$\gamma p \to \gamma\gamma p$

Beam Asymmetry

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Mar. 14, 2016 JEF Group Meeting

Acknowledgements: Justin Stevens, Dave Mack, Simon Taylor, Liping Gan, and Eugene Chudakov

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Jefferson Lab

UNCW

Outline

- Data sets
- Events selection and variant Distributions
- Background study
- Systematic Study
- Beam Asymmetry
- Summary and next to do

Data sample

- Data: 2016 spring Run 10491-10498
  - ~500M events
  - Perp: 10492, 10494, 10496
  - Para: 10493, 10495, 10497, 10498
  - Amorphous: 10491
- Inclusive MC: 2016 spring Run 10000
  - ~? events

Events Selection for $\gamma p \to \gamma\gamma p$

Pre-selection conditions

- No kinematic fit
- $\Delta t = t_{\gamma\mathrm{Max}} - t_{\mathrm{RF}} < 2.004ns$

  $\Delta t = (t_{\mathrm{TOF}} - t_{\mathrm{RF}}) < 1.0\mathrm{ns}$ $\Delta t = (t_{\mathrm{BCAL}} - t_{\mathrm{RF}}) < 10.0\mathrm{ns}$ $\Delta t = (t_{\mathrm{FCAL}} - t_{\mathrm{RF}}) < 10.0\mathrm{ns}$
- p>0.25 GeV and 49<z<76 cm, r<1 cm
- minimum photon energy cut: 0.3GeV in the BCAL & 0.5GeV in the FCAL

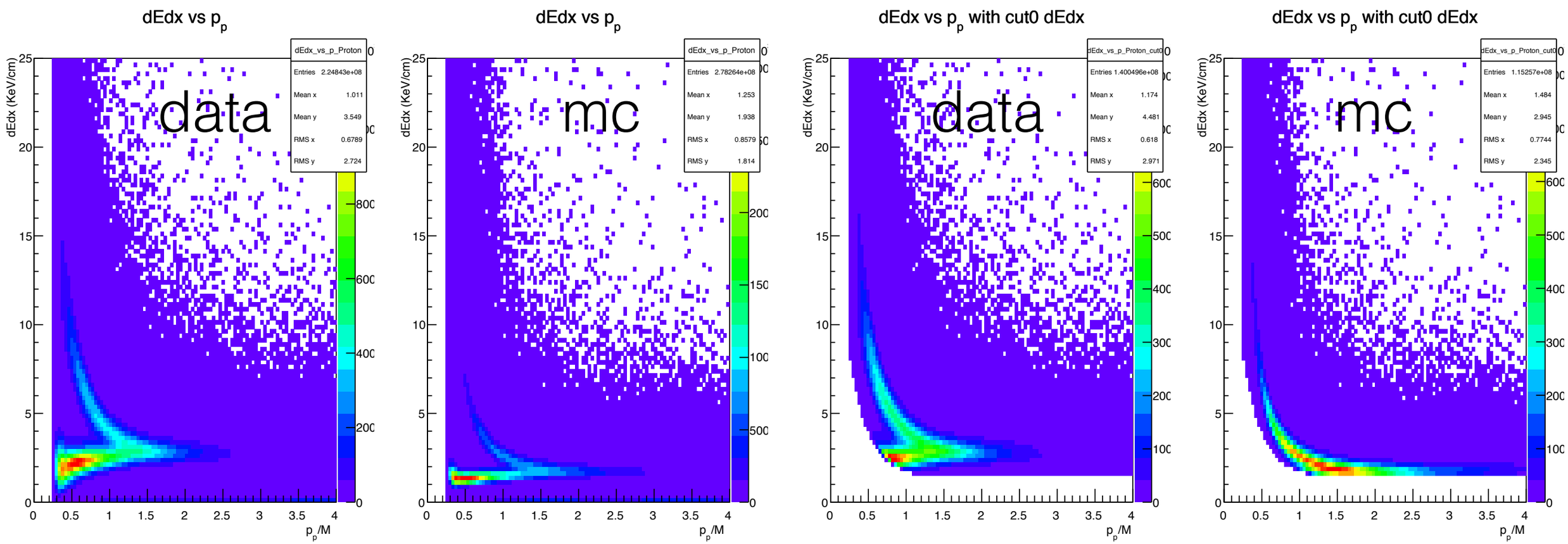
Selection conditions

dE/dx $|(\phi_{2\gamma} - \phi_p) - 180.0| < 5.0\,^{\circ}$ $-0.01 < MM^2 < 0.01$ GeV^2

$-0.15 < ME < 0.65$ GeV $BE > 4$ GeV

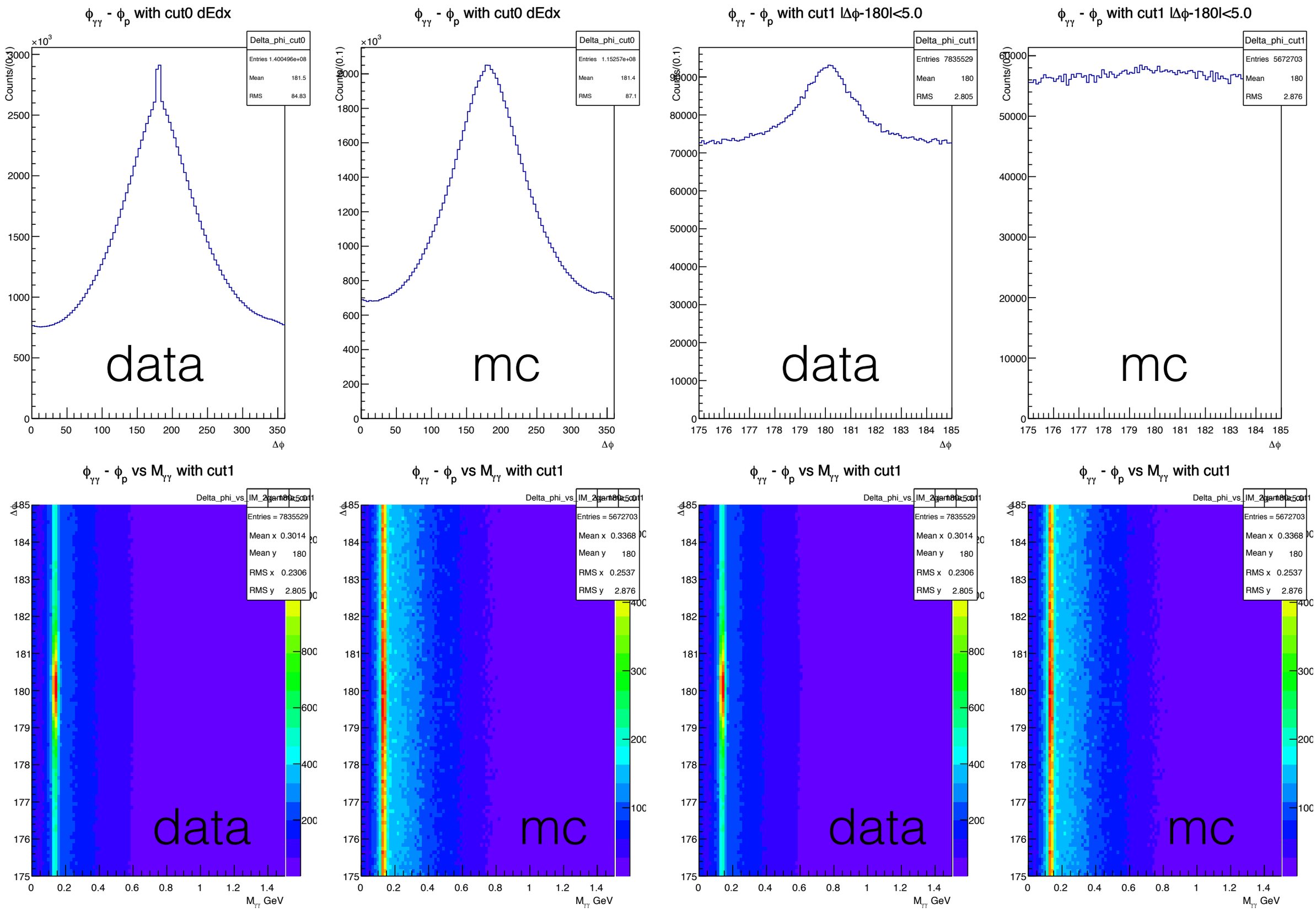
$\mathrm{UnusedEnergy} < 0.08$ GeV $MM(\gamma p \to pX) > 0.85$ or < 0.7 GeV

