# Some Comment on the Crossing Angle

D. Schulte

Interaction Point Layout

- Distance L^* between final quadrupole and interaction point can be chosen

  - preferred distance is $3.5\,\mathrm{m}$ (R. Tomas)

- Design of final doublet is challenging

  - high gradient required

  - support needs to be very stable

    detectors can be quite noisy

- Crossing angle must be large enough to allow extraction of the spent beam on the side of the final quadrupoles

  $\Rightarrow$ minimum crossing angle is given by quadrupole design and beam-beam interaction
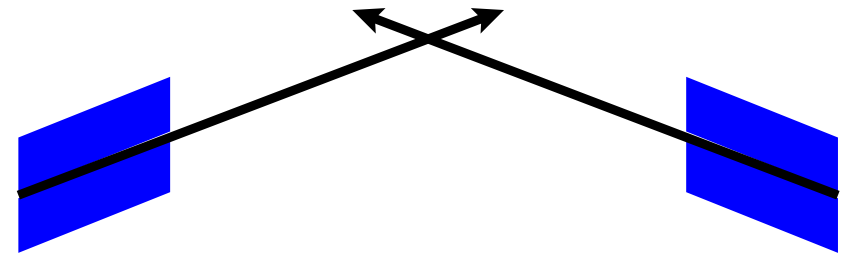
Main Spent Beam Contents

- The beam particles are deflected by the beam-beam forces

- They radiate hard photons, the beamstrahlung

- In the strong beam fields beamstrahlung photons can turn into an electron positron pair

- Cross section depends exponentially on the field

$\Rightarrow$ Rate of pairs is small for centre-of-mass energies below $1\,\mathrm{TeV}$

$\Rightarrow$ In CLIC, rate is substantial
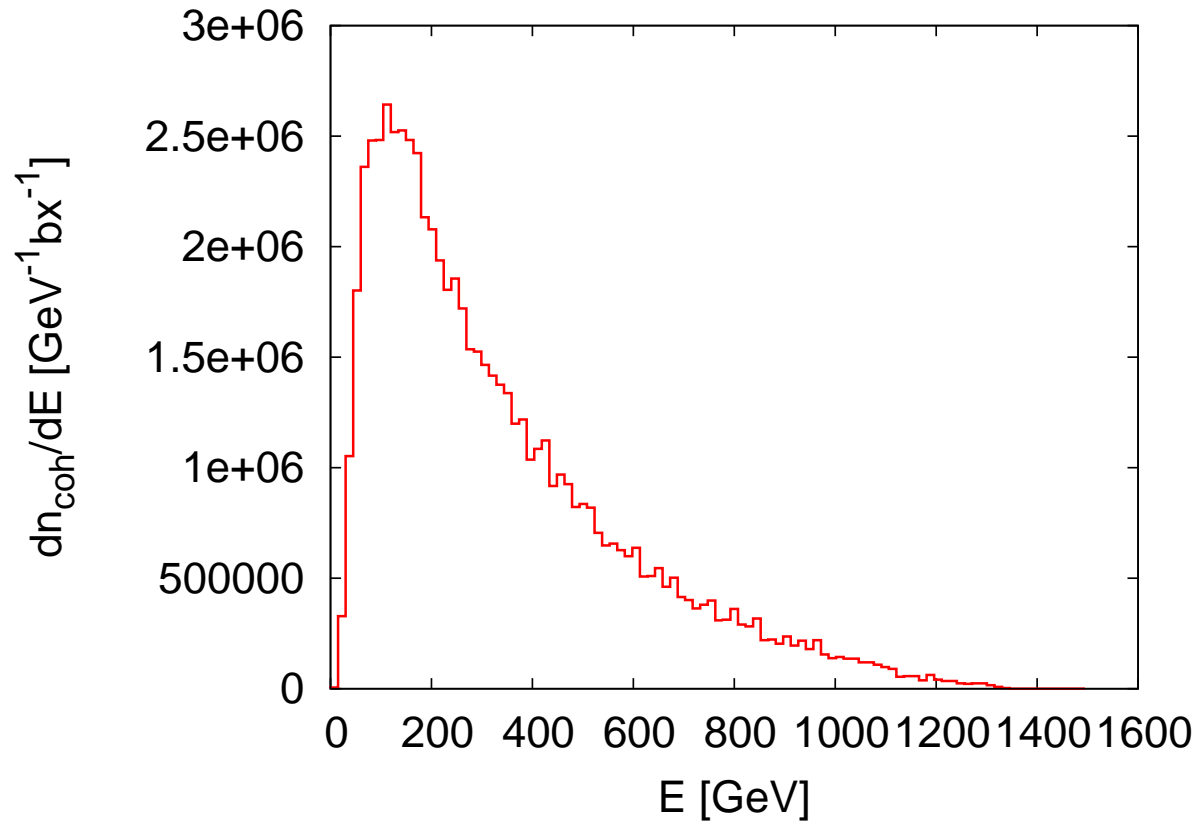
Spent Beam Angular Distribution

