γ – LASER Mode
Beam Monitoring & Scintillation Detectors

John Hallford

University College London

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The incidence of these particles on a detector plane orthogonal to a beampipe is described by this equation:

$$x = R(1 - cos(sin^{-1}(\frac{z_m}{R}))) + tan(sin^{-1}(\frac{z_m}{R}))z_d$$

We also must create a provision to account for the possible rotation of the detector in the Y axis by an angle of θ. Separating the components of the final x value into x_1, x_2 and x_3, we sum them to obtain the 'global' x-value of the hit.

$$x_1 = R(1 - cos(\phi))$$

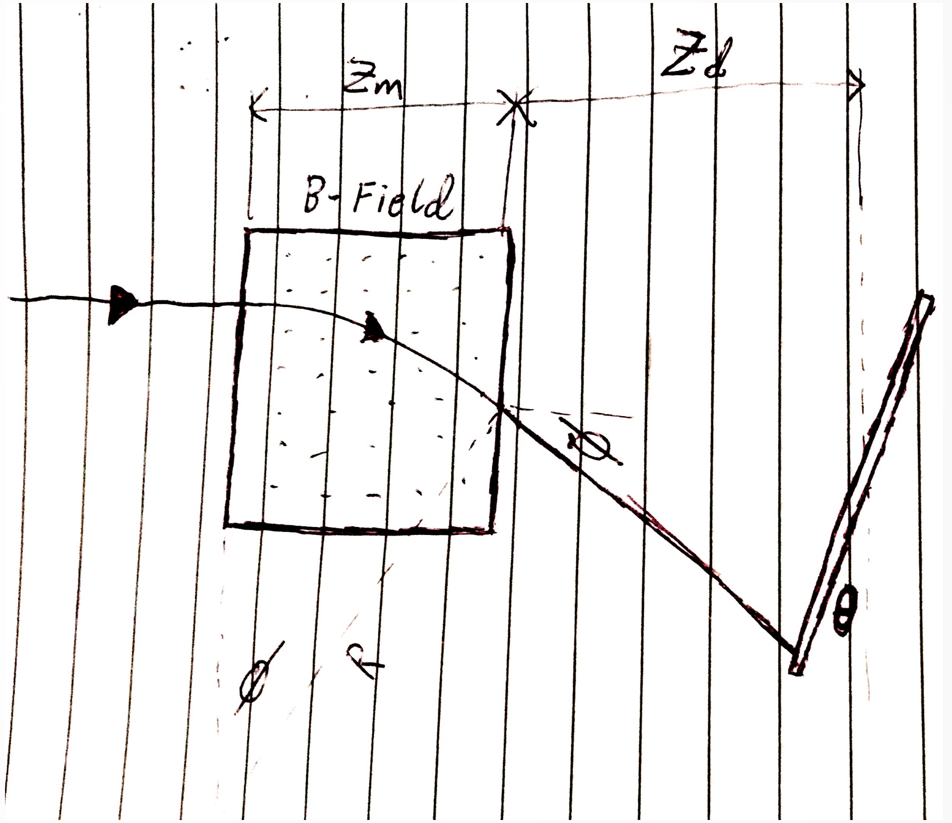
$$x_2 = tan(\phi)z_d$$

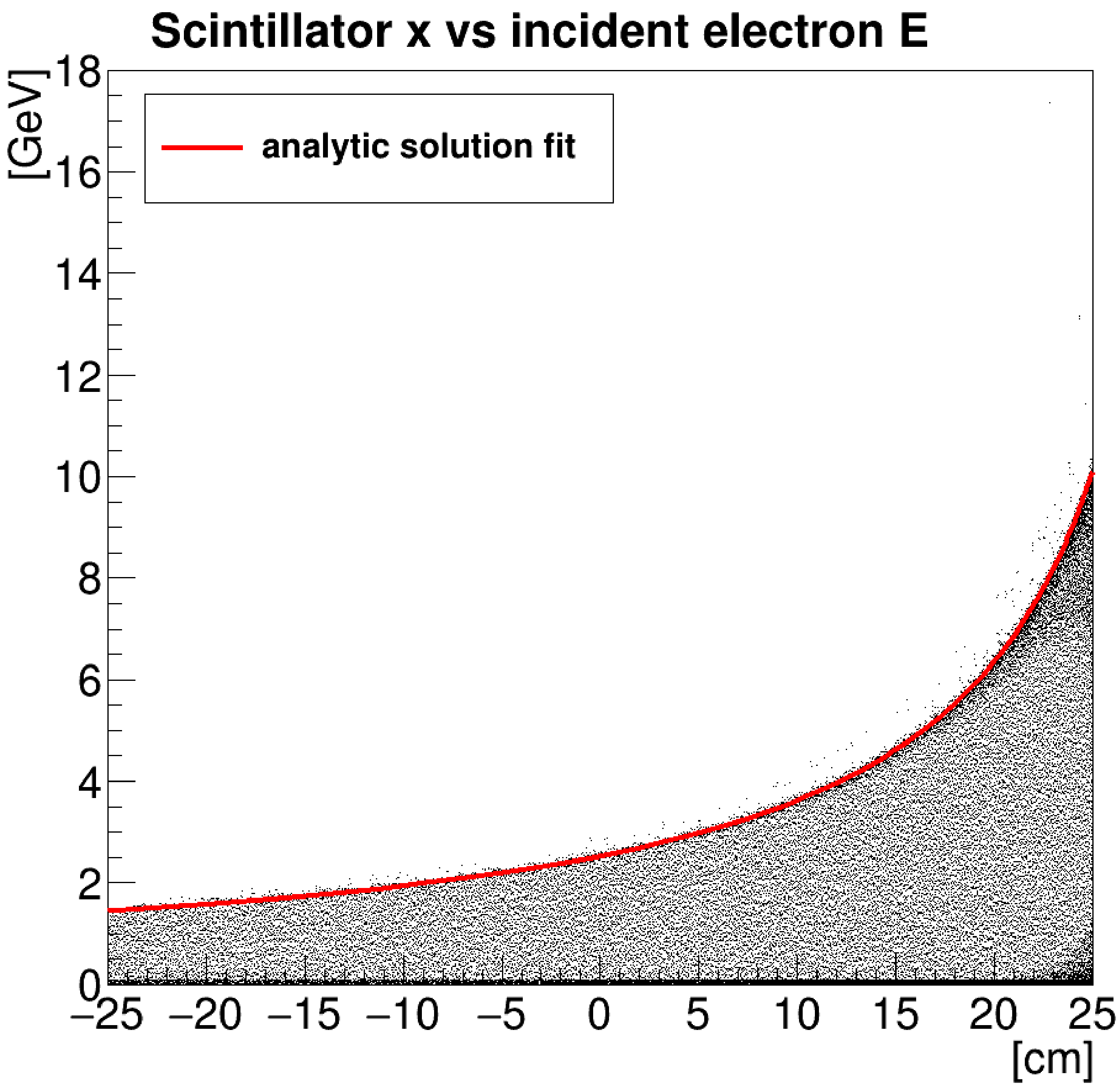
$$x_3 = \frac{tan(\theta)tan(\phi)(x_{detector} - x_1 - x_2)}{1 + tan(\theta)tan(\phi)}$$

Where $\phi = sin^{-1}(\frac{z_m}{R})$. From there mapping to the detector's 'local' x coordinates is elementary: $x_{local} = x_{global} - x_{detector}/cos(\theta)$

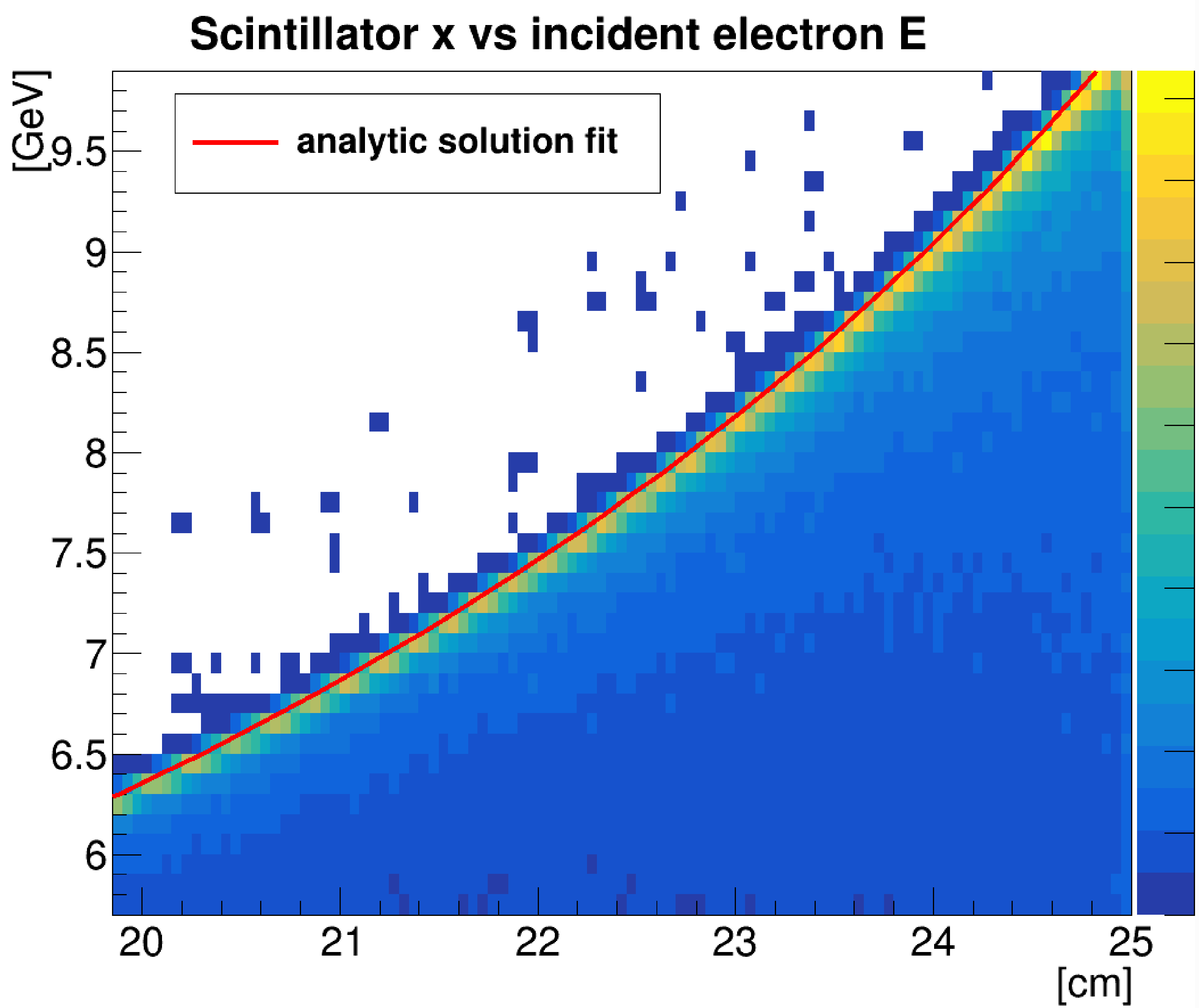
R = E / Bc

(Energy in eV)