PID dE/dx cut : empirical exponential function veto π/e/k



Before Cut 0

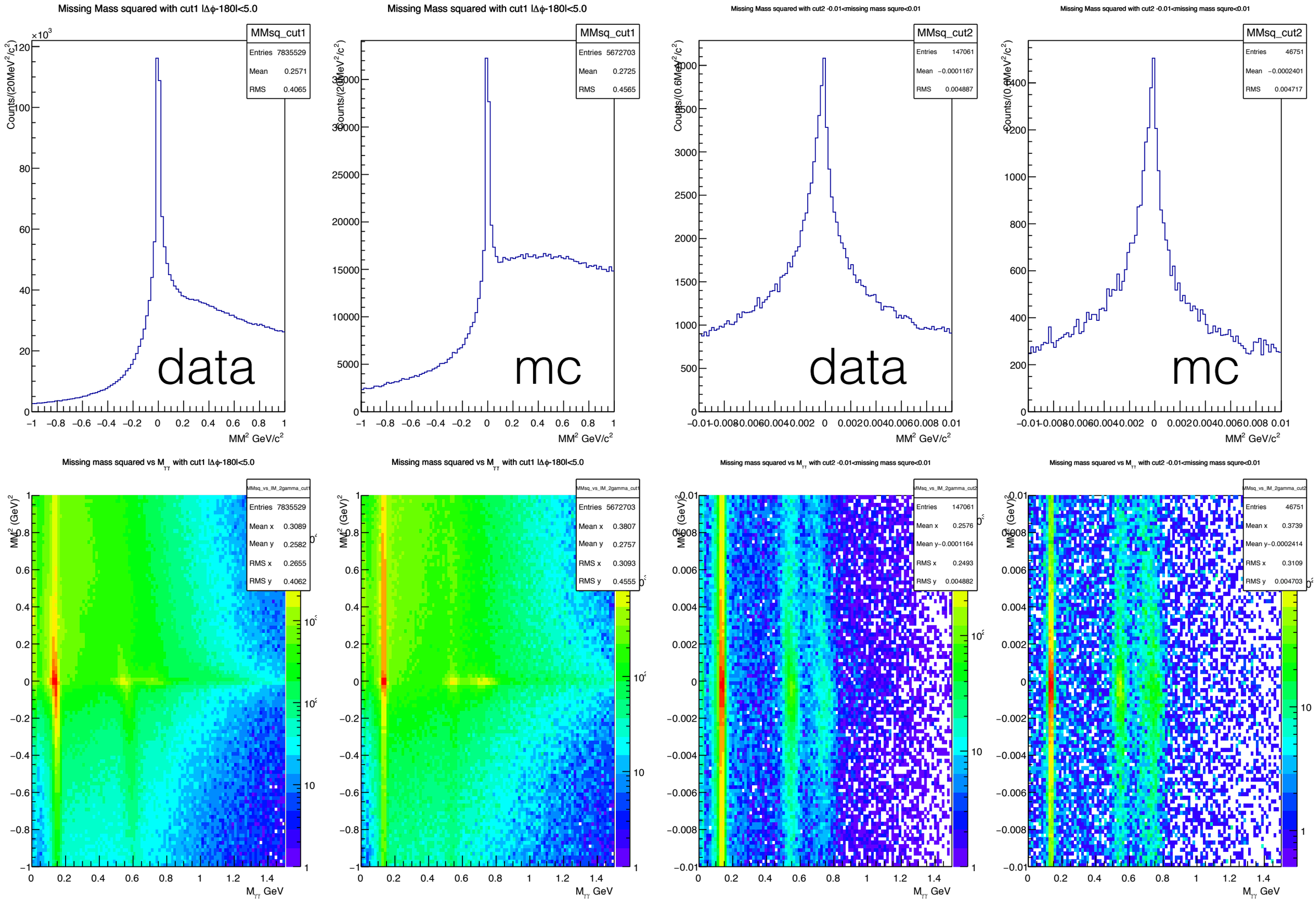
After Cut 0



Before Cut 1

After Cut 1

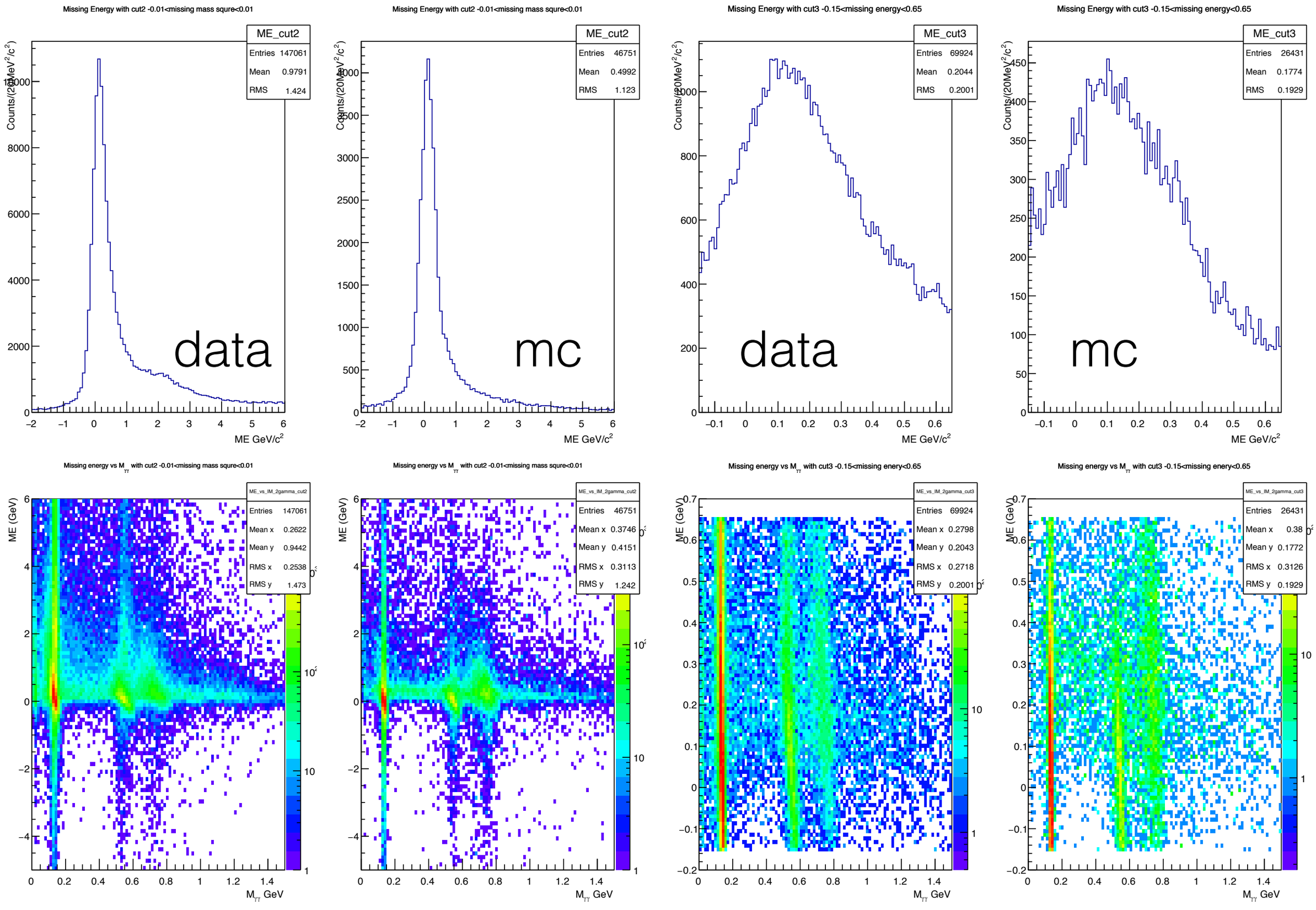
$$|(\phi_{2\gamma} - \phi_p) - 180.0| < 5.0^\circ$$



