General QA for large productions

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Big productions

UrQMD, BiBi@9.2, 50M events, minbias 0-16 fm: → **REQUEST 25 → QA**
- resonances (rho(770)0, phi(1020), K0(892)*, K+/-(892)*, Sigma(1385)+/-, Lambda (1520));
- charged hadrons (\pi, K, p, pbar) and hyperons (\Lambda, \Ksi), Omega;
- v1, v2, v3 vs pT, rapidity, centrality for charged pions, kaons, protons + KS, Lambda;
- neutral mesons and photons with the ECAL

DCM-QGSM-SMM, BiBi@9.2, 1M events, minbias 0-16 fm: → **REQUEST 26 → QA**
- trigger efficiency and centrality studies;

PHQMD, BiBi@9.2, 1M events, minbias 0-16 fm: → **REQUEST 27 → QA** (in progress)
- trigger efficiency and centrality studies;

UrQMD, BiBi@9.2, magnetic field 0.2T, 10M events, minbias 0-16 fm: → **REQUEST 28 → QA**
- same as Request 25 with the reduced magnetic field

PHQMD, BiBi@9.2, 20M events, minbias 0-16 fm: → **REQUEST 29 → QA** (in progress)
- (hyper)nuclei performance studies;

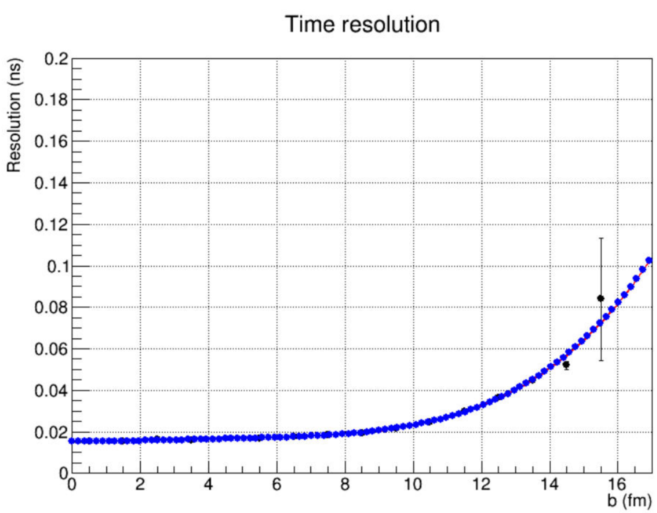
vHLLE+UrQMD with XPT, 15M events, minbias 0-16 fm: → **POSTPONED**
vHLLE+UrQMD with 1PT, 10M events, minbias 0-16 fm: → **POSTPONED**
- Flow, HBT;

PHSD, BiBi@9, 15M events, minbias 0-16 fm: → **POSTPONED**
- (anti)Lambda polarization studies;

Configuration

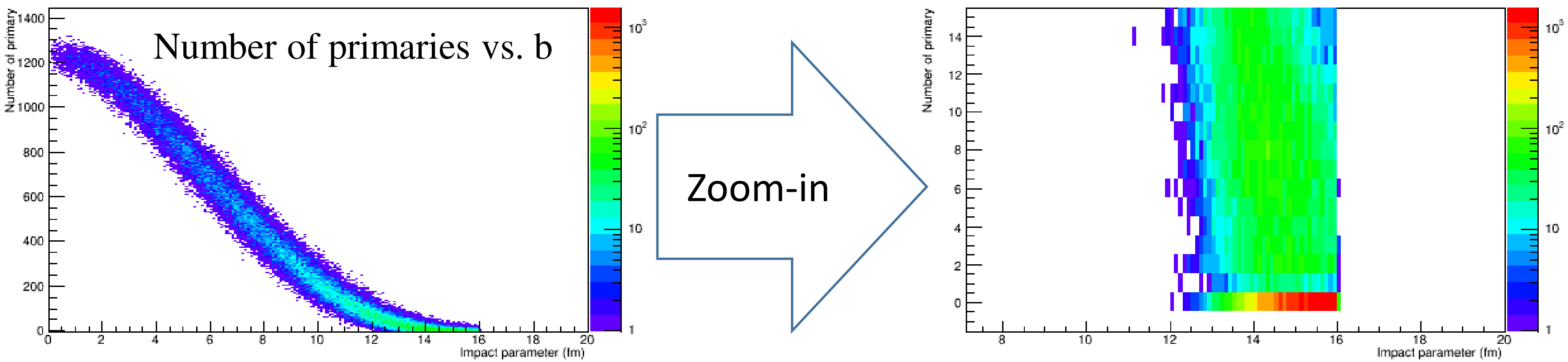
- The same configuration (MpdRoot version) is used for all productions
- Details are provided in description of Request 25. Other requests contain only small changes to read different input file formats, etc.:

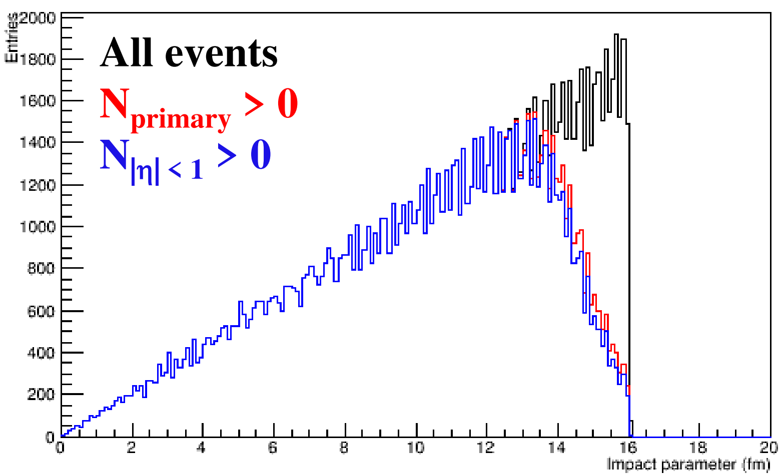
  ✓ Geant-4;
  ✓ Latest version (-dev) of MpdRoot;
  ✓ BiBi@9.2 GeV, 0-16 fm;
  ✓ Different input event generators, full events with UrQMD, DCM-QGSM-SMM, PHQMD, PHSD, etc.;
  ✓ Wide/realistic vertex distribution, sigma_z = 50 cm
  ✓ Full detector including all subsystems and materials
  ✓ Resonances are Dalitz decays are processed by Pythia-8 for realistic shapes (if present in the input files)
  ✓ Number of tracking steps is increased to "infinity" to make sure that heavy fragments are tracked to detectors
  ✓ Centrality dependent T_0 resolution (FFD resolution from DCM-QGSM-SMM simulations):



Event selection

- All events were simulated with b = 0-16 fm
- However, different event generators produce different output
- **<u>Empty (elastic) events must be rejected from physics analyses</u>**
- Examples for Request 25 (UrQMD) production

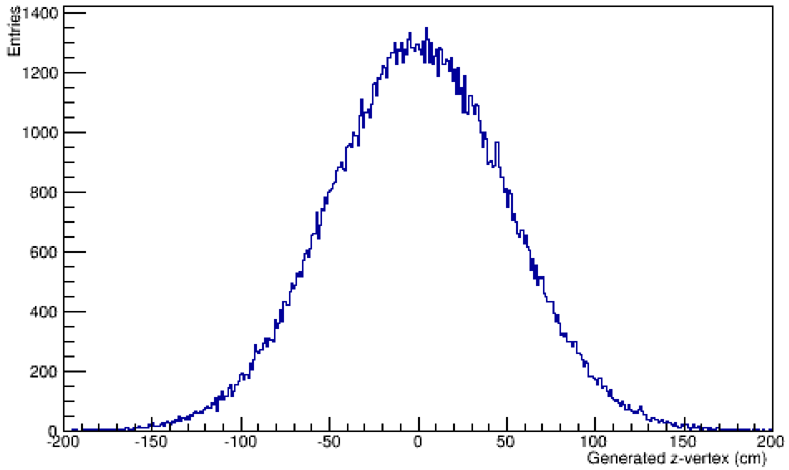




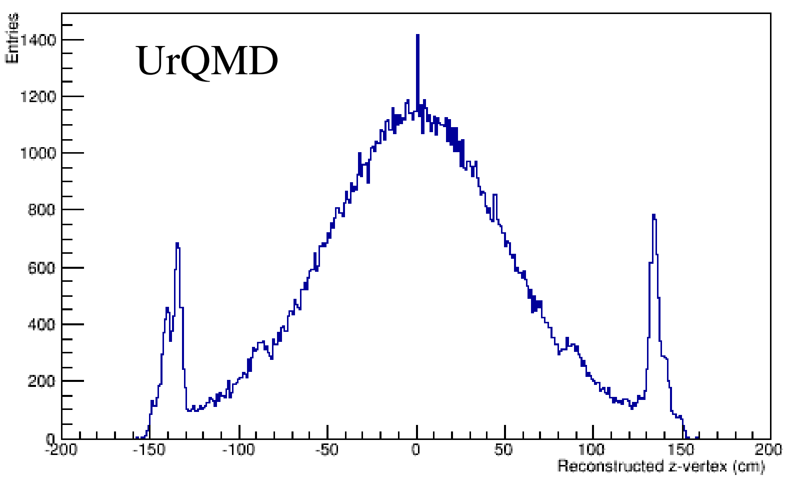
- ✓ Many empty events with only original 209*2 nucleons as primaries are simulated at large values of impact parameter, impact parameter distribution has a sharp edge at higher limit (16 fm)
- ✓ By selecting event with $N_{primary} > 0$ (or 209*2) one can reject the empty events and work with inelastic events only
- ✓ Alternative is to require at least one generated primary particle at $|\eta| < 1$

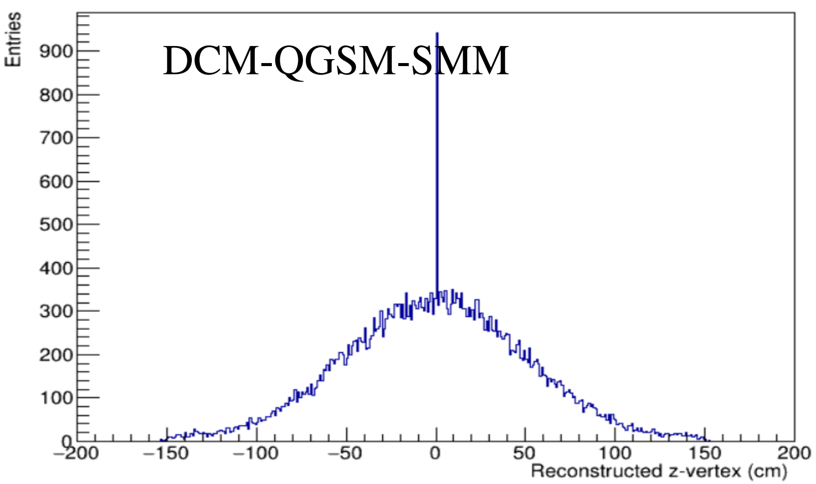
Generated and reconstructed vertices - I

- Generated z-vertex with sigma_z = 50 cm:



- Reconstructed z-vertex by TPC (inelastic events):

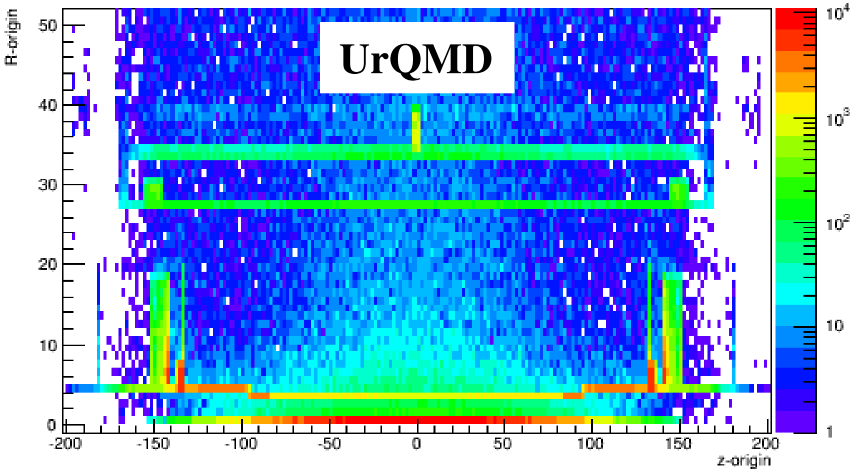


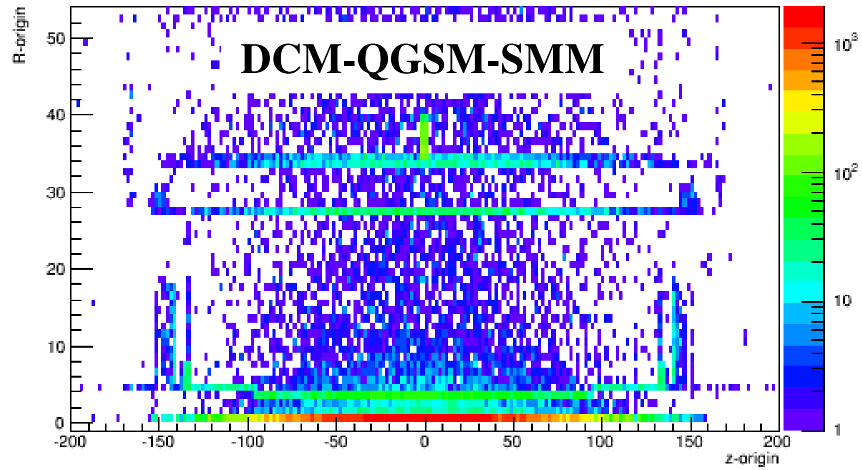


- ✓ Events in which vertex is not reconstructed have it set to (0,0,0) → spike at zero
- ✓ Spikes at large z-vertex values in UrQMD should have a reason (see next slide)

