SUPERB: NEXT-GENERATION e^+e^- B-FACTORY COLLIDER

Status and Latest Design Features

2011 Particle Accelerator Conference

Walter Wittmer

2011-03-29

SUPERB COLLABORATION TEAM

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APPROVED!!

The Italian Government Funds the Super-B Accelerator

Friday, 24 December 2010 10:02

The Ministry for Education, University and Research has decided to select the SuperB project conducted by the Italian National Institute of Nuclear Physics (INFN) as one of its "flagship projects" in Italy over the next few years and has delivered an initial funding for 2010 as a part of a multiannual funding program. Reconstructing the history of the Universe by researching the most infrequent events using high-precision technology. This is the INFN idea underlying the construction of SuperB, the particle accelerator based in Italy and with international involvement, which the Ministry for Education, University and Research has decided to sponsor and finance. A large interest has been expressed in many countries, meanwhile physicists from the United States, Germany, France, Russia, the United Kingdom, Israel, Canada, Norway, Spain, Poland are taking part to the design effort. The purpose of the project is to conduct top-level basic research, developing innovative

http://web.infn.it/superb/en/media-and-press-release

- 19M € committed for current fiscal year.
- Engineering Design Report.
- Construction plans.

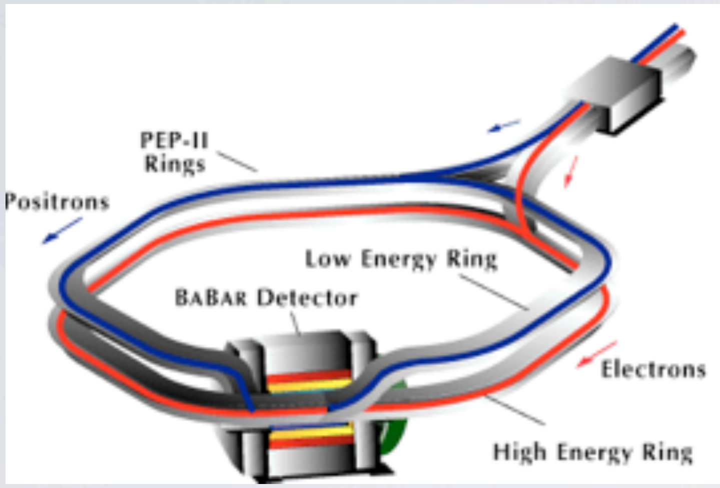
CONCEPTUAL DESIGN REPORT II IS PUBLISHED

2007: SuperB: A High-Luminosity Asymmetric e+ e- Super Flavor Factory. Conceptual Design Report http://arxiv.org/abs/0709.0451

2011: SuperB Progress Reports -- Accelerator

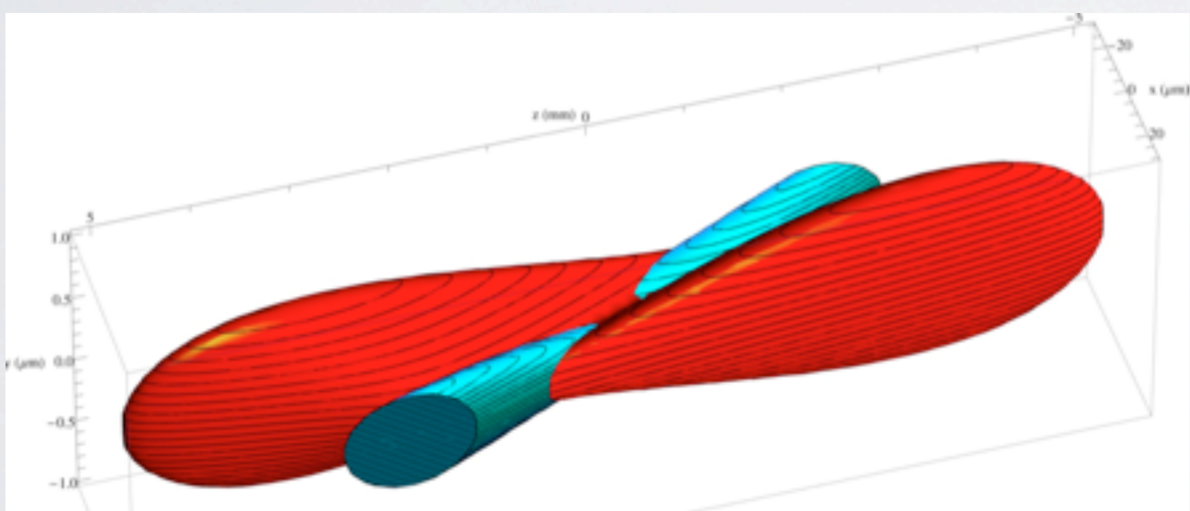
http://arxiv.org/abs/1009.6178v2

FROM B-FACTORY TO SUPERB



1.0E34 ➠ 1.0E36

SuperB



- Small beams
- Crab waist
- Crossing angle

DESIGN PARAMETERS

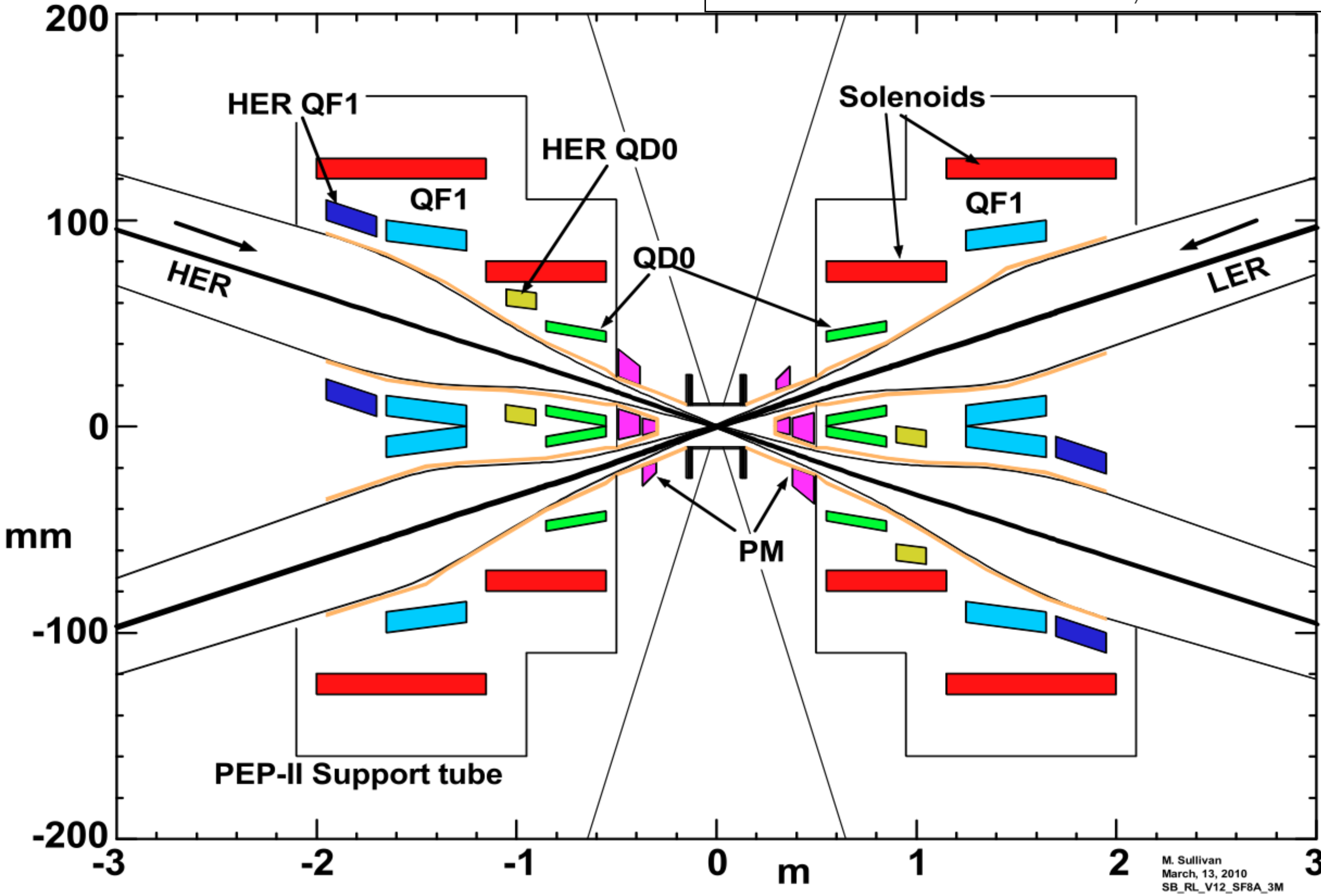
(Bold: computed values)		Base Line		Low Emittance		High Current		Tau/Charm (prelim.)	
Parameter	Units	HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)
LUMINOSITY	$cm^{-2} s^{-1}$	1.00E+36		1.00E+36		1.00E+36		1.00E+35	
Energy	GeV	6.7	4.18	6.7	4.18	6.7	4.18	2.58	1.61
Circumference	m	1258.4		1258.4		1258.4		1258.4	
X-Angle (full)	mrad	66		66		66		66	
β_x @ IP	cm	2.6	3.2	2.6	3.2	5.06	6.22	6.76	8.32
β_y @ IP	cm	0.0253	0.0205	0.0179	0.0145	0.0292	0.0237	0.0658	0.0533
Coupling (high current)	%	0.25	0.25	0.25	0.25	0.5	0.5	0.25	0.25
Emittance x (without IBS)	nm	1.97	1.82	1.97	1.82	1.97	1.82	1.97	1.82
Emittance x (with IBS)	nm	2.00	2.46	1.00	1.23	2.00	2.46	5.20	6.4
Emittance y	pm	**5**	**6.15**	**2.5**	**3.075**	**10**	**12.3**	**13**	**16**
Bunch length (zero current)	mm	4.69	4.29	4.73	4.34	4.03	3.65	4.75	4.36
Bunch length (full current)	mm	5	5	5	5	4.4	4.4	5	5
Beam current	mA	1892	2447	1460	1888	3094	4000	1365	1766
Buckets distance	#	2		2		1		1	
Ion gap	%	2		2		2		2	
RF frequency	Hz	4.76E+08		4.76E+08		4.76E+08		4.76E+08	
Revolution frequency	Hz	**2.38E+05**		**2.38E+05**		**2.38E+05**		**2.38E+05**	
Harmonic number	#	**1998**		**1998**		**1998**		**1998**	
Number of bunches	#	**978**		**978**		**1956**		**1956**	
N. Particle/bunch	#	**5.08E+10**	**6.56E+10**	**3.92E+10**	**5.06E+10**	**4.15E+10**	**5.36E+10**	**1.83E+10**	**2.37E+10**
σ_x @ IP	microns	**7.211**	**8.872**	**5.099**	**6.274**	**10.060**	**12.370**	**18.749**	**23.076**
σ_y @ IP	microns	**0.036**	**0.036**	**0.021**	**0.021**	**0.054**	**0.054**	**0.092**	**0.092**
$\sigma_{x'}$ @ IP	microrad	**277.4**	**277.3**	**196.1**	**196.1**	**198.8**	**198.9**	**277.4**	**277.4**
$\sigma_{y'}$ @ IP	microrad	**140.6**	**173.2**	**118.2**	**145.6**	**185.1**	**227.8**	**140.6**	**173.3**
Piwinski angle	rad	**22.88**	**18.60**	**32.36**	**26.30**	**14.43**	**11.74**	**8.80**	**7.15**
σ_x effective	microns	**165.22**	**165.30**	**165.14**	**165.18**	**145.60**	**145.78**	**166.12**	**166.67**
Σ_x	microns	**11.433**		**8.085**		**15.944**		**29.732**	
Σ_y	microns	**0.050**		**0.030**		**0.076**		**0.131**	
Σ_x effective	microns	**233.35**		**233.35**		**205.34**		**233.35**	
Hourglass reduction factor		0.950		0.950		0.950		0.950	
Tune shift x		**0.0021**	**0.0033**	**0.0017**	**0.0025**	**0.0044**	**0.0067**	**0.0052**	**0.0080**
Tune shift y		**0.0970**	**0.0971**	**0.0891**	**0.0892**	**0.0684**	**0.0687**	**0.0909**	**0.0910**
Longitudinal damping time	msec	13.4	20.3	13.4	20.3	13.4	20.3	26.8	40.6
Energy Loss/turn	MeV	2.11	0.865	2.11	0.865	2.11	0.865	0.4	0.166
Momentum compaction		4.36E-04	4.05E-04	4.36E-04	4.05E-04	4.36E-04	4.05E-04	*4.36E-04*	*4.05E-04*
Energy spread (zero current)	dE/E	6.31E-04	6.68E-04	6.31E-04	6.68E-04	6.31E-04	6.68E-04	*6.31E-04*	*6.68E-04*
Energy spread (full current)	dE/E	6.43E-04	7.34E-04	6.43E-04	7.34E-04	6.43E-04	7.34E-04	*6.94E-04*	*7.34E-04*
CM energy spread	dE/E	**5.00E-04**		**5.00E-04**		**5.00E-04**		***5.26E-04***	
Energy acceptance	dE/E	0.01	0.01	0.01	0.01	0.01	0.01	*0.01*	*0.01*
SR power loss	MW	**3.99**	**2.12**	**3.08**	**1.63**	**6.53**	**3.46**	**0.55**	**0.29**
Touschek lifetime	min	35	16	17	8	70	32	17	8
Luminosity lifetime	min	**4.81**	**6.23**	**3.71**	**4.80**	**7.88**	**10.18**	**34.69**	**44.88**
Total lifetime	min	**4.23**	**4.48**	**3.05**	**3.00**	**7.08**	**7.73**	**11.41**	**6.79**
RF Wall Plug Power (SR only)	MW	**12.22**		**9.43**		**19.98**		**1.68**	
Total RF Wall Plug Power	MW	17.08		12.72		30.48		3.11	

