Status of $\eta \to \pi\pi\gamma$ Analysis

Di Donato and Jacewicz

Analysis Scheme

- Event Signature:
  - ≥2 PNC: $|t_{cl}-l_{cl}/c|<5\sigma_t$ ⇒Only2 PNC with $E_\gamma \geq 10$ MeV: and $|t_{cl}-l_{cl}/c|<5\sigma_t$
  - Recoil photon: most energetic cluster with $E_\gamma \geq 250$ MeV
  - 2 tracks closest to IP (using PCA, no vertex requirement)
- Kinematical Constraints:
  - Two body ϕ decay kinematics to calculate E_γ recoil
  - η kinematics to calculate γ_η
  - γ_η : $|E_t-P_t|<10$ MeV (EtPt)
  - Best Photon: we choose one PNC with $\theta<0.2$ rad to the calculated γ_η (OPAN) ⇒No Chooise But still a good variable to reject background: fine tuning of the cut

Analysis Scheme

Main background is $\phi \to \pi^+\pi^-\pi^0$ (B:S=200:1): $M(\gamma_\phi\,\gamma_\eta) \sim M\pi^0$

- **ANGLE**: reject background *eeg*100
- Barrel cut: γ_ϕ only from the barrel
- **No Cut on cosθ $\gamma_\phi\,\gamma_\eta$ (**Background hypothesys: in the π^0 rest frame)

Combined fit to cosθ $\gamma_\phi\,\gamma_\eta$ and $M(\gamma_\phi\,\gamma_\eta)$ with two background contribution to fit Signal/ background fraction from MC to data.

Data-MC comparison and OpAnMin distribution: cluster split effect? We think no!

Recover Split

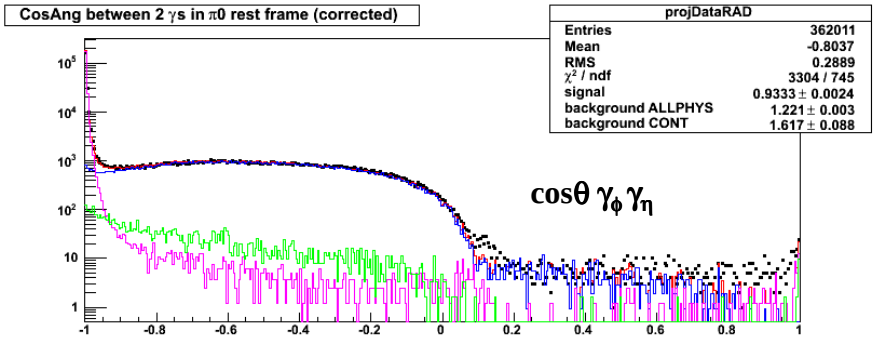
- We investigated Recover split effect, looking at the two stream separately
- Data-MC comparison has been done:
  - at preselection level
  - with barrel cut
  - with banana cut,

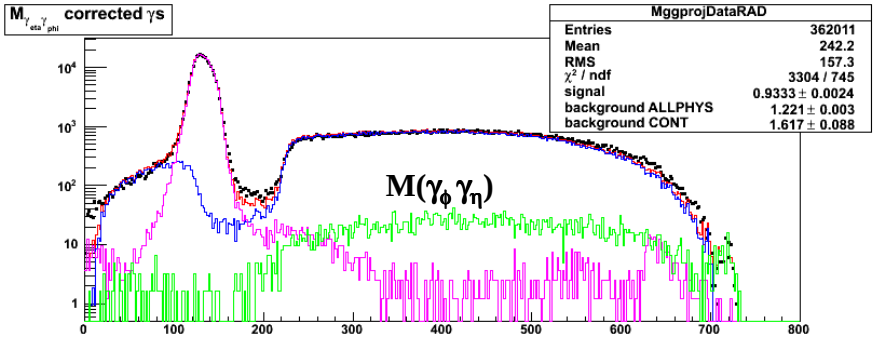
without **cos**θ γ_ϕ γ_η cut, and comparing the spectra normalized using the results from combined fit to cosθ γ_ϕ γ_η and M(γ_ϕ γ_η)

