IP solenoid & SR studies

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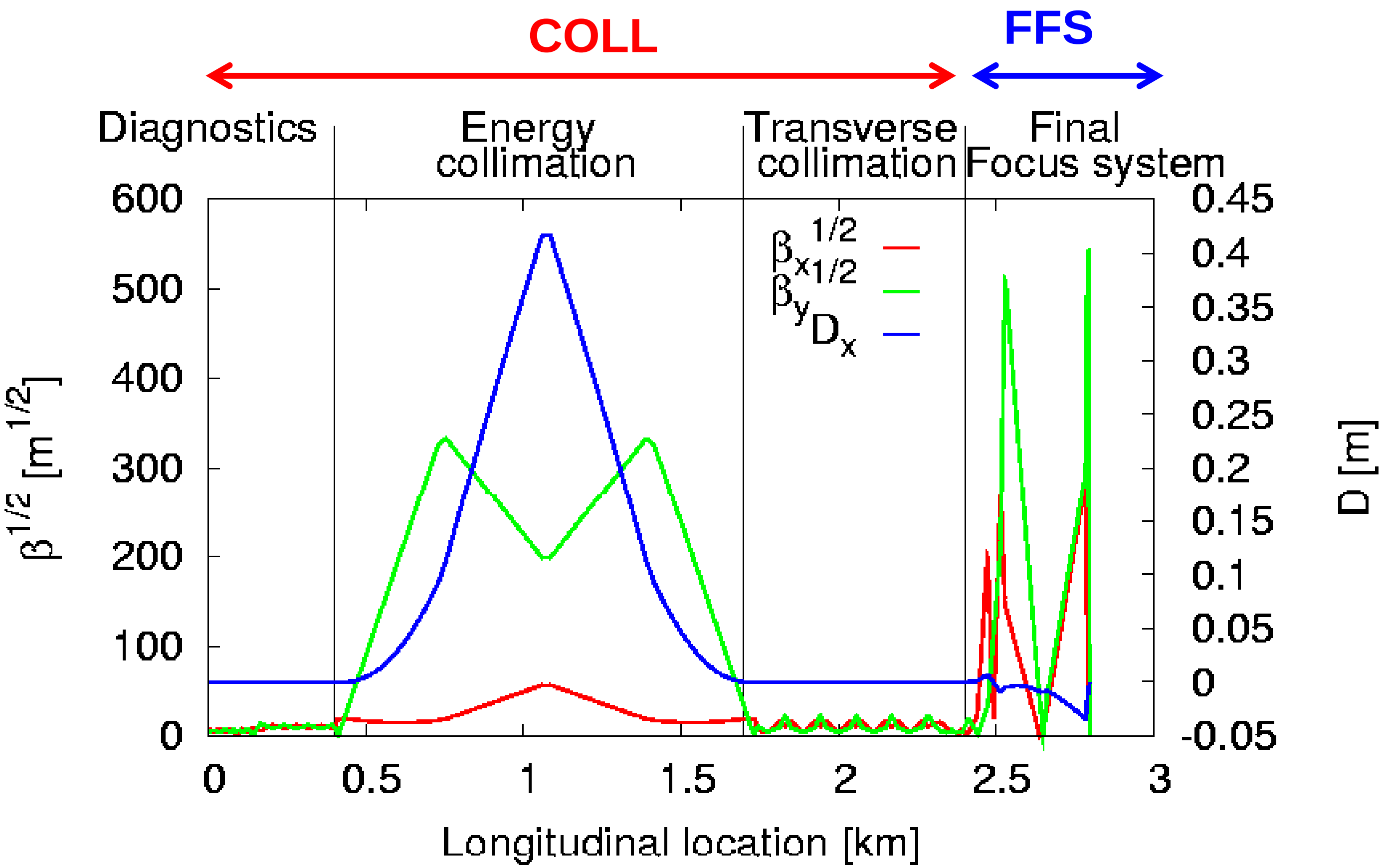
Outline

