# Update on LUXE GEANT4 Simulation, Magnetic field.

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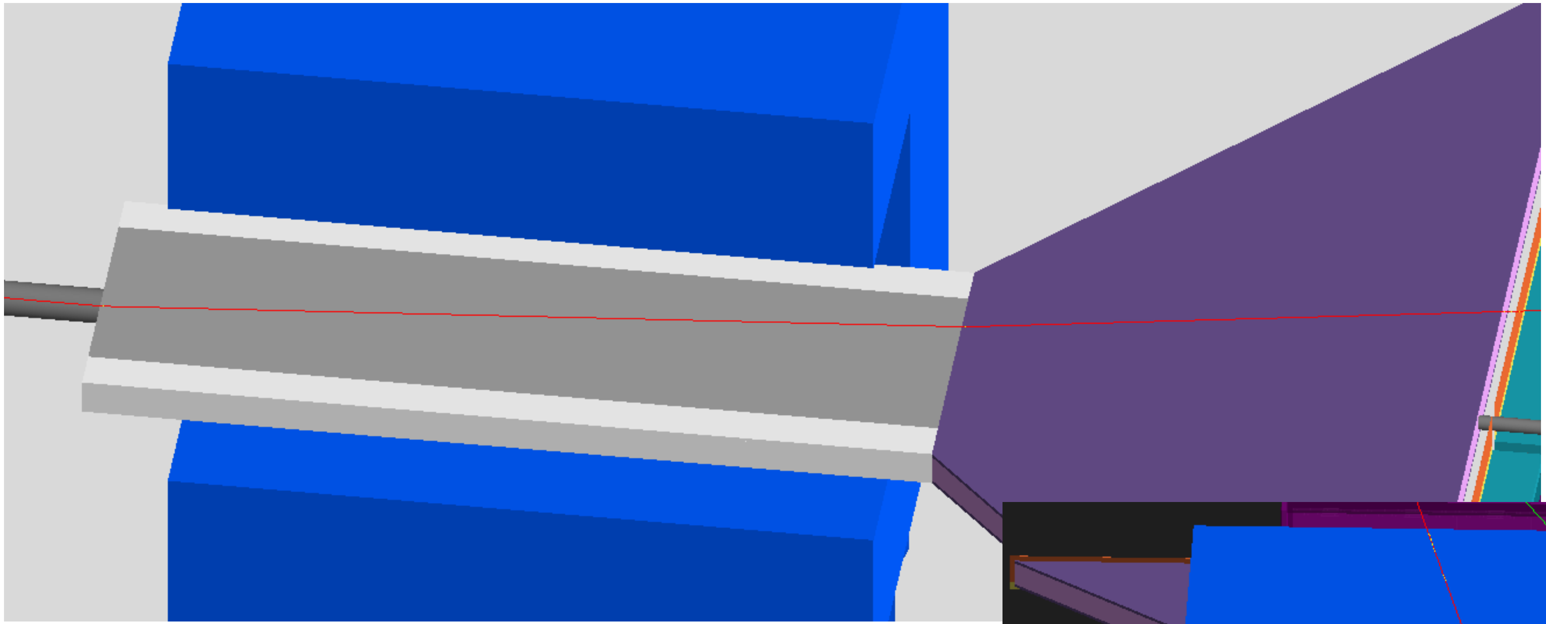
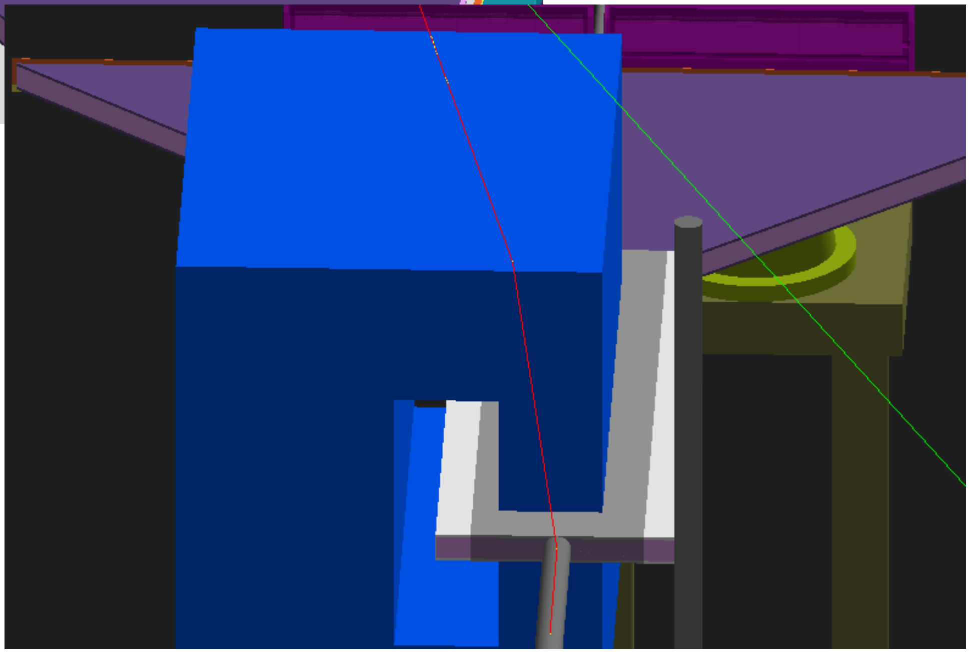
LUXE S&A Meeting
June 22, 2021

