BDS at reduced beam parameters

2nd Baseline Assessment Workshop on Reduced Beam Parameter set

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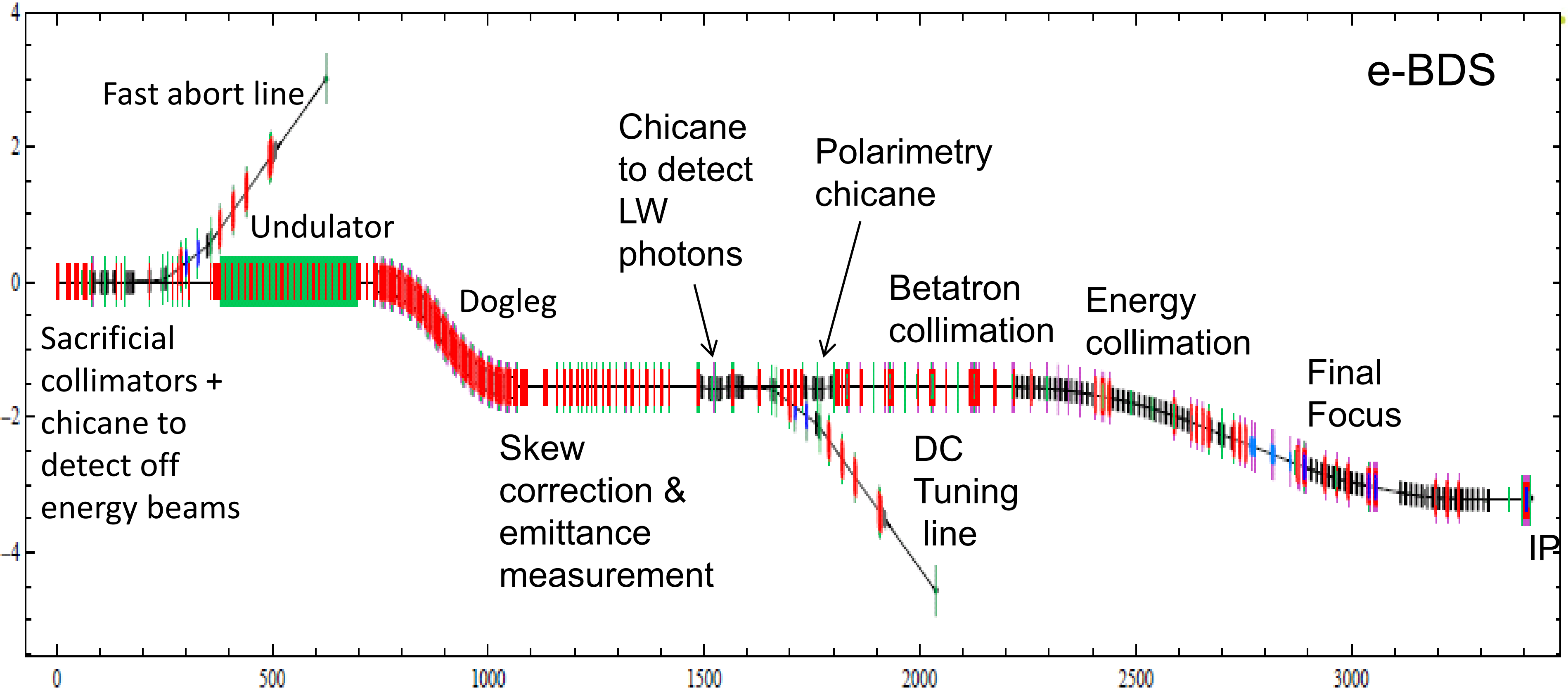
19 January 2011

Outline

- Layout and optics
- Parameters and luminosity in details
- FD updates
- Simulation of TF generation by transverse cavity
  - **Separate presentation (N.W.)**
- Wang-Gao-Kubo parameters

SB2009 e- BDS



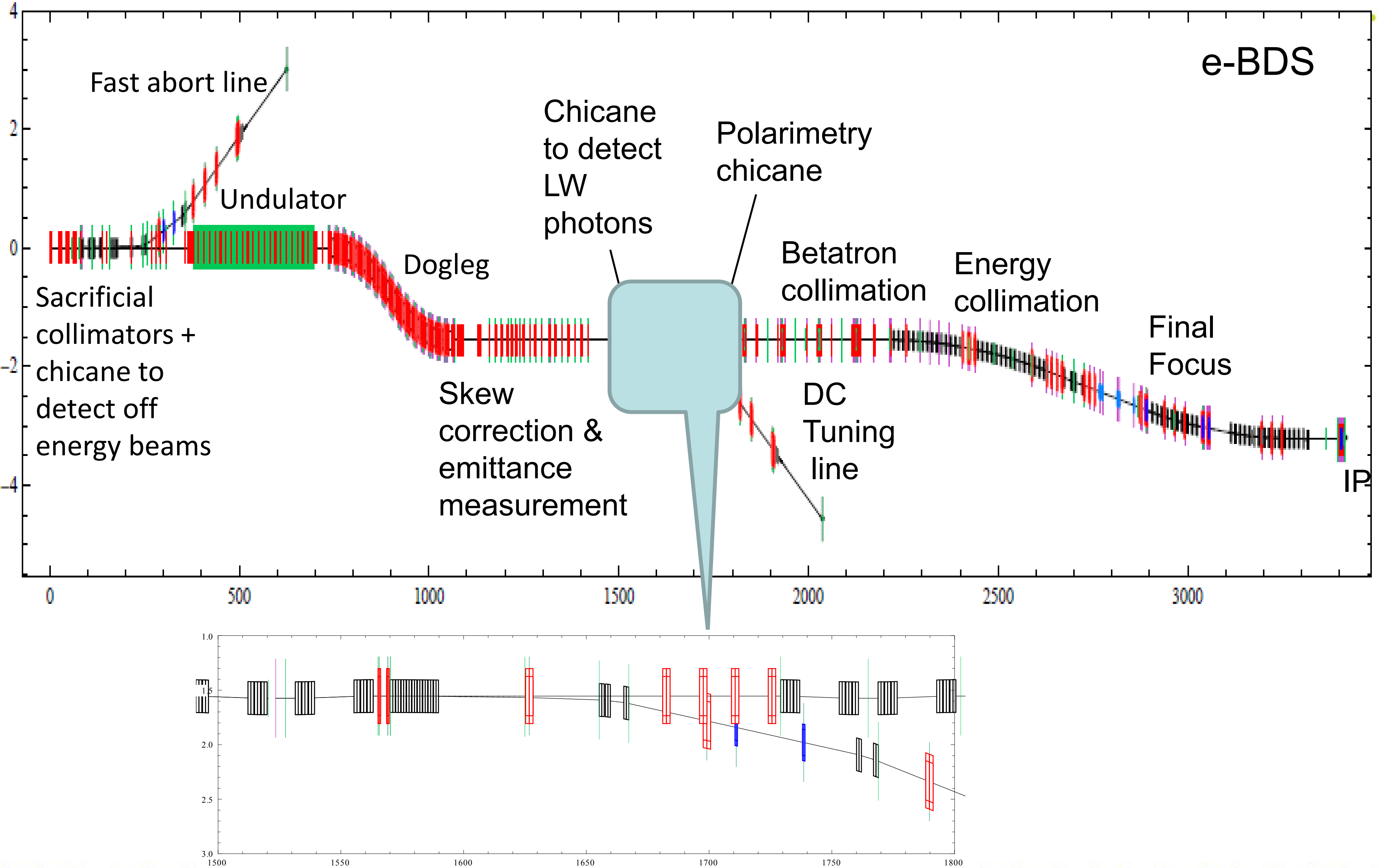
Changes on e- side due to central integration : dogleg design & tolerances

Separated polarimeter chicane from RDR combined functionalities.

