Drive Beam BPM's

CLIC 09 work shop, CERN, 12-16 of October 2009,

Lars Søby

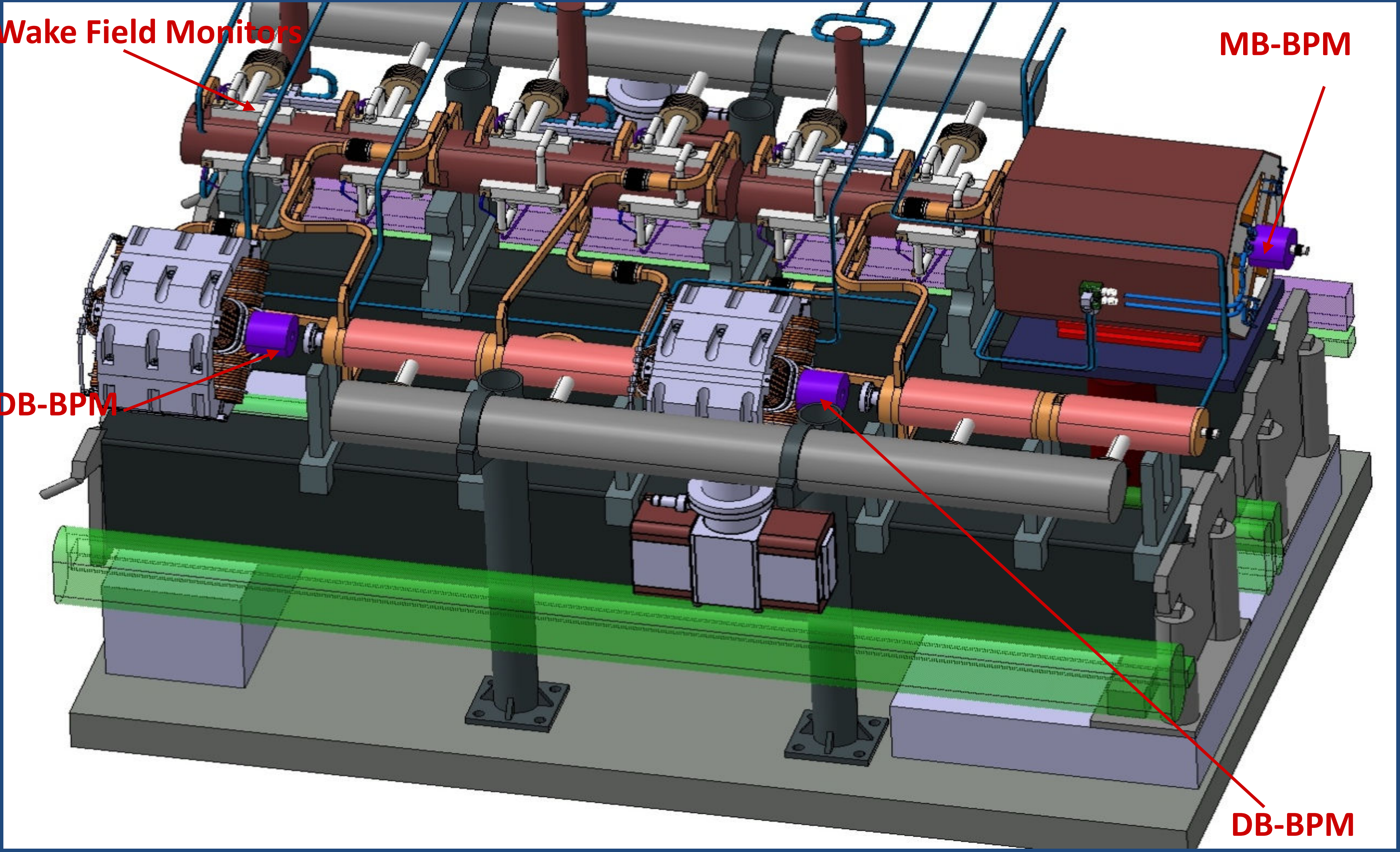
- CLIC BPM overview
- Specifications
- Constraints and possible BPM types
- Planning up to CDR

