Summary of the working group on High Luminosity issues - Single beam

S. Guiducci, C. Zhang

CESR-c Wiggler Magnet	A.Temnykh, CESR
Electron Cloud	R. Cimino, LNF
Super DAΦNE	
Lattice for Longitudinal β	C. Biscari , LNF
IR Design	M. Biagini , LNF
Lifetime	S. Guiducci , LNF
Background	M. Boscolo , LNF
Accelerator Physics Issues in BEPC-II	C. Zhang, IHEP

Contents

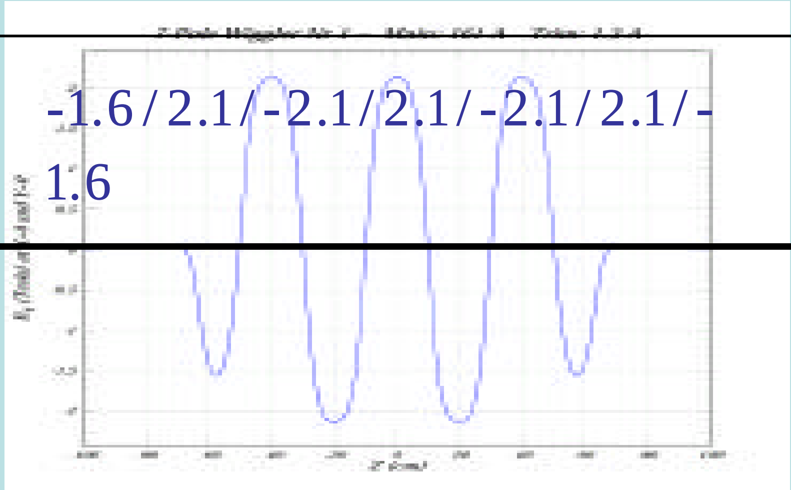
- Wiggler magnets specification choice
- Magnetic design and model calculation
- Cold mass and cryostat design
- Magnetic field performance
  - Hall probe field mapping
  - Stretched coil measurement
- Beam based characterization
- Conclusion

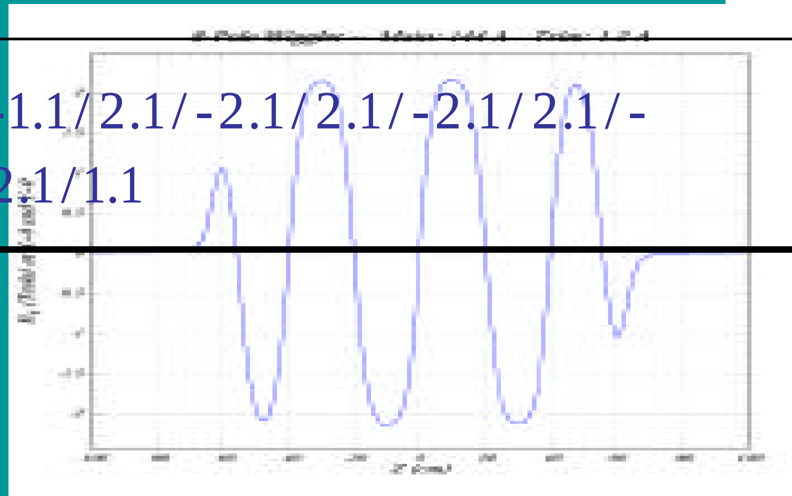
CESR-c Wiggler Magnets
A.Temnykh, CESR

Magnetic design: two types

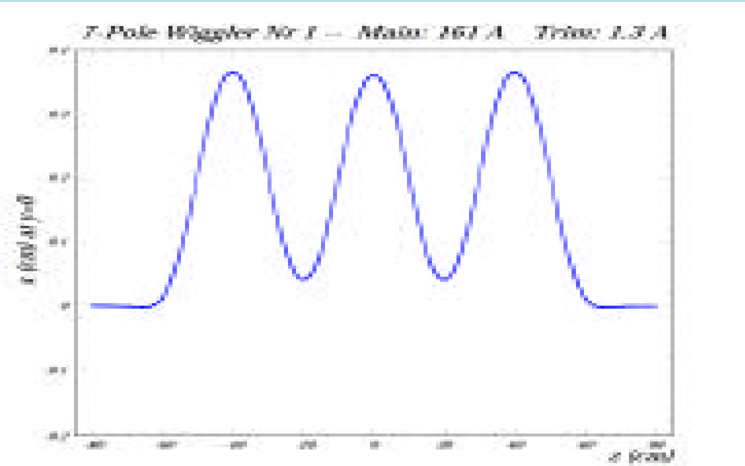
	7 poles (symmetric)	8 poles (asymmetric)
Poles length [cm]	15+20+20+20+20+20+15 = 130	10+15+20+20+20+20+15+10 = 130
Bmax/pole [T]	-1.6/2.1/-2.1/2.1/-2.1/2.1/-1.6	-1.1/2.1/-2.1/2.1/-2.1/2.1/-2.1/1.1