- OpAnMin in xy-plane and z has been investigated

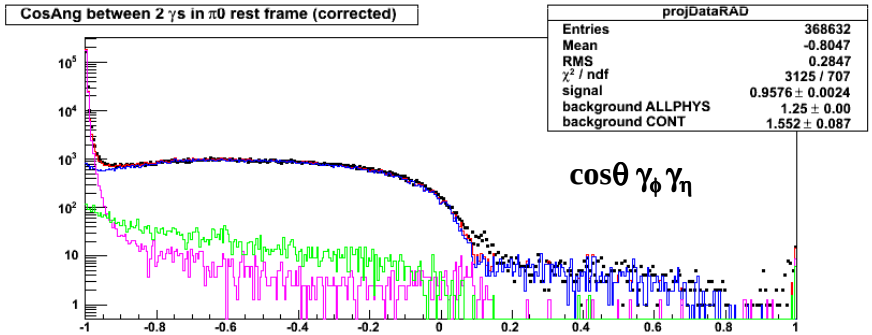
RAD: PreSelAngle

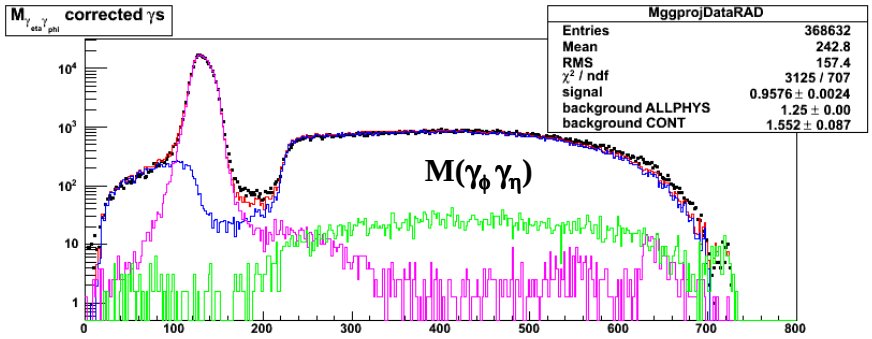
No RecoverSplit

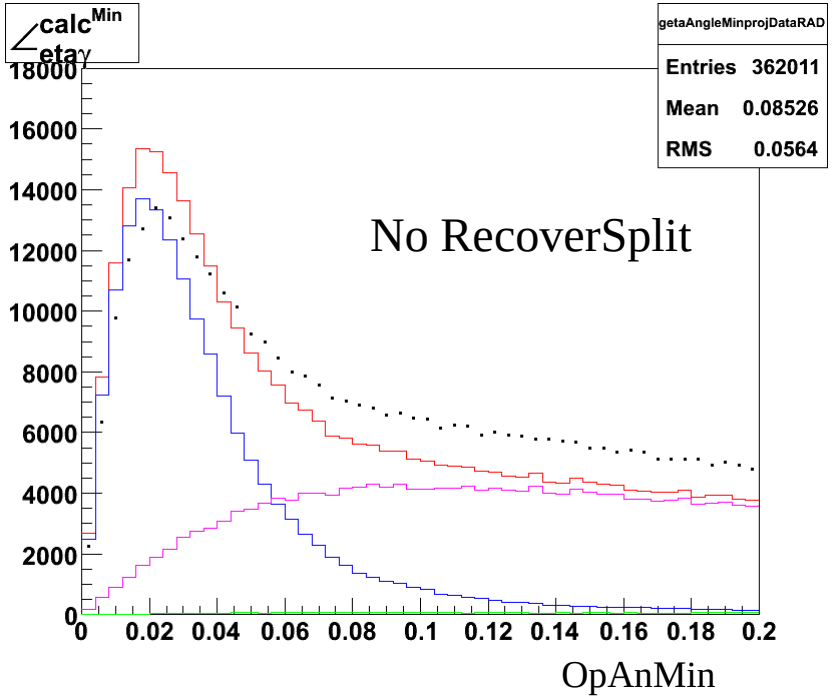


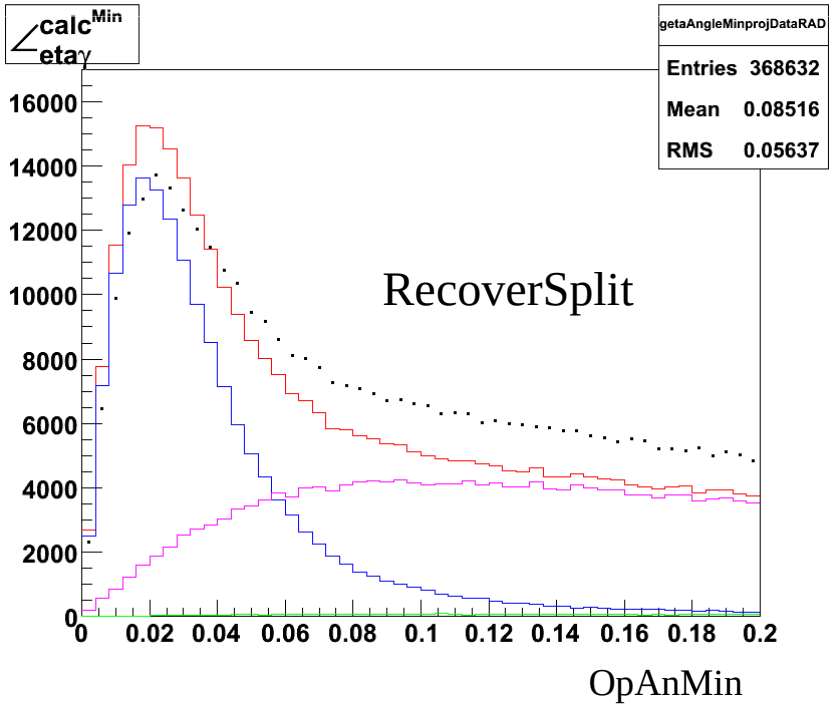


RecoverSplit



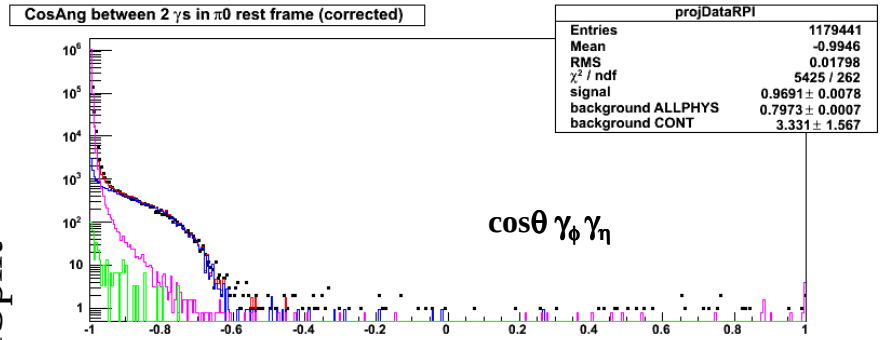


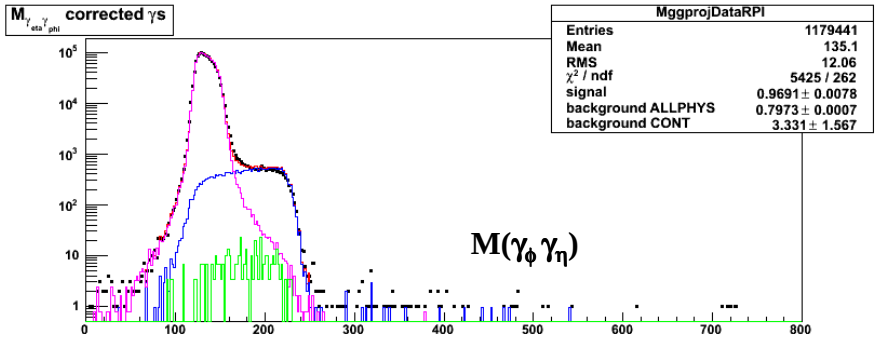




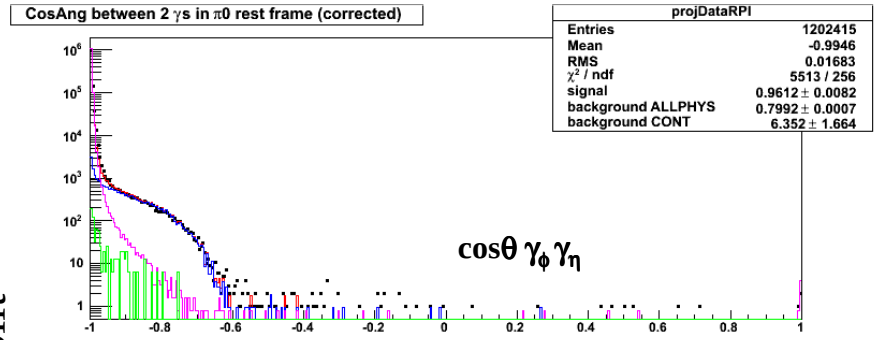
RPI: PreSelAngle

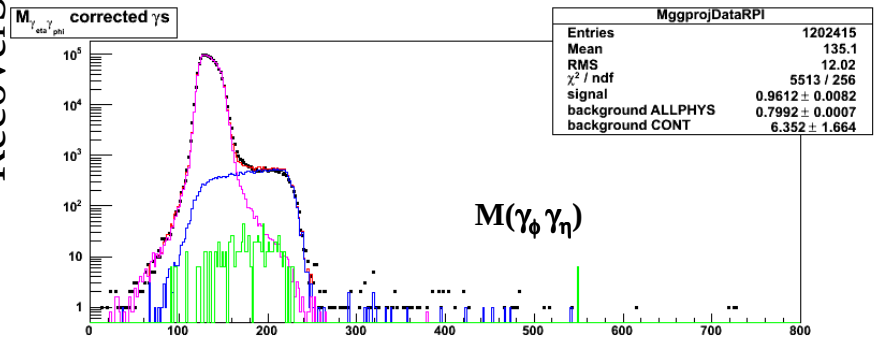
No RecoverSplit

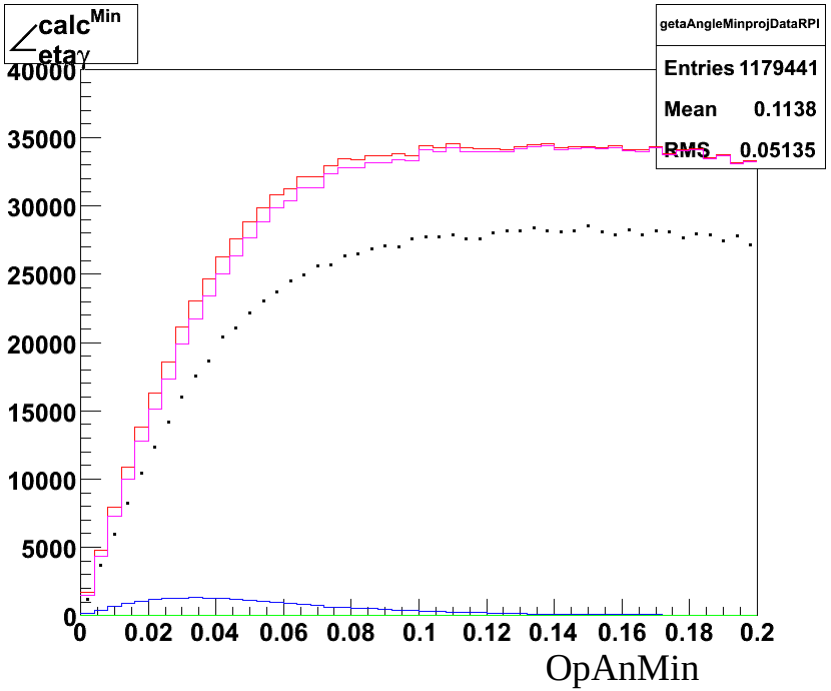


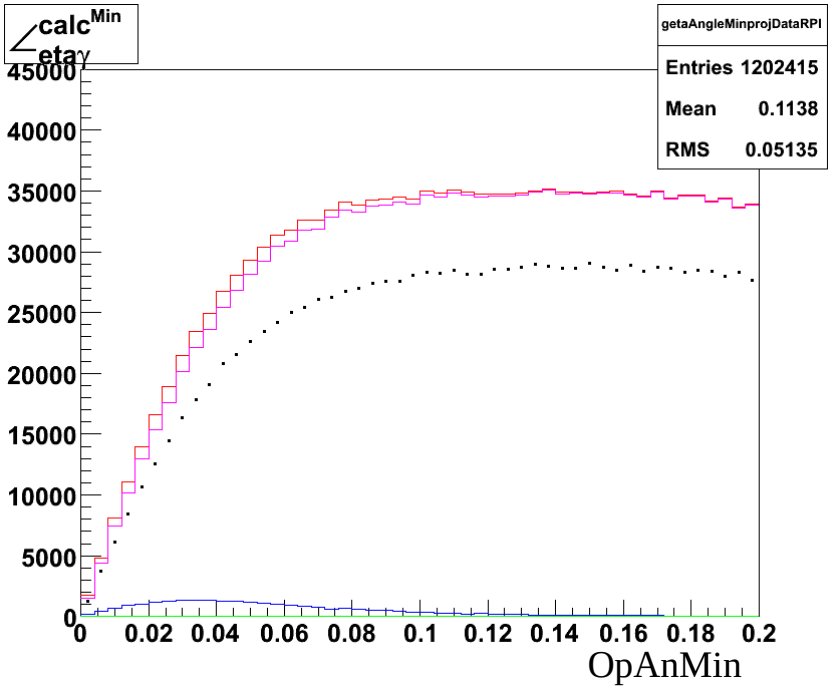


RecoverSplit



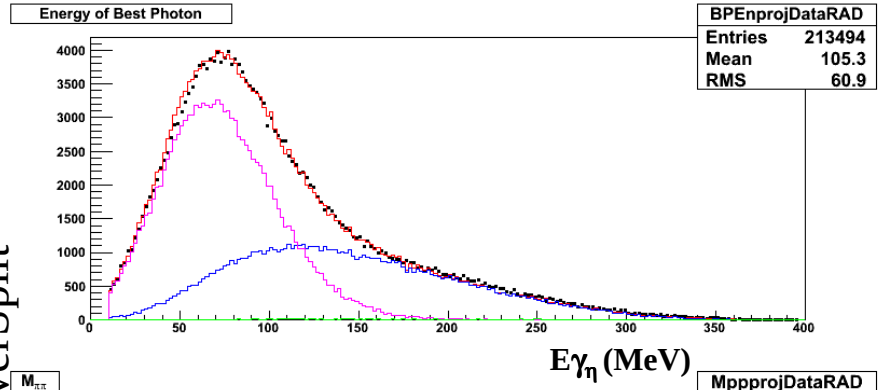


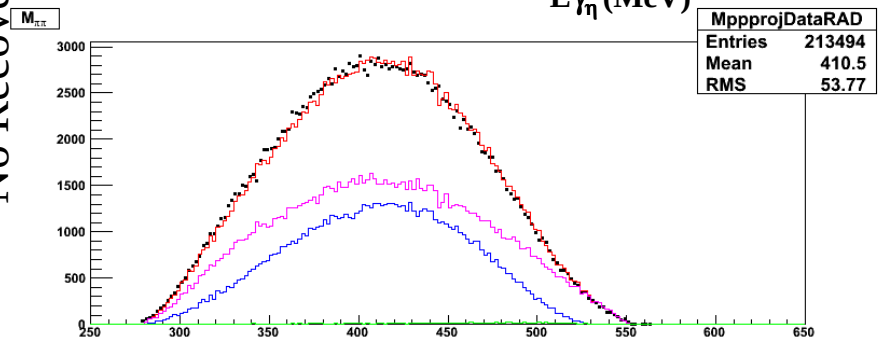




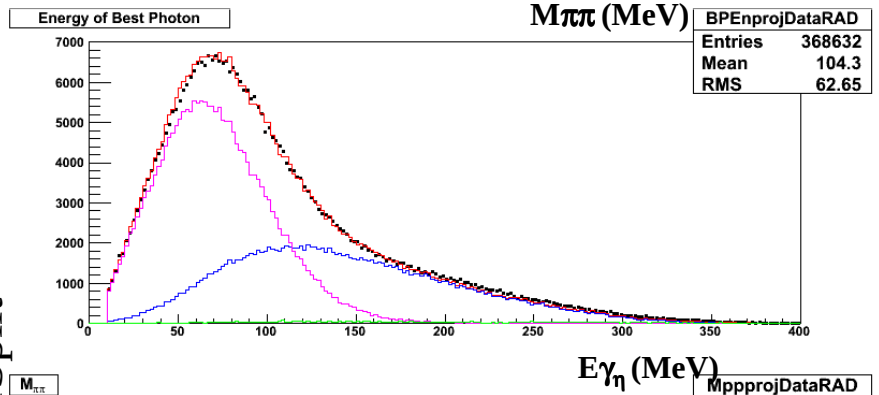
RAD/RPI: PreSelAngle

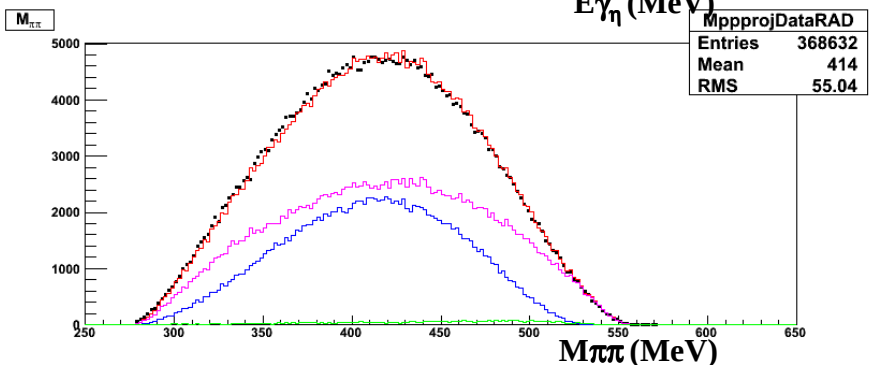
No RecoverSplit

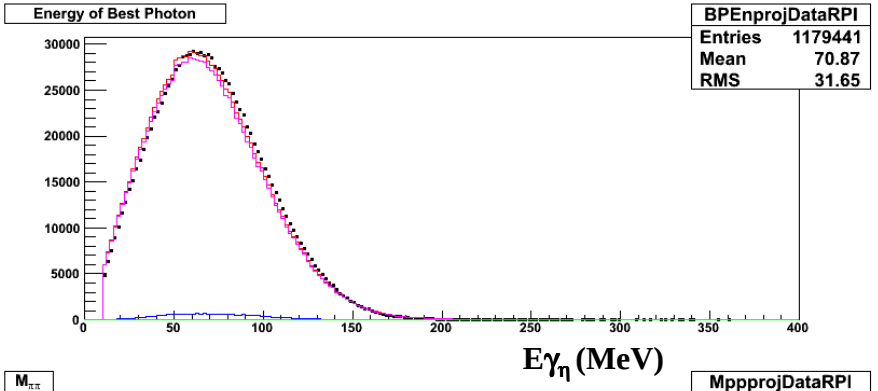


