DAΦNE Operation and Plans for DAΦNE2

M.Zobov on behalf of DAΦNE Team

Particle Accelerator Conference
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DAΦNE Team

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OUTLINE

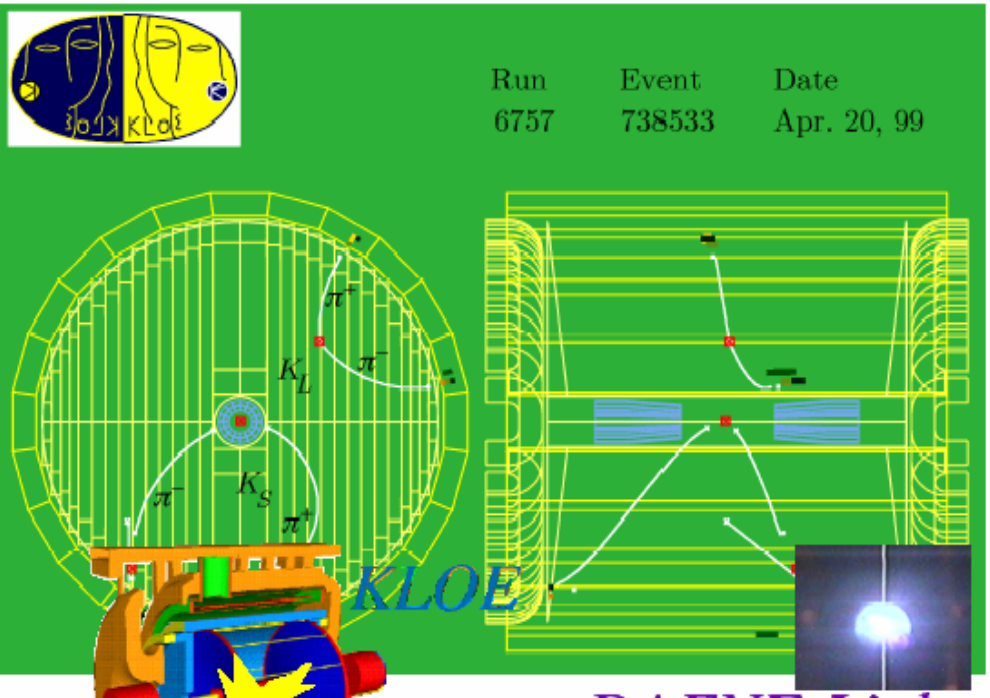
- DAΦNE: description and status
- Luminosity Progress: machine study and hardware modifications
- Performance Limitations
- Accelerator Schedule and Upgrade options
- Experimental Activity

DAΦNE

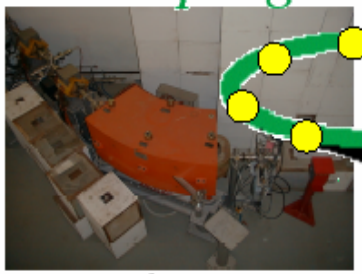
e^+e^-

$C = 97$ m

$E = 0.51$ GeV (Φ)



Damping ring



Test beam

Main rings

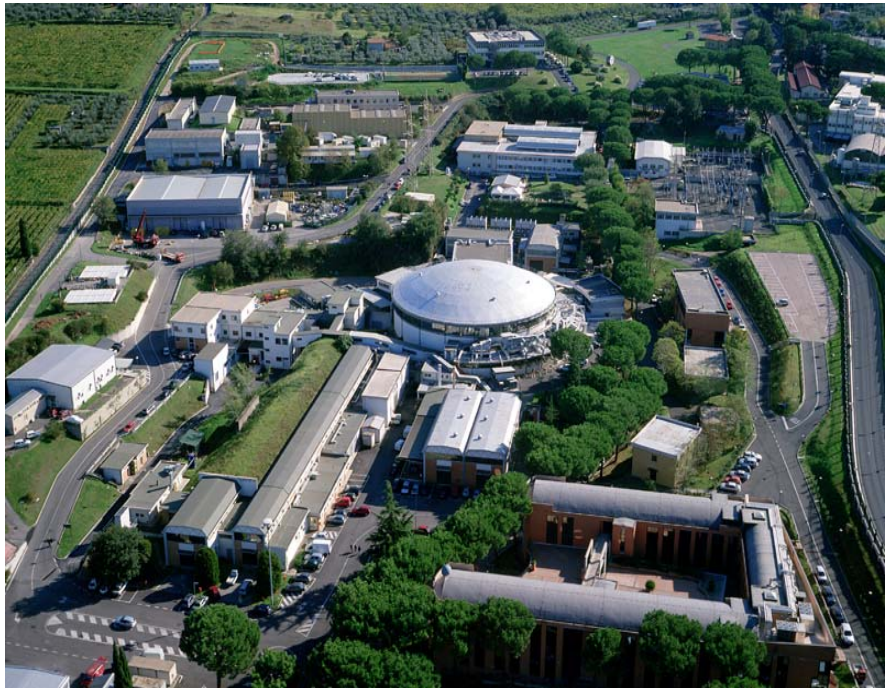
DAFNE-Light

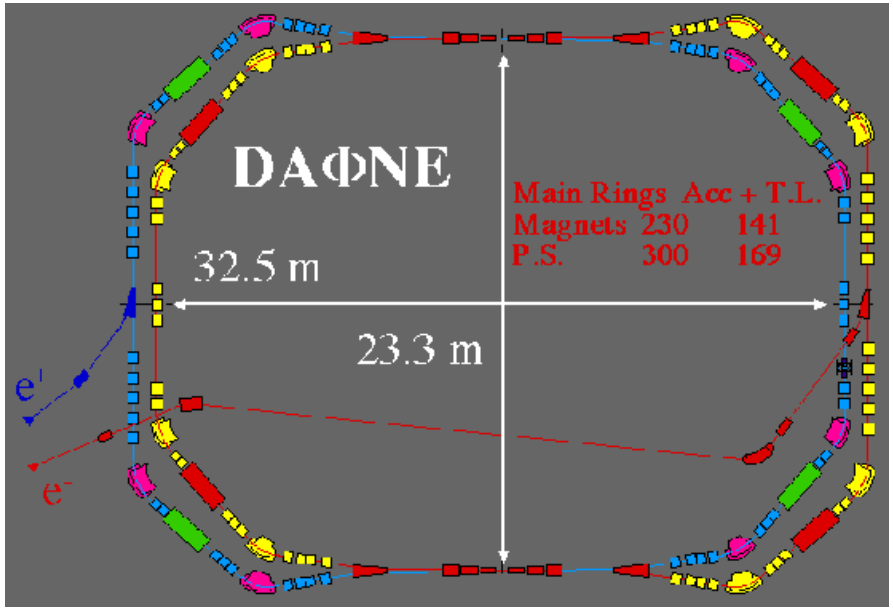
Linac

DEAR
&
FINUDA

DAΦNE Parameters
(KLOE configuration)

Energy, GeV	0.51
Circumference, m	97.69
RF Frequency, MHz	368.26
Harmonic Number	120
Damping Time, ms	17.8/36.0
Bunch Length, cm	1-3
Emittance, mmxmrad	0.34
Coupling, %	0.2-0.3
Beta Function at IP, m	1.7/0.017
Max. Tune Shifts	.03-.04
Number of Bunches	108
Max.Beam Currents, A	2.4/1.4

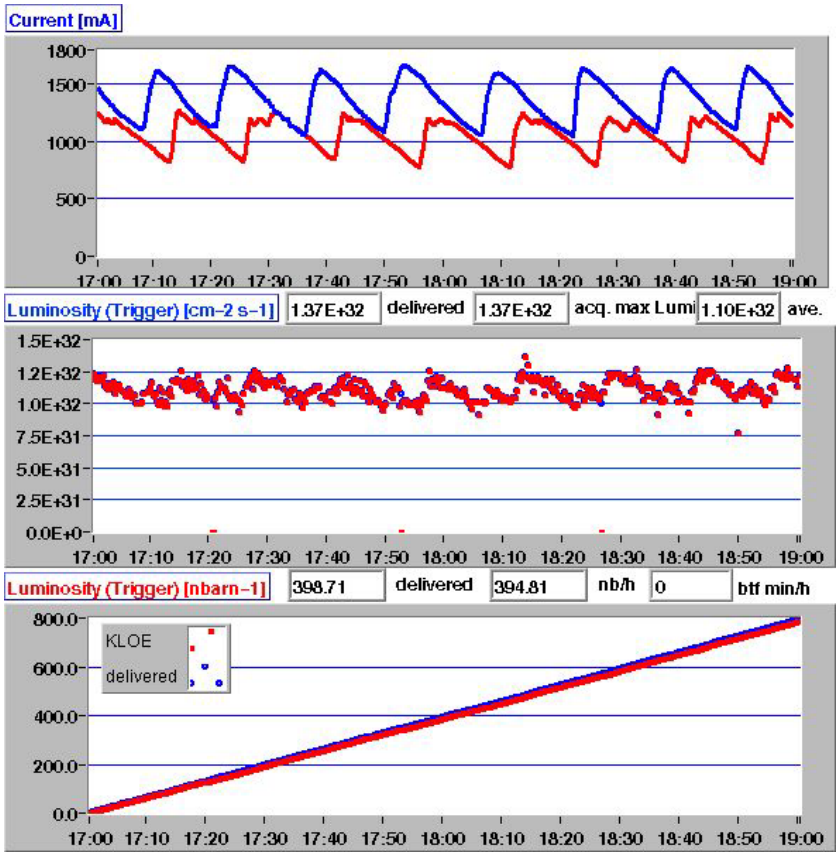




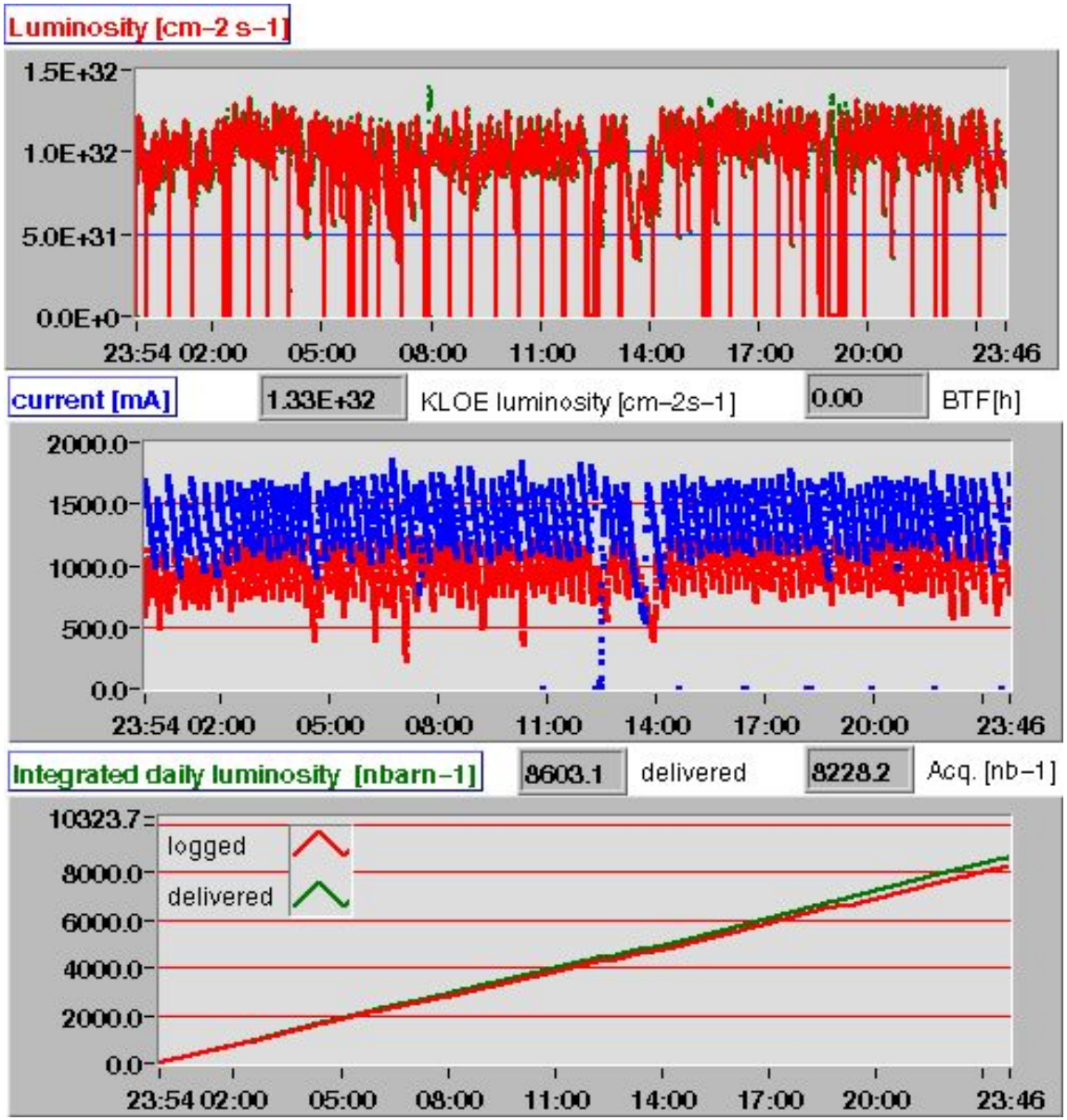
10^{32} Has Been Achieved

The nature of a Φ-factory in itself indicates a minimum target luminosity of 10^{32} cm^{-2} s^{-1} ….