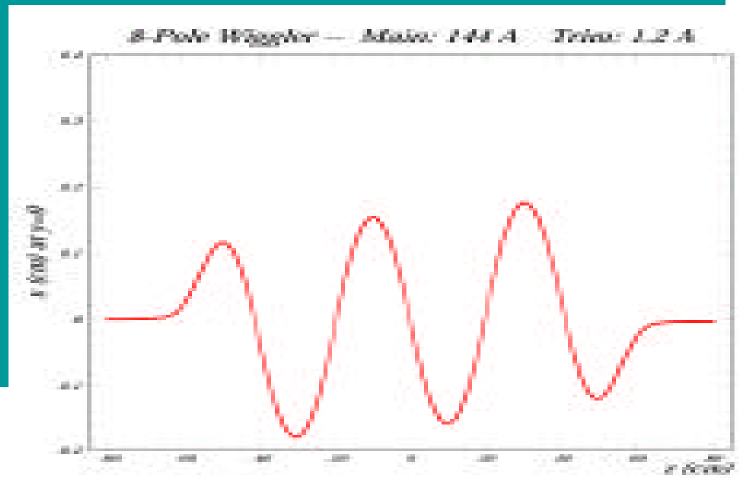
Field along magnet





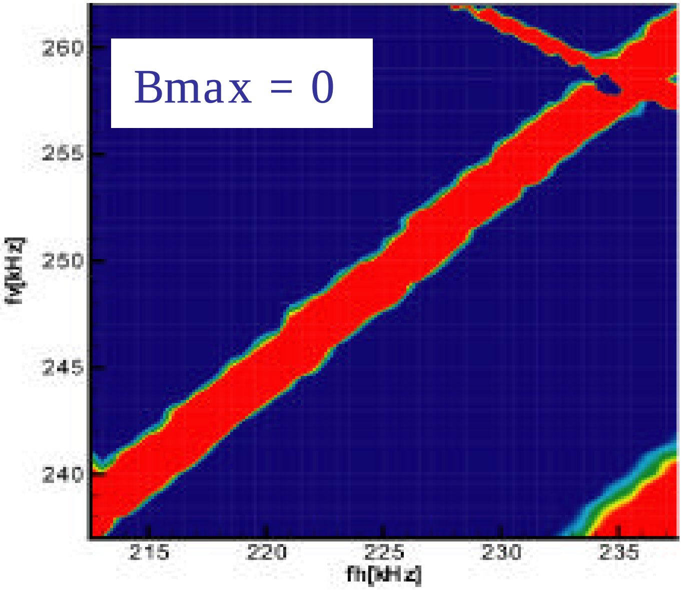
Beam trajectory

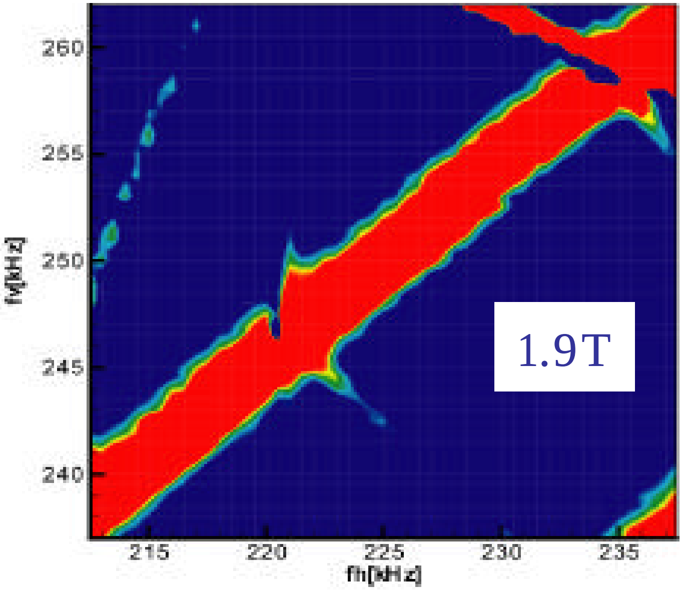


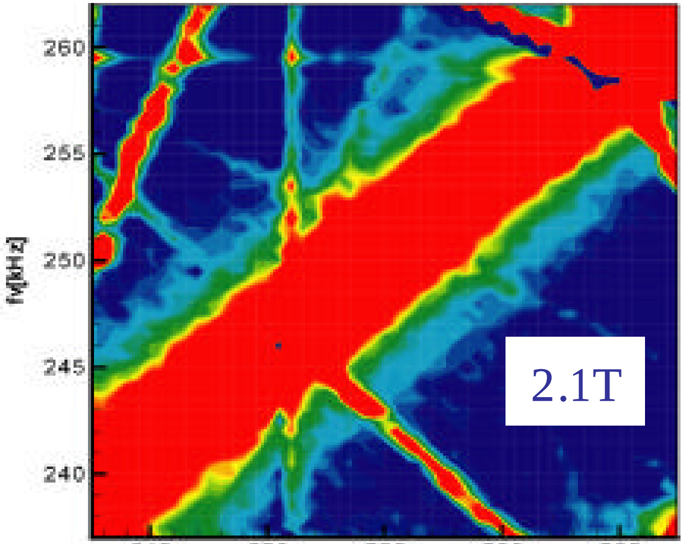


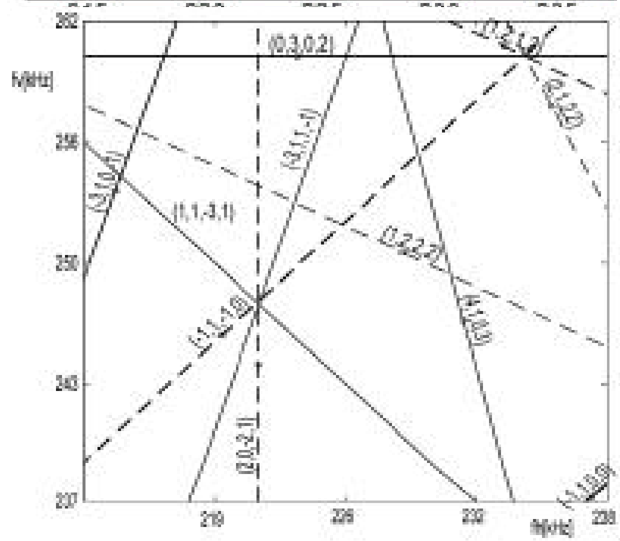
Beam based characterization: Nov 2002, one wiggler optics, wiggler #1 (7p)

3) 2D tune scan: vertical beam versus tune, evaluation with wiggler field









Oct. 14 2002, Optics: 1843MeV_1WIG_R3_OT, fs = 25kHz

Observed resonances

Wiggler OFF: -fh+fv = 0, -fh+fh-fs=0, fh+2fv + fs = 2f0, Pmax = 3

Wiggler ON: -3fh+fv= -f0, fh+fv-3fs=f0, 3fv=2f0, fh+2fv+2fs=2f0, 4fh+fv=3f0, 2fh+fv+2fs=2f0, 2fh-2fs=f0 and -3fh+fv+fs=-f0, Pmax = 5

The Electron Cloud Problem and Potential Remedies

R. Cimino

LNF-INFN Frascati (Roma) Italy.

- Introduction: DaΦne and the “e-cloud”
- The e- cloud problem: The LHC case
- Surface science techniques to provide input parameters.
- Some selected results
- Future work and implications to DaΦne-2 project.

DaΦne and the "e-cloud"

DaΦne runs with more than 1 to 1.3 A e^+ without observing detrimental phenomena induced by the "e-cloud" contrary to more recent simulations…..

This clearly indicates that either the geometry of the vacuum chamber, or the material properties or other important parameter or assumptions or…. are not correct!

- **Indicates as well that DaΦne is an ideal machine to benchmark the codes…**

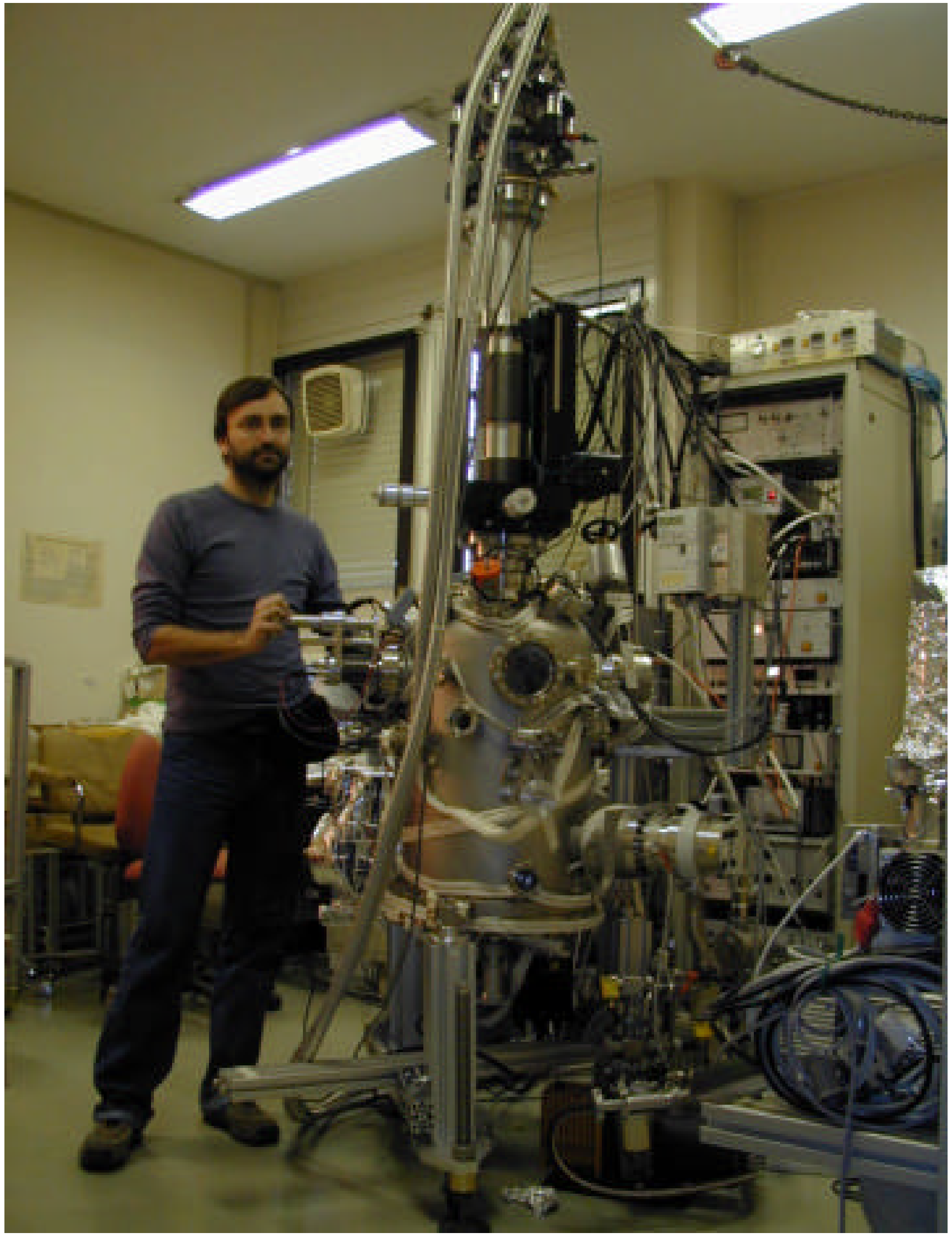
To predict the effect of the "e-cloud" on DAFNE - 2:

Surface Science Imputs: Constructive candidate materials (Al, Cu NEGs, etc etc) needs to be studied to give accurate:

- **Secondary electron yield,**
- **Photoemission,**
- **photon reflectivity**
- **electron and photon induced electron emission**
- **electron and photon induced desorbtion,**
- **Surface chemistry during operation**
- **etc etc.**

A surface science lab.

- μ-metal chamber;
- En. & angle res. analyser;
- Low T manipulator;
- LEED - Auger RFA;
- Faraday cup.
- Low energy electron gun
- Mass spectrometer
- Sample preparation



Conclusion:

Simulation codes needs to be upgraded: In particular to simulate the boundary condition specific to the DAΦNE and DAΦNE- 2 machines.

An experimental campaign not only in the lab. but on DAΦNE machine itself (measuring e- activity,etc)could be launched to benchmark the codes vs. experiments.