D. Angal-Kalinin et al

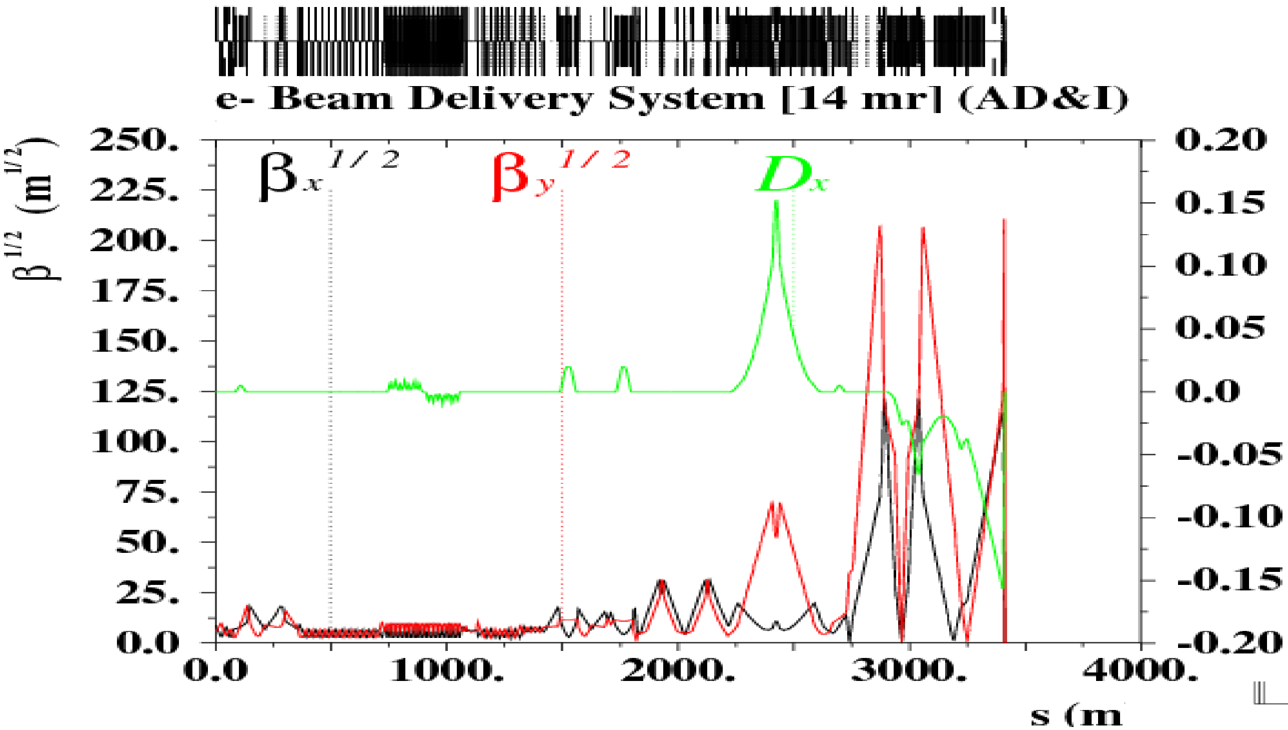
http://projects.astec.ac.uk/ilcdecks/

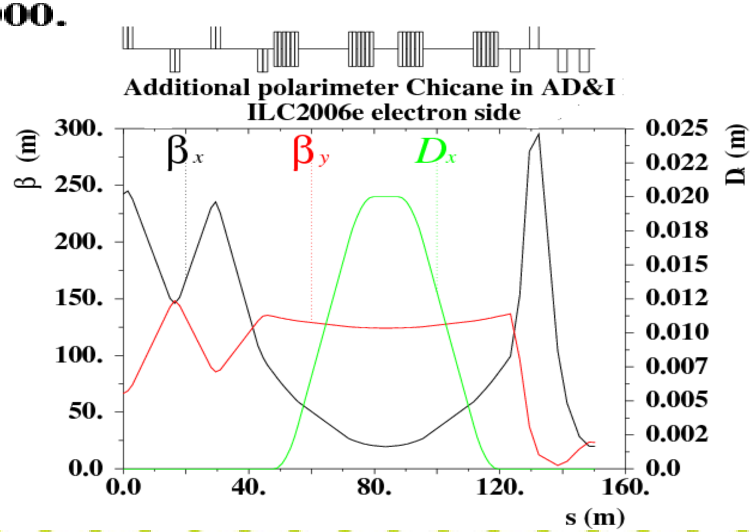
SB2009 e- BDS



e-BDS
Fast abort line
Undulator
Chicane to detect LW photons
Polarimetry chicane
Dogleg
Betatron collimation
Energy collimation
Sacrificial collimators + chicane to detect off energy beams
Final Focus
Skew correction & emittance measurement
DC Tuning line
IP
4
2
0
-2
-4
0
500
1000
1500
2000
2500
3000
1.0
1.5
2.0
2.5
3.0
1500
1550
1600
1650
1700
1750
1800

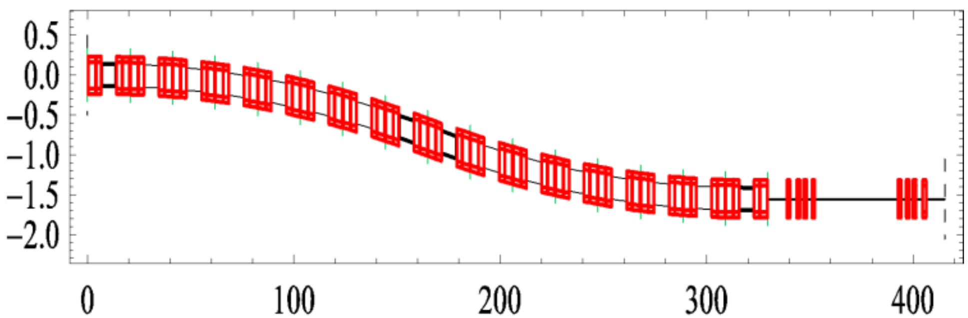
SB2009 e- BDS Optics

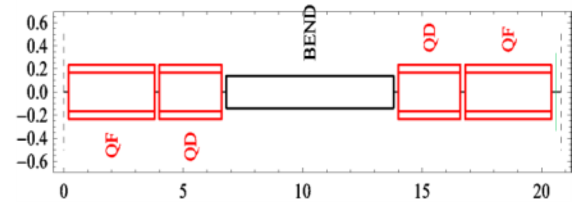




The Dogleg Design

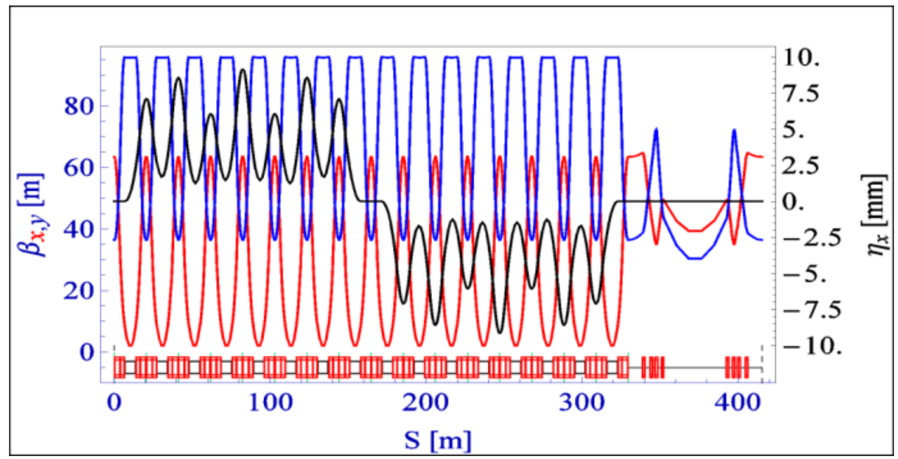
- Theoretical Minimum Emittance (TME) lattice.





- Provides ***1.5m*** offset in ***~400m***

- Emittance growth is ***~3.8%*** (1TeV CM)



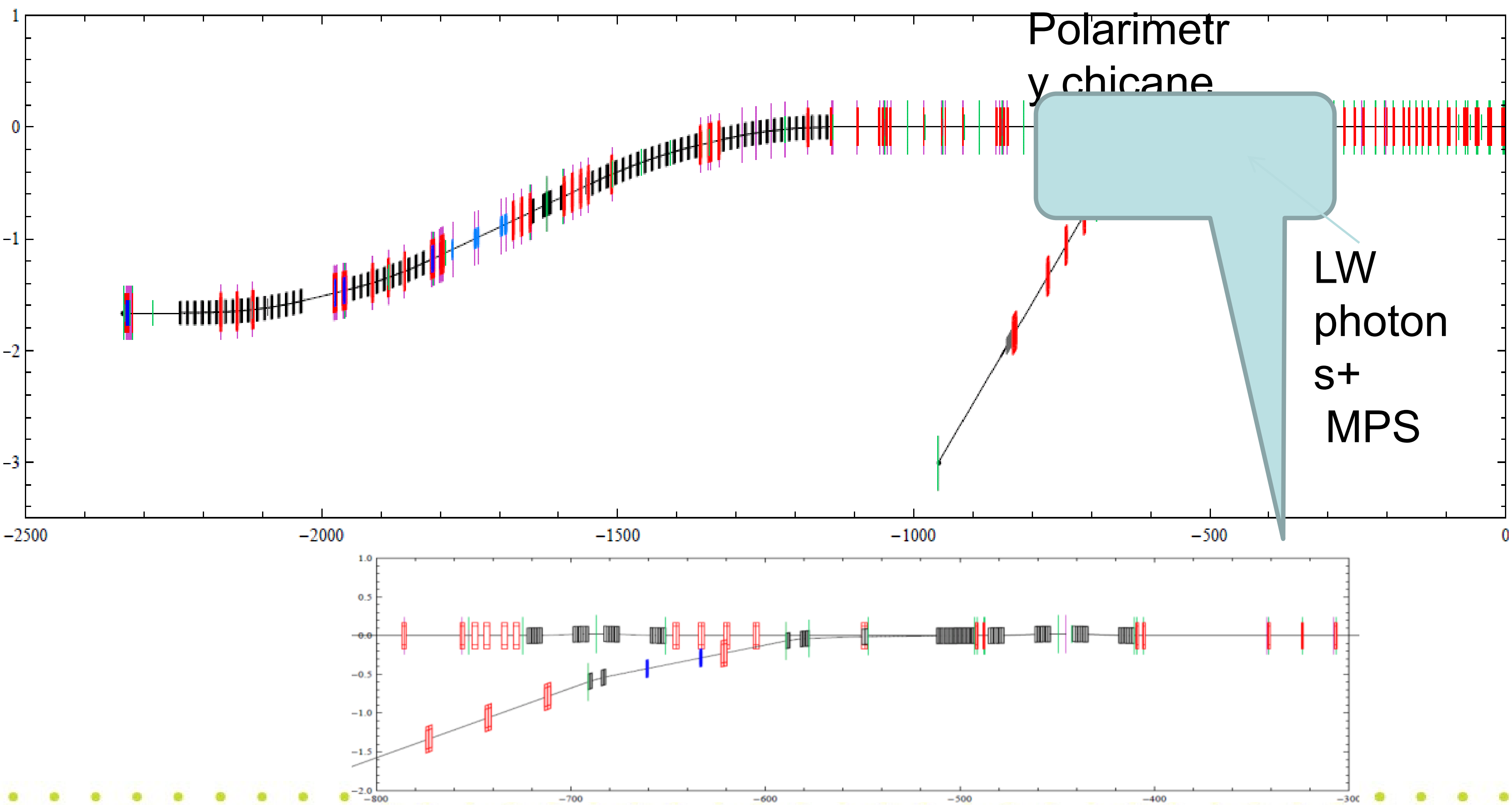
- Decimation of dipoles is possible

- The first and last dipoles in each of the two bending sections have lower bend angles to match the dispersion into, and out of, the dogleg.

