Solenoid and SR studies

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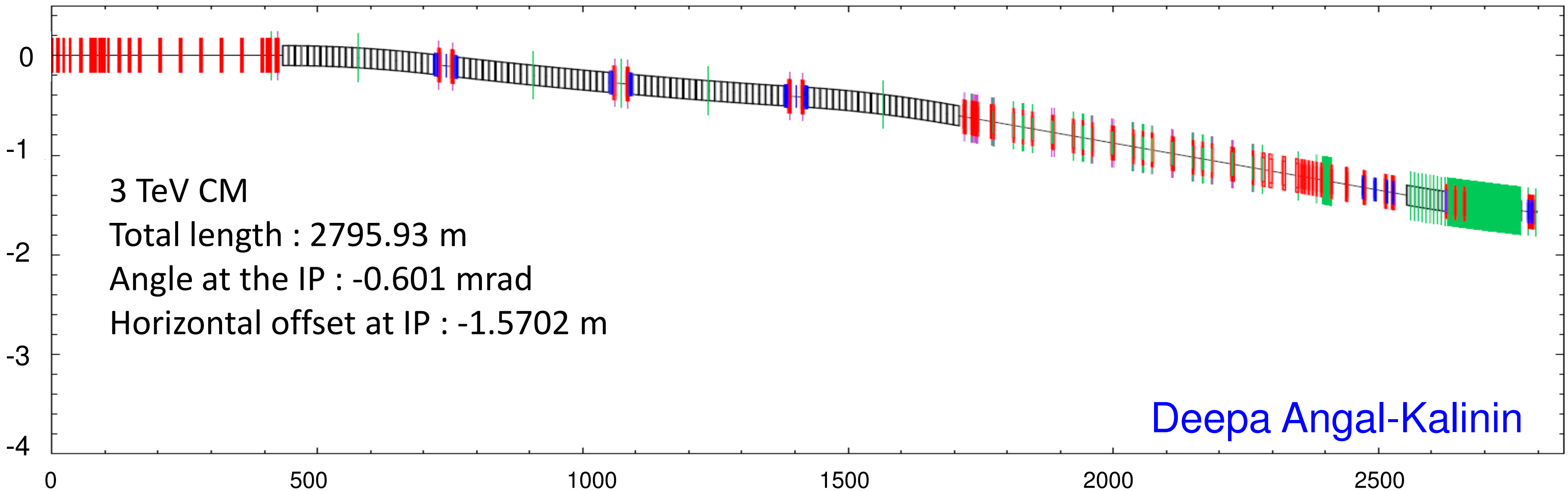
Outline

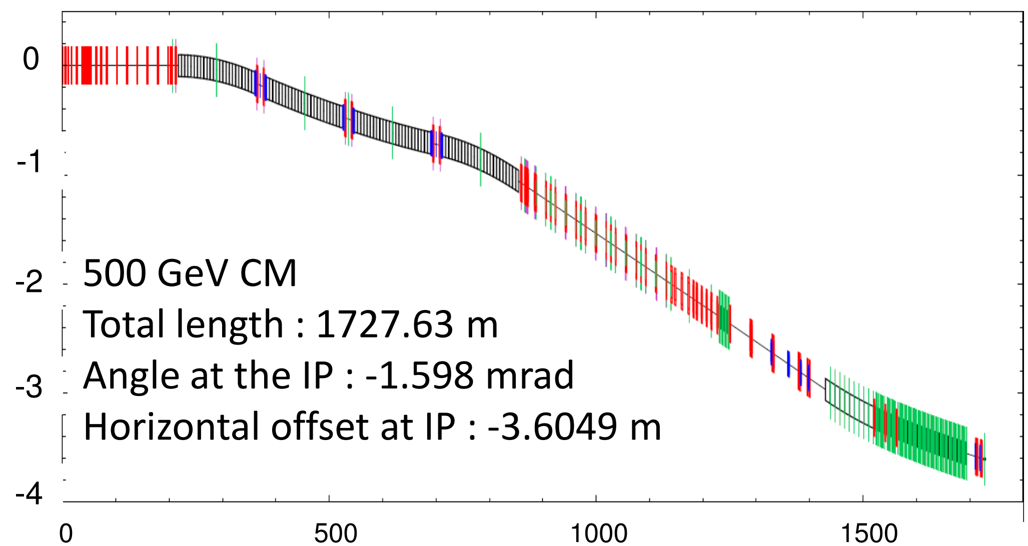
- Incoherent Synchrotron Radiation in the CLIC BDS
  - Oide's limit
  - Beam size growth and Luminosity loss
- Incoherent synchrotron radiation in the detector solenoid
  - Interaction Region Solenoid effects
  - Luminosity loss due to synchrotron radiation

