Status report on $\pi^+\pi^-\gamma$ / $\mu^+\mu^-\gamma$ at Small Angle

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Φ Decays 30-05-07

Where we are

Filfo — from the prescaled events - syst. error is negligible ✓

Trigger — Solid - compared with 2001 and DC trigger ✓

Background — MC shapes fitted to data - addressed today (✓)

M_{trk}, M_{miss} — from MC re-weighted and smeared from data (✓)

Vertex — difference data-MC of $O(1\%)$ - addressed today (✓)

Tracking — difference data-MC of $O(0.7\%)$ - addressed today (✓)

Acceptance — data-MC comparison for θ_π - addressed today ✓

unshifting ($Q^2_{+-} \rightarrow Q^2_{\gamma^*}$) (pions), FSR → ISR (muons) (✓)

Luminosity — VLAB. Eff. Cross section for 2002 - New BABAYAGA (✓)

Radiator — Only for absolute measurement, (cross check with muons) ✓

blue = estimated from MC
red = estimated from data

Vertex efficiency outline

1. definition of the control samples and of the vertex efficiency
2. data-MC comparison of the criteria in 1.
3. efficiency from data and MC for $\pi\pi\gamma$ and $\mu\mu\gamma$

- $\pi\pi\gamma$ MC (O(20) pb^{-1} ppgphok3)
- $\mu\mu\gamma$ MC (O(20) pb^{-1} pho5mmg)
- drc data (100 pb^{-1}, preselected with NEW ppgtag: m_{trk}, m_{miss} cuts
  with track momenta at the PCA

Definitions

- The vtx efficiency, $\varepsilon_{VTX} = \dfrac{\text{\# of events with a good vtx}}{\text{\# evts with (at least) a good pair of trks}}$

- 3 conditions (in cascade) define a "good" pair of tracks:
  - L0 = **both** tracks of opposite charge must satisfy usual acceptance cuts:

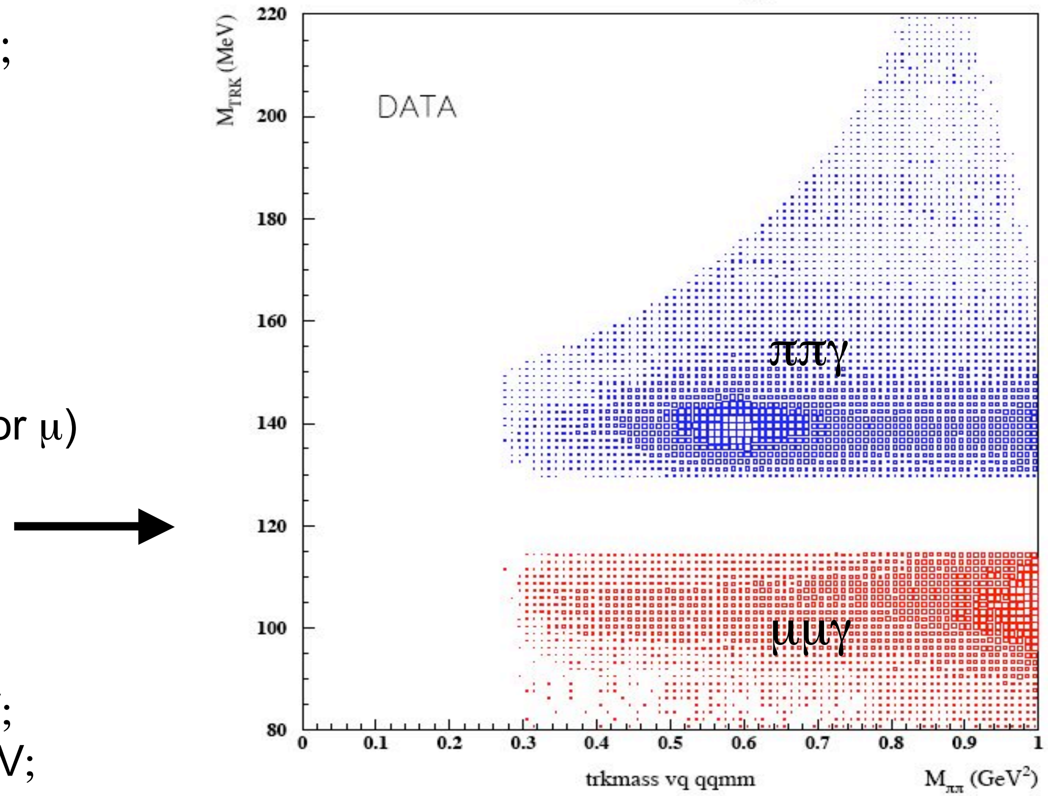
$$\rho_{F.H.} < 50cm; \rho_{PCA} < 8cm; |z_{PCA}| < 7cm;$$
$$50 < \vartheta_{\pi/\mu} < 130; \vartheta_{\Sigma} < 15 (\vartheta_{\Sigma} > 165)$$

  - L1 = (at least 1 track is not an e)

    Logrl>0 *and mlp*
    (-1<mlp<0.2 for π; 0.7<mlp<2 for μ)

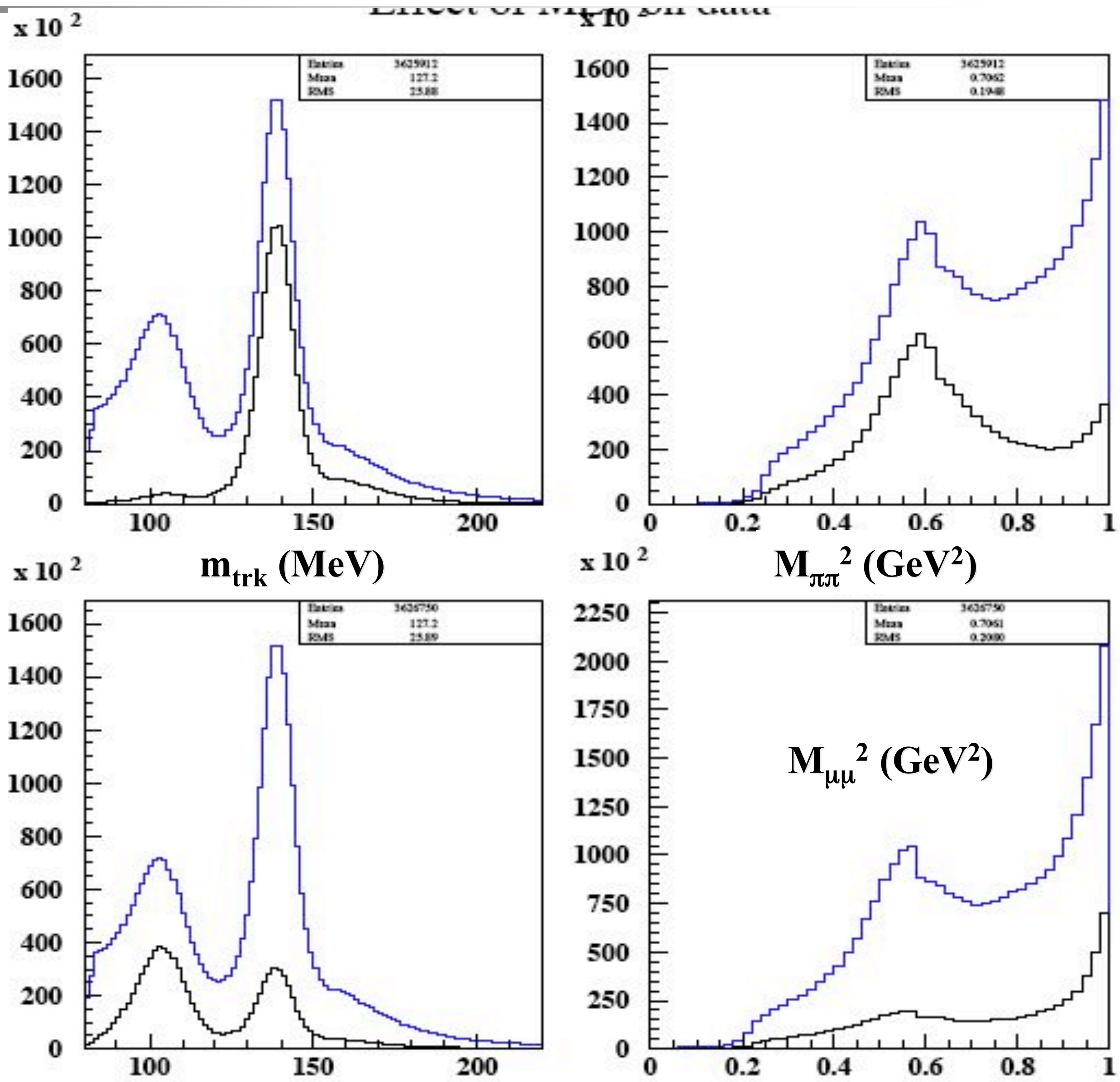
  - L2 = m_{trk} *and* ellipse cut

    For μ: 80MeV<m_{TRK}<115 MeV;
    For π: 130MeV<m_{TRK}<220 MeV;

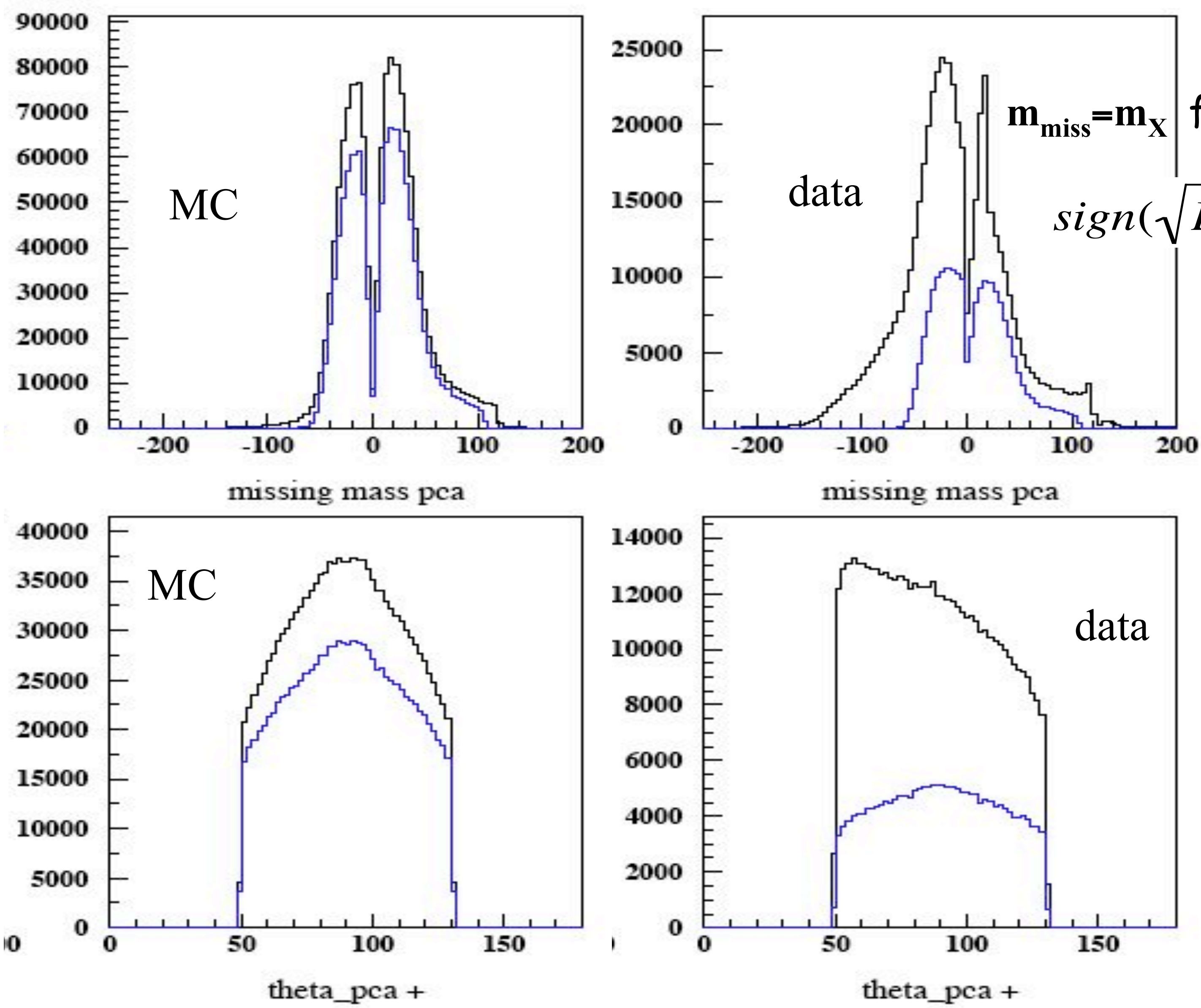


MLP performance on data

MLP = MultiLayer Perceptron developed for improving μ/π separation, (not used in the selection)



