Beam-Beam backgrounds estimates

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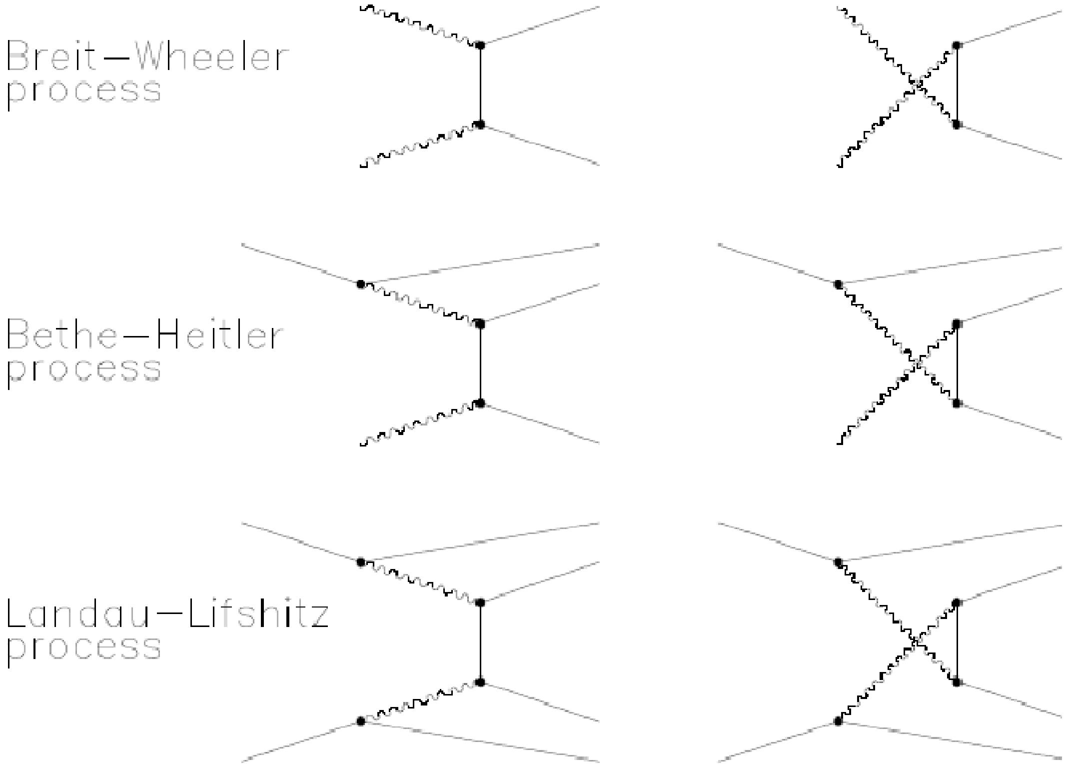
Outline

Beam-Beam Backgrounds at CLIC:

- Beam particles
- Beamstrahlung photons
- Coherent Pairs
- Incoherent Pairs
  - Impact on the vertex detector (D. Schulte)
- $\gamma\gamma \rightarrow$ hadrons
  - beam tracked trough Main Linac and BDS before collision
  - w and w/o machine imperfections