"Proposal for a Φ-factory", LNF-90/031 (IR),1990.

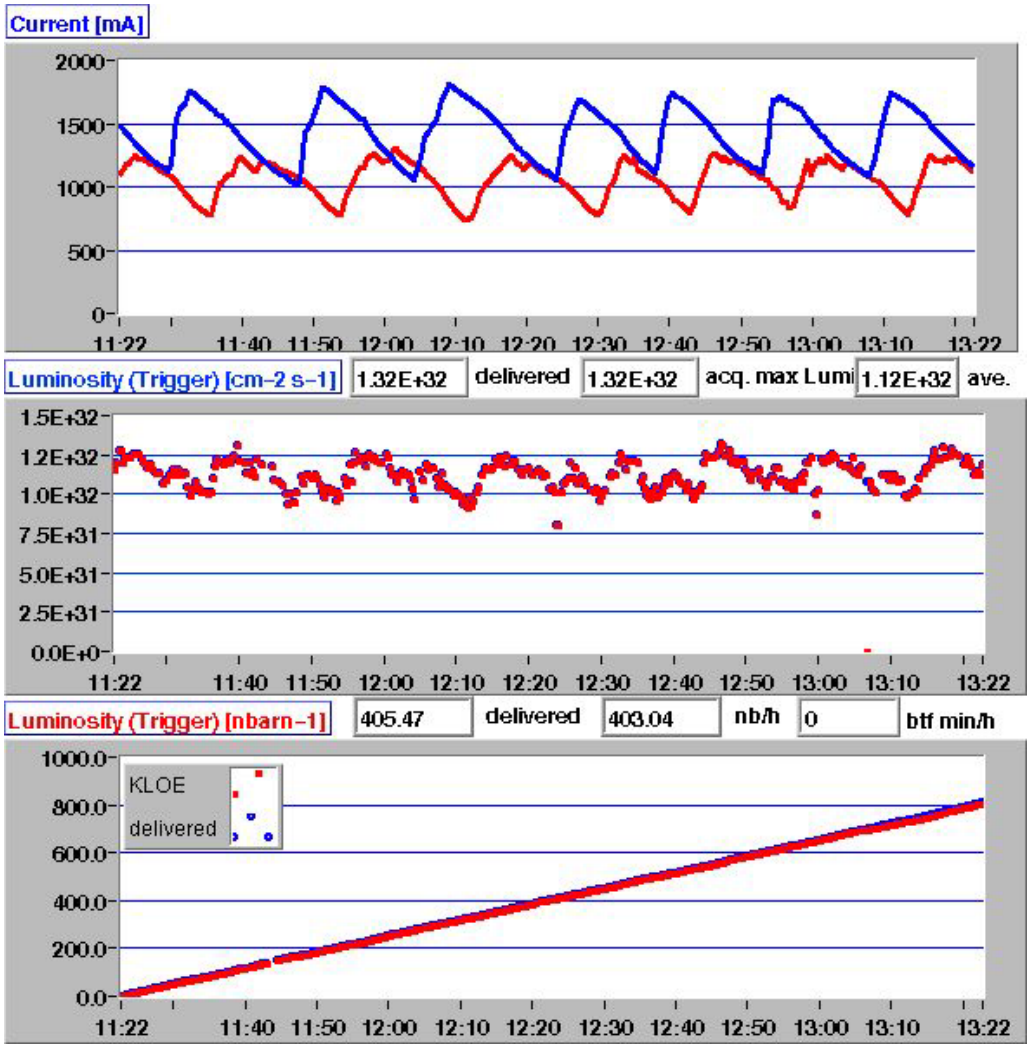


Best Daily Integrated Luminosity



$L = 8.6\ pb^{-1}$

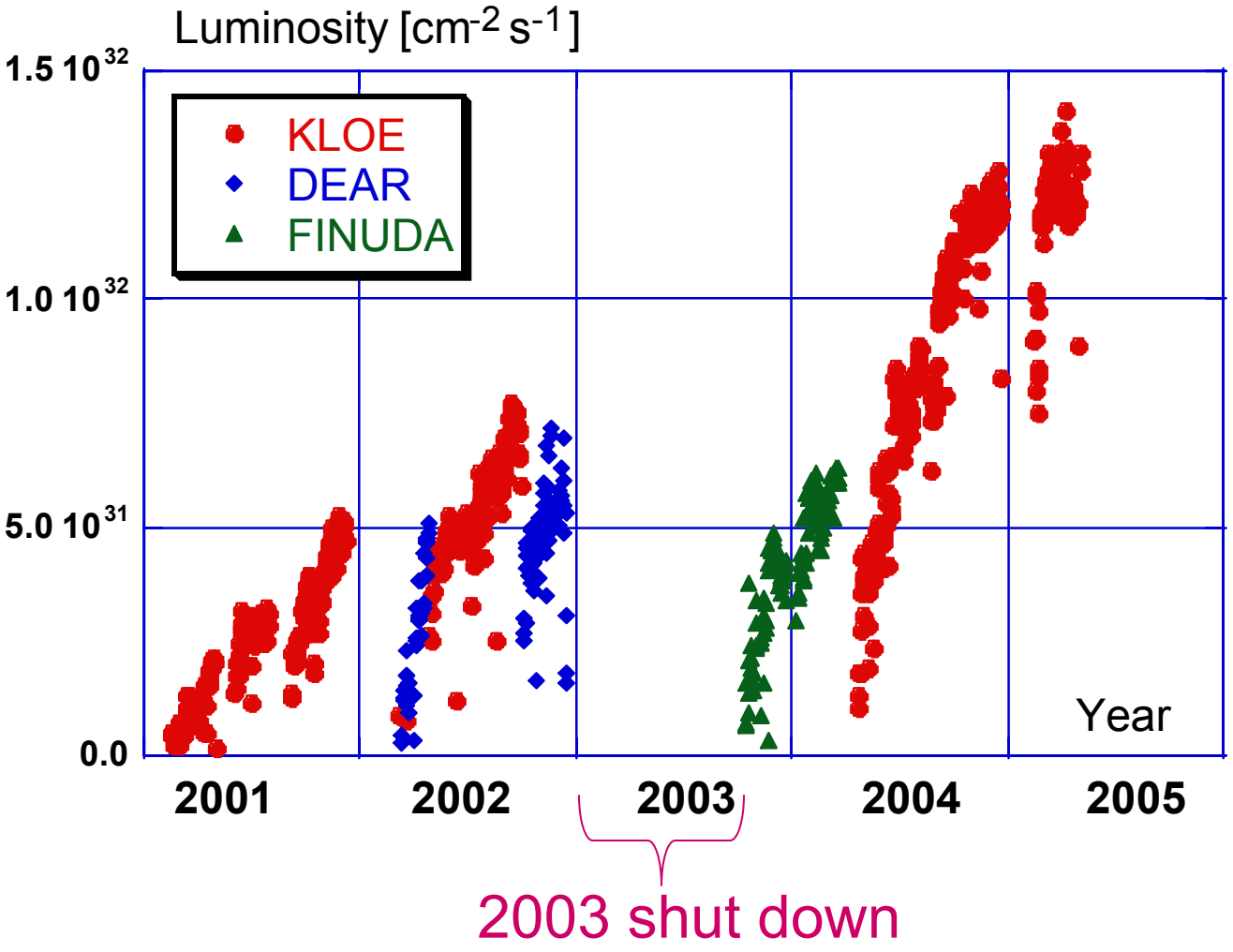
DAΦNE Peak Rate on a 2hrs Interval



$L = 405\ nb^{-1}/hr$

Corresponding to a potential of $9.7\ pb^{-1}$ in 24hrs of continuous operations

DAΦNE Peak Luminosity History



Accelerator Physics Issues
(studied, understood, optimized…)

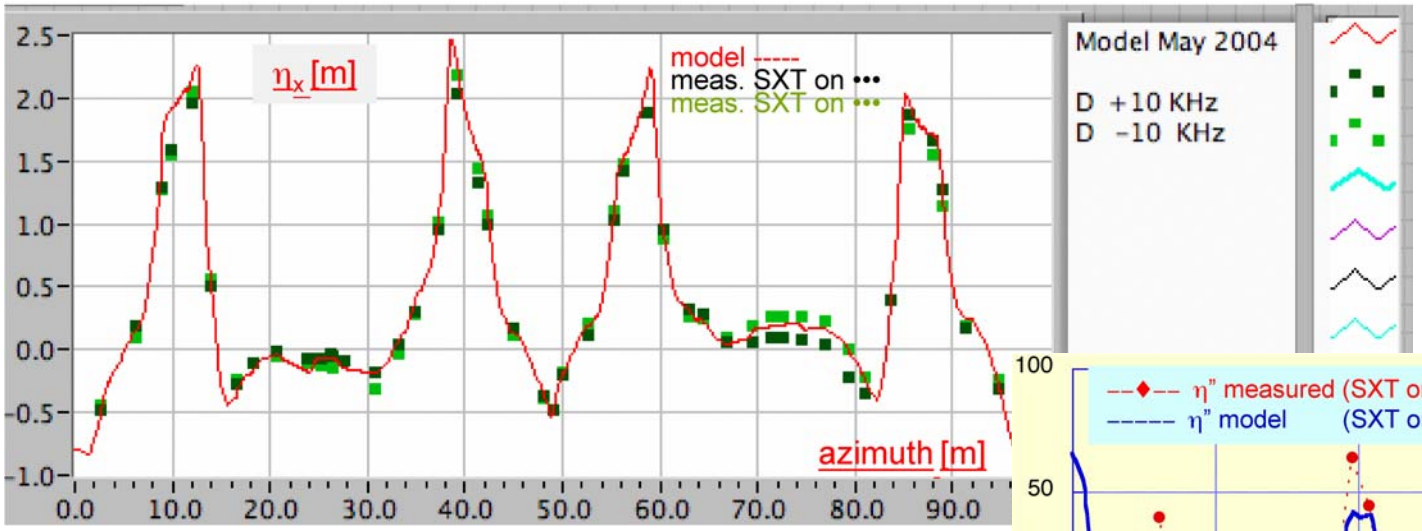
- Working point choice
- Coupling correction
- Careful optics modeling
- Nonlinear beam dynamics study
- Single- and multibunch instability cures
- Collision point parameter optimization
- Fine collider tuning in collisions