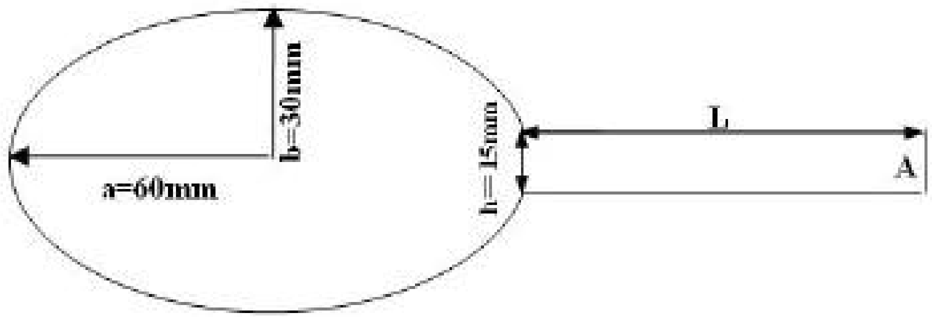
Accelerator Physics Issues in BEPCII

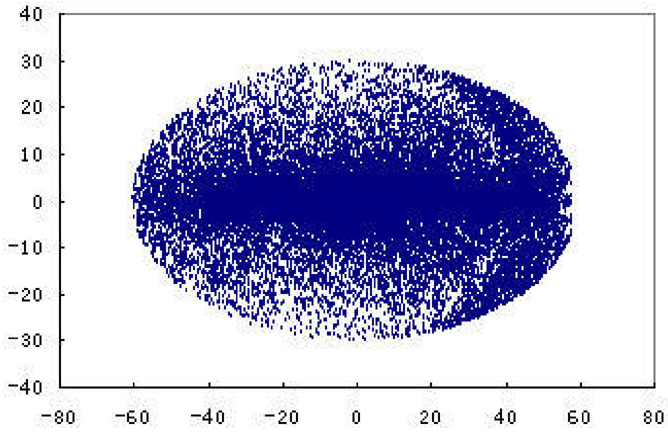
BEPCII AP Group

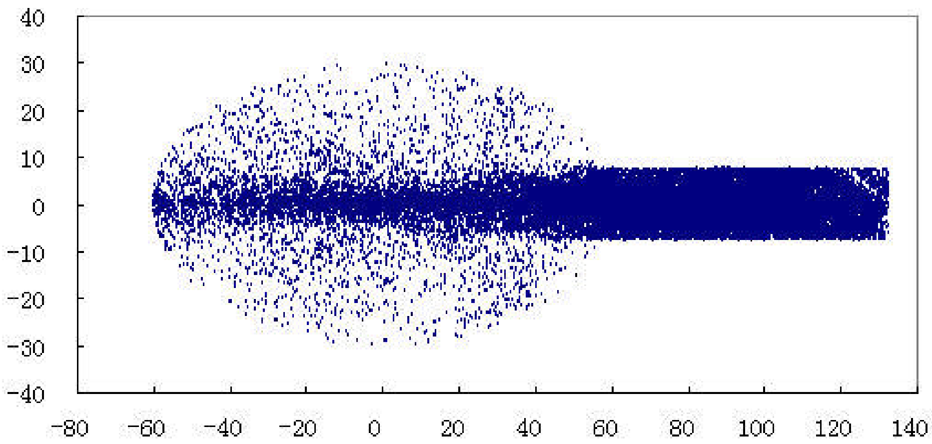
- Introduction
- Lattice and dynamic aperture
- Coupling impedance
- Single beam effects
- Beam-Beam interaction
- Summary

C. Zhang, IHEP

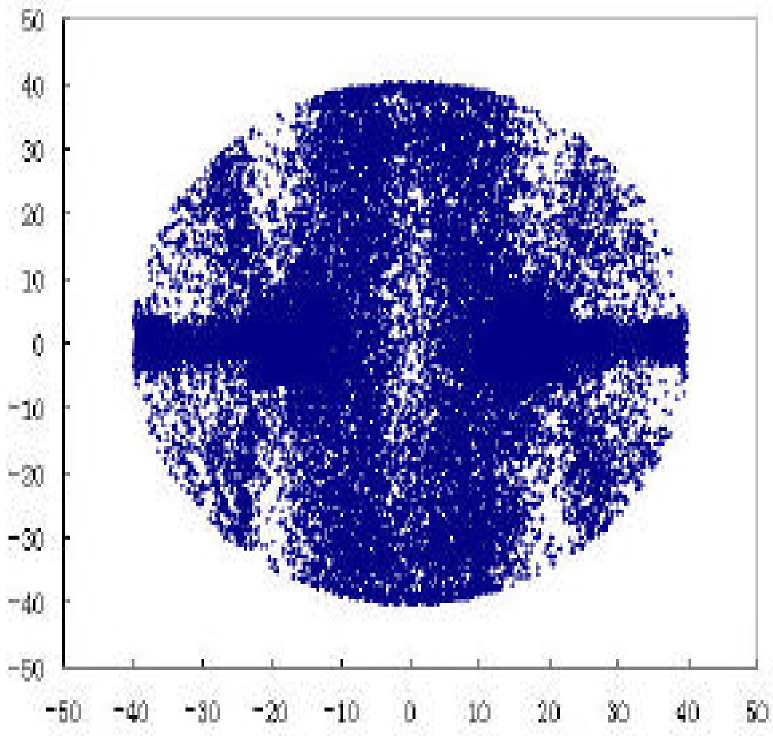
A code has been developed (Y. Liu) to study the effect of antechamber against ECI, based on Ohmi’s model

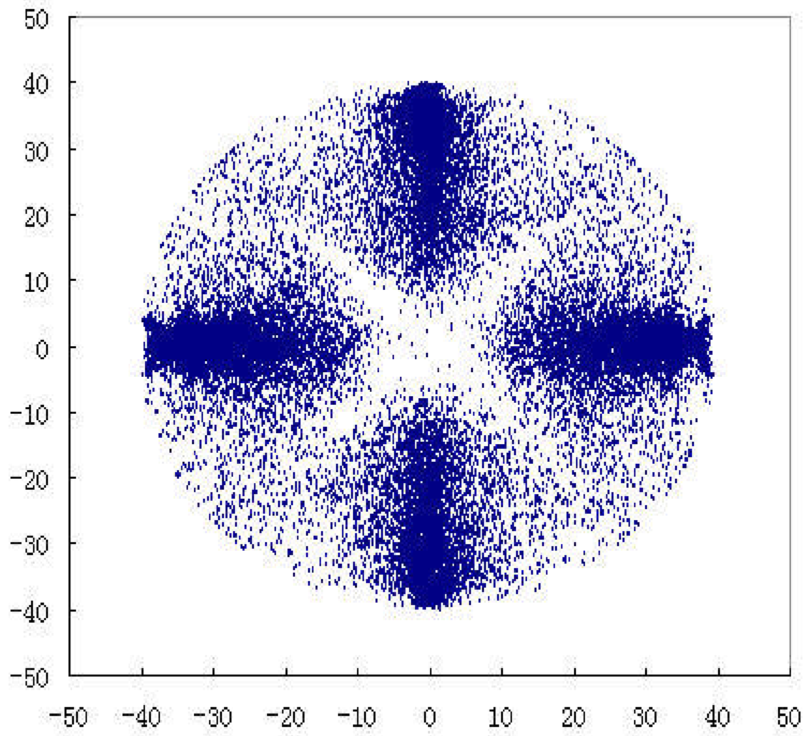






EC in magnetic fields





- EC density at the beam pipe center significantly reduced in B,Q,S magnet field;
- Advantages in BEPCII: more than _ space in arc occupied by magnets.