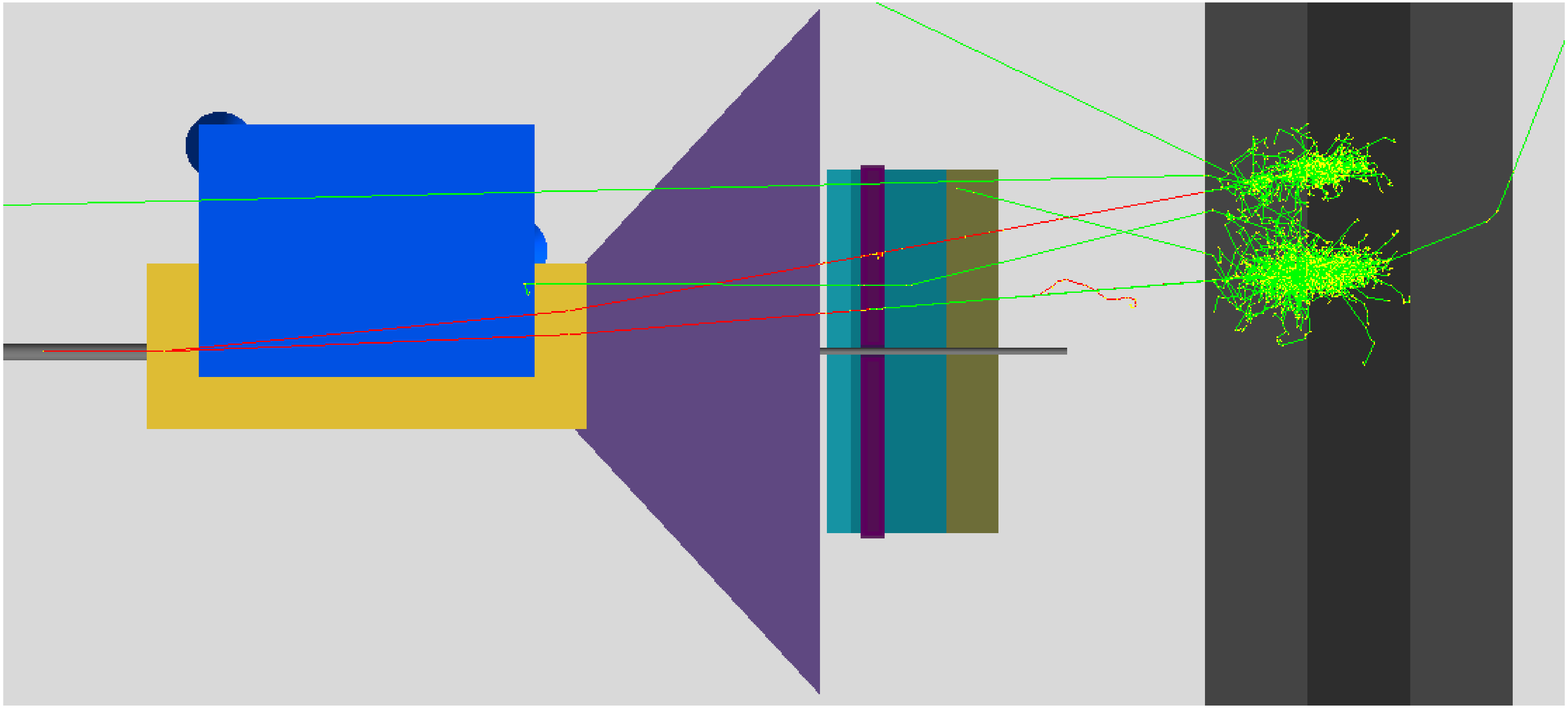
# Local Field



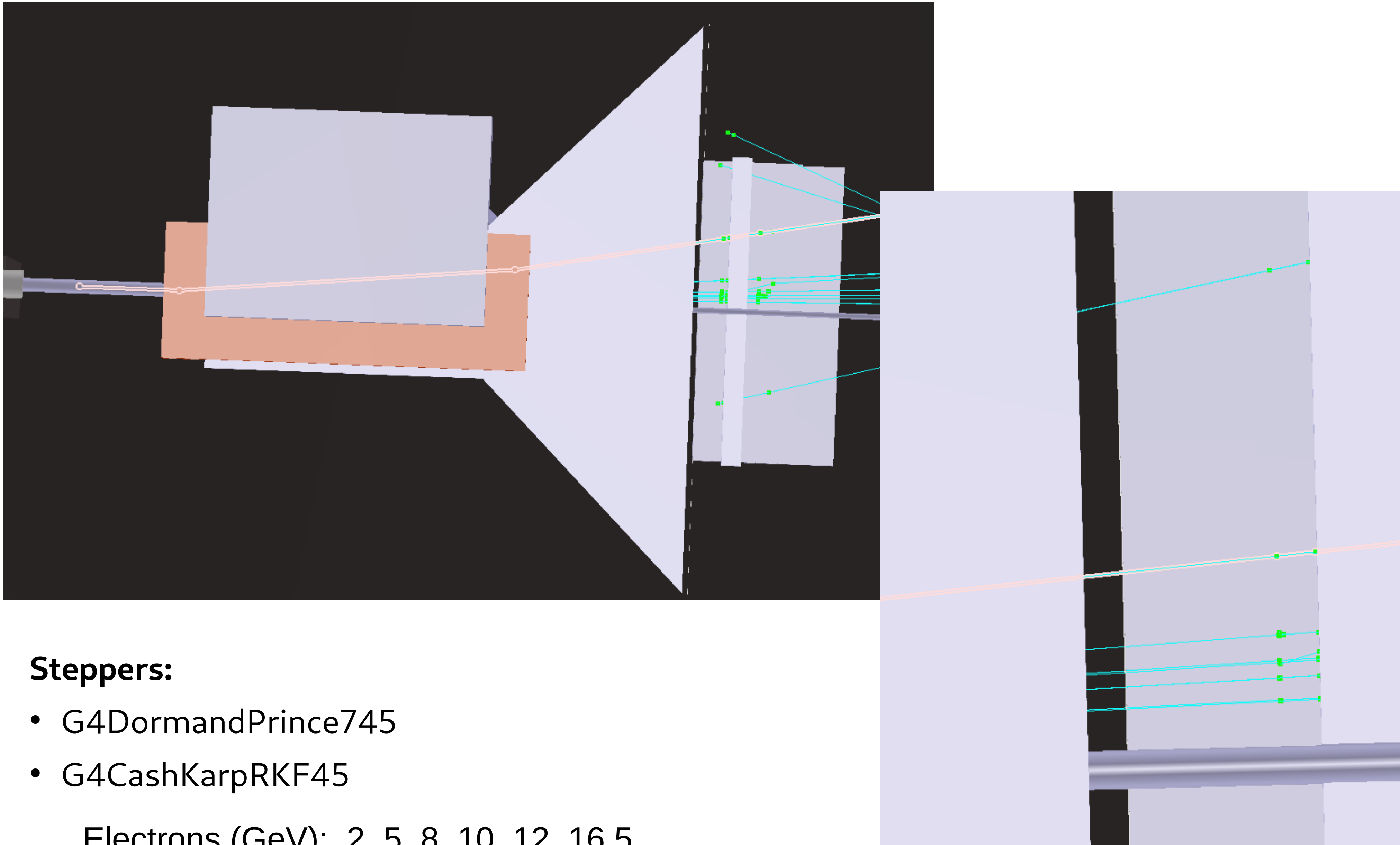


- Implemented as local field;
- i.e. present in a certain volume and not in the whole world;
- It is much better for computation time.

