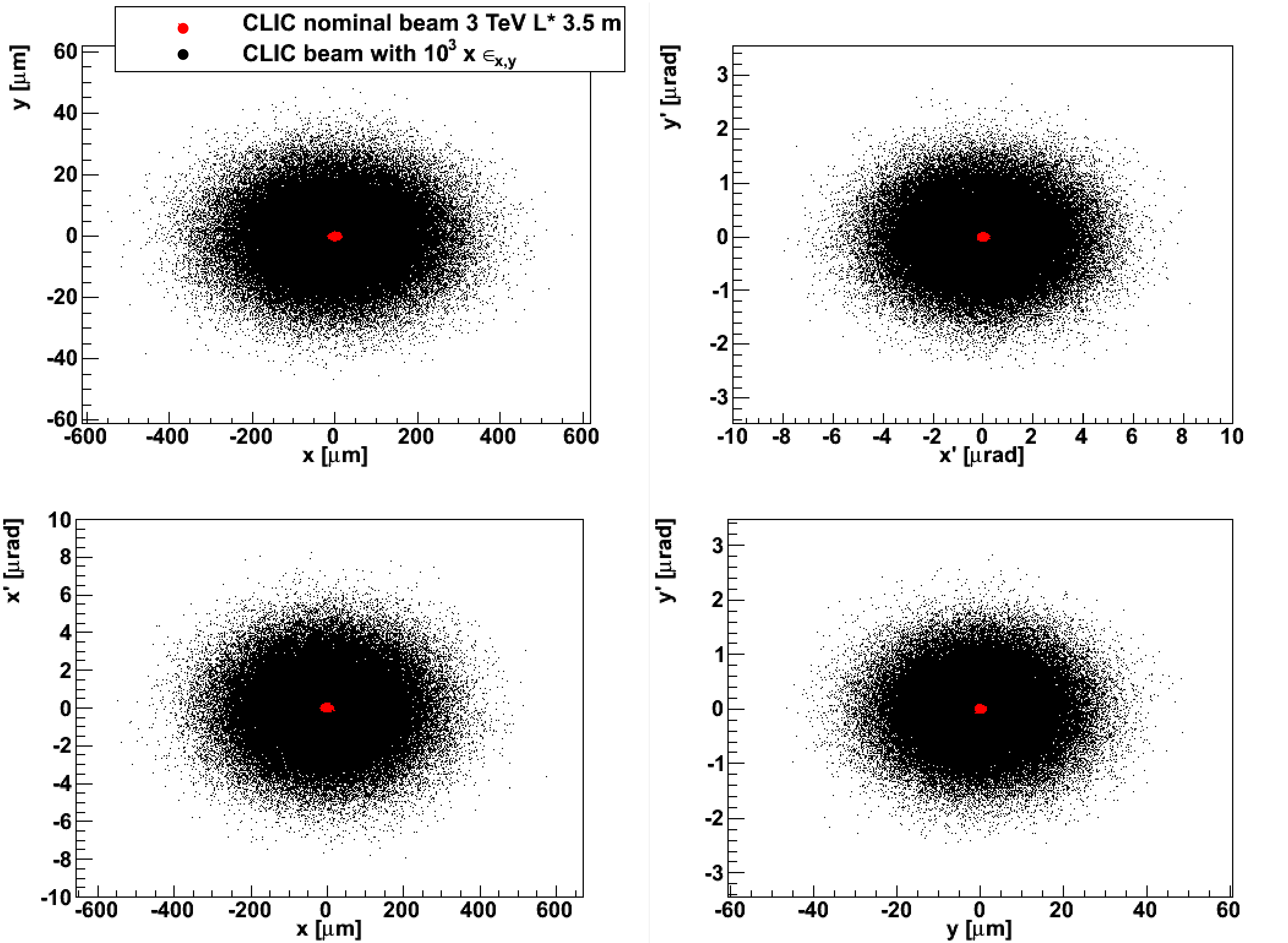
Synchrotron Radiation Studies in the CLIC BDS and Interaction Region

