Synchrotron Radiation in the electron polarimeter

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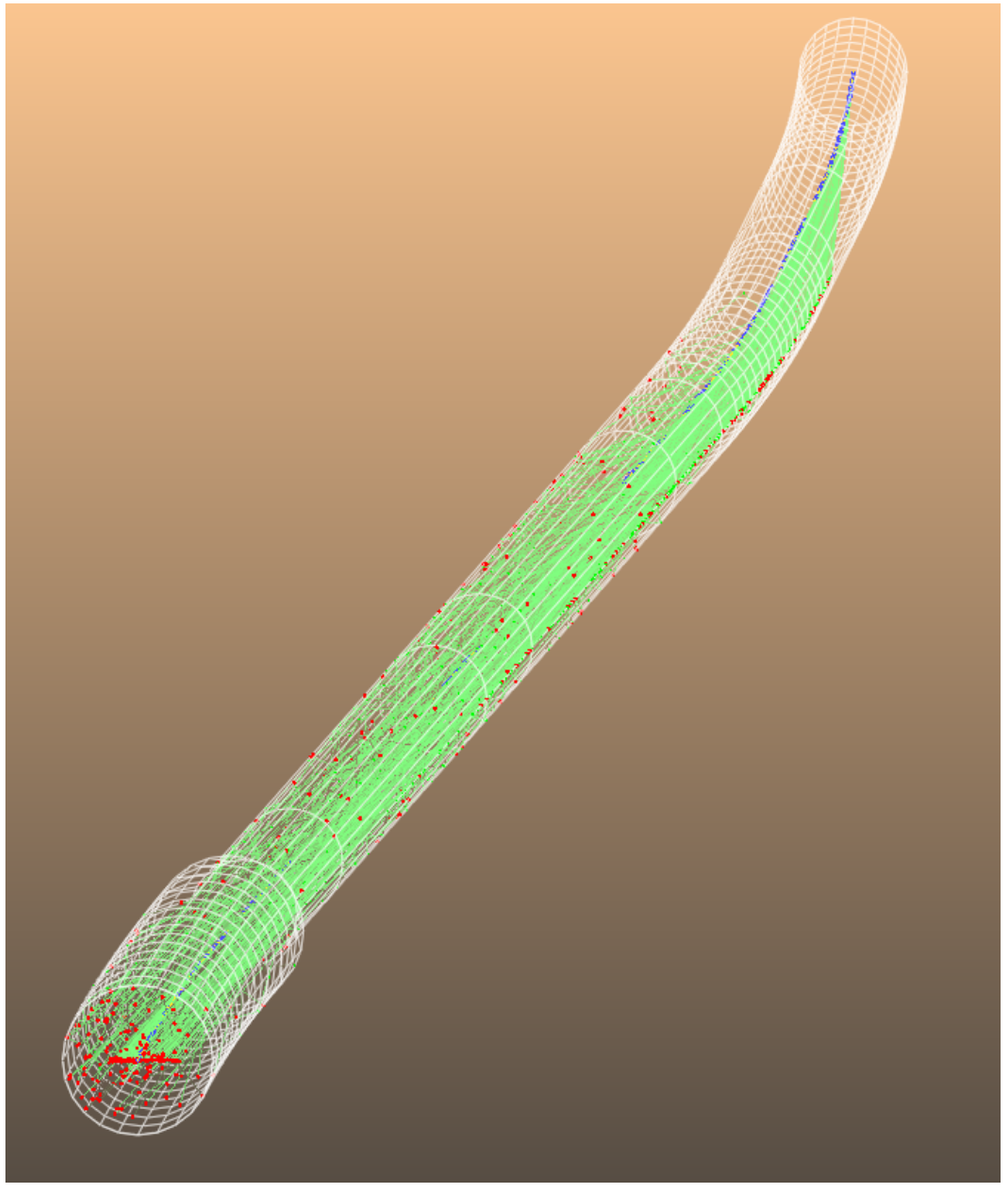
Synrad+ simulation

