Lattice Status

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for the SuperB Lattice Team

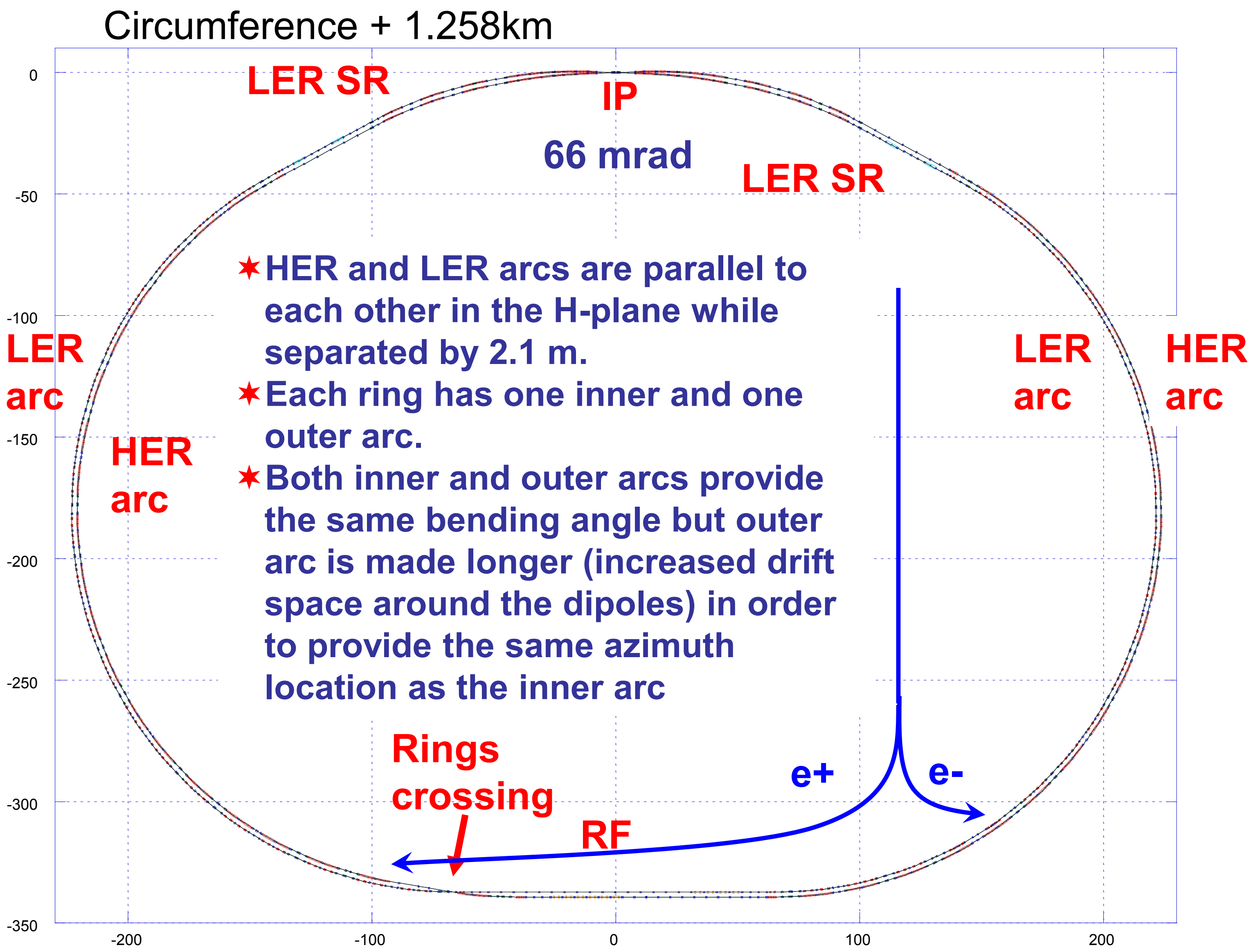
Major recent updates by P. Raimondi and S. Sinyatkin

SuperB Project Workshop
SLAC, October 6-9, 2009

Major Changes (compared to TorVergata)

- Shorter 1.3 km ring to fit the LNF site.
- Fewer arc cells, no arc straight (but may be included if needed).
- Doglegs with 140 mrad crossing on opposite side of IP.
- Beam energies 6.7 x 4.18 GeV.
- Higher momentum compaction factor 15-30%.
- Lower SR power loss 12-40%.
- Lower RF plug power ~12 MW.
- Spin rotator in LER.
- Closed and separated rings with the same circumference, 2 m radial separation, 60 mrad crossing at IP, and 140 mrad crossing at the doglegs.

Layout & geometry (Biagini)



- HER and LER arcs are parallel to each other in the H-plane while separated by 2.1 m.
- Each ring has one inner and one outer arc.
- Both inner and outer arcs provide the same bending angle but outer arc is made longer (increased drift space around the dipoles) in order to provide the same azimuth location as the inner arc

Latest Lattice Parameters

Parameter	Lattice V8	
	HER	LER
Energy, GeV	6.7	4.18
Circumference, m	1323.03	1323.03
Number of particles, $*10^{10}$	5.74	5.74
Horizontal tune	45.54	45.54
Vertical tune	20.57	20.57
Emittance, nm*rad	2.1*	2.2
Coupling, %	0.25	0.25
Energy spread, rms	6.15E-04	6.57E-04
Momentum compaction	4.06E-04	4.23E-04
Bunch length, mm	5.0	5.0
Damping time x / s, msec	29 / 14	44 / 22
Beta_X_IP, cm	2	2
Beta_Y_IP, cm	0.02	0.02
IBS transv./long. , Aibs/Ao	1.06 /1.03	1.24 / 1.12
Touschek lifetime, min	23	9

* Horizontal emittance needs to be reduced.

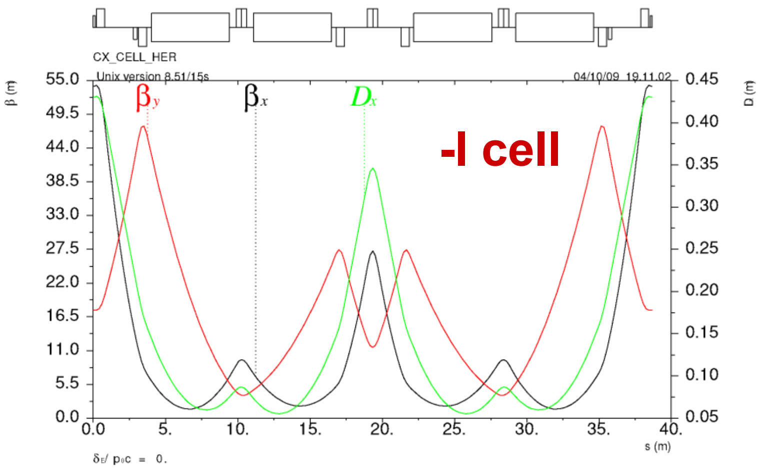
Lattice Systems

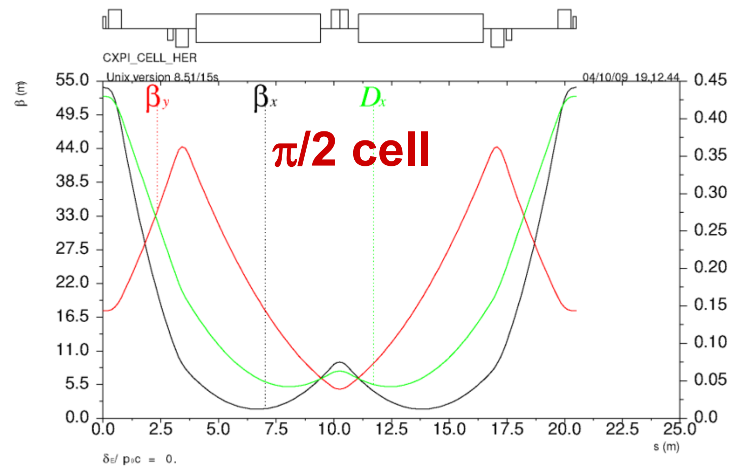
- **Two Arcs**
  - Provide the necessary bending to close the ring.
  - Optimized to generate the design horizontal emittance.
  - Correct arc chromaticity and sextupole aberrations.
- **Interaction Region**
  - Provides the necessary focusing for required small beam size at IP.
  - Corrects FF chromaticity and sextupole aberrations.
  - Provides the necessary optics conditions for Crab cavities.
- **LER Spin Rotator**
  - Includes solenoids in matched sections adjacent to the IR.
- **RF system**
  - Up to 24 HER and 12 LER cavities in the long straight section opposite to IP.

