Accelerator Summary

U. Wienands, SLAC

In this summary I will focus on issues directly affecting performance parameters, at the expense of some other work, which is not to be construed as a value statement

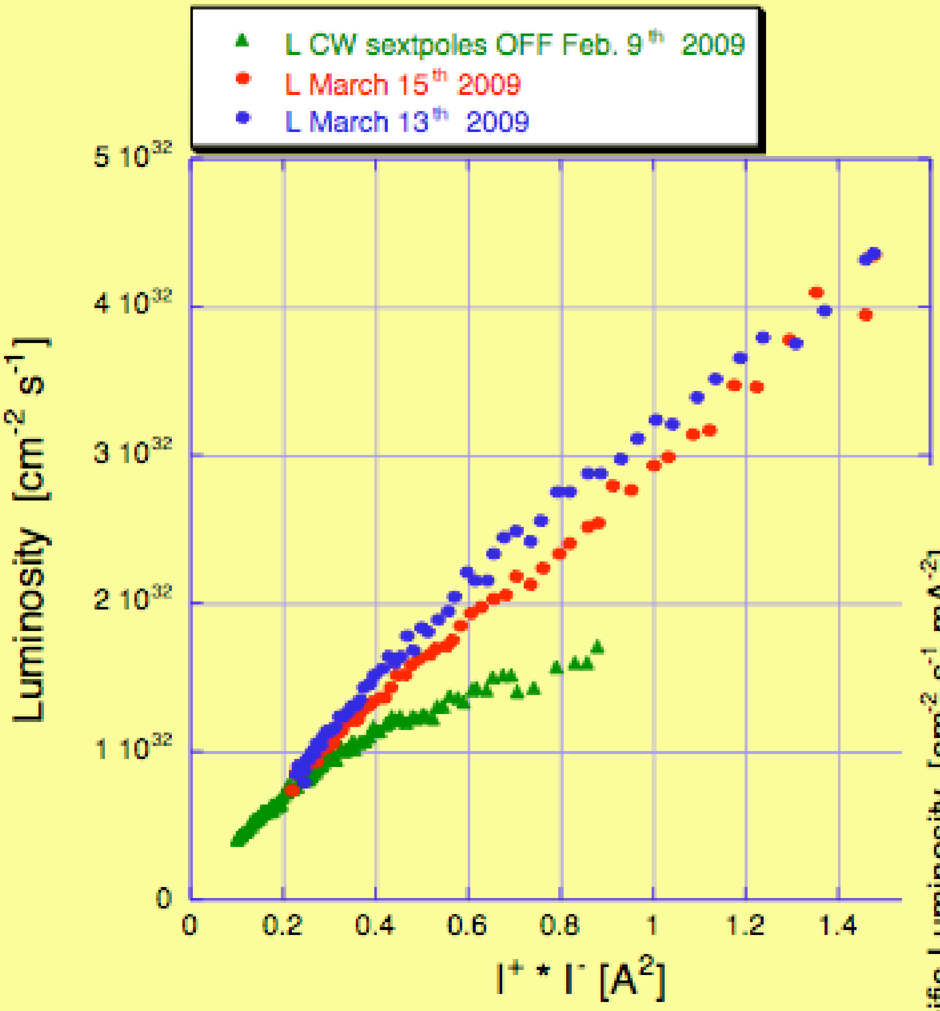
Accelerator/Storage Rings

- Tuesday & Wednesday reviewed the whole accelerator/ring design + detail aspects.
  - ≥34 presentations
- Thursday & Friday morning working groups
- A few key issues received particular attention:
  - Siting of facility & ramifications for design
  - Energy choice for the rings (4s running)
  - Work planning, collaborations, …