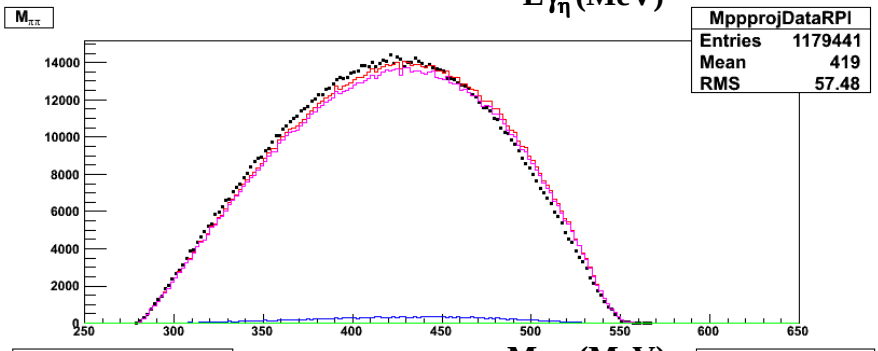


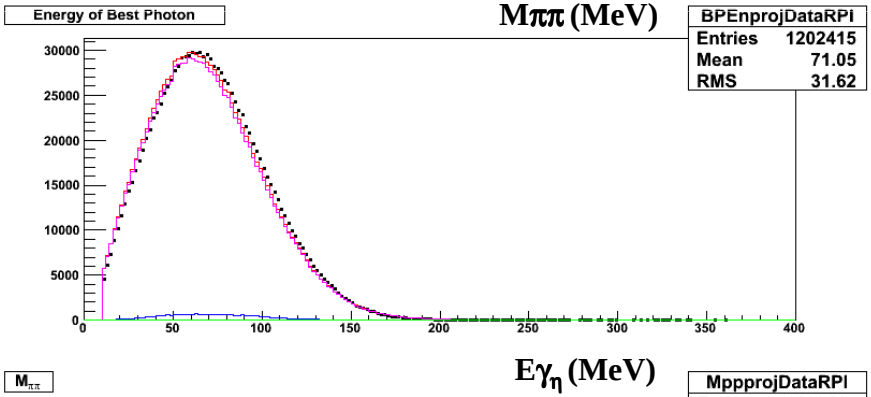
RecoverSplit

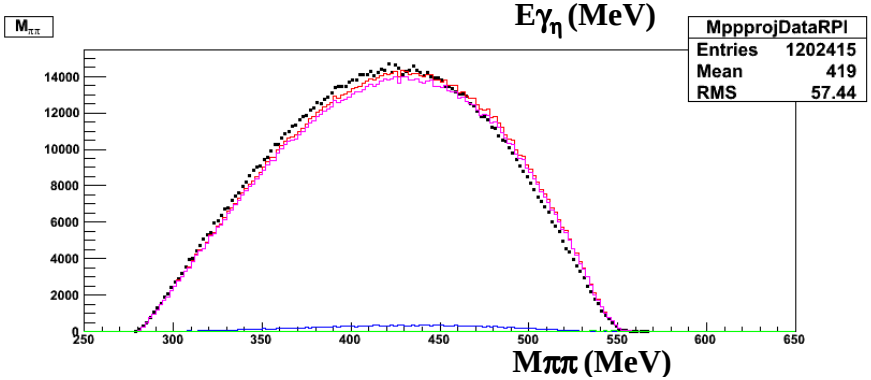






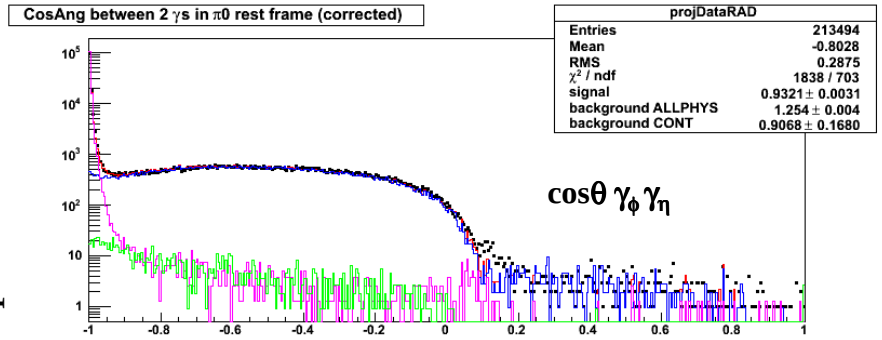


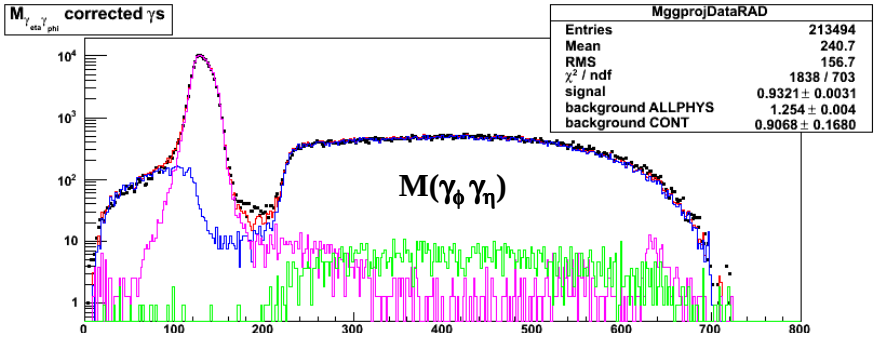


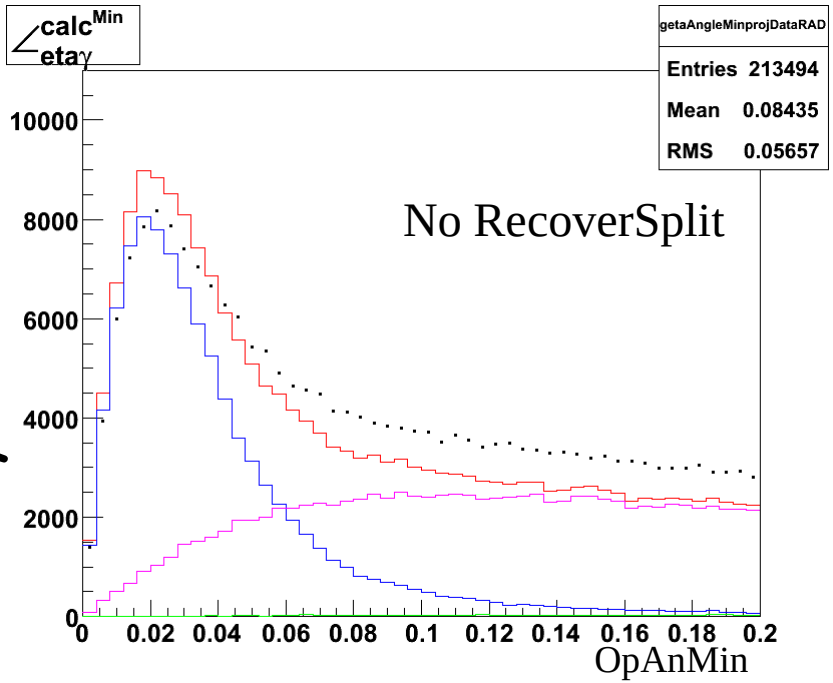


RAD: OnlyBarrel

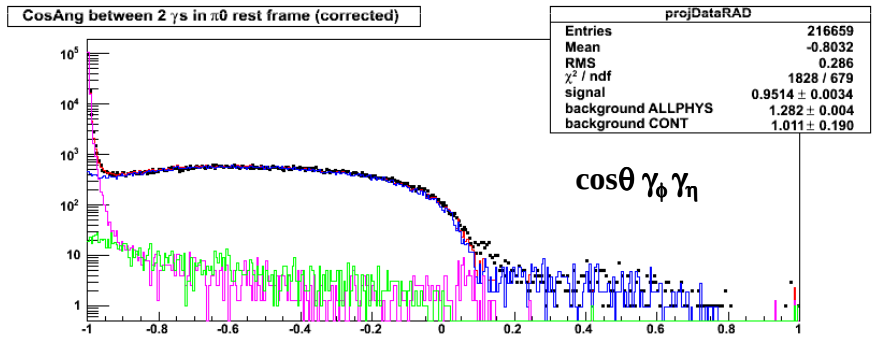
No RecoverSplit

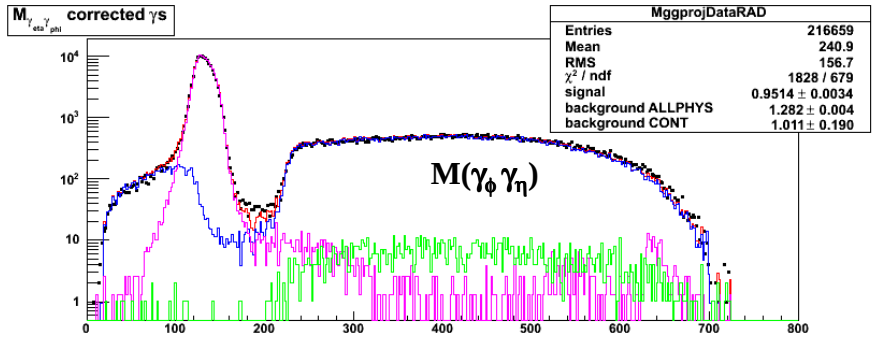


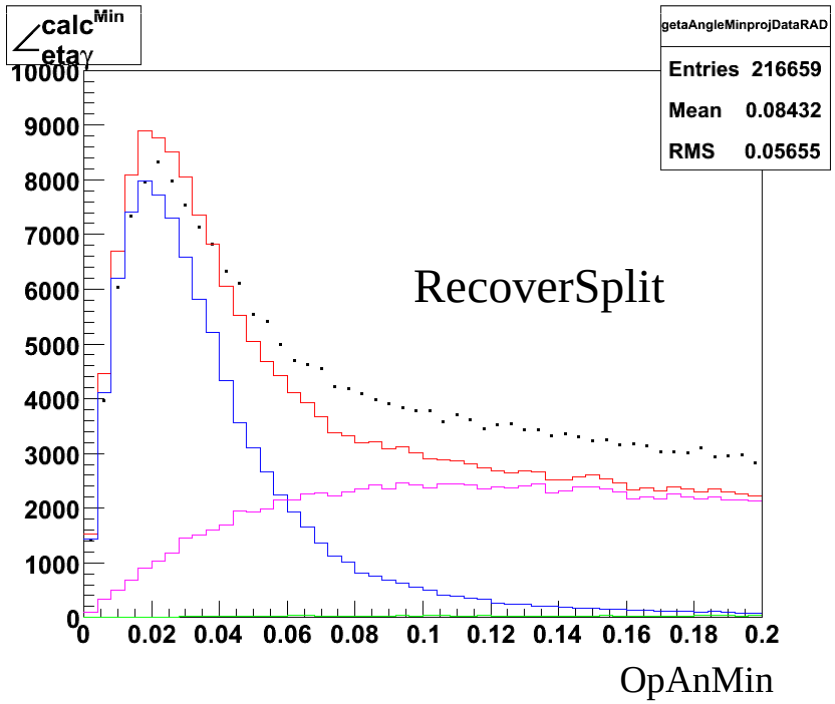




RecoverSplit

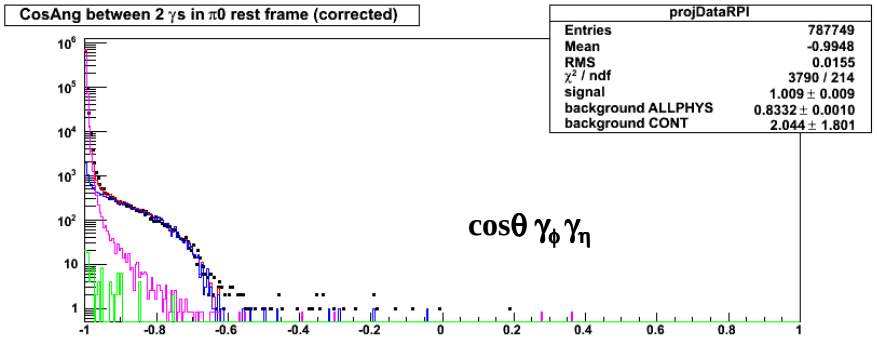


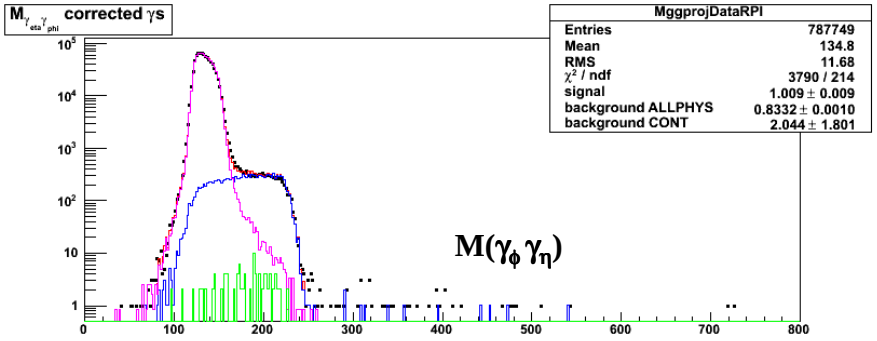


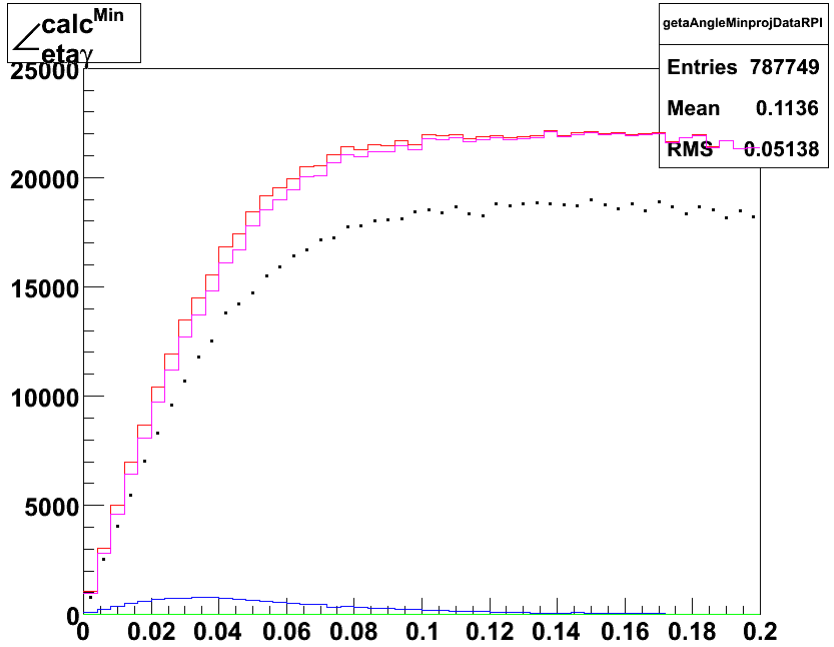


RPI: OnlyBarrel

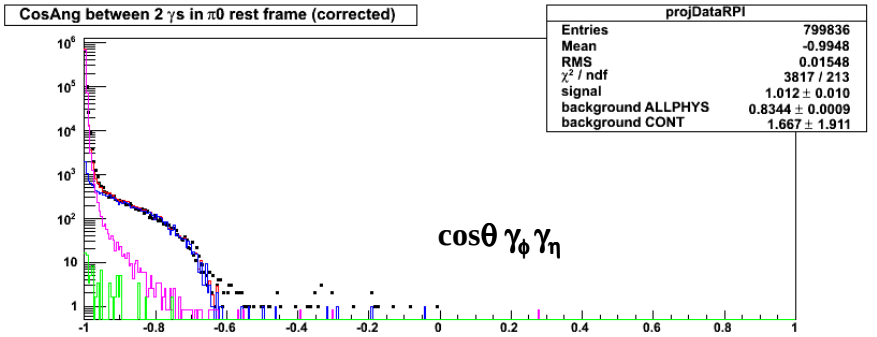
No RecoverSplit

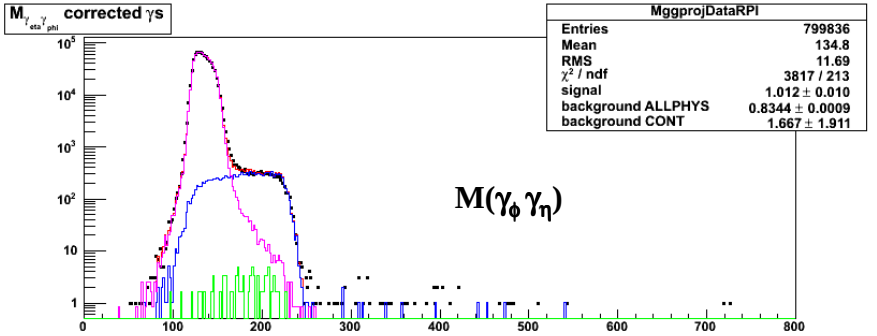


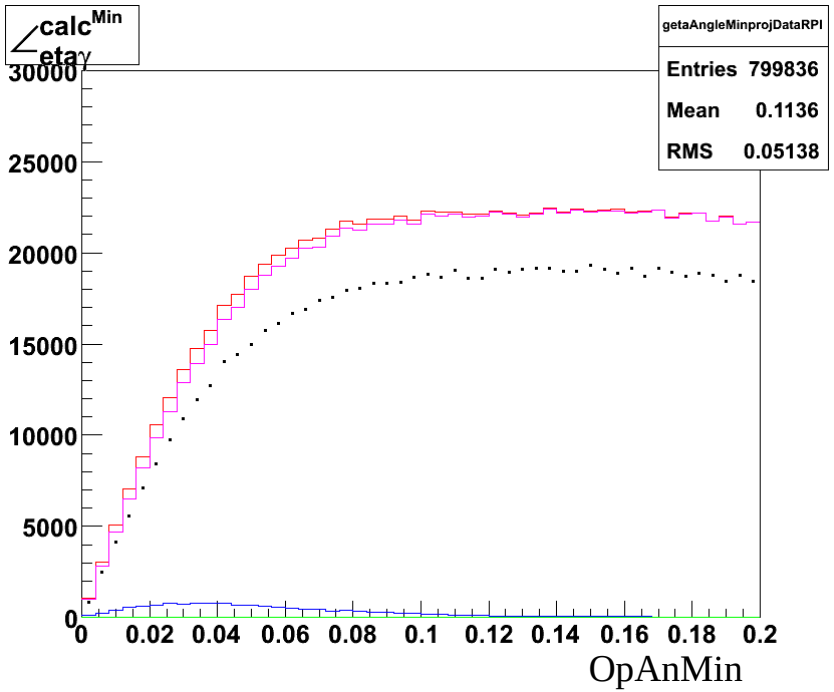




RecoverSplit





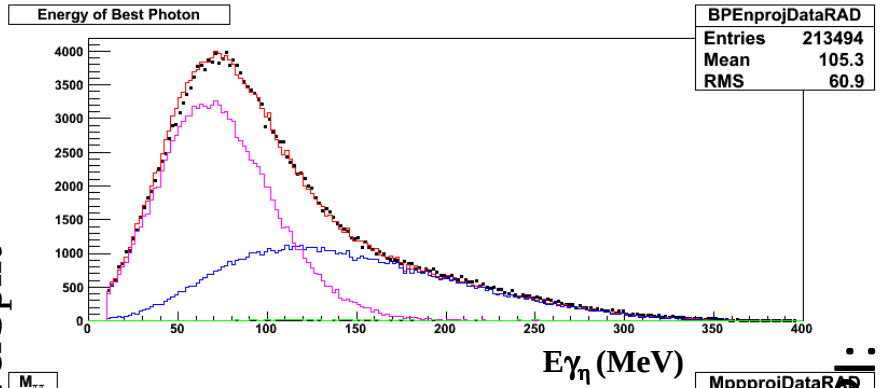


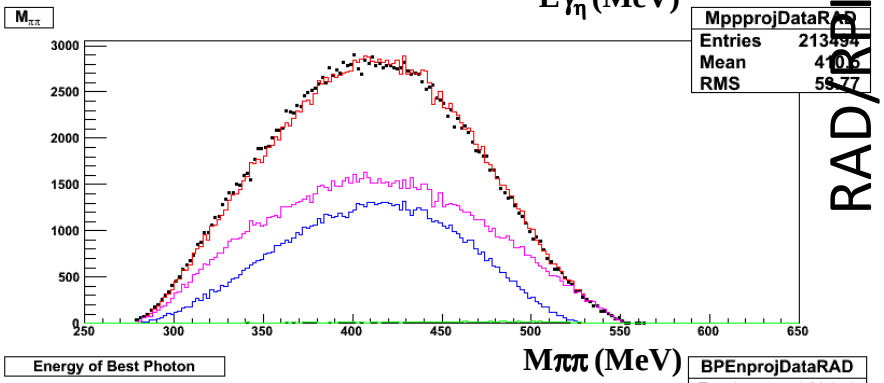
RAD/RPI:

