FRED meeting

FRED model validation

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11/03/2020

FRED electromagnetic model

What we have implemented:

Photons → Photoelectric effect;
Compton scatter (+ doppler broading);
Pair production;
Coherent scattering;
Fluorescence event.

Electrons and positrons → Bremsstrahlung;
Positron annihilation (+ doppler broading);
Multiple scattering.

What we have to implement:

Delta rays;
Electron back-scattering.

FRED electromagnetic model

What we have implemented:

Check of the model via FRED-FLUKA comparison

Photons → Photoelectric effect;
Compton scatter (+ doppler broading);
Pair production;
Coherent scattering;
Fluorescence event.

Electrons and positrons → Bremsstrahlung;
Positron annihilation (+ doppler broading);
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What we have to implement:

Delta rays;
Electron back-scattering.

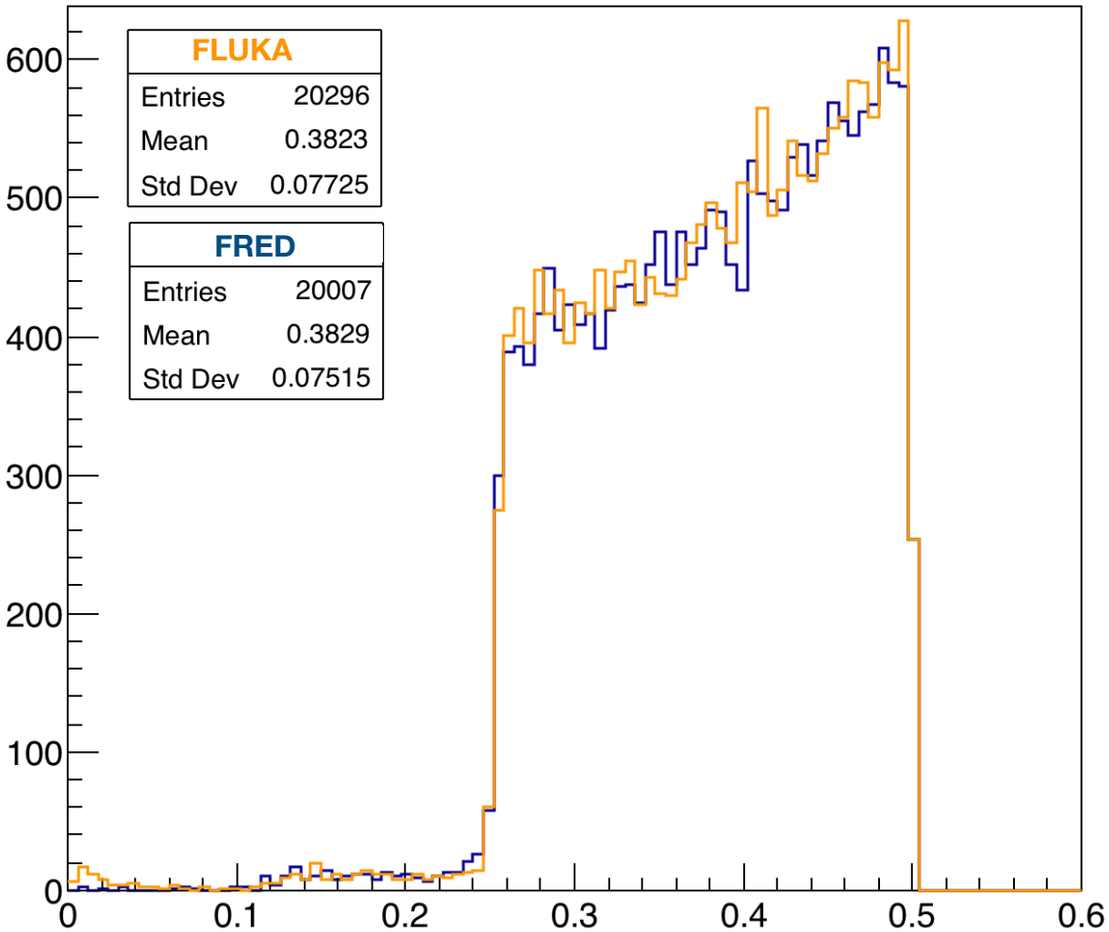
Photon transport validation - 500keV

To validate the photon transport I simulated $3*10^6$ photons impinging on a water target of [4x4x0.1] cm^3 at different energies.

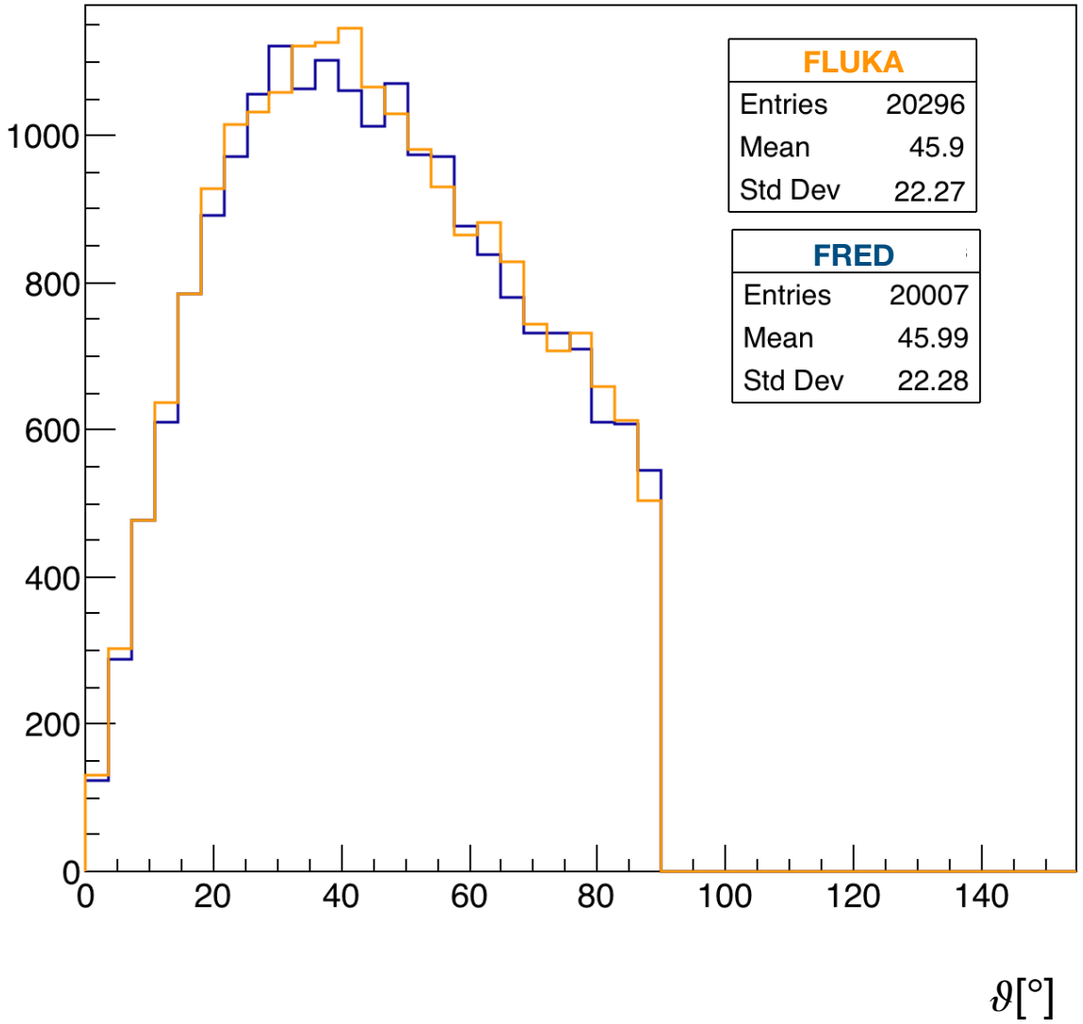
500 keV

$p_z > 0$

Kinetic energy of the outgoing photons with pz<0



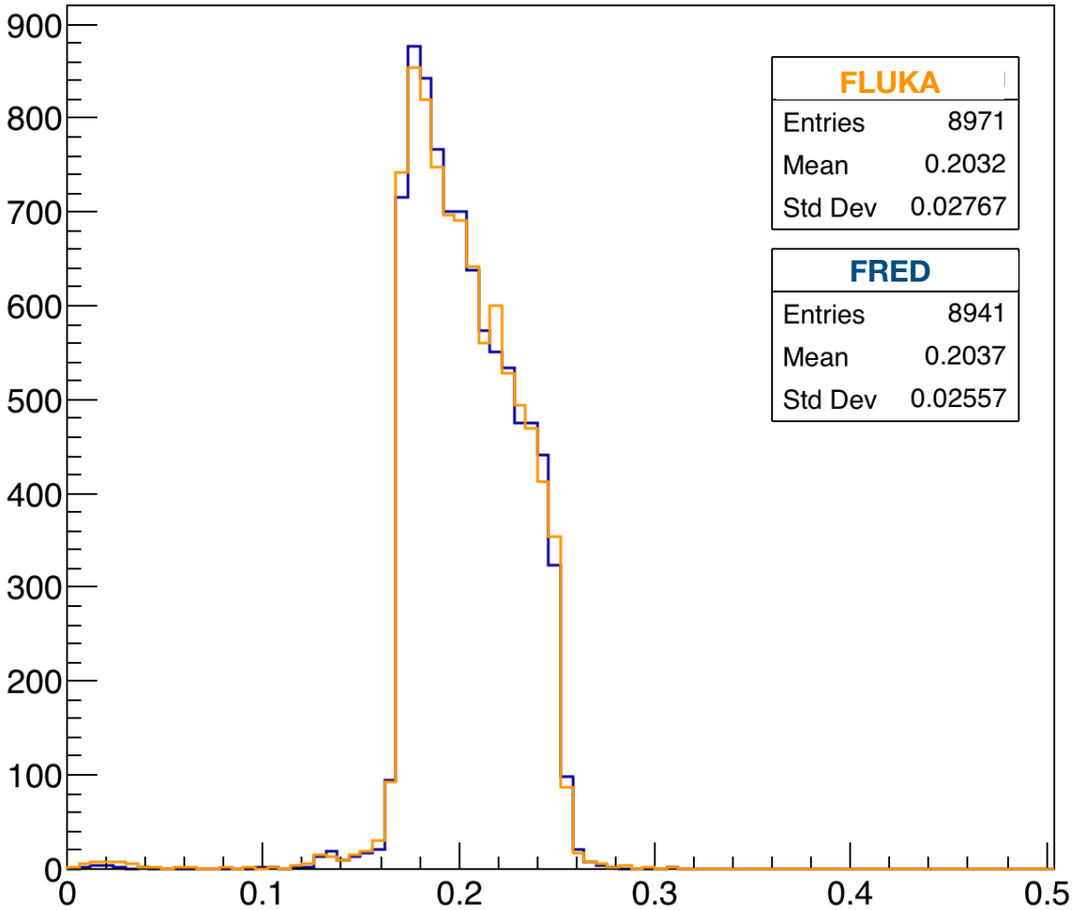
Angle of the outgoing photons with pz<0



Photon transport validation - 500keV

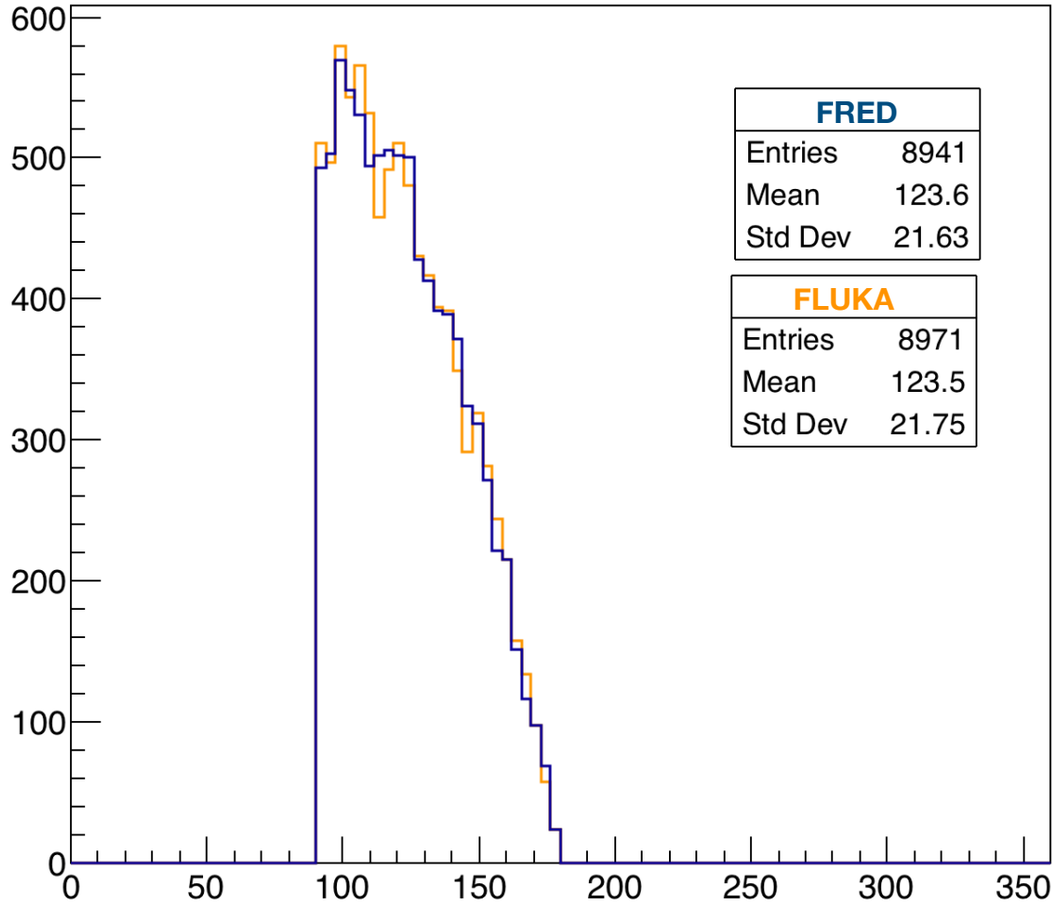
500 keV

Kinetic energy of the outgoing photons with pz<0



$p_z < 0$

Angle of the outgoing photons with pz<0



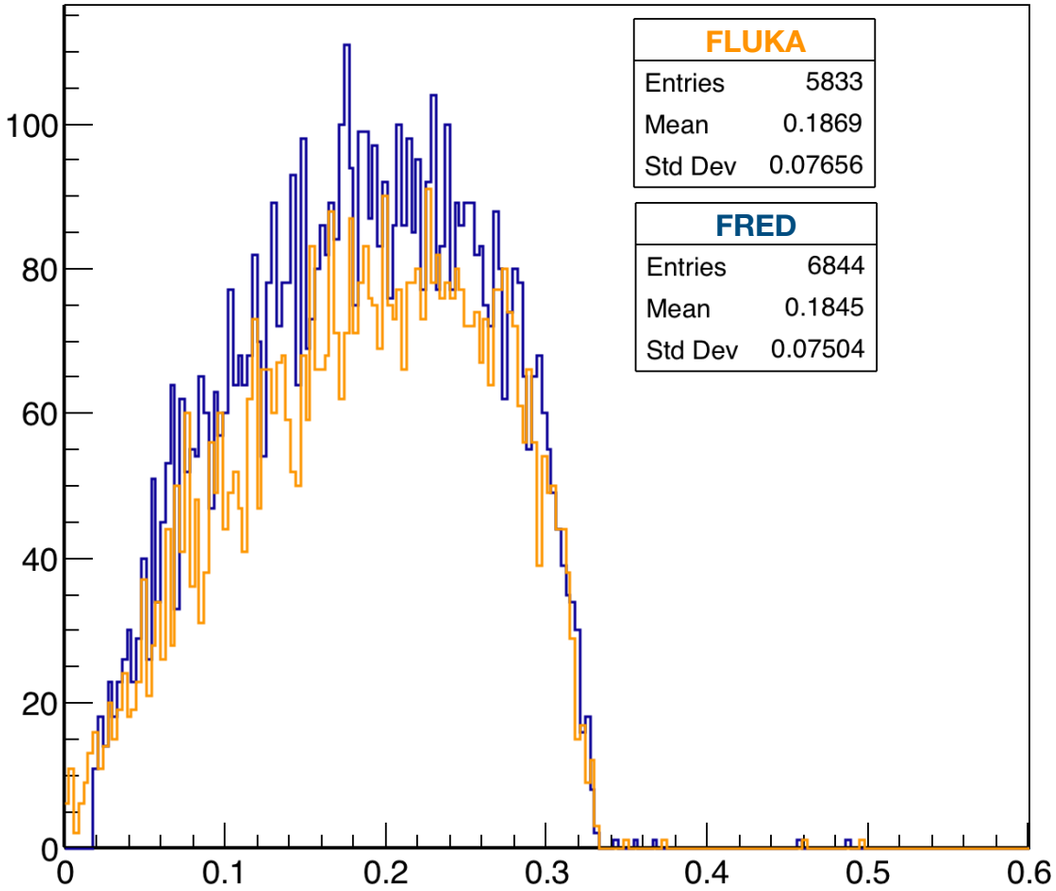
Photon transport validation - 500keV

Electrons produced inside the target -> at 500 keV the dominant process is the Compton scatter

500 keV

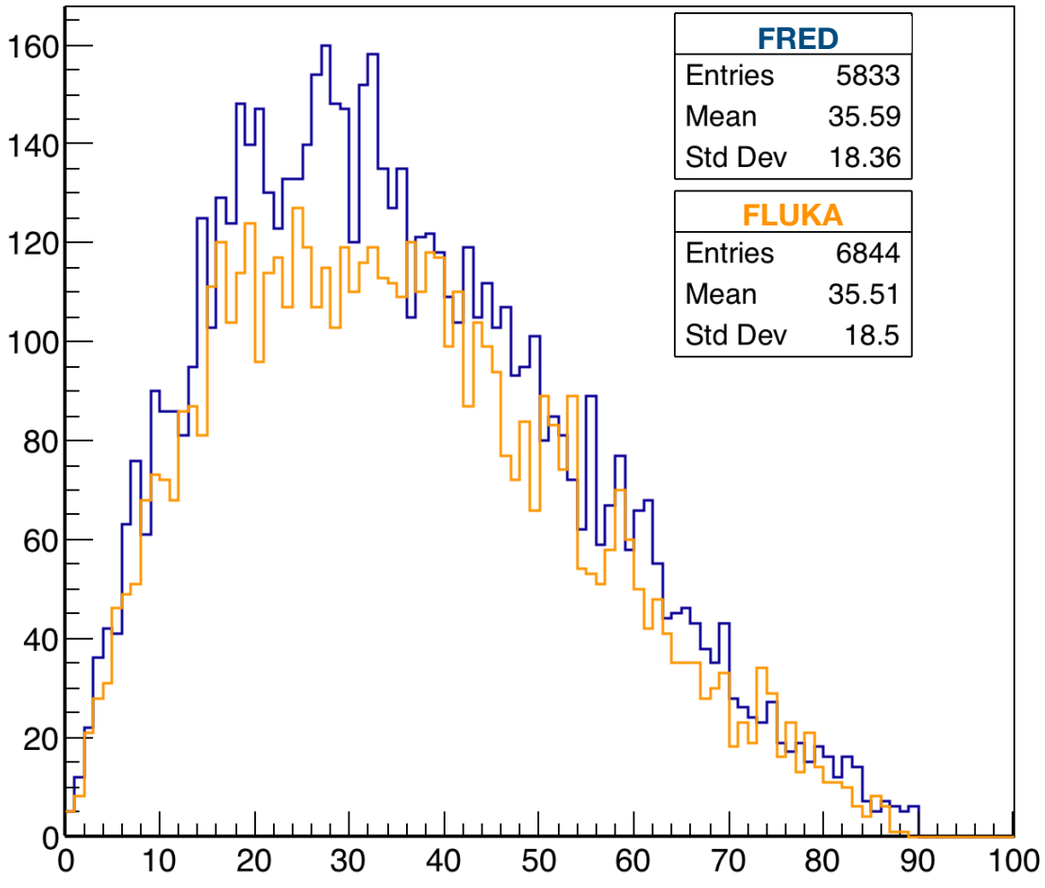
$p_z > 0$

Kinetic energy of the outgoing electrons with pz<0



E_K [MeV]