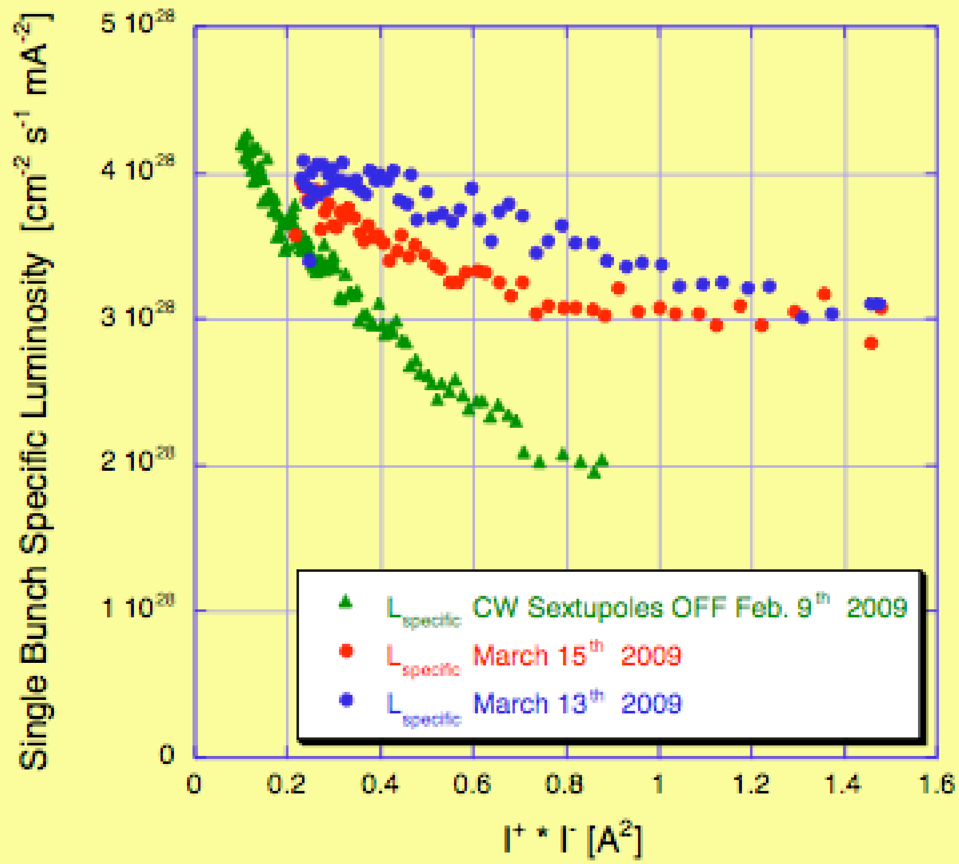
DAΦNE Crab-Waist Operation

Raimondi

Crab on/off Specific Luminosity vs Current Product



Crab on/off Luminosity vs Current Product



36th MEETING OF THE LNF SCIENTIFIC COMMITTEE

FINDINGS AND RECOMMENDATIONS

1 THE DAΦNE PROGRAM: STATUS AND RECOMMENDATIONS

1.1 DAΦNE UPGRADE: PERFORMANCE AND OUTLOOK

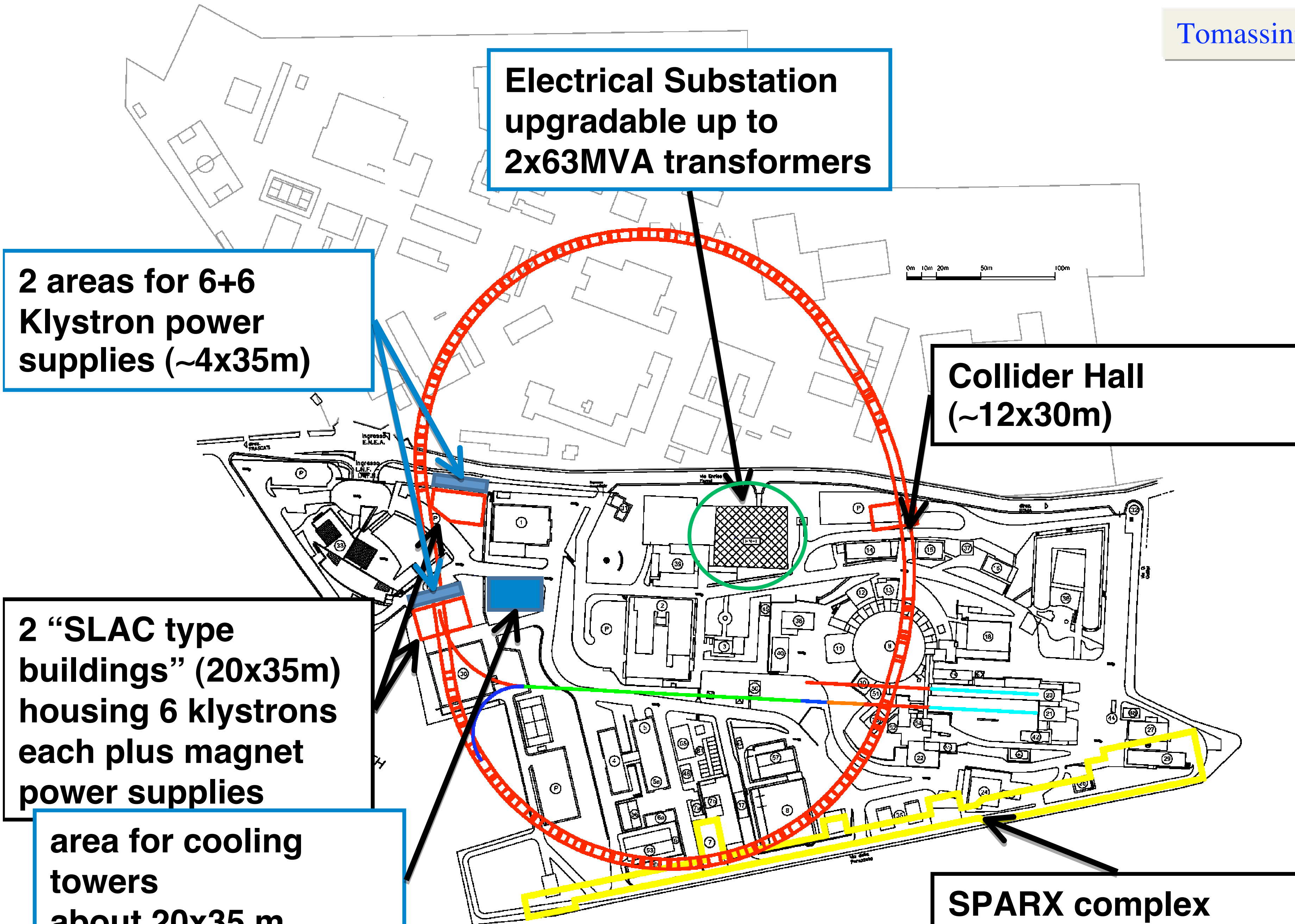
fact that the principle of crab-waist compensation has been shown to work; this must be recognised as a major advance in the long history of fighting the beam-beam effect in e^+e^- colliders. It is also an important step towards validation of the SuperB design concepts.

Finally, the effect of the crab-waist compensation is striking. As we were able to observe directly in the control room, excitation of the sextupoles on either or both beams reduces the corresponding beam sizes in collision, as predicted.

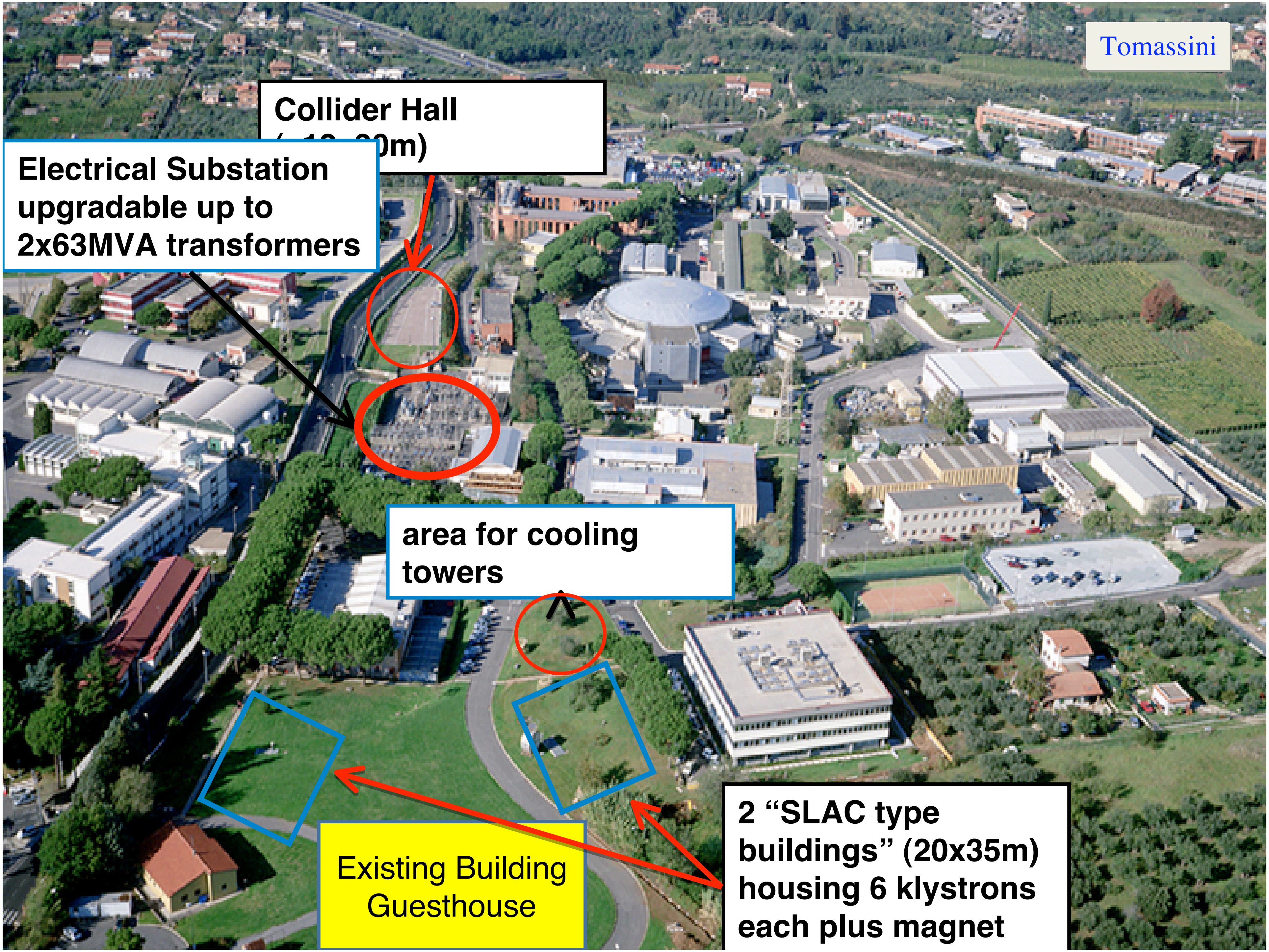
Siting

- An alternate design compatible with the LNF site has been developed.
  - Obvious synergies with LNF facilities
  - Most SuperB surface buildings on LNF site
    - esp. rf building & detector hall
  - Desire to fit the ring tunnel underneath LNF+ENEA site

Tomassini



SuperB at LNF with circumference about 1.25 km


Tomassini
Collider Hall
Electrical Substation upgradable up to 2x63MVA transformers
area for cooling towers
Existing Building Guesthouse
2 "SLAC type buildings" (20x35m) housing 6 klystrons each plus magnet

more Siting Considerations…

- New lattices with about 1300 m length fit on the combined site
- Polarized electrons now in the LER
  - spin rotators are easier to accomodate
  - spin depolarization time in the LER is longer
- Rf requirements lowered by equalizing beam currents in both machines