Shut down in 2003

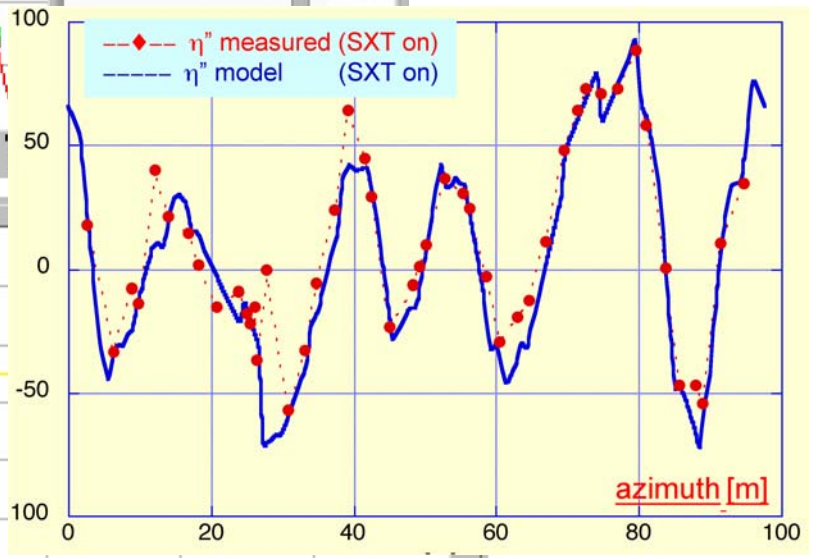
HARDWARE ACTIVITIES

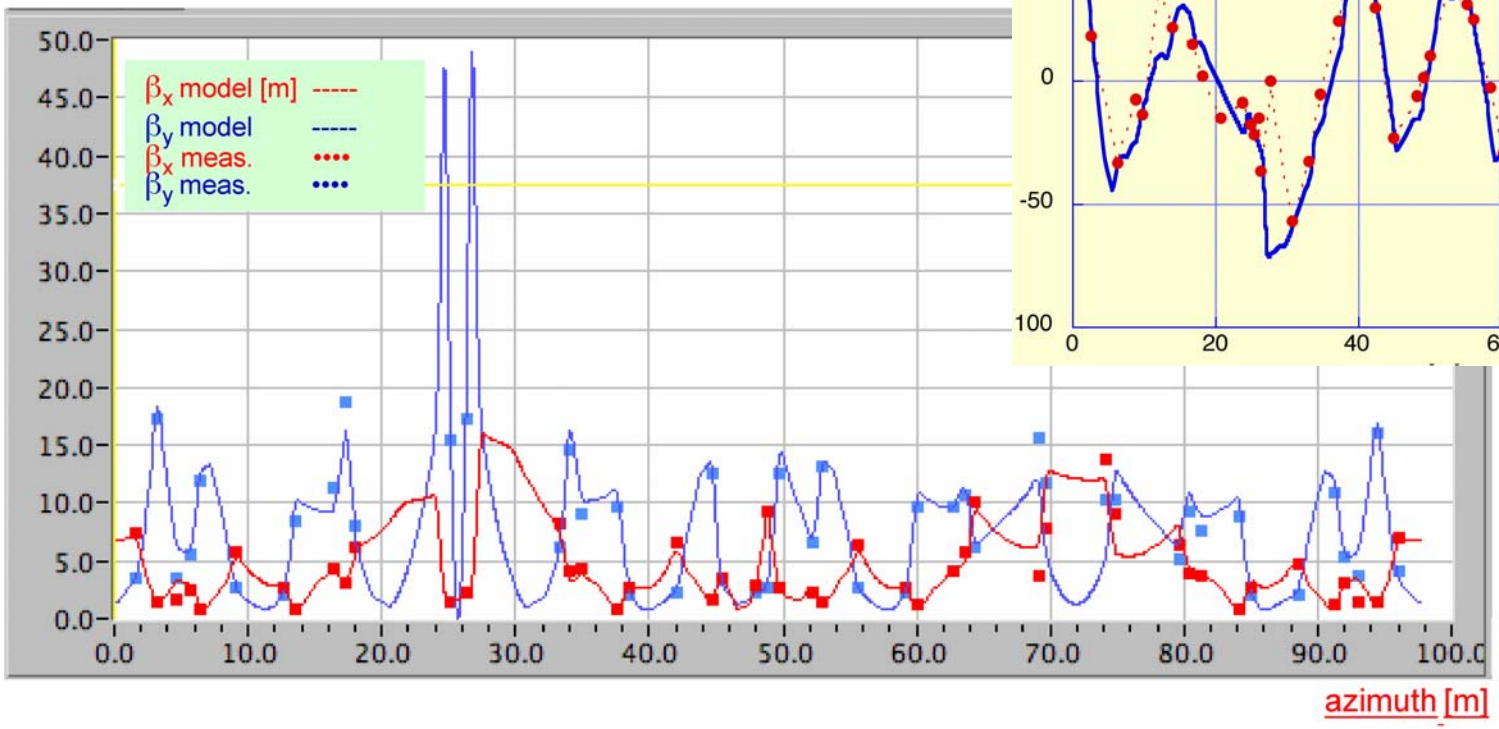
- Finuda Installation
- Kloe new I.R. installation
- Long straight sections and kickers modifications
- Wigglers poles shimming
- Scrapers and Bellows modifications
- New Ion clearing electrodes

Model & Measurements

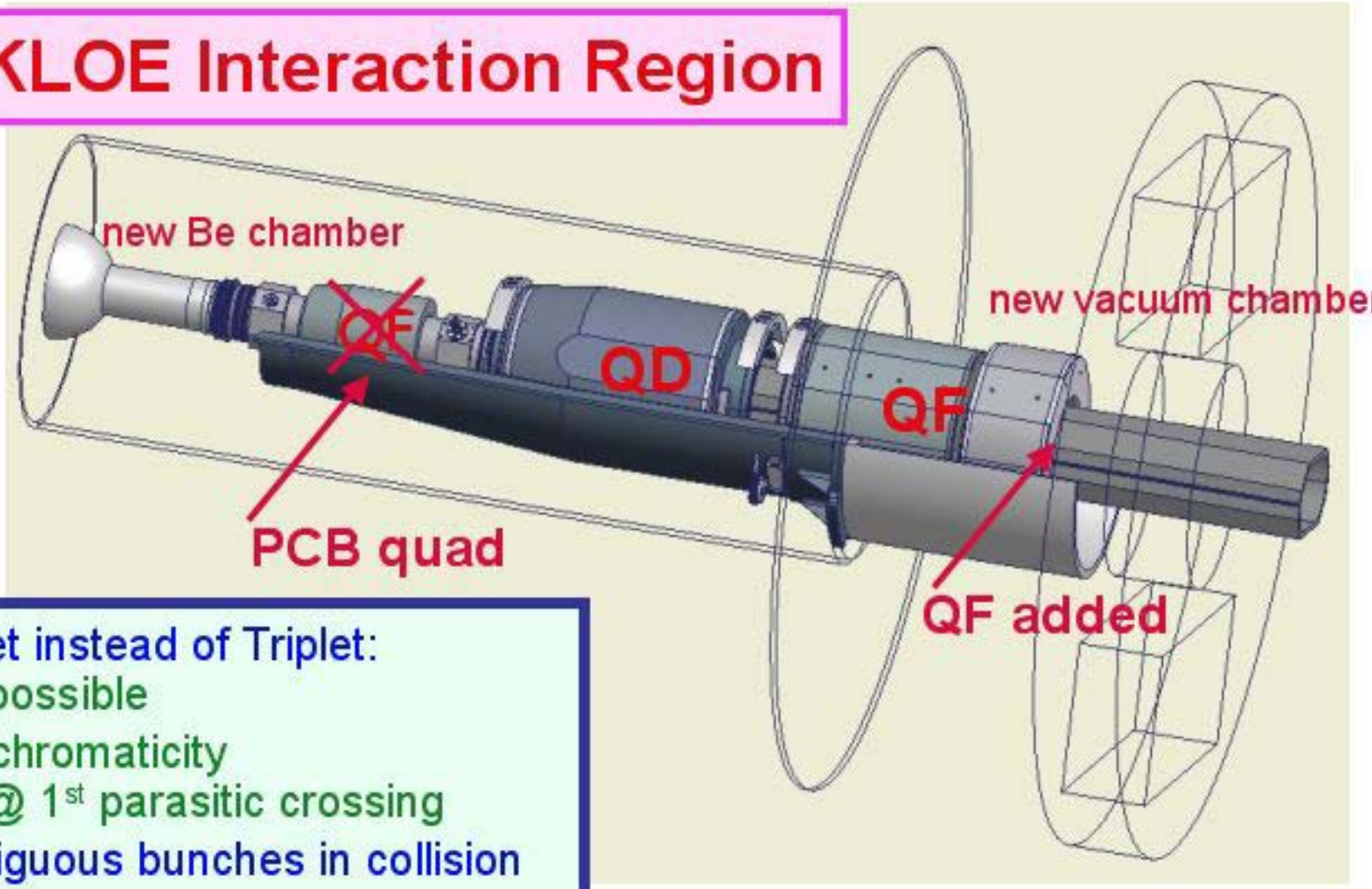


e^+ Ring
(May 04)





New KLOE Interaction Region



QUADs Doublet instead of Triplet:

- lower β_y possible
- reduced chromaticity
- lower β_x @ 1st parasitic crossing

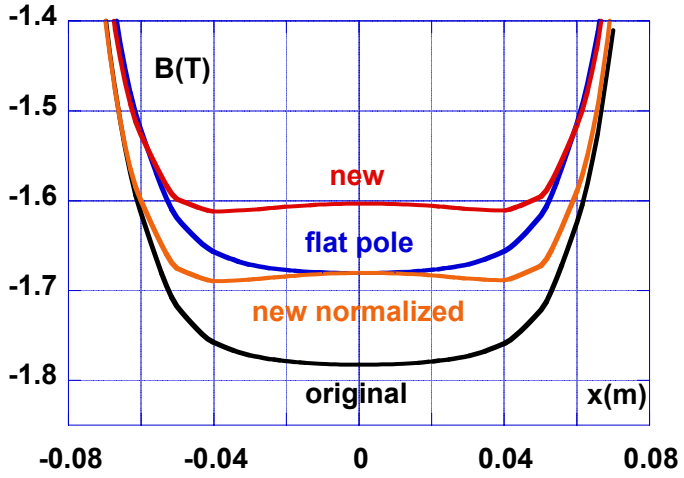
up to 120 contiguous bunches in collision

Independently rotating QUADs:

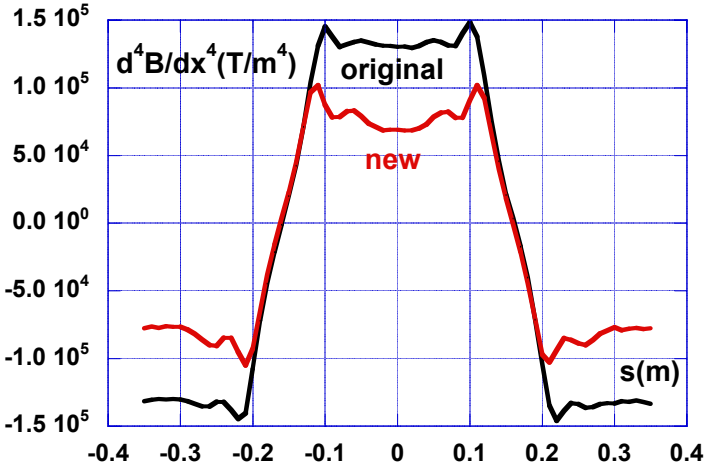
- different solenoid current allowed
- better coupling correction

