Electron cloud and feedback in DAFNE

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Electron Cloud Mitigation Workshop
ECM'08

CERN
AB Auditorium Meyrin
20-21 November 2008

Acknowledgements

- **DAFNE Team**
  - M.Zobov, P.Raimondi, C.Milardi, D.Alesini, A.Gallo, F.Marcellini, T.Demma, S.Guiducci, M.Biagini, M.Boscolo, C.Vaccarezza, A.Stella, O.Coiro, and many many others…
- **Feedback Design Collaboration**
  - *Two / three different design generations from SLAC, KEK, DAFNE/Frascati, ALS/Berkeley, Bessy,…:*
  - Shyam Prabhakar and DmitryTeytelman, John Fox, MakotoTobiyama, Fabio Marcellini, W.Barry, J.Olsen, Claudio Rivetta, J.Flanagan, Shaukat Khan, and many others…

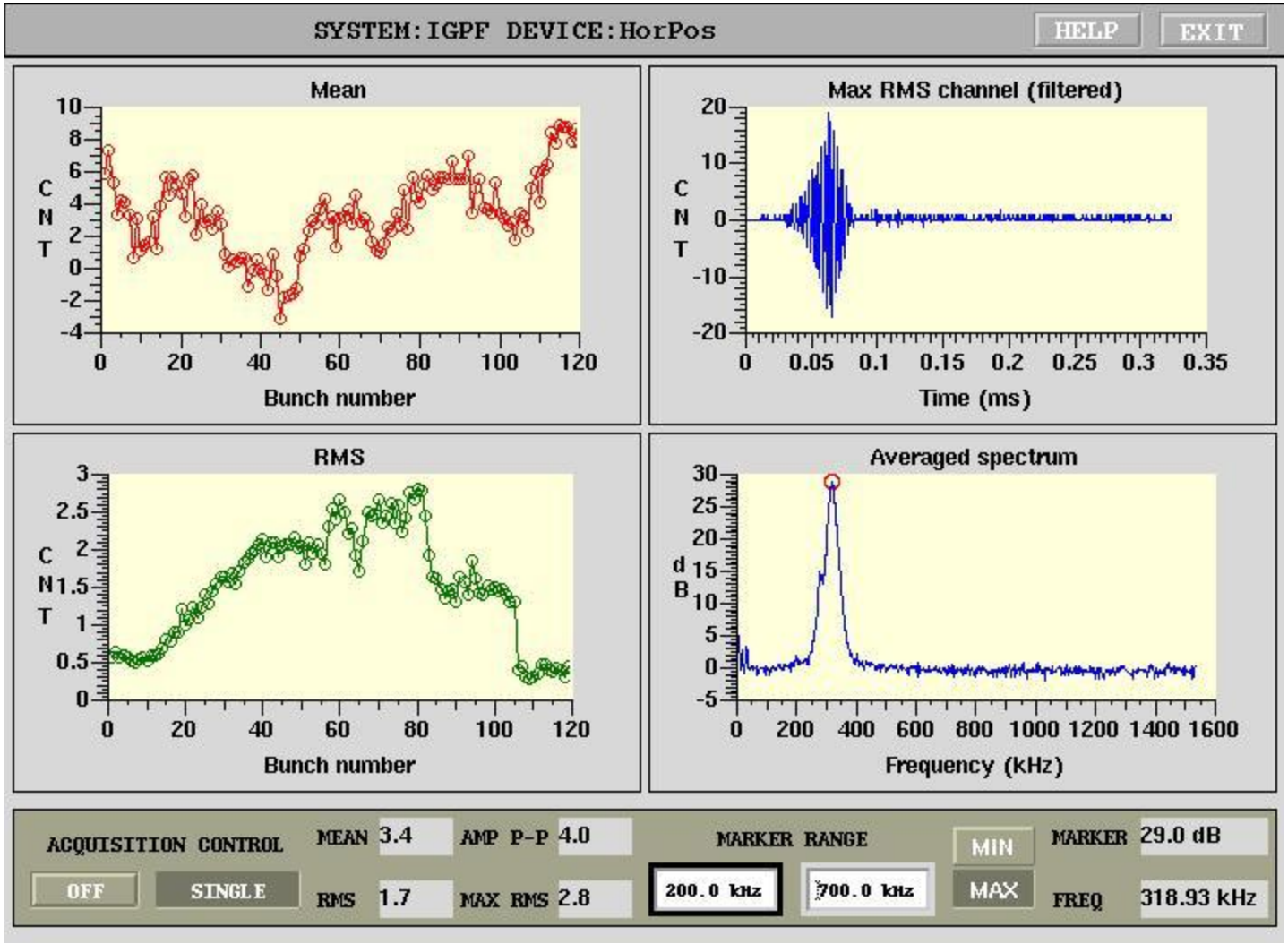
Main Topics

- Introduction
- Asymmetric behavior between e+ and e- maximum current in DAFNE main rings
- Measurements versus different optics parameters
- Solution implemented
- Conclusions

Introduction

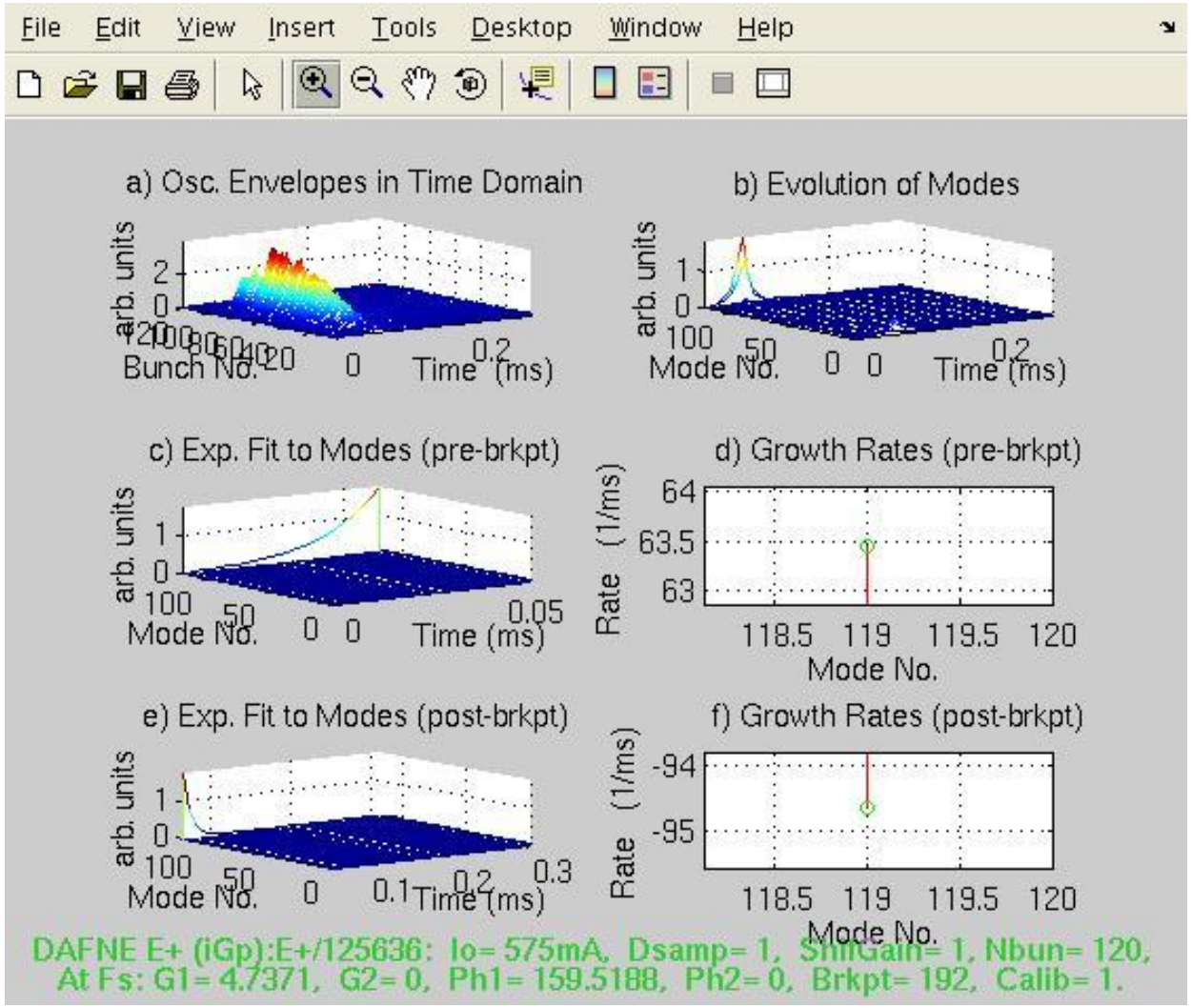
- As well known, DAFNE is a positron - electron collider at low energy (1.02 Gev) working since 1997 at Frascati, near Rome
- DAFNE has a linac, an accumulator ring, two transfer lines and two ~100 m main rings with 1 or 2 interaction point
- The two main rings are perfectly symmetric but the storable maximum beam currents are always been very different
- No evident limit for the e- current ($I^- > 2.4A$)
- Positron current limited a strong horizontal instability to ~1.1A (single beam), or <1.4 A (in collision) in the past years
- During this 2008 run, e+ current limited to less than 800mA. Of course this behavior has requested new investigations

Positron grow-damp record made switching off the horizontal feedback, I=575mA, 105/120 bunch [October 14, 2008]



