τ/charm Project

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on behalf of the τ/charm Accelerator study group

3rd LowεRing, Oxford, July 10th 2013

From SuperB to τ/charm

- The SuperB project was canncelled in December 2012 since the budget allocated (250 Meuro) was not sufficient to entirely cover its construction and operation
- It is a natural evolution of the SuperB to have a transition to a smaller and cheaper, but still frontline, accelerator such as the Tau/charm
- The new design is based on a symmetric beams collision. This makes the design a lot simpler. For example, for SuperB a state-of-the-art design of the first superconducting quadrupole doublet in the Final Focus, able to cope with the high gradients required and the small space available was developed. For the Tau/charm this elements will have more relaxed characteristics, and the symmetric FF will easy the design

From SuperB to τ/charm

- Most of the work done for SuperB can still be used for the Tau/charm project, making the "downgrade" a more easy and fast job. Tools which have been "ad hoc" created for SuperB can be readapted and all the experience gained will make the design process easier and faster
- The scope of the present design is to have a dedicated and optimized project, re-using all the competences, studies and tools developed for SuperB, keeping costs in the allocated budget
- The possibility to use the injection Linac for a SASE FEL facility is still valid and is part of the design

Accelerator study group

LNF team

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CabibboLab team

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τ/Charm Factory main features

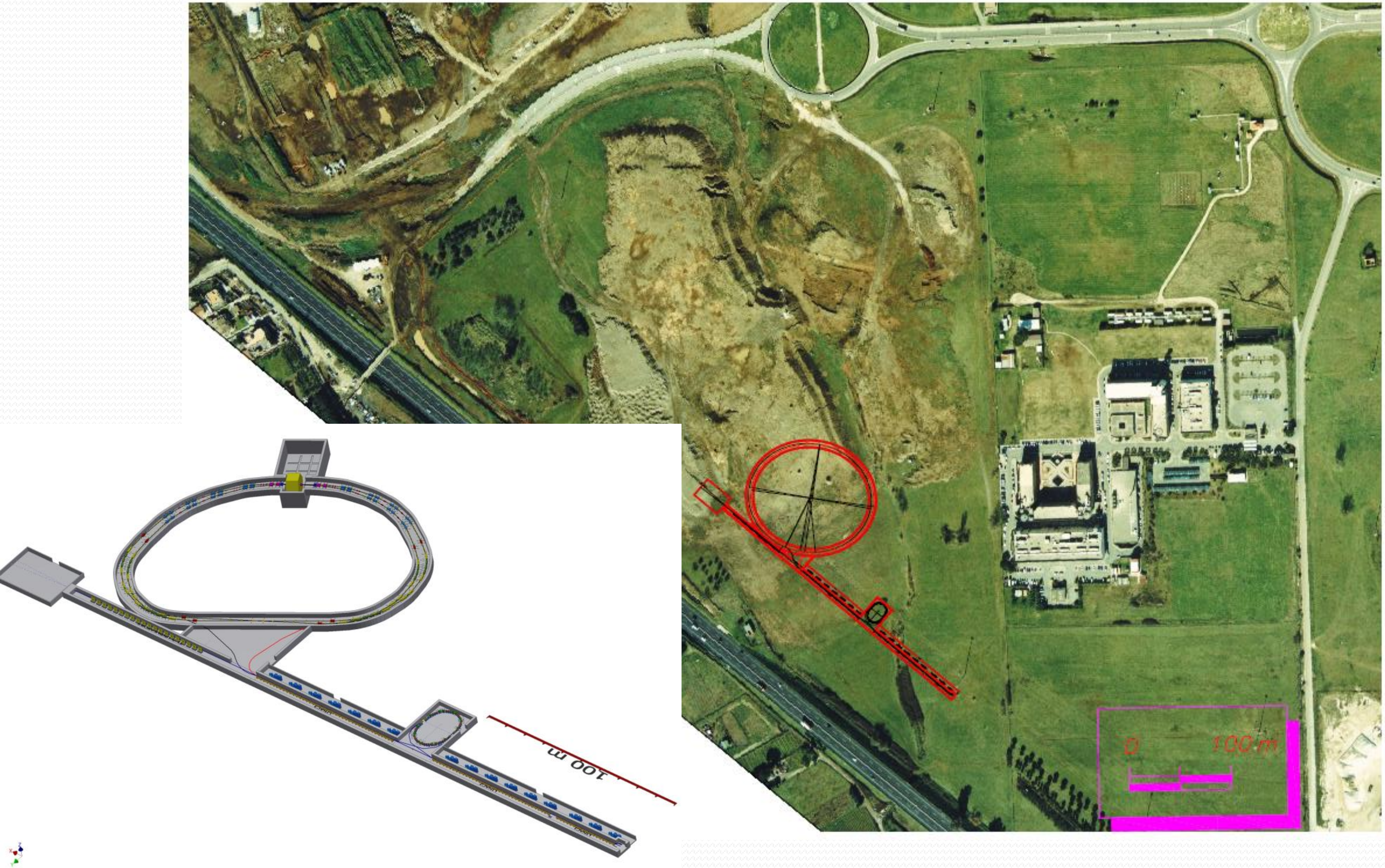
- Energy tunable in the range **E_{cm} = 1-4.6 GeV**
- **10^{35} cm^{-2} s^{-1}** peak luminosity at the τ/charm threshold and upper
- Symmetric beam energies
- Longitudinal polarization in the electron beam (60-70%)
- Possibility of e^-e^- collisions (to be studied)
- Design based on "Large Piwinski angle & crab waist sextupoles" collision scheme
- Low beam emittance (about 2 nm natural)
- Beam parameters for reasonable lifetimes and beam currents
- Wigglers needed at lower beam energy
- Injection system scaled from the SuperB one

Table of parameters

- Baseline design for L=10^{35}, with possibility to increase currents to reach $2x10^{35}$
- Intra Beam Scattering and Hourglass factors are included
- Beam power is about 15 times less than the SuperB baseline one

