

# New Feedback Commissioning

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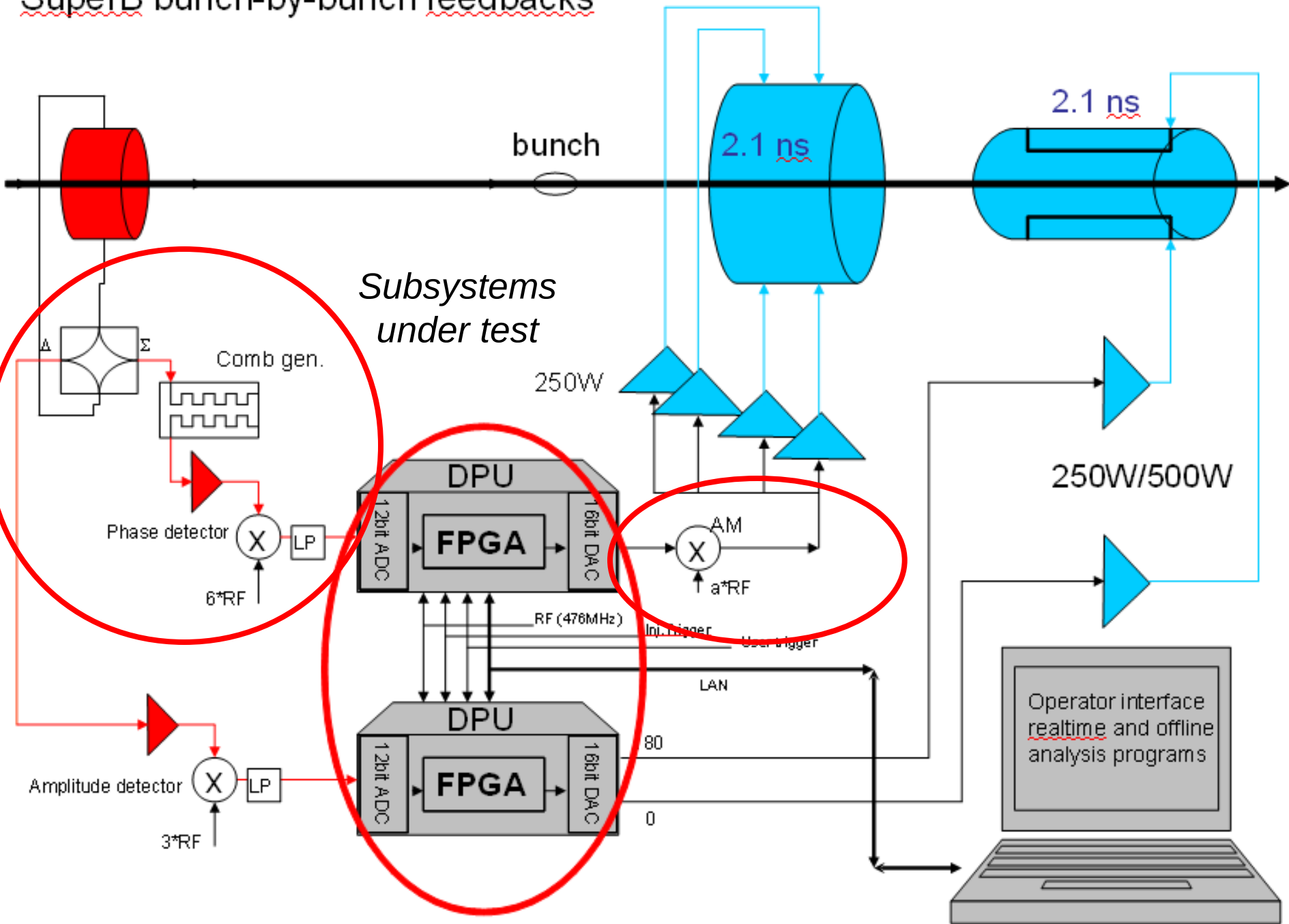
XV SuperB General Meeting - Caltech, Dec/14-17/2010



# Introduction

- This talk is focused on description and first results on commissioning of the new bunch-by-bunch feedback units installed in last month (Nov/2010) at DAFNE.
- In the **vertical** planes of the main rings, two iGp-12 have been installed at the place of the 8-bit [previous version] iGp feedback units
- iGp-12 is the last version of SLAC/KEK/DAFNE iGp feedback system, engineered by Dimtel, Inc., upgraded to 12-bit ADC (analog-to-digital converter), 12-bit DAC (digital-to-analog converter) and with a newer and more powerful FPGA (Xilinx Virtex-5) as digital core unit and a new software revision
- Briefly all the new features together are able to offer larger dynamic range and to give more powerful and flexible real time transfer functions
- In the **horizontal** plane the iGp-8 units have been upgraded to the last software and gateway version - compatible with most recent LINUX (CentOs 5.5) used by the EPICS server (also upgraded)
- About the **synchrotron** feedbacks, new front-end/back-end units have been installed together with the upgraded iGp-8 units
- So for the old longitudinal feedback systems, developed in 1993-1996, in collaboration with SLAC and ALS, the game should be over !

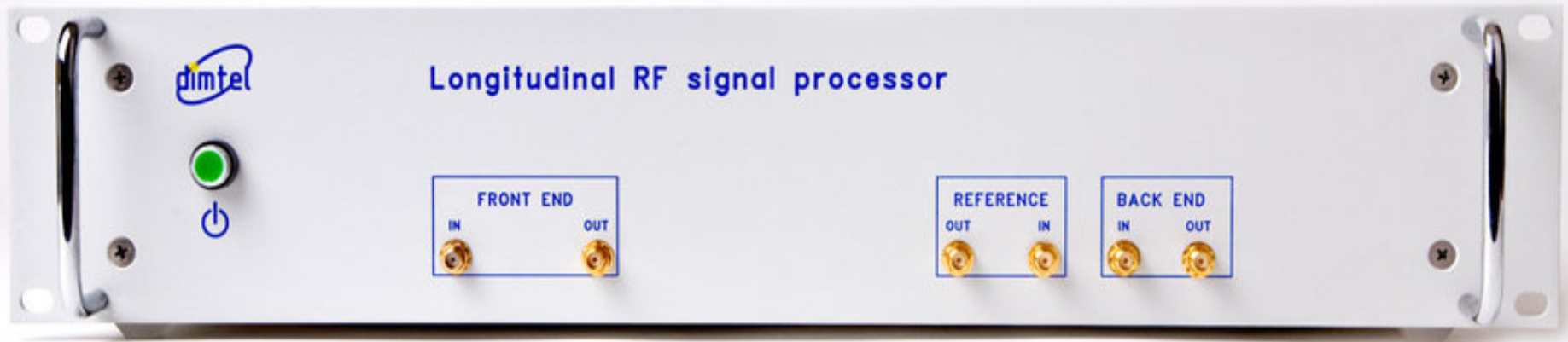
# SuperB bunch-by-bunch feedbacks



# Longitudinal front end / back end analog module

Very simple front panel:

- analog front end input and output
- clock in and out
- analog back end signal input and output



In rear panel: power supply and 68-pin signal cable used as bus for command & data from/to iGp unit

A look to FE/BE unit inside: two taps comb filter @  $4 \times \text{RF}$   
(four taps @  $6 \times \text{RF}$  for the previous system) -  
no more QPSK in backend – just amplitude modulation