Angle of the outgoing electrons with pz<0



ϑ[°]

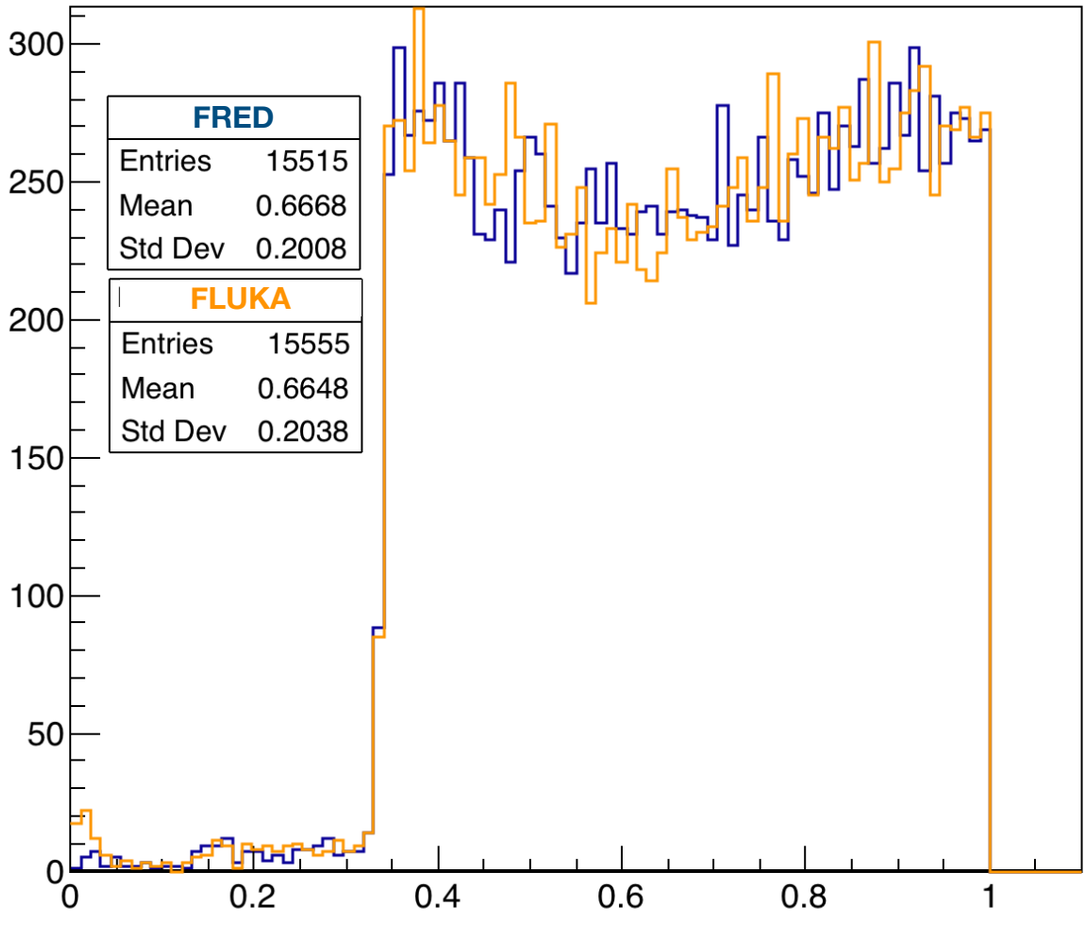
Photon transport validation - 1 MeV

To validate the photon transport I simulated 10^6 photons impinging on a water target of [4x4x0.1] cm^3 at different energies.

1 MeV

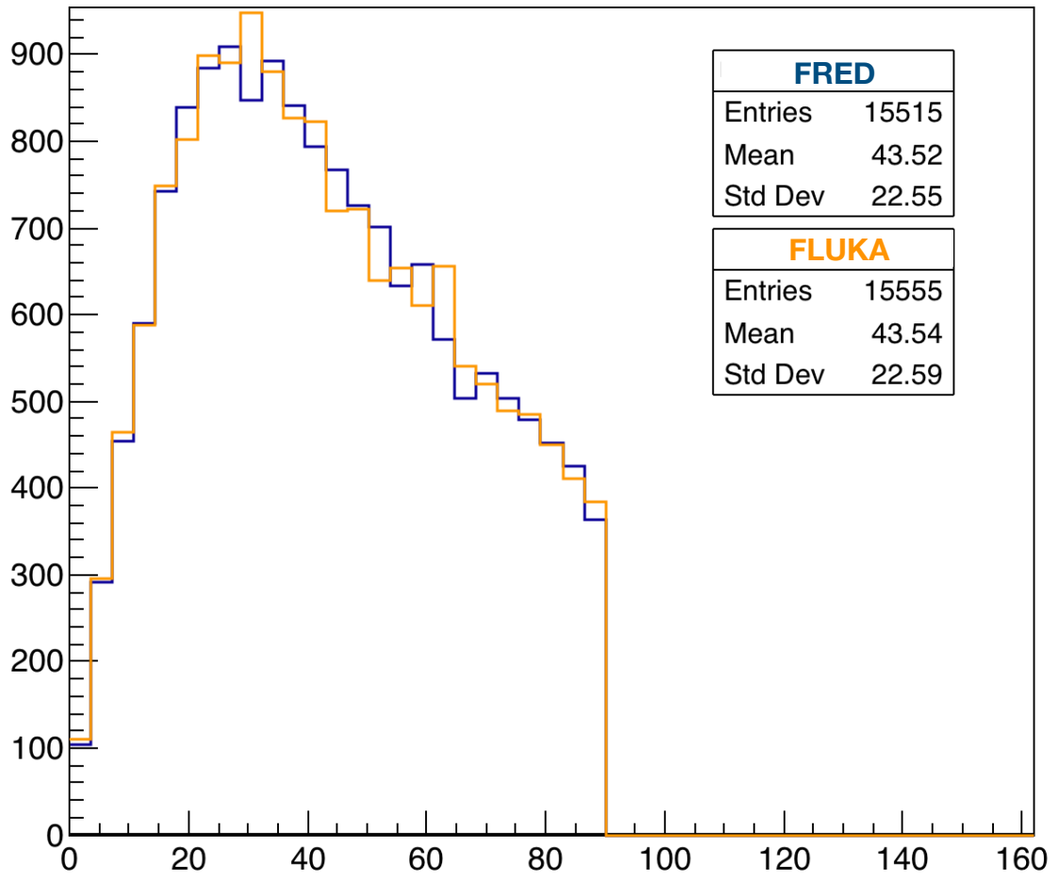
$p_z > 0$

Kinetic energy of the outgoing photons with pz<0



E_K [MeV]

Angle of the outgoing photons with pz<0



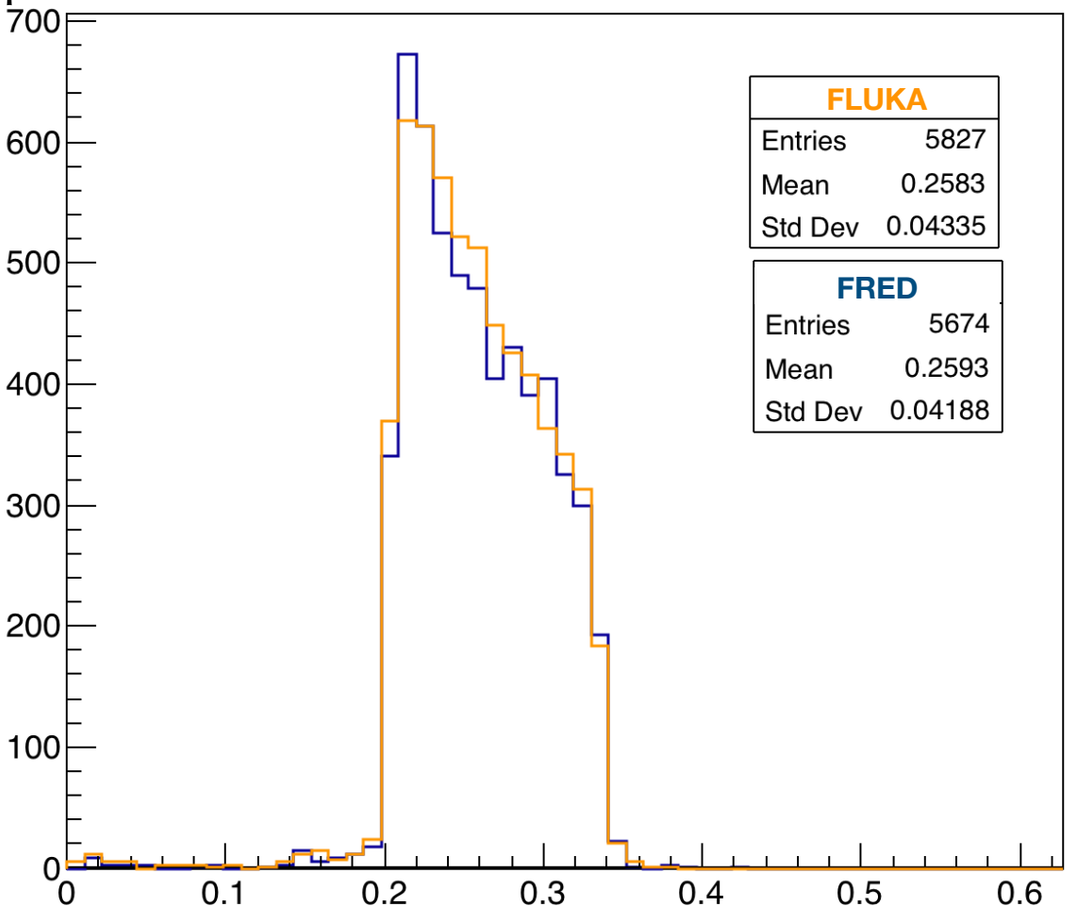
ϑ[°]

Photon transport validation - 1 MeV

1 MeV

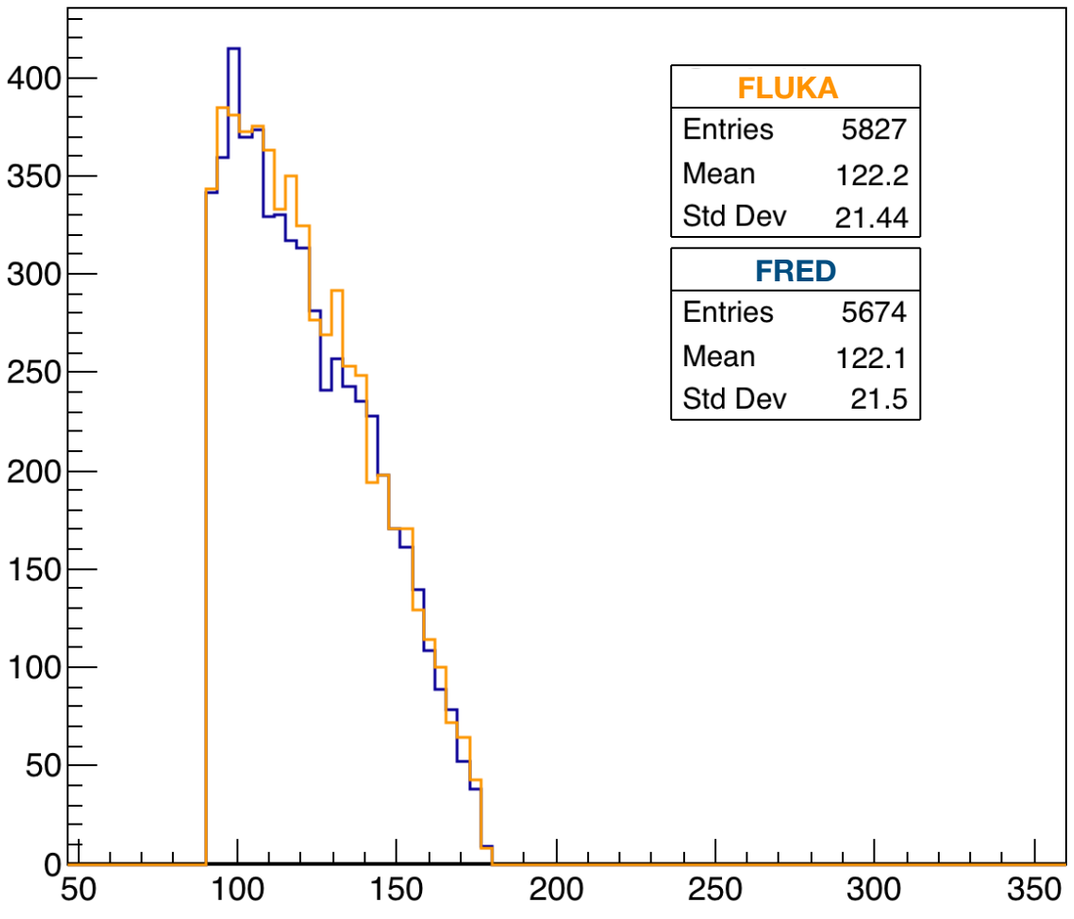
$p_z < 0$

Kinetic energy of the outgoing photons with pz<0



E_K [MeV]

Angle of the outgoing photons with pz<0



ϑ[°]

Photon transport validation - 1 MeV

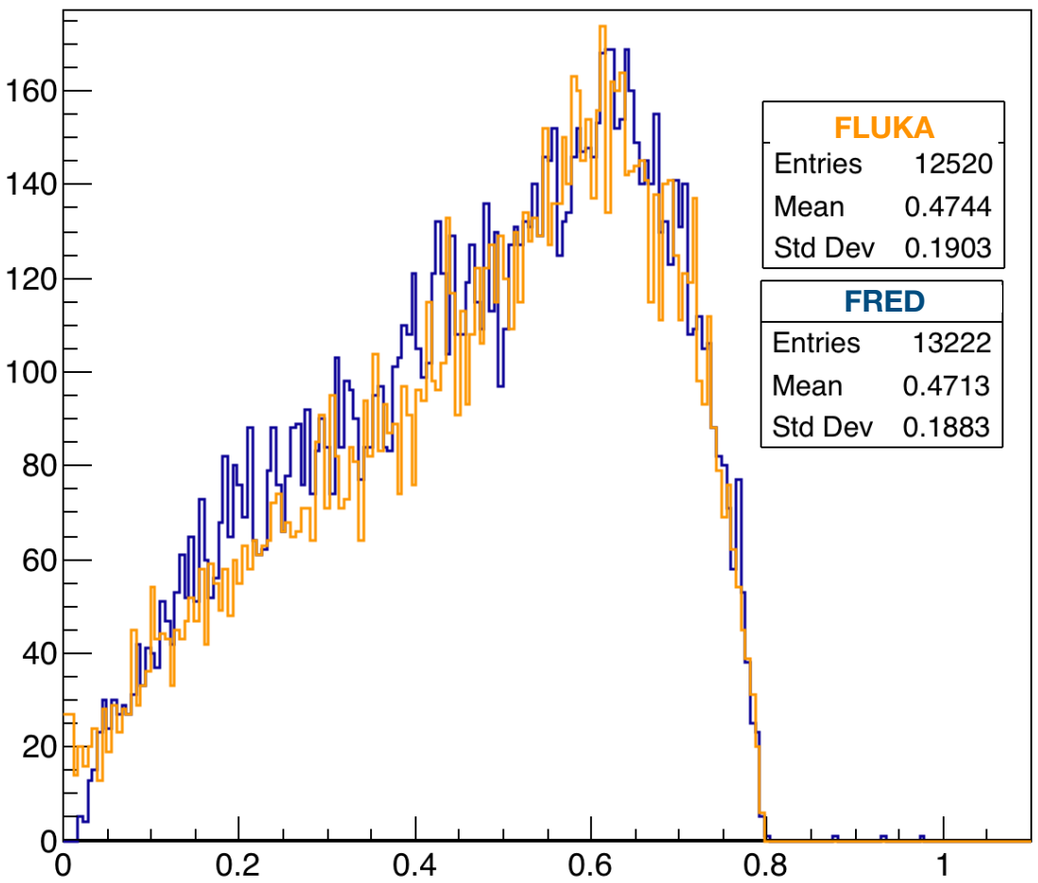
Electrons produced inside the target -> at 500 keV the dominant process is the Compton scatter

