Accelerator WG Summary

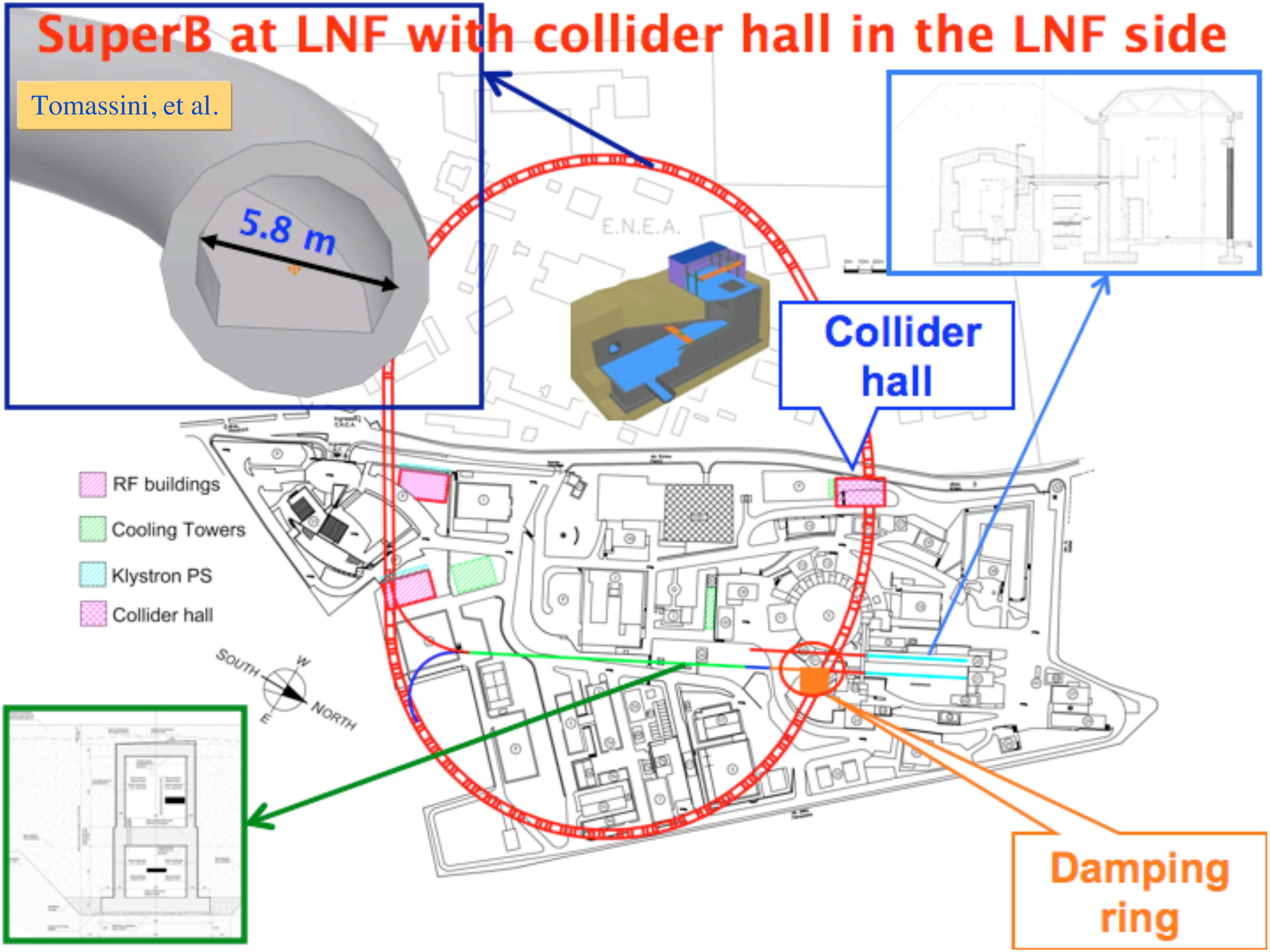
U. Wienands, SLAC

with thanks to everyone for the good work!

Accelerator/Storage Rings

- Reviewed progress since Perugia
  - focused on the LNF site
    - 1323 m ring
    - spin rotators in LER
  - 21 presentations (excl. Plenary & IR/MDI)
    - Injector
    - Siting & Lattice
      - Polarization
    - Beam Dynamics
    - Rf
    - Diagnostics & Vibrations/alignment
  - Won't be able to cover all…
- "White Paper"

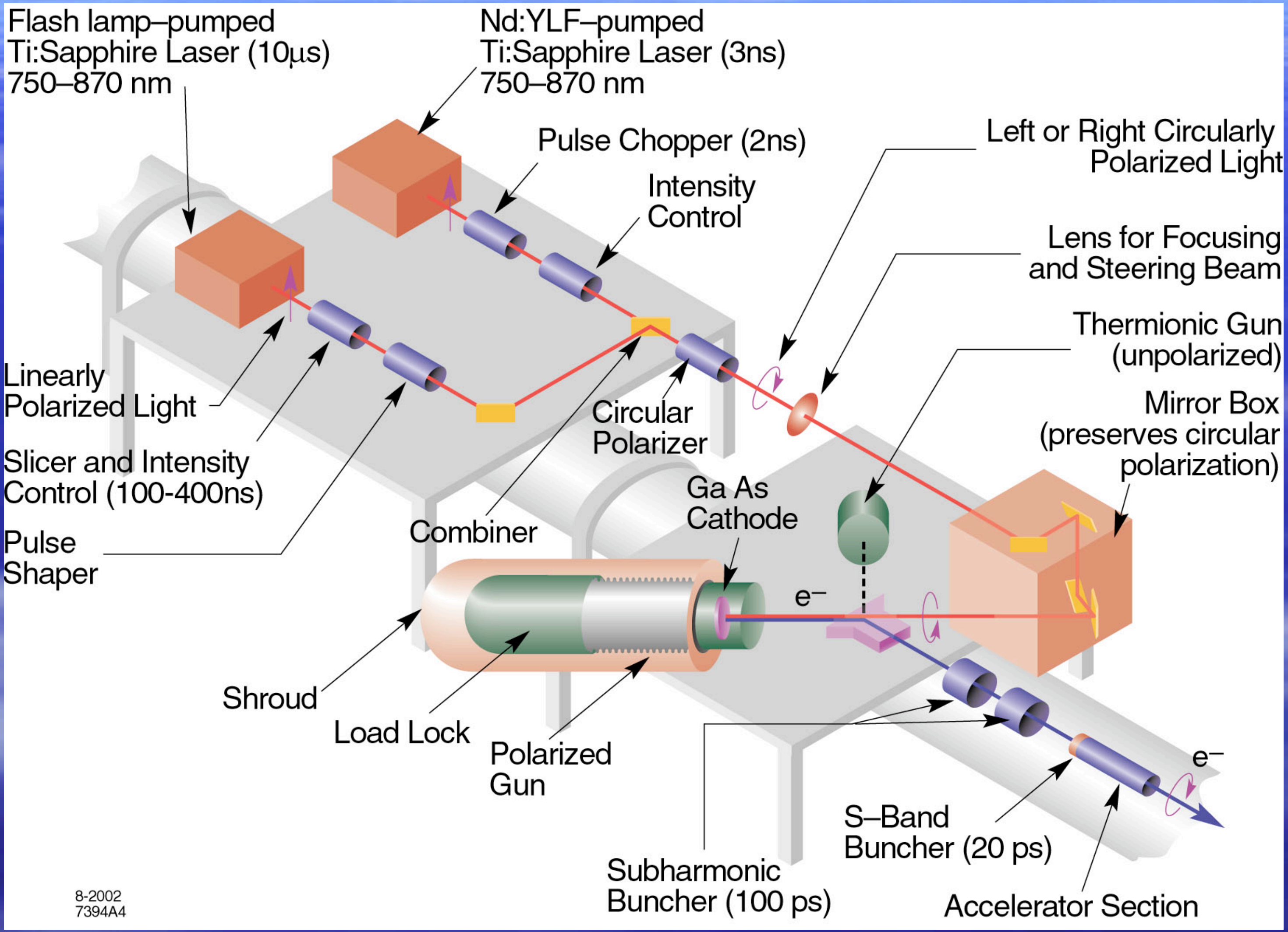
SuperB at LNF with collider hall in the LNF side



Injector

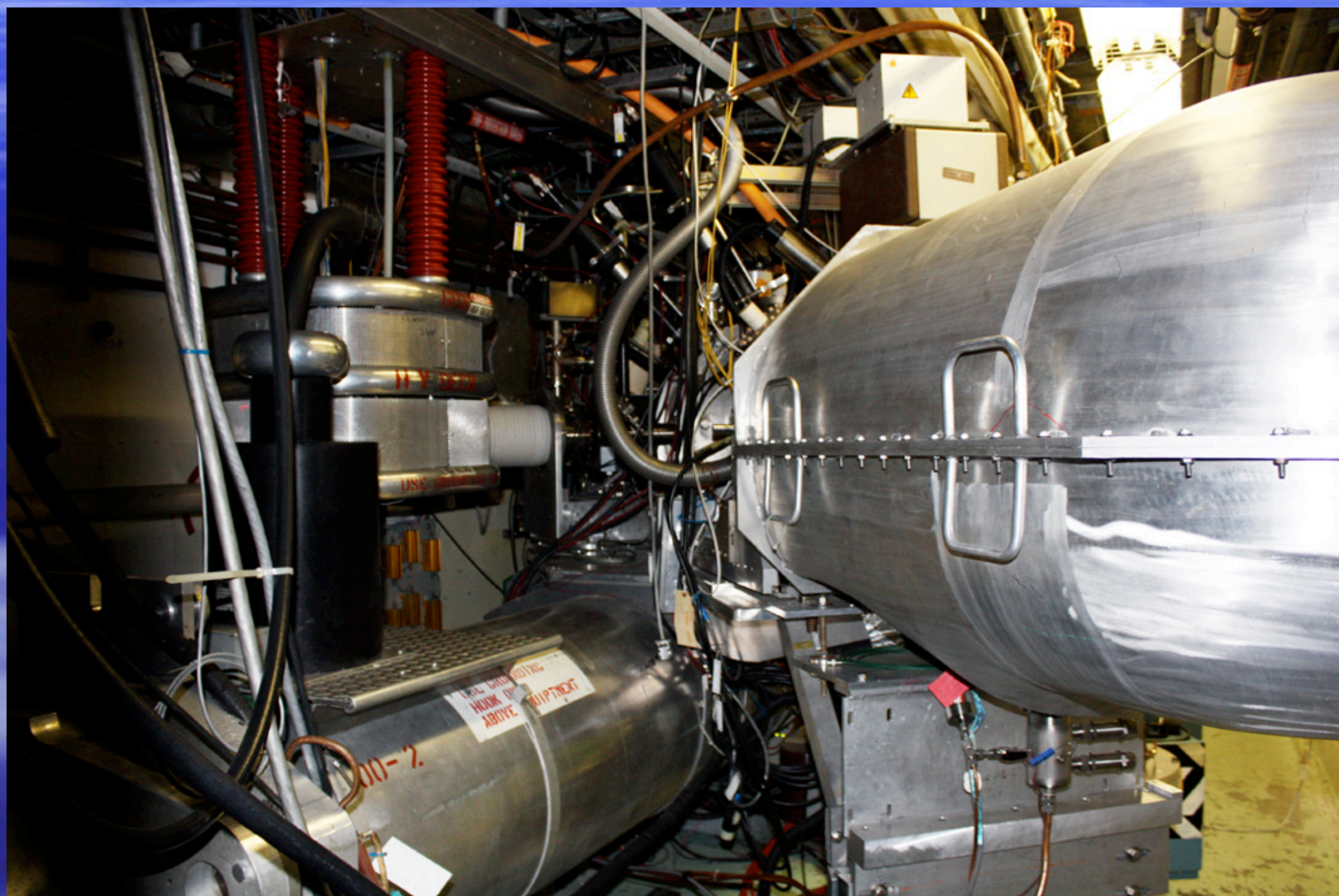
Brachmann

Polarized source layout (CID injector)



