CTF3 BPMs

Agenda

- Different types of BPMs
- Electronics
- Radiation problems
- From CTF3 to CLIC

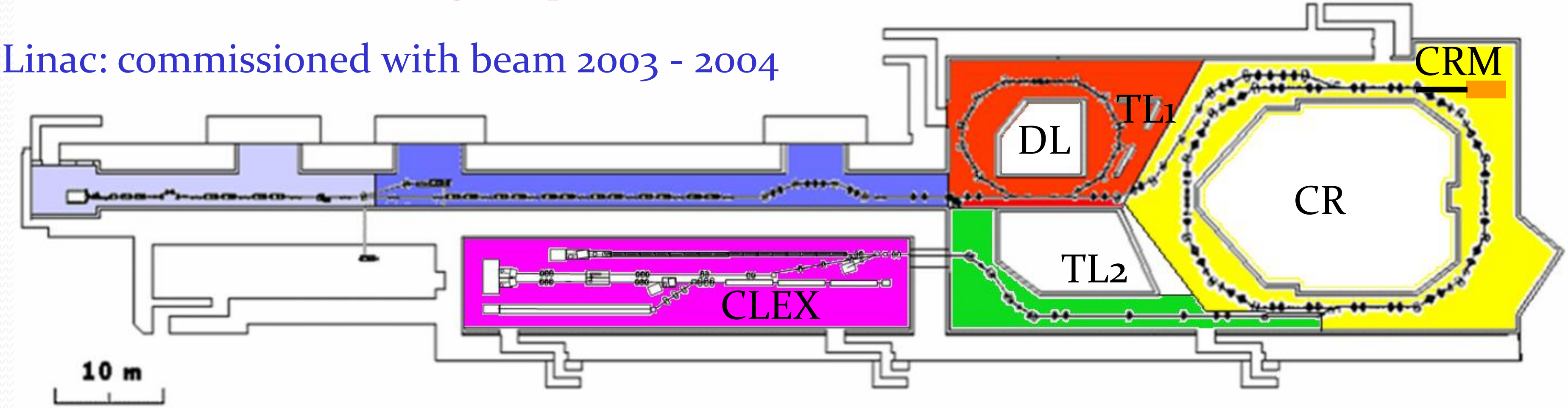
CLIC Test Facility 3

A total of 137 BPMs

TL1 & CRM commissioned fall 2006

Delay Loop: commissioned with beam 2005-2006

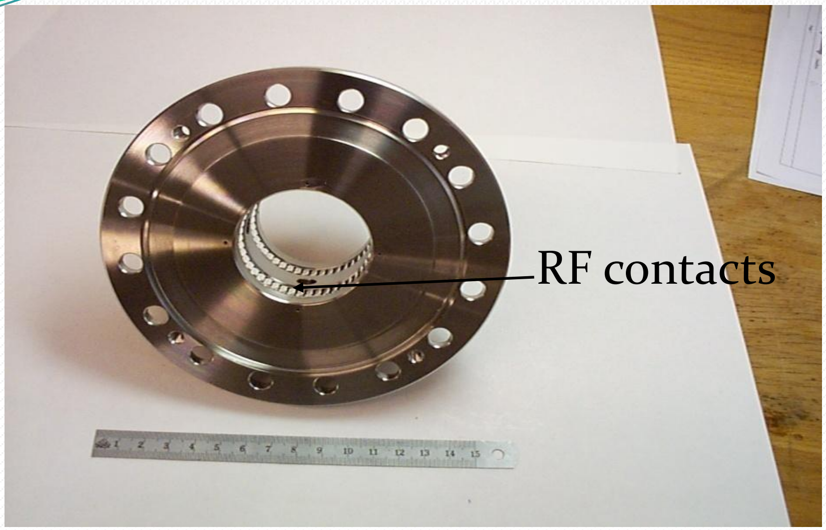
Linac: commissioned with beam 2003 - 2004

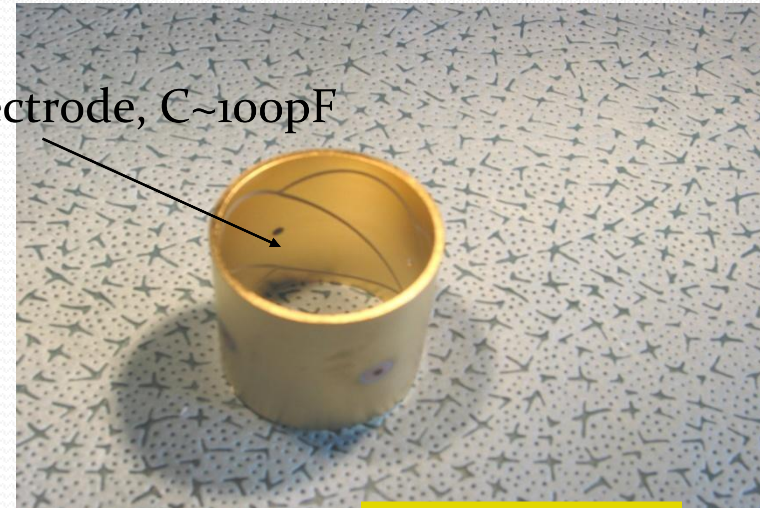


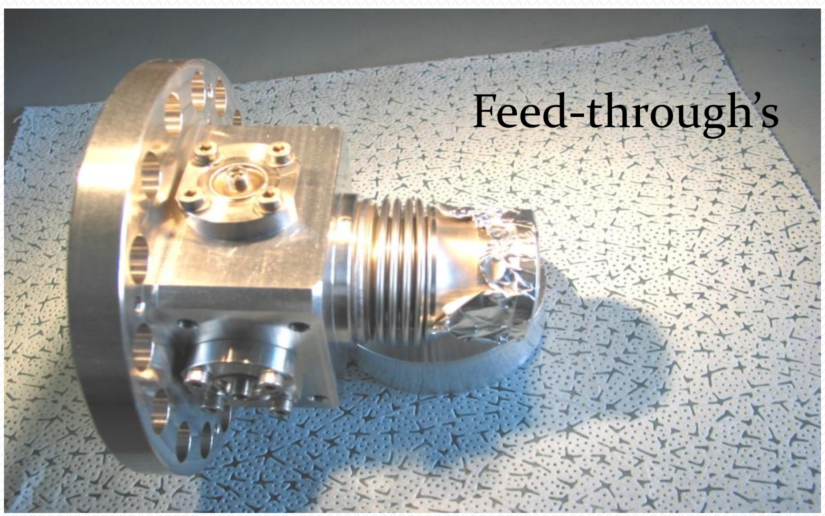
TL2 and TBTS commissioning started August 2008

CR commissioning since 2007

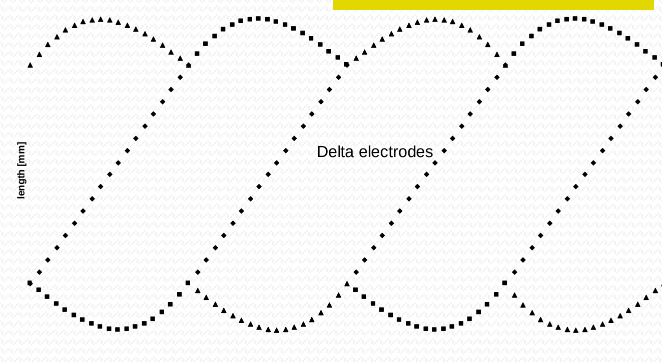
Electrostatic Pick-up (BPE)







$$\hat{V}(t) = \frac{i(t)}{v} \cdot \frac{l_{eff}}{C_{Elec}}$$



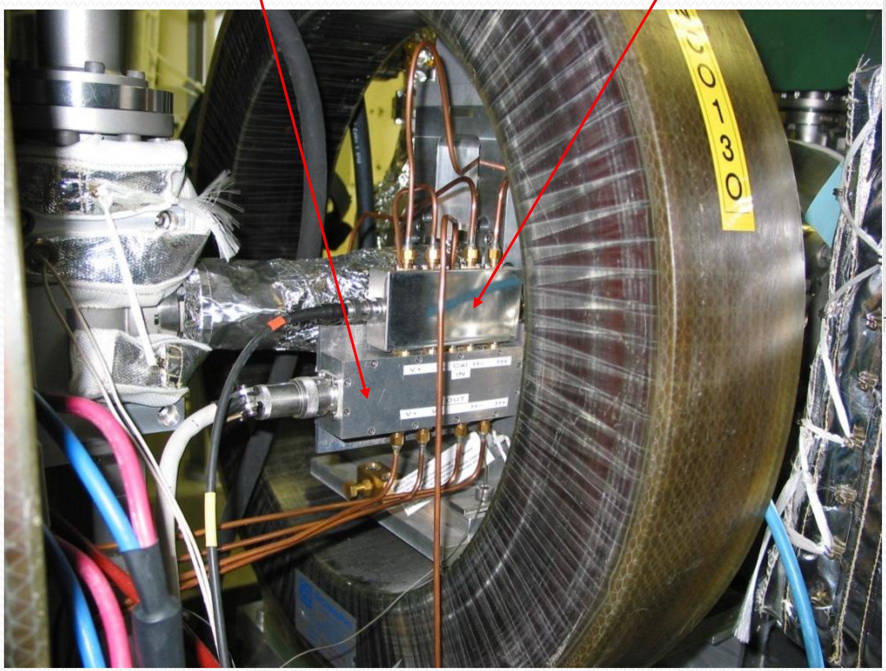
Developed by L. Søby, CERN

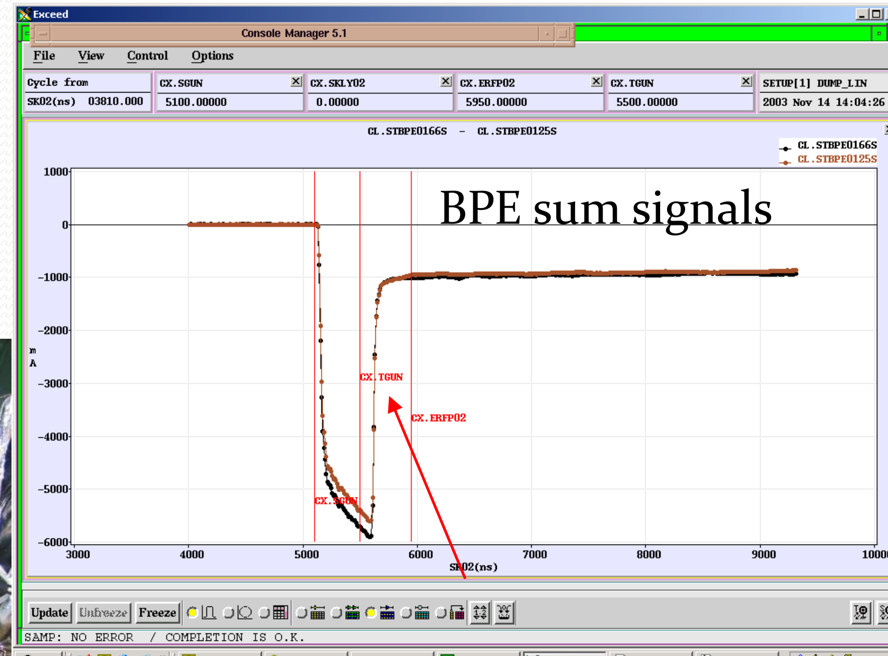
Electrostatic PU (BPE)