Arc Cells

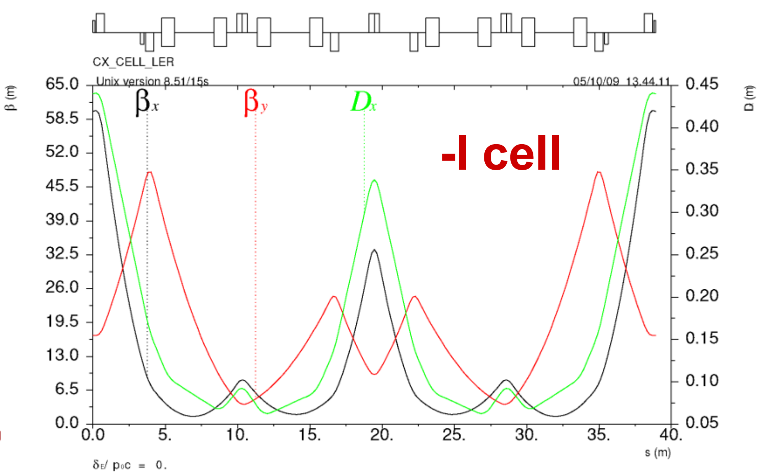
- Main cell types: -I cell with $\mu/2\pi$ = 1.5/0.5, and $\pi/2$ cell with $\mu/2\pi \cong$ 0.75/0.25.
- Two variations of each type: longer and shorter for outer and inner arcs.
- Optimized for low emittance and maximum momentum compaction.

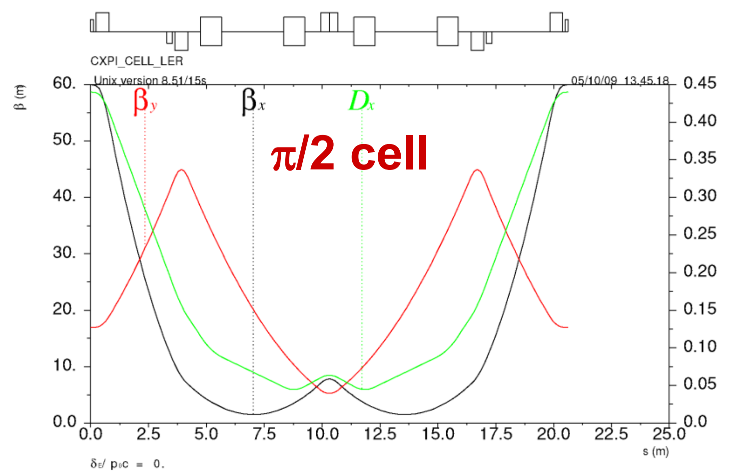
HER





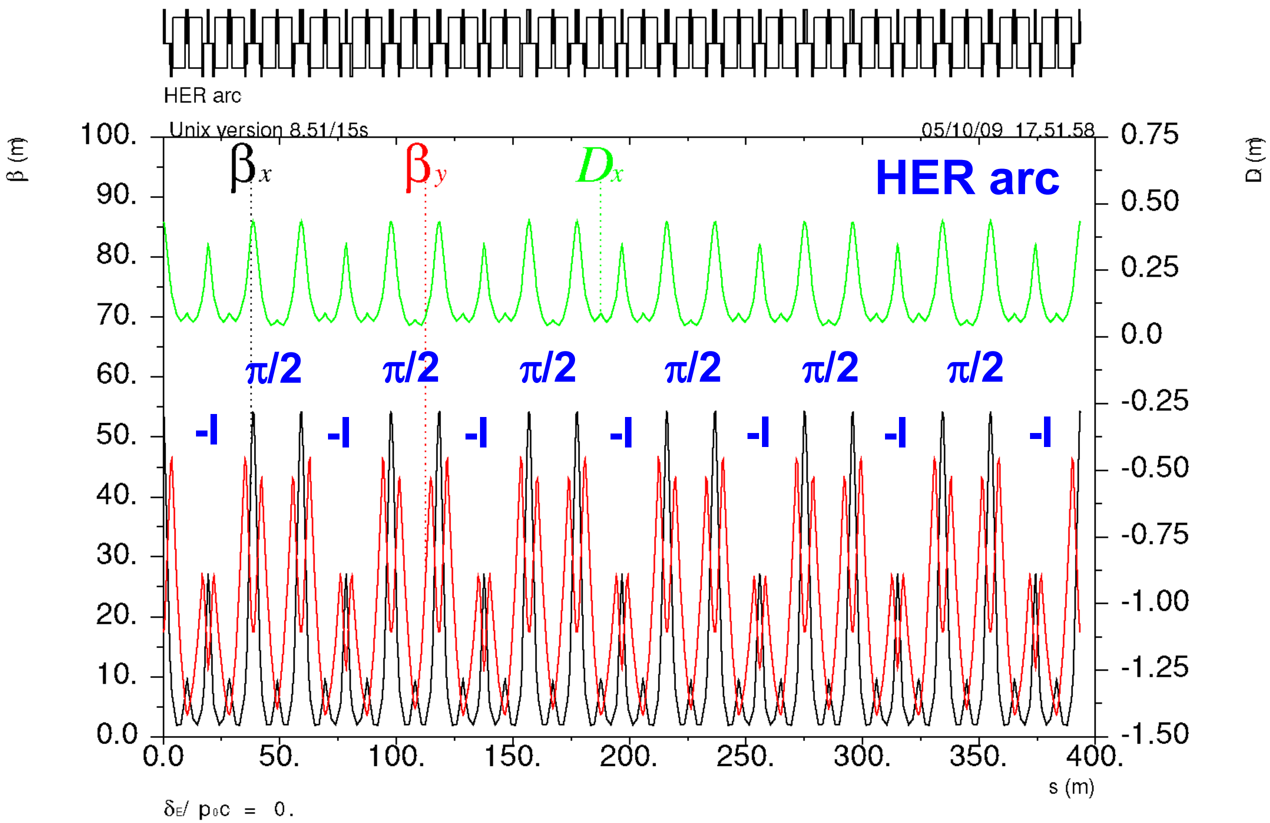
LER





Arcs

- Each arc contains seven –I cells and six π/2 cells.
- -I sextupole pairs for local compensation of sextupole geometric aberrations.
- ~π/2 phase between sextupole pairs for local chromatic beta compensation.
- One shorter and one longer arc for 2 m separation between HER and LER.
- Optimized for large arc transverse acceptance: >100 beam sigma.
- Designed to reuse the PEP-II magnets.



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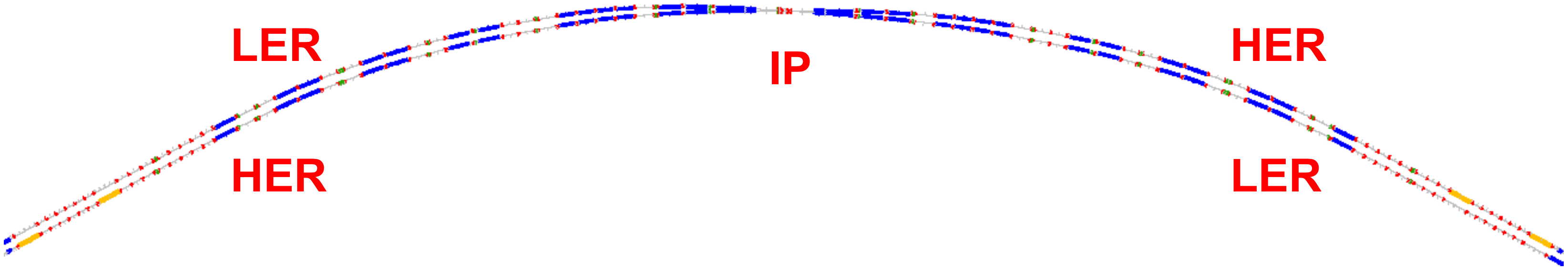
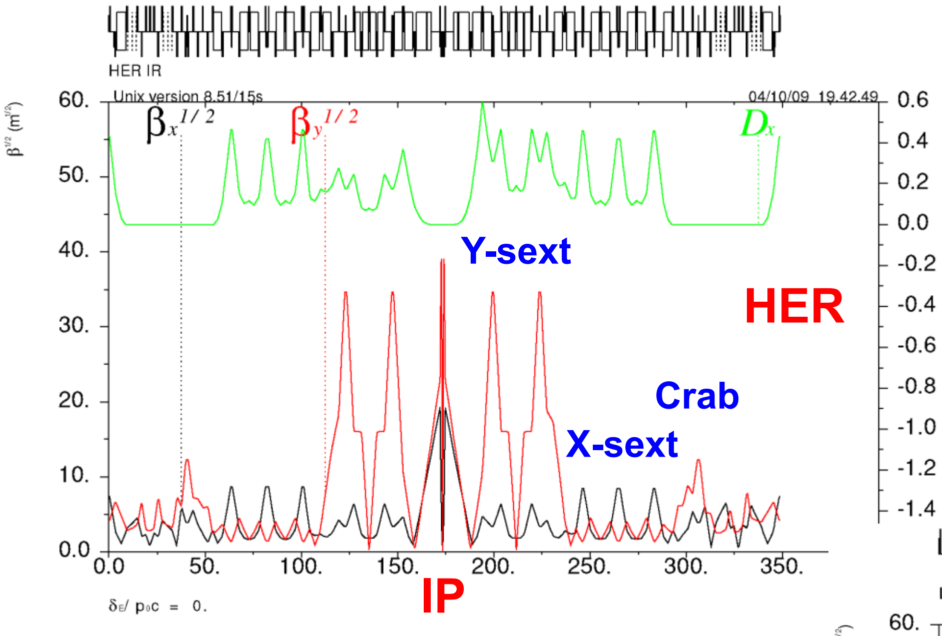
IR Geometry

• IR geometry is adjusted to provide 60 mrad IP crossing and 2 m separation in the arcs.
• IR bending in HER is made ±60 mrad asymmetric with respect to IP.
• IR bending in LER is kept symmetric for better match with spin rotators.
• Distribution of IR bending angles is optimized in order to provide 2 m separation in the arcs.
• The IR length in LER and HER are made equal.
• Total IR bending angle in LER is 2 x 0.4963 rad = 0.9926 rad.
• Total IR bending angle in HER is slightly different =0.9939 rad which helped to better match the circumference. This was possible because HER does not have spin rotator.
• Asymmetry of IR bending angles result in 7% emittance increase in HER.

