Emittance growth due to incoherent synchrotron radiation

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Synchrotron radiation in the BDS

- Incoherent synchrotron radiation in dipoles of BDS (Energy collimation, final focus and diagnostics chicanes) increase the emittance and the energy spread.
- To keep the emittance growth to minimum, need weak dipoles, which drive the length of the BDS.

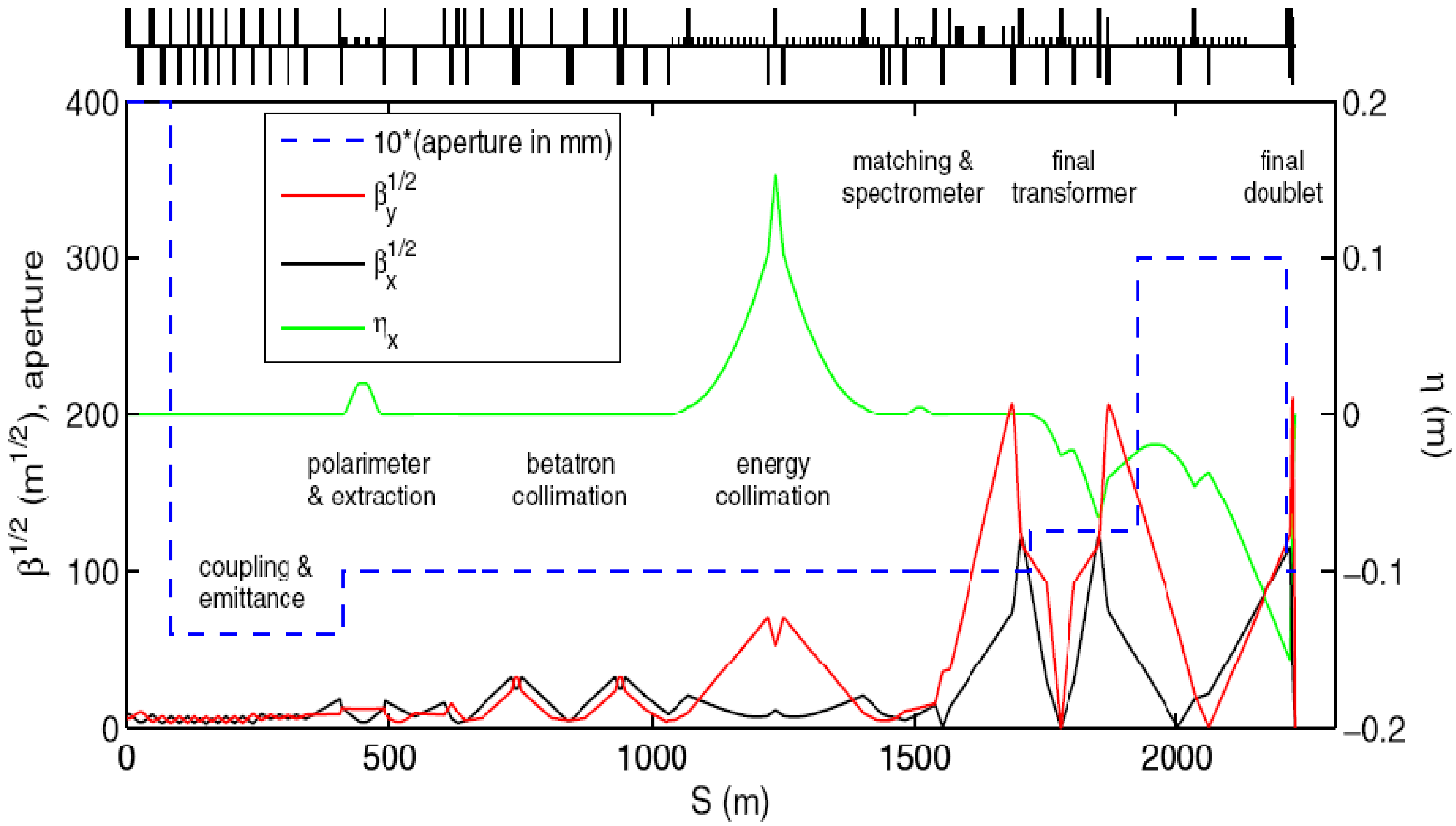
$$\Delta(\gamma\varepsilon_x) \approx (4.0\times10^{-8})E^6 I_5$$