- ISR studies on CLIC BDS
- Detector solenoid effects
- Conclusions and plans

CLIC BDS lattice

3 TeV



IP beam sizes

PLACET simulation

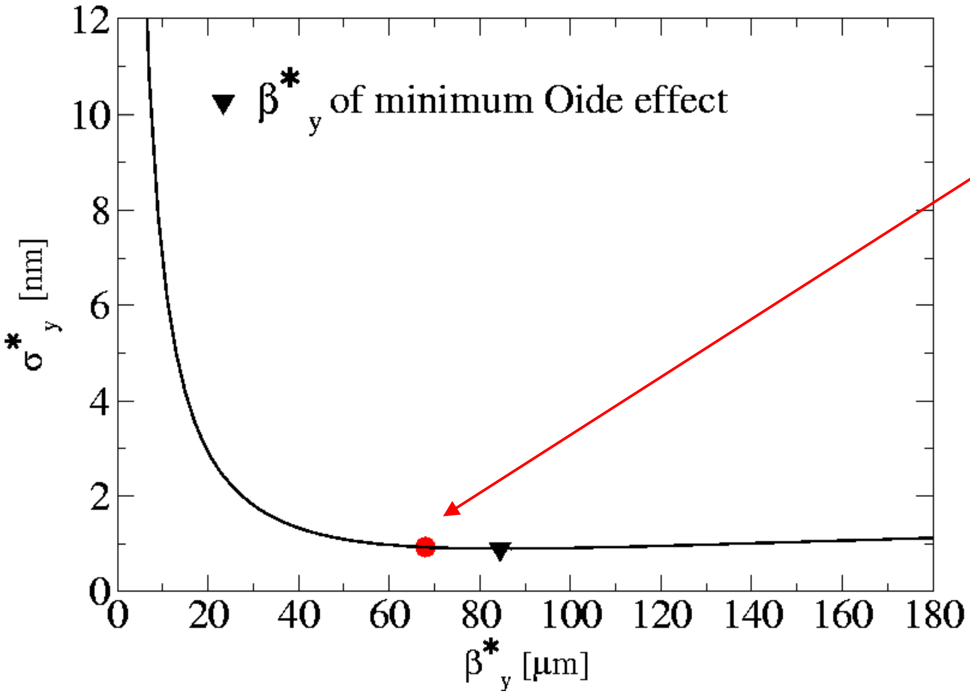
CLIC BDS ***l* = 3.5 m***

	σ_y^* (rms) [nm]	σ_y^* (Gaussian fit) [nm]
w/o ISR	1.0	0.8
w ISR	2.0	1.0

Oide Effect (QD0 ISR)

$$\sigma_y^* = \sqrt{\beta_y^* \varepsilon_y + \frac{110}{3\sqrt{6\pi}} r_e \lambda\!\!\!^{-}_e \gamma^5 F\left(\sqrt{K}L, \sqrt{K}l^*\right)\left(\frac{\varepsilon_y}{\beta_y^*}\right)^{5/2}}$$

K. Oide
PRL 61(1988)1714



CLIC BDS

l^* = 3.5 m

γ= 1500 GeV/ $m_e c^2$

K = 0.159/1.37 (m^{-2})

L = 2.74 m

β_y^* = 68 μm

Luminosity loss due to ISR in CLIC-BDS

PLACET + GUINEA PIG
First results

Luminosity in the peak per bunch crossing in m^{-2}
Nominal CLIC beam parameters

ALL BDS	lumi_high ($\times 10^{34}$ m^{-2})	L/L0
ALL ISR OFF	2,22±0.03	1,00±0.02
ALL ISR ON	1,72±0.05	0,78±0.02
ISR QUAD ON/rest off	2,00±0.03	0,90±0.02
ISR MULTI ON/rest off	2,22±0.04	1,00±0.02
ISR SBEND ON/rest off	1,92±0.02	0,86±0.02
ISR last quad off/rest on	1,91±0.02	0,87±0.02
ISR last quad on/rest off	2,00±0.03	0,90±0.02
COLL ON/FFS OFF	2,18±0.03	0,98±0.02
COLL OFF/FFS ON	1,78±0.03	0,80±0.03

