Feedback Update

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2nd SuperB Collaboration Meeting

INFN-LNF, Frascati

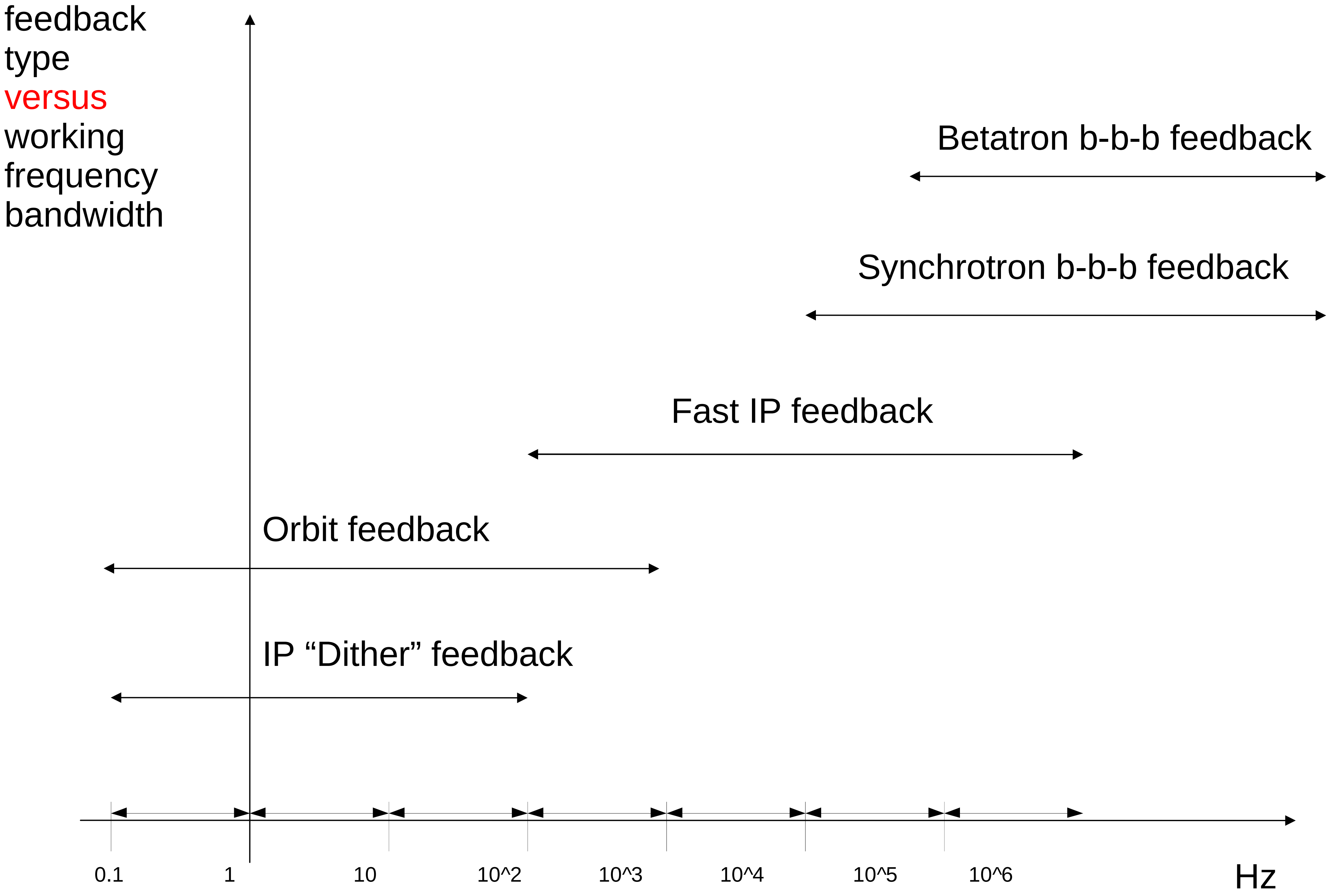
13-16 December 2011

Diagnostics for SuperB [from **Alan Fisher** talk, Annecy,10-03-17]

- Monitors:
  - Beam position
  - Beam profiles
  - Beam loss
  - Tunes
  - Total current
  - Bunch current
  - Luminosity
  - Polarization (LER)
- Measure/tweak in collision:
  - Coupling
  - Chromaticity
  - Phase advance
- Feedbacks:
  - Orbit
  - Luminosity *(=> Dither fb !)*
  - Tune
  - Transverse motion
  - Longitudinal motion
- Too much for 25 minutes
- Some are in other talks.
- Others are similar to PEP-II.
- I will concentrate on a few difficult issues.

Multiple feedback systems to maintain stable collisions

1) *Synchrotron bunch-by-bunch feedback* : it is used to maintain under control the longitudinal bunch-by-bunch motions (kicking each individual bunch in every turn)
2) *Betatron bunch-by-bunch feedback systems*: these are used to maintain under control the transverse bunch-by-bunch motions (kicking each bunch every turn in the vertical and horizontal planes)
3) *Tune feedback (eventually also chromaticity feedback)*
4) *Orbit feedback* (Libera or Libera–like based): it takes as reference a “golden orbit” for each ring and applies corrections using the “regular” corrector magnets
5) *IP “dither” feedback (or luminosity feedback)*: it should use 8 dedicated air-core coil correctors to generate orbit-bumps in 3 dimension (in just one of the two rings) at the IP - being based on the Luminosity monitor real-time data & tested in PEPii
6) *Fast IP feedback* : this system, in such a way inspired to FONT project (by JAI), is under study.


feedback type versus working frequency bandwidth
Betatron b-b-b feedback
Synchrotron b-b-b feedback
Fast IP feedback
Orbit feedback
IP "Dither" feedback
0.1
1
10
10^2
10^3
10^4
10^5
10^6
Hz

Betatron and synchrotron bunch-by-bunch feedback

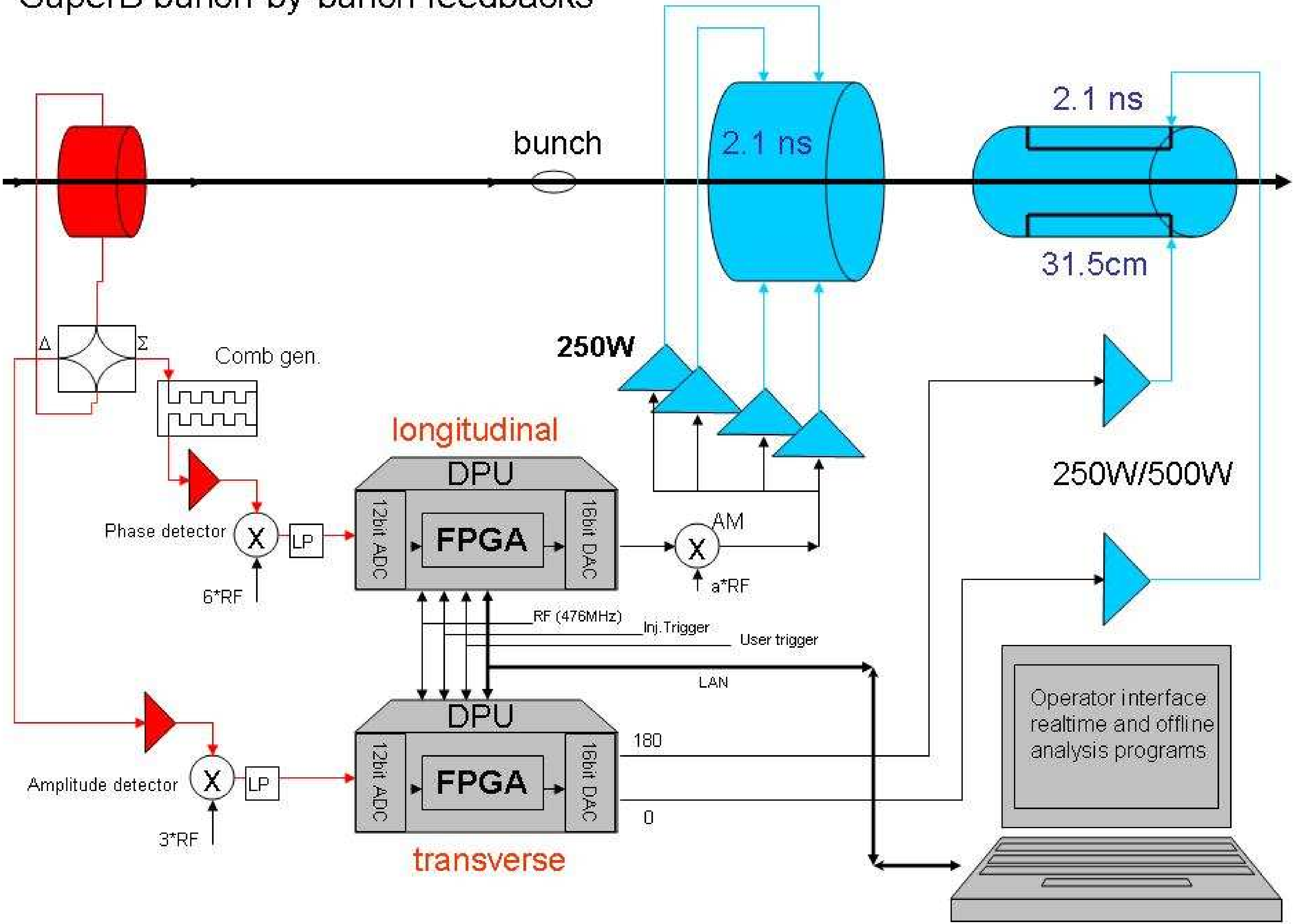
Given that bunch-bunch feedback is a device that is very difficult to be tested well without real cases, a strong R&D program has been carried on using DAFNE collider as test machine.