$$I_5 = \int \frac{H}{|\rho|^3} ds$$

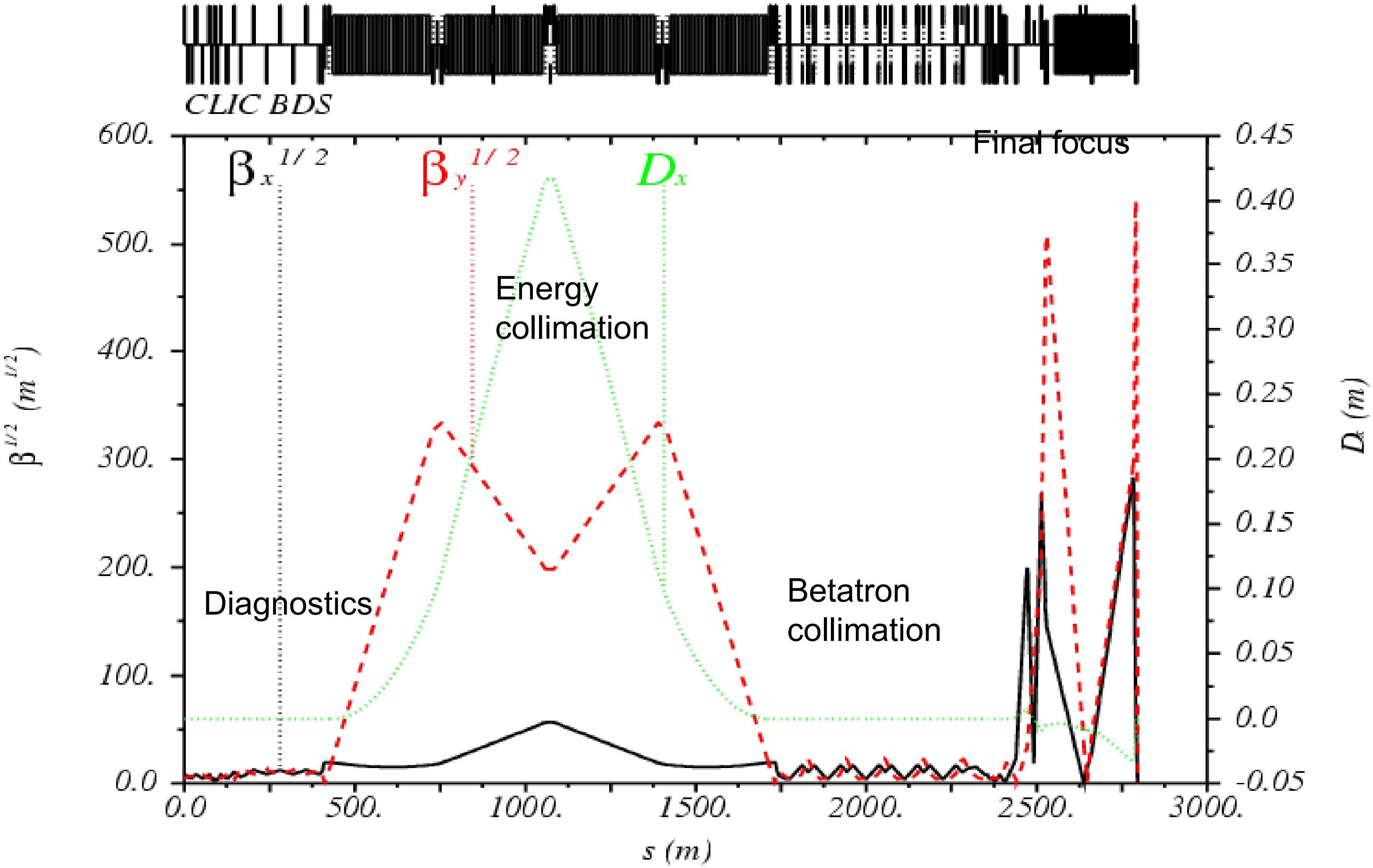
$$H = (1/\beta)(\eta^2 + (\beta\eta' - \frac{1}{2}\beta'\eta)^2)$$

