Data/MC study of tracking efficiencies and resolutions: a first look

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Thanks: S. Dobbs, J. Stevens

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Details and definitions

data: ver04 REST Spring 2016
mc: sim_1_2_1
plugin: **trackeff_missing**
(based on previous work by **P. Mattione**)

see References

METHOD Several processes allow to study the tracking efficiency of protons and pions, e.g.
proton: $\gamma p \to \pi^+\pi^-(p)$, $\gamma p \to \pi^+\pi^-\pi^+\pi^-(p)$,
pions ($\pi^{+,-}$:) $\gamma p \to p\pi^+\pi^-\pi^-(\pi^+)$, $\gamma p \to p\omega(\to(\pi^+)\pi^-\pi^0)$.

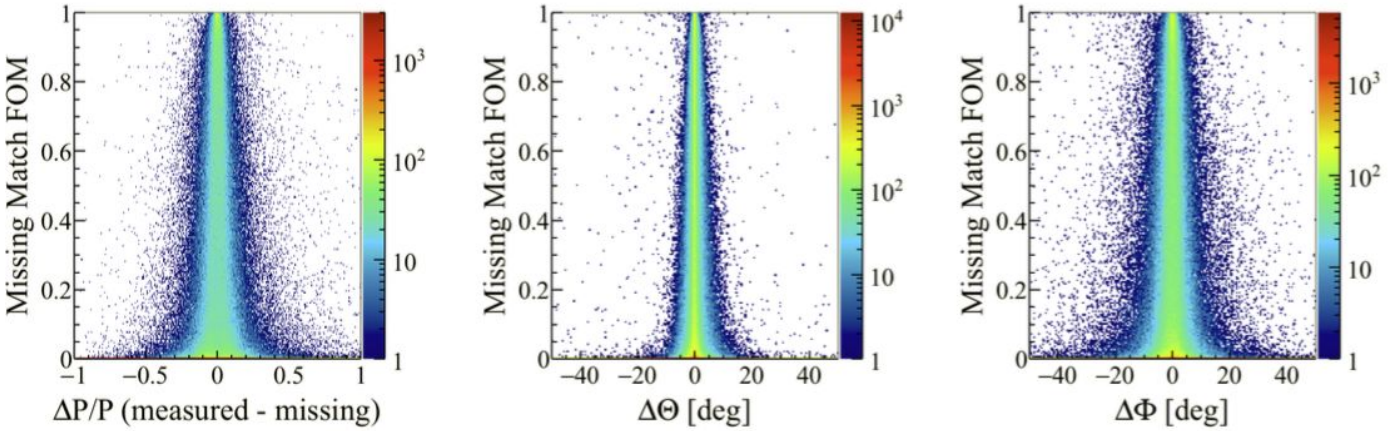
A track is found if $\Delta P/P < 20\%$, $\Delta\Theta < 10^\circ$ and $\Delta\Phi < 15^\circ$

Caveat: only compare to track with best found/missing χ^2

efficiency ~ found / missing

FOM found/missing

e.g. γp->(p)4π



(a) Matching FOM vs $\Delta P/P$(measured-missing) (b) Matching FOM vs $\Delta\Theta$(measured-missing) (c) Matching FOM vs $\Delta\Phi$(measured-missing)

Figure 16: Matching FOM built comparing the three-momenta of time-based tracks with the missing particle.

Details

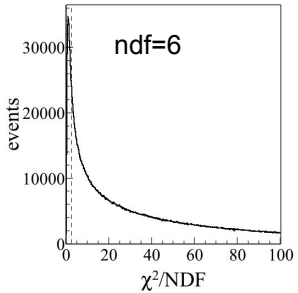
Selection

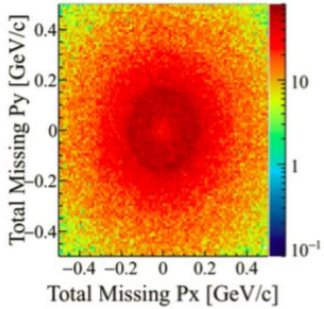
γp->(p)4π

plugin level

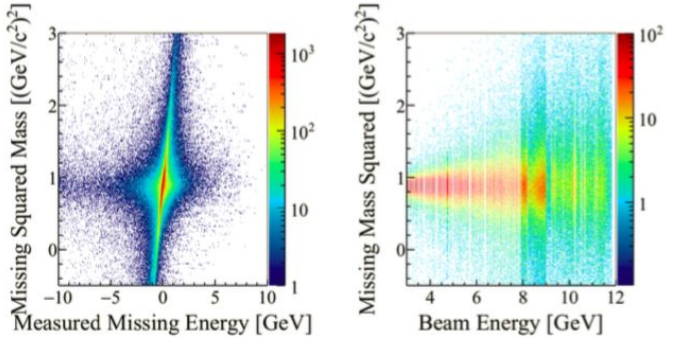
DSelector

- KinFit: P4AndVertex.
- Tracks purity: minimum number of hits 12.
- Cuts on the missing mass for each particle hypothesis.
- dE/dx cuts to separate protons form pions.
- E/p<0.5 to remove $e^{+,-}$ and keep the other charged tracks.
- Other PID cuts.
- The Z-coordinate of the tracks combination at DOCA to the beam-line is required to be within the target region (50,76) cm.
- $\chi^2_{kinfit}/NDF < 1$.





(b) The total missing Px and Py.



(c) Missing Mass Squared Vs Measured Missing Energy.

(d) Missing Mass Squared Vs Measured Missing Energy.

Figure 8: These plots are before the accidental subtraction and after a cut on the χ^2/NDF of the kinematic fit.

Should study in beam energy bins

Details

Background subtraction

e.g. γp->(p)4π

1) “Accidentals” subtraction

   Two methods (both have pros and cons):

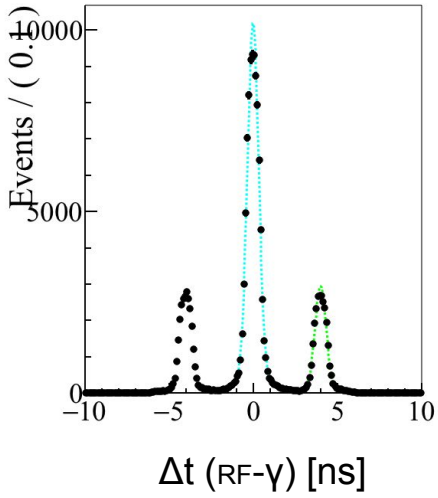
   × dilution factor (~const)

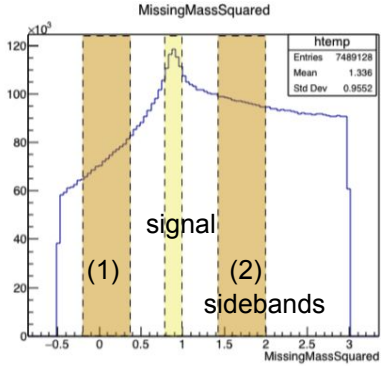
   ✓ direct subtraction of yields

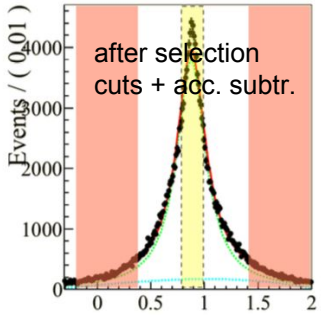
2) Sideband subtraction

   (other dilution factor:

   ~ negligible correction after selection)