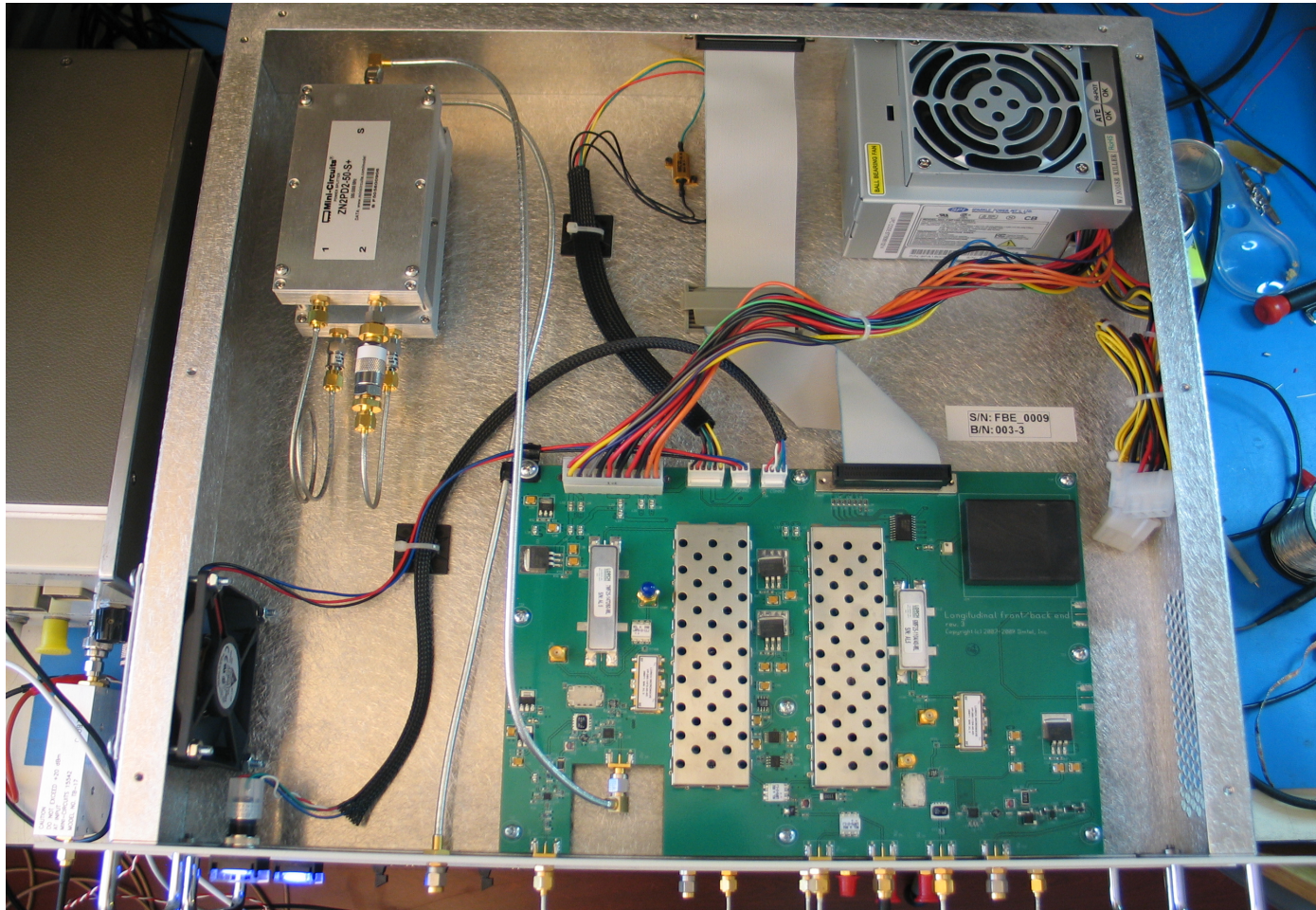


TABLE 1. ELECTRICAL SPECIFICATIONS

MODEL NO.	FREQ. RANGE (MHz)	ISOLATION (dB)		INSERTION LOSS <sup>1</sup> (dB)		PHASE UNBALANCE (Degrees)	AMPLITUDE UNBALANCE (dB)	VSWR (:1)		CASE STYLE	PRICE \$ Qty. (1-9)
		Typ.	Min.	Typ.	Min.	Max.	Max.	S Typ.	OUT Typ.		
ZN2PD2-50	500-5000	25	15	0.8	1.4	4	0.5	1.2	1.1	VVVB45	74.95
	600-1600	24	17	0.7	1.1	2	0.3	1.2	1.1		
	1600-2700	26	18	0.8	1.2	3	0.3	1.2	1.1		
	2700-3600	28	19	0.9	1.3	3	0.4	1.2	1.1		
	3700-4800	22	18	0.9	1.4	4	0.5	1.2	1.1		
ZN4PD1-50	500-5000	23	13	0.9	1.8	8	0.6	1.3	1.1	UU846	99.95
	500-1600	23	15	0.7	1.4	4	0.6	1.3	1.1		
	1600-2700	23	17	0.8	1.4	7	0.6	1.3	1.1		
	2700-3600	22	16	1.1	1.7	7	0.6	1.3	1.1		
	3700-4800	22	14	1.2	1.7	8	0.6	1.3	1.1		

<sup>1</sup> Theoretical Insertion Loss: 2-way, 3.0 dB; 4-way, 6.0 dB

ZN4PD1-50  
INSERTION LOSS

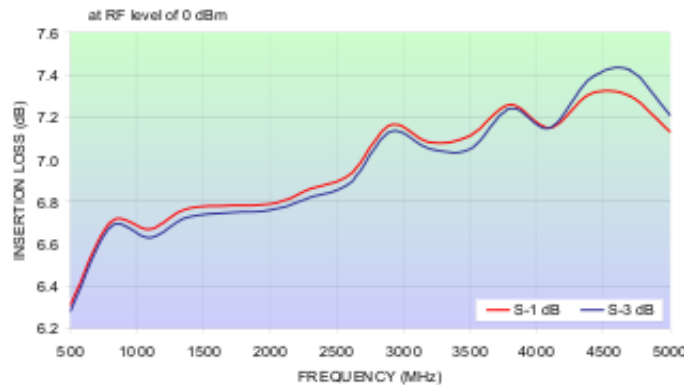


Fig. 3  
ZN4PD1-50  
ISOLATION

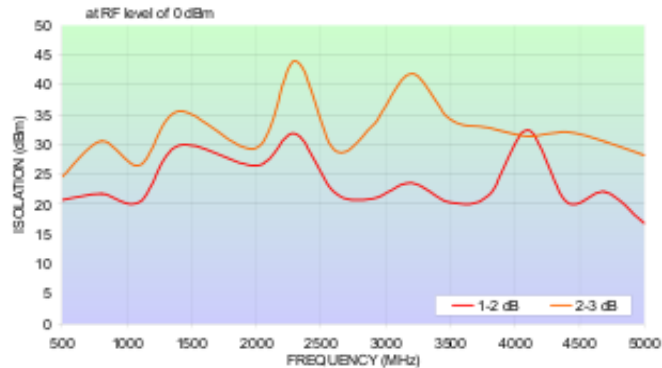


Fig. 4

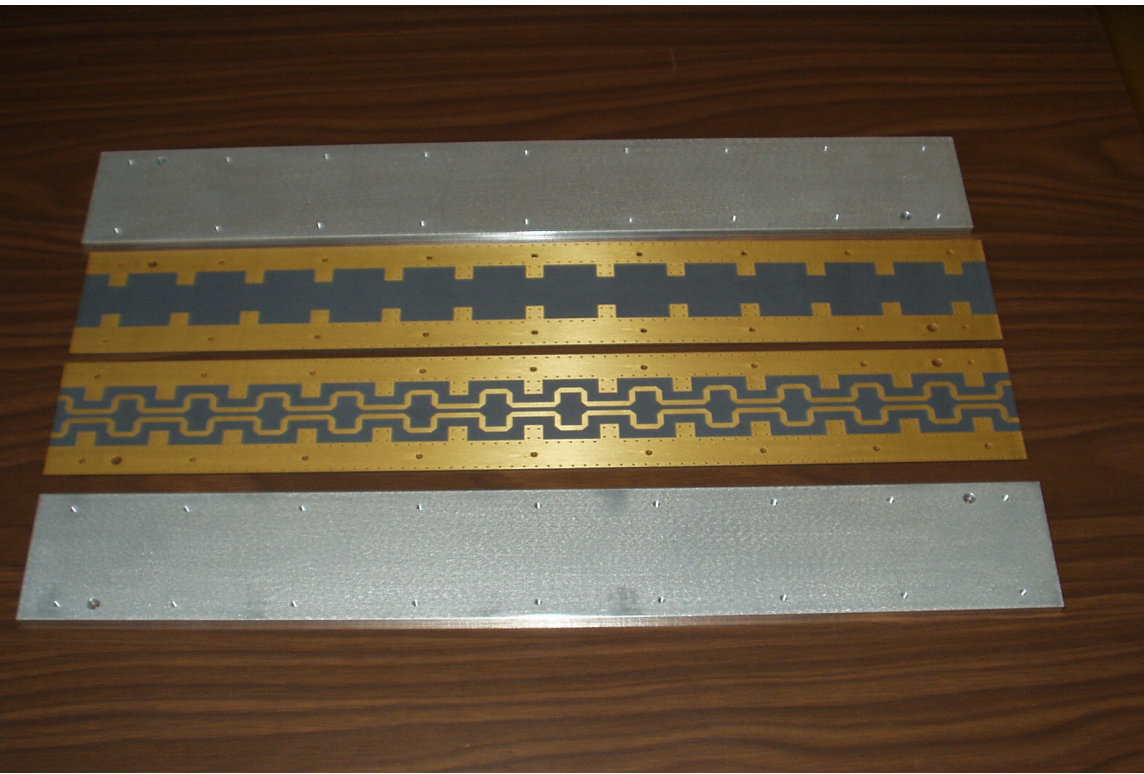
2 taps front end comb filter is made using cables and power splitter/combiners.

