PID studies with CLAS12

Harut Avakian (JLab)

Deep Processes PWG, Meeting, July 22, 2020

- CLAS12 Simulation
- MC data comparison
- MC studies of misidentified particles
- Kaon pion ratios from data and MC
- Pion PID efficiencies using LTCC
- Kaon ID from Lambdas
- Conclusions & Summary

MC Simulation for First Publications

G. Angelini

- Production with OSG.
- Inbending production completed : 2.3B MC events matching pass1 inbending statistics.
- Outbending statistics ongoing: 0.7B MC events produced out of 4B needed to match pass1 inbending statistics (by end of August will be ready).

OSG output in /volatile/clas12/osg/gangel/, each file contains 10K events, 5% of the file are corrupted. It delays the merging procedure into larger files.

So far 2B inbedning events have been merged in group of 50M events file in:
/work/clas12/rg-a/montecarlo/fall2018/torus-1/clasdis/nobg/

300M outbending events have been merged in :
/work/clas12/rg-a/montecarlo/fall2018/torus+1/clasdis/nobg/

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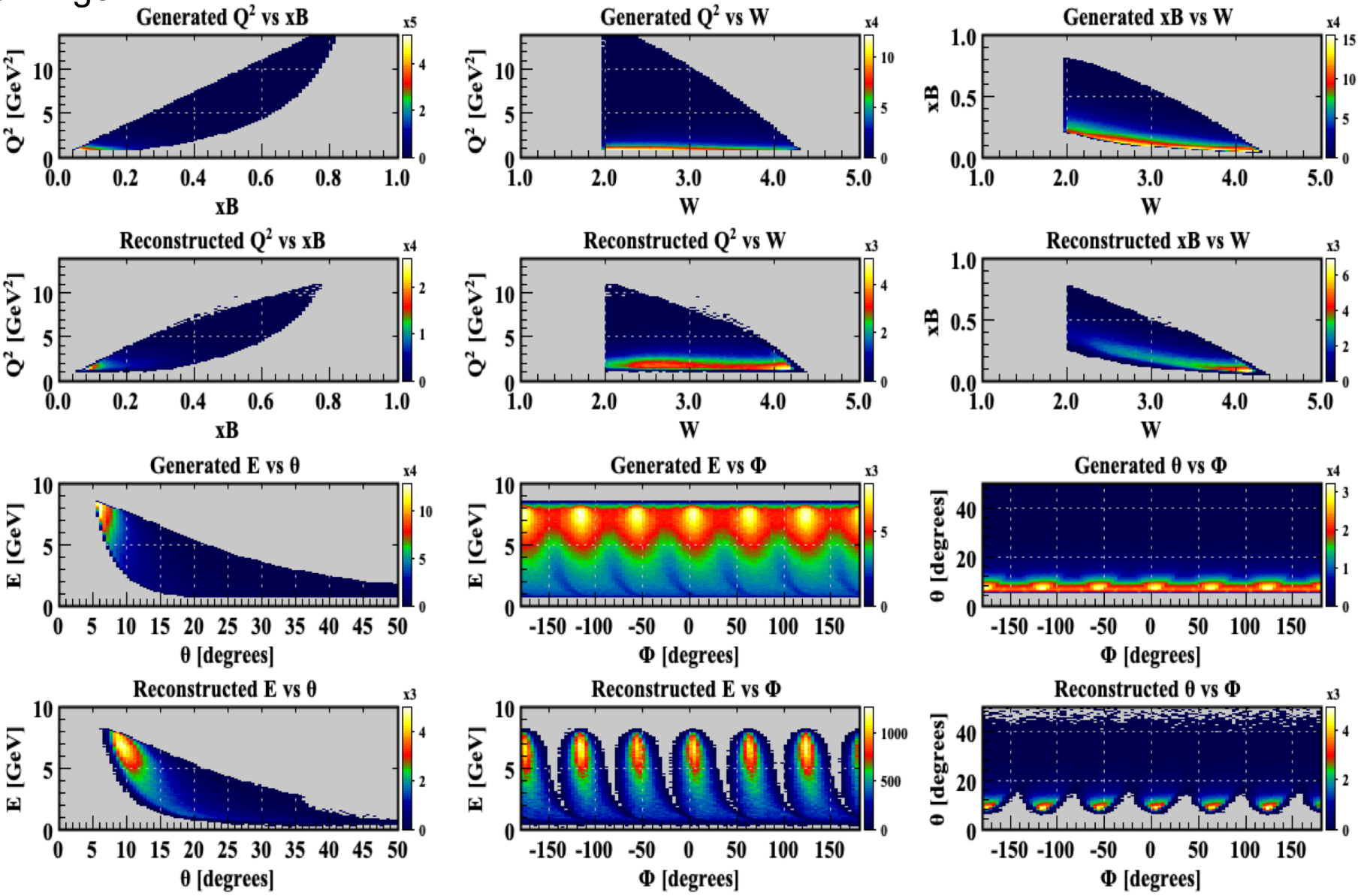

Simulated SIDIS events are close to actual CLAS12 events

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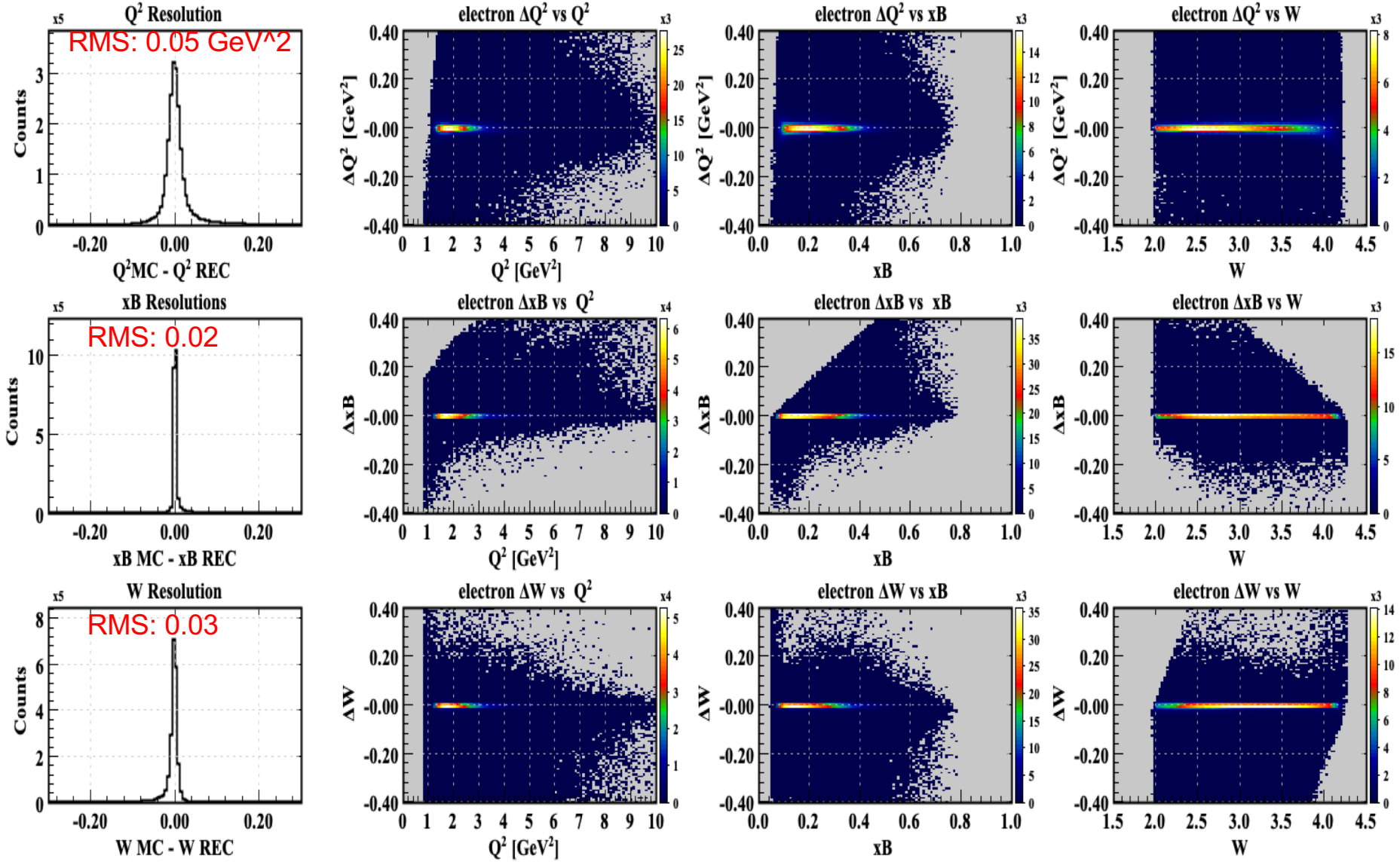

Coverage and resolutions for CLASDIS MC

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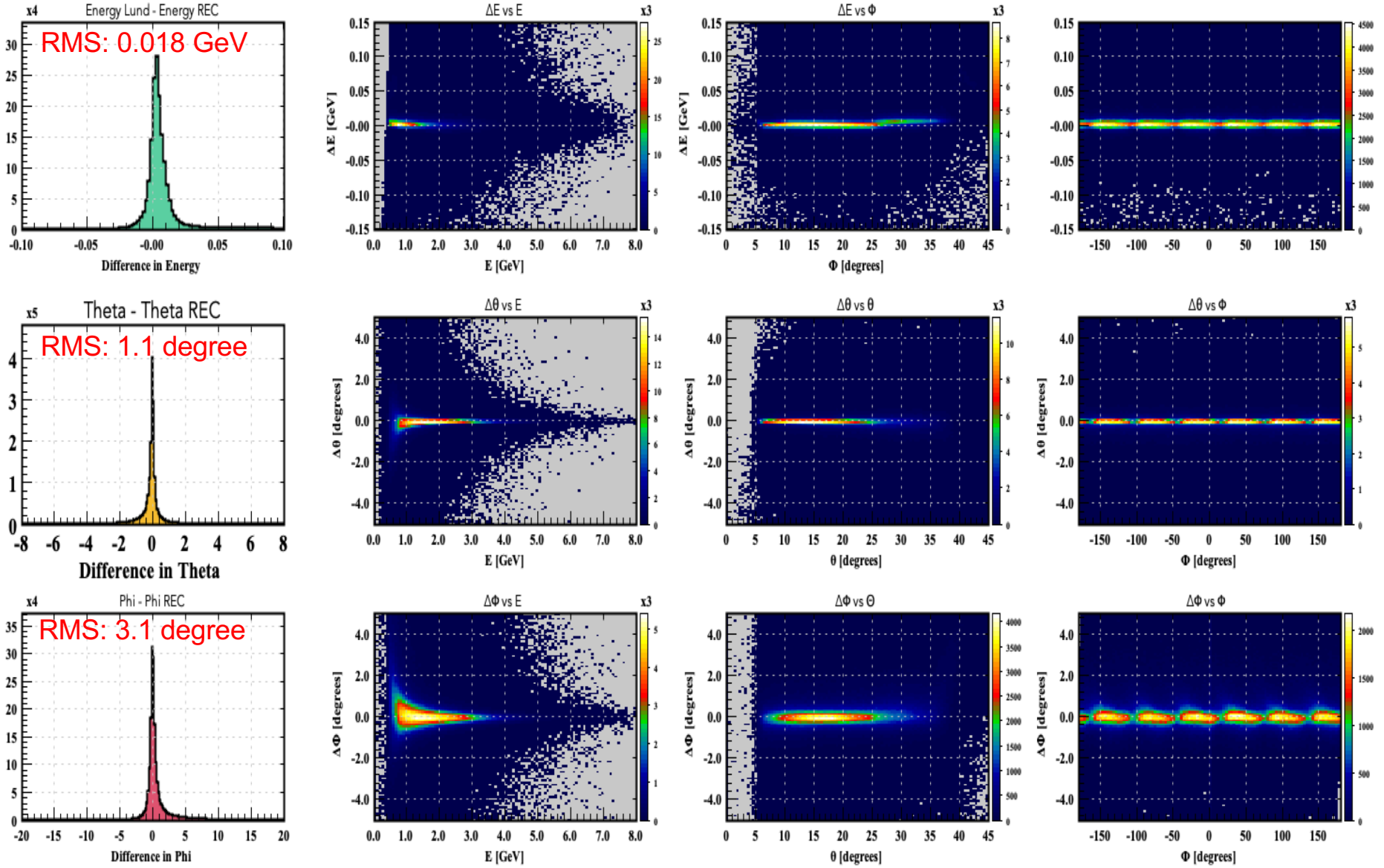

Resolutions in energy, polar and azimuthal angle for positive pions

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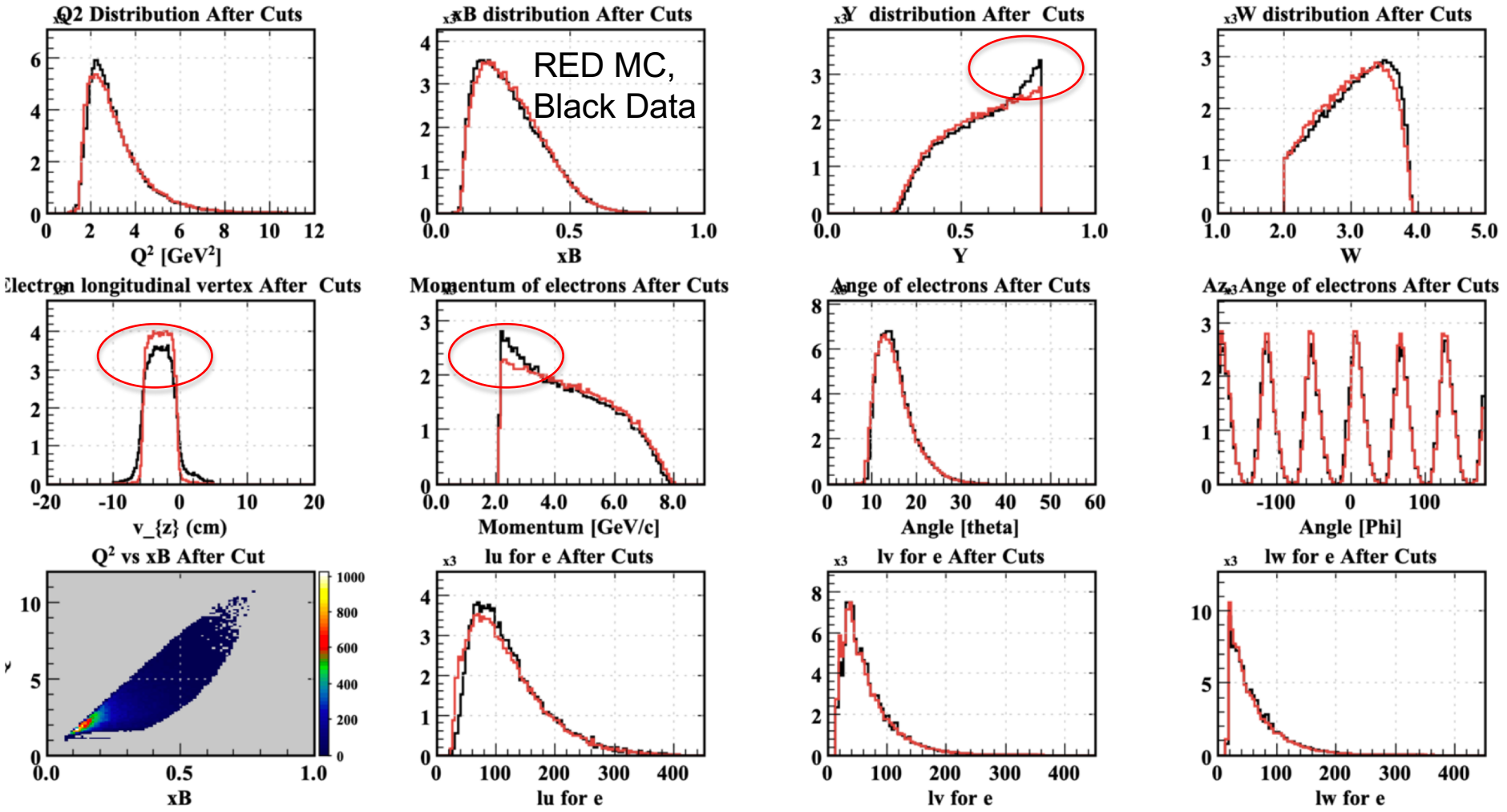
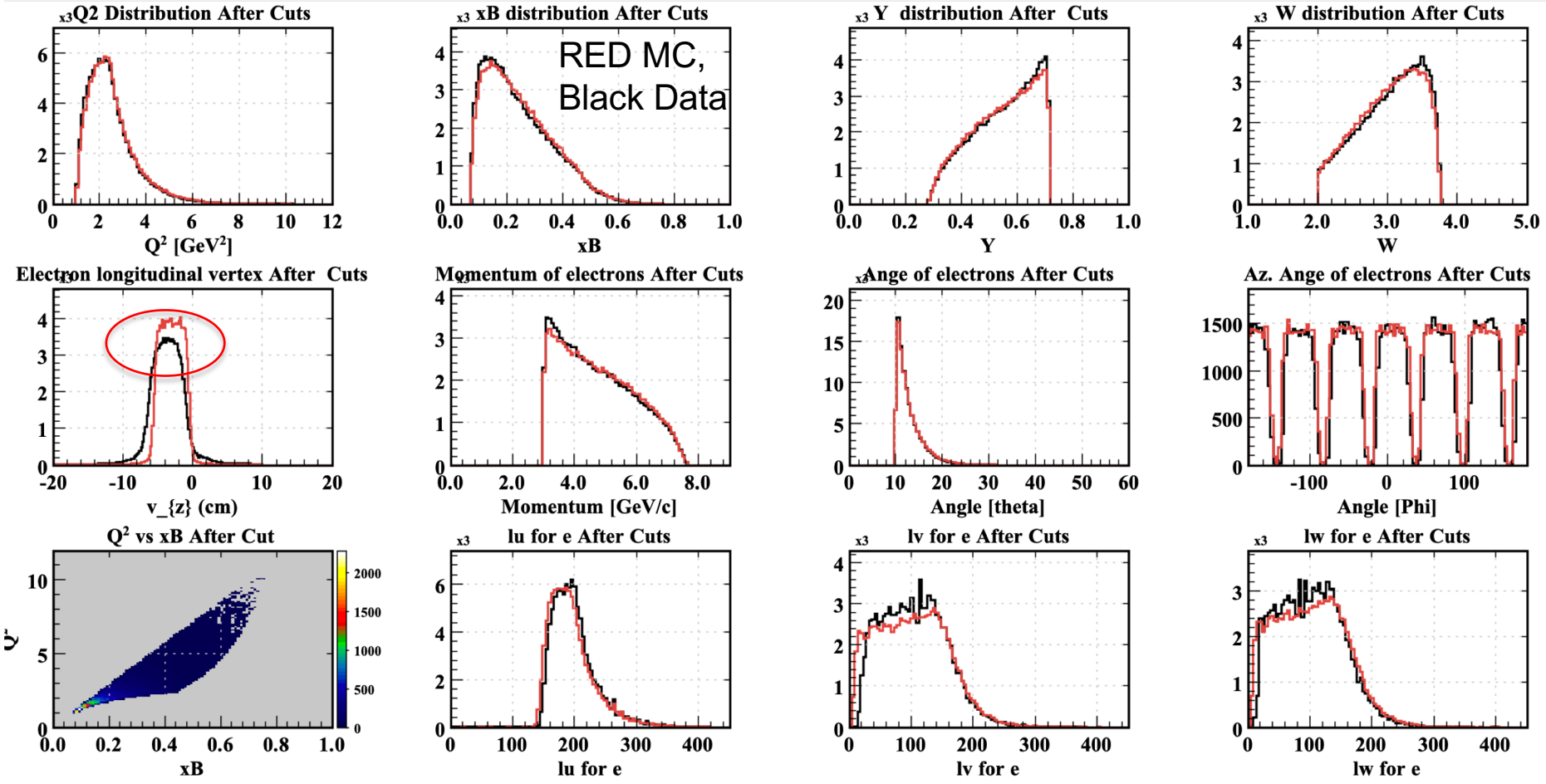
Comparison for electrons: inbending