Before Cut 2

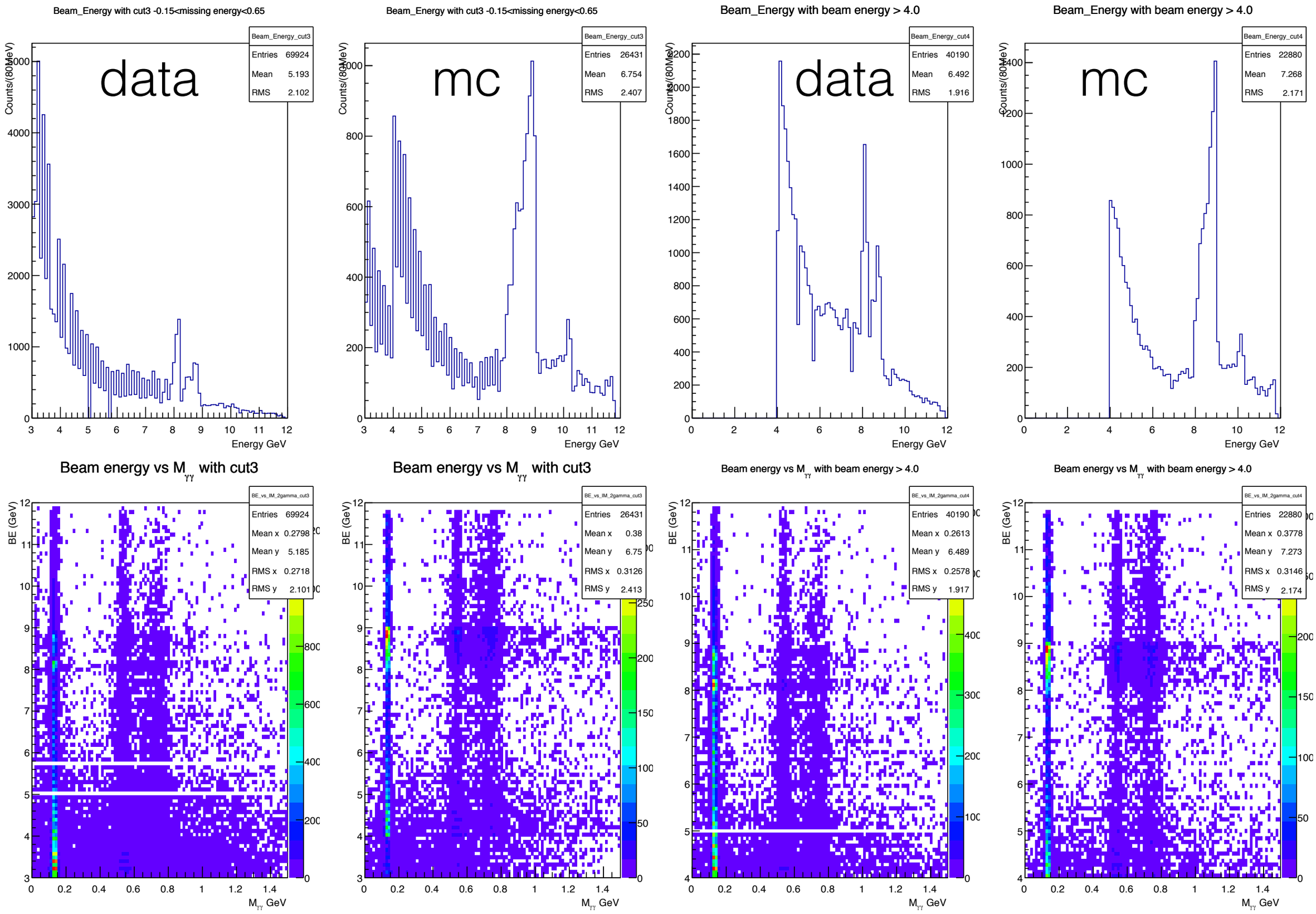
After Cut 2

$-0.01 < MM^2 < 0.01$ GeV²



Before Cut 3 After Cut 3

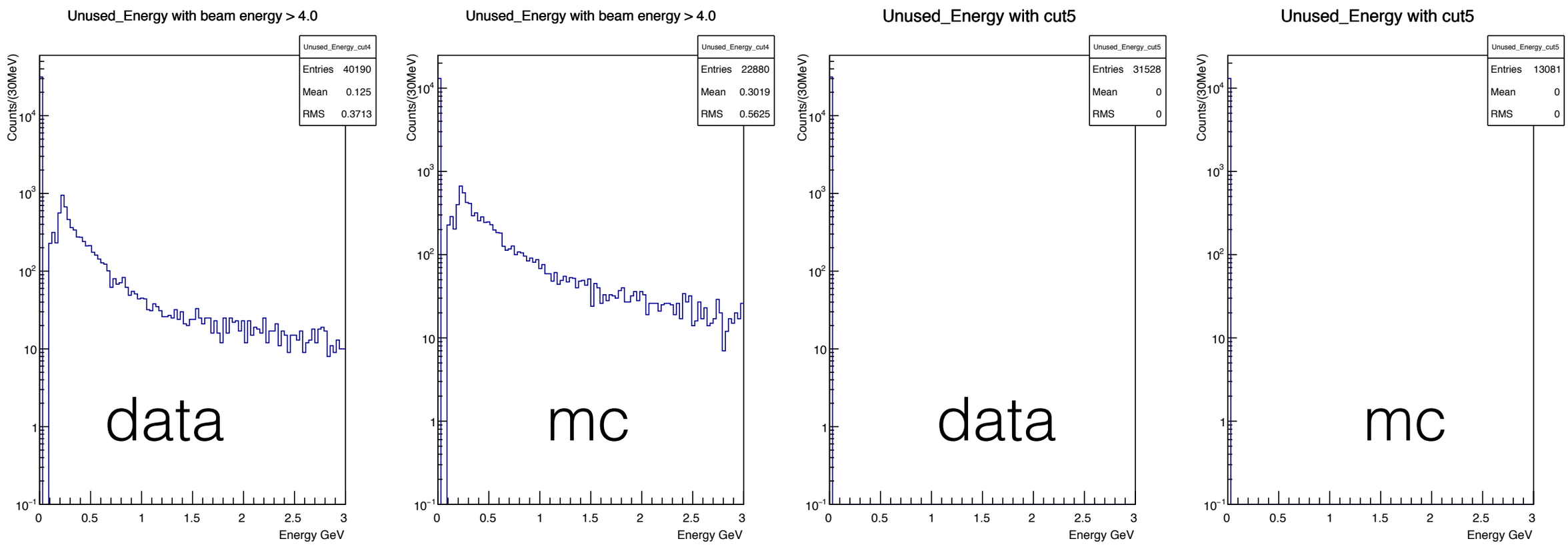
$-0.15 < ME < 0.65$ GeV



Before Cut 4

After Cut 4

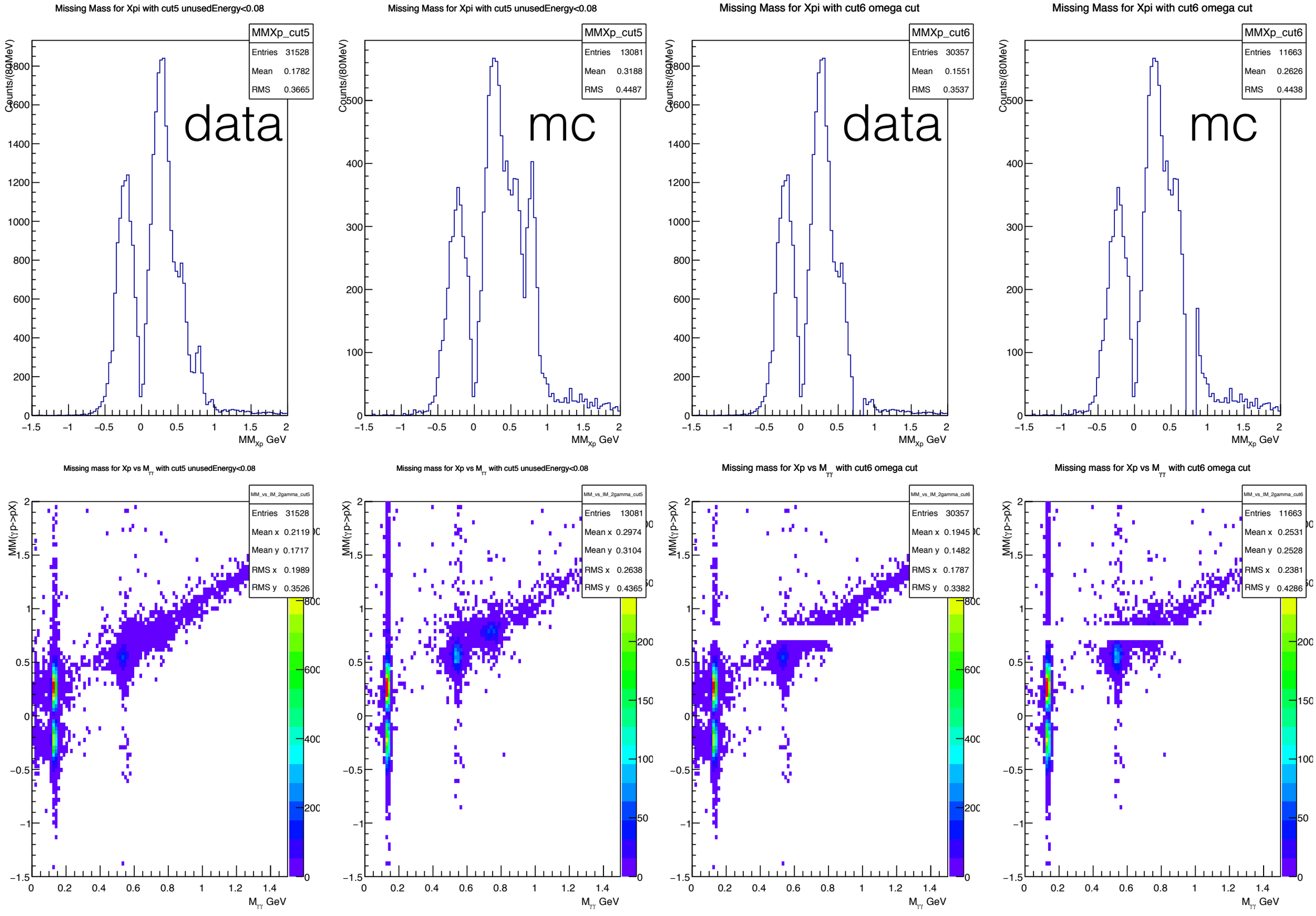
$BE > 4$ GeV



Before Cut 5 After Cut 5

$\mathrm{UnusedEnergy} < 0.08$ GeV

Only two photons events are selected.



Before Cut 6

After Cut 6

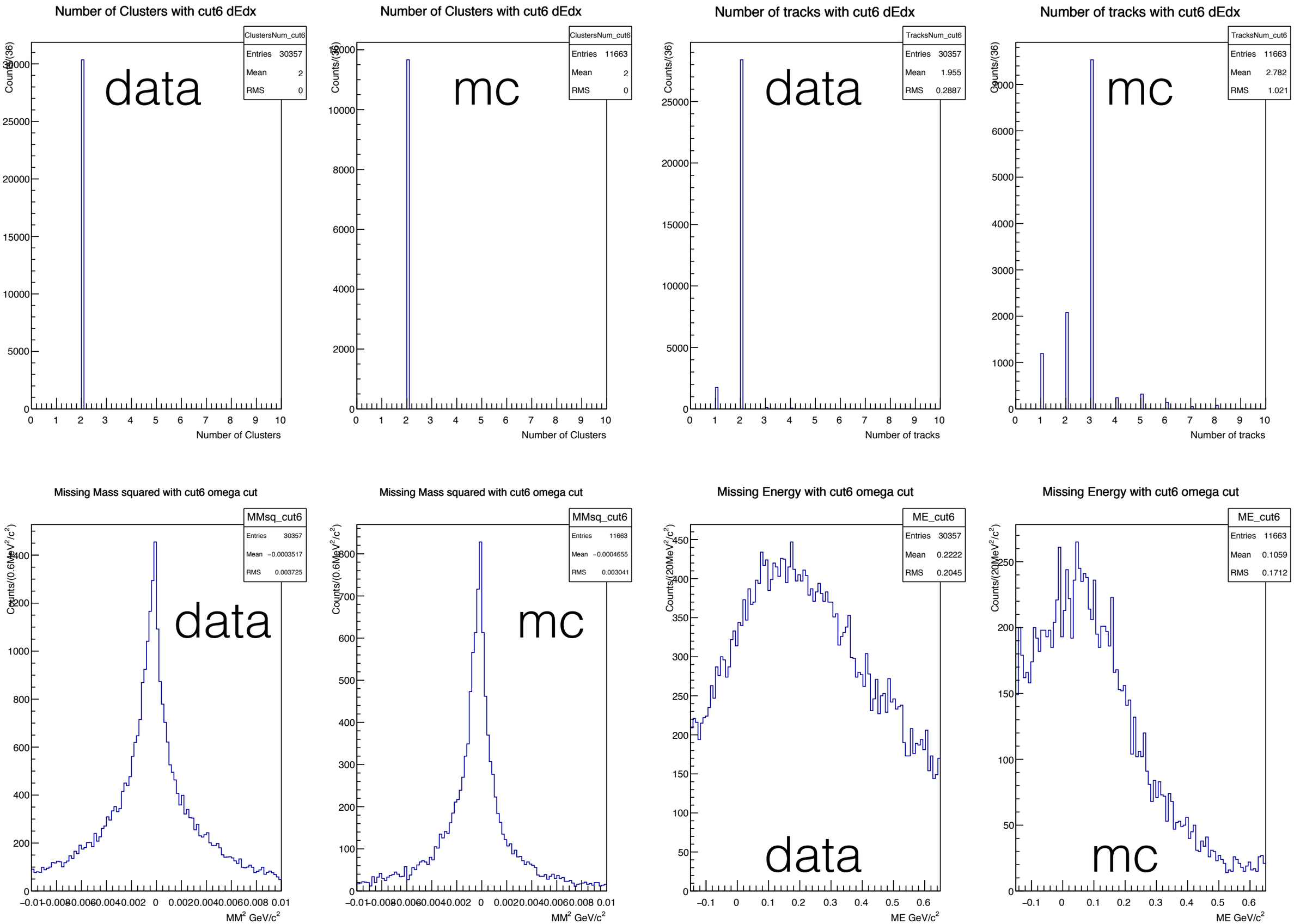
$$MM(\gamma p \to pX) > 0.85 \text{ or } < 0.7 \text{ GeV}$$

Cut flow:

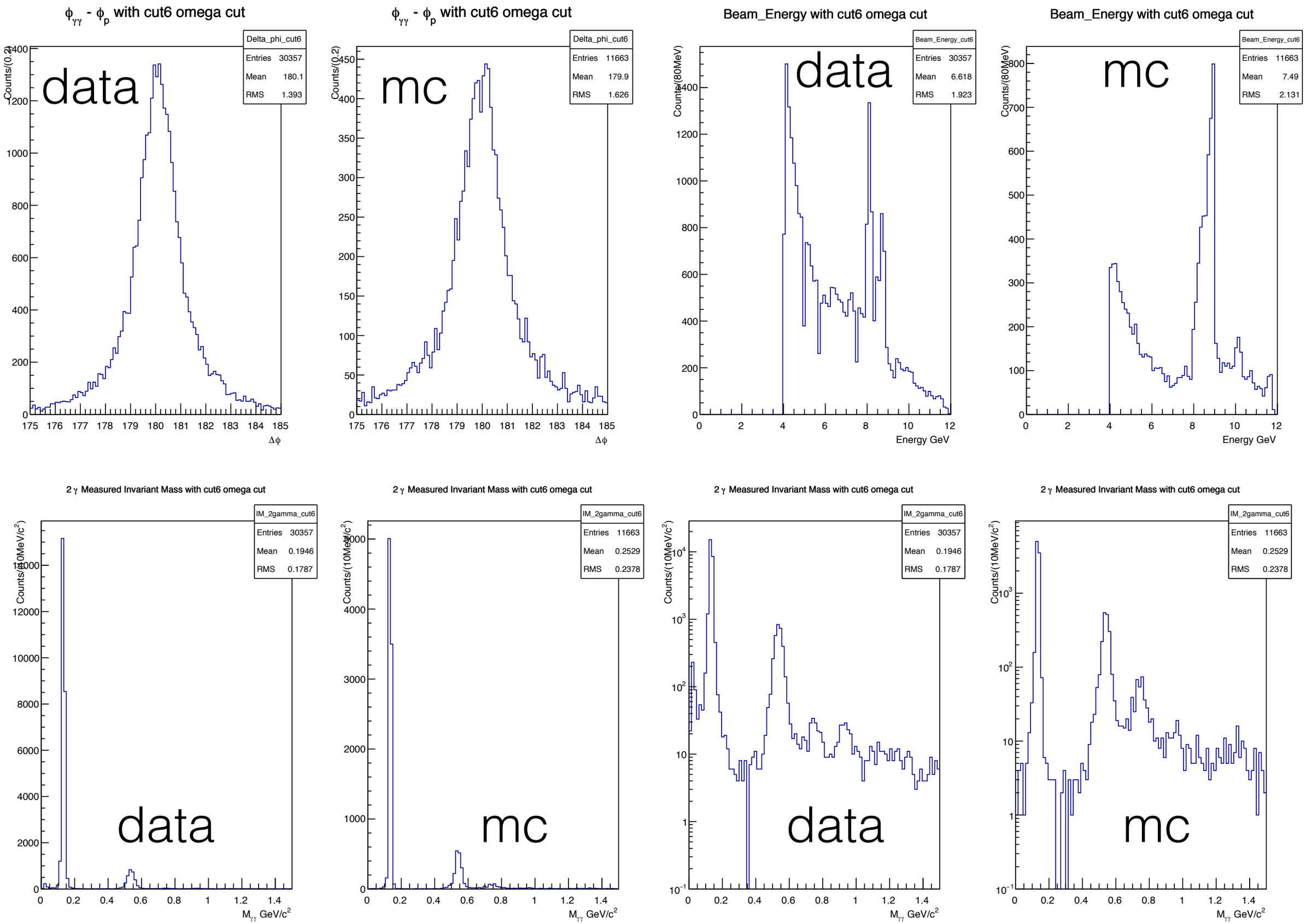
Cuts number	Cuts conditions	Events in Data	Events in MC
No Cuts		2.2×10^8	2.8×10^8
Cut0	dE/dx cut	1.4×10^8	1.2×10^8
Cut1	$\lvert(\phi_{2\gamma} - \phi_p) - 180.0\rvert < 5.0$	7.8×10^6	5.7×10^6
Cut2	$-0.01 < MM^2 < 0.01$	1.5×10^5	4.7×10^4
Cut3	$-0.15 < ME < 0.65$	7.0×10^4	2.6×10^4
Cut4	$BE > 4$	4.0×10^4	2.3×10^4
Cut5	$\mathrm{UnusedEnergy} < 0.08$	3.2×10^4	1.3×10^4
Cut6	$MM(\gamma p \to pX) > 0.85$ or < 0.7	3.0×10^4	1.2×10^4

Bishnu's MC analysis

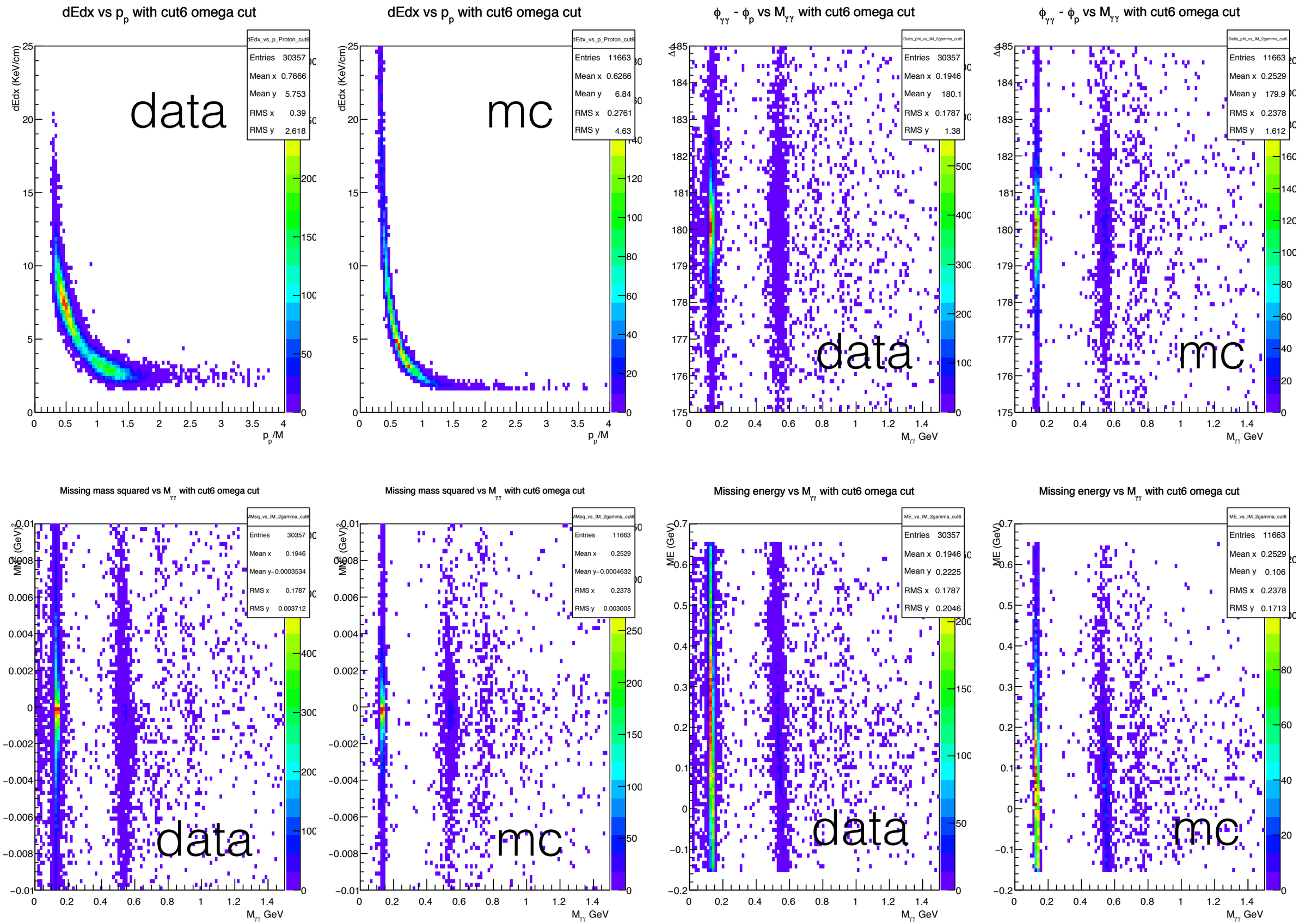
Simon's multi-photon analysis



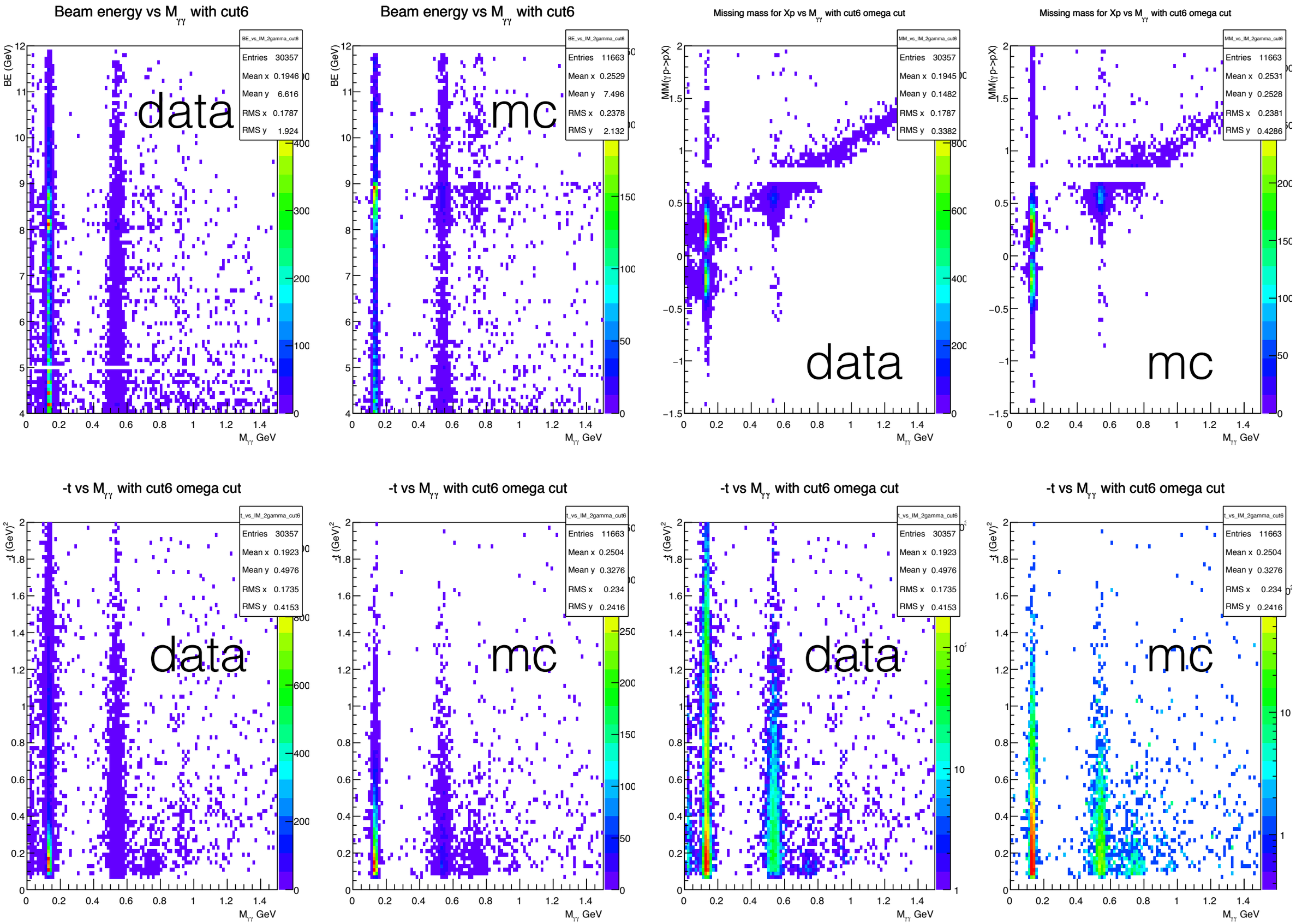
After Cuts 0-6



After Cuts 0-6



After Cuts 0-6



After Cuts 0-6

Background study
Definition of True Signal

- Two reconstructed photons matched to 2 generator level photons

- The first track is proton and only 2 generated photons in final states at generator level

