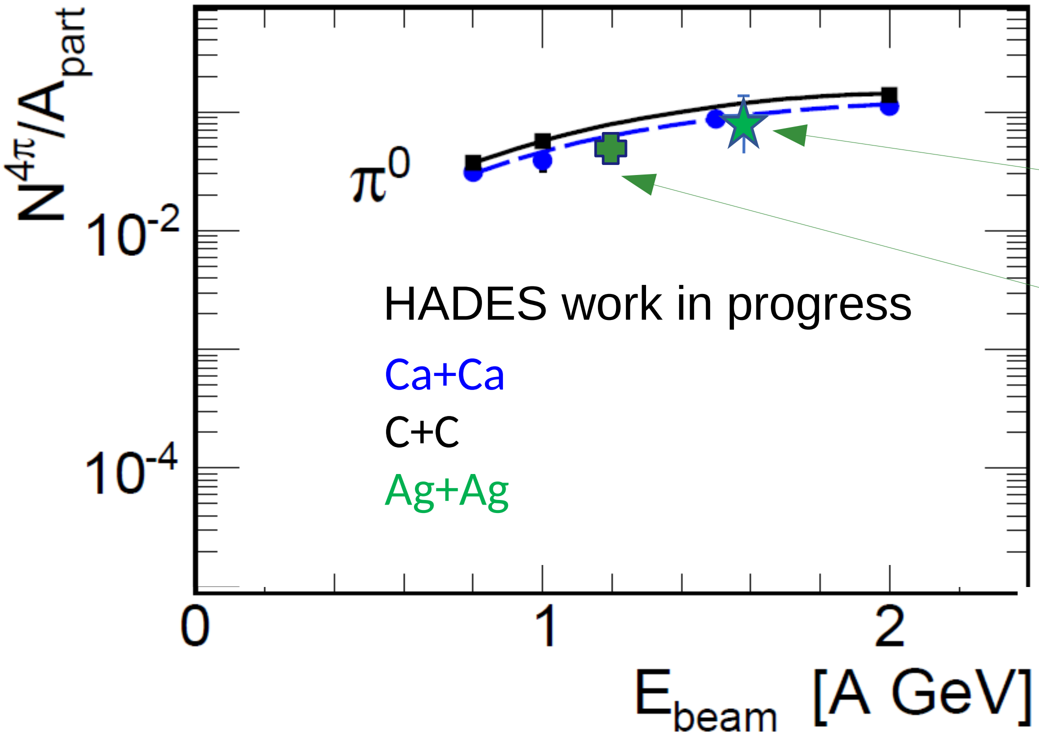
Extrapolation to y range which is not covered by acceptance of ECal: Gauss fit

$$\boxed{\frac{N_{\pi^0}}{N_{events}} = 5.1 \pm 0.3}$$

preliminary estimate of systematic error: ~15% due to efficiency determination

$(\pi^+ + \pi^-) / 2$ is drawn for comparison

Comparison to the world data



HADES Ag+Ag 1.58 A GeV beam energy

HADES Ag+Ag 1.23 A GeV beam energy

$N_{\pi 0} / A_{part} = 0.043 \pm 0.005$

Summary

- ECal detector successfully operated during 4 weeks of physics run in 2019
- π^0 peak is clearly reconstructed in Ag+Ag 1.23 and 1.58 A GeV
- First results show agreement with world data

To be done:

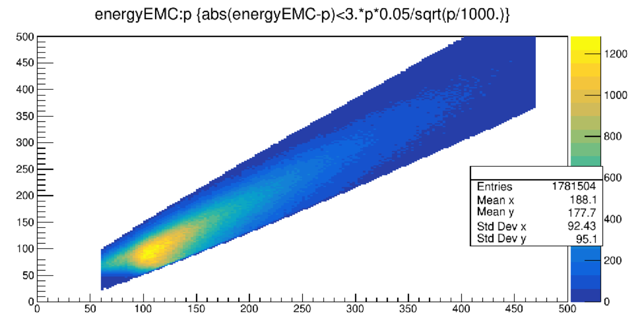
- flow analysis
- centrality dependence
- study of systematic errors
- comparison to transport models and other methods (Dalitz decay, conversion method)

Thank you for your attention!

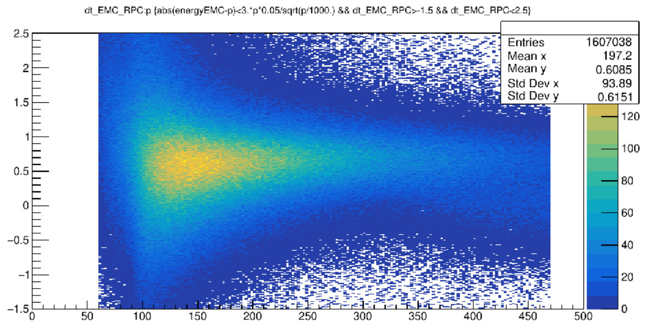
Efficiency

- Study efficiency with e+
- Predict the hitted cell using ML
- Check:
  - Ee-3sigme < Eecal < Ee+3sigma
  - t_{RPC} - 1.5 ns < t_{ECal} < t_{RPC} + 2.5 ns
- Divide