CLIC BPM overview

	Accuracy	Resolution	Stab.	BW	Φ	NB	FB	MPS
Injectors	100 µm	50 µm	?	1 GHz	40 mm	189	?	?
Pre damping rings	10 µm	10 µm	?	10MHz	20/9 mm	600	Yes	?
Damping rings	10 µm?	2 µm	?	10MHz	20/9 mm	600	Yes	?
BC1, Booster Linac, Transfer lines, BC2	100µm	10µm	?	10MHz?	?	1404	?	?
DBA, DL's, CR's and transfer lines	20µm	20µm	?	100MHz	40mm	900	?	?
DB long transfer lines	?	?	?	100MHz	200mm	848	?	?
DB Turn around's	20µm	20µm	?	100MHz	Var.	1920	?	?
DB decelerator's	20µm	2µm	2µm	10MHz	23mm	41576	Yes	Yes
MB Linac	5µm	50nm	5µm	10MHz	8mm	4776	Yes	Yes

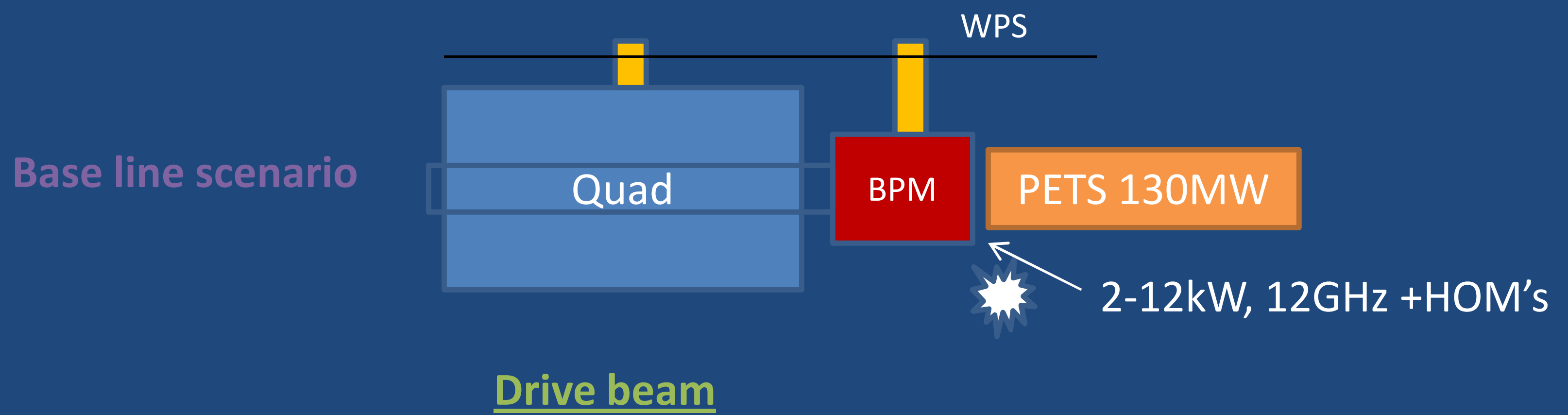
A total of 52813 BPMs!!...or ~800MCHF

CLIC module, type 1



Drive beam BPM

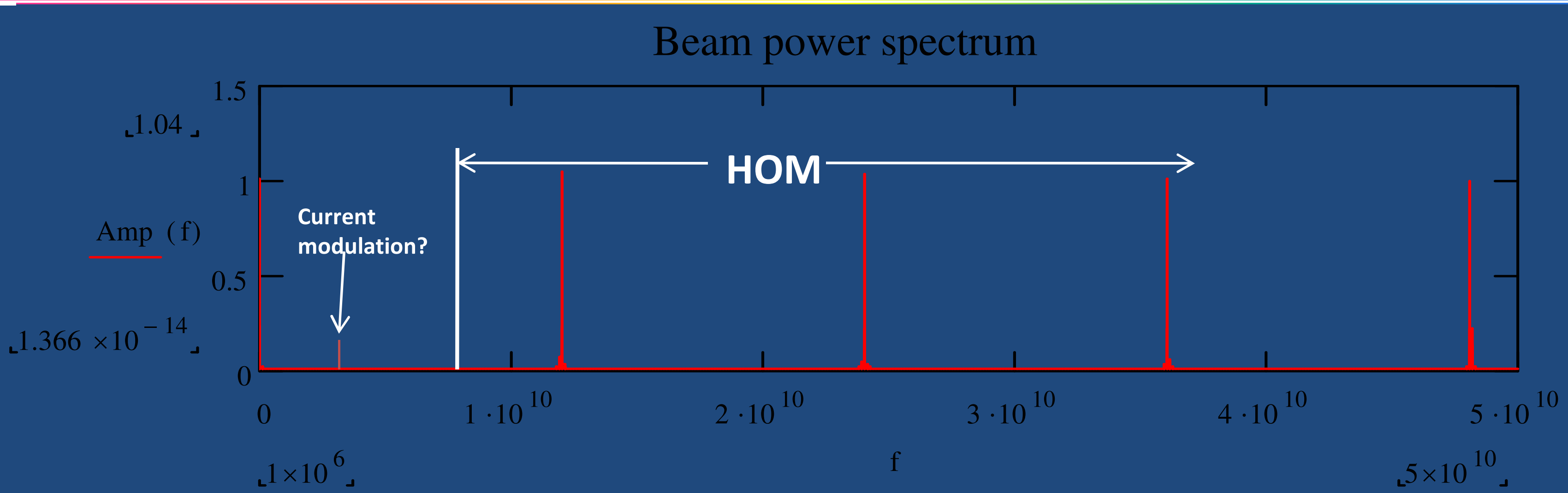
The drive beam quadrupole and BPM are mounted on the drive beam girders. BPMs cannot be moved independently of the PETS, the quadrupoles will either be on movers, or equipped with dipole corrector coils. The BPMs are mounted before quadrupoles. The acceptable level of wake field needs to be determined.



Nominal beam parameters: Charges/bunch :5.2*10[10], Nb of Bunches: 2922, Bunch length: 1mm, Train length: 243.7ns

	Accuracy	Resolution	Stability	Range	Bandwidth	Beam tube aperture	Available length	Intercepting device?	How many?	Used in RT Feedback?	Machine protection Item?	Comments	Ref
BPM	20µm	2µm	?	<5mm	35MHz	23mm	104/74mm	No	41480	Yes	Yes	Inductive ? Strip line ?	CLIC note 764

CLIC Drive beam



Chamber (23mm) cutoff frequency 7.6GHz!!! **HOM from PETS with several kilo Watt's**

