



Clearing electrodes at DAFNE

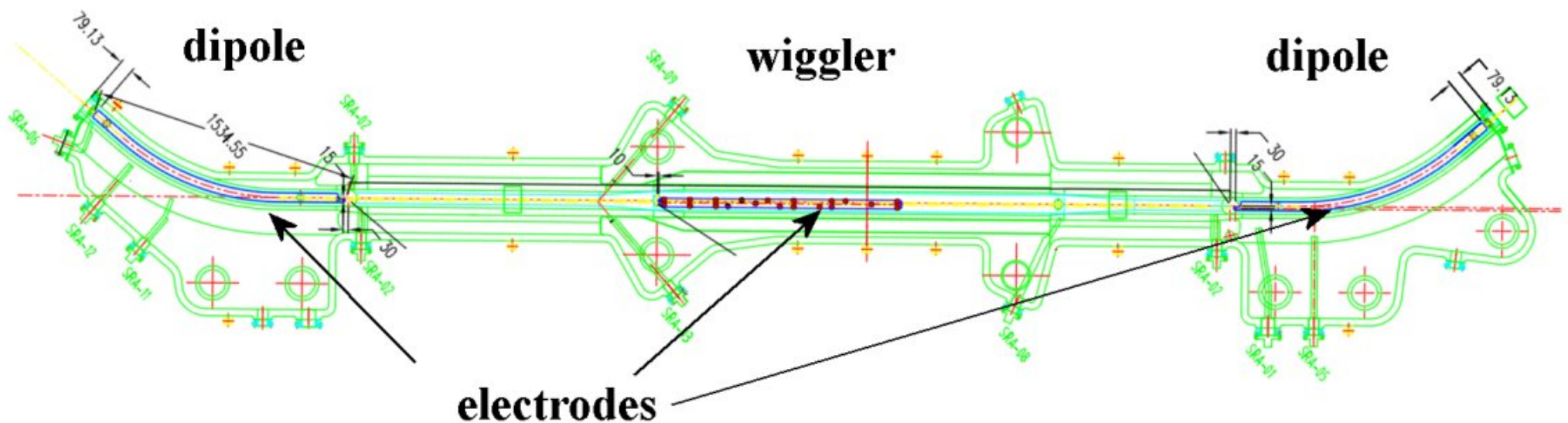
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INFN-LNF, Frascati

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Metallic clearing electrodes have been designed to absorb the photo-electrons in the DAΦNE positron ring. They have been inserted in the wiggler and dipole vacuum chambers and have been connected to external voltage generators.



A short description

The electrodes have been made in copper and have a distance of 0.5 mm from the vacuum pipe. This small distance has been chosen to reduce the beam coupling impedance of the devices. Special ceramic supports sustain the strips.

Analytical calculations and electromagnetic simulations have been done to estimate the power released from the beam to the electrodes. We expect a maximum temperature increase of the order of 100°C with a 2A beam for the wiggler electrodes. This temperature increase has been considered acceptable since the electrodes have been heated up to this level without damage and also because it is in the range of operation of all the components (SHAPAL and feed-throughs).

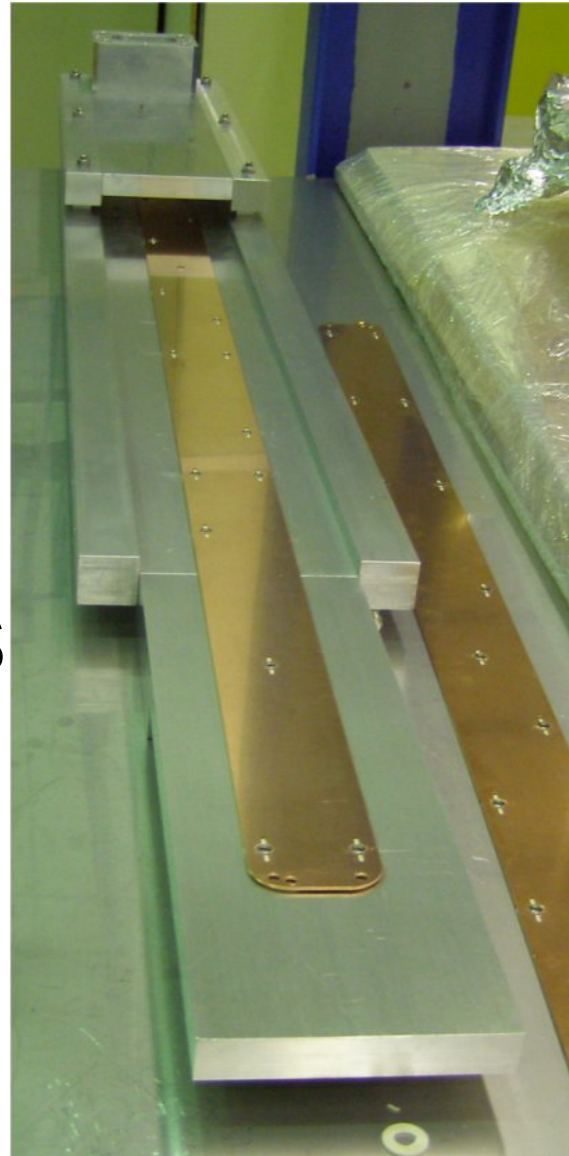
The electrodes are connected to external generators and have been tested (with the beam) applying dc voltages of up to 140 V.

RF measurements have been done to precisely measure the resonant frequencies of the electrodes modes.

