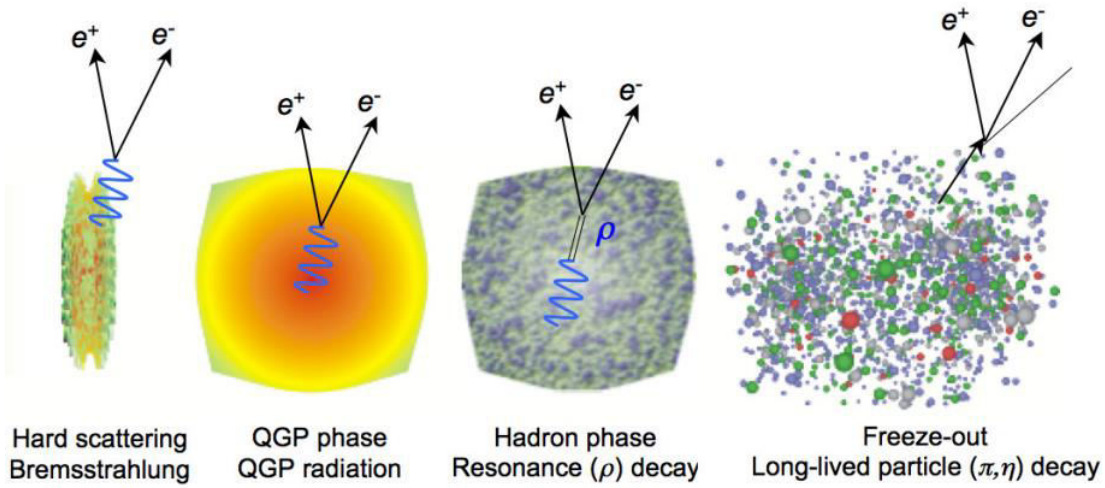
PWG4 summary

V. Riabov for the PWG4



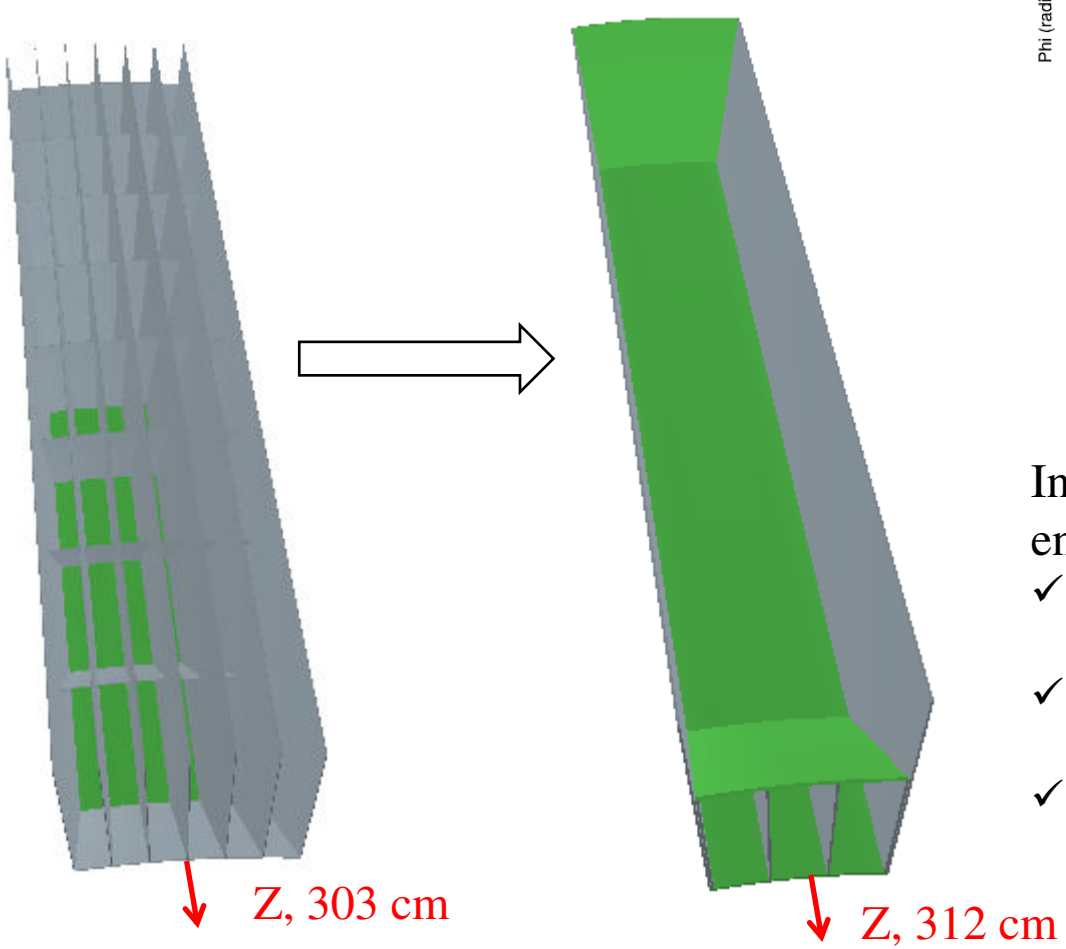
Status & structure

- PWG4 scope - electromagnetic probes:
  - ✓ electromagnetic calorimeter (ECAL) reconstruction software
  - ✓ reconstruction of photons and neutral meson
  - ✓ dielectron continuum and LVMs
  - ✓ estimation of direct photon yields and flow
- Conveners: V. Riabov, Chi Yang
- Talk outline: most recent results and activities

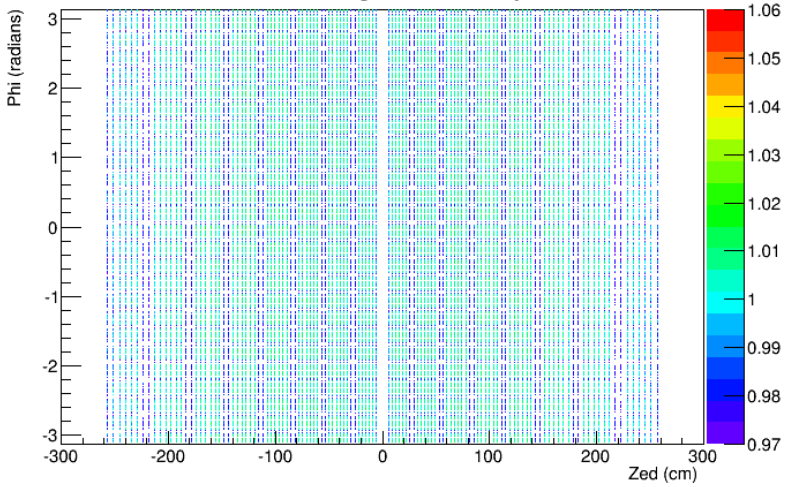
ECAL simulations

New ECAL geometry: v.4 vs. v.3

- See report by M. Martemyanov for details, https://indico.jinr.ru/event/2893/
- The main changes are in geometry of baskets (half-sectors) :
  - ✓ no internal walls in new (v.4) geometry



v.3 geometry



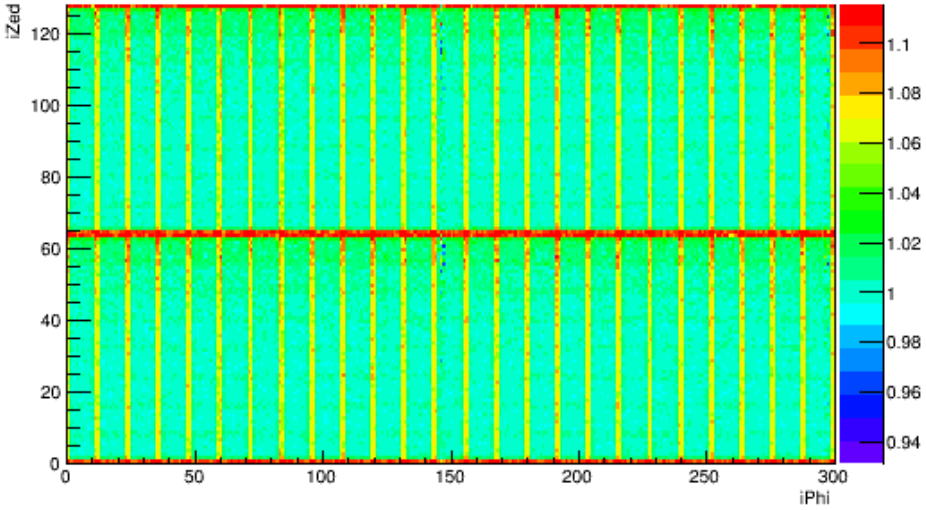
Internal walls in the basket worsen energy resolution:

- ✓ nonhomogenity of the ECAL absolute energy scale
- ✓ the closer the cluster to the walls the larger the energy scale drop (energy leaks)
- ✓ worse energy resolution after averaging over the whole detector acceptance

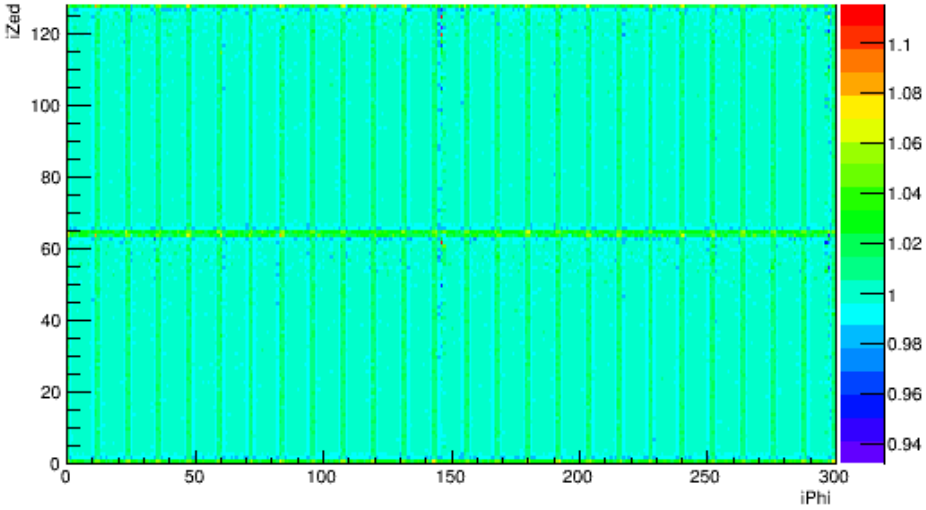
Tower-by-tower calibration (v.4)

- Recalculated tower-by-tower calibrations for the new ECAL geometry (v.4)
- Corrections are evaluated as a ratio of generated to reconstructed cluster energies for central cluster towers (40M single photons simulated)
- Process converges in two iterations
- Updated **MpdEmcCalib.root** has been committed in mpdroot/input

