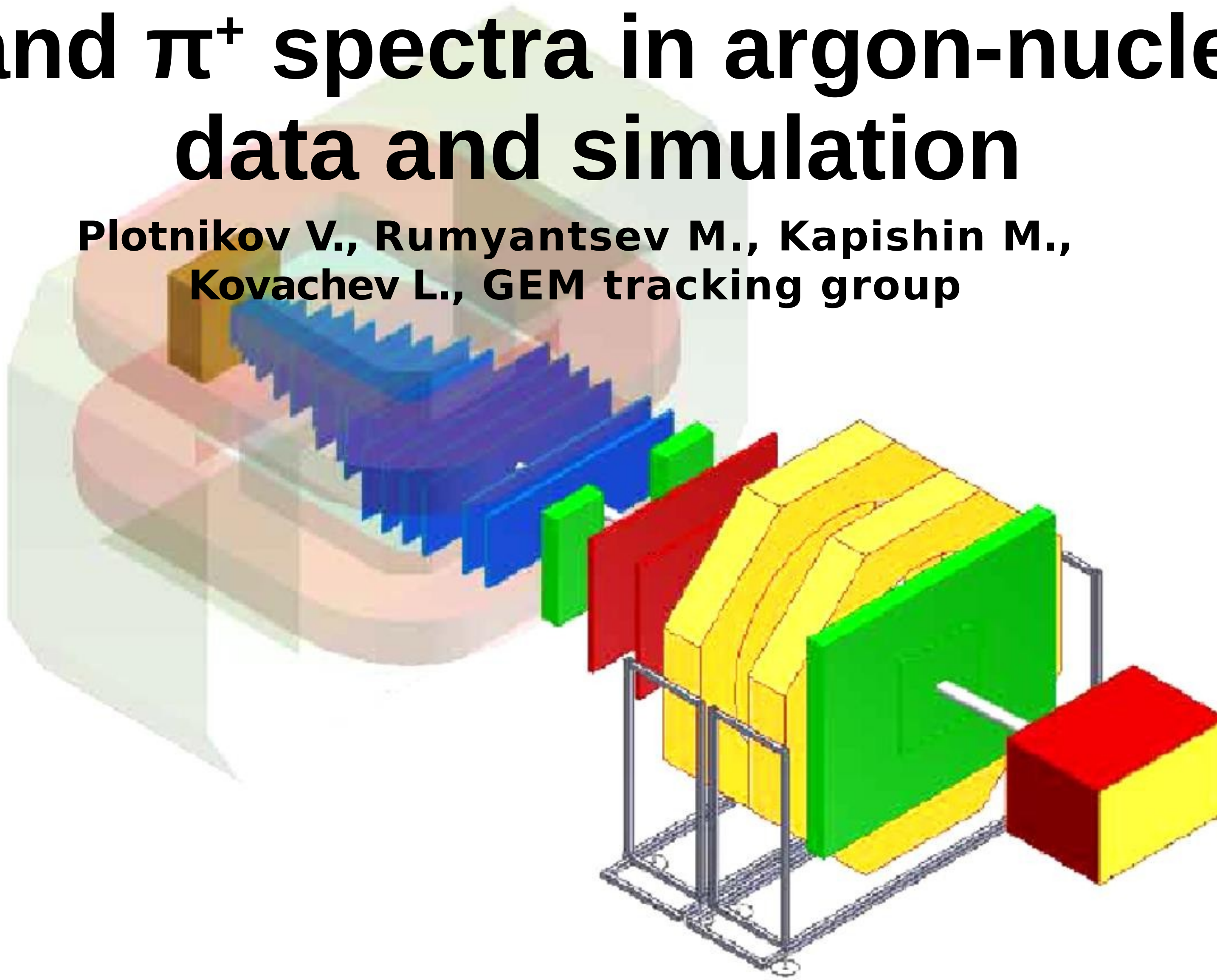
K^+ and π^+ spectra in argon-nucleus data and simulation

Plotnikov V., Rumyantsev M., Kapishin M.,
Kovachev L., GEM tracking group

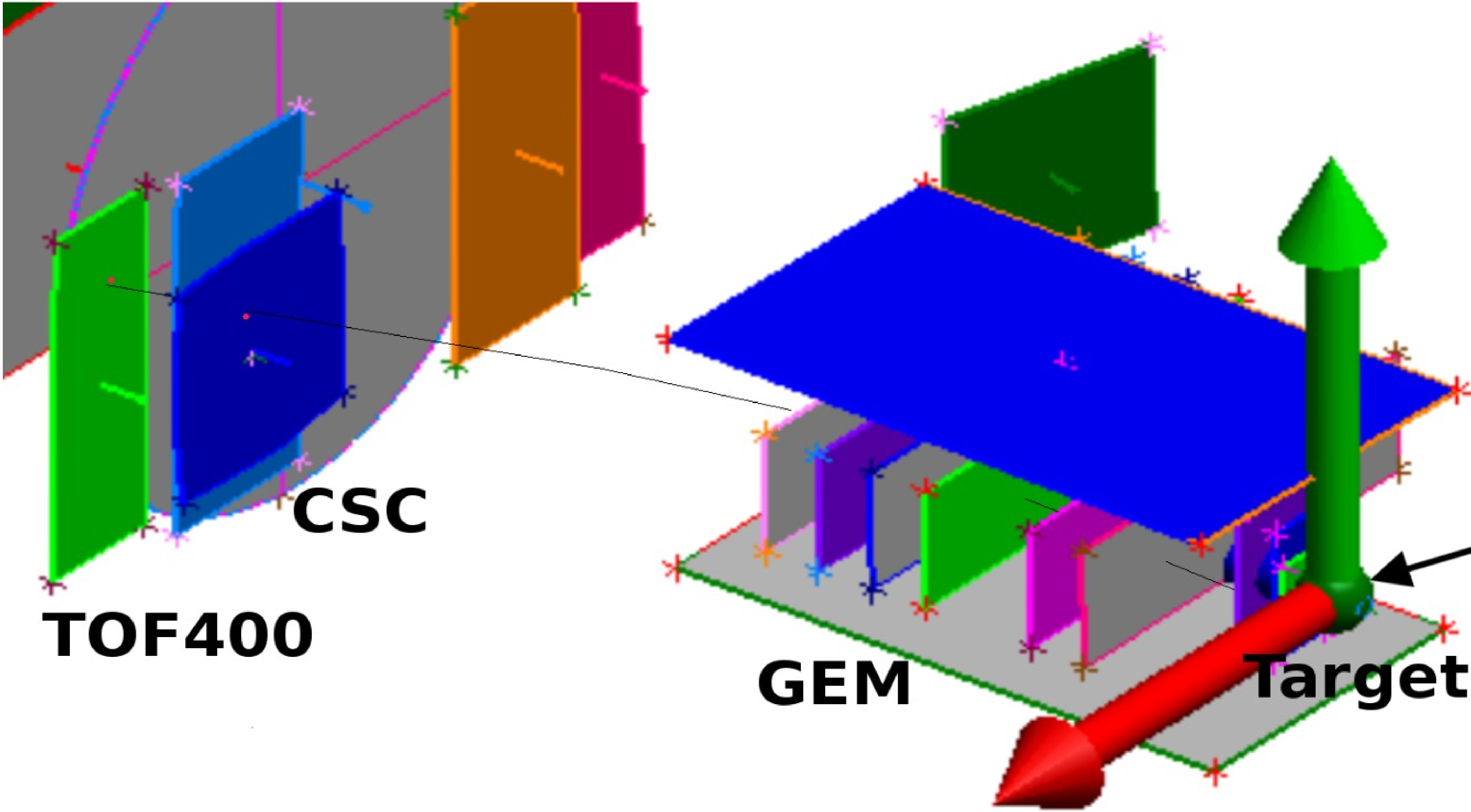


4th Collaboration Meeting of the BM@N Experiment at the NICA Facility
15.10.2019

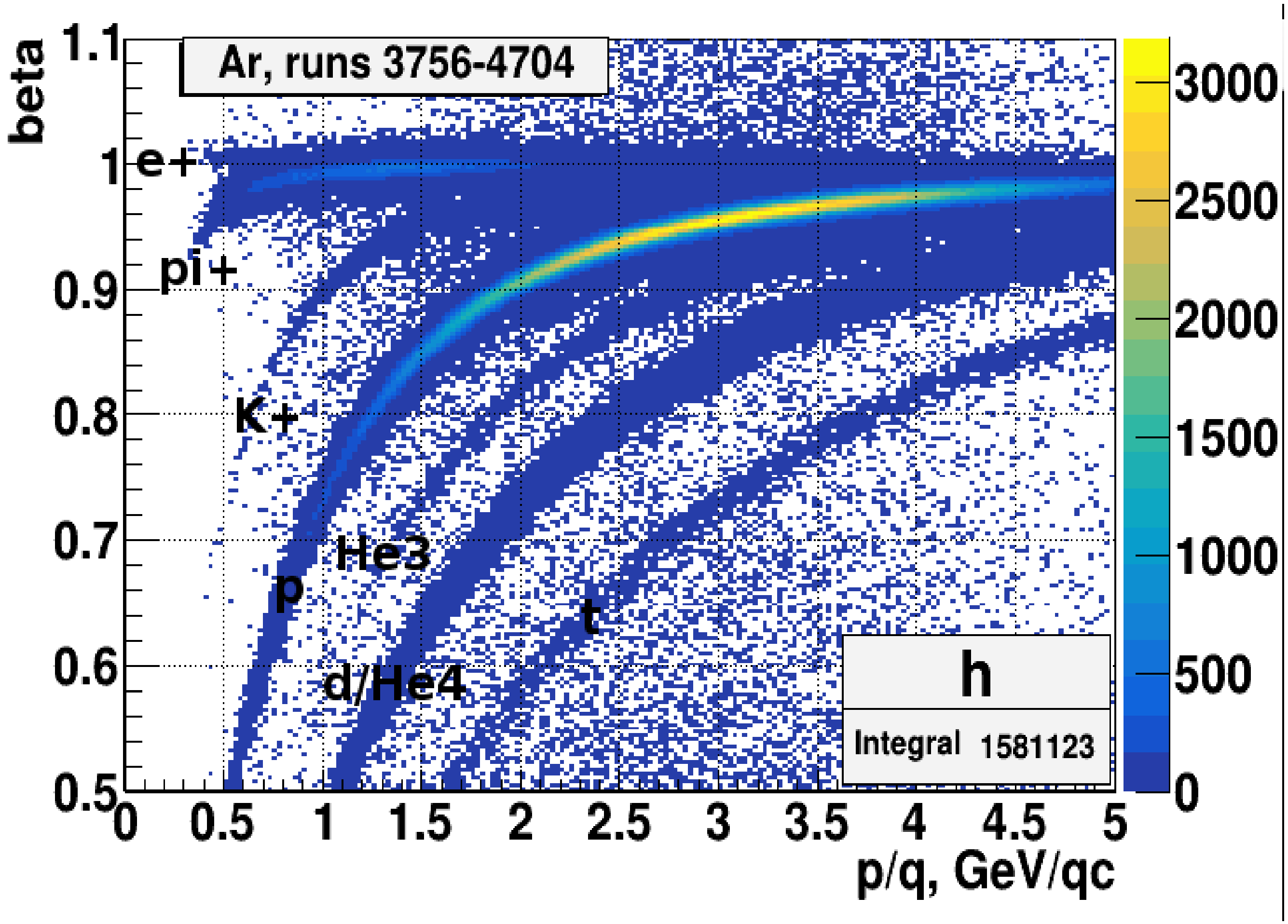
Recap

- Sketch of used detectors
- Particle identification result
- π^+ and K^+ extraction
- Time of flight resolution