SIDIS MC is in good agreement with data in the multidimensional space

G. Angelini

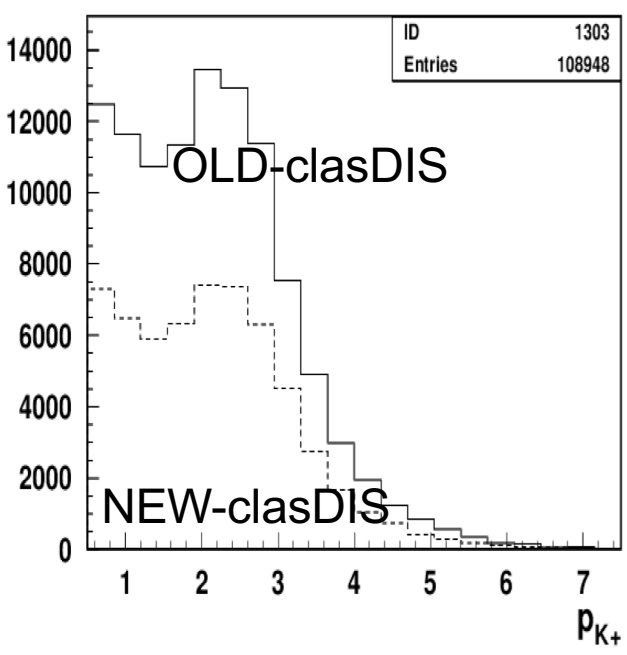
Comparison for electrons: outbending

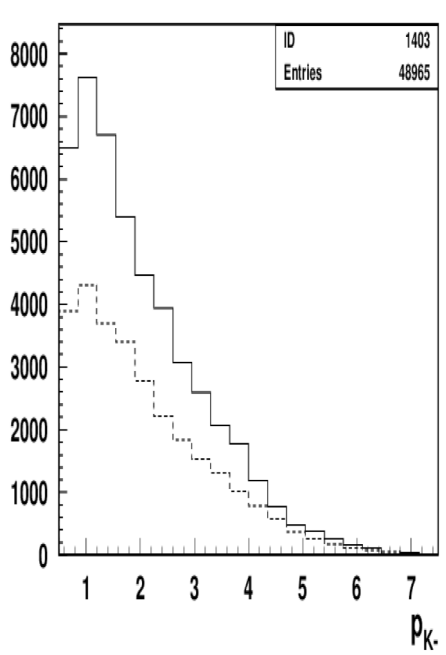


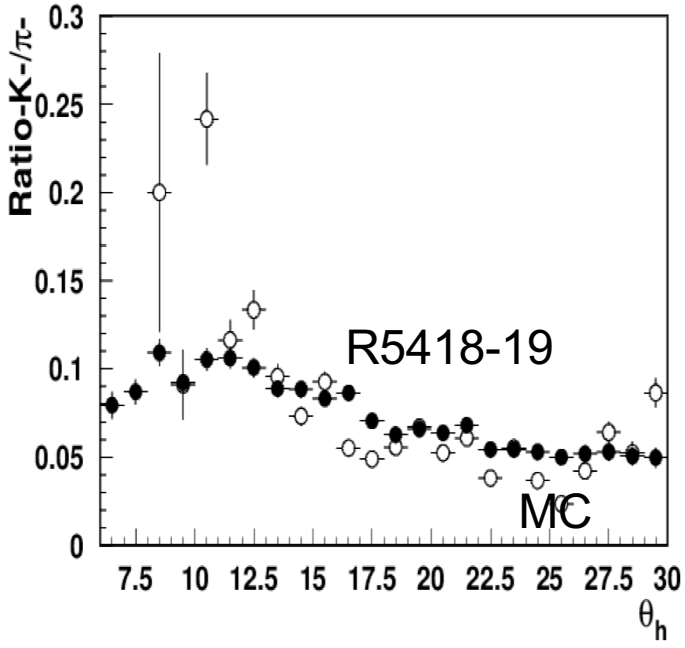
SIDIS MC is in good agreement with data in the multidimensional space

Comparing old MC with with new MC: e-

Normalize “old-MC (OSG)” (old-clasDIS+gemc 4.3.2, variation mc + coatjava 5.6.3)
and “new-MC” (new-clasDIS+gemc 4.4.0, rga_fall2018_dctune) + coatjava 5.6.6
for the same e- numbers



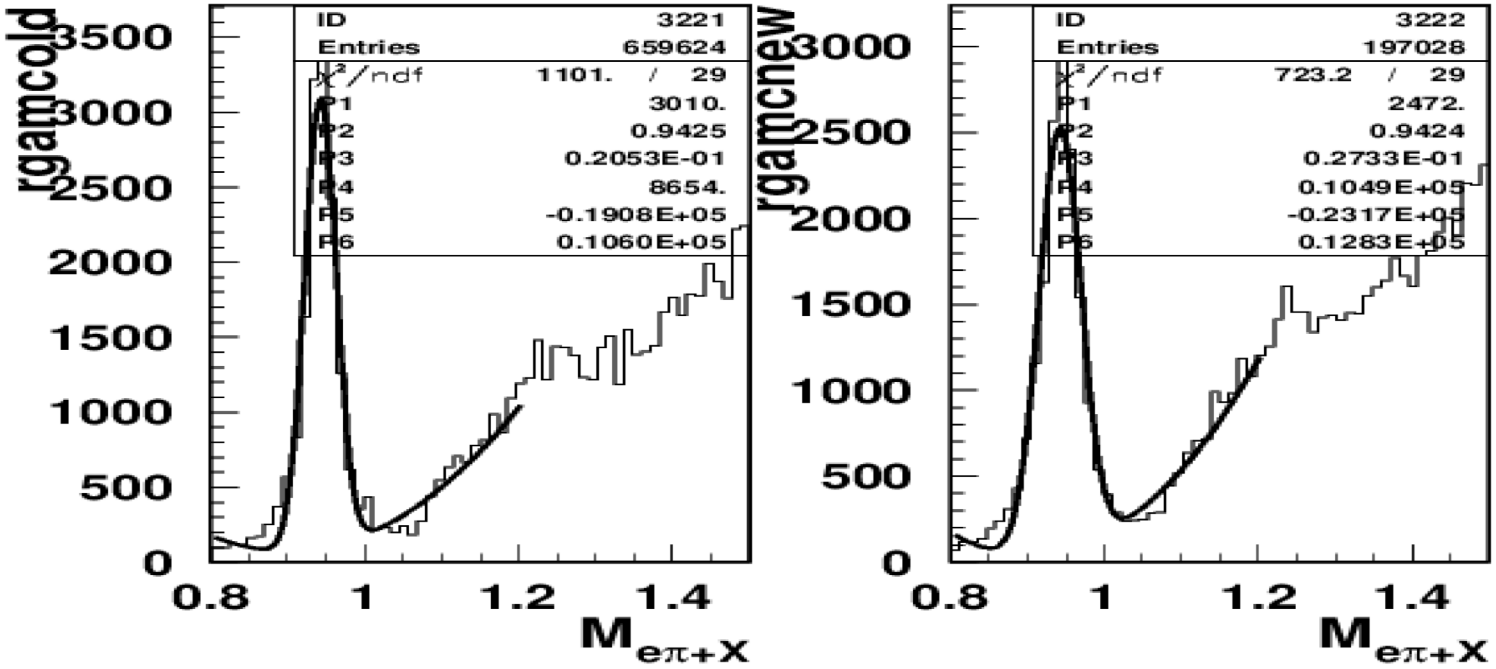




Significantly suppressed the kaon production in new MC→ consistent with data

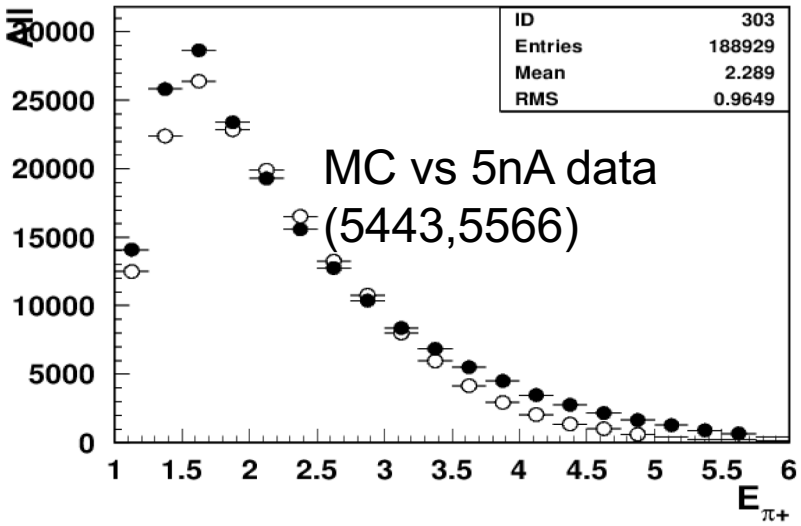
Comparing old MC with with new MC: e-

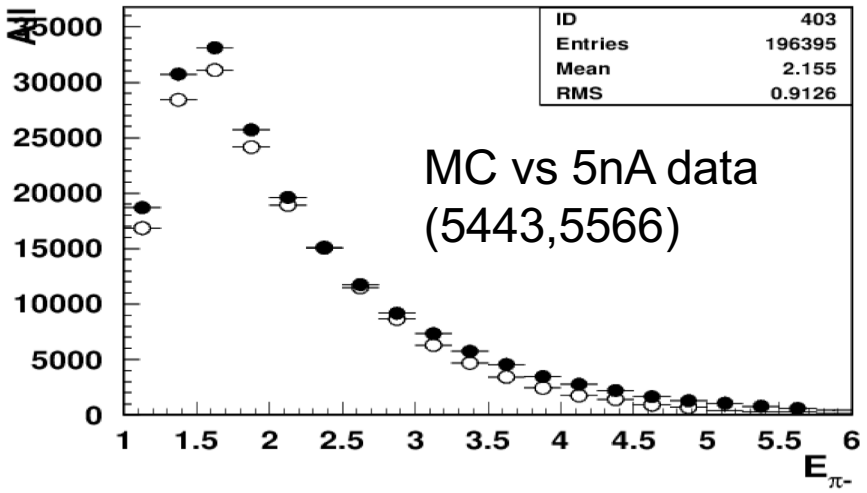
Normalize “old-MC(OSG)” (old-clasDIS+gemc 4.3.2, variation mc + coatjava 5.6.3)
and “new-MC” (new-clasDIS+gemc 4.4.0, use variation mc) + coatjava 5.6.6
for the same e- numbers

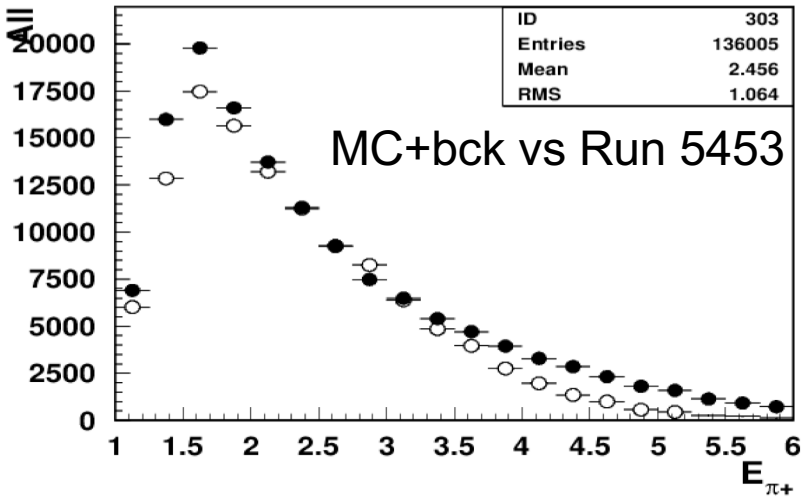


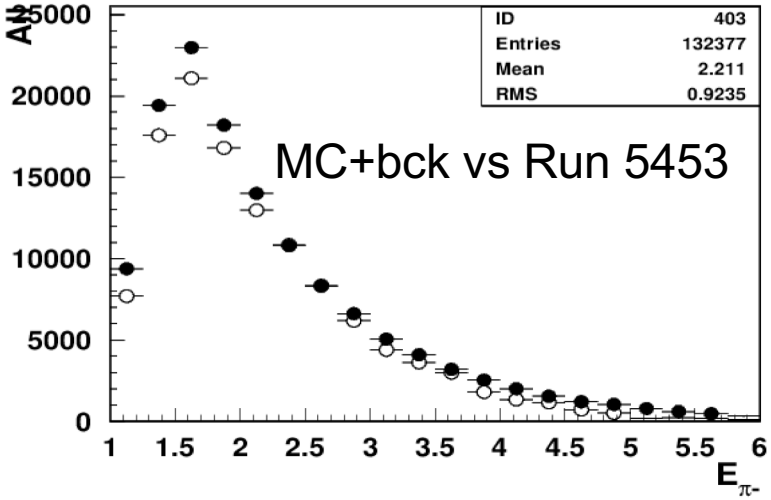
Resolution of neutron peak ~30% worse in new-MC (closer to data)

Outbending: MC vs Data



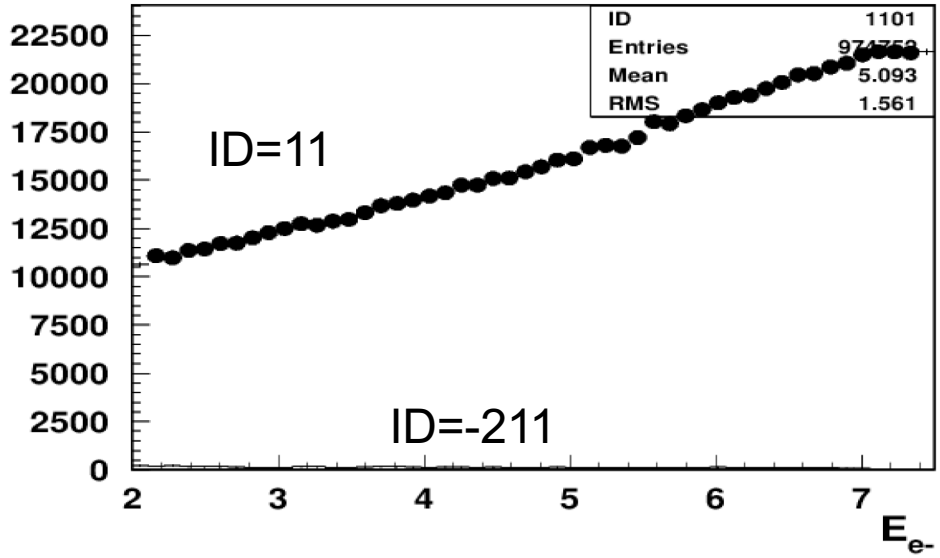


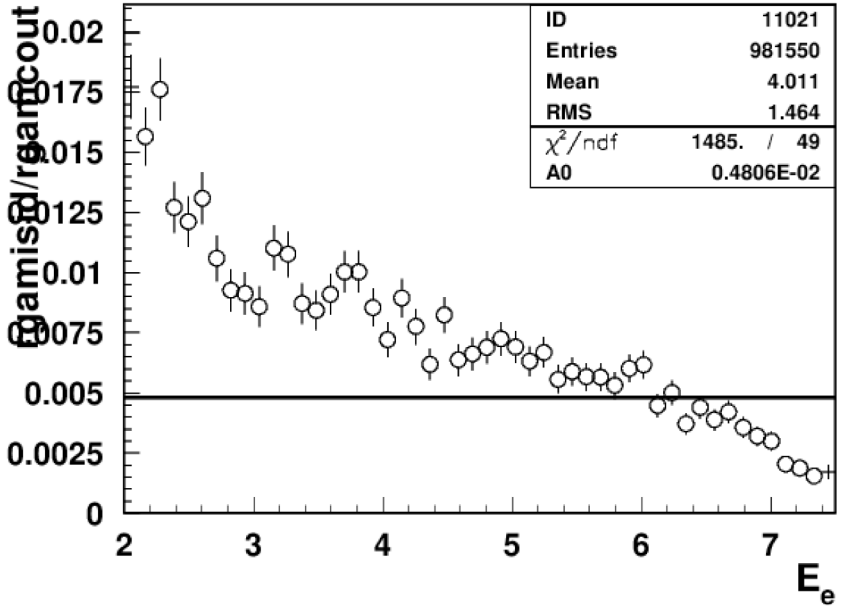


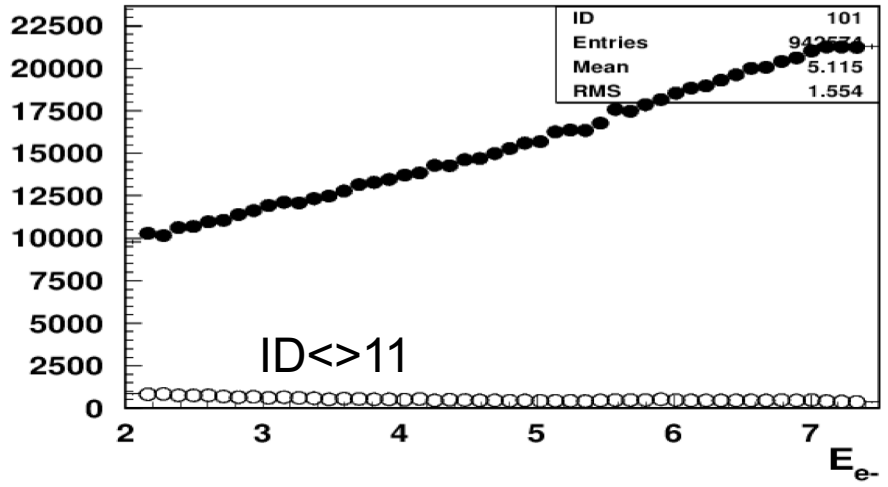


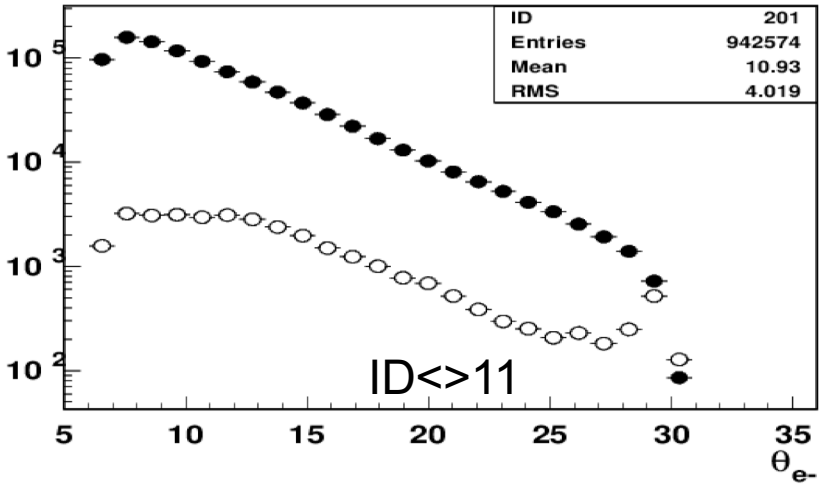
Overall agreement of MC with low lumi and MC+bck with high lumi counts