- These dipoles can be used to match and correct incoming errors to minimise the emittance growth seen in the dogleg sections.

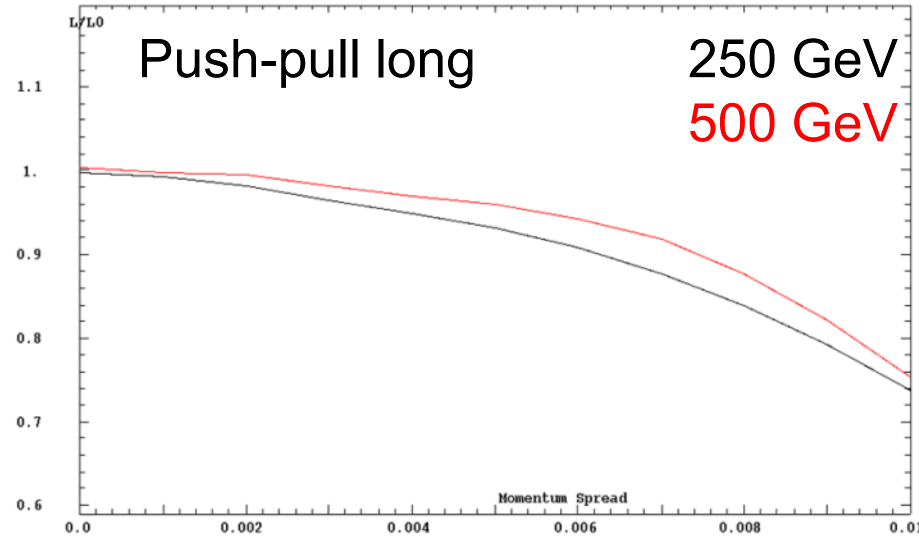
Positron BDS

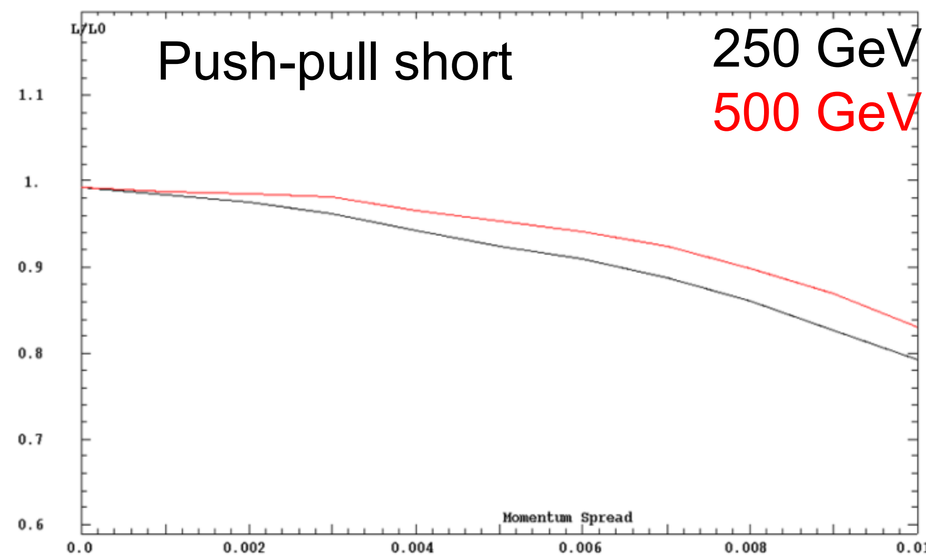
Separated polarimetry chicane, combined functionality of laser wire and MPS still in the same chicane. Need laser wire simulations to see if this is okay.



Shortening of Energy Collimation and Final Focus

- Emittance growth <1% @500 GeV beam for RDR.
- First attempt to reduce the FFS length of push-pull deck by R. Versteegen (CEA).
- Multiplied all the dipole lengths and drifts by 0.87 in the energy collimator and the FFS in order to approximately double emittance growth in these sections.
- Re-tuned linear optics and sextupoles to optimise the luminosity and the bandwidth.





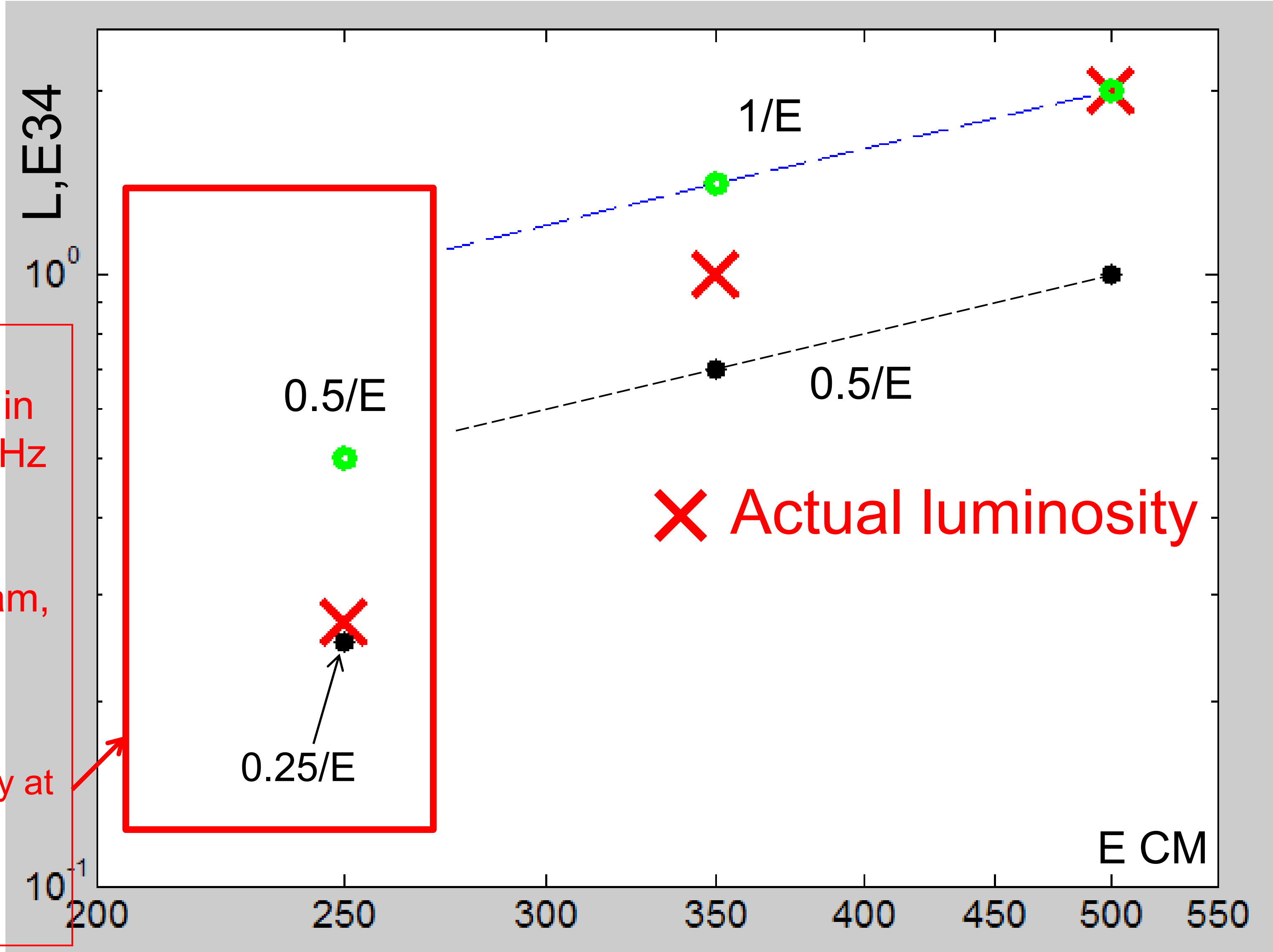
Beam Parameters

	RDR			SB2009 w/o TF				SB2009 w TF			
CM Energy (GeV)	250	350	500	250.a	250.b	350	500	250.a	250.b	350	500
Ne- (*10^{10})	2.05	2.05	2.05	2	2	2	2.05	2	2	2	2.05
Ne+ (*10^{10})	2.05	2.05	2.05	1	2	2	2.05	1	2	2	2.05
nb	2625	2625	2625	1312	1312	1312	1312	1312	1312	1312	1312
Tsep (nsecs)	370	370	370	740	740	740	740	740	740	740	740
F (Hz)	5	5	5	5	2.5	5	5	5	2.5	5	5
γex (*10^{-6})	10	10	10	10	10	10	10	10	10	10	10
γey (*10^{-6})	4	4	4	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
βx	22	22	20	21	21	15	11	21	21	15	11
βy	0.5	0.5	0.4	0.48	0.48	0.48	0.48	0.2	0.2	0.2	0.2
σz (mm)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
σx eff (*10^{-9} m)	948	802	639	927	927	662	474	927	927	662	474
σy eff (*10^{-9} m)	10	8.1	5.7	9.5	9.5	7.4	5.8	6.4	6.4	5.0	3.8
L (10^{34} $cm^{-2}s^{-1}$)	0.75	1.2	2.0	0.2	0.22	0.7	1.5	0.25	0.27	1.0	2.0

Rate at IP = 2.5Hz,
Rate in the linac = 5Hz (every other pulse is at 150GeV/beam, for e+ production)

Low luminosity at this energy reduces the physics reach

SB2009 Lumi



Rate at IP = 2.5Hz, Rate in the linac = 5Hz (every other pulse is at 150GeV/beam, for e+ production)

