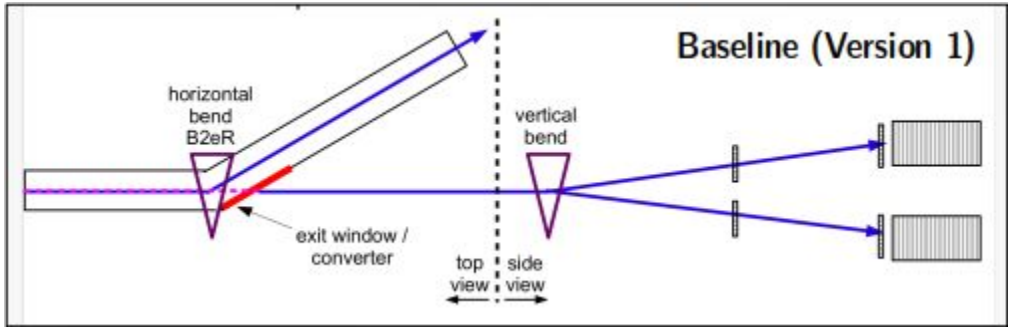
Luminosity Detector Studies in the Fun4All Software Framework

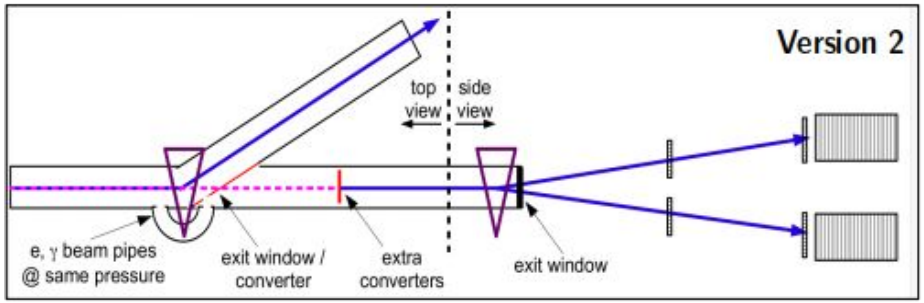
Progress report:

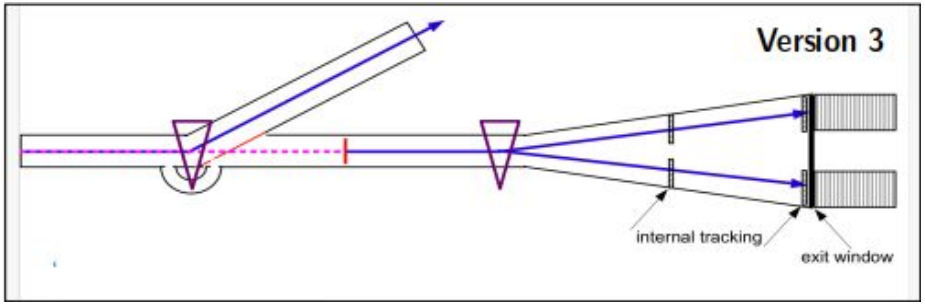
- Implementation of a Luminosity detector is now available to all in the Fun4All software framework.
  - Repo dir: eic/fun4all_eicdetectors/simulation/g4simulation/g4lumi
  - Spectrometer arm with silicon trackers enabled so far.
  - 3 configurations included: baseline detector + 2 extended vacuum designs.
- Initial simulation results to be shown today:
  - XY distributions of electron/positron hits in trackers