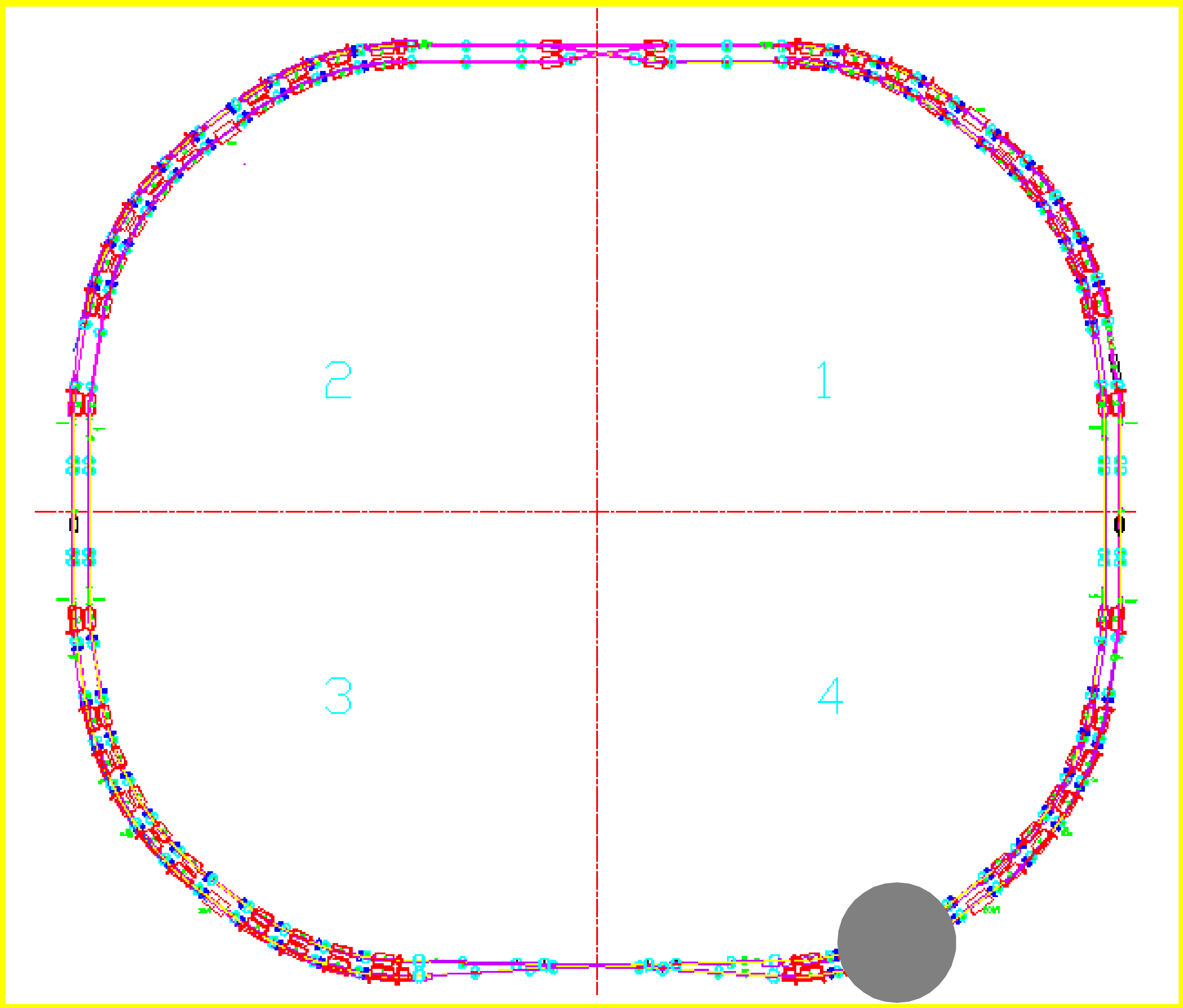
To control ECI

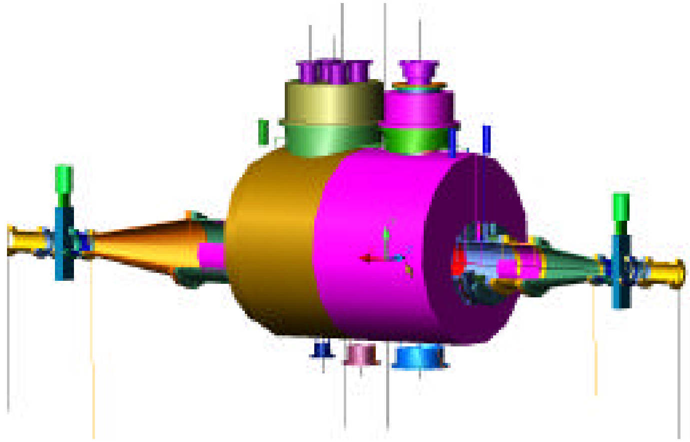
To guarantee the beam performance against ECI, precaution methods successfully adopted in PEPII and KEKB is considered in BEPCII design.

- **Antechamber**
- **TiN coating of the inner surface**
- **Solenoid winding (as backup)**
- **Clearing electrode (R&D)**

  - **Simulation study being done**

BEPCII: *a high luminosity double–ring collider*





Summary of single beam effects

- With the present impedance budget, σ_l <1.5cm.
- Coupled bunch instabilities due to HOMs and resistive wall can be damped with the feedback system.
- Gap is needed to avoid ion trapping, FBII in e-ring should be damped with feedback system.
- For ECI in e+ ring, antechamber (TiN coated) is adopted to reduce EC. R&D on other methods (solenoid, clearing electrode) is under way.
- Normal beam lifetime is about 3.1 hours. With top-off injection the average luminosity > $6.0\_10^{32}cm^{-2}s^{-1}$.

Summary of beam-beam effects

- To choose the horizontal tune close (above) to half integer is a good choice to get the higher luminosity;
- The luminosity reduction factor due to hour glass effects and crossing angle is about 80%;
- The designed value of ξy=0.04 is reasonable and reachable for ϕ_c =11mrad×2;
- Some further simulation should be done, including the coherent beam beam effects by strong-strong simulations.

(5) Summary

- Lattice and dynamics: optimized;
- Coupling impedance: investigated;
- Single beam effects: studied;
- Beam-Beam interaction: simulated;
- Design goal: feasible;
- Further study: needed!

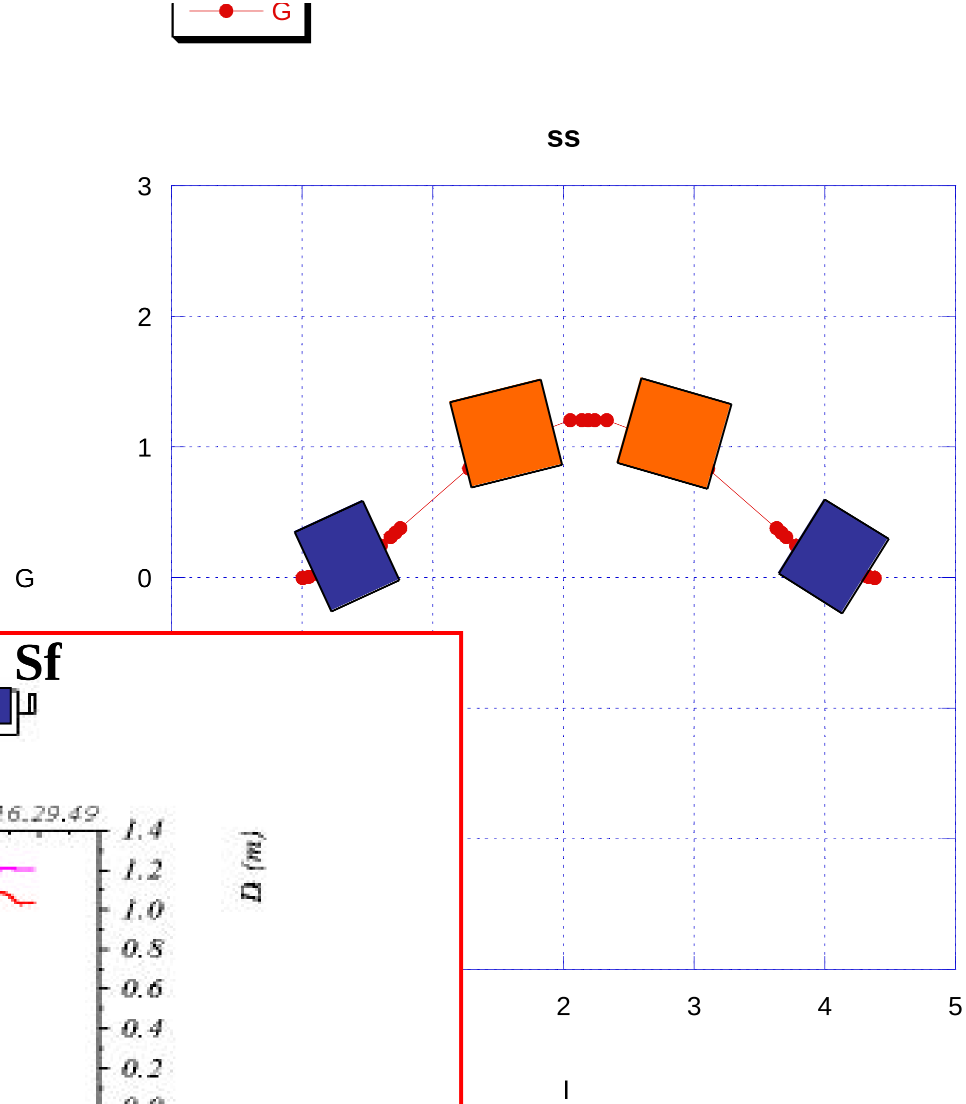
Main guidelines for the design
L > 10 ^{34}

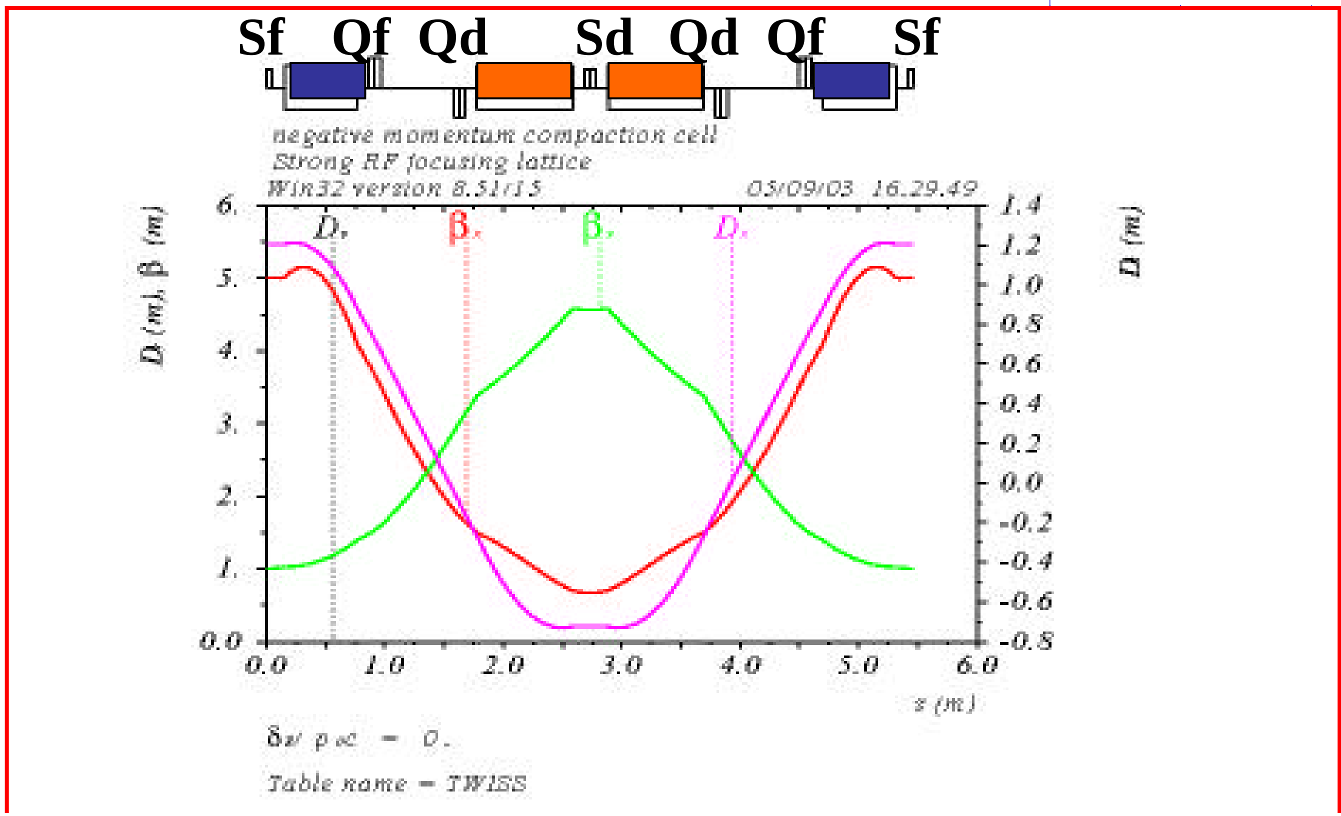
- **Powerful damping**
- **Short bunch at IP**
- **Negative momentum compaction**

Which kind of collider is possible at Frascati using present infrastructures?

