Beams diagnostics electronics for the CTF3 Combiner Ring

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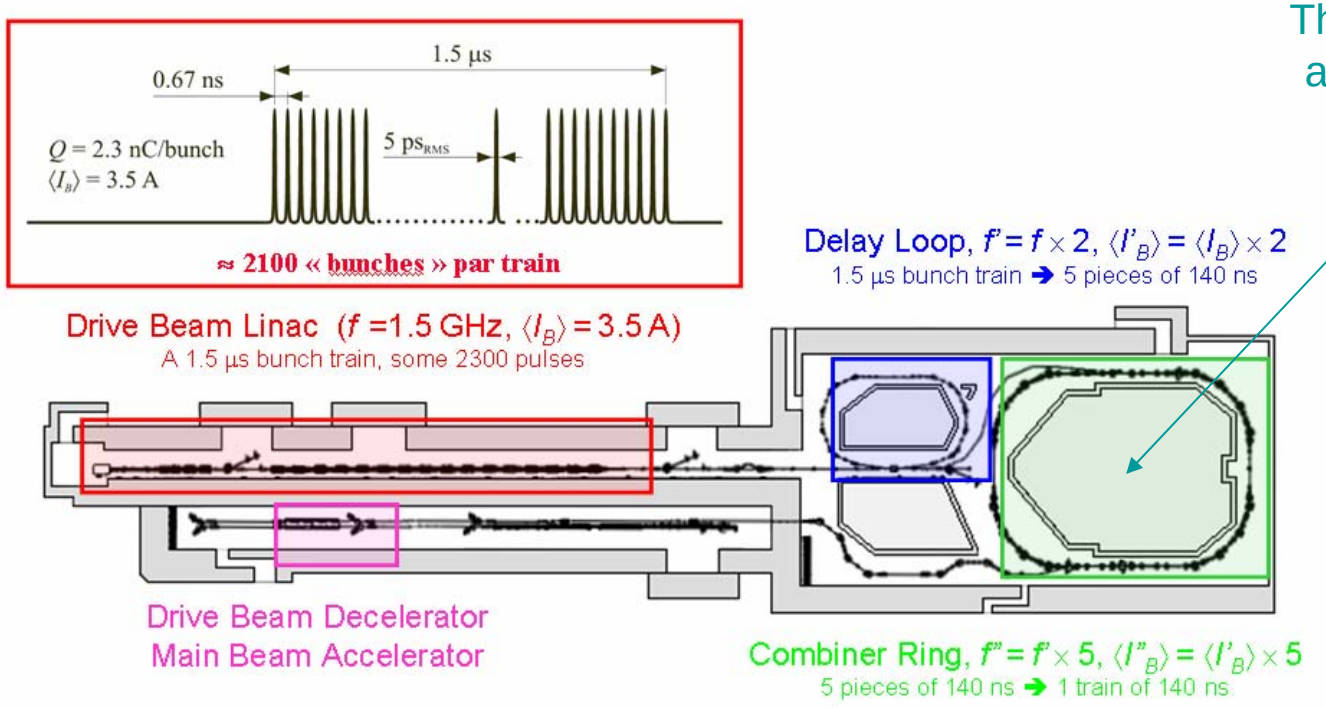
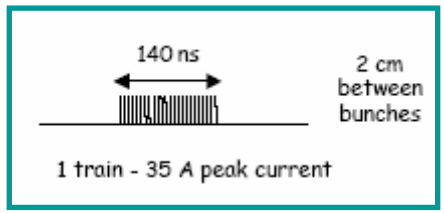
LAPP - Annecy

Reminder : Beam parameters in the Combiner Ring



The Combiner Ring performs a second compression step on the bunch trains.



