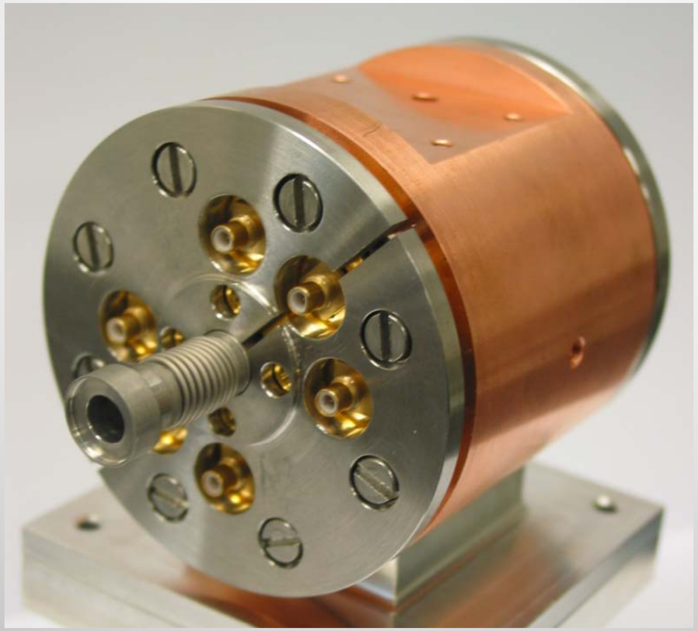
EUROTeV

Precision Beam Position Monitor



On the behalf of:
I. Podadera
F. Guillot-Vignot

Outlook

- Deliverables
- Design
- Bench tests
- Beam tests
- Choke Cavity BPM
- Conclusion and outlook

PBPM- deliverables

- **Prototype PBPM:**
  - Design and build prototype.
- **Report on bench tests:**
  - Design and build high resolution (100nm). mechanical stable test bench.
  - Characterize PBPM.
- **Report on beam tests:**
  - **Build 3 PBPMs and test with (CTF3) beam**.

Specifications

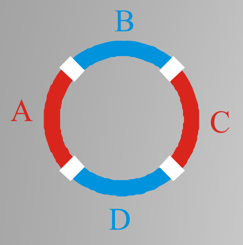
EUROTeV	Aperture	4mm (6mm)
	Resolution	100nm
	Accuracy	10µm
	Rise time	<15ns
Extended specifications	Dynamic range	±1.5mm (15 bits)
	Linearity error	< 1% (±1.5mm)
	24H stability	1µm
	Droop	< 5%
	Low frequency cutoff	100kHz *(3.6% droop, CLIC 58ns pulse)*
	High frequency cutoff	30MHz
	CMRR	>90dB
	Bake out temperature	150ºC
	Vacuum	10^{-9} Torr
	Operating temperature	~20°C

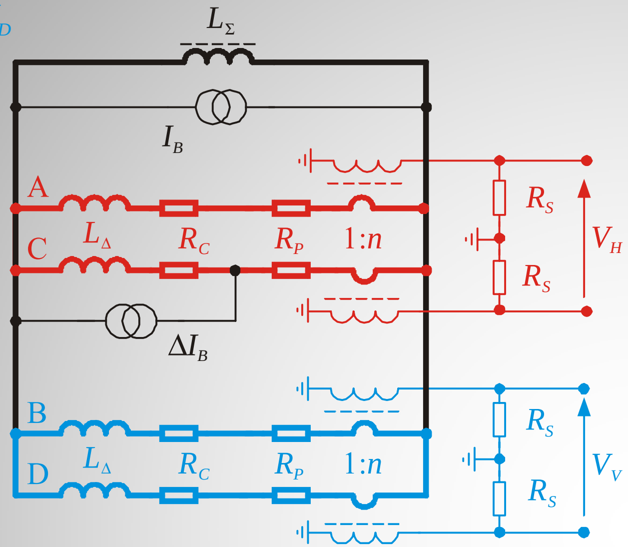
Inductive pick-up: basic scheme

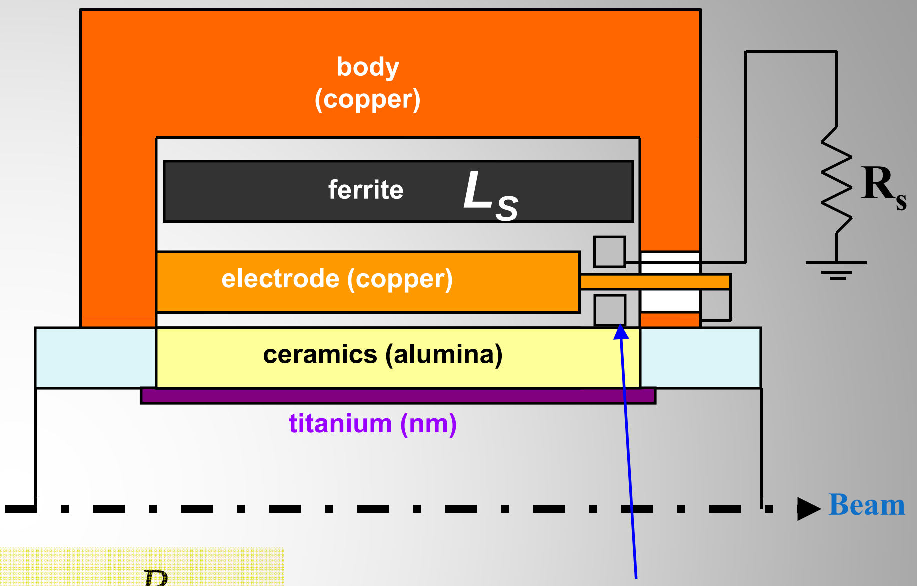
$V_\Sigma = V_A + V_B + V_C + V_D$

$V_{\Delta H} = V_A - V_C$

$V_{\Delta V} = V_B - V_D$







Coupling impedance

$$V_\Sigma = \frac{R_s}{n} I_B$$

Low cutoff (difference signal)

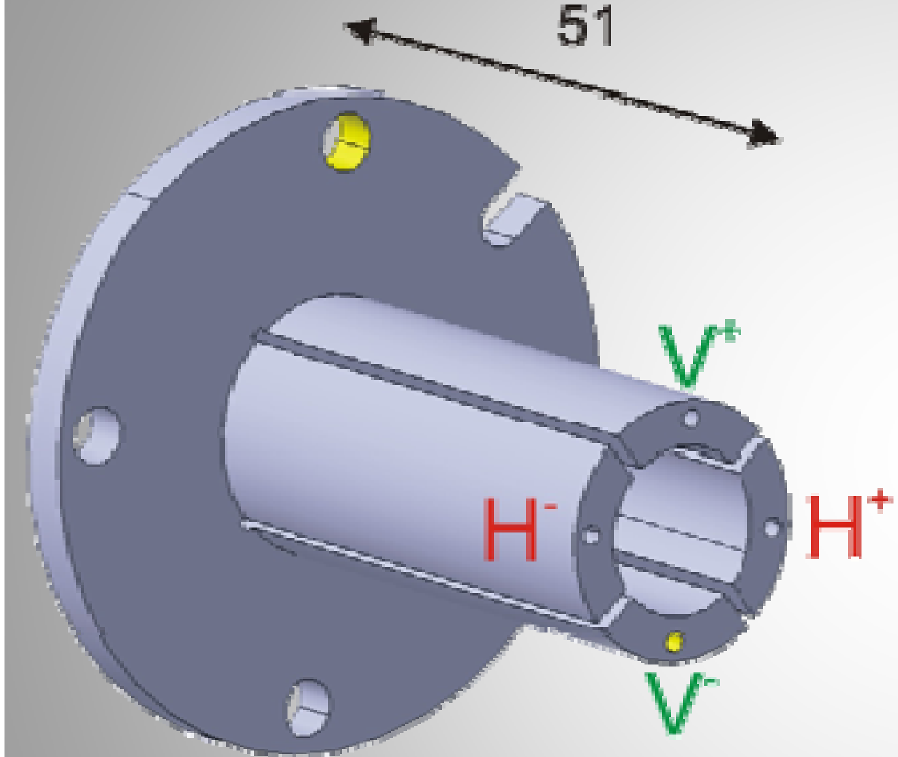
$$f_{L_\Delta} = \frac{R_s / n^2}{2\pi L_\Delta}$$