Parameter	Units			
LUMINOSITY	10^{35} cm^{-2} s^{-1}	1.0	1.0	0.2
c.m. Energy	GeV	4.6	4.0	2.0
Beam Energy	GeV	2.3	2.0	1.0
Circumference	m	340.7	340.7	340.7
X-Angle (full)	mrad	60	60	60
Piwinski angle	rad	11.19	10.84	14.66
Hourglass reduction factor		0.86	0.85	0.83
Tune shift x		0.004	0.004	0.002
Tune shift y		0.078	0.089	0.064
β_x @ IP	cm	7	7	7
β_y @ IP	cm	0.06	0.06	0.06
σ_x @ IP	microns	18.50	18.95	20.67
σ_y @ IP	microns	0.086	0.088	0.096
Coupling (full current)	%	0.25	0.25	0.25
Natural emittance x	nm	3.76	2.85	1.42
Emittance x (with IBS)	nm	4.89	5.13	6.11
Emittance y (with IBS)	pm	12.2	12.8	15.3
Natural bunch length	mm	6	5	6
Bunch length (with IBS)	mm	6.9	6.9	10.1
Beam current	mA	1720	1745	1000
Buckets distance	#	1	1	1
Ion gap	%	2	2	2
RF frequency	Hz	4.76E+08	4.76E+08	4.76E+08
Number of bunches	#	530	530	530
N. Particle/bunch	#	2.3E+10	2.3E+10	1.3E+10
Beam power	MW	0.28	0.16	0.05
Transverse damping times (x/y)	msec	23/33	35/49	35/49