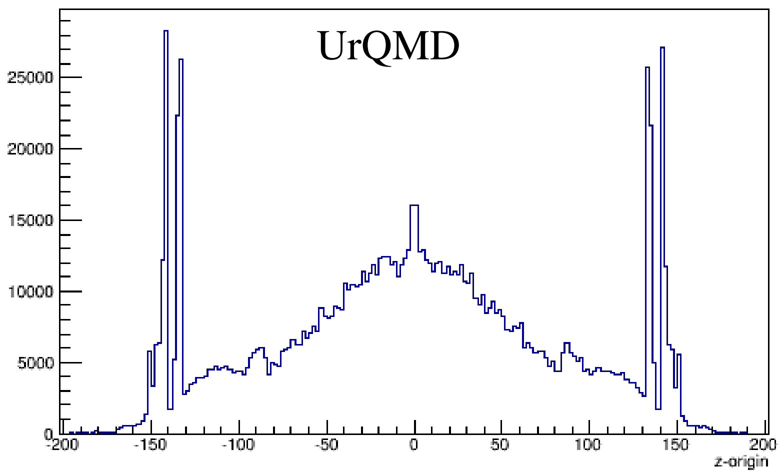
Generated and reconstructed vertices - II

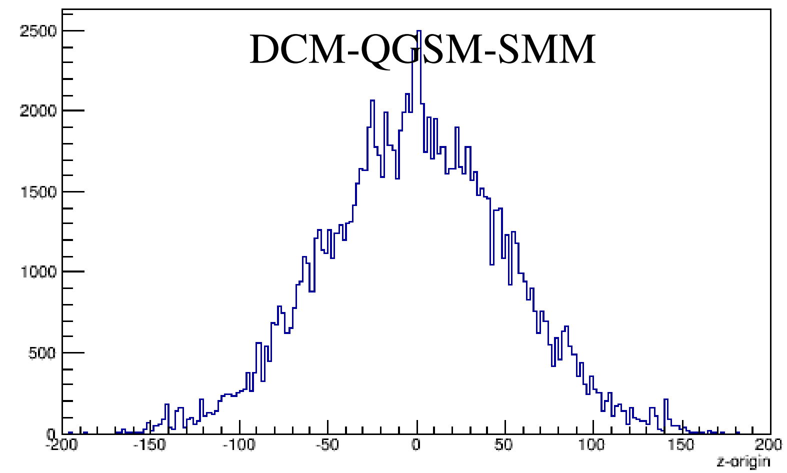
- Origin (starting points) of TPC tracks in peripheral events with b > 12 fm:





- Projections:



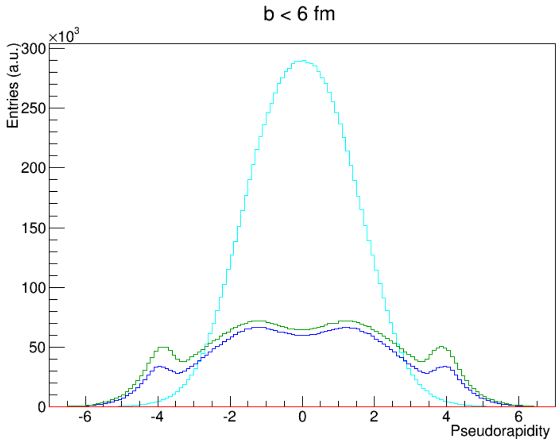


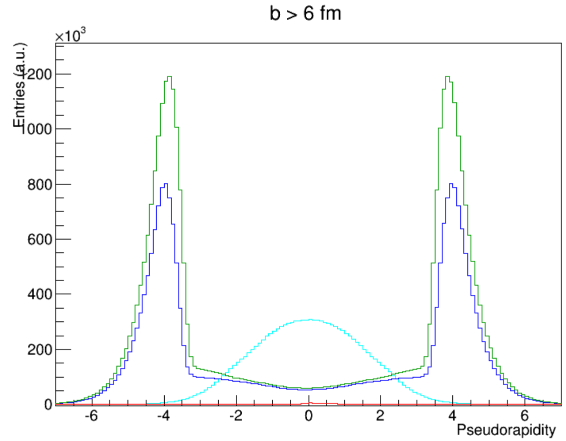
✓ In peripheral UrQMD events a big fraction of TPC tracks originate from interactions in the FFD and materials

✓ This is not observed in DCM-QGSM-SMM events

Generated and reconstructed vertices - III

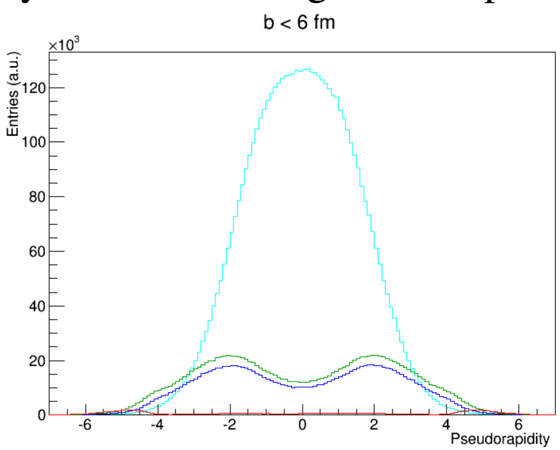
- Rapidity distribution of generated particles, UrQMD:

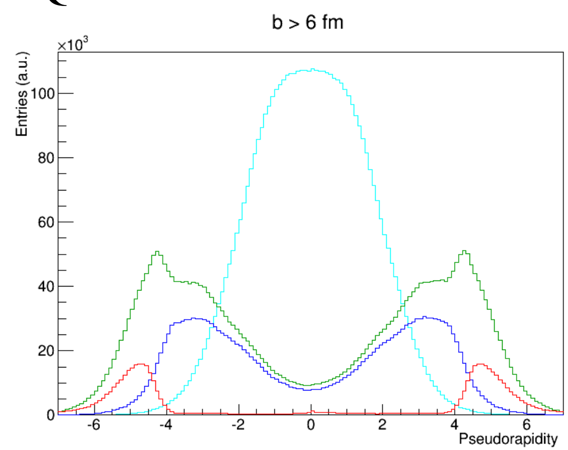




Protons
Neutrons
Pions
Fragments/ions

- Rapidity distribution of generated particles, DCM-QGSM-SMM:



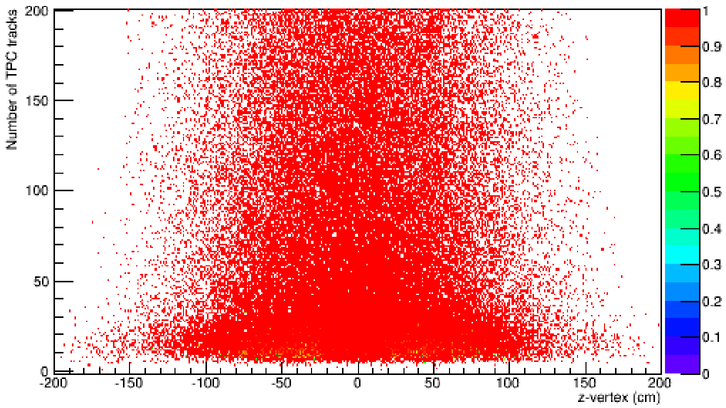


✓ In peripheral UrQMD events, the FFD/FHCAL is sprayed with nucleons, which are supposed to be bound in heavy fragments as predicted by DCM-QGSM-SMM → **forward simulations with UrQMD are wrong** (don't use for forward detectors) → **pay attention to spikes and structures in reconstructed distributions**.

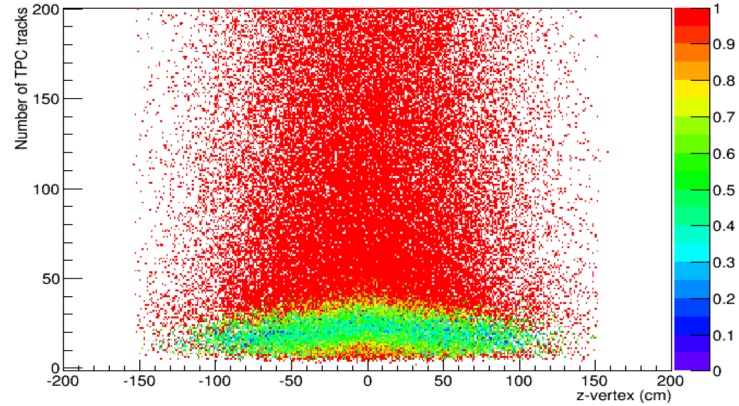
Generated and reconstructed vertices - IV

- Vertex reconstruction efficiency vs. generated z-vertex and number of TPC tracks (nhits>10), UrQMD:

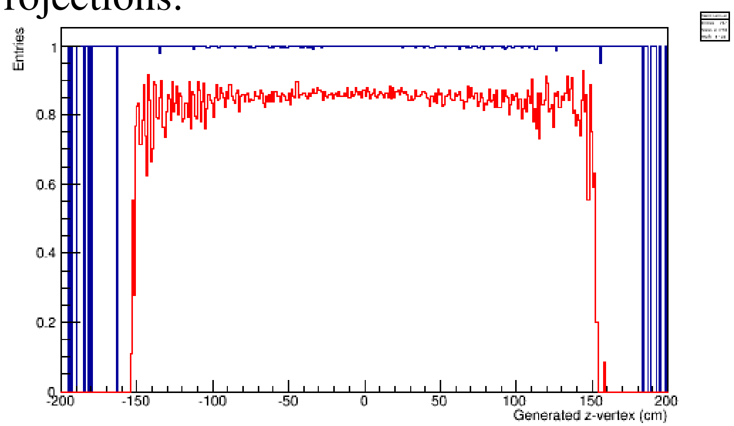
Vertex != 0

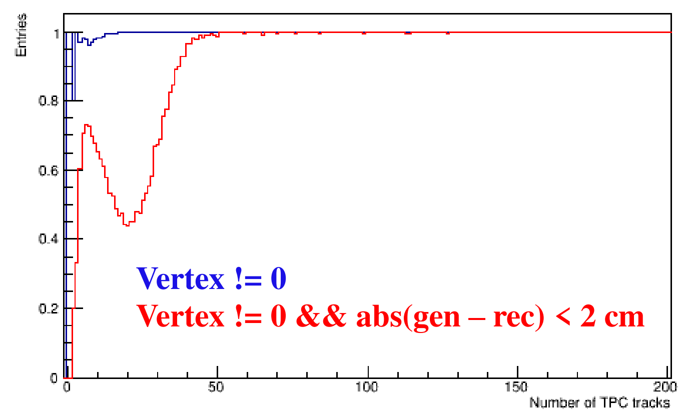


Vertex != 0 && abs(gen – rec) < 2 cm



- Projections:

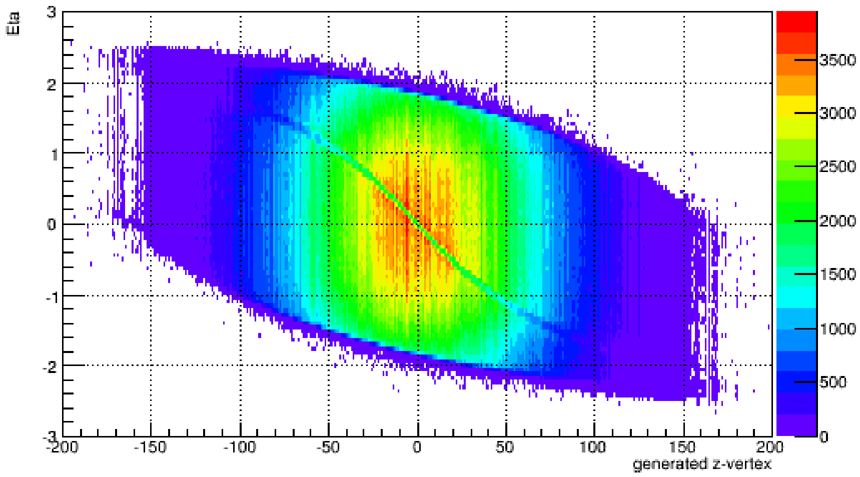


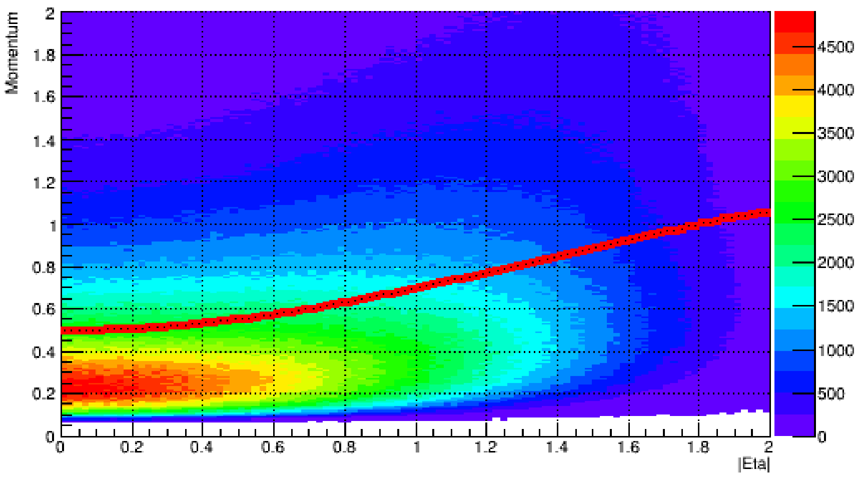


- ✓ Reconstructed |z-vertex| < 150 cm, even for events with generated |z-vertex| > 150 cm → **<u>limitations of TPC</u>**
- ✓ **<u>Reconstructed vertex (!=0) can be incorrect in peripheral events</u>**
- ✓ Need a vertex task to combine information from the TPC and FFD