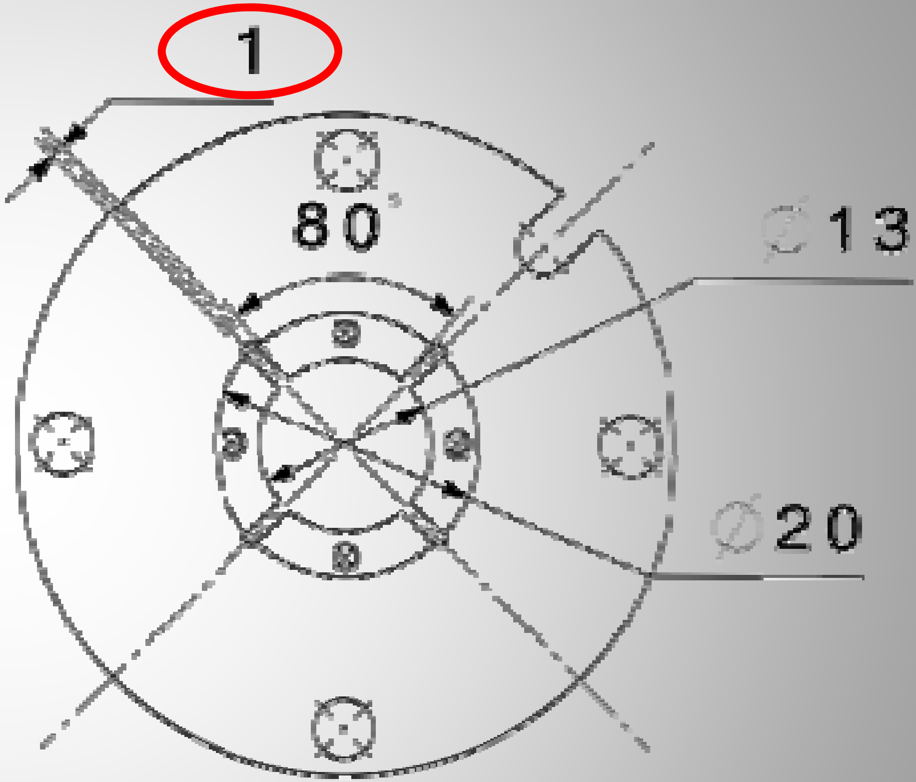
Low cutoff (sum signal)