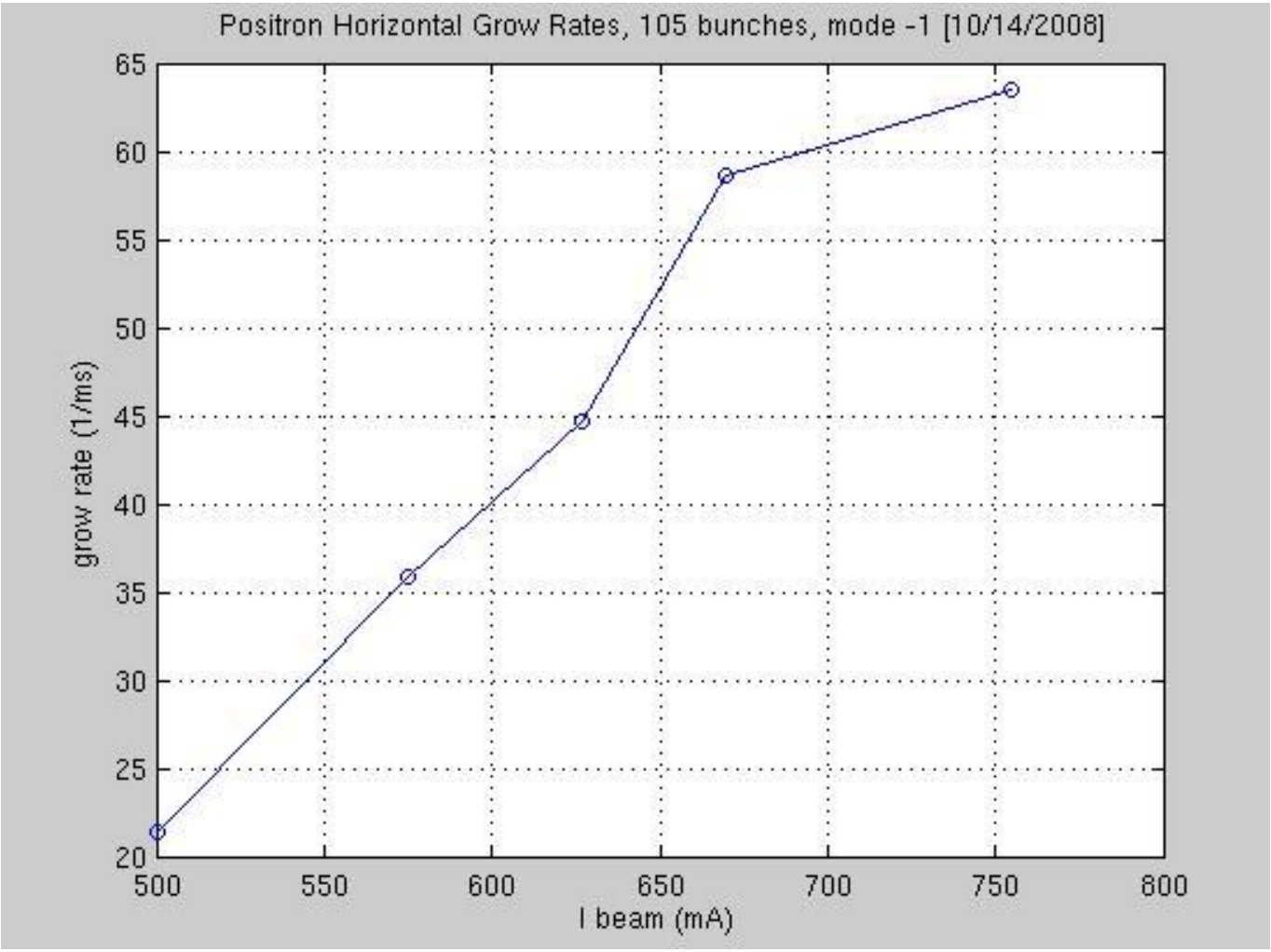
Real time waveform plot by the "iGp" feedback system

Horizontal e+ grow-damp analysis, I=575mA, 105/120 bunches [October 14, 2008]



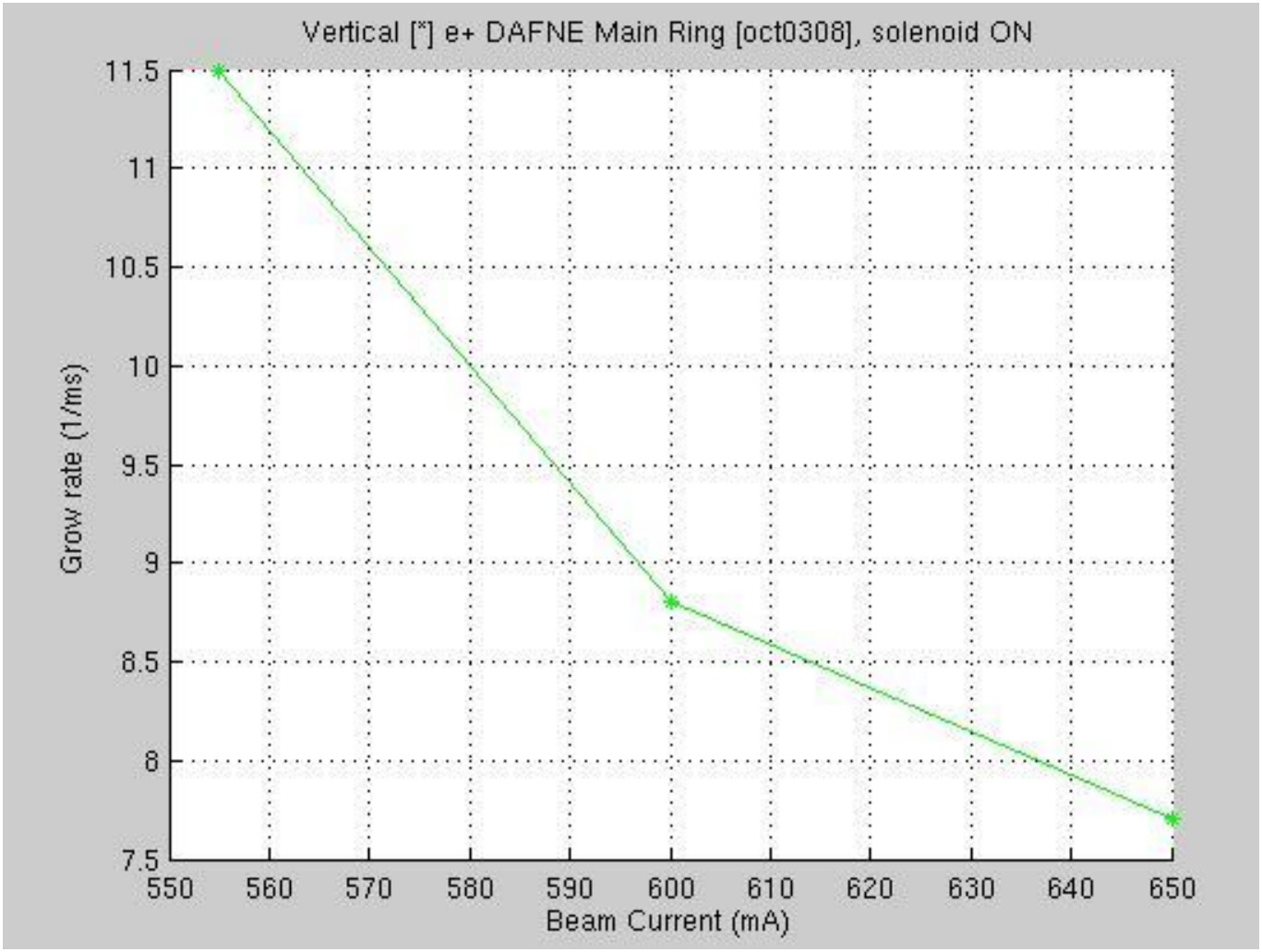
Unstable mode m=119 i.e. m=-1

e+ rings, horizontal grow rates, Imax=575mA, 105 bunches [October 14, 2008]



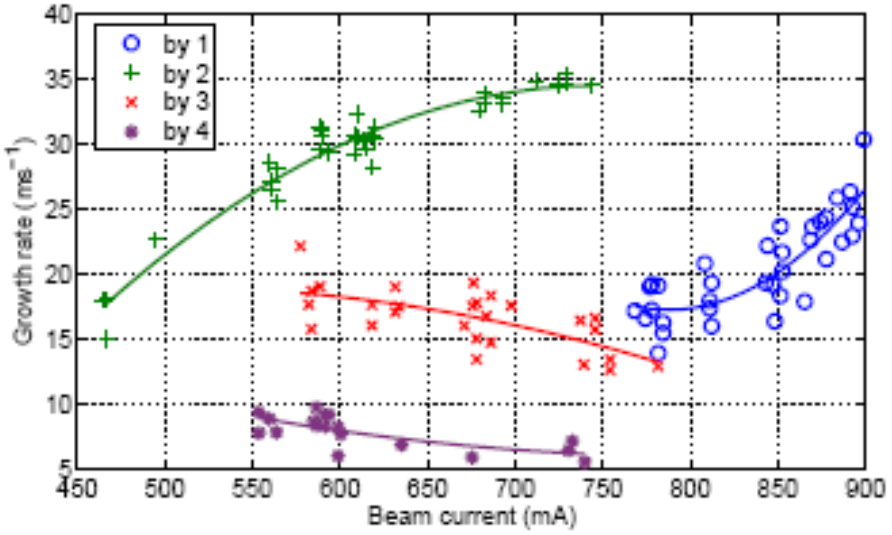
Grow rates are very fast and are linear versus beam current

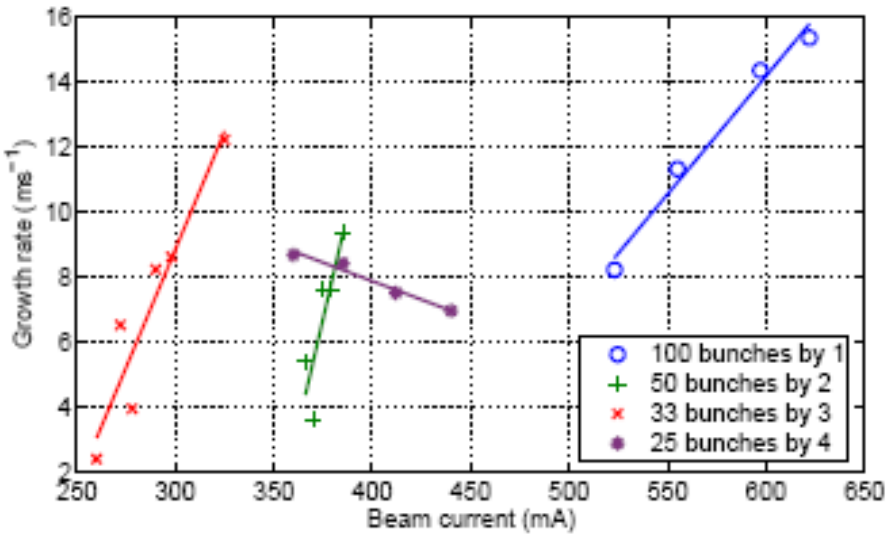
e+ rings, vertical grow rates, Imax=650mA, 105 bunches [October 14, 2008]