Aranya Giri & Dhevan Gangadharan
(University of Houston)
06-16-2022

Possible Designs



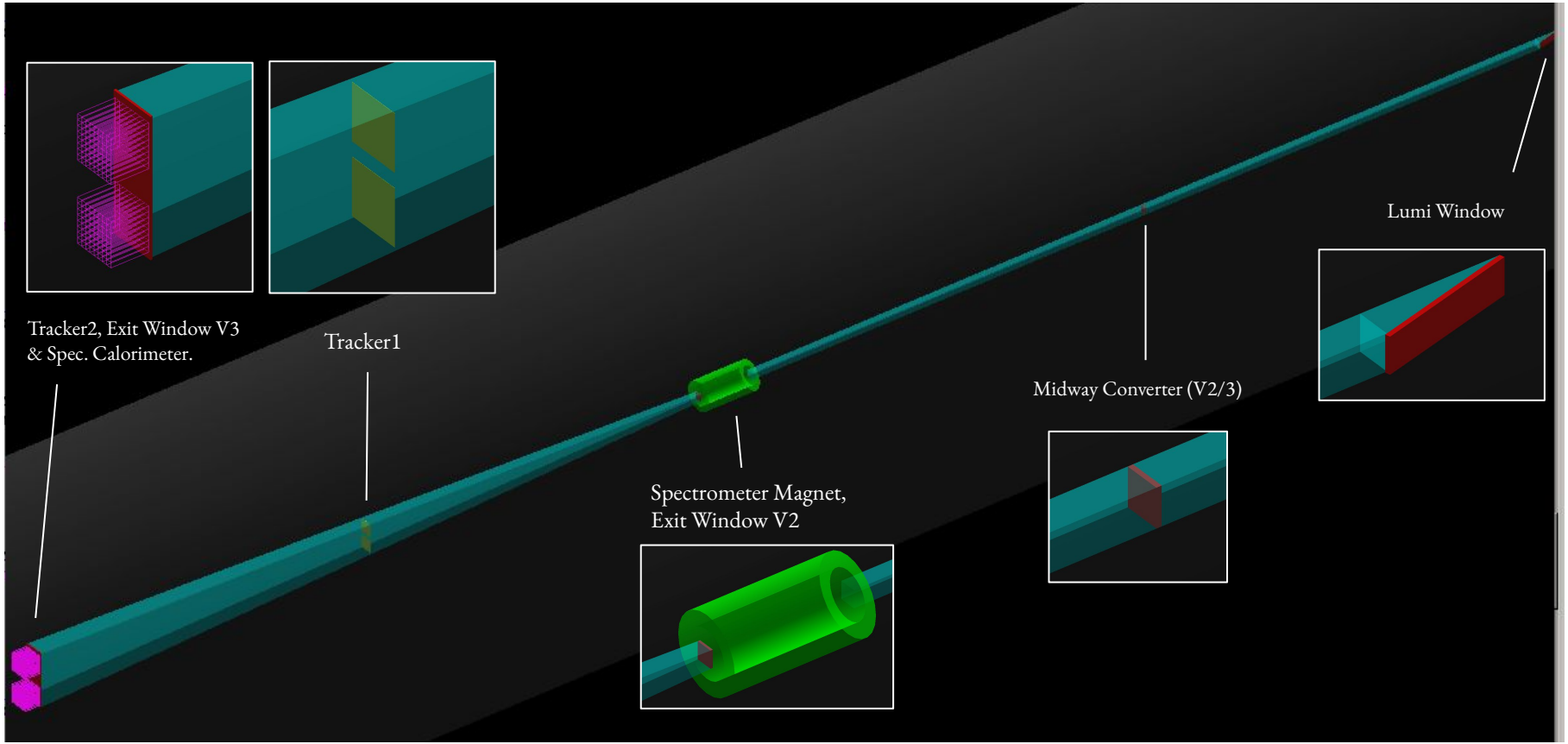




- The designs mainly differ in how far the vacuum region extends and where the thick Aluminum exit window is placed.

