Luminosity feedback/2: Fast IP feedback

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Introduction

- SuperB rings are specified to operate at 4 (HER) and 7 (LER) pm vertical emittance
- SuperB wants to make stable collisions between beams with 39 nm vertical sigma*
- Problems to a perfect stable match at the IP can come from:

  A) Mechanical vibrations from
    - Seismic sources
    - Vehicular traffic around the collider buildings

  B) Ripples in the electromagnet power supplies
- Both cases can make “slow” shift/drift of the beams decreasing luminosity

Two approaches

- We are evaluating two very different feedback approaches to be used in the SuperB interaction point:
- A) Dither Luminosity feedback
  - Evolution from the dither coil based luminosity feedback designed for PEP-II by SLAC team – see Kirk Bertsche's talk
- B) Fast IP feedback
  - inspired to the IntraTrain IP feedback designed for ILC by Phil Burrows team (Oxford Un.) - see PAC07, "THE FONT4 ILC INTRA-TRAIN BEAM-BASED DIGITAL FEEDBACK"

Common points

- Both feedbacks have the goal to compensate for residual vibrations or ripples induced jitter in the IP by steering the electron and positron beams into collision
- Both systems are faster than the supposed noise frequency bandwidth (<2 KHz)
- A **third** competitor that, in principle, should be considered, is an **orbit feedback**. Like for example the LIBERA-based feedback (working at ~1kHz, limited by corrector magnets) that has been implemented mostly in advanced circular light sources with very low emittance

Fast orbit feedback based on “Libera” by Instrumentation Technologies

“Libera” fast orbit feedback

FOSS objectives

Suppression of beam disturbances

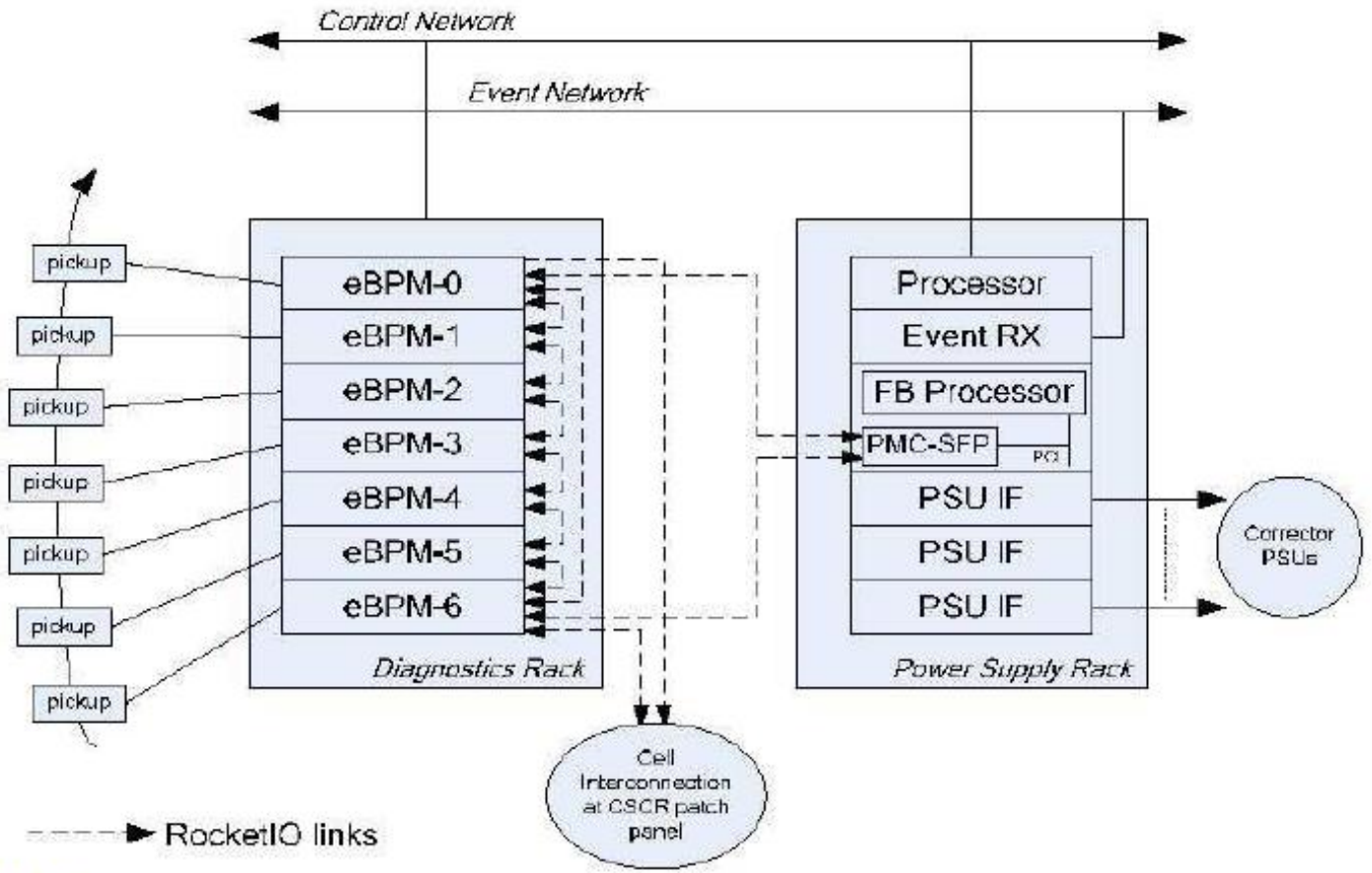
- aperiodic, stochastic: human activity
- periodic: power supply (50Hz)