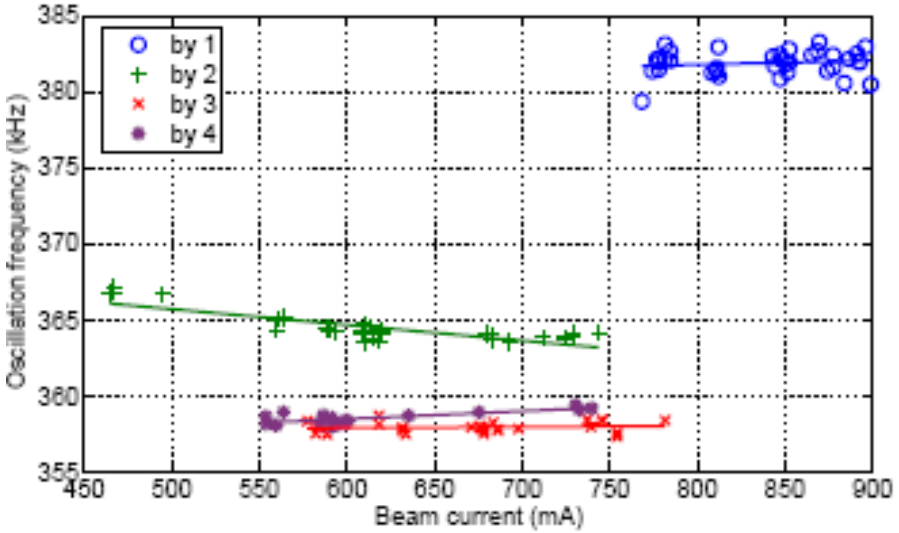


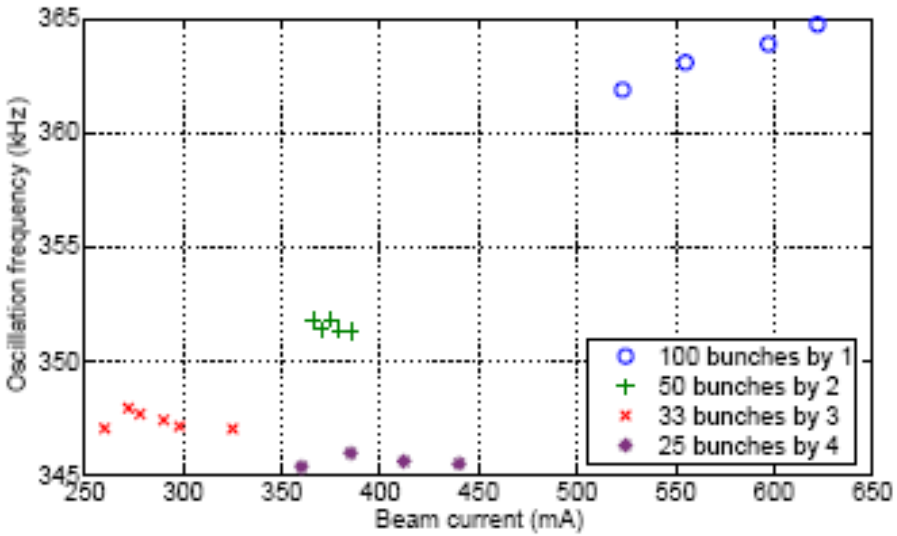
Grow rates are very slow and even more increasing the beam current

In the past years the trouble was much smaller!!!





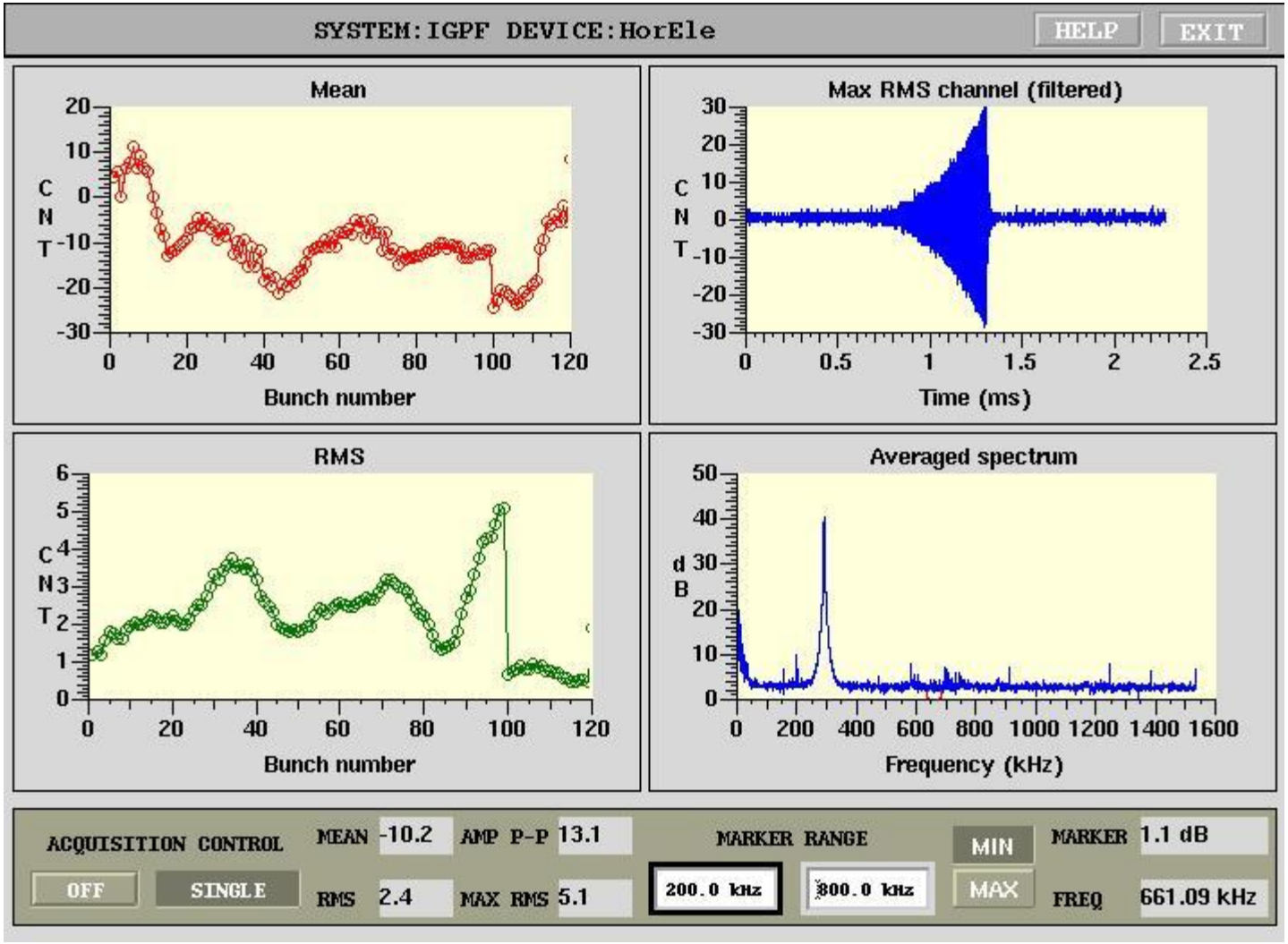




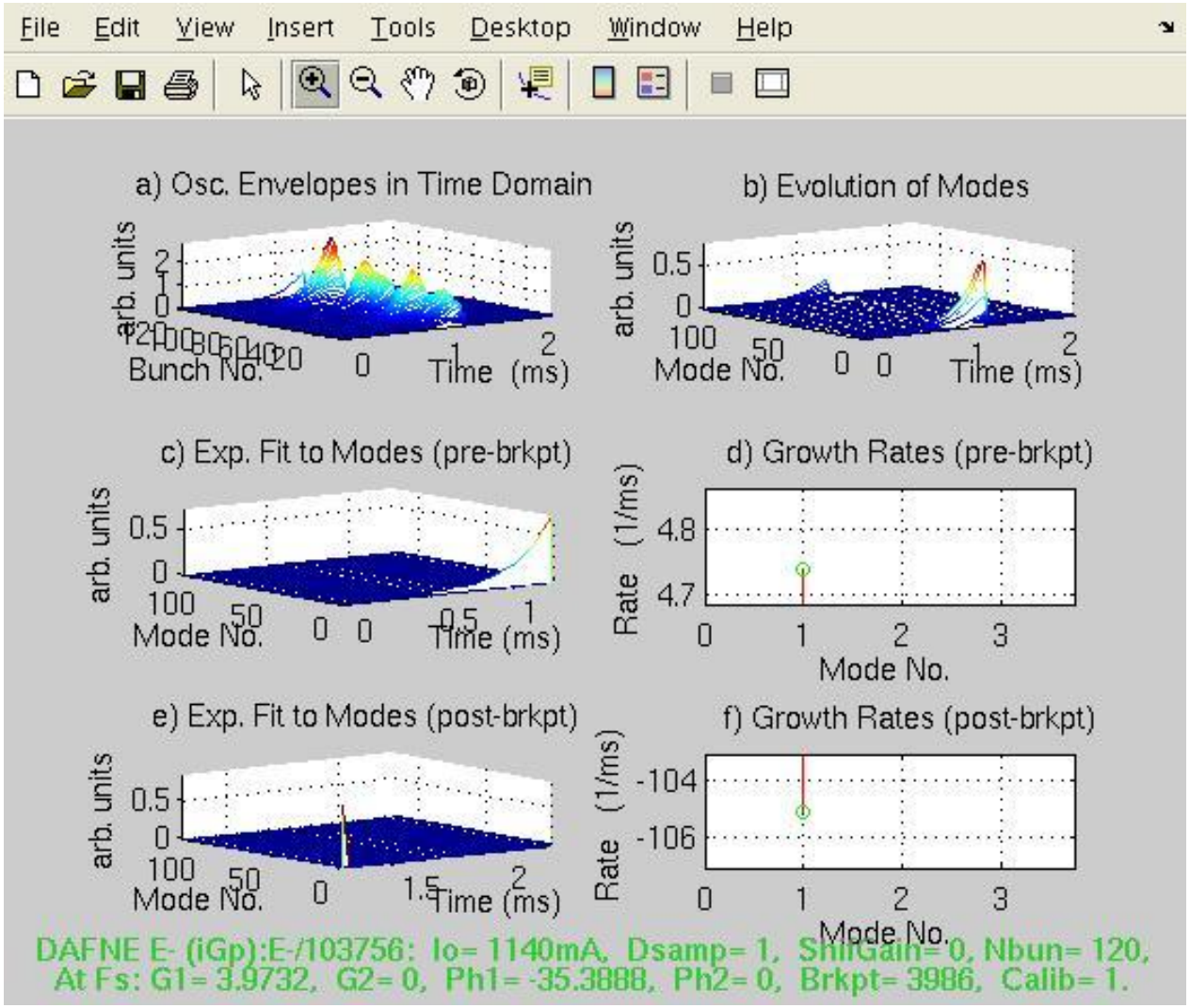
H e+ grow rates, August 4, 2005

H e+ grow rates, 2004

e- ring, I=1140mA, 100/120 bunches [October 7, 2008]

