Synchrotron Radiation in the electron polarimeter

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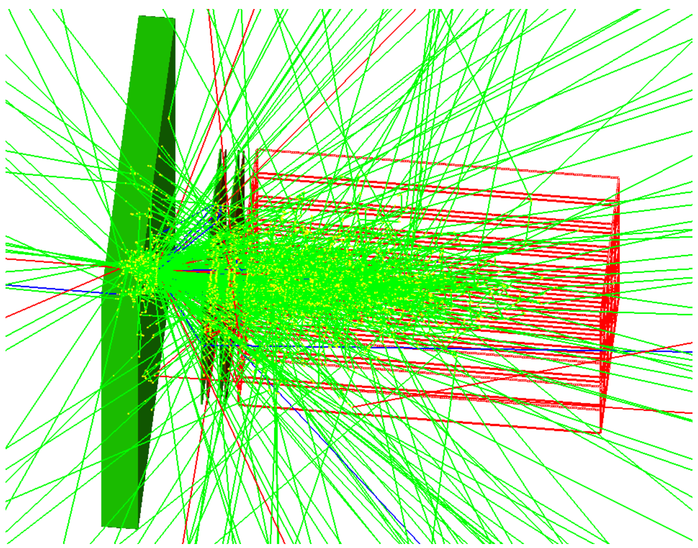
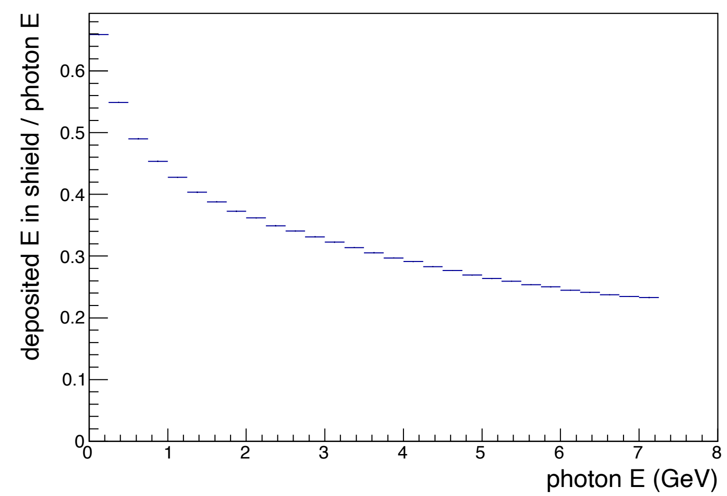
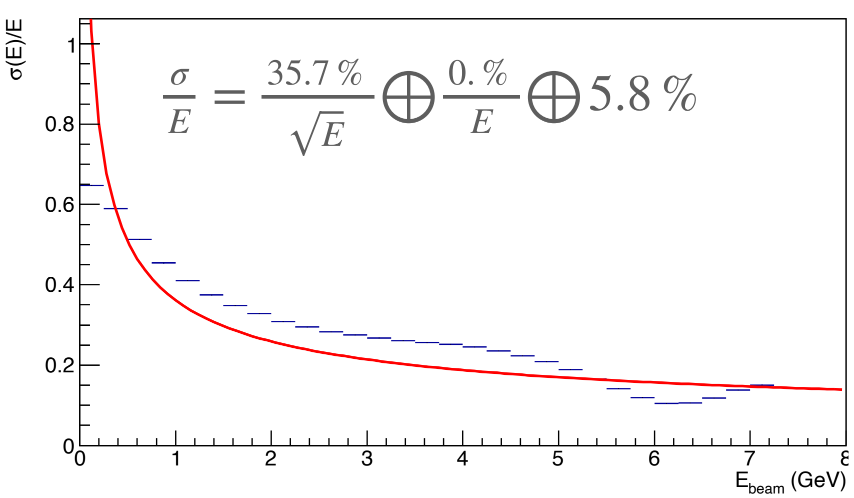
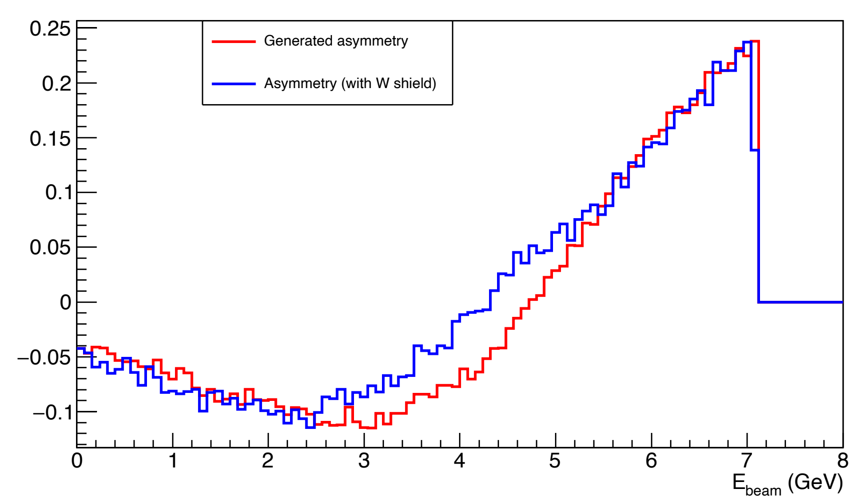
BNL

