Bunch-by-Bunch Feedback Upgrade Evaluation and Test

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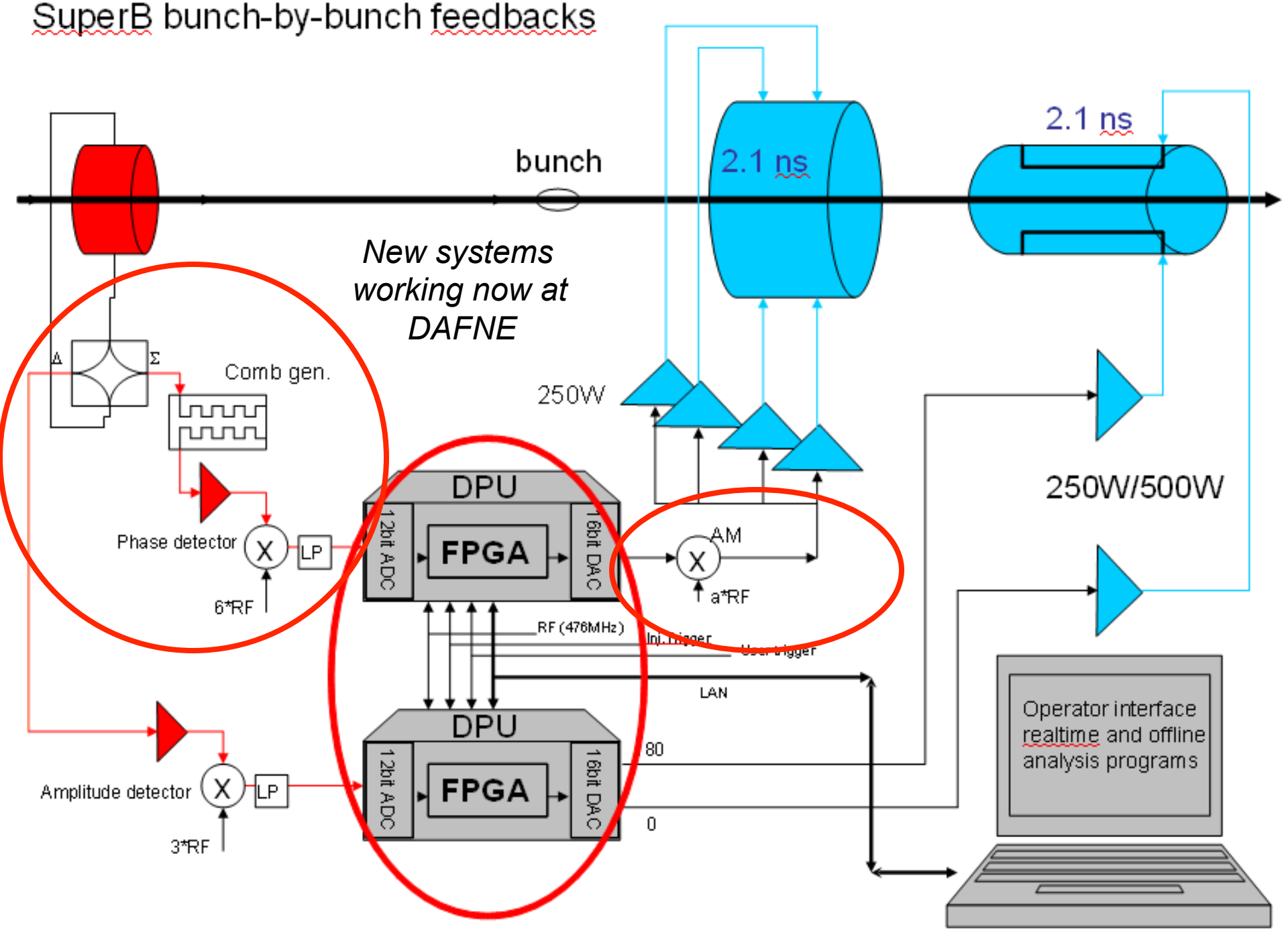
XVII SuperB Workshop and Kick Off Meeting
La Biodola, Isola d'Elba,
May,28th – June,2nd

Introduction

- The betratron and synchrotron bunch-by-bunch feedback systems are largely based on the previous designs that have given very positive results in the last 16 years.
- A new, more powerful feedback version has been installed in last November at LNF to be tested on DAFNE beams and basically it has described in my last talk in XVII General Meeting.
- Here I present comments on the tests and new developments based on the iGp12 system. In particular I'll speak on the following topics:
  - General behavior tests
  - Decoherence measurements
  - Application to manage FE saturation automatically
  - Tune spread analysis programs
  - Tune feedback application

