Electromagnetic monitors and acquisition systems

L. Søby

Electromagnetic monitors

Electrostatic Pick-up's (BPE)

Inductive Pick-up's (BPM, BPI, BPS, PBPM)

} Low frequency

Button Pick-up's (BPR)

Wall current monitors (WCM)

Cavity BPM's

} High frequency

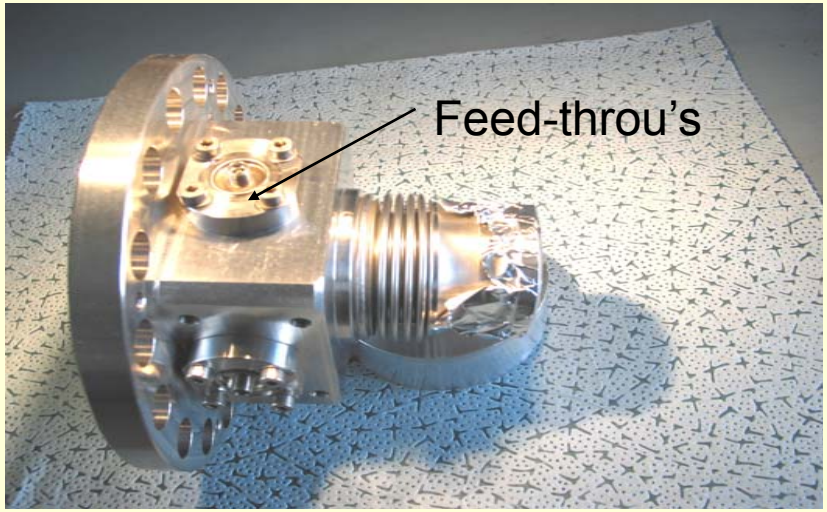
Overview

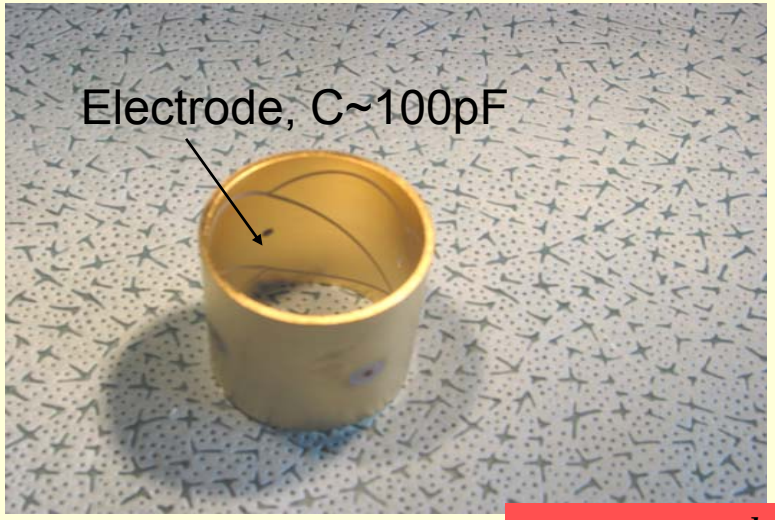
LINAC (CL)	PETS (CP)	CT (CT)	Delay-Loop (CD)	TL1 (CT)	Comb. Ring (CR)	TL2 (CC)	TL2' (CM)
2 * BPE 13 * BPM 2 * BPR 3 * WCM	3 * BPM	5 * BPM 3 * BPI 1 * BPR 1 * WCM 3 * PBPM	16 * BPI	7 * BPI	5 * BPM 20 * BPI 1 * BPR	5 * BPM 6 * BPI 1 * BPR 1 * WCM	3 * BPM

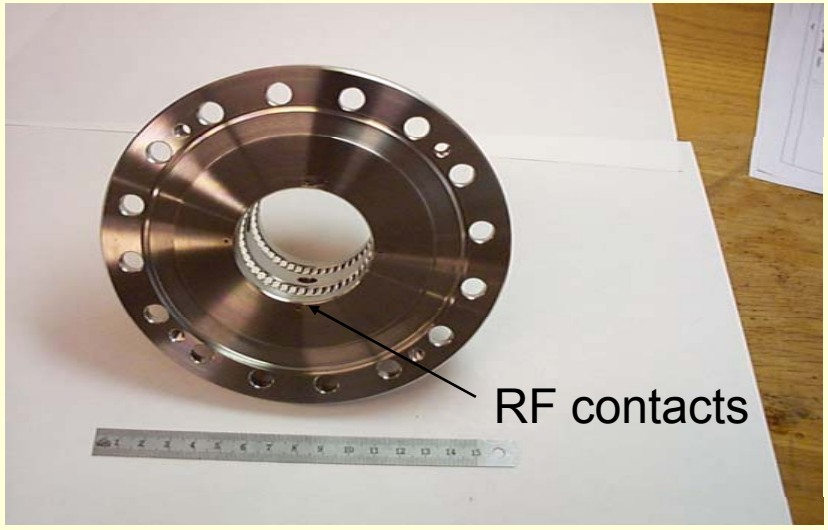
TBL (2008) (CB)	TBTS (CM, CA)	CALIFES (CT)
1 * BPM 1 * BPS	10 * BPM	6* CAV. BPM

A total of 116 Monitors

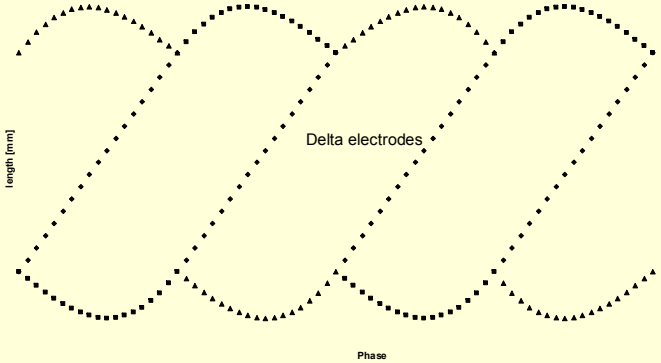
Electrostatic Pick-up (BPE)





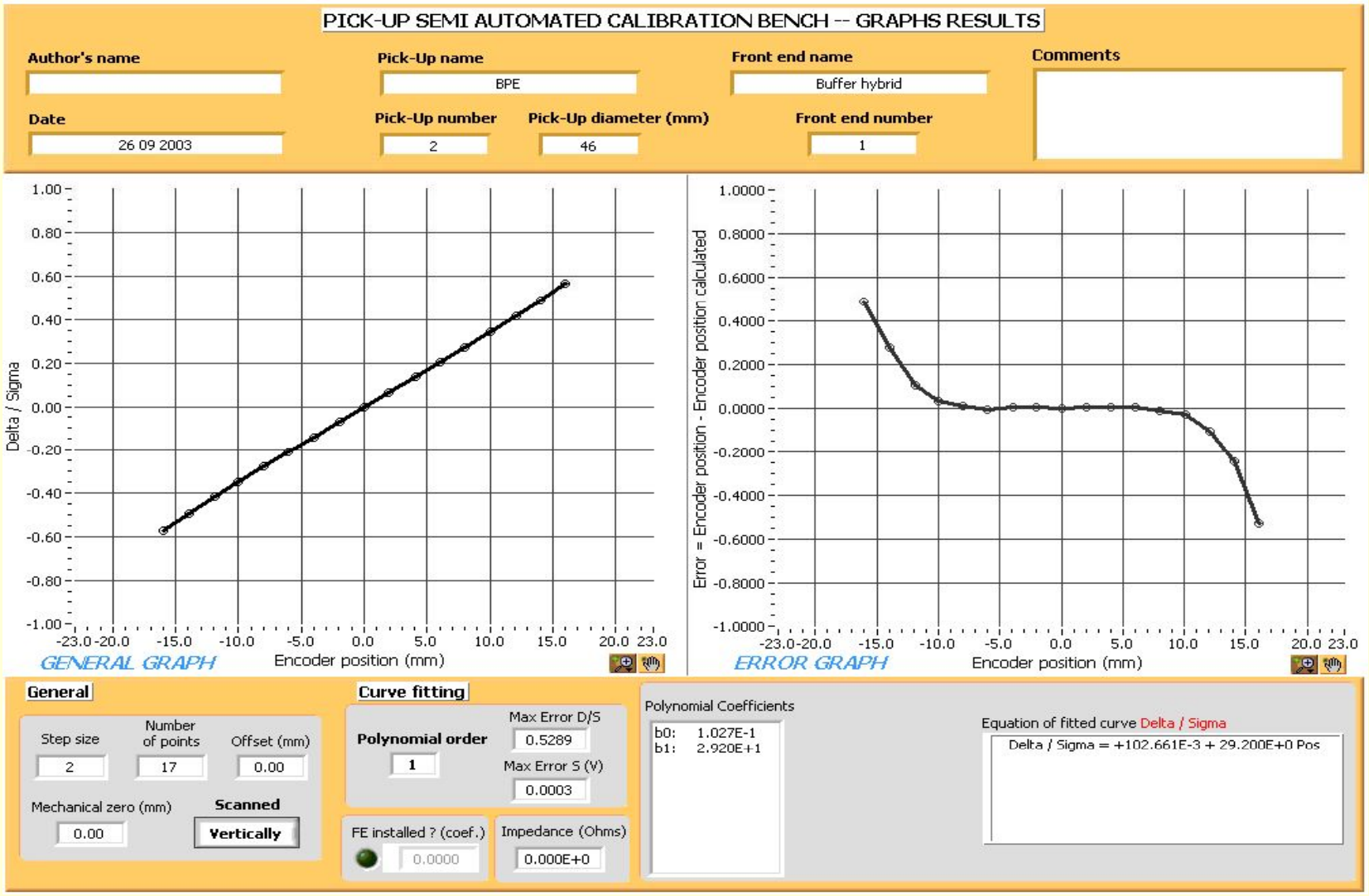


$$\hat{V}(t) = \frac{i(t)}{\nu} \cdot \frac{l_{eff}}{C_{Elec}}$$



Developed by L. Søby, CERN

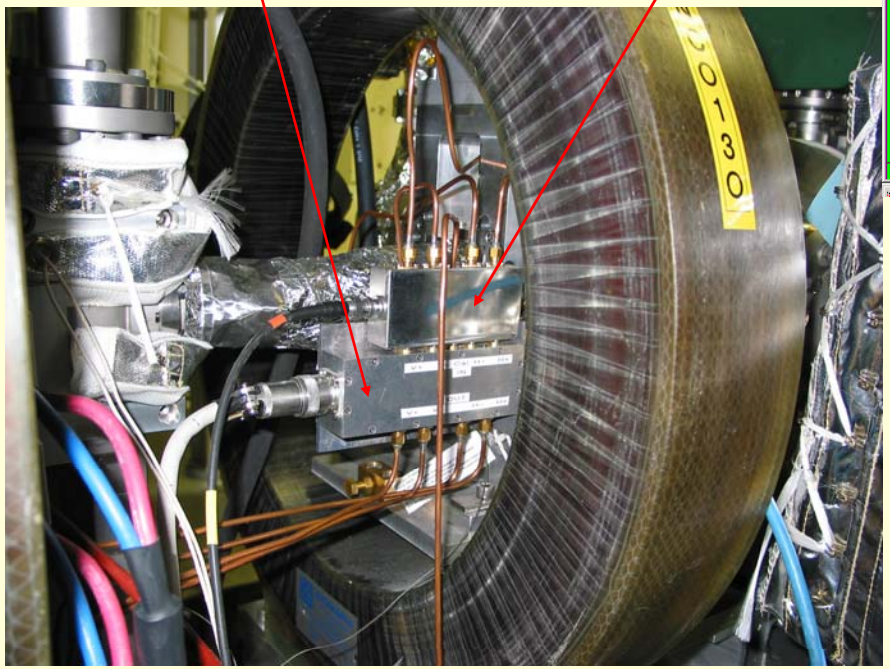
Electrostatic Pick-up (BPE)

