Measurement of π0 yield in Ag+Ag collisions at 1.23 A GeV beam energy

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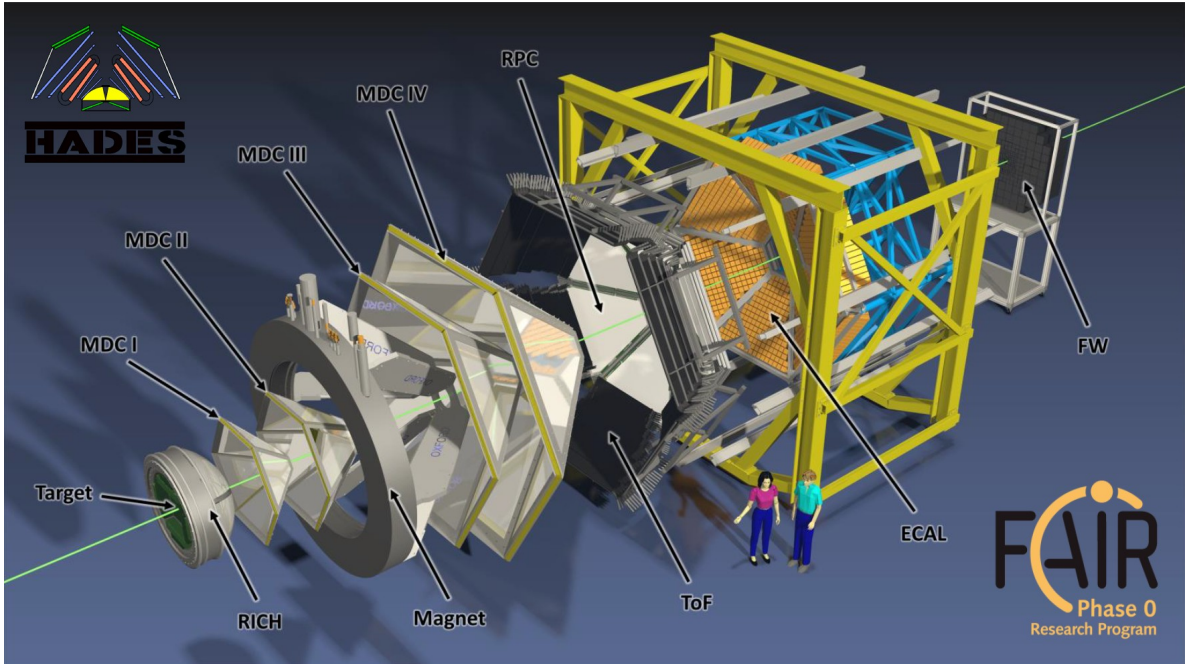
Outline

- HADES experiment
- ECal detector
- Measurement of π° yield

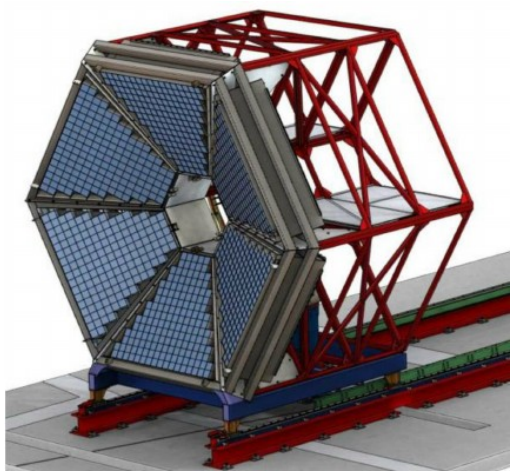
HADES experiment

- 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

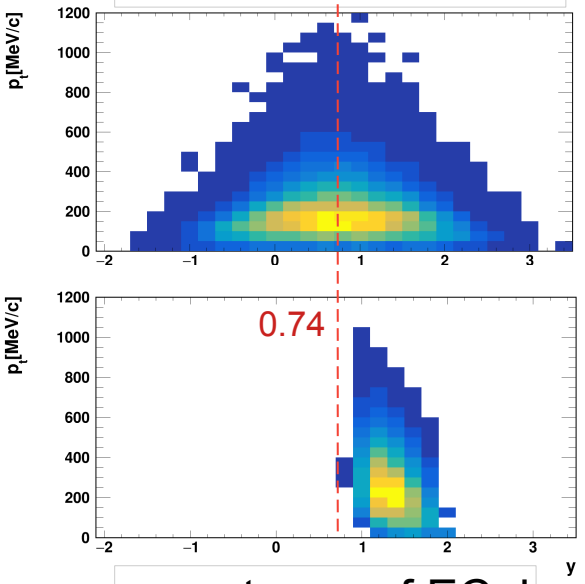


ECal detector



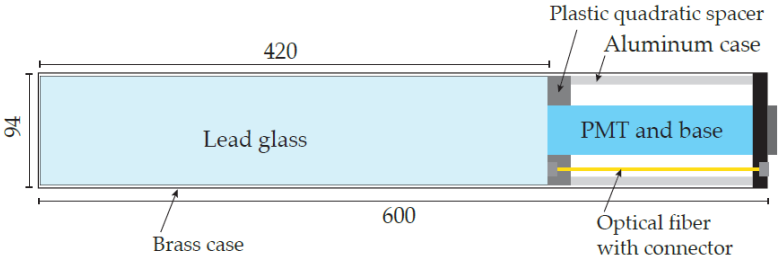
6 sectors covering
12˚ < θ < 45 ˚

phase space of π° 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 lead glass CEREN25 (16.7 radiation length long)
- PMT: Hamamatsu R6091 (3”)



