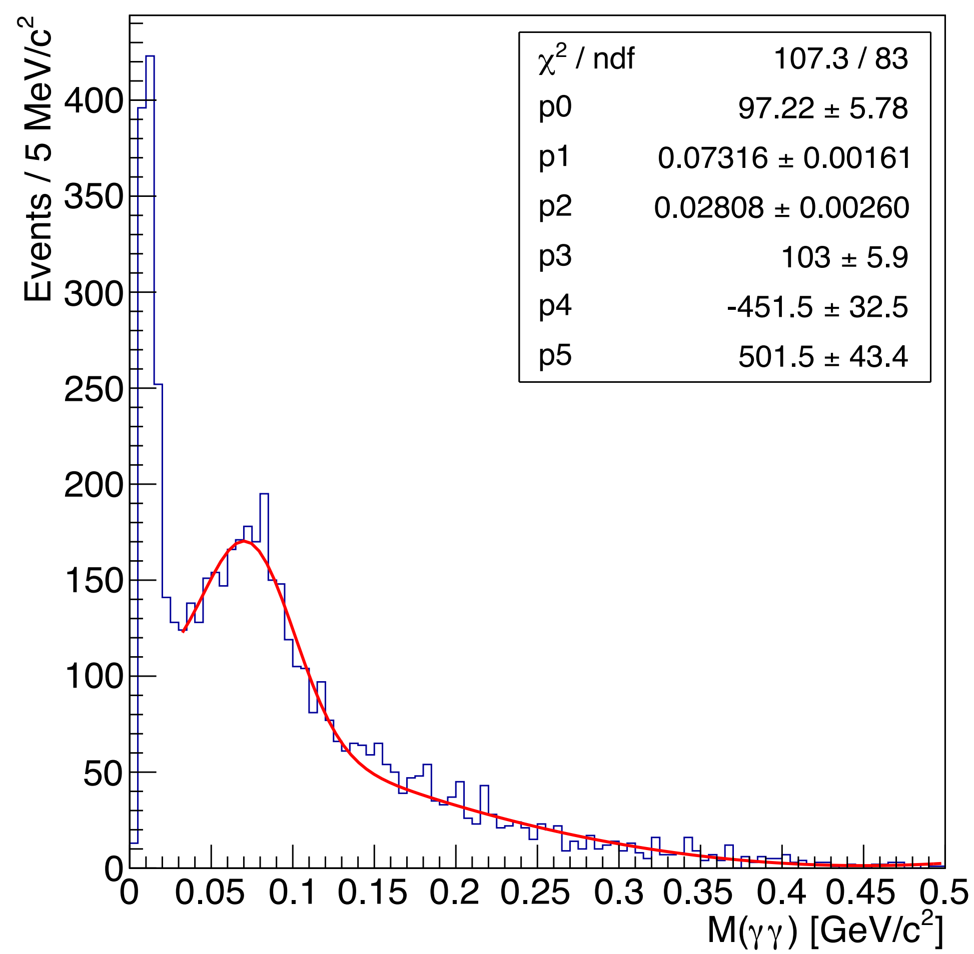
or

?

- 177K events from Run 1518
- Requirements:
  - lowest energy cluster > 500 MeV
  - two or more blocks hit in both the high and low energy cluster
  - cluster time difference < 5 ns
  - both clusters > 20 cm from beam line
  - FCAL energy < 6 GeV
- Notes:
  - low mass background strongly dependent on cluster separation cut (no cut made)
  - clusters in peak come from all over FCAL
  - need to verify energy scale by either E/p or second (η or ω) peak



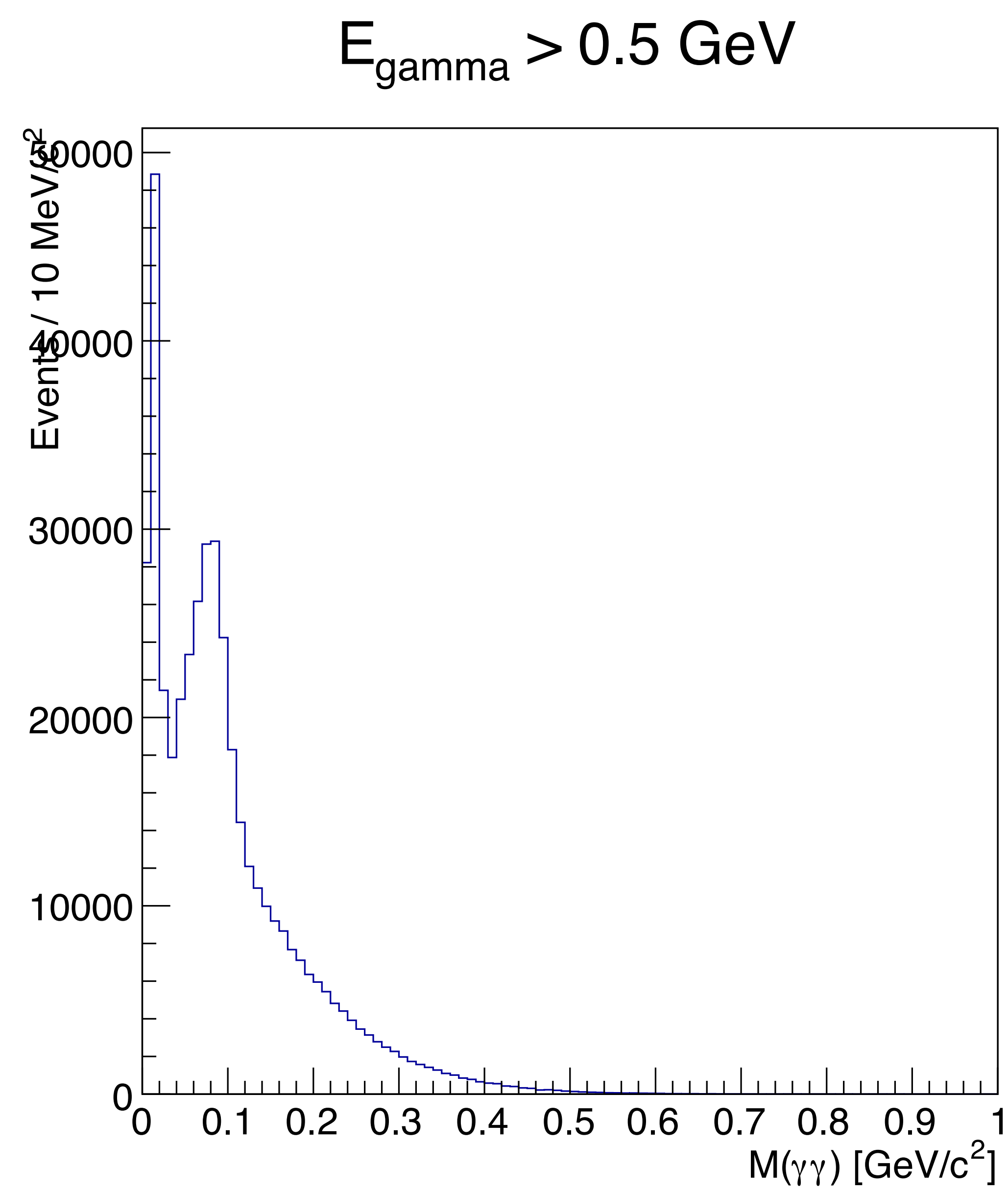
Shown at Run Coordination Meeting 25-Nov-2014

or

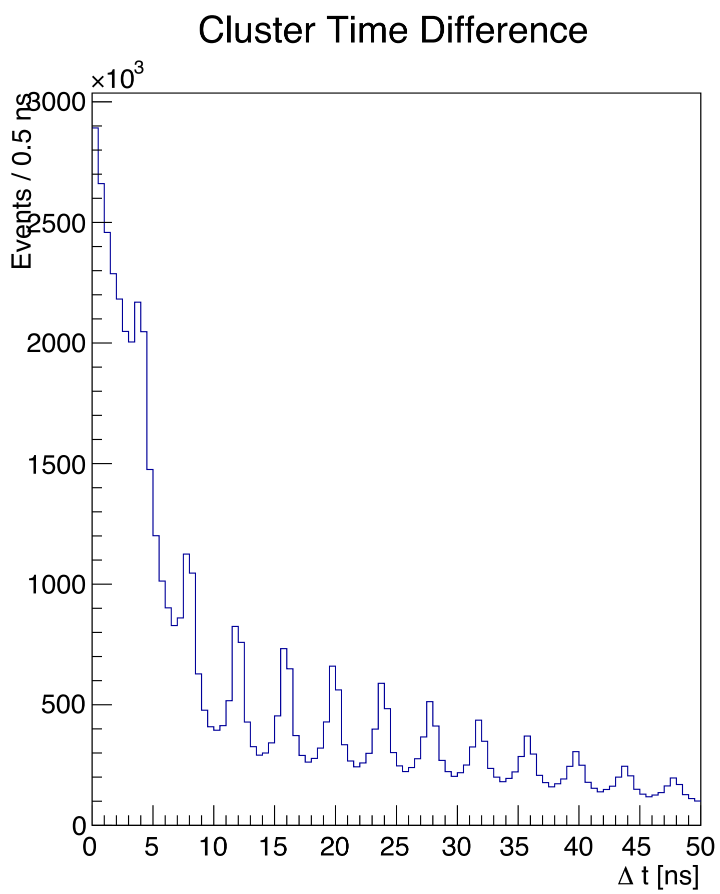
?