DESIGN PARAMETERS

Parameter	Unit	HER	LER
Luminosity	cm-2 s-1	1.00E+36	
Energy	GeV	6.7	4.18
X-angle	mrad	66	
IP β_x	cm	2.6	3.2
IP β_y	cm	0.0253	0.0205
ε_x	nm	2.00	2.46
ε_y	pm	5.00	6.15
Bunch length	mm	5.00	5.00
Beam current	mA	1892	2447
Horiz. tune shift		0.0021	0.0033
Vert. tune shift		0.0970	0.0971
δ @ Imax	dE/E	6.43E-04	7.34E-04
Lifetime	min	4.23	4.48

INTERACTION REGION

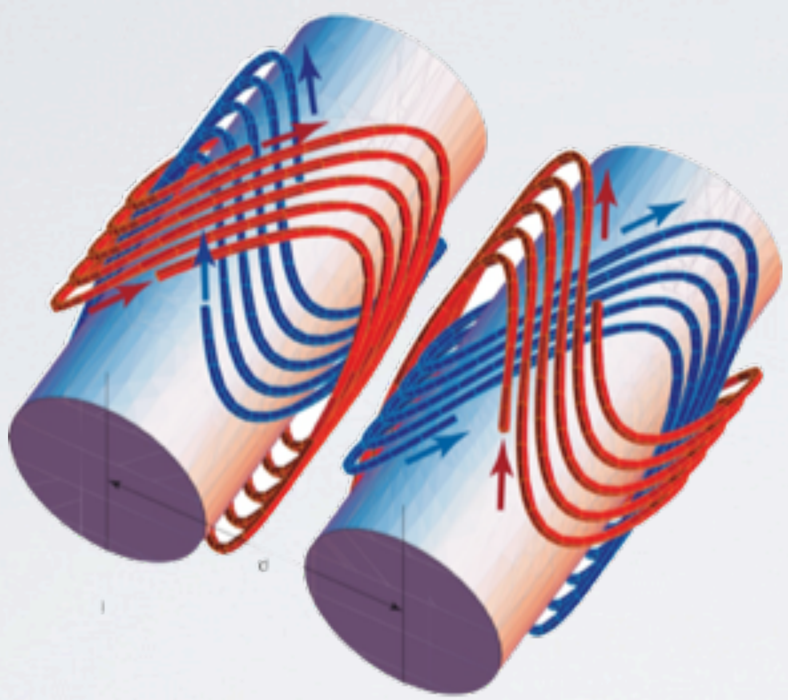
M. Sullivan, M. Boscolo, K. Bertsche, E. Paoloni, S. Bettoni,
P. Raimondi, M. Biagini, P.Vobly, I. Okunev,
A. Novokhatski, S. Weathersby, R. Centi, A. Perez, et al.



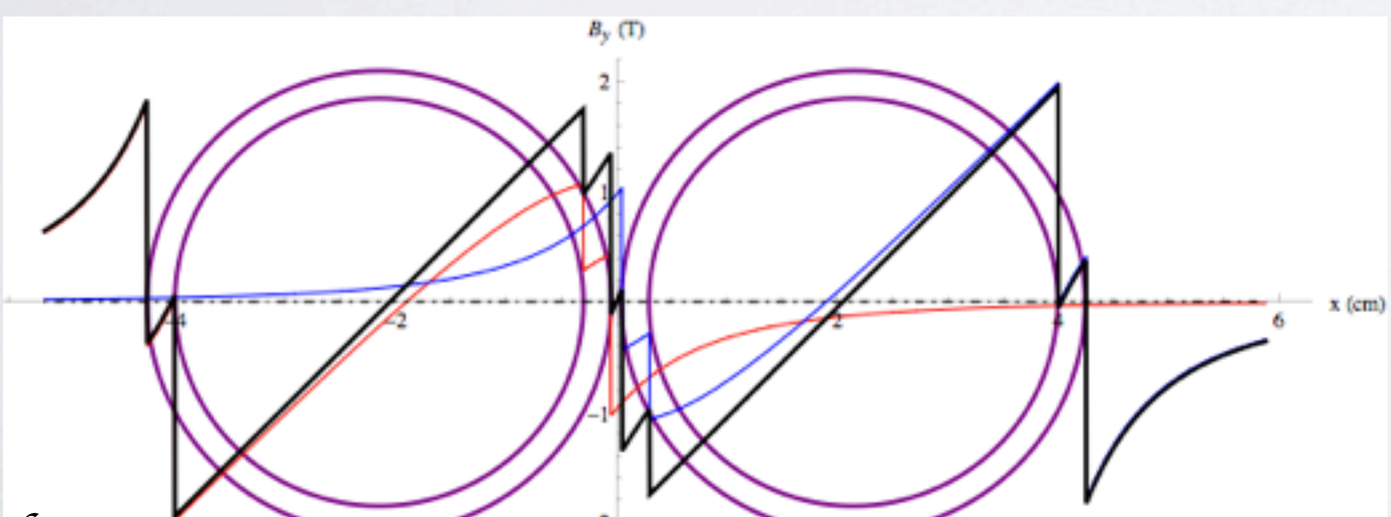
QD0 DESIGN OPTIONS

"Italian" Design

E. Paoloni ,
P. Fabbricatore,
R. Musenich,
S. Farinon ,
S. Bettoni



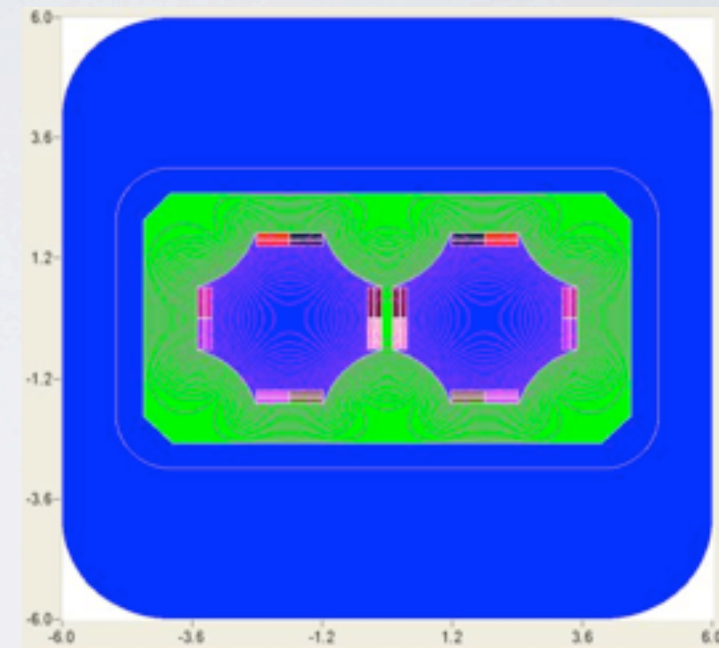
Conceptual sketch

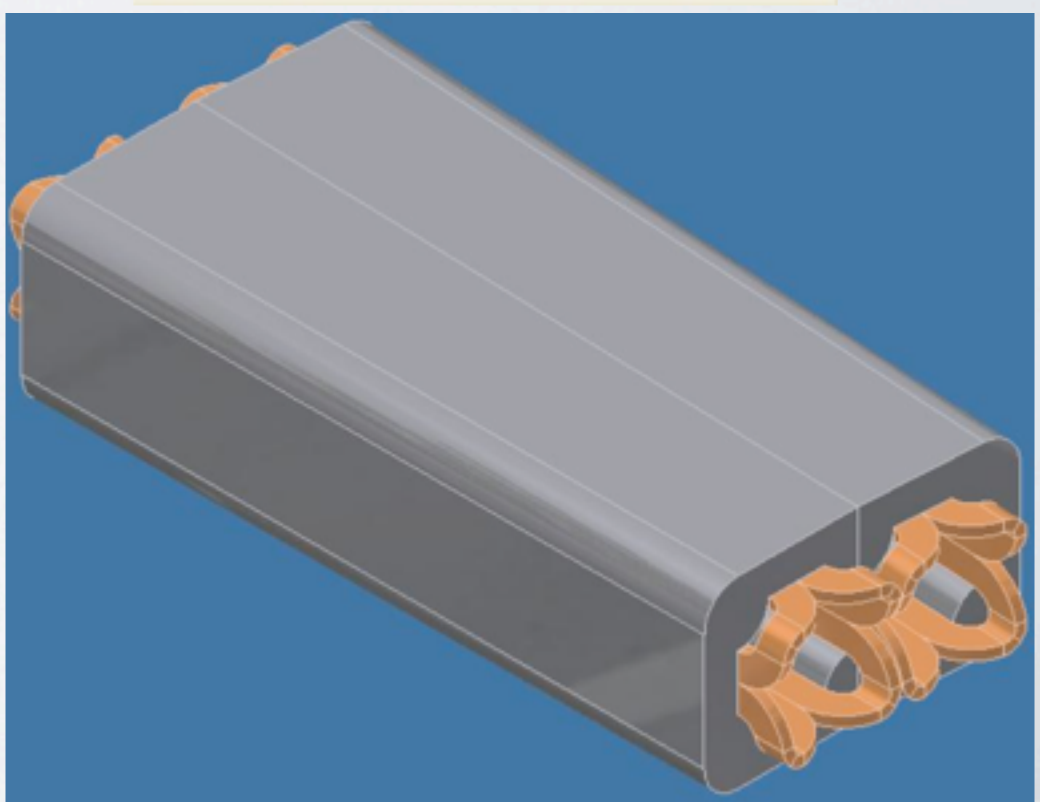


Design concept: the linear superposition of the fields generated by the left coil (in red) and by the right one (in blue) produces the needed quadrupolar field (in black).

"Russian" Design

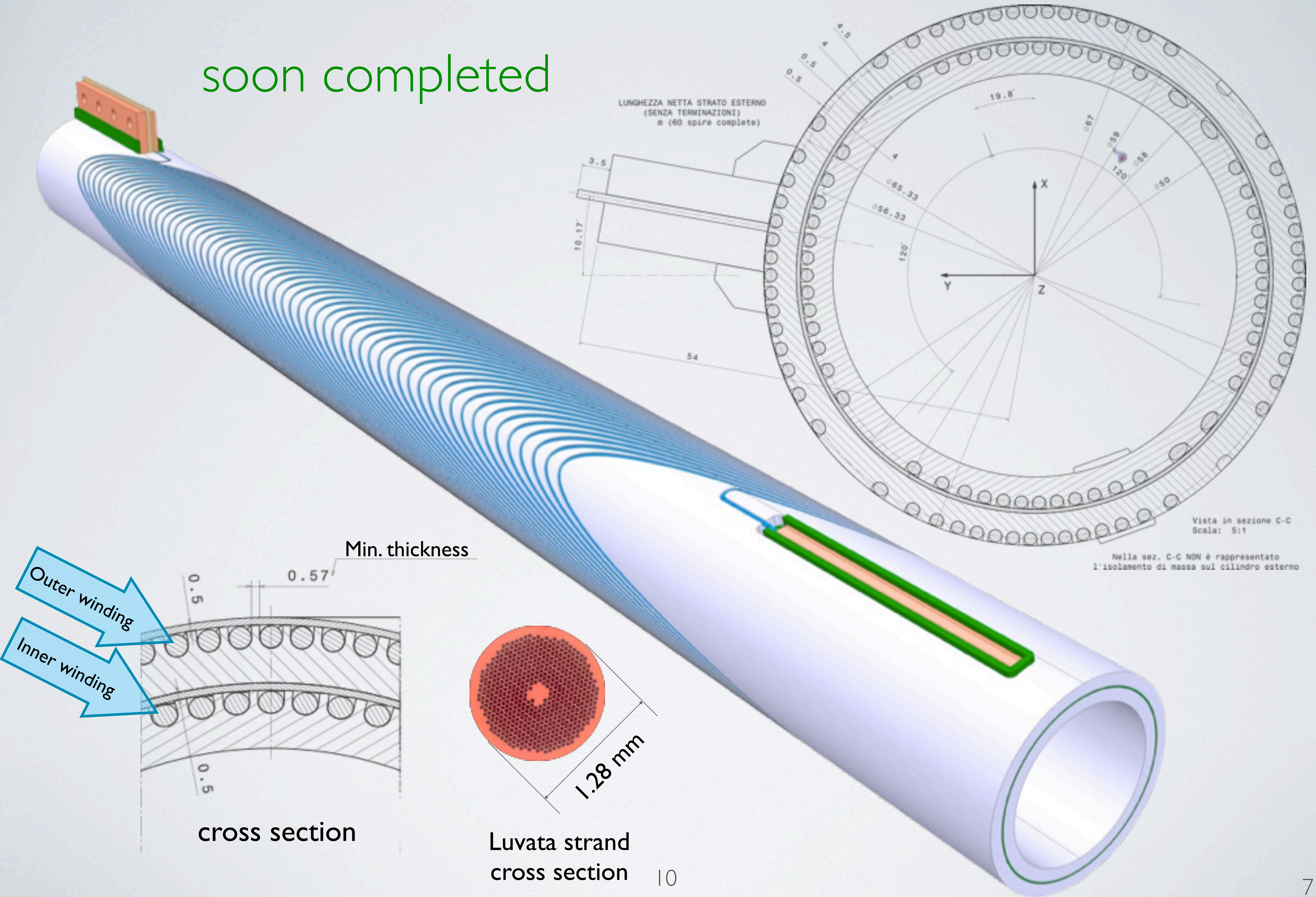
I. Okunev, V. Syrovatin, A. Bragin, P. Vobly