The first bunch-by-bunch digital feedback in DAFNE was developed in collaboration with PEP-II/SLAC and ALS/Berkeley in 1992-1996 and along the time this developing line was followed also with KEK.

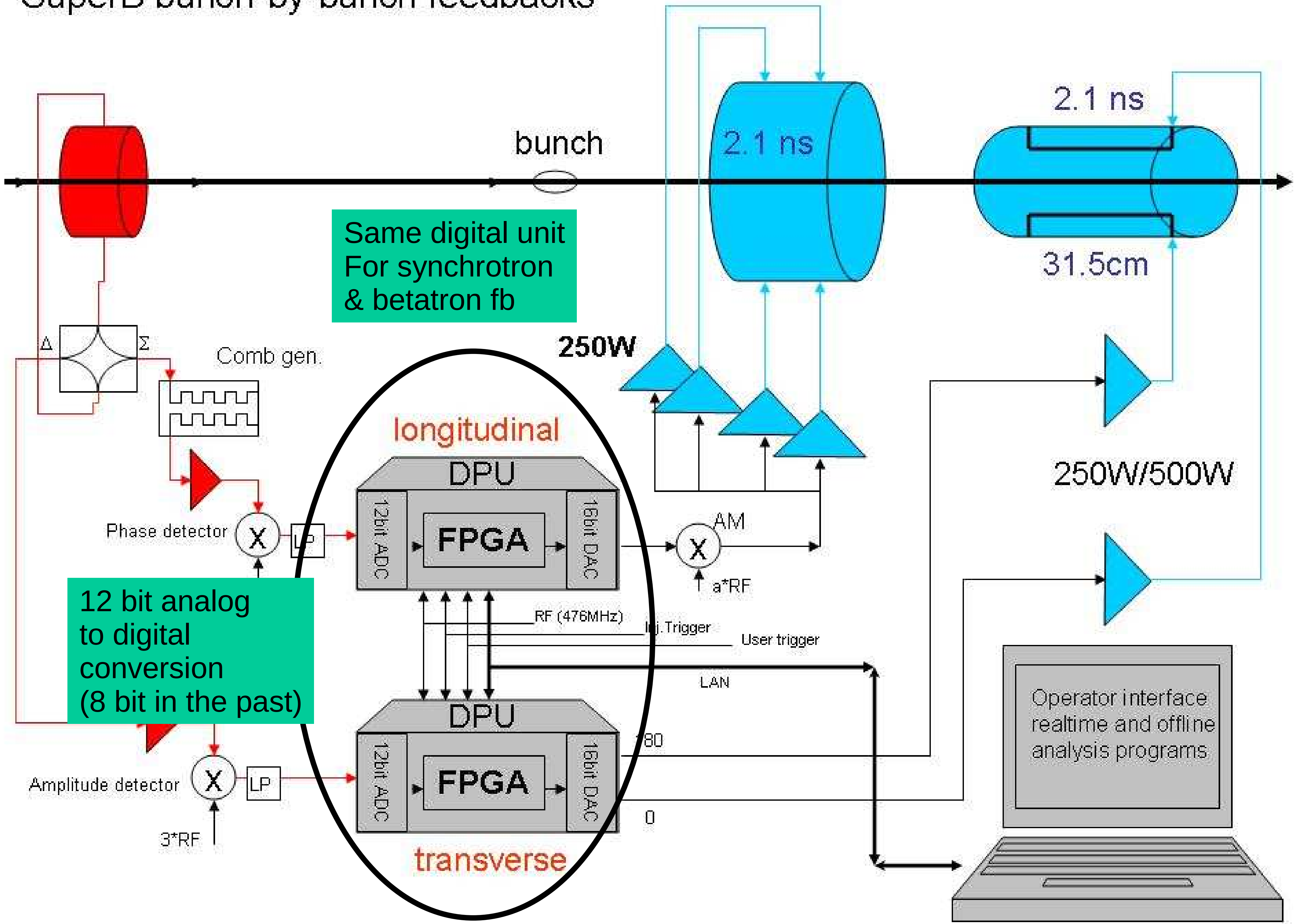
An updated version of feedback for SuperB has been thought having in mind the following main points:

- Legacy from the previous PEPii/DAFNE digital systems but upgrading at the same time the hardware & software parts to the current commercial releases
- Use only one system for betatron and synchrotron feedback to have a easier and better maintainability
- At least 12 bit analog to digital conversion to minimize quantization noise in the correction signals
- Cancellation or reduction of beam-beam enlargement effects due to the use of the feedback for a better compatibility with ultra low emittance
- Test on DAFNE beams of old and new powerful diagnostics features