SuperB bunch-by-bunch feedbacks

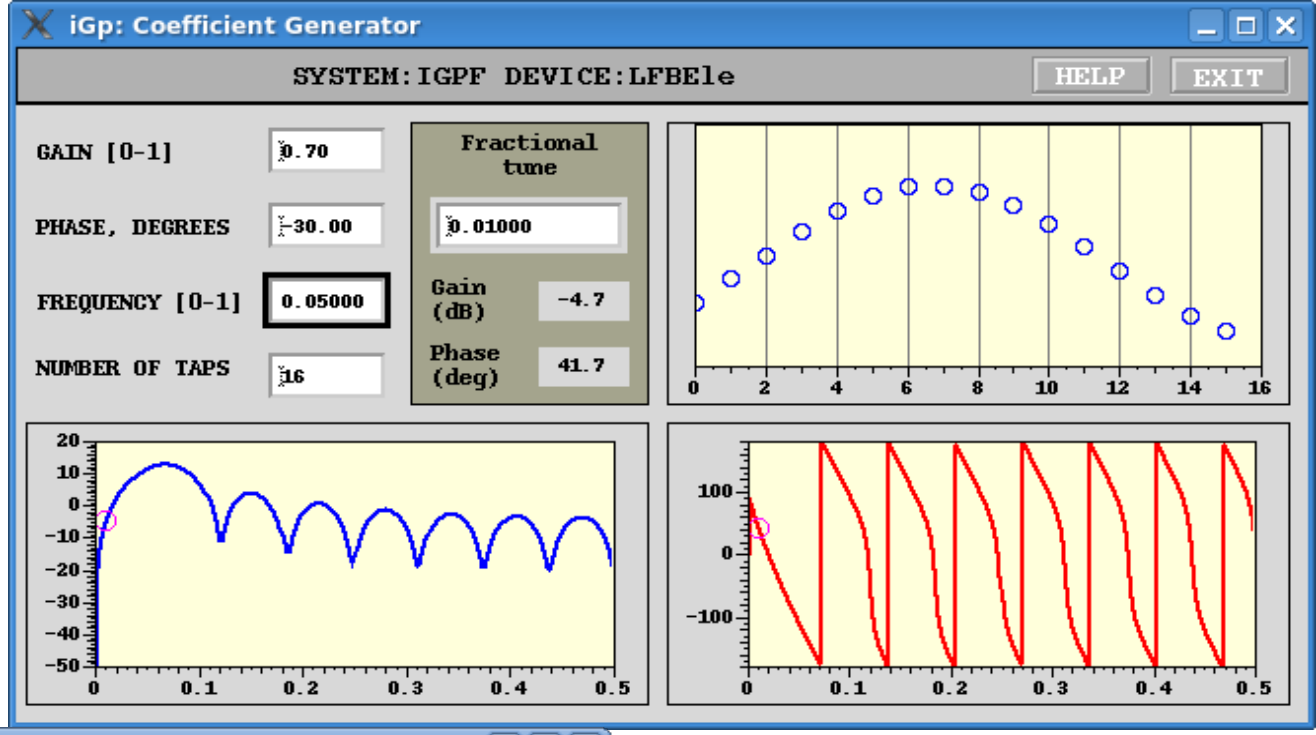


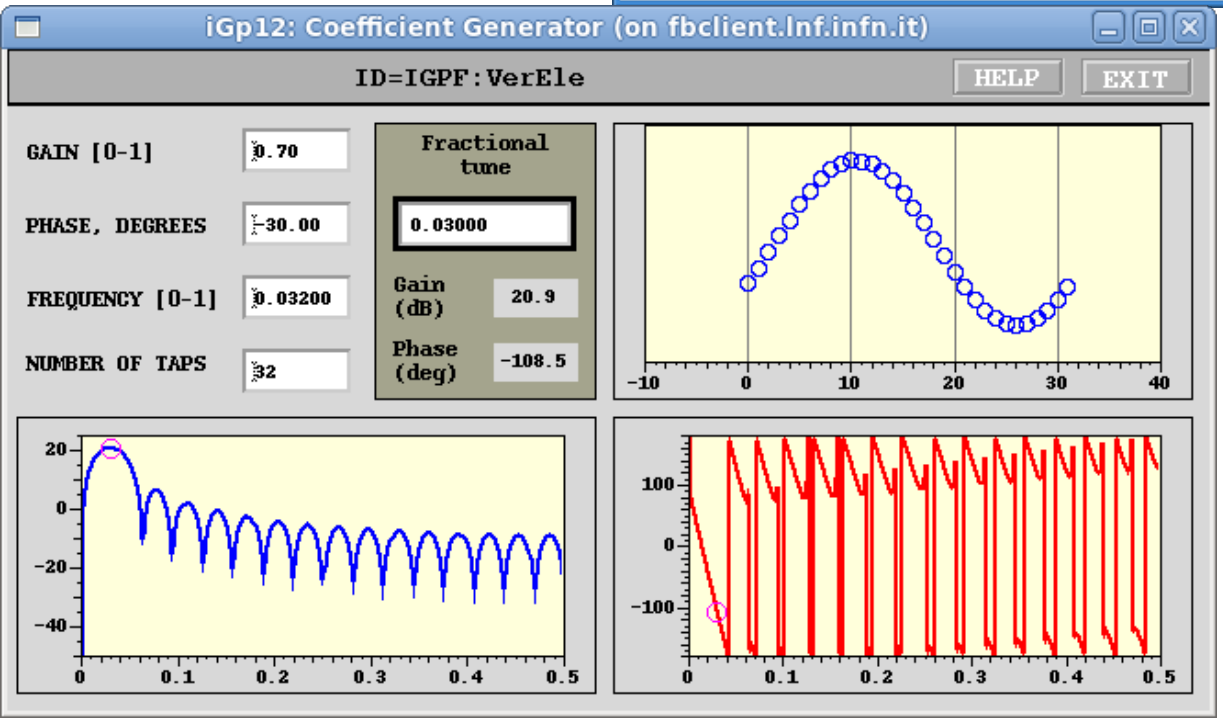
Core of the new betatron and synchrotron bunch-by-bunch feedback system is the iGp12 (i.e. DPU=Digital Processing Unit), just upgraded from the previous iGp feedback developed in collaboration with KEK and SLAC (2002-2005) and based on the old longitudinal bunch-by-bunch feedback designed in collaboration ('93-96 by SLAC/LNF/LBL for PEP-II, Dafne, ALS).

This year, during Dafne runs, we have tested the new feedback behavior together with all the old beam diagnostics tools:

all the tests show that the iGp12 works very well, without any compatibility troubles.

Only minor problem:
A larger (>32) number of FIR filter taps will be necessary in case of low frequencies motions;
downsampling factor >1 (needed for longitudinal fb) can be set easily



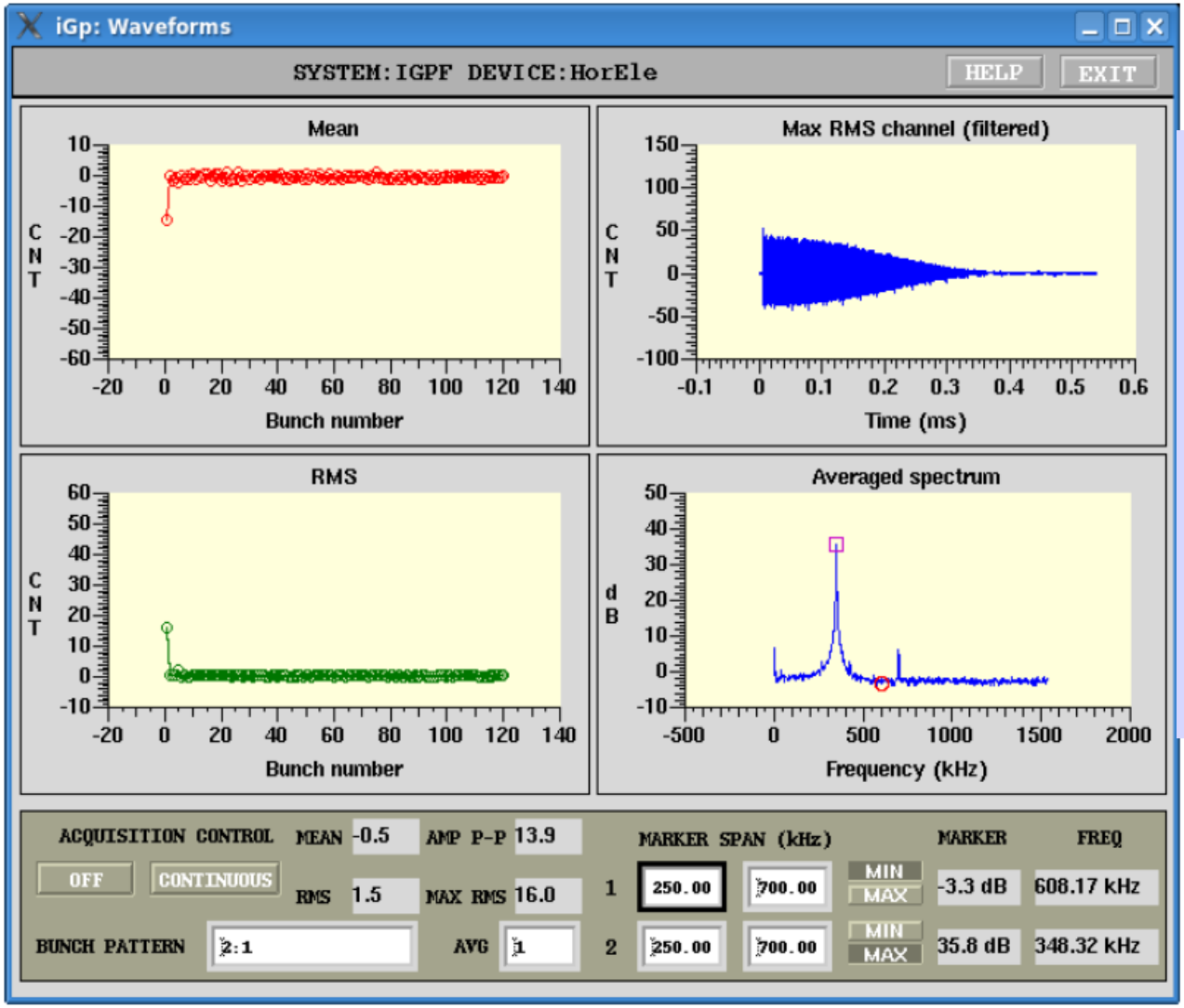


up: Filter with 16 taps (iGp8)

left: Filter with 32 taps (iGp12)