Outbending: MC-IDt vs MC-REC



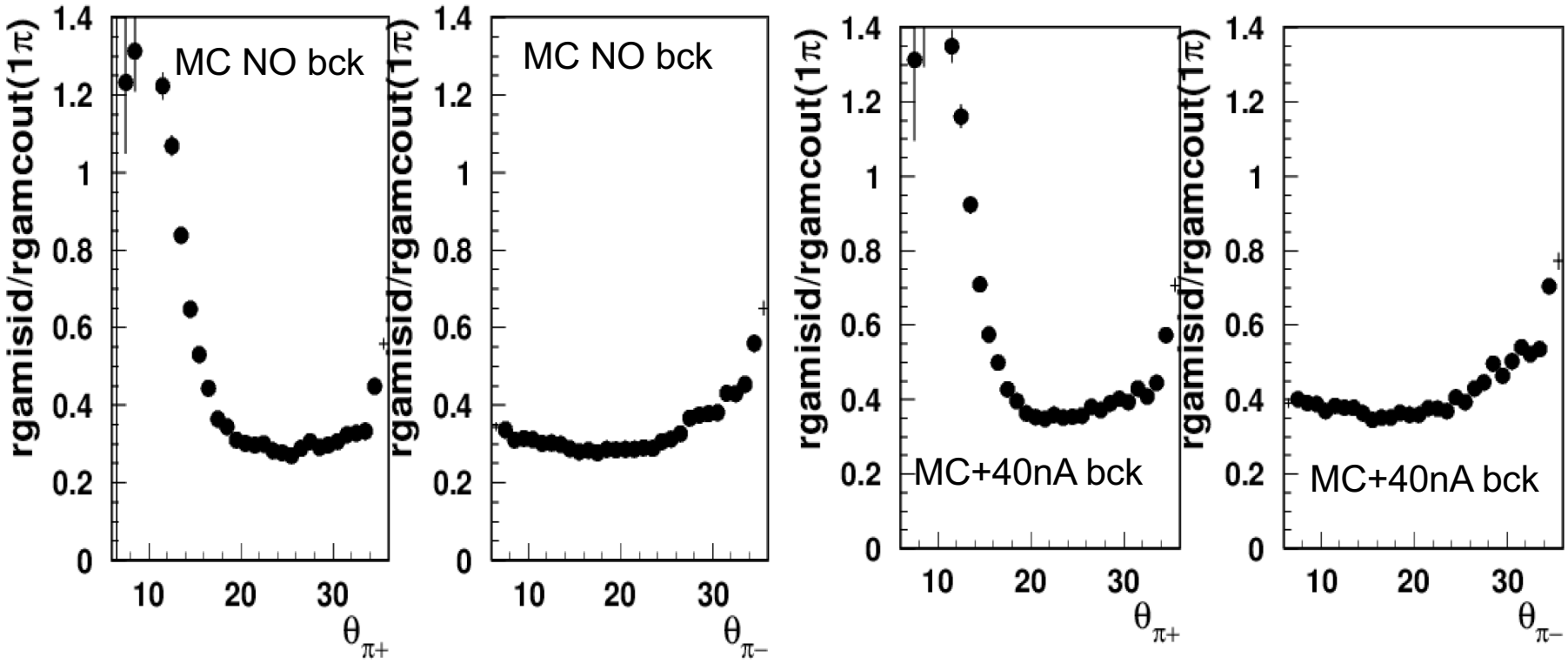






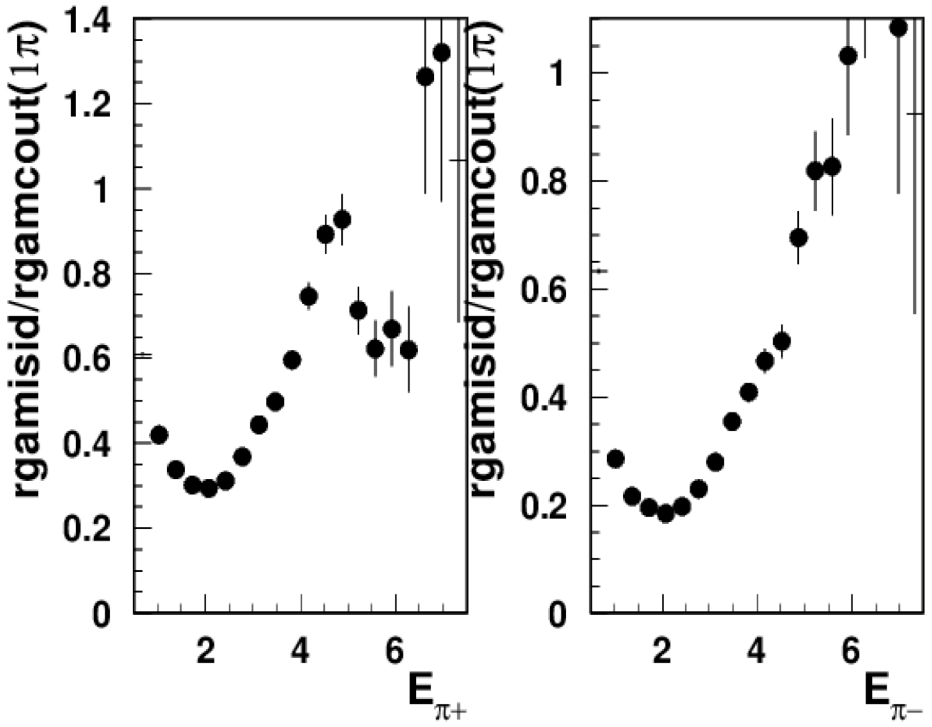
Significant fraction of reconstructed e- not identified at large angles

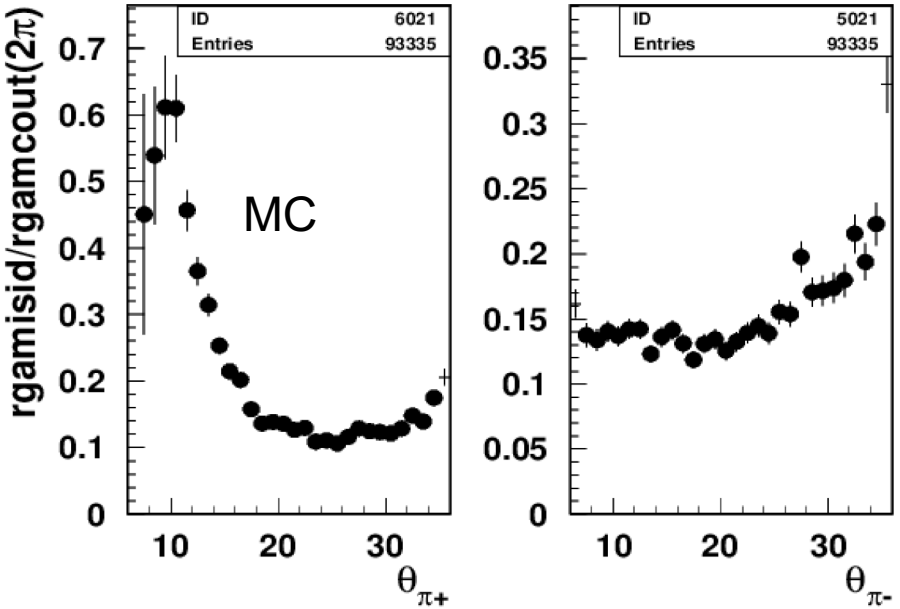
Outbending: MC-IDt vs MC-REC

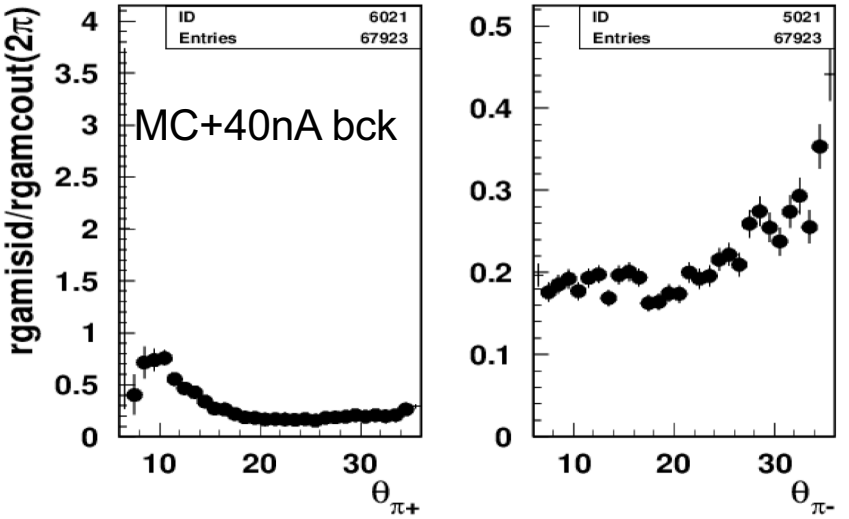


- Fraction of misidentified pions (PID#|211|) compared to properly identified (PID=|211|) can be very significant, at small angles
- Fraction increases slightly with background

Outbending: MC-IDt vs MC-REC



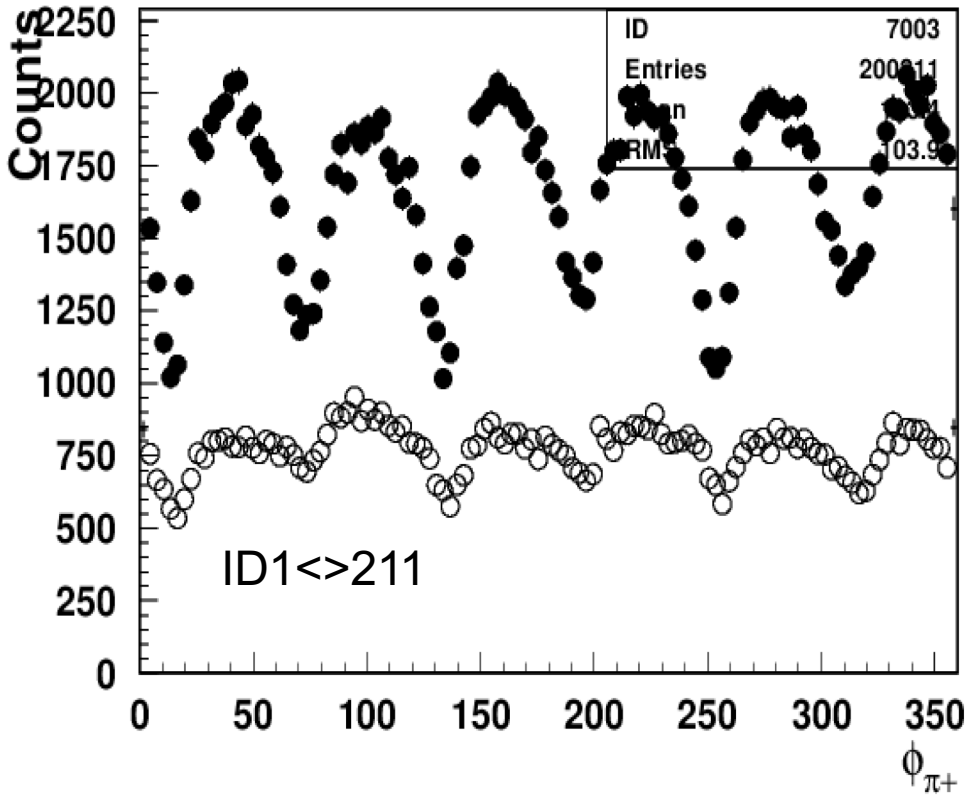




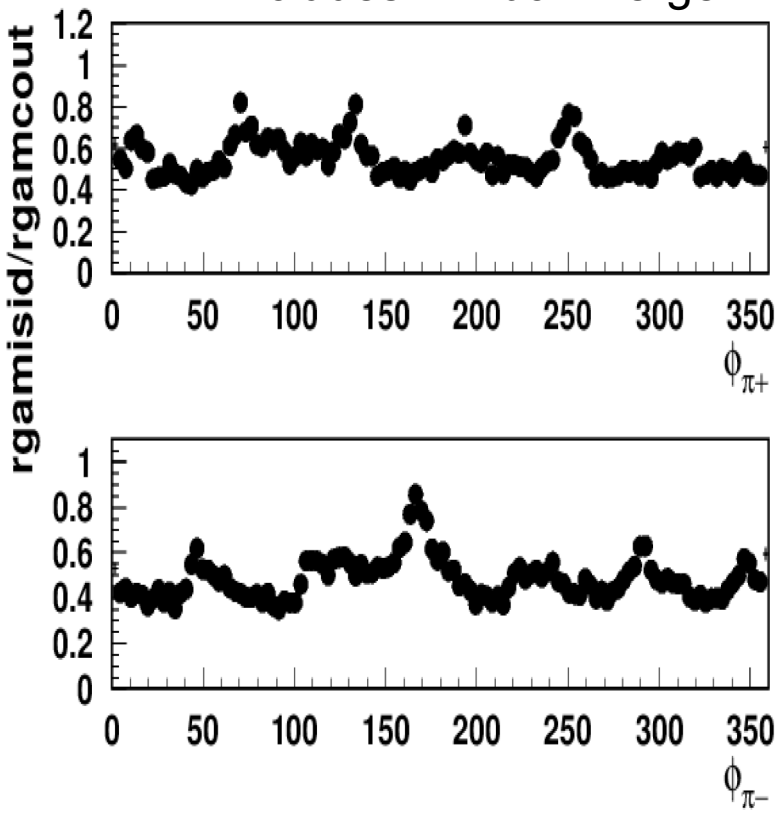
PID#211 / PID=|211|

Significant fraction of reconstructed hadrons lost in the ID stage, increases with momentum
Fraction bigger with background merged

Outbending: MC-IDt vs MC-REC



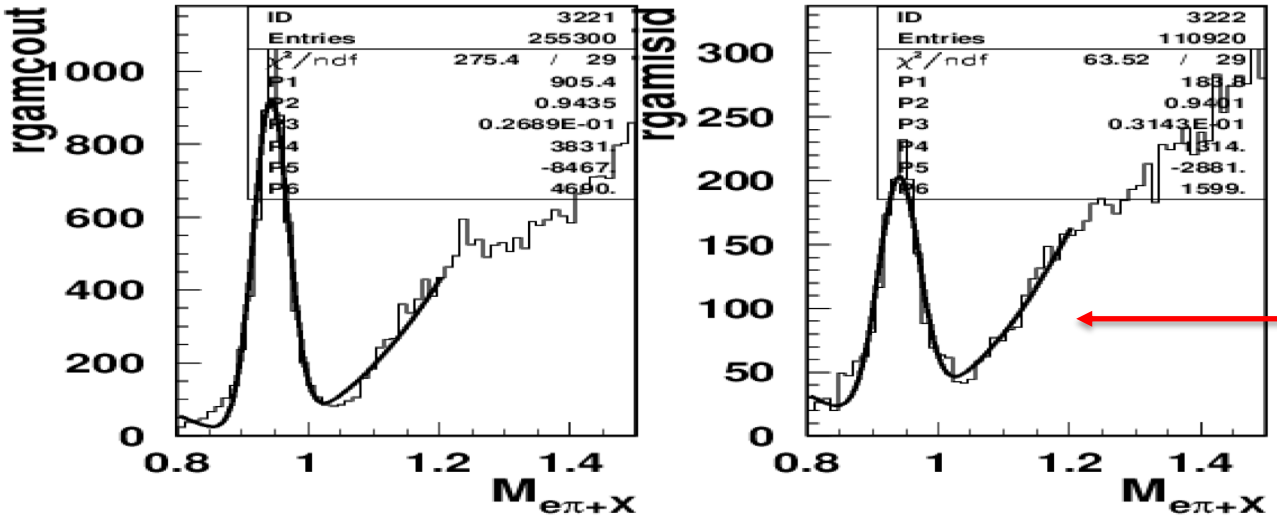
Includes 1M-bck merge



Significant fraction of misidentified hadrons in edges, but also spread over the full phi-range