Identification method

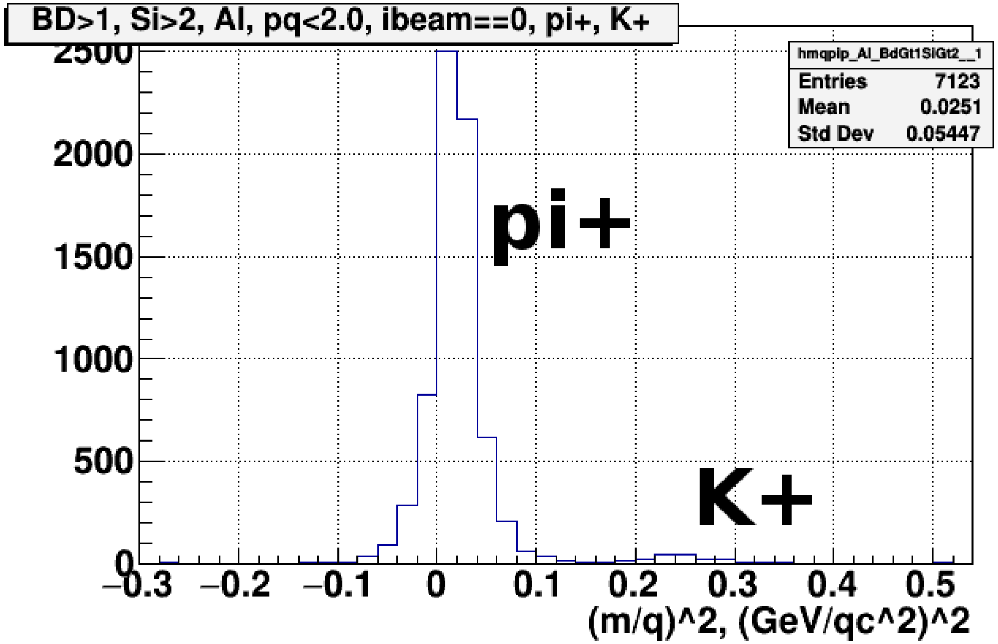


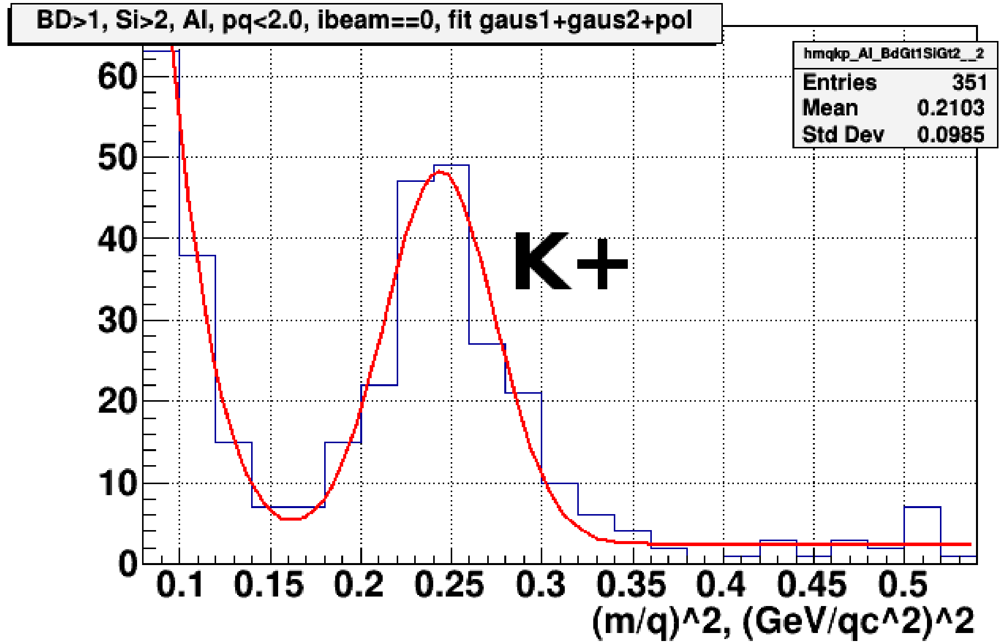
Identification for Ar



- For positive particles, all Ar data

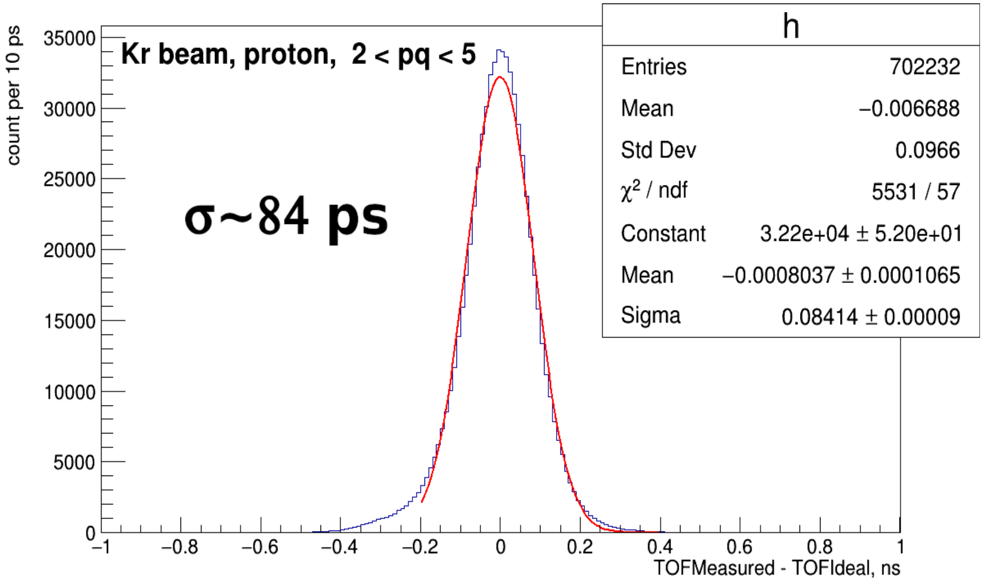
Kaon identification, Al

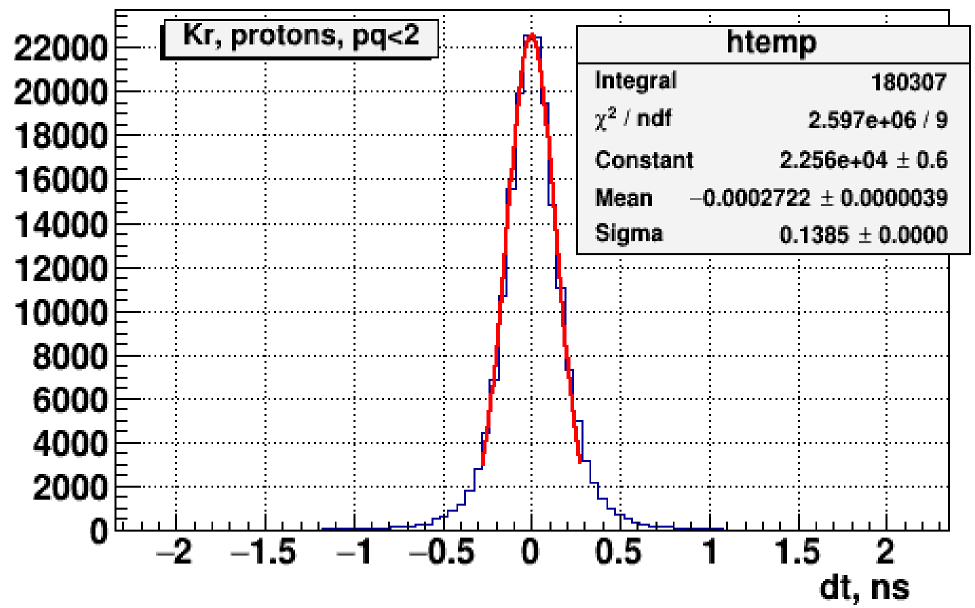




- Gaus2 – Kaon’s peak
- Gaus1 – background from pions
- pol0 – background from misidentified particles

Time resolution for Kr



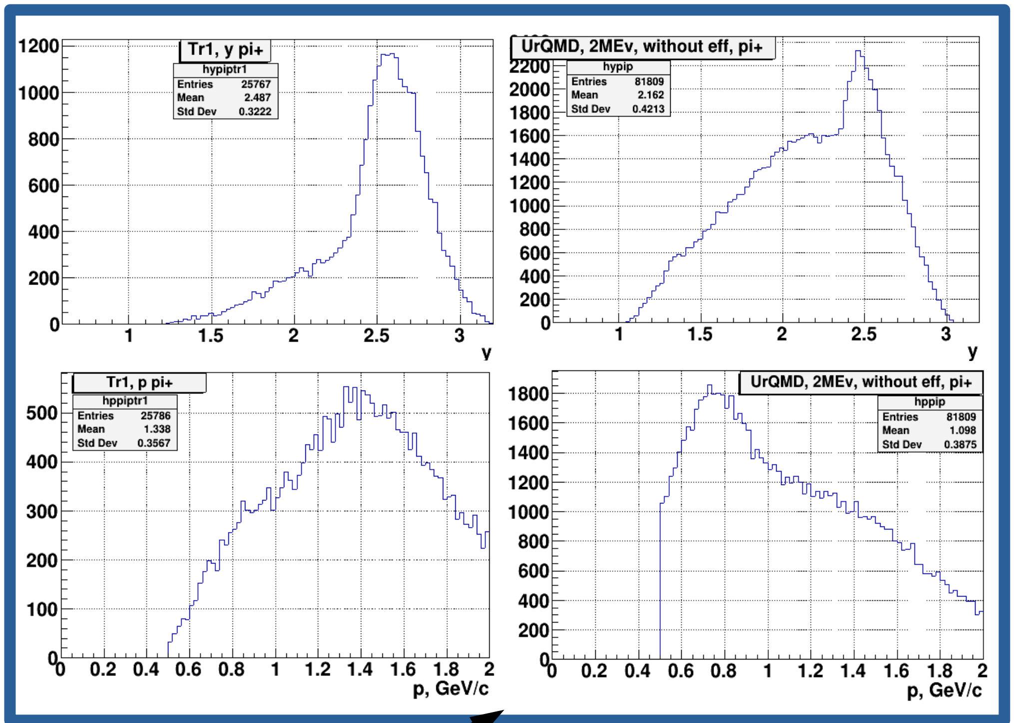


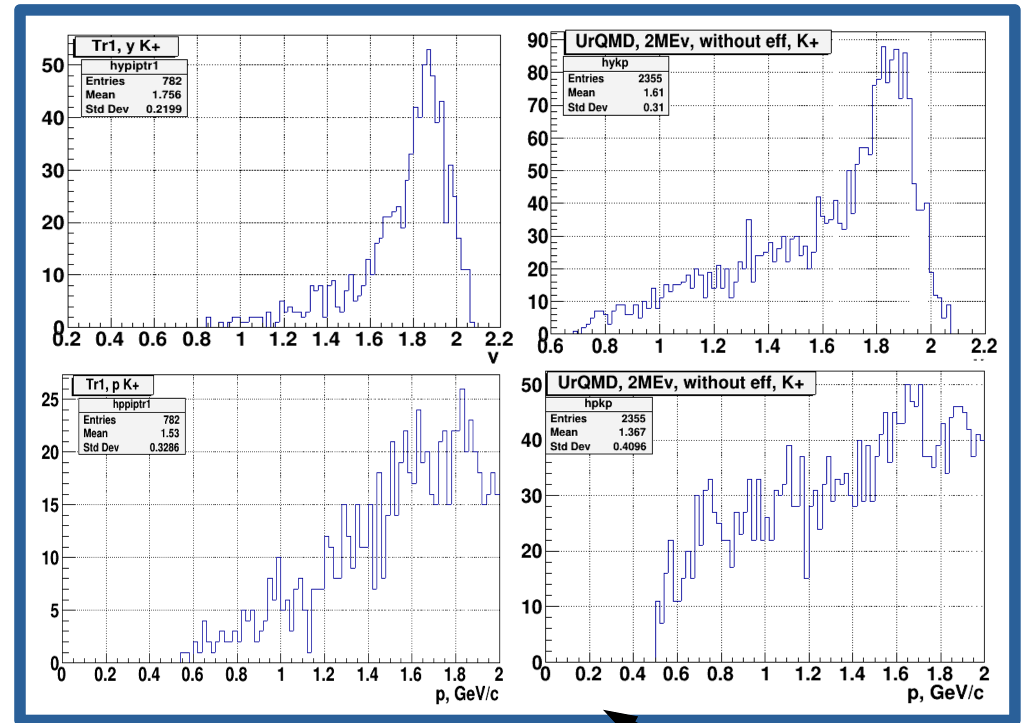
- Left – 2<p/q<5, right – p/q<2
- Time resolutions for Kr **~84 ps**
- It is similar to the **time resolution for Ar**

Content

- Discrepancy in y and p spectra for data and MC
- Efficiencies of GEM
- Efficiencies of CSC
- Efficiencies of TOF400
- Try GEM efficiencies before and after reconstruction
- Try primary vertex cuts
- Try the magnetic field Z shift
- Try the magnetic field scale
- residuals for GEM planes from data and MC
- Identification process automation

Discrepancy in y and p spectra for data and MC

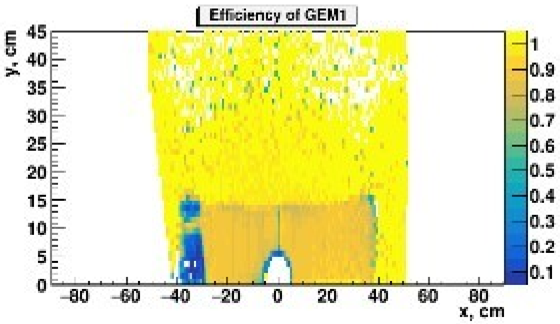


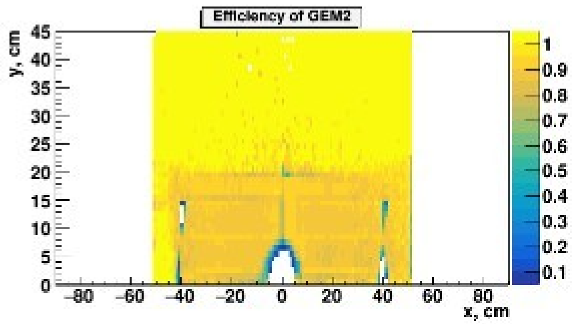


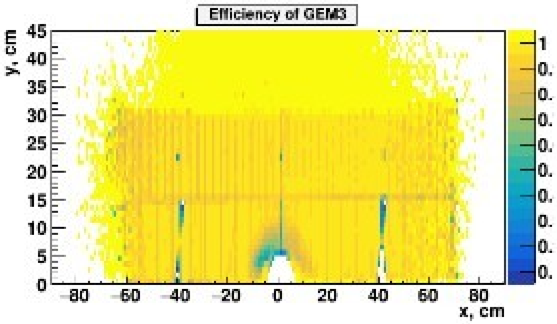
π^+ K^+

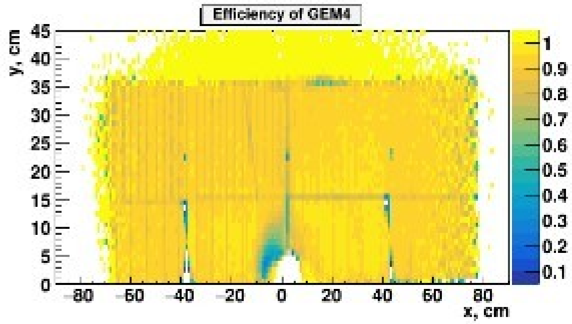
- In each box, top raw – y, bottom raw – p, left column – data, right column – MC (matching version 0, no efficiencies)
- Shapes and p peaks position for data and MC spectra are different

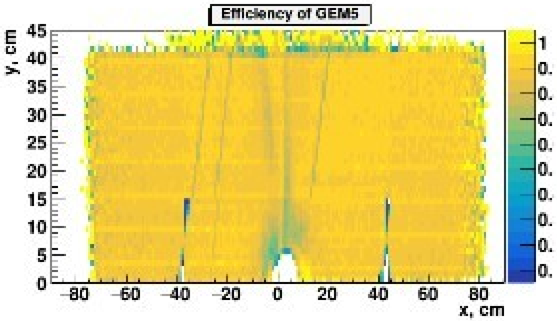
Efficiencies of GEM

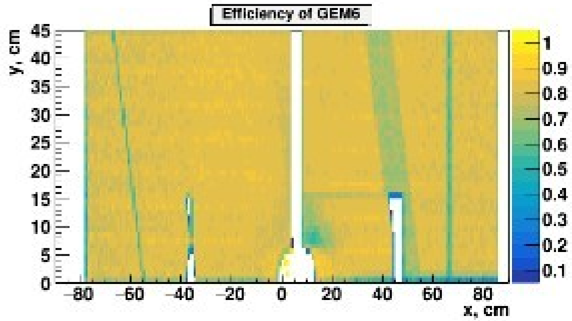






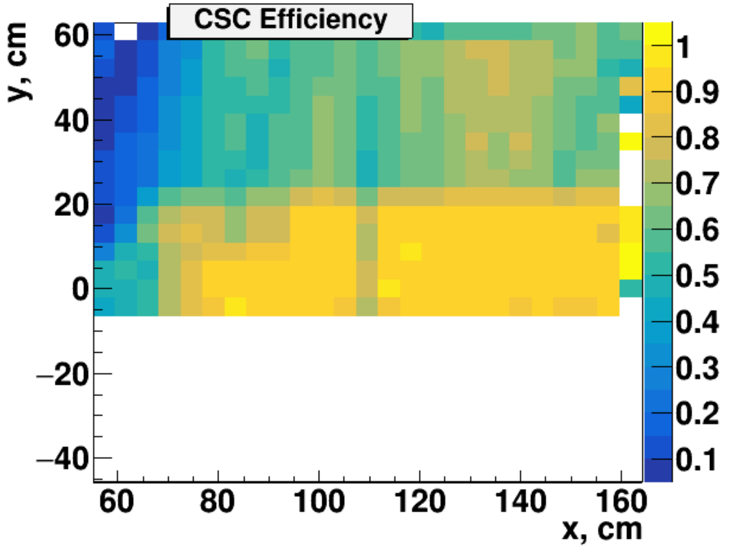




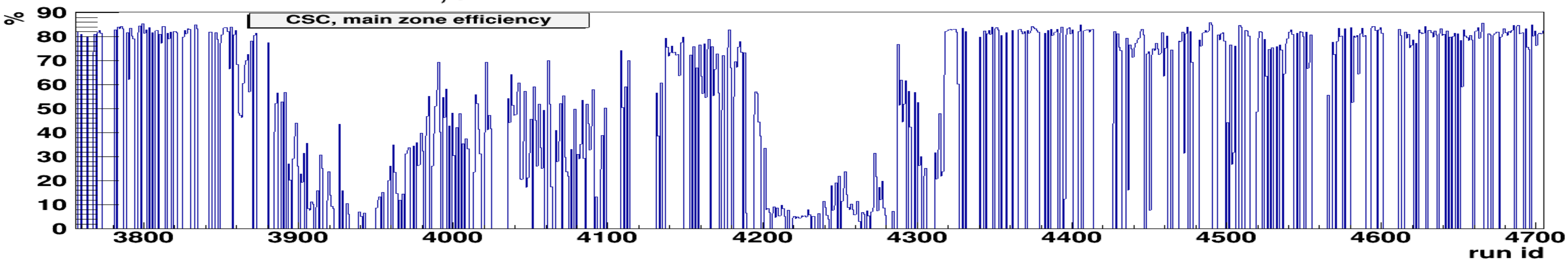


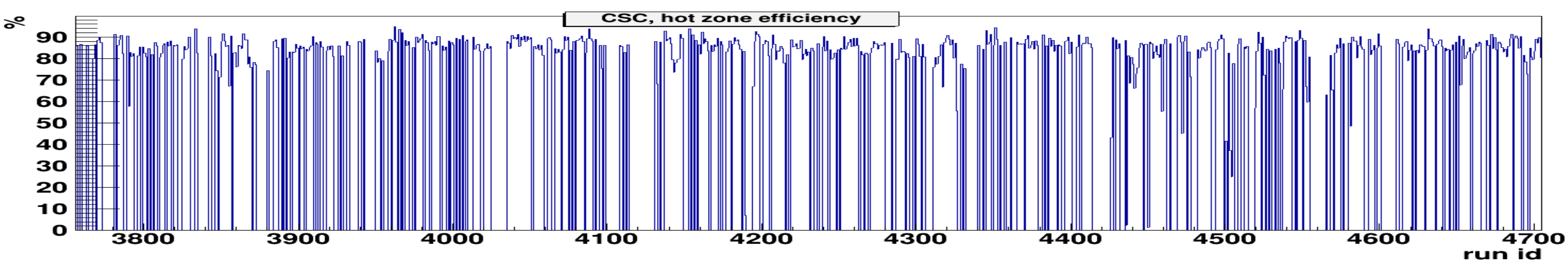
- Tracks with nhits>4 were used
- Same algorithm as for run 6
- Geometry bug is visible for GEM6