It is possible that for SuperB synchrotron feedbacks even more taps will be necessary [64 or 128] in base at the specifications

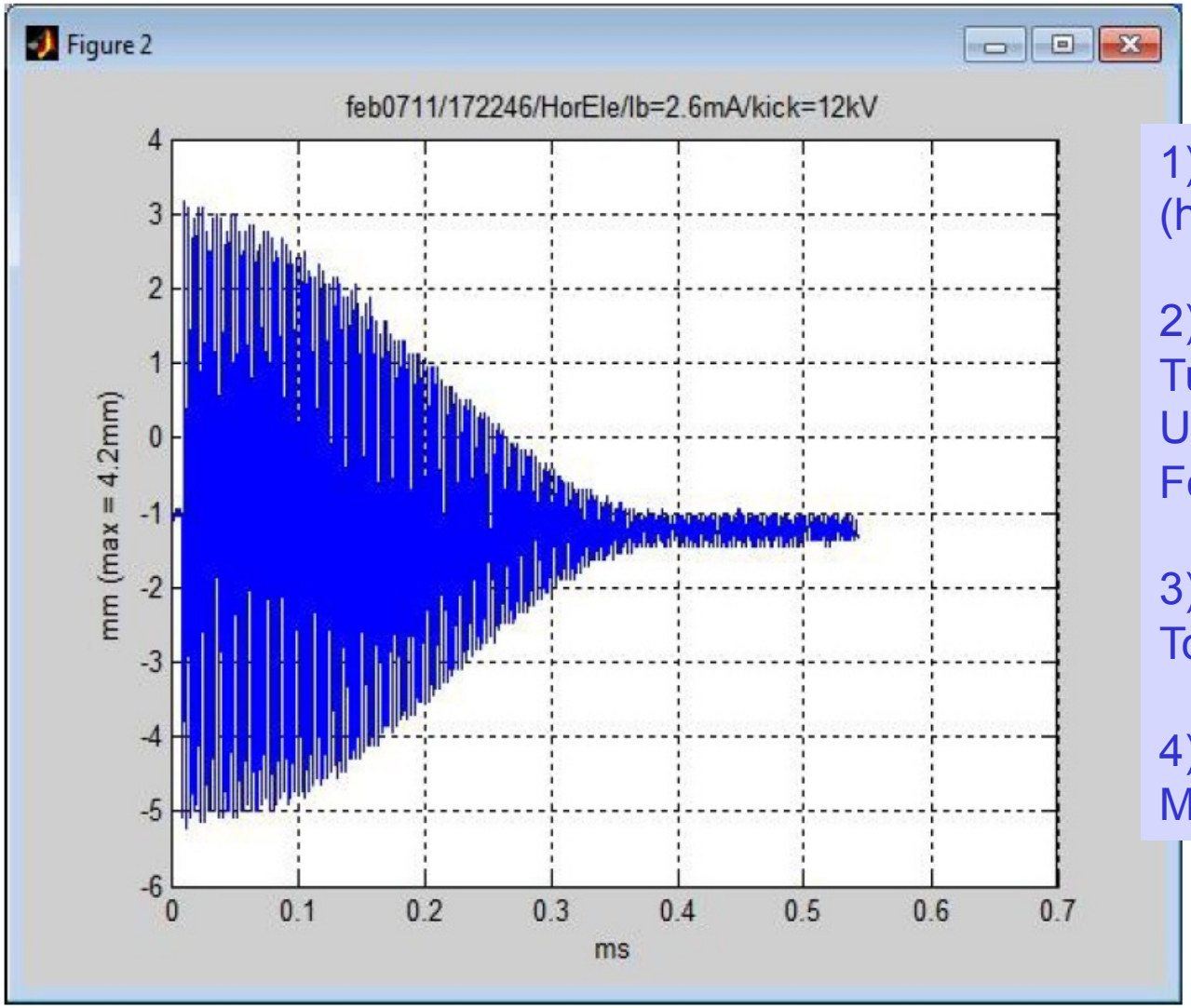
Dechoerence measurements done on Feb/ 7/2011 by the bunch-by-bunch transverse feedback systems



This EPICS panel gives In real time four data Windows:

a) Mean values
b) Motions of one bunch
c) Max rms motion versus bunch number
d) Averaged power spectrum with explicit maximum or minimum value marker

Dechoerence measurements done on Feb/7/2011



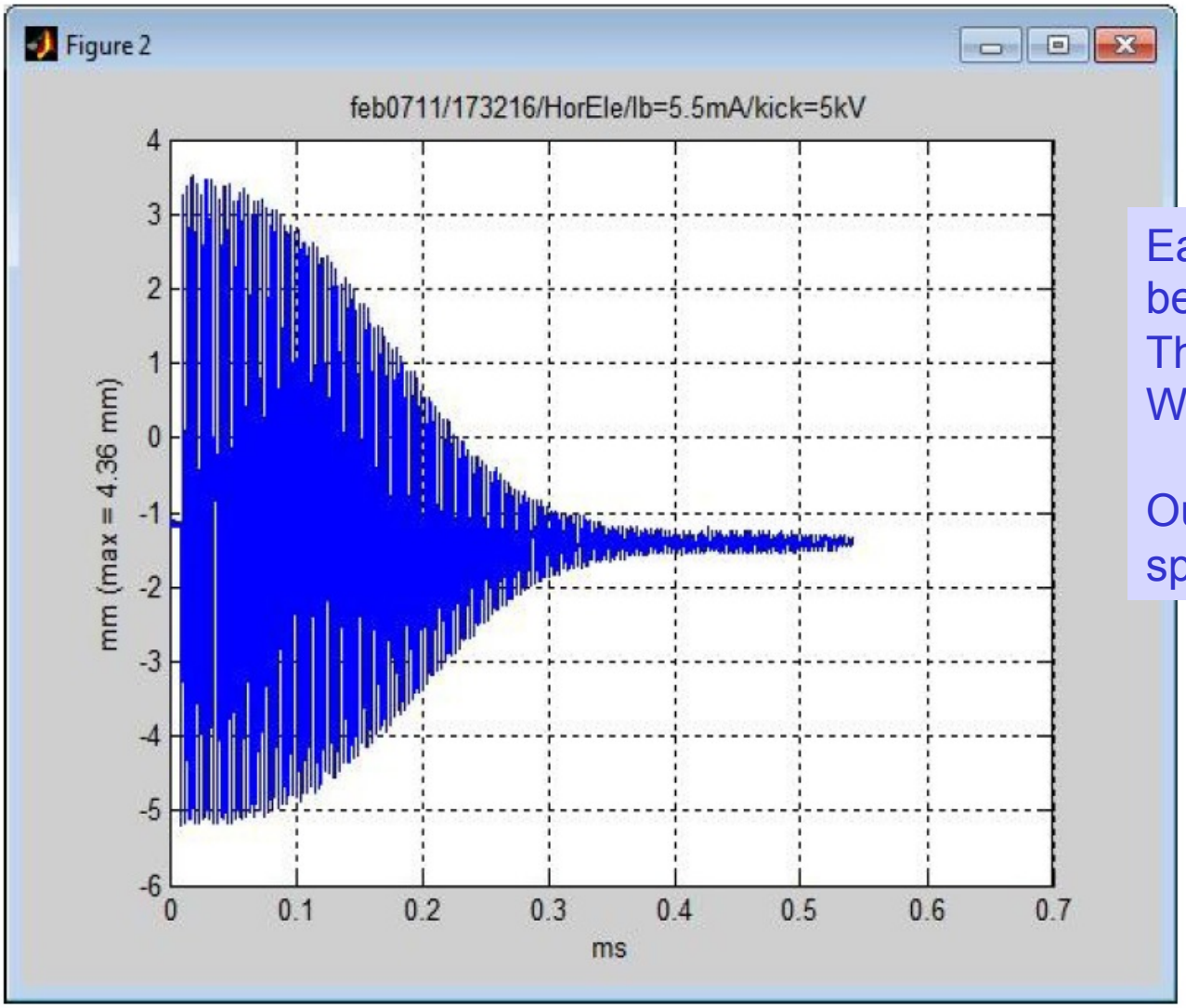
1) Kick by injection (horizontal) kicker

