Bremsstrahlung Photon Production for BPPP Study

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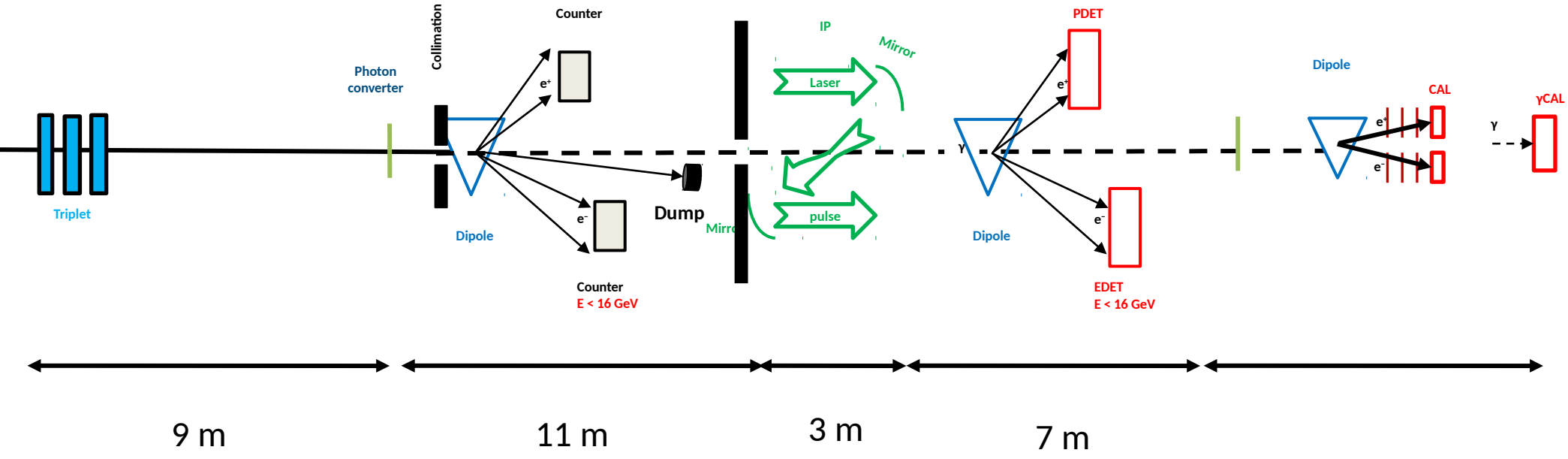
LUXE Meeting
January 31, 2019

Photon-Photon collisions at LUXE



9 m | 11 m | 3 m | 7 m

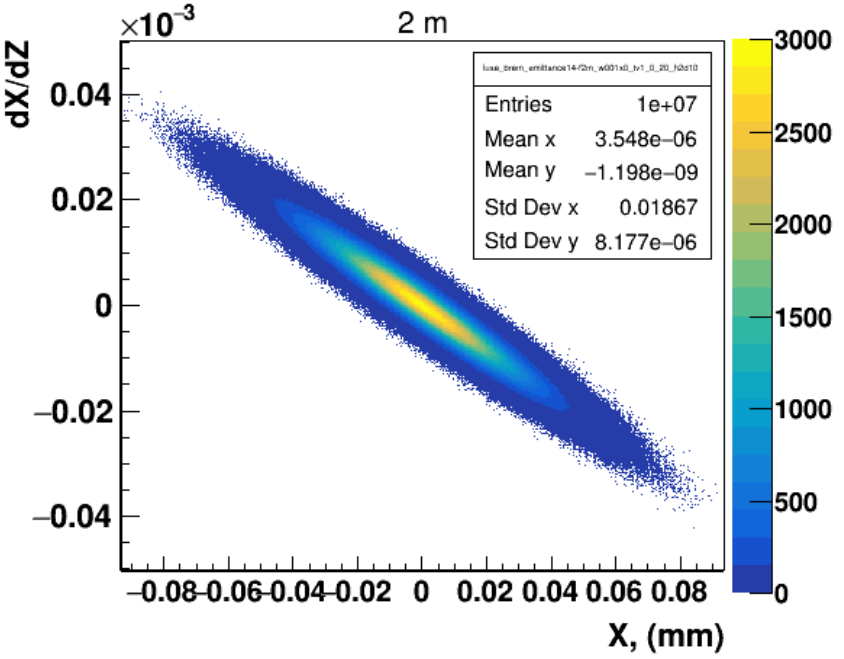
Preliminary estimates!

