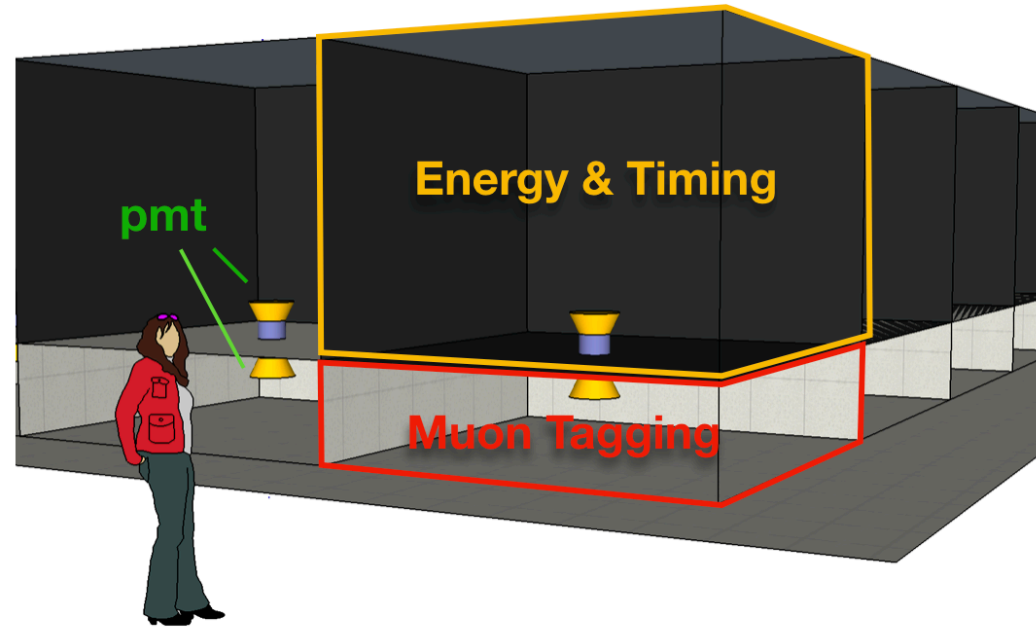


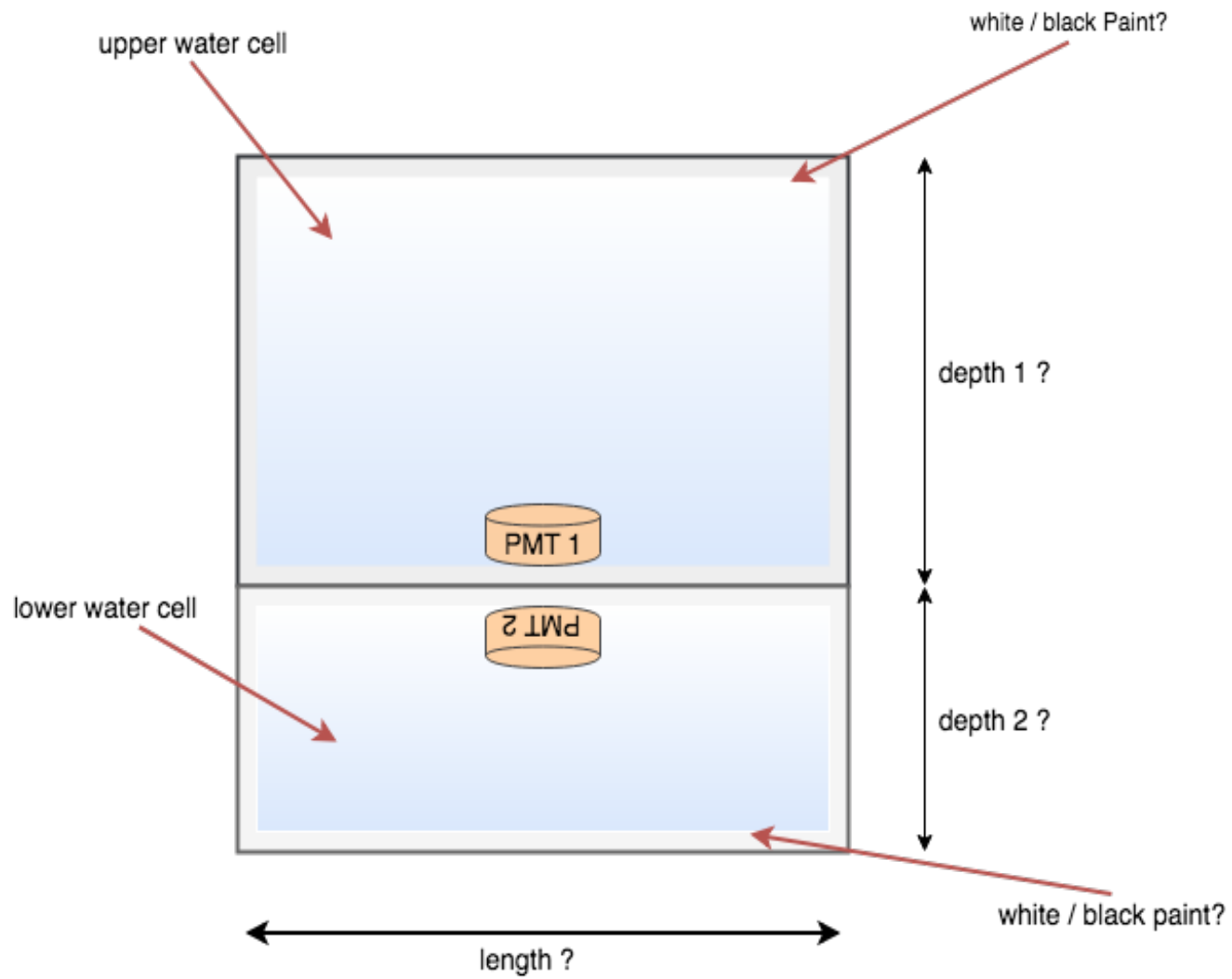
Optimization of Water Cherenkov Detectors



Samridha Kunwar
MPIK

SGSO F2F Meeting
Heidelberg, Germany
October 9th, 2018

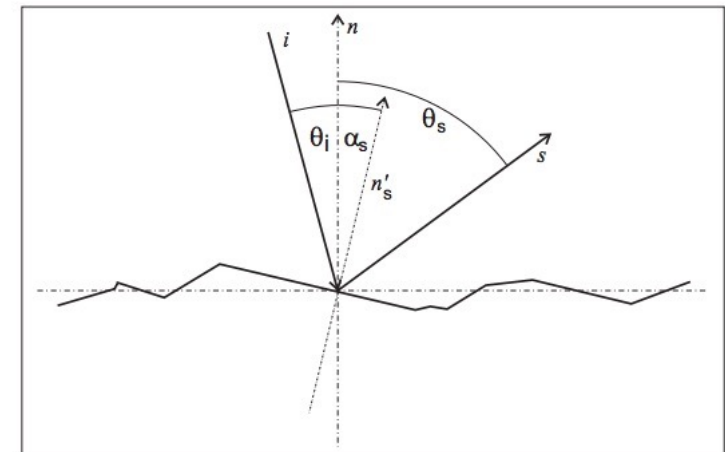




Aspect Ratio ?

Black or White paint ?

Tyvek / Polypropylene ?



rough surface with top layer paint

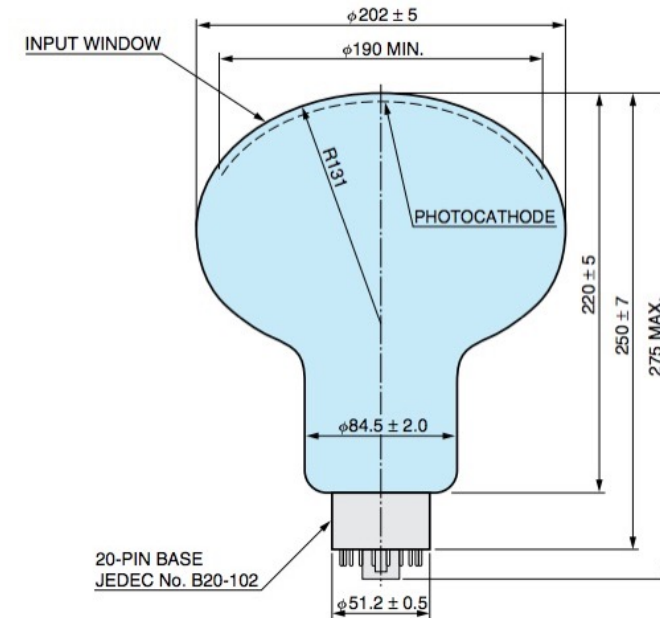
Hamamatsu R5912 – 8" Hemispherical PMT



Union of G4Ellipsoid and G4Tubs

Pyrex Glass with RI of typical Borosilicate glass (3mm)

●R5912/-20/-100



Bi-alkali Photocathode ← G4 Sensitive Detector

QE ~ 25 %

2 GeV Muon

Hit Time and Wavelength!

4 x 4 m Cell(s)