Detector acceptance

- TPC tracks with nhits > 10:

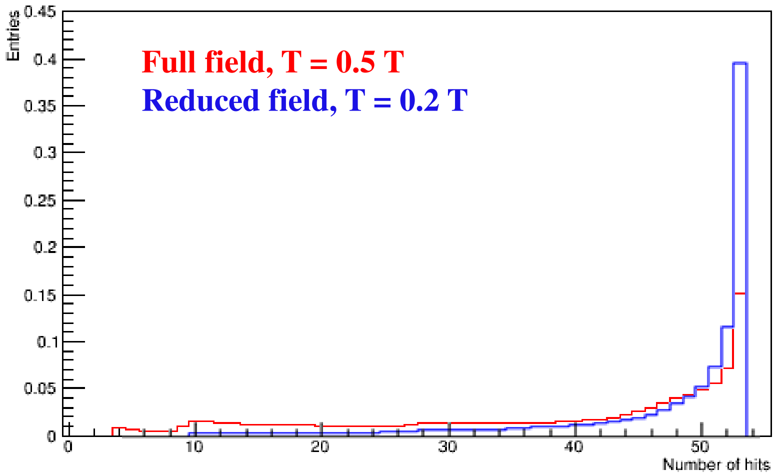




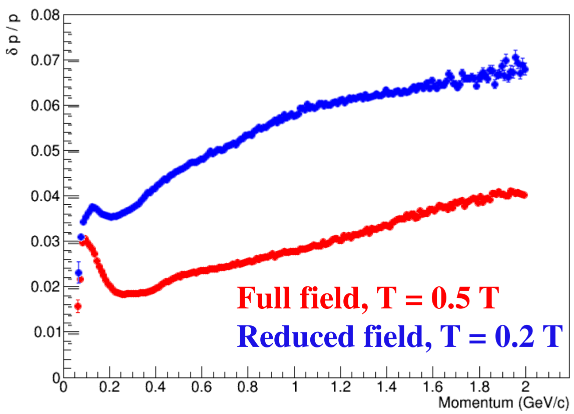
- ✓ With a wide z-vertex distribution, charged particles are reconstructed up to η ~ 2 with asymmetric acceptance
- ✓ Mean momentum of accepted particles increases with rapidity
- ✓ Observe effect of the central membrane?
- ✓ **Should think what physics could be gain from a wider rapidity coverage**

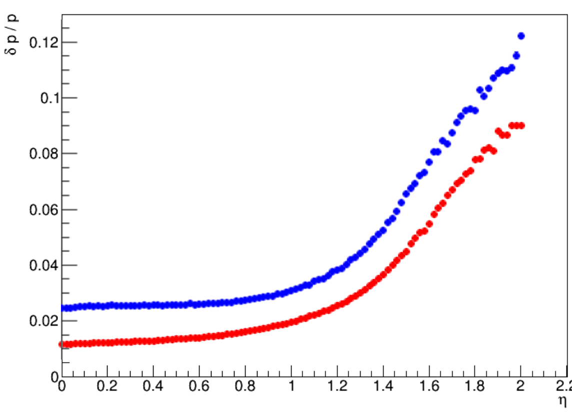
Momentum resolution

- Number of hits:



- Resolution:

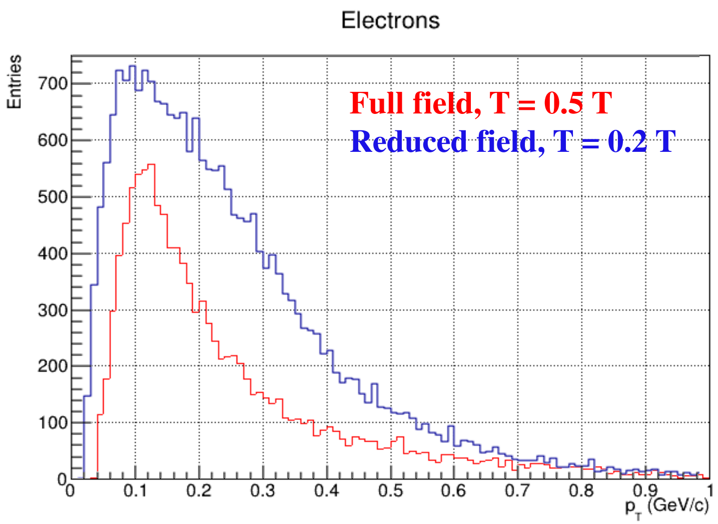


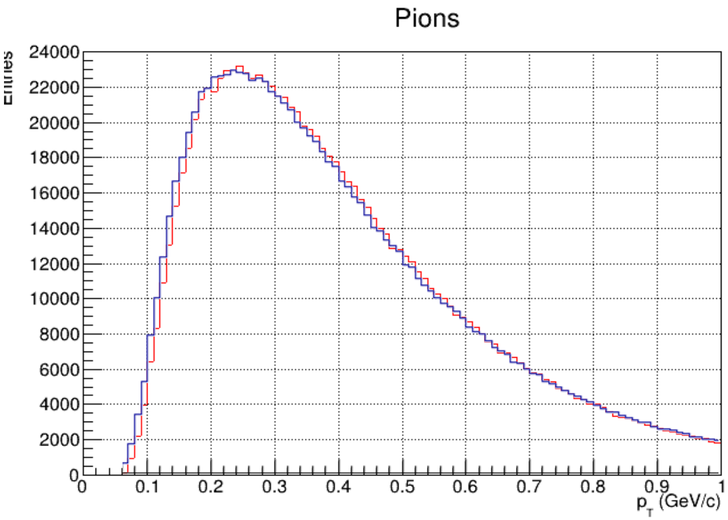


✓ More straight tracks with **<u>larger number of hits</u>** with the reduced magnetic field
✓ **<u>Momentum resolution is a factor of two worse</u>** with the reduced magnetic field

TPC acceptance

- Transverse momentum of reconstructed TPC tracks:



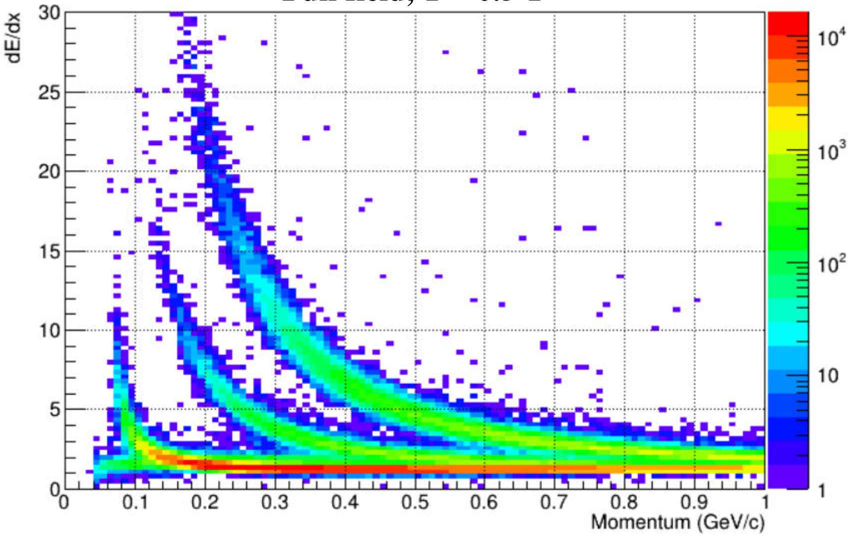


✓ **<u>Acceptance is larger</u>** for light particles with the reduced magnetic field;

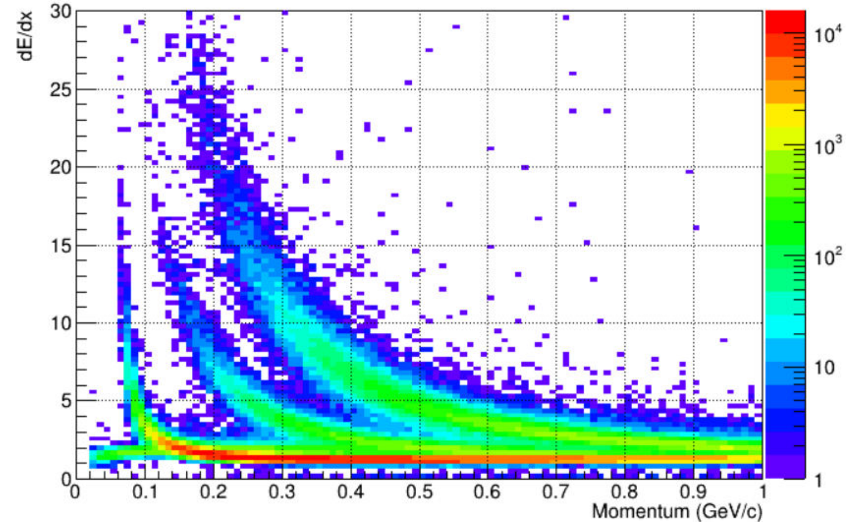
TPC – dE/dx

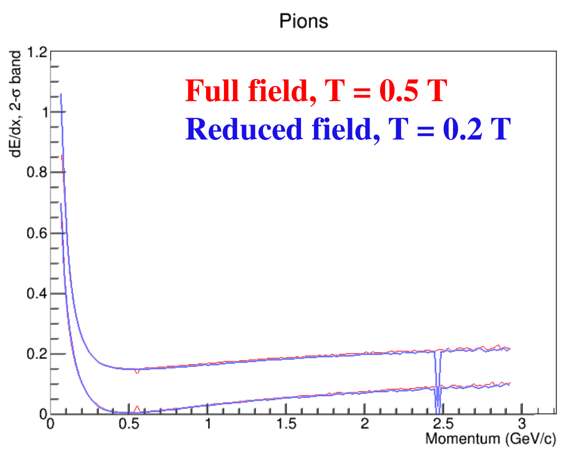
- dE/dx distributions for reconstructed TPC tracks → extended ranges are clearly seen:

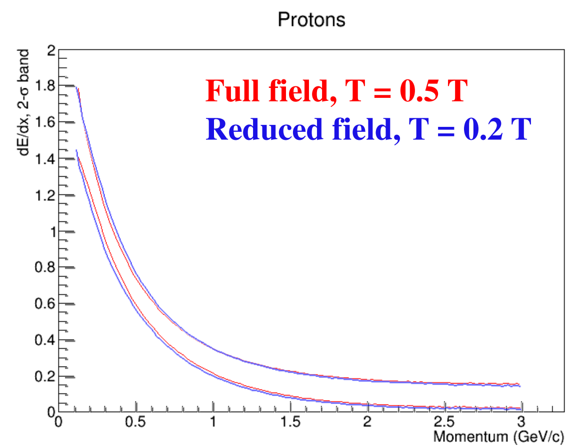
Full field, T = 0.5 T



Reduced field, T = 0.2 T



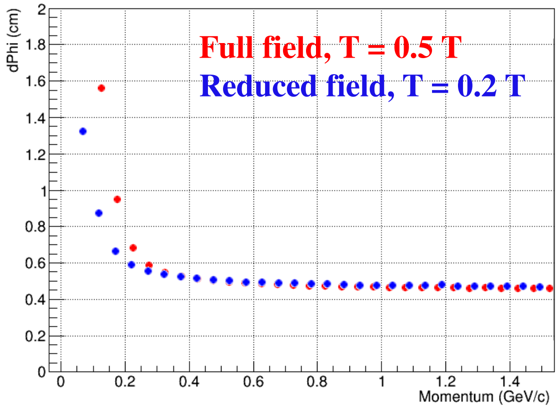


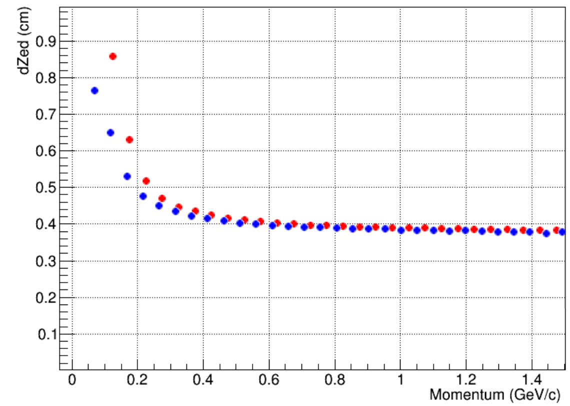


✓ **<u>dE/dx parameterizations for reconstructed particles ~ the same except for momentum smearing effect</u>**

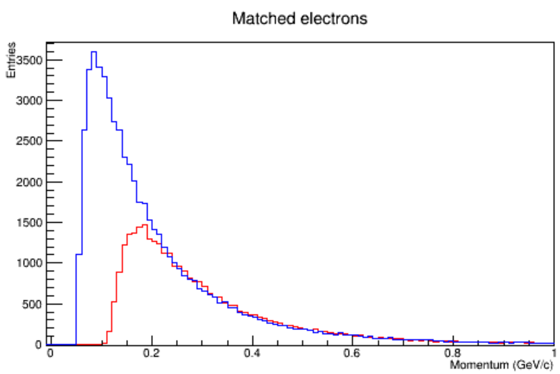
TOF matching

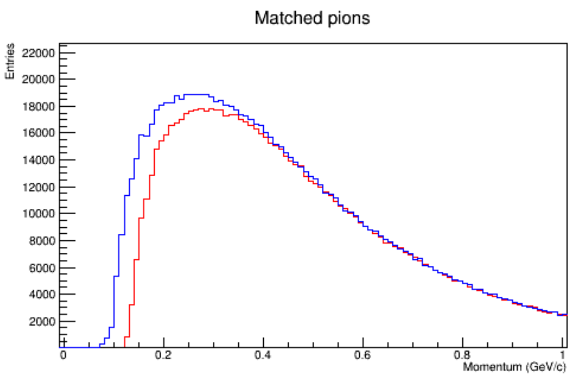
- Track matching in dPhi, dZed:

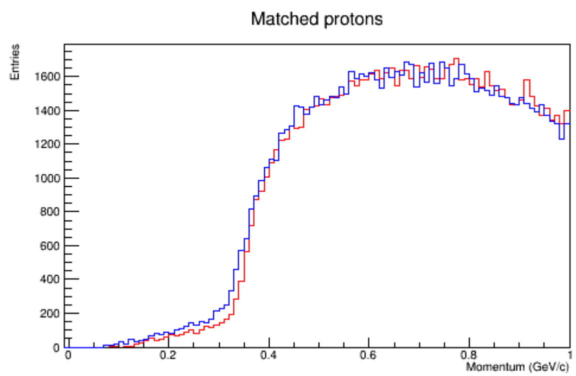




- Matched particles:





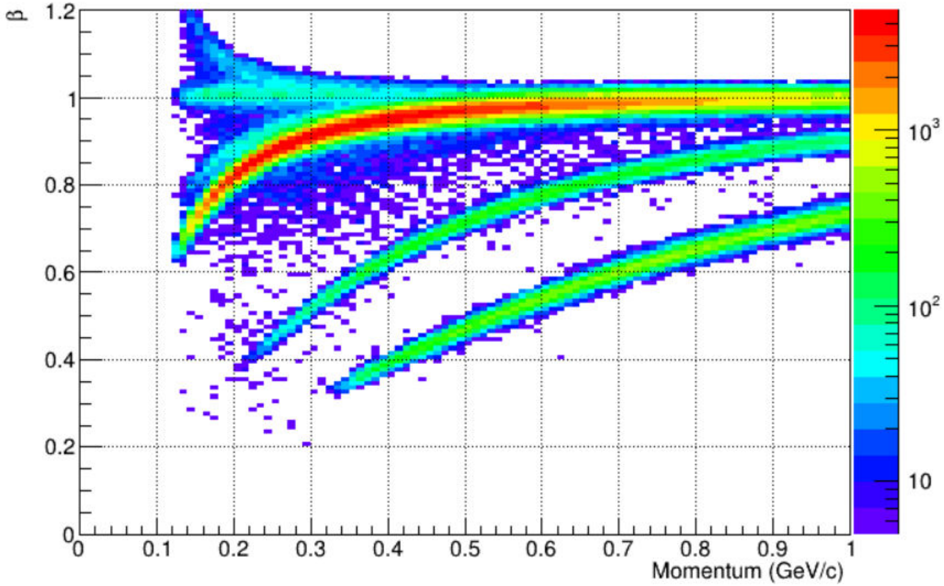


✓ **<u>Matching is better</u>** for tracks with the reduced magnetic field; **<u>softer tracks are matched</u>**

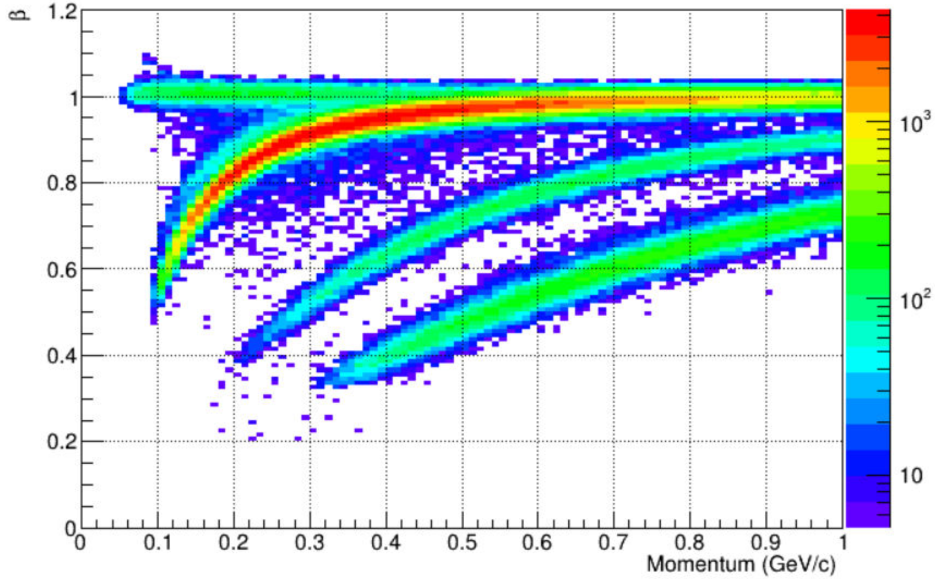
✓ **<u>The lower the particle mass the larger the gain in acceptance</u>**

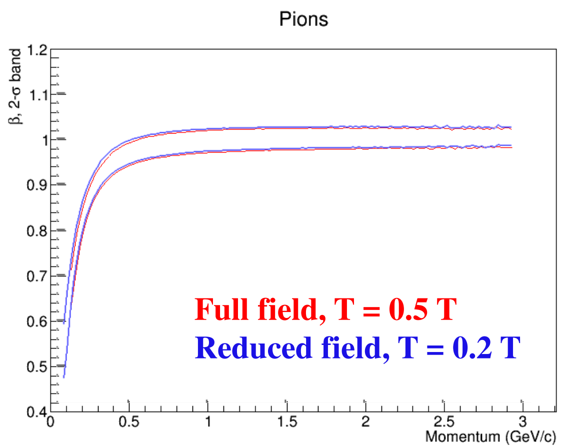
TOF acceptance

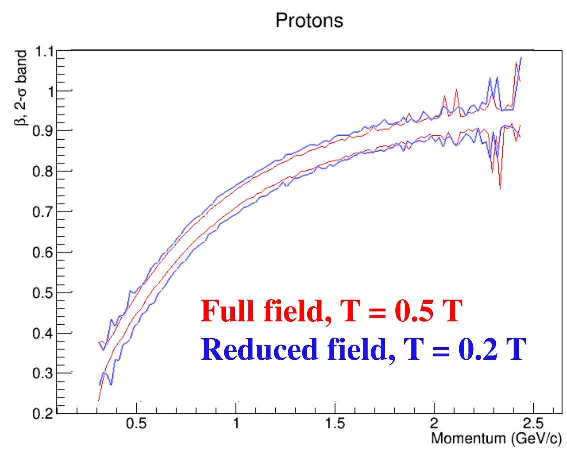
Full field, T = 0.5 T



Reduced field, T = 0.2 T



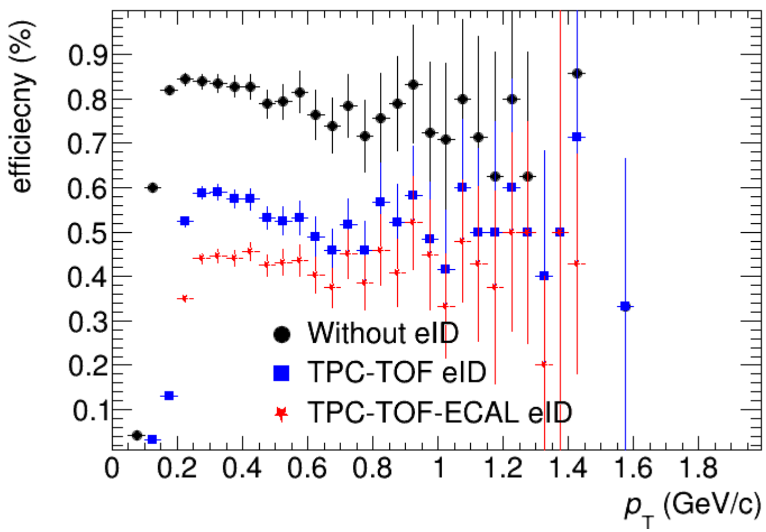


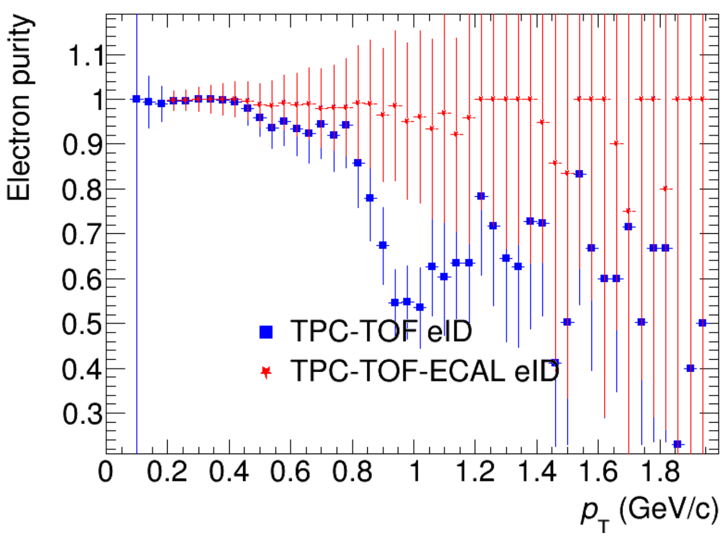


- ✓ **Acceptance is larger** with the reduced magnetic field; practically no mismatching signals with $\beta > 1$
- ✓ **Mass resolution is worse** with the reduced magnetic field

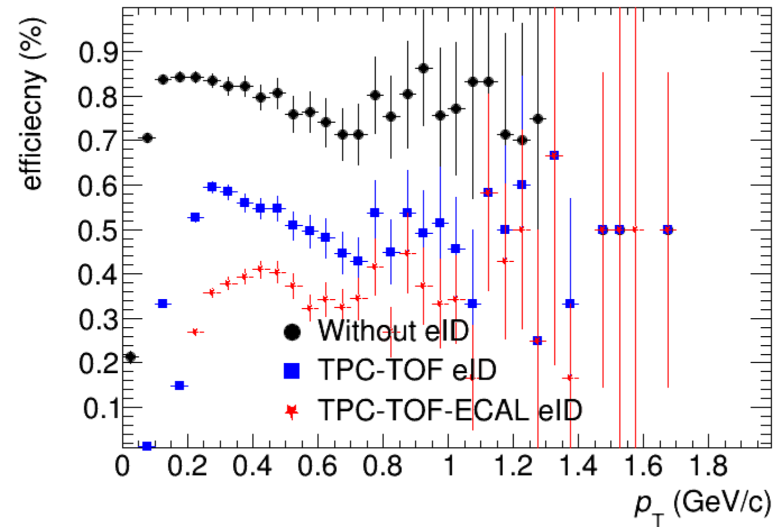
Electrons

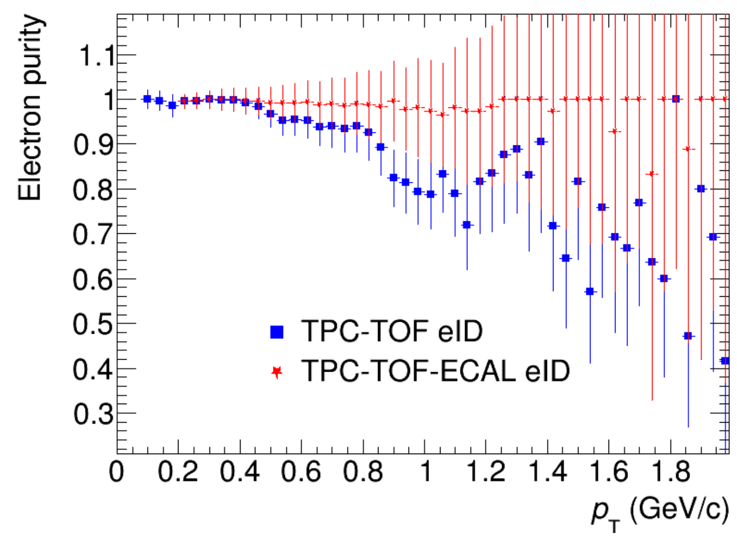
Full field, T = 0.5 T





Reduced field, T = 0.2 T

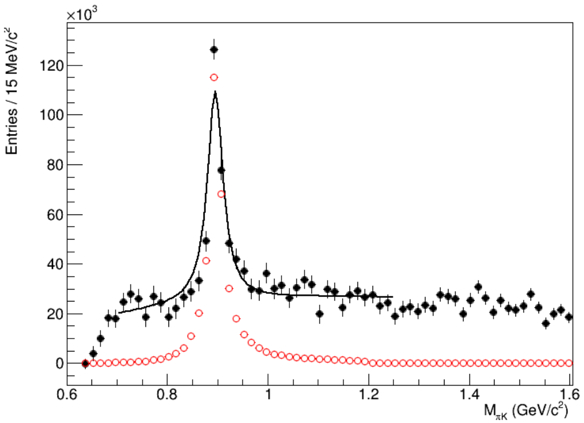


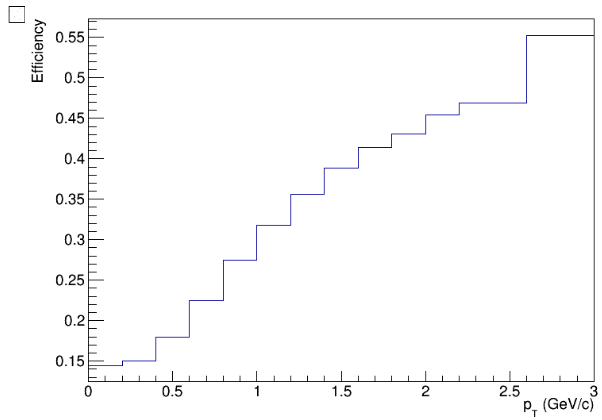


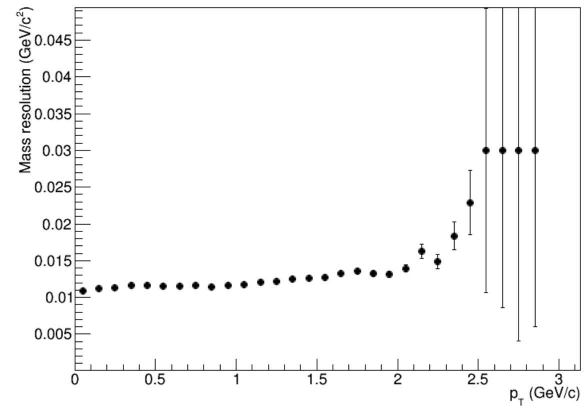
- ✓ **<u>Comparable electron reconstruction effiiecny and better electron purity</u>** with the reduced magnetic field;