Incoherent Pair Production



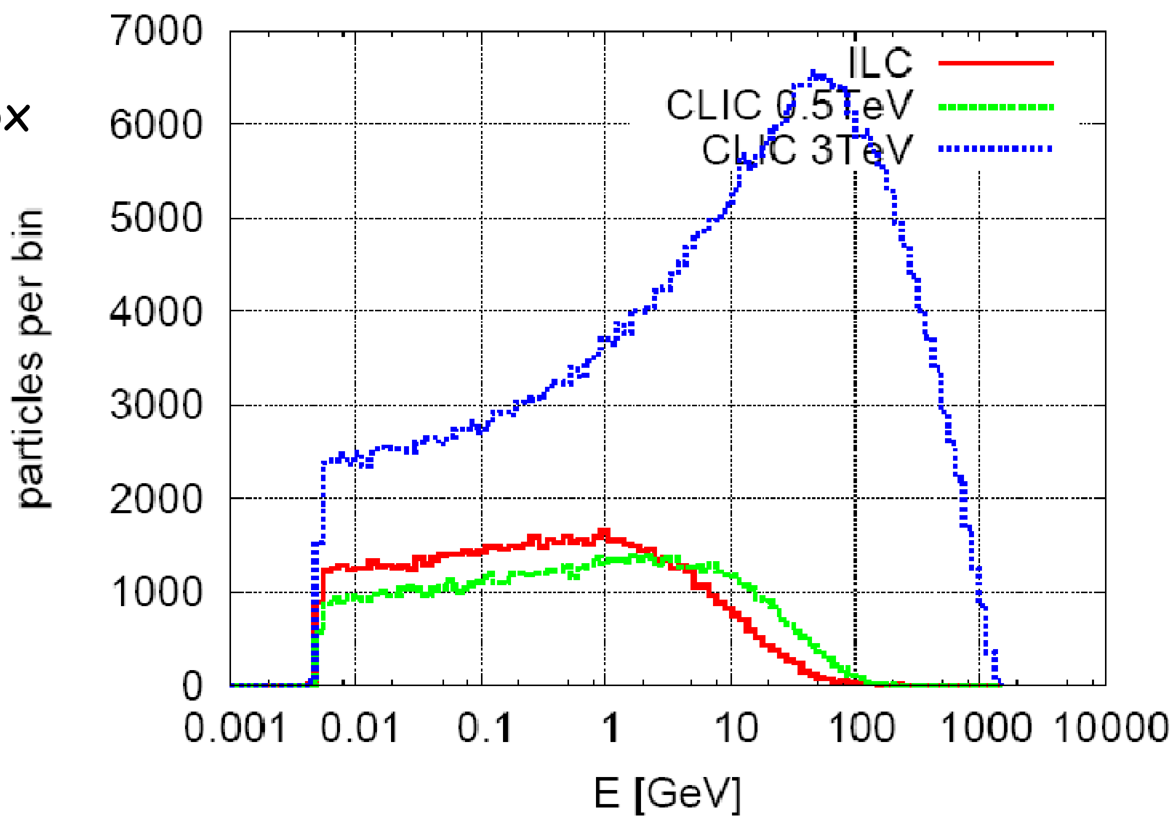
- Real-real, virtual-real and virtual-virtual scattering contribute
- Most significant background at all the energies