Analyzed data

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

Selection criteria

Selection of events

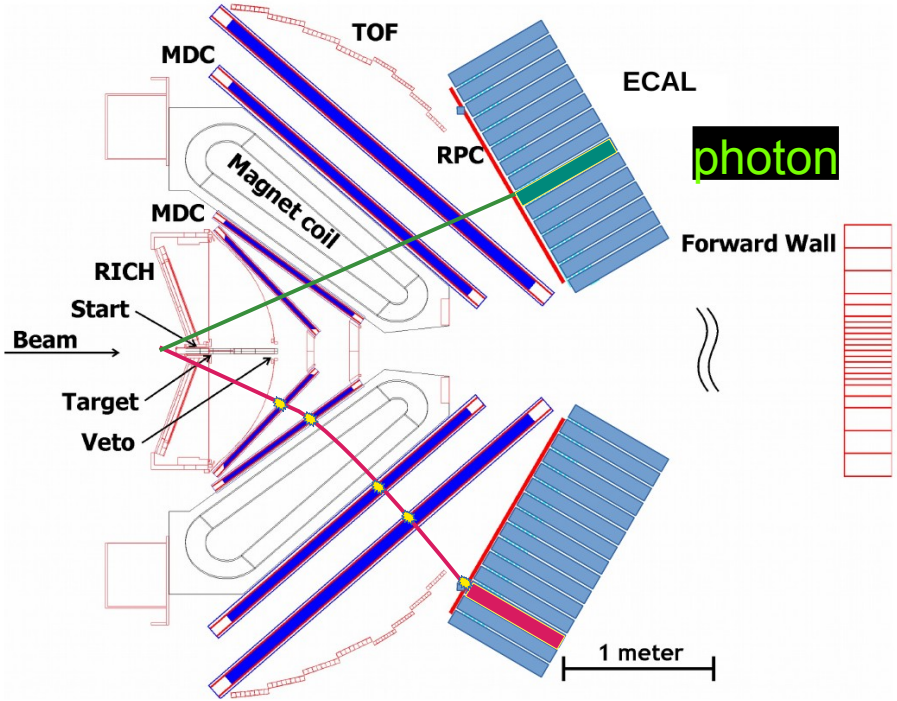
- centrality 0-30% (from TOF+RPC multiplicity)

Photon:

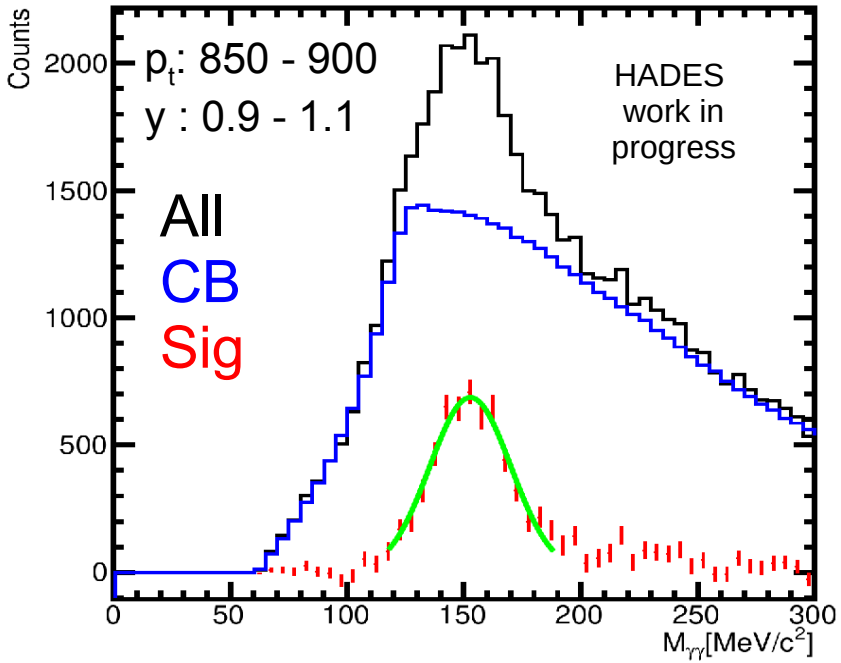
- No hit in RPC (closest detector to ECal)
- No match with any track
- $0.9 < \beta < 1.1$
- E > 100 MeV (reject neutrons)

Diphoton:

