$\gamma p \to \gamma\gamma p$
Beam asymmetry

Zhenyu Zhang, Justin Stevens, Dave Mack, Simon Taylor,
Liping Gan, and Eugene Chudakov
WHU & JLab & UNCW

Feb. 15, 2016 JEF Group Meeting

武漢大學 WUHAN UNIVERSITY

Jefferson Lab

UNCW

Outline

- A quick review for the last JEF meeting report
- M_2gamma plots
  A quantitative check on reconstruction quality
- M_2gamma vs theta_gamma
  A check for photon reconstruction near FCAL/BCAL boundary
- delta_T vs p plots
  A check for the delta_T cut conditions
- dE/dx plots vs p plots
  A check for pion background
- Summary

A quick review for the last JEF meeting report

Pre-selection

- Set_KinFitType(d_NoFit);
- The Energy of the shower $E_{\mathrm{shower}} > 0.1\mathrm{GeV}$
- Set_MaxPhotonRFDeltaT(0.5*4.008)
- PIDDeltaT
  - 1.0 SYS_TOF $\Delta t = (t_{\mathrm{TOF}} - t_{\mathrm{RF}}) < 1.0\mathrm{ns}$
  - 10.0 SYS_BCAL $\Delta t = (t_{\mathrm{BCAL}} - t_{\mathrm{RF}}) < 10.0\mathrm{ns}$
  - 10.0 SYS_FCAL $\Delta t = (t_{\mathrm{FCAL}} - t_{\mathrm{RF}}) < 10.0\mathrm{ns}$
- p>0.25 GeV and 47.5<z<80.5, r<1

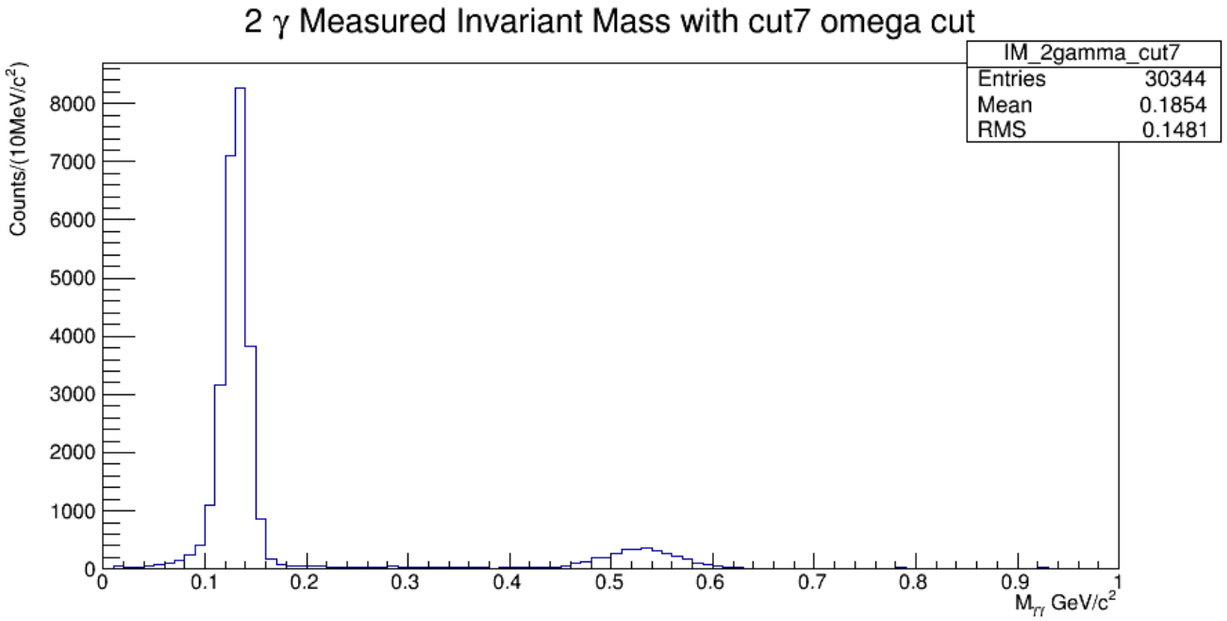
The Cuts in Selector

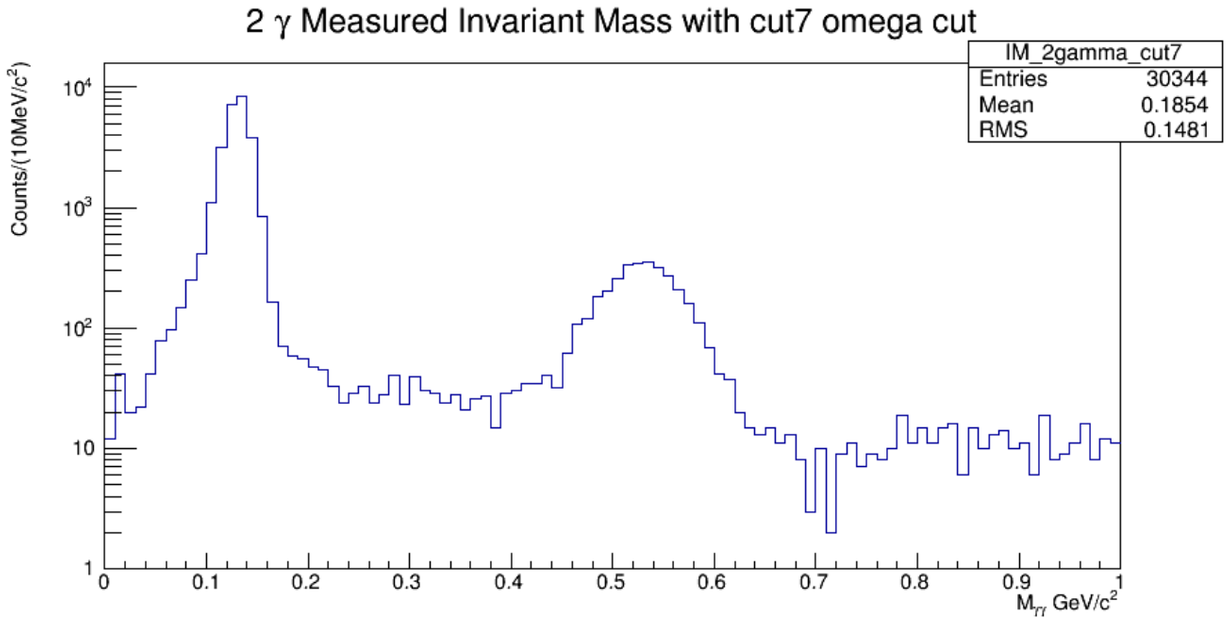
Cuts number	Cuts conditions	Events
No Cuts		1.39×10^7
Cut1	$\lvert(\phi_{2\gamma} - \phi_p) - 180.0\rvert < 5.0$	8.75×10^5
Cut2	$-0.015 < MM^2 < 0.01$	6.21×10^4
Cut3	$ME < 0.36$	3.77×10^4
Cut4	$\mathrm{UnusedEnergy} < 0.08$	3.13×10^4
Cut5	$MM(\gamma p \to pX) > 0.85$ or < 0.7	3.03×10^4