(updates from slides shown 25-Nov-2014 at RC meeting)

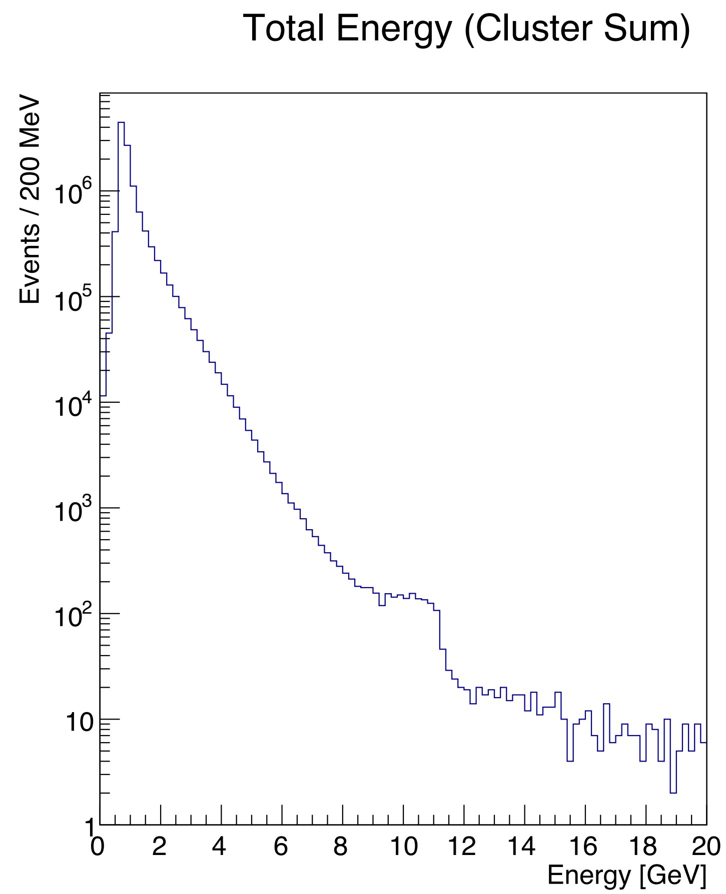
- 12.5M events (runs 1505 - 1520)
- Requirements (modified slightly)
    - cluster time difference < 10 ns
    - both clusters > 20 cm from beam line
    - FCAL energy < 7 GeV
    - number of clusters < 8
    - lowest energy cluster > 500 MeV
- Notes:
    - low mass background strongly dependent on cluster separation cut (no cut made)
    - clusters in peak come from all over FCAL
    - need to verify energy scale by either E/p or second (η or ω) peak



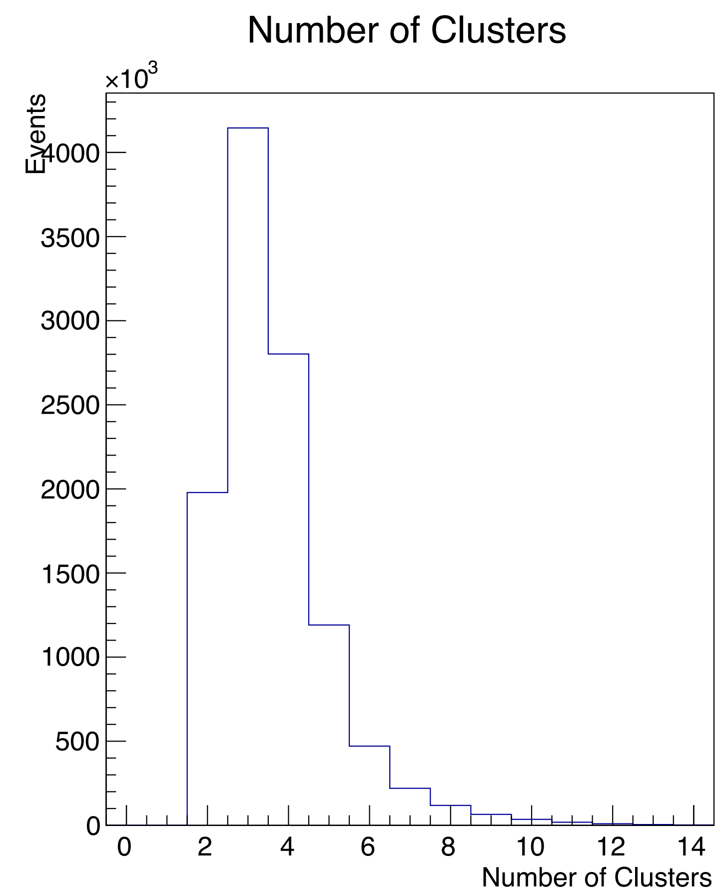
Fixed Requirements



require: $\Delta t < 10$ ns
(time structure is suspected
to be artifact of precision
timing algorithm on FADC)



require: Energy < 7 GeV



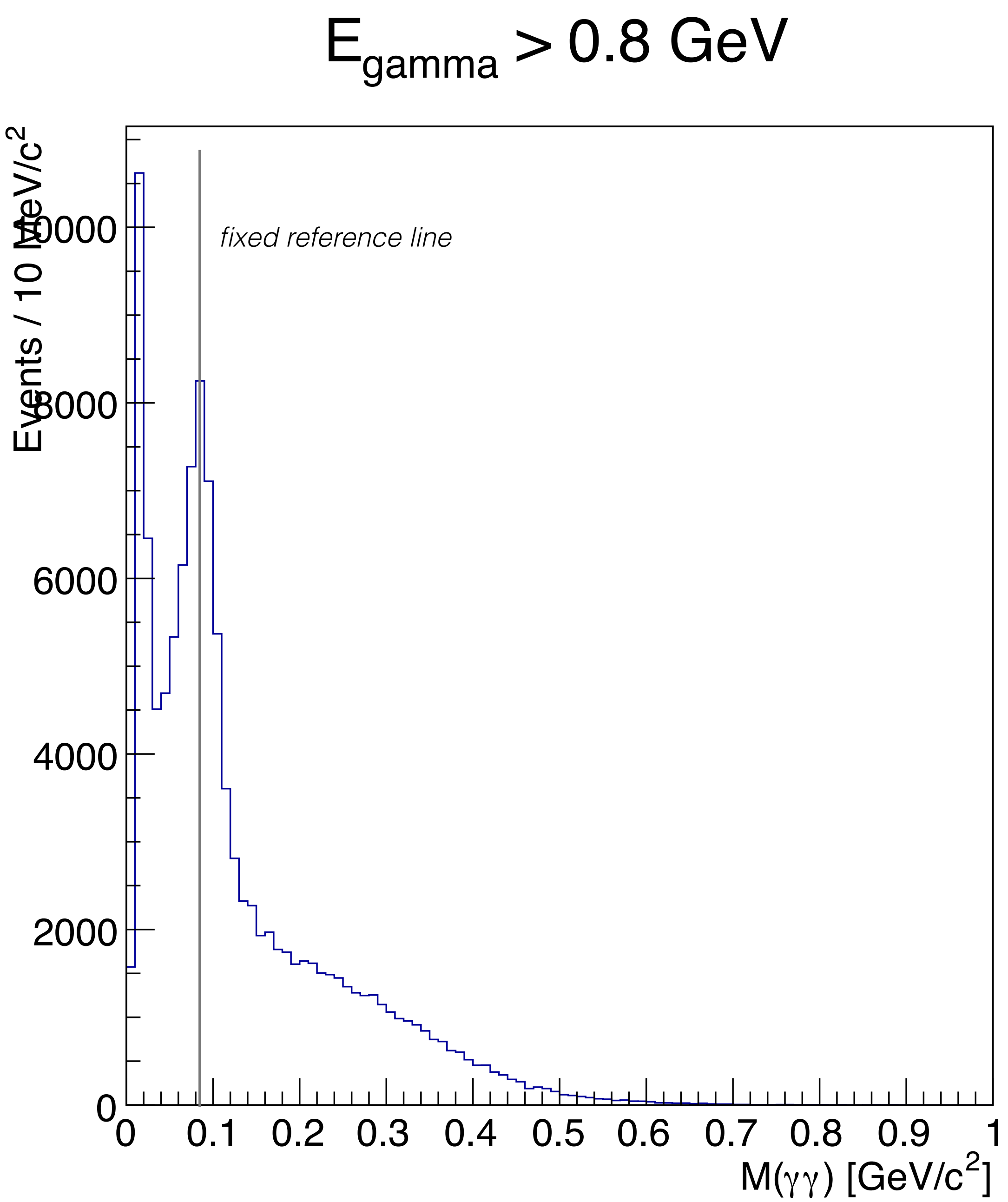
require: N < 8
(reduces combinatorics)