$$F_{Low} = \frac{1}{2 \cdot \pi \cdot R_L \cdot C_{Elec}}$$

Buffer amplifier, R_L=1MΩ

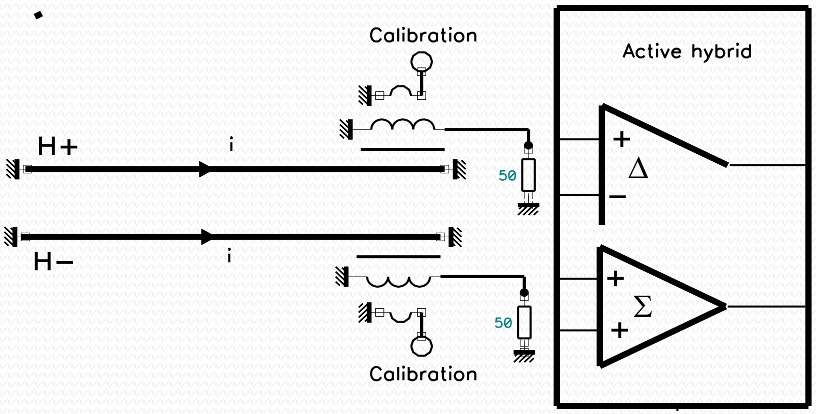
HT bias

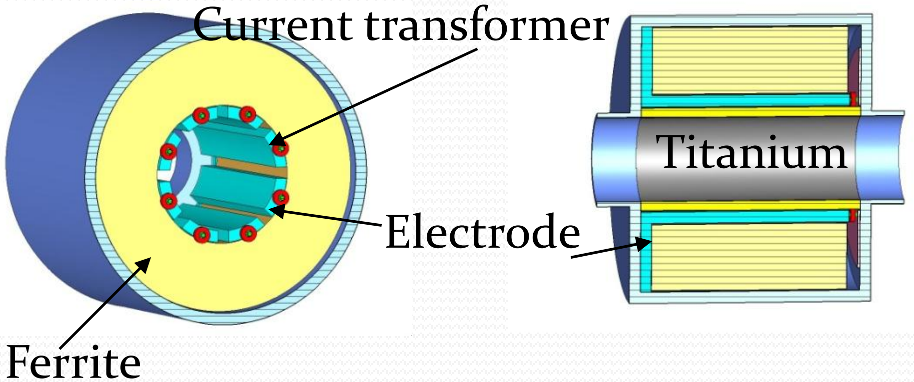




Electrodes charging up due to beam halo!

Inductive Pick-Up's (BPM, BPI, BPS, EuroTeV)





$$R_P = \frac{R_S}{2n^2}$$

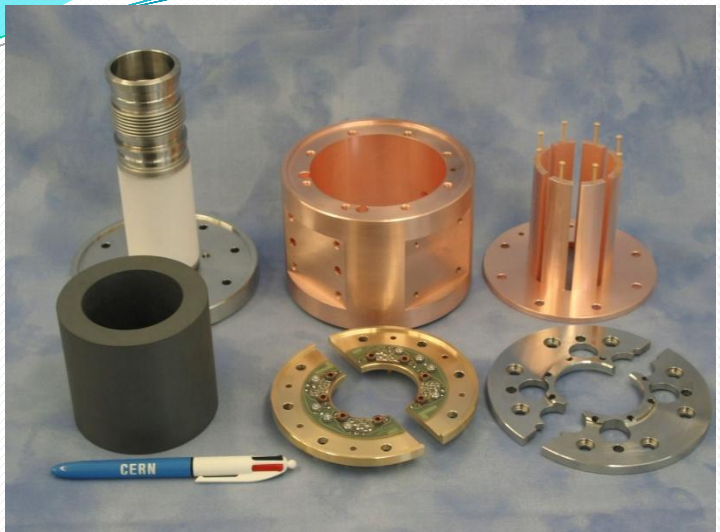
$$R_T = \frac{V_\Sigma}{I_B} = \frac{R_S}{2n}$$

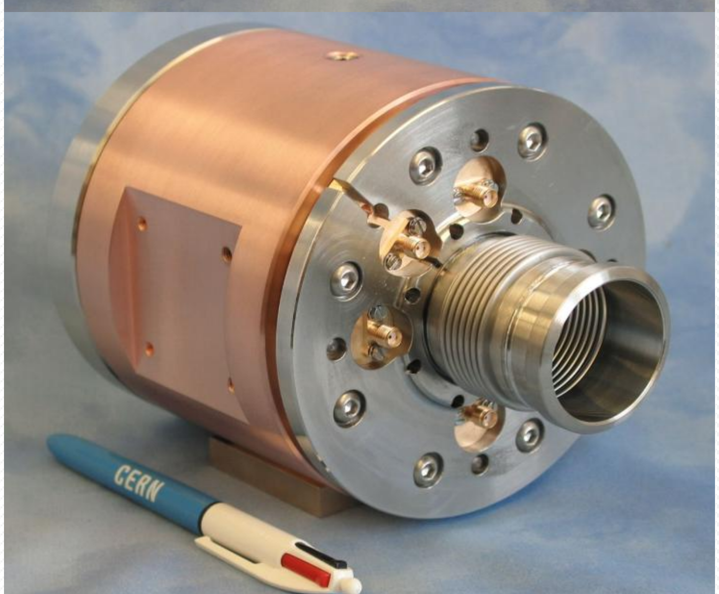
$$f_{L\Sigma} = \frac{1}{2\pi L_\Sigma}\left(\frac{R_S}{2n^2} + R_C\right)$$

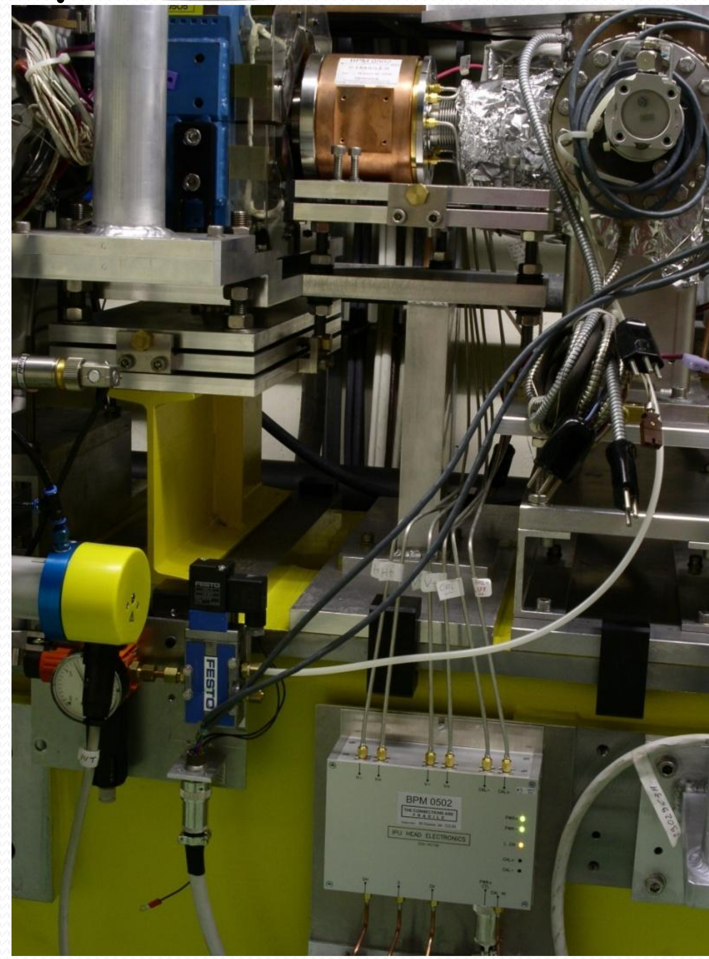
$$f_{L\Delta} = \frac{1}{2\pi L_\Delta}\left(\frac{R_S}{2n^2} + R_C\right)$$

- **Robust and well know design (LPI)**
- **Electrodes outside ceramic chamber**
- **Each transformer has one calibration turn.**
- **Provides current measurement.**
- **Many different parts gives limited absolute accuracy**
- **Resolution limited to ~ 50um.**

Inductive pick-up's (BPM)