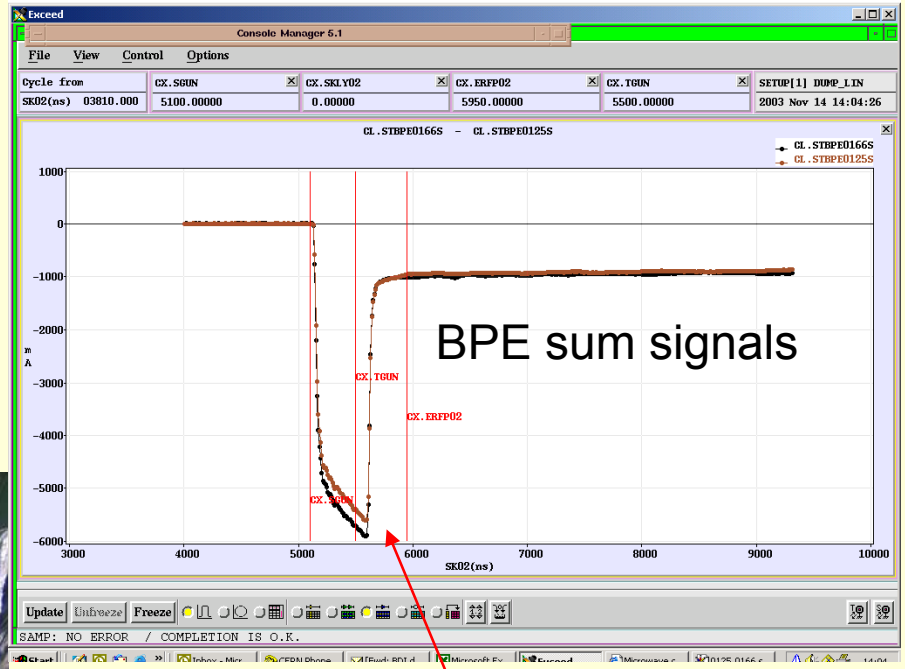


Electrostatic PU (BPE)

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

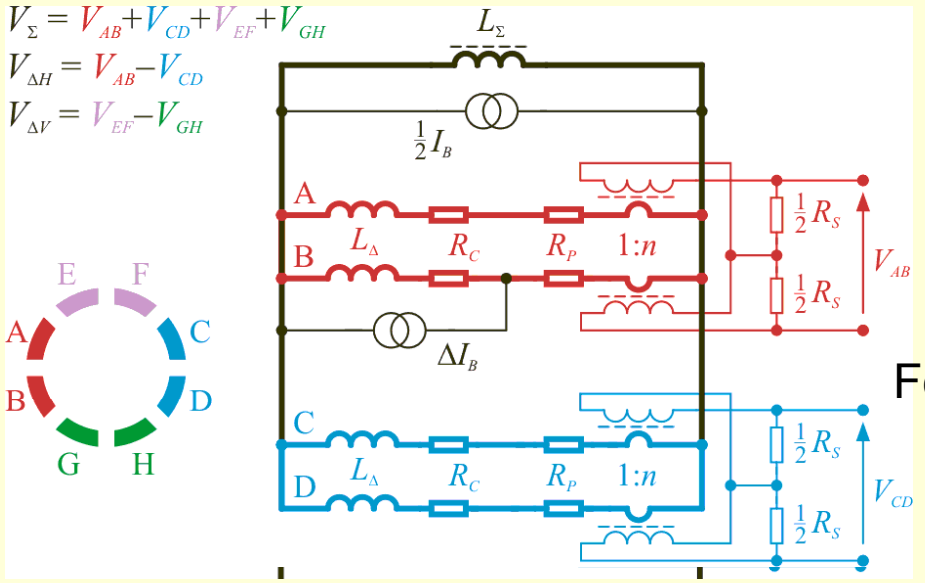
Buffer amplifier, R_L=1MΩ

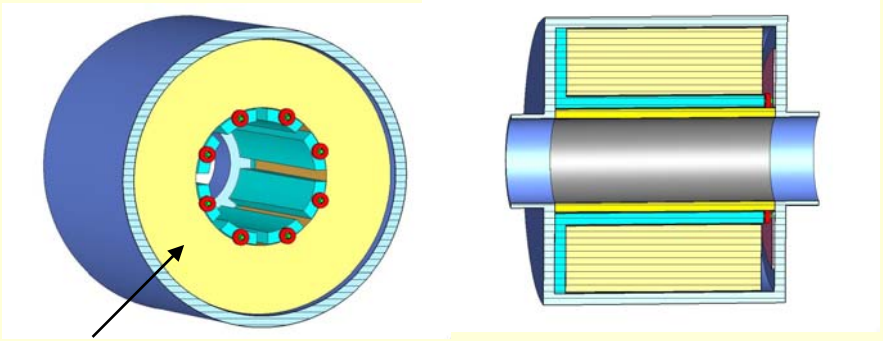




Electrodes charging up due to beam halo!

Inductive Pick-Up's (BPM, BPS)





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

- **Electrodes are combined in pairs so that each transformer sees half of the load**
- **Frequency low cut-offs are limited by connection parasitic resistances**
- **Each transformer has one calibration turn (not shown)**

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

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

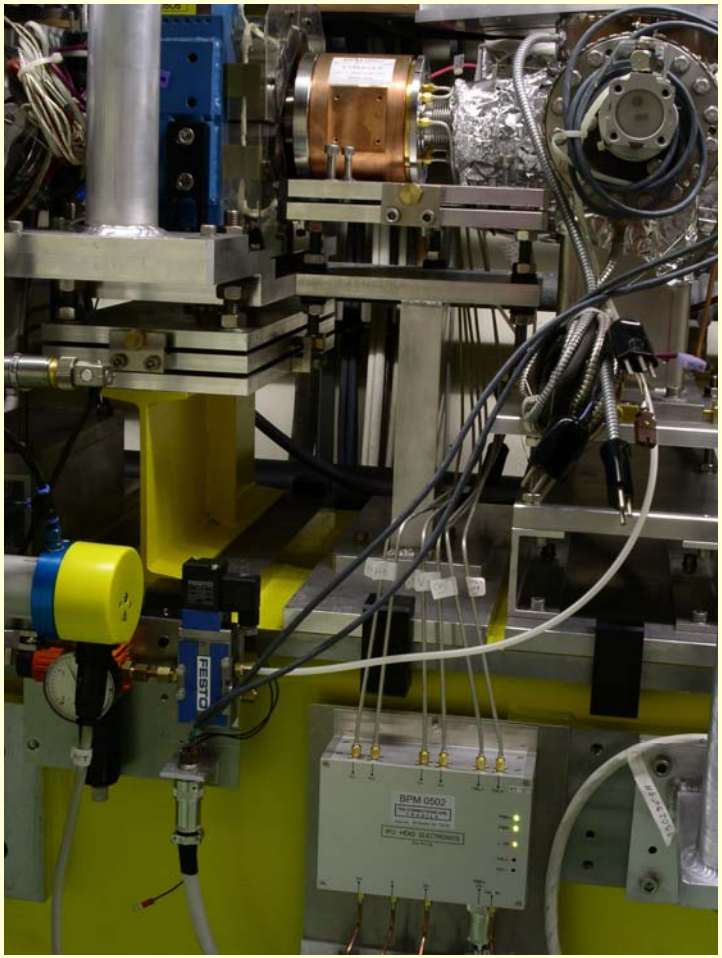
$n = 30$, $R_S \cong 7\ \Omega$ giving $R_T \cong 0.1\ \Omega$ and $R_P \cong 4\ m\Omega$

$f_{L\Sigma} \cong 150$ Hz (R_P with $L_\Sigma \cong 5\ \mu H$)

$f_{L\Delta} \cong 10$ kHz (R_P with $L_\Delta \cong 70$ nH)

Slide by M. Gasior

Inductive pick-up's (BPM)