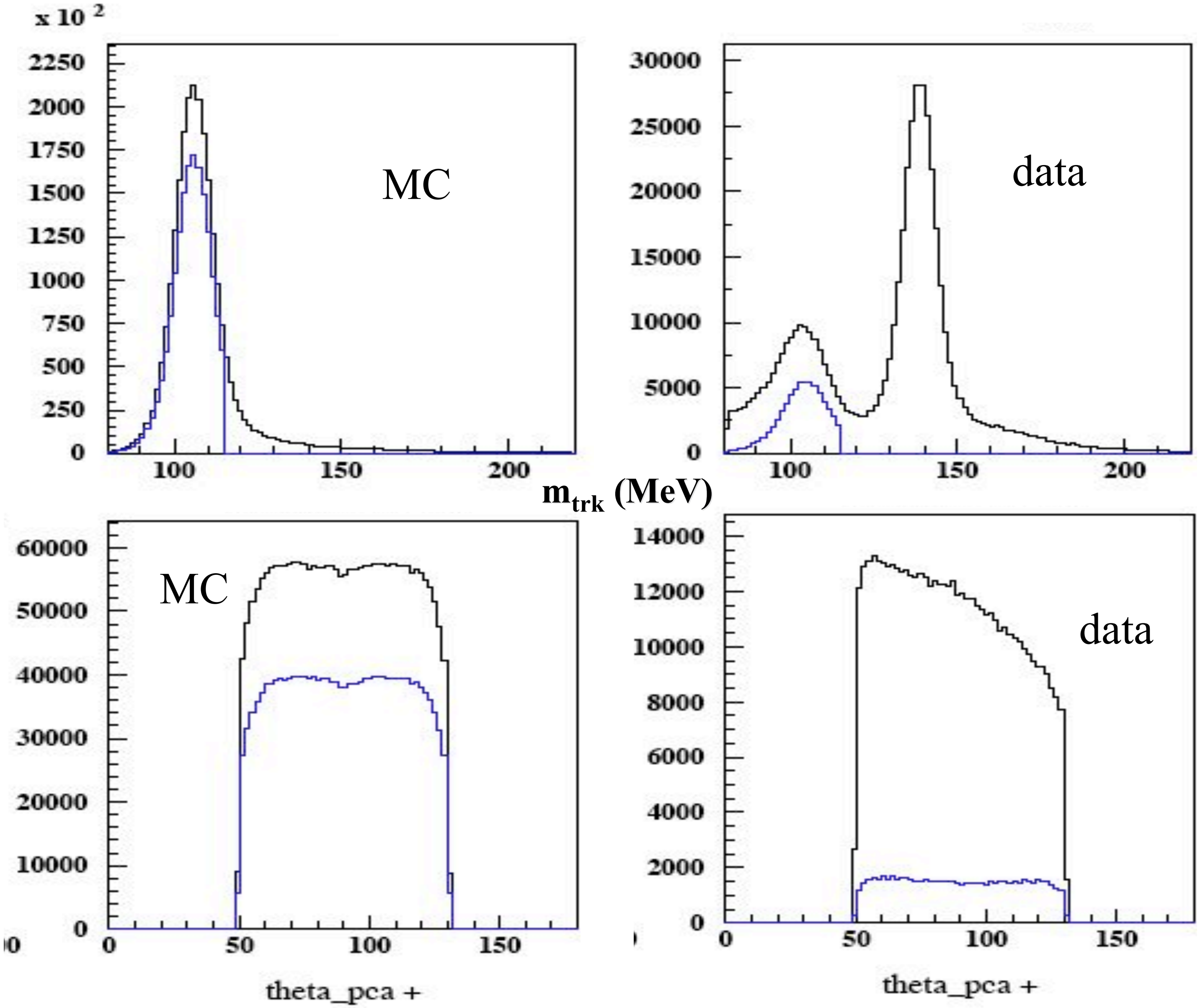
L_2 performance on $\pi\pi\gamma$



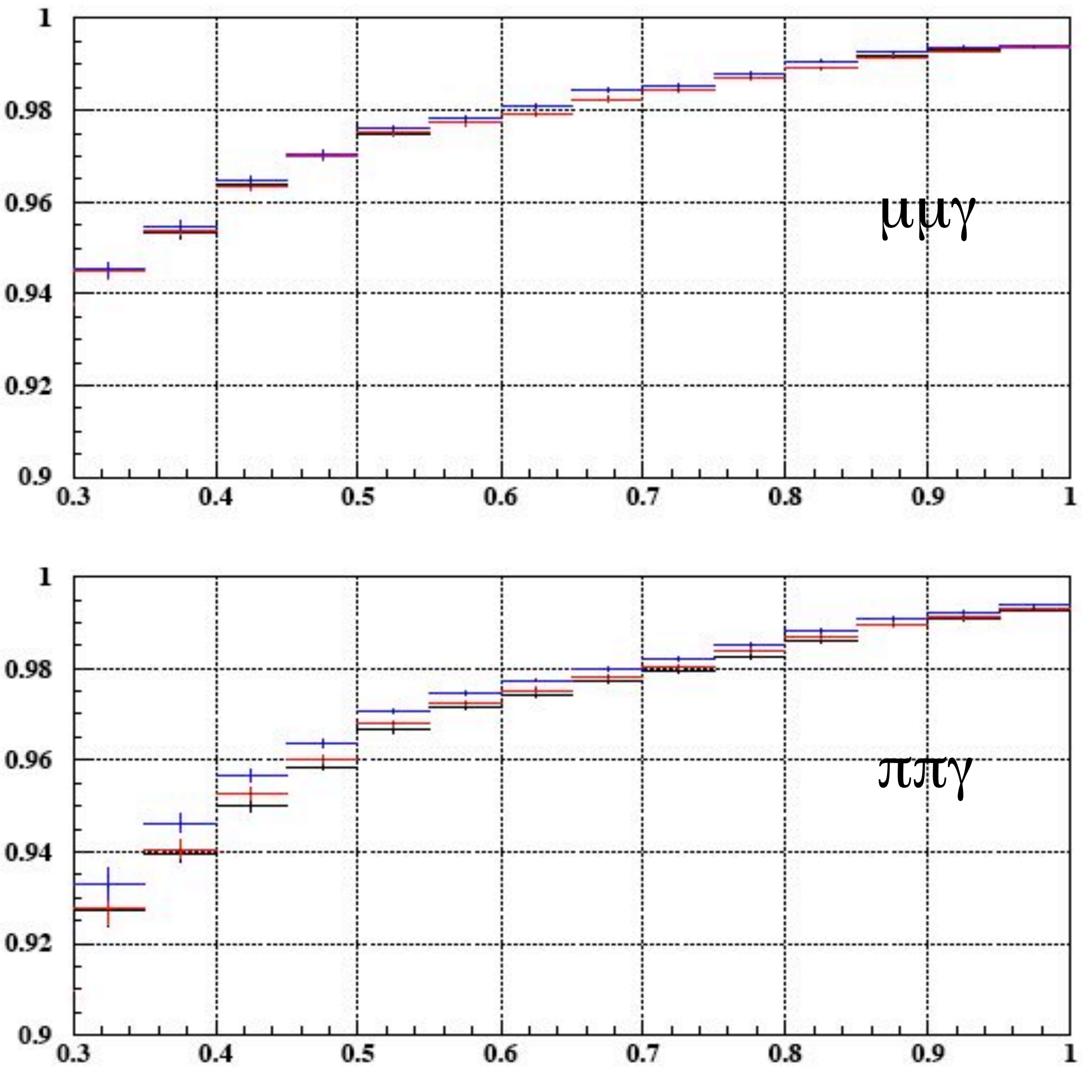
$m_{miss}=m_X$ for $e^+e^- \rightarrow X\pi^+\pi^-$

$$sign(\sqrt{E_X^2 - p_X^2}, E_X^2 - p_X^2)$$

L_2 performance on μμγ



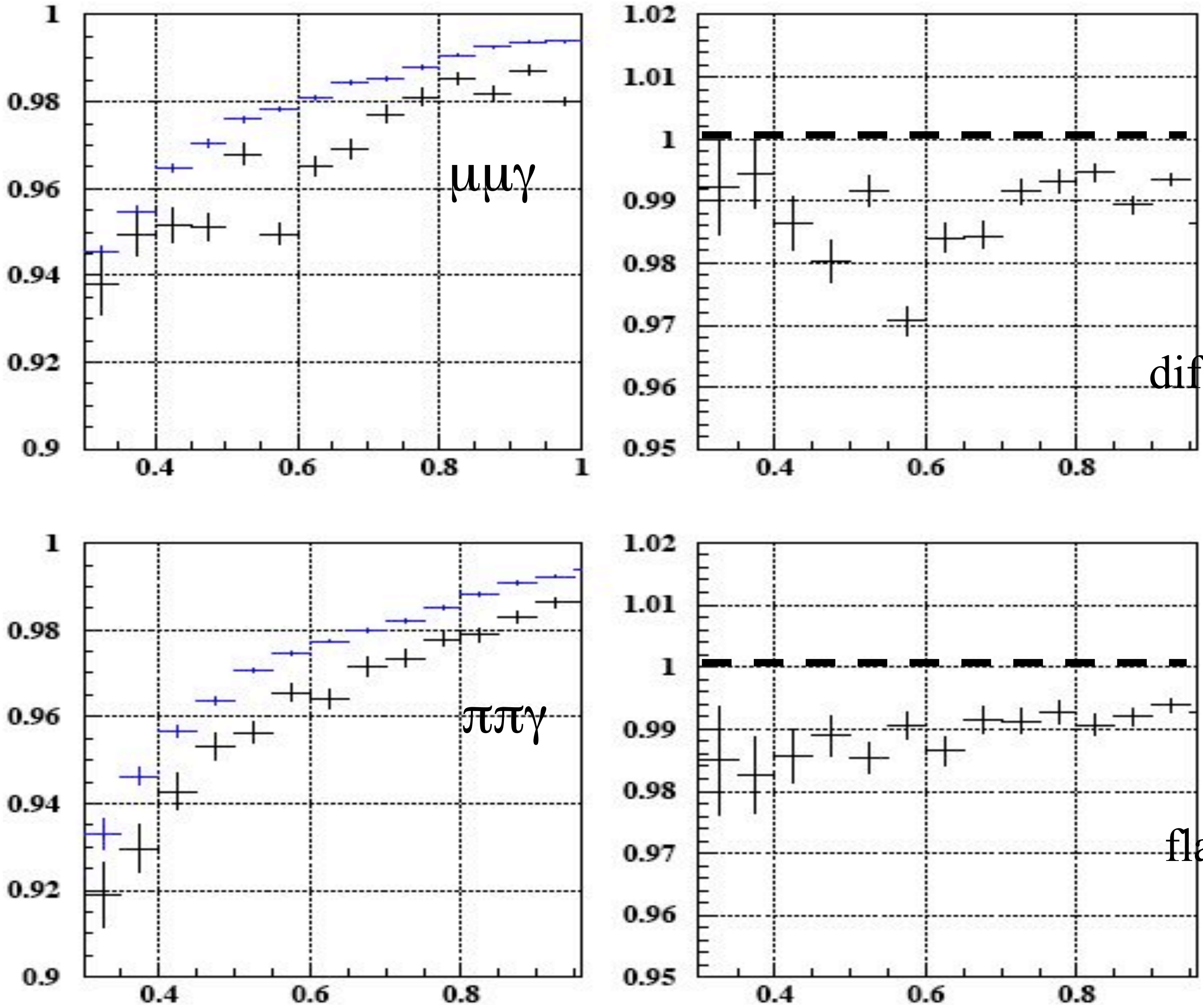
Comparison among the 3 criteria



ππγ and μμγ vtx efficiencies from MC

L0,L1,L2 vertex efficiencies are compared to check for possible bias… it does not seem the case!

Data/MC comparison for vertex

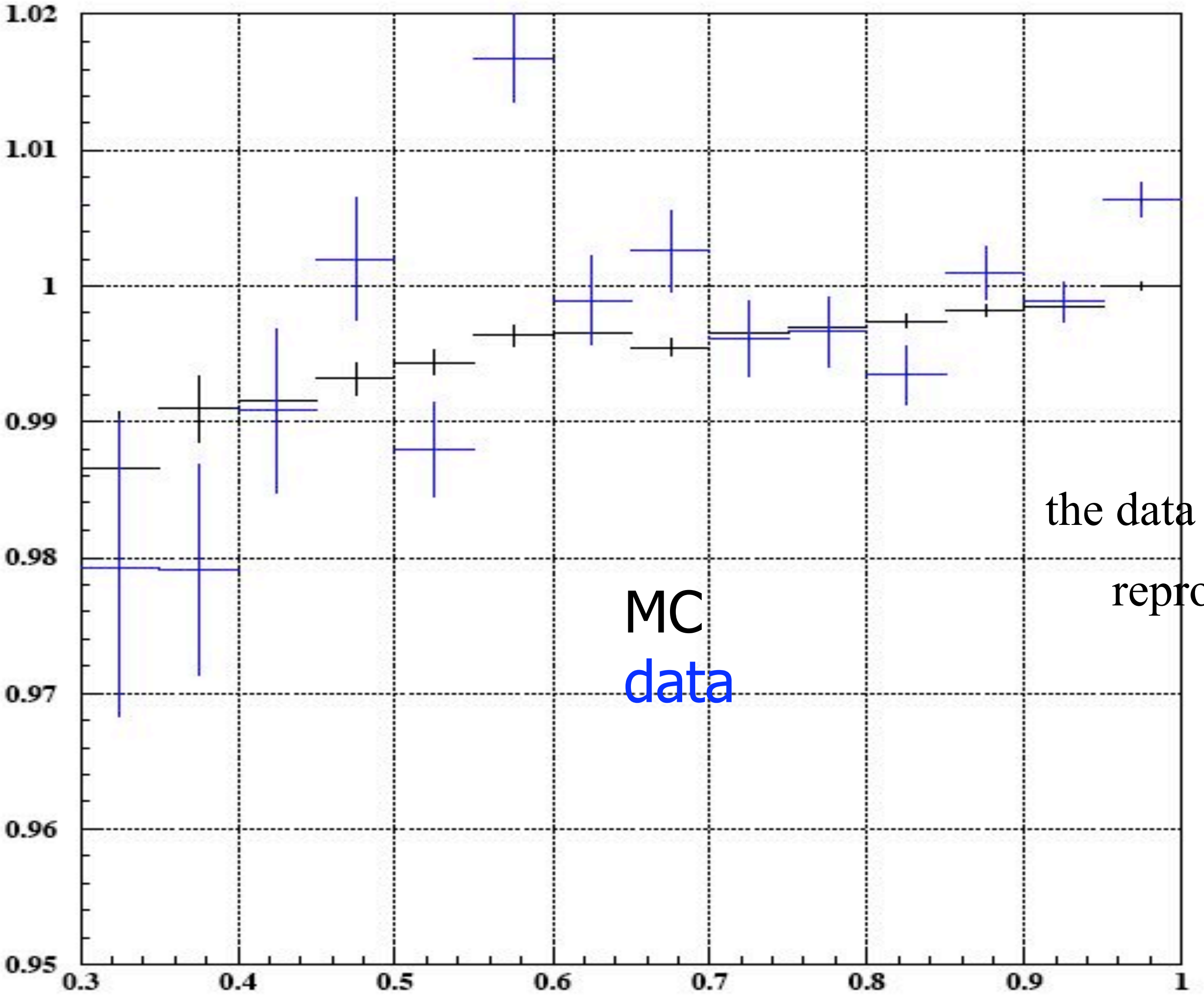


data vs MC

difference O(1.5%) for **μμγ**

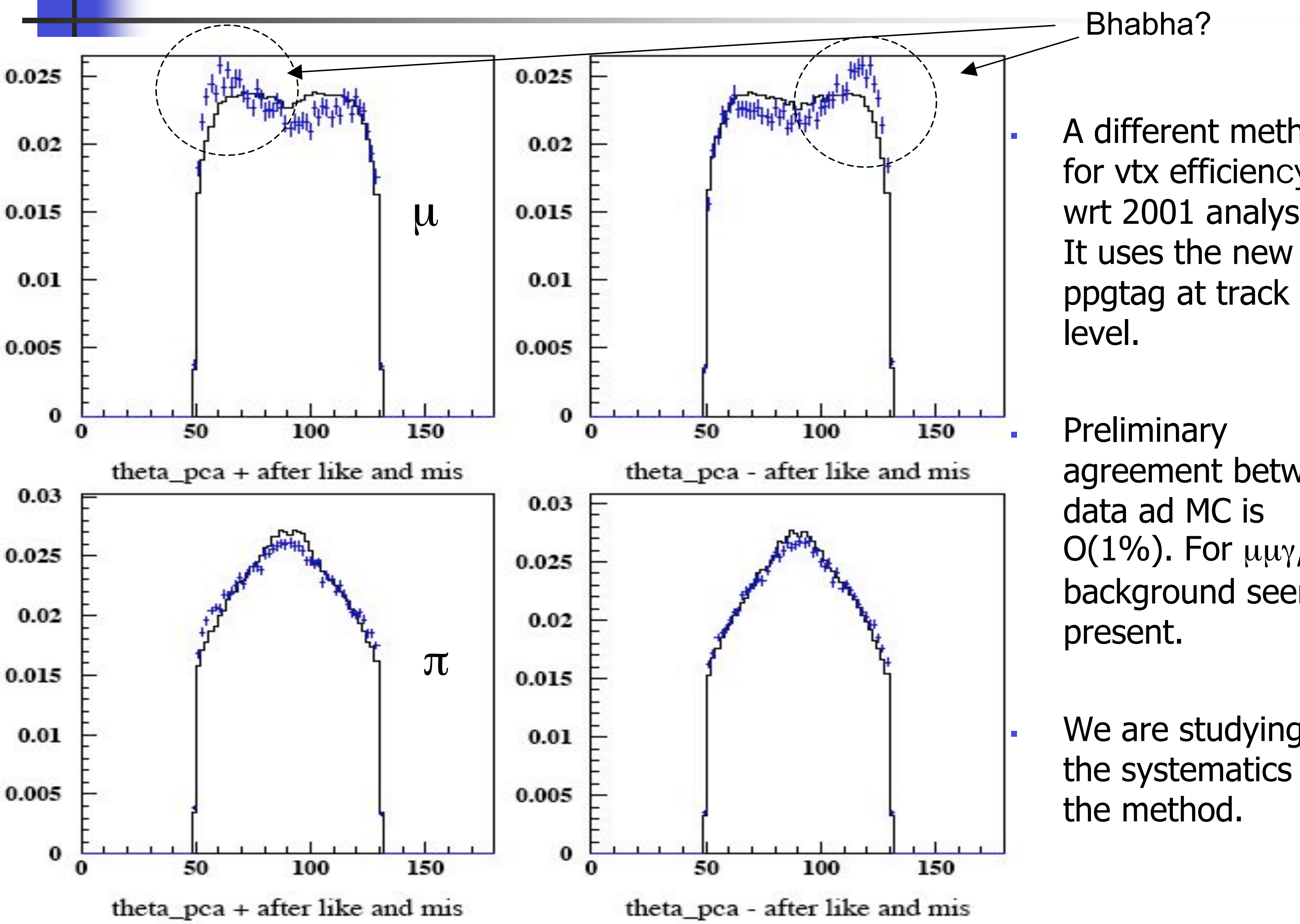
flat offset O(1%) for **ππγ**

Ratio $\pi\pi\gamma/\mu\mu\gamma$ for data and MC



the data trend seems to be reproduced by MC

Possible contamination and outlook

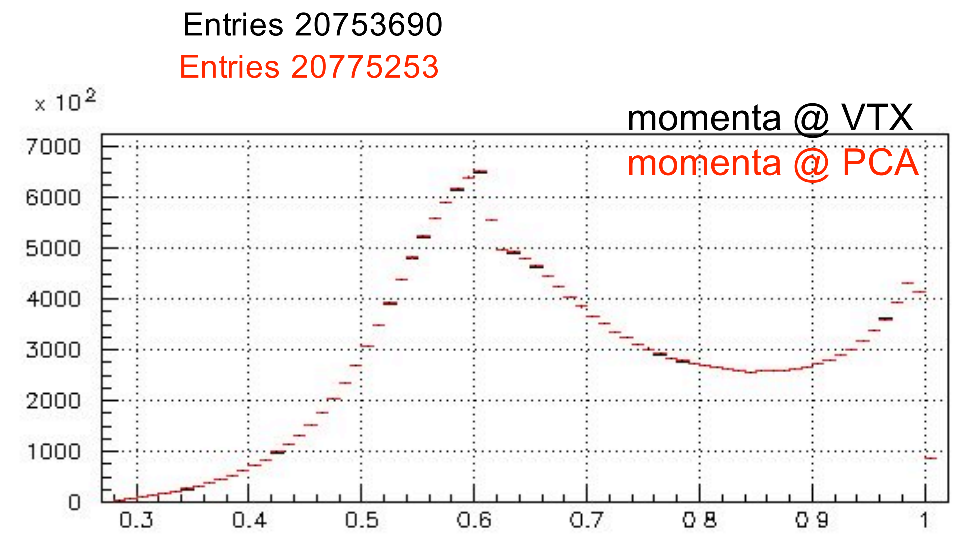


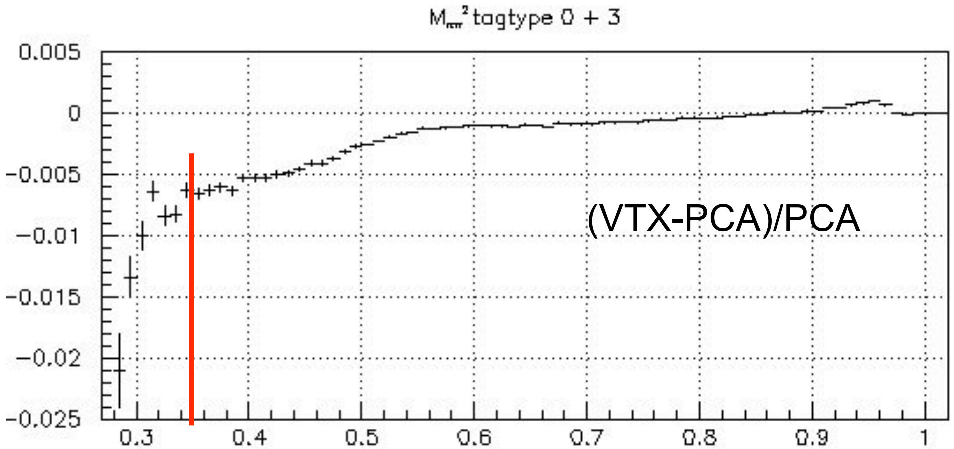
- A different method for vtx efficiency wrt 2001 analysis. It uses the new ppgtag at track level.
- Preliminary agreement between data ad MC is O(1%). For $\mu\mu\gamma$, background seems present.
- We are studying the systematics of the method.