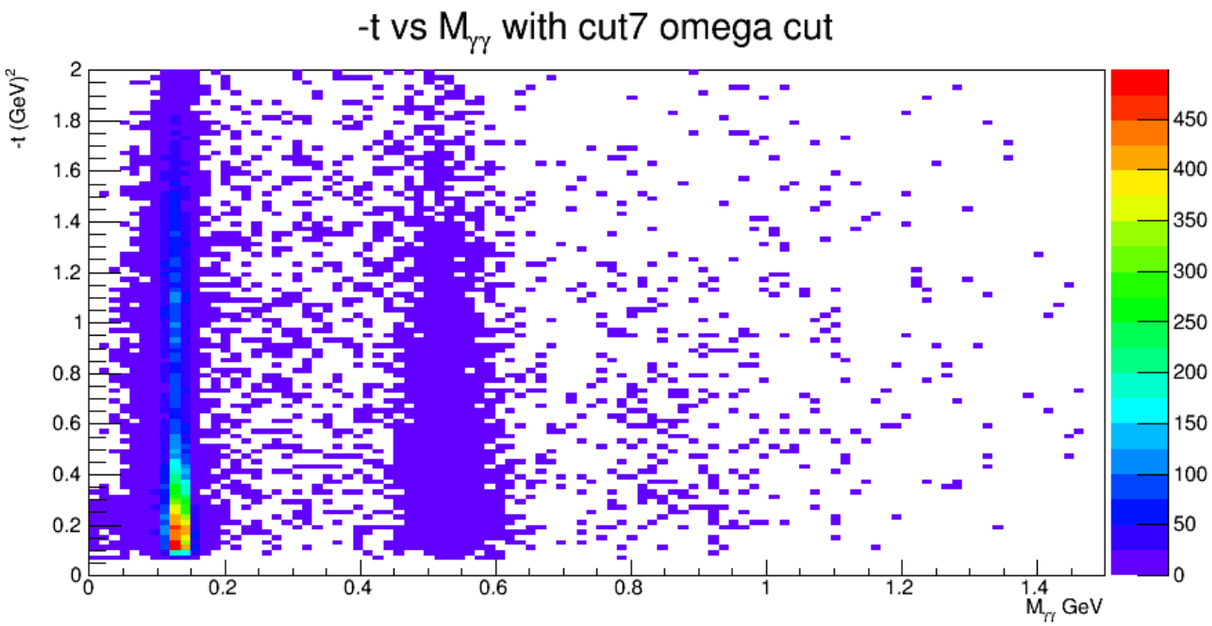
Bishnu's MC analysis

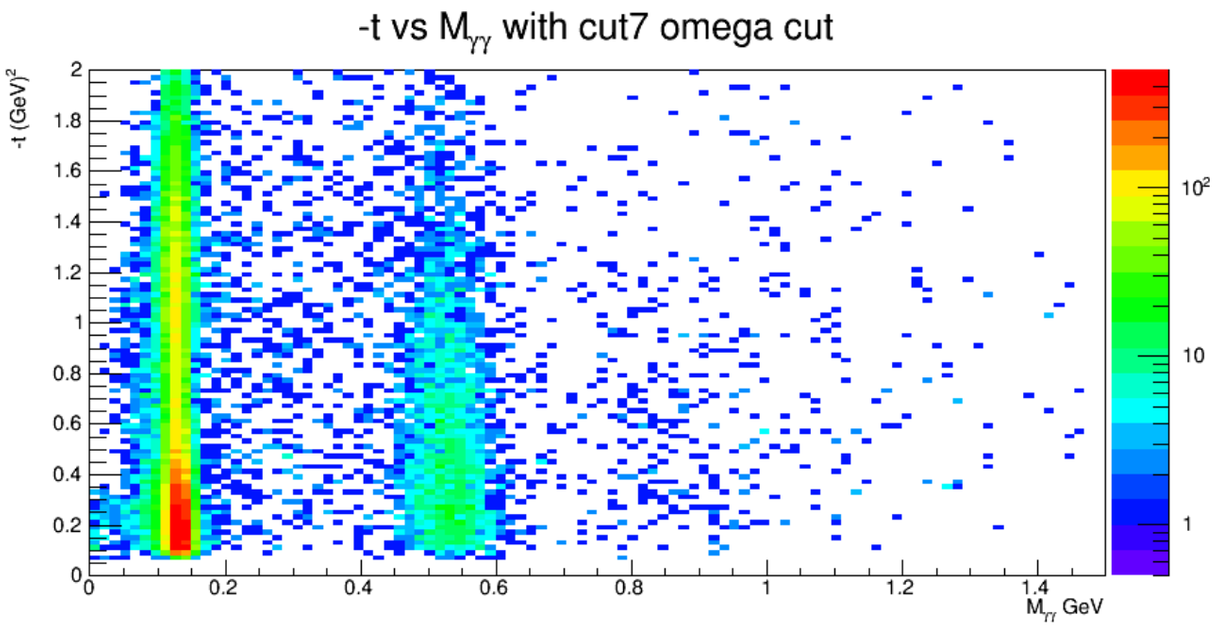
Simon's multi-photon analysis

Some distributions after all 5 cuts





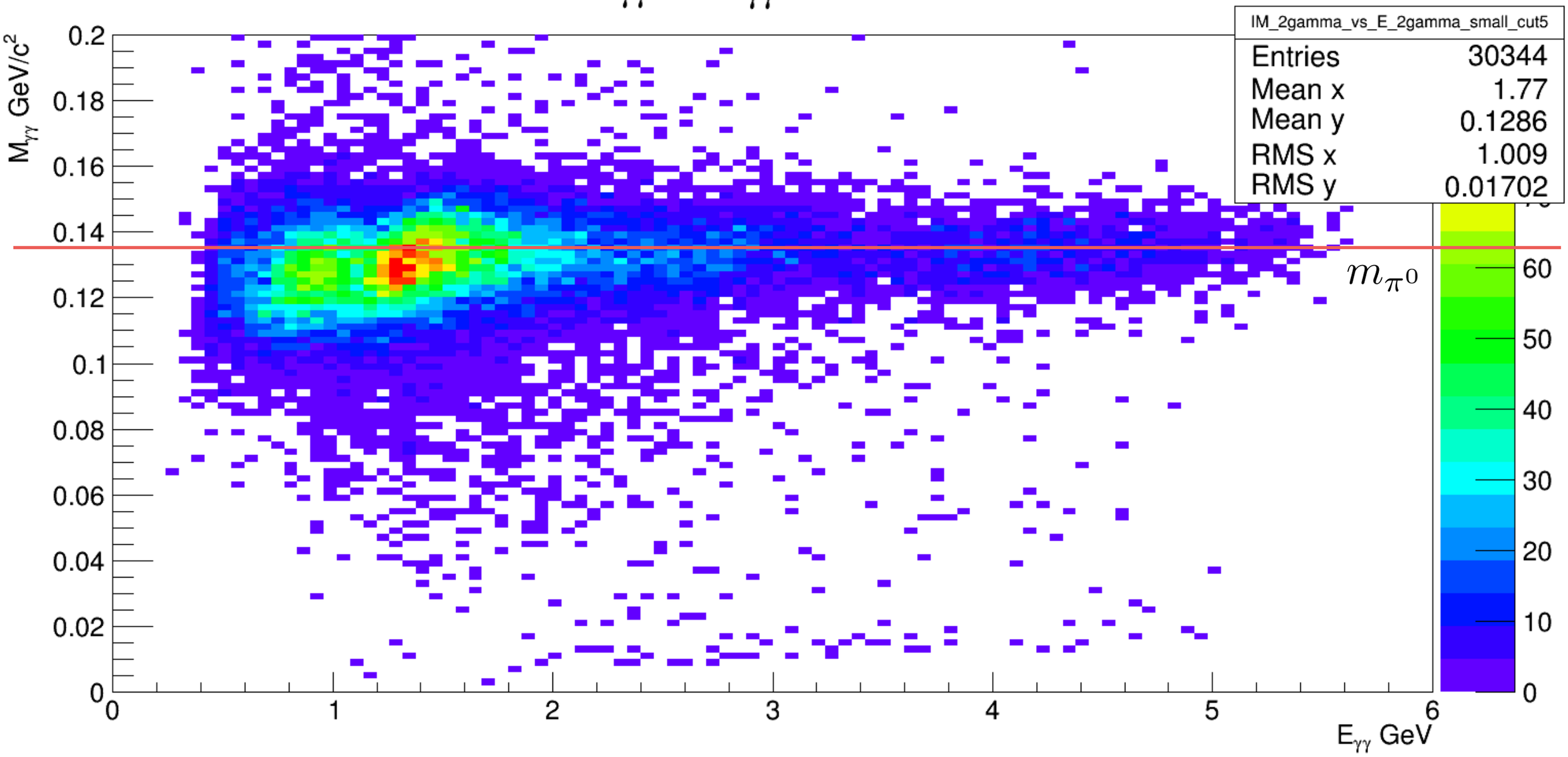




M_2gamma plots

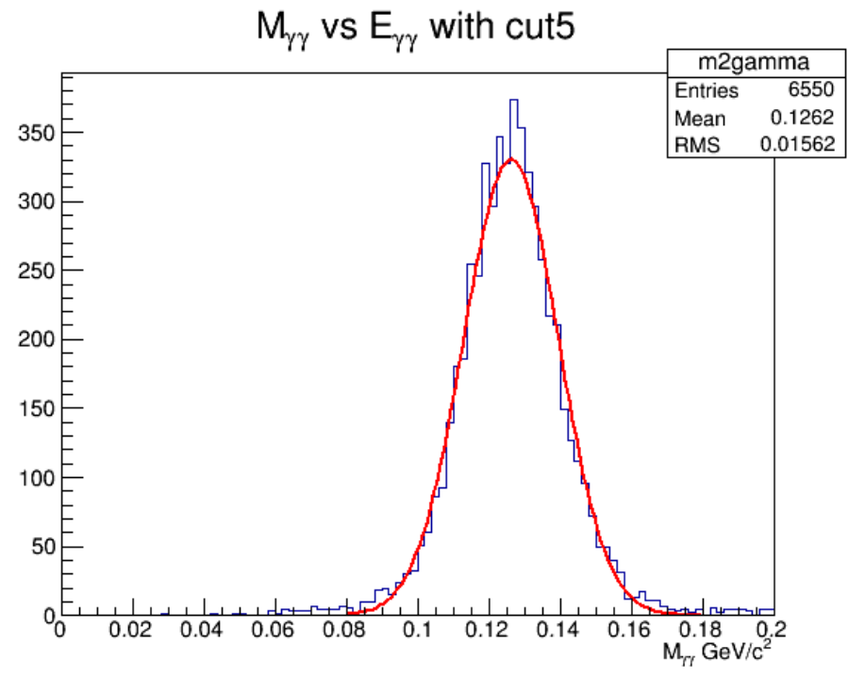
A quantitative check on reconstruction quality

m_2g vs E_2g

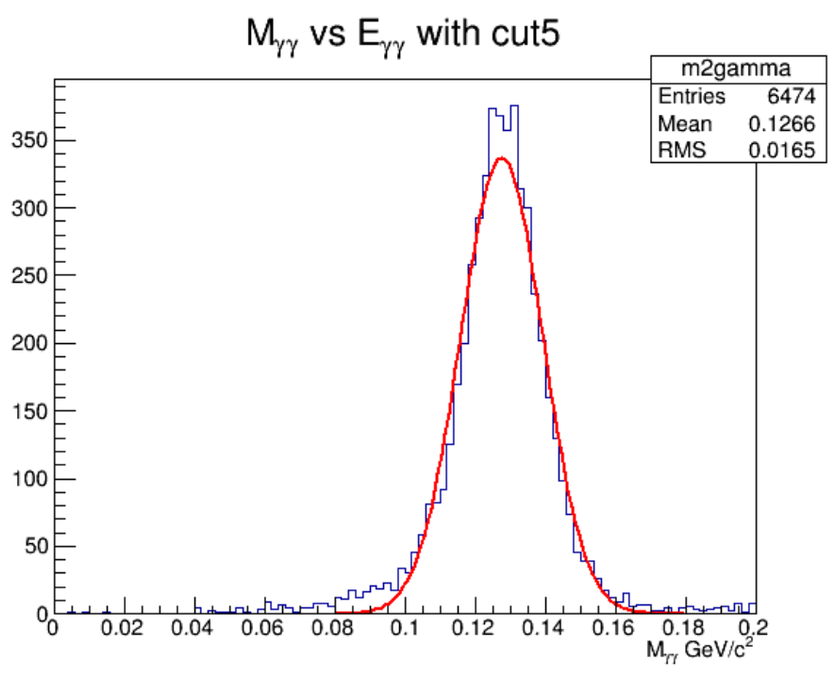

$M_{\gamma\gamma}$ vs $E_{\gamma\gamma}$ with cut5
IM_2gamma_vs_E_2gamma_small_cut5
Entries 30344
Mean x 1.77
Mean y 0.1286
RMS x 1.009
RMS y 0.01702
$M_{\gamma\gamma}$ GeV/c^2
$E_{\gamma\gamma}$ GeV
m_{π^0}

Gaussian fit of pi0

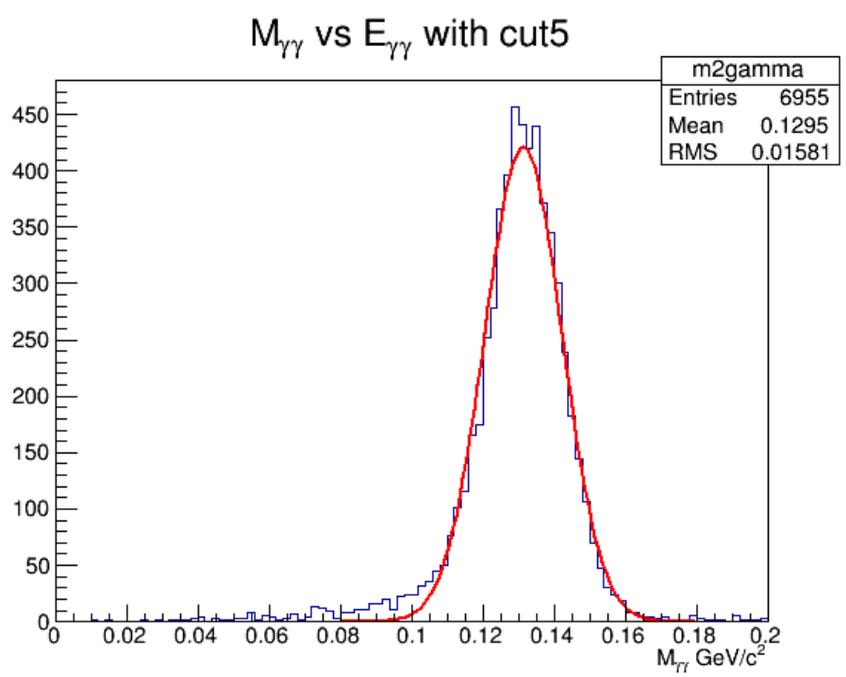
Epi0(GeV)	centroid_M2gamma (GeV)	sigma_M2gamma (GeV)
0.2-1.0 <Epi0>=0.6	0.1261 +/- 0.0002	0.0137 +/- 0.0002
1.0-1.3 <Epi0>=1.15	0.1275 +/- 0.0002	0.0124 +/- 0.0002
1.3-1.6 <Epi0>=1.45	0.1312 +/- 0.0002	0.0113 +/- 0.0001
1.6-2.3 <Epi0>=1.95	0.1326 +/- 0.0002	0.0115 +/- 0.0001
2.3-6.0 <Epi0>=4.15	0.1337 +/- 0.0001	0.0095 +/- 0.0001