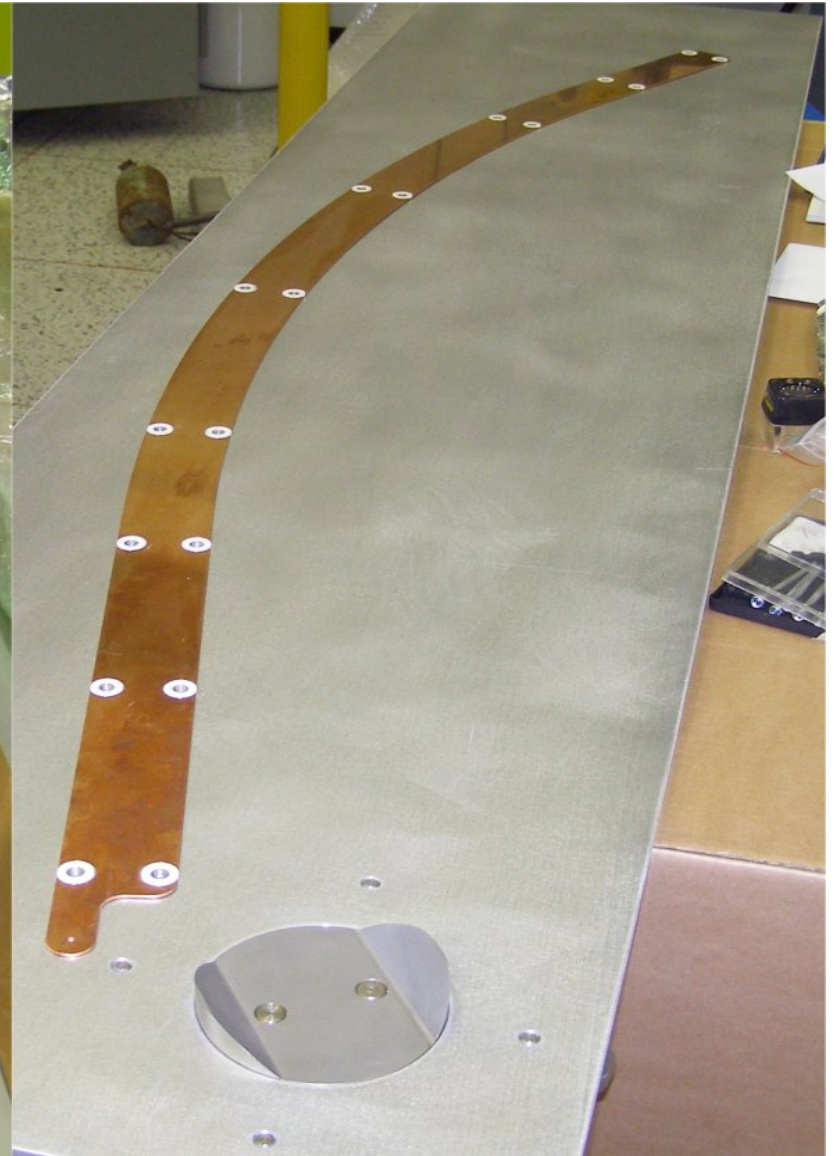
Electrodes before installation

The distance of the electrode from the beam axis is 8 mm in the wigglers and 25 mm in the dipoles.