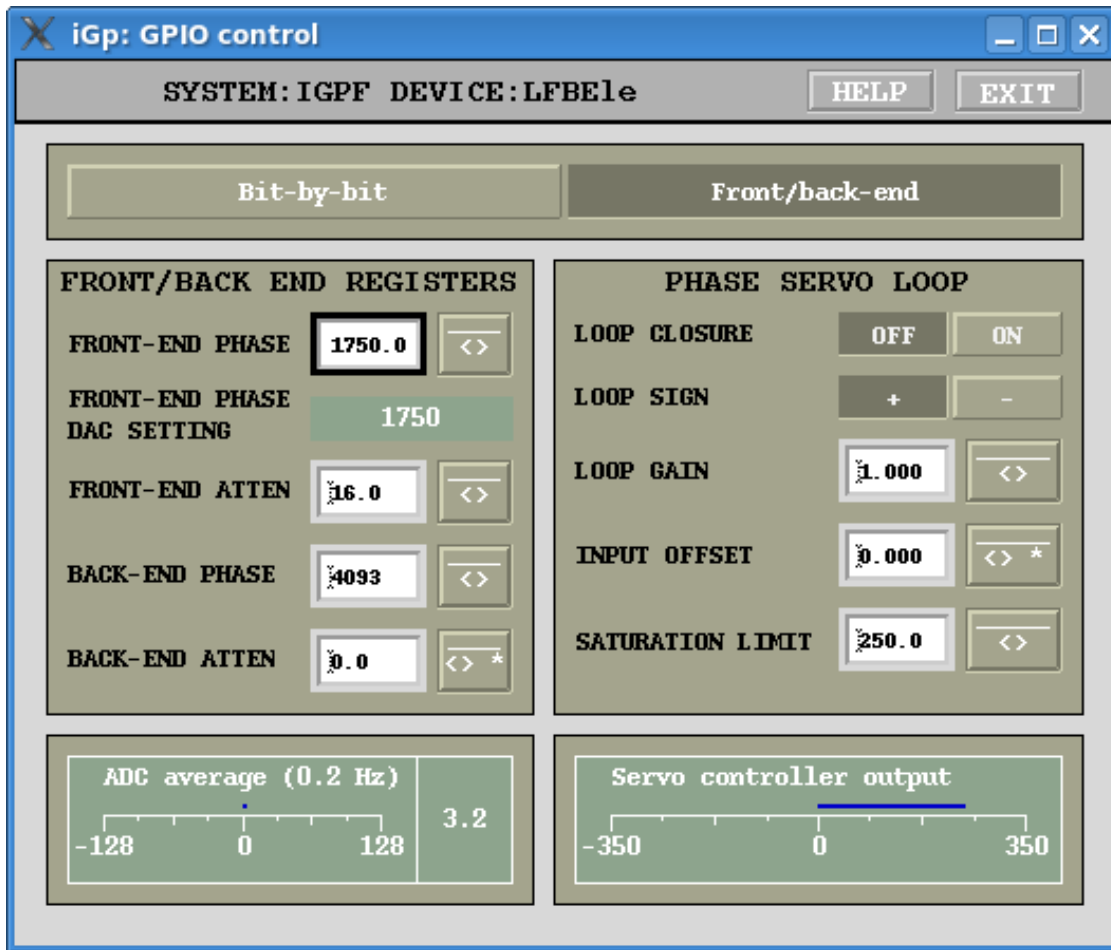
These are the ZN2PD2-5-S+ by Minicircuit offering 25 dB isolation.

This solution is much simpler and cheaper than the previous approach based on custom stripline circuit as in the next slide

# Comb filter example (13 taps)

This technology was used in the previous versions of longitudinal front end analog stage and it is not very flexible (any change asks for a complete new design! )





This is the control panel to command the analog unit. It is possible to modify:

- I) FE phase
- II) FE attenuation
- III) FE servo-loop
- IV) BE phase
- V) BE attenuation

The front end servo-loop is a feature that can be very useful at high beam current but for now it does not seem to be necessary



# Comment on front end / back end unit

- Phase shifter and signal attenuation for both FE and BE have large ranges giving very good flexibility to the system
- It has been tested up to 1.060 A beam current
- It is necessary to test this device with higher currents ( $\sim 2\text{A}$ ) to be sure that the crosstalk between adjacent bunches is within specification [ for now the vacuum in DAFNE is poor and beam currents are still limited by saturation in injection]
- In the back-end analog part, the bucket separation seems of the order of 30 dB – measuring it in single bunch mode by spectrum analyzer – to be investigated if this will be enough at high currents

# iGp12

Very similar to the 8-bit previous version, front panel offers almost the same functionality:



- Fast positive & negative ADC input
- Timing & trigger (there is one more external trigger)
- Fast positive and negative DAC output
- Status LED

Here are shown the analog output level differences measured versus the shift gain applied to FIR filter - [both systems implement a 6 taps filter with gain = 1]

Sinusoidal input signal:  
100kHz, 50mVp

iGp12

Starts to be saturated with shift gain 2 (expected 680mV)

