Experimental observations and e-cloud simulations at DAΦNE

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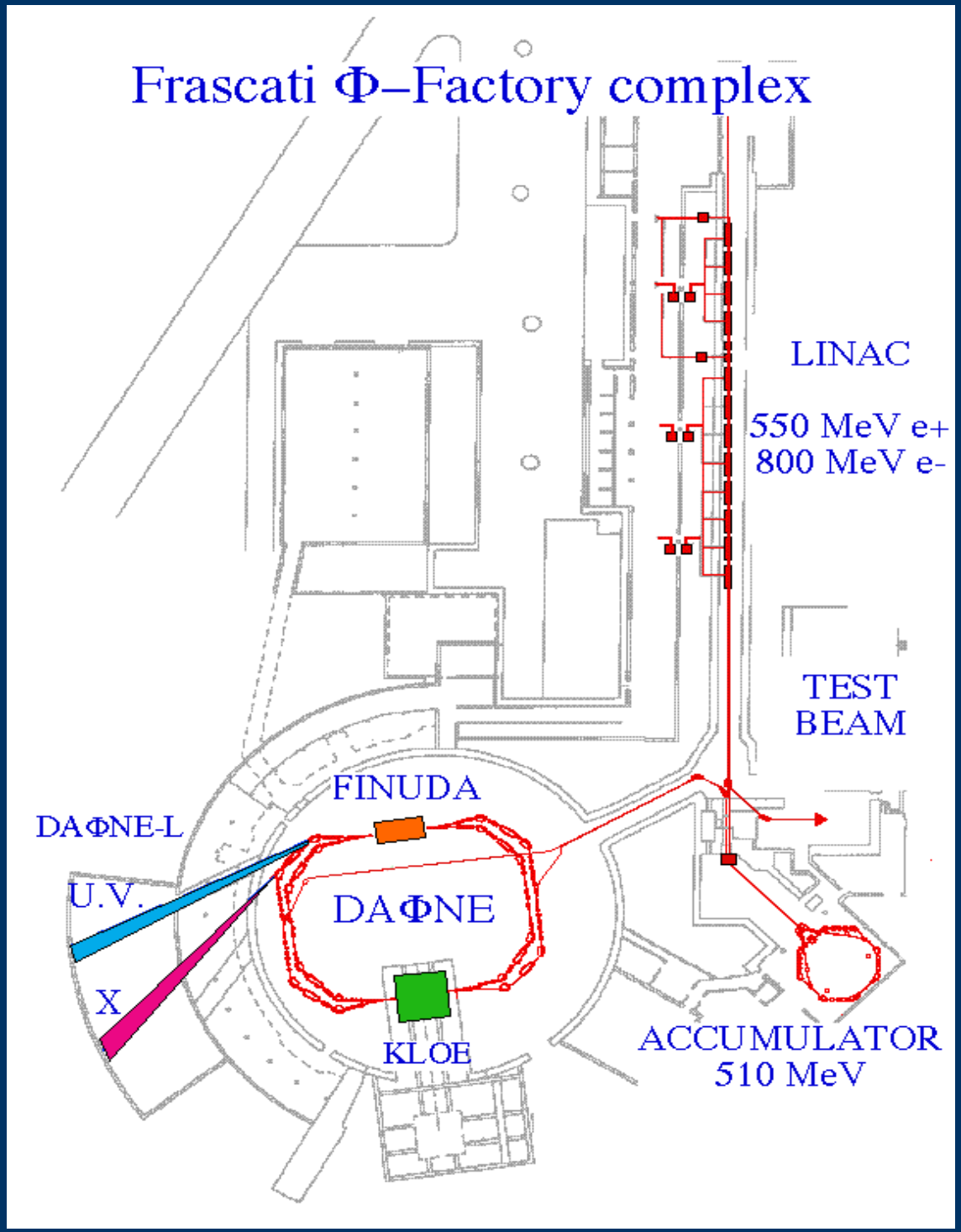
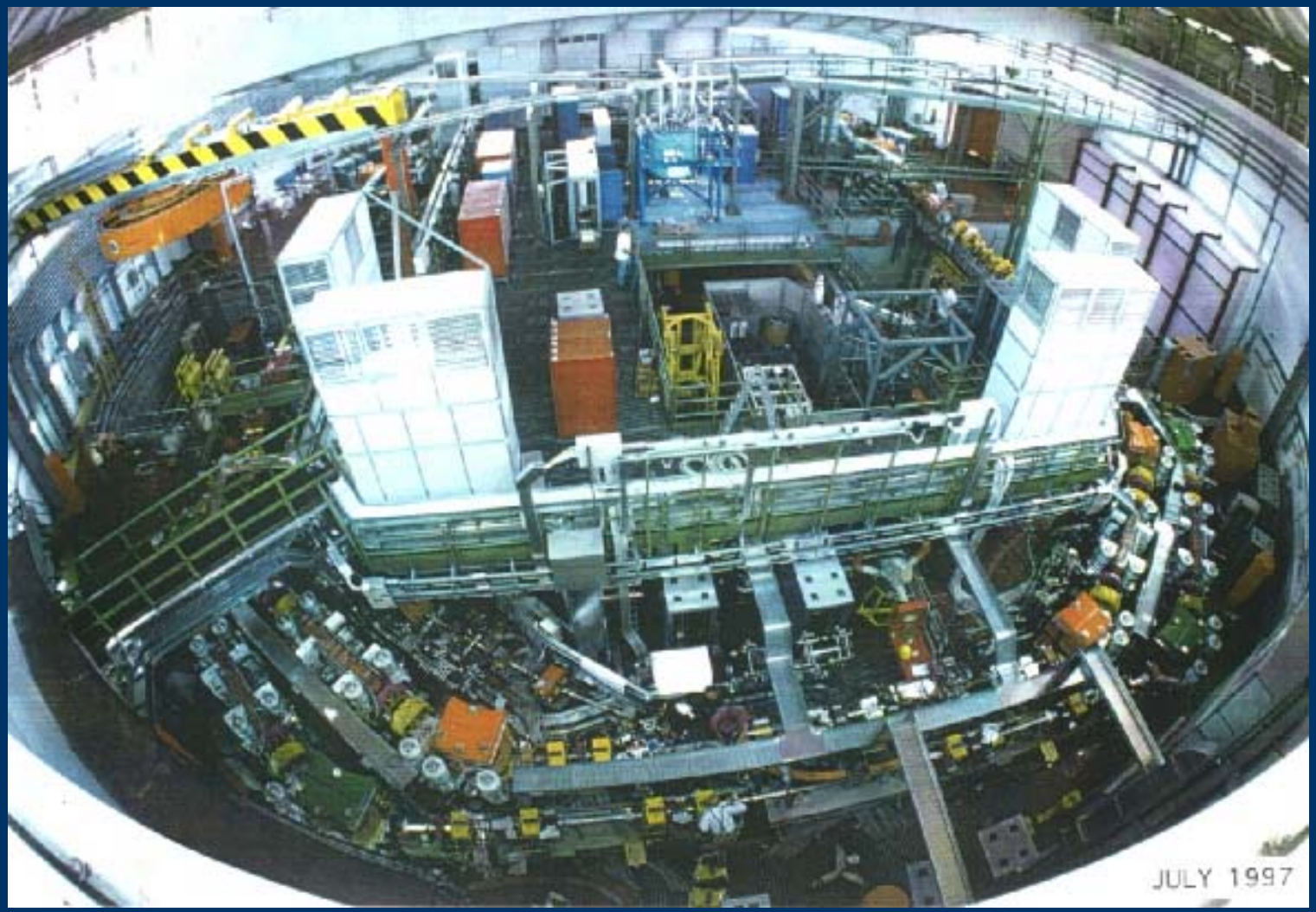
Outline:

- DAΦNE Φ-Factory short overwiew
- $e^{+/-}$ Main Ring vacuum chamber
- experimental observations on data taking conditions
- e-cloud build-up simulation
- Conclusions

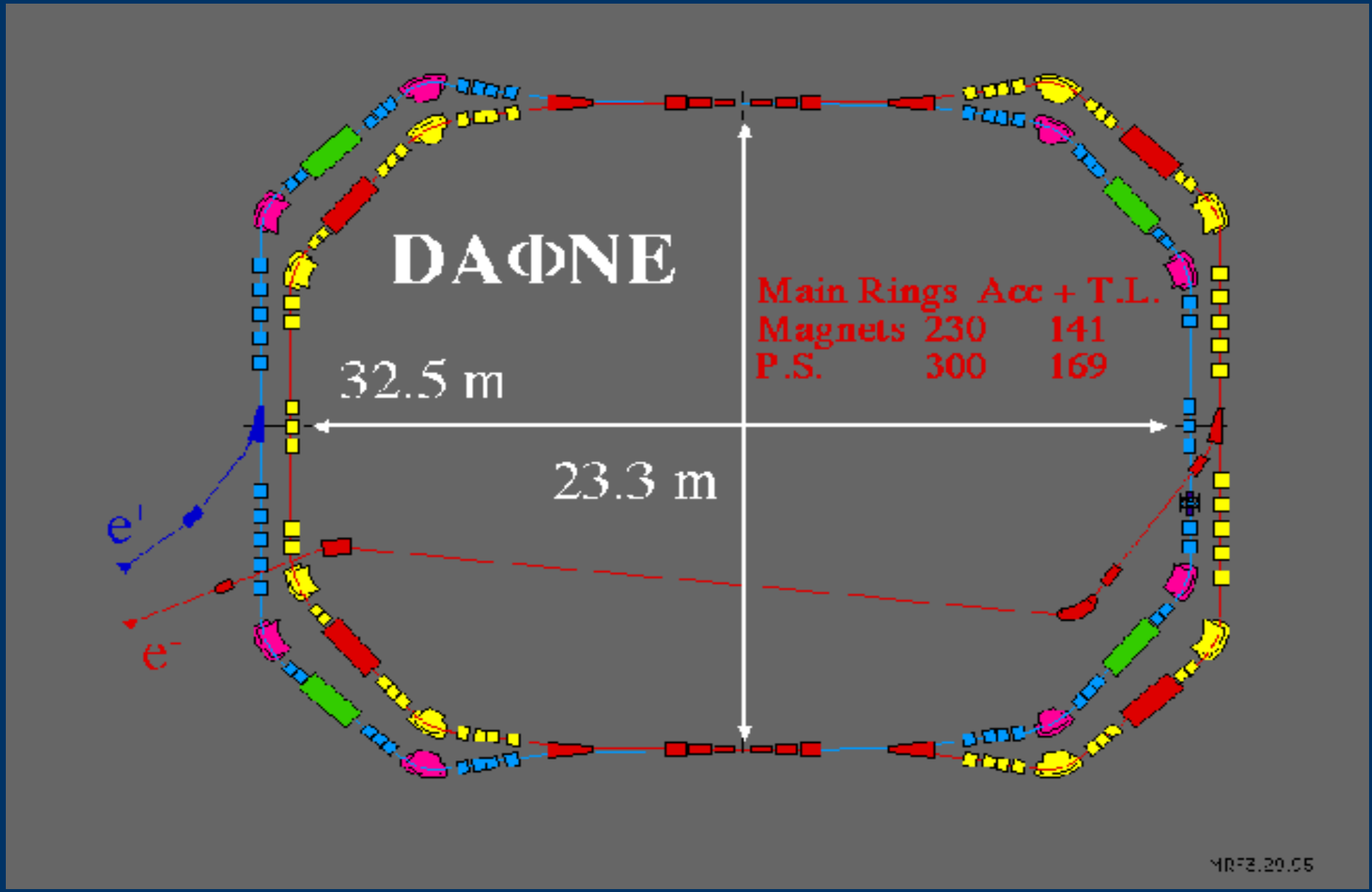
The Frascati Φ-Factory



The DAΦNE hall



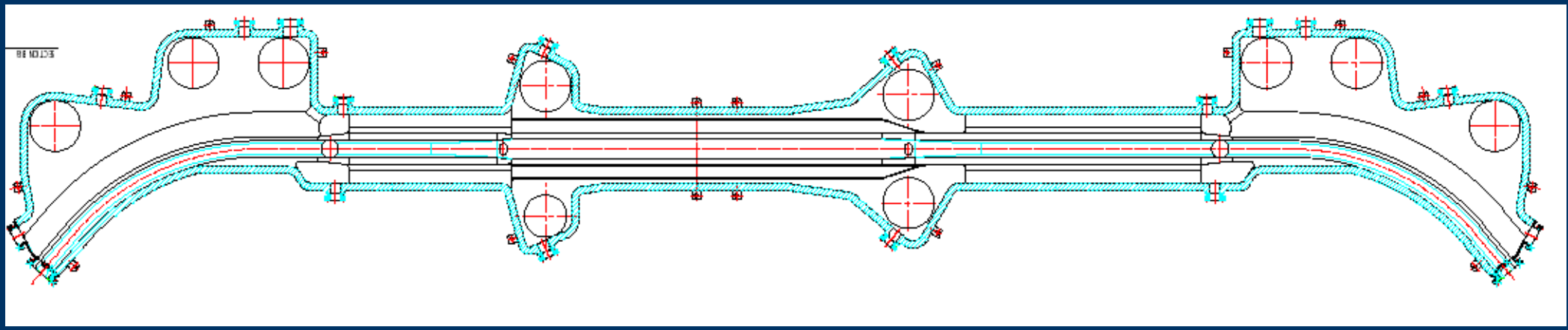
Schematic layout of the two DAΦNE Main Rings