Low luminosity at this energy reduces the physics reach

Work on mitigations of L(E) with SB2009 during and after ILC2010

- Discussion of double rep rate was initiated ~month before the ILC2010

  this allowed achieving significant progress at LCWS10

- Doubling the rep rate (below ~125GeV/beam)
  - **BDS WG discussed implications with other Working Groups:**
    - DR => ~OK (new conceptual DR design; duty factor issue)
    - Sources => OK
    - Linac, HLRF, Cryogenics => OK
- FD optimized for ~250GeV CM
  - **Shorter FD reduce beam size in FD and increase collimation depth, reducing collimation related beam degradation**
  - **Will consider exchanging FD for low E operation or a more universal FD that can be retuned**

Lumi(E) dependence in SB2009

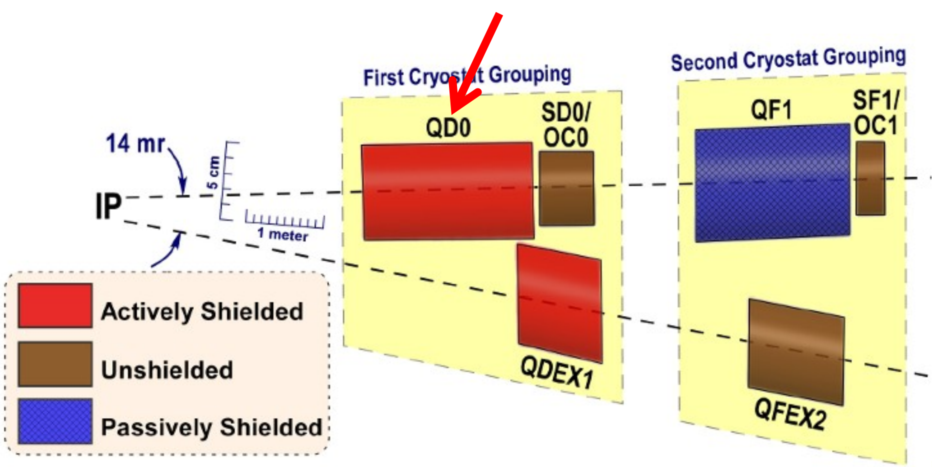
- Factor determine shape of L(E) in SB2009
  - **Lower rep (/2) rate below ~125GeV/beam**
  - **Collimation effects: increased beam degradation at lower E due to collimation wakes and due to limit (in X) on collimation depth**

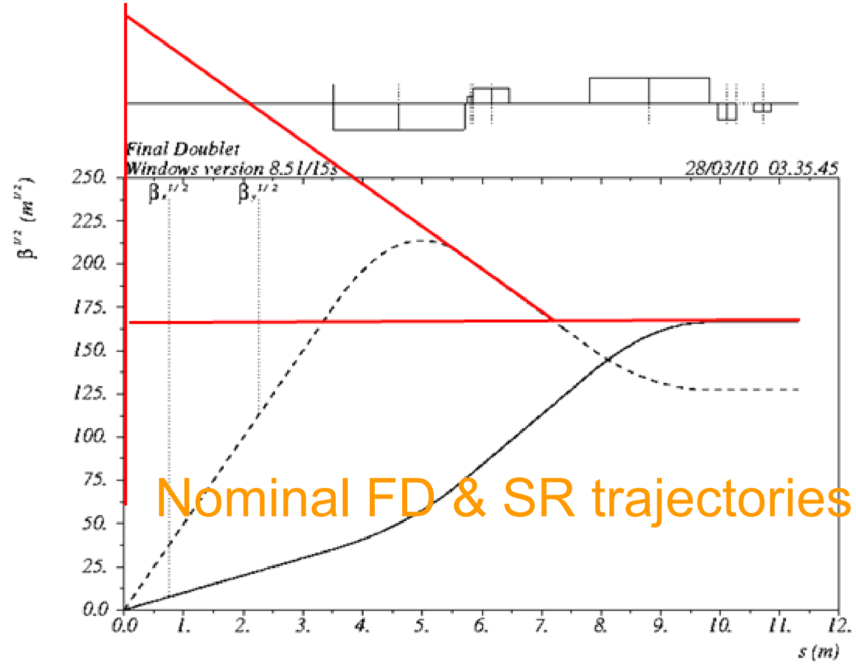
- Understanding the above limitations, one can suggest mitigation solutions:
  - **1) Consider doubling the rep rate at lower energy**
  - **2) Consider Final Doublet optimized for 250GeV CM**

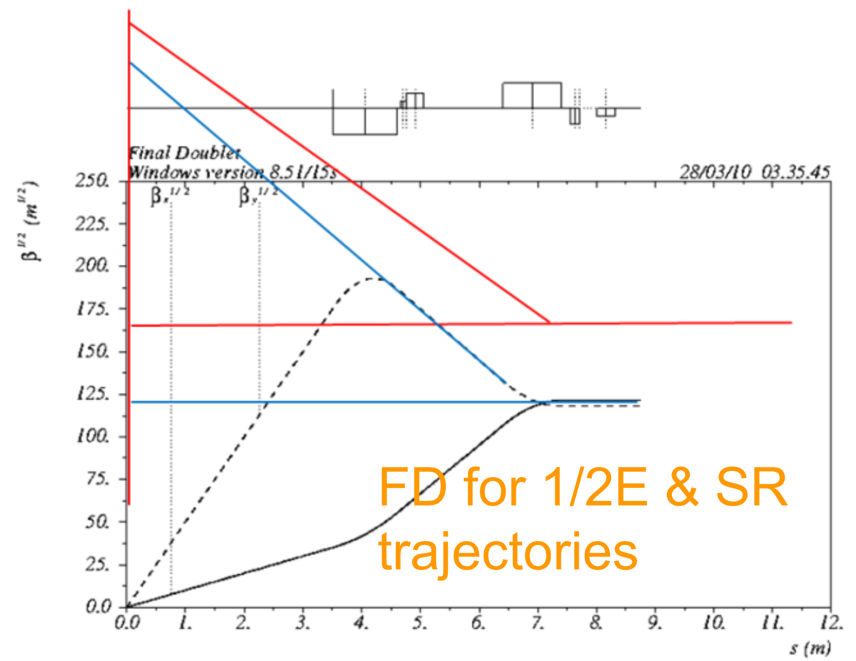
FD for low E

FD optimized for lower energy will allow increasing the collimation depth by ~10% in Y and by ~30% in X (Very tentative!)

- One option would be to have a separate FD optimized for lower E, and then exchange it before going to nominal E
- Other option to be studied is to build a universal FD, that can be reconfigured for lower E configuration (may require splitting QD0 coil and placing sextupoles in the middle)





