e-Cloud Instabilities @ DAFNE

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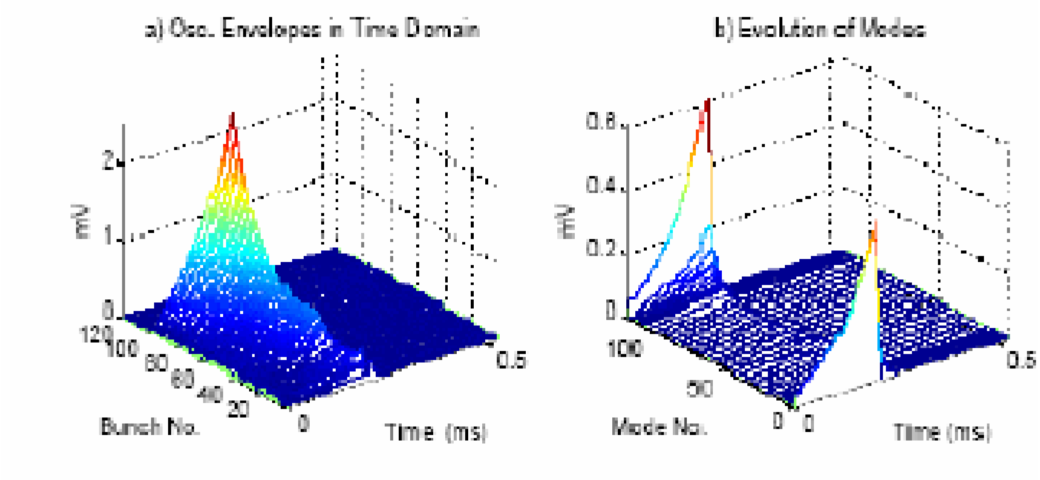
Plan of Talk

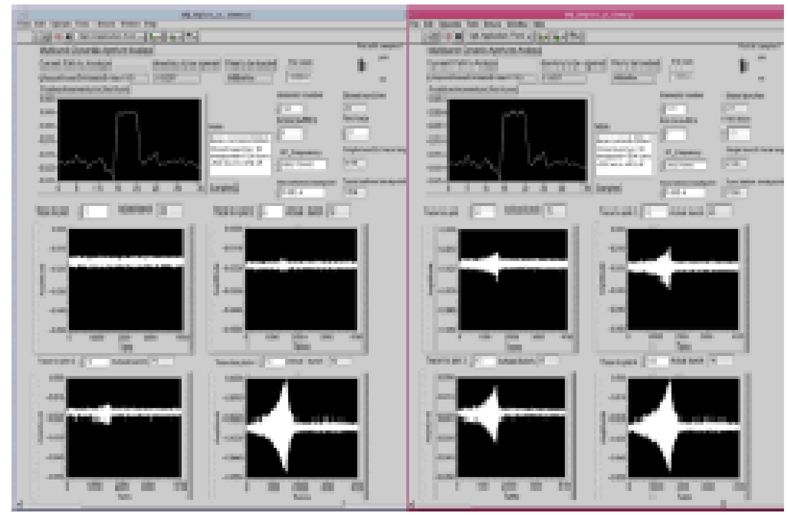
- Introduction
- Analysis of the e-cloud induced instabilities @ DAFNE
  - Coupled bunch
  - Single bunch
- Clearing electrodes for DAFNE dipoles and wigglers
- Summary

E-Cloud effects @ DAFNE

- e^+ current limited to 1.2 A by a strong horizontal instability
- Large positive tune shift with current in e^+ ring, not seen in e^- ring
- Instability depends on bunch current
- Instability strongly increases along the train
- Anomalous vacuum pressure rise has been oserved in e^+ ring
- Instability sensitive to orbit in wiggler and bending magnets
- Main change for the 2003 was wiggler field modification

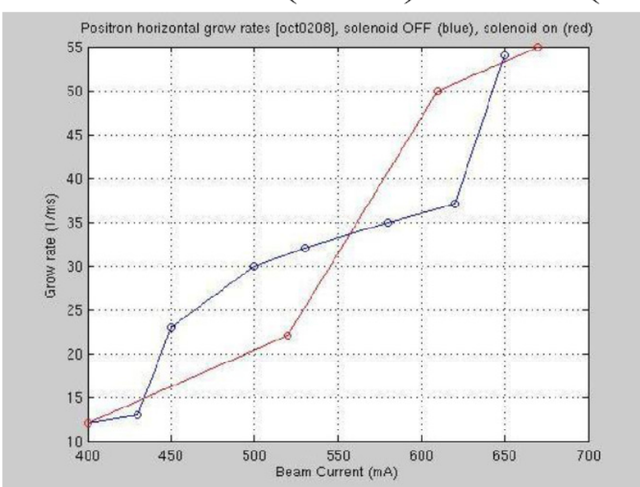
Characterization of the Horizontal Instability