“ITALIAN” PROTOTYPE IN CONSTRUCTION

soon completed

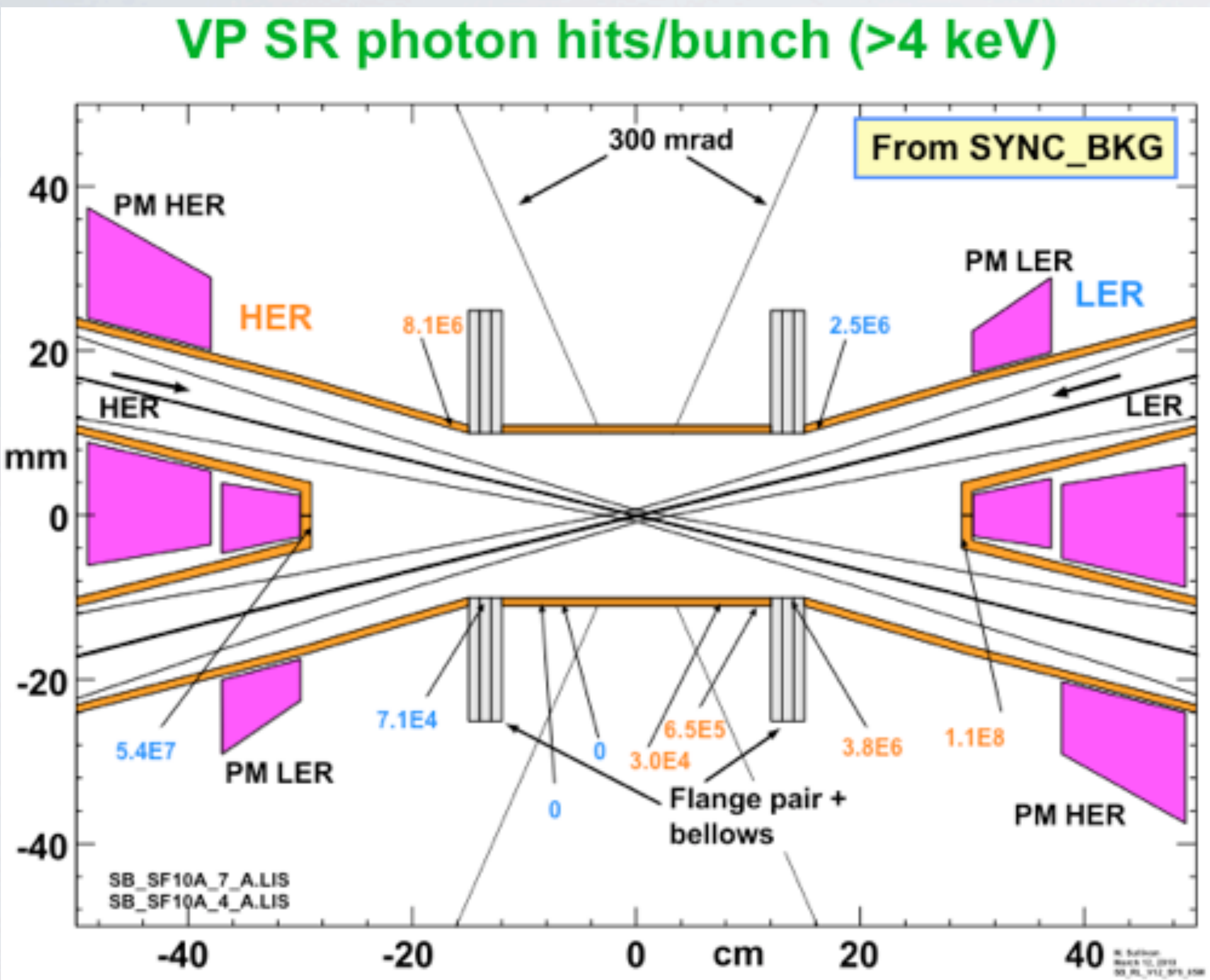


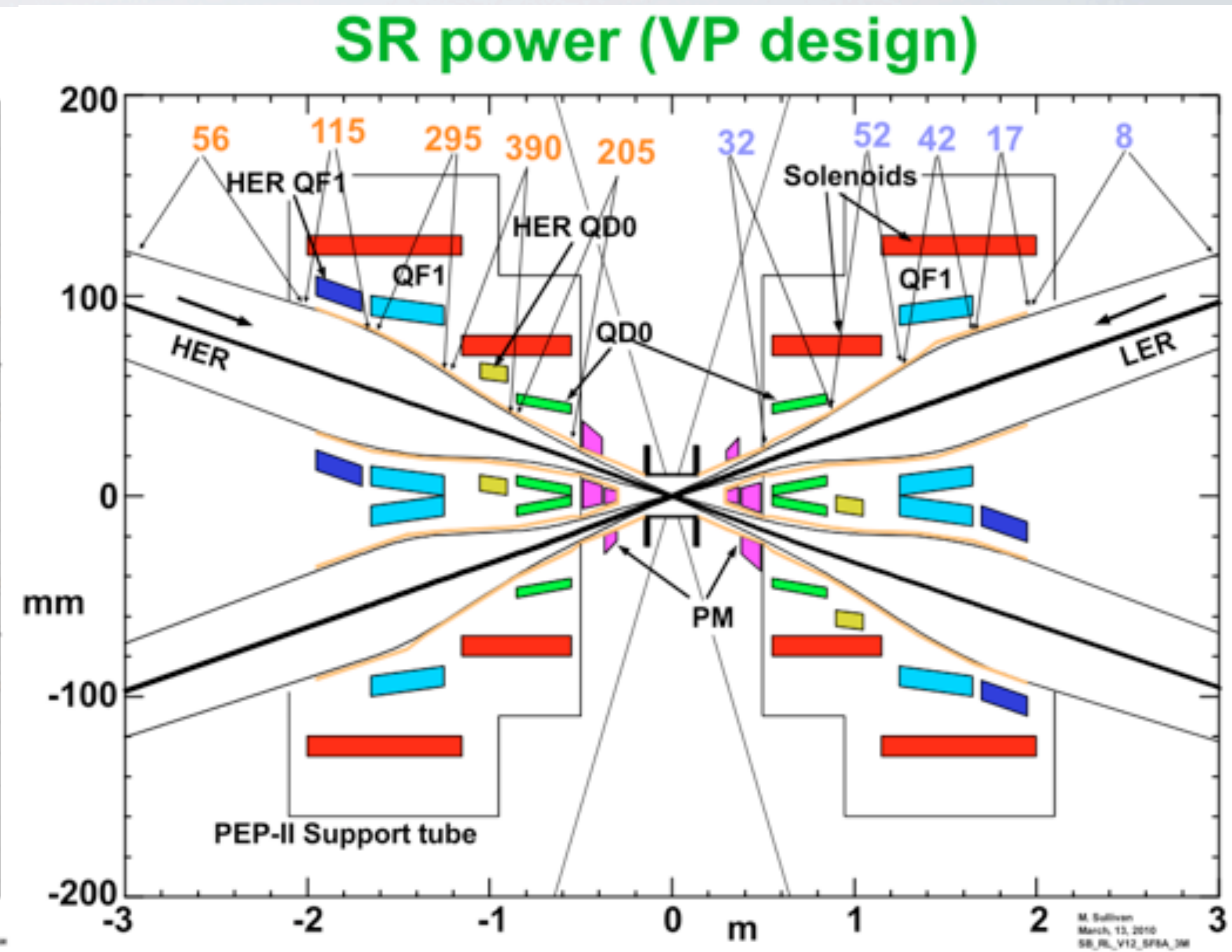
cross section

Luvata strand cross section

SYNCHROTRON RADIATION

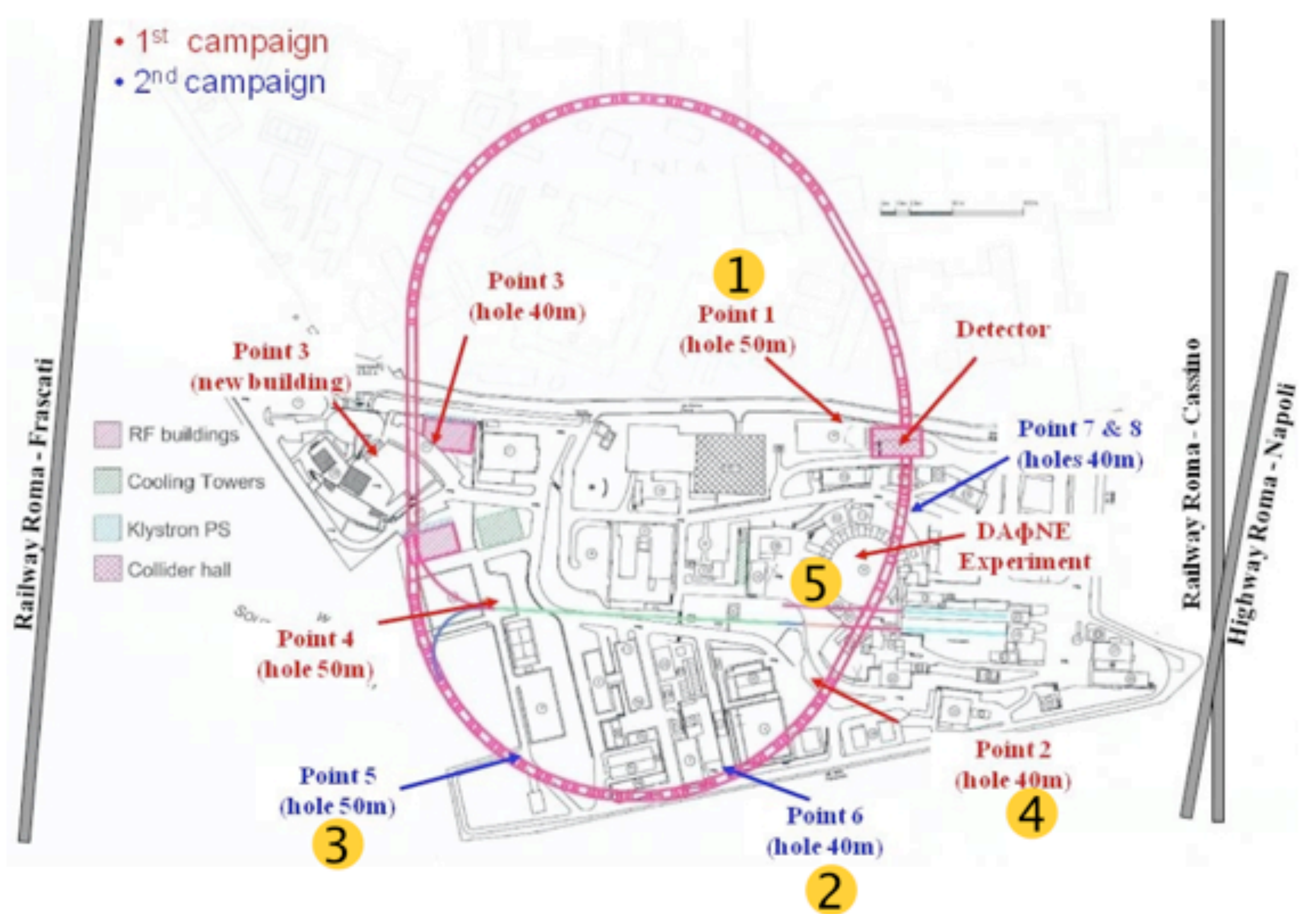
M. Sullivan, M. Boscolo, K. Bertsche, E. Paoloni, S. Bettoni,
P. Raimondi, M. Biagini, P. Vobly, I. Okunev,
A. Novokhatski, S. Weathersby, R. Centi, A. Perez, et al.





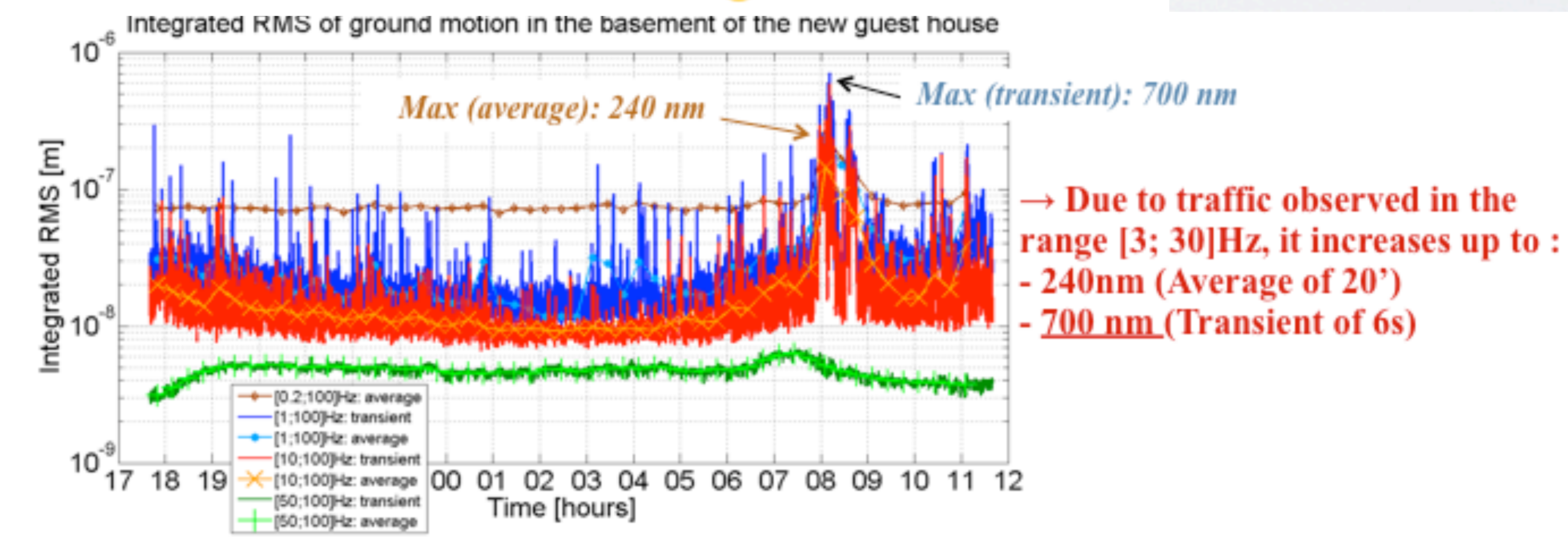
Setup to rapidly model various designs and find the best design parameters that minimize the backgrounds from SR

FRASCATI SITE GROUND MOTION



B. Bolzon,
L. Brunetti,
A. Jeremie

Analysis in progress but preliminary results show that LNF seems to be a good site for vibrations