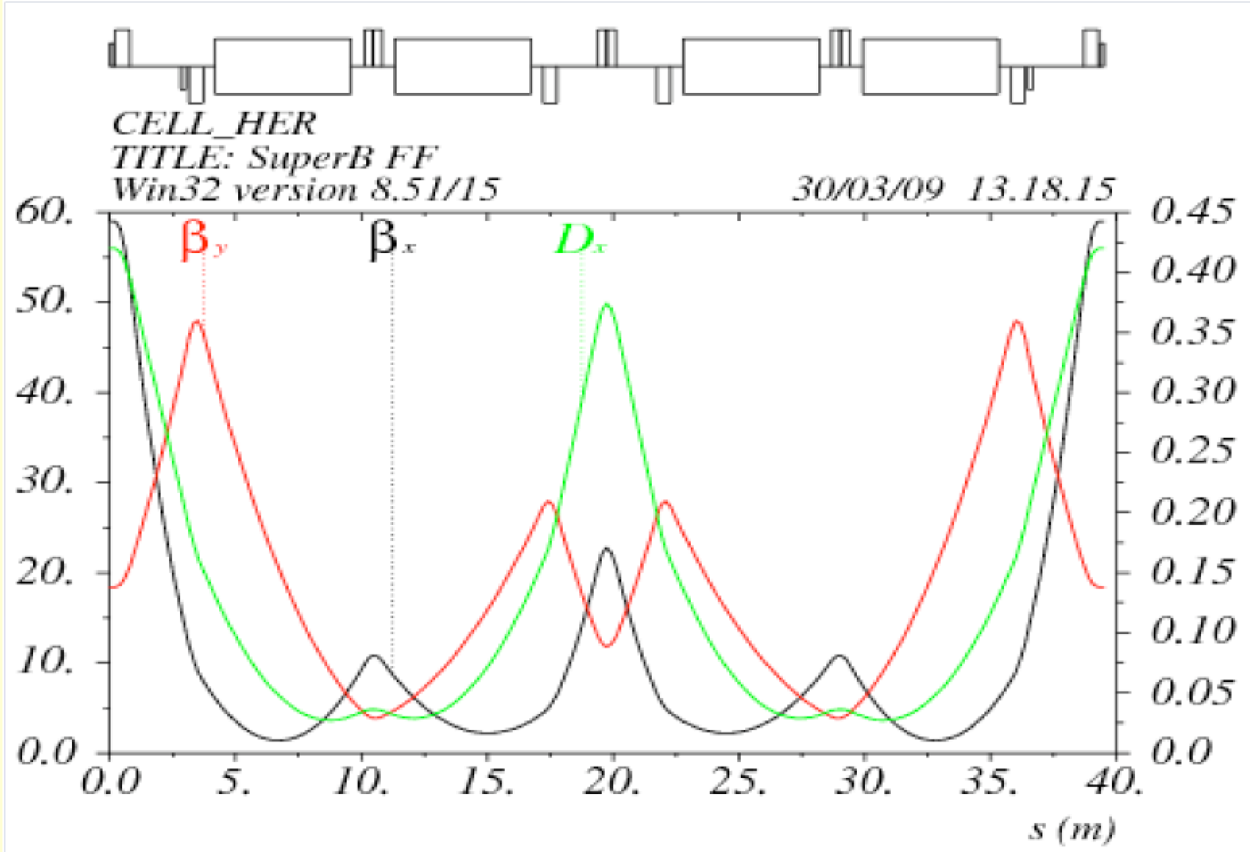
New Parameter set

Lattices

Lattice Evolution

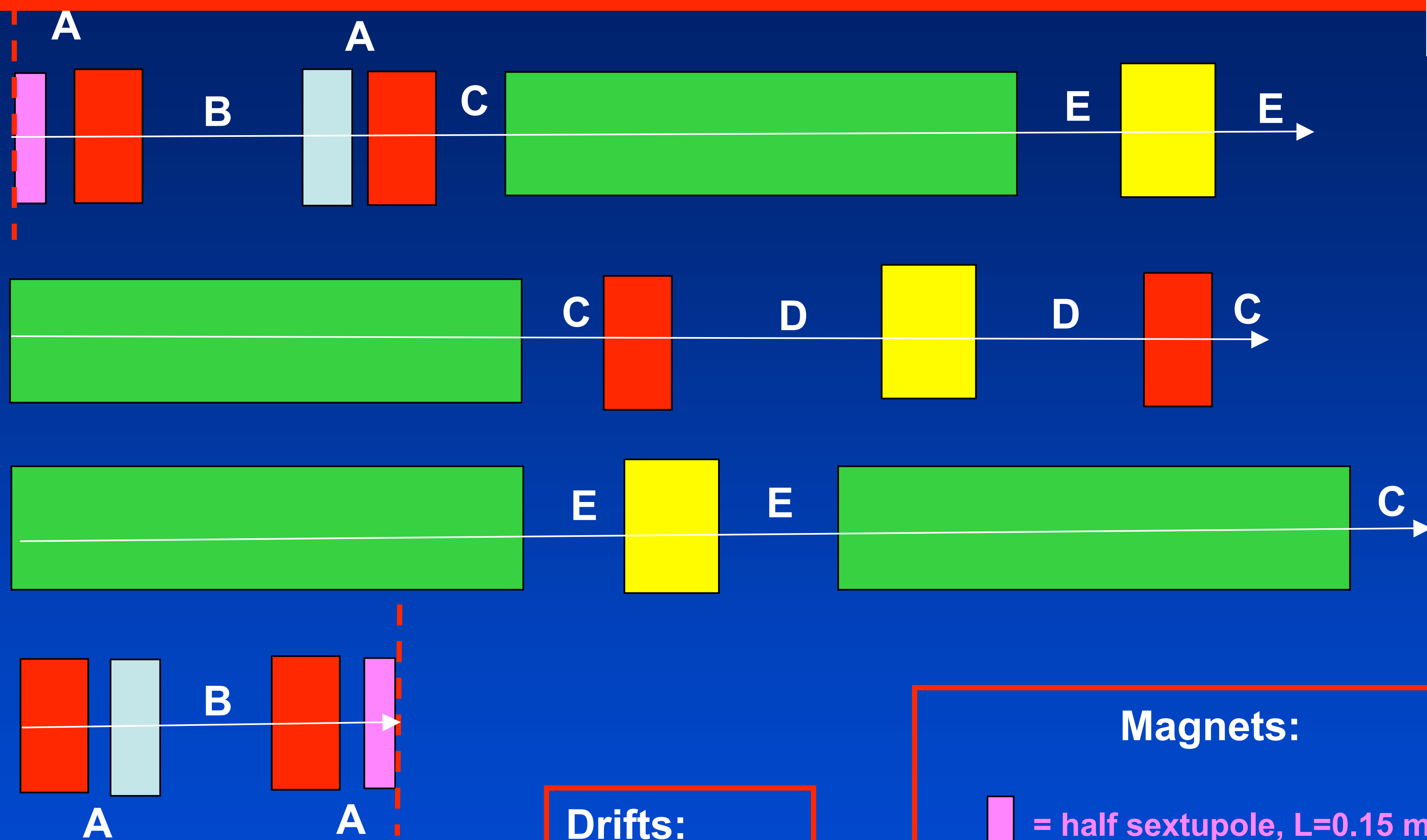
Raimondi/
Biagini

- New arc cell with μ_x, μ_y = .75, .25 * 2π phase advance
  - more compact, better acceptance, smaller emittance



Cell HER # 1 (Note: drawing not in scale !)

Biagini



Total cell length is 38.9 m

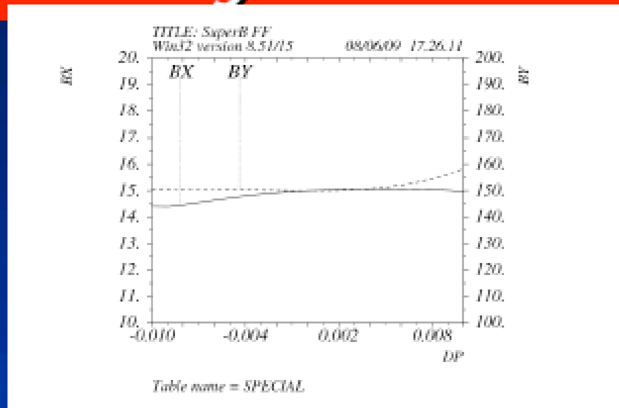
Drifts:
A = 0.015 m
B = 1.915 m
C = 0.15 m
D = 1.48 m
E = 0.3 m

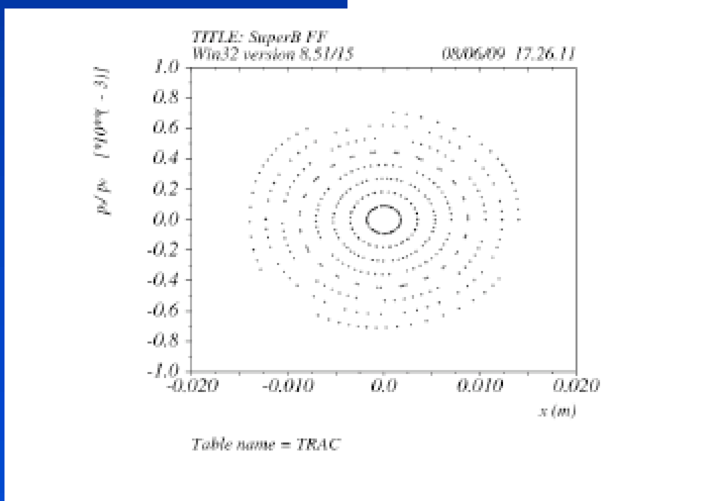
Magnets:

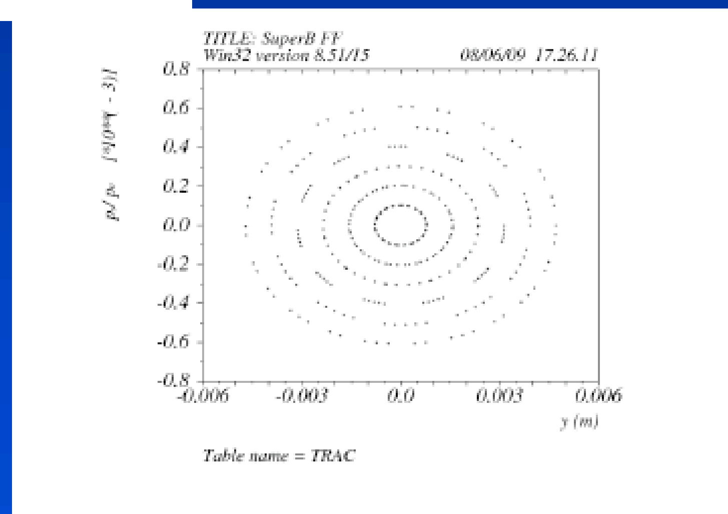
- **= half sextupole, L=0.15 m**
- **= sextupole, L=0.30 m**
- **= quadrupole, L=0.68 m**
- **= quadrupole, L=0.85 m**
- **= dipole, L=5.68 m**

Raimondi/
Biagini

Arcs Dynamic Aperture







15sigmas contour rings in X 5sigmas full coupled contour rings in y

FF properties similar to previous versions:

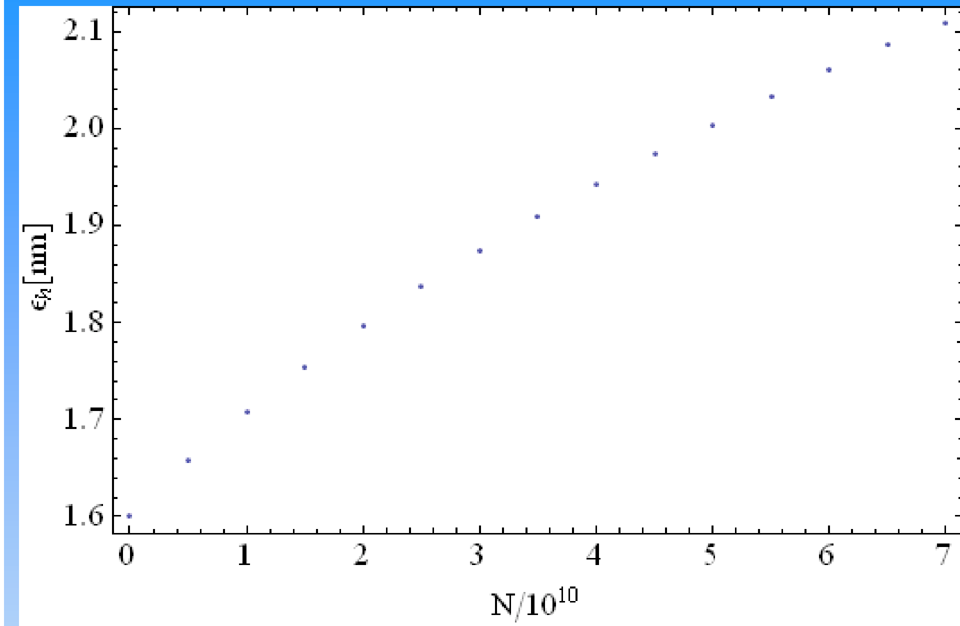
X>50sigmas, Y>30sigams dE/E about +/-1%

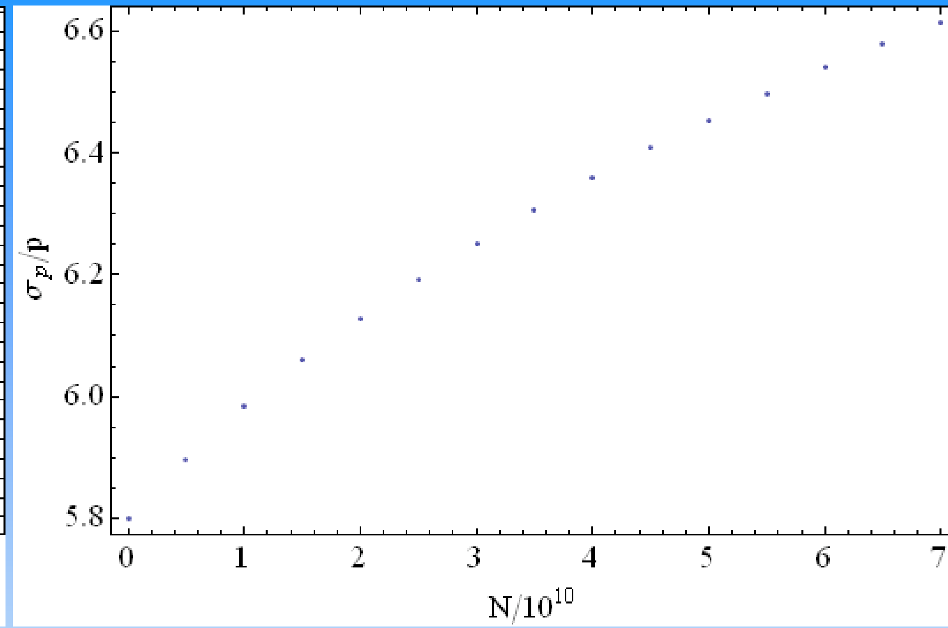
Ramifications…

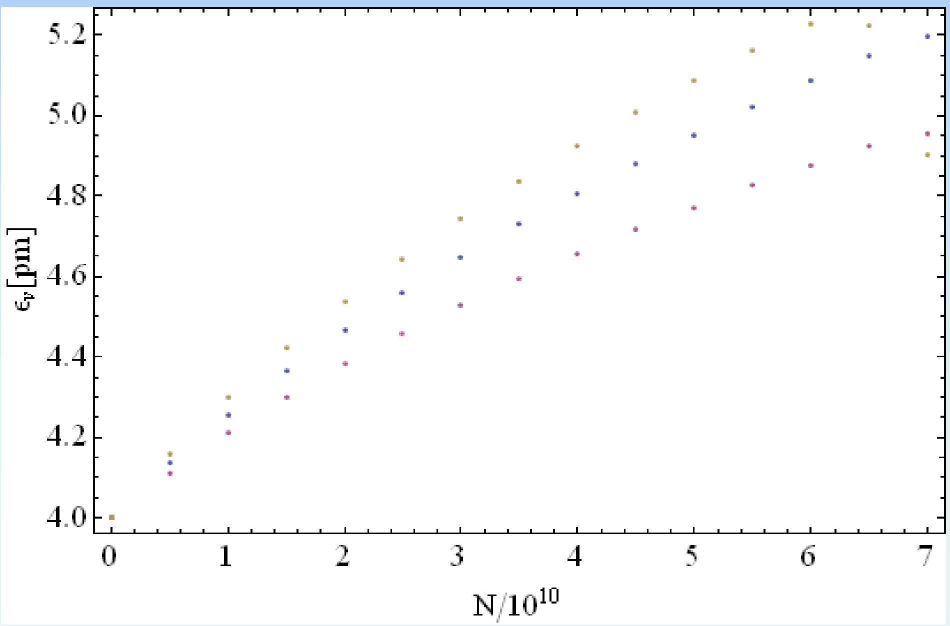
- There are issues to be aware of:
  - IBS appears to be significant in the LER, the more so the lower the energy
  - In the shorter rings, only symmetric spin rotators are a viable option => bad spin-match (in *s*-*E* plane).
    - Polarization will be decent only at short beam lifetime
  - polarization will be in the LER, which changes the allowed energies (to avoid depolarizing resonances in LER).

IBS in SuperB LER (LNF configuration)

