SOLEIL TRANSVERSE BUNCH BY BUNCH FEEDBACK SYSTEM UPGRADE

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INTRODUCTION

The 2.75 GeV storage ring of SOLEIL, the French third generation light source, which was commissioned in 2006, is routinely providing high multibunch and single bunch currents to users.

The transverse digital bunch by bunch feedback is successfully operating from the beginning of the user operation and it turned out to be essential in storing a stable high current electron beam. In particular, it allows operating the machine with reduced chromaticity and therefore with increased beam lifetime, which is mandatory for light source rings.

Recent upgrades of this system were made in collaboration with SPRing-8. The previous version, based on Virtex-2 pro, is in operation since more than 10 years in both modes, high average current and high bunch current. The new one, based mainly on 2 cascaded Virtex 7, 11 fast ADCs and 12 DACs, was recently validated under hard transverse instability conditions. Comparative performance results are reported.

CURRENT SOLEIL TRANSVERSE BUNCH BY BUNCH DIGITAL FEEDBACK :
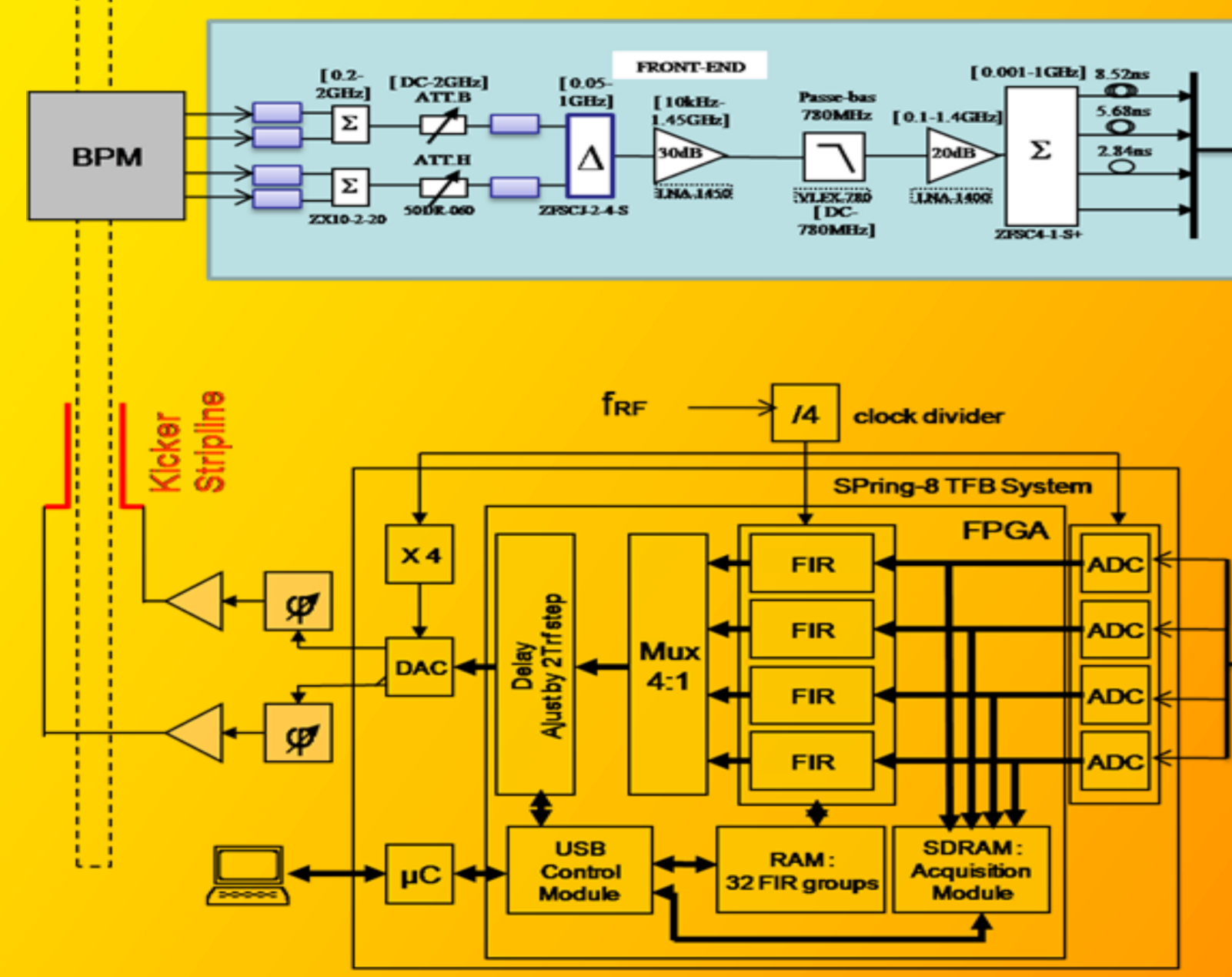
Layout of a SOLEIL feedback chain