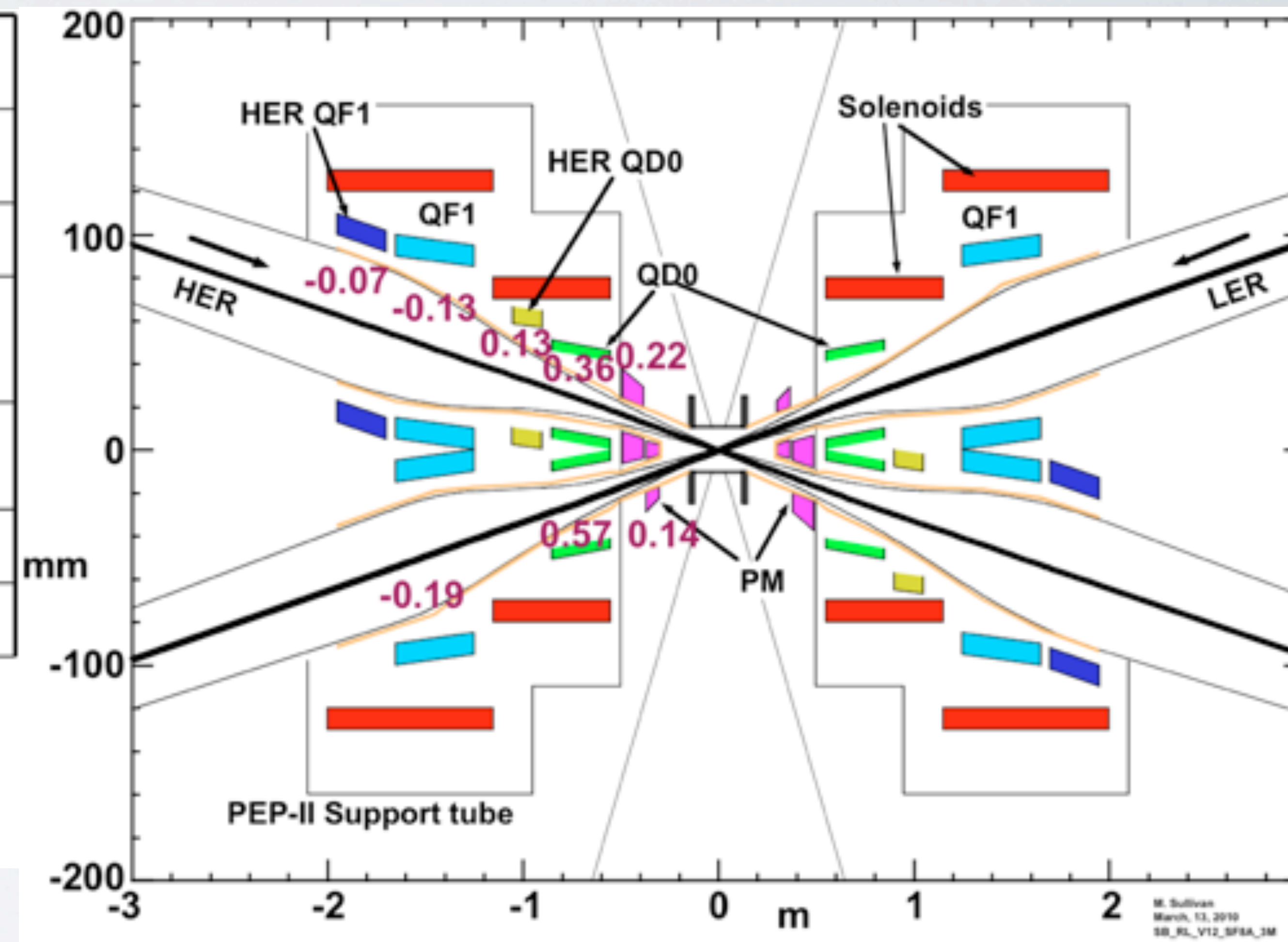
VIBRATION REQUIREMENTS AND EXPECTATIONS FOR SUPERB

Proposed Vibration Budget

Element	RMS motion	Xfer Fn (total both rings)	IP displacement	
			no fdbk	with fdbk
Cryostat linear	< 1 μm	< 0.03	< 30 nm	< 3 nm
Cryostat rotation	< 1 μrad	0.02 m/rad	< 20 nm	< 2 nm
Remaining final focus quads	<100 nm	<0.6 RMS	< 60 nm	< 6 nm
Arc quads	< 500 nm	<0.076RMS	< 38 nm	< 3.8 nm
Total (two rings)			< 80 nm	< 8 nm

- Assumes beam feedback achieves > 10x reduction of motion at IP
  - If motion is kept 10x smaller, may not need beam feedback
- Budget applies to integrated RMS motion > 1 Hz
- This budget will keep relative motion < 8 nm, and lumi loss < 1%

Transfer Functions of IR Components



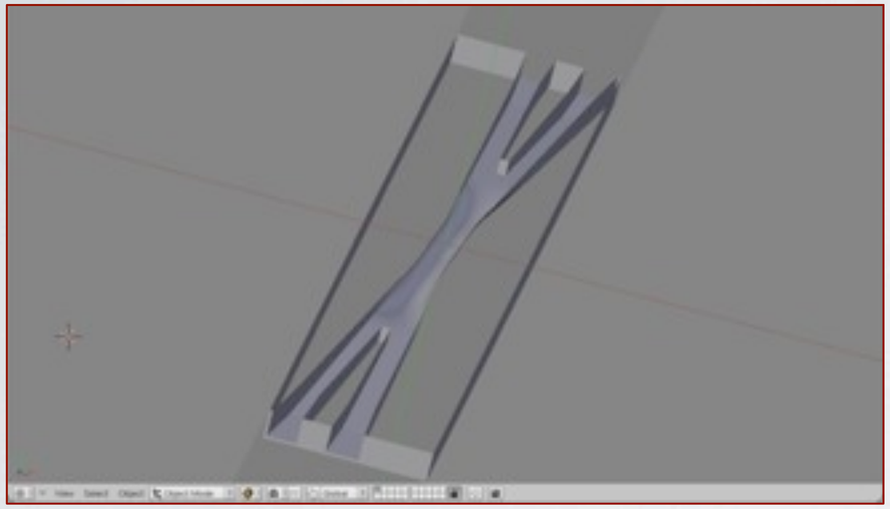
First Preliminary Results for LNF Frascati Site

K. Bertsche

IR HOM STUDIES

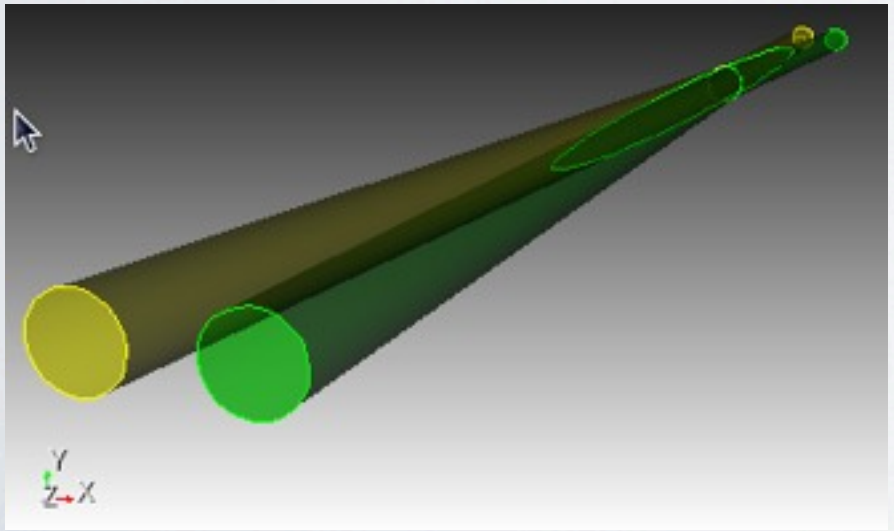
S. Weathersby

First model of IR with square chambers

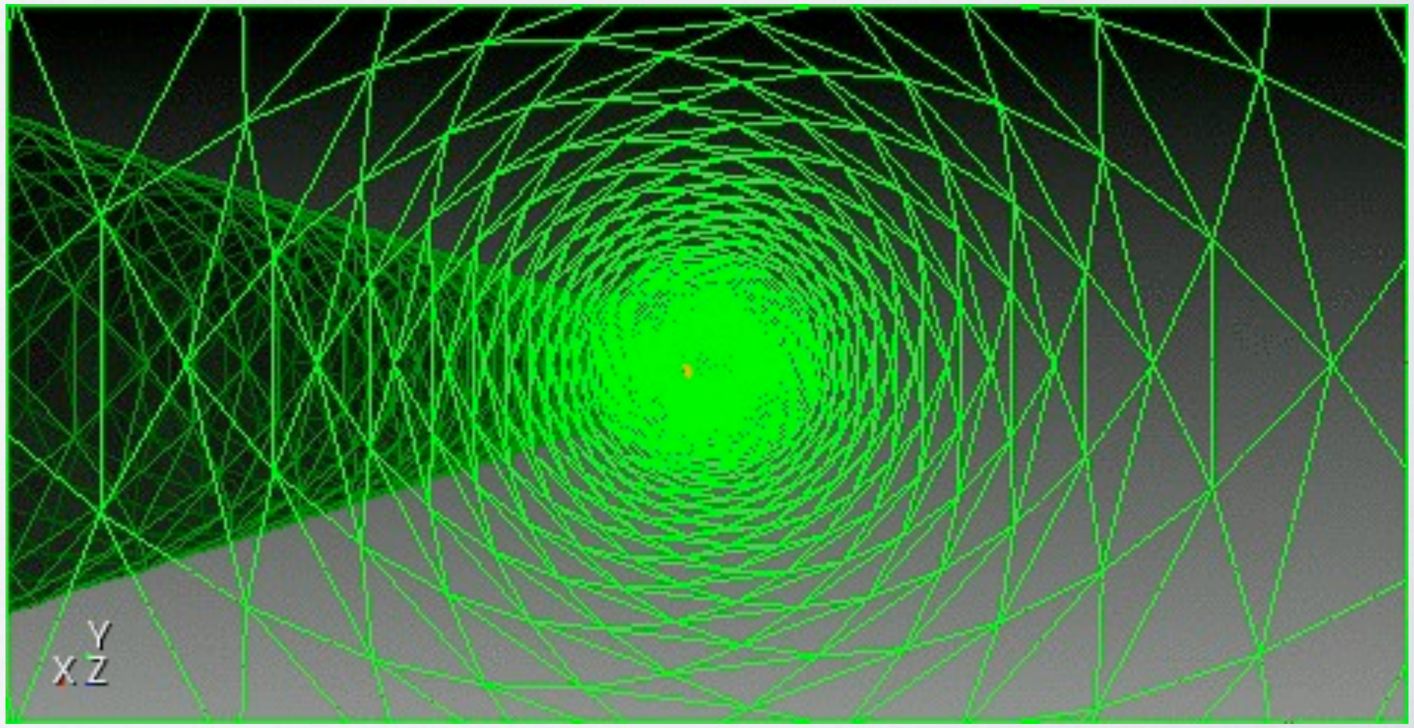


First results: Loss factor for round tubes is small compared to model of the Super B IR.

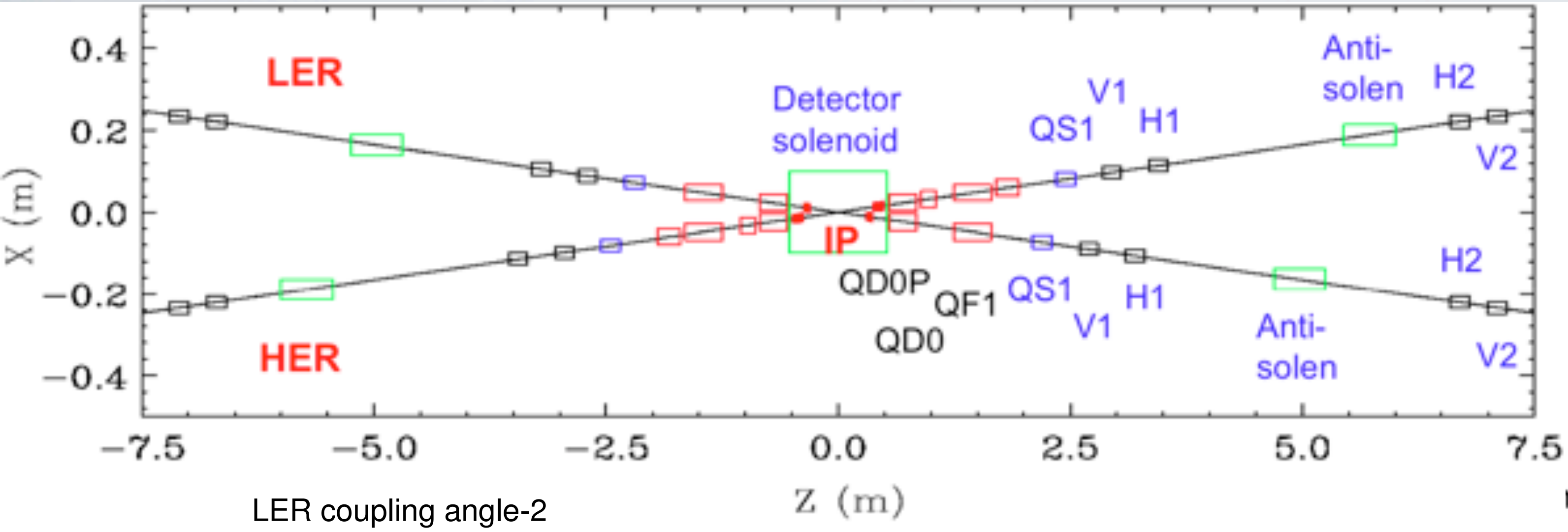
New round chamber introduced in this study

