Start to End Simulations for the ILC with Fast Feedback Systems

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  - BDS
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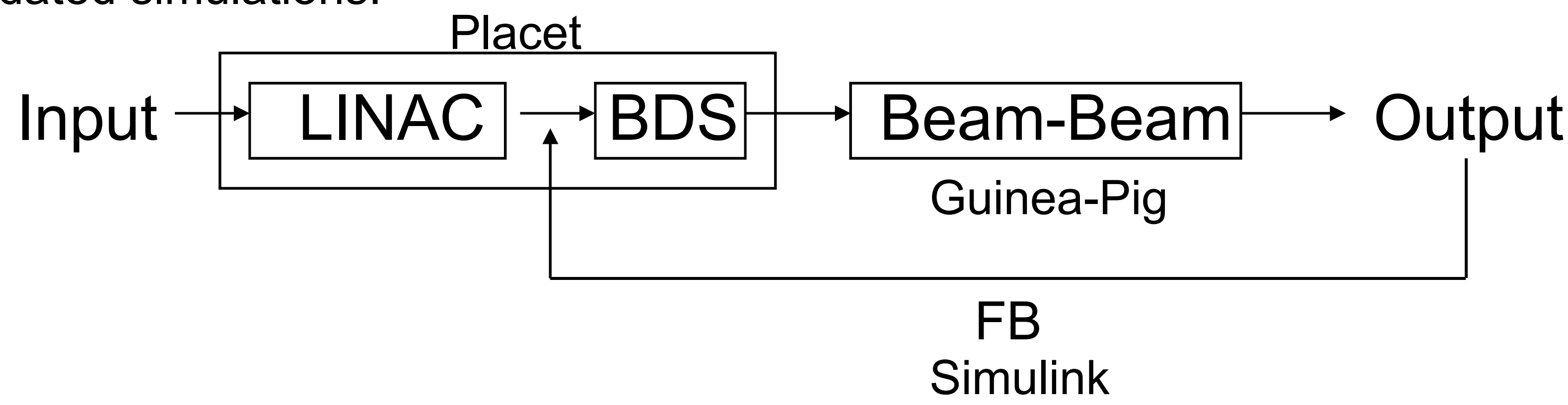
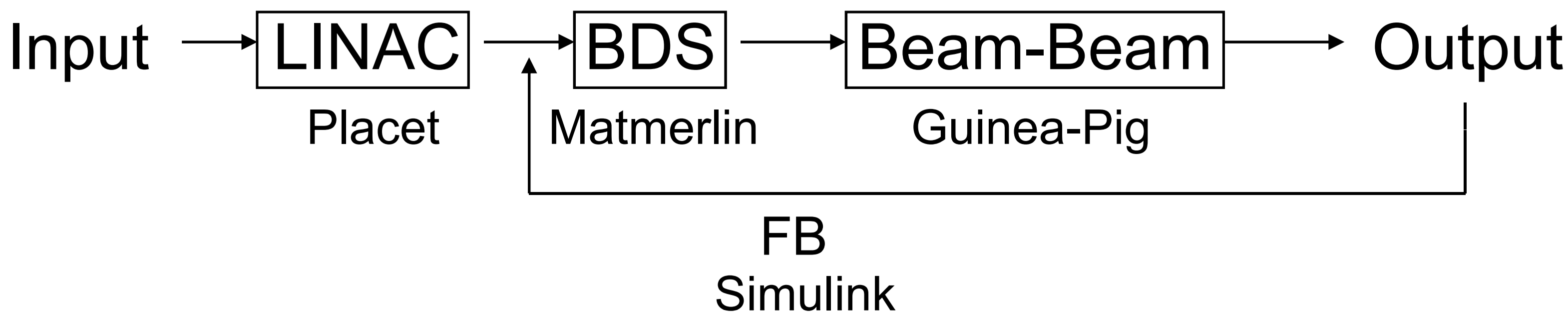
ILC integrated simulations

Updated simulations:



G. White version (2005):



ILC integrated simulations
LINAC

- Placet scripts for tracking along LINAC + BDS, linked with Simulink (Matlab)
- LINAC:
  - Sliced bunches tracked along the LINAC
  - Initial vertical norm. emittance (exit from DR and RTML) = 24 nm
  - Initial injection jitter (from DR and RTML) = 0.1σ
  - Including long- and short-range transverse and longitudinal wakefield functions
  - Structure misalignment. Alignment errors:

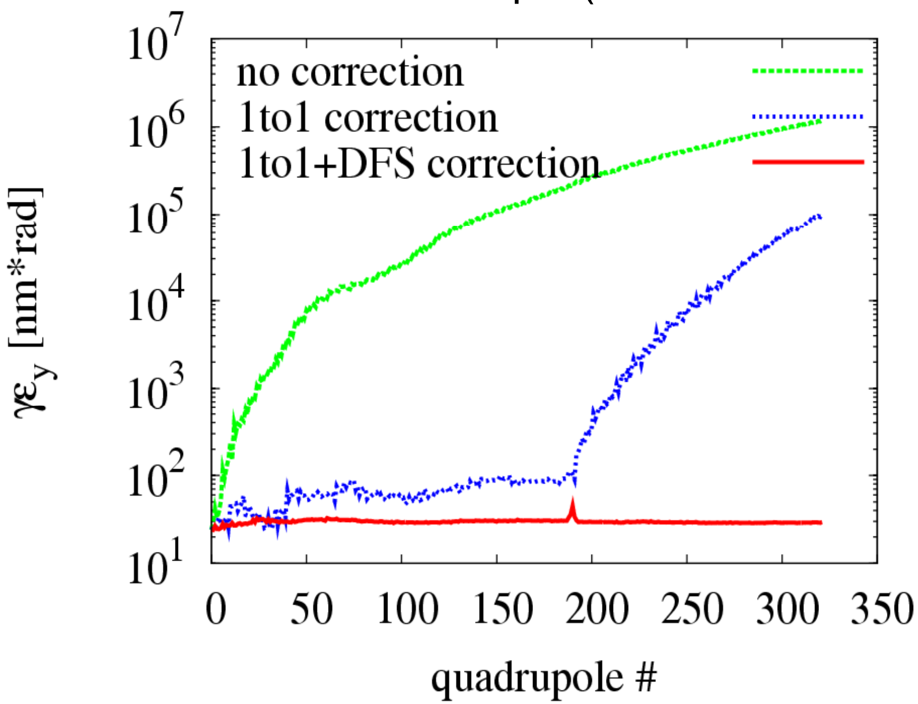
	$\sigma_{x,y}$	σ_{rot-z}	$\sigma_{rot-x,y}$
Quad	300 μm	300 μrad	
BPM	200 μm		
Cavity	300 μm		300 μrad