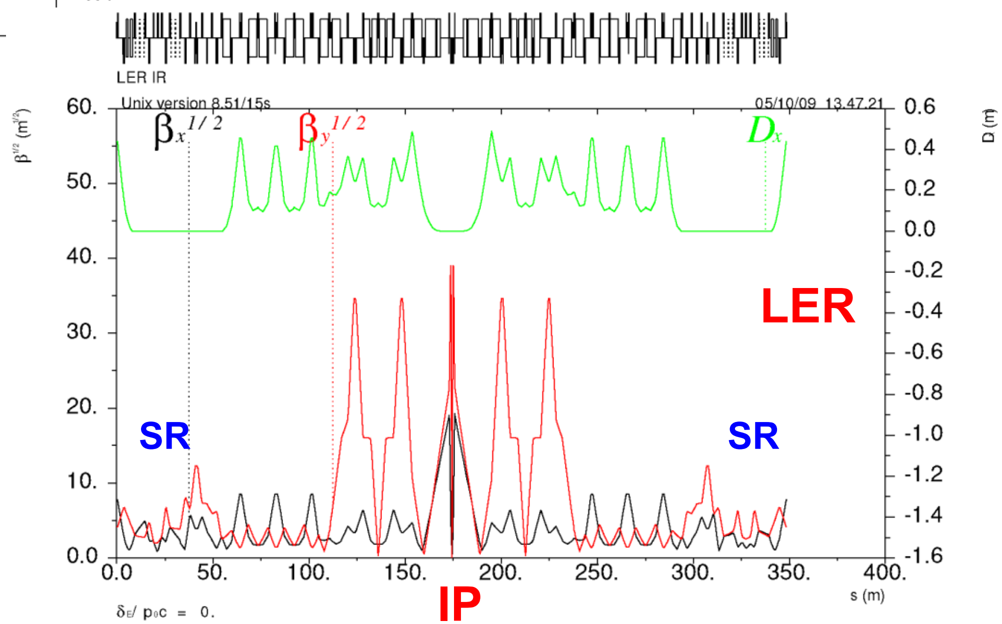


IR Optics



IR quadrupoles are rematched, but more optimization of chromatic correction is needed.

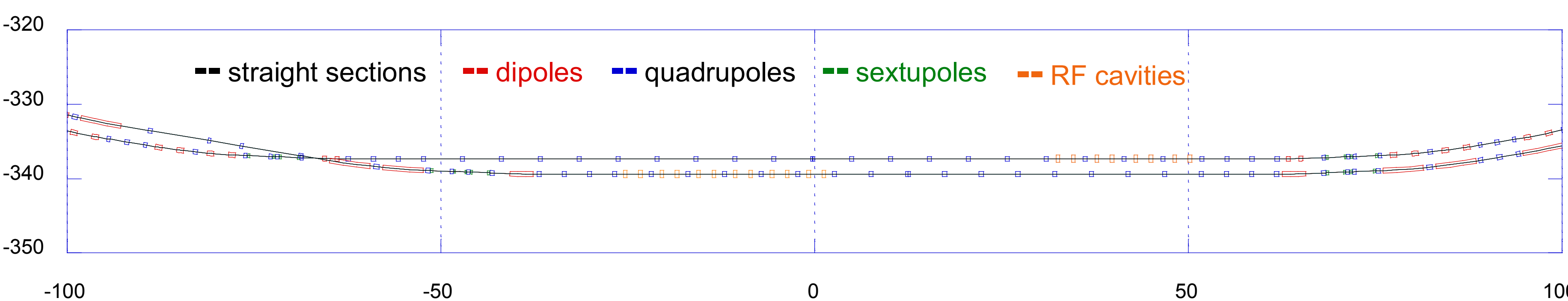
LER Spin Rotators need to be updated.



Additional IR correcting sextupoles are proposed for better dynamic aperture, but not yet included.

"Parasitic" crossing (Raimondi)

* Doglegs have been removed and the secondary crossing ("parasitic) is made by lengthening the first 3π cell in HER by about 25 meters
* This makes the two beam lines cross with and angle of about 165mrad (was about 150 with the dogleg) and there should be no interference between the two beam lines (some readjustment still needed for LER → in progress)
* This longer HER cell is suitable for the injection
* Lot of space remaining for utilities (RF, feedbacks, wigglers,...)



Impact of Spin Rotator on LER Optics
(P. Raimondi)

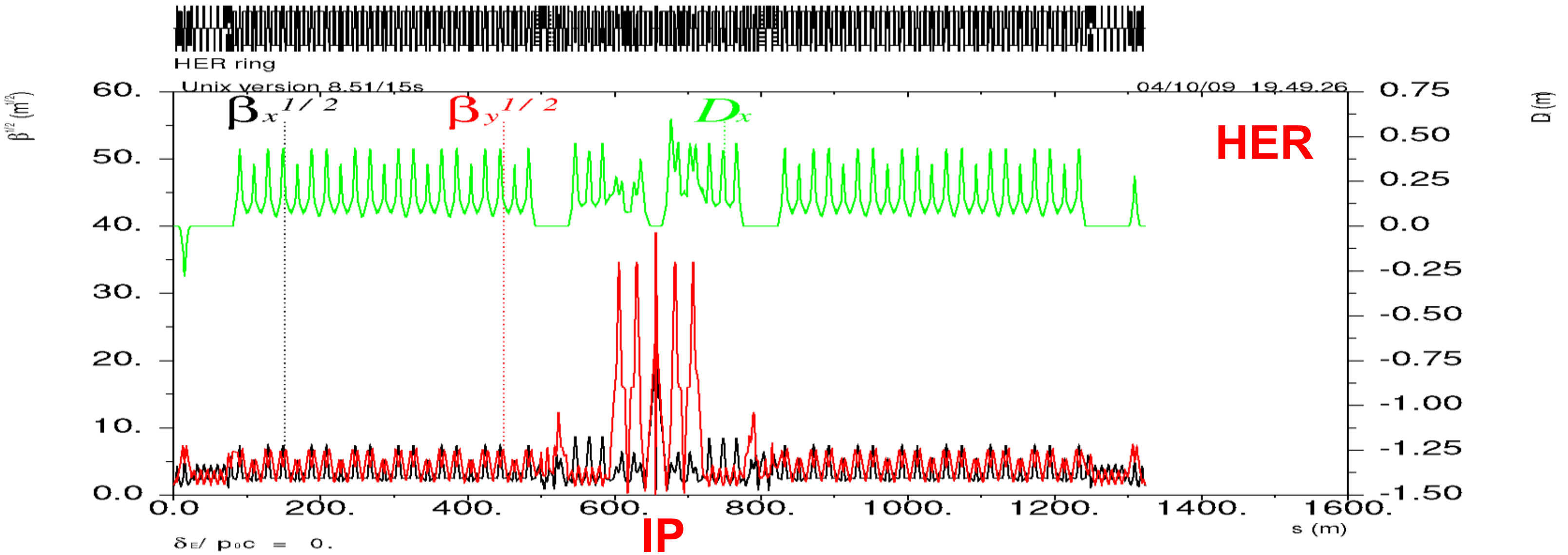
Two solenoid Spin Rotator sections are included in LER IR because their impact on optical properties in LER is much smaller than in HER.