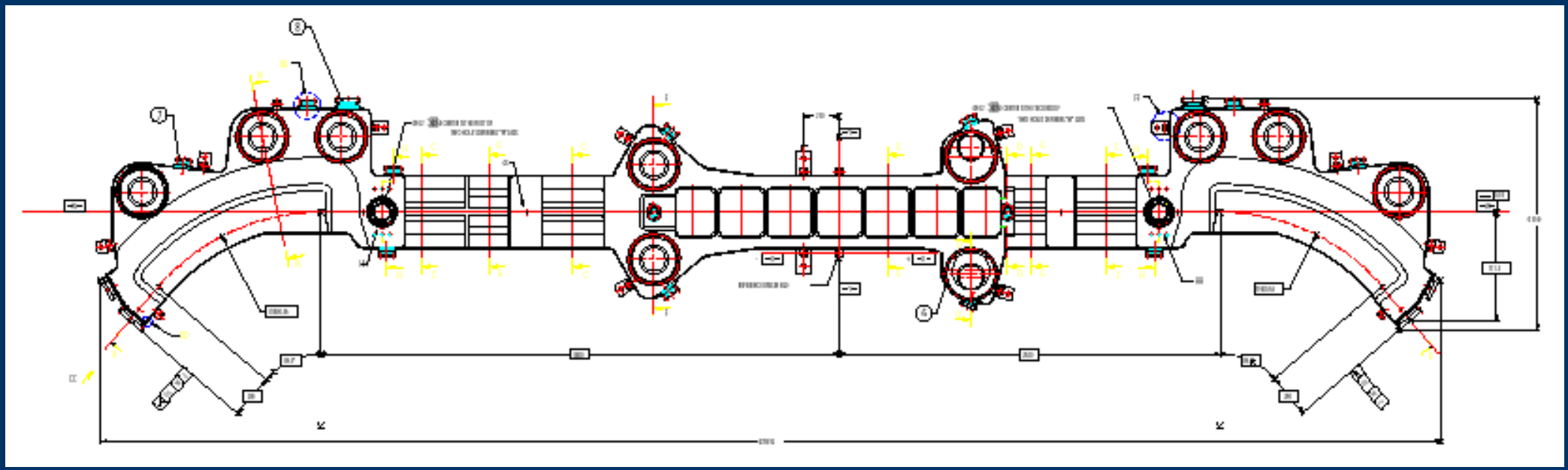
Present DAΦNE parameter list

Single beam energy	E	0.51 GeV
Max number of bunches per ring	h	120
Crossing frequency	f	up to 368.25 MHz
Horizontal emittance	ε_x	.45 mm mrad
Vertical emittance	ε_y	.0045 mm mrad
Coupling factor	k	0.01
Hor. beta function at crossing	β_x	2.00 m
Ver. beta function at crossing	β_y	0.027 m
Total crossing angle in the hor. plane	ϕ	20-30 mrad
Hor beam beam tune shift per cross.	ξ_x	0.03
Hor beam beam tune shift per cross.	ξ_y	0.03
Bunch length	σ_z	10÷20 mm rms
Hor beam size at crossing	σ_x	2.0 mm r.m.s
Ver beam size at crossing	σ_y	0.012 mm r.m.s
Long betatron damping time	τ_s	17.8 ms
Max stored current e^-/e^+	I_{max}	1.9 /1.3 A
Maximum achieved Luminosity	L_{peak}	0.9×10^{32}

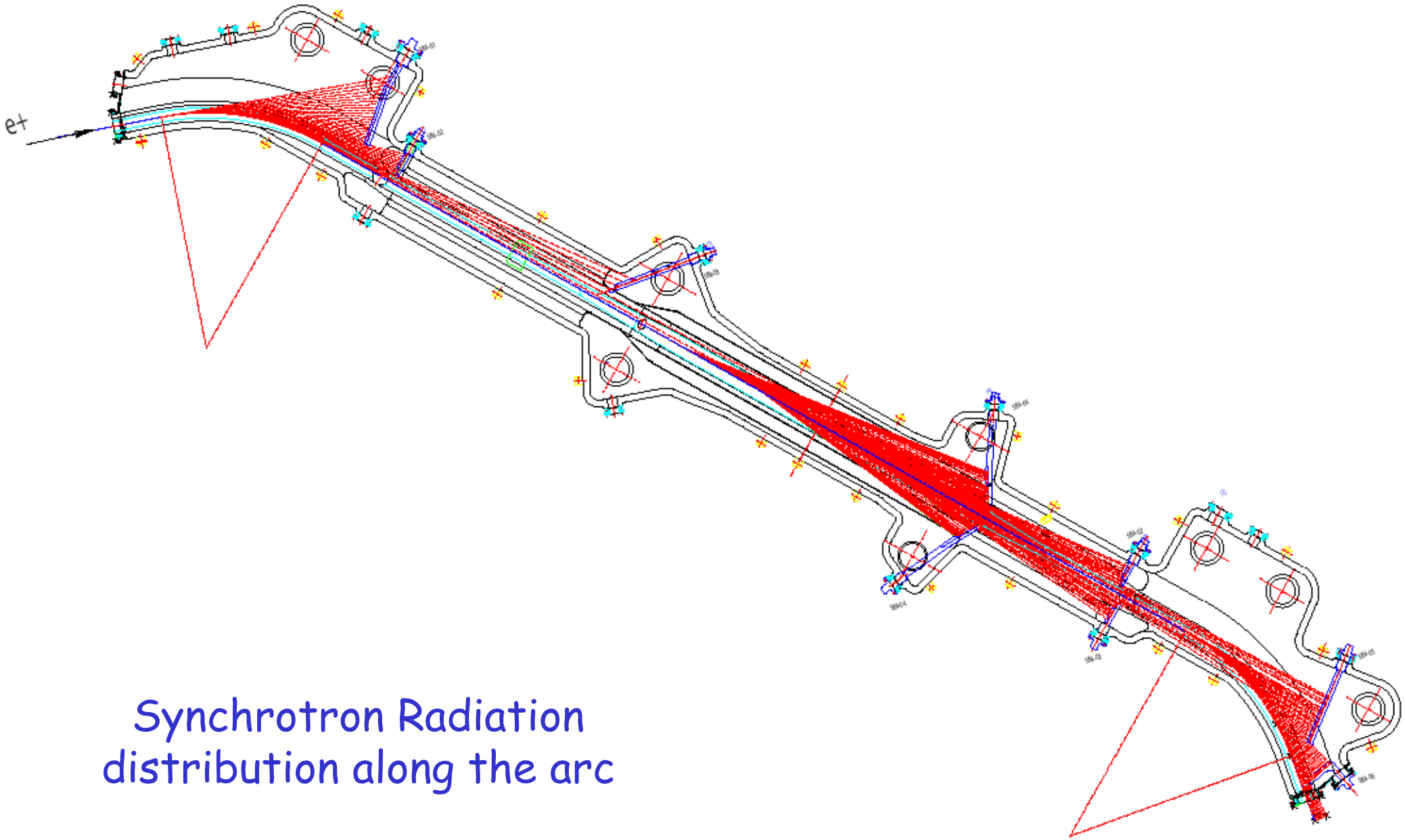
The DAΦNE $e^{+/-}$ Arc vacuum chamber



top view inside

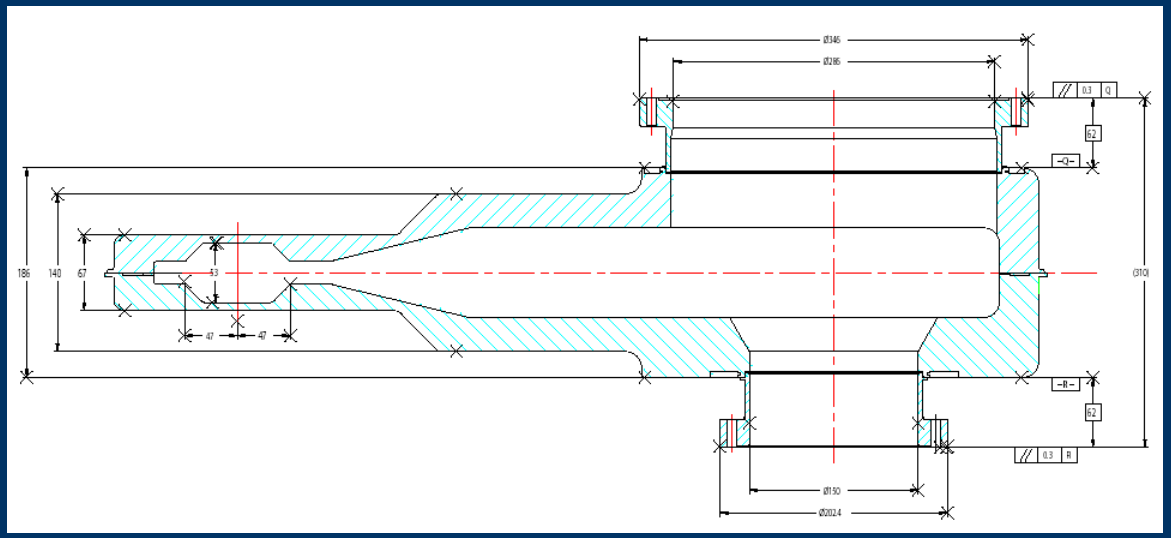


top view outside

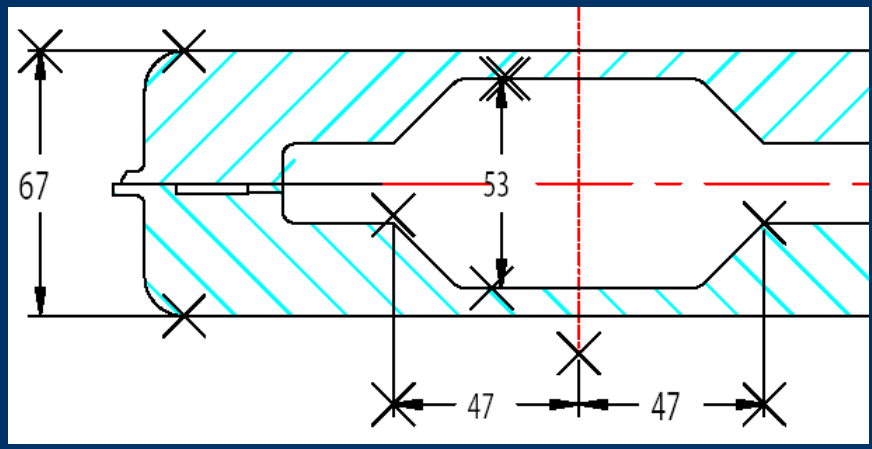


Synchrotron Radiation
distribution along the arc

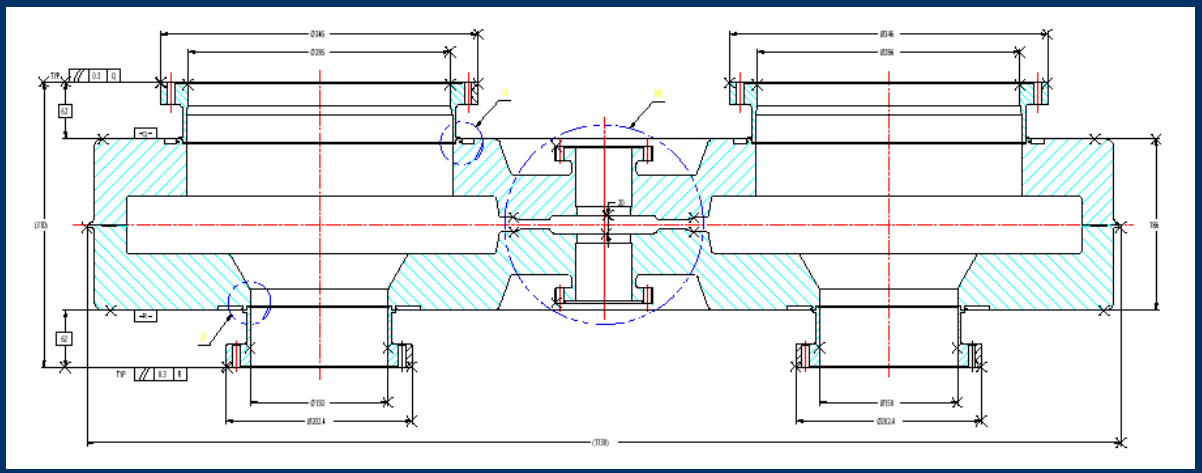
The DAΦNE $e^{+/-}$ Arc vac. Chamber cross sections