- Opening angle > 10°

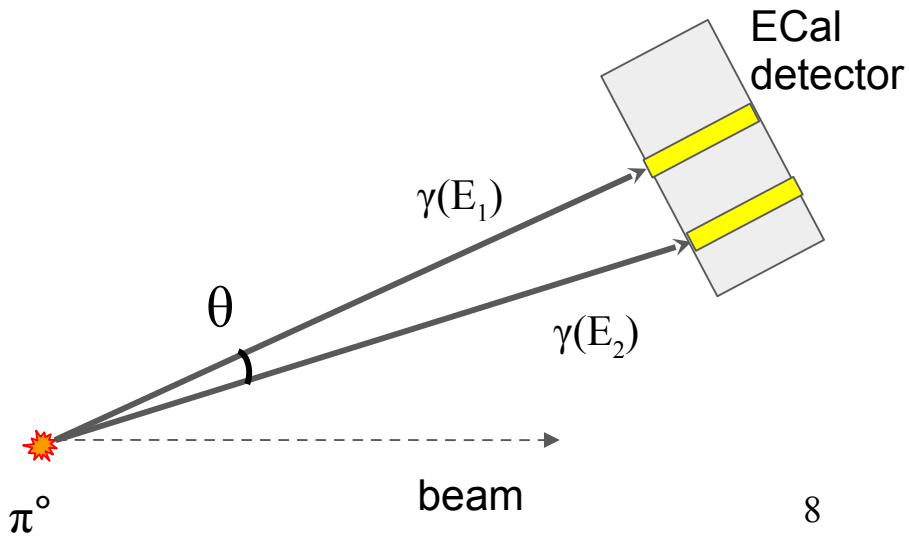


Reconstruction of π^0-mesons

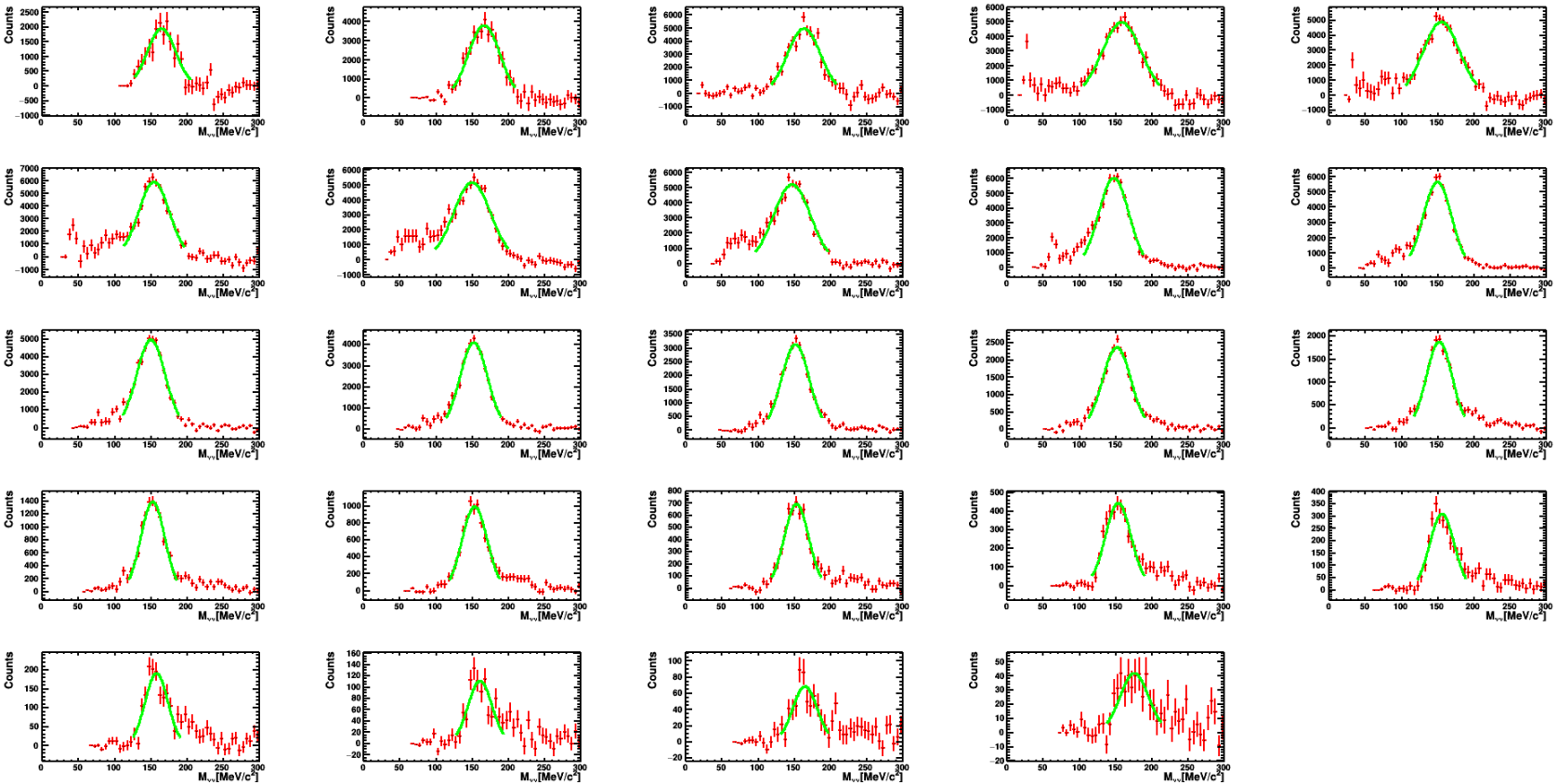


All – experimental data
CB – mixed-event combinatorial background
Sig – signal
Signal is fitted with Gauss