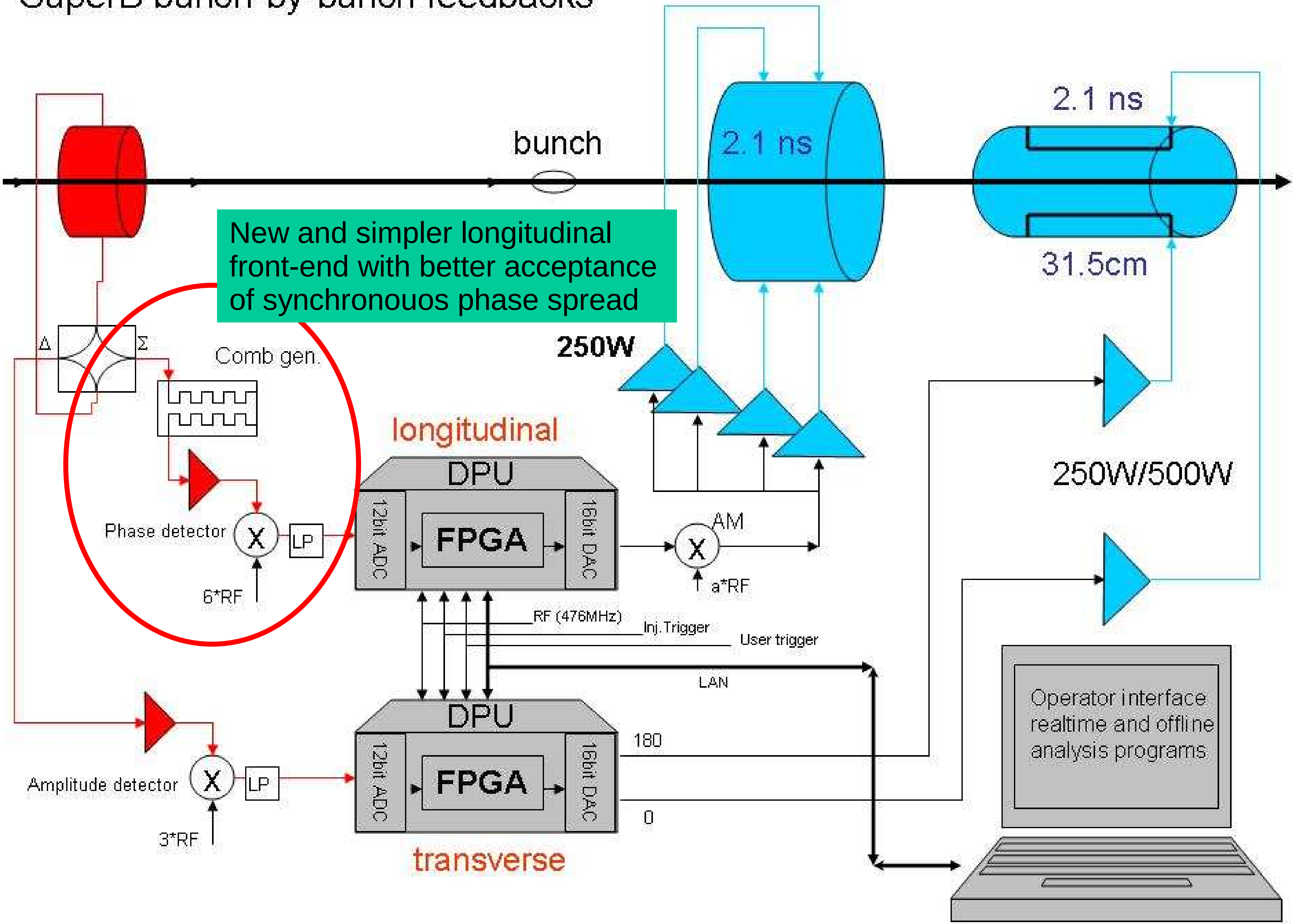
SuperB bunch-by-bunch feedbacks



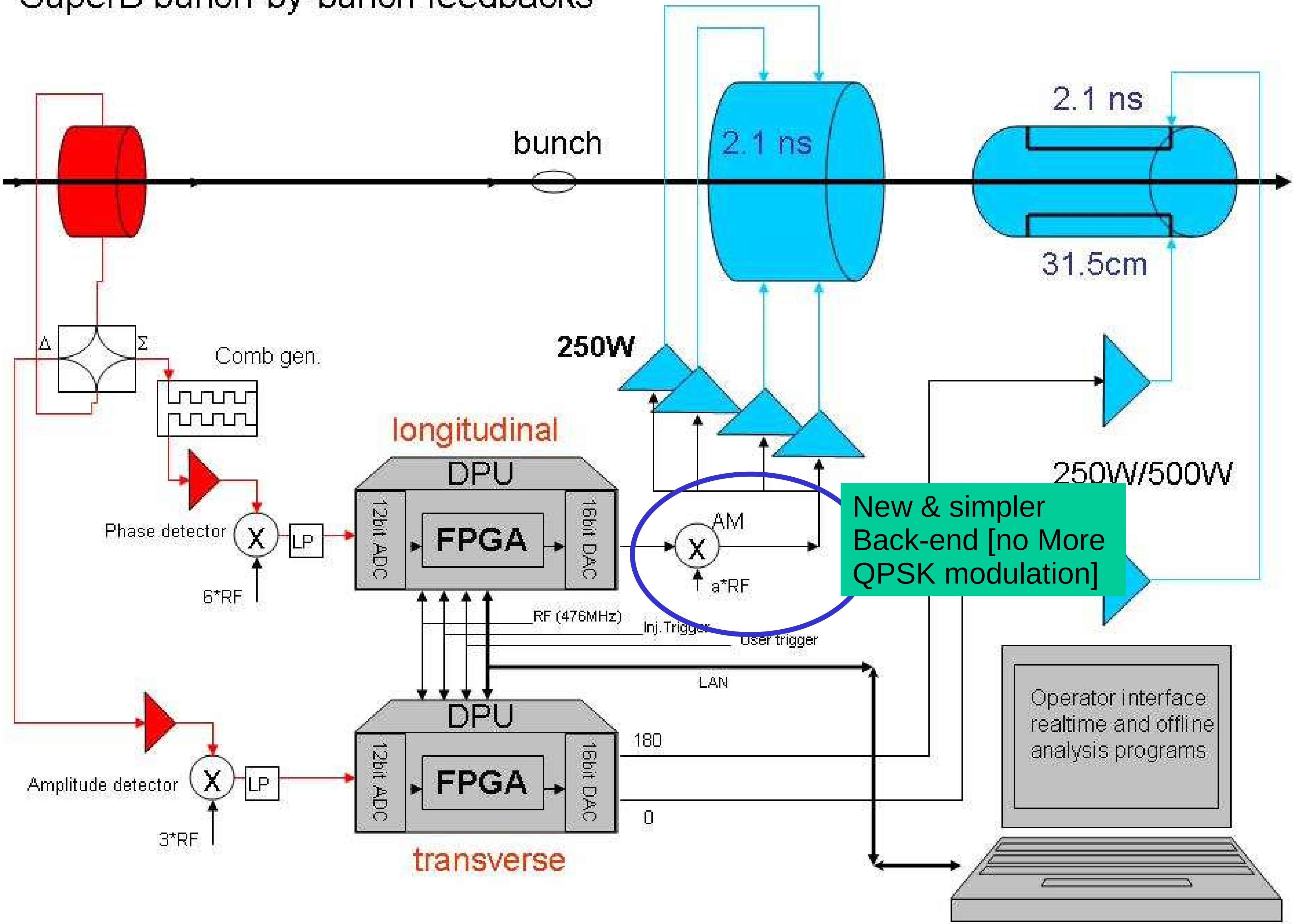
SuperB bunch-by-bunch feedbacks



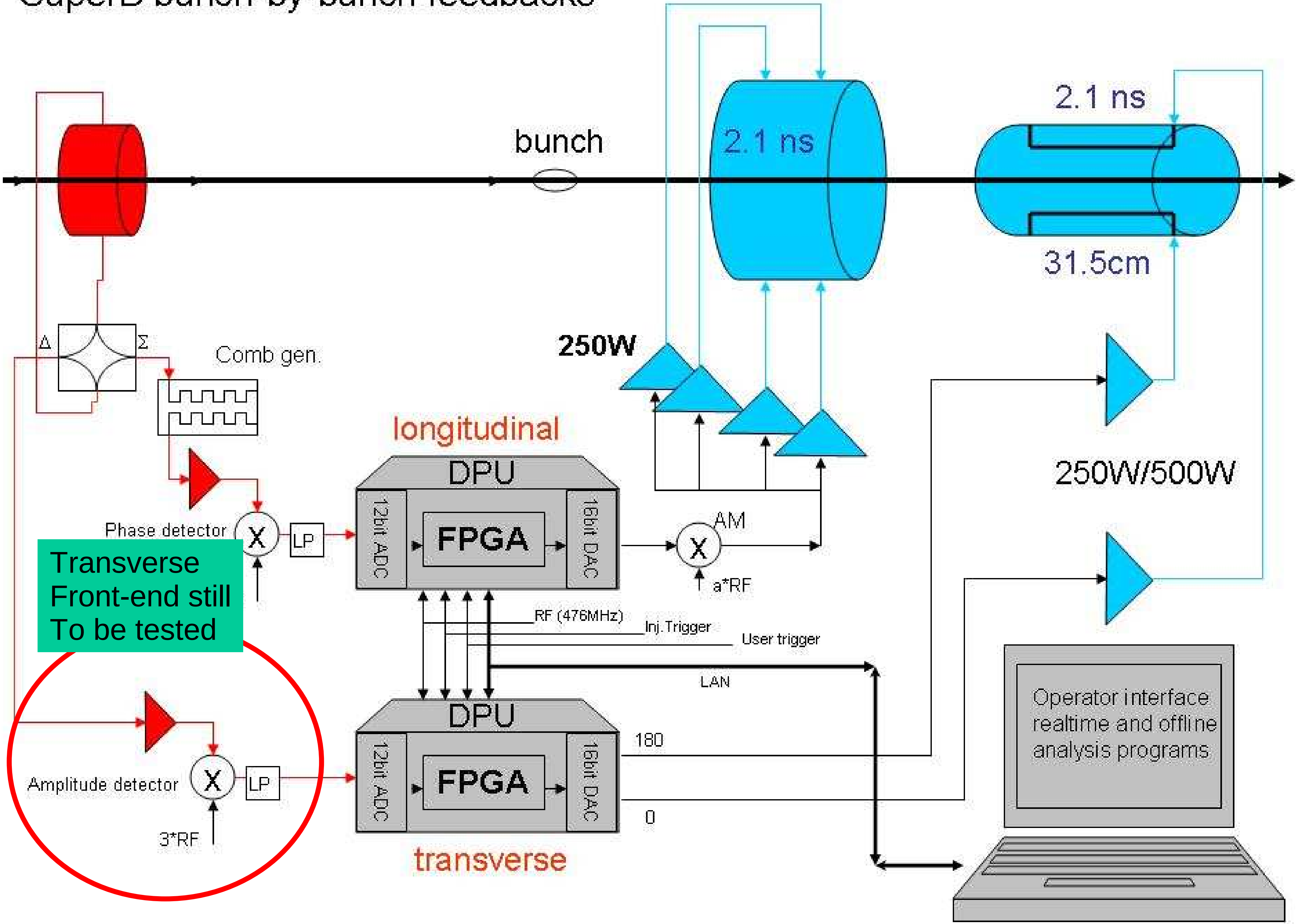