Grow-damp measurements

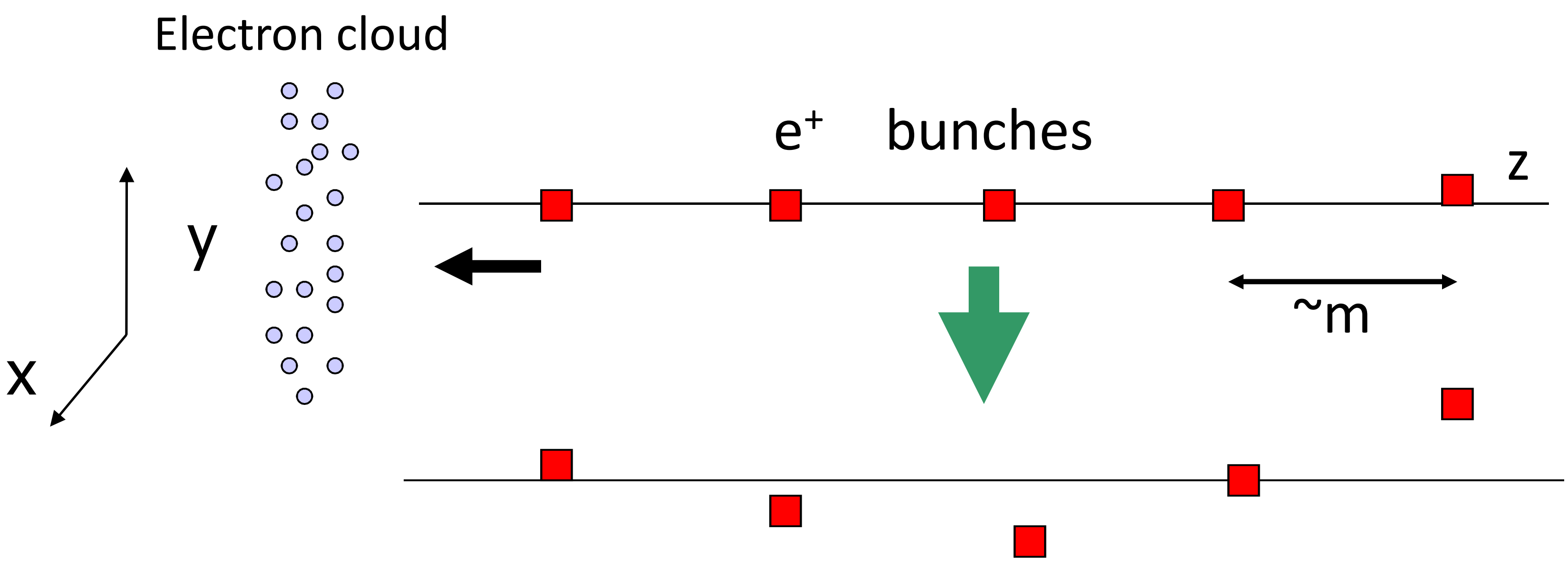
solenoids off (blue) & on (red)



- Solenoids installed in free field regions strongly reduce pressure but have poor effect on the instability
- Most unstable mode -1

PEI-M Tracking simulation

K.Ohmi, PRE55,7550 (1997),K.Ohmi, PAC97, pp1667.



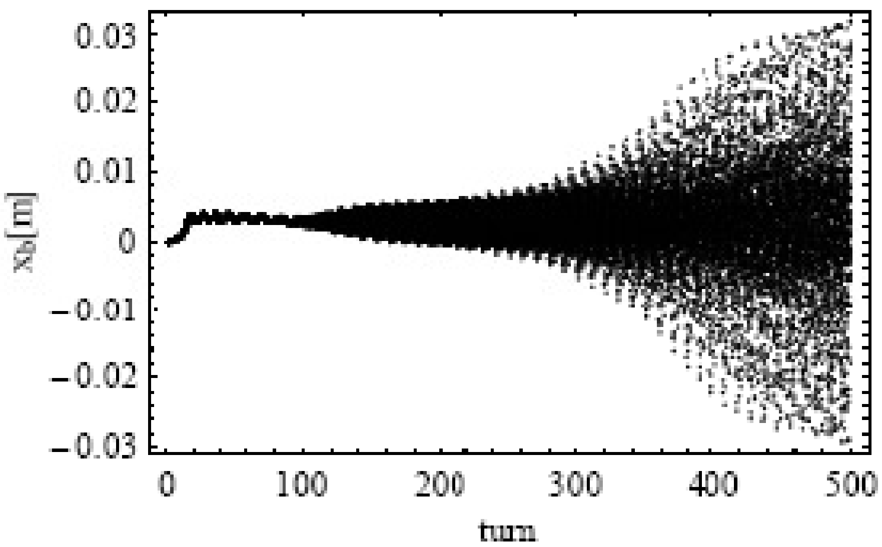
•Solve both equations of beam and electrons simultaneously, giving the transverse amplitude of each bunch as a function of time.

•Fourier transformation of the amplitudes gives a spectrum of the unstable mode, identified by peaks of the betatron sidebands.

Input parameters for DAFNE simulations

Bunch population	N_b	2.1; (4.2 x10^{10})
Number of bunches	n_b	120; (60)
Missing bunches	N_{gap}	0
Bunch spacing	L_{sep}[m]	0.8;(1.6)
Bunch length	σ_z [mm]	18
Bunch horizontal size	σ_x [mm]	1.4
Bunch vertical size	σ_y [mm]	0.05
Chamber Radius	R [mm]	40
Hor./vert. beta function	β_x[m]/β_y[m]	4.1/1.1
Hor./vert. betatron tune	ν_x/ν_y	5.1/5.2
Primary electron rate	$d\lambda/ds$	0.0088
Photon Reflectivity	R	100% (uniform)
Max. Secondary Emission Yeld	Δ_{max}	1.9
Energy at Max. SEY	E_m [eV]	250
Vert. magnetic field	B_z [T]	1.7