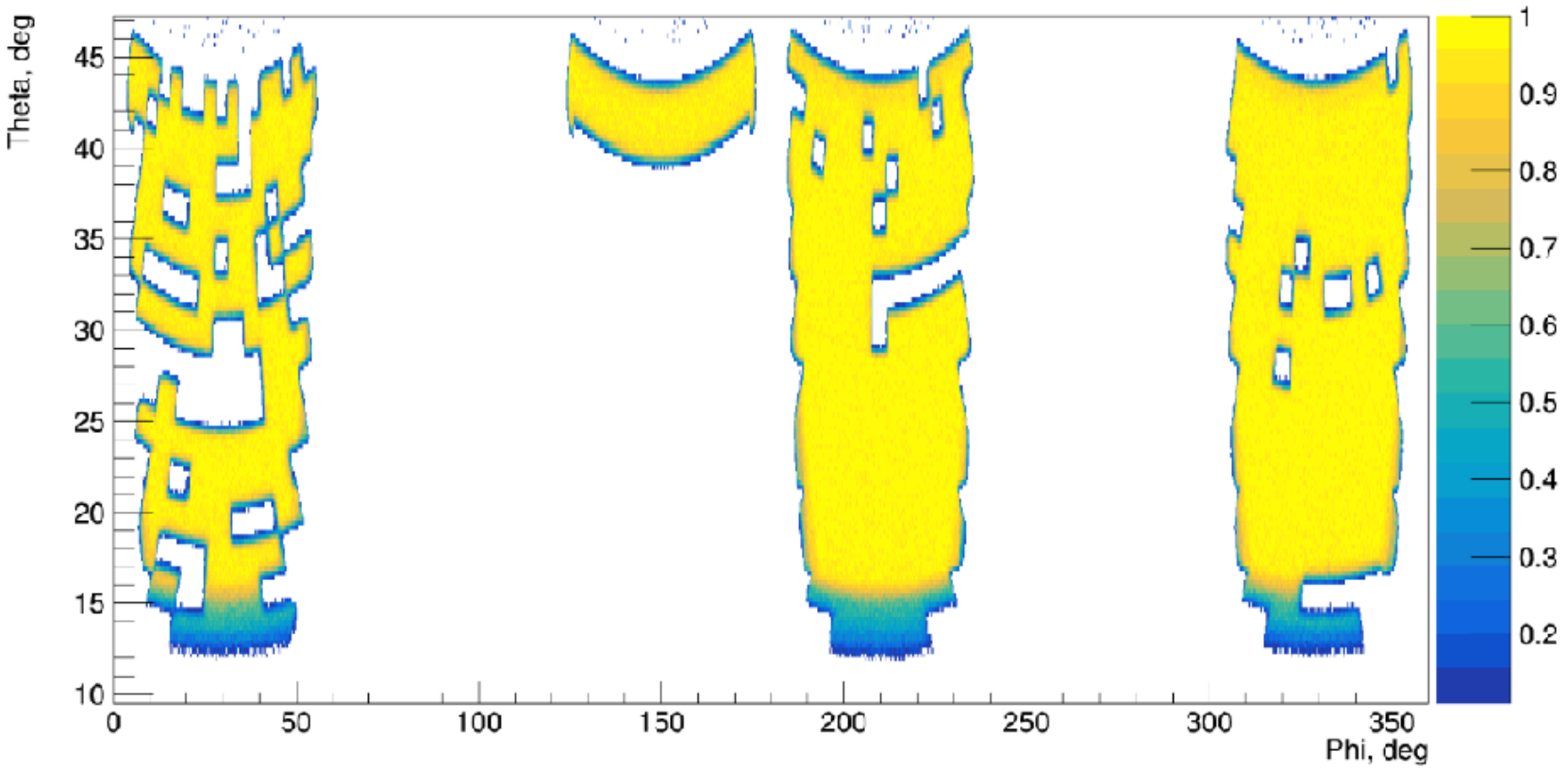
$$m_{\pi^0} = \sqrt{E_1 \cdot E_2 \cdot (1 - \cos\theta)}$$