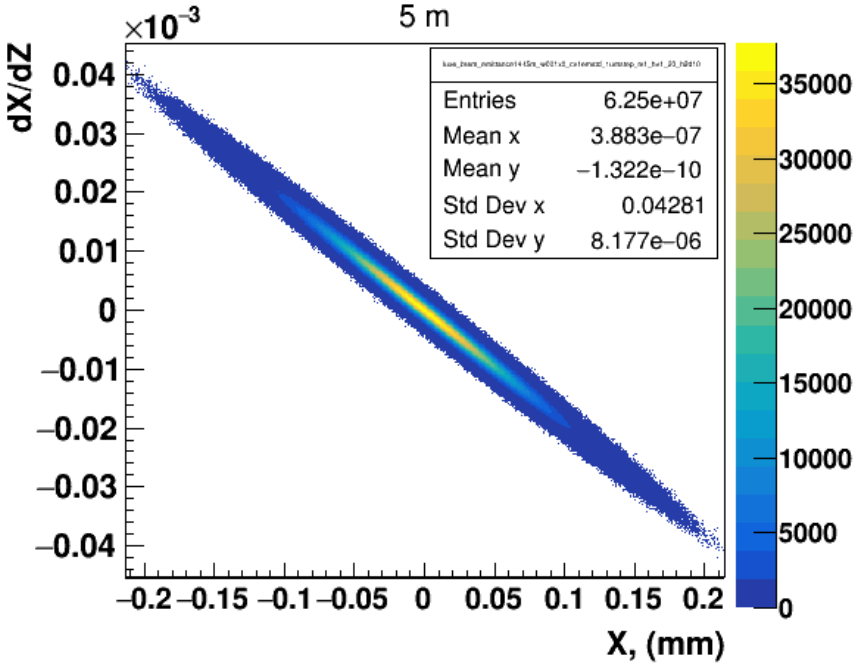
Target 2 m, 5 m and 12 m upstream of IP

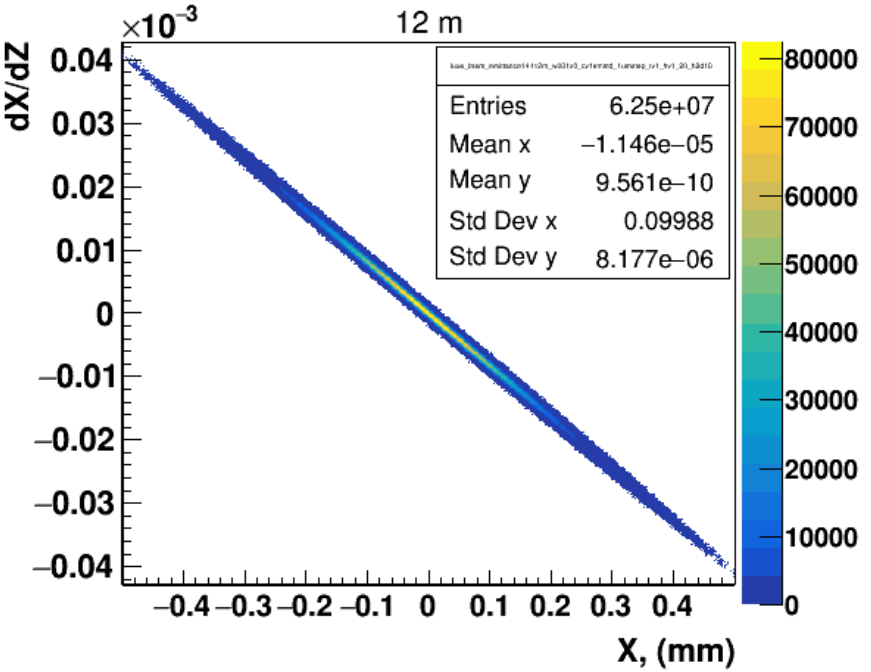
Initial electrons distribution in phase space for Gaussian beam with $\sigma_{x,y}$ = 5um at IP.