HIGH and NEGATIVE MOMENTUM COMPACTION

strong RADIATION emission

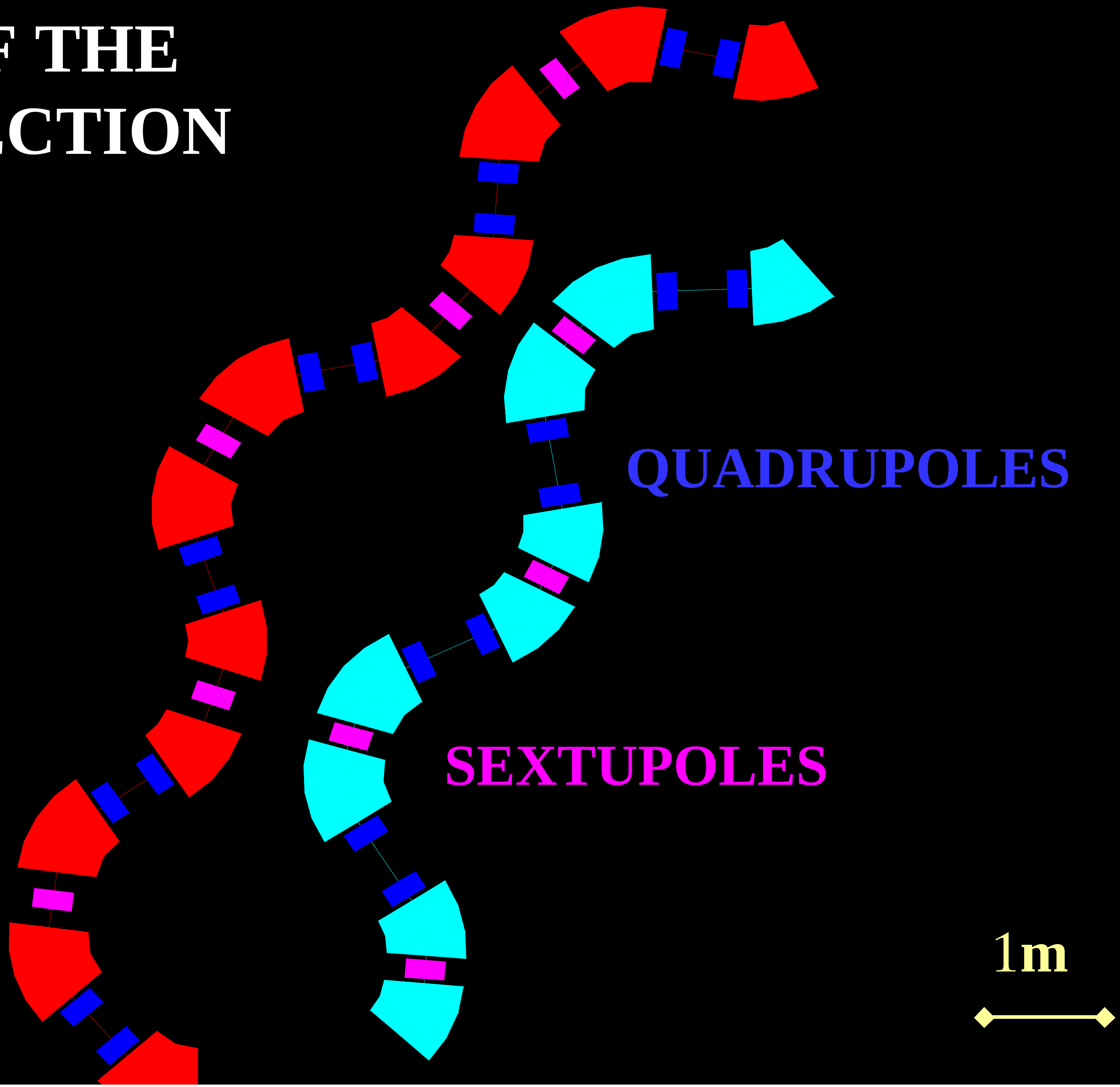




Alternating positive and negative bending dipoles

(proposed by Raimondi)

ZOOM OF THE RINGS SECTION



Maximum bunch length at cavity
Minimum bunch length at IP

$$\sigma_z(Cav) = \frac{\alpha_c L}{\sin\mu}\left(\frac{\sigma_E}{E}\bigg|_0\right)\sqrt{\frac{2+\cos\mu}{3}}; \quad \sigma_z(IP) = \alpha_c L\left(\frac{\sigma_E}{E}\bigg|_0\right)\sqrt{\frac{2+\cos\mu}{6\,(1-\cos\mu)}}$$

α_c = - 0.23

L = 100 m

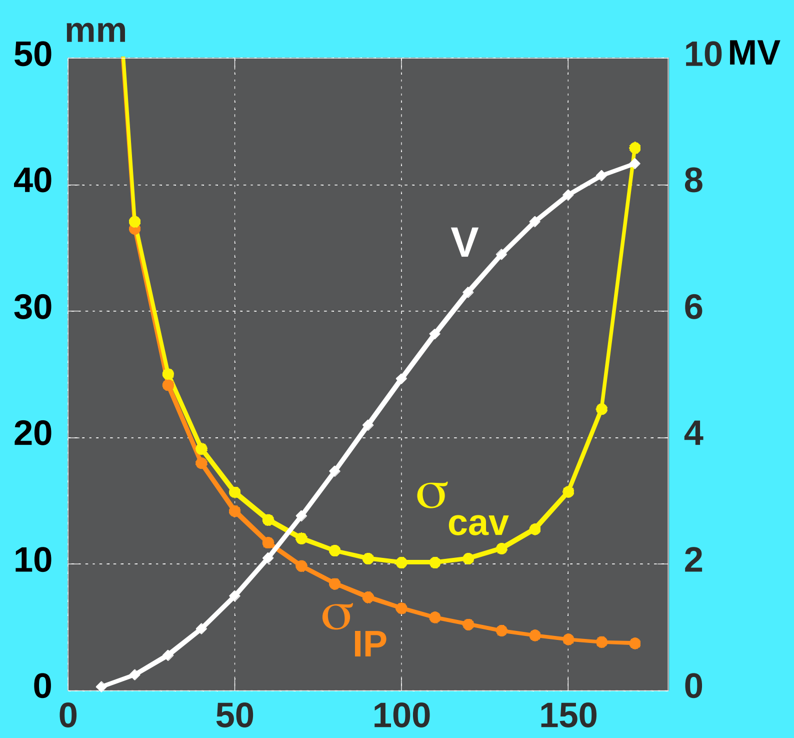
$\sigma_e/E|_o$ = 5 10^{-4}

V = 8.2 MV

μ = 165°

σ_{cav} = 30 mm

σ_{IP} = 3.8 mm



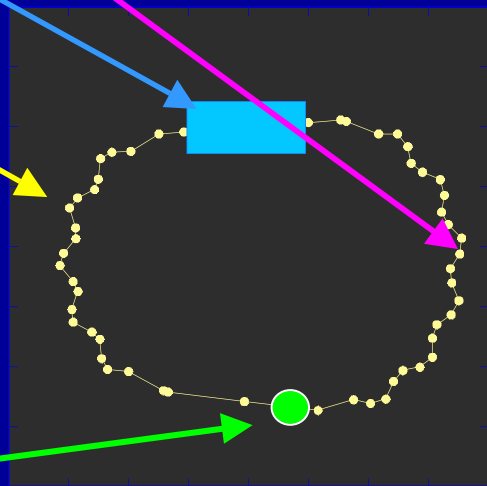
Layout similar to present DAΦNE rings:

One IR

Second crossing for injection, rf, diagnostics

Short inner arc and long outer arc with the condition of equal longitudinal phase advance between cavity and IP in both directions

$$R_{56}(rf \rightarrow IP) = R_{56}(IP \rightarrow rf)$$



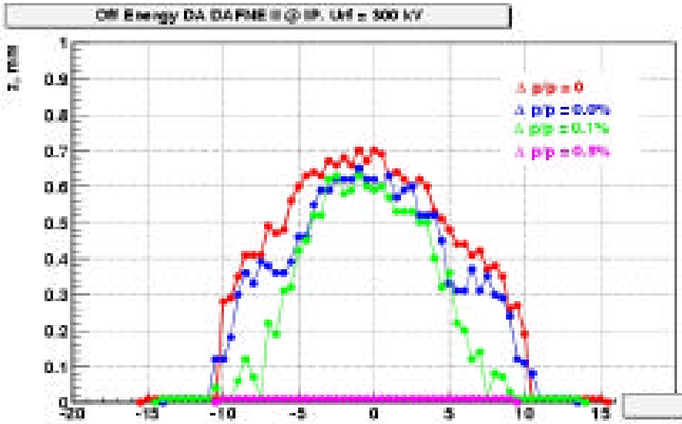
rf

Dynamic aperture

First evaluation by
***E.Levichev, P.Piminov*[*)]**
BINP, Lavrentiev 13, Novosibirsk 630090, Russia

ACCELERATICUM computer code [*]
Symplectic 6-D tracking for transversely and longitudinally coupled magnetic lattice

[*] Tracking code ACCELERATICUM, VEPP-4M Internal Note, BINP, Novosibirsk, 2003.