# Electrons of 2 GeV and 5 GeV



# Electrons

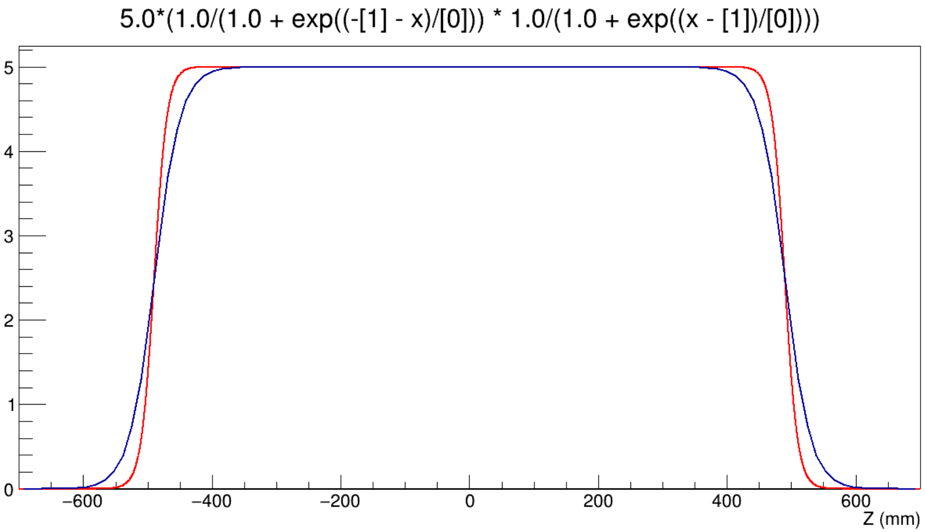


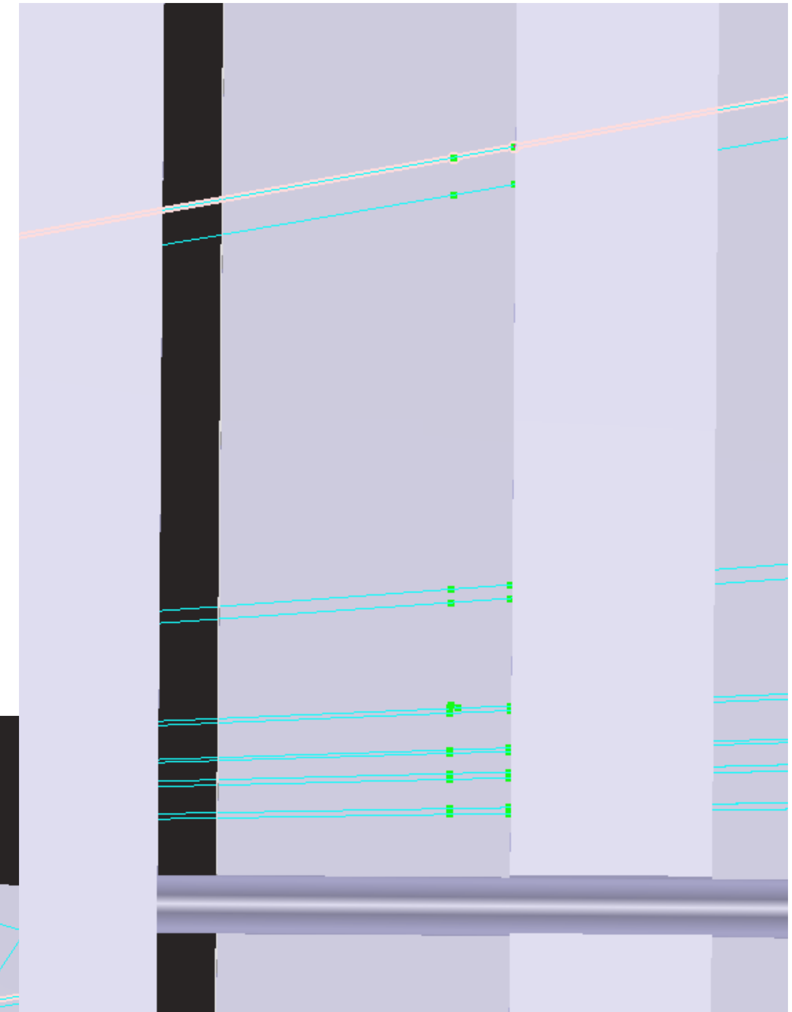
**Steppers:**

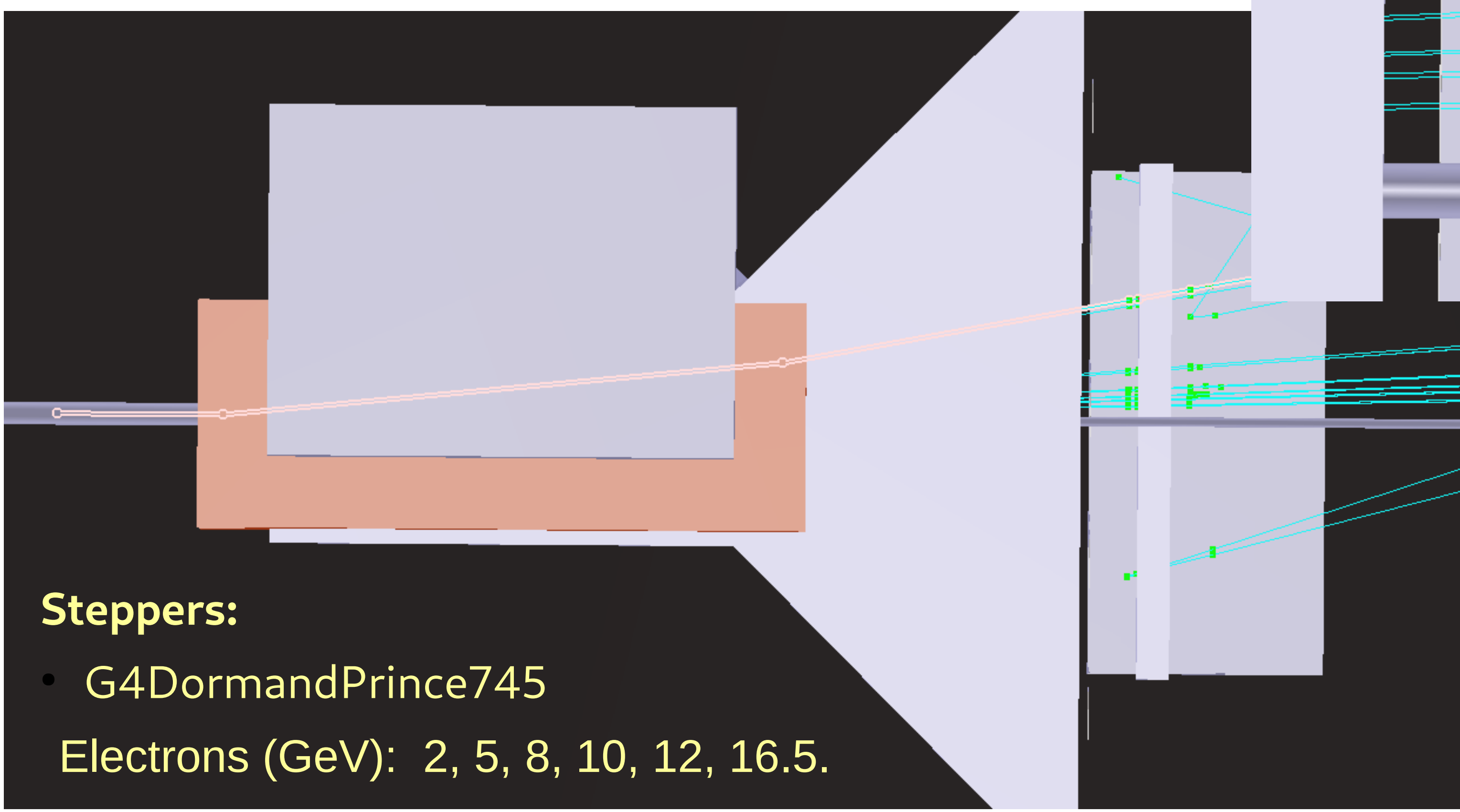
- G4DormandPrince745
- G4CashKarpRKF45

Electrons (GeV): 2, 5, 8, 10, 12, 16.5.