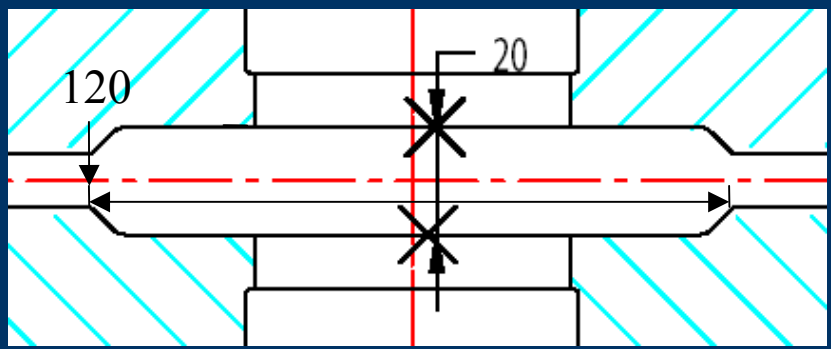
Arc dipole vacuum chamber cross section



dipole beam chamber detail

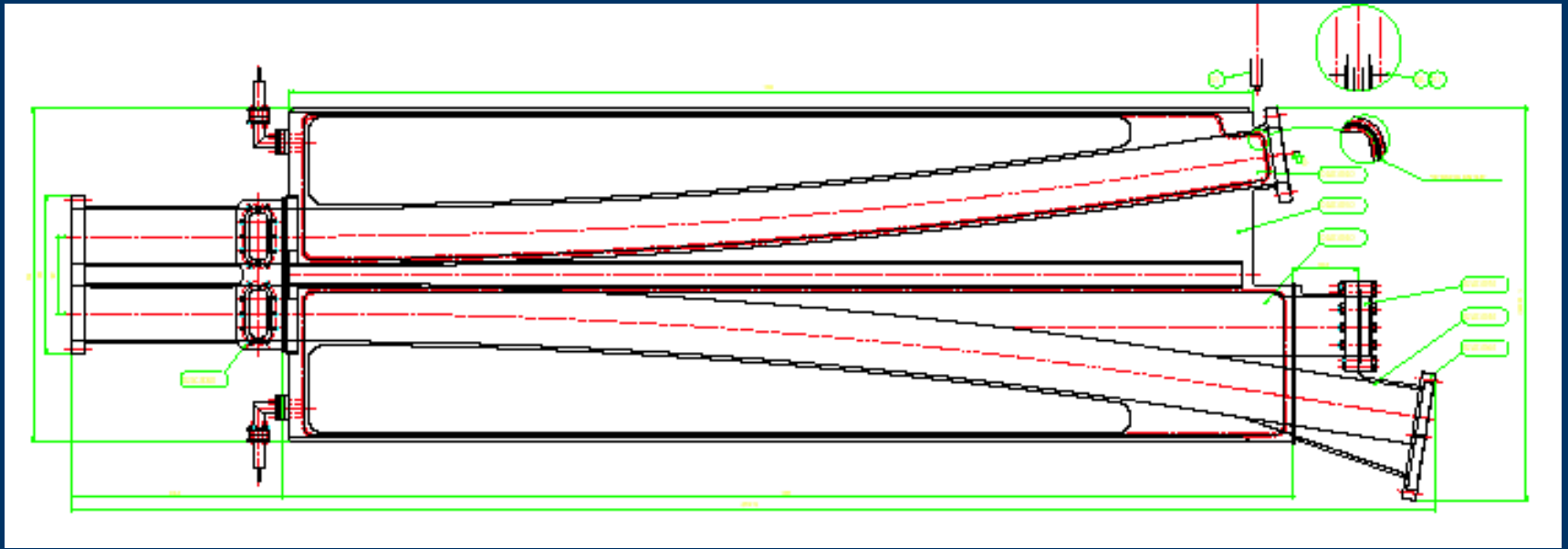


Arc wiggler vacuum chamber cross section

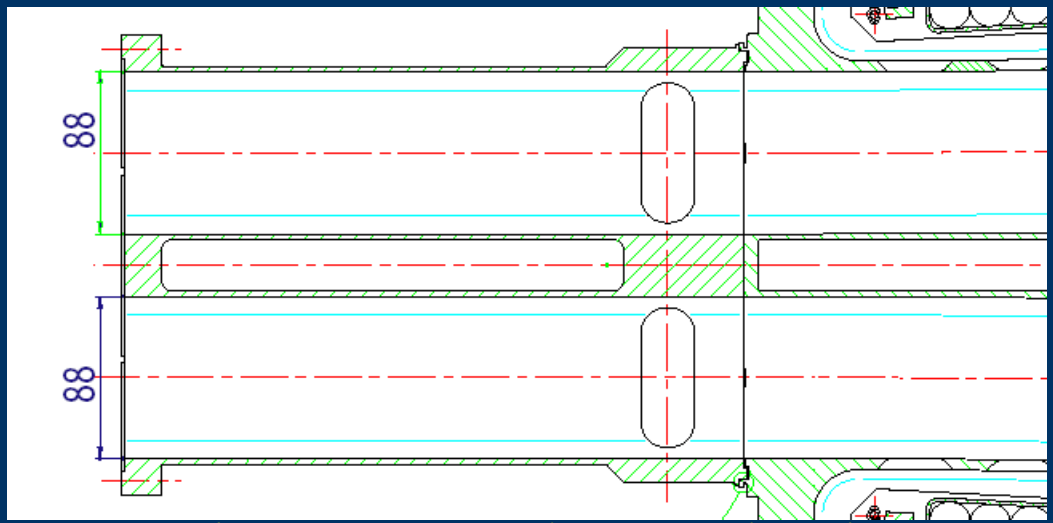


wiggler beam chamber detail

The DAΦNE $e^{+/-}$ Arc splitter chamber



splitter vacuum chamber top view



splitter vacuum chamber detail

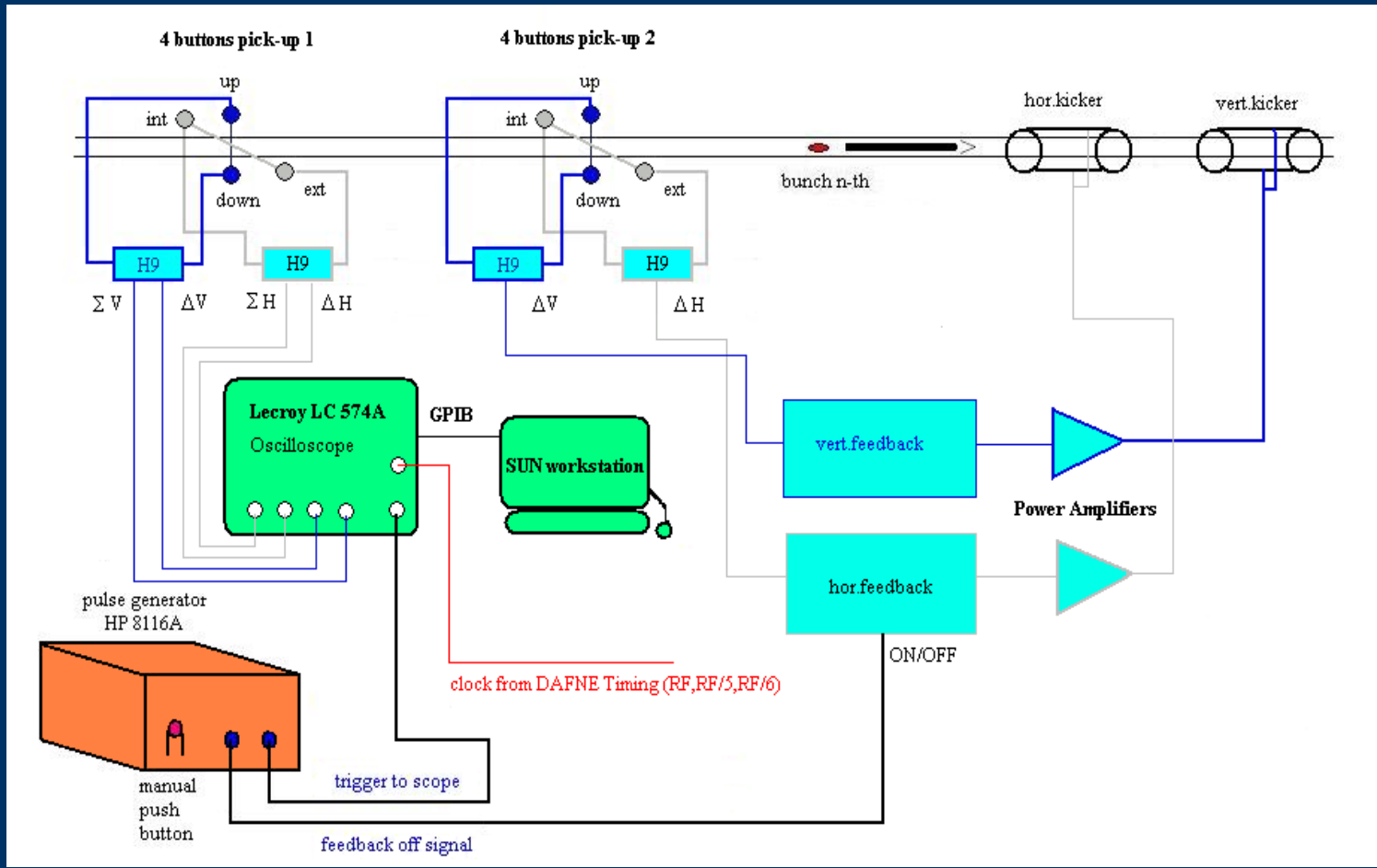
Experimental results:

- Grow-damp measurement for positron beam.
- Correlation between total positron current value and a positron Main Ring straight section VG reading with different patterns and transverse feedback on and off.
- Positron transverse bunch size measurement (@ SLM) as a function of total positron current (above conditions).
- Correlation between tune shift and total positron current (above conditions).
- Positron injection threshold (above conditions).

Grow-damp measurement set-up

In 2003, a strong horizontal multibunch instability was limiting the positron beam current at the level of ~450 mA. The instability behavior was studied by tracking the transverse displacements for each bunch on turn-by-turn basis. Switching off the horizontal feedback for short periods, transverse grow-damp measurements have been performed to estimate the instability growth rates for each bunch at different beam currents and to evaluate the tune shift along the bunch train.

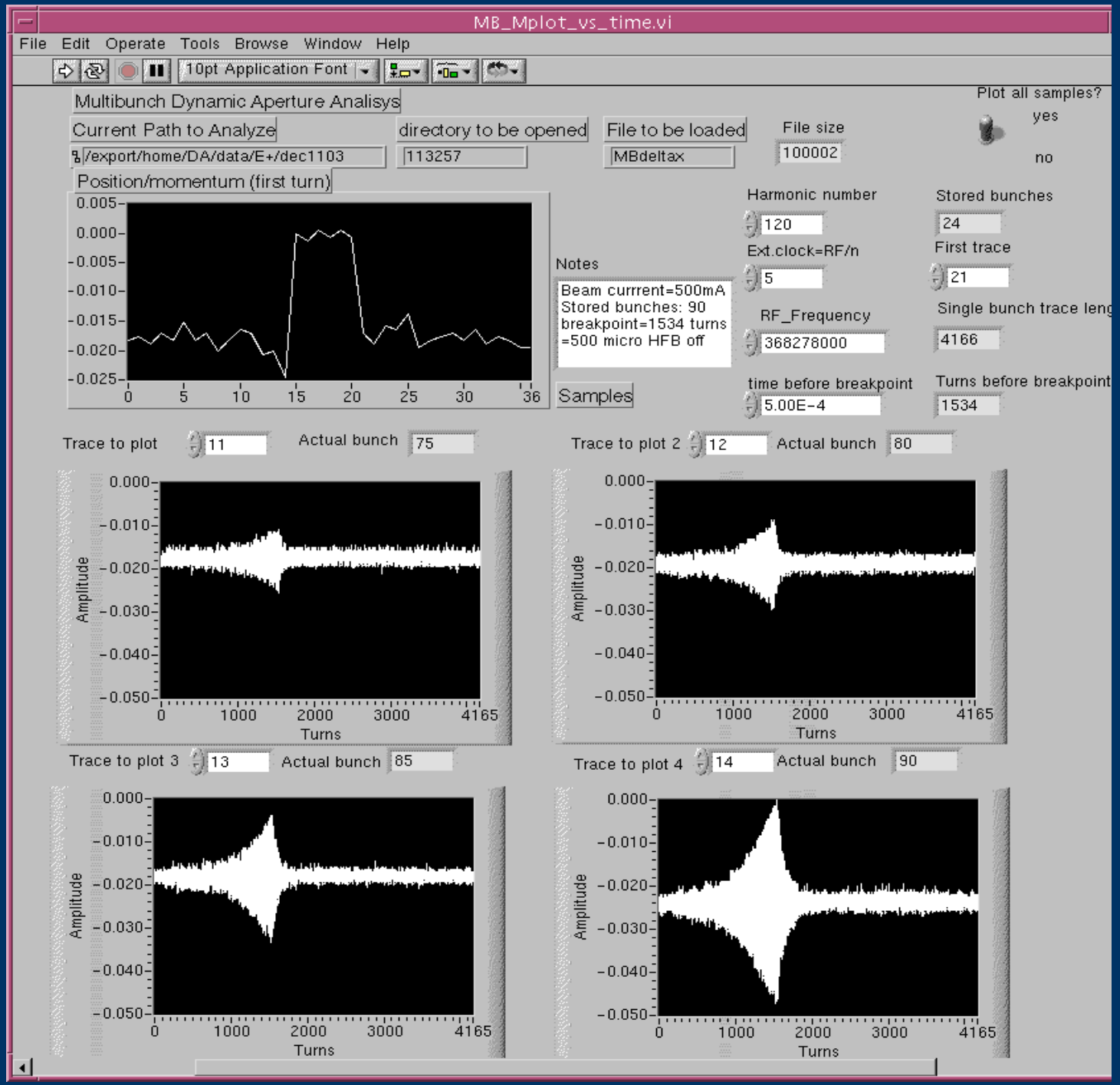
A strong dependence of the oscillation amplitudes on the bunch relative position in the train has been revealed. No evidence of tune shift along the train has been observed.