Pair Spectrum

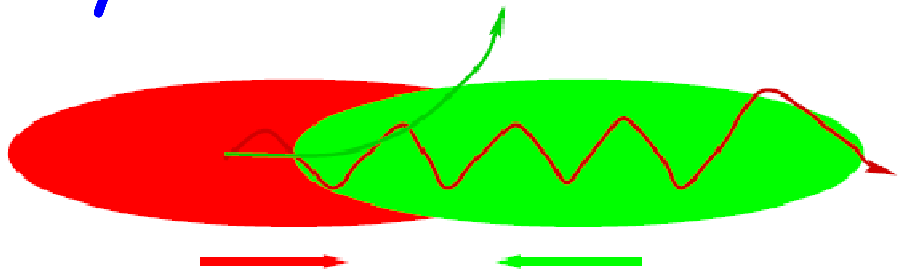
ILC 0.5 TeV: n_{incoh} 0.1×10^6 bx

CLIC 0.5 TeV: n_{incoh} 0.08×10^6 bx

CLIC 3 TeV: n_{incoh} 0.3×10^6 bx

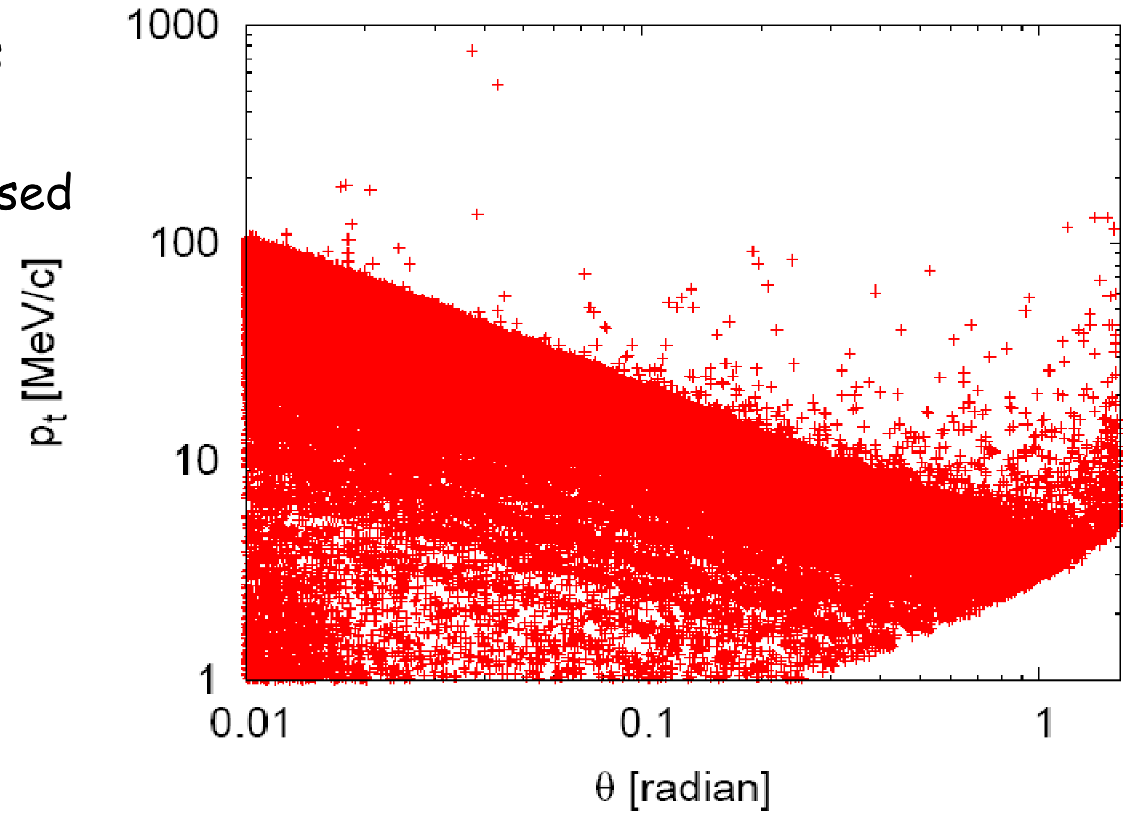


Deflection by the beams



- Most of the produced particles have small angles with random direction

$\Rightarrow$ some of the pairs are focused
some are defocused

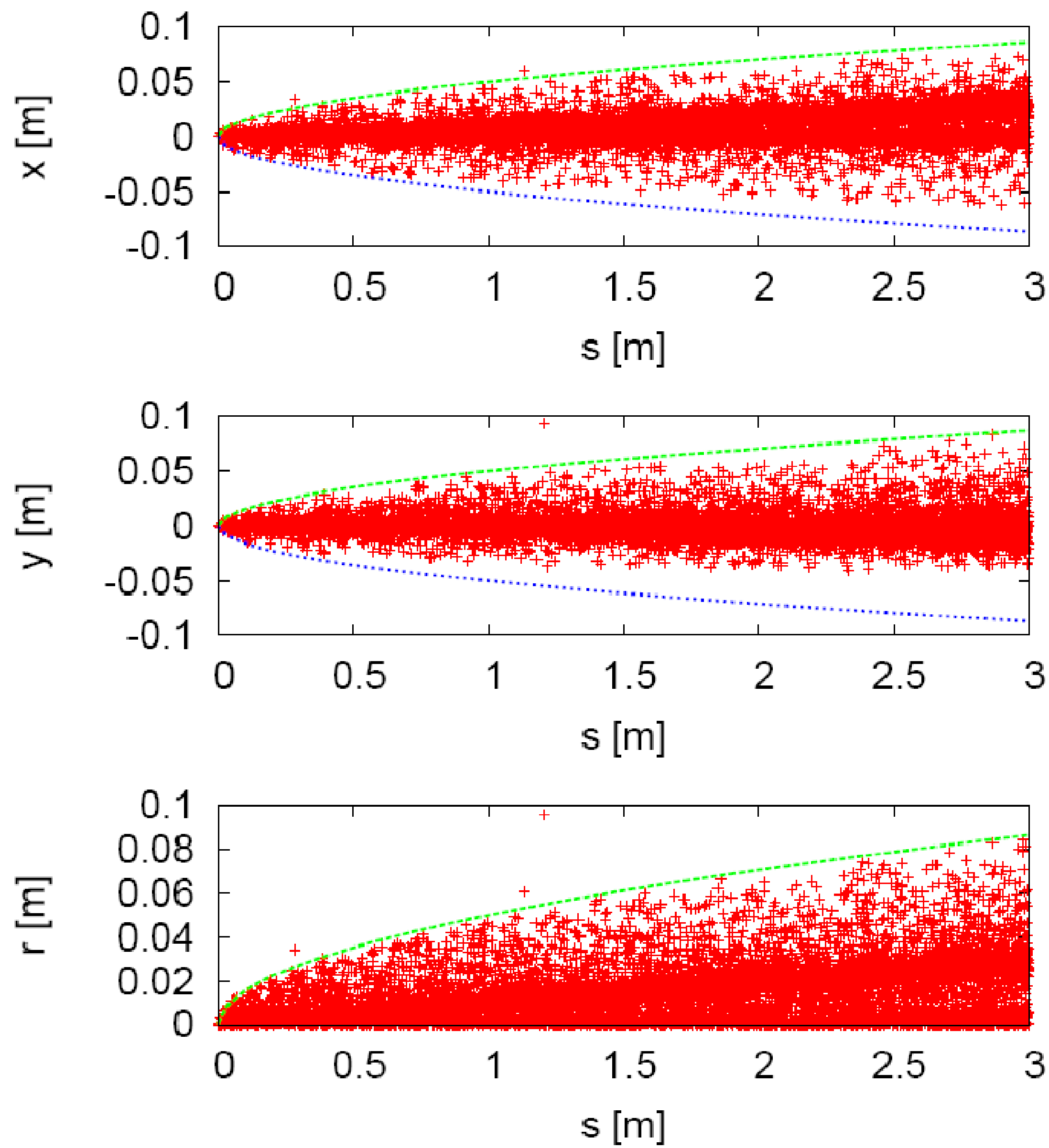


Required Aperture

- Incoherent pairs are shown
  - Deflection of coherent pairs is similar
  - But have higher energies, i.e. smaller angles
- Aperture requirement is roughly