0.9 < y < 1.1

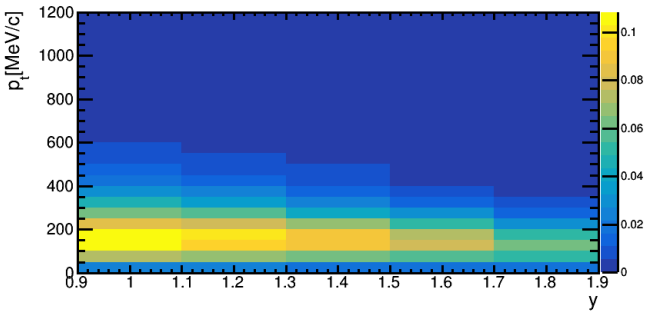


Acceptance corrections

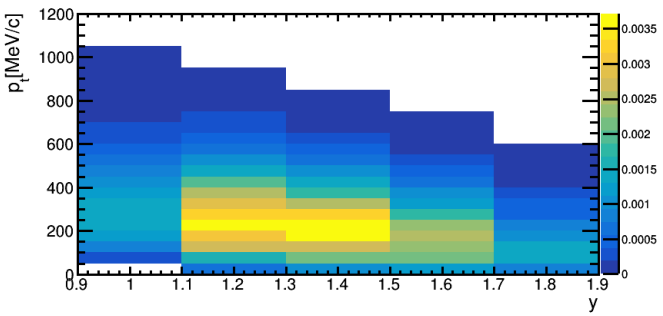


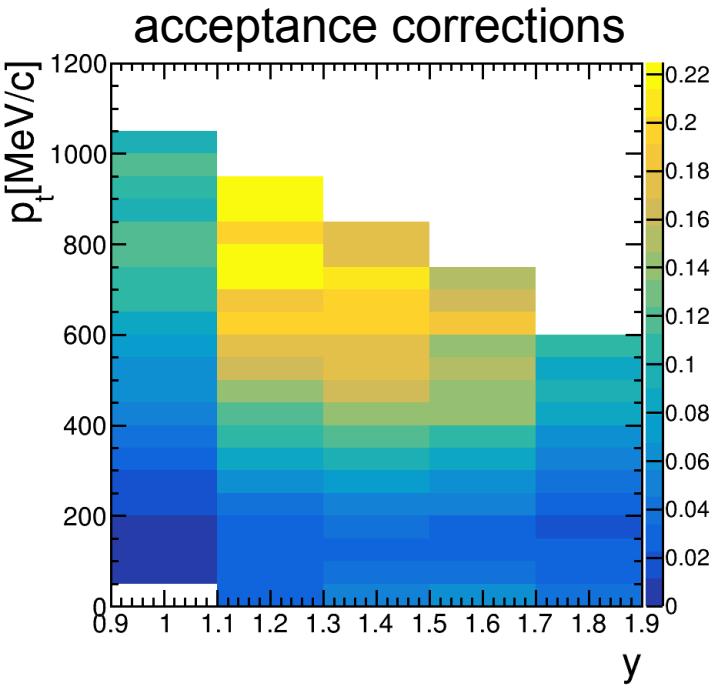
Acceptance corrections

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



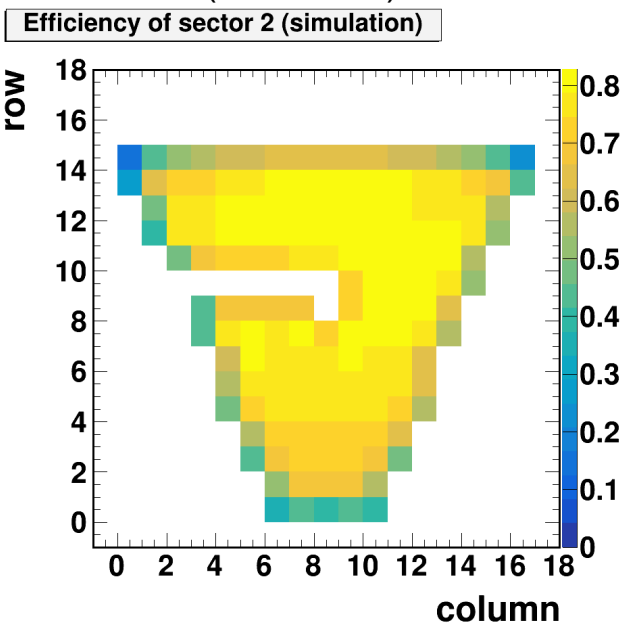
Reconstructed from **simulation** number of pions within pt-y bin per event



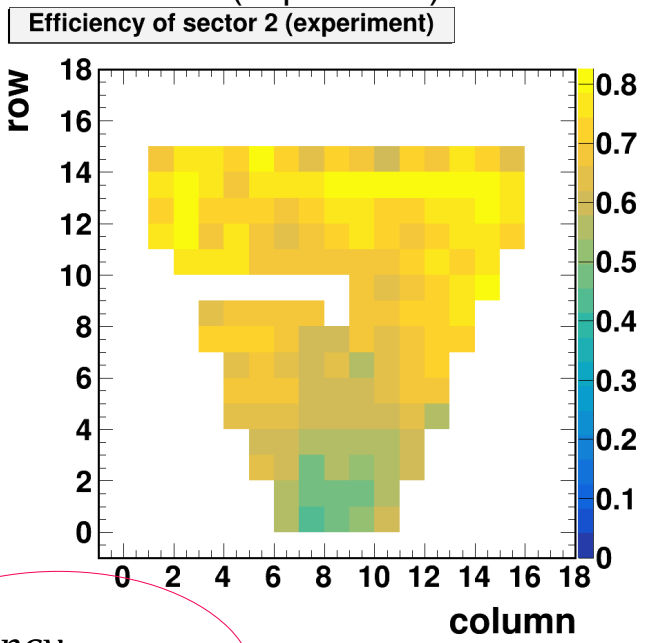


Efficiency corrections

efficiency of detection of positrons (simulation)

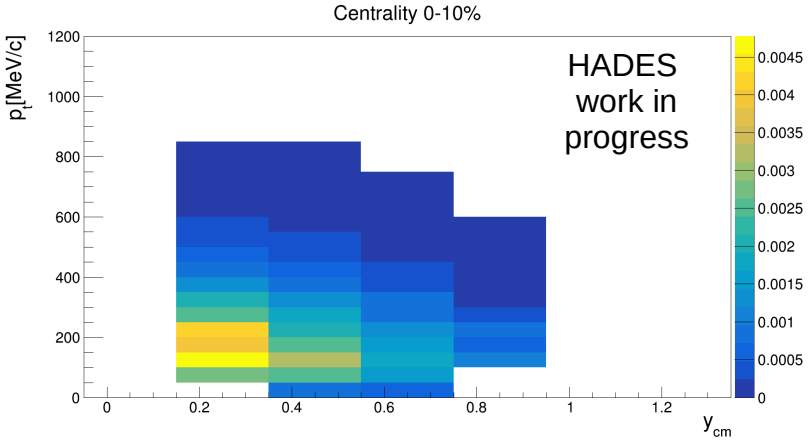


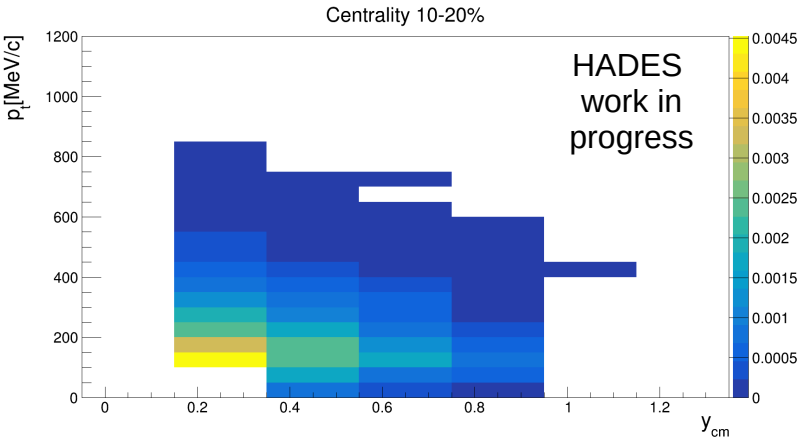
efficiency of detection of positrons (experiment)