Brachmann

Walk through the Source - Gun



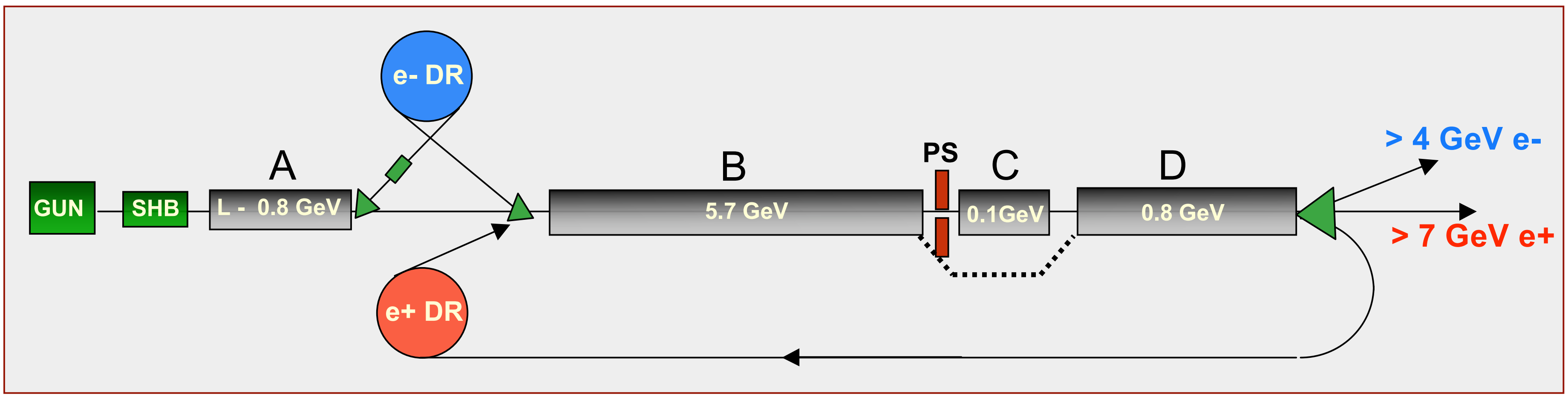
Boni et al.

STATUS OF THE THOUGHTS ABOUT THE INJECTION SYSTEM
(*oct. 2009*)

Injection process in 3 phases, to avoid simultaneous acceleration of *high-charge e- bunches* and *damped e+ bunches* in the linac B.

No fast kickers required

Rings filled every 60 msec (16.66 Hz)



R.Boni, S.Guiducci, M.Preger, J.Seeman,

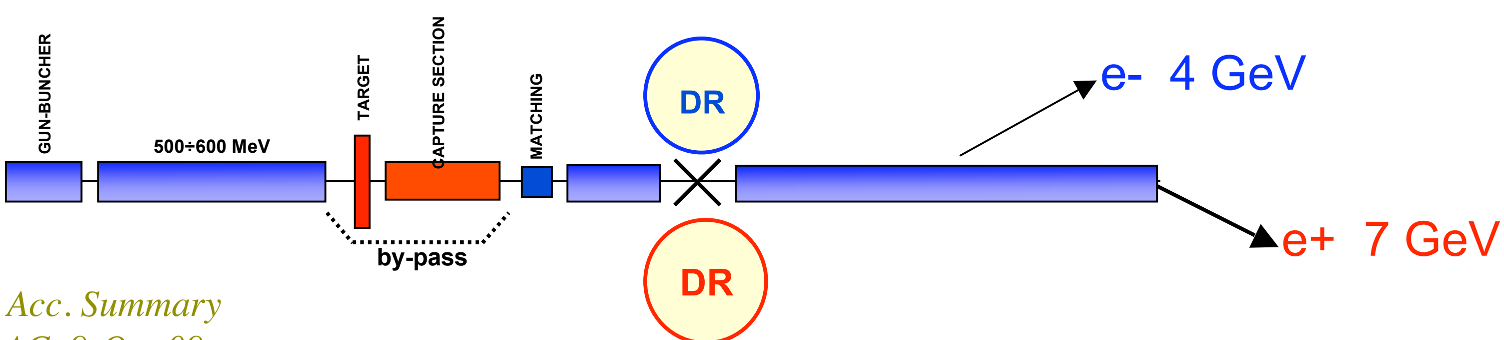
LATEST PROPOSAL FROM IN2P3 GROUP
(A.Variola & c.)

- # To perform e-/e+ conversion at lower energy, i.e. 500÷600 MeV instead of 3 GeV

- # They claim it is possible to produce enough positrons at much lower energy with a careful design of the matching system (focusing+capture section) after the target

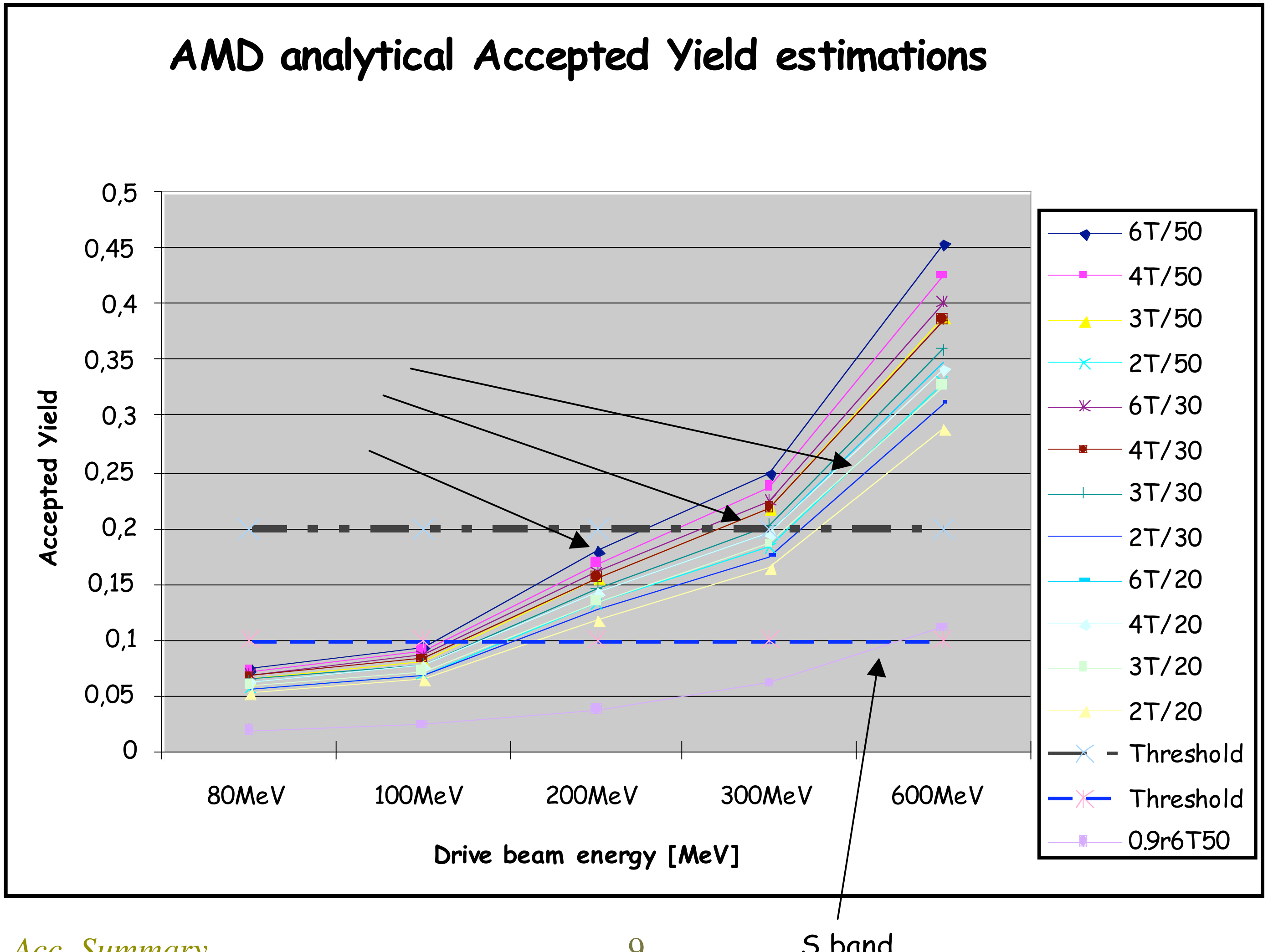
- # They made simulations that are presented apart (*see Variola slides*)

- # **Re-circulation not necessary; rings injection rate: 40 msec**



Analytical estimations (dependents from arbitrary, AMD length and field scan

Variola et al.



Lattice & DA

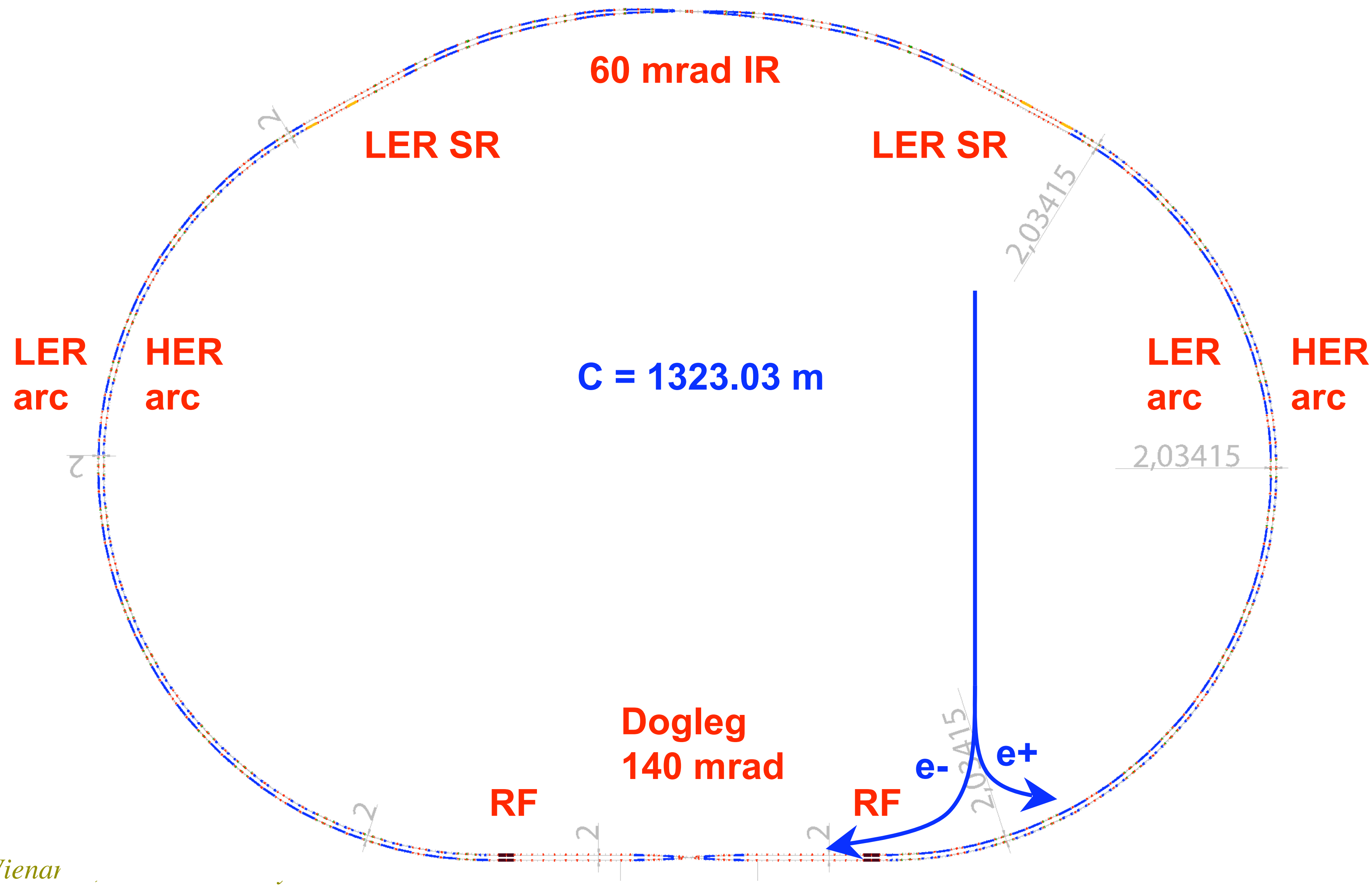
Major Lattice Changes (compared to TorVergata)

Nosochkov et al.