Wiggler poles modification

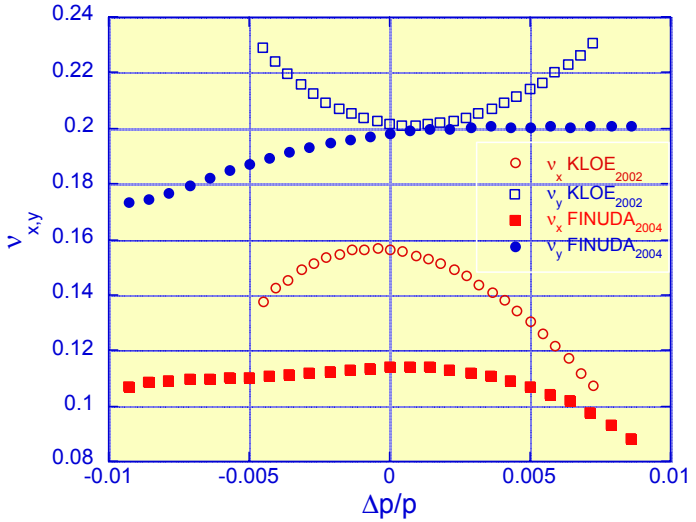
Additional plates glued on wiggler poles



Field at pole center

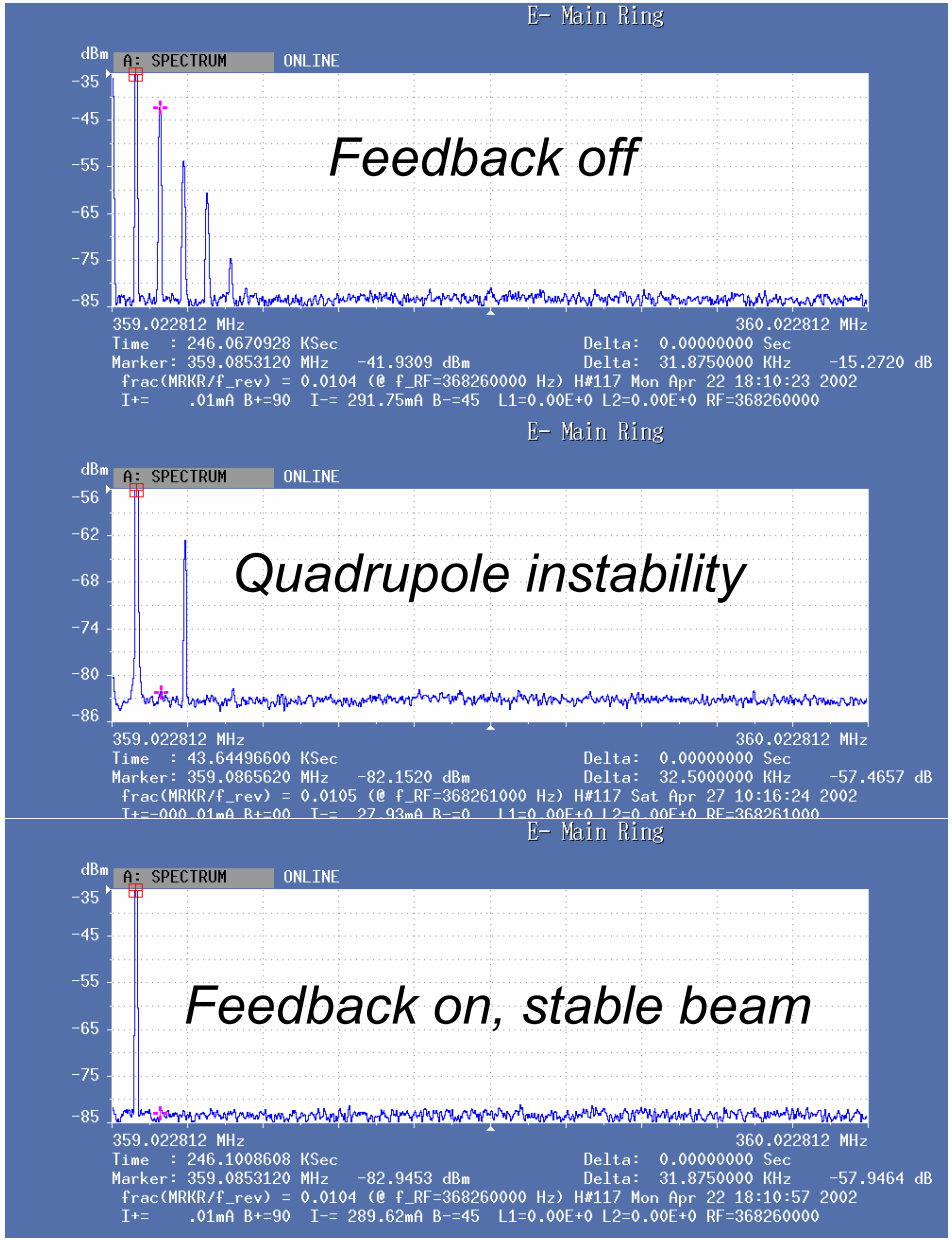


Improvement of the 4th order term generating cubic nonlinearity



Improvement of the energy acceptance due to the wiggler modification

Longitudinal Feedback Systems



Damp:

- Dipole mode instability
- 0-mode instability
- Quadrupole mode instability

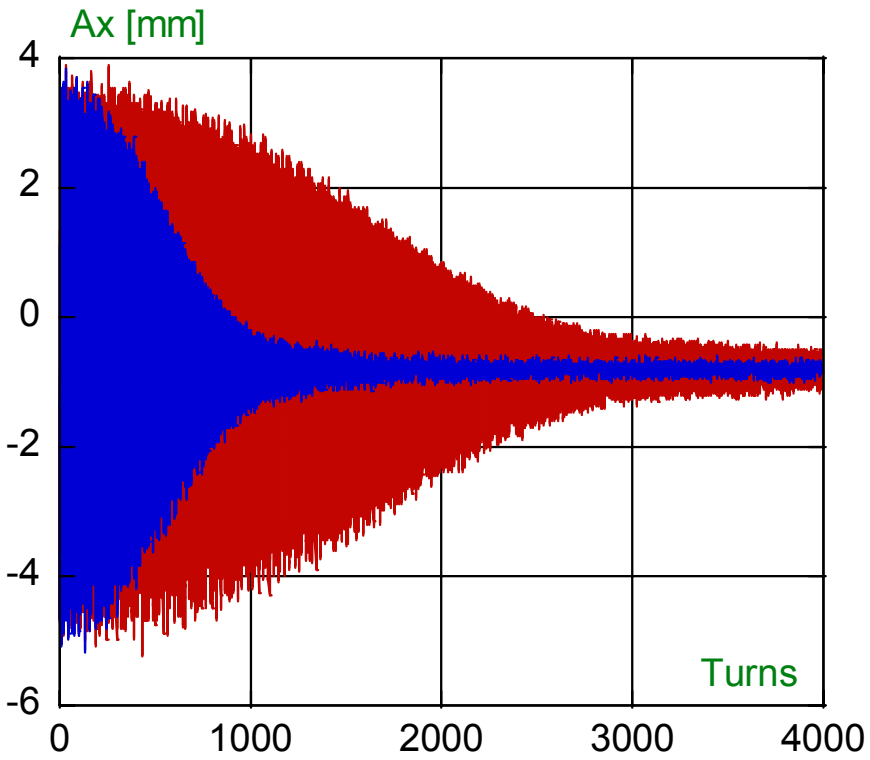
Maximum beam current

➢2.4 A in the e- ring (administrative limit)

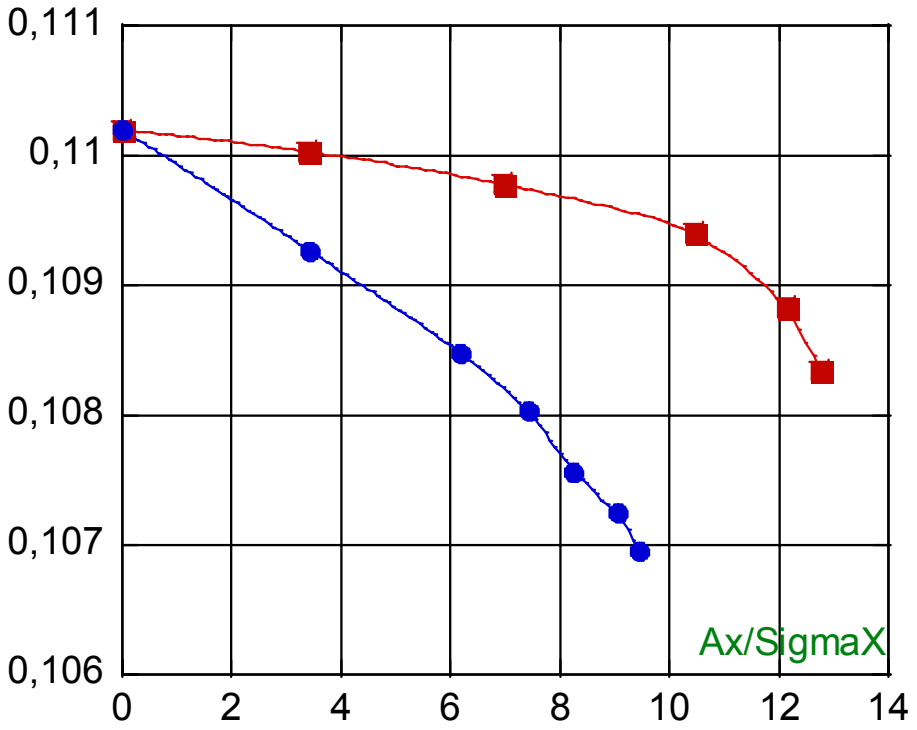
➢1.3 A in the e+ ring (limited by strong horizontal instability)

Present Lattice: Octupoles On and Off

Beam Decoherence



Tune Shift with Amplitude

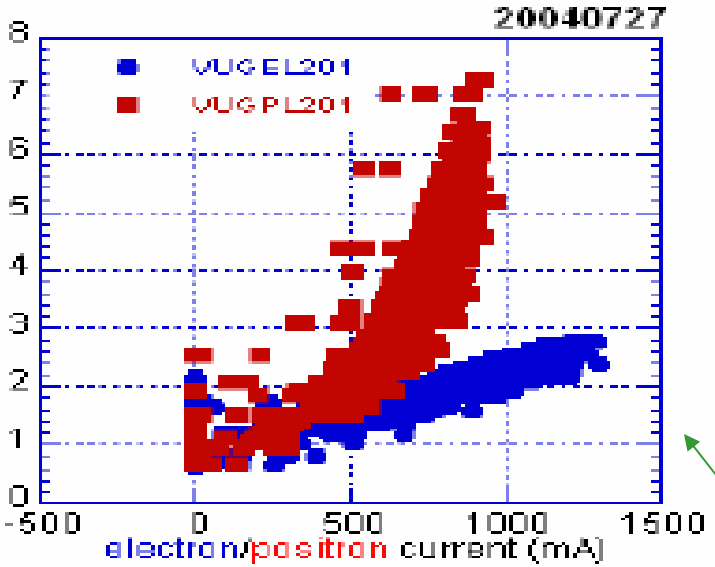


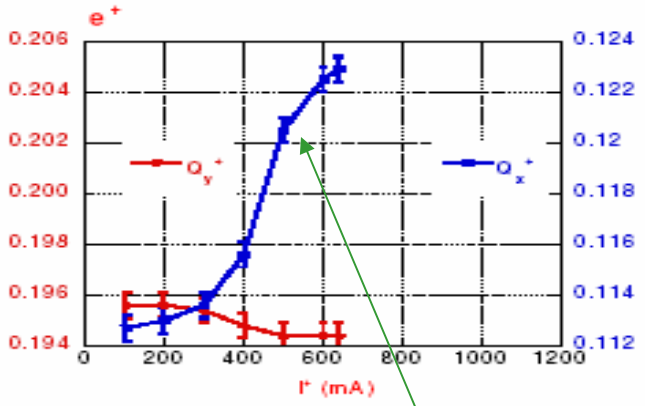
(RPAT098)