# Field shape





**Steppers:**

- G4DormandPrince745

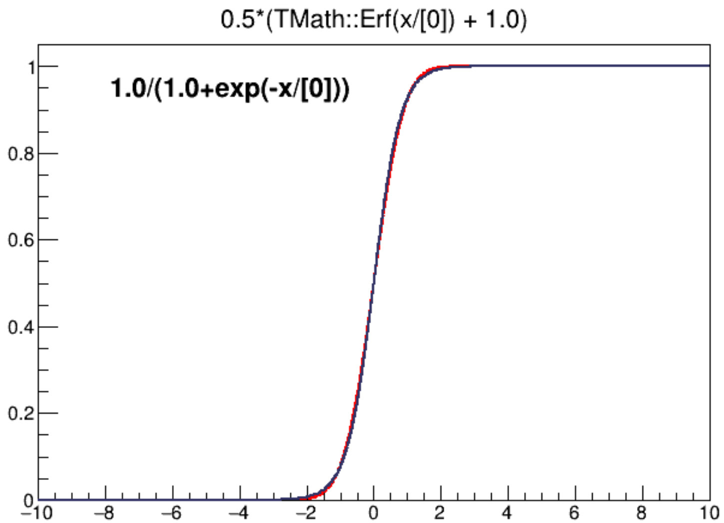
Electrons (GeV): 2, 5, 8, 10, 12, 16.5.

# G4 Algorithms (Stepper)

- G4DormandPrince745 - default, fifth order stepper, requires 7 field evaluations;
- G4CashKarpRKF45 - fifth order stepper, requires fewer (6) field evaluations;

```
// Can choose one of the following Steppers
pStepper = new G4SimpleRunge( fEquation );  // 2nd
pStepper = new G4SimpleHeum( fEquation );   // 3rd
pStepper = new G4ClassicalRK4( fEquation ); // 4th
pStepper = new G4HelixExplicitEuler( fEquation );
pStepper = new G4CashKarpRKF45( fEquation );
pStepper = new G4NystromRK4( fEquation );   // New!
```

# Field shape approximation




$$f(x) = \frac{1}{1 + e^{\frac{a-x}{b}}}$$

- It took some time to find Noam's slides
- Idea can be well represented using function similar to Fermi-Dirac distribution (or Woods-Saxon potential).
- exp is ~2 faster then erf.

12:40 → 13:00 **Simulation & Analysis Task Force status**

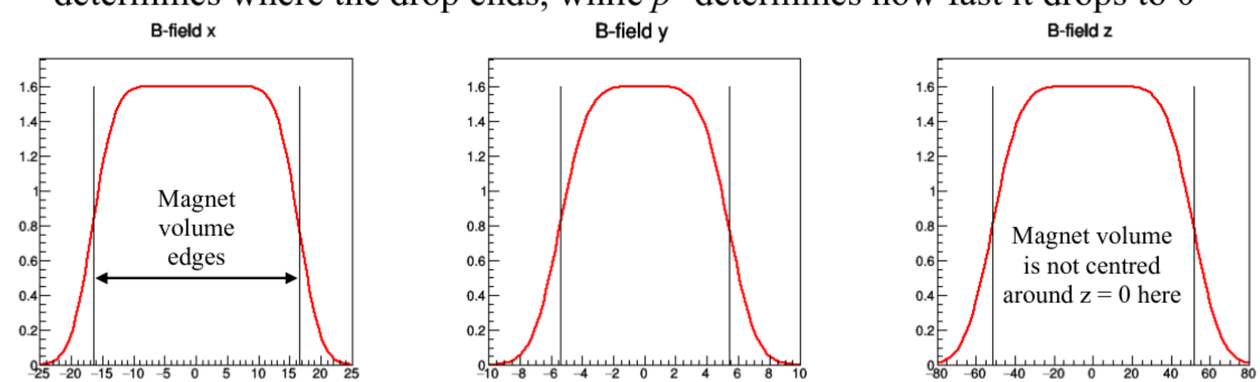
Speakers: Dr Anthony Hartin (DESY) , Dr Gianluca Sarri (Queen's University Belfast) , Dr Noam Tal Hod (Weizmann Institute of Science)

Slides

## Non-uniform B-field [Noam]

- See slide 4 in this link for examples, and more details in this link
- Propose to implement as 3D symmetrical product of two-sided error functions (in each dimension) at the edges of the dipole's active volume
- 1D two-sided error function (smooth turn-on between 0 and 1):

$$f(x_i | p_i^0, p_i^1) = \frac{1}{4} \times \left[2 - \mathrm{Erf}\left(\frac{p_i^0/2 + x_i}{p_i^1}\right)\right] \times \left[2 - \mathrm{Erf}\left(\frac{p_i^0/2 - x_i}{p_i^1}\right)\right]$$, where $p^0$ determines where the drop ends, while $p^1$ determines how fast it drops to 0




Noam Tal Hod, WIS Aug 19 2020

# Approximation of the field measurements

[0] / ( (1.0 + exp(([1]-x)/[2])) * (1.0 + exp((x-[3])/[4])) )