Fiducial Cut: require distance to beam line for both clusters > 20 cm

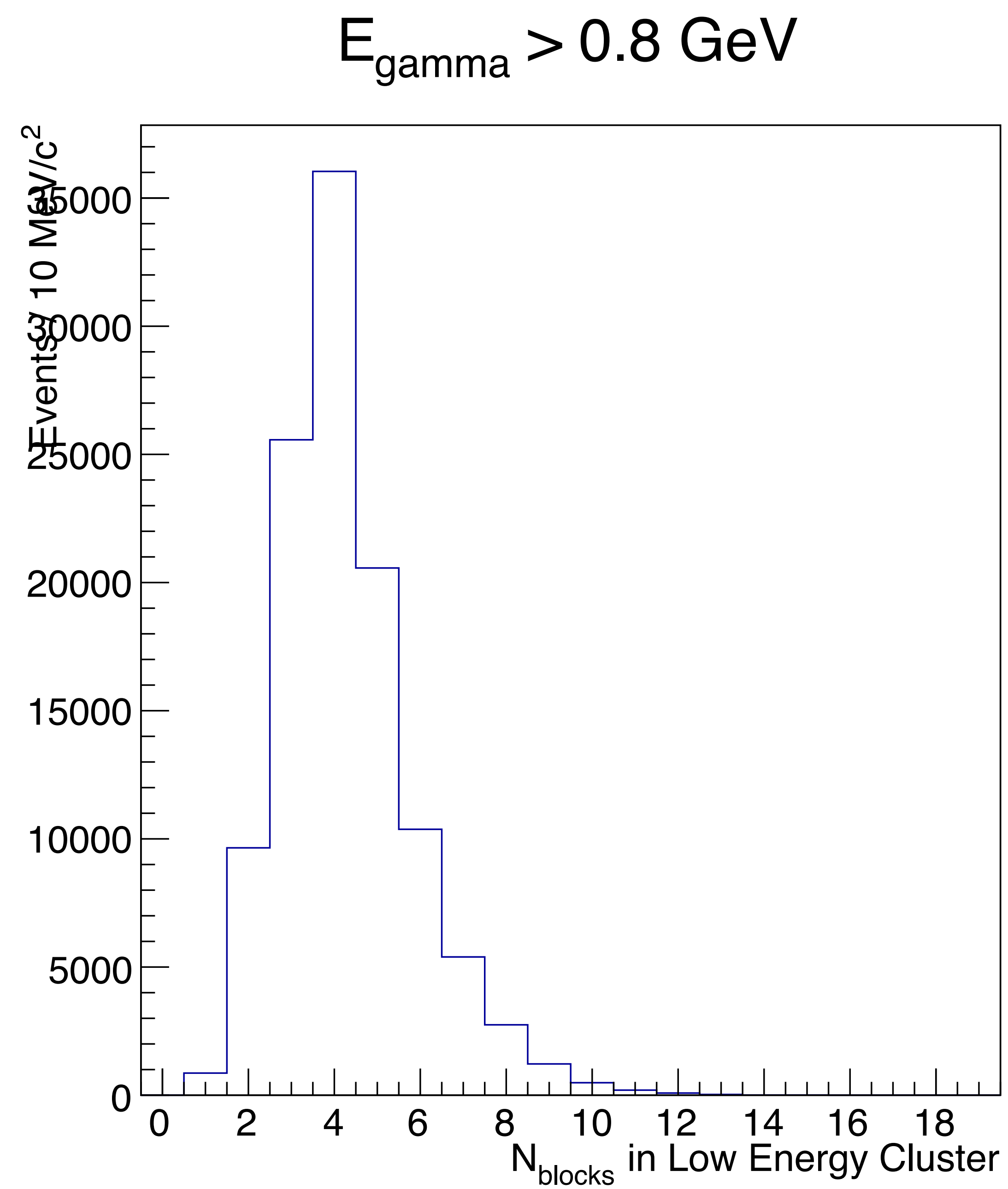
<u>The cuts above are applied on all subsequent slides.</u>

Analysis Strategy

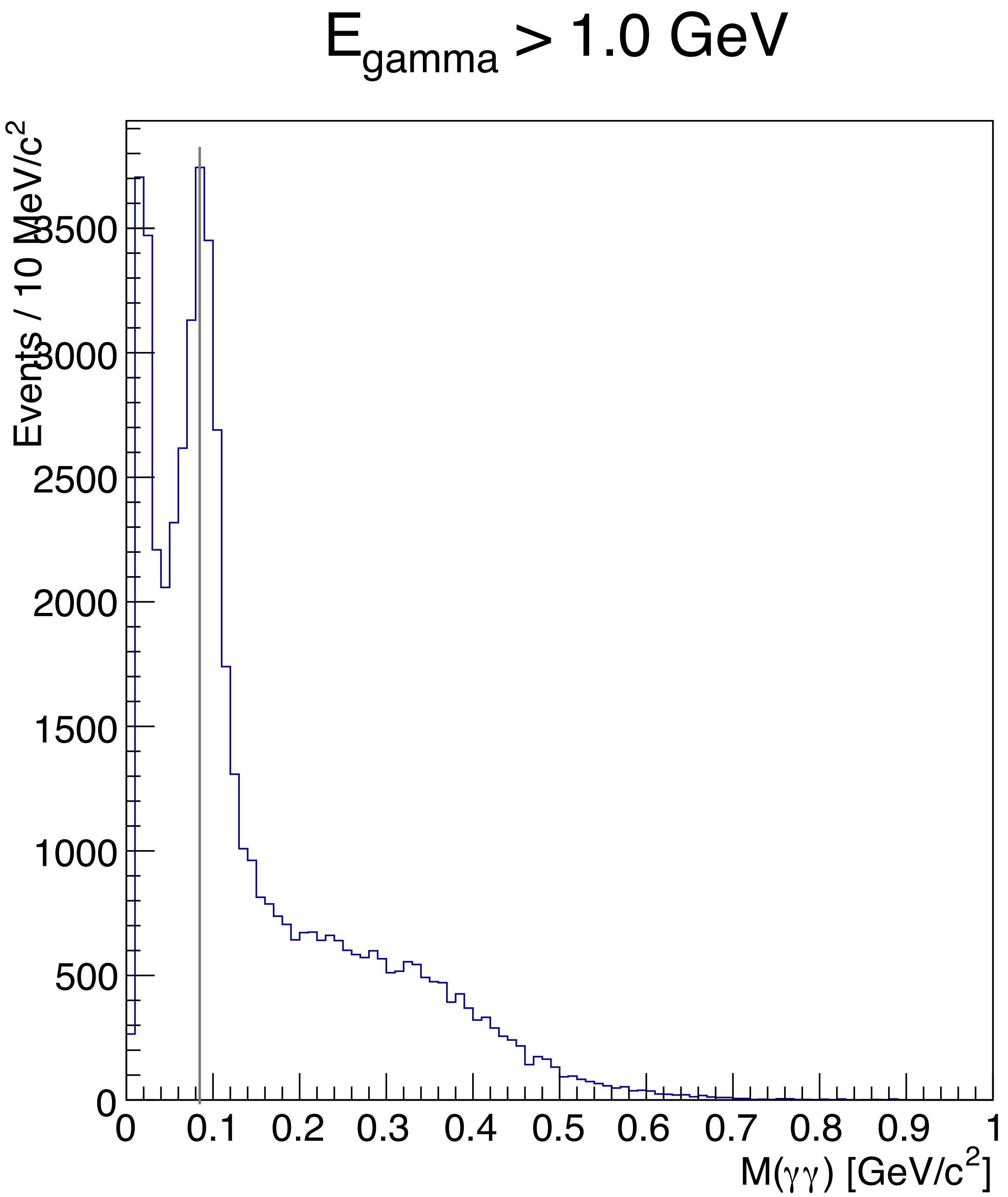
- Gradually increase the minimum photon energy cut from 0.8 GeV to 2.0 GeV
  - note: this is measured energy based on dead-reckoning — true energy can only be determined after the energy is calibrated
- As energy increases:
  - resolution improves ⇒ mass peaks narrow
  - smaller fractional energy loss due to fixed thresholds ⇒ mass peaks shifts to higher mass
    - number of blocks in a shower increases on average
  - yield of η with respect to π^0 increases
    - Pythia predicts N(η) / N(π^0) in FCAL about 20% at E(γ) > 2 GeV for this beam energy range