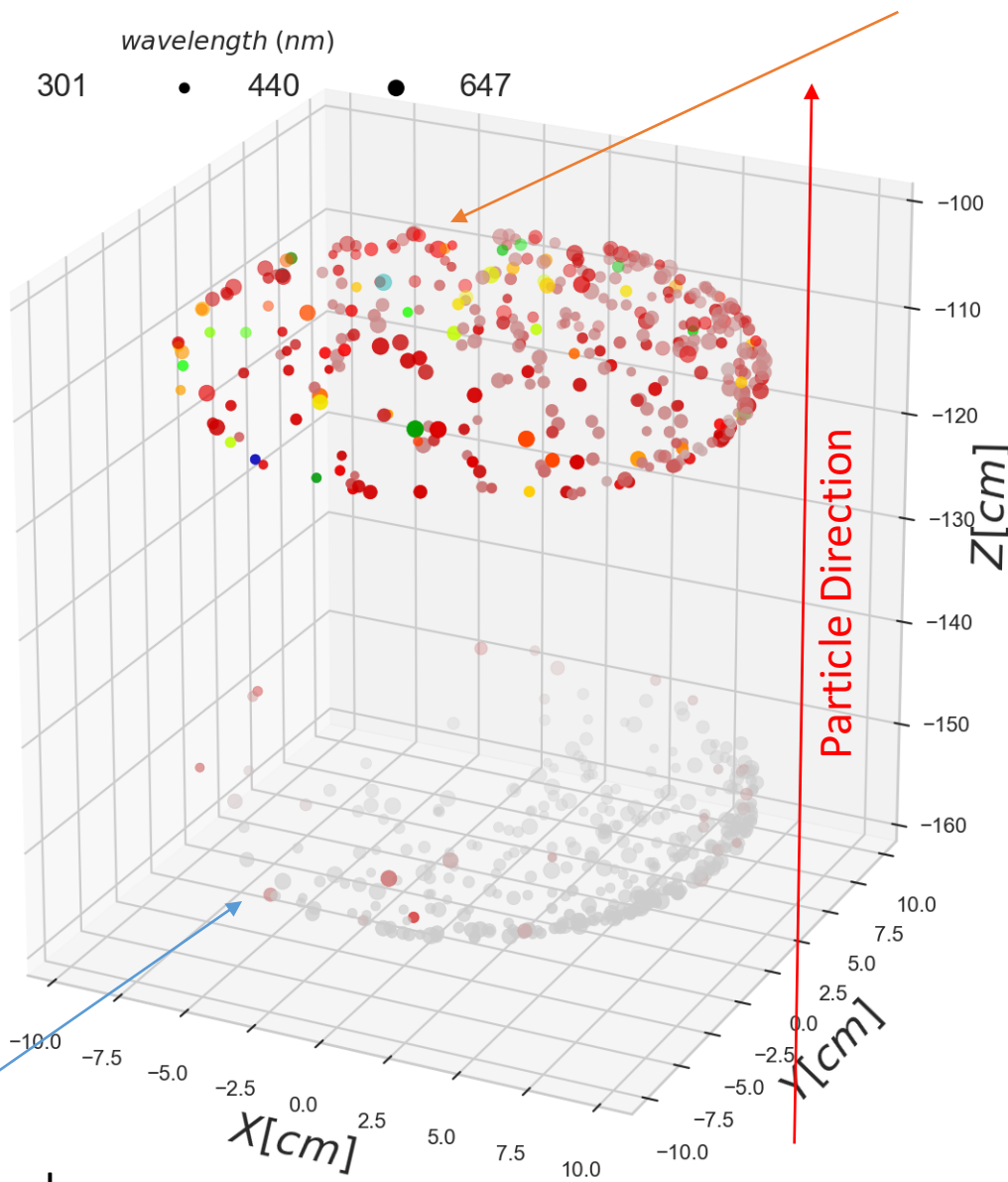
Depth upper cell = 350 cm
Black Walls

Submerged by 20 cm

Upper Photocathode

wavelength (nm)
• 301 • 440 • 647

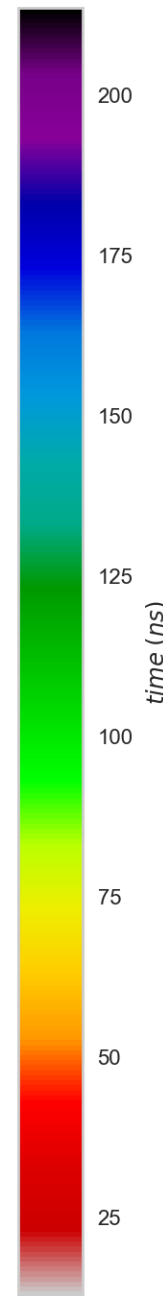
Lower Photocathode



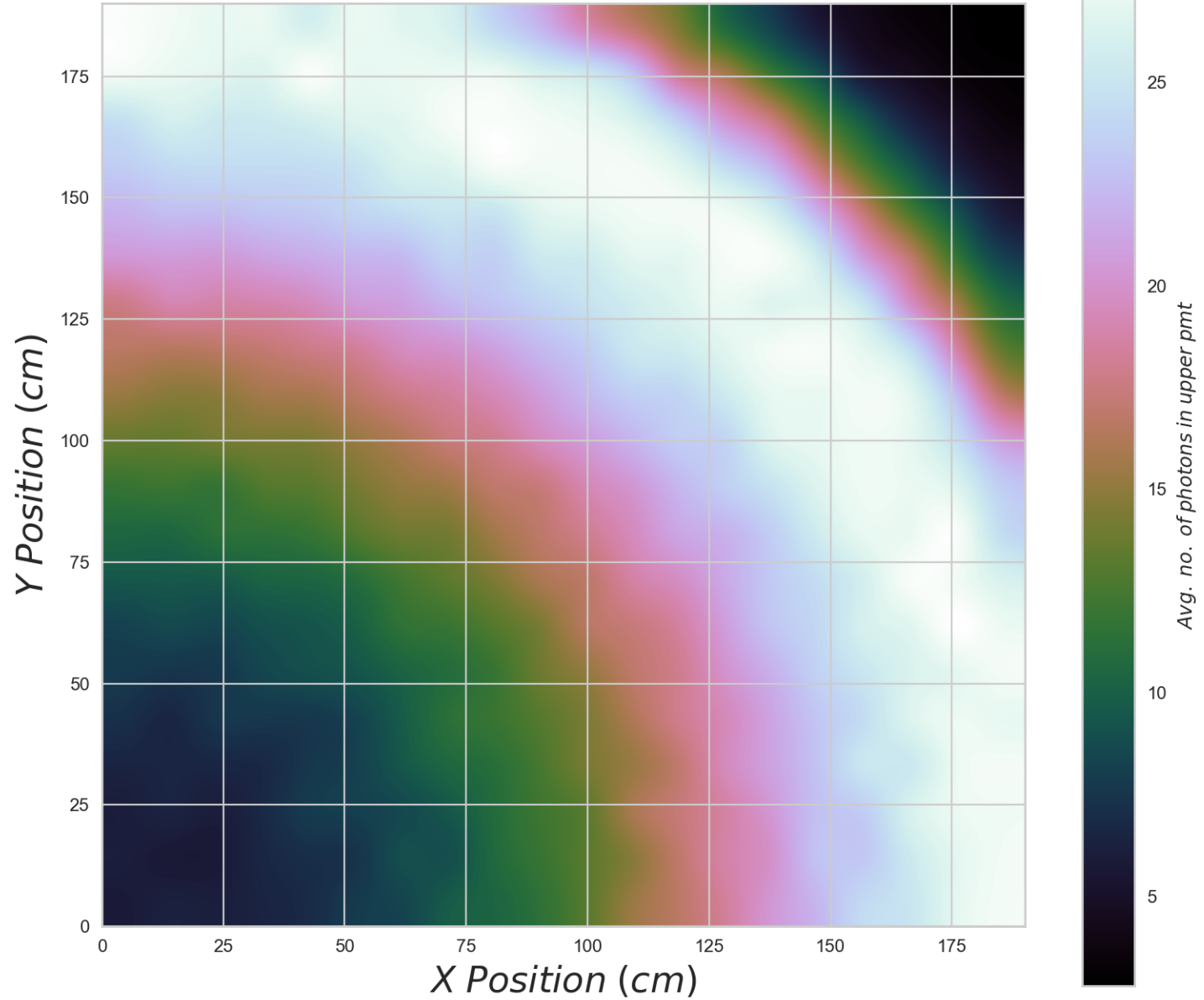
1 Event!

Depth lower cell = 50 cm
White Walls

Gun Offset x = 50 cm
Momentum (0, 0, 1)



250 MeV μ^-



4 x 4 m Upper Cell

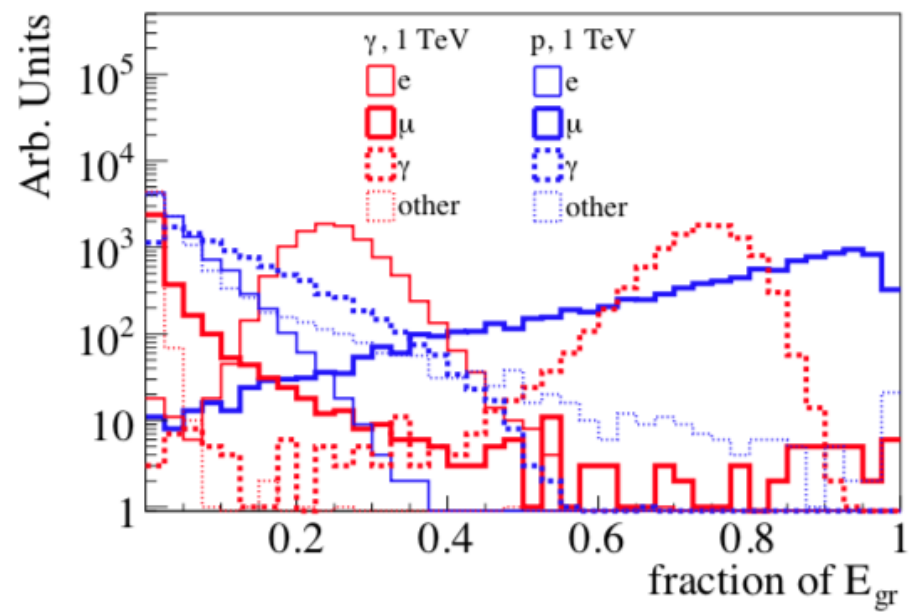
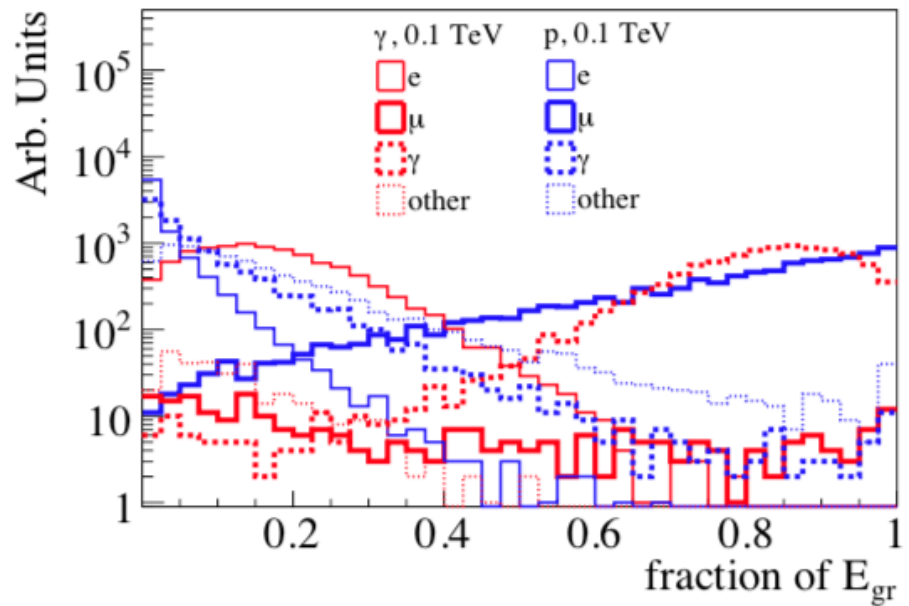
250 MeV μ^-

Submerged by 20 cm

PMT Depth = 300 cm

Black Walls

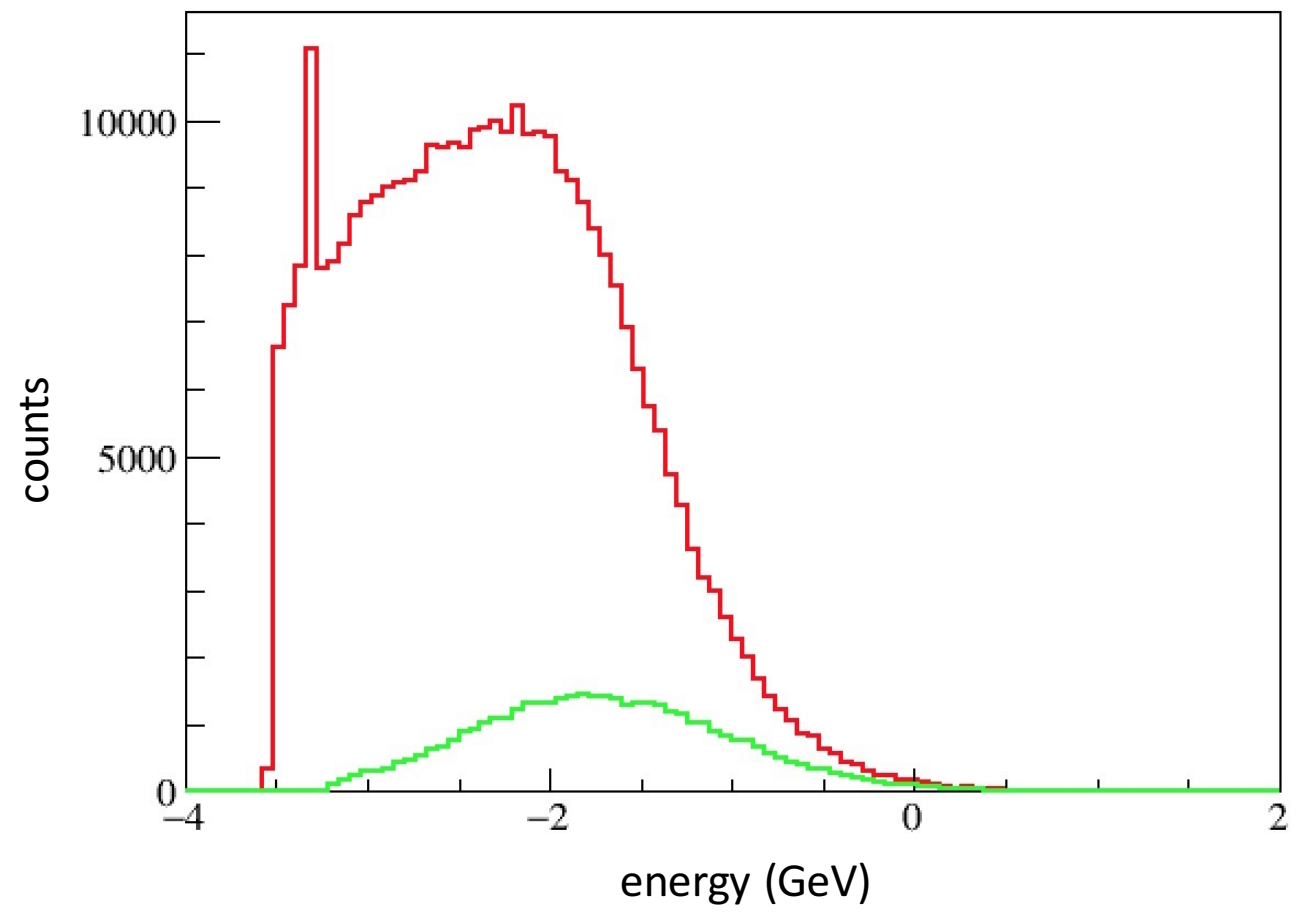
Quadrant of tank
Momentum (0, 0, 1)



At 5 KM

What do we optimize for?

Gamma , Electron /positron



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

What is the best case for a **black walled** unit?