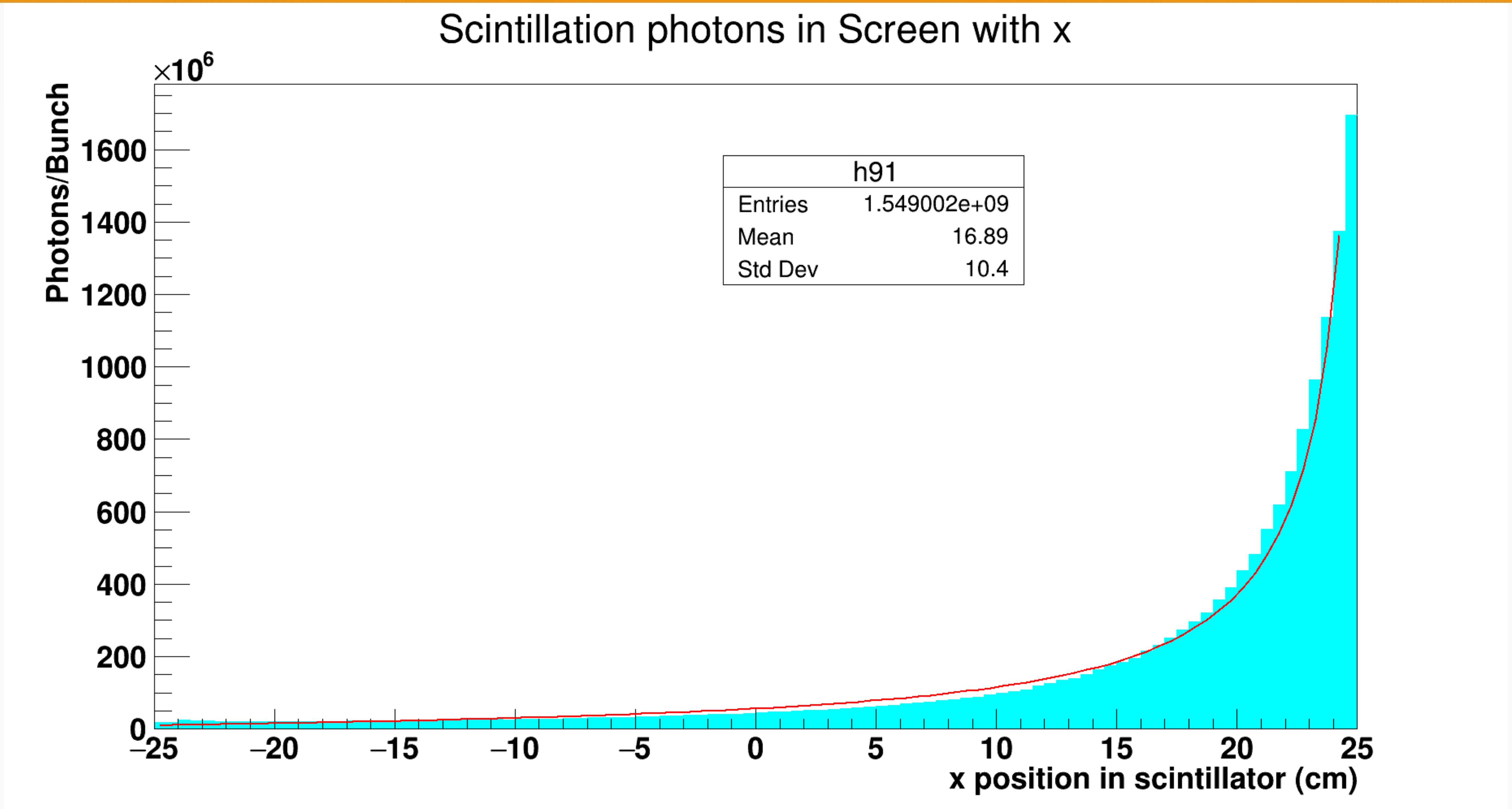
Function overlaid on GEANT electron energy vs hit for scintillator screen. Clearly in good agreement.



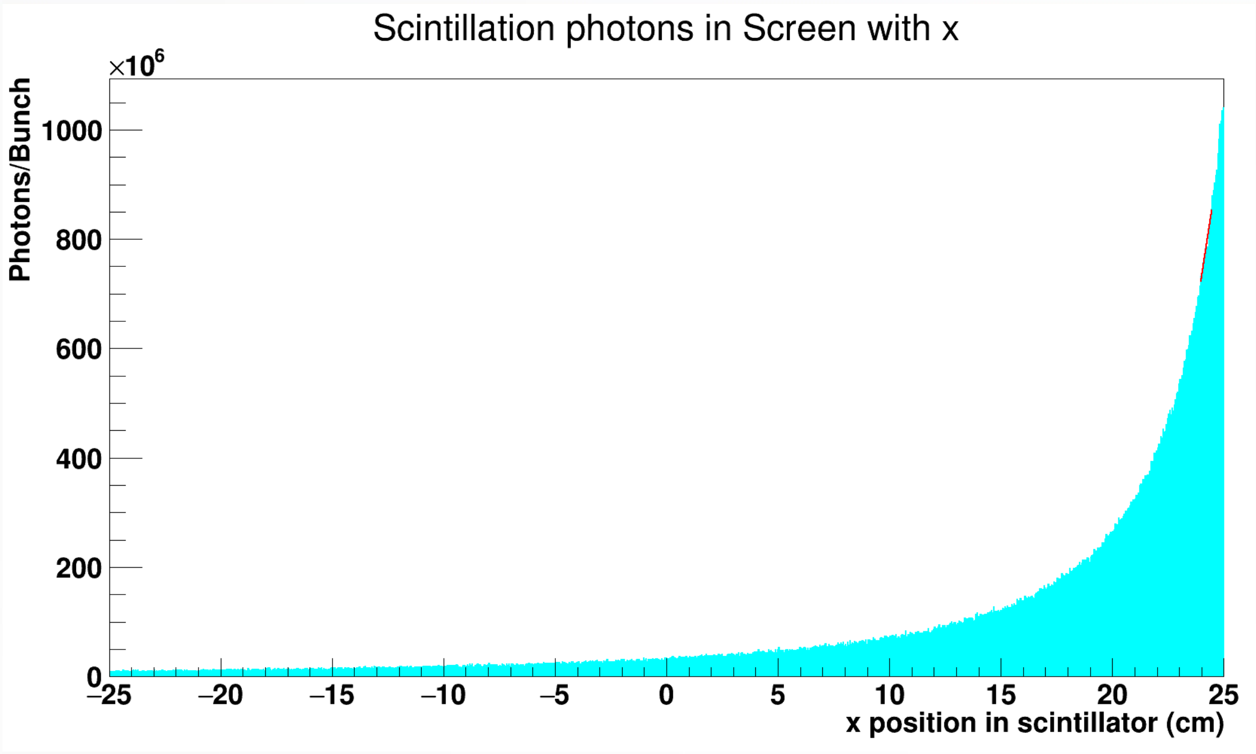
This should lend validity to the equation as it agrees with simulation, and vice versa. A minimal angular spread in electrons after target looks like a good assumption for our purposes. Need to remember both models assume constant B-field box (& no fringe field)

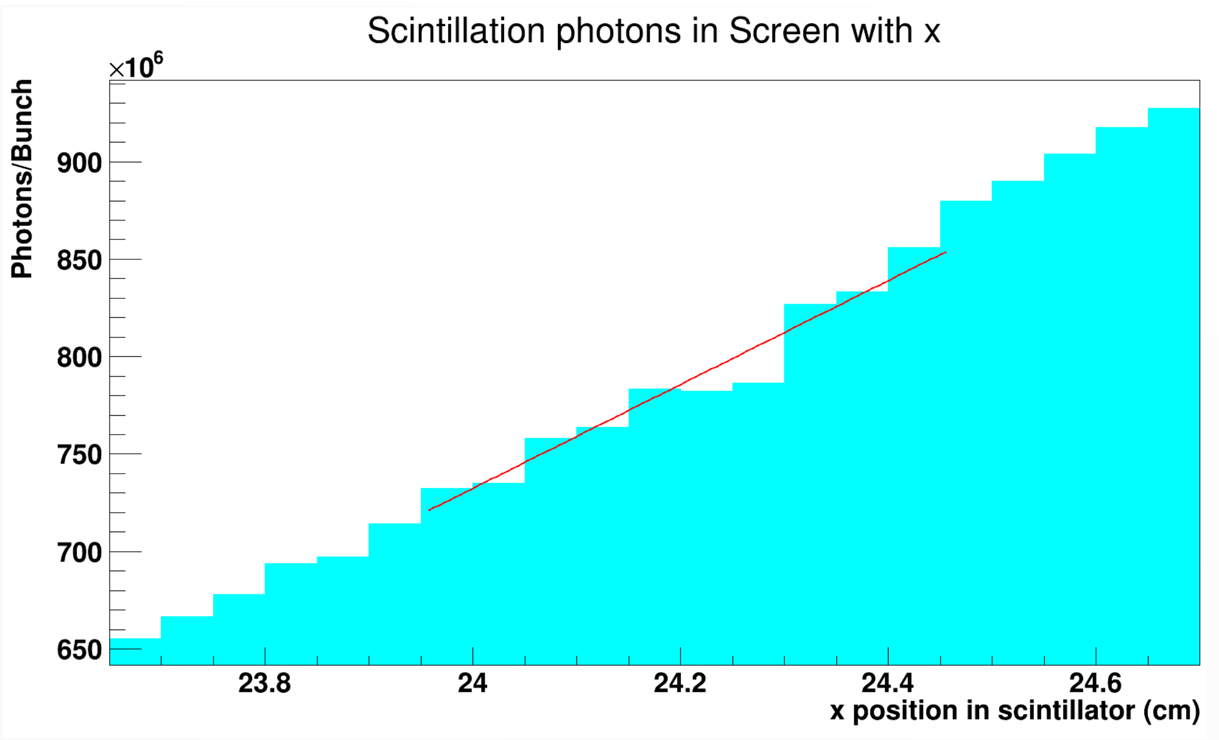
From here, I have looked at the simulated light output profile across detector ‘x’, and used the previous function to determine x-position for some E. For chosen intervals of E, find the corresponding interval in x, and find the integral of Scintillation light within. Then need to divide N_photons by photons/Electron for each electron energy, to find an electron E spectrum.