SOLEIL storage ring parameters

Energy [GeV]	2.75
Circumference [m]	354.097
(Operating current)$present$ [mA]	500, 1×16, 8×12, 16 × 9.6
RF frequency [MHz]	352.2
Harmonic number h	416
Betatron tunes Q_H/Q_V	18.16/10.22
Momentum compaction α	4.38×10^{-4}
Emittance $\varepsilon_H/\varepsilon_V$	3.74 nm/38 pm
(Transverse beam size)$typical$ σ_H/σ_V	200 µm/17 µm
(Bunch length)RMS σ_z [ps]	17.0
Radiation damping times [ms] $\tau_H/\tau_V/\tau_L$	6.56/6.56/3.27

MAIN CHARACTERISTICS:

Digital processor: (Virtex-II Pro based SPring-8 development)
- Four 12-bit ADCs working at 88 MHz (352.2 MHz/4)
- Two 20-tap FIR filters, five 12-bit DACs

Detector:
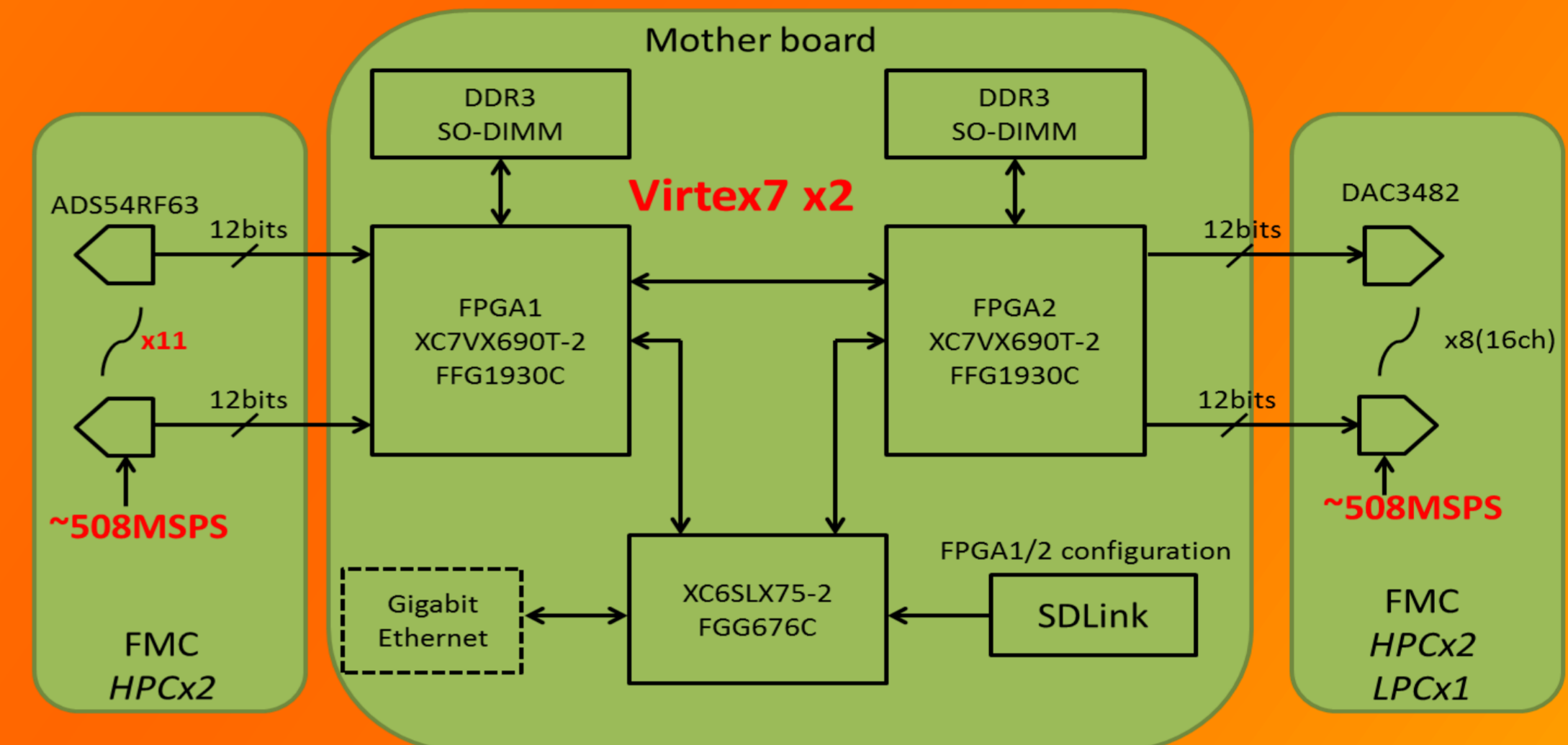- Standard SOLEIL BPM sensitivity: D_{peak} ~47 mV/mA/mm