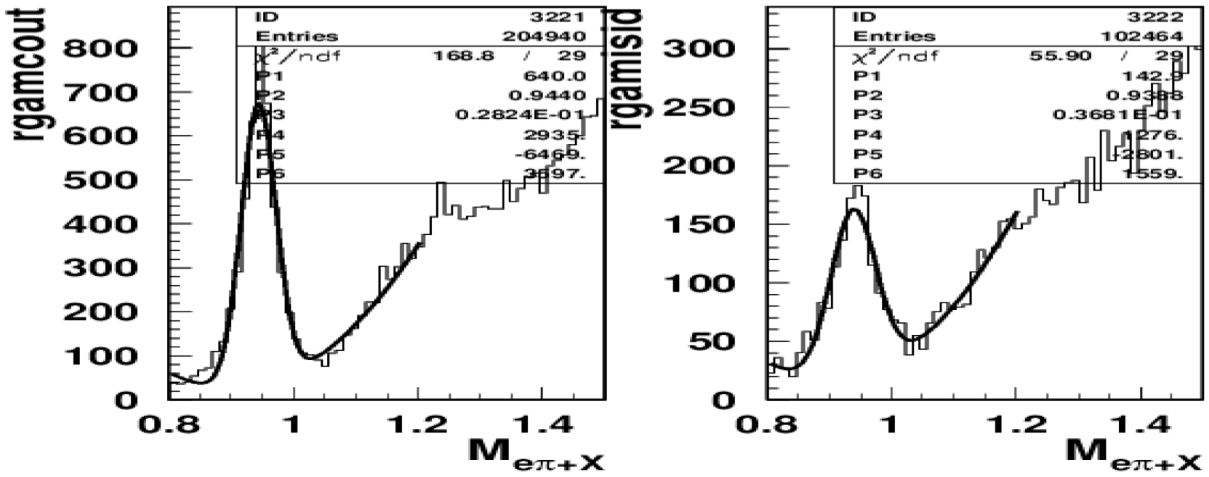
Outbending: MC-IDt vs MC-REC

MC – NO background



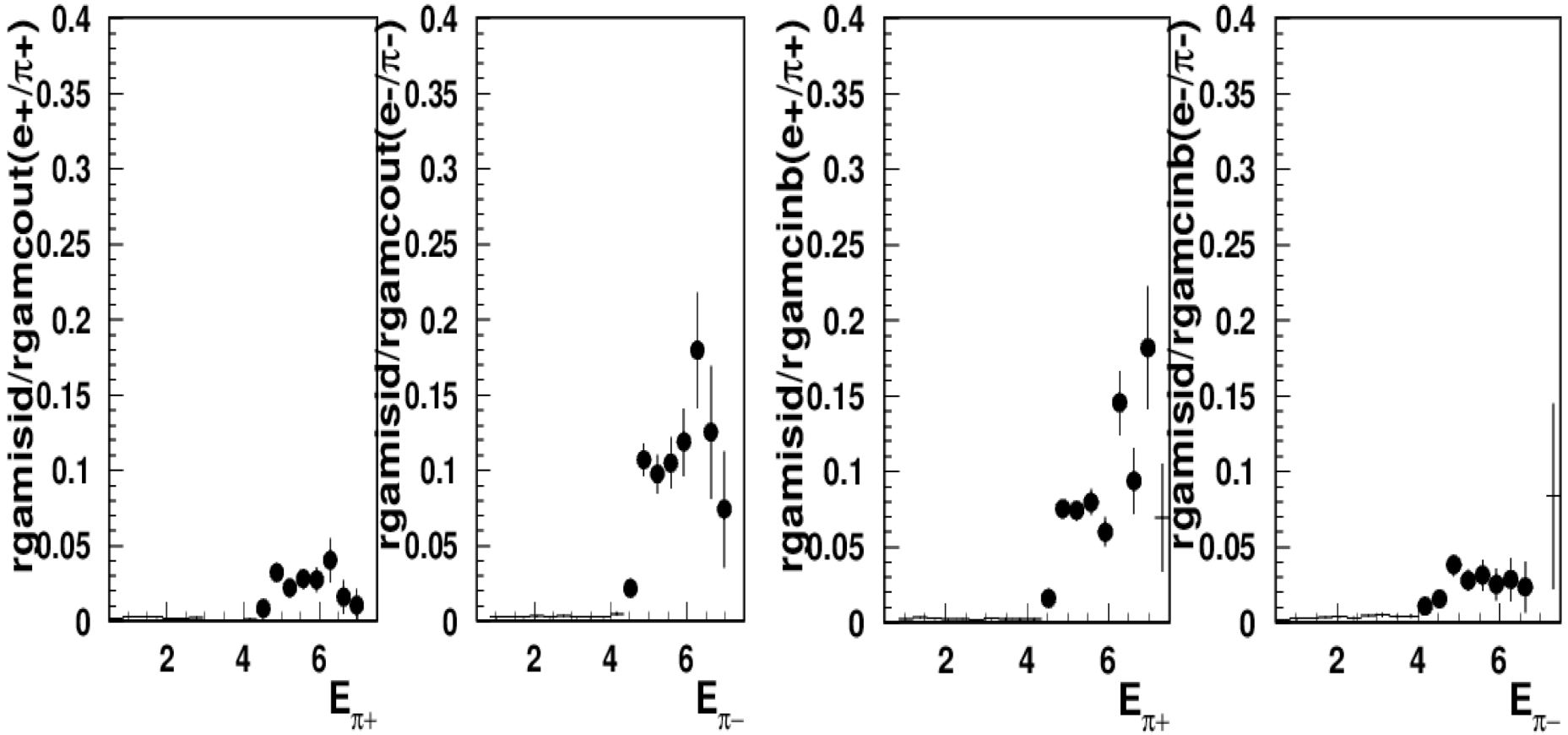
ID#211

Includes 1M-bck merge



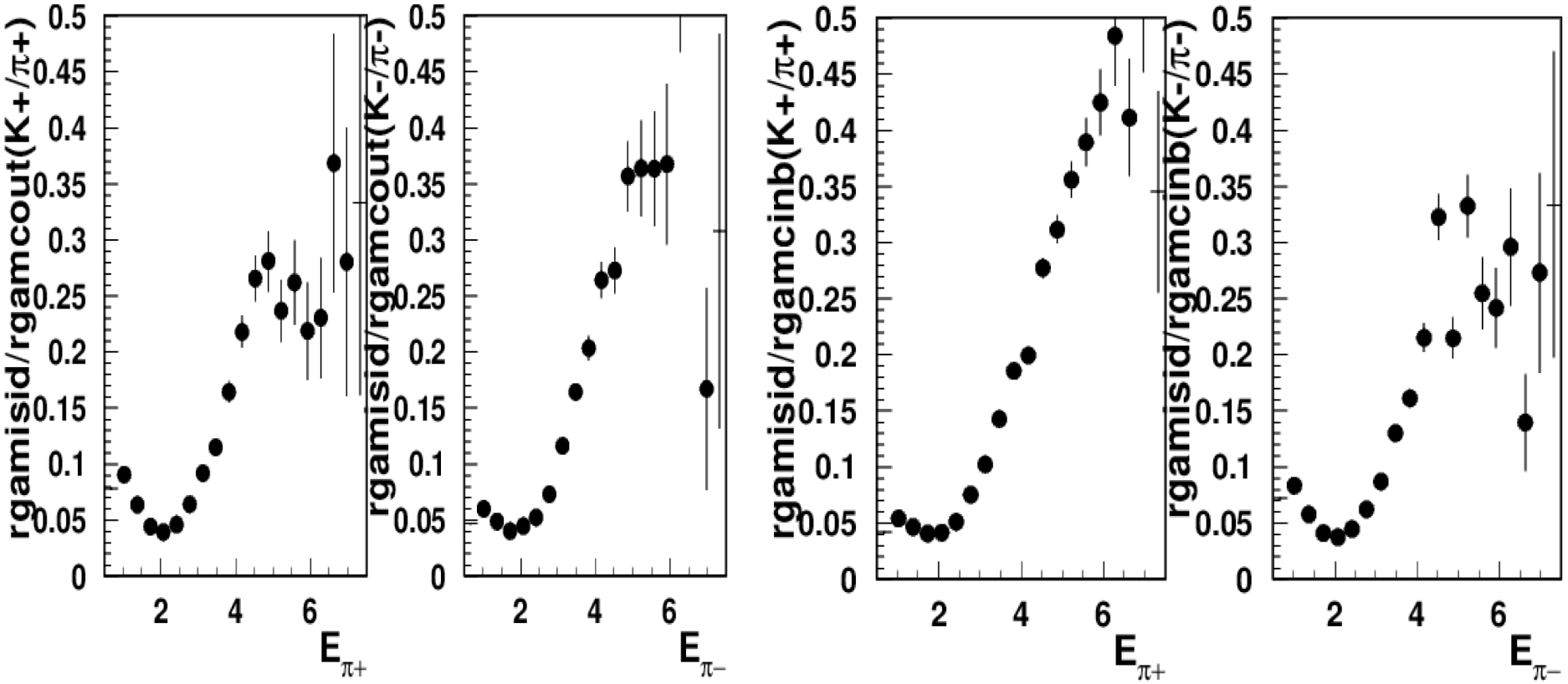
- Misidentified pi+ good enough to make a peak (a bit wider)
- Additional bck makes fraction bigger and width wider

Misidentifying pions with leptons



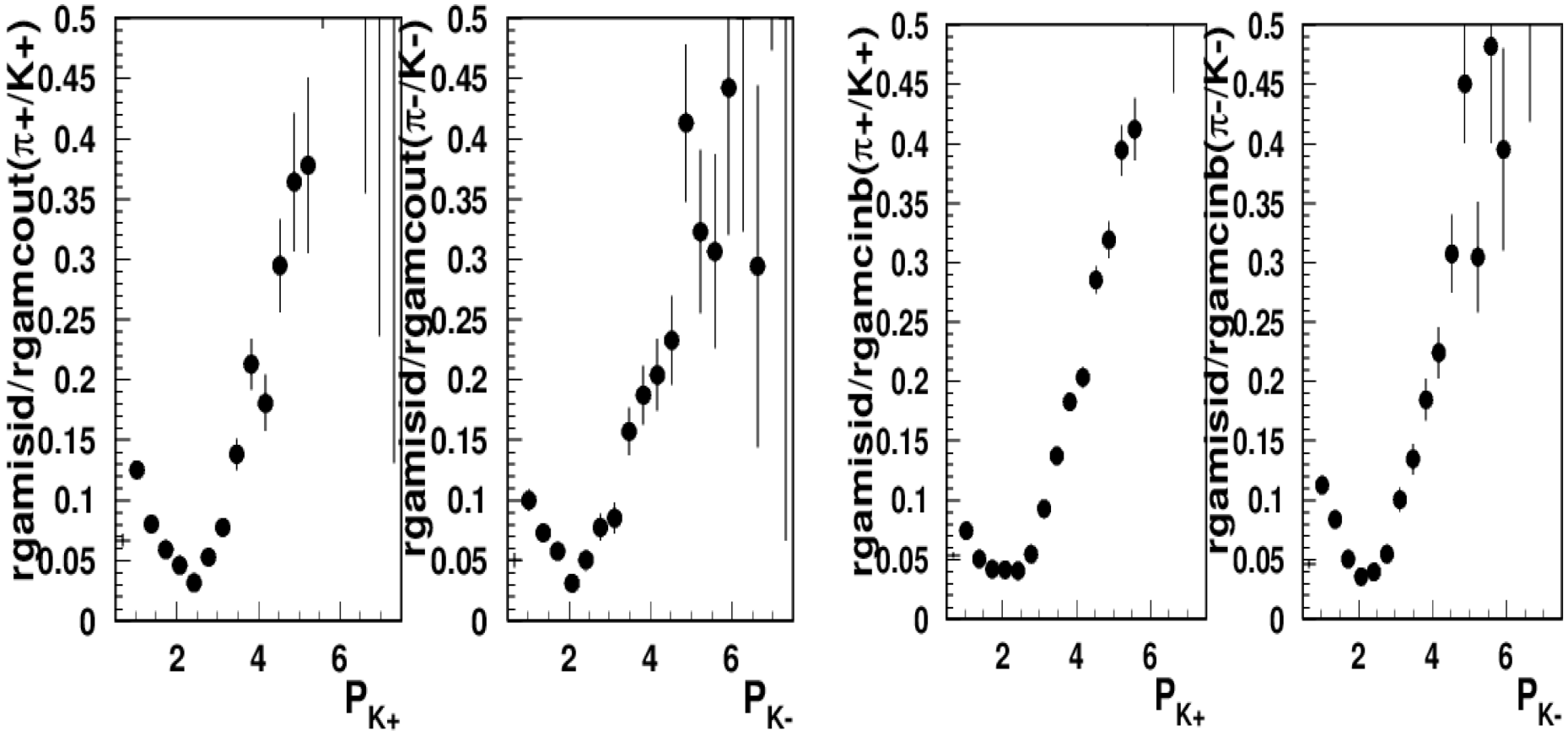
Misidentification of pions detected as lepton increases above 4 GeV
Can be used to estimate pion contamination combined with flux

Misidentifying pions with kaons



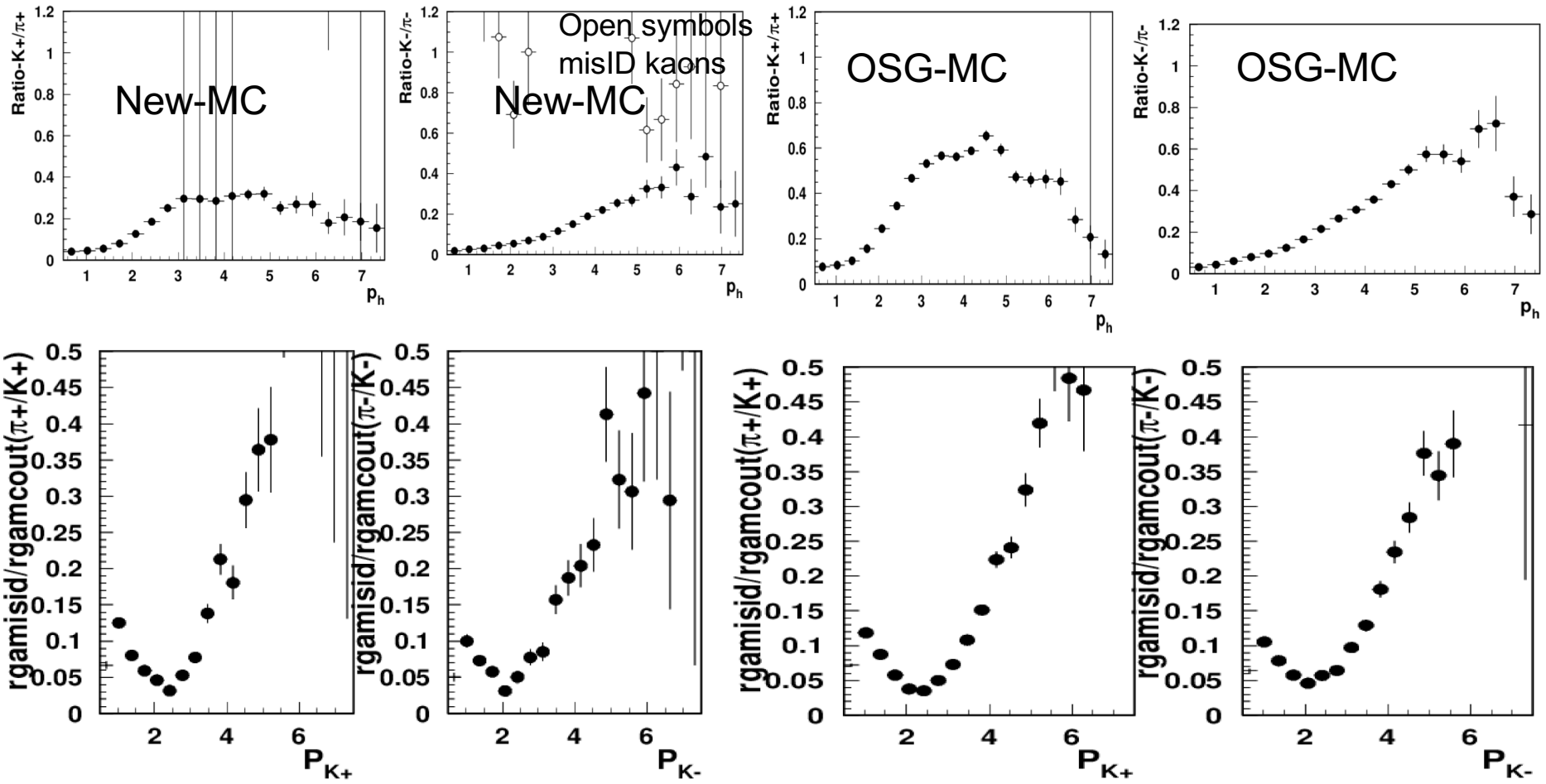
At momenta above 3 GeV the misidentification of pions by kaons increases rapidly
Can be used to estimate pion contamination combined with relative flux

Misidentifying kaons with pions



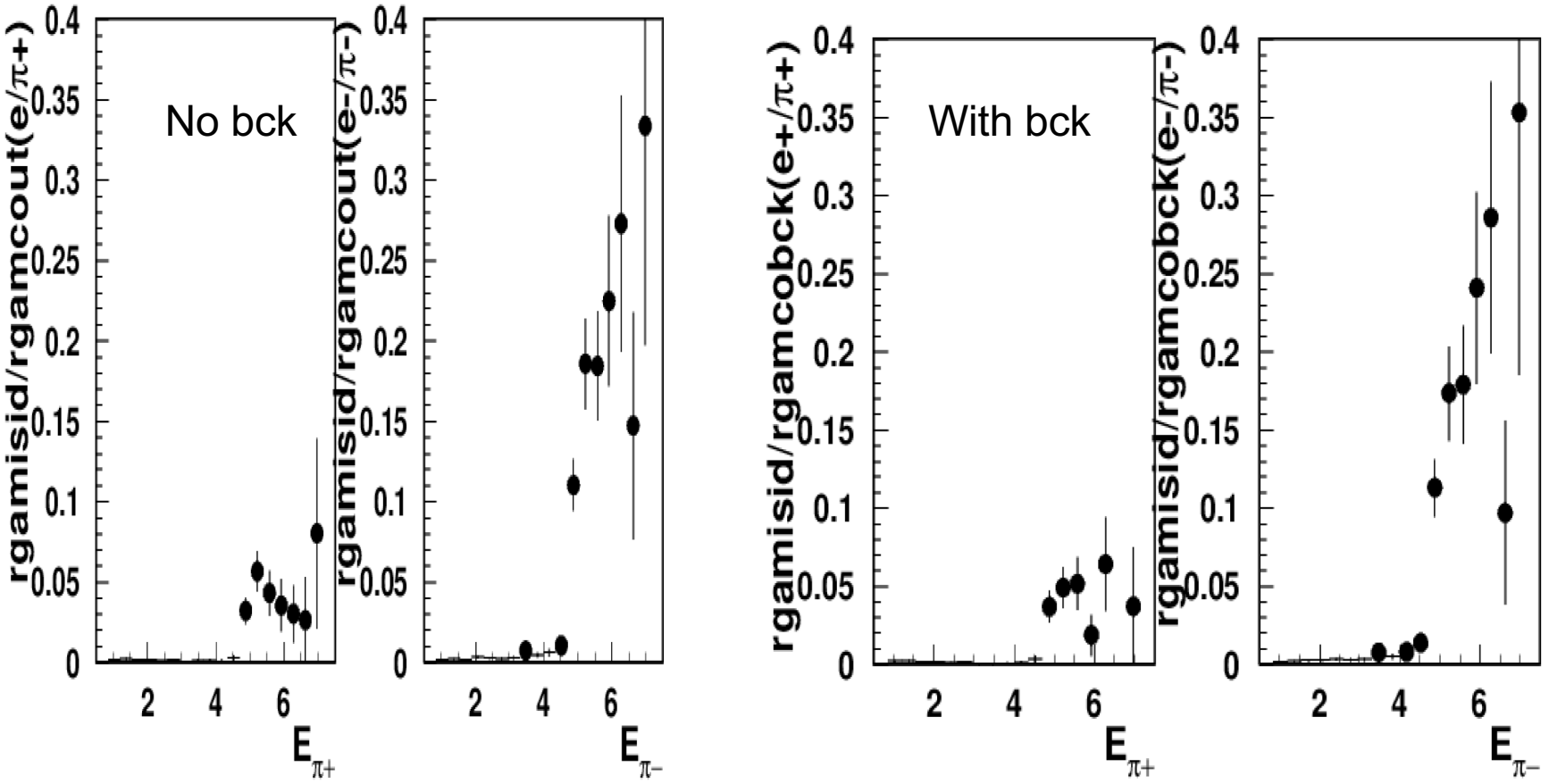
At momenta above 3 GeV the misidentification of Kaons by pions increases
Can be used to estimate kaon contamination combined with kaon flux

Misidentifying kaons with pions for 2MC



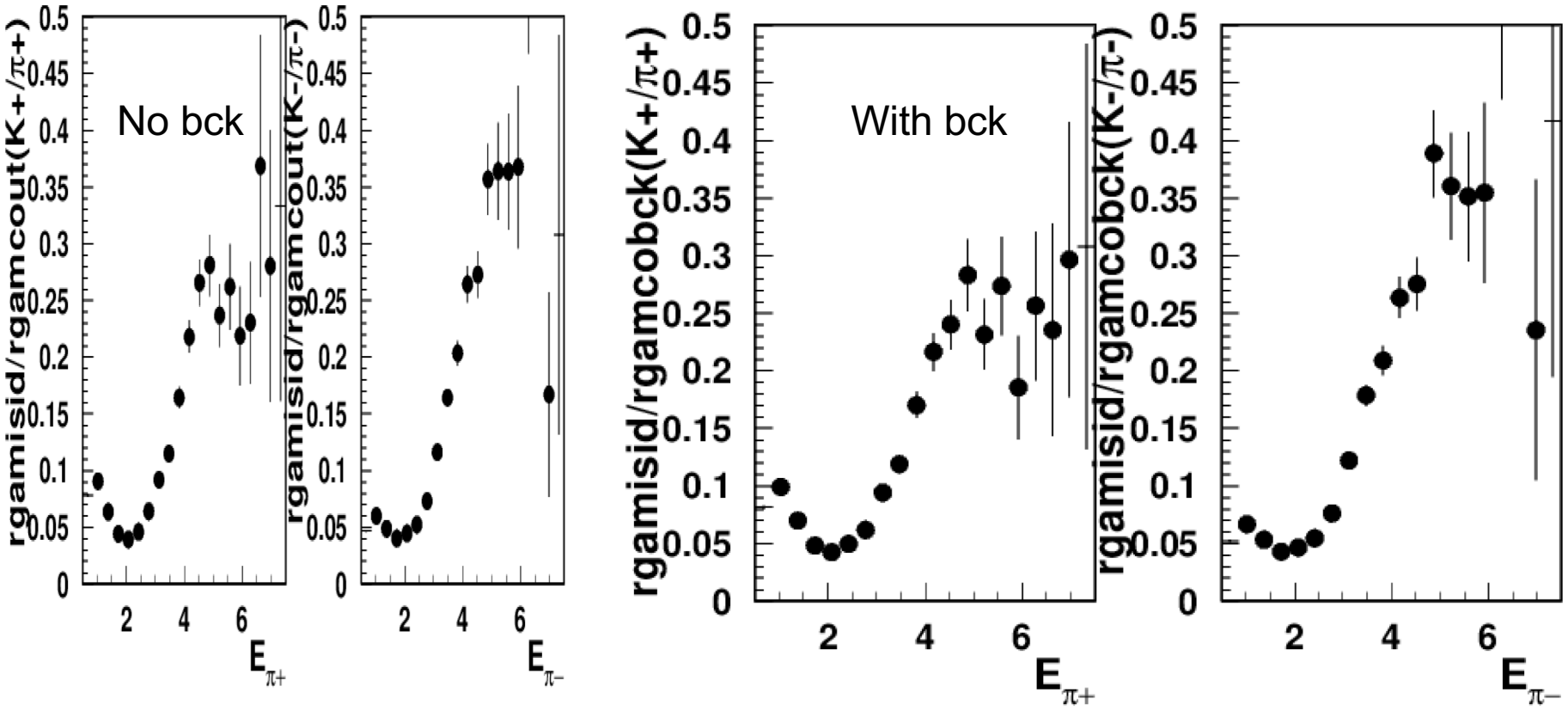
The fraction of misidentified pions, seem to have week dependence on actual input K/pi ratio, which was x2 different in 2 MCs (new Kaon-MC vs OSG-clasDIS)