$$f_{L_\Sigma} = \frac{R_s / n^2}{2\pi L_\Sigma}$$

Different electrodes

Also tests with 2mm (70º) 3mm (60º), 4mm (50º), 5mm (40º),



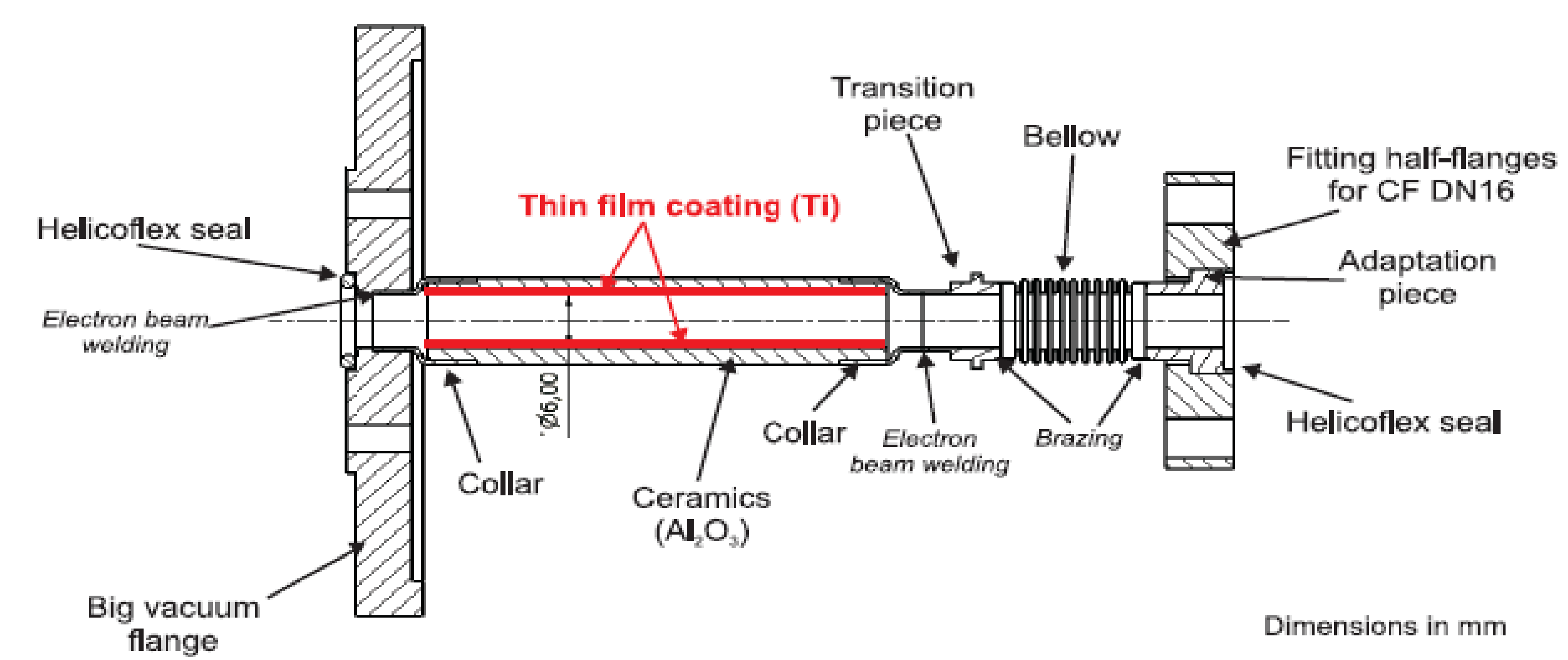


$\Delta_H = H^+ - H^-$

$\Delta_V = V^+ + V^-$

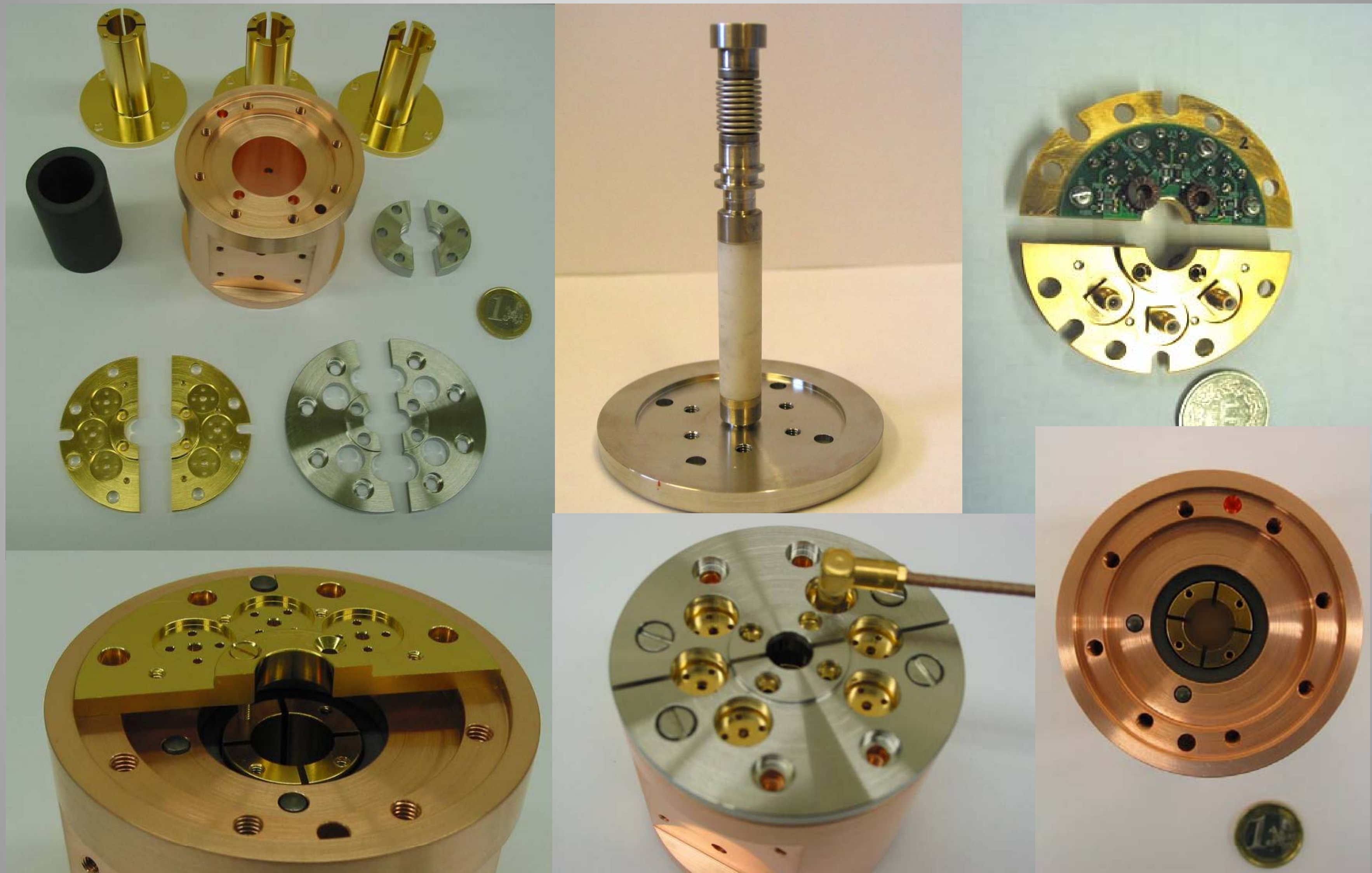
Dimensions in mm

Vacuum assembly



- The sputtering technique used, require homogenous plasma inside the tube and this needs the use of a magnetron.
- Due to the magnetic properties **(Covar)** of the collars of the vacuum assembly it was not possible to obtain an homogenous field along the ceramic tube.
- With stainless steel collars coating is still not homogeneous. But end to end resitance of 10-15 ohms have been obtained.

PBPM assembly



PBPM bench tests

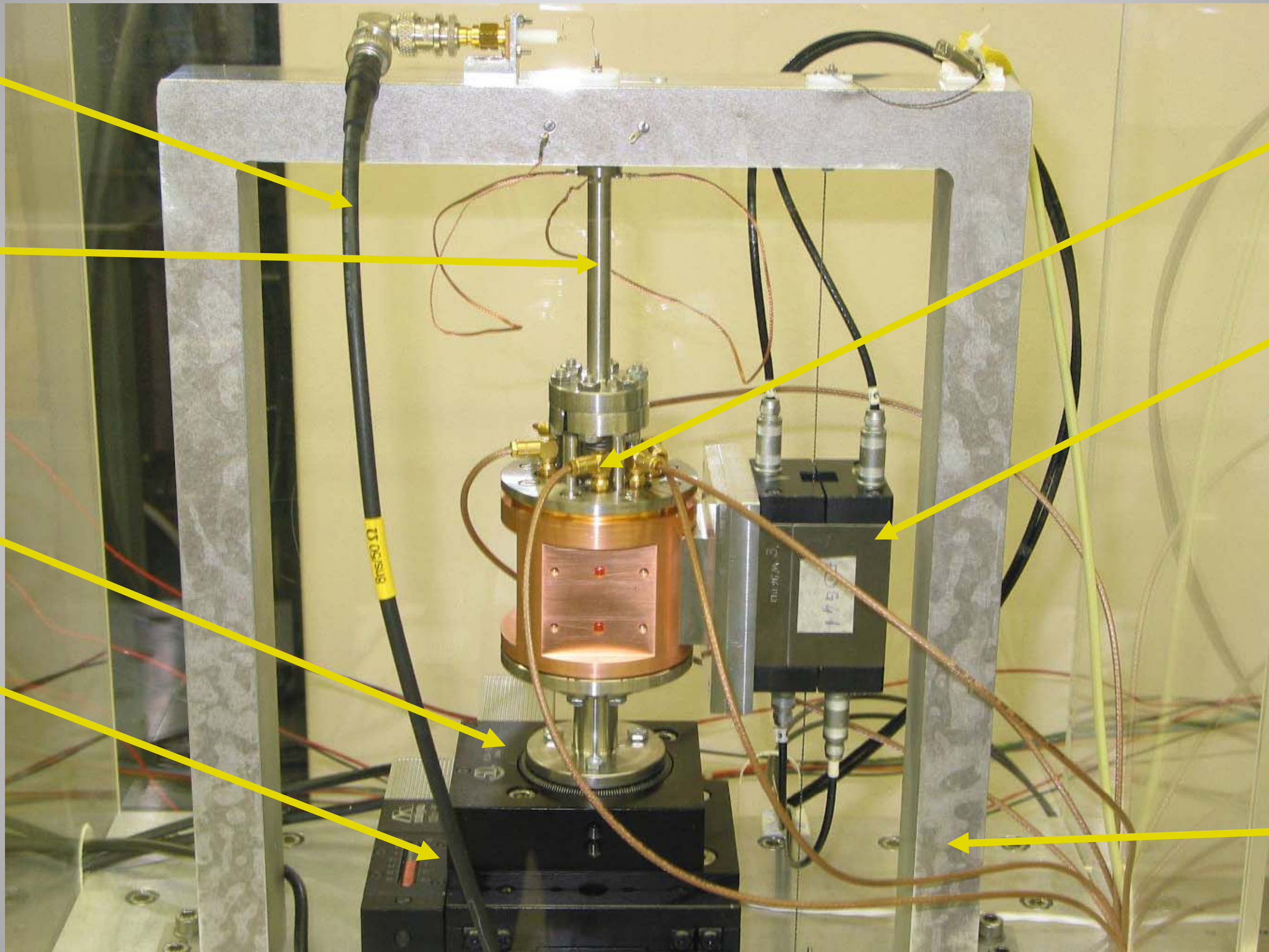
- Sensitivity
- Linearity
- Resolution
- Long-term stability
- Bandwidth
- Electrical offset
- Longitudinal impedance