Tau-Charm Layout @ Tor Vergata

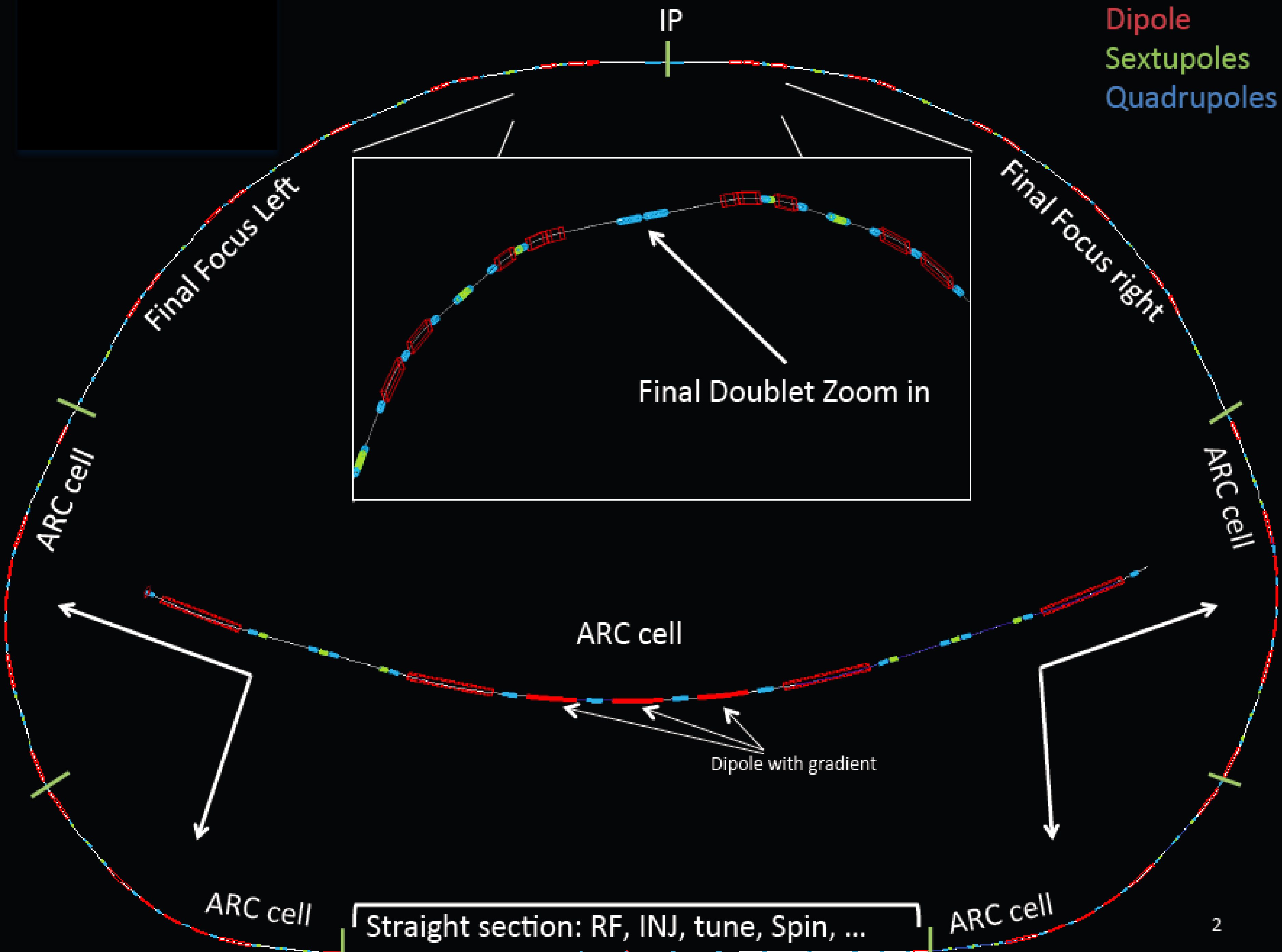


Rings layout

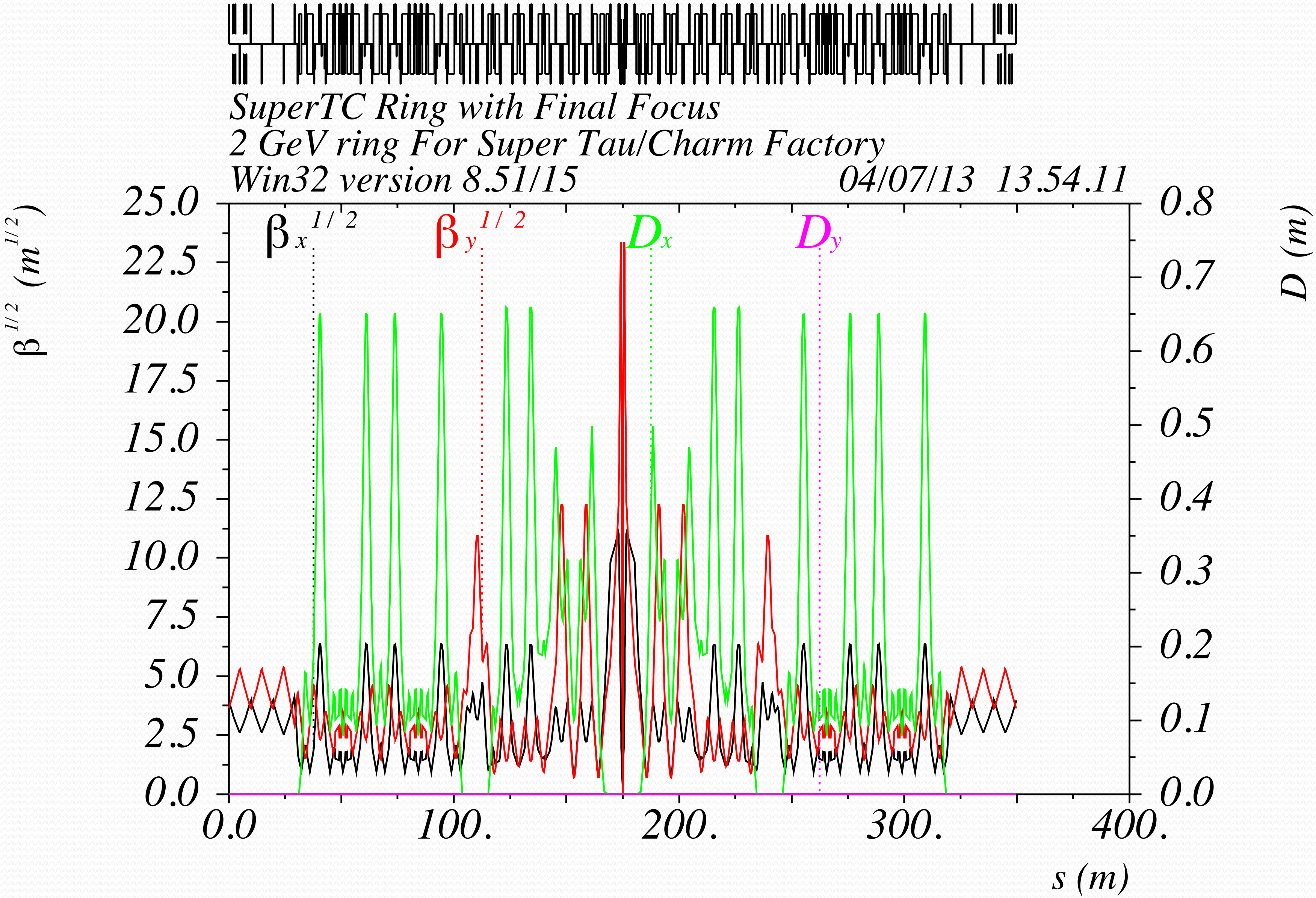
- The equal beam energies simplify the design with respect to the SuperB one, and result in a more compact and cheaper complex
- One Siberian Snake (SS) in the electron ring will rotate the spin to have longitudinal polarization at the IP (in SuperB this was accomplished by 2 Spin Rotator sections). The polarization is optimal (about 65%) at 2 GeV
- The magnetic structure of the two rings is identical, except for the SS insertion in the electron ring, installed in the long straight section opposite to the IP
- The rings will cross with a large horizontal crossing angle both at the IP and will be tilted about 11 mrad in vertical to avoid crossing on the other side

Rings lattice @ 2 GeV

- The lattice has to provide the minimum emittance in order to reach the goal luminosity
- The arcs layout is similar to the ESRF upgrade lattice
- Some of the dipoles have a gradient component, so X and Y damping times are different
- The Final Focus has been re-optimized for the lower energy and to have beams passing as much as possible on-axis in the first doublet to avoid SR in the detector.
- Particular care is taken to cancel as much as possible non-linearities in the FF between the crab sextupoles
- The present FF design includes octupoles to compensate for the first doublet fringing fields
- Tolerances to magnet errors have been studied and a table of acceptable values produced