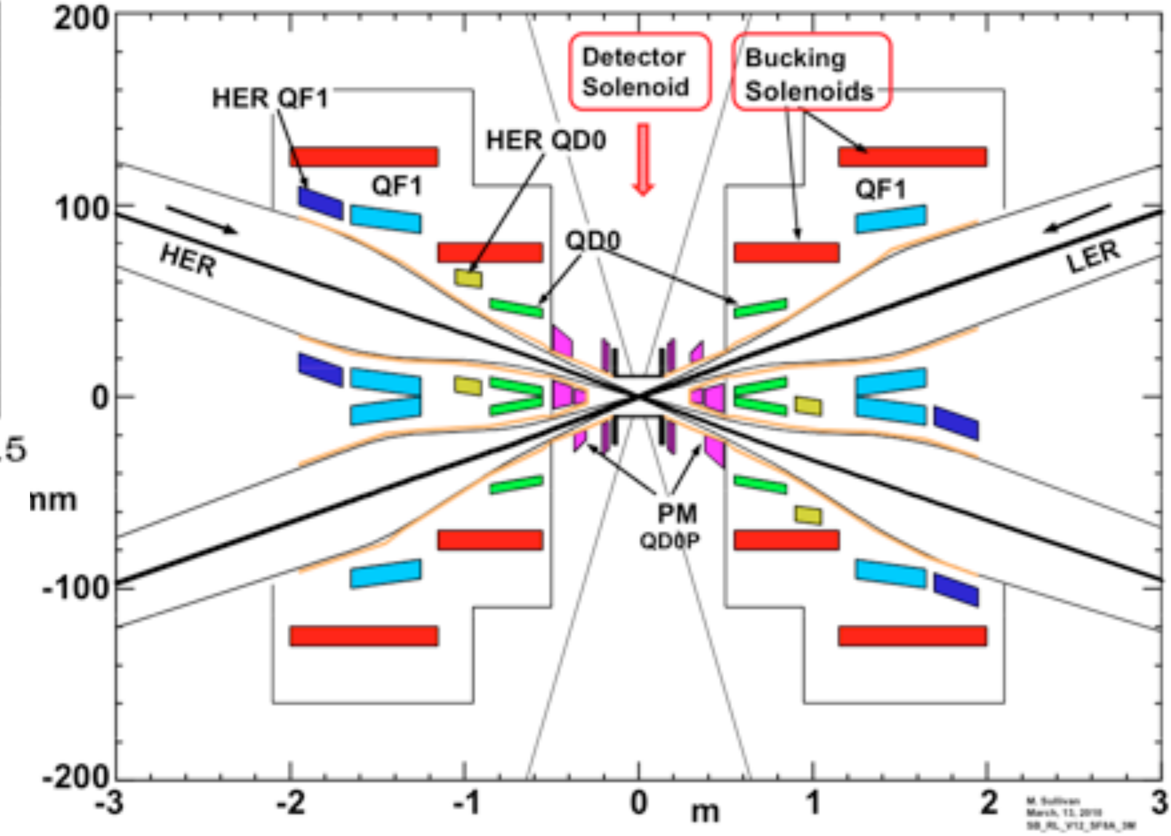


Beams Eye View



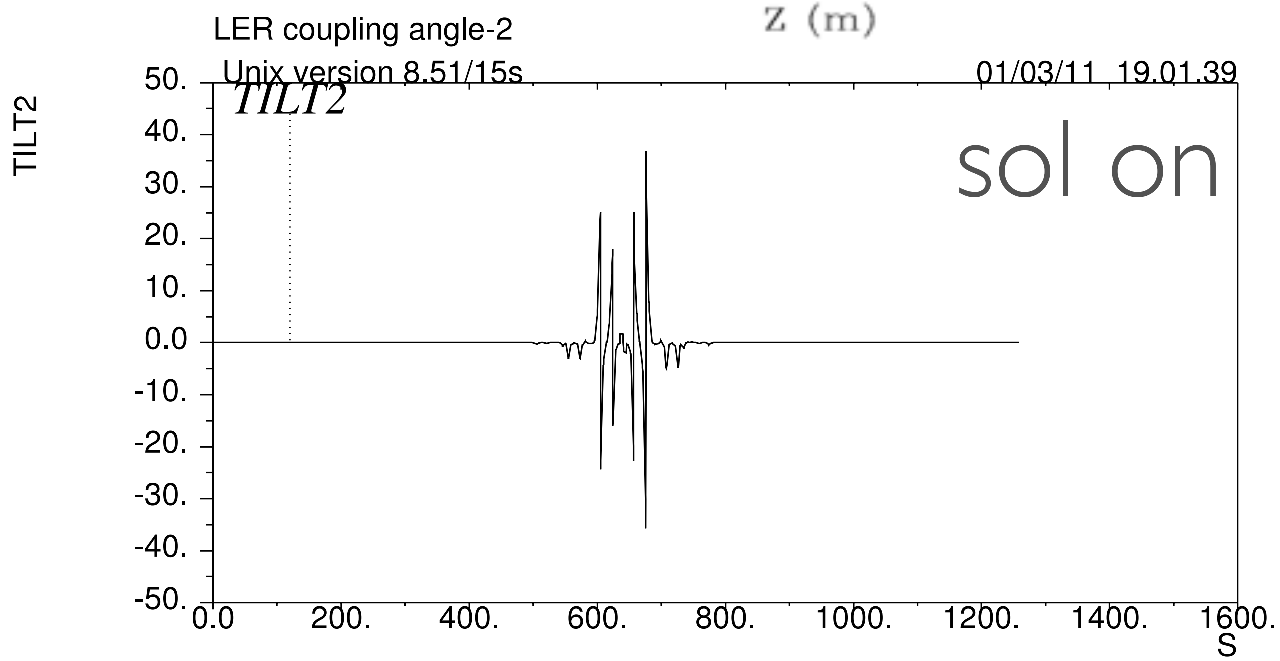
COMPENSATION OF DETECTOR SOLENOID

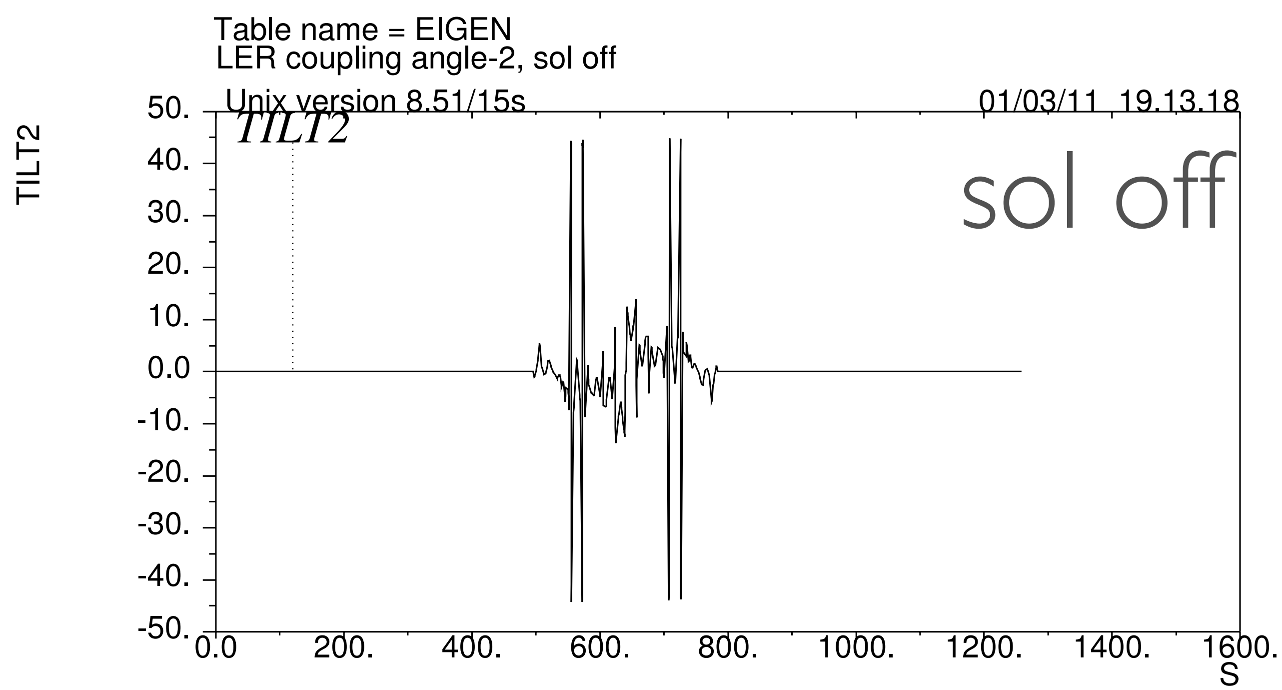


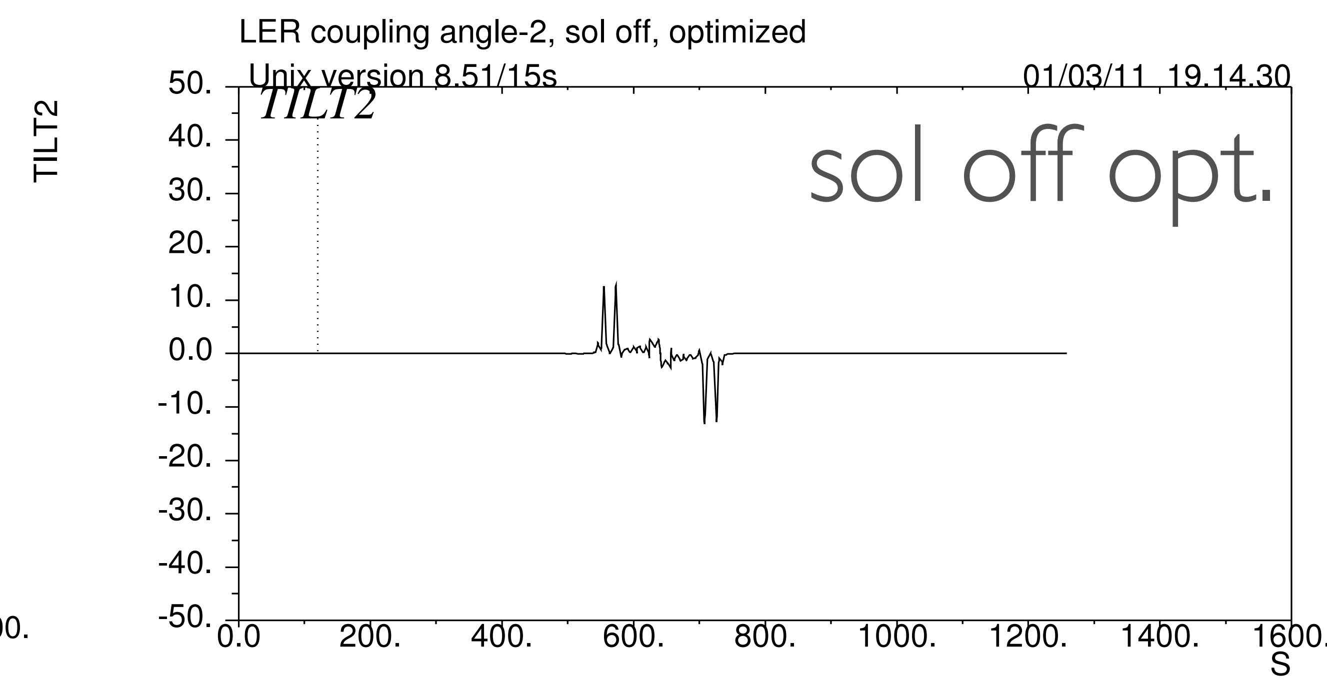


Y. Nosochkov, K. Bertsche, M. Sullivan

THP072 this conference







LOW EMITTANCE TUNING

New correction scheme:
Orbit and Dispersion Free Steering +
Coupling and Beta-Beating Free Steering

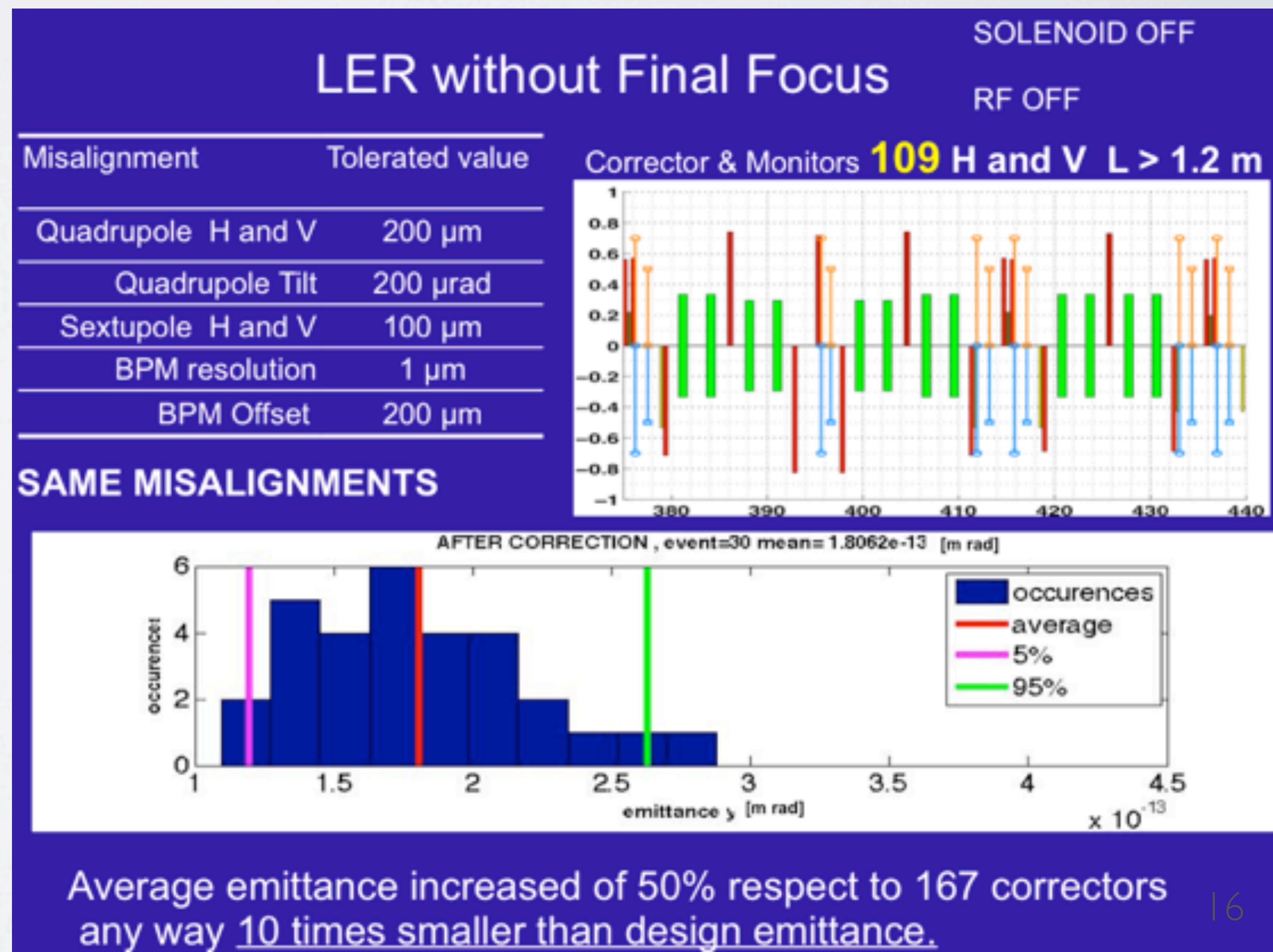
$$m\left\{\begin{pmatrix}(1-\alpha-\omega)\cdot\vec{y}\\ \alpha\cdot\vec{\eta}_y\\ \omega\cdot ORM_{VC\vec{x}}\\ \omega\cdot ORM_{HC\vec{y}}\\ \vdots\end{pmatrix}\right. = M_{m\times n}\begin{pmatrix}\vec{\theta}_y\\ \vec{K}_{skq}\\ \vec{T}_{tilts}\end{pmatrix}\left.\vphantom{\begin{pmatrix}a\\b\\c\\d\\e\end{pmatrix}}\right\}n$$