CLIC BDSs



beam is bent in the horizontal plane it emits incoherent synchrotron radiation

$$P_S = \frac{e^2 c}{6\pi\varepsilon_0} \frac{1}{(m_0 c^2)^4} \frac{E^4}{R^2}$$

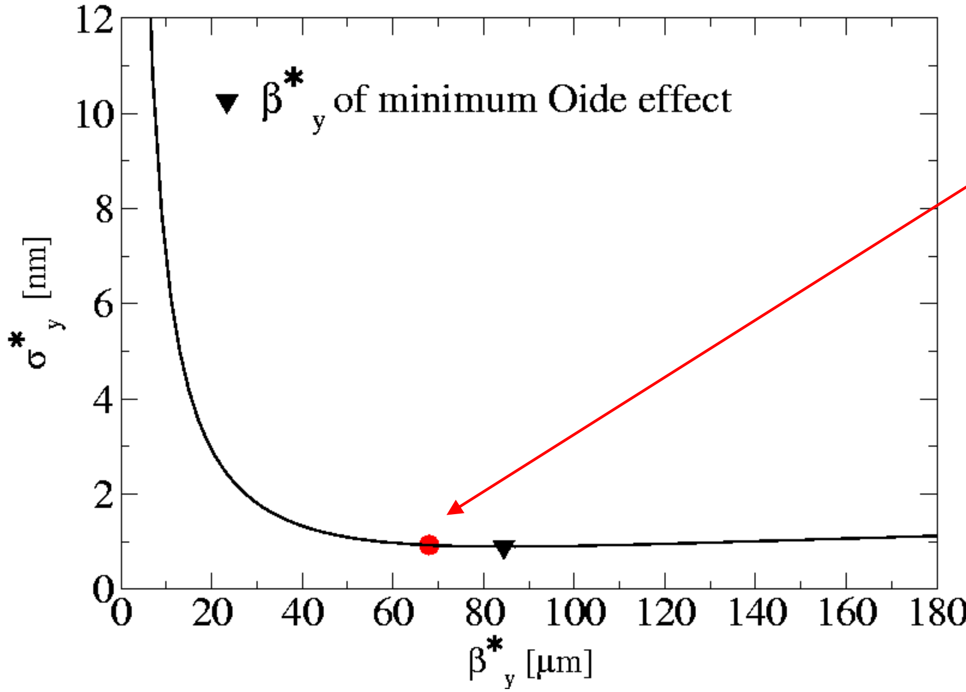


Oide Effect

focusing of electron beams is limited due to the emission of incoherent synchrotron radiation in the final focusing lens.

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

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

σ_y^*(Oide) ≅ 0.93 nm

IP beam sizes

PLACET simulation

CLIC BDSs
1% flat beam energy spread

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

		σ_y^* (rms) [nm]
0.5 TeV CM	w/o ISR	5.8
	w ISR	5.9

Very good agreement between PLACET and DIMAD σ_y^* (rms) with a 0.4% Gaussian energy spread beam.

Luminosity Loss due to ISR in CLIC-BDS

PLACET + GUINEA PIG

ALL BDS	L/L0
ALL ISR OFF	1,00±0.02
ALL ISR ON	0,78±0.02
ISR QUAD ON/rest off	0,90±0.02
ISR MULTI ON/rest off	1,00±0.02
ISR SBEND ON/rest off	0,86±0.02
ISR FD off/rest on	0,87±0.02
ISR FD on/rest off	0,90±0.02
COLL ON/FFS OFF	0,98±0.02
COLL OFF/FFS ON	0,80±0.03

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

~20% of luminosity loss due to synchrotron radiation:

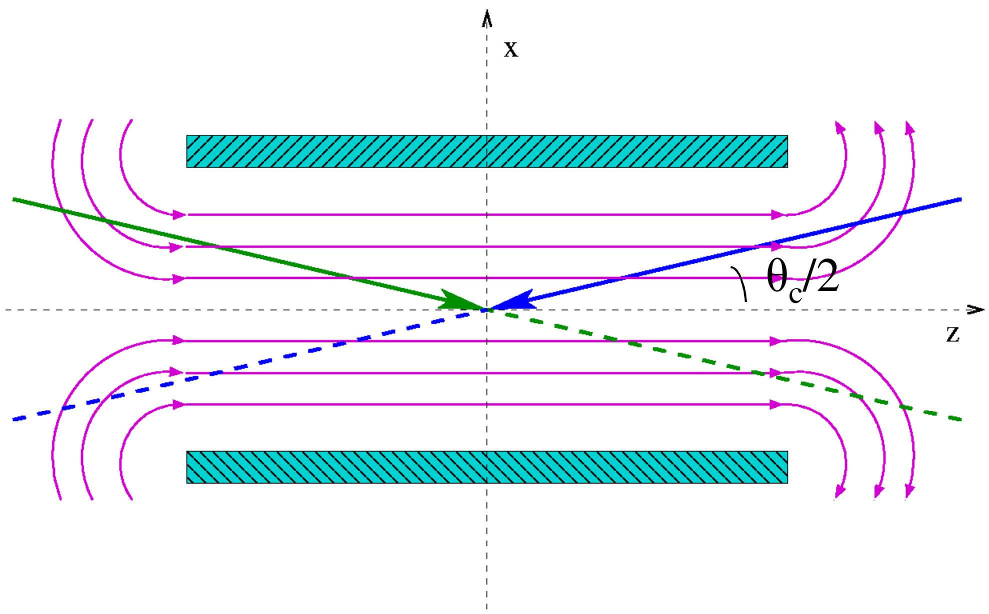
-~ 10% of luminosity loss due to Final Doublet.