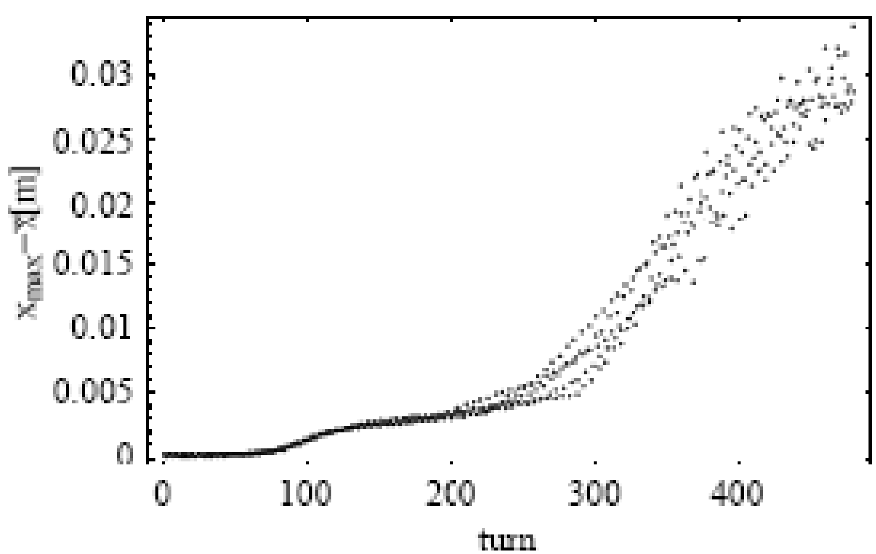
Mode spectrum and growth rate

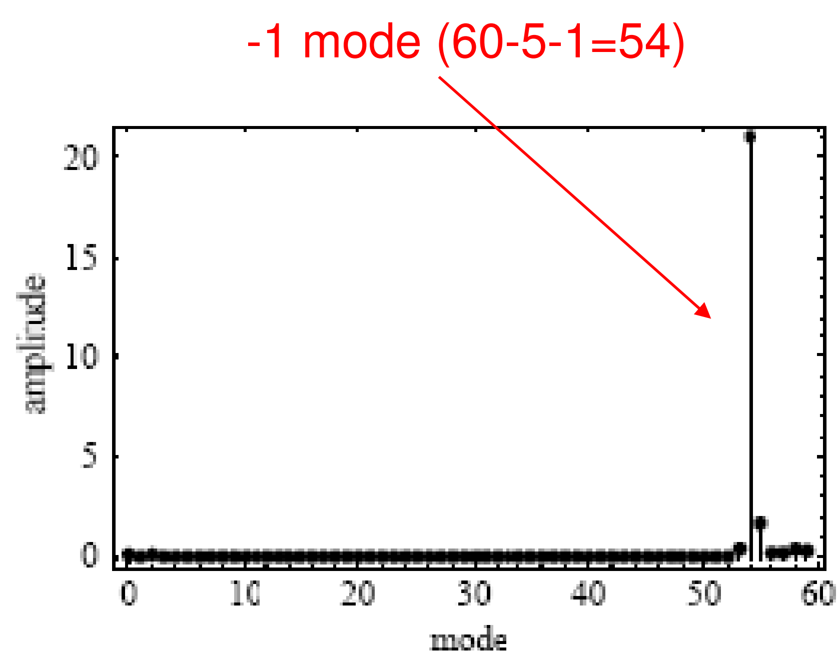


60 equispaced bunches

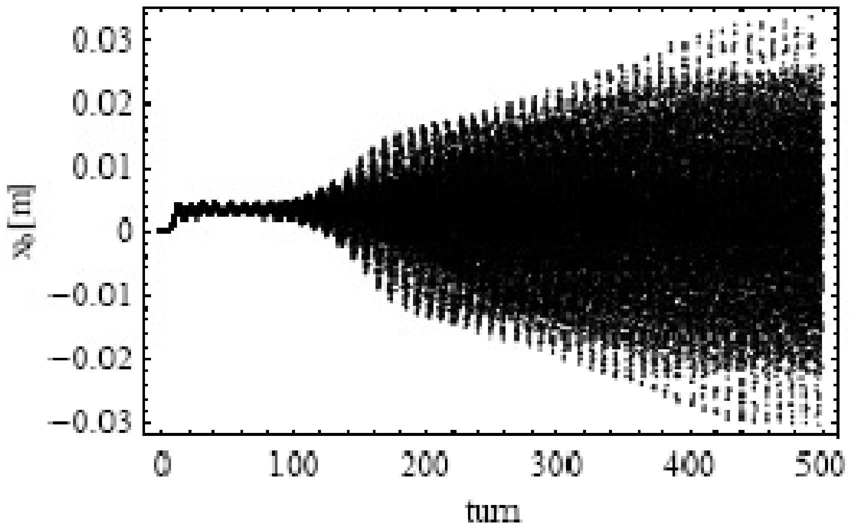
Beam current 1.2 A

Growth time ~ 100 turn

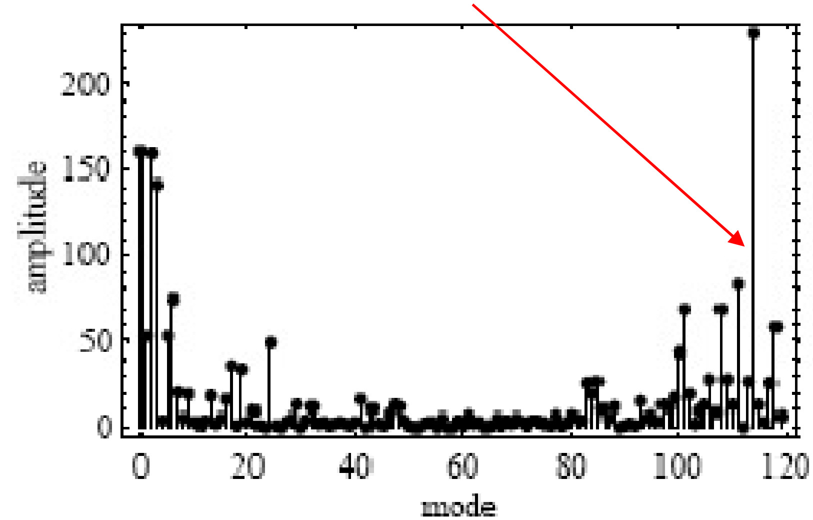


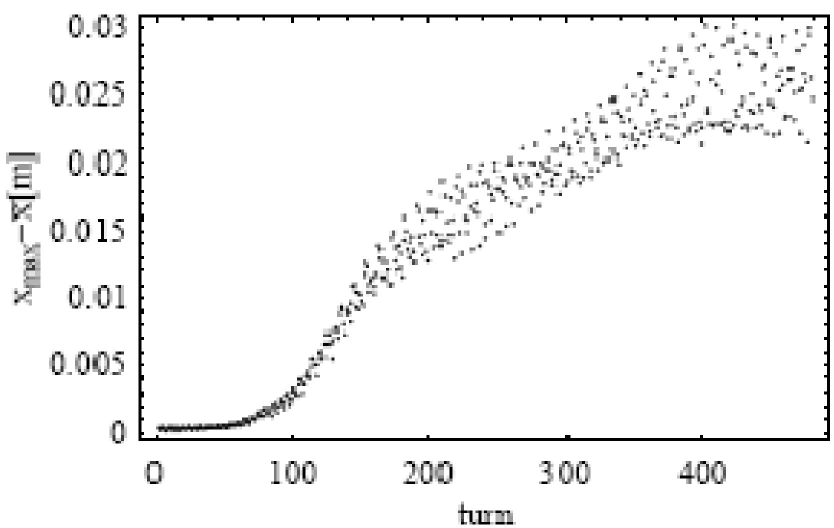


Mode spectrum and growth rate



-1 mode (120-5-1=114)





Measurment		Simulation	
I[A]/nb	τ/T_0	I[A]/nb	τ/T_0
1/105	**73**	**1.2/120**	**100**
0.75/105	56	900/120	95
0.5/105	100	600/120	130

Simulation of Single-bunch Instability

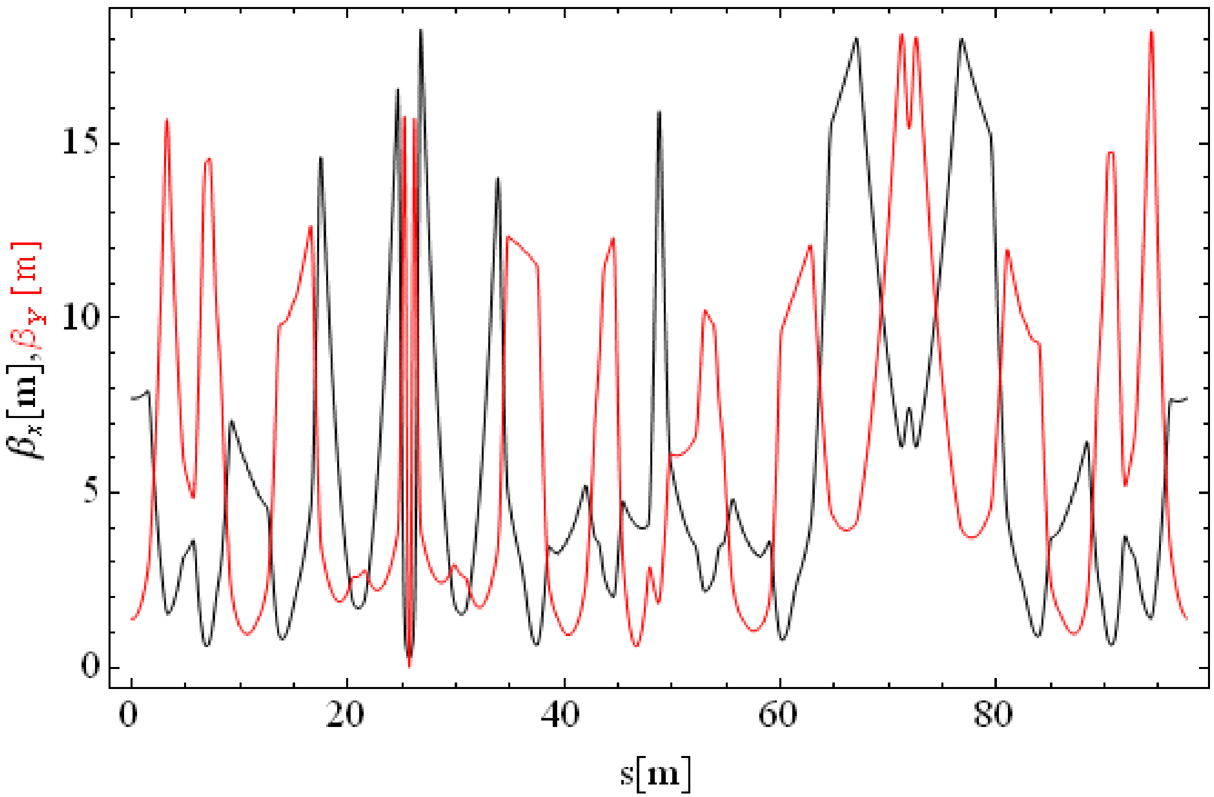
•Simulations were performed using CMAD (M.Pivi):

- –Tracking the beam (x, x', y, y', z, δ) in a MAD lattice by 1st order and 2nd (2nd order switch on/off) transport maps
- –MAD8 or X "sectormap" and "optics" files as input
- –Apply beam-cloud interaction point (IP) at each ring element
- –Parallel bunch-slices based decomposition to achieve perfect load balance
- –Beam and cloud represented by macroparticles
- –Particle in cell PIC code 9-point charge deposition scheme
- –Define at input a cloud density level [0<r<1] for each magnetic element type