Efficiencies of CSC

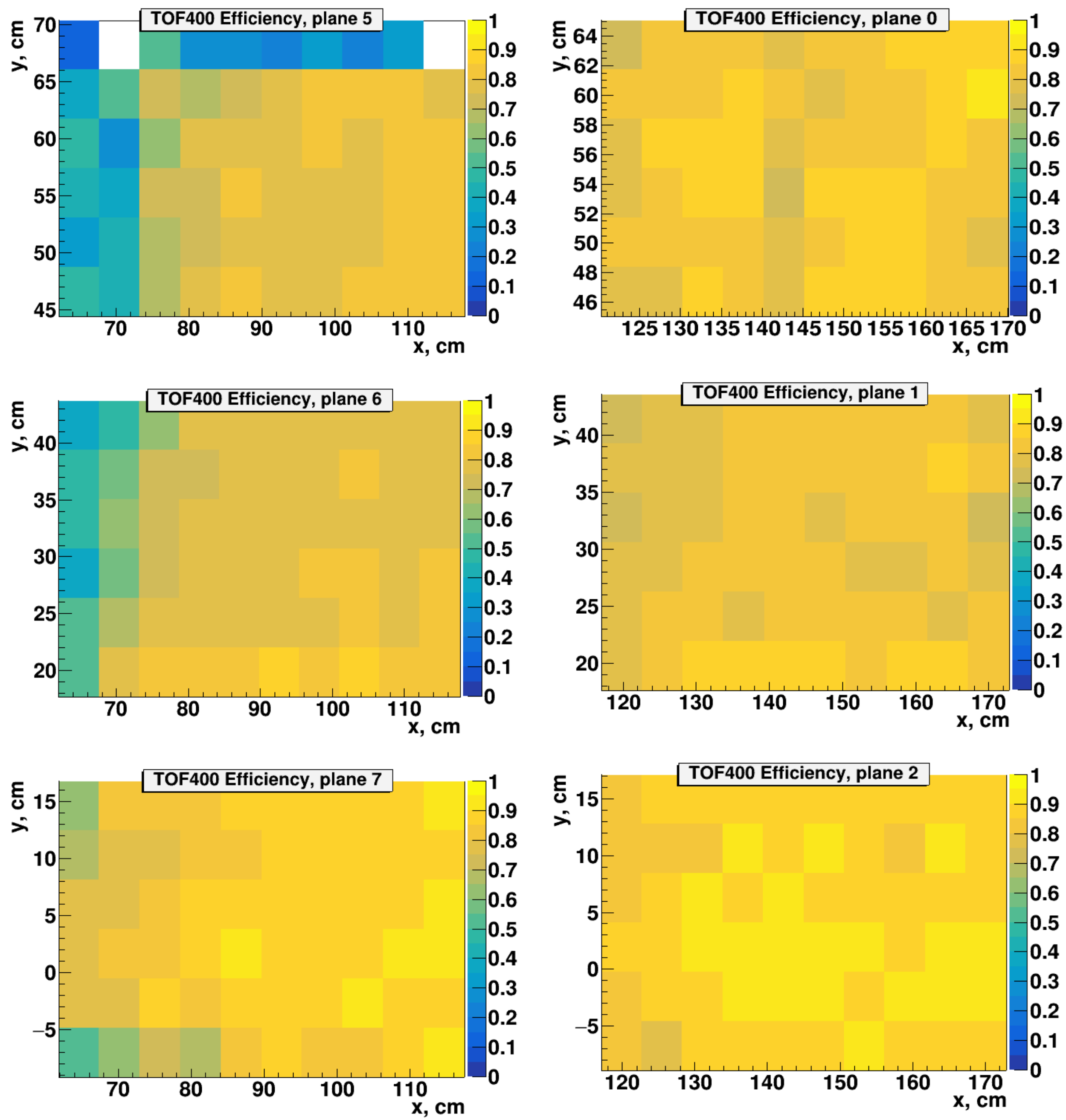


- Low efficiency at low x, large y
- There are deep drops of efficiency by runs in the main zone
- Hot zone efficiency is pretty stable





Efficiency of TOF400

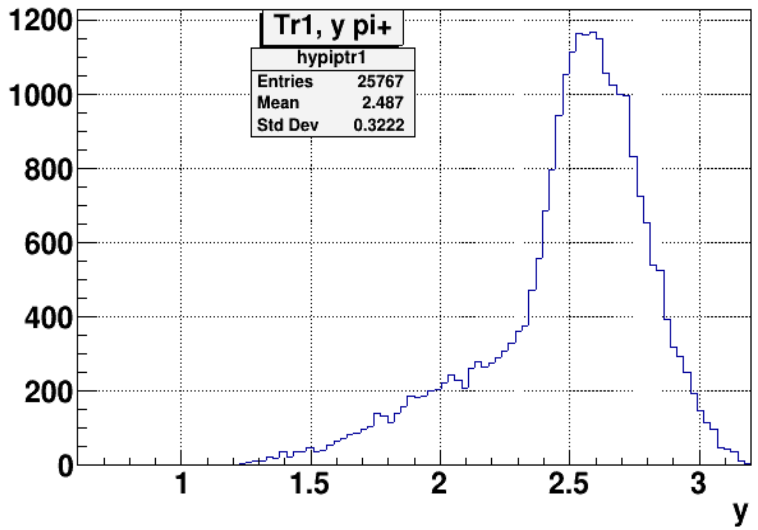


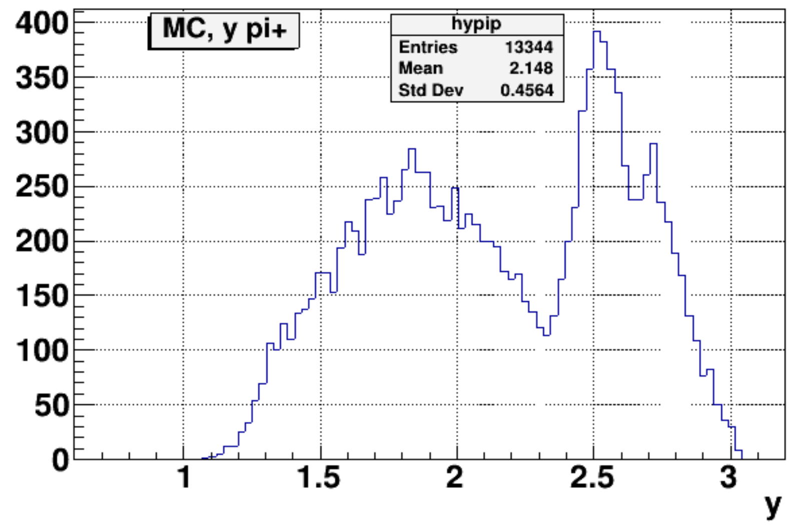
- From Exp, runs with stable CSC
- Min 5 GEM + CSC hit
- Low efficiency at low x (possible due CSC)

Identification algorithm for MC

- Same as for the data
- GEM track is extrapolated to the TOF400 Z position
- Matrix of all GEM tracks to TOF400 hits distances is calculated
- Pairs with smallest distances are selected
- Selected GEM tracks and TOF400 hits are not used during further selection

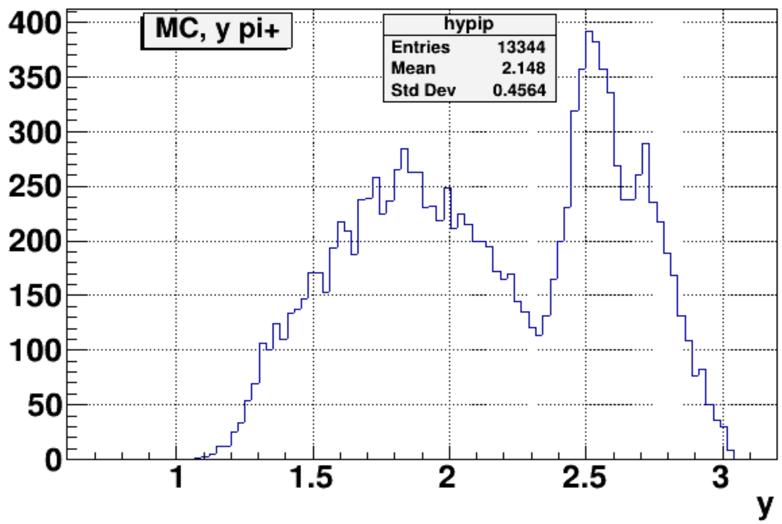
Discrepancy in y spectra for data and MC

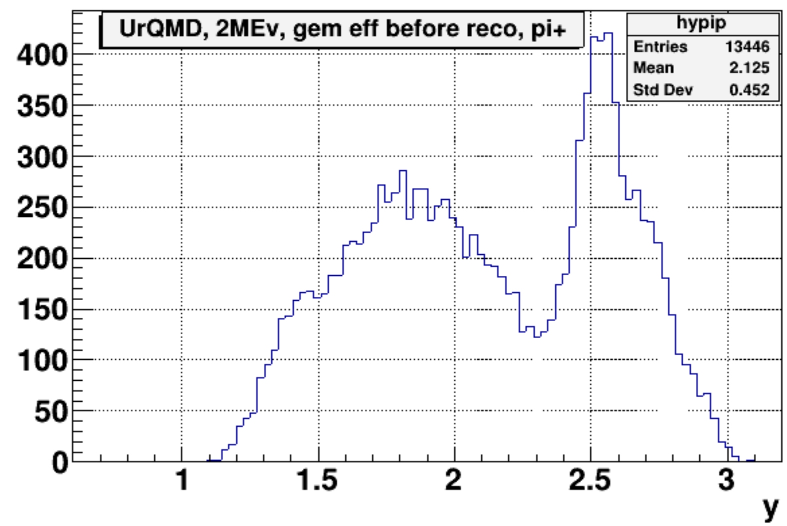




- Left – data, right – MC (matching version 1)
- MC is UrQMD with GEM, CSC, TOF400 efficiencies and the same identification algorithm as for the data
- Low part of data spectra contains less tracks than MC

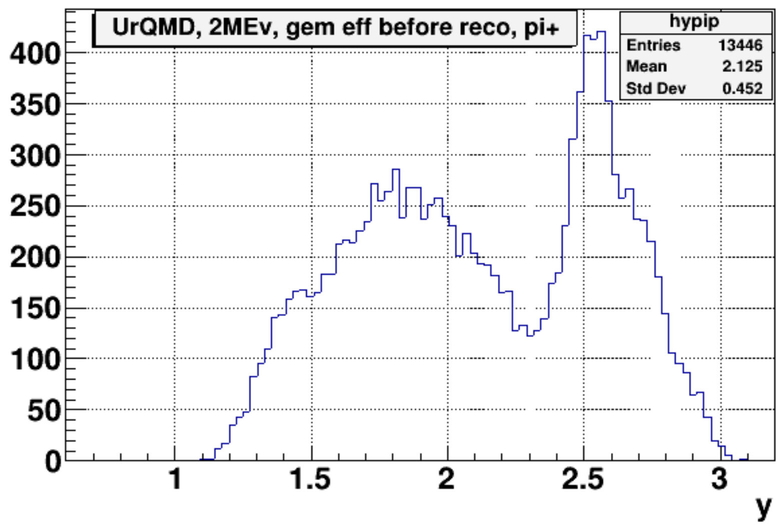
Try GEM efficiencies before and after reconstruction

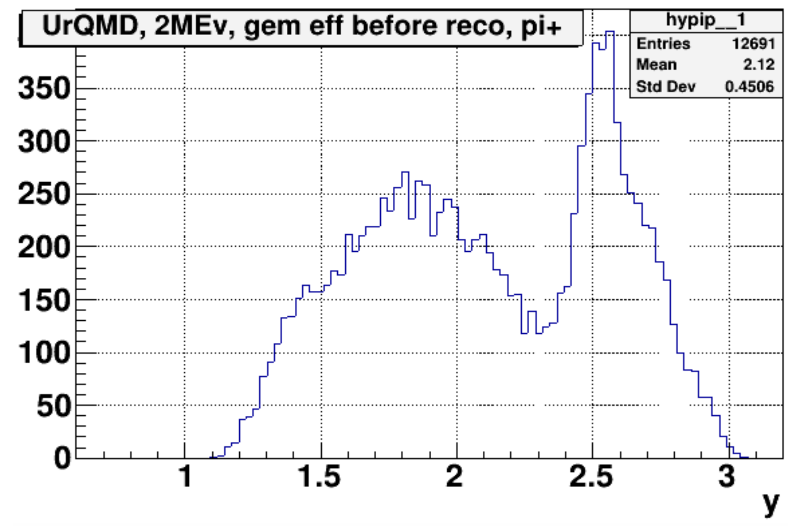




- Left – MC, eff after reco; right – MC, eff befo reco
- MC is UrQMD with GEM, CSC, TOF400 efficiencies and the same identification algorithm as for the data
- Both distributions are pretty similar

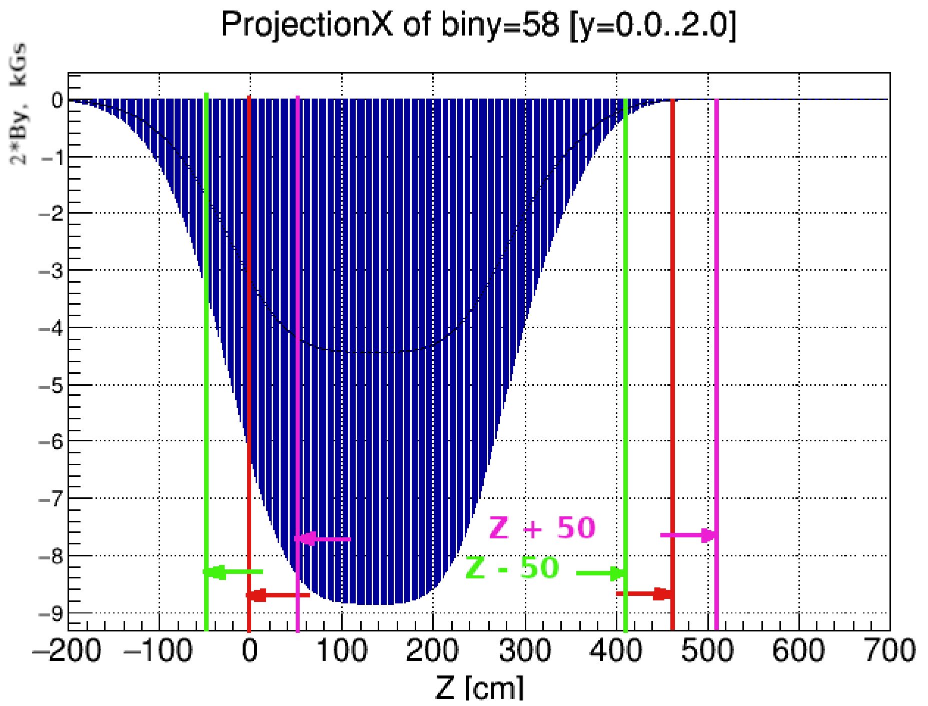
Try primary vertex cuts





- Left – MC, without pv cuts; right – MC, with pv cuts
- MC is UrQMD with GEM efficiencies befo reco and CSC, TOF400 efficiencies, the same identification algorithm as for the data
- Both distributions are pretty similar