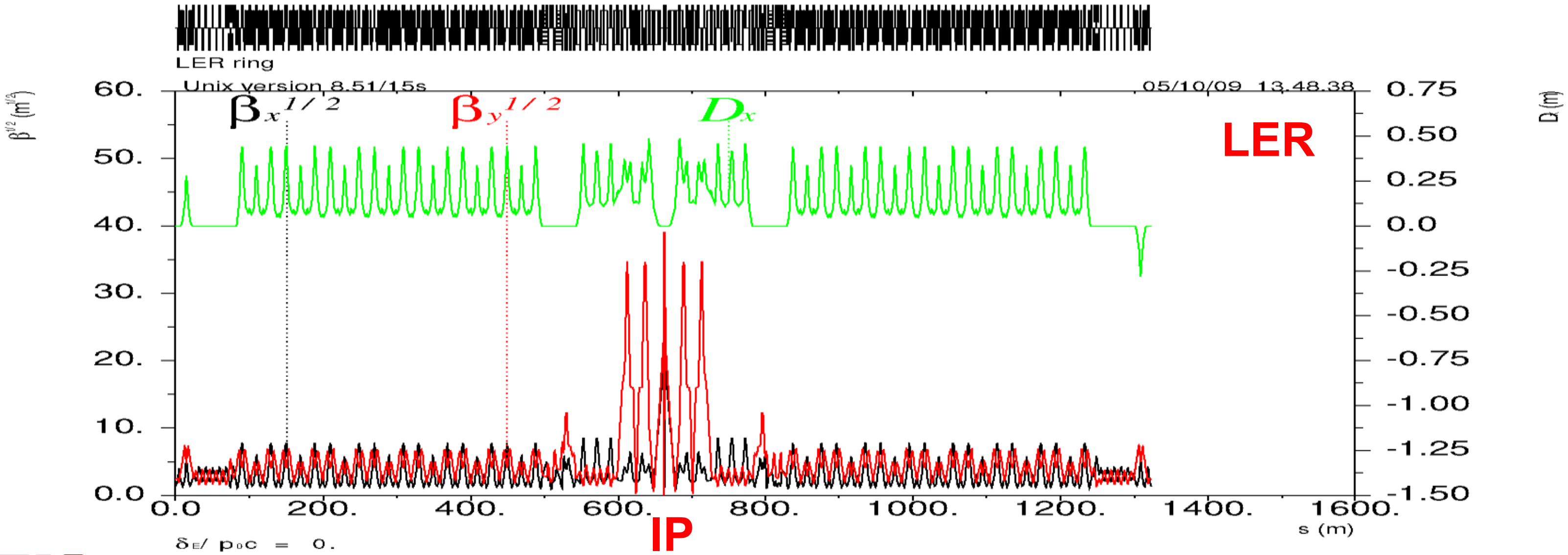
The main consequences for LER:

• FF adjustment for providing the necessary optics conditions for the Crab Waist is more difficult.
• FF bandwidth is reduced by 20% and the minimal achievable vertical beta is 20% higher.
• Energy acceptance is reduced by 20% and the Touschek lifetime is 40% shorter.
• Circumference is ~20% longer compared to the SuperB without SR.
• Polarization lifetime is ~20 min (compared to >2 hrs for the HER).
• HER to LER energy asymmetry is reduced to 1.603.

⇒ See details of the new Spin Rotator design in the report by W. Wittmer.

Complete SuperB Optics





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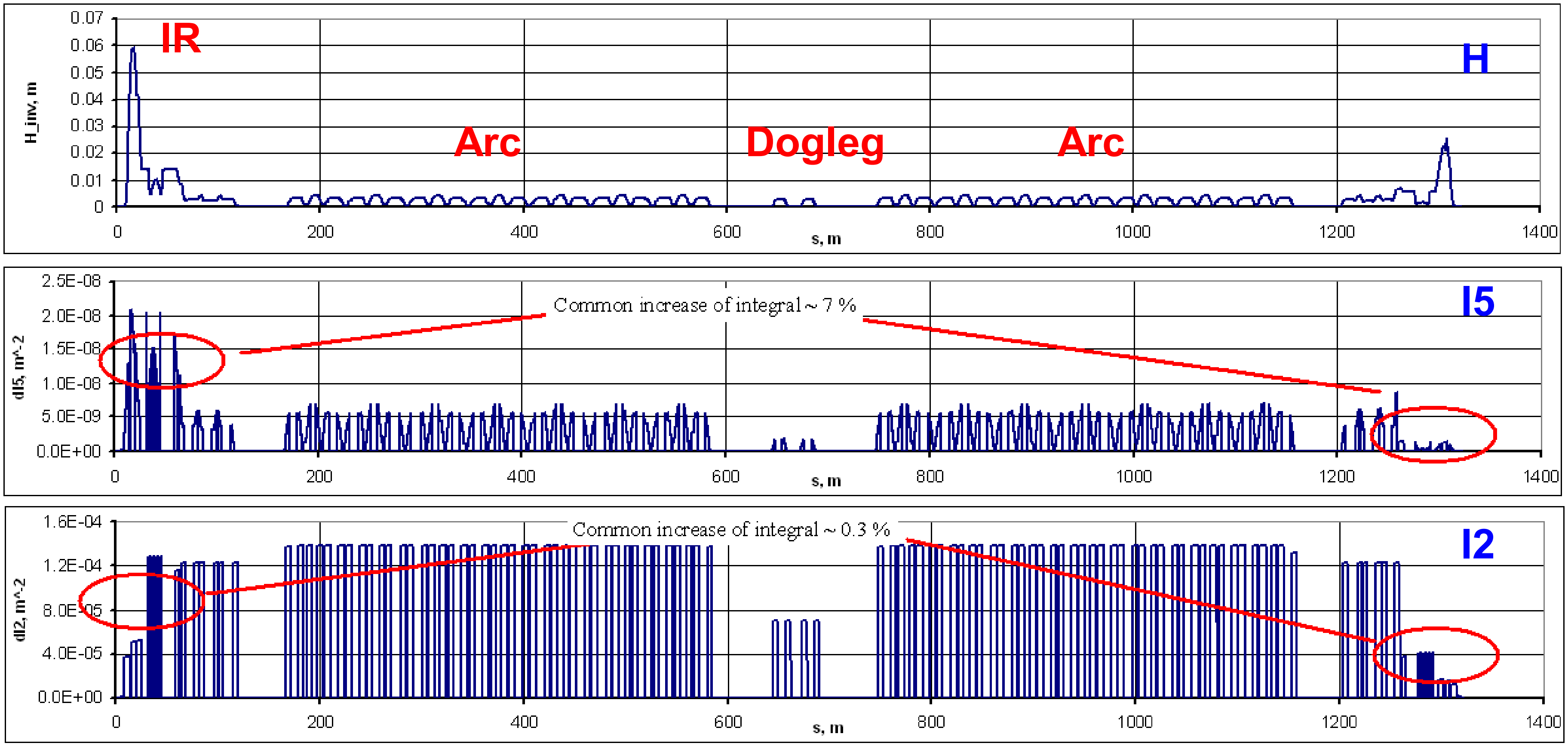
Contributions to emittance in HER

H-invariant and radiation integrals I2, I5 vs. azimuth



The asymmetry of bending angles in HER IR creates ~7% of additional emittance.

Further Optimization and Studies

- IR optimization including beta match and sextupole correction.
- Reduction of HER emittance.
- Realistic placement of RF cavities in the dogleg straight.
- Optics for injection system.
- Minimization of quadrupole strengths where needed.

Alternative option studies:

- Fewer cells in LER for higher momentum compaction as a function of emittance and IBS.
- Asymmetric IR bending in both LER and HER for a lower ±30 mrad angle asymmetry, lower impact on FF properties and easier geometry match.