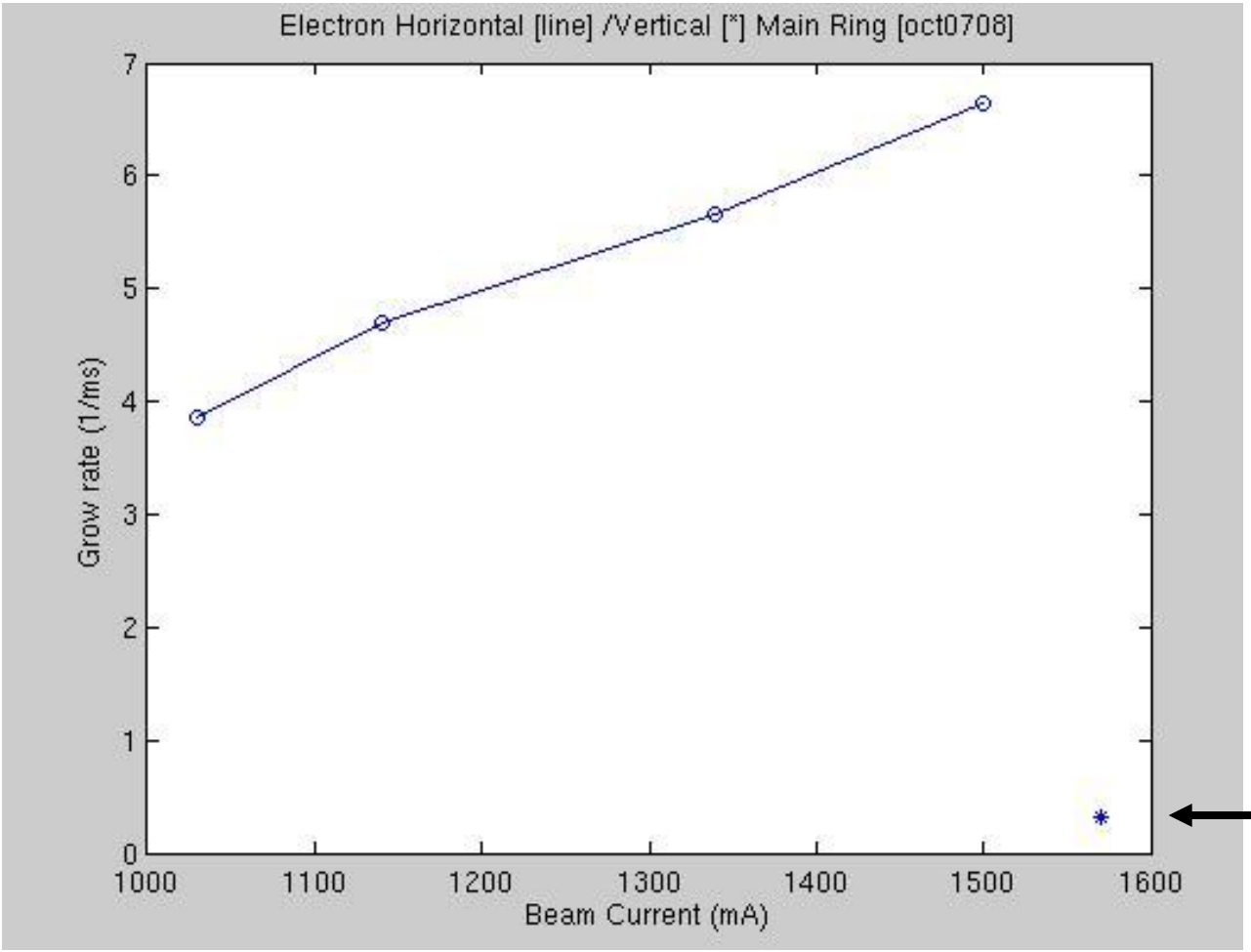


e-, I=1140mA, 100/120 bunches, unstable mode=1, [October 7, 2008]



Different
and much slower
unstable
mode compared
with e+ beam

e- ring, Imax=1.5 A, 100/120 bunches [October 7, 2008]



Vertical instability much slower

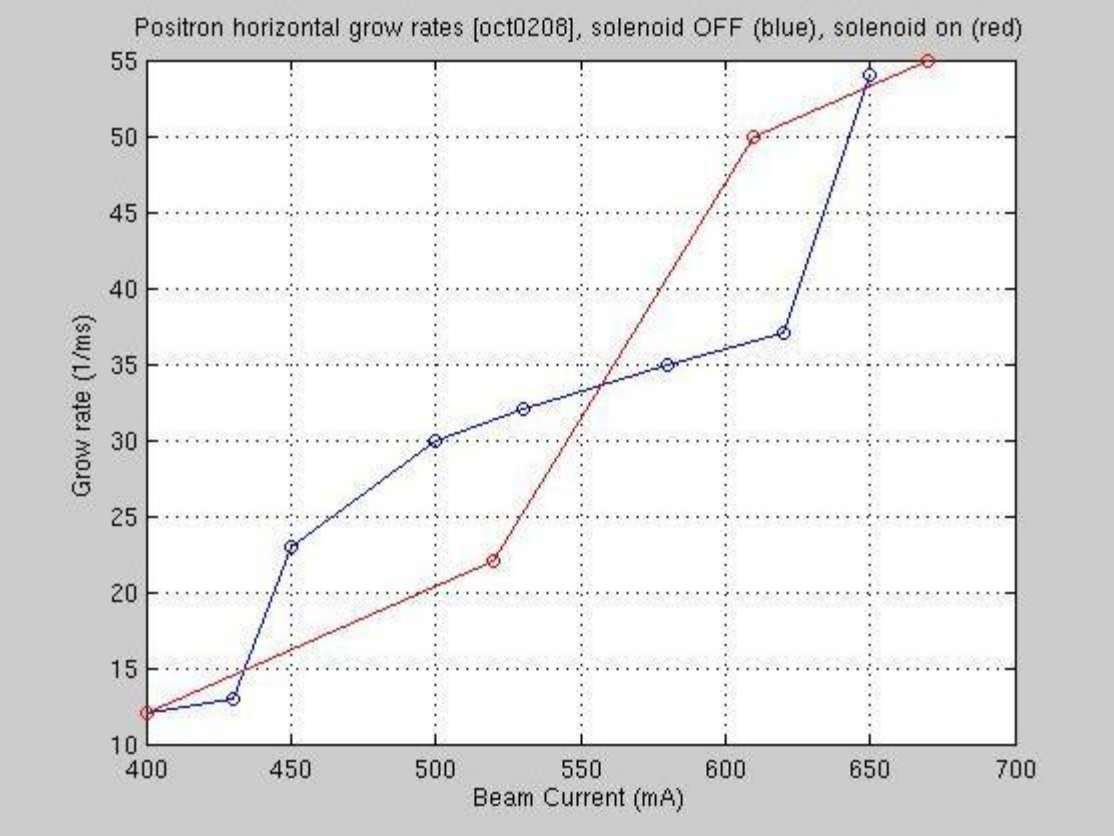
Why ?

- Why the different behavior between e+ and e- beams in terms of maximum current?
- Why much faster instability grow rates ?