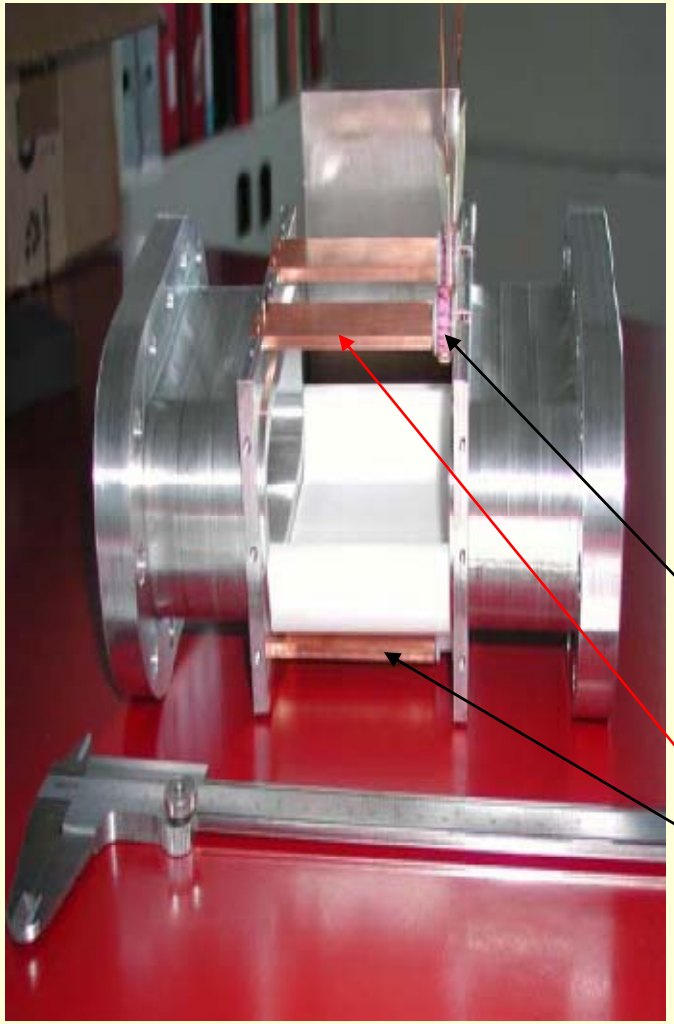


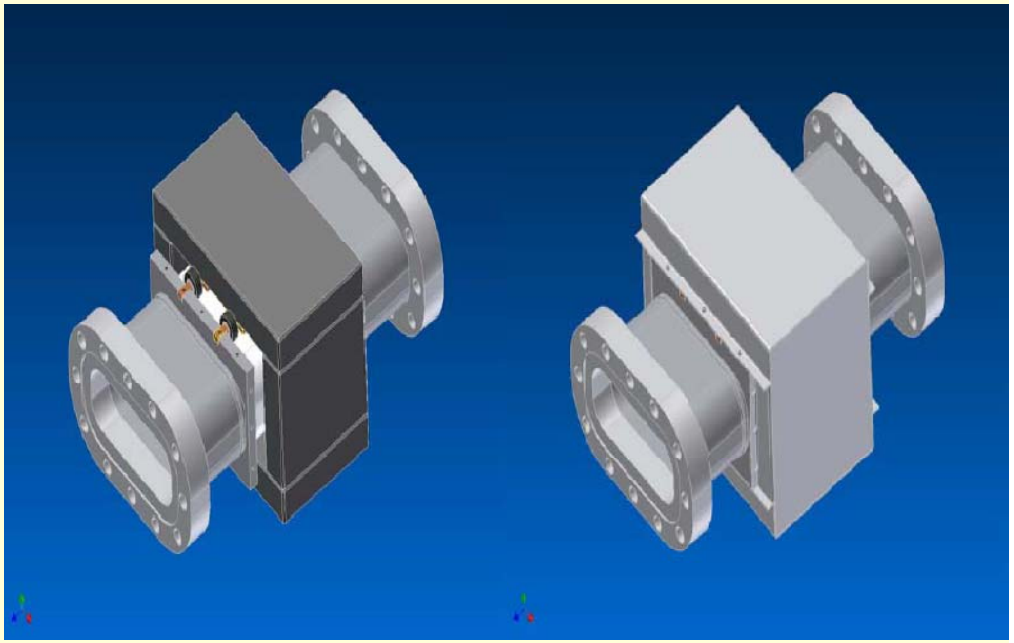
Developed by M. Gasior, CERN

45 BPM's installed as from march 2008

Inductive Pick-up's (BPI)

Developed by A. Stella, Frascati



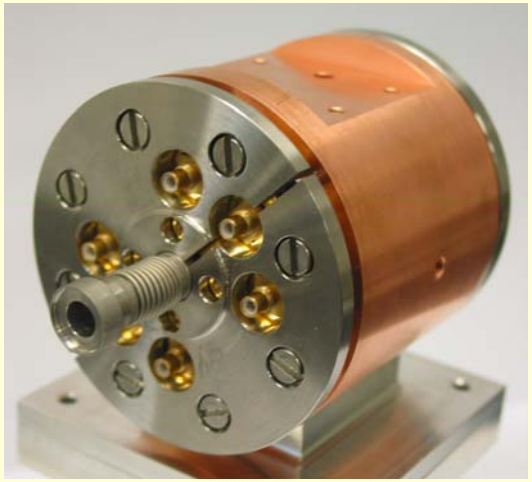


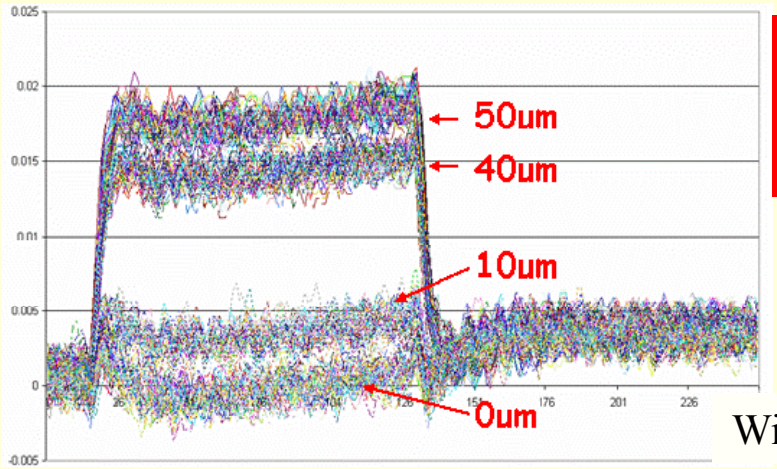
Current transformer with 30 turns and R_L=14Ω