Measured at BPM

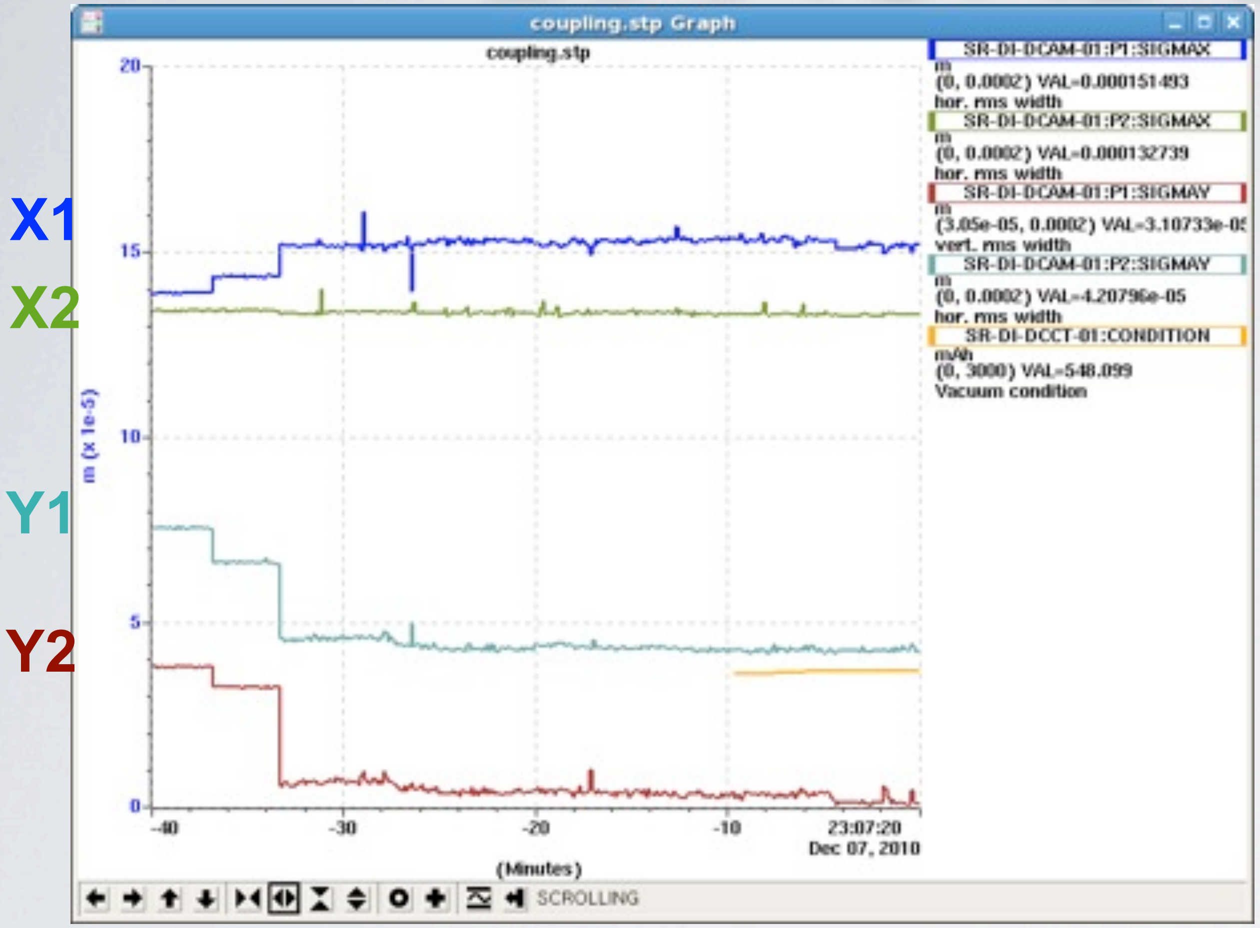
	HER	LER
ε_x [nm]	2.07	2.37
ε_y [pm]	5.17	5.92

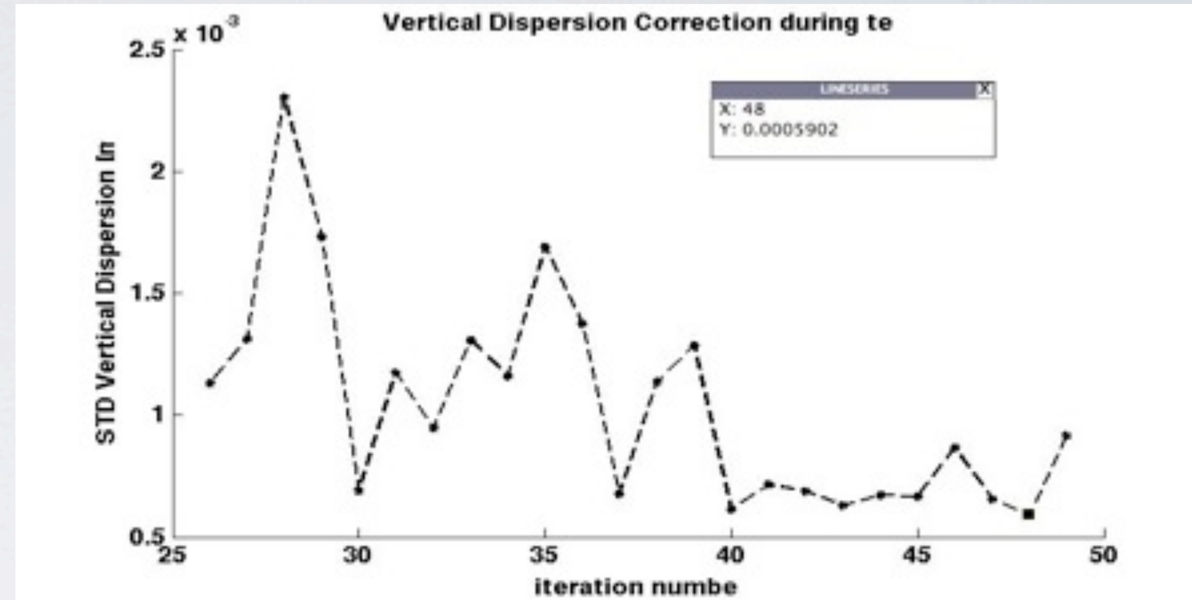
S. M. Liuzzo

Method successfully evaluated in lattice model for LER ARCs and FF.



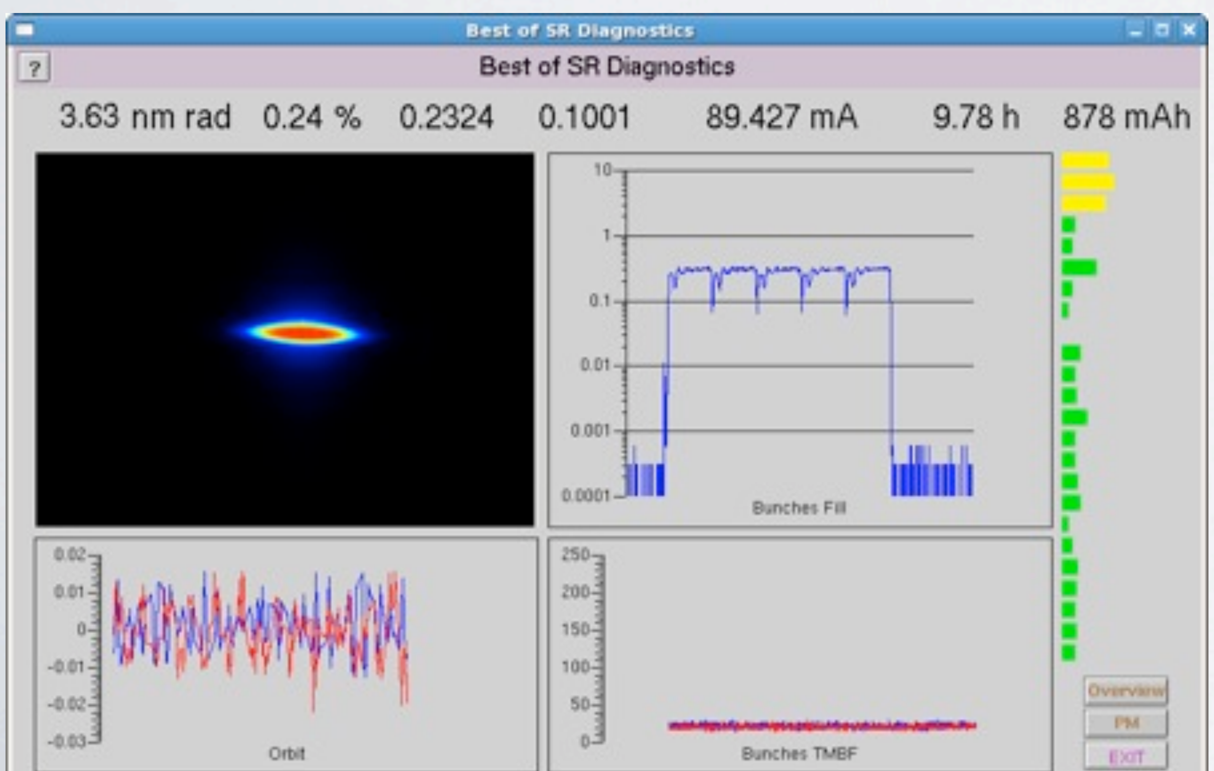
LOW EMITTANCE TUNING AT THE DIAMOND LIGHT SOURCE