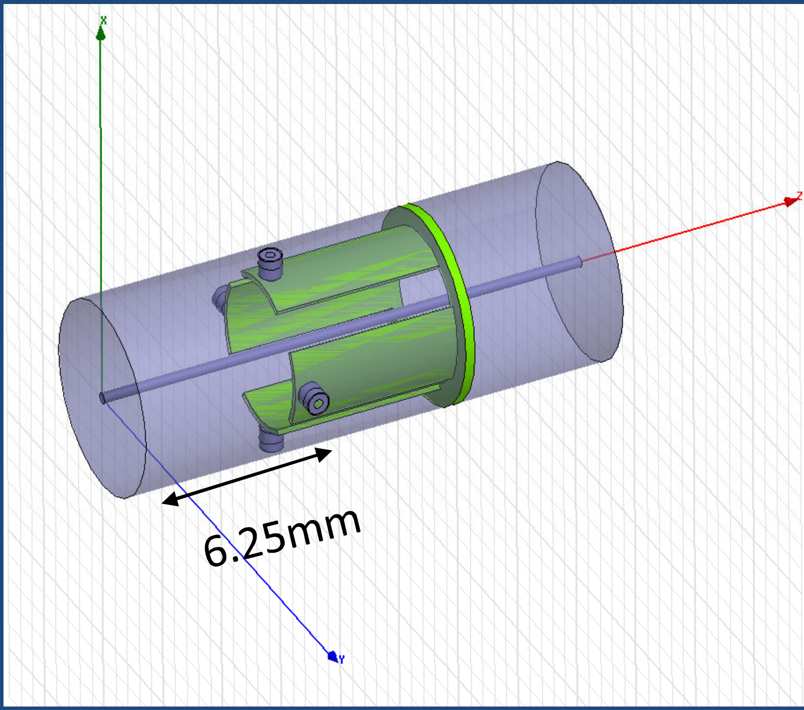
Beam pulse current 100A

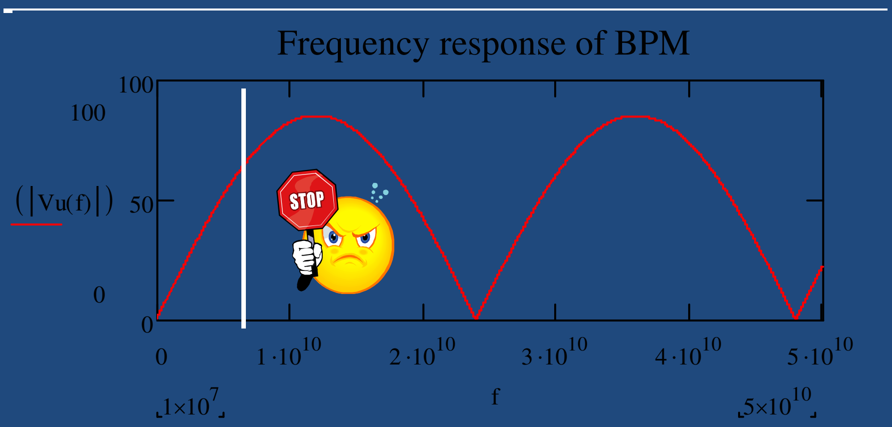
BPM coupling impedance of -40dB would pump 50W peak!
40000 BPMs would dissipate 2MW peak per pulse!!
Average dissipated power is only 25W

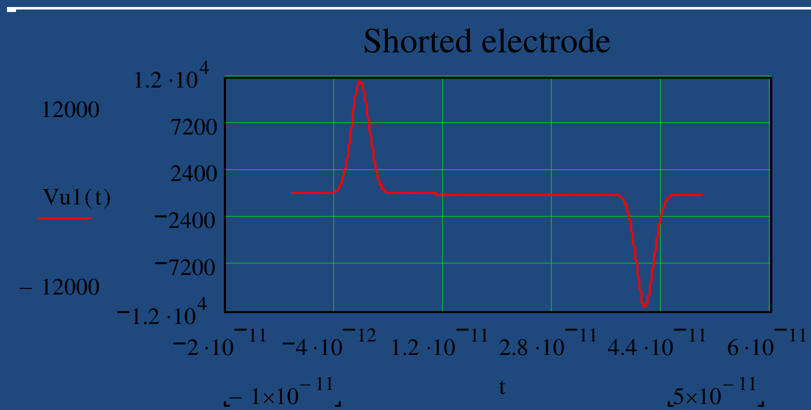
1) **<u>Introduce</u> current modulation of 10-4 at e.g. 2GHz?**
2) **Measure with button, strip line or inductive BPM at baseband**
3) **Use other (unknown) spectral lines**

Strip line BPM

- 50 ohm electrodes, 4 feedthrough's.
- Good linearity.
- Accuracy 20um difficult to obtain
- Resolution 2 um:
  1. Limited by CMRR to ~10^{-3} i.e. ~10um
  2. Thermal noise not a problem
  3. Time resolution OK, determined by filter
- Accuracy 20um difficult to obtain