From there we can take E_beam – E_e to gather a Photon spectrum

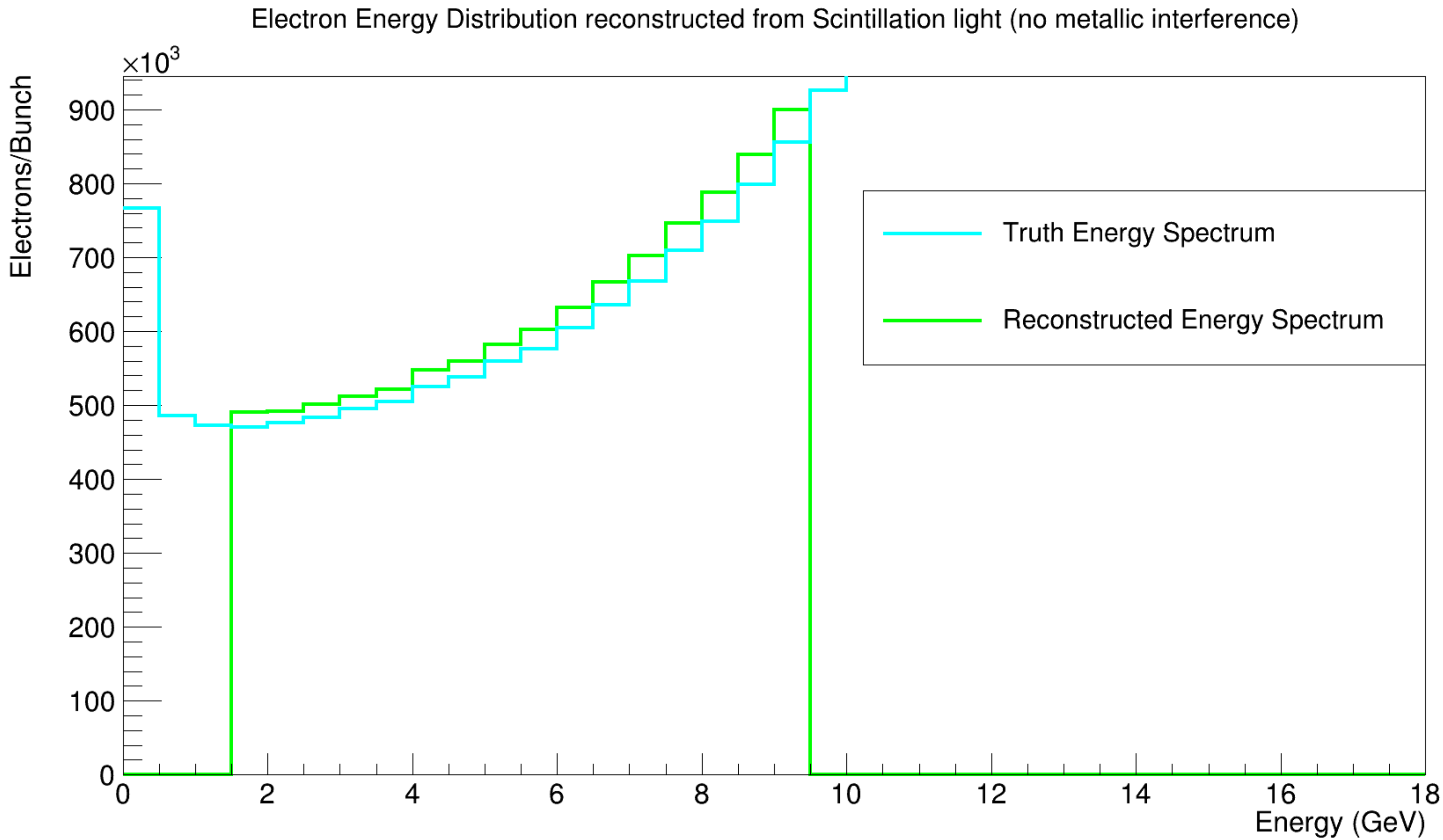


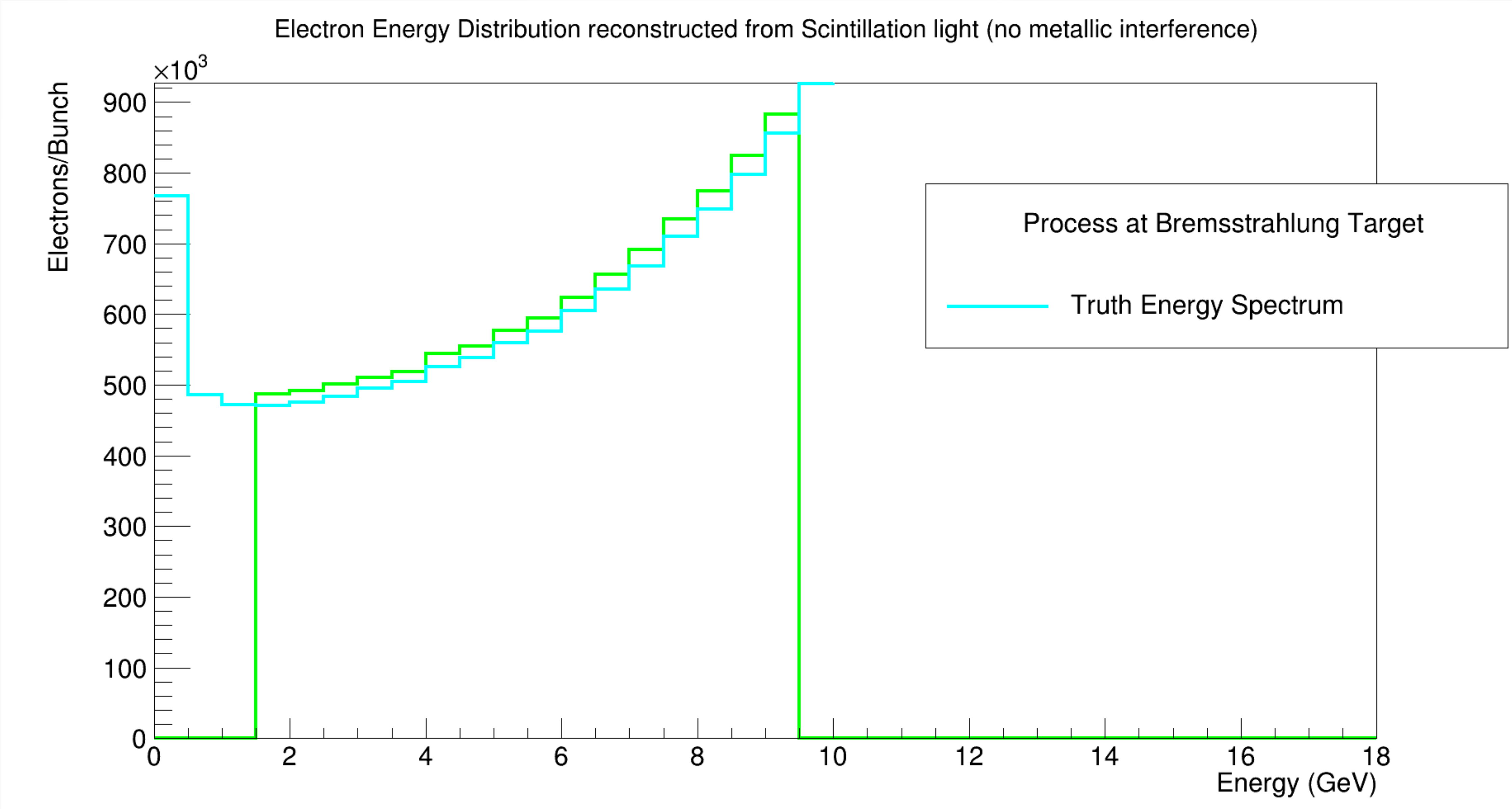
Functional fit of the output Scintillation light (with eg. exp, inverse 1/x) has not been satisfactory. So, I have constructed linear fits only between the intervals (bins)