Synchrotron Radiation (Ver5.6)







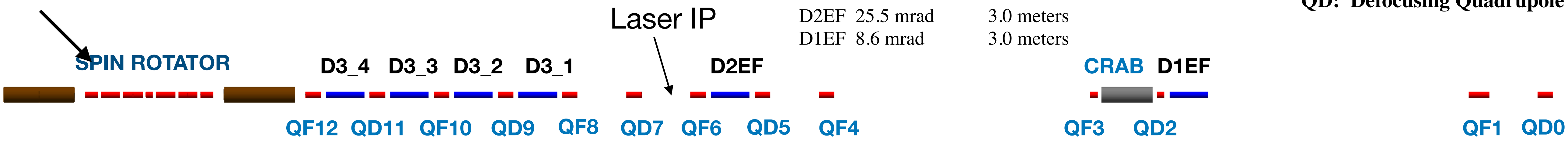


- The 2cm-thick tungsten shield would significantly degrade the energy resolution. And the measurement of the position would be almost impossible.
- The D2EF_6 and D3EF_6 are too strong for us. A potential solution is to subdivide each dipole into a dual setup: one weaker dipole paired with a stronger one.

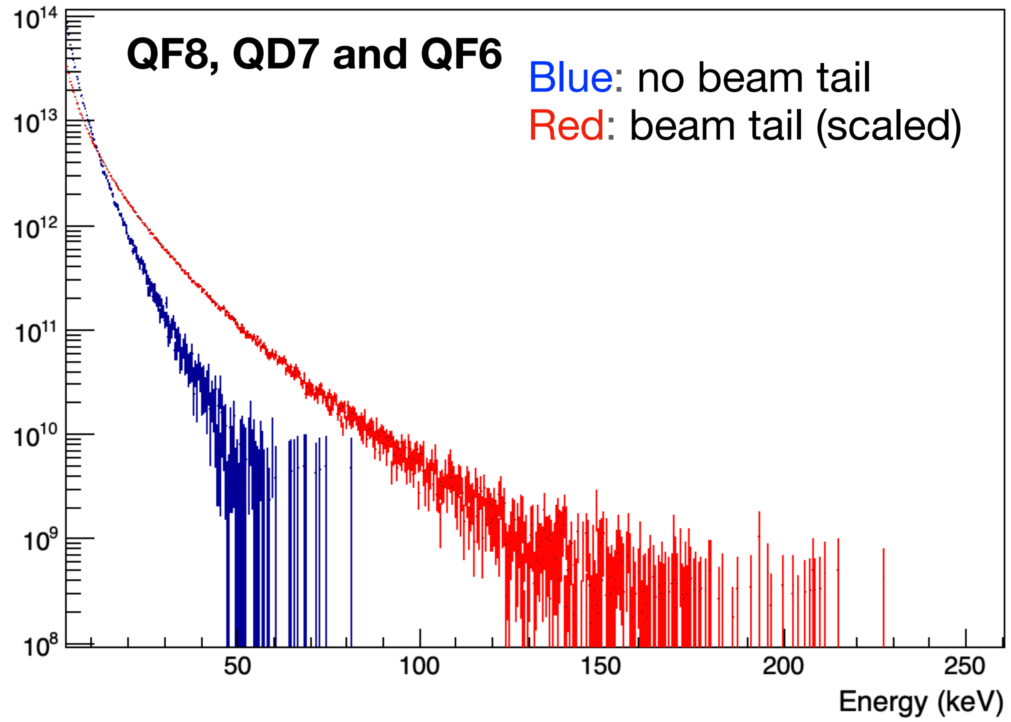
Version 6.0:

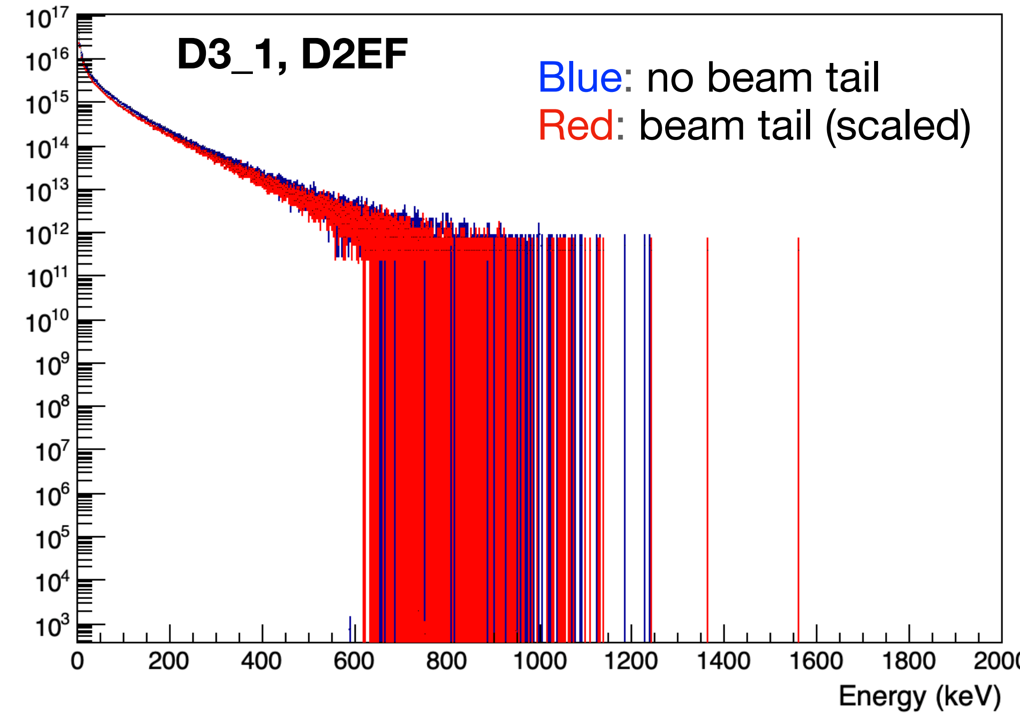
	bending angle	length
D3	18.2 mrad	3.0 meters
D2EF	25.5 mrad	3.0 meters
D1EF	8.6 mrad	3.0 meters