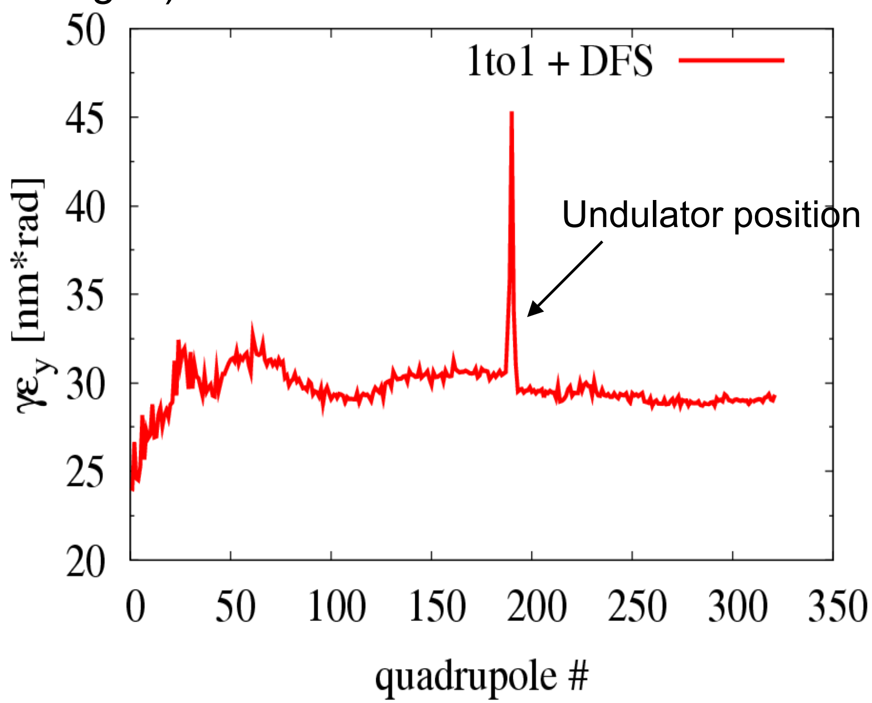
  - Static beam based alignment algorithms: 1to1, DFS
  - Inter-train ground motion (different models tested)

Beam based corrections

- In order to keep the beam quality (low emittance transport (LET) in the Main Linac)✸Static corrections : 1 to 1 correction; dispersion free steering (DFS); accelerating structure alignment; emittance tuning bumps

LET simulation example (100 random seeds averaged) for the ILC:





The undulator alignment is still an open issue. In this simulation we have replaced the undulator by a matching transport matrix !

ILC integrated simulations
BDS, beam-beam, Fast intra-train FB system

- BDS & IP:
  - BDS optics 14 mrad used (version 2007)
  - Macroparticle tracking (Placet)
  - 0.2 s of GM (different models tested)
  - Beam-beam interaction at the IP (Guinea-Pig):
    - Luminosity and beam-beam deflection
    - Output for studies on EM background
  - Fast intra-train FB:
    - Simulink model (G. White)
    - Assuming BPM resolution: 2 μm (IP angular FB), 5 μm (IP position FB)
    - Kicker errors: 0.1 % rms bunch-bunch offset
    - Kick in the vertical plane ≤ 70 σ_y
    - Kick in the vertical angle ≤ 5 $\sigma_{y'}$

Luminosity versus beam-beam offset

Analytic calculation considering a rigid gaussian beam (no beam-beam effects):

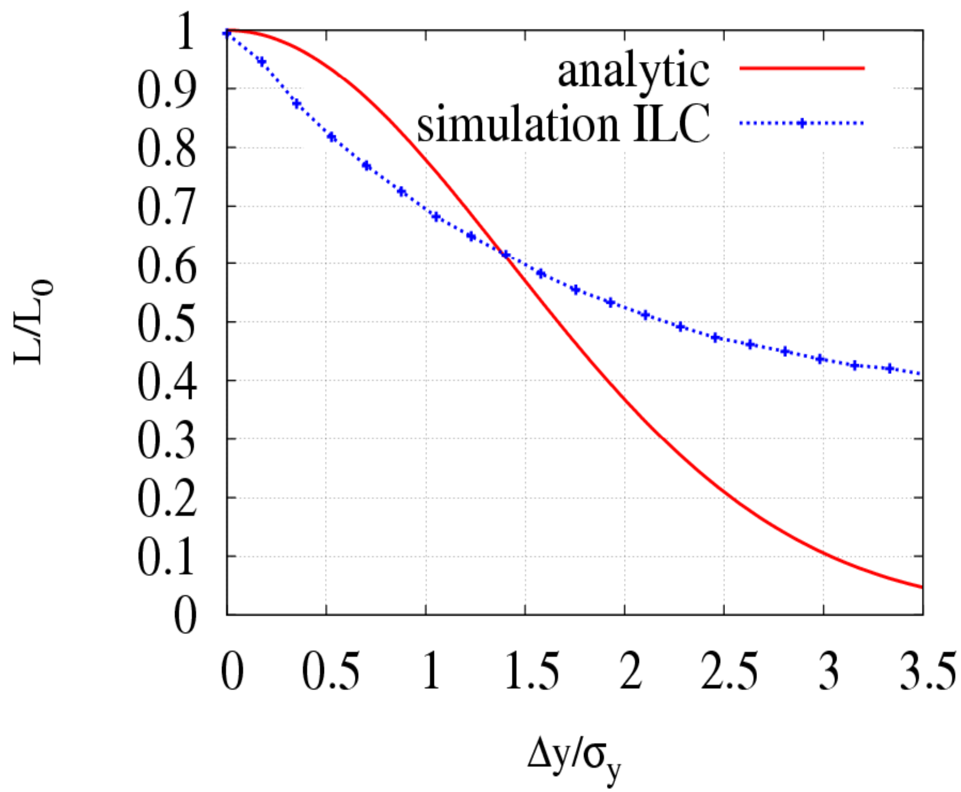
$$\frac{L}{L_0} = e^{-\frac{\Delta y^2}{4\sigma_y^2}}$$

Simulations with Guinea-Pig: it includes beam-beam effects (beamstrahlung, hourglass effect, pair creation, …)