Misidentifying pions with leptons with bck



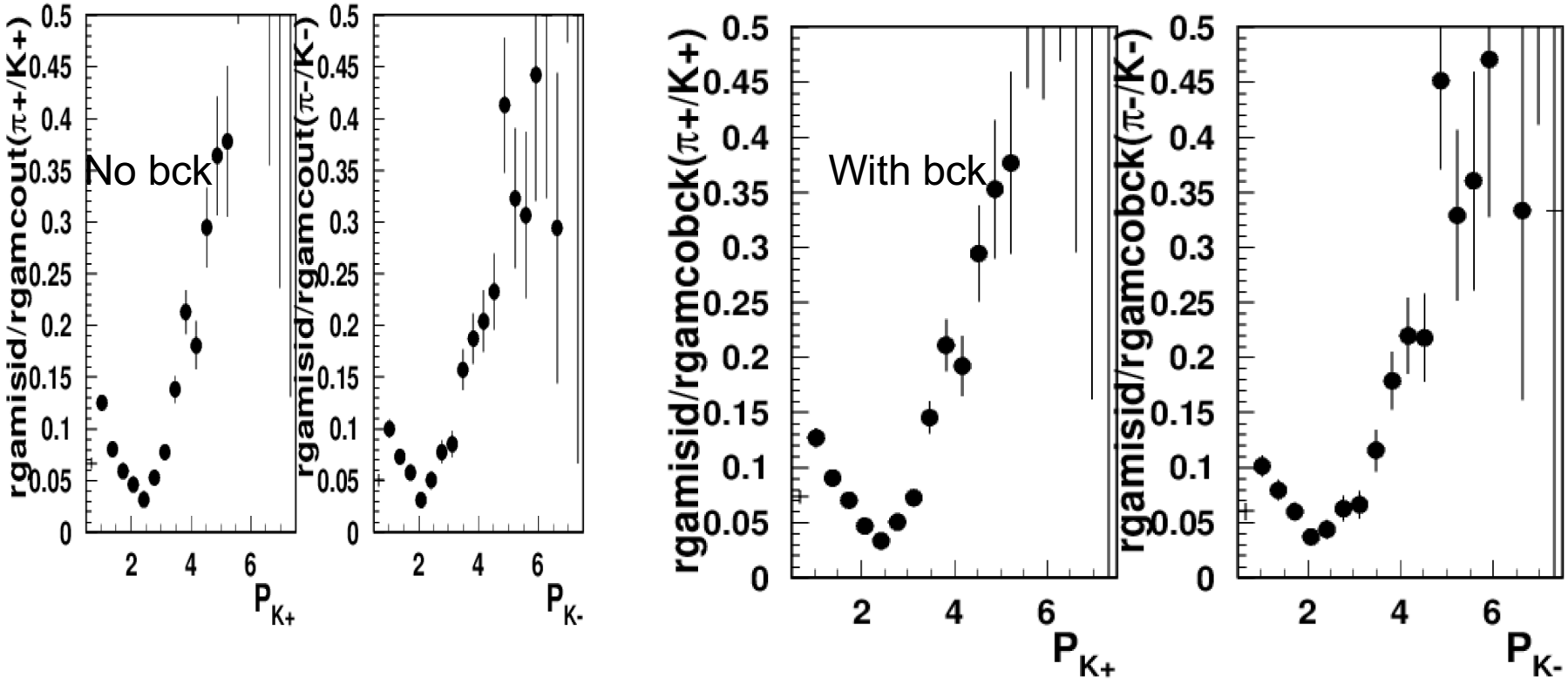
Background has a minor contribution on misidentification of pions detected as lepton increases above 4 GeV

Misidentifying pions with kaons with bck



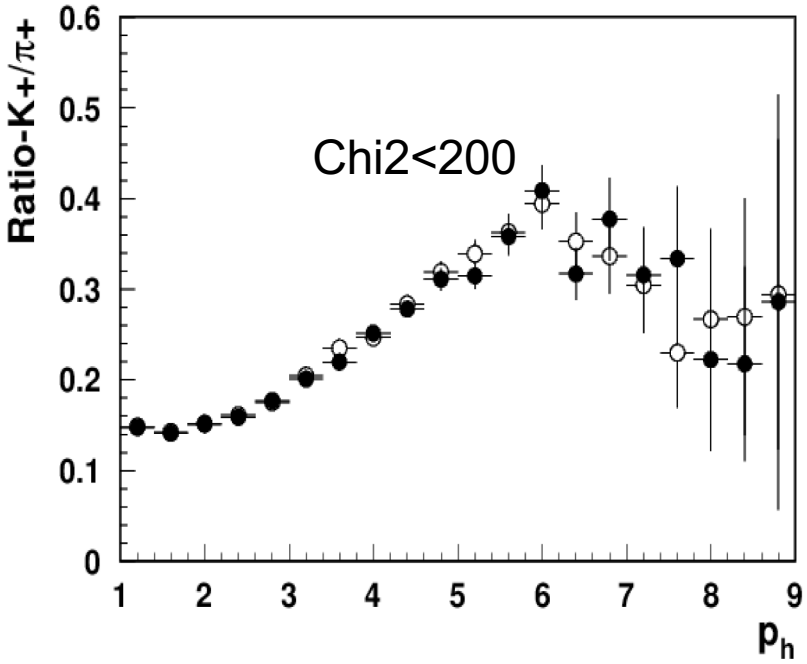
Background has some contribution on misidentification of pions by kaons to be studied with higher stats

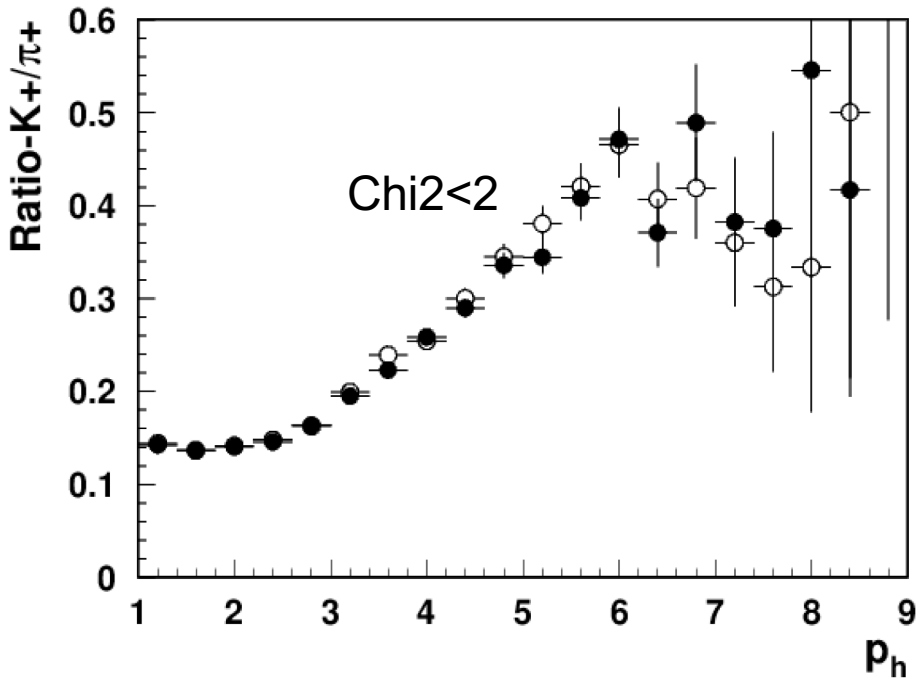
Misidentifying kaons with pions with bck



Background has some contribution on misidentification of Kaons by pions to be quantified

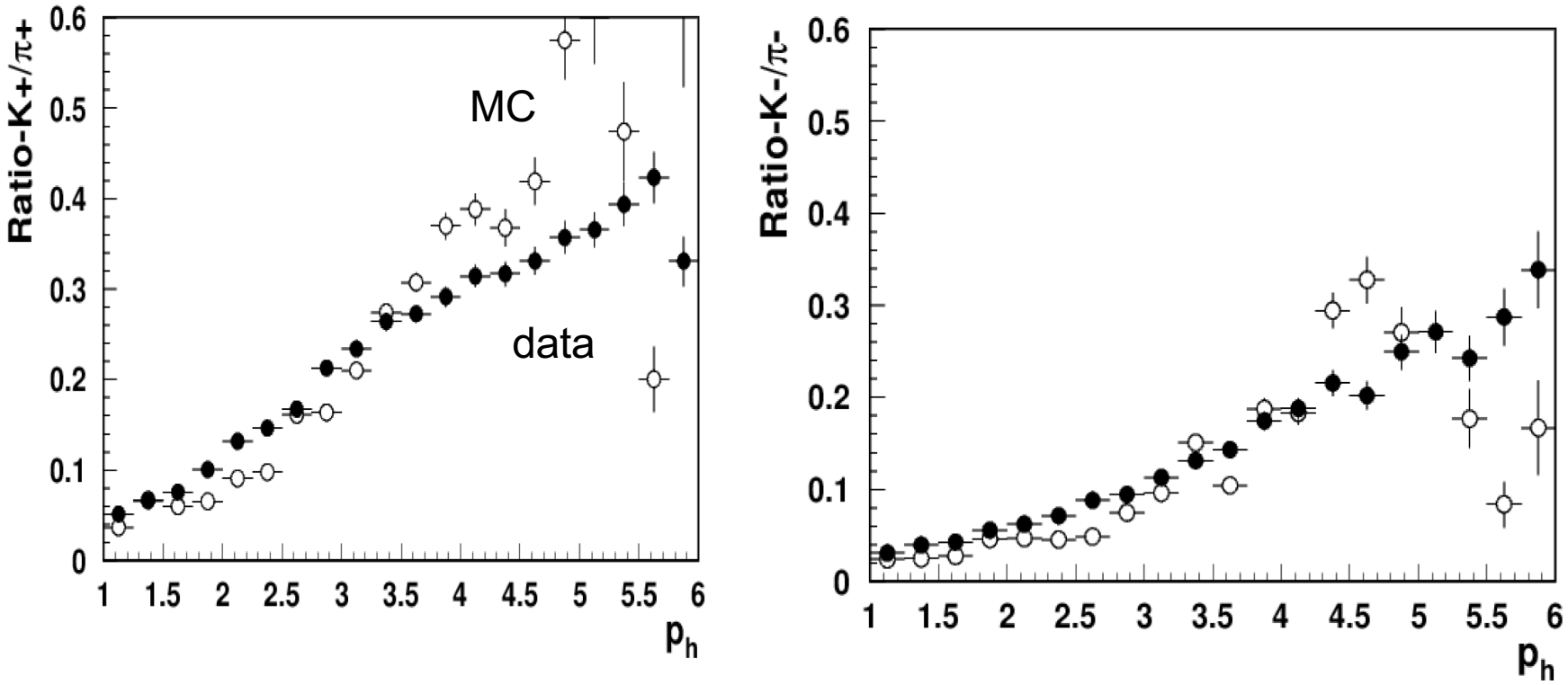
K/p separation low lumi RGA-outb





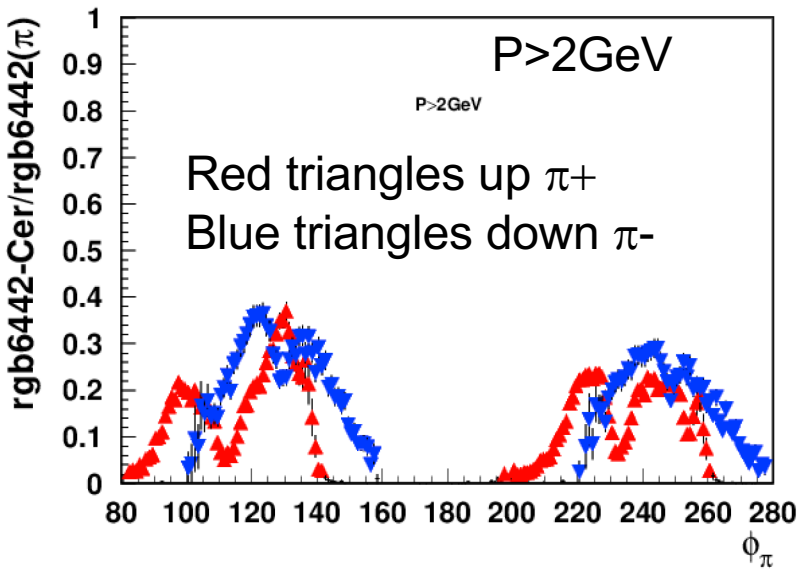
Total ratio (filled circles 5443, open 5566) vs momentum
Relative fraction has week dependence on chi2 cut (some effect at large P)

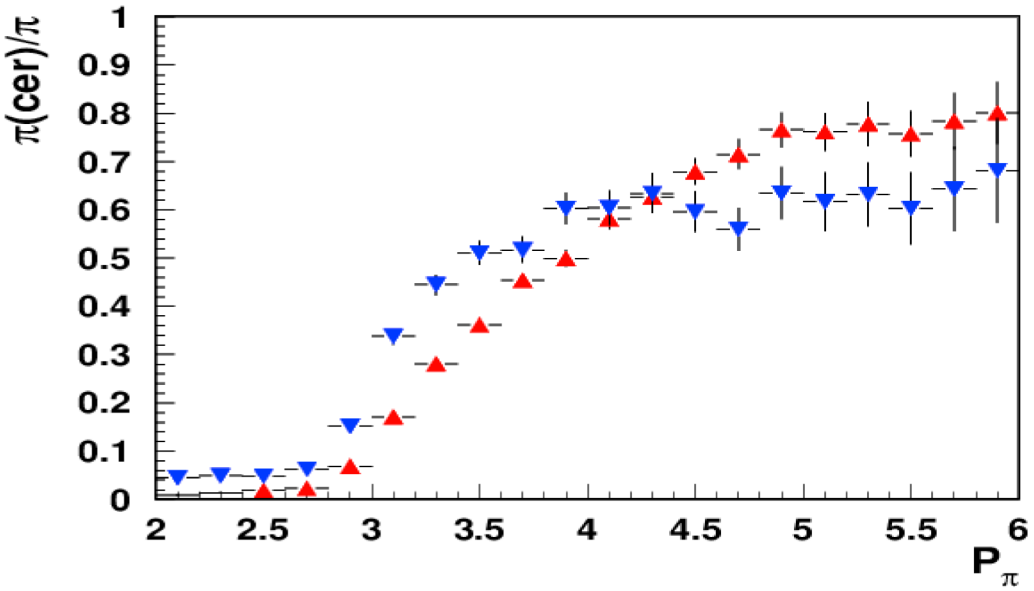
Outbending: MC+bck vs Run 5453 (40nA)

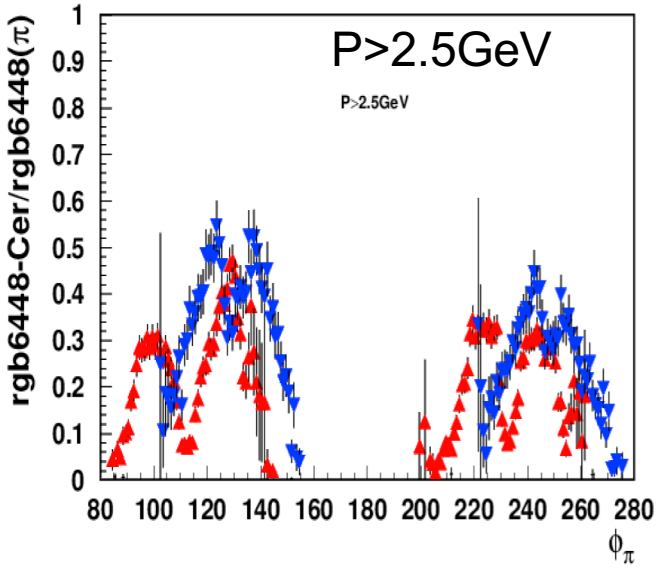


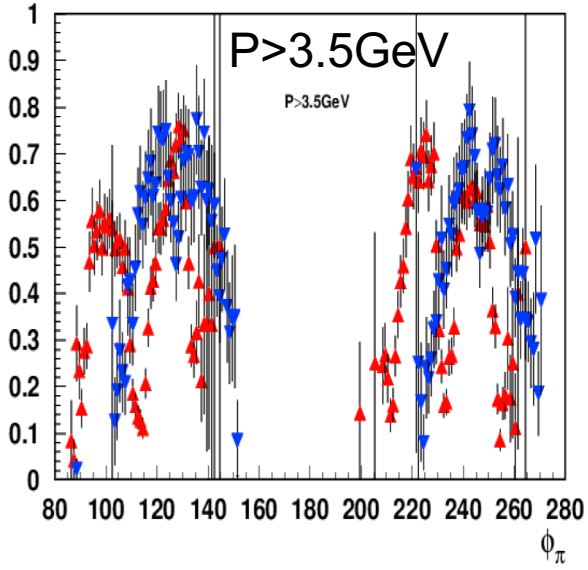
Overall agreement OK, more high energy kaons in the MC at higher momenta