QF: Focusing Quadrupole
QD: Defocusing Quadrupole

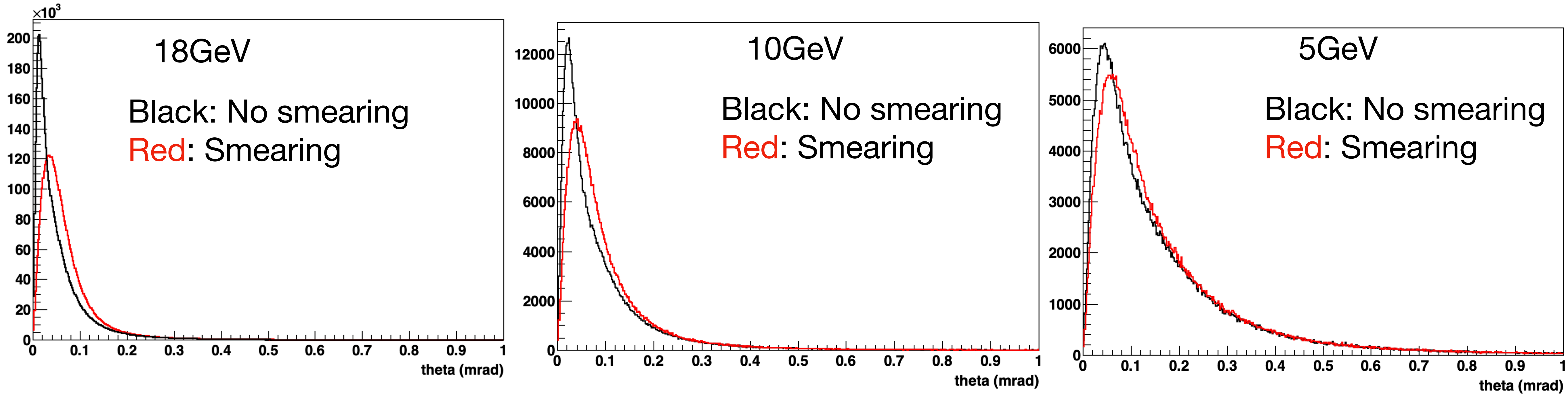


The Synchrotron Radiation mainly comes from D3_1, D2EF, QF8, QD7 and QF6;



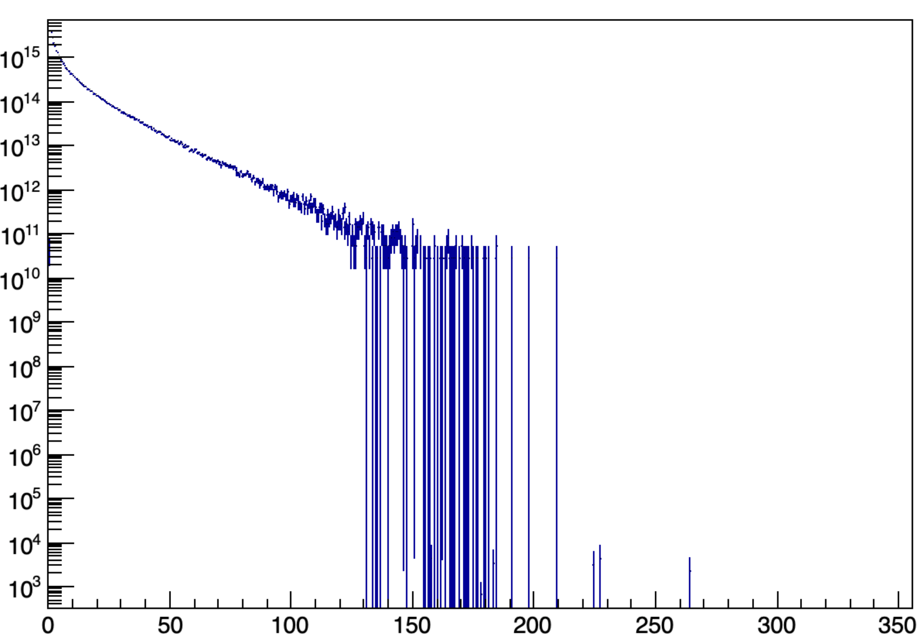


- Synchrotron Radiation (SR) from quadrupoles (QF8, QD7, QF6) reliably enters the acceptance range of the photon detector, though the energy of this SR is generally lower compared to the radiation emitted from dipoles.
- The beam tail significantly influences the detected SR:
  - For quadrupoles: The energy of the SR is increased due to the beam tail effects.
  - For dipoles: The energy distribution of the SR remains unchanged; however, SR originating from the beam tail has a substantial offset from the beam line, which may impact the performance of our polarimeter.
- Predicting the beam tail is inherently challenging:
  - Numerous variable effects can populate the beam tail, and these effects are highly time-dependent.
  - Early stages of machine operation are likely to exhibit the largest beam tails; however, this will change dynamically as machine commissioning progresses.
  - As machine operators adjust parameters and increase current in the ring, the sources contributing to the beam tail will also change (Comment from Mike Sullivan).
- Assumptions used in the simulation:
  - The integral of the beam tail is set to be 5% of the integral of the core beam for our analysis.
  - For beam tail standard deviations (sigmas), the X sigma is assumed to be 4 times larger than the core X sigma, and the Y sigma is assumed to be 10 times larger than the core Y sigma (Suggested by Mike Sullivan).