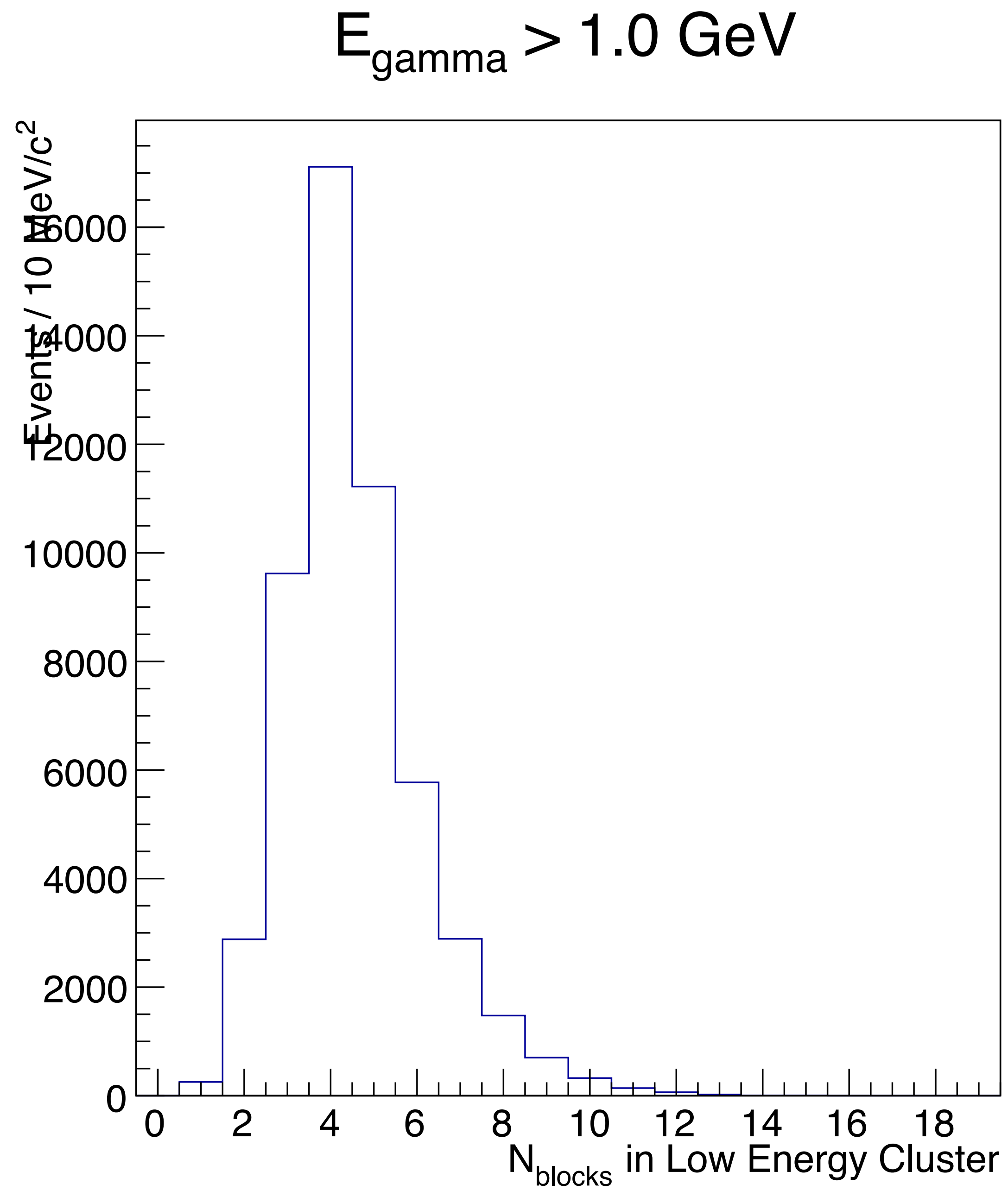


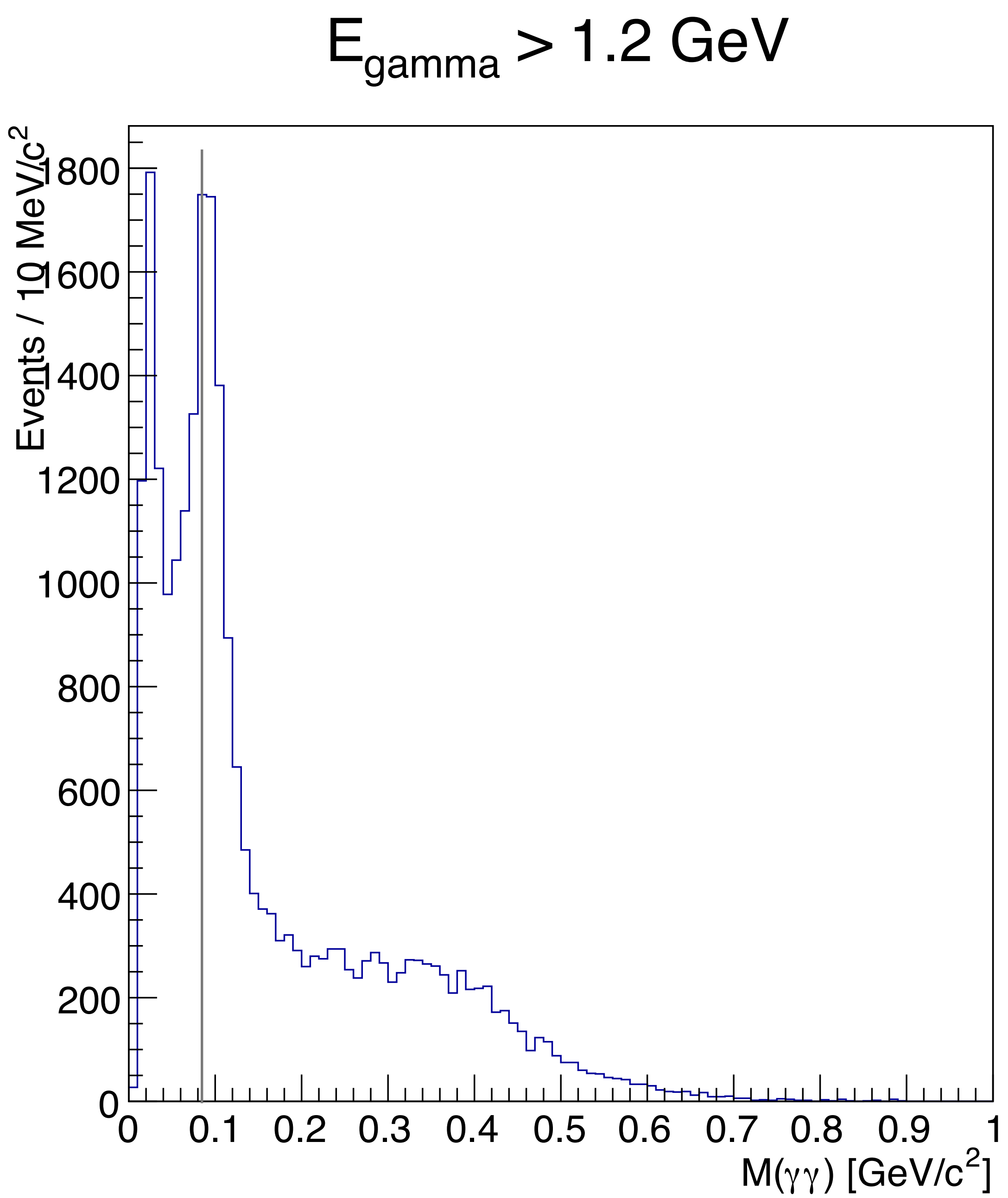
E_{gamma} > 0.8 GeV
Events / 10 MeV/c^2
fixed reference line
0
2000
4000
6000
8000
10000
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
M(γγ) [GeV/c^2]