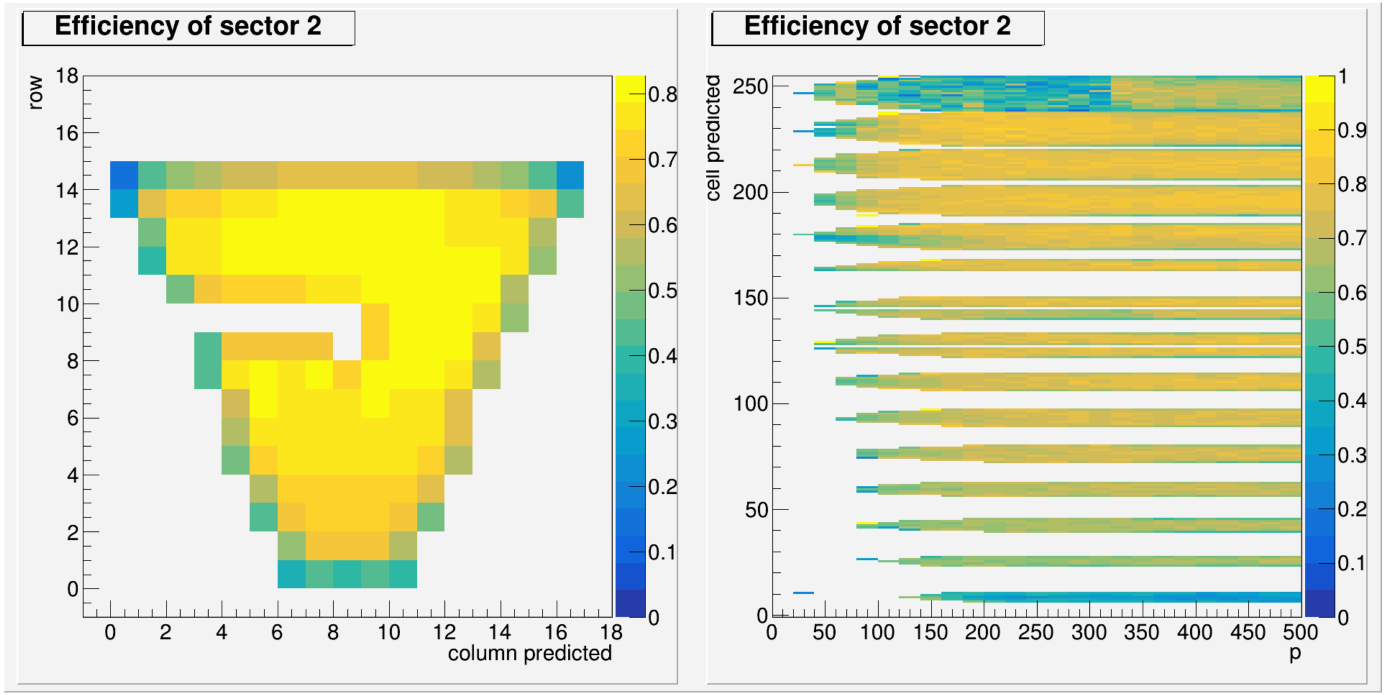
Energy cut



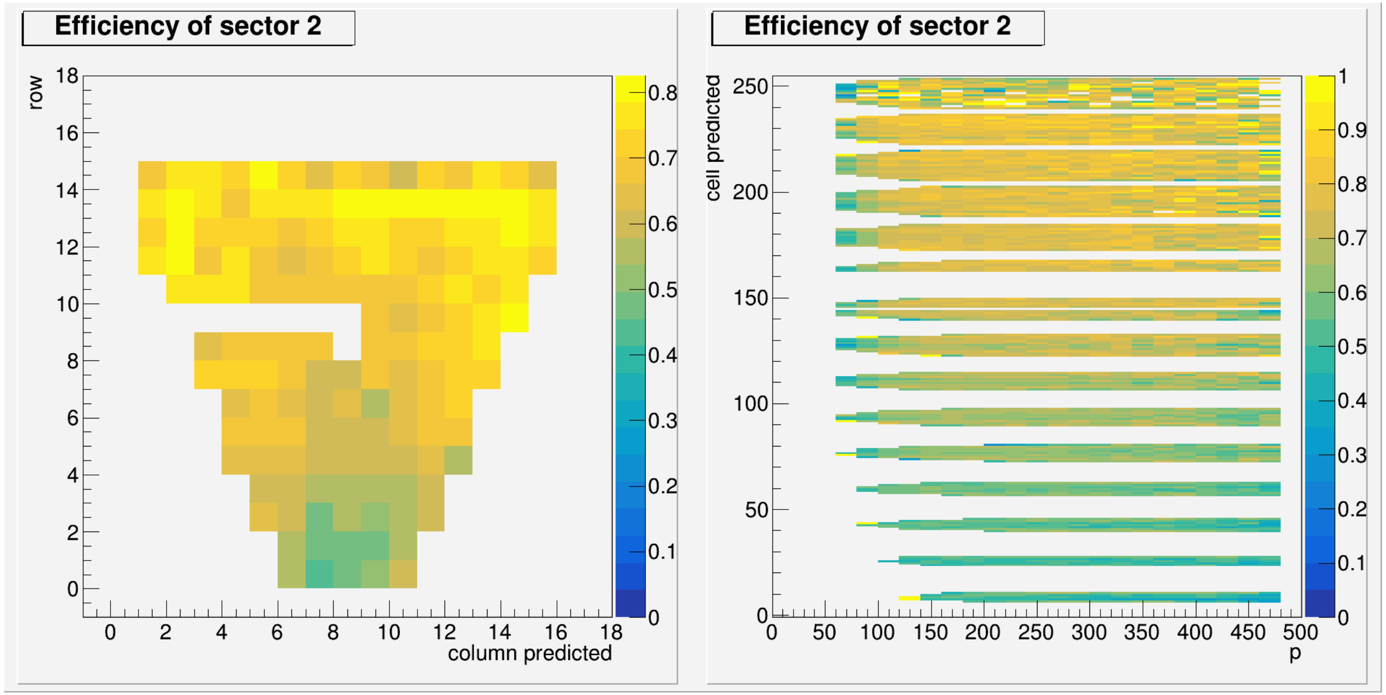
Time cut



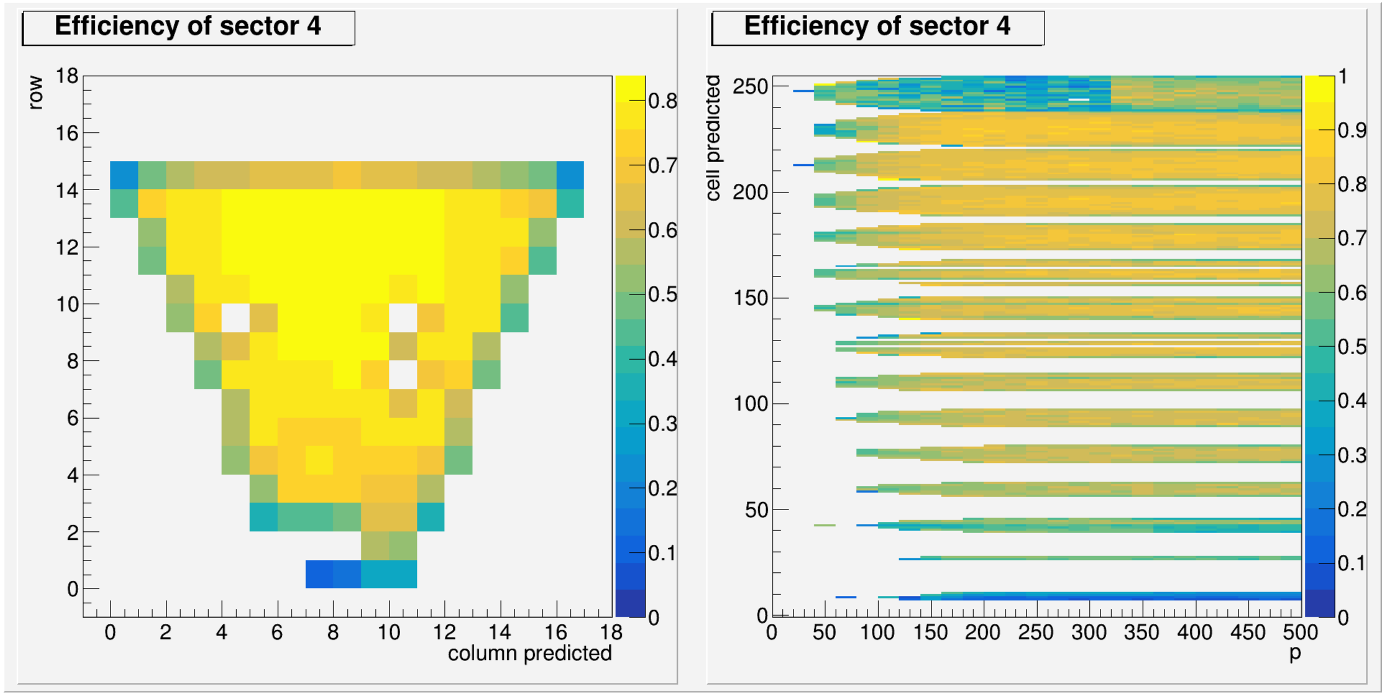
2 sector simulation