→ **Network analyzer**
CW 1-10MHz, 100mA, narrow band

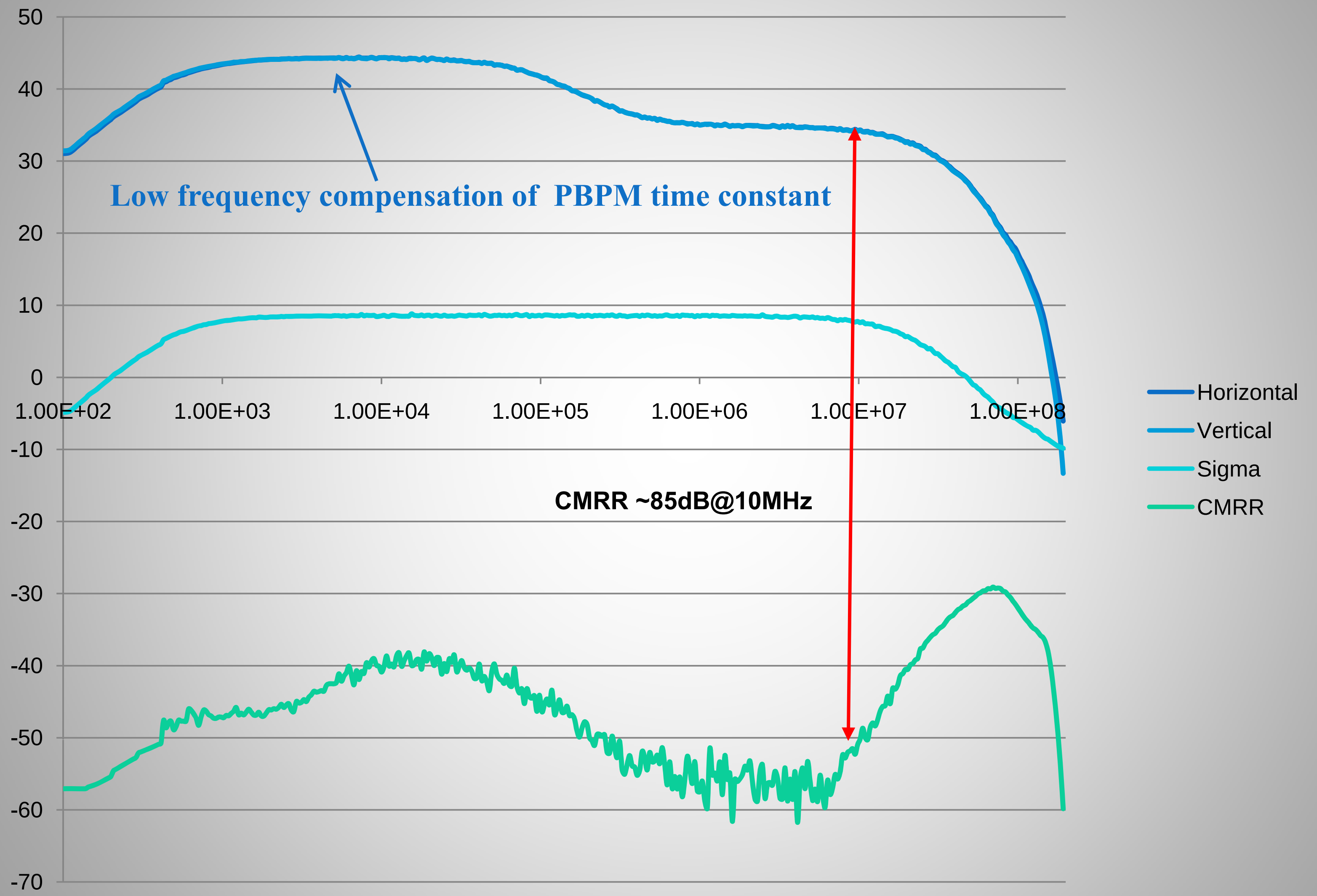
- Resolution
- Linearity

→ **Function generator and oscilloscope**
200ns, 200mA pulse, 25MHz BW