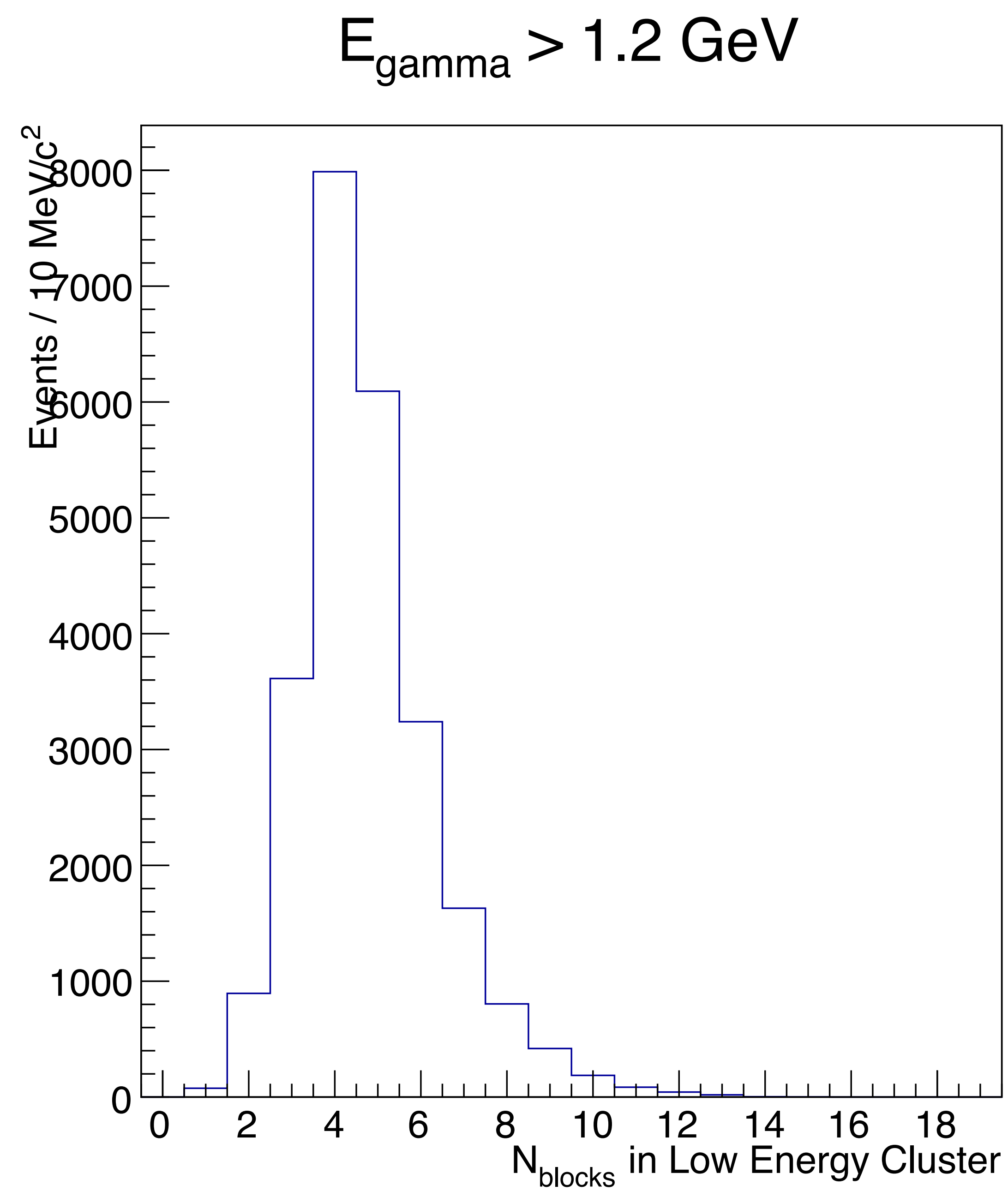


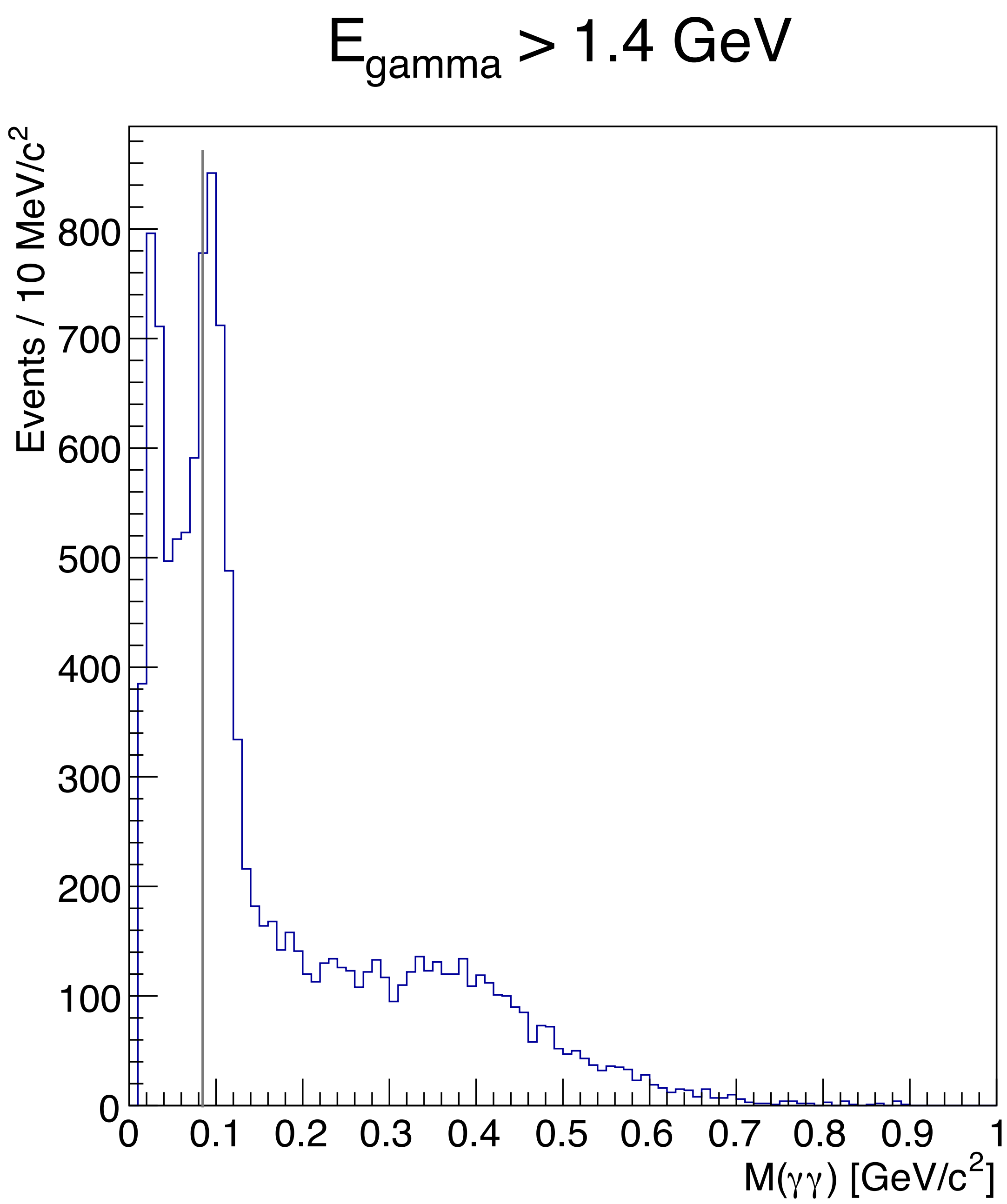
E_{gamma} > 0.8 GeV
Events / 10 MeV/c^2
0
5000
10000
15000
20000
25000
30000
35000
0 2 4 6 8 10 12 14 16 18
N_{blocks} in Low Energy Cluster


$E_{gamma} > 1.0$ GeV
Events / 10 MeV/c²
M(γγ) [GeV/c²]
0
500
1000
1500
2000
2500
3000
3500
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

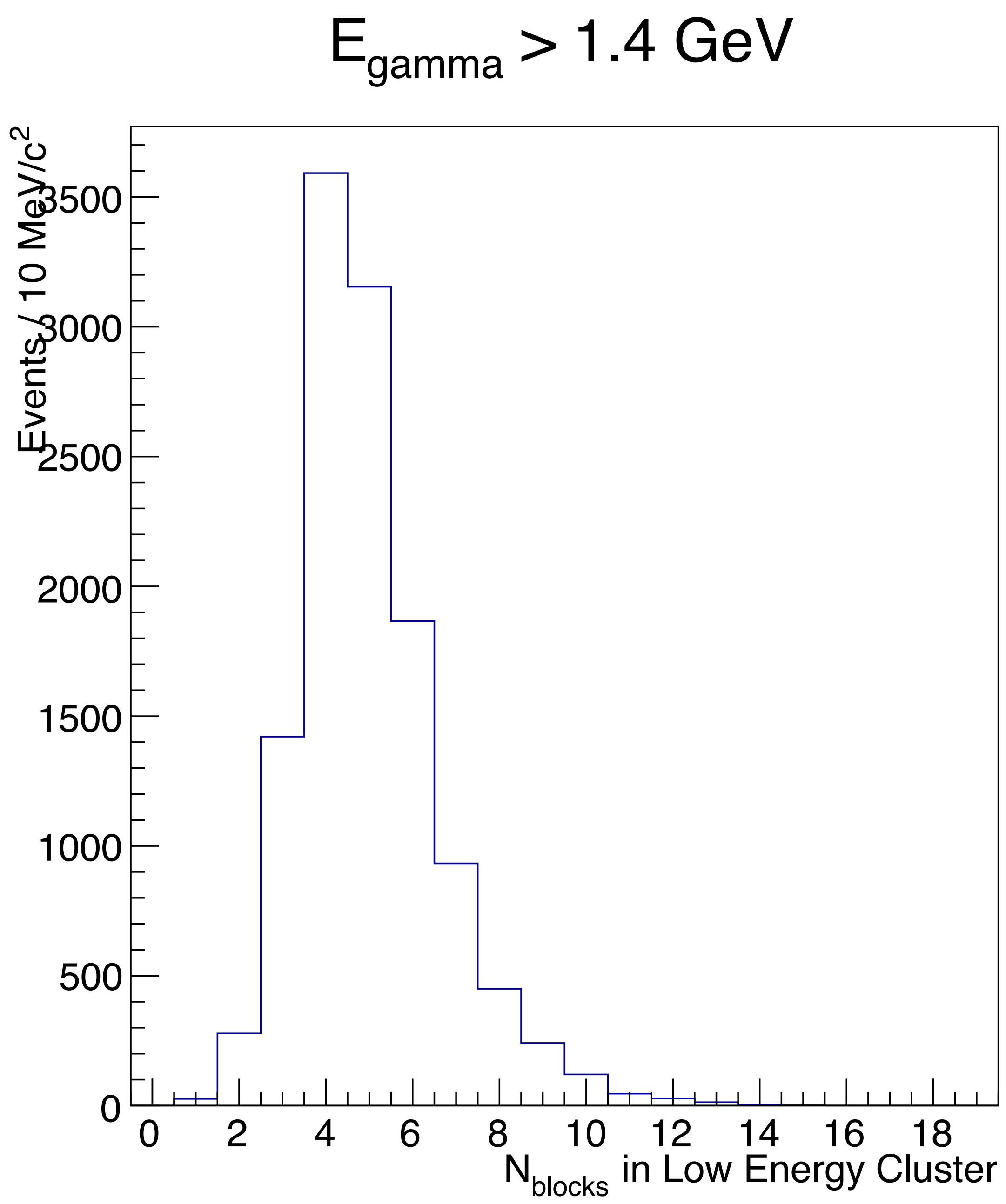

$E_{gamma} > 1.0$ GeV
Events / 10 MeV/c²
N_{blocks} in Low Energy Cluster
0
2000
4000
6000
8000
10000
12000
14000
16000
0 2 4 6 8 10 12 14 16 18


