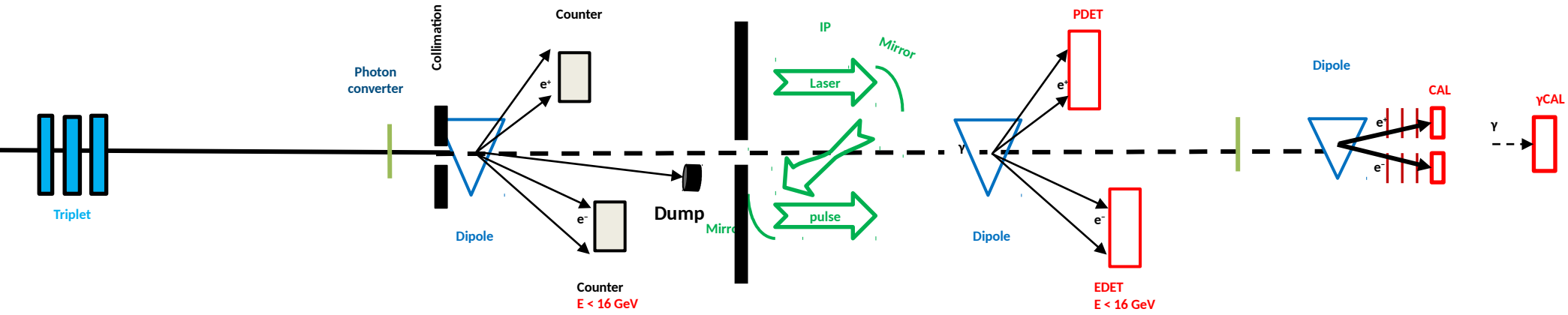
Bremsstrahlung simulation with Geant4

Oleksandr Borysov

LUXE Meeting
January 21, 2019

Photon-Photon collisions at LUXE

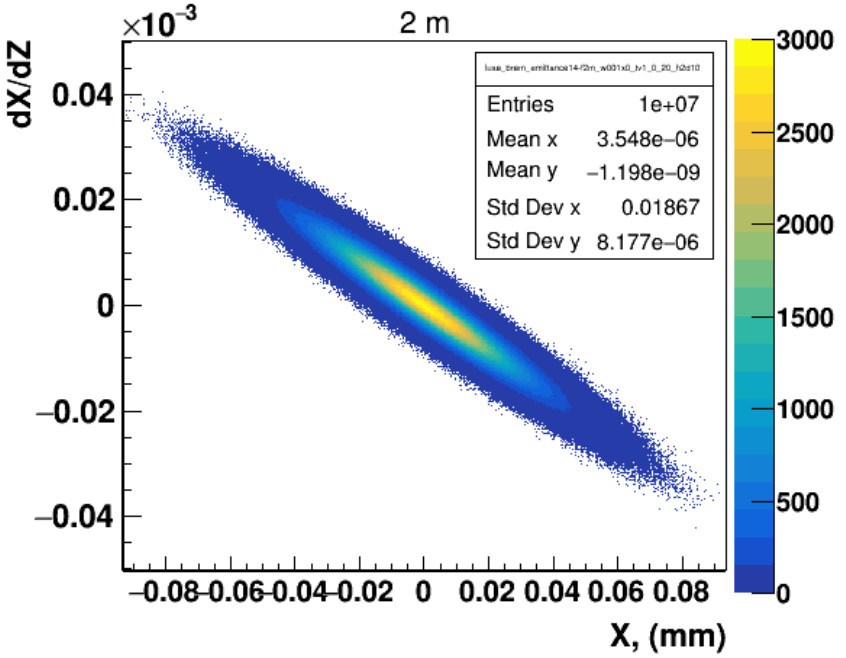


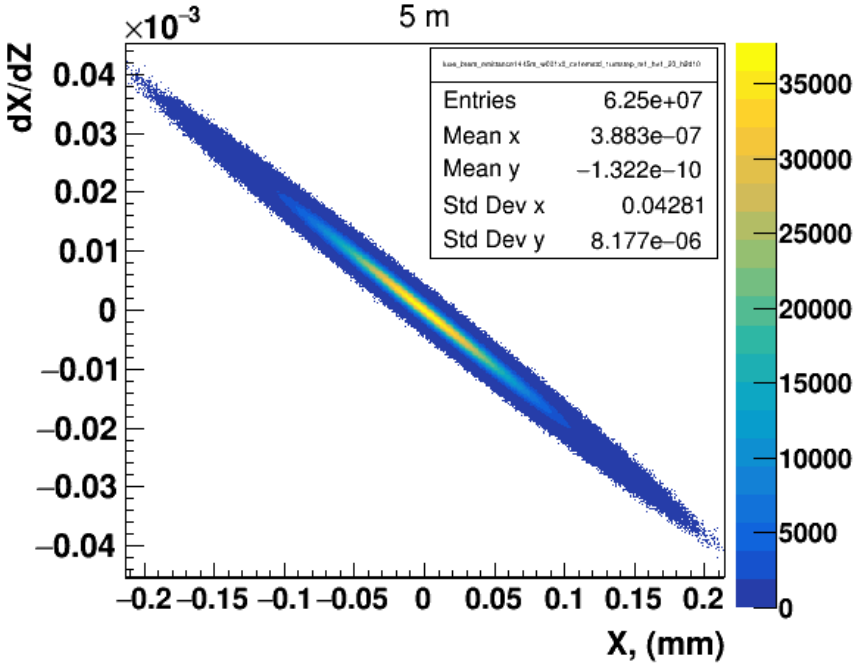