Beam spot size on the target

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

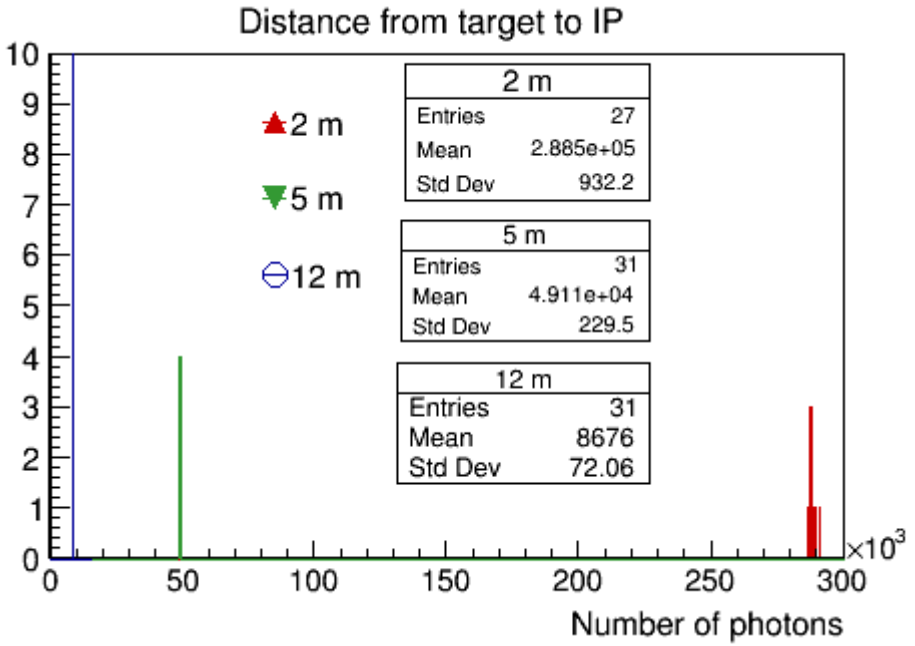






Number of photons

- Geant4 simulation;
- Tungsten target 1%X0 (35um) at different distance to IP;
- Gaussian beam focused on IP;
- 6.25e7 electrons;



Number of photons inside
|x|<25um and
|y|<25um
around IP.

Within 10% scales as $N \sim \frac{1}{l^2}$

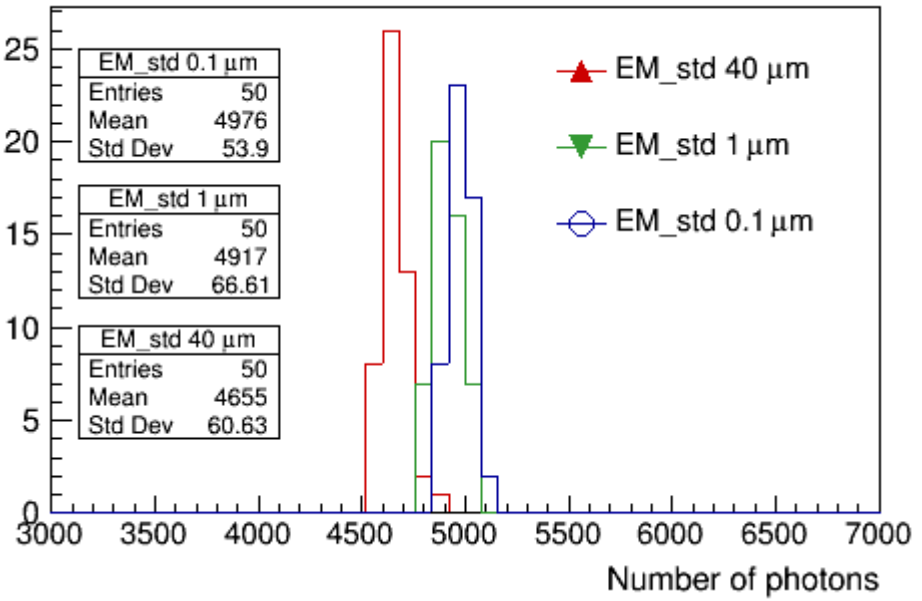
Z, (m)	Z^2	N_Gamma	Z1^2 / Z2^2	N2 / N1		Z1^2 / Z2^2	N2 / N1	
2	4	2.89E+05	6.25	5.87	0.94	36	33.2565	0.924
5	25	4.91E+04	5.76	5.66	0.98			
12	144	8675						