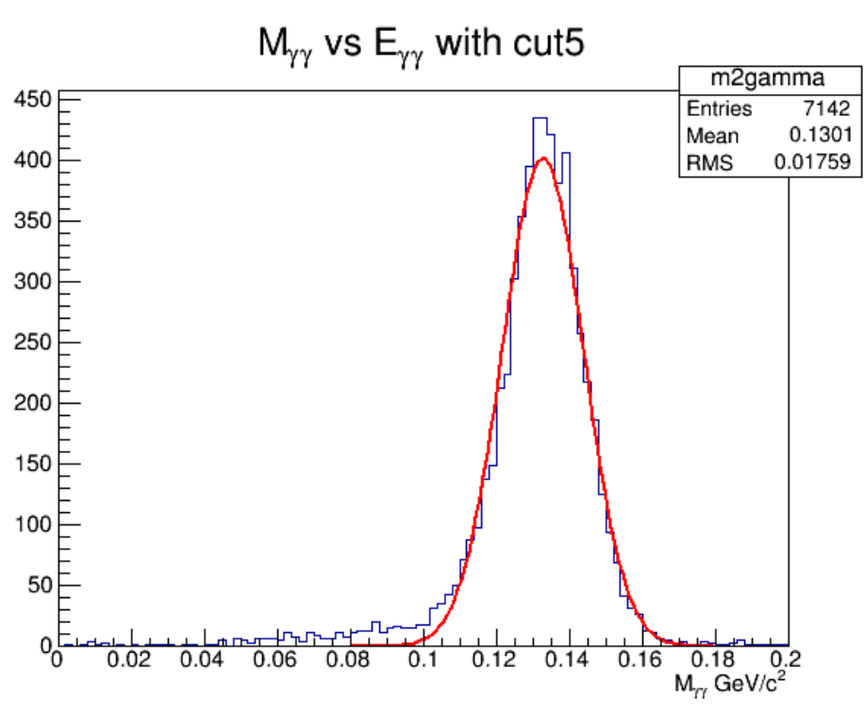
Epi0=0.2-1.0 GeV



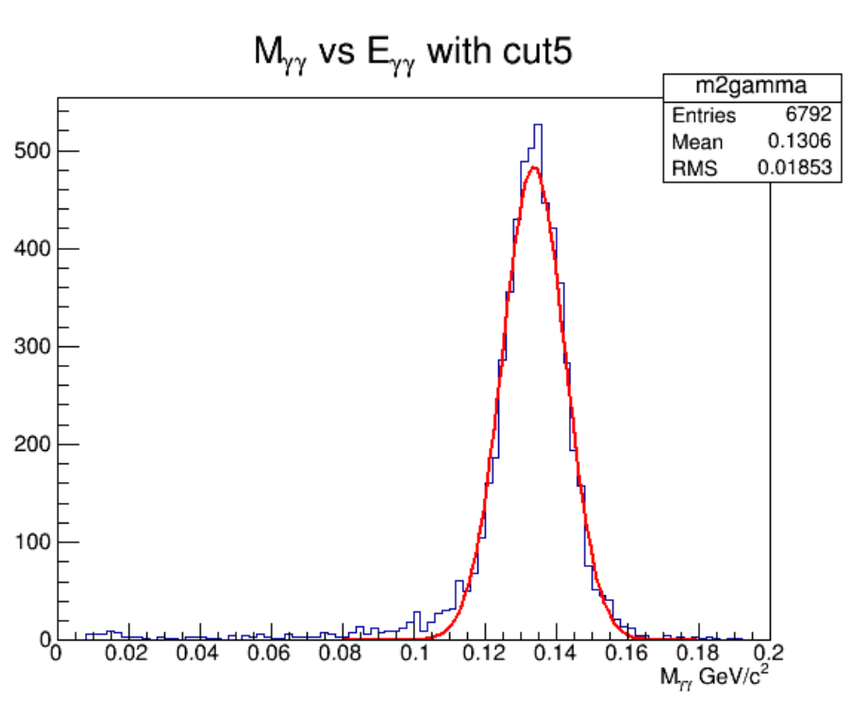
Epi0=1.0-1.3 GeV



Epi0=1.3-1.6 GeV

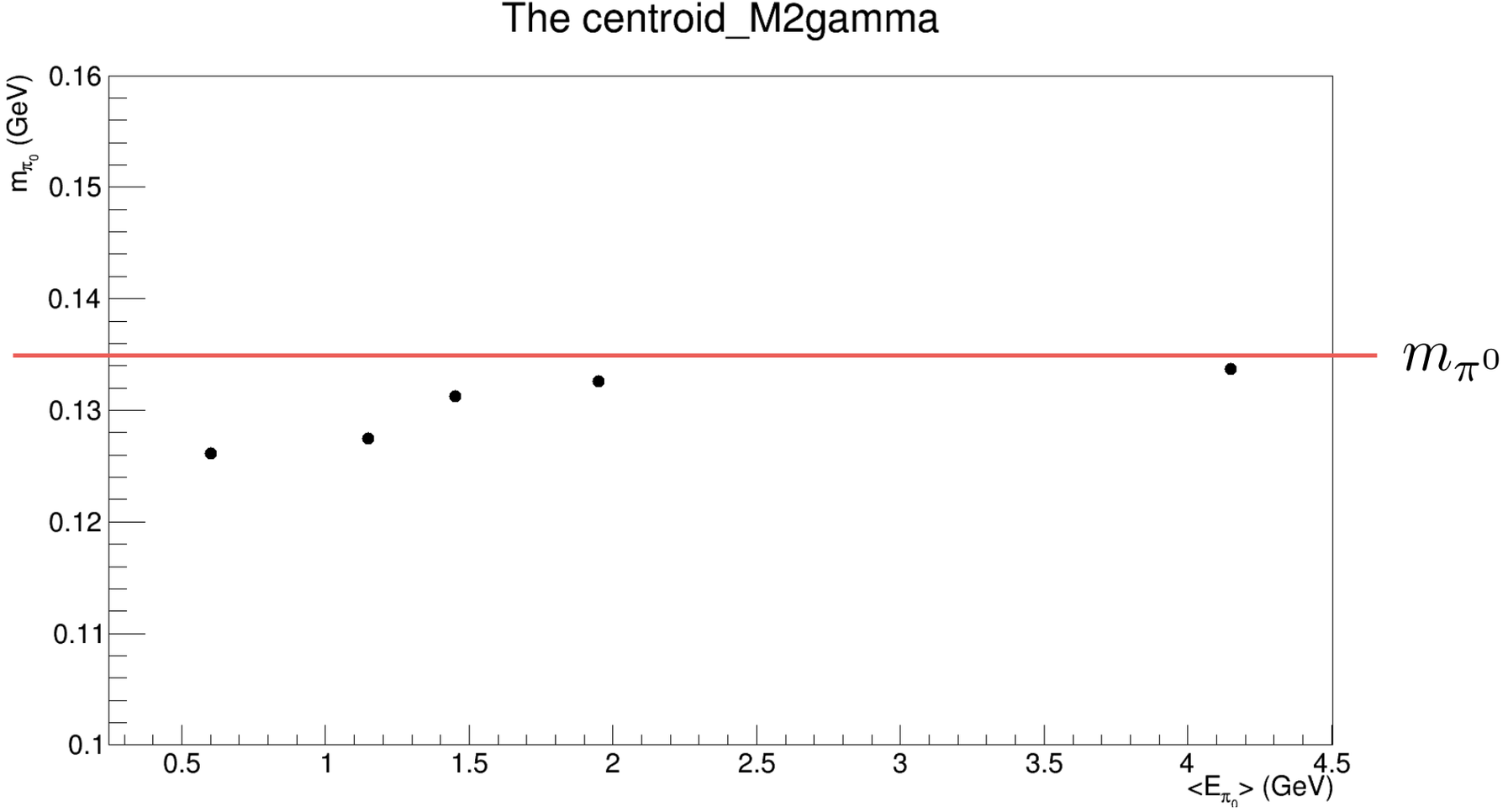


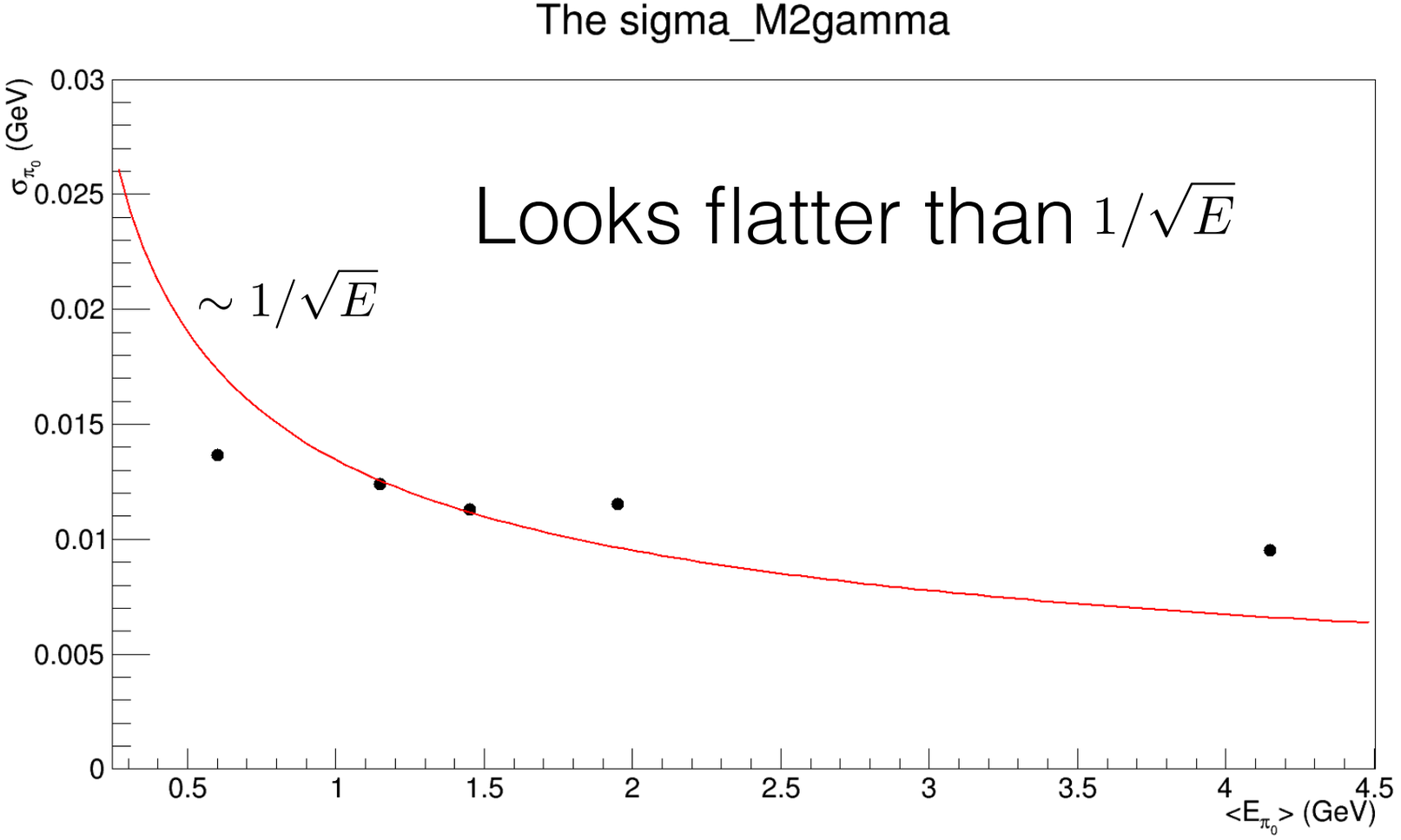
Epi0=1.6-2.3 GeV



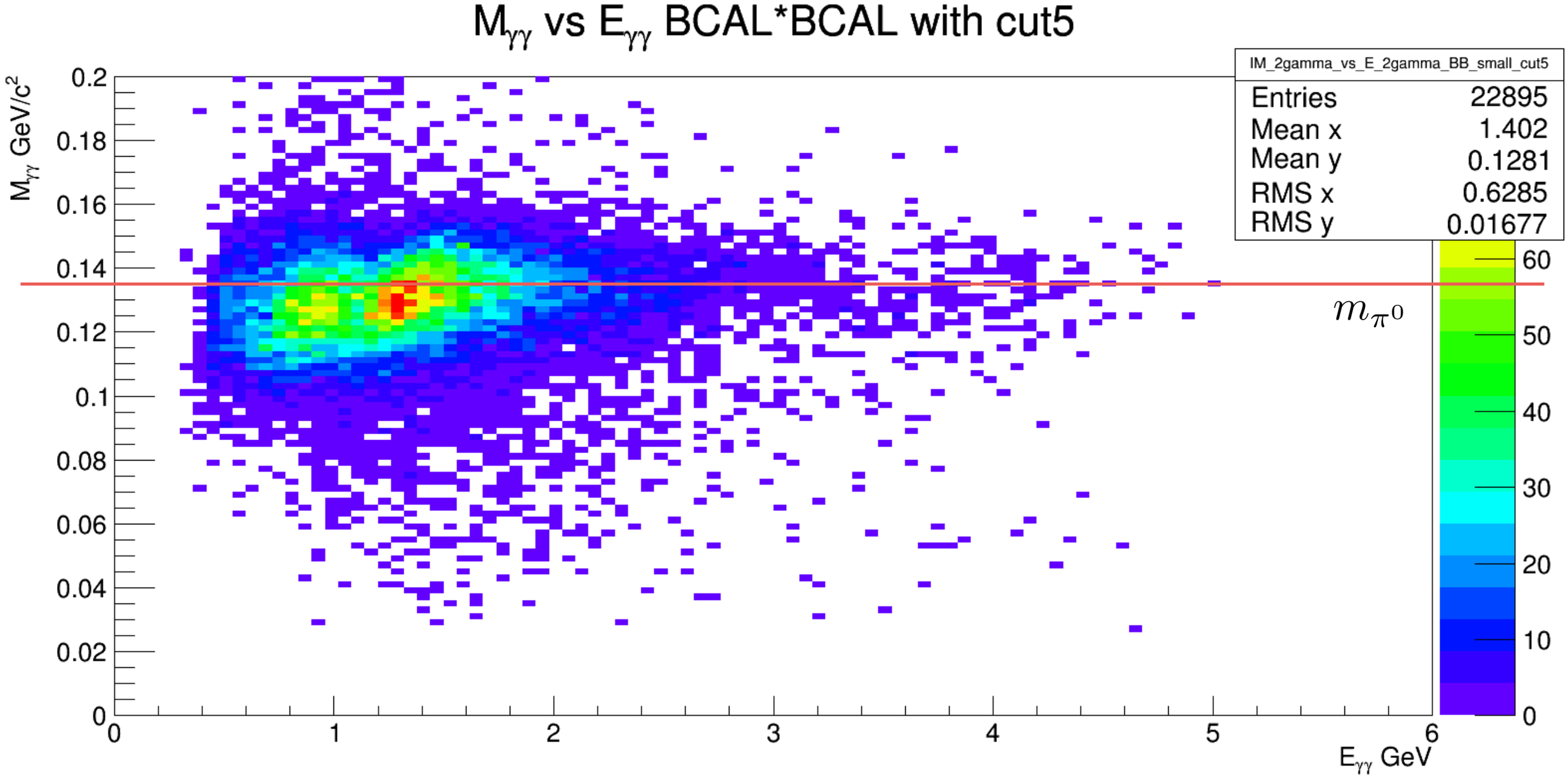
Epi0=2.3-6.0 GeV

The low tail is from BCAL

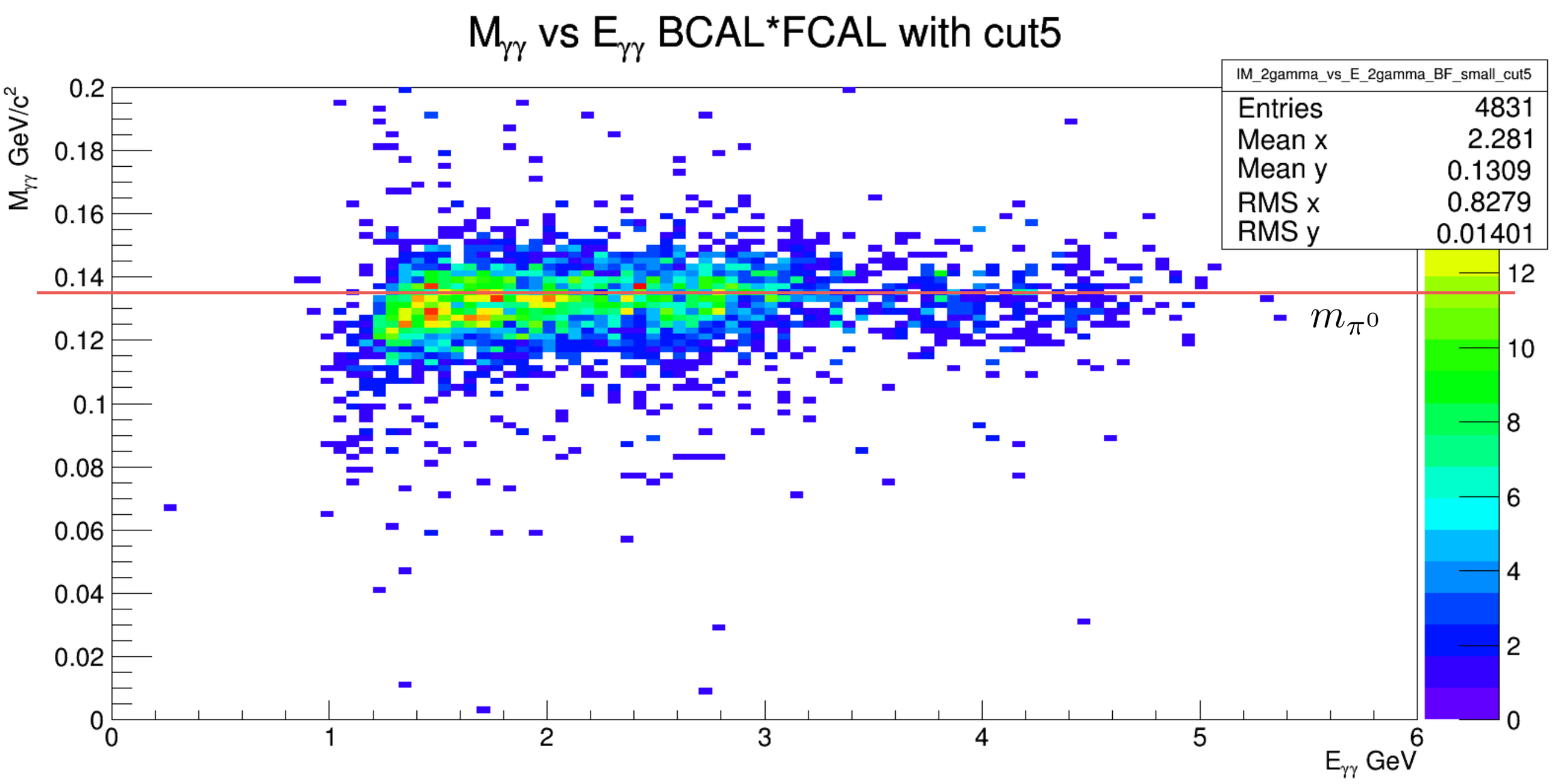

The centroid_M2gamma
m_{π_0} (GeV)
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.5
1
1.5
2
2.5
3
3.5
4
4.5
<E_{π_0}> (GeV)
m_{π^0}