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

CLIC-BDS at 0.5 TeV CM:
< 1%

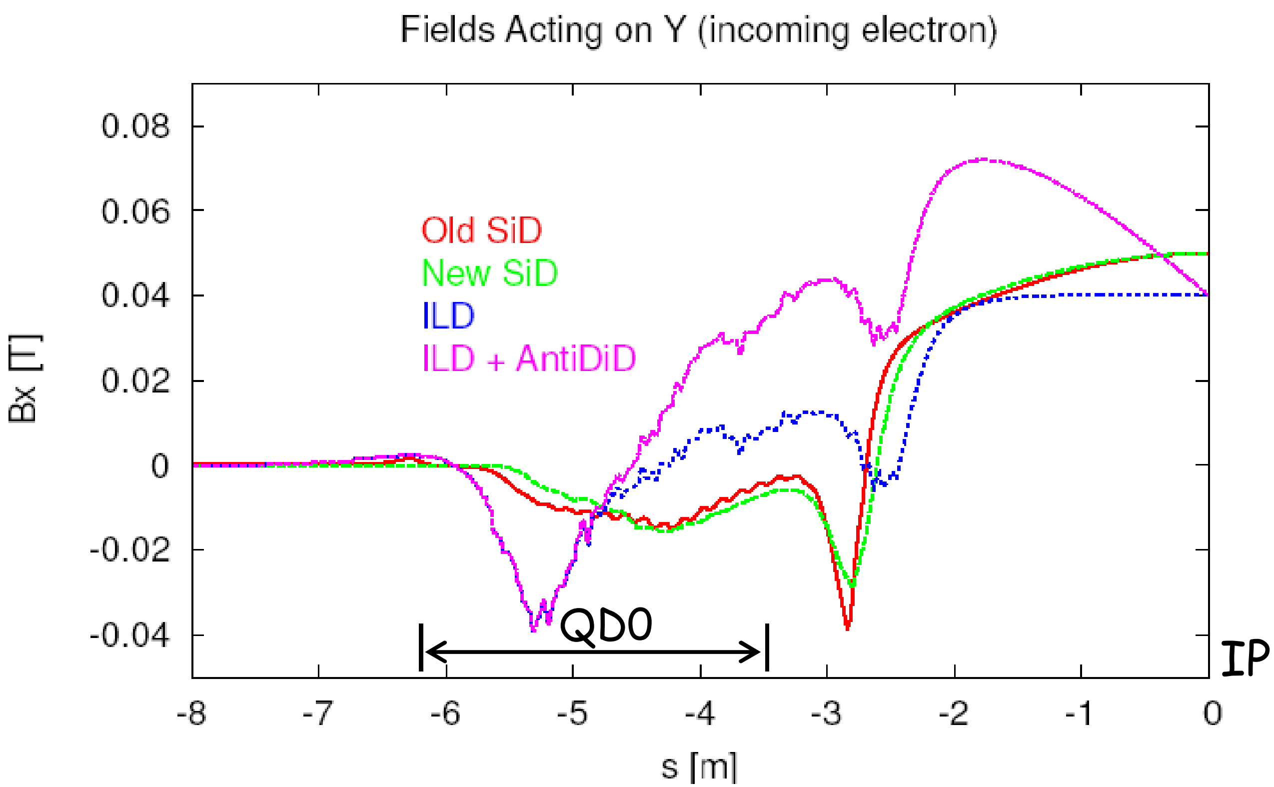
Solenoid Effects

- ***Weak focusing***: in the two transverse planes
- ***Orbit deviation***: the beam is bent as it traverses the magnetic field
- ***Coupling between x-y plane***: the particle position in one plane depends on the position in the other plane
- ***Dispersion***: particles at lower energies experience a larger deflection than those at higher energies
- The beam emits ***Incoherent Synchrotron Radiation*** (ISR) as it is deflected



Schematic view of the two beam colliding with a crossing angle in the detector solenoid.