SuperB bunch-by-bunch feedbacks



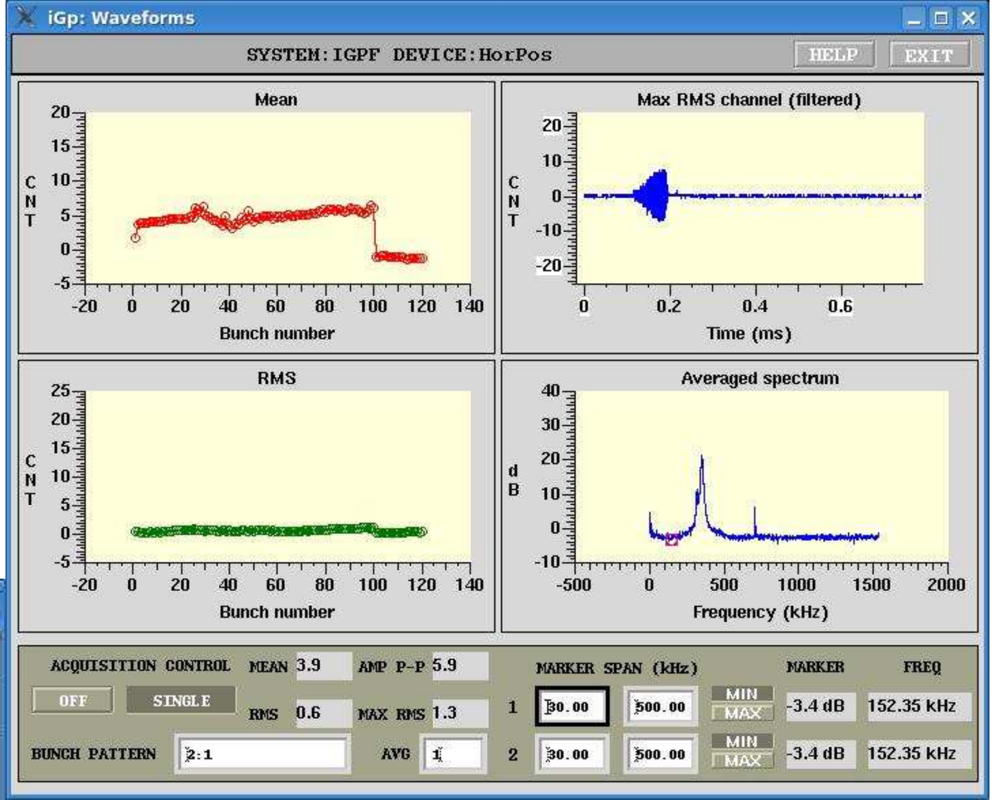
SuperB bunch-by-bunch feedbacks

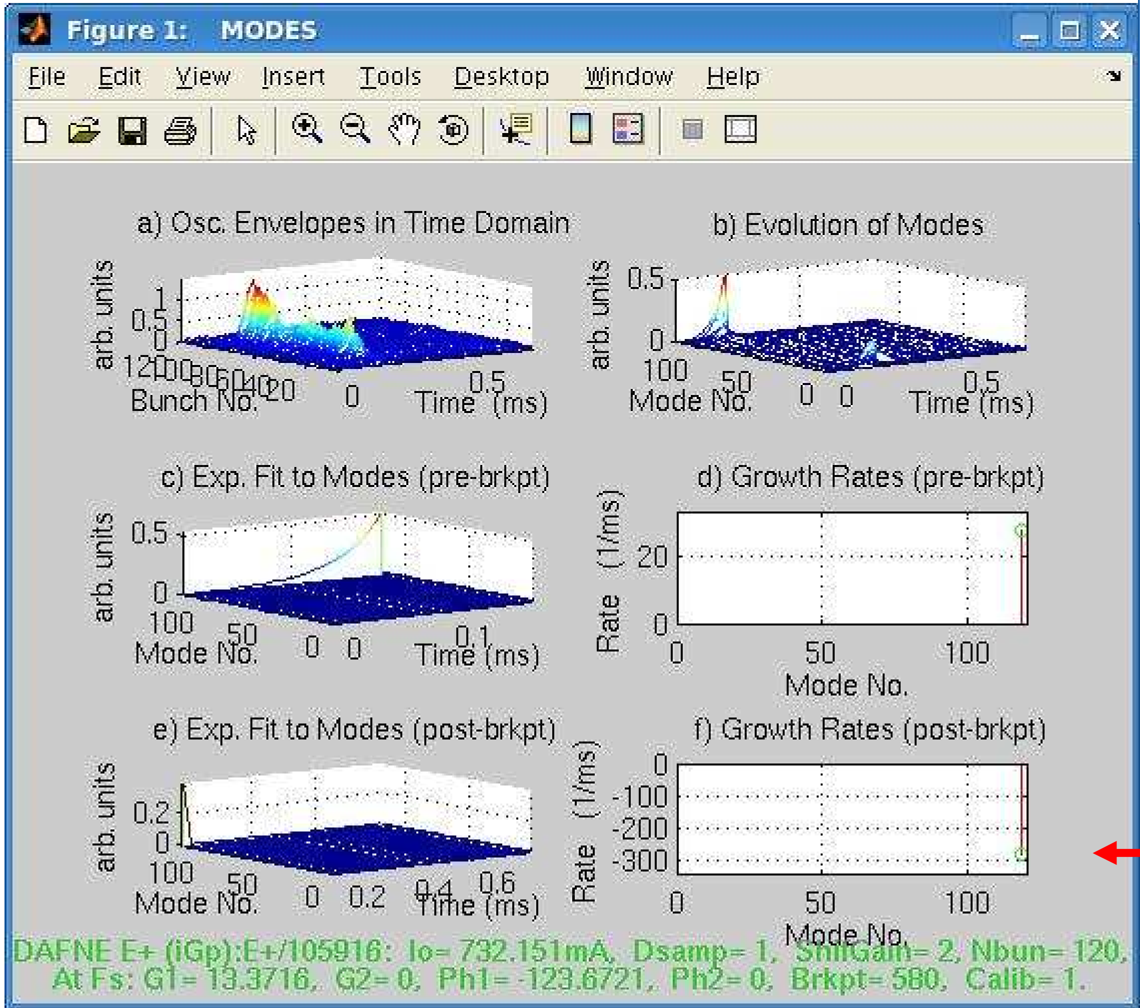


SuperB bunch-by-bunch feedbacks



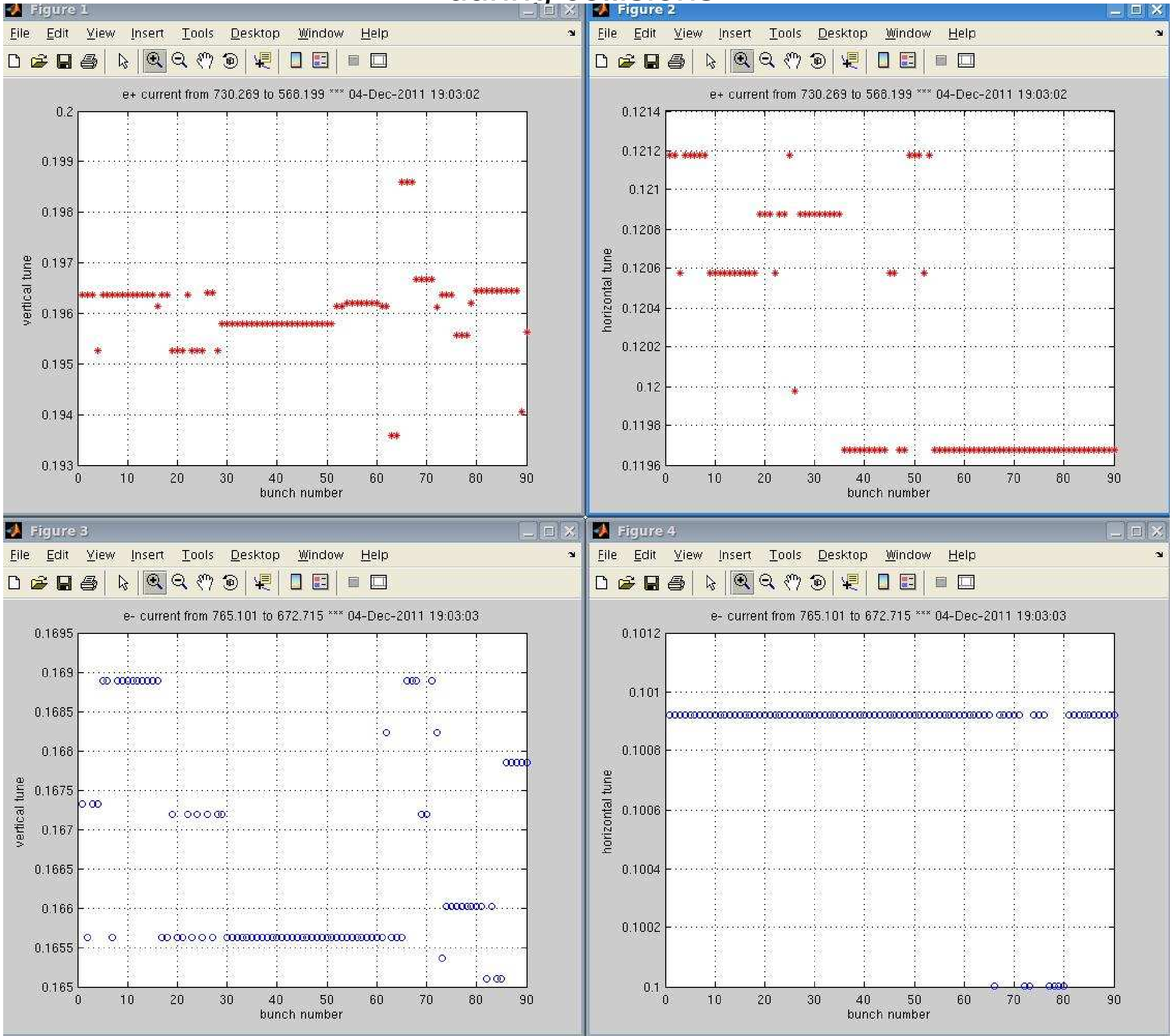