Designs by W. Schmidke @ Far Backward Meeting on 4-28-2022

Geant4 implementation for the Design



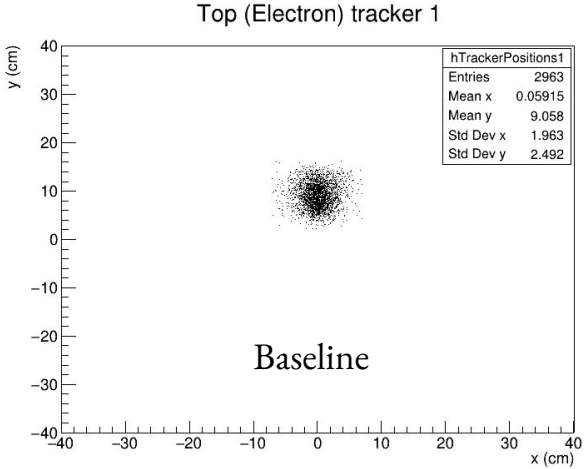
Geant4 implementation Paradigm

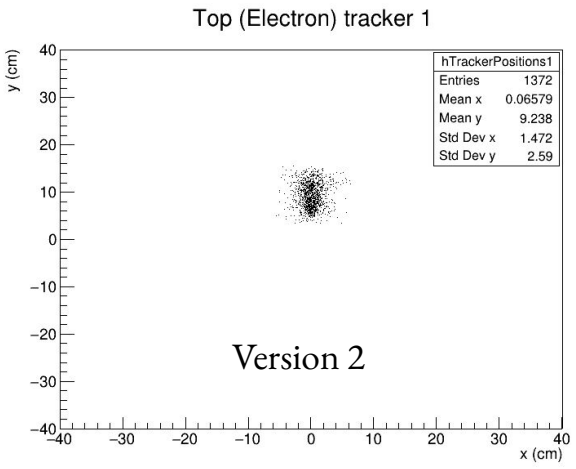
```
##
## sizes are in cm and angles in radians
##
# Lumi Detector Design Version (1,2,3)
Version                 3
# Lumi exit window
LumiWin_X               0
LumiWin_Y               0
LumiWin_Z               -1850
LumiWin_Tilt            1.3207963
LumiWin_Thickness       1.0
LumiWin_Height          7.4
LumiWin_Length          29
LumiWin_Material        G4_Al
# Lumi spectrometer dipole magnet
LumiMag_Z               -2820
LumiMag_innerR          10
LumiMag_outerR          16
LumiMag_DZ              60
LumiMag_B               0.37
LumiMag_VesselMaterial  G4_Fe
# Lumi spectrometers up and down
LumiSpec_Z              -3640
LumiSpec_XY             20
LumiSpec_DZ             35
LumiSpec_YS             6
#Luminosity direct photon calorimeter
LumiPhotonCAL_Z         -3700
LumiPhotonCAL_XY        16
LumiPhotonCAL_DZ        35
#Tracker2 Details
LumiTracker2_DZ         0.06
LumiTracker2_XY         20
#Tracker1 Details
LumiTracker1Gap         2.0
#Dimension for single ee spectrometer Tower
LumiSpecTower_XY        2.5
LumiSpecTower_DZ        17
TotalLumiSpecTower      8
~
```