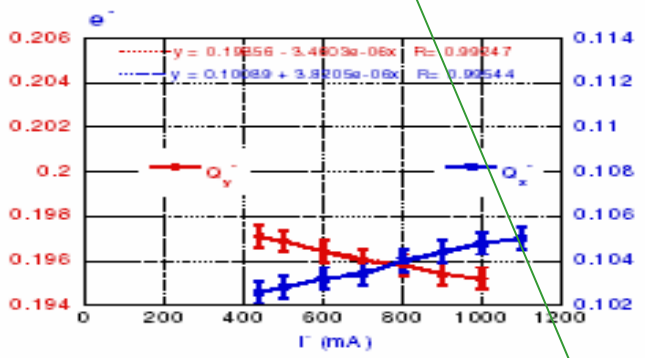
Present Performance Limintations

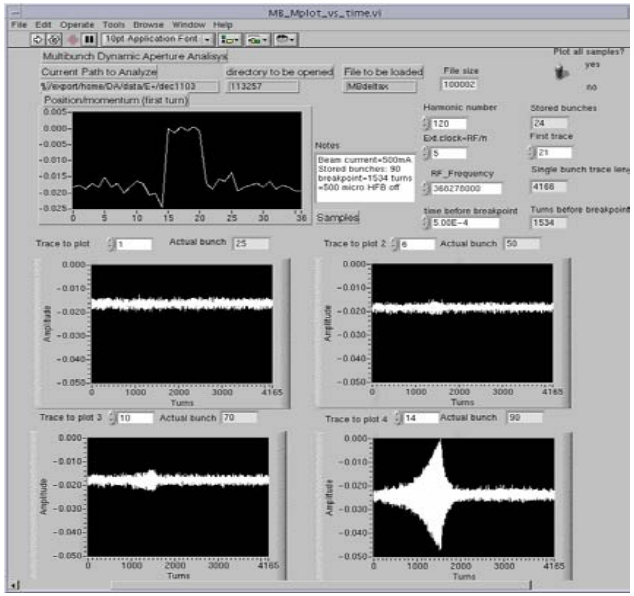
- Horizontal positron beam instability
- Electrons transverse sizes enlargement with bunch current due to ions-trapping and coupling with longitudinal microwave instability
- Residual coupling from IP1-solenoid and sextupoles
- Vertical size enlargement due to the beam-beam interaction
- Lifetimes in collisions at maximum current

Positron Beam Horizontal Instability









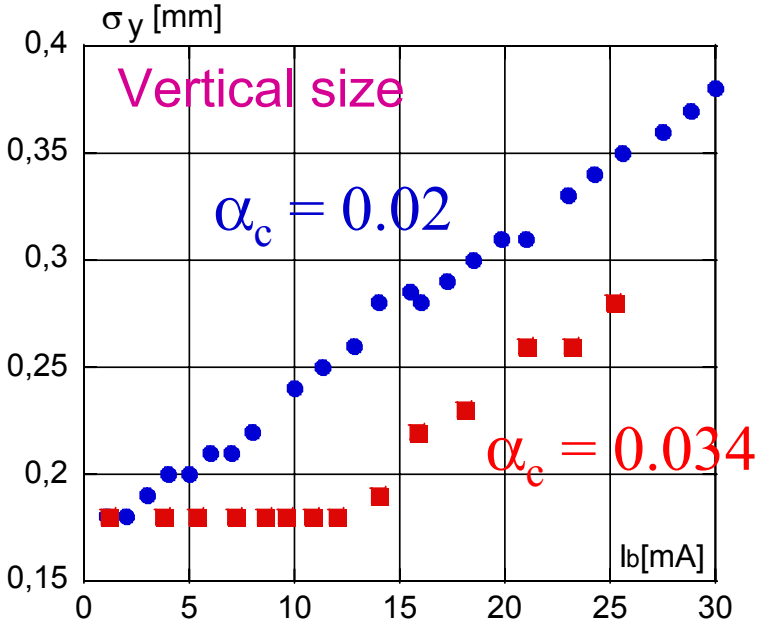
Vacuum pressure rise

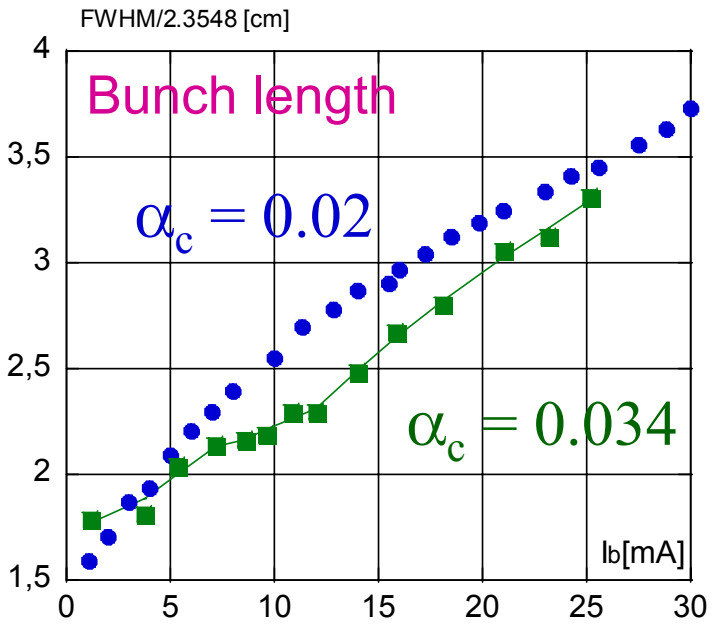
Tune shift

Fast rise time

(MPPP024,FPAP001)

Vertical Size Blow Up





- Single bunch (beam) effect
- It is correlated with the longitudinal microwave instability:

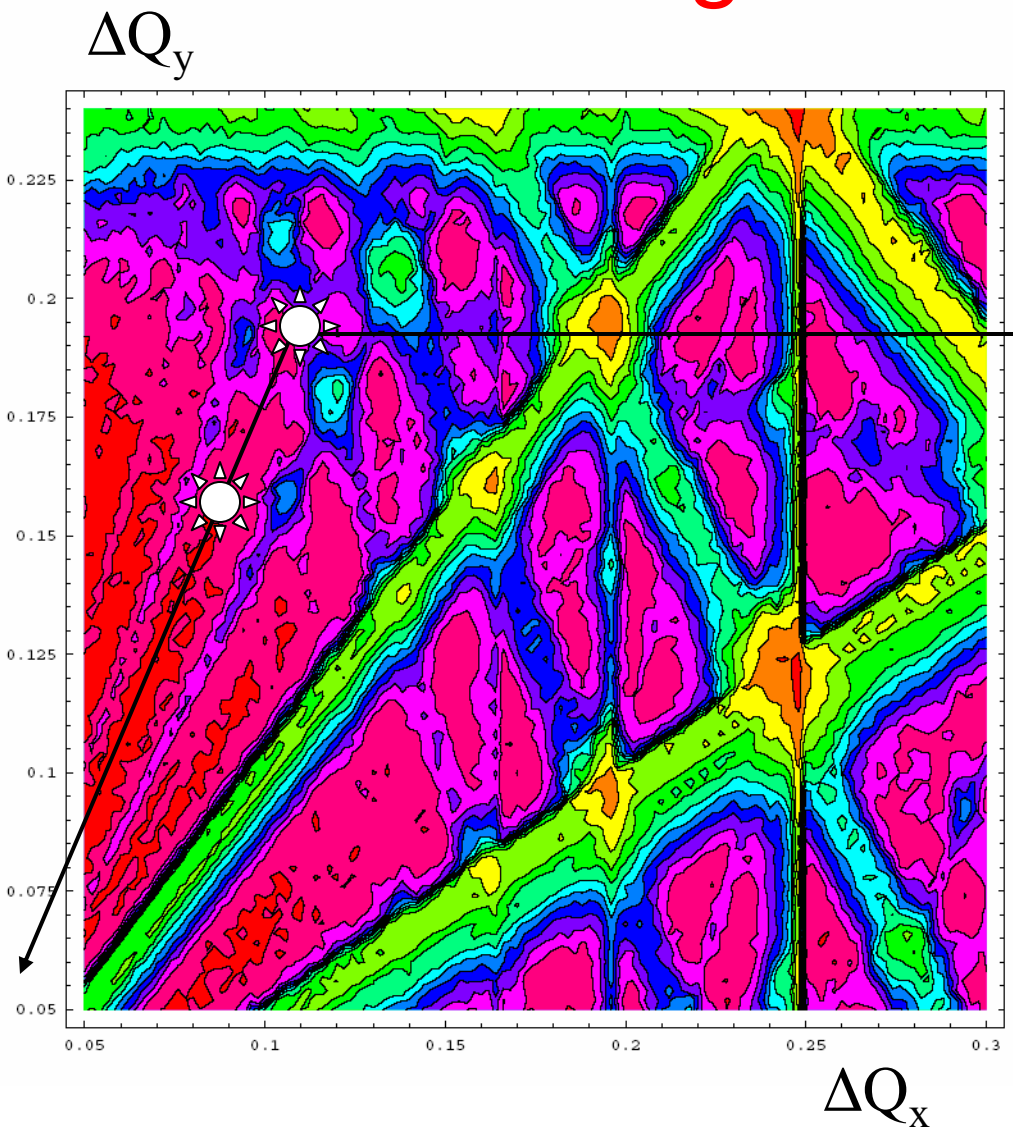
a) The same threshold

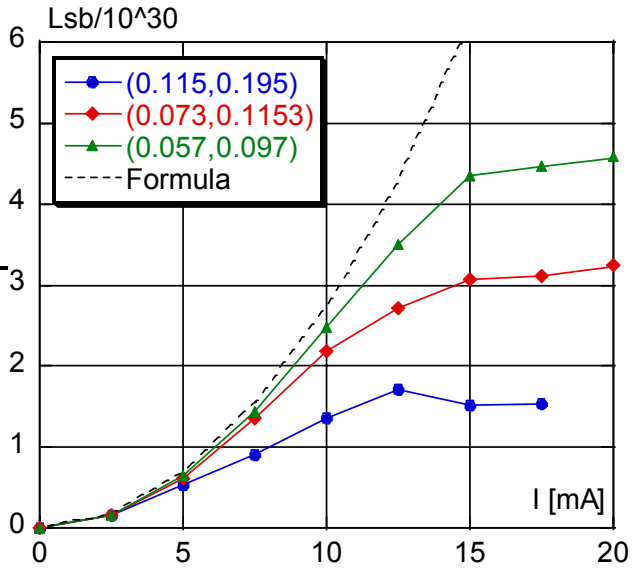
b) The same dependence on RF voltage

c) The threshold is higher for higher momentum compaction

d) More pronounced for e- ring having higher coupling impedance

Working Point Choice

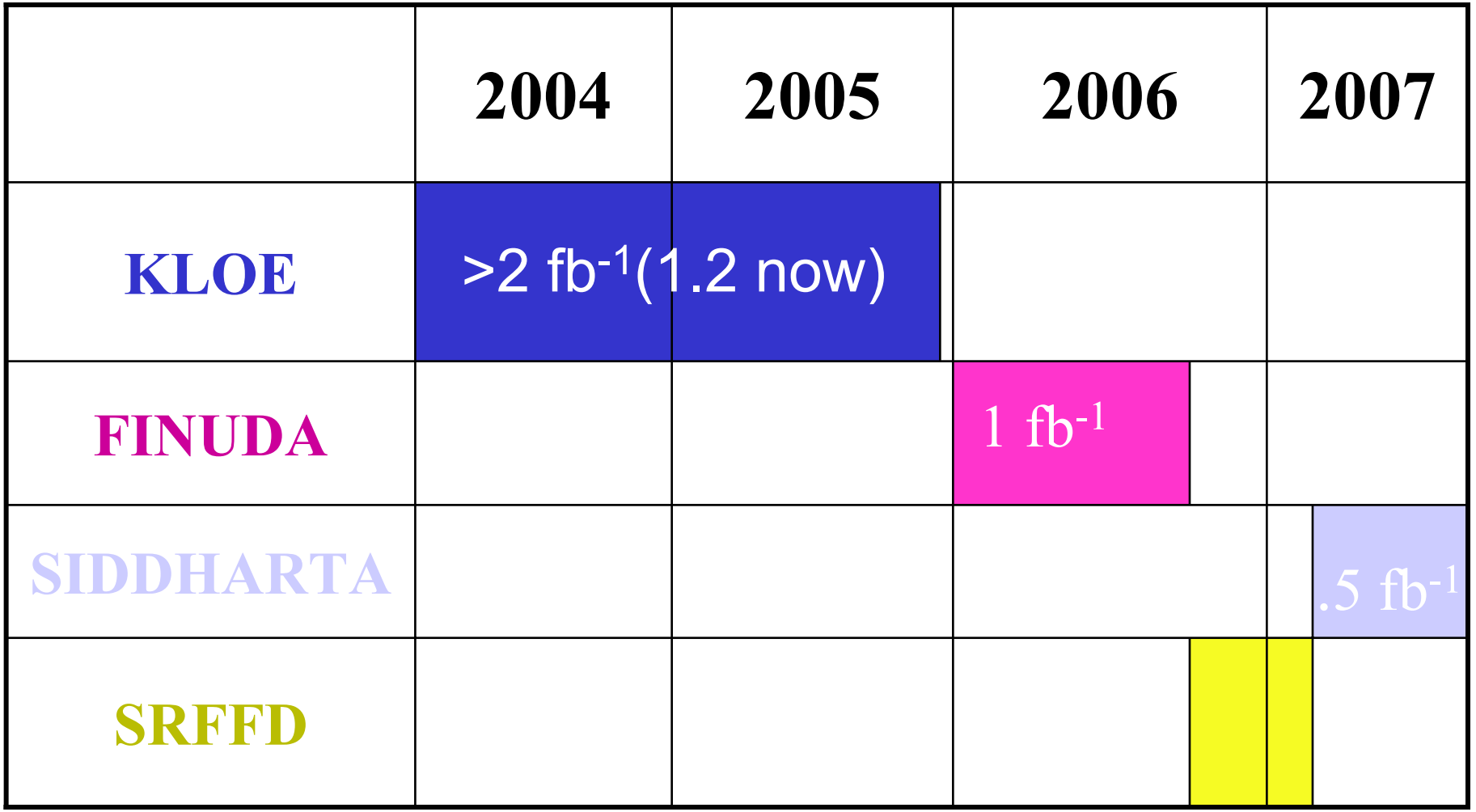




Going closer to the integers we hope to improve both the peak luminosity and lifetime

This is possible with the new wigglers since DA is satisfactory at low tunes!

Schedule of Physics Experiments



Possible Future Scenarios

DAFNE2: → **Energy upgrade (to 1.1 GeV/beam) + preserve Φ operation**

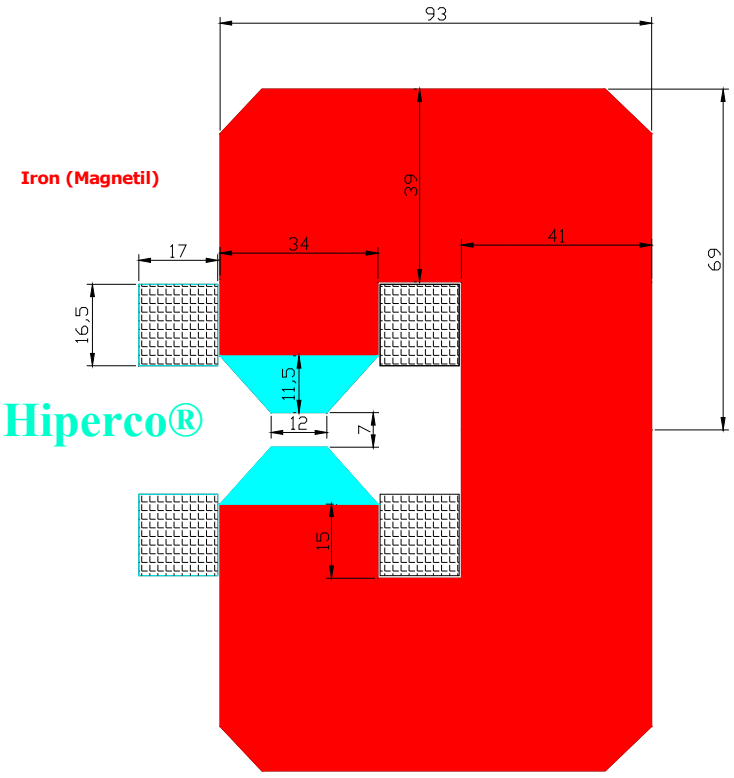
DAΦNE2: → **Major upgrade of the present machine to reach $L > 2 \cdot 10^{33}$ $cm^{-2}s^{-1}$**

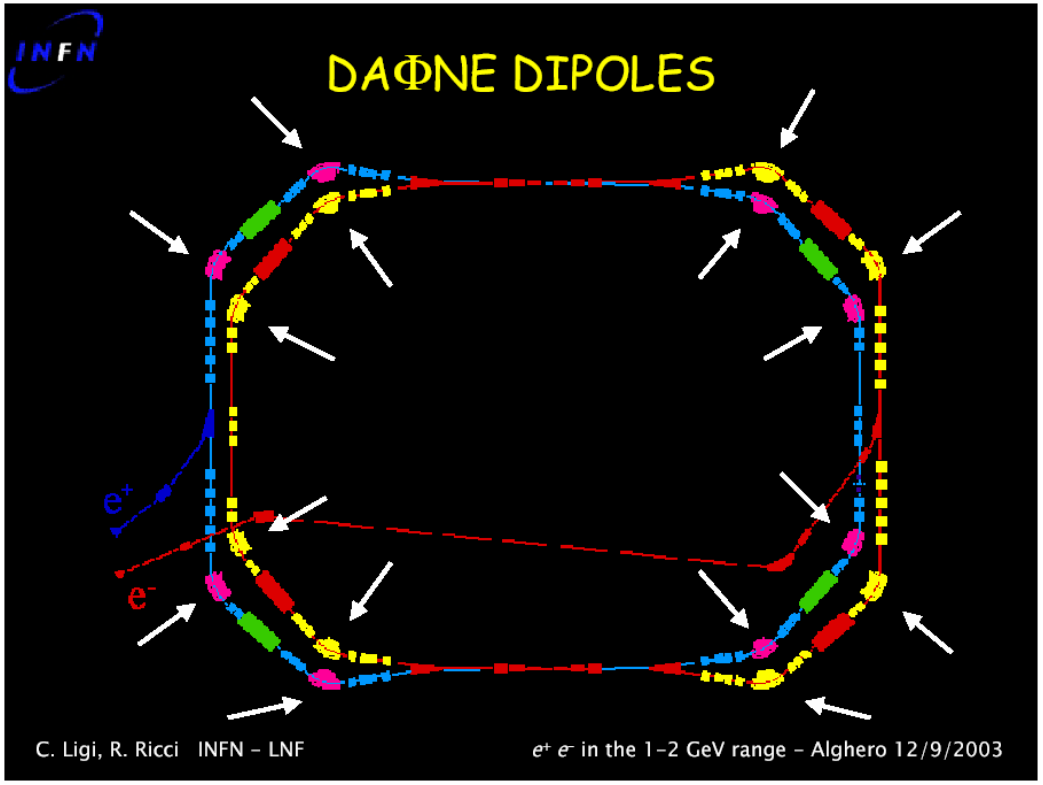
LNF$^{\tau}$: → **New τ-charm factory for $L > 10^{34}$ $cm^{-2}s^{-1}$ @ 1.9 GeV/beam**

DAFNE2:
Φ and n-nbar sharing DAFNE

Energy (GeV)	0.51	1.1
Current (A)	1 - 2	0.5
Luminosity (10^{32})	1.5	1
N bunches	100	30
I/bunch (mA)	10-20	17
τ damping (msec)	70/40	11/9
Uo (keV)	4.3 / 9.3	64 / 84
τ (h)	<1	> 4

Modification of DAΦNE Dipole Magnets

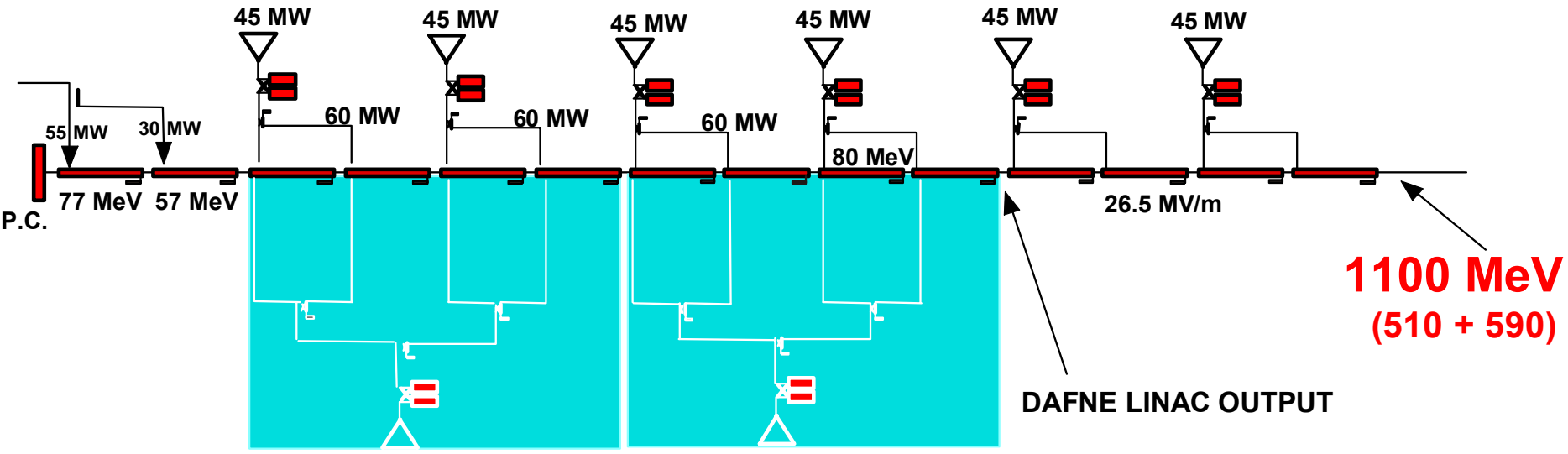


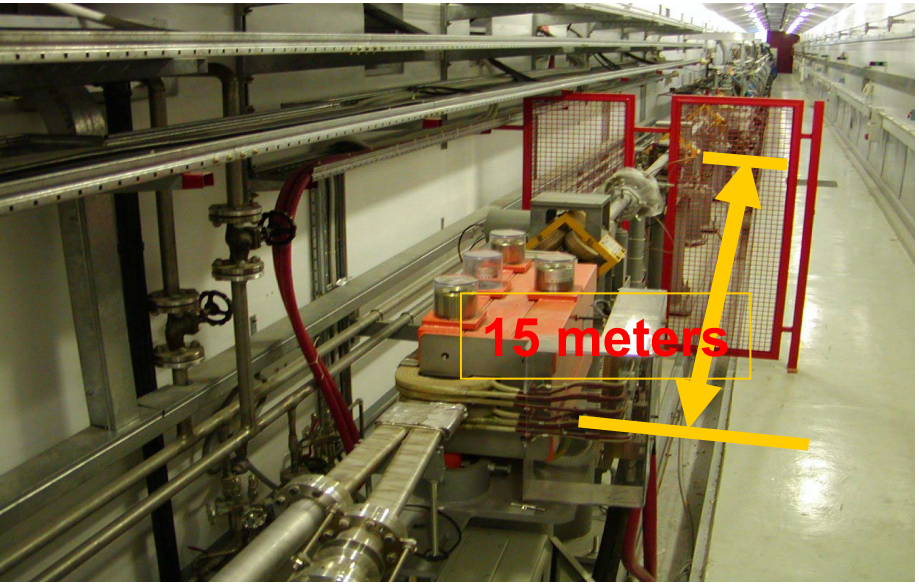


2.4 T → 1.1 GeV

DAFNE2 - LINAC UPGRADE

Mixed version





Extra Components

- 4 Acc. Sections
- 4 SLEDs
- 4 Power Stations
- Waveguides + accessories
- Vacuum - Diagn. - Magnetics - Cooling - Controls etc ...