B.Dalena, D. Schulte, R. Tomás

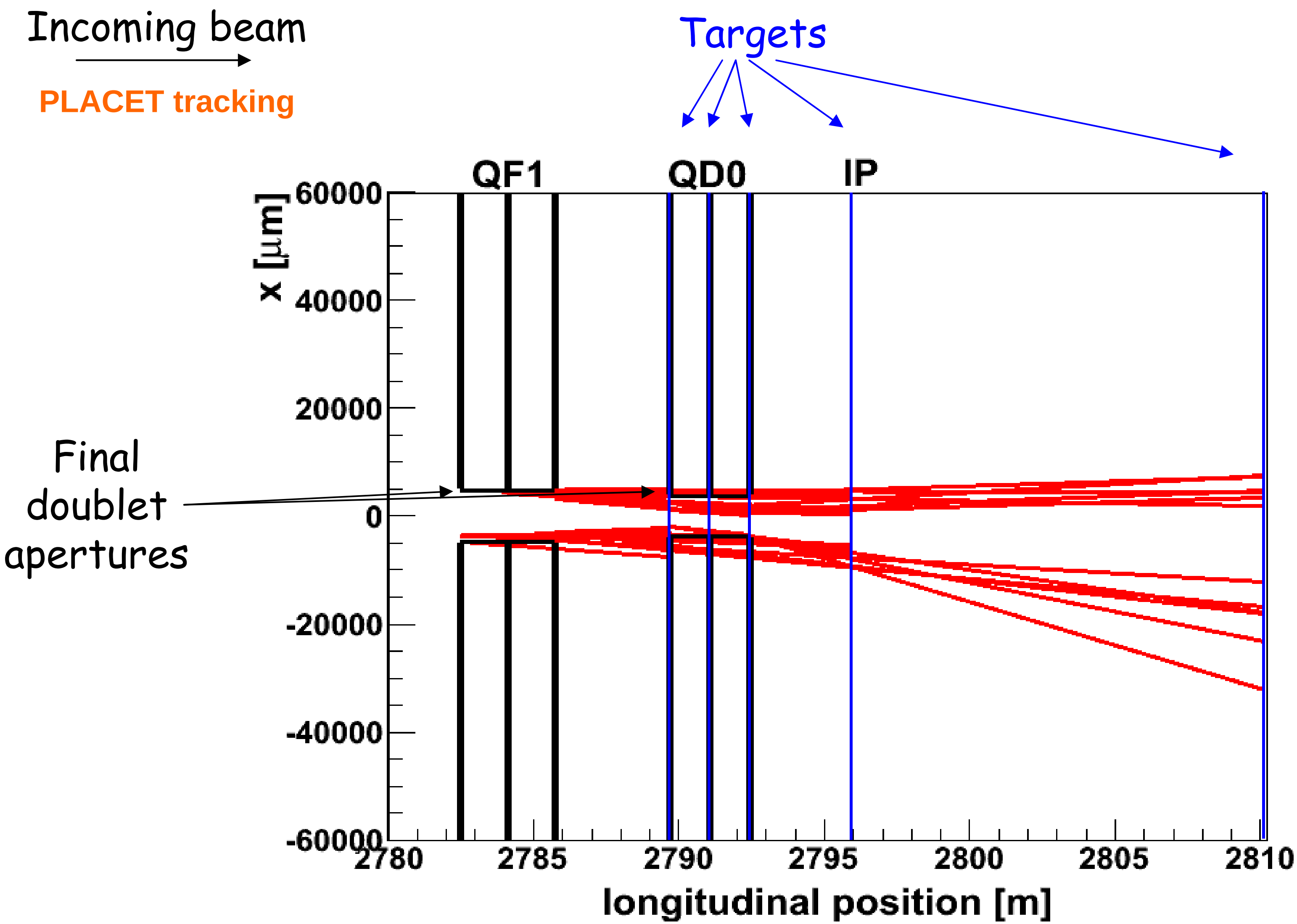
Outline

- Incoherent synchrotron radiation in the CLIC BDS
  - Collimation depths
  - Scan of X,Y collimation apertures
- Incoherent synchrotron radiation in the detector solenoid
  - Different maps analyzed
  - Luminosity loss due to synchrotron radiation

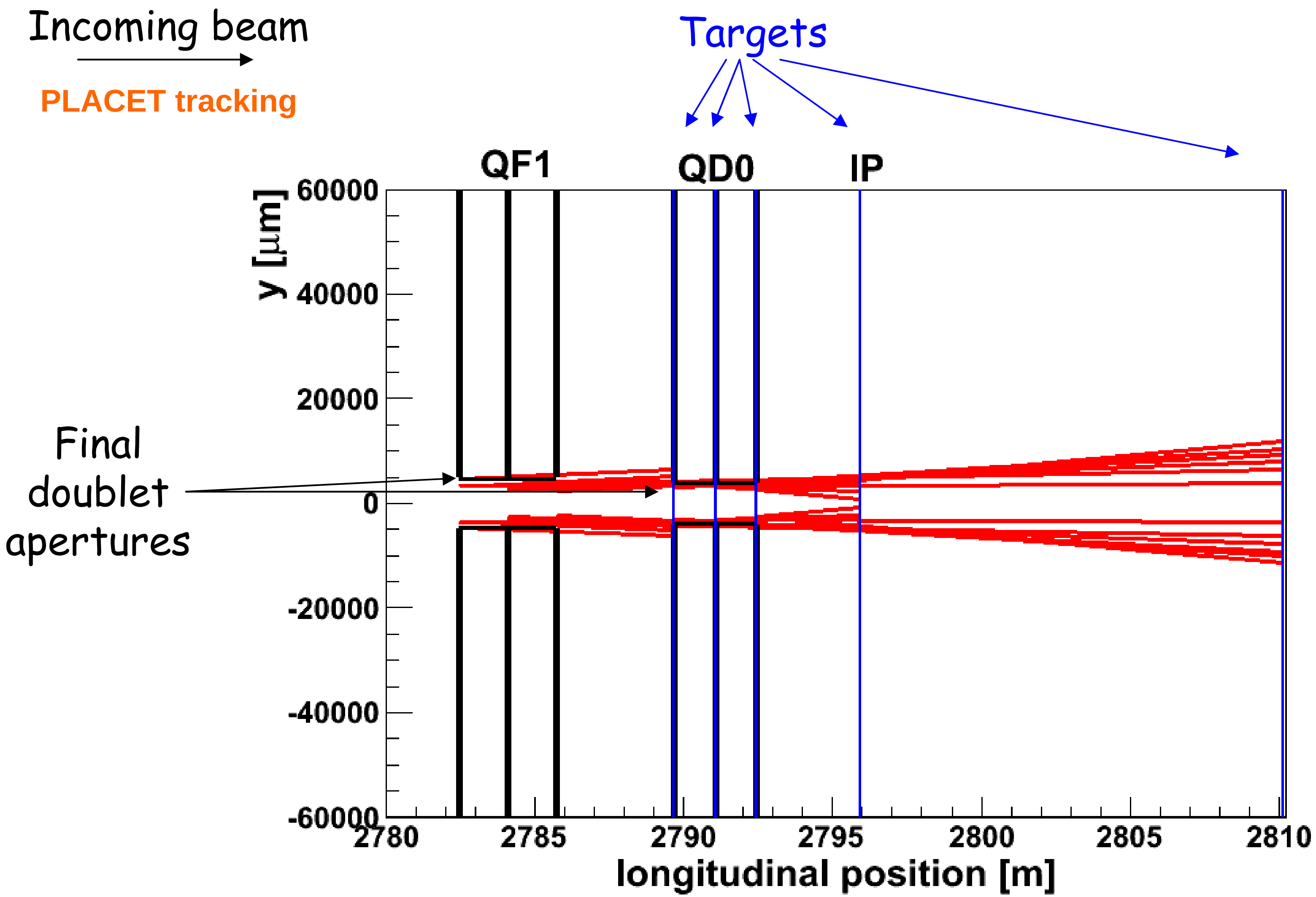
Beam at BDS entrance



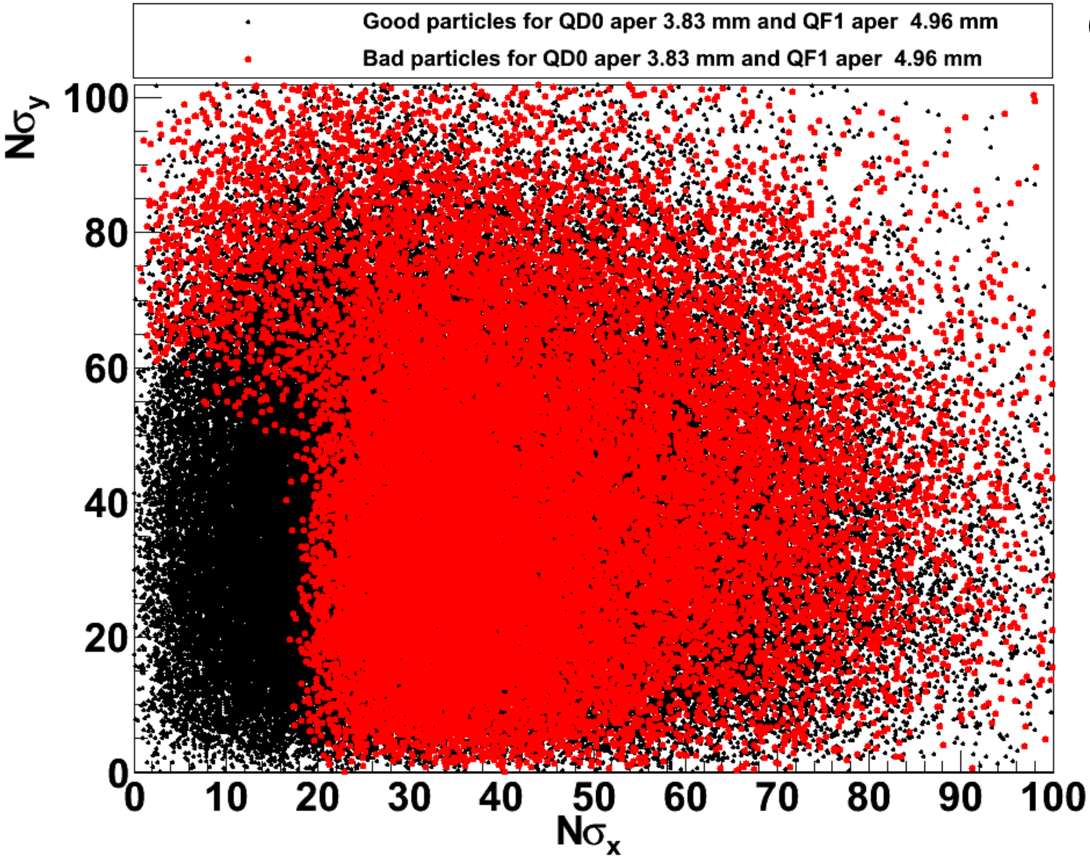
Photons fan (x)