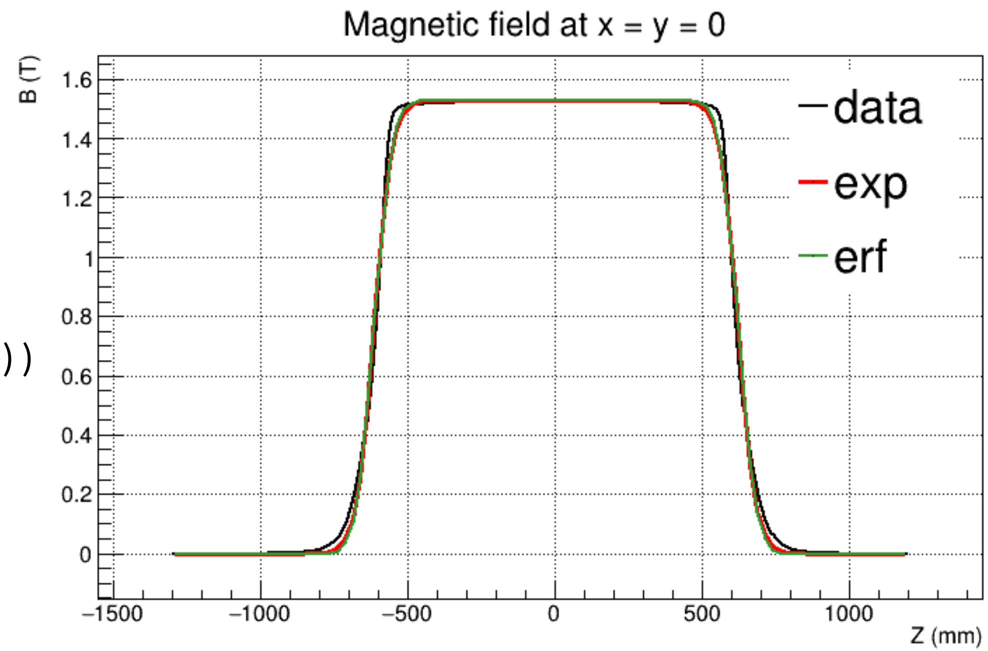
```
****************************************
Minimizer is Minuit / Migrad
Chi2                      =     0.334513
NDf                       =          496
Edm                       =  7.19831e-09
NCalls                    =          166
p0                        =      1.52962   +/-   0.00179954
p1                        =     -615.371   +/-   0.513627
p2                        =      28.9891   +/-   0.456426
p3                        =      621.238   +/-   0.516122
p4                        =      29.2464   +/-   0.458235
```

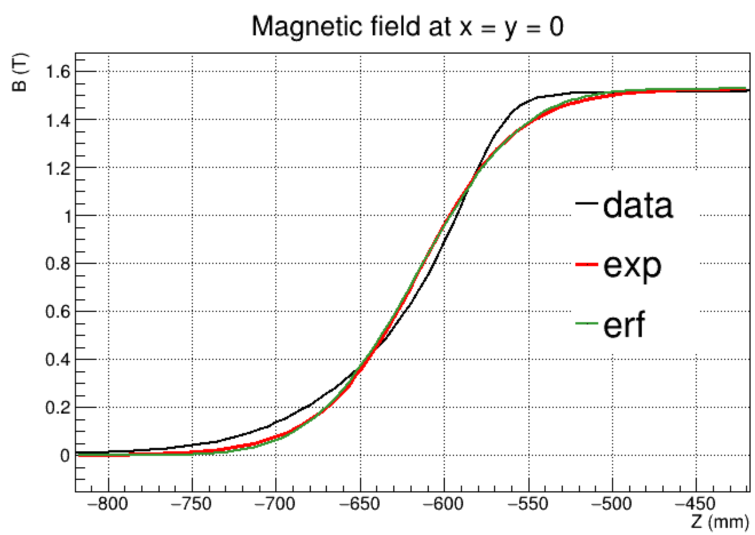
I = 380 A

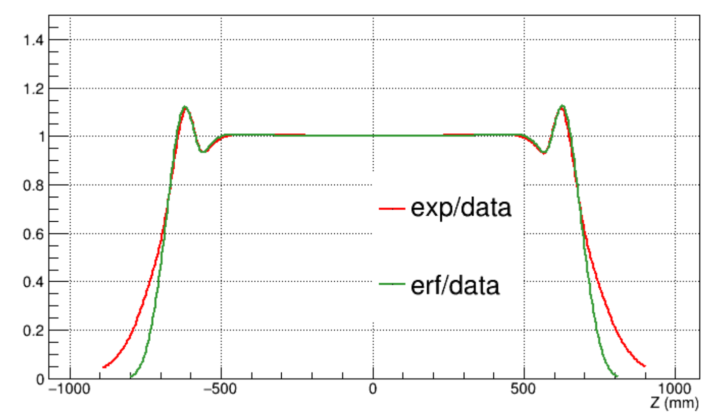
[0] * ( (1.0 + TMath::Erf((x-[1])/[2])) * (1.0 + TMath::Erf(([3]-x)/[4])) )

```
****************************************
Minimizer is Minuit / Migrad
Chi2                      =     0.360549
NDf                       =          496
Edm                       =   6.6431e-07
NCalls                    =          192
p0                        =     0.381775   +/-   0.000464131
p1                        =     -615.852   +/-   0.5342
p2                        =      69.1129   +/-   1.10464
p3                        =      621.732   +/-   0.536833
p4                        =      69.7404   +/-   1.1092
```