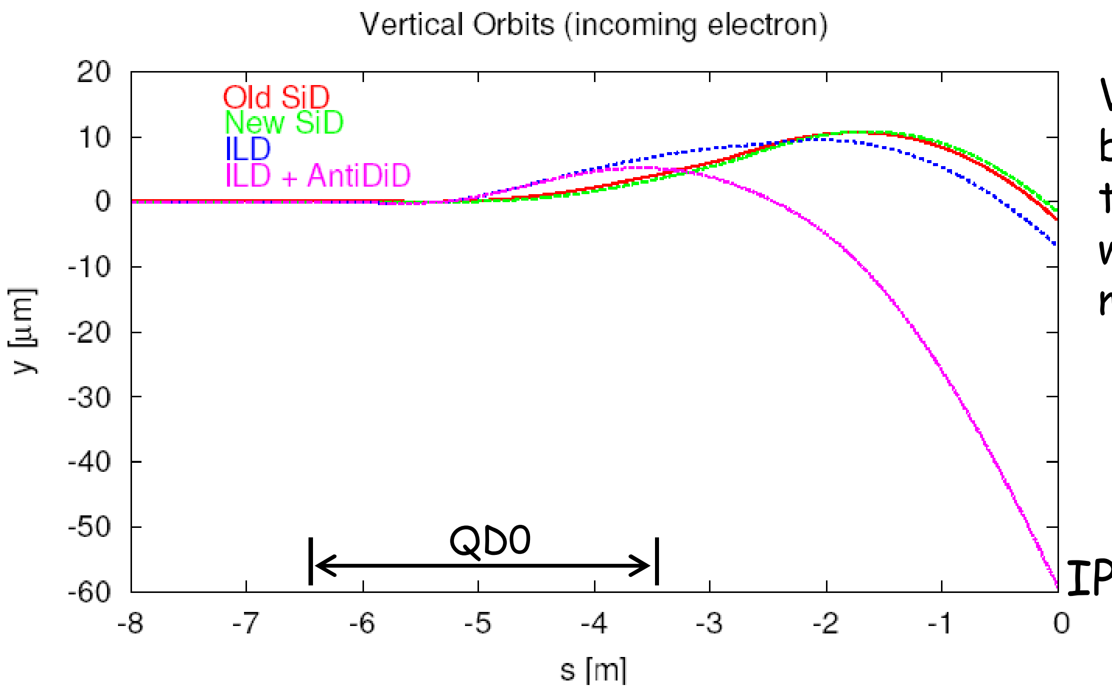
Detector Solenoid magnetic fields



B_x component of solenoid fields in the beamline reference system

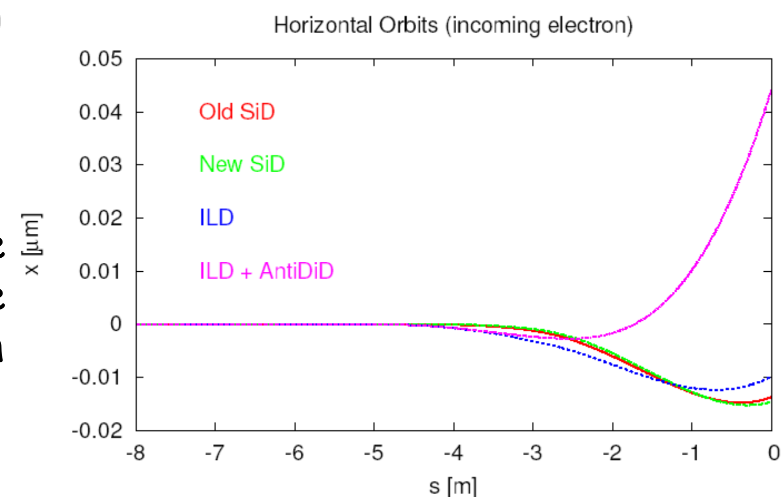
Old SiD: http://www-project.slac.stanford.edu/lc/bdir/Meetings/beamdelivery/2005-10-04/index.htm
New SiD: Kurt Krempetz (FNAL)
ILD (AntiDiD): A. P. Sailer (CERN) Mokka database

Orbits



Vertical orbits deviation in the beamline reference system due to the Solenoid field and its overlap with QD0 (and the other FF magnets).

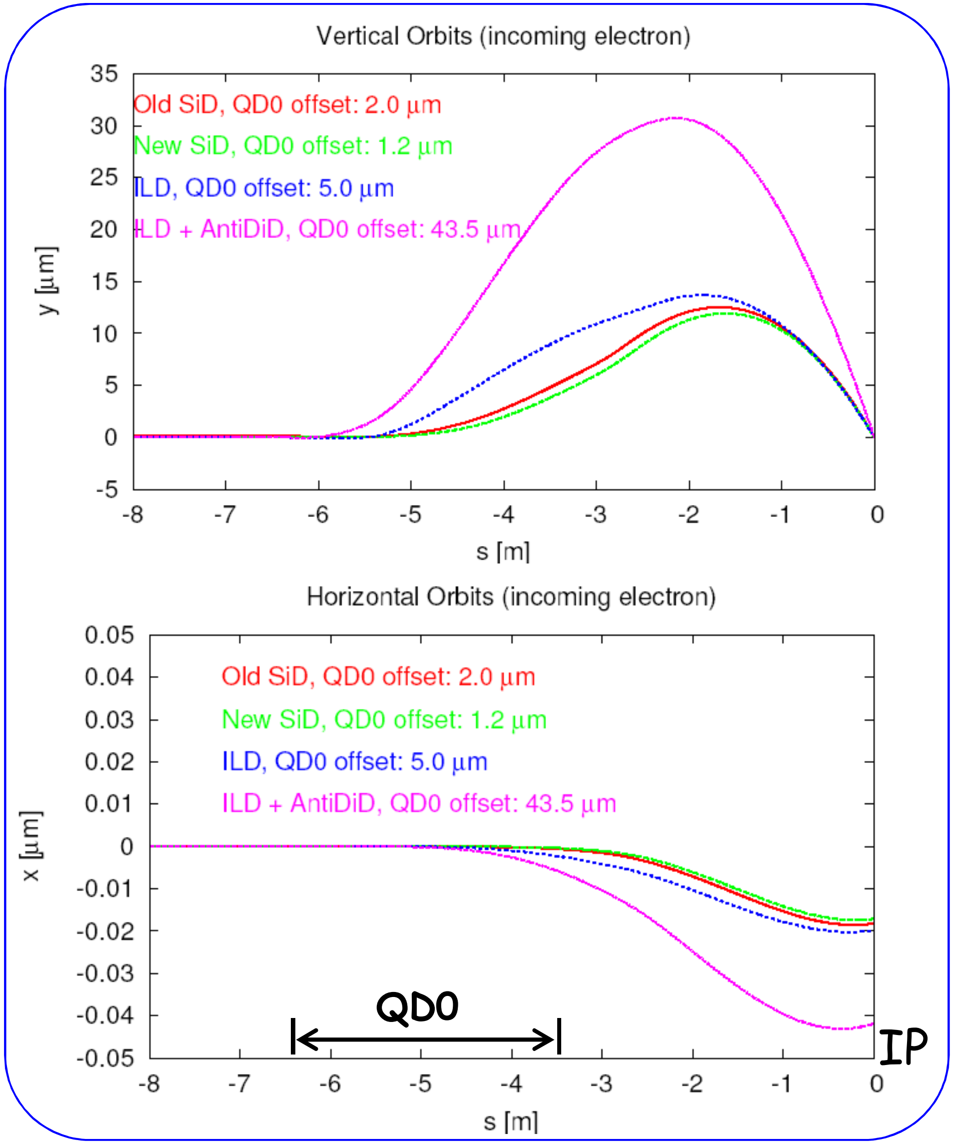
Horizontal orbits deviation in the beamline reference system due to the Solenoid field and its overlap with QD0(and the other FF magnets).