Photons fan (y)



Particle distribution at BDS entrance



$$N\sigma_{x_i} \overset{\alpha=0}{=} \sqrt{\frac{x_i^2}{\sigma^2_{xref}} + \frac{x_i'^2}{\sigma^2_{x'ref}}}$$

Good particles:

- ✓ no photons hitting QD0
- ✓ no particles hitting QF1 && QD0

Bad particles:

- ✓ emitted photons hit QD0
- ✓ particles hit QF1 OR QD0

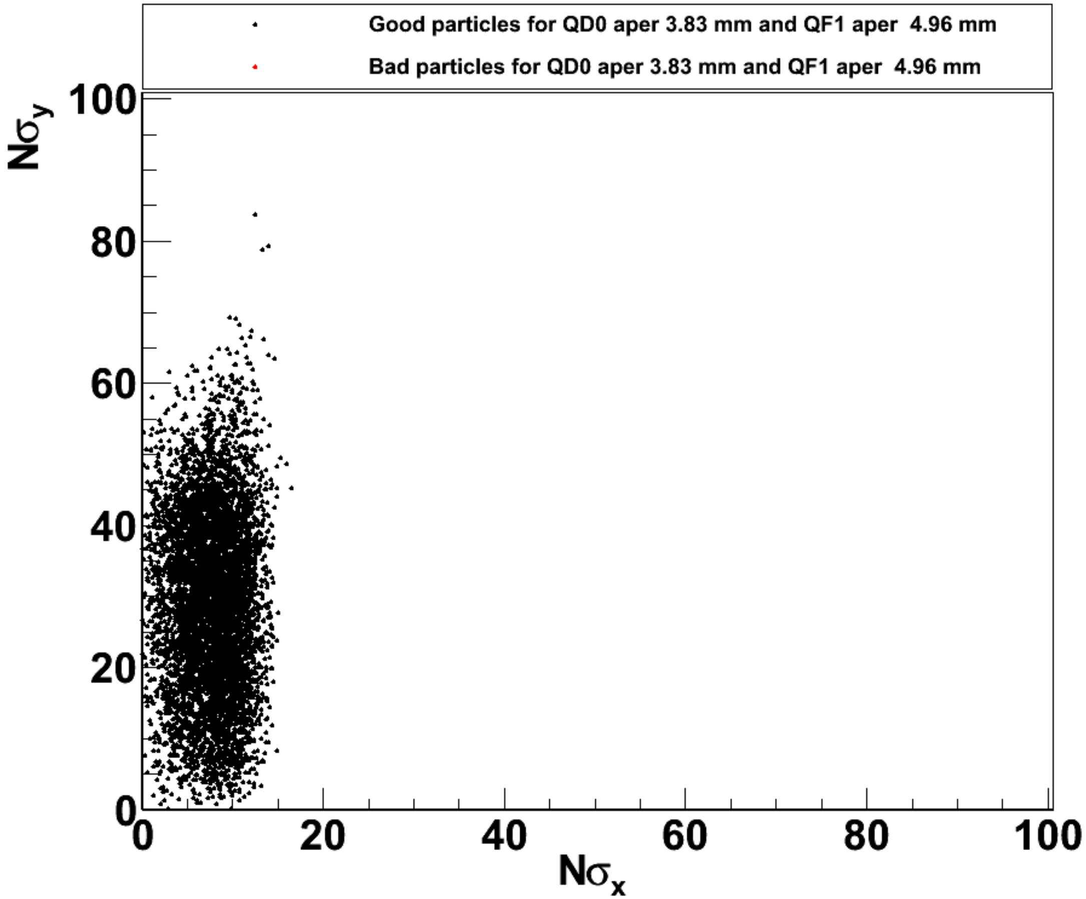
- input: 150000 particles $10^3 \times \varepsilon_{x,y}$
- QD0 aperture 3.83 mm
- QF1 aperture 4.96 mm
- **no collimators** in the lattice
- all other elements apertures 1 m
- incoherent synchrotron radiation ON in the tracking

Collimator parameters

s[m]	Name	β_x[m]	β_y[m]	D_x[m]	a_x[mm]	a_y[mm]	Geometry	Material
907.098	ENGYSP	1406.33	70681.9	0.27	3.51	25.4	rect	Be
1072.098	ENGYAB	3213.03	39271.5	0.417	5.41	25.4	rect	Ti(Cu coated)
1830.872	YSP1	114.054	483.253	0.	10.	0.08	rect	Be
1846.694	XSP1	270.003	101.347	0.	0.08	10.	rect	Be
1923.893	XAB1	270.102	80.9043	0.	1.	1.	ellip	Ti(Cu coated)
1941.715	YAB1	114.054	483.184	0.	1.	1.	ellip	Ti(Cu coated)
1943.715	YSP2	114.054	483.188	0.	10.	0.08	rect	Be
1959.537	XSP2	270.002	101.361	0.	0.08	10.	rect	Be
2036.736	XAB2	270.105	80.9448	0.	1.	1.	ellip	Ti(Cu coated)
2054.558	YAB2	114.055	483.257	0.	1.	1.	ellip	Ti(Cu coated)
2056.558	YSP3	114.054	483.253	0.	10.	0.08	rect	Be
2072.379	XSP3	270.003	101.347	0.	0.08	10.	rect	Be
2149.579	XAB3	270.102	80.9043	0.	1.	1.	ellip	Ti(Cu coated)
2167.401	YAB3	114.054	483.184	0.	1.	1.	ellip	Ti(Cu coated)
2169.401	YSP4	114.054	483.188	0.	10.	0.08	rect	Be
2185.222	XSP4	270.002	101.361	0.	0.08	10.	rect	Be
2262.421	XAB4	270.105	80.9448	0.	1.	1.	ellip	Ti(Cu coated)
2280.243	YAB4	114.055	483.257	0.	1.	1.	ellip	Ti(Cu coated)