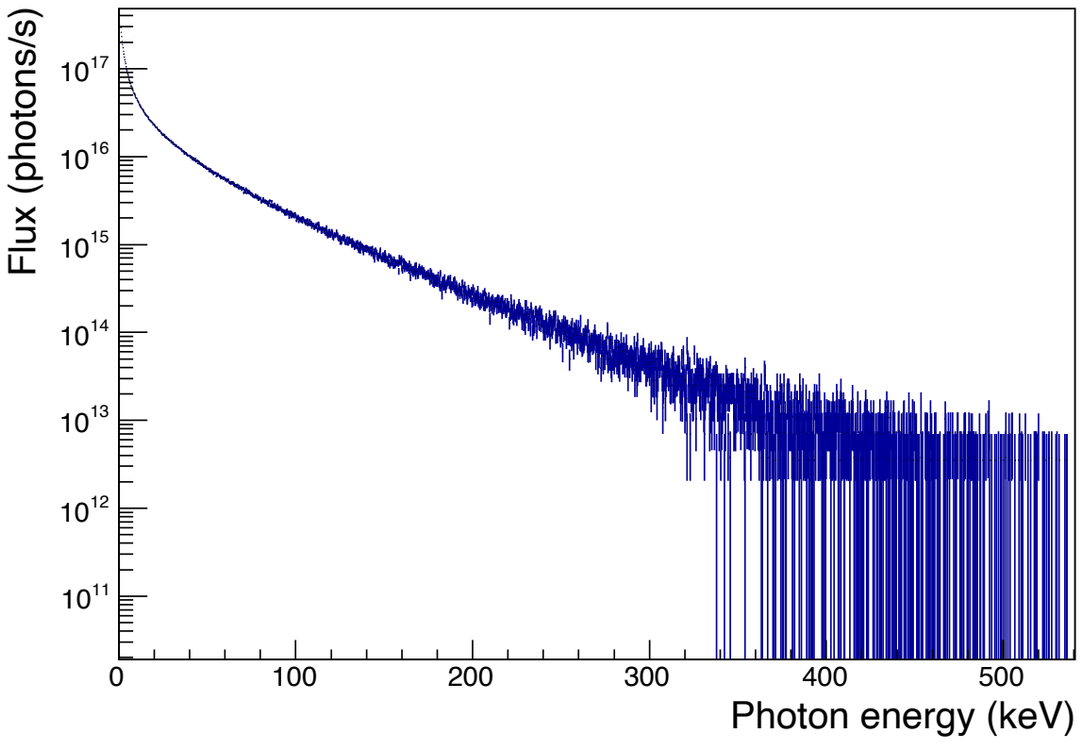
- 18 GeV electrons
- 227 mA beam current
- Emittance_X 2.4x10^-8 meter,
  Emittance_Y 2.0x10^-9 meter,
  - Energy spread 0.10%
- Photon energy cut 1keV
- Beam pipe material: Cooper with 0.01 roughness
- Electron beam profile from accelerator lattice files
- Add radiation from three dipoles and four quadrupoles in the upstream
- Beam tail would be added in the further study, 5% beam current with 3-4 times bigger than the core X sigma and the Y sigma usually about 10 times bigger than the core sigma —— suggested by Mike Sullivan