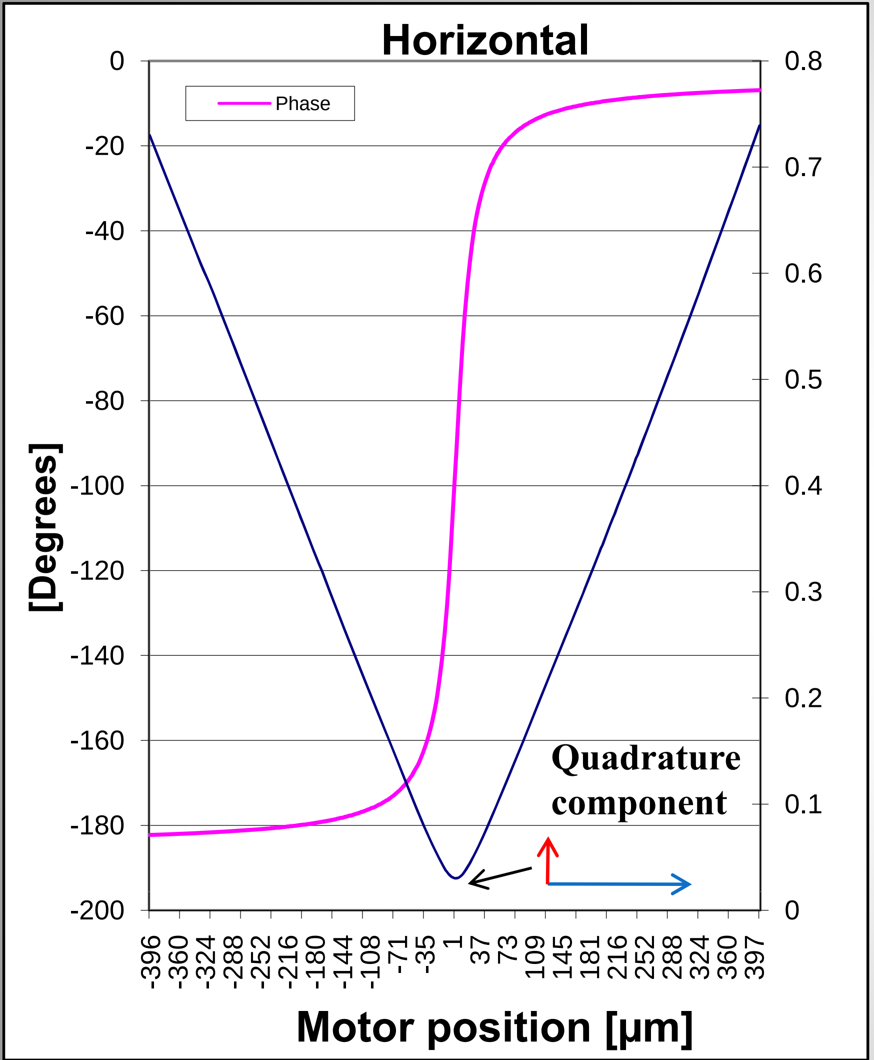
Test bench assembly

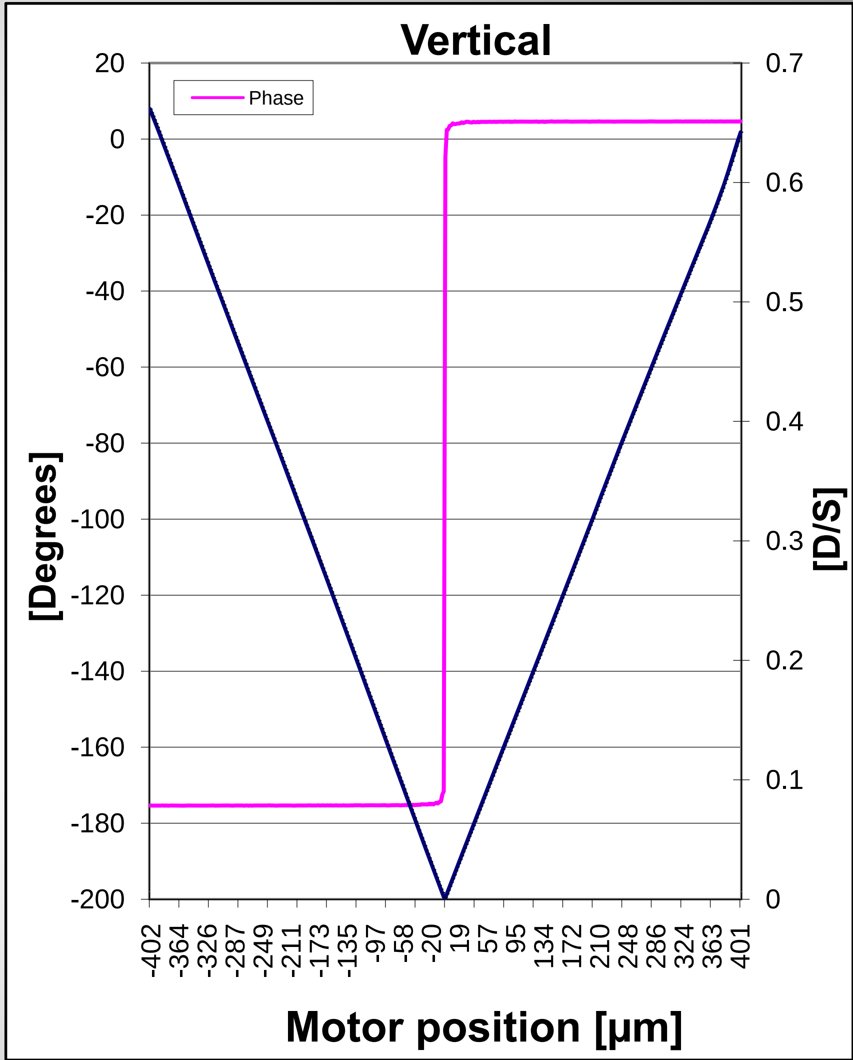


Difference amplifier

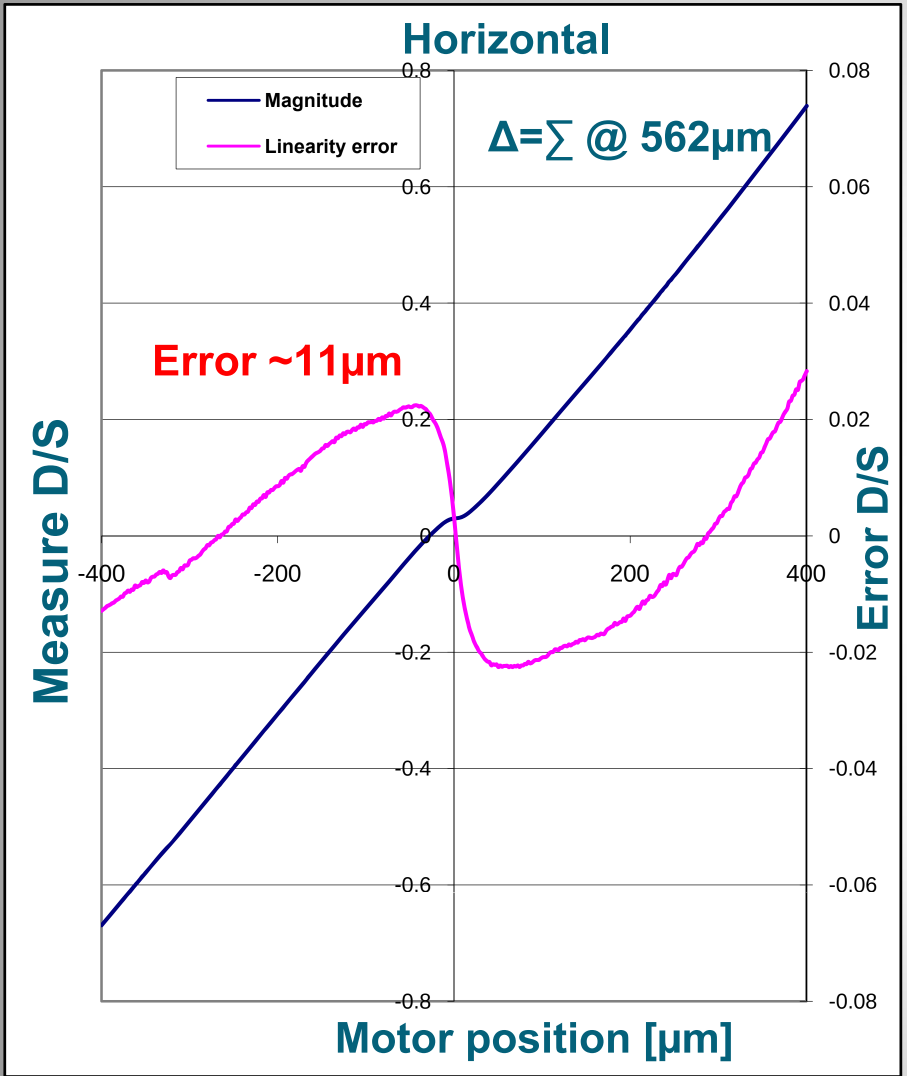


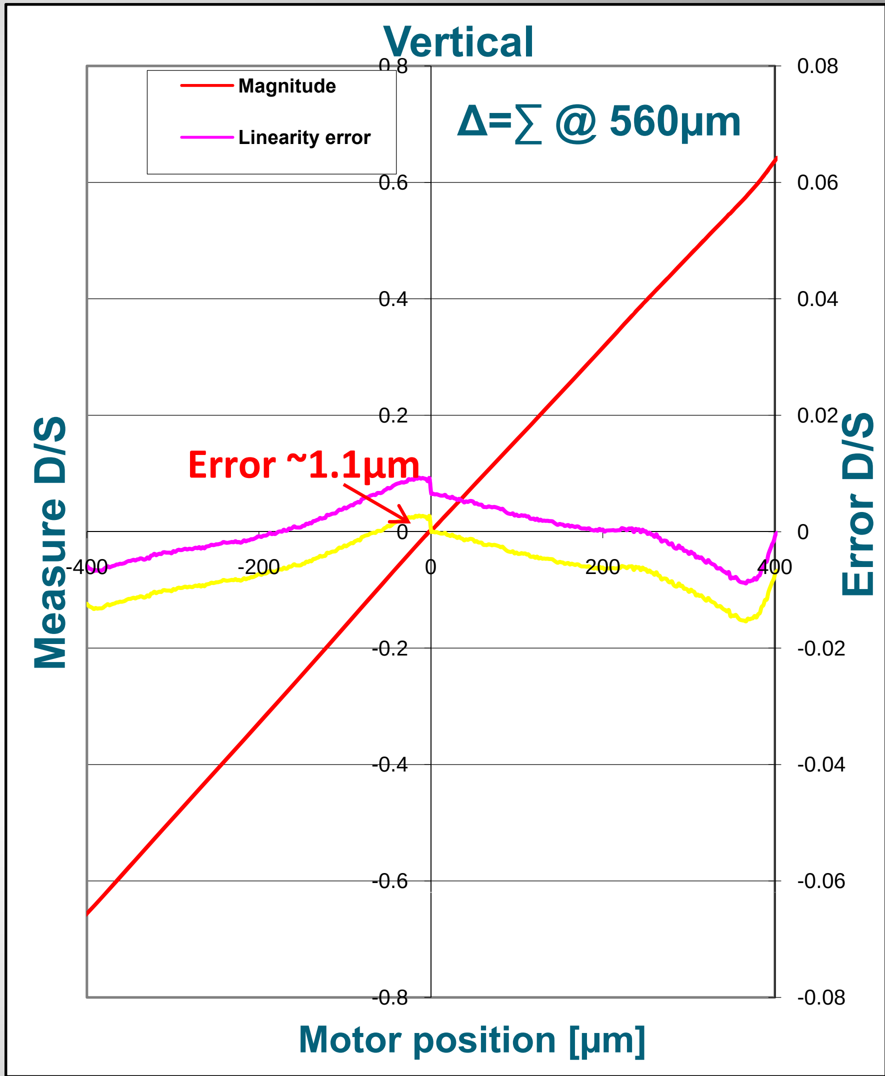