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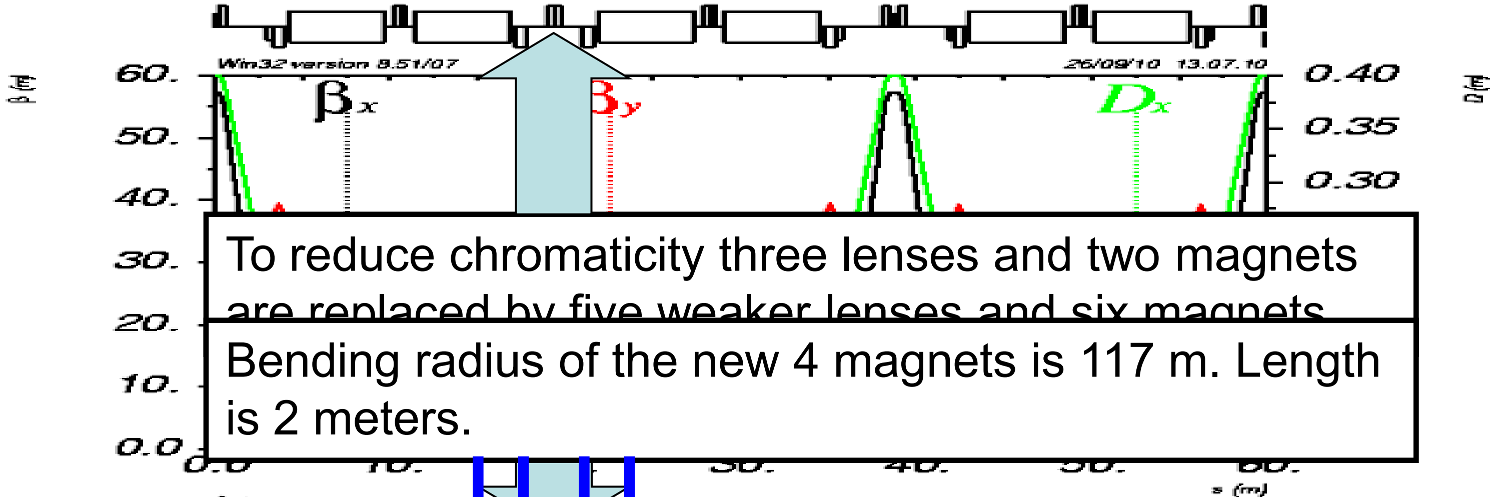
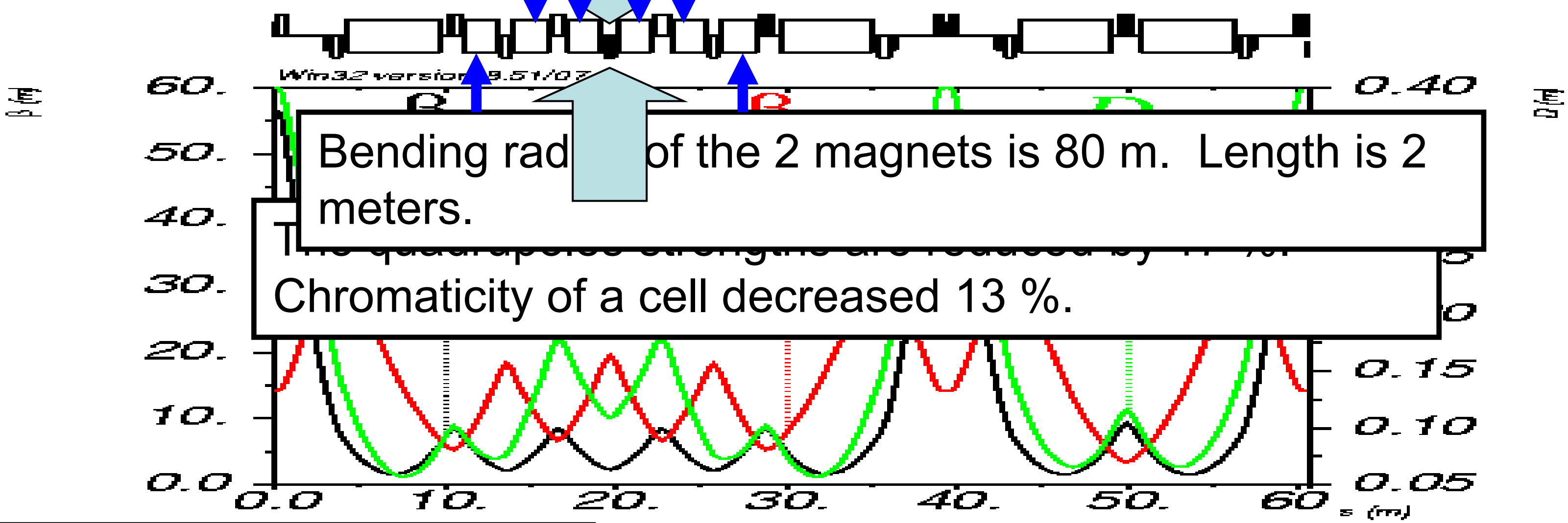
Twiss functions of arc cell

HER old 12 version



To reduce chromaticity three lenses and two magnets are replaced by five weaker lenses and six magnets

Bending radius of the new 4 magnets is 117 m. Length is 2 meters.

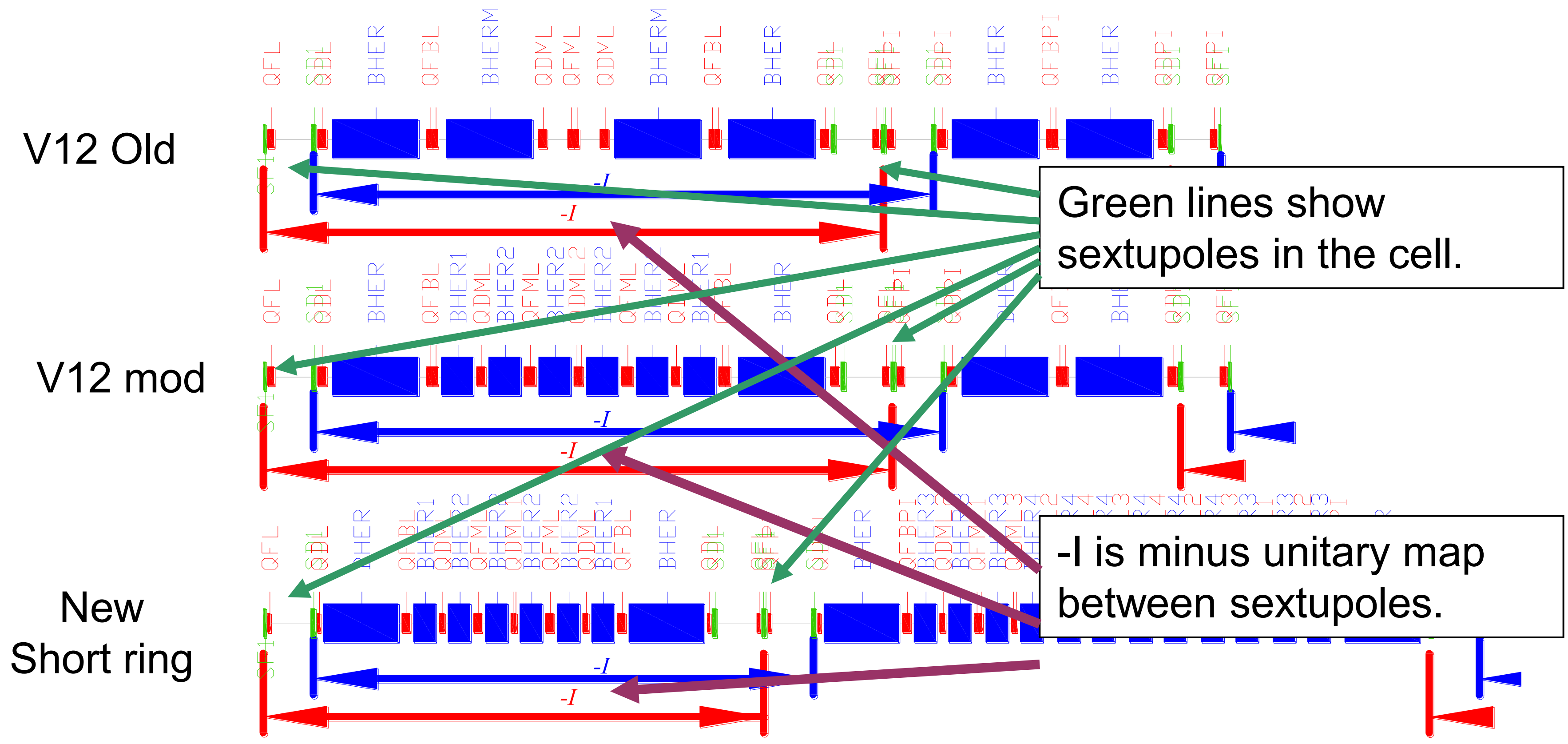


Bending rad of the 2 magnets is 80 m. Length is 2 meters.

Chromaticity of a cell decreased 13 %.