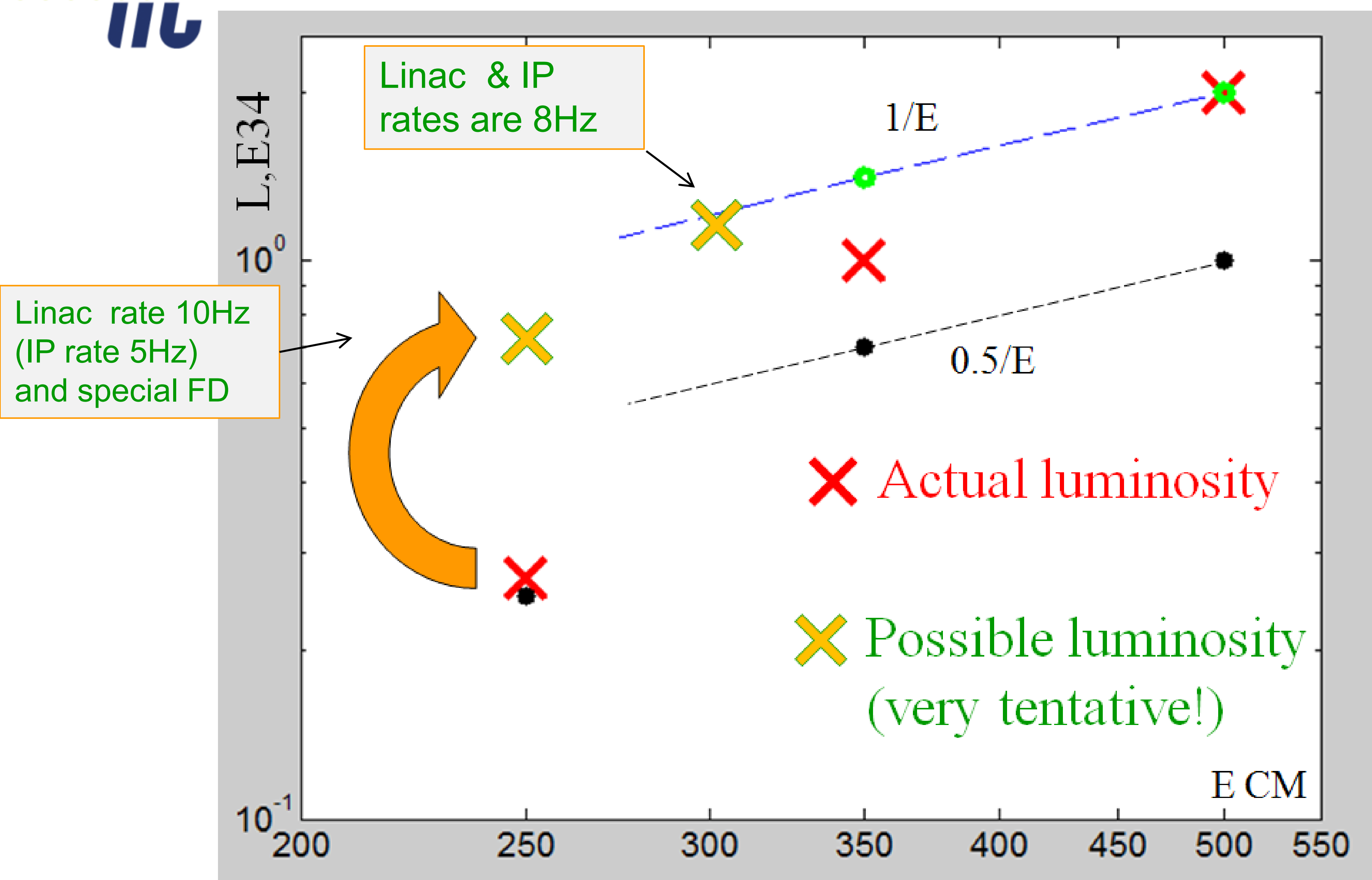


Beam Parameters & mitigation

	RDR			SB2009 w/o TF				SB2009 w TF			
CM Energy (GeV)	250	350	500	250.a	250.b	350	500	250.a	250.b	350	500
Ne- ($*10^{10}$)	2.05	2.05	2.05	2	2	2	2.05	2	2	2	2.05
Ne+ ($*10^{10}$)	2.05	2.05	2.05	1	2	2	2.05	1	2	2	2.05
nb	2625	2625	2625	1312	1312	1312	1312	1312	1312	1312	1312
Tsep (nsecs)	370	370	370	740	740	740	740	740	740	740	740
F (Hz)	5	5	5	5	2.5	5	5	5	2.5	5	5
γex ($*10^{-6}$)	10	10	10	10	10	10	10	10	10	10	10
γey ($*10^{-6}$)	4	4	4	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
βx	22	22	20	21	21	15	11	21	21	15	11
βy	0.5	0.5	0.4	0.48	0.48	0.48	0.48	0.2	0.2	0.2	0.2
σz (mm)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
σx eff ($*10^{-9}$ m)	948	802	639	927	927	662	474	927	927	662	474
σy eff ($*10^{-9}$ m)	10	8.1	5.7	9.5	9.5	7.4	5.8	6.4	6.4	5.0	3.8
L (10^{34} cm^{-2}s^{-1})	0.75	1.2	2.0	0.2	0.22	0.7	1.5	0.25	0.27	1.0	2.0

- Tentative! At 250 GeV CM the mitigations may give
  - *** 2 L due to double rep rate**
  - *** about 1.4 L due to FD optimized for low E**

SB2009 Lumi



Linac & IP
rates are 8Hz
Linac rate 10Hz
(IP rate 5Hz)
and special FD
1/E
0.5/E
Actual luminosity
Possible luminosity
(very tentative!)
L, E34
E CM
10^0
10^-1
200
250
300
350
400
450
500
550

New parameters based on the following assumptions

- **Starting point: parameters developed by the Physics Questions Committee (B. Foster, A. Seryi, J. Clarke, M. Harrison, D. Schulte, T. Tauchi) in December 2009.**
- **Take into account progress on 10Hz rep rate for low E achieved after LCWS10**
  - There are issues with DR duty cycle that are being studied, however assume that they will be solved
- **Assume that we will develop and use new universal FD that gives additional luminosity improvement (only) for 200 and 250 GeV energies**
- **Consider the following energies: 200, 250, 350, 500 GeV CM**
- **Assume single stage bunch compressor (min sigma_z=230um – will use 300um and consider 230 as an overhead or safety margin)**
- **Assume 10Hz and 1300 bunches**
- **Consider separately the cases with and without Travelling Focus**
- **Energy and rep rate:**

E=	200	250	350	500	GeV CM
IP rep rate	5	5	5	5	Hz
Linac rate	10	10	5	5	Hz
	(double pulsing)				

BAW-2 Themes

								upgrade
Centre-of-mass energy	E_{cm}	**GeV**	**200**	**230**	**250**	**350**	**500**	**1000**
Luminosity	L	$\times 10^{34}$ cm^{-2}s^{-2}	**0.5**	**0.5**	**0.7**	**0.8**	**1.5**	**2.8**
Luminosity (Travelling Focus)	L_{TF}	$\times 10^{34}$ cm^{-2}s^{-2}	**0.5**		**0.8**	**1.0**	**2.0**	
Number of bunches	n_b		1312	1312	1312	1312	1312	2625
Collision rate	f_{rep}	Hz	5	5	5	5	5	4
Electron linac rate	f_{linac}	Hz	10	10	10	5	5	4
Positron bunch population	N_+	$\times 10^{10}$	2	2	2	2	2	2

Formally agreed parameter sets across energy range
ILC-EDMS document ID 925325

http://ilc-edmsdirect.desy.de/ilc-edmsdirect/document.jsp?edmsid=*925325

BAW-2 Issues

Travelling Focus

- More detailed simulations required
- Stability issues → impact on feedback and tolerances
- considered higher-risk option
- Inclusion not a cost issue

10Hz Operation (Low E_{cm})

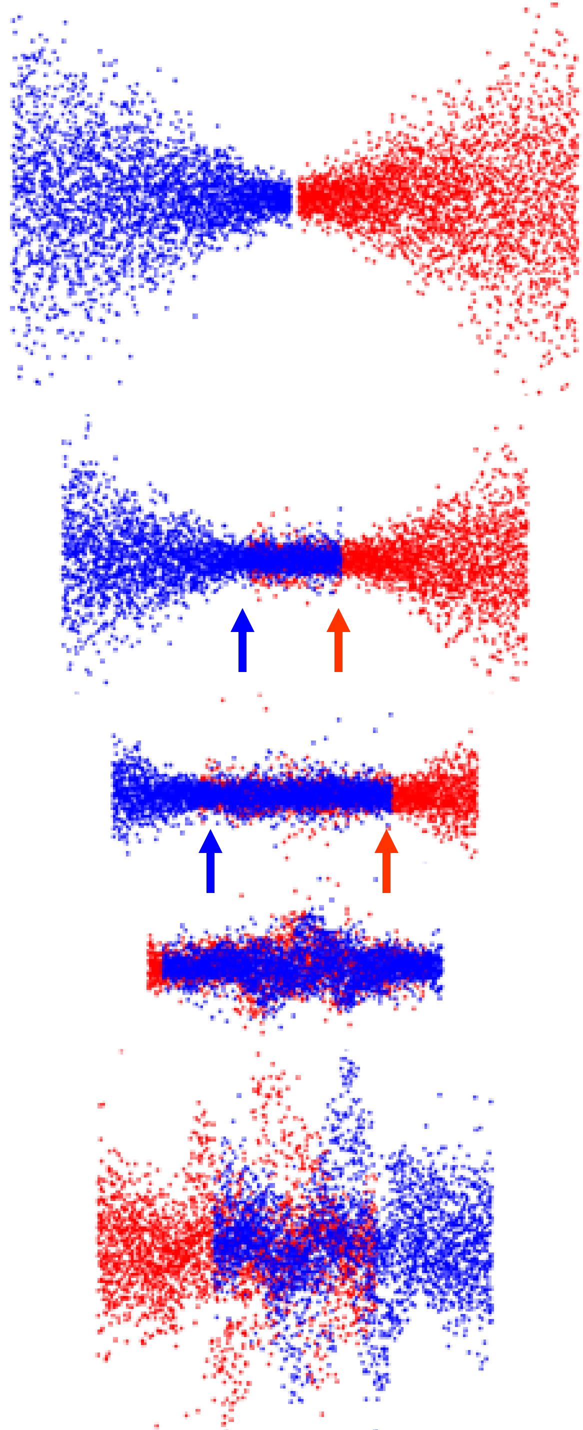
- Positron damping ring 50% duty cycle
- RF solution still required (this workshop)
- Understanding cost impact (1.9% TPC)
- Other emerging options (high-field undulator)

Upgrade / Risk-Mitigation

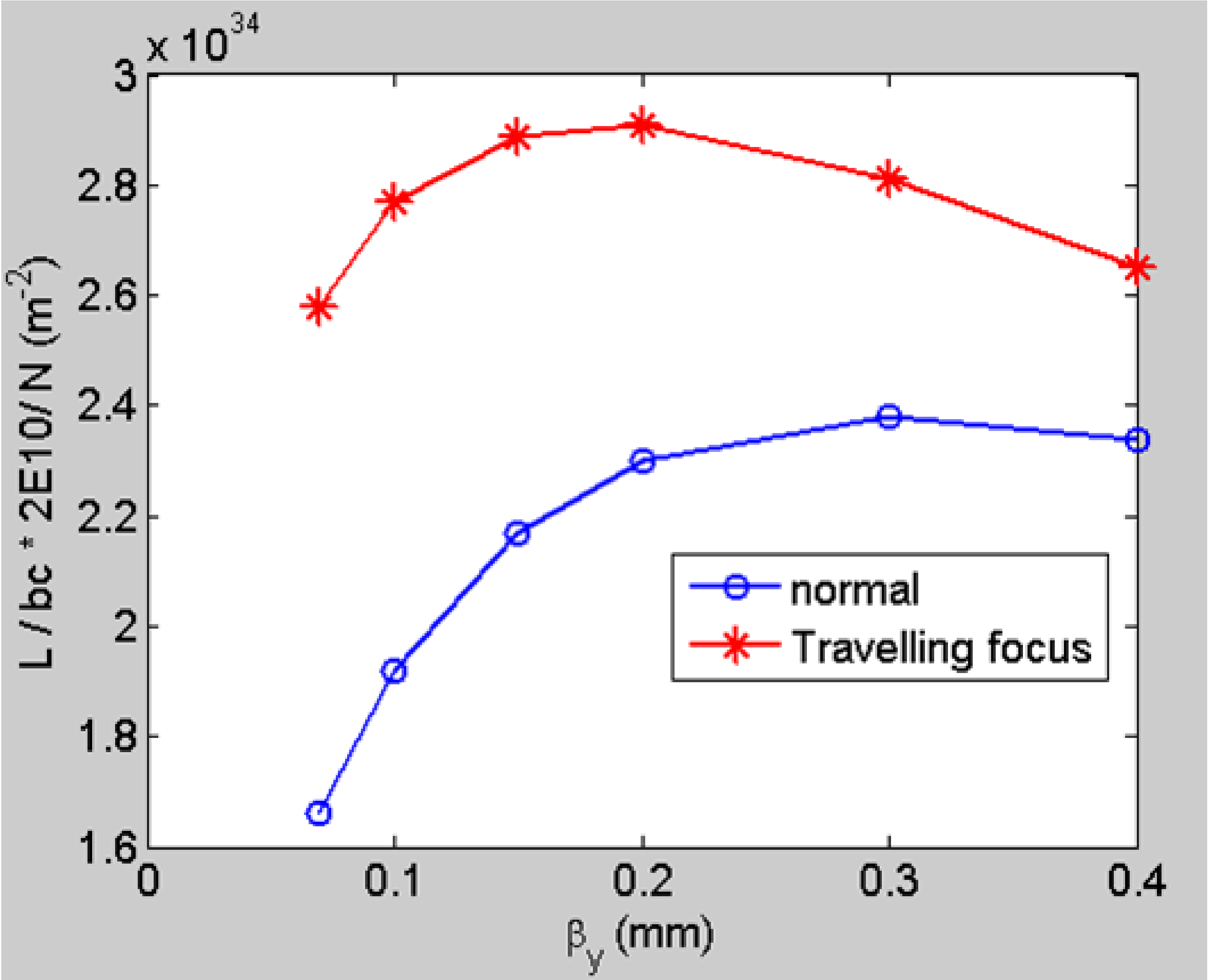
- Understand scenarios for re-establishing RDR bunch number
- Cost impact (mostly CFS)
- Considered either as possible luminosity upgrade or risk-mitigation (GDE PAC)