----- no synchr oscill

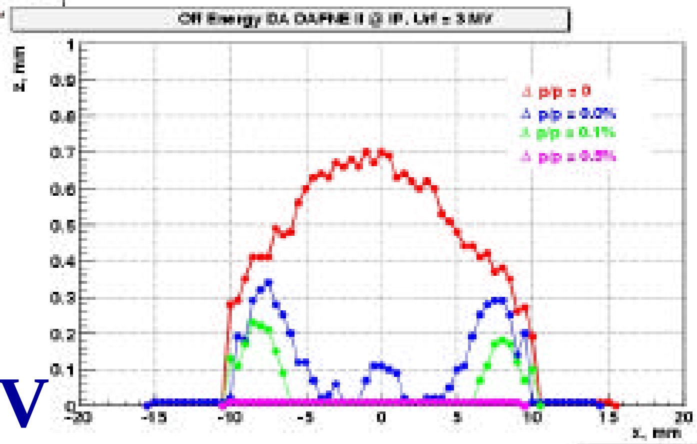
----- Dp/p = 0

----- Dp/p = 0.1%

----- Dp/p = 0.5%

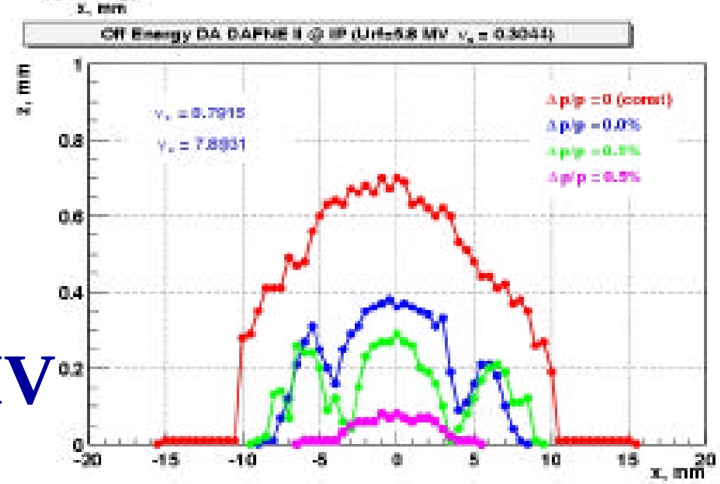
V = 300 kV

Q_s = 0.059



V = 3 MV

Q_s = 0.2



V = 5 MV

Q_s = 0.3

Strong dependence on V
but specially on Q_s
=> Resonances in 3D

2. Dependence of dynamic aperture in the case of the strong RF focusing on the tune point is to be explored (in other words, more accurate choosing of the betatron and synchrotron tunes). It seems that all the three tunes are important now.

Luminosity 10^{34}

$$N^{+,-} = 5\ 10^{10}$$

$$\beta_x = 0.5\,m$$

$$\beta_y = 4\,mm$$

$$\varepsilon_x = 0.26\,\mu\,rad$$

$$\kappa = 0.6\%$$

$$n_b = 150$$

$$I_b = 24\,mA$$

$$I_{tot} = 3.7\,A$$

challenges

OUTLINE

- IR design constraints & requirements
- Crossing angle
- Parasitic Crossings
- Tune shifts and luminosity with crossing angle
- IR design layout & parameters
- IR flexibility
- To do list

IR Design

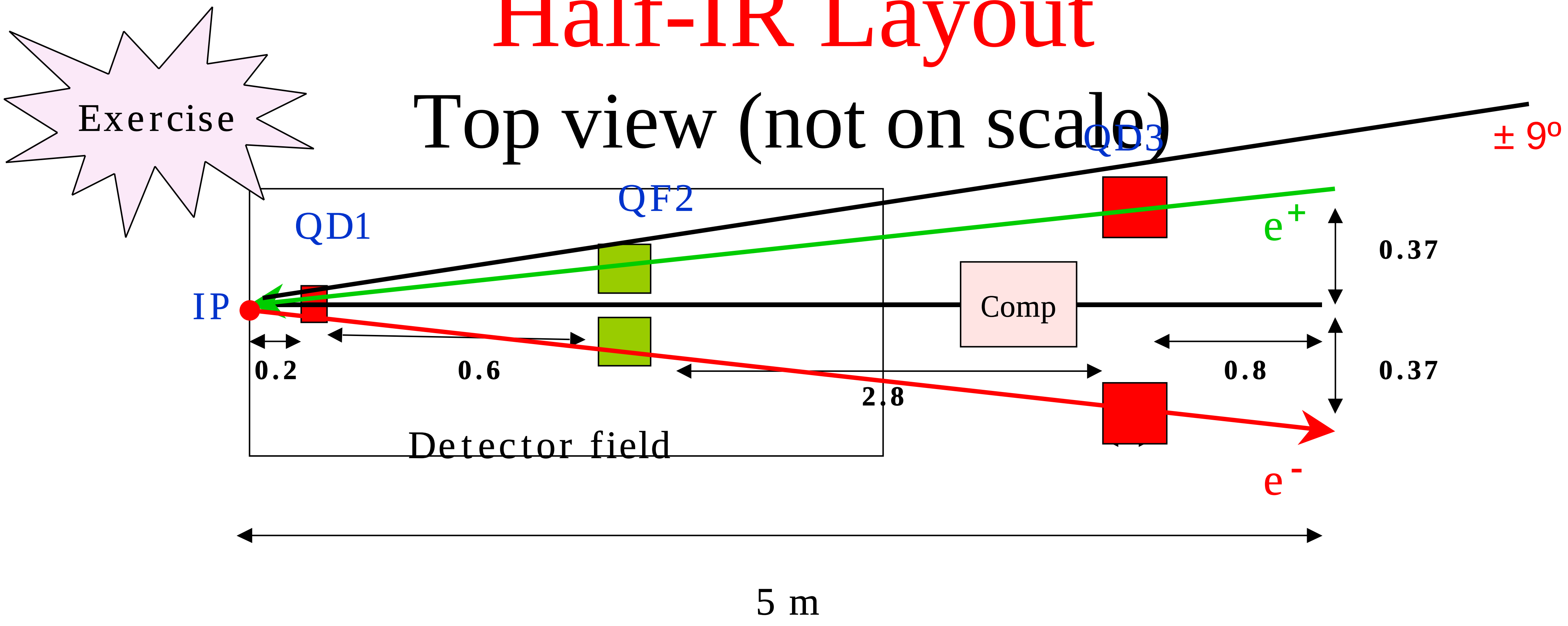
M. Biagini, LNF-INFN

IR Design Requirements
(Machine & Detector)

- Maximum detector solid angle, try to keep accelerator components far enough away from the IP (D)
- Large high-field solenoid (KLOE, FINUDA-like) (D)
- Push Q1 close to IP, to minimize IP spot size (M)
- Horizontal crossing angle (M) (DAΦNE experience)
- Small quadrupoles, embedded in detector field (M,D)
- Coupling correction (M) (DAΦNE experience)
- Adequate shielding from Touschek background (M,D)
- Ultra-vacuum (M,D)
- Impedance budget (M)
- Thin beam pipe (D)
- "Instrumented" IR (D)

The IR design is a common Machine & Detector business !!

Half-IR Layout



With ± 10σ_x clearance, ± 9º cone, ±30 mrad angle:

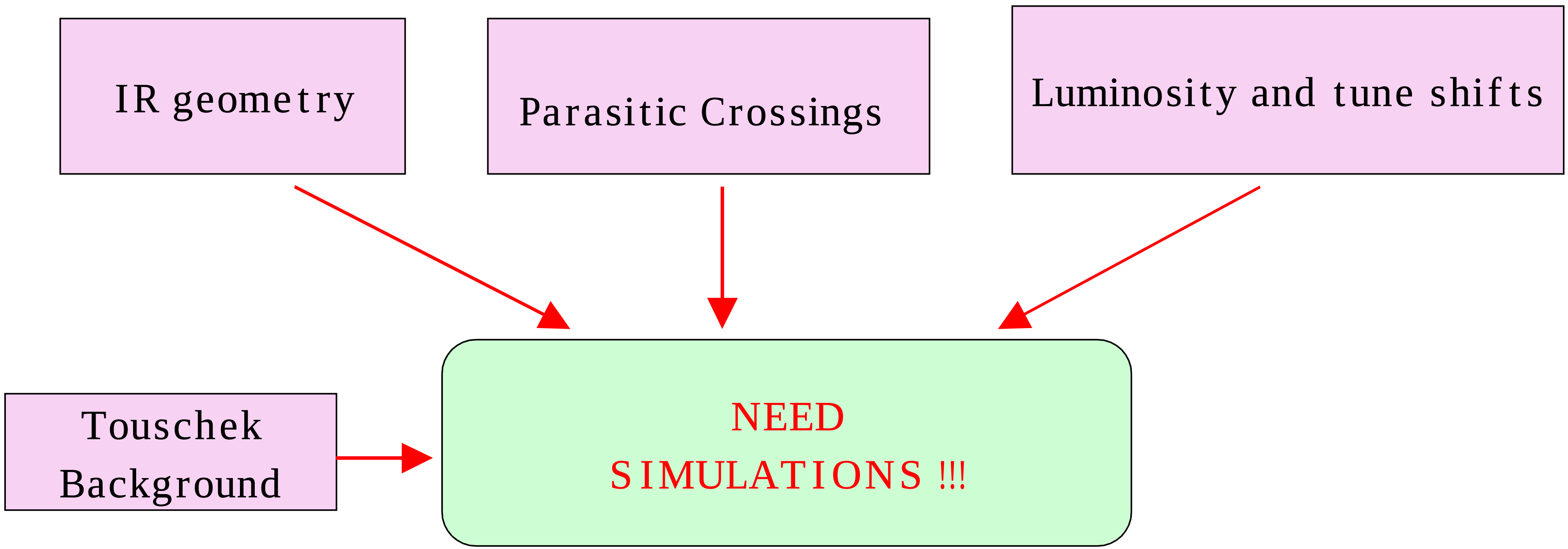
QD1: L= 20 cm, pole radius = 1.5 cm, R_{ext} = 3 cm, pm thickness= 1.5 cm