9 m | 11 m | 3 m | 7 m

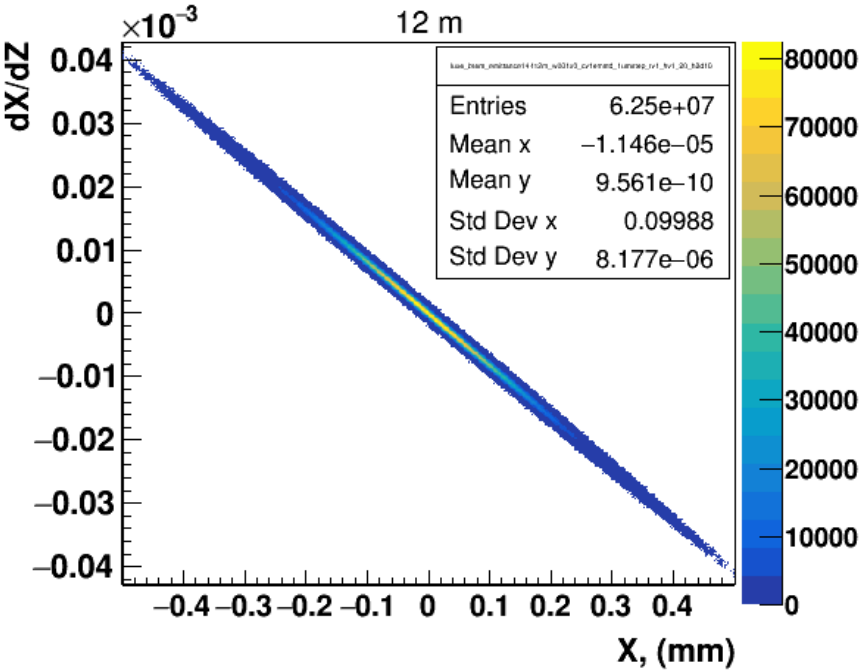
Preliminary estimates!

Target 2 m, 5 m and 12 m upstream of IP

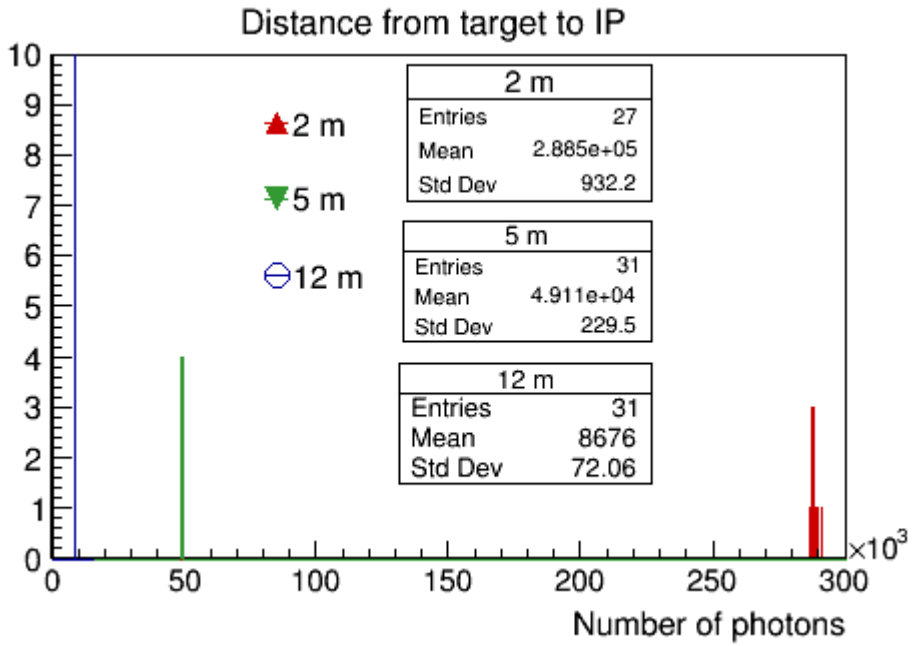
- 2 m: σx = 19 μm;
- 5 m: σx = 43 μm;
- 12 m: σx = 100 μm;