- 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~~. (≈17 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.

Nosochkov et al.

Latest Ring Layout



Correction by additional sextupole pair

Levichev et al.

$$x_1 = -x_0 - \frac{B_1(S_1,S_2,k)}{12}\left(x_0^3 + x_0 y_0^2\right)L^4$$

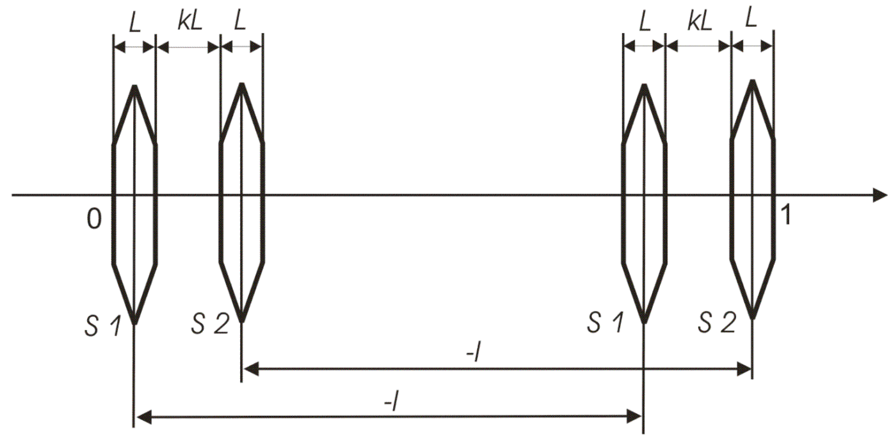
$$p_{x1} = -\frac{B_2(S_1,S_2k)}{6}\left(x_0^3 + x_0 y_0^2\right)L^3$$

$$y_1 = -y_0 - \frac{B_1(S_1,S_2,k)}{12}\left(y_0^3 + x_0^2 y_0\right)L^4$$

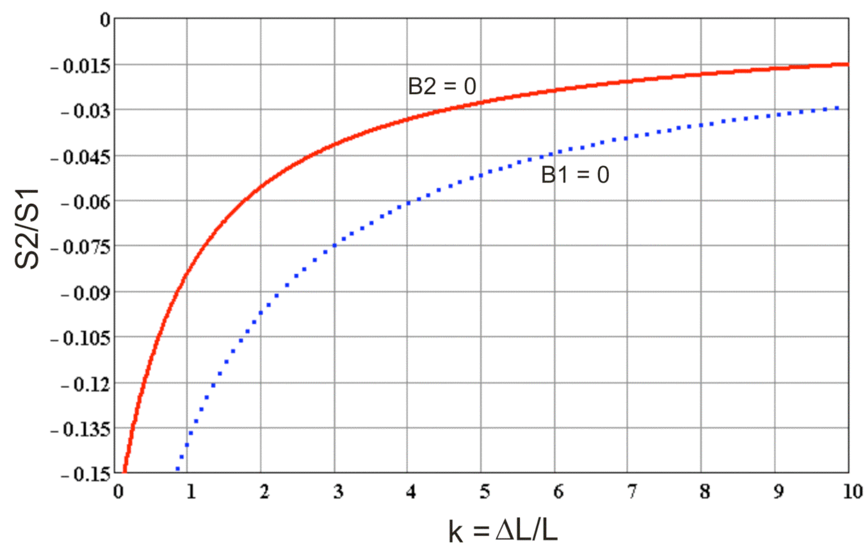
$$p_{y1} = -\frac{B_2(S_1,S_2k)}{6}\left(y_0^3 + x_0^2 y_0\right)L^3$$

$$B_1(S_1,S_2,k) = (3+2k)S_1^2 + 6\left(2+3k+k^2\right)S_1S_2 + S_2^2$$

$$B_2(S_1,S_2,k) = S_1^2 + 6(1+k)S_1S_2 + S_2^2$$



This quadratic equations are incompatible and have no common root. But, fortunately, if we set to zero one coefficient, the second reduces by 3-5 times.

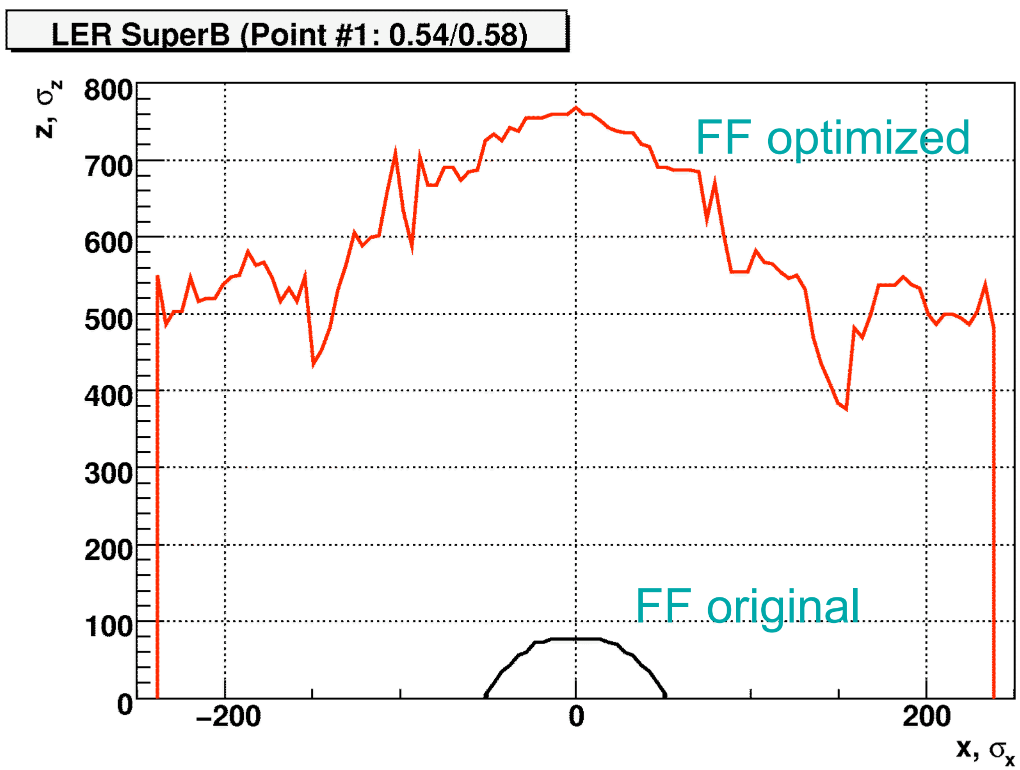


The strength of the correction sextupole is ~5-10% of the main one dependently on the distance between the sextupoles

Levichev et al.

FF 4D dynamic aperture

All sextupoles in the arcs are switched off.
The black curve shows original DA (50 sigma_x X 80 sigma_y)
The red curve shows DA optimized by correction sextupoles (250 sigma_x X 750 sigma_y)



Polarization

Slicktrack Result (SB418 29-Jly)

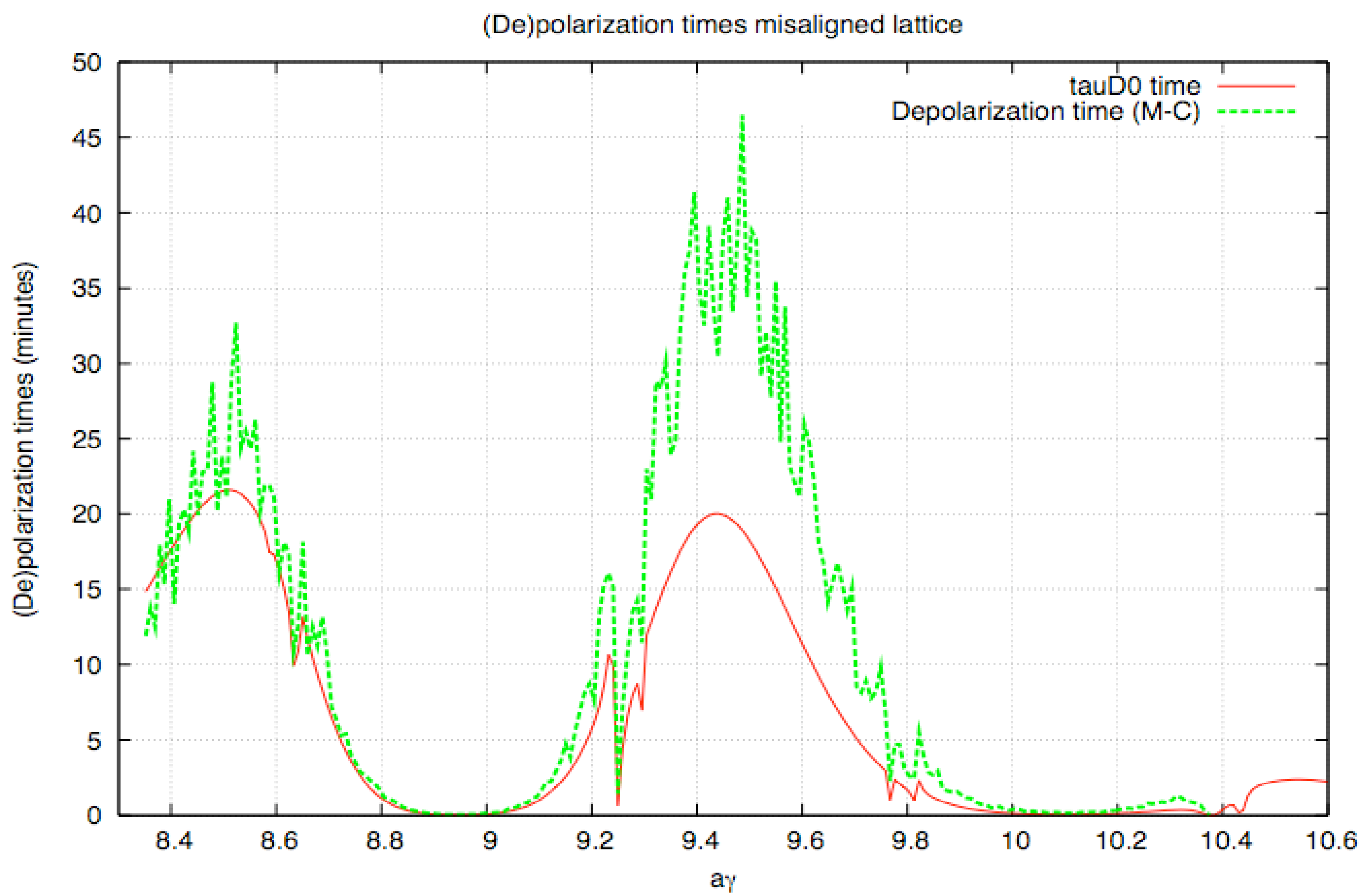
$\varepsilon_x \approx 1.7$ nmr

$\varepsilon_y \approx 1$ nmr(!)