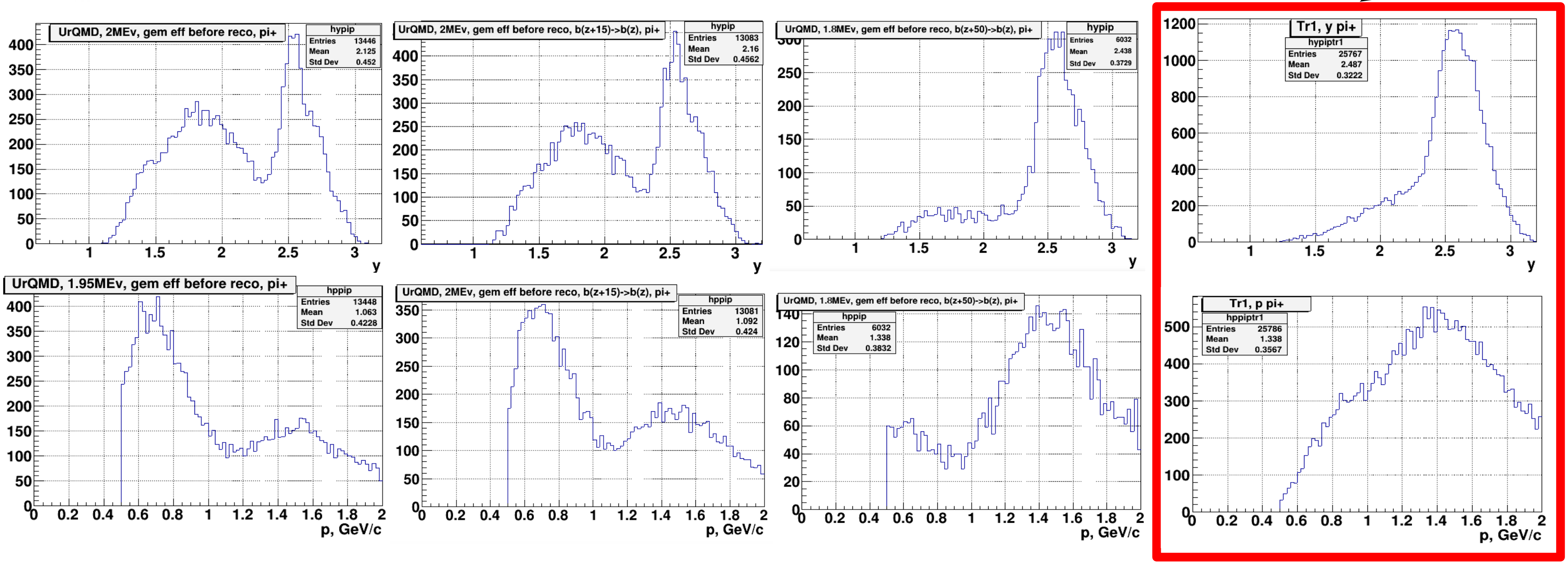
Try the magnetic field Z shift



- Distribution of 2·By(0,0,z) (900A)
- We use 0<z<460 cm interval during identification process

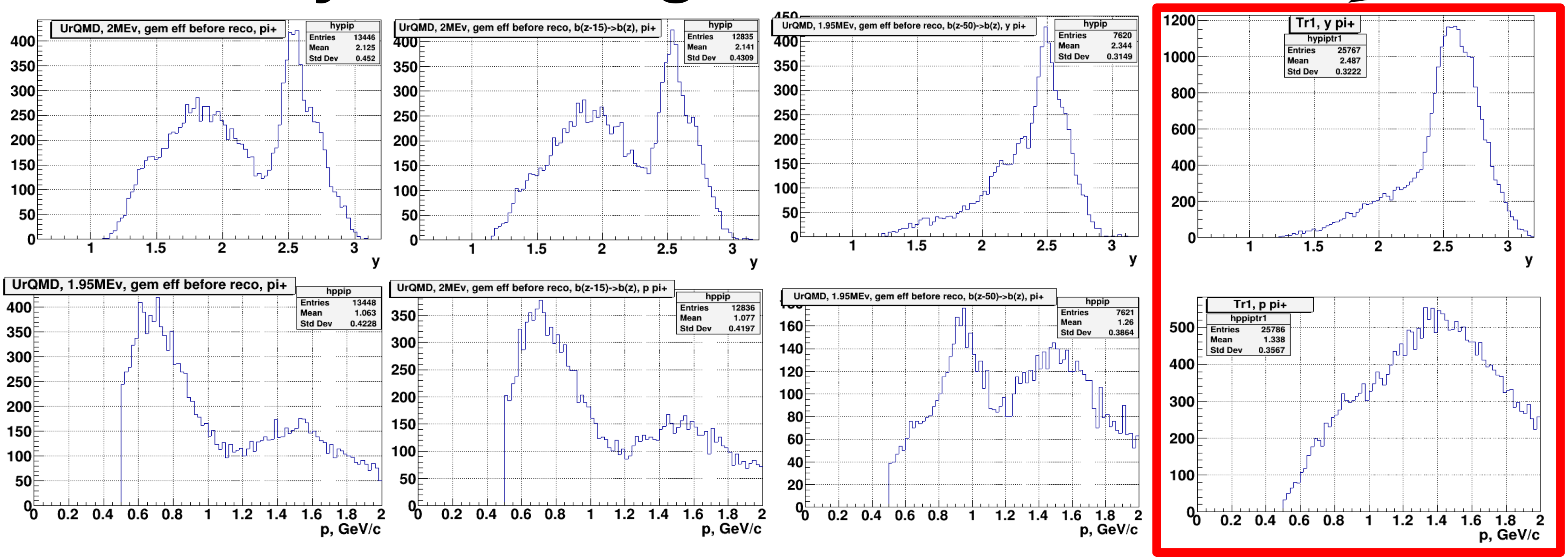
Try the magnetic field Z shift

data



- From left to right: MC; MC, B(z+15)→B(z); MC, B(z+50)→B(z); data. Top raw – y, bottom raw – p
- MC is UrQMD with GEM efficiencies befo reco and CSC, TOF400 efficiencies, the same identification algorithm as for the data
- Better agreement with data was obtained for MC, B(z+50)→B(z). Shapes for data and MC are compatible. Most discrepancy in the lower part of spectra

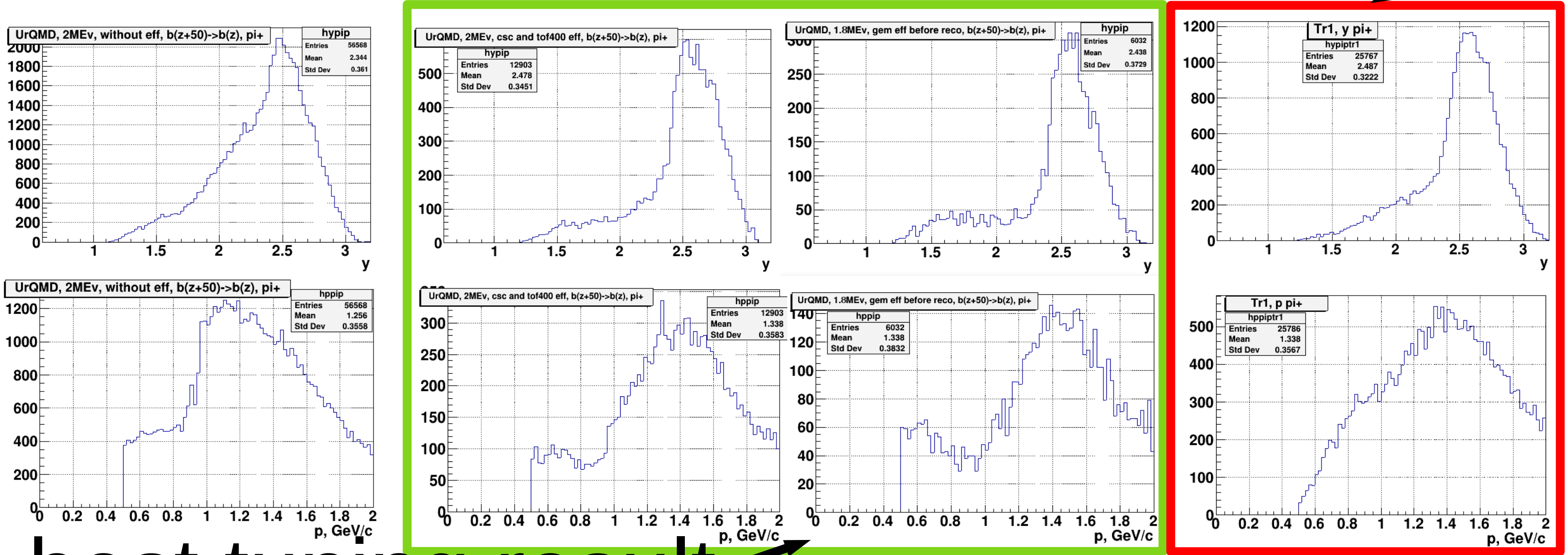
Try the magnetic field Z shift



- From left to right: MC; MC, B(z-15)→B(z); MC, B(z-50)→B(z); data. Top raw – y, bottom raw – p
- MC is UrQMD with GEM efficiencies befo reco and CSC, TOF400 efficiencies, the same identification algorithm as for the data
- For y. Better agreement with data was obtained for MC, B(z-50)→B(z). Shapes for data and MC are compatible. Most discrepancy in the upper part of spectra
- For p. Agreement significantly worse than for B(z+50)→B(z)

Try the magnetic field z+50->z shift and efficiencies

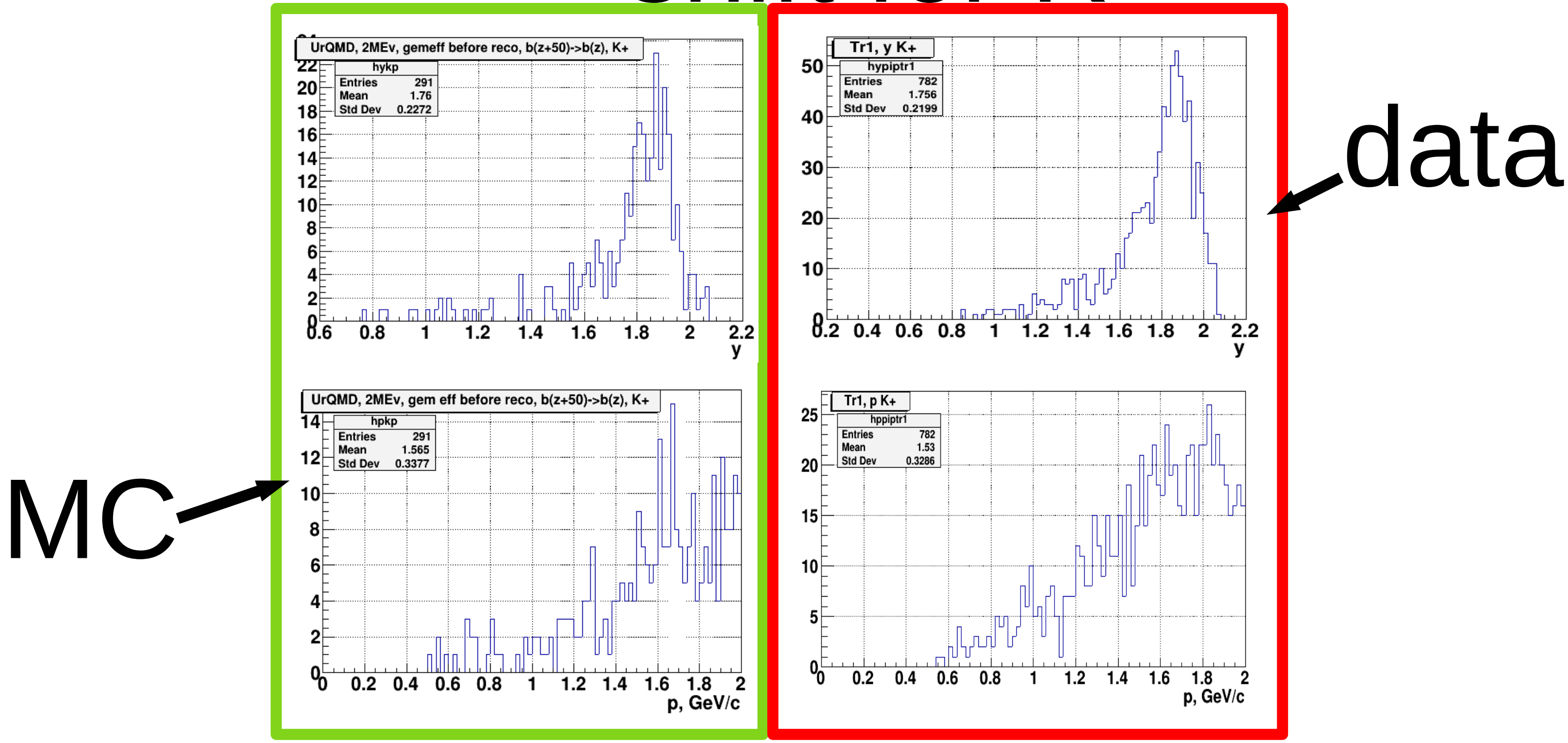
data



best tuning result

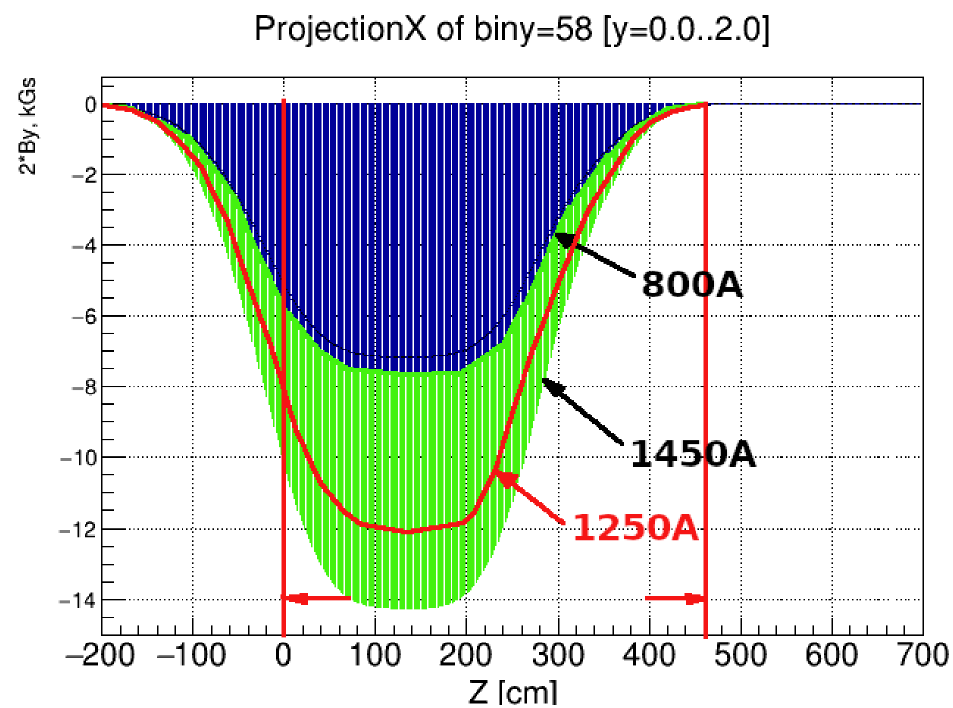
- From left to right: MC without efficiencies; MC with CSC and TOF400 efficiencies; MC with all efficiencies; data
- MC is UrQMD, the same identification algorithm as for the data
- Efficiencies change y and p spectra significantly. We need to take into account efficiencies which we got
- Most discrepancy in the lower part of p spectrum