Iteration 0



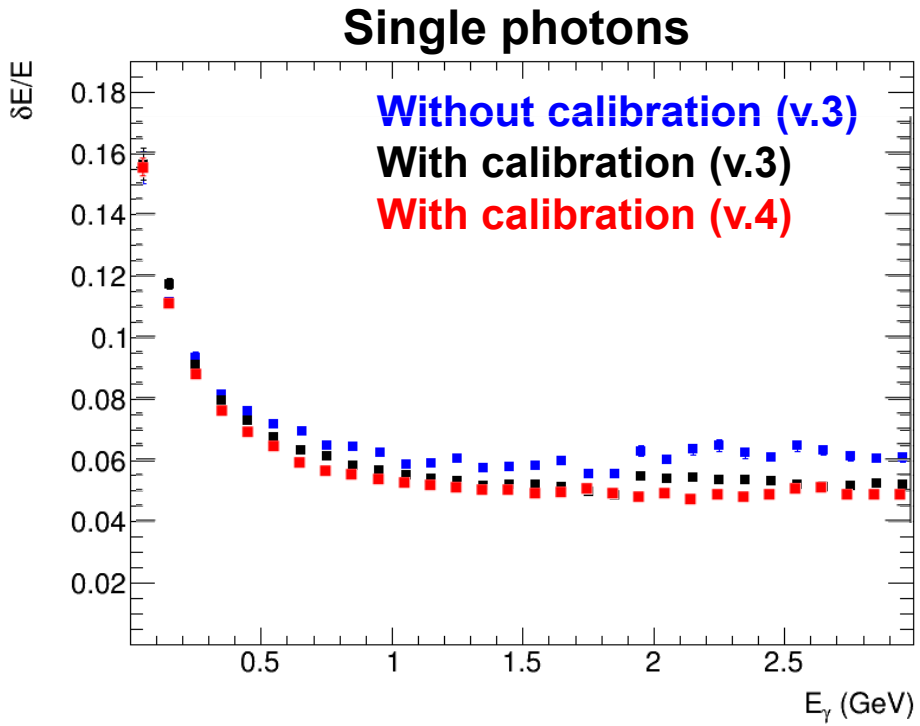
Iteration 2

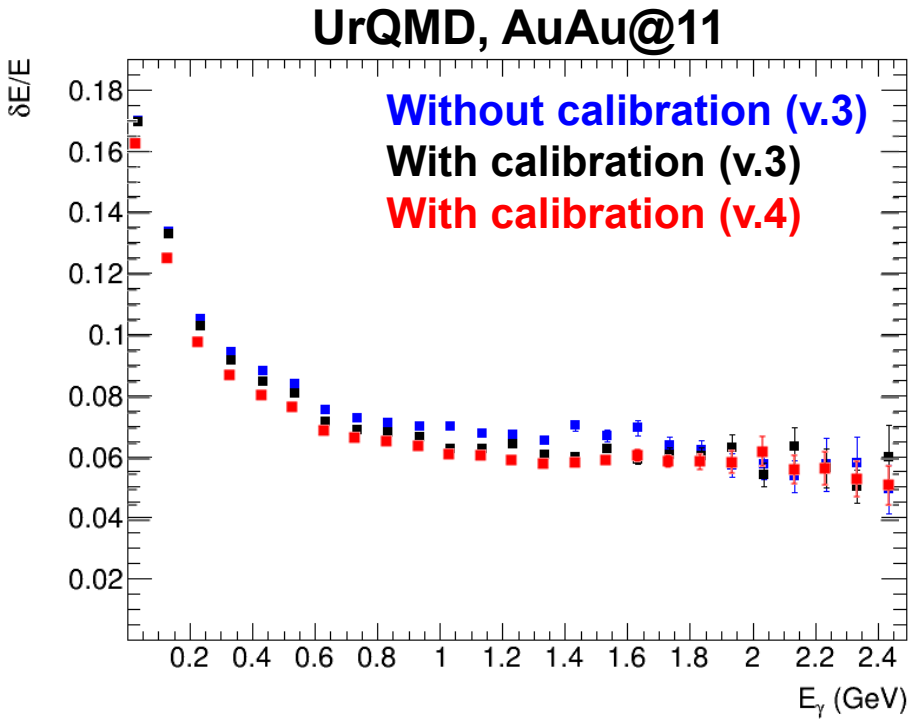


- After tower-by-tower calibration the absolute scale variation is significantly reduced

Energy resolution (photons)

- Energy resolutions with/without the fine tower-by-tower calibration
- Single photons and photons from AuAu@11 (UrQMD); realistic vertex distributions

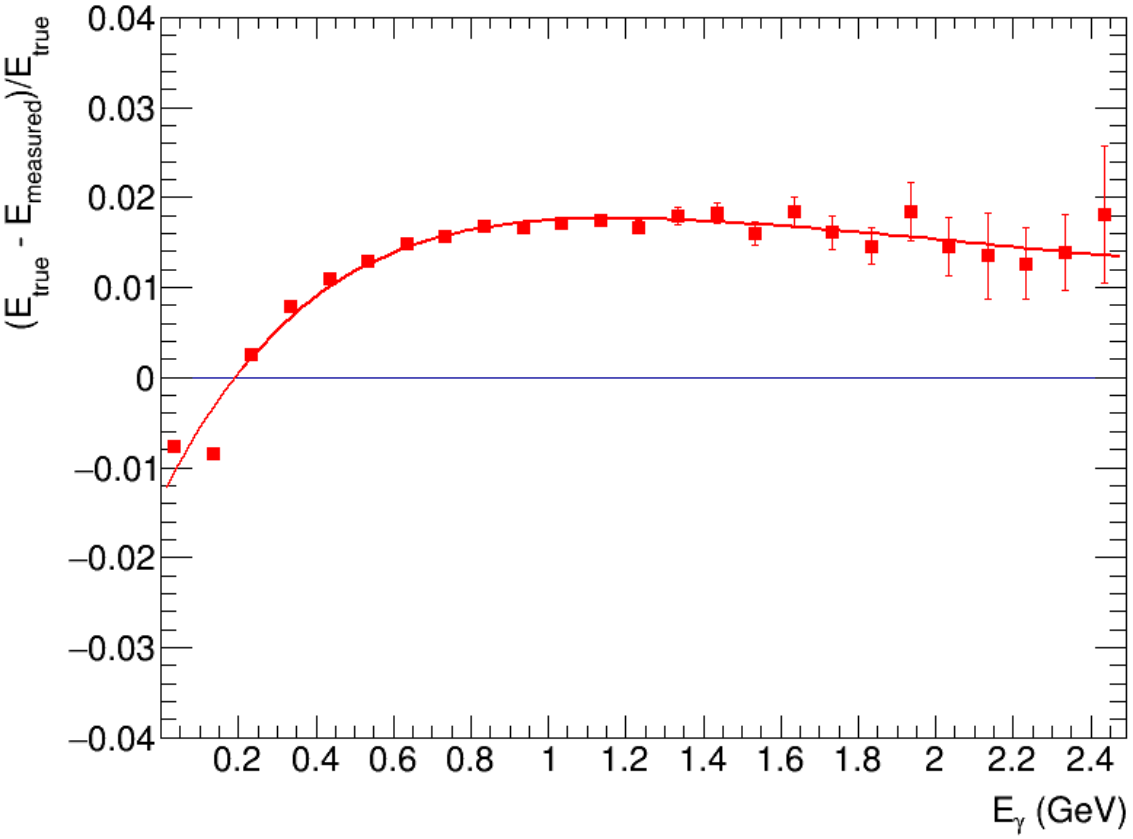




- Tower-by-tower calibrations with v.4 geometry are less important compared to v.3
- Energy resolution with v.4 geometry is better, but not much
- This is not intrinsic energy resolution of the ECAL, the resolution also accounts for clusterization algorithm which may not account for the whole deposited energy

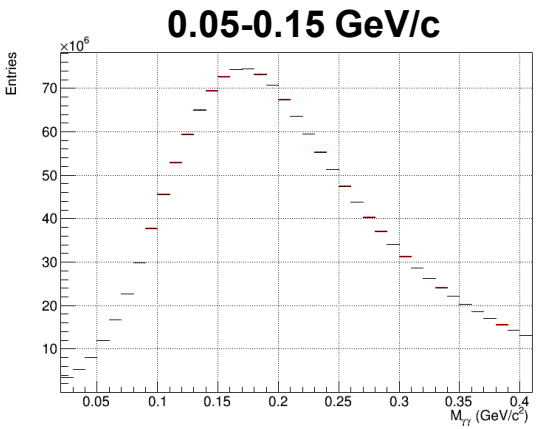
Non-linearity

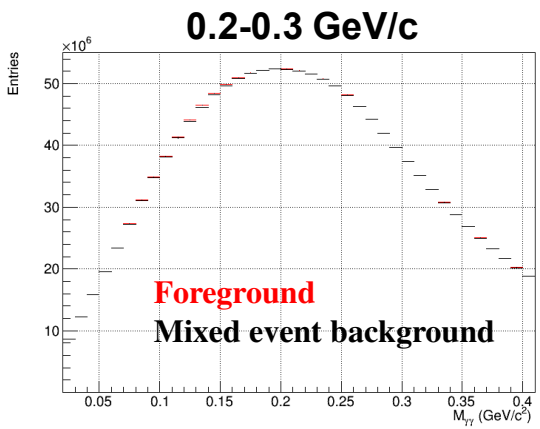
- Reconstructed photon energy does not exactly match the generated one
- Observe non-linearity of ~ 3%
- Can be parameterized as a function of reconstructed energy and reduced to ~ 0.5%

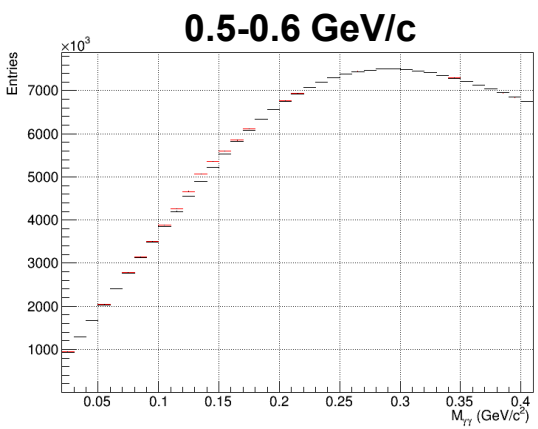


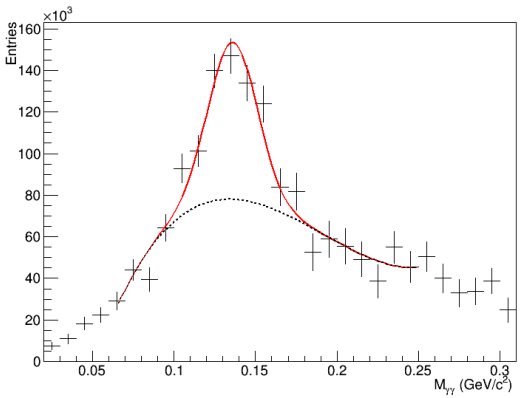
π^0 peak examples

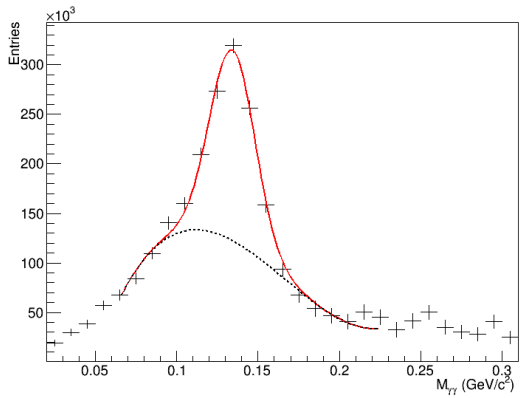
- UrQMD. Minbias BiBi@9.2, realistic vertex distribution