Vertical offset correction (1/2)

- Compensation of detector solenoid effects:
  - J.J. Murray, SLAC-CN-237
  - Y. Nosochkov and A. Seryi, PRST-AB 8, 021001 (2005)
  - B.Parker and A. Seryi, LCC-0143

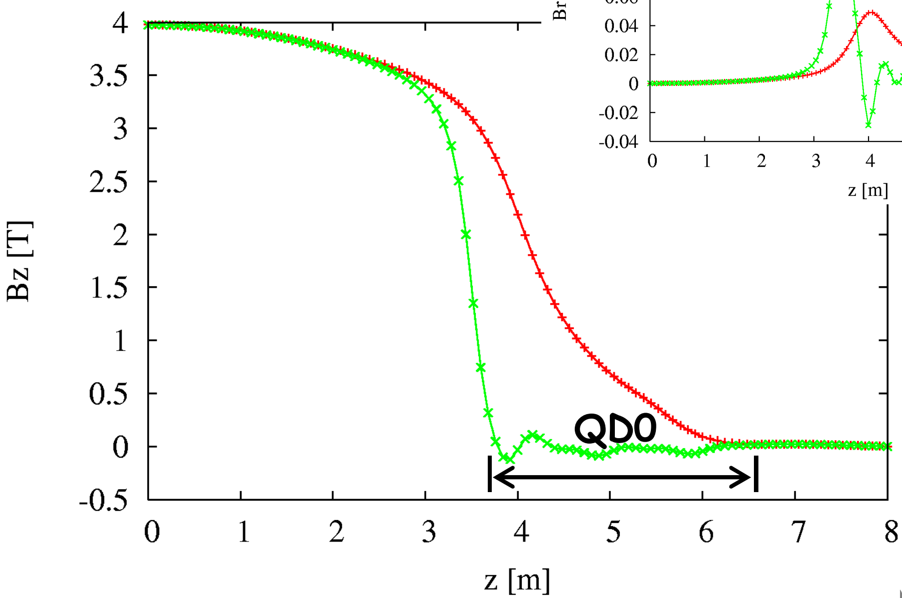
- The vertical offset at IP can be compensated with QD0 offset.

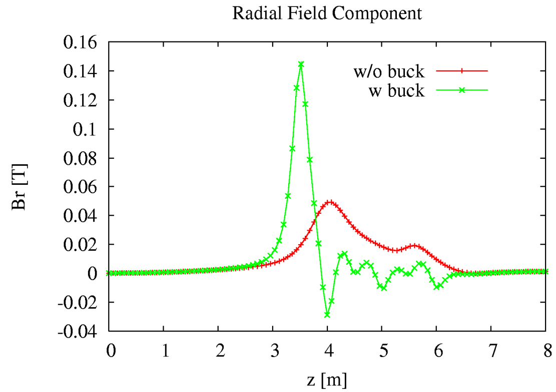


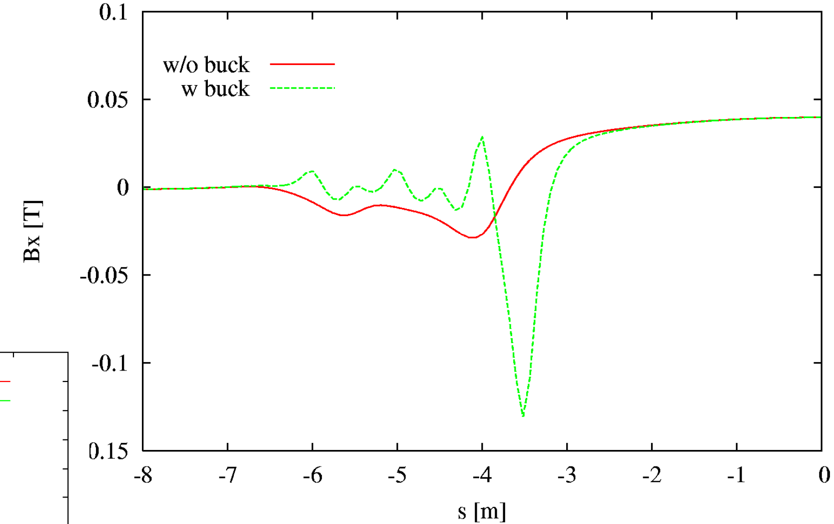
Vertical offset correction (2/2)

- "anti-solenoids" (bucking coils covering QD0), cancelling the main solenoid magnetic field component, can also reduce offset at IP (z=s=0).