Input parameters for **CMAD**

Beam energy E[GeV]	0.51
circumference L[m]	97.588
bunch population N_b	2.1×10^{10}
bunch length σ_z [mm]	12
horizontal emittance ε_x[um]	0.56
vertical emittance ε_y [um]	0.035
hor./vert. betatron tune Q_x/Q_y	5.1/5.2
synchrotron tune Q_z	0.012
hor./vert. av. beta function	6/5
momentum compaction α	0.019

Tracking through the DAFNE ring optics

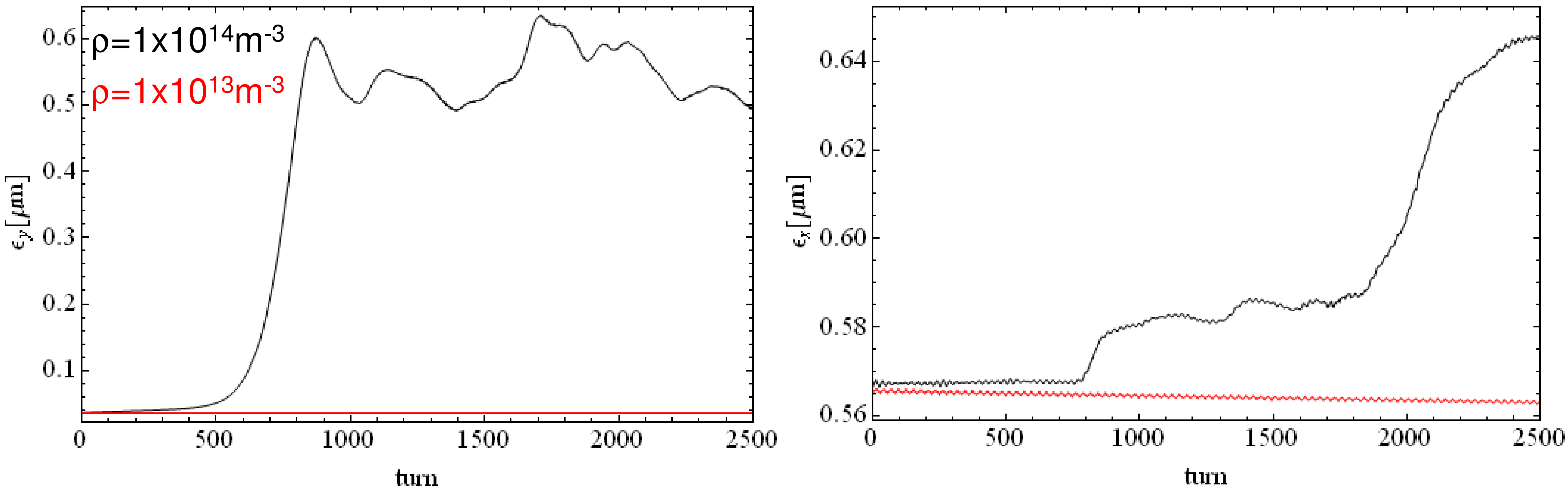


DAFNE MADX model matches quite well beam measurements (C.Milardi)

•Tracking the beam (x,x’,y,y’,z,d) in the DAFNE MADX lattice by 2nd order transport maps.

•Applying beam-cloud kicks in dipoles and wigglers only: assume e-cloud in field free Drift regions is mitigated by solenoids.