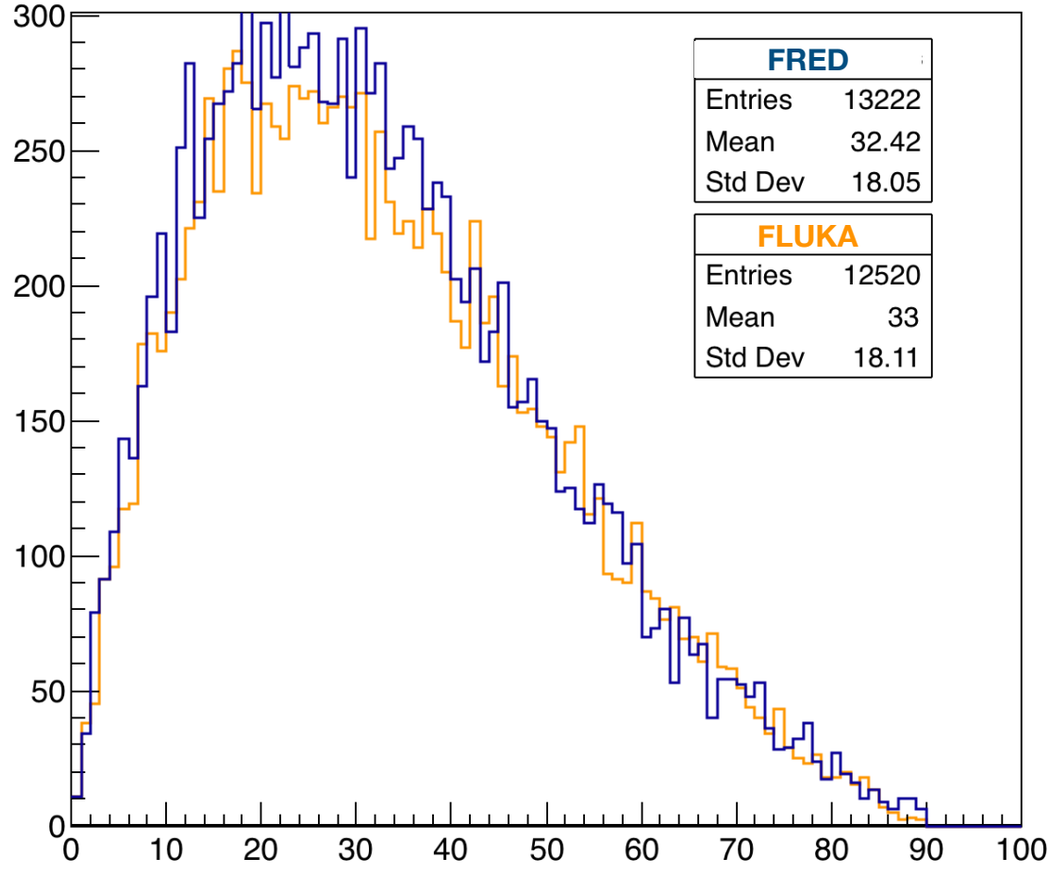
1 MeV

Kinetic energy of the outgoing electrons with pz<0

$p_z > 0$

Angle of the outgoing electrons with pz<0





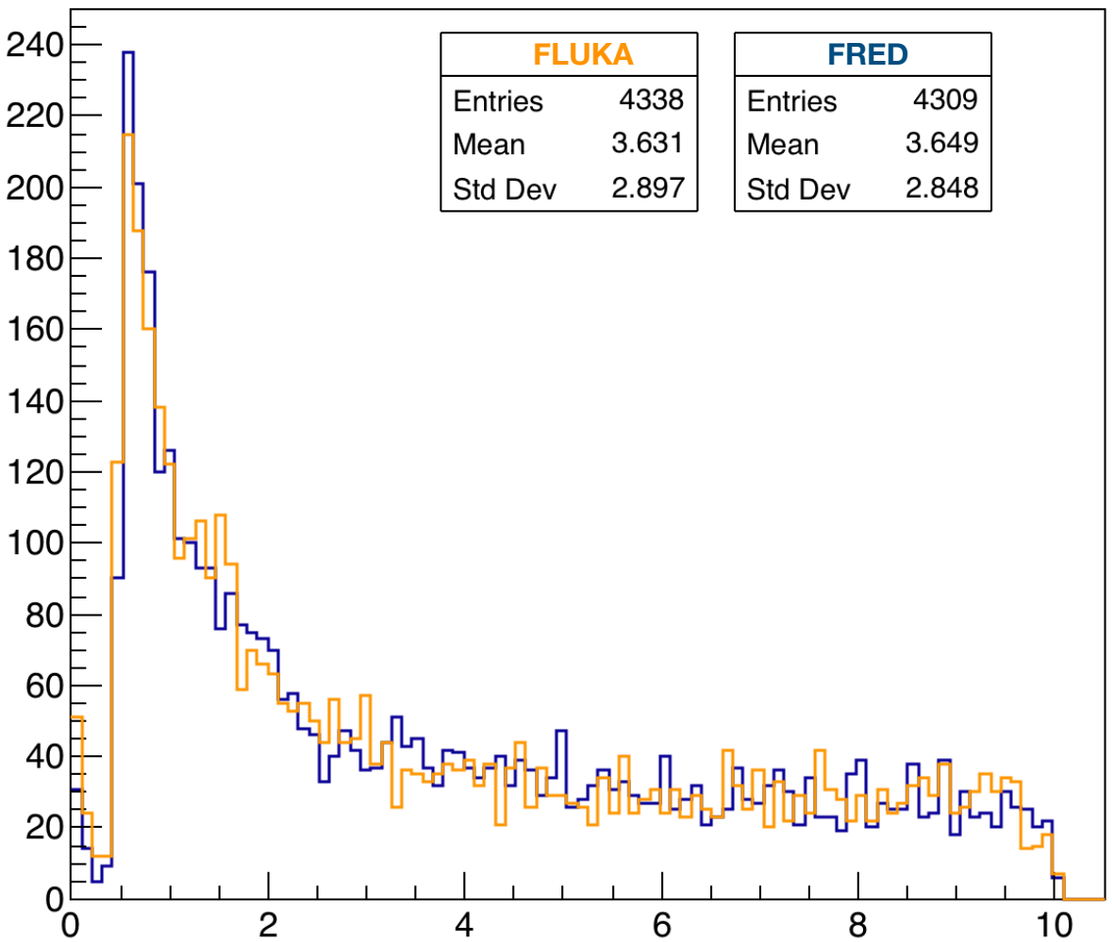
Photon transport validation - 10 MeV

To validate the photon transport I simulated 10^6 photons impinging on a water target of [4x4x0.1] cm^3 at different energies.

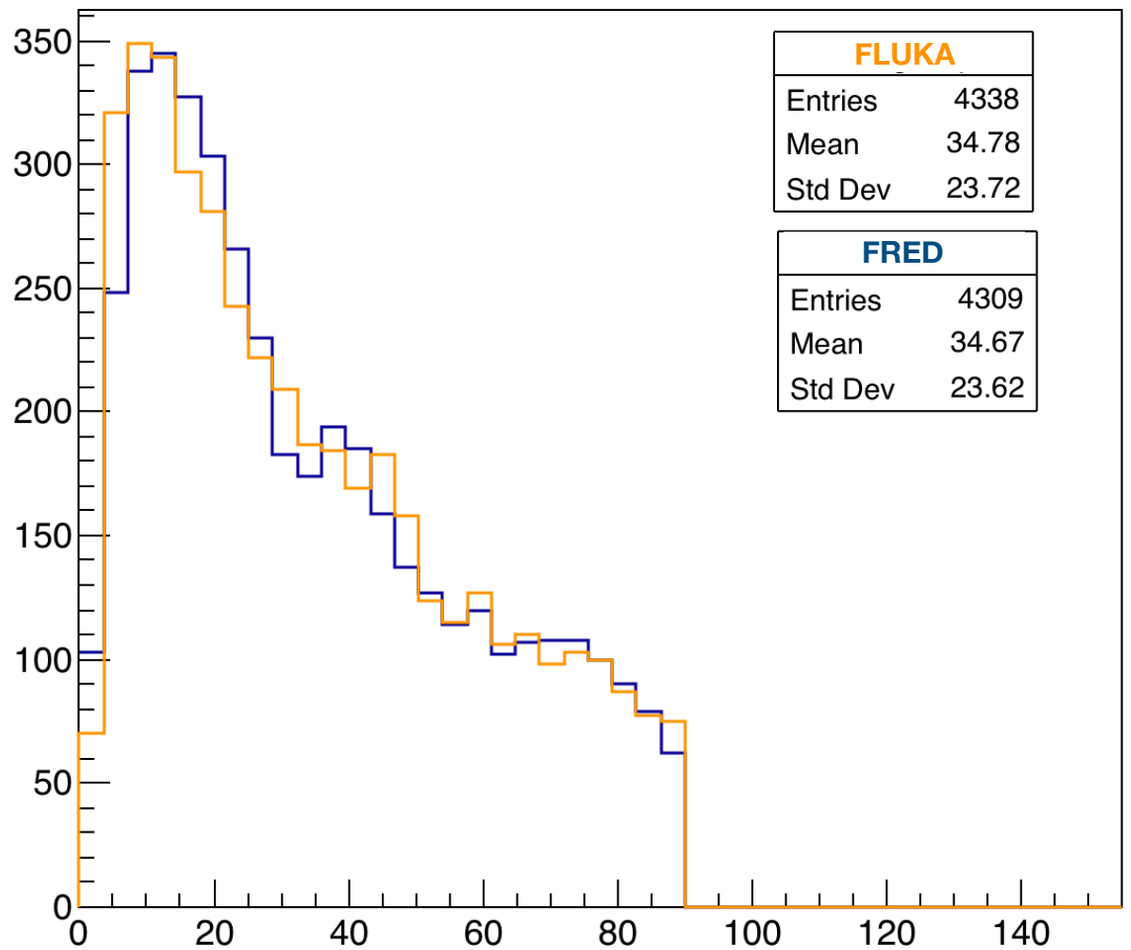
10 MeV

$p_z > 0$

Kinetic energy of the outgoing photons with pz<0



Angle of the outgoing photons with pz<0

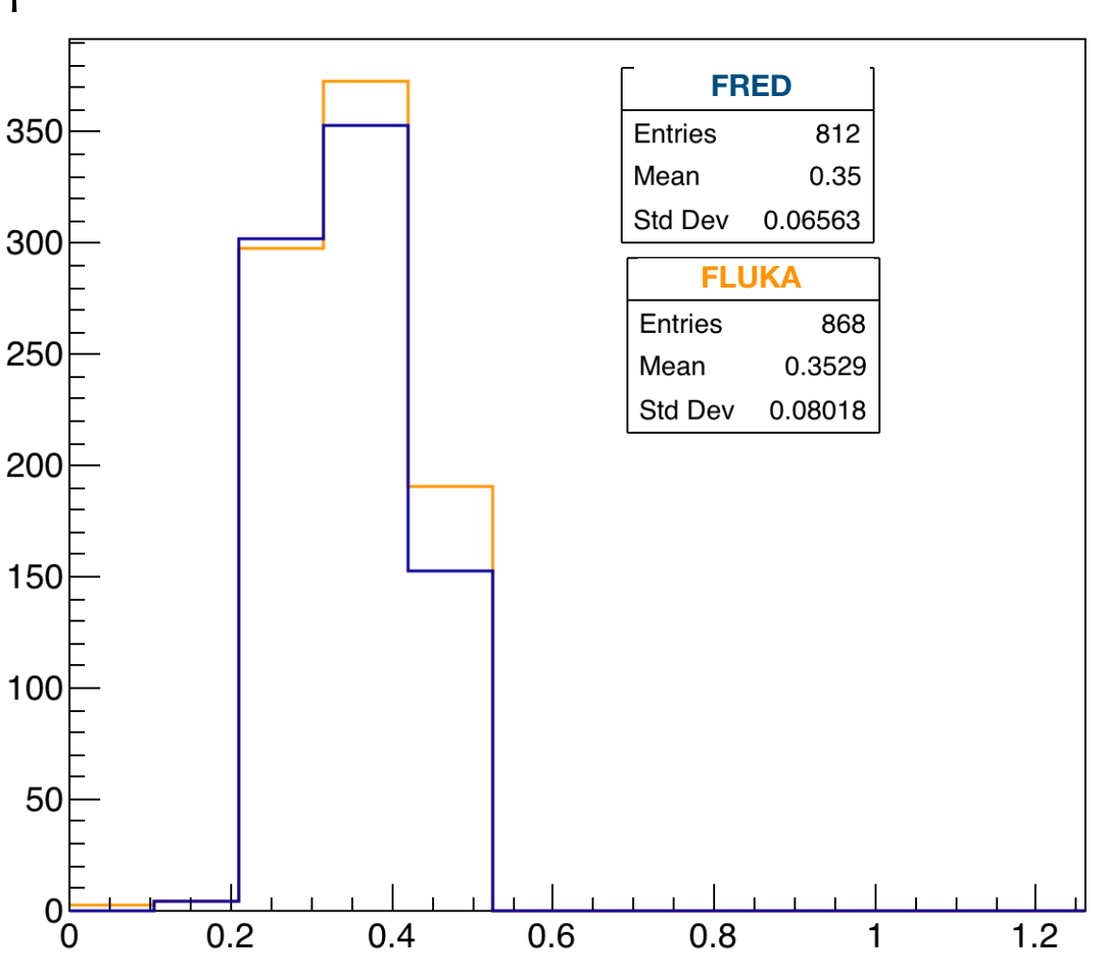


Photon transport validation - 10 MeV

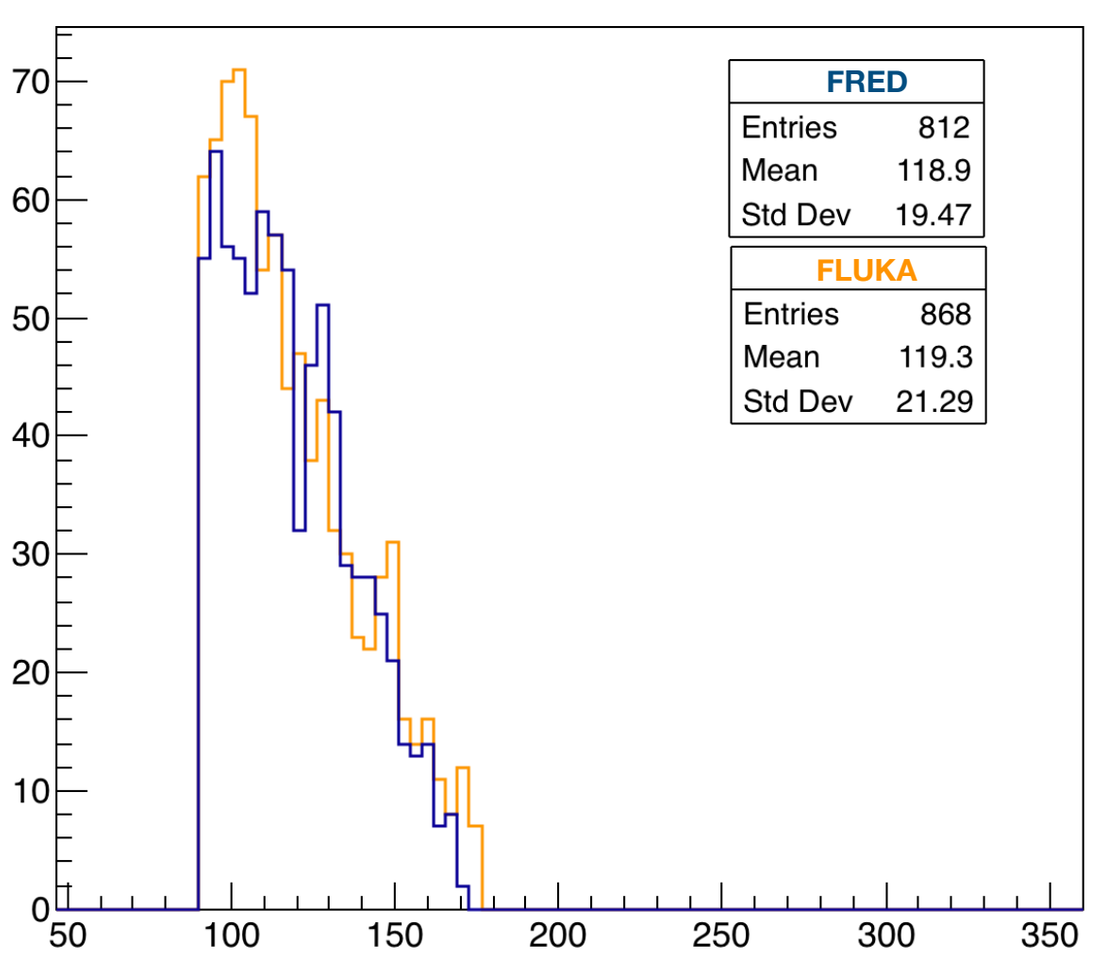
10 MeV

$p_z < 0$

Kinetic energy of the outgoing photons with pz<0



Angle of the outgoing photons with pz<0



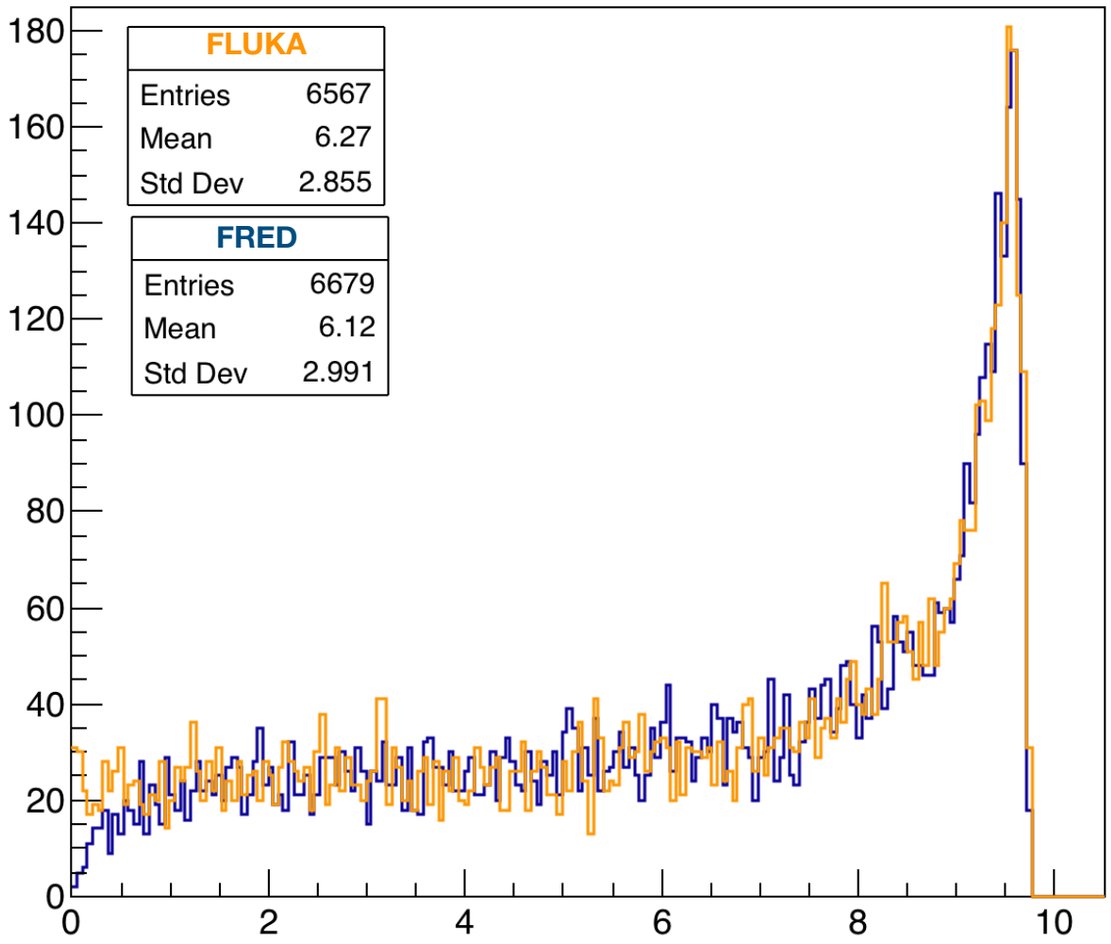
Photon transport validation - 10 MeV

Electrons produced inside the target -> at 500 keV the dominant process is the Pair production