2) Read bunch-by-bunch Turn-by-turn motion Using the horizontal Feedback

3) Download .5ms data To the server data base

4) Read database by Matlab routine

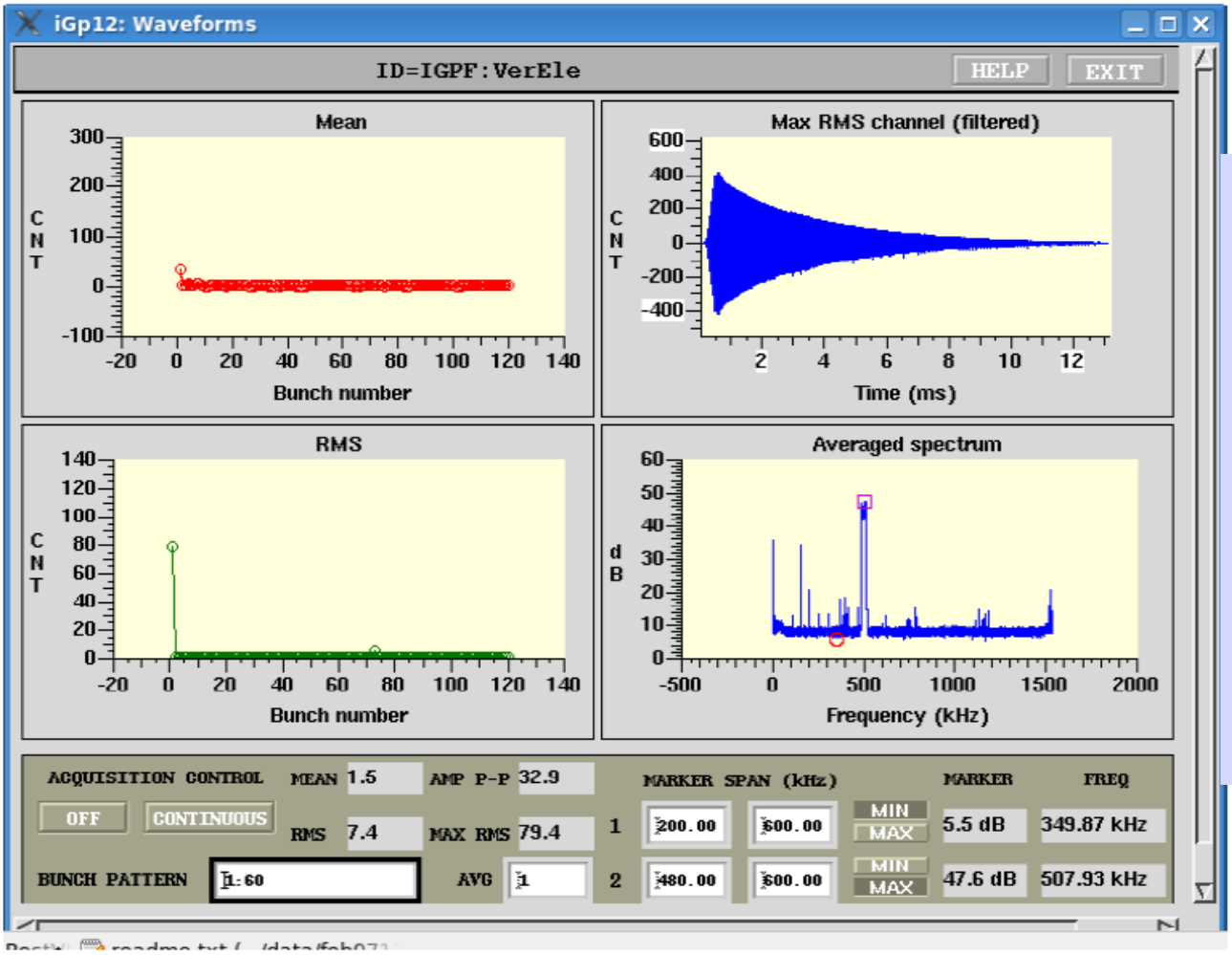
Dechoerence measurements done on Feb/7/2011