e+ instability characterization

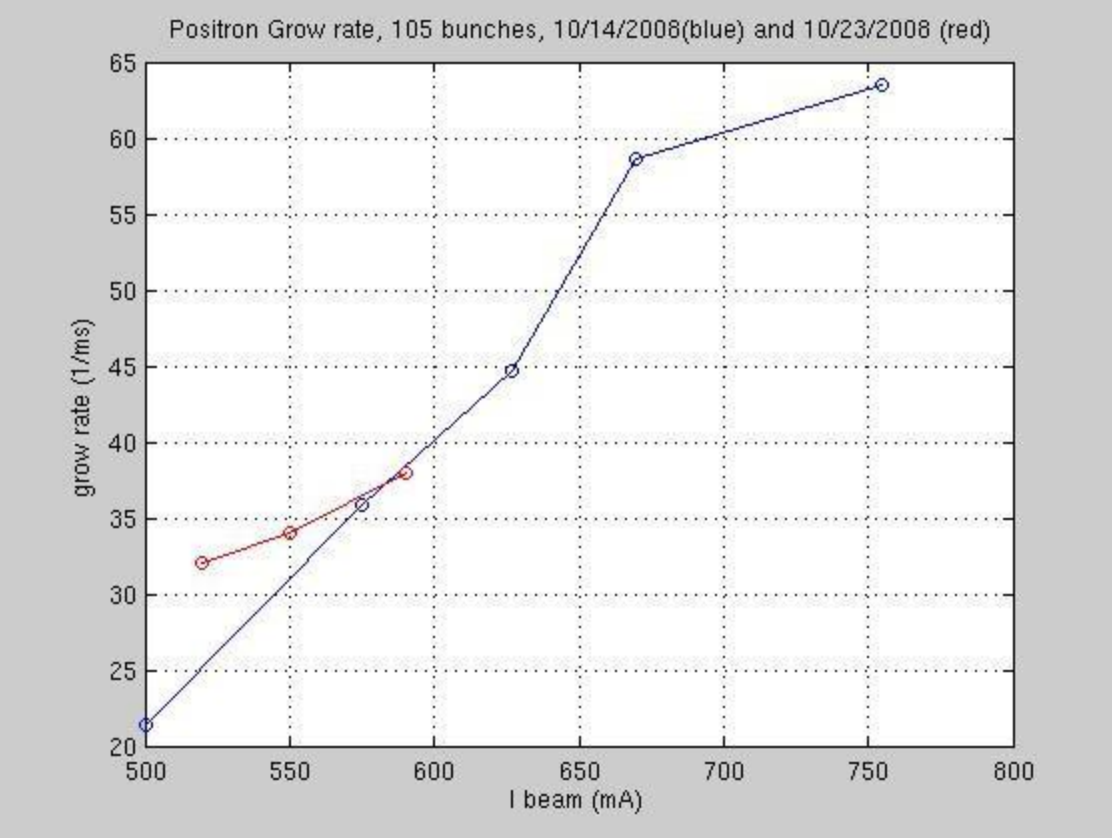
- studies to restrict the possible sources of instability
- grow-rate studies versus:
- Solenoids on/off [Oct 03 2008]
- βx in the RF cavity [Oct 23 2008]
- $\Delta \nu x$ in PS1-PS2, +0.5 [Nov 04 2008]
- $\Delta \nu x$ in RCR , +1 [Nov 05 2008]
- Orbit in the dipoles [Nov 10 2008]

e+ instability behavior switching solenoids off (blue) & on (red)



- Switching off the solenoids installed in the positron ring the grow rates of the e+ instability does not change

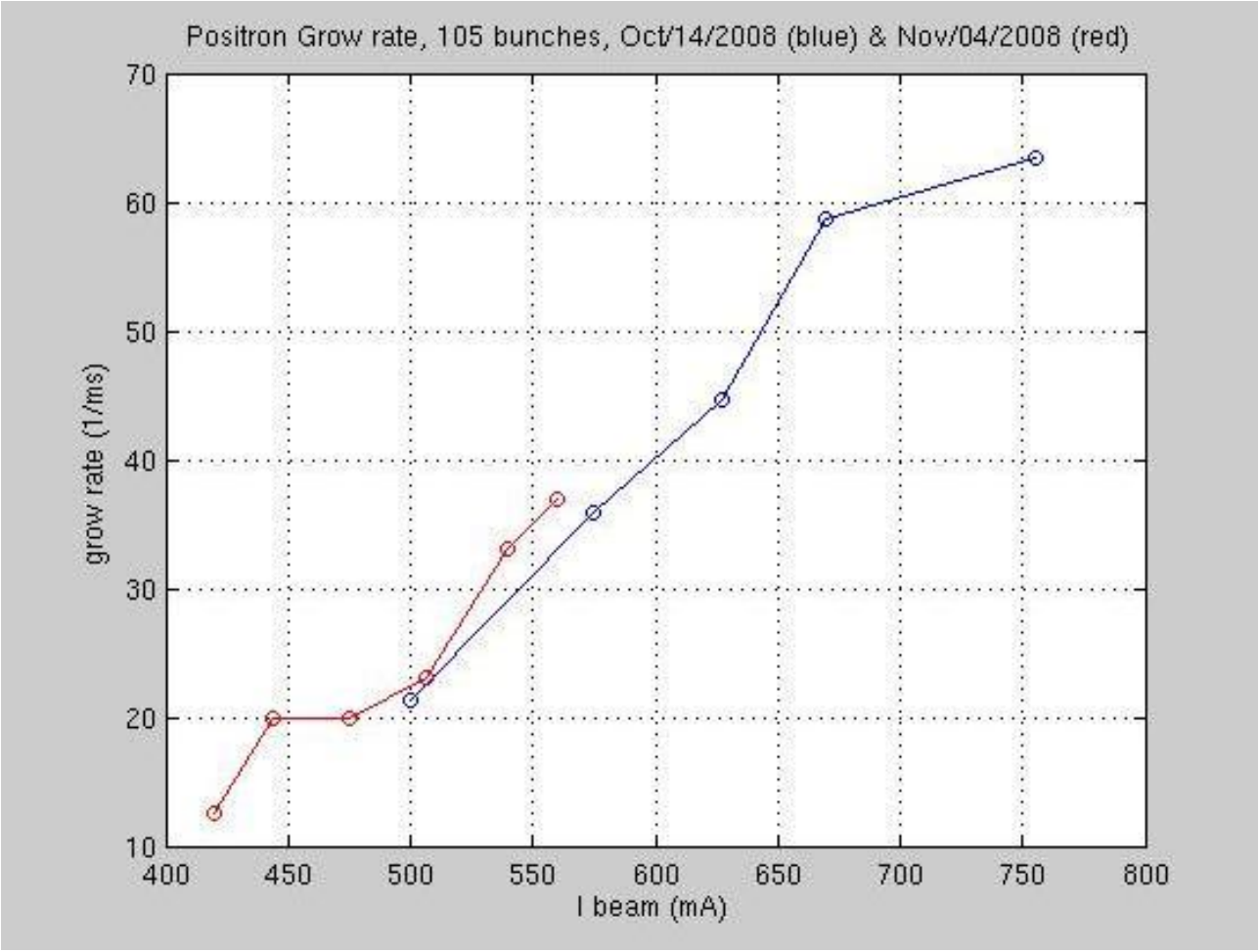
e+ instability grow rates by halving βx in the RF cavity



- OPTICS for collision (blue)
- βx 4 [m] -> 2 [m] in the RF cavity (red)
- $\nu+_x = 6.096$,
- $\nu+_y = 5.182$
- $\Delta\nu+_x$ between the Wigglers unchanged

Conclusion: the instability does not depend on hypothetical high order mode in the e+ RF cavity

e+ instability grow rates versus Δνx in PS1-PS2



OPTICS:

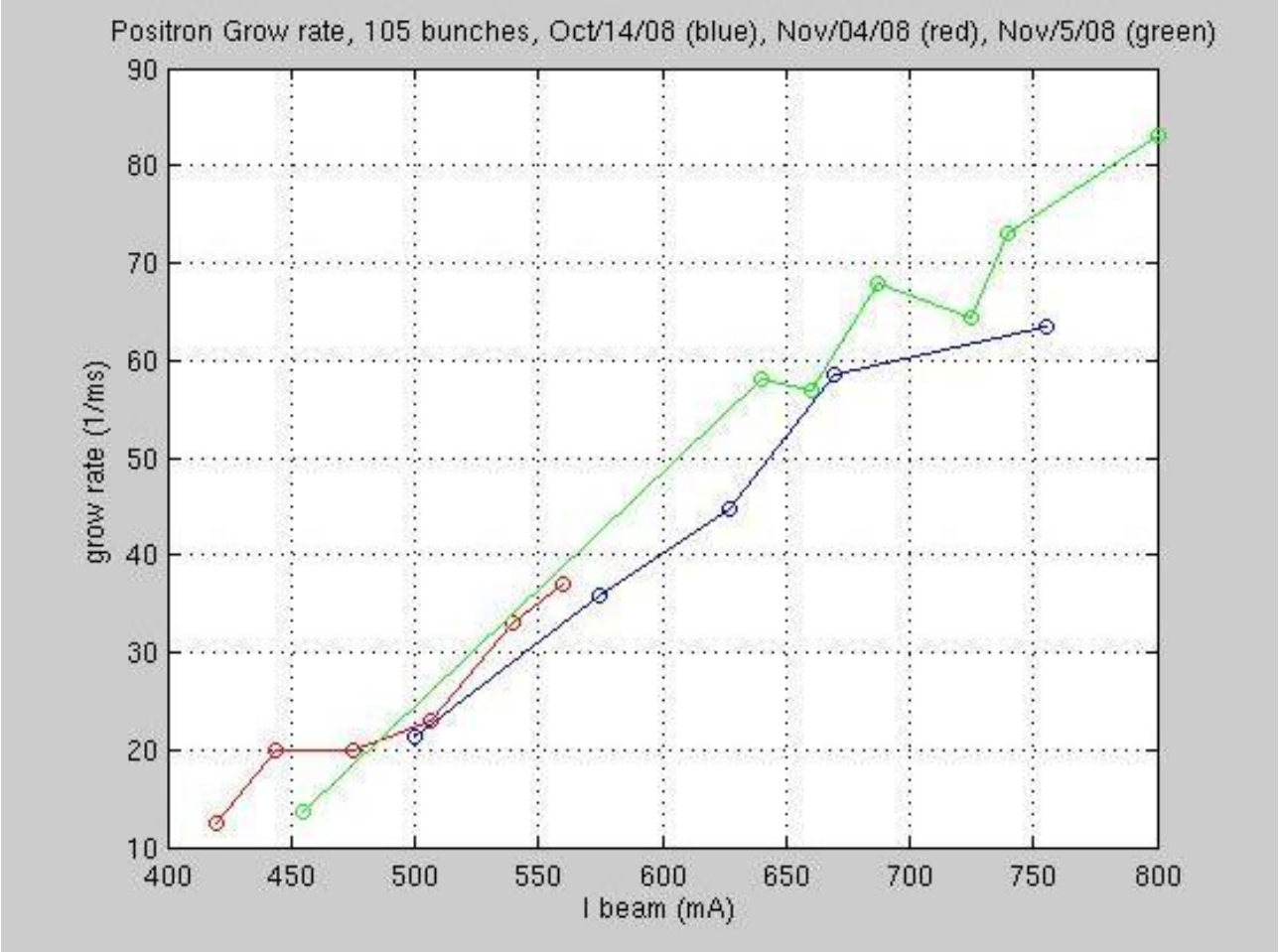
- Collision
  mode m = -1 (blue)
- Δνx = + 0.5

(PS1÷PS2)