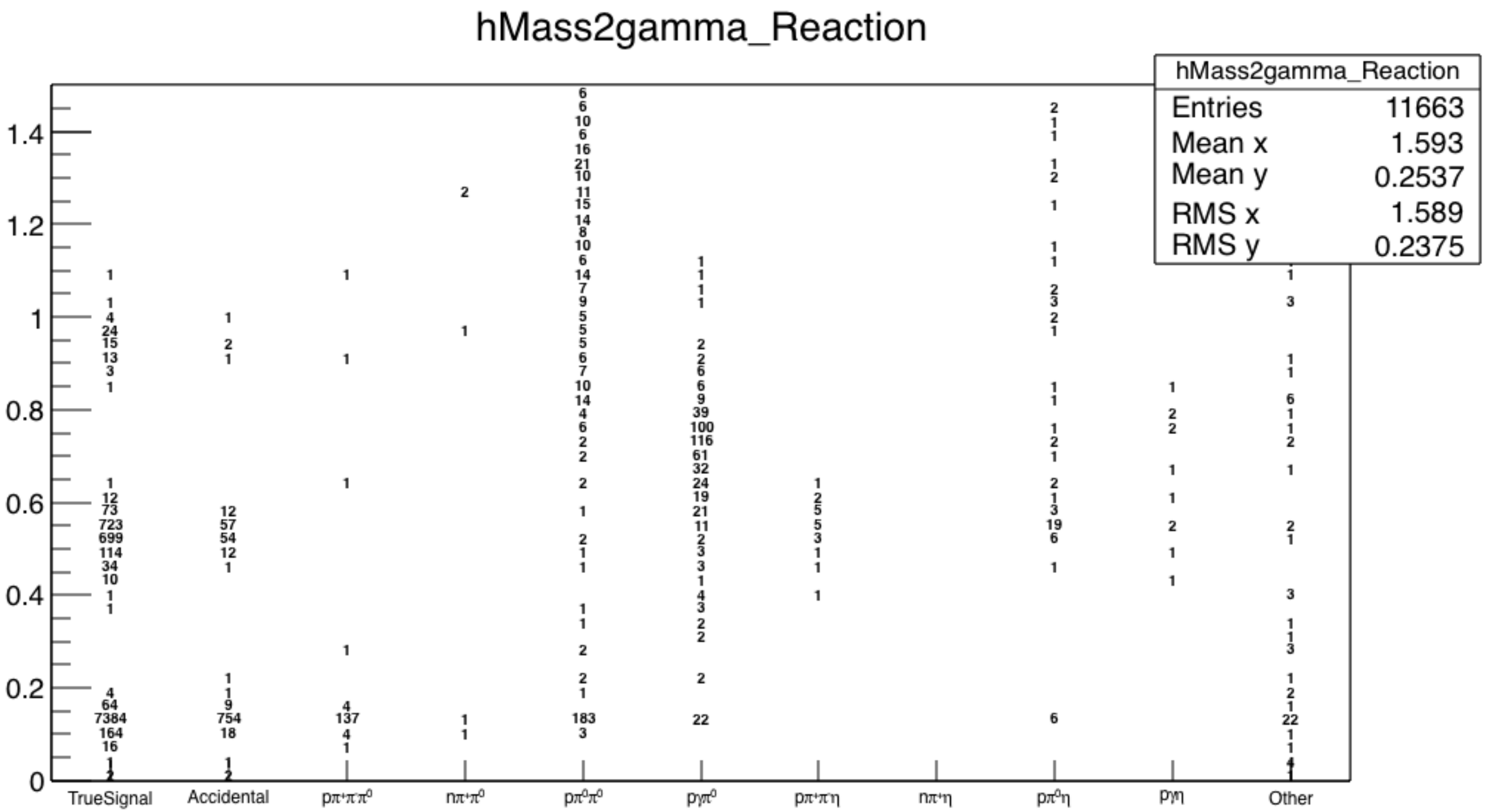
- |Missing Mass squared($\gamma p \rightarrow \gamma\gamma p$)| < 0.01 GeV at generator level (no extra generated particles in final state)

- True Beam particle (having correct beam photon which generates this event) for correct time of interaction.

Bishnu's MC analysis: https://cnidlamp.jlab.org/RareEtaDecay/JDocDB/system/files/biblio/2015/11/bishnuoct-4p2gamma.pdf