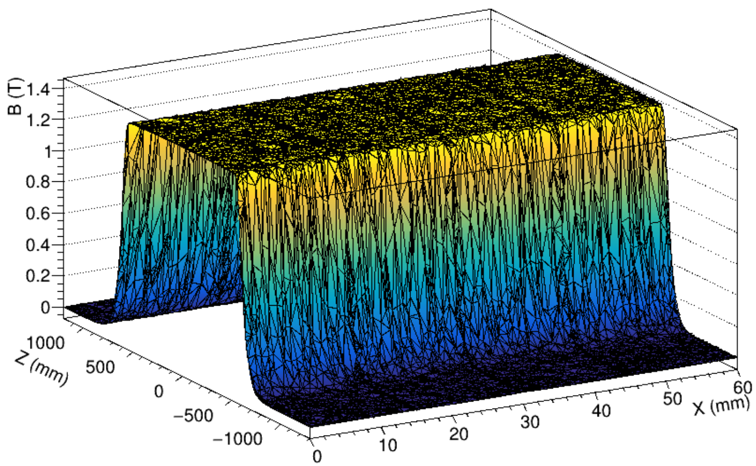
Magnet current I = 380 A



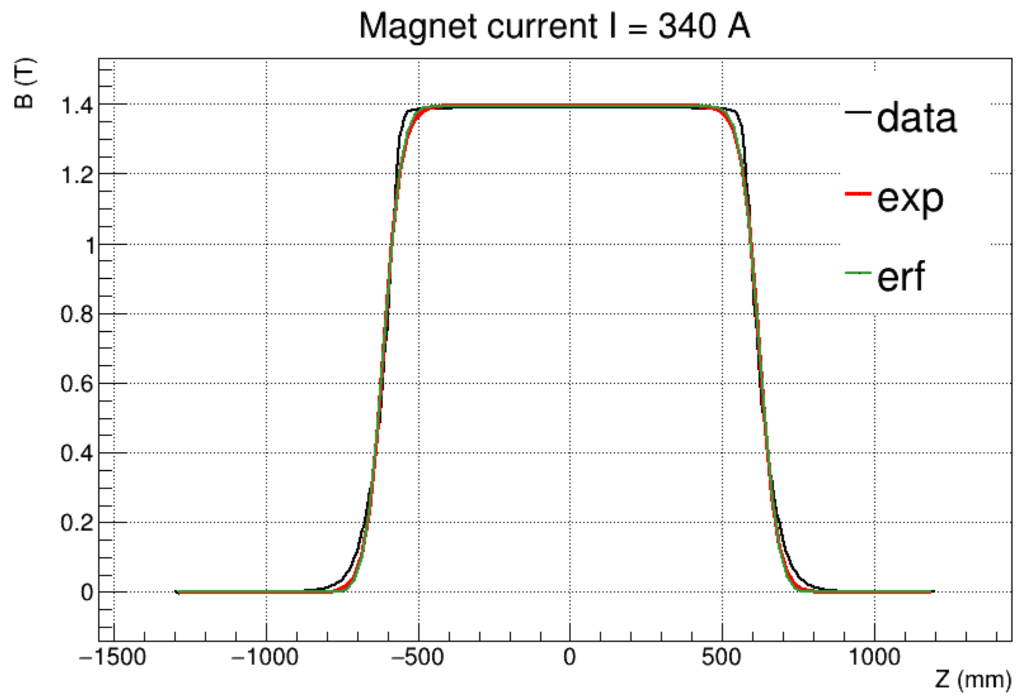



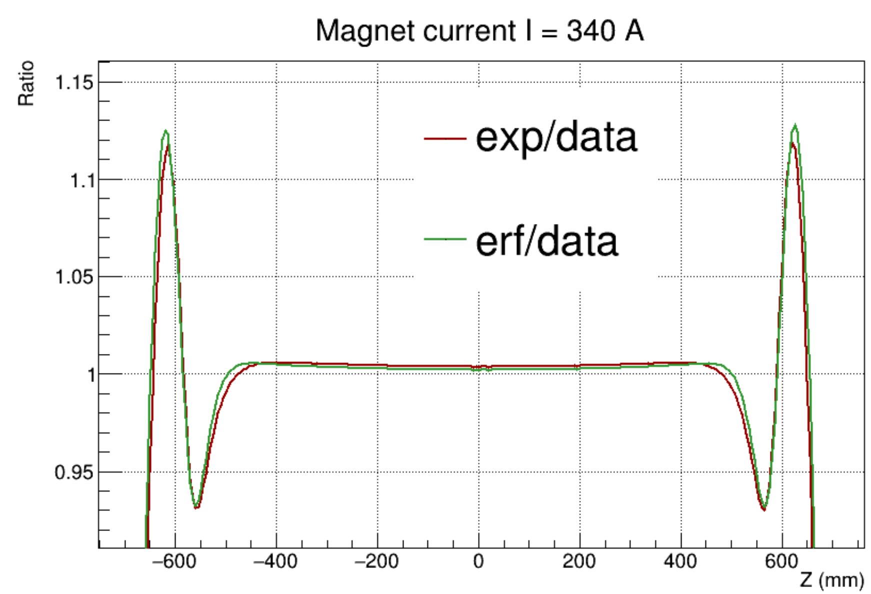



# Field shape, Magnet current 340A




```
****************************************
Minimizer is Minuit / Migrad
Chi2                      =     0.297061
NDf                       =          496
Edm                       =  5.47555e-09
NCalls                    =          207
p0                        =      1.39676   +/-   0.00169342
p1                        =     -615.647   +/-   0.52858
p2                        =      28.7795   +/-   0.46825
p3                        =      621.492   +/-   0.53114
p4                        =      29.0338   +/-   0.470135

****************************************
Minimizer is Minuit / Migrad
Chi2                      =     0.316079
NDf                       =          496
Edm                       =  1.34967e-07
NCalls                    =          327
p0                        =     0.348625   +/-   0.000433989
p1                        =     -616.129   +/-   0.546244
p2                        =      68.6334   +/-   1.12582
p3                        =      621.992   +/-   0.548953
p4                        =      69.2627   +/-   1.13065
```



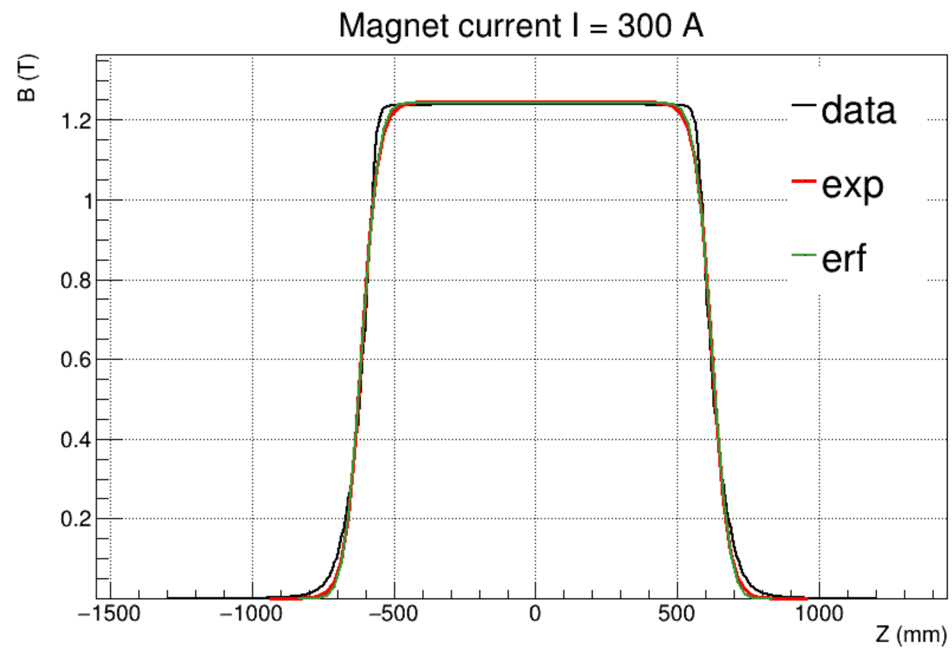
# Field, currents 300A and 200A

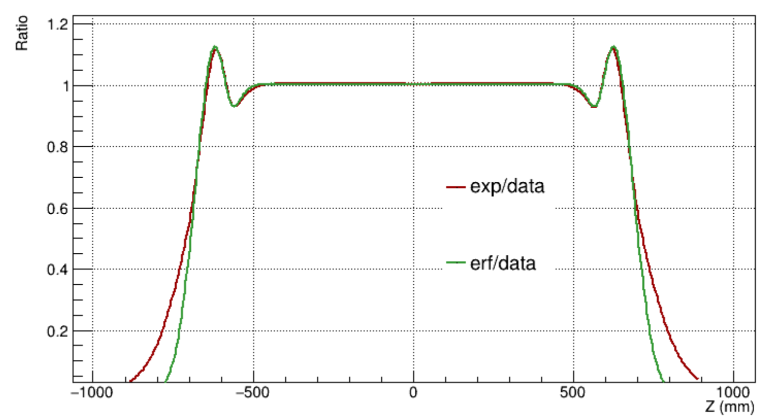
I = 300 A

```
****************************************
Minimizer is Minuit / Migrad
Chi2                      =      0.24468
NDf                       =          496
Edm                       =  5.25513e-07
NCalls                    =          180
p0                        =      1.24491   +/-   0.00153566
p1                        =     -615.807   +/-   0.537391
p2                        =      28.6578   +/-   0.475096
p3                        =      621.643   +/-   0.539987
p4                        =      28.9133   +/-   0.477082

****************************************
Minimizer is Minuit / Migrad
Chi2                      =     0.258534
NDf                       =          496
Edm                       =  4.11289e-08
NCalls                    =          404
p0                        =     0.310733   +/-   0.000392206
p1                        =     -616.284   +/-   0.553427
p2                        =      68.3636   +/-   1.13834
p3                        =       622.14   +/-   0.556146
p4                        =      68.9829   +/-   1.14323
```