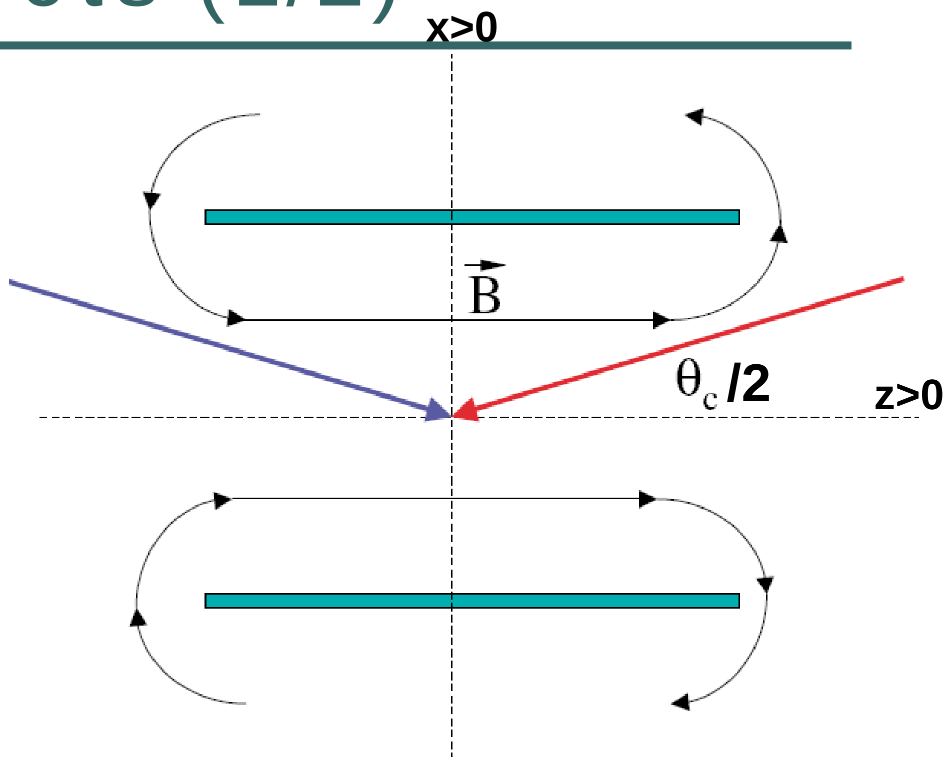
20% of luminosity loss due to synchrotron radiation:

-About 10% of luminosity loss due to QD0

-About 10% of luminosity loss due to SBEND in the FFS.

IP Solenoid effects (1/2)

- Due to the crossing angle the beam encounters a nonzero vertical bending (y) as it travels in the solenoid detector.
- Particles at lower energies experience a larger deflection than those at higher energies $\Rightarrow$ vertical dispersion
- The beam emits synchrotron radiation as it is deflected $\Rightarrow$ growth in the vertical direction of the IP spot size.

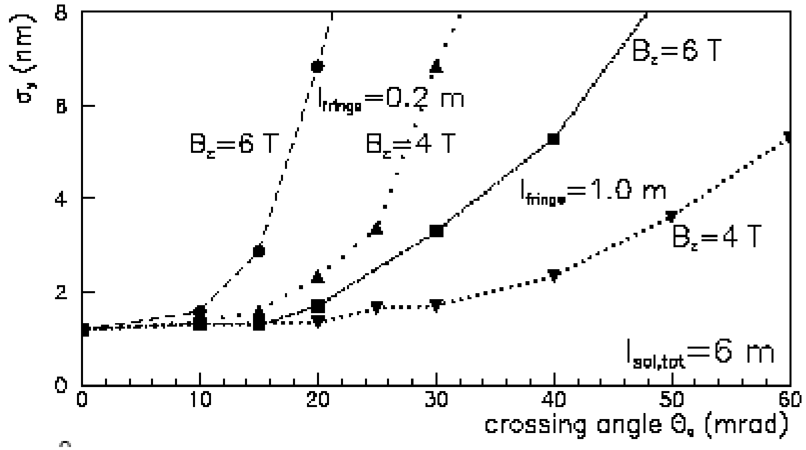


Schematic view of the two beams colliding with a crossing angle in the detector solenoid.
P. Tenenbaum et al., PR ST- AB, vol. 6, 061001 (2003)

IP Solenoid effects (2/2)

- Literature agrees that vertical size increase is acceptable for θ_c < 20 mrad, B=4 T and Lfringe >1 m [(1)]
- If solenoid field extends over the FD quadrupoles important problems appear that can be compensated with *antisolenoids*, Y. Nosochkov and Andrey Seryi LCC-0142 SLAC-PUB-10592.

