Template based Gamma-ray direction reconstruction for WCD based Air Showers arrays

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MPIK

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Heidelberg, Germany
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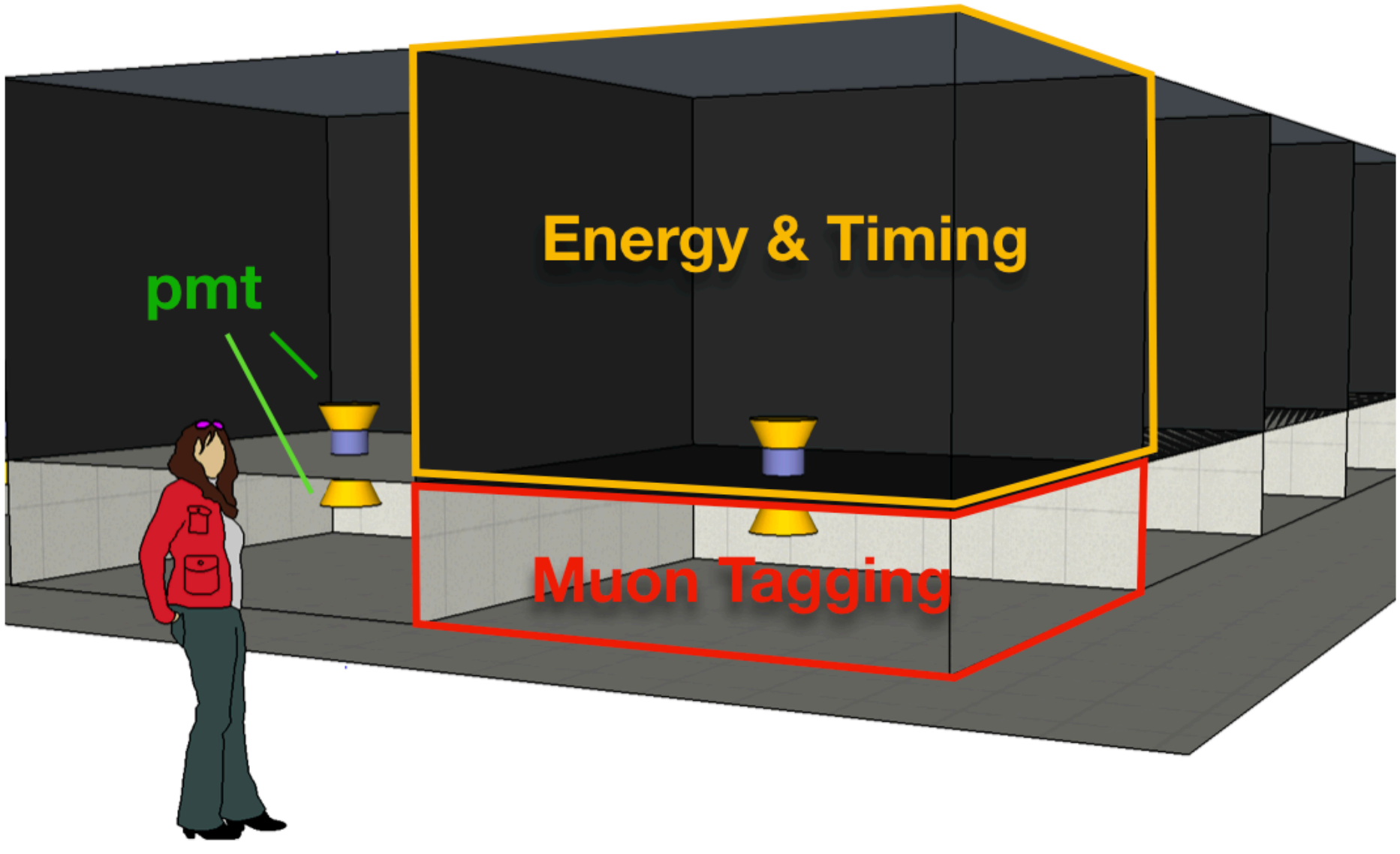
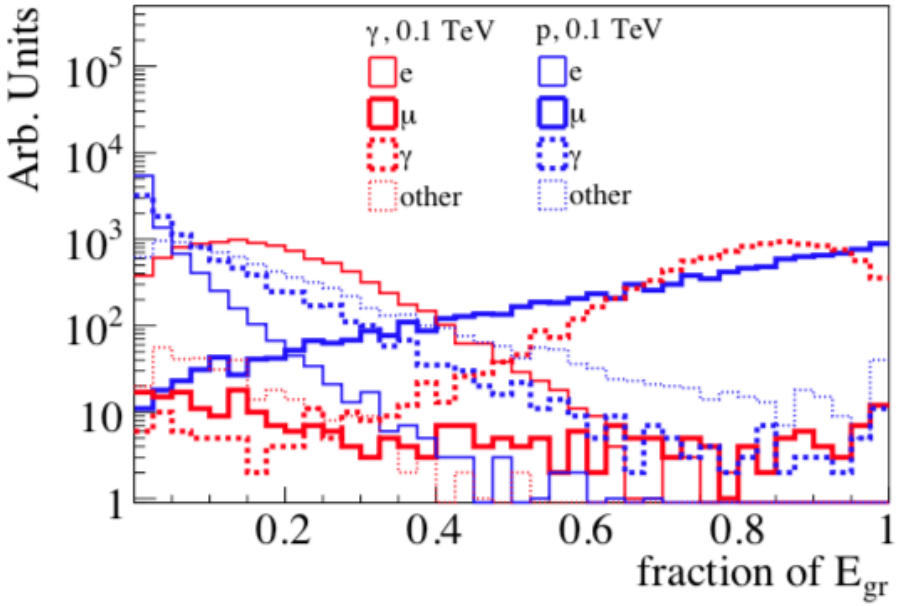
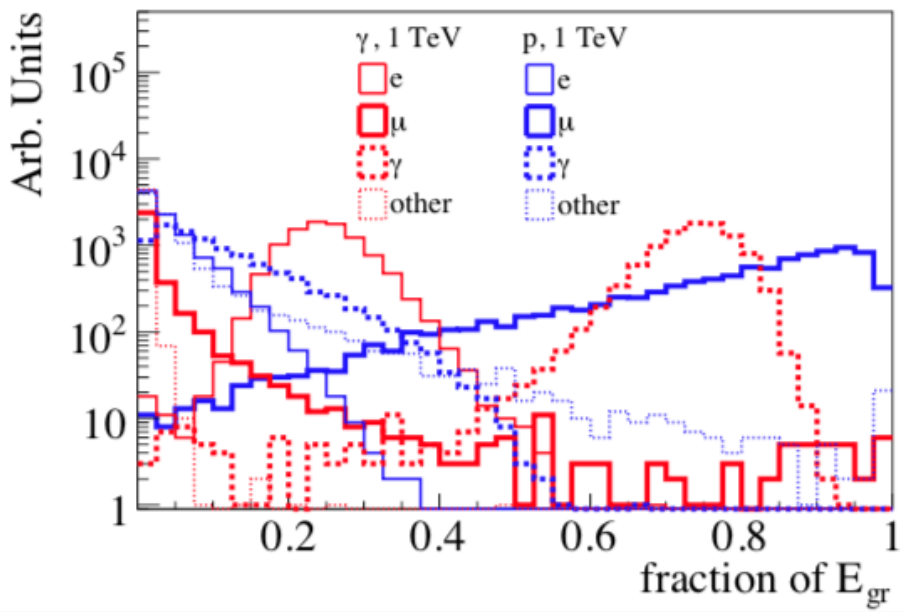

pmt
Energy & Timing
Muon Tagging

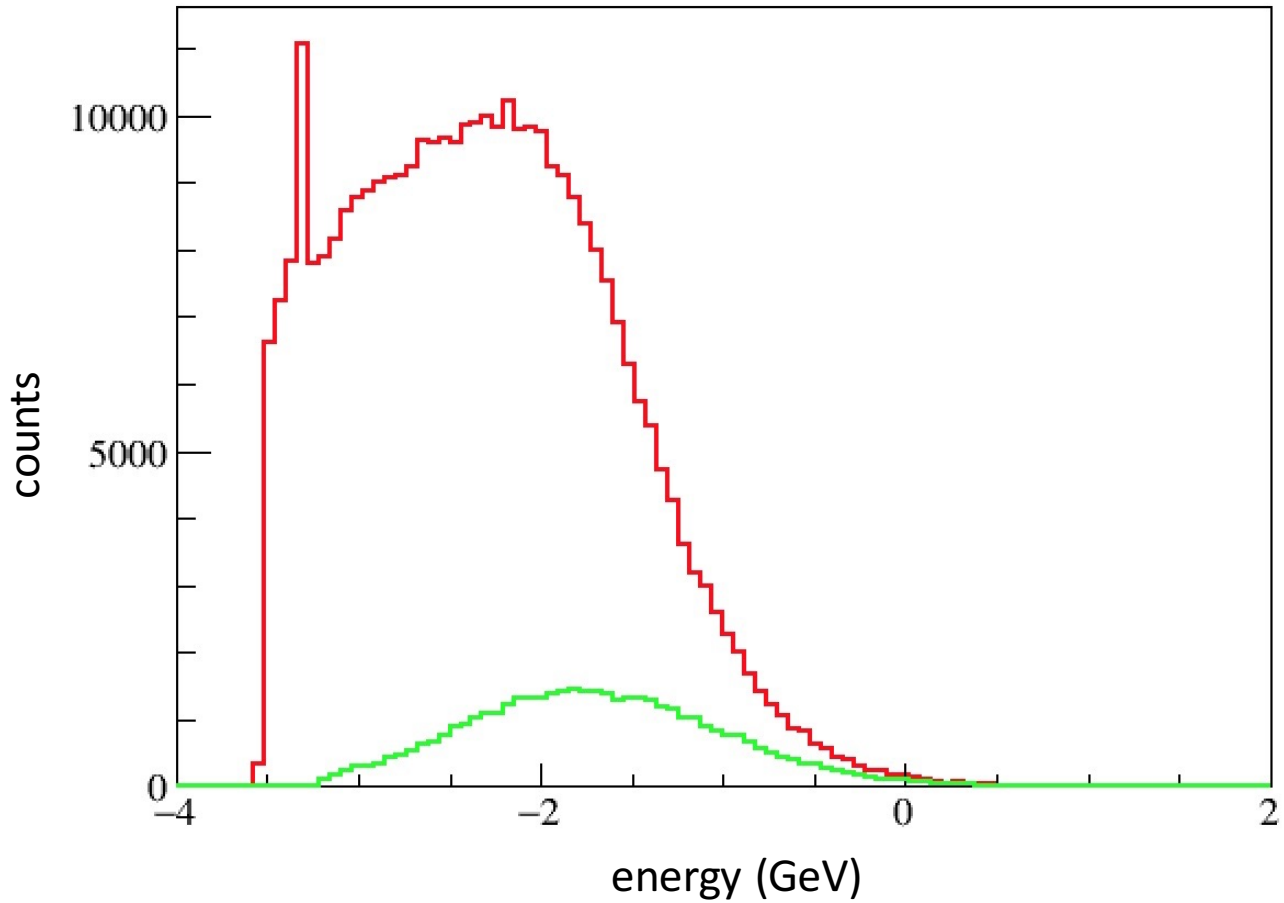
What do we optimize for?