- Design considerations for ILC and some estimates for CLIC are discussed.

ILC Optical Functions



CLIC Optical Functions



ILC Design Criterion

- Single interaction region @ 14 mrad "push-pull" detectors
- Initial operation at (up to) 250 GeV; upgrade to 500 GeV by adding magnets only (no layout/geometry changes)
- Decimate dipoles : reduce ∫BdI for 250 GeV operation by reducing lengths (i.e. number of dipoles); reserve space for additional dipoles to keep layout fixed
- Quadrupoles & sextupoles unchanged …reduce ∫GdI for 250 GeV operation by reducing strengths [Final Doublet magnets will have to be replaced for 500 GeV]
- Final Focus: 12 m "soft" bends divided into 5 × 2.4 m pieces
  - start with center piece only at each location
  - space reserved for remaining 4 pieces at each location for 500 GeV

http://www.slac.stanford.edu/~mdw/ILC/2006e/doc/BDS2006e.ppt
Mark Woodley

ILC Design Criterion

- Synchrotron Radiation Emittance Growth (DIMAD tracking; SYNC option 2)

  @ 250 GeV, emit/emit0 = 1.0036

  @ 500 GeV, emit/emit0 = 1.0078

  (emit0 = 1e-5 m)

- dEmitX/EmitX0 (BDS)