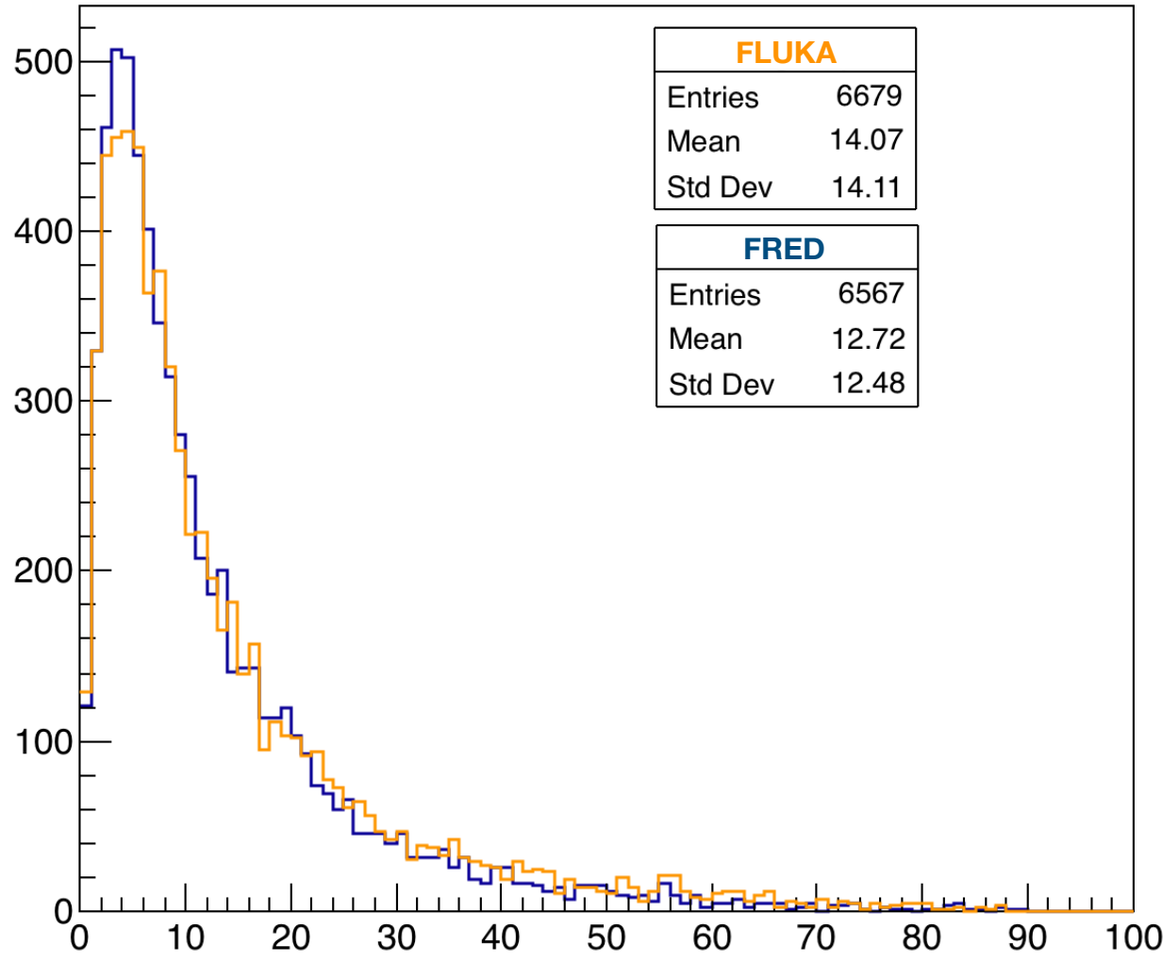
10 MeV

$p_z > 0$

Kinetic energy of the outgoing electrons with pz<0

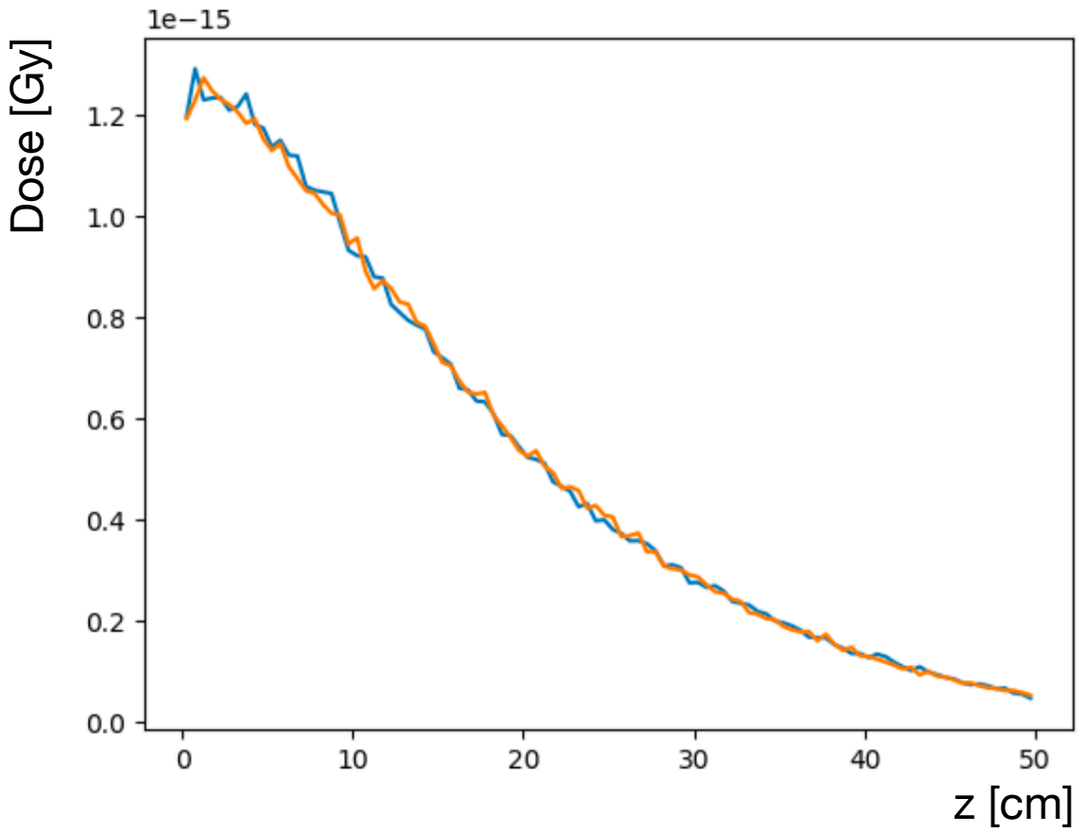


Angle of the outgoing electrons with pz<0



Photon dose

500 keV



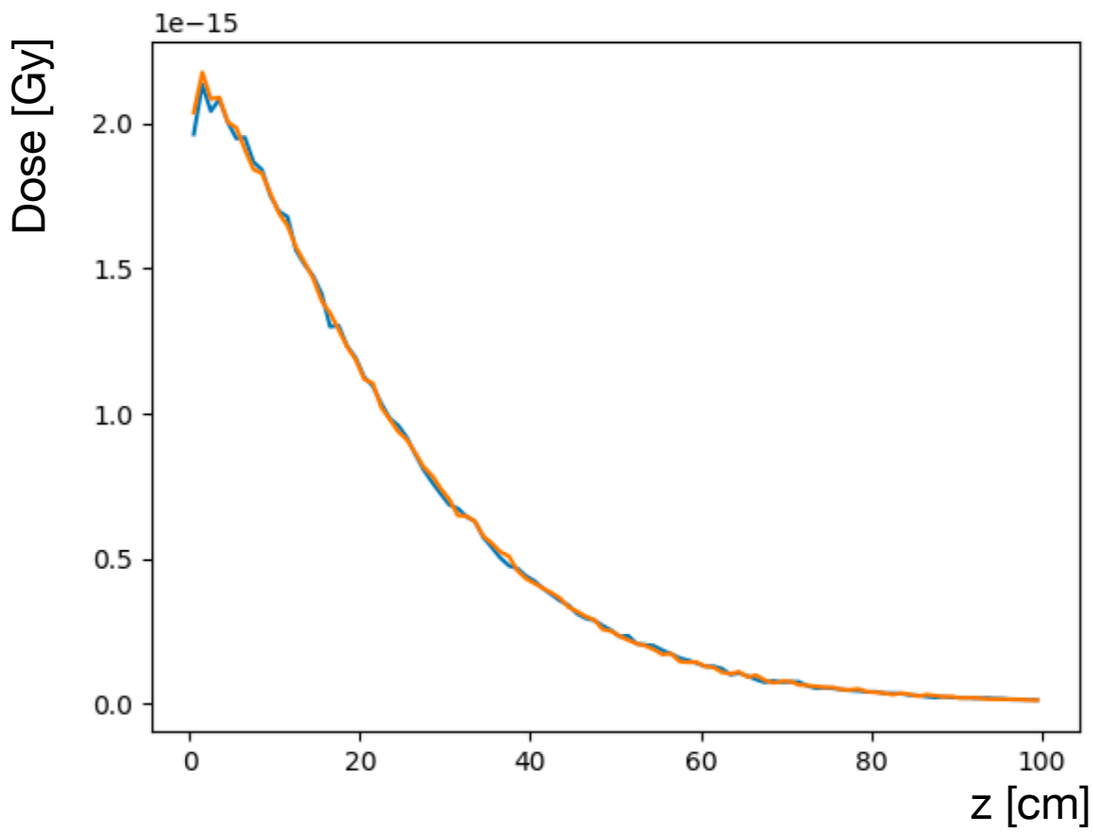
Target [50x50x50] cm^3

FRED → sum: 5.134594e-14 Gy

FLUKA → sum: 5.1326533e-14Gy

δ = 0.038 %

1 MeV



Target [50x50x100] cm^3

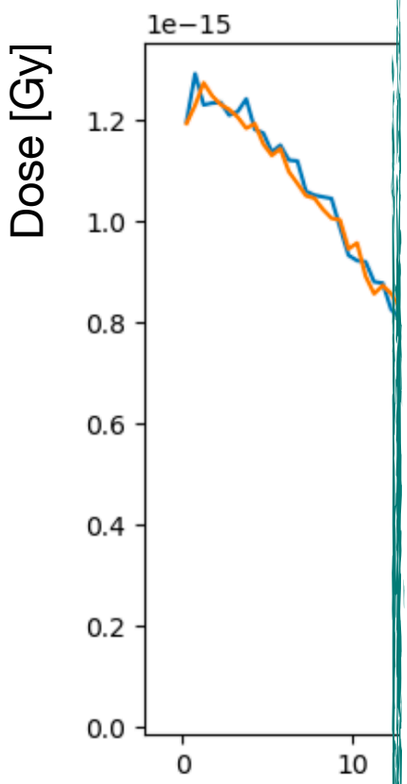
FRED → sum: 5.5958564e-14 Gy

FLUKA → sum: 5.6091355e-14Gy

δ = 0.23 %

Photon dose

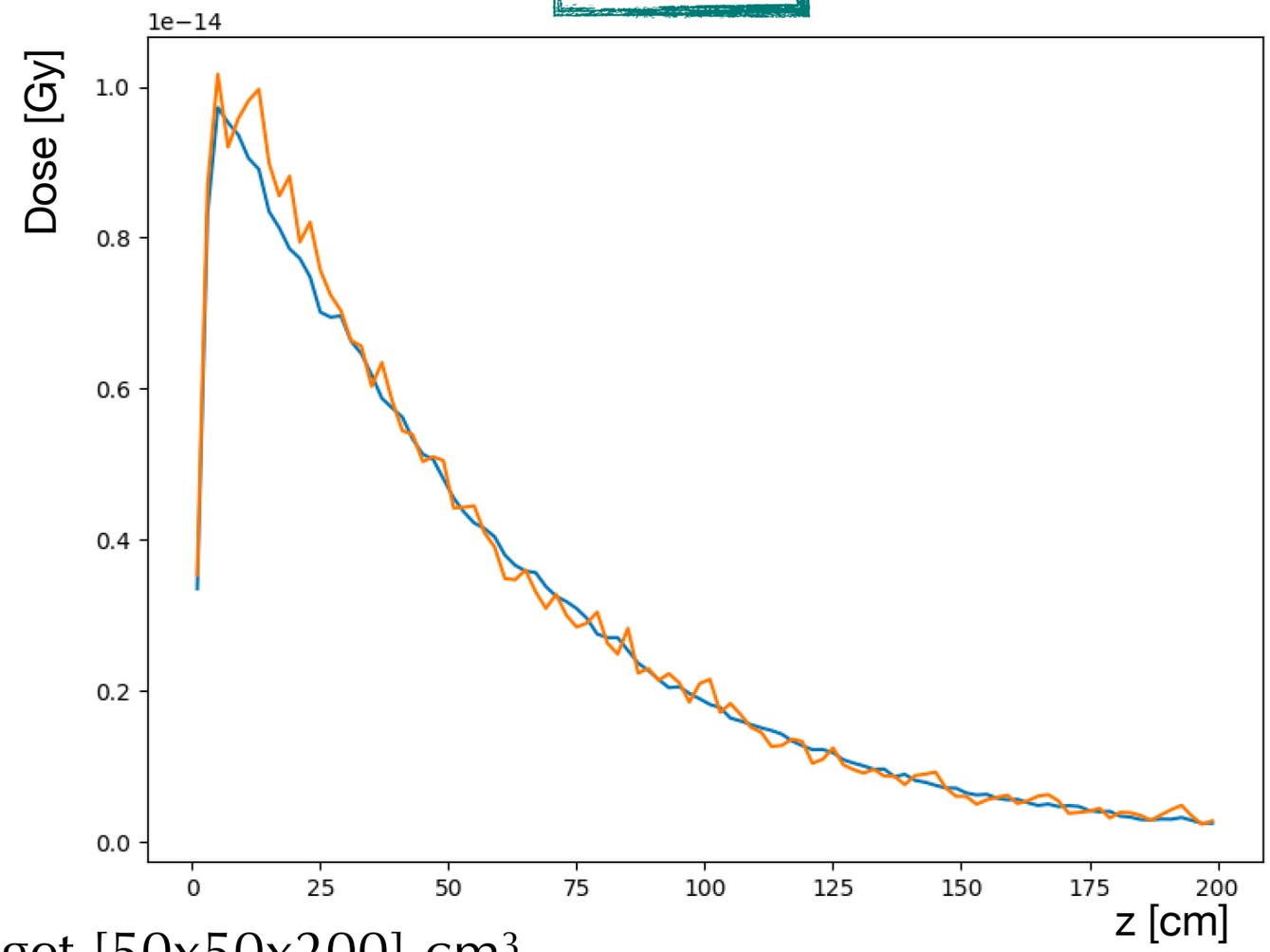
10 MeV



Target [50x

FRED → su

FLUKA →

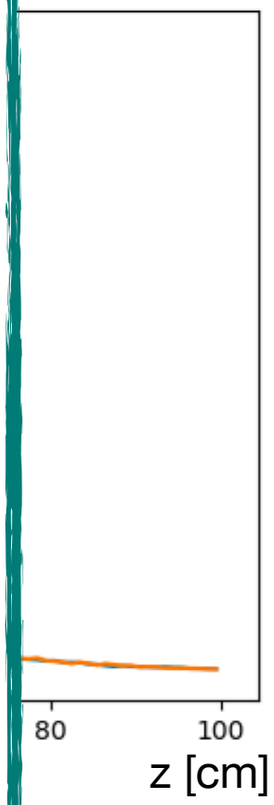


Target [50x50x200] cm³

FRED → sum: 2.9297333e-13 Gy

FLUKA → sum: 2.9929367e-13Gy

δ = 2.11 %



4 Gy

-14Gy

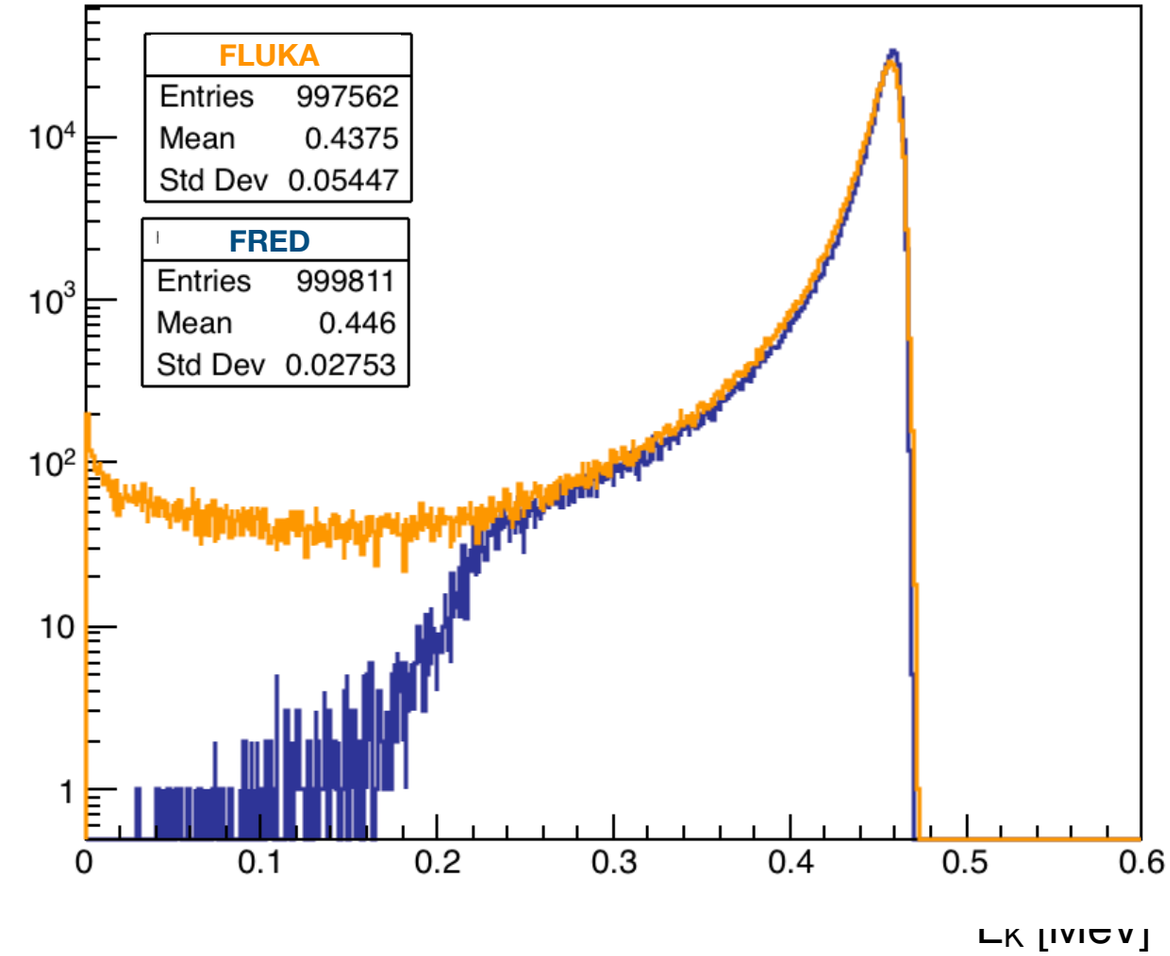
Electron transport validation - 500 keV

To validate the photon transport I simulated 10^6 electrons impinging on a water target of [4x4x0.025] cm^3 at different energies.