BW ultimately limited by corrector magnets (<500Hz)

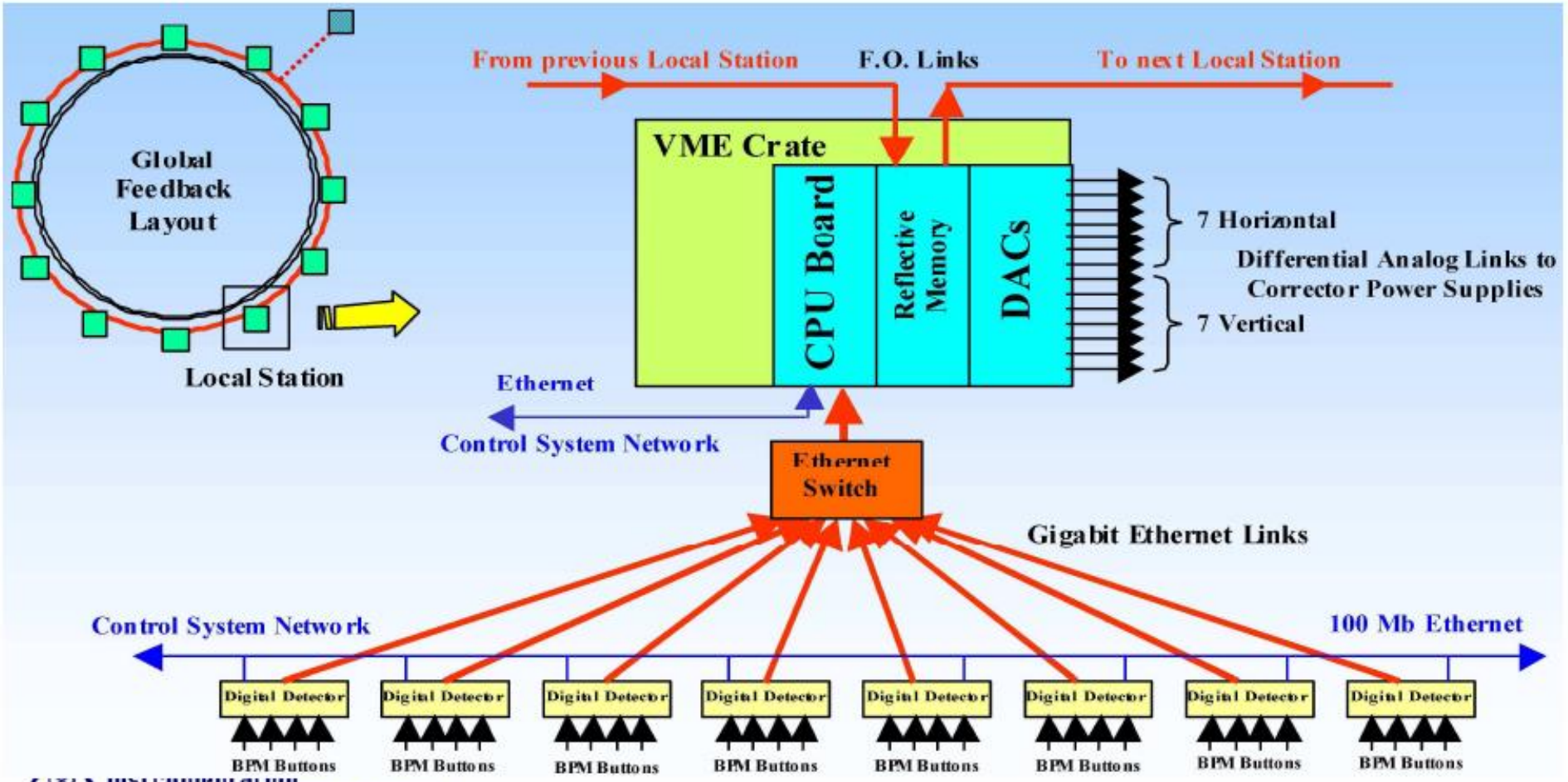
Basic building blocks

- Libera Brilliance and other sources, e.g XBPM
- Fast, low latency communication system
- Computational engines
- Interfaces to PS and corrector magnets