$\nu_x = 0.69$

$\nu_y = 0.73$

shorter time mostly due to shorter dipoles



Siberian Snake estimation

Nikitin et al.

1. **Classical Siberian Snake with "π" spin rotation around velocity**

Spin-Orbit coupling: $\left\langle \gamma \left(\frac{\partial \vec{n}}{\partial \gamma} \right)^2 \right\rangle \approx \frac{\pi^2 \nu^2}{3} \left(1 + \frac{3}{4} \frac{\sin^2 \pi\nu}{\nu^2} \right)$

$\nu = \frac{E[MeV]}{440.65} = 9.5$ at $E = 4.18$ GeV $\rightarrow \left\langle \gamma \left(\frac{\partial \vec{n}}{\partial \gamma} \right)^2 \right\rangle \approx 300$

Depolarization time: $\tau_{dep} \approx \frac{\tau_0}{1 + \frac{11}{18} \left\langle \gamma \left(\frac{\partial \vec{n}}{\partial \gamma} \right)^2 \right\rangle} \simeq \frac{\tau_0}{181} = 1.3\,\text{min}$

Radiative polarization time (no snakes): $\tau_0 \approx 2.74 \times 10^{-2} \frac{\rho^2 R}{E^5} \simeq 4$ hr (LER: $\rho = 29$ m, $R = 211$ m)

"Fast kicker injection" (Raimondi) with τ_i=40 sec period: a final degree ~ exp(- τ_i / τ_{dep}) $\simeq 0.6 \cdot P_0$

Nearly good. Increase of τ_0 is desired.

2. **"π/2" Siberian snake** at $\nu = (2k+1)/2$ values

Longitudinal projection at I.P.: $n_{\parallel} = \frac{\sqrt{2}}{2}$

Spin-Orbit coupling: $\left\langle \gamma \left(\frac{\partial \vec{n}}{\partial \gamma} \right)^2 \right\rangle \approx \frac{\pi^2 \nu^2}{6} + \frac{\pi^2}{16} \approx 150 \rightarrow \tau_{dep} \simeq 2.6$ min

a polarization degree at the end of cycle $\propto 0.77 \cdot P_0 \cdot n_{\parallel}$

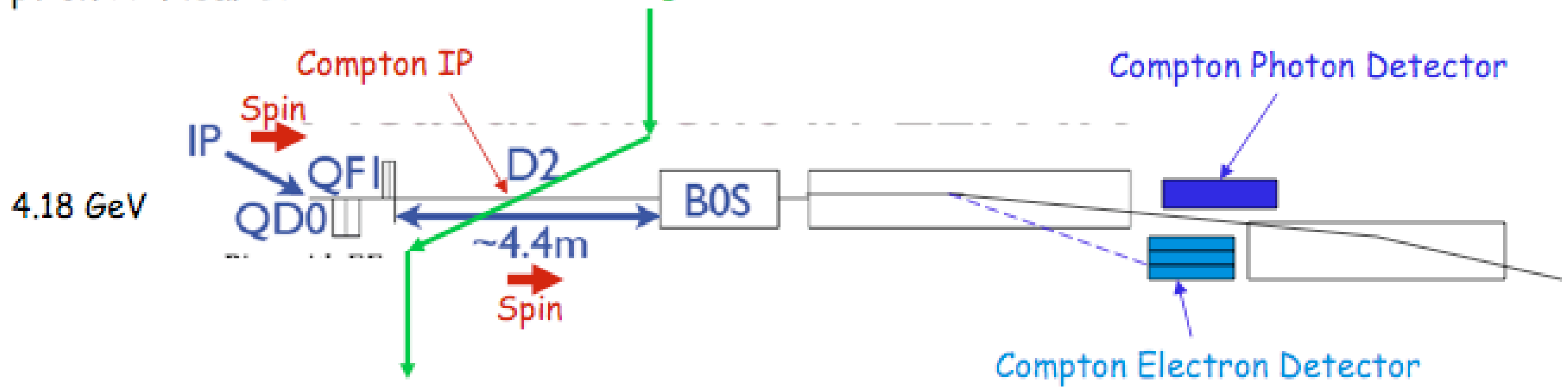
It is not worth the trouble!

3. **Radical increase of τ_0 by a factor of 10:**
reciprocation of the LER (ρ=29 m) and HER (ρ=85 m) arc magnets

Moffeit et al.

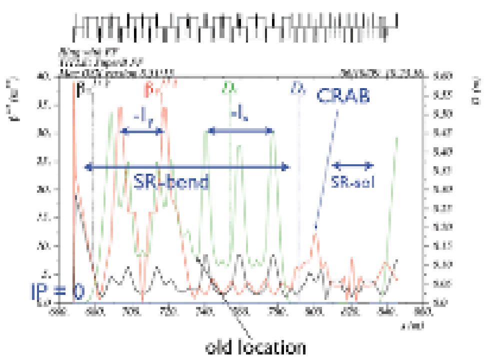
Compton Polarimeter

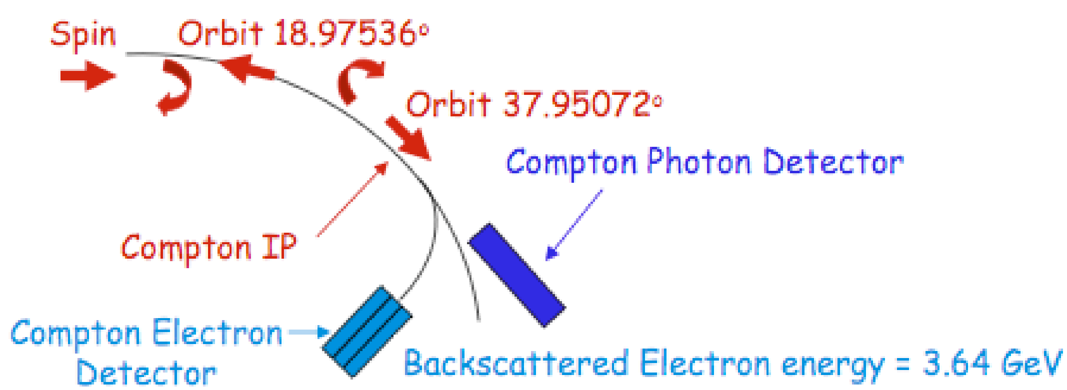
Option A: Near IP



Pros: Near IR   Cons: Beam size large. Backgrounds from beamstrahlung large. Crossing angle ~50 mrad.

Option B: Compton IP after n*pi spin rotations between IP and solenoid section



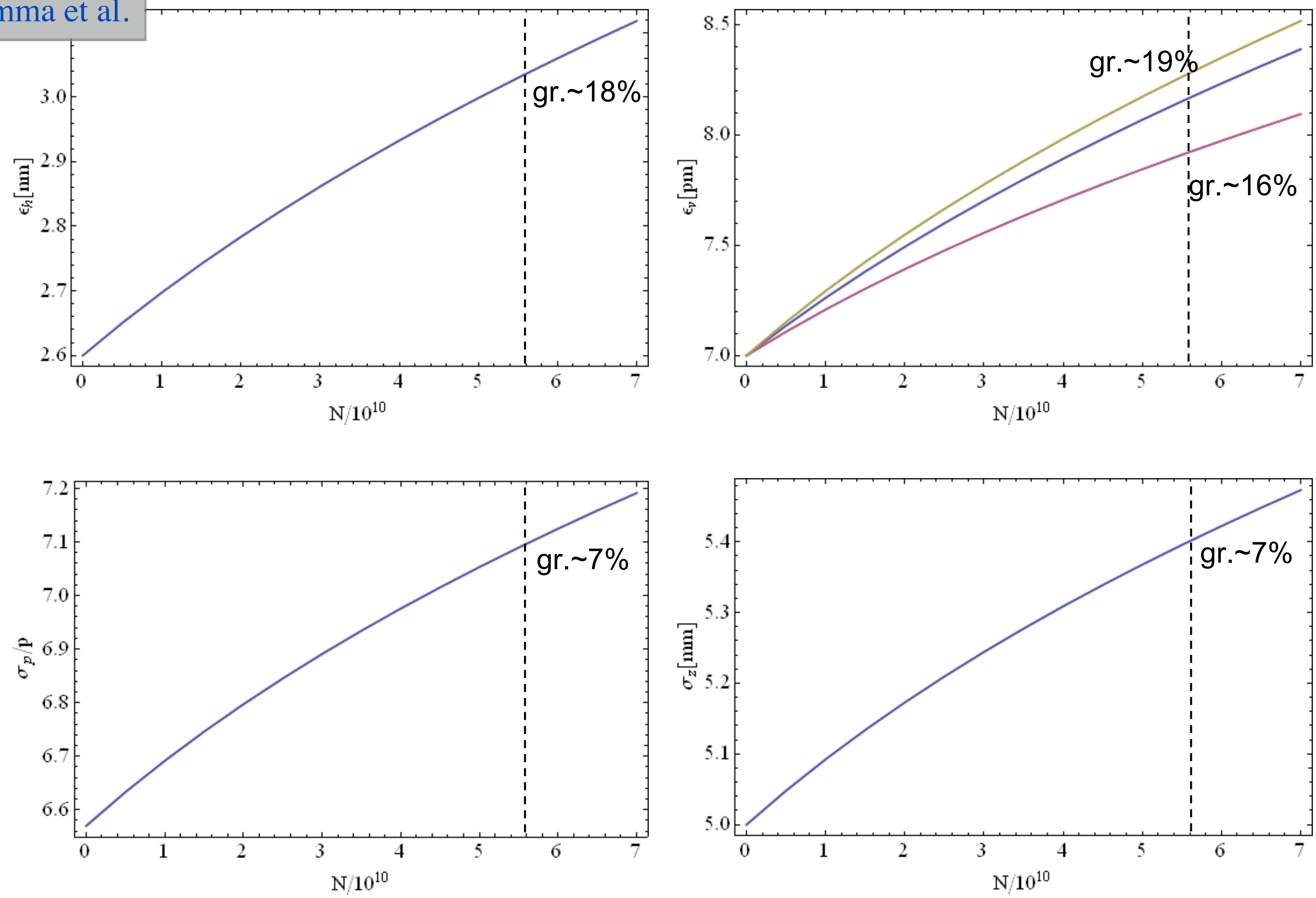


Pros: Beam size small~100μm. Backgrounds small. Smaller Compton Crossing angle due to larger spacing for Compton IP.   Cons: After n*pi spin rotations Systematic error due to uncertainty in n*pi spin rotations between IP and Compton IP. Uncertainty in electron beam orbit angle < 2.983 mrad