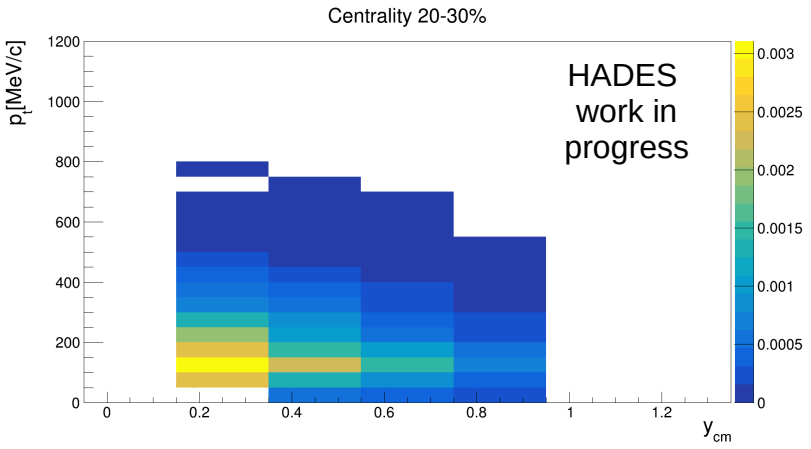


$$efficiency_{\gamma} = efficiency_{\gamma simulation} \cdot \frac{efficiency_{e\ experiment}}{efficiency_{e\ simulation}}$$

π° yield depending on transverse momentum and rapidity





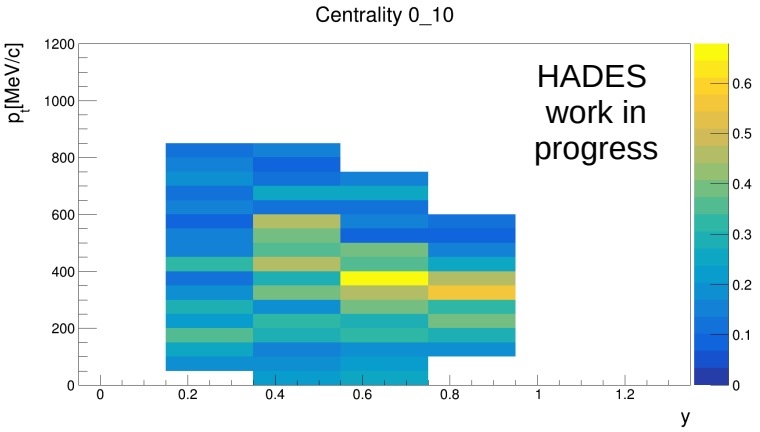


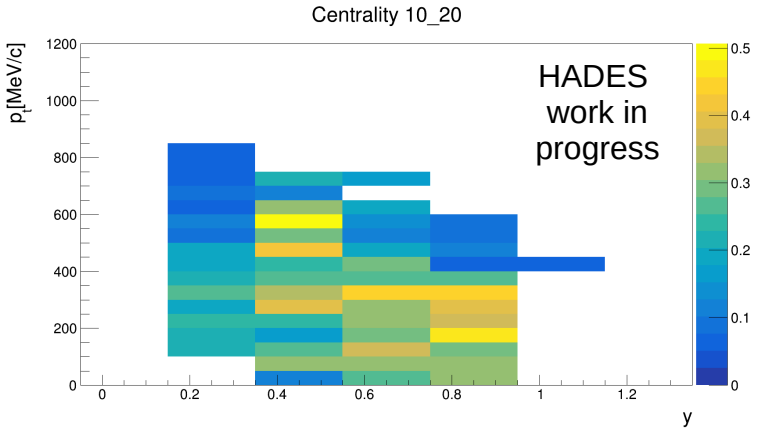
$1/N_{events} \cdot dN_{\pi^\circ} / dp_t \cdot dy$
in each pt – y bin

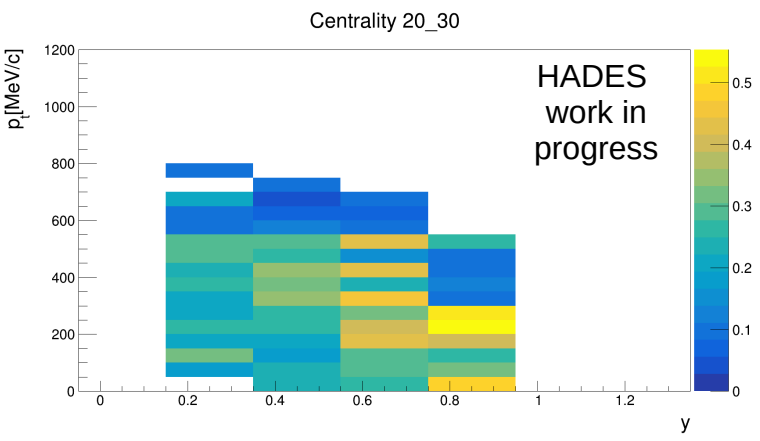
Systematic uncertainty study

Energy cut	100 MeV	150 MeV	200 MeV	250 MeV	• **0.6%**
Angle cut	6 deg	10 deg	15 deg		• **3%**
Beta cut	1 σ	1.5 σ	2 σ	3 σ	• **13.8%**
RPC time cut	1 σ	1.5 σ	2 σ		• **0.7%**
RPC coordinate cut	2 σ	3 σ			• **1%**
Cluster size cut	1	2	3		• **0.5%**