I = 200 A

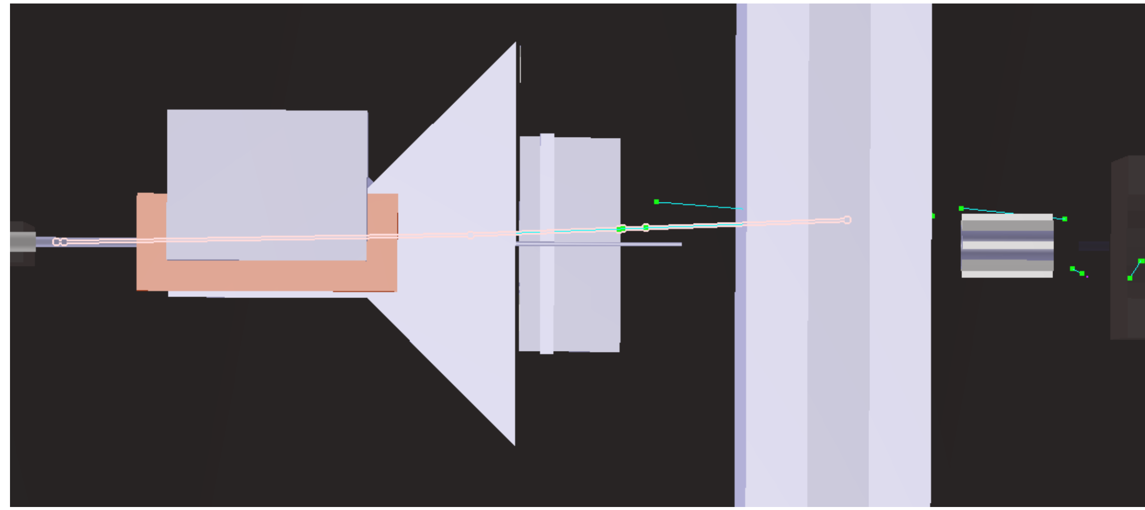
```
****************************************
Minimizer is Minuit / Migrad
Chi2                      =     0.113243
NDf                       =          496
Edm                       =  3.98098e-10
NCalls                    =          400
p0                        =     0.836847   +/-   0.00104426
p1                        =     -615.971   +/-   0.543578
p2                        =      28.6125   +/-   0.480073
p3                        =      621.764   +/-   0.546193
p4                        =      28.8639   +/-   0.482101

****************************************
Minimizer is Minuit / Migrad
Chi2                      =     0.119176
NDf                       =          496
Edm                       =  8.09864e-08
NCalls                    =          720
p0                        =     0.208877   +/-   0.00026617
p1                        =     -616.456   +/-   0.558677
p2                        =       68.251   +/-   1.14772
p3                        =      622.259   +/-   0.561387
p4                        =      68.8561   +/-   1.15268
```

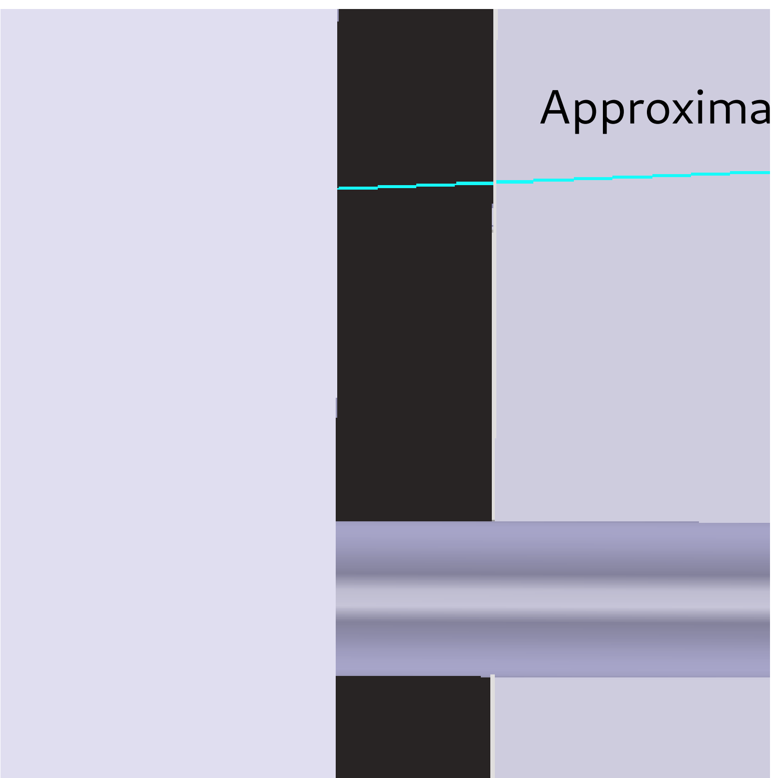


# 10 GeV electron, 300A field

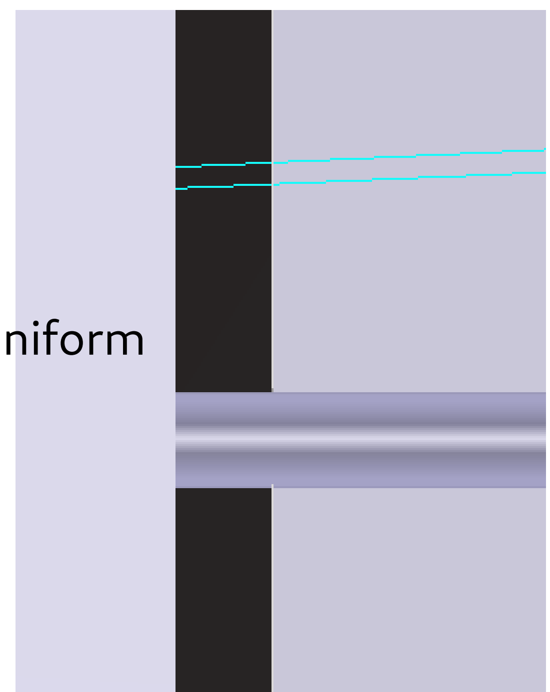
- Uniform field
- Approximation using fit function in z and x
- Interpolated data (measurements) in z and approximation in x