Javier Resta Lopez 15th January 2009

Collimation depths



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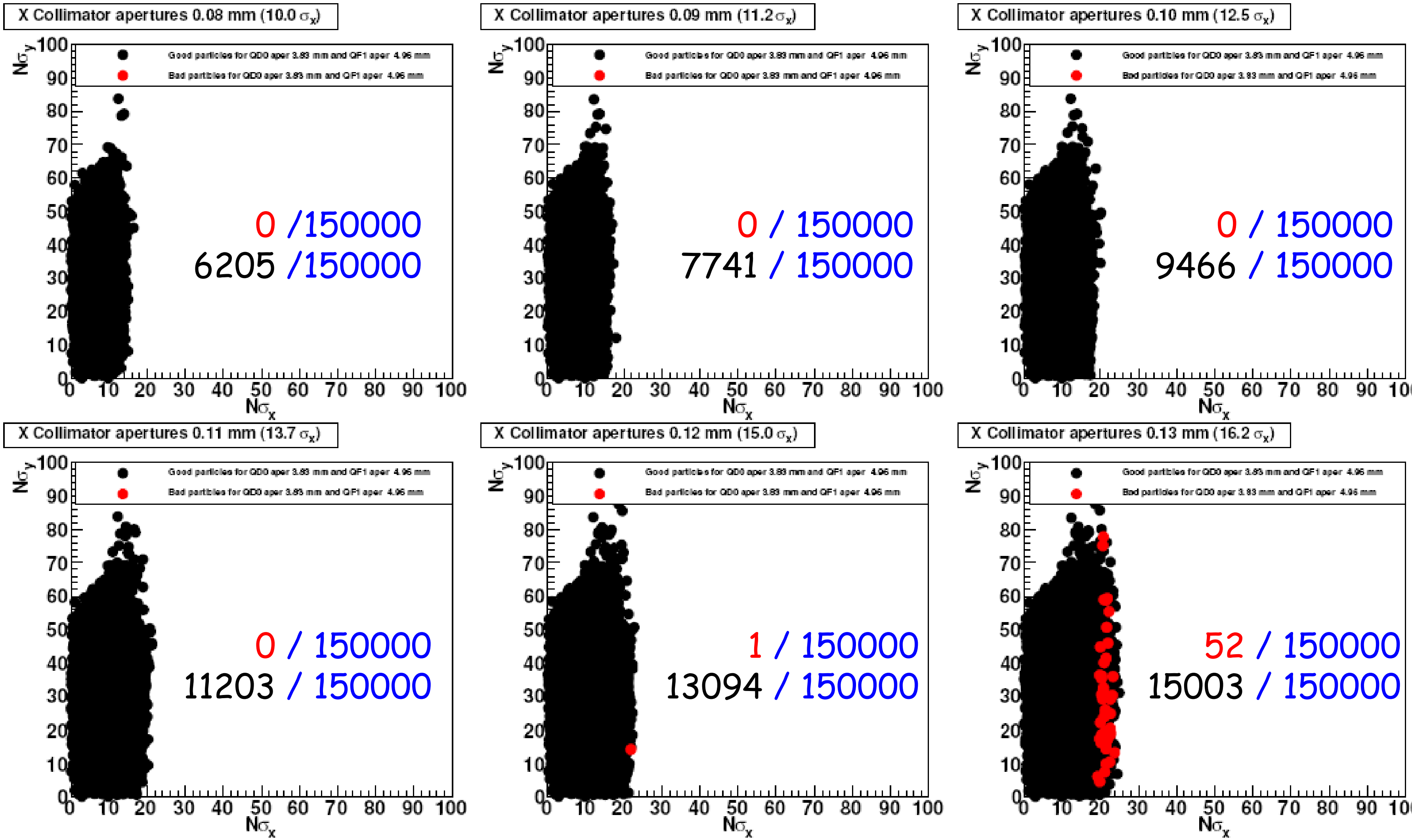
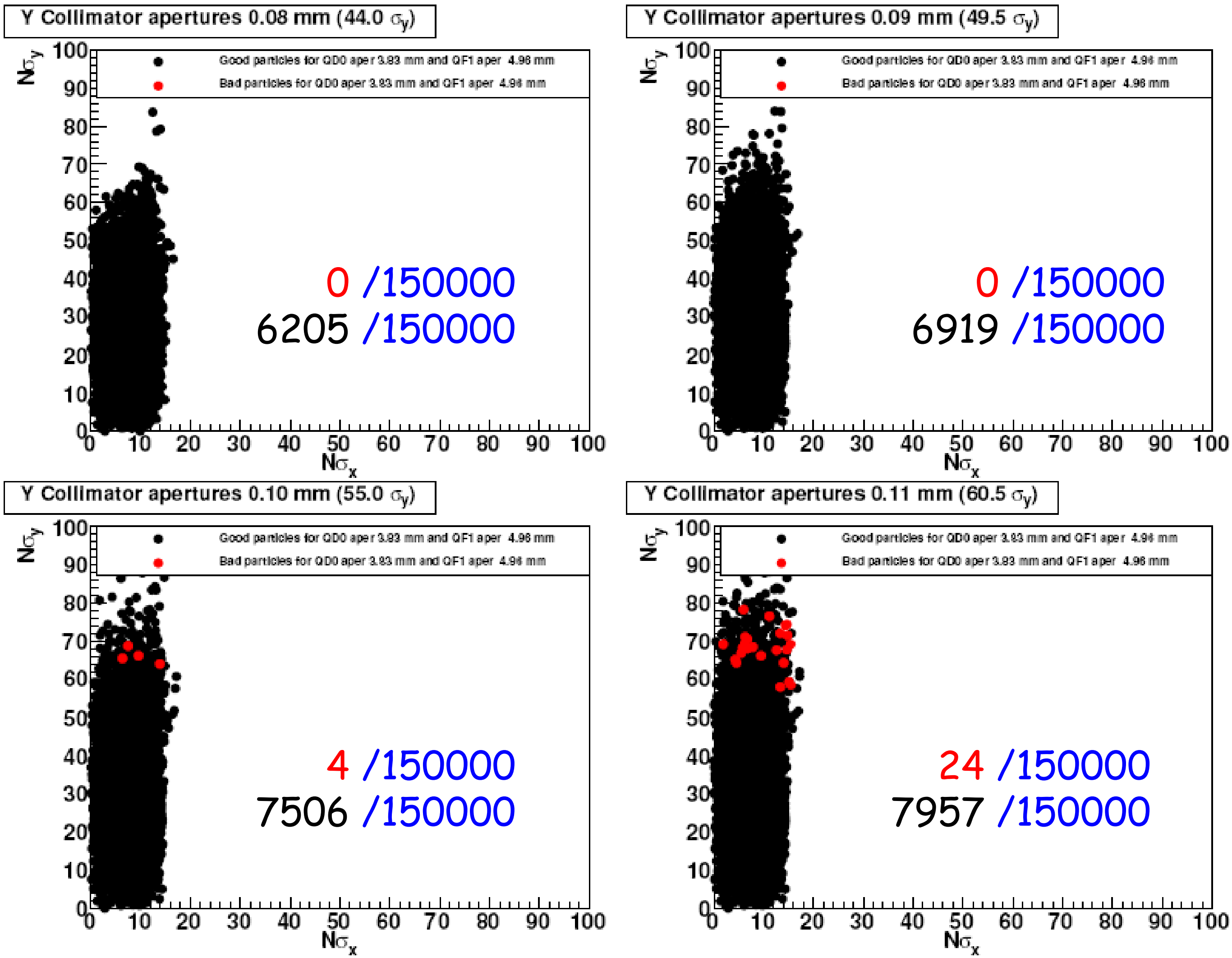
Scan of X collimator apertures