QF2: L= 20 cm, pole radius = 11 cm, R_{ext} = 16 cm, pm thickness= 1.5 cm,
4 cm space between 2 quads

QD3: L= 20 cm, pole radius = 15 cm , R_{ext} = 63 cm, 25 cm space between 2 quads

Conclusions on crossing angle choice

The crossing angle should be chosen by considering:



To Do List (practically everything...)

- Technical design
- Engineering studies of pm quads
- Chromaticity correction study
- Coupling correction scheme
- Background evaluation
- Beam pipe design
- Vacuum design
- Impedance budget
- Trapped HOM study
- Temperature control
- ......

DAFNE lifetime

DAFNE beam lifetime is dominated by Touschek effect.

The average residual gas pressure is well below 10^{-9} Torr and the contributions of beam gas interactions are negligible.

Increasing the luminosity by 2 orders of magnitude is done by squeezing the beams and therefore reduces the Touschek lifetime.

This is a preliminary estimate of beam lifetime for a machine with an extremely short bunch length σ_z 2.5 ÷ 4mm at a luminosity of 10^{34}.

Touschek lifetime

Neglecting $C(u_{min})$ which is a slowly varying function of ε:

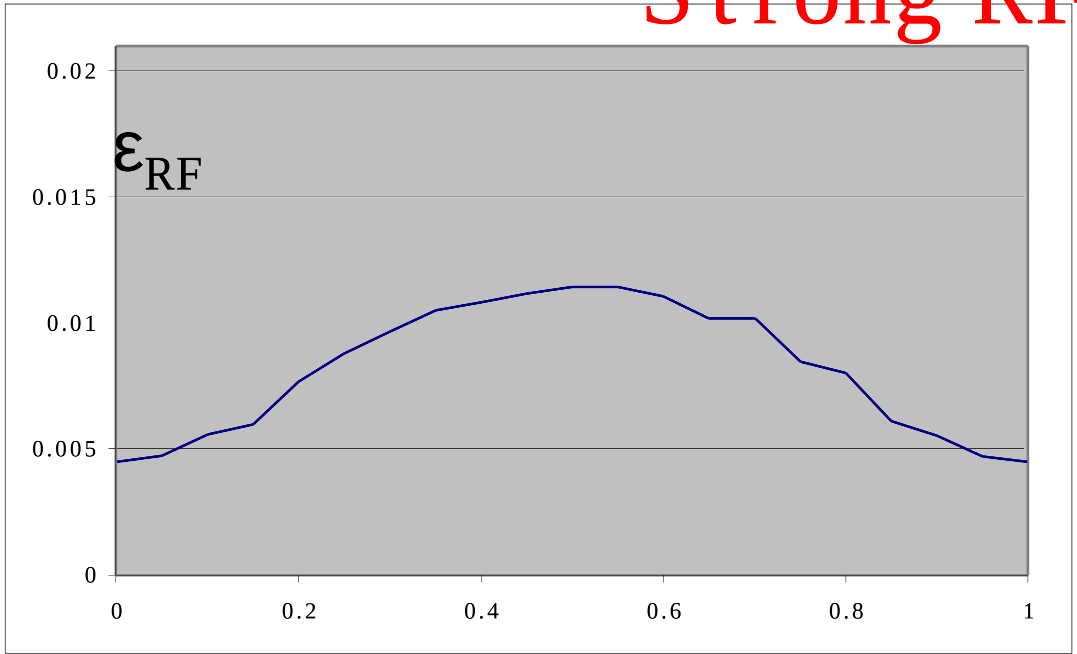
$$\frac{1}{\tau} \quad \frac{N}{\gamma^3 \sigma_x' \varepsilon^2 \sigma_x \sigma_y \sigma_l}$$

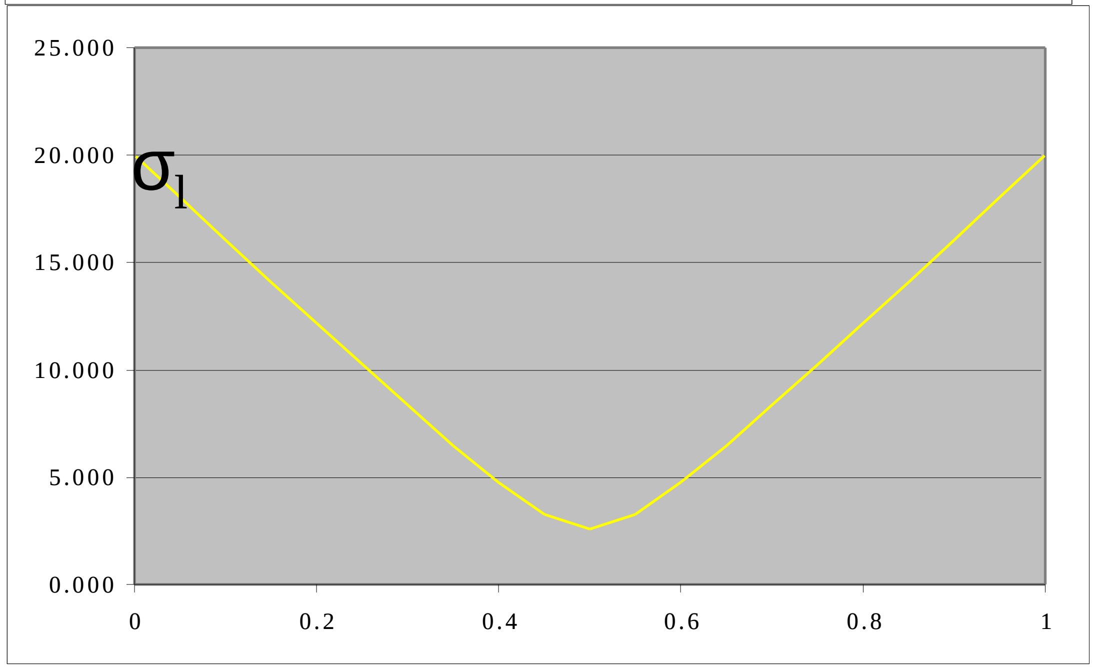
τ is proportional to ε^2 and to the bunch density.

ε is the energy acceptance of the ring and is the minimum between:

- RF acceptance
- Aperture limitation
- Dynamic aperture

Strong RF focusing





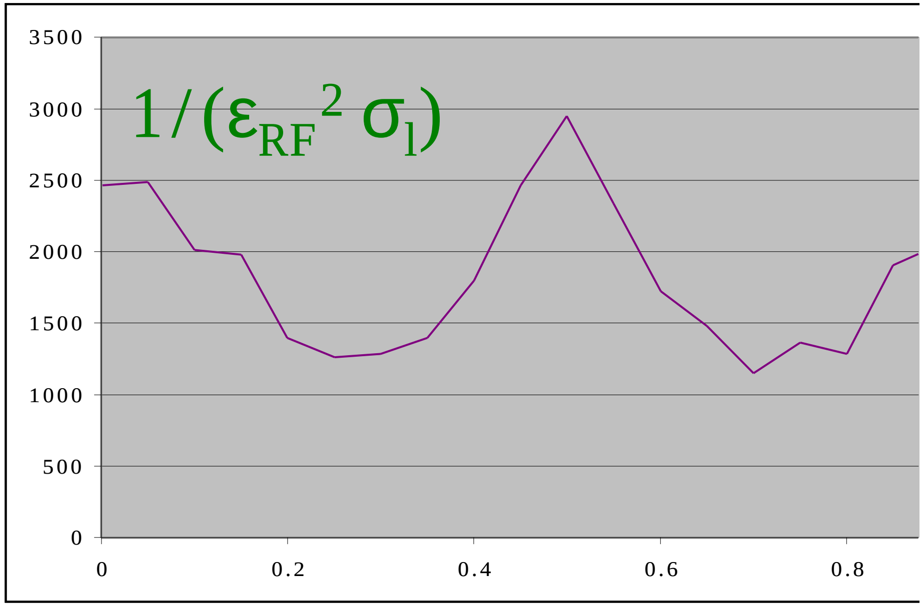
$\sigma_l^{IP} = 2.6$ mm , $\sigma_l^{RF} = 20$ mm

$\mu_{long} = 165^o$

$\alpha_c = -.17$, $V_{RF} = 10.68$MV

$\sigma_p = 2.2\ 10^{-3}$

$1/\tau \quad \langle 1/(\varepsilon_{RF}^2\, \sigma_l) \rangle = 1890\text{mm}^{-1}$



To calculate $1/\tau$ we substitute the value of $1/(\varepsilon_{RF}^2\, \sigma_l)$ with its average along the ring.