Resonances: $K^*(892)^0$

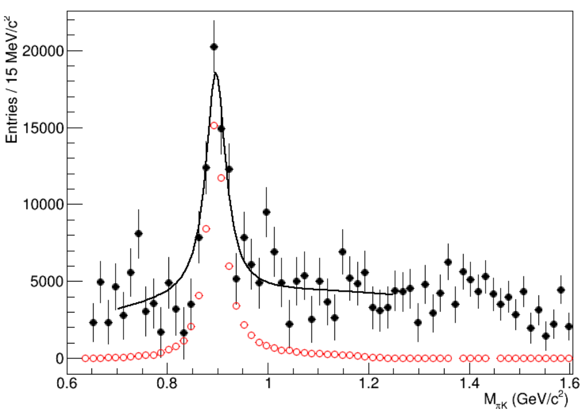
Full field, T = 0.5

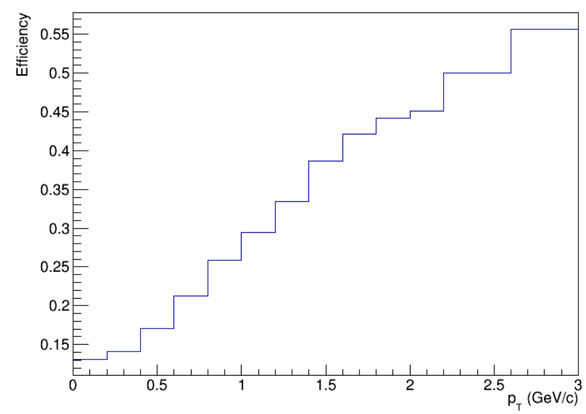


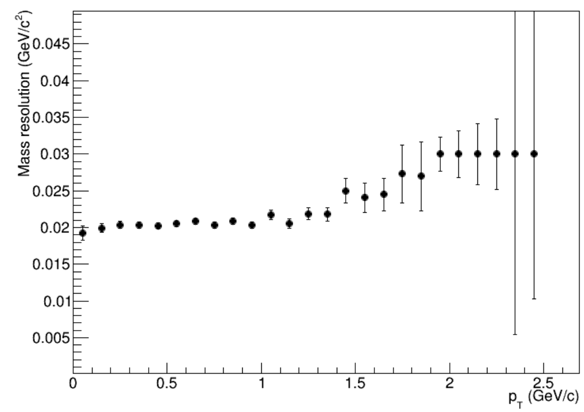




Reduced field. T = 0.2 T



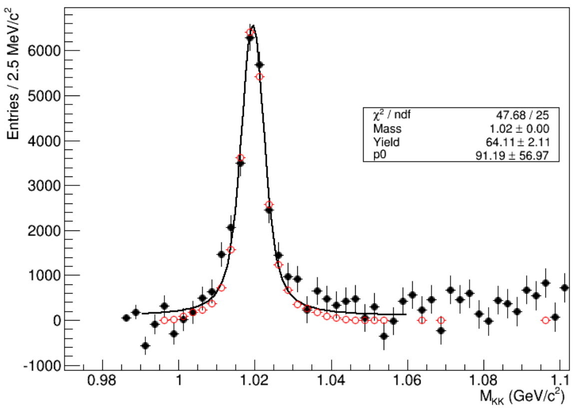


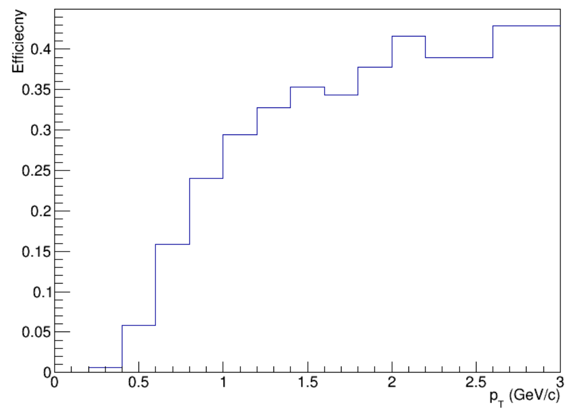


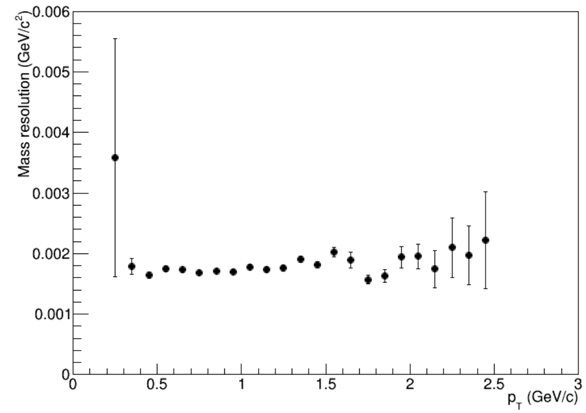
- ✓ **<u>Comparable signals and efficiecnies</u>**
- ✓ **<u>Worse mass resolution</u>** with the reduced magnetic field;

Resonances: $\phi(1020)$

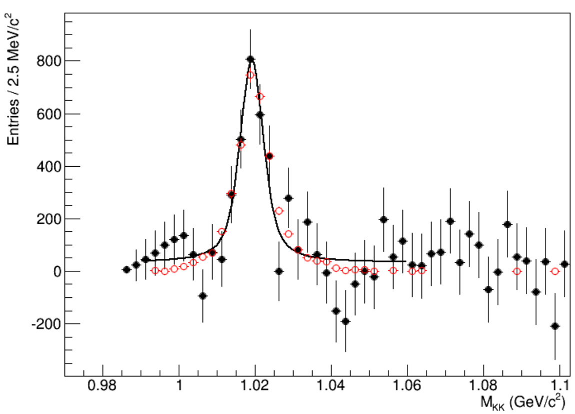
Full field. T = 0.5

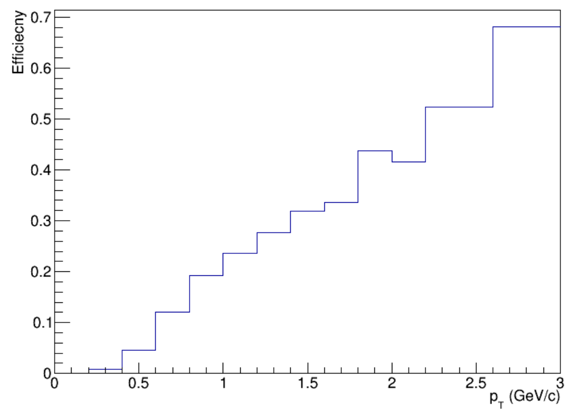


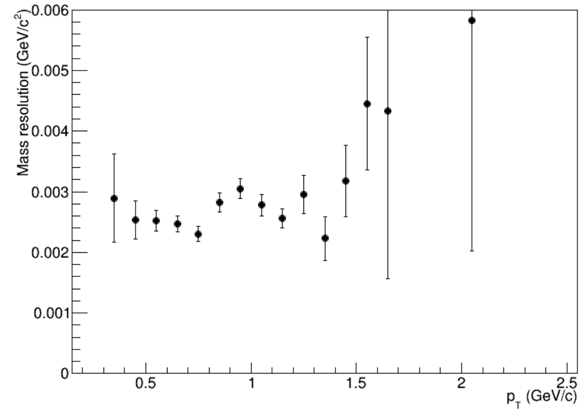




Reduced field, T = 0.2 T



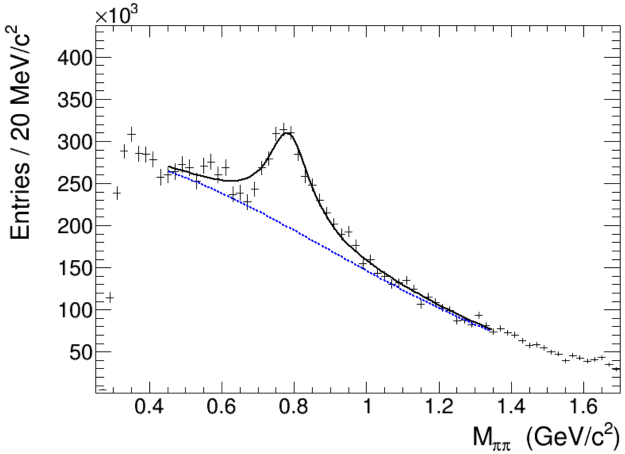


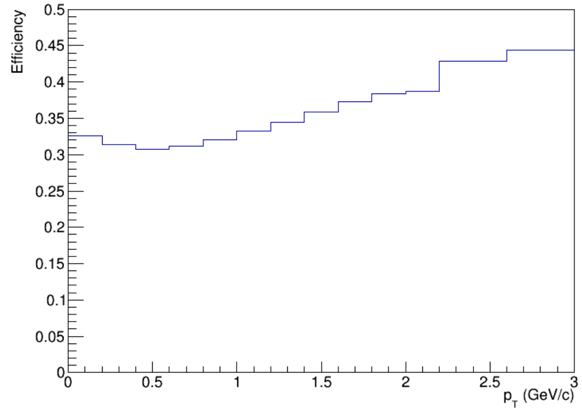


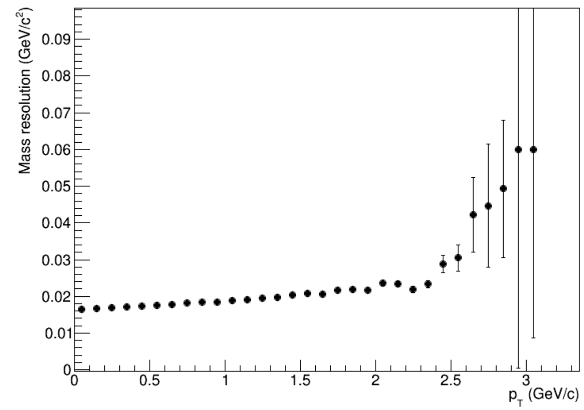
- ✓ **<u>Comparable signals and efficiecnies</u>**
- ✓ **<u>Worse mass resolution</u>** with the reduced magnetic field;