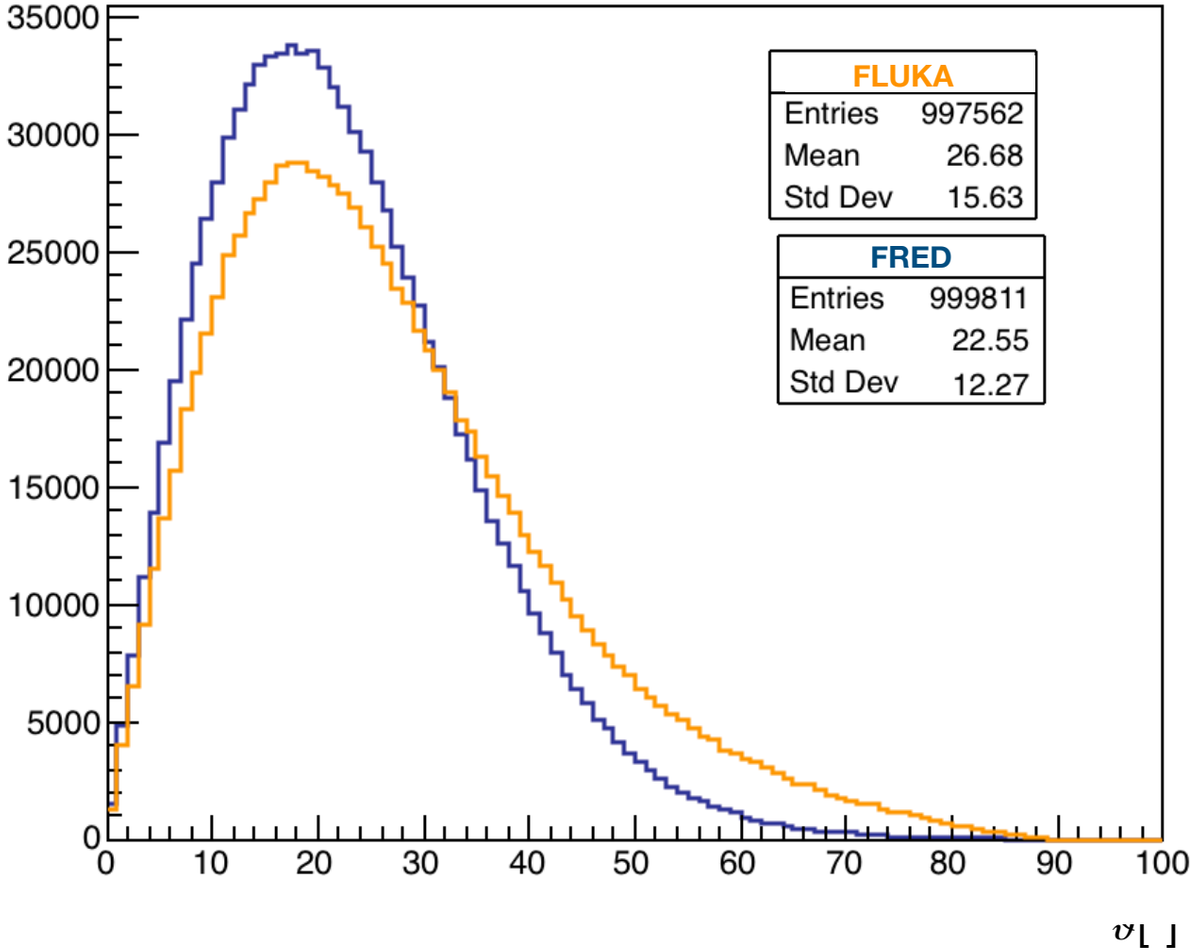
500 keV

$p_z > 0$

Kinetic energy of the outgoing electrons with pz>0



Angle of the outgoing electrons with pz>0



Electron transport validation - 500 keV

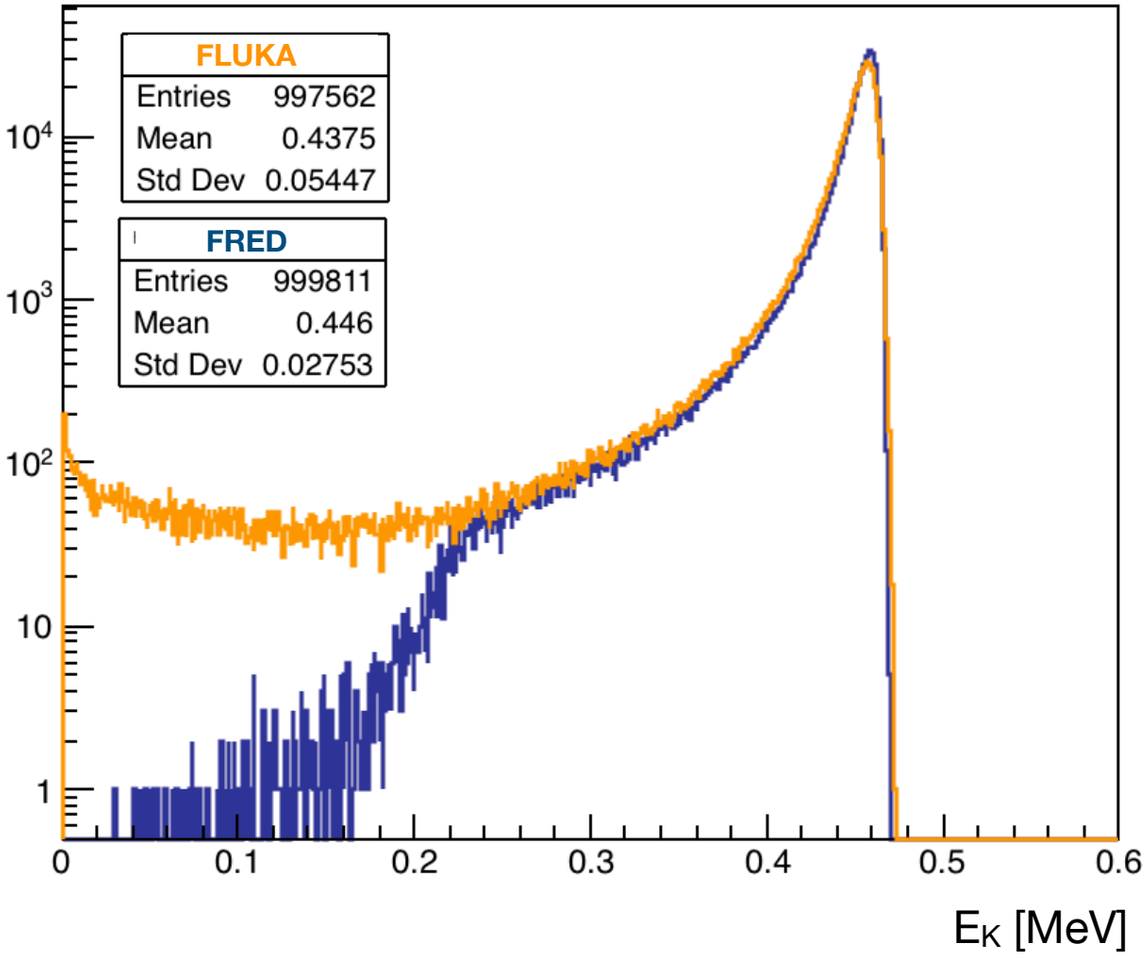
To validate the photon transport I simulated 10^6 electr et of [4x4x0.025] cm^3 at different energies.

No electrons back scattering implementation
E ($p_z < 0$), $\vartheta(p_z < 0)$ missing

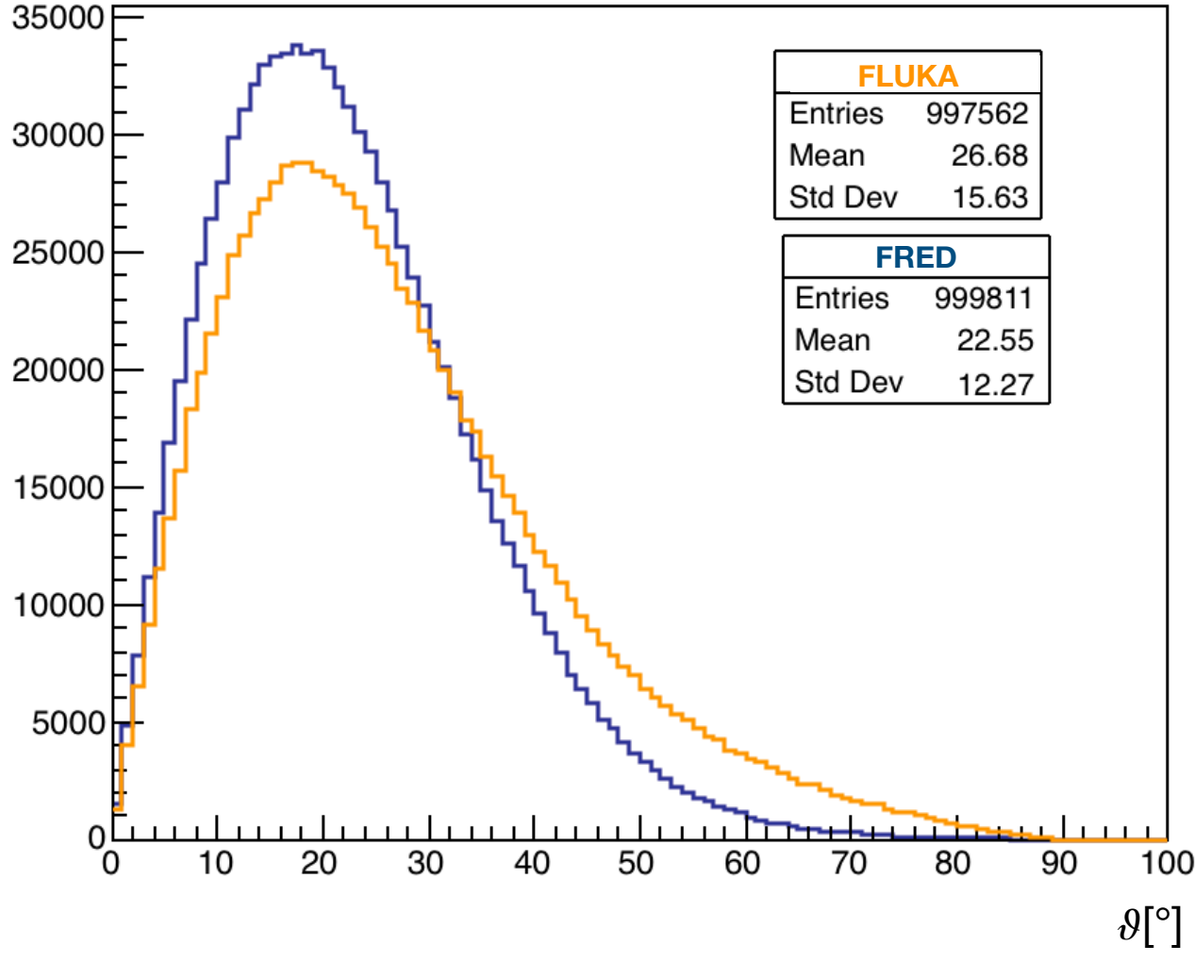
500 keV

$p_z > 0$

Kinetic energy of the outgoing electrons with pz>0



Angle of the outgoing electrons with pz>0

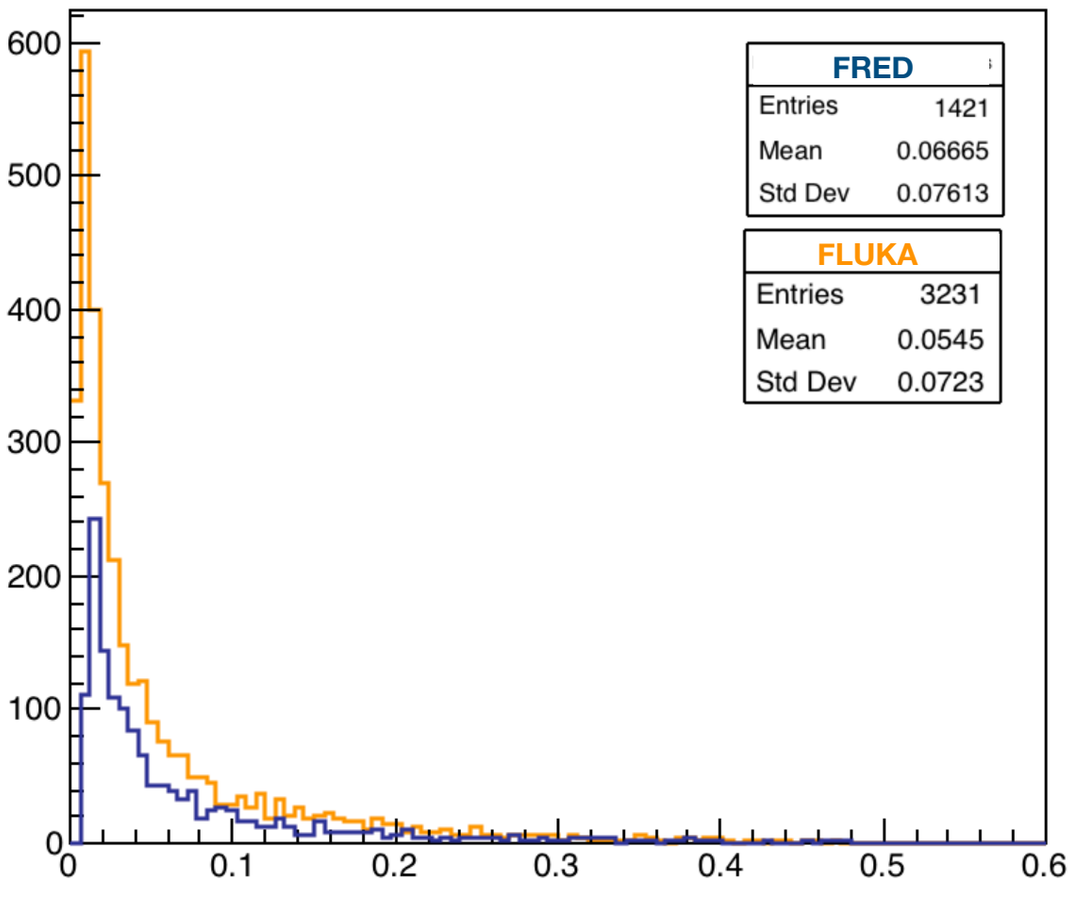


Electron transport validation - 500 keV

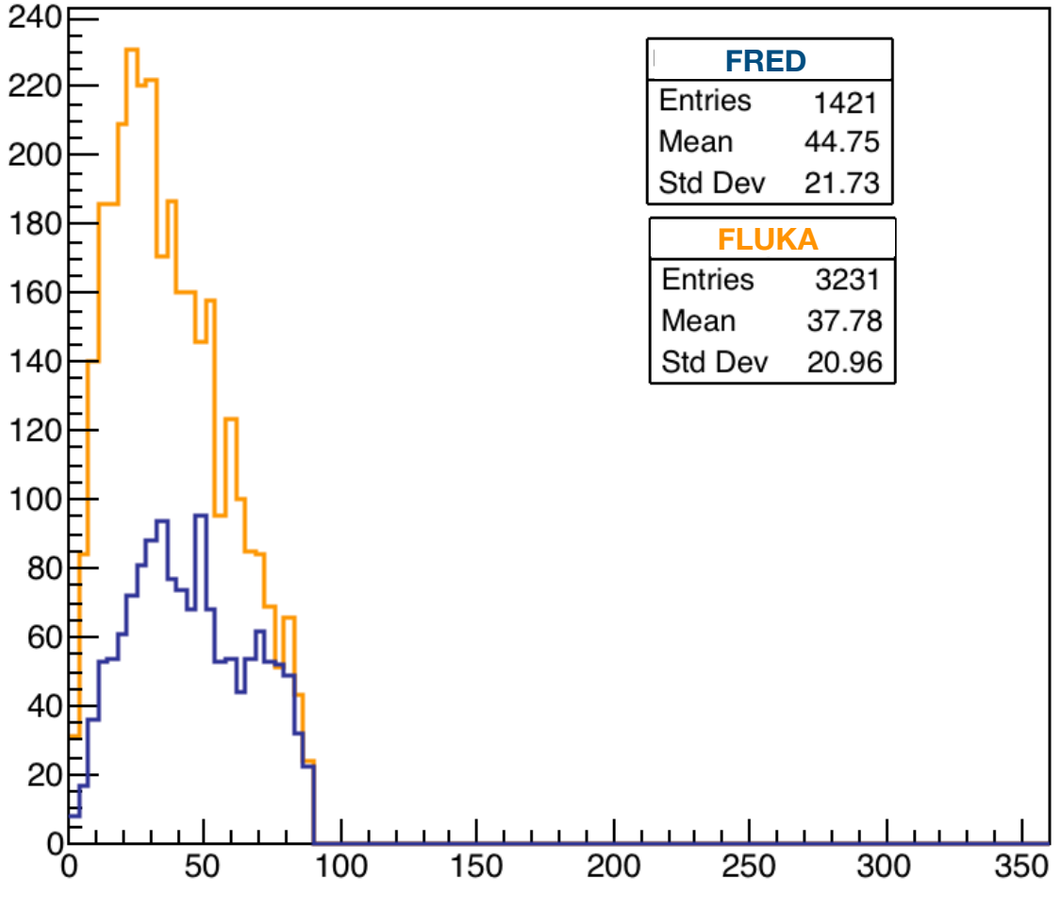
500 keV

$p_z > 0$

Kinetic energy of the outgoing photons with pz>0



Angle of the outgoing photons with pz>0

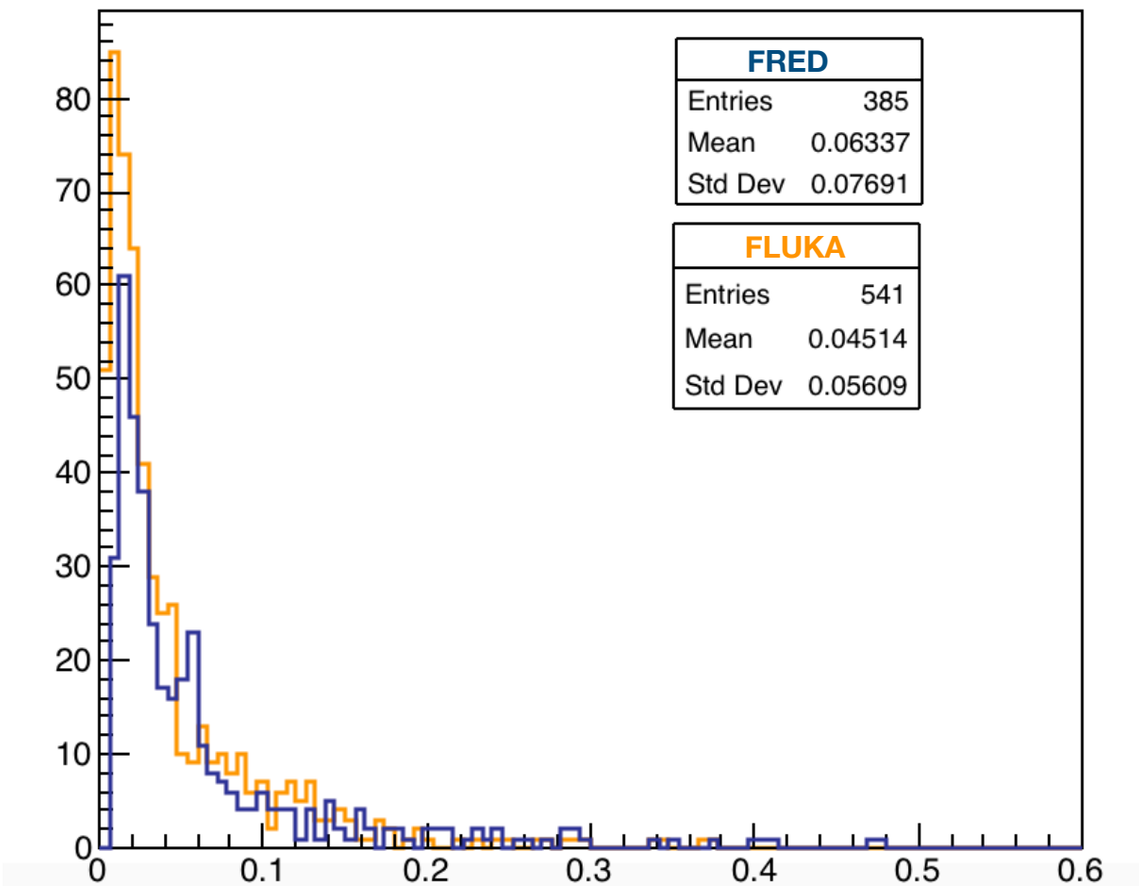


Electron transport validation - 500 keV

500 keV

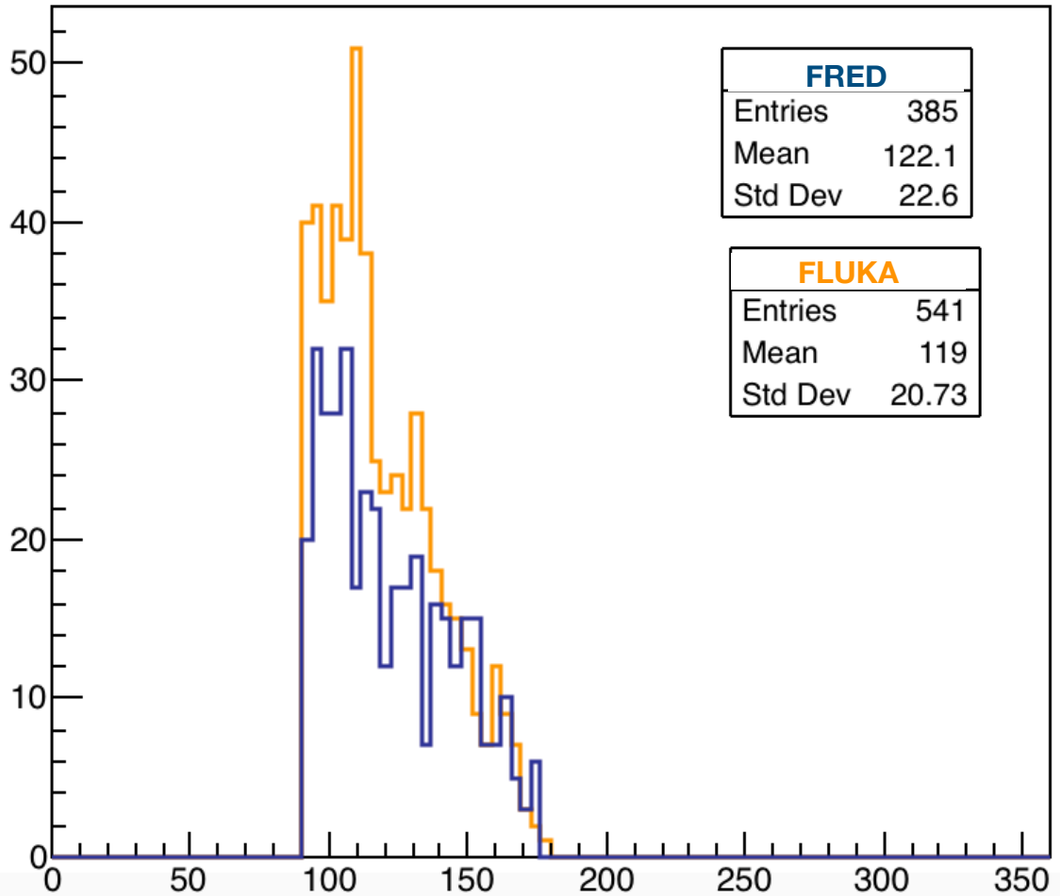
$p_z < 0$

Kinetic energy of the outgoing photons with pz>0



E_K [MeV]