E_gamma > 1.2 GeV
Events / 10 MeV/c²
M(γγ) [GeV/c²]
0
200
400
600
800
1000
1200
1400
1600
1800
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

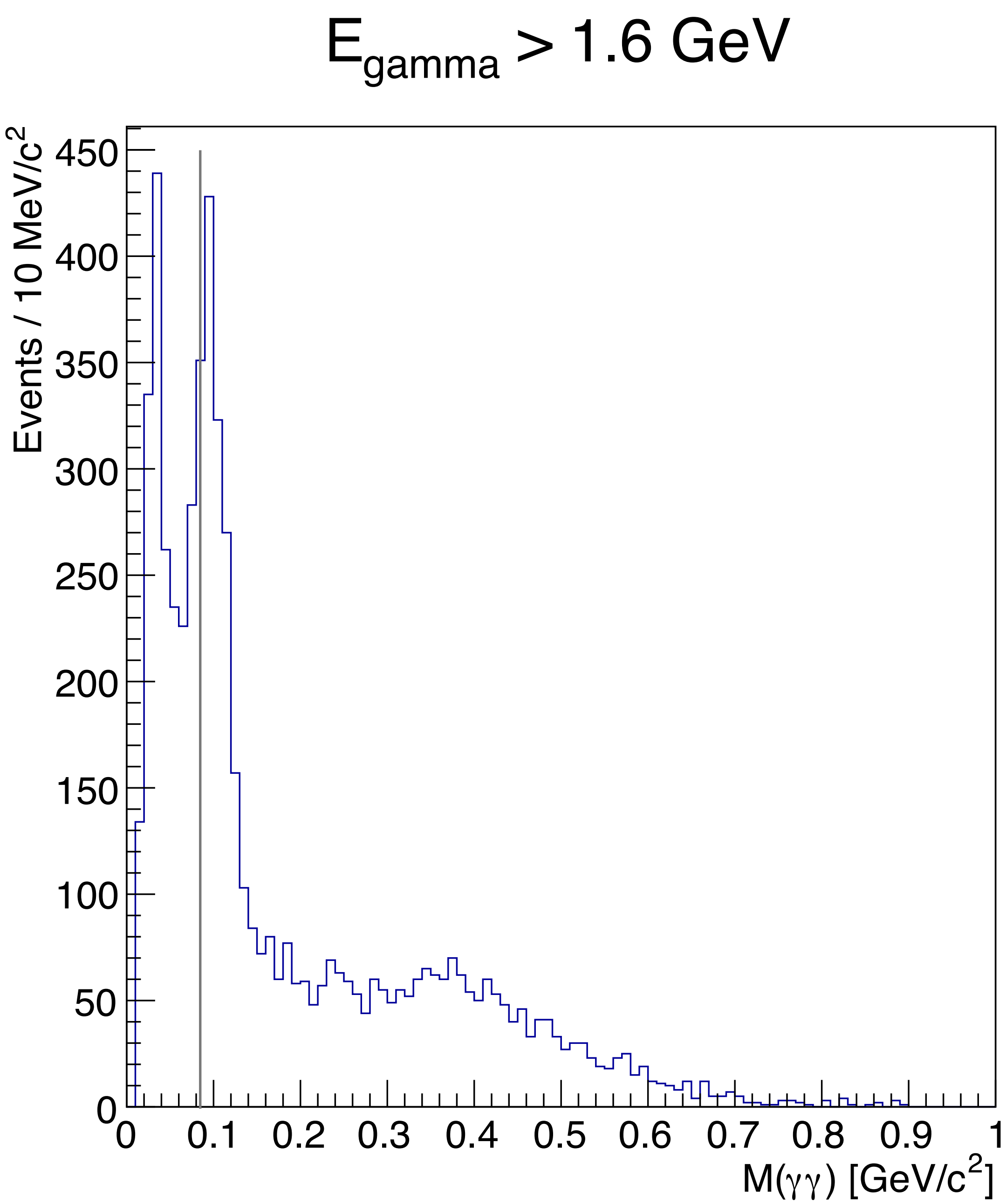

E_gamma > 1.2 GeV
Events / 10 MeV/c²
N_blocks in Low Energy Cluster
0
1000
2000
3000
4000
5000
6000
7000
8000
2
4
6
8
10
12
14
16
18