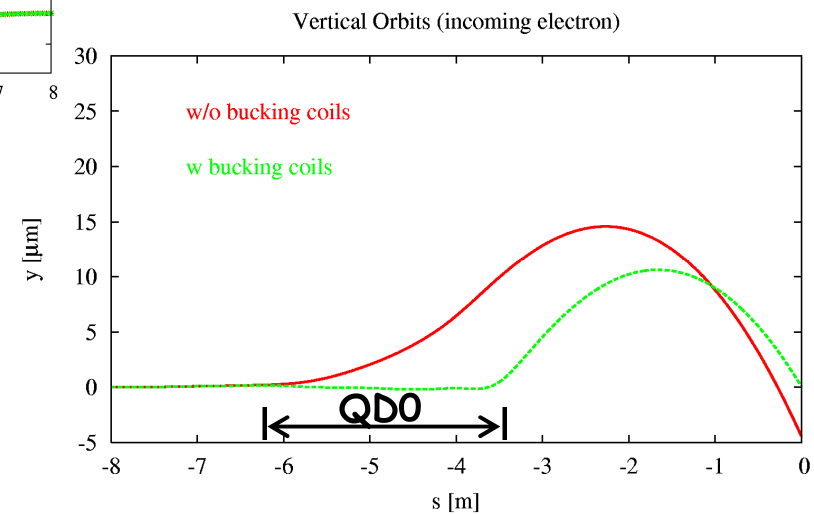
solenoid reference system







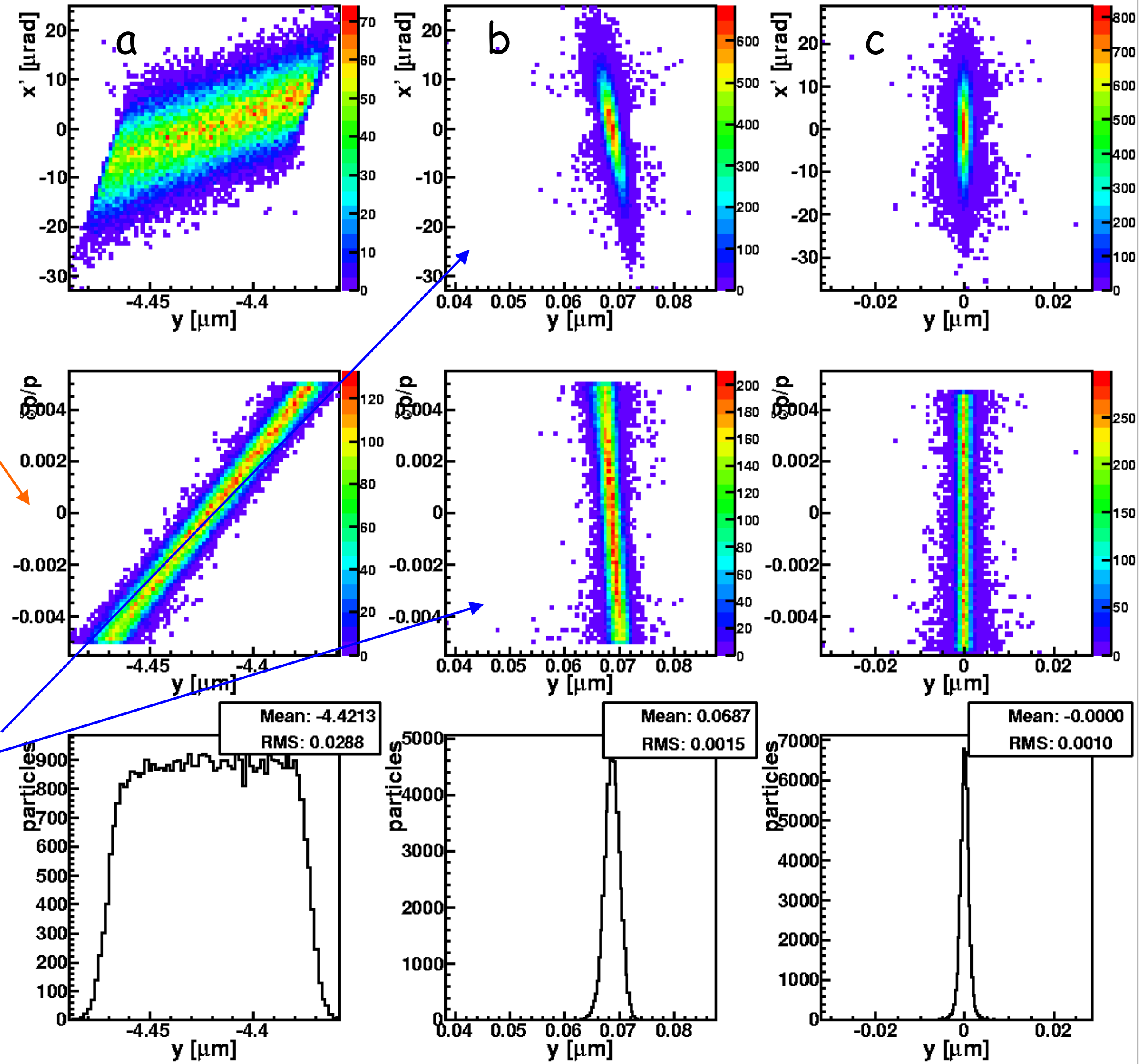
beamline reference system



Vertical dispersion and <x',y> coupling

< x',y > coupling and vertical dispersion at IP

a) Tracking trough FFs and IP Solenoid
b) Tracking trough FFs and IP Solenoid + anti-solenoids covering QD0
c) Tracking trough FFs only



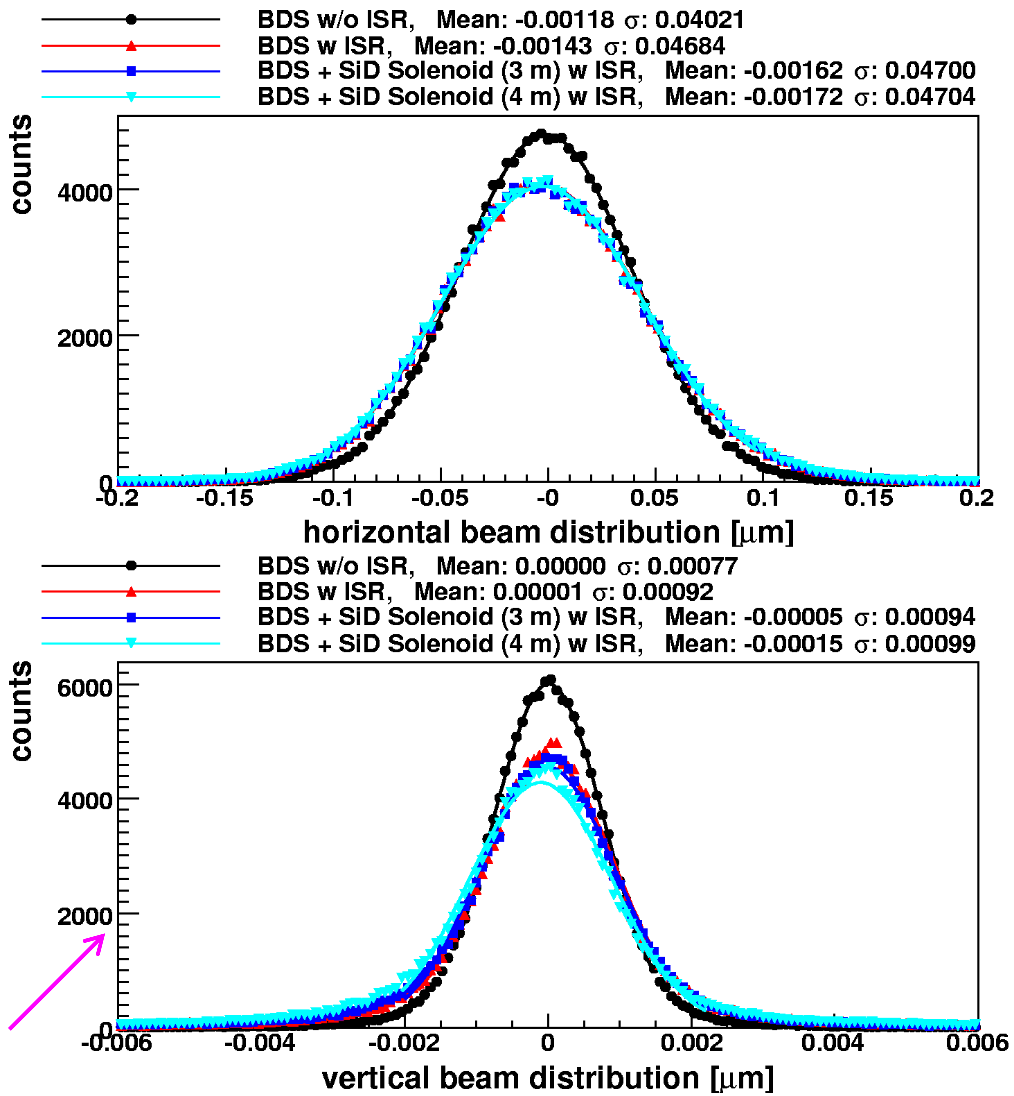
Residual <x',y> coupling and dispersion can be compensated using the other FFs magnets

Incoherent Synchrotron Radiation

- In order to evaluate ISR effect (O(nm)) we need to consider fully compensated optical effects (O(μm))

- Incoherent synchrotron radiation due to detector solenoid is evaluated by tracking, a compensated beam (from backtracking), taking into account the Monte Carlo synchrotron radiation implemented in PLACET