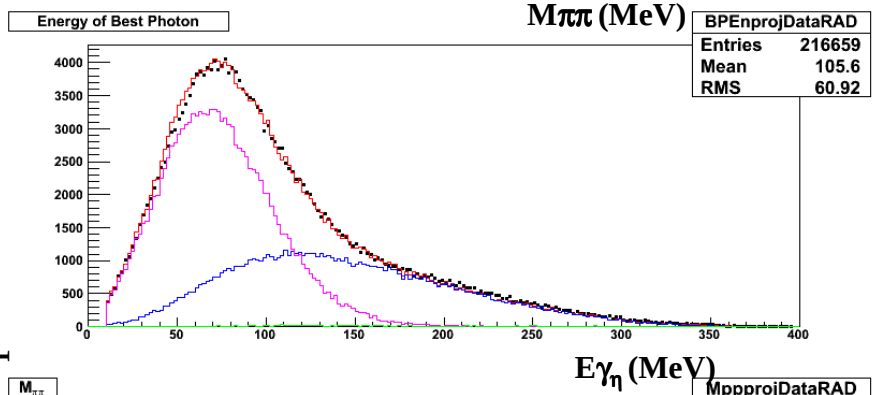
No RecoverSplit

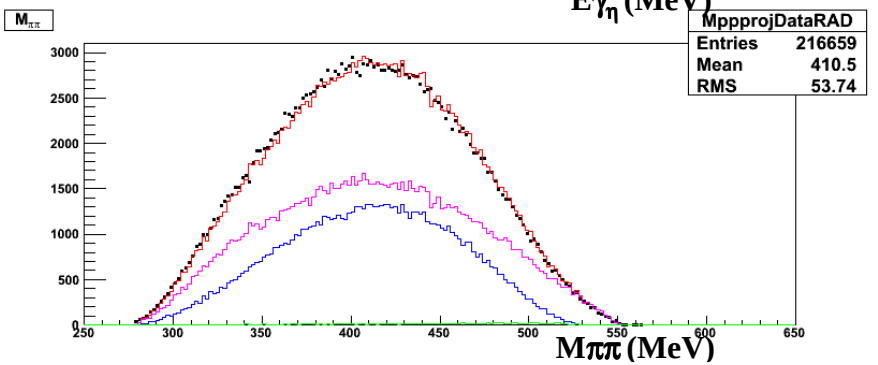
RecoverSplit

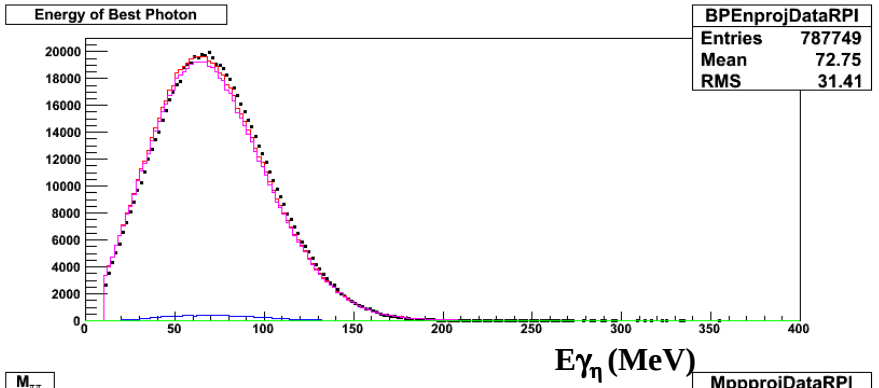
OnlyBarrel

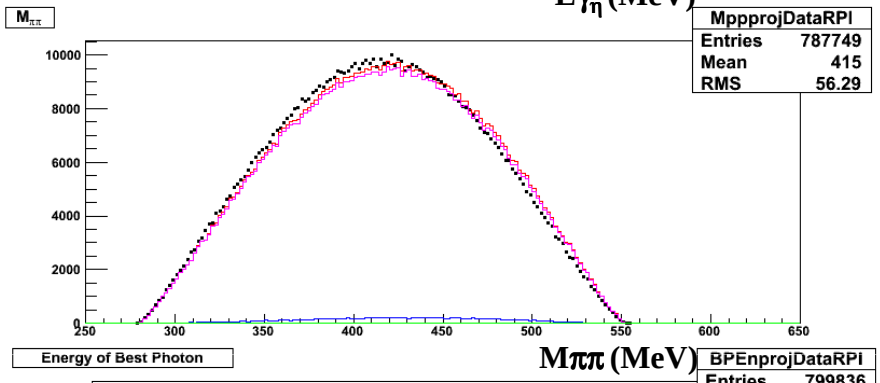


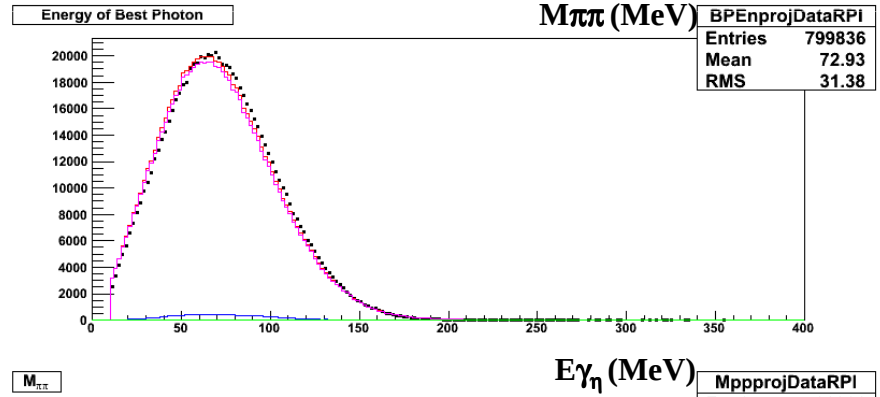


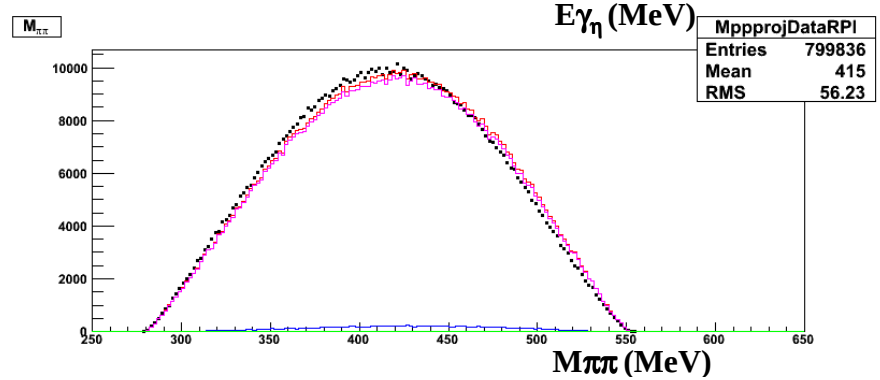






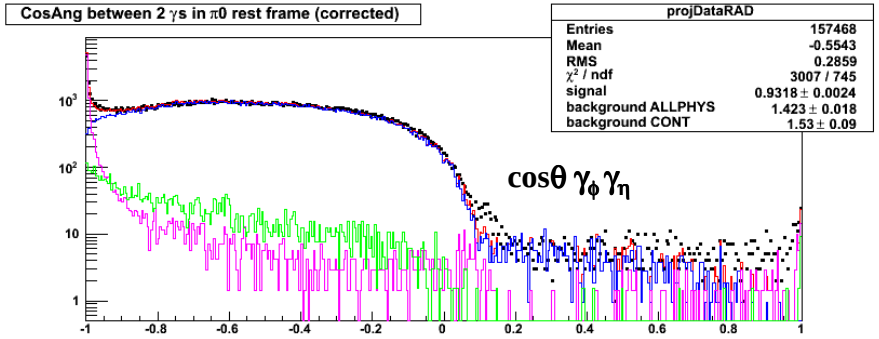


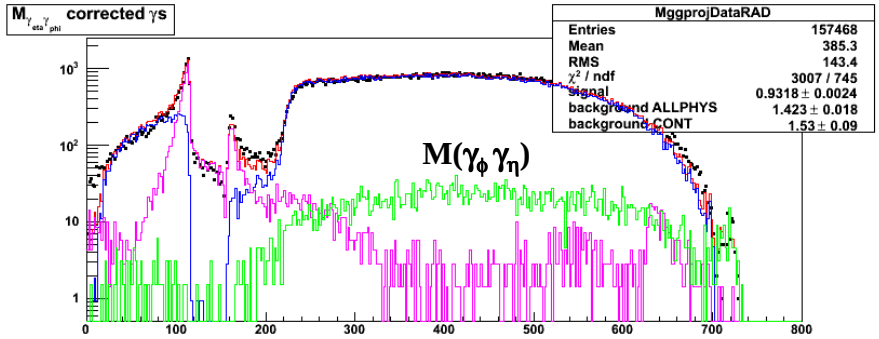


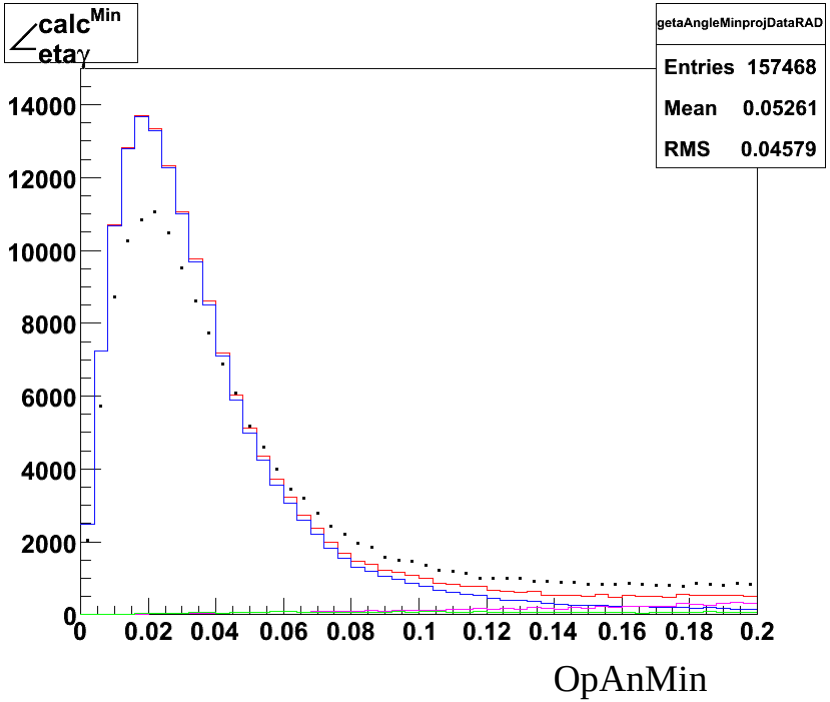


RAD: BANANA

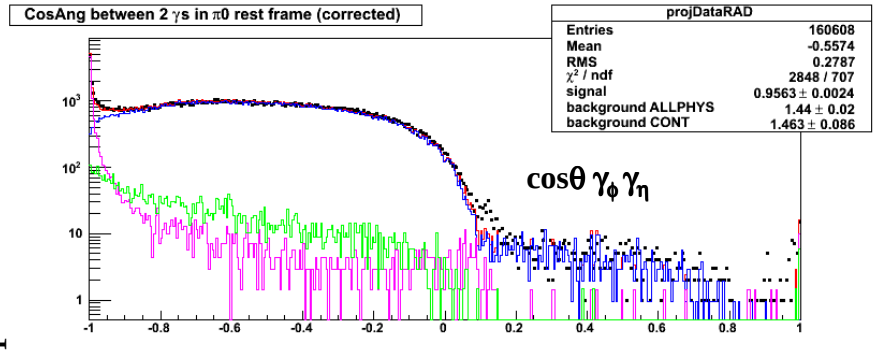
No RecoverSplit

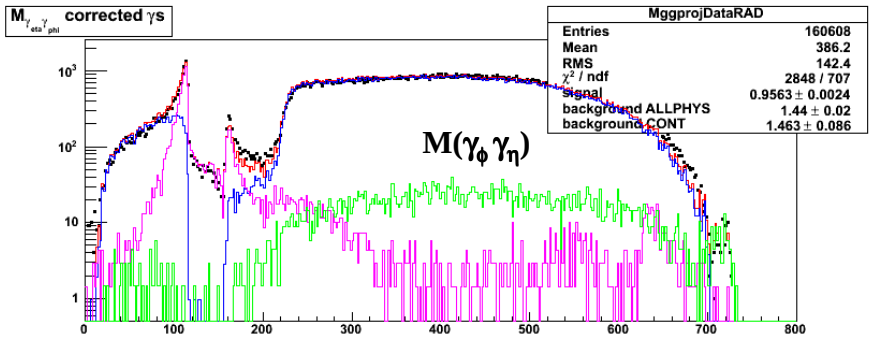


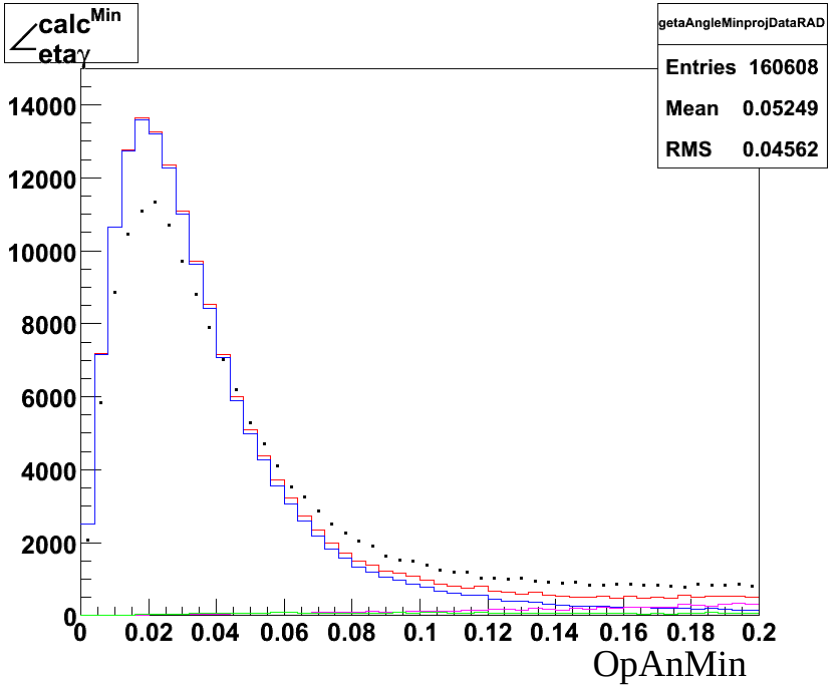




RecoverSplit

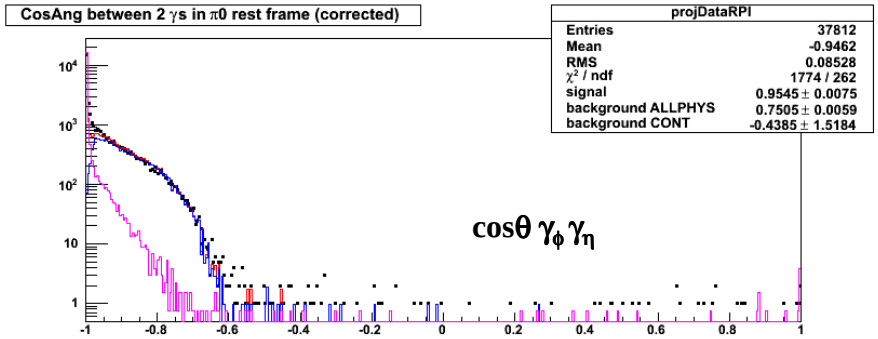


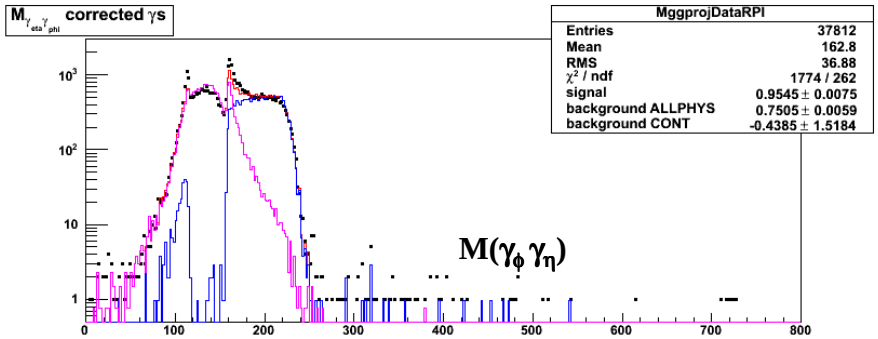




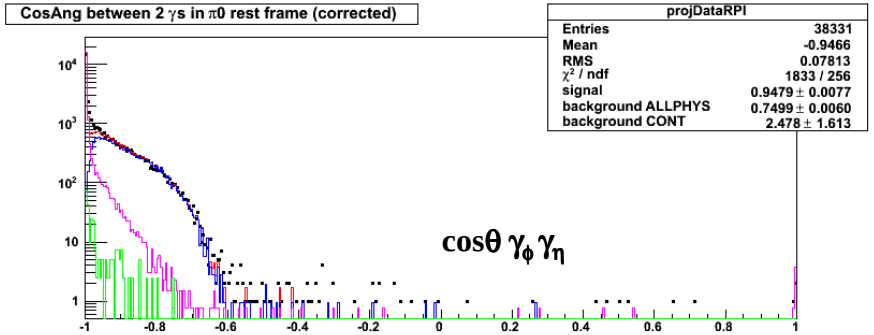
RPI: BANANA

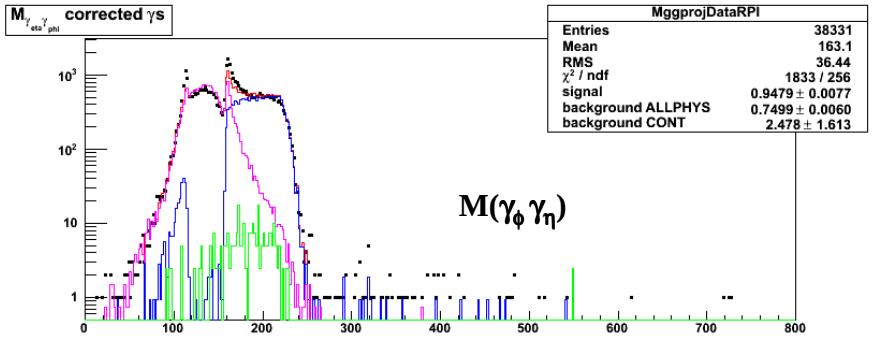
No RecoverSplit

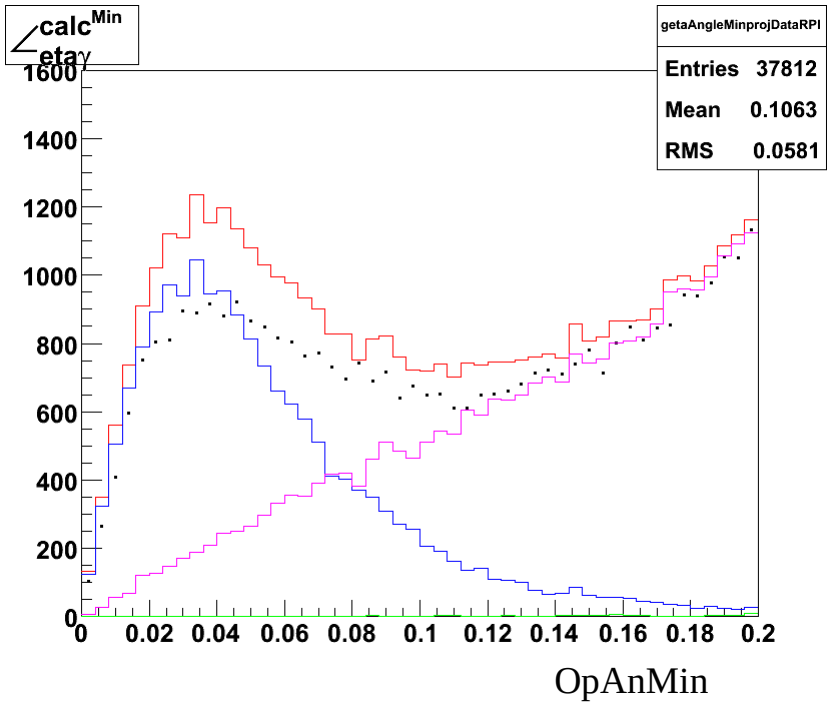


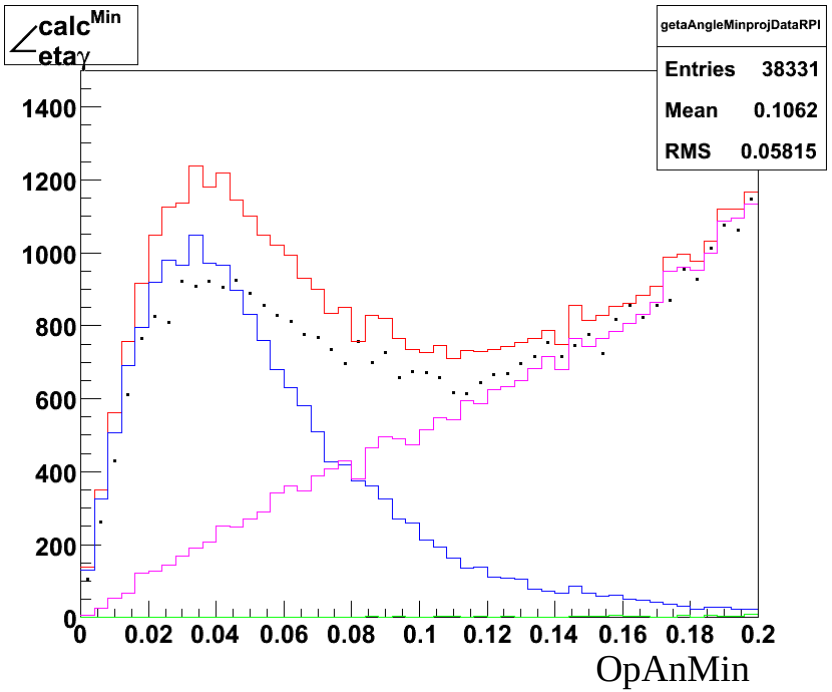


RecoverSplit





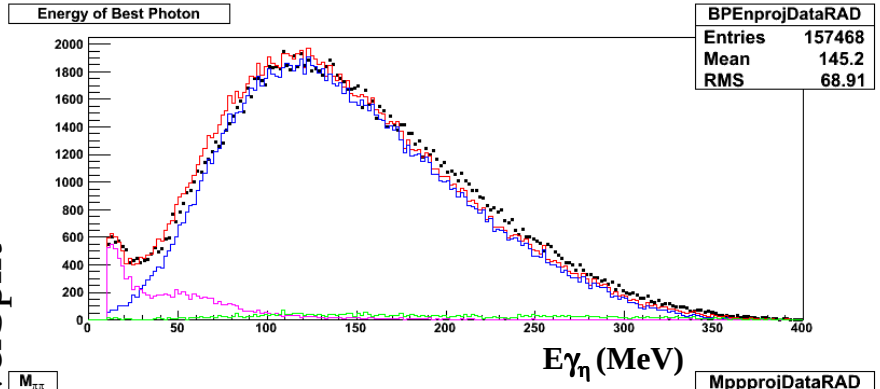


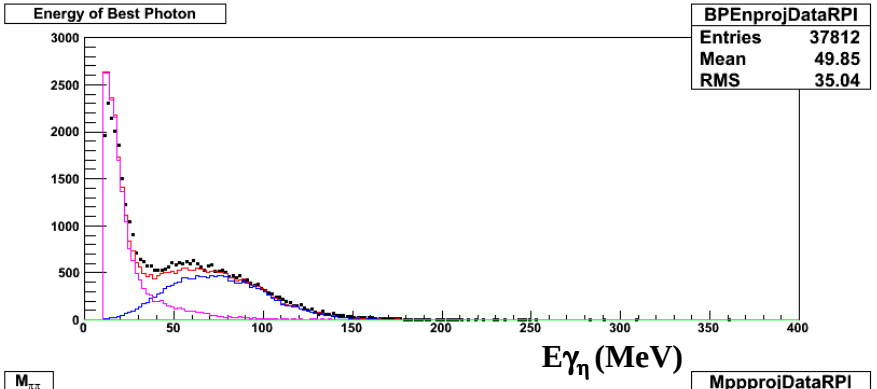


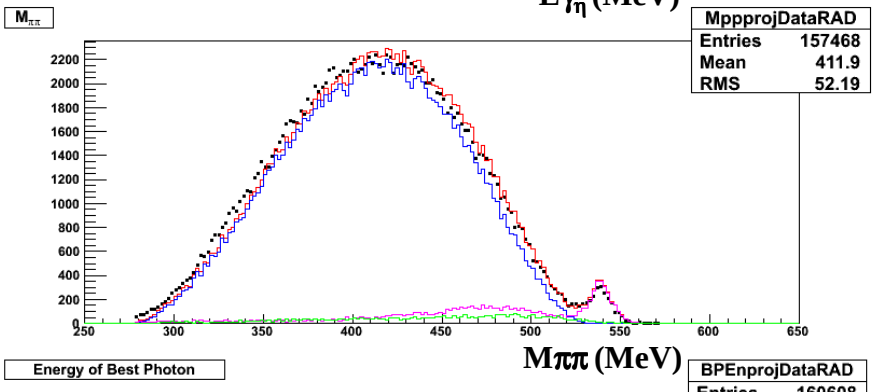
No RecoverSplit

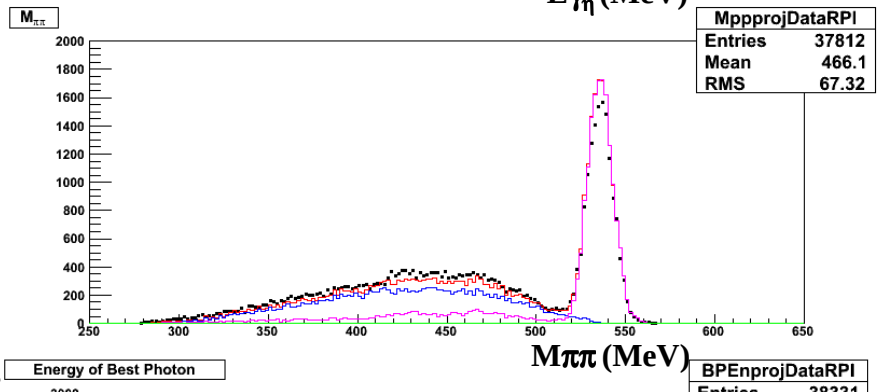
RAD/RPI: BANANA

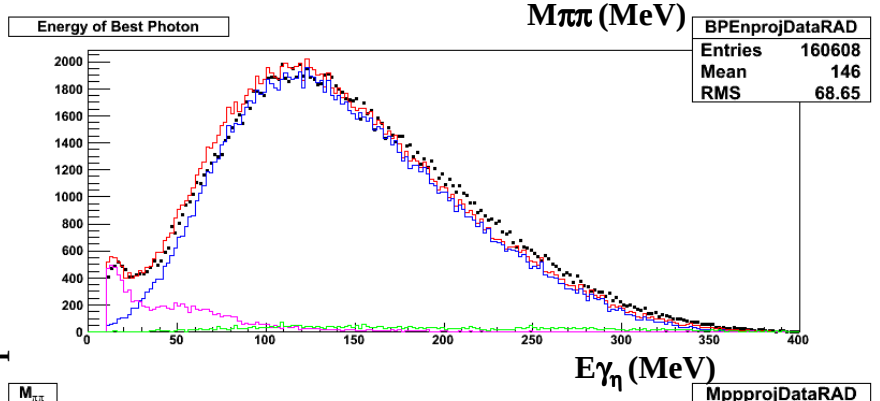
RecoverSplit

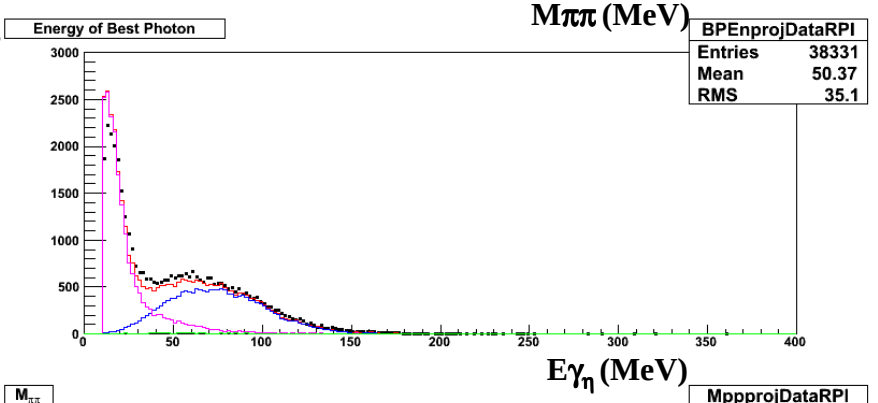


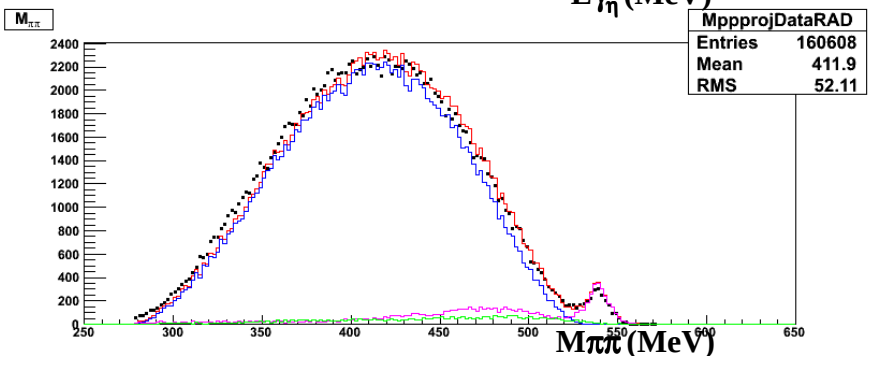


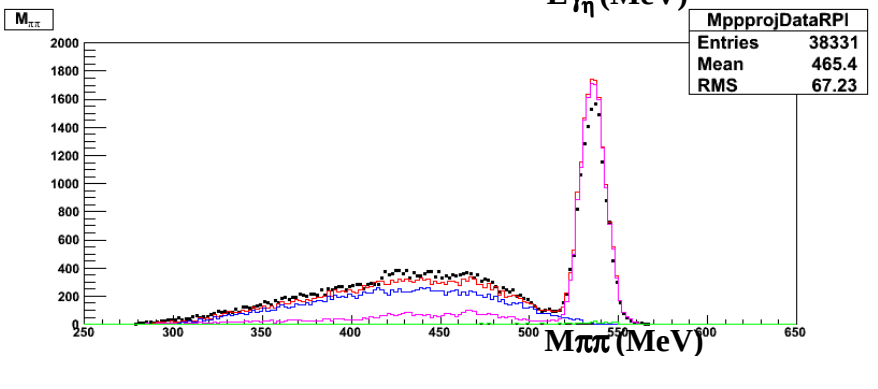












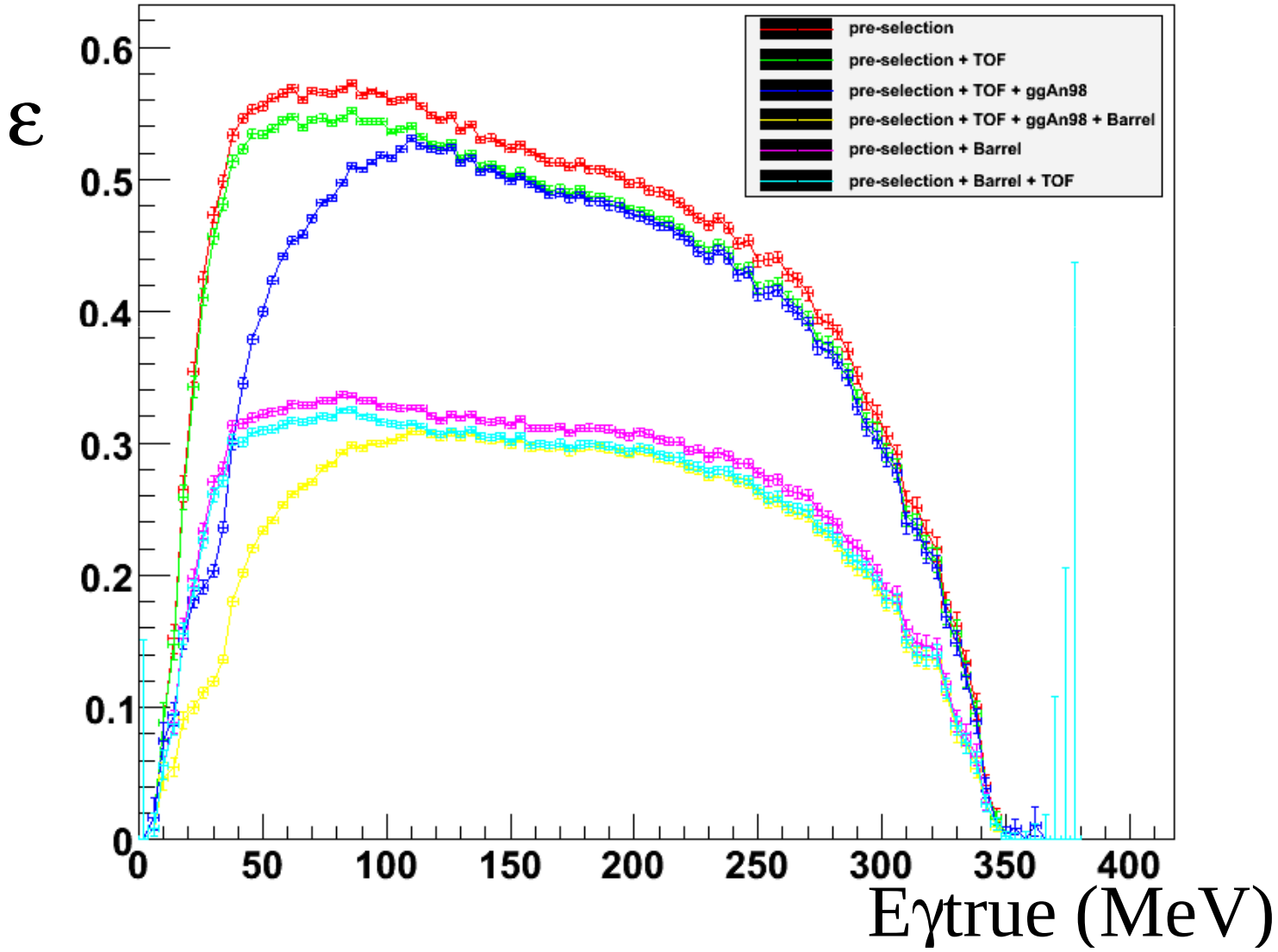
Analysis Scheme: New

Only2 PNC with $E_\gamma \geq 10$ MeV and $|t_{cl}-l_{cl}/c|<5\sigma_t$

OpAnMin: No search of best photon, but still a good variable to reject background: fine tuning of the cut

- **ANGLE**: reject background eeg100
- **TOF**: clean up residual background
- **BARREL**: we investigated before and after **cos**$\theta\ \gamma_\phi\ \gamma_\eta$ cut
- **cos**$\theta\ \gamma_\phi\ \gamma_\eta$ (Background hypothesys: in the π^0 rest frame)
- **BANANA**: in the plane $\theta\ \gamma_\phi\ \gamma_\eta$ versus $E\gamma\eta$ good S/B separation, (to be checked)

Efficiencies



Which CUT?