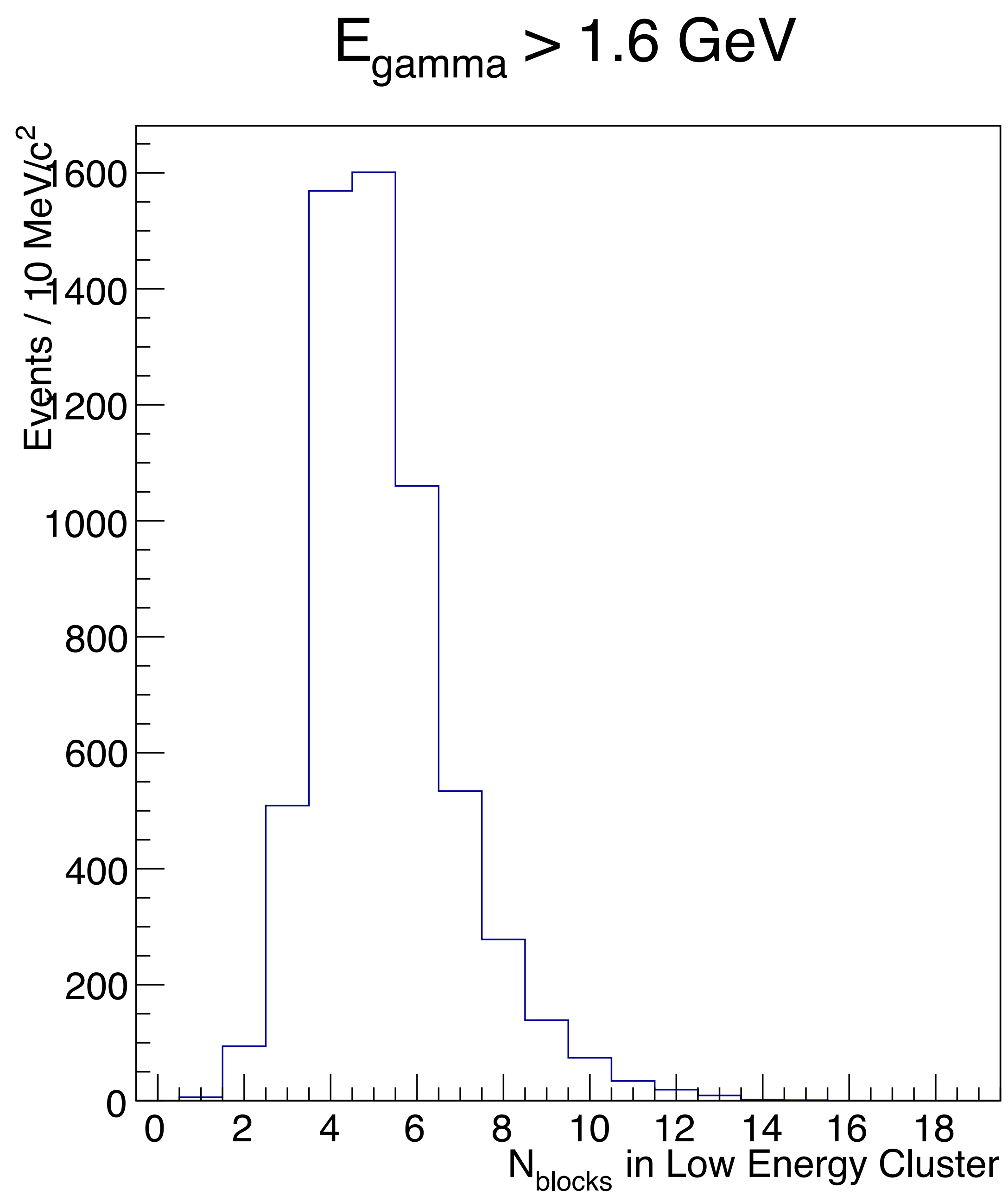


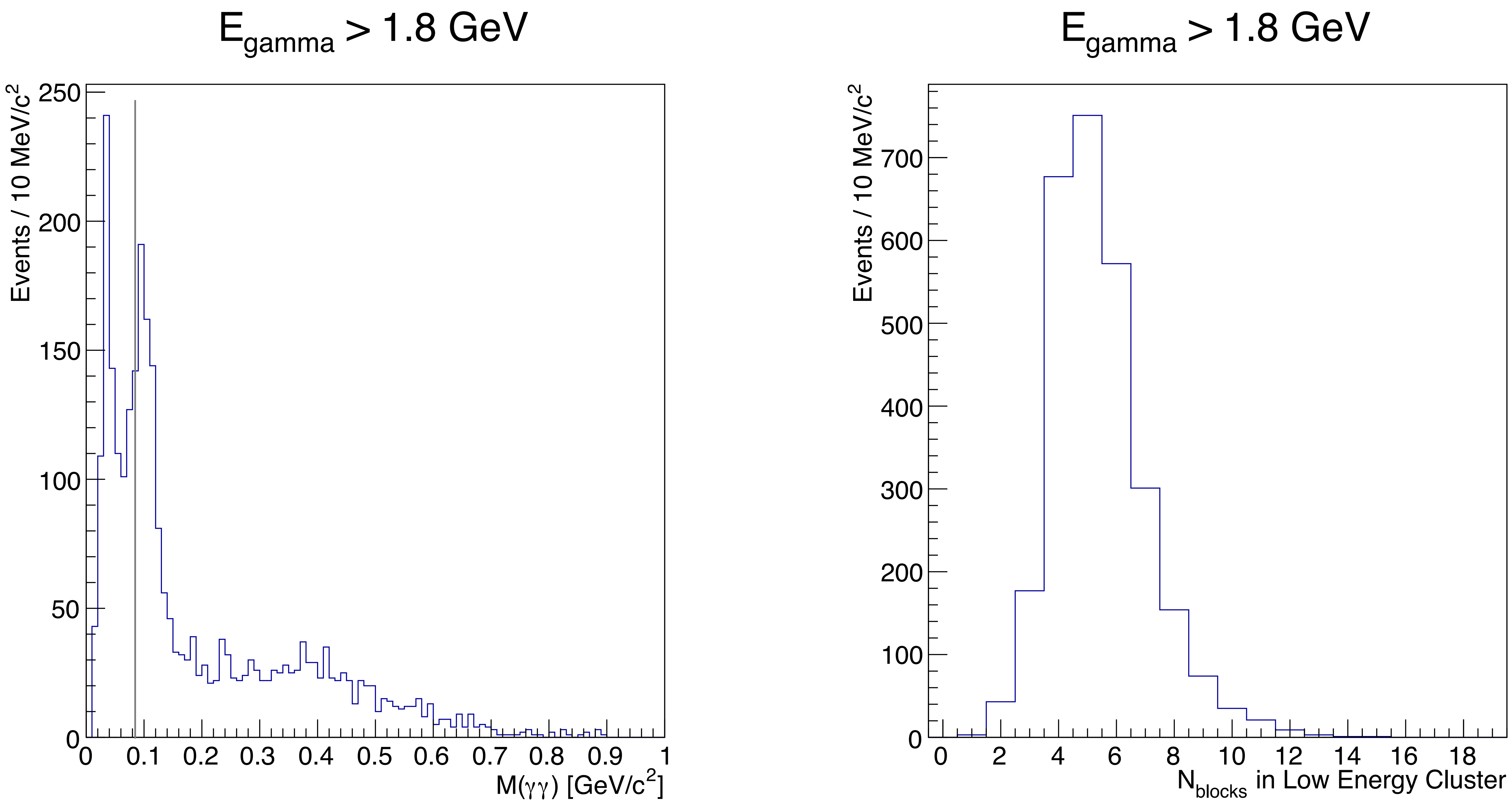
E_{gamma} > 1.4 GeV
Events / 10 MeV/c^2
M(γγ) [GeV/c^2]



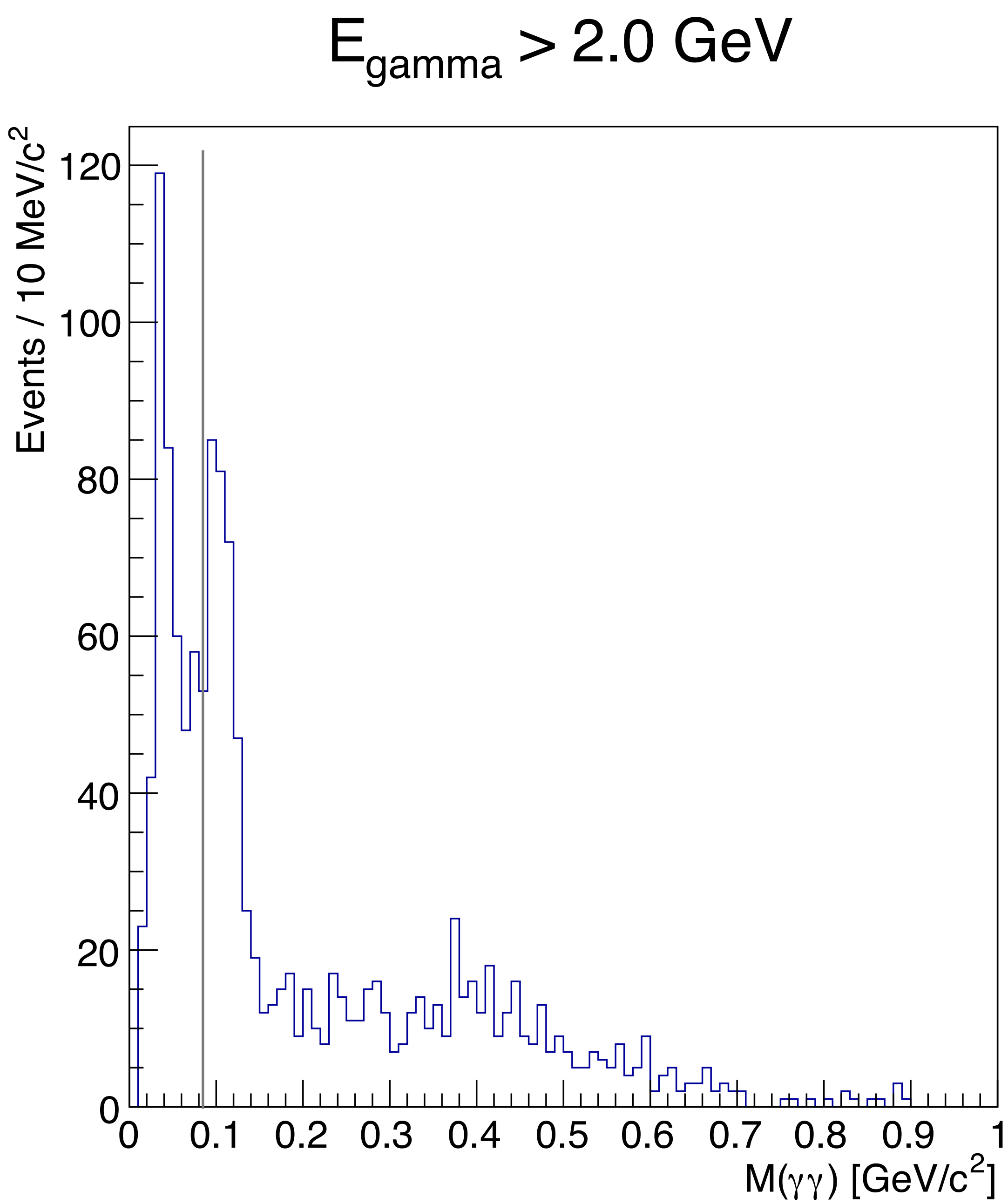
E_{gamma} > 1.4 GeV
Events / 10 MeV/c^2
N_{blocks} in Low Energy Cluster


E_gamma > 1.6 GeV
Events / 10 MeV/c²
M(γγ) [GeV/c²]
0
50
100
150
200
250
300
350
400
450
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