$$r \approx 50\,\mathrm{mm}\sqrt{\frac{s}{\mathrm{m}}}$$

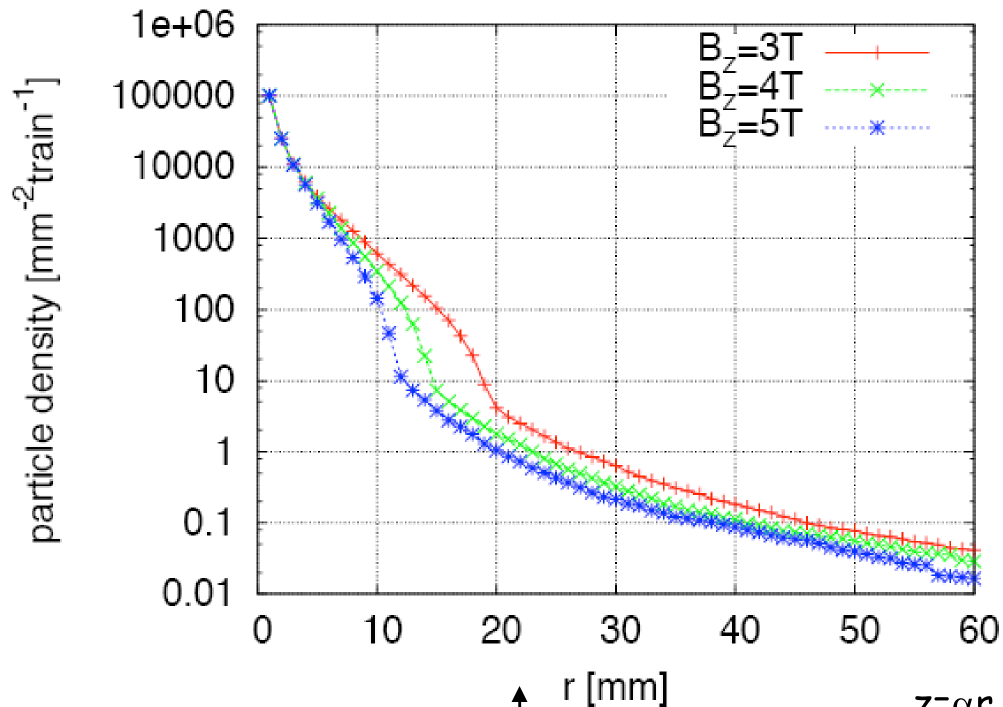
- No detector magnetic field included

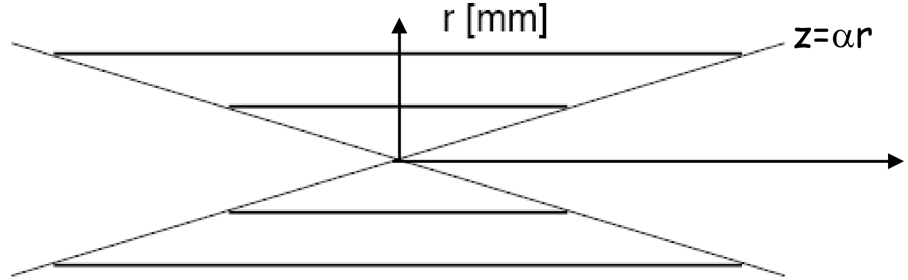


Impact on the vertex detector

- Simplified study using simple cylinder without mass
  - Coverage is down to 200 mrad
- Simulating number of particles that hit at least once
  - Experience indicates that number of hits is three per particle