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

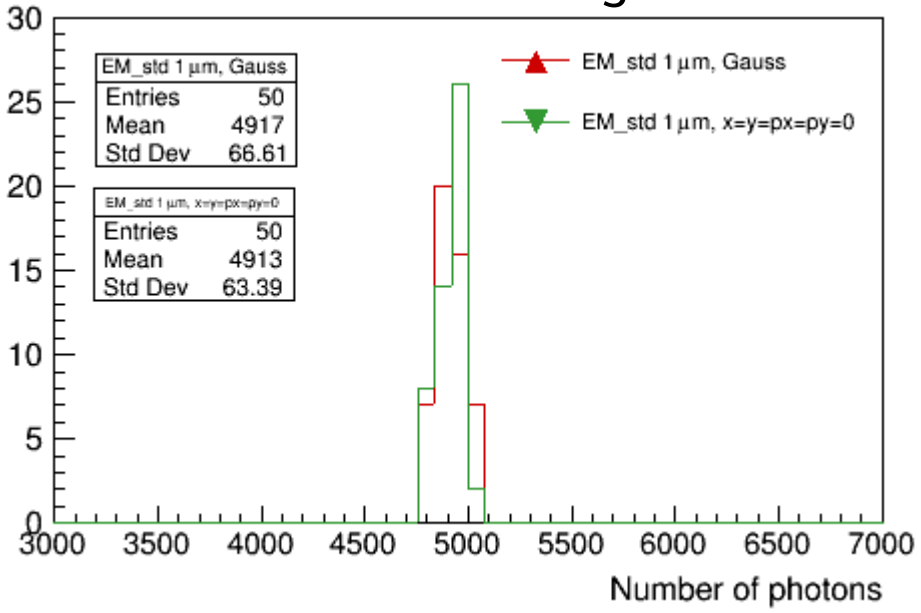
- Gaussian beam, focused on IP;
- Tungsten target 1%X0 (35um) thickness
- 5 m from IP;
- 6.25 M electrons (BX/1000);
- Production cut: 1 μm.