Sensitivity



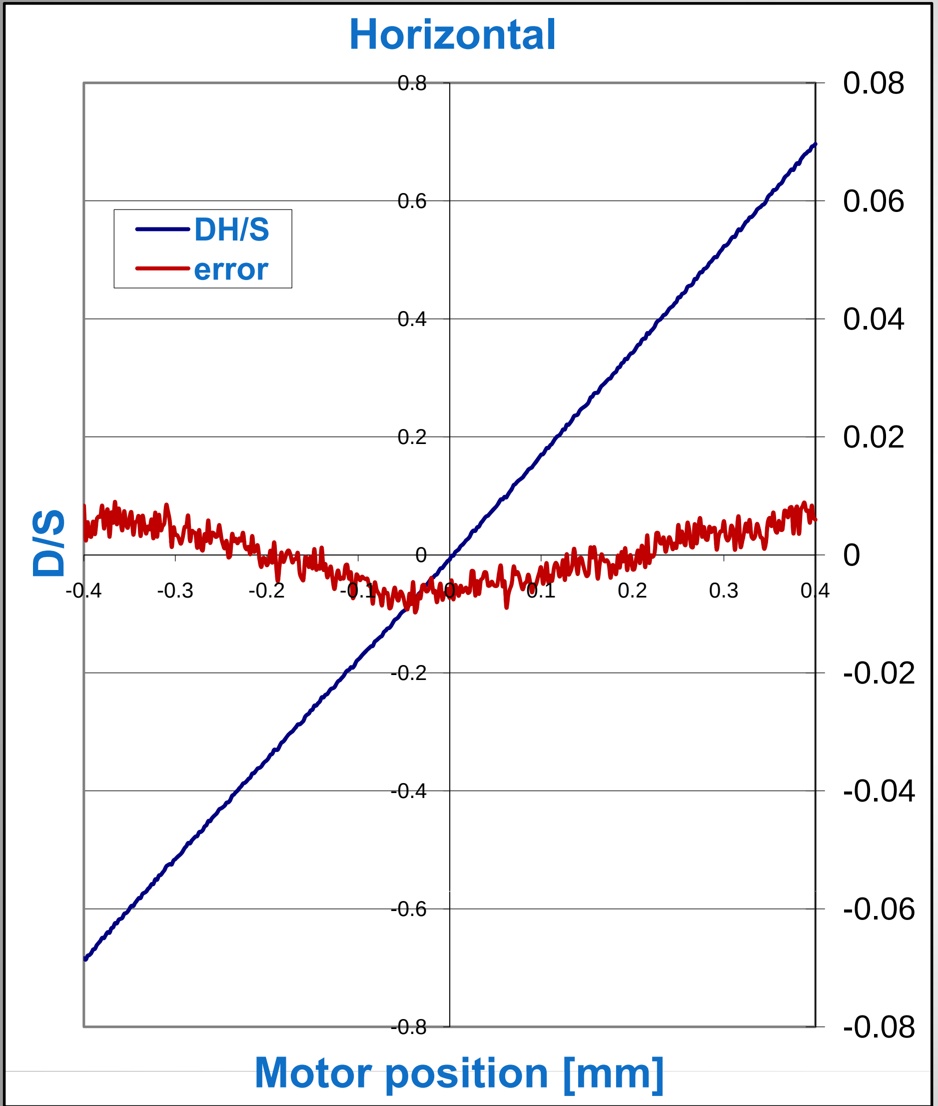


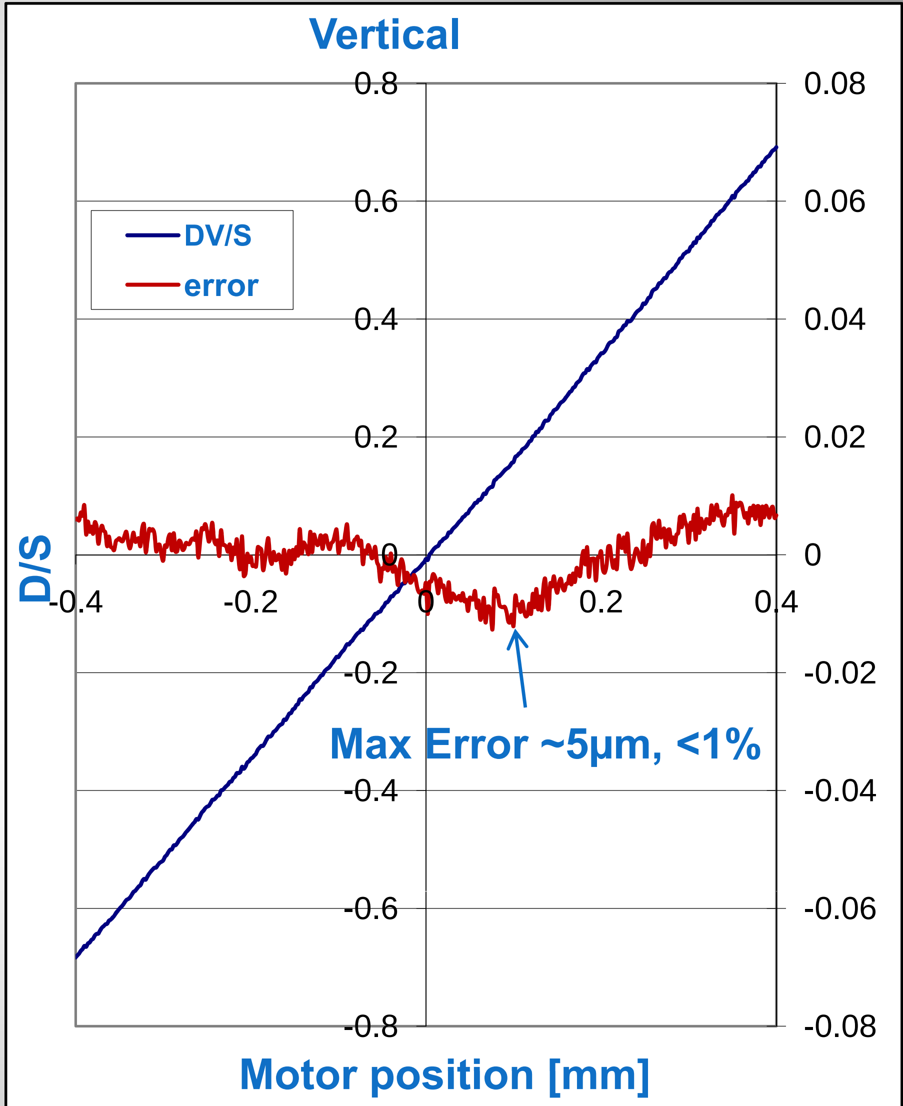
Bench tests-Linearity



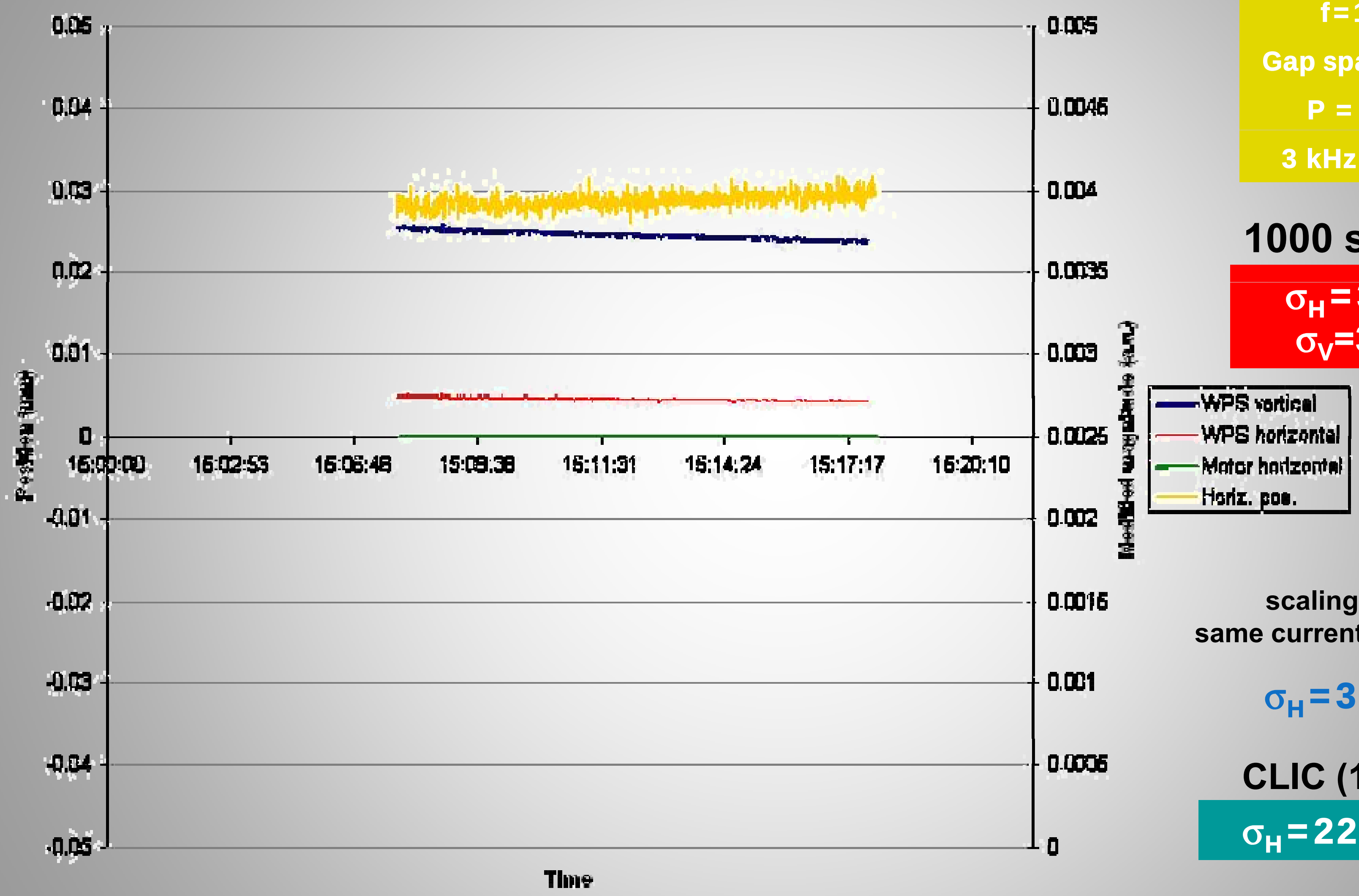


Linearity - time domain





Resolution