ANGLE+TOF+ggAng+Barrel

- TOF & ANGLE reject eeg background
- Barrel w/o ggAng: barrel cut is still effective also after the most powerful cut on background

TOF: Particle identification based on Time of flight: ΔT =Ttrk-Tclu in pion-electron hypothesis

Cos$\theta\gamma\gamma$ in π^0 hypothesys:

- Old approach: No cut, but variable to fit and S/B evaluation
- New Approach: Cut to hardly reduce background from $\phi \rightarrow \pi\pi\pi$: Scan

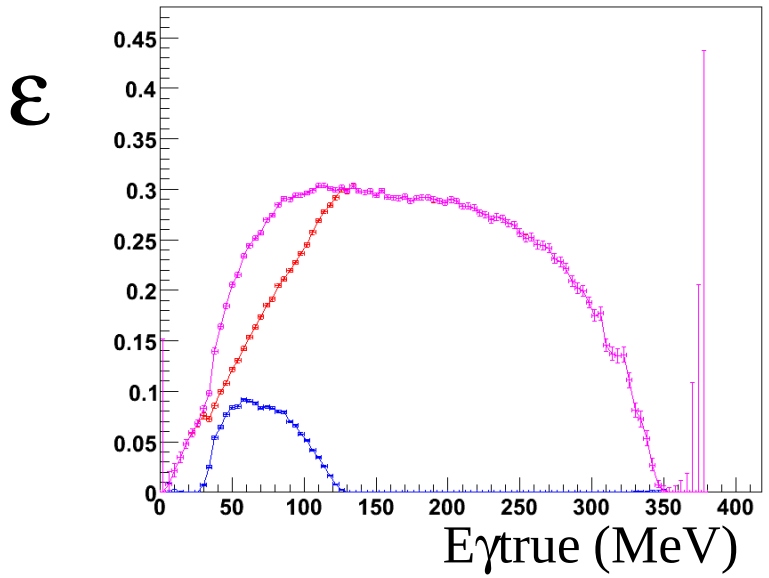
Present Scheme

- PreSel
- ANGLE
- TOF
- **cos**θ γ_ϕ γ_η
- Only Barrel

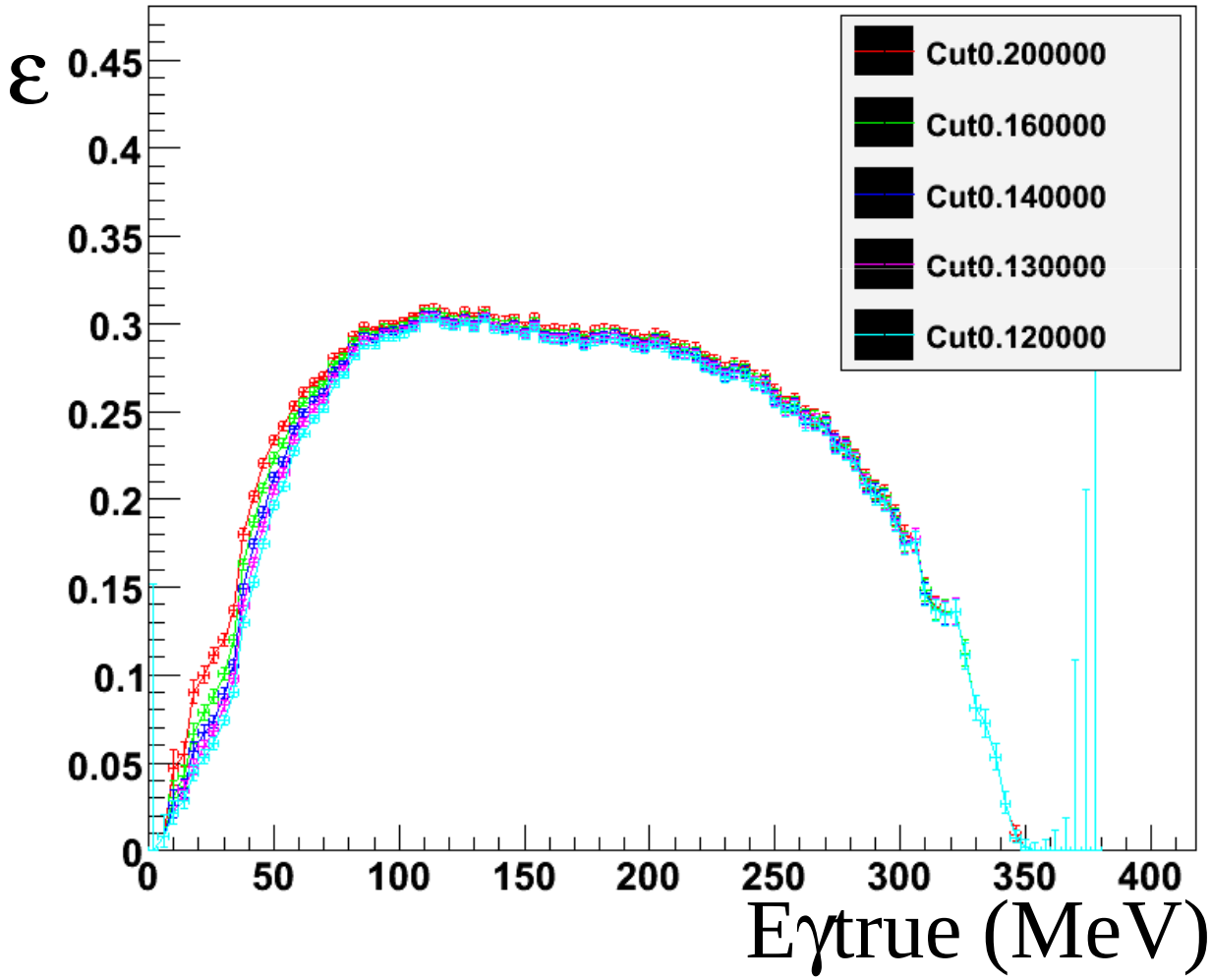
Scan on OpAnMin:
new cut 0.13

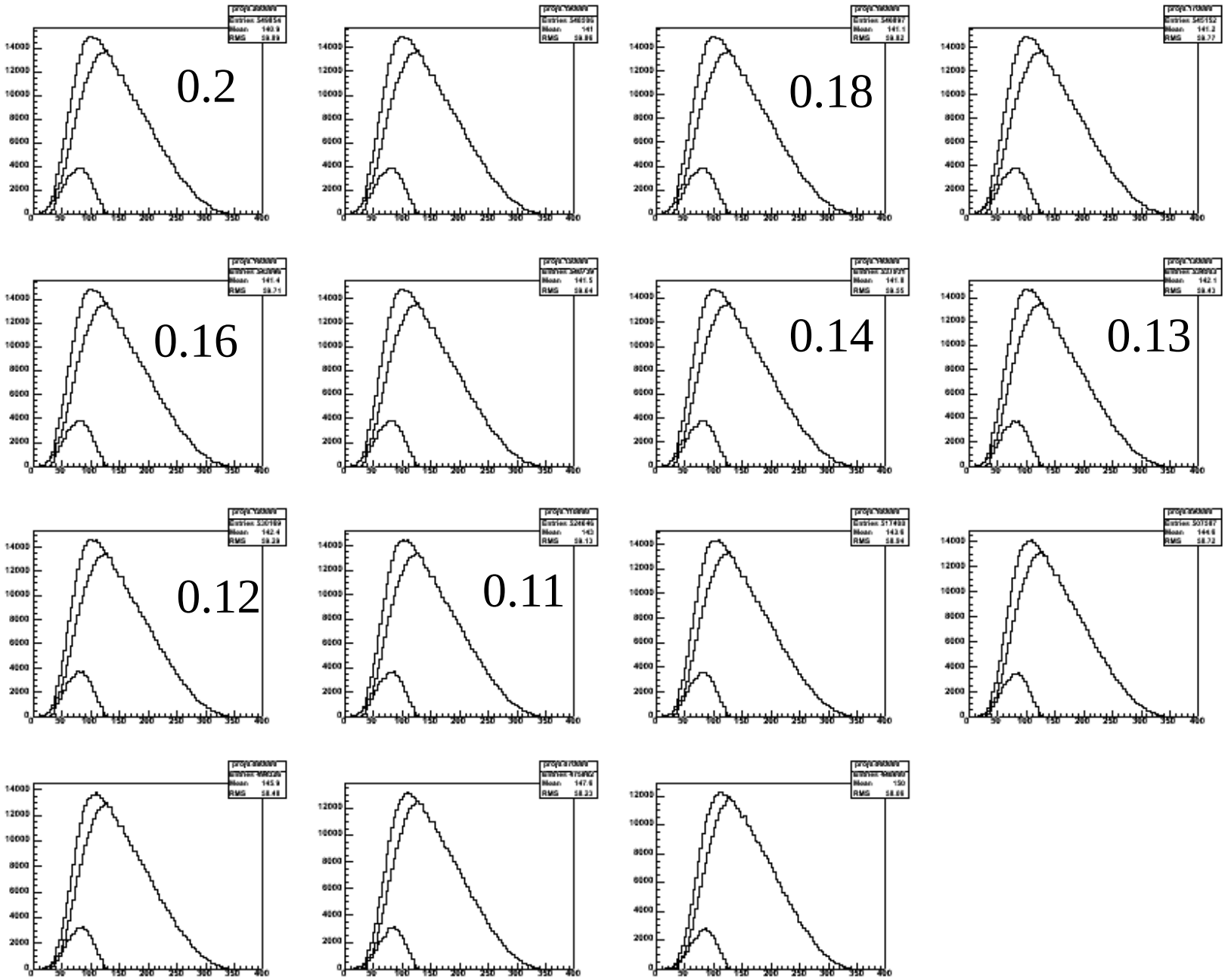
Efficiencies VS OpAncut

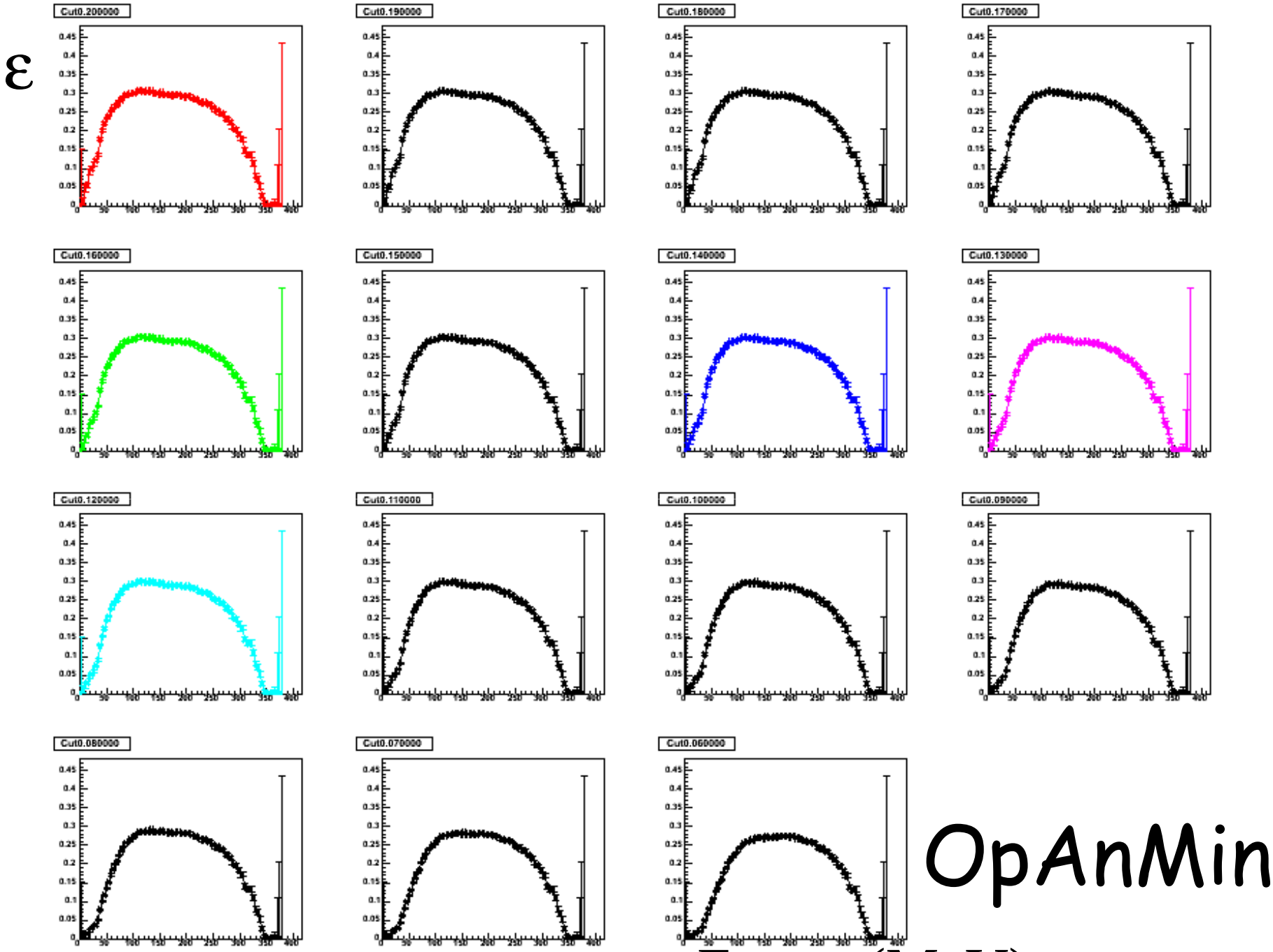
OpAn	0.2	0.18	0.16	0.14	0.13	0.12	0.11
Efficiency (%)	28.188	.28.036	27.841	27.576	27.401	27.178	26.895
Delta	0	0.005	0.012	0.022	0.028	0.035	0.045



OpAnMin

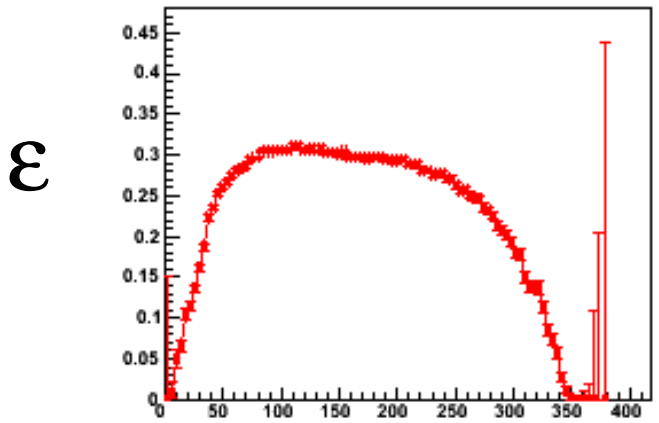

ε
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
250
300
350
400
Eγtrue (MeV)
Cut0.200000
Cut0.160000
Cut0.140000
Cut0.130000
Cut0.120000


0.2
0.18
0.16
0.14
0.13
0.12
0.11
Eγtrue (MeV)

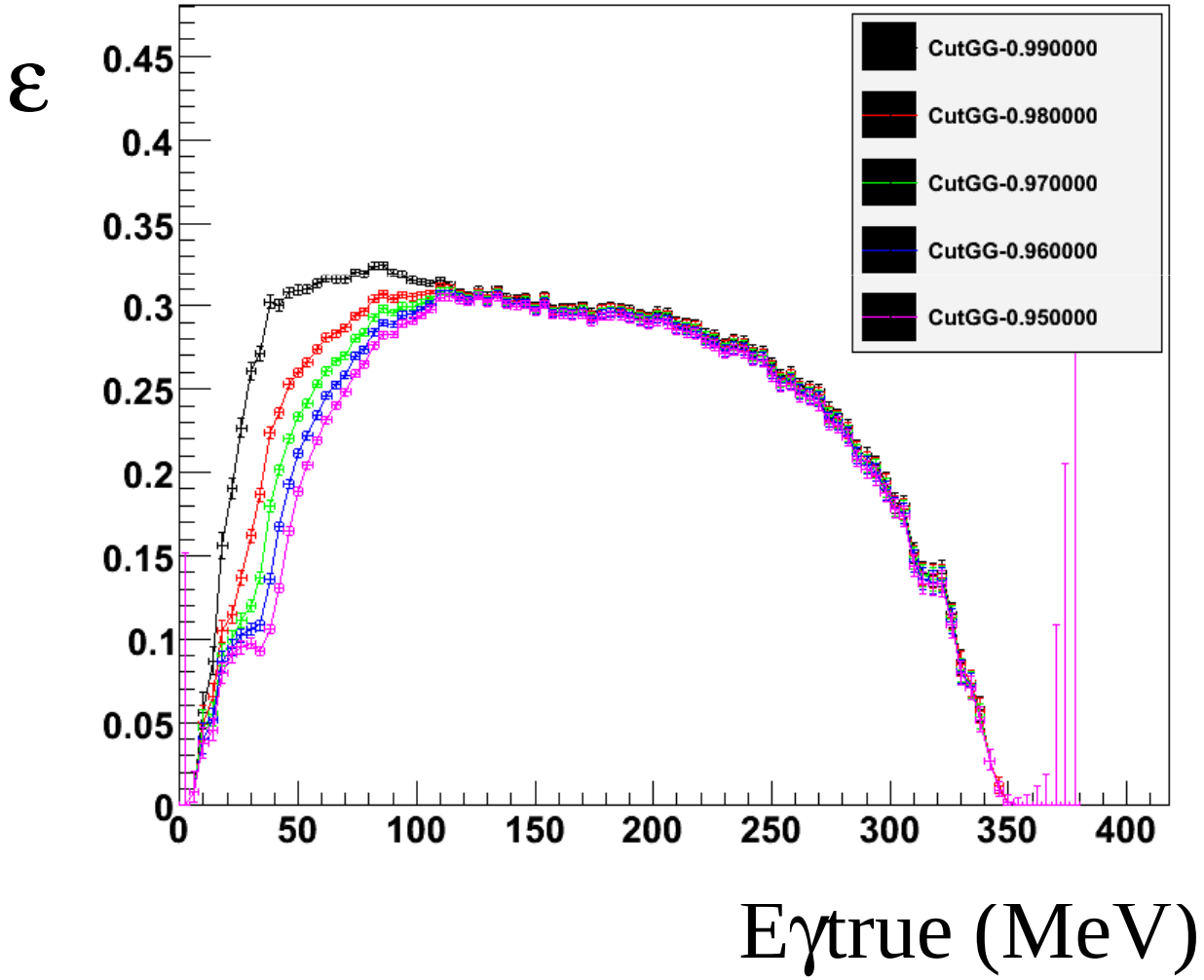

ε
Cut0.200000
Cut0.190000
Cut0.180000
Cut0.170000
Cut0.160000
Cut0.150000
Cut0.140000
Cut0.130000
Cut0.120000
Cut0.110000
Cut0.100000
Cut0.090000
Cut0.080000
Cut0.070000
Cut0.060000
OpAnMin
Eγtrue (MeV)