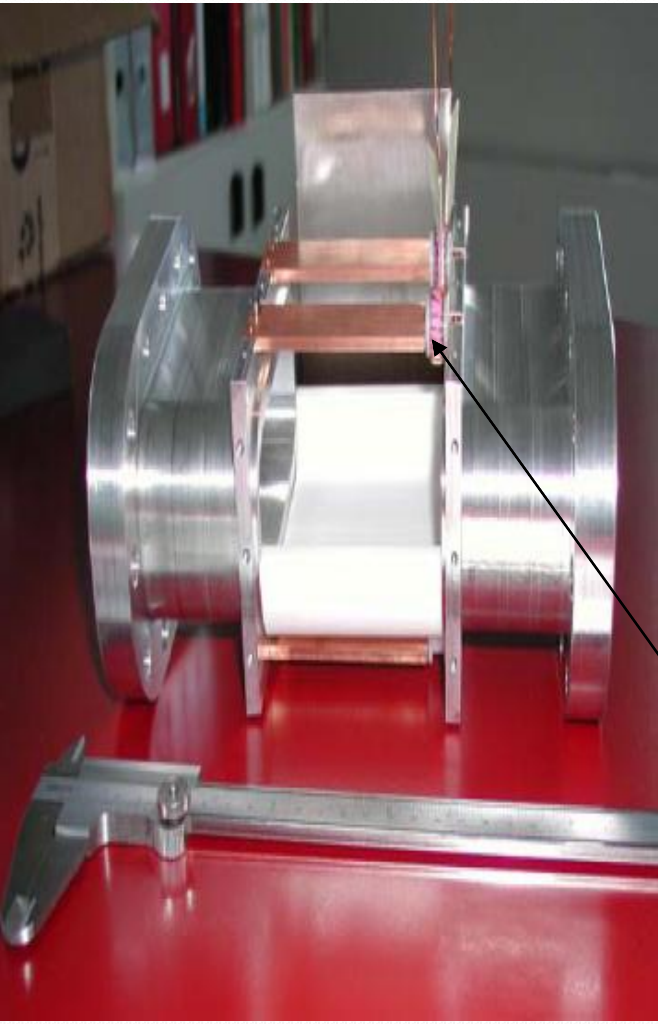


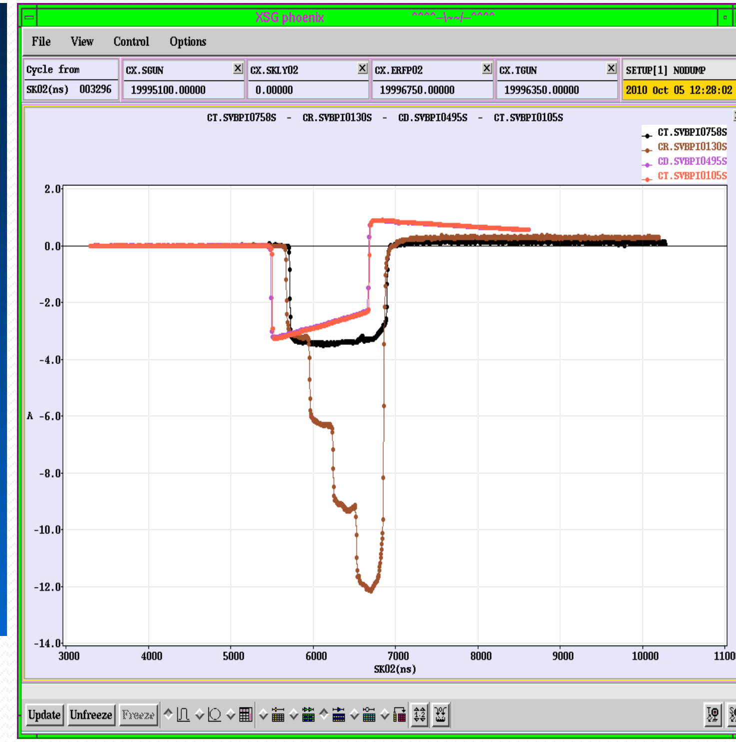
Developed by M. Gasior, CERN

46 BPM's installed as from march 2008

Inductive Pick-up's (BPI)

Developed by A. Stella, Frascati



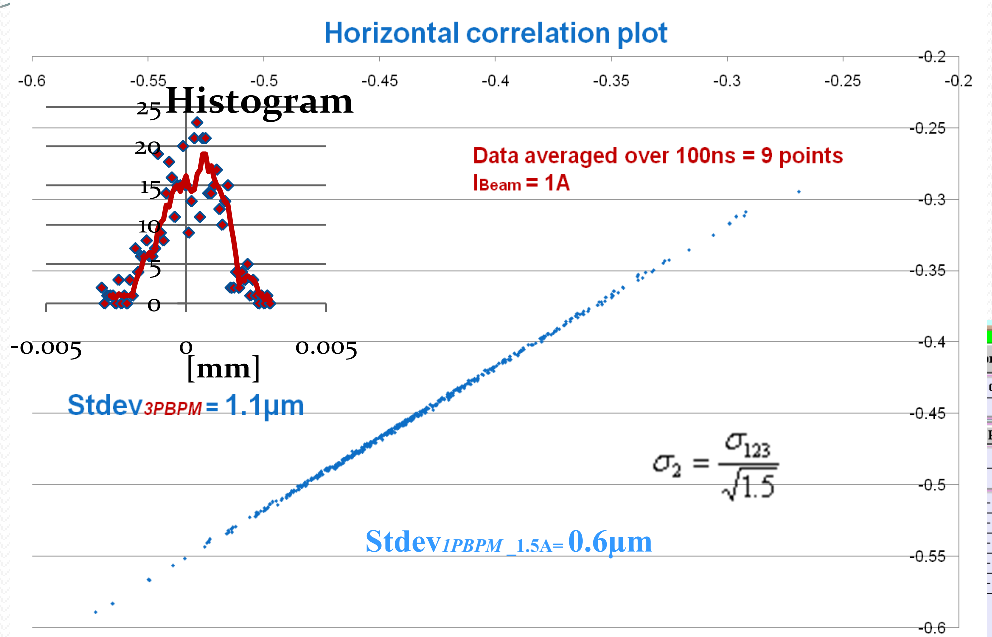


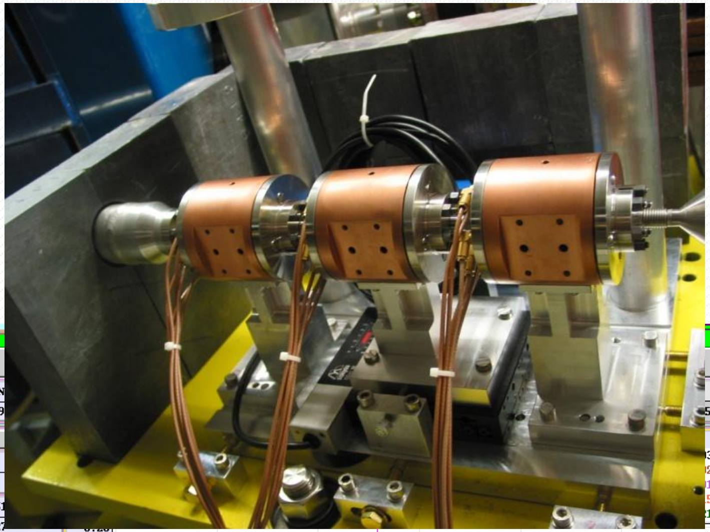
Current transformer with 30 turns and R_L=14Ω

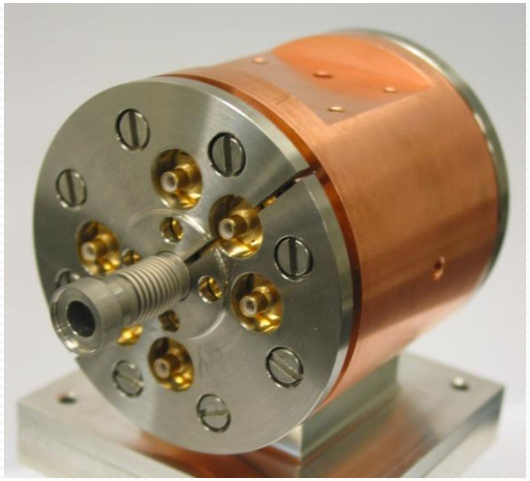
4 electrodes installed on racetrack chamber