Physics impact ↔ Working with Physics & Detector groups as part of the TLCC process

18.11.10 N. Walker et al 25



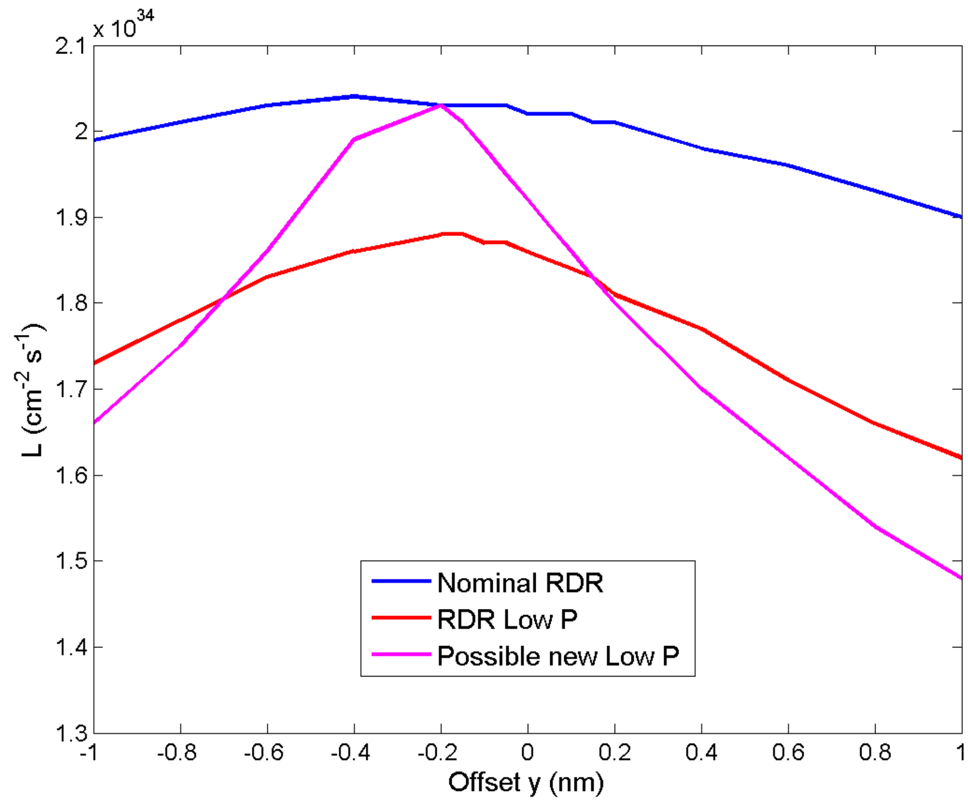
Arrows show location of focal point for each bunch at a particular moment



x 10^34
3
2.8
2.6
2.4
2.2
2
1.8
1.6
L / bc * 2E10/ N (m^-2)
0
0.1
0.2
0.3
0.4
βy (mm)
normal
Travelling focus

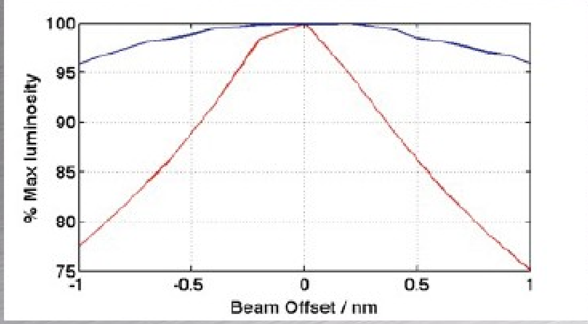
SB2009 beam offset sensitivity

- Higher Disruption
  - **Higher sensitivity to Δy**
  - **Intratrain Feedback more challenging**
  - **Vertical bunch-bunch jitter to be <200pm for <5% lumi loss**
  - **However, twice longer bunch separation will help to improve bunch-bunch uniformity & jitter**

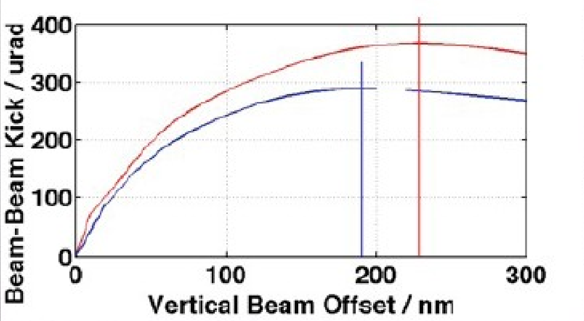


Glen White (SLAC)
Javier Resta-Lopez (JAI)
GDE/ALCPG Workshop Sept. 2009

IP Beam-Beam Dynamics



SB2009 (lowP with trav focus)
Nominal Parameter Set



GUINEA-PIG Simulations

- IP vertical position feedback based on beam-beam kick
- "turn over" point of kick sets desired dynamic range
- SB2009 more sensitive
- Vertical beam offset must be kept <200pm for <5% lumi loss
- SB2009 parameter set gives slightly larger dynamic range for FFB system