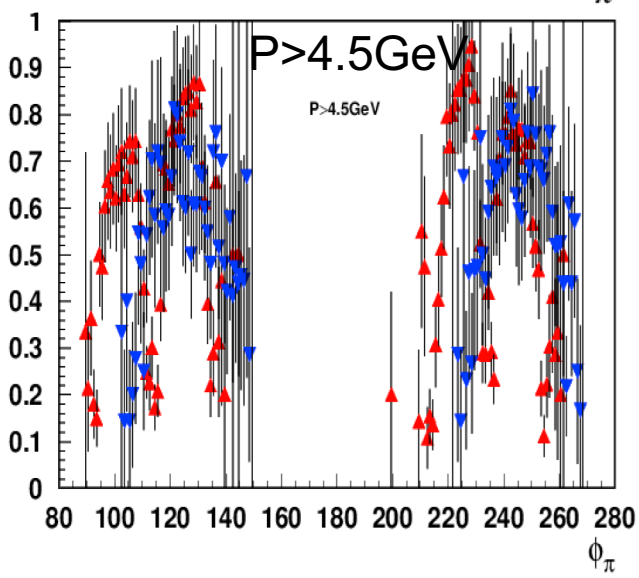
Cherenkov signal for pions from RGB



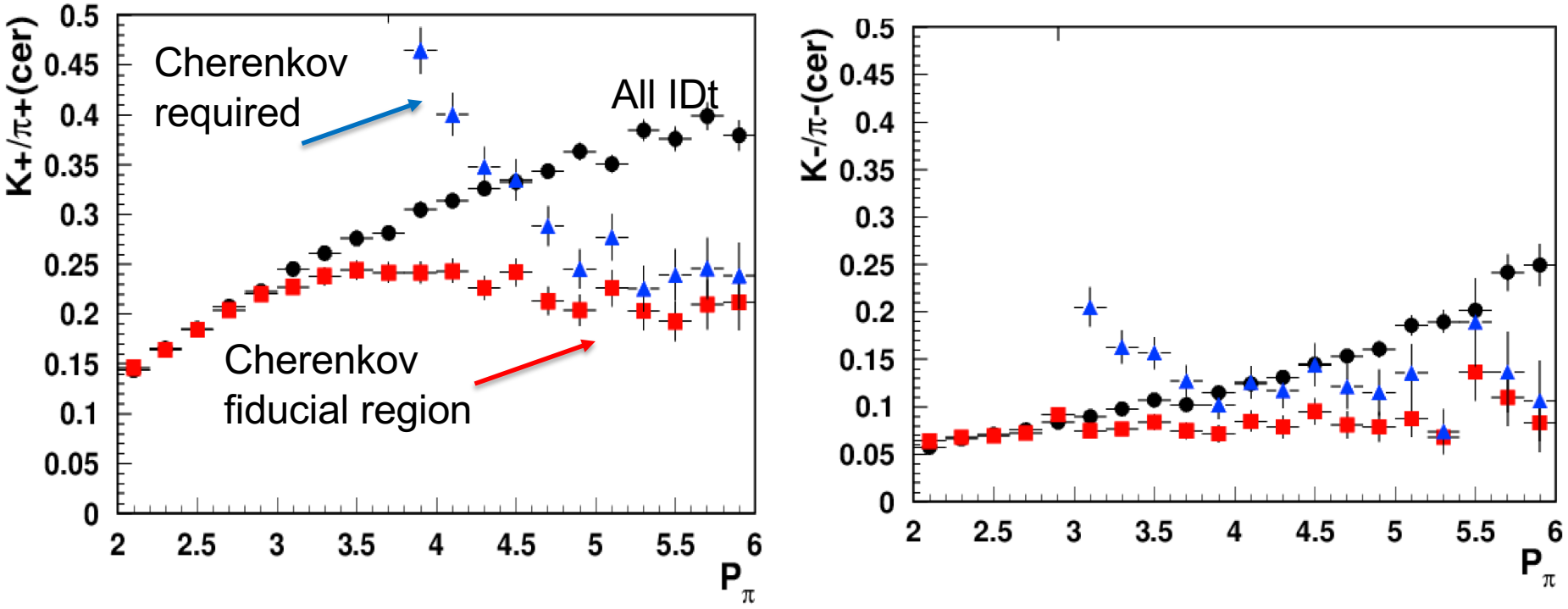








K/p separation with Cherenkov (RGB)

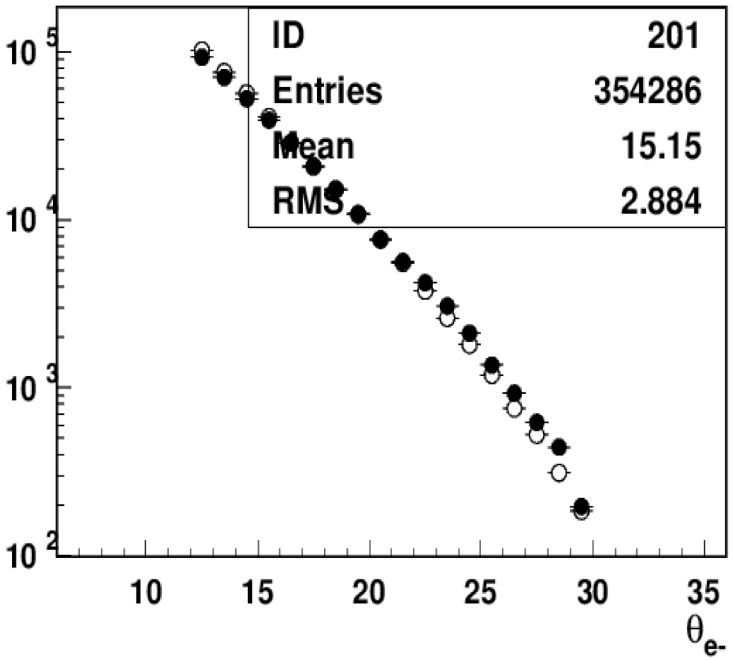


Total ratio (black filled circles) increases with momentum
Sector 3/5 within high eff. Limit in phi (red) goes to plato (affected by cherenkov)
Requiring Cerenkov signal (blue triangles) becomes consistent with total in the limit

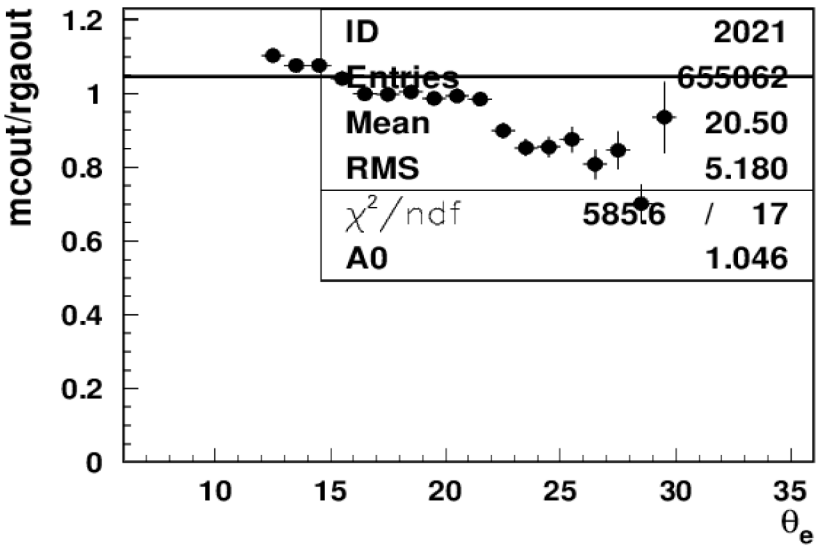
Kaons in exclusive Lambdas (RGA vs MC)

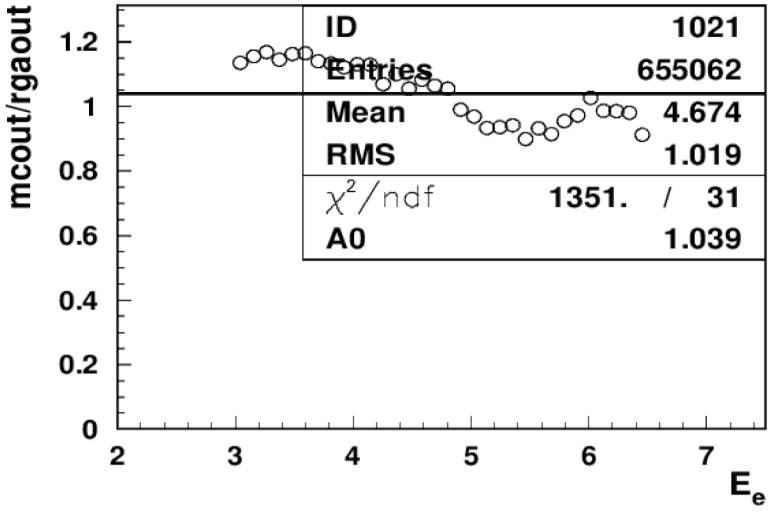
Compare clasDIS-MC-outbending (open circles) with RGA 40nA outbending data (filled)

Counts normalized by the number of electrons in 12<theta<30, 3<E<6.5



Electron distributions consistent within 20%



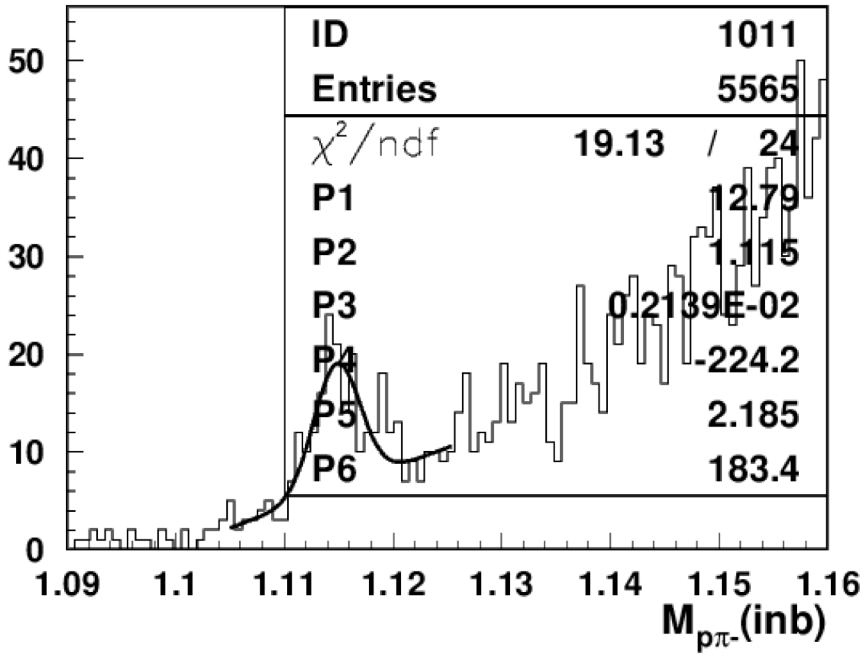


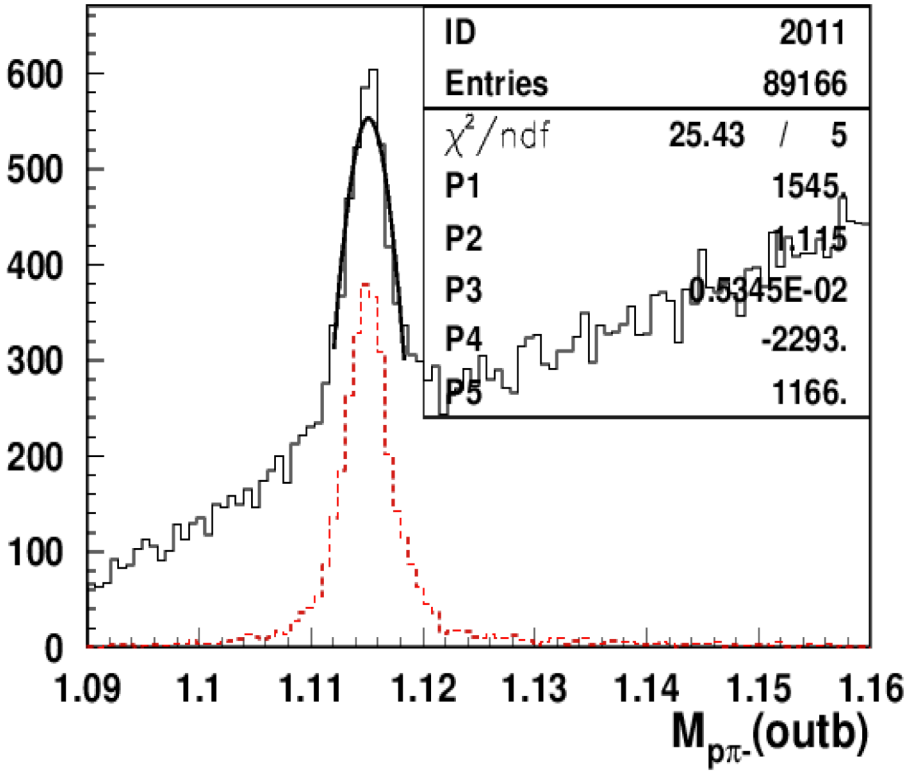
Lambdas in MC (forward ppi-)

Check the mass clasDIS-MC

Only for forward π- peak is visible.

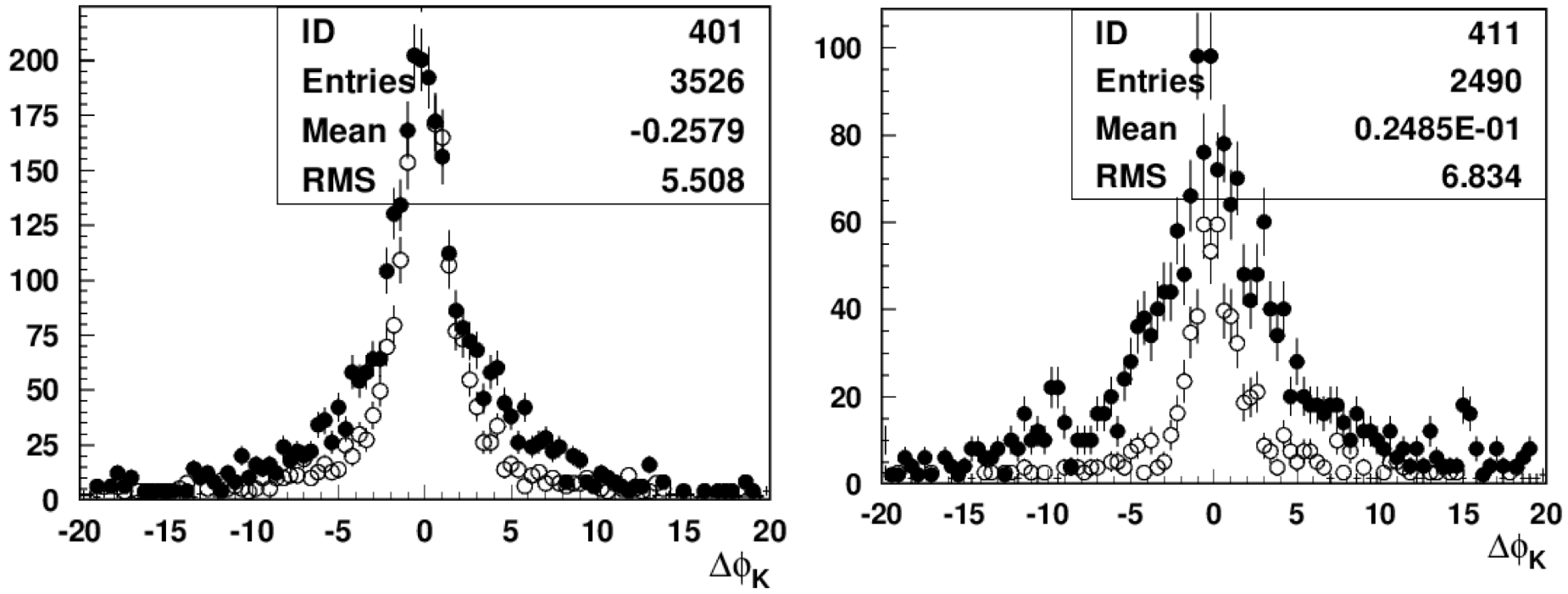
Counts normalized by the number of electrons in 12<theta<30, 3<E<6.5





Kaons in exclusive Lambdas (RGA vs MC)

Compare clasDIS-MC-outbending (open circles) with RGA 40nA outbending data (filled)
Counts normalized by the number of electrons in 12<theta<30, 3<E<6.5



Calculate the Kaon phi assuming an exclusive Lambda is detected, and compare with detected in that direction kaon (left) or pion (right)
About 50% of Kaons in data and ~30% in MC are identified as pions

Summary

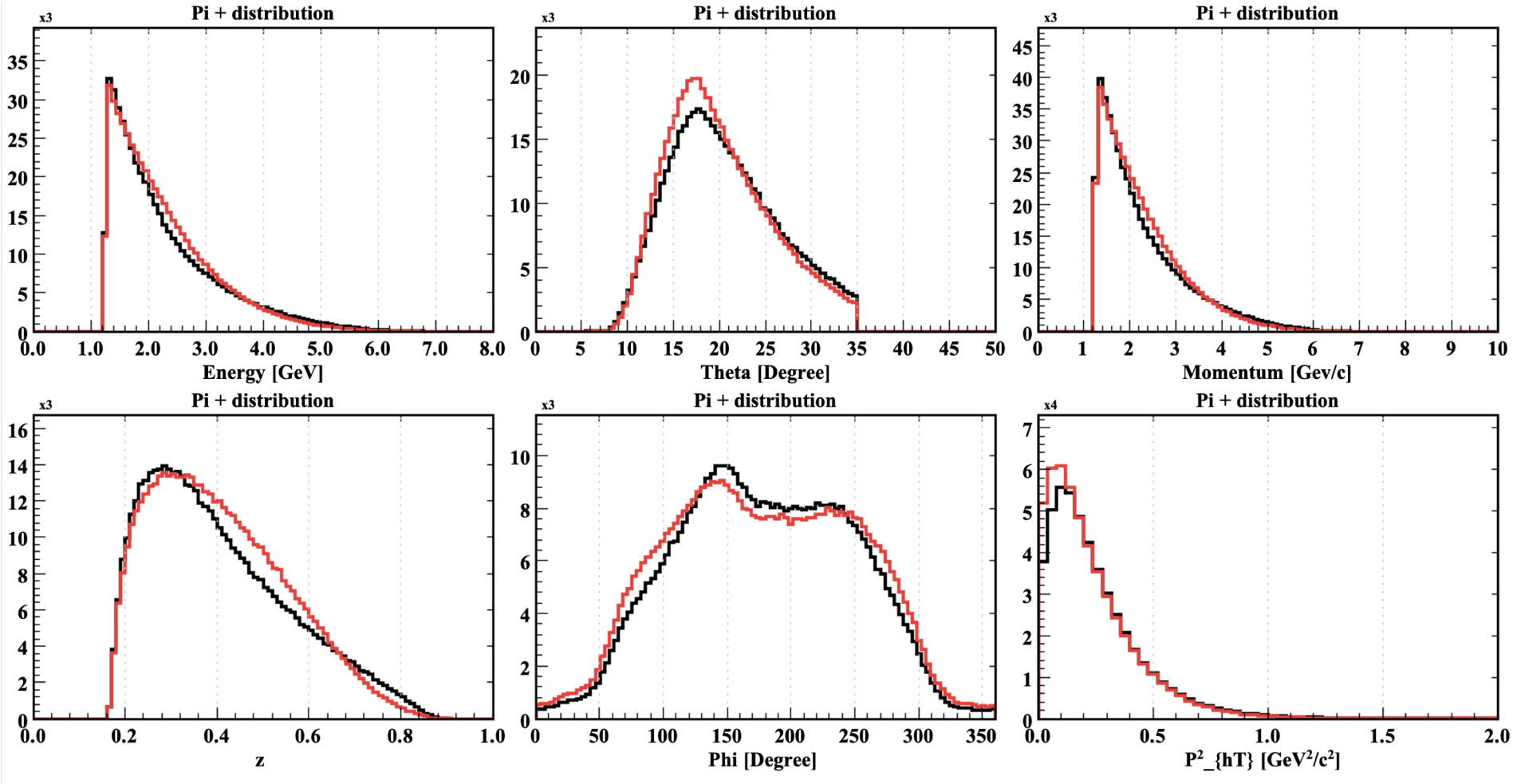
- Significant fraction of SIDIS MC needed for the first publications are already available
- The MC is in good agreement with data allowing studies of different detector effects, including particle identification and mis-identification
- Misidentification of pions and kaons at large momenta can be very significant (~20-30%), need to be optimized
- K/pi ratio increases in the momentum range covered by the TOF (P<3 GeV)
- At large momenta different approaches give different ratios, more studies needed
- MC data comparison for Lambdas indicate the contamination may be consistent with MC
- The ratio of K/π can be tuned in MC and tested with data

- Need RGA spring 2019 with LTCC for more precise estimate of K/π ratios
- RICH will be crucial to define the real K/π ratio