IBS, e-Cloud, Beam-Beam

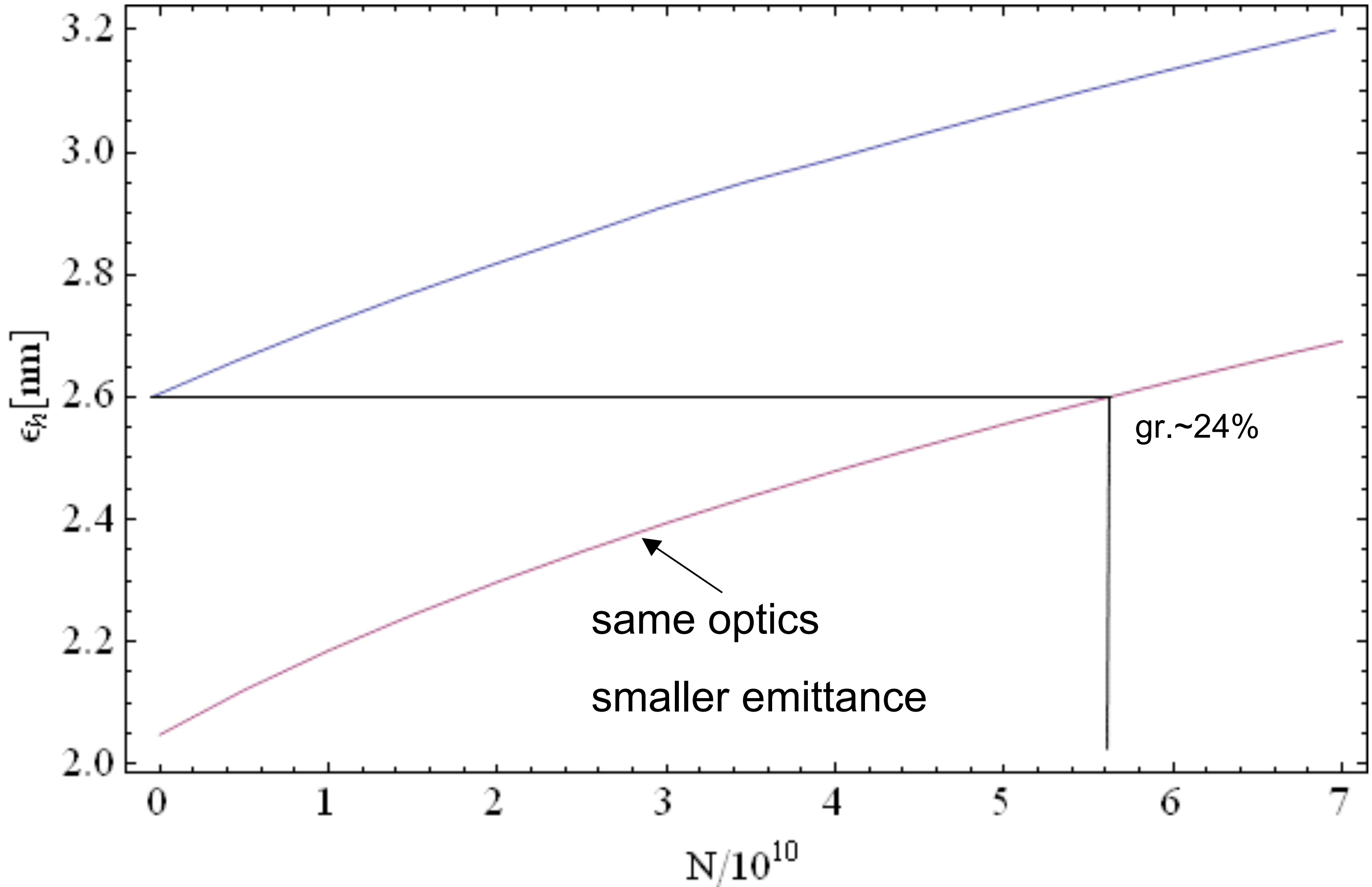
IBS in SuperB LER Sep.09 configuration

Demma et al.



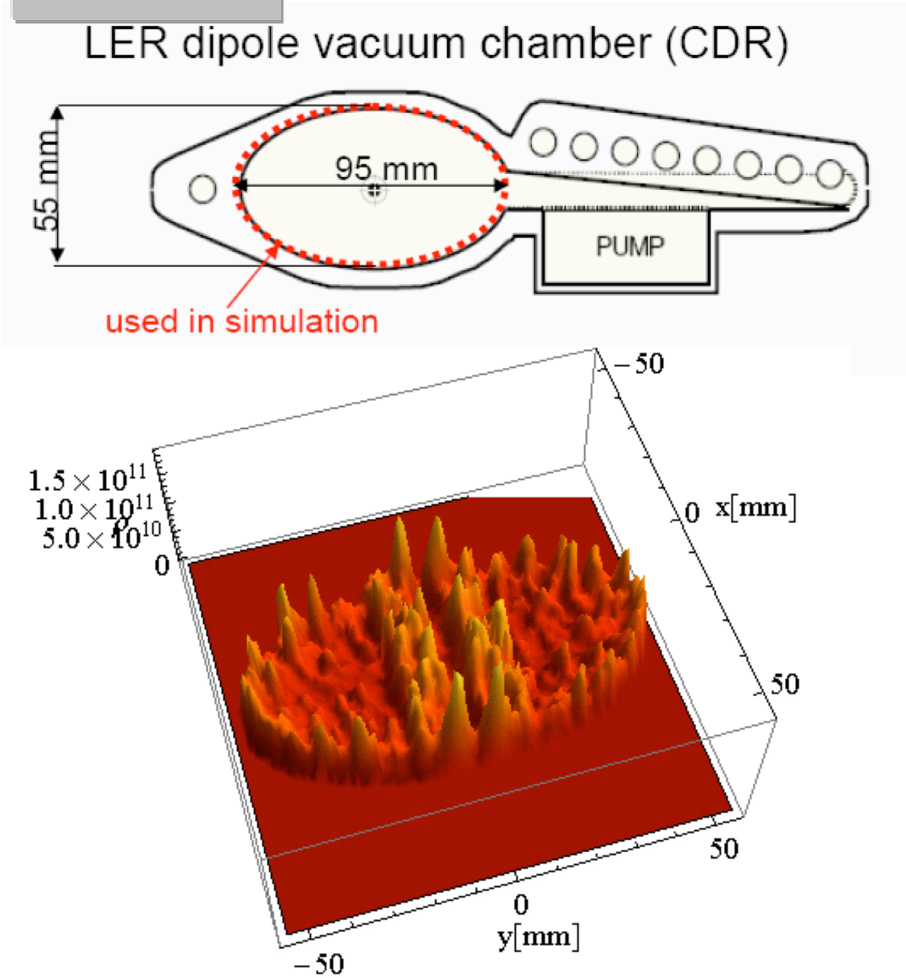
Recovering nominal emittance in LER

Demma et al.



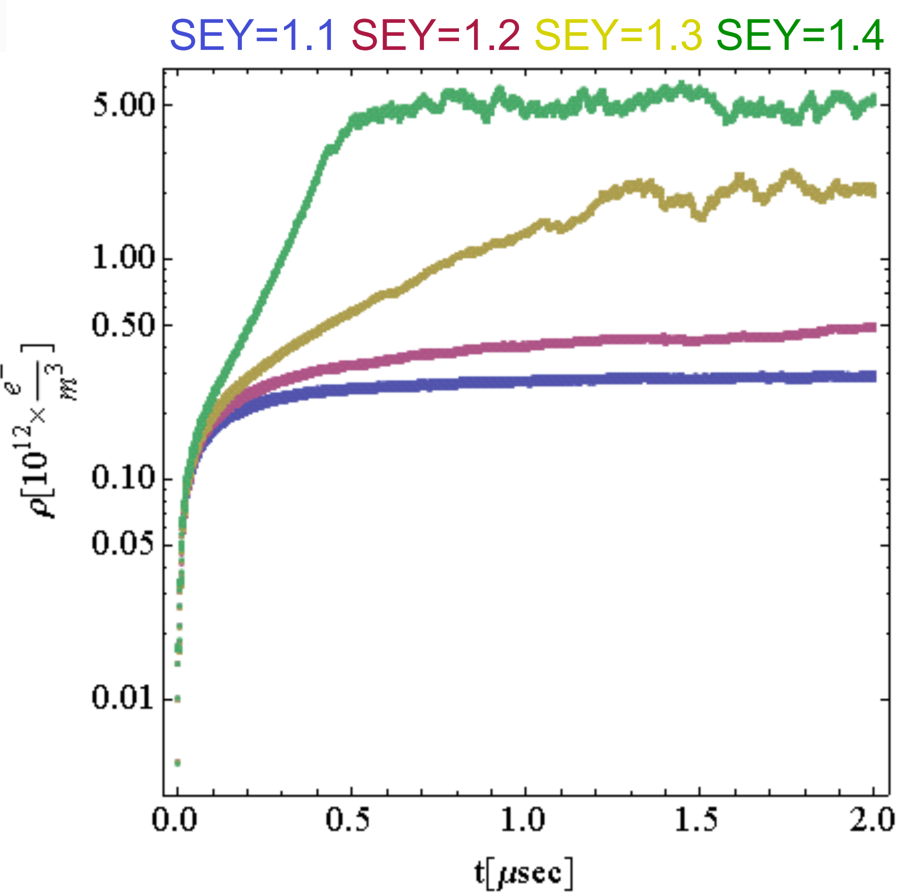
Buildup in the SuperB arcs: Dipoles

Demma et al.



Snapshot of the electron (x,y) distribution
"just before" the passage of the last bunch

By=0.3 T; η=95%



Head-Tail Instability Threshold

Demma et al.

		June 2008		January 2009		March 2009		LNF conf.
		ρ_{int} [$10^{15}m^{-2}$] solenoids	ρ_{int} [$10^{15}m^{-2}$] no solenoids	ρ_{int} [$10^{15}m^{-2}$] solenoids	ρ_{int} [$10^{15}m^{-2}$] no solenoids	ρ_{int} [$10^{15}m^{-2}$] solenoids	ρ_{int} [$10^{15}m^{-2}$] no solenoids	ρ_{int} [$10^{15}m^{-2}$] solenoids
SEY=1.1	95%	0.06	2.1	0.09	2.5	0.22	2.7	0.1
	99%	0.02	0.25	0.04	0.3	0.04	0.7	0.07
SEY=1.2	95%	0.22	2.8	0.27	3.2	0.45	6.5	0.3
	99%	0.045	0.71	0.06	0.82	0.07	2.4	0.1
SEY=1.3	95%	2.7	20.2	2.9	25.7	5.4	25	2.0
	99%	0.94	3.2	1.3	4.1	4.5	13	0.7

Instability occurs if:

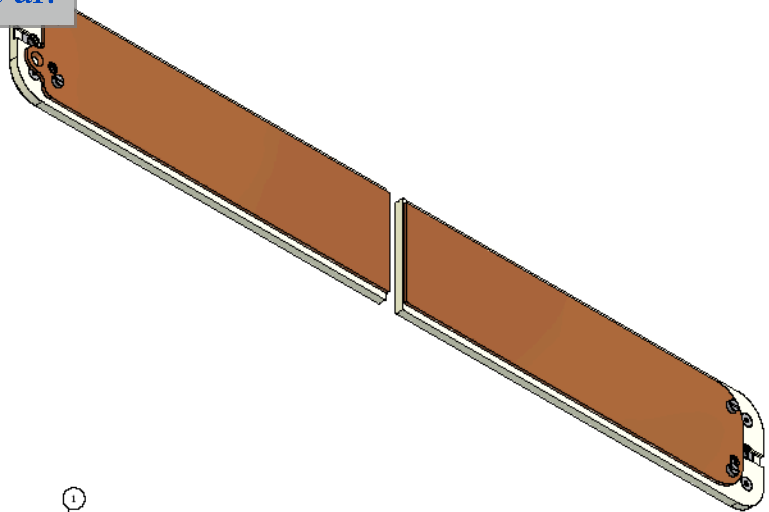
$$\rho_{\text{int}} = \int_{drift} \rho_{cent.} ds + \int_{dipoles} \rho_{cent.} ds + \int_{quads} \rho_{cent.} ds \geq \int_{L_{tot}} \rho_{e,th} ds = \begin{matrix} 0.9 \times 10^{15} m^{-2} \\ 0.5 \times 10^{15} m^{-2} \end{matrix}$$

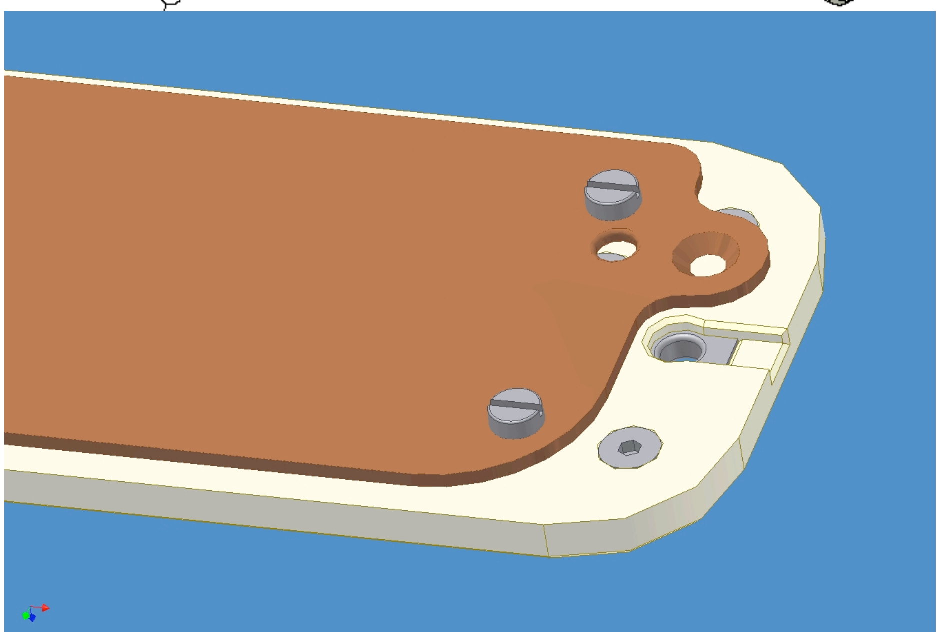
where $\rho_{cent.}$ and $\rho_{e,th}$ are obtained from simulations.