4 electrodes installed on racetrack chamber

52 BPI's installed as from march 2008

Inductive pick-ups, PBPM

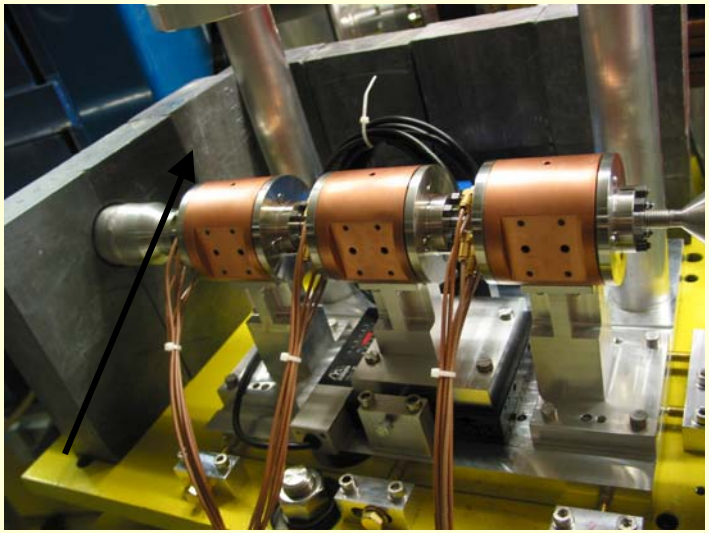


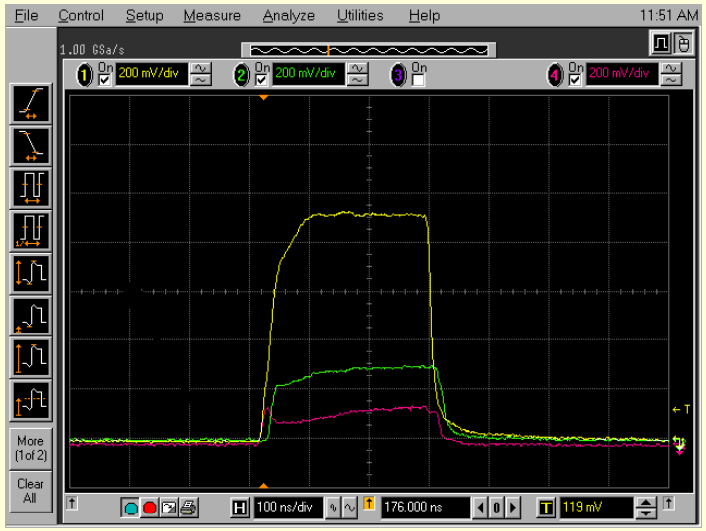


Mean=17.4mV
σ=0.87mV
σ=2.5µm

Wire current 100mA

PBPM proto type with 6mm inner diameter and 4 electrodes, resolution 200nm

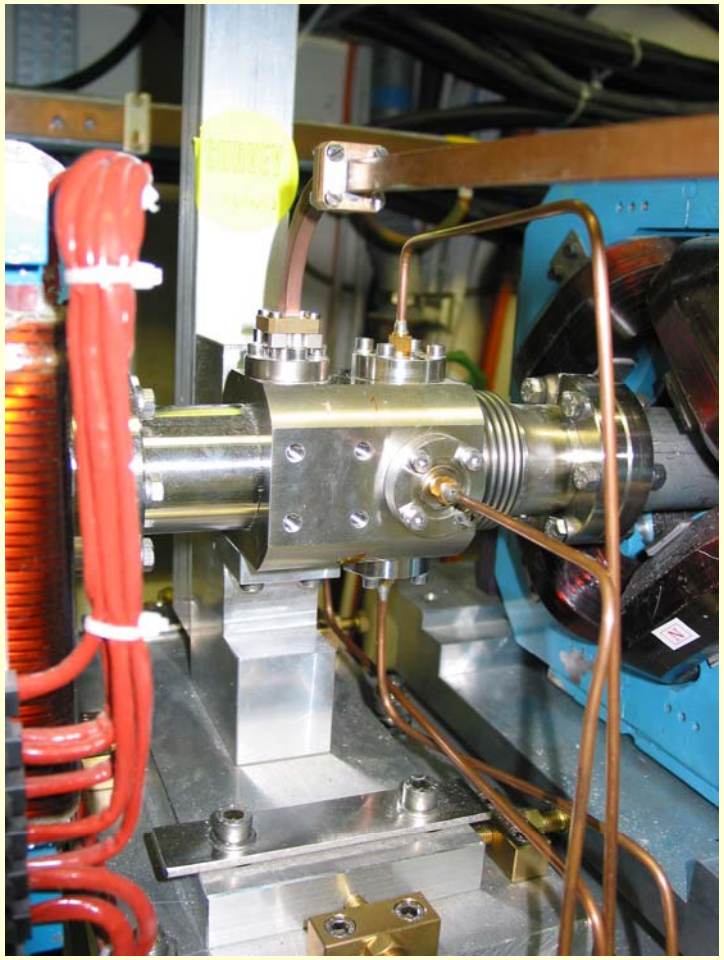


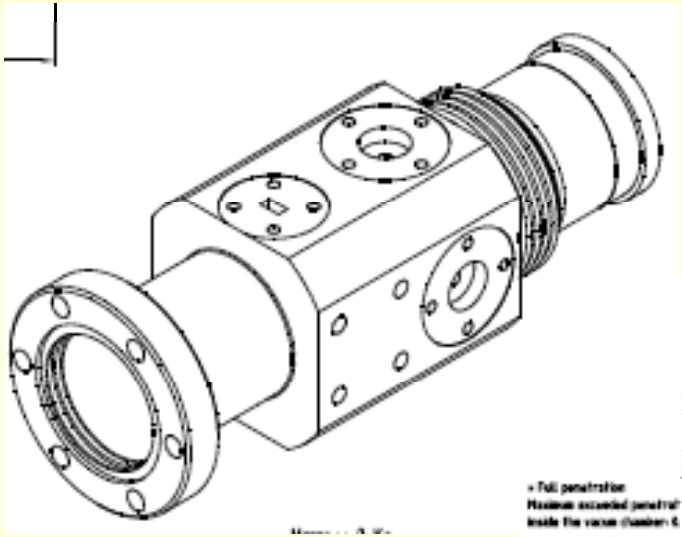


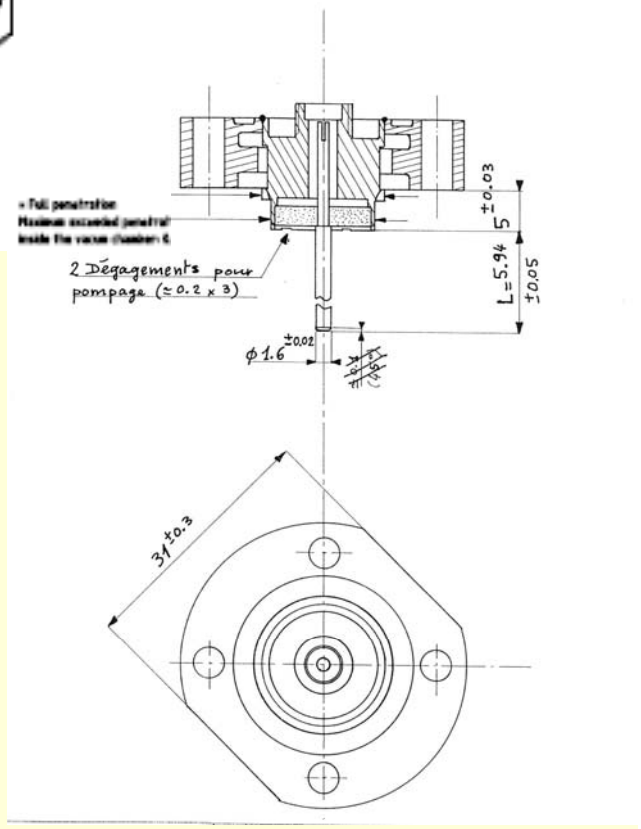
1st beam with poor transmission 3rd December 2007. 3rd PBPM only 10%

Developed by I. Podadera L. Søby

Button Pick-up's (BPR)



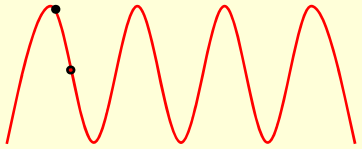


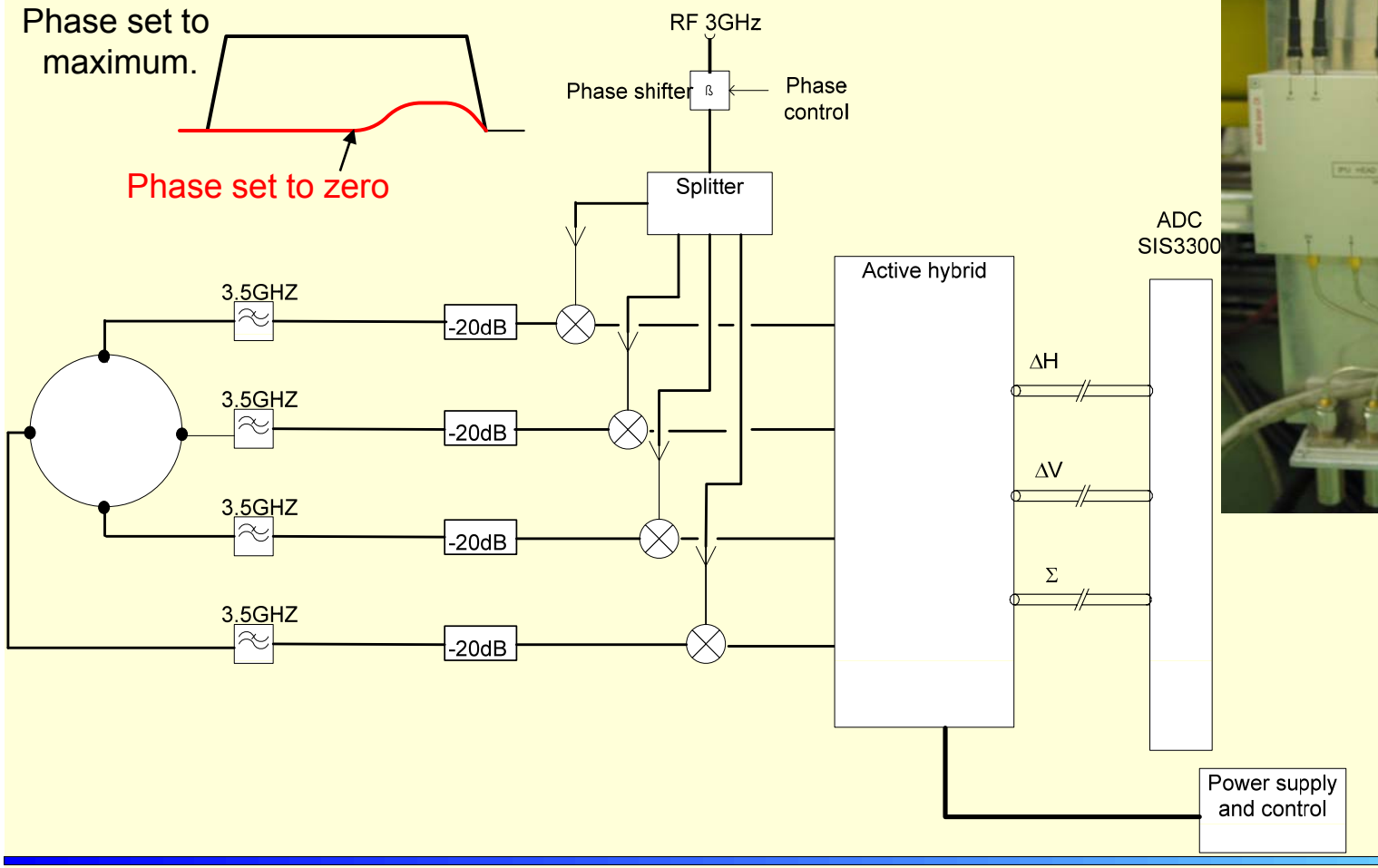


Developed by L. Thorndahl et al.

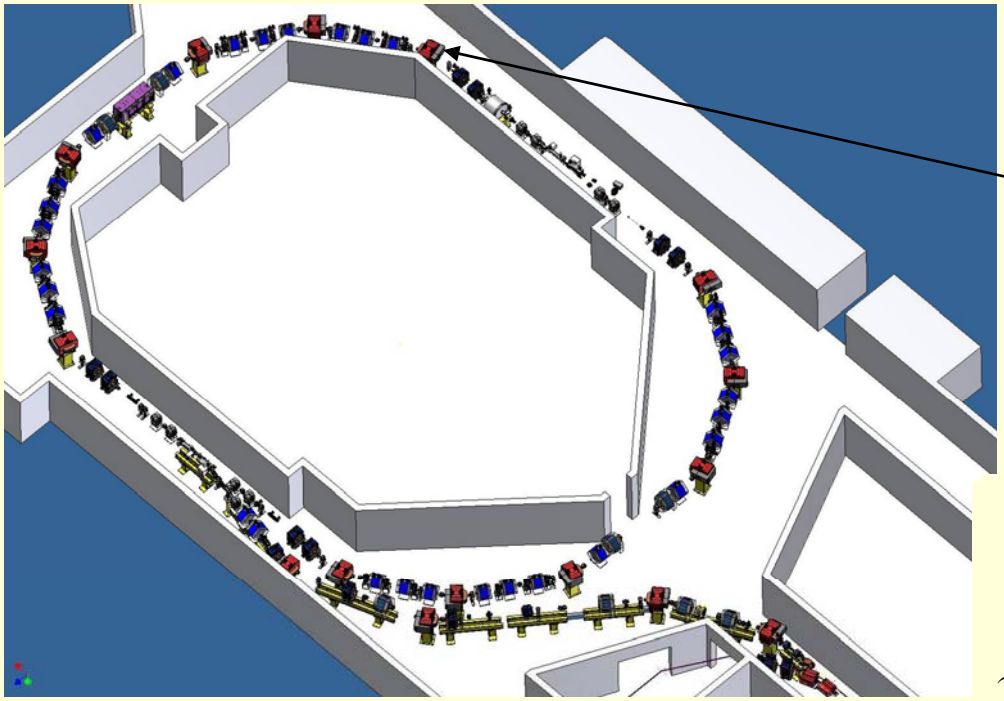
Button Pick-up's (BPR)

Button electronics



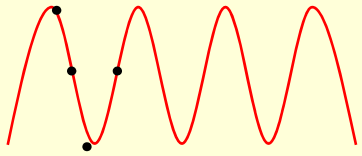


Button Pick-up's (BPR)