Kickers:
- A shorted 4-electrode stripline used diagonally for the standard operation (Chain 1).
- A 2-electrode vertical stripline with high shunt impedance of ~ 60 kW (Chain 2).
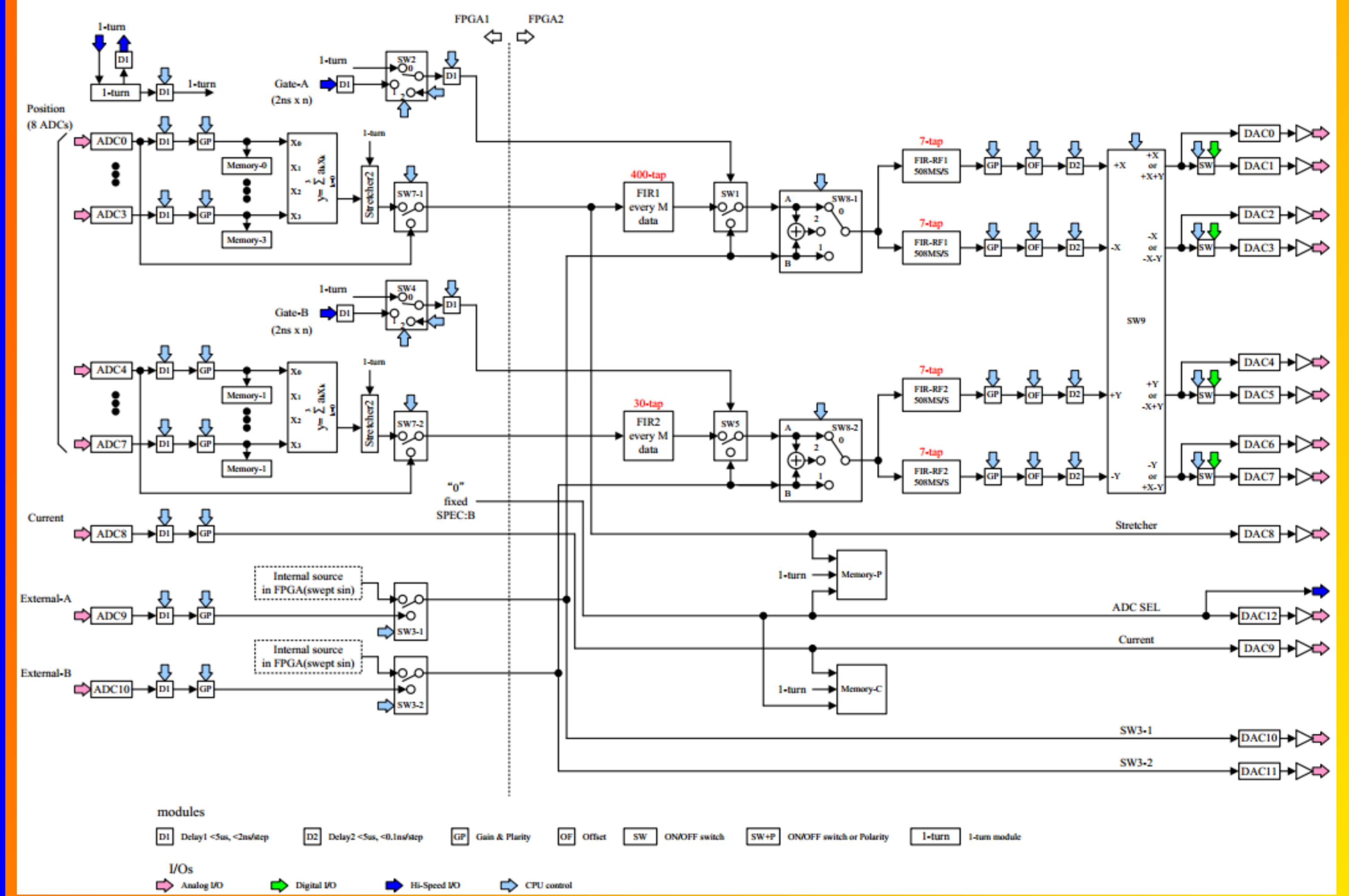- A 4-electrode stripline (horizontal and/or vertical) with high shunt impedance of ~ 35 kW (Chain 3).