Relative Uncertainties of measured yields



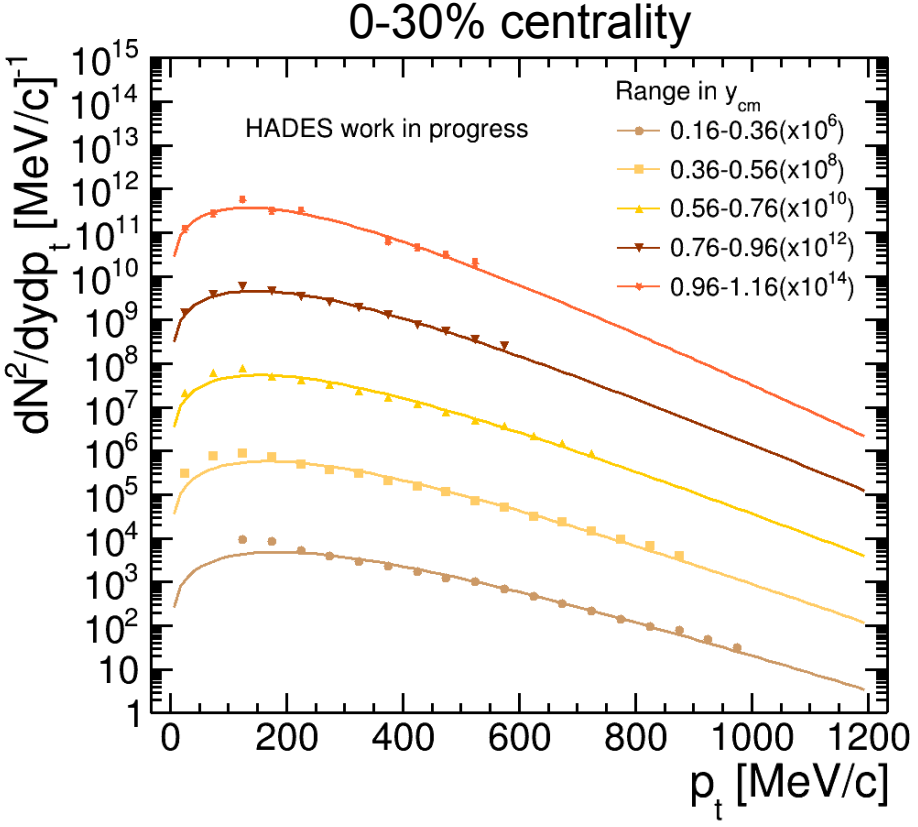




Uncertainties / N pions in each pt – y bin

Extrapolation of dN/dp_t distribution

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



$$\frac{d^2N}{dp_t dy} \propto p_t m_t \cosh y \exp\left(-\frac{m_t \cosh y}{T}\right)$$

$$m_t = \sqrt{{p_t}^2 - m^2}$$

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)

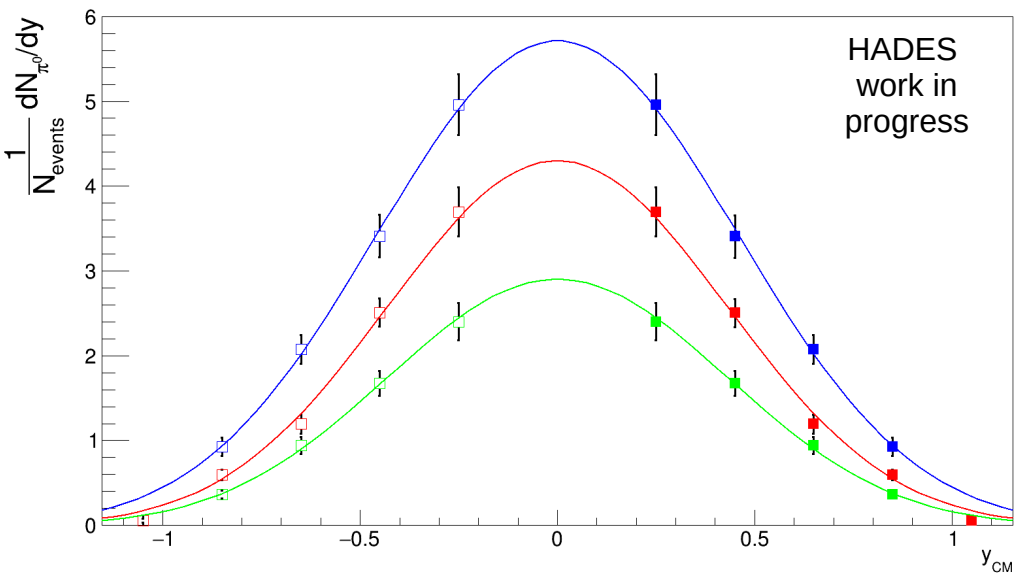
Extrapolation of dN/dy distribution

Integration of dN / $dp_t \cdot dy$ over p_t =>

$$\frac{dN}{dy} = CT \exp\left(-\frac{m_{\pi^0}\cosh y}{T}\right)\left(m^2{}_{\pi^0} + 2m_{\pi^0}\frac{T}{\cosh y} + 2\frac{T^2}{\cosh^2 y}\right)$$

It can be approximated as Gauss function:

$$\frac{dN}{dy} \propto \exp\left(-\frac{y^2}{2\sigma^2}\right) \qquad \sigma = \sqrt{T/m_0}$$