Try the magnetic field z+50->z shift for K^+



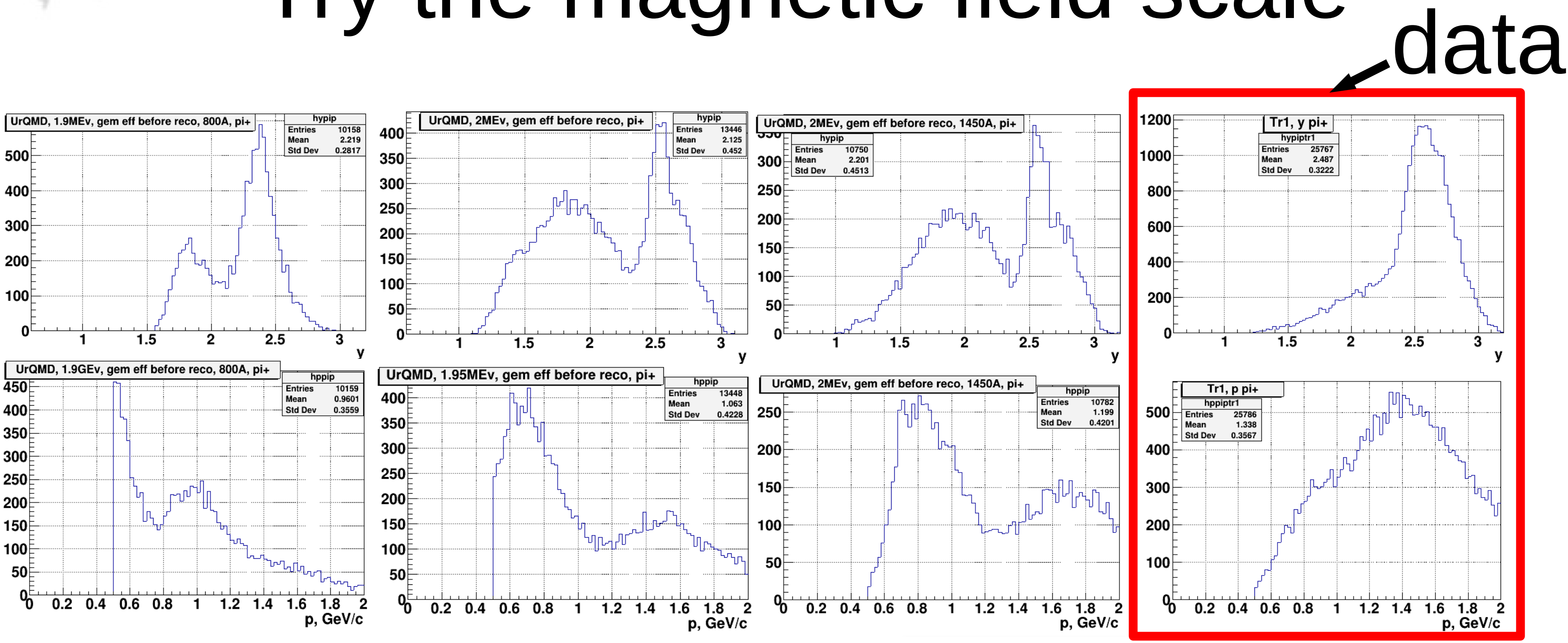
- The same spectra as on the previous slide but for K^+
- MC is UrQMD, the same identification algorithm as for the data
- The K^+ spectra for data and MC look pretty similar

Try the magnetic field scale



- Distribution of 2·By(0,0,z)
- 1250 A – working current
- We try use 800<I<1450 A interval during identification process

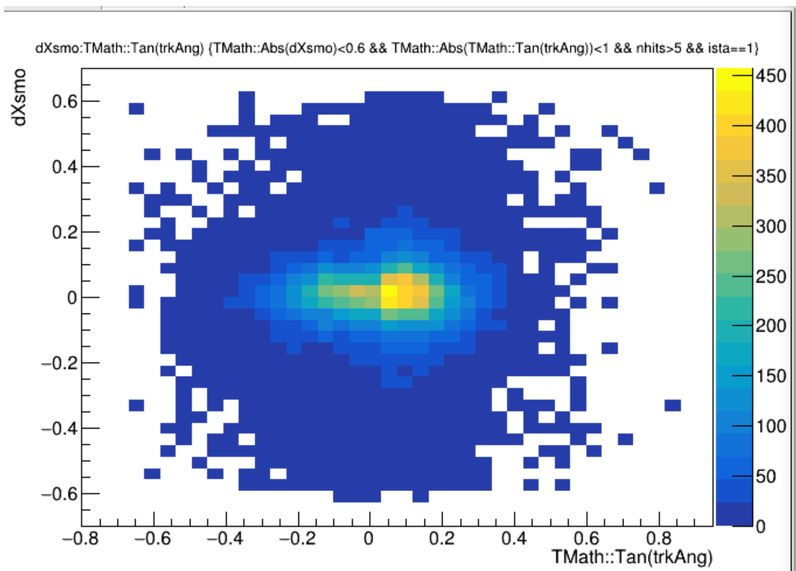
Try the magnetic field scale

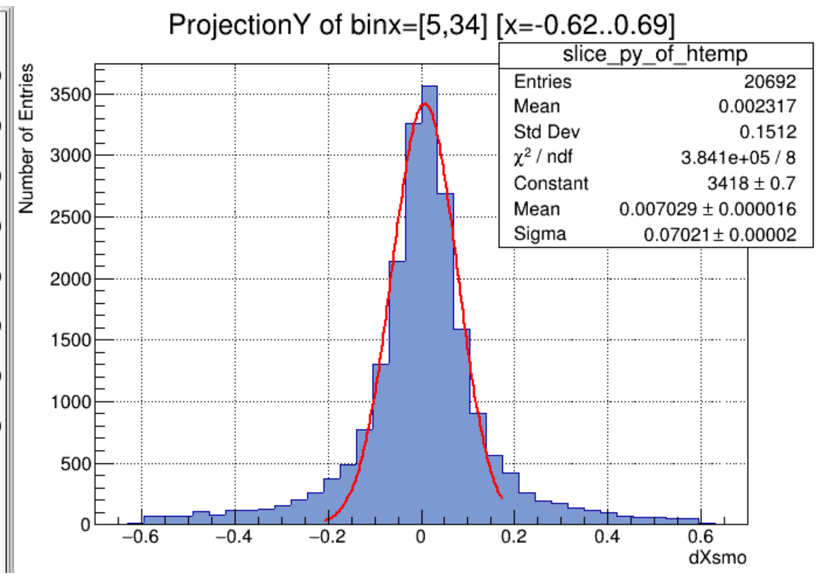


- From left to right: MC, 800A; MC, 1250A; MC, 1450A; data
- MC is UrQMD with GEM efficiencies befo reco and CSC, TOF400 efficiencies, the same identification algorithm as for the data
- The magnetic scale changes width of the peaks
- Changing of the magnetic scale does not give us proper shape of the spectra

X residuals for GEM planes from data and MC

	GEM1	GEM2	GEM3	GEM4	GEM5	GEM6
σ_{data},um	702	432	408	363	345	583
σ_{MC},um	351	273	213	197	264	352



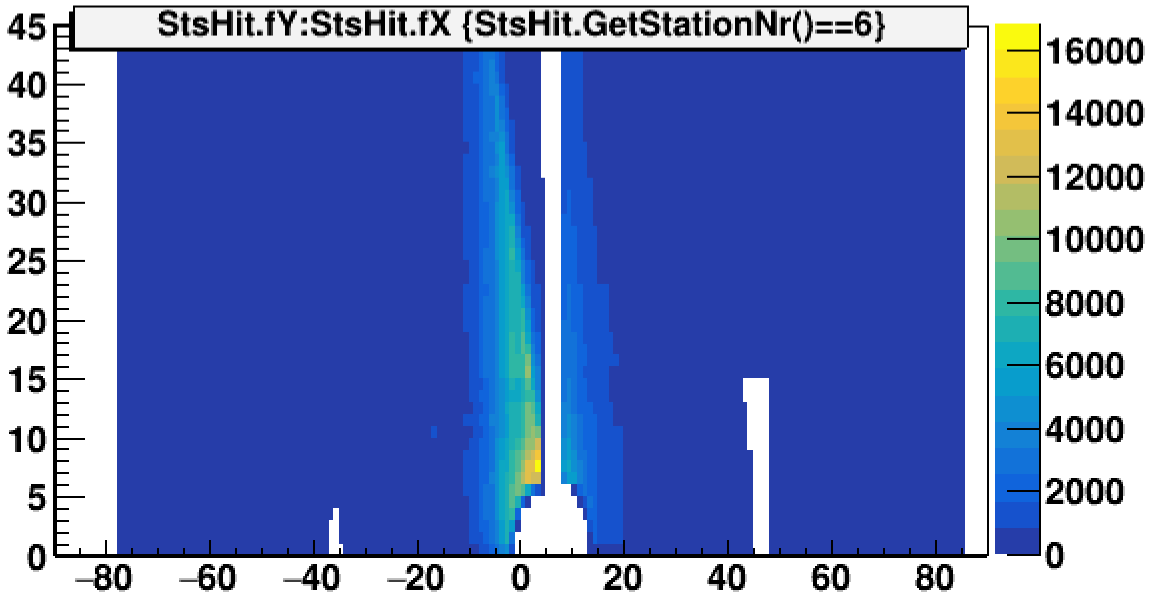


- An example for GEM1 from data
- Left – x residuals vs tan(α_{zox}); x residuals
- Residuals for GEM1 and GEM6 have largest values
- Residuals for data approximately twice larger than for MC

TODO

- Implement internal physical details of GEM into MC as for carbon run
- Try to take into account MC reconstruction algorithm efficiencies
- Use CSC implementation in MC
- It would be useful to check identification in data with Z field shift (we need to have automated analysis process for that)

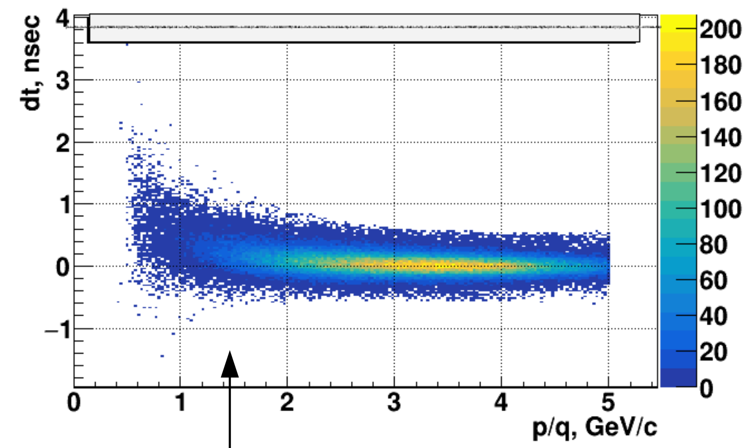
Bug in geometry for GEM

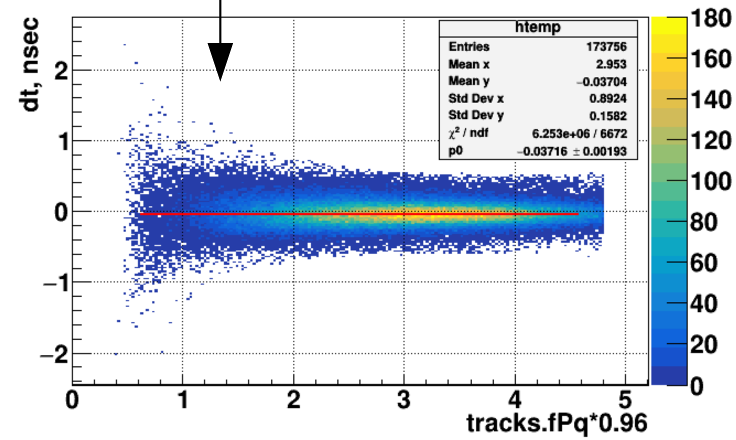


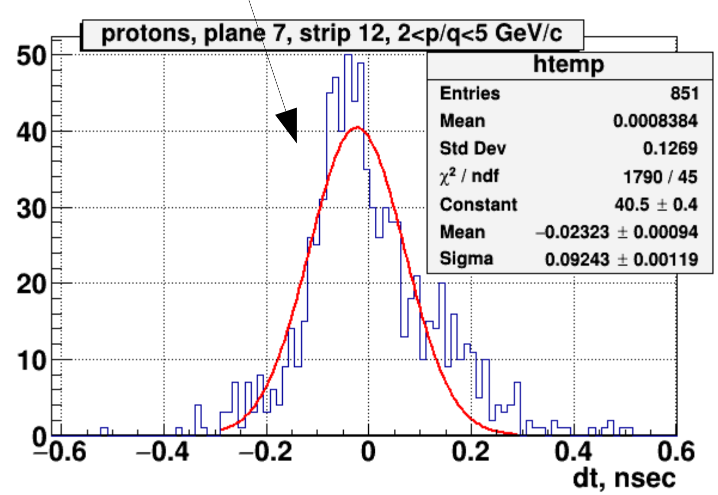
- GEM6 here
- Wrong X shift for one of GEM6 modules
- Wrong geometric filter for all GEM planes
- Identification process automation is needed

Evaluation identification steps

1. TOF400 hits and GEM+CSC tracks (verify digits by run #)
2. Match GEM+CSC tracks with TOF400 hits (compare to QA hists)
3. Sorting runs by triggers and targets (verify files by run #)
4. Add trigger and primary vertex info (compare to QA hists)
5. Correction of momentum and masses of identifiable tracks (compare to QA hists, check fit functions)







Kovachev L.

Plans for Identification process automation

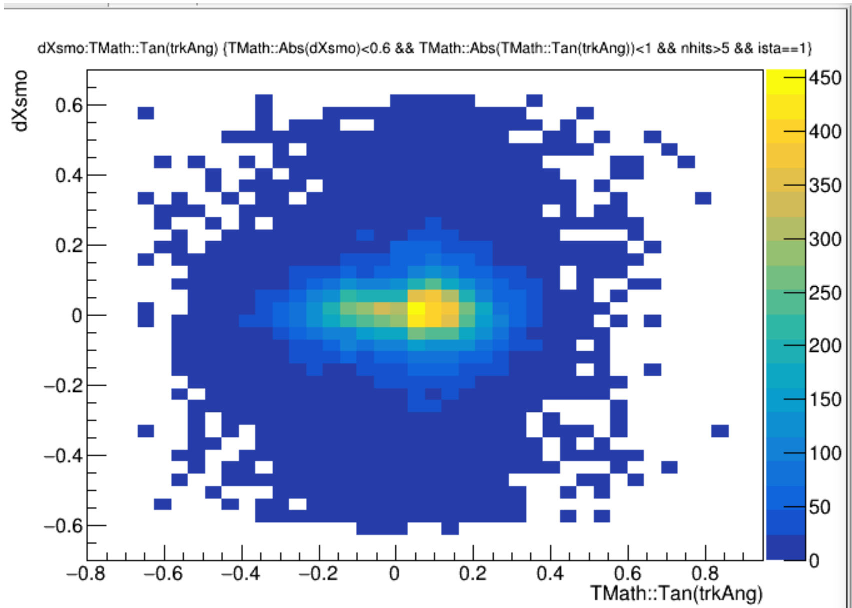
- Merge scattered analysis into ordered chain
- Validate new methods with previous results
- Documentation for analysis stages
  (with extended description)
- Automation of all manually done processes
  (sort runs by triggers and targets)
- Quality assurance histograms at each step

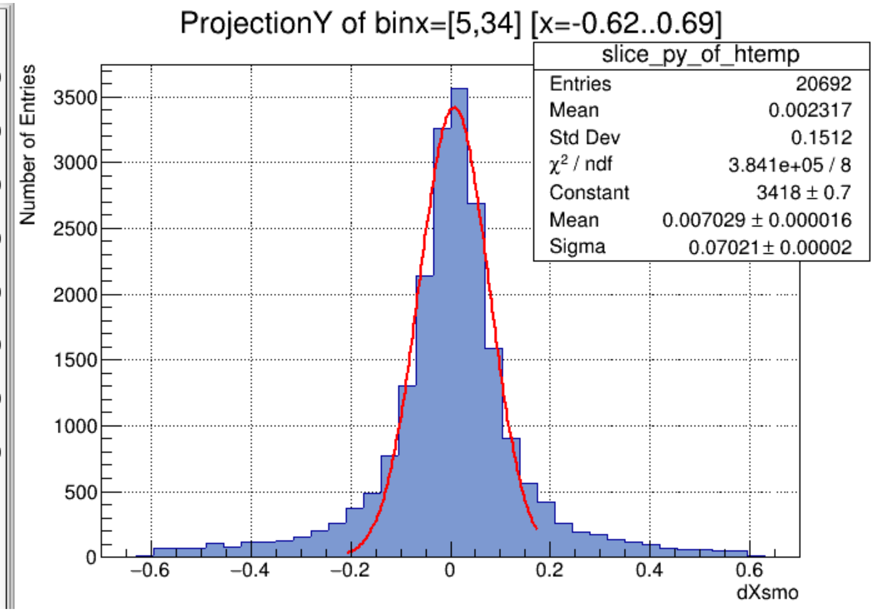
Kovachev L.