Efficiencies VS CosGG

CosGG	0.99	0.98	0.97	0.96	0.95	0.94	0.93
Efficiency (%)	29.865	28.788	28.188	27.694	27.237	26.819	26.417
Delta	0	0,04	0,06	0,07	0,09	0,10	0,11

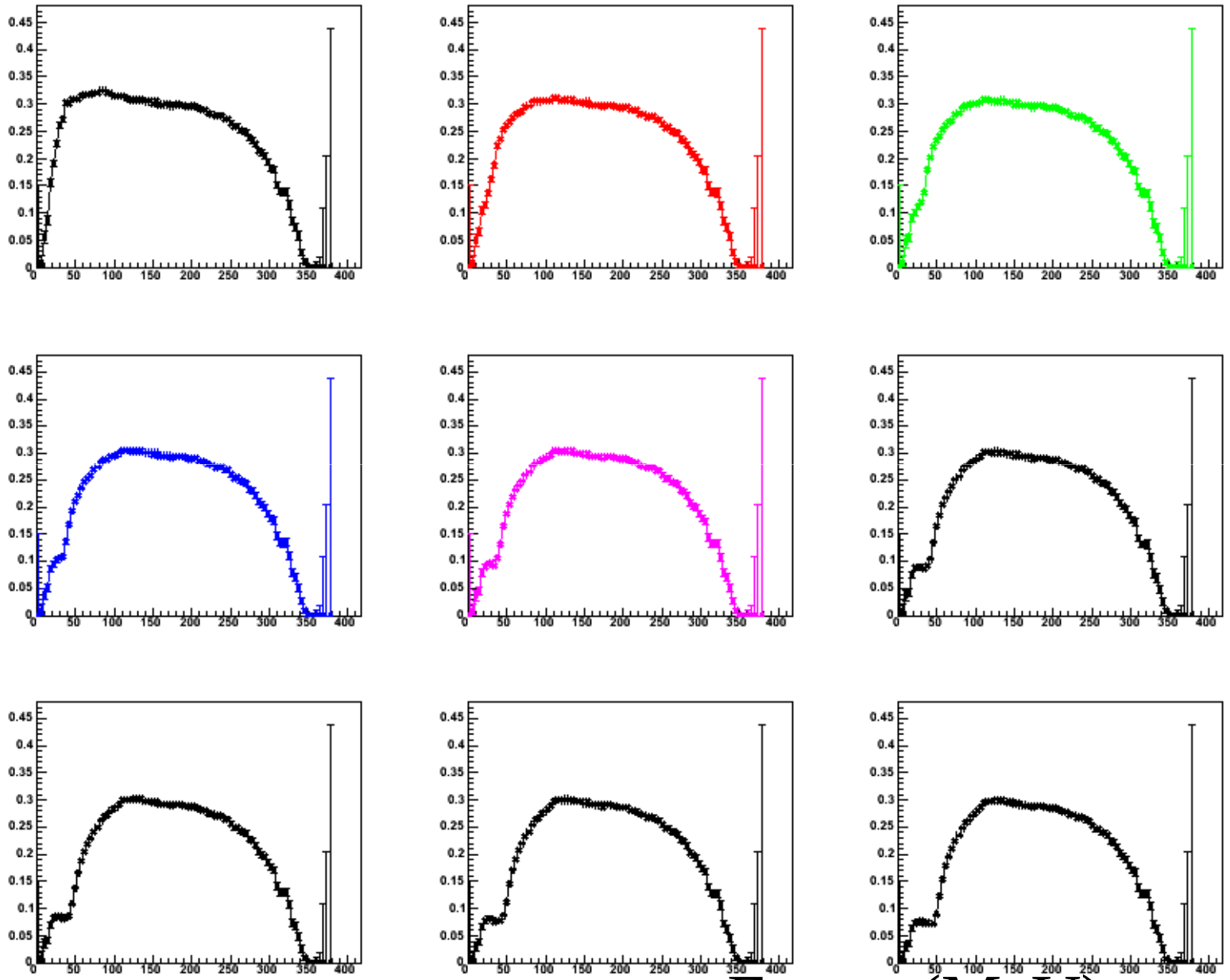


CosGG


ε
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
250
300
350
400
CutGG-0.990000
CutGG-0.980000
CutGG-0.970000
CutGG-0.960000
CutGG-0.950000
Eγtrue (MeV)

ε

CosGG

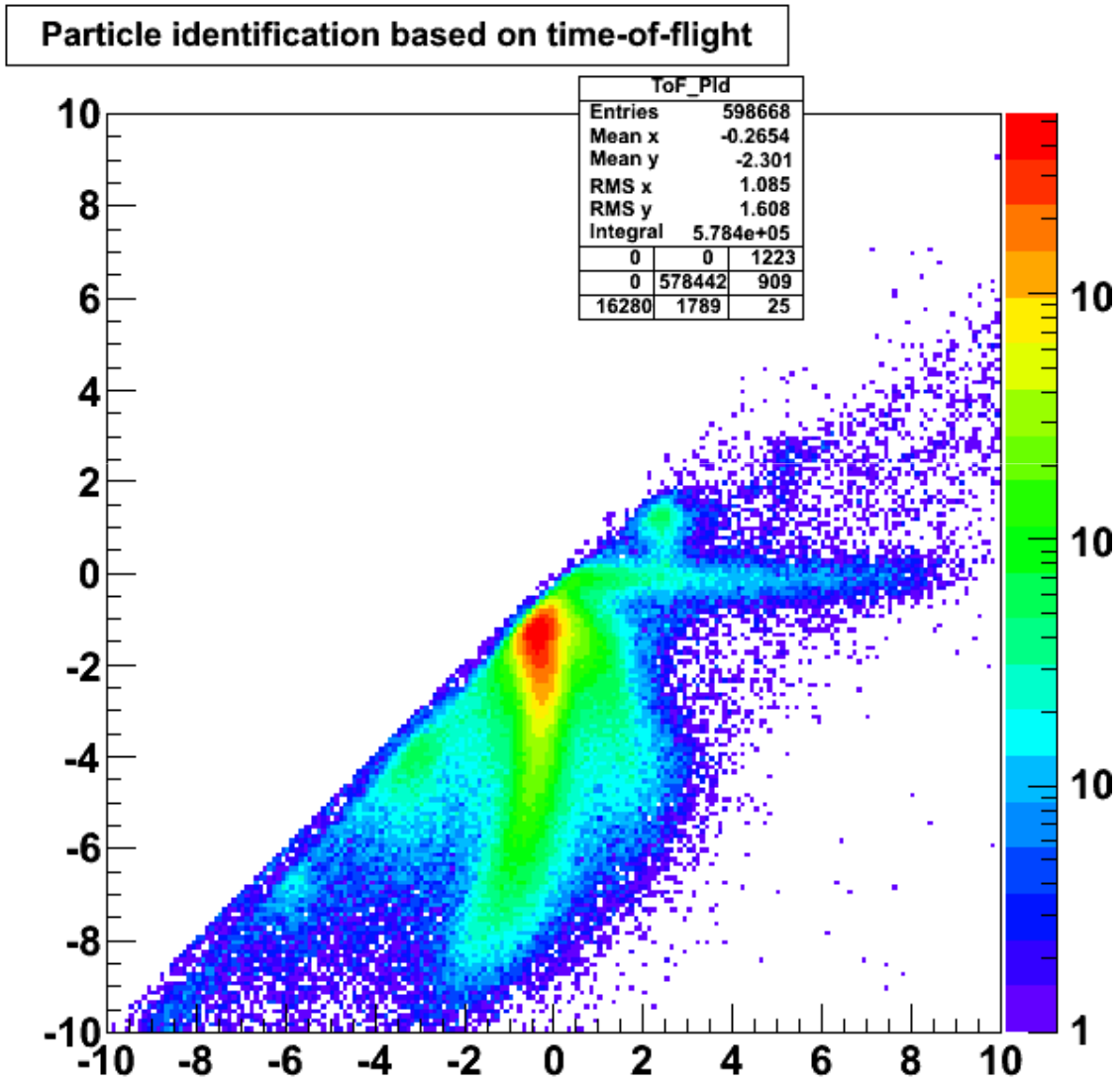


Eγtrue (MeV)

Which cut is more effective?

- We investigate effect of CUTS:
  - ANGLE VS TOF
  - TOF VS Barrel

TOF


Particle identification based on time-of-flight
ToF_Pid
Entries 598668
Mean x -0.2654
Mean y -2.301
RMS x 1.085
RMS y 1.608
Integral 5.784e+05
0 0 1223
0 578442 909
16280 1789 25
10
8
6
4
2
0
-2
-4
-6
-8
-10
-10 -8 -6 -4 -2 0 2 4 6 8 10
10
10
10
1

Preliminary BR

RAD

Efficiency = 0.0219

MC(signal) = 481328

MC(Background) = 3856

N on DATA = 457382

without subtracting bkg BR = 0.0424

RPI

Efficiency = 0.0242

MC(signal) = 53175

MC(Background) = 6703

N on DATA = 61403

After subtracting bkg BR = 0.0449

RAD+RPI

534503 signal with 0.2429 efficiency

11151 all background

in the exp. data I see 518785 events

After subtracting bkg BR = 0.0424

(BR=0.0437 Marek Blessing

Constraints:

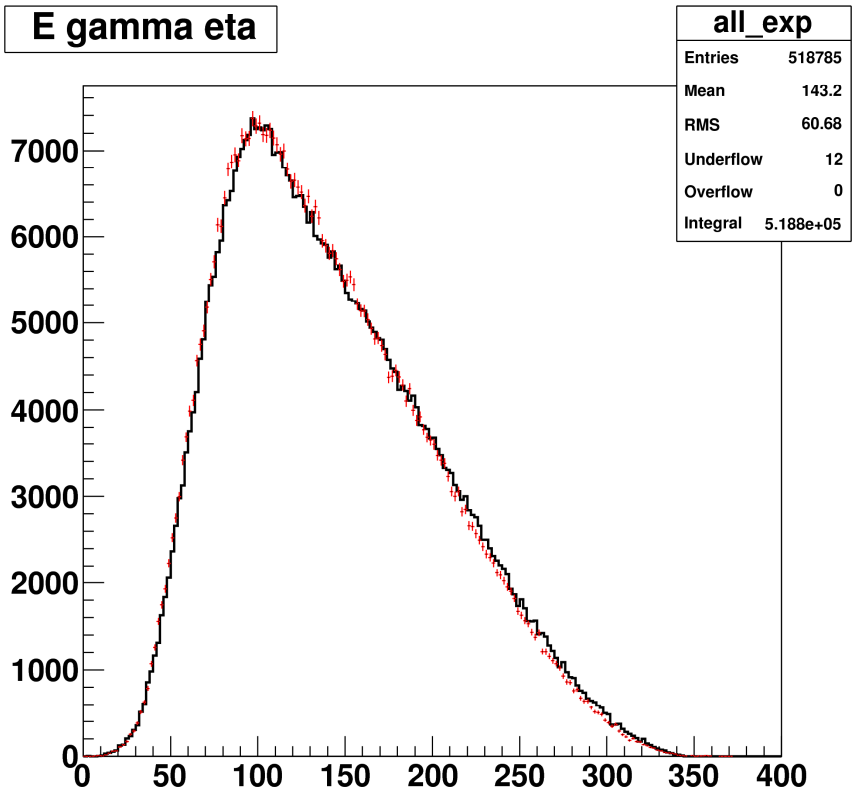
EtPt (10MeV)

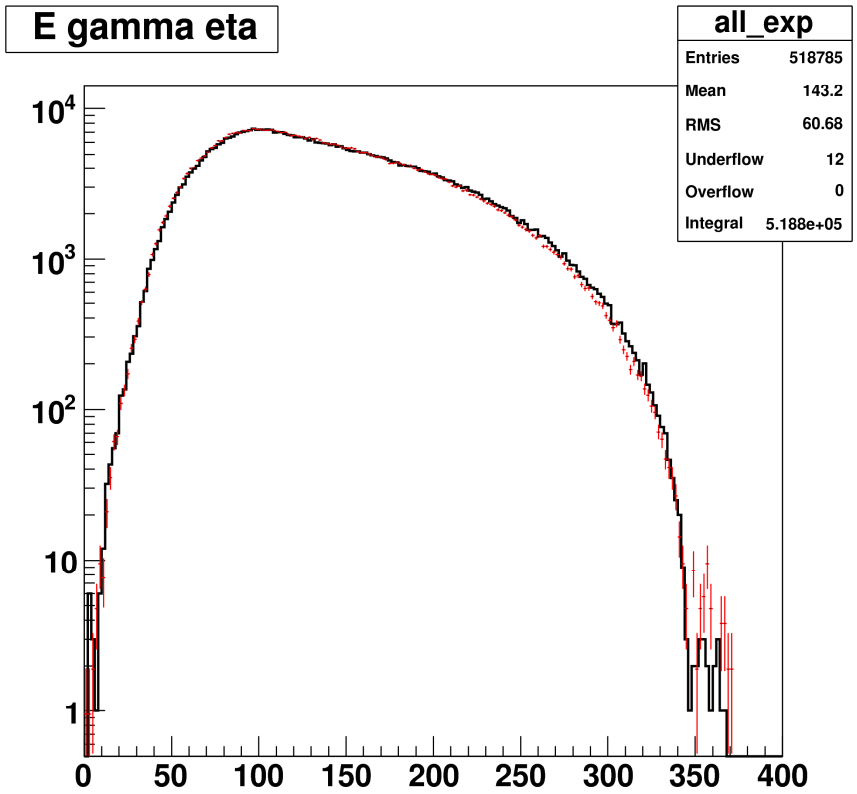
OpAngle (<0.13 rad)

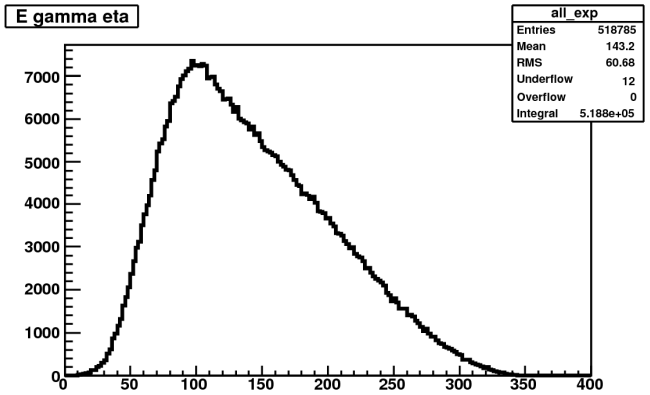
ANGLE + TOF

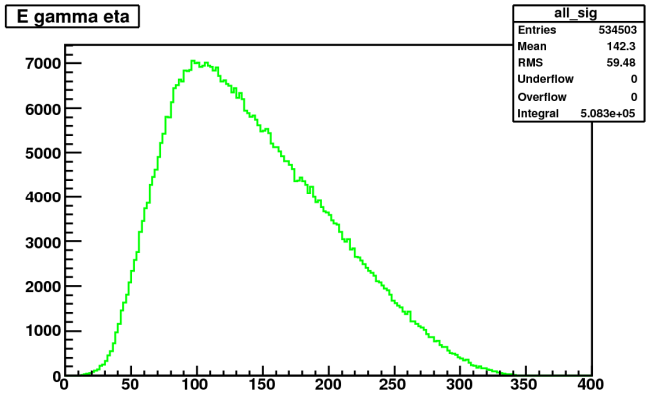
OnlyBarrel for $\eta_\circ$ (phi)

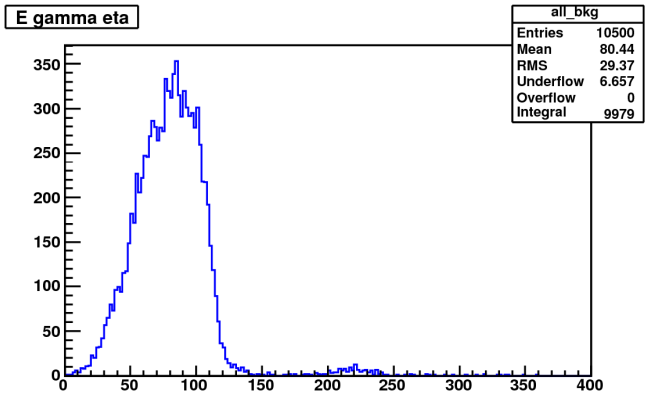
Cos($\eta_\circ$ $\eta_\circ$) (-0.98)

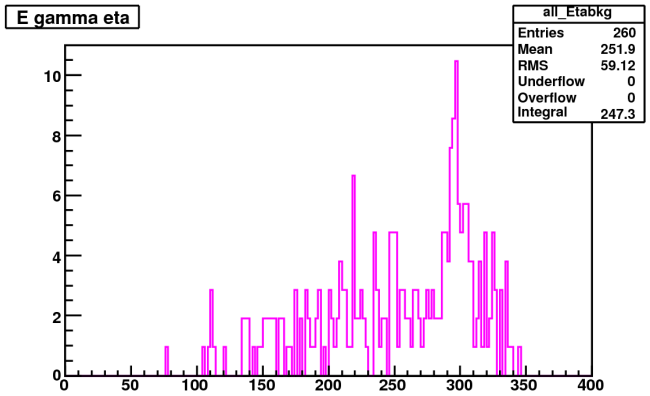


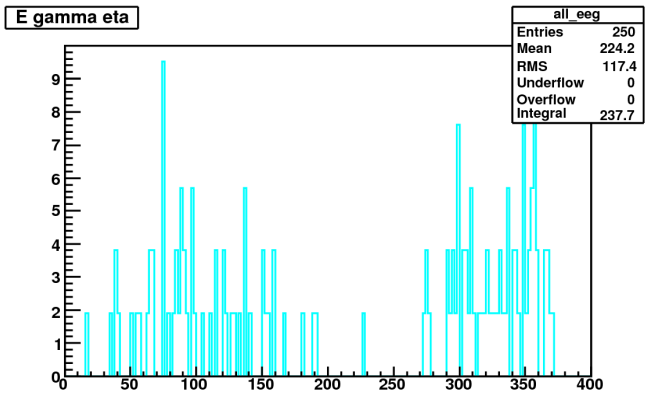


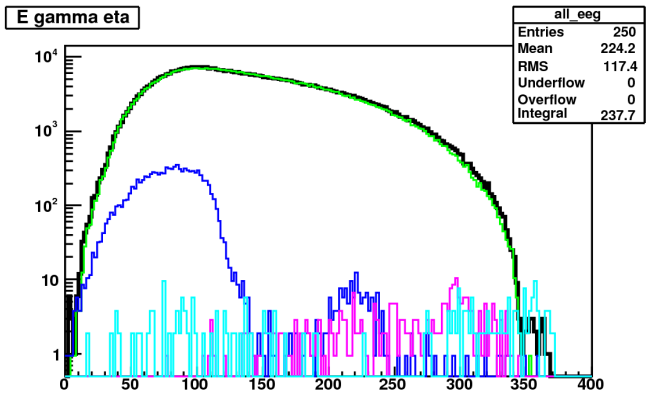

E gamma eta
all_exp
Entries 518785
Mean 143.2
RMS 60.68
Underflow 12
Overflow 0
Integral 5.188e+05