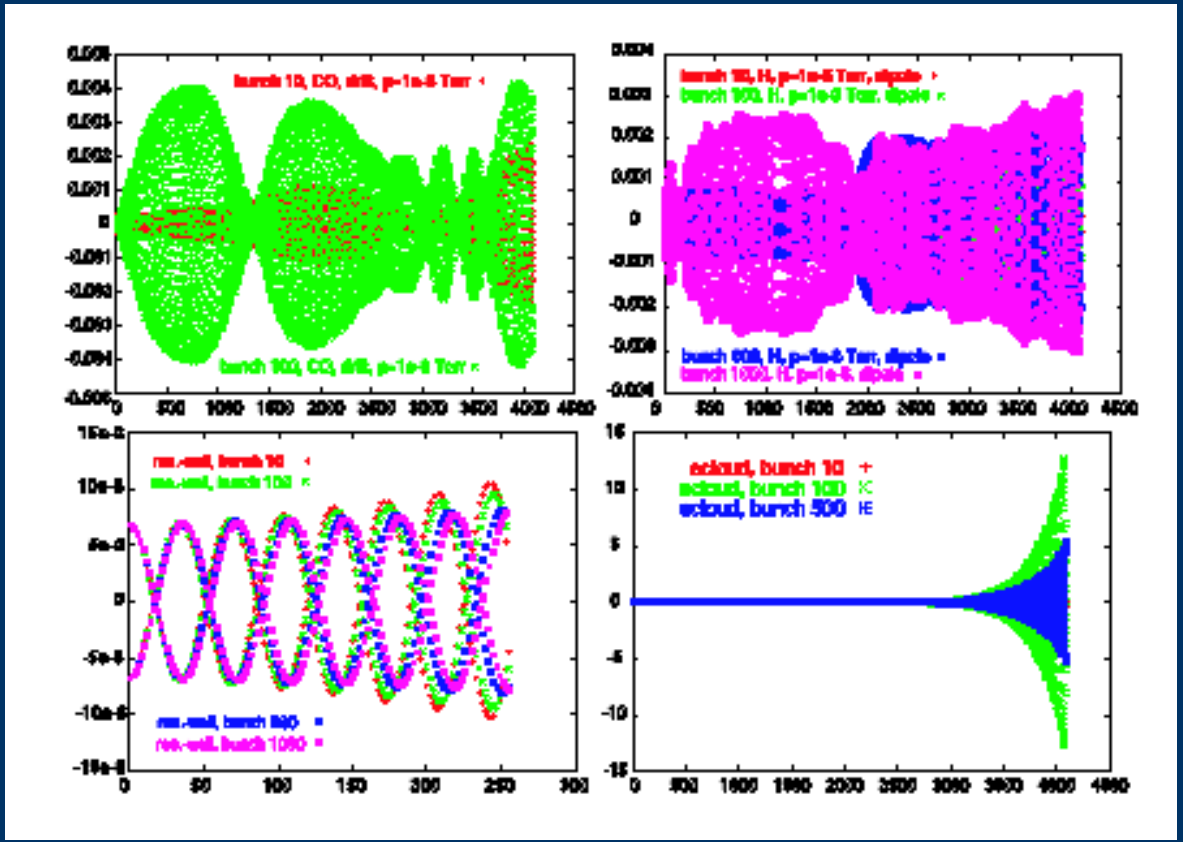
Grow-damp measurement of transverse instability

e^+ Finuda conf.

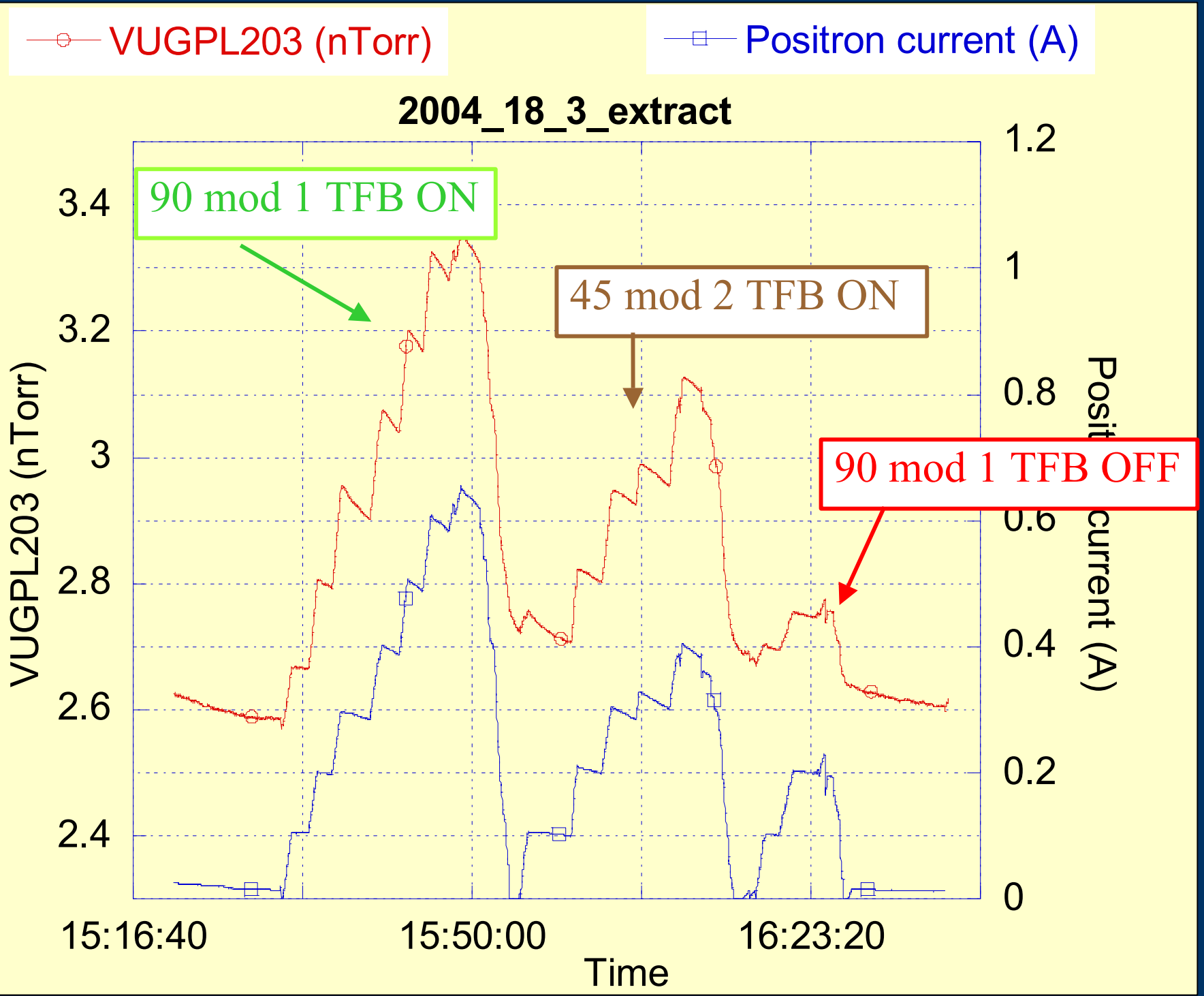
Beam current = 500 *mA*
Stored bunches = 90
Breakpoint= 1534 turns
$\Longrightarrow$ 500 μs HFB off



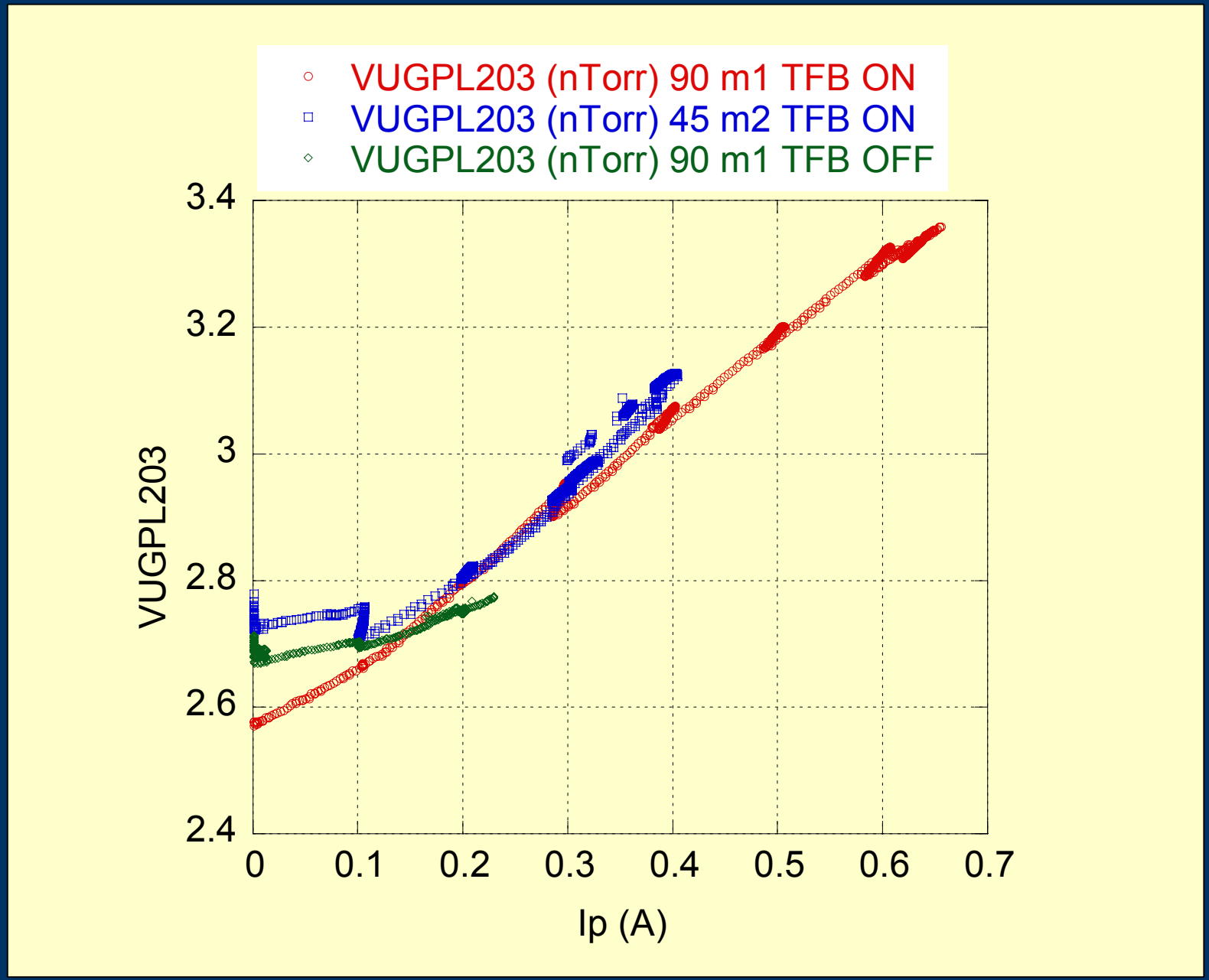
from : F. Zimmermann, Fukuma, K. Ohmi, Y. Ohnishi, CERN-AB-2003-035 ABP