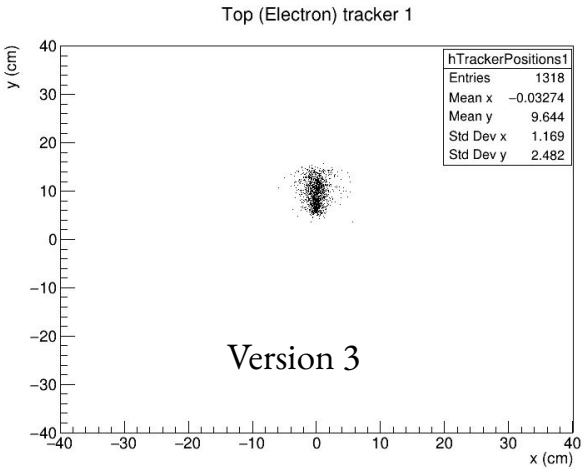
```
// LumiWin_Thickness*factor for different exit window versions/Midway Converter.
double factorV1 = 1.0;
double factorV2 = 1.0;
double factorV3 = 1.0;
double factorMC = 1.0;

// Initialisation of diff. volume region.
std::string LumiWin_Material = m_Params->get_string_param( "LumiWin_Material" );
std::string LumiMag_VesselMaterial = m_Params->get_string_param( "LumiMag_VesselMaterial" );

std::string TrianTrapMaterial = "G4_AIR";
std::string CuboidMaterial = "G4_AIR";
std::string MagCoreMaterial = "G4_AIR";
std::string RecConeMaterial = "G4_AIR";
std::string ExitWinV2Material = "G4_AIR";
std::string ExitWinV3Material = "G4_AIR";
std::string MidConvMaterial = "G4_AIR";

//Change the material according to Version.
switch(Version){

  case 1: //No change in material def.
    break;

  case 2: TrianTrapMaterial       = "G4_Galactic";
          CuboidMaterial          = "G4_Galactic";
          MagCoreMaterial         = "G4_Galactic";
          MidConvMaterial         = LumiWin_Material;
          ExitWinV2Material       = LumiWin_Material;
          factorV1                = 0.1;
          break;

  case 3: TrianTrapMaterial       = "G4_Galactic";
          CuboidMaterial          = "G4_Galactic";
          MagCoreMaterial         = "G4_Galactic";
          RecConeMaterial         = "G4_Galactic";
          ExitWinV2Material       = "G4_Galactic";
          MidConvMaterial         = LumiWin_Material;
          ExitWinV3Material       = LumiWin_Material;
          factorV1                = 0.1;
          break;

  default : std::cout<<"WRONG CHOICE (ONLY 1, 2 & 3)"<<endl;
            break;

}
```

According to Version, the material of detector components change.

Initial Simulation Results







- 5000 events generated
- 5 GeV photon beam without transverse smearing.
- Hit_points considered only when electron crosses top two trackers and its pair produced positron crosses bottom two trackers.

Initial Simulation Results

Top (Electron) Tracker 1

(in cm)	Baseline	Version 2	Version 3
$\langle x \rangle$	0.059	0.066	-0.033
σ_x	1.963	1.472	1.169
$\langle y \rangle$	9.058	9.238	9.644
σ_y	2.492	2.590	2.482

Botton (Positron) Tracker 1

(in cm)	Baseline	Version 2	Version 3
$\langle x \rangle$	-0.035	0.024	0.019
σ_x	1.949	1.369	1.134
$\langle y \rangle$	-8.992	-9.197	-9.463
σ_y	2.541	2.571	2.383

- Spread of hit points along x-axis decreases from baseline to Version 3.

Initial Simulation Results

Top (Electron) Tracker 2

(in cm)	Baseline	Version 2	Version 3
$\langle x \rangle$	0.051	0.130	-0.01422
σ_x	2.663	2.368	1.785
$\langle y \rangle$	17.41	17.9	18.37
σ_y	4.22	4.7	4.71

Botton (Positron) Tracker 2

(in cm)	Baseline	Version 2	Version 3
$\langle x \rangle$	-0.041	0.020	0.074
σ_x	2.667	2.308	1.728
$\langle y \rangle$	-17.33	-17.82	-17.98
σ_y	4.30	4.629	4.44

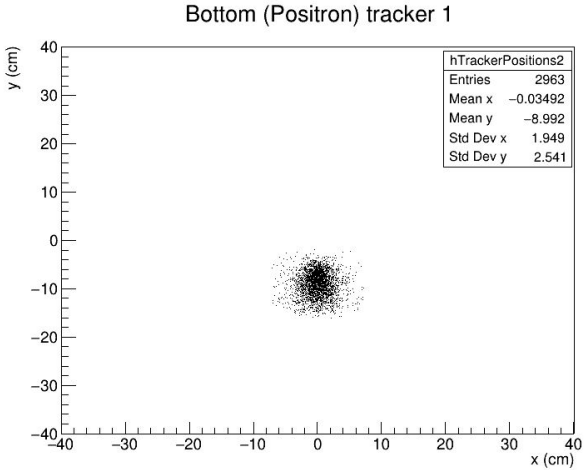
- Spread of hit points along x-axis decreases from baseline to Version 3.