⇒ At $r_1 \approx 30$ mm expected 1 hit per train and mm^2



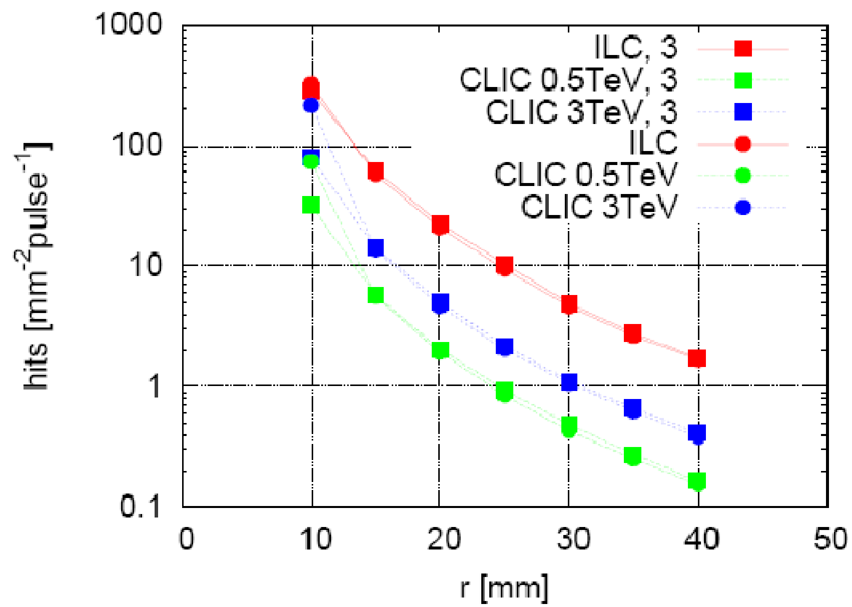


Hit distribution

- GEANT 3 based simulation

- Angular coverage Δz/r = 3, 5 and Bz = 5 T

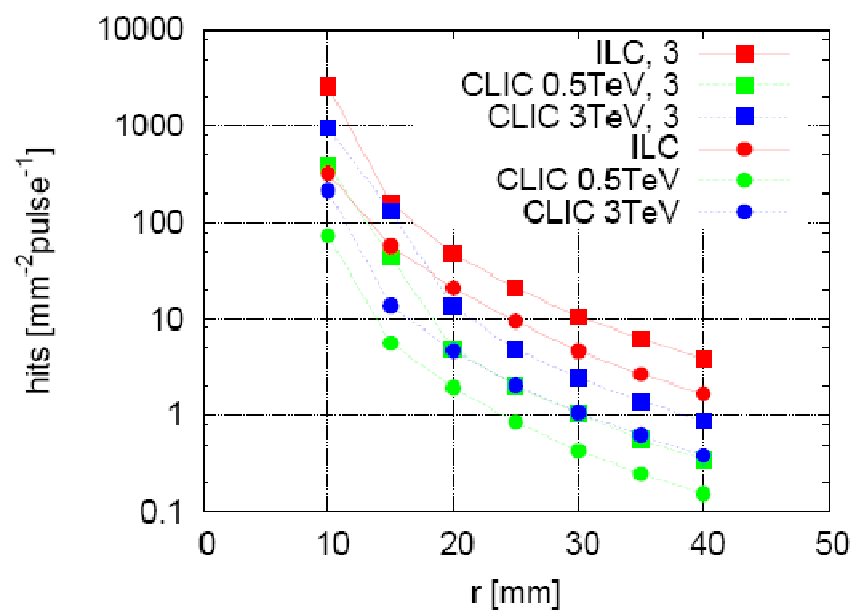
⇒ hit density does not depend on coverage angle if the radius is large enough to avoid deflected particles



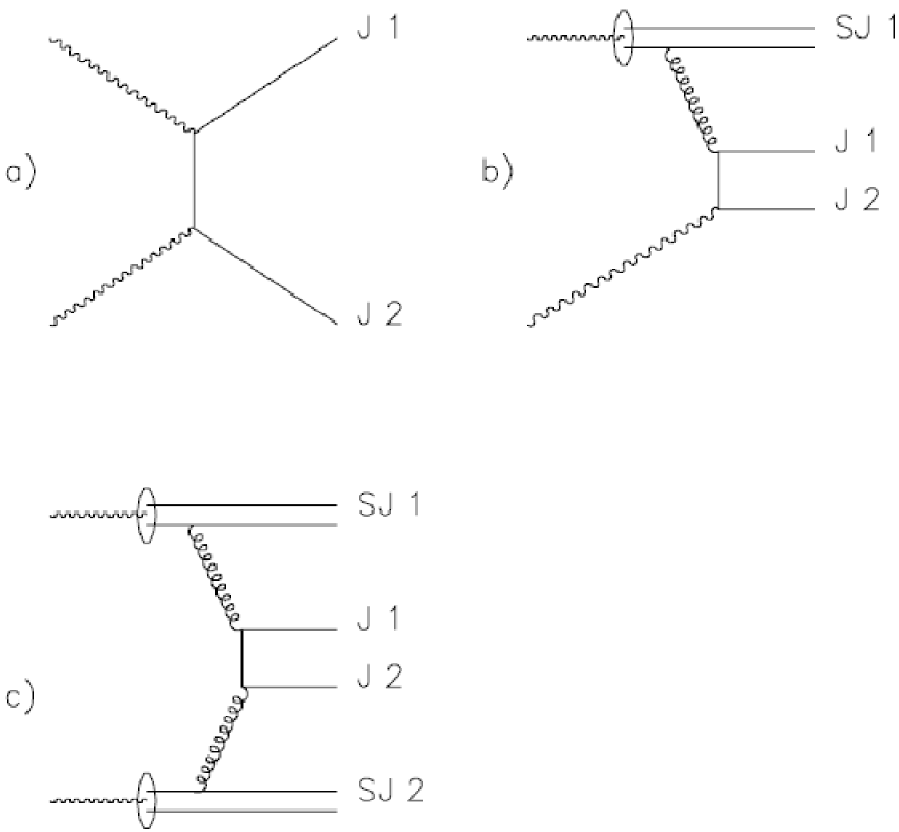
- Angular coverage Δz/r = 5 and Bz = 3, 5 T