The sigma_M2gamma
σ_{π_0} (GeV)
0.03
0.025
0.02
0.015
0.01
0.005
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
<E_{π_0}> (GeV)
$\sim 1/\sqrt{E}$
Looks flatter than $1/\sqrt{E}$

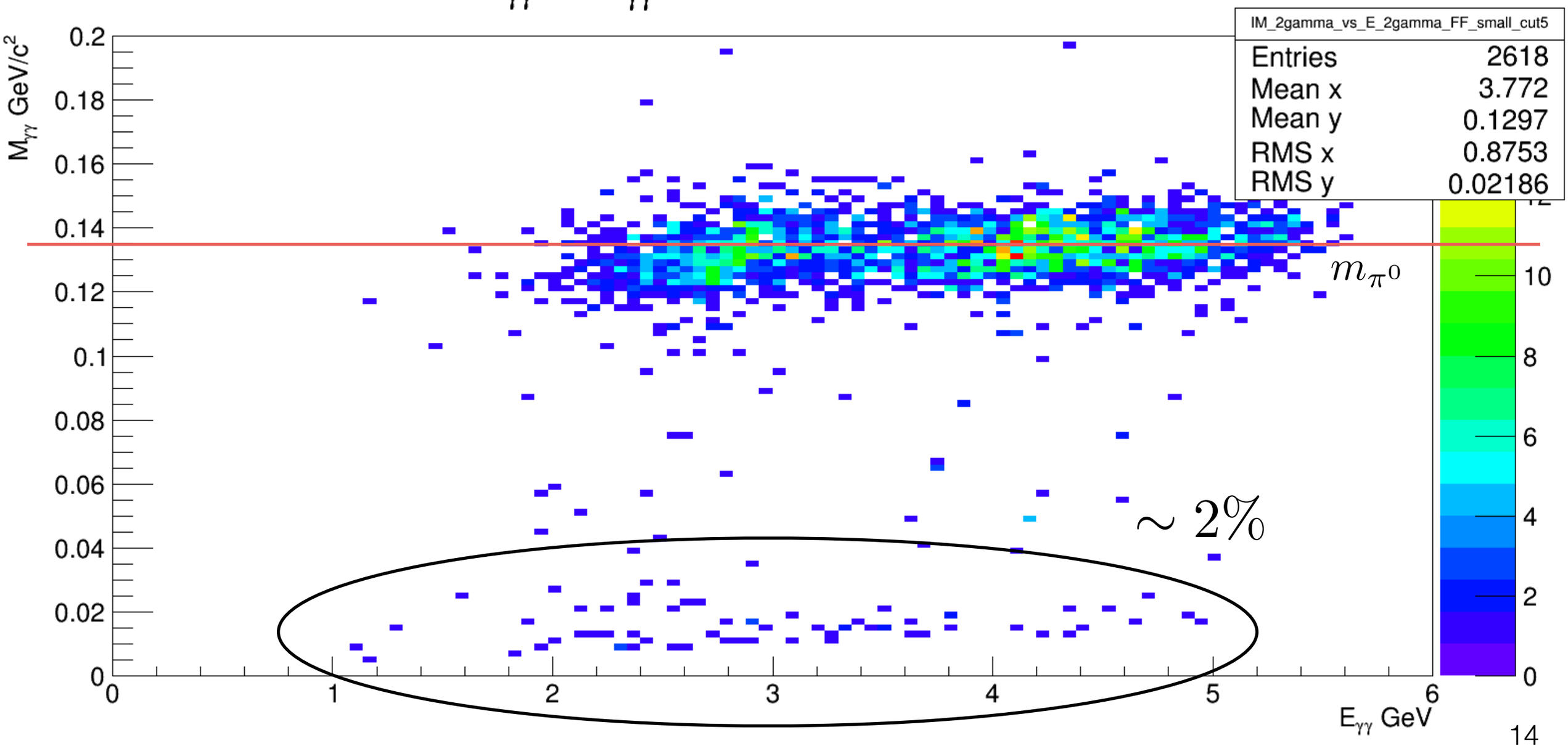
m_2g vs E_2g with both photons hit on BCAL



m_2g vs E_2g with one photon hit on BCAL and one on FCAL



m_2g vs E_2g with both photons hit on FCAL

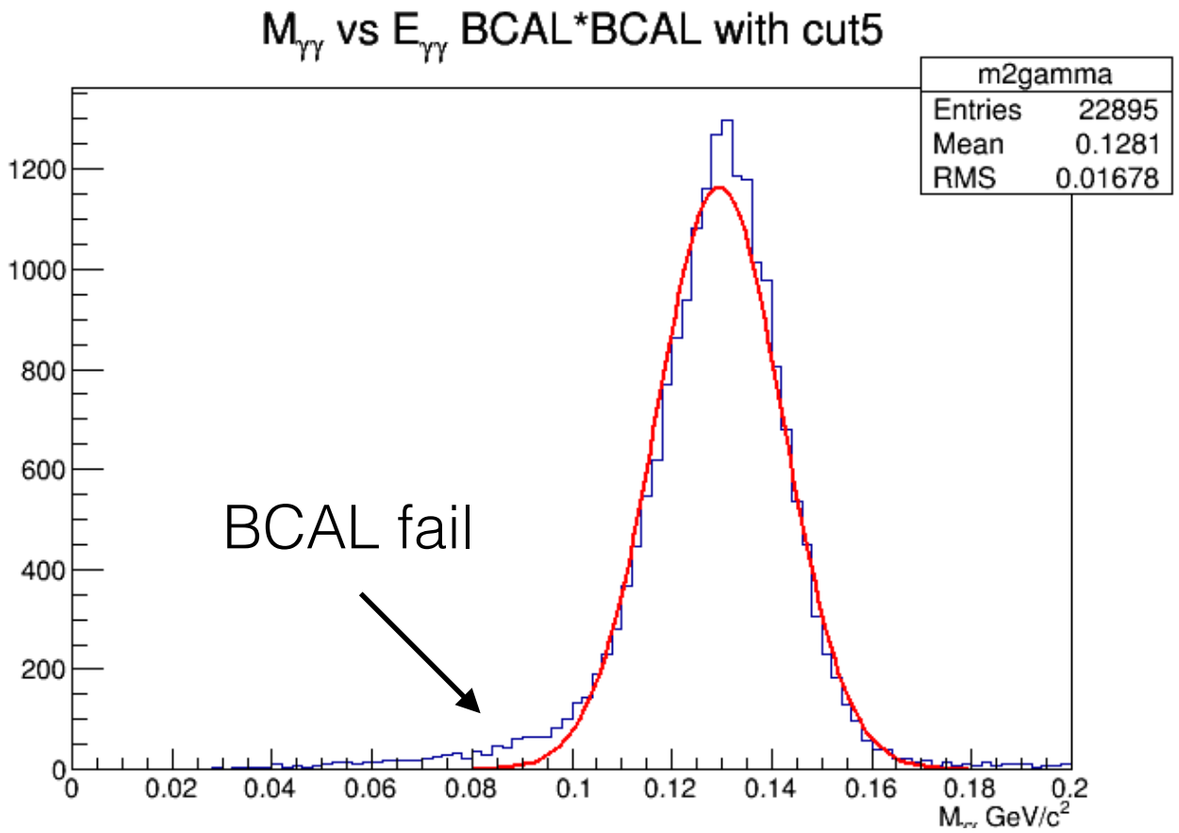


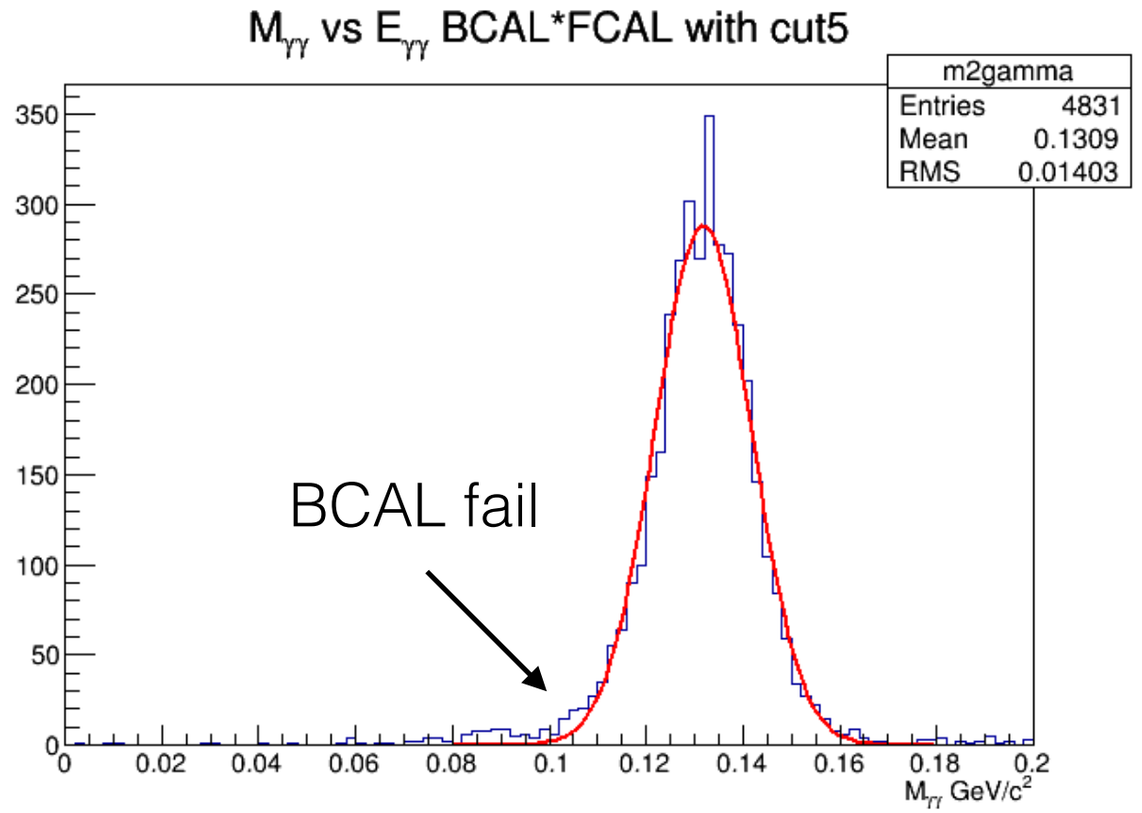
Gaussian fit of pi0
for $BCAL^2$, BCAL*FCAL or $FCAL^2$