Checks on ppgtag: m_{trk} and m_{miss} cuts

1. in the selection we cut on variables defined with vtx momenta, (for vertex efficiency… obviously not!!!), what about cutting at the level of pca momenta?

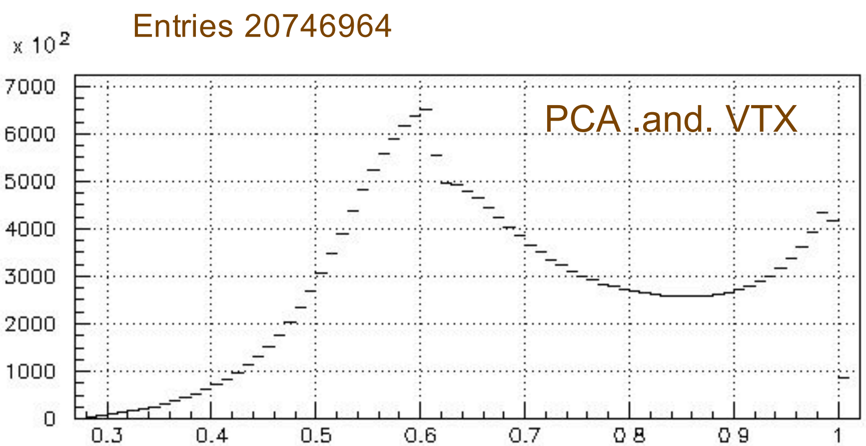
Check for pions from MC



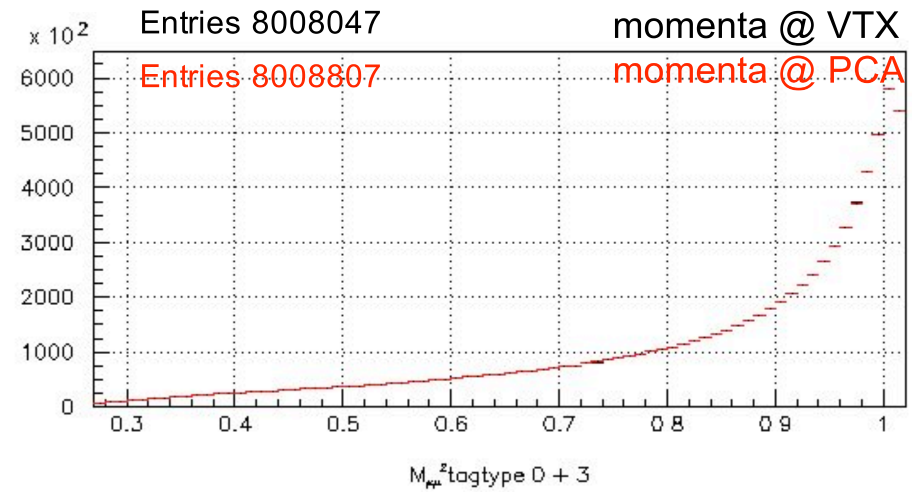


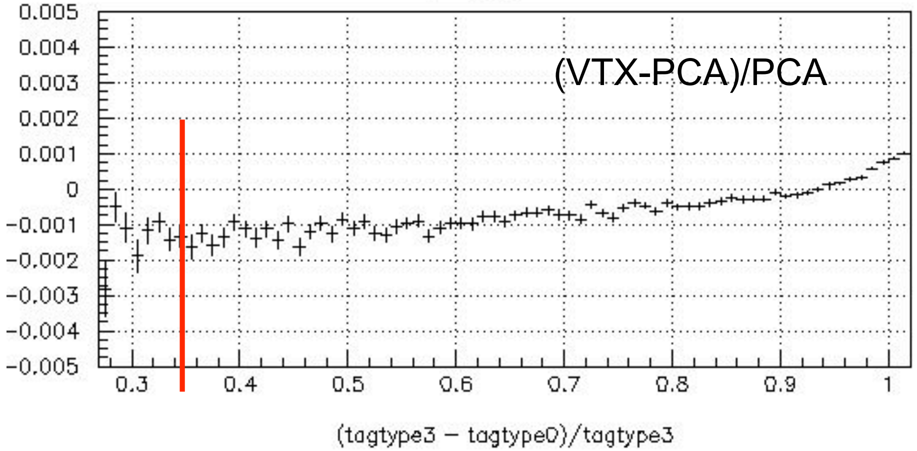
Standard Selection performed with:

- no FILFO
- no analysis cuts on M_{Trk},M_{Miss}



Check for muons from MC

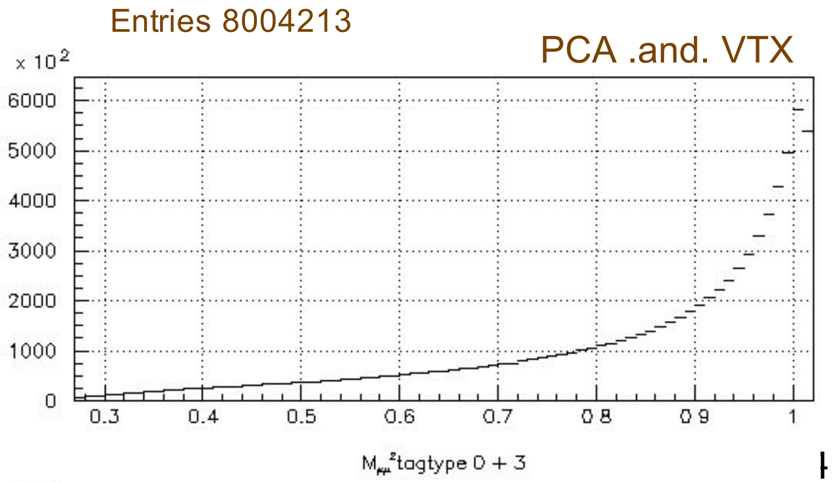




no bias at all for muons,

slight (~ 0.5%) for pions @

small M values

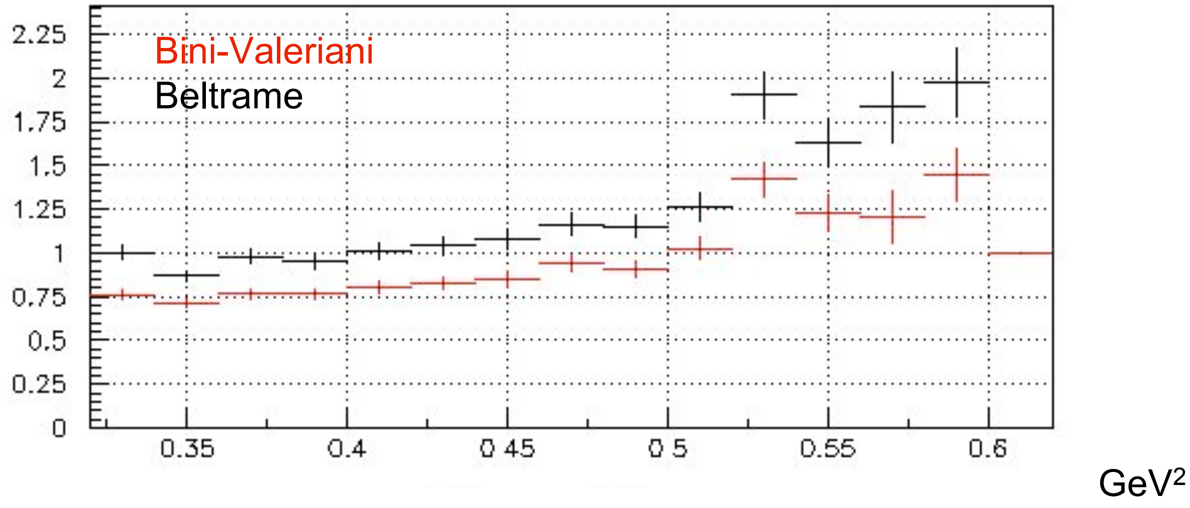


Updates on background fit

1. P. Beltrame's corrections on both data an MC are applied to the m_{trk} shapes to check for differences, no significant change aside from p+p-p0

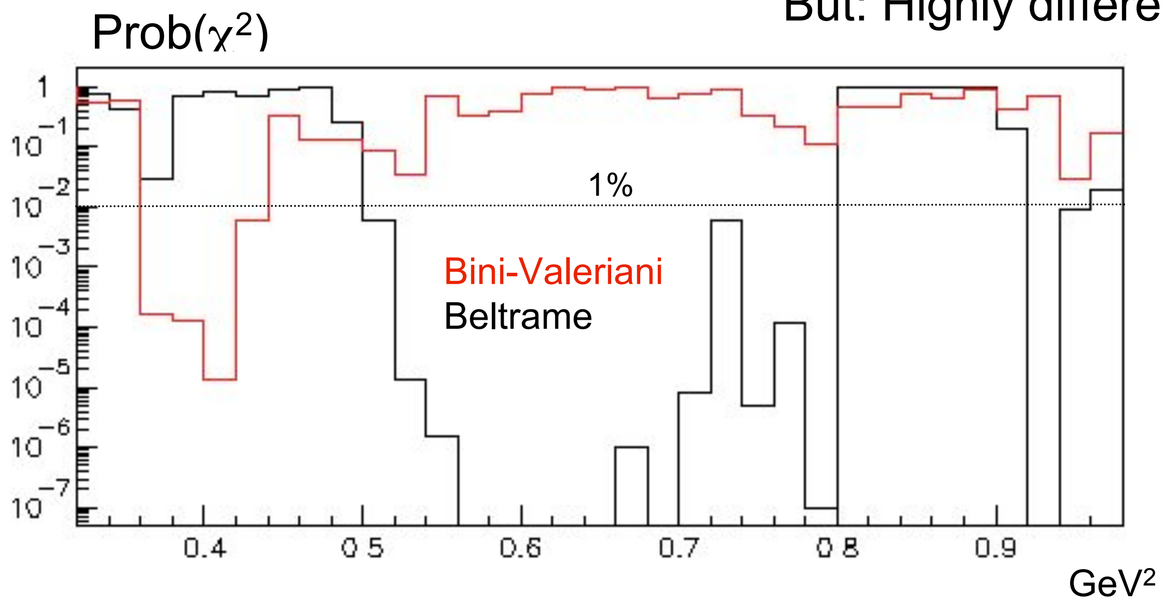
2. found an effect in the p+p-p0 MC events, smaller weights (< 1.5), slight net effect

Effects of P. Beltrame on the bckgr



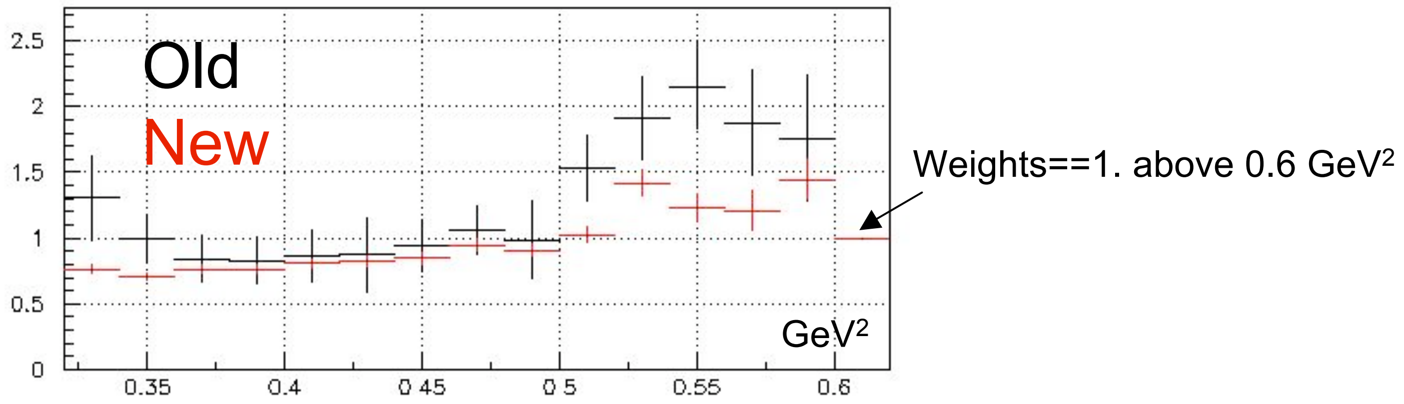
small difference in weights for $\pi\pi\pi$:

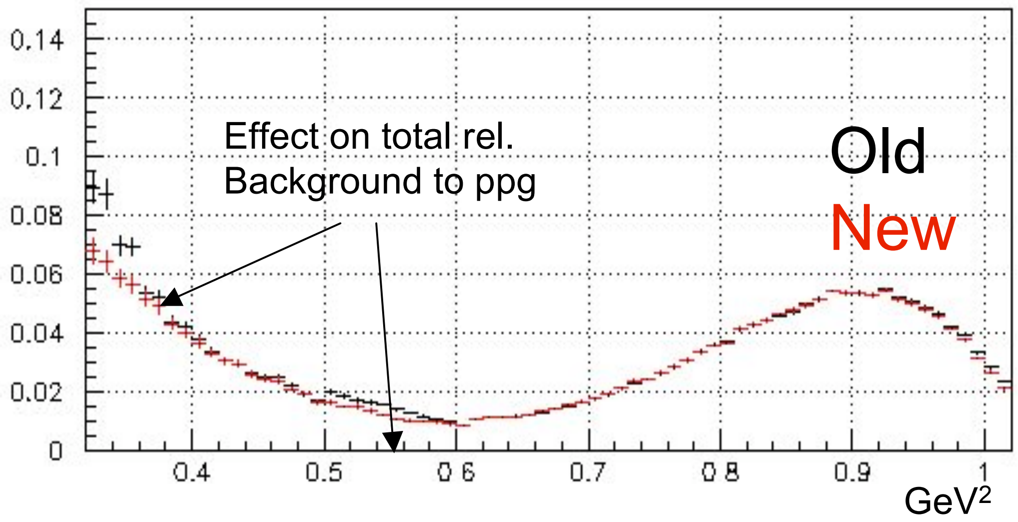
But: Highly different behavior for χ^2 probablility:

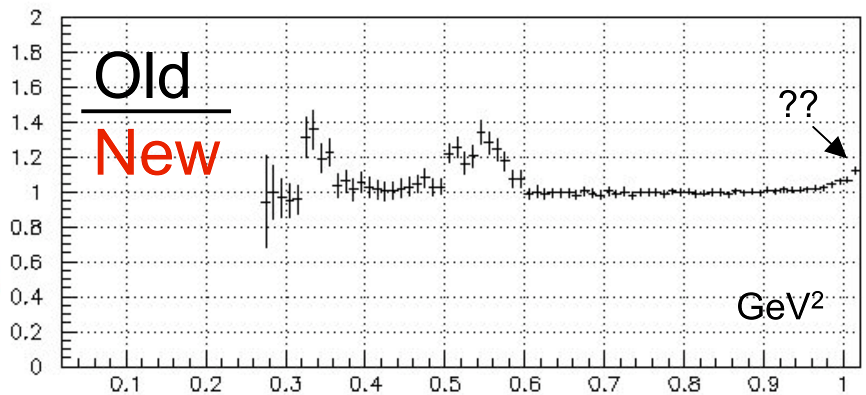


Better 3π weights

• When correcting MC momenta, one should recreate PPGTAG condition with the corrected momenta
This was not possible before for 3π, since the MC-sample for 3π was already filtered by PPGTAG
→ Redid 3π sample incl. w.resp. to PPGTAG, redid background fit - weights for 3π contr. change.