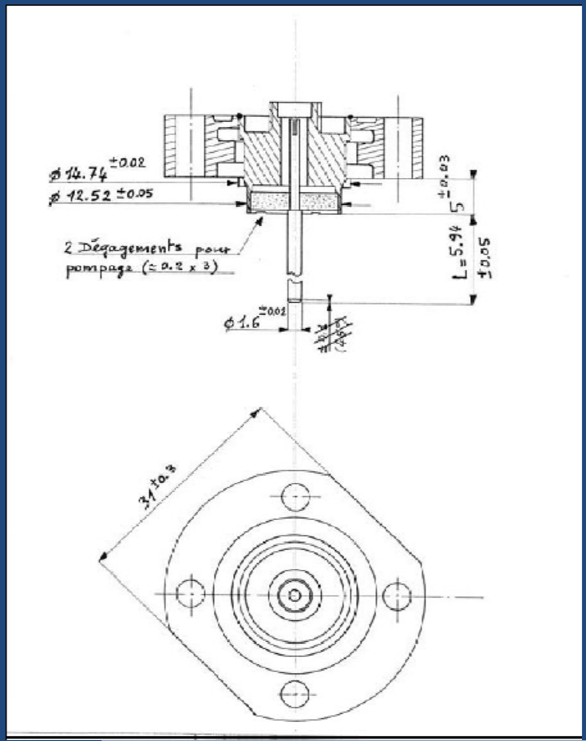


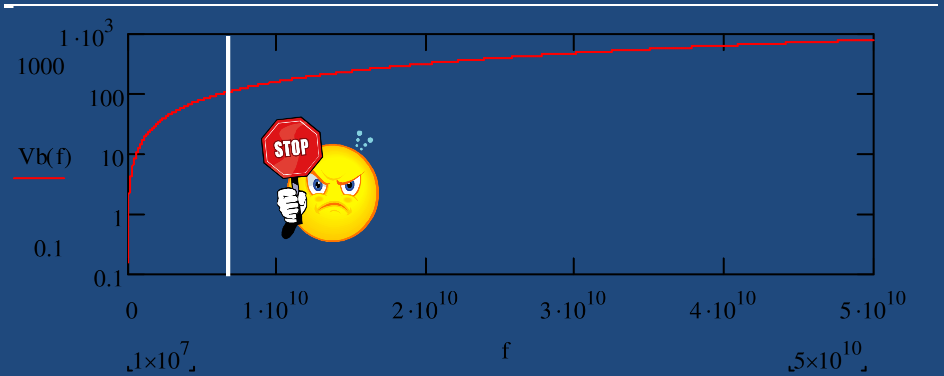


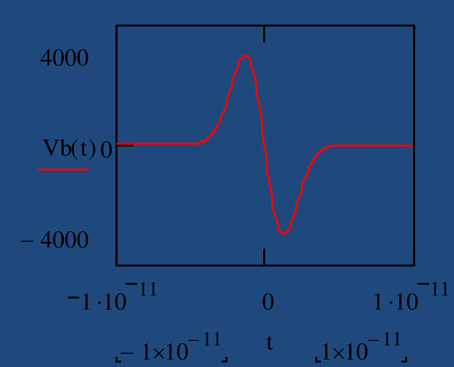


Button BPM

- Consist of 4 ~1mm pins mounted on feedthrough’s
- Non linear but good center position
- Lowest longitudinal impedance.
- Accuracy 20um difficult to obtain
- Resolution:
  1. Limited by CMRR to 10^{-3} i.e. ~10um
  2. Thermal noise not a problem
  3. Time resolution OK, determined by filter