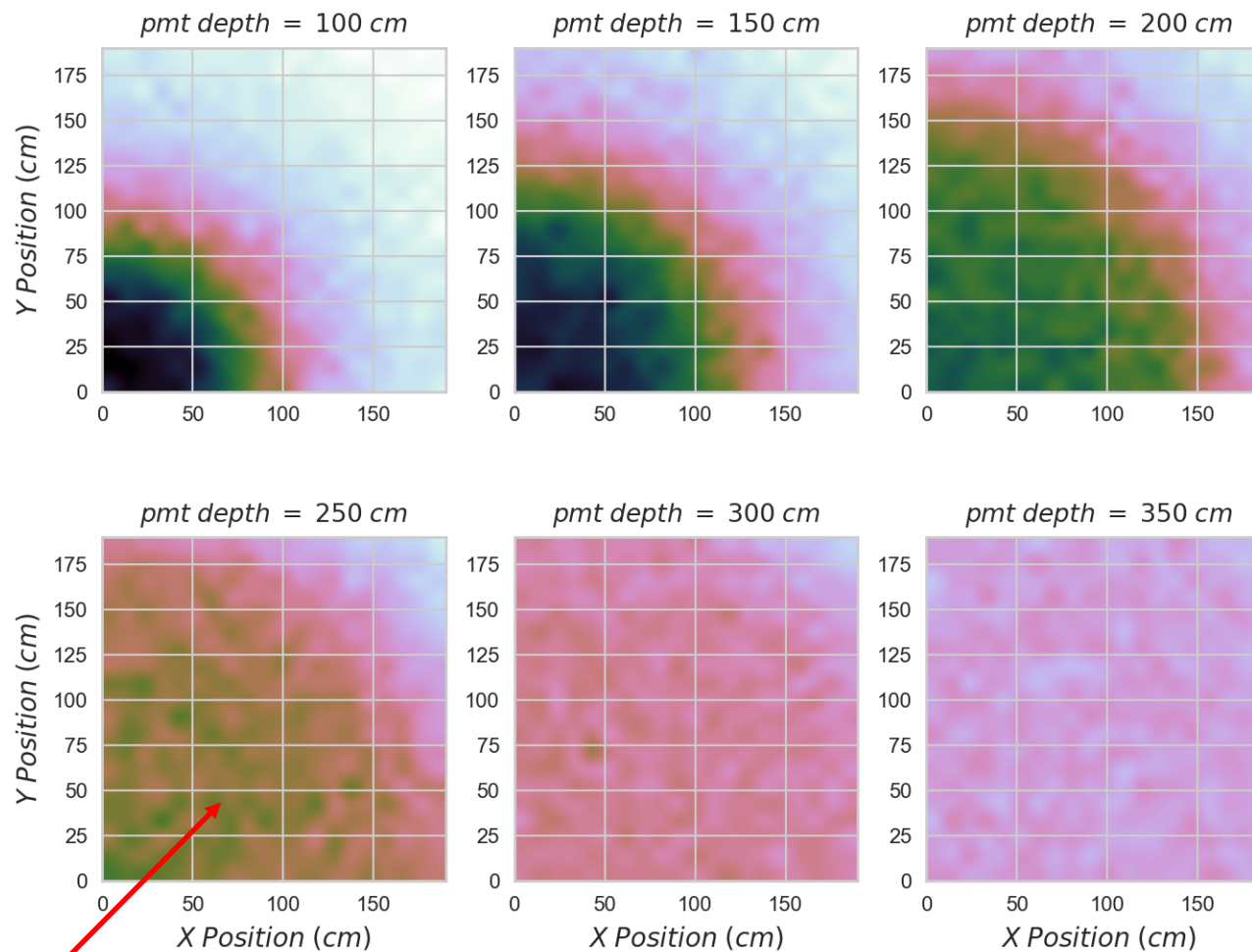
4 x 4 m Upper Cell

10 MeV γ

Hit Count $n > 0$

10 MeV gamma

Black Walls

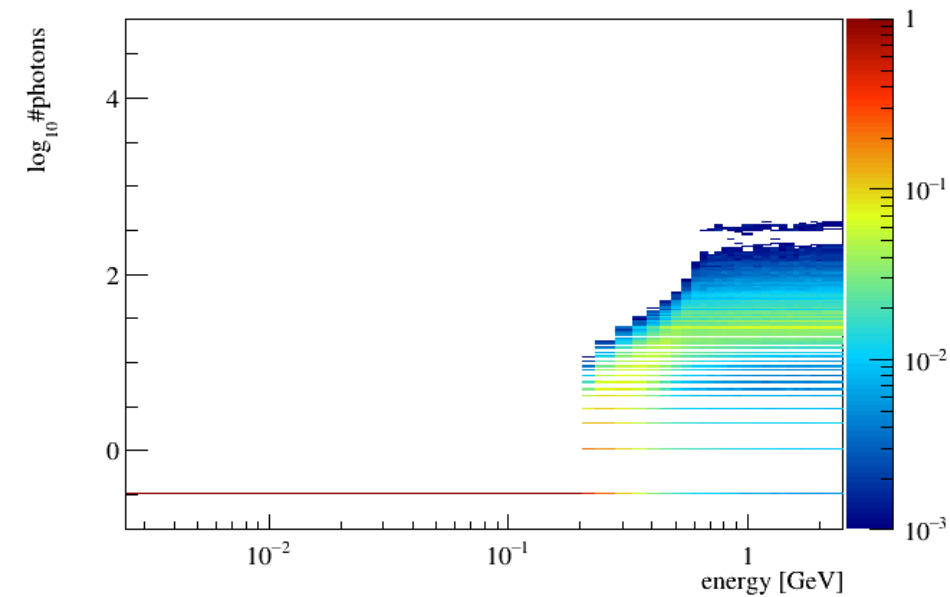


Submerged by 20 cm

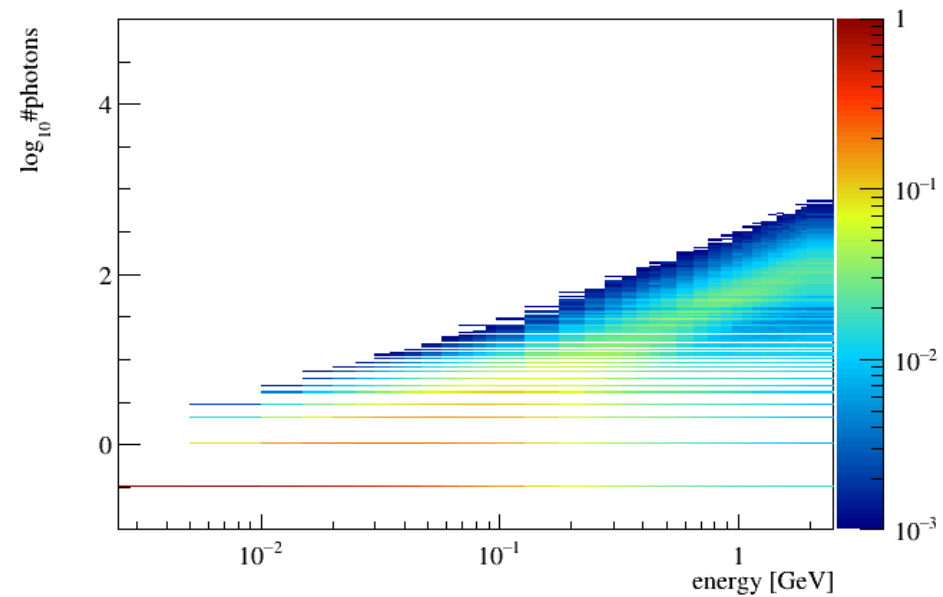
3.6 x 3.6 x 2.5 m

10 MeV,
Momentum (0, 0, 1)

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

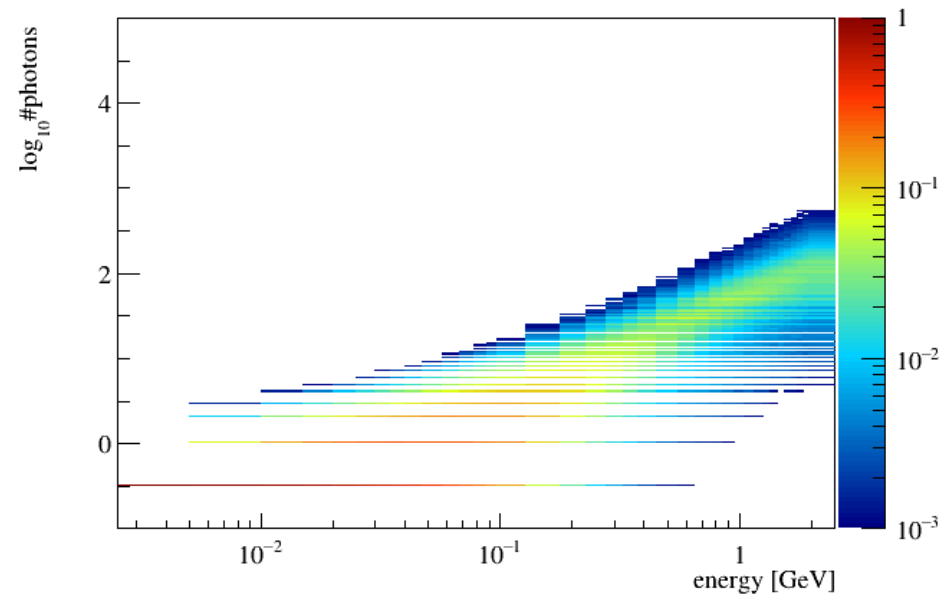


muons



electrons

gammas

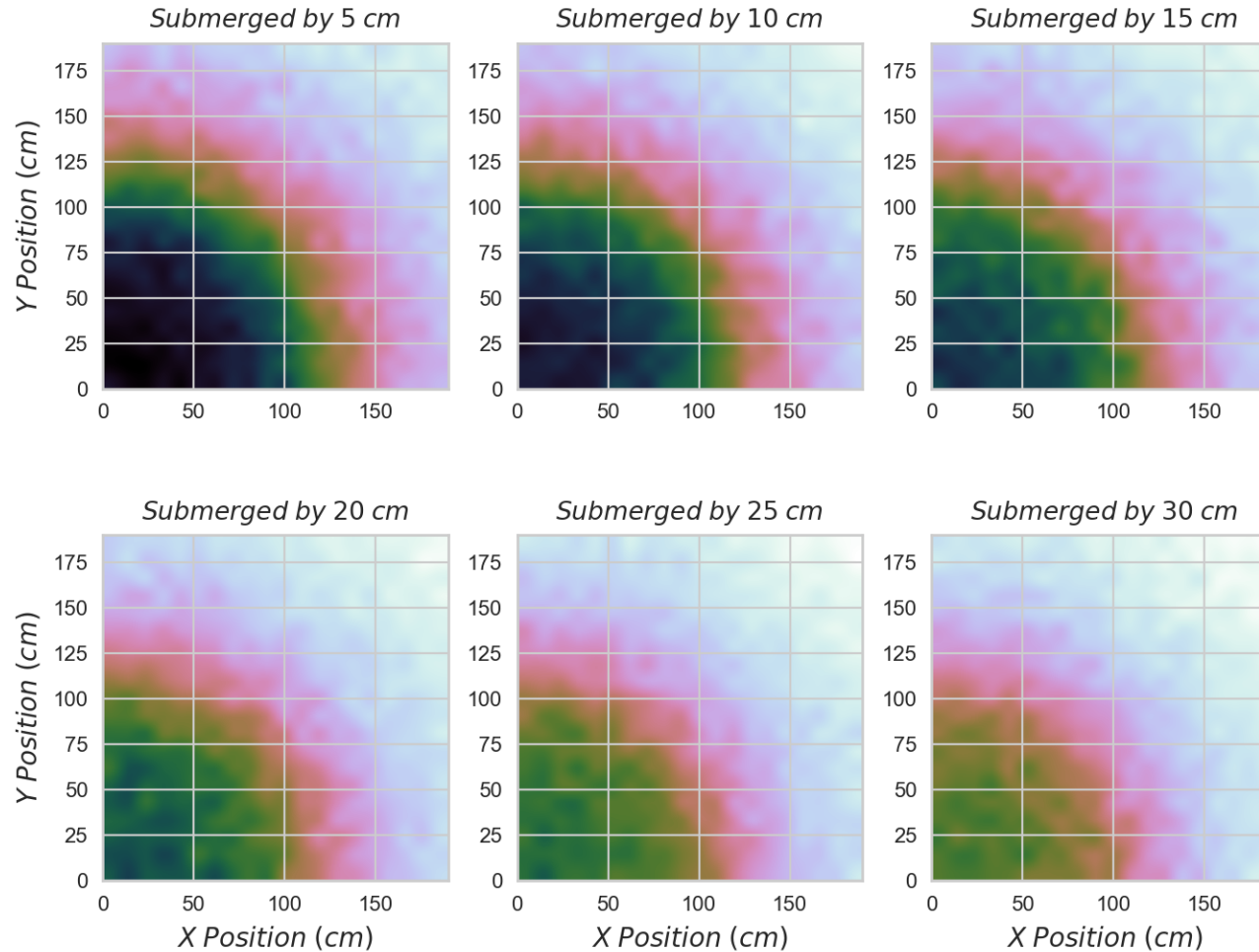


What happens when we **submerge** in water?

10 MeV γ , pmt depth = 150 cm

4 x 4 m Upper Cell

10 MeV gamma

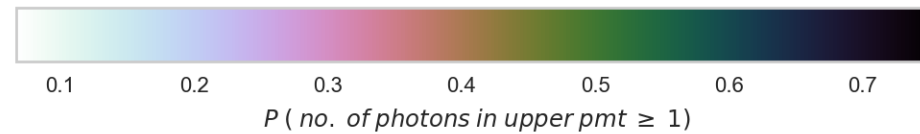


Hit Count $n > 0$

Black Walls

PMT depth 150 cm

10 MeV,
Momentum (0, 0, 1)



What is the best case for a **white walled** unit?