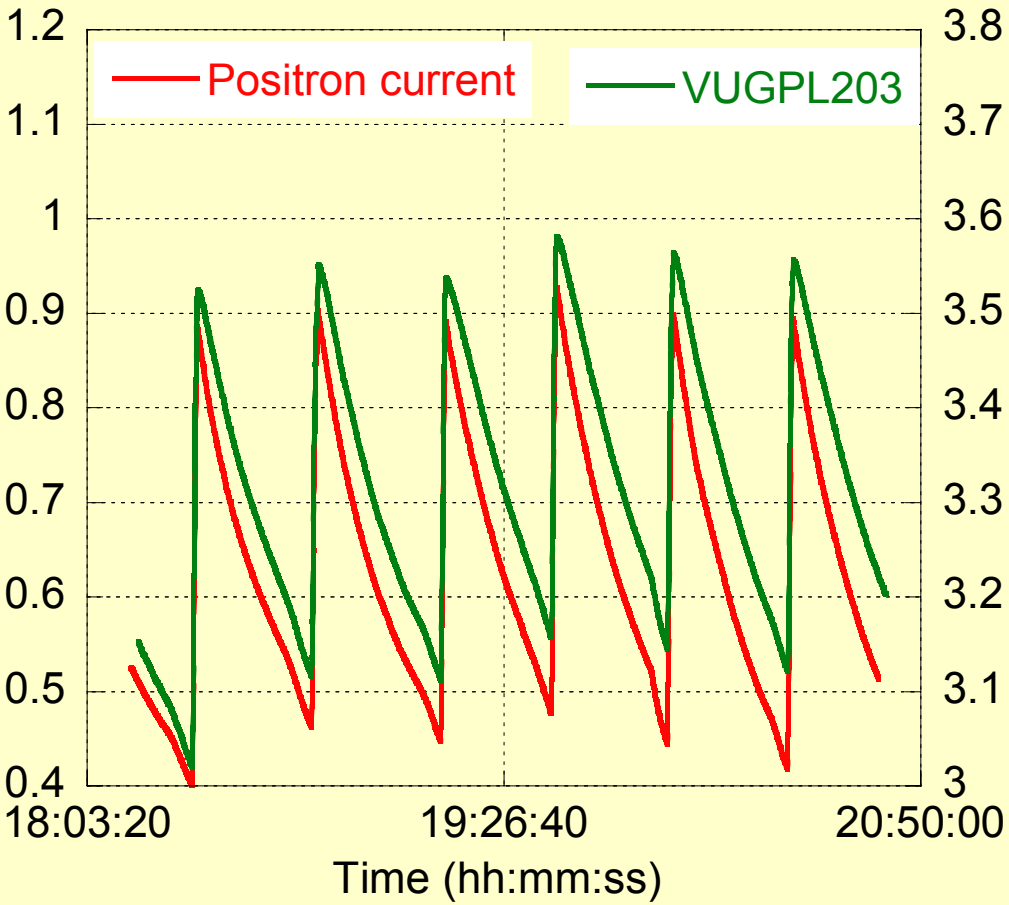
"Simulated horizontal position of different bunches as a function of turn number interacting with carbon monoxide without magnetic field after 50 turns (top left), for hydrogen in a dipole field after 4000 turns (top right), for the resistive wall instability after various numbers of turns (bottom left) and for the electron cloud after 4000 turns (bottom right)"

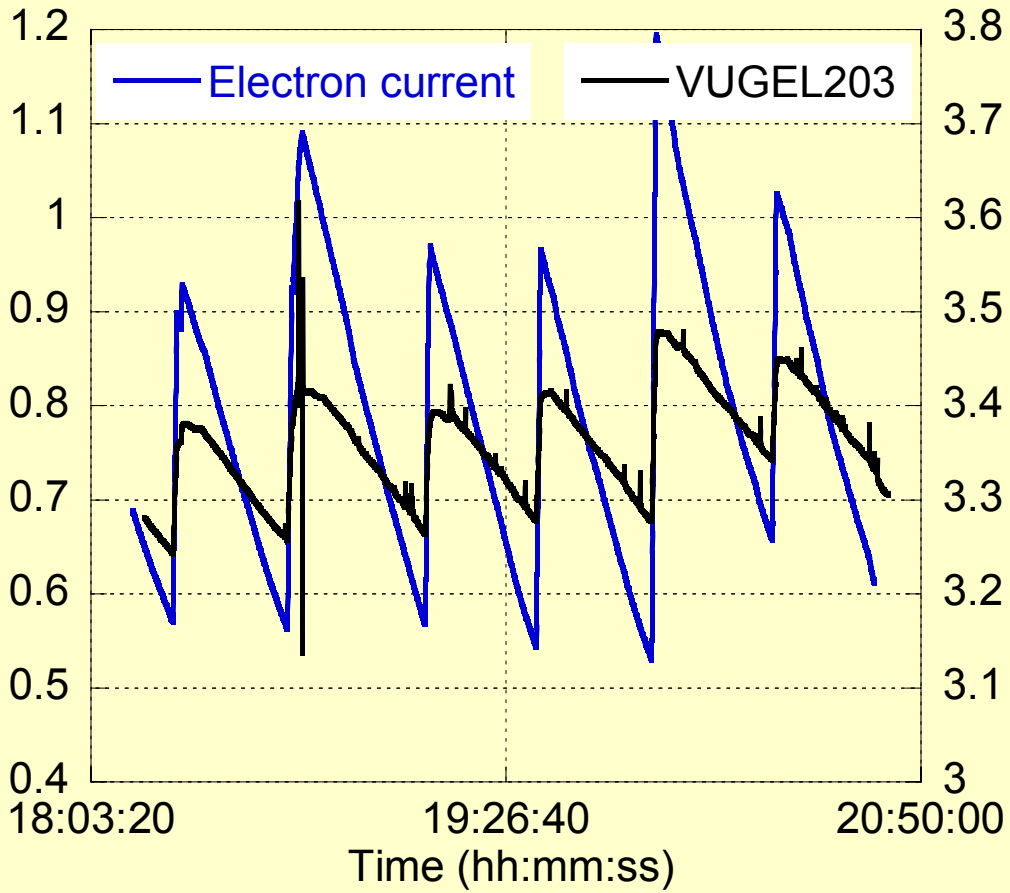

VUGPL203 (nTorr)
Positron current (A)
2004_18_3_extract
90 mod 1 TFB ON
45 mod 2 TFB ON
90 mod 1 TFB OFF
VUGPL203 (nTorr)
Positron current (A)
3.4
3.2
3
2.8
2.6
2.4
1.2
1
0.8
0.6
0.4
0.2
0
15:16:40
15:50:00
16:23:20
Time

VG reading comparison:

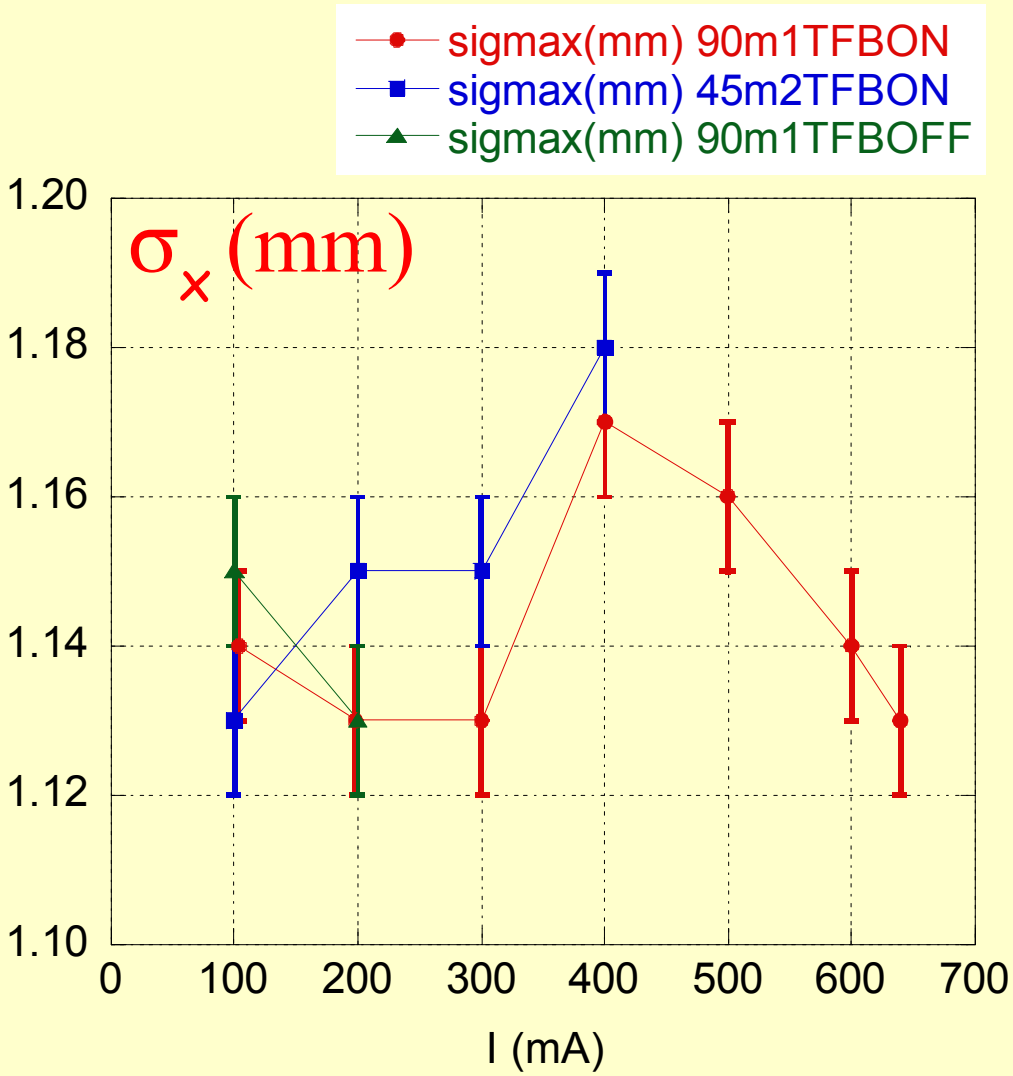


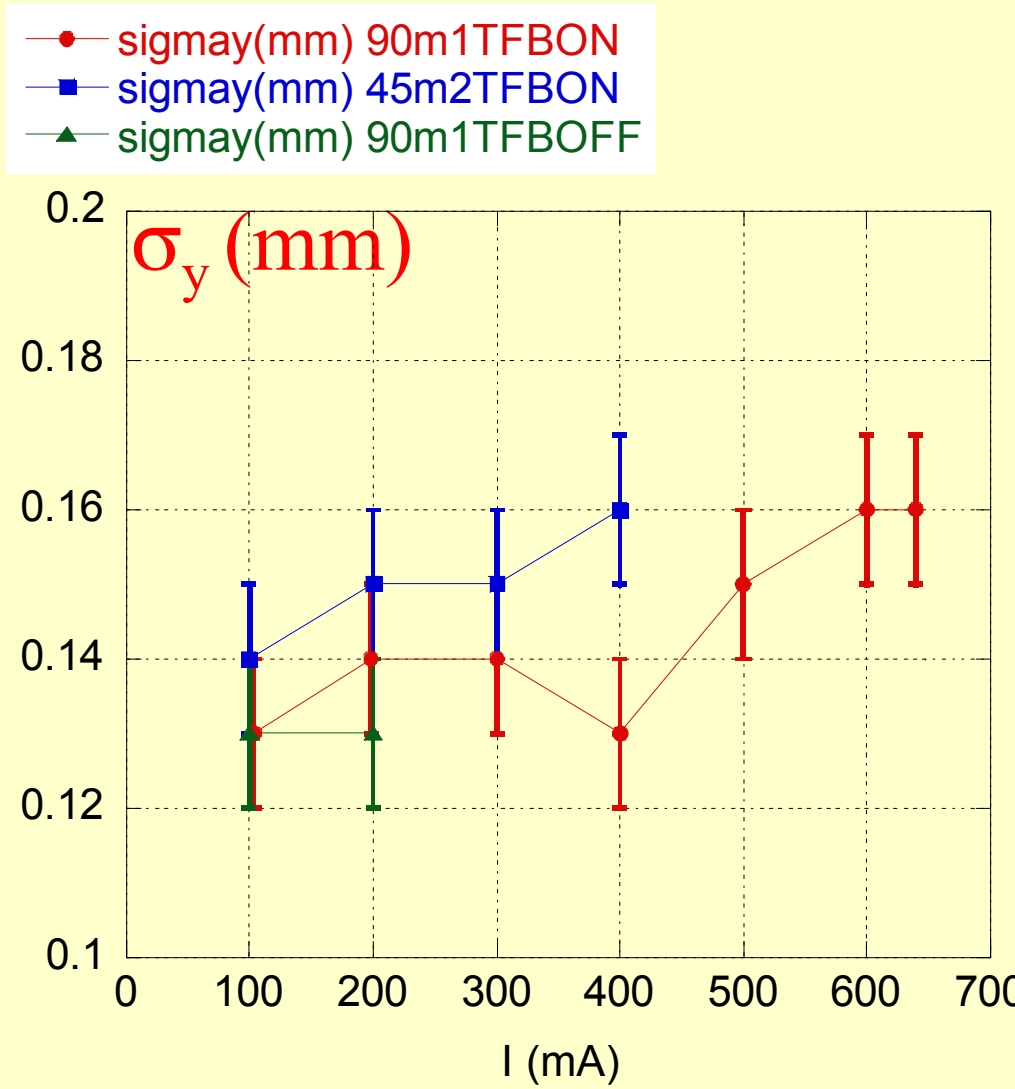
FINUDA experiment data taking
(March 18th, 2004)