Number of photons



$$N \sim \frac{1}{l^2}$$

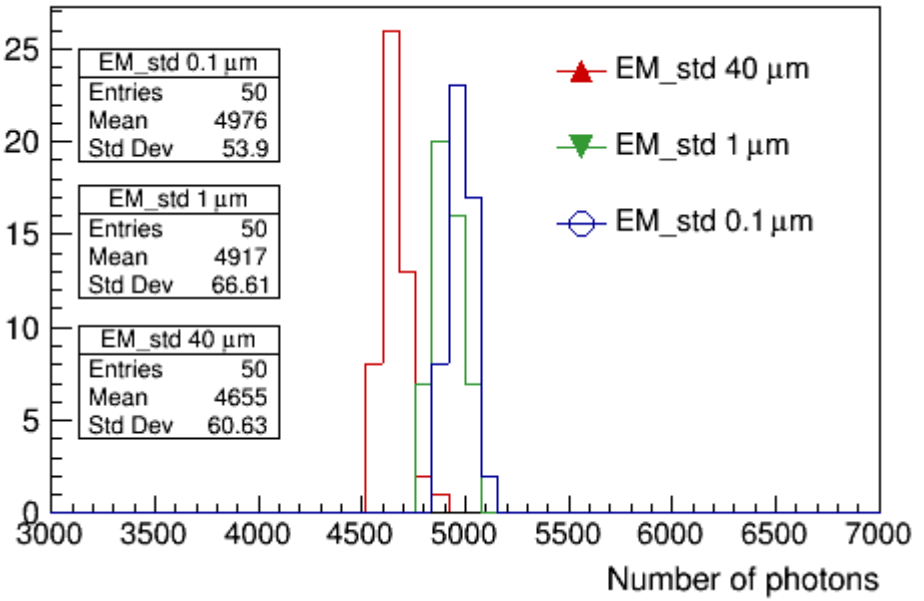
Z, (m)	Z^2	N_Gamma	Z1^2 / Z2^2	N2 / N1		Z1^2 / Z2^2	N2 / N1	
2	4	2.89E+05	6.25E+00	5.8746	0.94	36	33.2565	0.924
5	25	4.91E+04	5.76E+00	5.6611	0.983			
12	144	8675						

Geant4 simulation with different step, different physics lists, different beam

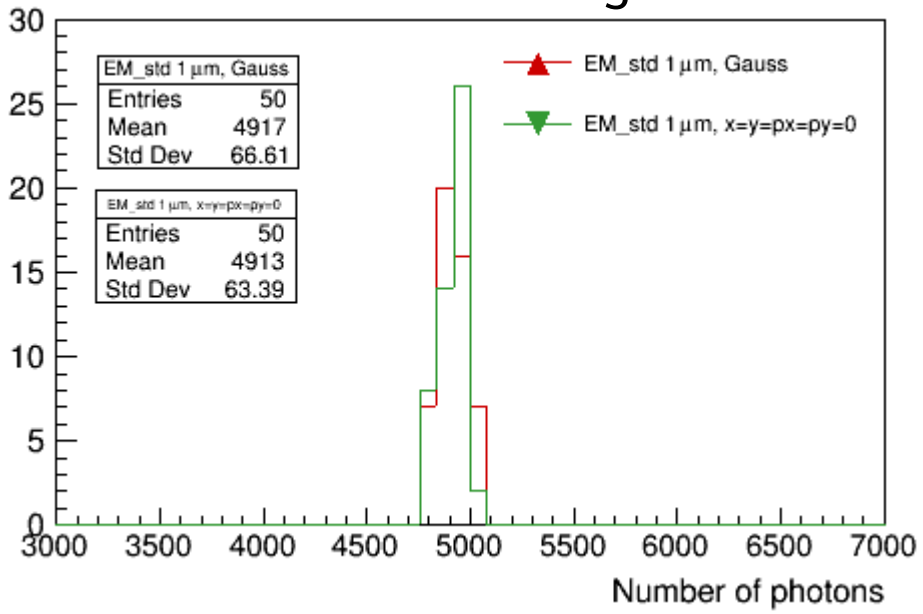
- Gaussian beam, focused on IP;
- Tungsten target 1%X0 (35um) thickness
- 5 m from IP;
- 6.25 M electrons (BX/1000);
- Production cut: 1 μm.