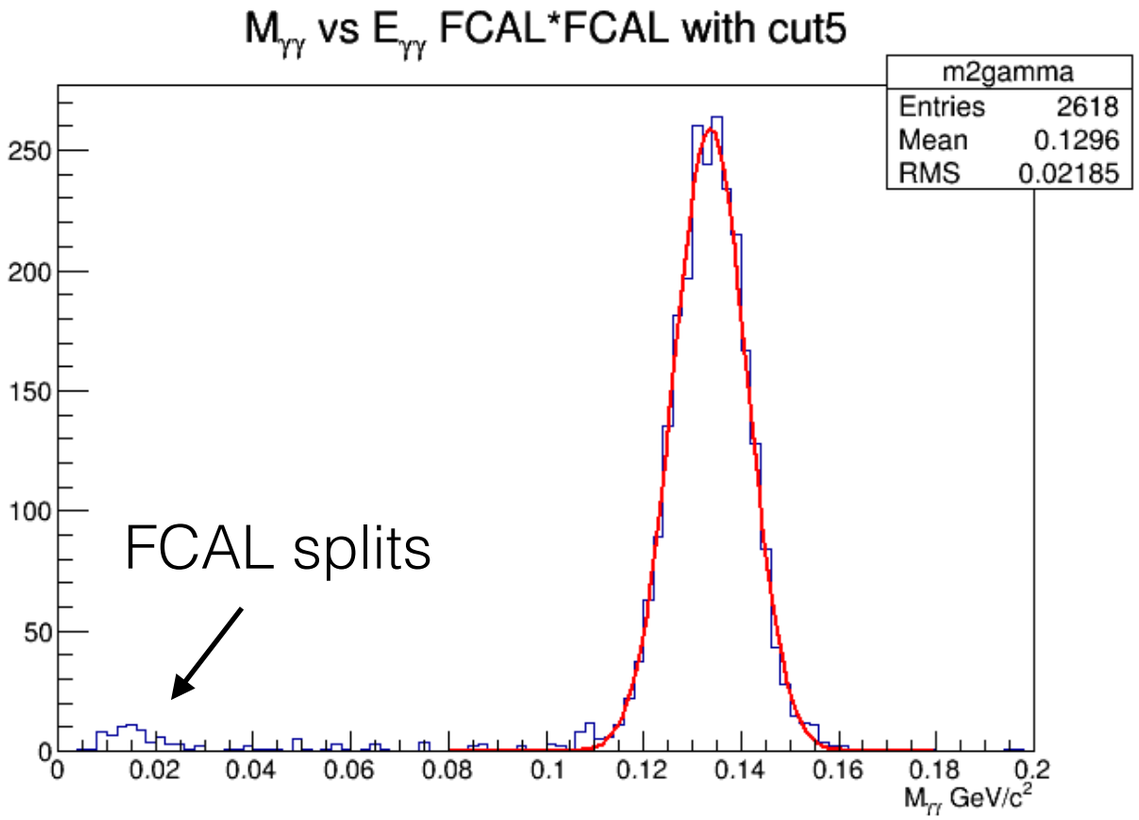
Epi0(GeV)	2 photon on BCAL or FCAL	centroid_M2gamma(GeV)	sigma_M2gamma(GeV)
0.2-6.0 <Epi0>=3.1	BCAL*BCAL	0.1295 +/- 0.0001	0.0126 +/- 0.0001
0.2-6.0 <Epi0>=3.1	BCAL*FCAL	0.1318 +/- 0.0002	0.0100 +/- 0.0002
0.2-6.0 <Epi0>=3.1	FCAL*FCAL	0.1337 +/- 0.0002	0.0075 +/- 0.0001

$$m_{\pi^0} = 0.135$$

Most of these are probably energy dependence


$M_{\gamma\gamma}$ vs $E_{\gamma\gamma}$ BCAL*BCAL with cut5
m2gamma
Entries 22895
Mean 0.1281
RMS 0.01678
BCAL fail
$M_{\gamma\gamma}$ GeV/c^2


$M_{\gamma\gamma}$ vs $E_{\gamma\gamma}$ BCAL*FCAL with cut5
m2gamma
Entries 4831
Mean 0.1309
RMS 0.01403
BCAL fail
$M_{\gamma\gamma}$ GeV/c^2

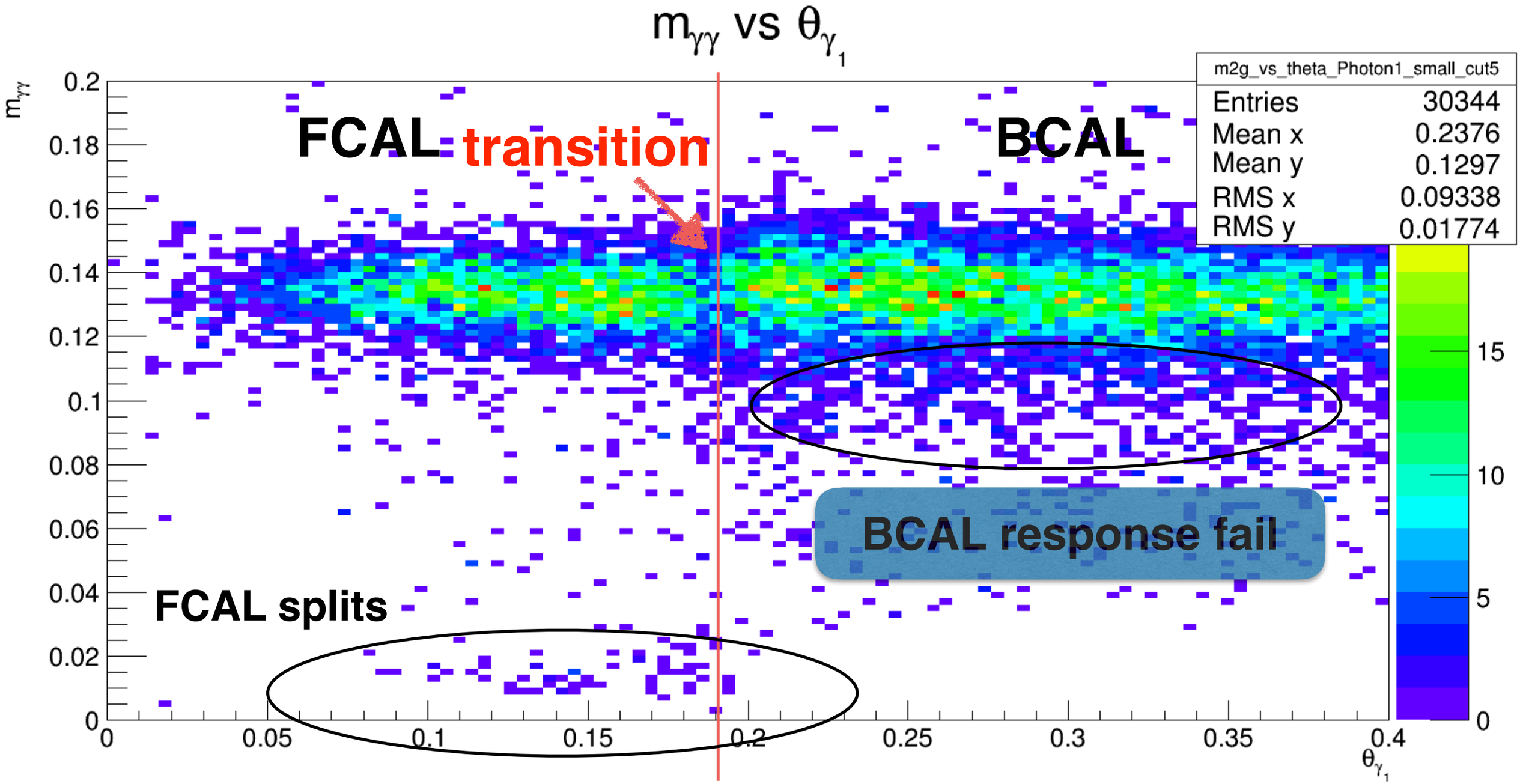

$M_{\gamma\gamma}$ vs $E_{\gamma\gamma}$ FCAL*FCAL with cut5
m2gamma
Entries 2618
Mean 0.1296
RMS 0.02185
FCAL splits
$M_{\gamma\gamma}$ GeV/c^2

M_2gamma vs theta_gamma

a check for photon reconstruction near FCAL/BCAL boundary

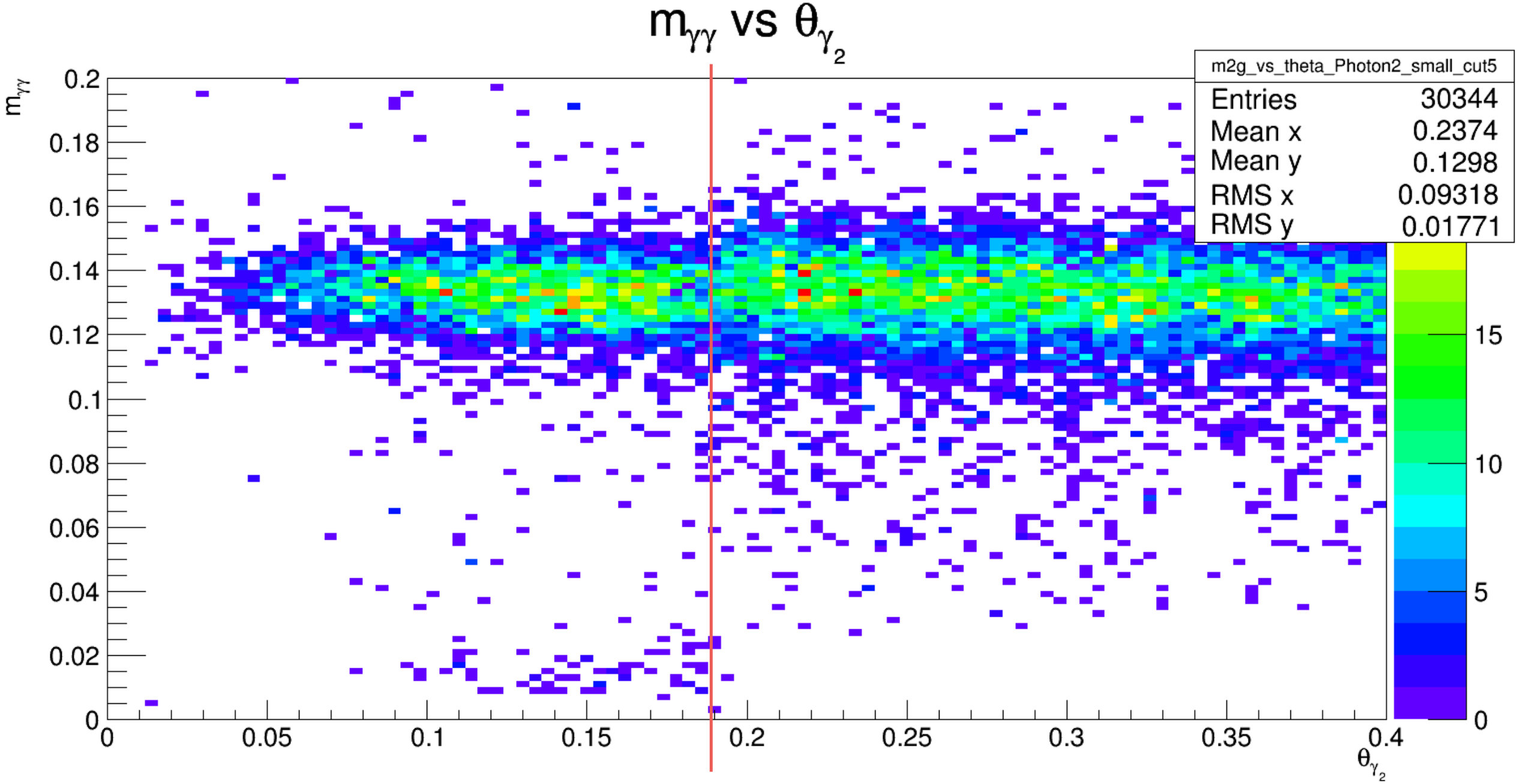
M2gamma vs theta for only one of the gamas