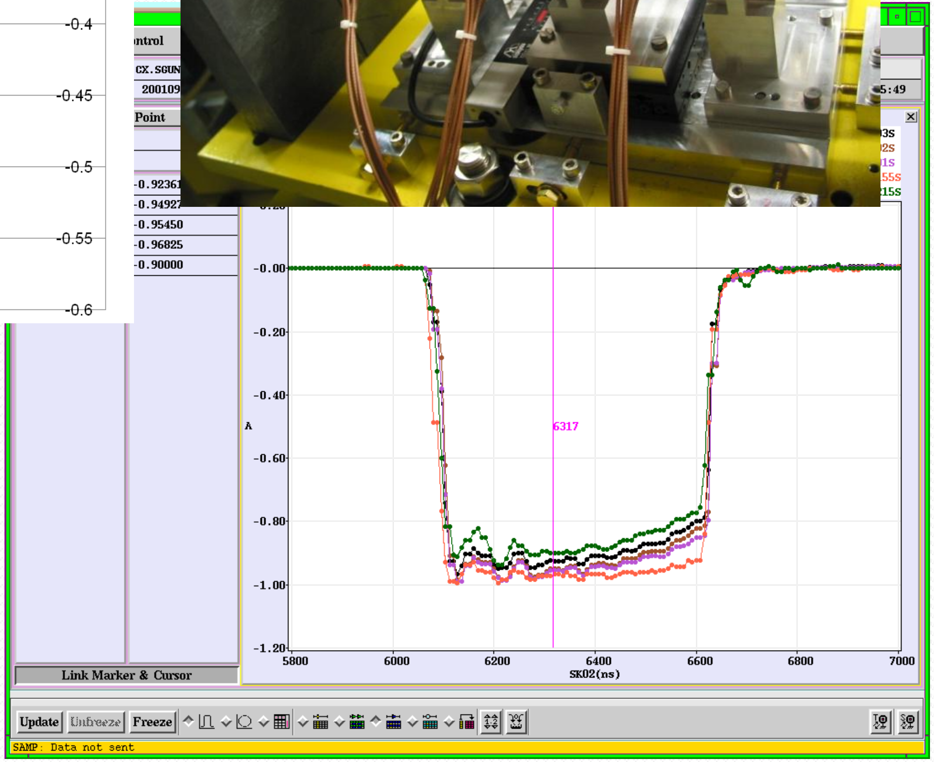
52 BPI's installed as from march 2008

EuroTeV Inductive BPM

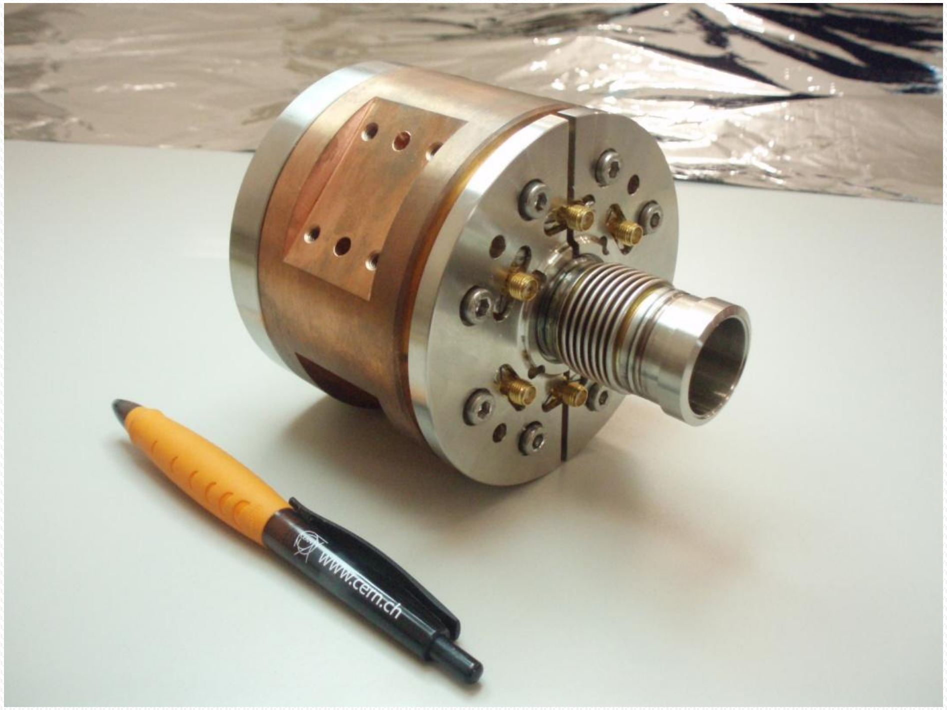


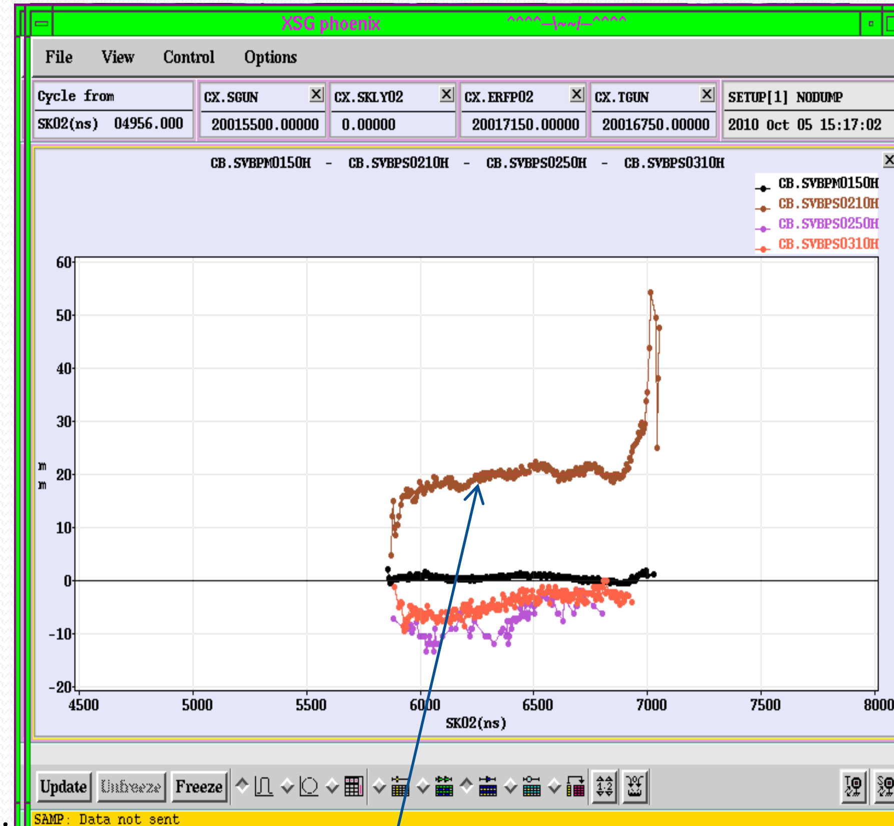






Inductive BPS



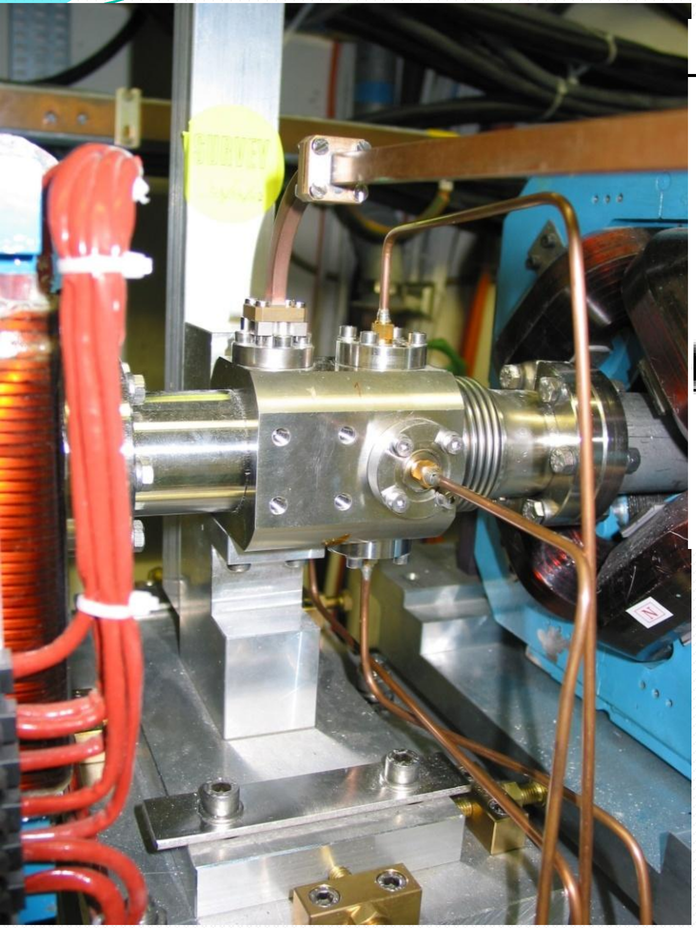


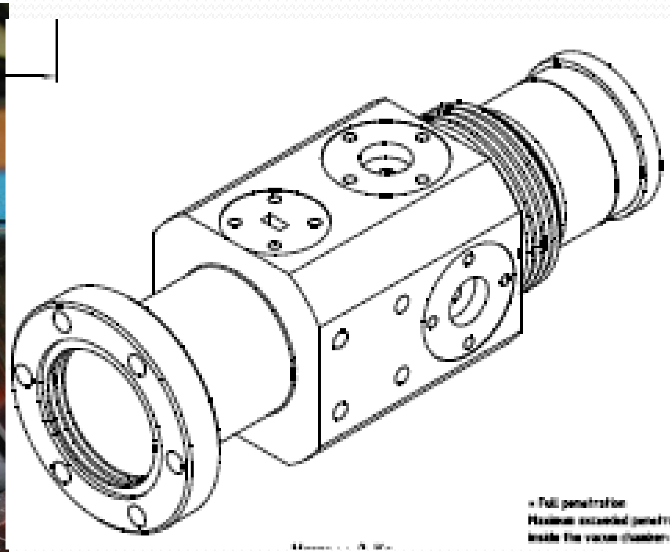
BPM developed by Juan J. Garcia-Garrigos, IFIC Valencia, Spain

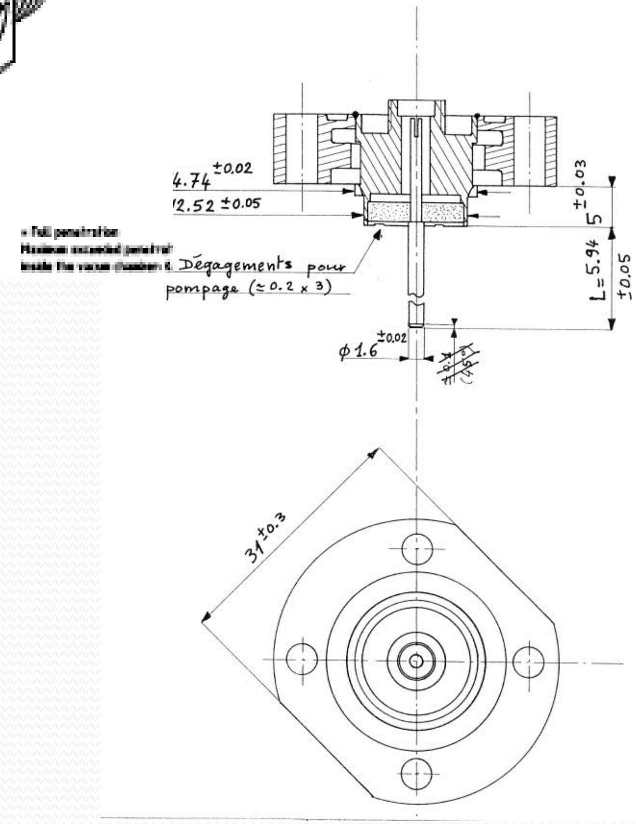
Electronics by: G. Montero UPC, Barcelona, Spain

Noisy and wrong measurements close to PETS

Button Pick-up's (BPR)





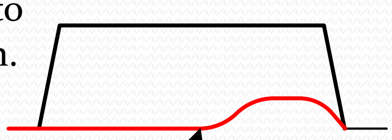


Developed by L. Thorndahl et al.

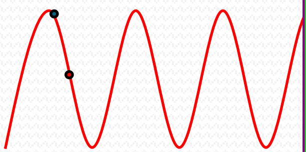
Button Pick-up's (BPR)