f=10 MHz

Gap spacing 3 mm

P = 25 dBm

3 kHz bandwith

1000 samples

σ_H=36 nm

σ_V=36 nm

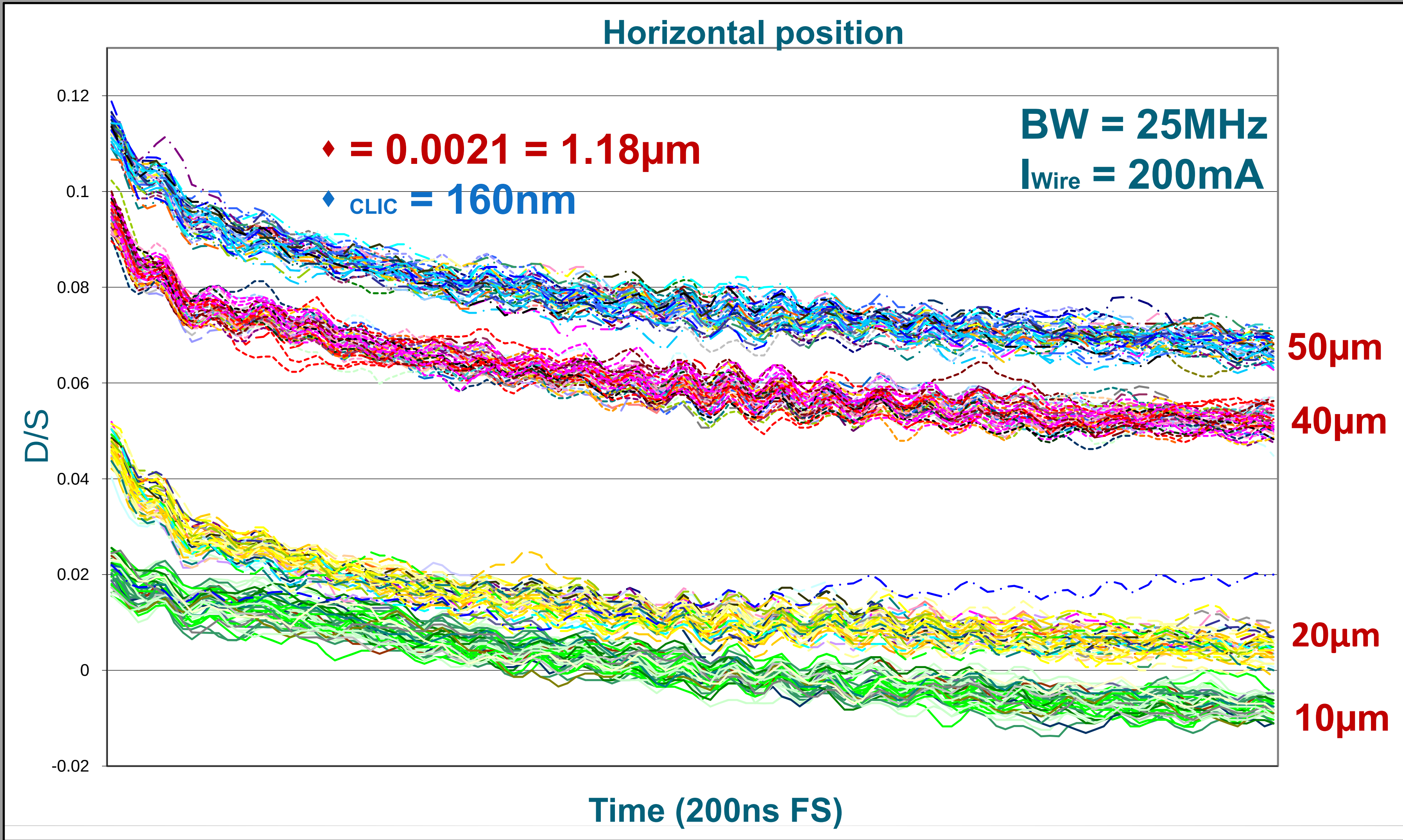
scaling noise to same current at 25 MHz BW

σ_H=3.2 μm

CLIC (1.5 A)