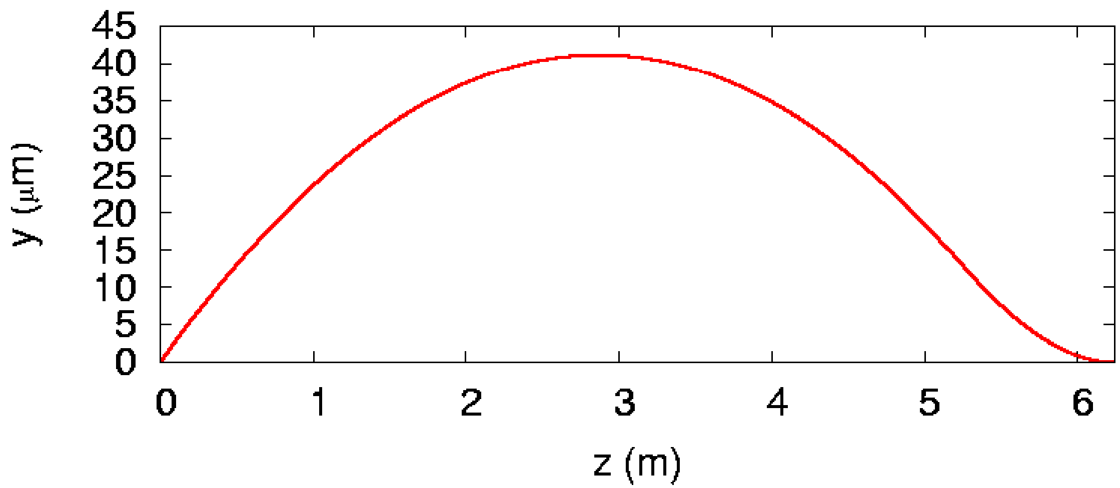
⇒ Detailed studied needed in order to be able to evaluate the Solenoid effects (*not only ISR*) with a *Realistic Magnetic Field*



[(1)] *D.Schulte and F.Zimmermann,* Proc. Part.Acc.Conf. (2001) Chicago

Models and Tools

- Tracking program:
  - solves numerically the Lorentz equations of motion in the solenoid.
  - takes into account the Monte Carlo simulation for synchrotron radiation implemented in PLACET.
  - reads realistic magnetic field map from an external file