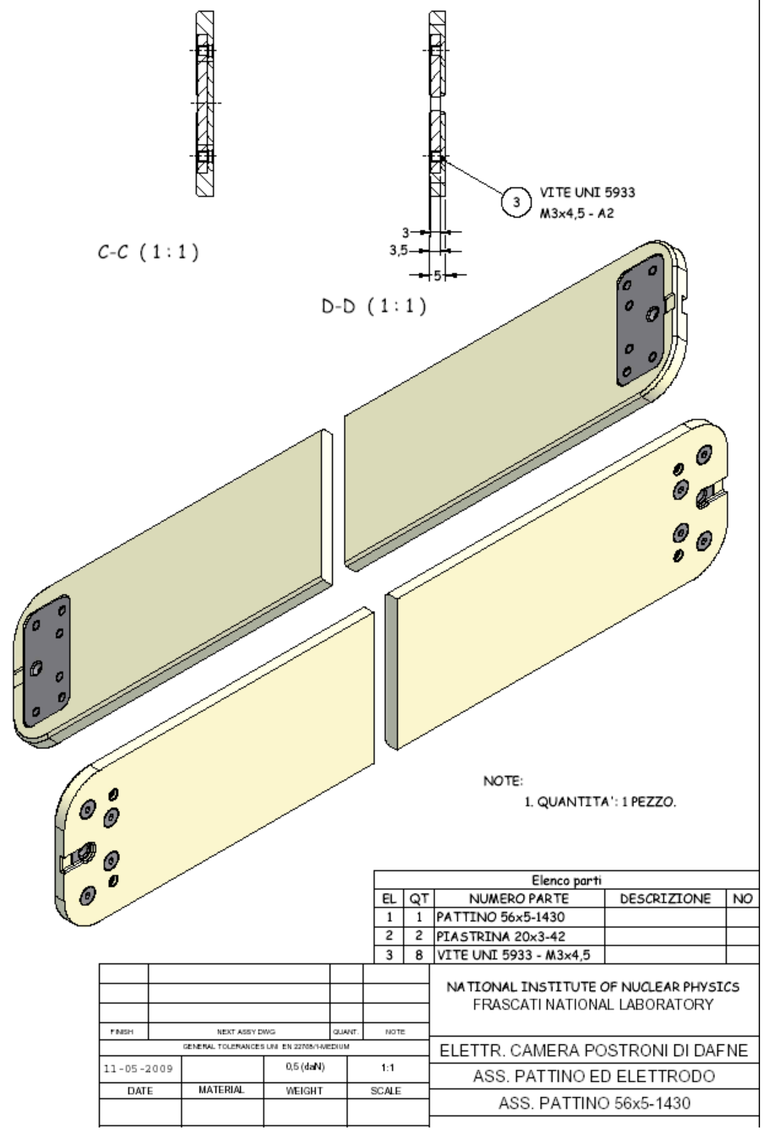
LNF conf.

Clearing Electrodes for DAFNE

Demma et al.



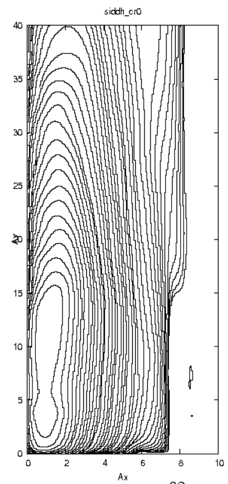
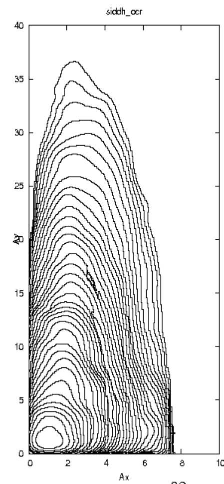
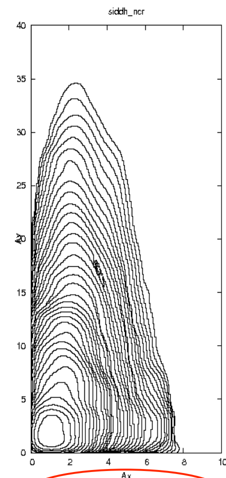
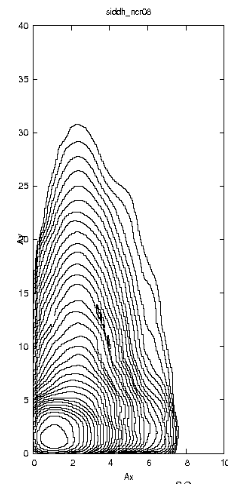
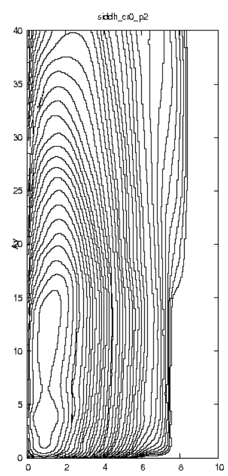
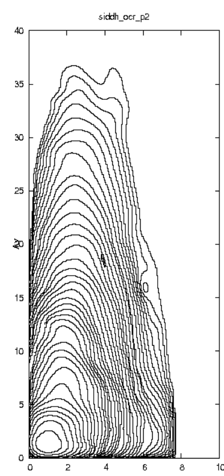
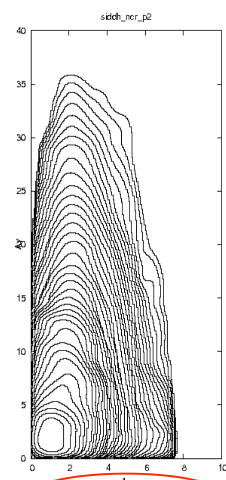
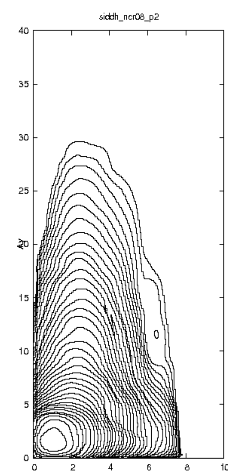


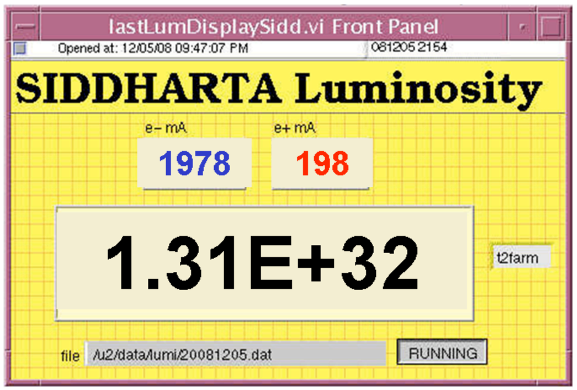


D.Alesini, A.Battisti, R. Sorchetti, V. Lollo (LNF)

Weak-Strong Simulations vs. Experiment

Shatilov et al.

	Crab OFF	Old program	New program	Optimal Crab
	Gauss vs. Gauss	Gauss vs. Crab=0.5	Crab=0.5 vs. Crab=0.5	Crab=0.8 vs. Crab=0.8
(experiment, 2008-12-05)	 $L = 0.47 \cdot 10^{32}$	 $L = 1.75 \cdot 10^{32}$	 $L = 1.54 \cdot 10^{32}$	 $L = 1.86 \cdot 10^{32}$
(experiment, 2009-05-28)	 $L = 0.47 \cdot 10^{32}$	 $L = 1.59 \cdot 10^{32}$	 $L = 1.36 \cdot 10^{32}$	 $L = 1.67 \cdot 10^{32}$



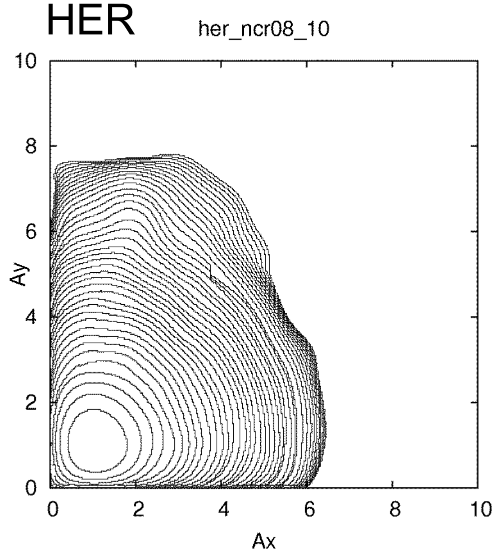
Simulations for SuperB with Linear Lattice

Shatilov et al.

Due to asymmetry in emittances and beta-functions between HER and LER the optimum "crab" values are different: **0.8** for HER and **1.0** for LER.

The designed tune shifts are rather small: $\xi_y < 0.12$, so there is now blowup, but the effect of dynamic beta exists. Plus the geometric luminosity gain due to crab… As a result, the luminosity becomes even higher than the designed value: $\mathbf{L \approx 1.07 \cdot 10^{36}}$ instead of $1.02 \cdot 10^{36}$.

HER

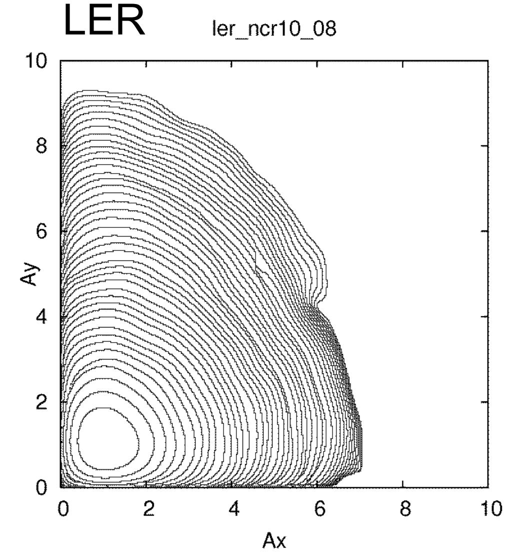


Tunes: (0.542, 0.580, 0.01)

$N_p = 5.74 \cdot 10^{10}$

$N_b = 1011$

LER



The next step: simulations with the real lattice (sextupoles, etc.). It will be done as soon as the lattice will be finalized and optimized for DA.

Rf, HOM

Novokhatski et al.