10 MeV γ , white walls

Upper Cell

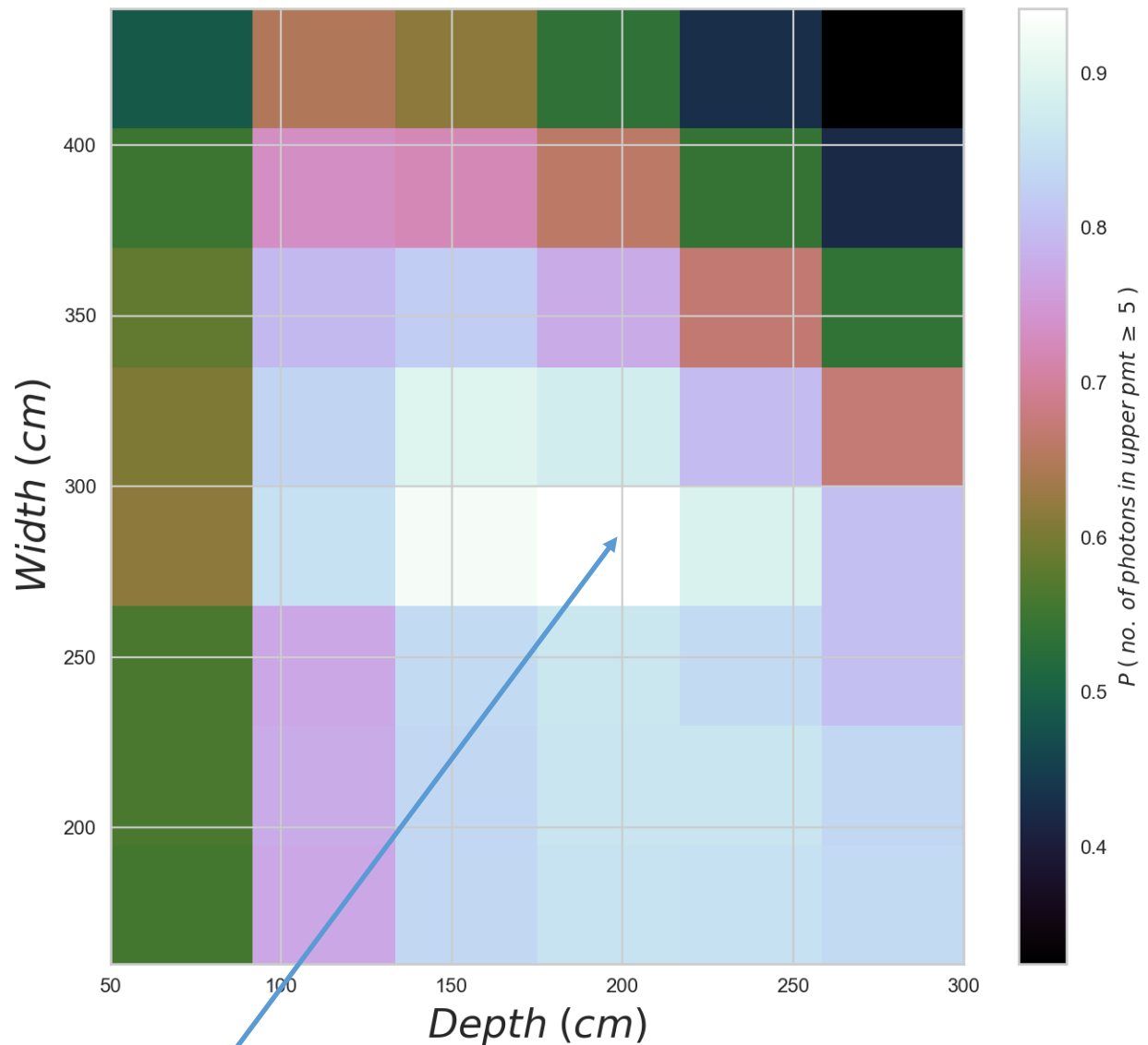
All positions, All photons

Hit Probability

White Walls

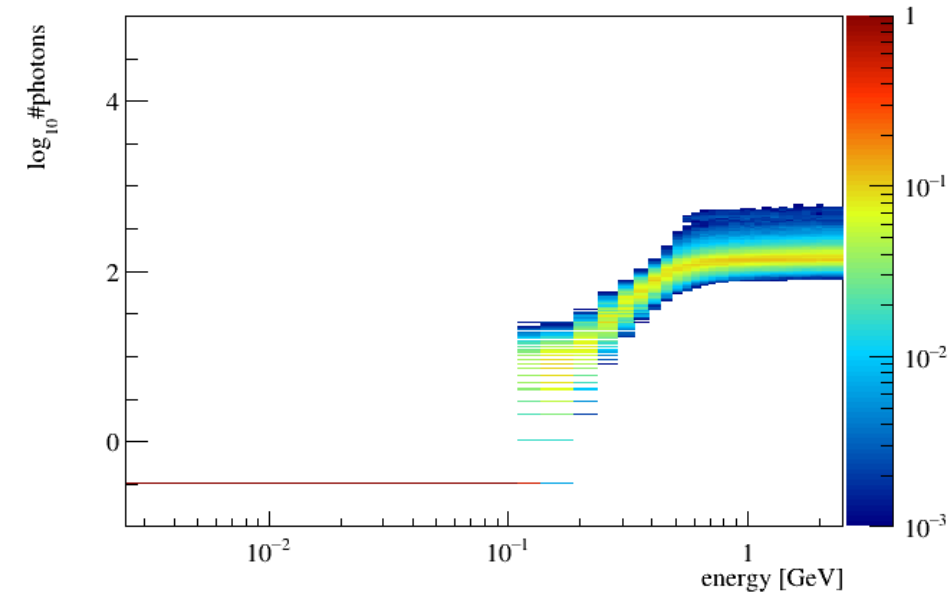
PMT depth variable cm
Submerged by 0 cm

10 MeV, Gamma
Momentum (0, 0, 1)

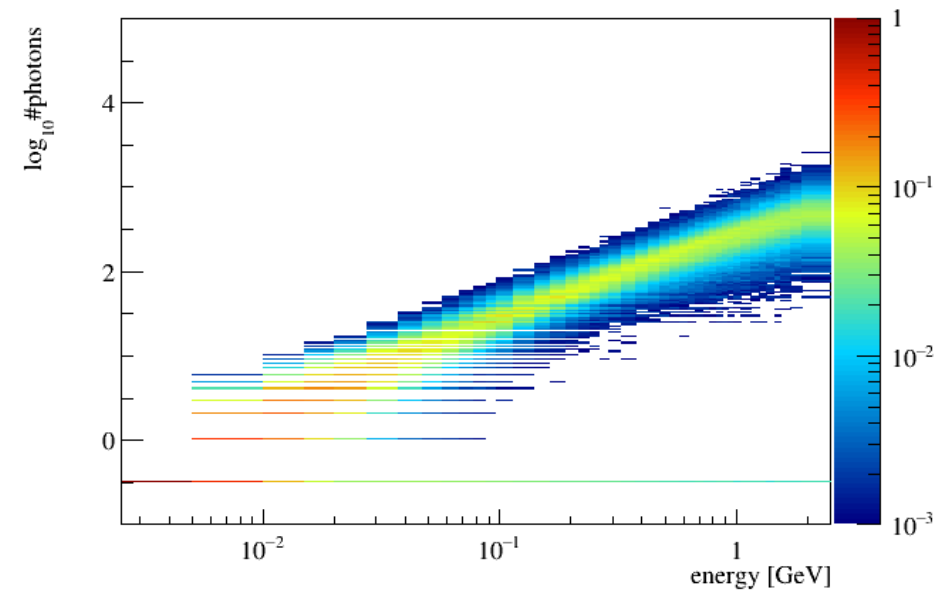


Best Case for 10 MeV Gamma Detection?