Resonances: $\rho(770)^0$

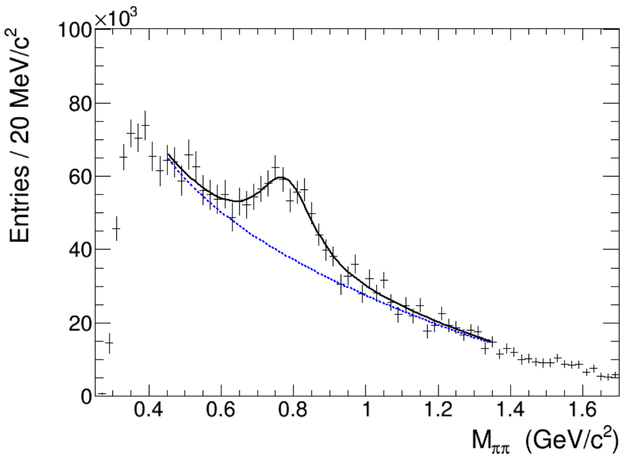
Full field. T = 0.5

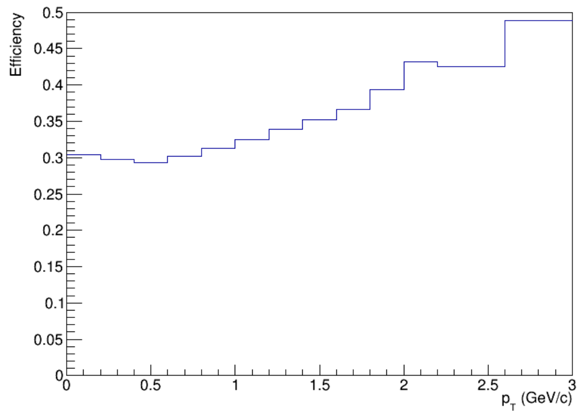


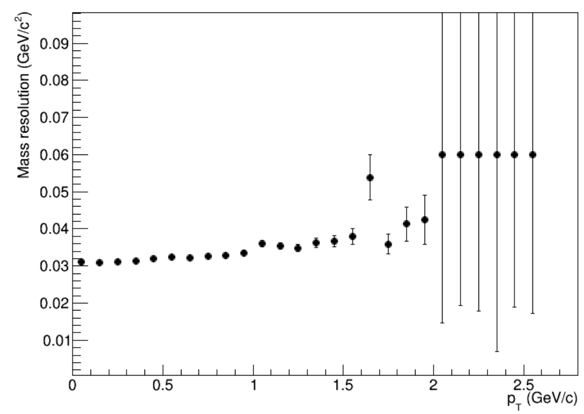




Reduced field, T = 0.2 T



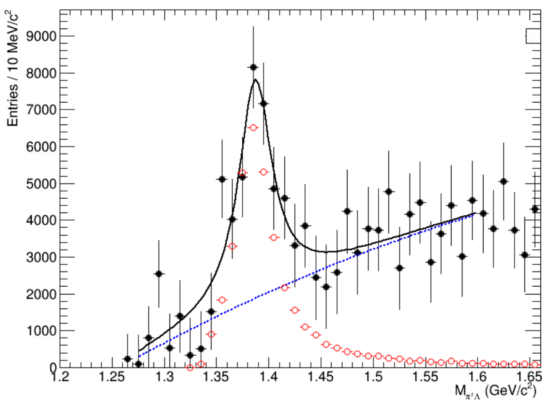


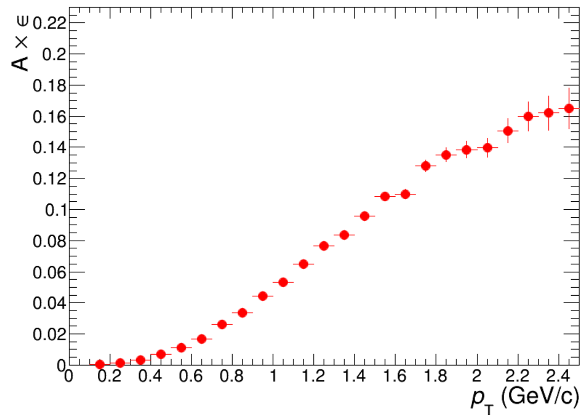


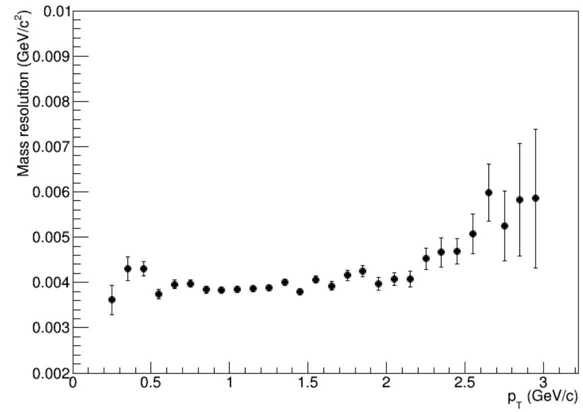
- ✓ **<u>Comparable signals and efficiecnies</u>**
- ✓ **<u>Worse mass resolution</u>** with the reduced magnetic field;

Resonances: Σ(1385)$^{\pm}$

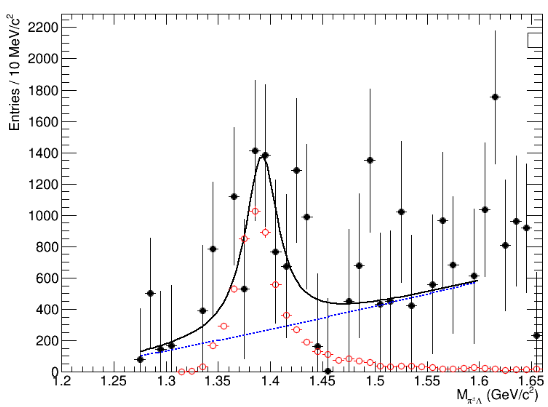
Full field, T = 0.5

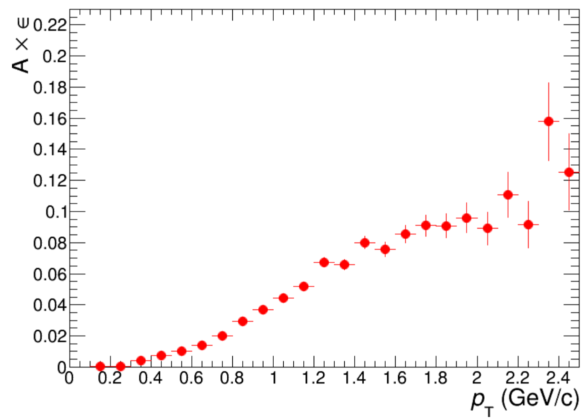


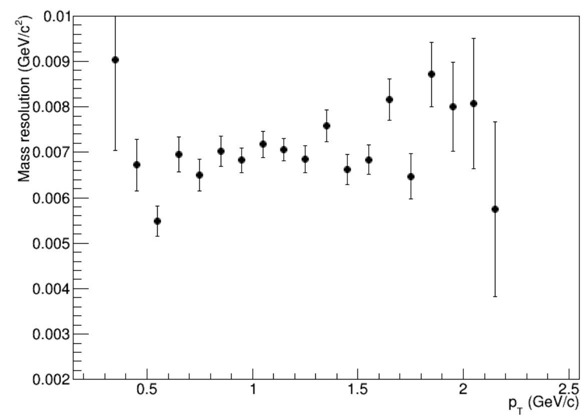




Reduced field, T = 0.2 T



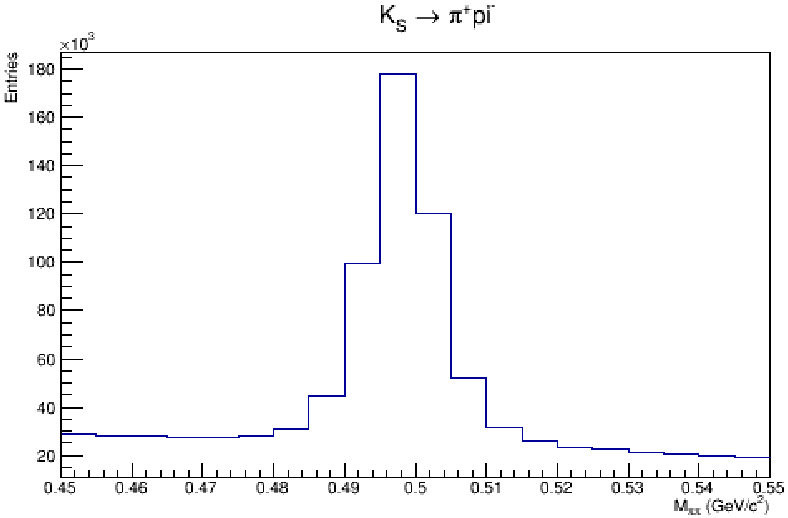


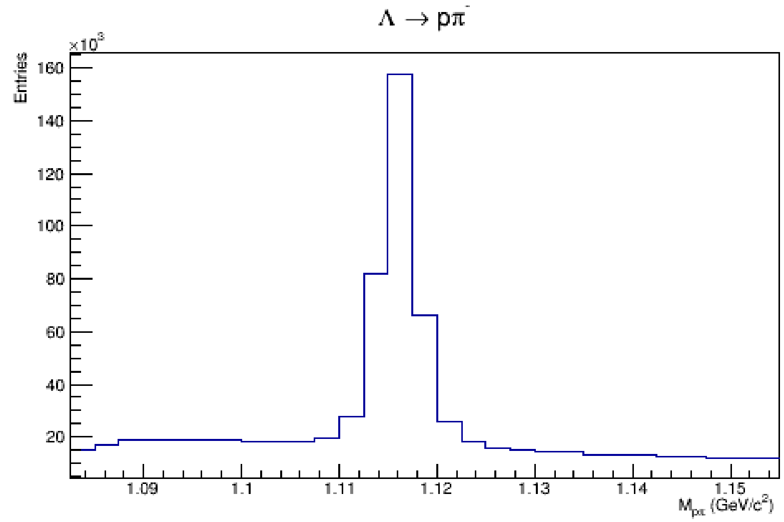


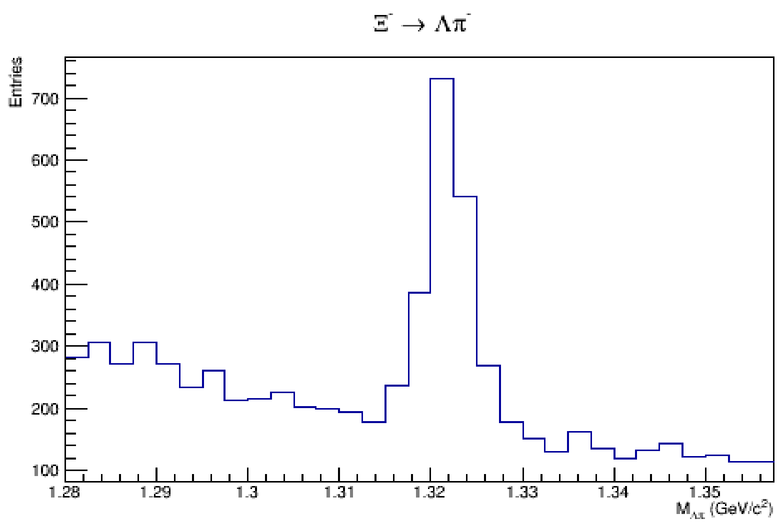
- ✓ <u>**Comparable signals and efficiecnies**</u>
- ✓ <u>**Worse mass resolution**</u> with the reduced magnetic field;

Weak decays: K_s, Λ, Σ^-

Full field, T = 0.5

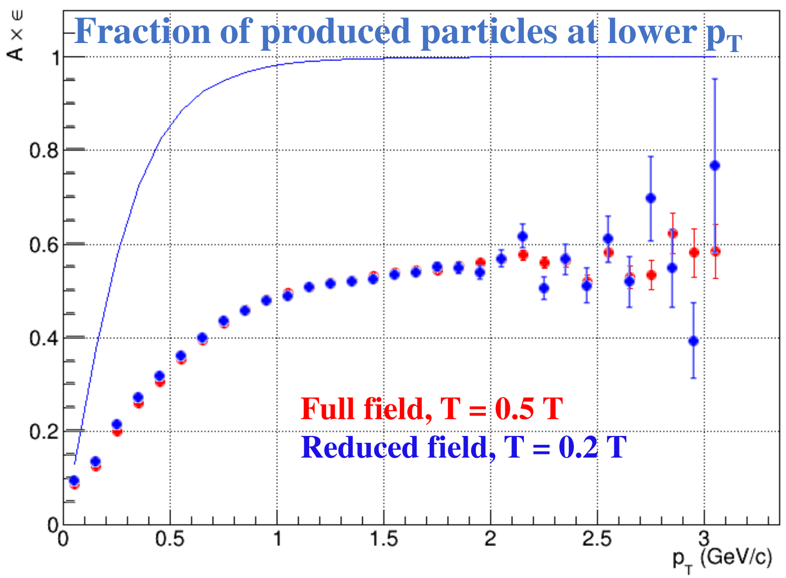


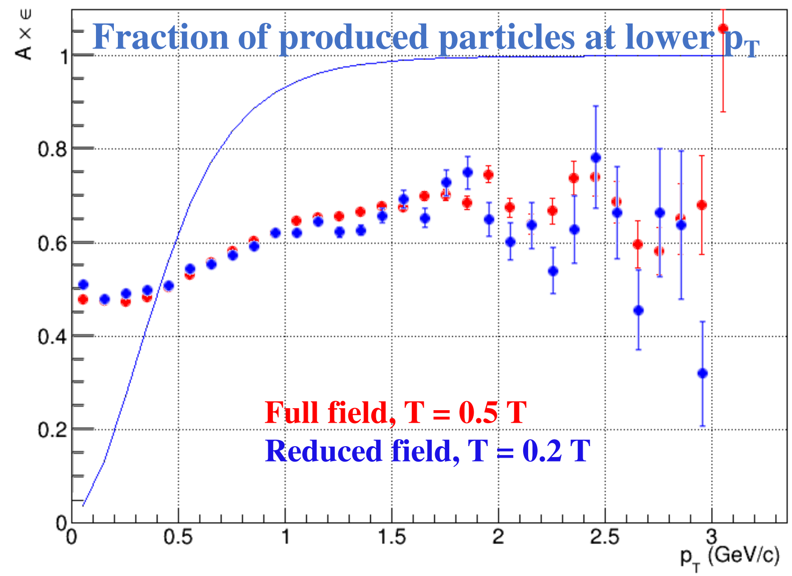




Neutral mesons: π^0 and η

- Reconstruction efficiencies:
  - ✓ Photons: E > 0 GeV, $T_{reduced}$ < 2 ns
  - ✓ |E1-E2|/(E1+E2) < 0.75
  - ✓ Pairs: |y| < 0.5





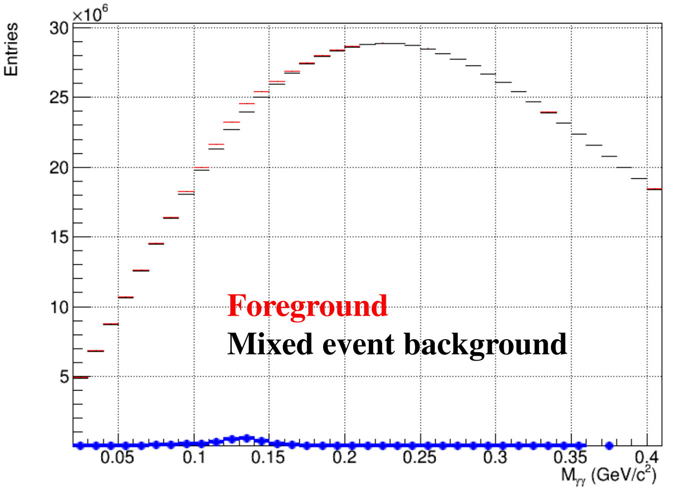
- Efficiency for π^0 is > 10% at p_T > 50 MeV
- Signal is measurable starting from ~ 50 MeV/c
- Efficiencies are identical