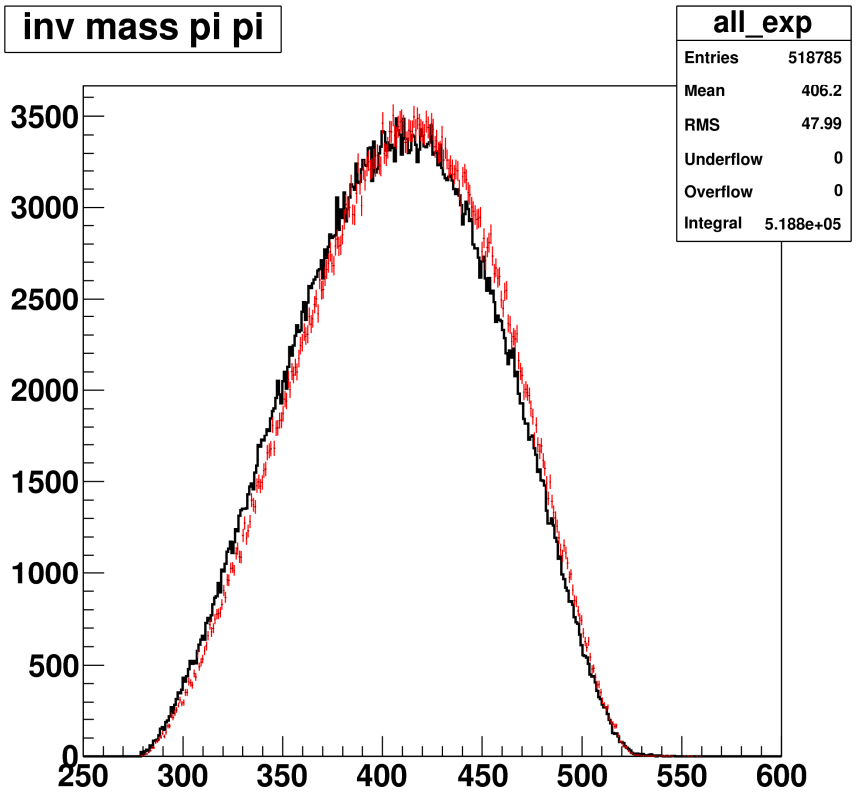

E gamma eta
all_sig
Entries 534503
Mean 142.3
RMS 59.48
Underflow 0
Overflow 0
Integral 5.083e+05

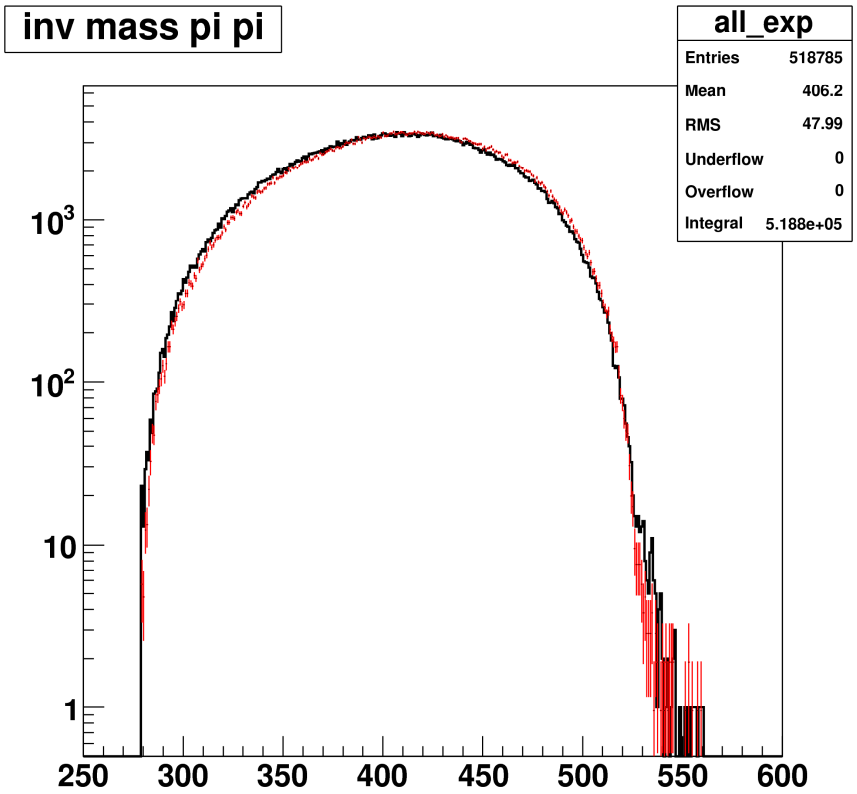

E gamma eta
all_bkg
Entries 10500
Mean 80.44
RMS 29.37
Underflow 6.657
Overflow 0
Integral 9979

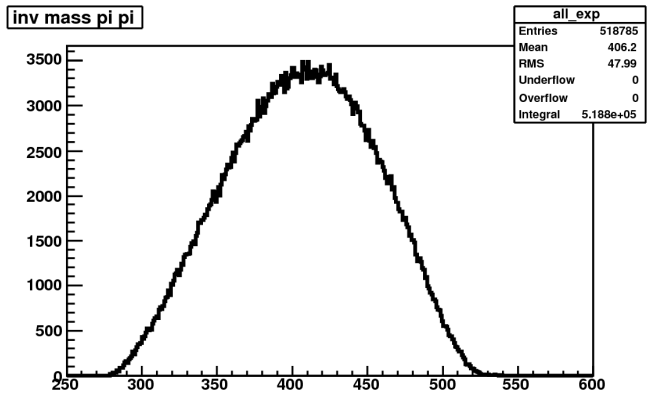

E gamma eta
all_Etabkg
Entries 260
Mean 251.9
RMS 59.12
Underflow 0
Overflow 0
Integral 247.3

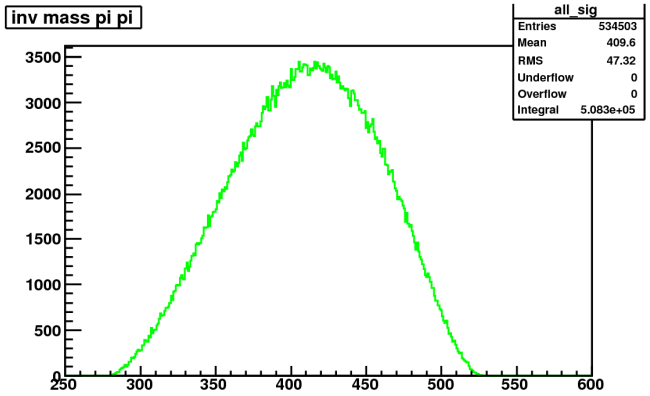

E gamma eta
all_eeg
Entries 250
Mean 224.2
RMS 117.4
Underflow 0
Overflow 0
Integral 237.7

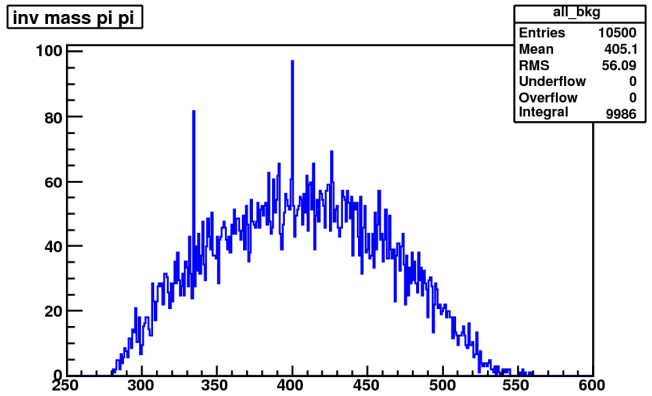

E gamma eta
all_eeg
Entries 250
Mean 224.2
RMS 117.4
Underflow 0
Overflow 0
Integral 237.7

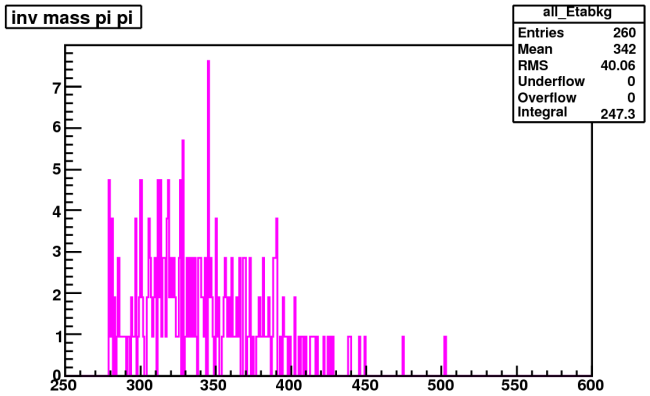

inv mass pi pi
all_exp
Entries 518785
Mean 406.2
RMS 47.99
Underflow 0
Overflow 0
Integral 5.188e+05
3500
3000
2500
2000
1500
1000
500
0
250
300
350
400
450
500
550
600

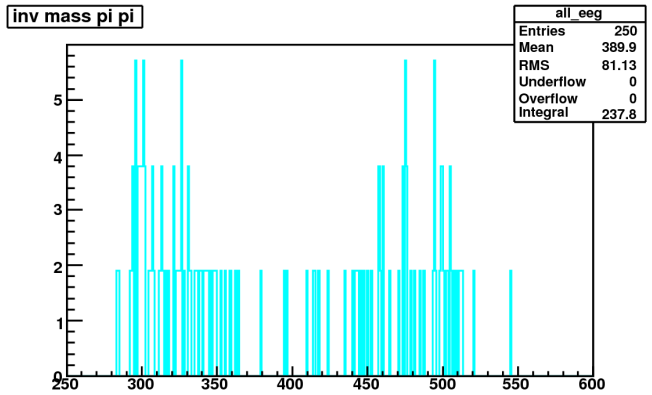

inv mass pi pi
all_exp
Entries 518785
Mean 406.2
RMS 47.99
Underflow 0
Overflow 0
Integral 5.188e+05
10^3
10^2
10
1
250
300
350
400
450
500
550
600

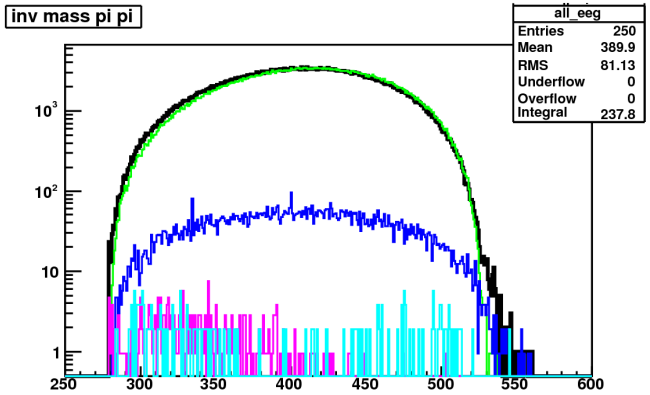

inv mass pi pi
all_exp
Entries 518785
Mean 406.2
RMS 47.99
Underflow 0
Overflow 0
Integral 5.188e+05

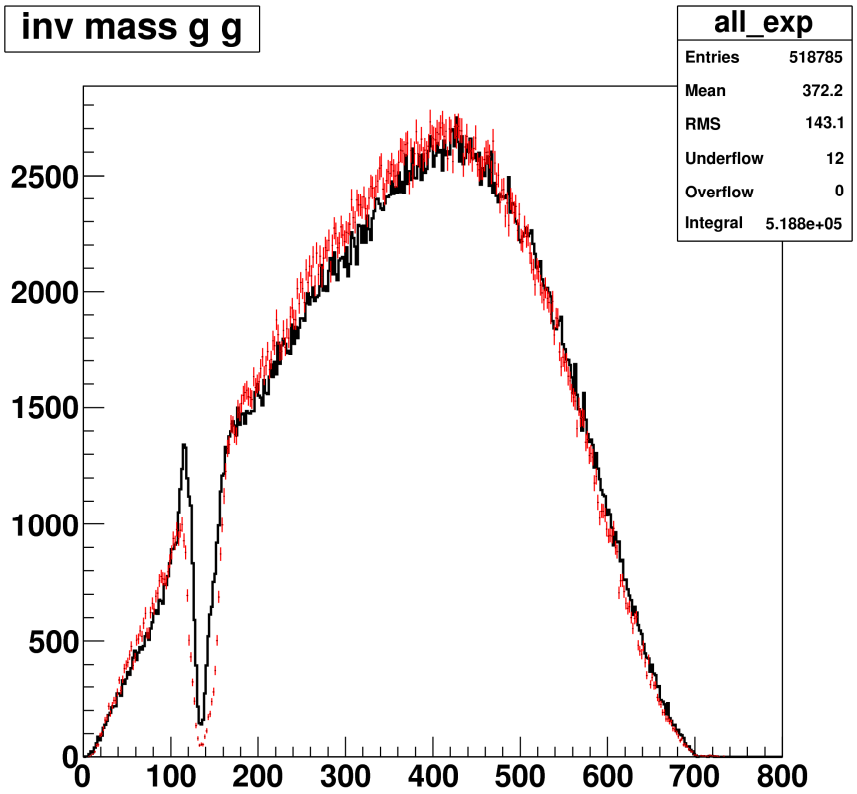

inv mass pi pi
all_sig
Entries 534503
Mean 409.6
RMS 47.32
Underflow 0
Overflow 0
Integral 5.083e+05

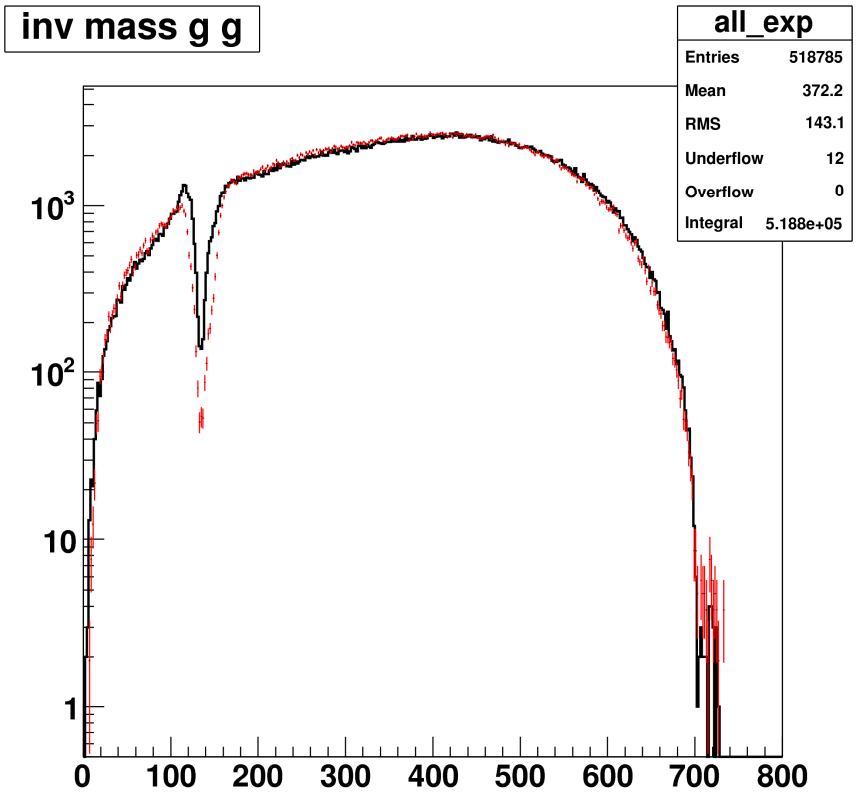

inv mass pi pi
all_bkg
Entries 10500
Mean 405.1
RMS 56.09
Underflow 0
Overflow 0
Integral 9986

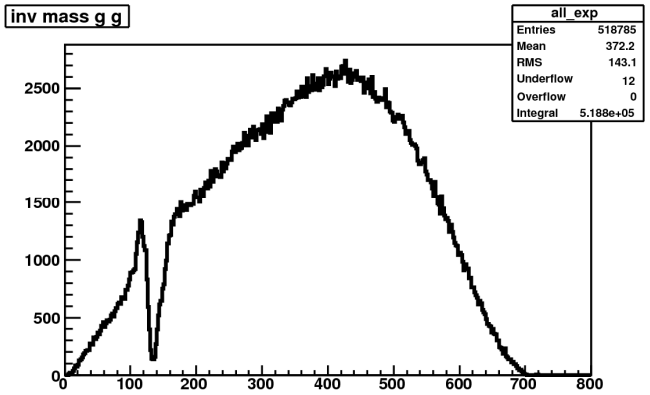

inv mass pi pi
all_Etabkg
Entries 260
Mean 342
RMS 40.06
Underflow 0
Overflow 0
Integral 247.3

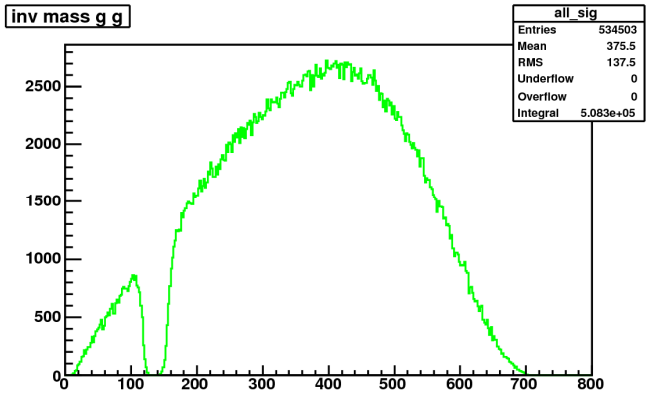

inv mass pi pi
all_eeg
Entries 250
Mean 389.9
RMS 81.13
Underflow 0
Overflow 0
Integral 237.8

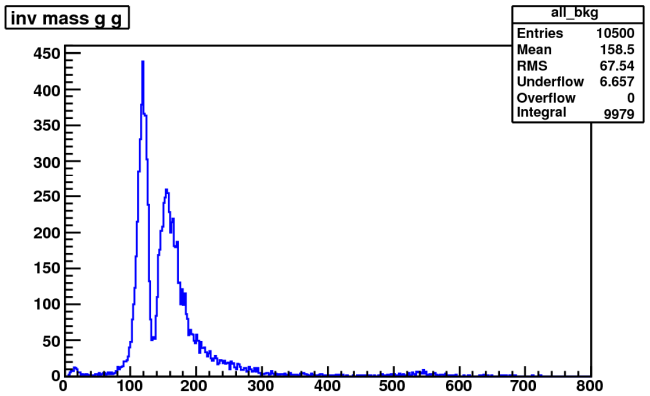

inv mass pi pi
all_eeg
Entries 250
Mean 389.9
RMS 81.13
Underflow 0
Overflow 0
Integral 237.8