Number of photons inside
|x|<25um and
|y|<25um;

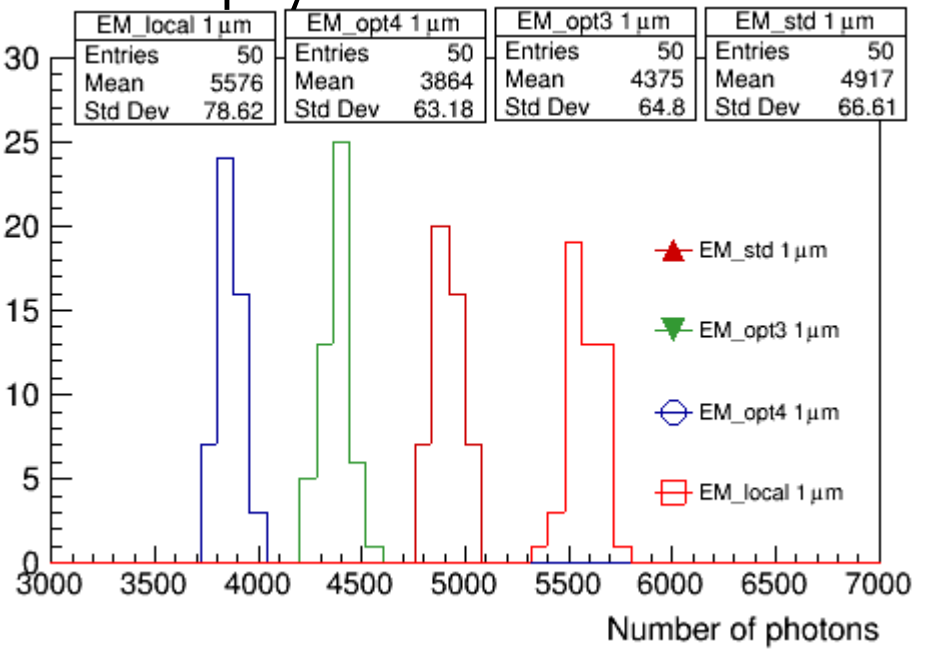
Different step



Different beam settings



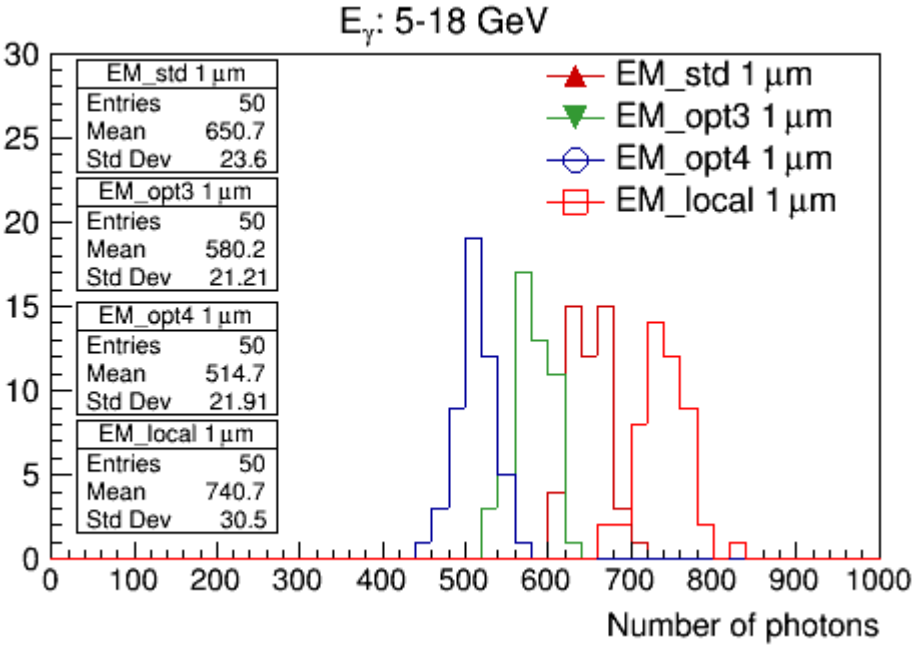
Different physics lists

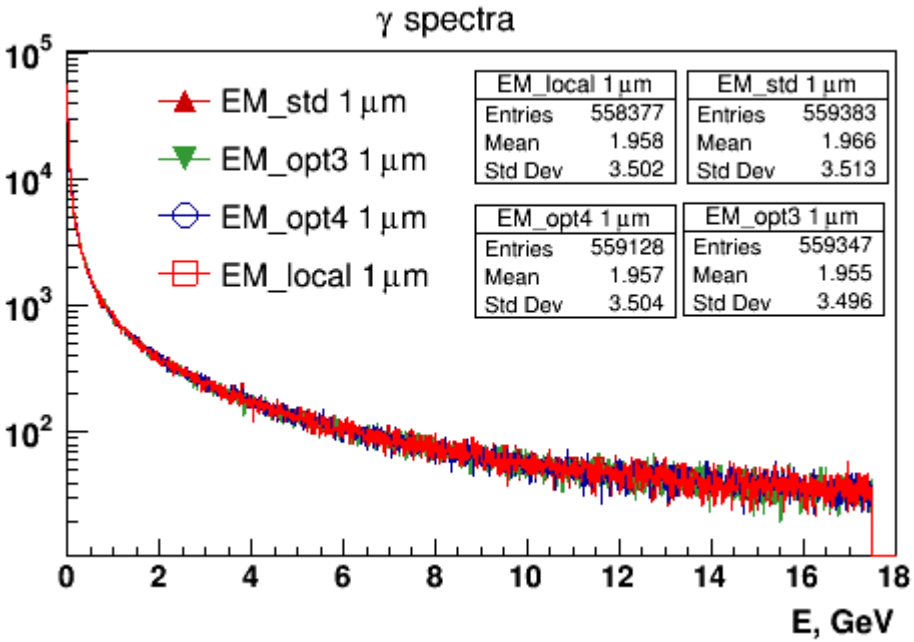


Spectra for different physics lists

- Gaussian beam, focused on IP;
- Tungsten target 1%X0 (35um) thickness
- 5 m from IP;
- 6.25 M electrons (BX/1000);
- Production cut: 1 μm.

Number of photons inside
|x|<25um and
|y|<25um and
5GeV < Ey < 18GeV;





Geant4 reference physics lists

- EM physics for simulation with high accuracy due to "UseDistanceToBoundary" multiple scattering step limitation and usage of `G4UrbanMscModel` for all charged particles, reduced *finalRange* parameter of stepping function optimized per particle type, alternative model `G4KleinNishinaModel` for Compton scattering, enabled fluorescence, enabled nuclear stopping, `G4Generator2BS` angular generator for bremsstrahlung, `G4IonParameterisedLossModel` for ion ionisation, `G4ePairProduction` for electron/positron, 20 bins energy decade of physics tables, and 10 eV low-energy limit for tables (class name `G4EmStandardPhysics_option3`)
- Combination of EM models for simulation with high accuracy includes multiple scattering with "UseSafetyPlus" type of step limitation by combined `G4WentzelVIModel` and `G4eCoulombScatteringModel` for all particle types, for of e+- below 100 MeV `G4GoudsmitSaundersonMscModel` is used, `RangeFactor = 0.2`, `Scin = 3` (error free stepping near geometry boundaries), reduced *finalRange* parameter of stepping function optimized per particle type, enabled fluorescence, enabled nuclear stopping, enable accurate angular generator for ionisation models, `G4LowEPComptonModel` below 20 MeV, `G4PenelopeGammaConversionModel` below 1 GeV, `G4LivermoreIonisationModel` for electrons and positrons below 100 keV, `G4IonParameterisedLossModel` for ion ionisation, `G4Generator2BS` angular generator for bremsstrahlung, `G4ePairProduction` for electron/positron, and 20 bins per energy decade of physics tables, (class name `G4EmStandardPhysics_option4`)