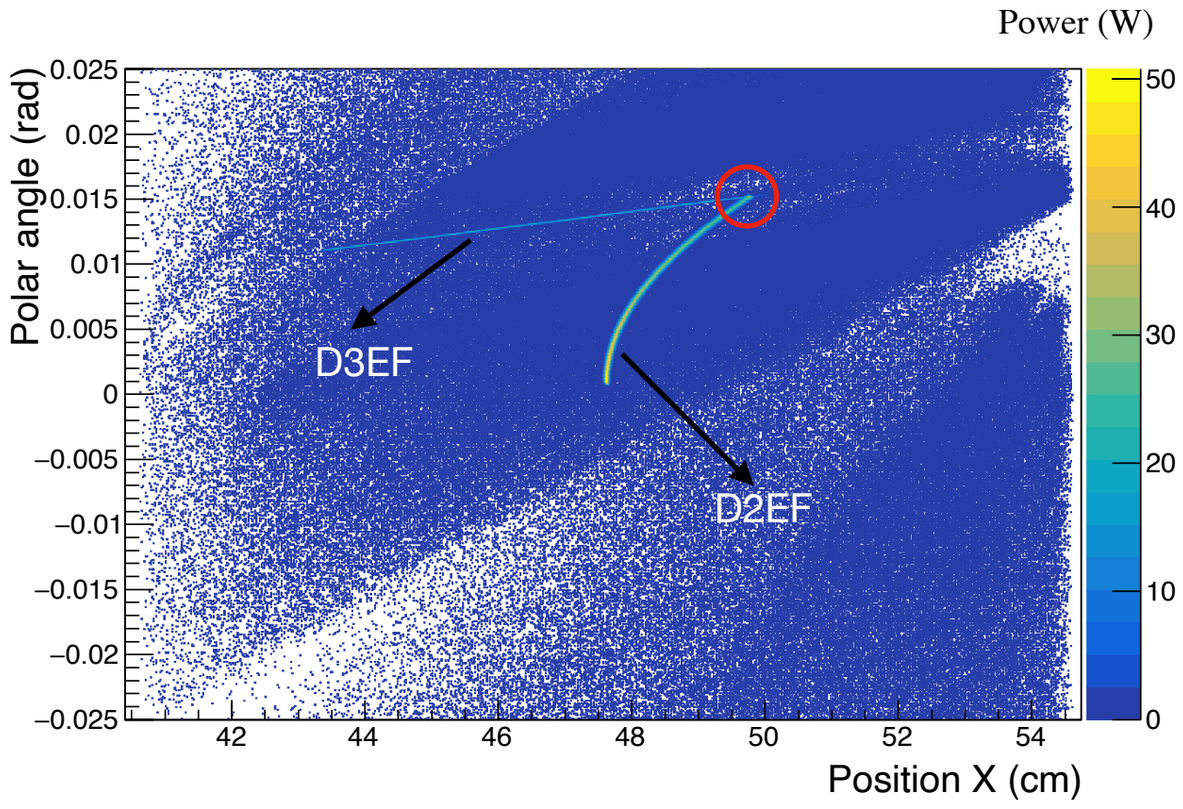


Syrad+ simulation

Record the photon information (position, momentum, flux) at the facet just after D2EF_6;

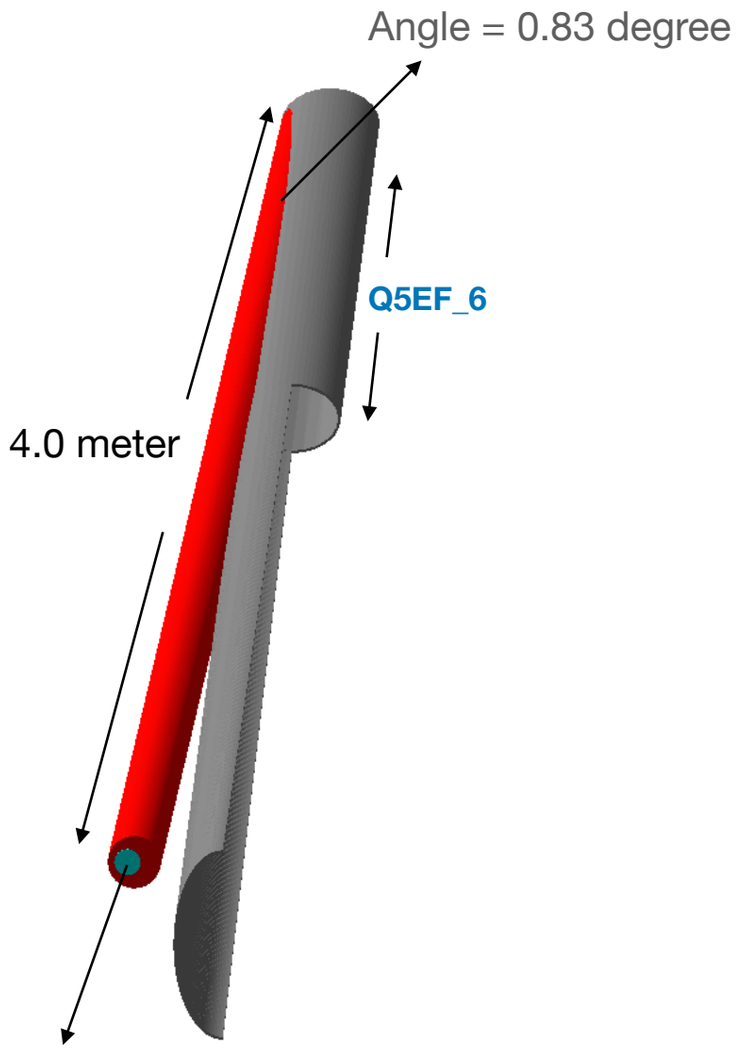
Pos_X_[cm]	Pos_Y_[cm]	Pos_Z_[cm]	Pos_u	Pos_v	Dir_X	Dir_Y	Dir_Z	Dir_theta_[rad]	Dir_phi_[rad]	LowFluxRatio	Energy_[eV]	Flux_[photon/s]	Power_[W]
49.8103	0.0103213	6687.12	0.560052	0.64692	0.0152623	2.44105e-05	-0.999884	3.12711	1.17978	1	1644.76	3.45761e+08	9.11157e-08
48.9467	0.000738733	6687.12	0.53688	0.589175	0.012506	-2.26787e-05	-0.999922	3.12987	1.17616	1	8053.65	3.93212e+11	0.000507379
48.9711	1.32024	6687.12	0.449725	0.627177	0.0206955	0.00171845	-0.999784	3.12161	1.26419	0.016771	17686.8	7.12999e+09	2.02047e-05
44.1236	-0.0450725	6687.12	0.406955	0.266885	0.0115776	-3.59751e-05	-0.999933	3.1308	1.17476	1	1568.41	4.25139e+11	0.000106833
47.8549	0.0175614	6687.12	0.50566	0.516971	0.0056647	1.77579e-05	-0.999984	3.13671	1.18174	1	10181.8	3.93212e+11	0.000641455
48.3812	-0.0174335	6687.12	0.522498	0.551034	0.00938125	-1.43132e-05	-0.999956	3.133	1.17643	1	9285.62	3.93212e+11	0.000584994
48.0215	-0.0205862	6687.12	0.512791	0.527006	0.00666118	-7.9709e-05	-0.999978	3.13572	1.16453	1	18282.4	3.93212e+11	0.00115179