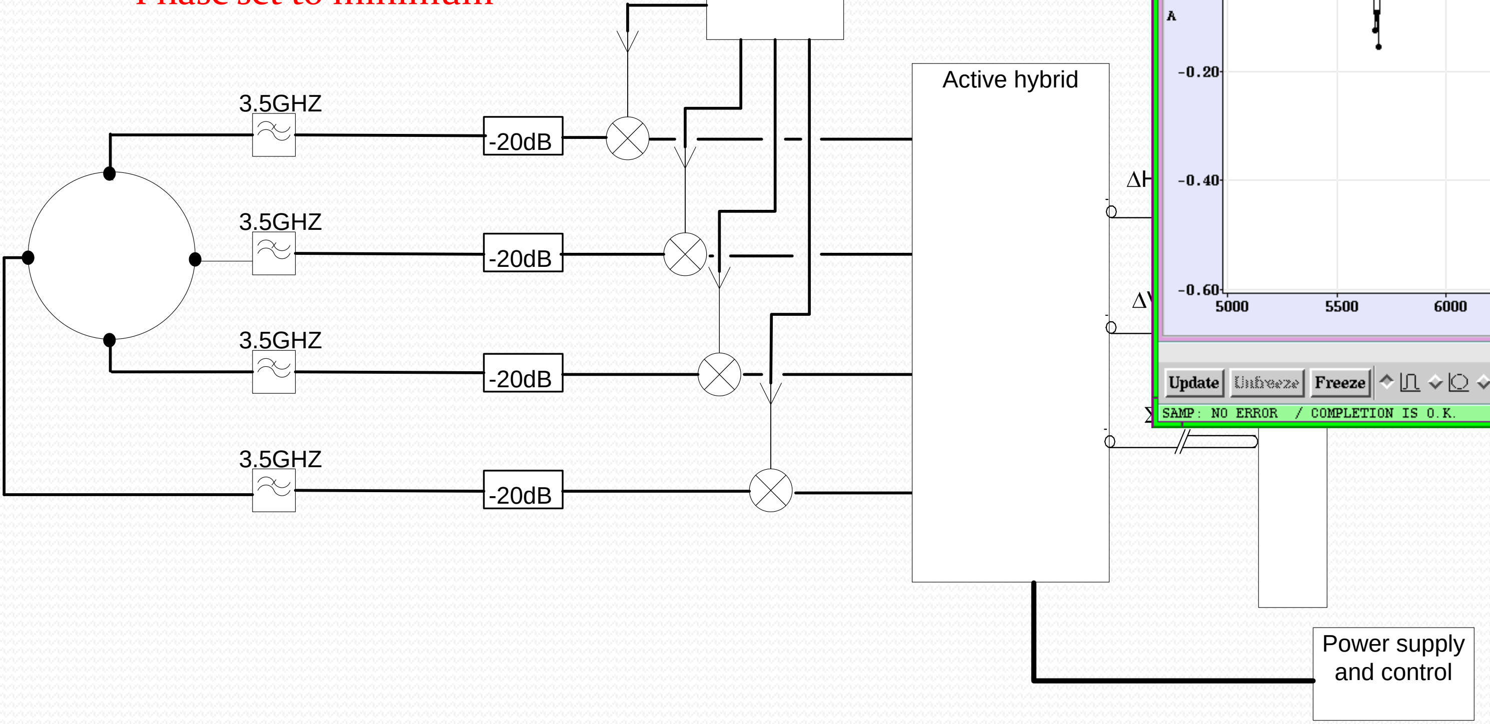
Button electronics

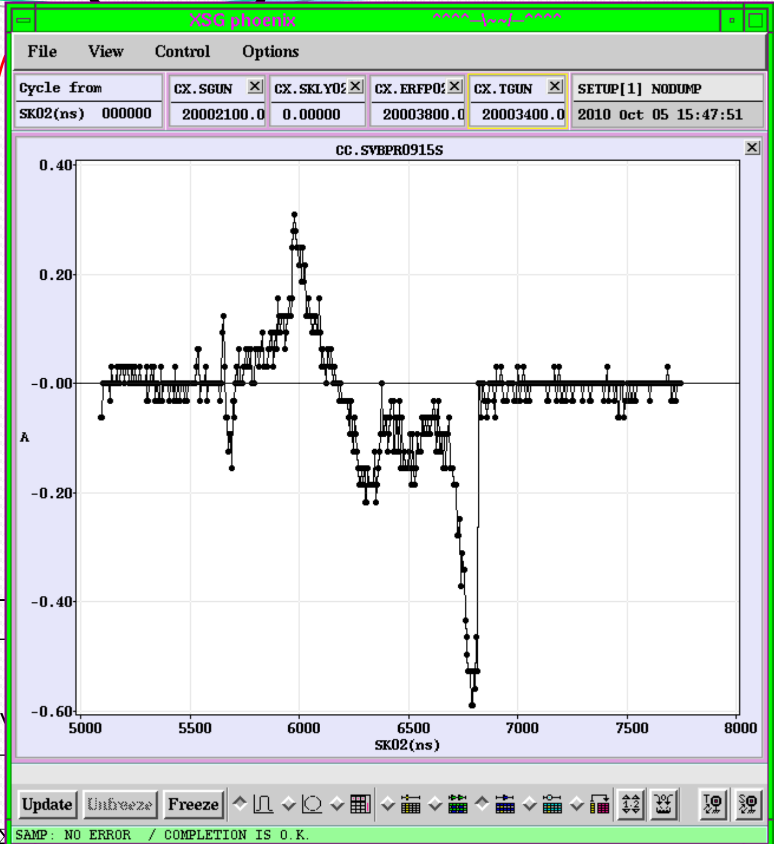
Phase set to maximum.

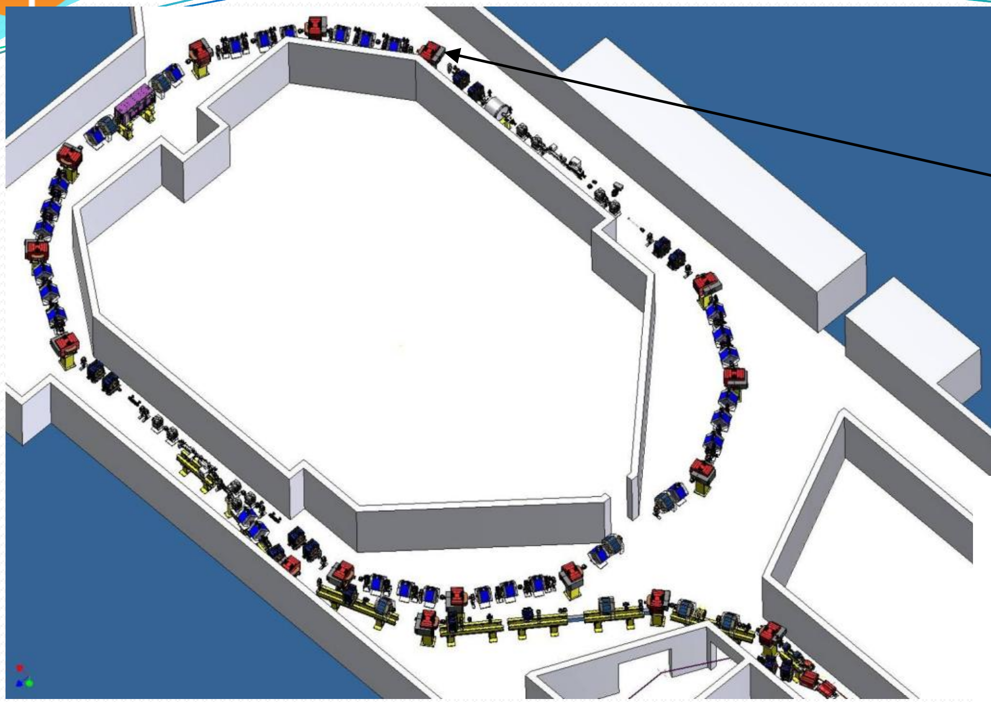


Phase set to minimum



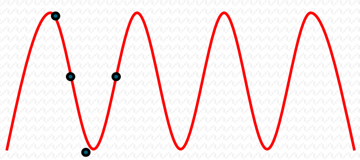






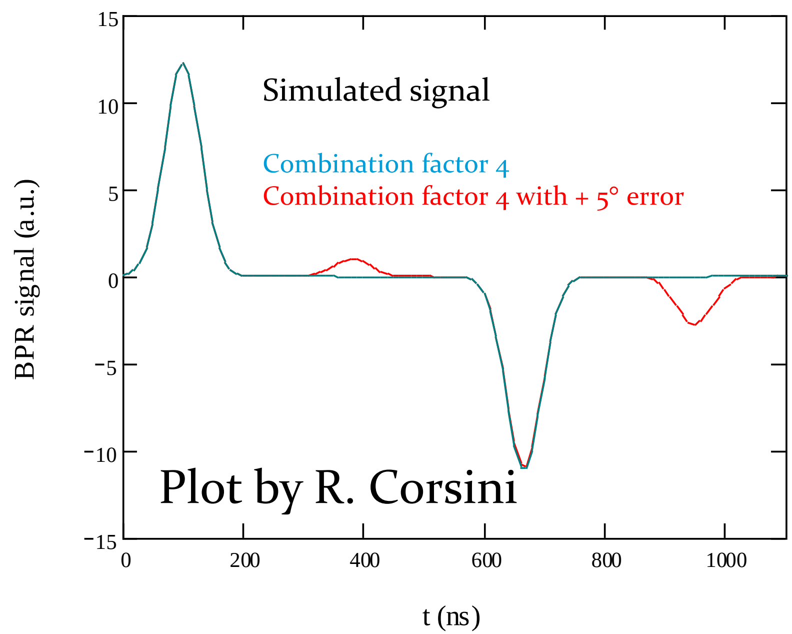
BPR – RF phase monitor

$$N * \lambda + \frac{\pi}{2}$$



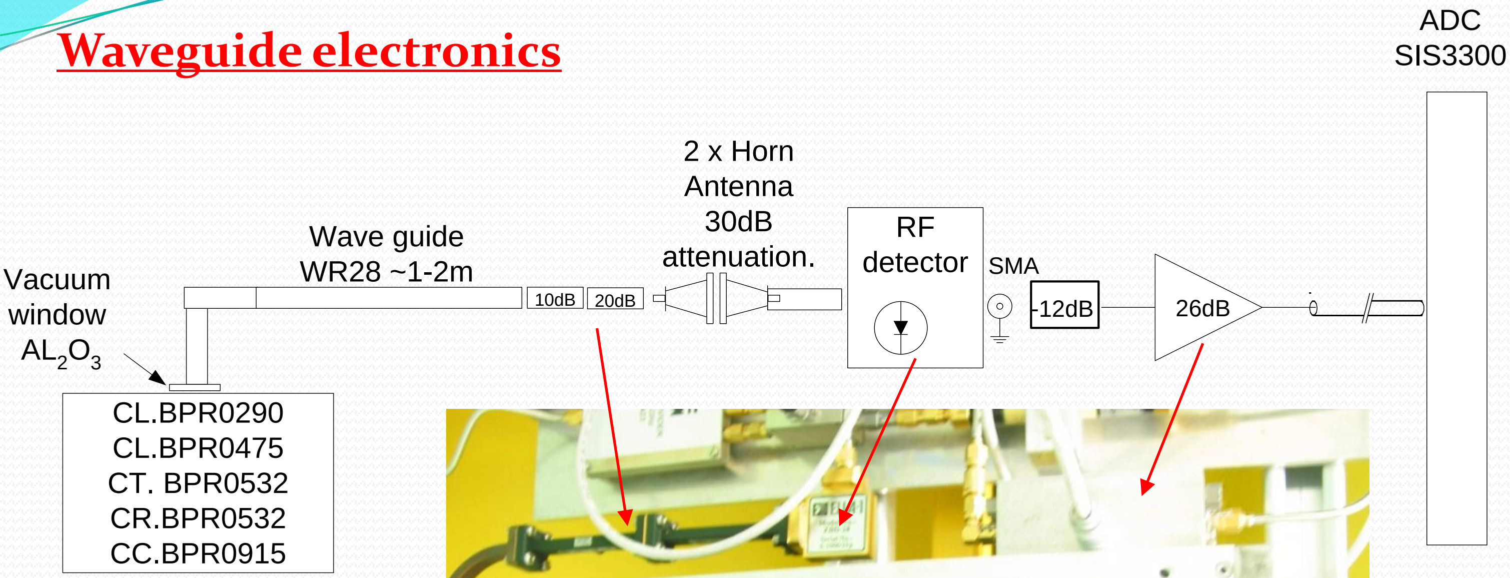
Phase advance per turn (3GHz)