Next Steps

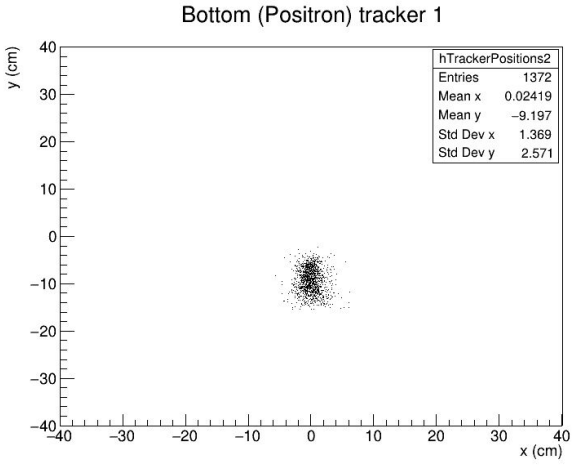
- From the hit locations reconstruct the e+e- energy and thus the photon energy.
- Compare E_gen to E_rec for each vacuum configuration to assess the advantages of designs 2 and 3 over the baseline.

BACK UP

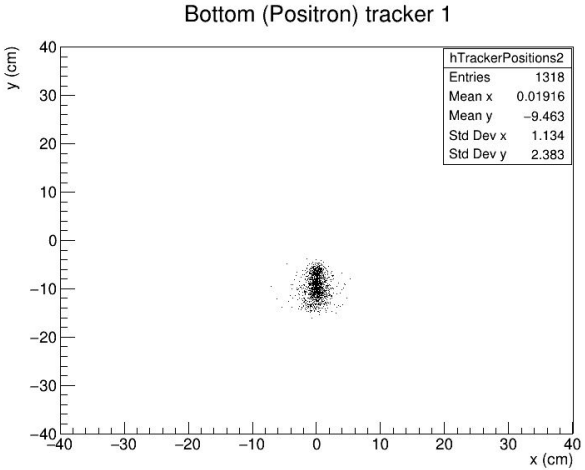
Initial Simulation Results



Baseline

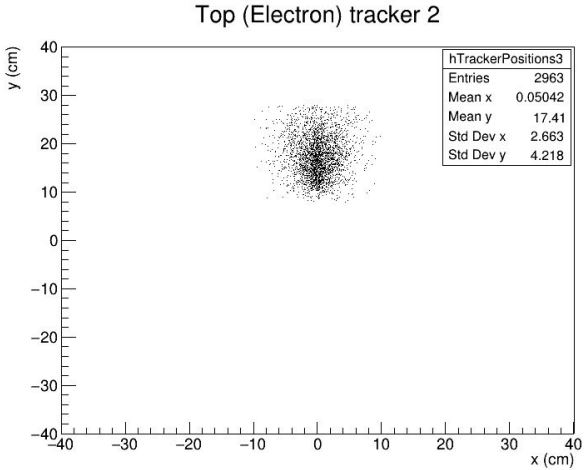


