2d FCC-ee Energy Calibration and Polarization WG meeting

Requirements on Optics and Power for the Polarimeter

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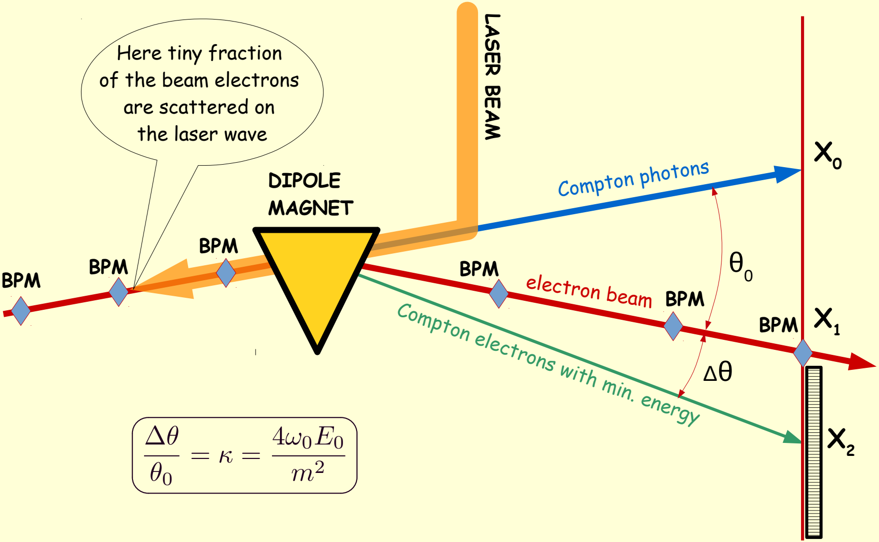
The experiment (horizontal plane)



$$\frac{\Delta\theta}{\theta_0} = \kappa = \frac{4\omega_0 E_0}{m^2}$$

Beam optics: vertical dimension

- Head-on beam collision with a laser radiation will produce scattered electrons with angles up to $\theta_{max} = 2\omega_0/m$, where ω_0 is the laser photon energy and m is the electron rest energy.
- As we see this angle does not depend on the initial electron energy. Considering $\omega_0 = 2.33$ eV we obtain $\theta_{max} \simeq 10\ \mu$rad.
- Electrons with θ_{max} scattering angle are most sensitive to the beam polarisation. The vertical size of the scattered electrons distribution will be $S_y = 2 \cdot \theta_{max} \cdot L$, where L is the distance between the laser interaction point and the detector (FIG. 1).
  If $L = 30$ m this size will be as small as $\simeq 0.6$ mm.
- Detector for scattered electrons should have a vertical pixel size $\lesssim 10\ \mu$m.
- FCC beam divergence will add some smearing $\theta_y \simeq \sqrt{\varepsilon_y/\beta_y}$.
- With $\varepsilon_y = 1$ pm and $\beta_y = 100$ m this smearing is as small as 0.1 μrad, very good!

Beam optics: horizontal dimension

- In order to place a detector for scattered electrons, we need them to be separated from the main beam.
- This is done by the bending magnet and free space (FIG. 1). The separation is expressed as $\Delta X = \kappa \cdot \theta_0 \cdot L_{arm}$, where κ is the scattering parameter, θ_0 is the main beam bending angle, L_{arm} is the distance to the detector.
- Scattering parameter ($\kappa = 4\omega_0 E_{beam}/m^2$) is linearly scaled with either ω_0 or E_{beam}. For $\omega_0 = 1$ eV and $E_{beam} = 100$ GeV one has $\kappa \simeq 1.53$.
- For this value of κ and $\theta_0 = 1$ mrad and $L_{arm} = 20$ m we obtain $\Delta X \simeq 30$ mm. This seems to be too close to the beam axis, so we need to increase either κ or/and θ_0 or/and L_{arm}.
- 1st question: implementation of the spectrometer section to FCC lattice. A bend + long free space without any fields, is this possible?
- 2nd question: how close to the beam axis could we place the detector for scattered electrons?

Laser power requirements

- Consider a Q-switched solid state laser operating at 1 kHz repetition rate and a pulse energy of 0.1 – 1 mJ.
- Today this is not a problem to have such parameters for either IR, green or UV radiation.
- We can have 10–100 scattered electrons per one laser shot.
- From simulations we know that we need about 10^7 scattered electrons to measure beam polarization with 1% accuracy.
- So one measurement will take 100–1000 seconds.

Conclusion

In order to understand the relevance of the approach for the FCC-ee needs I think we need:

- Introduce the spectrometer/polarimeter section(s) to existing FCC lattice.
- Consider an appropriate detector options.
- Perform a detailed simulation study:
  - Laser-electron I.P.
  - Tracking of scattered electrons/photons.
  - Detection of scattered electrons/photons.
  - Analysis of the distributions.
- I would like to reiterate that the Compton polarimeter/energy spectrometer with scattered electrons is still not used.
- I think it is very important to check this method on existing installations.