The three feedback chains can be configured and combined in different ways including the one in which all of them work in the vertical plane.

Vertical and horizontal stripline design

2-electrode vertical stripline designed to cope with multibunch and single bunch instabilities (TMCI).

4-electrode horizontal stripline

Performance achieved in single bunch

Performance achieved in single bunch

UPGRADED SOLEIL TRANSVERSE BUNCH BY BUNCH DIGITAL FEEDBACK :

New Feedback processor hardware block diagram manufactured by Tokyo Electron Device
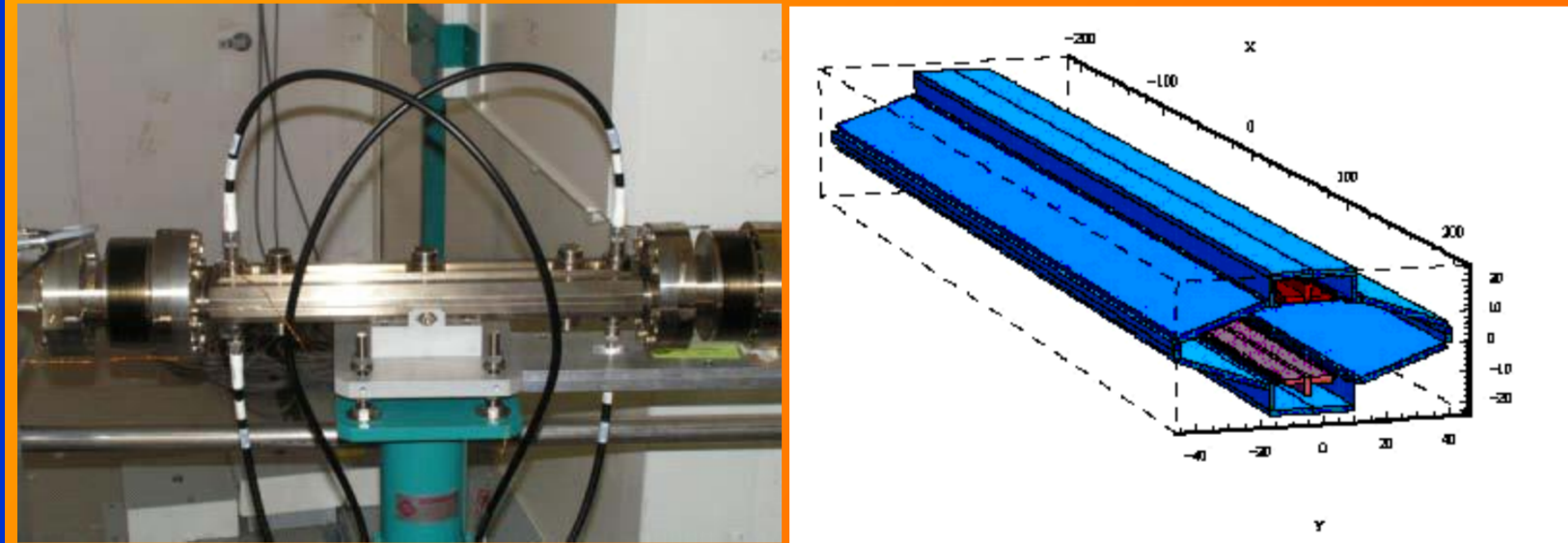