νx = νy

mode m = 0 (red)

e+ instability grow rates versus Δνx in PS1-PS2 and RCR

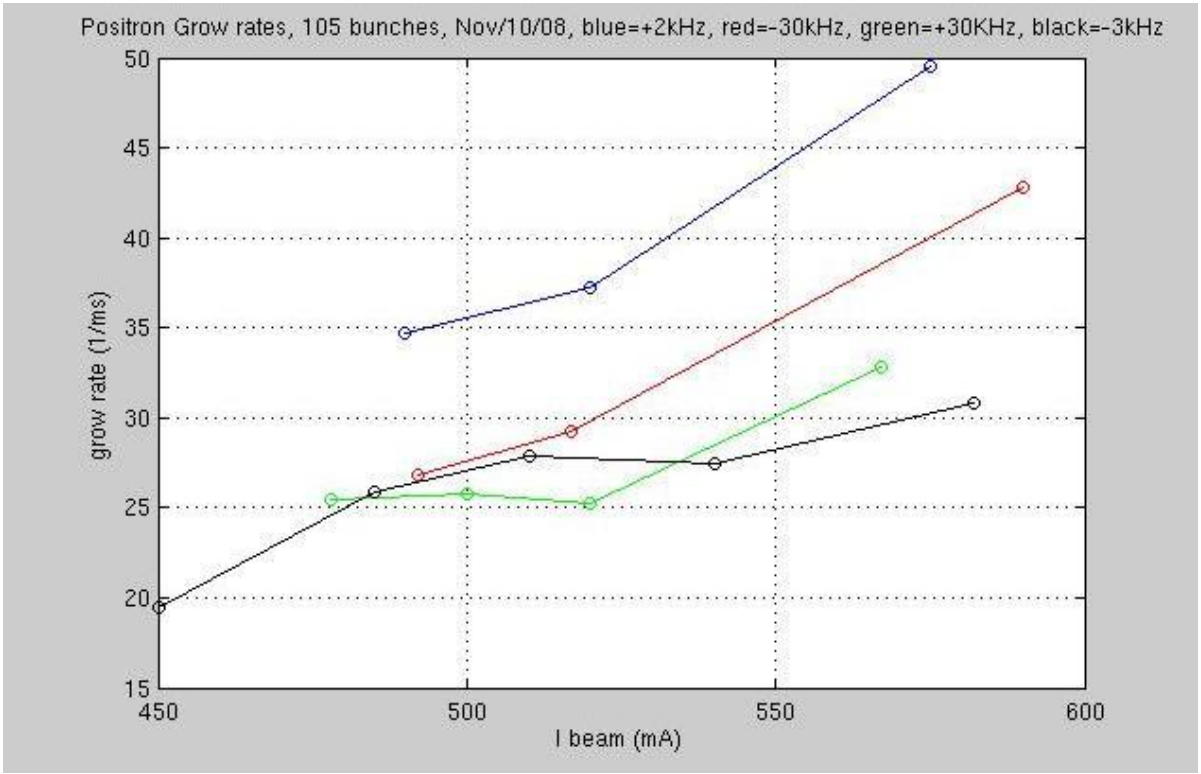


OPTICS:

- Collision
  mode m = -1 (blue)
- Δνx = + 0.5 (PS1÷PS2)
  νx = νy
  mode m = 0 (red)
- Δνx = + 1.0 (0.5 in PS1÷PS2 0.5 in RCR)
  νx = νy
  mode m = -1 (cyan)

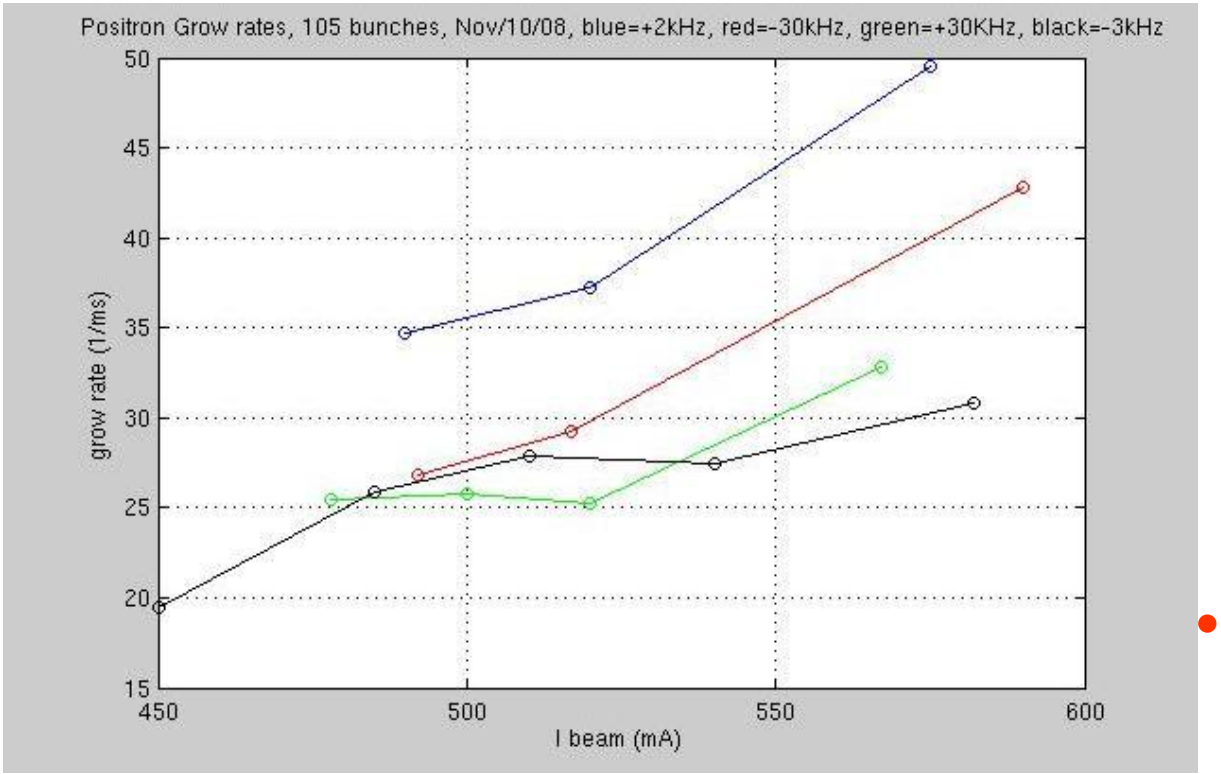
This is to study the e+ instability as a function of the relative phase advance between the WGLs

e+ instability grow rates versus orbit in the main ring dipoles



The orbit variation is performed changing the RF frequency and then compensating the beam energy

e+ instability grow rates versus orbit in the main ring dipoles

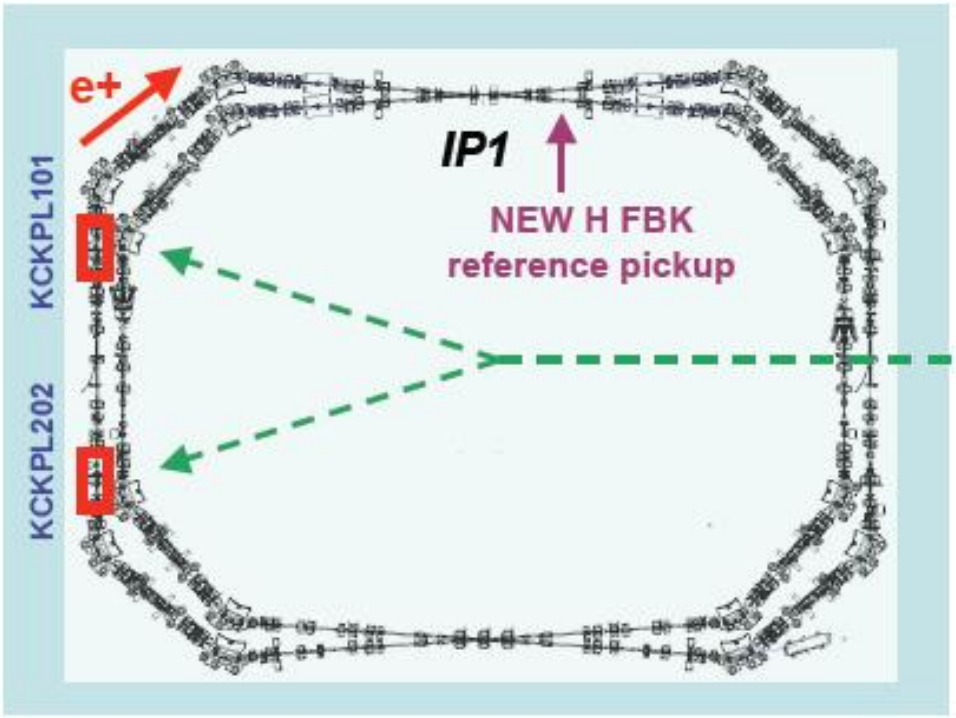


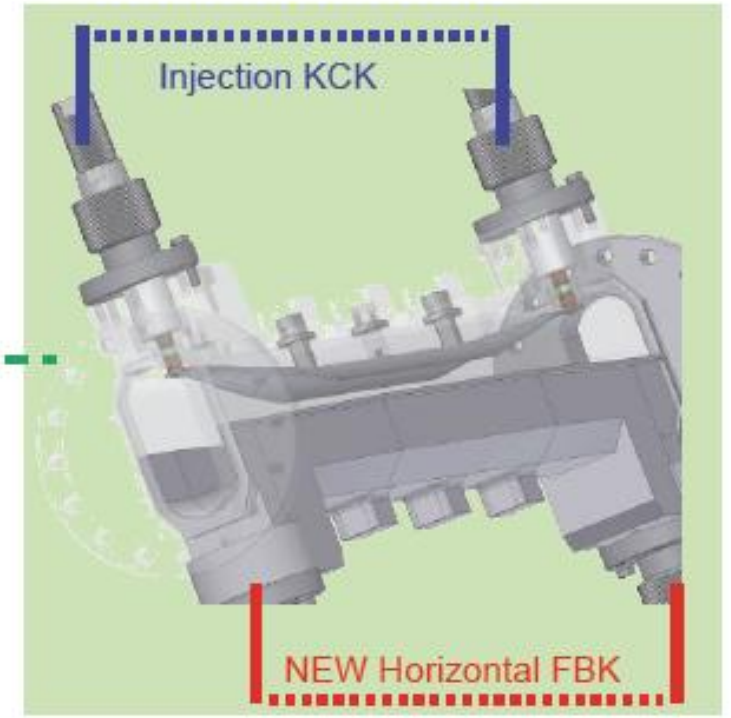
- The orbit variation shows **important differences** from the point of view of understanding the instability source
- but not to solve completely the e+ current threshold