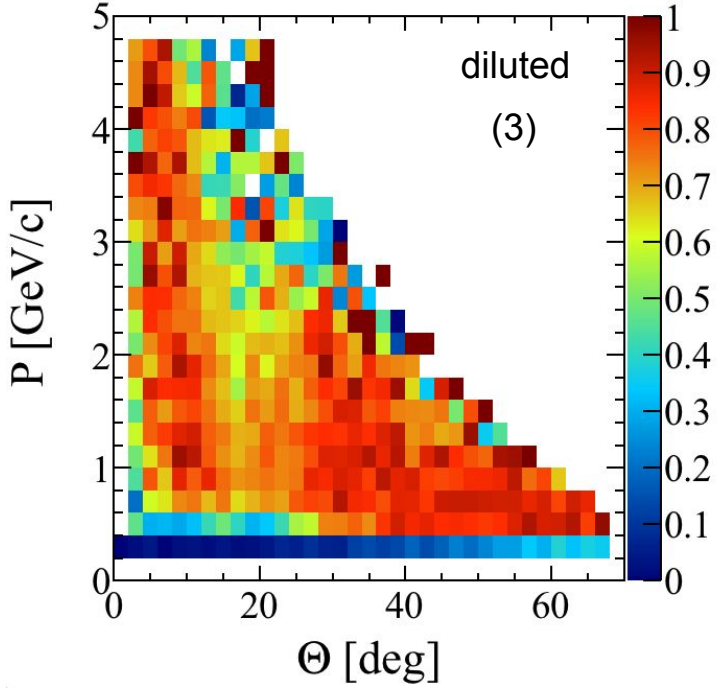
Details

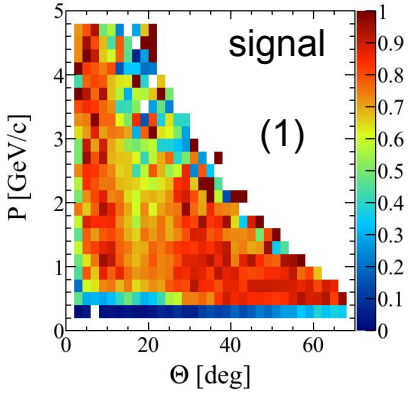
Efficiencies

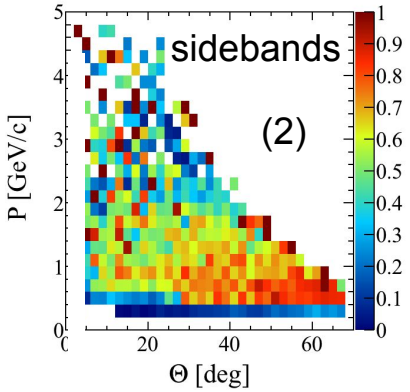
Efficiency 2D

γp->(p)4π

N.B. all histograms are **after** accidental subtractions





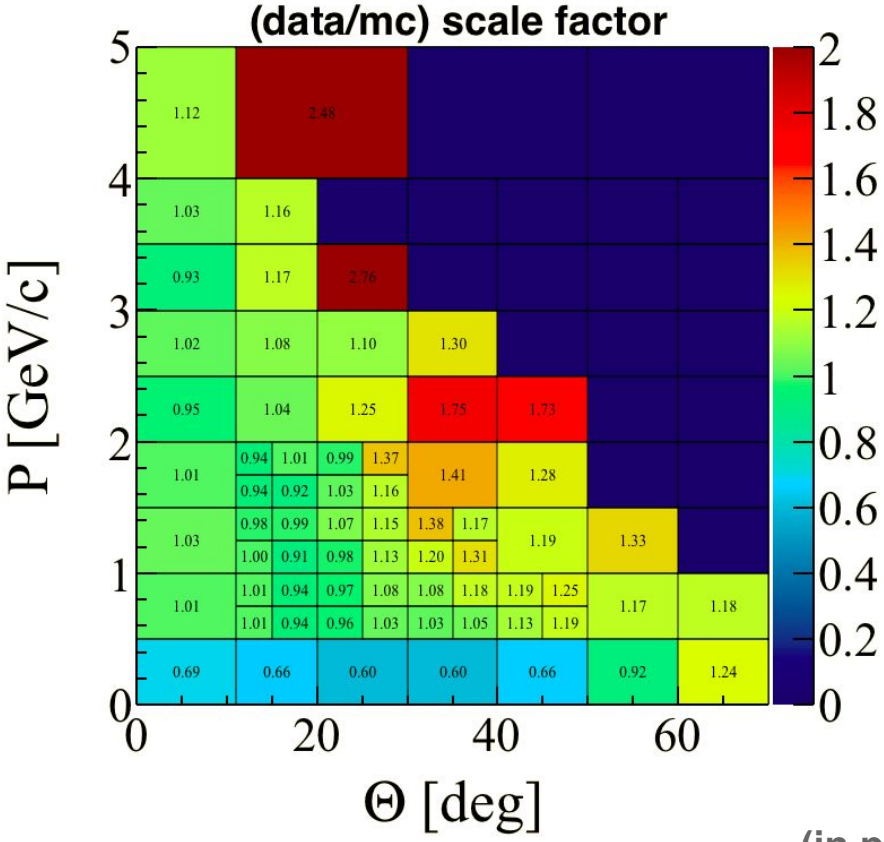


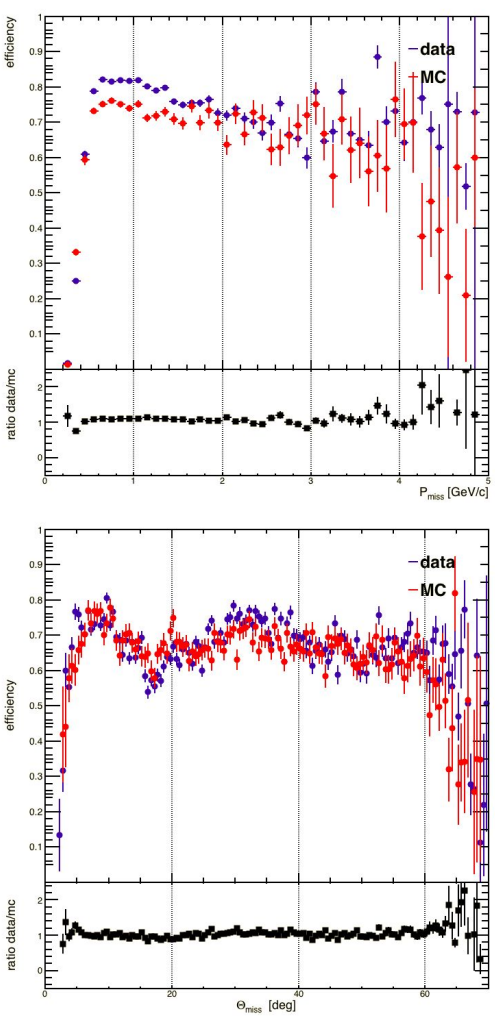
The 2D plot shows only the range [0,1].
Few stats, coarse binning.
Fluctuations “masked”.

A better picture (with uncertainties) is in 1D projections as shown in the following.