Systematic uncertainty in the polar angle of the track @ small angle

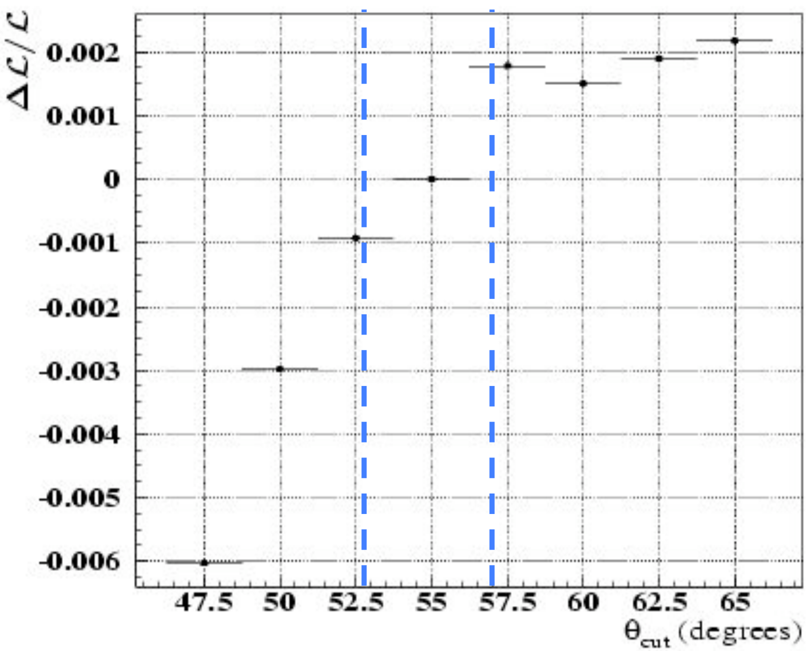
1. apply corrections to reconstructed momenta in MC to reproduce m_{trk} peak from data (smearing+offset…)

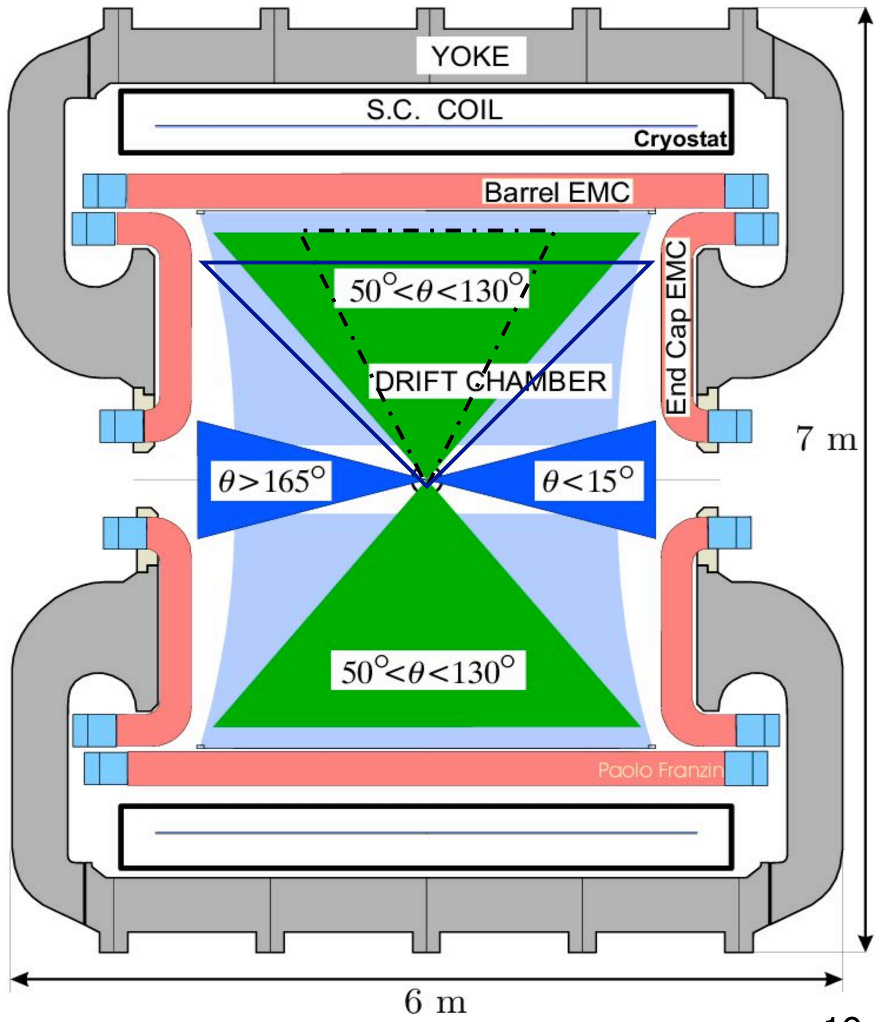
2. estimate polar angle resolution as the RMS of θ_{rec}-θ_{gen} and take it as the standard deviation = σ

3. vary θ_{cut} and take the fractional difference of the spectra (after the standard selection) at 1σ as the systematic uncertainty

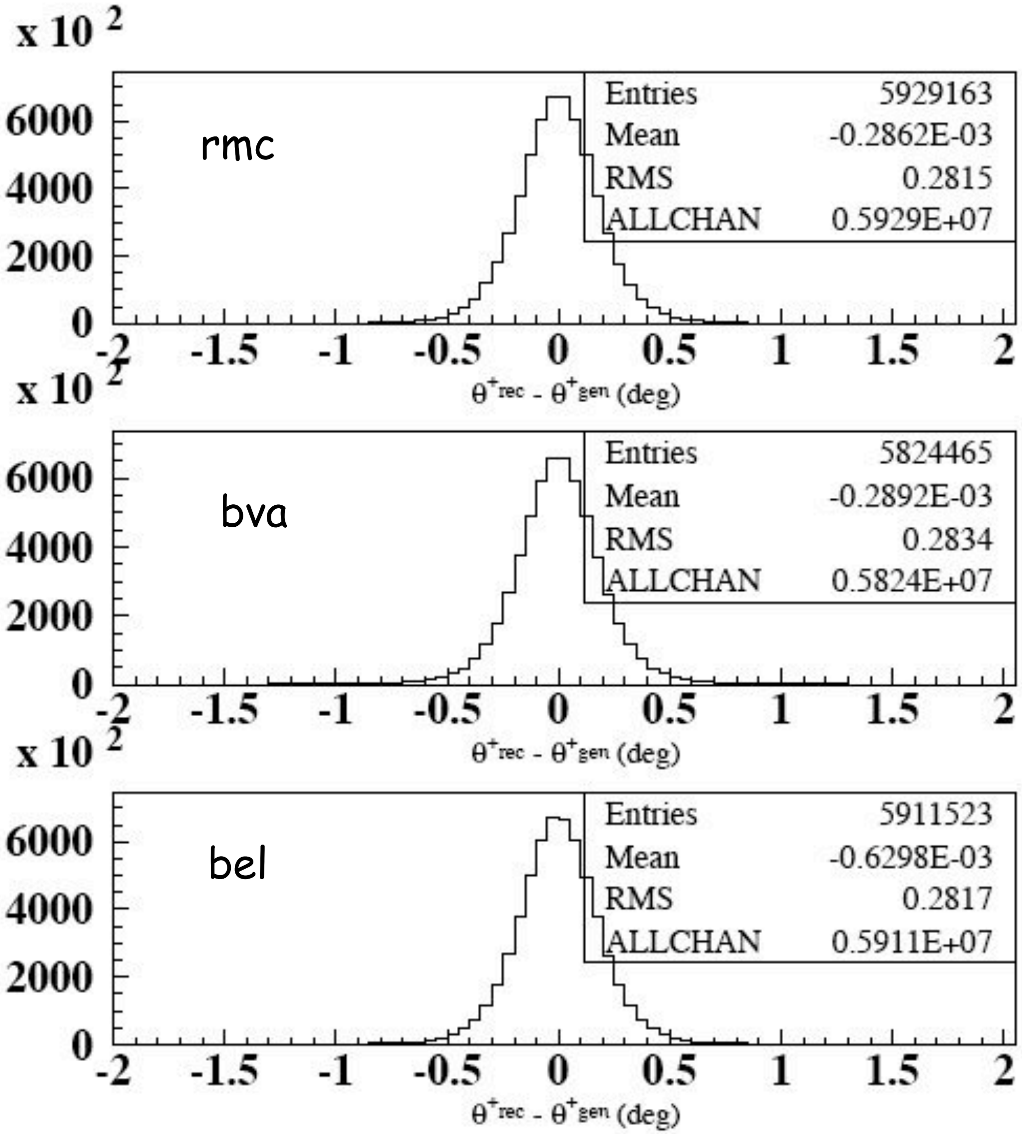
Check mc-data differences in resolution

we check the effects on the spectrum squeezing/stretching the opening cone and estimate the relative difference wrt the chosen cut (similarly to what we did for the Lumi, but there the cluster polar angle is used… σ ~ 2°, Kloe Note 202)





Resolutions in θ_π: a comparison



LEGENDA:

rmc = no smearing at all

bva = Bini-Valeriani

bel = from P. Beltrame

same RMS (resolution) btw doing nothing and Paolo's recipe

same MEAN (offset) btw doing nothing and Bini-Valeriani

a RMS ~ 0.3° is taken as the conservative resolution in θ

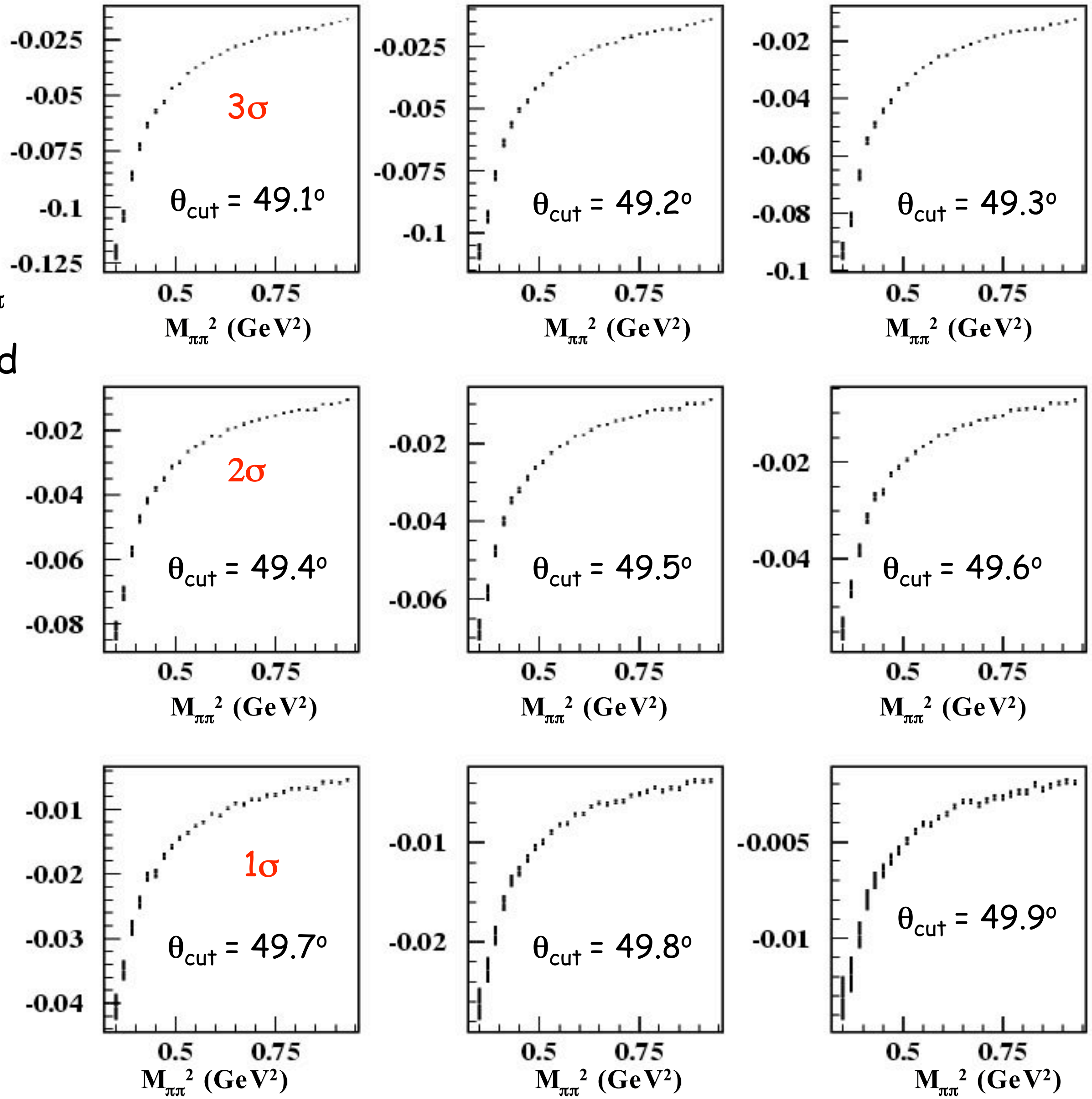
Relative differences: data (I)

$$1 - \frac{N_i(\theta_{cut} < \theta)}{N_i(50^o < \theta)}$$

relative difference btw the $M_{\pi\pi}$ spectrum evaluated with θ_{cut} and the reference 50^o

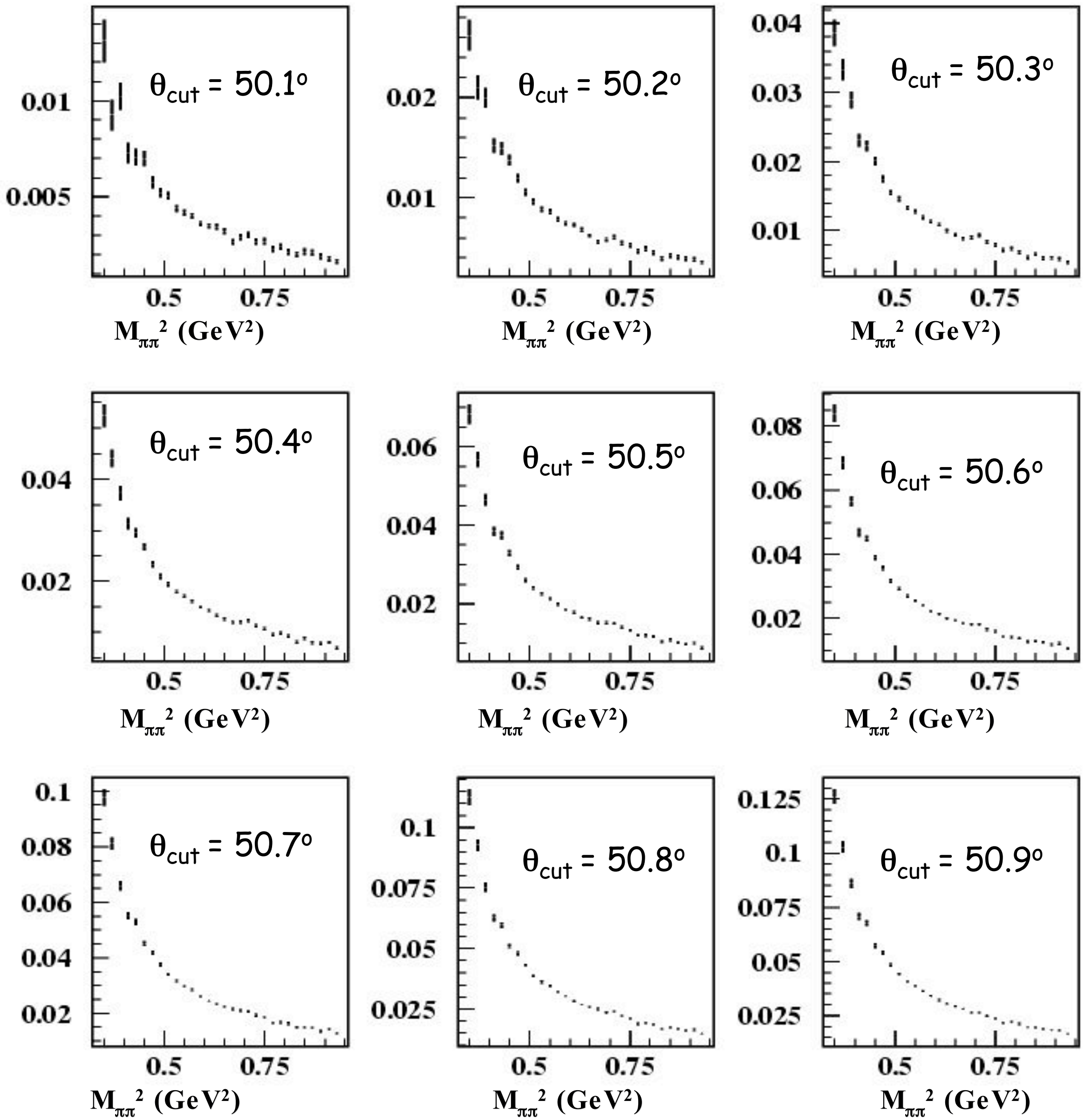
all spectra after all standard small angle cuts (except for polar angle...)