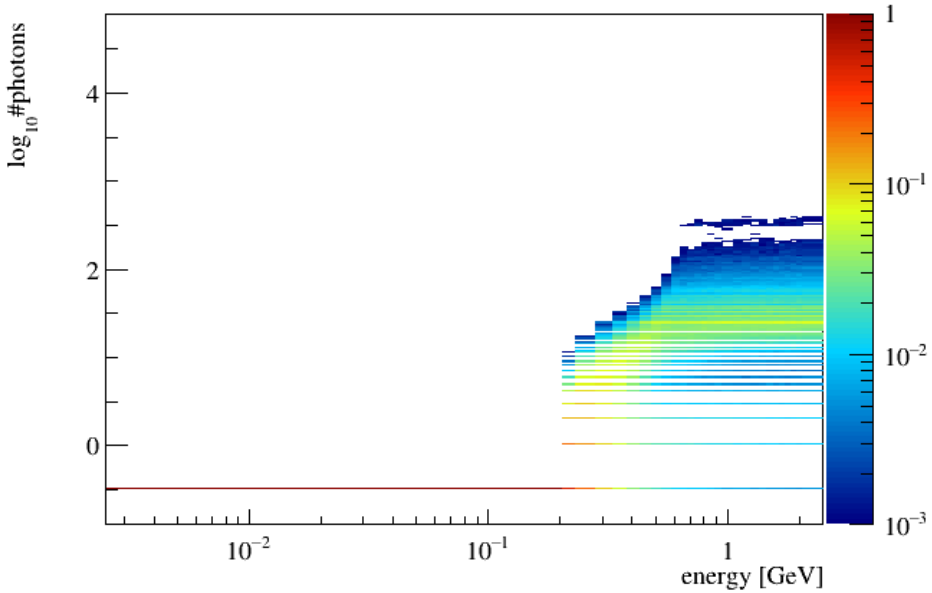
At 5 KM

Gamma , Electron /positron

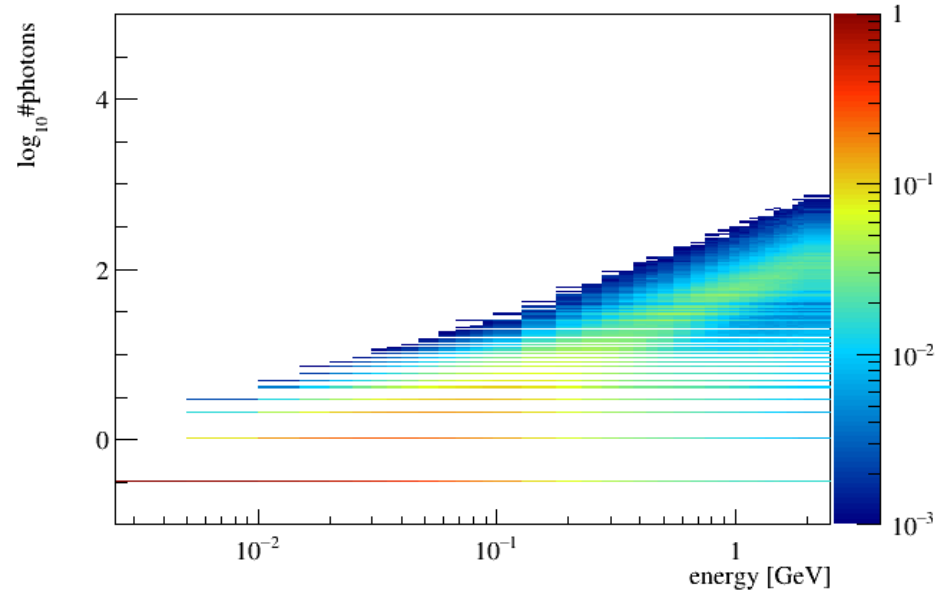


1 TeV , 5 KM, $\phi = 0$

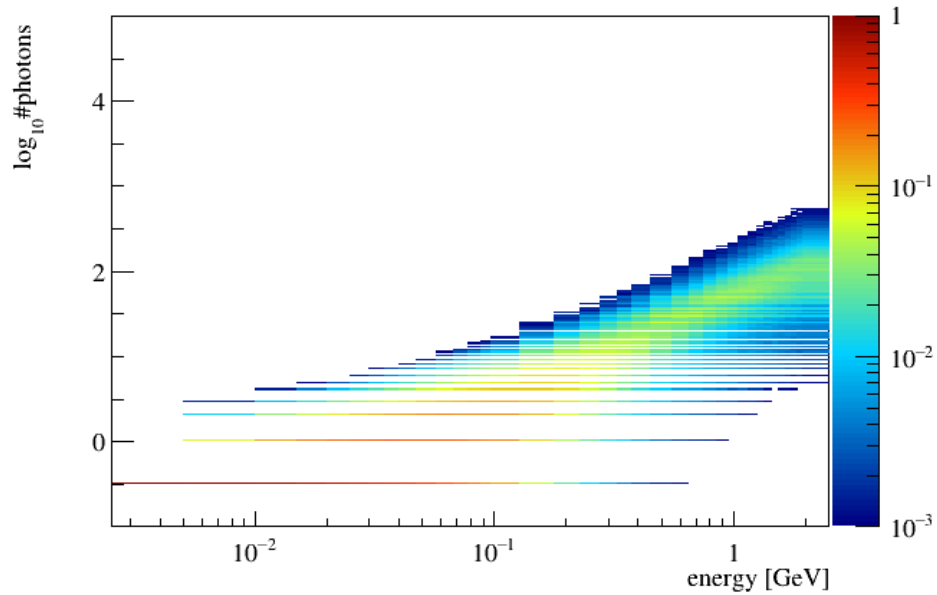
Tank Response 3.6x3.6x2.5 m, Black Walls