Beam current range : 1A - 35 A
Beam pulse length : 140 ns – 1500 ns
Repetition rate : 5Hz - 50 Hz

Beam Position Monitor (BPM)

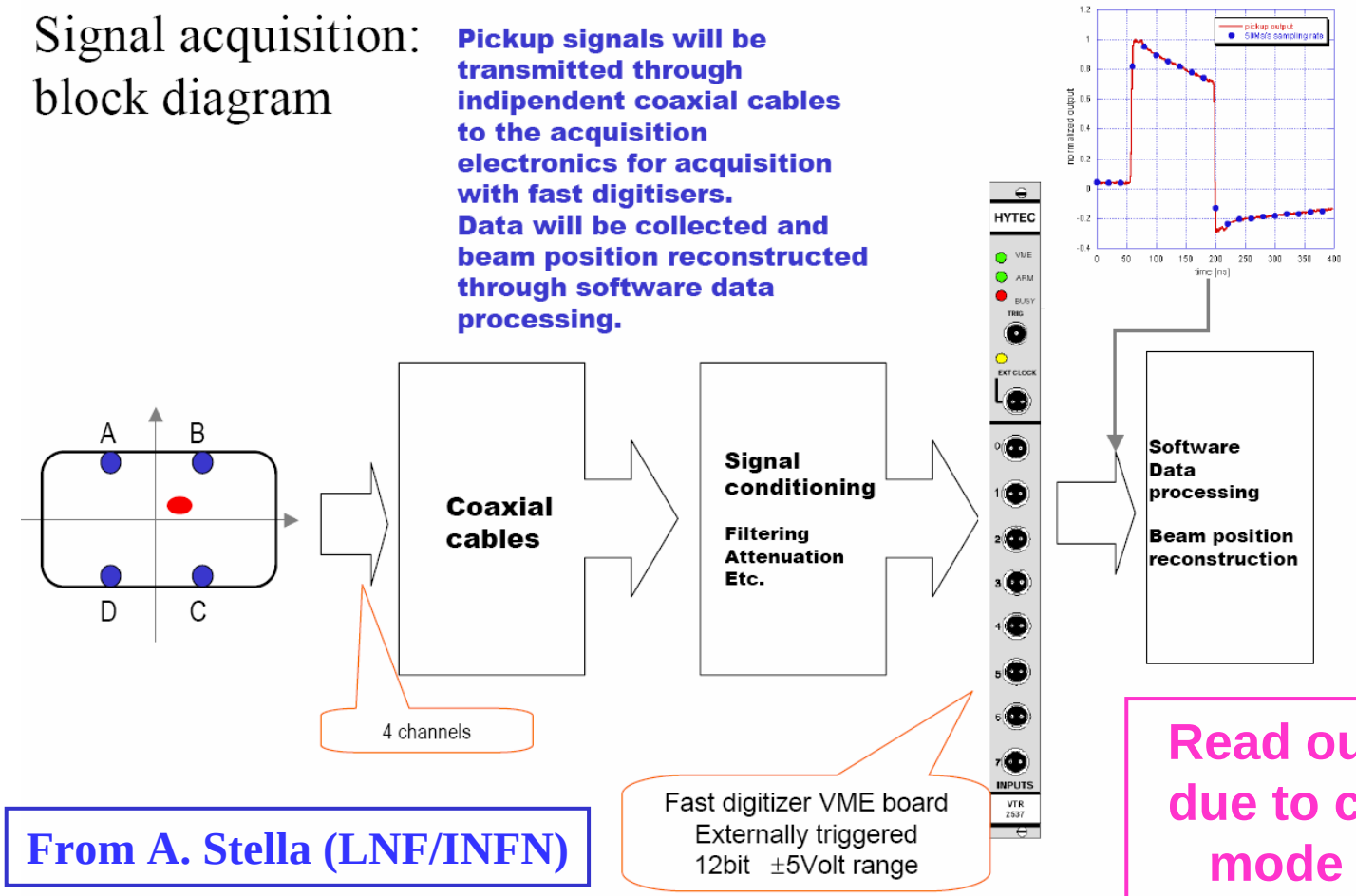
- Inductive sensor delivered by INFN:
  - Works as a transformer excited by the beam.
  - 4 electrodes located on top and bottom.
  - Max horizontal deviation : +/- 15 mm
  - Max vertical deviation : +/- 10 mm
  - Expected resolution : 50 μm
  - Total length : 24 cm.

Signal amplitude depends on the beam position and the beam current.