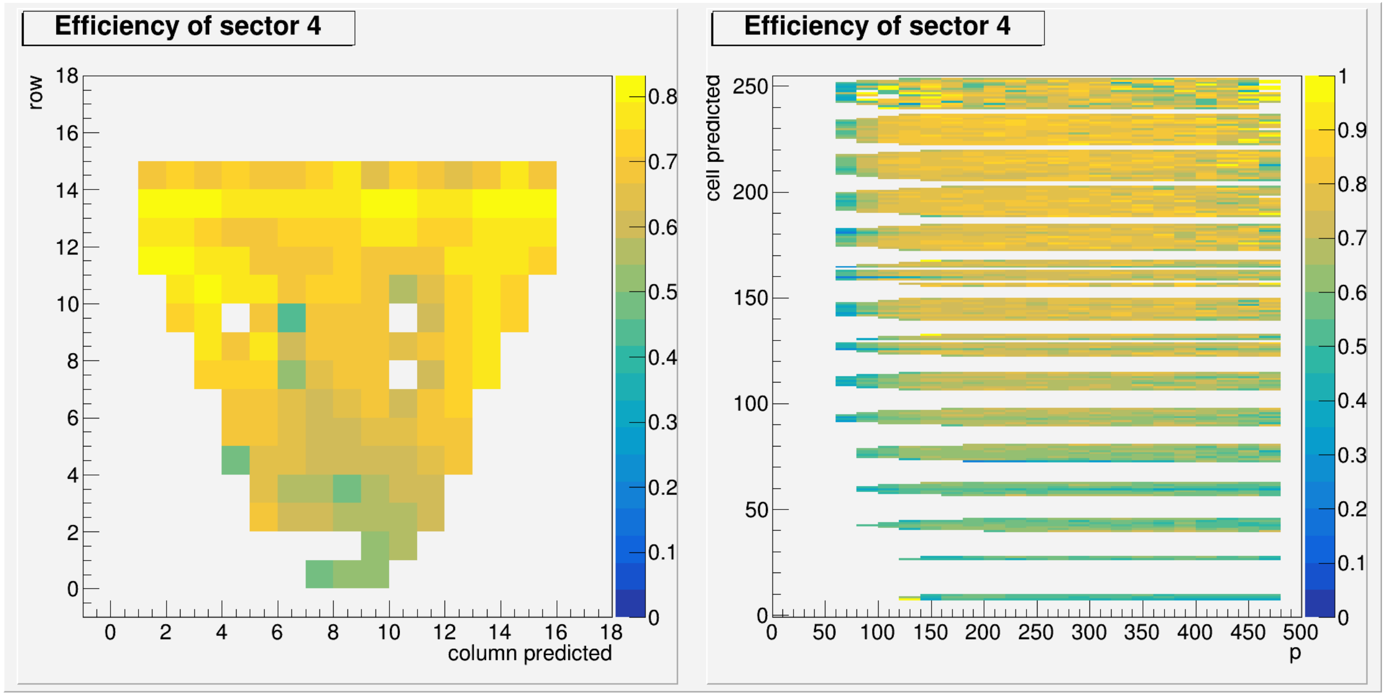
2 sector experiment



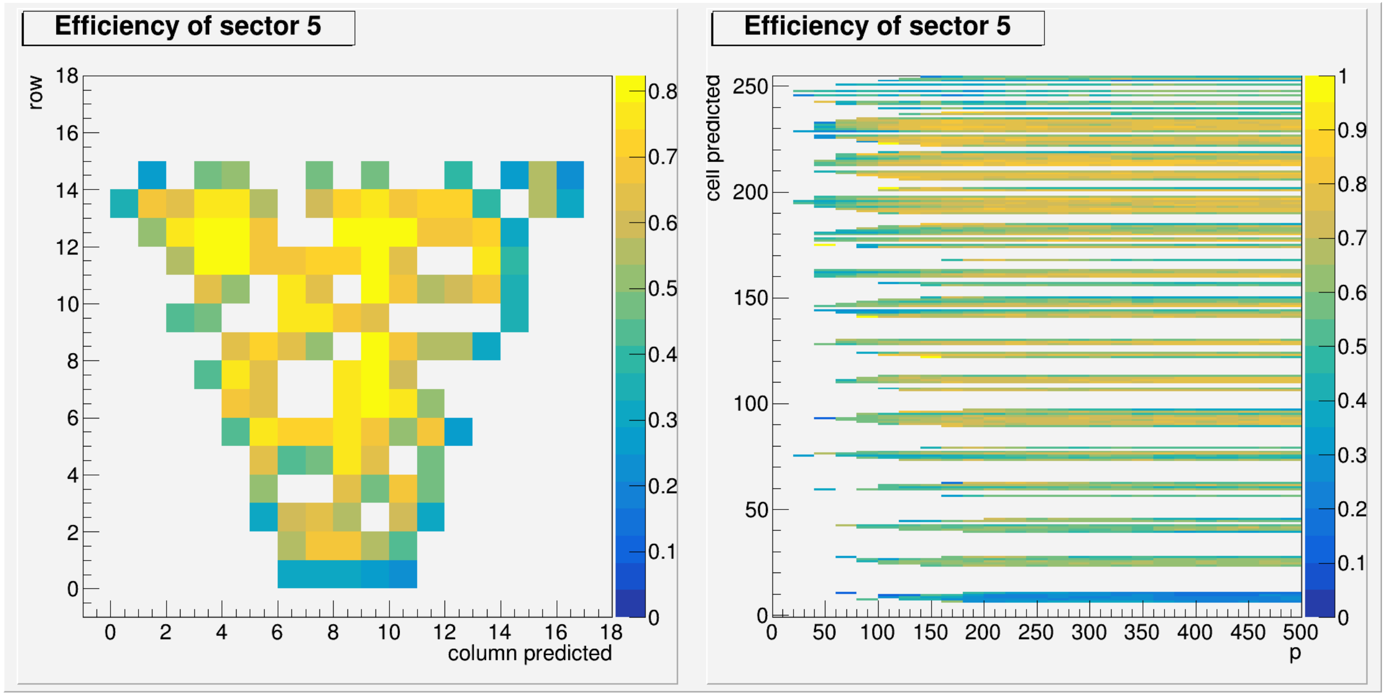
4 sector simulation



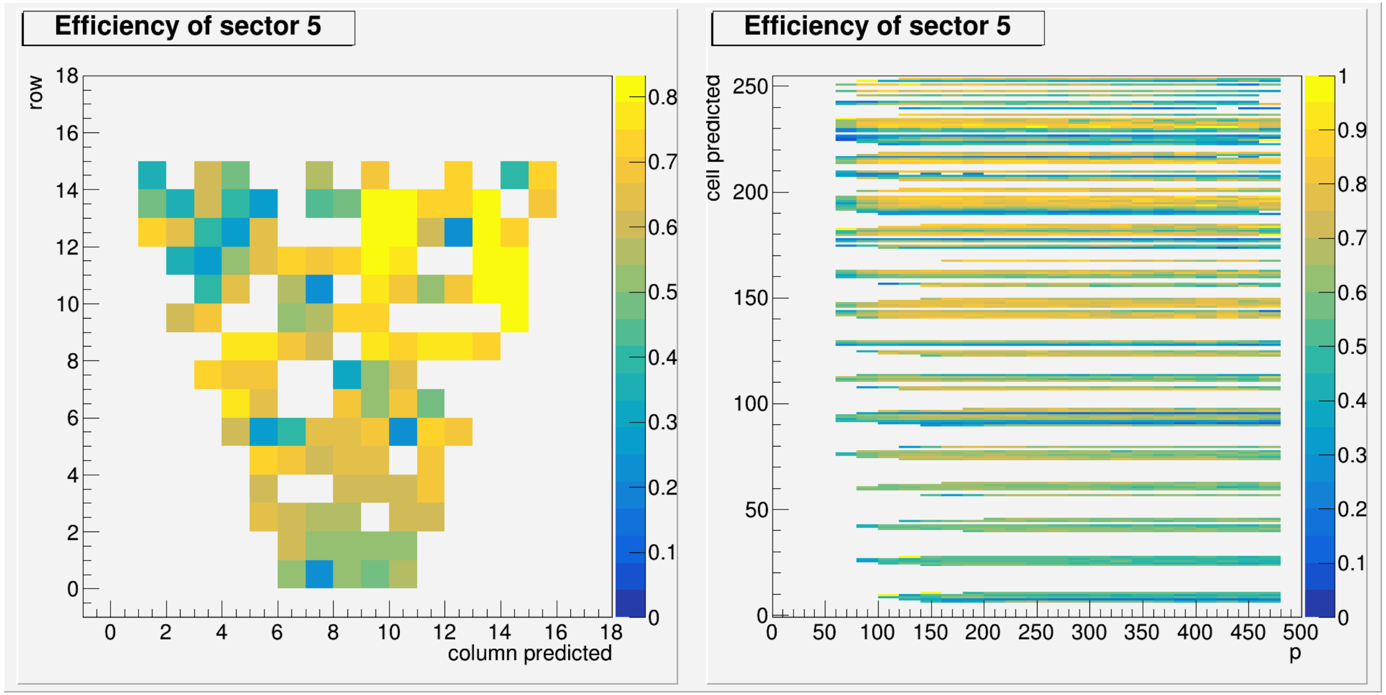
4 sector experiment