low $M_{\pi\pi}$ difference can reach 4% at 1σ, and also the high $M_{\pi\pi}$ region can be offset by 1%



Relative differences: data (II)

$$1 - \frac{N_i(\theta_{cut} < \theta)}{N_i(50^o < \theta)}$$



similar conclusions take place:

low $M_{\pi\pi}$ slope can reach 4% at 1σ, and also the high $M_{\pi\pi}$ region can be offset by 1%

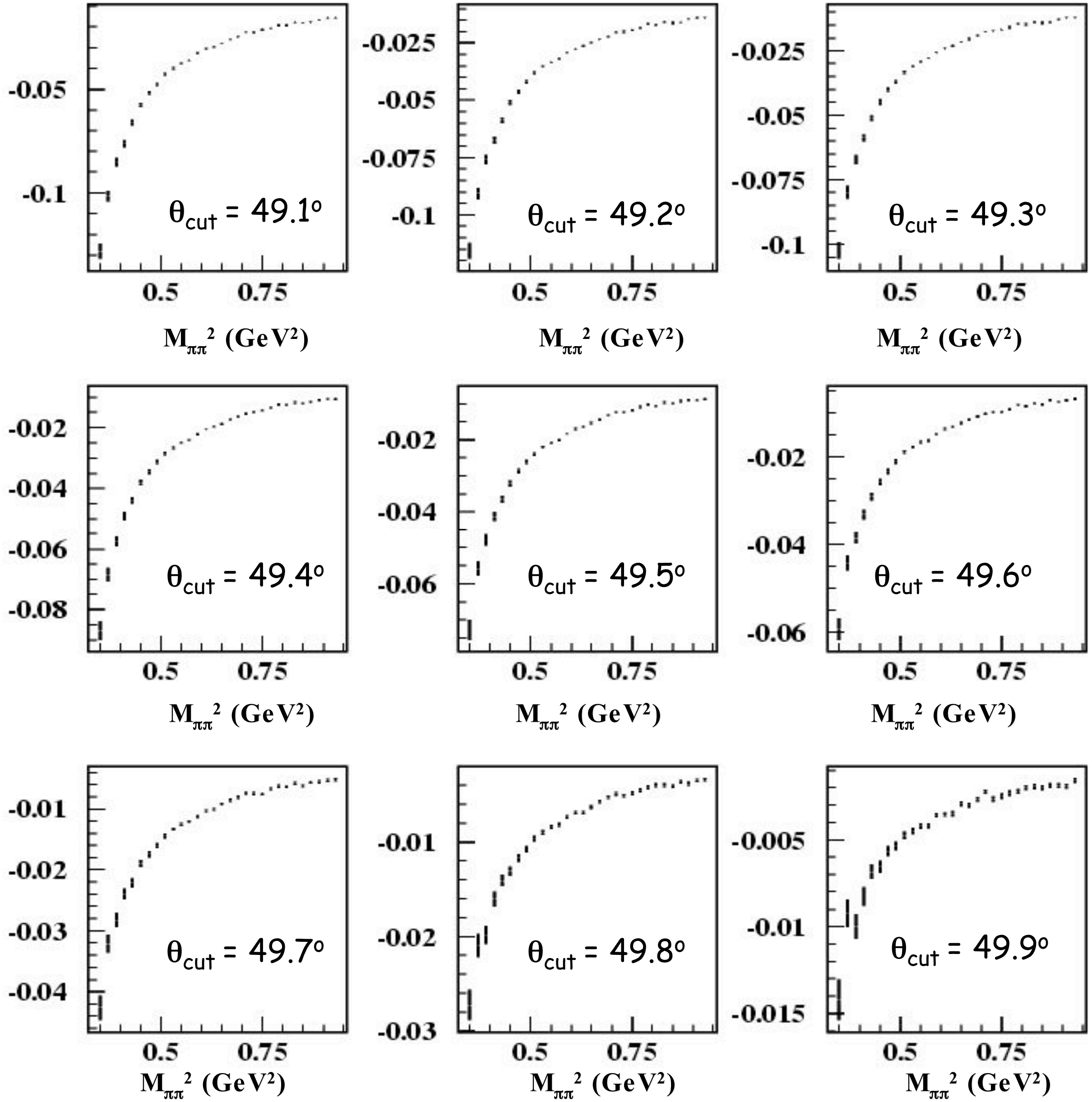
does MC reproduce these trends?

Relative differences: MC-BV (I)

$$1-\frac{N_i(\theta_{cut}<\theta)}{N_i(50^o<\theta)}$$

it seems yes!!!

low $M_{\pi\pi}$ slope can reach 4% at 1σ, and also the high $M_{\pi\pi}$ region can be offset by 1%



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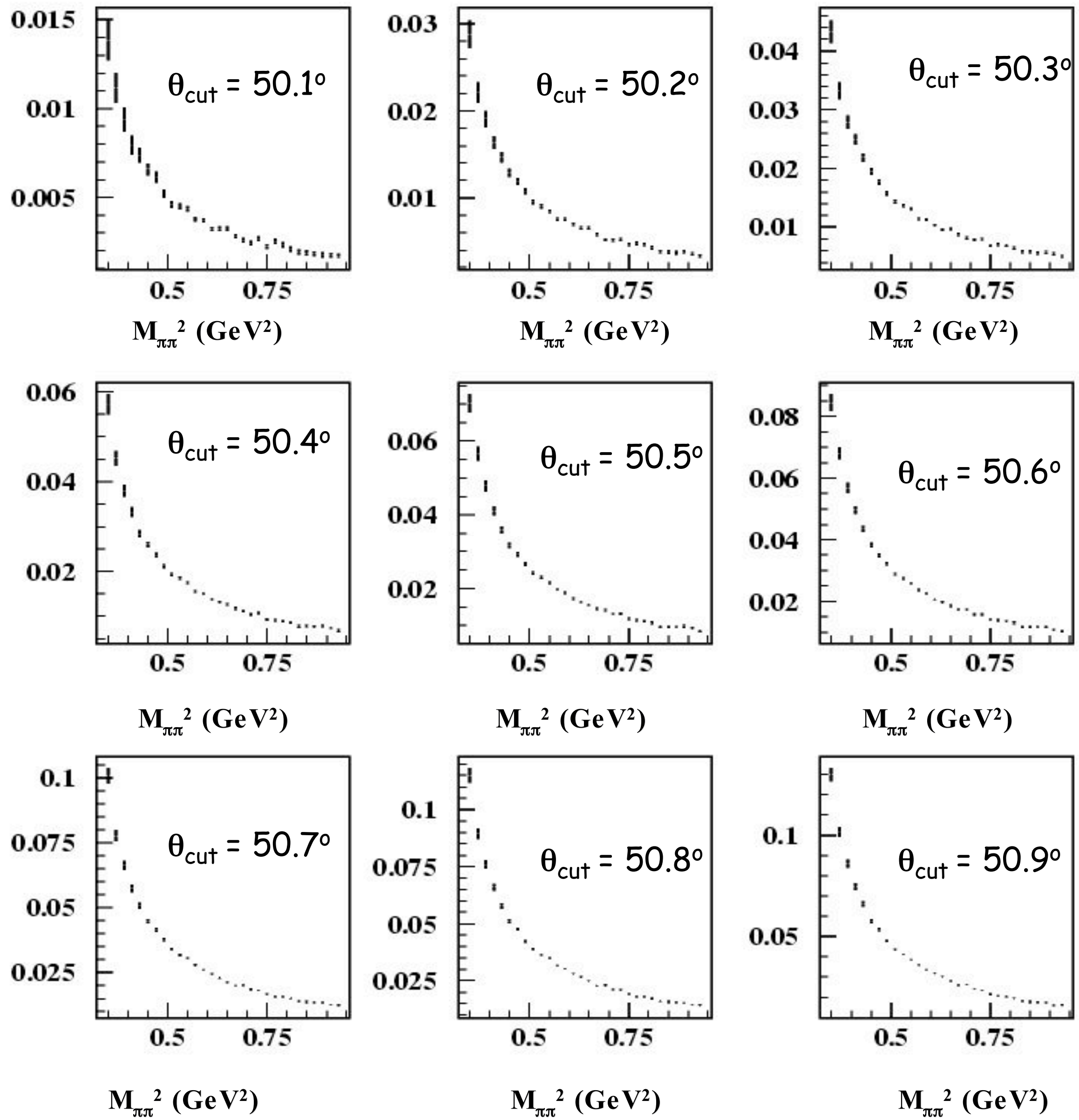

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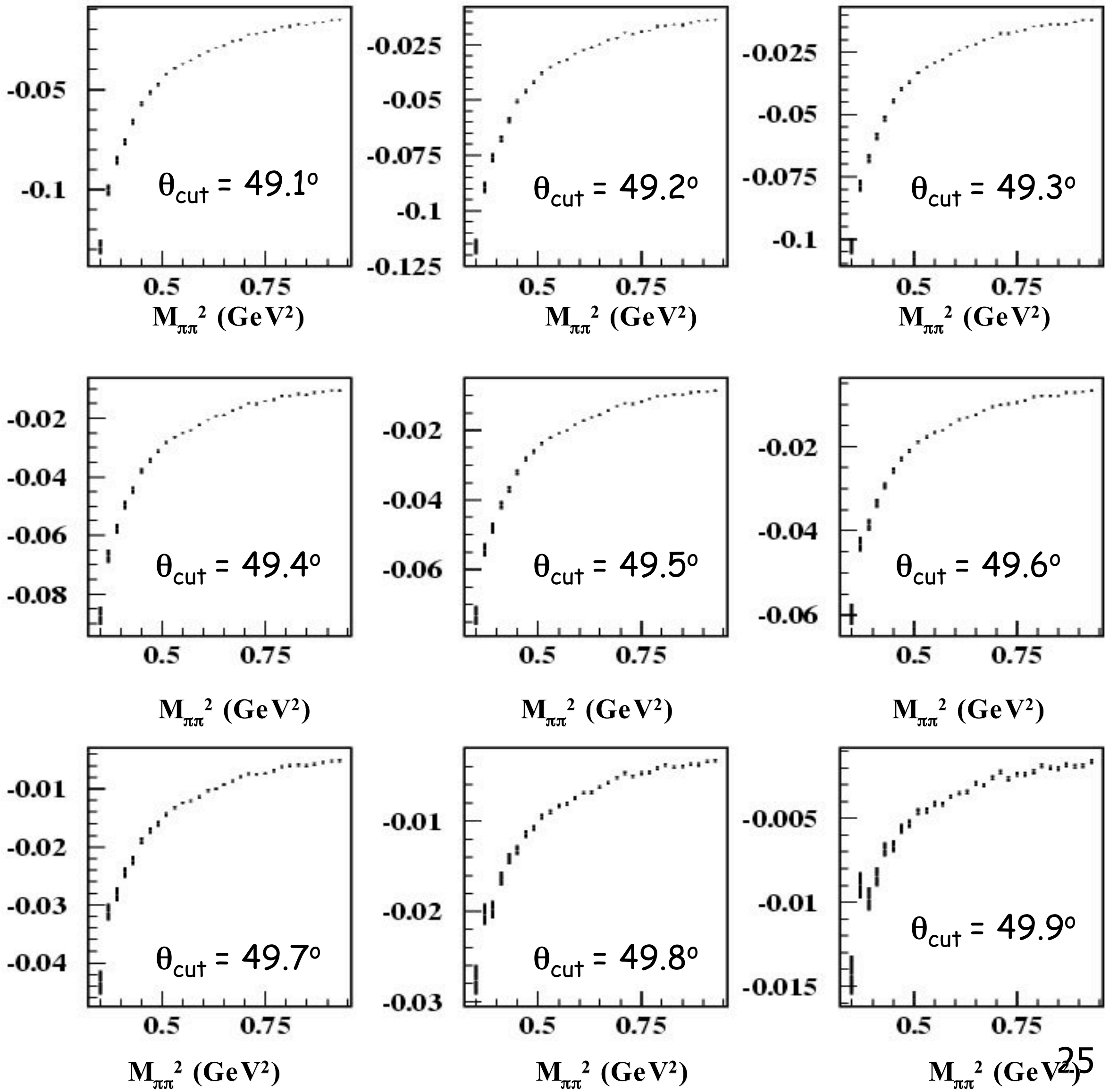
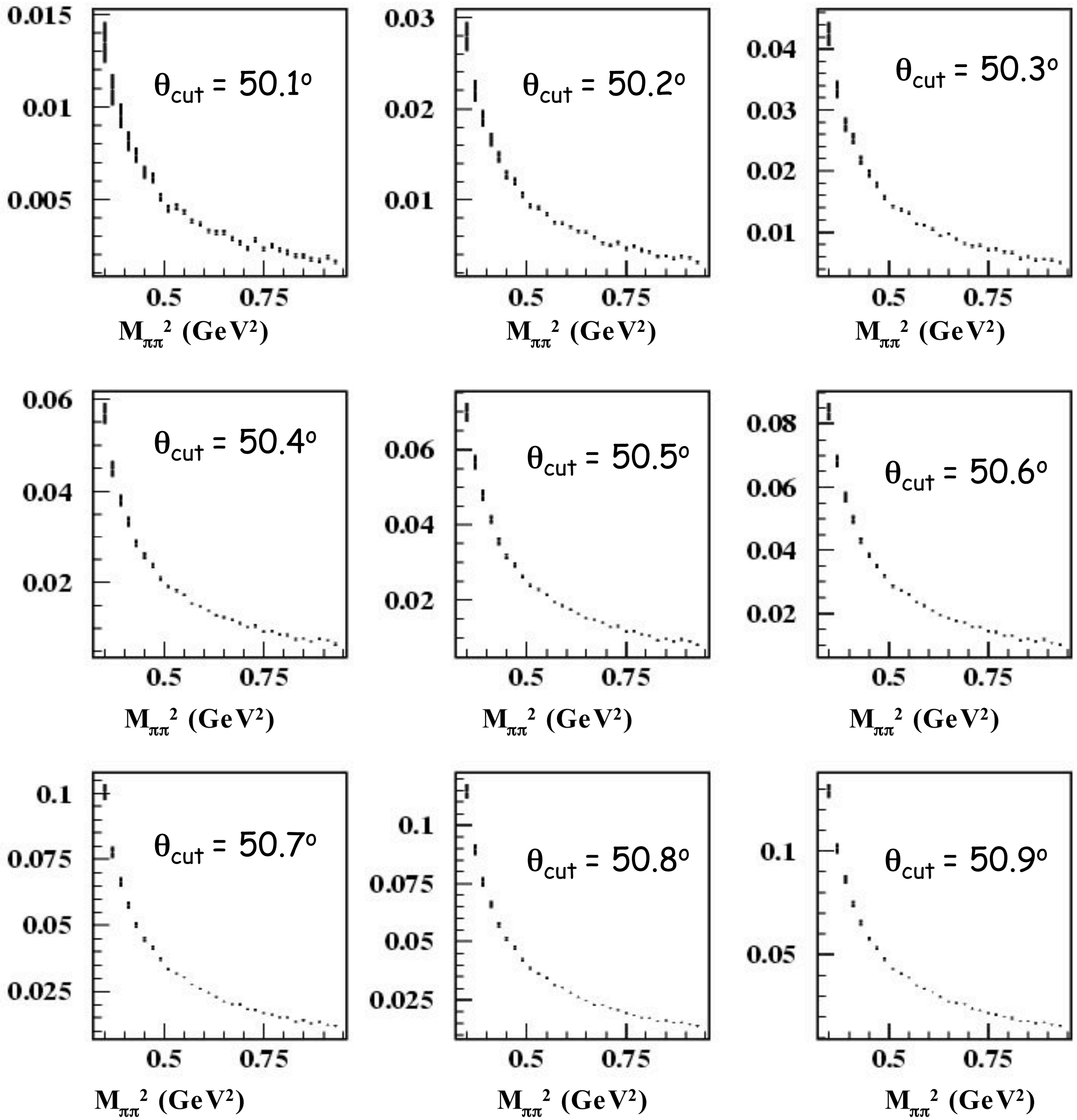