Orbit in a simple solenoid magnetic field model

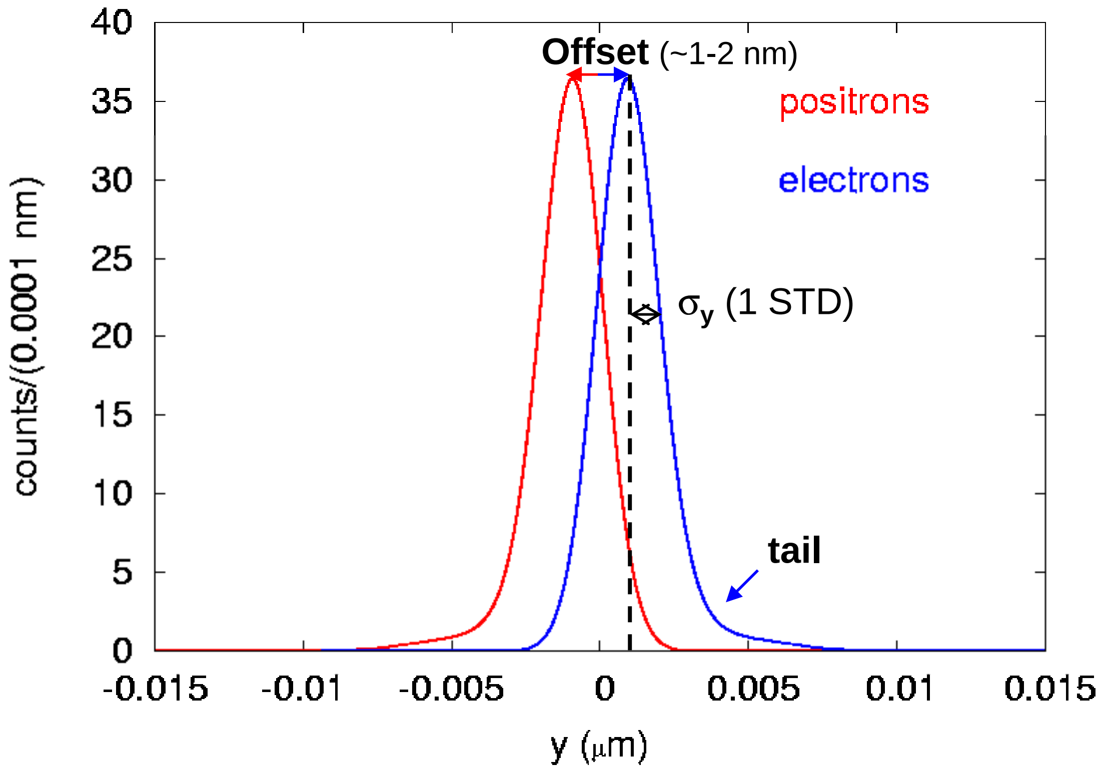
Estimating Synchrotron Radiation effects due to IP solenoid

- Constant field in the central solenoid region 0< z < 3.5 m.

traced ~ 3000 particles (all @ CLIC nominal energy) with synchrotron radiation.

convolution of the simulated spectrum with a Gaussian (beam size σ_{y0} = 1 nm).

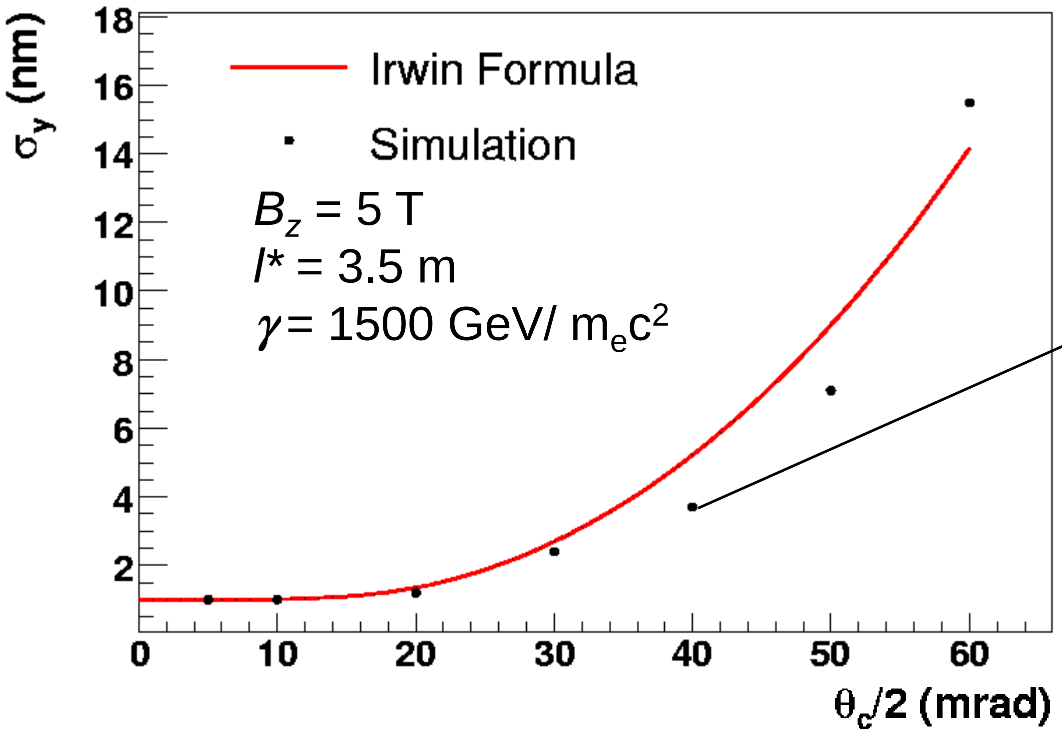
the vertical increase of the beam spot size is evaluated at 1 STD.