IP beam distributions



Luminosity Loss

Map	Bz [T]	L[m]	Lumi loss [%]
Old SiD	5	2.8	~4.0
New SiD	5	2.8	~3.0
ILD	4	3.7	~4.0
ILD + AntiDiD	4	3.7	~25.0

- luminosity calculation by GUINEA-PIG
- CLIC half horizontal crossing angle 10 mrad
- ILD values are computed with QD0 offset: 5μm (ILD), 43.5μm (ILD+AntiDiD)

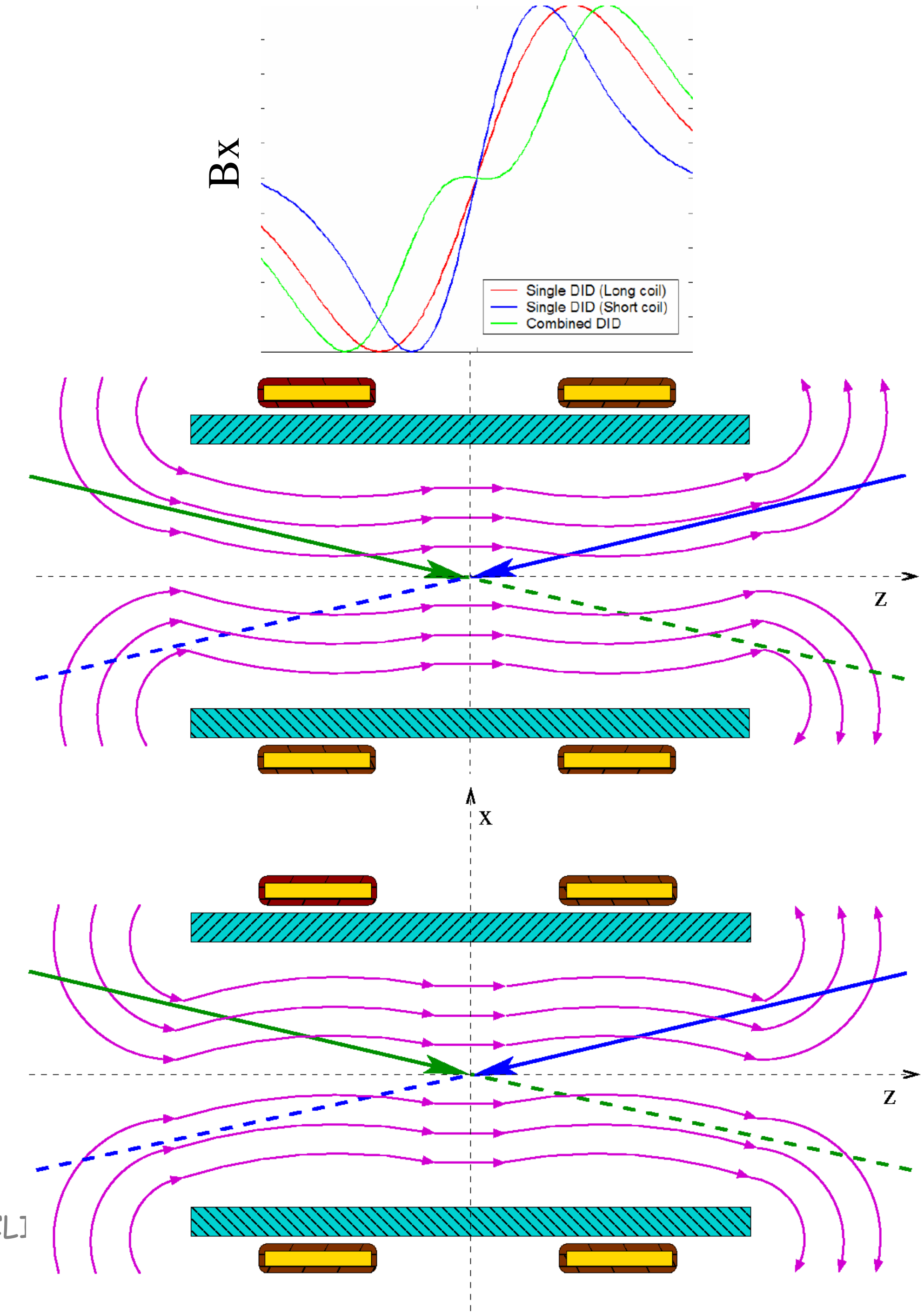
Conclusion

- Luminosity Loss due to ISR in CLIC-BDS at 3TeV CM
  - ~ 20% luminosity loss
  - Horizontal and Vertical IP spot sizes increase
- Interaction region studies
  - Luminosity loss due to detector solenoids depend on field shape and its overlap with QD0
  - AntiDiD increases the luminosity loss up to 25%
  - Anti-Solenoids (bucking coils covering QD0) reduces beam distortion due to Solenoid and QD0 overlap (effect of radiation to be evaluated)

spares

DiD - AntiDiD

- DiD
  - Coil wound on detector solenoid giving transverse field (Bx)
  - It can zero y and y′ at IP
  - But the field acting on the outgoing beam is bigger than solenoid detector alone ⇒ pairs diffuse in the detector



- AntiDiD
  - Reversing DiD's polarity and optimizing the strength, more than 50% of the pairs are redirected to the extraction apertures

A. Seryi