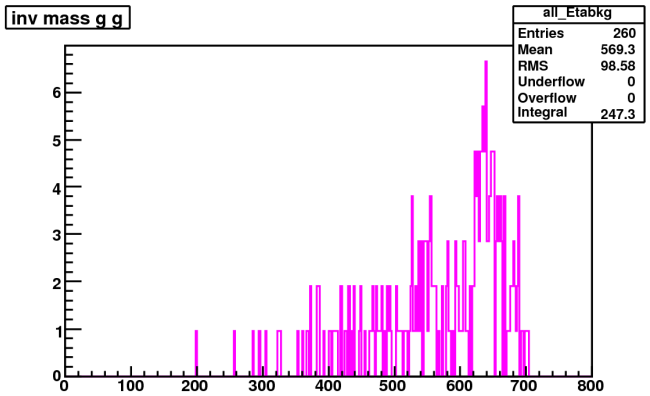

inv mass g g
all_exp
Entries 518785
Mean 372.2
RMS 143.1
Underflow 12
Overflow 0
Integral 5.188e+05
2500
2000
1500
1000
500
0
0 100 200 300 400 500 600 700 800

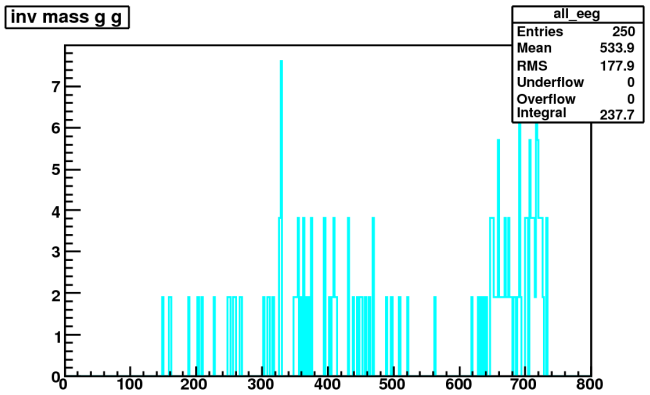

inv mass g g
all_exp
Entries 518785
Mean 372.2
RMS 143.1
Underflow 12
Overflow 0
Integral 5.188e+05
10^3
10^2
10
1
0 100 200 300 400 500 600 700 800

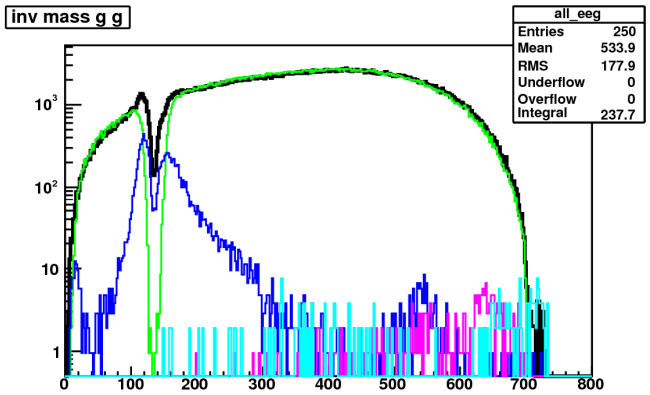

inv mass g g
all_exp
Entries 518785
Mean 372.2
RMS 143.1
Underflow 12
Overflow 0
Integral 5.188e+05

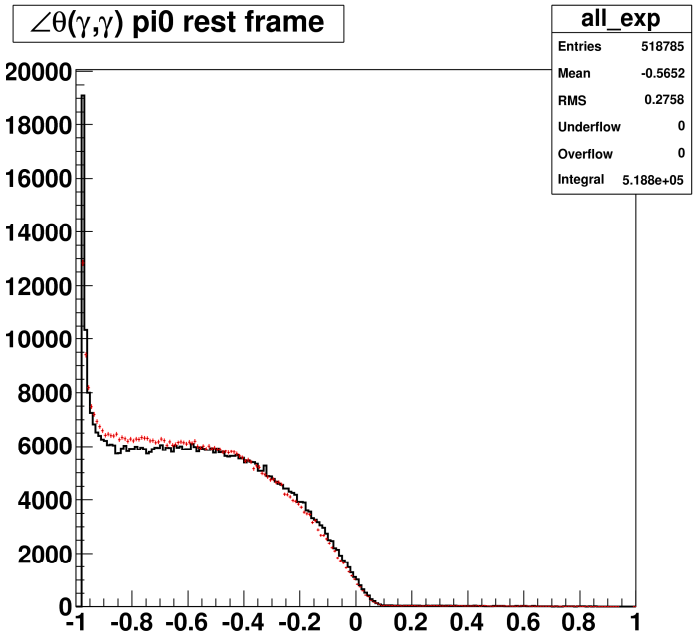

inv mass g g
all_sig
Entries 534503
Mean 375.5
RMS 137.5
Underflow 0
Overflow 0
Integral 5.083e+05

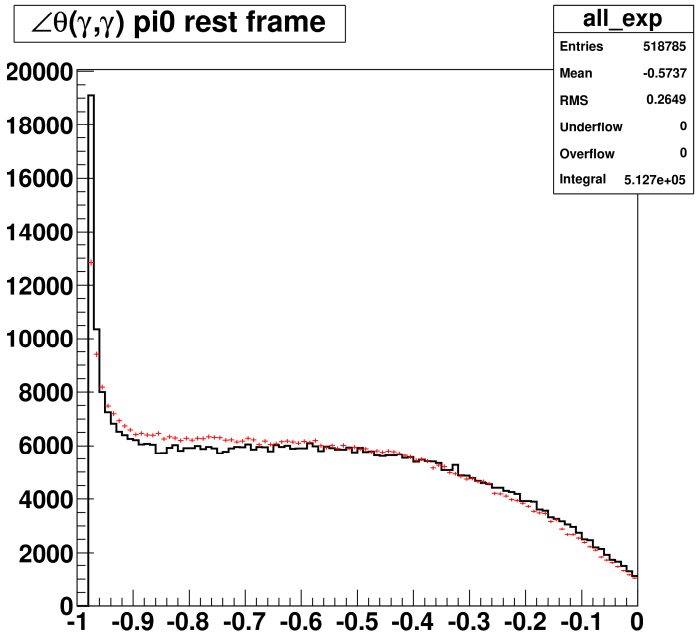

inv mass g g
all_bkg
Entries 10500
Mean 158.5
RMS 67.54
Underflow 6.657
Overflow 0
Integral 9979

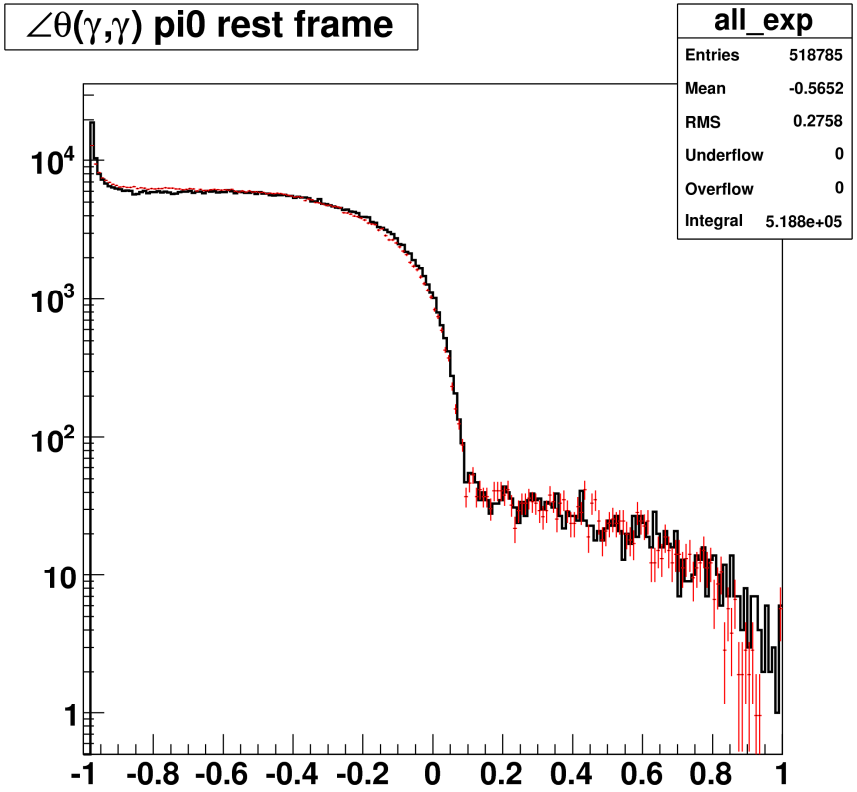

inv mass g g
all_Etabkg
Entries 260
Mean 569.3
RMS 98.58
Underflow 0
Overflow 0
Integral 247.3

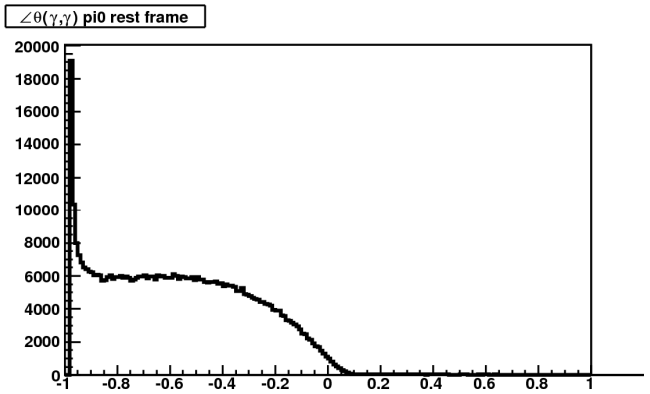

inv mass g g
all_eeg
Entries 250
Mean 533.9
RMS 177.9
Underflow 0
Overflow 0
Integral 237.7

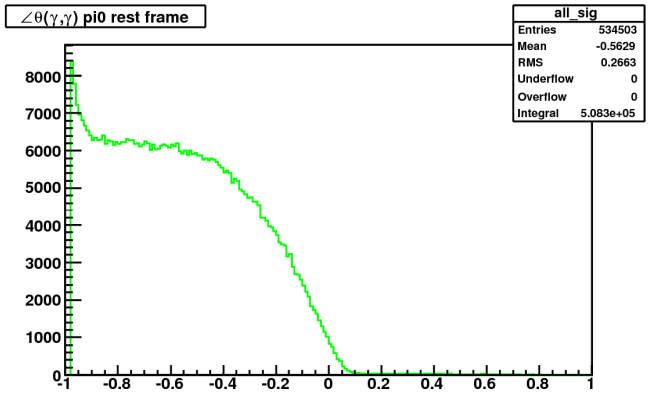

inv mass g g
all_eeg
Entries 250
Mean 533.9
RMS 177.9
Underflow 0
Overflow 0
Integral 237.7

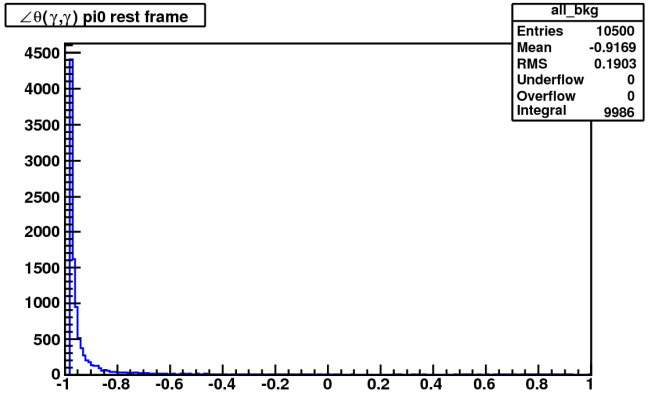

∠θ(γ,γ) pi0 rest frame
all_exp
Entries 518785
Mean -0.5652
RMS 0.2758
Underflow 0
Overflow 0
Integral 5.188e+05
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1

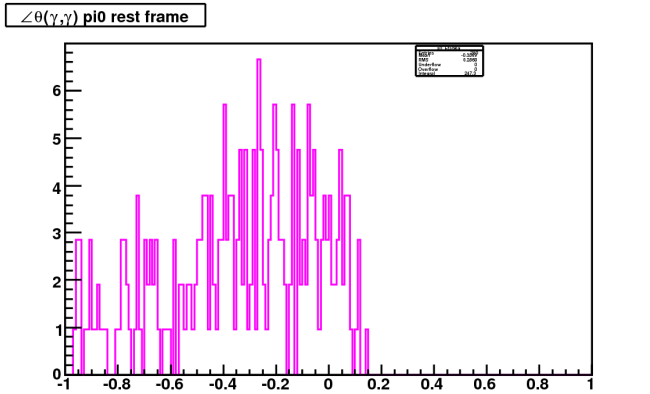

∠θ(γ,γ) pi0 rest frame
all_exp
Entries 518785
Mean -0.5737
RMS 0.2649
Underflow 0
Overflow 0
Integral 5.127e+05
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-1 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0

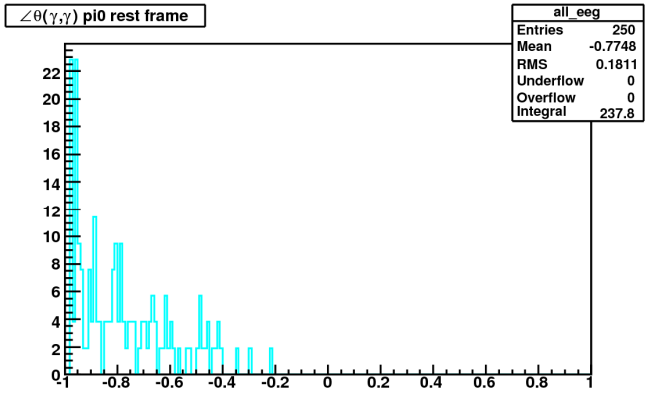

∠θ(γ,γ) pi0 rest frame
all_exp
Entries 518785
Mean -0.5652
RMS 0.2758
Underflow 0
Overflow 0
Integral 5.188e+05
10^4
10^3
10^2
10
1
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1

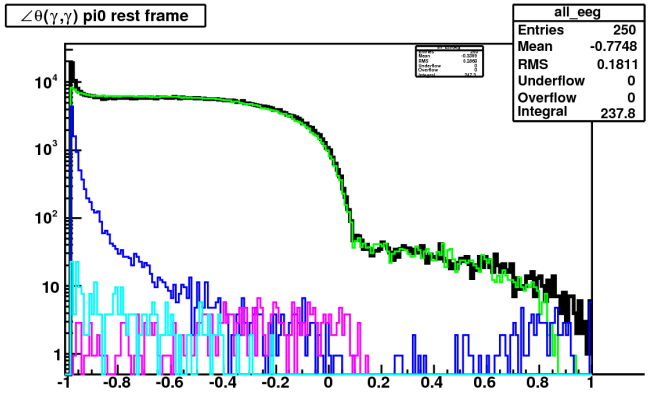

∠θ(γ,γ) pi0 rest frame


∠θ(γ,γ) pi0 rest frame
all_sig
Entries 534503
Mean -0.5629
RMS 0.2663
Underflow 0
Overflow 0
Integral 5.083e+05


∠θ(γ,γ) pi0 rest frame
all_bkg
Entries 10500
Mean -0.9169
RMS 0.1903
Underflow 0
Overflow 0
Integral 9986

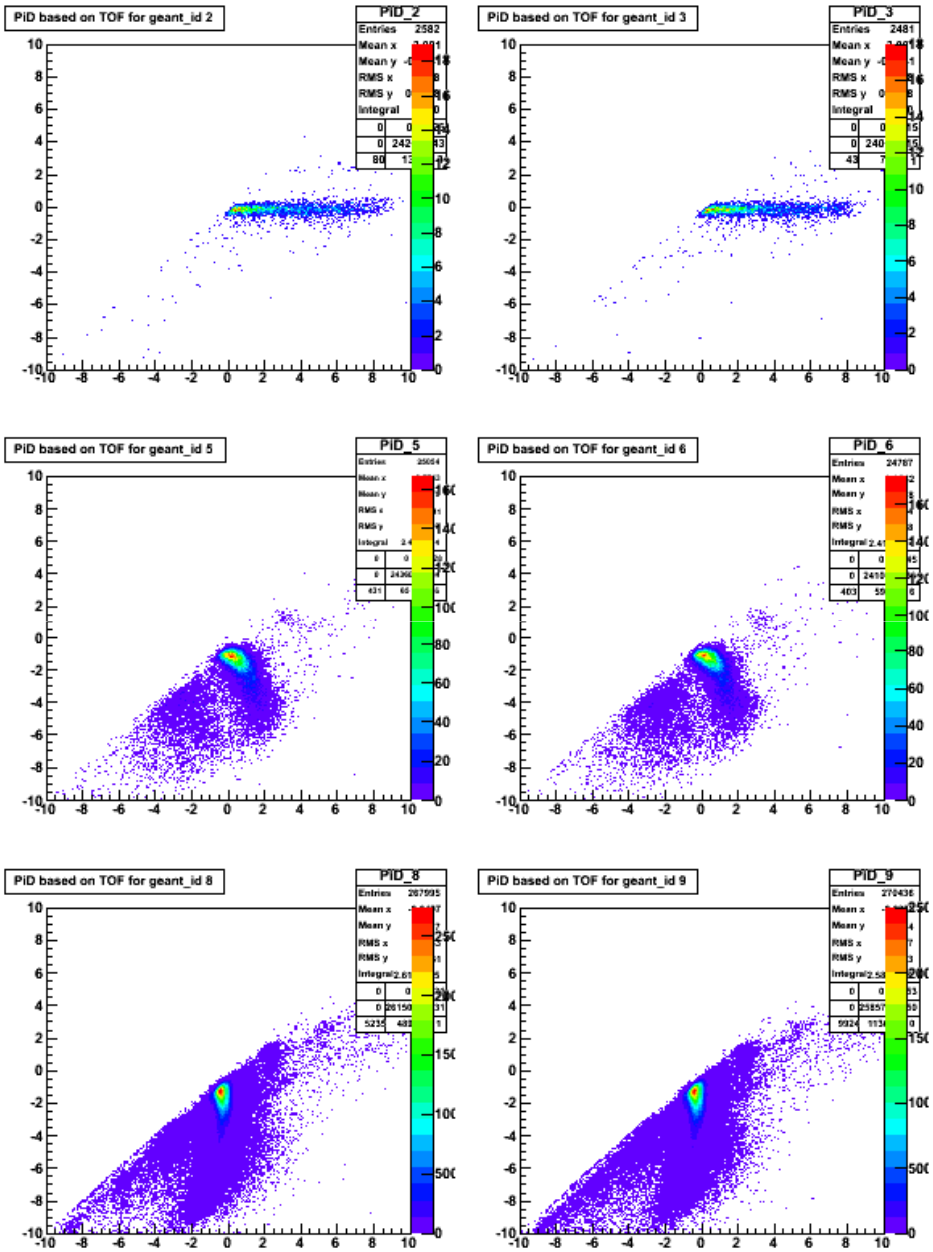

∠θ(γ,γ) pi0 rest frame


∠θ(γ,γ) pi0 rest frame
all_eeg
Entries 250
Mean -0.7748
RMS 0.1811
Underflow 0
Overflow 0
Integral 237.8


∠θ(γ,γ) pi0 rest frame
all_eeg
Entries 250
Mean -0.7748
RMS 0.1811
Underflow 0
Overflow 0
Integral 237.8

Summary and Outlooks

- New Scheme Analysis
- No recover Split
- Reject background
- Systematic study to be completed with efficiency on bkg and DeltaBR
- Results consistent with PDG and previous one


PID based on TOF for geant_id 2
PID_2
Entries 2582
PID based on TOF for geant_id 3
PID_3
Entries 2481
PID based on TOF for geant_id 5
PID_5
PID based on TOF for geant_id 6
PID_6
PID based on TOF for geant_id 8
PID_8
PID based on TOF for geant_id 9
PID_9