Paolo Beltrame confirms data as well as MC Bini-Valeriani trends

Relative differences: MC-P.B. (II)

$$1 - \frac{N_i(\theta_{cut} < \theta)}{N_i(50^o < \theta)}$$



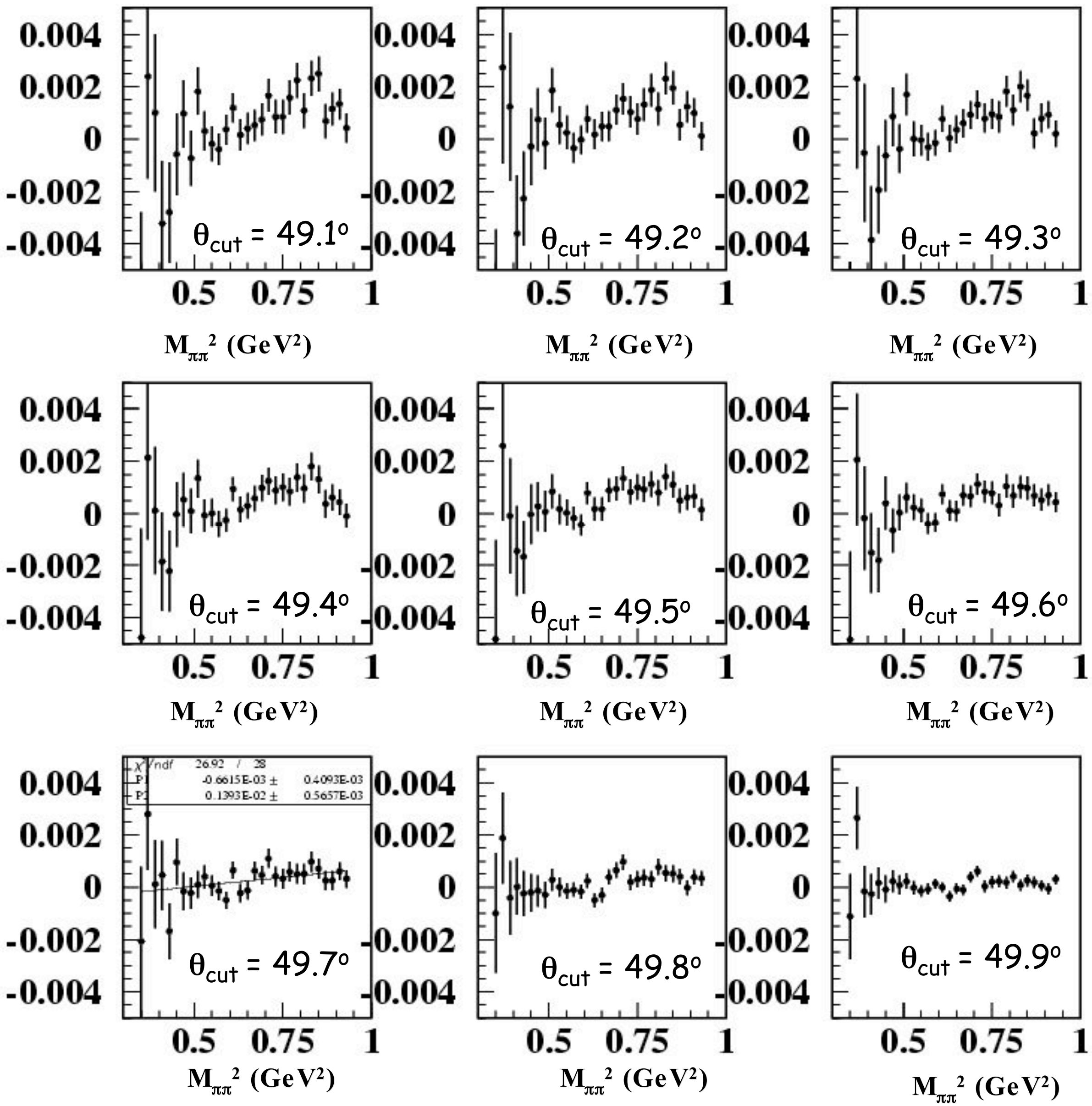
let's be quantitative!!!

Systematic uncertainty: data-BV (I)

$$\frac{N_i^{MC}(\theta_{cut} < \theta)}{N_i^{MC}(50^o < \theta)} - \frac{N_i^{data}(\theta_{cut} < \theta)}{N_i^{data}(50^o < \theta)}$$

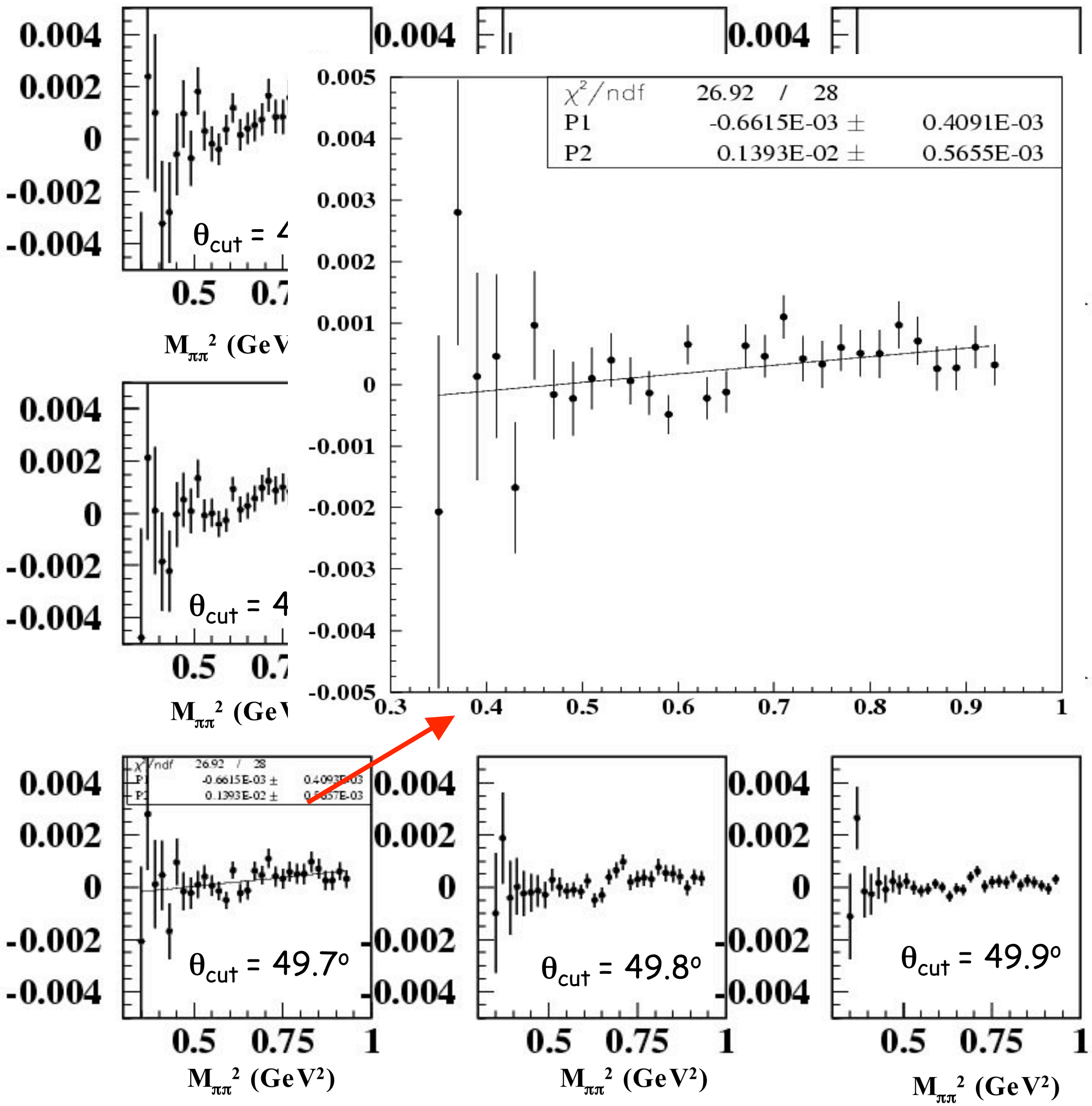
systematic error < 0.2% at 1σ

for the low cut



… zooming the previous one

$$\frac{N_i^{MC}(\theta_{cut} < \theta)}{N_i^{MC}(50^o < \theta)} - \frac{N_i^{data}(\theta_{cut} < \theta)}{N_i^{data}(50^o < \theta)}$$



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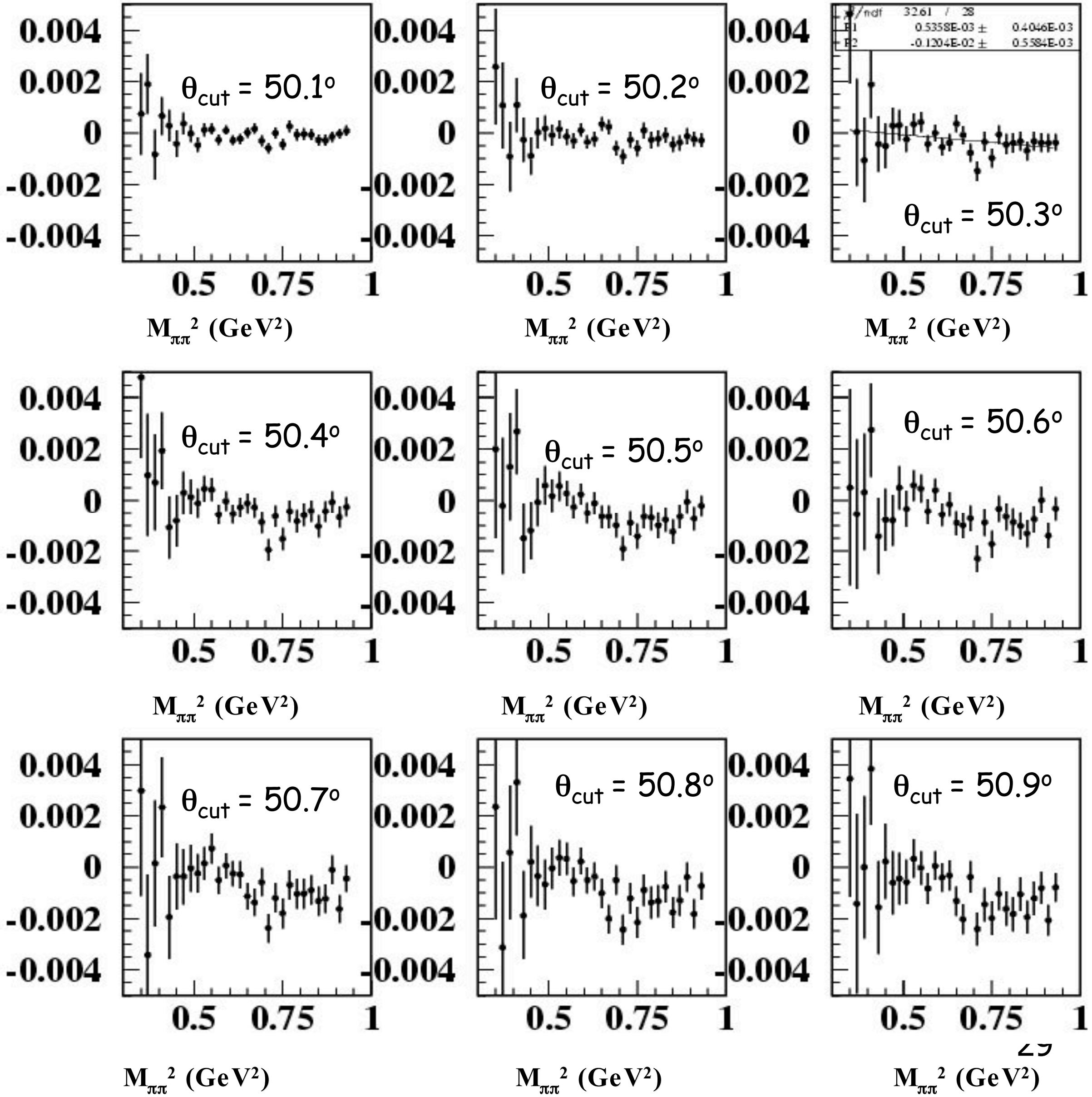

systematic error < 0.2% at 1σ

also for the high cut

…zooming the previous one

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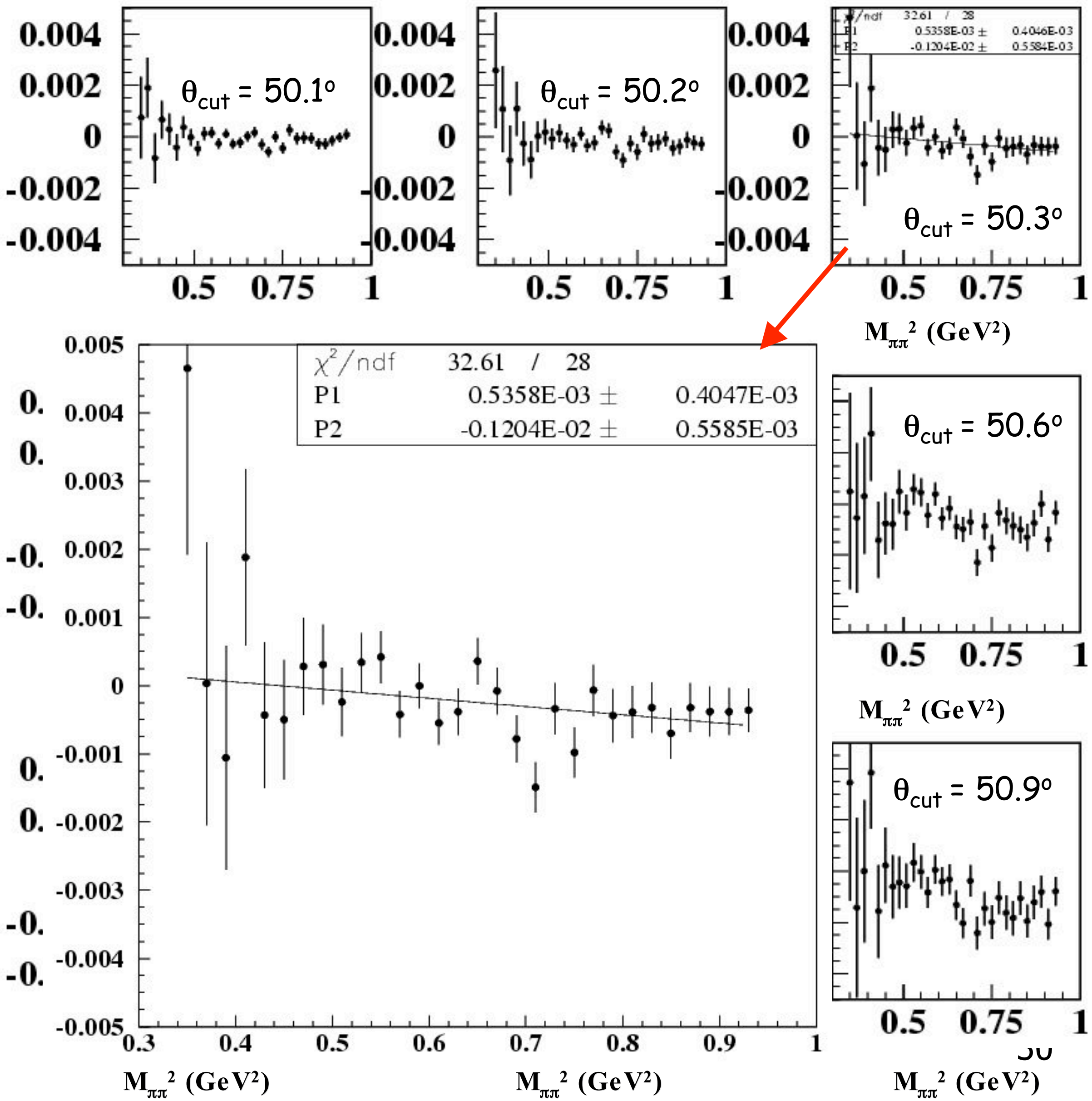