  DIMAD SYNC option 2 @ 250 GeV: x=0.3%, y=0.1%

  DIMAD SYNC option 4 @ 250 GeV: x=0.4%, y=0.2%

  DIMAD SYNC option 2 @ 500 GeV: x=0.8%, y=0.1%

  DIMAD SYNC option 4 @ 500 GeV: x=1.0%, y=2.3%

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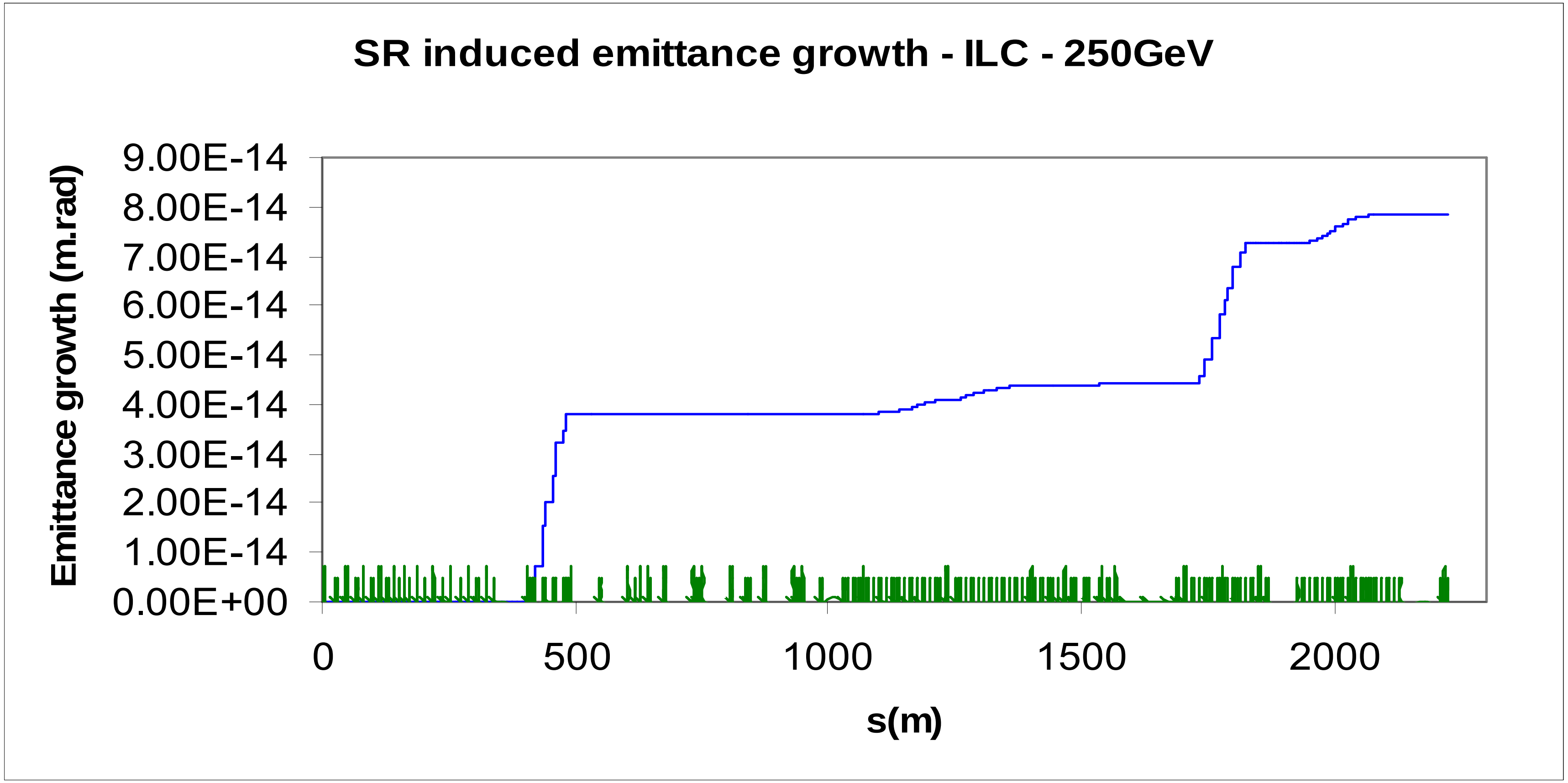


Design emittance : 2.044E-11 m
Emittance growth : 0.4%

Simulated in BETA
[J.Payet, CEA]

DIMAD $\gamma\Delta\varepsilon_x$= 3.789E-8 m
= 0.38%

When estimates done by BETA and DIMAD for CLIC @1.5TeV : values very different.