Disruption parameter: D_y=19.4

In order to keep the beams in collision

Fast IP FB system

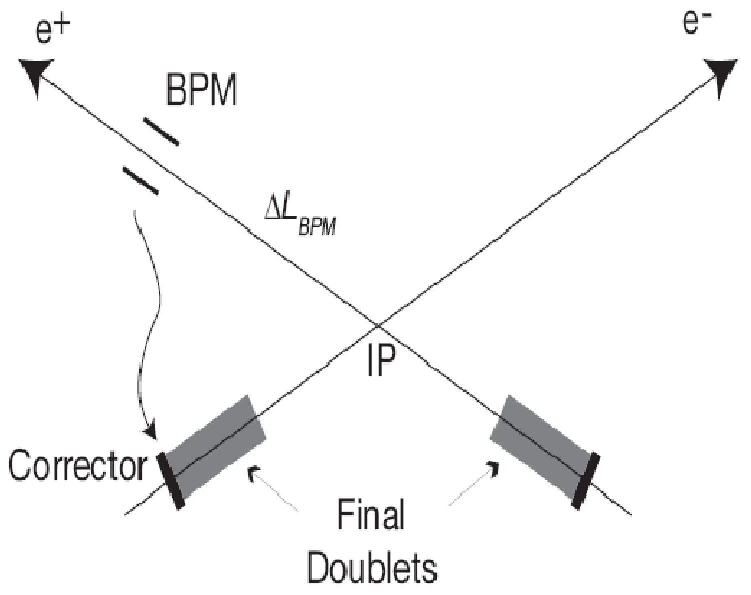


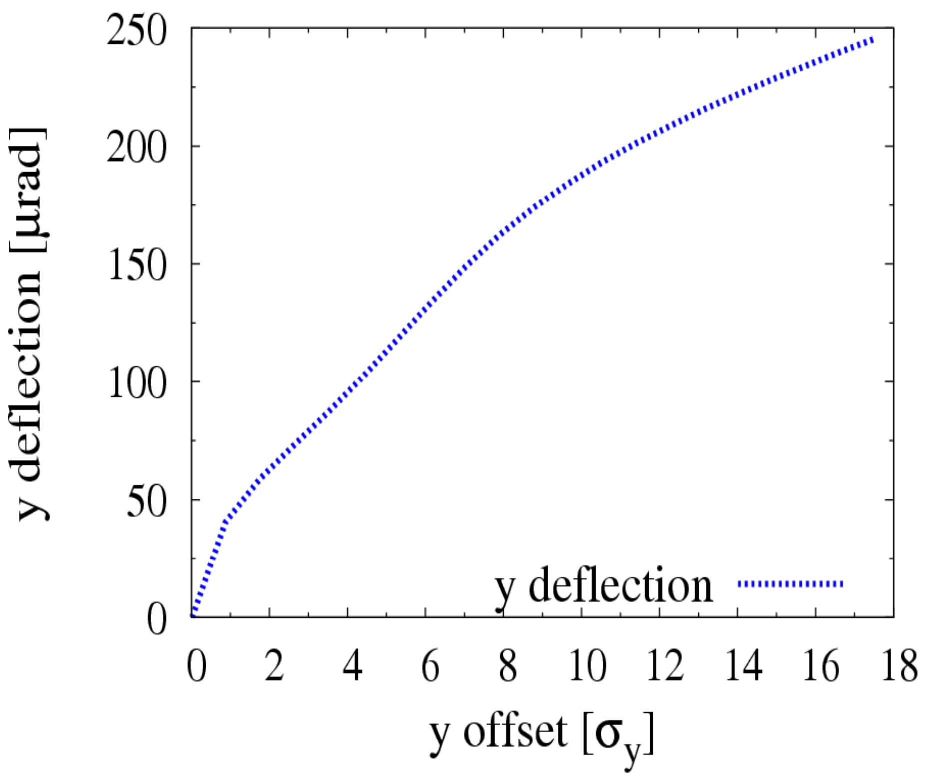
Vertical separation between beams Δy mainly from fast ground motion, and damping ring extraction errors

Fast feedback system

FONT project:

Feedback On Nano-Second Timescales

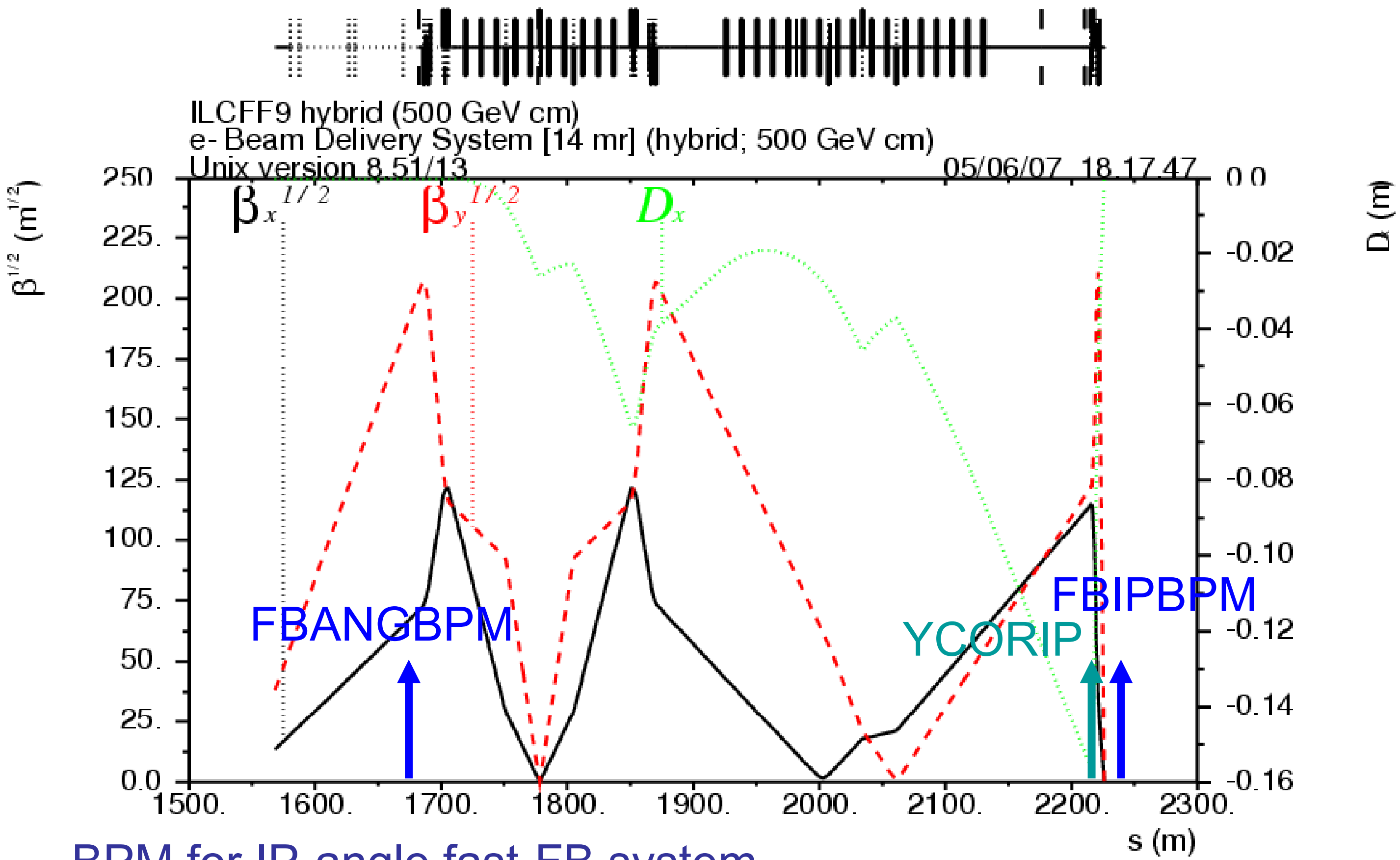




- Operates at high frequency and acts within a bunch train
- Removes the relative offset jitter at the IP by measuring the beam-beam deflection angle and steering the beams back into collision