Tank response 3x3x2, White Walls

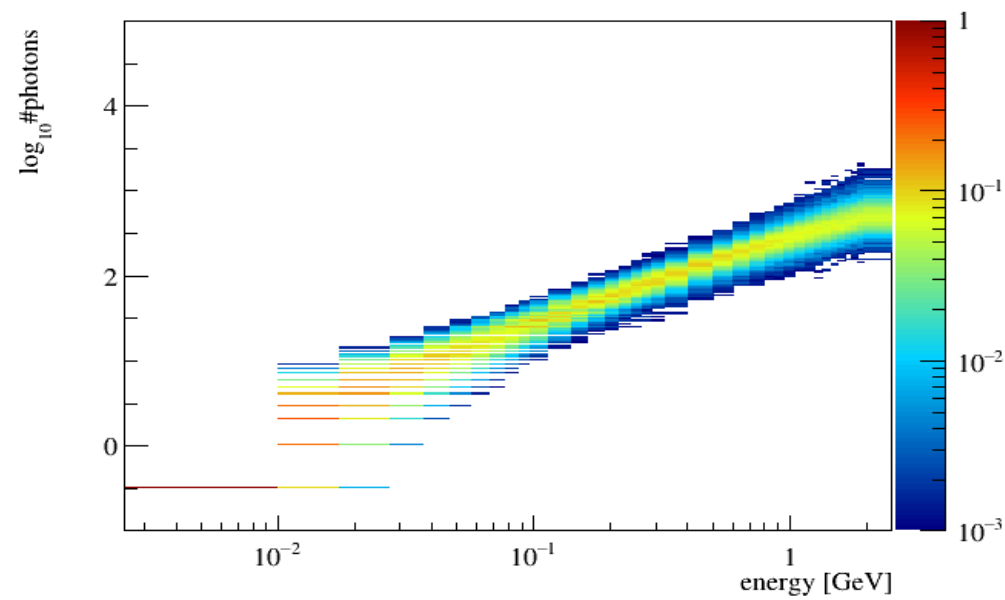


muons

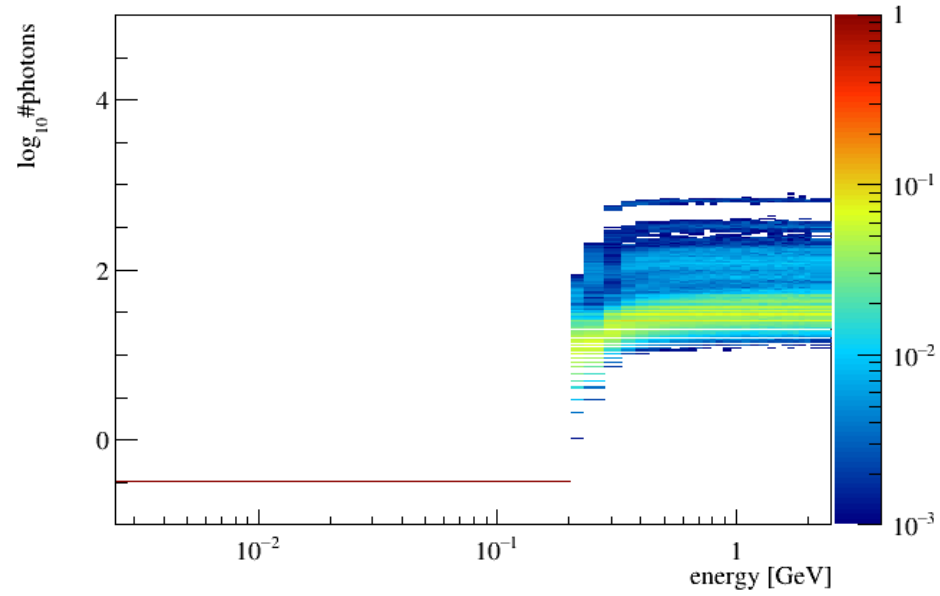


electrons

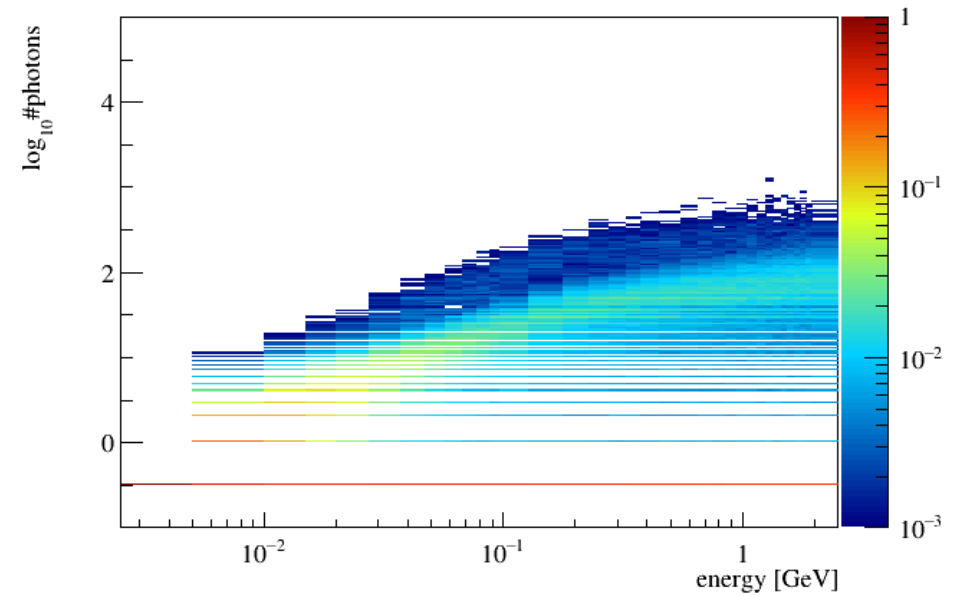
gammas



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

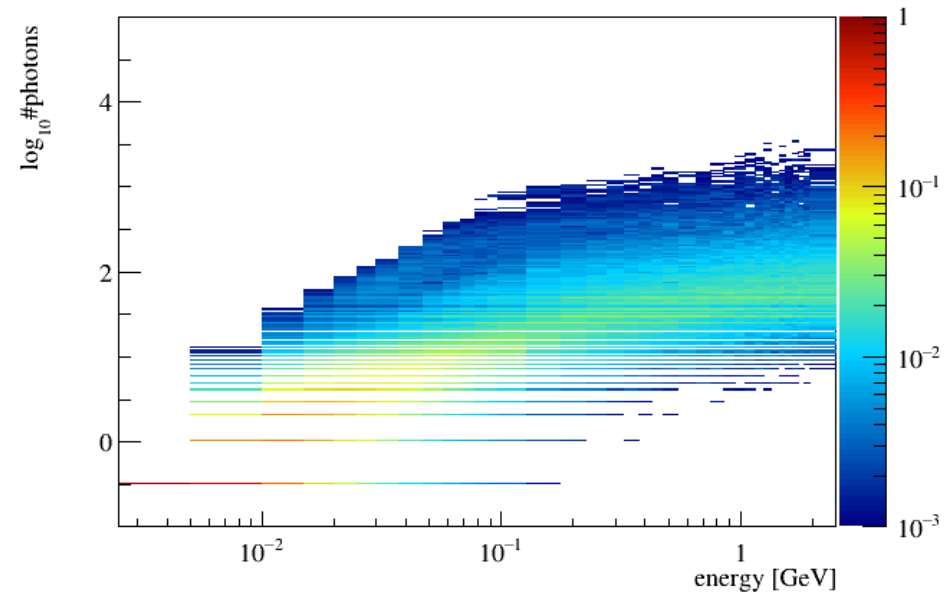


muons



electrons

gammas



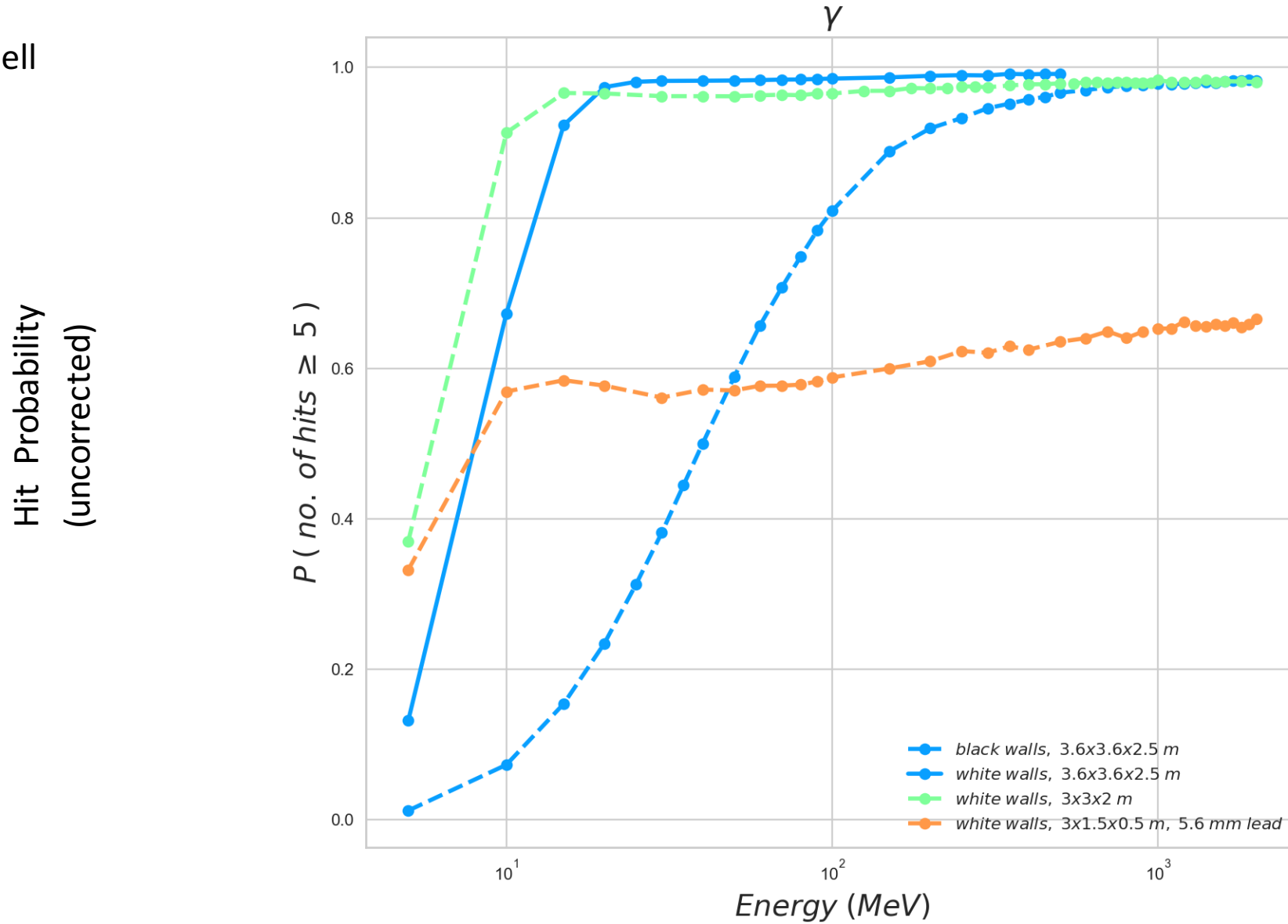
How do the different designs compare?

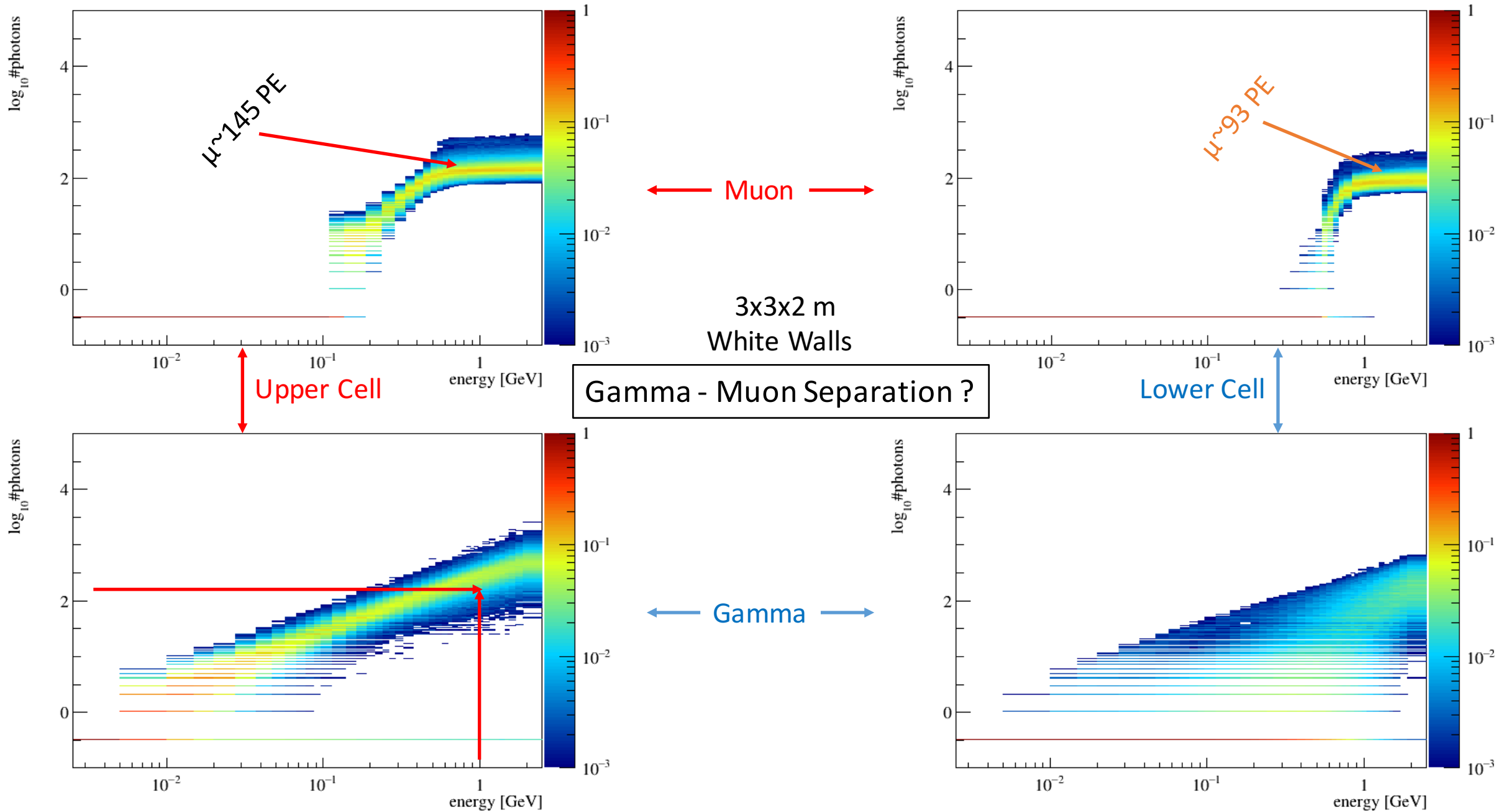
Upper Cell

All positions, All photons

Gamma

Momentum (0, 0, 1)





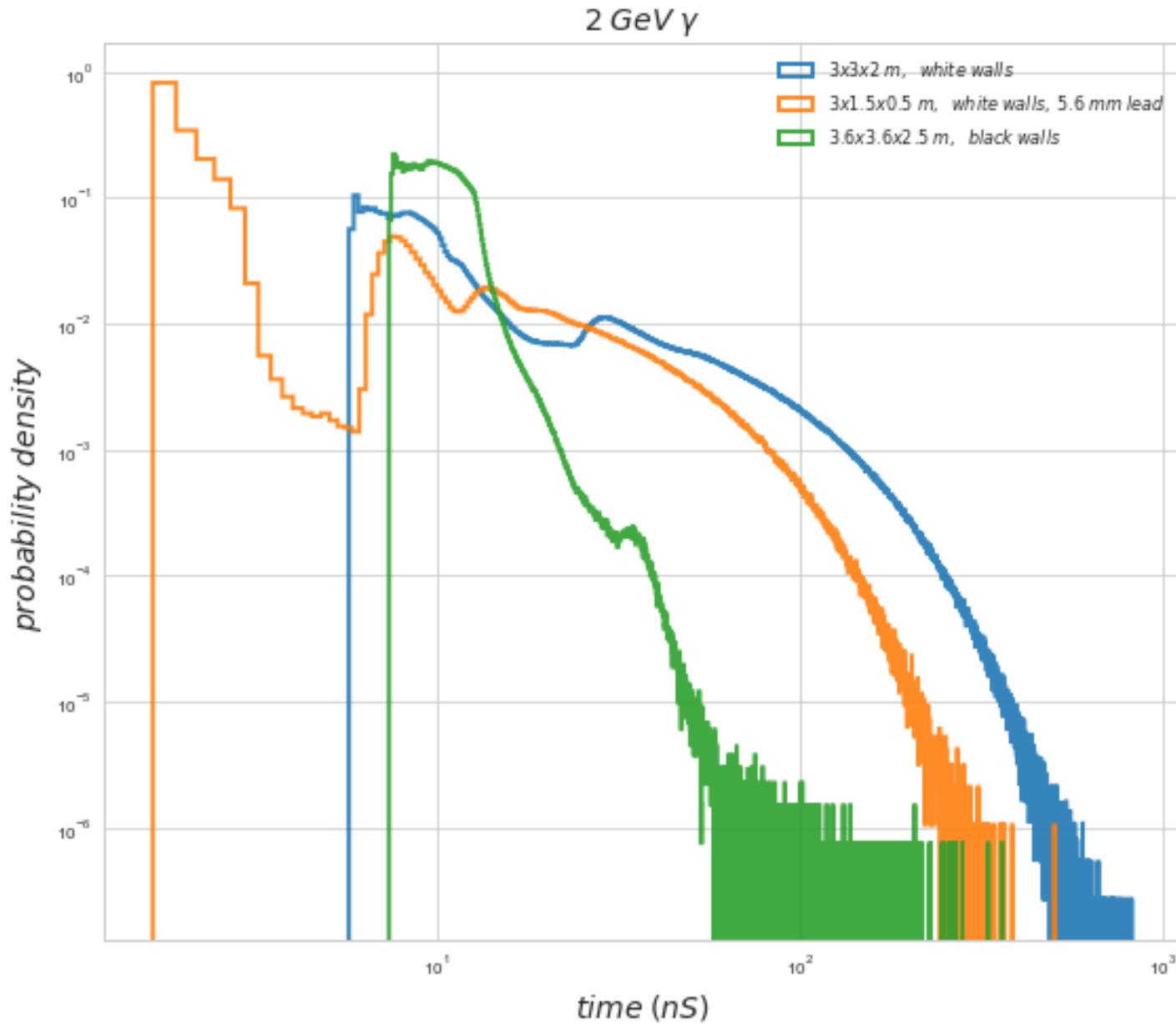
How do we do a muon – gamma separation?