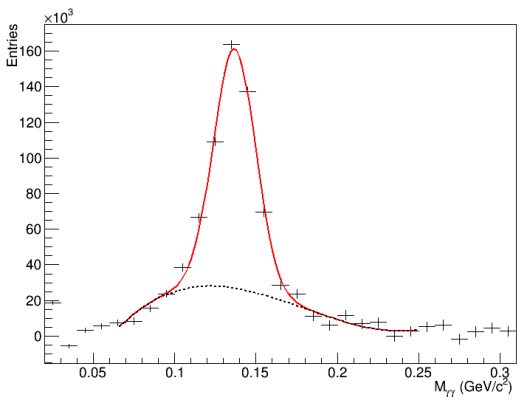








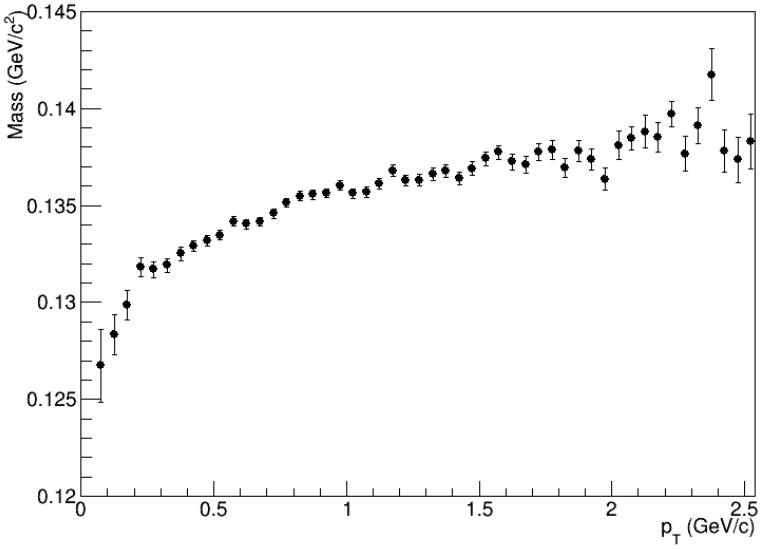


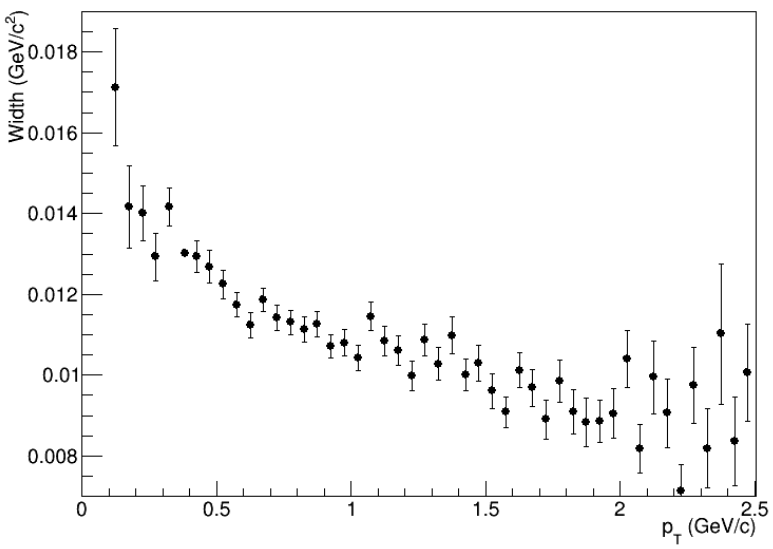


- Reconstruction of neutral pions from ~ 100 MeV/c
- S/B can be increased in expense of the reconstruction efficiency → subject of optimization

π^0 mass and width (Gaussian fits)

- UrQMD. Minbias BiBi@9.2, realistic vertex distribution, |z-vertex| < 50 cm





- Mass dependence is due to energy leakage
- Width is driven by single photon energy resolution

Conclusions for ECAL

- New (v.4) geometry provides better energy resolution and uniform performance
- Nonlinearity ~ 3% → can be corrected to ~ 0.5%
- New tower-by-tower calibration file has been produced and committed to MpdRoot
- π^0 reconstruction and parameters have not changed much

ECAL Tutorial has been released and presented, https://indico.jinr.ru/event/3016/

Electron ID and dielectrons

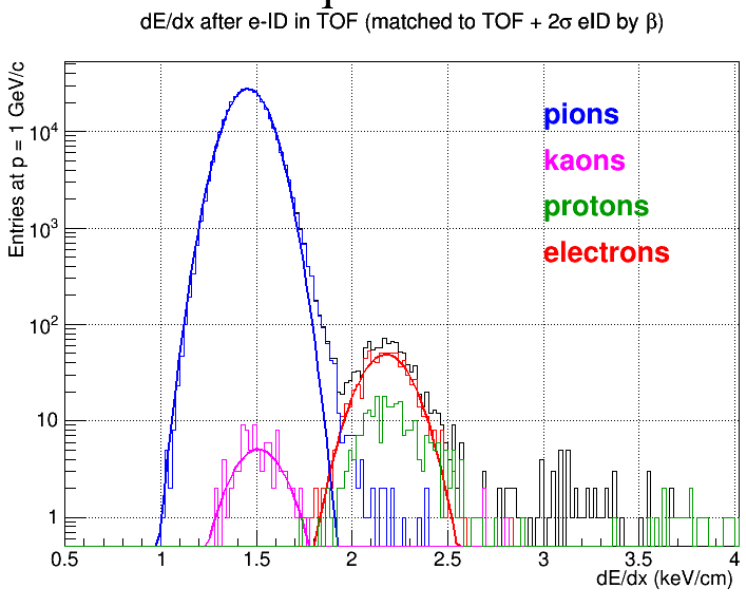
Problems with dE/dx calculations

- BiBi@9.2, UrQMD v.3.4
- dE/dx distributions for tracks identified as electrons in TOF

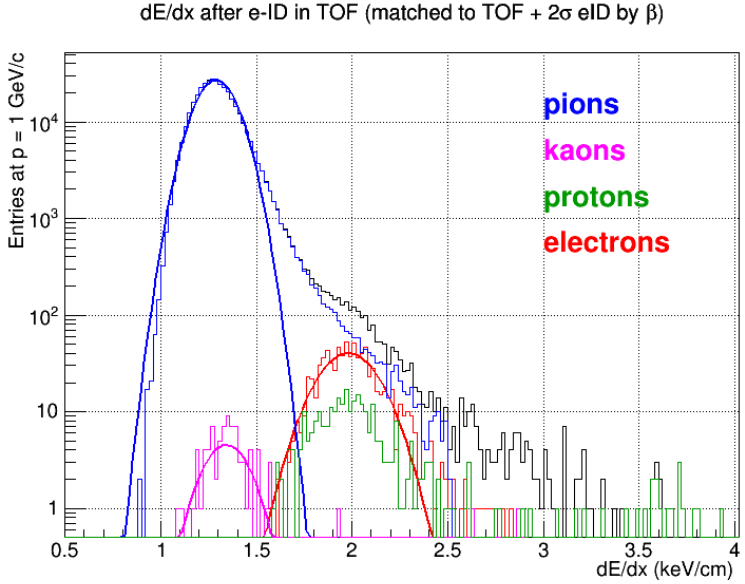
- Selected tracks:
  - ✓ hits > 39
  - ✓ $|\eta| < 1$
  - ✓ $|DCA_{x,y,z}| < 2.5\ \sigma$
  - ✓ $p_T = 1$ GeV/c

- eID selections:
  - ✓ 2σ matching to TOF
  - ✓ 2σ TOF-eID

Request 11



Request 13

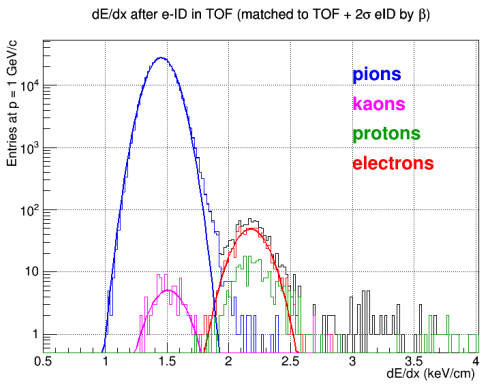


- Request 11 vs. Request 13:
  - ✓ <dE/dx> changed (new dE/dx parameterizations); shape changed (new TPC digitizer)
  - ✓ Kaon and proton contributions are comparable after TOF e-PID
  - ✓ non-Gaussian tails in dE/dx distributions in Request 13 → electrons can not be distinguished from the pion tail

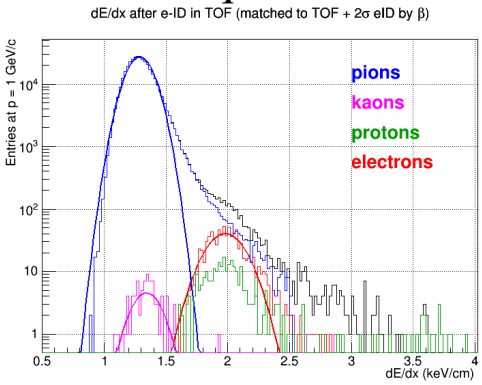
New version of dE/dx

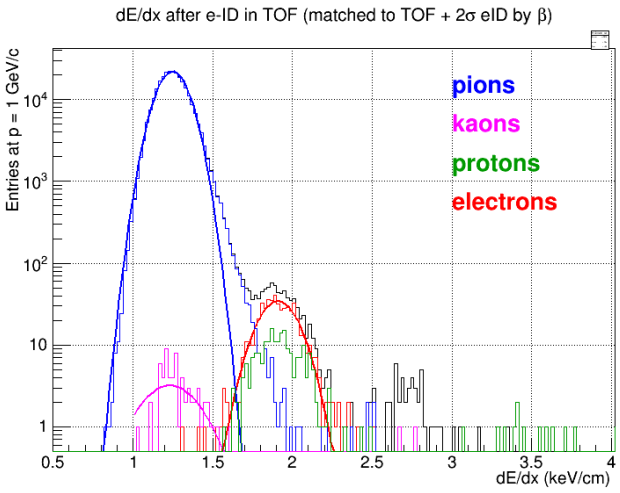
- Origin of tails was traced to the edges of read-out chambers in the TPC
- New version of TPC digitizer takes care of the tails (committed to MpdRoot)