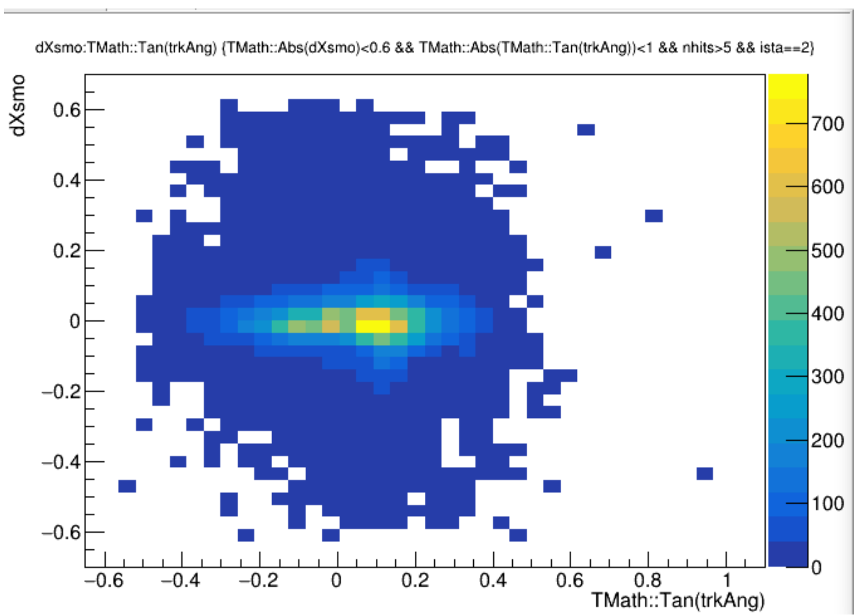
Thank you!