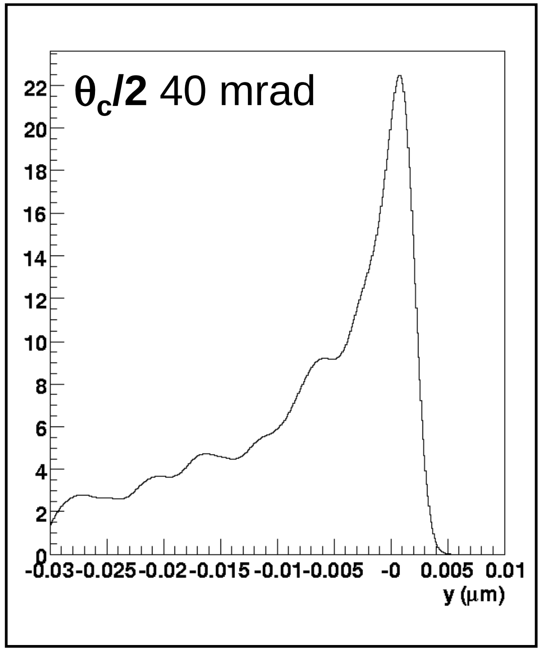


ISR in constant solenoid field vs crossing angle

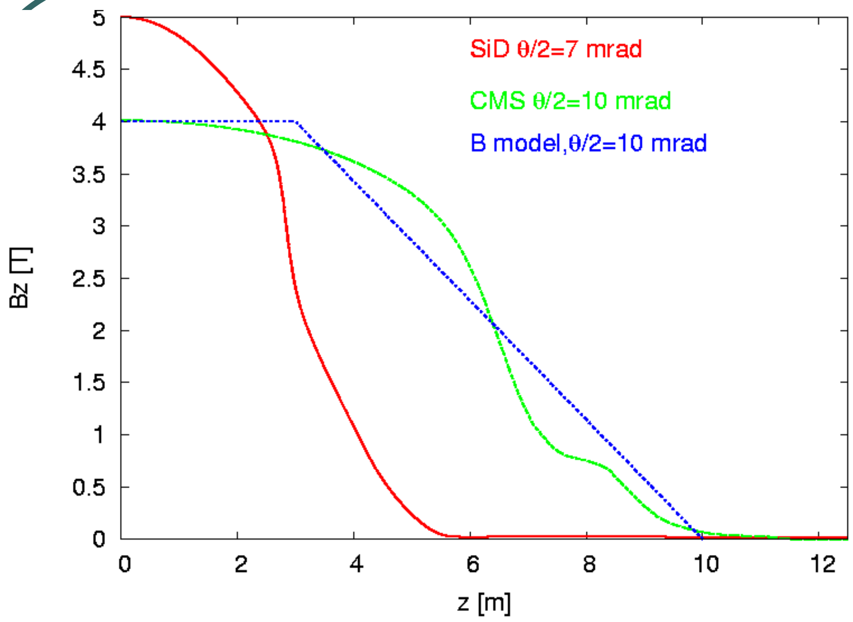
$$\frac{\Delta\sigma_y^2}{\sigma_{y0}^2} = \frac{1}{20}\frac{c_u r_e \lambda\!\!\!^-_e}{\sigma_{y0}^2}\left(\frac{B_z\theta_c l^*\gamma}{2(B\rho)}\right)^5$$