Ongoing: smoothing with KDE

data/mc comparison



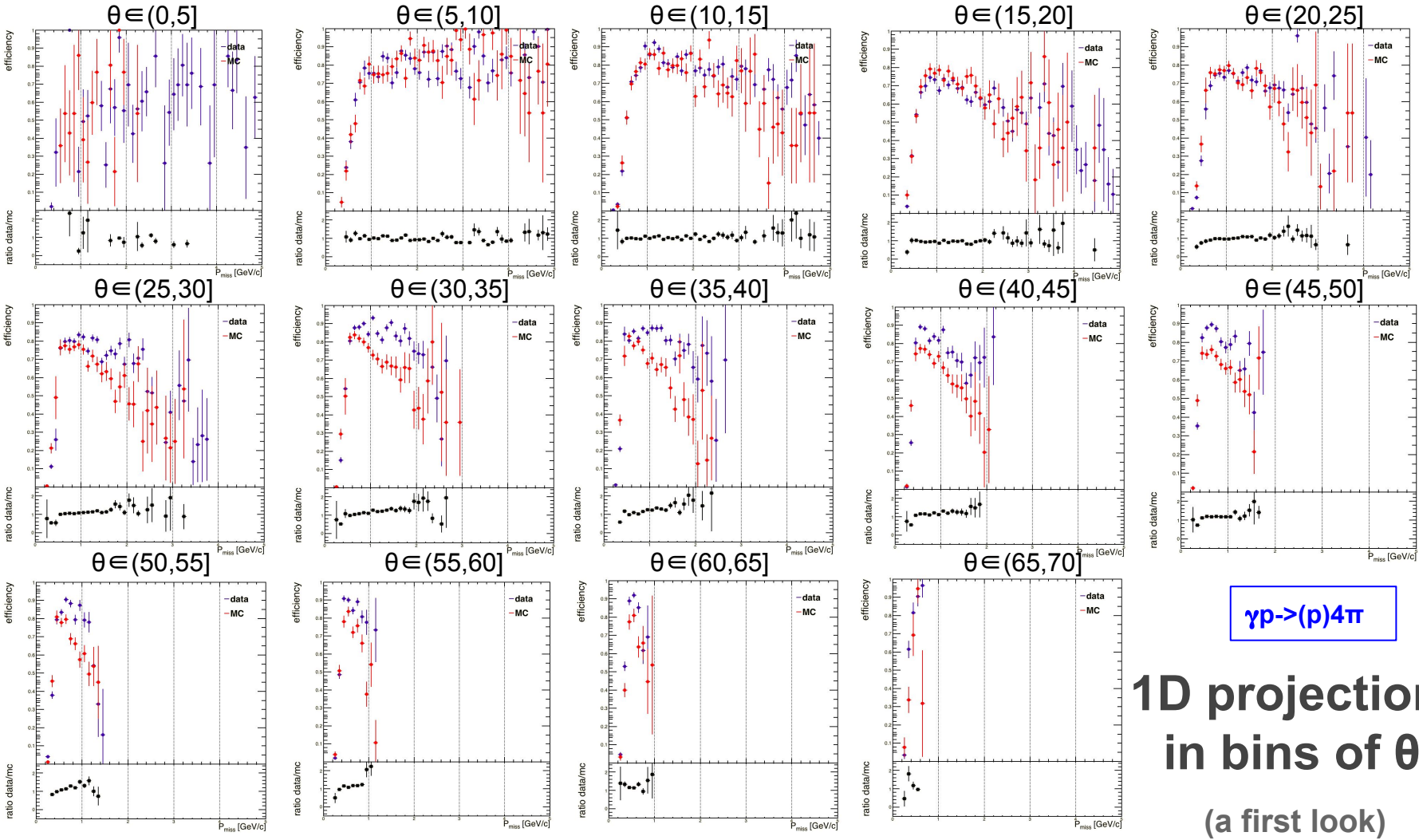


γp->(p)4π

CDC: 65 – 75%
FDC: 55 – 80%
Btw.: 55 – 65%

(in progress)

Efficiency Studies



γp->(p)4π

1D projections in bins of θ

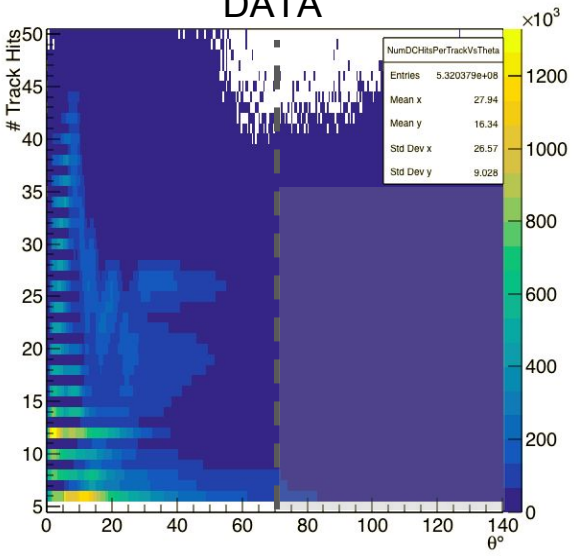
(a first look)

Number of hits per track vs θ

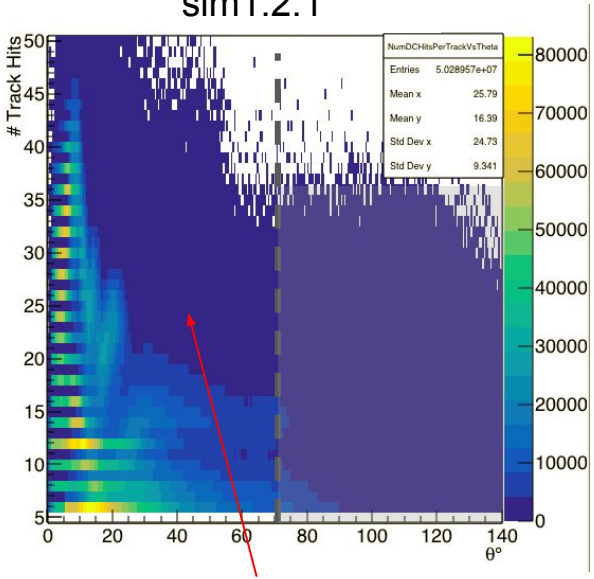
data: run 11366
mc:

- sim1.2.1
- genr8 (p4π) @9 GeV

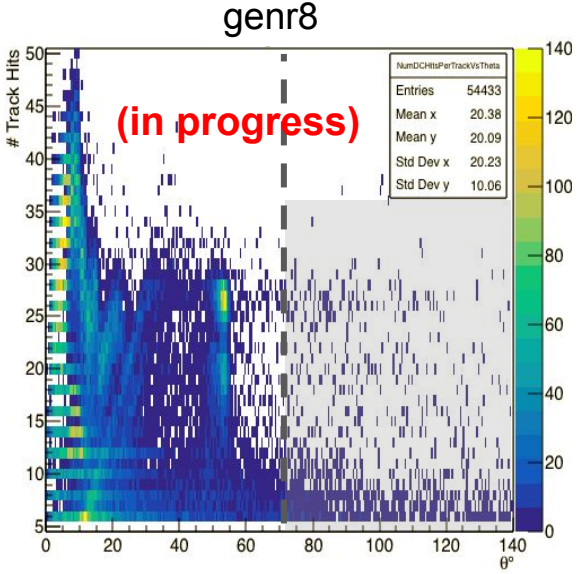
DATA



sim1.2.1



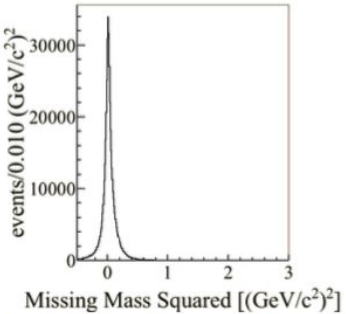
genr8



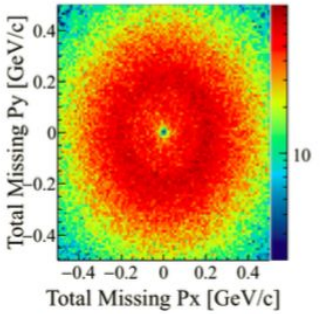
sim1.2.1 MC has a known problem for tracks with theta > 20 deg.
We can't draw many conclusions in that region.