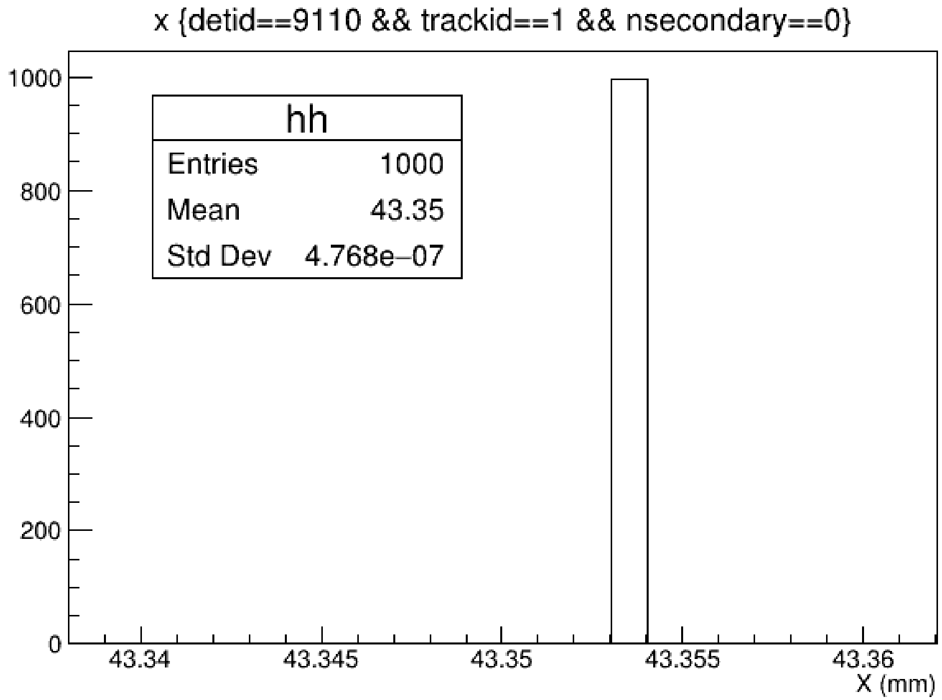


Approximated vs measured

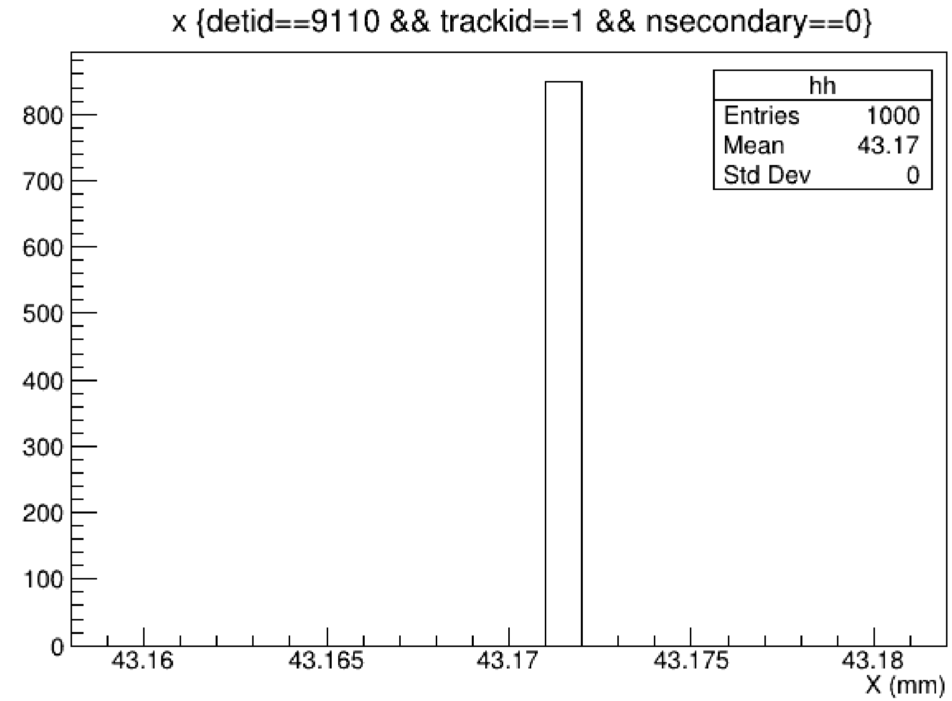
Approximated vs uniform

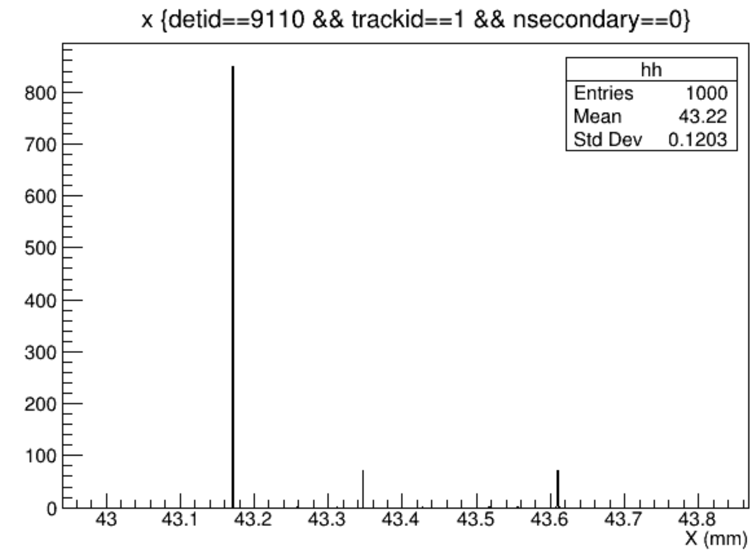


# 10 GeV electron, 300A field




Approximation




Measurements

# Geometry development

| | Item | Description | Dependency | Priority | Commit |
|---|---|---|---|---|---|
| | | | | | |
| 10 | Provide an output of weight and density of all volumes | This might help to check if all volumes in simulation use correct material, and help in absorbed dose calculation. | | M | 56861e7 |
| 11 | Copy primary particle to the Tracks tree | It would be very convenient for MC | | H | ebfb5580 |
| 12 | Interaction chamber with internal components | Current version does not fit the building | 3D CAD | M | |
| 13 | Magnets | All magnets need to be changed | Model choice | | |
| 14 | Realistic magnetic field | | | | |
| 15 | Beam dumps | Coordinate present models with XFEL and update as needed | XEFL | | |
| 16 | Target containers | Vacuum containers for the targets (bremsstrahlung and gamma spectrometer) | 3D CAD | | |
| 17 | Gamma spectrometer mechanical design | Support for the LANEX screens, position, camara positions | 3D CAD | | |
| 18 | Cherenkov detector | Update the model to match recent detector design. Light production. | | | |
| 19 | Tracking detector services | Cooling, kapton cables, connectors, etc | 3D CAD | | |
| 20 | ECal updated casing and electronics | | 3D CAD | | |
| 21 | CALICE ECal for electrons | Import existing model from xml | | | |
| 22 | Beam profiler | Detector design (sensors, PCB, motors), and support | | | |