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

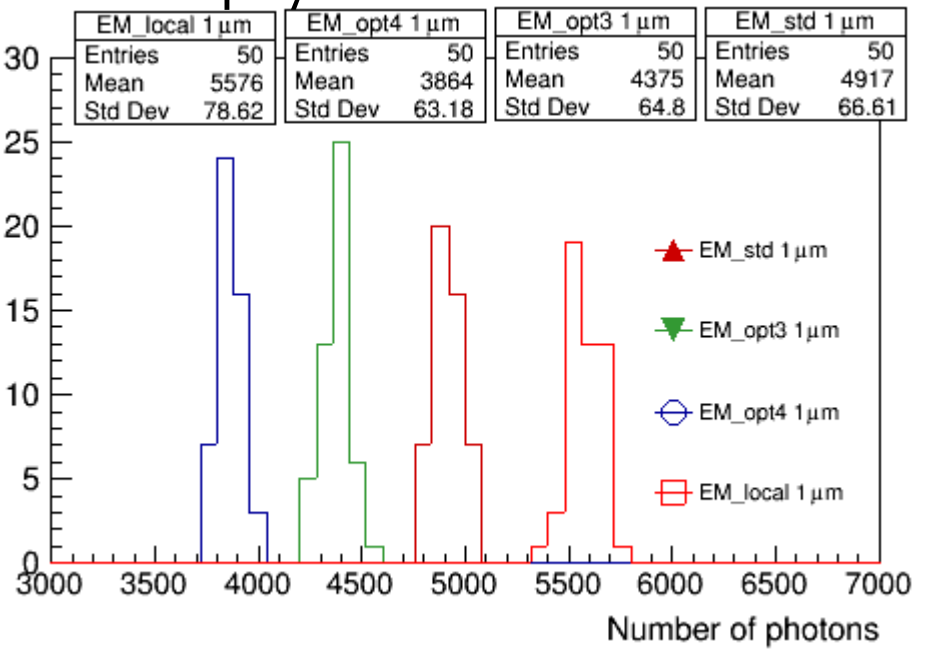
Different step



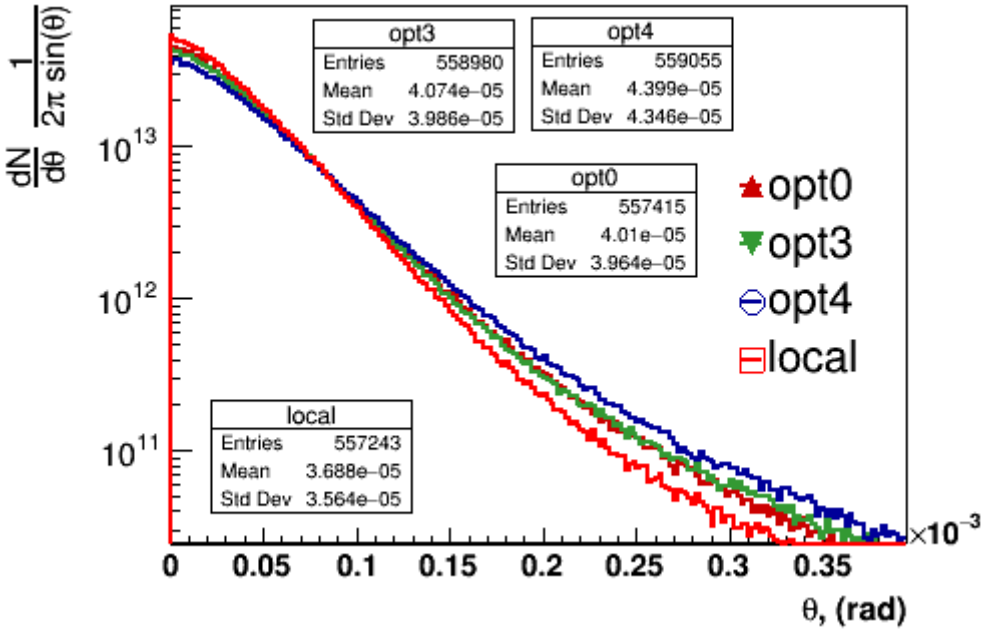
Different beam settings

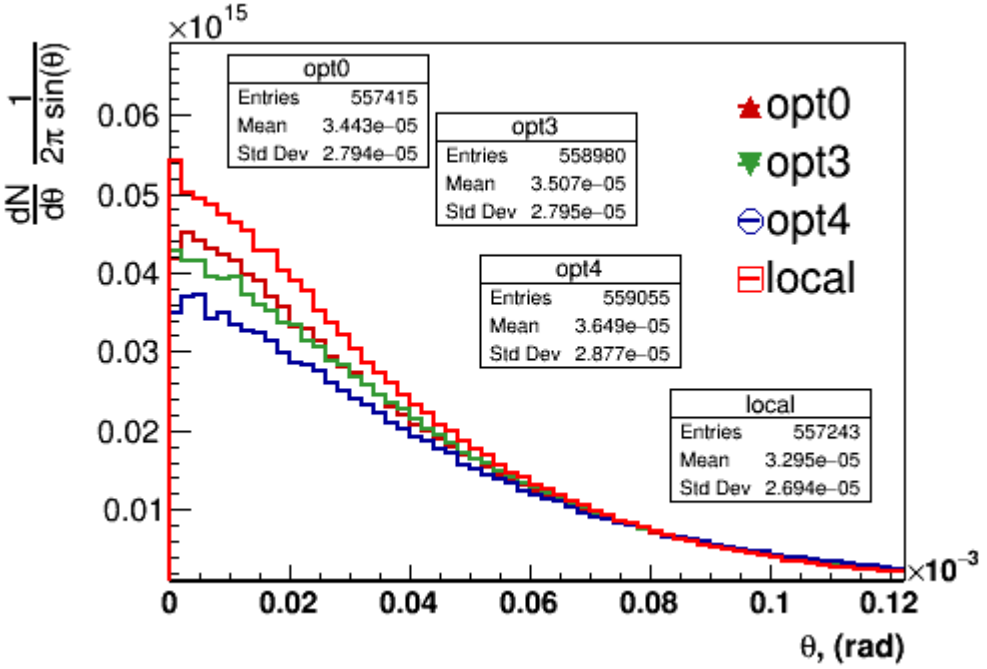


Different physics lists



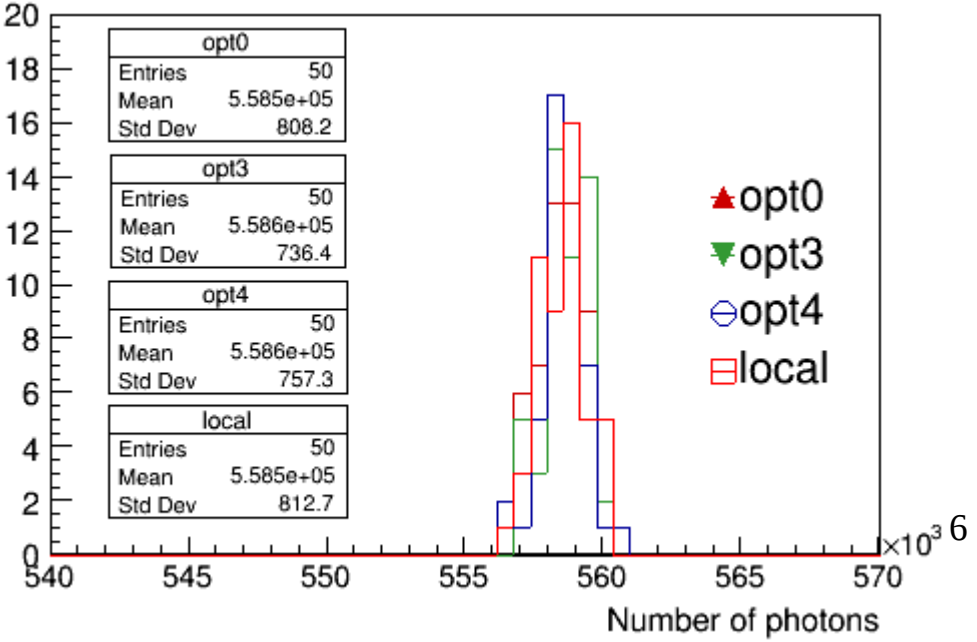
γ angular distribution for different physics lists