Shift gain 3 or more gives a strong saturation

iGp8

Stronger saturation starts with shift gain=0

**the effect of a larger dynamic range is evident !!!**

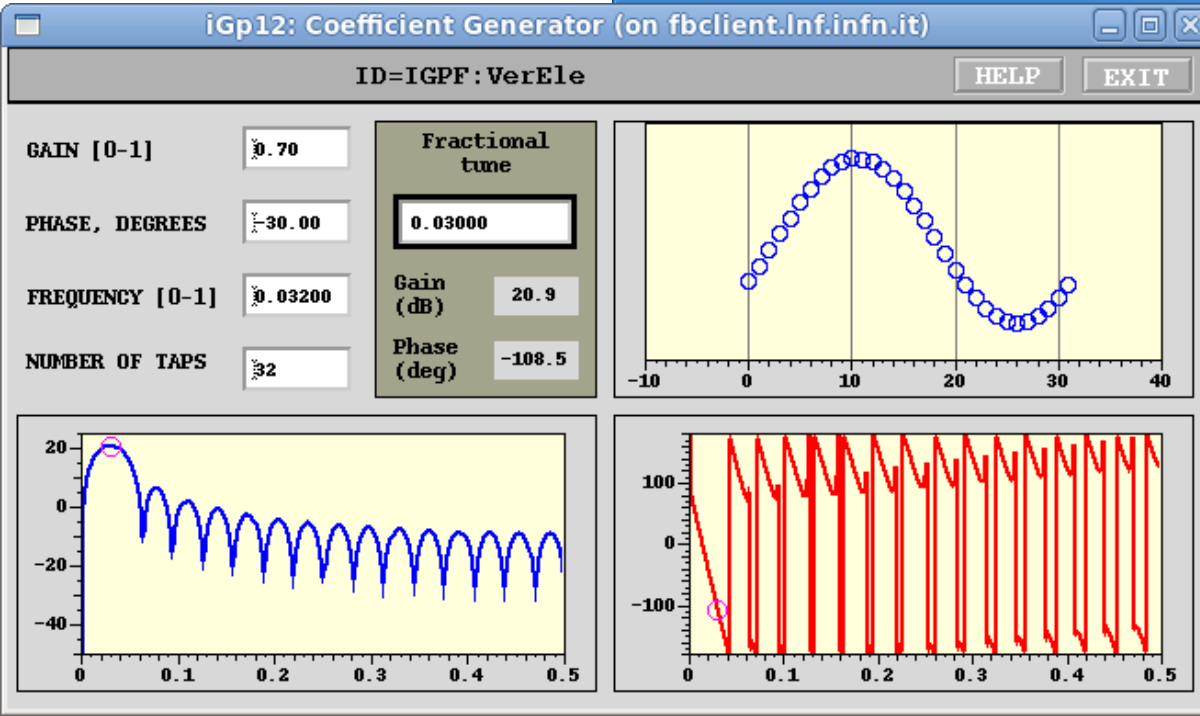
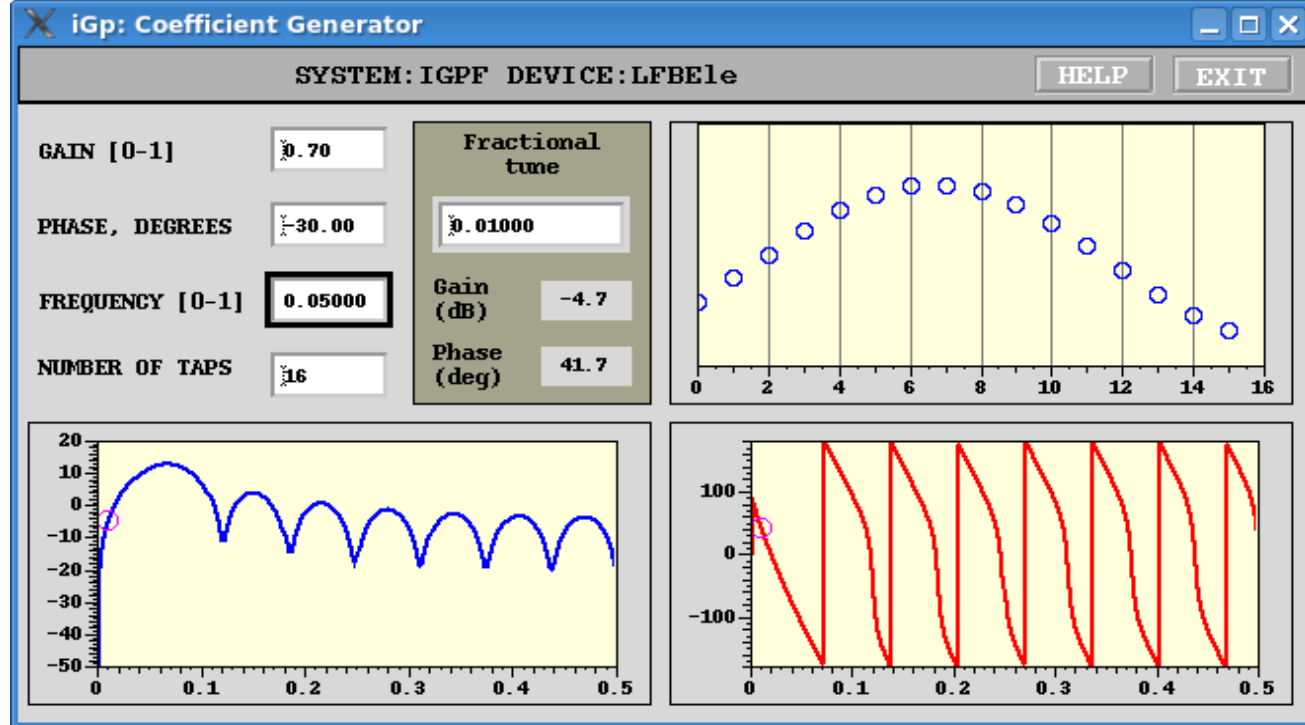
iGp12

170 mV	Shift gain = 0
340 mV	Shift gain = 1
650 mV	Shift gain = 2
700 mV	Shift gain = 3

iGp8

480 mV	Shift gain = 0
524 mV	Shift gain = 1
524 mV	Shift gain = 2
524 mV	Shift gain = 3

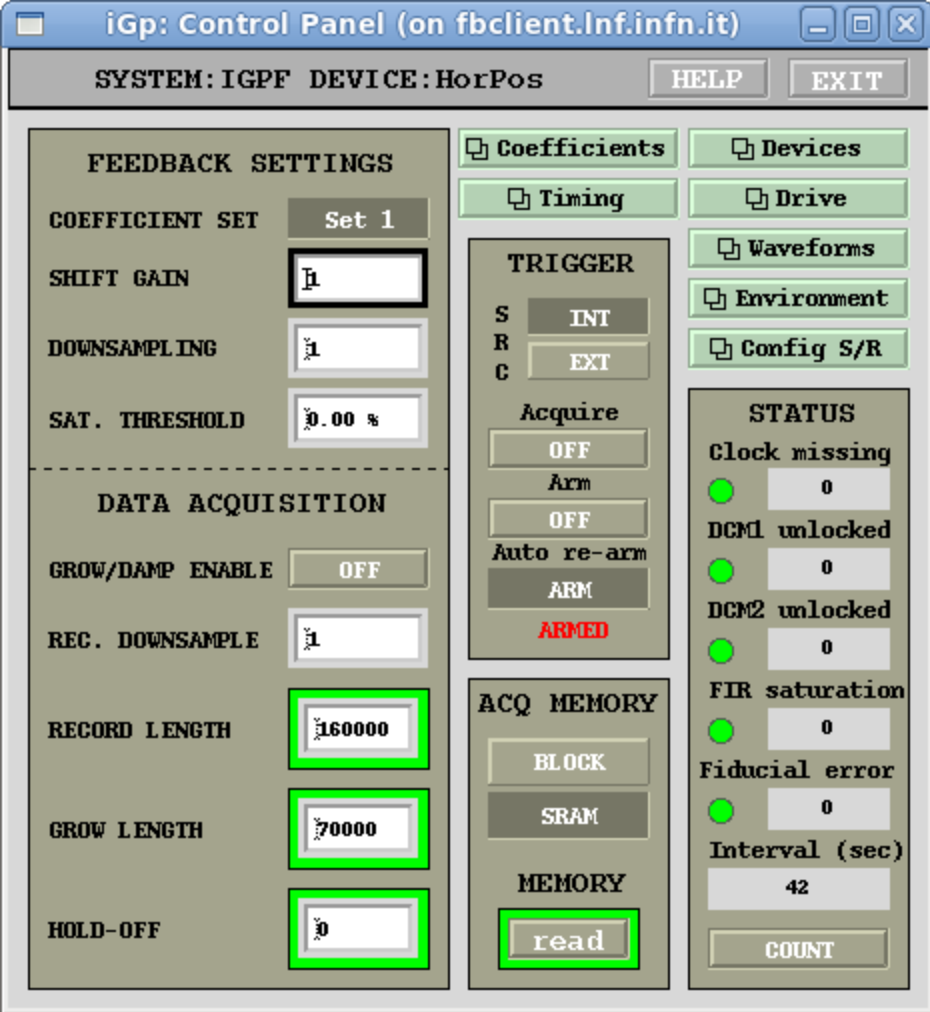
A larger number of filter taps is necessary in case of low frequencies or downsampling factor  $>1$  (i.e. longitudinal feedback)