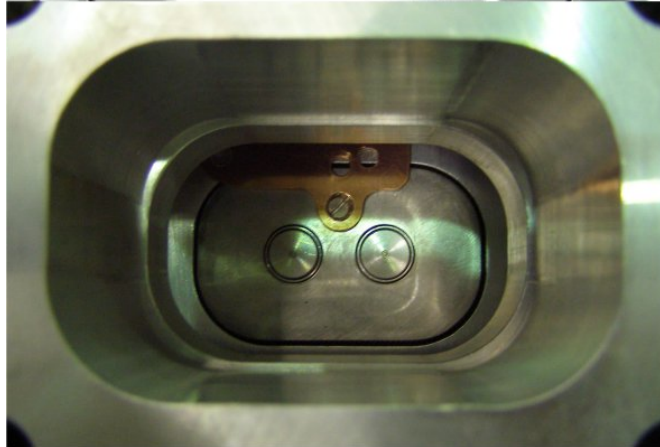
In wigglers



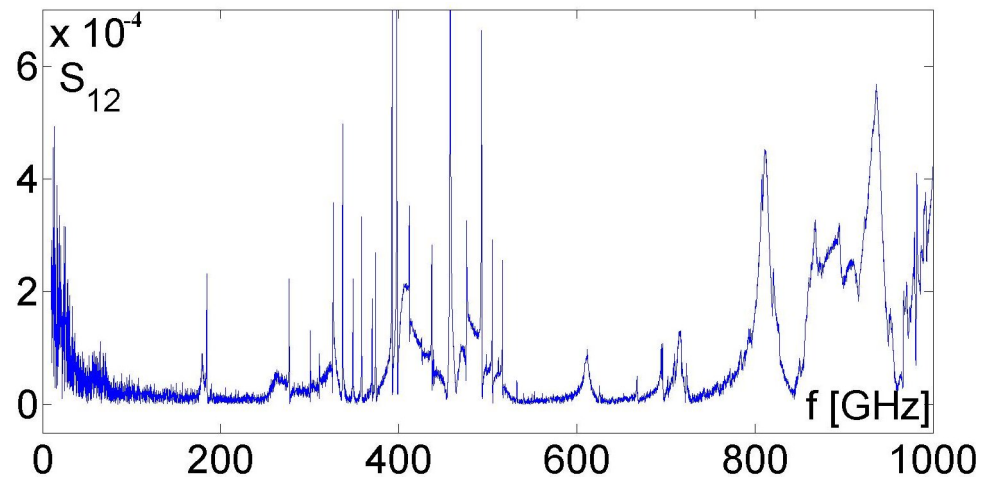
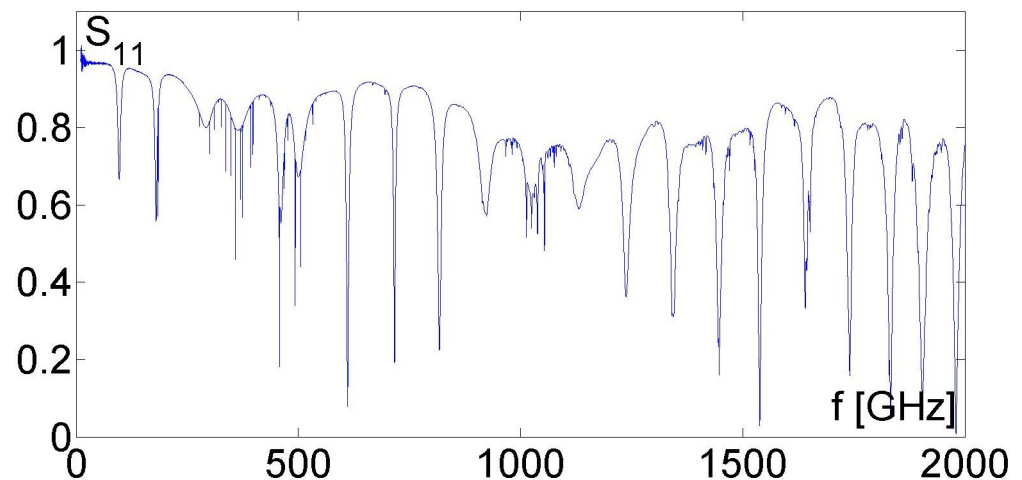
In dipoles



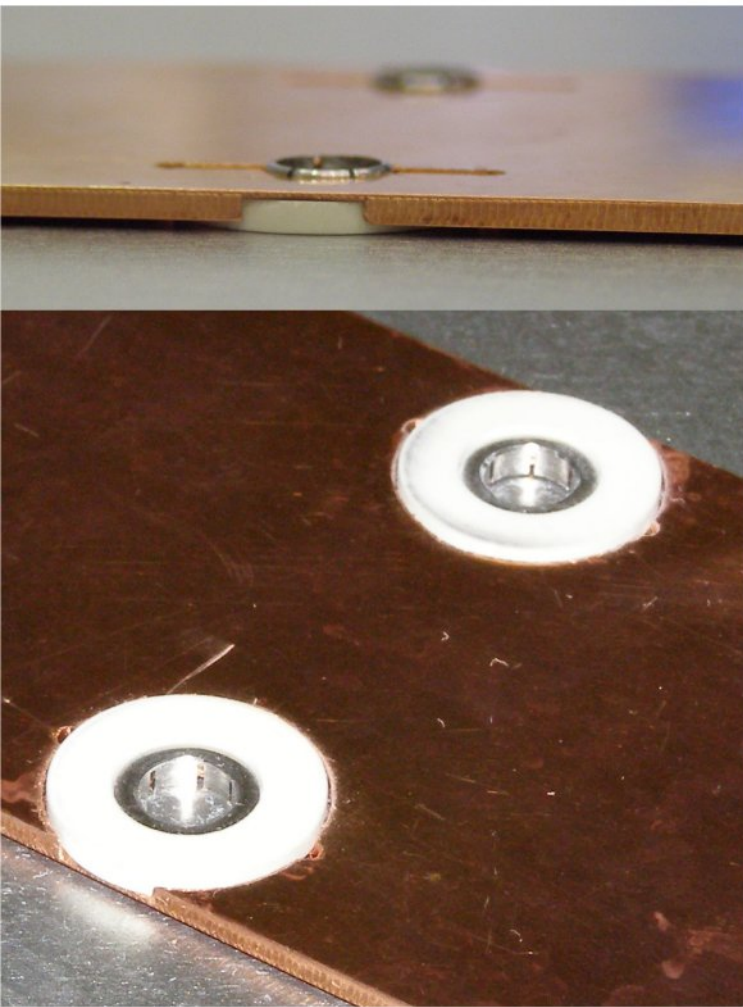
RF measurements with a network analyzer have been performed before and after the electrode installation. We have done two types of measurements: reflection coefficient at the feedthrough port and transmission coefficient between one BPM near to the strip and the feedthrough. ***In both cases it was possible to measure the resonant frequencies of the strip modes.***



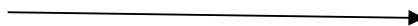
Detail of the electrode output connection



The ***dipole electrodes*** have a length of 1.4 or 1.6 m depending on the considered arc, while the ***wiggler ones are 1.4 m long***. They have a width of 50 mm, thickness of 1.5 mm and their distance from the chamber is about 0.5 mm. This distance is guaranteed by special ceramic supports made in SHAPAL and distributed along the electrodes.



Installed
electrodes



The electrode impedance consists of two contributions: a resistive wall impedance due to a finite conductivity of the electrode and a strip-line impedance since the stripline is created between the electrode and the vacuum chamber wall.

Resistive wall

$$\frac{dP}{dz} = \frac{(eN)^2 n_b c}{2\pi R} \frac{dk_l}{dz} = 5.58 \frac{W}{m}$$

Considering 120 circulating bunches with 20 mA we each electrode should dissipate **7.8 W**, or 112 W/m² for the 50 mm wide electrode. Such power density would result in electrode heating under vacuum up to 50^o-55^o C.