$11^\circ \sim 0.19$



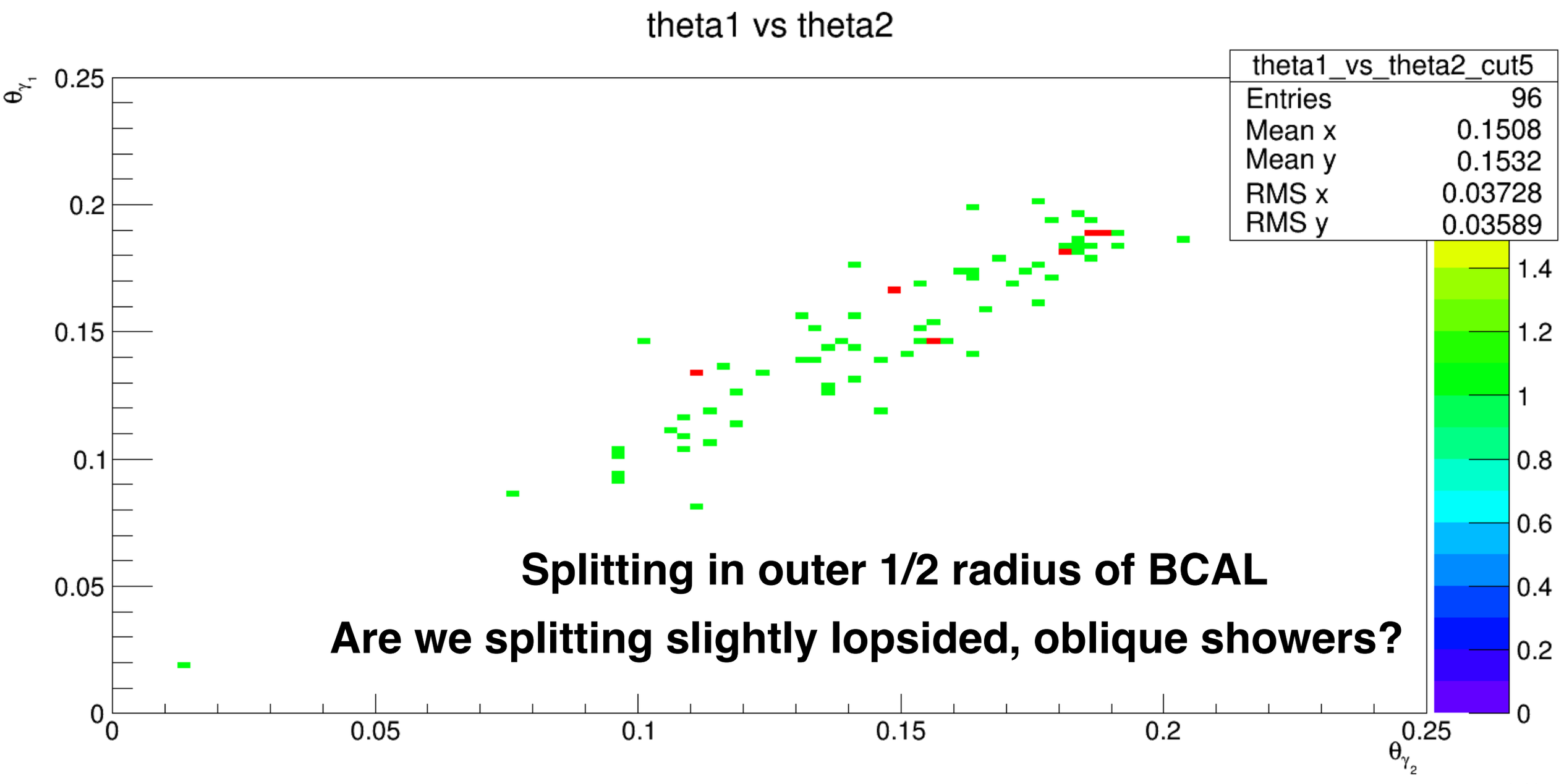
M2gamma vs theta for only one of the gamas