Request 11



Request 13

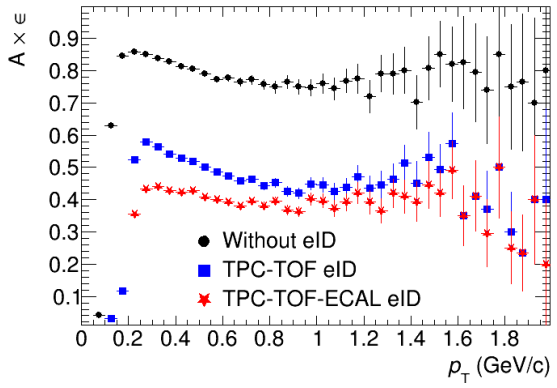


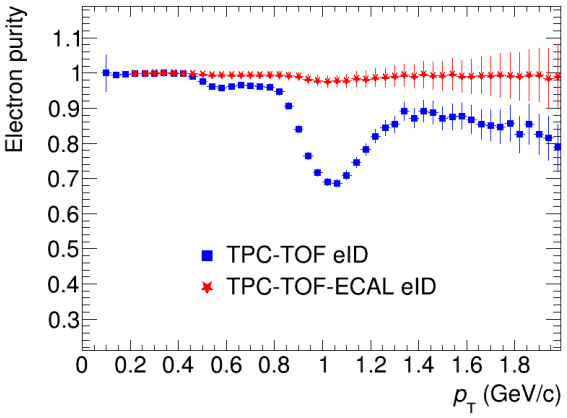


New TPC digitizer gives intermediate results, closer to Request 11 → electrons can be distinguished from pions but not as good as with Request 11

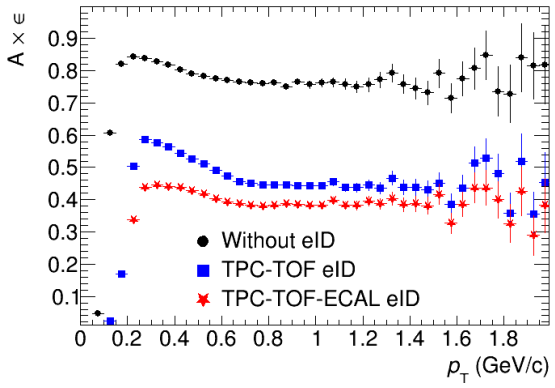
Electron efficiency and purity

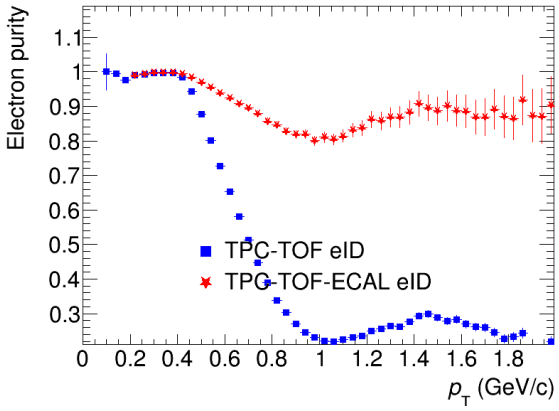
Request 11



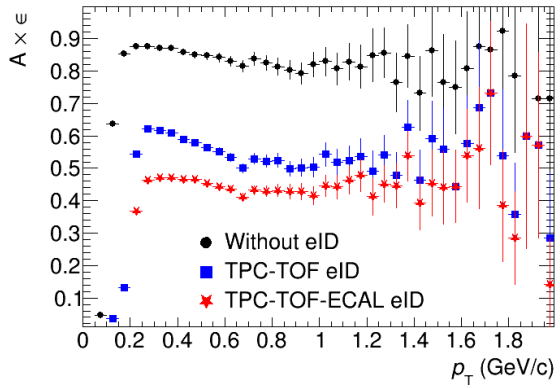


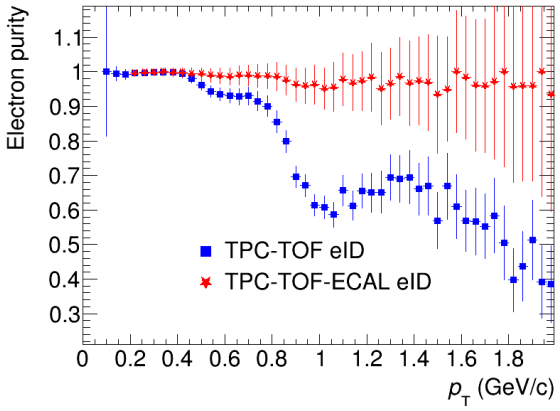
Request 13





New digitizer

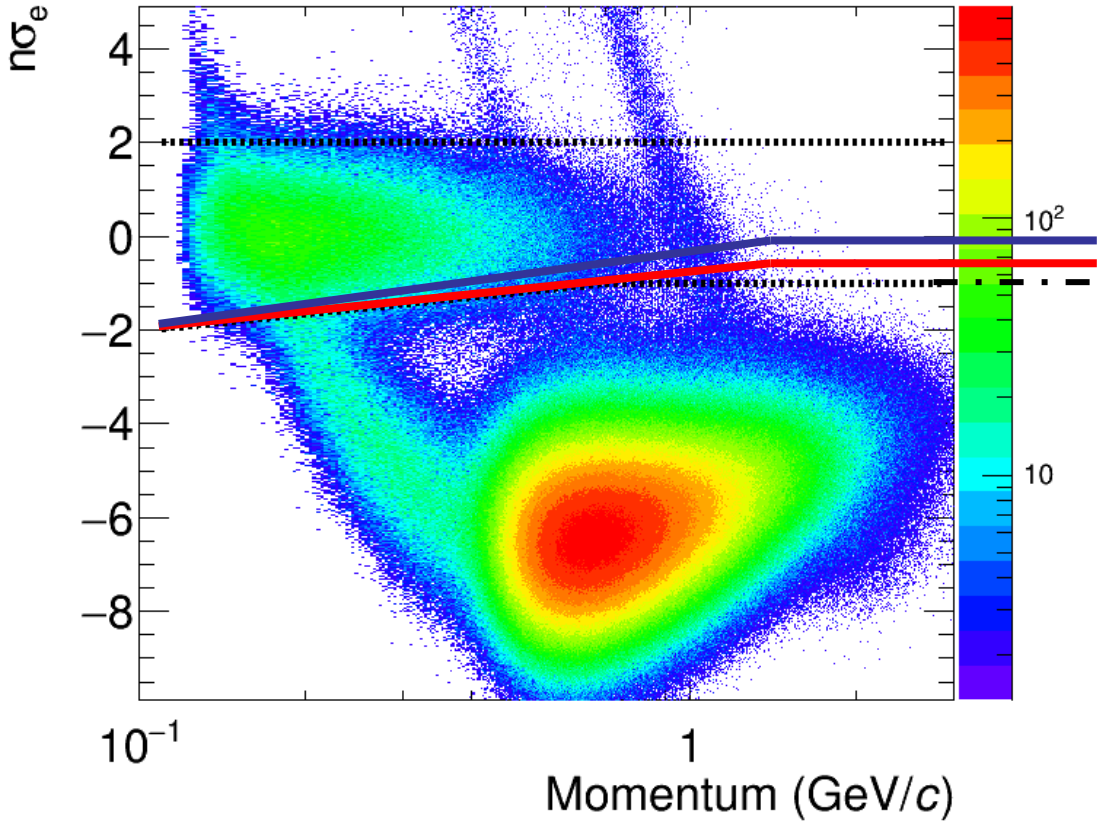


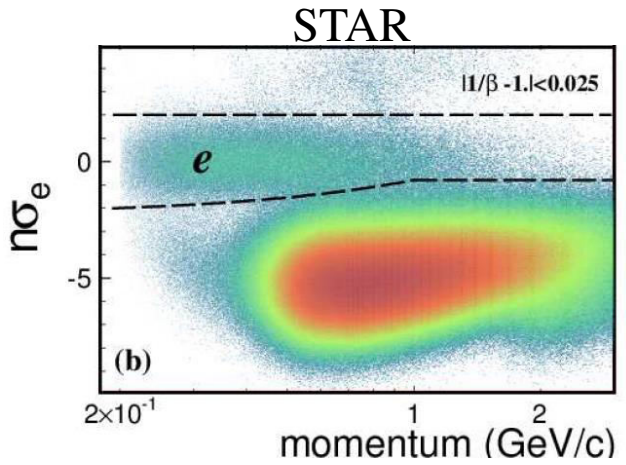


- Efficiencies are identical
- As expected, TPC-TOF purity is closer to Request 11, EMC-TPC-TOF purity is the same

Improving purity …

- dE/dx for tracks TOF-identified electrons

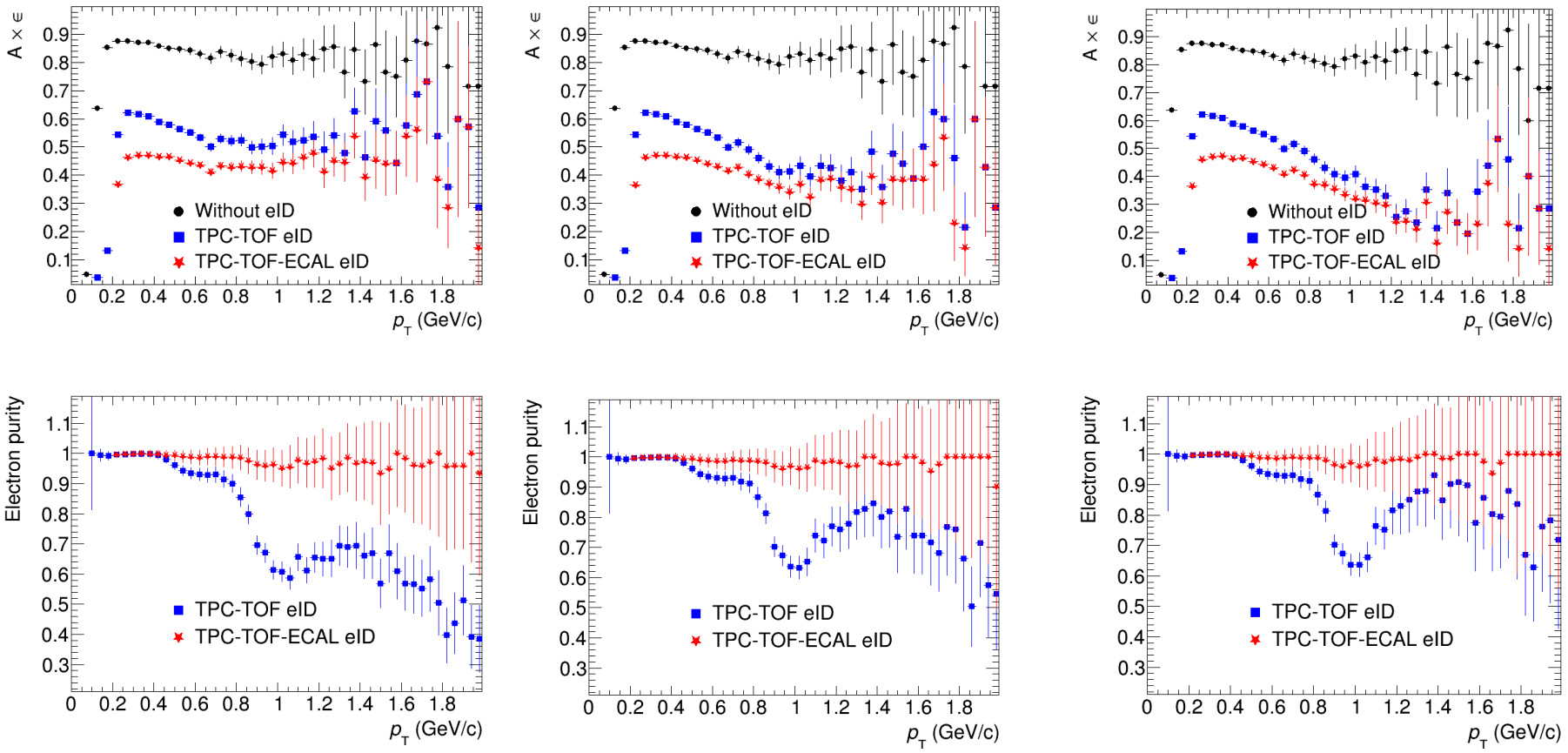




0.0 σ
-0.5 σ
-1.0 σ (default)