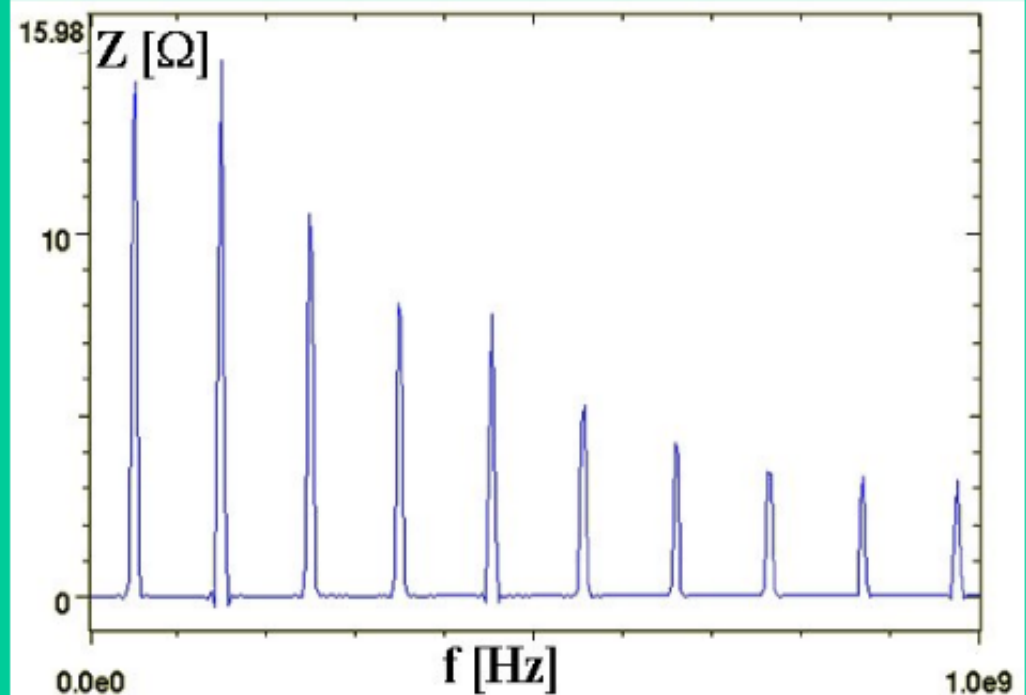
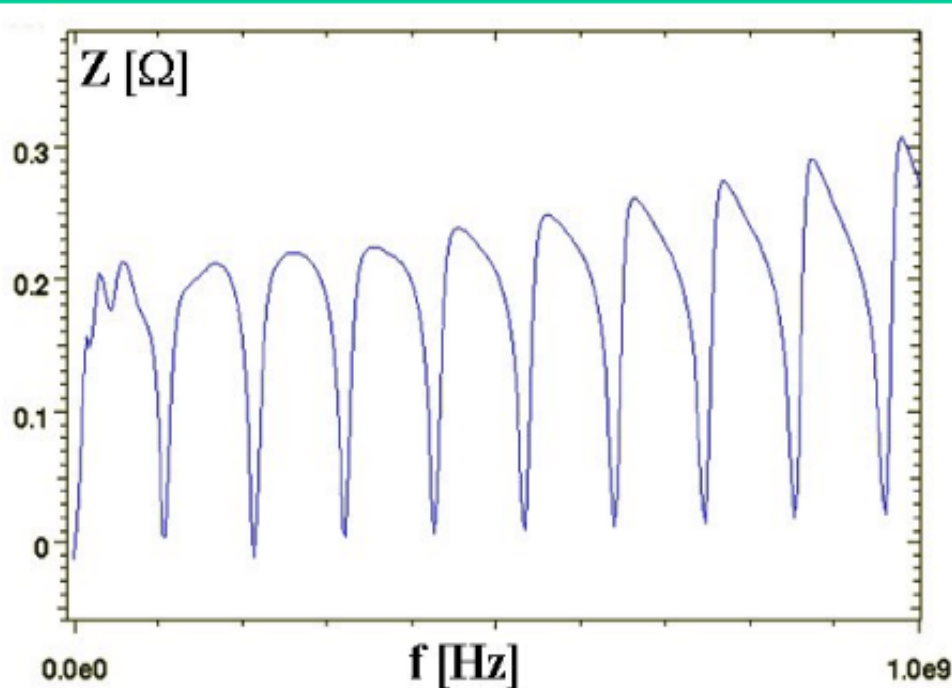
Strip-line Impedance

We have simulated **two extreme cases**: the perfectly matched electrode and the short-circuited one.

Loss factors: 1.87×10^9 V/C (shorted) and -1.56×10^9 V/C (matched).

In both cases the lost power is not negligible and can result in excessive heating of the electrode. In order to prevent this possible damage, electrode supports are made of thermo-conducting dielectric material the SHAPAL.