Very fast feedback damping !



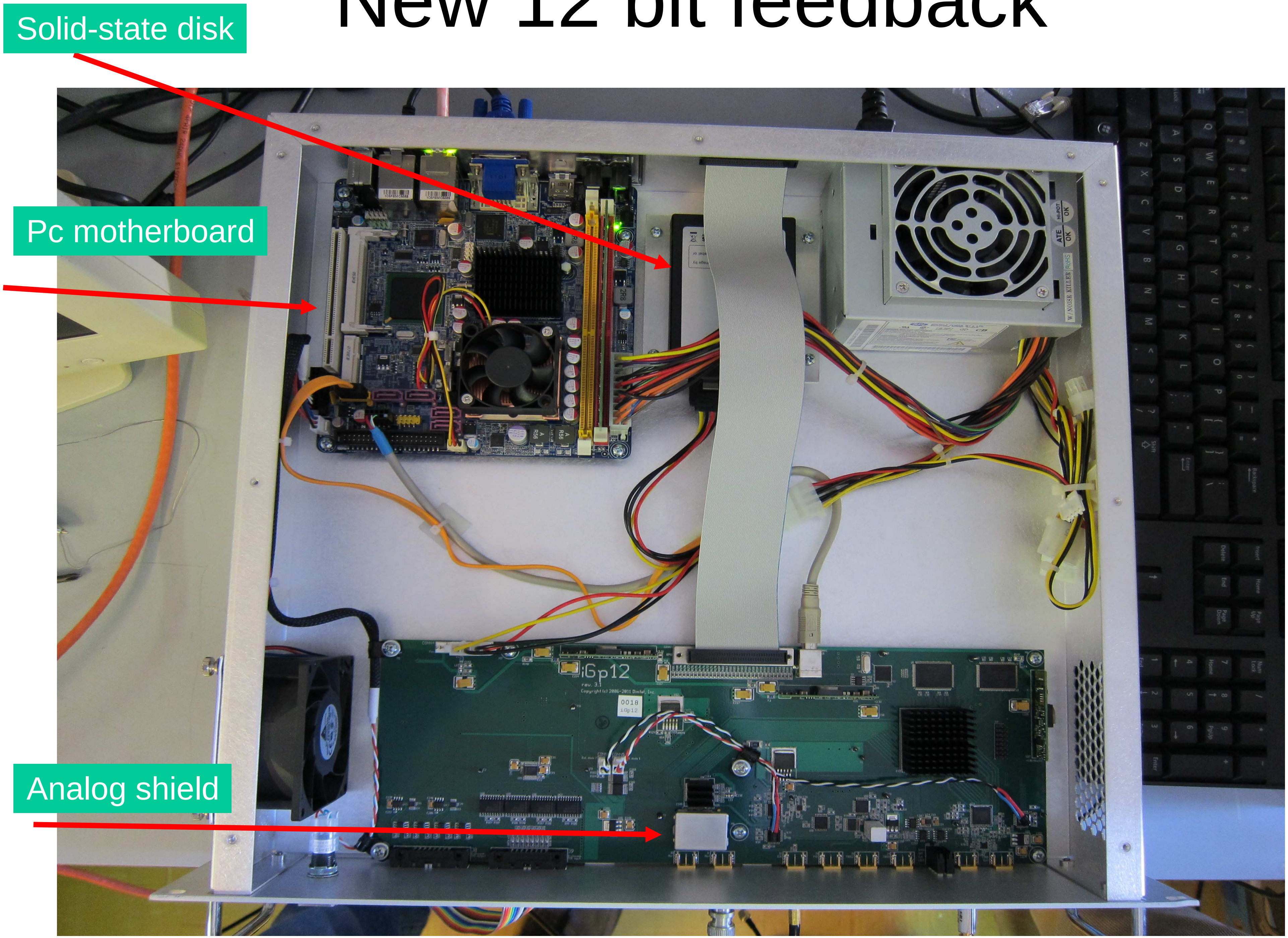


During this DAFNE run achieved the best result: 283 ms-1, corresponding to a damping time of 3.5 microsecons [about 10 turns]