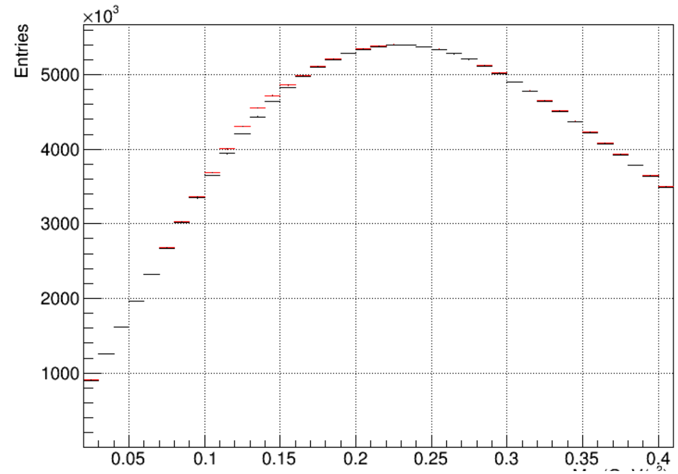
Neutral mesons at low p_T: π^0

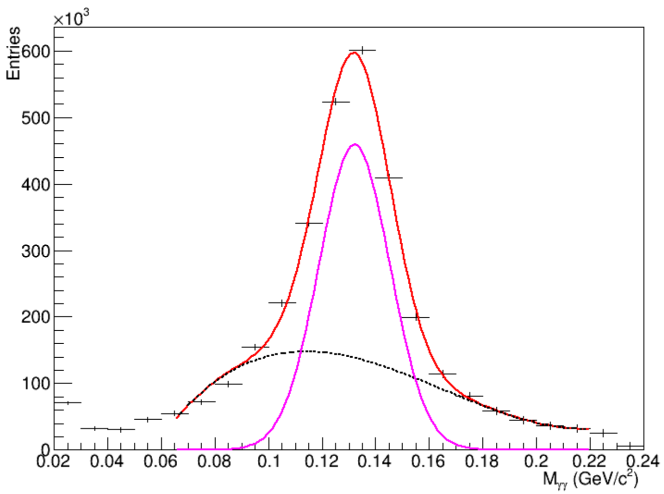
Full field, T = 0.5

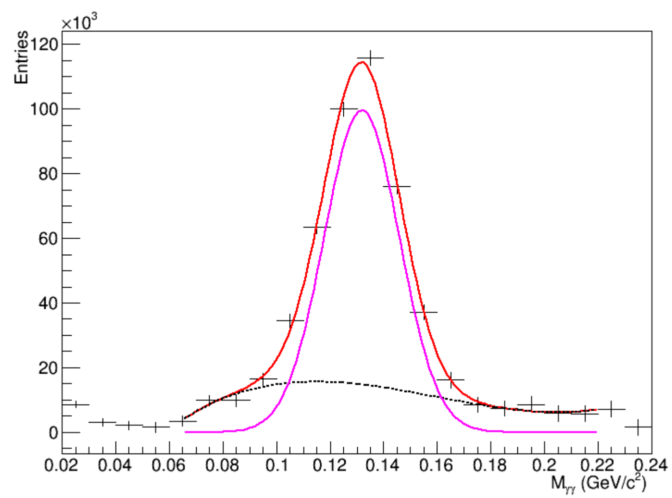
Reduced field, T = 0.2 T

0.025-0.075 GeV/c









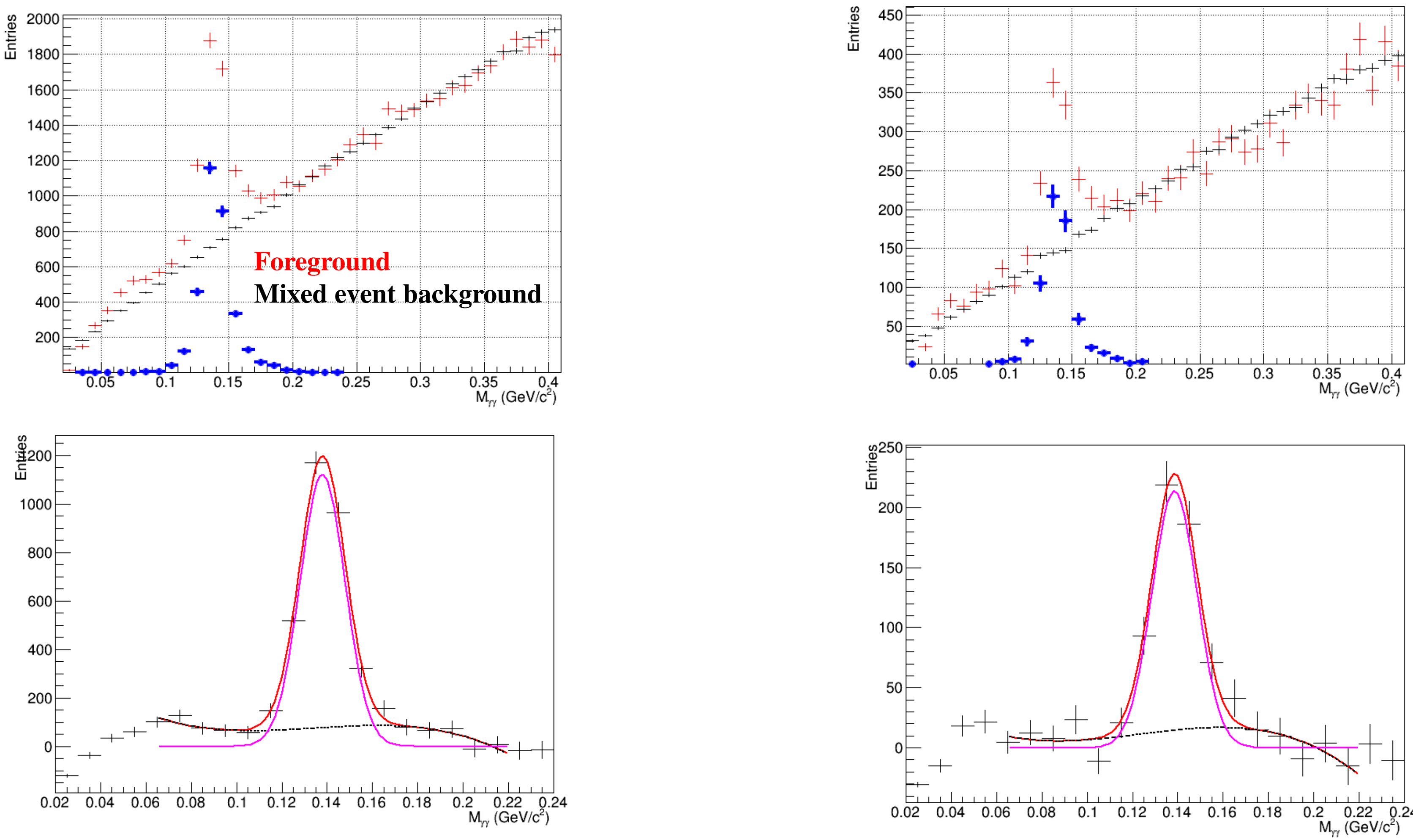
- Signal is measurable from ~ 50 MeV/c
- Similar S/B ratios

Neutral mesons at high p_T: π^0

Full field, T = 0.5

2-3 GeV/c

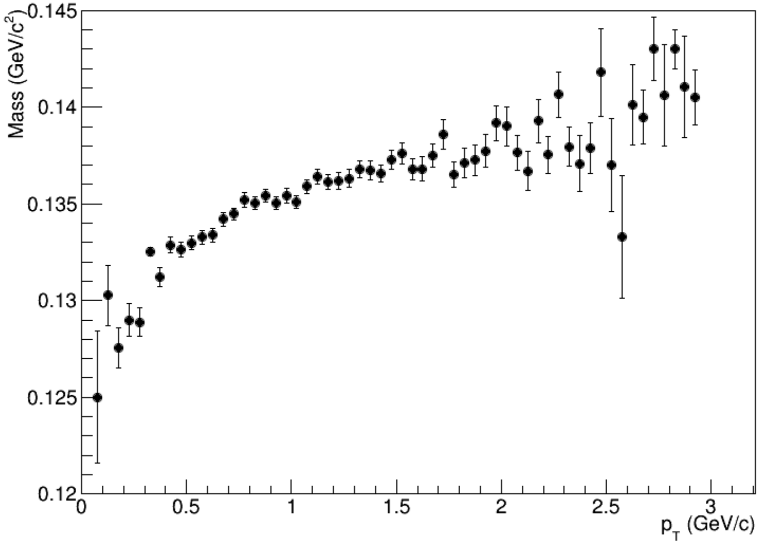
Reduced field, T = 0.2 T

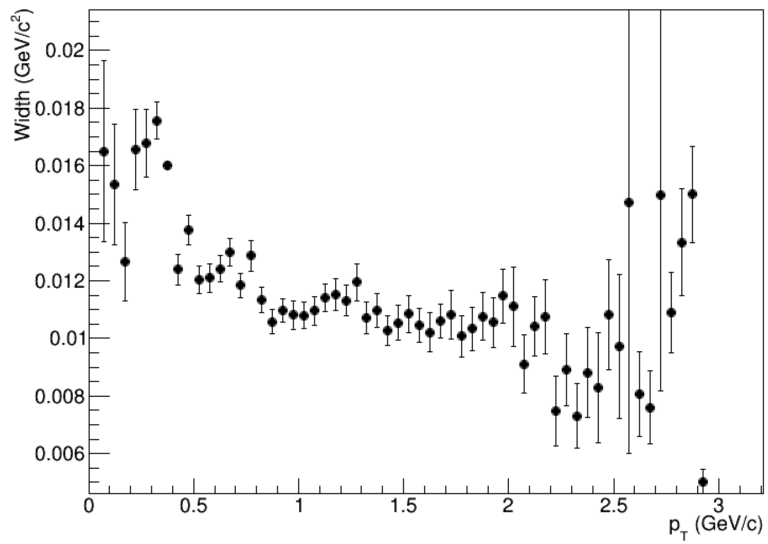


- The peak width decreases with increasing momentum (better energy resolution)
- The S/B improves with increasing momentum; similar S/B ratios

Mass and width of π^0

Full field, T = 0.5



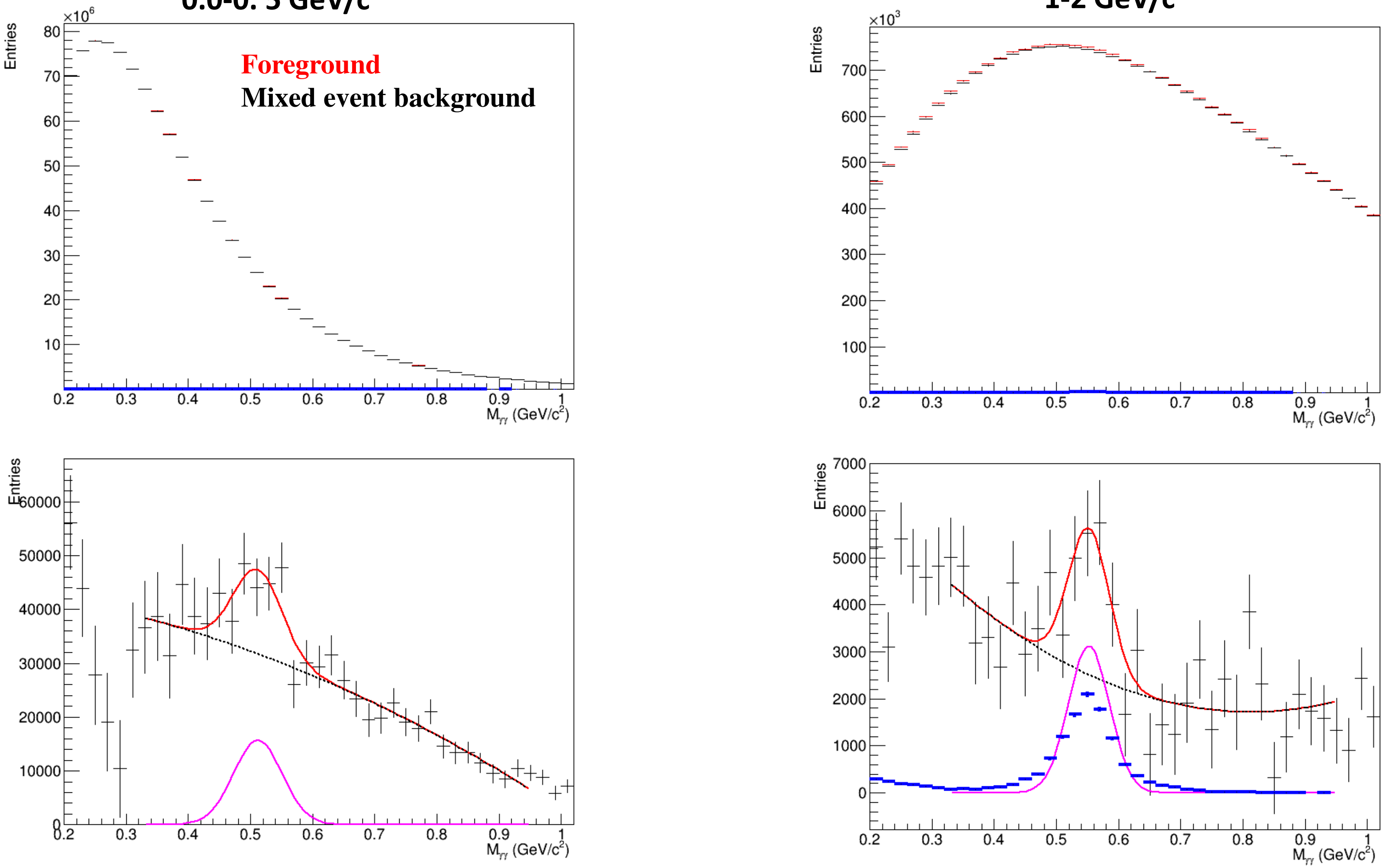


- Width is driven by single photon energy resolution
- Mass and width have modest dependence on collision centrality and analysis cuts