BPM and kicker positions

IP-position fast-FB system

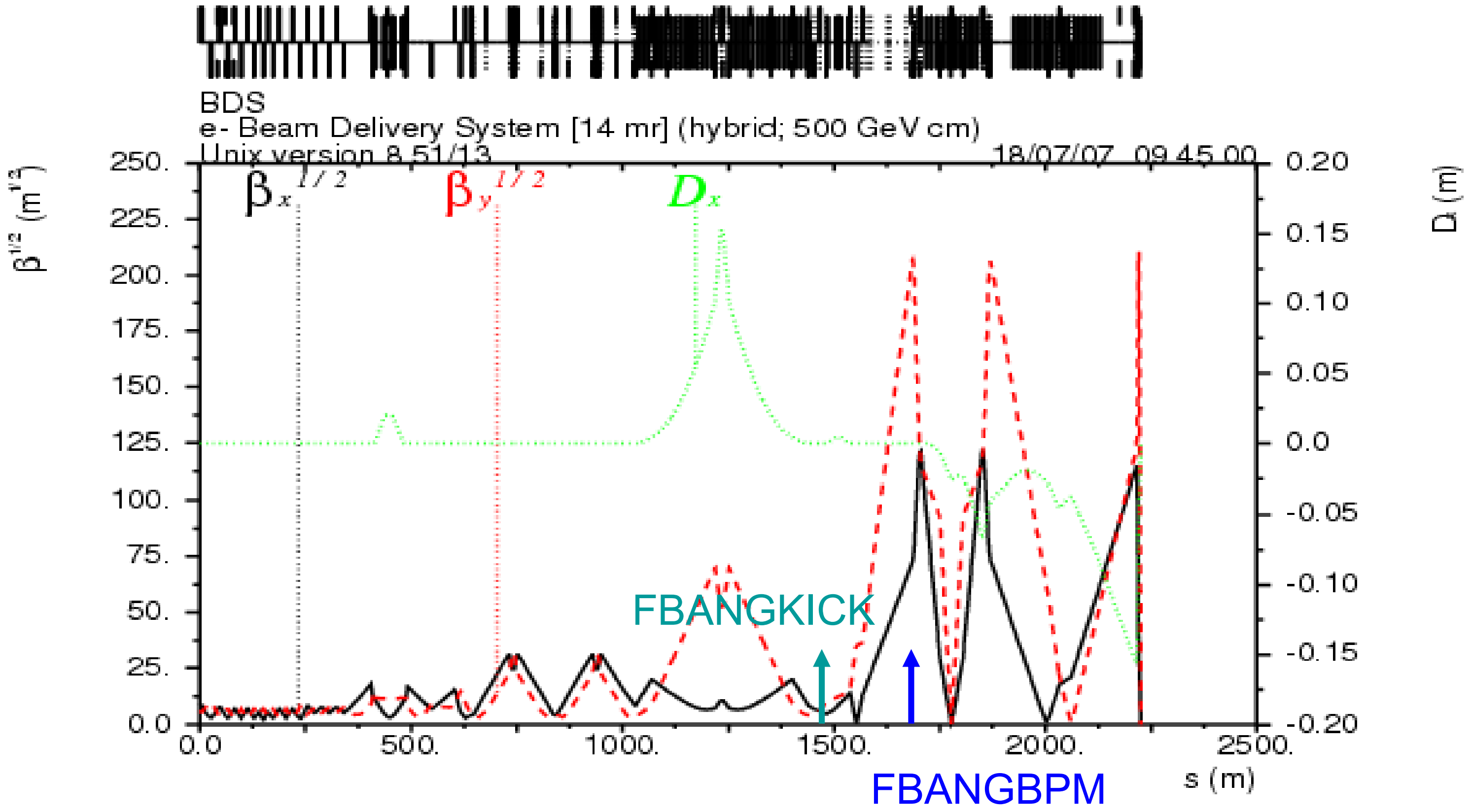


BPM for IP-angle fast-FB system

IP corrector at 3.5 m upstream of the IP

BPM and kicker positions

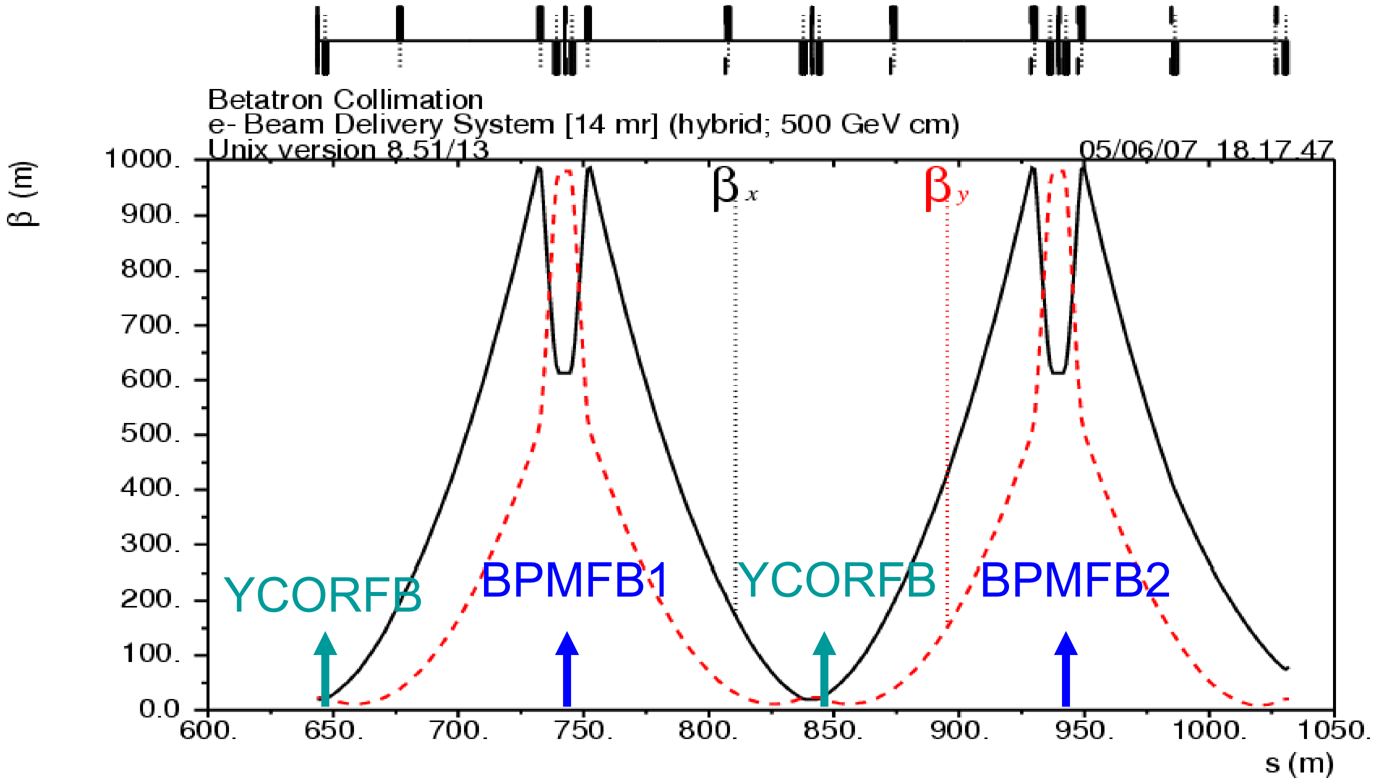
IP-angle fast-FB system



BPM at $\pi/2$ phase advance downstream of the kicker

BPM and kicker positions

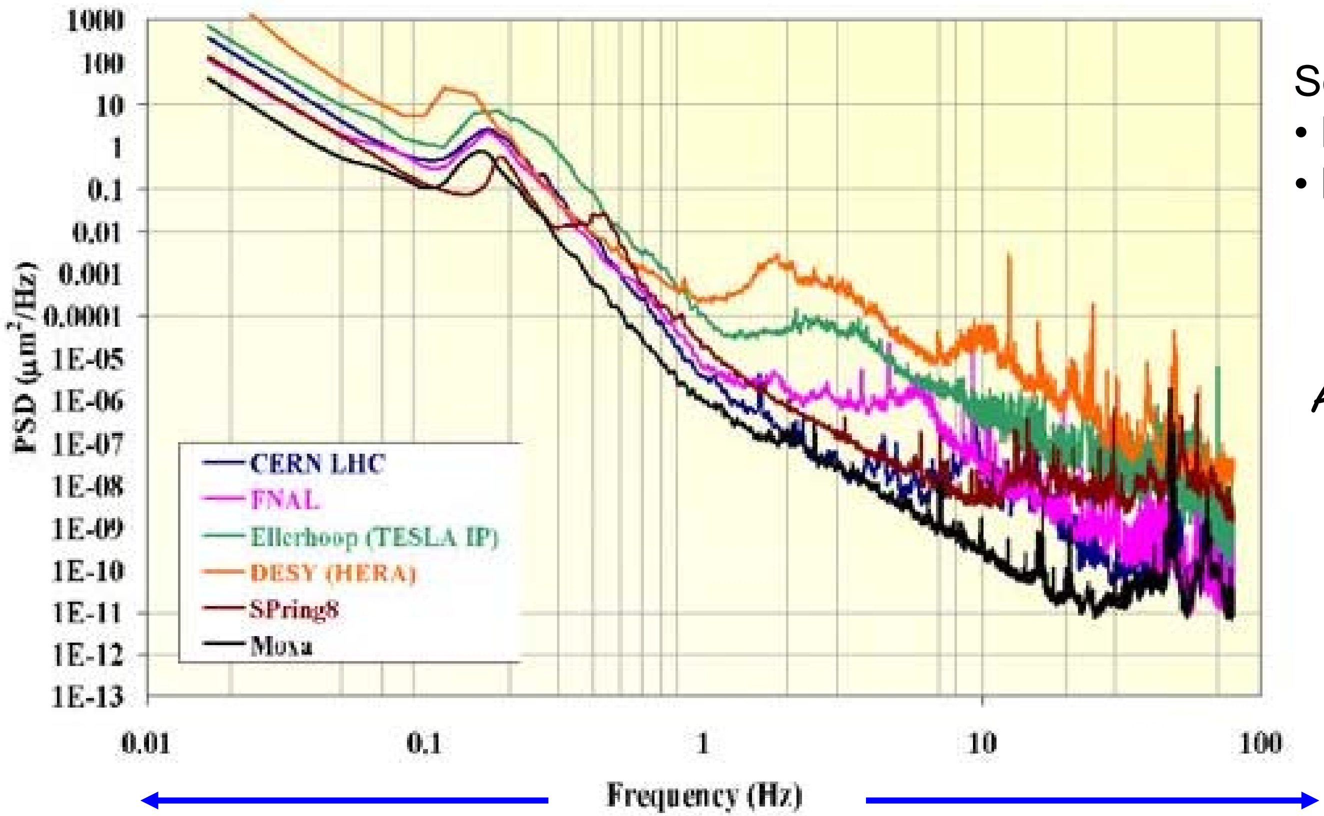
Upstream bunch-bunch FB system



Pair of kicker-BPM for orbit correction in both vertical degrees of freedom (y-y')

Ground motion

Power spectral density



Sources of vibration:

- Natural seismic motion
- Man-made (cultural noise)

Andrei Seryi's models:

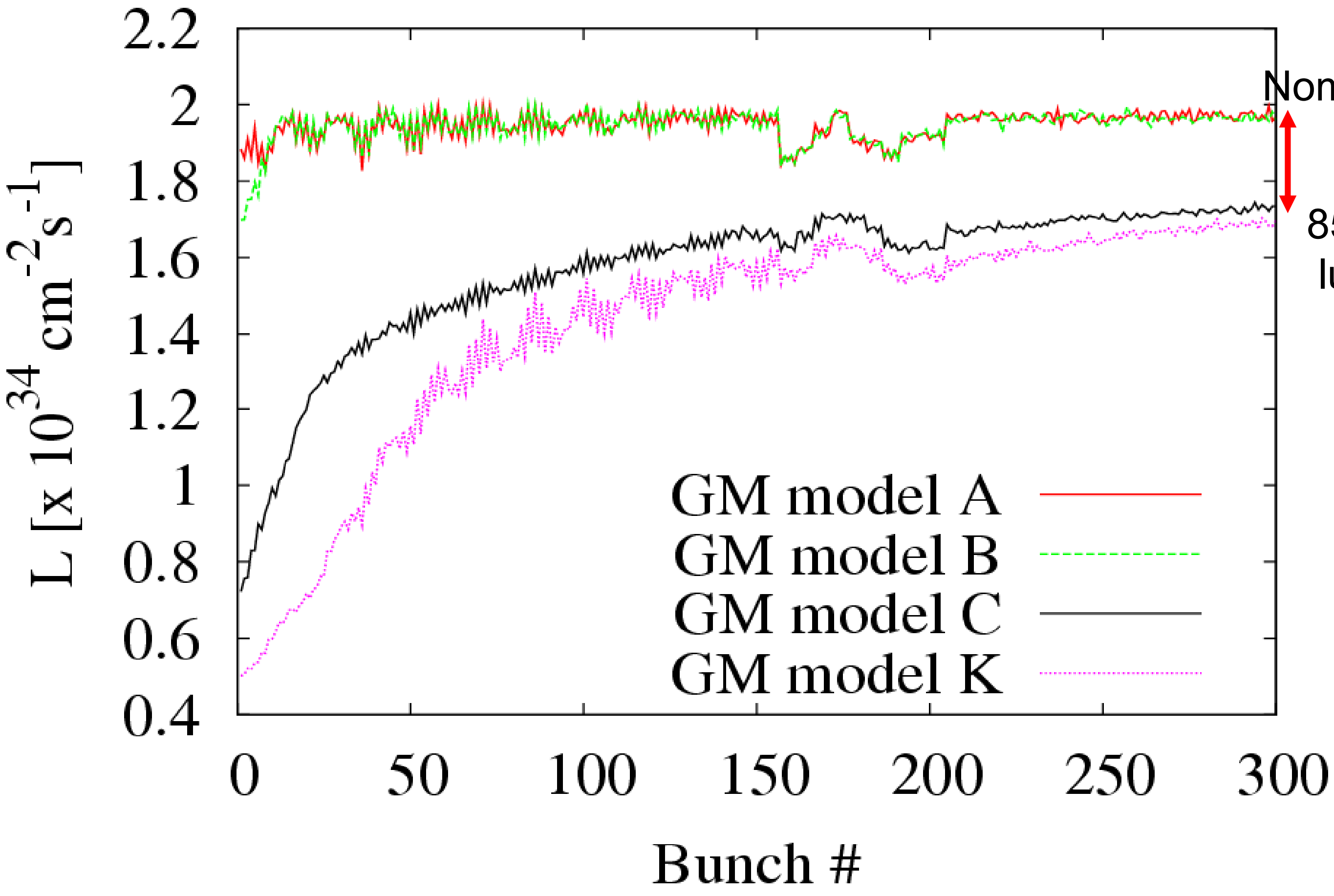
Model A=CERN
Model B=Fermilab
Model C=DESY
Model K=KEK

Slow motion: emittance growths
Beam size effects

> 5 Hz

Fast motion: beam jitters
Beam-beam offsets

Ground motion and FB system switched on

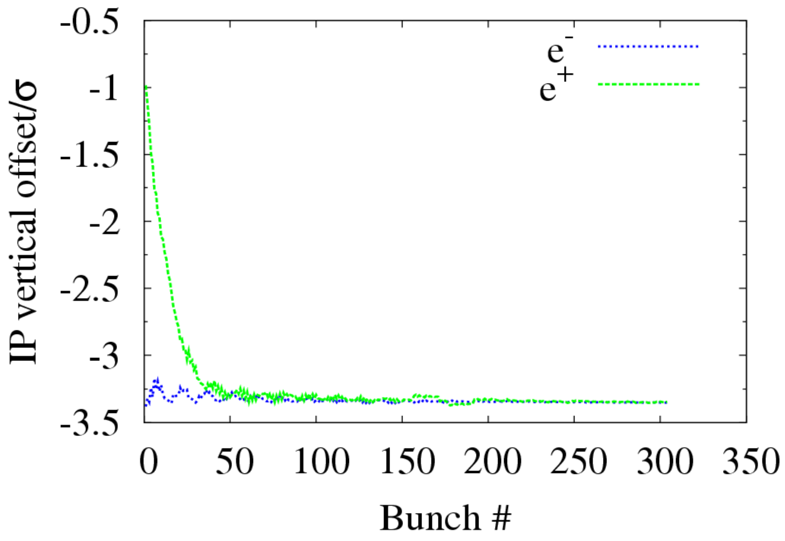


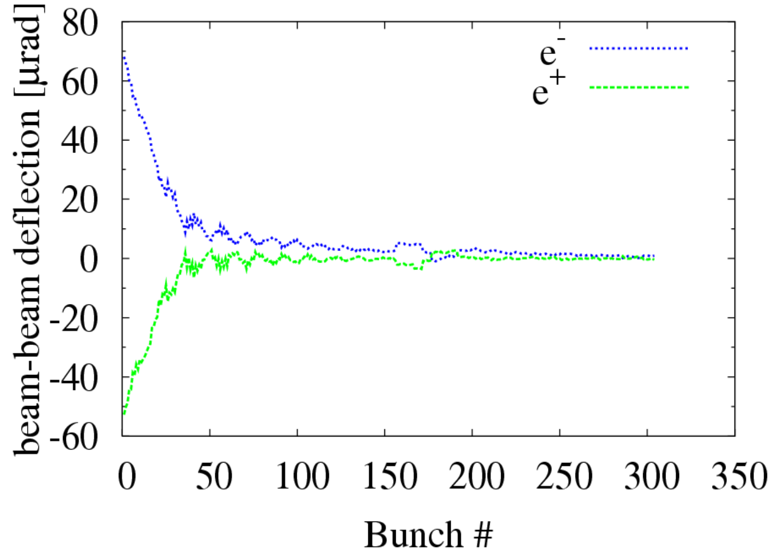
Nominal: $L=2x10^{34}\ cm^{-2}s^{-1}$

85 % of the nominal luminosity

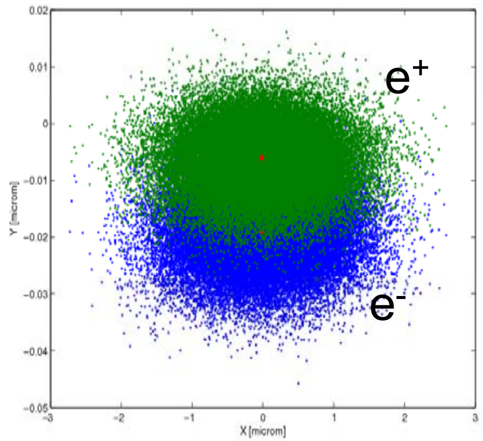
Model A=CERN
Model B=Fermilab
Model C=DESY
Model K=KEK