Background study

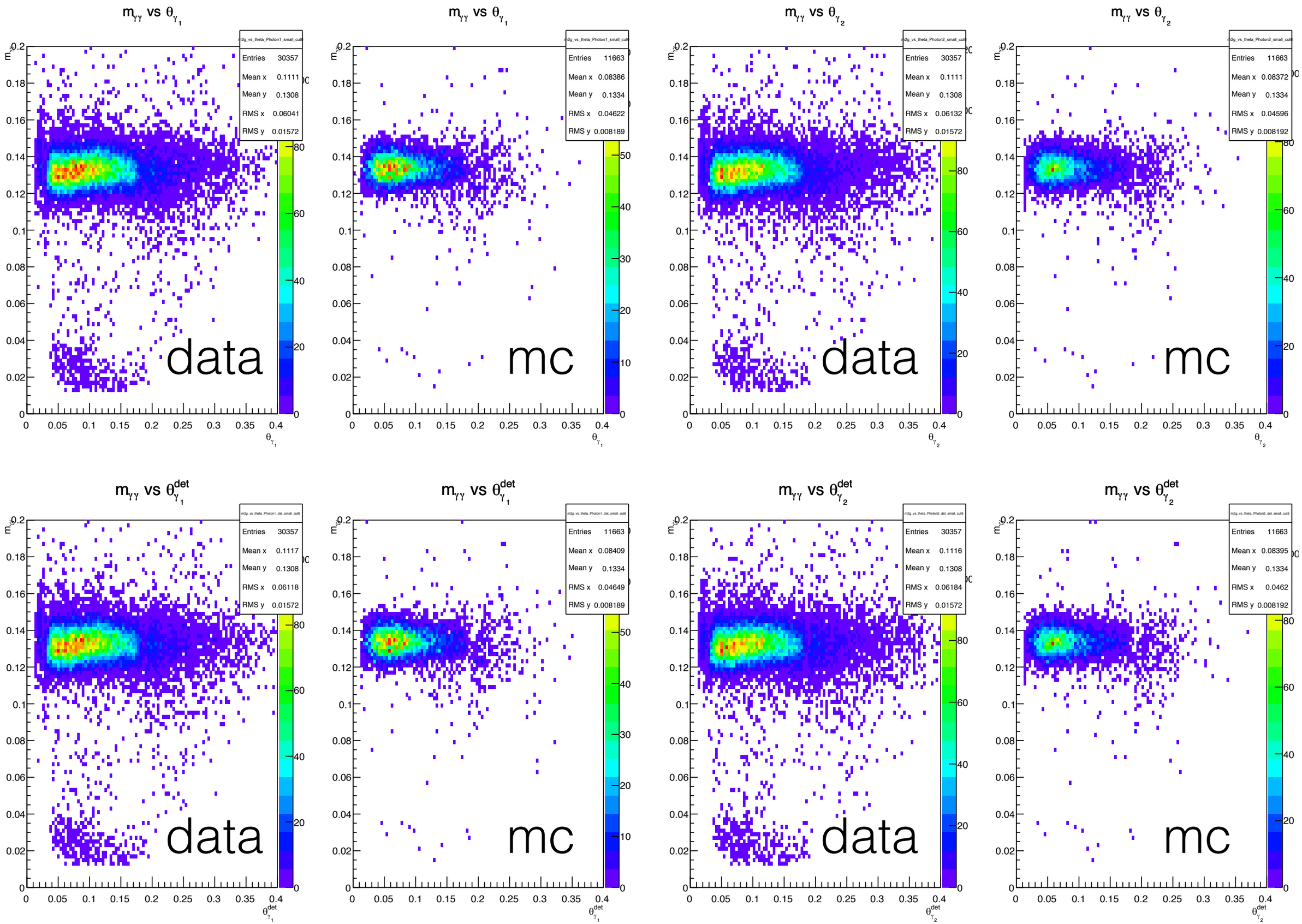
Background study



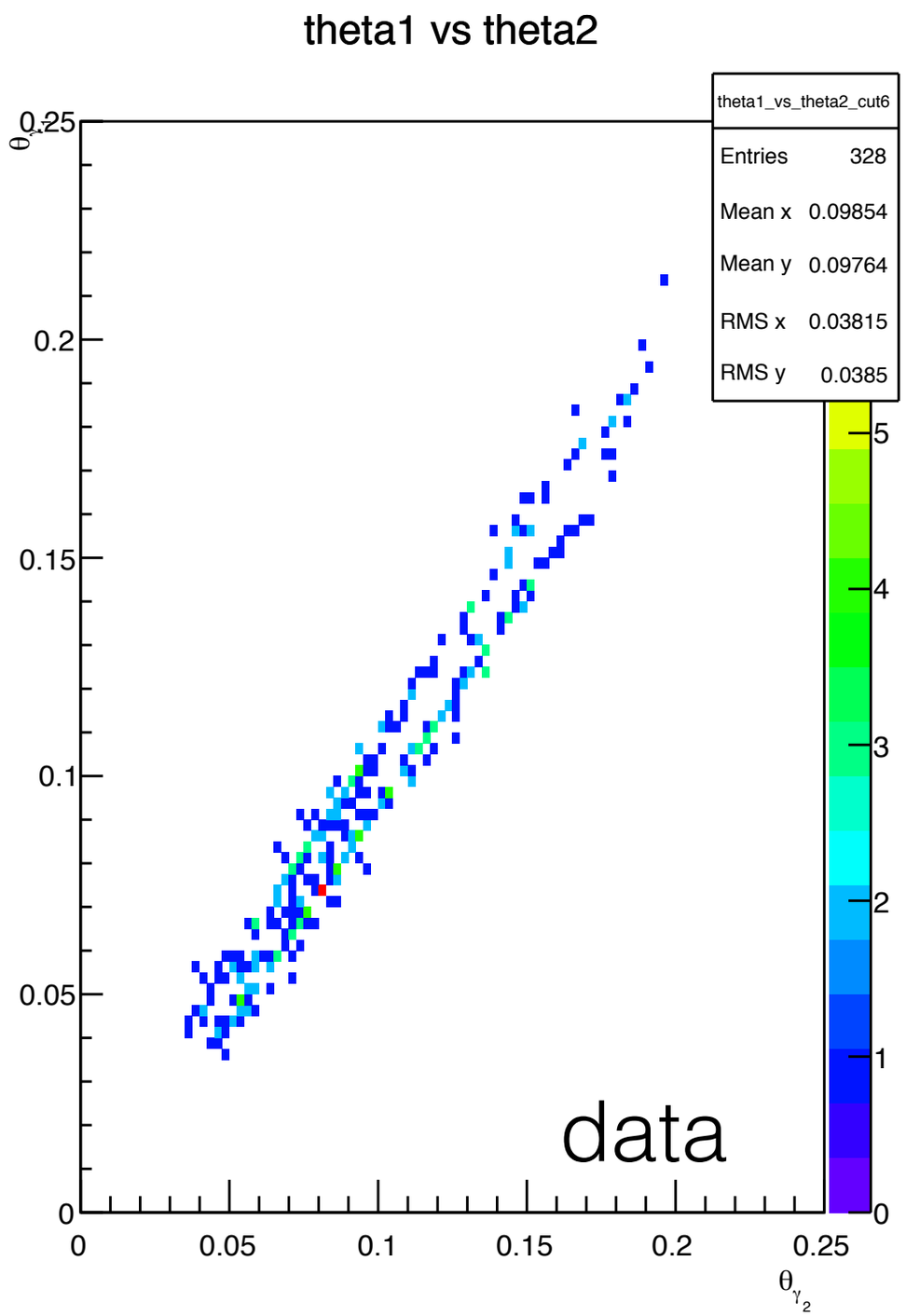
Systematic Study

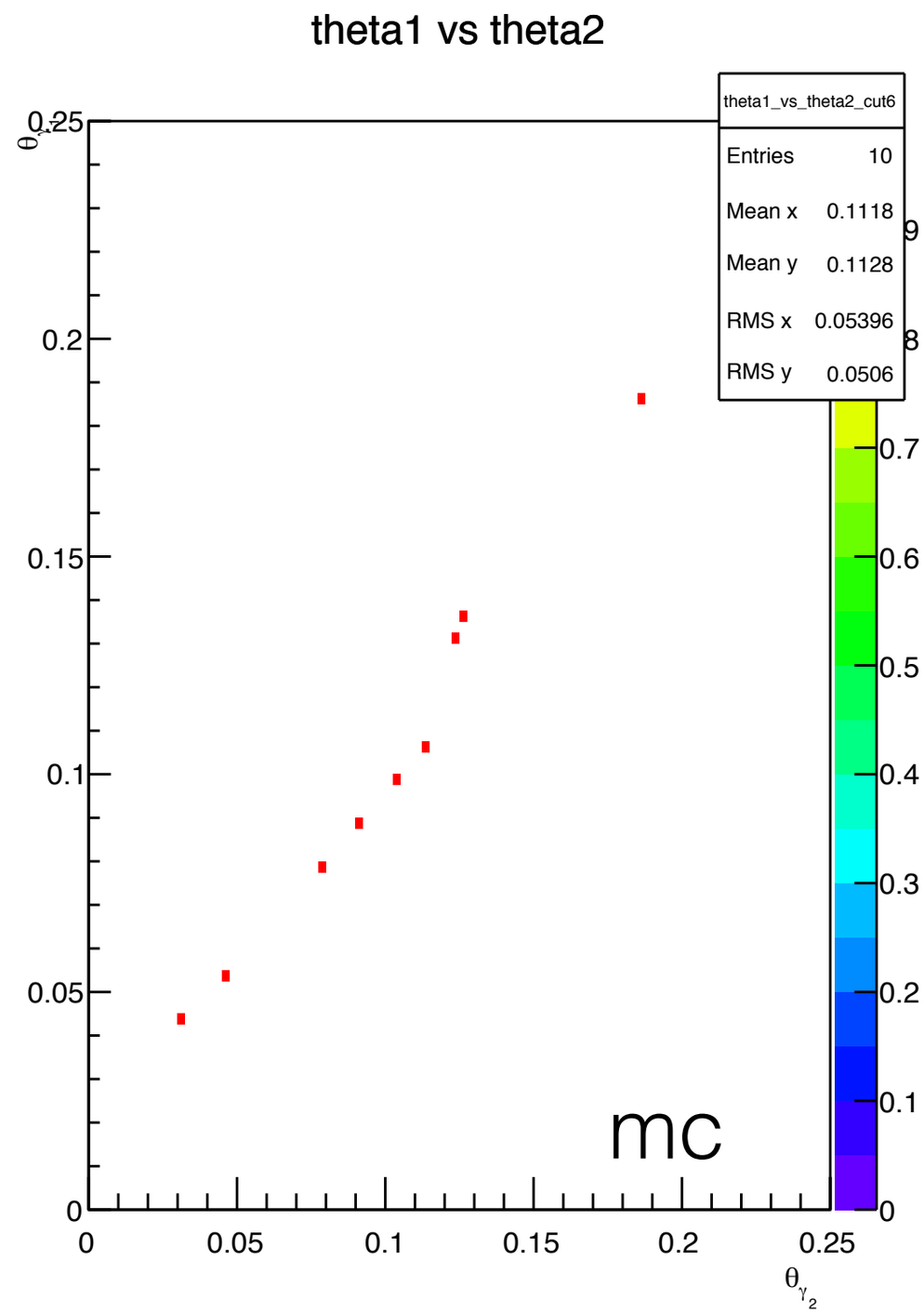
- A systematic study on the 2016 spring data Run 10389-10465 has been done and put in the docDB: http://argus.phys.uregina.ca/cgi-bin/private/DocDB/ShowDocument?docid=2970

- The systematic studies will be updated with the new data taking in this spring.


$m_{\gamma\gamma}$ vs θ_{γ_1}
Entries 30357
Mean x 0.1111
Mean y 0.1308
RMS x 0.06041
RMS y 0.01572
data
$m_{\gamma\gamma}$ vs θ_{γ_1}
Entries 11663
Mean x 0.08386
Mean y 0.1334
RMS x 0.04622
RMS y 0.008189
mc
$m_{\gamma\gamma}$ vs θ_{γ_2}
Entries 30357
Mean x 0.1111
Mean y 0.1308
RMS x 0.06132
RMS y 0.01572
data
$m_{\gamma\gamma}$ vs θ_{γ_2}
Entries 11663
Mean x 0.08372
Mean y 0.1334
RMS x 0.04596
RMS y 0.008192
mc
$m_{\gamma\gamma}$ vs $\theta^{det}_{\gamma_1}$
Entries 30357
Mean x 0.1117
Mean y 0.1308
RMS x 0.06118
RMS y 0.01572
data
$m_{\gamma\gamma}$ vs $\theta^{det}_{\gamma_1}$
Entries 11663
Mean x 0.08409
Mean y 0.1334
RMS x 0.04649
RMS y 0.008189
mc
$m_{\gamma\gamma}$ vs $\theta^{det}_{\gamma_2}$
Entries 30357
Mean x 0.1116
Mean y 0.1308
RMS x 0.06184
RMS y 0.01572
data
$m_{\gamma\gamma}$ vs $\theta^{det}_{\gamma_2}$
Entries 11663
Mean x 0.08395
Mean y 0.1334
RMS x 0.0462
RMS y 0.008192
mc

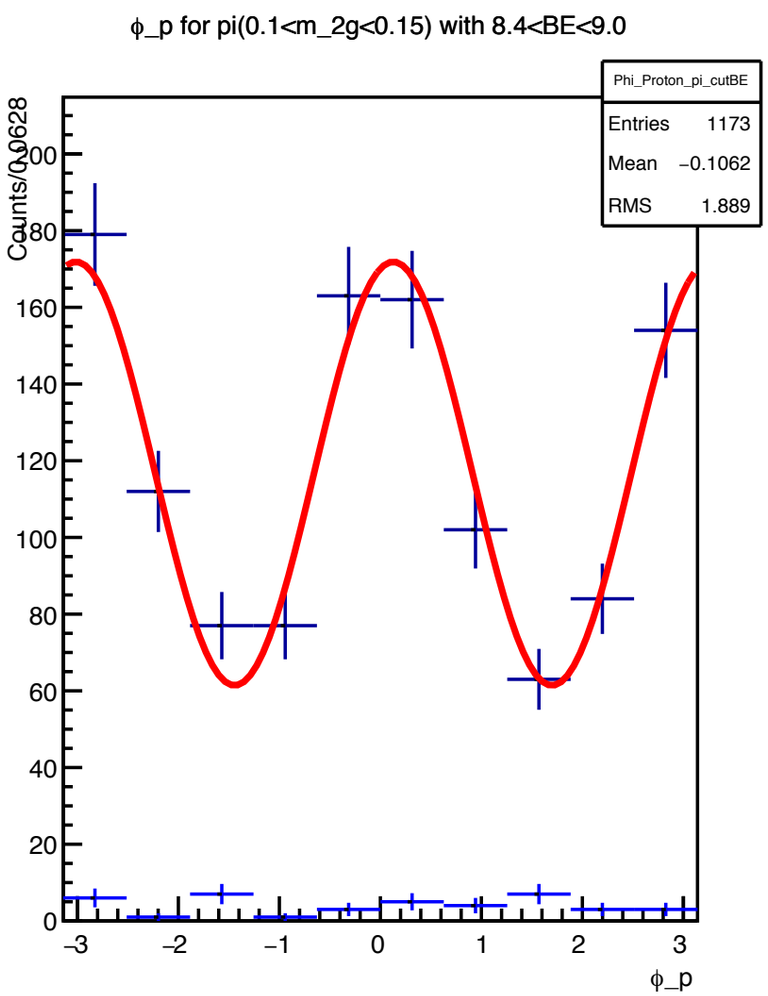
Understanding FCAL Splits
theta1 vs theta2
with m_2g <0.04 GeV