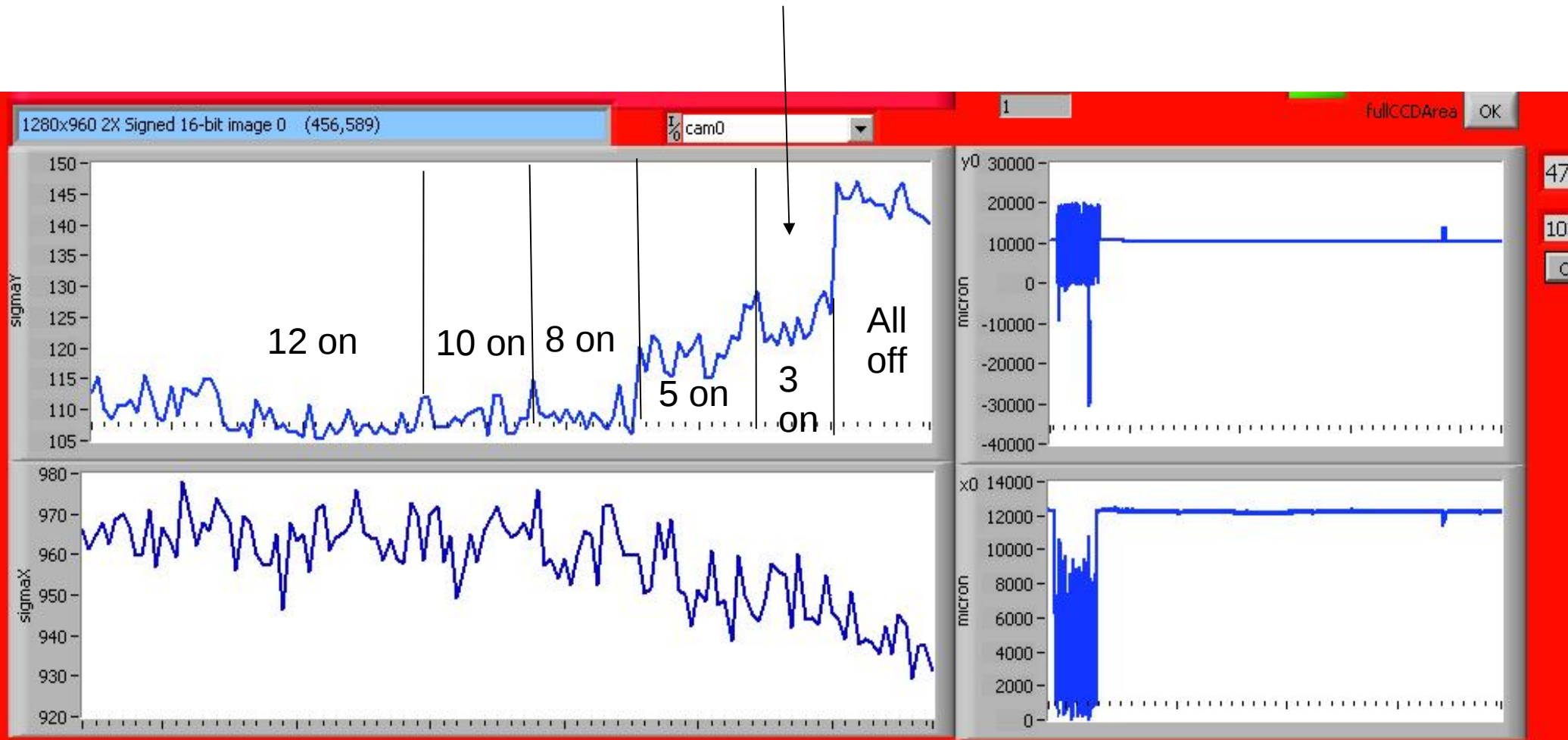
The estimated low frequency broad-band impedance of the electrode Z/n is about 0.005Ω that should be a small contribution to the total ring impedance.



Looking at the effect on the real positron beam

Test have been carried on making
measurements by synchrotron light monitor,
spectrum analyzer, and bunch-by-bunch
horizontal and vertical feedback

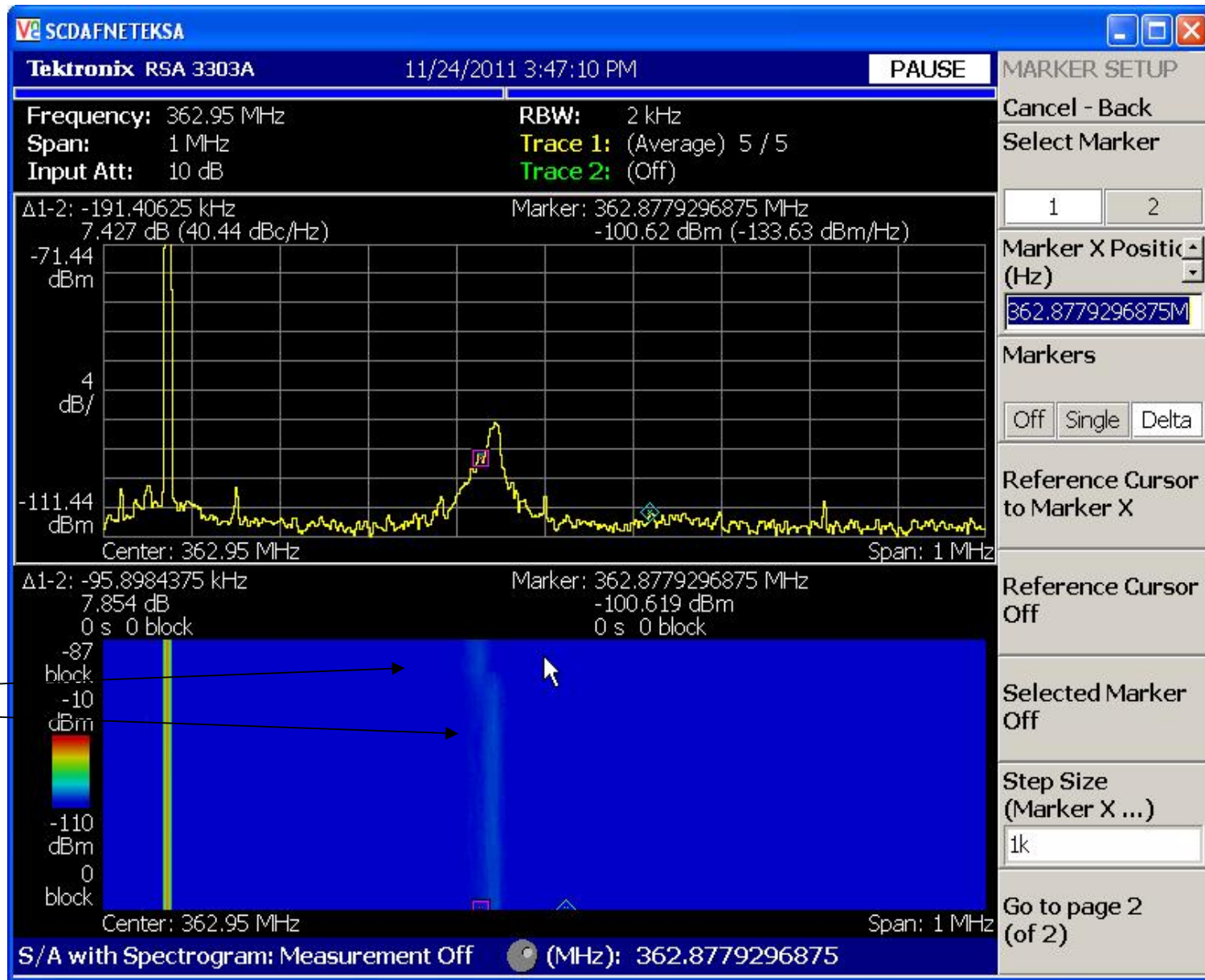
Turning off the electrodes, a vertical enlargement is evident...