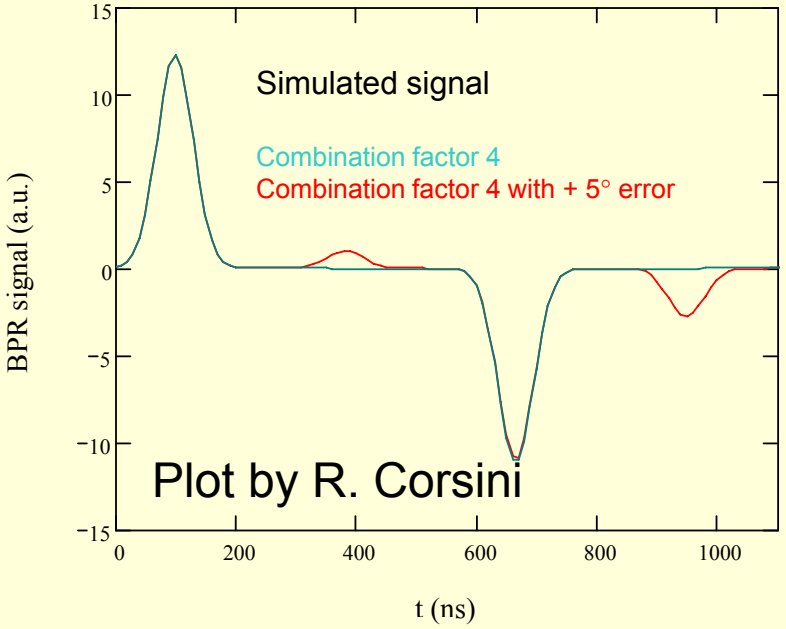
BPR – RF phase monitor

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



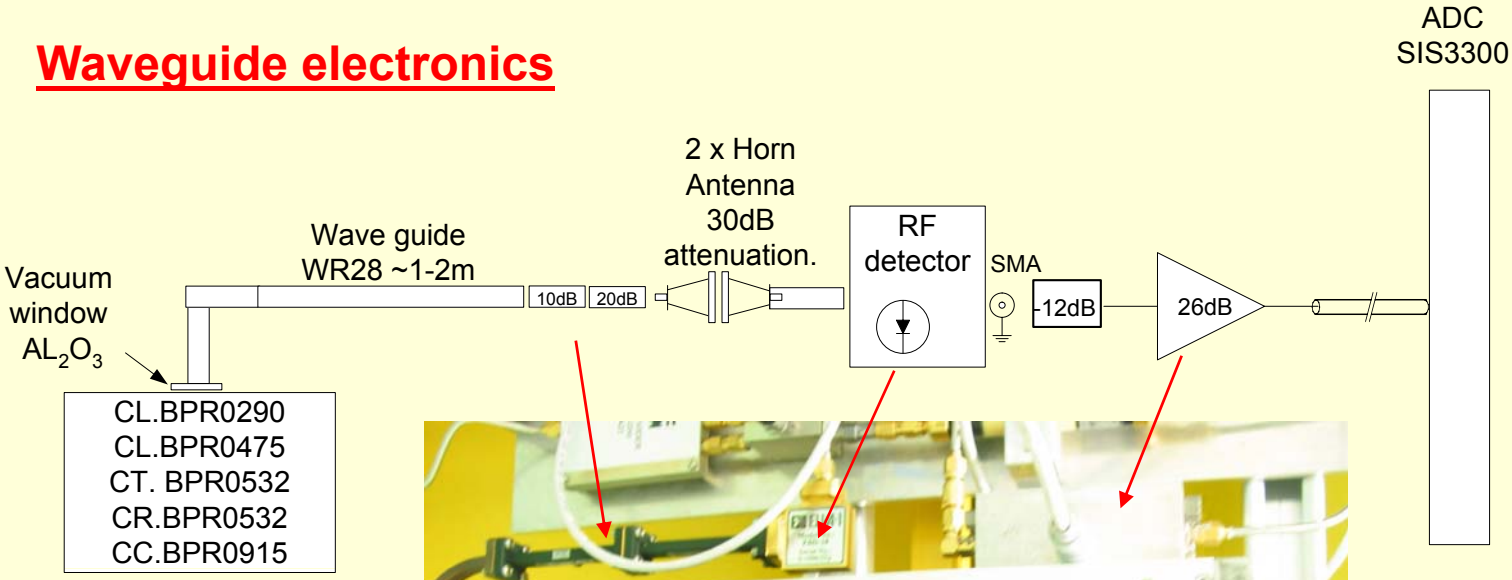
Phase advance per turn (3GHz)

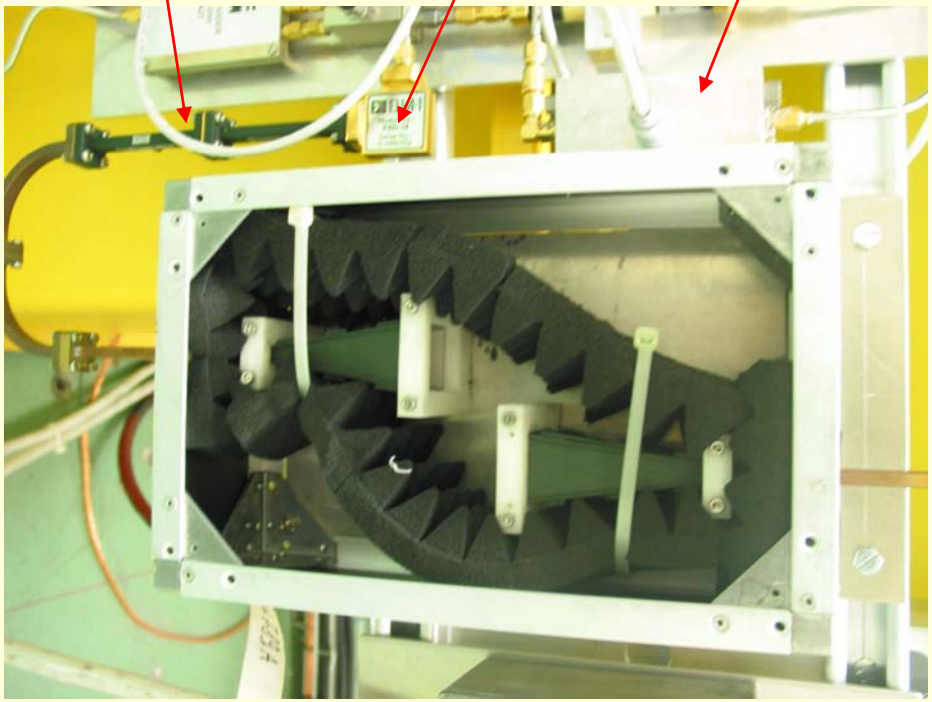
Combiner ring path length

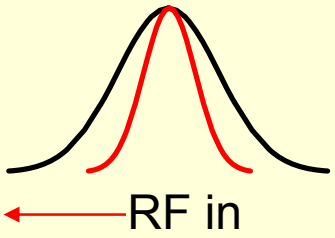


Button Pick-up's (BPR)

Waveguide electronics





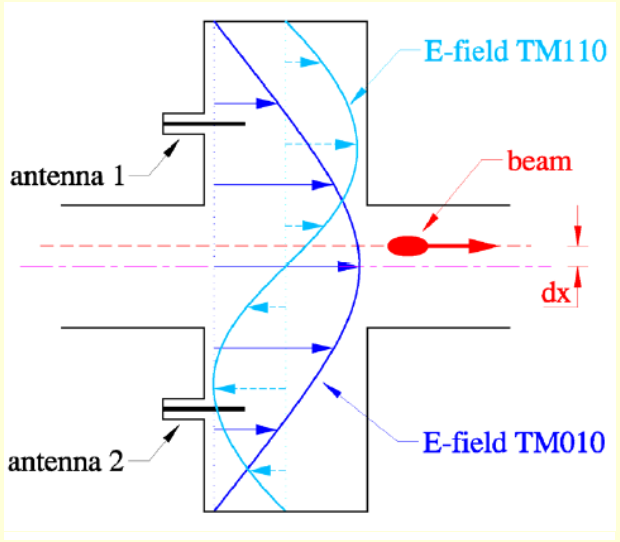


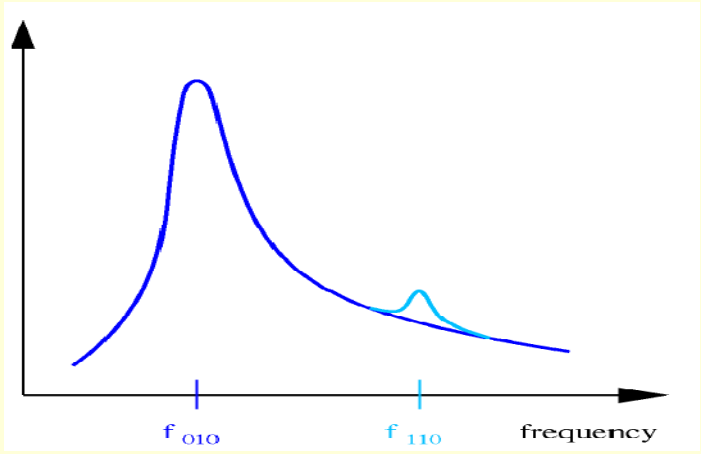
Shorter bunches means more power in the WR28

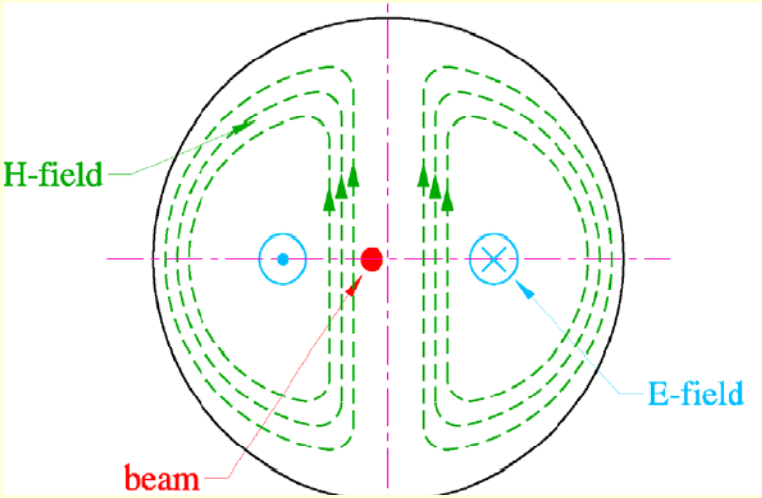
Re-entrant Cavity BPM (CALIFES)

- Difference of large numbers problem reduced to rejection of the primary fundamental peak. Frequency domain.
- Damping time quite high due to intrinsic high Q. $Q_L \rightarrow$ <50

$$\tau = \frac{Q_{ld}}{\pi * f_{Dip}} \quad \rightarrow \text{Poor time resolution (~100ns)}$$

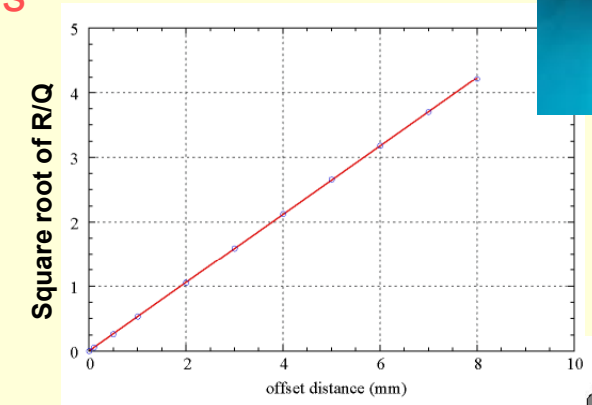




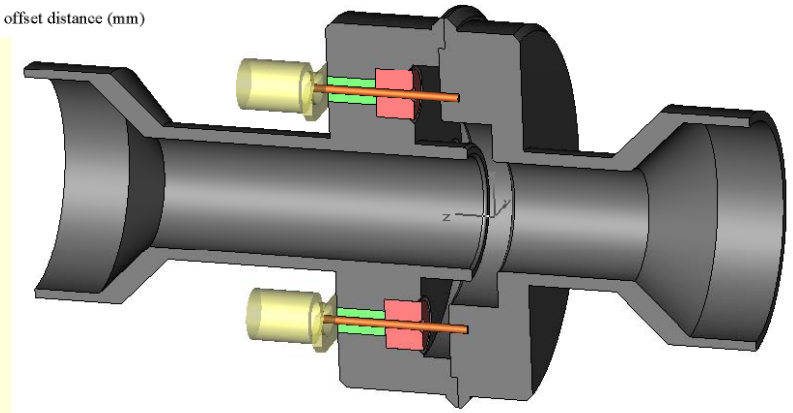


Re-entrant Cavity BPM (CALIFES)

- 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.