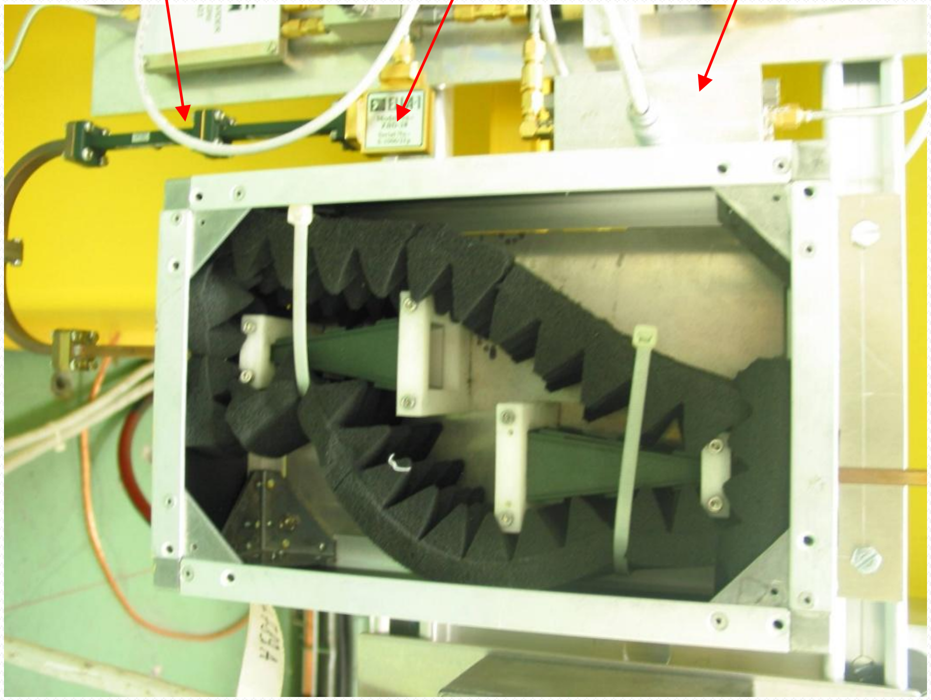
Combiner ring path length

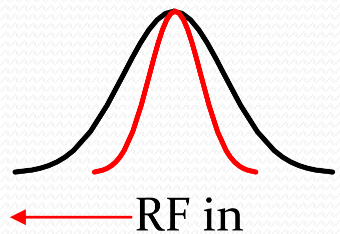


Button Pick-up's (BPR)

Waveguide electronics



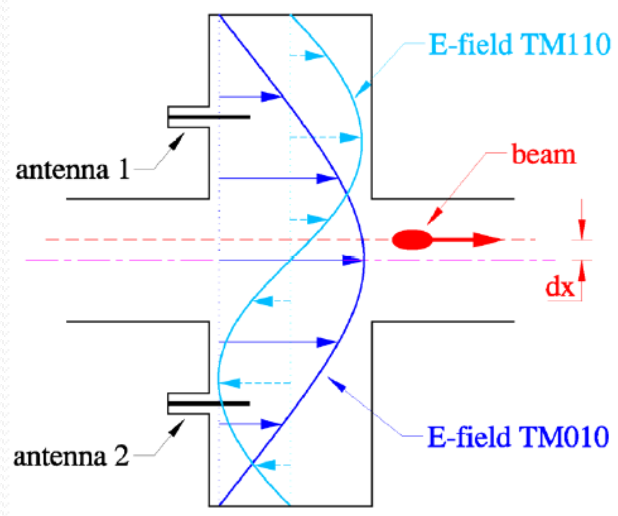


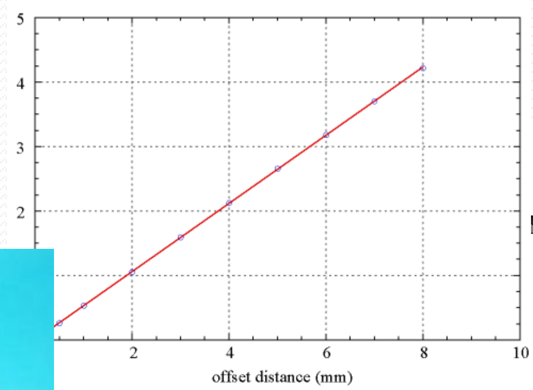


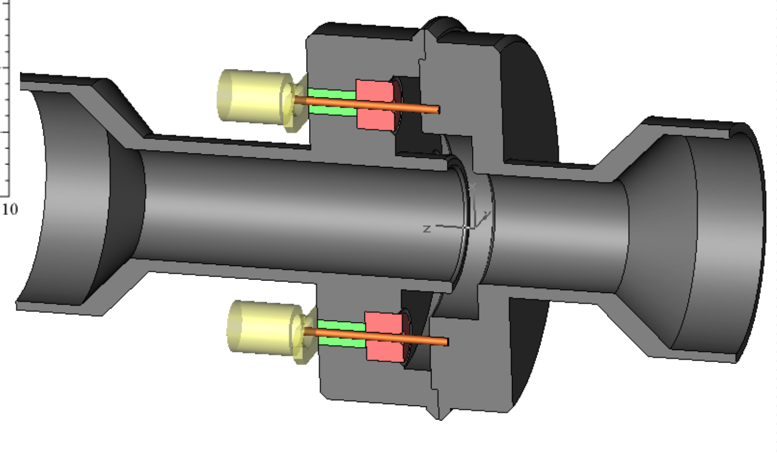
Shorter bunches means more power in the WR28

Re-entrant Cavity BPM (CALIFES)

- Re-entrant geometry for a higher frequency separation between the monopole and dipole modes. → Better CMRR
- Resolution: ~ 1um (CALIFES ~5um)
- Q_{ld} = 50 → Time resolution ~ 2-3ns
- ID 18mm; Length ~100mm.