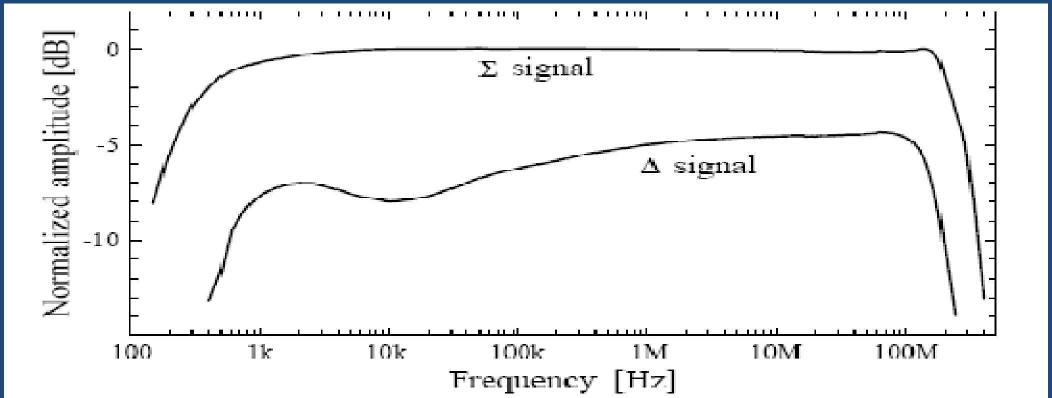


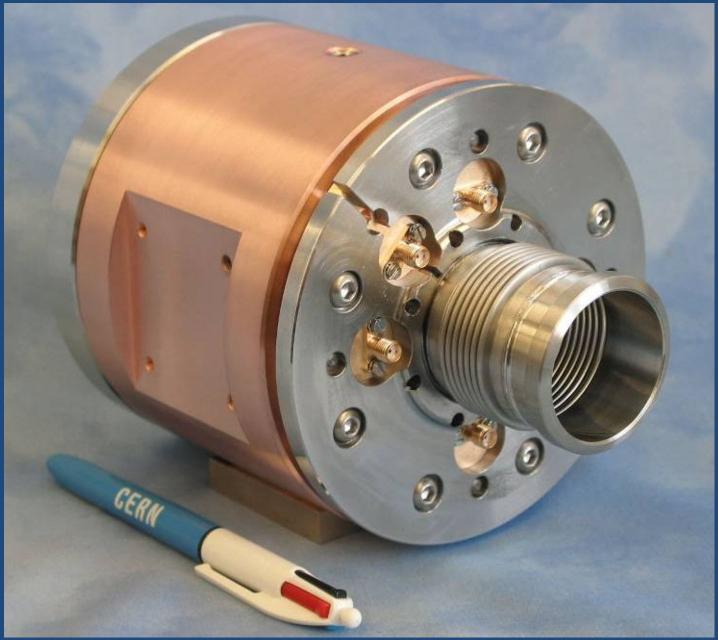




Inductive BPM

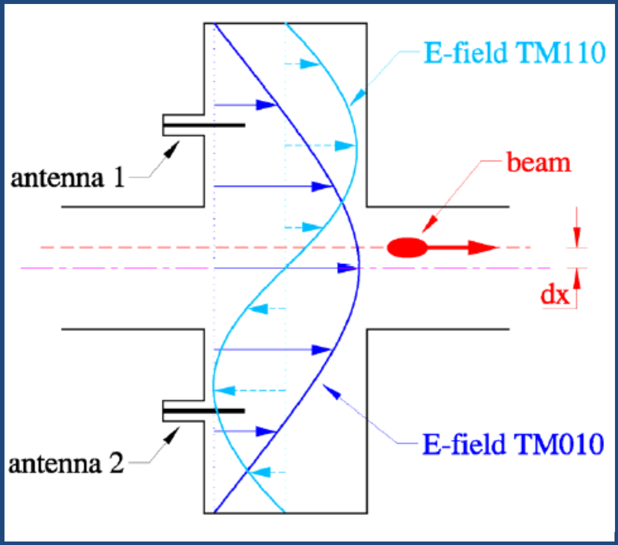
- Low frequency BPM (10kHz-100MHz). Used in CTF3.
- Good linearity in the center. Low longitudinal impedance
- Accuracy 20um difficult to obtain, due to many pieces
- Real current measurement. No feed-through's
- Resolution:
  1. Limited by CMRR to 10^{-4} i.e. ~2um
  2. Thermal noise not a problem.
  3. Time resolution OK.