Beam-beam offset evolution at IP

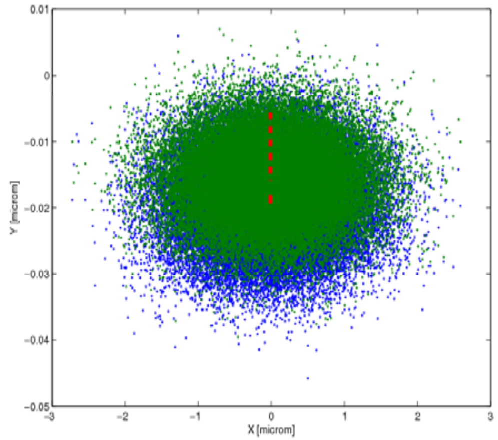




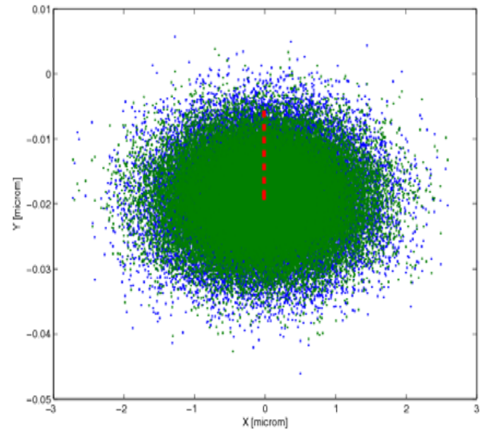
Bunch #1 …



Bunch #20 …



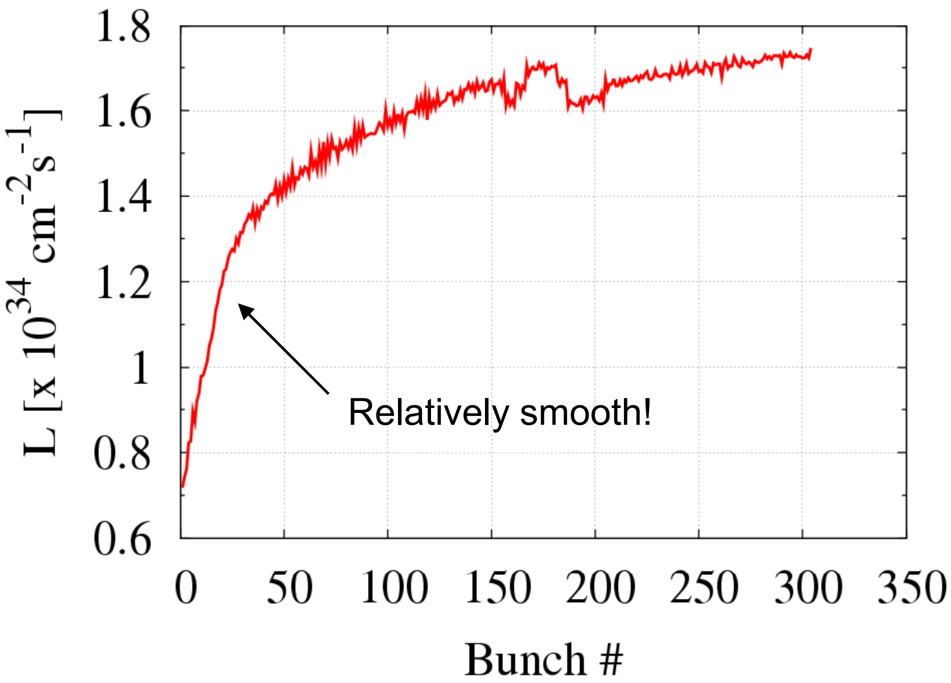
Bunch #60 …



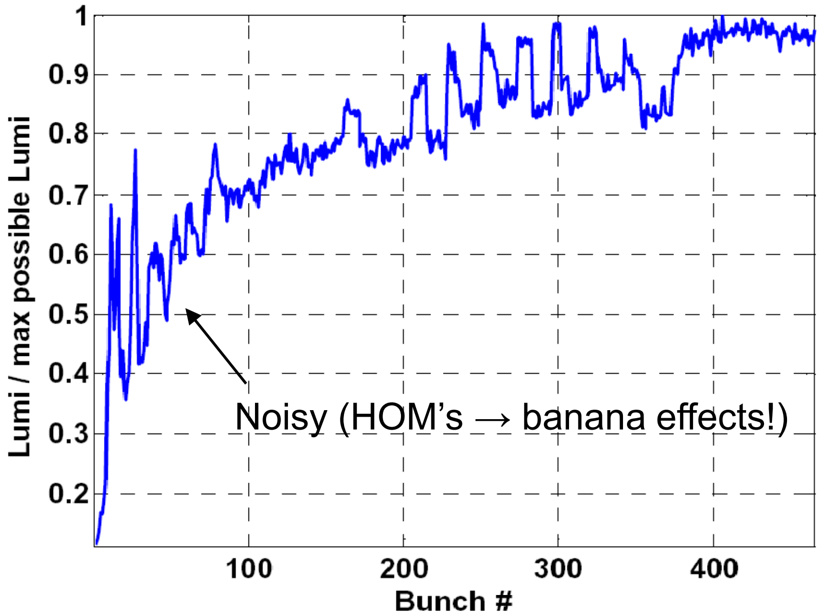
Example of transverse profile evolution at the IP with FB system switched on

Luminosity

(This work)