- Angular distribution is the widest for option_4 physics list and the narrowest for the local one.
- Angular distribution explains bottom right plot on previous slide.
- Total number of photons in forward region is identical for all physics lists.

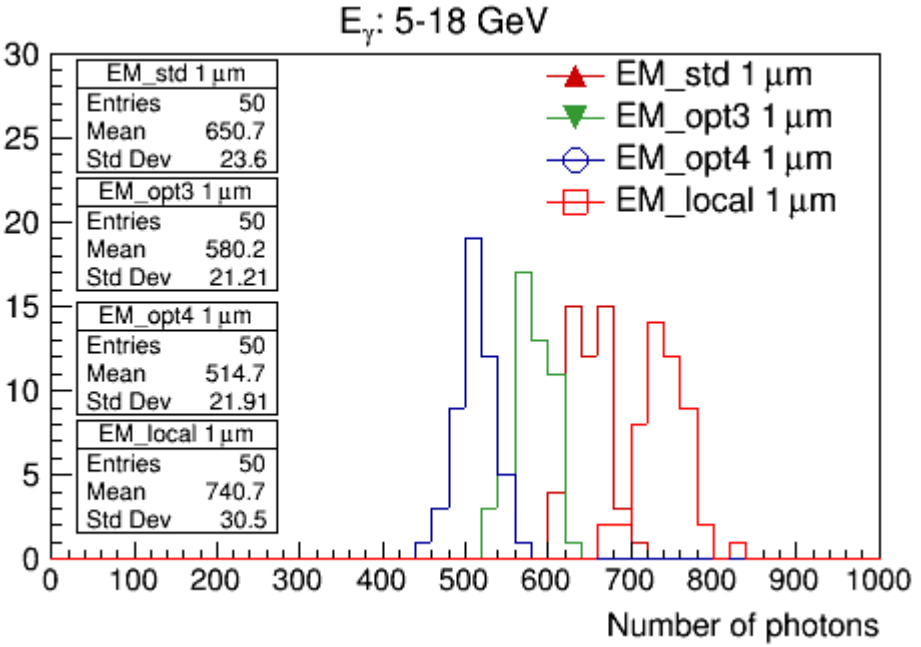
Number of photons inside
|x|<1.5 m and
|y|<1.5 m