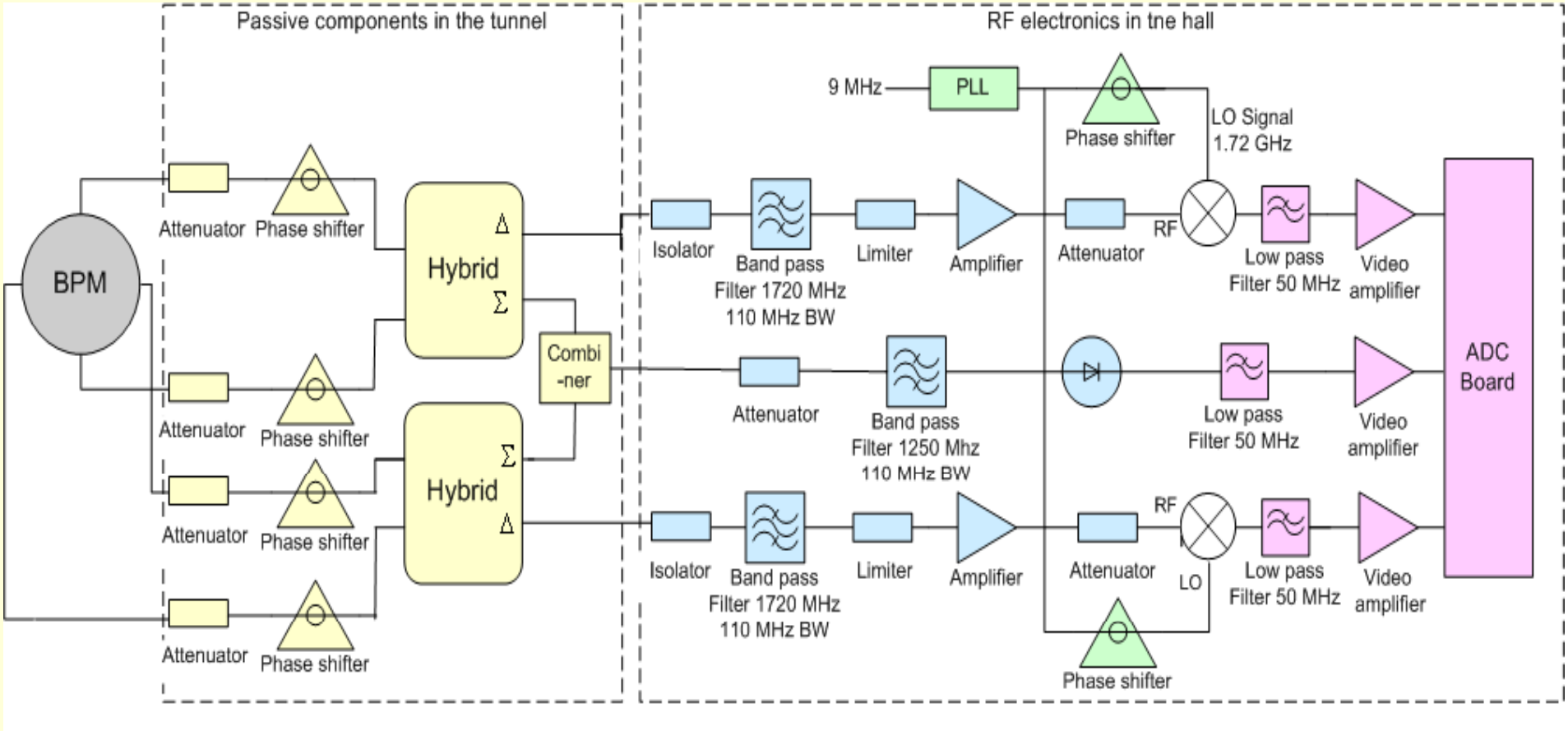


Offset (mm)	Monopolar mode (3.851 GHz)		Dipolar mode (5.942 GHz)	
	X direction	Y direction	X direction	Y direction
0.0	22.26	22.26	2.441e-6	2.441e-6
0.1	22.24	22.19	3.115e-3	4.895e-6
0.5	22.13	22.18	6.843e-2	3.359e-6
1.0	22.24	22.21	2.816e-1	7.891e-6
2.0	22.19	22.23	1.117	4.880e-7
3.0	22.19	22.19	2.532	4.124e-6
4.0	22.27	22.21	4.524	9.080e-7
5.0	22.26	22.23	7.059	1.174e-5
6.0	22.19	22.21	10.13	3.217e-6
7.0	22.09	22.05	13.70	6.641e-6
8.0	21.94	22.34	17.77	5.918e-5