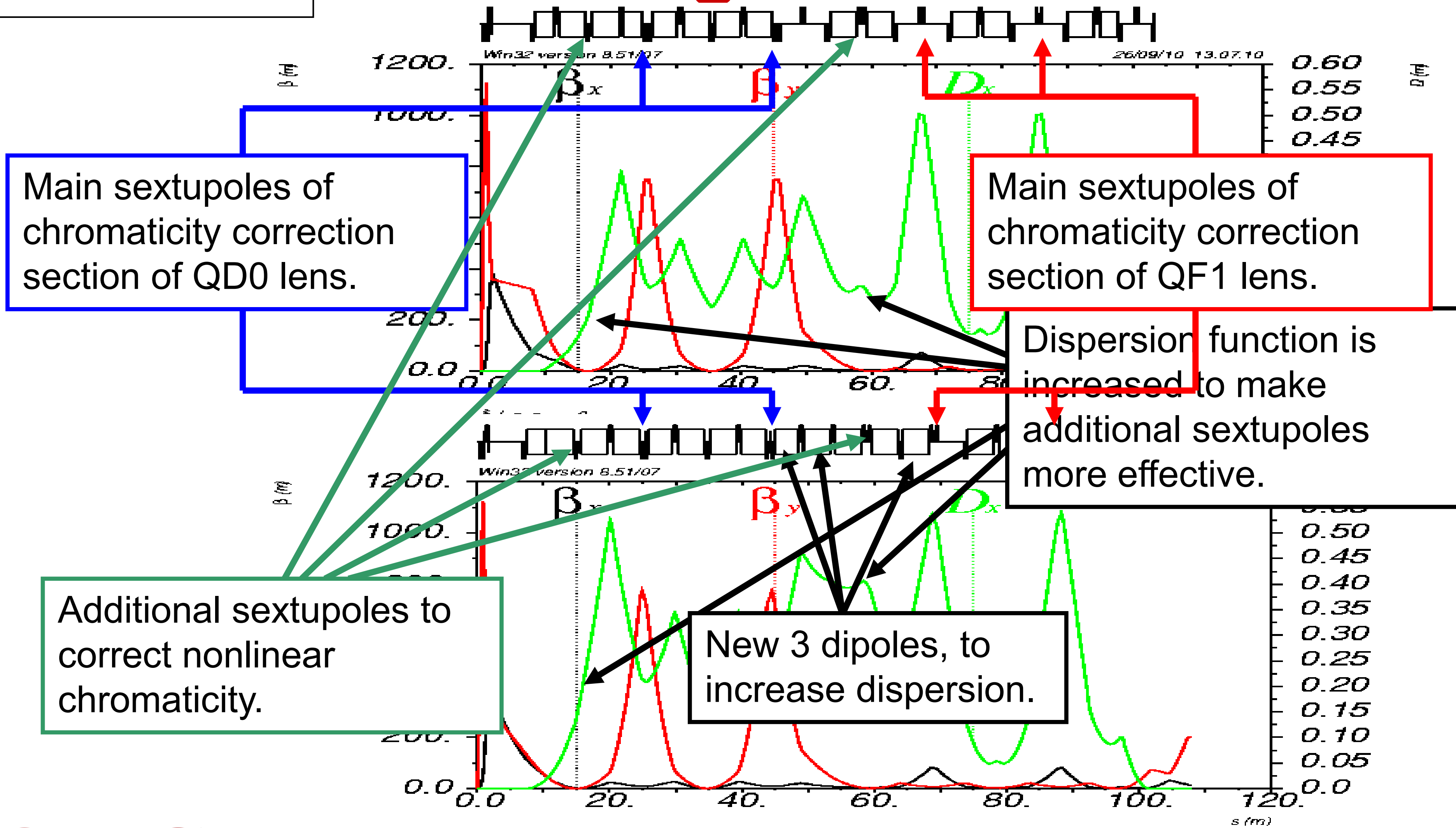
HER modified 12 version

Scheme of sextupole compensation



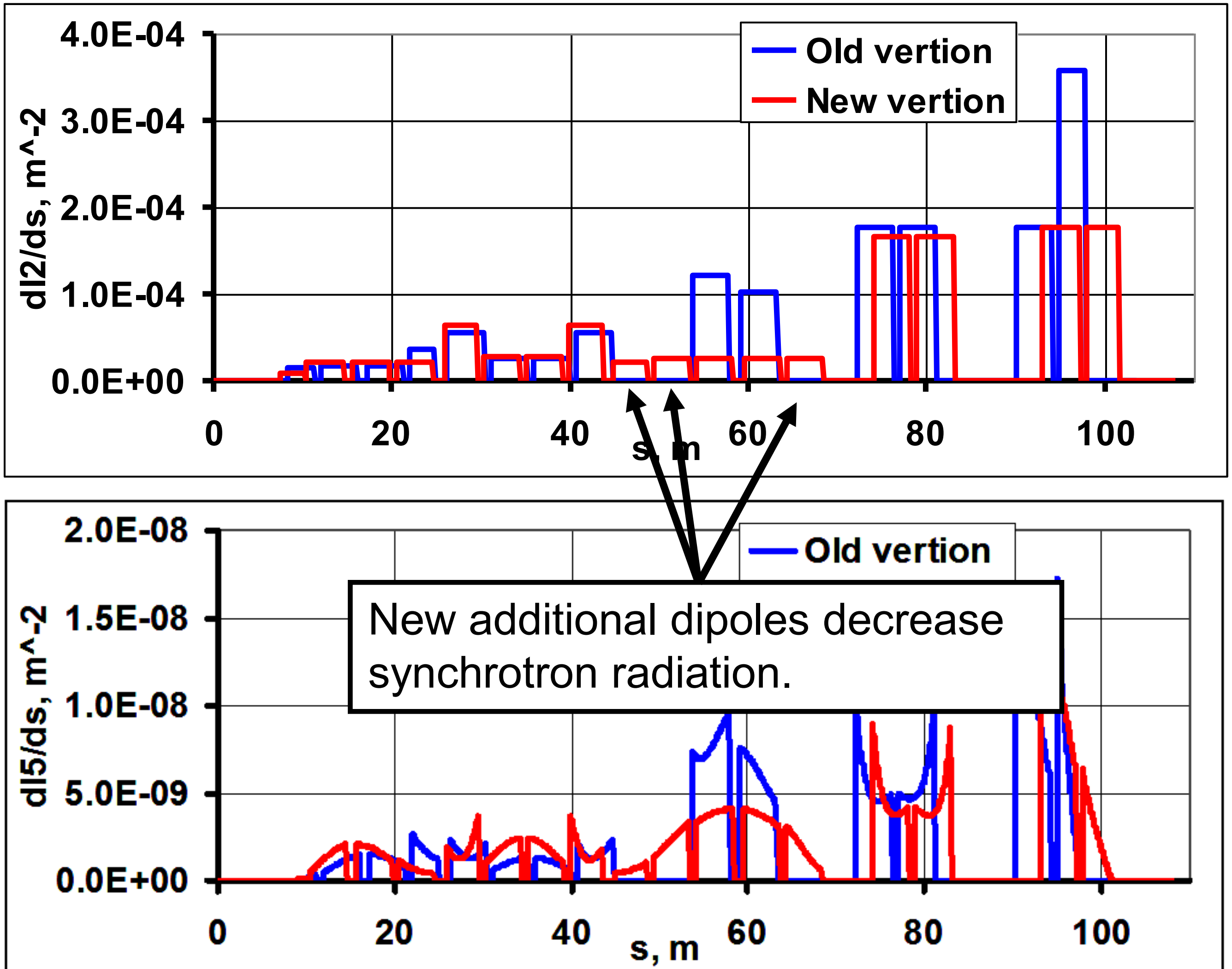
Twiss functions of experimental region

HER old version



HER new version

Synchrotron radiation integrals of experimental region



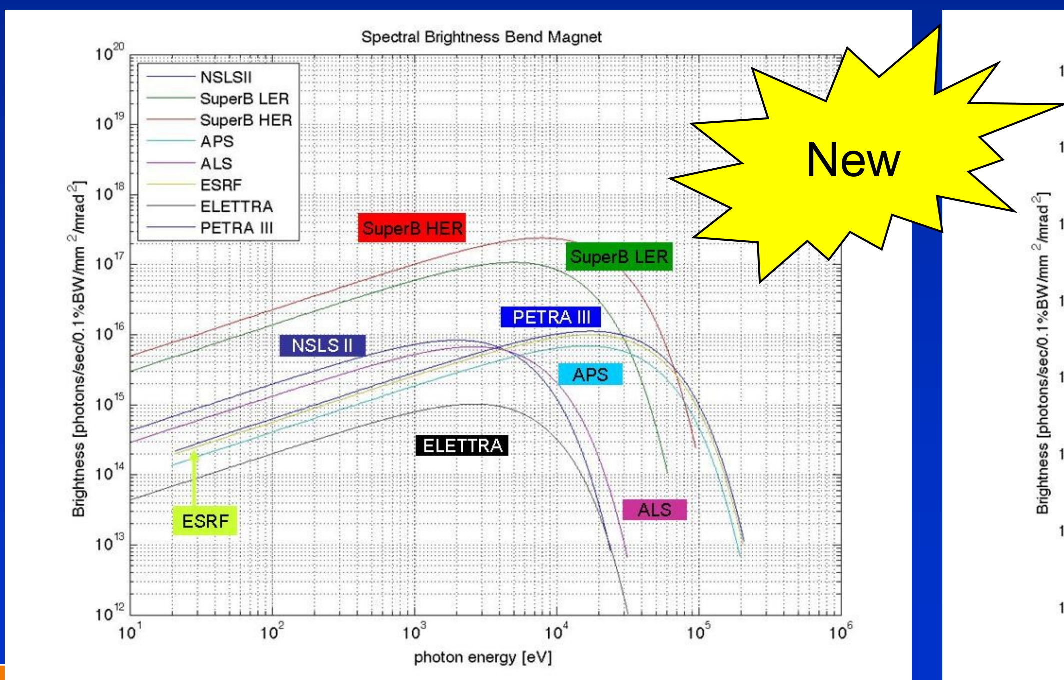
Further Developments

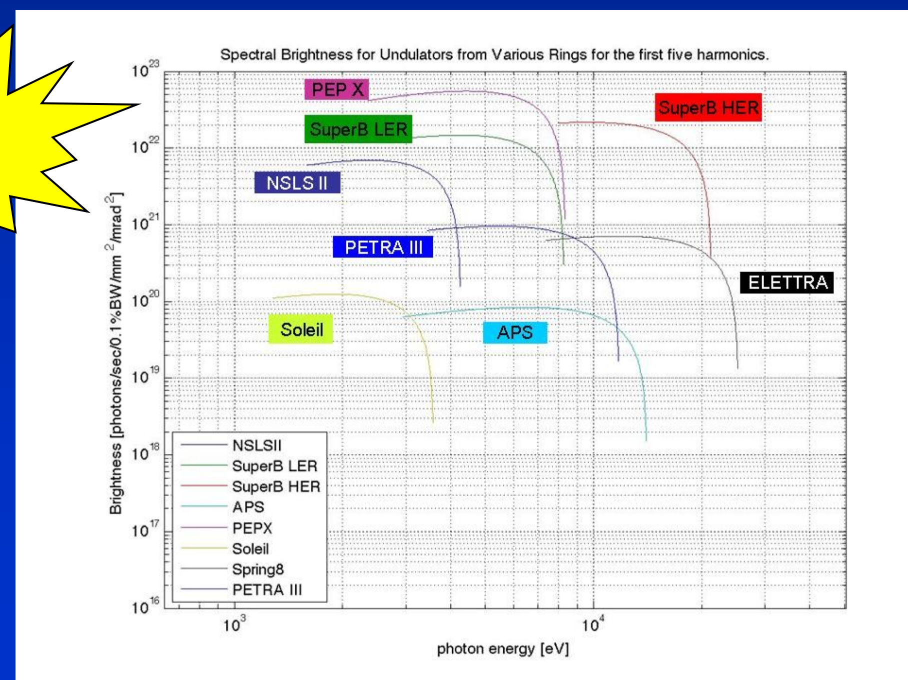
* IIT will need to install 3 undulators for SL and have the possibility to run at least parasitically during the SuperB data taking.
* Ideally the infrastucture could become a very competitive SL source.
* We would like to make sure that the infrastucure will have the potential for installation and run of several SL's without major modification and added-costs.