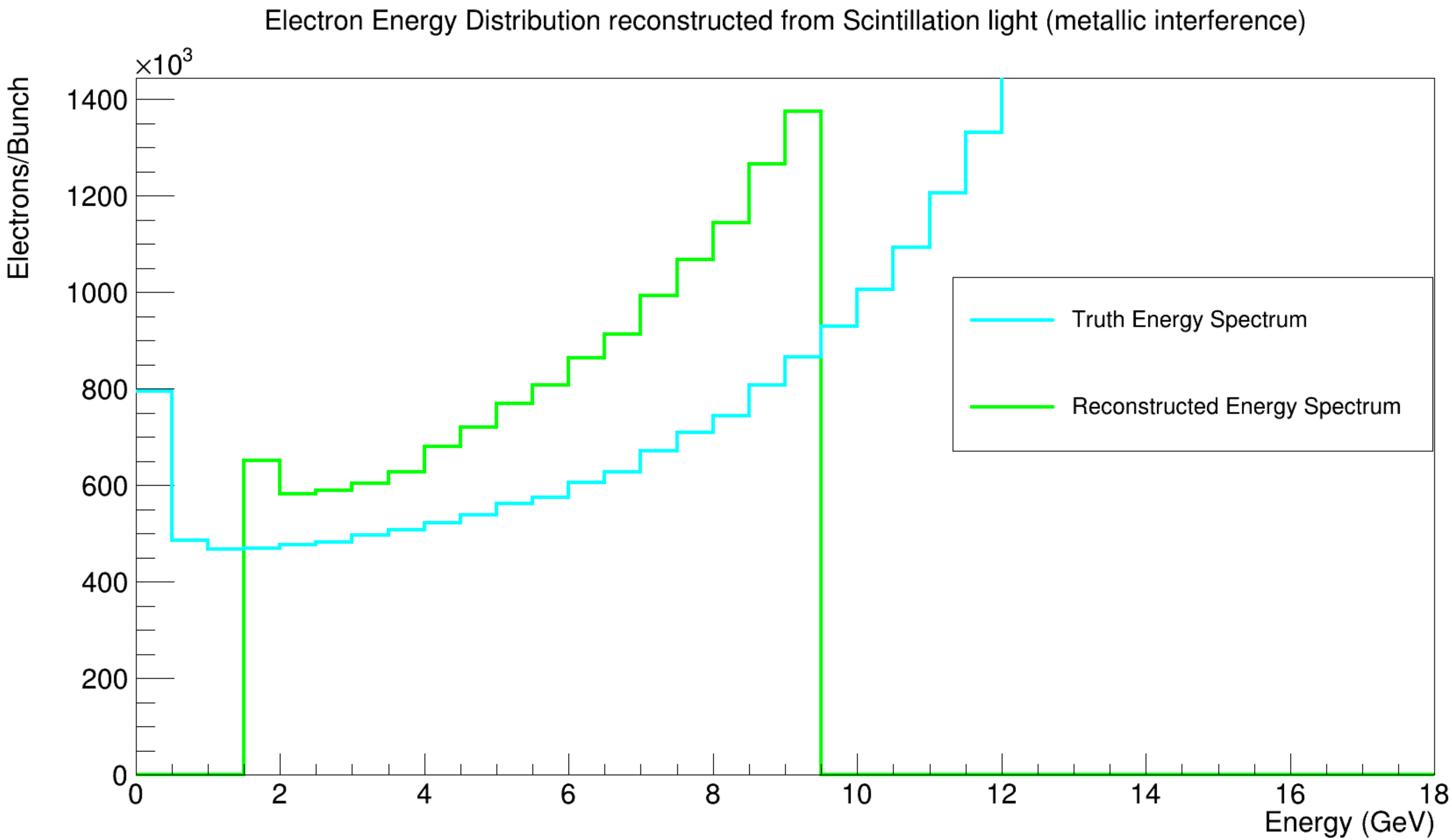


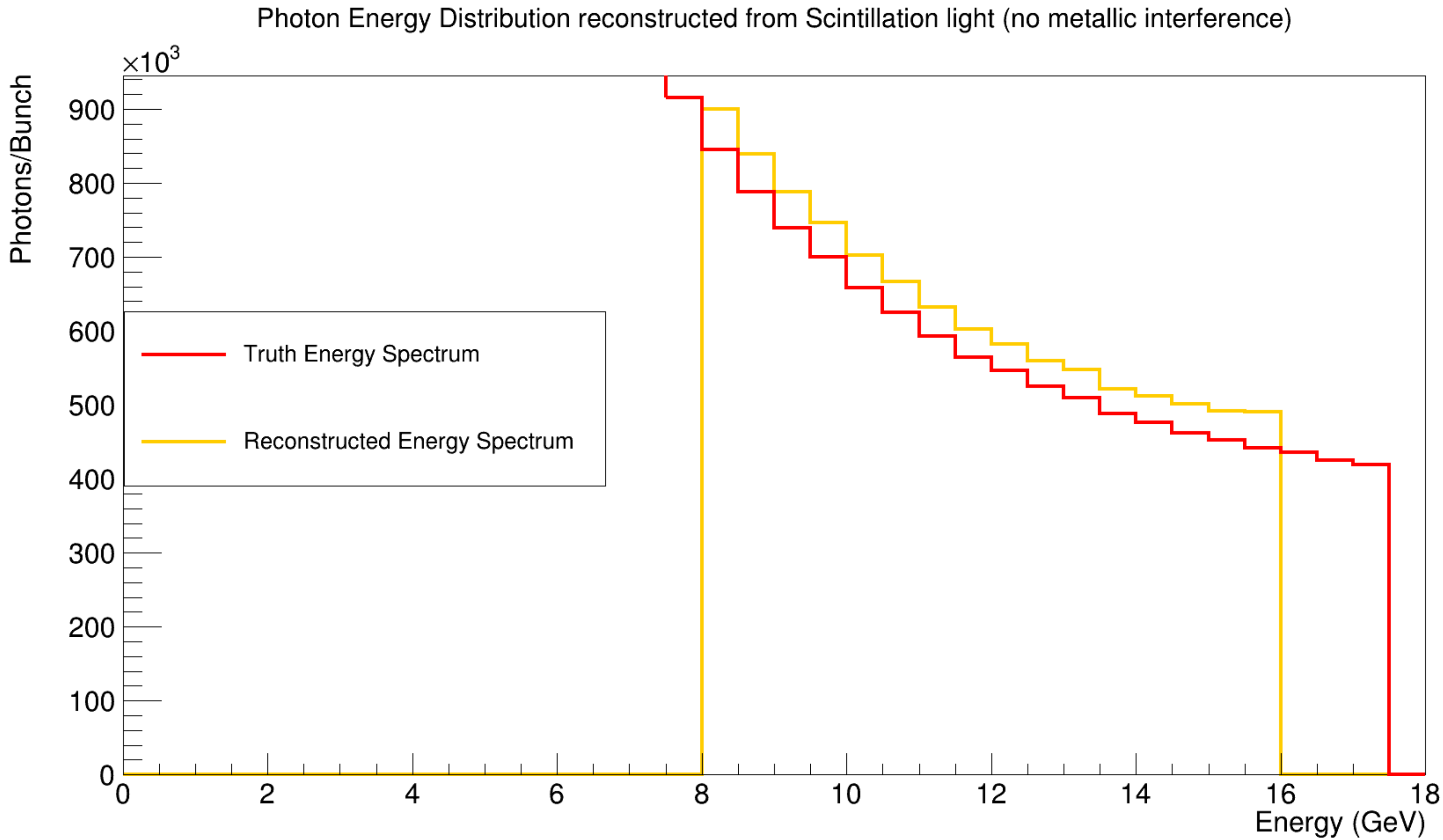
The method of approximating here looks reasonable for the small intervals, by eye at least, even at the steeper section of the spectrum.


Electron Energy Distribution reconstructed from Scintillation light (no metallic interference)
×10^3
Electrons/Bunch
900
800
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
18
Energy (GeV)
Truth Energy Spectrum
Reconstructed Energy Spectrum

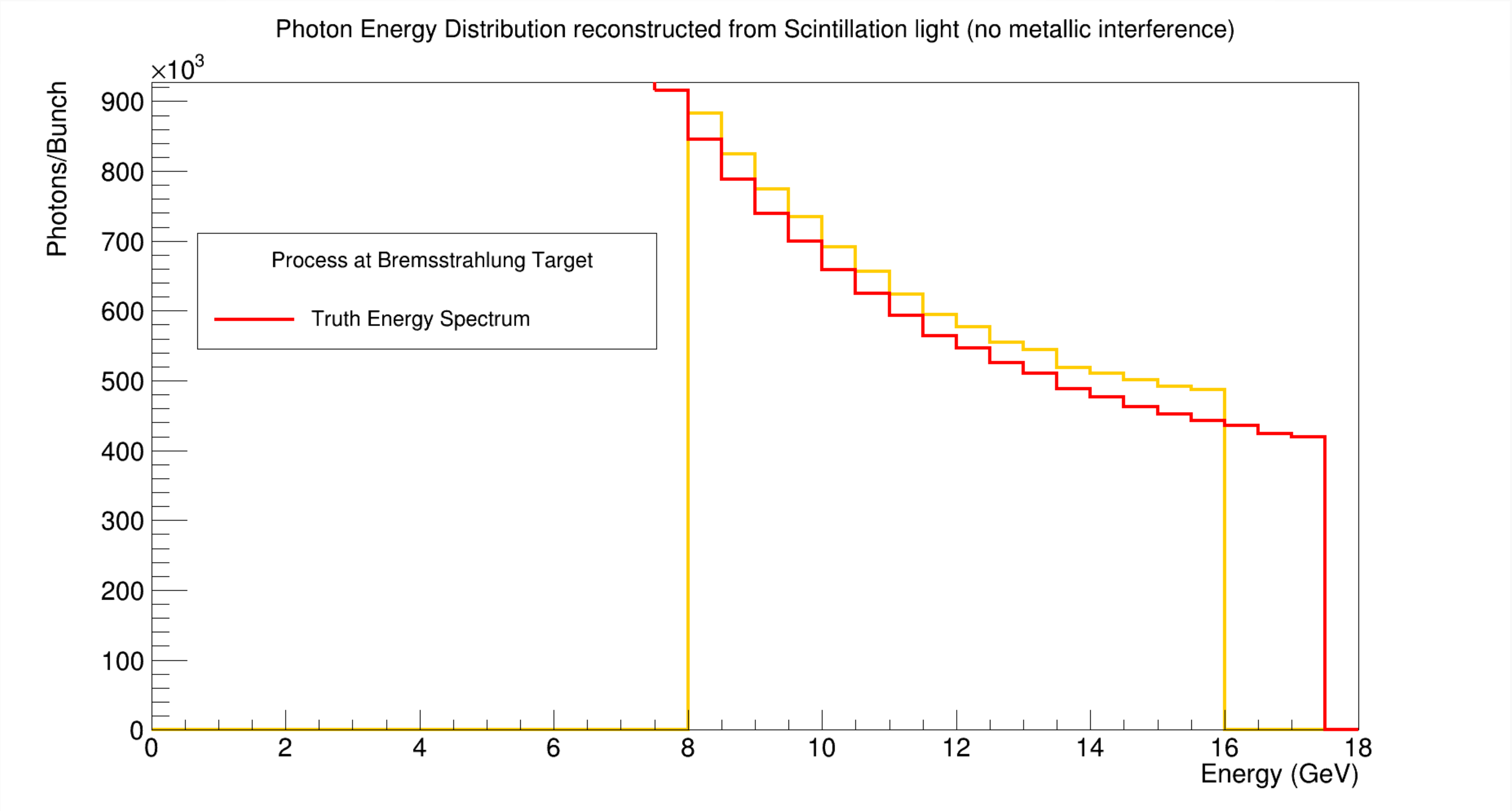


Now with (cos(ϕ-θ)) correction. Small reduction in reconstructed integral, <5%


Electron Energy Distribution reconstructed from Scintillation light (metallic interference)
×10^3
Electrons/Bunch
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
16
18
Energy (GeV)
Truth Energy Spectrum
Reconstructed Energy Spectrum