How does the timing compare?

Upper Cell

pdf

Gamma



All positions, All photons

Momentum (0, 0, 1)

But what about the first photons hits?

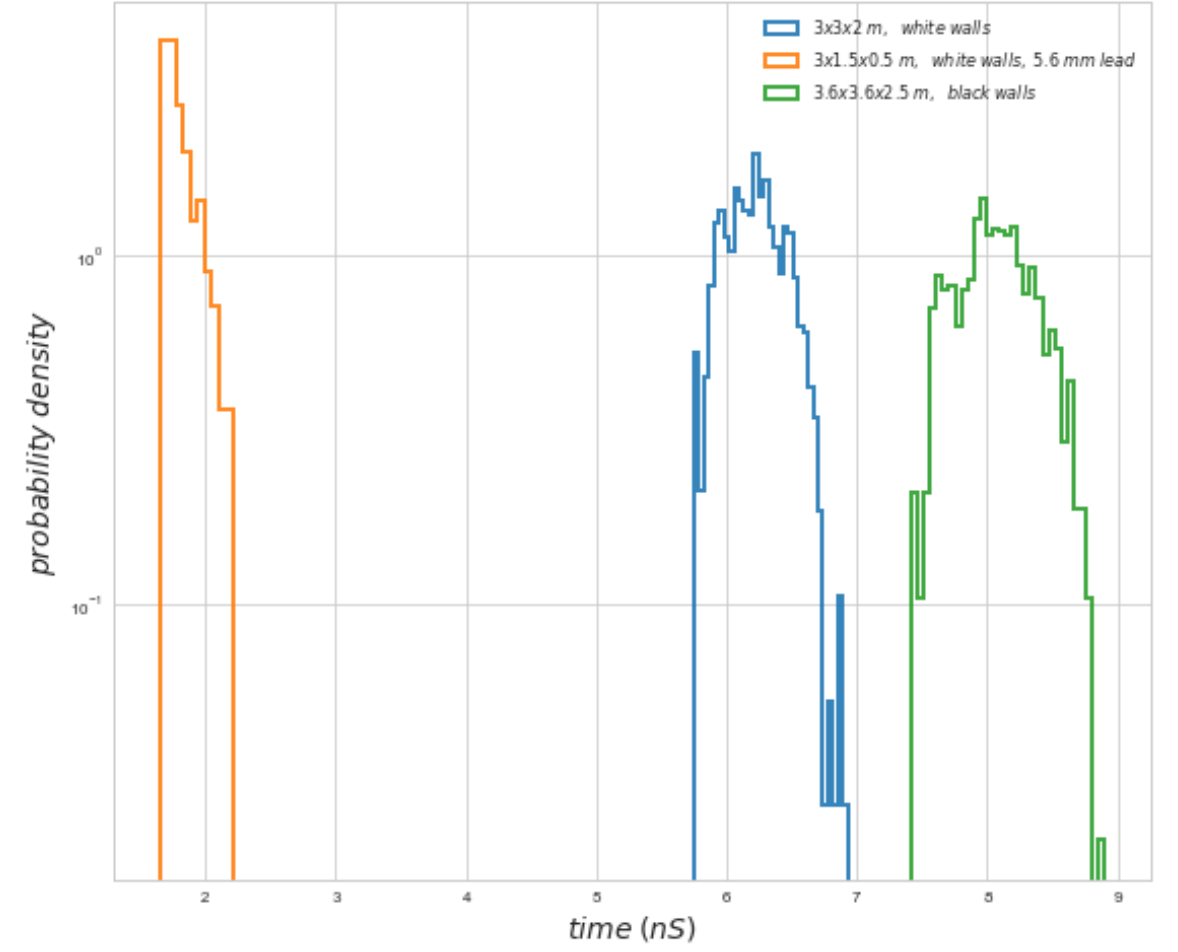
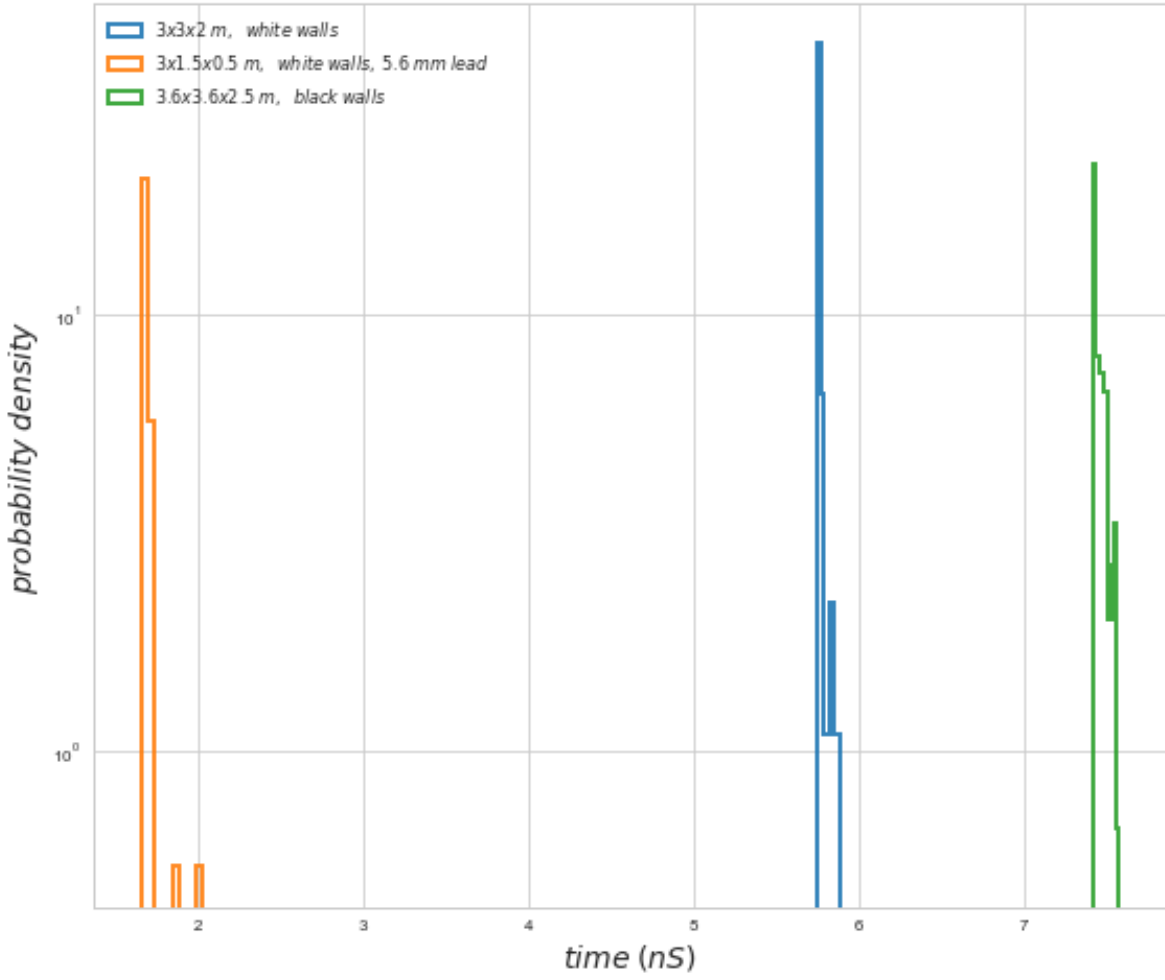
2 GeV

First Photons

50MeV

2 GeV γ

50 MeV γ

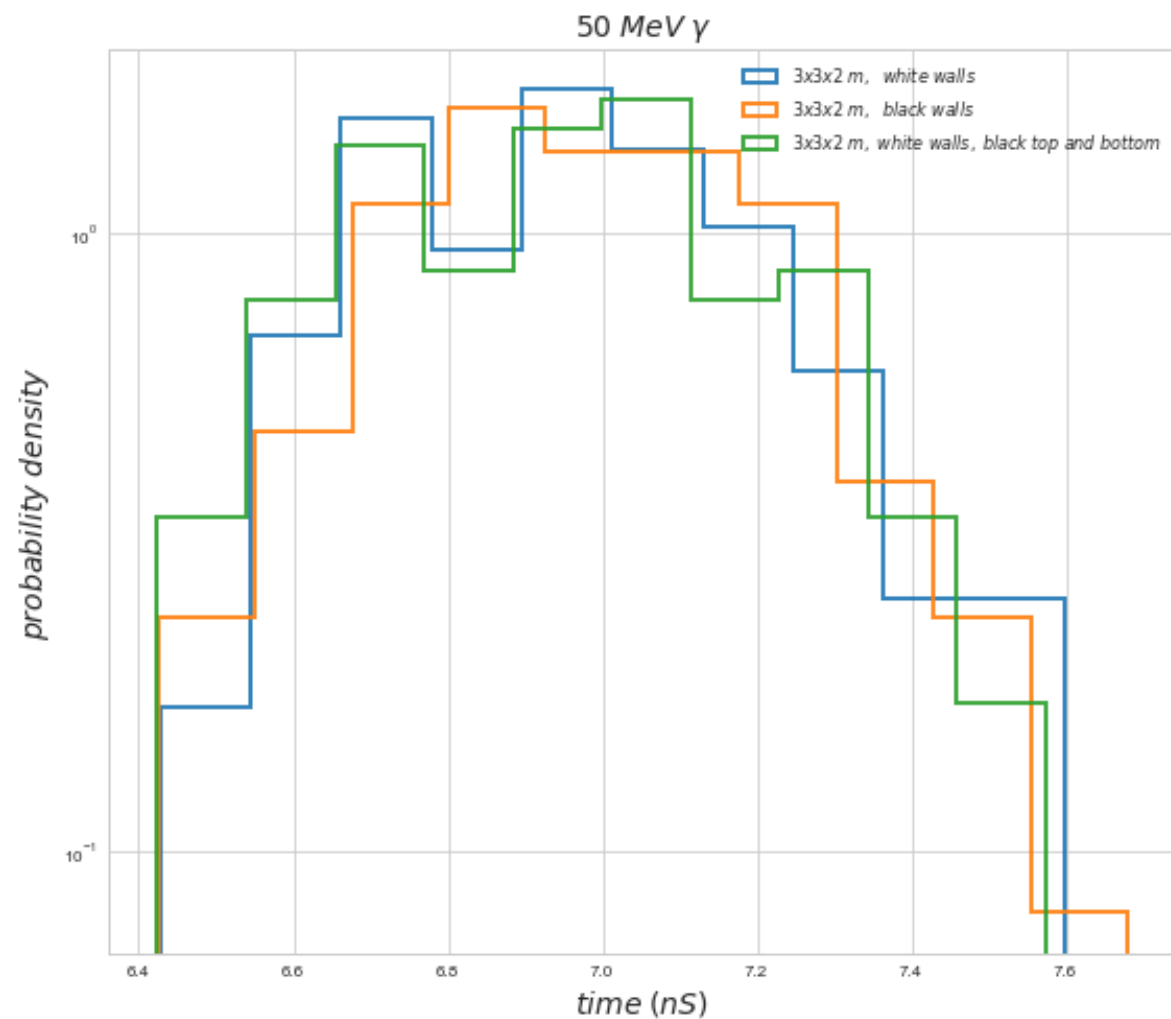
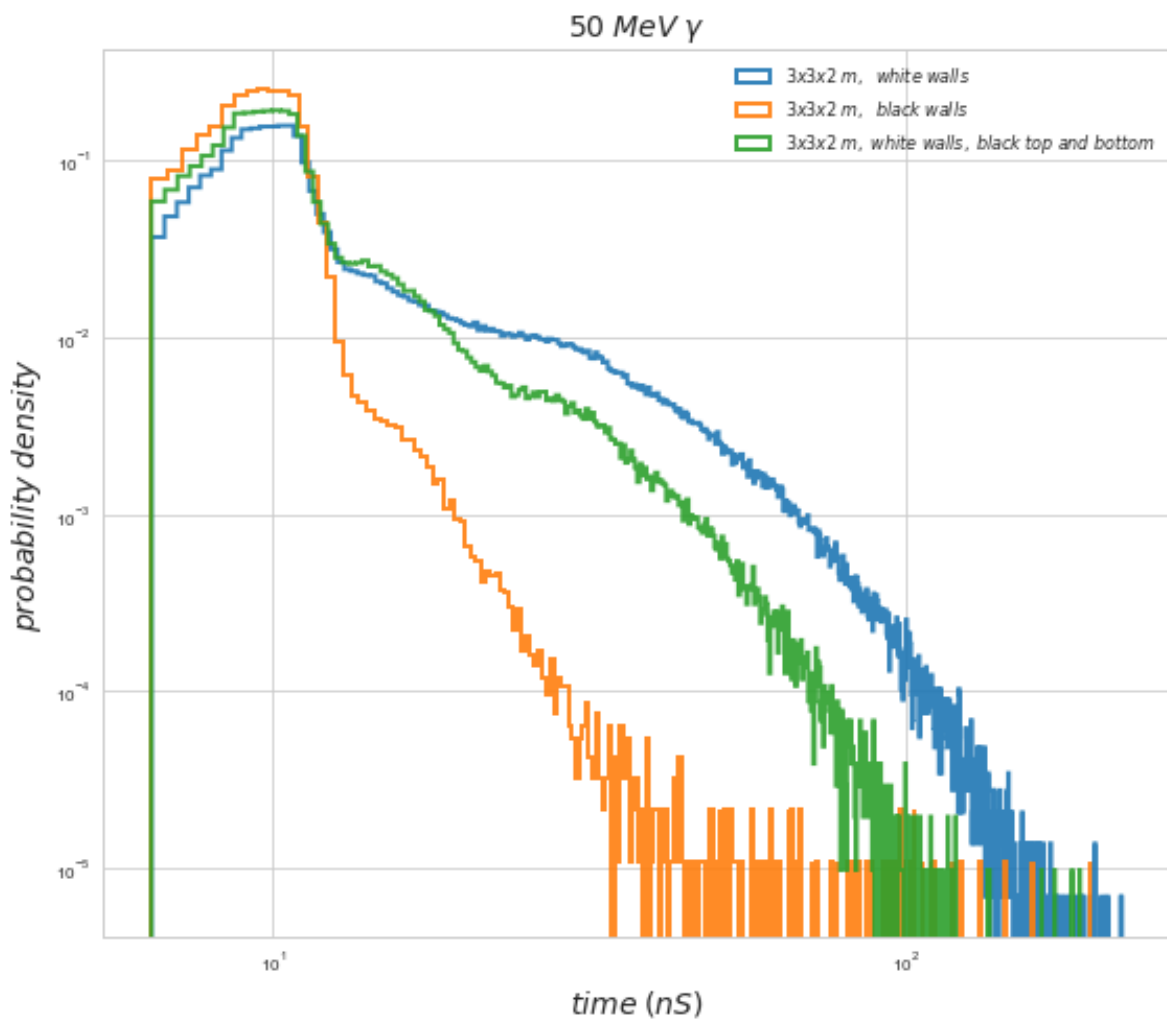