⇒ vertex radius for constant hit density scale as:

$$r \propto \sqrt{1/Bz}$$



Hadronic background

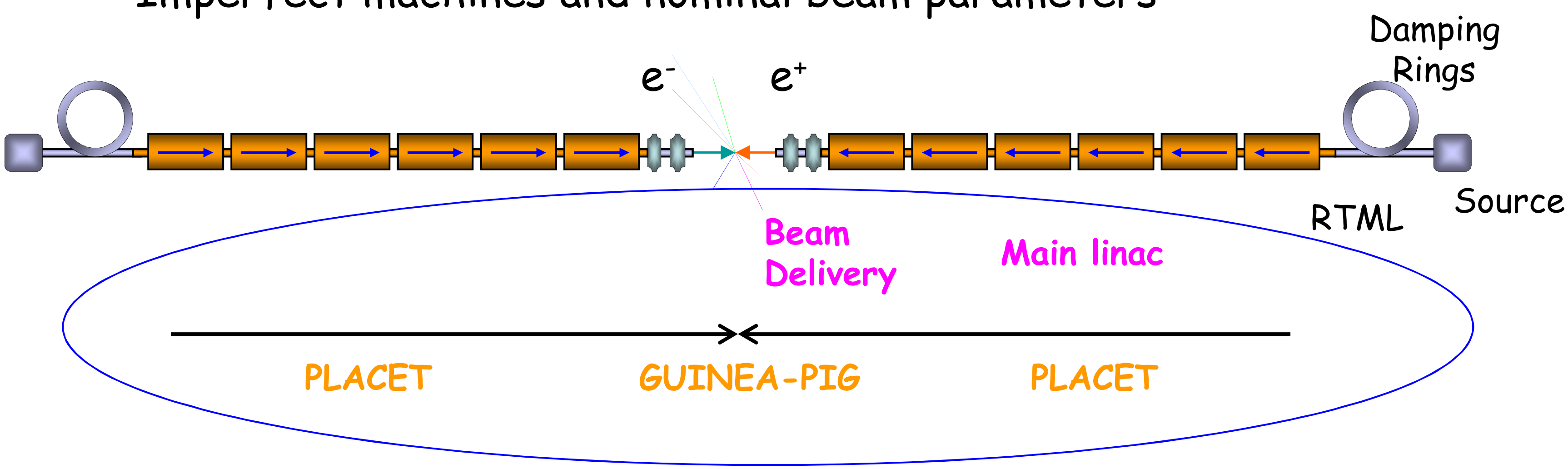


- G.A.Schuler and T.Sjostrand, CERN-TH/96-119 (1996) parametrization of cross section used in GUINEA-PIG
- Cross section slightly increase with CM energy

- Most energy is in the forward/backward direction
  - Evis ≈ 450 GeV per hadronic event for no cut
  - Evis ≈ 23 GeV for $\theta > 0.1$
  - Evis ≈ 12 GeV for $\theta > 0.2$