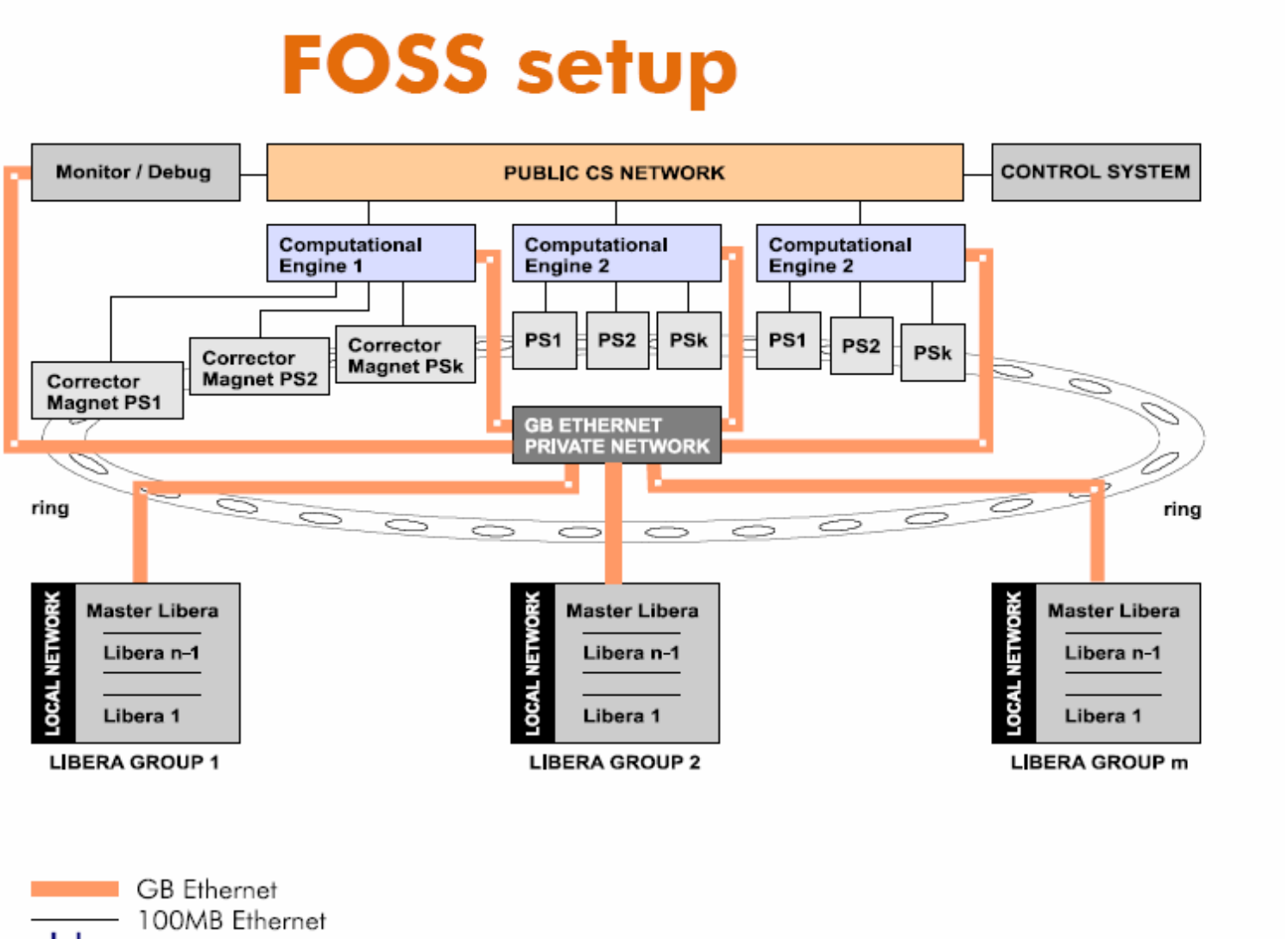
“Libera” fast orbit feedback @ DIAMOND



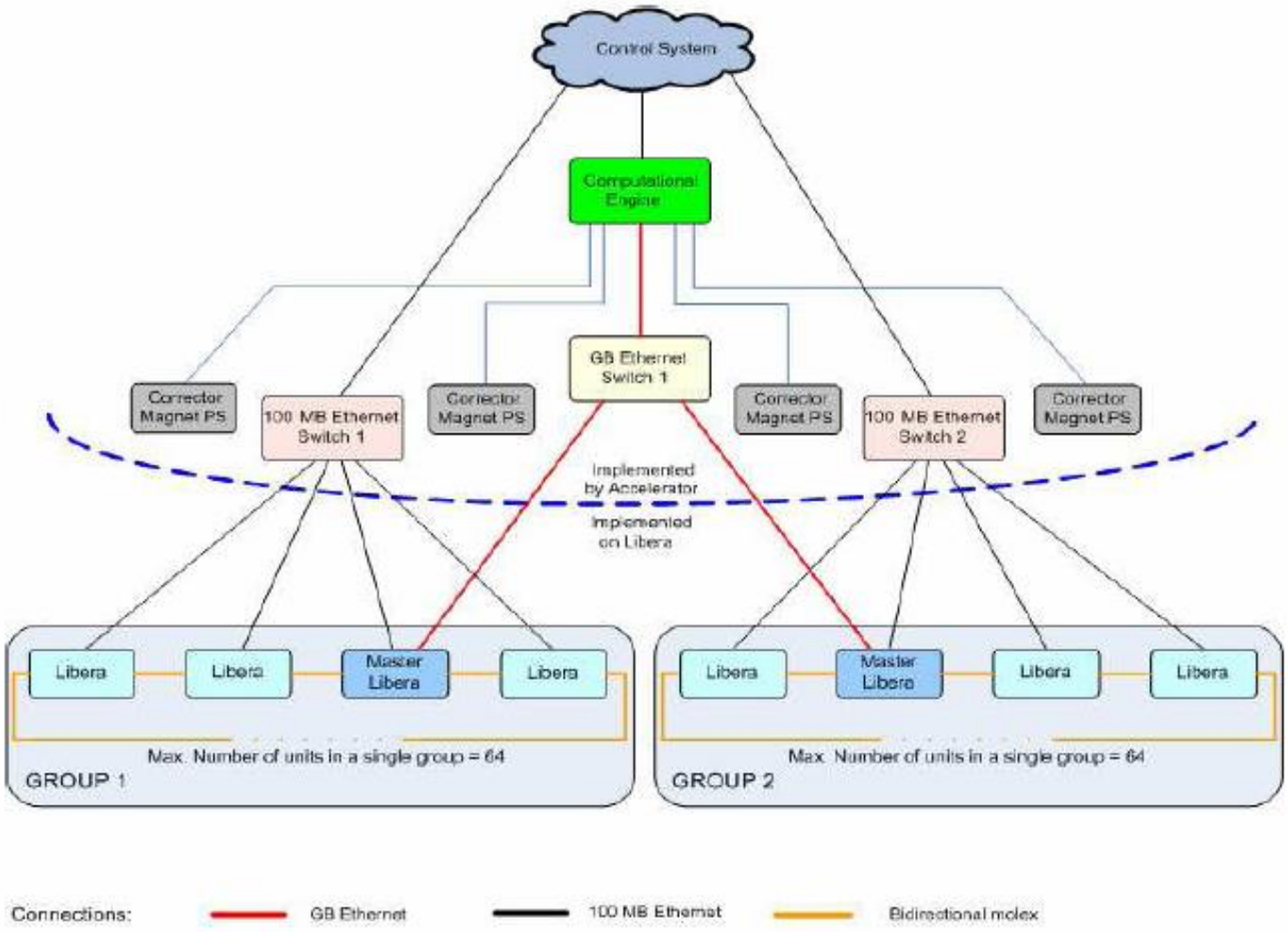
“Libera” fast orbit feedback @ ELETTRA



“Libera” fast orbit feedback



“Libera” fast orbit feedback



Fast IP feedback

- The key components of each such system are
  - beam position monitors (BPMs) to pickup the beam orbit, two BPM in case of angle correction
  - Analog front end circuits
  - Analog to Digital Conversion (at 12 or 14 bits)