E-cloud induced emittance growth in DAFNE: solenoids on

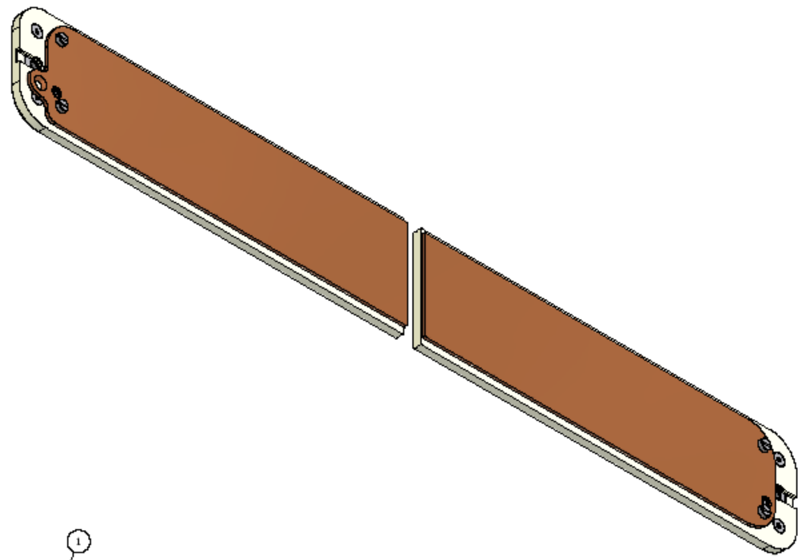


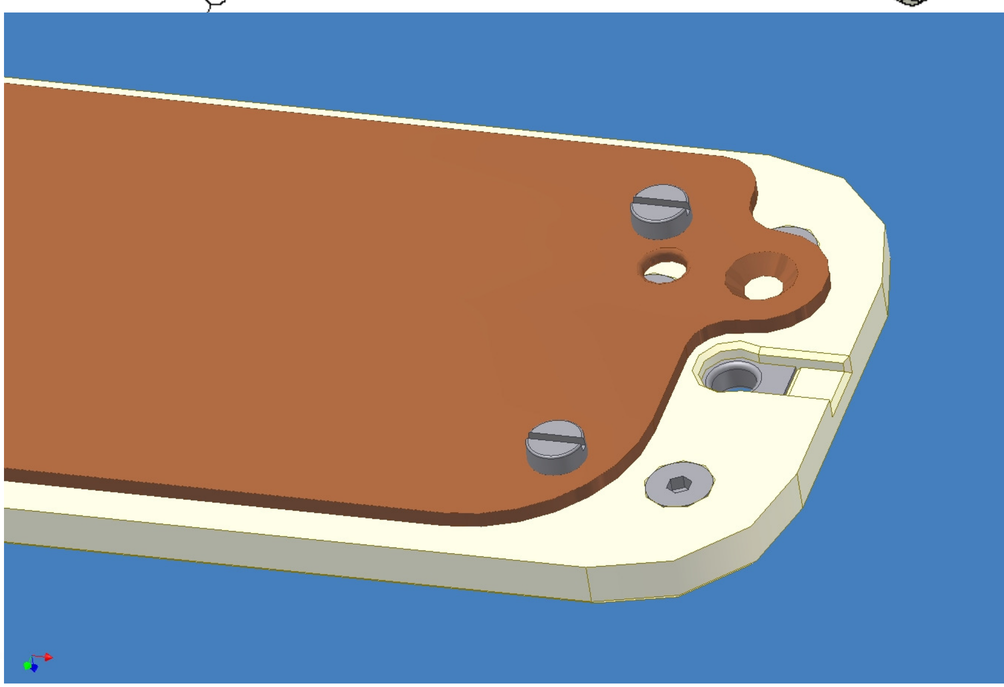
•Beam is tracked using a DAFNE MADX lattice model that matches quite well beam measurements (C.Milardi).

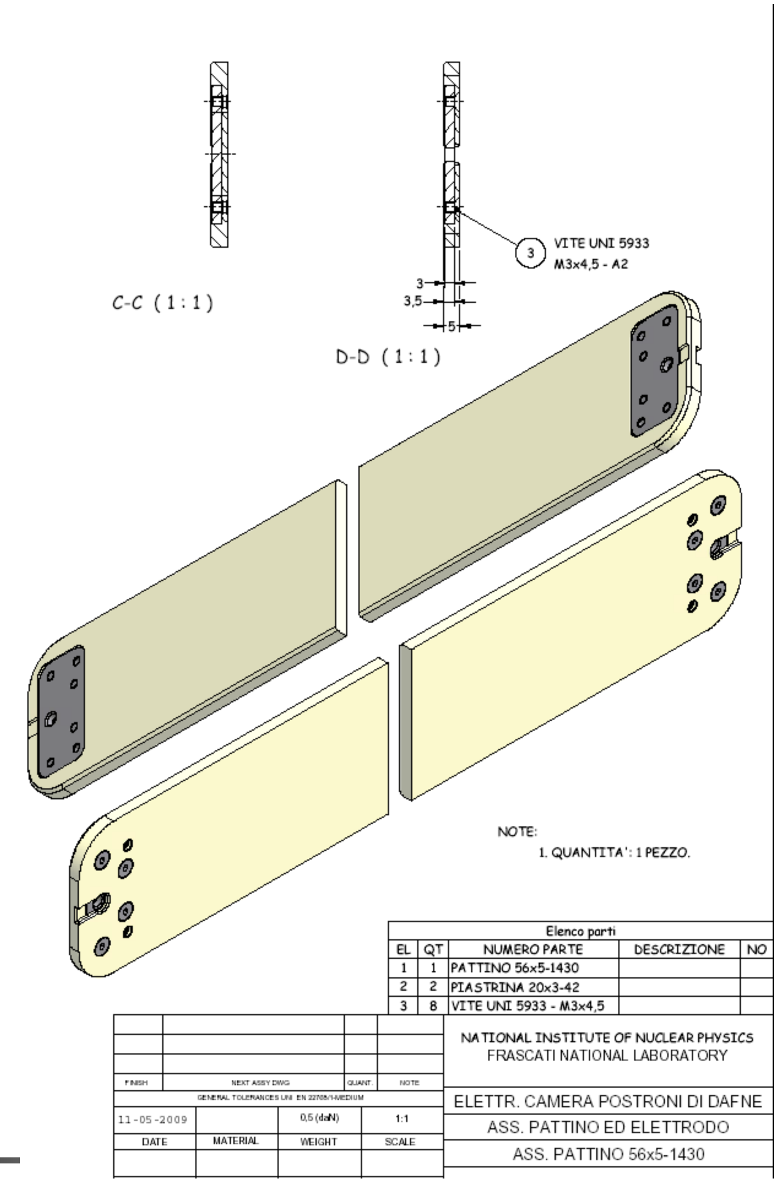
•Applying beam-cloud kicks in dipoles and wigglers only: assume e-cloud in field free Drift regions is mitigated by solenoids.

• Threshold well above the current estimated (simulated) e-cloud density for DAFNE ($<10^{13}e^-/m^3$)