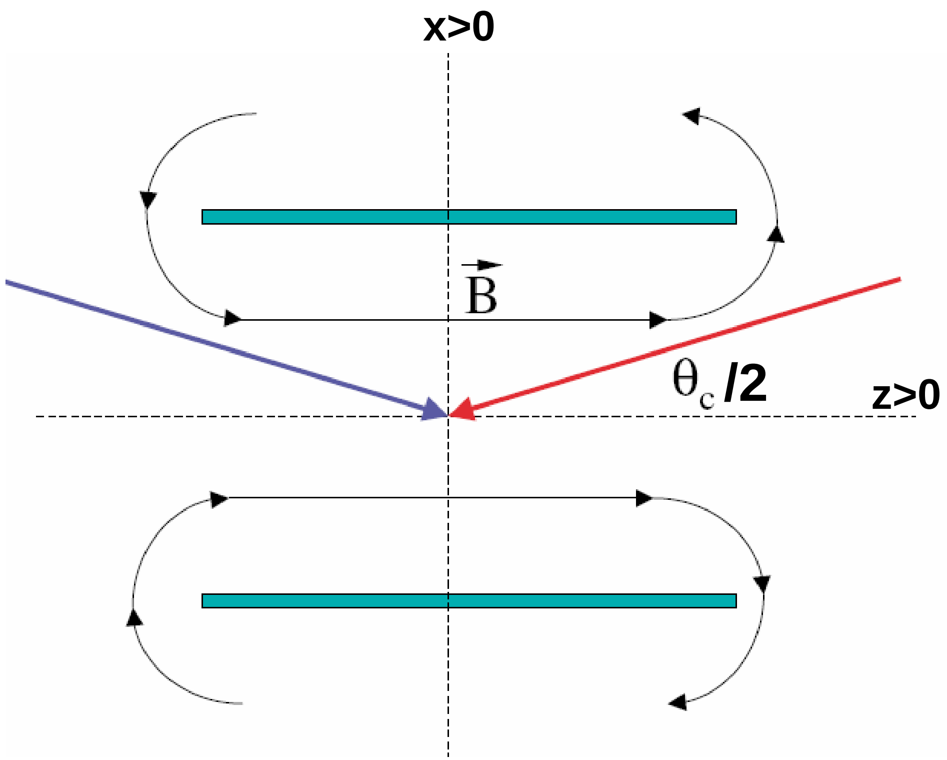


Scan of Y collimator apertures



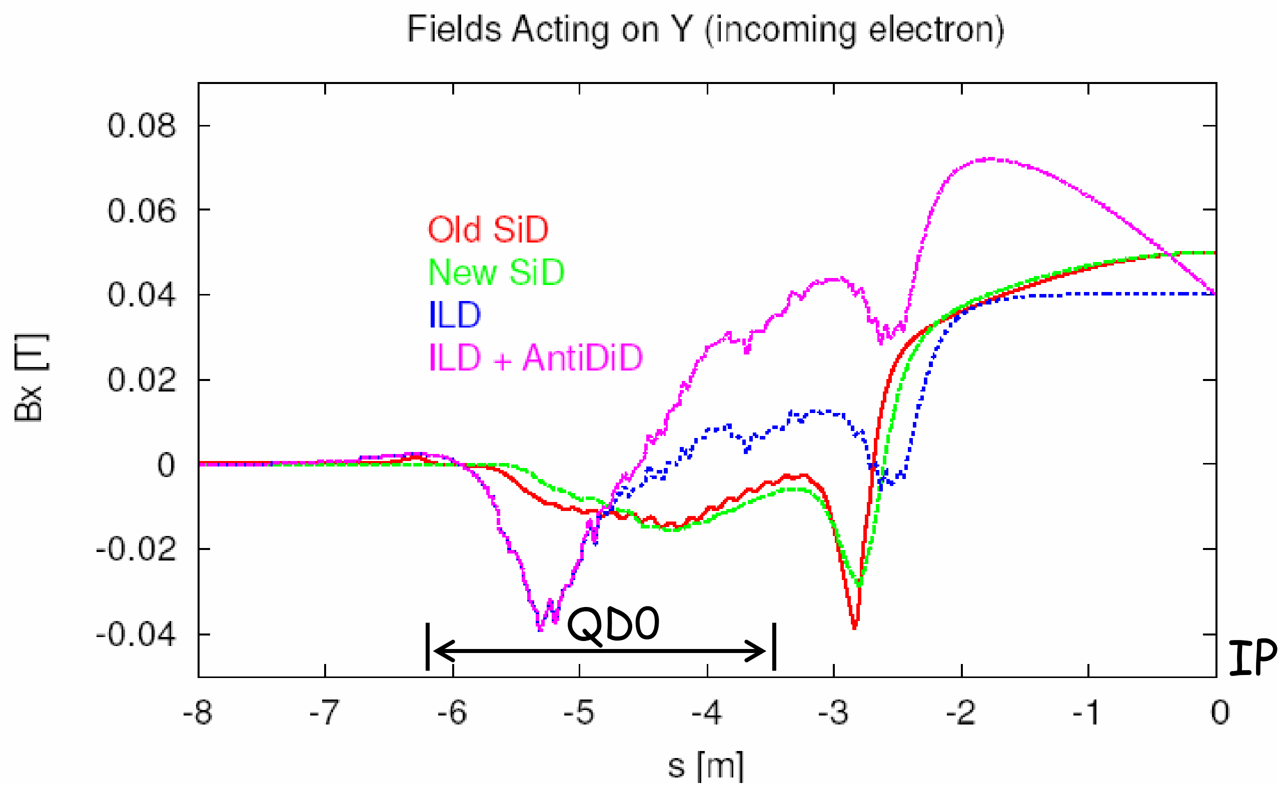
Solenoid Effects

- ***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.
P. Tenenbaum et al., PR ST- AB, vol. 6, 061001 (2003)