  - DSP (Digital Signal Processors) in just one FPGA (Field Programmable Gate Array) to translate the raw BPM signals into a position output
  - Digital to Analog Conversion (at 16 bits)
  - amplifiers to provide the required output drive signals;
  - kickers for applying position (or angle) correction to the beam.
  - A schematic of the IP feedback is shown in Figure 1, (next slide) for the case in which the electron and positron beams cross with a small angle; the current ILC design incorporates a crossing angle of 14 mrad.
- The use of DSP will allow for the implementation of more sophisticated algorithms which can be optimised for possible beam jitter scenarios at the IP.

Fast IP feedback

Two possible implementation

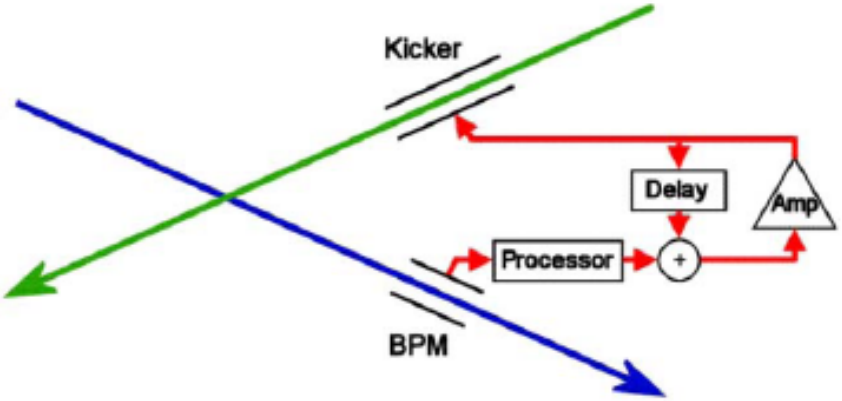


Figure 1: Schematic of IP intra-train feedback system for an interaction region with a crossing angle. The deflection of the outgoing beam is registered in a BPM and a correcting kick applied to the incoming other beam.