Demma







$\varepsilon_h/\varepsilon_{h0}$=1.20

$\sigma_p/\ \sigma_{p0}$=1.13

@ N=4.06•10^{10}

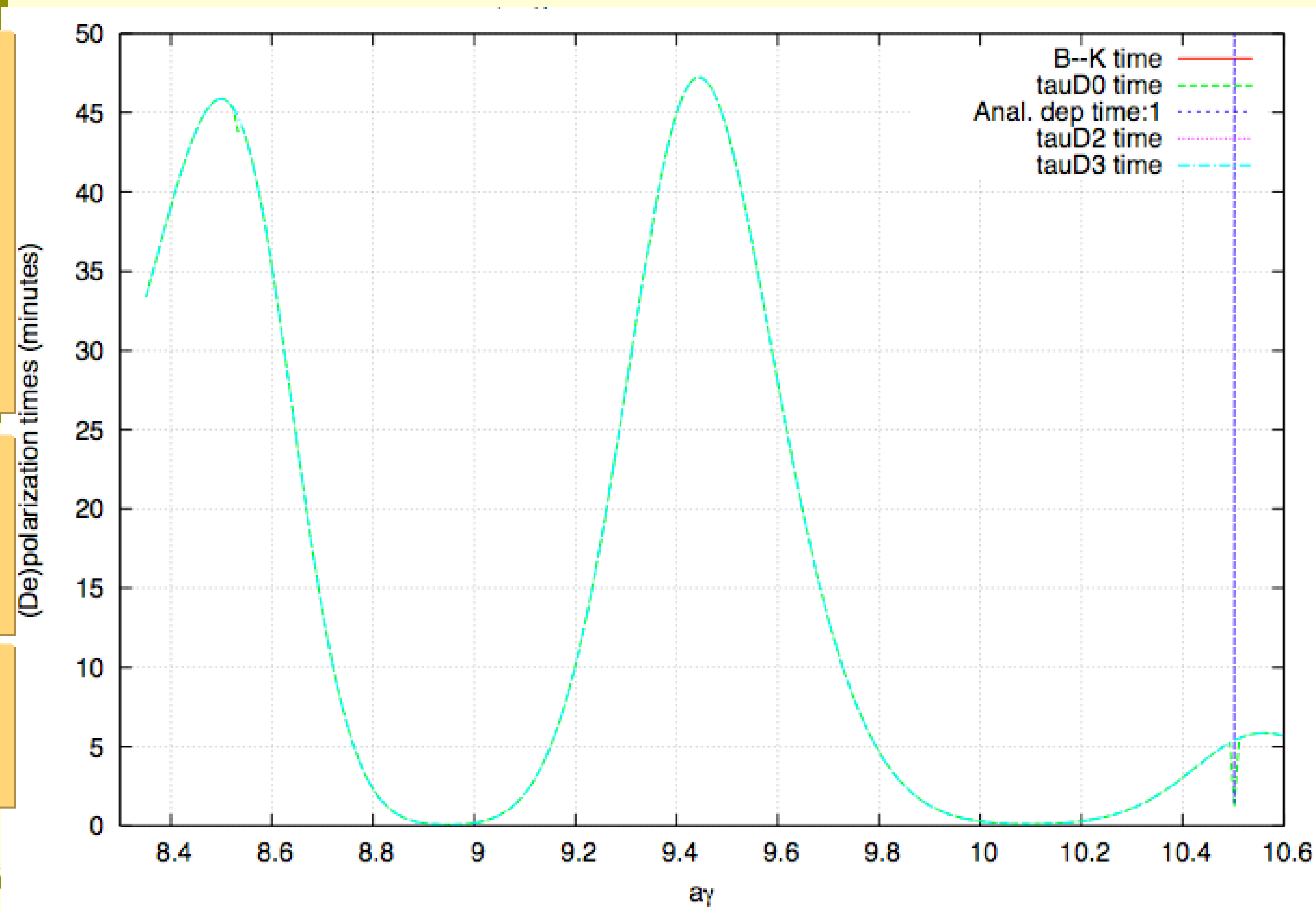
$\varepsilon_v/\varepsilon_{v0}$	r_ε
1.20	0
1.25	0.5
1.28	1

LER Polarization Settling Time

The settling time for polarization is about 45 min at best.
P **will settle to a few** ***%*** **i.e. this is the depolarization time.**

Disclaimer: Optics in this Slicktrack run is not verified yet.

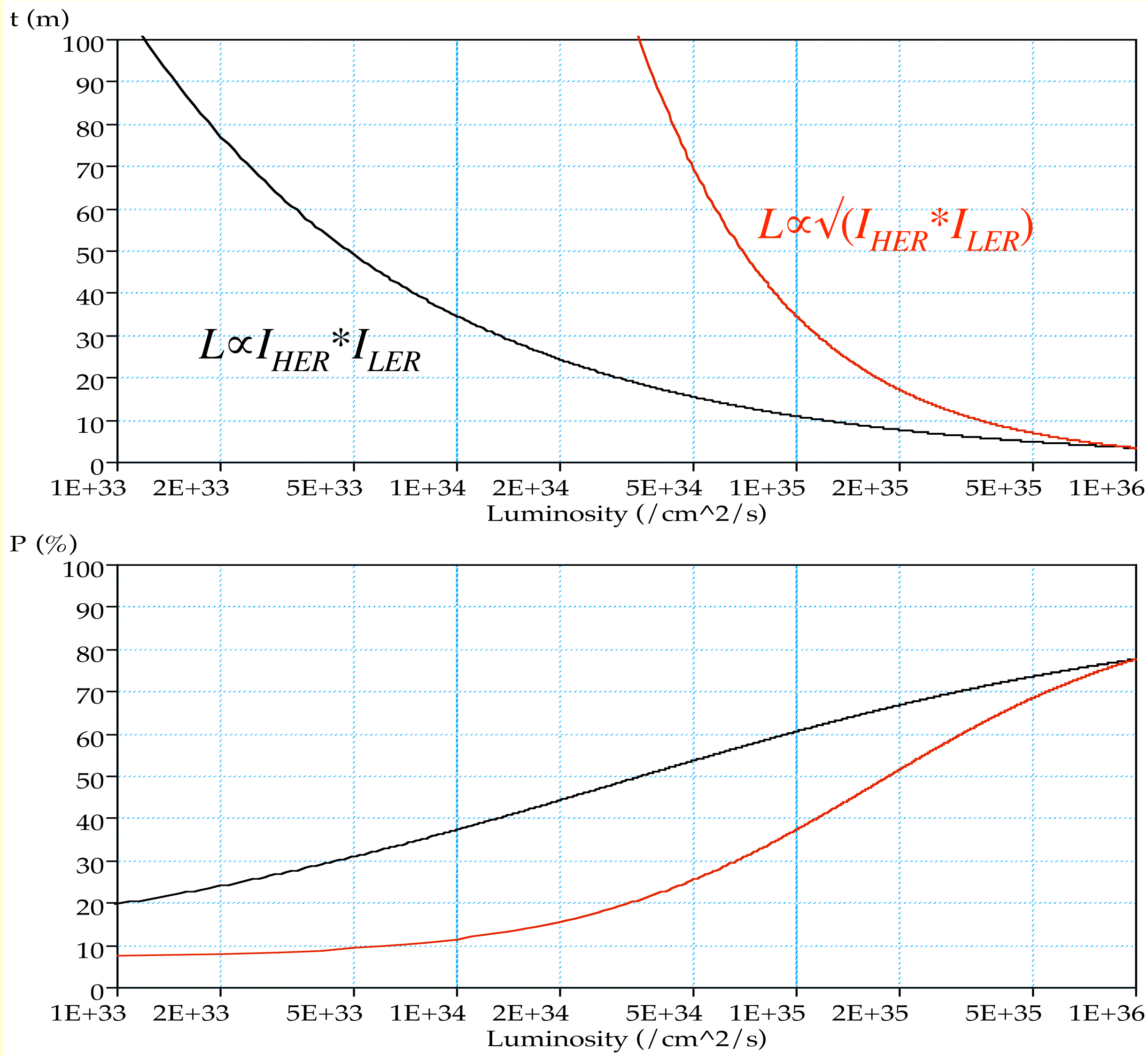
Disclaimer: 20ms damping reduces peaks to ≈20 min,



LER Life Time & Polarization *vs* *L*

These curves indicate beam lifetime & polarization vs luminosity with certain assumptions:
t_{pol} = 20 min
P_{inj} = 90%
P_{eq} = 7%
Touschek & lumi lifetime for LER beam

updated for 20 ms damping time!



≈3.5 m

≈78%

The Choice of Energies

- The depolarization time makes it advisable to run at spin tunes of γG near 8.5 or 9.5, 3.75 or 4.2 GeV.
- IBS is significant at 4.2 GeV (>20%), already prompting us to increase damping. It will be worse at 3.75 GeV, potentially intolerable.
  - The reason for the bad IBS behaviour lies in the reduced LER emittance (2.8–>1.6 πnmr). This change will be revisited.
  - There are tradeoffs to other parameters like rf power…

More Energy…

- The spin rotation at 4.2 GeV just works out when using the whole IR bending for 270° spin rot.
  - At 3.75 GeV the bending angle would need to be increased, potentially causing (emittance-) problems.