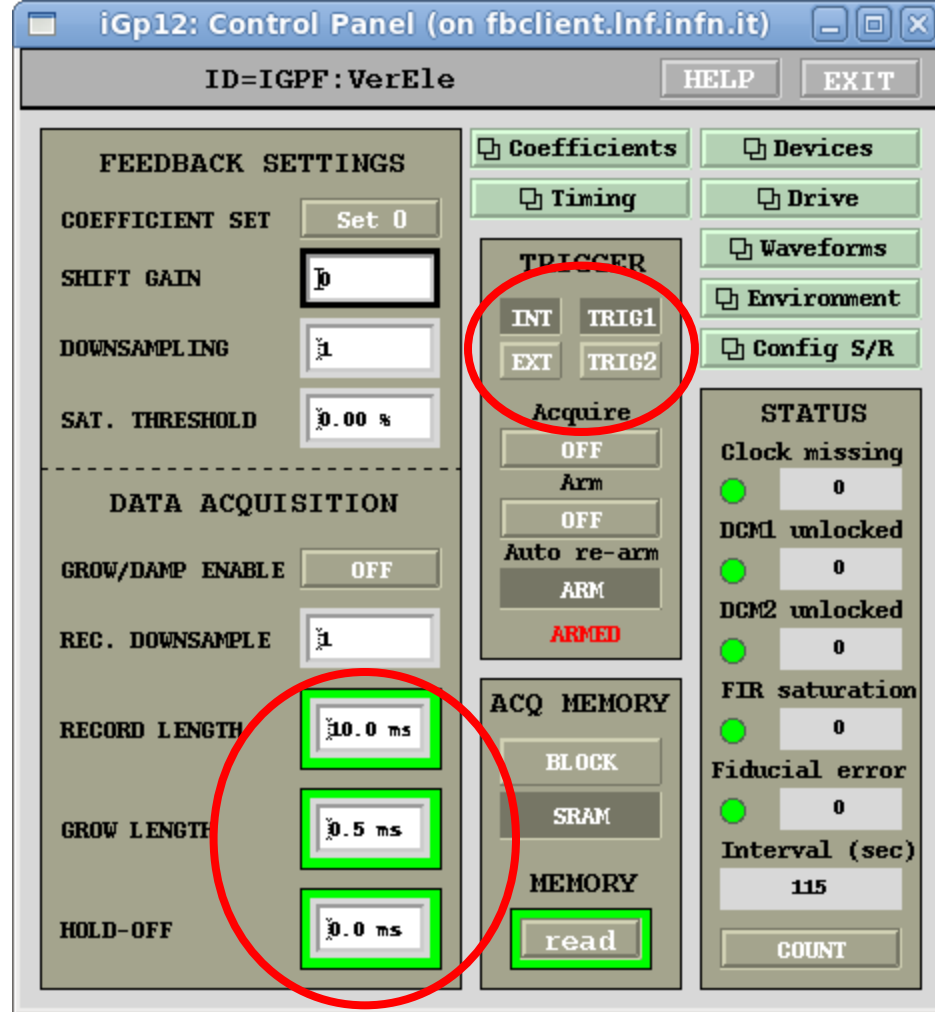
up: Filter with 16 taps (iGp8)

left: Filter with 32 taps (iGp12)

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



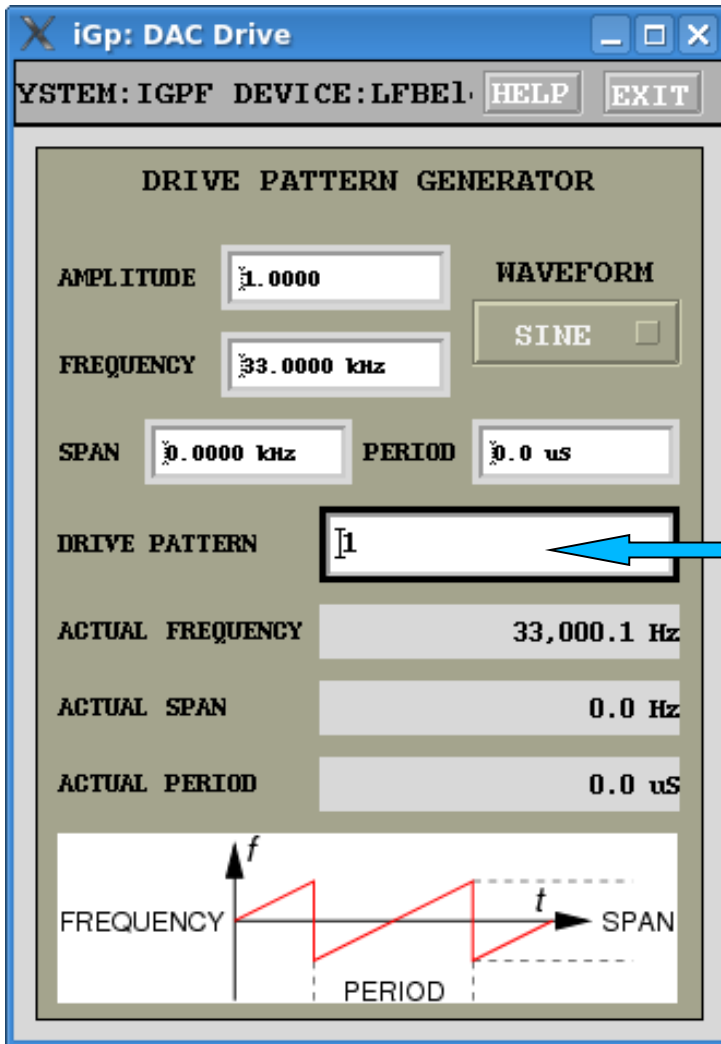
IGP8



iGp12

Other improvements in triggers and data length

# Output signals



Improvements in generation of drive signals, in both iGp12 and iGp8, allow now a fast and easy back-end timing in the trasverse or longitudinal systems without need of external generator and/or analog delay lines (by trombone or relays) even if digitally controlled

“Drive pattern” value selects the number of bunch or the bunch pattern that have to be driven by a sinusoidal excitation

# FIR transfer function choice

The screenshot shows the 'iGp: Coefficients' software interface. It features three panels for defining coefficient sets, each with a 'Description' field and a 'Generate' button. The first panel, 'NEW COEFFICIENTS VECTOR', has a description '[Gain=1.00;Phase=90.0;Freq=0.12;Taps=8]' and a 'Generate' button. The second panel, 'COEFFICIENT SET 0', has a description 'Gain=1.00;Phase=-100.0;Freq=0.12;Taps=8'. The third panel, 'COEFFICIENT SET 1', has a description 'Gain=1.00;Phase=90.0;Freq=0.12;Taps=8'. Below these is a 'FEEDBACK PATTERN' field containing '2:1' and a 'Bunch cleaning' button. At the bottom, there are 'TARGET SET' buttons for 'Set 0' and 'Set 1', and 'LOAD COEFFICIENTS' and 'VERIFY COEFFICIENTS' buttons. Three plots are shown on the right, each with a yellow background and a grid. The top plot shows blue circles, the middle plot shows red circles, and the bottom plot shows red circles. A blue arrow points from the 'FEEDBACK PATTERN' field to the bottom plot.