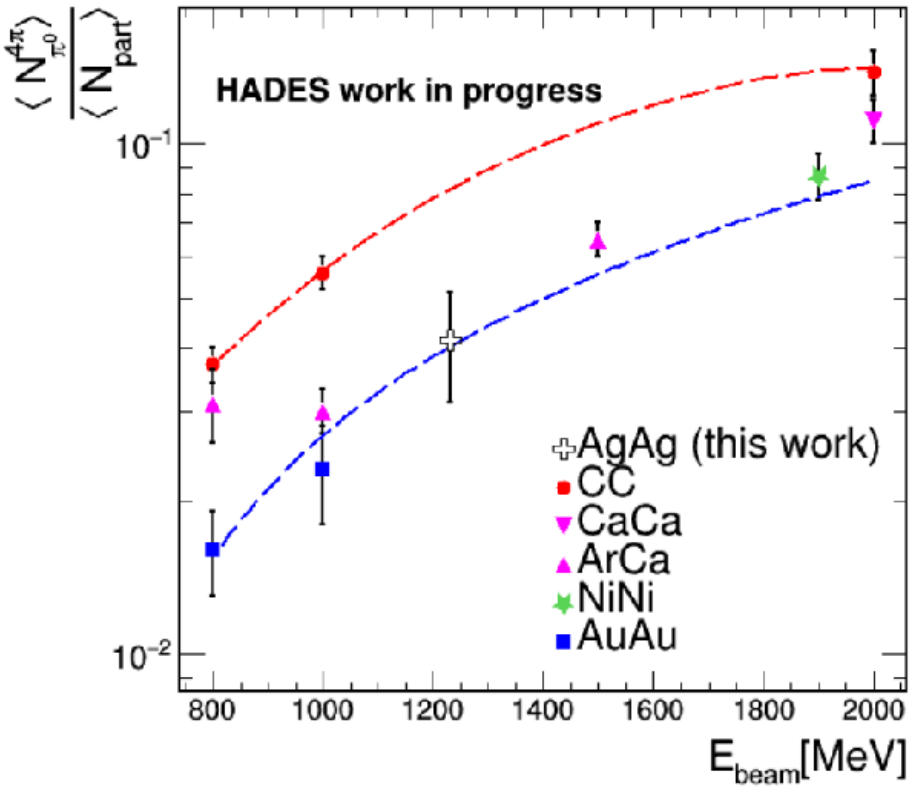


0-10%, 10-20%, 20-30% centrality

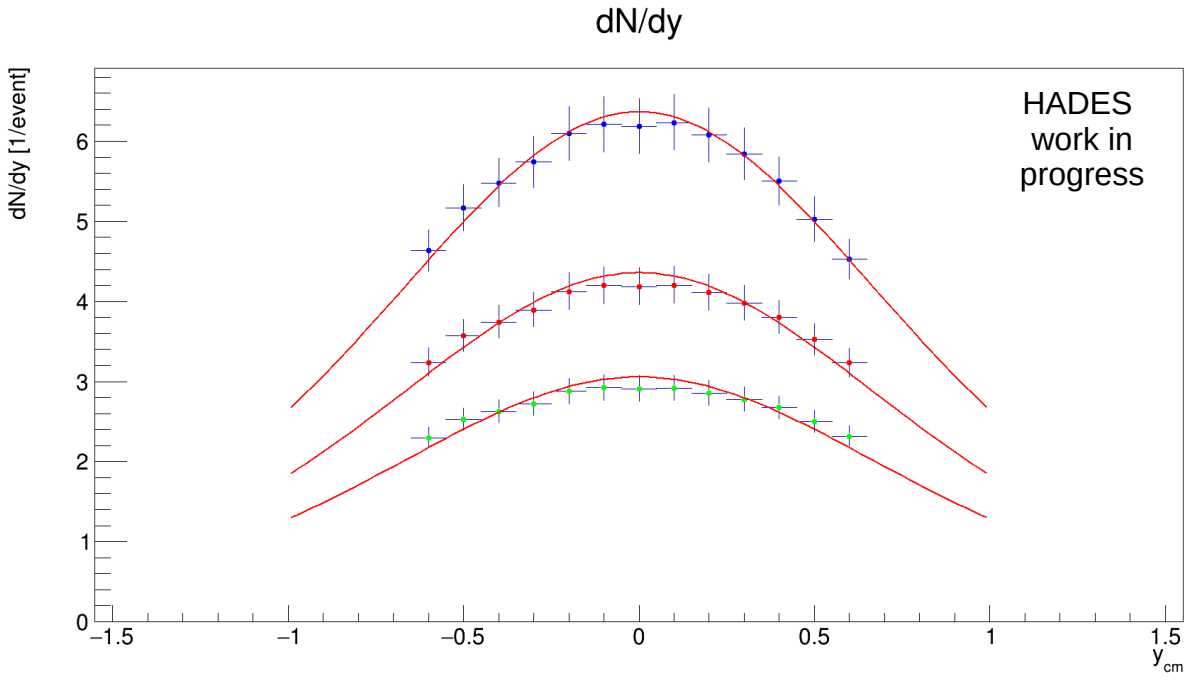
π° production yield

centrality	N π° / N events	N participants	M π° / (N participants · N events)
0-10%	$6.42 \pm 0.20_{stat} \pm 1.28_{syst}$	163.4	$(3.93 \pm 0.12_{stat} \pm 0.79_{syst}) * 10^{-3}$
10-20%	$4.55 \pm 0.15_{stat} \pm 0.91_{syst}$	113.3	$(4.01 \pm 0.13_{stat} \pm 0.80_{syst}) * 10^{-3}$
20-30%	$3.08 \pm 0.12_{stat} \pm 0.616_{syst}$	77.9	$(3.95 \pm 0.16_{stat} \pm 0.79_{syst}) * 10^{-3}$

Comparisson to the world data



Charged pions



centrality	1/2 (Mπ⁺ + Mπ⁻)
0-10%	$7.60 * 10^{-3}$
10-20%	$7.65 * 10^{-3}$
20-30%	$7.83 * 10^{-3}$

0-10%, 10-20%, 20-30% centrality

Conclusions

- π° yield is measured in Ag+Ag collisions at 1.23 A GeV beam energy
- The measured yield is lower compared to charged pion production and to the known world data
- Efficiency of the detector must be studied more carefully

Thank you for your attention !