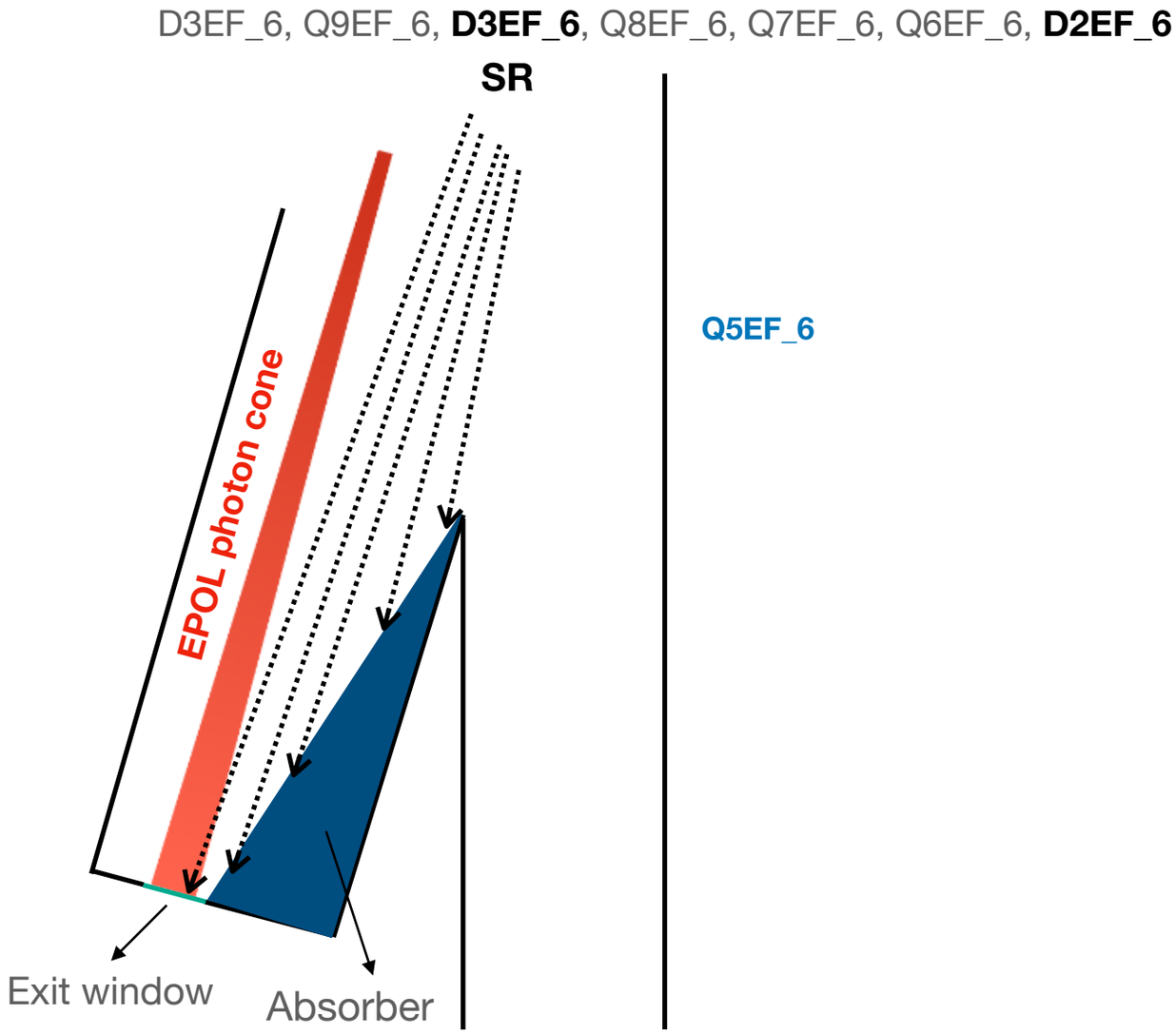


Most of the synchrotron radiation comes from D3EF_6 and D2EF_6

Exit window for scattered photons

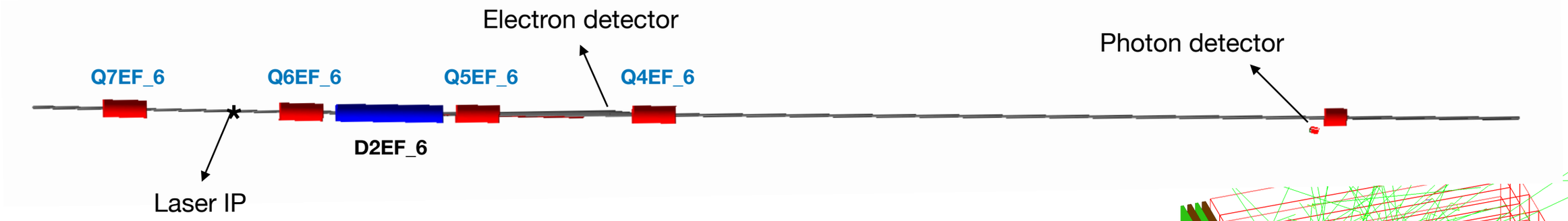


Exit window (2mm Be)
R = 1.0cm

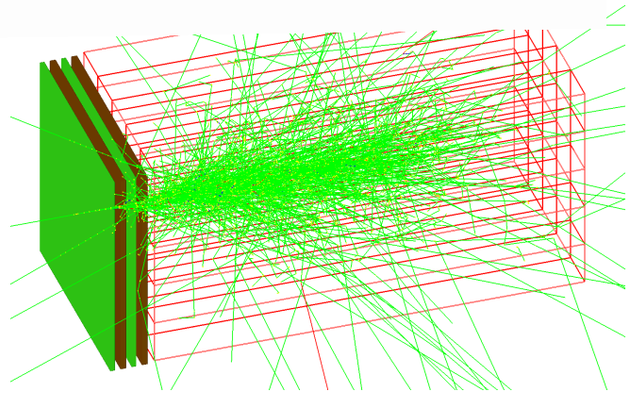


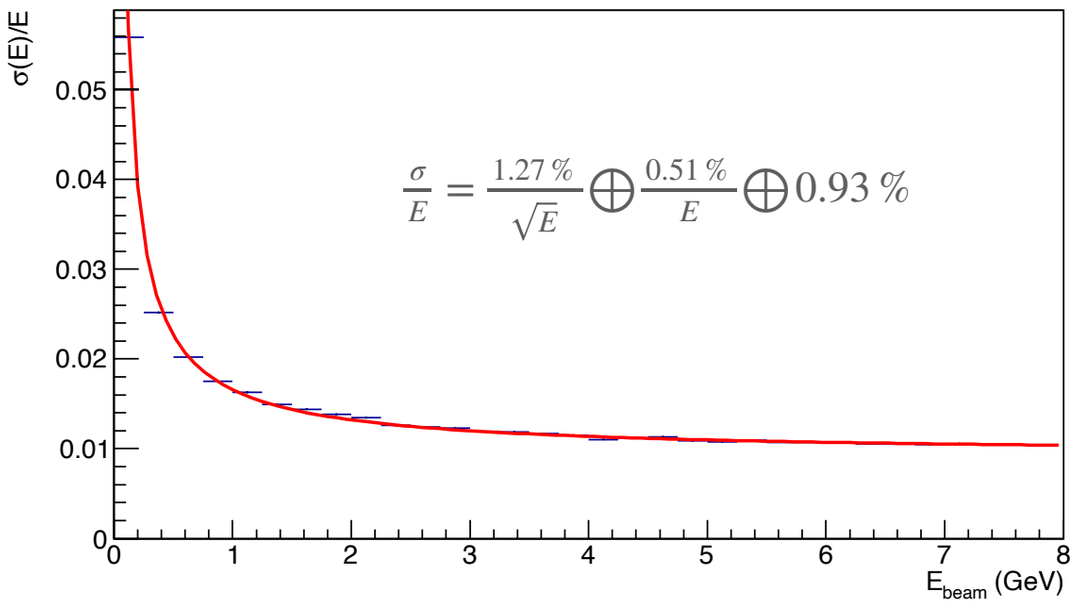
- The exit window measures 4.0 meters in length, with a width and height of 2.2 cm; it is situated at an angle of approximately 0.83 degrees relative to the beam pipe;