- Beam particles are focused by oncoming beam

- Photons are radiated into direction of beam particles

- Coherent pair particles can be focused or defocused by the beams

⇒ Extraction hole angle should be significantly larger than $6\,\mathrm{mradian}$
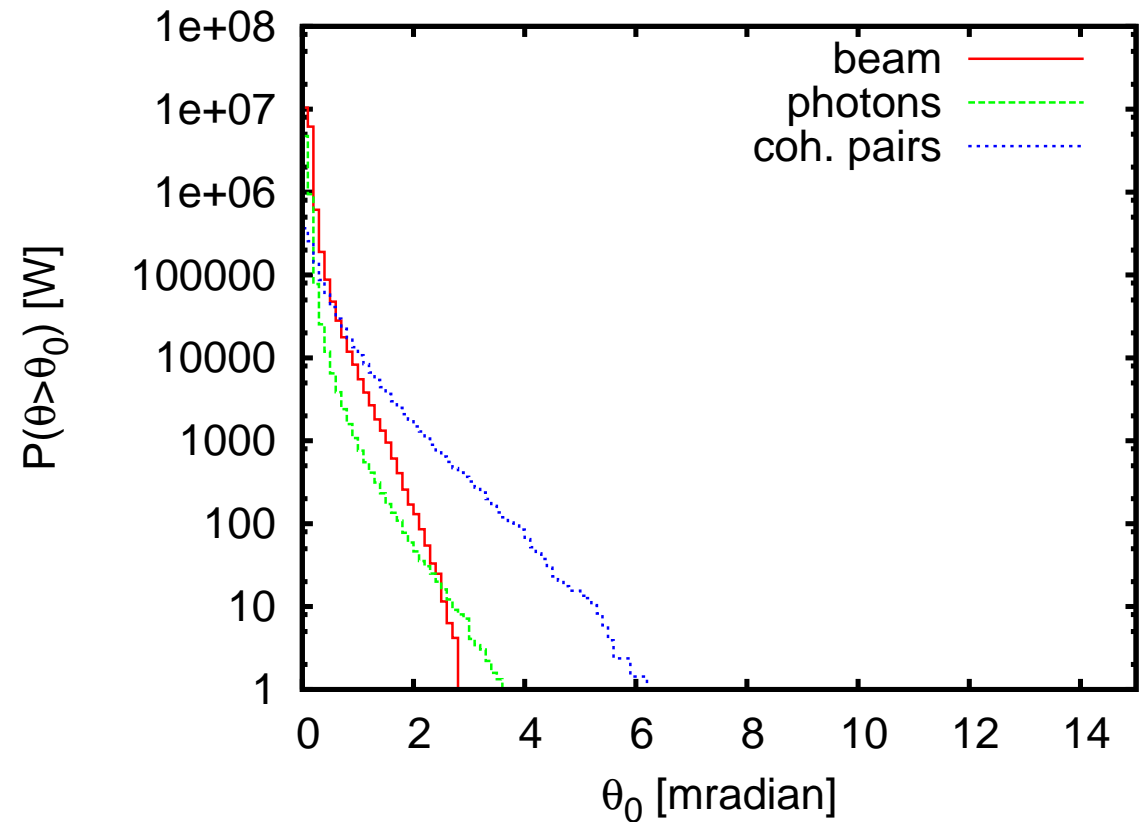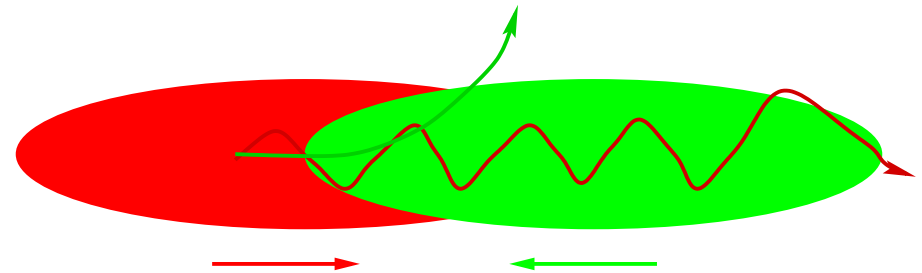
Quadrupole Design

- A design based on permanent magnets has been made some years ago for a magnet with out radius of $20\,\mathrm{mm}$

  - field gradient was $468\,\mathrm{T/m}$

  - aperture was $2 \times 3.3\,\mathrm{mm}$

- For the new beam delivery system, the requirements have changed

  - field gradient should be $575\,\mathrm{T/m}$ $(382\,\mathrm{T/m})$

  - aperture should be $2 \times 3.83\,\mathrm{mm}$ $(2 \times 6.76\,\mathrm{mm})$

- With $L^* = 3.5\,\mathrm{m}$ the old quadrupole occupies $\approx 6\,\mathrm{mradian}$

  - for the new design that might change

Conclusion

- The absolute minimum required angles are

    - $6\,\mathrm{mradian}$ for the extraction

    - $6\,\mathrm{mradian}$ for the quadrupole

$\Rightarrow$ With $14\,\mathrm{mradian}$ crossing angle there is no margin

    - to shield quadrupole from extraction line

    - for small design modifications

$\Rightarrow$ 14 $\mathrm{mradian}$ could be feasible but has a high risk

- We would need input how high a risk we should take to push the crossing angle

- We will discuss at the next machine detector interface working group