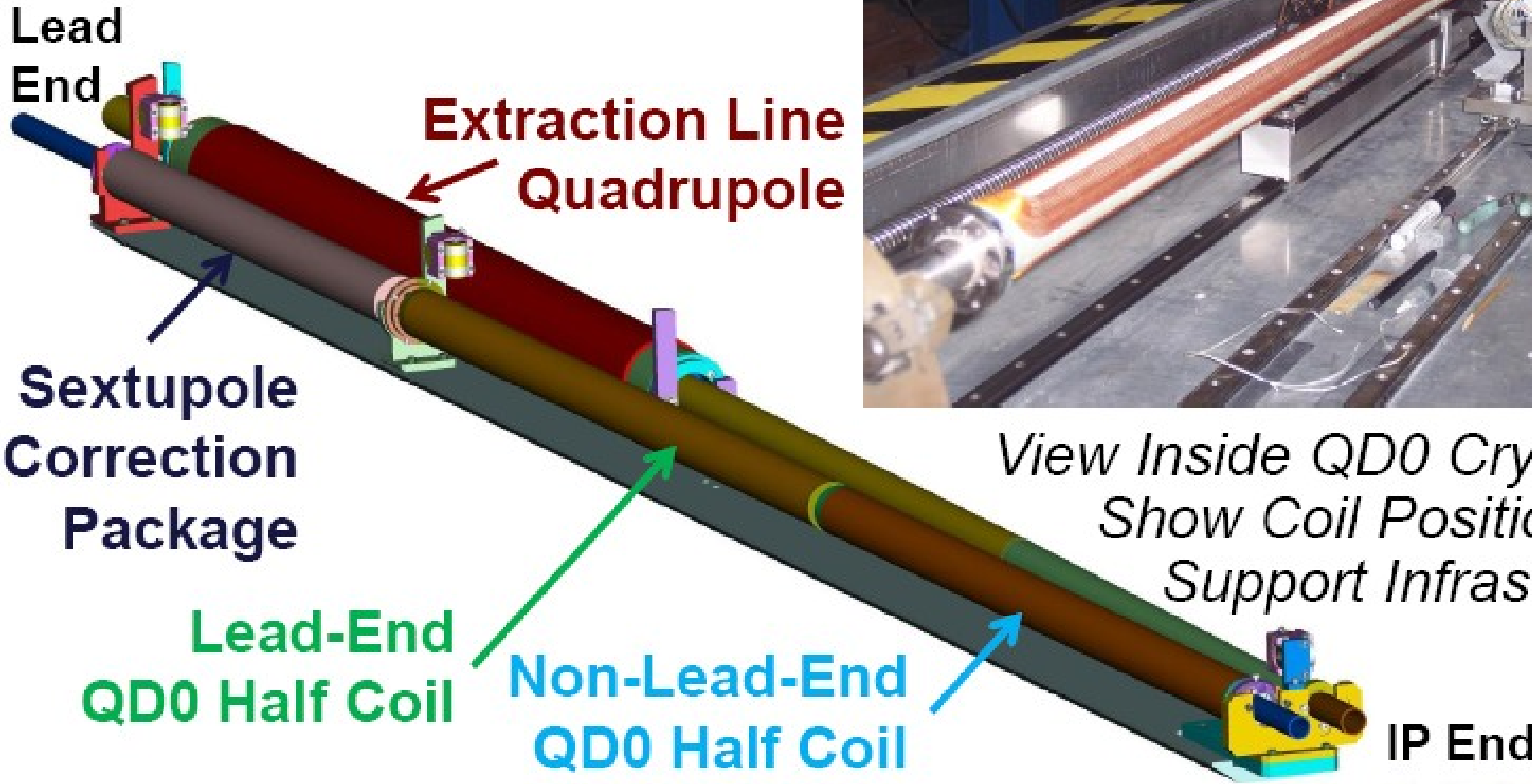
Thursday, October 1, 2009

- The travelling focus can be created in two ways.
- The first way is to have small uncompensated chromaticity and coherent E-z energy shift $\delta E/\delta z$ along the bunch. One has to satisfy $\delta E\ k\ L^{*}_{eff} = \sigma_z$ where k is the relative uncompensated chromaticity. The δE needs to be 2-3 times the incoherent spread in the bunch. Thus, the following set may be used: δE=0.3%, k=1.5%, L^{*}_{eff} =6m.
- It is clear that additional energy spread affect the physics. Therefore, second method is considered:

- The second way to create a travelling focus is to use a transverse deflecting cavity giving a z-x correlation in one of the FF sextupoles and thus a z-correlated focusing
- The cavity would be located about 100m upstream of the final doublet, at the $\pi/2$ betatron phase from the FD
- The needed strength of the travelling focus cavity can be compared to the strength of the normal crab cavity (which is located just upstream of the FD):
  - **$U_{trav.cav.}/U_{crab.cav.} = \eta_{FD} R_{12}^{cc}/ (L^{*}_{eff}\, \theta_c\, R_{12}^{trav})$.**
  - **Here η_{FD} is dispersion in the FD, θ_c full crossing angle, R_{12}^{trav} and R_{12}^{cc} are transfer matrix elements from travelling focus transverse cavity to FD, and from the crab cavity to IP correspondingly.**
- For typical parameters η_{FD} =0.15m, θ_c =14mrad. R_{12}^{cc} =10m, R_{12}^{trav} =100m, L^{*}_{eff} =6m one can conclude that the needed strength of the travelling focus transverse cavity is about 20% of the nominal crab cavity.

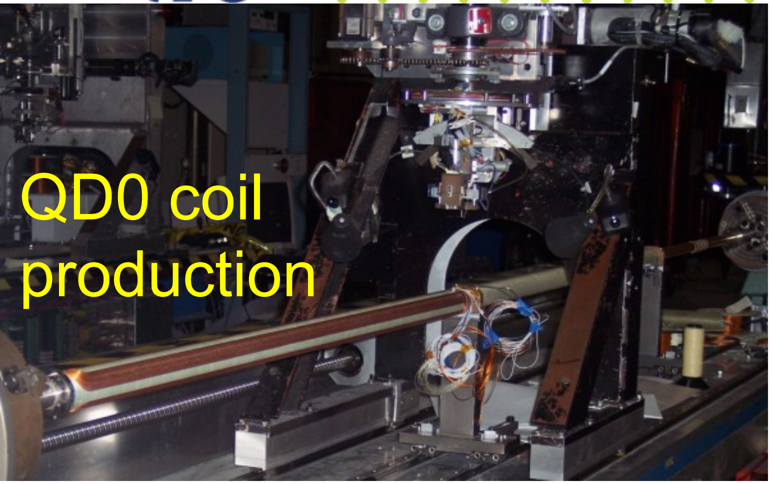
QD0 Split Coil Winding Implementation

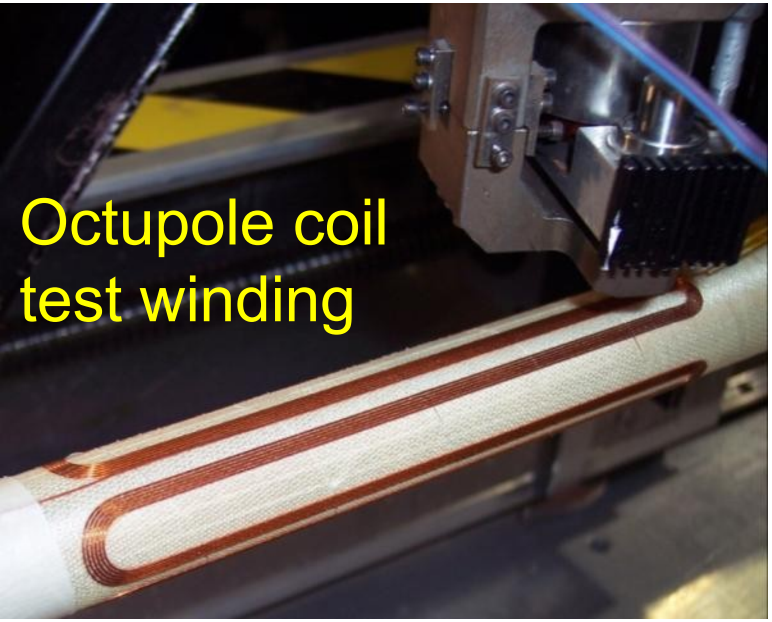
QD0 split coil variant may be useful for low-energy running as a Universal Final Focus.



View Inside QD0 Cryostat to Show Coil Positions and Support Infrastructure

QD0 R&D Prototype Coil Winding Status



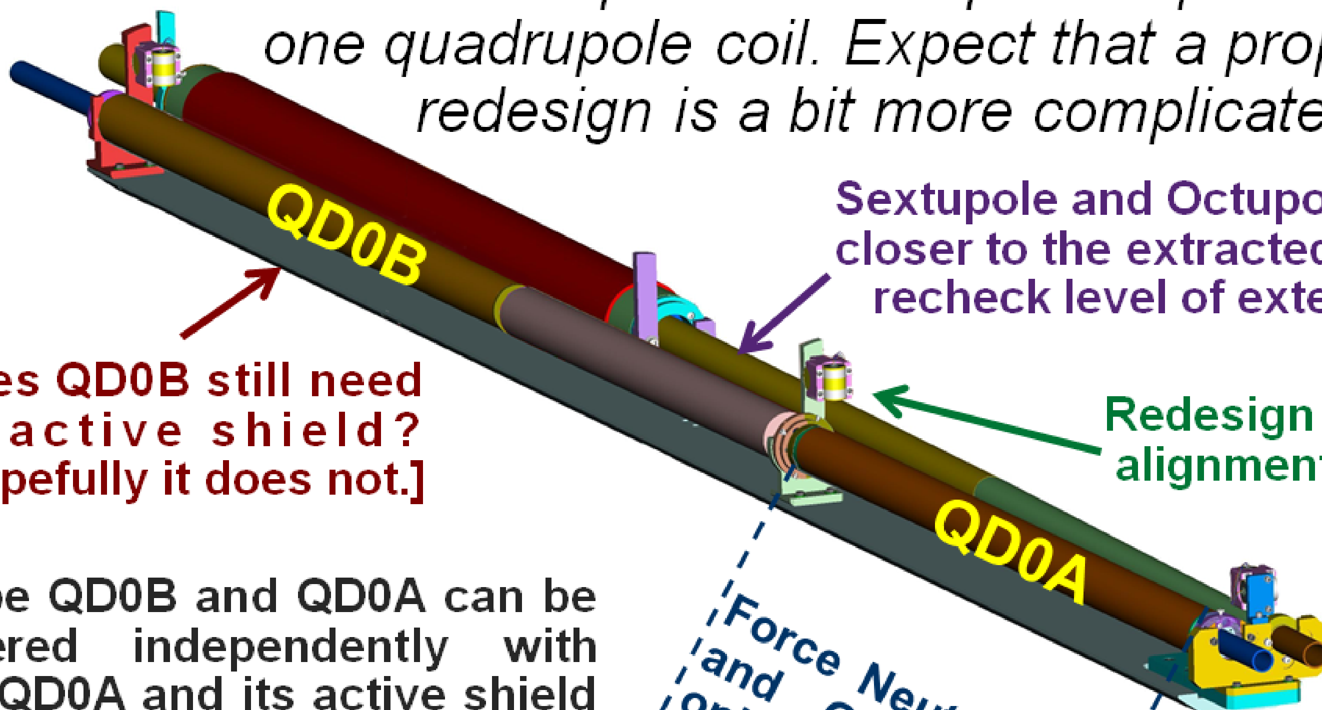


- To control coil support tube position during winding, we split QD0 coil in order to have a fixed support.
- Coil winding of all the quadrupole layers is complete and the measured harmonic agree with expectations.
- Vertical cold test has been done; tested to 10% above operating current without quenching; forced quenches with spot heater, saw no degradation.
- Have started winding octupole coil correction windings; next we will start winding the main sextupole coil sets.

"Report to ATF2 Technical Board,"
Brett Parker, BNL-SMD

Universal Final Focus (Cartoon) Issues

Here I took the CAD layout from slide #7 and did cut/paste to swap sextupole and one quadrupole coil. Expect that a proper redesign is a bit more complicated.



Sextupole and Octupole coils are now closer to the extracted beam; so must recheck level of external B-field.

Redesign support & alignment scheme.