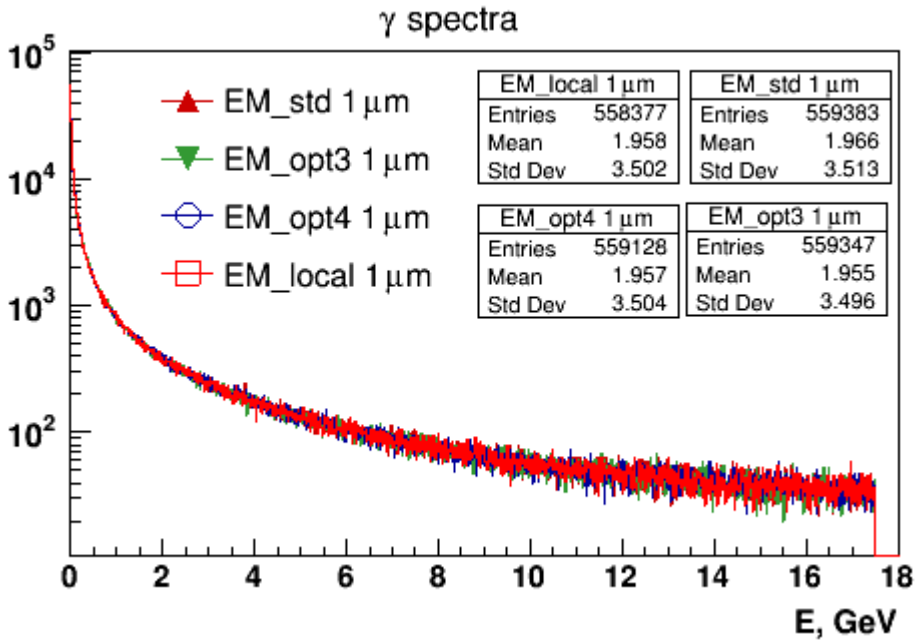


Spectra for different physics lists

- 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 < Eγ < 18GeV;





- The ratio between numbers with and without energy cut is identical:
- For option_0 and option_4 physics sit it is 26%-27% .

```
root [1] 4917.0/3864.0
(double) 1.27252
root [2] 650.0/514.0
(double) 1.26459
```

Physics list comparison

Option 3

```
msc:   for e-    SubType= 10
      RangeFactor= 0.04, stepLimitType: 3, latDisplacement: 1, skin= 1, geomFactor= 2.5
      ===== EM models for the G4Region  DefaultRegionForTheWorld ======
            UrbanMsc :  Emin=        0 eV    Emax=       10 TeV  Table with 220 bins Emin=    100 eV    Emax=     10 TeV
```

```
eIoni:   for  e-    SubType= 2
      dE/dx and range tables from 10 eV  to 10 TeV in 240 bins
      Lambda tables from threshold to 10 TeV, 20 bins per decade, spline: 1
      finalRange(mm)= 0.1, dRoverRange= 0.2, integral: 1, fluct: 1, linLossLimit= 0.01
      ===== EM models for the G4Region  DefaultRegionForTheWorld ======
        MollerBhabha :  Emin=        0 eV    Emax=       10 TeV
```

Option 4

```
msc:   for e-    SubType= 10
      RangeFactor= 0.02, stepLimitType: 3, latDisplacement: 1, skin= 1, geomFactor= 2.5
      ===== EM models for the G4Region  DefaultRegionForTheWorld ======
            UrbanMsc :  Emin=        0 eV    Emax=      100 MeV  Table with 120 bins Emin=    100 eV    Emax=    100 MeV
         WentzelVIUni :  Emin=      100 MeV   Emax=       10 TeV  Table with 100 bins Emin=    100 MeV   Emax=     10 TeV
```