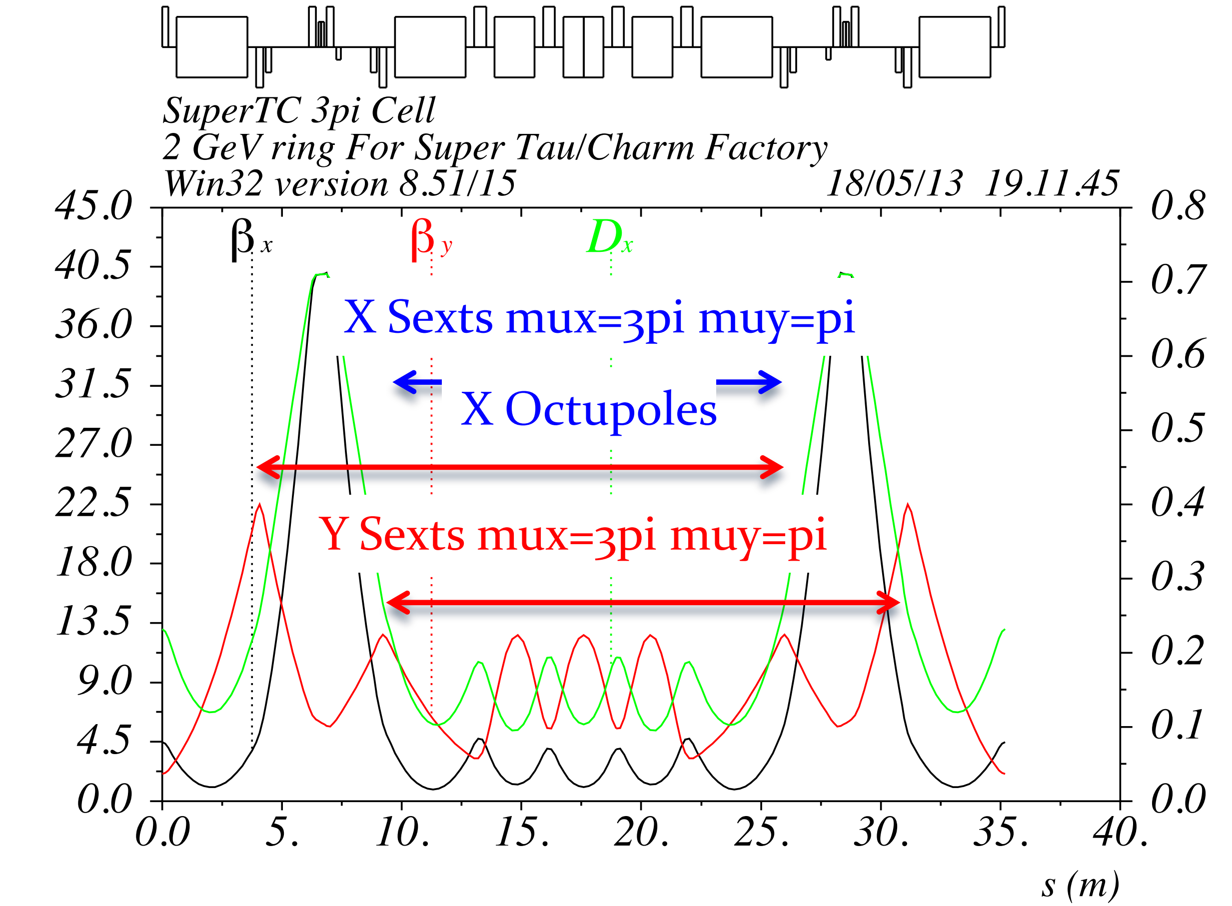

IP
Dipole
Sextupoles
Quadrupoles
Final Focus Left
Final Focus right
Final Doublet Zoom in
ARC cell
ARC cell
ARC cell
ARC cell
ARC cell
Dipole with gradient
ARC cell
Straight section: RF, INJ, tune, Spin, ...