Rf

Rf Parameters LNF Site

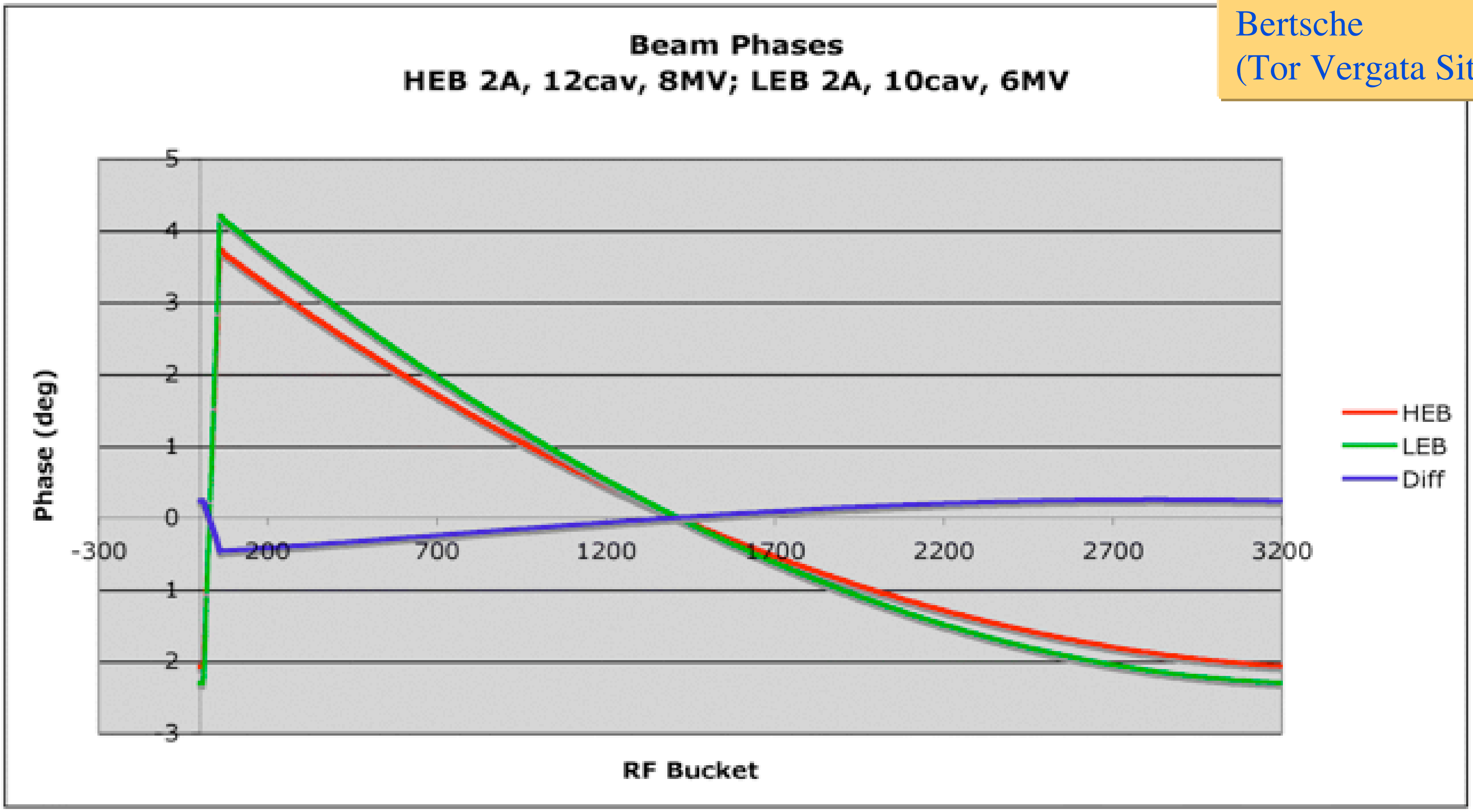
Novokhatski

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	um com-	tum	voltag	length	pacing	er cavit	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	1.5	2.1	4.4E-04	6.5E-04	8	6.0	4.2	0.7	12	3.15	0.1719	0.702	0.2171	4.24	0.35	6.58
										6							
1E+36	6.7	1.5	2.1	4.4E-04	6.5E-04	9.5	5.5	4.2	0.7	14	3.15	0.2041	0.848	0.1045	4.31	0.31	6.61
										7							
1E+36	6.7	1.5	2.1	4.4E-04	6.5E-04	11.5	5.0	4.2	0.7	16	3.15	0.2437	1.088	0.0188	4.50	0.28	6.91
										8							

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	um com-	tum	voltag	length	pacing	er cavit	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	2.335	0.6	4.4E-04	5.4E-04	3.4	6.0	4.2	0.65	6	1.401	0.3545	0.254	0.3254	2.33	0.39	13.15
										3							
1E+36	4.18	2.335	0.6	4.4E-04	5.4E-04	4	5.5	4.2	0.65	6	1.401	0.4013	0.351	0.1539	2.31	0.38	13.23
										3							
1E+36	4.18	2.335	0.6	4.4E-04	5.4E-04	4.8	5.0	4.2	0.65	8	1.401	0.4849	0.379	0.1457	2.41	0.30	13.82
										4							

Super-B Phase Transient

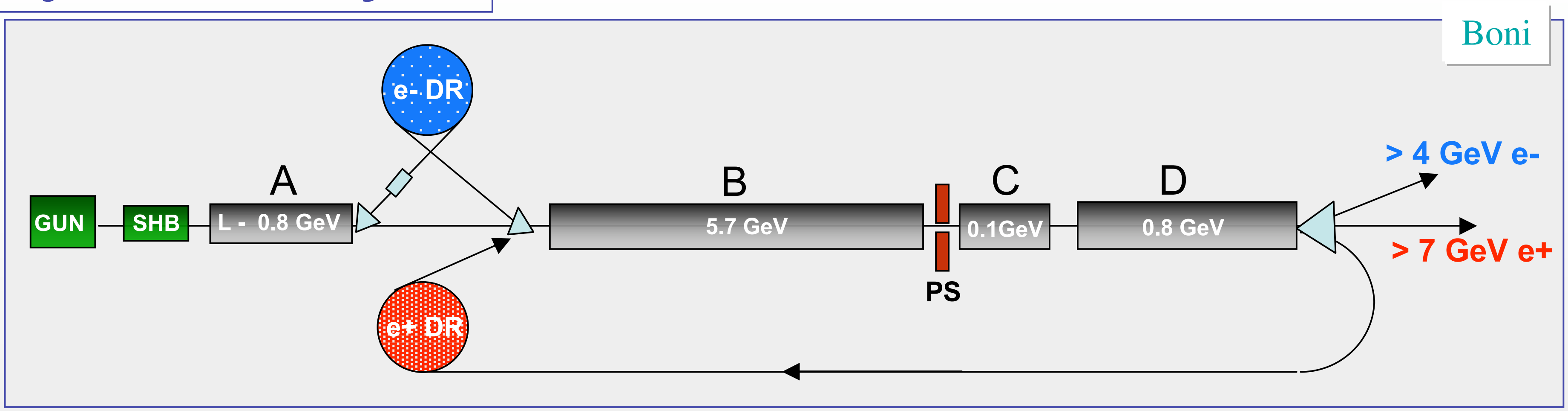
Bertsche
(Tor Vergata Site)



- Nominal parameters OK (0.5 deg max error)
- Phase transients better matched than PEP-II
  - Beam loading and synch phase more similar