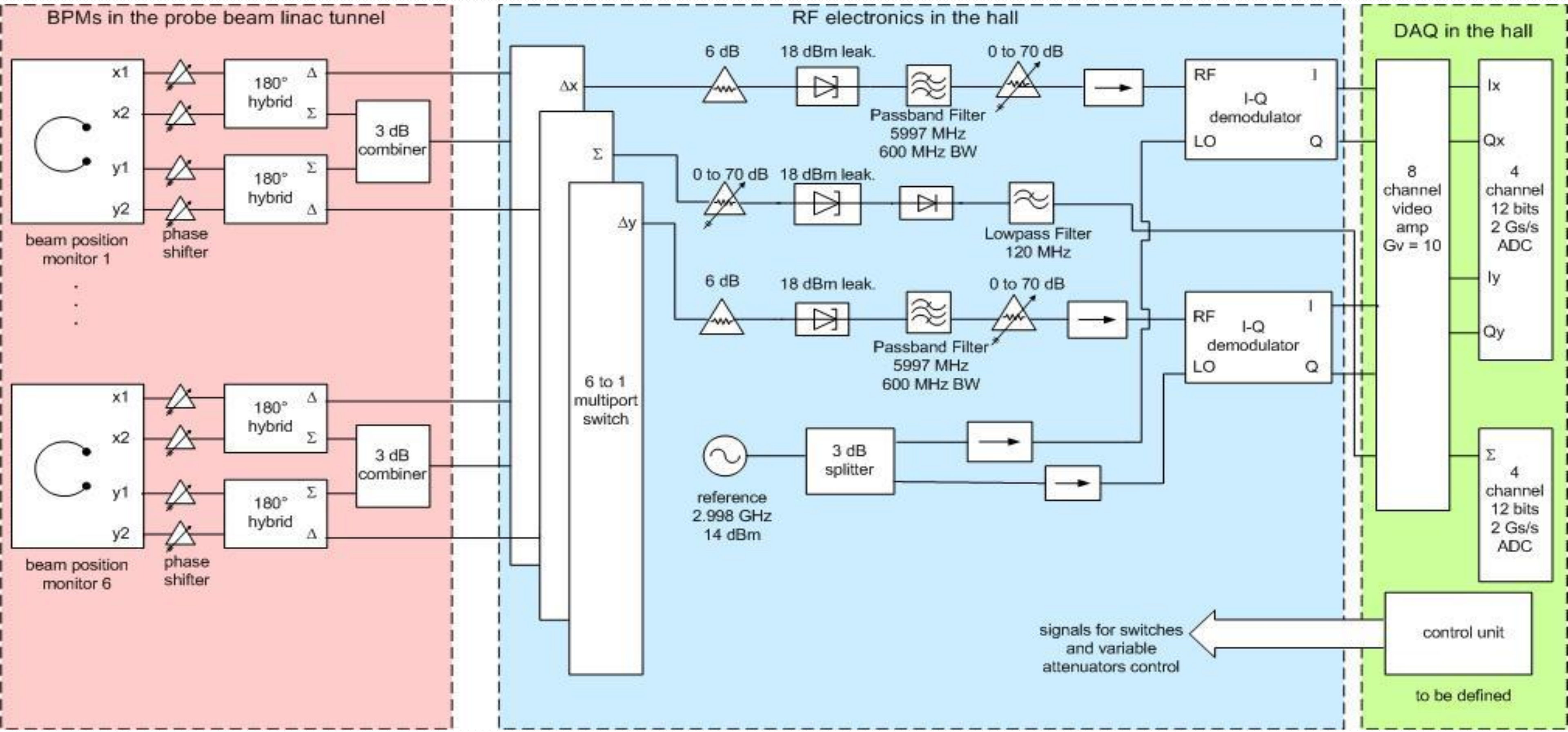






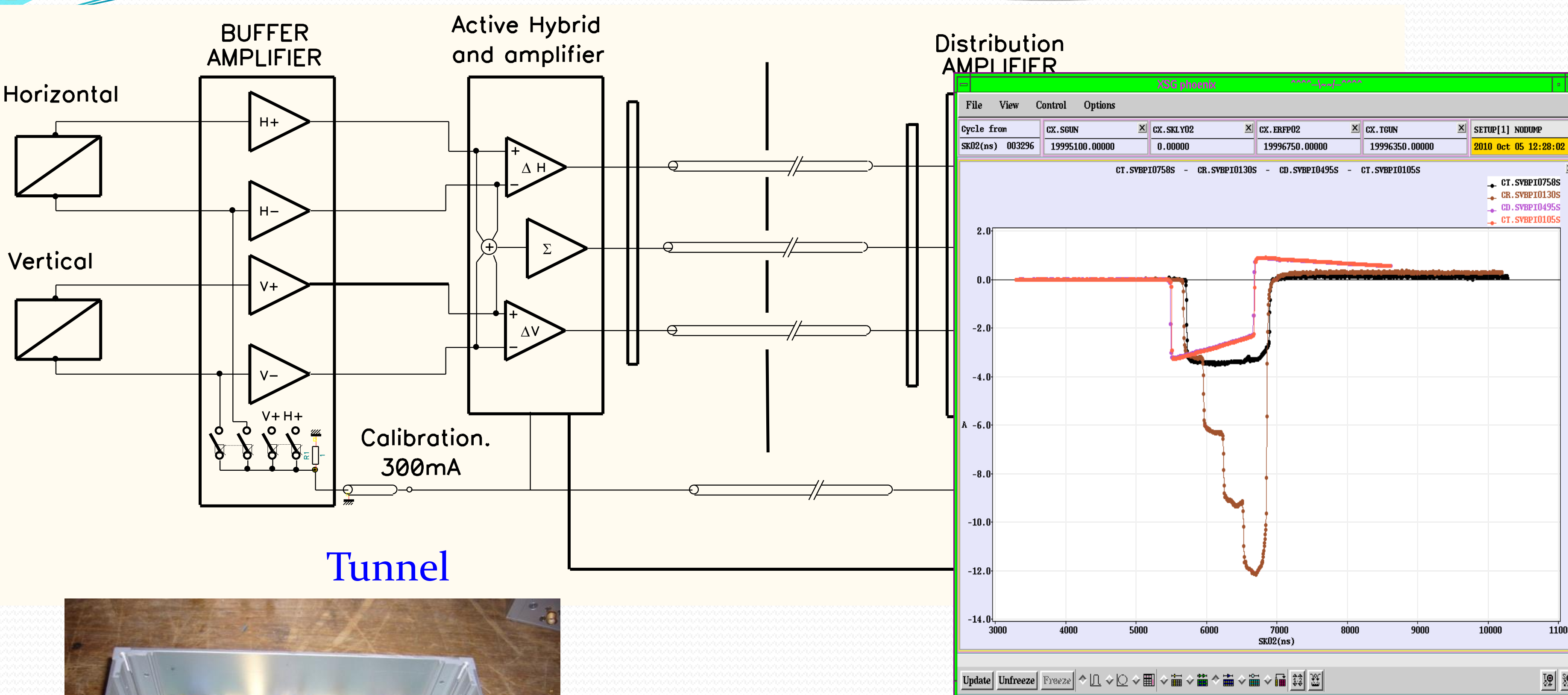
Developed by M. Loung, C. Simon, Sacley

Re-entrant Cavity BPM (CALIFES)



Only one BPM at a time ☹

"Standard" acquisition system

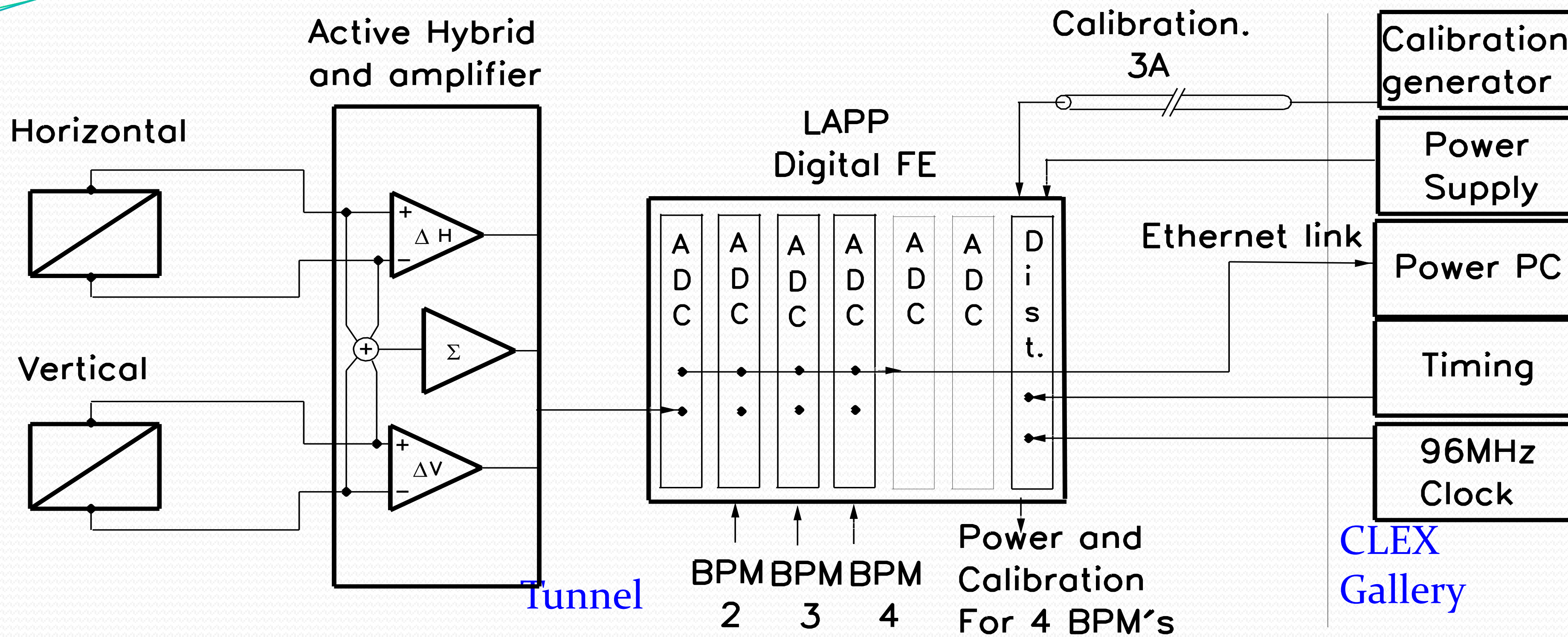


- Front-end electronics gives improved CMRR.

  Calibration of position and intensity .

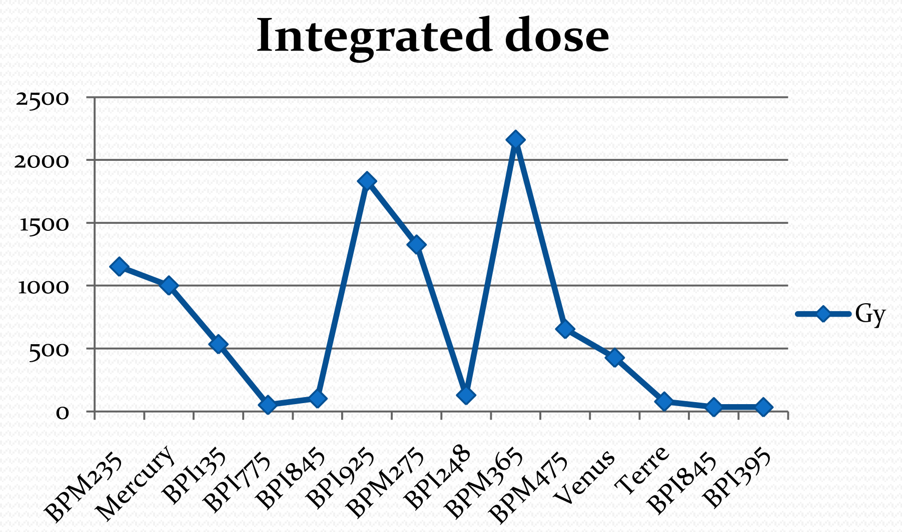
- Observation of analogue signals

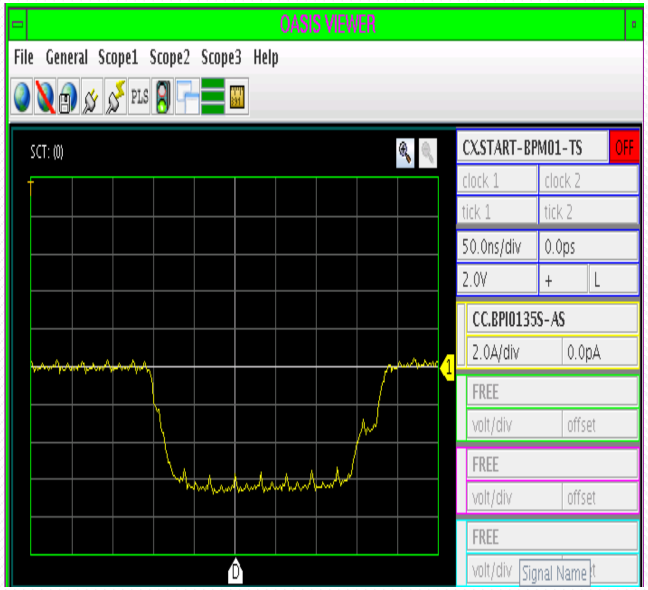
LAPP Acquisition system: TL2, CLEX



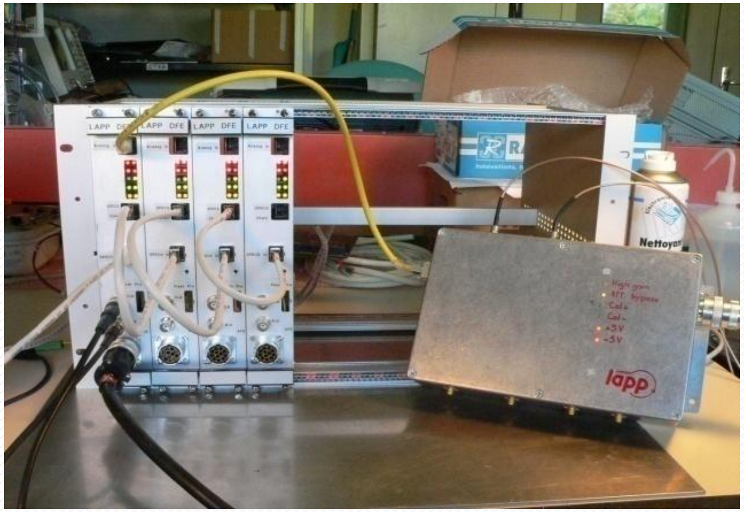
- **Front-end electronics maintained.**
- **Signals digitized in tunnel →Big reduction in cable costs**
- **No analogue signal observation .**