→ *D.Schulte and F.Zimmermann*, Proc. Part.Acc.Conf. (2001) Chicago



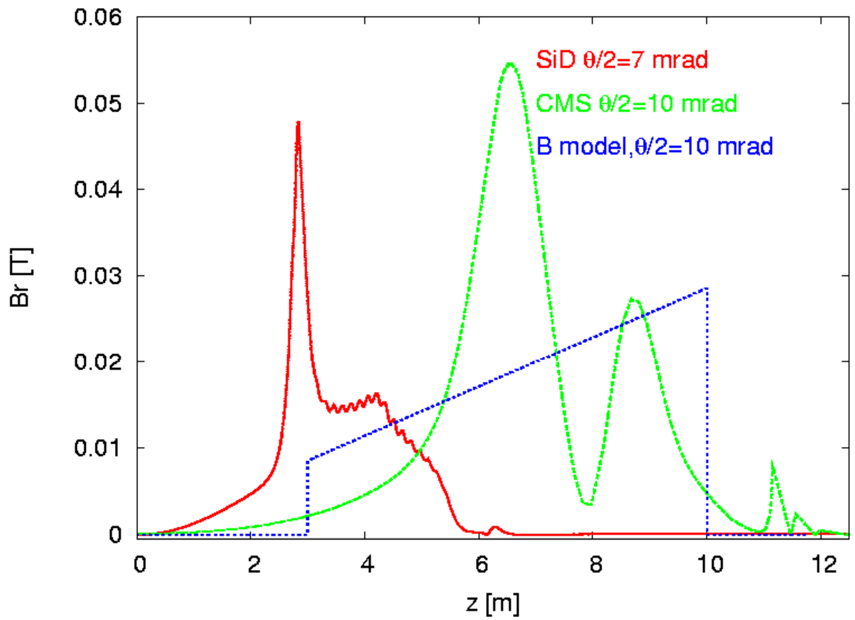


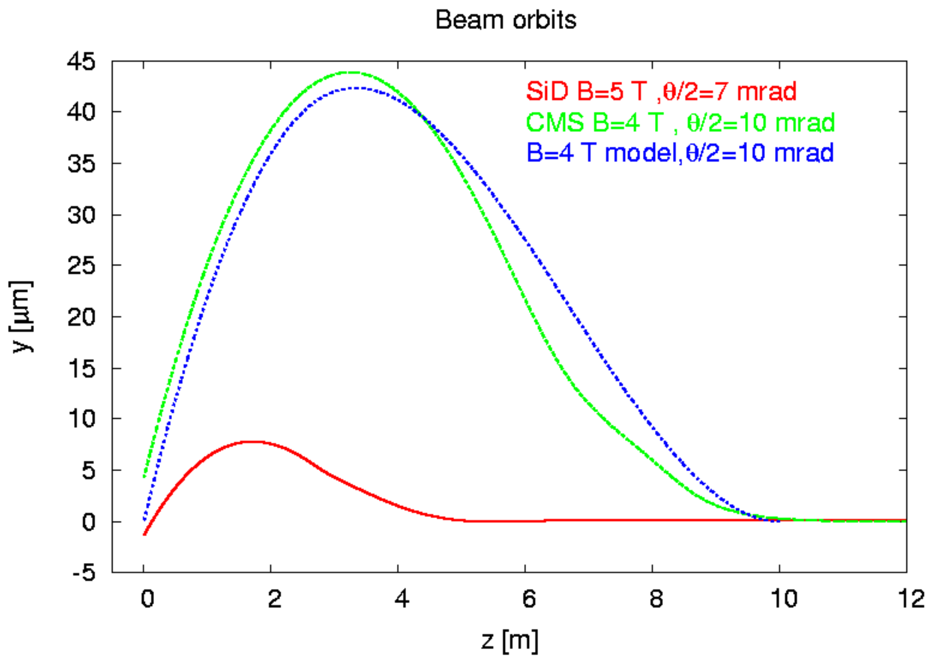
Gaussian approximation does not hold!