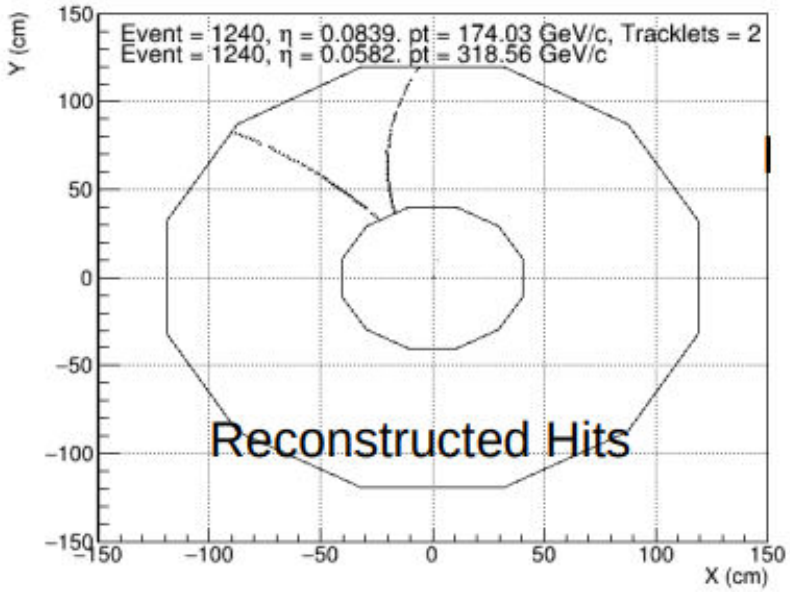
Improving purity …

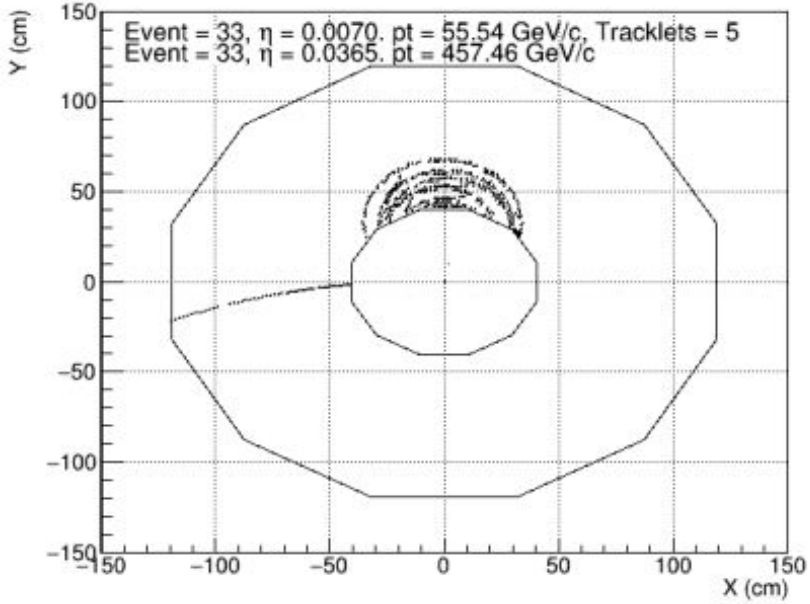
-1.0 σ | **-0.5 σ** | **0 σ**



- TPC-TOF purity can be improved at the expense of lower efficiency
- TPC-TOF-EMC purity remains ~ 1
- Exact selections are to be decided based on the purity and significance of physical signals

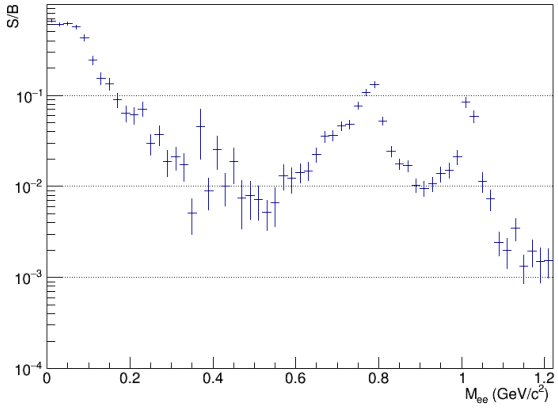
Dielectrons, random e^+e^- pairs





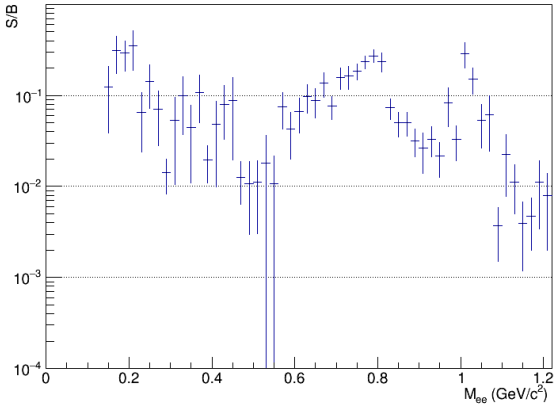
- With eID in TPC-TOF-ECAL the MPD provides reconstruction of e^+e^- pairs with high purity (small hadronic contamination)
- The main background for dielectron measurements are random e^+e^- pairs where at least one of them is from photon conversion or Dalitz decays of π^0 and η mesons.
- Conversions and Dalitz decays of π^0 and η mesons are well identified *IF* both e+ and e- tracks are reconstructed and identified in the detector
- With a improved track reconstruction, especially for low p_T spiral tracks, a significant improvement in the S/B can be obtained
- Different methods are being developed to suppress the combinatorial background

Dielectrons



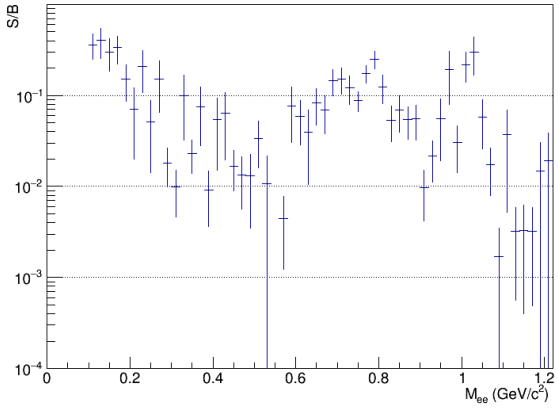
S/B in 0.2-1.5: 0.025
==========
Omega (s/sqrt(b)): 1.62
Phi (s/sqrt(b)): 0.84
LMR (s/sqrt(b)): 0.39
==========

M_{cut} = 150 MeV/c^2



S/B in 0.2-1.5: 0.082
==========
Omega (s/sqrt(b)): 1.38
Phi (s/sqrt(b)): 0.82
LMR (s/sqrt(b)): 0.36
==========
=

M_{cut} = 150 MeV/c^2 $|\eta| < 0.5$



S/B in 0.2-1.5: 0.091
==========
Omega (s/sqrt(b)): 0.72
Phi (s/sqrt(b)): 0.78
LMR (s/sqrt(b)): 0.22
==========

- S/B decreased but not dramatically
- S/B ~ 0.1 is still reachable

Conclusions for eID

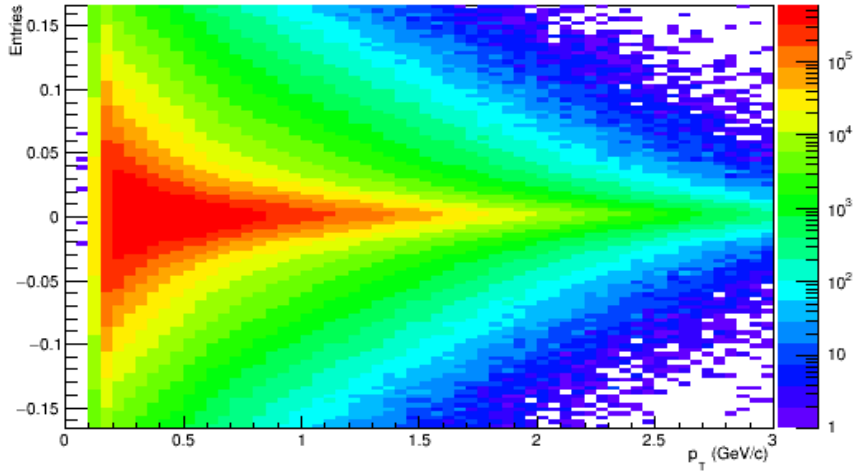
- The problem of tails in dE/dx distributions has been solved
- eID performance with TPC&TOF became worse but not dramatically
- Suggestion is to stay with this option of dE/dx and wait for real data for further fine tuning
- Going to request a mass production for dielectrons