Angle of the outgoing photons with pz>0



ϑ[°]

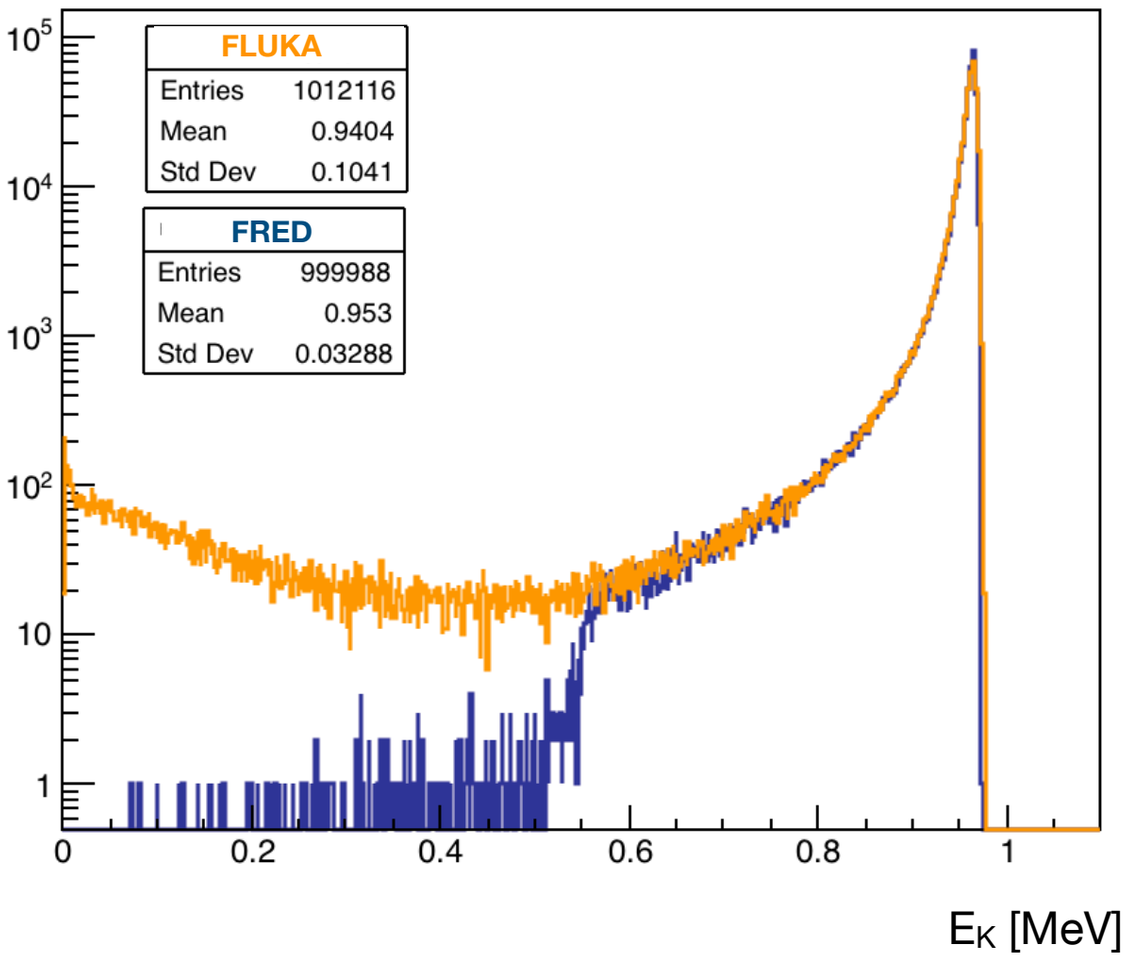
Electron transport validation

To validate the photon transport I simulated 10^6 electrons impinging on a water target of [4x4x0.025] cm^3 at different energies.

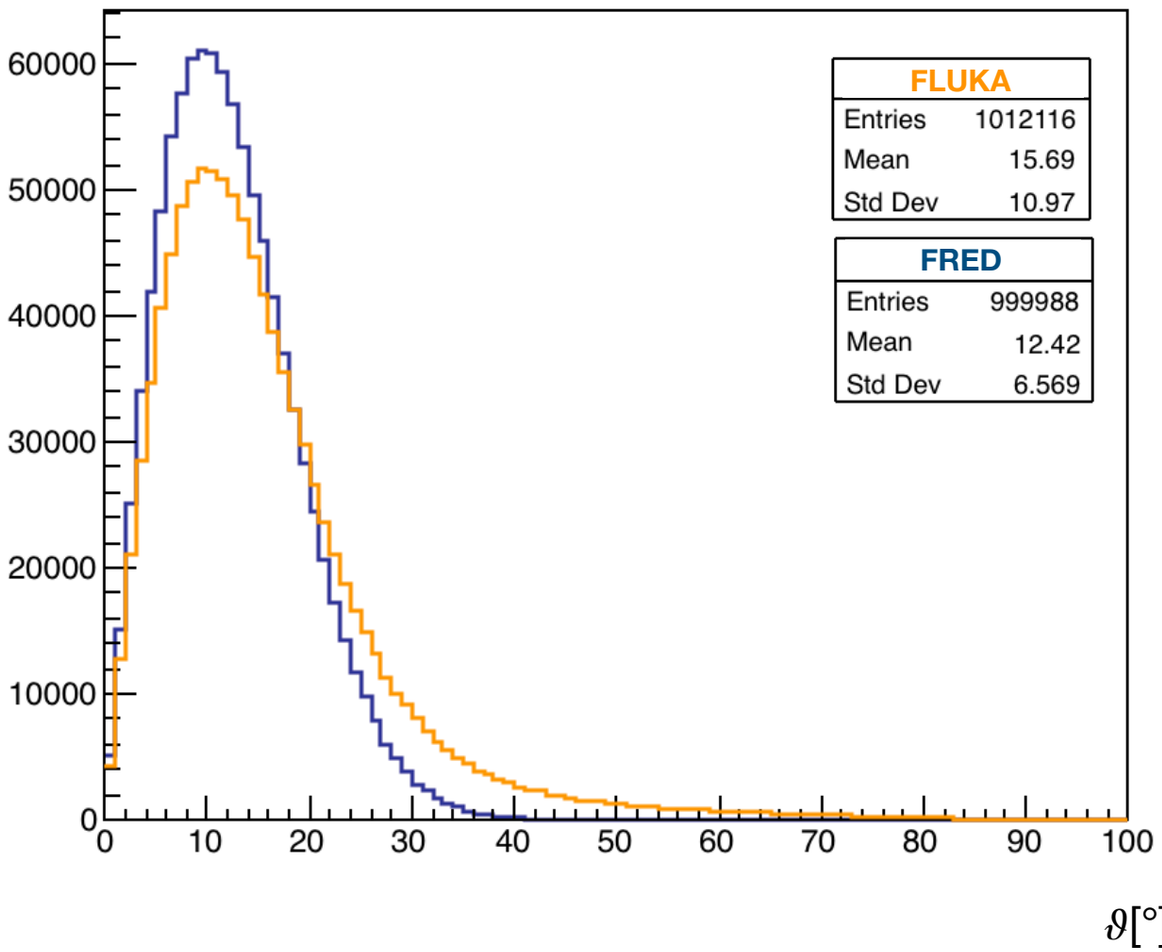
1 MeV

$p_z > 0$

Kinetic energy of the outgoing electrons with pz>0



Angle of the outgoing electrons with pz>0



Electron transport validation - 1 MeV

1 MeV

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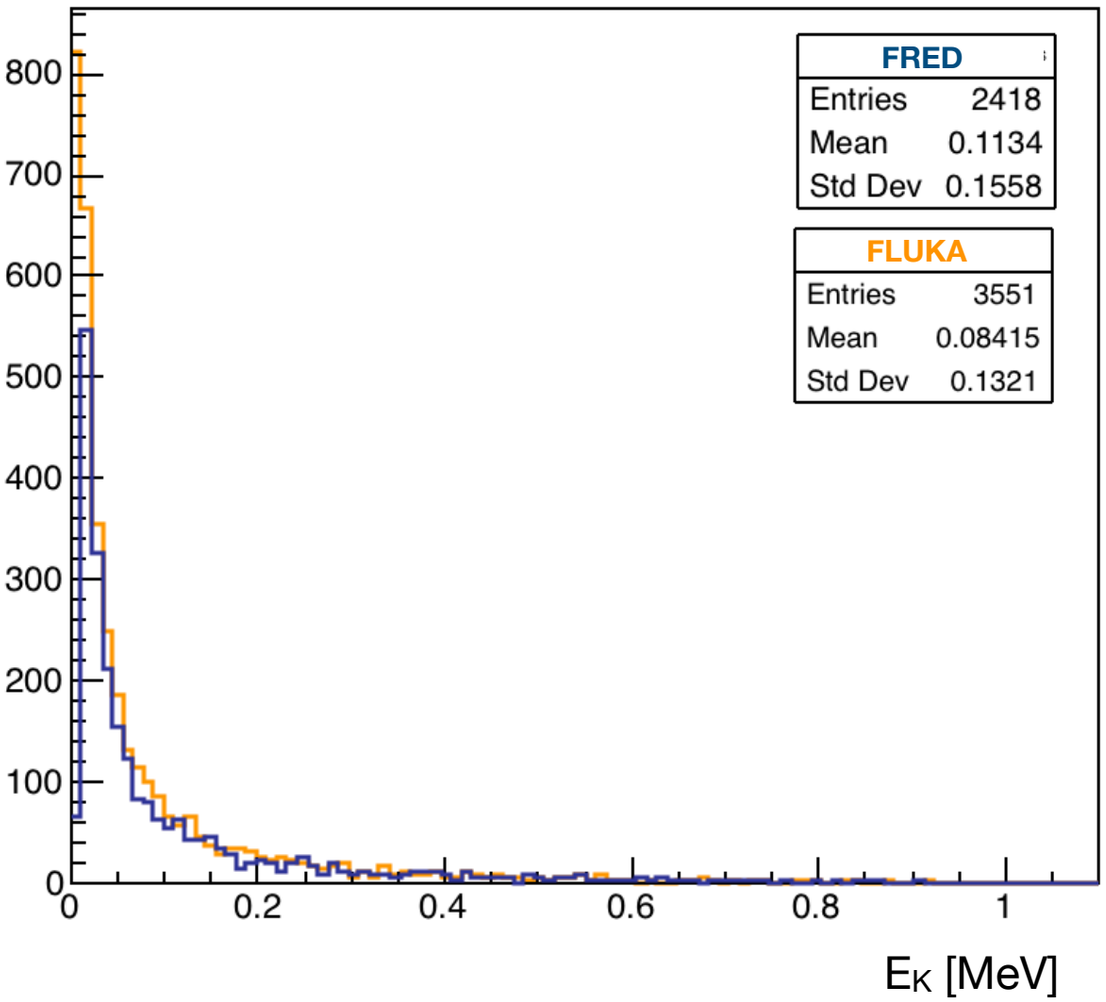
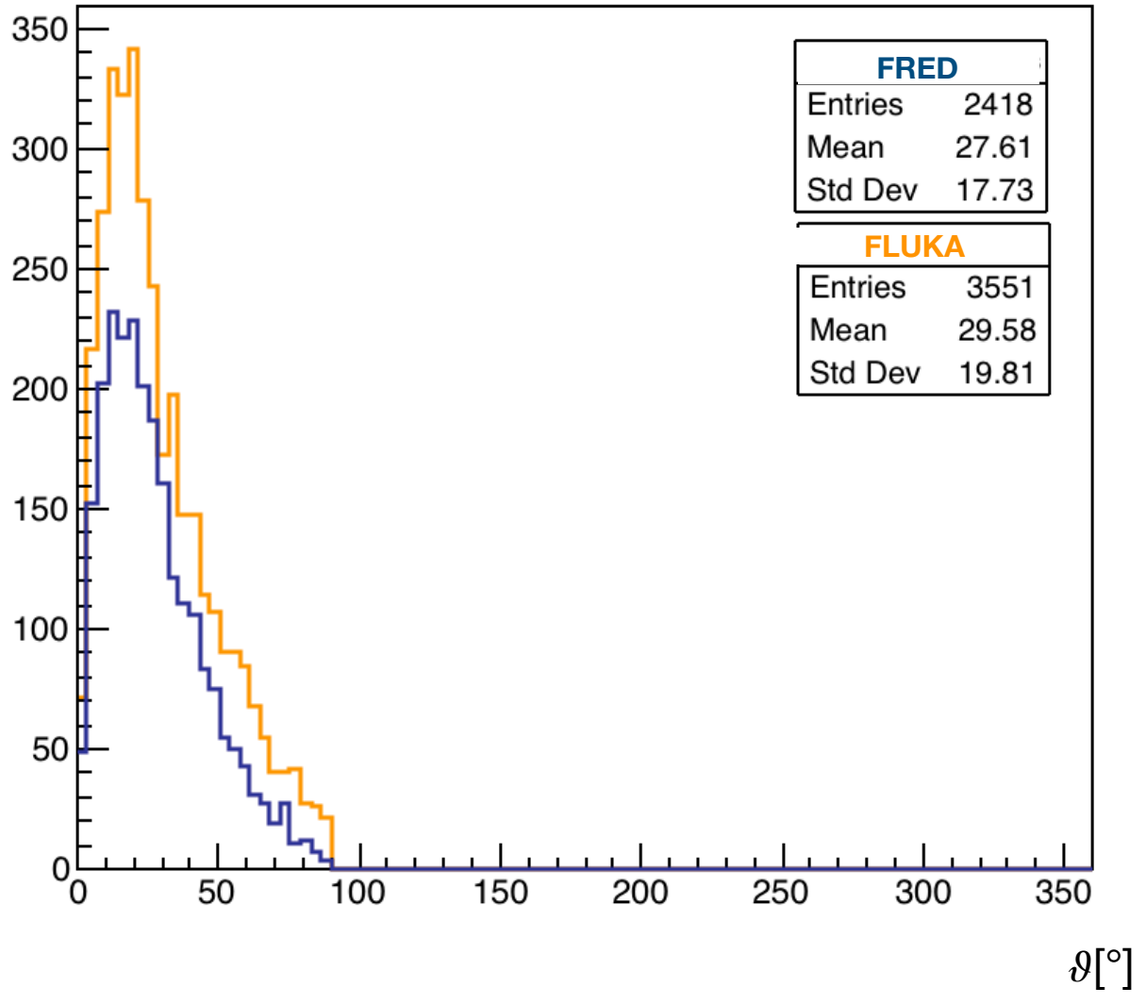
Kinetic energy of the outgoing photons with pz>0