The solution

- Observing the linearity of the horizontal instability, growing > 70 (1/ms) for Ibeam>800mA
- Considering the further energy given to the instability by the injected bunch, kicked in the horizontal plane
- We decide to double the feedback power from 500W to 1kW, but we lack power combiners to join other two 250W amplifiers
- We decide to test another pickup (to see if less noisy) and to use the spare striplines of the injection kickers
- Due to the fact that in this way the feedback betatron phase advance would have to be different from the other system, we decide to implement two complete different horizontal feedbacks

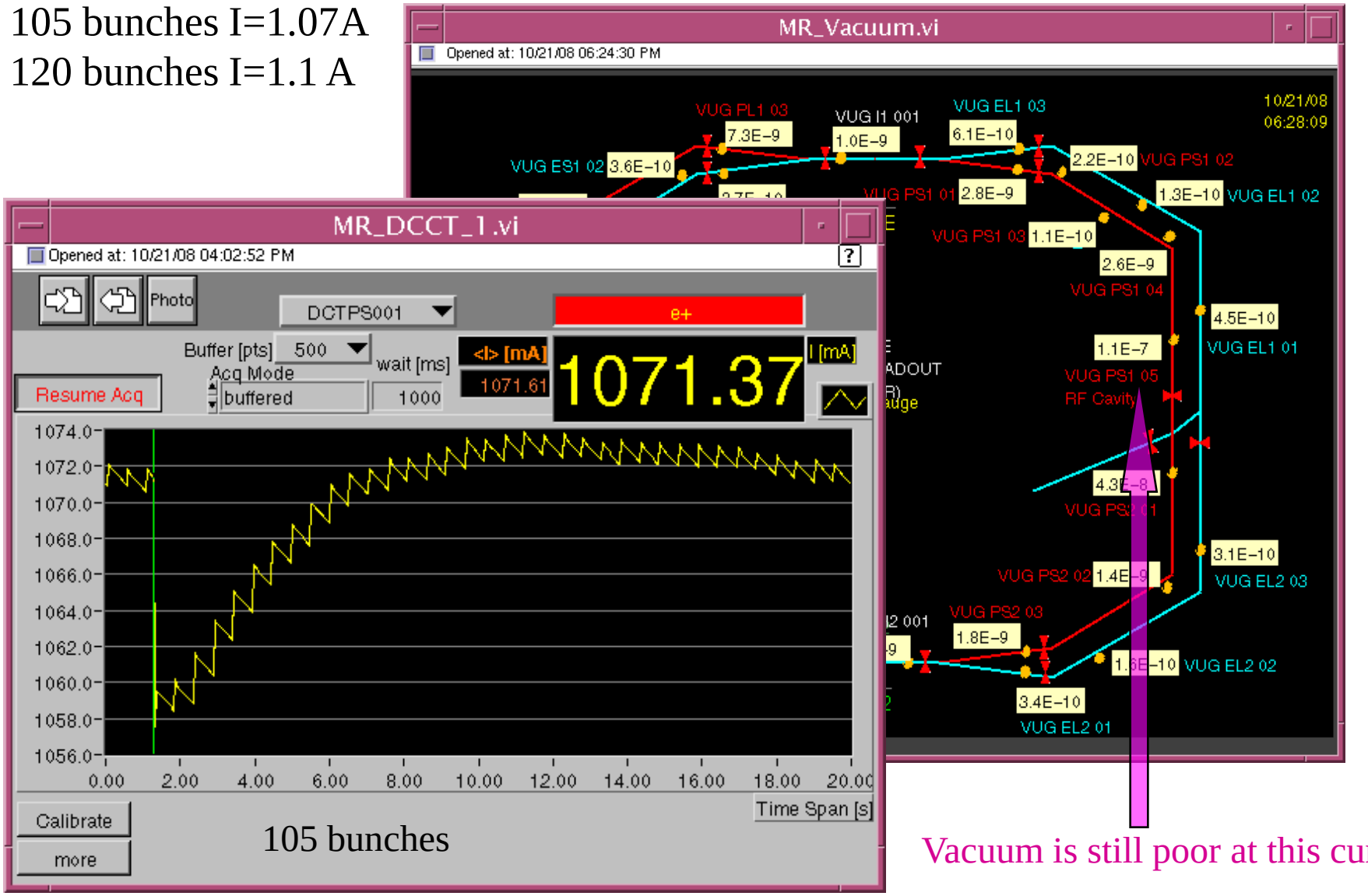
- **New e+ Transverse Horizontal Feedback**
- The damping times of the two feedbacks add up linearly
- Damping time measured:
- ~100 ms-1 (1 FBKs) ➔ fb damps in 30 revolution periods (~10 us)
- ~200 ms-1 (2 FBKs) ➔ fb damps in 15 revolution periods (~ 5 us)
- The power of the H FBK has been doubled





The current limit has been exceed

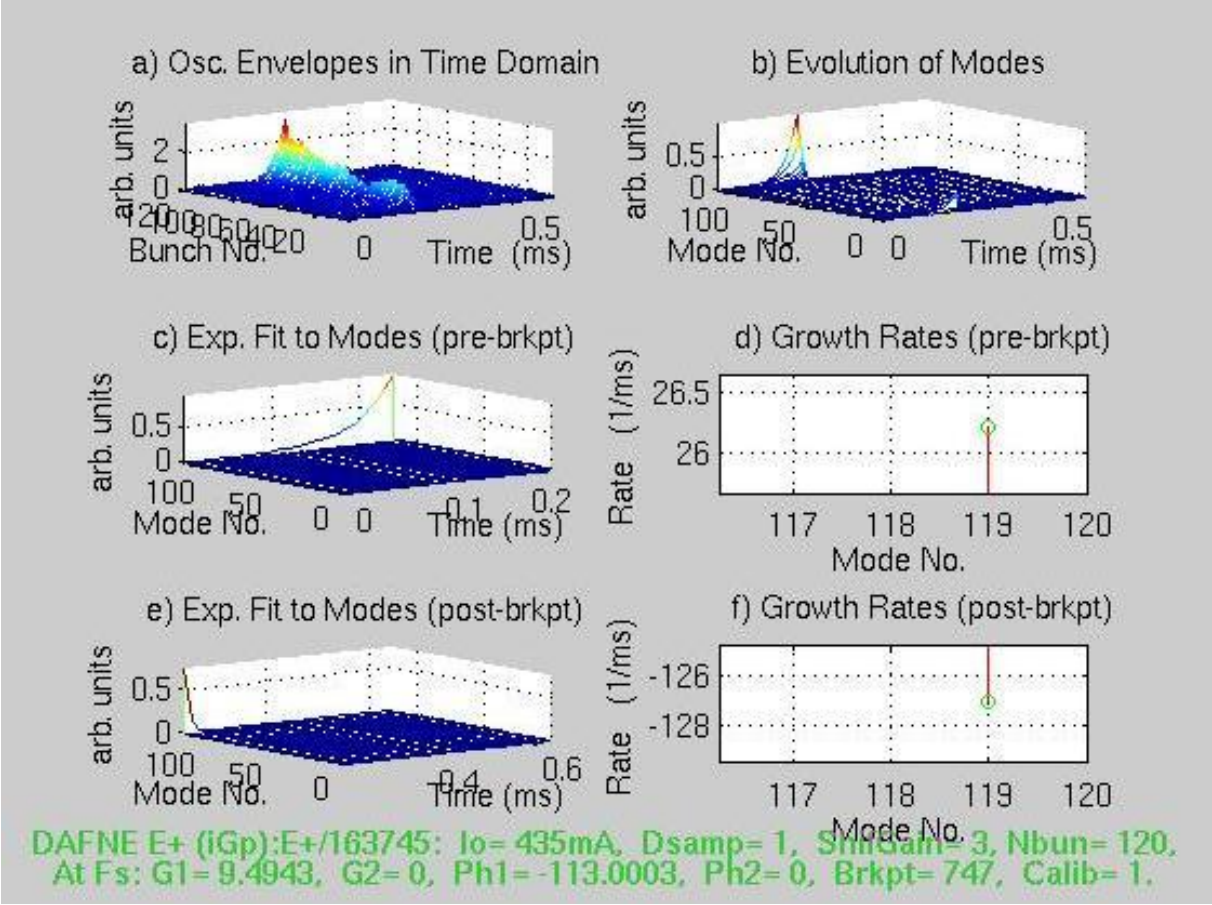
In 105 bunches I=1.07A
In 120 bunches I=1.1 A