Selection

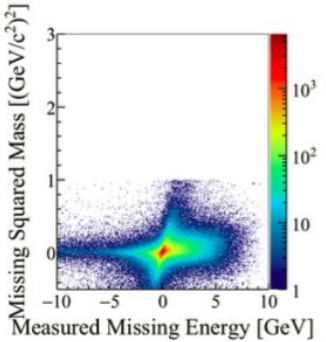
γp->p3π(π)



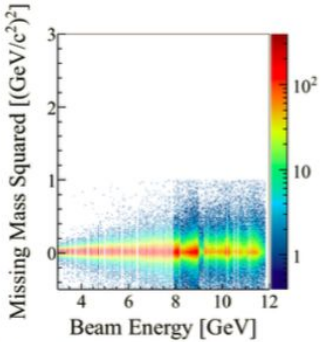
(a) π^+ Missing Mass Squared off the 3 charged π and proton.



(b) The total missing Px and Py.



(c) Missing Mass Squared Vs Measured Missing Energy.



(d) Missing Mass Squared Vs Measured Missing Energy.

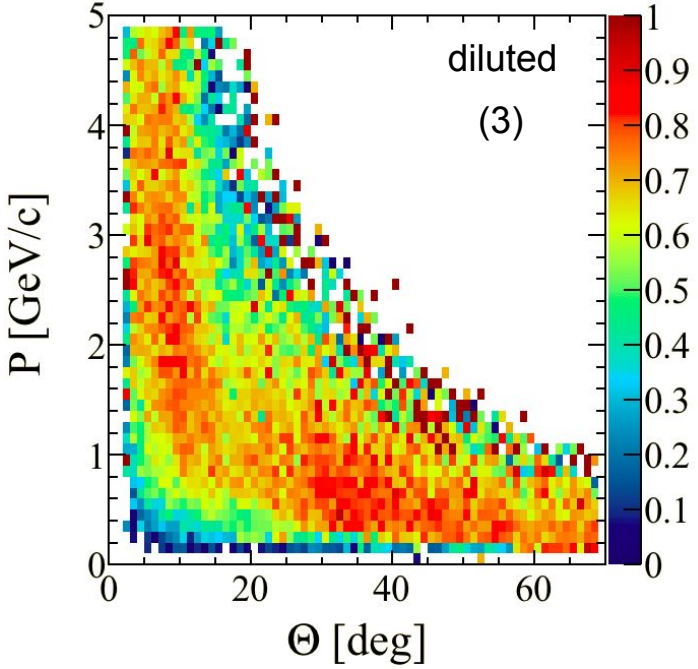
Figure 14: These plots are before the accidental subtraction and after a cut on the χ^2/NDF of the kinematic fit

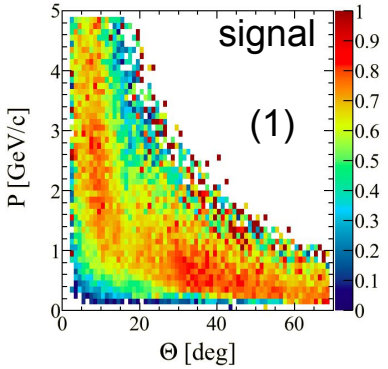
Efficiency Studies

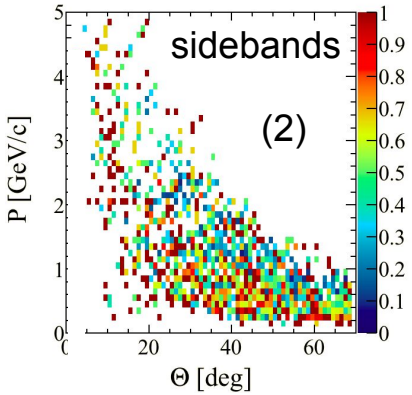
Efficiency 2D

γp->p3π(π)

all histograms are **after** accidental subtractions



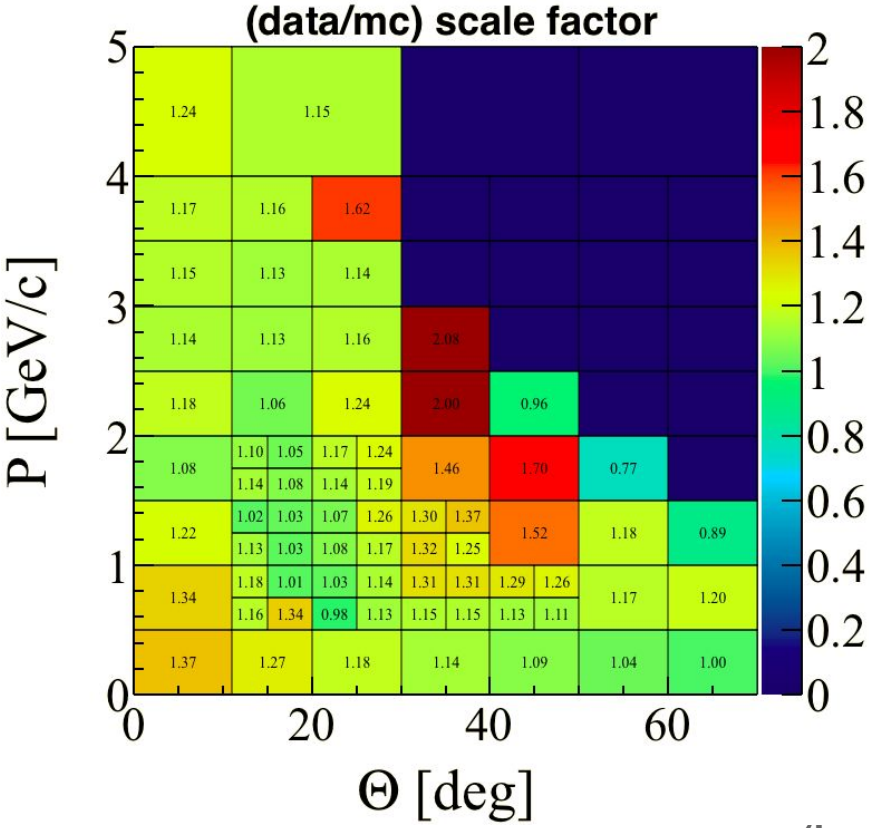


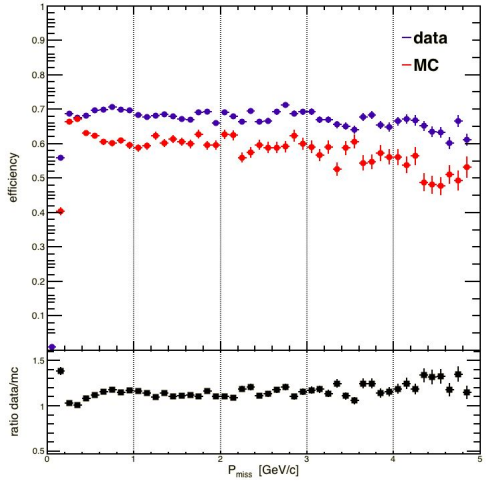


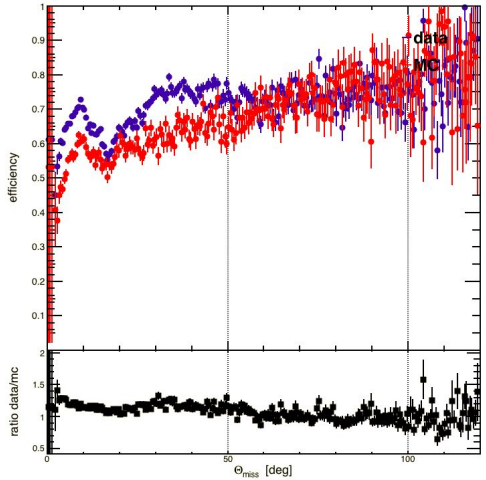
Efficiency Studies

data/mc comparison

γp->p3π(π)