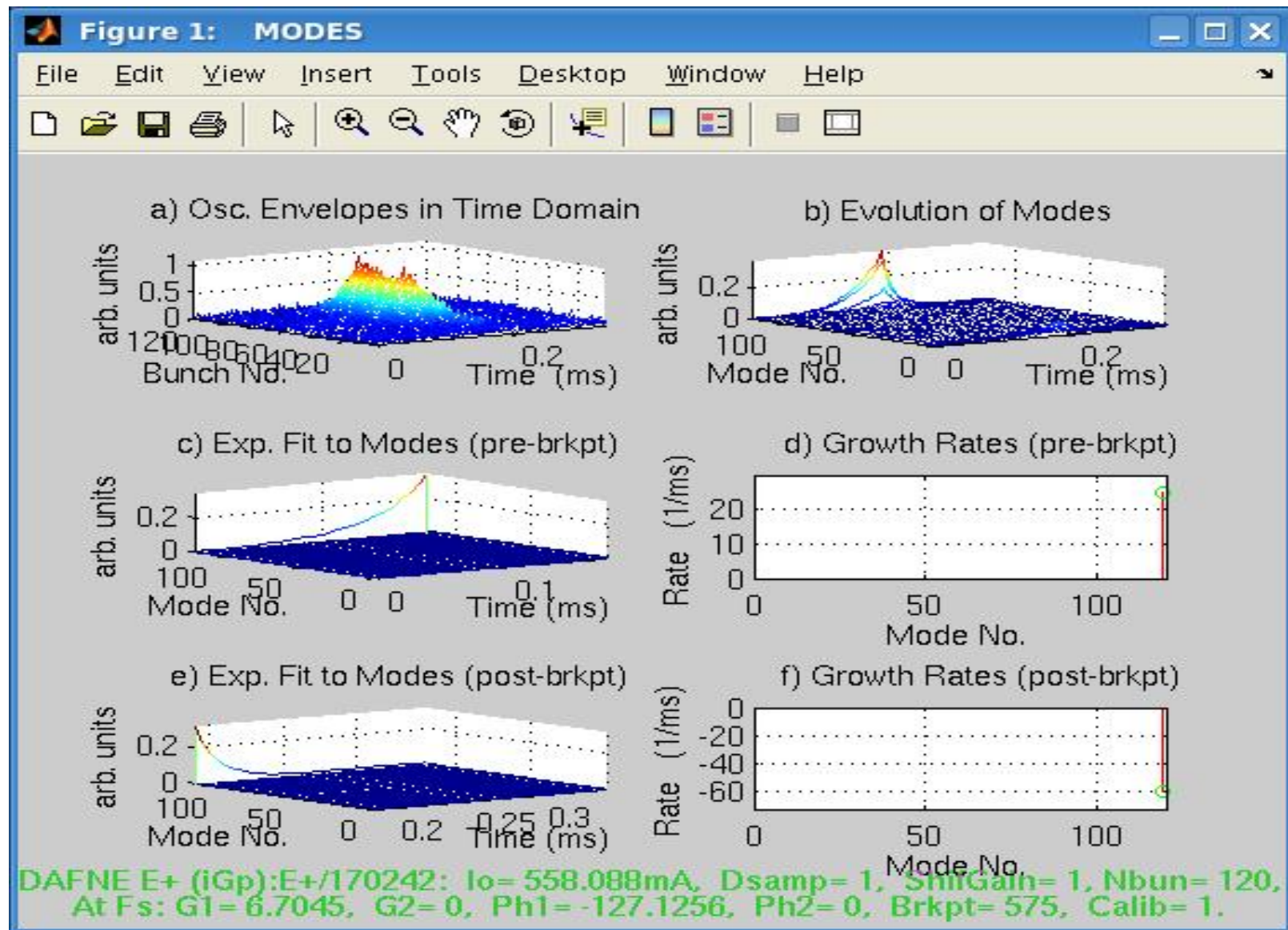
E+ horizontal tune shift goes up when electrodes are turned off