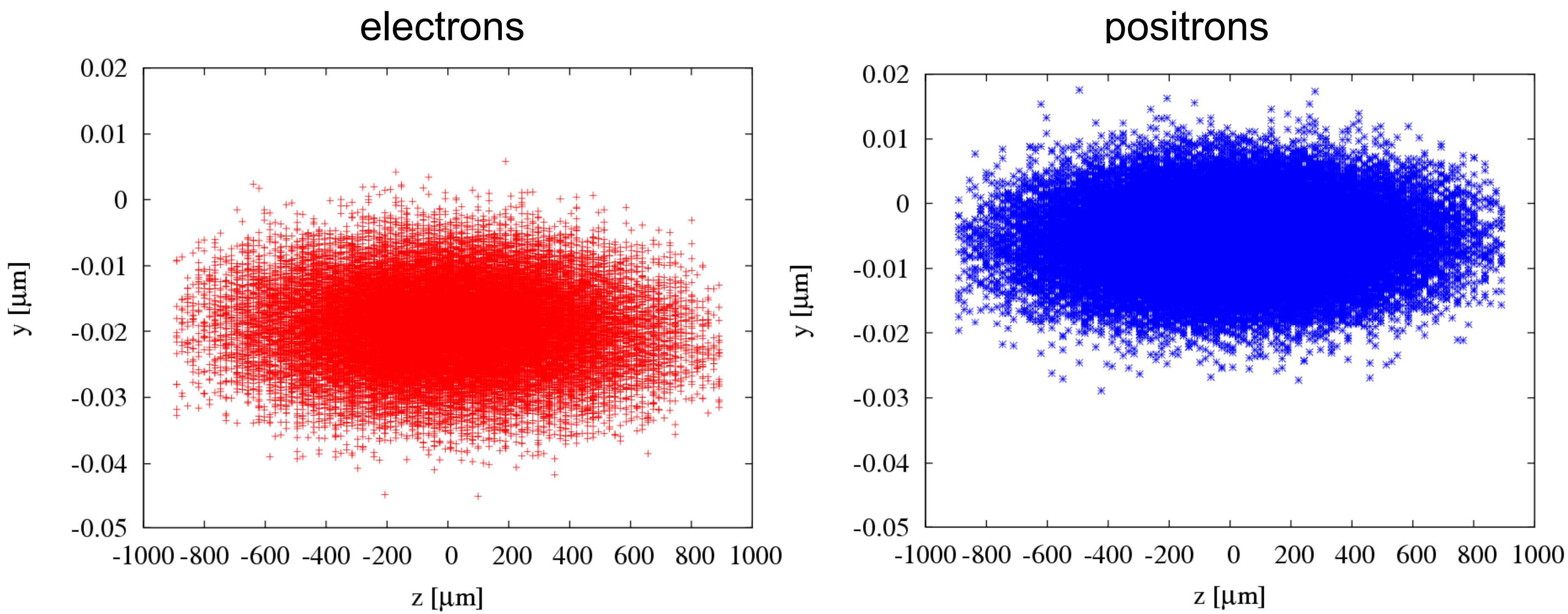
(Glen White et al., EUROTeV-Report-2006-088)



Assuming a pessimistic case of 40 % emittance growth in the linac
Applying 0.2 s of GM model C to the Linac + BDS (1 single seed)
Additional component jitter: 25 nm for the quads in the BDS;
50 nm for the quads in the Linac

Longitudinal profile of a sample bunch at the IP

y vs z



Practically no banana effect!

For the present ILC linac simulations the short-range wakefield effects are much weaker than for the previous TESLA linac simulations.

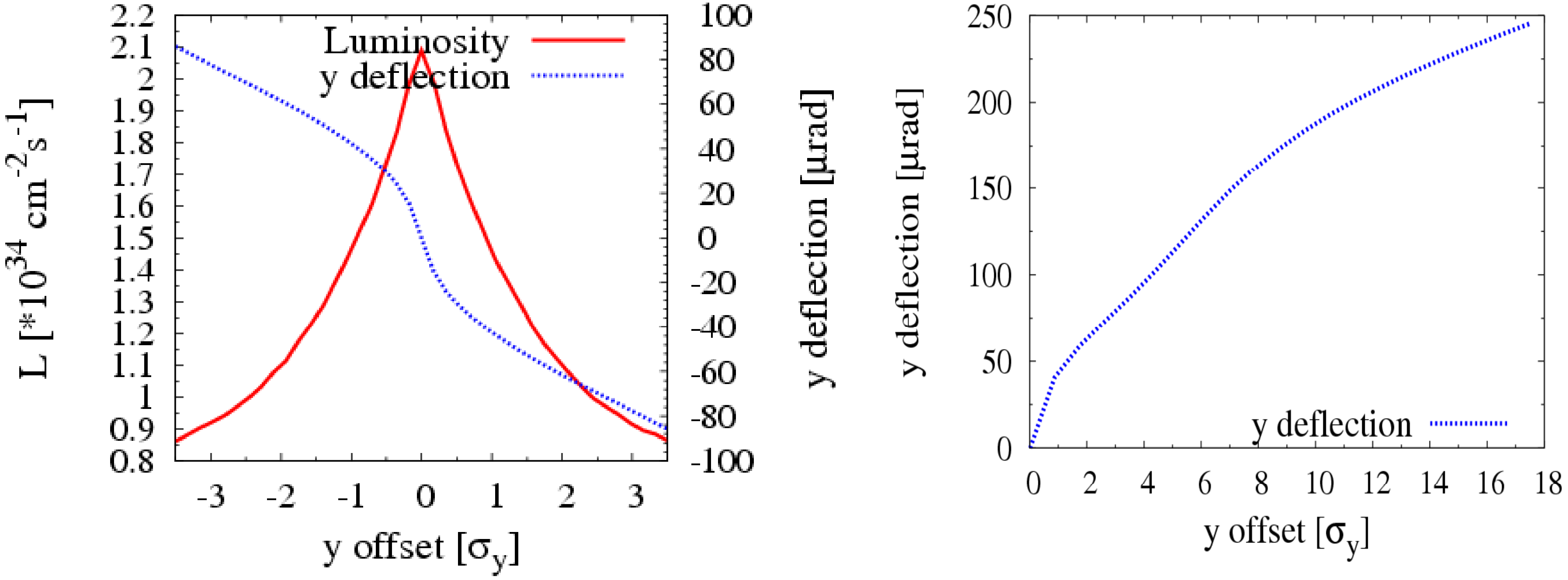
Ongoing studies and future work

- FB system Simulink model is being ported to Octave (a free clone of matlab callable from within Placet)
- Addition of the crab cavities in our Placet based integrated simulations
- Addition of collimator wakefield effects
- The different sources of beam jitter and their contribution to the luminosity loss should be carefully studied

Extra …

Luminosity and beam-beam deflection at the IP

The beam-beam deflection is linear in beam offset only for small vertical displacements



~ nm vertical offset →

~ tens of urad deflection angle

Simulink model