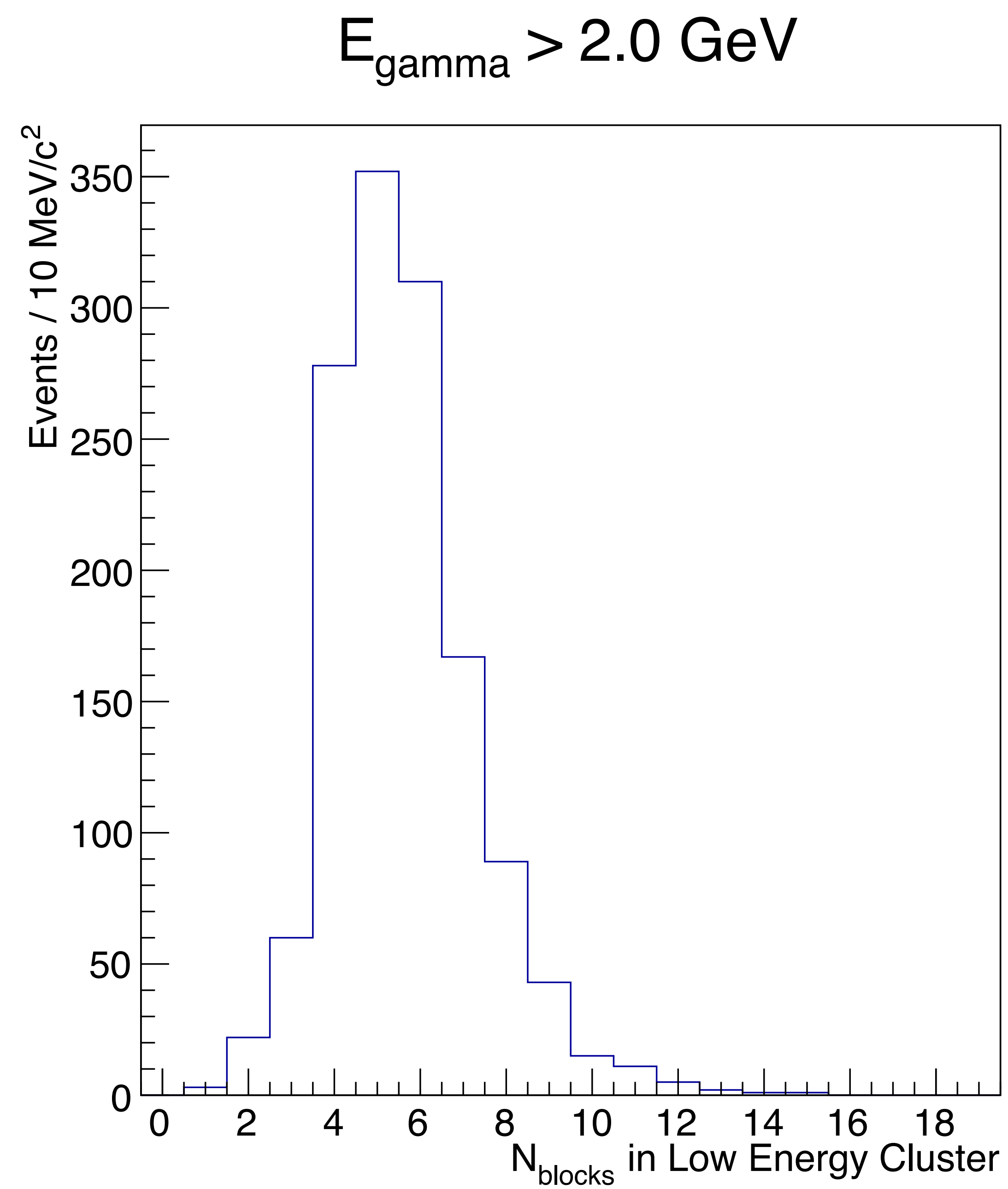

E_gamma > 1.6 GeV
Events / 10 MeV/c²
N_blocks in Low Energy Cluster
0
200
400
600
800
1000
1200
1400
1600
0
2
4
6
8
10
12
14
16
18



E_gamma > 1.8 GeV
Events / 10 MeV/c^2
250
200
150
100
50
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
M(γγ) [GeV/c^2]
E_gamma > 1.8 GeV
Events / 10 MeV/c^2
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
18
N_blocks in Low Energy Cluster

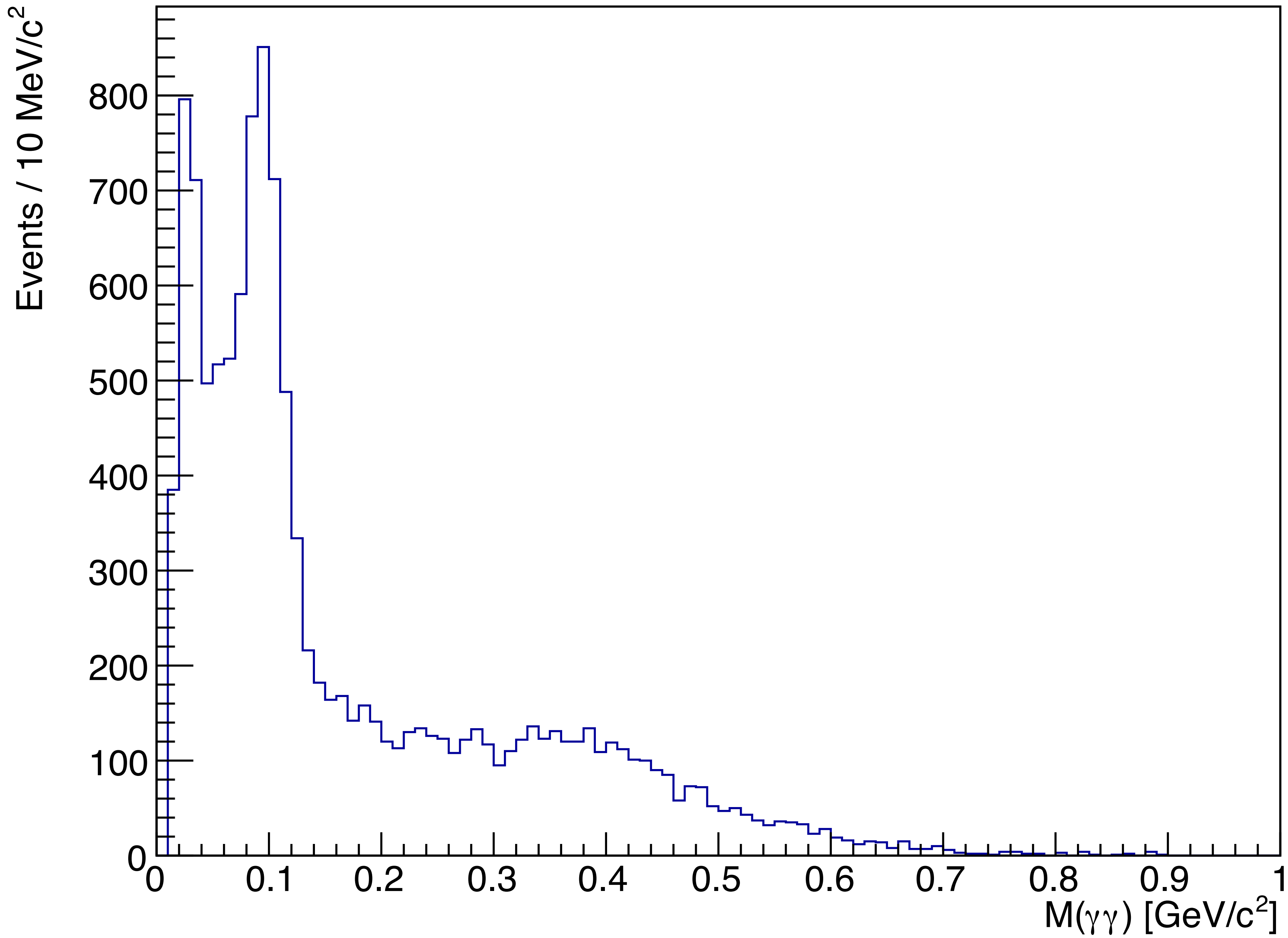


E_{gamma} > 2.0 GeV
Events / 10 MeV/c^2
0
20
40
60
80
100
120
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
M(γγ) [GeV/c^2]



E_{gamma} > 2.0 GeV
Events / 10 MeV/c^2
0
50
100
150
200
250
300
350
0
2
4
6
8
10
12
14
16
18
N_{blocks} in Low Energy Cluster

$E_{gamma} > 1.4$ GeV



- If the peak bin at 95 MeV/c^2 is the π^0, then:
  - one would expect an η peak at 385 MeV/c^2 with a width of about 150 MeV/c^2
  - the true photon energy cut is about 2 GeV
  - Pythia predicts N(η→γγ) / N(π^0) of about 0.2 in the FCAL acceptance

Summary

- Results seems to indicate the observation of $\pi^0 \rightarrow \gamma\gamma$
  - π^0 peak behaves as expected when photon energy requirement is increased
  - hint of evidence for $\eta \rightarrow \gamma\gamma$
- Qualitative analysis: fitting is complicated by non-trivial background shape
  - requiring a track reduces background (M. Staib) but at an estimated efficiency cost of about a factor of 5
  - unlikely that cuts alone (of any type) will produce a sharp significant η peak without doing gain balancing of the detector first (which requires more stats and effort)
- A measure of $E_{cluster}$ / p_{track} for electrons seems to be the easiest way to provide definitive evidence for electron and π^0 reconstruction capability
- Energy scale estimate for “300 mV” FCAL HV setting is 0.37 MeV per unit of FADC pulse integral (where pulse integral is about 5 x peak sample)