Block diagram of the SOLEIL 2 dimensional Feedback by a single processor
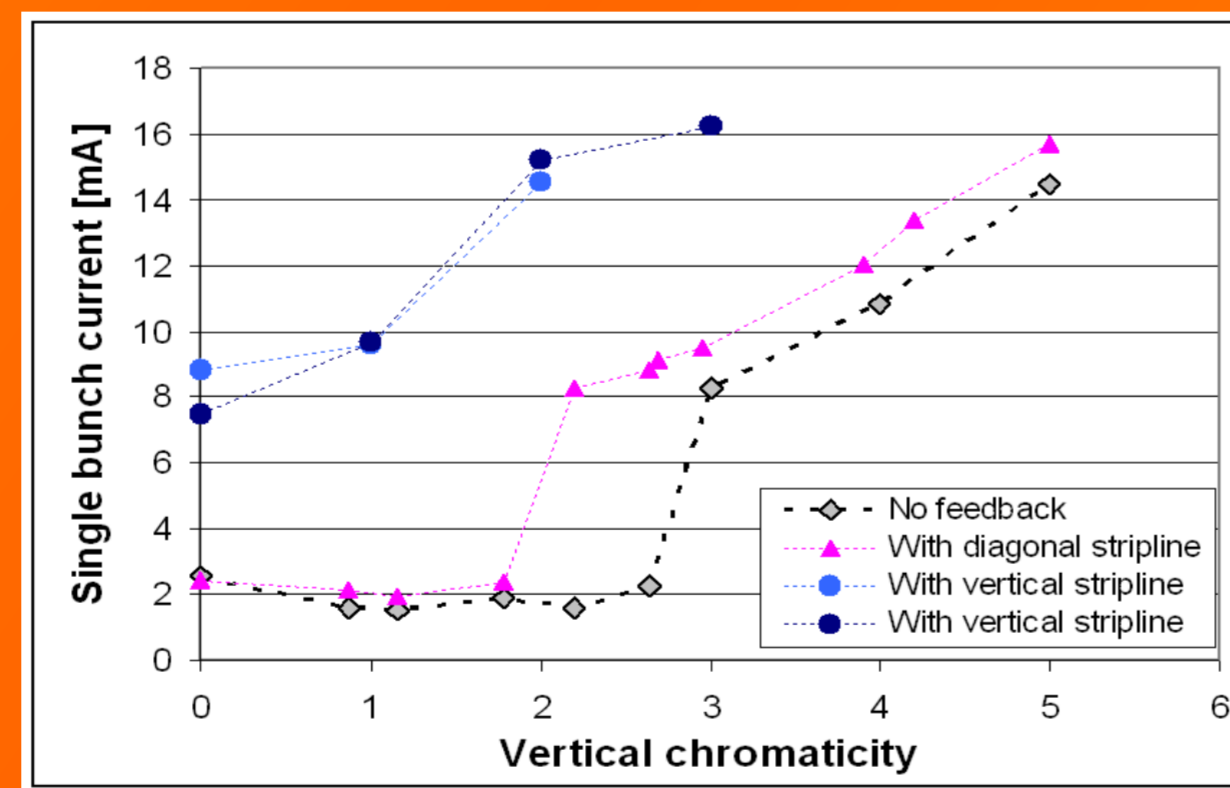