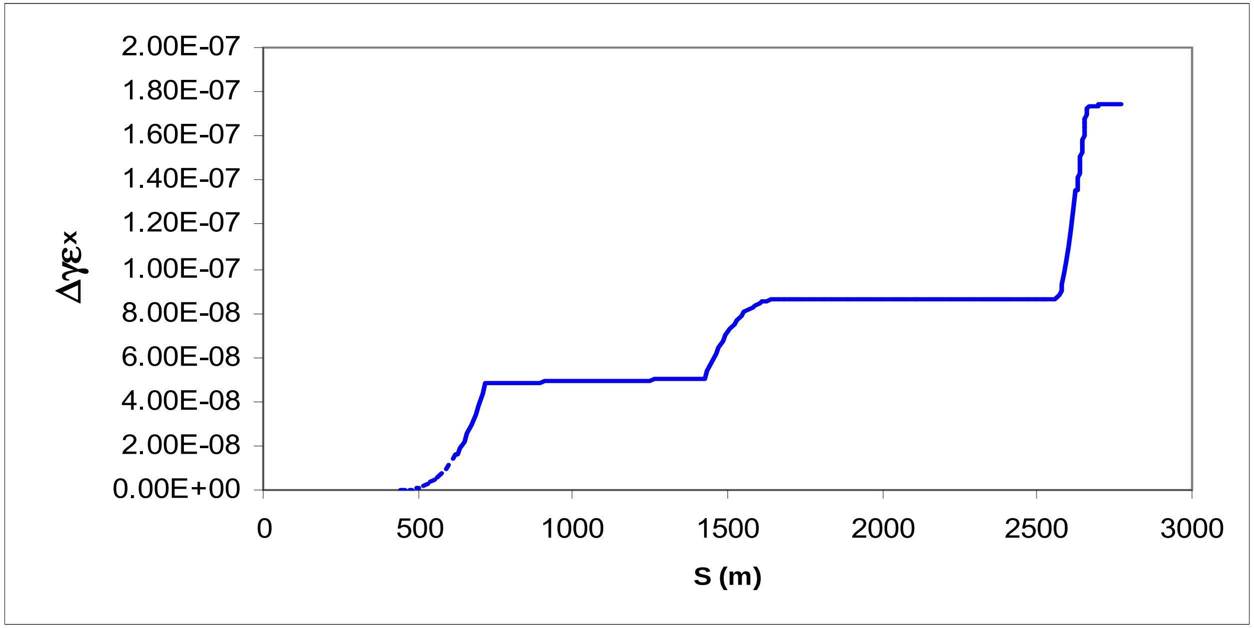
Used analytical formula to check :

Emittance growth $(\gamma\Delta\varepsilon_x) \approx (4.0 \times 10^{-8}\ m^2/GeV^{-6})\ E^6\ I_5$

$$I_5 = \int H/|\rho|^3\, ds = 3.83E\text{-}19\ m$$

$\gamma\Delta\varepsilon_x \approx$ 174 nm ; Normalised emittance = 660 nm

~ 25% dilution



CLIC @500GeV = 2.196673168E-10 meters (0.03%)

Note : 1.5 TeV deck scaled down to 500 GeV (not used BDS design for 500 GeV

DIMAD – CLIC deck at 1.5 TeV

Starting normalised emittances : x=660 nm, y=20nm

Horizontal Normalized Emittance Dilution = 1.601374740E-07 meters
(~24% dilution)

Tracking 10000 particles :

sigma_x* = 0.4325E-07 norm_eps_x = 0.1051E-05
sigma_y* = 0.1352E-08 norm_eps_y = 0.3963E-07

Including SR (SYNC option 2):

sigma_x* = 0.5022E-07 norm_eps_x = 0.1275E-05
sigma_y* = 0.1537E-08 norm_eps_y = 0.4506E-07

Including SR (SYNC option 4):

sigma_x* = 0.5021E-07 norm_eps_x = 0.1271E-05
sigma_y* = 0.2523E-08 norm_eps_y = 0.7395E-07

PLACET (B. Dalena)

	IP vertical beam rms core (nm)	(from gaussian fit +-3sigma) (nm)
w/o ISR	1	0.8
w ISR	2	1

To be compared with DIMAD

w/o ISR	1.35 nm
w ISR	1.57 nm (dipoles)
w ISR	2.52 nm (dipoles+quad)

- ILC 2006e : $\gamma\Delta\varepsilon_x \approx 3.78 \times 10^{-8}$ m (0.37%)
  $\varepsilon_{x0}=1 \times 10^{-5}$ m
  Collimation+E,P chicanes = 2.13×10^{-8} m
  (56% contribution to the emittance growth)

- CLIC 1.5 TeV : $\gamma\Delta\varepsilon_x \approx 1.60 \times 10^{-7}$ m (24%)
  $\varepsilon_{x0}=6.60 \times 10^{-7}$ m
  Collimation = 8.58×10^{-8} m
  (53% contribution to the emittance growth)

- CLIC BDS gives net angle of 0.6mrad at the IP, if this angle is cancelled in the collimation section, the emittance increase will further increase.