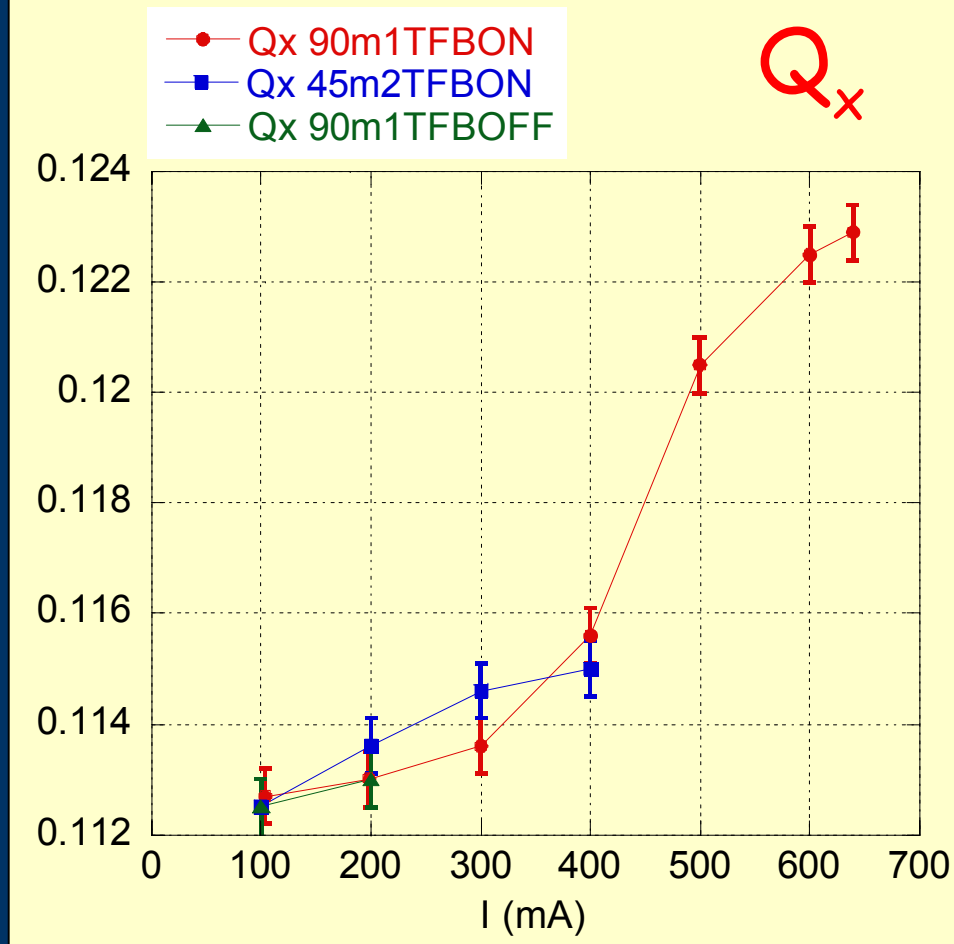


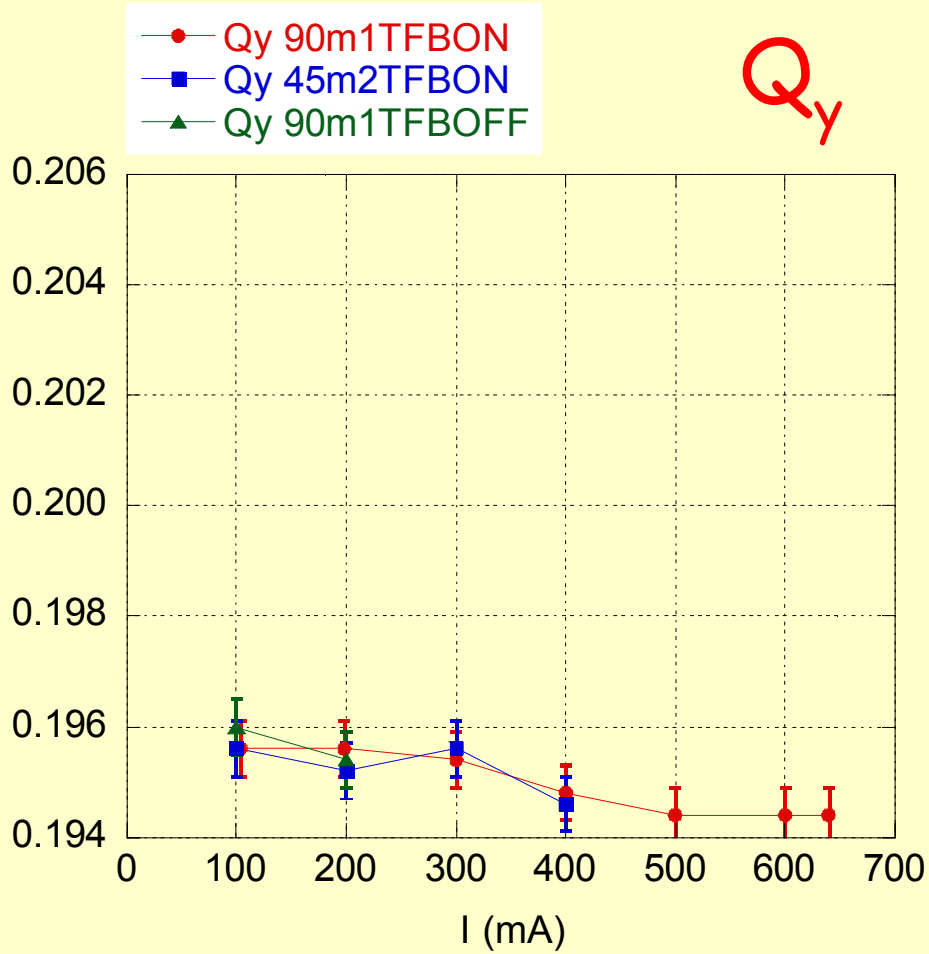
Transverse beam size comparison:



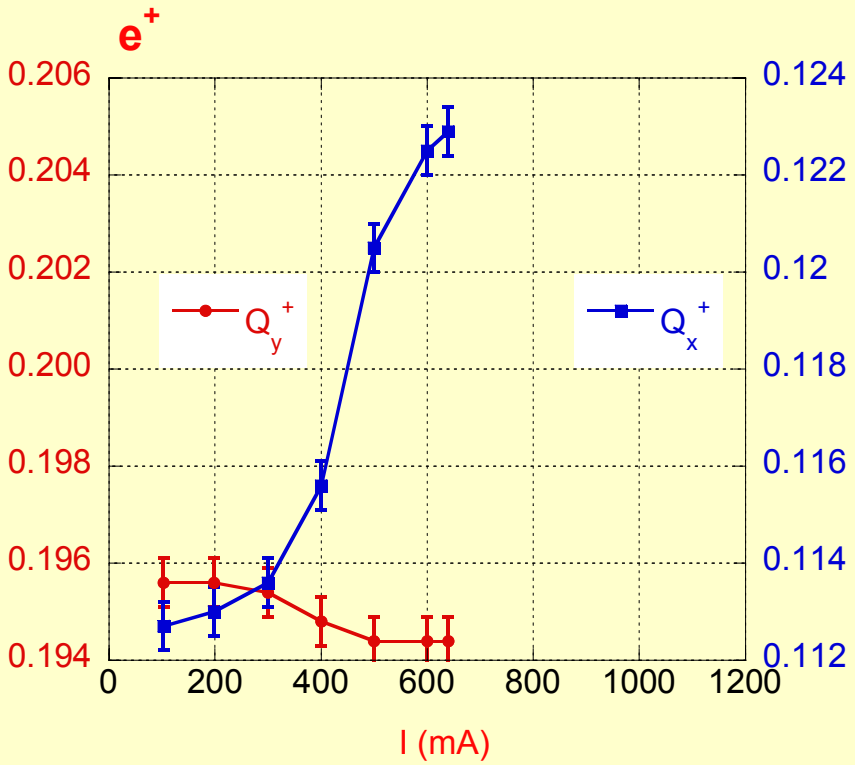


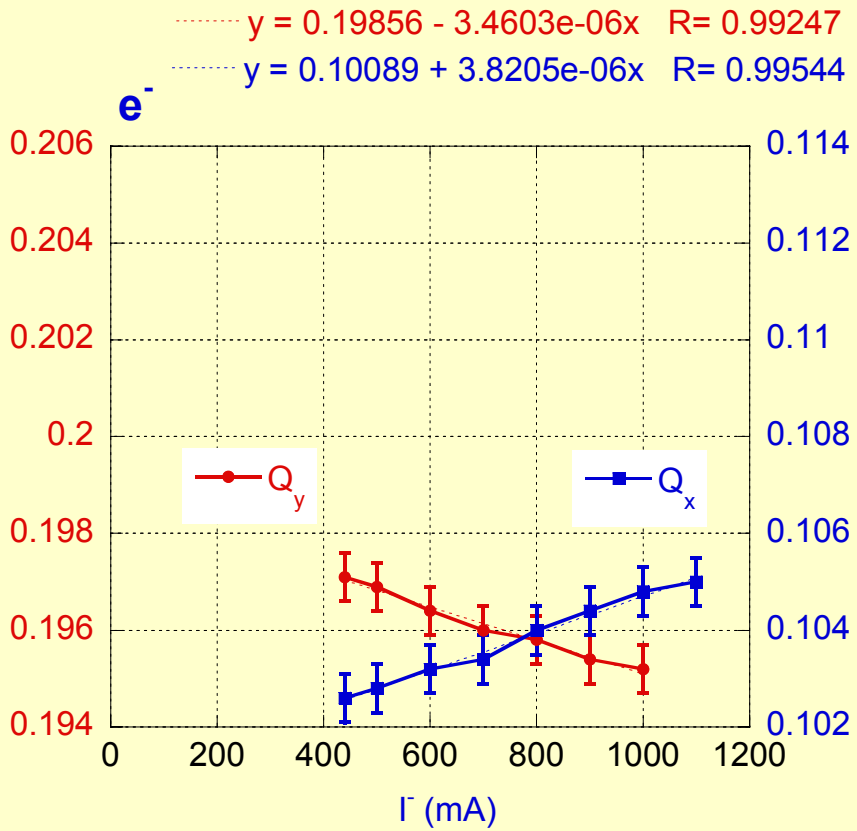
Positron tune shift vs current:





Positron-Electron tune shift comparison:





Injection current threshold measurement: (Finuda configuration)

Table I

Pattern	TFB	Spacing (m)	I_{max} (mA)
90/120	ON	0.8	~ 650
45/120	ON	1.6	~ 400
90/120	OFF	0.8	~ 200
30/120+gap+30/120+gap	ON	0.8	~ 600
90/120 **with e^- beam**	ON	0.8	~ 900
45/120 KLOE conf.	ON	1.6	~ 1300

Table II (*)

Δf (kHz)	I_{max} (mA)
0	~ 600
-5	~ 720
-10	~ 940
-15	~ 960
5	~ 700
10	~ 760

(*) G. Rumolo, W. Fischer

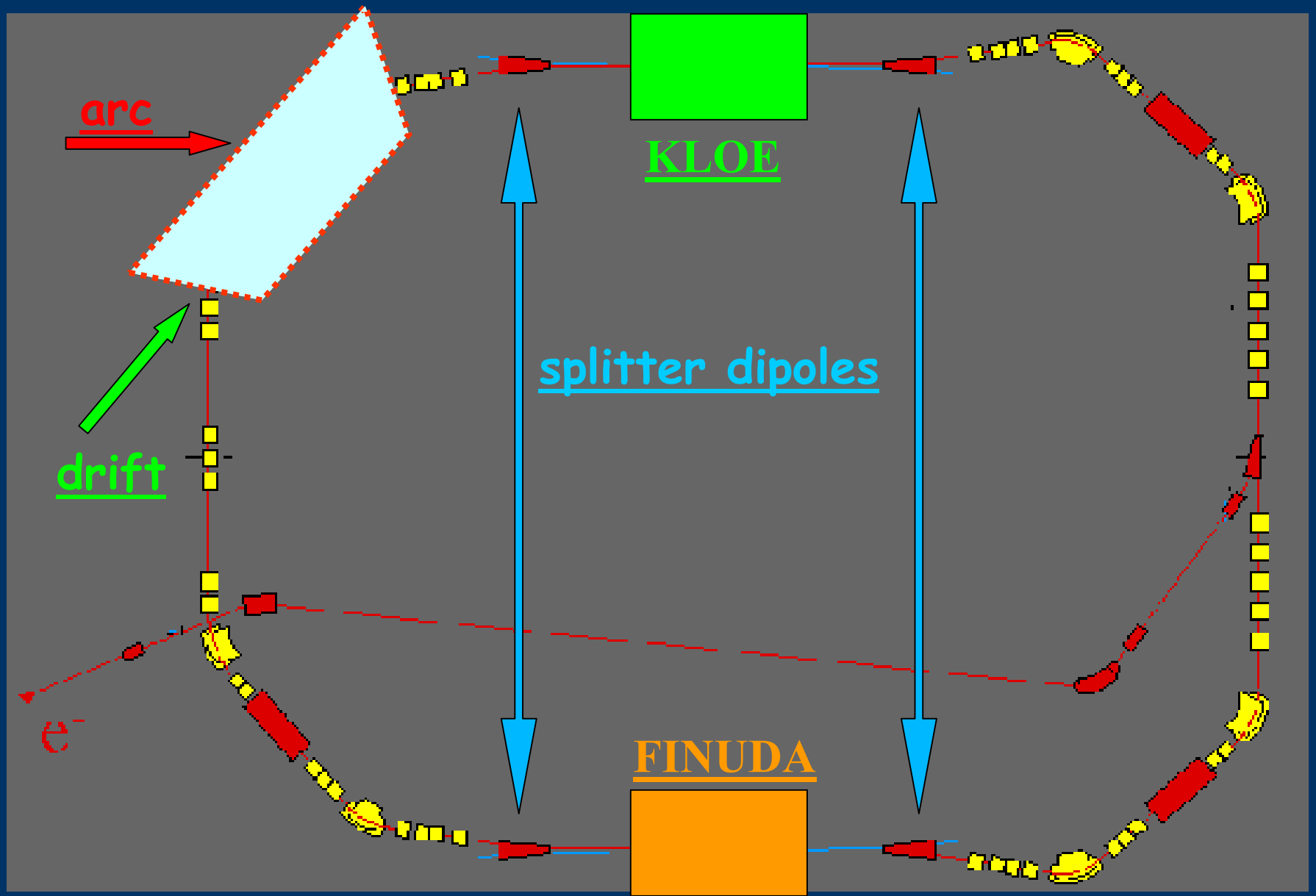
e-cloud build-up simulation:

- Ecloud code version 2.2.2 (G. Rumolo, F. Zimmermann CERN- SL-Note-2002-016)

- Relevant zones of DAΦNE positron ring :
  - ✓ Double achromat Arc (L≈10 m, B≈ 1.2 T)
  - ✓ Drift zone after Arc (L≈.5 m)
  - ✓ Splitter dipole (L≈1.5 m, B≈ .18 T)

- Parameters set exploitation for :
  - ✓ Photon reflectivity
  - ✓ Max Secondary emission yield

Schematic layout of the positron ring

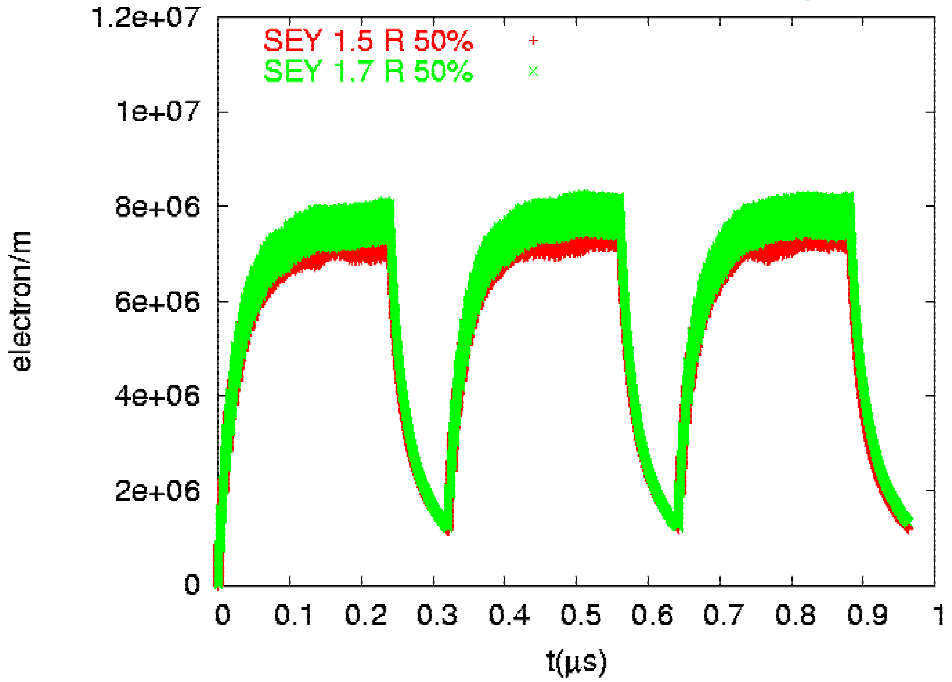


Parameters assumed for DAΦNE e-cloud simulation:

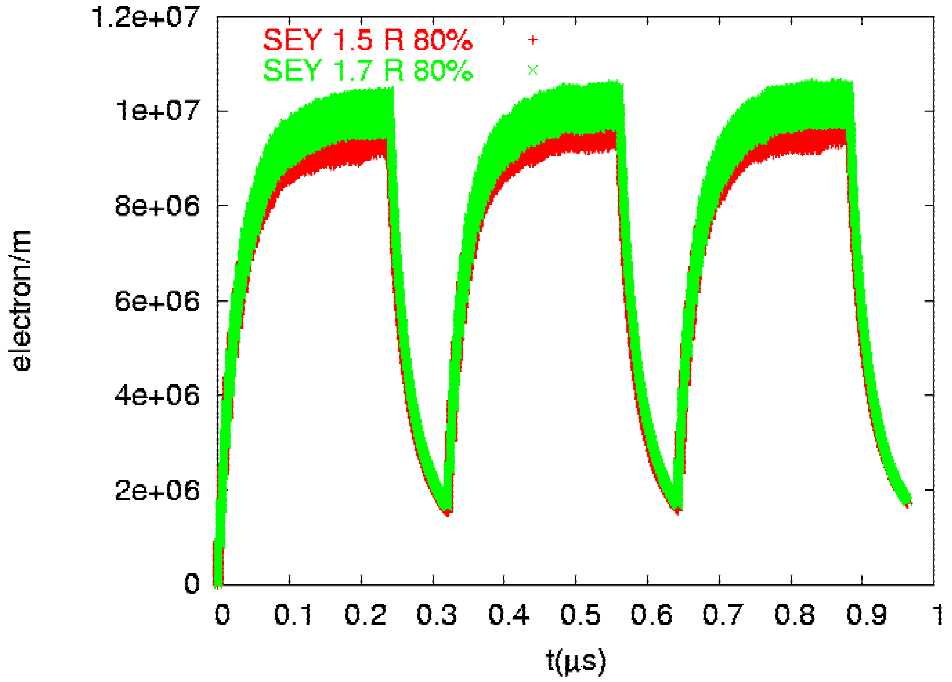
variable	symbol	value
bunch population	N_b	3.4×10^9
number of bunches	n_b	90
missing bunches	N_{gap}	30
bunch spacing	L_{sep}	.8 m
rms bunch length	σ_z	1.1 cm
rms horizontal beam size	σ_x	1-2.5 mm
rms vertical beam size	σ_y	.1-.25 mm
max sec. emission yield	δ_{max}	1.5-1.9
energy at max sec. em. yield	ε_{max}	250 eV
Al effective photoelectron yield	Y_{eff}	0.1
chamber hor. half aperture	h_x	44 – 60 mm
chamber ver. half aperture	h_y	44 – 10 mm
bending field	B	0 – 1.2 T
primary electron rate	$d\lambda_e/ds$	.003 - .131
photon reflectivity	R	15-50-80 %
elastic electron reflection	-	Cimino Collins

e-cloud build-up evaluation in the arc (L≈10 m, B≈ 1.2 T):

R=50%



R=80%

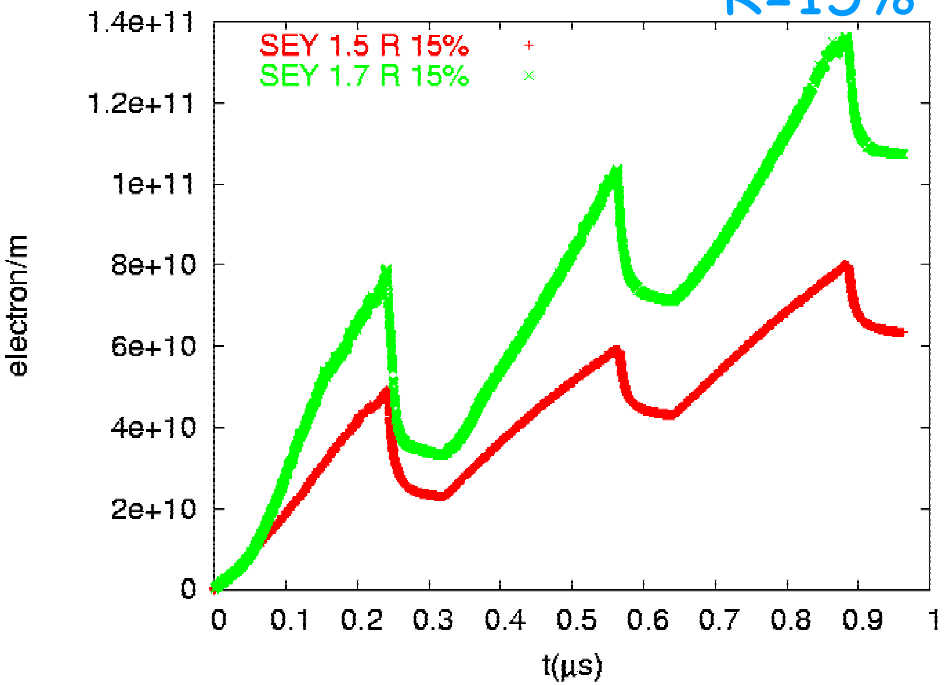


vacuum chamber cross section:
w = 120 mm
h = 20 mm

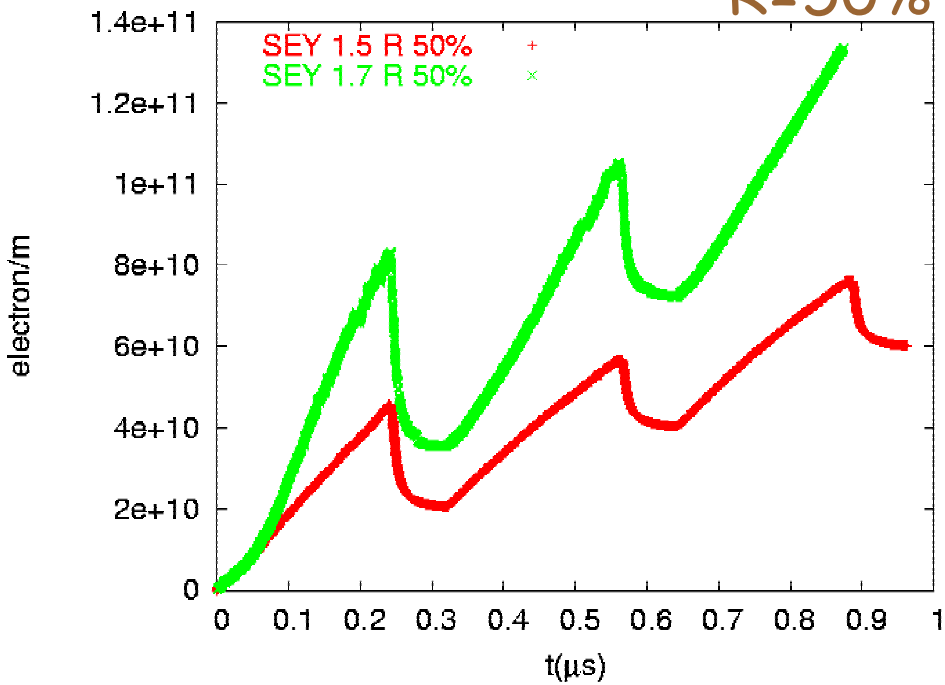
σ_x ~ 1.2 mm
σ_y ~ 0.7 mm

e-cloud build-up evaluation in the drift zone after arc (L≈.5 m):