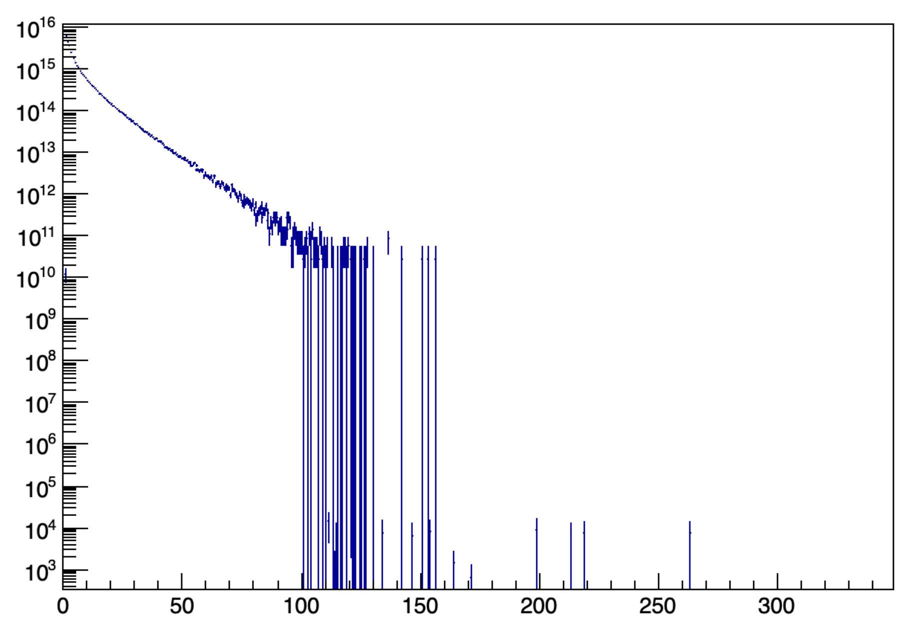


- (-0.5mrad, 0.5mrad) acceptance should be good enough for the scattered photons for the polarimeter;

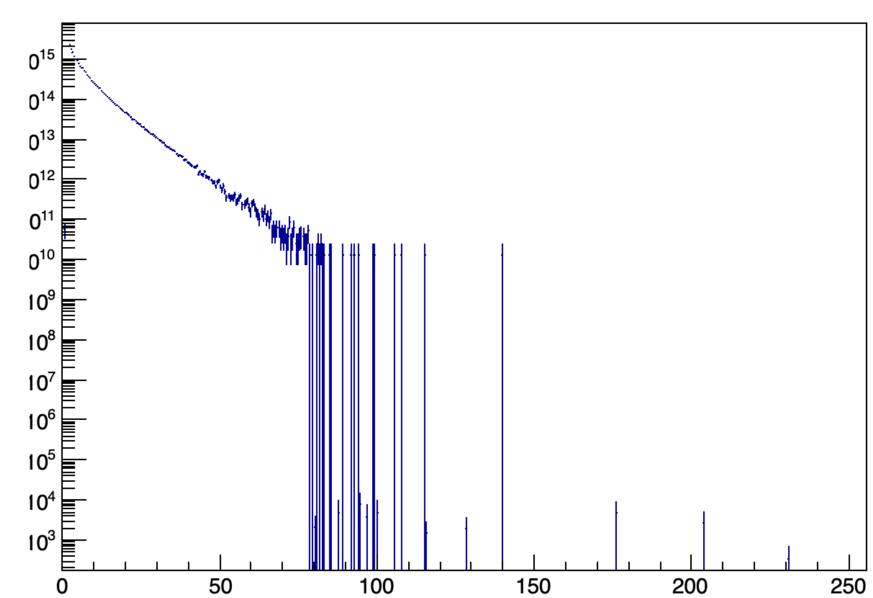
Dipole: 1.0meter, 1.5mrad, ρ = 667meters, 2mm Be + 1.75mm W