Neutral mesons: η

Full field, T = 0.5

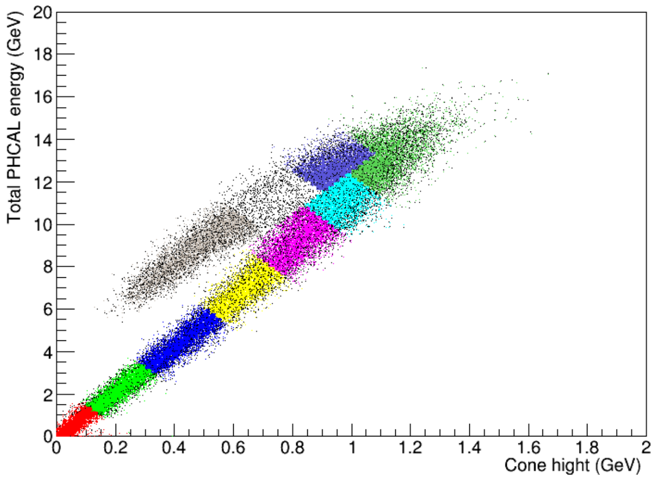
0.0-0. 5 GeV/c **1-2 GeV/c**

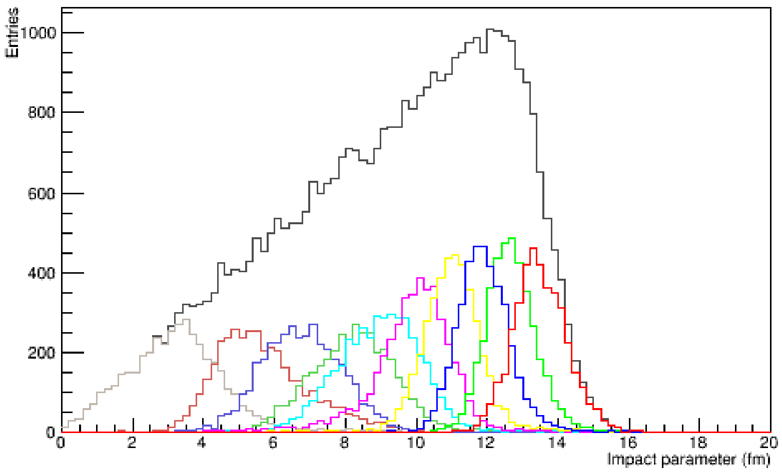


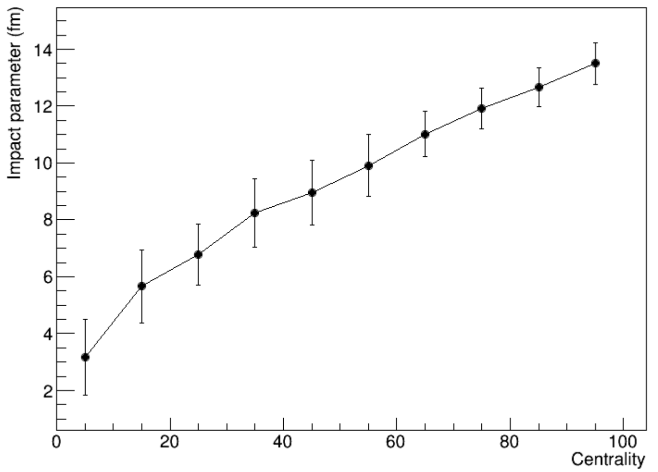
- The peak width decreases with increasing momentum (better energy resolution)
- The S/B improves with increasing momentum

Centrality with DCM-QGSM-SMM (Request 26)

E_{TOT} vs. E_{cone}

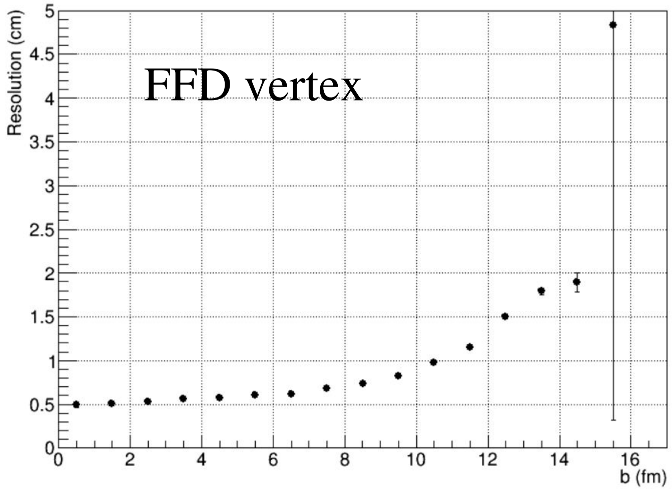


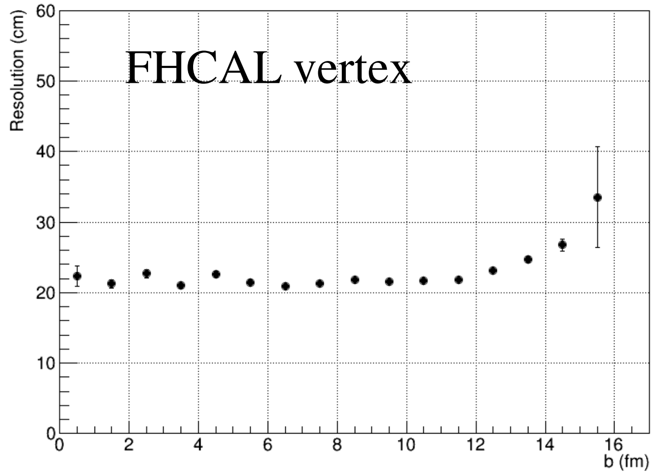


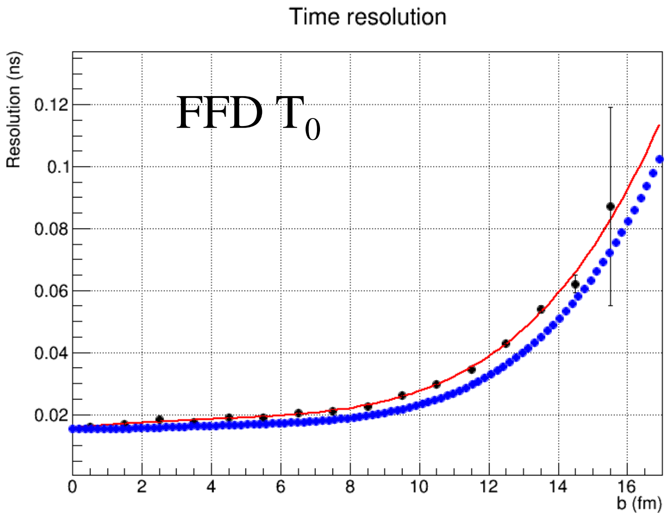


- Results are as expected

Vertex and T_0 resolution (Request 26)

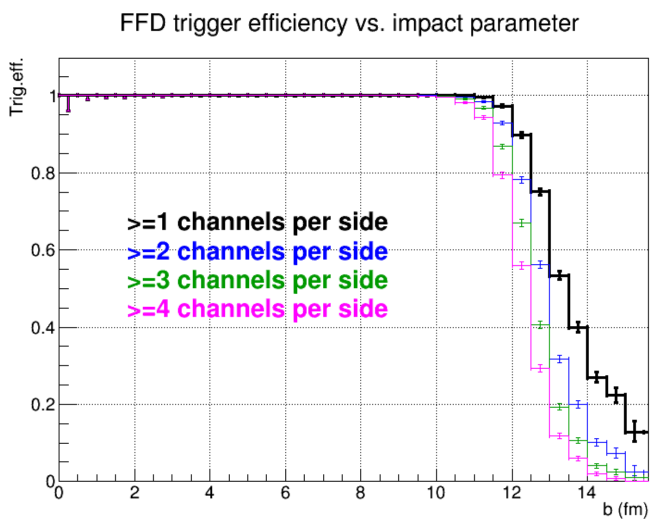


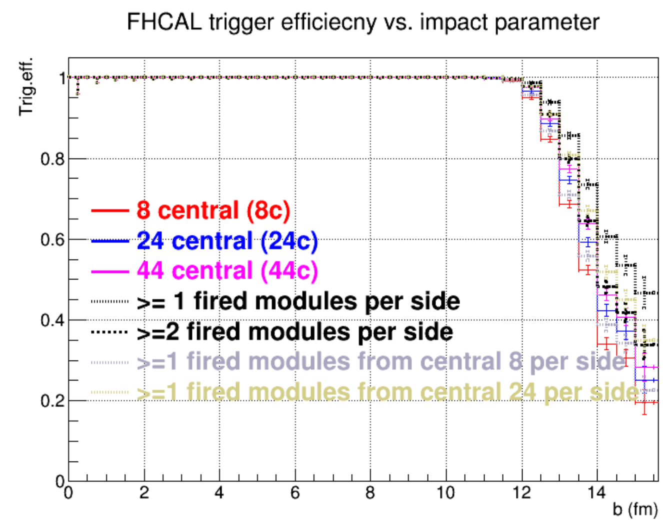


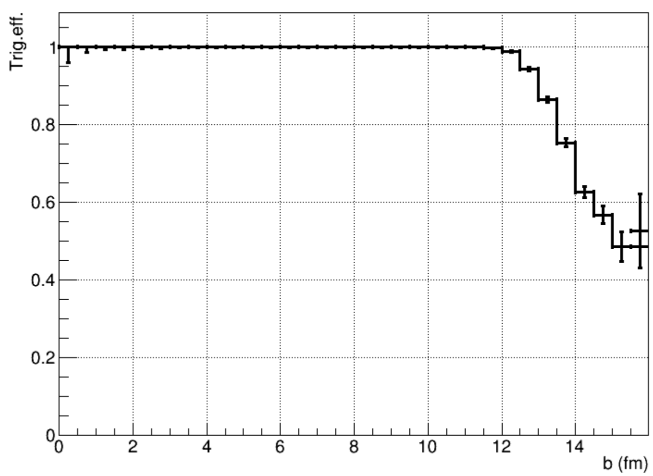


- Results are as expected

Trigger efficiency vs. b (Request 26)

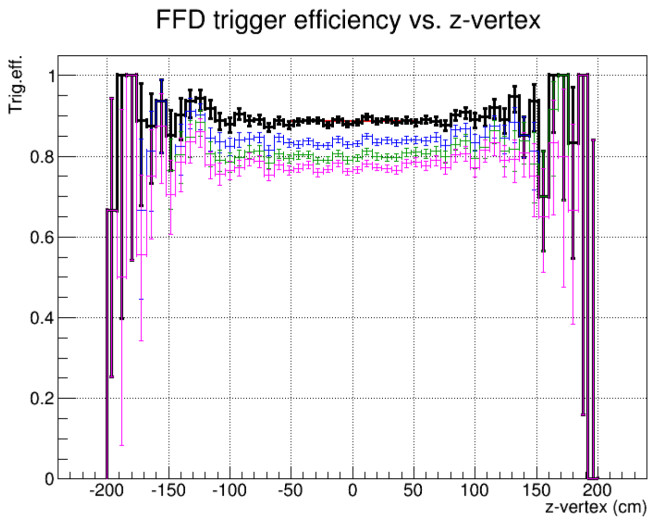


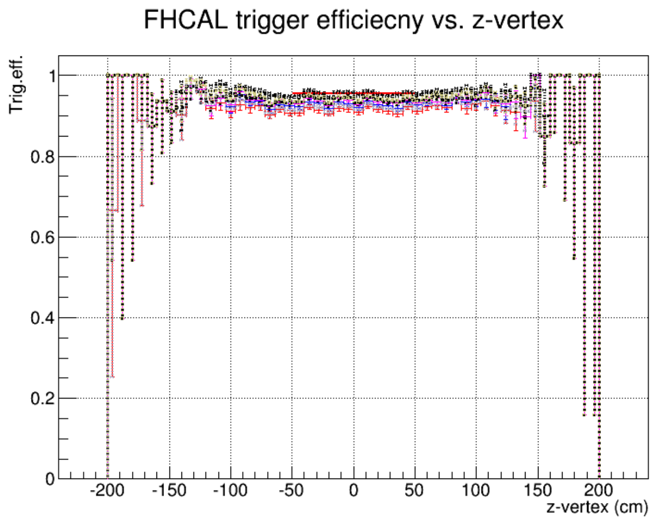


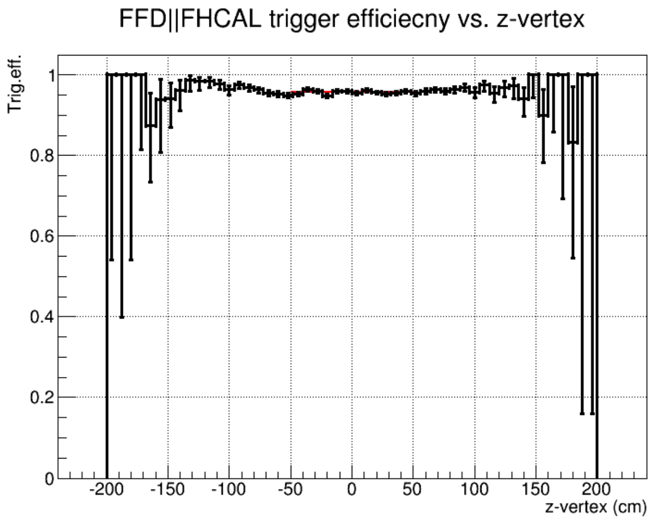


- Results are as expected

Trigger efficiency vs. z-vertex (Request 26)







- Results are as expected

Conclusions

- Do not see any problems with the productions