550mA
e+
current

~20kHz



Growth rate measurements can be easily done by using bunch-by-bunch feedback



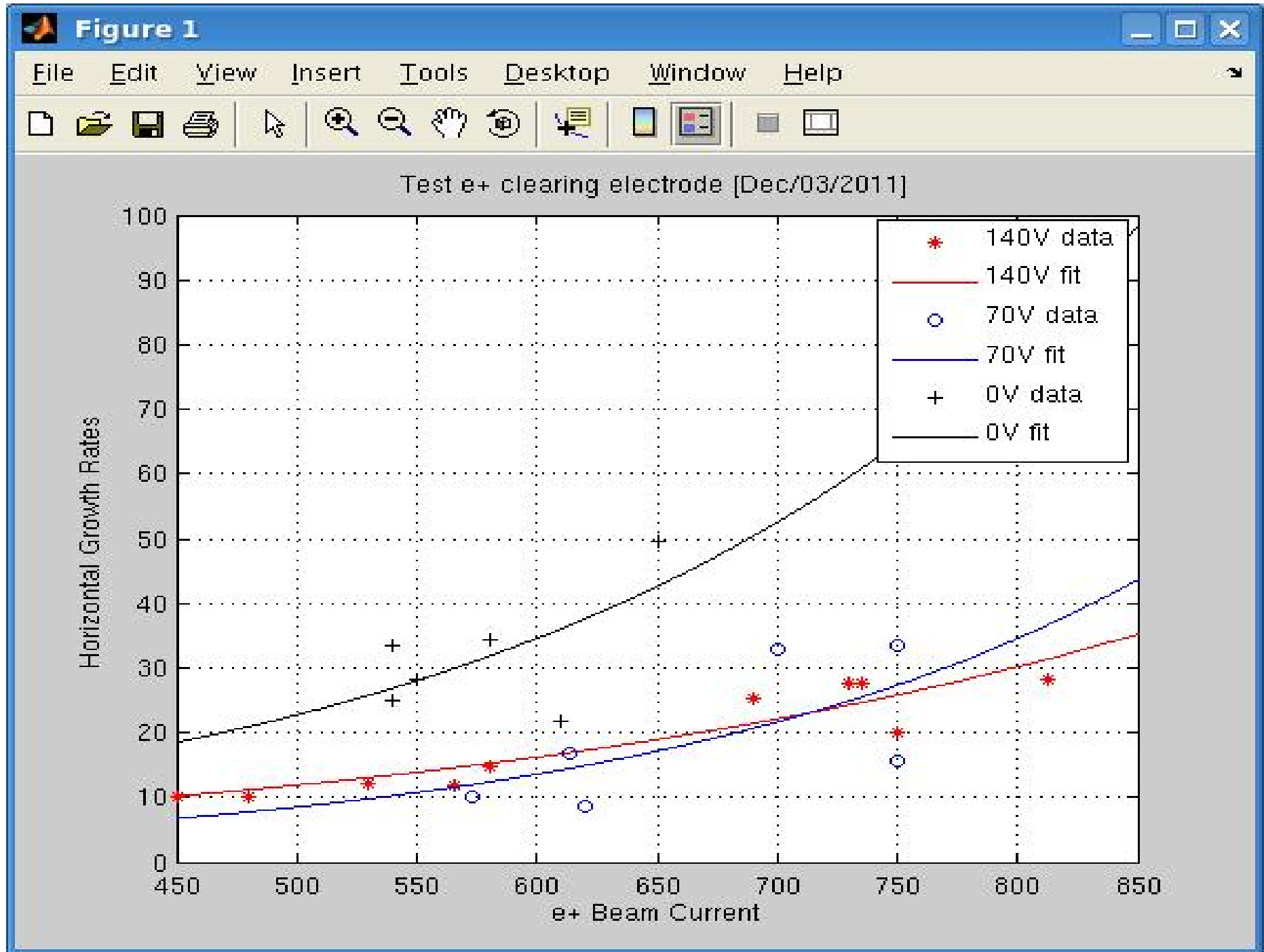
Horizontal growth rate measurements

```
readme.txt (~/.data/dec0311/E+) - gedit
File Edit View Search Tools Documents Help
New Open Save Print... Undo Redo Cut Copy Paste Find Replace

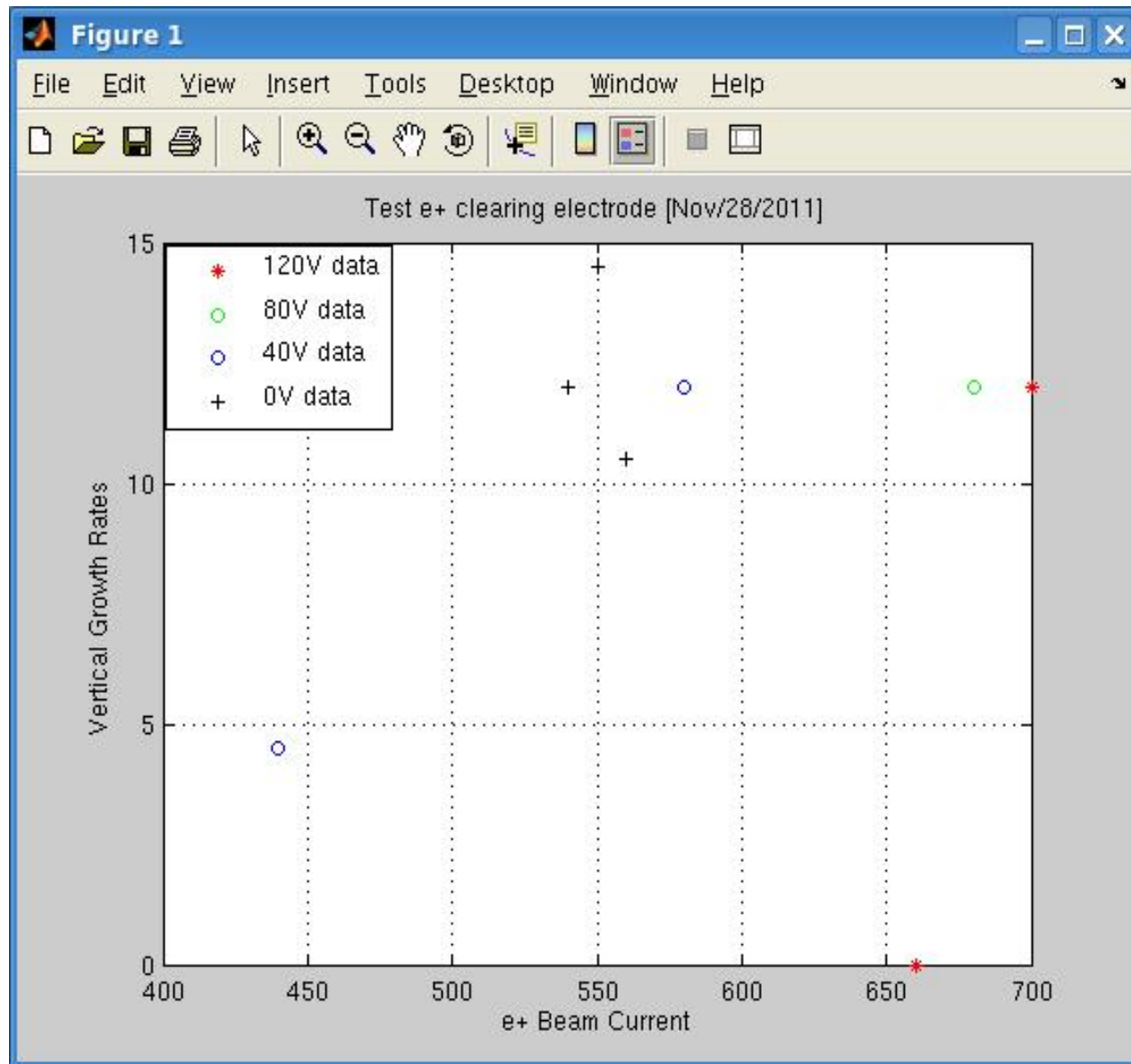
readme.txt x
1 13/12/2011
2 e+ clearing electrode
3
4 ===== tensione elettrodi: 140V
5 1 104737 HorPos 690mA 100 bunch grow 25.4ms-1; mode=-1; damp -170ms-1
6 2 105001 HorPos 480mA 100 bunch grow 10.0ms-1; mode=-1; damp -100ms-1
7 3 105039 HorPos 450mA 100 bunch grow 10.0ms-1; mode=-1; damp -100ms-1
8 4 105337 HorPos 750mA 100 bunch grow 20.0ms-1; mode=-1; damp -200ms-1
9 5 105543 HorPos 566mA 100 bunch grow 11.8ms-1; mode=-1; damp -71ms-1
10 6 105833 HorPos 813mA 100 bunch grow 28.3ms-1; mode=-1; damp -87ms-1
11 7 105916 HorPos 735mA 100 bunch grow 27.7ms-1; mode=-2; damp -282ms-1 ***Dafne WR***
12 *** oltre 850mA vuoto va a 10-8
13 8 105916 HorPos 730mA 100 bunch grow 27.7ms-1; mode=-2; damp -282ms-1 ***Dafne WR***
14 9 105916 HorPos 730mA 100 bunch grow 27.6ms-1; mode=-2; damp -282ms-1 ***Dafne WR***
15 10 111756 HorPos 580mA 100 bunch grow 14.8ms-1; mode=-1; damp -54.8ms-1
16 11 111842 HorPos 530mA 100 bunch grow 12.1ms-1; mode=-1; damp -87.2ms-1
17
18 ===== tensione elettrodi 70V
19 12 112410 HorPos 750mA 100 bunch grow 15.5ms-1; mode=-1; damp -160ms-1