The new processor, which uses 11 high speed ADC's and has a big amount of available memory, brings about considerable benefits as compared to the previous one :
- many feedback chains can be driven from a single processor
- availability for many turn by turn and bunch by bunch based diagnostics
- one or several following bunches can be excited while the others are stabilized in order to measure the betatron tune
- in the same way, the cleaner function can also be achieved by changing the setup of the excitation signal which can be generated in the FPGA or outside via an ADC.
- control of the beam size by adding some digital noise to the calculated correction kick in the FPGA
- possibility of using several betatron detection BPM's from different machine areas without waiting several turns to calculate a convergent kick (this remains to be validated on the machine)
- most of the previous analog treatments can now be digitally processed, as for instance, the fine delay to adjust some timing setups.
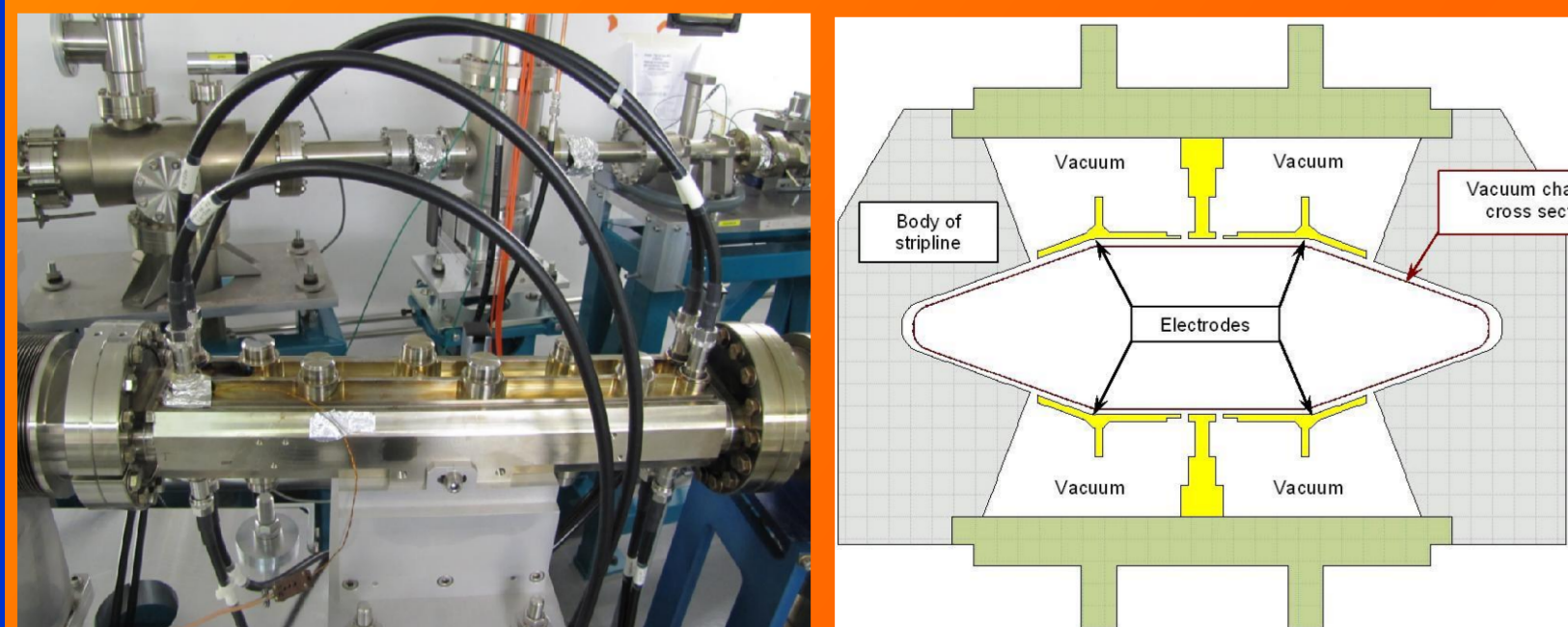
SOLEIL TRANSVERSE BUNCH BY BUNCH DIGITAL FEEDBACK PERFORMANCES :