R=15%



R=50%

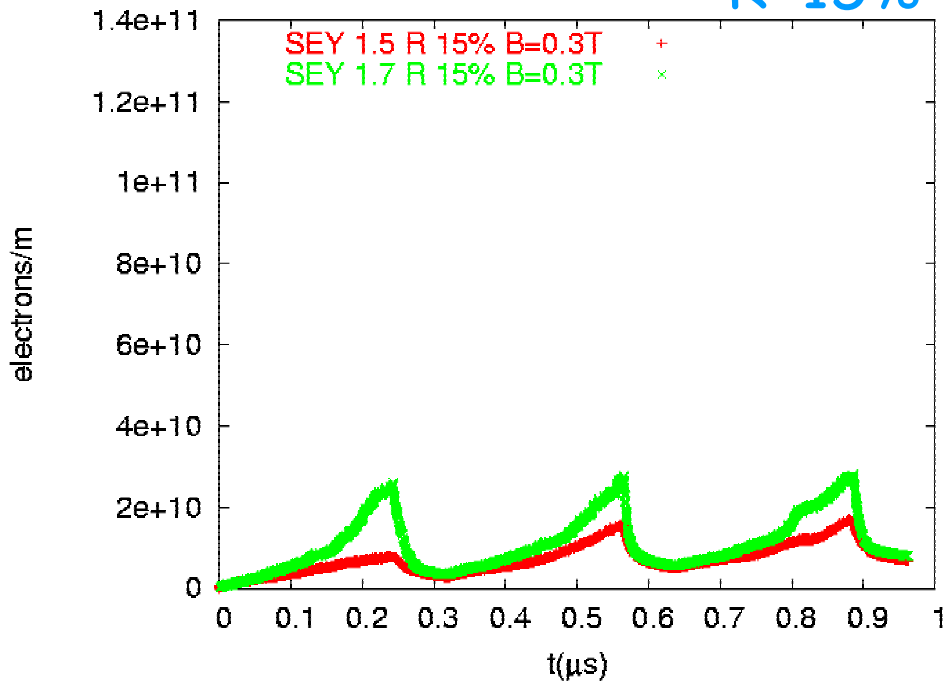


vacuum chamber:
Ø = 44 mm

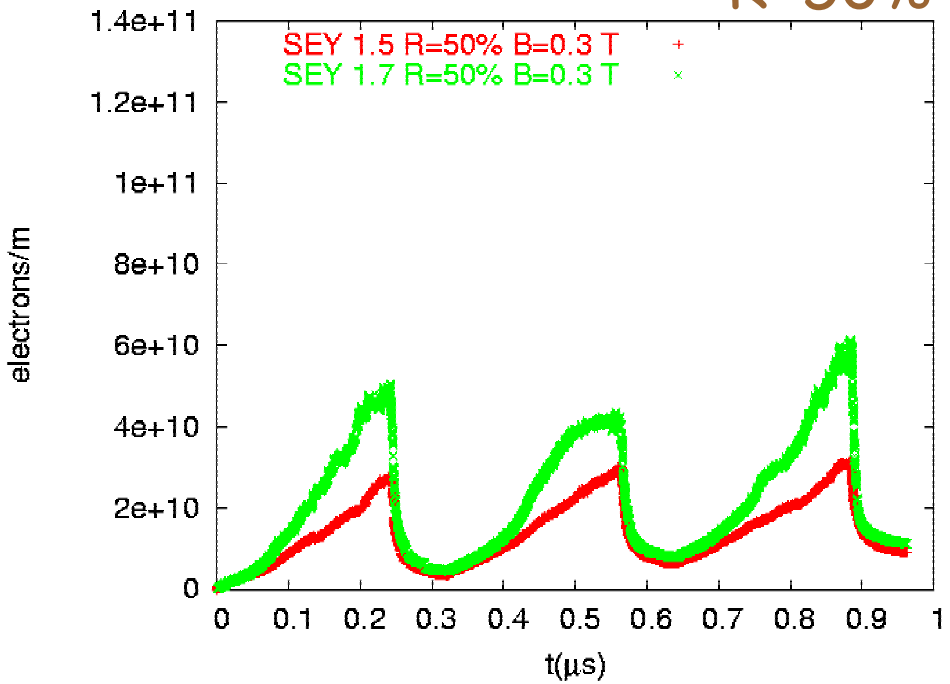
σ_x ~ 2.0 mm
σ_y ~ 0.3 mm

drift zone after arc (L≈.5 m) with dipole fringing field considered:

R=15%



R=50%

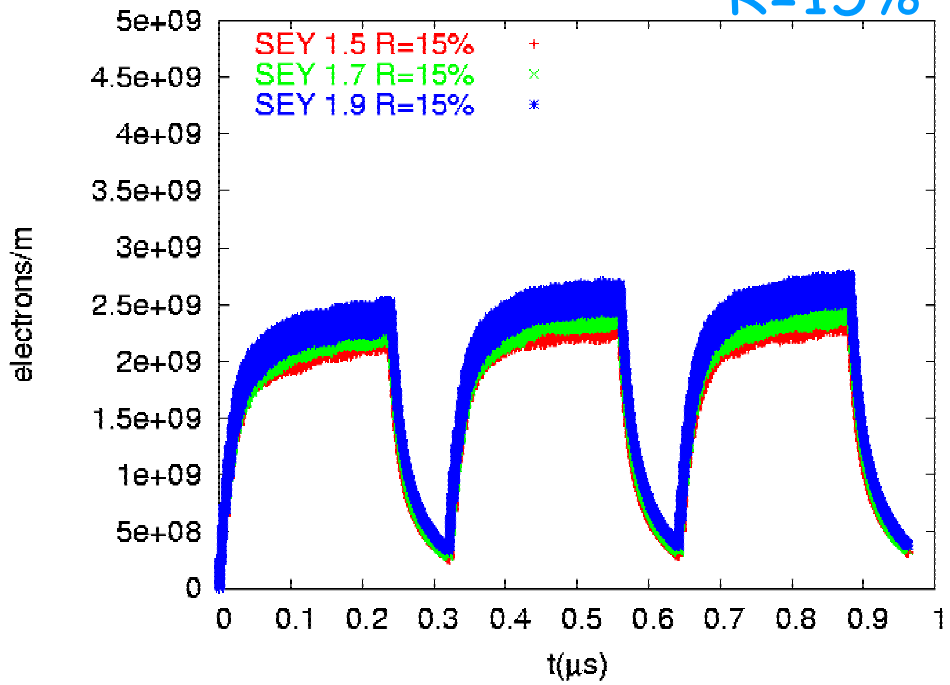


vacuum chamber:
Ø = 44 mm

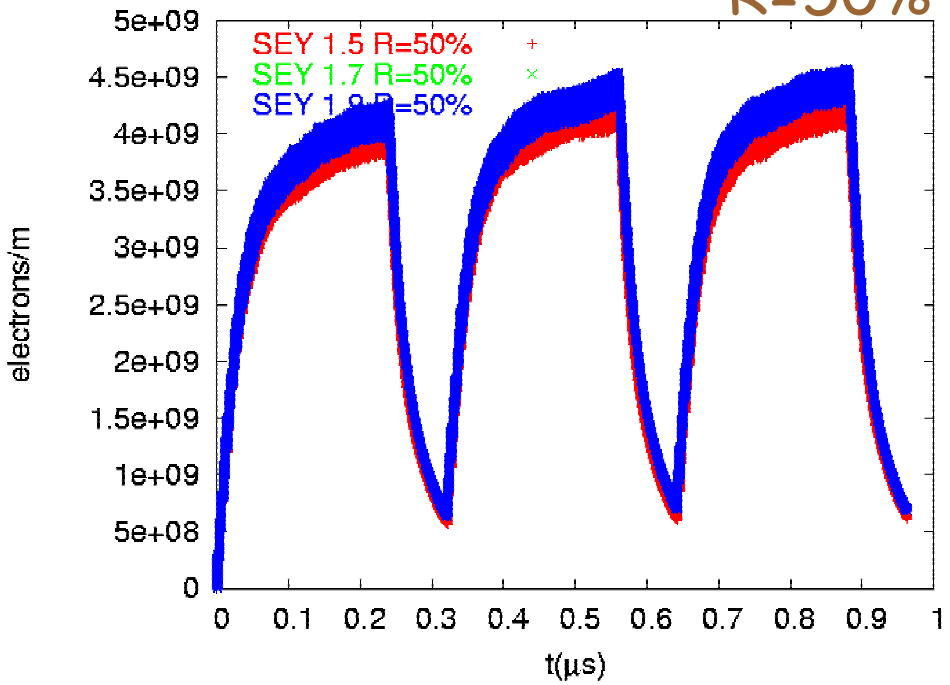
σ_x ~ 2.0 mm
σ_y ~ 0.3 mm

e-cloud build-up evaluation on the splitter dipole (L≈1.5 m, B≈ .18 T):

R=15%



R=50%

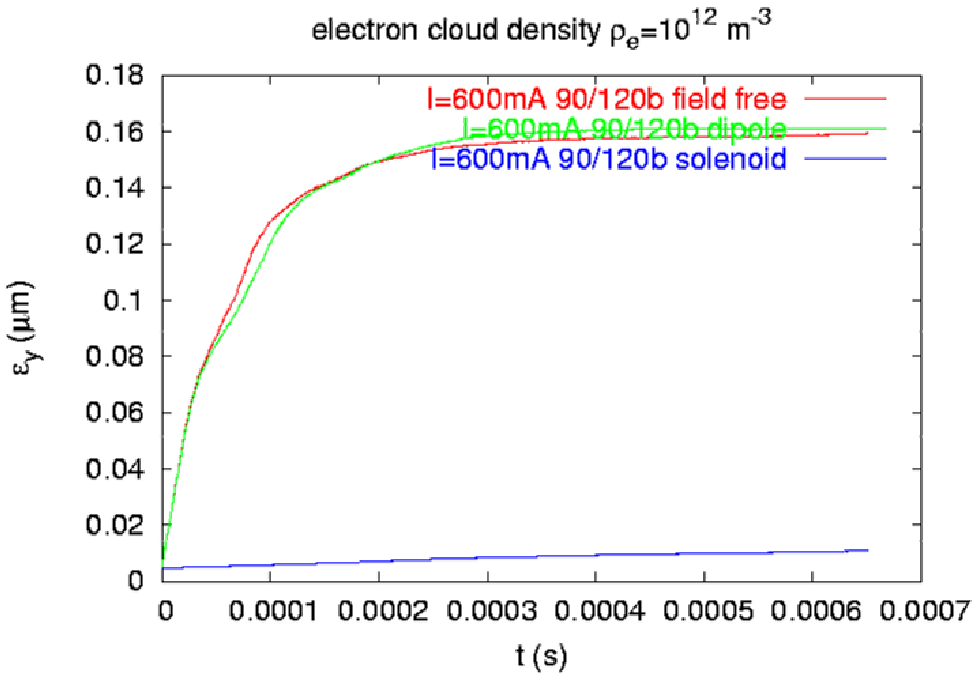


vacuum chamber:
w = 88 mm
h= 54 mm

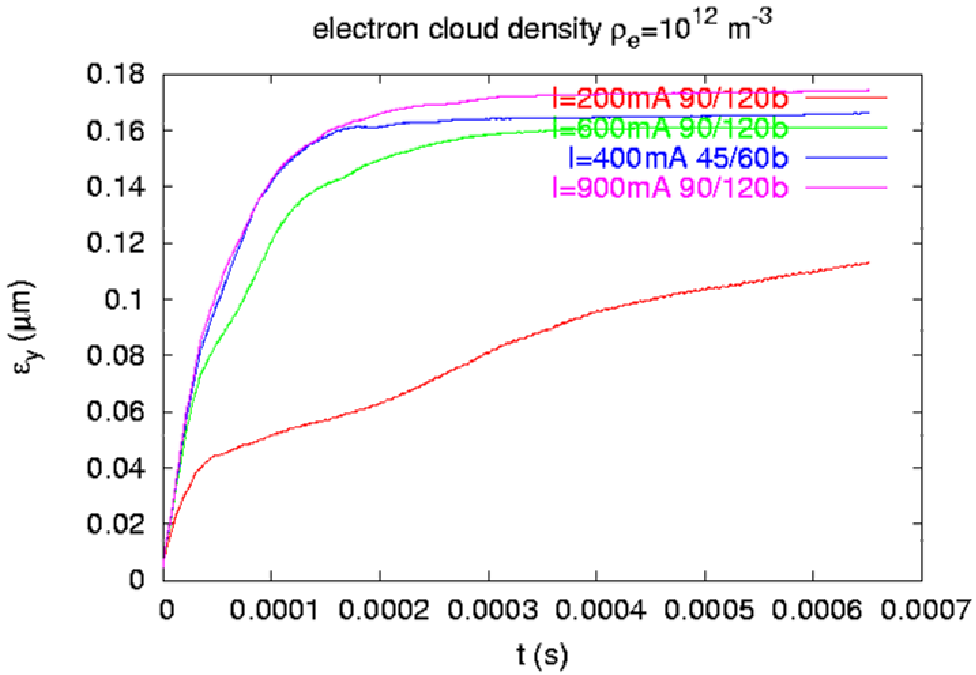
σ_x ~ 2.5 mm
σ_y ~ 1.5 mm

from "Headtail" (E. Benedetto, G. Rumolo):

Vertical emittance growth vs time (2k turns)



a) same bunch pattern, different B field



b) different bunch patterns and currents

In favour of e-cloud…

- Growth w/o TFB
- Different behavior of the current induced tune shift in transverse planes for $e^{+/-}$
- Few betatron sidebands- tune is split in two or more lines $\Longrightarrow$rather short range wakes (Finuda conf.)
- Slight beam size increase with current.

Questions to be further investigated..

- Single bunch instability at I ≥15mA (horizontal plane)
- Single bunch beam size increase
- 90/120 vs 45/60 : $I_{threshold}$ is smaller by a factor 2
- No evident multipacting induced vacuum increase
- Similar instability for e- beam (vertical plane)

Conclusions

- Some experimental results aimed at e-cloud observation at DAΦNE have been presented with open remarks on the e-cloud evidence for our machine.
- On this basis preliminary results of e-cloud simulations have been shown advising:
  - ✓ the relevance of the stray magnetic field due to the compactness of the DAΦNE Main Rings plus Transfer Lines complex.
  - ✓ the presence of two Interactions Regions with high field detector solenoids surrounding Be vacuum chambers, has to be considered in more detail from the point of view of the gas scattering induced multipacting.
- The study is effectively just started and it has to be rigorously continued. Discussion proposals are welcomed.