Angle of the outgoing photons with pz>0

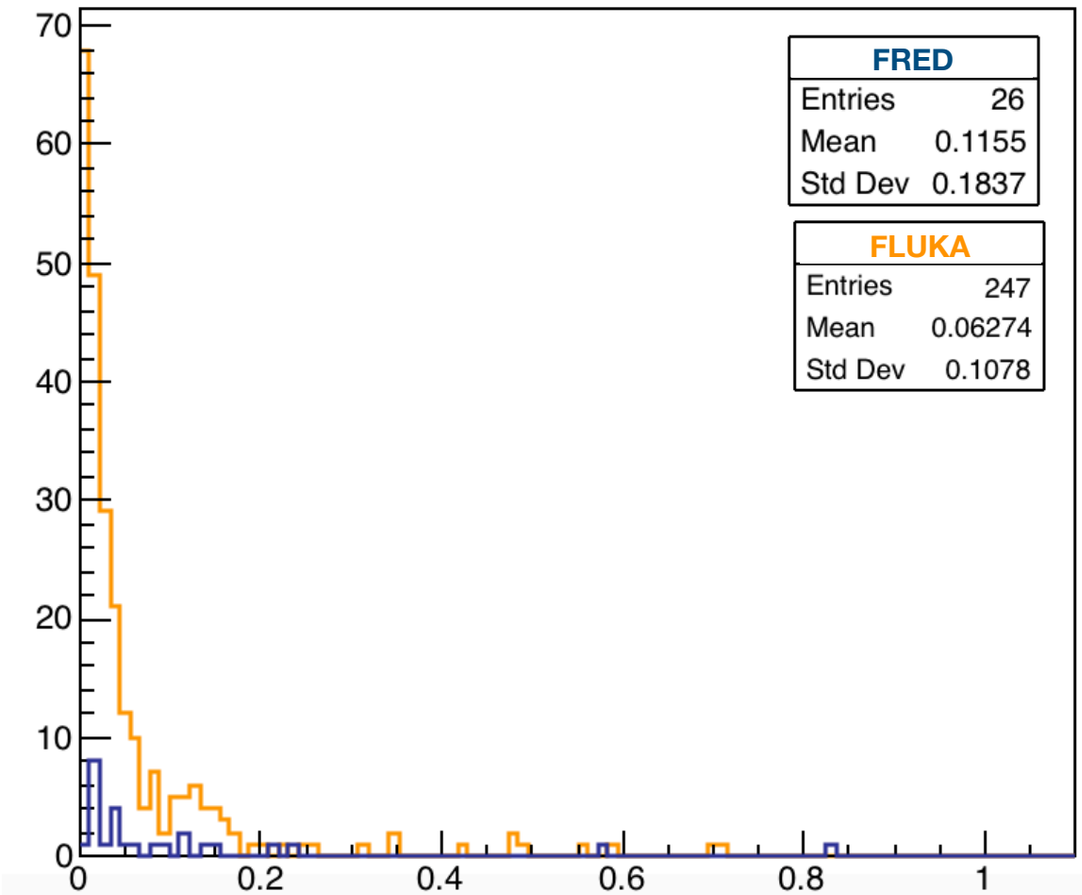


Electron transport validation - 1 MeV

1 MeV

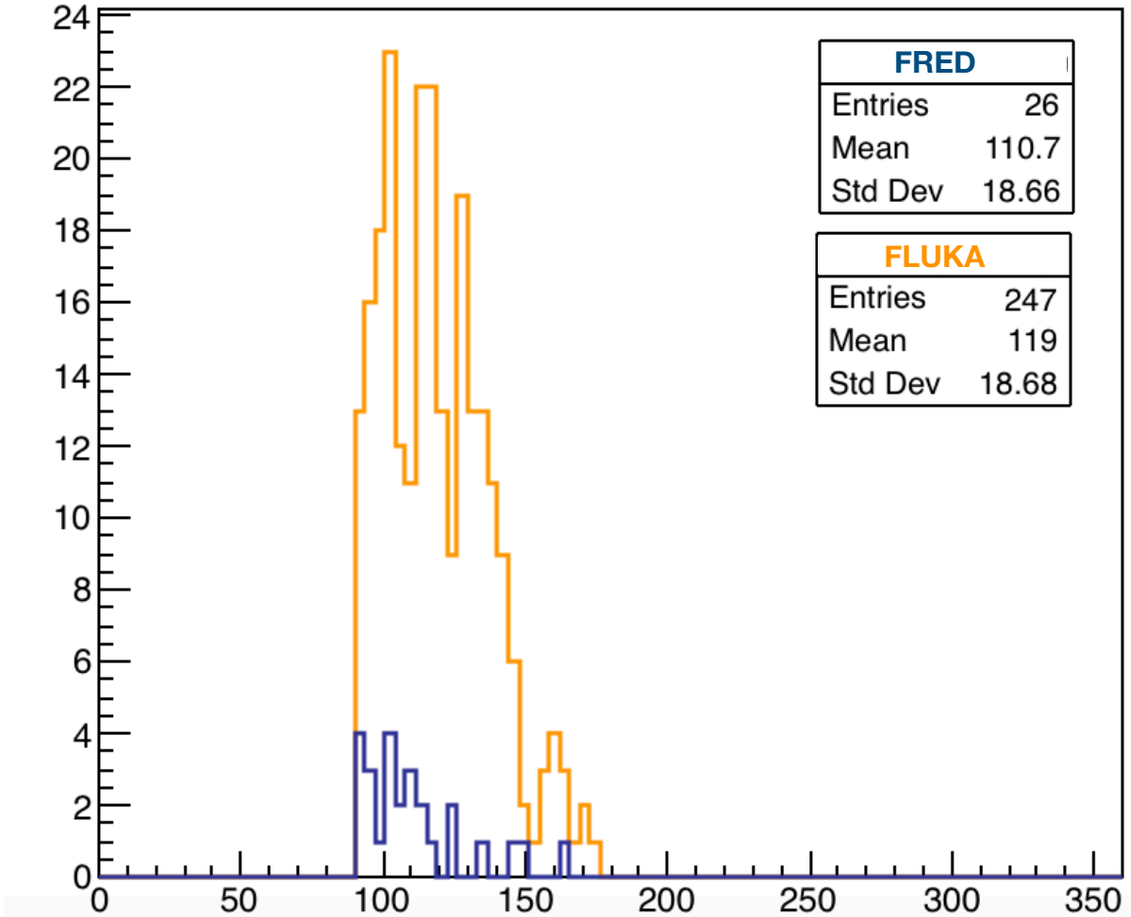
$p_z < 0$

Kinetic energy of the outgoing photons with pz>0



E_K [MeV]

Angle of the outgoing photons with pz>0



ϑ[°]

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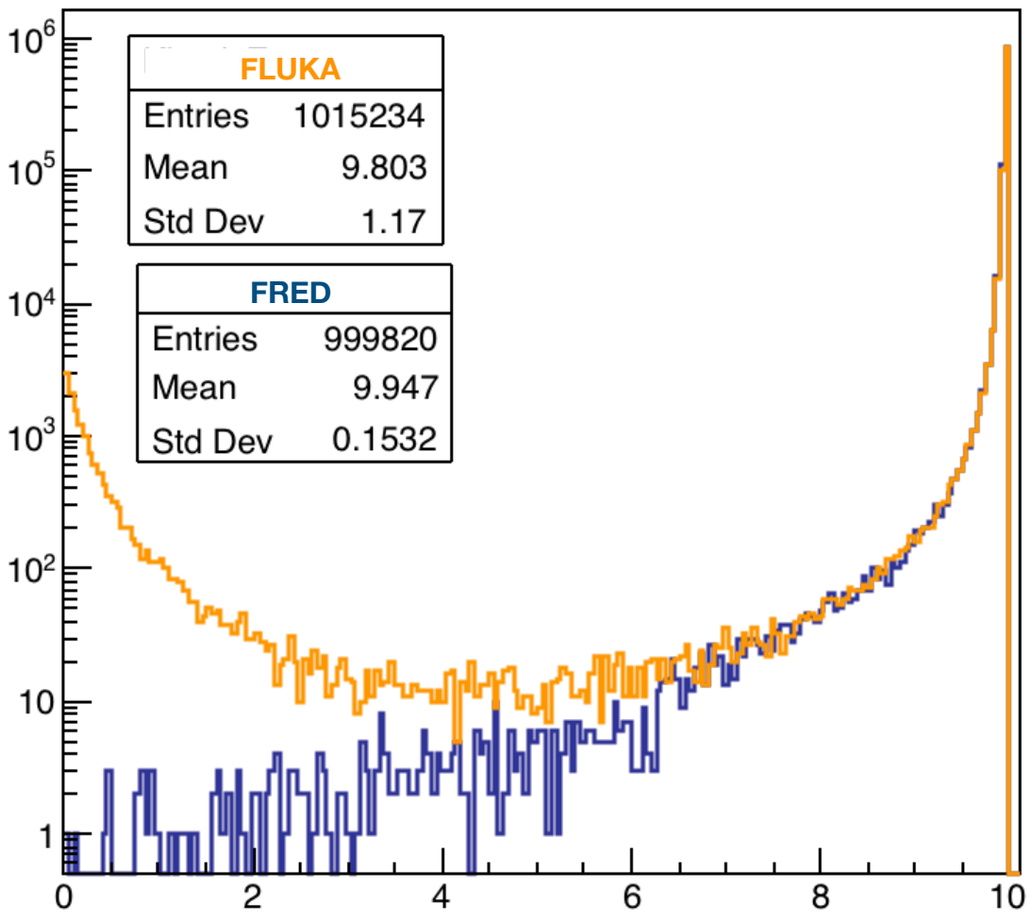
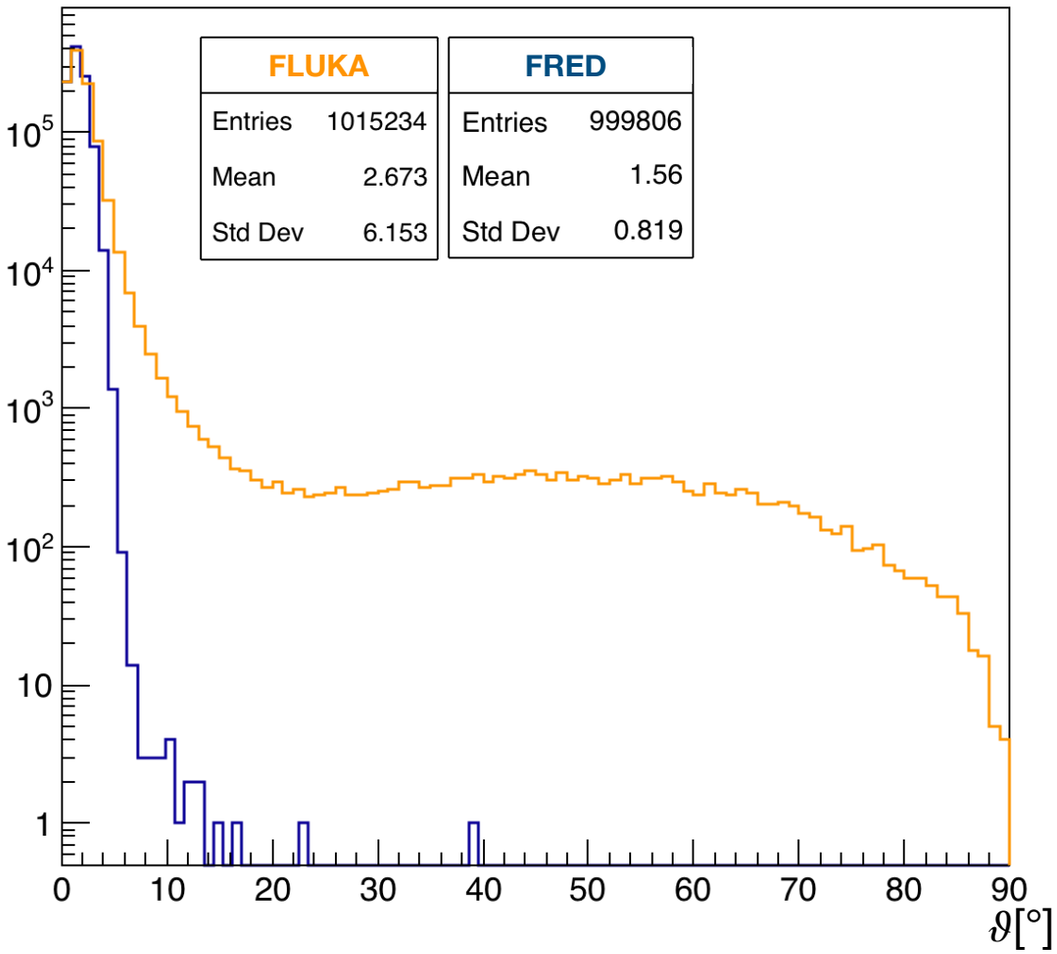
10 MeV