Lets paint have the top and bottom black....

All Photons

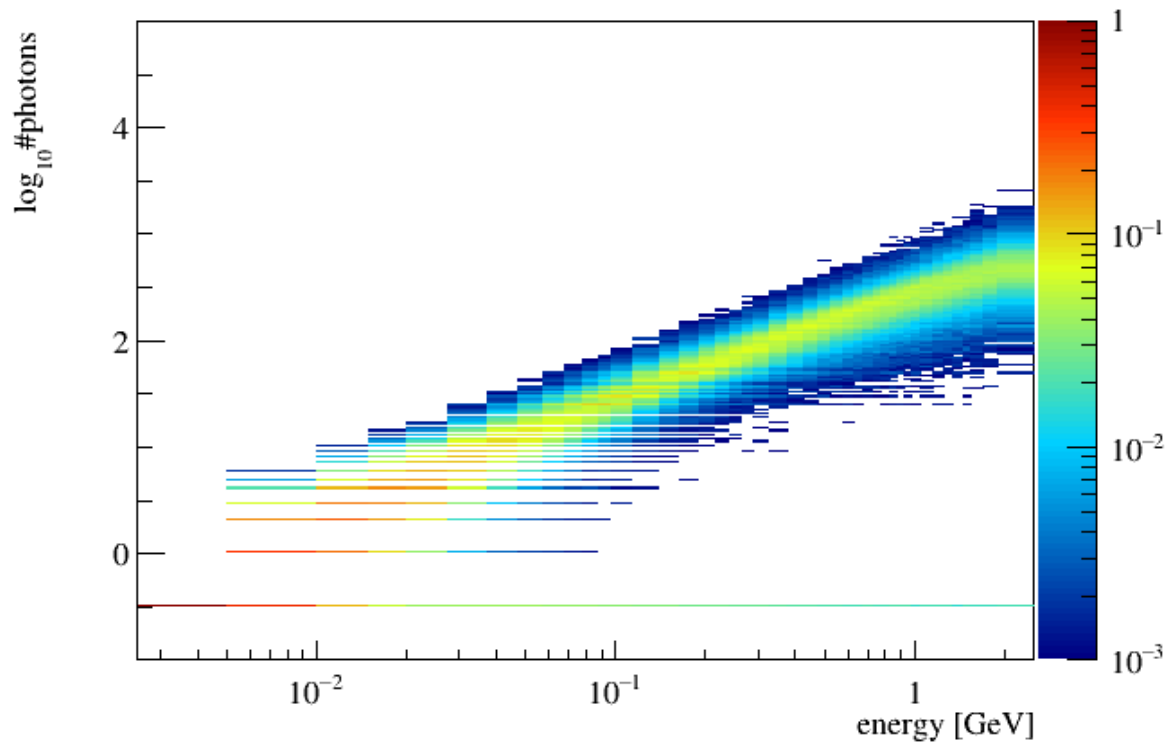
3x3x2 m

First photons

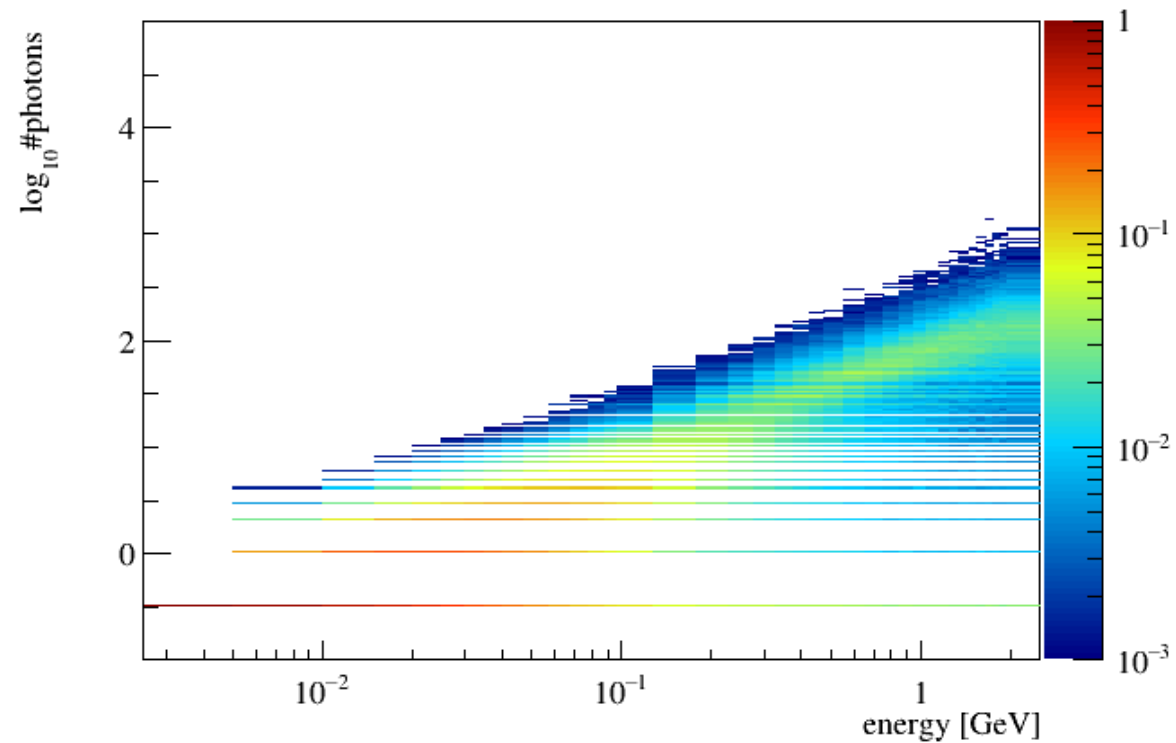


Momentum (0, 0, 1) 17

Tank response for an entirely white painted vs a white walled and black top and bottom cell....

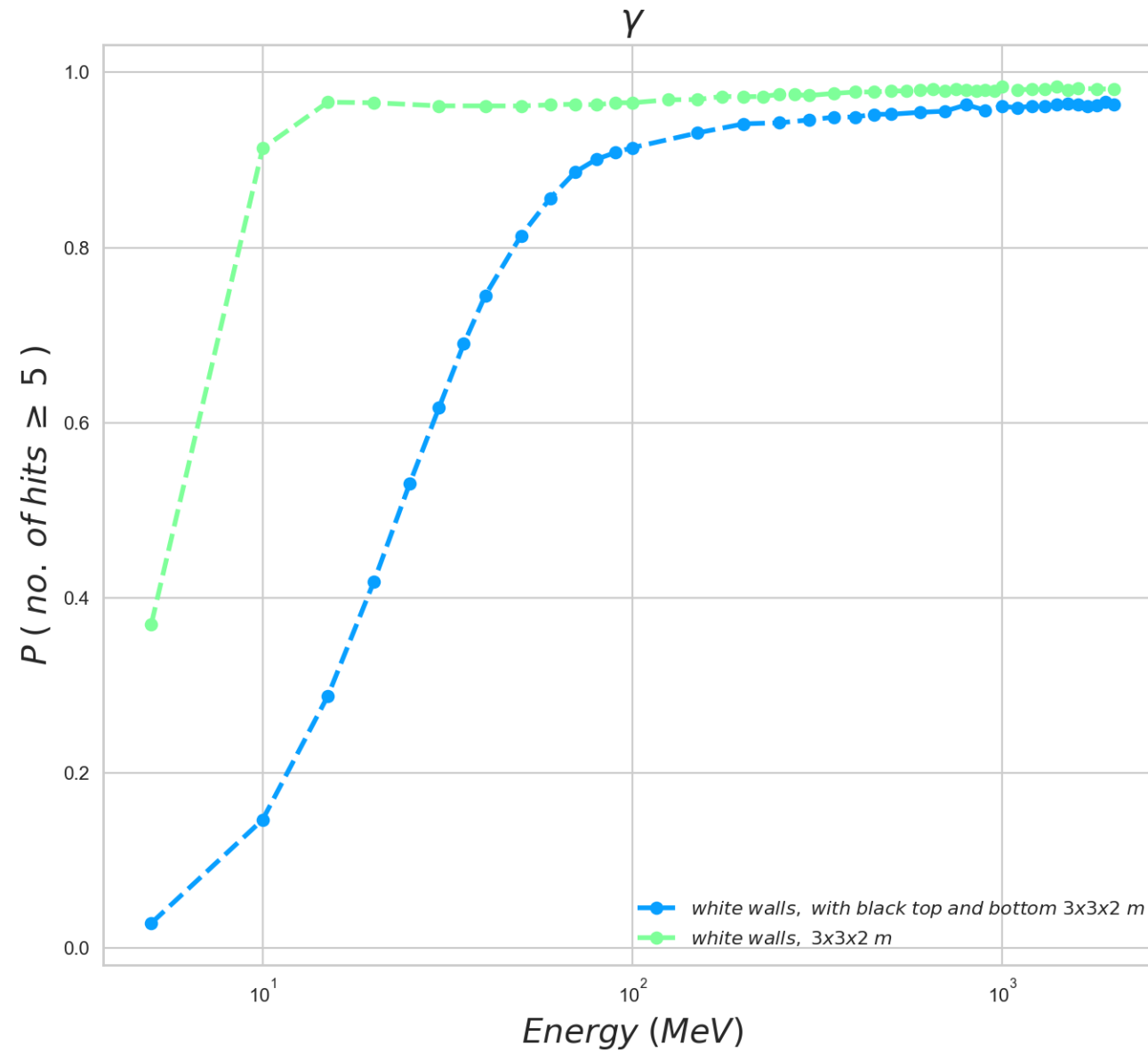


white walls, 3x3x2



white walls w/ black top and bottom, 3x3x2

How do the two compare?