Developed by M. Loung, C. Simon, Sacley

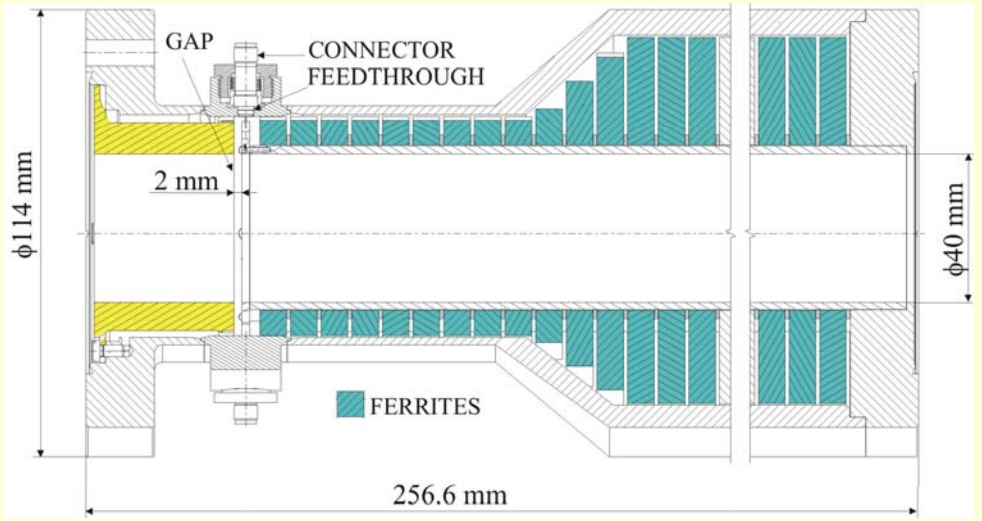
Re-entrant cavity BPM electronics

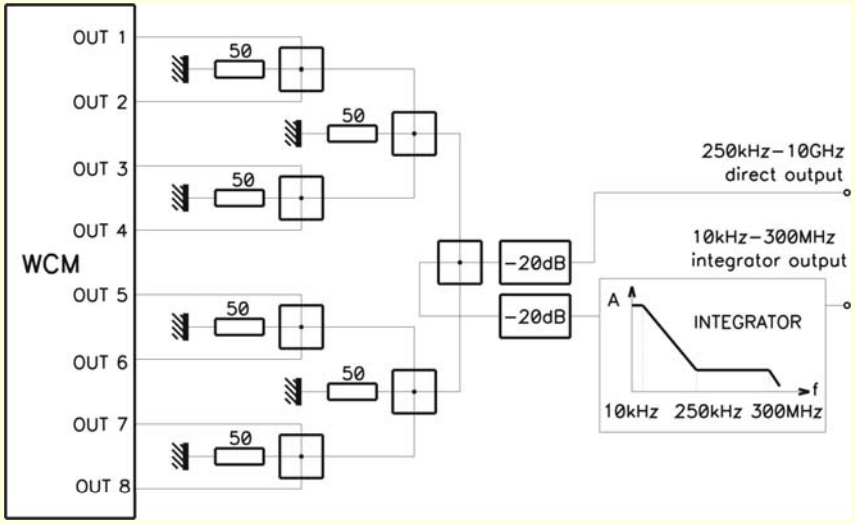


Wall current monitor, WCM

Developed by J. Durand,P. Odier Cern

Non-dismountable WCM

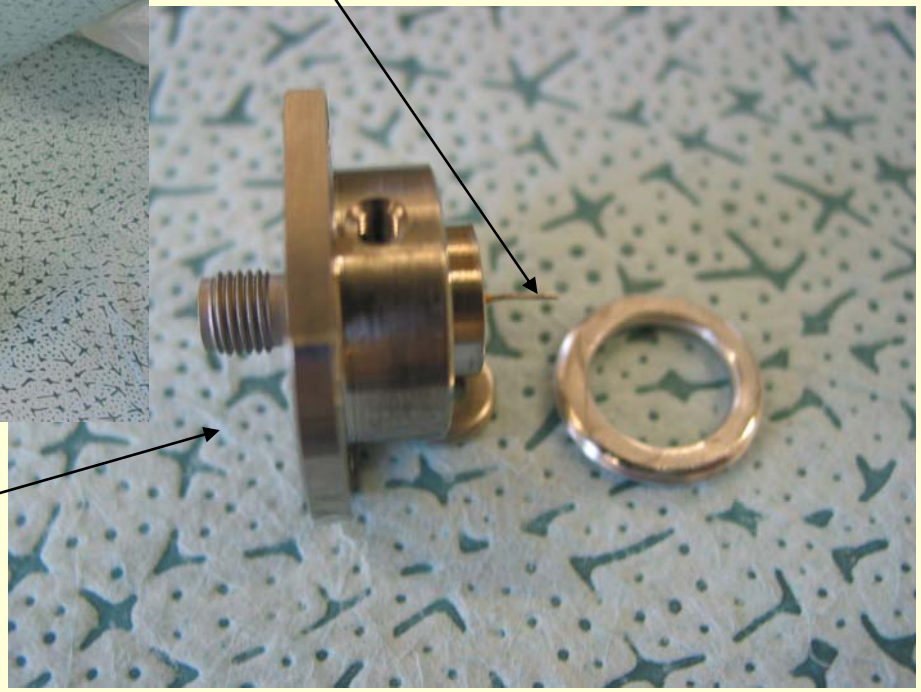




Wall current monitor, WCM

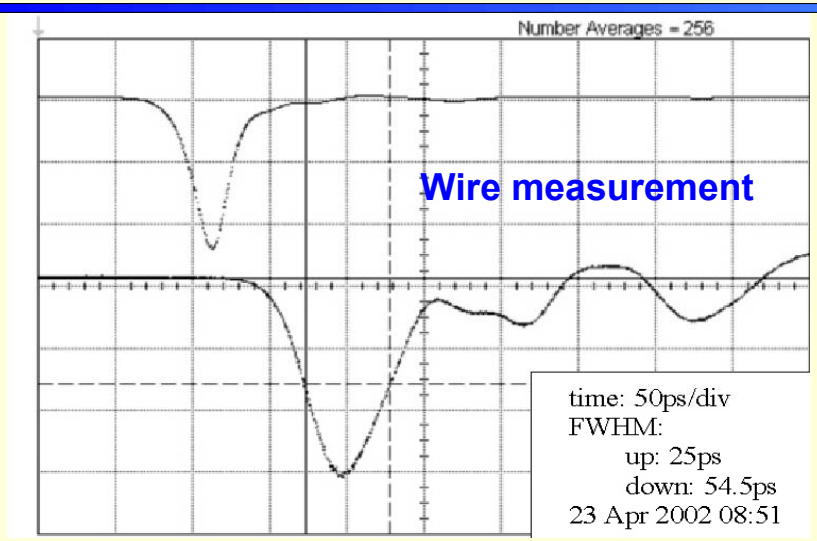
Feed-thru connection

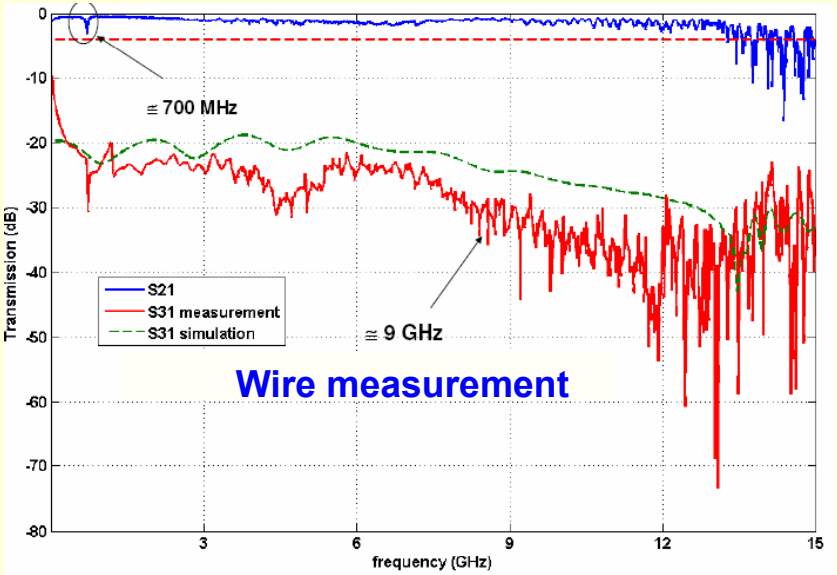
Dismountable WCM

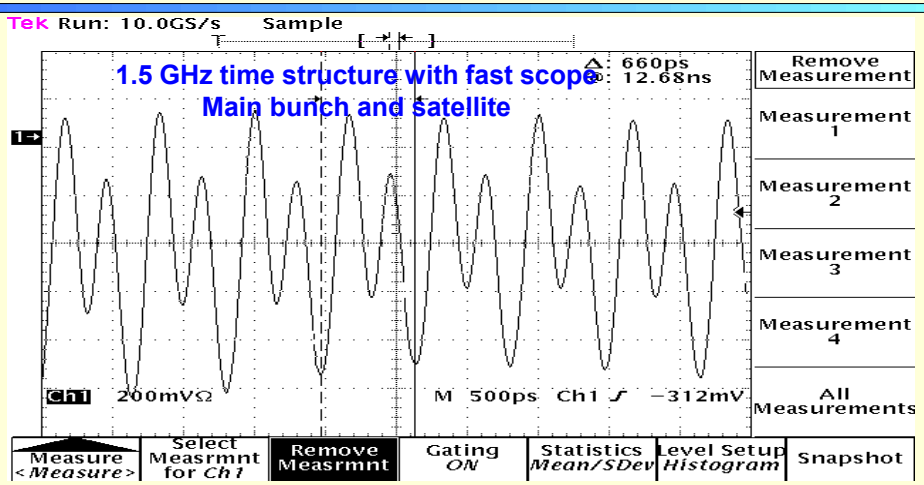


Feed-thru

Wall current monitor





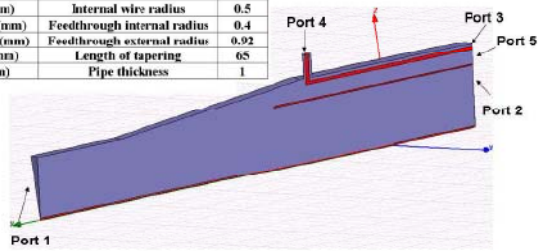


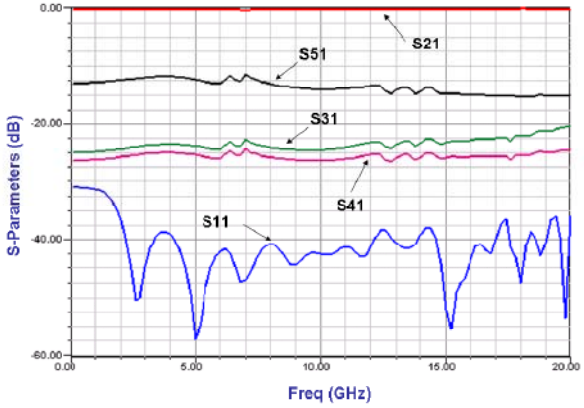
Impedance	~5 ohms
Resolution	***
Absolute precision	~ 1%
Low freq. cut off	10kHz
High freq. cut off	7GHz
Calibration	No
Nb. of feed-troughs	8
Gap length	2mm
ID / Length	40mm / 256.6mm
Flange types	DN63CF
Bake-out temp.	165 °C

EUROTeV WCM

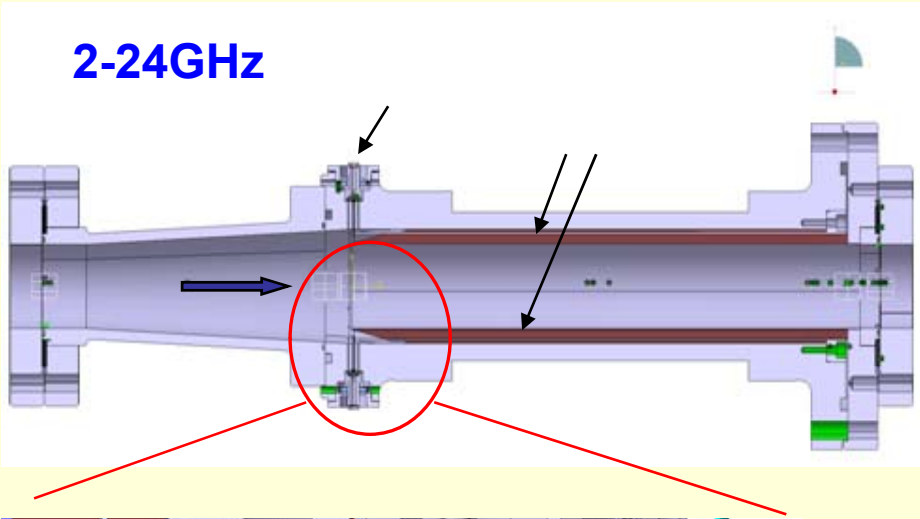
New triaxial structure with tapering, and 16 feed-thru's

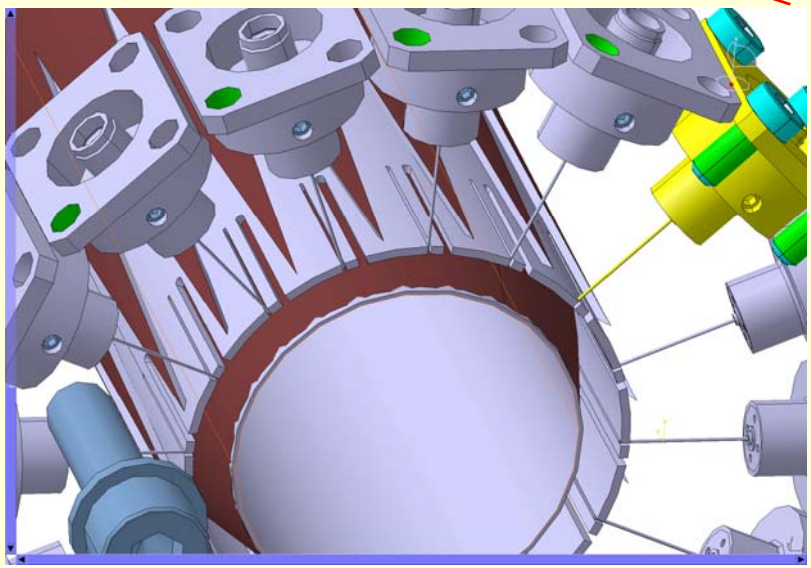
R_i (mm)	Inner coaxial radius	20
R_{feed_coax} (mm)	Feedthrough coaxial radius	25
R_o (mm)	Outer coaxial radius	27
R_w (mm)	Internal wire radius	0.5
R_{feed_in} (mm)	Feedthrough internal radius	0.4
R_{feed_out} (mm)	Feedthrough external radius	0.92
L_{tap} (mm)	Length of tapering	65
t (mm)	Pipe thickness	1