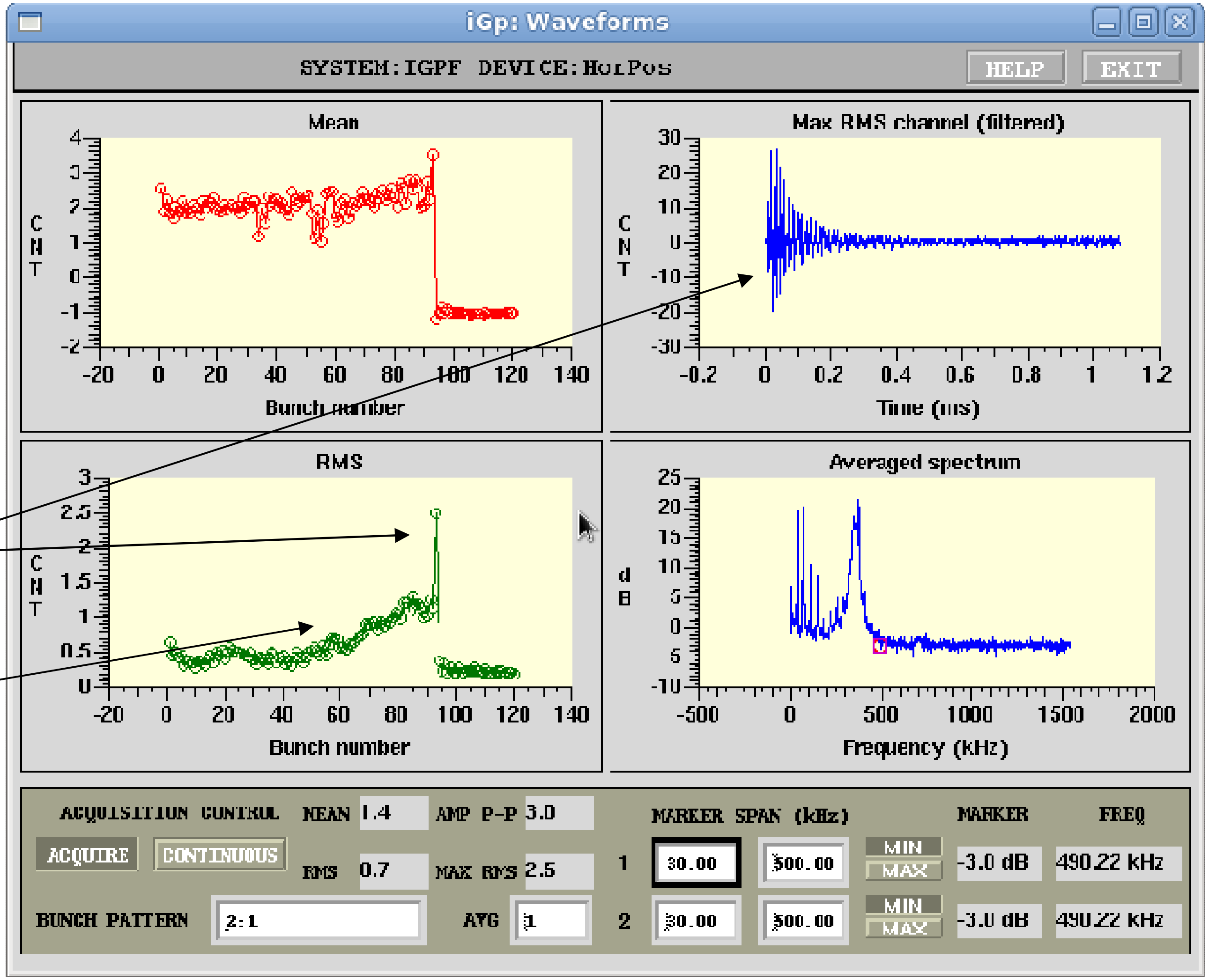
Studies on tune spread can be easily done by the new feedback parassitically during collisions



New 12 bit feedback



Effect of injection kicker on the horizontal plane: data taken by using the injection trigger for diagnostics



Injected bunch #92

Other bunches are
Also sensible to the
kick

SuperB parameter:

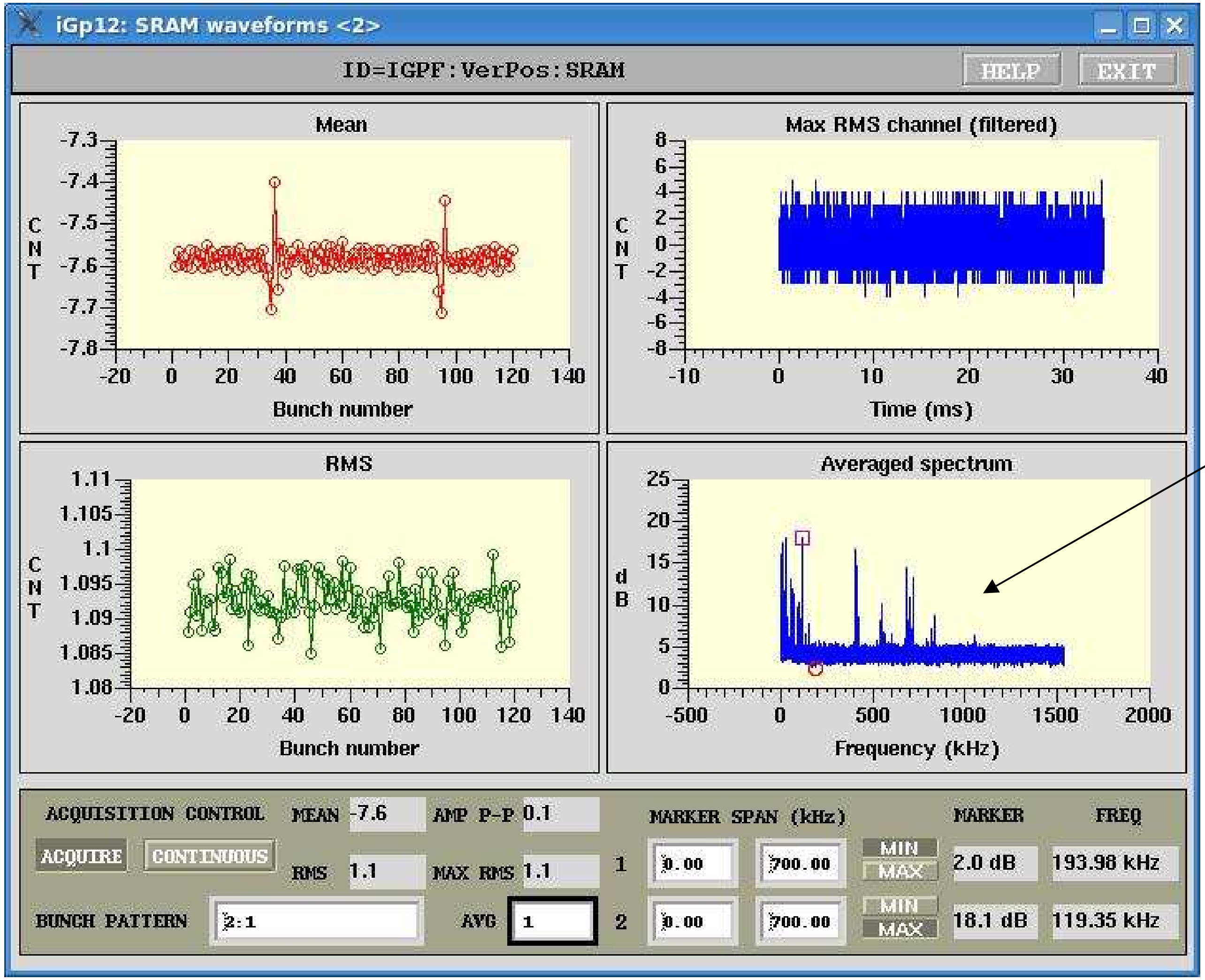
version Sep/28/10

(Bold: computed values)		V12		V13		V14	
Parameter	Units	HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)
LUMINOSITY	$cm^{-2}\ s^{-1}$	**1.00E+36**		**1.10E+36**		**1.11E+36**	
Energy	GeV	6.7	4.18	6.7	4.18	6.7	4.18
Circumference	m	1258.4		1263.5		1159.5	
X-Angle (full)	mrad	66		60		60	
β_x @ IP	cm	2.6	3.2	2.6	3.2	2.6	3.2
β_y @ IP	cm	0.0253	0.0205	0.0253	0.0205	0.0253	0.0205
Coupling (full current)	%	0.25	0.25	0.25	0.25	0.25	0.25
Emittance x (without IBS)	nm	1.97	1.82	2.09	1.93	1.90	1.82
Emittance x (with IBS)	nm	2.07	2.37	2.19	2.51	2.00	2.37
Emittance y	pm	**5.17**	**5.92**	**5.49**	**6.27**	**4.99**	**5.92**
Bunch length (zero current)	mm	4.69	4.29	4.8	4.4	4.53	4.29
Bunch length (full current)	mm	5	5	5	5	5	5
Beam current	mA	1892	2447	**1930**	2470	1892	2447
Buckets distance	#	2		2		2	
Buckets distance	ns	4.20		4.20		4.20	
Ion gap	%	2		2		2	
RF frequency	Hz	4.76E+08		4.76E+08		4.76E+08	
Revolution frequency	Hz	**2.38E+05**		**2.37E+05**		**2.59E+05**	
Harmonic number	#	**1998**		**2006**		**1841**	
Number of bunches	#	**978**		**982**		**901**	
N. Particle/bunch	#	**5.08E+10**	**6.56E+10**	**5.18E+10**	**6.63E+10**	**5.08E+10**	**6.57E+10**
σ_x @ IP	microns	**7.334**	**8.701**	**7.554**	**8.960**	**7.202**	**8.701**
σ_y @ IP	microns	**0.036**	**0.035**	**0.037**	**0.036**	**0.036**	**0.035**
$\sigma_{x'}$ @ IP	microrad	**282.1**	**271.9**	**290.5**	**280.0**	**277.0**	**271.9**
$\sigma_{y'}$ @ IP	microrad	**143.0**	**169.9**	**147.3**	**174.9**	**140.4**	**169.9**
Piwinski angle	rad	**22.50**	**18.96**	**19.86**	**16.74**	**20.83**	**17.24**
σ_x effective	microns	**165.22**	**165.29**	**150.24**	**150.31**	**150.22**	**150.30**
Σ_x	microns	**11.379**		**11.719**		**11.295**	
Σ_y	microns	**0.050**		**0.052**		**0.050**	
Σ_x effective	microns	**233.35**		**212.13**		**212.13**	
Hourglass reduction factor		0.950		0.950		0.950	
Tune shift x		**0.0021**	**0.0033**	**0.0026**	**0.0040**	**0.0026**	**0.0040**
Tune shift y		**0.0989**	**0.0955**	**0.1067**	**0.1041**	**0.1089**	**0.1070**
Longitudinal damping time	msec	13.4	20.3	13.6	20.6	11.6	20.3
Energy Loss/turn	MeV	2.11	0.865	2.08	0.88	2.24	0.865
Momentum compaction		4.36E-04	4.05E-04	4.69E-04	4.35E-04	4.60E-04	4.05E-04
Energy spread (zero current)	dE/E	6.31E-04	6.68E-04	6.30E-04	6.68E-04	6.52E-04	6.68E-04
Energy spread (full current)	dE/E	6.43E-04	7.34E-04	6.43E-04	7.34E-04	6.64E-04	7.34E-04
CM energy spread	dE/E	**5.00E-04**		**5.00E-04**		**5.11E-04**	
Energy acceptance	dE/E	0.01	0.01	0.01	0.01	0.01	0.01
SR power loss	MW	**3.99**	**2.12**	**4.01**	**2.17**	**4.24**	**2.12**
Touschek lifetime	min	33	16	33	16	33	16
Luminosity lifetime	min	**4.81**	**6.22**	**4.48**	**5.73**	**3.99**	**5.16**
Total lifetime	min	**4.20**	**4.48**	**3.94**	**4.22**	**3.56**	**3.90**
RF Wall Plug Power (SR only)	MW	**12.22**		**12.38**		**12.71**	
Total RF Wall Plug Power	MW	17.08					

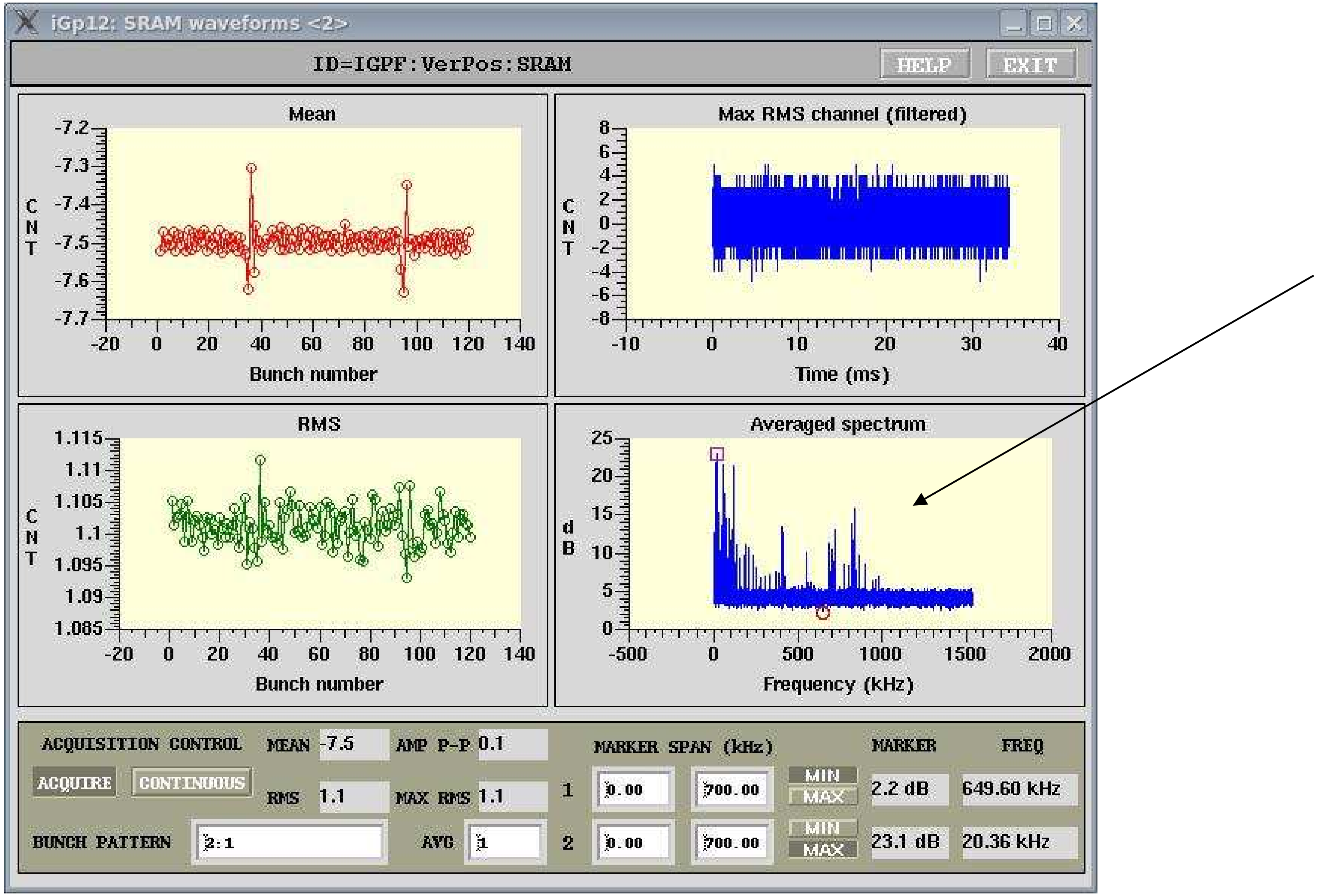
Approach & studies for ultra low emittance