Easy comparison between
The previous 12kV kick
With this 5kV kick

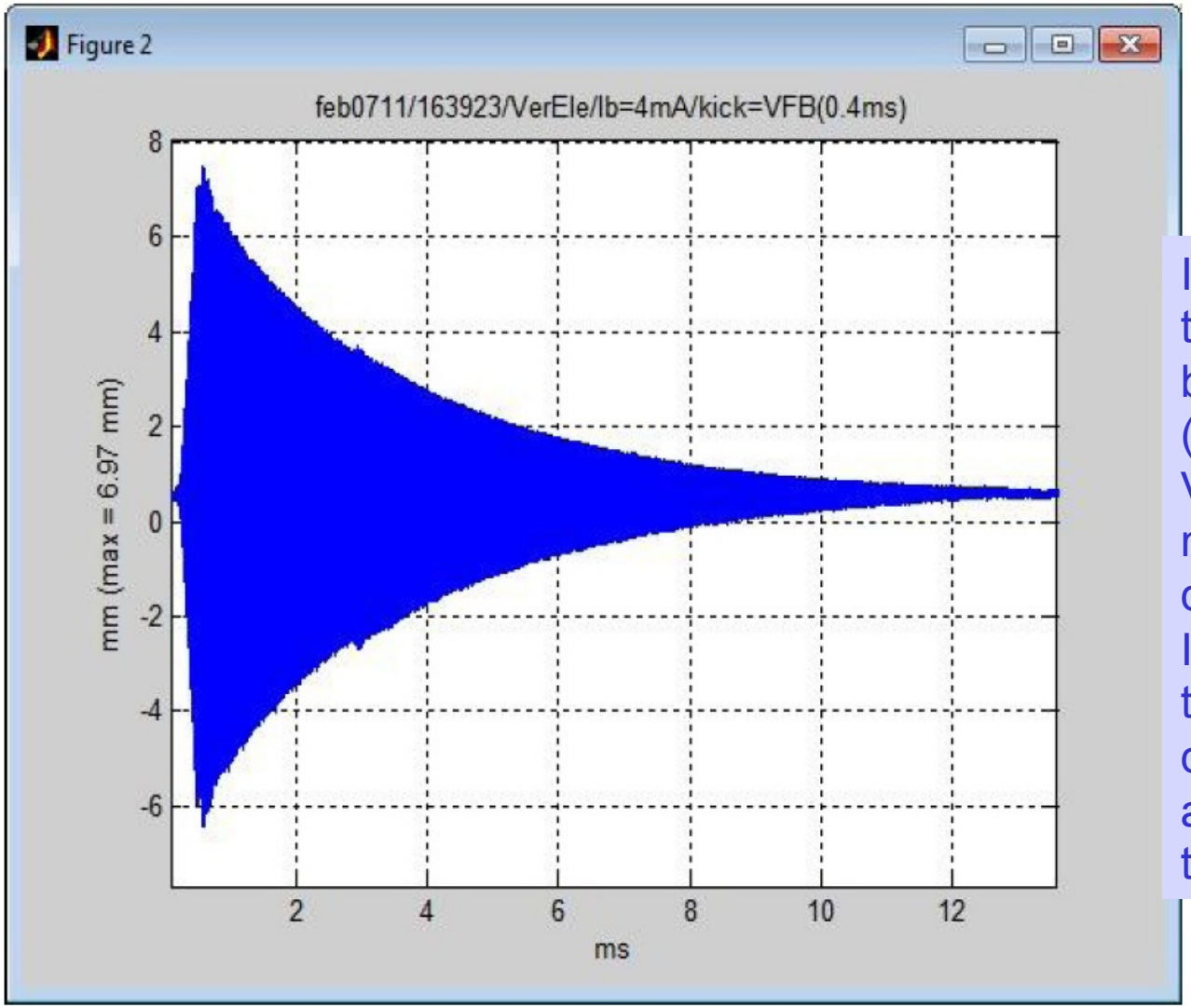
Output data also in spreadsheet format

Dechoerence measurements done on Feb/7/2011 in the vertical plane



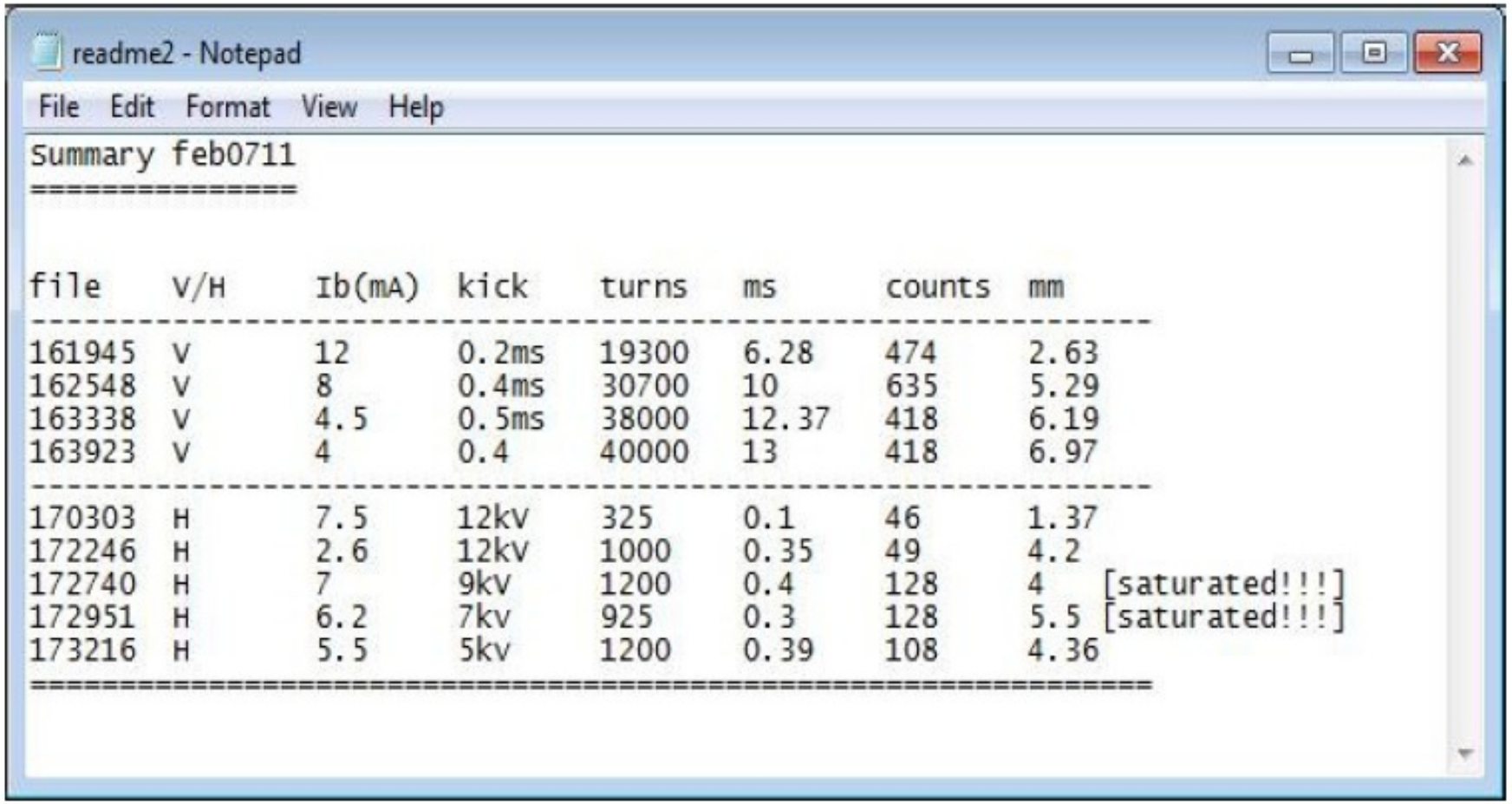
DAFNE has not a vertical kicker like the injection kicker so We use the feedback also as excitation generator.
A .4ms antidamping signal is sufficient to excite in the vertical plane one bunch

Dechoerence measurements done on Feb/7/2011 in the vertical plane



In the plot it is possible to see that the iGp12 based on Xilinx Virtex-5 (in place of the old Virtex-II) offers much more data space; 12ms data for each bunch !
It is possible to see also that the 12bit analog to digital conversion has an impressive effect in terms of resolution !!!

Summary of dechoerence measurements recorded by the bunch-by-bunch feedback on both vertical and horizontal plans



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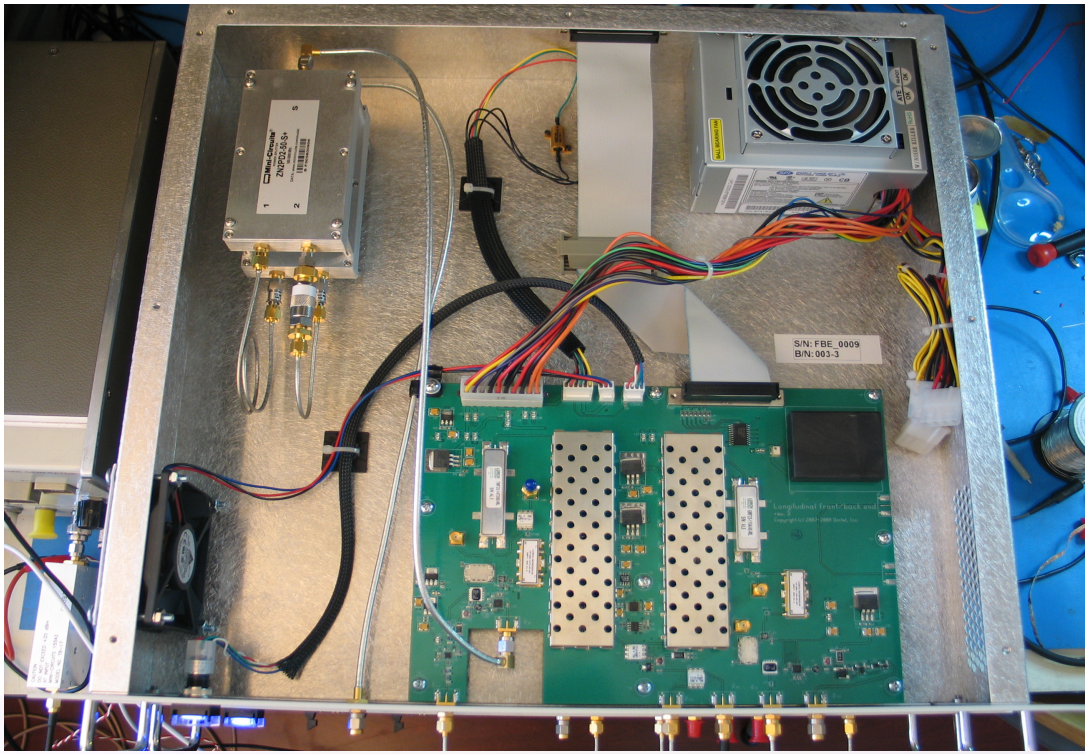
Summary feb0711
==========