Hadronic background estimates

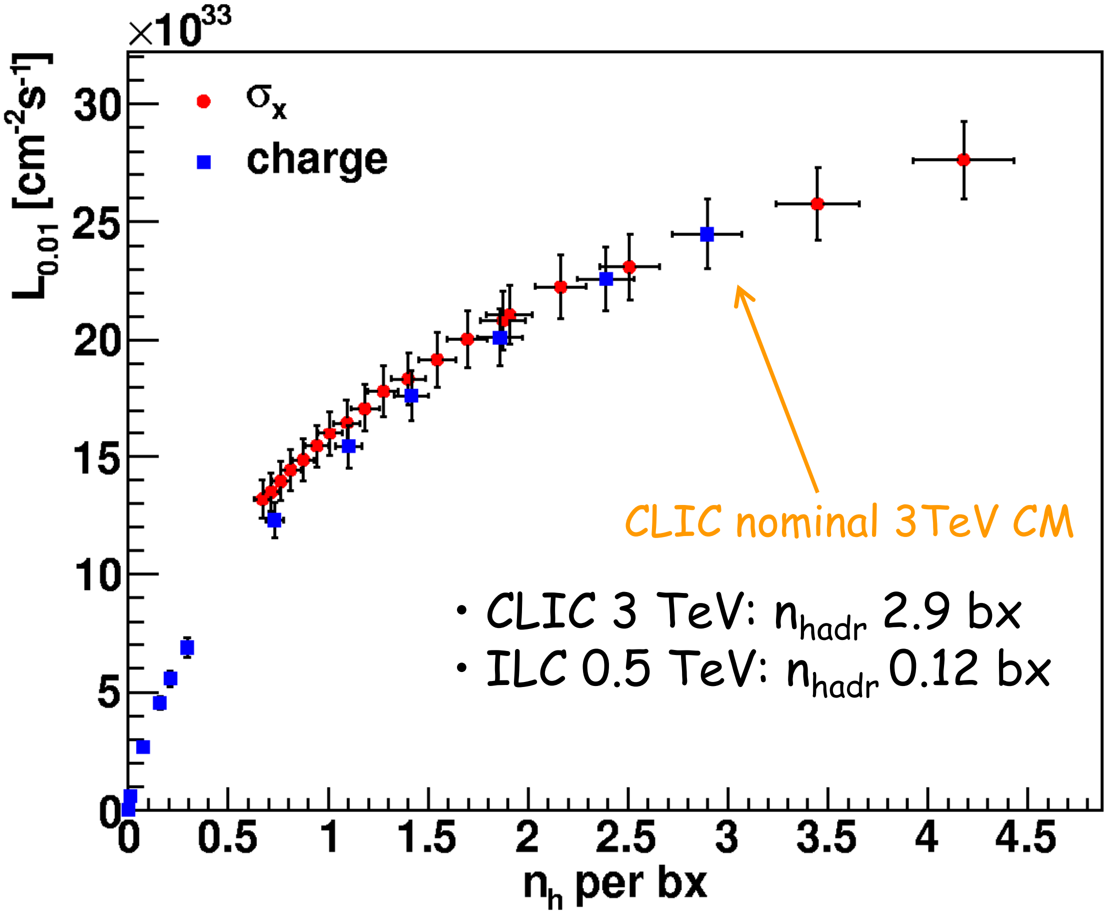
- Beam tracking with PLACET trough LINACs and BDSs
- Beam-Beam ($\gamma\gamma \rightarrow$ hadrons) calculation with GUINEA-PIG
- Aim $\rightarrow$ study BB background at different machine parameters/conditions
  - Perfect machines and non-nominal beam parameters
  - Imperfect machines and nominal beam parameters



Horizontal beam size and charge

- Perfect machines scan of horizontal beam size and of the charge

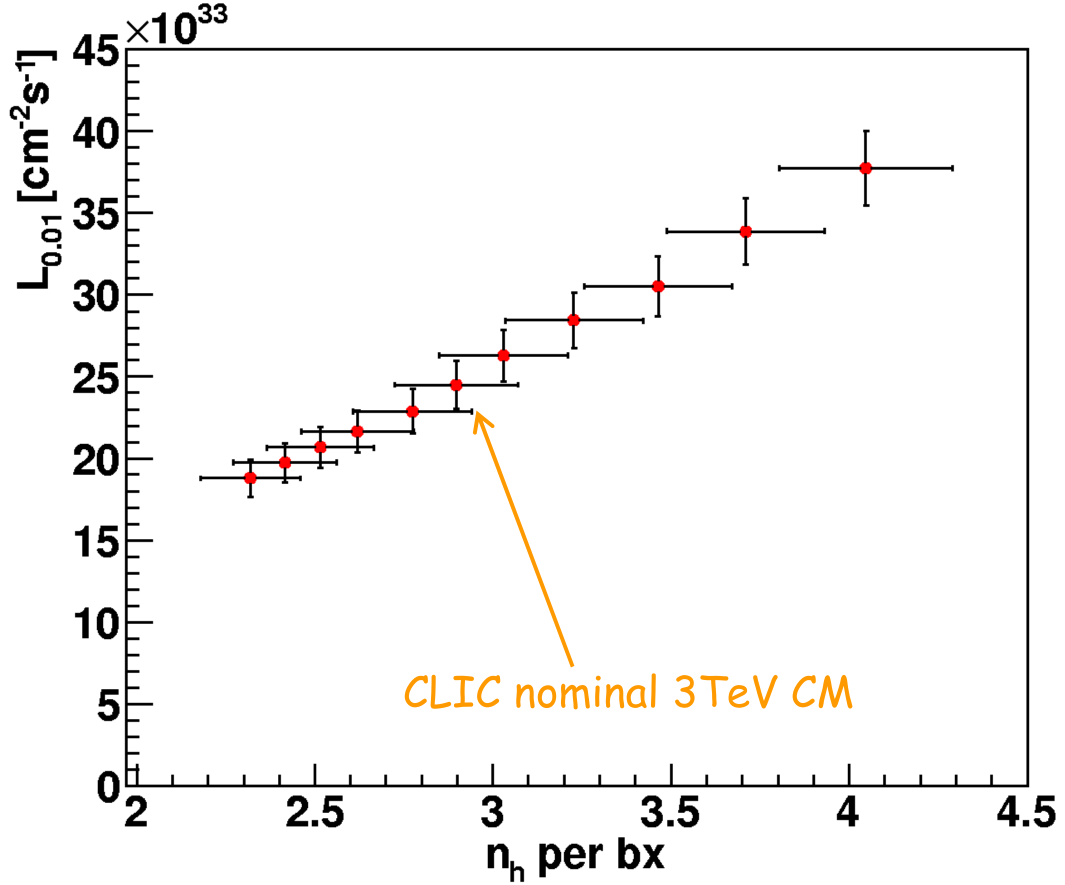
$$15 < \sigma_x < 85 \text{ nm}$$
$$0.3e^{-6} < \text{charge} < 3.72e^{-9}$$