(in progress)

Efficiency Studies

Resolutions

Resolution Studies

- Resolutions are channel dependent: what matters is that simulation match the data
- Caveat: compare to track with best found/missing χ^2
- The resolution calculated combining the standard deviations of two gaussian fit (A: integral)

$$\sigma^2_{total} = \frac{A_1\sigma_1^2 + A_2\sigma_2^2}{A_1 + A_2}$$

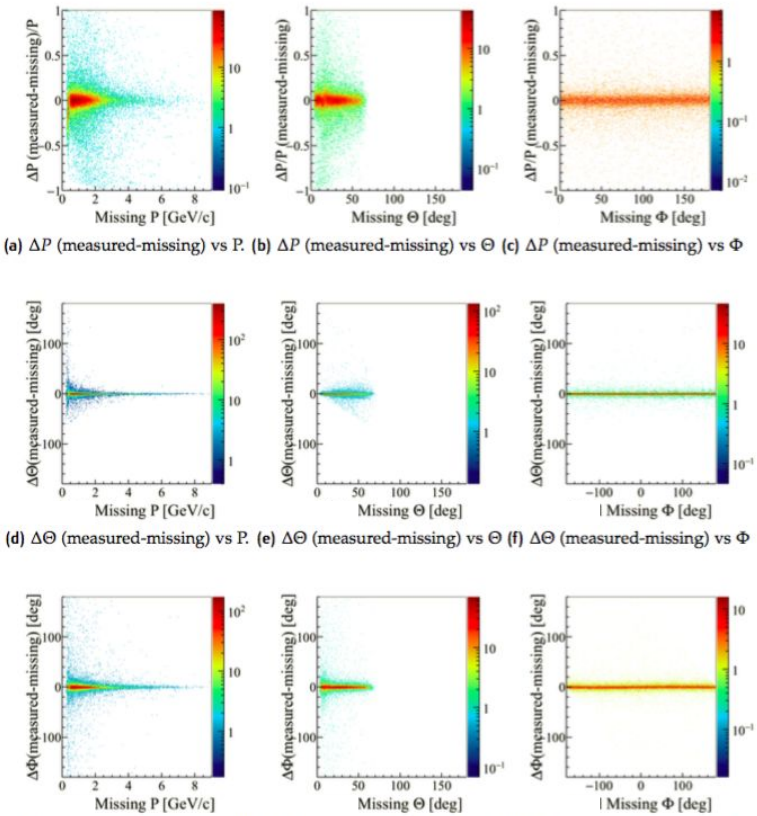
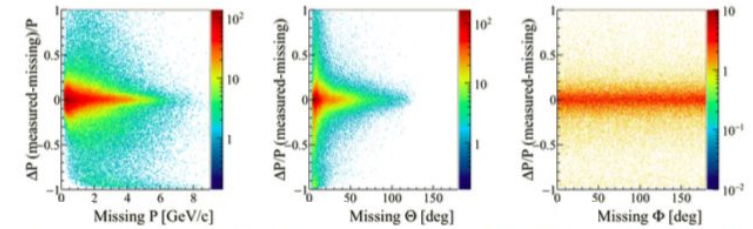


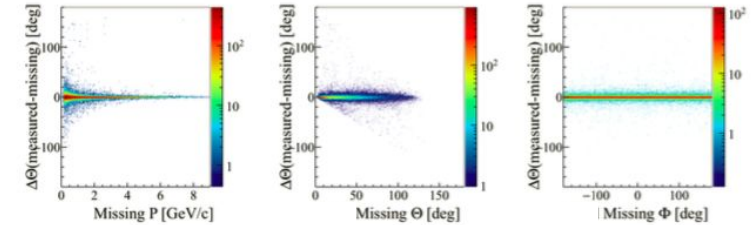
Figure 9: Resolution studies of the proton p, Θ, Φ. A tight cut on the missing squared mass around the proton has been applied, as well as the matching conditions on the complementary variables P, Θ, Φ (e.g. a plot showing ΔP has matching requirements applied on Θ, Φ). For completeness, the bins in Θ, Φ are of 0.5° and in P are of 50 MeV.

Resolution Studies

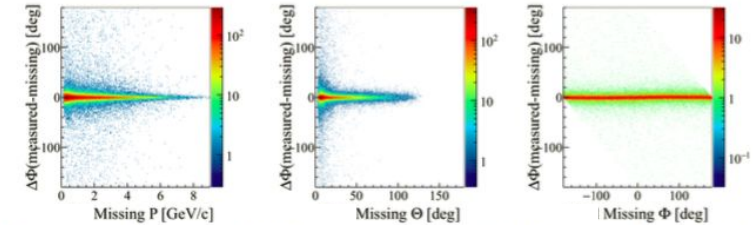
γp->p3π(π)



(a) ΔP (measured-missing) vs P. (b) ΔP (measured-missing) vs Θ (c) ΔP (measured-missing) vs Φ



(d) ΔΘ (measured-missing) vs P. (e) ΔΘ (measured-missing) vs Θ (f) ΔΘ (measured-missing) vs Φ

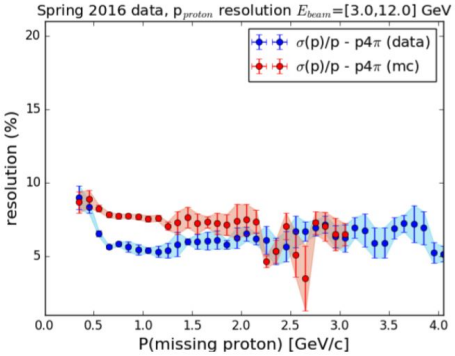


(g) ΔΦ (measured-missing) vs P. (h) ΔΦ (measured-missing) vs Θ (i) ΔΦ (measured-missing) vs Φ

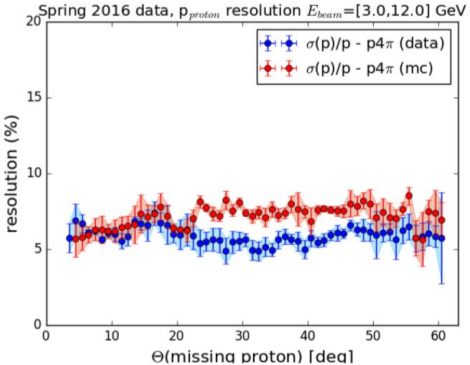
Figure 15: Resolution studies of the π^+ P, Θ, Φ. A tight cut on the missing squared mass around the pion has been applied.

Momentum Resolution: ongoing

γp->(p)4π

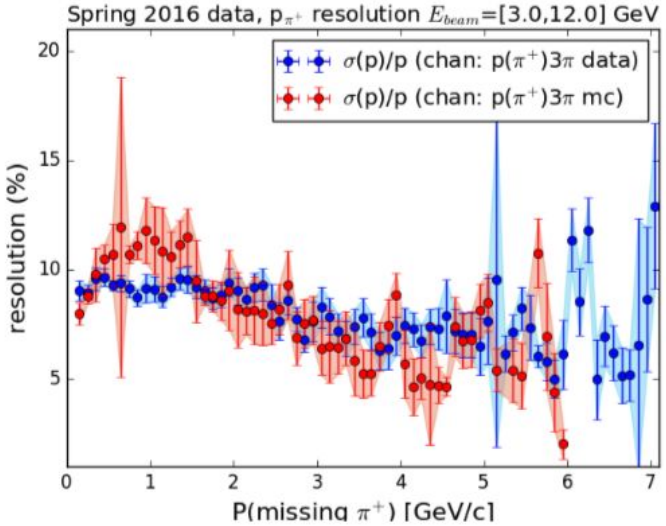


The proton momentum resolution as a function of the momentum.