* This compatibility shuold not harm the potential for the SuperB experiment
* At the moment the only use foreseen for the SuperB infrastructure after the completition of data-taking is as SL source

Synchrotron light properties @ SuperB

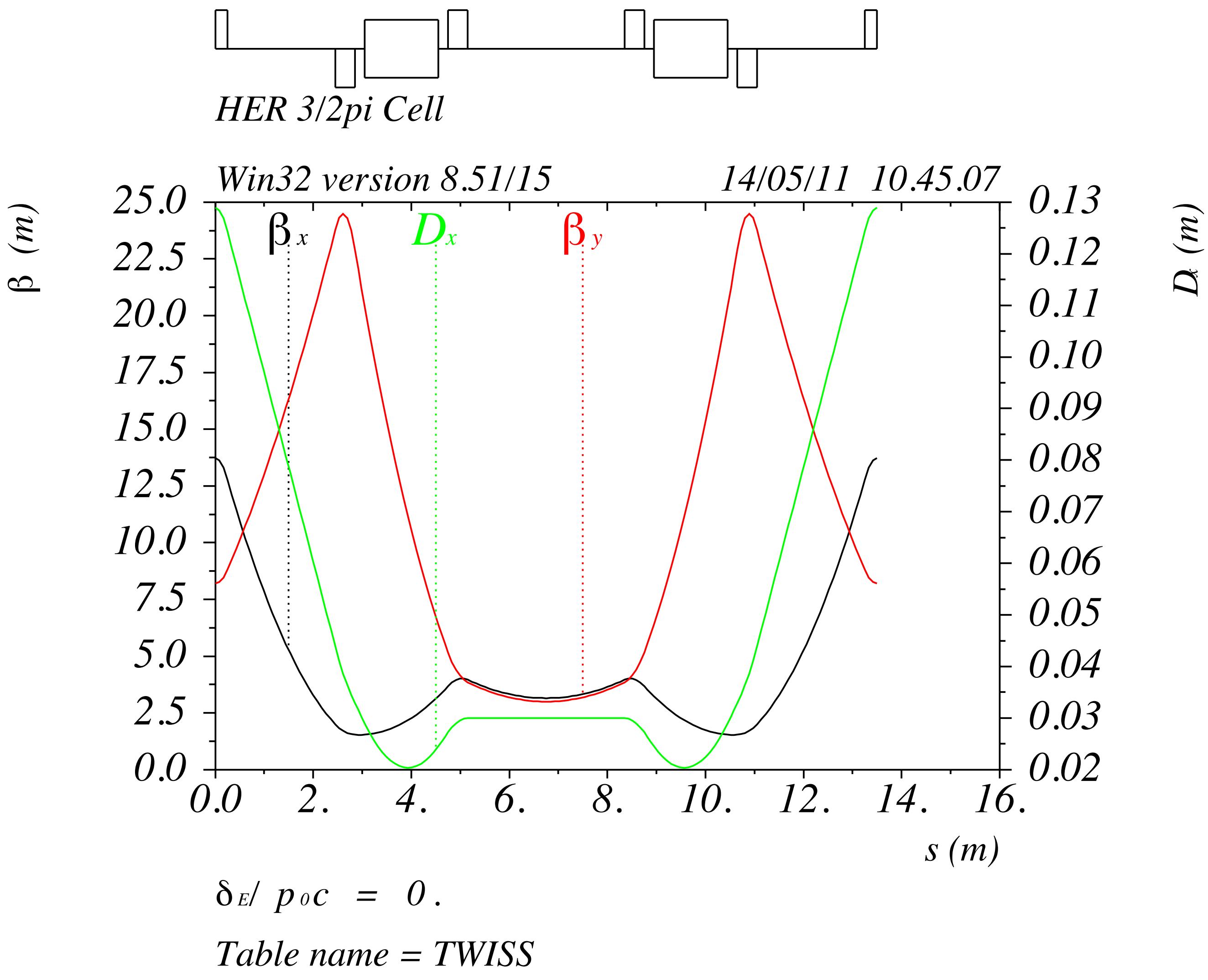
Wittmer

- Comparison of brightness and flux from bending magnets and undulators for different energies dedicated SL sources & SuperB HER and LER
- Synchrotron light properties from dipoles are competitive
- Assumed undulators characteristics as NSLS-II
- Light properties from undulators still better than most LS, slightly worst than PEP-X (last generation project)