muons

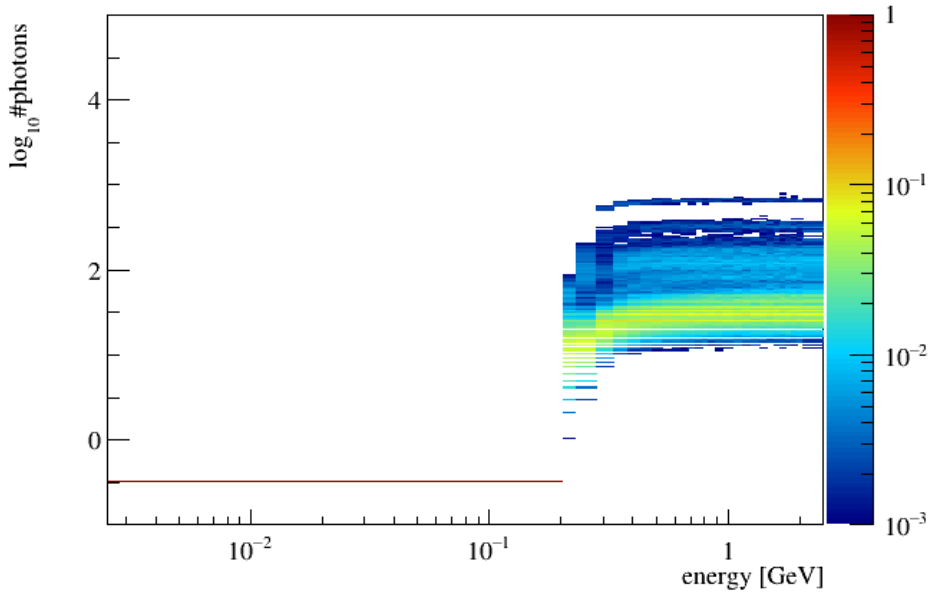


gammas

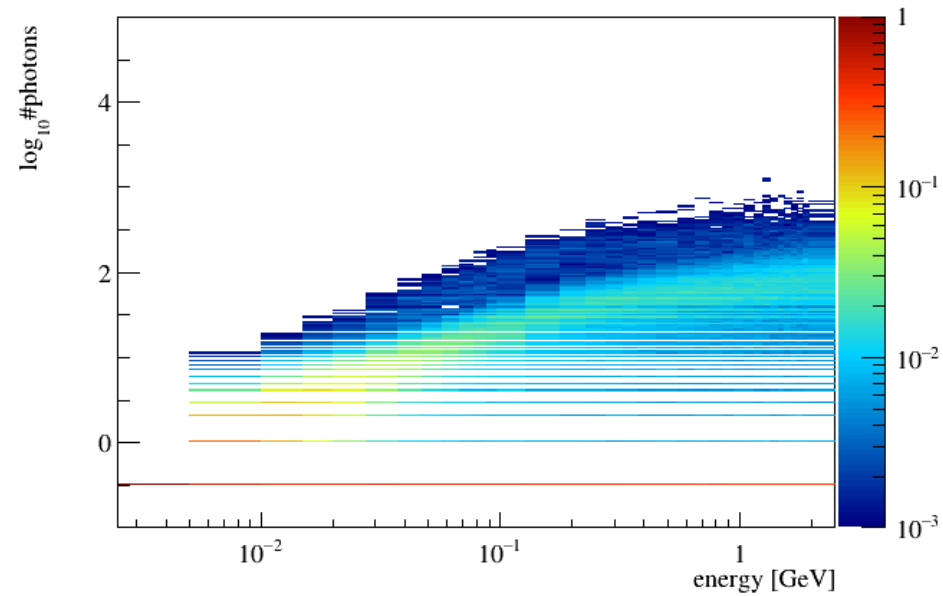


electrons

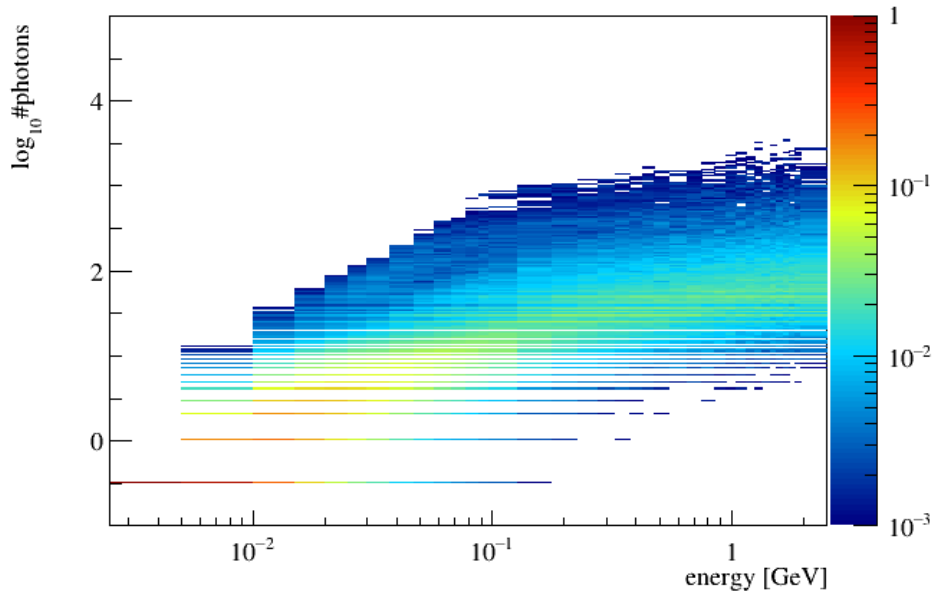
Tank response 3x1.5x0.5 , White Walls, lead block 5.6 mm