Photon Energy Distribution reconstructed from Scintillation light (no metallic interference)
×10^3
Photons/Bunch
900
800
700
600
500
400
300
200
100
0
Truth Energy Spectrum
Reconstructed Energy Spectrum
0
2
4
6
8
10
12
14
16
18
Energy (GeV)



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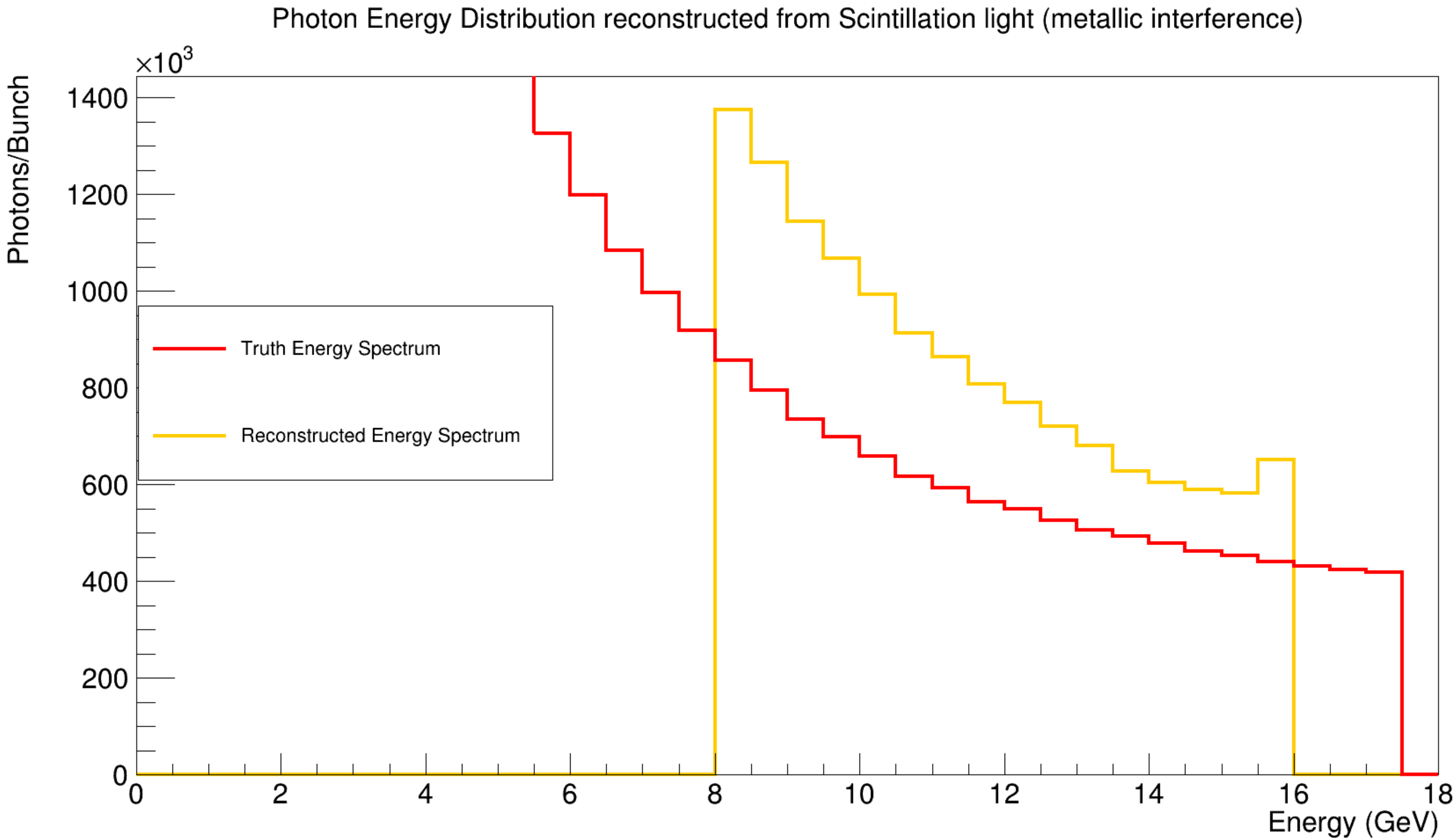

Photon Energy Distribution reconstructed from Scintillation light (metallic interference)
×10^3
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Truth Energy Spectrum
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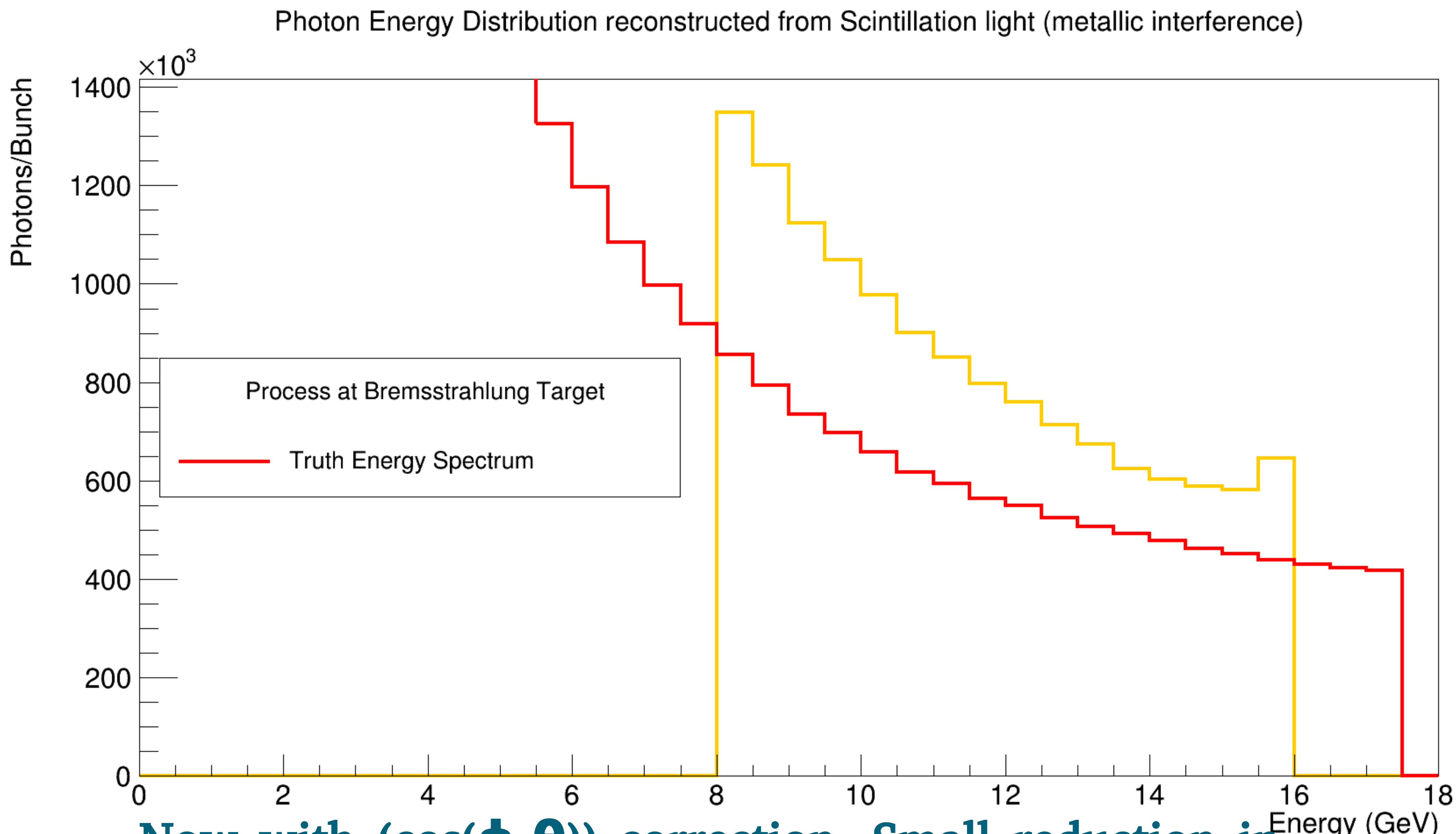
Energy (GeV)



Now with (cos(ϕ-θ)) correction. Small reduction in reconstructed integral, < 5%

Still to do:

Use screen response of electrons with 1mm of intermediate Al, for instance, to better account for beampipe

Could use similar angular correction to account for shallower angle → longer path through beampipe wall

Look at effect of proximity between screen & Cerenkov

Still to do:

Observe modified beampipe section (Kapton window?)