- Minimal quantization noise
- More flexibility in feedback gain steps
- Use less analog parts because more sensitive to noise
- Test on pickups (in DAFNE) that are antennae of low frequency and high frequency noise

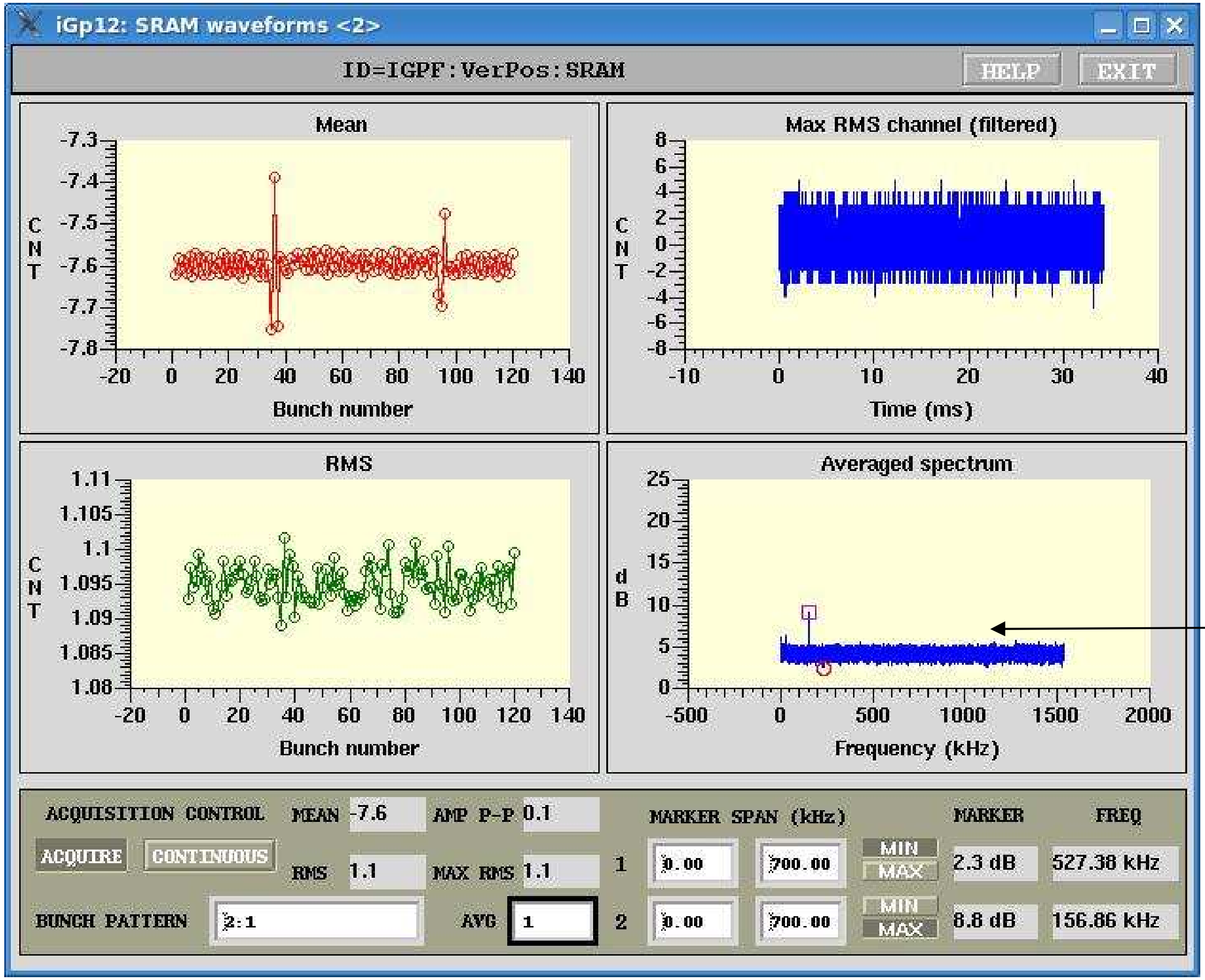
Noise figure from pickup in PS section – no RF [real time plot from bunch-by-bunch feedback]



Noise figure from pickup in IP2 section – no RF [real time plot from bunch-by-bunch feedback]



No pickup cable connected !!!



Very good Result in Terms of noise

Dear participant/speaker of the SuperB meeting,   in view of the planning of work needed for the TDR, we'd like to ask you to answer in your talk as much as possible to the following questions:

(1) Clear list of the describing system components.

(2) Is the system ready to start the technical design?

(3) If "not", what kind of activity (calculation, simulation, etc.) should be done before? Please estimate time, specialists and schedule necessary for that.

(4) If "yes", could you estimate manpower (engineers, designers, etc.) and time schedule for the technical design?

(5) What are according to you the critical points, which may influence performances of the system?

(6) What kind of prototyping work should be done before the mass production? Time schedule for that?

(7) Rough estimate of resources and time schedule for the whole system manufacture.

We will have a dedicated session on Thursday 15th at 5pm to discuss in detail all these plans, so those of you attending but not giving a talk will have a chance to participate and contribute actively.

Thank you very much for your collaboration!

We are looking forward to meet you in Frascati.

Best regards

Eugene Levichev and Marica Biagini

Many questions from project management that have to be carefully evaluated...

First of all

a) *Which systems should we talk about ?*

b) *What do we mean for TDR: complete detailed and running system or a description with specification ?*

in the first case:

I) what kind of budget we could have to proceed?

II) we should consider collaborations? In which terms ?

Answers to TDR questions/1

- ✓ *Synchrotron bunch-by-bunch feedback* : a strong R&D program has been carried on and the results are extremely good. The new system has been tested at DAFNE main rings and it is almost ready for SuperB. The only item still to be completely verified is the new analog backend by a test on the performance at very high beam currents. This is necessary given that the new system has simplify this part, avoiding QPSK modulation and letting in the analog BE only the amplitude modulation. This strategy that in theory brings a small loss of power but gives advantages in term of easier maintainability and less critical timing operations works fine but must be tested up to 2A beam current.

Answers to TDR questions/2

- ✓ *Betatron bunch-by-bunch feedback systems*: same as the previous. A strong R&D program has been carried on and the results are extremely good. The new systems has been tested at DAFNE main rings and it is almost ready for SuperB. R&D on the impact on ultra low emittance beams can still bring to further studies. Front end analog part still has to be tested and engineered even if a preliminary design is in the lab. Not strictly necessary for DAFNE, it must be foreseen for SuperB to because could give better results in terms of decreasing noise in the feedback loop.

Answers to TDR questions/3

- ✓ *Tune feedback:* not a big system; it can be tested at DAFNE basing the data acquisition on the bunch-by-bunch betatron feedback.
- ✓ *Orbit feedback*: it can be designed by using commercial devices or by international collaborations. It is necessary to have a stable orbit at the interaction point and at the insertion devices for the beam lines
- ✓ *IP "dither" feedback (or luminosity feedback):* design, hardware and know-how of this system is at SLAC…(???)

Answers to TDR questions/4

- ✓ *Fast IP feedback:* R&D on this system are very preliminary stage; in my opinion this system will be complementary to the orbit feedback, working in a smaller vertical range. A first analog & digital board, based on Virtex-6 FPGA is in the lab but to carry on serious efforts we need 1 system analyst (myself) + 1 sw engineer + 1 fpga engineer + 1 technician