The proton momentum resolution as a function of the polar angle.

γp->p3π(π)



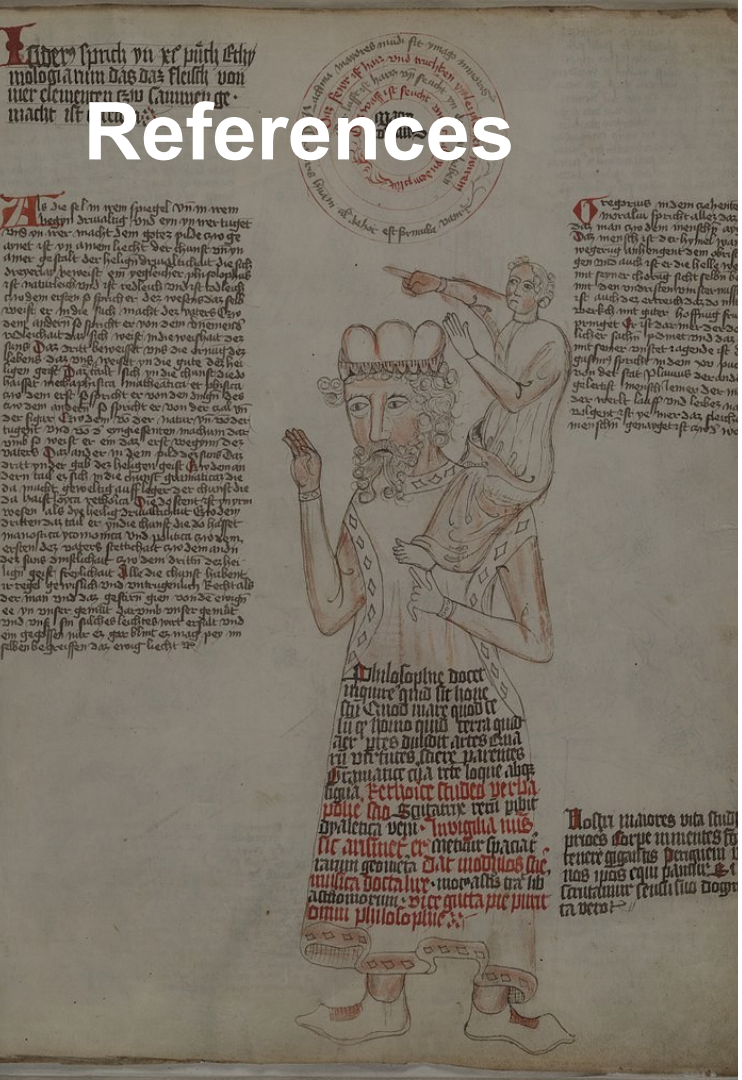
matching requirements only (to be updated)

Conclusions

Conclusions

- sim1.2.1 MC has a known problem for tracks.
- Generating a new MC sample to test this hypothesis and we expect the data/MC to agree better when that is ready.
- There may still be some residual discrepancies even with the new MC, but we have to wait to say more.
- Improve selection and do a study in energy bins.
- Compare efficiency from different channels.
- Test other approaches for subtraction.
- Eventually extend these studies to 2017 data.

References



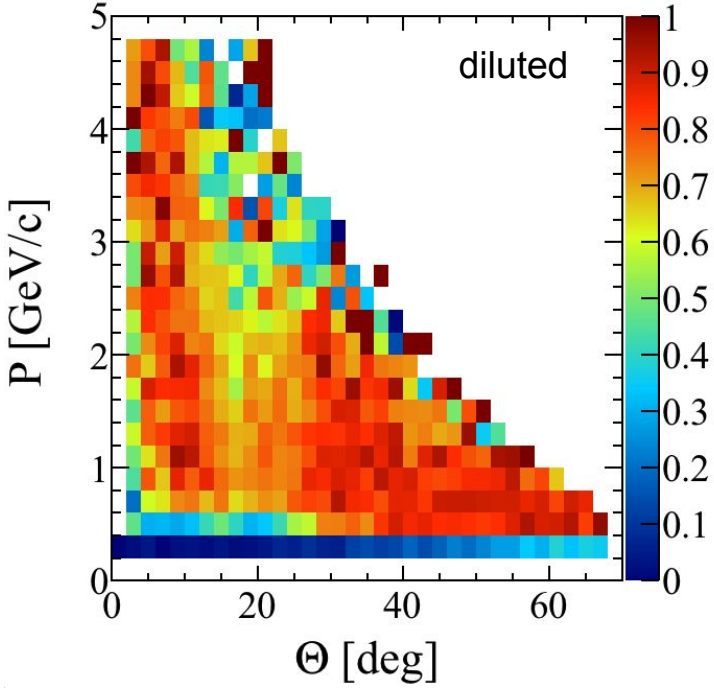
- Pion tracking efficiencies P. Mattione
- Tracking studies, P. Mattione
- https://meerkat.hepforge.org