Case a

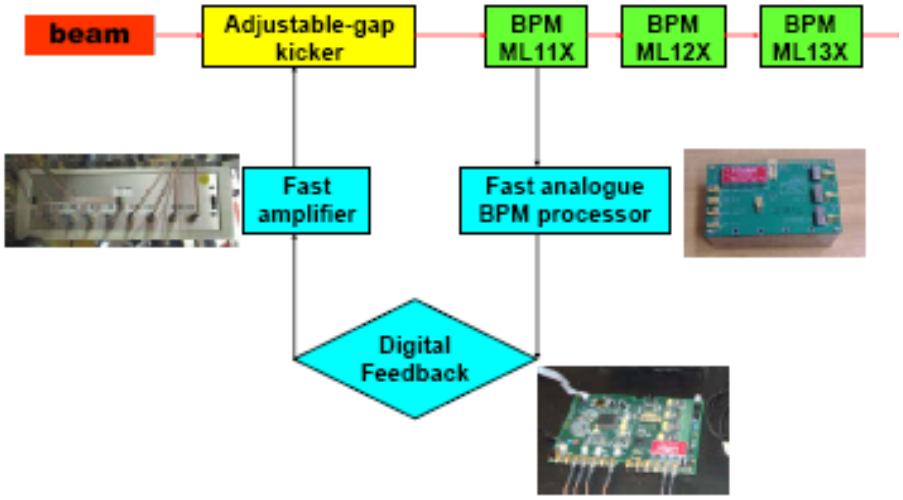


Figure 2: Schematic of FONT4 at the ATF extraction beamline showing the relative locations of the kicker, BPMs and the elements of the feedback system.

Case b

Fast IP feedback should reasonably run at ~ 5-10 MHz depending also by the implemented algorithm

Table 1: Design parameters for the FONT4 system

Source of delay	Contribution to latency (ns)
Beam time-of-flight	4
Signal return time	10
BPM processor	7
ADC/DAC	40
FPGA processing	25
I/O	3
Amplifier risetime	40
Kicker fill time	3
Total	**132**

Design and implementation

- The Fast IP feedback can be implemented for the SuperB by the same digital processing unit that will be used by the bunch by bunch transverse feedback, of course **differently programmed**
- In case of angle correction, the ADC dual inputs can be used to take input signals from two different pickups
- The Fast IP feedback can work in bunch by bunch mode but it does not replace the transverse (betatron) bunch by bunch feedback systems
- Of course the Fast IP feedback should installed close to the IP

Design and implementation/2

- Powerful algorithm should be used to be compatible with very low vertical beam emittance and dimension avoiding to feed noise to the beam
- No direct connection with the luminosity monitor is foreseen

	Dither LUMIN. FB	FAST-IP-FB
Pickup	Dither coils	BPM or striplines
Actuators	Magnet power supplies	kicker
processing technol.	Mixed	FPGA
Excitation to beam	yes	No
Luminosity monitor link	yes	no
Working planes	X, Y, Yp	position or angle
Main algorithm	Newton zone finder	F.I.R. (Finite Impulse Response)
sensitivity	**???**	**???**
Response time	~1ms	<200ns
Low emittance impact	low	very low
Feedforward or b-b-b	no	yes
tested @	PEP-II	ATF2

R & D

- **1D or 2D bunch-by-bunch diagnostics**
  - Diagnostics in 1D or 2D, bunch-by-bunch and turn-by-turn, seems necessary for colliding two beams with so small vertical emittance and sigma
  - Without powerful real time tools, it could be impossible to evaluate the wasting of luminosity along the bunch train

Conclusions

a) It seem interesting try to implement both approaches (Dither and Fast IP feedbacks) and maintaining them separate
b) The two systems should cohabit without any problems
c) The “Dither Coil Feedback” should be developed considering fast data exchange with the luminosity monitor
d) The “Fast IP Feedback” should be designed and implemented in close connection with the fast bunch-by-bunch feedback system