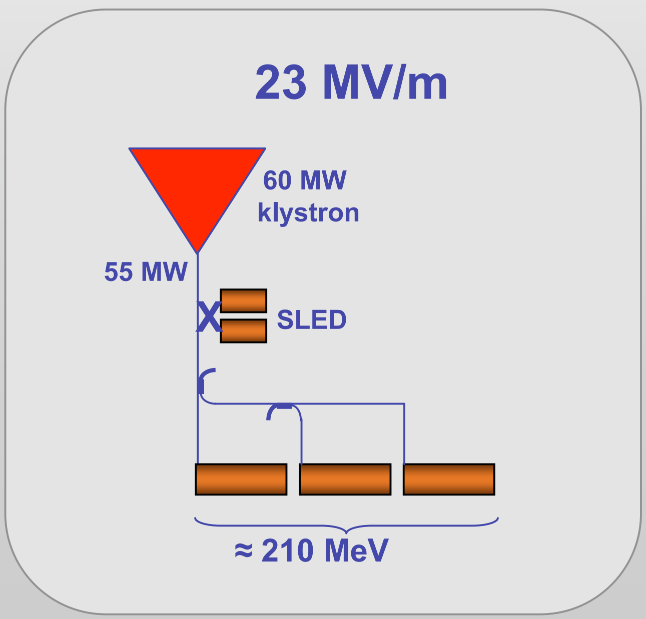
Injector & Injection

Injector RF Layout

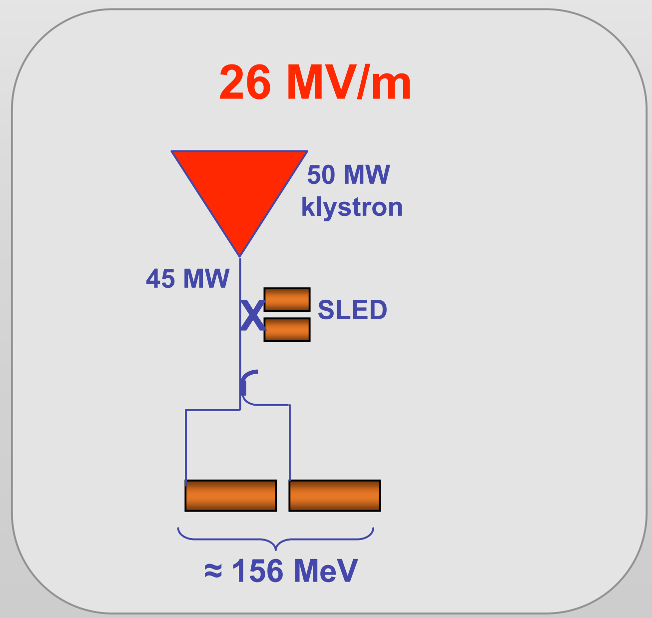


ACCELERATING FIELD

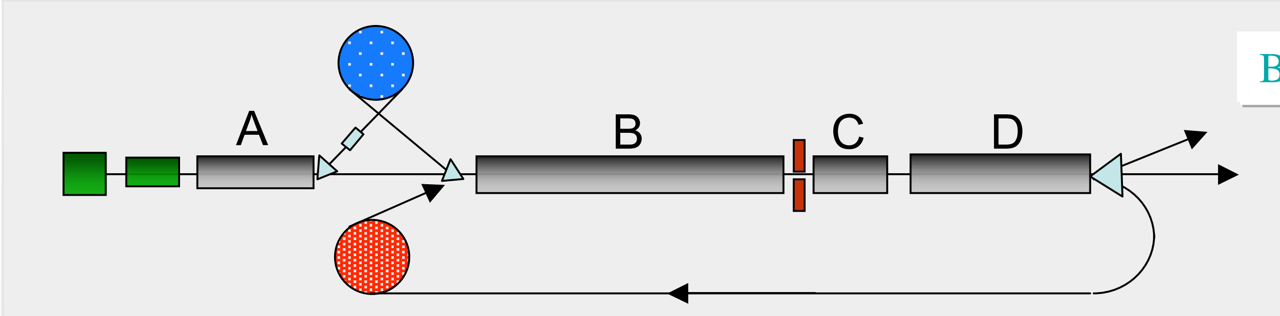
MEDIUM GRADIENT



HIGH GRADIENT



RF LAYOUT



Boni

Accelerating gradient	23 MV/m	26 MV/m
N° of Kly's Linac A/Energy(MeV)	4/840	5/780
N° of Kly's Linac B/Energy	27/5670	37/5772
N° of Kly's Linac C */Energy	1 @ 26 MV/m/156	1/156
N° of Kly's Linac D/Energy	4/840	5/780
Tot. n° of RF stations	36	48
N° of accel. structures	107	96
Total energy (GeV)	7.5	7.5
RF active length (m)	321	288

(*) high gradient capture linac

PROS & CONS

23 MV/m

\+ easier RF conditioning
lower trip-rate
less klystrons

\- longer linac

26 MV/m

\+ shorter linac

\- hard RF conditioning
higher trip-rate
more klystrons

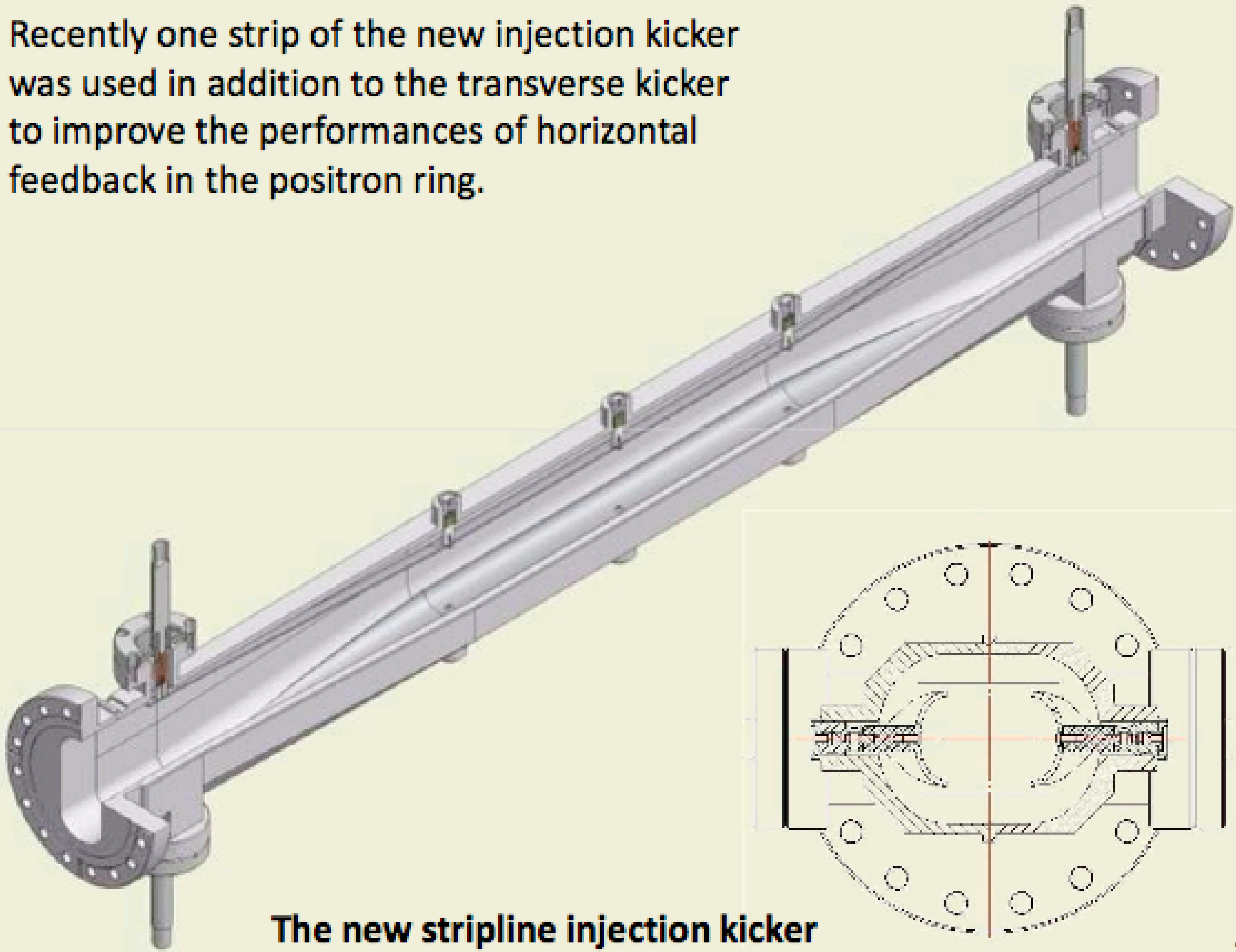
How to reduce A_x?

Guiducci

	LER	HER	LER (off coupling)	HER (off coupling)
$\varepsilon_x^{injected}$ (nm)	8.3	8.3	4.2	4.2
k	3	3	2	2
β_x^{stored} (m)	75	75	150	150
$\beta_x^{injected}$ (m)	25	25	50	50
β_x^{kicker} (m)	75	75	75	75
β_x^{max} (m)	400	400	400	400
σ_x^{stored} (mm)	0.46	0.35	0.65	0.49
Δs (mm)	4	4	1	1
$\Delta s/\sigma_x$	8.7	11.5	1,5	2,0
$n_x = A_x/\sigma_x^{stored}$	19	21.5	8.4	8.9
A_x (mm)	8.6	7.4	5.4	4.4
x_{inj}^{max} @β_x^{max} (mm)	19.8	17.2	8.8	7.1
δ_{kick} (mrad)	0.90	0.81	0.27	0.23

BSC = 30 σ_x

Recently one strip of the new injection kicker was used in addition to the transverse kicker to improve the performances of horizontal feedback in the positron ring.