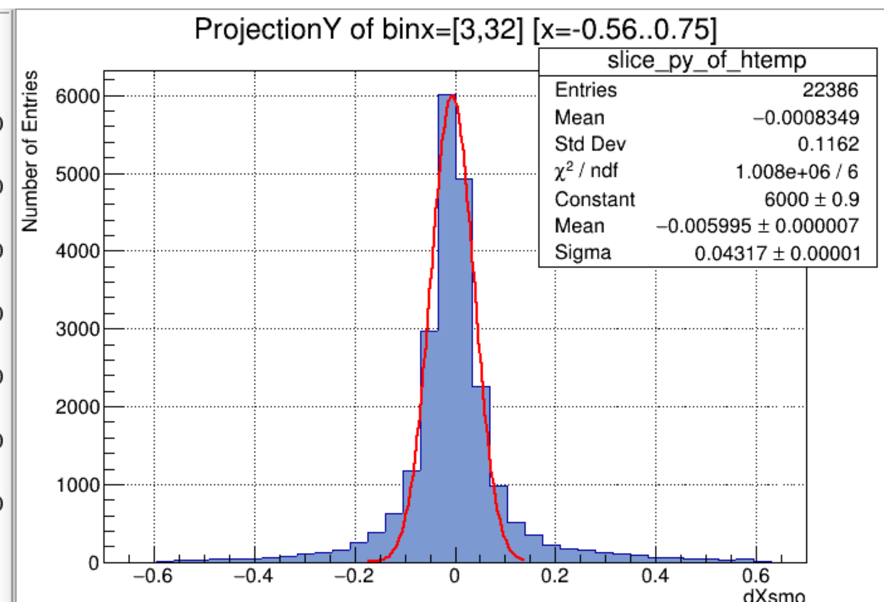
Backup

X residuals for GEM1 and GEM2 from data

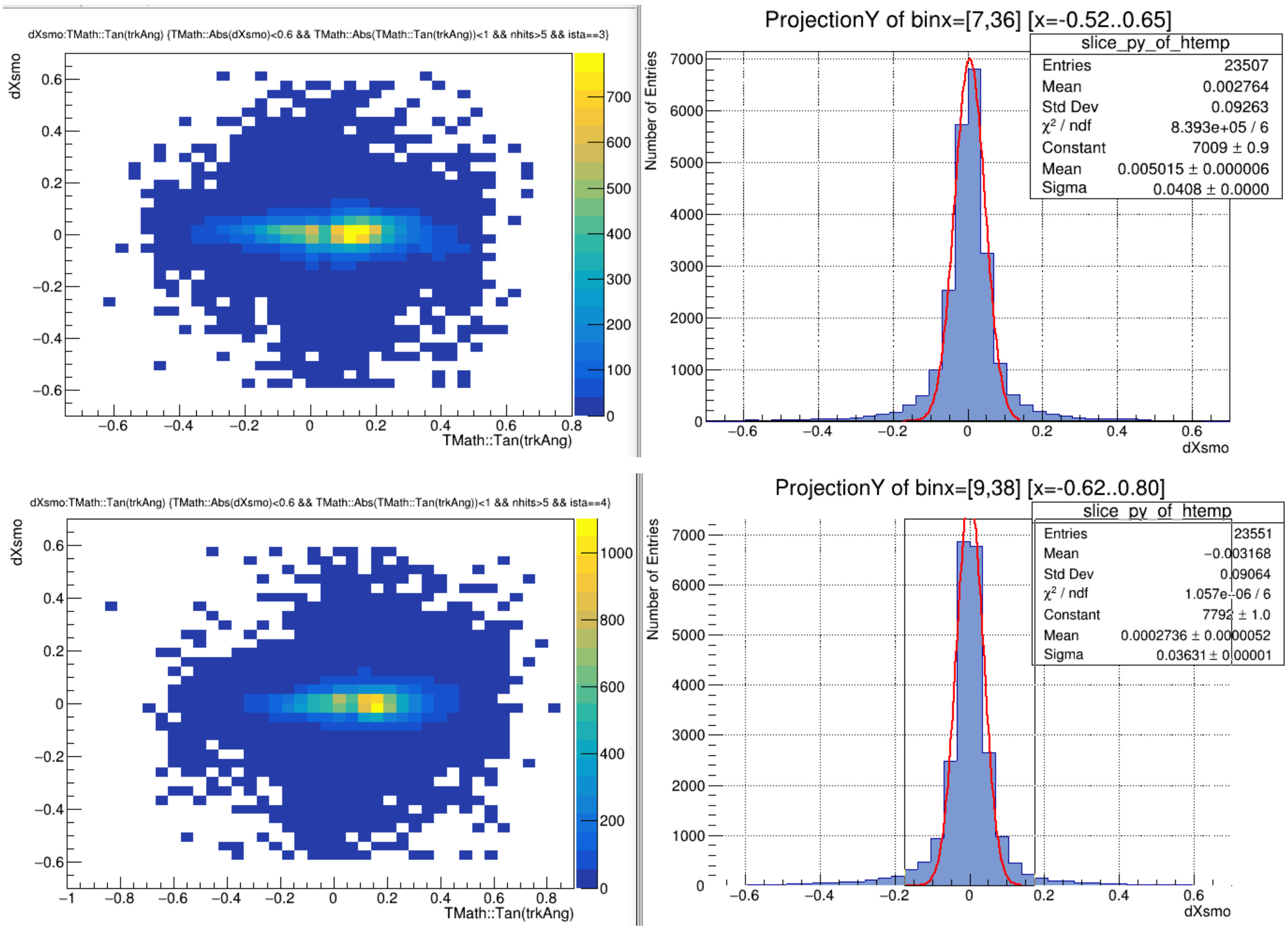




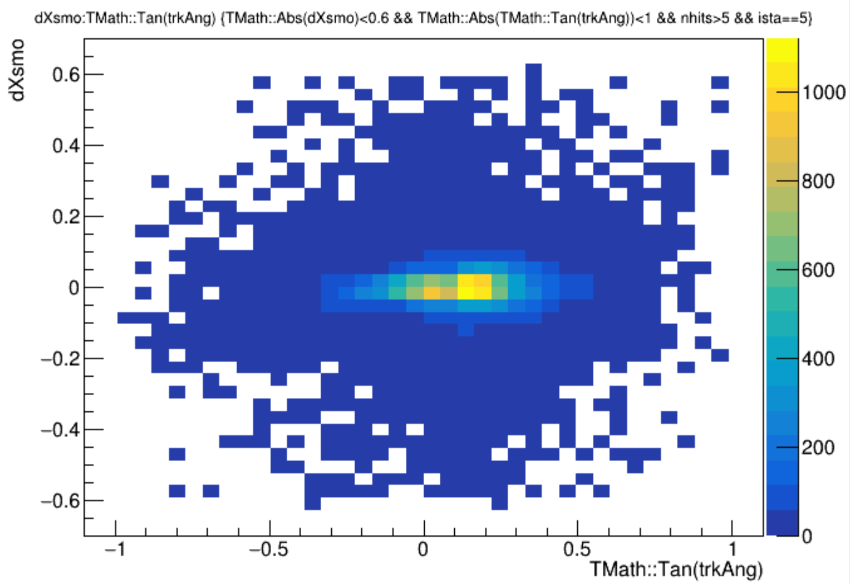


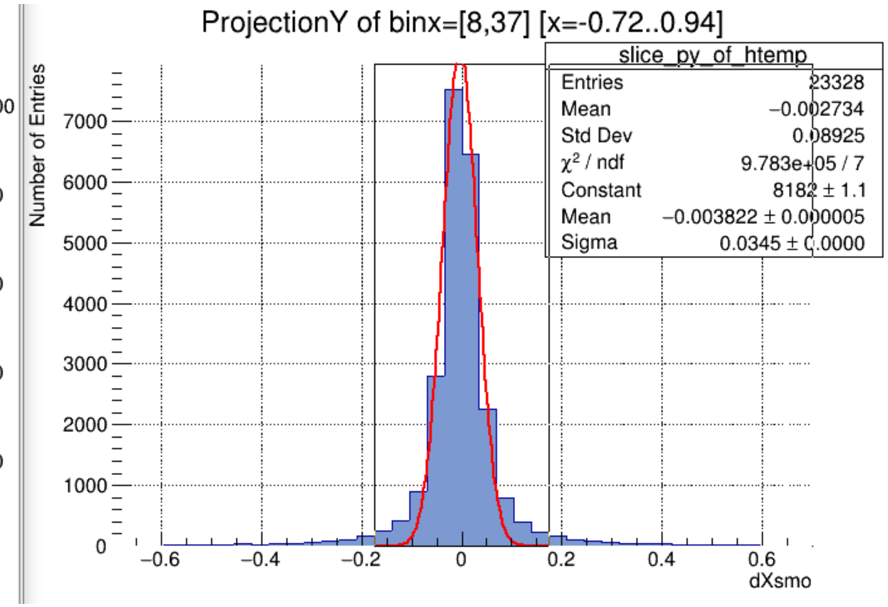


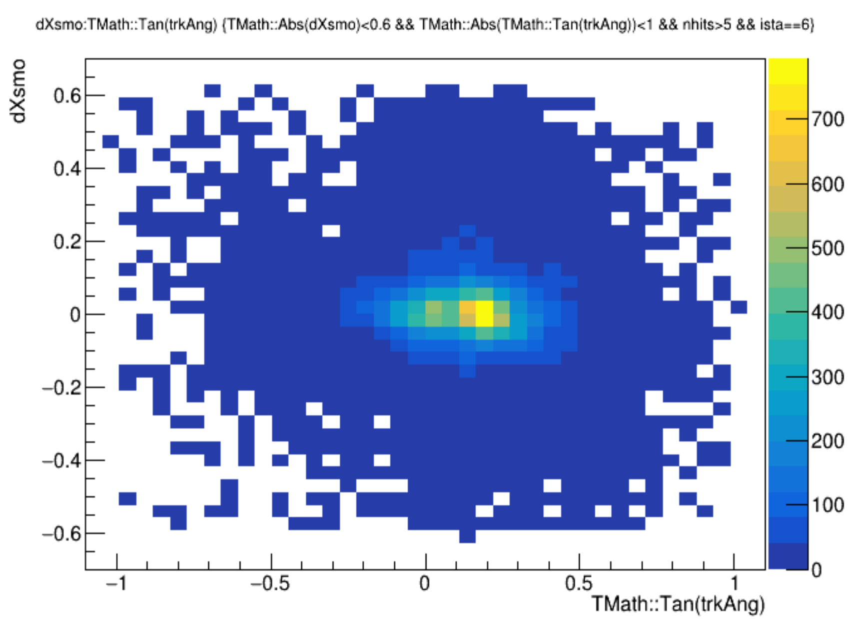
X residuals for GEM3 and GEM4 from data

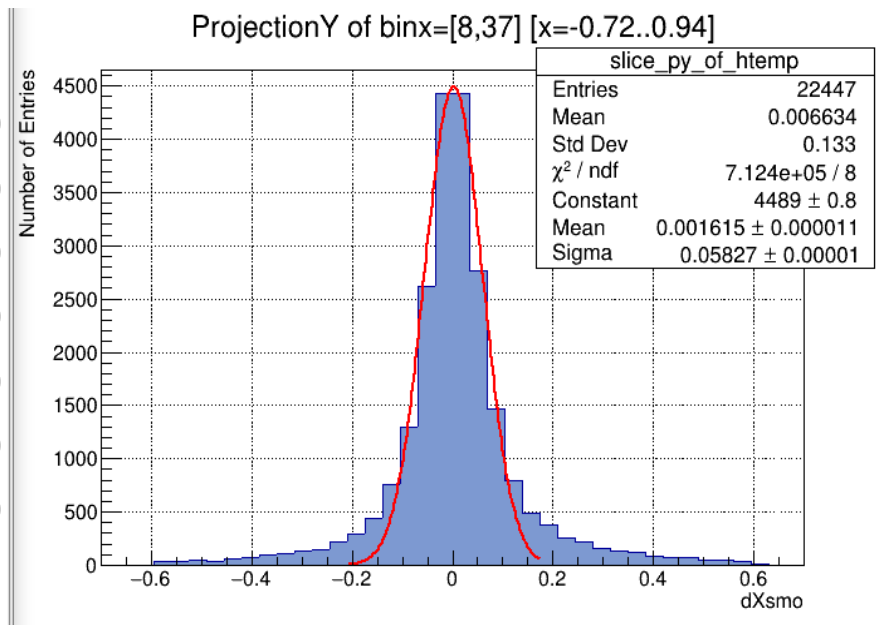


X residuals for GEM5 and GEM6 from data

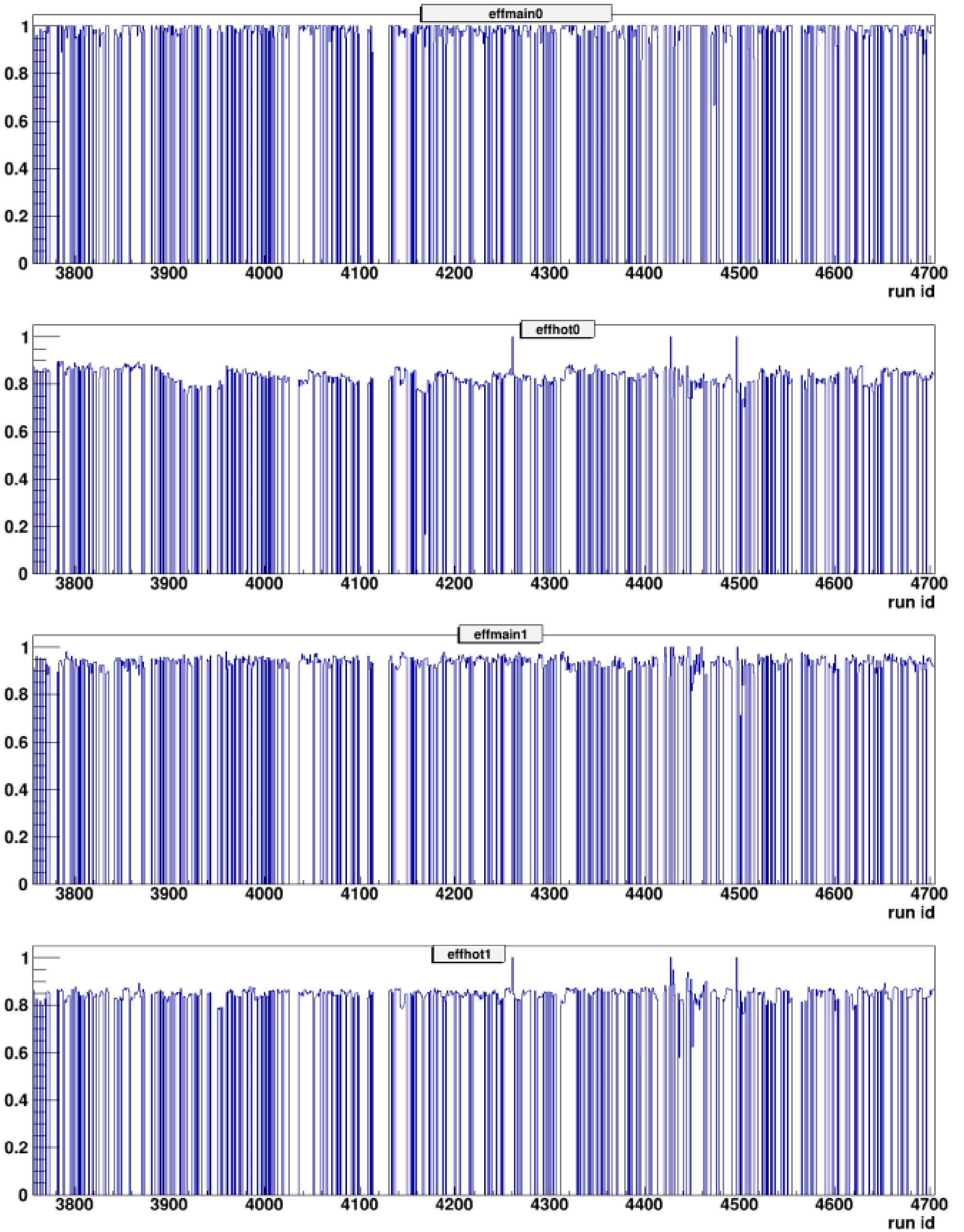






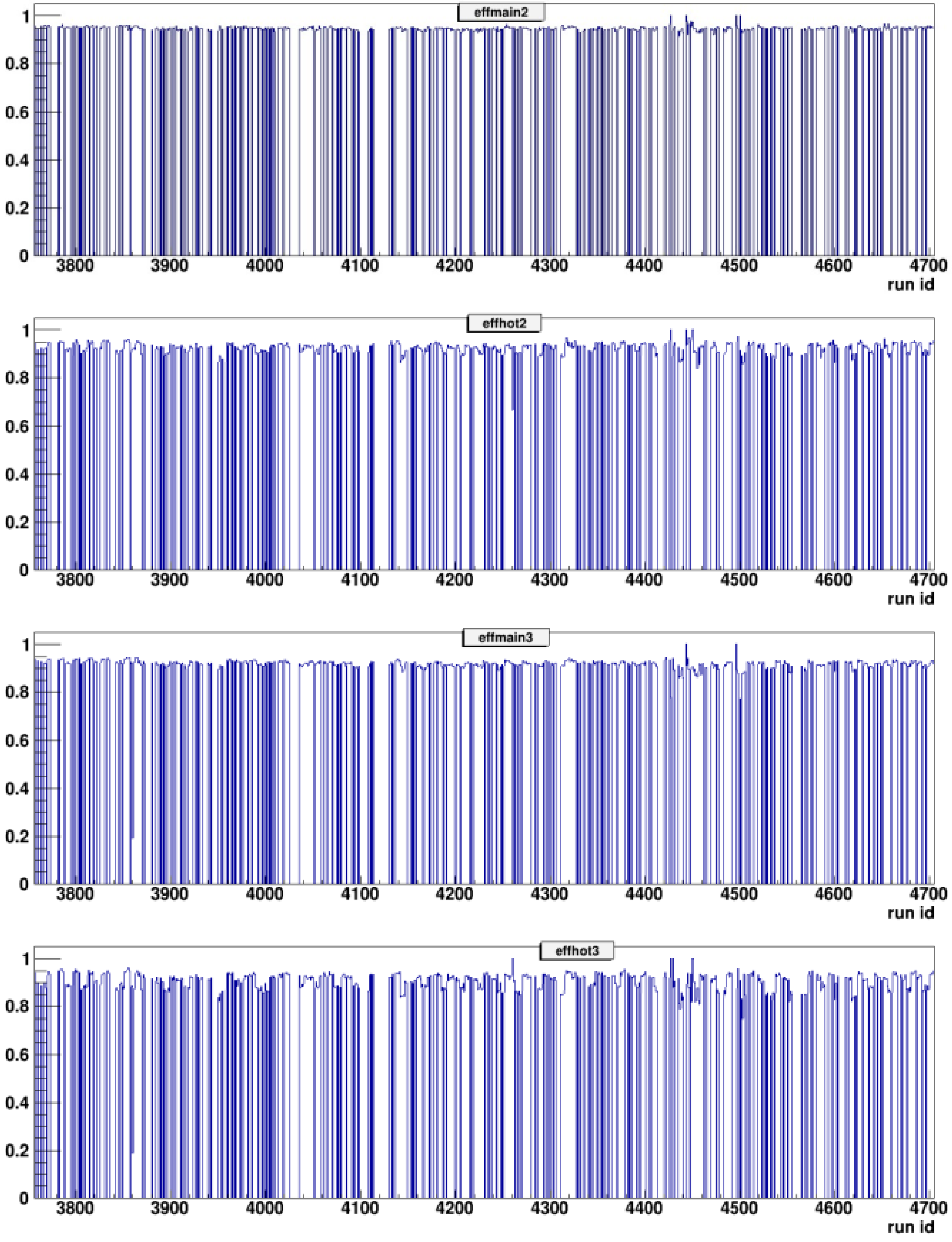


Efficiency of GEM by run id



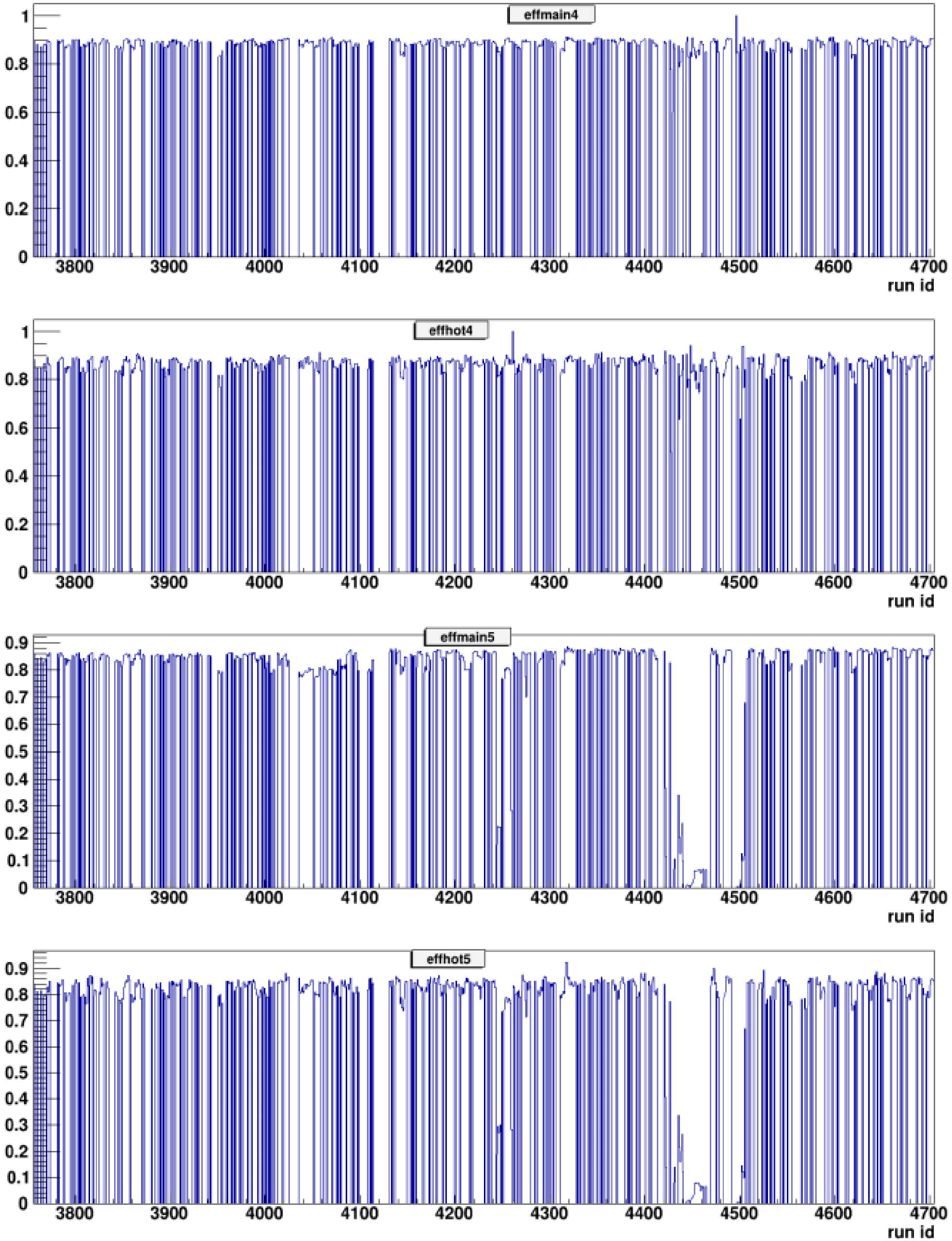
- Main and hot zones for GEM1 and GEM2 here
- GEM efficiency is pretty stable

Efficiency of GEM by run id



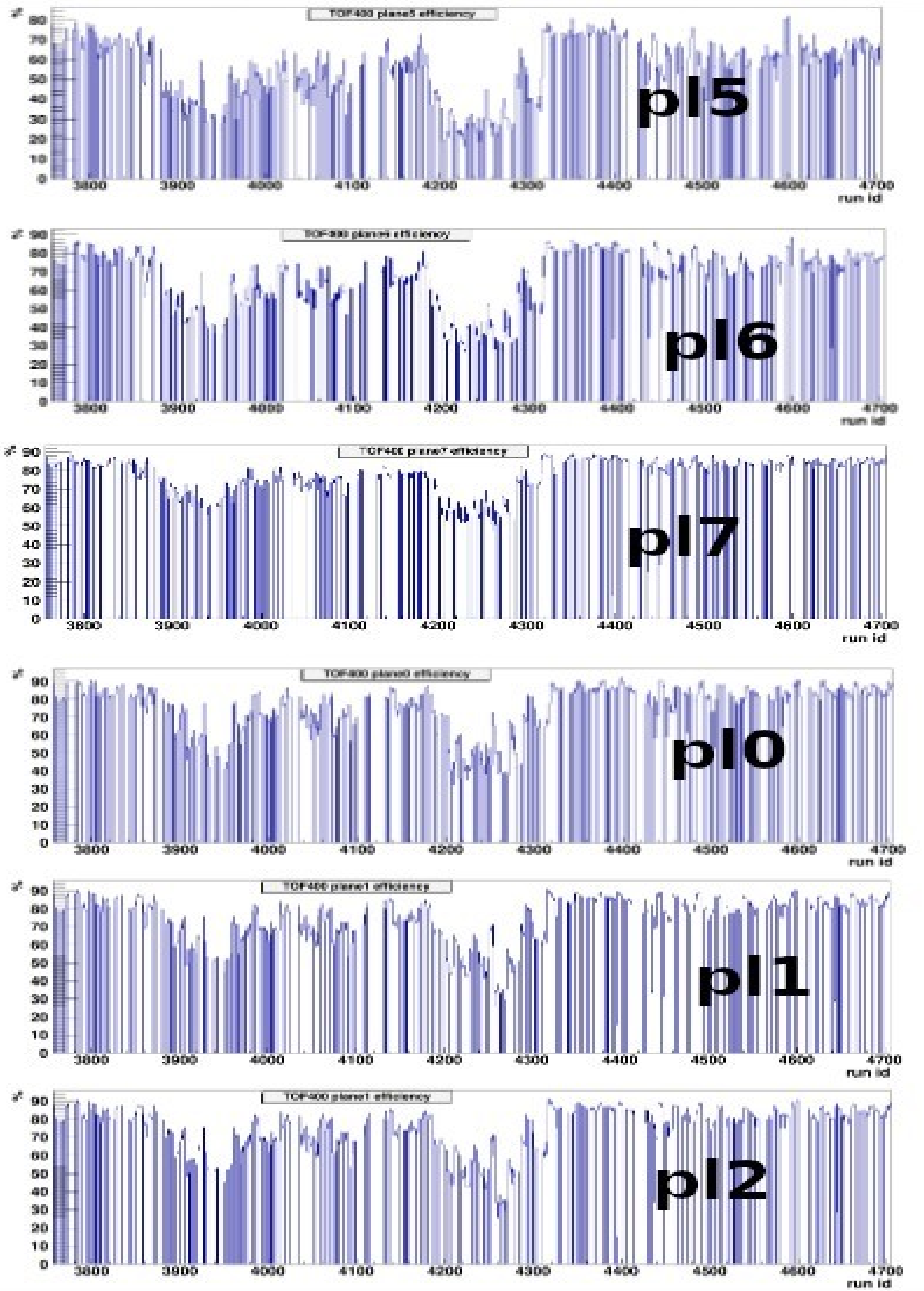
- Main and hot zones for GEM3 and GEM4 here
- GEM efficiency is pretty stable

Efficiency of GEM by run id



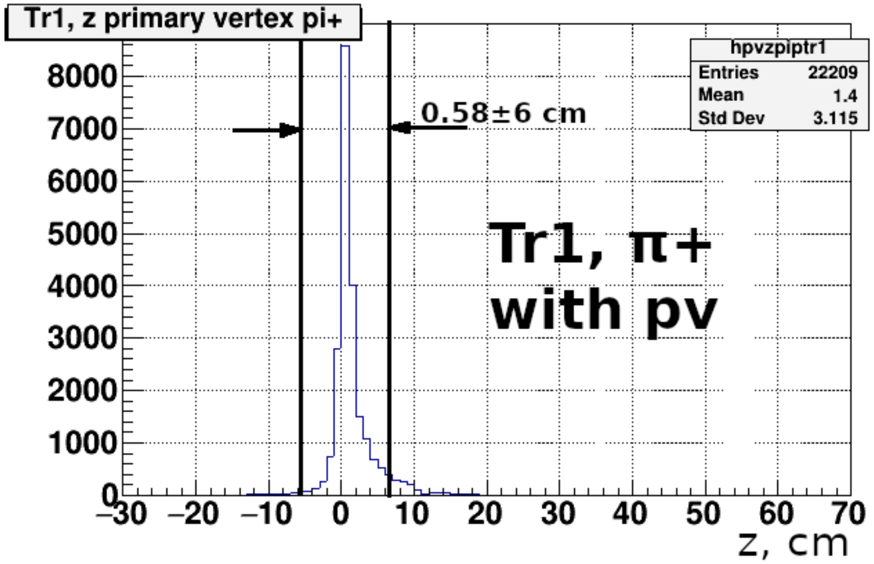
- Main and hot zones for GEM5 and GEM6 here
- GEM efficiency is pretty stable
- Small efficiency drop for GEM6 is visible