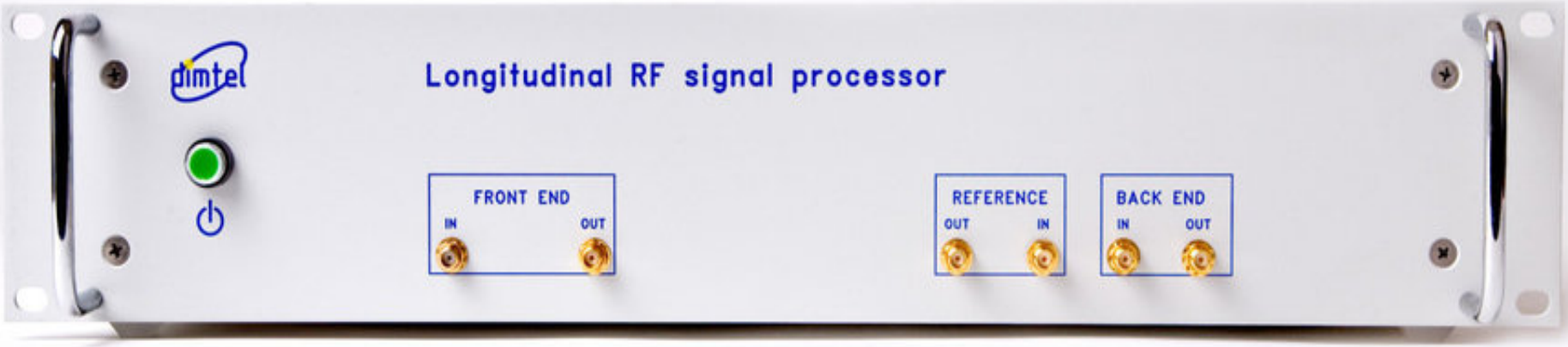
file	V/H	Ib(mA)	kick	turns	ms	counts	mm
161945	V	12	0.2ms	19300	6.28	474	2.63
162548	V	8	0.4ms	30700	10	635	5.29
163338	V	4.5	0.5ms	38000	12.37	418	6.19
163923	V	4	0.4	40000	13	418	6.97
170303	H	7.5	12kv	325	0.1	46	1.37
172246	H	2.6	12kv	1000	0.35	49	4.2
172740	H	7	9kv	1200	0.4	128	4 [saturated!!!]
172951	H	6.2	7kv	925	0.3	128	5.5 [saturated!!!]
173216	H	5.5	5kv	1200	0.39	108	4.36

Longitudinal frontend / backend analog module

Very simple and compact front panel:

It is mainly analog but it can be programmed in the basic functionalities by EPICS panel and through a digital flat cable connection with the iGp12 module (having a pc inside)





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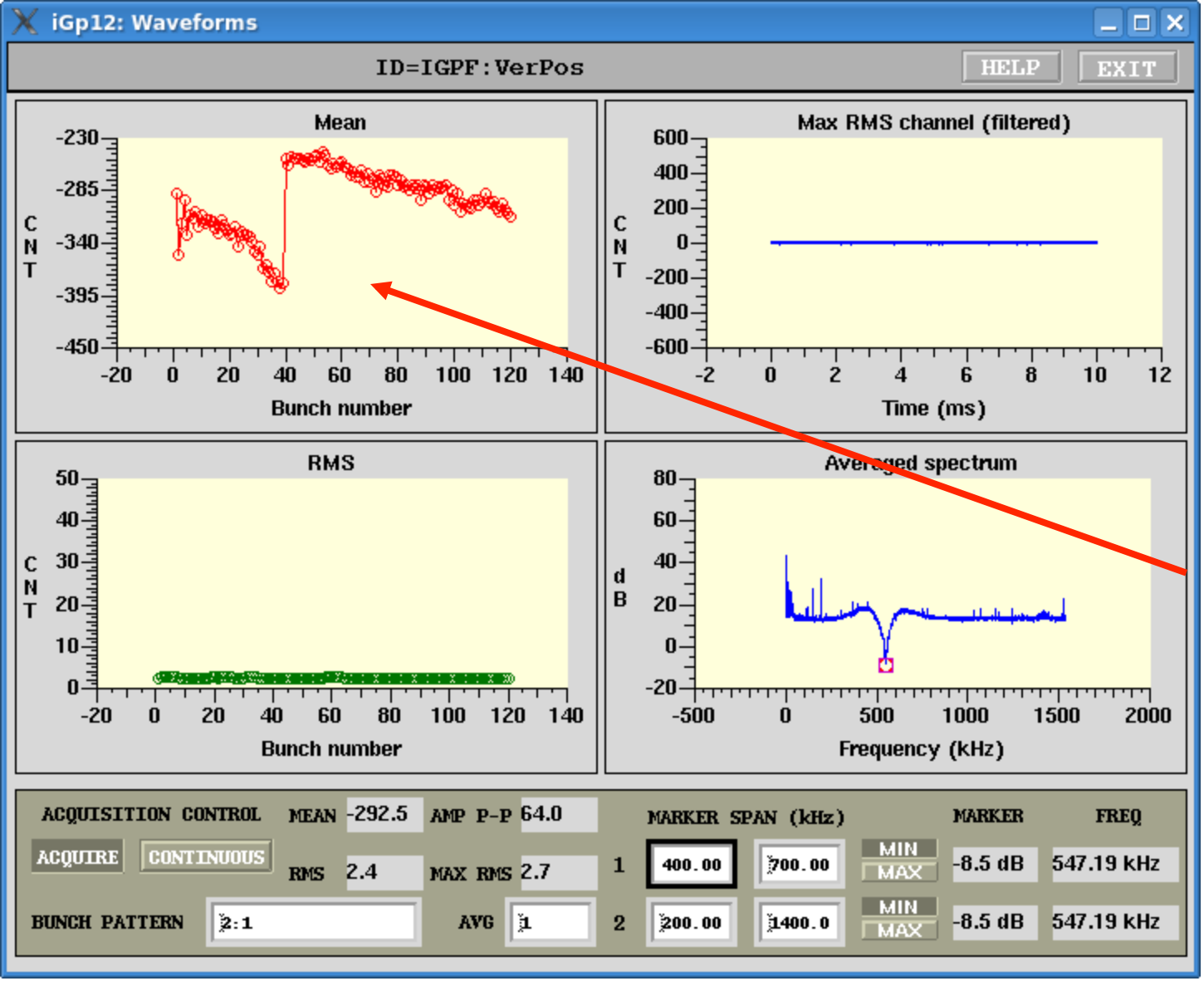
```
5   limit_val_n= -80;  % typ. -80
6   step=1;
7   secondi=10;
8   while (1)
9     % ********************* LFBEle ******************************
10    display('checking LFB e- FE saturation');
11    [mean_val,tim_stamp]=lcaGet('IGPF:LFBEle:MEAN');
12    max_val=max(mean_val)
13    min_val=min(mean_val)
14    att_val=lcaGet('IGPF:LFBEle:FE_ATTEN')
15    %
16    % check if front-end is too attenuate
17    if ((max_val > limit_val_p) && (att_val >.5) )
18        att_val=att_val-step
19        lcaPut('IGPF:LFBEle:FE_ATTEN',att_val)
20    end
21    %
22    % check if front-end is not enough attenuate
23    if ((min_val < limit_val_n) && (att_val < 30.5) )
24        att_val=att_val+step
25        lcaPut('IGPF:LFBEle:FE_ATTEN',att_val)
26    end
27    % ********************** LFBEPos ****************************
28    display('checking LFB e+ FE saturation');
29    [mean_val,tim_stamp]=lcaGet('IGPF:LFBPos:MEAN');
30    max_val=max(mean_val)
31    min_val=min(mean_val)
32    att_val=lcaGet('IGPF:LFBPos:FE_ATTEN')
33    %
34    % check if front-end is too attenuate
35    if ((max_val > limit_val_p) && (att_val >.5) )
36        att_val=att_val-step
37        lcaPut('IGPF:LFBPos:FE_ATTEN',att_val)
38    end
39    %
40    % check if front-end is not enough attenuate
41    if ((min_val < limit_val_n) && (att_val < 30.5) )
42        att_val=att_val+step
43        lcaPut('IGPF:LFBPos:FE_ATTEN',att_val)
44    end
45    display('.....waiting some seconds..... ');
46    pause(secondi);
47  end
```