$11^\circ \sim 0.19$



theta1 vs theta2 with m_2g <0.04

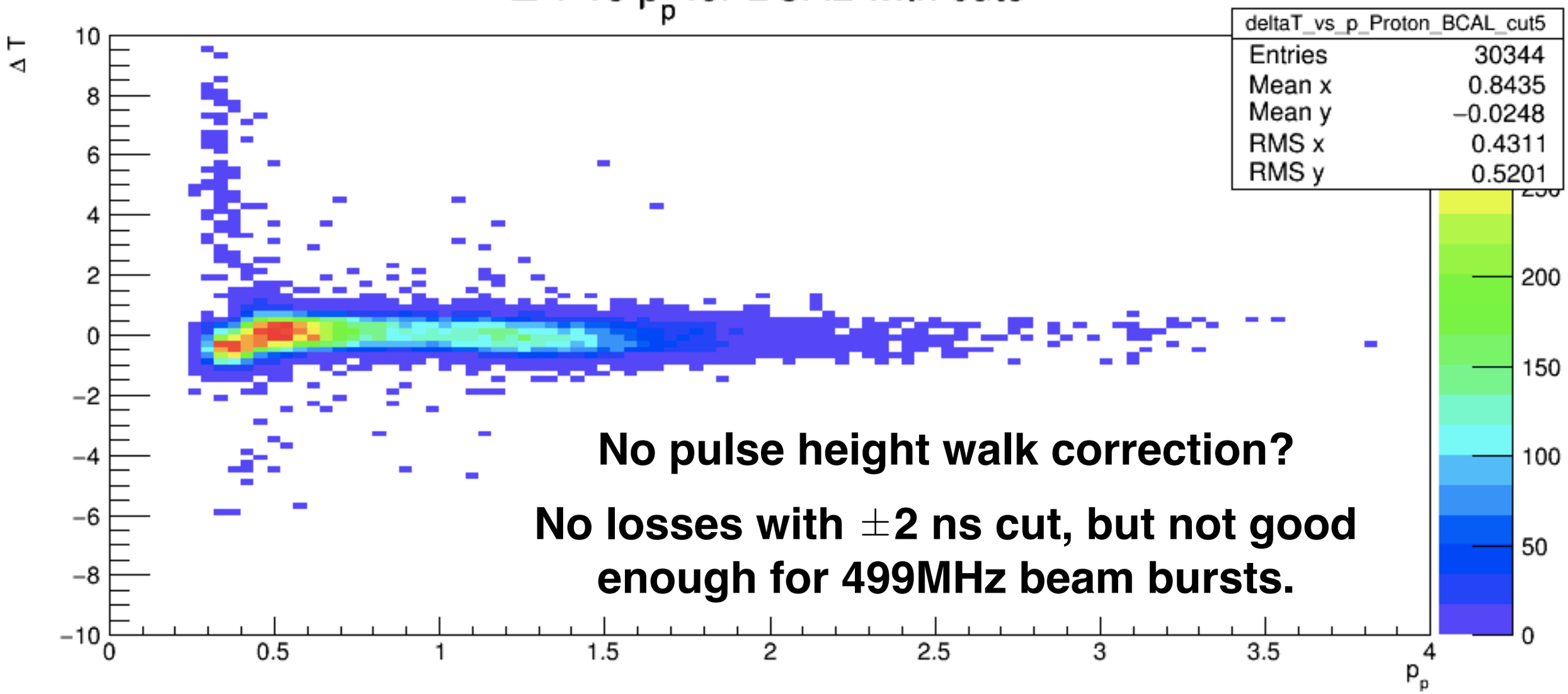
$11^\circ \sim 0.19$

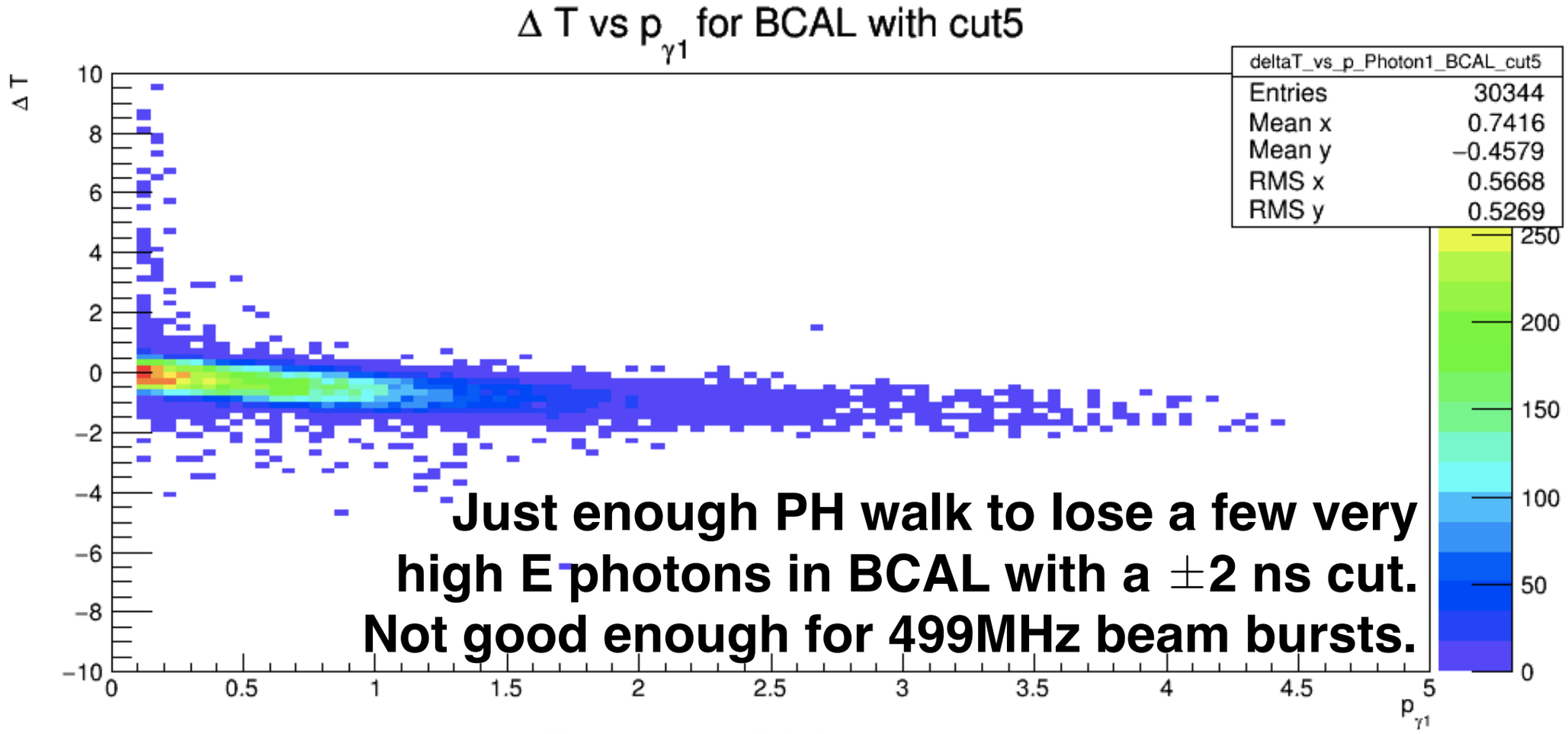


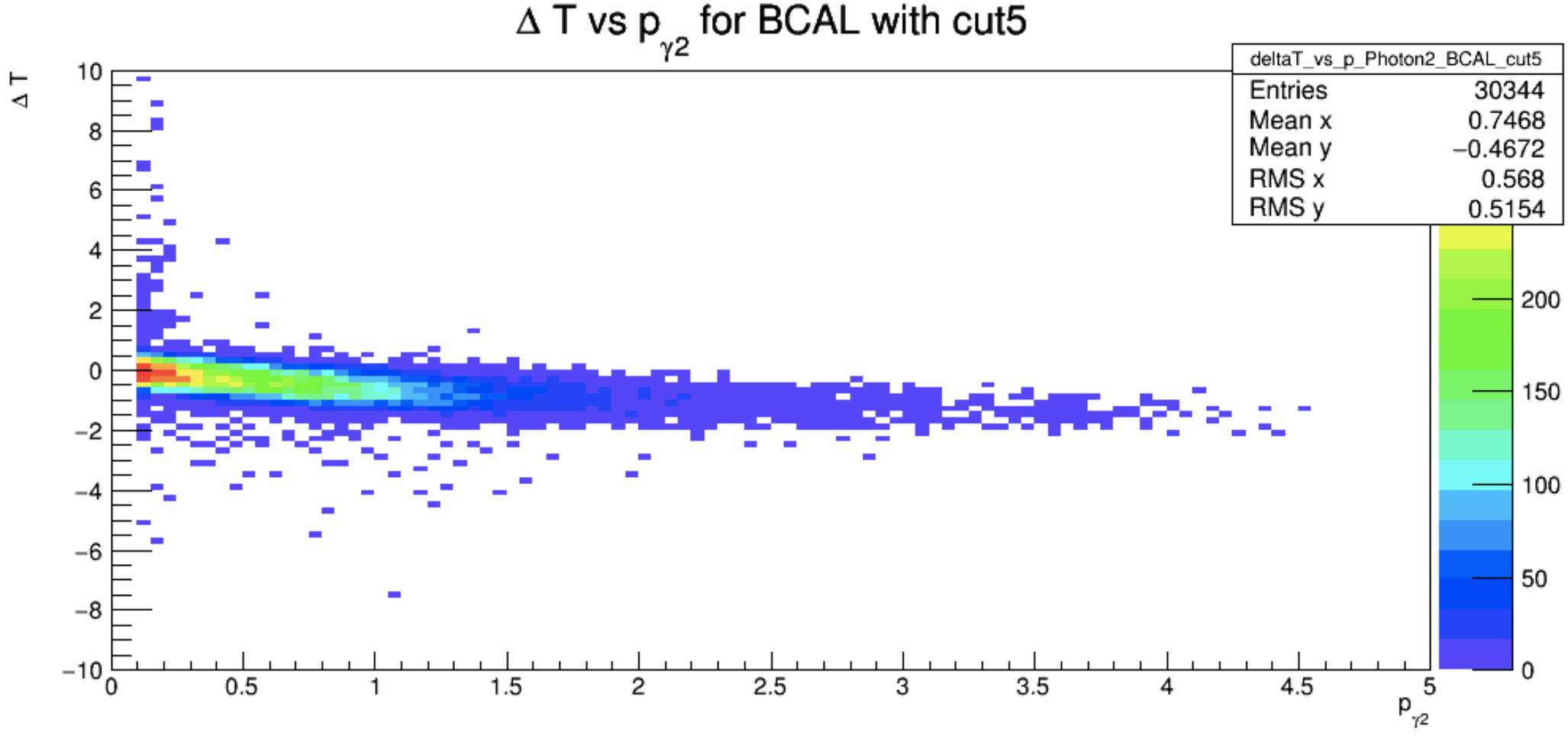
delta_T vs p plots

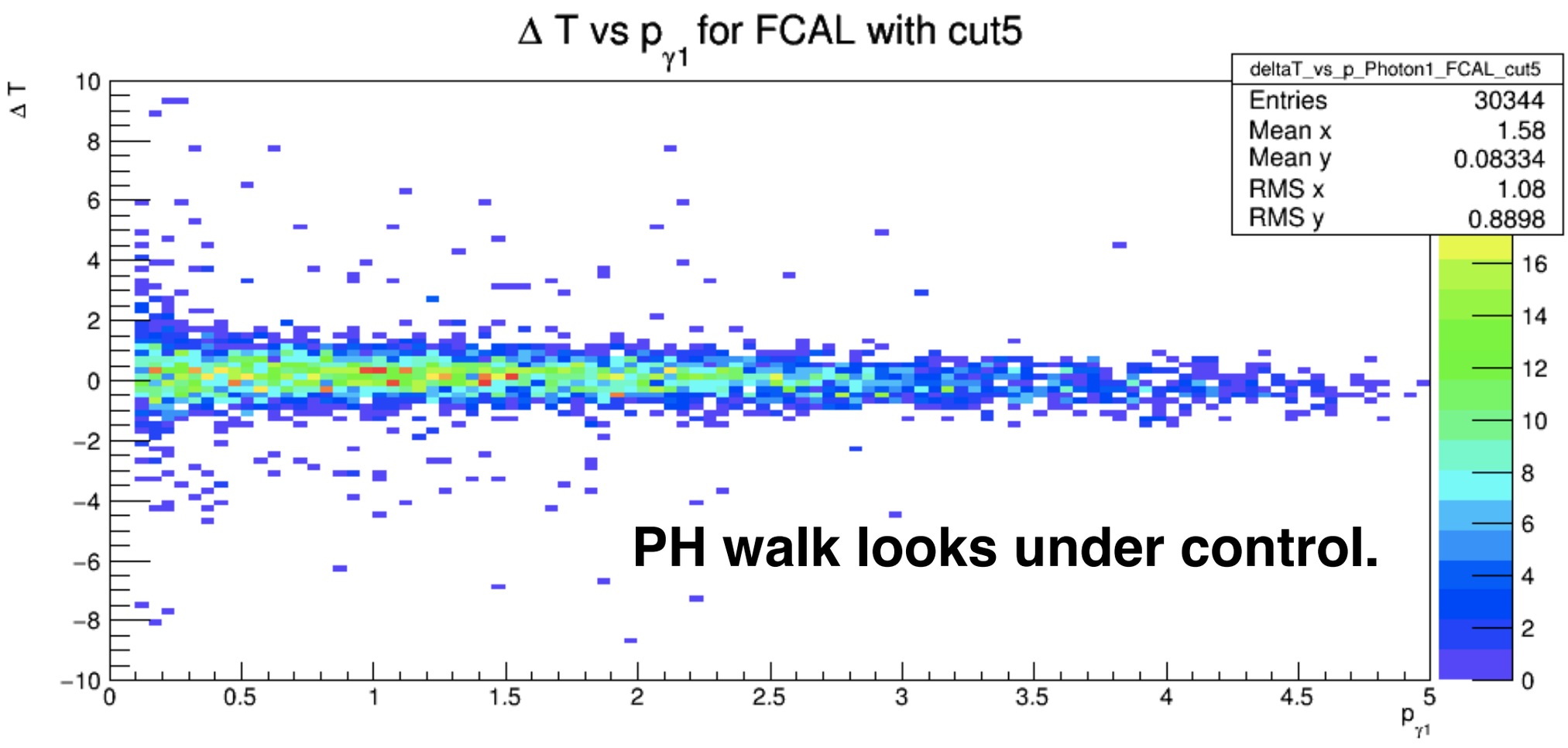
a check for the delta_T conditions

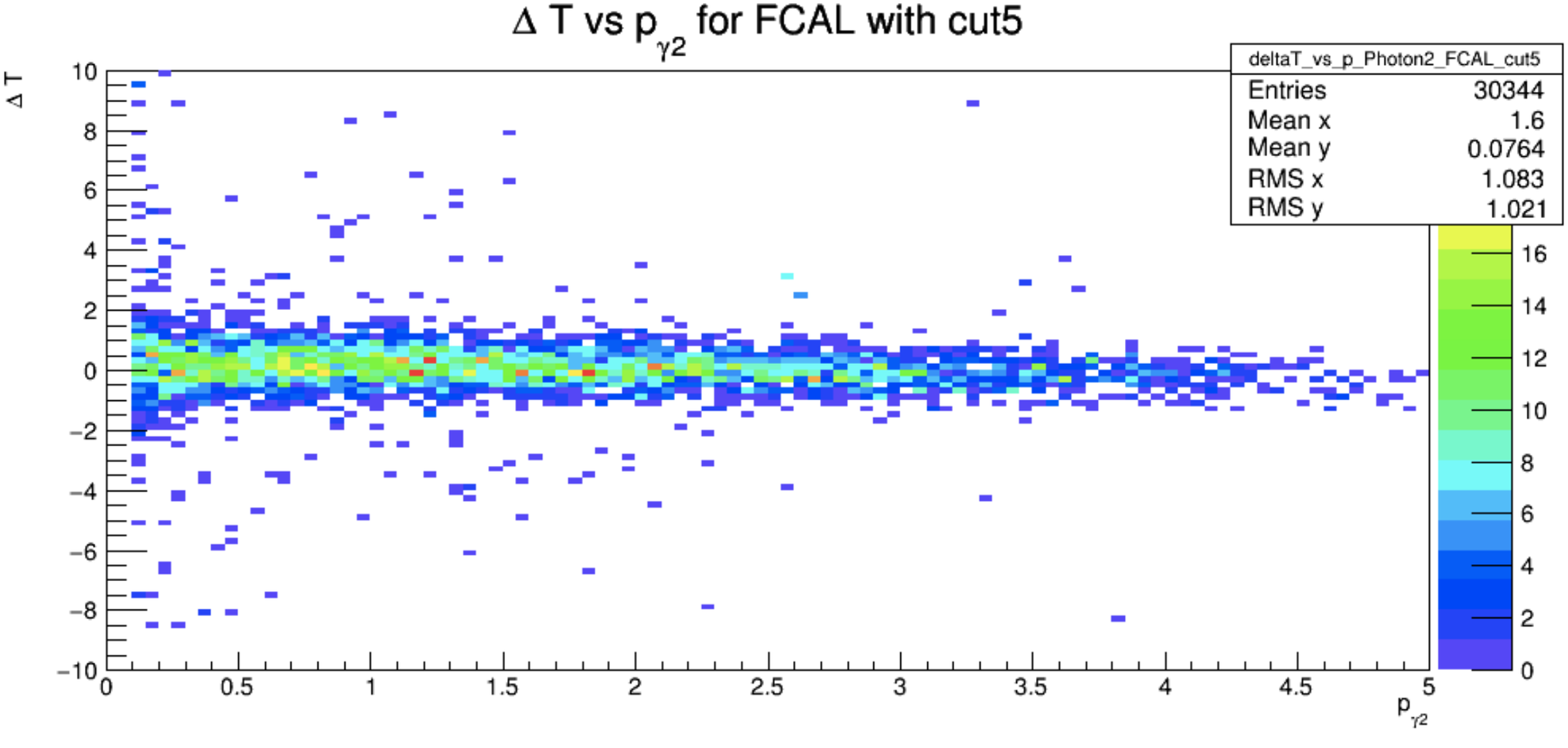
Delta T vs p for proton (BCAL)




Δ T vs p γ1 for BCAL with cut5
deltaT_vs_p_Photon1_BCAL_cut5
Entries 30344
Mean x 0.7416
Mean y −0.4579
RMS x 0.5668
RMS y 0.5269
Δ T
p γ1
Just enough PH walk to lose a few very high E photons in BCAL with a ±2 ns cut.
Not good enough for 499MHz beam bursts.

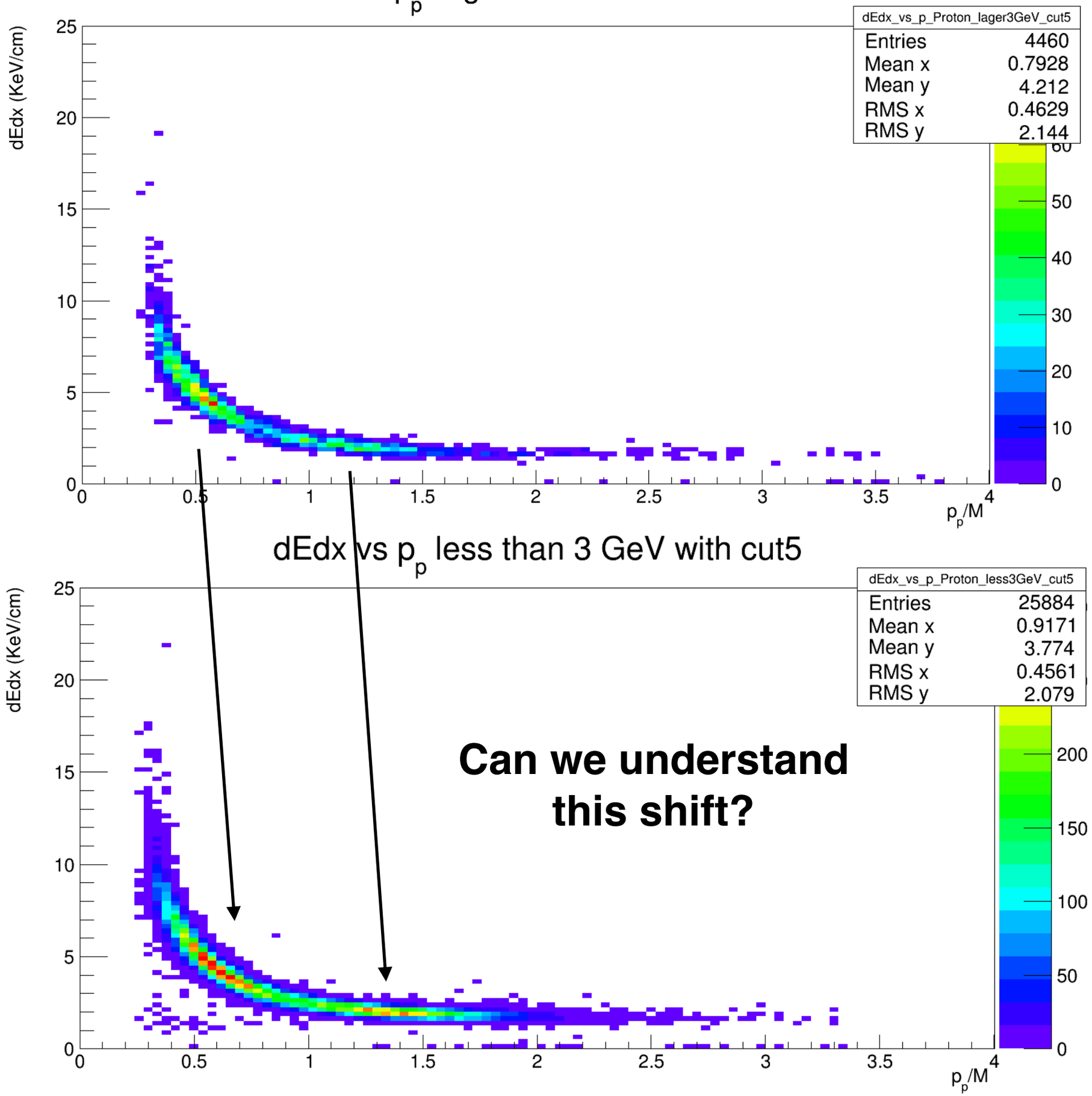

Δ T vs p γ2 for BCAL with cut5
deltaT_vs_p_Photon2_BCAL_cut5
Entries 30344
Mean x 0.7468
Mean y −0.4672
RMS x 0.568
RMS y 0.5154
Δ T
p γ2


Δ T vs p γ1 for FCAL with cut5
deltaT_vs_p_Photon1_FCAL_cut5
Entries 30344
Mean x 1.58
Mean y 0.08334
RMS x 1.08
RMS y 0.8898
Δ T
p γ1
PH walk looks under control.