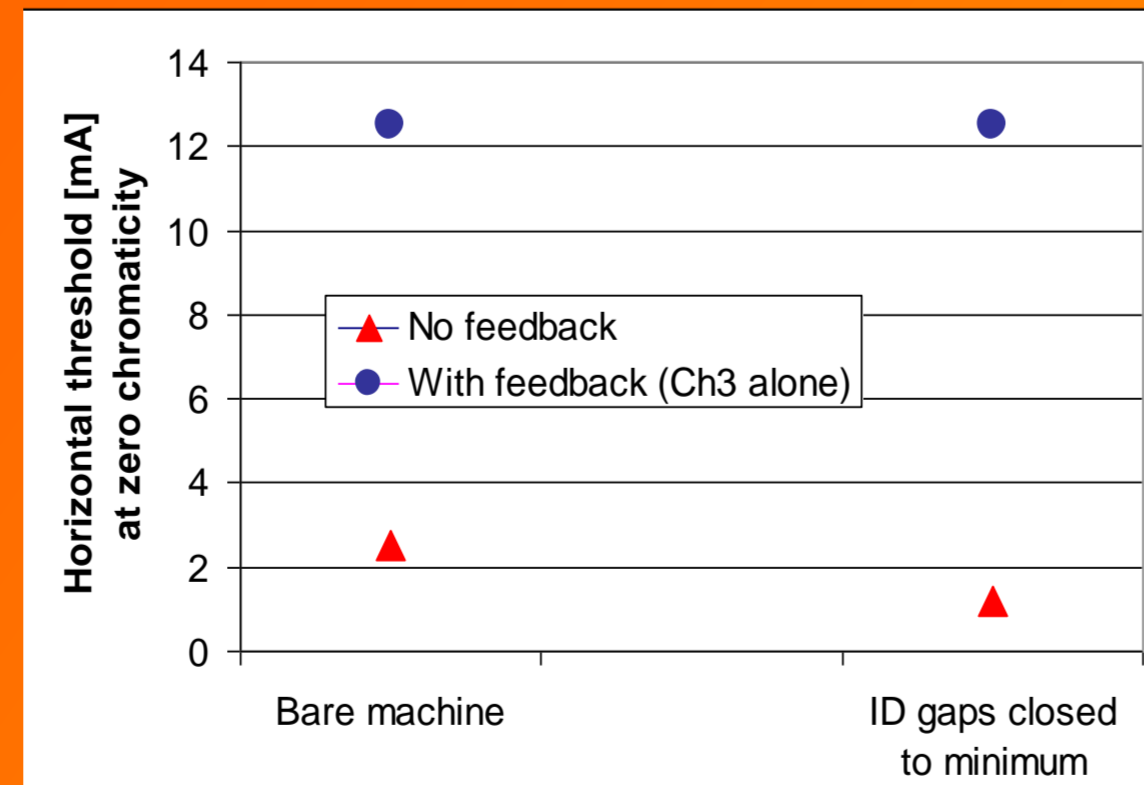
The SOLEIL Transverse Feedback system has proved its efficiency, allowing to reach the target intensity in the multibunch mode (500 mA) as well as in the temporal structure mode (8x12.5 mA), (1x16mA), (16x8.75mA), with the various insertion device configurations.

Thanks to striplines, dedicated to each transverse plane, the TMCI threshold is pushed by more than a factor of 3 in both vertical and horizontal planes.

Front End without down-conversion brought about a significant simplification in the system tuning.

The feedback system is fully integrated into the TANGO machine control system with useful applications for machine operation such as tune measurement and post-mortem.

FPGA applications have been developed allowing to select a single bunch and excite it while superposing feedback or anti-feedback.

Characterization and optimization will go on (detailed FIR filter vs. stability range for example).

Taking advantage of the FPGA application capabilities, systematic and intensive feedback damping time measurements will help studying fast ion instabilities.