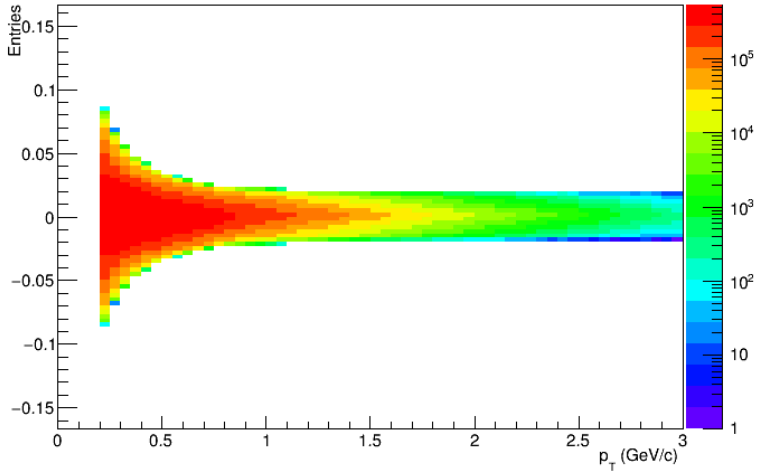
E/p distribution

Track-to-cluster matching: 2σ selections

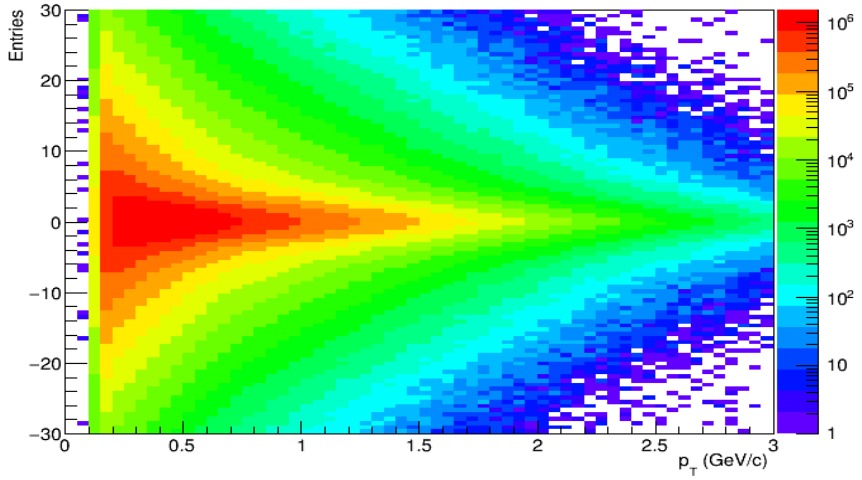
- BiBi@9.2, UrQMD
- Track selections: n-hits > 39, $|\eta| < 1$, $|DCA_{x,y,z}| < 3\sigma$

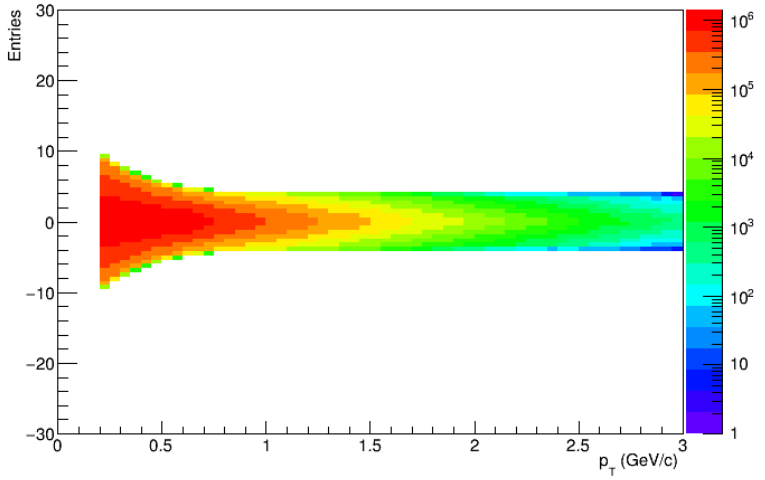
- dPhi





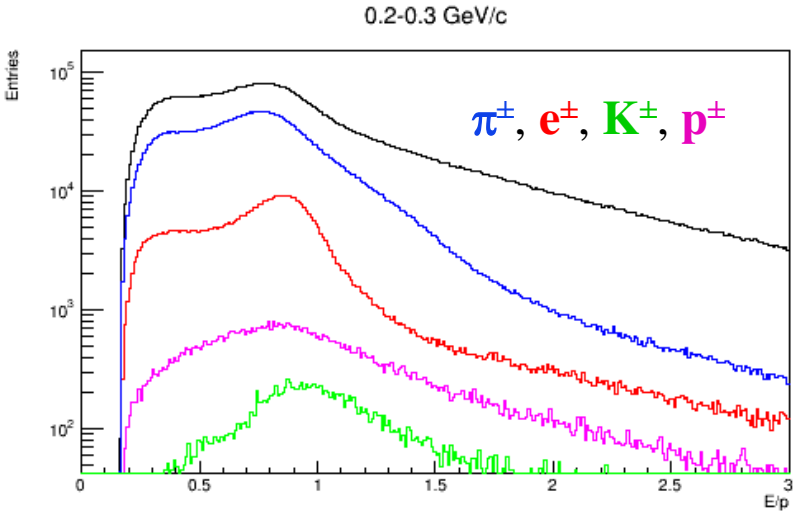
- dZed

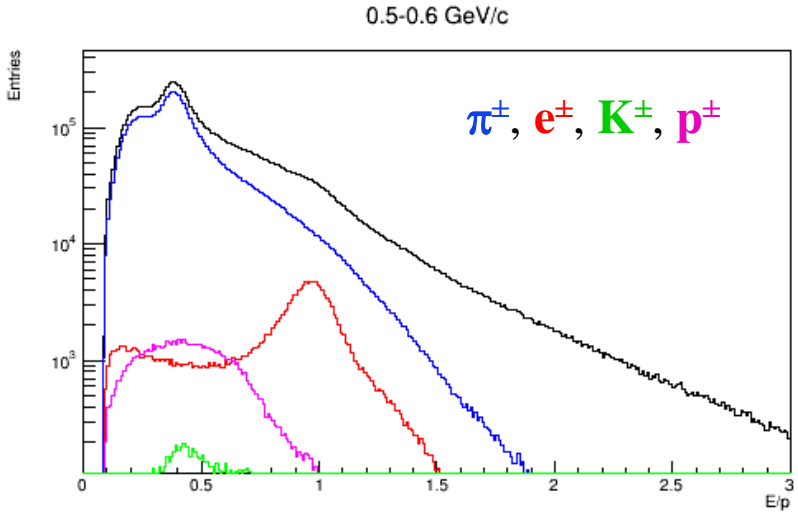




E/p in different p_T bins

- BiBi@9.2, UrQMD
- Track selections: n-hits > 39, $|\eta| < 1$, $|DCA_{x,y,z}| < 3\sigma$
- 2σ matching in dPhi and dZed





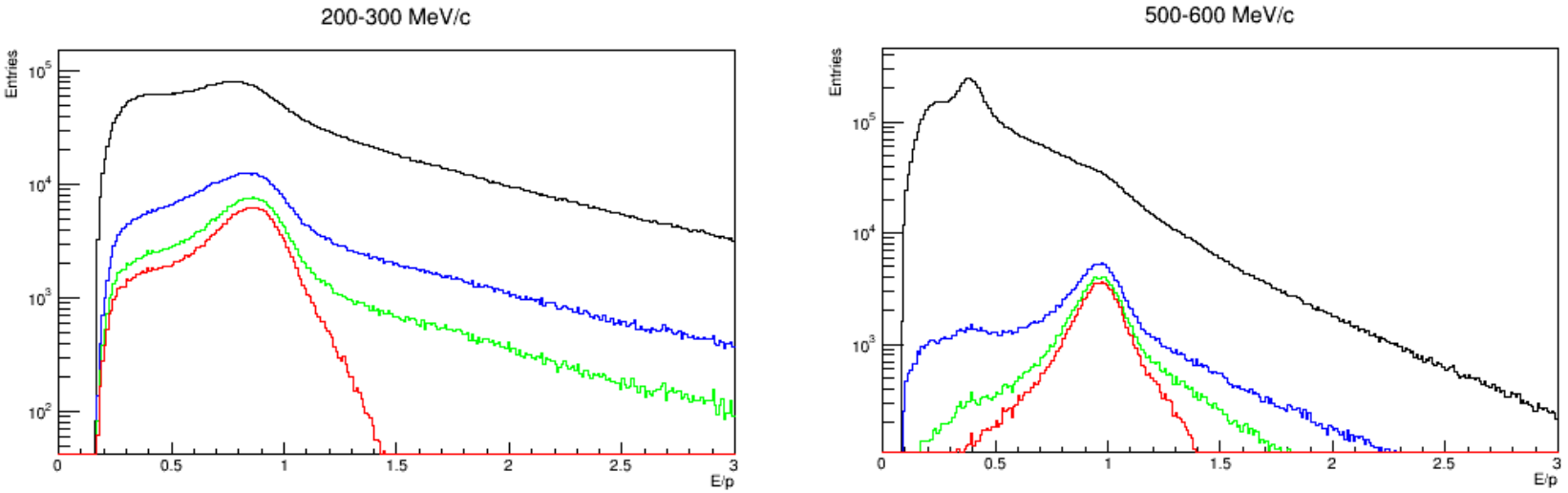
- At low momentum, E/p ~ 1 for most of charged hadrons → low efficiency of e/h
- At high momentum, E/p ~ 1 is for electrons only, high hadron rejection power

E/p rejection power

- BiBi@9.2, UrQMD

- Track selections: n-hits > 39, $|\eta| < 1$, $|DCA_{x,y,z}| < 3\sigma$
- 2σ matching in dPhi and dZed
- eID in the TPC && TOF

eID in TPC, **eID in TPC && TOF**, **true $e^{\pm}$**

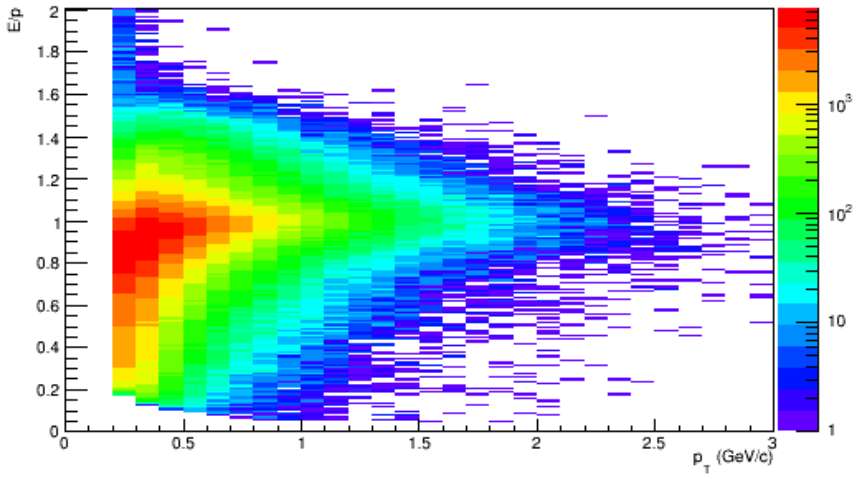


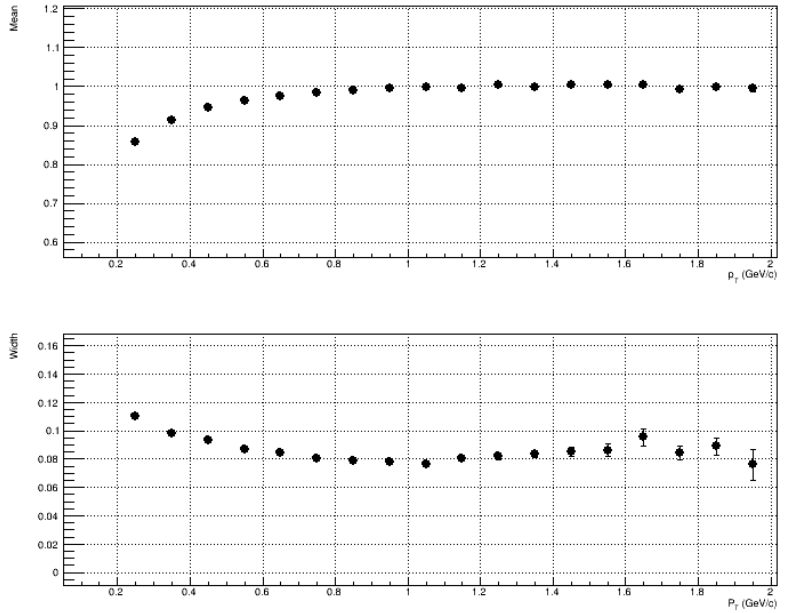
- E/p peaks are observed at low and high momentum
- Electron peak is shifted from E/p ~ 1 and is not Gaussian at low momentum
- Width of the peaks is momentum dependent