script Ln 1 Col 1 OVR

Using the new frontend, a very simple routine has been written in last Febrary (using Matlab & EPICS) to control the input signal saturation and, in the case, to modify the FE setup. This program has been tested in DAFNE runs for long time without any troubles this year.



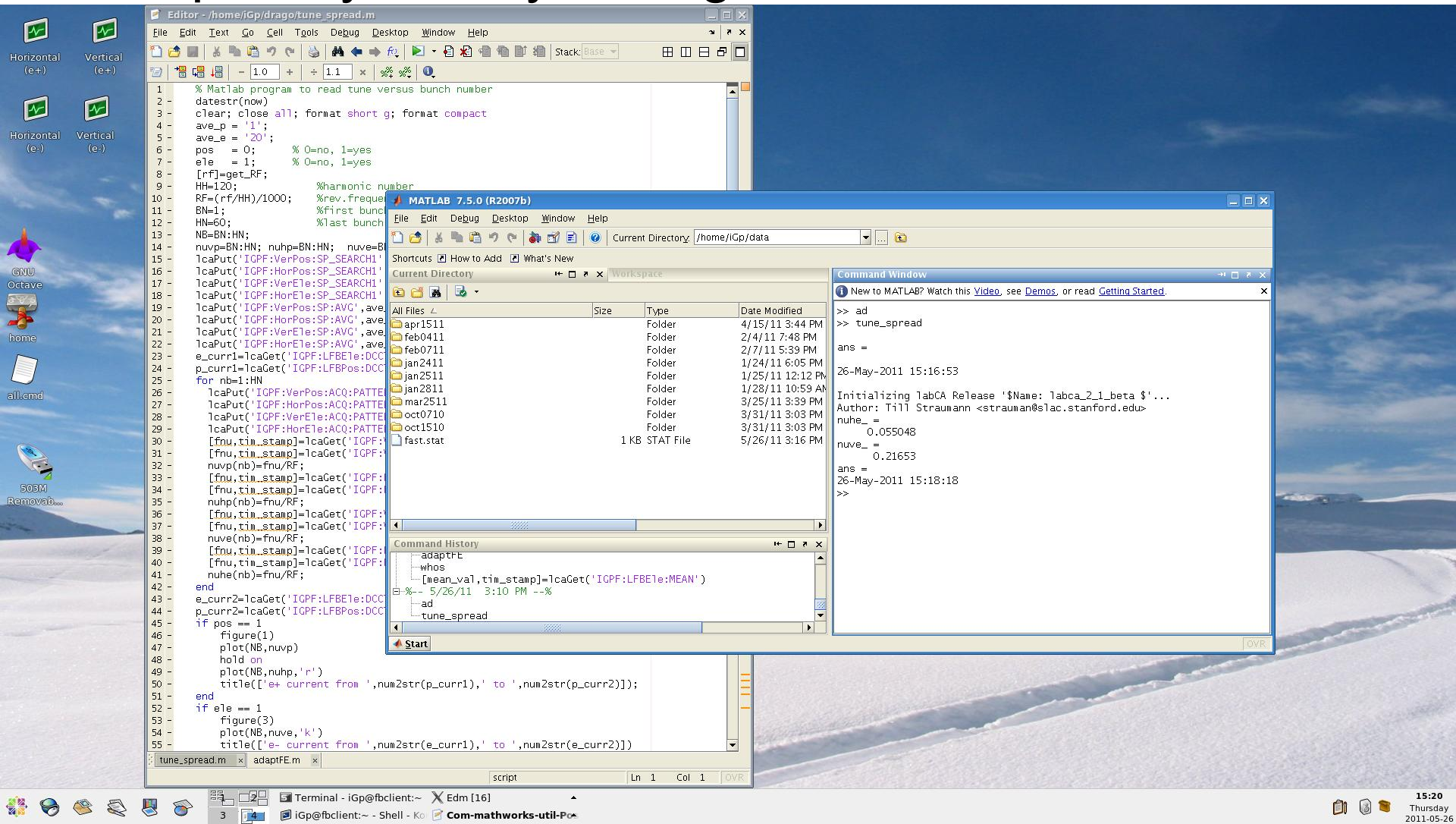
The iGp12 performance are clearly better than the previous system in terms of dynamic range and internal memory

A bunch pattern (or a single bunch) selection can be used (by a dedicated external program) to plot the bunch-by-bunch tune spread and the gap transient

Beam diagnostics

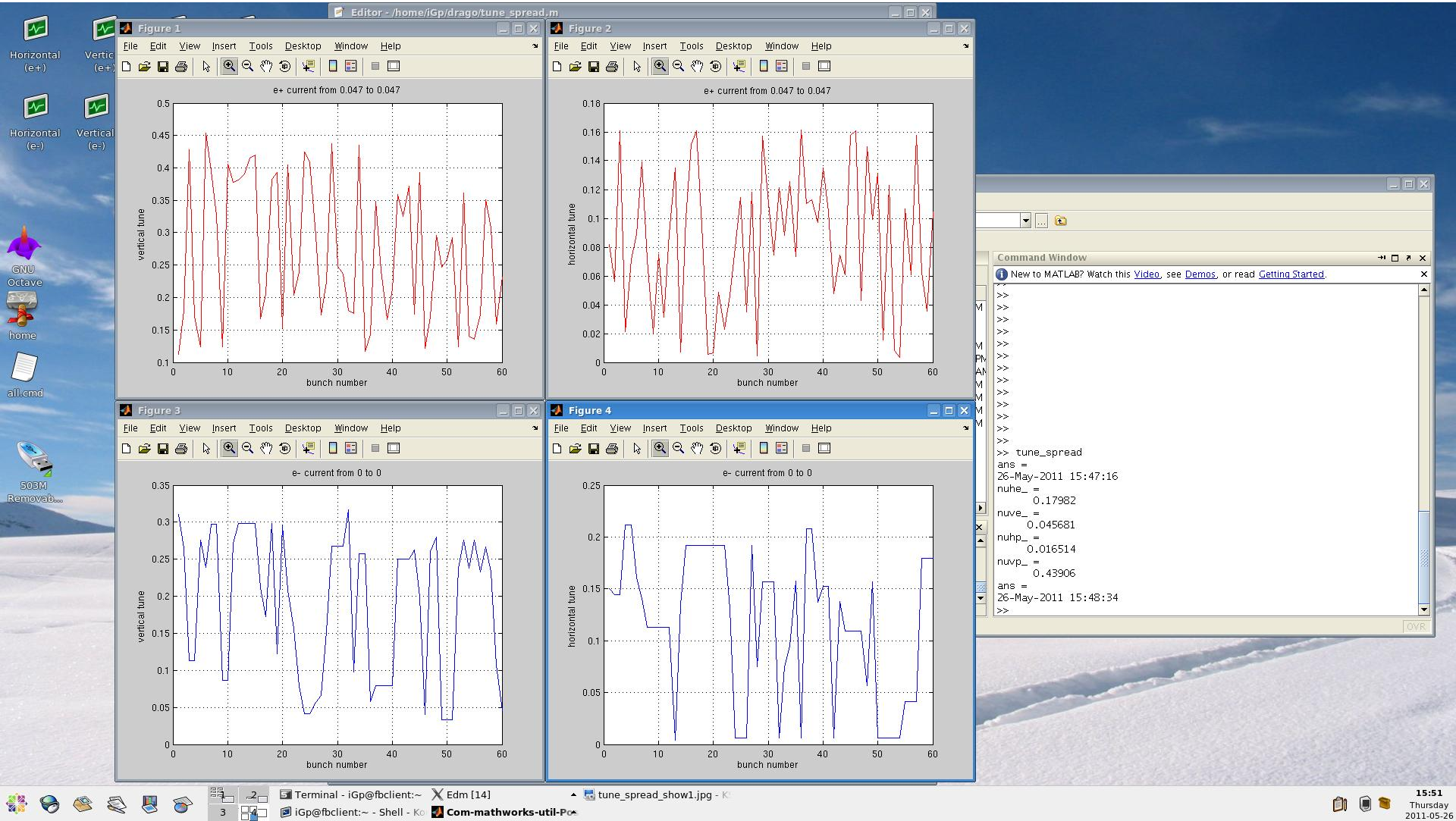
Tune spread measurements:

this is done using the bunch-by-bunch feedback capability and by writing a Matlab/EPICS routine



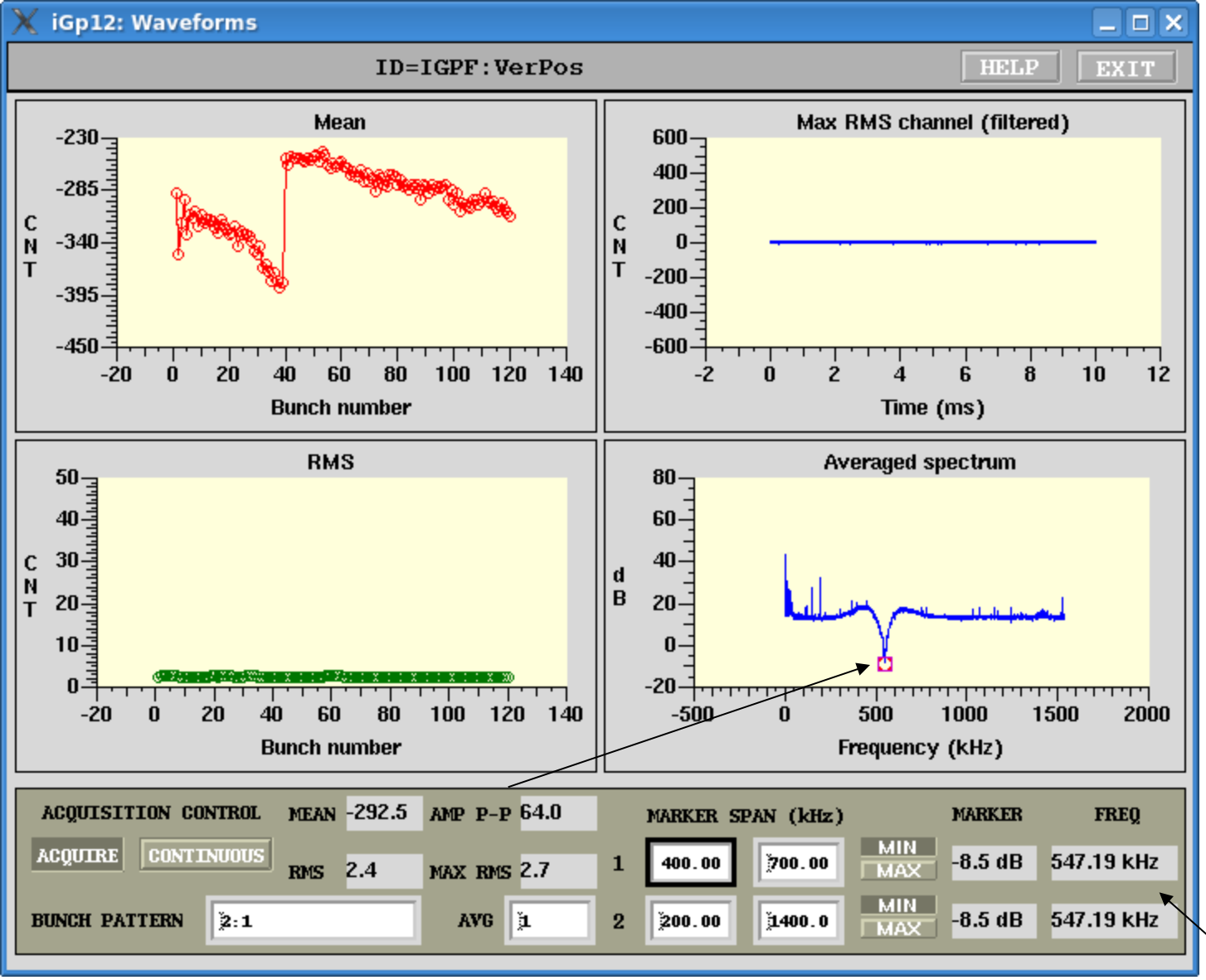
Tune spread (fake results in this case):

the tune spread analysis works in the four oscillation planes (H+,V+,H-,V-) without stopping the feedback regular functions



Tune Monitor and Tune Feedback

- PEP-II used downconversion in a mixer, followed by:
  - A spectrum analyzer
  - A phase-locked loop, with single-frequency excitation and detection by a lock-in amplifier
- Both should be good for SuperB
- Direct Diode Detection (or “barbeque”, for Baseband Q), now used for LHC protons, is very sensitive
  - Can measure the tune of a single bunch without driving the beam.
- Tune feedback
  - Tune spectrum in collision is too wide for a single value
  - Need a “pilot” (noncolliding) bunch
    - Unstable when colliding tune is just above 0.5
    - Must shake the pilot to raise its tune above the half integer



The iGp12 processing unit can be used to implement tune feedback systems that don't need a pilot bunch out of collision with excitation.

The marker value gives in real time the betatron oscillation frequency that can be exported to implement easily a tune feedback

Betatron tunes (also in collision) from bunch-by-bunch feedbacks

Transverse front end

- This analog module still has to be designed
- A preliminary scheme is under study in collaboration with KEK expert (Makoto Tobiyama).
- A first version of the hardware (coming from Japan) is at LNF lab, and it is ready to be tested as soon as possible.
- It should be completed with programmable digital parts and interface
- This new front-end could be a base for an engineered version to be designed together with KEK for the SuperKEKB

Conclusions

- New betatron and synchrotron bunch-by-bunch feedback systems have been succefully tested at DAFNE this year.
- The upgrade consists in using 50% bit more in conversion (8 ➔ 12), in having more memory available for data tracking, in having much more powerful FPGA with more DSP inside and, last but not least, a perfect software compatibility with the previous systems
- Three applications have been developed or are in progress with minimum manpower and efforts.
- In particular a tune feedback could be easily implemented using the internal iGp12 diagnostics
- Tranverse frontend unit is still in a preliminary design phase in collaboration with KEK.