Super-B RF: Supply power 2009 in Frascati in July

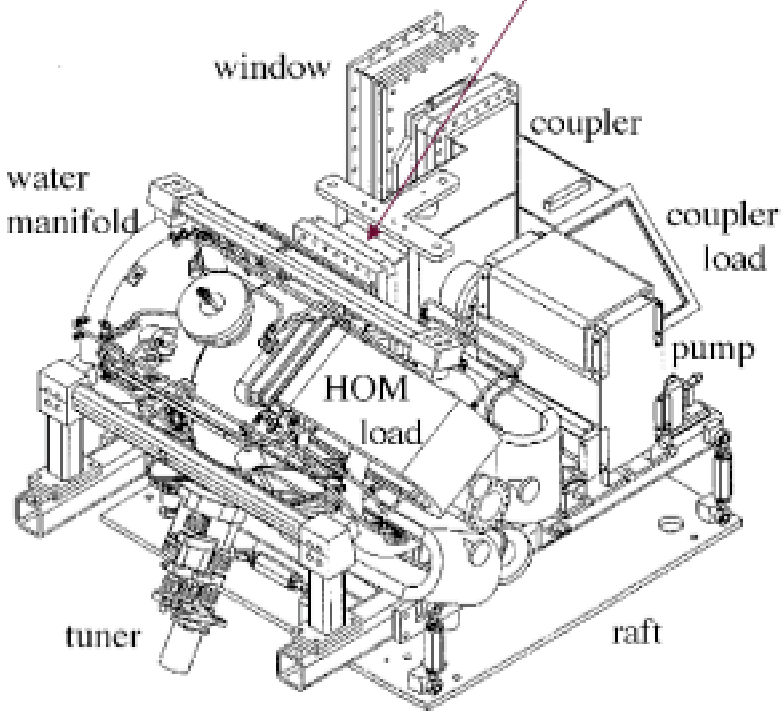
Changing coupling from 3.6 to 7.0

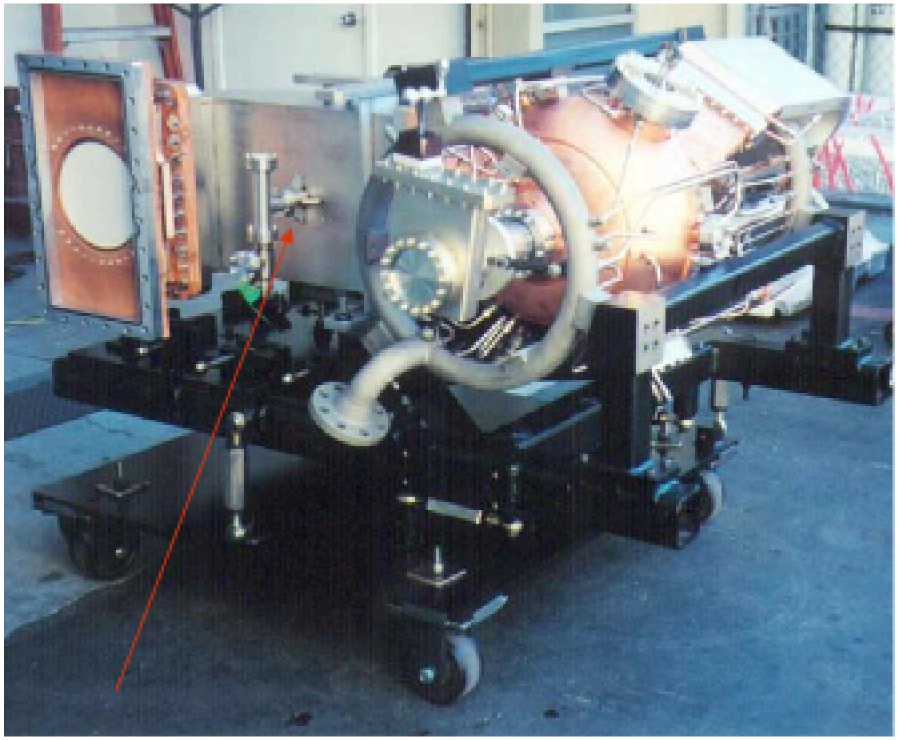
Sasha Novokhatski "RF/Impedance"

HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER+
			S.R. energy			Total	Zero I		Max	Number			Total	Total	Total	Power for	LER
Lumi	Beam	Beam	loss	Momen-	Momen-	RF	Bunch	Bunch	voltage	of	S.R.	HOM	cavity	reflected	forward	one	Total
	energy	current	per turn	tum com-	tum	voltage	length	spacing	per cavity	cavities	power	power	loss	power	power	cavity	forward
	GeV	A	MeV	paction	spread	MV	mm	nsec	MV	klystro	MW	MW	MW	MW	MW	MW	MW
1E+36	6.7	2.12	2.03	4.0E-04	6.2E-04	5.7	5.0	4.2	0.4	14	4.3036	0.4611	0.58	0.2858	5.63	0.40	8.53
										7							
1E+36	6.7	2.12	2.03	4.0E-04	6.2E-04	7	4.5	4.2	0.5	14	4.3036	0.5411	0.875	0.0299	5.75	0.41	8.84
										7							

LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	HER+ LER
			S.R. energy			Total	Zero I		Max	Number			Total	Total	Total	Power for	Supply
Lumi	Beam	Beam	loss	Momen-	Momen-	RF	Bunch	Bunch	voltage	of	S.R.	HOM	cavity	reflected	forward	one	Power
	energy	current	per turn	tum com-	tum	voltage	length	spacing	per cavity	cavities	power	power	loss	power	power	cavity	eff.~50%
	GeV	A	MeV	paction	spread	MV	mm	nsec	MV	klystro	MW	MW	MW	MW	MW	MW	MW
1E+36	4.18	2.12	0.83	4.2E-04	6.6E-04	4.1	5.0	4.2	0.65	6	1.7596	0.3836	0.7	0.0533	2.90	0.48	17.05
										3							
1E+36	4.18	2.12	0.83	4.2E-04	6.6E-04	5	4.5	4.2	0.65	8	1.7596	0.4694	0.781	0.0763	3.09	0.39	17.67
										4							

We may disconnect a coupler box

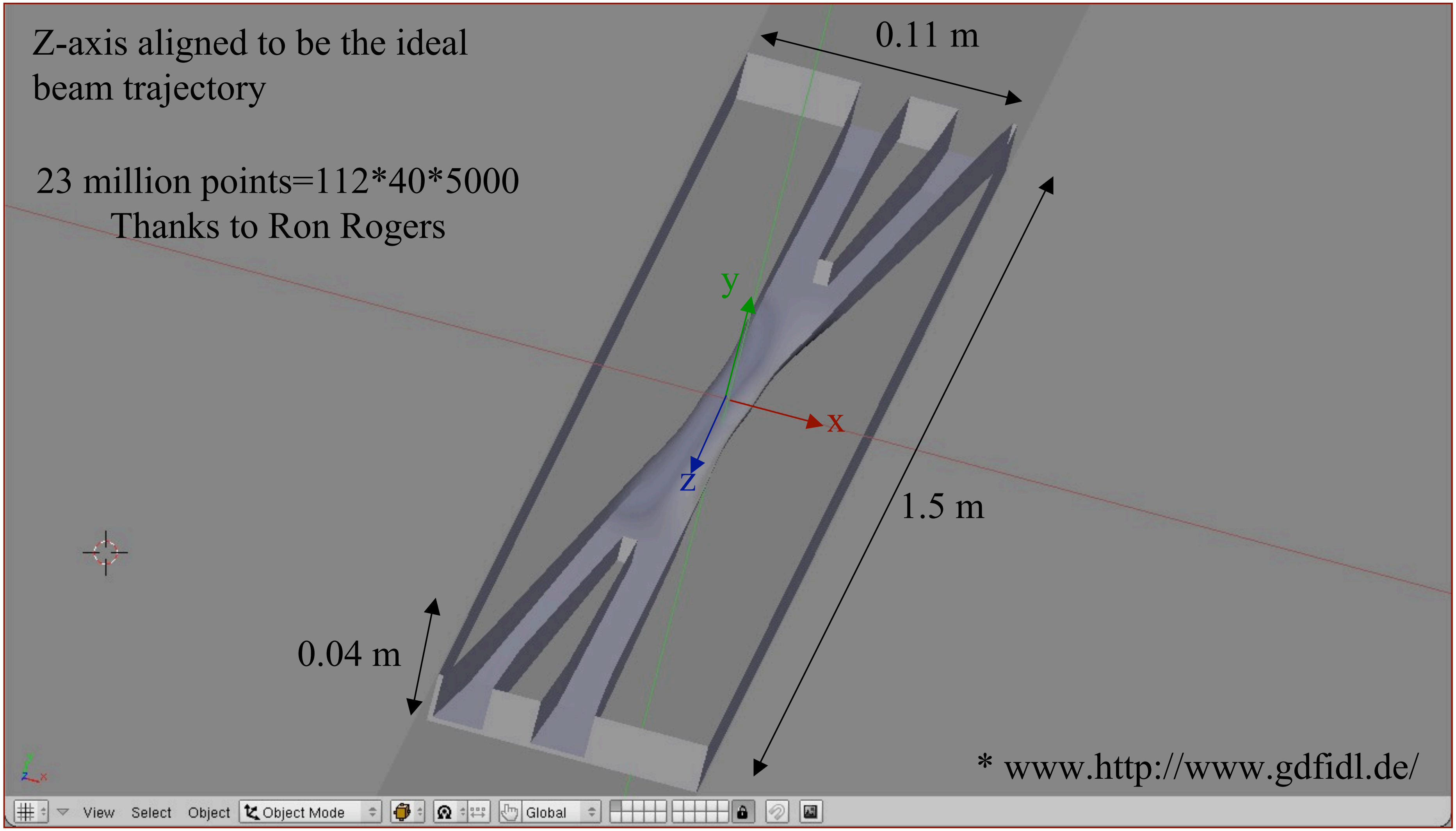




Coupler box

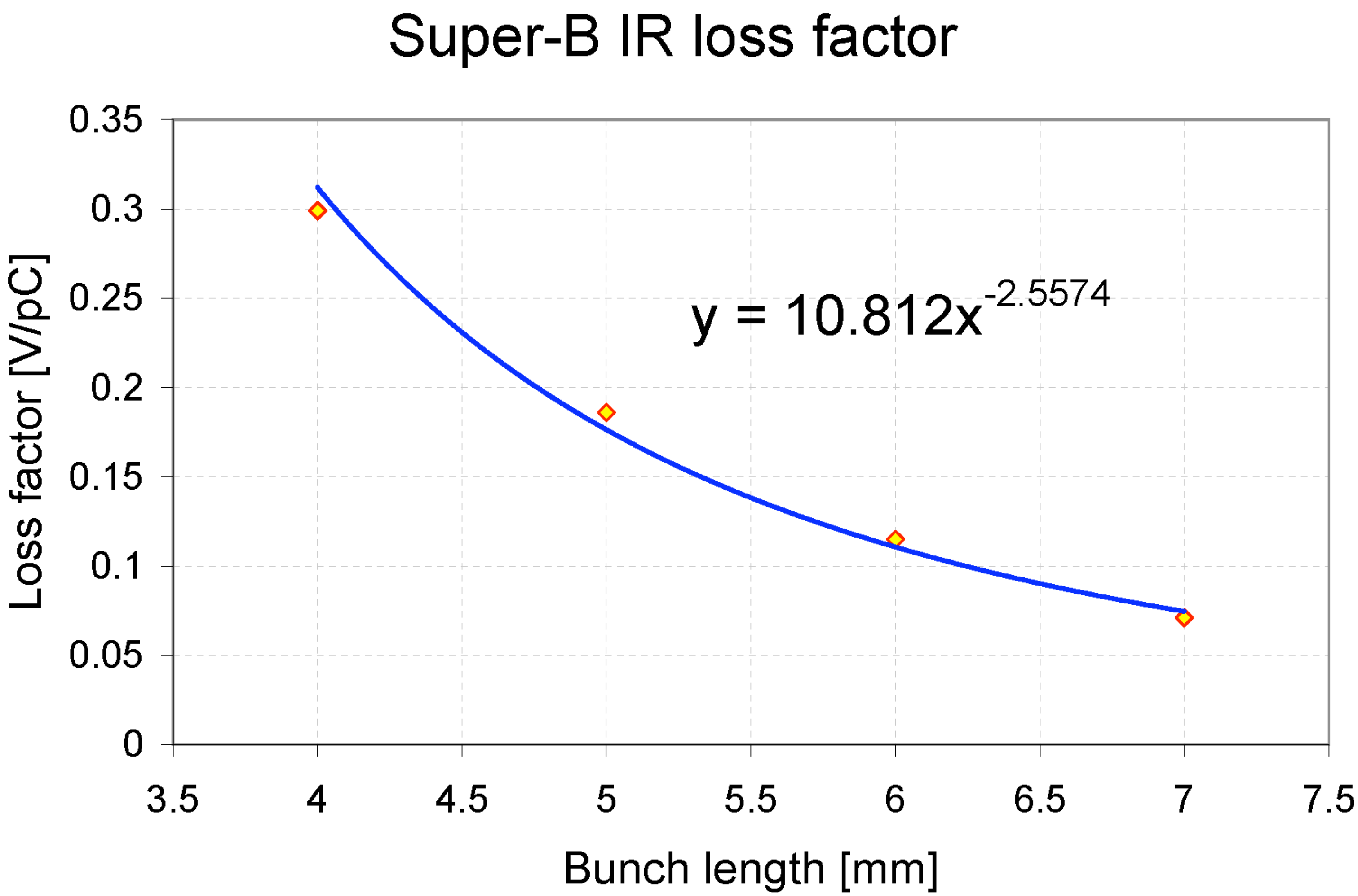
Model for Gdfidl*

Wheathersby et al.