Clearing Electrodes for DAFNE

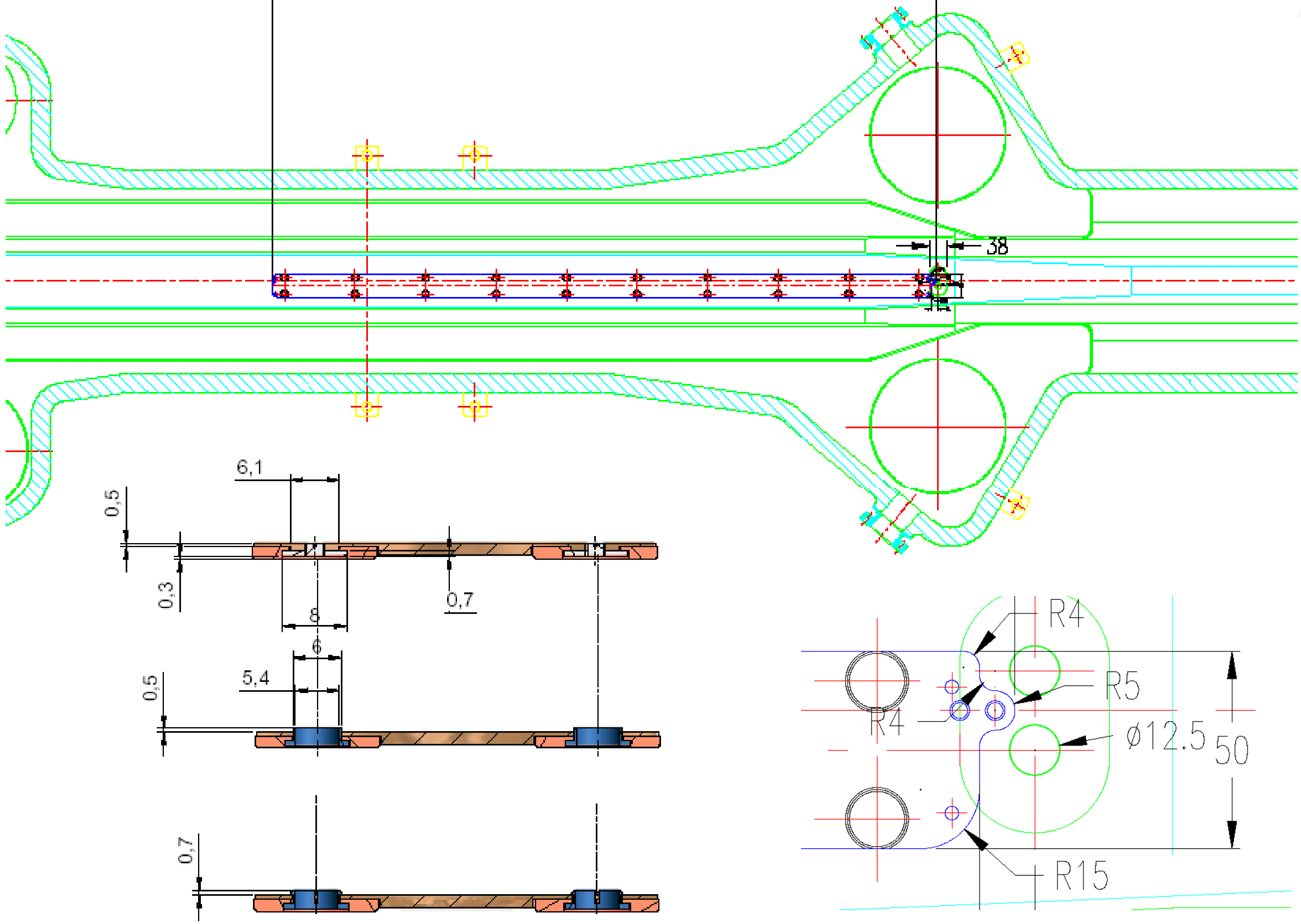






D.Alesini, M.Zobov, A.Battisti, R. Sorchetti, V. Lollo (LNF)

Clearing Electrodes Installation: Wigglers



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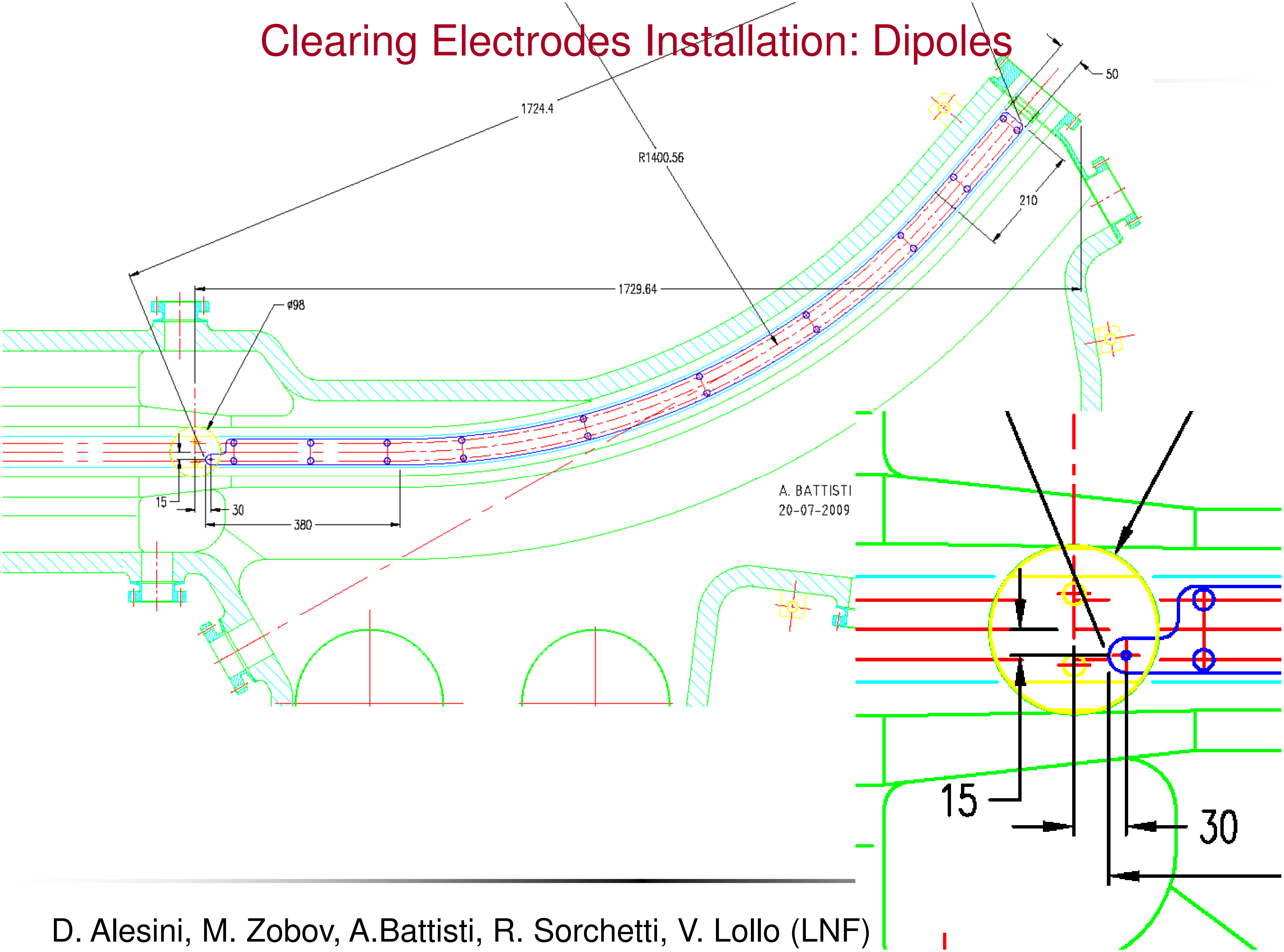
Clearing Electrodes Installation: Dipoles