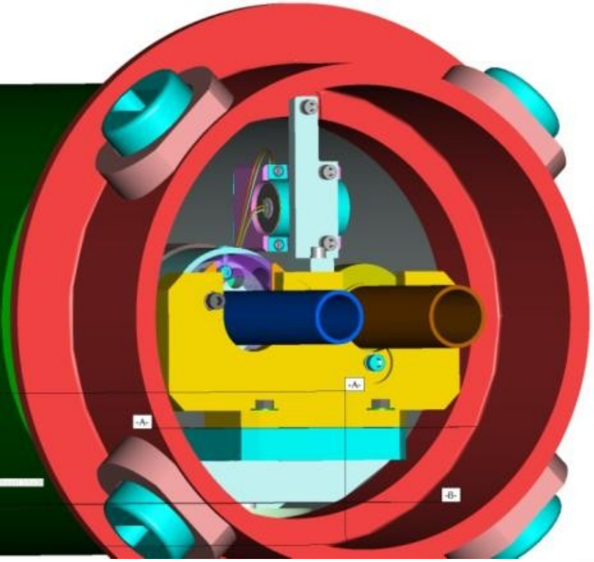
Does QD0B still need an active shield? [Hopefully it does not.]

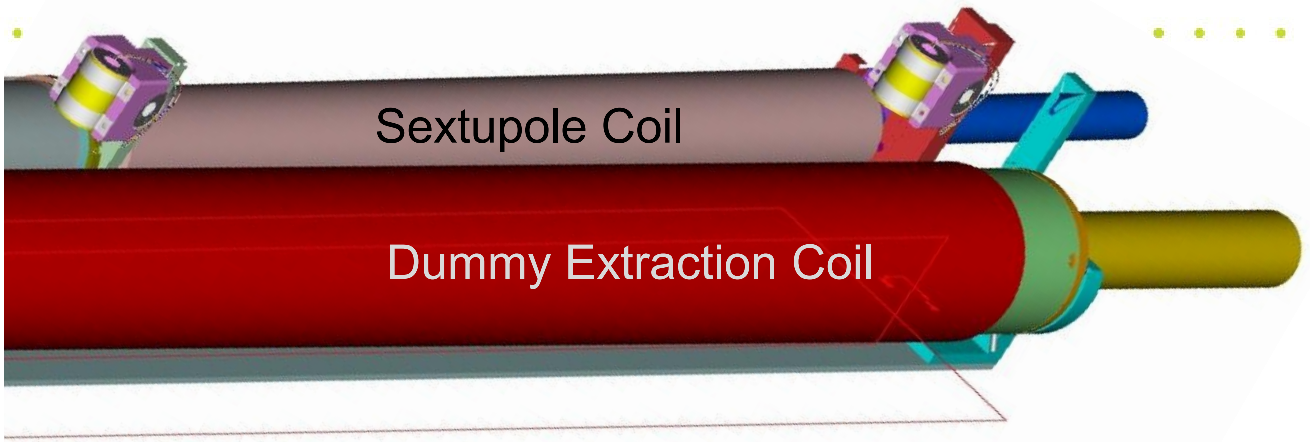
Force Neutral Anti-Solenoid and QD0A Active Shield only need to extend over this region?

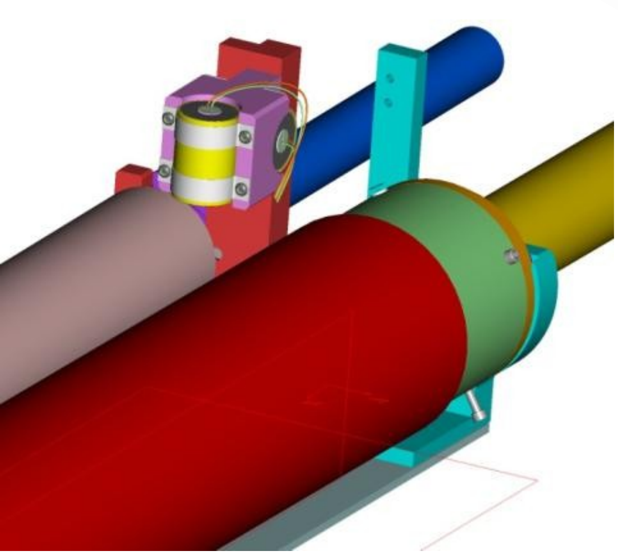
Maybe QD0B and QD0A can be powered independently with only QD0A and its active shield run in series?

Do QD0A and QD0B have to have the same coil structure and magnetic length?

Geophone Locations Inside QD0 Cold Mass





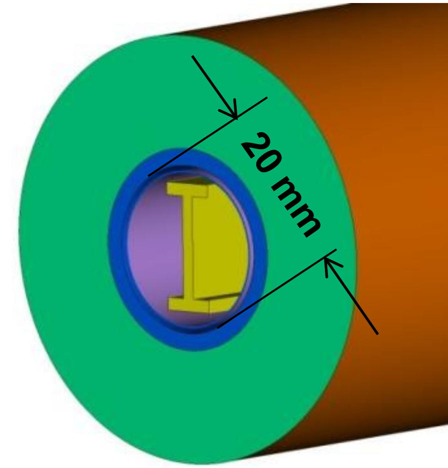


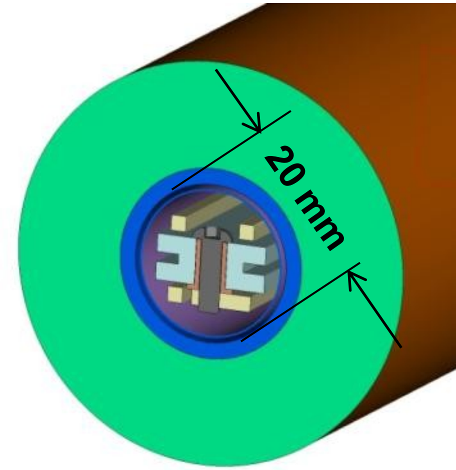
- Building upon RHIC IR quad experience, we look to put geophones inside the QD0 R&D prototype cold mass.
- Two mounting points at the coil support attachment points are under consideration.
- Only make measurements with coils off!
- Work underway to determine if fringe fields from coils might still damage sensors.

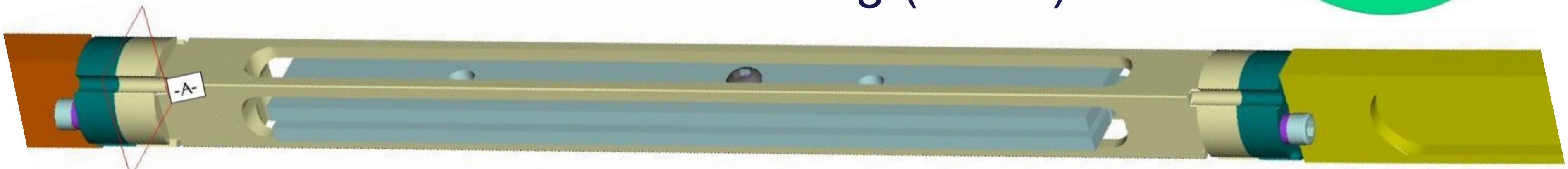
"Report to ATF2 Technical Board,"
Brett Parker, BNL-SMD

QD0 Field Stability Direct Measurement

- Develop thin walled, warm finger design with test coil stabilized independent of QD0 structure.
- Multi-turn probe coil would be mounted in fixture that could be rotated 90º to measure changes in either the horizontal or vertical field.
- It is critical to carefully adjust coil centering so as to minimize sensitivity to power supply ripple.
- Do this adjustment via deliberate AC current excitation of the magnet coils.
- Need to determine if “I-Beams” on either side of coil holder have to be non-conducting (or SS).







“Report to ATF2 Technical Board,”
Brett Parker, BNL-SMD

Beam parameters

Dou Wang (IHEP), Jie Gao (IHEP), K. Kubo (KEK)

	Nominal RDR	SB2009	RDR Low charge	New low charge
E_{cm} (GeV)	500	500	500	500
Ne	2×10^{10}	2×10^{10}	1.0×10^{10}	1.0×10^{10}
F_{rep} (Hz)	5	5	5	5
N_b	2625	1320	5640	2625
P_b (MW)	10.5	5.3	11.3	5.37
β_x (mm)	20	11	12	8
β_y (μm)	400	200	200	166
$\gamma\varepsilon_x$ (μm)	10	10	10	10
$\gamma\varepsilon_y$ (nm)	40	36	30	10
σ_x (nm)	639	474	495	404
σ_y (nm)	5.7	3.8	3.5	2.0
σ_z (μm)	300	300	150	166
δ_B	0.031	0.056	0.026	0.0241
n_γ	1.3	1.74	0.832	1.01
Dy	19.0	38.4	10.0	24.0
H_D	1.74	1.63?	1.56	1.6
θ (rad)	0.00036	0.00048	0.00023	0.00029
N_{had}	1.1	3.6	0.21	0.66
Trav. focus	No	Yes	No	Yes
L_0 ($cm^{-2}s^{-1}$)	2.0×10^{34}	1.9×10^{34}	2.0×10^{34}	2.0×10^{34}

New low charge (GP):

L=1.75E34 w/o TF,

L=2.0E34 with TF

Wang-Gao-Kubo parameters

- The luminosity gets to 2E34 with travelling focus
- Some of the nasty beam-beam effects and sensitivities are eased
- The additional issues with this set is stronger focusing and tighter collimation depth and large wakes effect of the beam
- The need of 2 stage bunch compressor
- Cannot comment on cost saving
- Worth to have a look at this alternative set

Conclusion

- The RDR (2007) focused on nominal energy
- Parameter set that maintains the physics reach and optimizes the cost/performance has been developed – SB2009
- Future studies
  - **Detailed design of the universal final doublet**
  - **Optimization of collimation depth**
  - **Study of FF tuning with needed beta***
  - **Detailed beam-beam studies**
  - **Damping ring design**
  - **…**