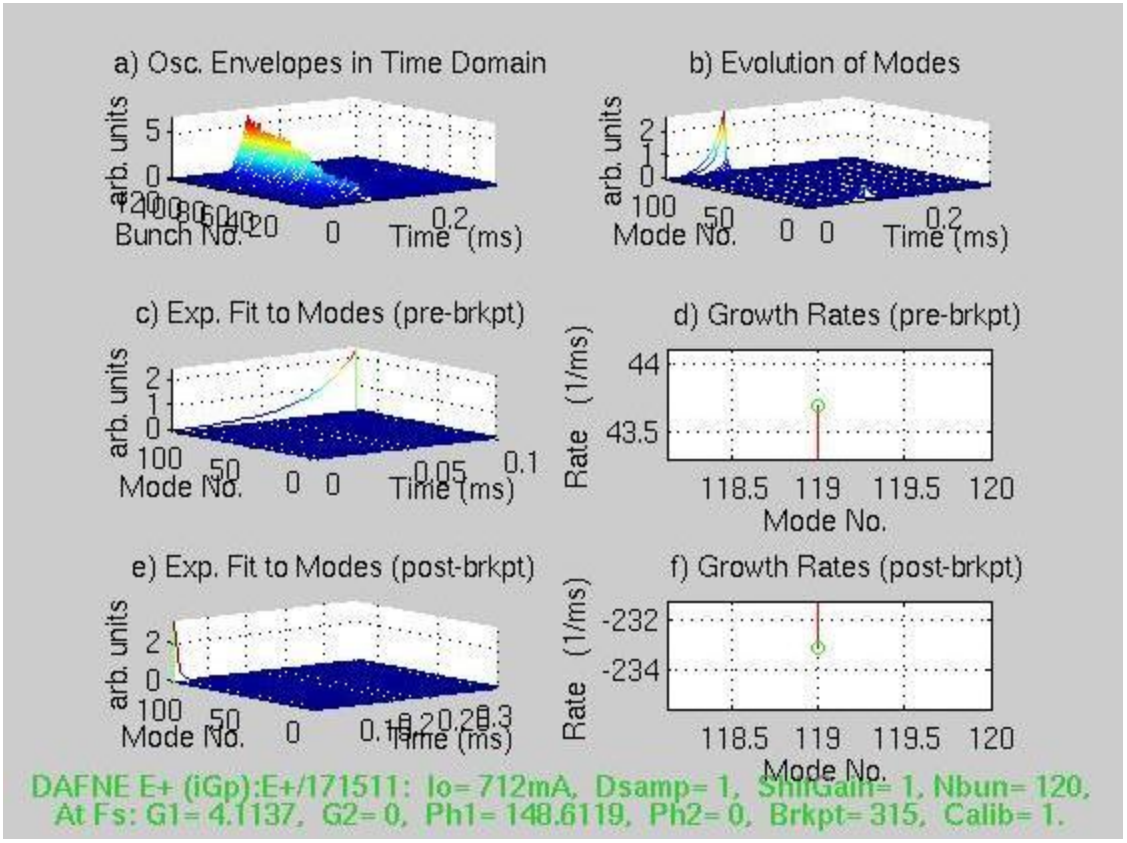
105 bunches

Vacuum is still poor at this current

Single horizontal feedback: I=560mA, mode -1 [=119] , grow=34.5 (ms-1), damp=-104 (ms-1)

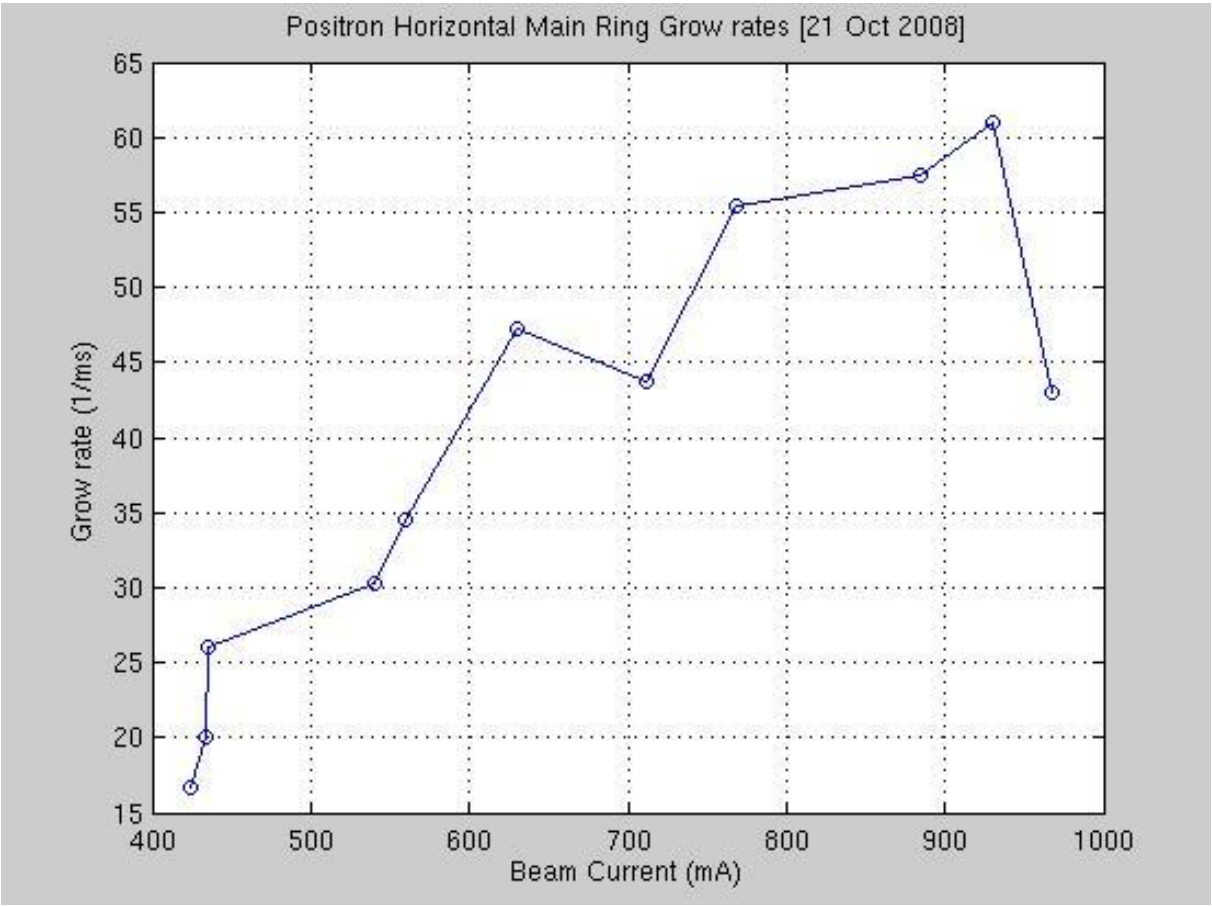


Double horizontal feedback: I=712mA, mode -1 [=119] , grow=43.7 (ms-1), damp=-233 (ms-1)

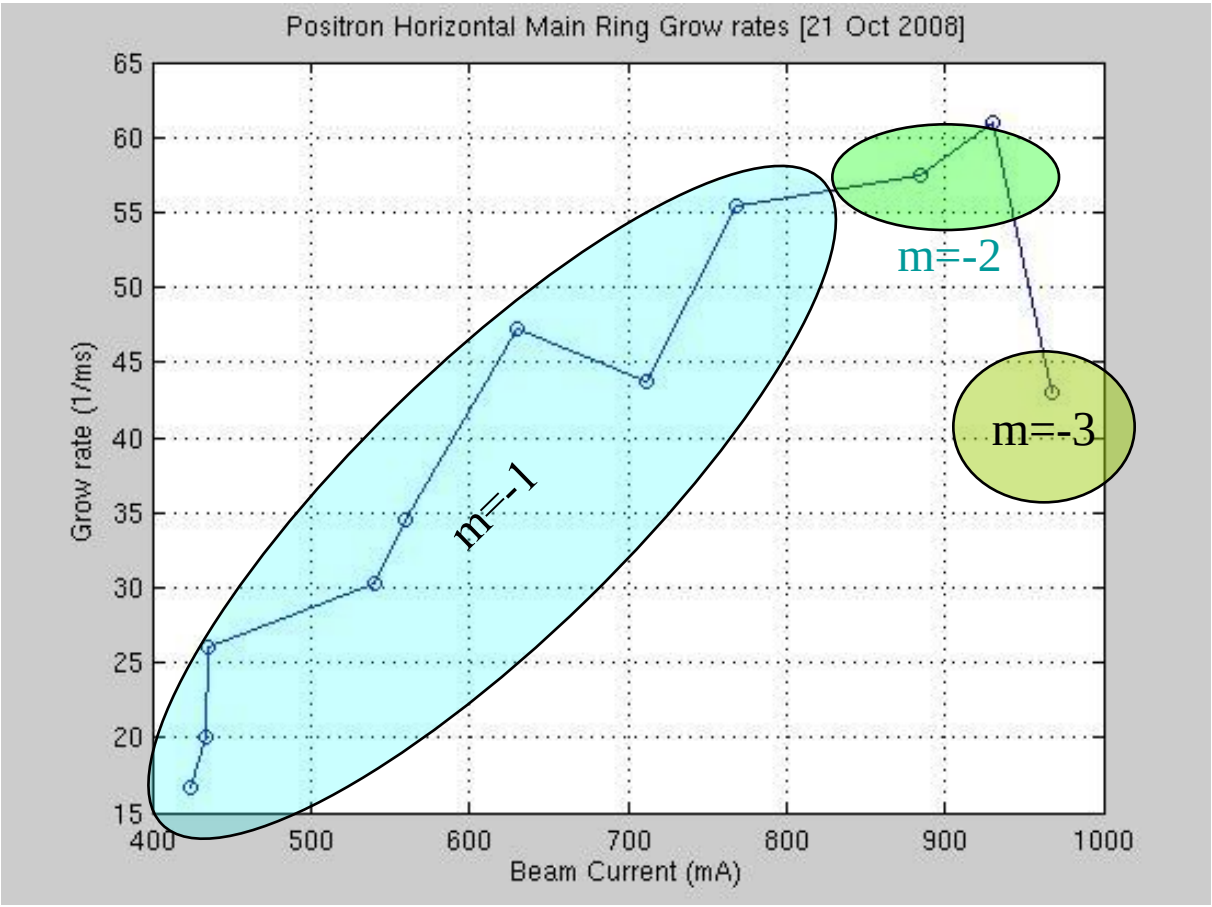


Damping time in 4.3 microsecond i.e. in ~13 revolution turns

Grow rates at higher e+ current controlling instability by 2 feedback



Grow rates at higher e+ current: the unstable mode changes and becomes slower !



The beam current does not seem limited by the horizontal instability

Conclusions

- It seems evident that the beam current limit in the e+ ring is due to an **e-cloud induced instability**.
- More power on the horizontal e+ feedbacks help in keeping I+ MAX as higher as possible.
- Two separate feedback systems for the same oscillation plane work in perfect collaboration doubling the damping time
- Damping time in 4.3 microsecond i.e. in ~13 revolution turns
- The measurements show a good agreement with e-cloud model and simulations (See Theo Demma's talk)
- Further investigations at even higher beam currents can improve the knowledge of the instability behavior