muons

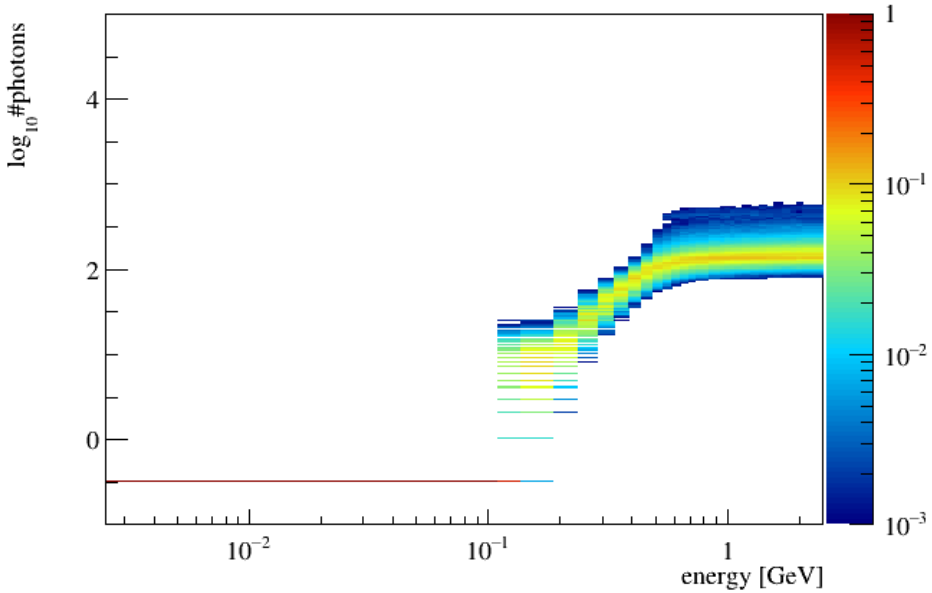


electrons

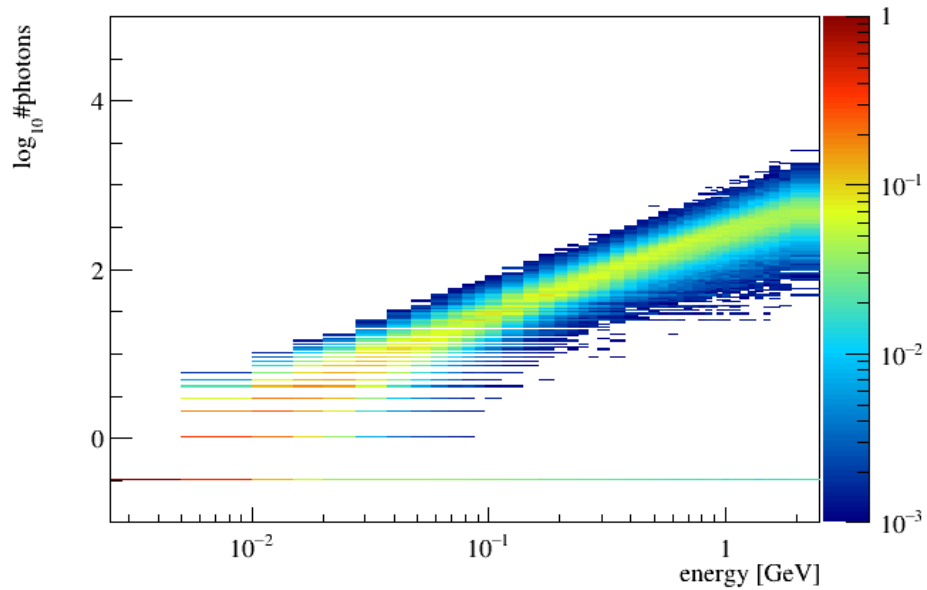


gammas

Tank response 3x3x2, White Walls

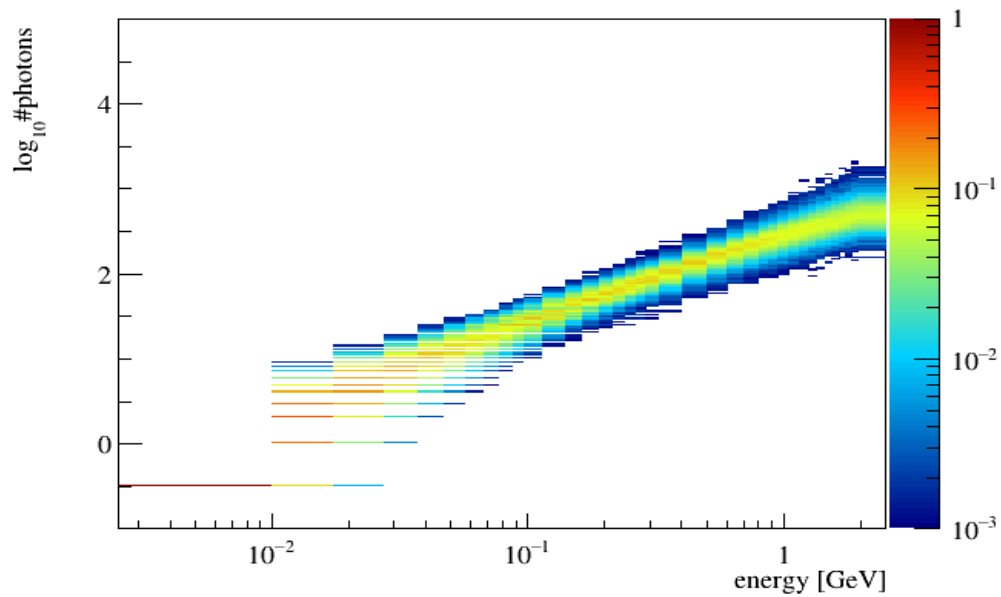


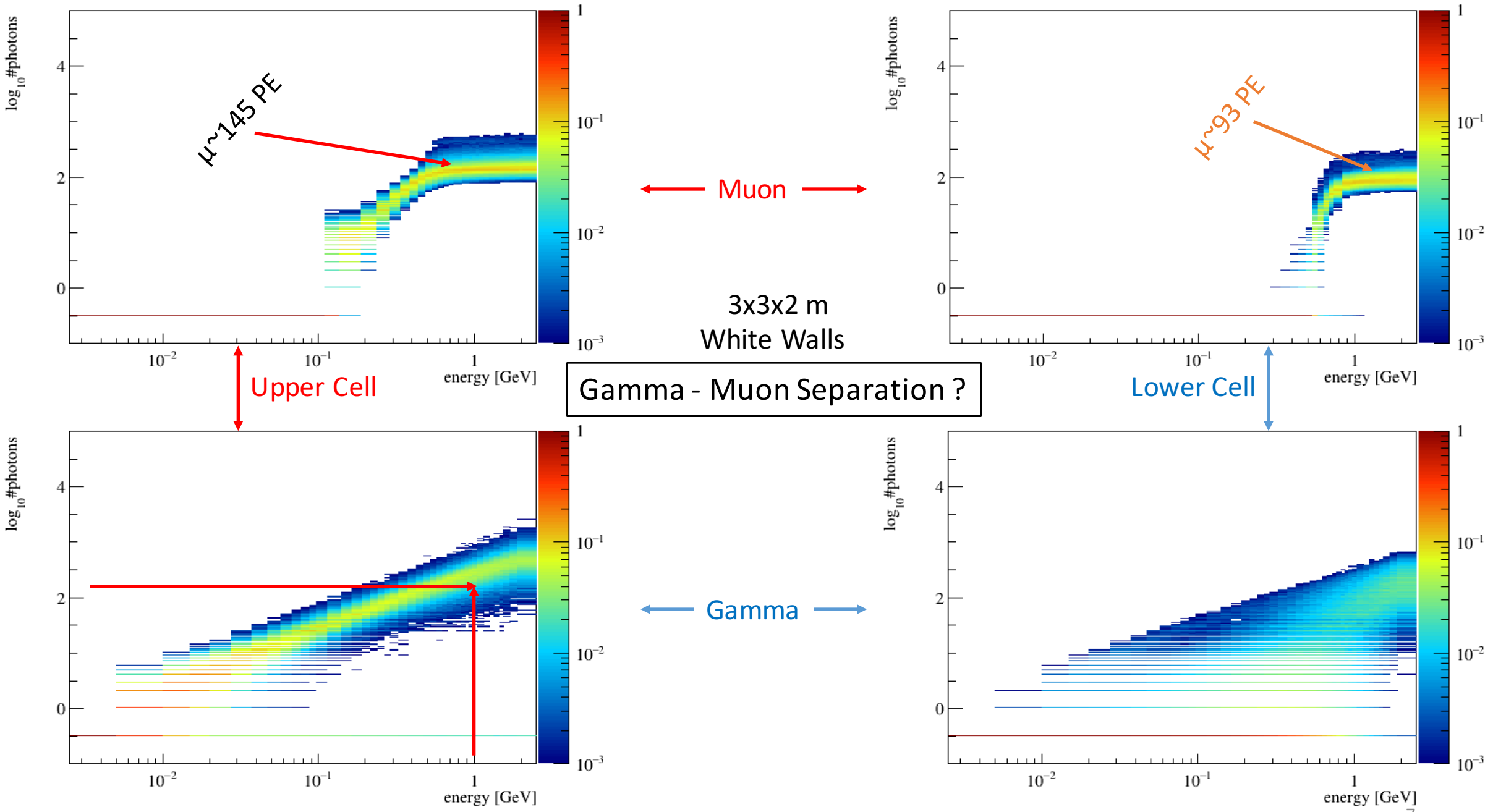
muons



gammas

electrons





How do we do a muon – gamma separation?

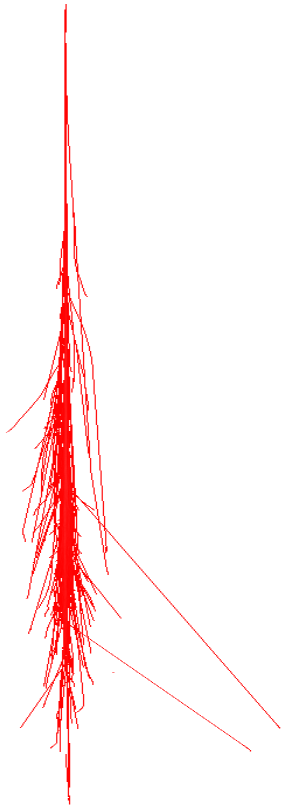
Corsika Shower Library

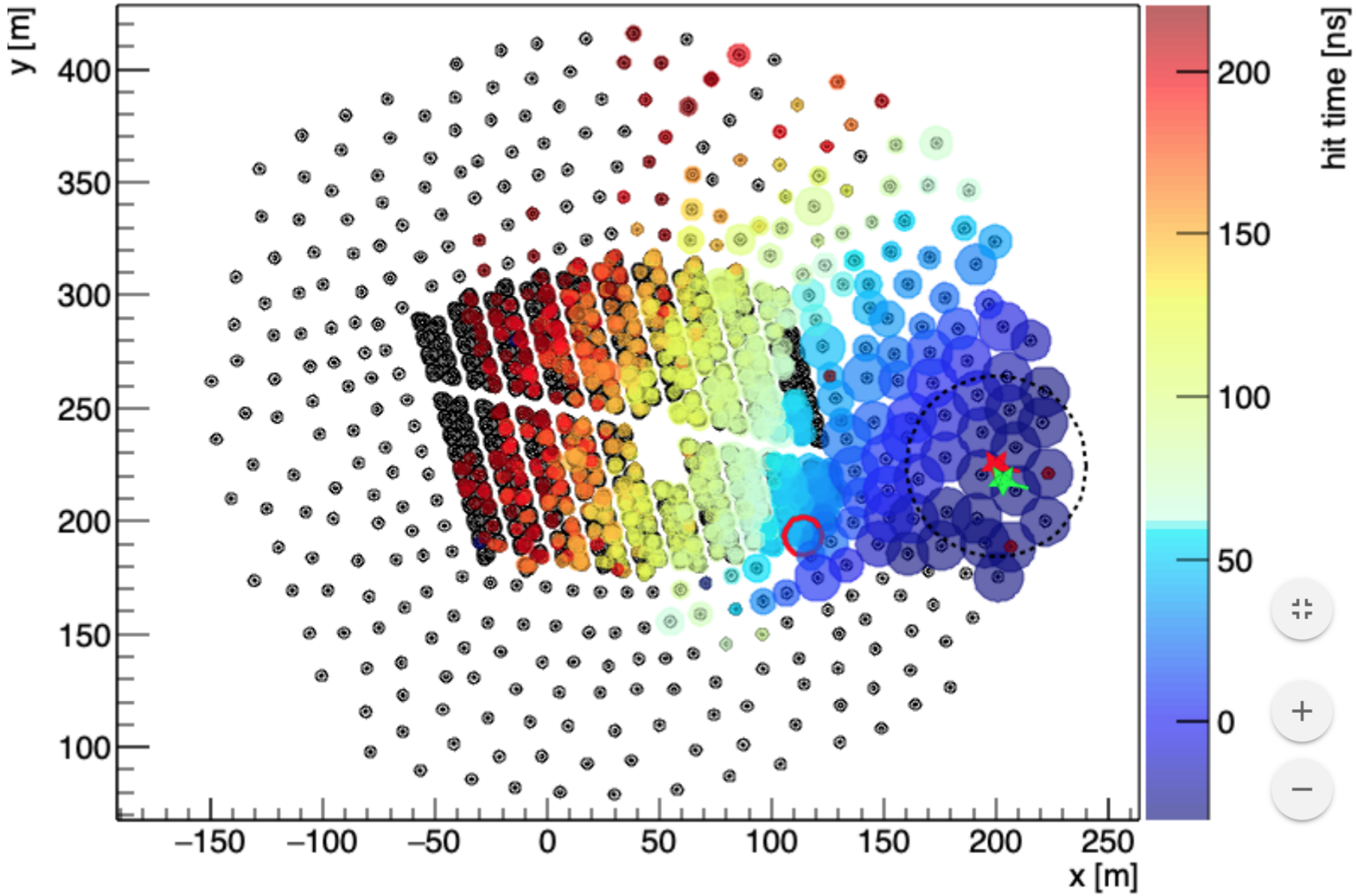
Gamma

5 KM

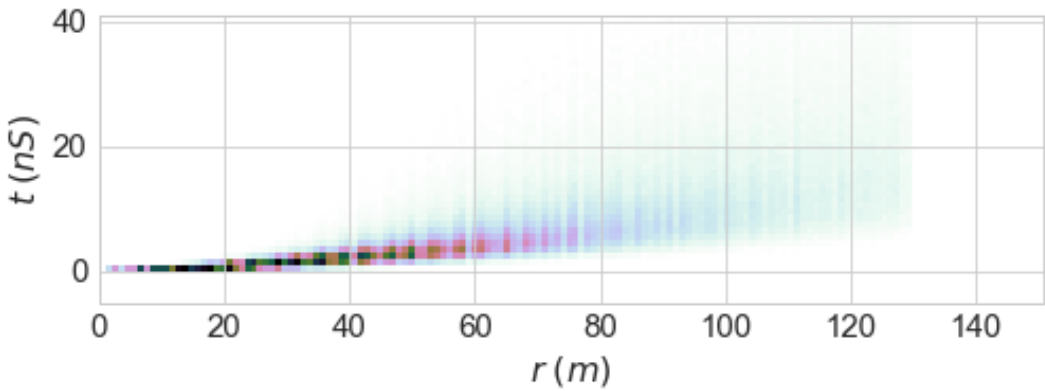
Zenith (0 to 50 deg)

Energy(0.05 to 200 TeV)