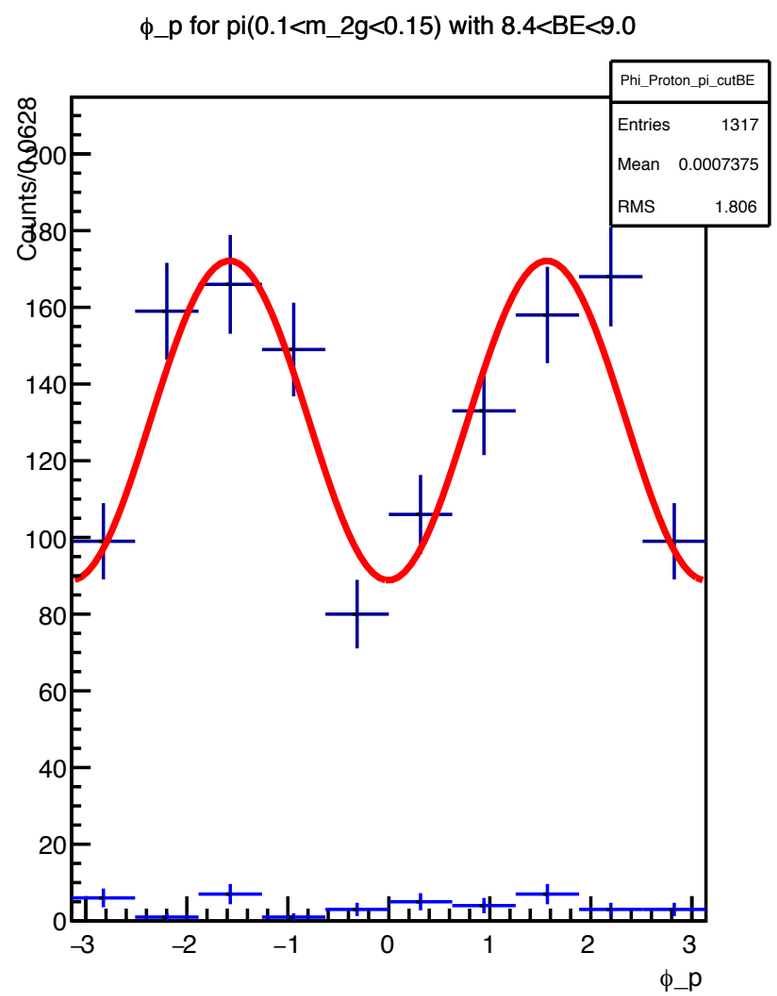


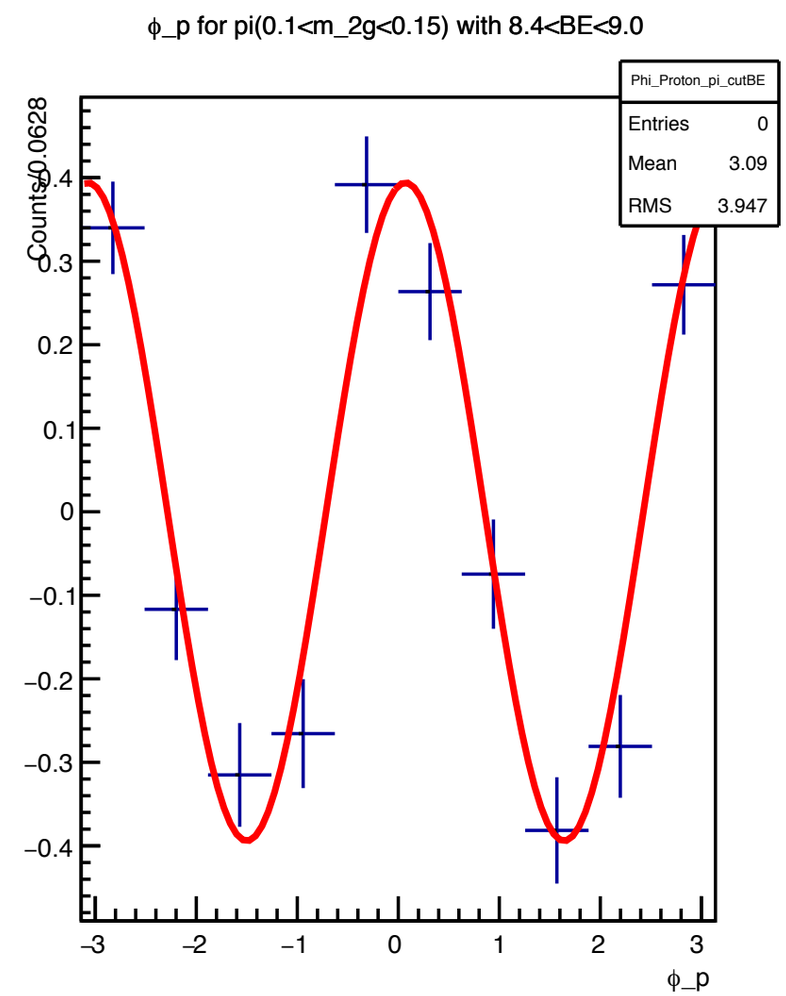


Beam Asymmetry for π^0

24 hour data Run 10491-10498







$$P_{\perp}\Sigma = 0.47 \pm 0.04$$

$$d\sigma_{\perp} \sim 1 - P_{\perp}\Sigma \cdot \cos 2\psi$$

$$P_{\parallel}\Sigma = 0.32 \pm 0.04$$

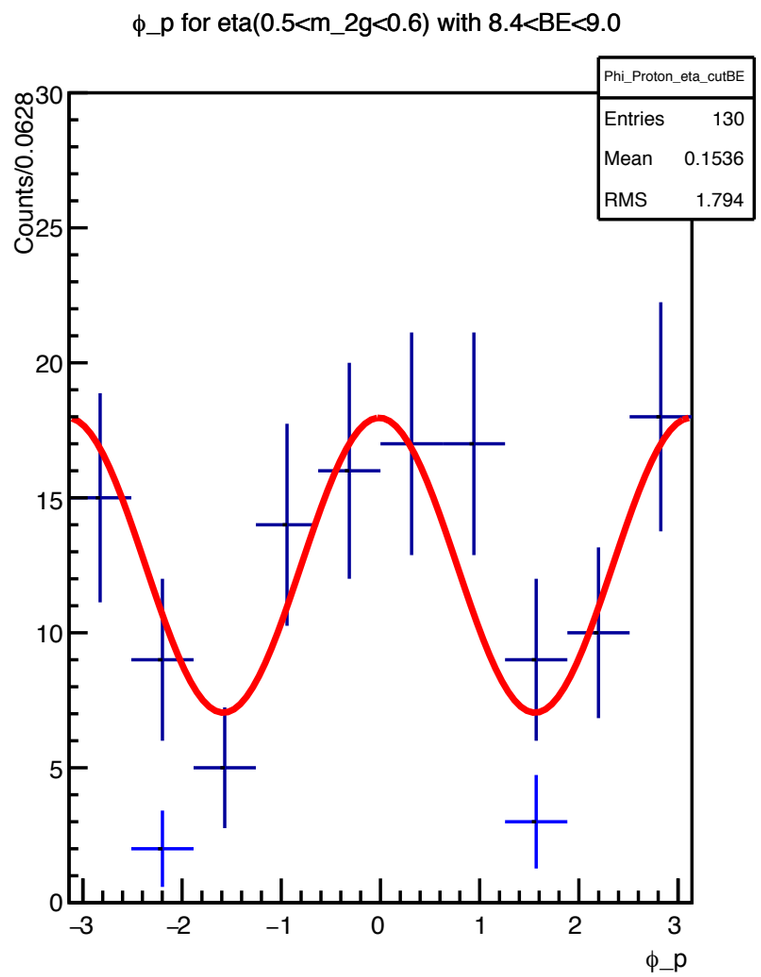
$$d\sigma_{\parallel} \sim 1 + P_{\parallel}\Sigma \cdot \cos 2\psi$$