Support slides

G. Angelini

Comparison for electrons: outbending

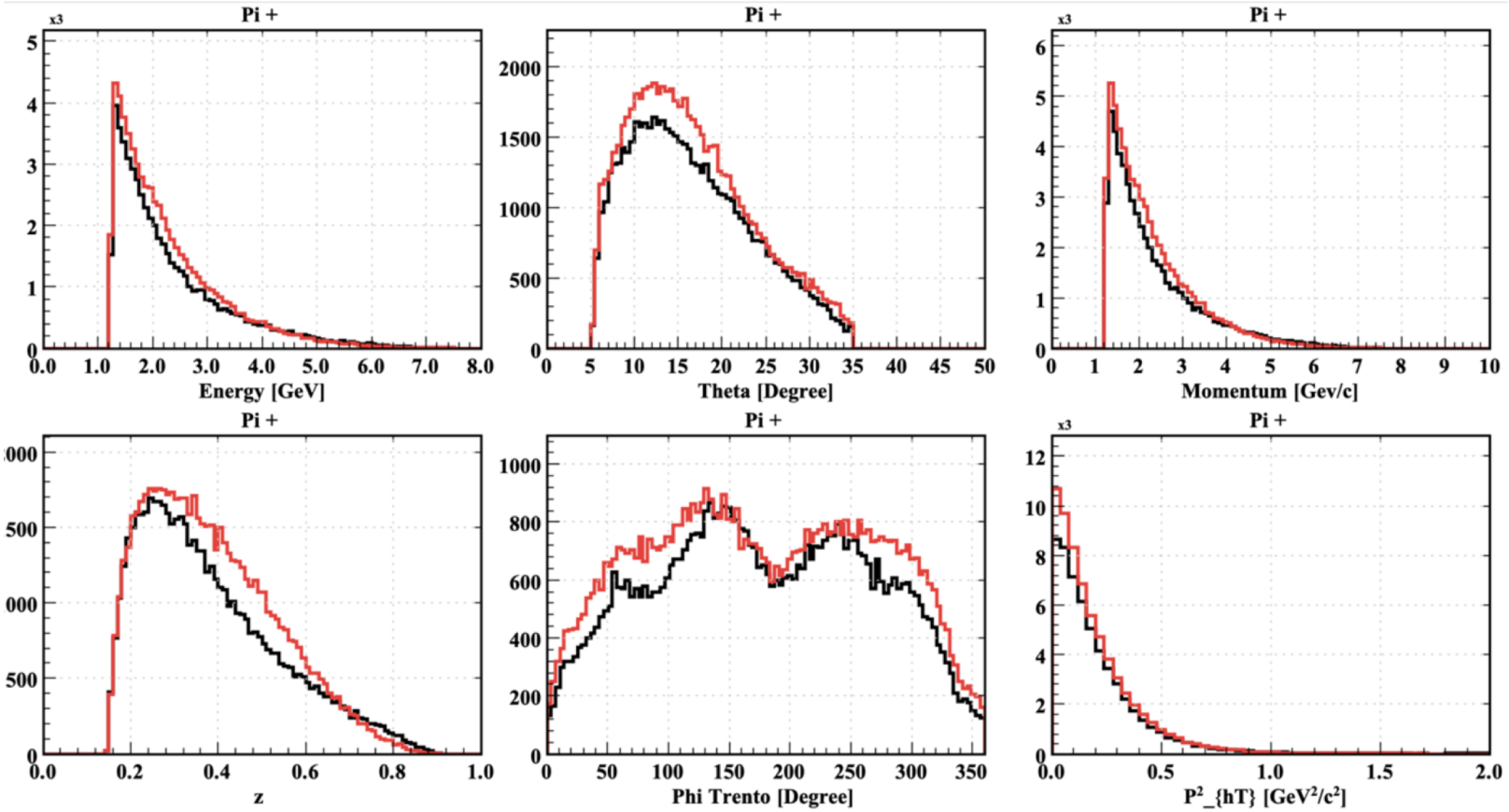


SIDIS MC is in good agreement with data in the multidimensional space

G. Angelini

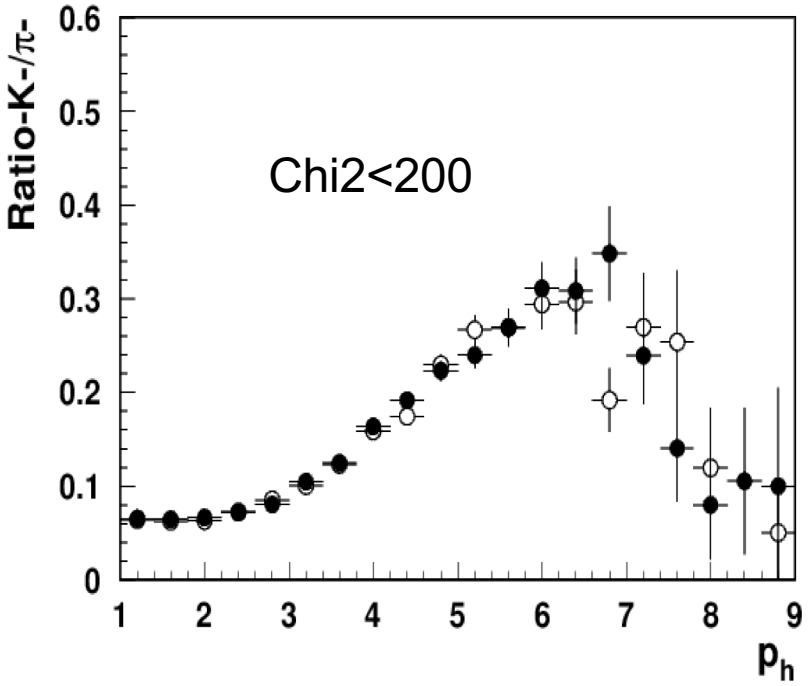
Comparison for electrons: inbending

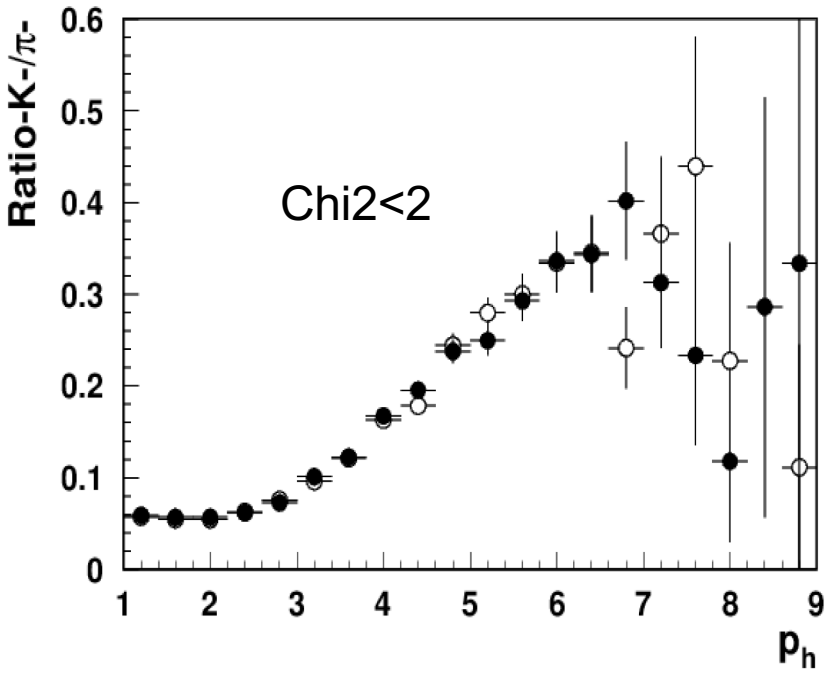
Plot normalized to the electron numbers



SIDIS MC is in good agreement with data in the multidimensional space

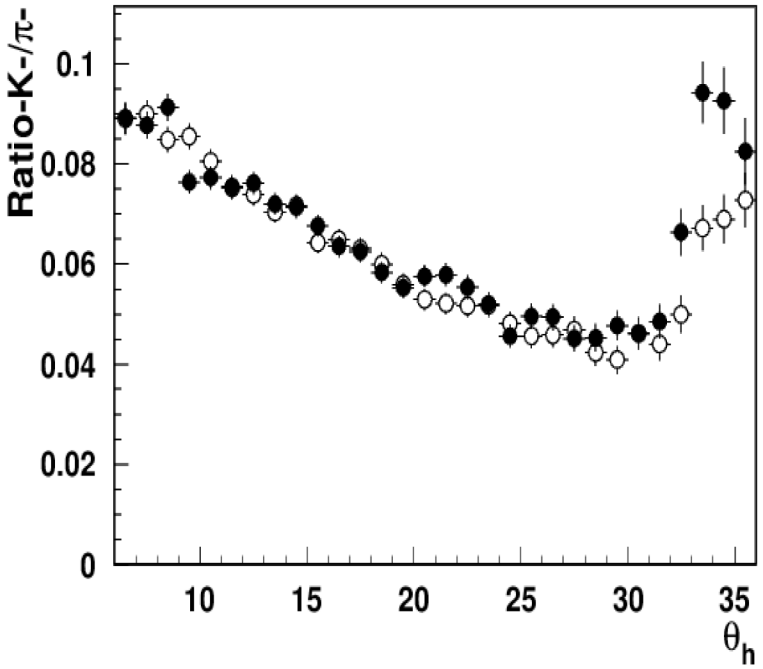
K/p separation low lumi RGA-outb



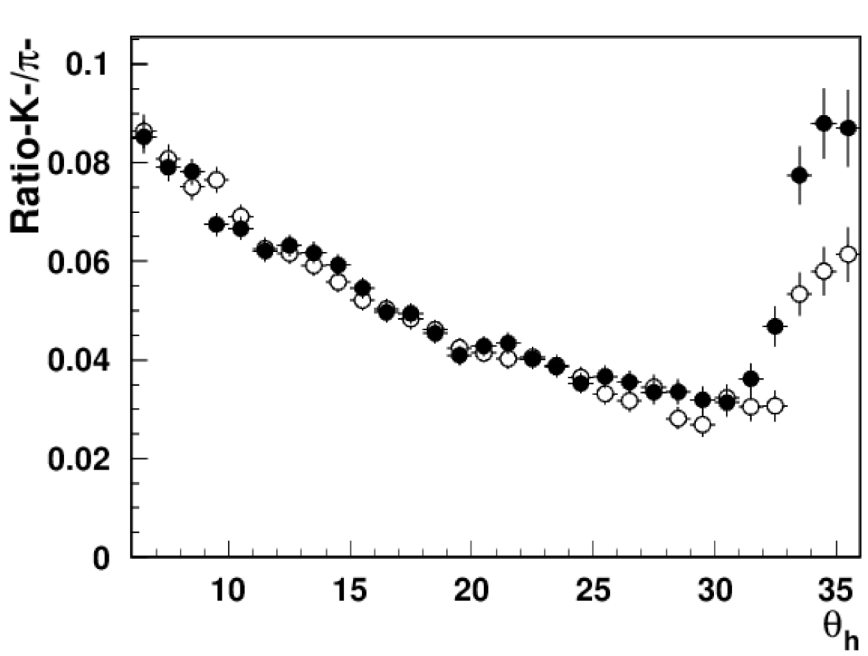


Total ratio (filled circles 5443, open 5566) vs momentum
Need more statistics (checking with high lumi runs)

K/p separation low lumi RGA-outb

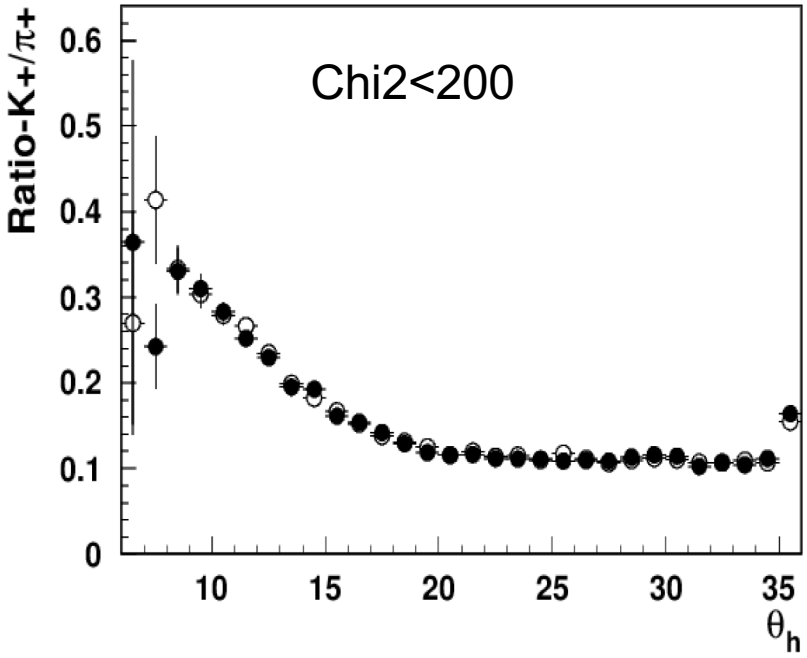


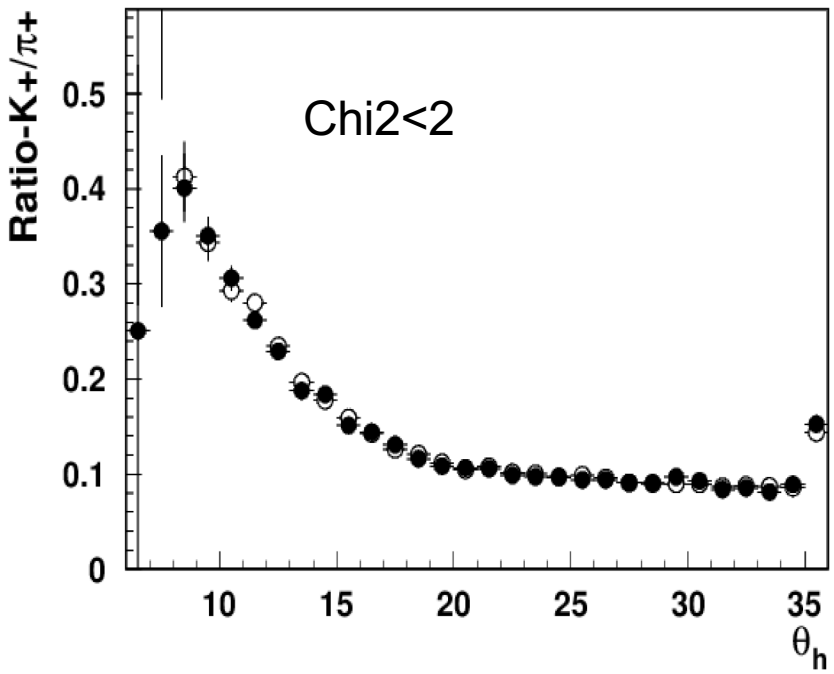
Chi2<2



Total ratio (filled circles 5443, open 5566) vs momentum

K/p separation low lumi RGA-outb



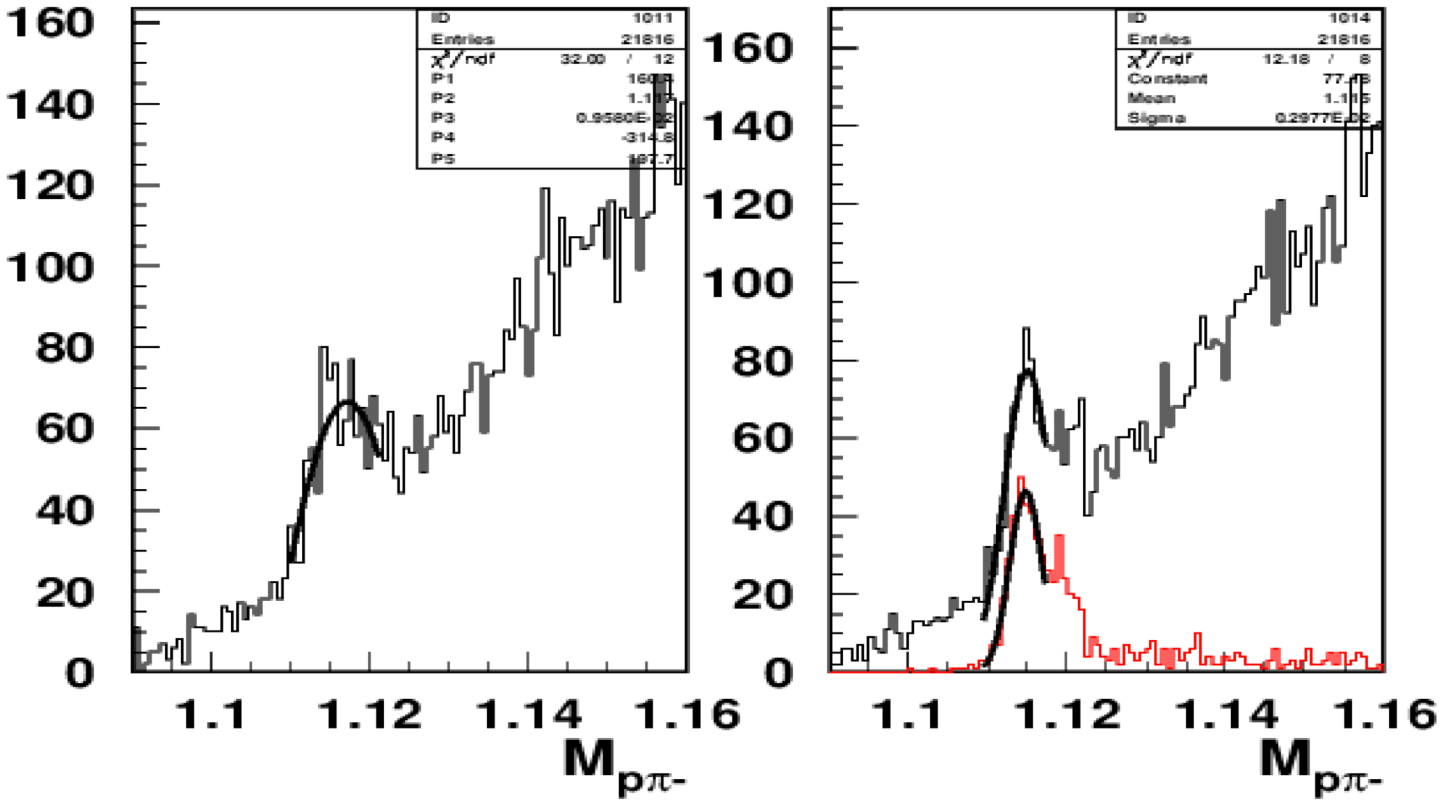


Total ratio (filled circles 5443, open 5566) vs momentum

Lambdas in MC (Central pi-)

Check the mass clasDIS-MC
Only for forward pi- peak is visible.