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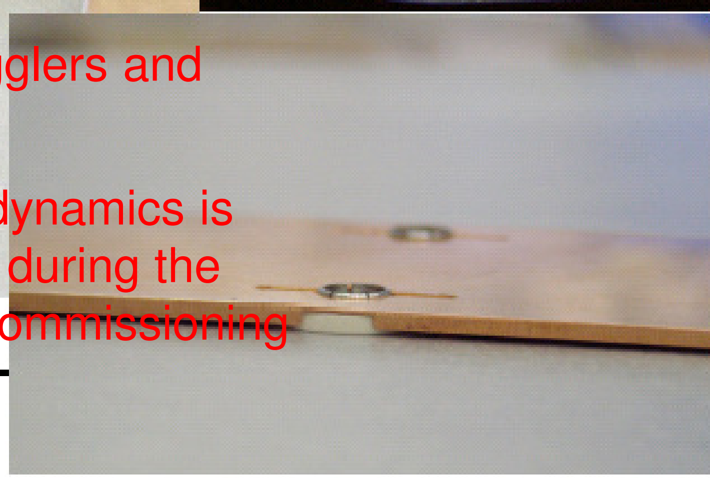
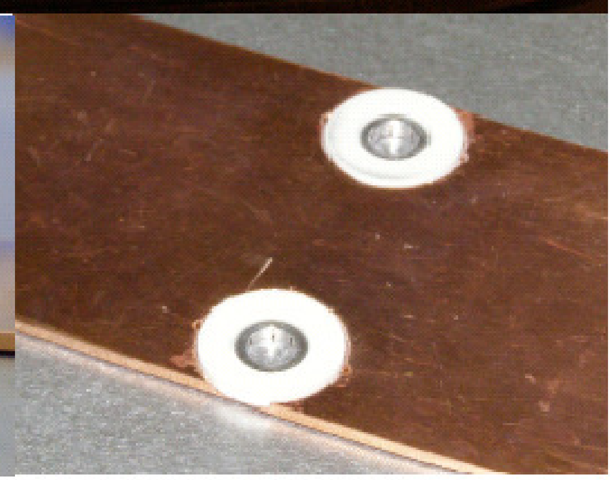
Clearing electrodes



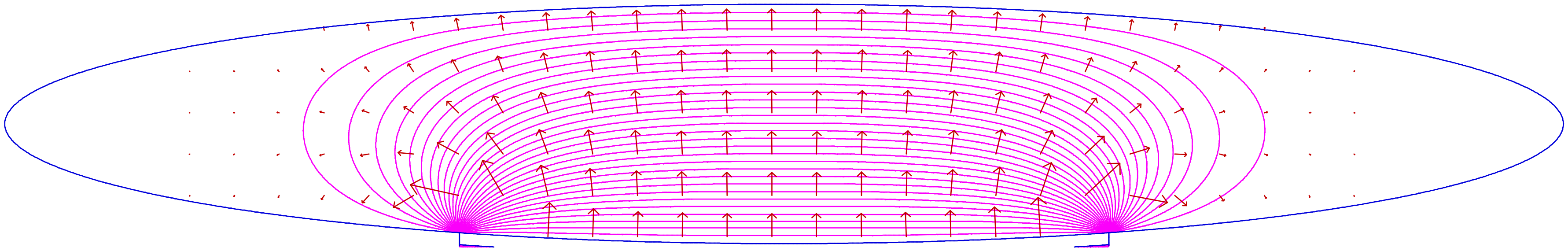


- Installed in all wigglers and bending magnets
- effects on beam dynamics is going to be tested during the ongoing DAFNE commissioning

Summary

- Coupled-bunch instability has been simulated using PEI-M for the DAFNE parameters. Results are in qualitative agreement with grow-damp measurements.
- Single-bunch instability has been simulated with CMAD tracking the beam through a realistic ring optics model. The obtained instability threshold is well above the current estimated e-cloud density for DAFNE.
- Clearing electrodes for DAFNE have been designed, installed, and are going to be tested during the ongoing commissioning of the machine.
- More work is needed to simulate a more realistic model of beam chambers in the coupled bunch instability code (taking into account also the effect of clearing electrodes).

Electrodes Field and e-Cloud build-up



Simulation of electron cloud build-up and suppression with clearing electrodes.

Bunch population	2.1×10^{10}
Bunch spacing L[m]	0.8
Bunch length σ_z [mm]	18
Primary electron rate	0.0088
Photon Reflectivity	100%
Max. SEY	1.9