Existing Electronics

Signal acquisition: block diagram

Pickup signals will be transmitted through indipendent coaxial cables to the acquisition electronics for acquisition with fast digitisers. Data will be collected and beam position reconstructed through software data processing.



From A. Stella (LNF/INFN)

Read out errors due to common mode noise.

Expensive coaxial cables.

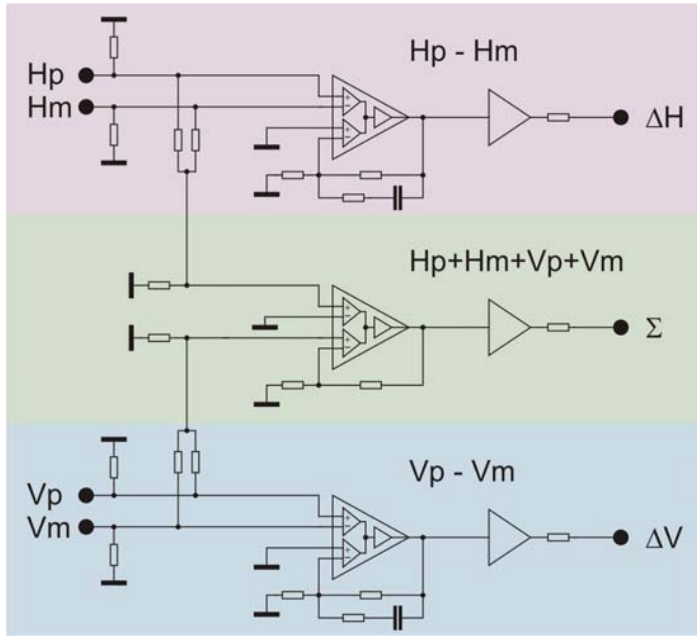
LAPP's involvement

- Equip the Frascati BPM of the Combiner Ring.
- Analog part : Final electronics by next summer.
  - From electrode voltages A, B, C,D, summing and 2 differences are generated.
- Digital part : Complete study for the end of 2006
  - Analog to digital conversion
  - Local calculations
  - Data transmission / reception through optical fibers.
  - Shaping for the acquisition part.

Full compatibility with the existing electronics.

Analog electronics (1)

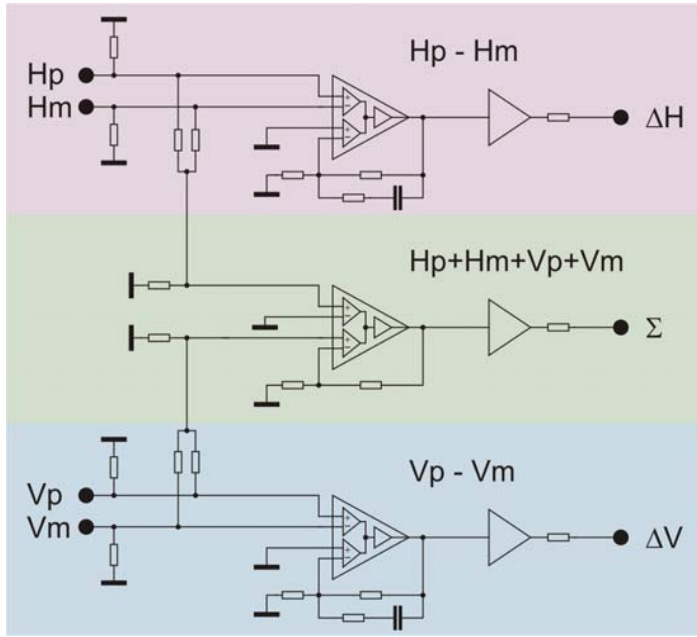
- Horizontal and vertical deviations :
  - $V_{\Delta V}$ = (A+B) - (C+D)
  - $V_{\Delta H}$ = (B+C) - (A-D)
- Sum proportional to the beam current :
  - V_{Σ}= A+B+C+D
- A similar electronics has been developed by M. Gasior for the Linac part, but with different beam parameters.
- A first study was made at LAPP.
  - Draft schematics.
  - Components ordered.
  - Home made proto for the beginning of 2006.
  - A BPM should be received from INFN by the end of the year.
  - First tests will be done using the Calibration input.
  - Final validation with wire test bench ?