$p_z > 0$

Kinetic energy of the outgoing electrons with pz>0



Angle of the outgoing electrons with pz>0

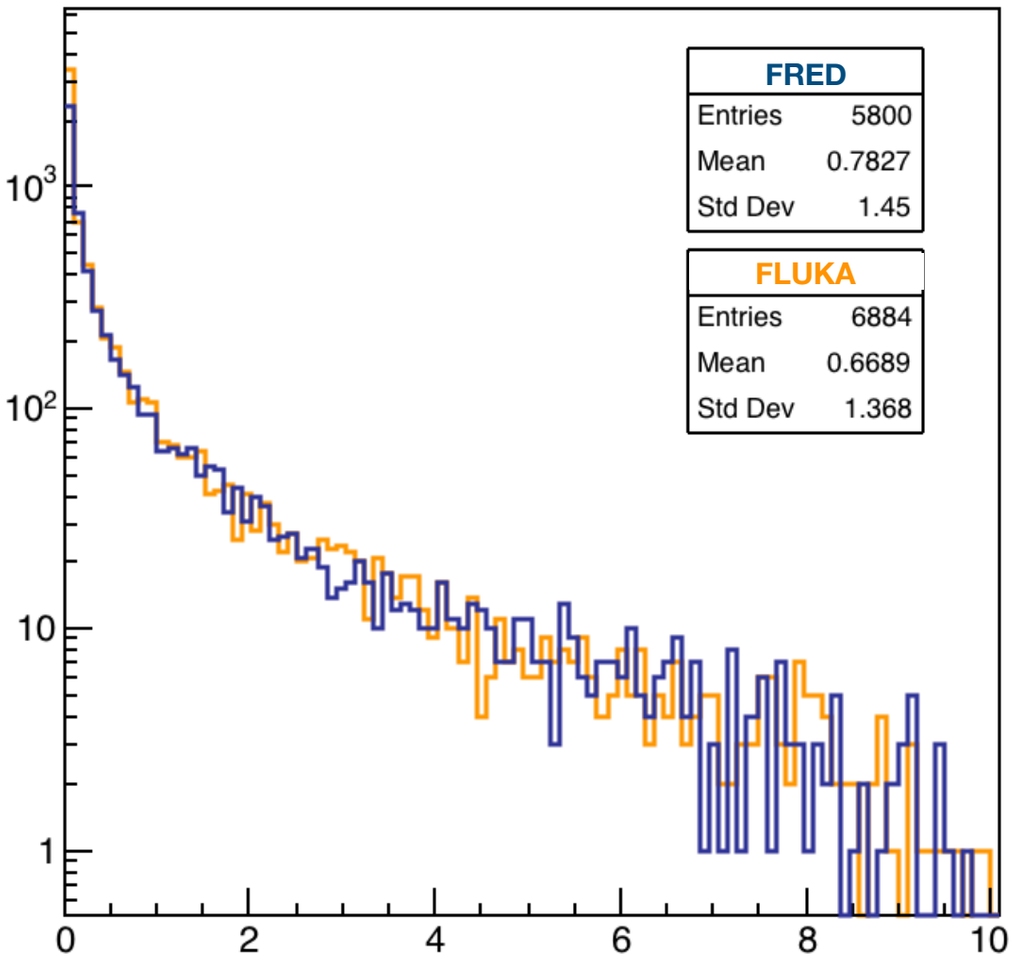


Electron transport validation - 10 MeV

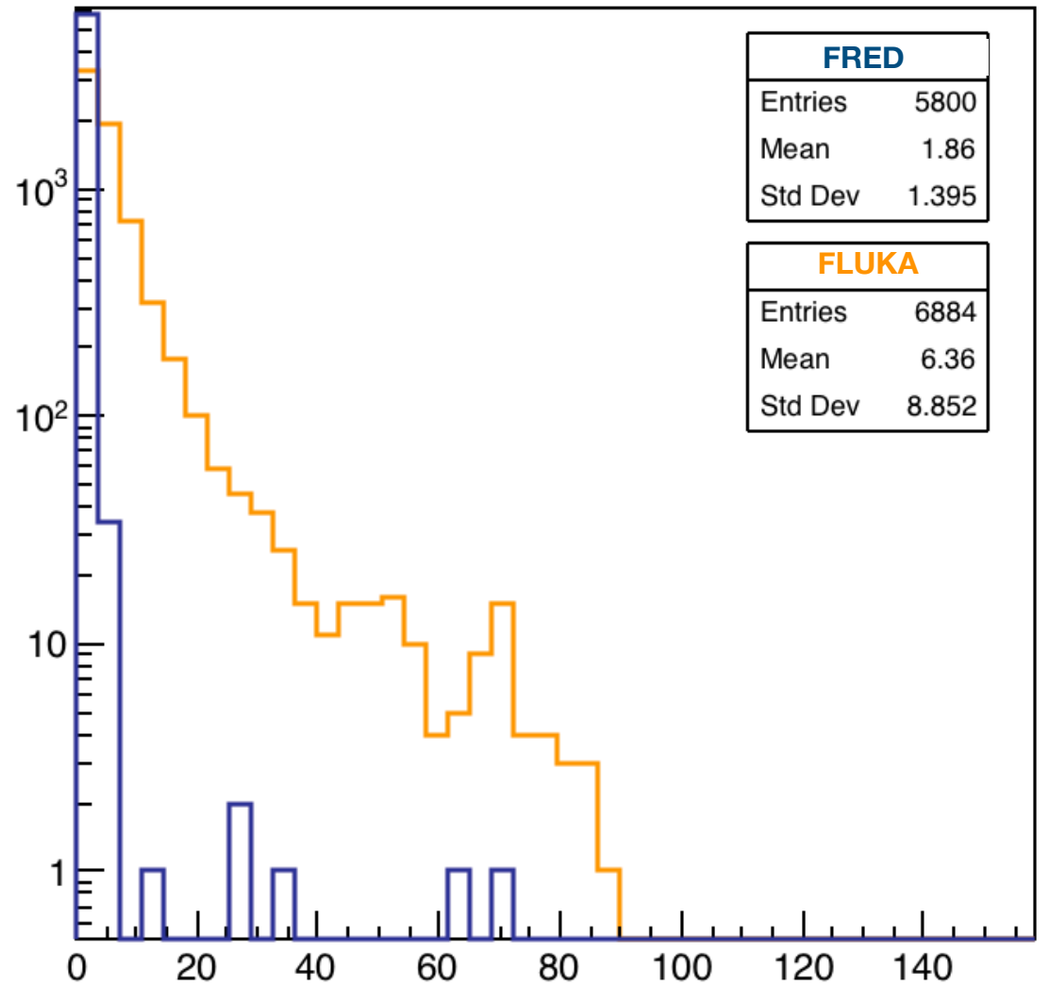
10 MeV

$p_z > 0$

Kinetic energy of the outgoing photons with pz>0

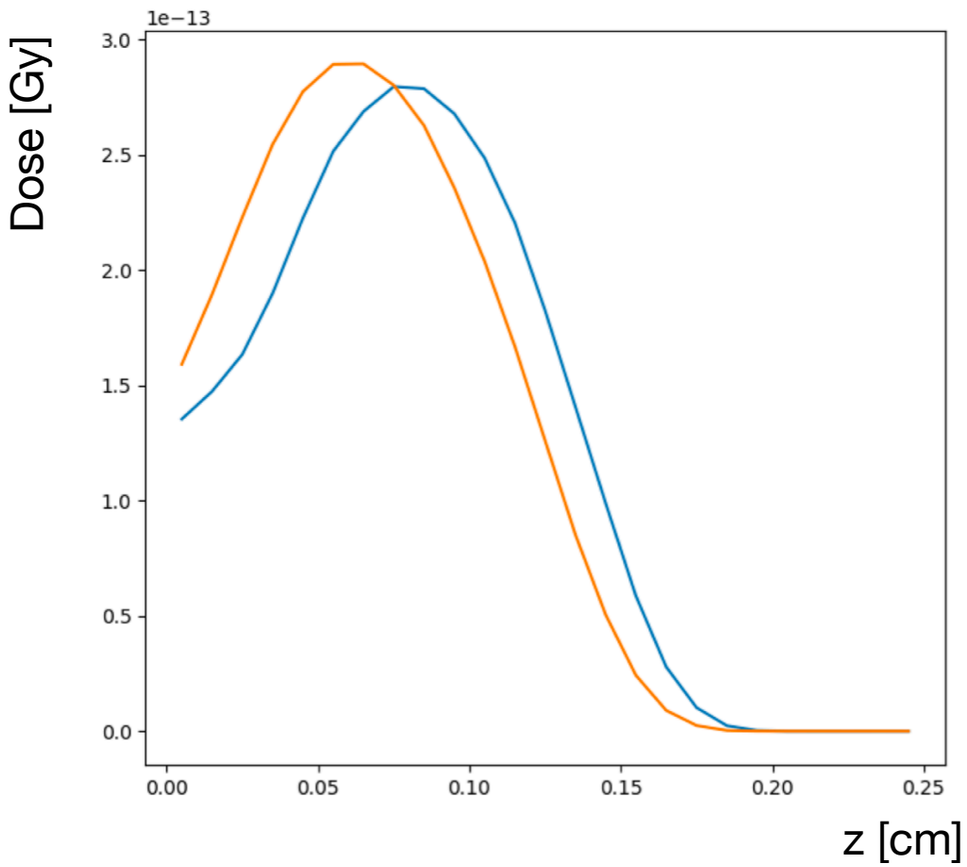


Angle of the outgoing photons with pz>0



Electron dose

500 keV



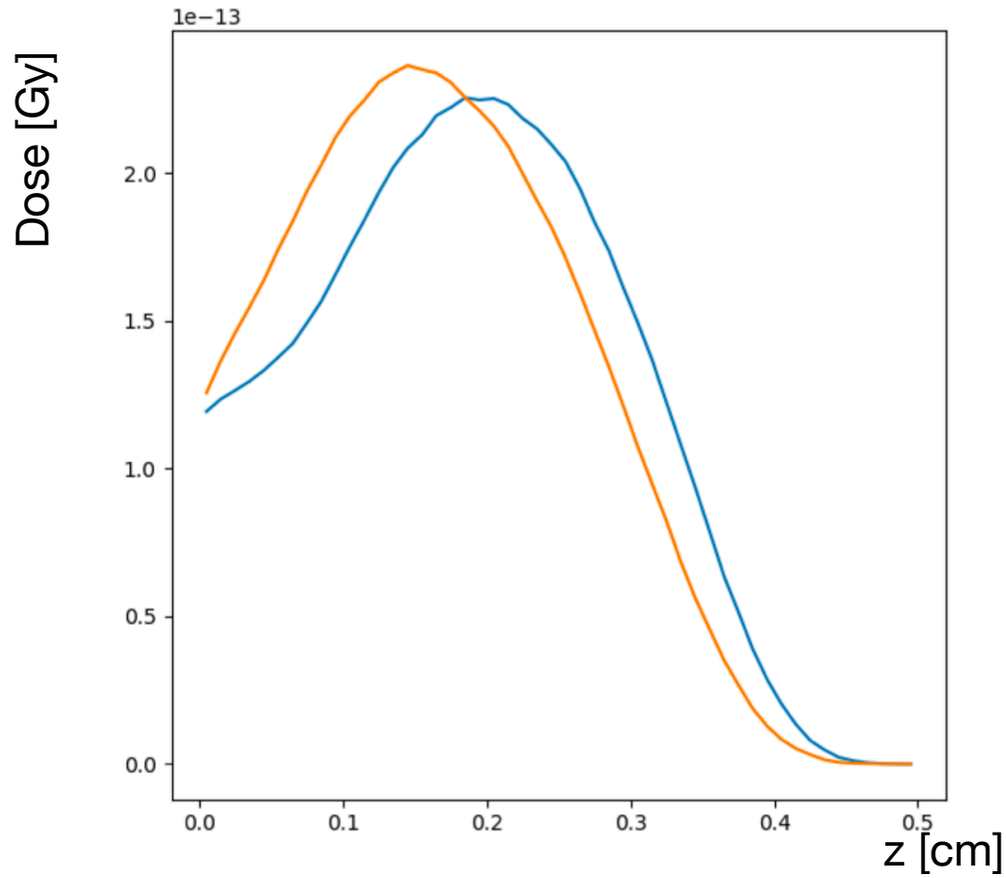
Target [50x50x0.25] cm^3

FRED → sum: 3.1939523e-11 Gy

FLUKA → sum: 3.1277969e-12Gy

δ = 2.11 %

1 MeV



Target [50x50x0.5] cm^3

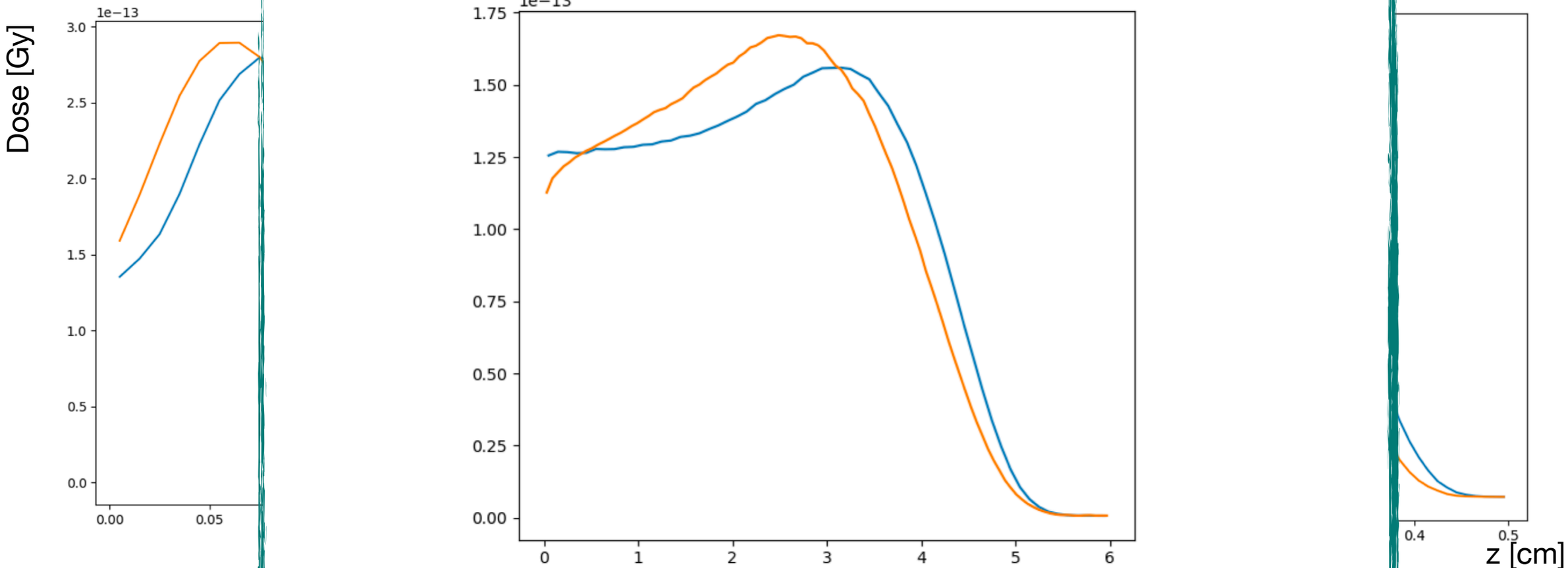
FRED → sum: 6.383595e-12 Gy

FLUKA → sum: 6.2835021e-12Gy

δ = 1.6 %

Electron dose

10 MeV



Target [50x5

Target [50x50x6] cm³

FRED → su

FRED → sum: 6.1793366e-12 Gy

e-12 Gy

FLUKA →

FLUKA → sum: 1.0279018e-11Gy

21e-12Gy

δ = 40 %

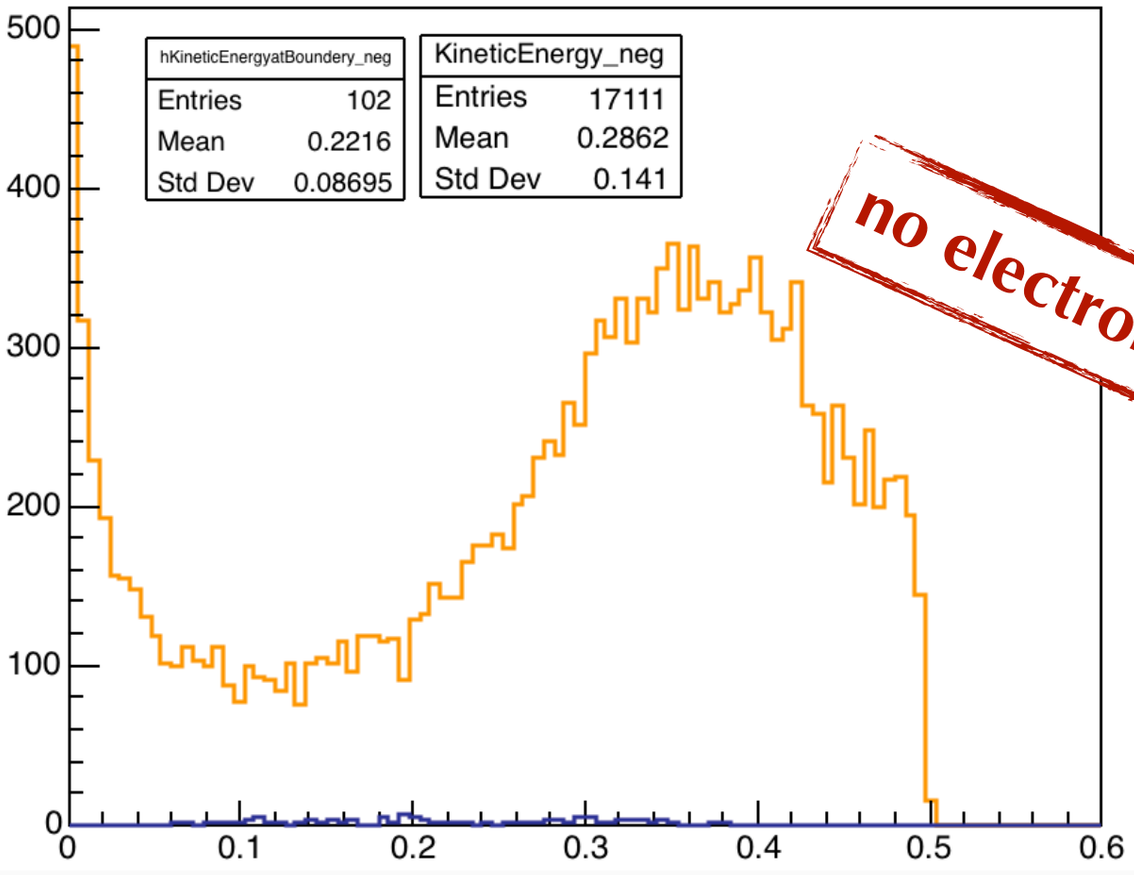
Spare slide

Electron transport validation

500 keV

$p_z < 0$

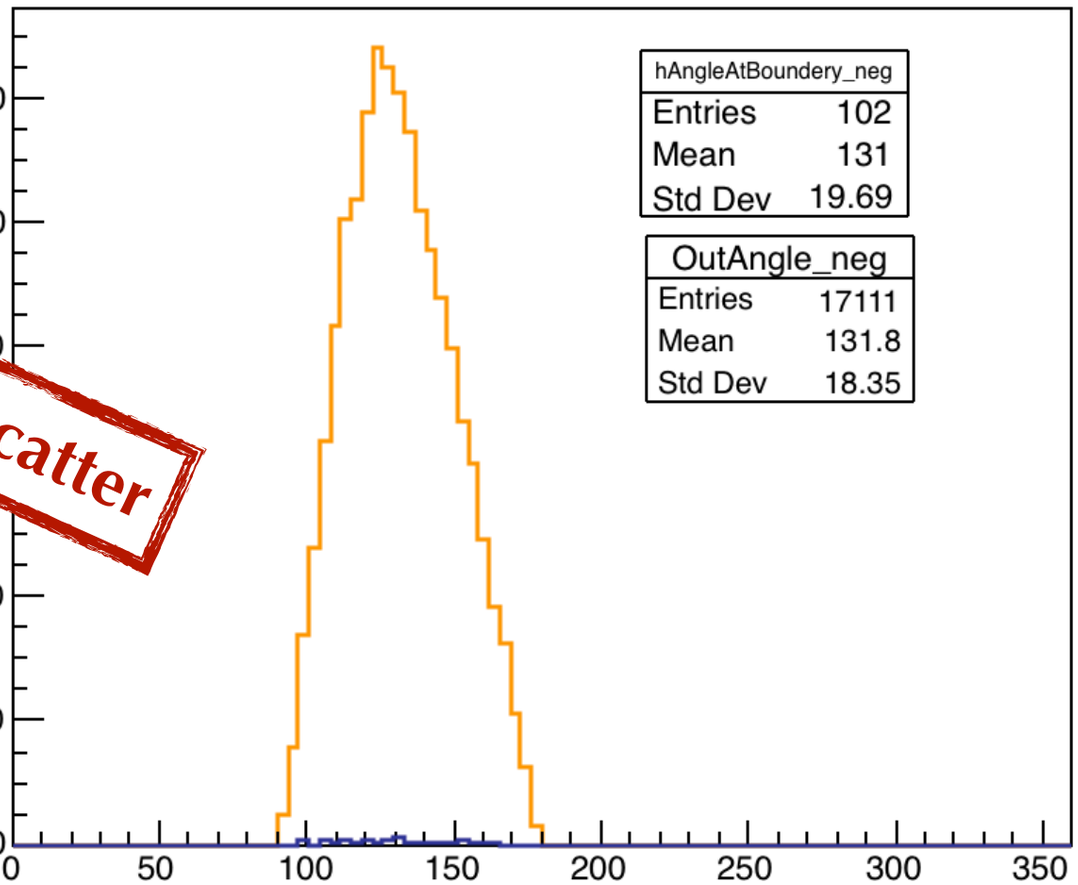
Kinetic energy of the outgoing electrons with pz>0



E_K [MeV]

no electron back-scatter

Angle of the outgoing electrons with pz>0



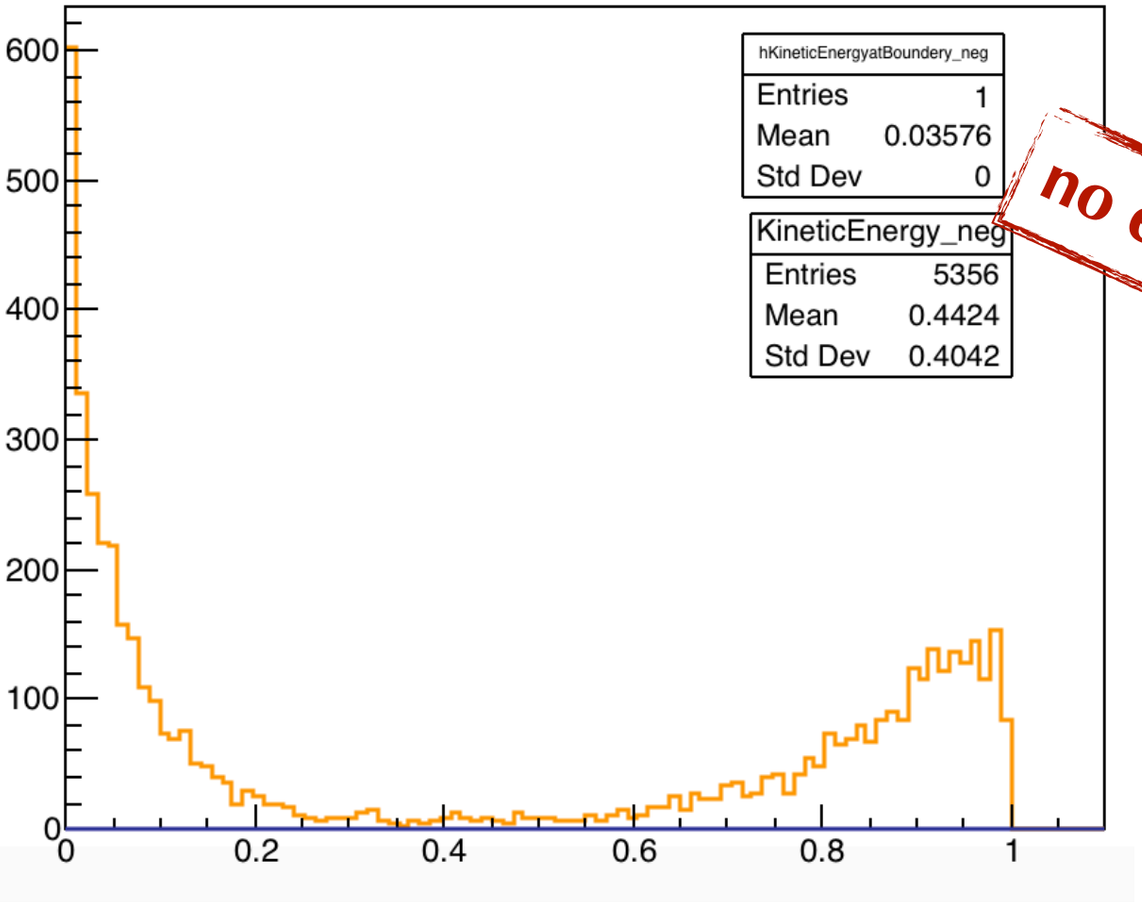
ϑ[°]

Electron transport validation

1 MeV

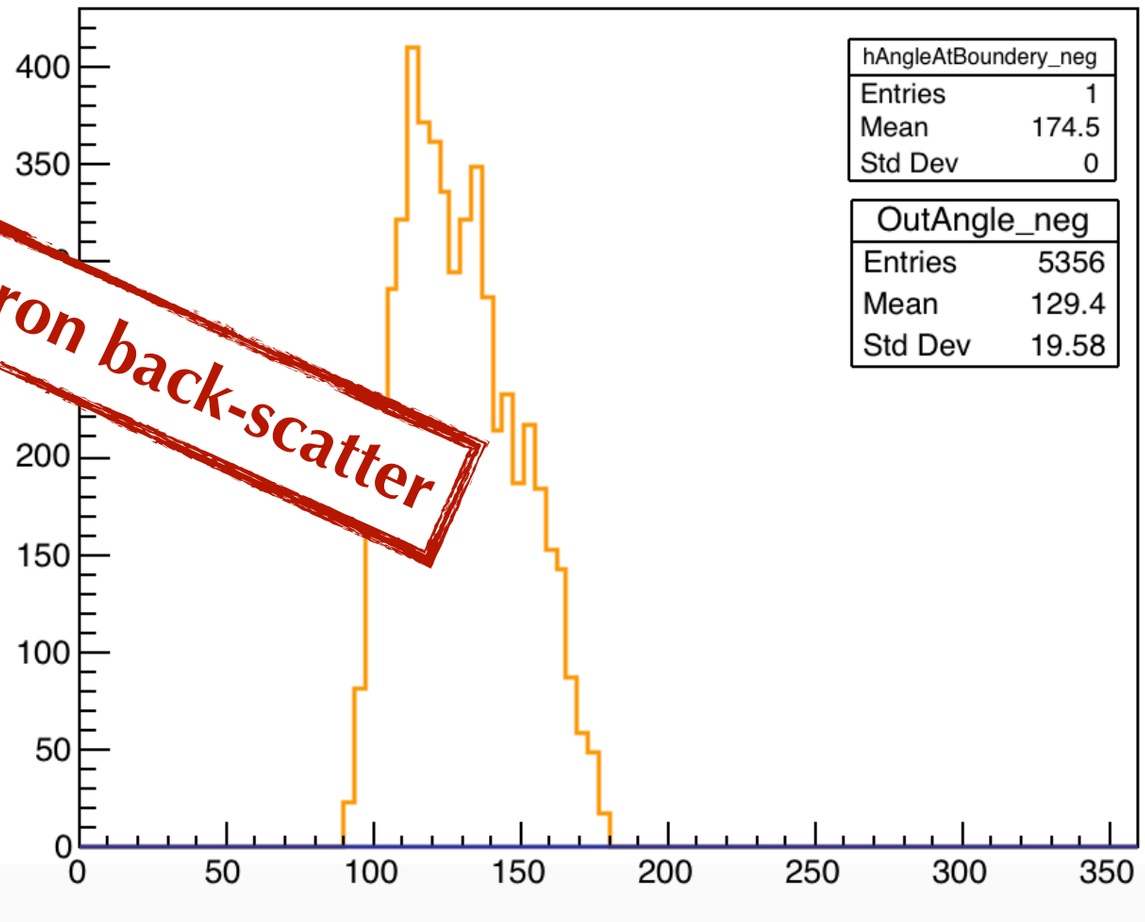
$p_z < 0$

Kinetic energy of the outgoing electrons with pz>0



E_K [MeV]

Angle of the outgoing electrons with pz>0



ϑ[°]

no electron back-scatter