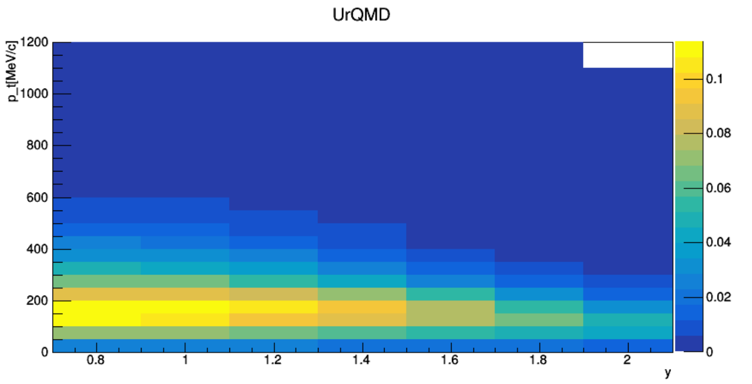
5 sector simulation

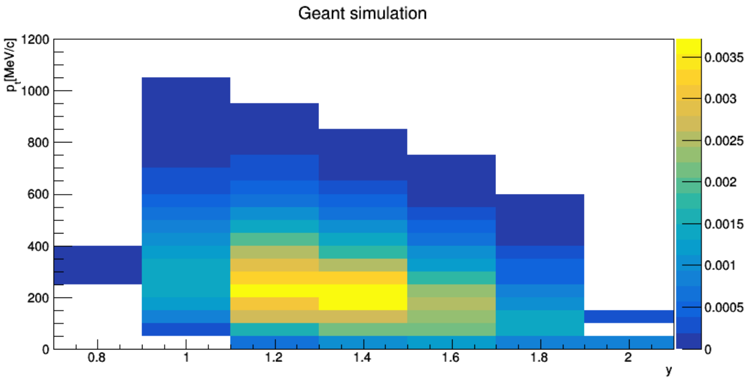


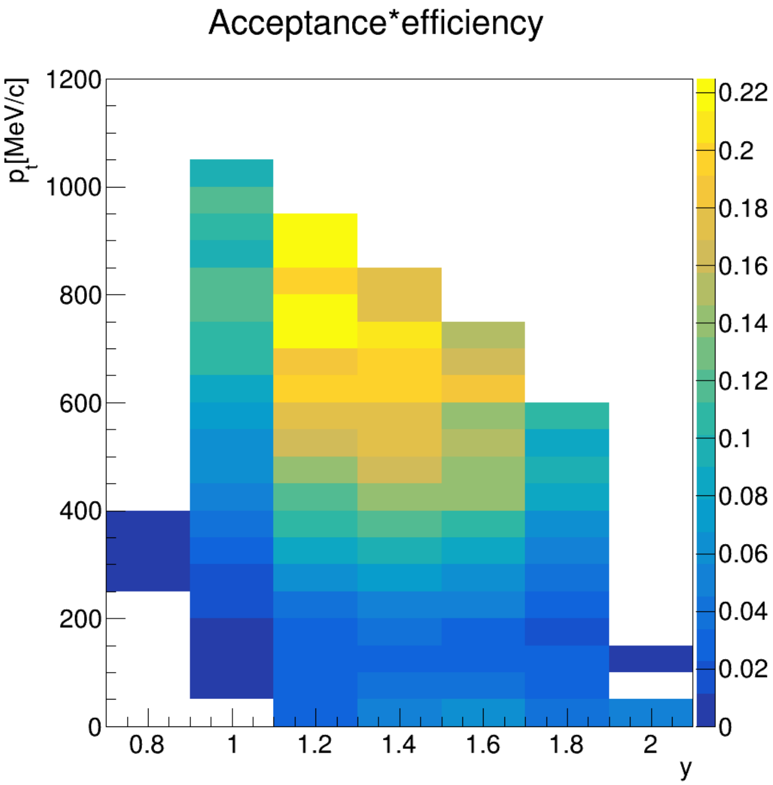
5 sector experiment

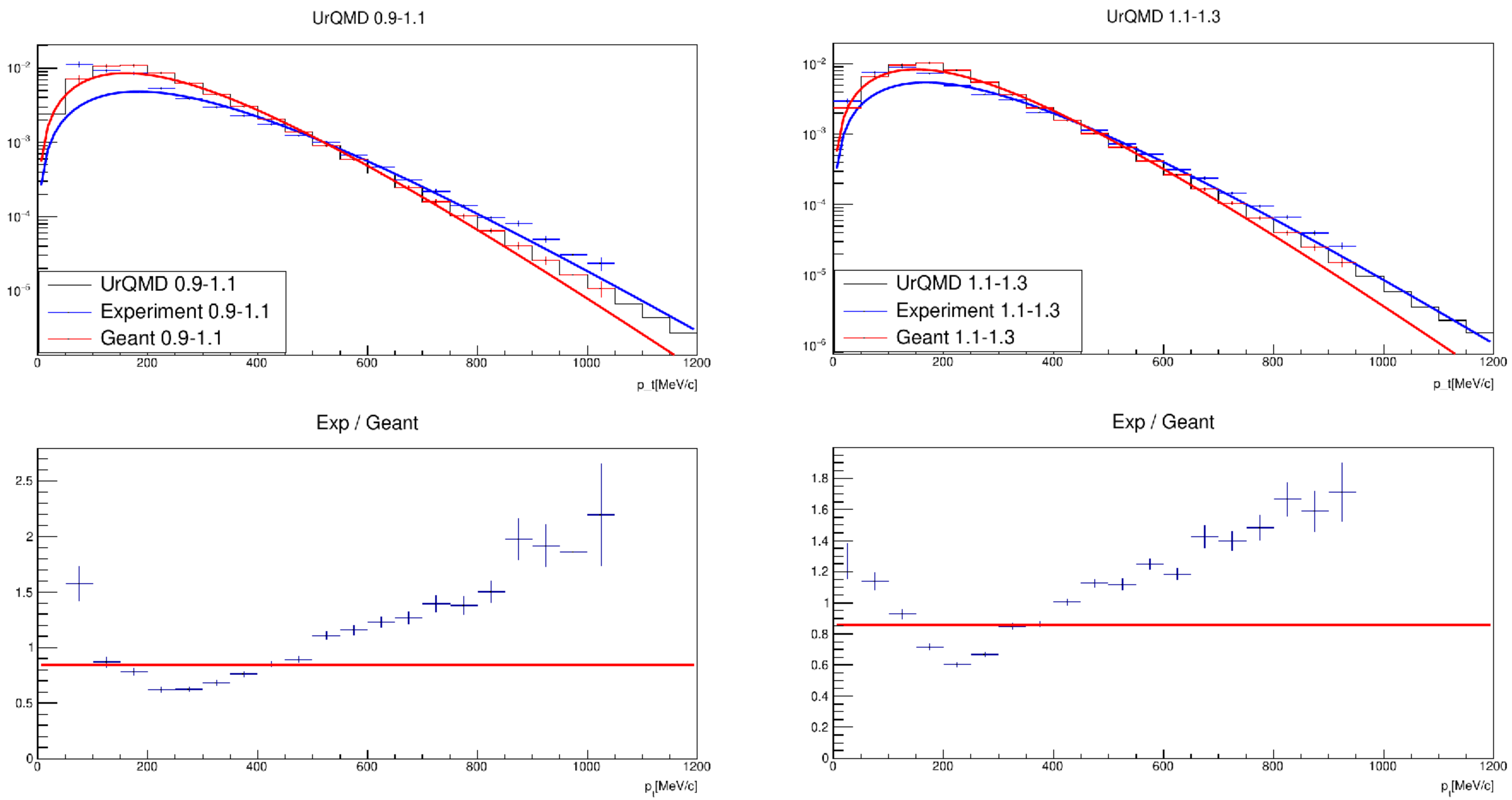