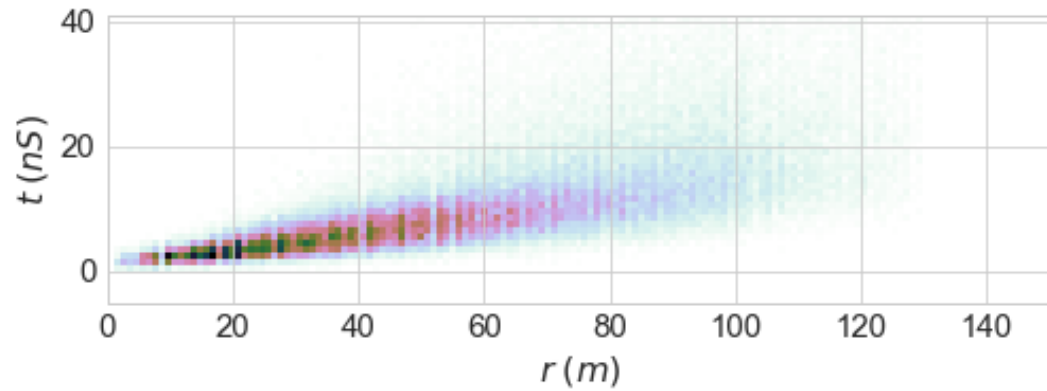



y [m]
400
350
300
250
200
150
100
−150
−100
−50
0
50
100
150
200
250
x [m]
hit time [ns]
200
150
100
50
0

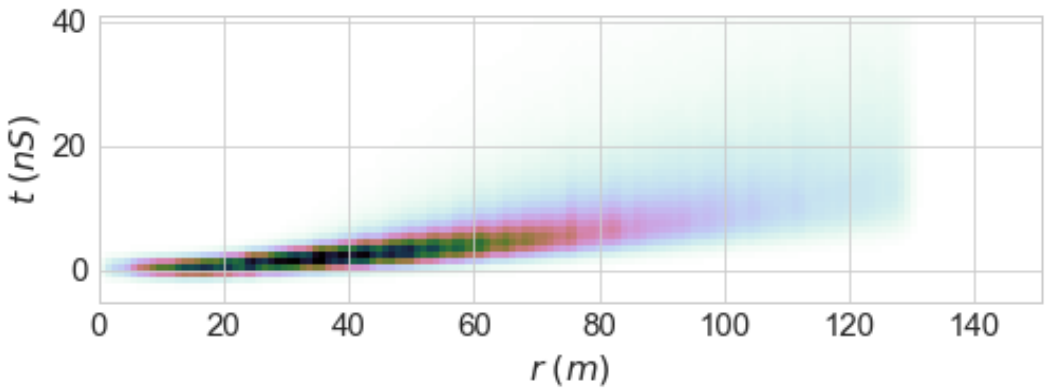
E = 5 GeV, Xmax = 425, Theta = 10, Phi = 4.73



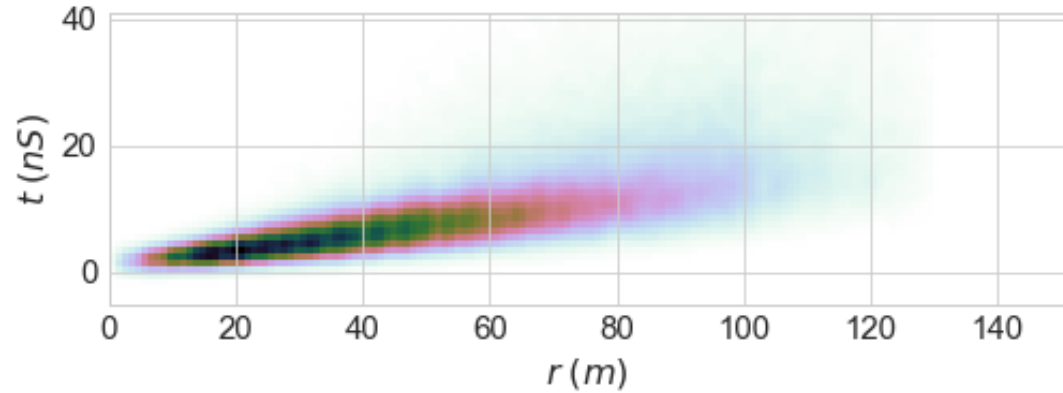
E = 5 GeV, Xmax = 425, Theta = 40, Phi = 4.73



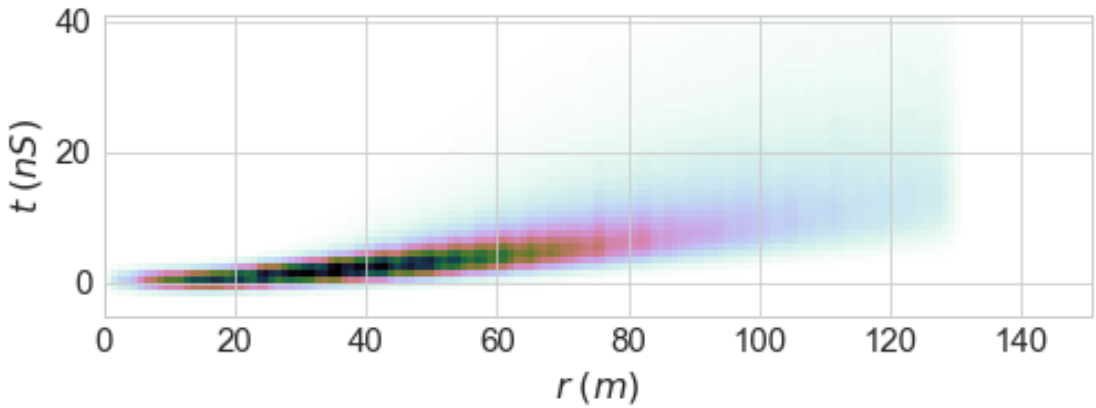
E = 5 GeV, Xmax = 425, Theta = 10, Phi = 4.73



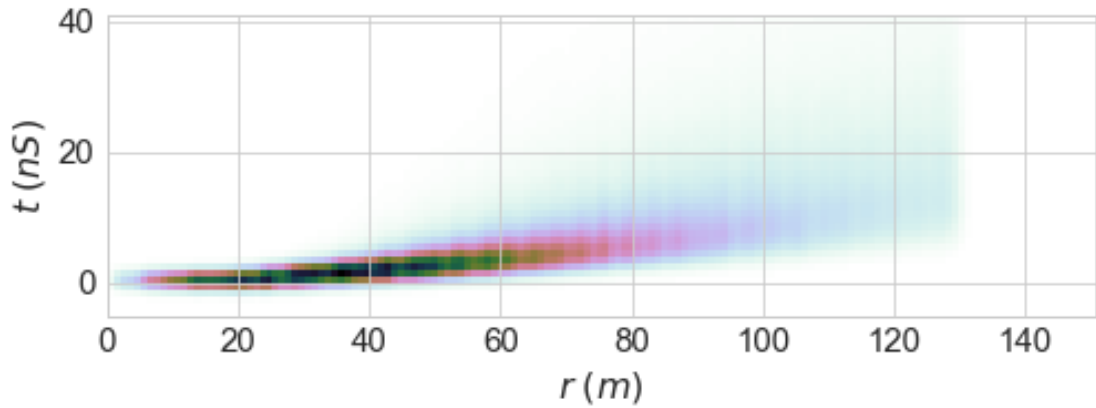
E = 5 GeV, Xmax = 425, Theta = 40, Phi = 4.73



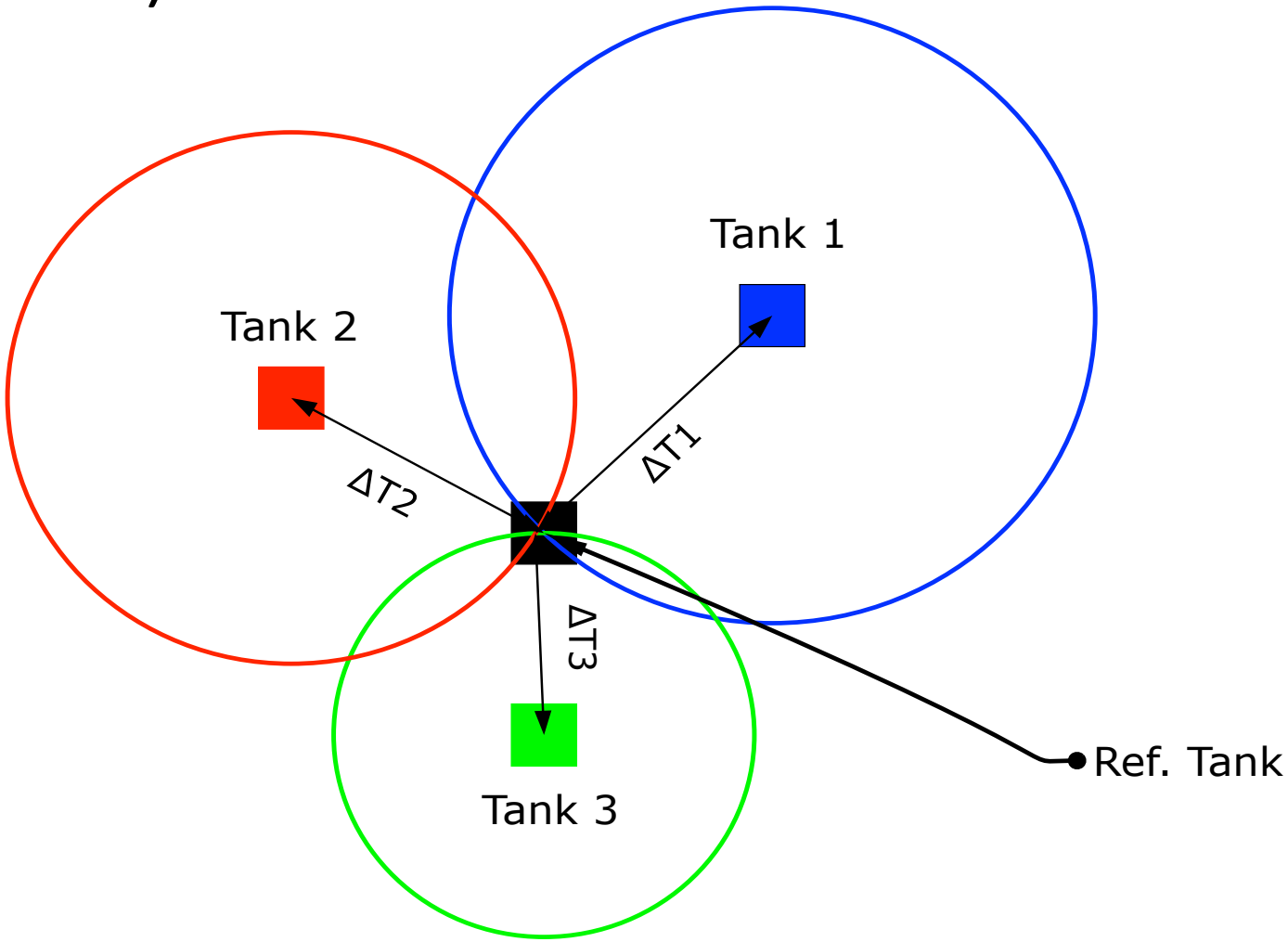
E = 5 GeV, Xmax = 425, Theta = 10, Phi = 4.73