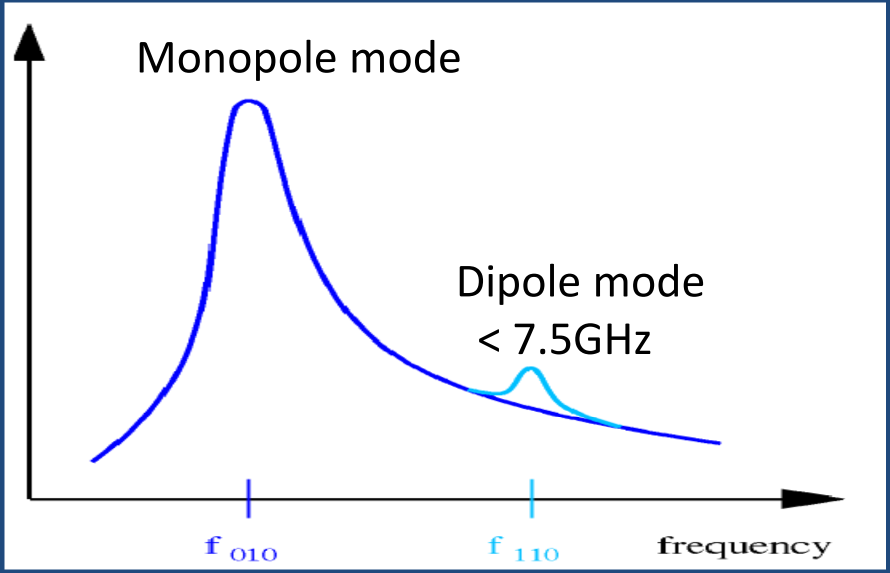


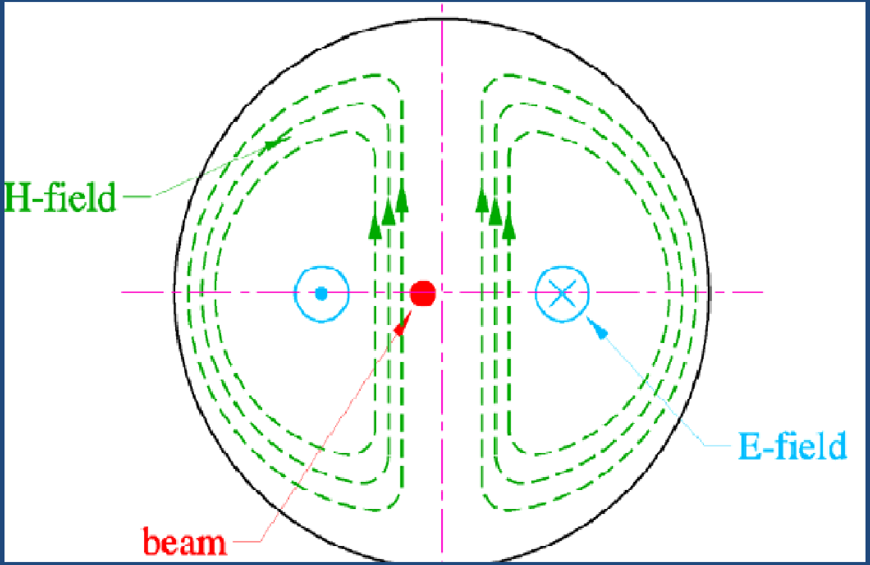


Cavity BPM

- Difference of large numbers problem reduced to rejection of the primary fundamental peak. Frequency domain.
- Stainless steel to reduce Q. $Q_L \rightarrow \sim 100$
- $$\tau = \frac{Q_{ld}}{\pi * f_{Dip}}$$ → Time resolution
- Sub-micron resolution
- Precision machining, good accuracy