Variable σ_l

μ_l	165	150
Emittance (mm mrad)	.19	.19
κ	.01	.01
I (mA)	16	16
α_c	-.17	-.17
VRF (MV)	10.68	10.15
σ_l^{IP} (mm)	2.5	2.8
σ_l^{RF} (mm)	20.0	10.9
σ_p	2.2e-3	1.2e-3
ε_{RF} at IP	1.1e-2	1.1e-2
ε_{RF} at RF	4.5e-3	4.5e-3
Luminosity/csi	1e34/.083	1e34/.083
τ_{TOU} (s)	1050 (17.5')	550 (9.2')
$\tau_{quantum}$ (s)	86 (1.4') !!	6.1e14

Conclusions

Strong RF focusing (bunch length variation along the ring) seems promising to get very short bunch length at the IP.

Touschek lifetime has been calculated with a preliminary set of longitudinal parameters. A further optimization is possible.

Anyway at $L = 10^{34}$ lifetimes are of the order of 10 minutes:

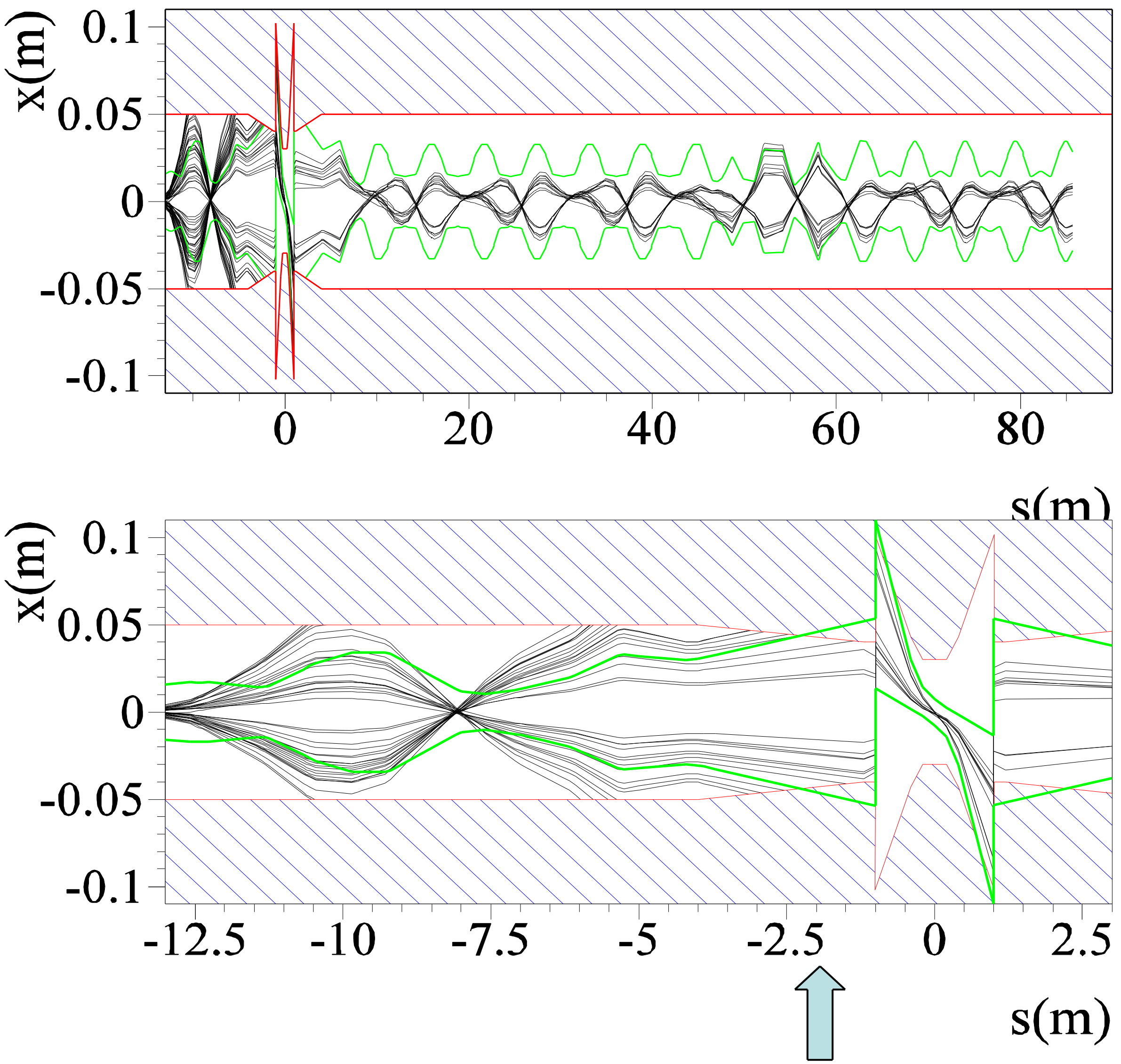
- continous injection is needed
- a setup for Luminosity optimization with rapidily decreasing currents has to be provided.

Background

M. Boscolo, LNF-INFN

- Simulation code used for Touschek background studies at DAΦNE
- Preliminary parameters for Superdafne
- Touschek trajectories
- Background dependence on various parameters

Touschek particles trajectories



GREEN: 20 σ_x

20 σ_x of physical aperture is not enough at IR

to cut all particles with all phases they have to be at least 2 at a 90°-phase between them

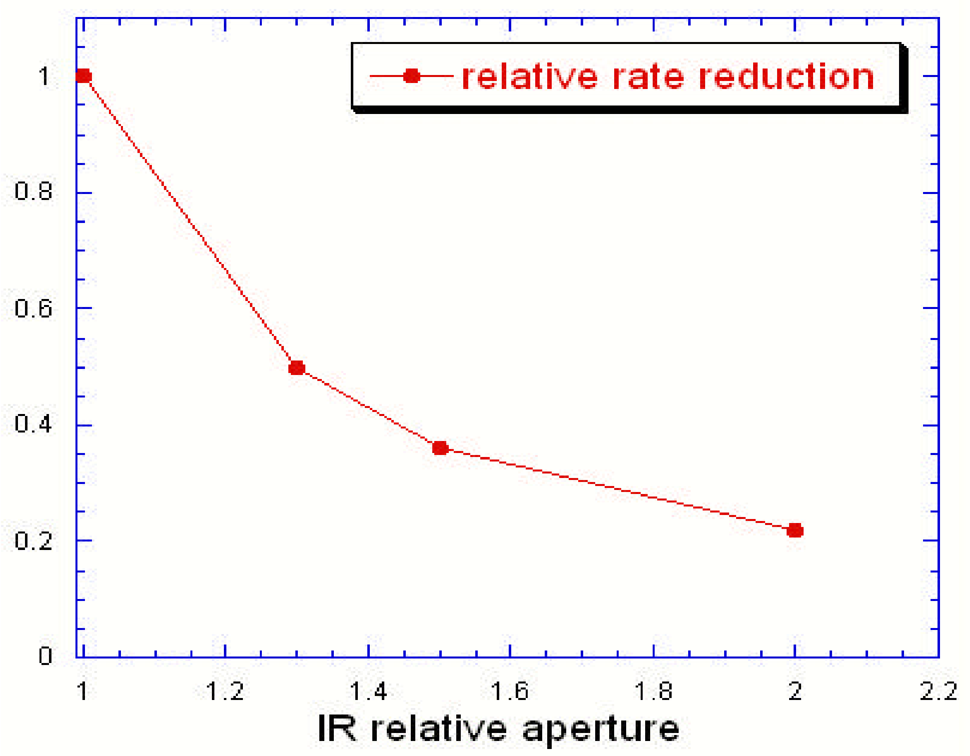
Collimators must be inserted upstream the IR

Rates vs IR aperture

First background estimates indicate that most of losses occur at IR

⇓

IR shape must be carefully chosen to minimize particle losses



For example:

by increasing IR aperture by 30%

losses are decreased by 50%

CONCLUSIONS

The Touschek simulations successfully used at DAFNE

The same tool can be used for the SUPERDAFNE design

- to define position and shape of collimators, masks,...
- to design the beam pipe in the ring - especially at IR
- to optimize the horizontal phase advance between last cell and IP.

Super DAΦNE

L ~ 10^{34} => a new idea => Strong RF focusing

A lot of work to do:

• Optimize longitudinal parameters and define the RF system.

• More simulations:

- Dynamic aperture with Synchrotron oscillations
- Magnetic errors and fringing fields
- Longitudinal dynamics
- Impedance budget
- Beam-beam

Strong RF focusing
A lot of work to do:

- Tests:
  - Negative α_c at DAΦNE (done at KEK)
  - Strong focusing (CESR ?)
- Final IR design
- Lifetime : Simulations and measurements agreement has to be extremely good (check on DAΦNE)
- Instability and feedbacks
- Lattice: can be made compatible with DAFNE2?

- Dipole design

- S.C. quadrupoles in IR.