Positron Ring



Arc Twiss Functions

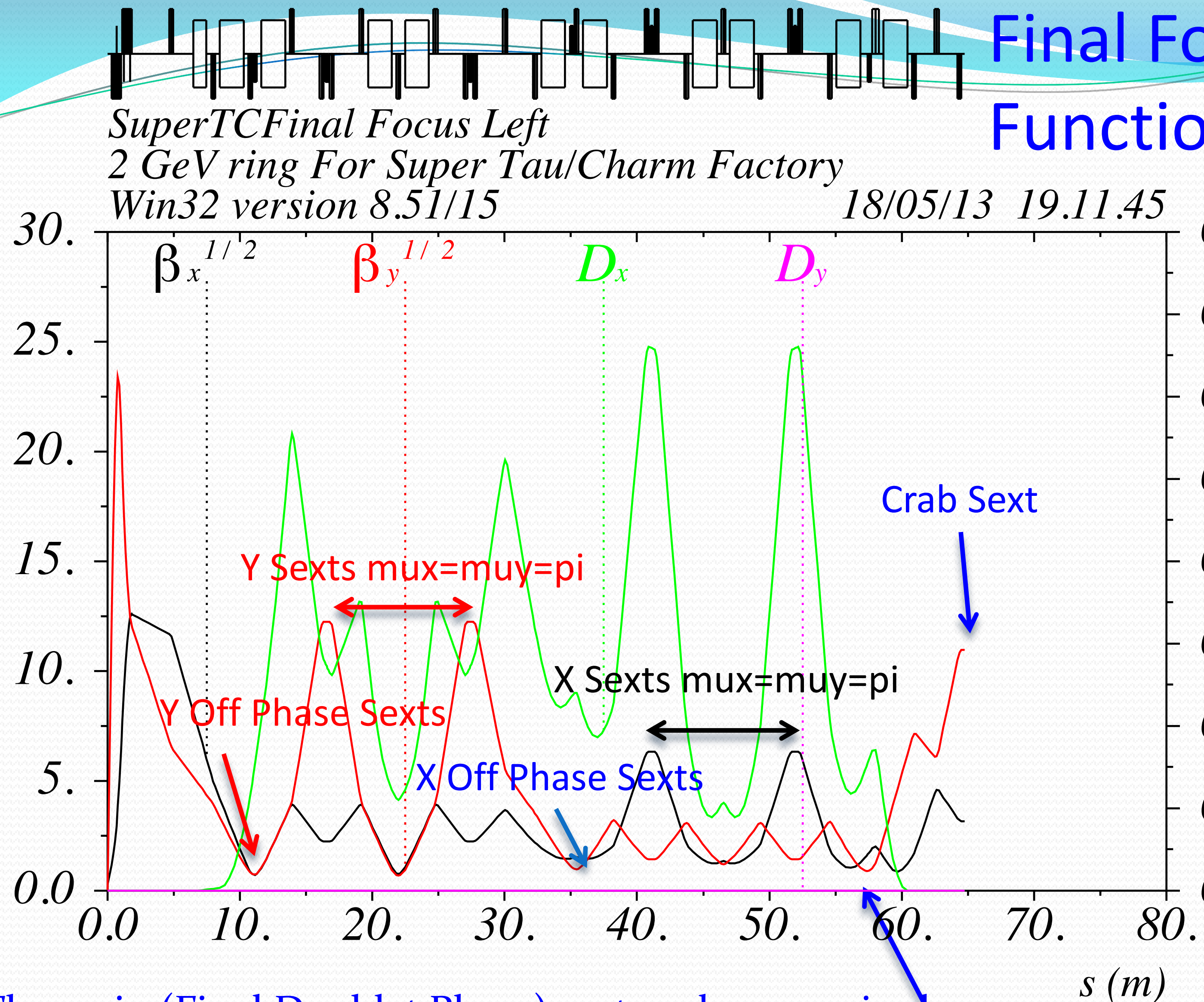
Raimondi



All sextupoles are paired
The sextupoles pairs are interleaved, this generates X and Y tune shift vs Jx and Jy
The X tune shift dependence from Jx is canceled by the octupoles pair
The Y tune shift from Jy is canceled by having a proper value of alfay at the X sextupoles
(or a proper R43 between them)
The cross term is very small and can be zeroed by choosing the proper z-location for the octupoles
As result the ARC optics is virtually linear for several hundred beam sigmas (x and y and dE/E)

Final Focus Twiss Functions

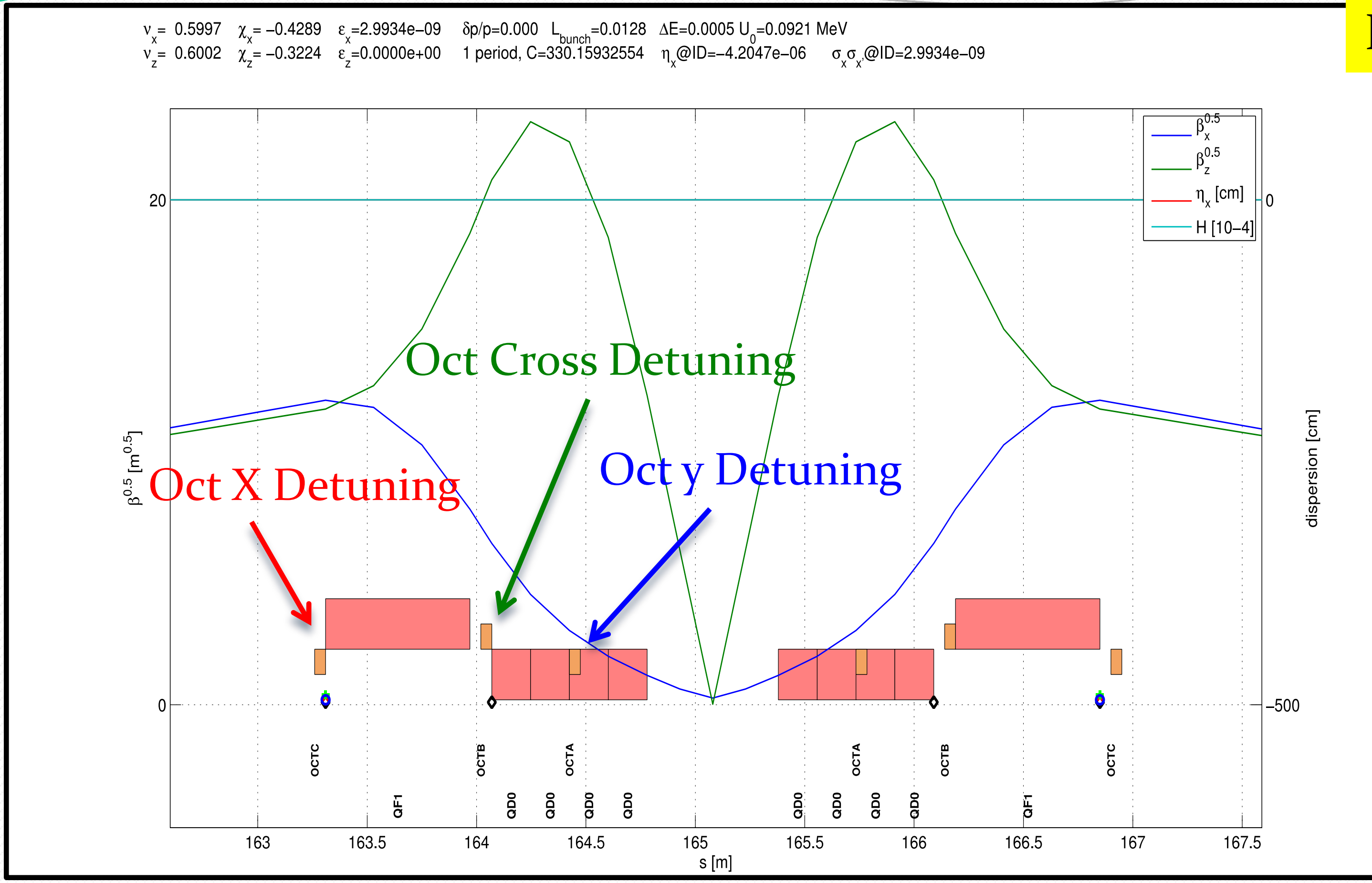
Raimondi



The main (Final Doublet Phase) sextupoles are paired
The Off Phase (IP Phase) sextupoles correct the third order chromaticity, their residual geometric aberrations are very small (a third sextupole further reduces them). Thanks to these sexts, the FF bandwidth becomes about 3 times larger.