$D_Y \approx 600\ \mu m$

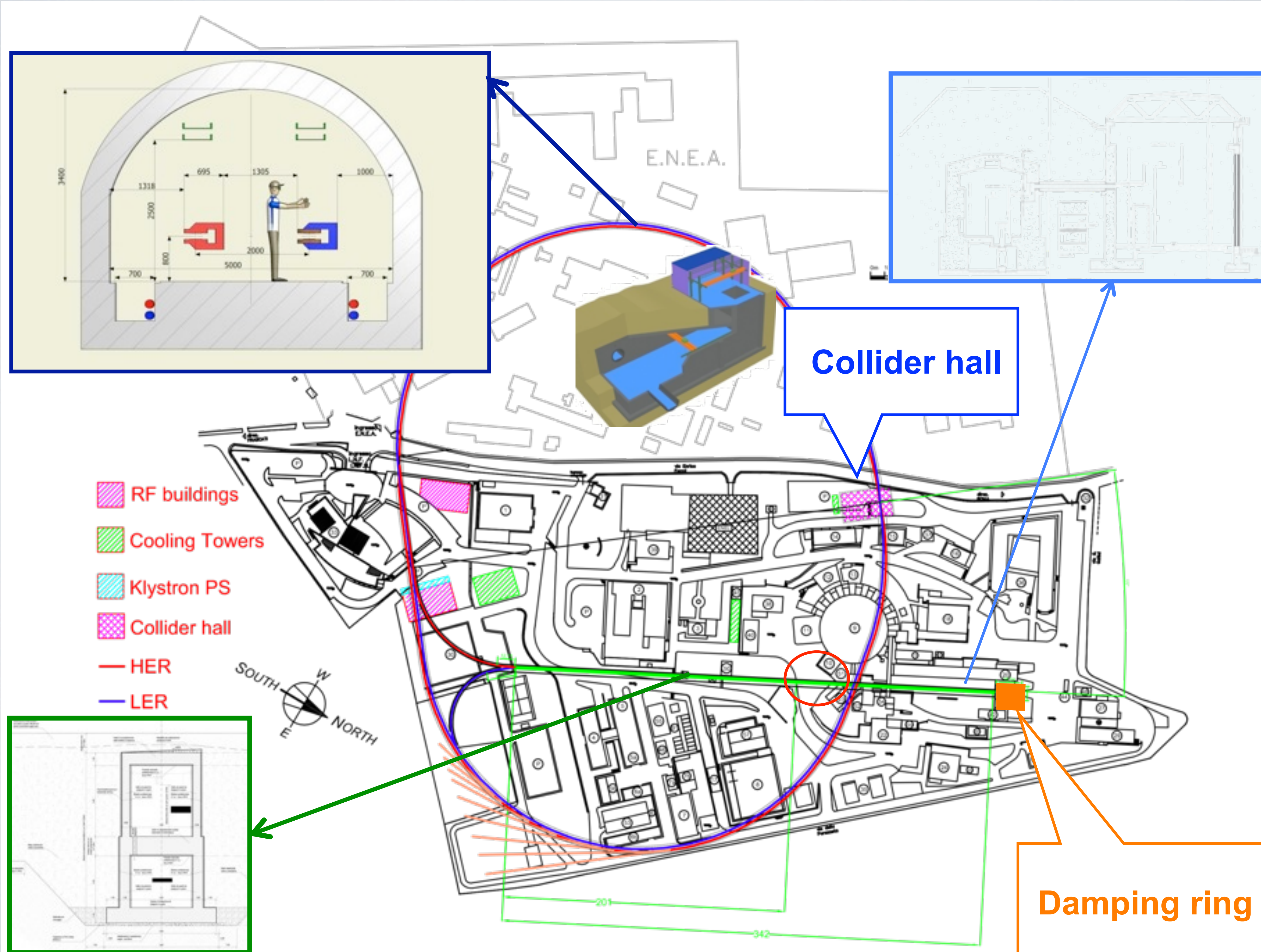
Coupling 0.23%



First Preliminary Test results

S. M. Liuzzo,
R. Bartolini
P. Raimondi

SITE & LAYOUT

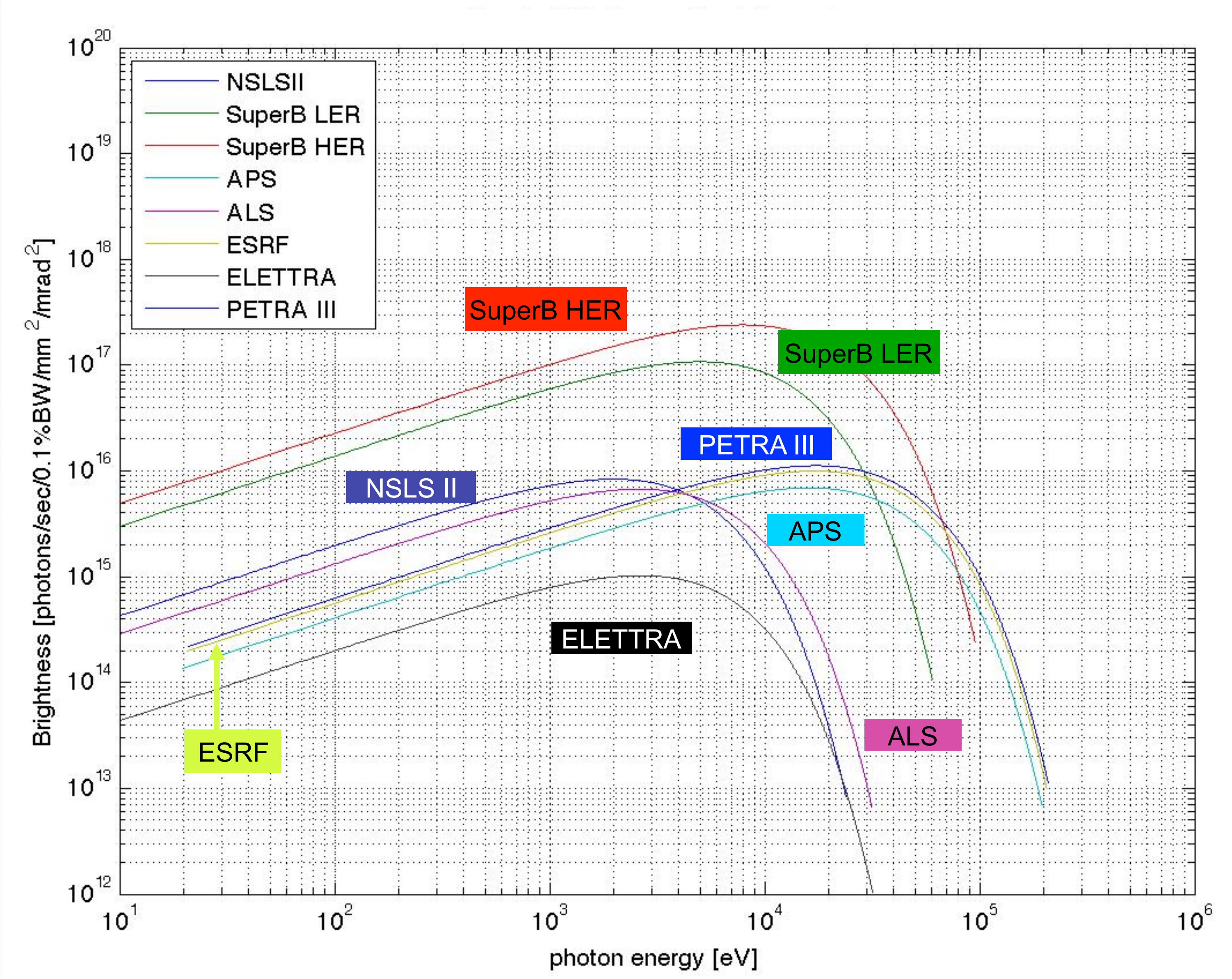


E.N.E.A.
Collider hall
RF buildings
Cooling Towers
Klystron PS
Collider hall
HER
LER
SOUTH
NORTH
W
E
Damping ring

SYNCHROTRON LIGHT OPTIONS AT SUPER-B

Bend Magnet

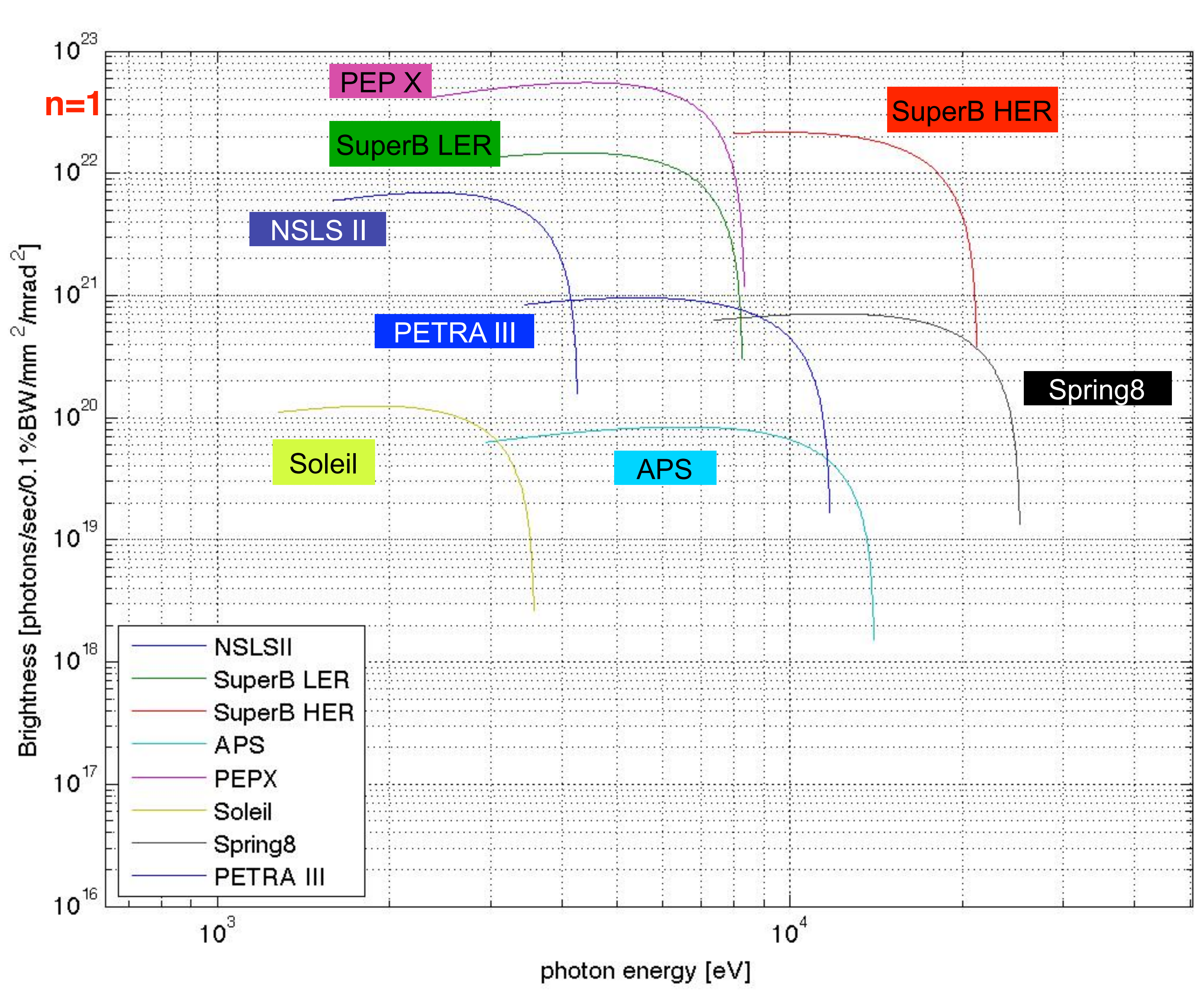
Parameters *	SuperB HER	SuperB LER	NSLS II
E [GeV]	6.7	4.18	3
I [mA]	1892	2447	500
ρ [m]	69.64	26.8	24.975
εx [m rad]	2.0 E-9	2.46 E-9	0.55 E-9
εy [m rad]	5.0 E-12	6.15 E-12	8.0 E-12
γy [m^-1]	0.334	0.537	0.05
σx [mm]	82.1 E-3	92.1 E-3	125.0 E-3
σy [mm]	8.66 E-3	9.11 E-3	13.4 E-3



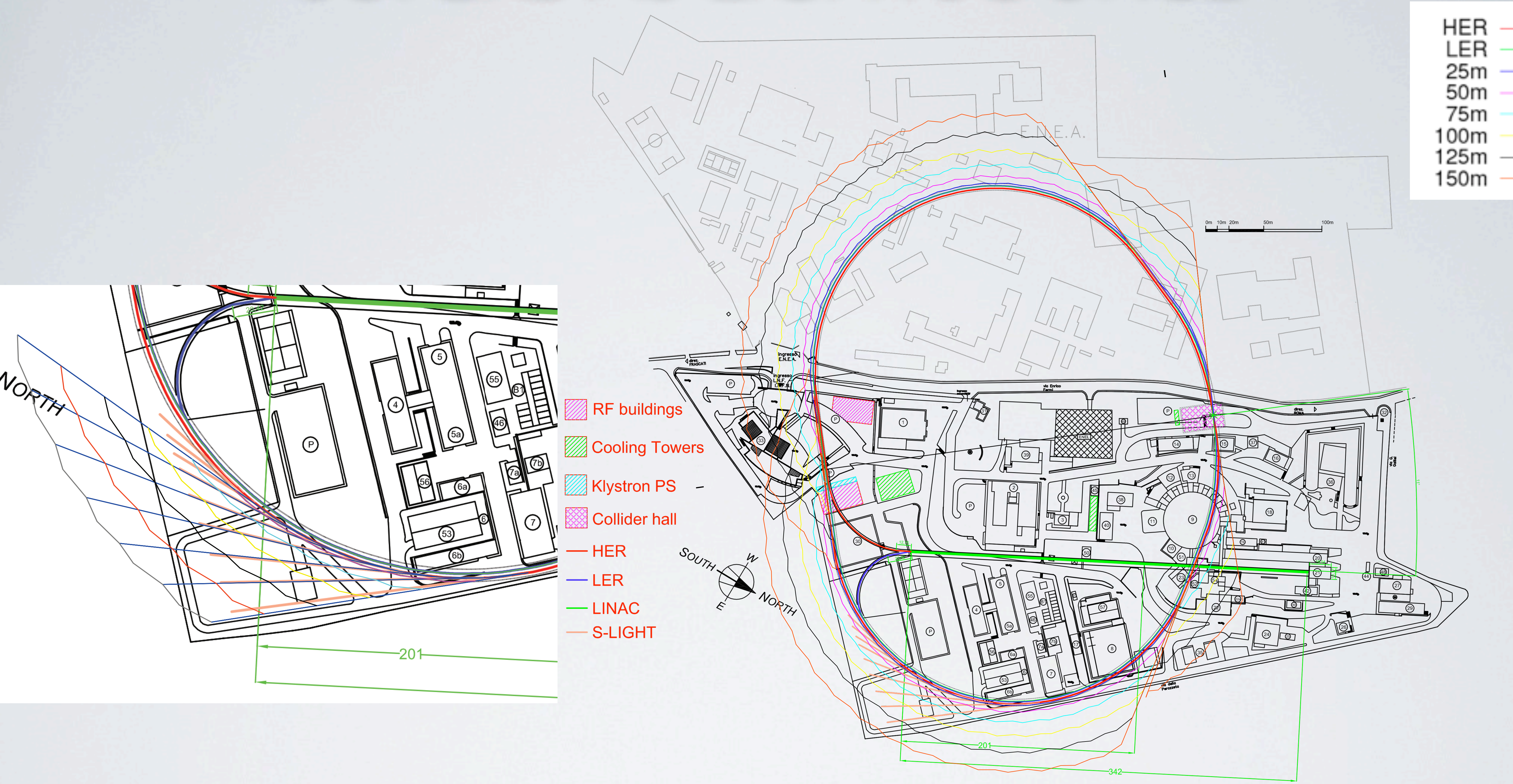
W. Wittmer

STANDARD UNDULATOR SPECTRAL BRIGHTNESS

Parameters *	SuperB HER	SuperB LER	NSLS II
	IVU20	IVU20	IVU20
E [GeV]	6.7	4.18	3
I [mA]	1892	2447	500
σx [mm]	60.0 E-3	66.5 E-3	33.3 E-3
σy [mm]	2.4 E-3	2.6 E-3	2.9 E-3
σx' [mrad]	33.3 E-3	37.0 E-3	16.5 E-3
σy' [mrad]	2.1 E-3	2.7 E-3	2.7 E-3
N [1]	148	148	148
λu [mm]	20	20	20
Kmax [1]	1.83	1.83	1.83
Kmin [1]	0.1	0.1	0.1