From Marek Gasior (CERN)

Analog electronics (2)

- 5 decades of BW required :
  - 10 kHz - 100 MHz
- High output voltage range delivered by BPM (for 35 A current beam):
  - 0V - 40 V on the electrodes
  - 0V- 88 V for the sum.
- Expected numbers of the LAPP proto design :
  - 3.8V max output amplitude
  - 140µV RMS output noise
  - Output dynamic range = 27.10^3



From Marek Gasior (CERN)

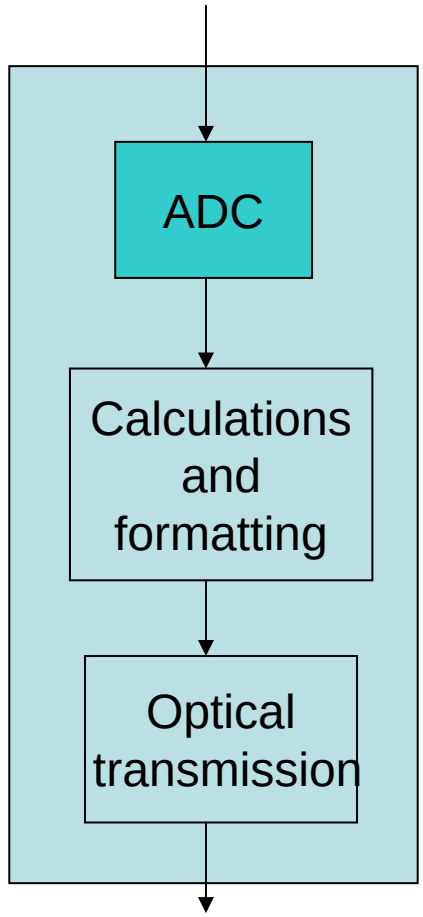
Analog to digital conversion (1)

- 12 bits, 200 MSPS ADC are foreseen :
  - 12 bits to keep a resolution of 50 μm on the 30 mm maximum deviation and a SNR of 7.
  - Min sampling @ 200 MHz = 2 * max Analog bandwidth.

  => 12 bit, 200 MSPS ADC reach the limits of current techno.
  Three ADC are needed per BPM (one per voltage).

- Possibility to increase the sampling frequency, using an analog memory.
  - IN2P3 has developed the MATACQ chip.
    - Circular buffer of 2500 samples.
    - Sampling frequency up to 2 GHz.
  - Dead time between 2 bunches could be used to digitalized data.

  = > But this increases also the design complexity !



Analog to digital conversion (2)

- Most of 12 bits 200 MSPS ADC have ENOB bellow 11.
  - ENOB = Effective Number Of Bits

Reference	Resolution	Sampling Frequency	ENOB	Voltage supply
AD 9430	12 bits	210 MSPS	10.5 @100 MHz	3.3 V
AD12400	12 bits	400 MSPS	10.8 @100 MHz	3.3 V
Maxim 1214	12 bits	210 MSPS	10.6	1.8 V
Maxim 1215	12 bits	250 MSPS	10.4	1.8 V
Telasic 1411	14 bits	250 MSPS	11.5	+/-5 V
VTR 2537 (linac)	12 bits	50 MSPS	10.5	?
SIS 3320 (CR)	12 bits	200 MSPS	10.5	?