Final Doublet Fringe compensation

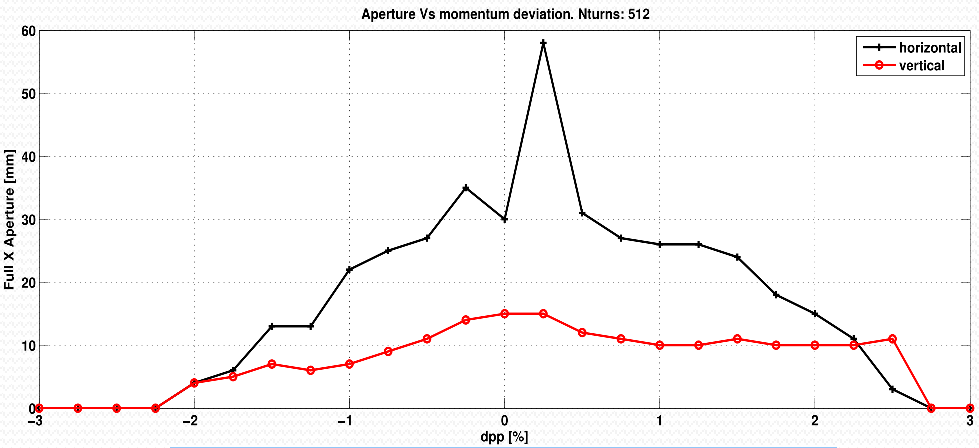
Raimondi



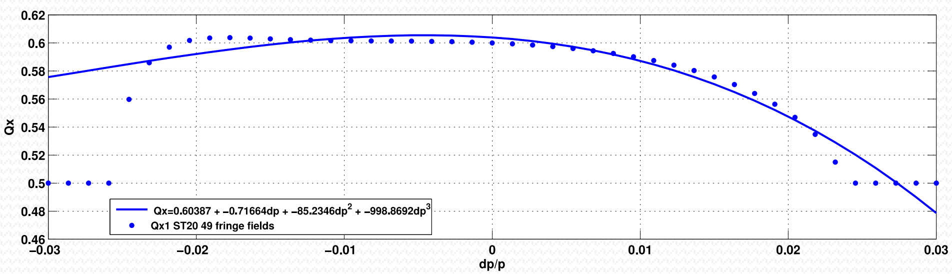
Doublets are very long and weak in order to minimize the effect of the fringe fields. The most efficient solution is to have 3 octupoles to cancel the detuning due to fringes and kynematic term (about ¼ of the fringes). The added complexity is very modest, since at lest 2 octupoles are anyway needed to compensate the residual on-axis detuning and magnets/lattice imperfections.

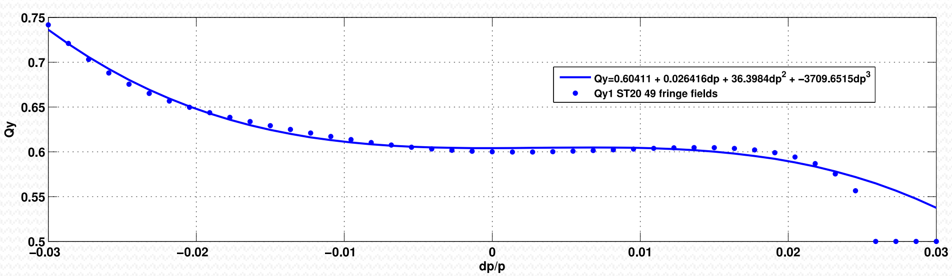
DA and bandwidth

Liuzzo

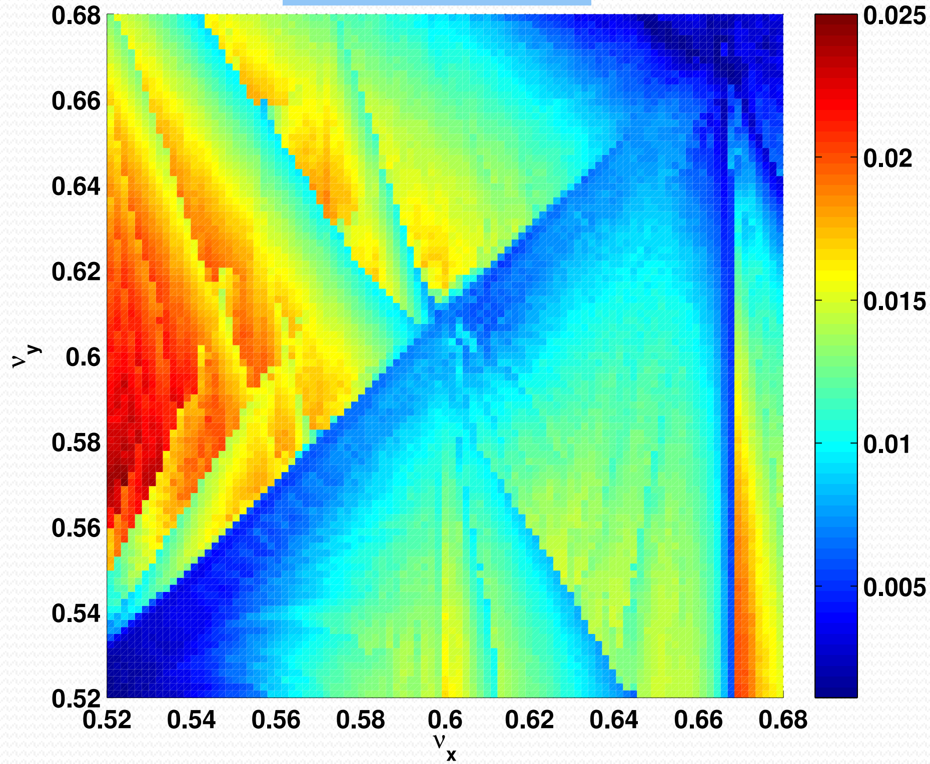


DA vs Δp/p (x,black) (y,red)