E/p rejection power

- BiBi@9.2, UrQMD

- Track selections: n-hits > 39, $|\eta| < 1$, $|DCA_{x,y,z}| < 3\sigma$
- 2σ matching in dPhi and dZed
- eID in the TPC && TOF





- E/p eID selections are effective at p_T > 300-500 MeV/c
- E/p peak position and width will be used for global calibration of the ECAL

Conclusions for E/p

- E/p can be used for the absolute calibration of the ECAL using tracks identified in TPC/TOF
- E/p electron ID selection is effective at p_T > 300-400 MeV/c

Summary

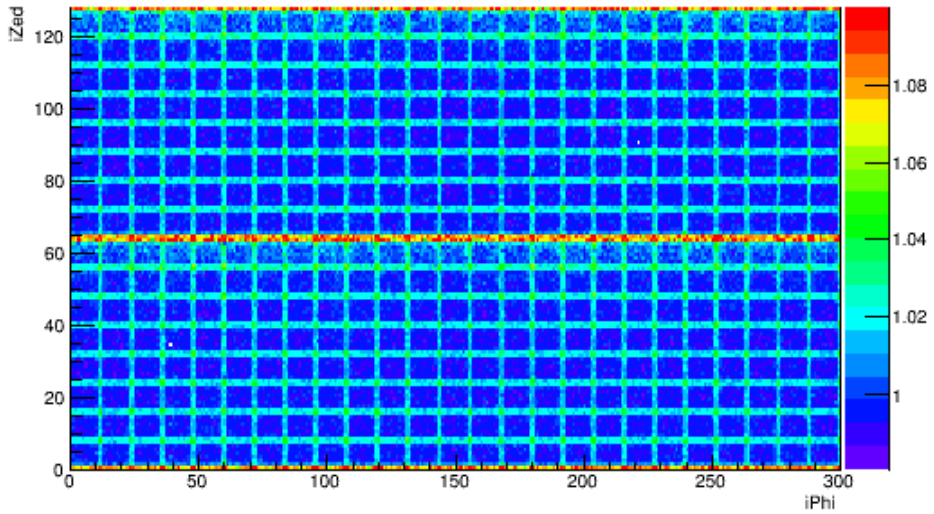
- PWG4 is active and works to enhance the MPD physical program
- Many studies are in progress
- Many vacant tasks, need extra man power and deeper involvement of the collaboration
- Contact conveners if you wish to join or have any questions

BACKUP

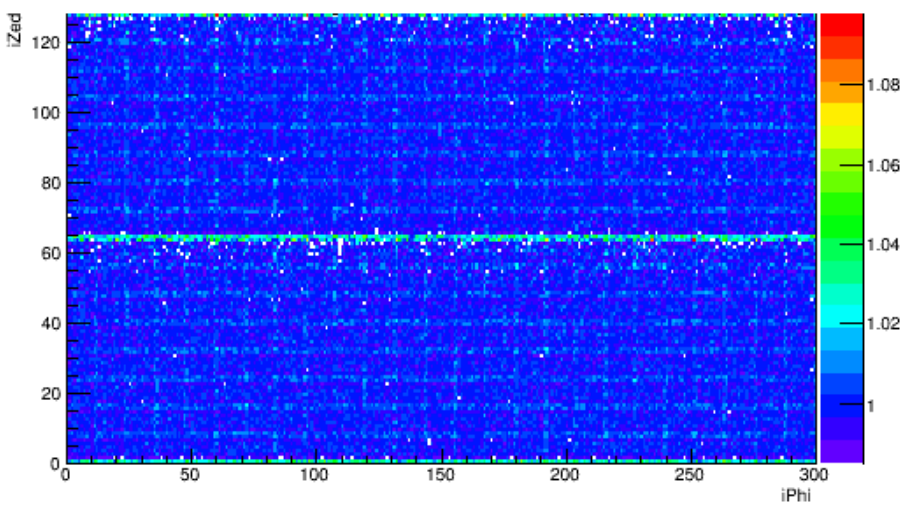
Tower-by-tower calibration (v.3)

- Intended to reduce effect of absolute scale variation in the ECAL acceptance
- Corrections are evaluated as a ratio of generated to reconstructed cluster energies for central cluster towers
- Process converges in two iterations
- Stored in mpdroot/input/**MpdEmcCalib.root** and are used by default in the reconstruction

Iteration 0



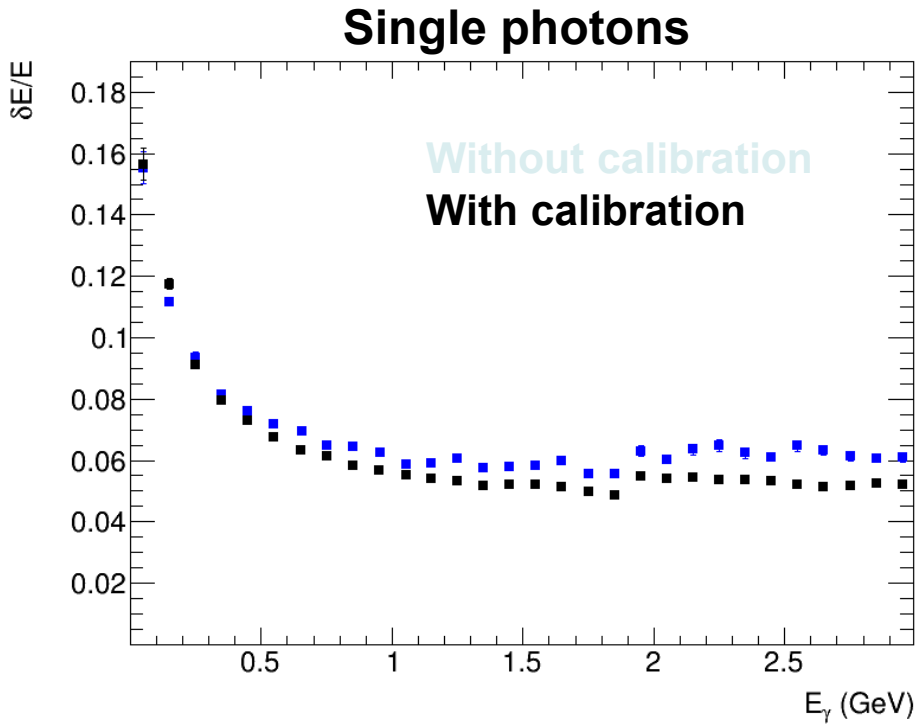
Iteration 2

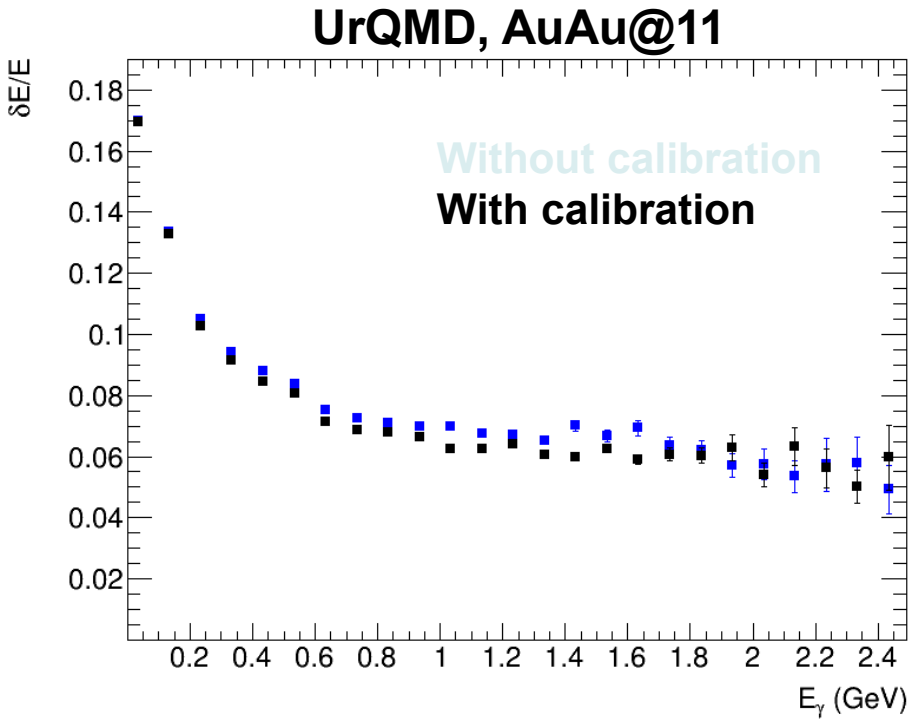


- After tower-by-tower calibration the absolute scale variation is significantly reduced

Effect of tower-by-tower calibration (v.3)

- Compared energy resolutions with/without the fine calibration
- Single photons and UrQMD, minbias AuAu@11; realistic vertex distributions





- Calibration improves energy resolution
- Equivalent effect is quadratic subtraction of 2%: $\delta_{NEW} = \sqrt{\delta_{OLD}^2 - 0.02^2}$

Latest Monte Carlo productions

- **Request11**: *PWG4 - dielectrons, 15M minbias BiBi@9.2*
- Geant-4 based simulation
- Aims at dielectron studies but good for most of other analyses:
  - ✓ enhanced dielectron BRs for vector mesons (x20)
  - ✓ updated materials, detector response and reconstruction algorithms
  - ✓ dphi, dzed variables for better track-to-TOF matching
  - ✓ most probable first collision system, BiBi@9.2
  - ✓ high statistics, 15 M events
- Output:
  - ✓ /eos/nica/mpd/sim/data/exp/dst-BiBi-09.2GeV-mp02-21-500ev/BiBi/09.2GeV-mb/UrQMD/BiBi-09.2GeV-mp02-21-500ev
  - ✓ 30,000 files

- **Request13**: *PWG4 - dielectrons, 15M minbias BiBi@9.2*
- Same as Request 11 but with a different simulation of dE/dx in the TPC
  - ✓ new dE/dx parameterization
  - ✓ new TPC digitizer (MpdTpcDigitizerAZlt vs. MpdTpcDigitizerAZ)