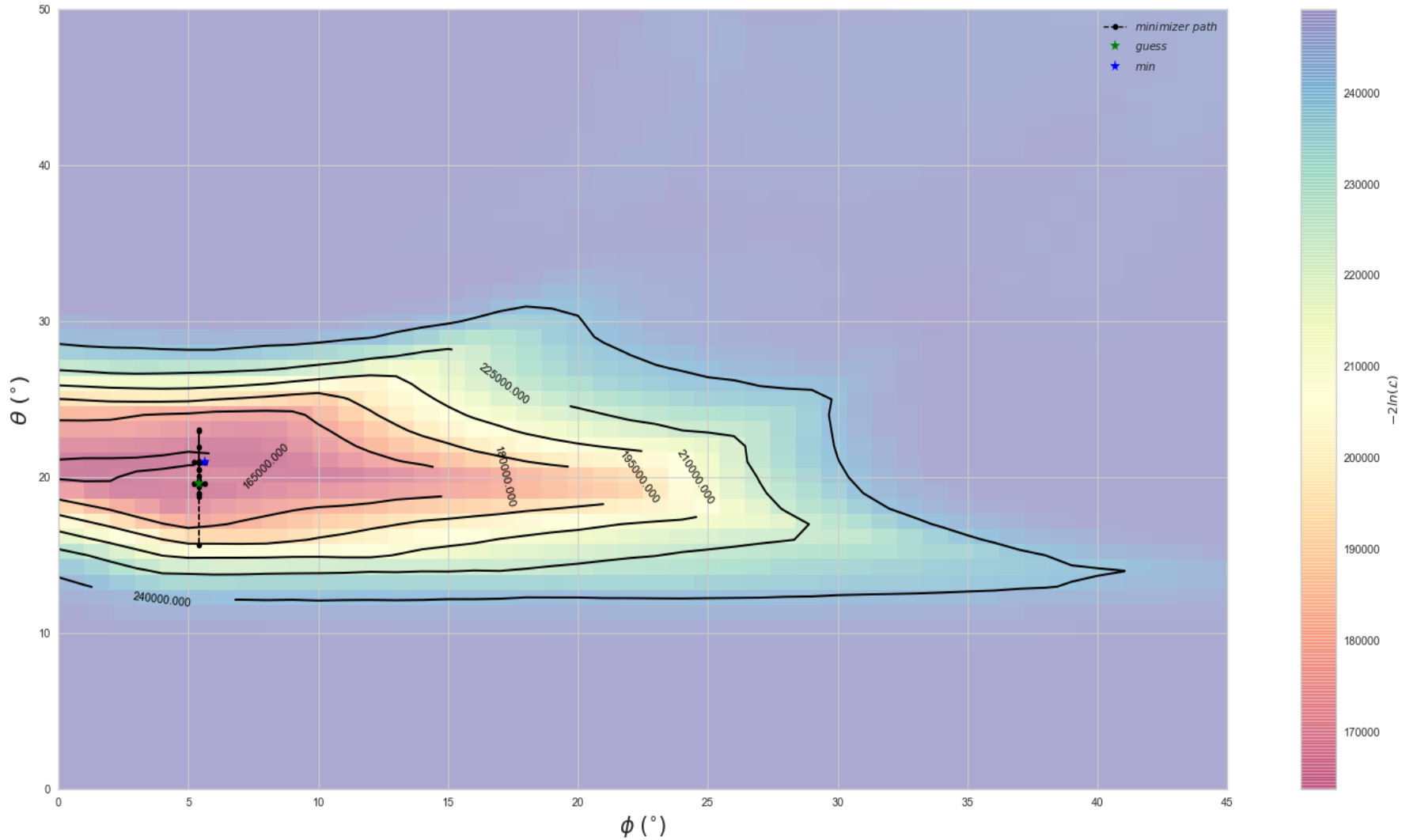


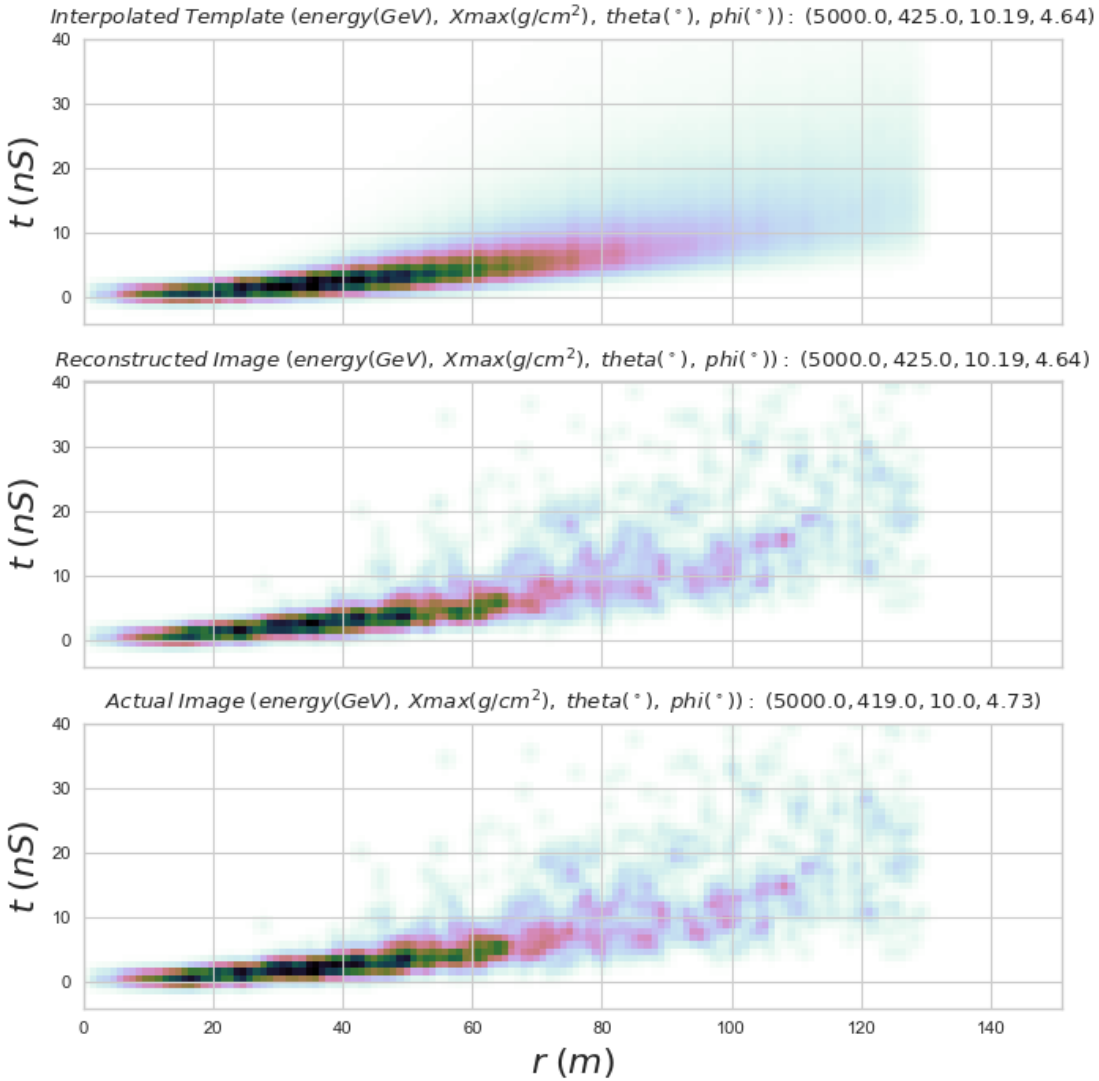
E = 5 GeV, Xmax = 425, Theta = 5, Phi = 4.73