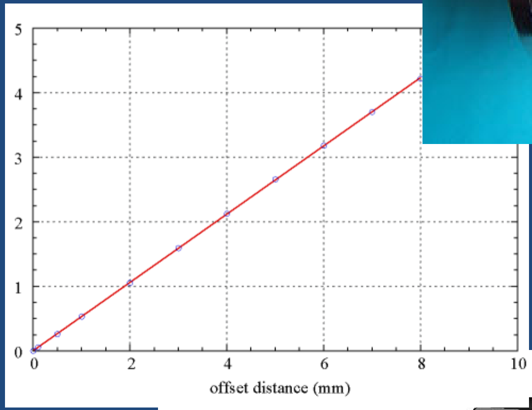




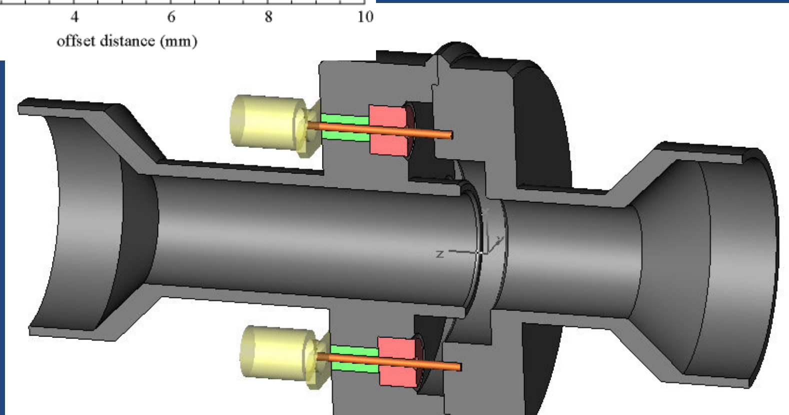


Re-entrant Cavity BPM (CALIFES)

- 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
- Precision machining, good accuracy



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

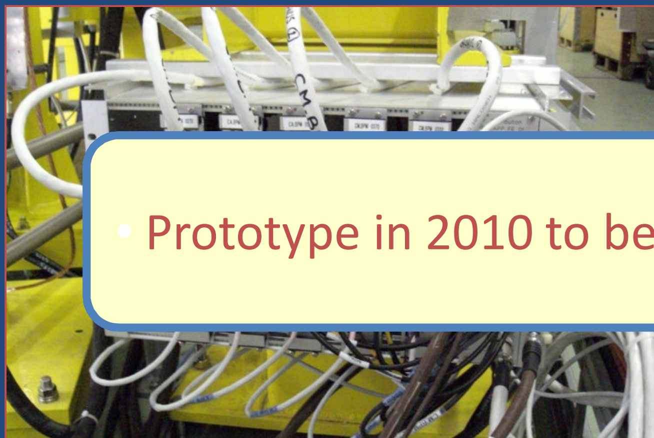


ID 18mm; Length ~100mm.

DB BPM strategy

- Steve Smith from SLAC will come to CERN as from 1^{st} of January 2010 for 1 year.
  - Study DB BPM, select best principle.
  - Build and test 1 prototype
  - Contribute to CDR end 2010

LAPP BPM Read-out electronics



From CTF3 – to the development of
IC

- Prototype in 2010 to be tested in CTF3 for radiation hardness

Rare acces from surface, high number of channels, rad-hard, low-cost, low consumption, Standartisation…

Most important points to develop: ***elimination of cables***

– ***Power supplies:*** *autonomous (220V sector, DC-DC converters…).*
– ***Local calibration***
– ***Network :*** *flexible data collection, repetition crates…*
– ***Acquisition architecture:*** *faster ADC, direct BPM read-out, continuous sampling…*
– ***FPGA processing:*** *raw data, processed data…*
– ***Radiation hardness ?***
– ***Timing/clock and connection via synchronous ethernet (White Rabbit)***

BPM collaborations

	Main beam BPM	Main beam BPM	Drive beam BPM	WFM	FE electronics
Institute	FNAL	RHUL	SLAC	CEA	LAPP
Contact	M. Wendt	G. Blair	S. Smith	F. Peauger	S. Vilalte
Deliverable	3D design, low cost Cavity BPM Acq. system	3D design Choke BPM, Lab tests Beam tests?	1 year at CERN. 3D design. 1 proto type Lab tests	Design, build and test in CTF3	Design and test of standard acquisition module.
CERN	Mechanical design. Build 3 (4) proto types Lab tests	Mechanical design. Build proto type.	Mechanical design. Build 1 (3) proto types	?	Write specifications Test in CTF3
MOU	Unofficial	Not yet	Yes	Yes	Not yet

Summery

- Huge number of BPM's, which might be reduced by a factor two.
- 20um accuracy difficult to obtain in large scale system.
- HOM will propagate above 7.5GHz. High beam currents to be dealt with.
- Dedicated BPM study will start January 2010.
- General acquisition system will be developed by LAPP.