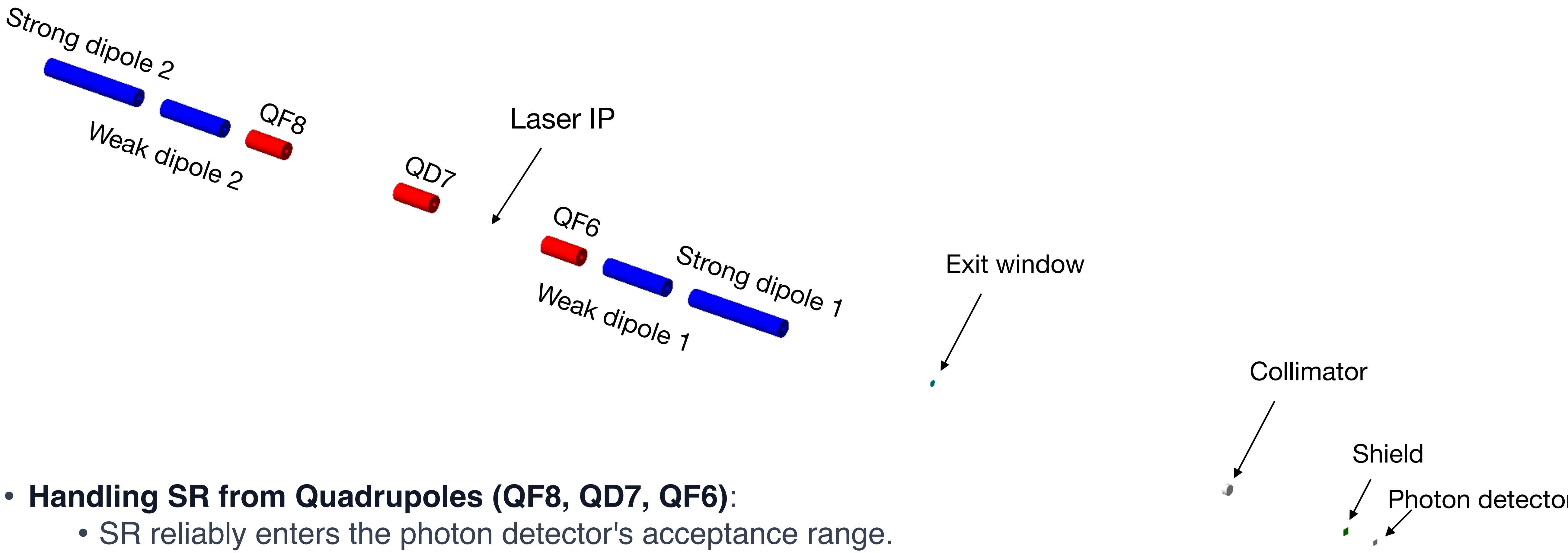


1.5meter, 1.5mrad, ρ = 1000 meters, 2mm Be + 1.25mm W

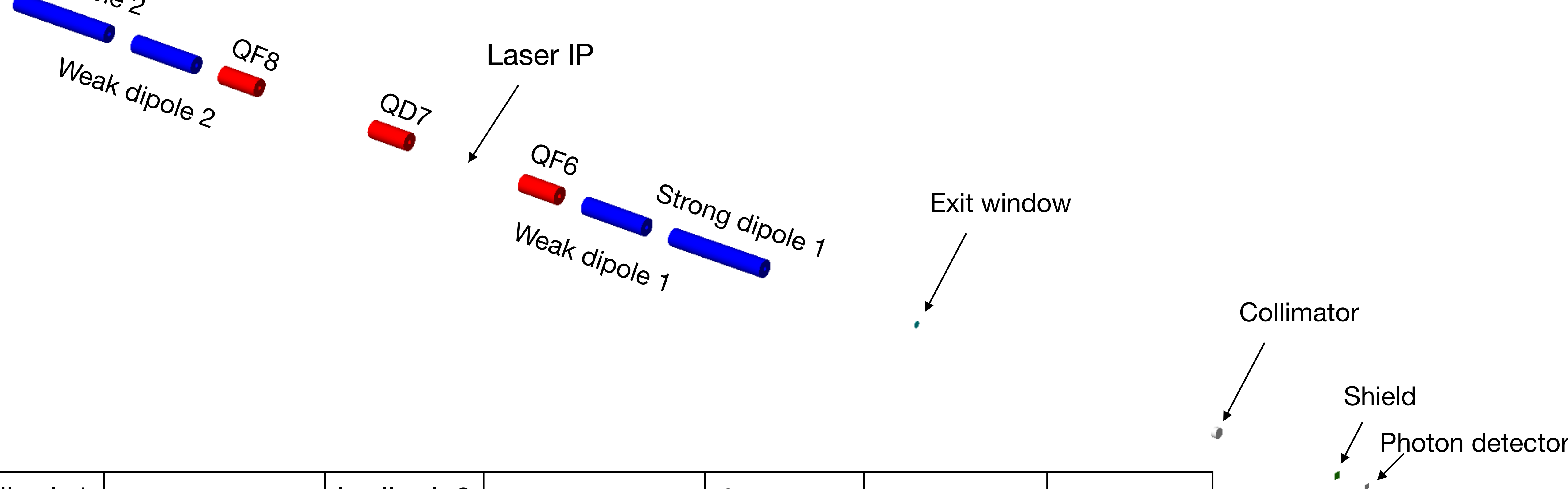


1.5meter, 1.0mrad, ρ = 1500 meters, 2mm Be + 0.9mm W





- **Handling SR from Quadrupoles (QF8, QD7, QF6)**:
    - SR reliably enters the photon detector's acceptance range.
    - Limited options for mitigation; collimators provide minor relief.
- **Shielding Considerations without Beam Tail**:
    - 2mm Be (exit window) + **0.5mm** W (shield) can effectively block SR.
- **Shielding Considerations with Beam Tail**:
    - For 1mrad acceptance (Collimator): 1.3mm W (shield) needed.
    - For 0.5mrad acceptance (Collimator): **1.1mm** W (shield) needed.
- **Reduce SR from Dipoles**:
    - Separate dipoles flanking the laser IP into two types:
    - A weaker dipole eliminates SR from the stronger dipole. Requires sufficient bending angle and large bend radius (ρ) as $k_c(keV) = 2.2183 \times E^3(GeV)/\varrho(m)$).
    - Stronger dipole post-laser IP must provide enough bending angle to separate scattered photons and electrons from the beamline.
    - The opening angle of the SR in both the horizontal and vertical directions is given approximately by: Dx' = Dy' ≈ 1/γ = 2.9e-2 mrad (18GeV), much smaller than 0.5mrad.
    - If we don't consider the beam size and the beam tail, then 0.5mrad bending angle of the weak dipoles would be enough;



L_dipole1 (meter)	Bending angle of dipole1 (mrad)	L_dipole2 (meter)	Bending angle of dipole2 (mrad)	Collimator (mrad)	Exit window (Be)	Shield (W)