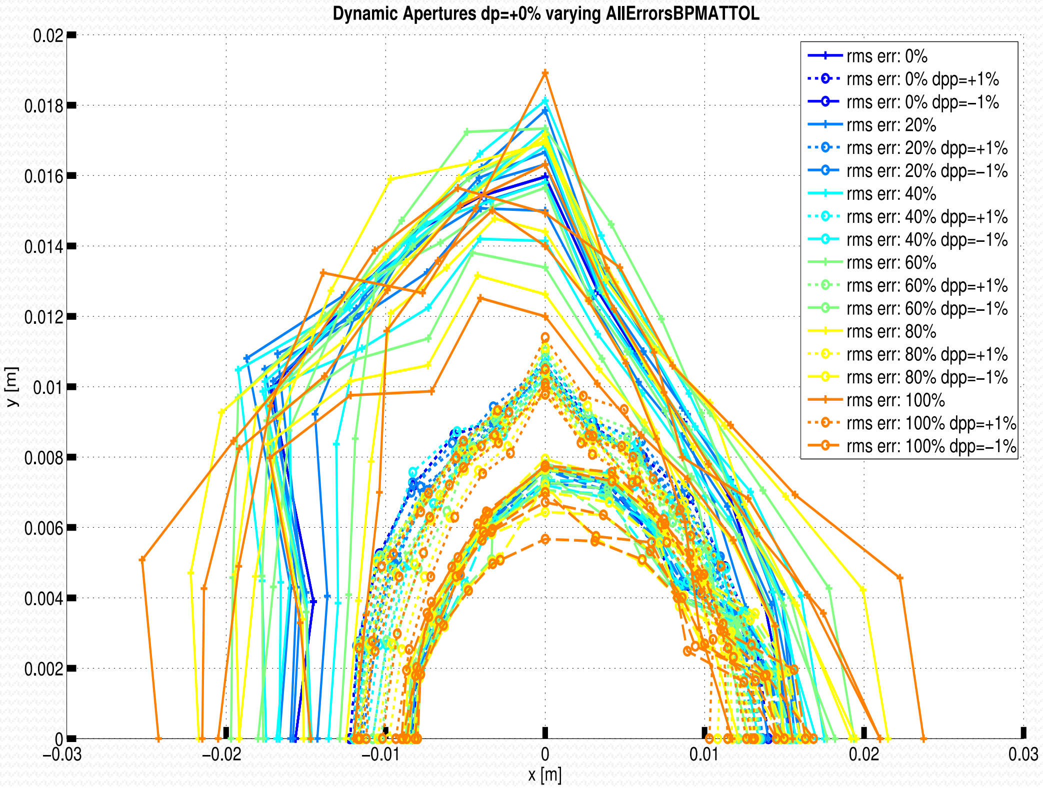
DA vs tunes



Tunes vs Δp/p (x,top) (y,bottom)

Tolerance to errors

Liuzzo



Error	max	accepted
Dipole Δ_ψ	400 μrad	150 μrad
Girder Δ_ψ	400 μrad	175 μrad
Girder Δ_x	200 μm	100 μm
Girder Δ_y	200 μm	65 μm
BPM Δ_x	100 μm	100 μm
BPM Δ_y	100 μm	100 μm
Quadrupole Δ_ψ	400 μrad	75 μrad
Quadrupole Δ_x	100 μm	50 μm
Quadrupole Δ_y	100 μm	45 μm
Sextupole Δ_x	100 μm	50 μm
Sextupole Δ_y	100 μm	50 μm
$\Delta BL/BL$	$1\ 10^{-3}$	$0.5\ 10^{-3}$
$\Delta K_1L/K_1L$	$2\ 10^{-3}$	$1\ 10^{-3}$
$\Delta K_2L/K_2L$	$2\ 10^{-3}$	$1\ 10^{-3}$

LET procedure includes correction of:

- x, y orbit
- x-y dispersion,
- b-beating

Touschek lifetime-with tracking

# σX (@QF1)	Machine set	Lifetime (s) with IBS	Lifetime (minutes)
30	R(QD0)=1.5cm; R(QF1)=2cm; R(10m-)=3cm	**376** (162 s NO IBS)	**6.3**
40 +kinterm	R(QD0)=2.0cm; R(QF1)=3.5-4.6cm; R(10m-)=3cm with kinematic term	**484**	**8.0**

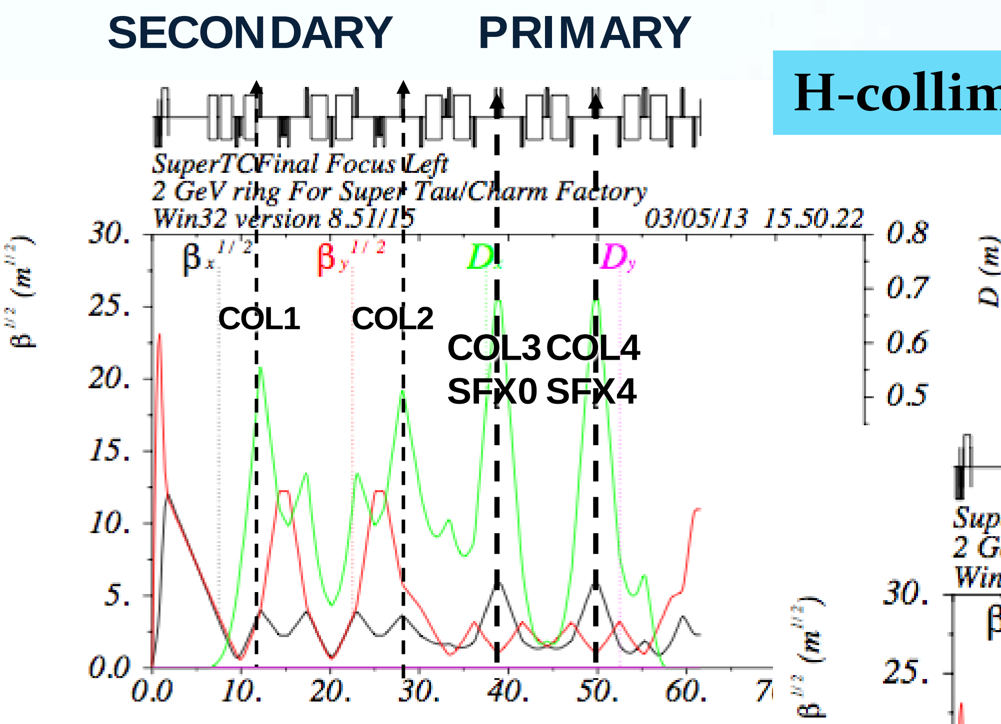
Lifetime Summary

	minutes
Touschek	7.8
Coulomb beam-gas	1.5hrs*60
Bremsstrahlung with residual gas	80hrs*60
Radiative Bhabha	11.3