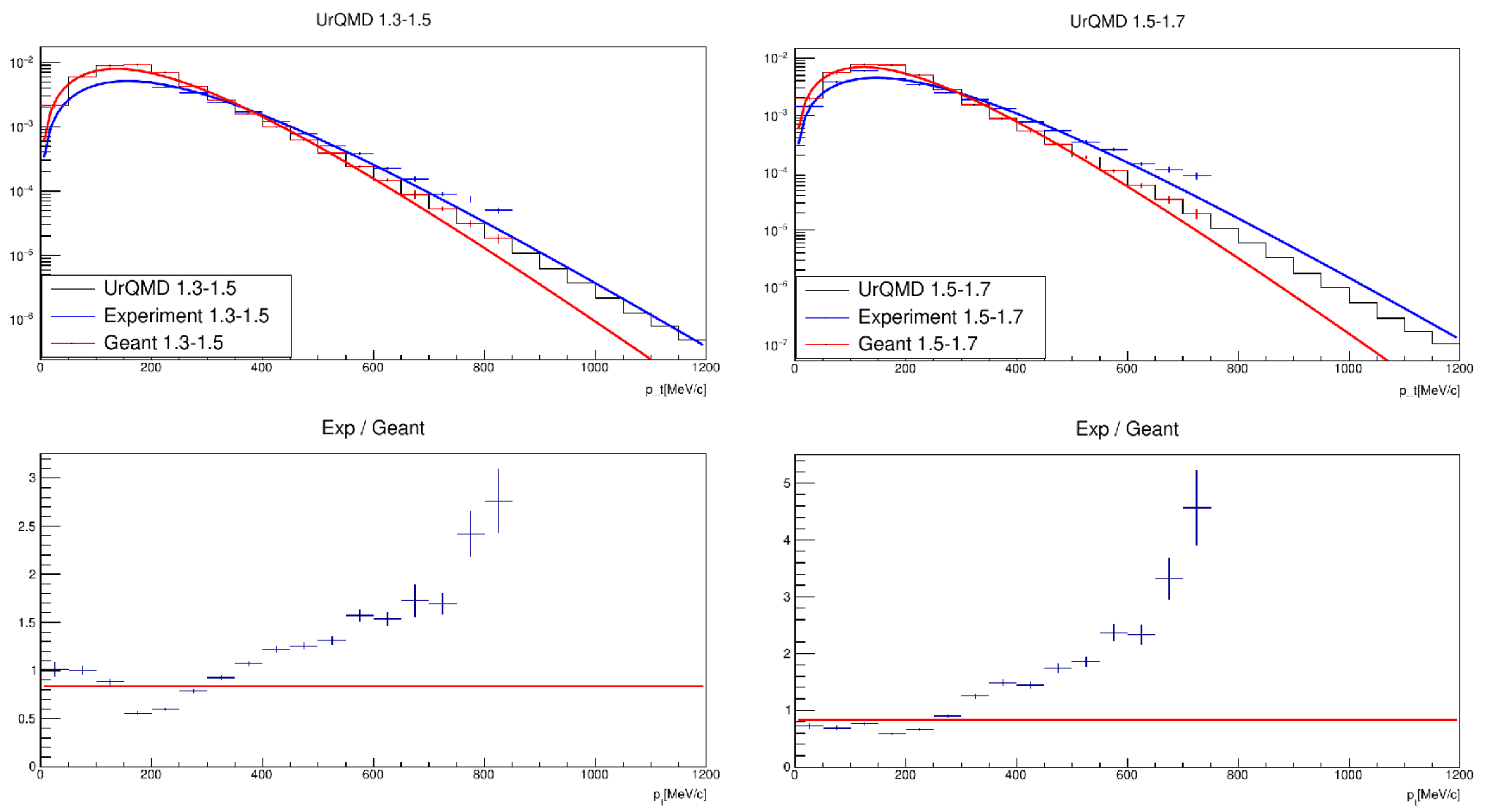
Acceptance * efficiency
2, 4, 5 sectors

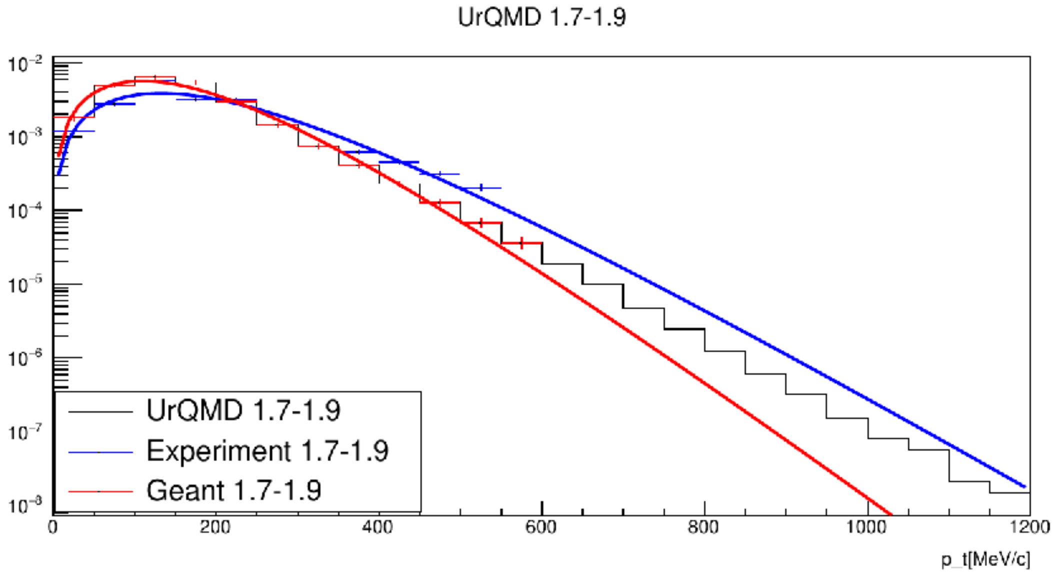




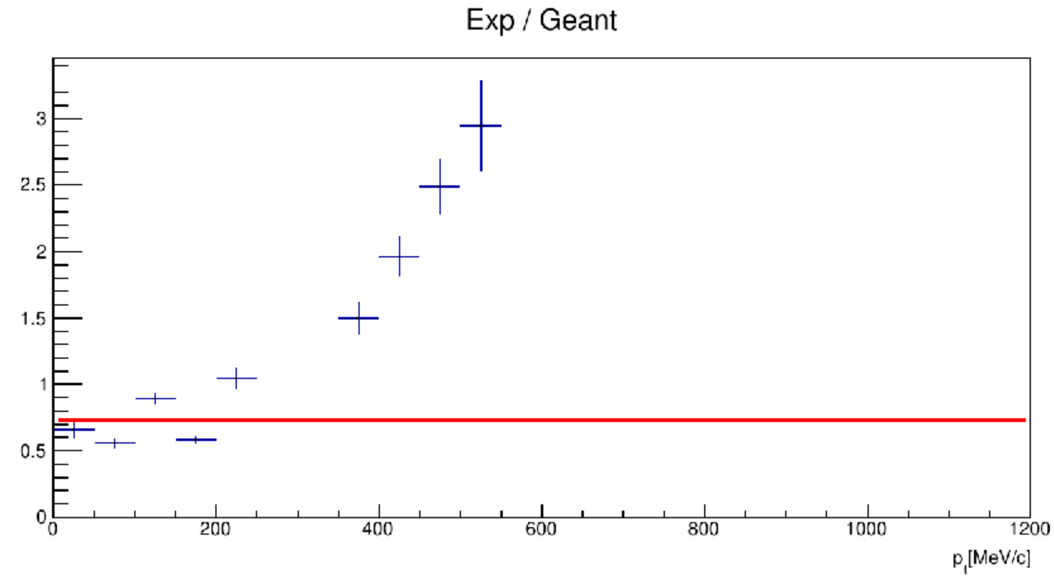



UrQMD 0.9-1.1
UrQMD 0.9-1.1
Experiment 0.9-1.1
Geant 0.9-1.1
p_t[MeV/c]
UrQMD 1.1-1.3
UrQMD 1.1-1.3
Experiment 1.1-1.3
Geant 1.1-1.3
p_t[MeV/c]
Exp / Geant
p_t[MeV/c]
Exp / Geant
p_t[MeV/c]


UrQMD 1.3-1.5
UrQMD 1.3-1.5
Experiment 1.3-1.5
Geant 1.3-1.5
p_t[MeV/c]
UrQMD 1.5-1.7
UrQMD 1.5-1.7
Experiment 1.5-1.7
Geant 1.5-1.7
p_t[MeV/c]
Exp / Geant
p_t[MeV/c]
Exp / Geant
p_t[MeV/c]