20 13 112649 HorPos 614mA 100 bunch grow 16.7ms-1; mode=0 e -1; damp -30ms-1
21 14 112741 HorPos 573mA 100 bunch grow 10.0ms-1; mode=0 e -1; damp -68ms-1
22 15 113148 HorPos 750mA 100 bunch grow 33.5ms-1; mode=0 e -1; damp -100ms-1
23 16 113227 HorPos 700mA 100 bunch grow 32.8ms-1; mode=0 e -1; damp -144ms-1
24 17 113343 HorPos 620mA 100 bunch grow 8.6ms-1; mode=-1; damp -105ms-1
25
26 ===== tensione elettrodi 0 V
27 *** a 800mA muore fascio
28 18 114032 HorPos 540mA 100 bunch grow 33.5ms-1; mode=-1; damp -45.5ms-1 [da 690mA a 540mA perdita corrente]
29 19 114229 HorPos 580mA 100 bunch grow 34.5ms-1; mode=-1; damp -100ms-1
30 20 114823 HorPos 650mA 100 bunch grow 49.5ms-1; mode=-1; damp -160ms-1
31 21 114903 HorPos 610mA 100 bunch grow 21.8ms-1; mode=-1; damp -40ms-1
32 si perde fascio a 750mA
33 22 currents log
34 -----

Saving file '/home/iGp/data/dec0311/E+/readme.txt'... Ln 2, Col 22 INS
```

Horizontal growth rate measurements



Vertical growth rate measurements are less interesting



Conclusion

- Metallic clearing electrodes have been inserted in the wiggler and dipole vacuum chambers of the DAΦNE positron ring to fight the instability due to the e-cloud.
- Experience with clearing electrodes in the Dafne positron beam is largely positive: vertical dimension, tune shift and growth rates clearly indicates a good behaviour of these devices.
- Electrode placement is complementary to solenoids that are placed in the straight sections
- Engineering work is in progress.