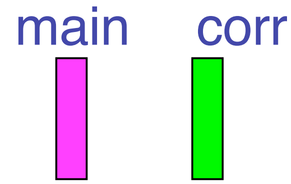


The new stripline injection kicker

F. Marcellini
D. Alesini

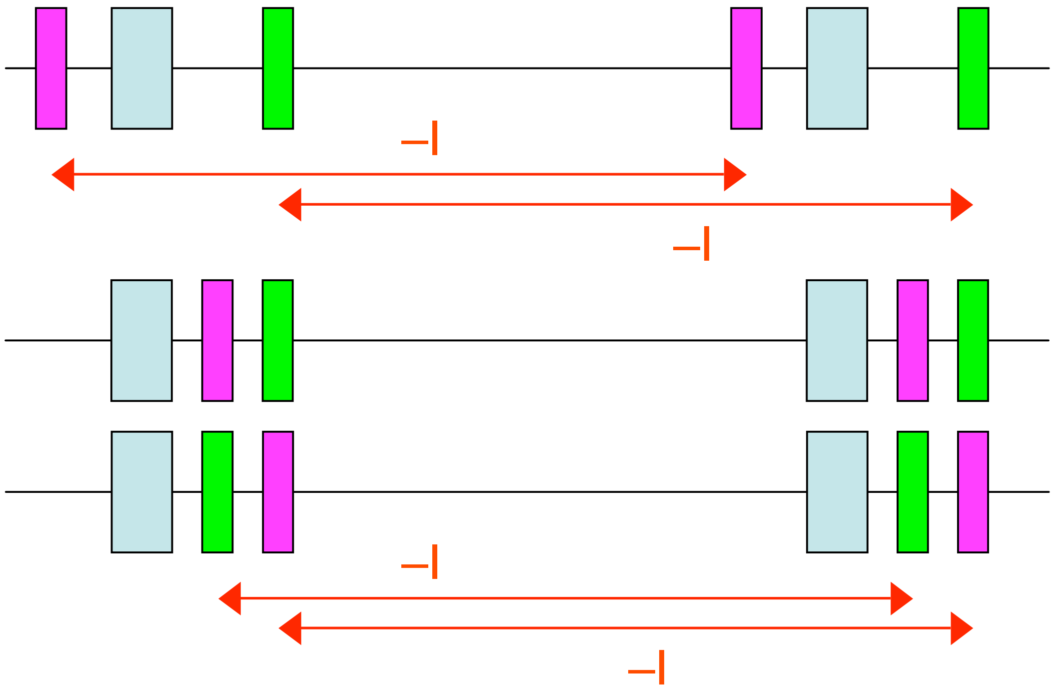
Acceptance, correction

2+2 sextupoles



Levichev

8 cubic aberration terms are produced



Piminov’s empiric config.

Theory: 2 terms can be zero exactly and other 6 are reduced

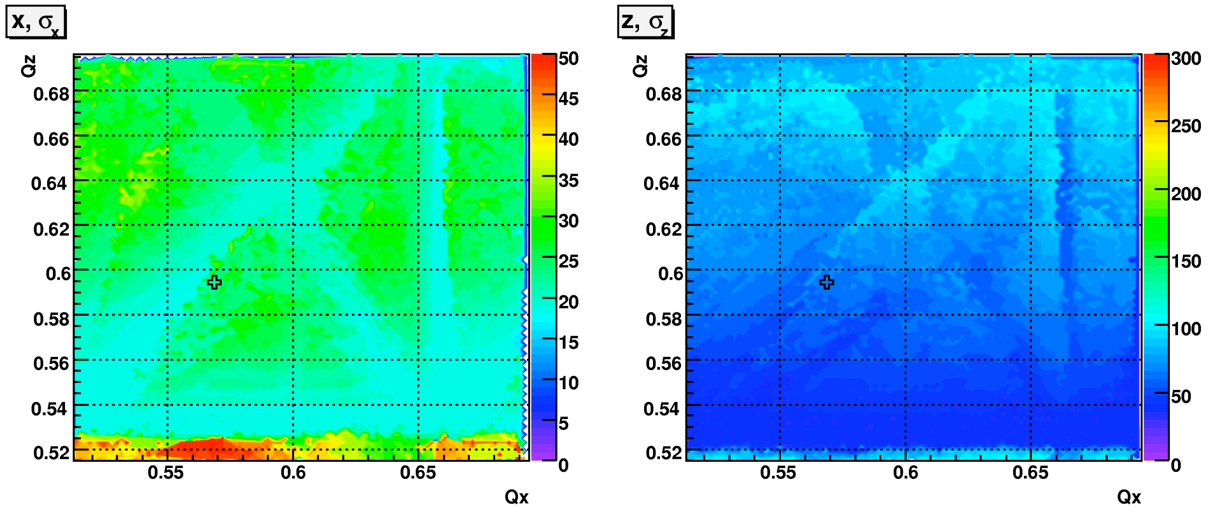
Bogomyagkov’s theory Predics better results

Theory: 4 terms can be zero exactly and other 4 are reduced

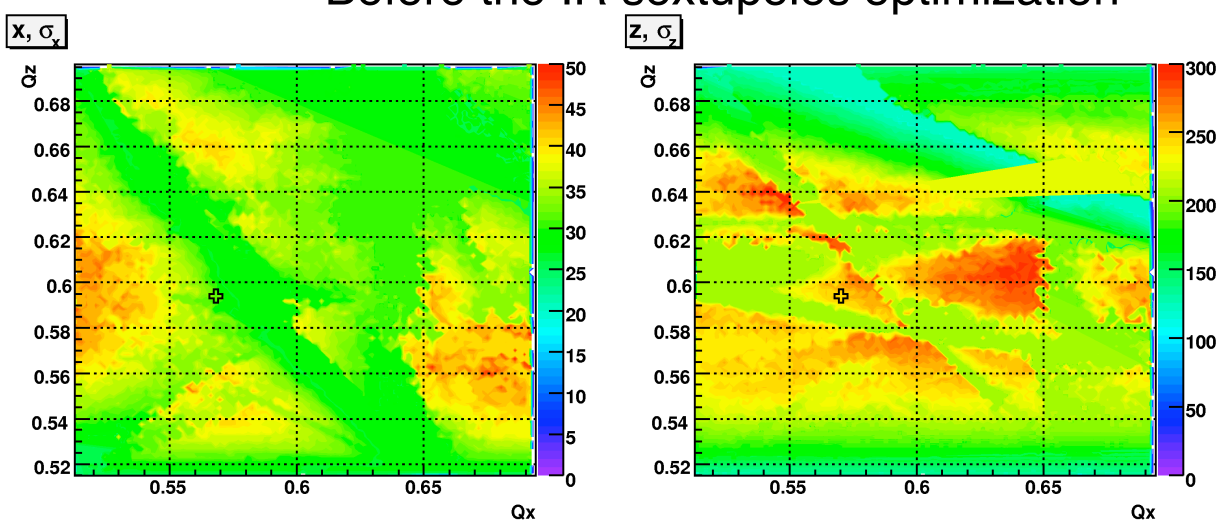
1. Pair of the correction sextupoles increases the on-energy DA substantially. The strength of the corr. sexts is 3-10% of the main ones.
2. No quadratic aberration terms appear
3. No influence on the nonlinear dispersion

LER DA tune scan

Levichev



Before the IR sextupoles optimization



After the IR sextupoles optimization

The tune point optimization should be done together with the beam-beam simulation and the luminosity/lifetime optimization

Working Groups, Summary & Conclusion

Preliminary new Parameters

Parameter	Units		Super-B TorVergata 1-Mar-09 with SR	Super-B LNF 1-Jun-09
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	1207
N. Buckets distance			2	2
Gap			0.97	0.97
Frf	Hz		4.76E+08	4.76E+08
Fturn	Hz		1.43E+05	2.49E+05
Fcoll	Hz		2.31E+08	2.31E+08
Num Bunch			1619	928
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

Working groups

- Lattices
  - Polarization with shorter dipoles, ZGOUBI
- Rf, collective effects
  - Mafia model of IR, reduction of gap transient with unequal beam currents, checking IBS codes
- Injection
  - updated parameters & optimized. 0.8 GeV DR.
- Site layout
  - Details with present lattice
- IR Design

Collaborative Efforts

- LPSC (F. Meot + student) would like to join the lattice effort.
- D. Barber (DESY) now collaborating on polarization issues.
- Planned visit by BINP acc. physicists at LNF in September.

Critical Issues

- Need to continue pushing forward with lattices
  - focus on one option, not able to keep several options "in flight"
  - The energy ratio has reared its head again. It will require a concerted effort & communication to settle.
- In order to be able to proceed we are planning to focus in the near term on the option most likely leading to a consistent & buildable design
  - 6.7 on 4.2 GeV, symmetric spin rotators, ≈1320 m length, contained on LNF+ENEA site
  - does not preclude individual "forays" into other options

Conclusion

- DAΦNE has continued to deliver crab-waist goodness.
- New lattices are allowing more compact rings, making LNF site option viable.
  - switch e^- to LER for polarization
- Injector & injection are in much better shape & a reasonable conceptual design exist
- Significant challenges exist. The team will be stretched. Good communication and openness as well as speedy resolution of issues are key