Basic Ideas for DAΦNE2 with L=2-3x10^{33}

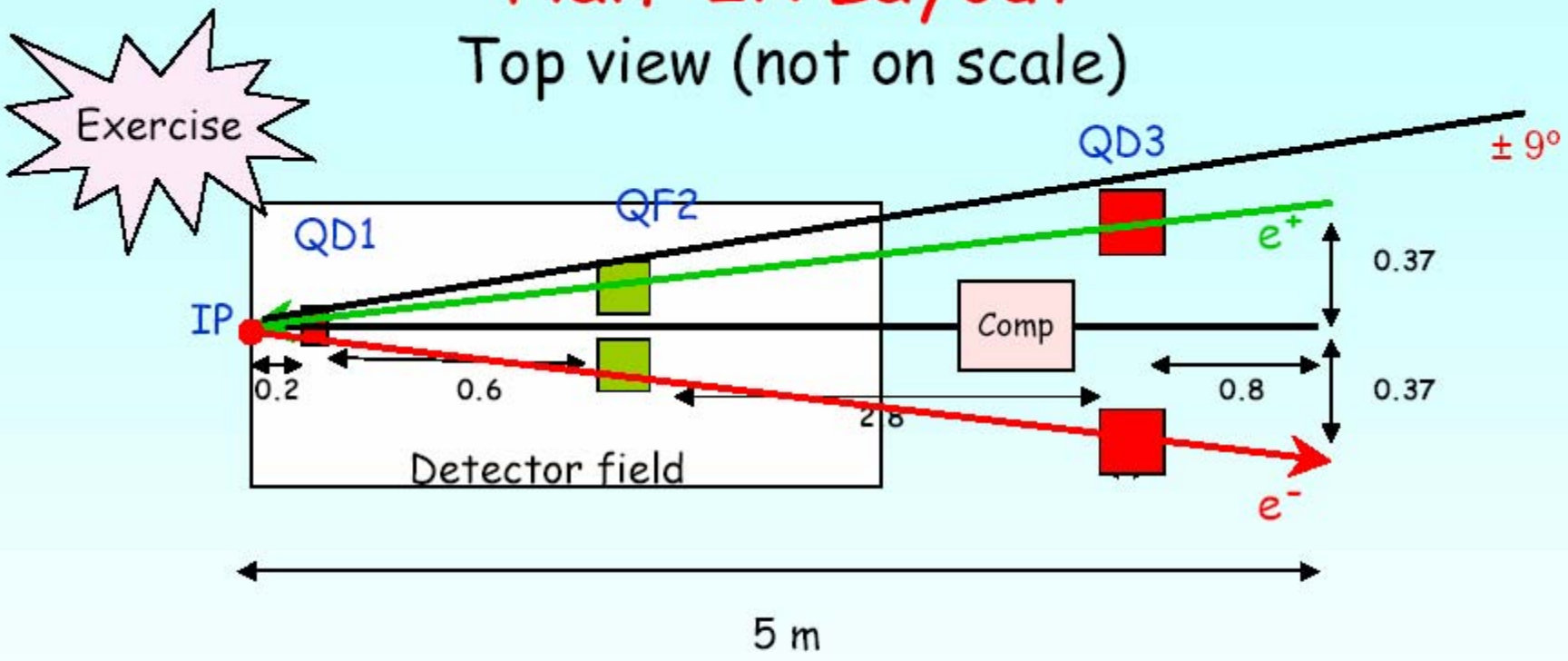
- Shorter bunches and lower β_y at IP (a factor of 2-2.5)
- Stronger damping (a factor of > 2)
- Higher number of bunches (368 MHz → 500 MHz)
- Higher colliding currents → 2A and higher
- Lower tunes (closer to integers or half-integers)
- Continuous injection (new transfer lines)

This would require:

- Vacuum chamber modifications
  - Low coupling impedance components
  - Smaller gap in wiggler sections
  - Larger antechamber gap
  - Ti coating in e+ ring
  - No ICE in wiggler sections of e- ring
- New wigglers in FINUDA IR (4 T, Novosibirsk)
- New RF cavities (500 MHz, 1 MV)
- New KLOE IR: lower betas, higher separation at PCs
- New separate transfer lines (between DR and MR)

Half-IR Layout

Top view (not on scale)



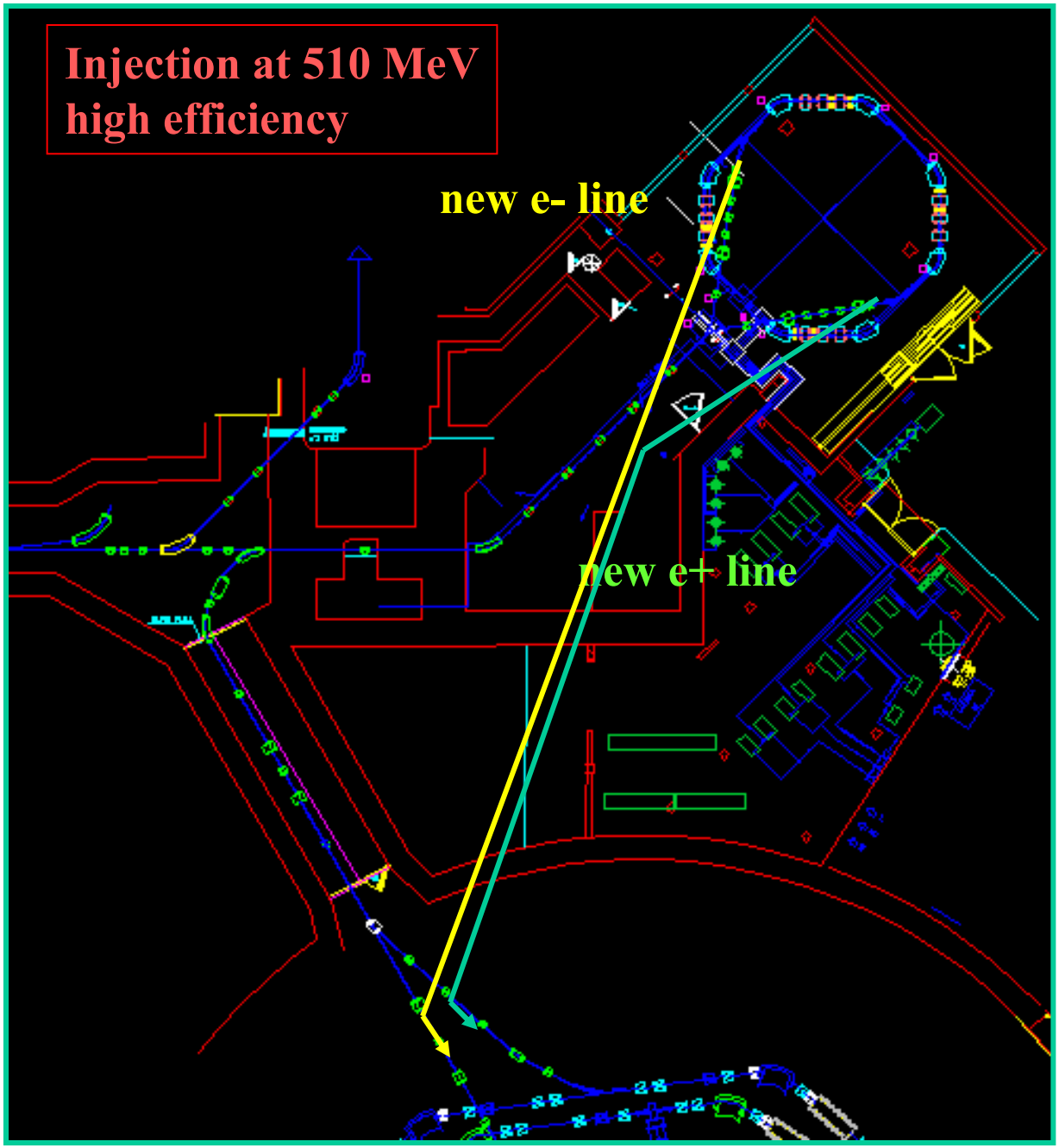
With ± 10σ_x clearance, ± 9° cone, ±30 mrad angle:

small

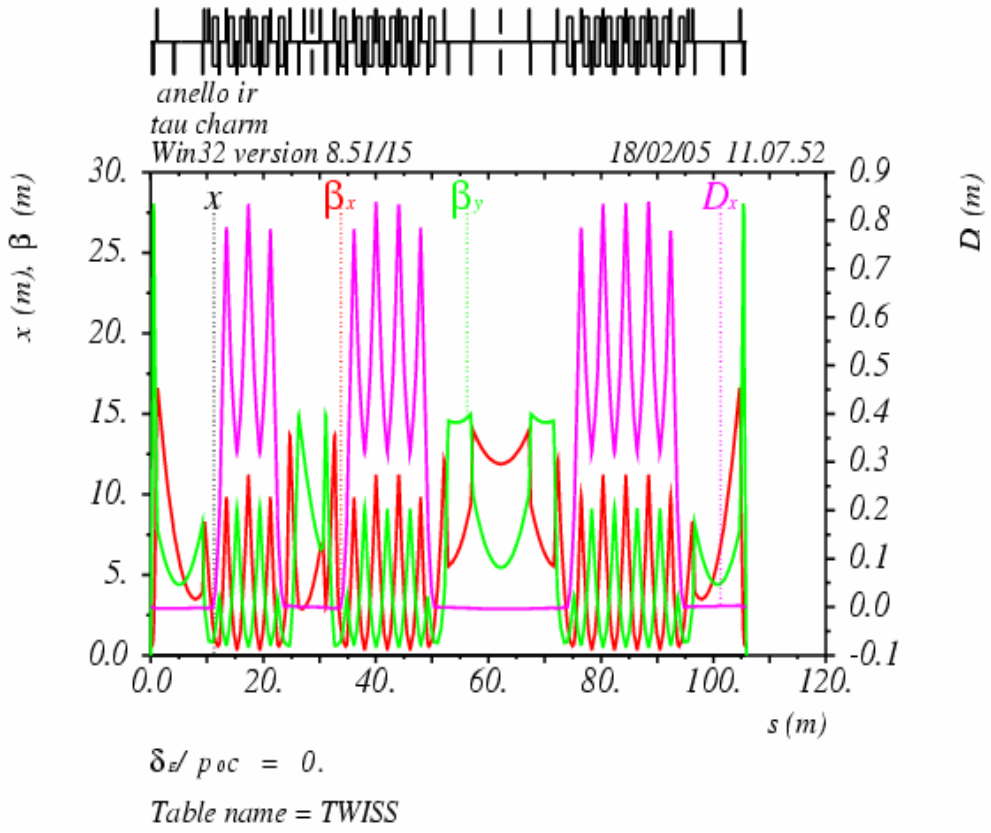
QD1: L= 20 cm, pole radius = 1.5 cm, R_{ext} = 3 cm, pm thickness= 1.5 cm