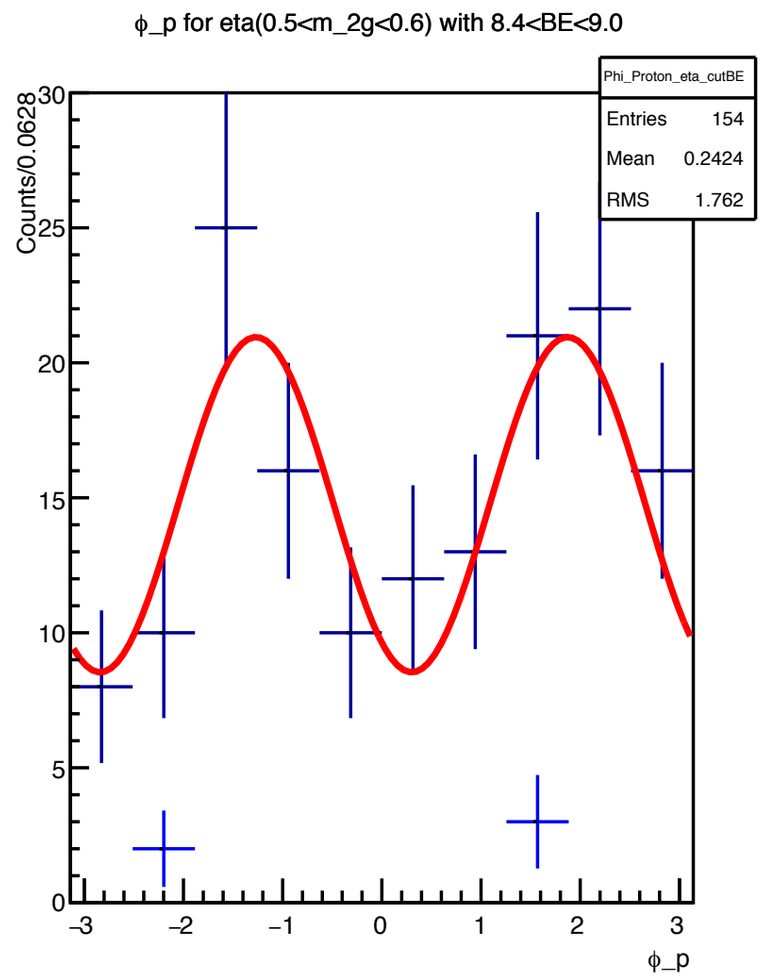
$$P\Sigma = 0.39 \pm 0.03$$

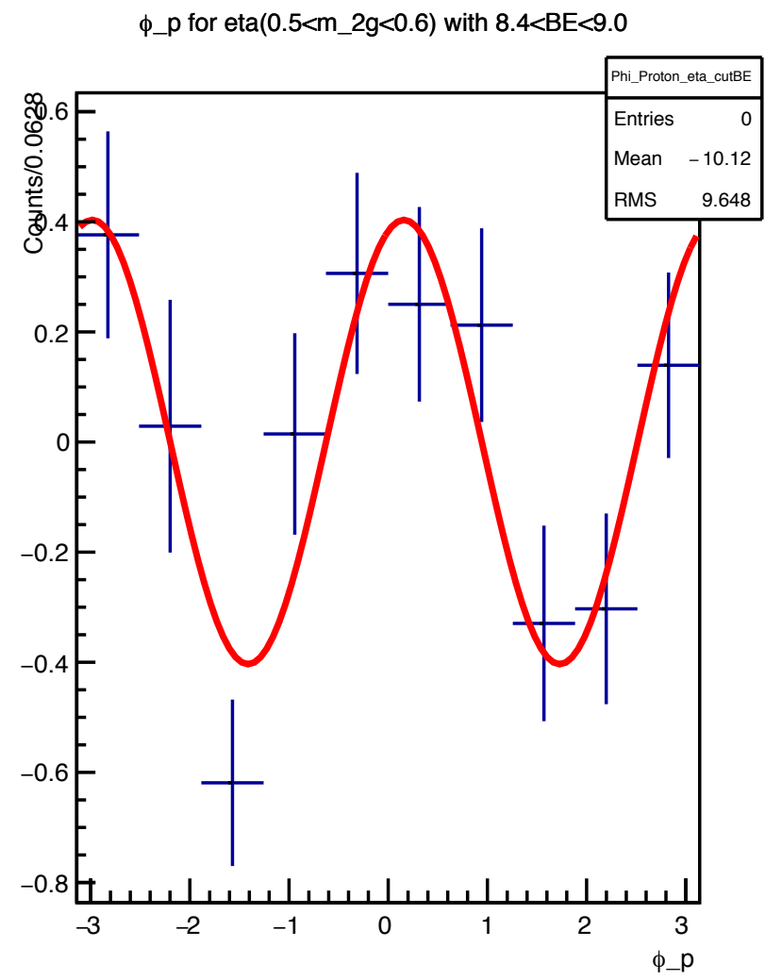
$$\frac{N_{\parallel} - N_{\perp}}{N_{\parallel} + N_{\perp}} = P\Sigma \cdot \cos 2\psi$$

Beam Asymmetry for η

24 hour data Run 10491-10498







$$P_{\perp}\Sigma = 0.4 \pm 0.1$$

$$d\sigma_{\perp} \sim 1 - P_{\perp}\Sigma \cdot \cos 2\psi$$

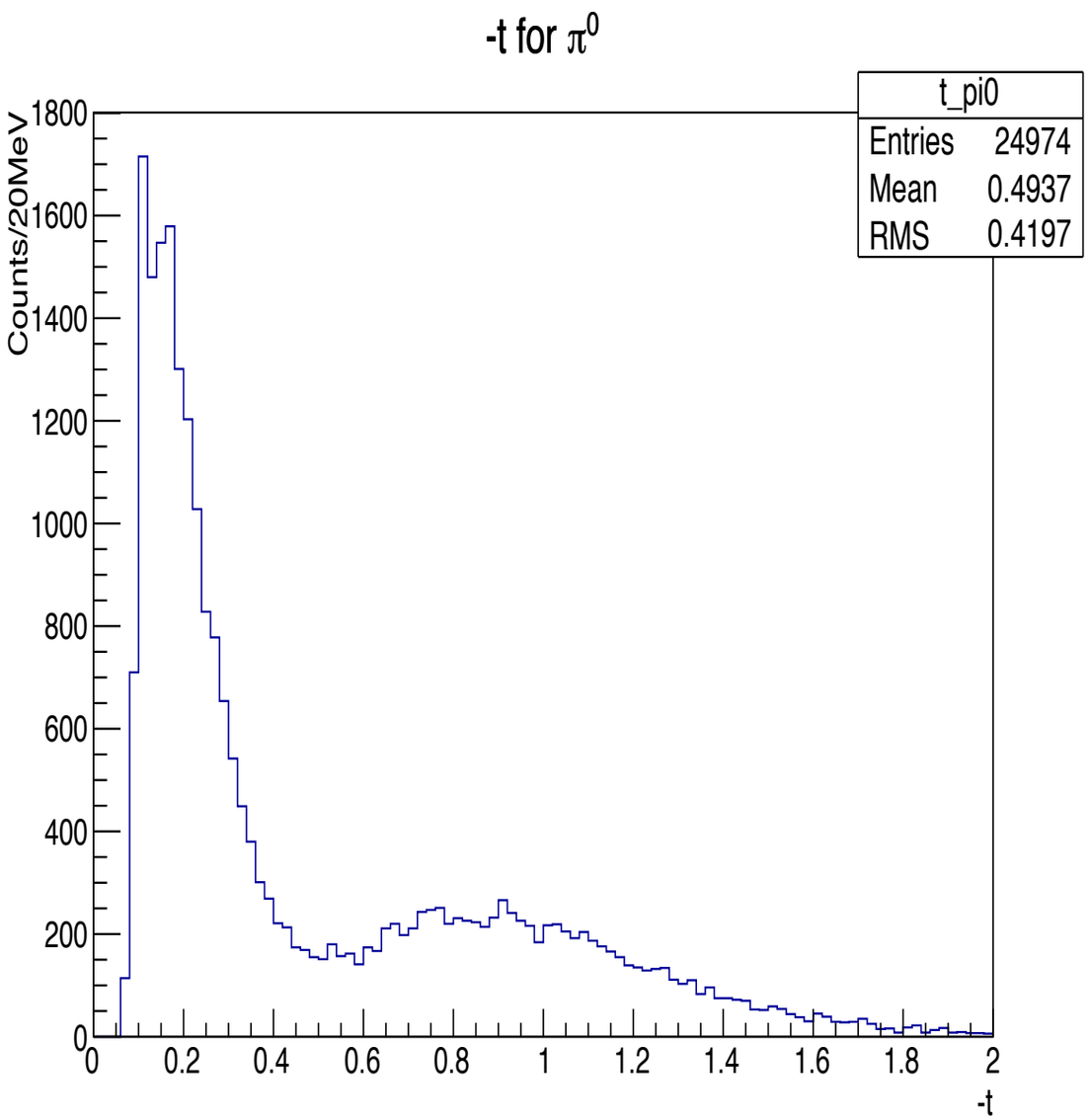
$$P_{\parallel}\Sigma = 0.4 \pm 0.1$$

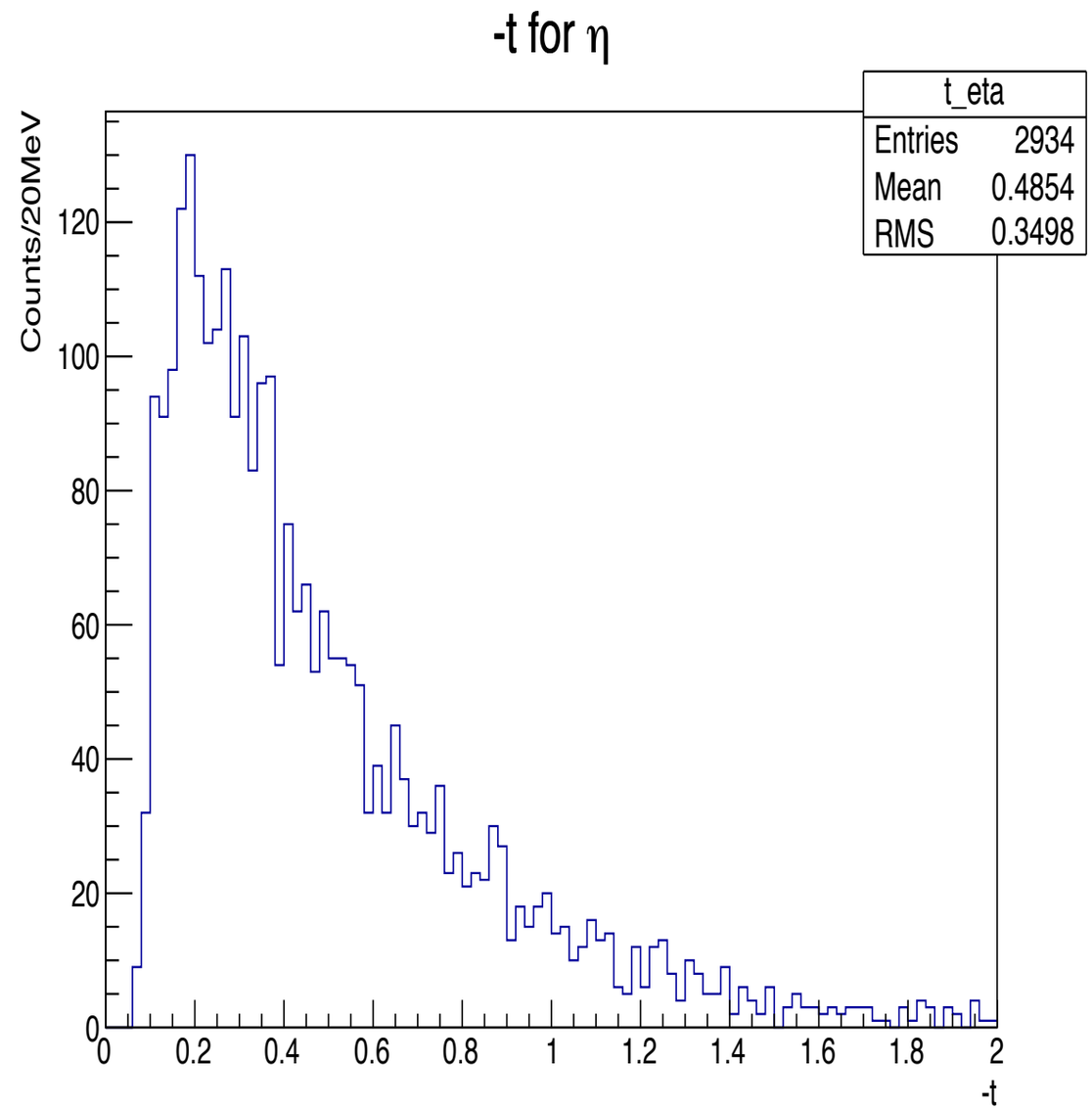
$$d\sigma_{\parallel} \sim 1 + P_{\parallel}\Sigma \cdot \cos 2\psi$$

$$P\Sigma = 0.4 \pm 0.1$$

$$\frac{N_{\parallel} - N_{\perp}}{N_{\parallel} + N_{\perp}} = P\Sigma \cdot \cos 2\psi$$

-t distributions for π^0 and η





Summary

- The variant distributions are compared between 2016 new data and new inclusive MC under different cut conditions.
- A primary background analysis shows the main background channels come from $p\pi^+\pi^-\pi^0$, $p\pi^0\pi^0$, $p\gamma\pi^0$.
- A first look on the systematic study on the new data has been done and will be updated with the new data taking.
- Beam asymmetry for π^0 and η photoproduction are studied. The parameter $P\Sigma = 0.39 \pm 0.03$ for π^0 and $P\Sigma = 0.4 \pm 0.1$ for η.
- -t distribution for π^0 shows a dip which is different from the one for η.

Next to do

- The timing cutting conditions studies
- The cutting conditions dependence
- Background studies
- Systematic studies
- Signal MC studies
- ……


Thanks !