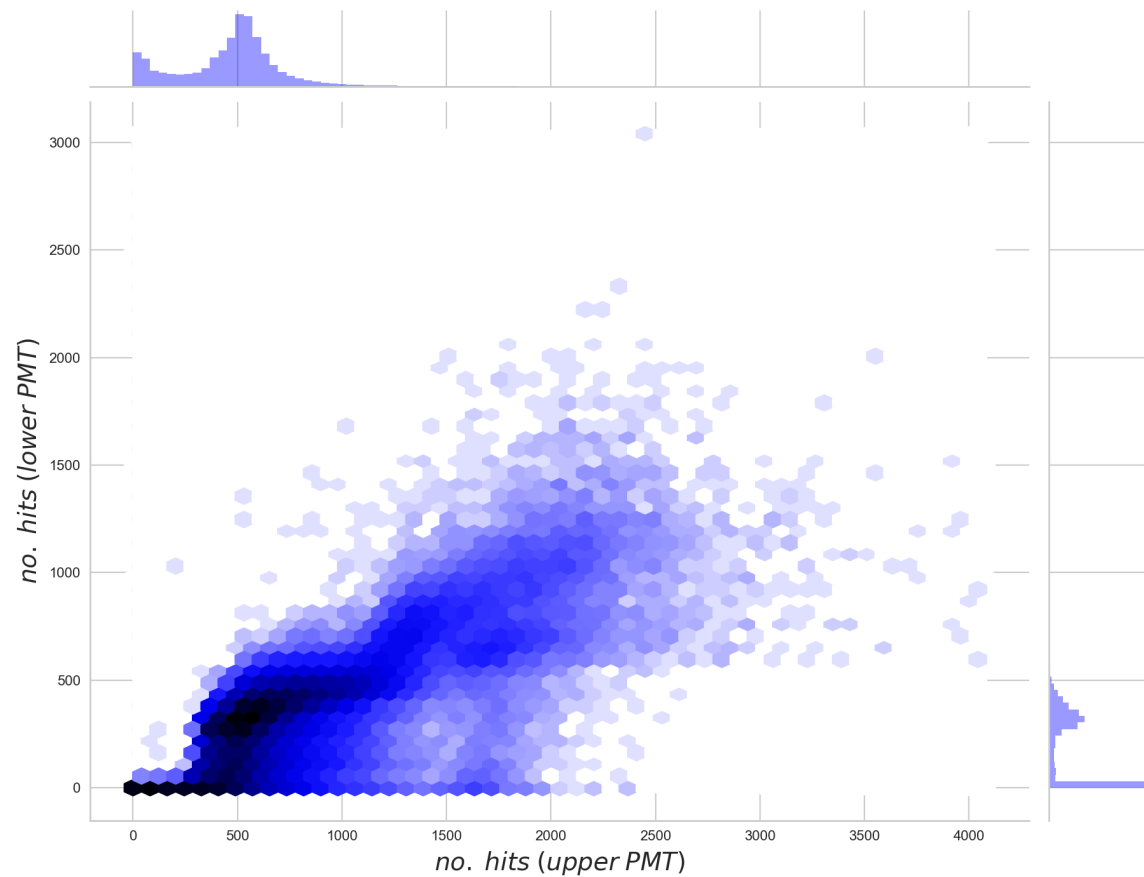


Thank You

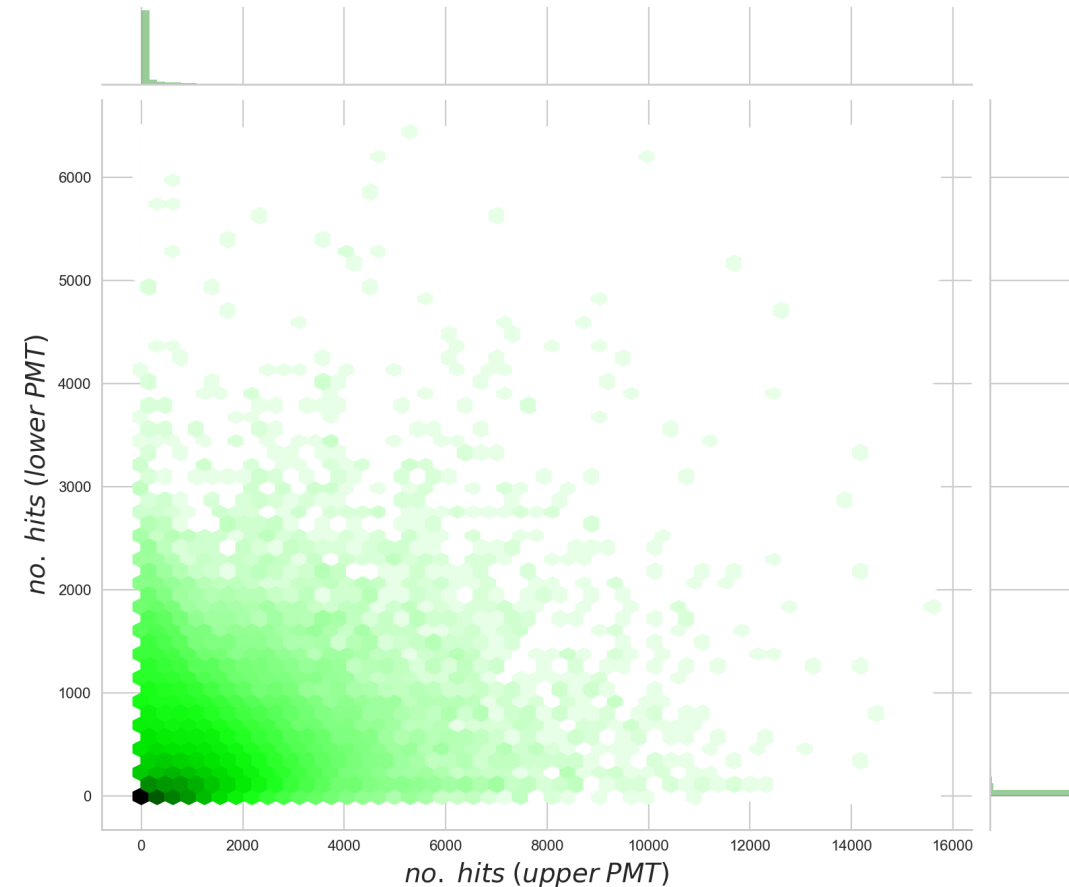
White Walls

Upper Cell : 3x3x2 , Lower Cell : 3x3x1 m

All positions, All photons



Distribution



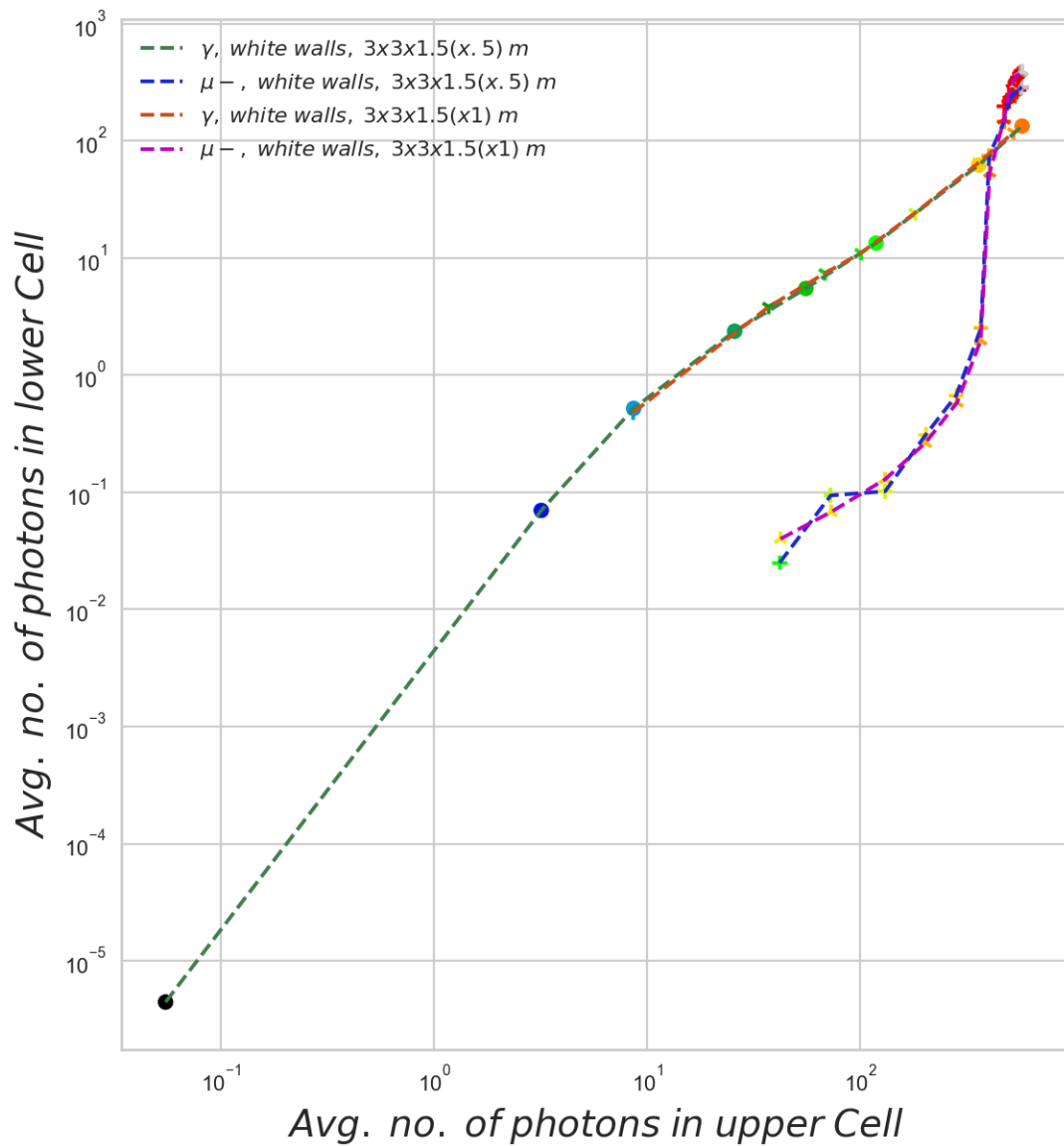
PMT depth variable cm
Submerged by 0 cm

Muon (100 -2000 MeV),
Gamma (5 – 2000 MeV)
Momentum (0, 0, 1)

Upper Cell

Hit Distribution

Submerged by 20 cm



All positions, All photons

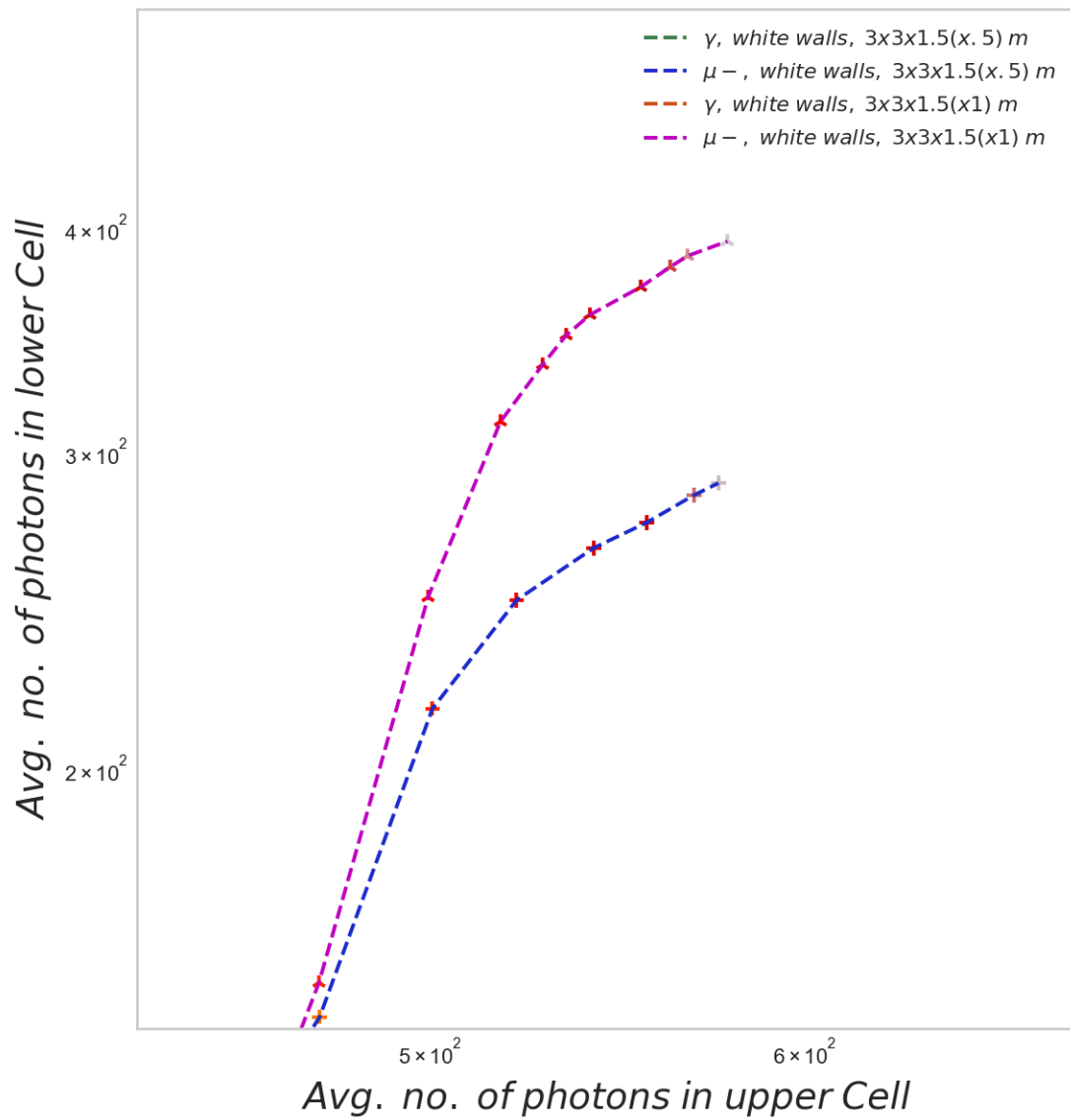
Tyvek

Muon and gamma
Momentum (0, 0, 1)

Upper Cell

Hit Distribution

PMT depth 150 cm
Submerged by 20 cm



All positions, All photons

Tyek

muon
Momentum (0, 0, 1)