Detector Solenoid magnetic fields



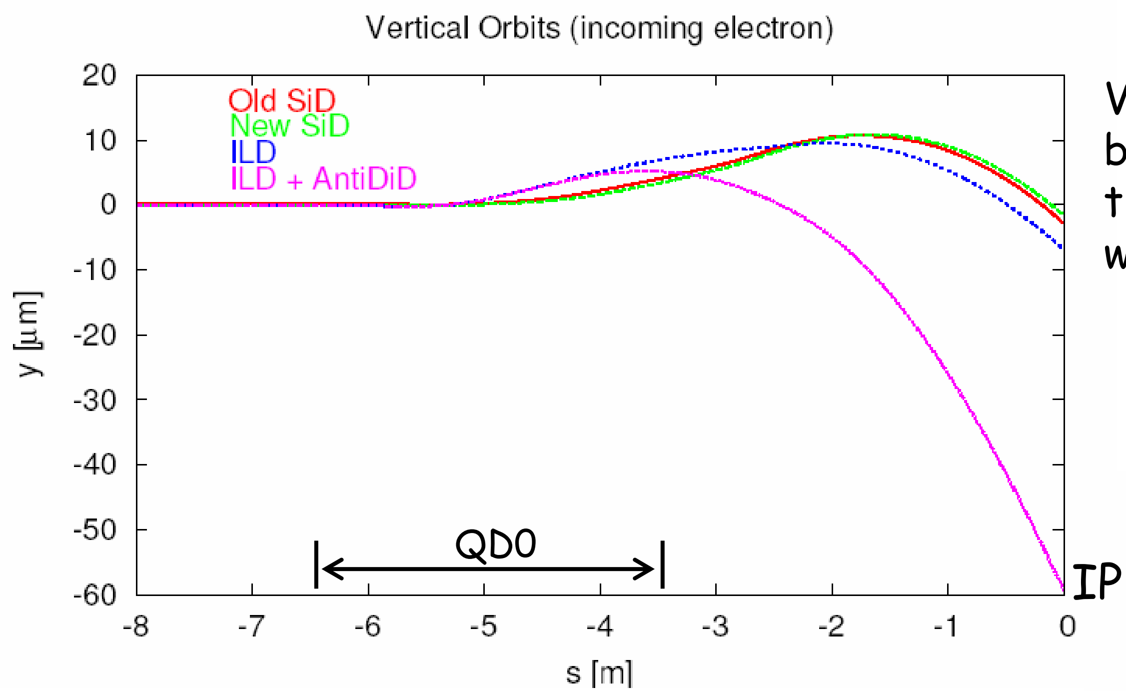
B_x component of solenoid fields in the beamline reference system

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)

Thanks to K. Elsener

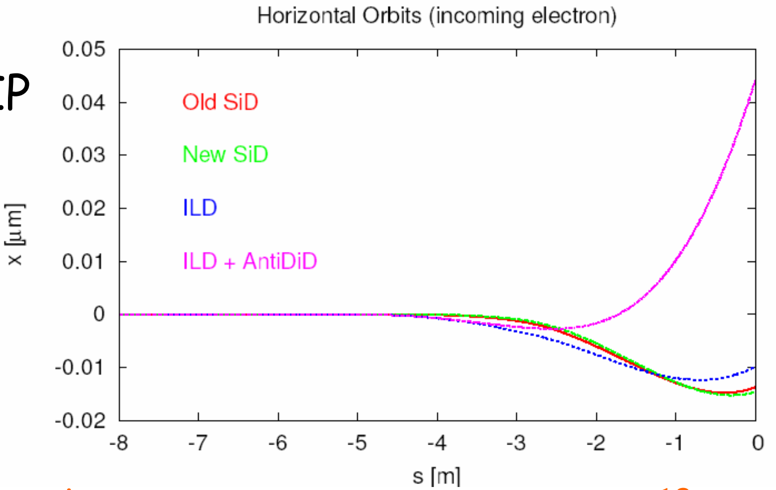
Orbits

6D tracking (by Lorentz differential equations solver)



Vertical orbits deviation in the beamline reference system due to the Solenoid field and its overlap with QD0.

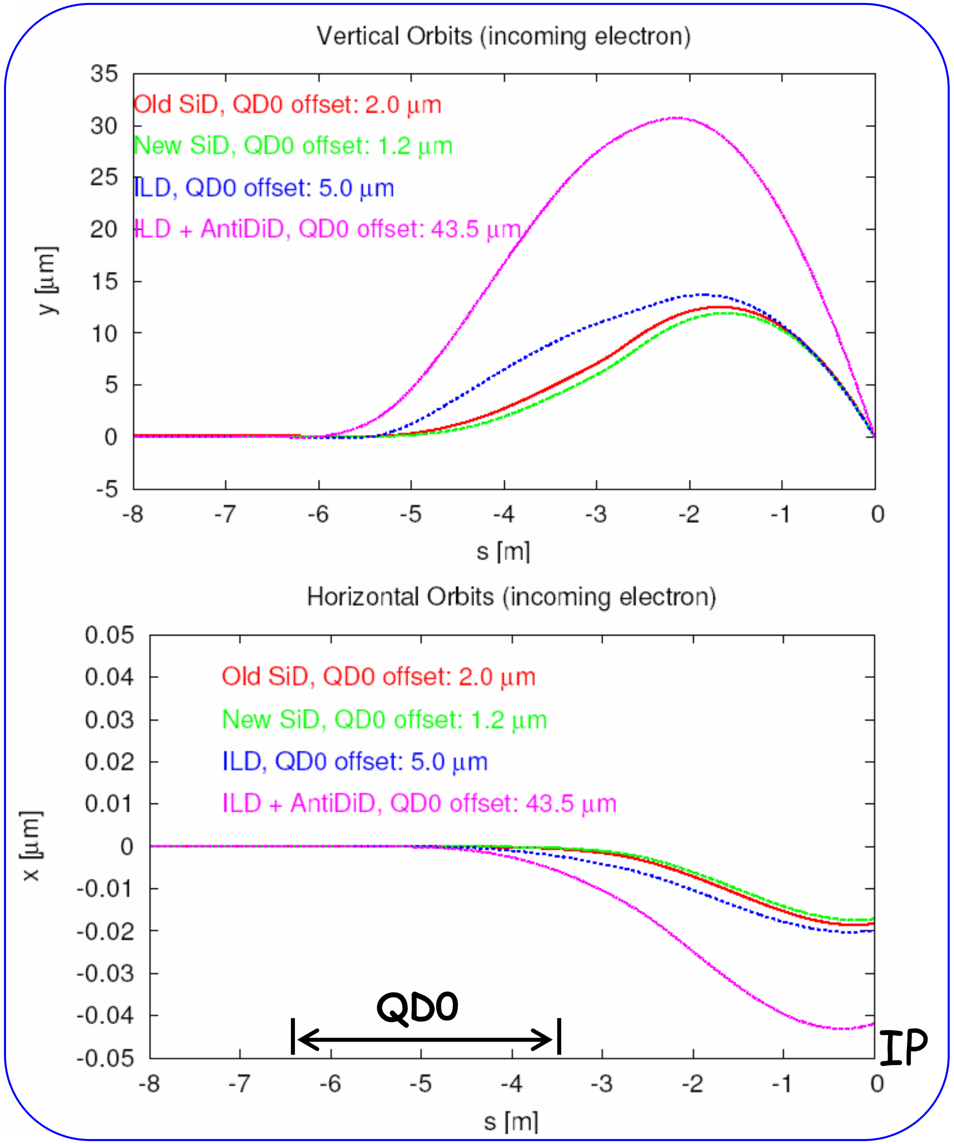
Horizontal orbits deviation in the beamline reference system due to the Solenoid field and its overlap with QD0.