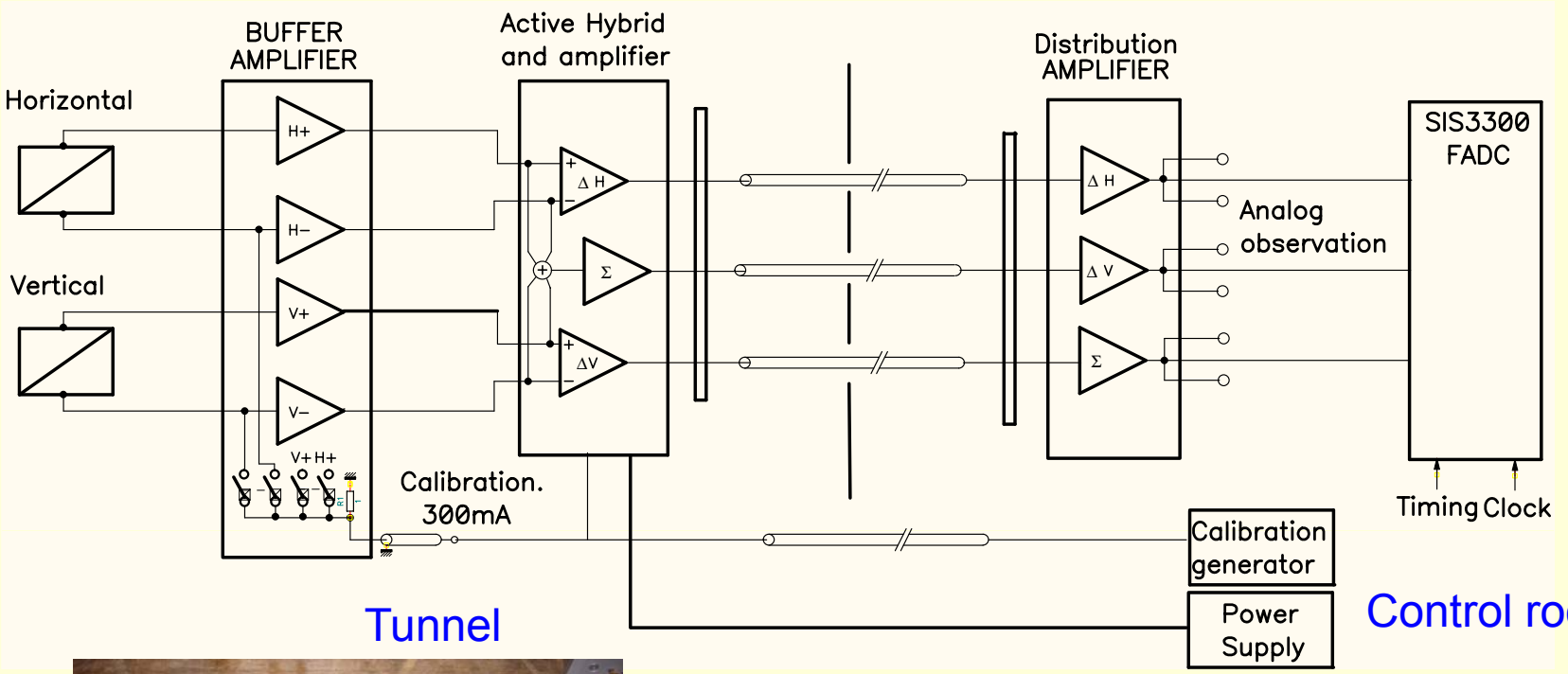
2-24GHz

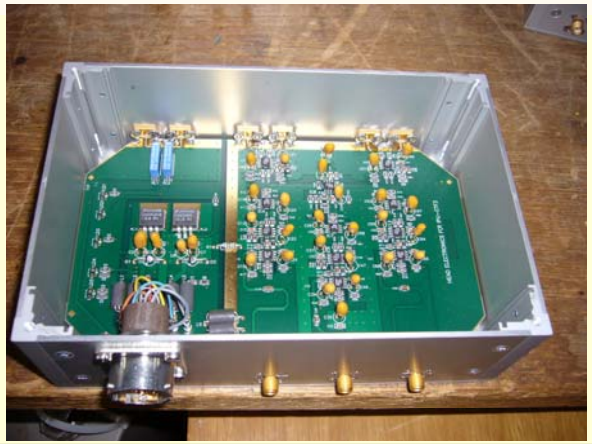




Developed by A. D'Elia, CERN

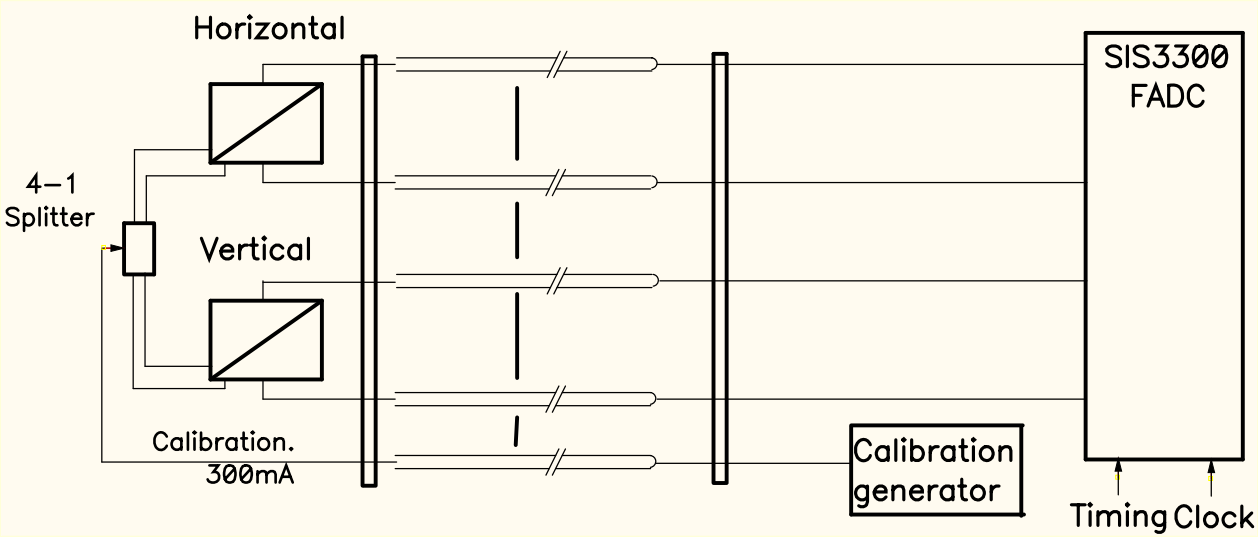
Acquisition system: Linac, CR

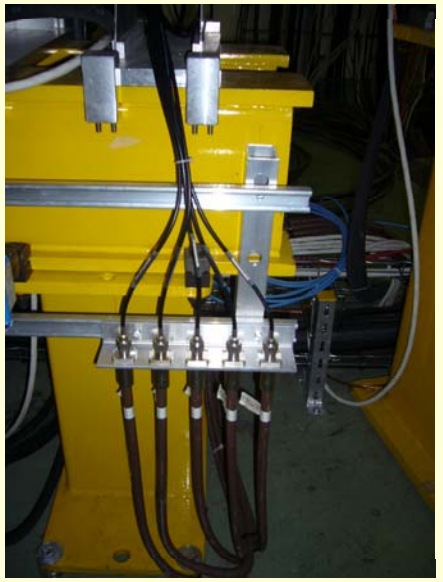




- **Front-end electronics gives improved CMRR.**
- **Calibration of position and intensity .**
- **Observation of analogue signals**

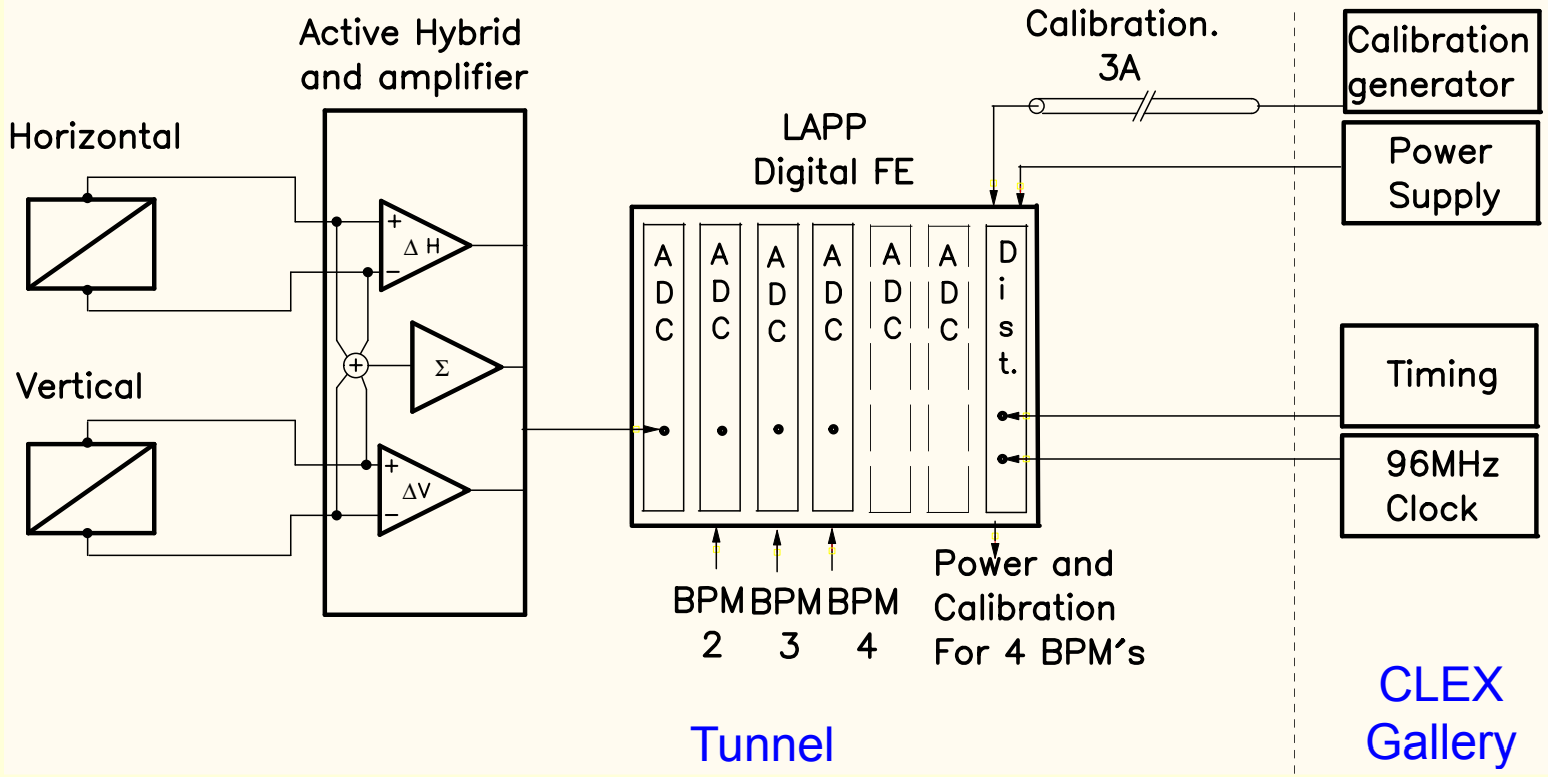
Acquisition system: Delay loop





- No front-end electronics
- The four electrodes are via long cables directly connected to the 100MS ADC.
- Calibration of sum only.

Acquisition system: TL2, CLEX



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


Thank you for your attention

Position and intensity monitors

	BPE	BPM	BPI	BPS	PBPM	BPR
Transverse sensitivity, $\Delta = \Sigma$ [mm]	30	30	33 / 50		12	~10
Resolution pos.	0.1mm	0.1mm			200nm	0.1mm
Relative precision (3/4 half aperture)	0.2%	1%	1%	1%	1%	1-5%
Longitudinal transfer impedance [Ω]	0.17 / 1.7	0.1 / 1				0.1 / 1
Resolution current [mA]	12 / 1.2	10 / 3				12 / 1.2
Low frequency cut off Δ / Σ [kHz]	1 / 1	10 /0.15	~20 / 0.3			1kHz
High frequency cut off	200MHz	200MHz	200MHz		50MHz	200MHz (10MHz)
Calibration	Yes	Yes	Yes	Yes	Yes	No
ID / Length [mm]	46 / 130	40 / 168	90*39/240		6	40 / 196
Number of feedthroughs	4	0	0	0	0	5
Waveguide	--	--	--	--	--	WR28
Flange types	DN40CF / DN100CF	DN40CF	Racetrack		Helicoflex 10.9*7.7	DN40CF
Max. bake-out temperature	130 °C	130 °C	130 °C	130 °C	130 °C	130 °C