SYSTEM: IGPF DEVICE: HorPos

NEW COEFFICIENTS VECTOR

Description

[Gain=1.00;Phase=90.0;Freq=0.12;Taps=8]

Generate

COEFFICIENT SET 0

Description

Gain=1.00;Phase=-100.0;Freq=0.12;Taps=8

COEFFICIENT SET 1

Description

Gain=1.00;Phase=90.0;Freq=0.12;Taps=8

FEEDBACK PATTERN

2:1

Bunch cleaning

TARGET SET

Set 0

Set 1

LOAD COEFFICIENTS

LOAD

VERIFY COEFFICIENTS

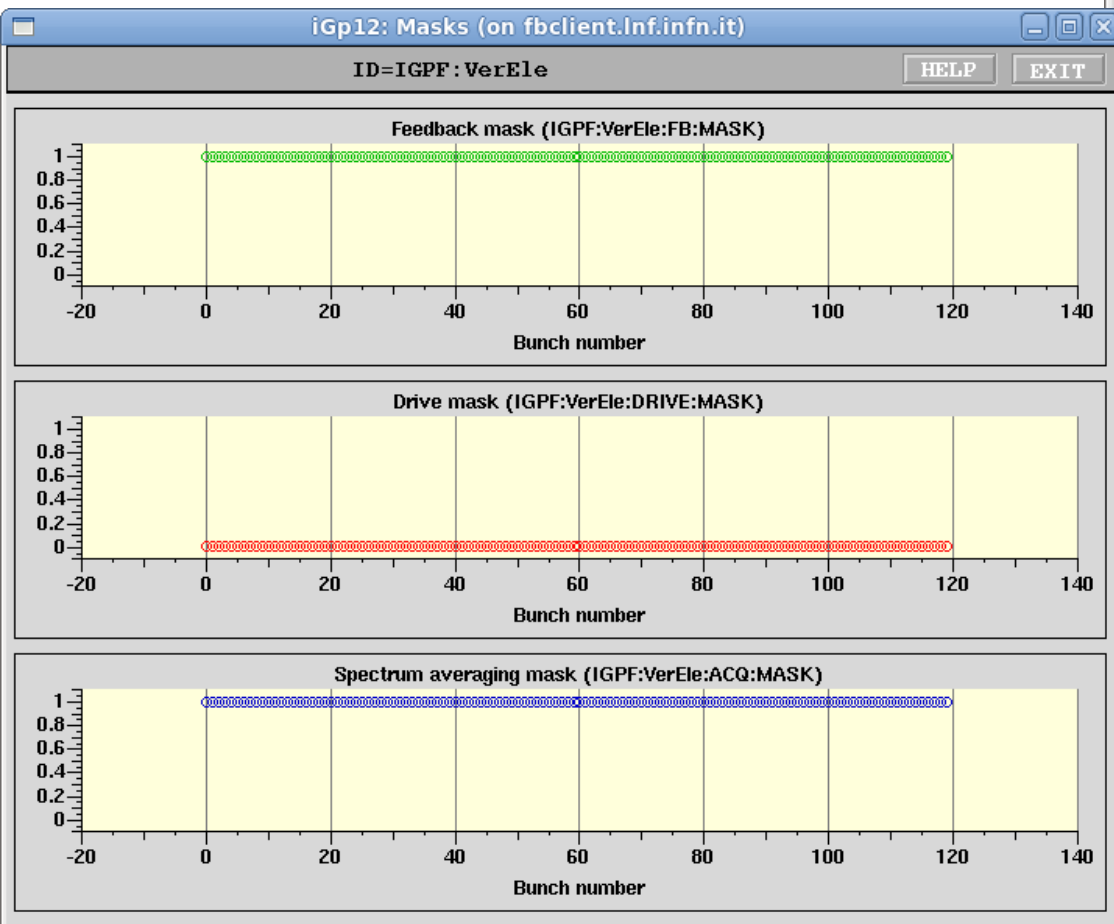
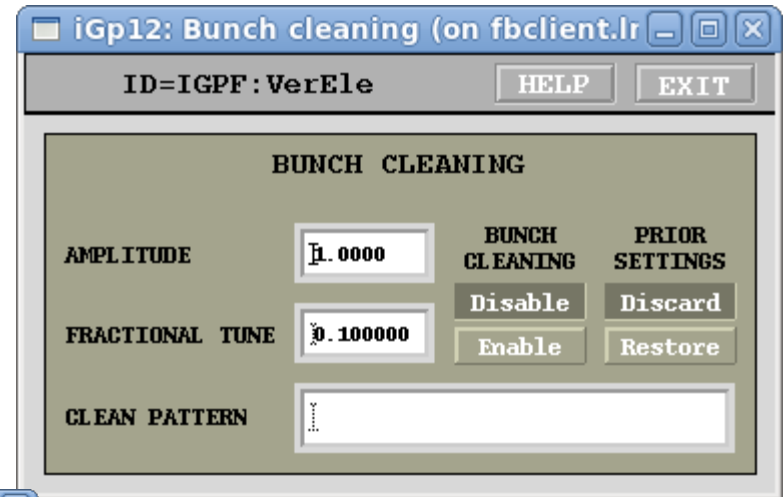
VERIFY

two different FIR filter (as in the previous version) that now can be applied or not applied to any bunch patterns

There is also a bunch cleaning function

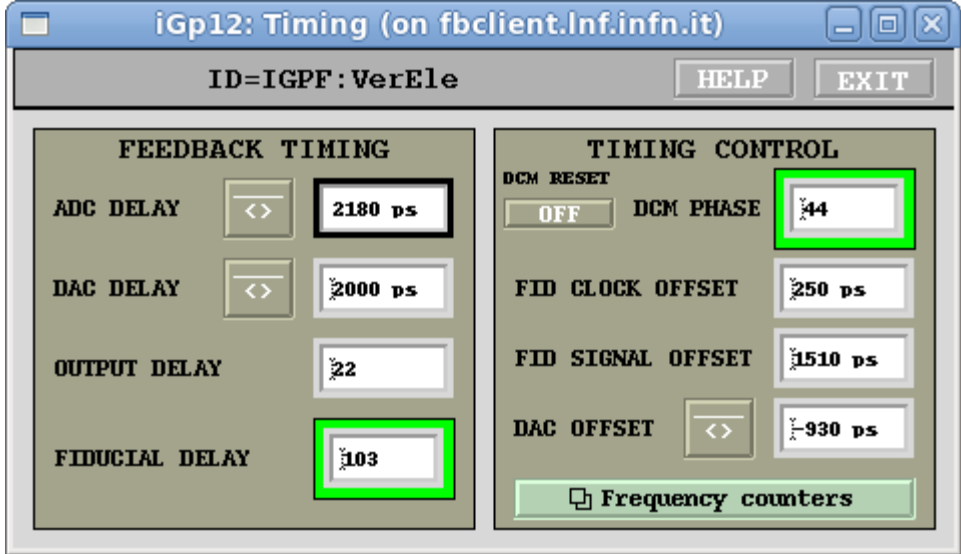
# Bunch cleaning

This new function can be used to “kick out” a specific bunch or bunch pattern

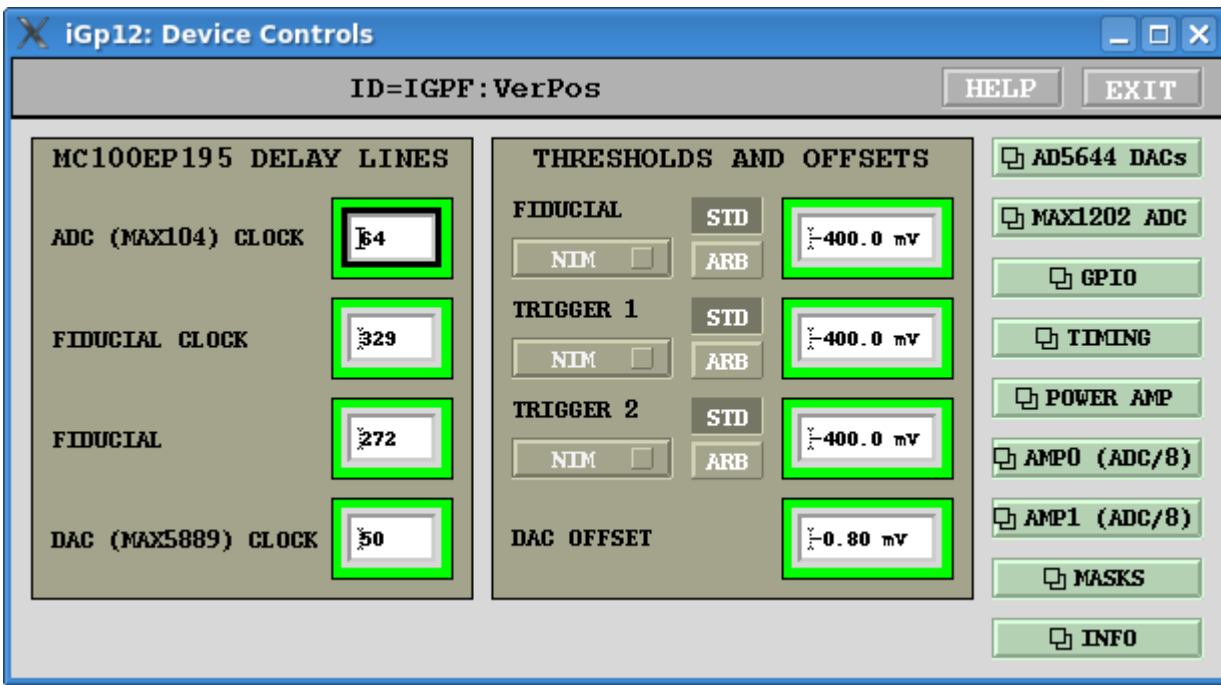


The panel “Masks” shows a summary of every bunch setup about feedback, drive and spectrum average