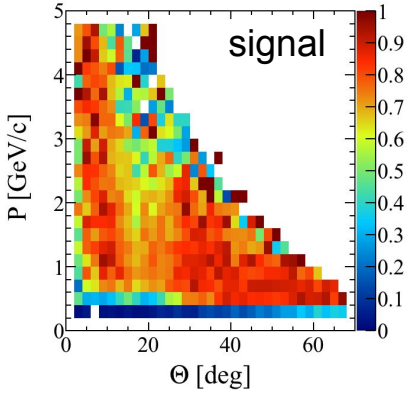
Backup

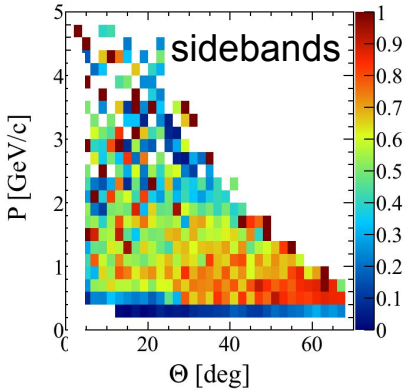
Efficiency 2D

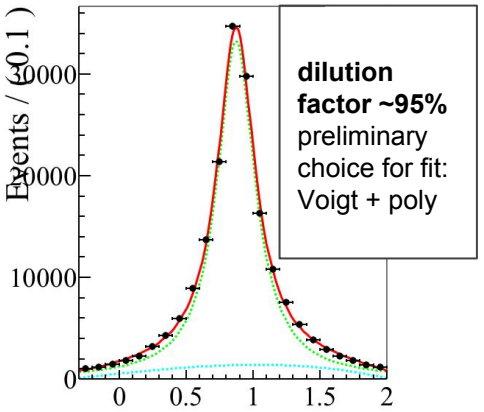
γp->(p)4π

all histograms are **after** accidental subtractions





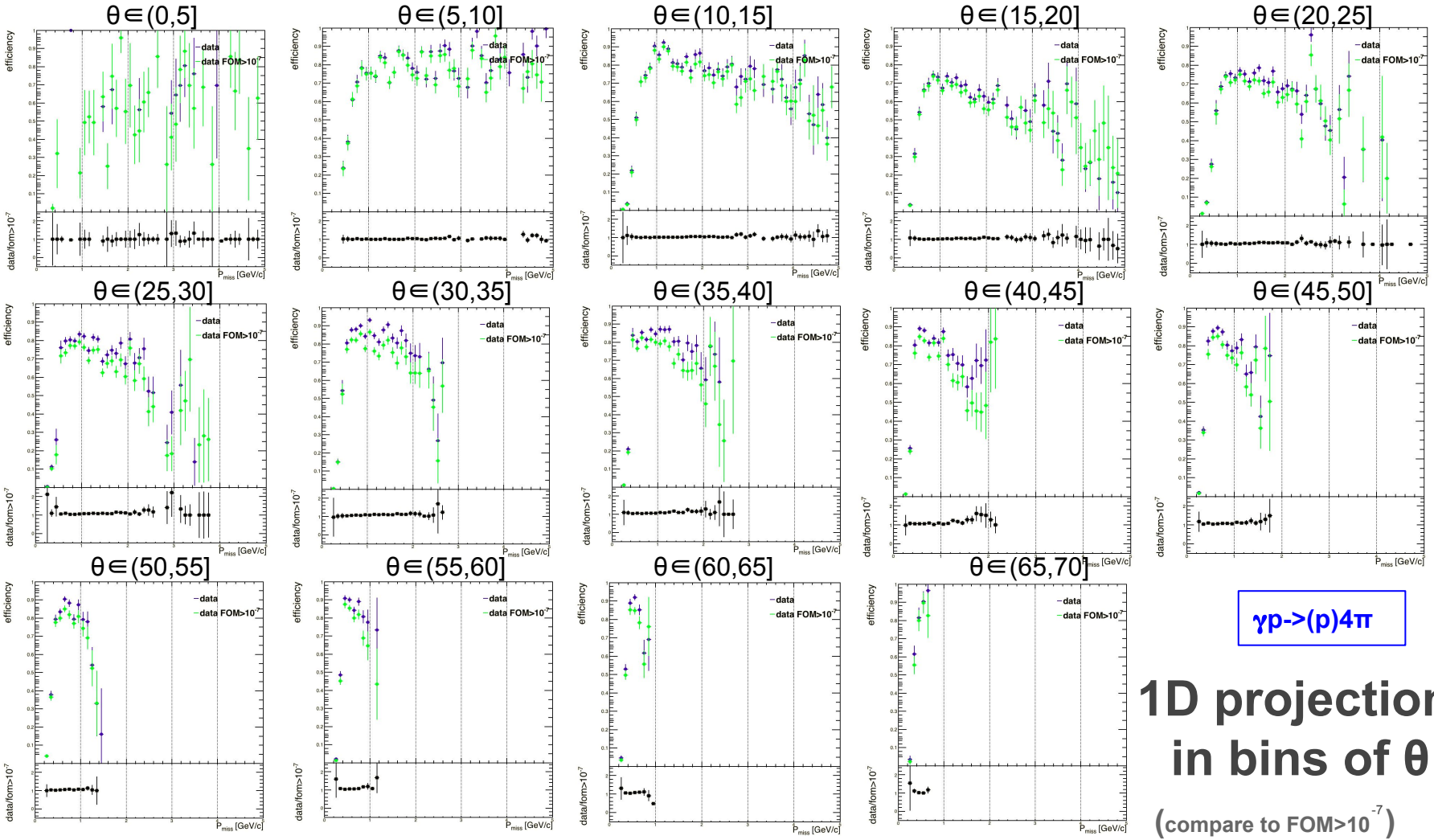




$$\epsilon_S = \frac{\epsilon - (1 - f_S \epsilon_B)}{f_S}$$

$$f_S = D_S / (D_S + D_B)$$

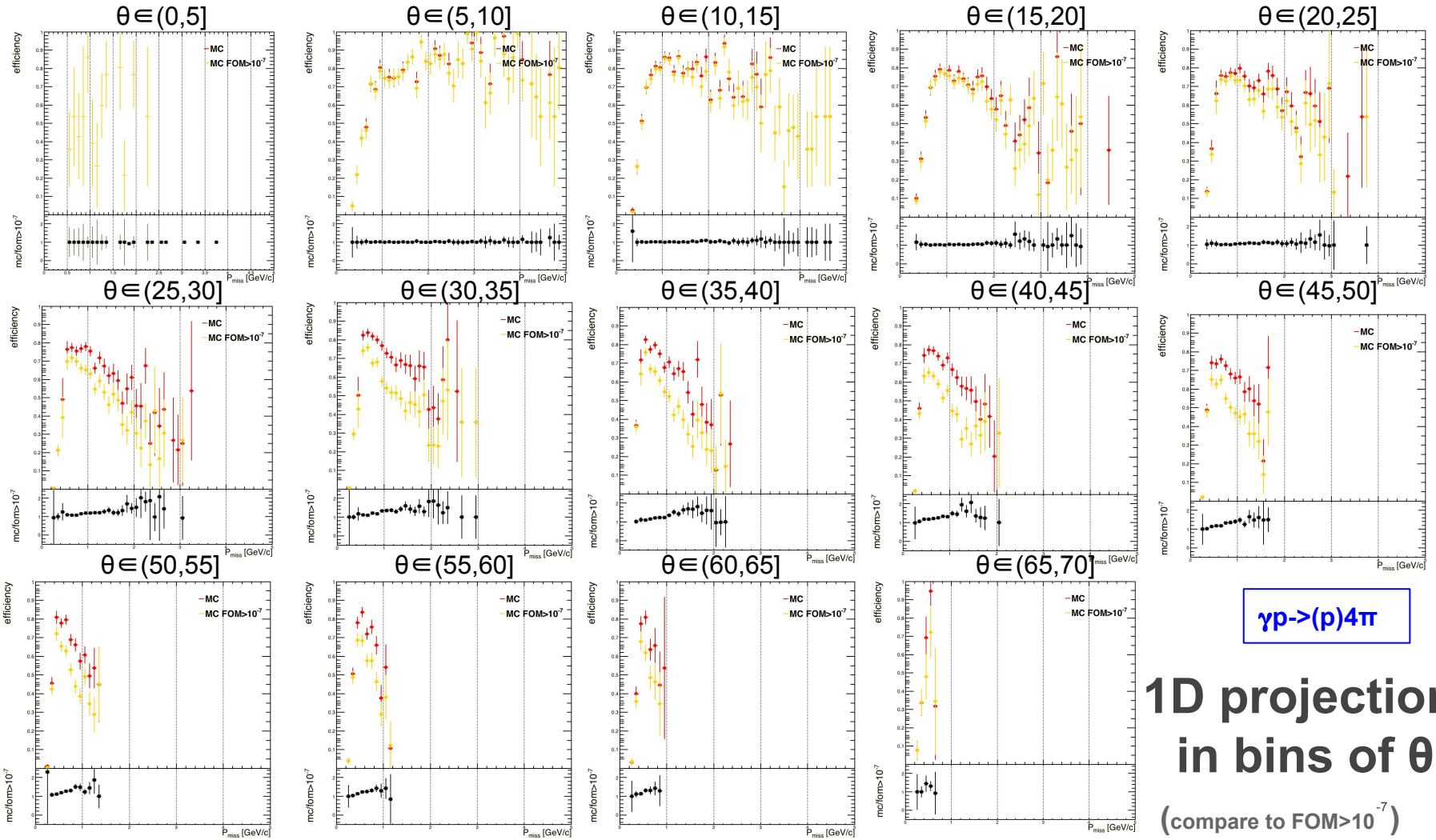