Counts normalized by the number of electrons in 12<theta<30, 3<E<6.5

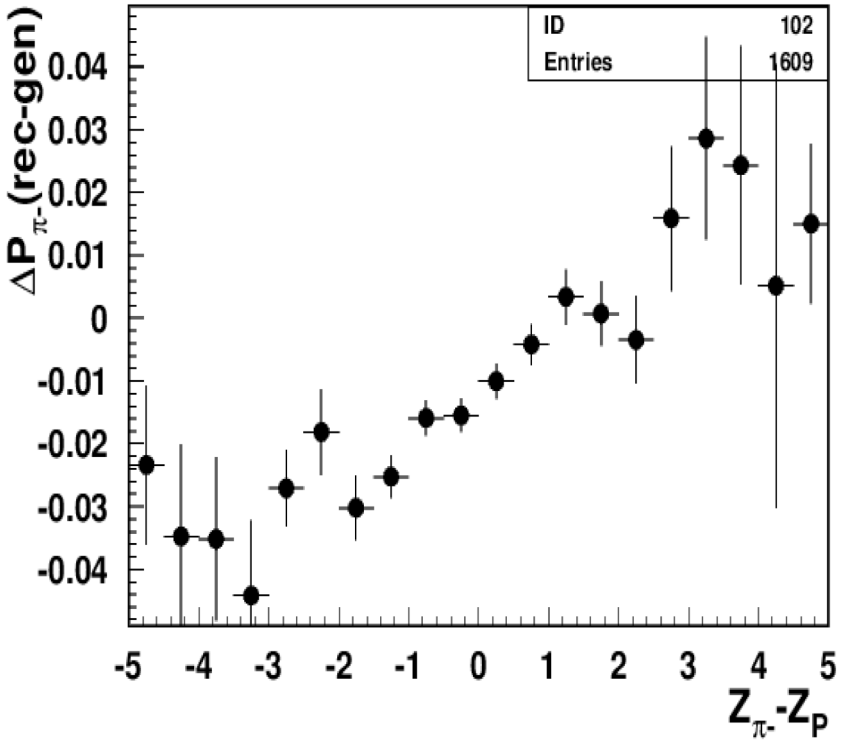


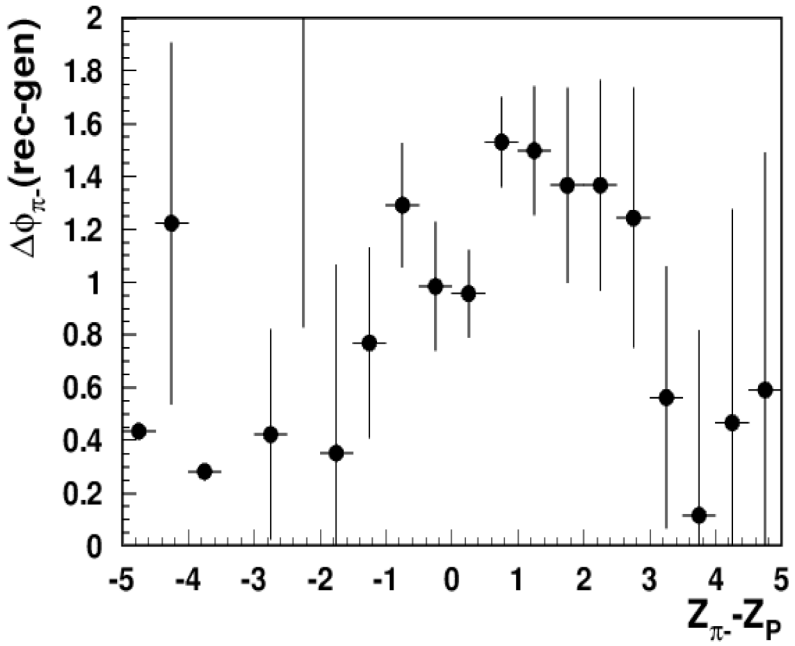
With azimuthal angle correction for large angle pi- resolution can get to 3 meV

Lambdas in MC (central pi-)

Check the mass clasDIS-MC
Only for forward pi- peak is visible.

Counts normalized by the number of electrons in 12<theta<30, 3<E<6.5



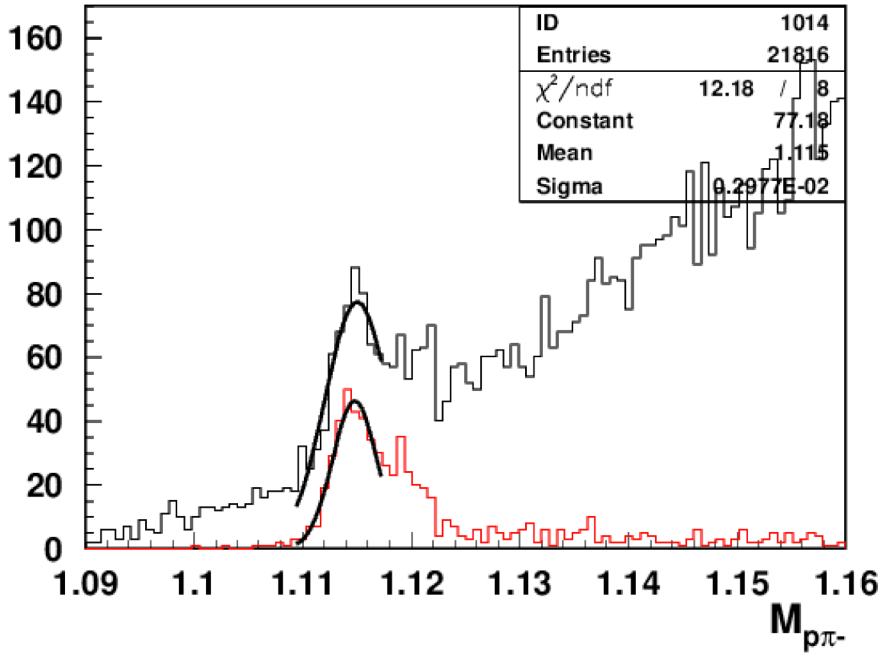


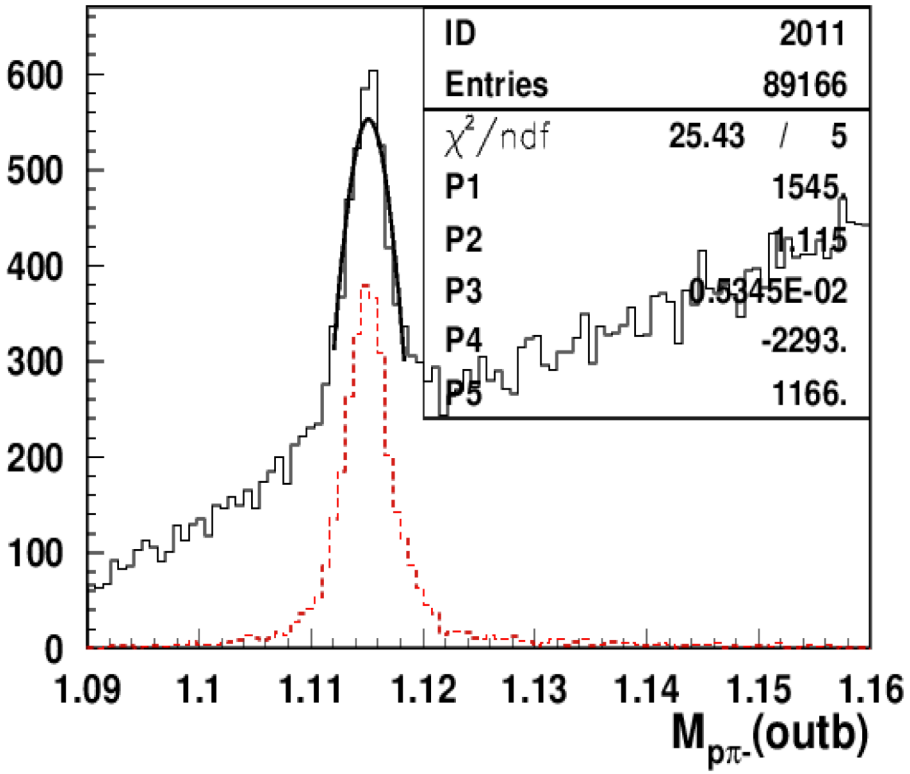
Vertex z of proton can be used for pi- to correct for momentum

Lambdas in MC

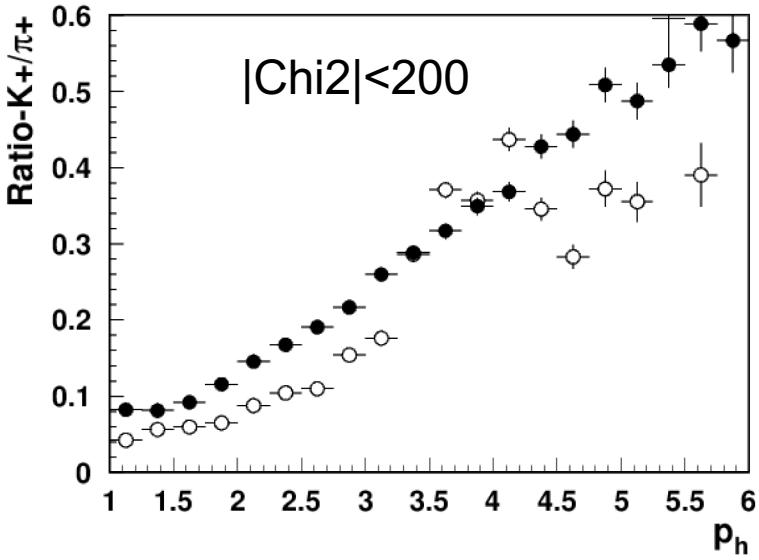
Check the mass clasDIS-MC
Only for forward pi- peak is visible.

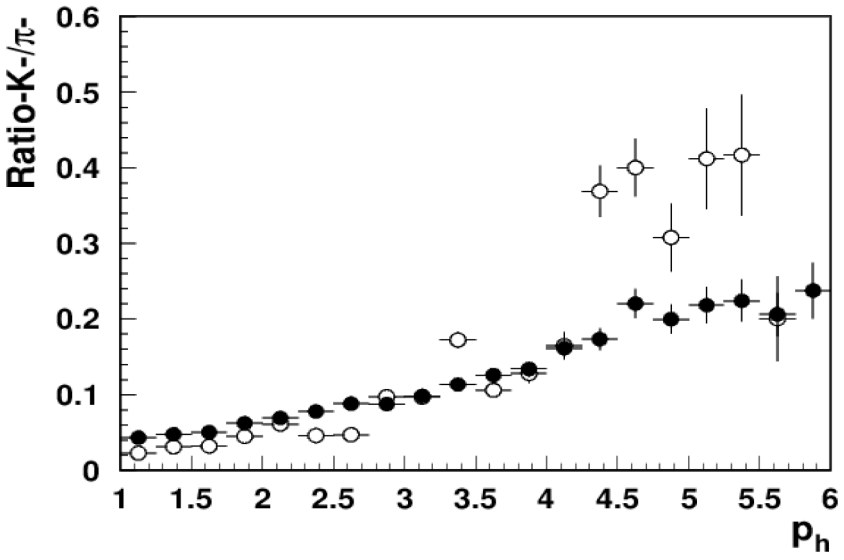
Counts normalized by the number of electrons in 12<theta<30, 3<E<6.5

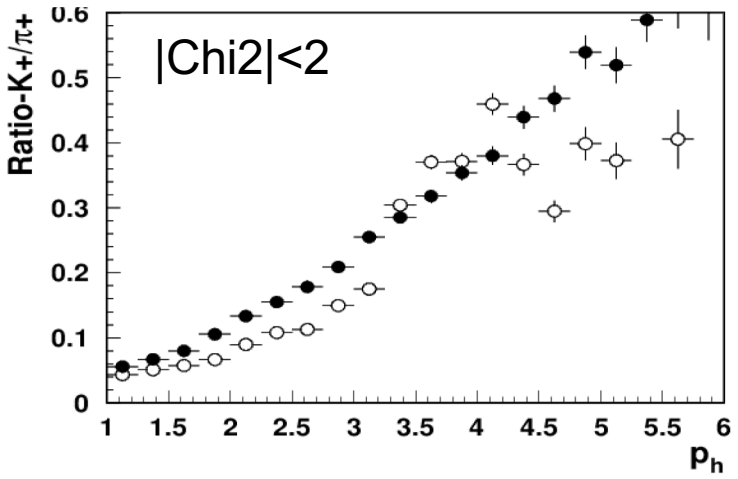


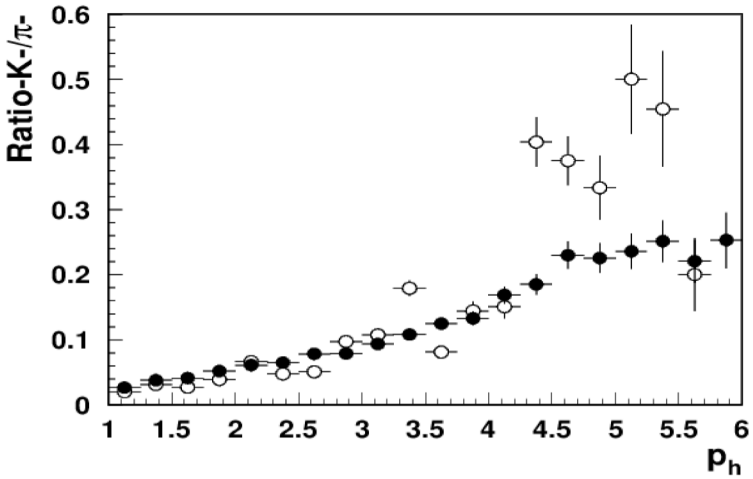


Chi2 cuts: kaon fractions



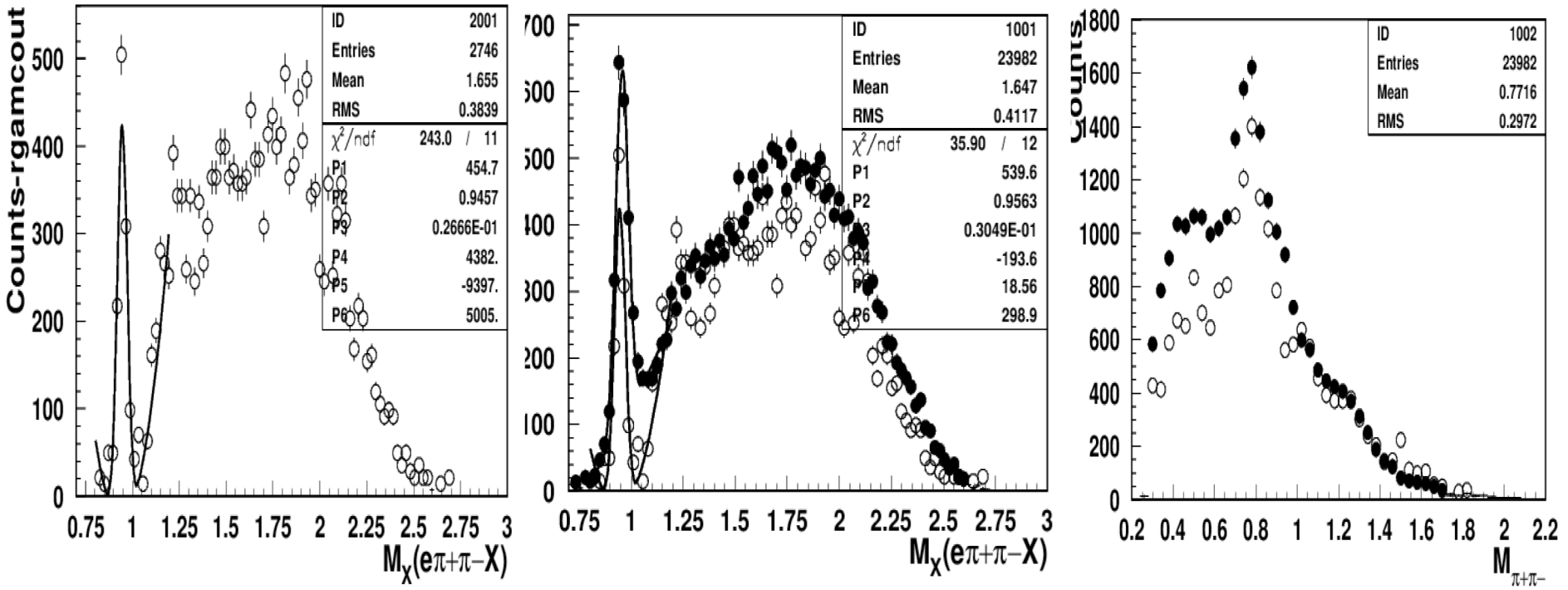






Loss of electron may affect initial generated samples

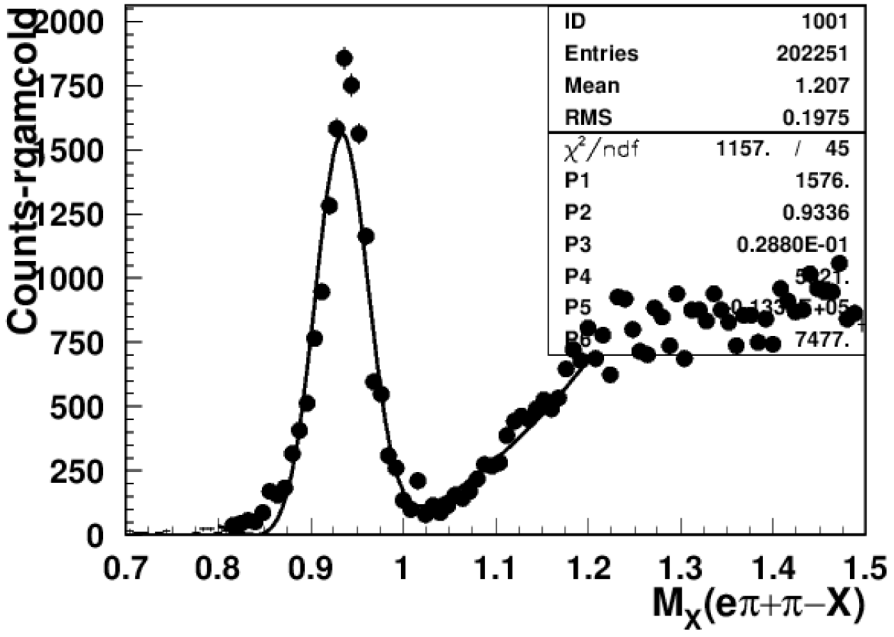
Outbending: MC vs 5nA data

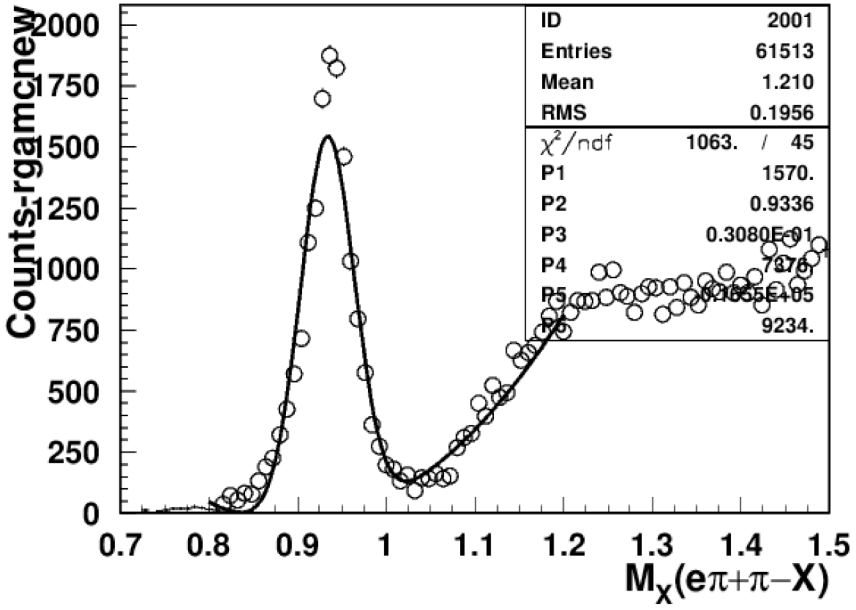


MC resolution much closer to data, but still better.

Comparing old MC with with new MC: e-

Normalize “old-MC” (old-clasDIS+gemc 4.3.2, variation mc + coatjava 5.6.3)
and “new-MC” (new-clasDIS+gemc 4.4.0, use variation mc) + coatjava 5.6.6
for the same e- numbers





Outbending consistent resolutions? Checking the fits.