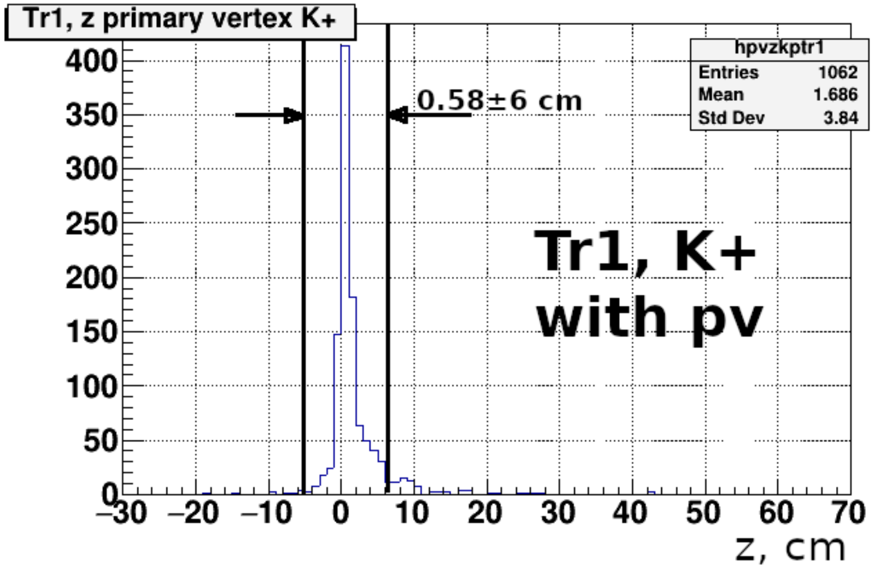
Efficiency of TOF400 by run id



- TOF400 efficiency drops for the same runs as for CSC
- We use stable CSC runs to calculate TOF400 efficiency to include it into MC

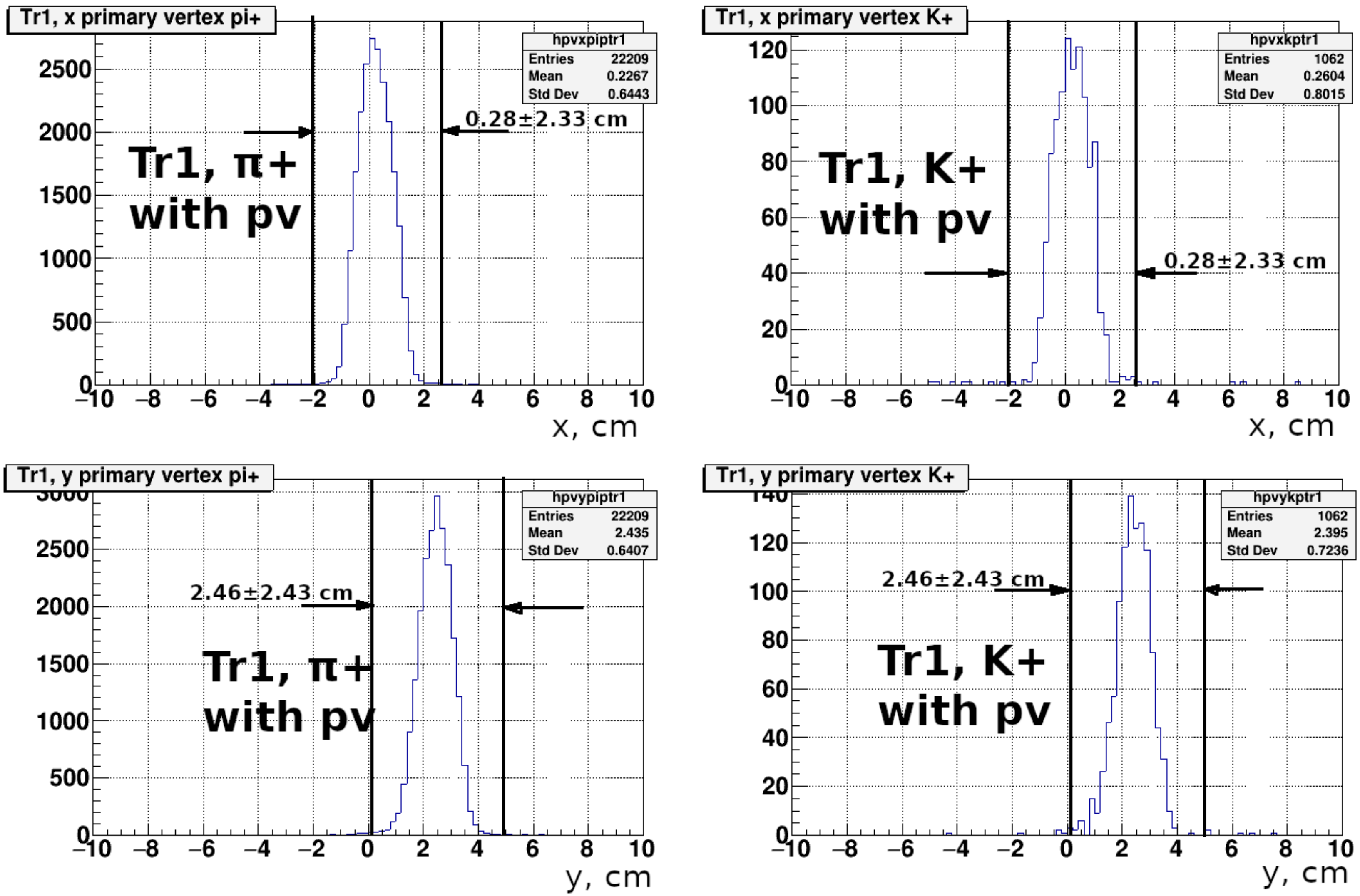
Primary vertex cuts



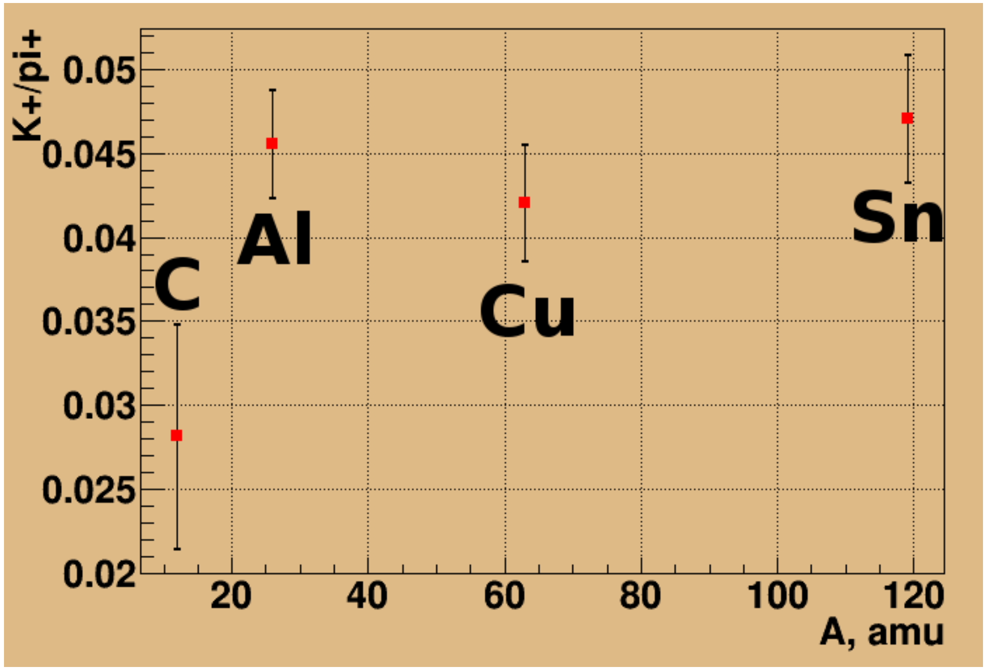


- PV with >=2 tracks
- dca < 1 cm

Primary vertex cuts

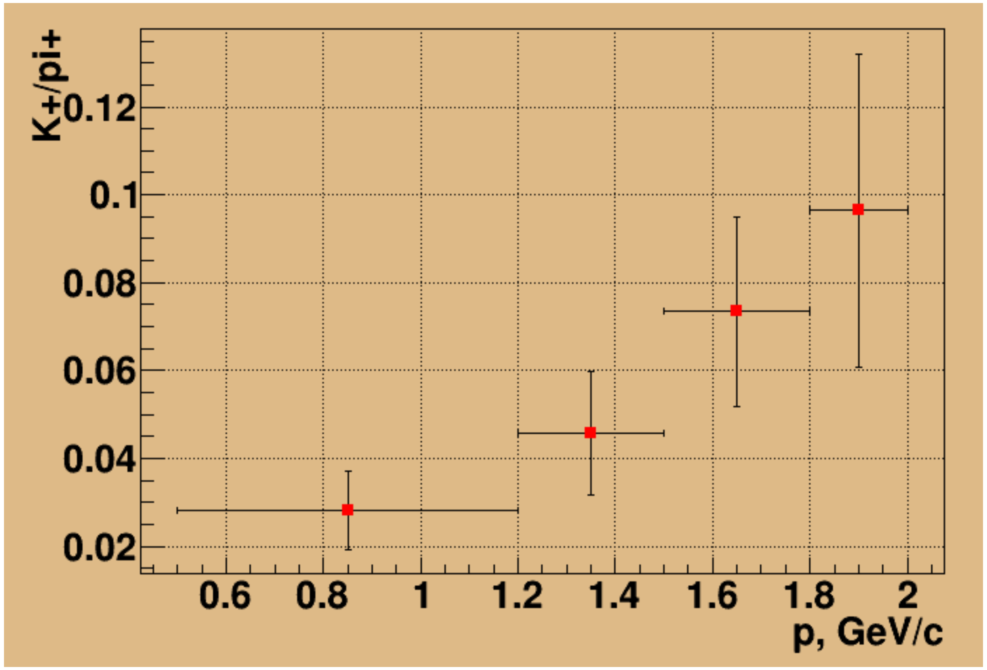


$K^+/\pi^+(A)$ with efficiency of triggers and acceptance corrections (old)



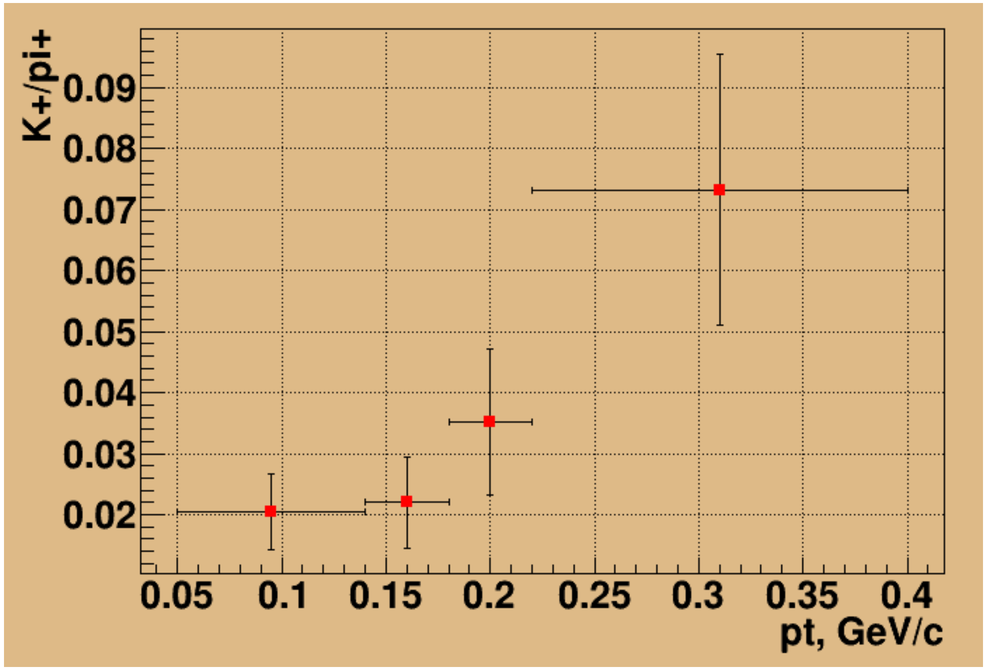
- AccCorr=K^+/π^+(TOF400)/$K^+/\pi^+(4\pi)$=0.5568
- Same correction for all targets

$K^+/\pi^+(p)$ with efficiency of triggers and acceptance corrections (old)



- Efficiency of triggers correction error ~25%
- Acceptance correction error ~7%

K^+/π^+(pt) with efficiency of triggers and acceptance corrections (old)



- Corrections errors as for the p dependence case

Chemical freeze-out temperature

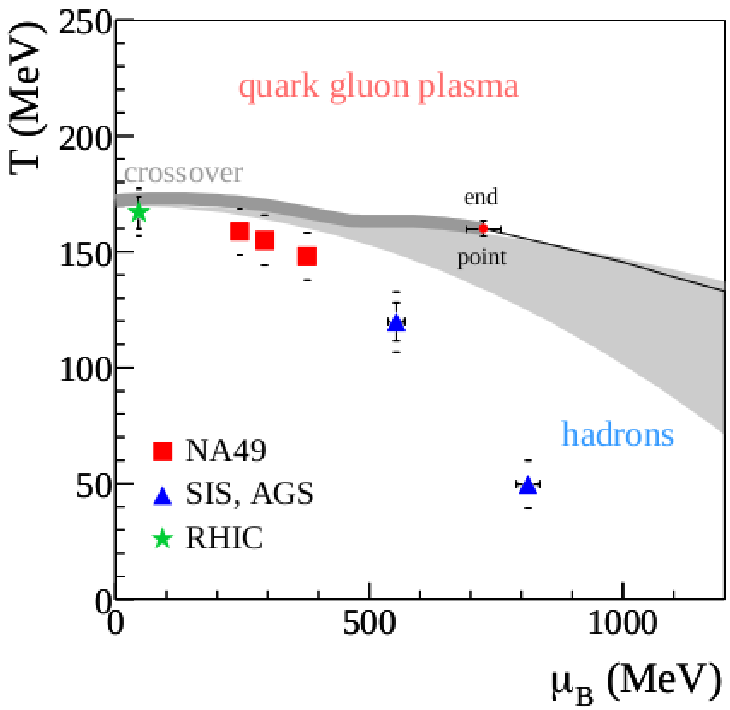


Fig. 33: QCD phase diagram with chemical freeze-out points extracted from hadron abundance ratios from heavy ion ($A \simeq 200$) collisions at center of mass energies $\sqrt{s_{NN}}$ ranging from 2.4 to 200 GeV [54]. The curve and shaded region indicate estimates for the deconfinement phase transition at finite baryon chemical potential μ_B from recent lattice QCD calculations [2, 156]. The critical endpoint where the transition changes from first order (high μ_B) to continuous crossover (low μ_B) is also indicated (although for unrealistically large quark masses [2]). Figure taken from Ref. [54].

- arXiv:hep-ph/0407360v1
- It is likely that, due to the larger net baryon densities in lower-energy heavy-ion collisions, inelastic hadronic rescattering processes happen faster than at higher energies and are able to lead to kinetic readjustment of the chemical temperatue below T_{cr}