Realistic Solenoid fields

Orbits in different magnetic fileds:
1)SiD: field calculated by ANSYS
2)CMS: interpolated from measured data points
3)Simple model of solenoid magnetic field (for comparison)





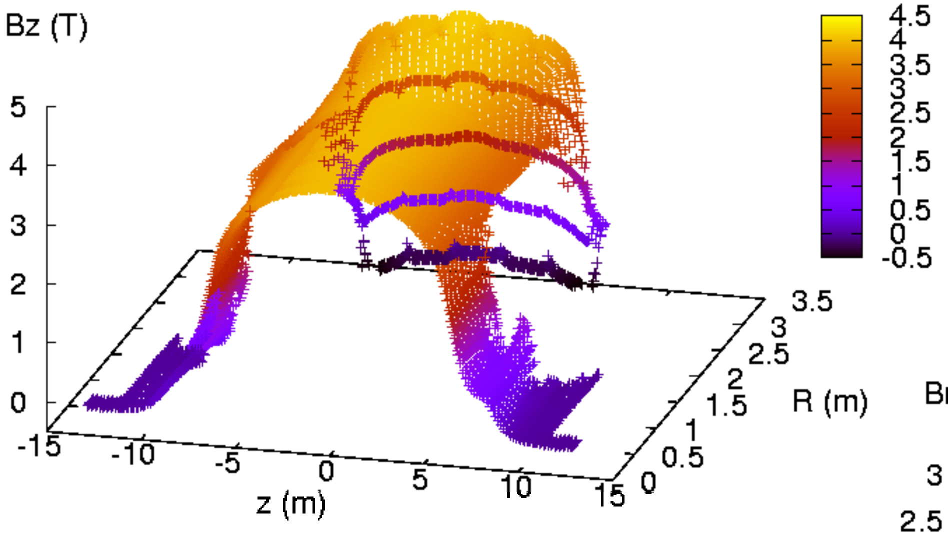
Conclusion and plans

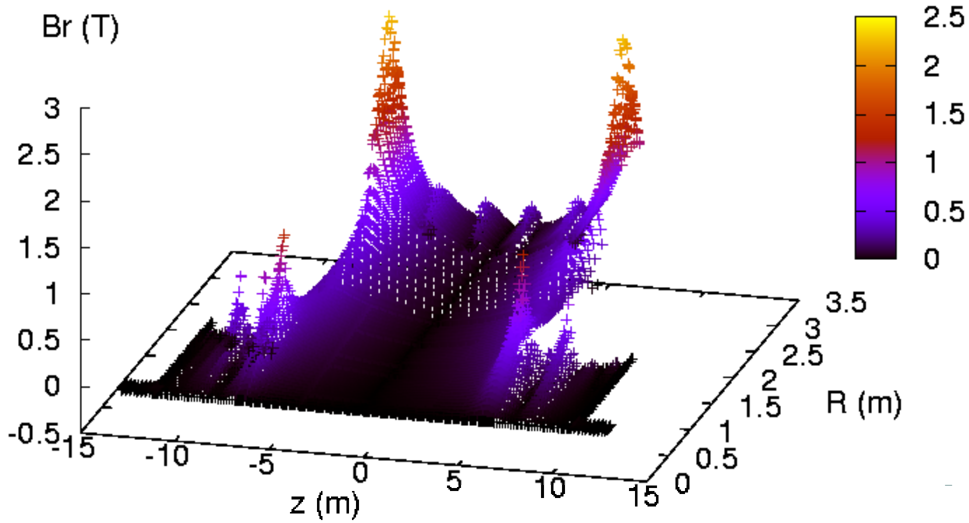
- First results of ISR studies on CLIC BDS:
  - σ_y^* beam size of the core is ~ 1 nm.
  - Luminosity loss is **20%**: 10% from QD0 and 10% from the SBEND in the FFS.
- ISR due to IP Solenoid alone is limited for $\theta_c < 20$ mrad B $\leq$ 5 T, but how it couples with the last QD0 has still to be considered.

- Work in progress:
  - include in the tracking CLIC BDS magnets to which the IP Solenoid field is overlapped.
  - include in the tracking realistic beam conditions.

Back-Up

CMS measured magnetic field





CMS measured magnetic field (interpolation)