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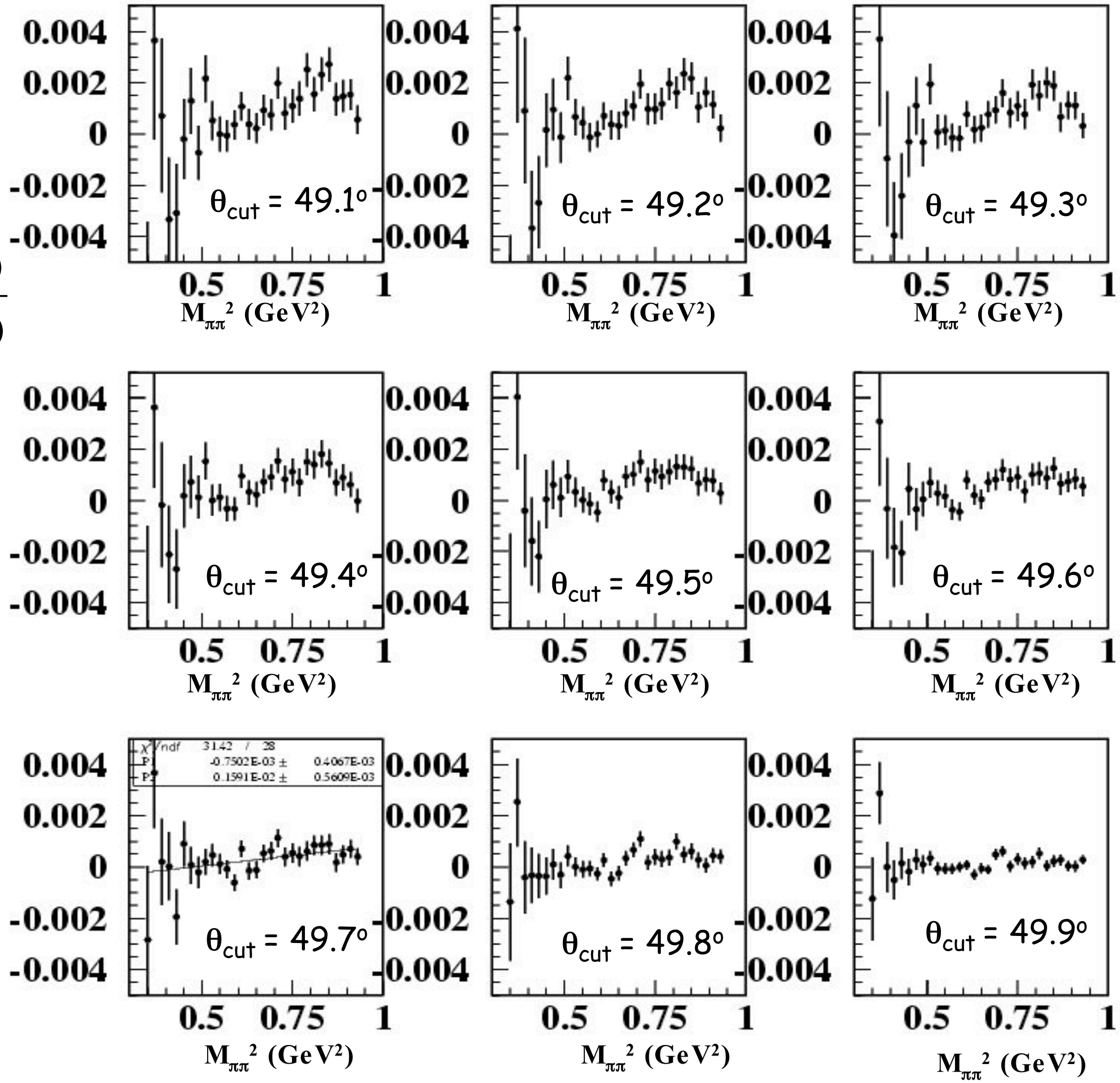

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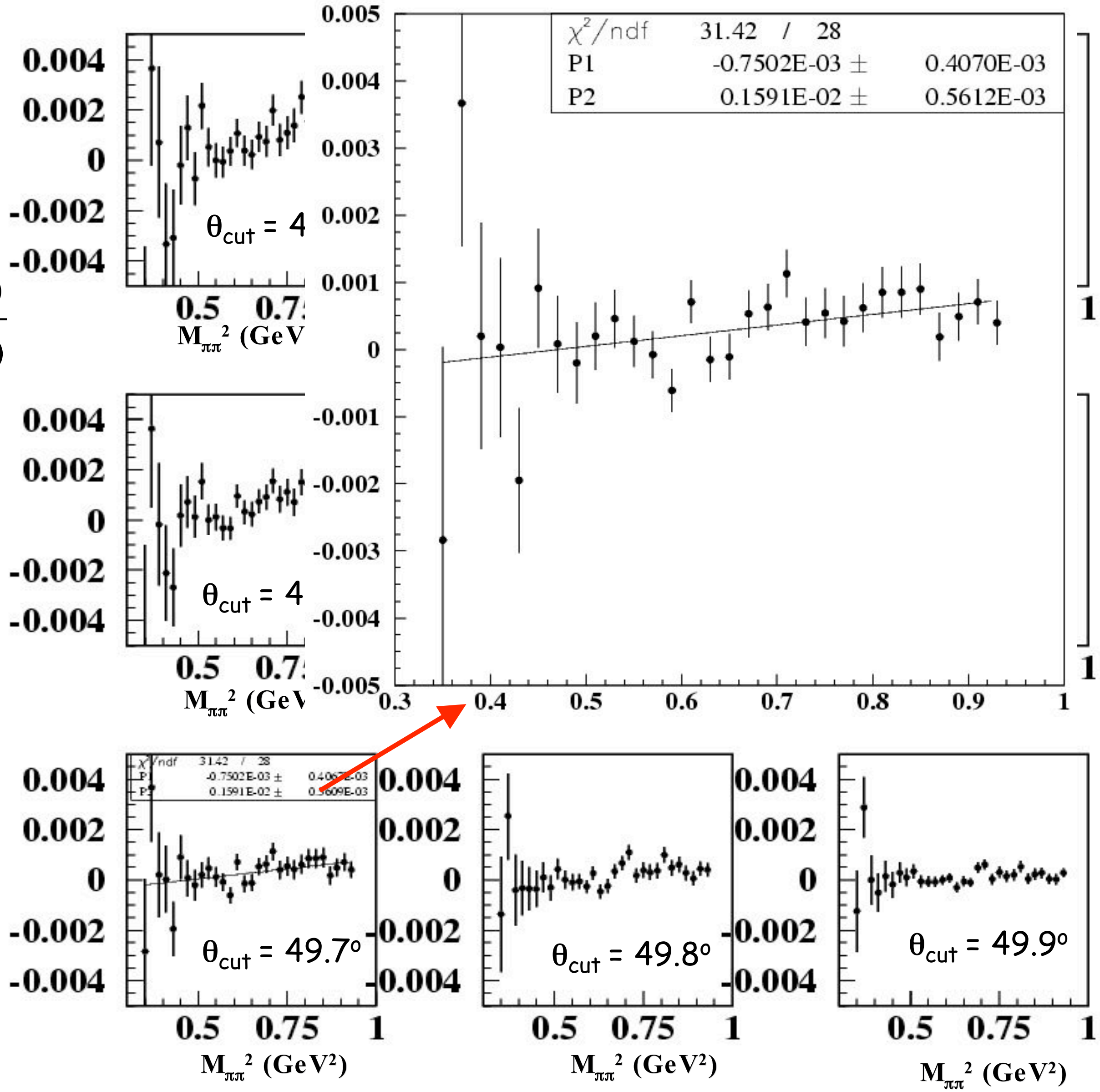

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Systematic uncertainty: data-P.B. (II)

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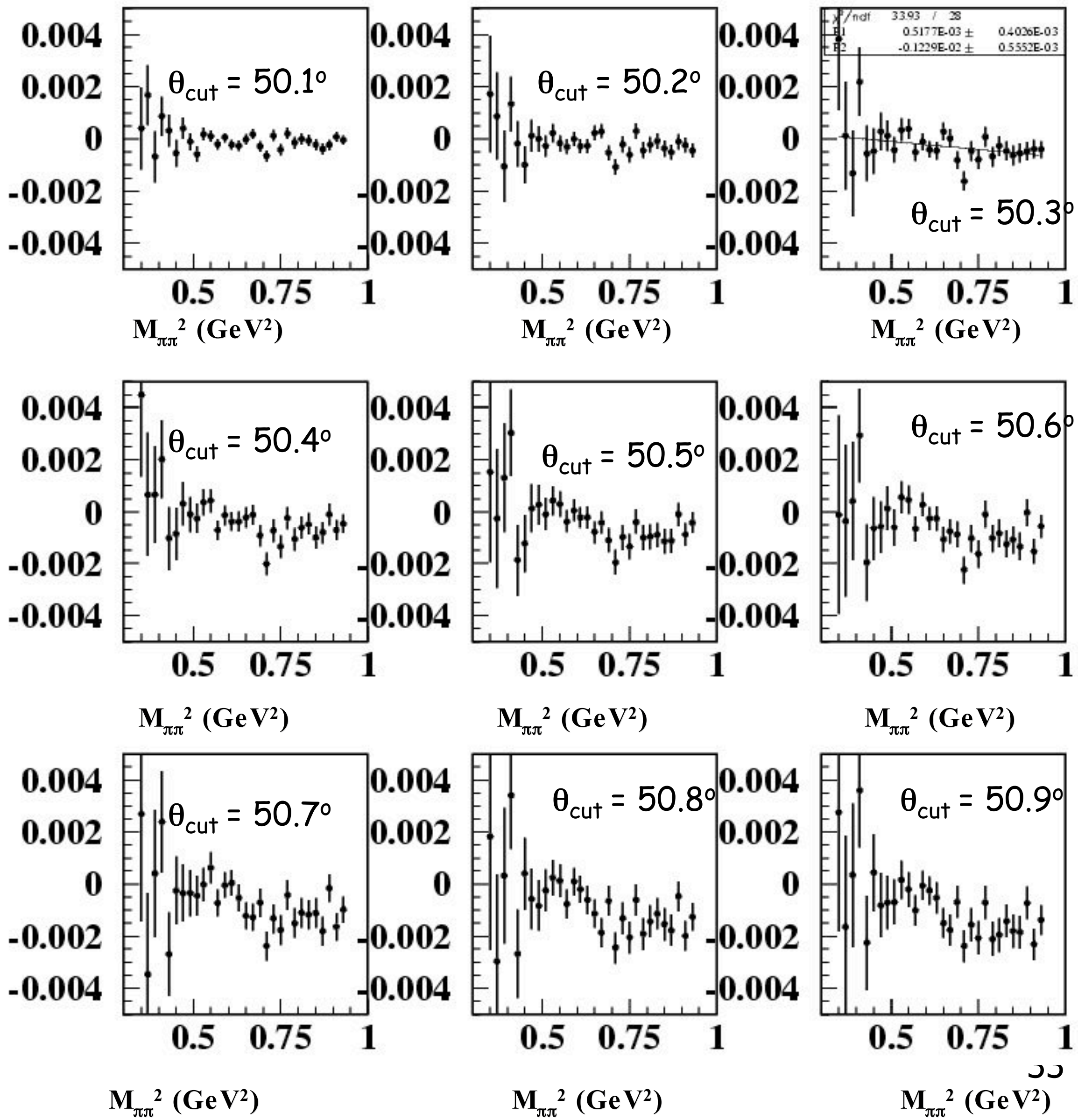
systematic error < 0.2% at 1σ

also for the high cut

despite my fear, the small

angle obtains similar findings

of the large angle



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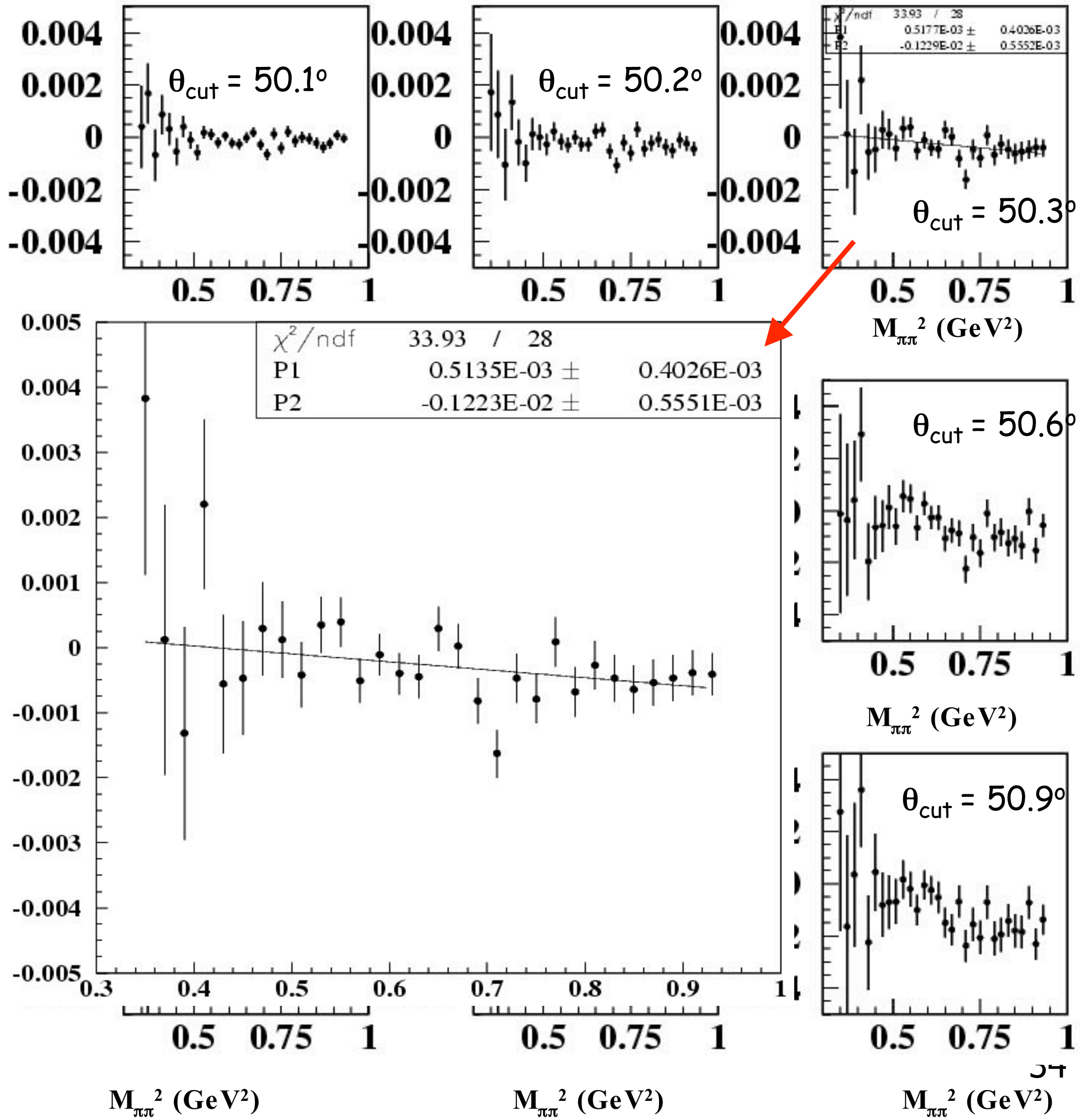

systematic error < 0.2% at 1σ

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Tracking efficiency: data control samples

Selection of the data control samples from RAW:

$\pi^+\pi^-\pi^0$

1) 2 and only 2 clusters with E>30 MeV and

29 cm/ns < R/t < 32 cm/ns

2) $|M_{\gamma\gamma} - m_{\pi 0}| < 20$ MeV

3) a tagging track recognized as a pion by

the Likelihood, extrapolating back to the IP

$\pi^+\pi^-$

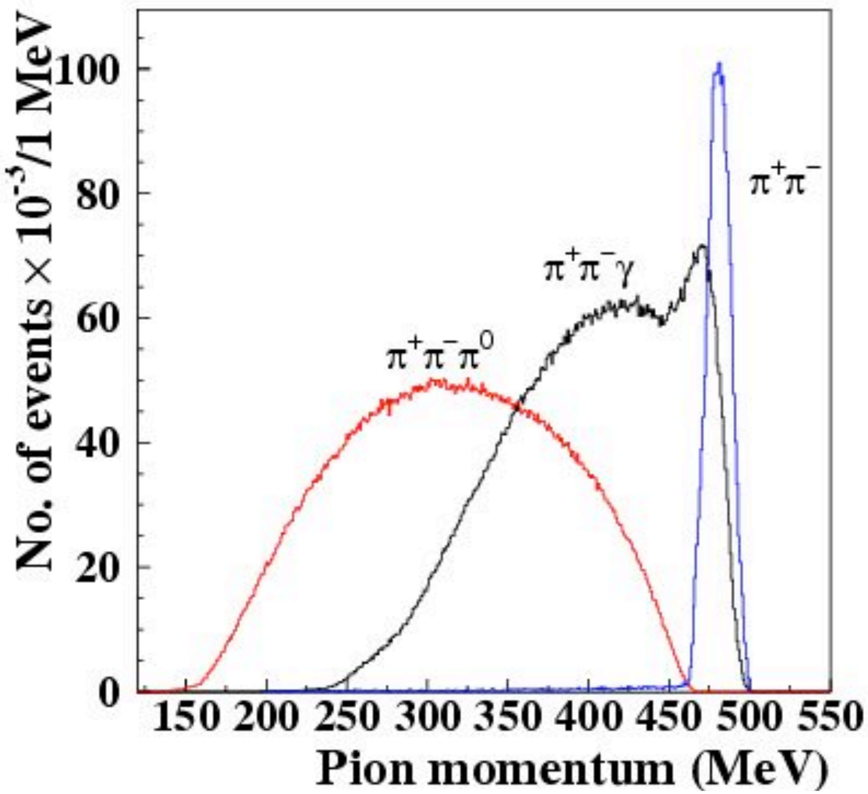
1) 1 or 2 clusters in the barrel

with 5 ns < t < 8 ns

2) a tagging track recognized as a pion by

the Likelihood, extrapolating back to the IP,

and with $|p_{CM}-490| < 5$ MeV



Tracking efficiency: the candidate track

The *candidate track* must satisfy the following cuts (on data):