E_T distribution

Selection cuts

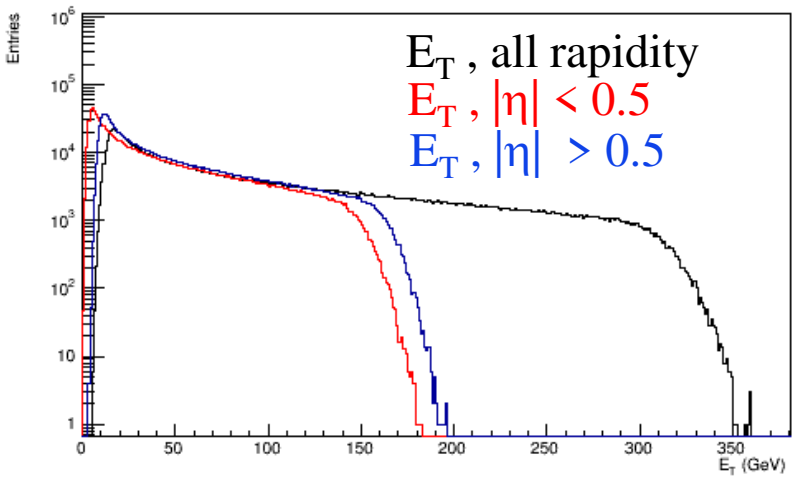
- Event selections:
  - ✓ BiBi@9.2, UrQMD v.3.4
  - ✓ z-vertex smeared with σ = 22 cm, |z-vertex| < 50 cm
  - ✓ no centrality/multiplicity selections

- Track selections:
  - ✓ n-hits > 10
  - ✓ $|\eta| < 0.5$
  - ✓ $|DCA_{x,y,z}| < 3\sigma$

- ECAL cluster selections:
  - ✓ $E_{\gamma} > 50$ MeV
  - ✓ n-towers > 1

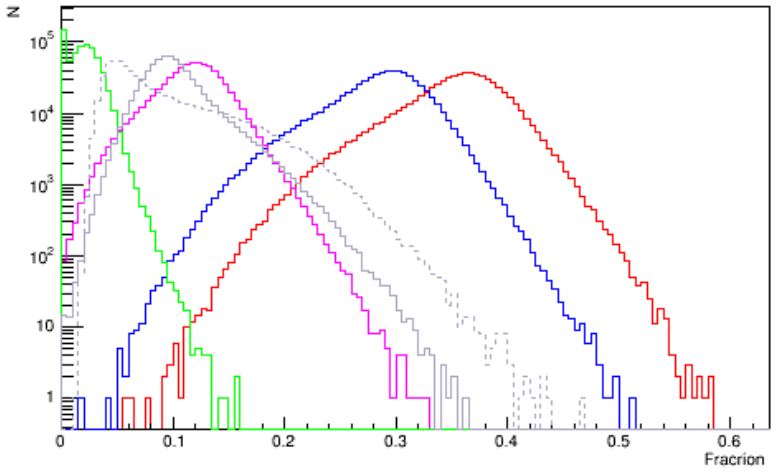
E_T distributions

- Transverse energy E_T



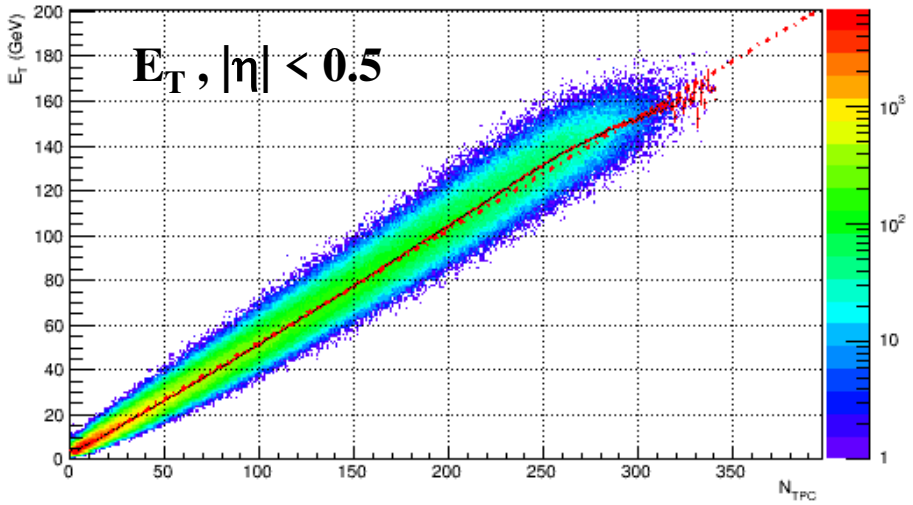
- Contributors:

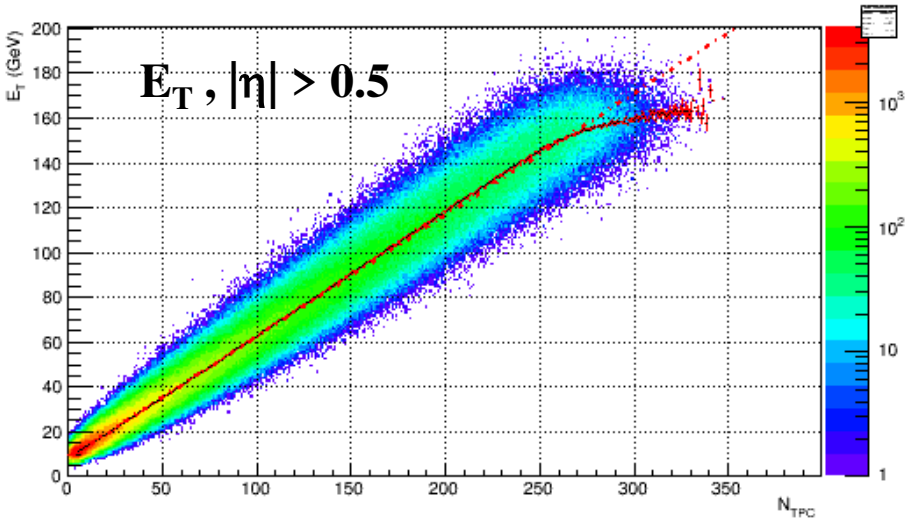
γ, $\pi^{\pm}$, $e^{\pm}$, $K^{\pm}$, $p^{\pm}$, n



- Main contributors:
  - ✓ pions (**photons**, $\pi^{\pm}$)

E_T vs. N_{tracks}

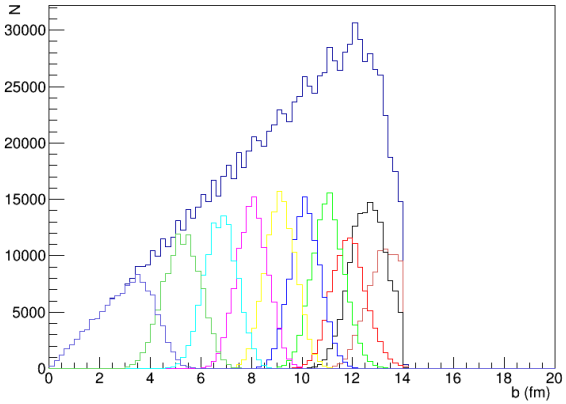


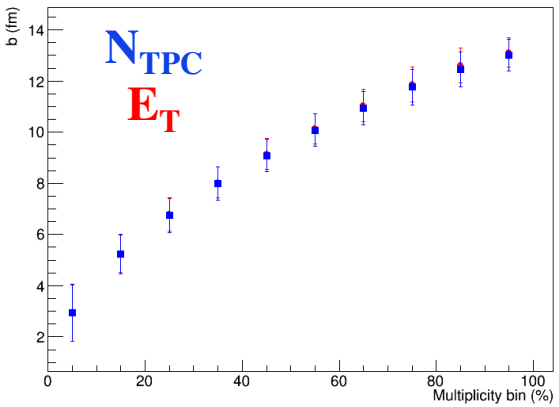


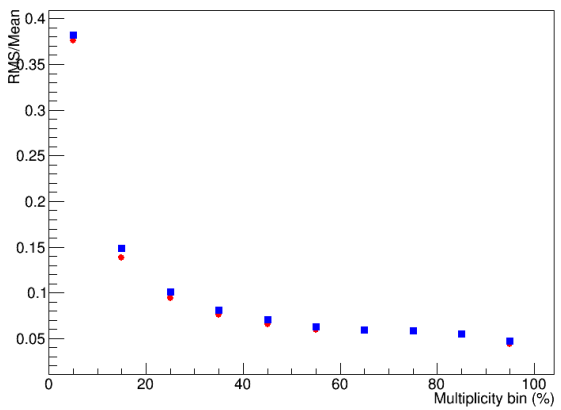
- N_{TPC} is counted within |η| < 0.5
- Width of E_T vs. N_{TPC} correlations depends on rapidity selections in the ECAL

Multiplicity bins by E_T

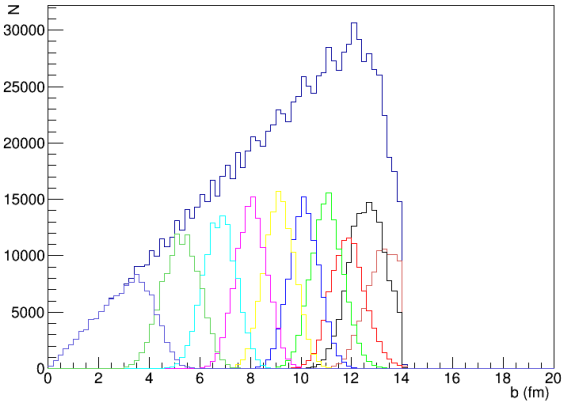
- E_T , $|\eta| < 0.5$

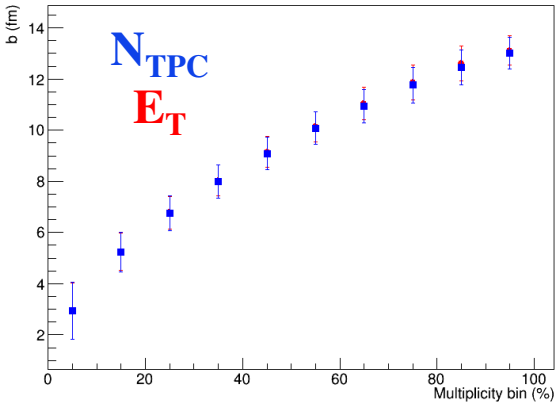


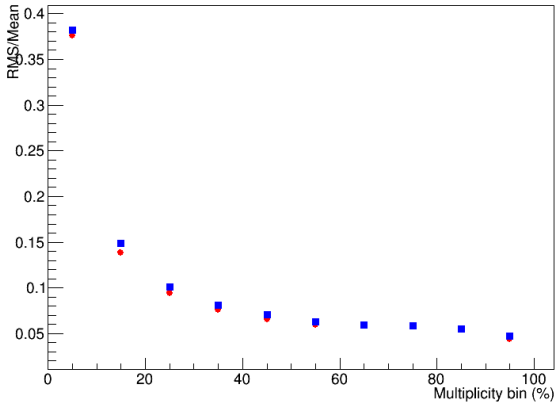




- E_T , $|\eta| > 0.5$







- Very similar events are selected with N_{TPC} ($|\eta|<0.5$) and different E_T multiplicity selections
- No obvious dependence on rapidity for E_T

Conclusions

- Observe close correlation between E_T and N_{TPC}
- Correlation width depends on rapidity selections