LAPP acquisition system



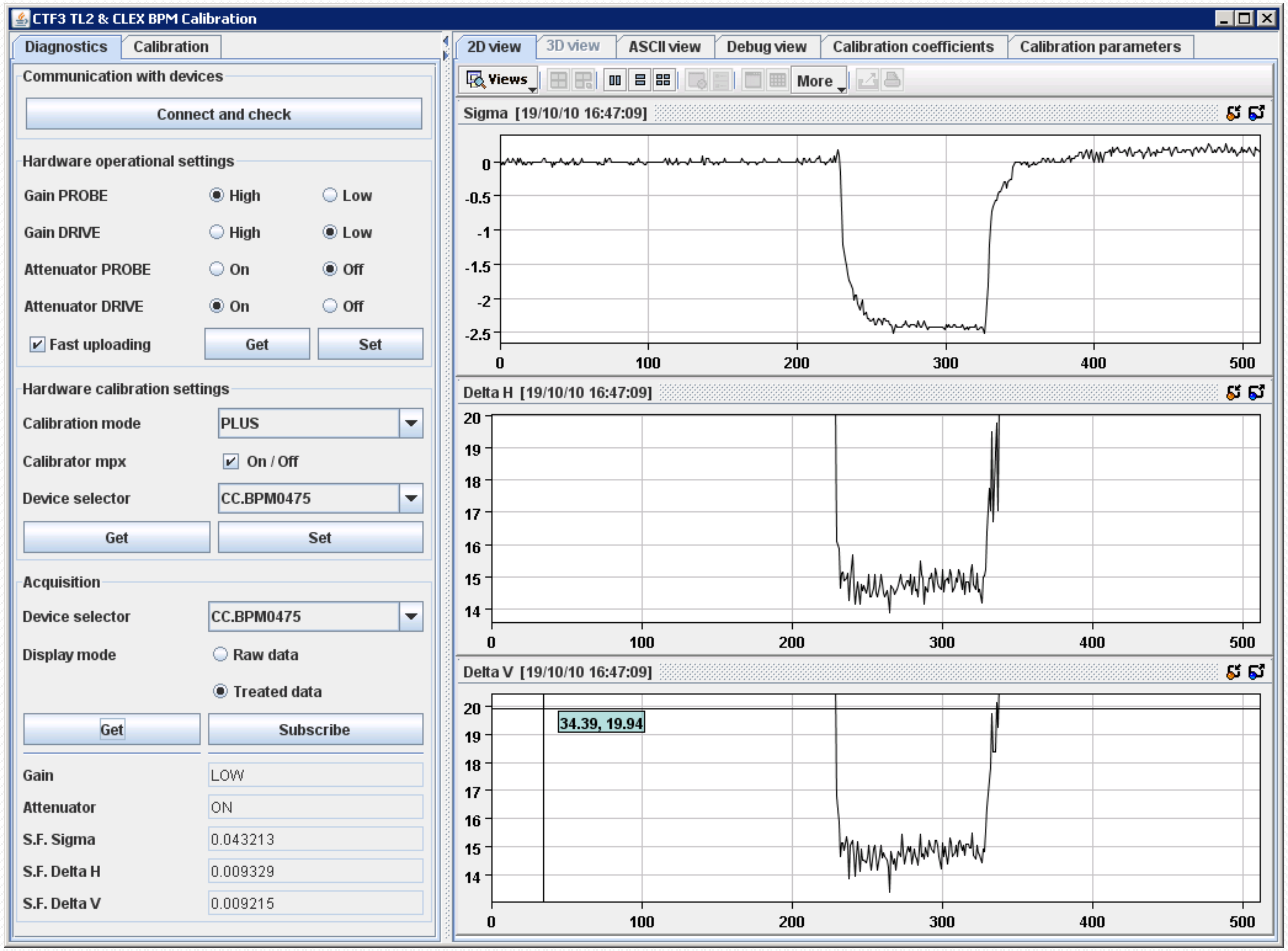


Designed to withstand 300GY.
FPGA sensitive part.
Communication link died rather quickly due to too high radiation doses.



LAPP is developing new front end acquisition system. To be used on each CLIC module not only for BPMs, but for all “clients”

Calibration



From CTF3 to CLIC

	Accuracy	*Resolution*	*Stability*	*Bandwidth*	*Beam tube aperture*	*Available length*	*How many?*	*Used in RT Feedback*
MB	**5µm**	**50nm**	**100nm**	**20MHz**	**8mm**	**< 80mm**	**4176**	**Yes**
DB	**20µm**	**2um**		**20MHz**	**23mm**	**~100mm**	**43000**	**Yes**

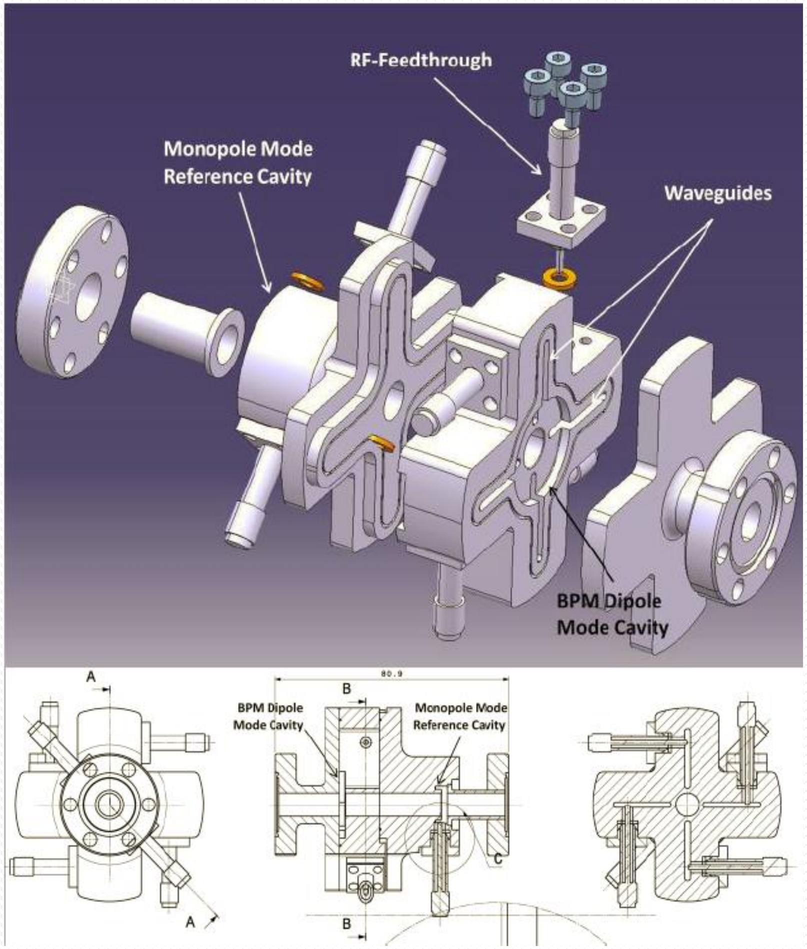
CTF3	**~300µm**	**<50µm**	**?**	**100MHz**	**40mm?**	**~200mm**	**135**	**No**

High accuracy and resolution as well as big numbers eliminates inductive BPM's!

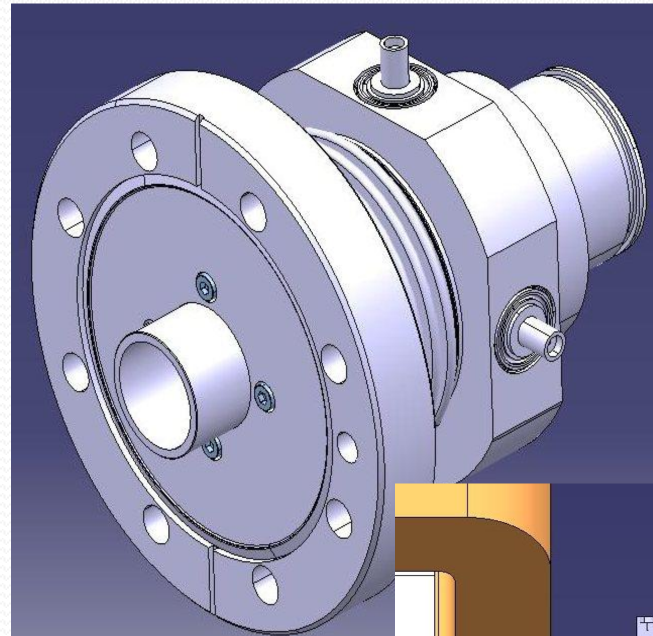
If 1% of our BPMs fail we have more than 500 BPMs not working and which must be repaired. IN CTF3 we have had only 2 BPMs failing.......

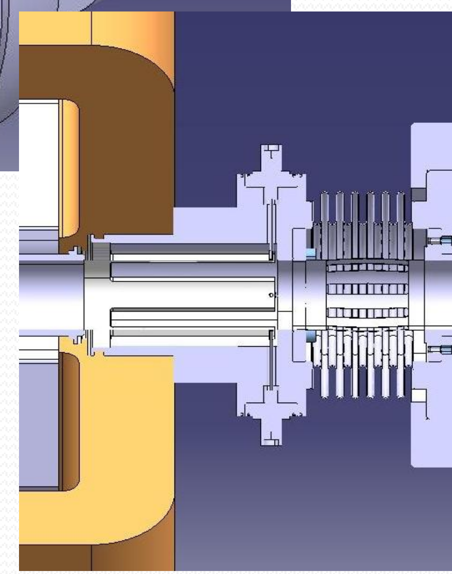
Main linac BPM's (baseline)

Main beam BPM



Drive beam BPM





From CTF3 to CLIC

- Large scale projects come along very rarely at CERN
  - SPS ⇒ LEP 13 years
  - LEP ⇒ LHC 19 years
  - LHC ⇒ CLIC ?
- Experience is unfortunately lost along the way
  - Few of the LEP BI construction team saw beam in LHC
  - Similar mistakes were probably made again
- Main Points Retained from LHC Experience (1000 BPMs)
  - Clear functional specifications required very early
  - Clear project management structure essential from the outset
  - R&D, design & testing times largely underestimated
    - Especially true when designing for radiation environments
  - Standardisation across domains improves effectiveness as a whole
  - Quality assurance procedures important for large scale production
  - Host laboratory personnel time to be foreseen for collaborations

Slide by R. Jones

Summery

- New CLEX and TL2 acquisition system has problems with CPU load, due to too many clients. Work around being looked into by CERN controls group.
- New calibration GUI is very useful.
- Noisy signals on BPS close to PETS in TBL line. This is an important information for CLIC and is being looked into.
- Radiation damage of first generation FE digitizers has shown the need for a robust, simple and standard module acquisition system.
- CLIC is **very different** (numbers) from CTF3 and it is very difficult to draw any other conclusions which can be used for CLIC.