Vertical offset correction

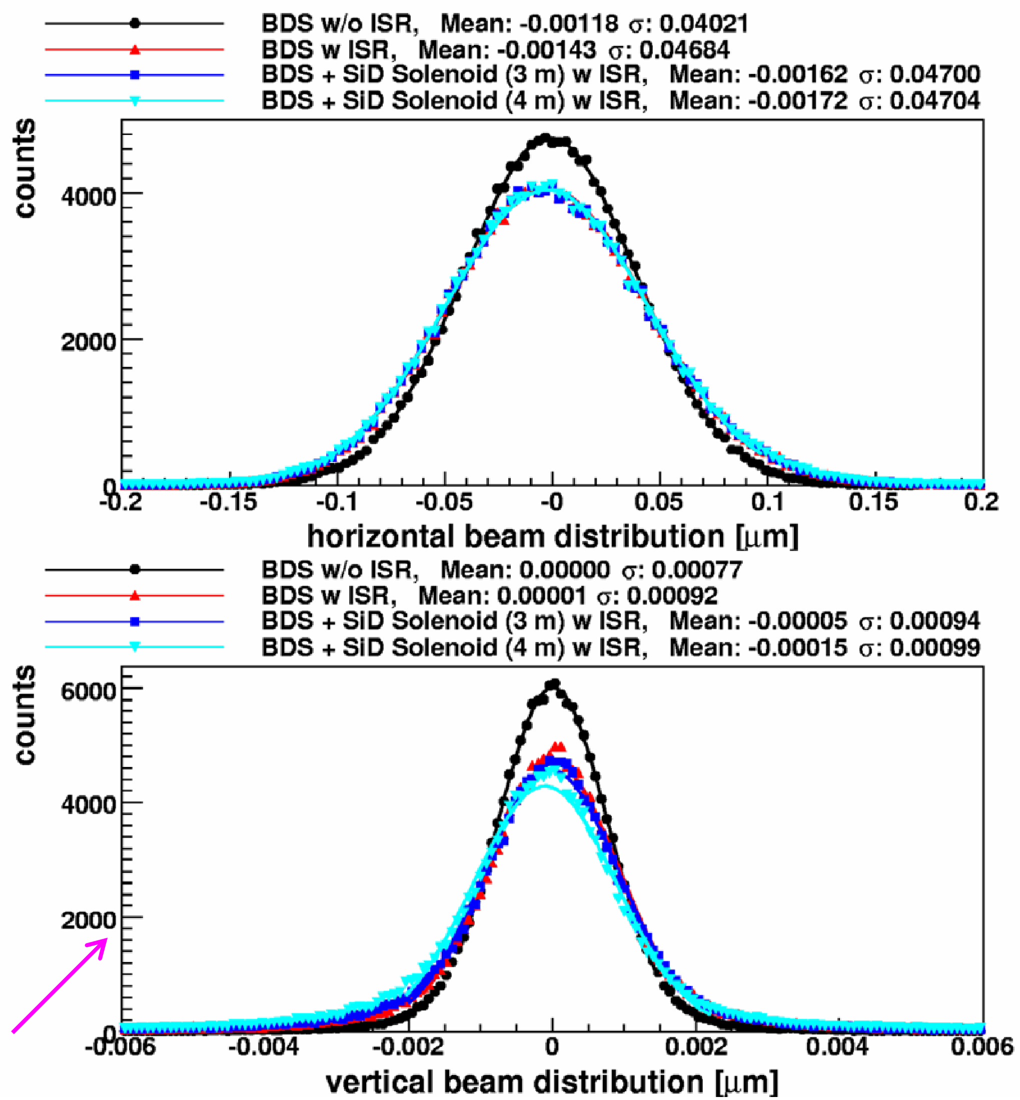
- Compensation of detector solenoid effects:
  - J.J. Murray, SLAC-CN-237
  - Y. Nosochkov and A. Seryi, PRST-AB 8, 021001 (2005)
  - B.Parker and A. Seryi, LCC-0143

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



Incoherent Synchrotron Radiation

- Compensation of optical effects ongoing
- 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