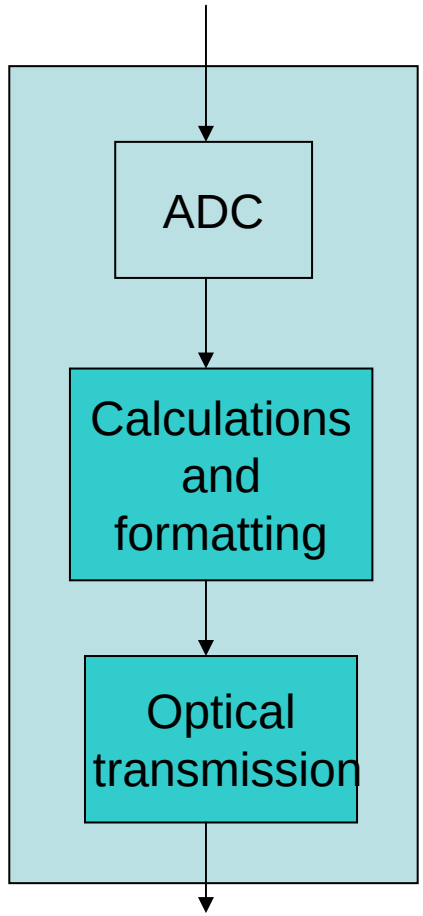
Do we accept an effective resolution bellow 12 bits ?
Current BPM have ADC with ENOB equal to 10.5.

Calculations and optical transmissions

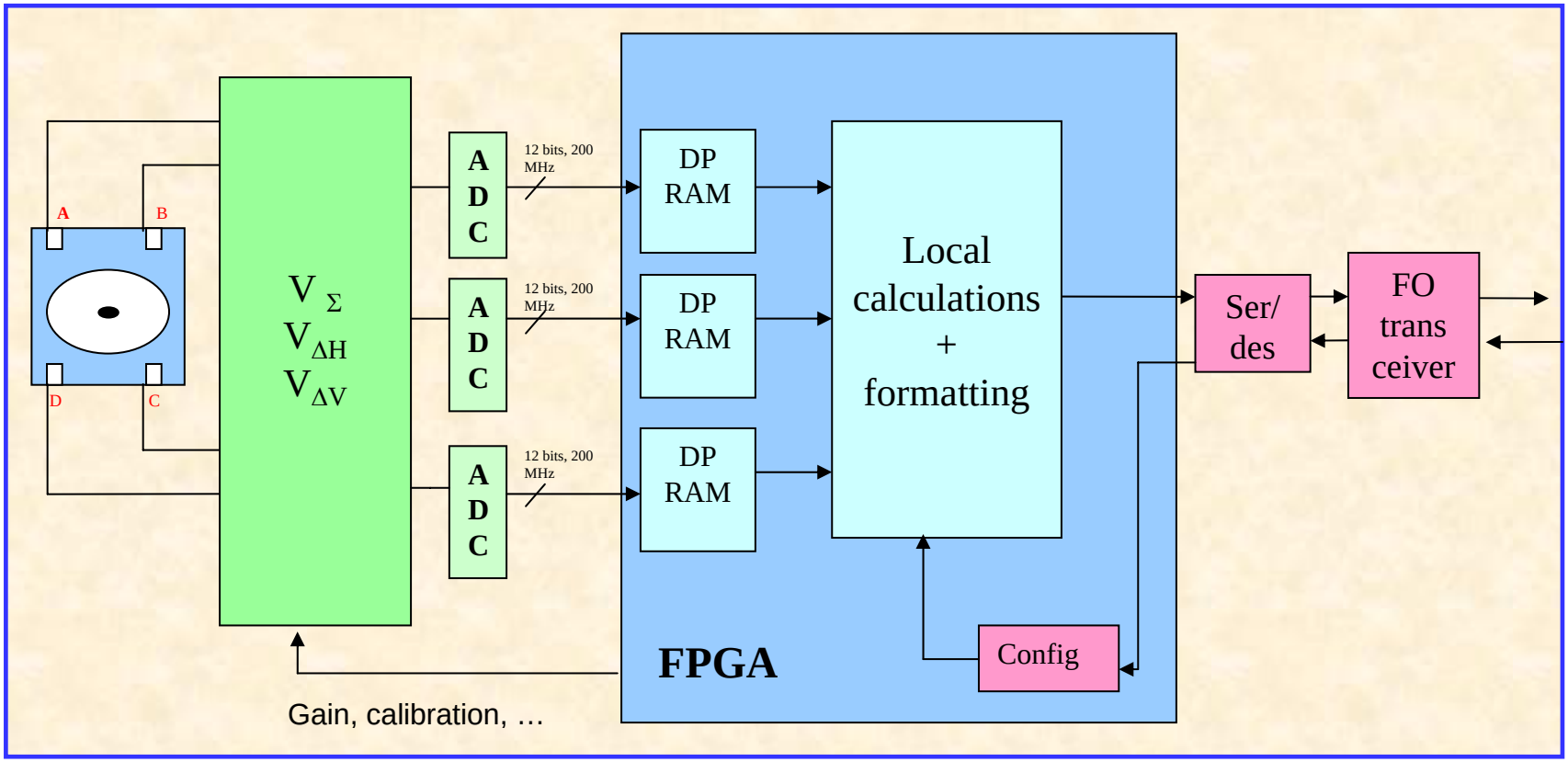
- Data transmission through optical fibers..
  - Fast and high security point to point connection between the front end and the acquisition.
  - Transmission of BPM raw data.
  - Optical transceivers also allow data reception. This can be used for the online configuration and the calibration.
  - 150 µs are needed to output data from 1500 ns long pulses, sampled at 200 MHz, on OF running at 1 Gbits/s.