Loss factor and bunch length

Wheathersby et al.



Vibrations

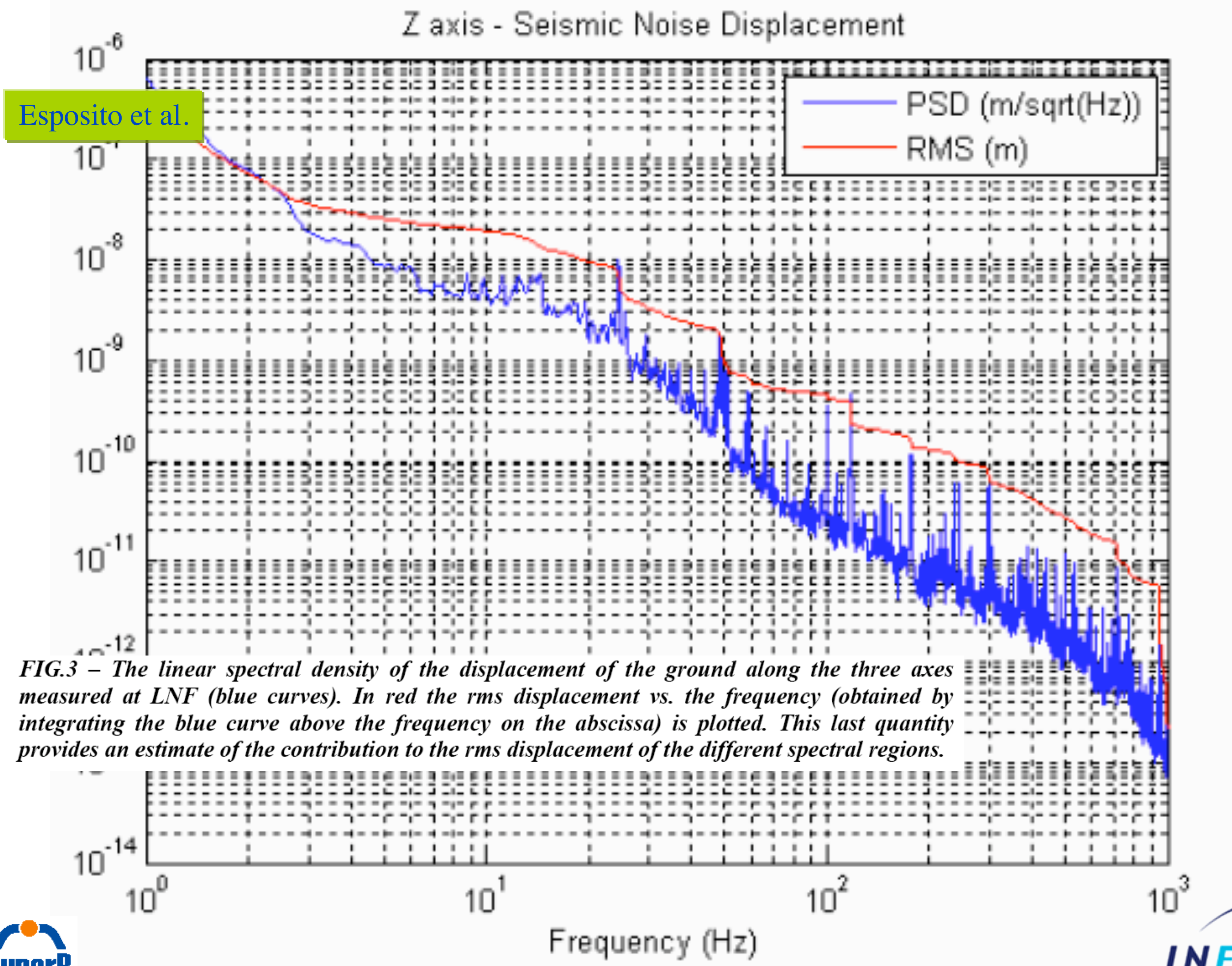
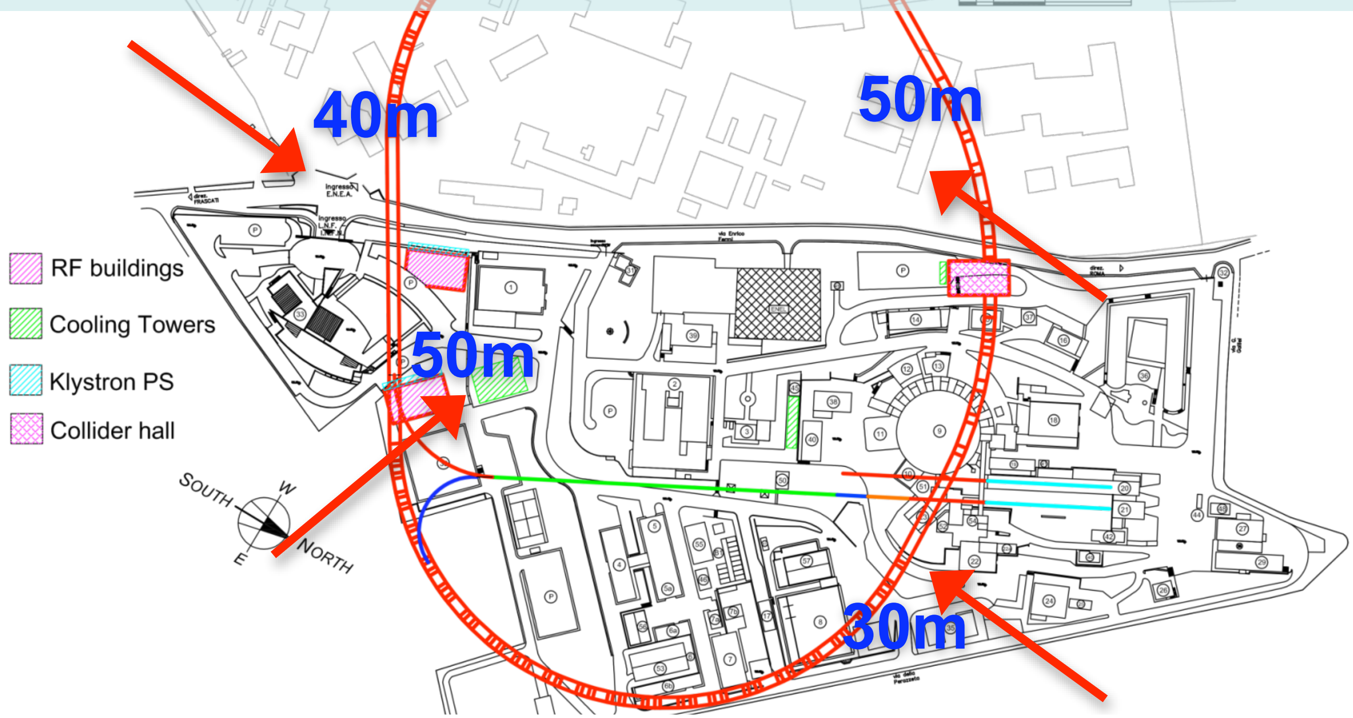


FIG.3 – The linear spectral density of the displacement of the ground along the three axes measured at LNF (blue curves). In red the rms displacement vs. the frequency (obtained by integrating the blue curve above the frequency on the abscissa) is plotted. This last quantity provides an estimate of the contribution to the rms displacement of the different spectral regions.

Underground Measurements

Esposito et al.

- On September 14th the first campaign of geological tests started at LNF site: 4 holes of different depth have been bored in the points shown below. Each hole was tubed with a plastic pipe with an inner bore of about 70mm.
- A second campaign of other four-five holes is foreseen soon
- **These holes will also be used for underground vibration measurements**



White Paper, Conclusions

Biagini et al.

What → Who

- Chapters easily updated:
  - Overview → Seeman
  - Layout → Biagini,Raimondi
  - IR + QD0 + backgrounds → Sullivan, Raimondi, Paoloni, Boscolo, Bettoni
  - Lattice → Raimondi, Biagini, Siniatkin, Nosochkov, Yocky, Wittmer
    - Tolerances + Vibrations ????
    - Emittance tuning (Yocky)
  - Intensity dependent effects (Demma, Boscolo, Novokhatski, Wienands, Seeman, Shatilov)
    - Beam beam (Shatilov)
    - Touschek lifetime (Boscolo)
    - IBS (Demma)
    - e-cloud (Demma)
    - HOM (Novokhatski)
    - Single bunhc inst (Wienands)
    - Multibunch inst (Wienands, Novokhatski)
    - Fast ion (Seeman)
    - Space charge ??
    - CSR (Novokhatski)
  - RF → Novokhatski, Bertsche
  - Injection system → Seeman, Boni, Preger, Guiducci,Variola
  - Polarization → Wienands, Nikitin
  - Feedbacks → Drago
  - Costs → Seeman
  - Operation costs → Seeman
  - Schedule → Seeman

Biagini et al.

When ?

- Deadline is December
- We can decouple the Accelerator from the Physics and the Detector sections
- We need to choose a deadline that we can actually meet
- In order to start writing everyone should stop working → we probably want to finish what we are doing before starting writing
- Since we will have a December 5-9 meeting in Frascati I propose that we start writing just after this meeting and have January 31 2010 as a deadline for the Accelerator

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**

Parameter	Units		TorVergata	LNF
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**

To-Do List

- Further beam dynamics study
  - HER emittance
  - machine acceptance
  - misalignments, emittance tuning, magnet errors…
  - ensure parameter set can be achieved
- Study flexibility in parameter space
  - How many ways to get to 10^{36}?
- Investigate hardware modifications necessary
  - esp. the rf coupling box
  - what will vacuum system look like?
- …

In Conclusion

- Good progress in defining lattices fit for the LNF/ENEA site
  - Siting remains a rather tight fit.
- IBS estimate indicates LER emittance goal can be met
- Beam dynamics & other details being worked
  - no showstoppers apparent, but constant attention needed
- Rf System will likely involve changing the rf-cavity couplers
  - not a prohibitive effort
- Proposed LLRF Collaboration with LPSC Grenoble
- Polarization remains a challenge
  - 80% will be tough to get, some scenarios hardware intensive
  - Polarimetry requires space near the IP
- "White Paper" effort being organized.