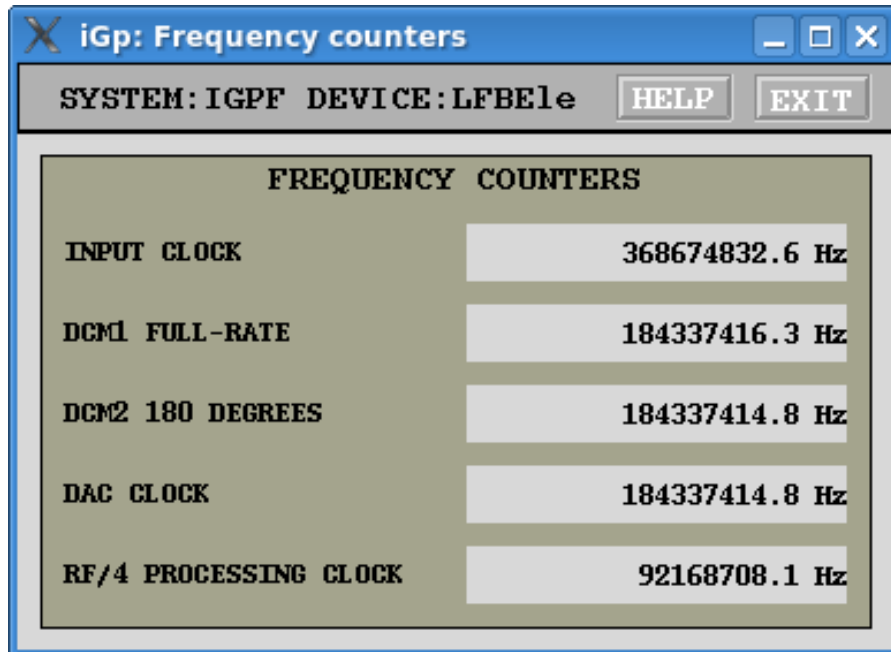
Delay can be set in picoseconds and the values act directly on ecl / pecl register 100EP195 avoiding to use more complicate devices that along the time can work badly



Variable trigger levels, with both positive and negative voltage and large choice:

- No dc
- NIM
- ECL
- LVPECL
- LVDS
- LVTTL
- TTL/2

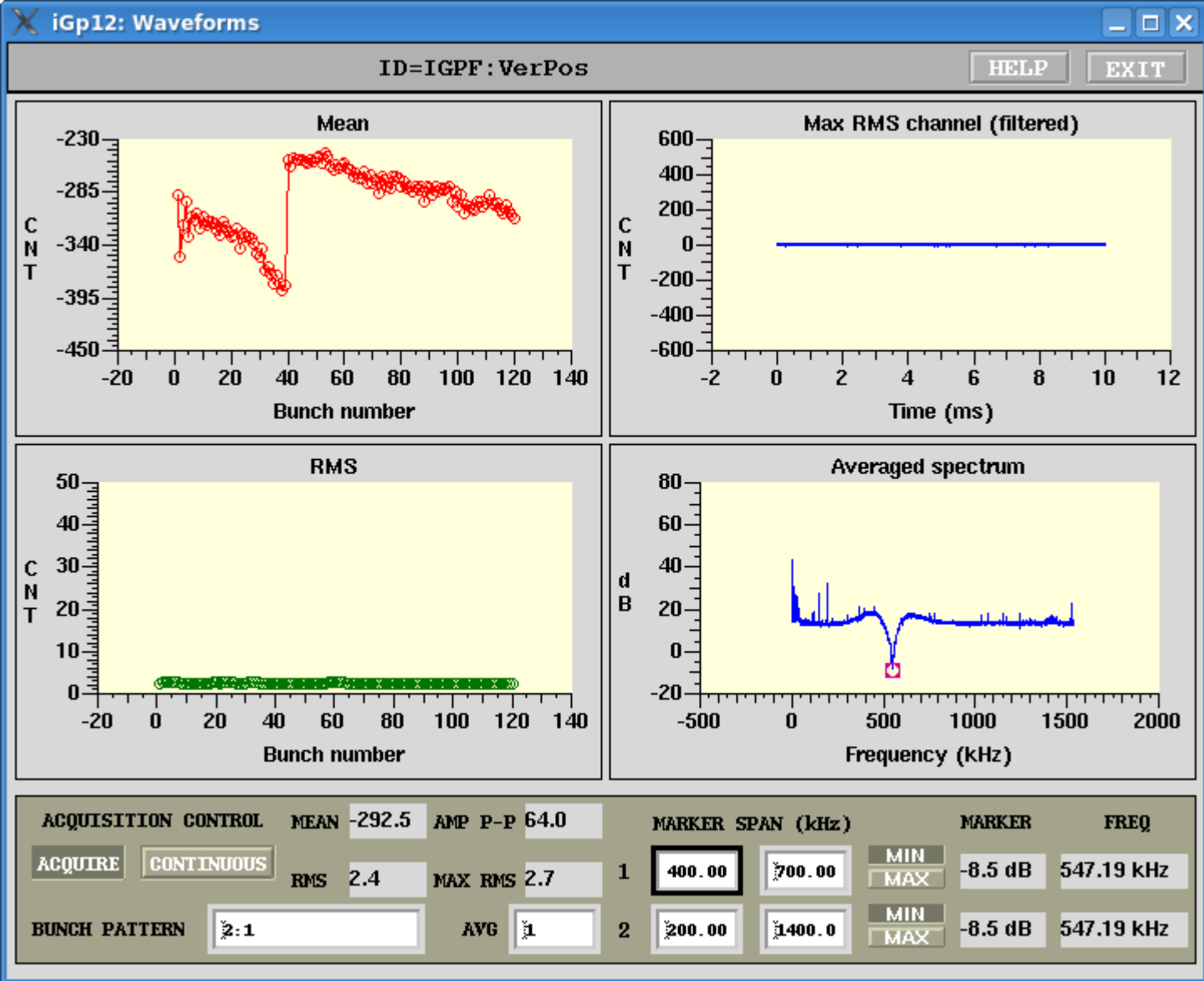
# Internal diagnostics



The screenshot shows a window titled "iGp: Frequency counters" with a system path of "SYSTEM:IGPF DEVICE:LFBEle". It contains a table of frequency counters with the following data:

FREQUENCY COUNTERS	
INPUT CLOCK	368674832.6 Hz
DCM1 FULL-RATE	184337416.3 Hz
DCM2 180 DEGREES	184337414.8 Hz
DAC CLOCK	184337414.8 Hz
RF/4 PROCESSING CLOCK	92168708.1 Hz