- Considered three dipoles and four quadrupoles, synchrotron radiation mainly comes from D3EF_6 and D2EF_6;

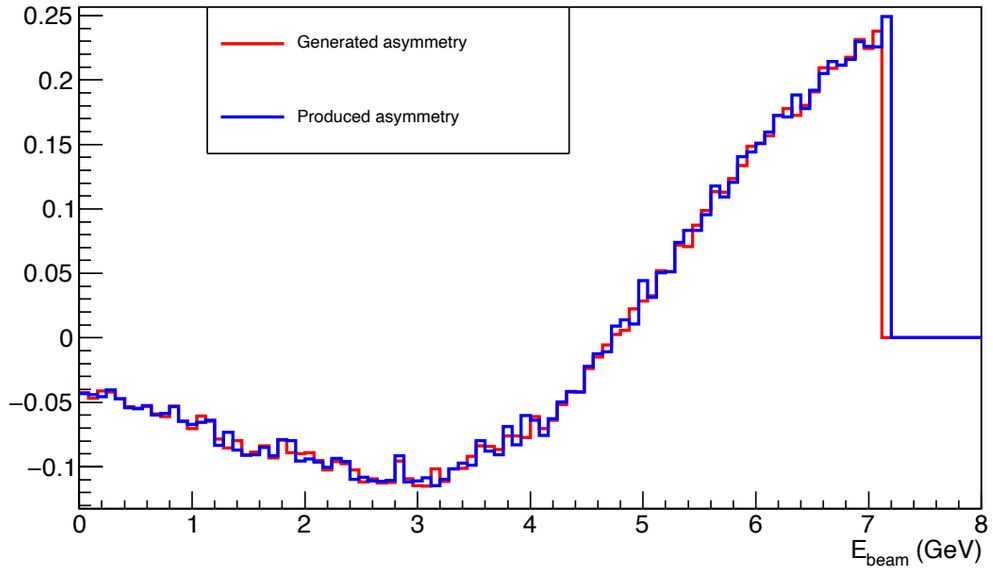
Photon detector



- A homogeneous Calorimeter (10cmX10cmX20cm) with Preshower detector is being considered;
- The preshower is made of two planes of lead (0.25mm) followed by silicon sensors;
- The segmentation of the silicon sensor on the order of 100-400 μm is required;
- The slow component of PbWO4 would be an issue for (bunch frequency: 11ns for 10GeV and 44ns for 18GeV), we need to discuss a new photon detector;