Efficiency Studies



γp->(p)4π

1D projections in bins of θ

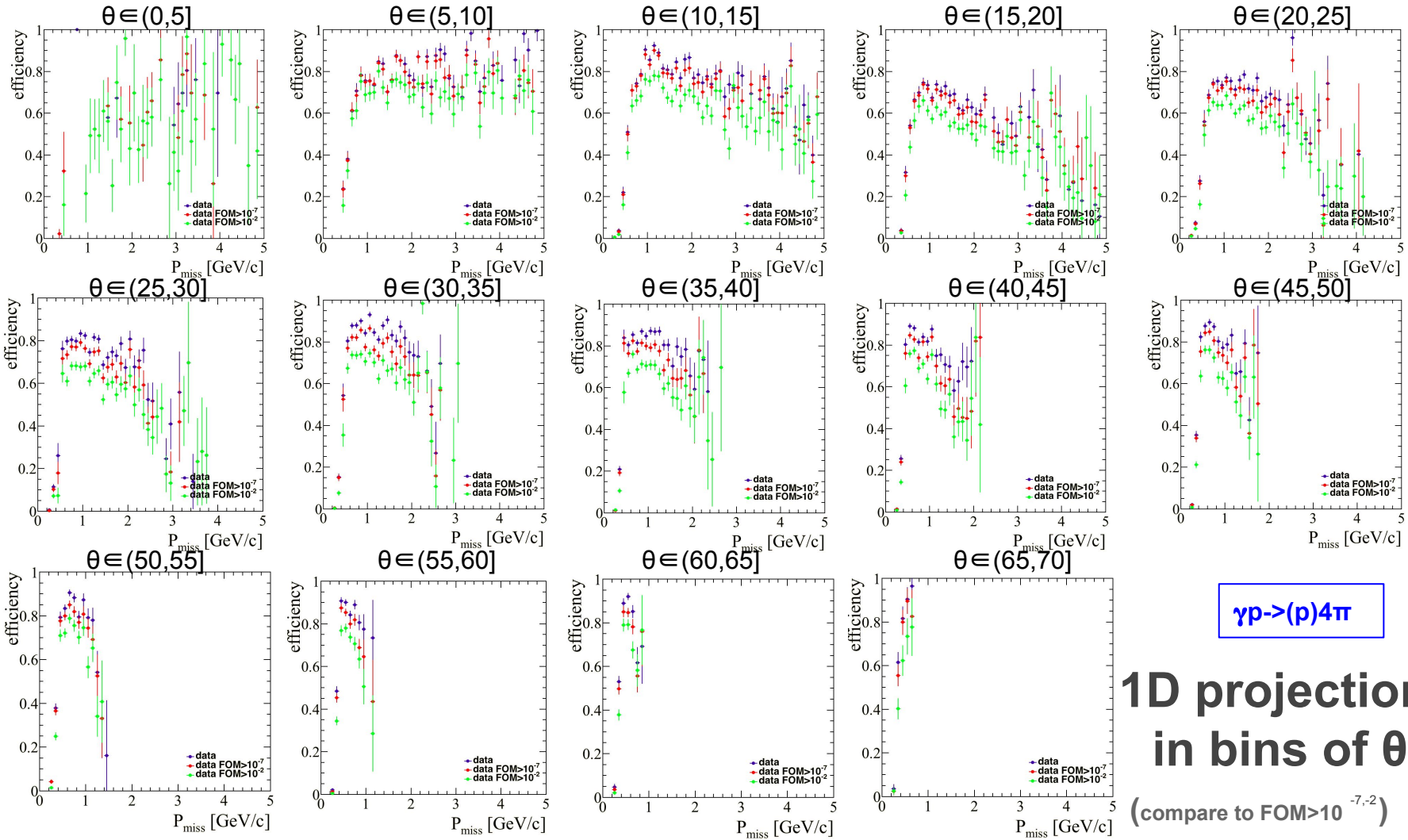
(compare to FOM>10^{-7})



γp->(p)4π

1D projections in bins of θ

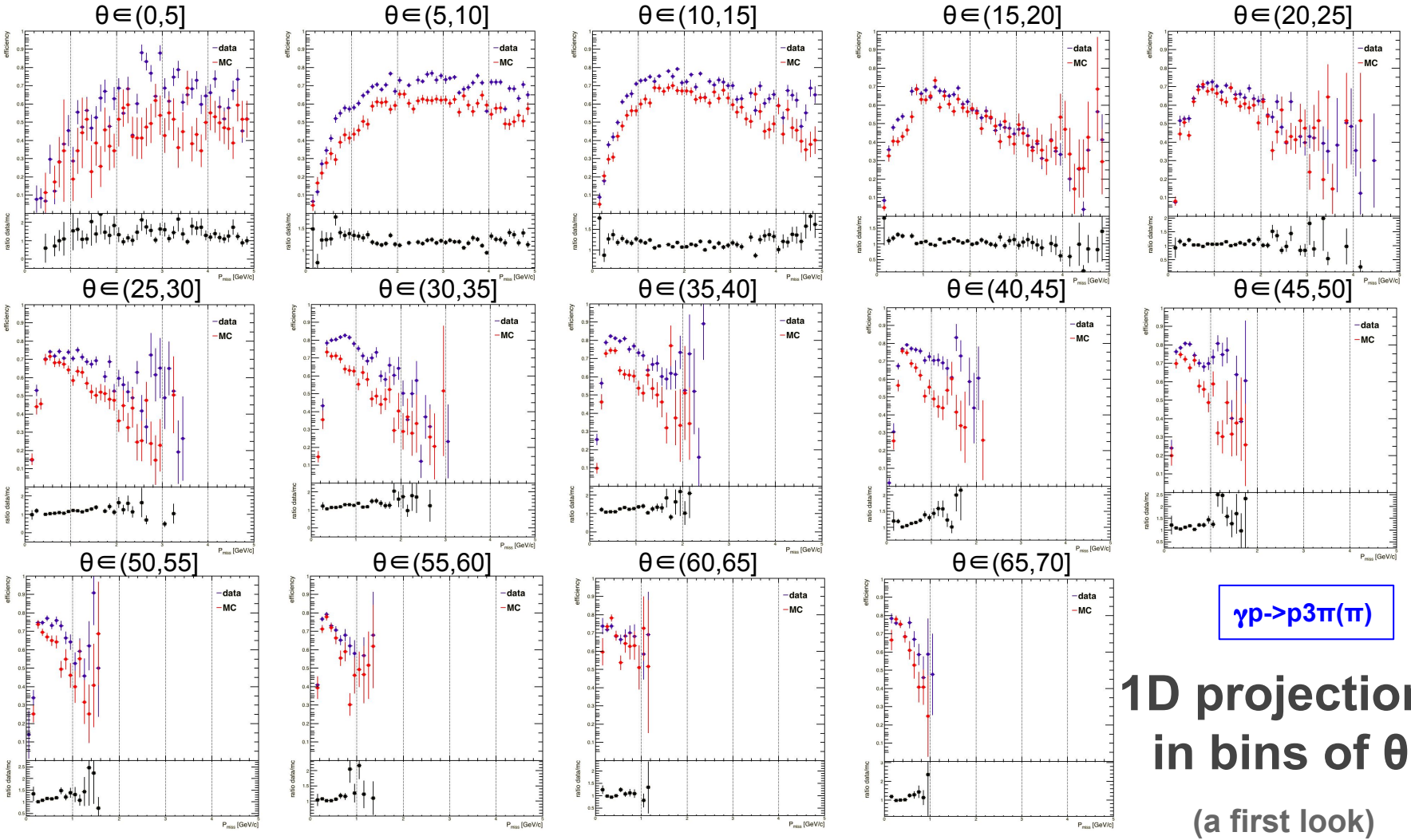
(compare to FOM>10^{-7})



γp->(p)4π

1D projections in bins of θ

(compare to FOM>$10^{-7,-2}$)



γp->p3π(π)

1D projections in bins of θ

(a first look)