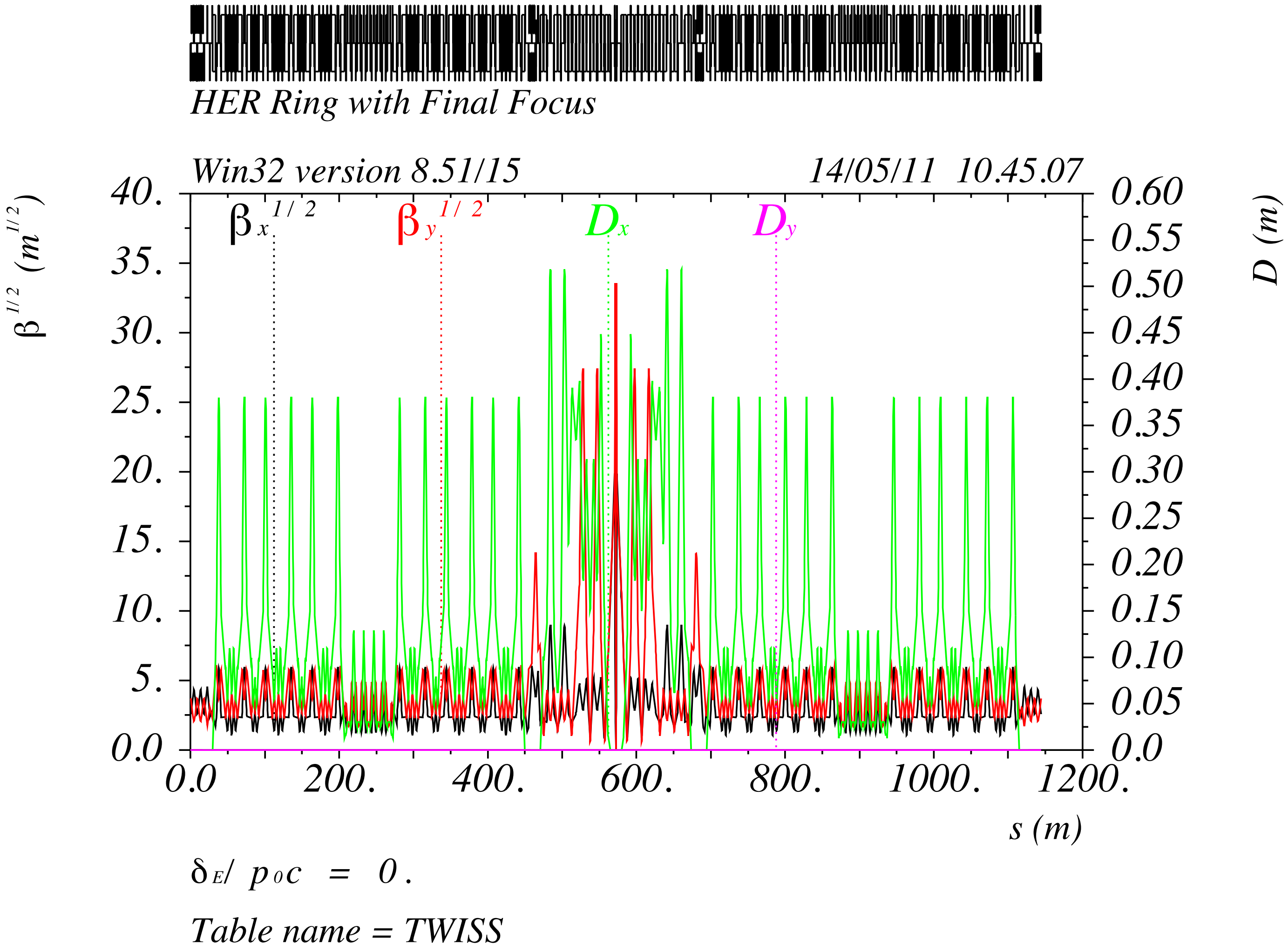




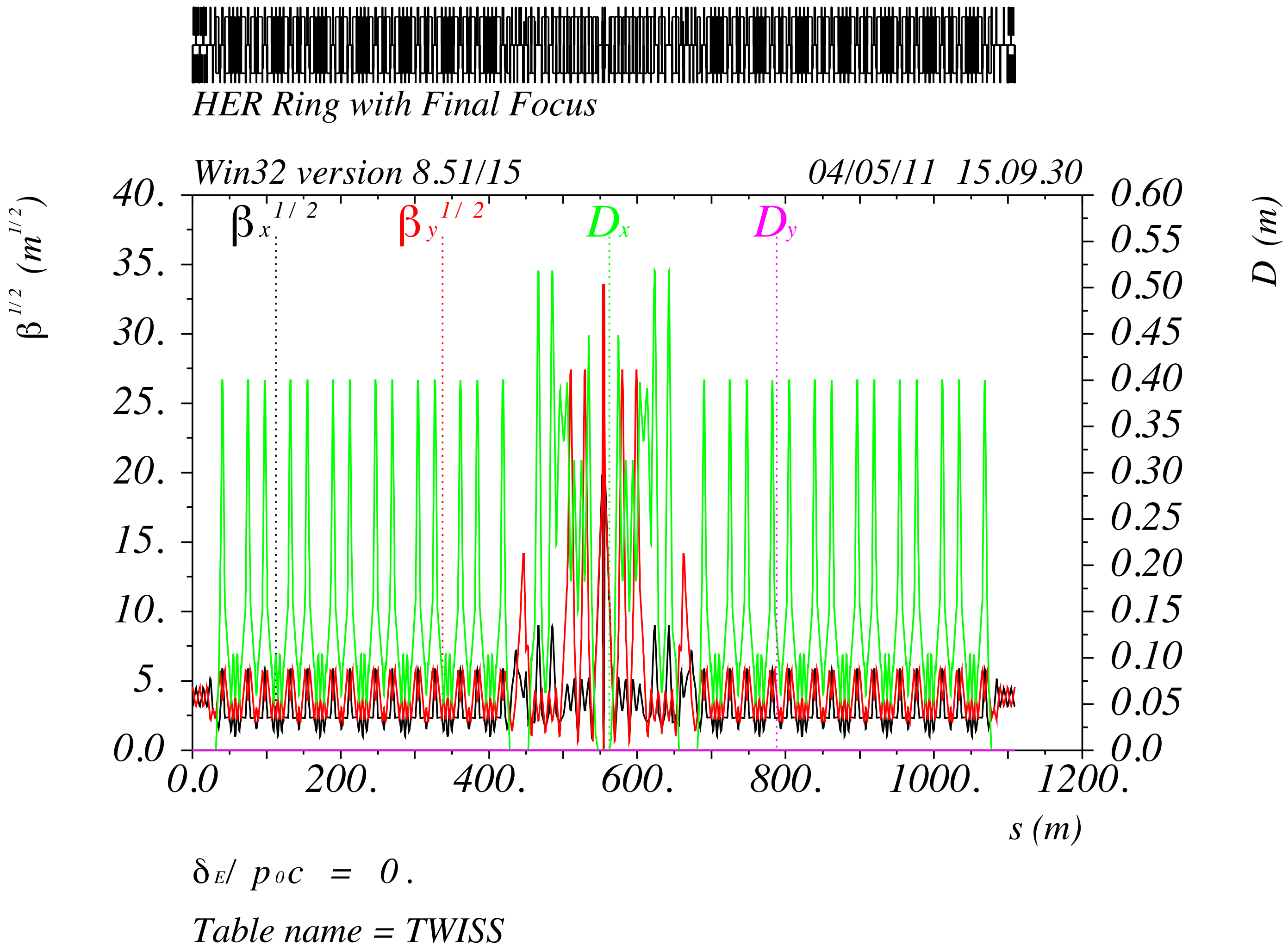
Possible Undulator Section for Syncrotron Light Users



Arcs Modified with 5*2 straights (concentrated in two sections) for undulators



Arcs Modified with 6*2 straights (distributed along the arcs) for undulators



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Conclusions

* Lattice design very much advanced
* Still some significative changes have to be added (SL straights)
* A lot of optimization still necessary and possible
* Needs to move to the TDR fast
* Needs to finalize it for starting construction:

  - infrastructure

  - components

SuperB parameter list (July 2009) (P. Raimondi)

Parameter	Units		TorVergata	LNF
			1-Mar-09	22-Jul-09
			with SR HER	with SR LER
E HER (positrons)	GeV		6.9	6.7
E LER (electrons)	GeV		4.06	4.18
Energy ratio			1.70	1.60
r0	cm		2.83E-13	2.83E-13
X-Angle (full)	mrad		60	60
Beta x HER	cm		2	2
Beta y HER	cm		0.037	0.032
Coupling (high current)			0.0025	0.0025
Emit x HER	nm		1.6	1.6
Emit y HER	nm		0.004	0.004
Bunch length HER	cm		0.5	0.5
Beta x LER	cm		3.5	3.2
Beta y LER	cm		0.021	0.02
Coupling (high current)	%		0.0025	0.0025
Emit x LER	nm		2.8	2.56
Emit y LER	nm		0.007	0.0064
Bunch length LER	cm		0.5	0.5
I HER	mA		2200	2120
I LER	mA		2200	2120
Circumference	m		2105	1315
N. Buckets distance			2	2
Gap			0.97	0.97
Frf	Hz		4.76E+08	4.76E+08
Fturn	Hz		**1.43E+05**	**2.28E+05**
Fcoll	Hz		**2.31E+08**	**2.31E+08**
Num Bunch			**1619**	**1011**
N HER			**5.96E+10**	**5.74E+10**
N LER			**5.96E+10**	**5.74E+10**
Sig x HER	microns		**5.657**	**5.657**
Sig y HER	microns		**0.038**	**0.036**
Sig x LER	microns		**9.899**	**9.051**
Sig y LER	microns		**0.038**	**0.036**

Piwinski angle HER	rad		**26.52**	**26.52**
Piwinski angle LER	rad		**15.15**	**16.57**
Sig x HER effective	microns		**150.15**	**150.15**
Sig x LER effective	microns		**150.37**	**150.32**
X-angle factor HER			**0.038**	**0.038**
X-angle factor LER			**0.066**	**0.060**
Cap Sig X	microns		**11.402**	**10.673**
Cap Sig Y	microns		**0.054**	**0.051**
R (hourglass factor)			0.900	0.900
Cap Sig X eff	microns		212.13	212.13
Lumi calc	/cm2/s		**1.02E+36**	**1.02E+36**
Tune shift x HER			**0.0018**	**0.0017**
Tune shift y HER			**0.1271**	**0.1170**
Tune shift x LER			**0.0052**	**0.0045**
Tune shift y LER			**0.1220**	**0.1170**
Damping_long HER	msec		21	14.5
Damping_long LER	msec		20.0	22.0
Uo HER	MeV		2.3	2.03
Uo LER	MeV		1.40	0.83
alfa_c HER			3.50E-04	4.04E-04
alfa_c LER			3.20E-04	4.24E-04
sigma-EHER			5.80E-04	6.15E-04
sigma-E LER			8.20E-04	6.57E-04
CM sigma_E			**5.02E-04**	**4.50E-04**
SR power loss HER	**MW**		**5.06**	**4.30**
SR power loss LER	**MW**		**3.08**	**1.76**
Touschek lifetime HER	min		33	35
Touschek lifetime LER	min		17	16
Luminosity lifetime HER	min		5.20	4.95
Luminosity lifetime LER	min		5.20	4.95
Total lifetime HER	**min**		**4.49**	**4.34**
Total lifetime LER	**min**		**3.98**	**3.78**
RF plug power	MW		**16.28**	**12.13**

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