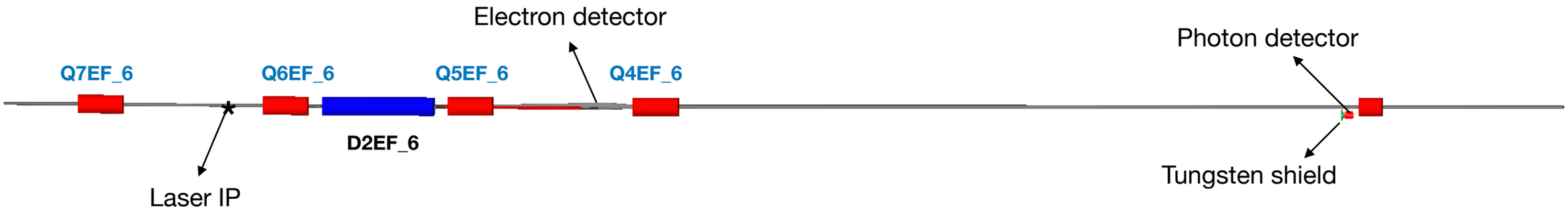


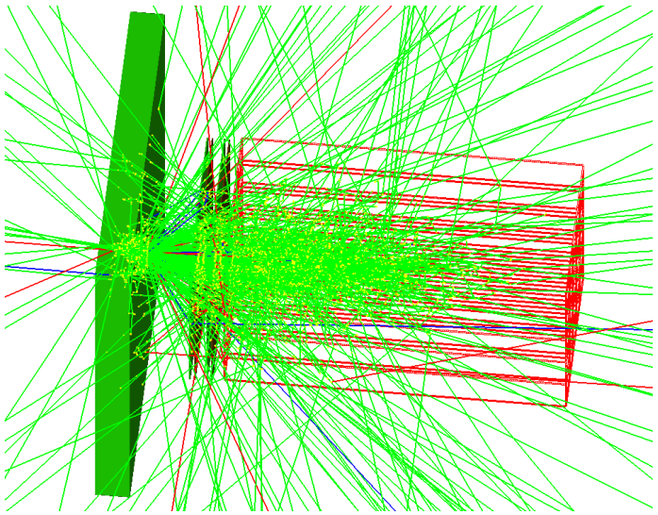
Synchrotron Radiation

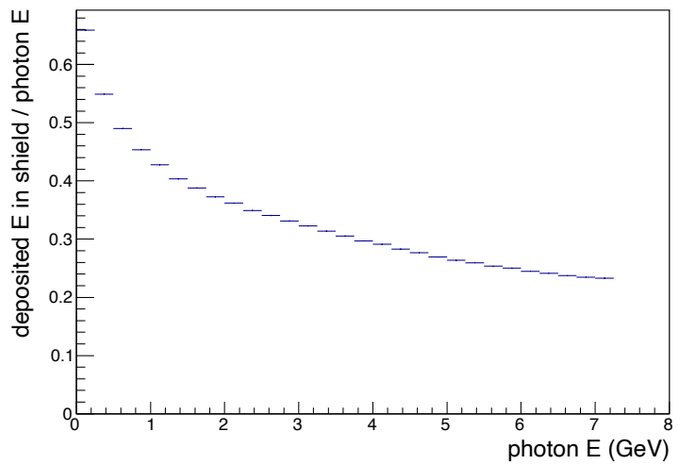
- physicsList: G4EmStandardPhysics_option4 (most precise EM physics);
- Exit window material: 2mm beryllium;
- total photon number (>1keV) per bunch =1.27833e+11, (>20keV) per bunch = 4.67013e+10;
- Power in exit beam pipe is 12341W and before the exit window is 3185W (1cm radius) and 773W (0.25cm);
- Power deposited at Q4EF_6 is141W (radius of exit window is 1cm);
- Mike Sullivan mentioned that '10 W/mm2 is approximately the usual engineering maximum', indicating that the 2mm Be exit window is considered safe;
- Furthermore, it has been determined that at least 2.0cm of tungsten is required to effectively block synchrotron radiation, aligning with Mike's findings;