1.0	**1.5**	**1.0**	**1.5**	**1.0**	**2mm**	**1.75mm**
1.5	**1.5**	**1.5**	**1.5**	**1.0**	**2mm**	**1.25mm**
1.5	**1.5**	**1.5**	**1.5**	**0.75**	**2mm**	**1.1mm**
2.5	**1.0**	**2.5**	**1.25**	**1.0**	**2mm**	**0.5mm**
1.5	**0.75**	**1.5**	**0.75**	**1.0**	**2mm**	**0.9mm**
1.5	**0.75**	**1.5**	**0.75**	**1.0**	**2mm**	**>3mm**
2.5	**1.0**	**2.5**	**1.25**	**0.5**	**2mm**	**>3mm**
2.5	**1.5**	**2.5**	**1.5**	**0.5**	**2mm**	**1.2mm**

Beam tail

Requirements for the weak dipoles:

- If we consider the beam tail, the bending angle for the weak dipoles needs to be at least **1.5mrad**. The length needs to be at least **2.5meters** (ρ at least 1667 meters);
- Since the beam tail is a key factor here, in our simulation for the weak dipole1, betaX is 55 meters. So the beta function for the weak dipoles should not be significantly greater than 55 meters.

Summary

- A polarimeter acceptance of (-0.5mrad, 0.5mrad) appears sufficient for capturing scattered photons.
- Beam tailing is a significant factor requiring our attention.
- For the weak dipoles, a minimum bending angle of 1.5mrad is needed, and the length should be no less than 2.5 meters (corresponding to ρ of at least 1667 meters).
- Given that beam tailing plays a crucial role, in our simulation for weak dipole 1, the beta function β_x was set at 55 meters. Thus, the beta function for weak dipoles should not significantly exceed 55 meters.
- A shield of 2mm Beryllium (Be) + 1.2mm Tungsten (W) seems to be the optimal setup we can approach.