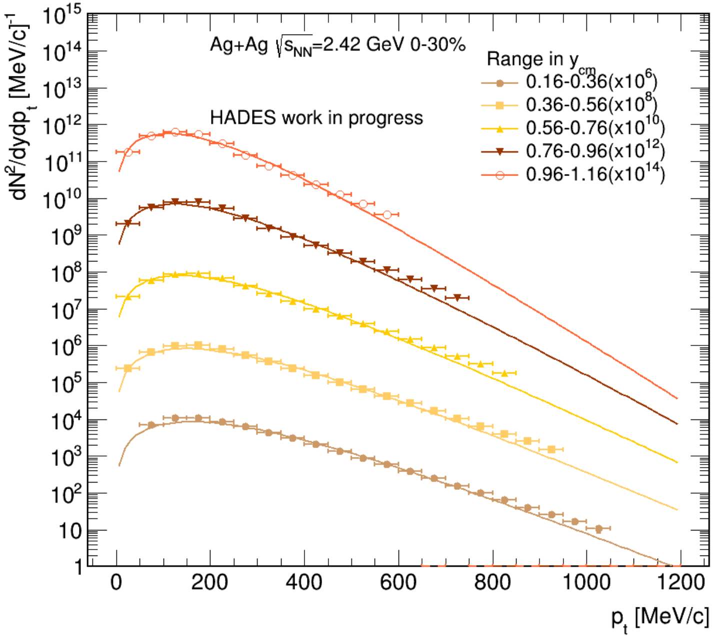


UrQMD 1.7-1.9
UrQMD 1.7-1.9
Experiment 1.7-1.9
Geant 1.7-1.9
p_t[MeV/c]

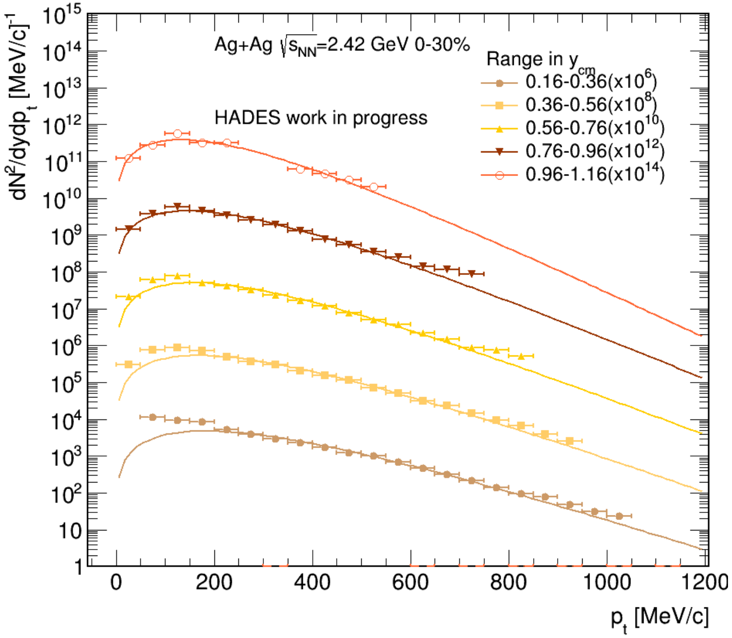


Exp / Geant
p_t[MeV/c]

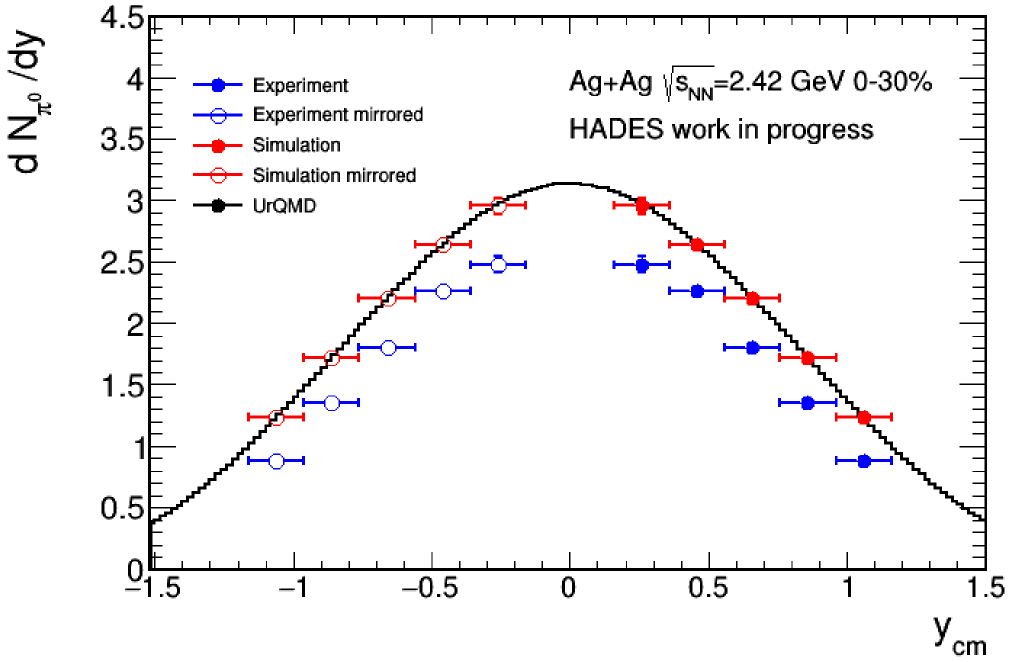
Preliminary results



Simulation



Experiment


Ag+Ag $\sqrt{s_{NN}}$=2.42 GeV 0-30%
HADES work in progress
Experiment
Experiment mirrored
Simulation
Simulation mirrored
UrQMD
$d N_{\pi^0} /dy$
y_{cm}
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
−1.5
−1
−0.5
0
0.5
1
1.5

- conversion method
- Dalitz decay $\pi^0 \rightarrow e^+e^-\gamma$
- $\pi^+ + \pi^- / 2$

- low statistics, large systematic errors
- low statistics (1% decays vs 99%)
-