  => OK for a pulse repetition period = 20 ms.
- A digital interface is required between the ADCs and the optical serializer.

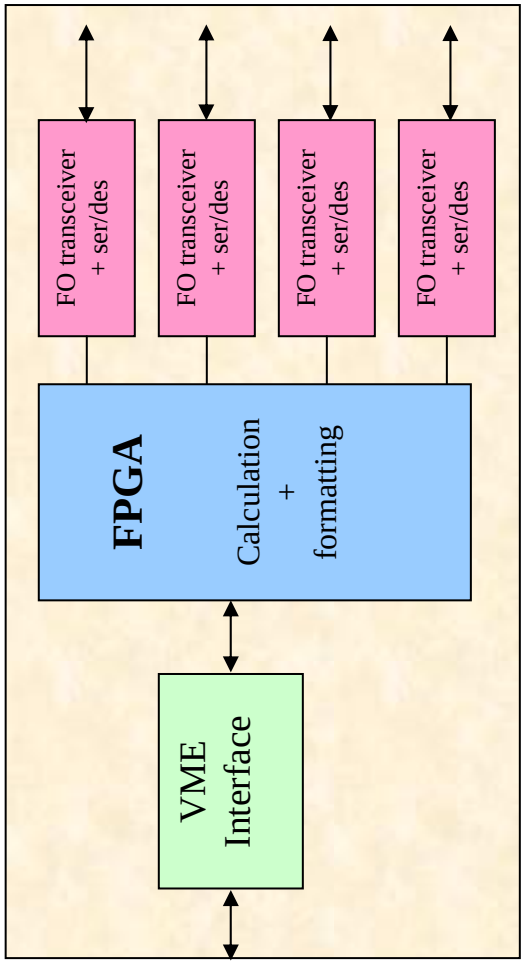
  => Digital logic that will be included in a FPGA.
- This FPGA could also be used to make local calculations and formatting.
  - Online beam parameters (average current, average position, maximal deviations …).
  - Local filtering and feedback calculations.
  - BPM tagging and data formatting (header, trailer).
  - ...



Functional diagram of the Front End electronics



Acquisition part



- Acquisition electronics
  - Data reception through optical fibers.
  - Several BPM treatment per board. 8 ?
  - Possibility of calculations and formatting in a FPGA.
  - VME interface.
  - Driver to be developed.

=> Full compatibility will be kept with the current system

Conclusion

- Happy to join the CTF3 collaboration.
- LAPP's project aims to :
  - Transmit signals in differential mode to avoid perturbations. (sum + differences + optical fiber)
  - Reduce number of cables, but also the cable cost.
  - Offer the possibility of local digital calculations and formatting.
- Some parameters to be checked :
  - ADC resolution and dynamic range.
  - Calibration mode.
- Radiation level to be understood :
  - Do we need rad-hard electronics or move away from the beam ?
- Test bench :
  - Do we need wire test bench for the electronics ?