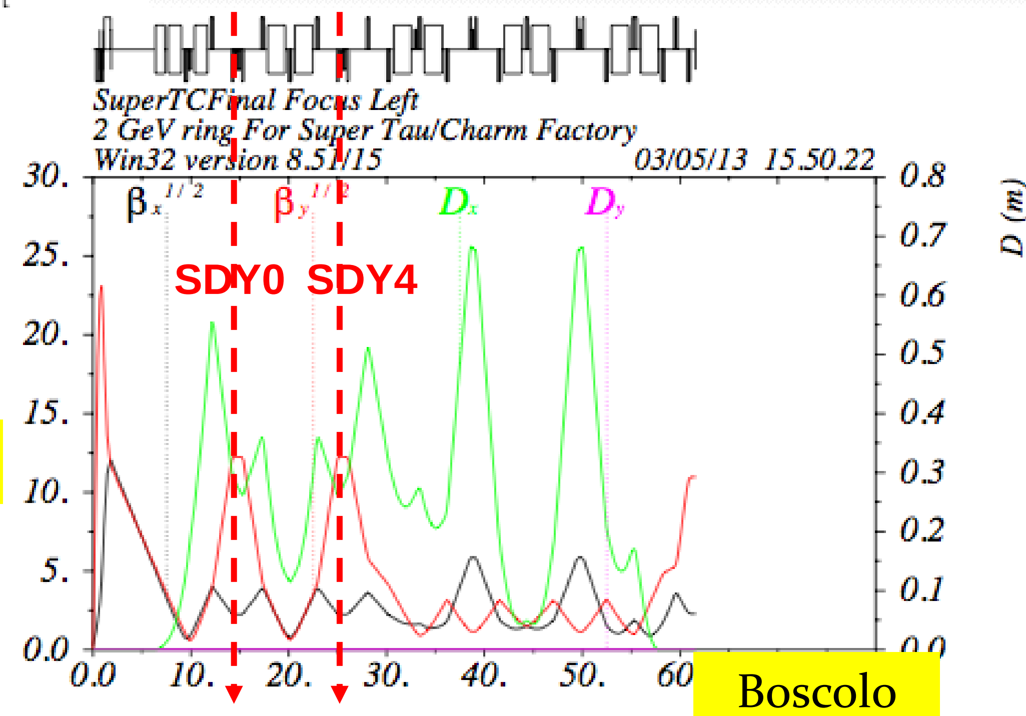
Boscolo

Final Focus collimation system

H-collimators



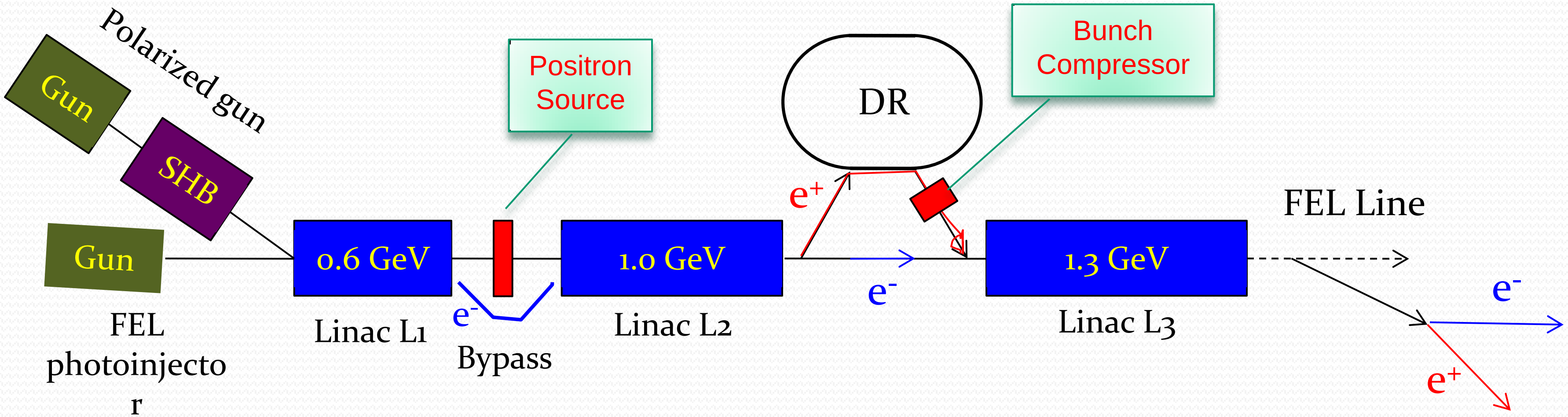
V-collimators



M. Boscolo, Super

Boscolo

Tau-Charm Injection System



Total electron linac energy 2.9 GeV
Total positron linac energy 2.3 GeV

	Linac L1	Linac L2	Linac L3
N. of klystrons	3	6	7
N. of cavities	9	18	21
Max. Energy (GeV)	0.62	1.24	1.45

The number of klystrons and cavities allows to reach the maximum positron energy of 2.3 GeV also with one klystron off

Much more material not included for lack of time!

See Elba June 2013 meeting:

https://agenda.infn.it/conferenceDisplay.py?confId=6193

Conclusions

- A design for a Tau/charm factory is in progress, based on the previous work done for the SuperB Factory
- A consistent set of parameters has been found for a baseline luminosity of 10^{35} cm^{-2} s^{-1} @ 4 GeV c.m. energy, with possibility to increase currents to reach $2x10^{35}$ cm^{-2} s^{-1}
- Layout and lattice have been studied
- Interaction Region layout and backgrounds evaluation has started
- Injection system was re-scaled and adapted
- Study of the technical aspects and engineering has started
- A preliminary cost estimate sets the total price below the "promised" budget
- We are writing a White Paper on the accelerator design to be presented to INFN management and Minister of Science in the Fall for final decision