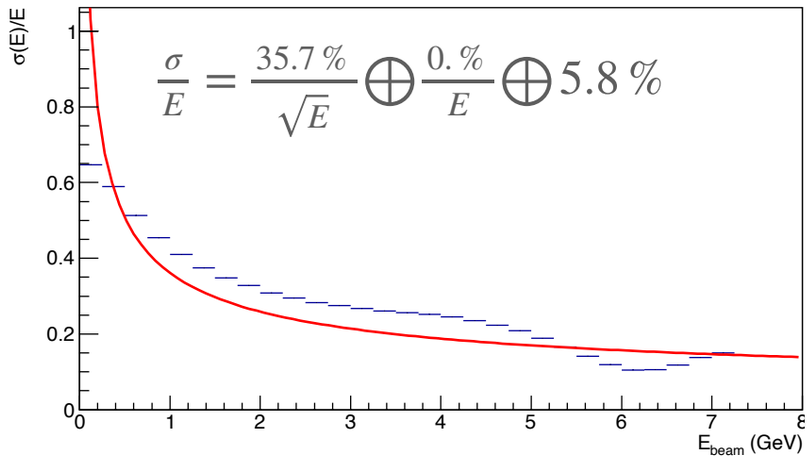
Exit window radius/ Tungsten shield thickness	1cm/0.5cm	1cm/1.0cm	1cm/2.0cm	0.5cm/ 1.0cm	0.5cm/ 2.0cm	0.25cm/ 0.5cm	0.25cm/ 1.0cm	0.25cm/ 2.0cm
Power deposited on the exit window (W)	167.4	167.4	167.4	91.3	91.3	49.6	49.6	49.6
Power deposited in shield (W)	1580.1	1581.1	1582.4	765.7	766.7	372.6	378.1	380.2
Power deposited in photon detector (W/GeV per bunch)	9.1/2472.8	2.6/701.3	0	0.84/230.4	0	2.8/777.1	0.42/114.3	0

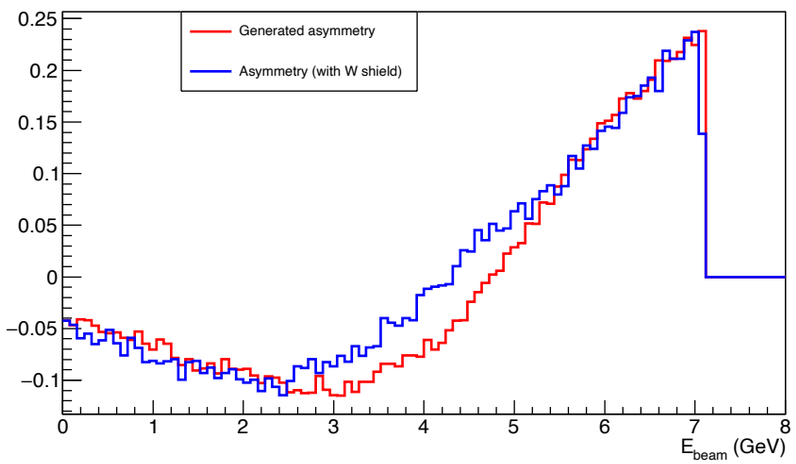
Synchrotron Radiation











- The 2cm-thick tungsten shield would significantly degrade the energy resolution. And the position resolution would also decrease (need to think about the algorithm to obtain the position from numerous sensor hits).
- The D2EF_6 and D3EF_6 may be too strong for us, need to find the maximum bending angle we can afford and meanwhile too small bending angle would require longer drift distance to separate photon and scattered electron from the beam;
- Maybe we need to really consider a two dipole setup (a weak dipole and a strong dipole). The dipole before the laser would also be a concern.

Next step

- Need to have rough estimate of the maximum bending angle of the dipoles (before and after the laser IP) that we can accept for the photon detector;
- Work with the lattice experts to find a solution, right now this section in the IR is being redesigned;
- Beam pipe design and synchrotron radiation study for electron detector;