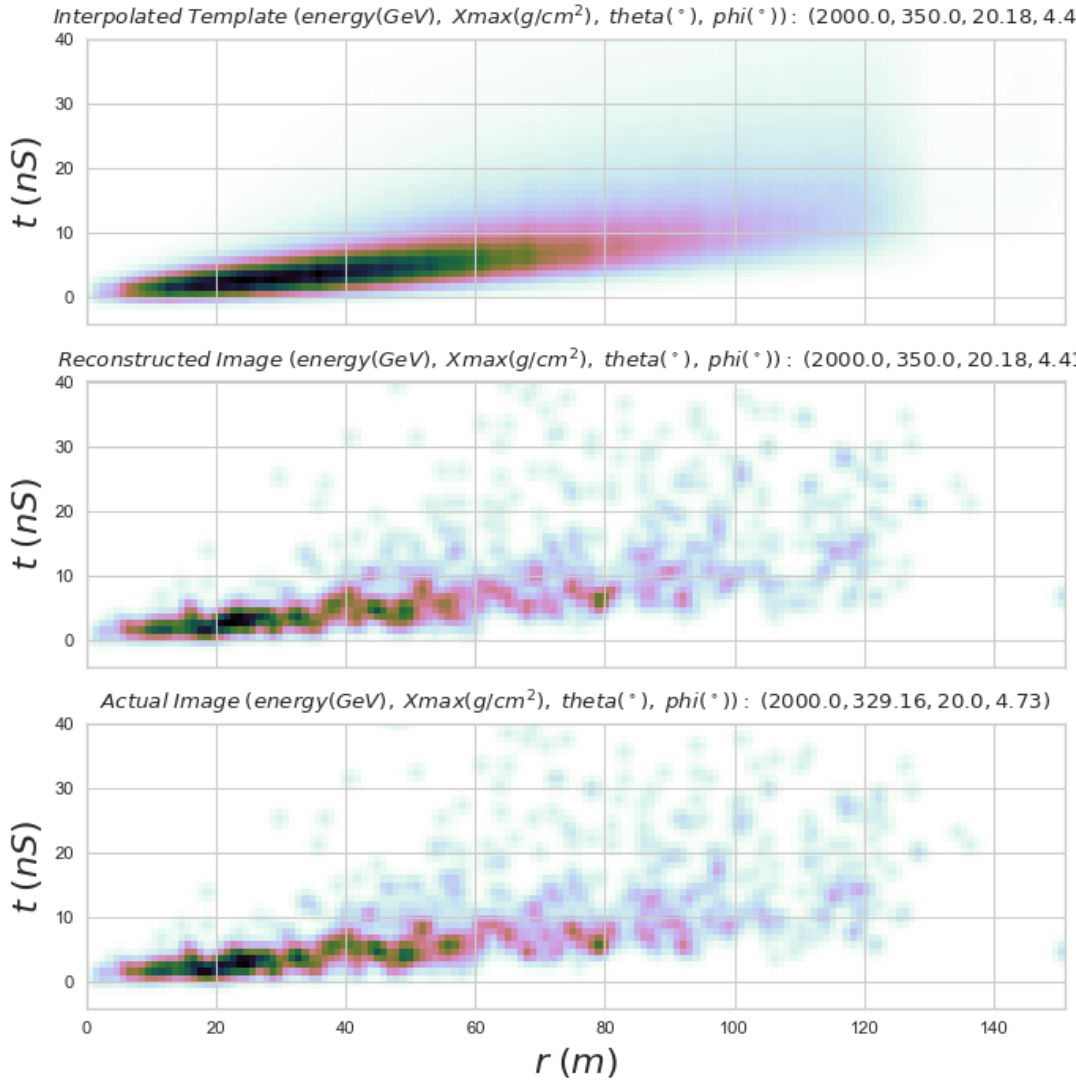


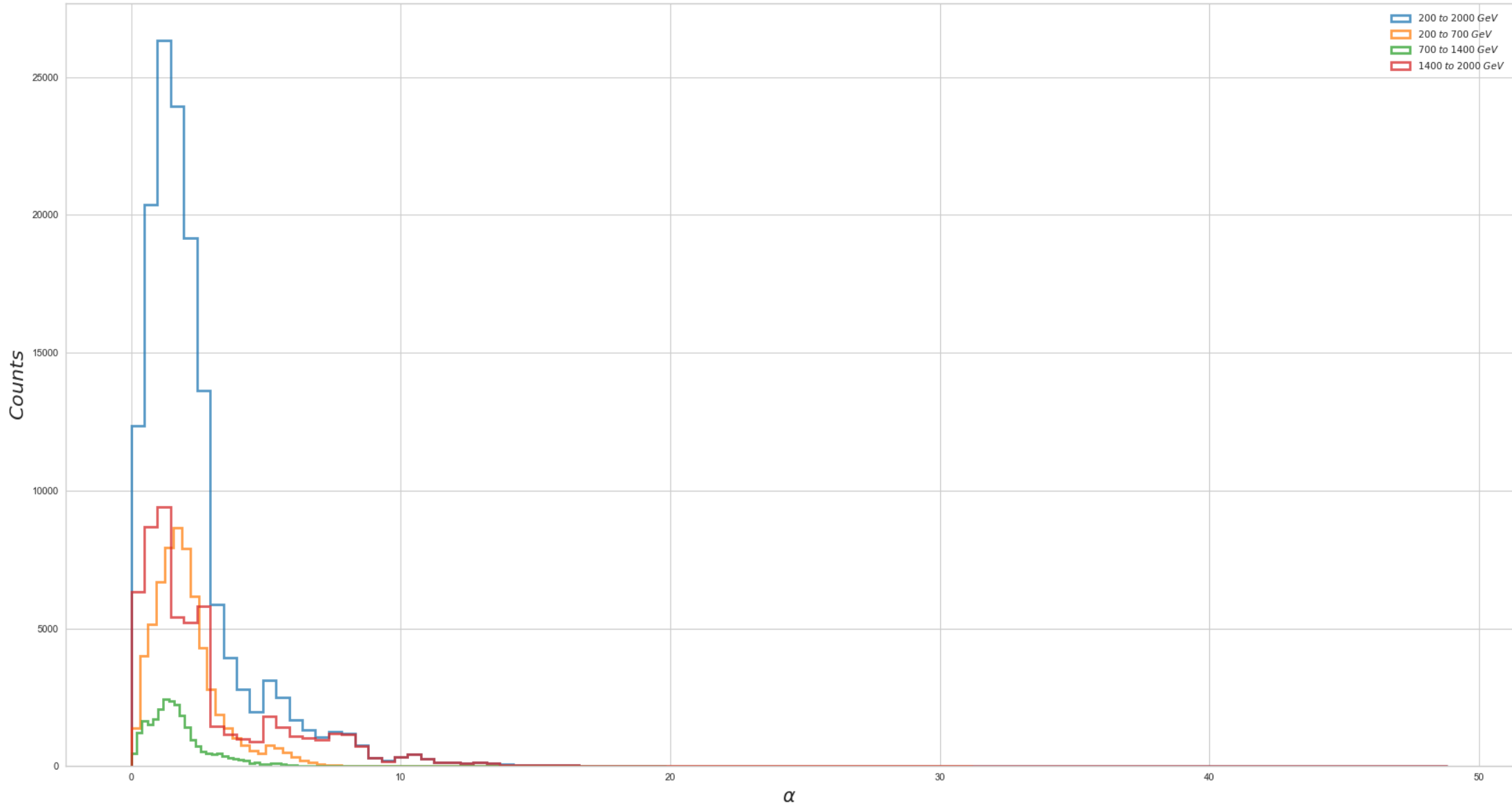
TDOA (guess)

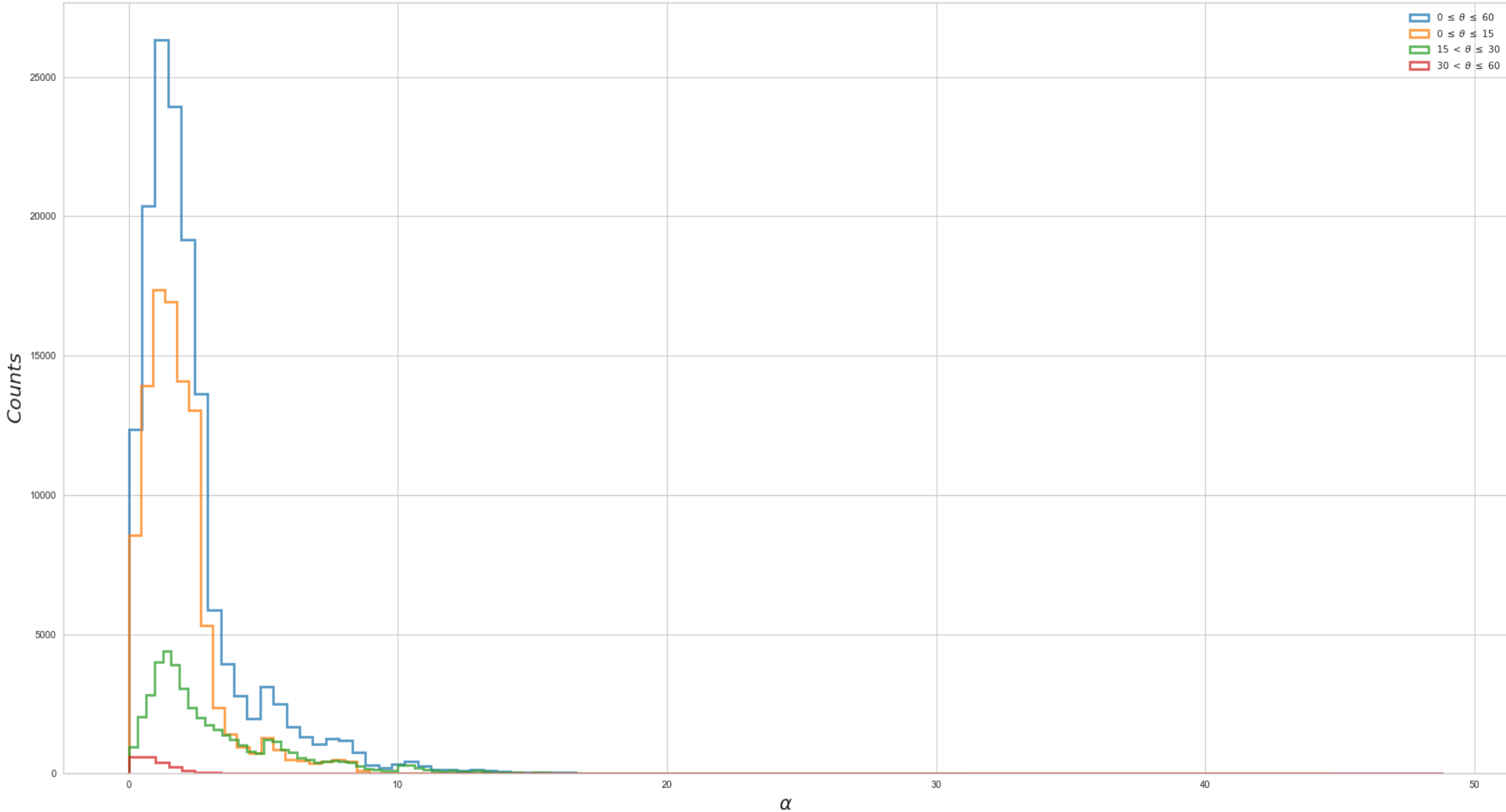



minimizer path
guess
min
225000.000
210000.000
195000.000
180000.000
165000.000
240000.000
θ (°)
ϕ (°)
−2ln(ℒ)
0
10
20
30
40
50
0
5
10
15
20
25
30
35
40
45
170000
180000
190000
200000
210000
220000
230000
240000