1) charge must be opposite wrt tagging track

2) first hit must have $\rho_{FH} < 50$ cm

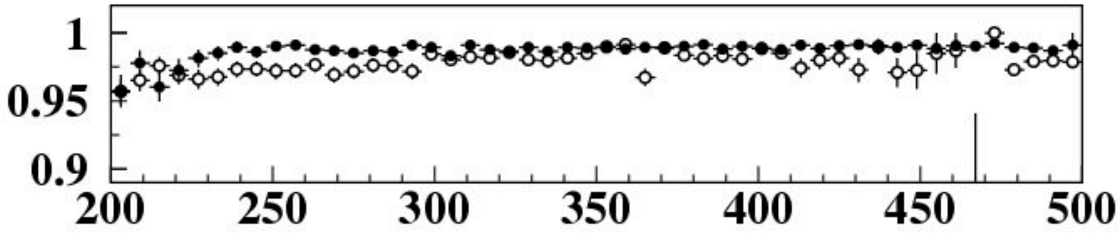
3) the point of closest approach (PCA) of backward track extrapolation must have $\rho_{PCA} < 8$ cm and $|z_{PCA}| < 7$ cm

4) χ^2 algorithm to assign the track based on the conservation of momenta known from BMOM, the tagging track (and the π^0 for the 1st sample)

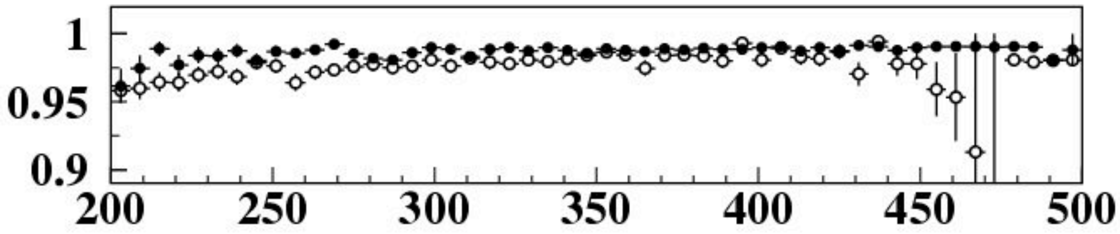
From MC:

take the KINE track and look for the DTFS track of the same sign having the same 2) and 3) features

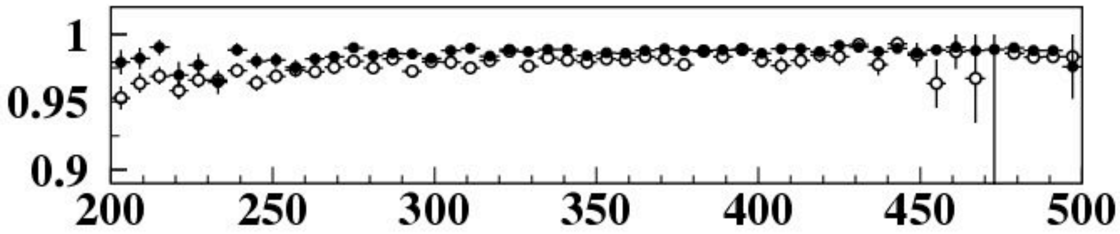
Data-MC comparison



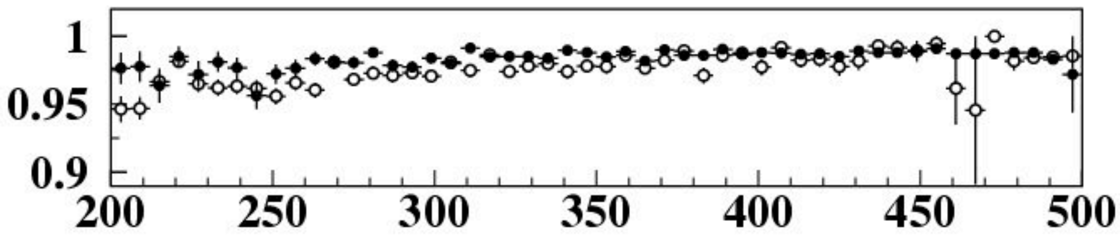
Efficiency vs π momentum - θ slice (80,90)



Efficiency vs π momentum - θ slice (70,80)



Efficiency vs π momentum - θ slice (60,70)



Efficiency vs π momentum - θ slice (50,60)

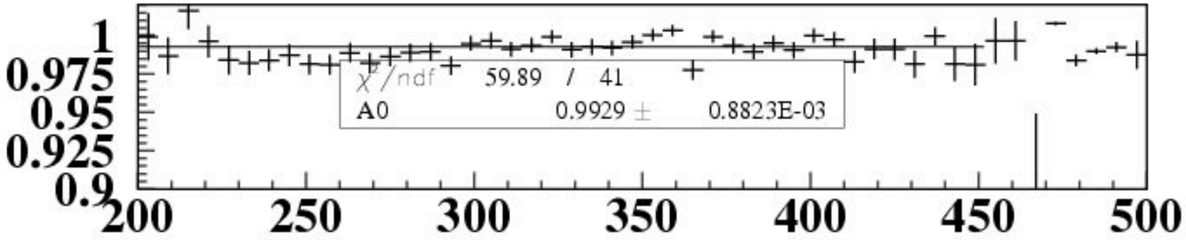
black = MC, white = data

the 450-475 MeV reflects the gap due to merging the 2 control samples

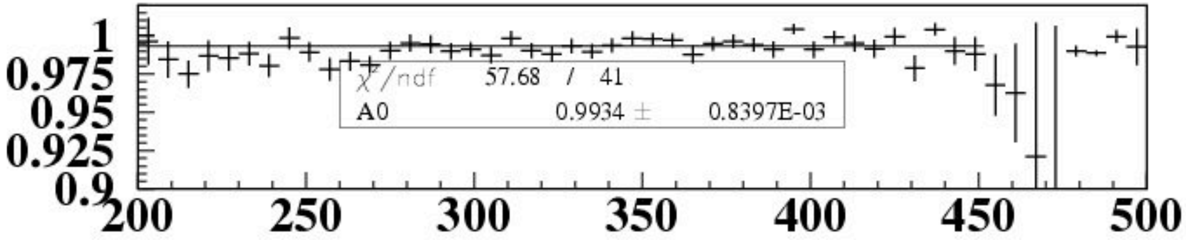
Fit to the ratio data/MC

the agreement is on the level of 0.6-0.7% (validated by a good χ^2/ndf) in the region covered by $\pi^+\pi^-\pi^0$ events

$\pi^+\pi^-$ events (4 bins) worsen a little the agreement at high θ values and enforce that at low θ values



Efficiency vs π momentum - θ slice (80,90)



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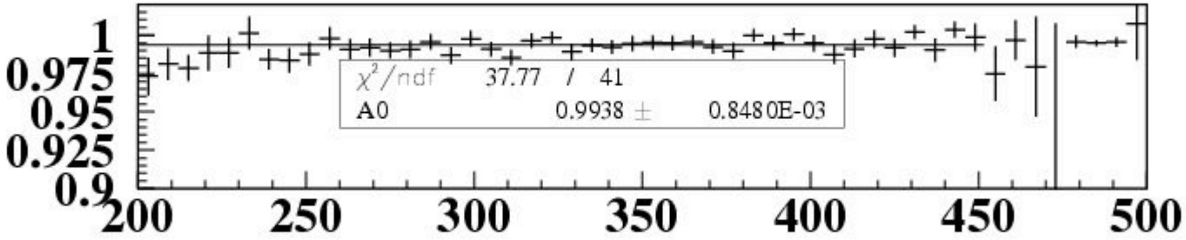

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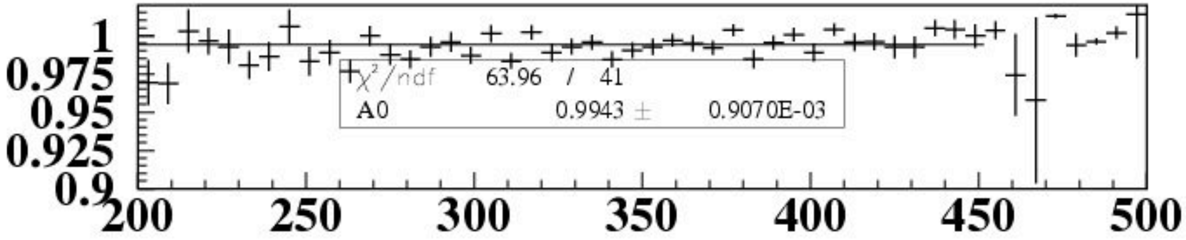

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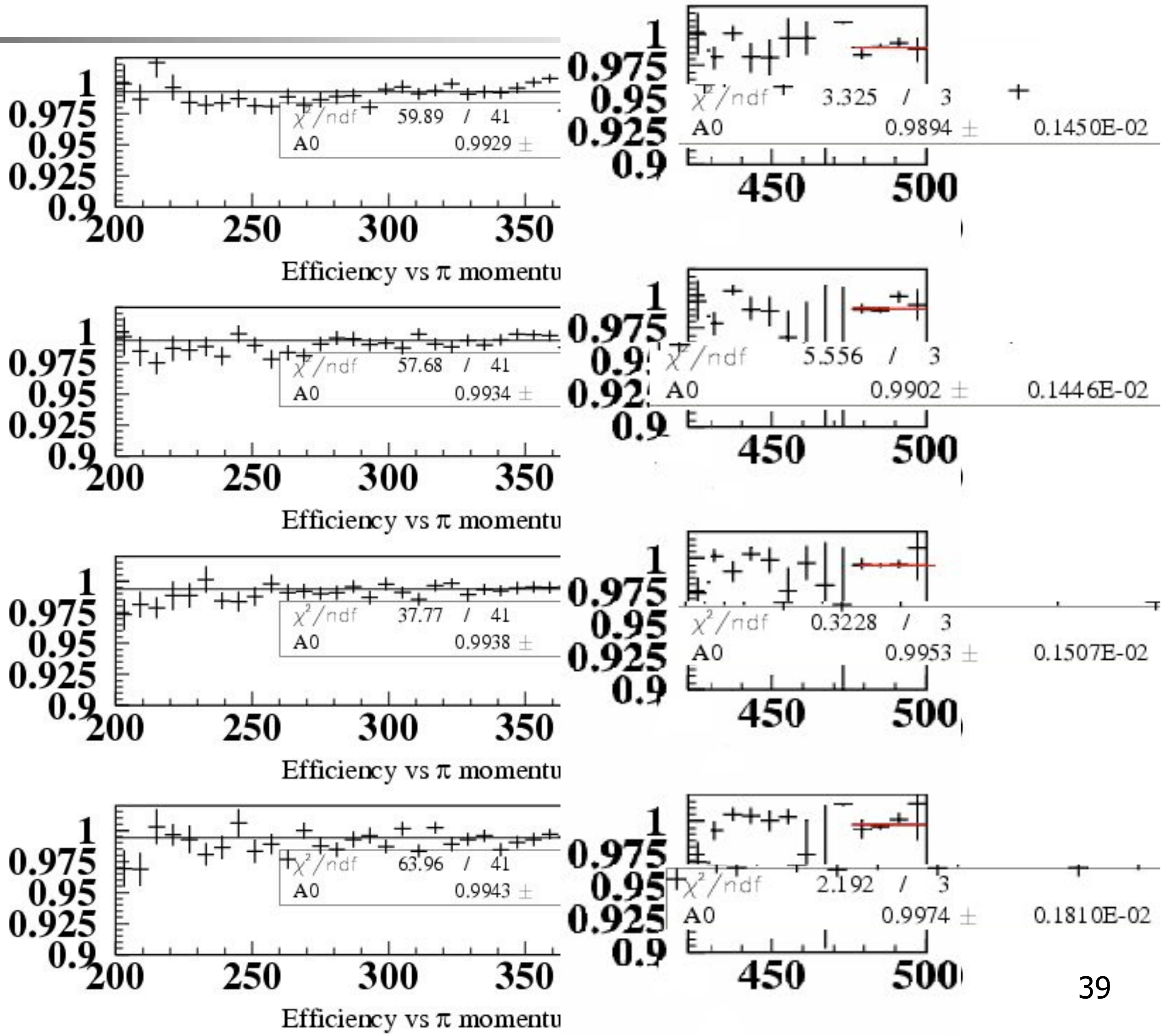
Fit to the ratio data/MC

the agreement is on the level of 0.6-0.7% (validated by a good χ^2/ndf) in the region covered by $\pi^+\pi^-\pi^0$ events

$\pi^+\pi^-$ events (4 bins) worsen a little the agreement at high θ values and confirm that at low θ values



Outlook and plans for tracking

quoted numbers show the qualitative stability of the procedure, they will be used for correcting MC tracking efficiency after:

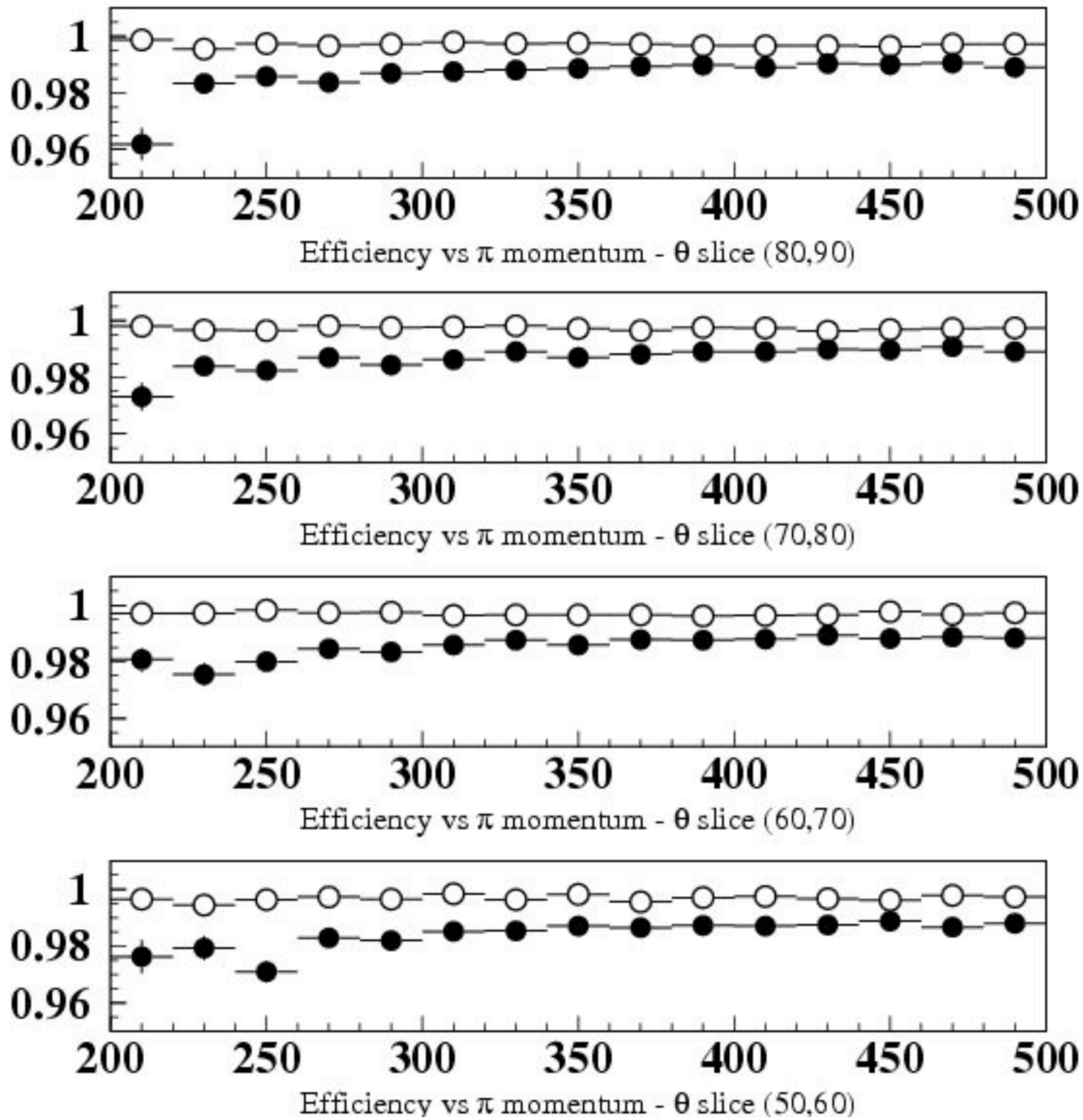
1) a little more $\pi\pi\gamma$ MC-data systematic checks
2) evaluating $\mu\mu\gamma$ tracking efficiency and comparing with $\pi\pi\gamma$

Conclusions

1. efficiencies have been evaluated with refined/different methods wrt published analysis
2. the results are stable, and when compared, similar to the 2001
3. detailed studies of the systematics are going on, their outcomes with F_{π} will be presented @ Capri

Back up slides

MC Comparison ππγ – μμγ



MC Comparison $\pi\pi\gamma$ – $\mu\mu\gamma$