Invert B-field polarity and measure positrons

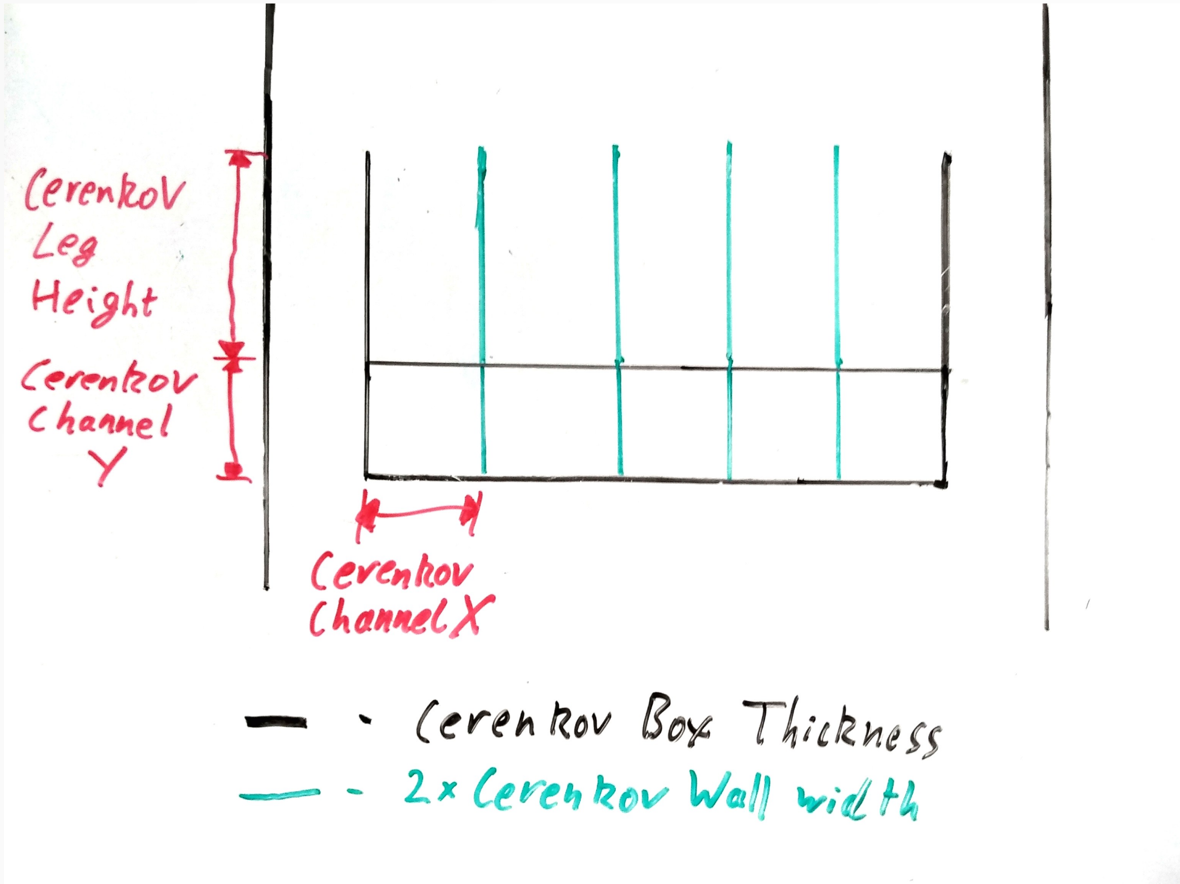
Either to obtain photon energy distribution directly (E_gamma ~ 2*E_e+) or to subtract numbers of pair-production electrons from

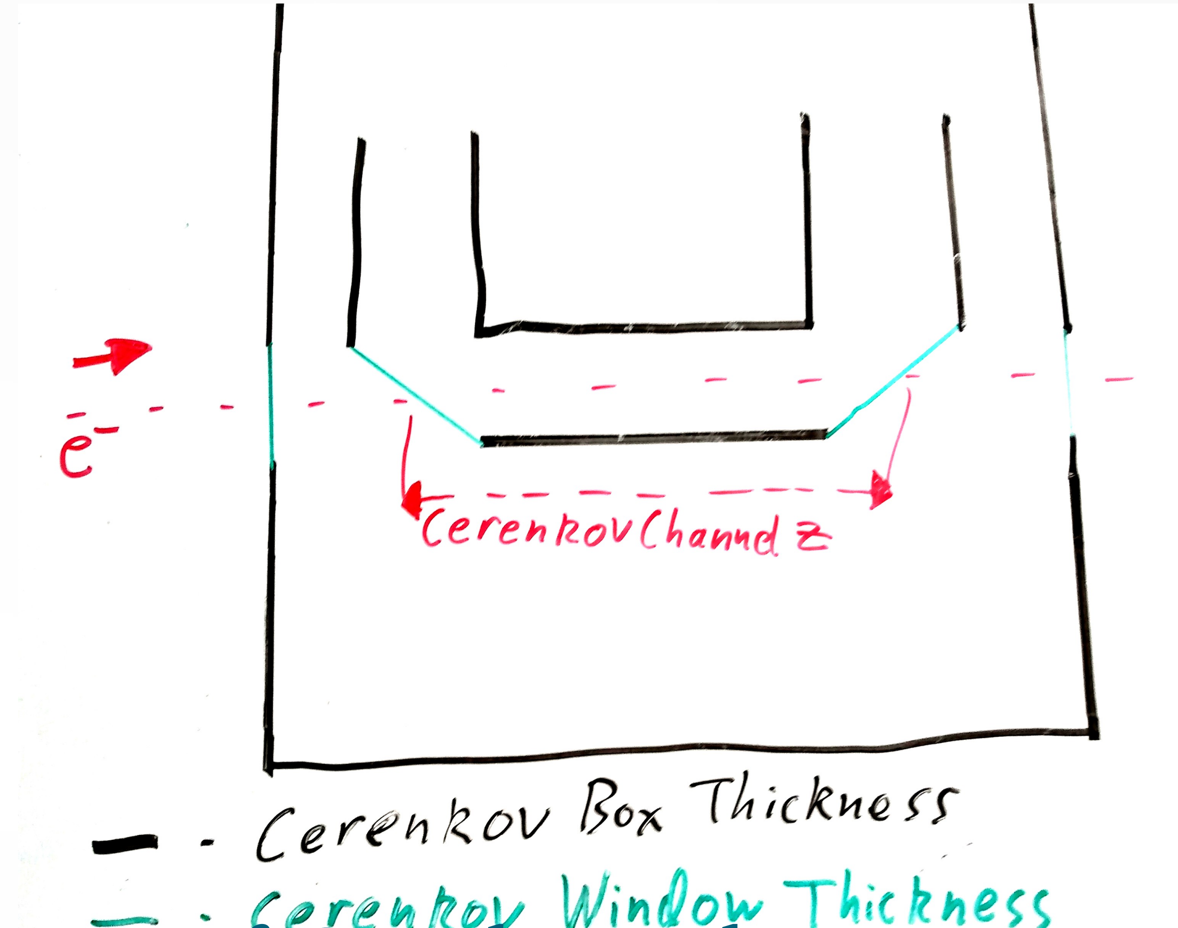
Still to do:

UCL first-year PhD transfer report & presentation in September

With the CDR also, progress on these points could be slowed

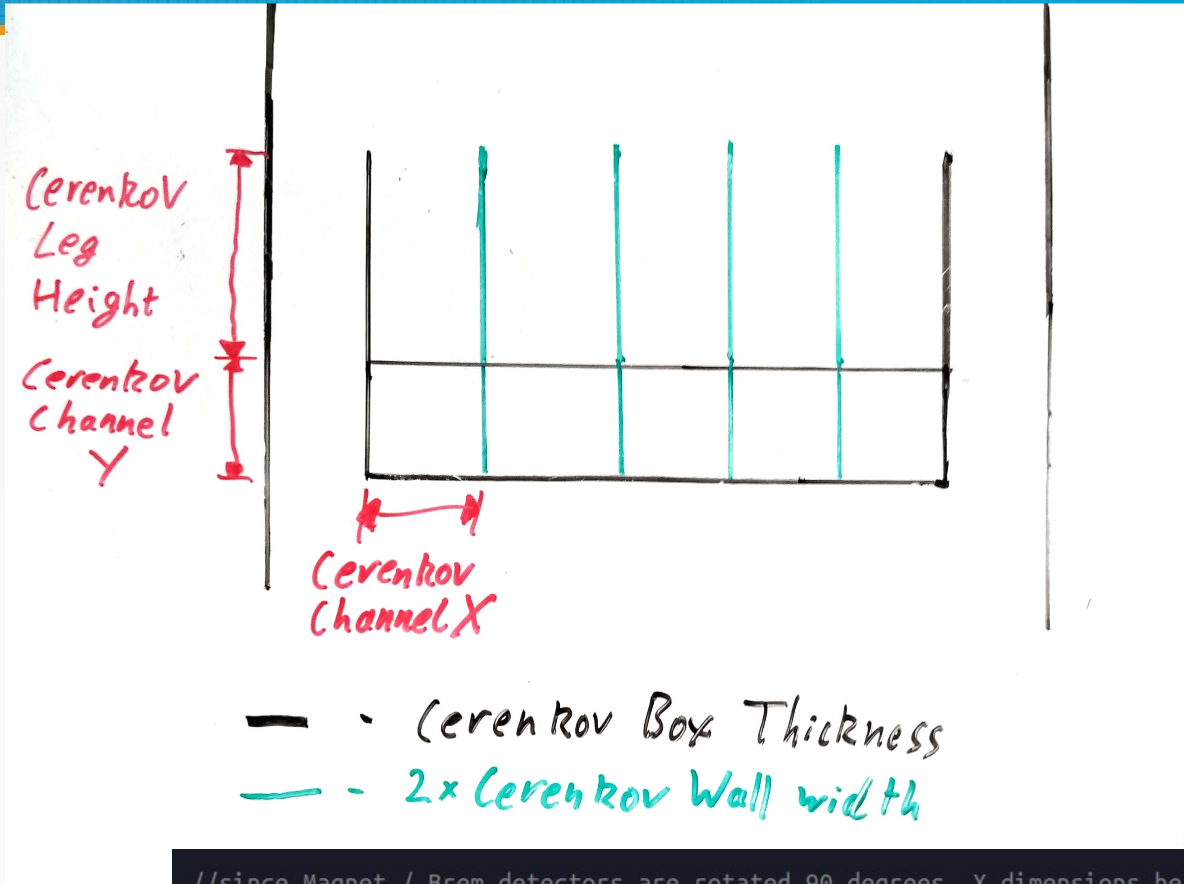
Backup

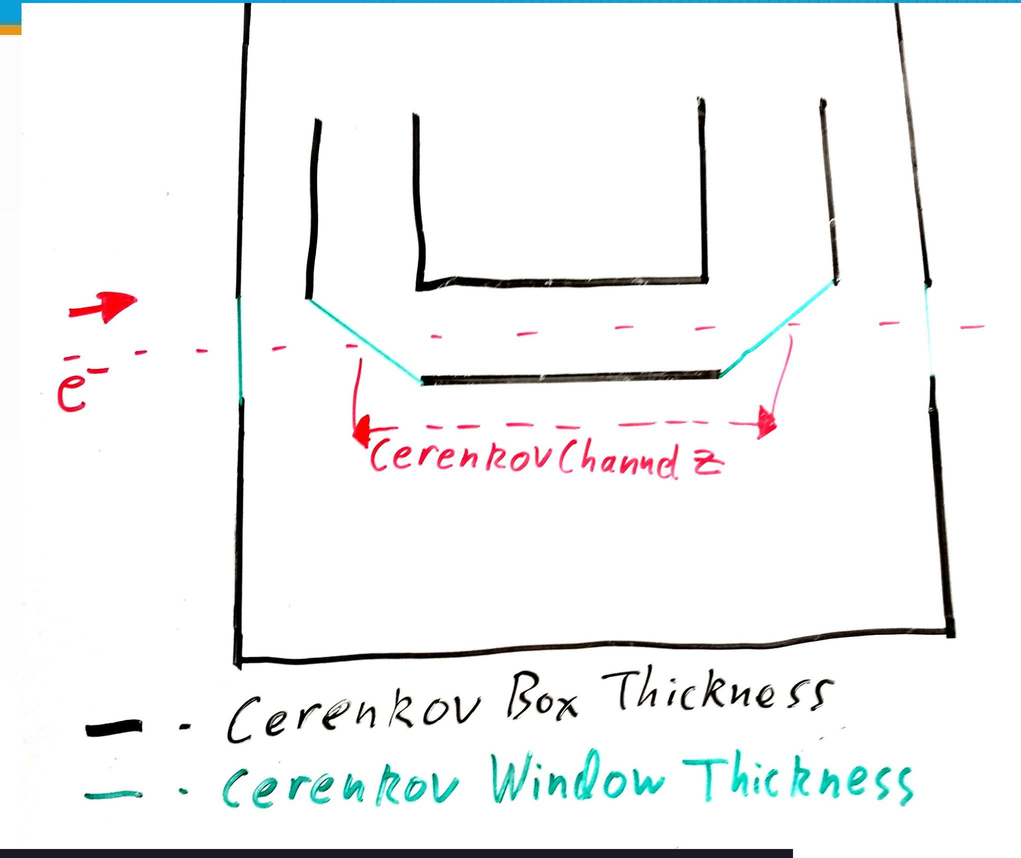




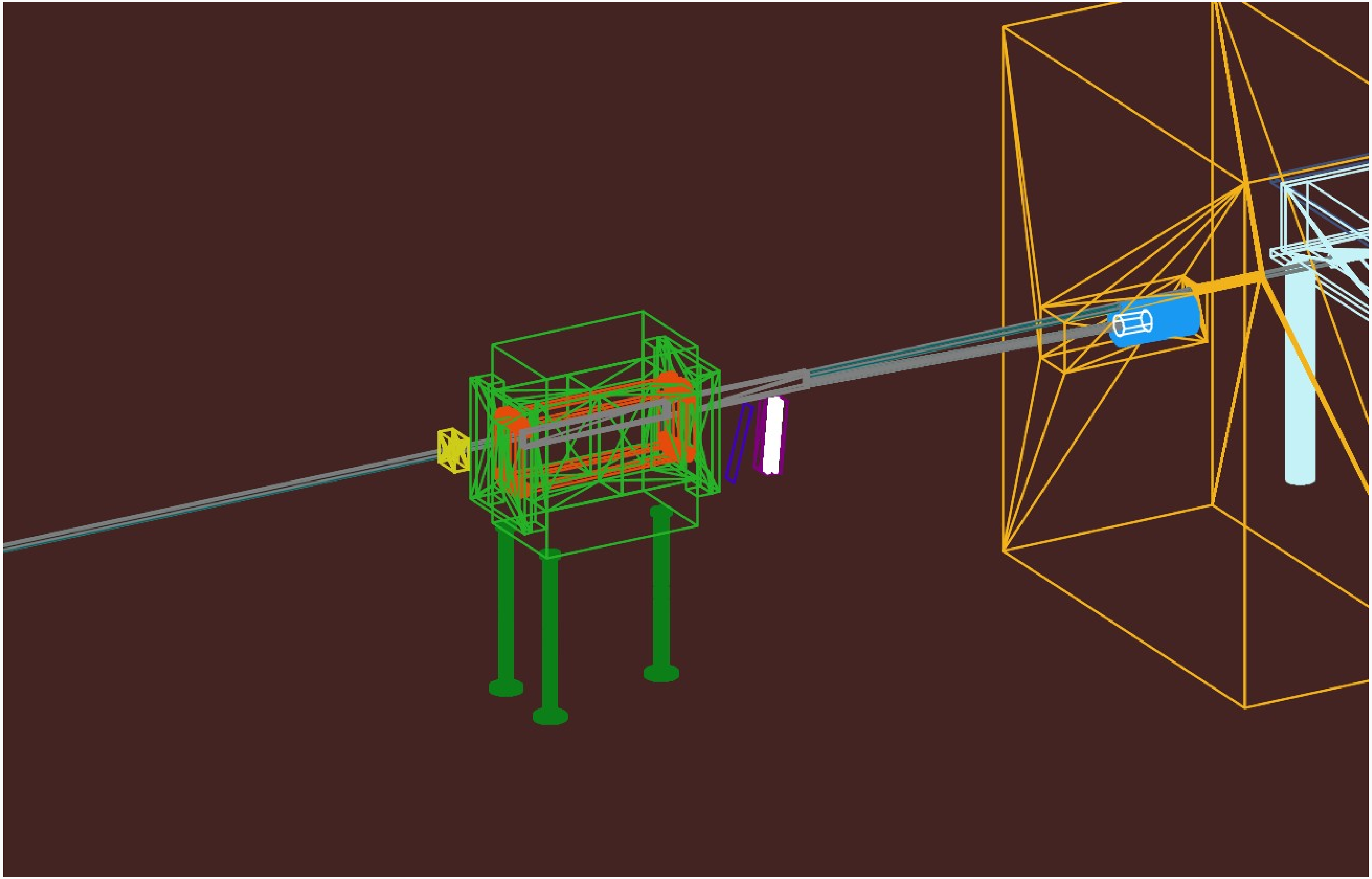
x-y (left) and z-y (right) diagrams of Cerenkov volume.

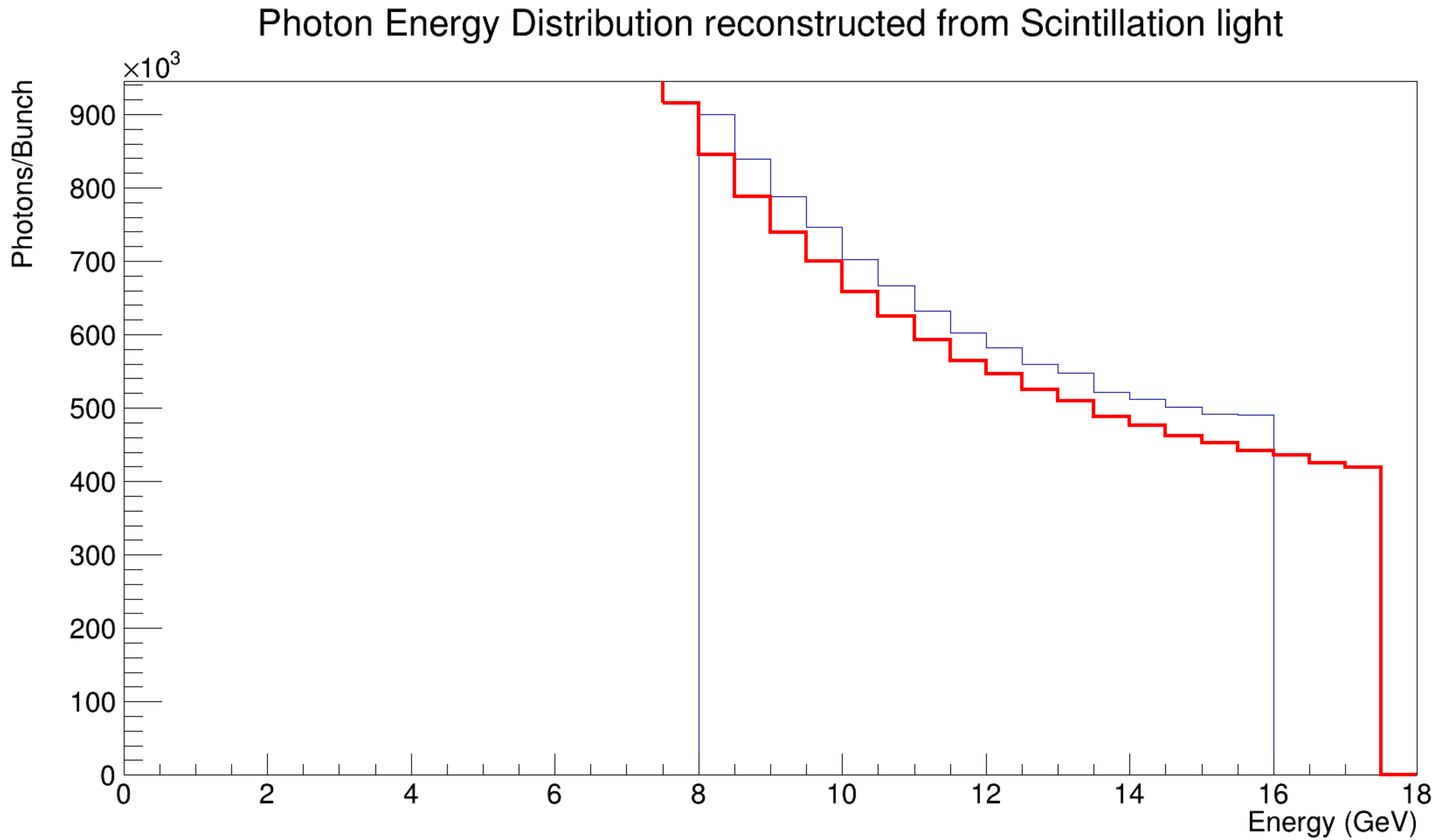
Upon rotation and placement beside beampipe, ‘x’ and ‘y’ directions interchange






```
//since Magnet / Brem detectors are rotated 90 degrees, X dimensions here (Scint/Cerenkov) map to global Y dimensions & vice versa
ScintCerenkovPhysics = false;
ScintAngle = 15. *deg;
ScintXpos = -360. *mm;
ScintZpos = DumpMagnetZpos + (1520./2. + 275.) *mm; //  defining in relation to position of the beam-dump magnet and its length
CerenkovAngle = 5. *deg;
CerenkovXpos = -350. *mm;
CerenkovZpos = DumpMagnetZpos + (1520./2. + 500.) *mm;
ScintX = 500. *mm;
ScintY = 100. *mm;
ScintZ = 1. *mm;
CerenkovWallWidth = 0.15 *mm;
CerenkovBoxThickness = 1. *mm;
CerenkovWindowThickness = 0.3 *mm;
CerenkovchannelX = 9. *mm;
CerenkovchannelY = 9. *mm;
CerenkovchannelZ = 50. *mm;
CerenkovChannels = 50;          // will crash if not even!! unfortunately..
CerenkovLegHeight = 50. *mm;
ScintMaterial = "G4_GADOLINIUM_OXYSULFIDE";
CerenkovMetal = "Aluminium";
CerenkovMedium = "HeliumGas";
```