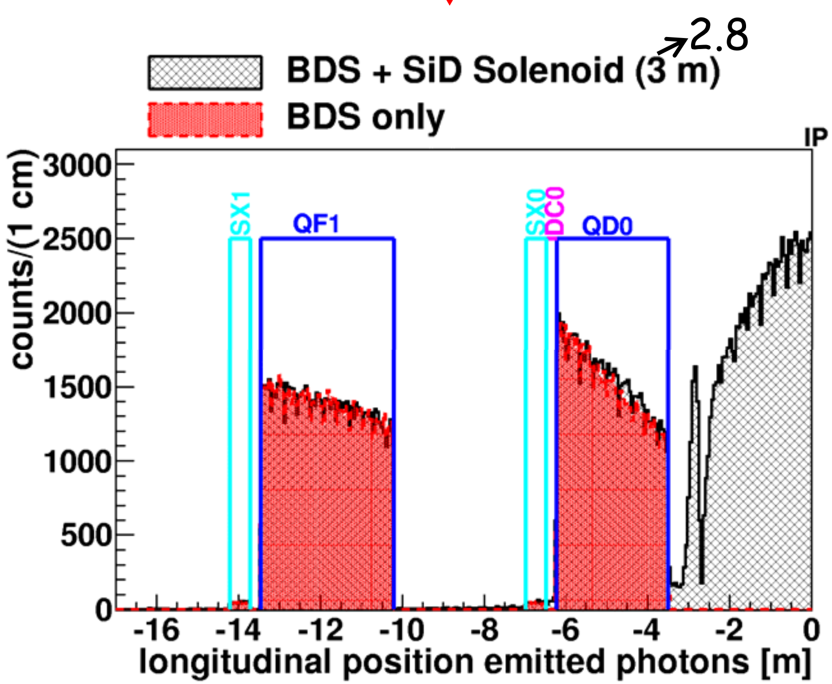
Luminosity Loss

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

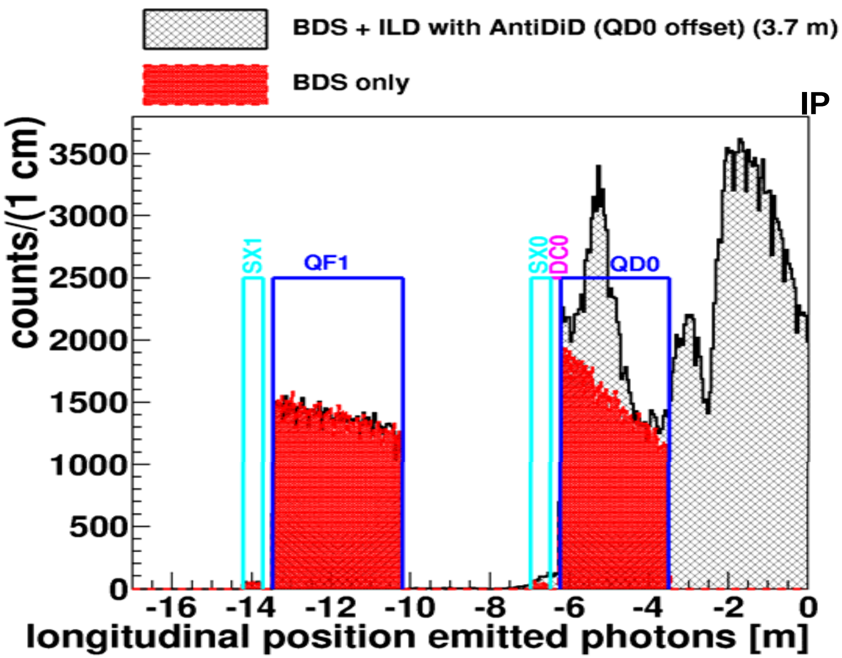
- luminosity calculation by GUINEA-PIG
- CLIC horizontal crossing angle 10 mrad
- ILD values are computed with QD0 offset: 5μm (ILD), 43.5μm (ILD+AntiDiD)

Position of emitted photons

Old SiD field map
~4% luminosity loss



ILD+AntiDiD field map
~25% luminosity loss

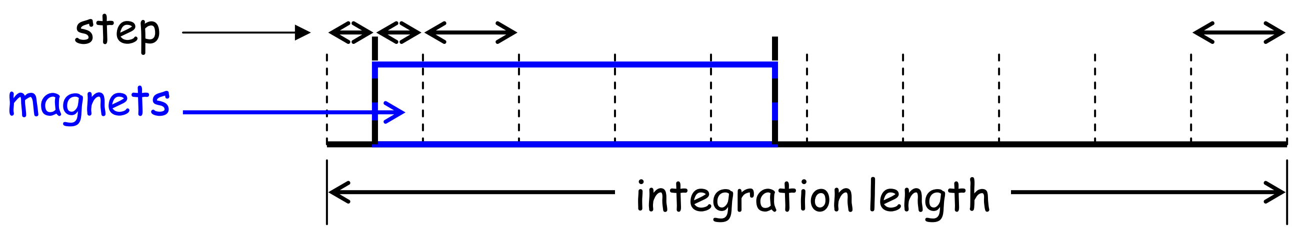


Conclusion

- Analysis of the CLIC collimation system
  - Old apertures clean the dangerous particles efficiently
  - Larger collimator apertures $15\sigma_x$ (0.12 mm) and $55\sigma_y$ (0.10 mm) give acceptable collimation efficiency
- 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%

Spares

The tracking core



$$\frac{d^2\vec{r}}{ds^2} = \frac{1}{B\rho}\frac{d\vec{r}}{ds}\times\vec{B}$$

B solenoid : 1D external field map
2D external field map
3D external field map

B magnets : $B_y + iB_x = k(x+iy)^n$

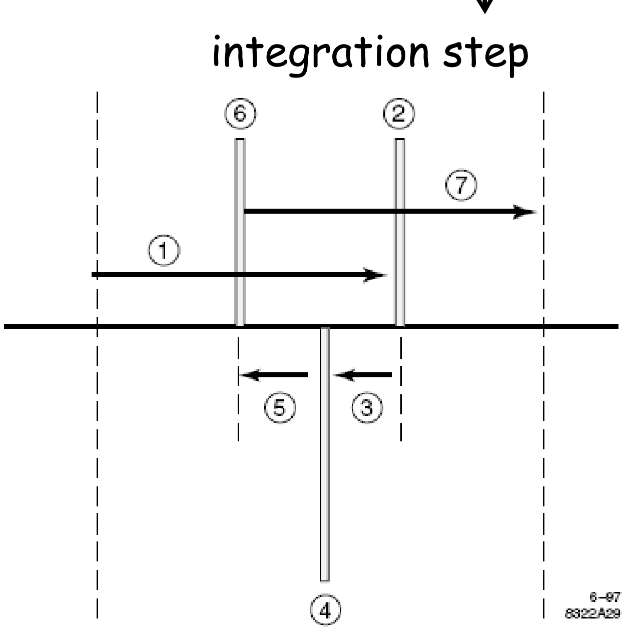


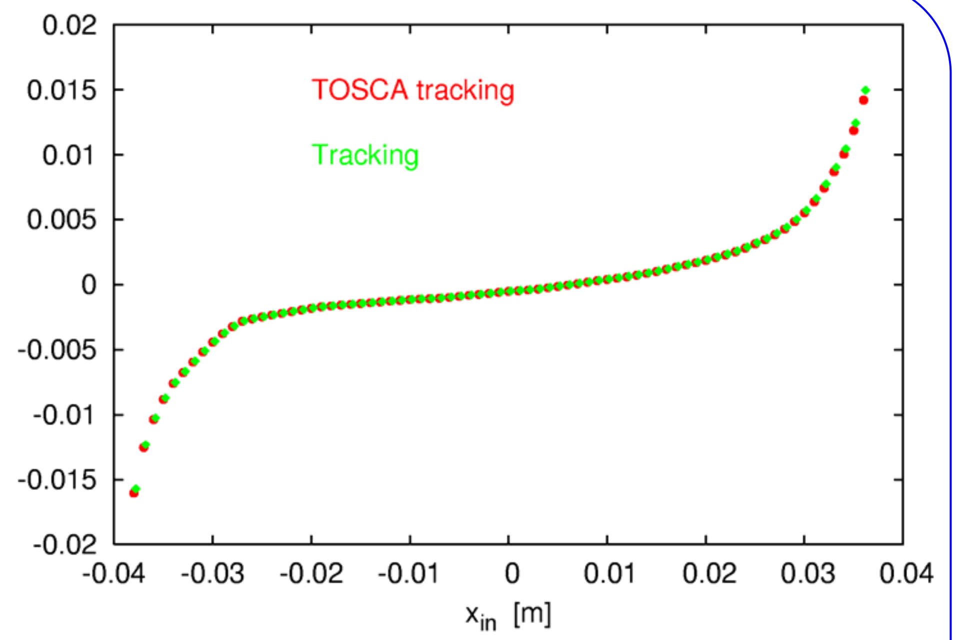
Figure 7.3: Seven steps in the 4-th order symplectic integration.

A. Chao Lectures

tests

step = 1 mm

- 3D Wiggler map (S. Bettoni)
- Constant field B(0,By,0)



step = 0.5 cm