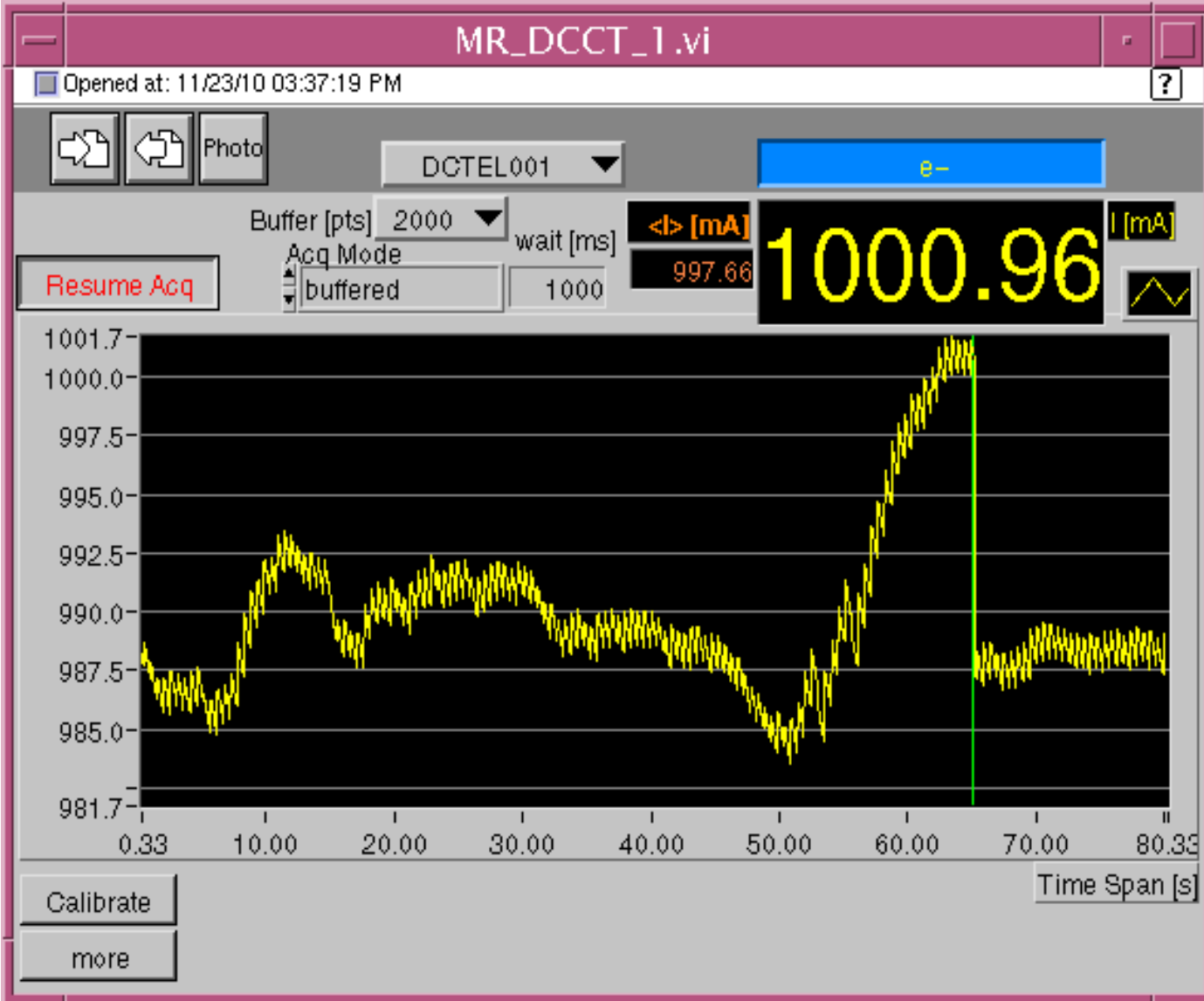
Reference clock diagnostics can show if the fpga or part of its code is not correctly running



The iGp12 performance are clearly better than the previous system

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

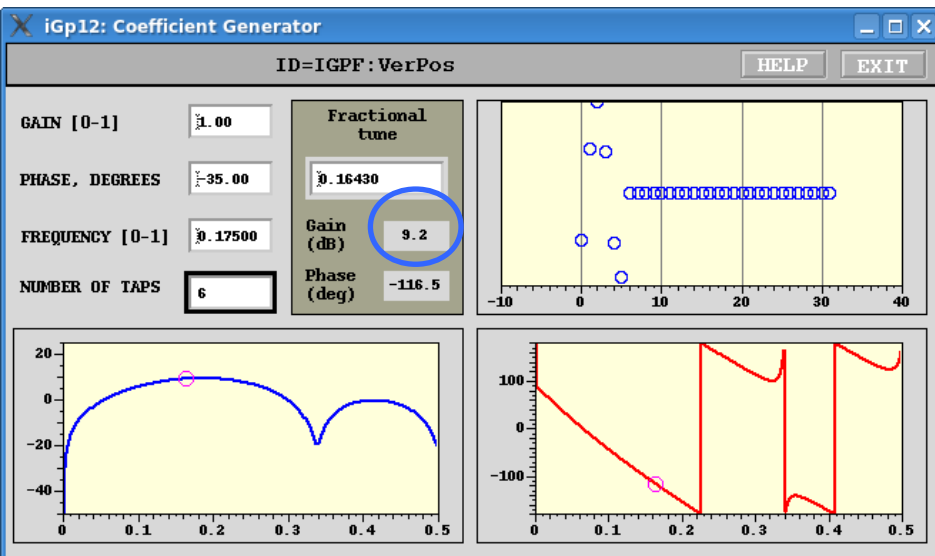
# Beam diagnostics



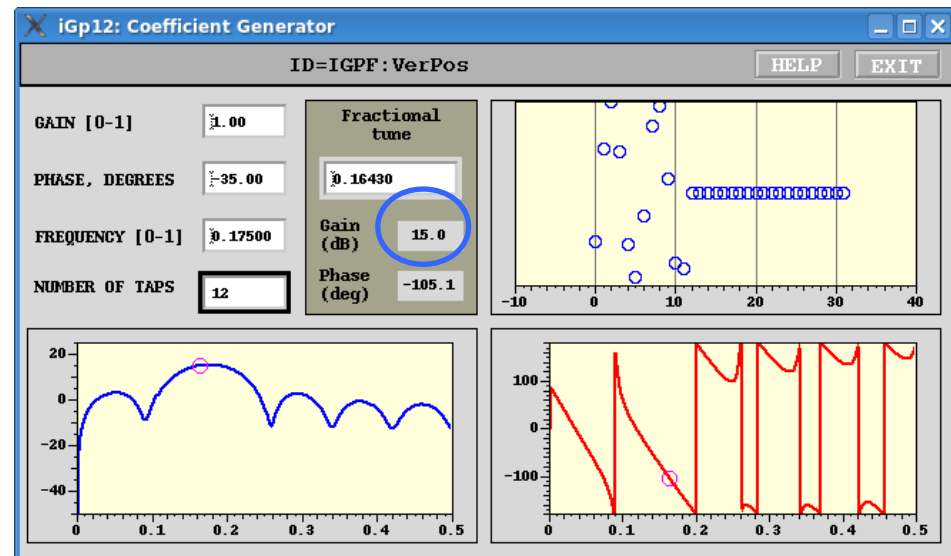
Electron beam current stored in November

# Experiment in progress @ DAFNE:

the goal is to see variations (in collision) on the vertical beam size using 2 filters with different quantization noise



6 taps FIR, shift gain=2



12 taps FIR, shift gain=1

The filter on the left has double quantization noise of the filter on the right, while the overall gain (for both transfer function) is 21 dB

The large dynamic range of iGp12 allows more flexibility than in the past

# Conclusions

- An upgraded version of iGp feedback system (with 12bit ADC, 12bit DAC and a more powerful FPGA) has been installed and tested with DAFNE beams in the last weeks.
- Looking at the previous feedback versions, there is a simplification in the hardware design and, on the contrary, an extremely sophisticated and powerful software design
- The operator interface is so rich to be even more difficult to be used by a “non-expert” operator
- Commissioning is going very well, nevertheless it cannot consider finished until DAFNE beams are still not at full regime [up to now this doesn't depend by the feedbacks]
- Studies on the effects on collisions given by feedback quantization noise are in progress
- It is proved that a larger dynamic range gives more flexibility to the system