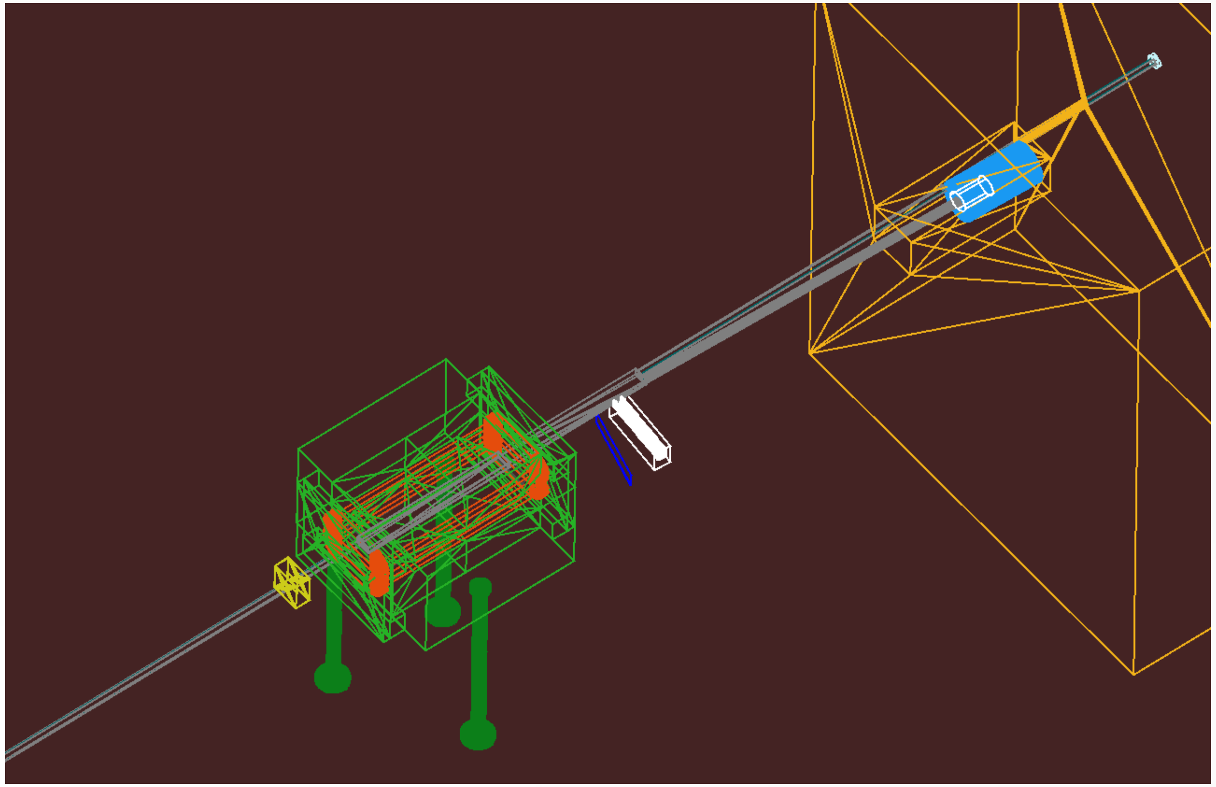




Consistent overestimate from this method?

As analysed before, ~ 10% of Brem events are more complex than $E_\gamma = E_{beam} - E_e$

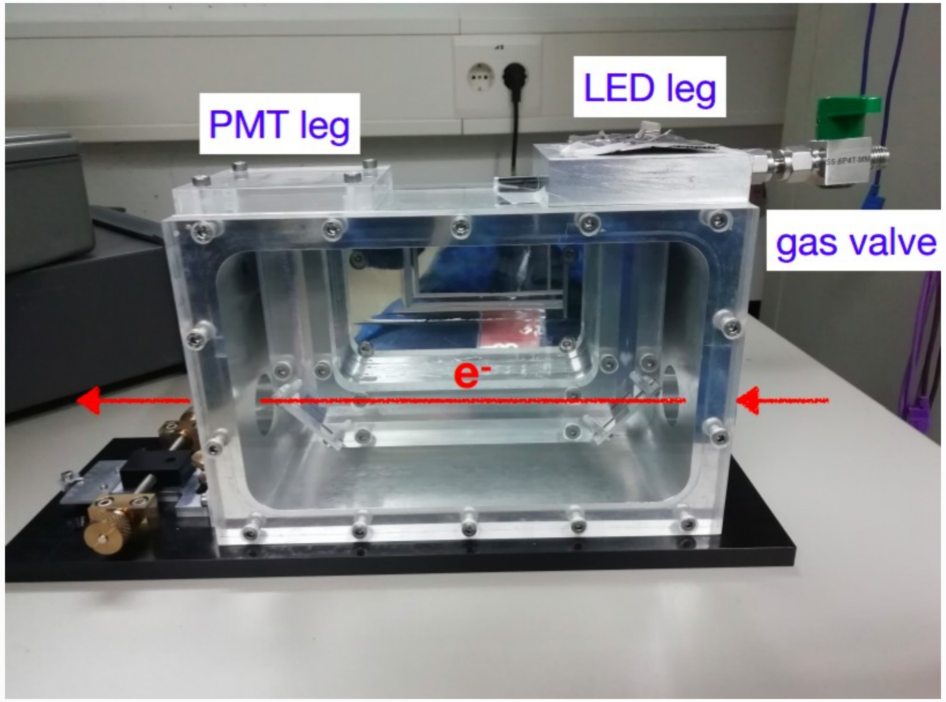
Scintillator/Cerenkov in GEANT4

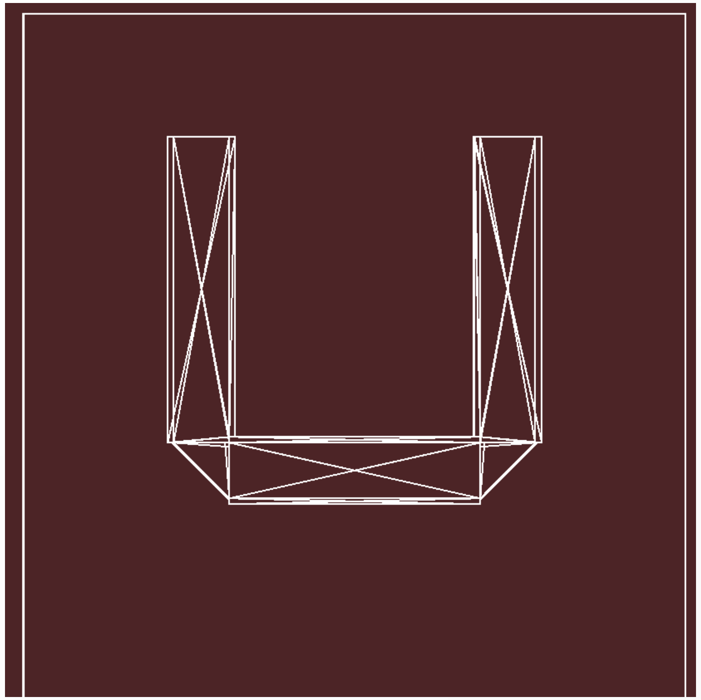


Have implemented geometries for an example simple Scintillating screen and more detailed Cerenkov Devices. Instantiated by

DetectorConstruction::ConstructScintCerenkov()

Takes key parameters from LXSetUp.cc





Scintillator/Cerenkov in GEANT4

I have set up Cerenkov and Scintillation Physics which can be turned on or off, and collect data for histograms (HistoManager) in SteppingAction.

These processes slow down simulation but should not affect validity of background simulation at IP.

Will push a version with these detectors to lxsim git stash (new branch) with physics/histograms commented out

```
ScintCerenkovPhysics = false;
ScintAngle = 15. *deg;
ScintXpos = -350. *mm;
ScintZpos = DumpMagnetZpos + (1520./2. + 300.) *mm; //  defining in relation to position of the beam-dump magnet and its length
CerenkovAngle = 5. *deg;
CerenkovXpos = -340. *mm;
CerenkovZpos = DumpMagnetZpos + (1520./2. + 500.) *mm;
ScintX = 500. *mm;
ScintY = 100. *mm;
ScintZ = 1. *mm;
CerenkovWallWidth = 0.15 *mm;
CerenkovBoxThickness = 1. *mm;
CerenkovWindowThickness = 0.3 *mm;
CerenkovchannelX = 9. *mm;
CerenkovchannelY = 9. *mm;
CerenkovchannelZ = 50. *mm;
CerenkovChannels = 50;          // will crash if not even!! unfortunately..
CerenkovLegHeight = 50. *mm;
ScintMaterial = "Polystyrene";
CerenkovMetal = "Aluminium";
CerenkovMedium = "ArgonGas";
```