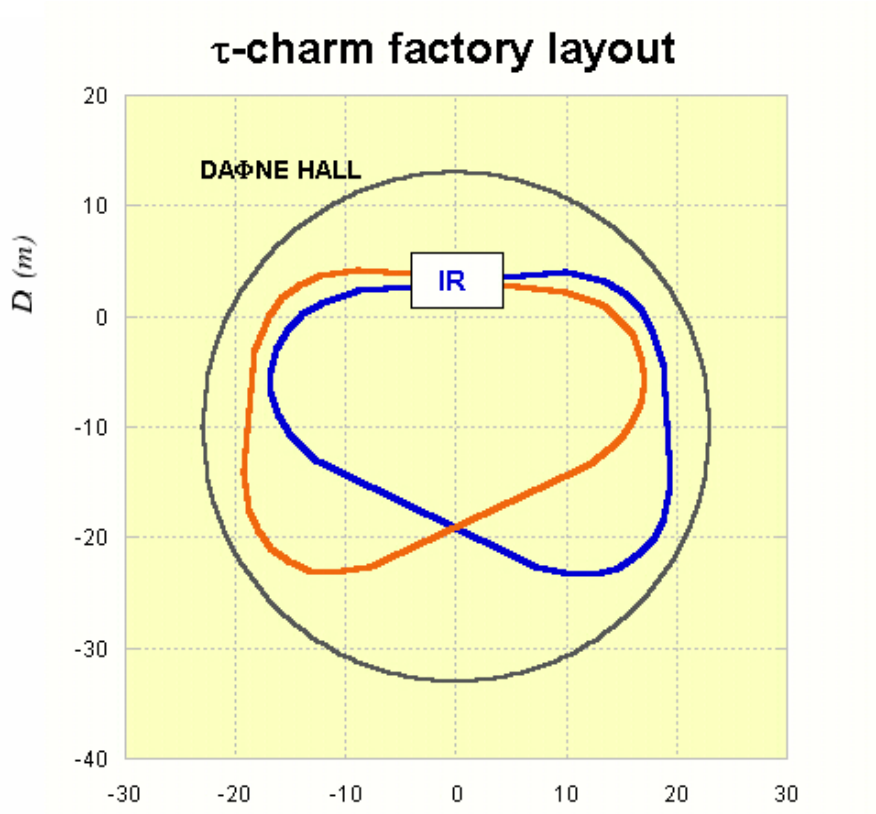
QF2: L= 20 cm, pole radius = 11 cm, R_{ext} = 16 cm, pm thickness= 1.5 cm,
4 cm space between 2 quads

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


Injection at 510 MeV
high efficiency
new e- line
new e+ line

Lattice of a τ-charm factory fitting the existing DAΦNE building





LNF$^{\tau}$: Preliminary parameters

Energy	**1.89 GeV**	**B**	**1.8 T**
C	**105 m**	**Uo**	**328 keV**
L	**10^{34} cm^{-2}s^{-1}**	**V_{RF}**	**2 MV**
f_{RF}	**500 MHz**	**V_{3RF}**	**2 MV**
ε_x	**1.5 10^{-7} μm**	**α_c**	**0.022**
β_x β_y	**0.5 m - 5 mm**	**σ_E/E**	**8.7 10^{-4}**
κ	**0.003**	**P_{rad}**	**900 kW**
N_{bun}	**160**	**σ_L**	**6 mm**
$N^{\pm}$/bunch	**3.5 10^{10}**	**I_{th}** (@Z/n=0.5Ω)	**25 mA**
ξ_x ξ_y	**0.03 - 0.05**	**I_{tot}**	**2.7 A**

Ideas for DAΦNE2 with L → 10^{34}

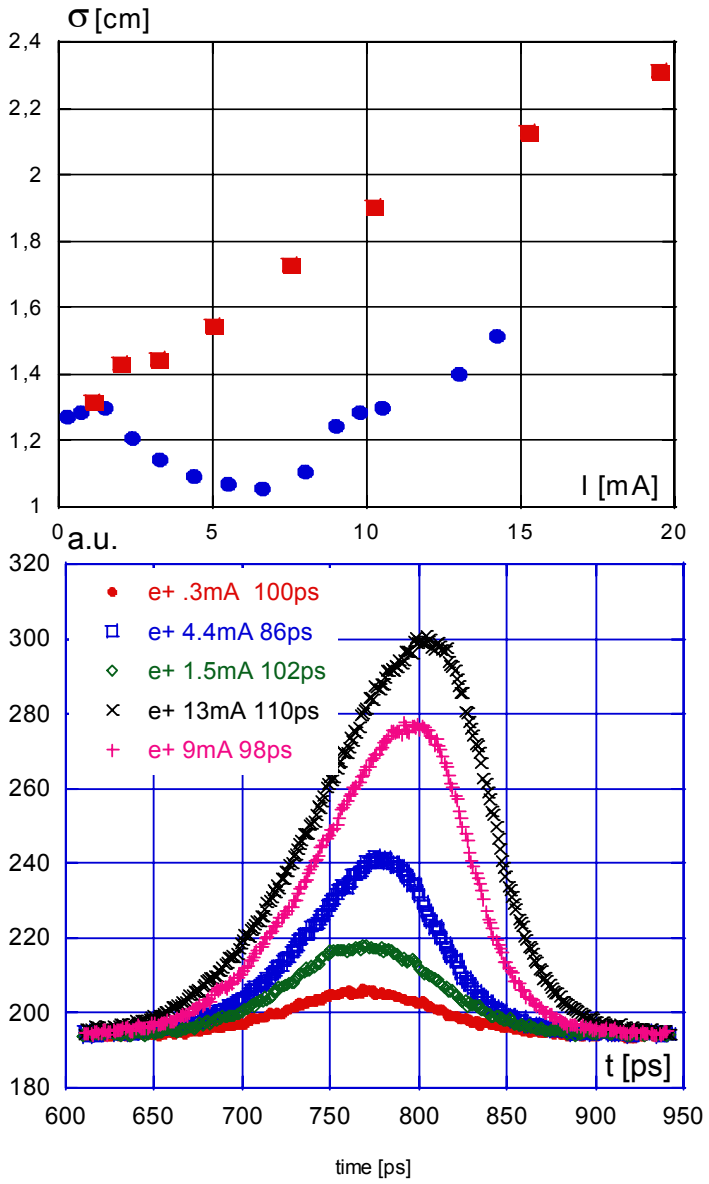
- Lattice with a negative momentum compaction factor

- Strong RF focusing (bunch length modulation) scheme

-…..

have to be tested experimentally!

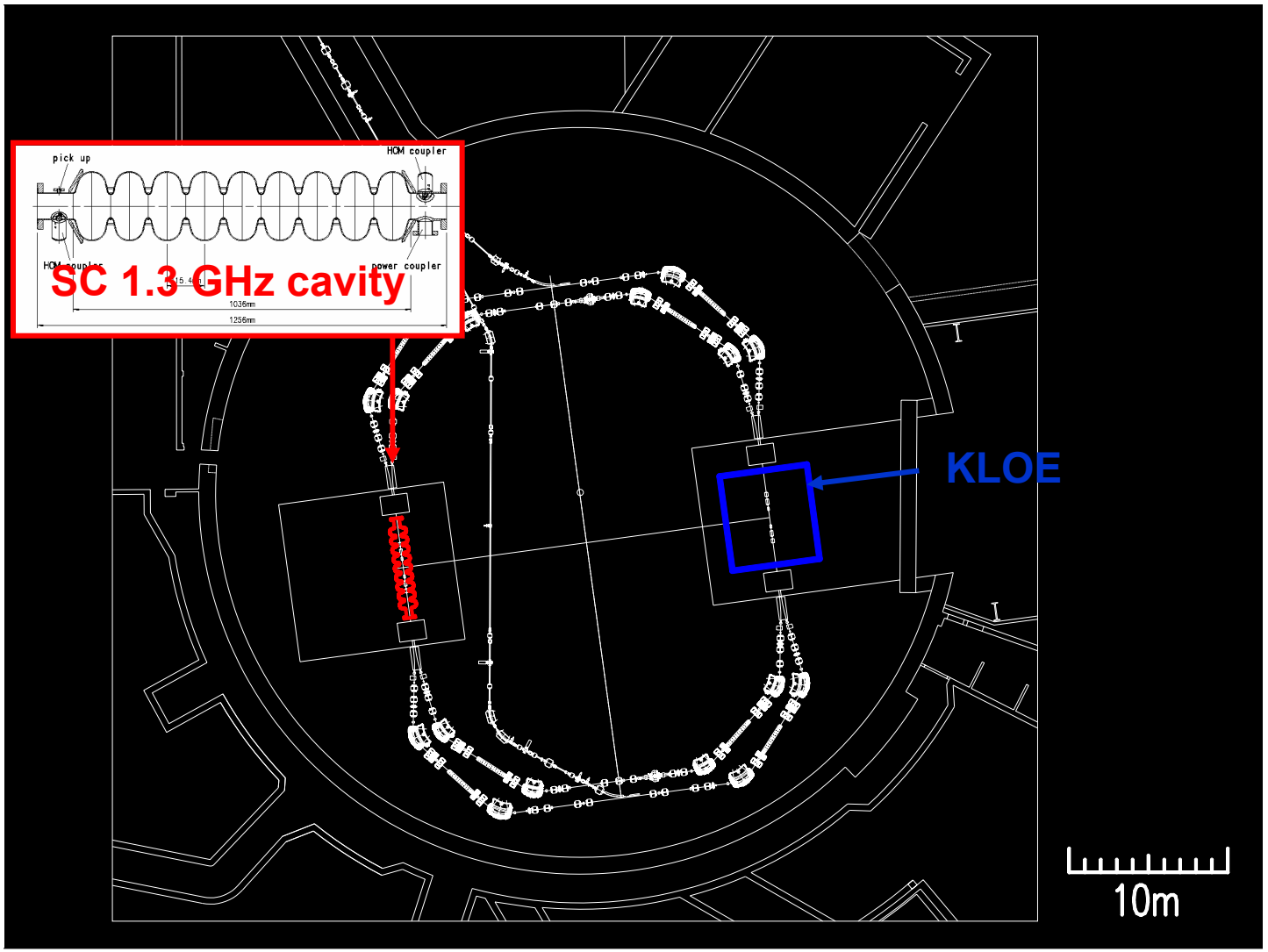
Experiment with $\alpha_c < 0$



- Bunch shortens as predicted by numerical simulations
- Good agreement with DAΦNE optics model
- I_{bunch} > 40 mA is stored with negative chromaticity
- No problems with RF and feedbacks: about 1 A of stable current in both beams
- Coupling and geometric luminosity as in usual operation conditions
- First collisions at low currents (200 mAmps) with L_{peak} =2.5 x10^{31}
- Fast growth of electron vertical beam size with currents above the longitudinal microwave instability threshold => hardware changes are needed to overcome the effect

Bunch Length Modulation Experiment

to be presented by C. Biscari in 30-40 minutes…



Conclusions

- DAΦNE is running regularly for the subnuclear (KLOE), nuclear (FINUDA) and atomic (DEAR) experiments with a continuous luminosity performance improvement.
- The scientific program of the experiments should be completed by end 2007 and a new high-energy physics program beyond that date is under discussion in the physics and accelerator communities at Frascati.
- Experimental activity aimed at testing accelerator concepts that could help pushing the luminosity at the Φ resonance is under way.

Thank you!