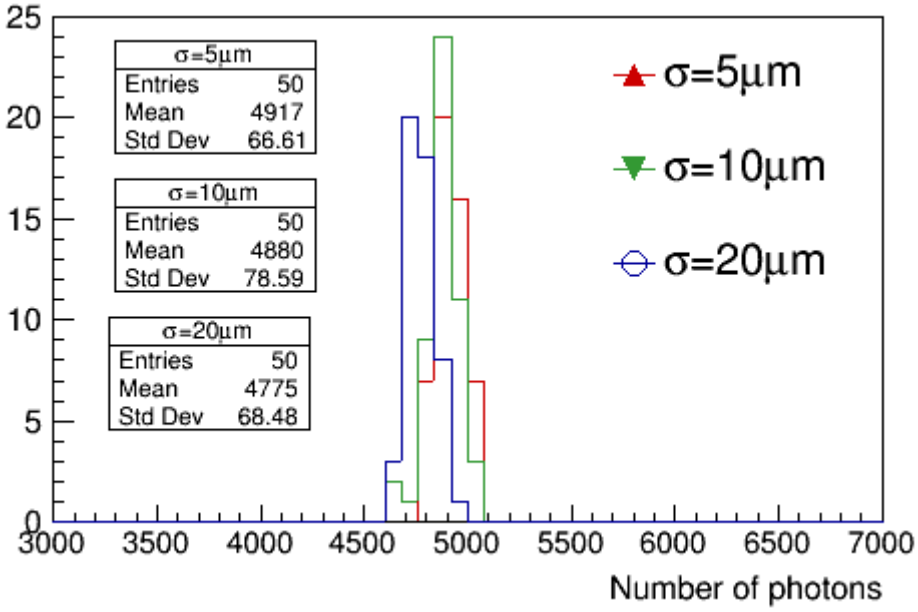
```
eIoni:   for  e-    SubType= 2
      dE/dx and range tables from 100 eV  to 10 TeV in 220 bins
      Lambda tables from threshold to 10 TeV, 20 bins per decade, spline: 1
      finalRange(mm)= 0.1, dRoverRange= 0.2, integral: 1, fluct: 1, linLossLimit= 0.01
      ===== EM models for the G4Region  DefaultRegionForTheWorld ======
            PenIoni :  Emin=        0 eV    Emax=        1 MeV
        MollerBhabha :  Emin=        1 MeV   Emax=       10 TeV   deltaVI
```

```
CoulombScat:   for  e-, integral: 1     SubType= 1  BuildTable= 1
      Lambda table from 100 MeV to 10 TeV, 20 bins per decade, spline: 1
      180 < Theta(degree) < 180; pLimit(GeV^1)= 0.139531
      ===== EM models for the G4Region  DefaultRegionForTheWorld ======
  eCoulombScattering :  Emin=      100 MeV   Emax=       10 TeV
```

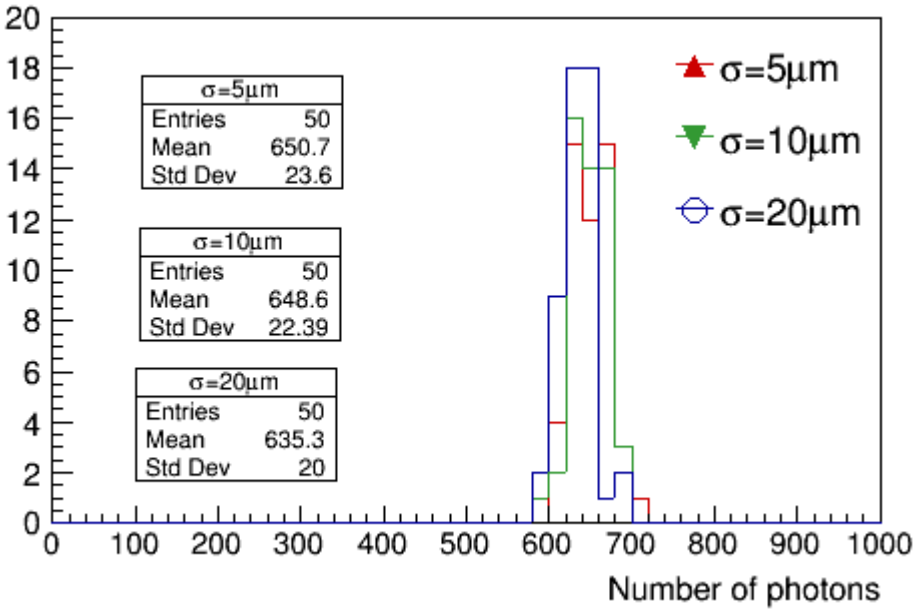
Different beam size in IP

- 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;
- EM standard option_0 physics list.

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



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



Summary and plans

- Bremsstrahlung photons were generated in Geant4 simulation with 1%X0 tungsten target 5m and 12 m to IP and are used for BPPP simulation study.
- Number of Bremsstrahlung photons in IP area scales with the distance from the target as $1/L^2$ (within 10%).
- Number of Bremsstrahlung photons produced in Geant4 simulation was studied with different simulation parameters:
  - different step size (difference is 1% below 1um);
  - different physics lists (difference within 30%; significant contribution from multiple scattering processes);
  - different focusing (less than 1% for beam size below 20um).
- Consider a possibility of beam test study.

Electron and laser beam parameters

E_pulse, μJ	Crossing angle, rad	Laser σxy, μm	Laser σz, ps	N Electrons	Electron σx, mm	Electron σy, mm	Electron σz, ps
3.5*10^6	0.3	10	0.035	6.25E+09	0.005	0.005	0.08

- Laser wavelength = 800.00 nm (1.5498 eV);
- Circular polarized.