Version 2

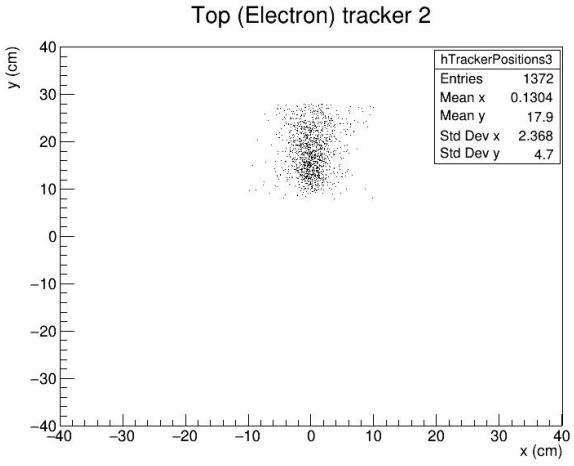


Version 3

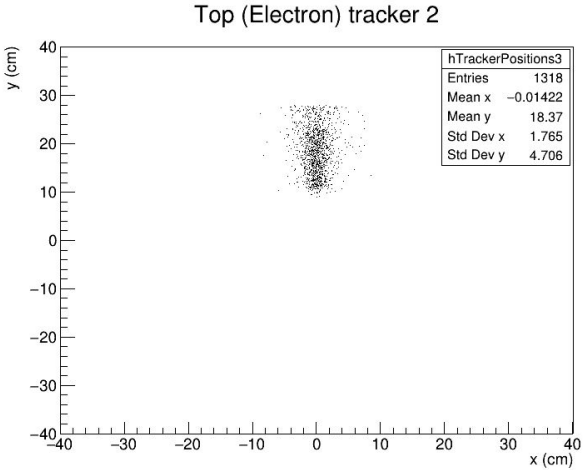
Initial Simulation Results



Baseline

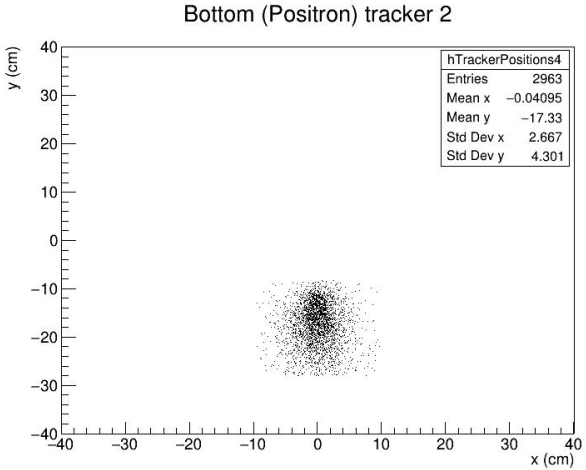


Version 2

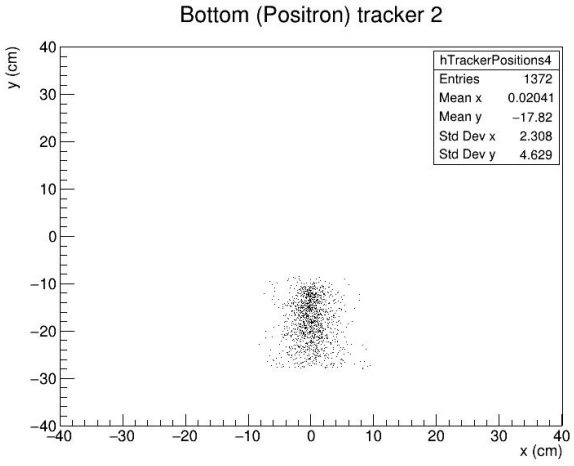


Version 3

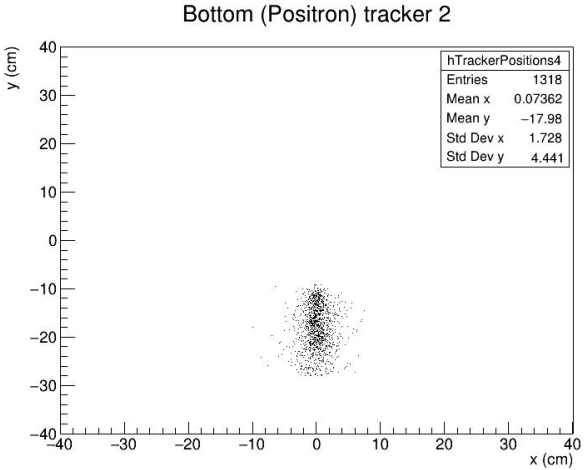
Initial Simulation Results



Baseline



Version 2



Version 3