Interpolated Template (energy(GeV), Xmax(g/cm^2), theta(°), phi(°)) : (5000.0, 425.0, 10.19, 4.64)
Reconstructed Image (energy(GeV), Xmax(g/cm^2), theta(°), phi(°)) : (5000.0, 425.0, 10.19, 4.64)
Actual Image (energy(GeV), Xmax(g/cm^2), theta(°), phi(°)) : (5000.0, 419.0, 10.0, 4.73)
t (nS)
r (m)

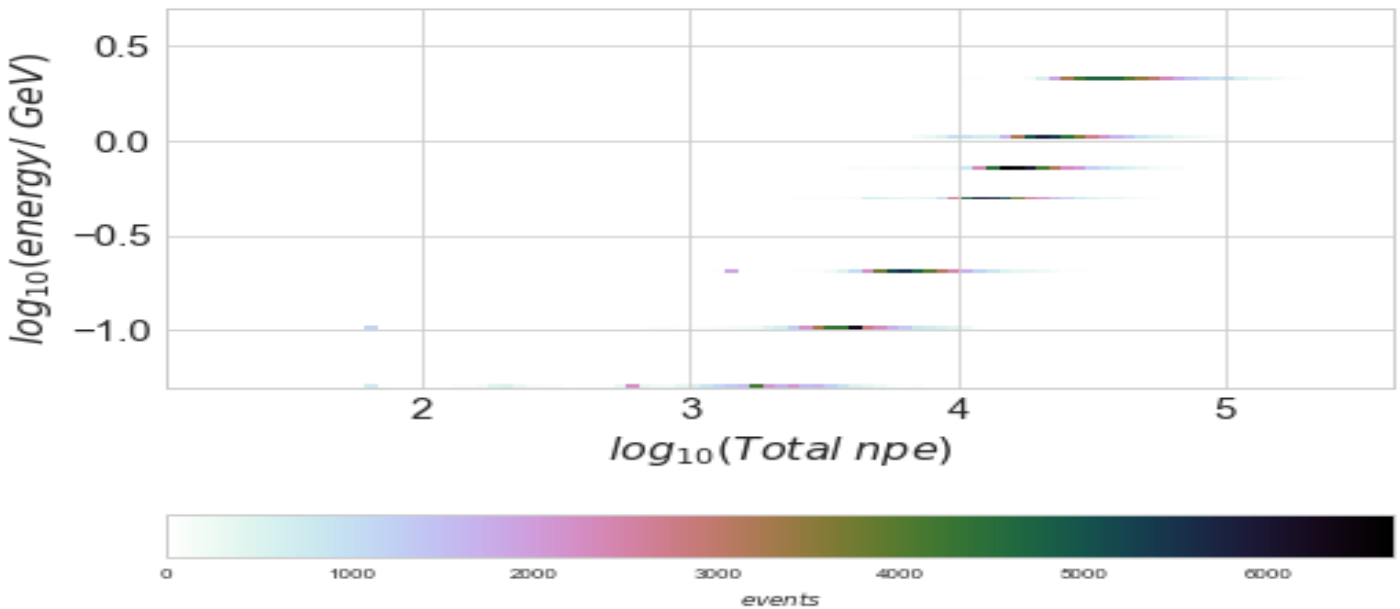

Interpolated Template (energy(GeV), Xmax(g/cm^2), theta(°), phi(°)) : (2000.0, 350.0, 20.18, 4.41)
Reconstructed Image (energy(GeV), Xmax(g/cm^2), theta(°), phi(°)) : (2000.0, 350.0, 20.18, 4.41)
Actual Image (energy(GeV), Xmax(g/cm^2), theta(°), phi(°)) : (2000.0, 329.16, 20.0, 4.73)
t (nS)
r (m)

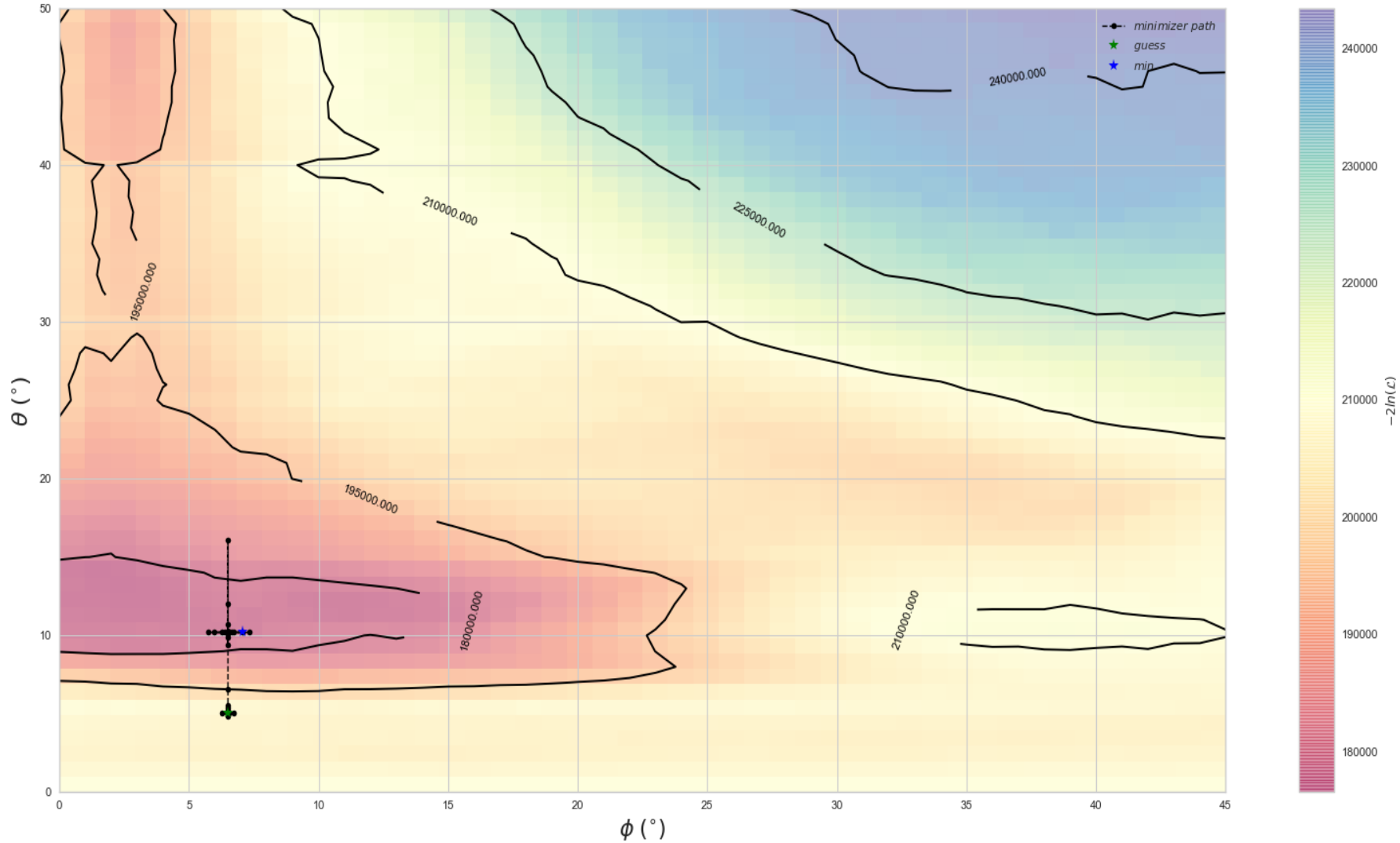

200 to 2000 GeV
200 to 700 GeV
700 to 1400 GeV
1400 to 2000 GeV
Counts
25000
20000
15000
10000
5000
0
0
10
20
30
40
50
α


$0 \leq \theta \leq 60$
$0 \leq \theta \leq 15$
$15 < \theta \leq 30$
$30 < \theta \leq 60$
Counts
25000
20000
15000
10000
5000
0
0
10
20
30
40
50
α

Reconstruction

- Simple Direction
- Core / LDF energy
- Better Direction
- Refine Core
- 6 – D ?


0.5
0.0
−0.5
−1.0
$log_{10}(energy/\ GeV)$
2
3
4
5
$log_{10}(Total\ npe)$
0
1000
2000
3000
4000
5000
6000
events


minimizer path
guess
min
240000.000
225000.000
210000.000
195000.000
195000.000
180000.000
210000.000
θ (°)
ϕ (°)
−2ln(ℒ)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
180000
190000
200000
210000
220000
230000
240000