Vertical beam size

- Perfect machines scan of vertical beam size

$0.1 < \varepsilon_y < 0.3 \times 10^{-7}$ m rad



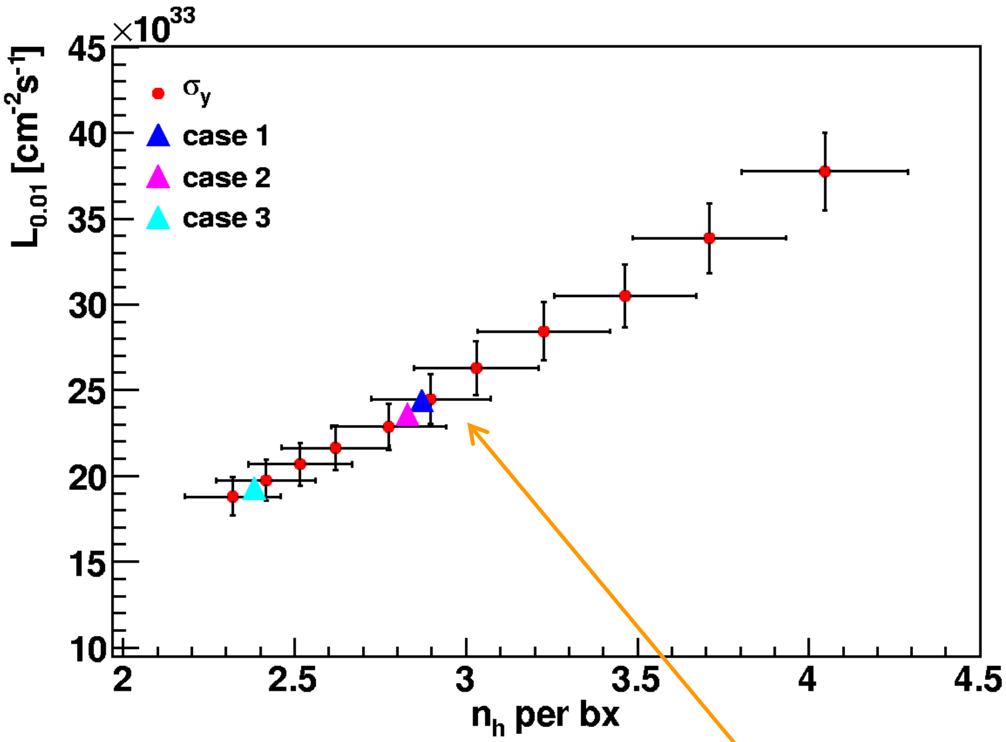
Vertical emittance growth

- Nominal CLIC beam parameters
- Static imperfections:

  case 1
  - quadrupole offset and rotation in the main linac
  - perfect bds
  - 1-to-1 steering in linac and bds

  case 2
  - quadrupole offset and rotation + cavity misalignment
  - perfect bds
  - 1-to-1 steering in linac and bds

  case 3
  - quadrupole and cavity misalignment + cavity phase and gradient errors
  - perfect bds
  - 1-to-1 steering in linac and bds



CLIC nominal 3TeV CM

Summary and Outlook

- Beam-Beam background study
  - Simplified simulation with GUINEA-PIG + GEANT 3 yields 3 hit in the vertex detector (r = 30 mm) due to incoherent pairs production
  - ~ 2.9 $\gamma\gamma \rightarrow$ hadronic events for CLIC nominal parameter 3 TeV CM
  - considering different beam parameter and machine conditions

  $\Rightarrow$ background increase with luminosity

- To do… realistic beam-beam background simulation
  - Static and dynamic machine imperfections + their corrections (alignment-tuning-feedback) all along the machine