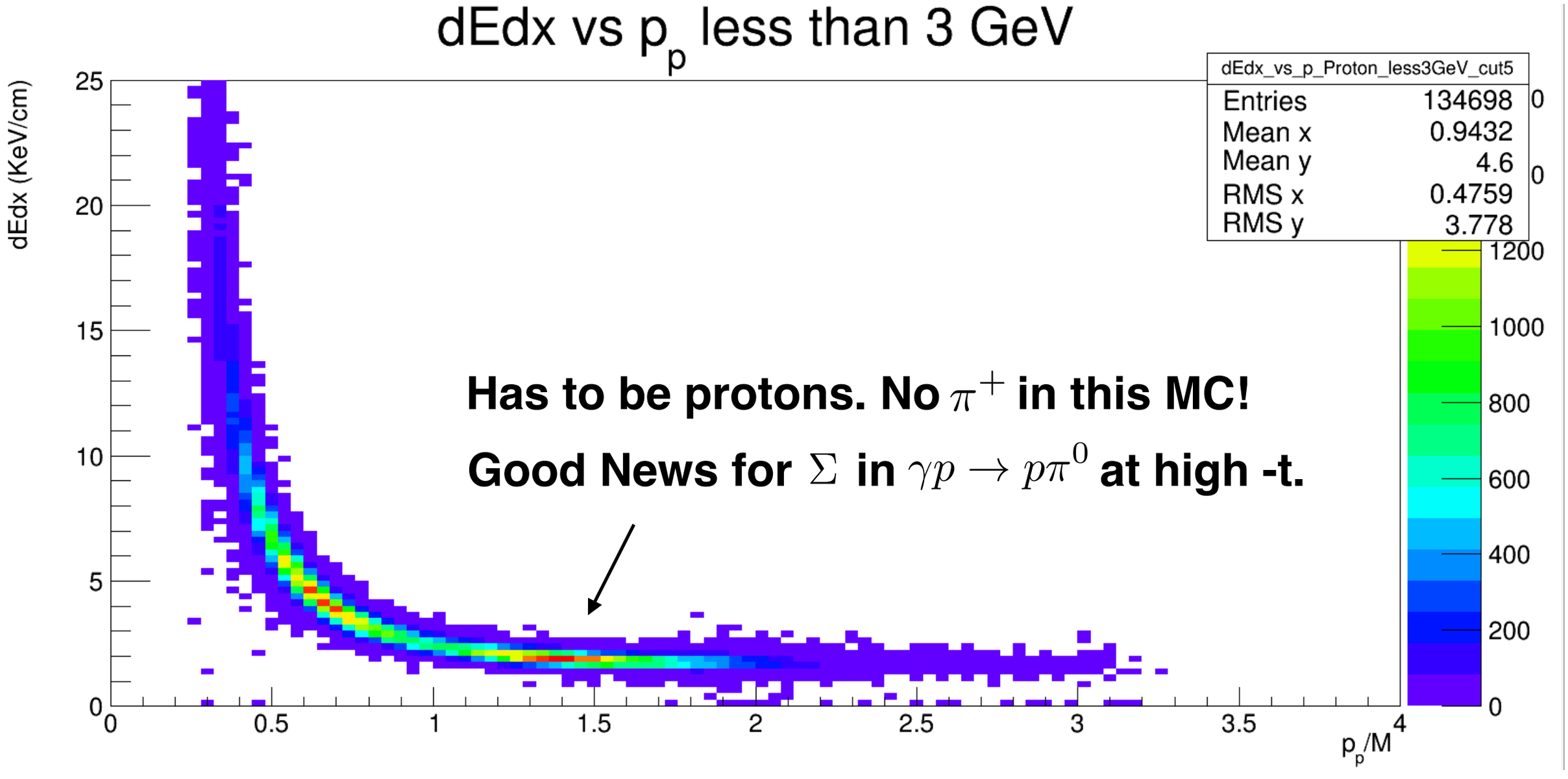

Δ T vs p γ2 for FCAL with cut5
deltaT_vs_p_Photon2_FCAL_cut5
Entries 30344
Mean x 1.6
Mean y 0.0764
RMS x 1.083
RMS y 1.021
Δ T
p γ2

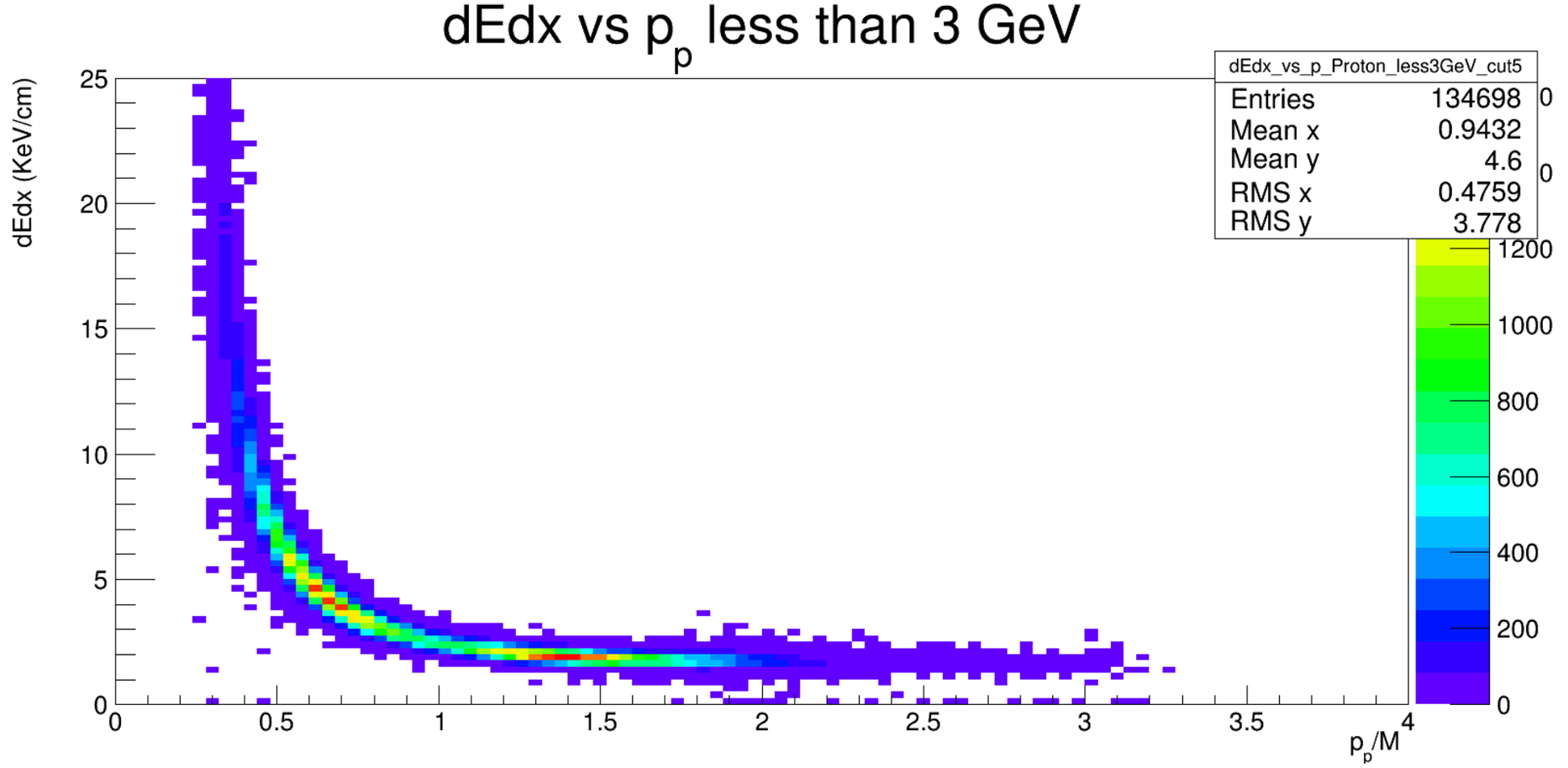
dE/dx plots vs p plots

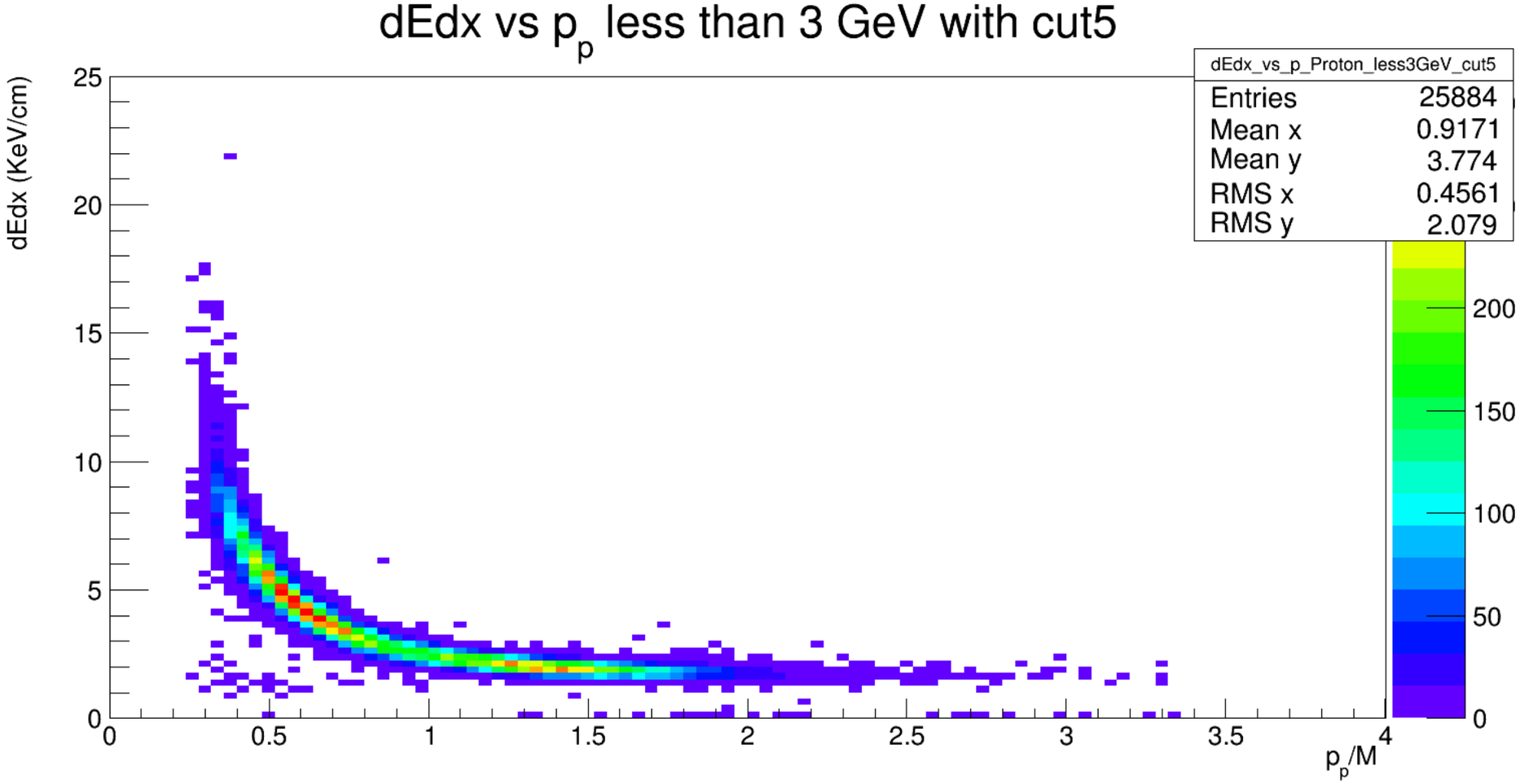
a check for pion background


dEdx vs p_p larger than 3 GeV with cut5
dEdx_vs_p_Proton_lager3GeV_cut5
Entries 4460
Mean x 0.7928
Mean y 4.212
RMS x 0.4629
RMS y 2.144
dEdx (KeV/cm)
p_p/M
dEdx vs p_p less than 3 GeV with cut5
dEdx_vs_p_Proton_less3GeV_cut5
Entries 25884
Mean x 0.9171
Mean y 3.774
RMS x 0.4561
RMS y 2.079
dEdx (KeV/cm)
p_p/M
Can we understand this shift?

dEdx vs p for signal MC (SAID mode)




dEdx vs p_p less than 3 GeV
dEdx_vs_p_Proton_less3GeV_cut5
Entries 134698
Mean x 0.9432
Mean y 4.6
RMS x 0.4759
RMS y 3.778
dEdx (KeV/cm)
p_p/M


dEdx vs p_p less than 3 GeV with cut5
dEdx_vs_p_Proton_less3GeV_cut5
Entries 25884
Mean x 0.9171
Mean y 3.774
RMS x 0.4561
RMS y 2.079
dEdx (KeV/cm)
p_p/M

Summary

- It seems low energy photon reconstruction has unresolved systematic issues. The problem may comes from BCAL.
- There is a hole near FCAL/BCAL boundary, not too bad.
- No much losses with 2 ns cut for delta T, but not good enough for 499MHz beam bursts.
- The locus at higher momentum is physics and not a large pi+ background leaking in.

Thanks!