SUPERB AS LIGHTSOURCE



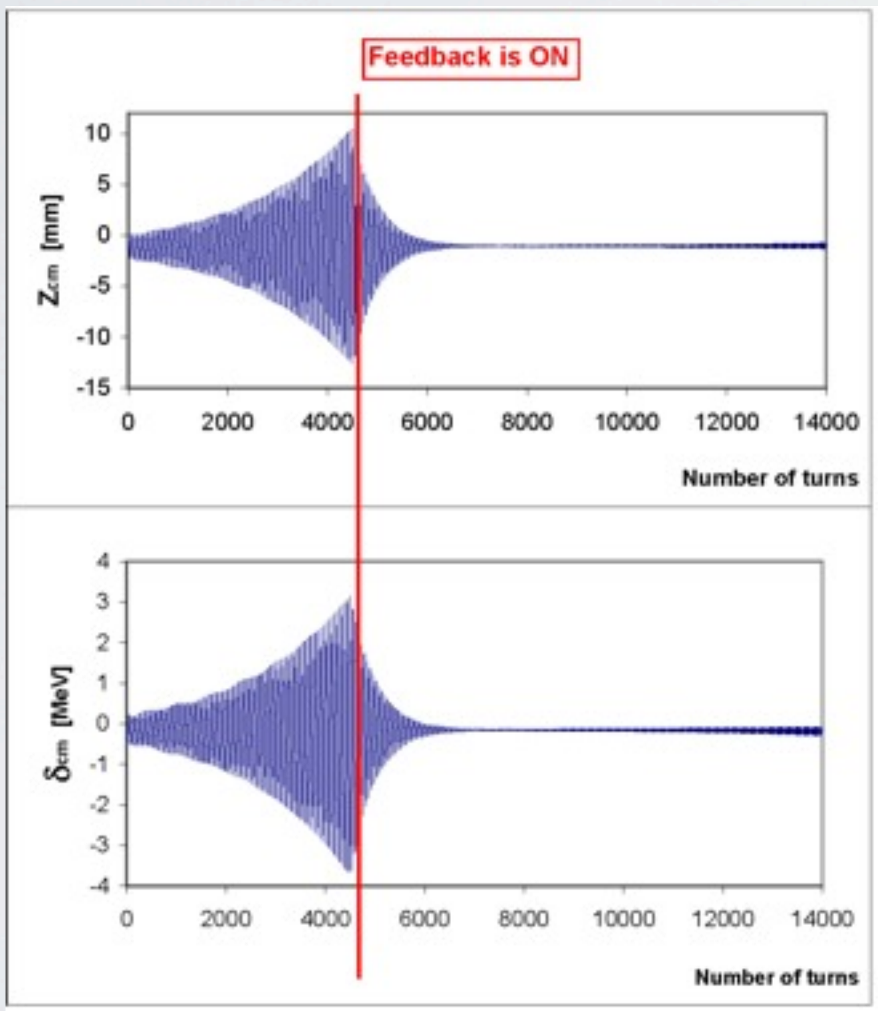
specific applications concerning particle detection, advanced simulation techniques, nanometre metrology, and others." Istituto Italiano di Tecnologia (IIT) is cooperating to the project with INFN. It will be in fact possible the use of the accelerator as a high brilliancy light source. The machine will be equipped with several photon channels, allowing the extension of scientific program to physics of matter and biotechnology.

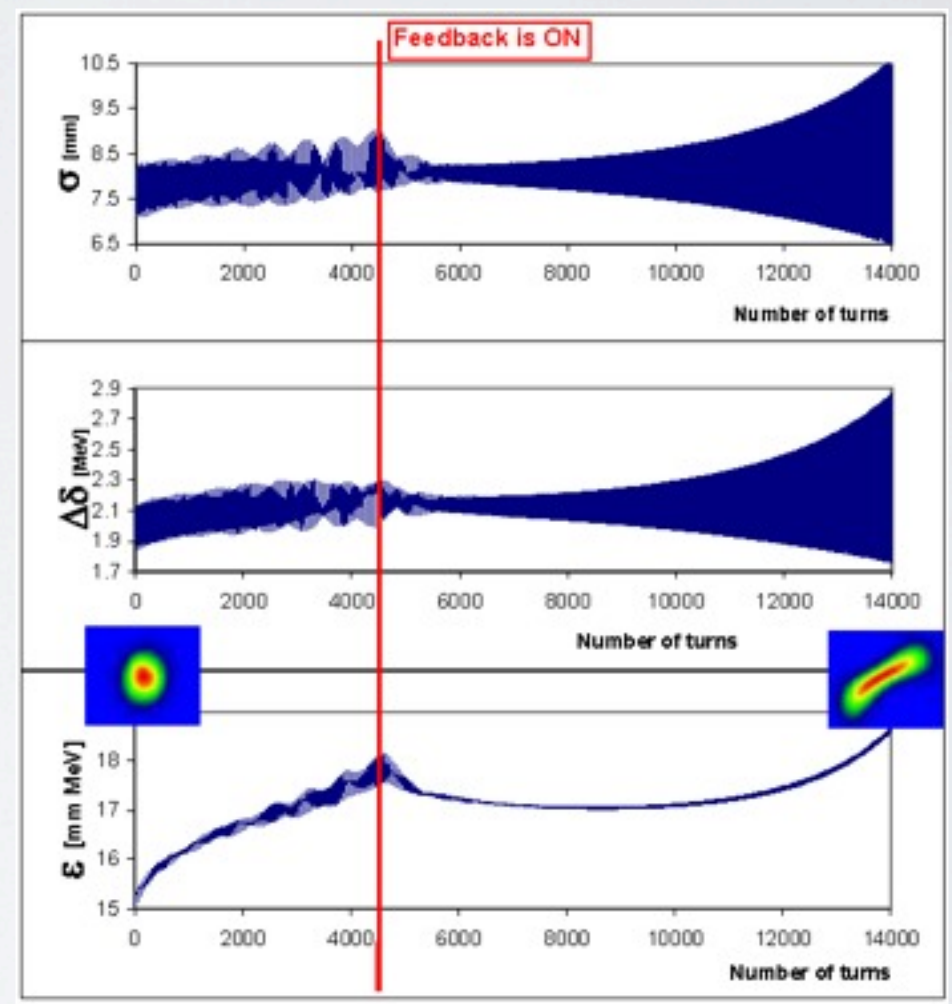
http://web.infn.it/superb/en/media-and-press-release

EFFECT OF SECOND ORDER MOMENTUM COMPACTION

$$\alpha = \alpha_1 + \alpha_2\delta + \alpha_3\delta^2$$

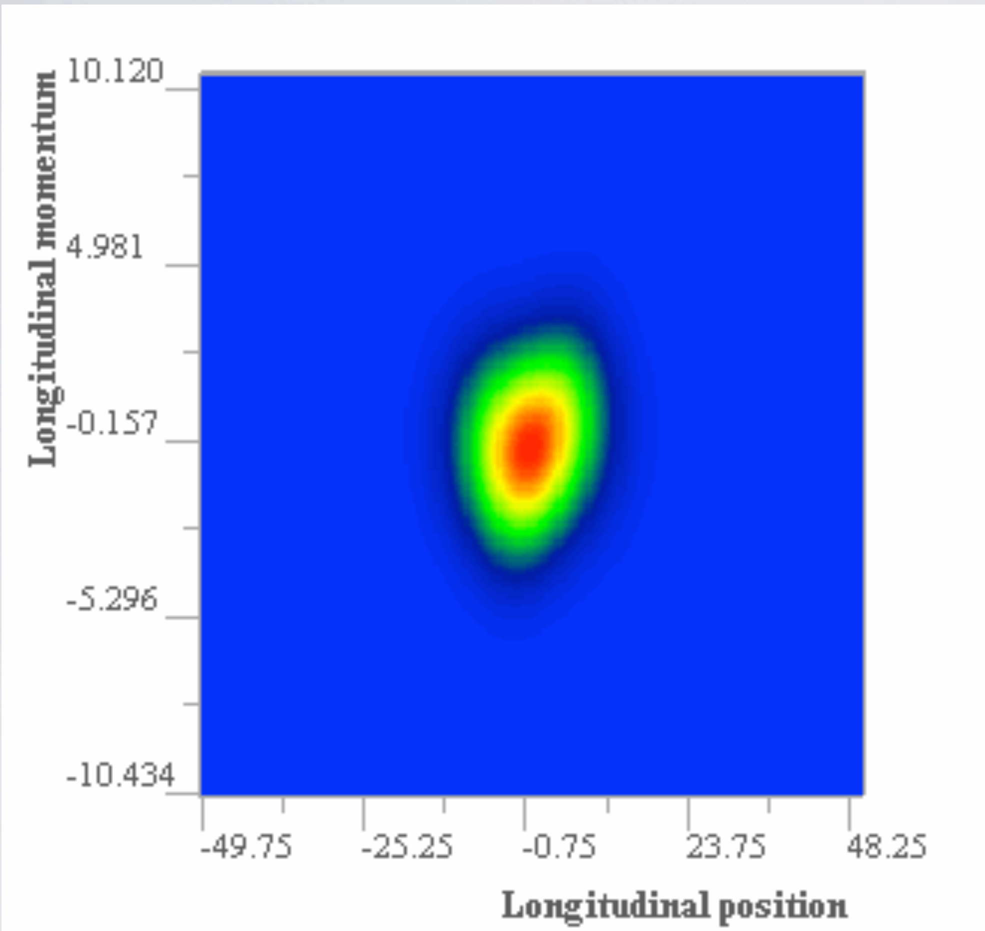
If the energy loss decreases with bunch length we have an instability without any threshold for a positive sign of $\frac{\alpha_2}{\alpha_1}$



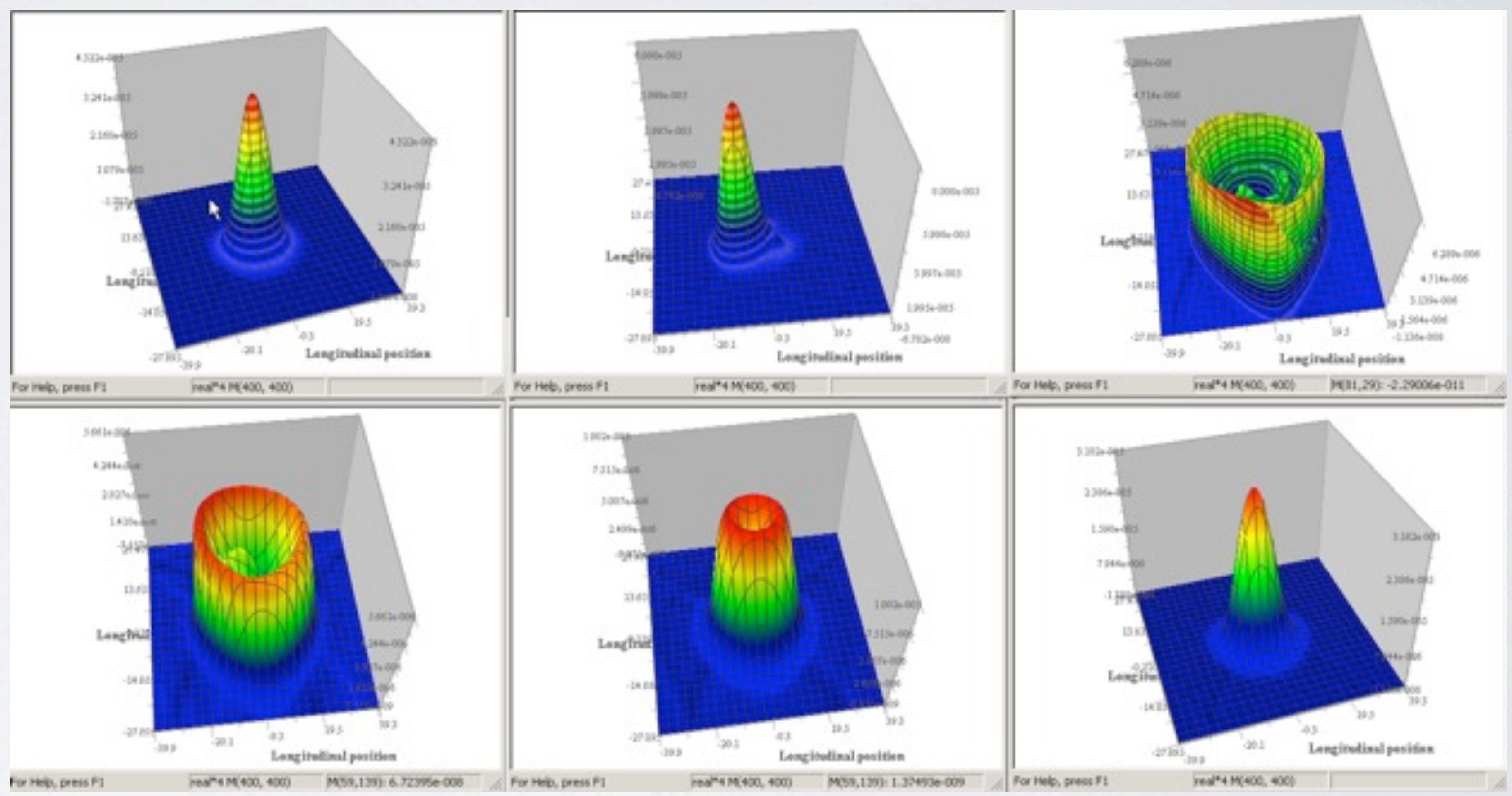


S. Novokhatski

LONGITUDINAL HEAD-TAIL INSTABILITY



Saw tooth behavior



FURTHER AREAS OF PROGRESS

- e-cloud instability in the HER.
- Intra-beam scattering.
- Bunch-by-bunch feedback.
- Tracking studies for invariant spin field with Zgoubi.
- Site committee work.
- .....