σ_H=220 nm

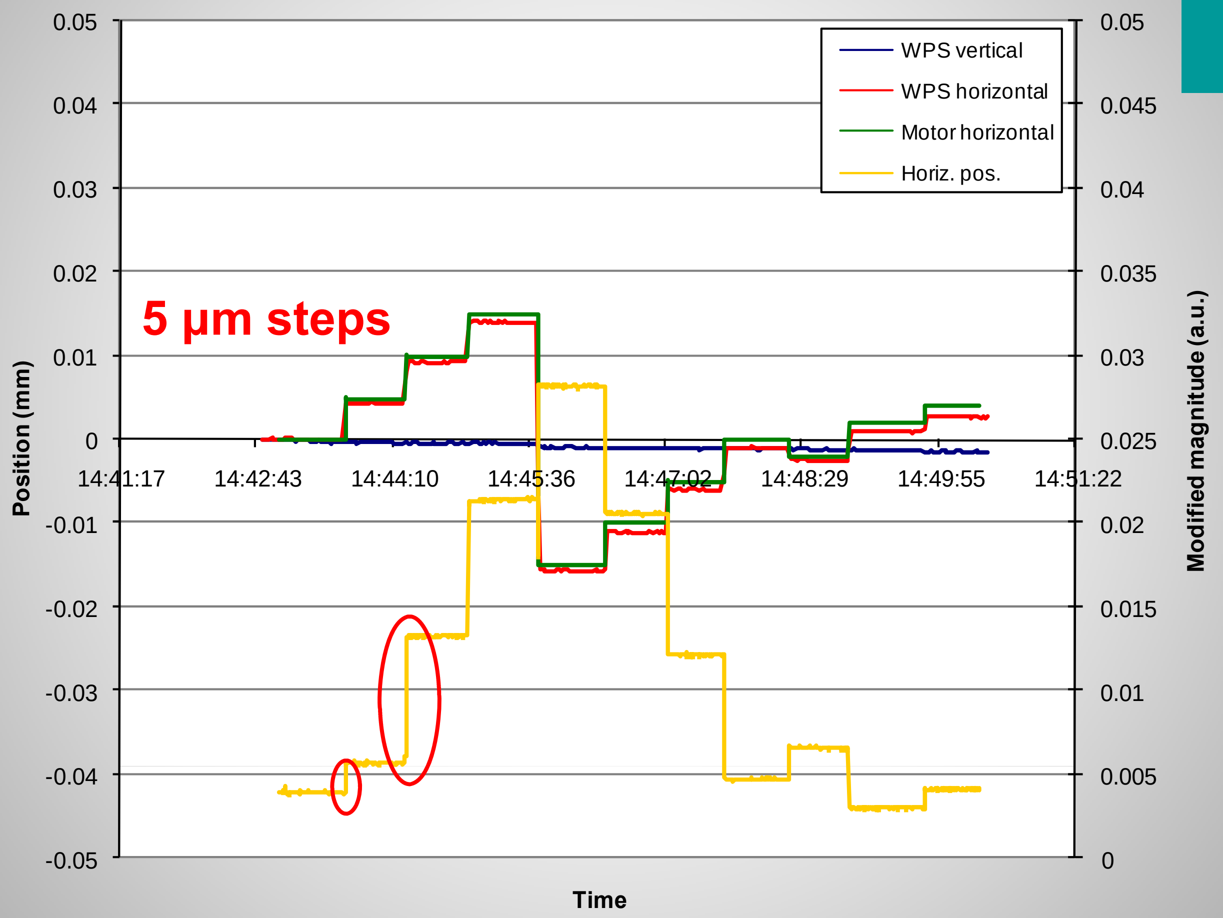
Resolution -Time domain



Resolution with movement

Correlation between x movements and monitoring signals

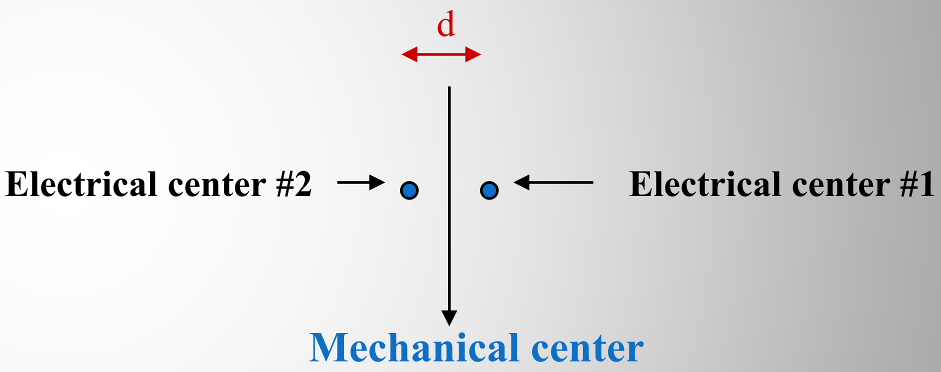
f=10 MHz
Gap spacing 3 mm
P = 25 dBm
3 kHz bandwith



Electrical offset

Difficult to know exactly where the wire is (inside) with respect to external reference.

1. Find electrical center #1
2. Rotate 180º
3. Find electrical center #2
4. Offset = d/2



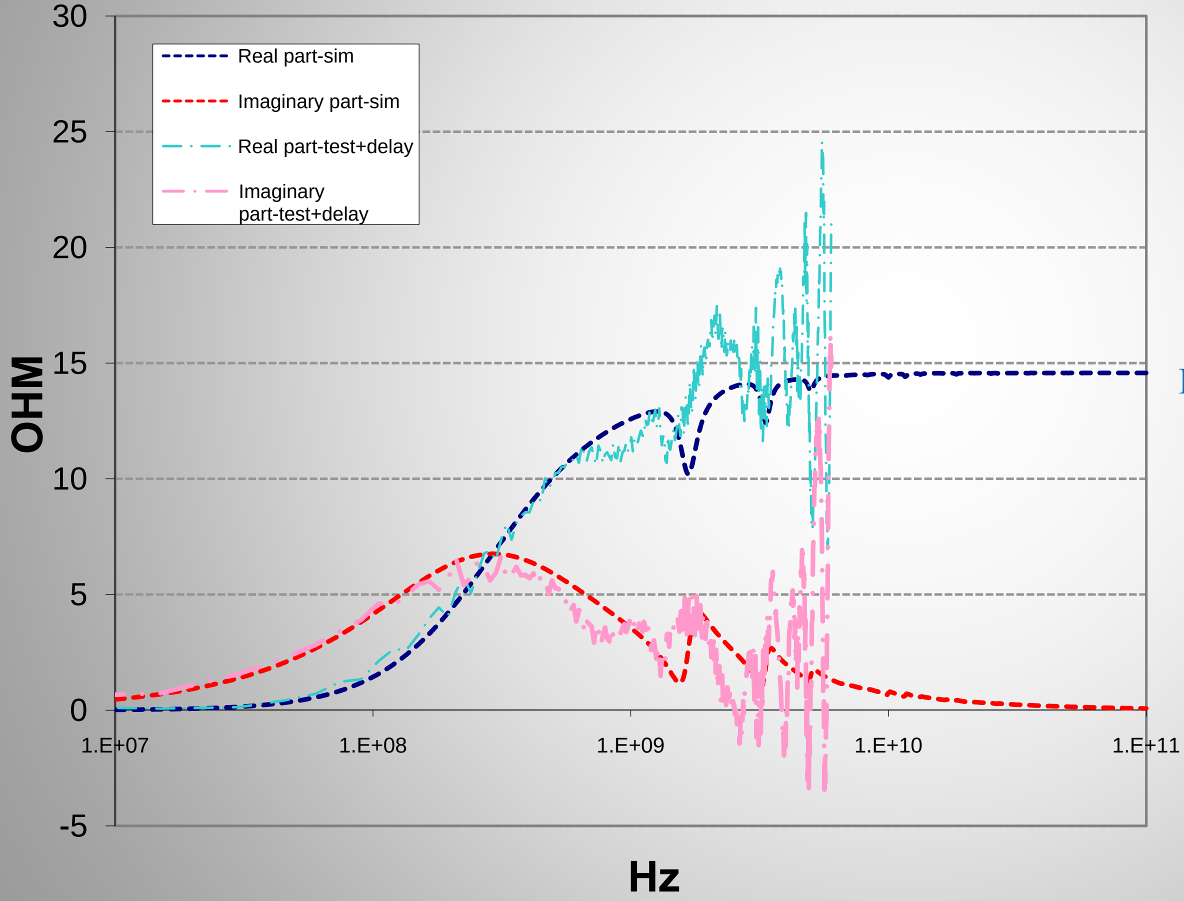
The electrical offset was measured to ~50µm.

The reason for this was due to imprecise alignment of the PBPM on the rotation stage, and assembly of the setup.

Impedance measurement

$$Z_{//} = -2Z_L \ln\left(\frac{S_{21}}{S_{21R}}\right)$$

Steady state at 15 Ohm, which is the end to end DC resistance



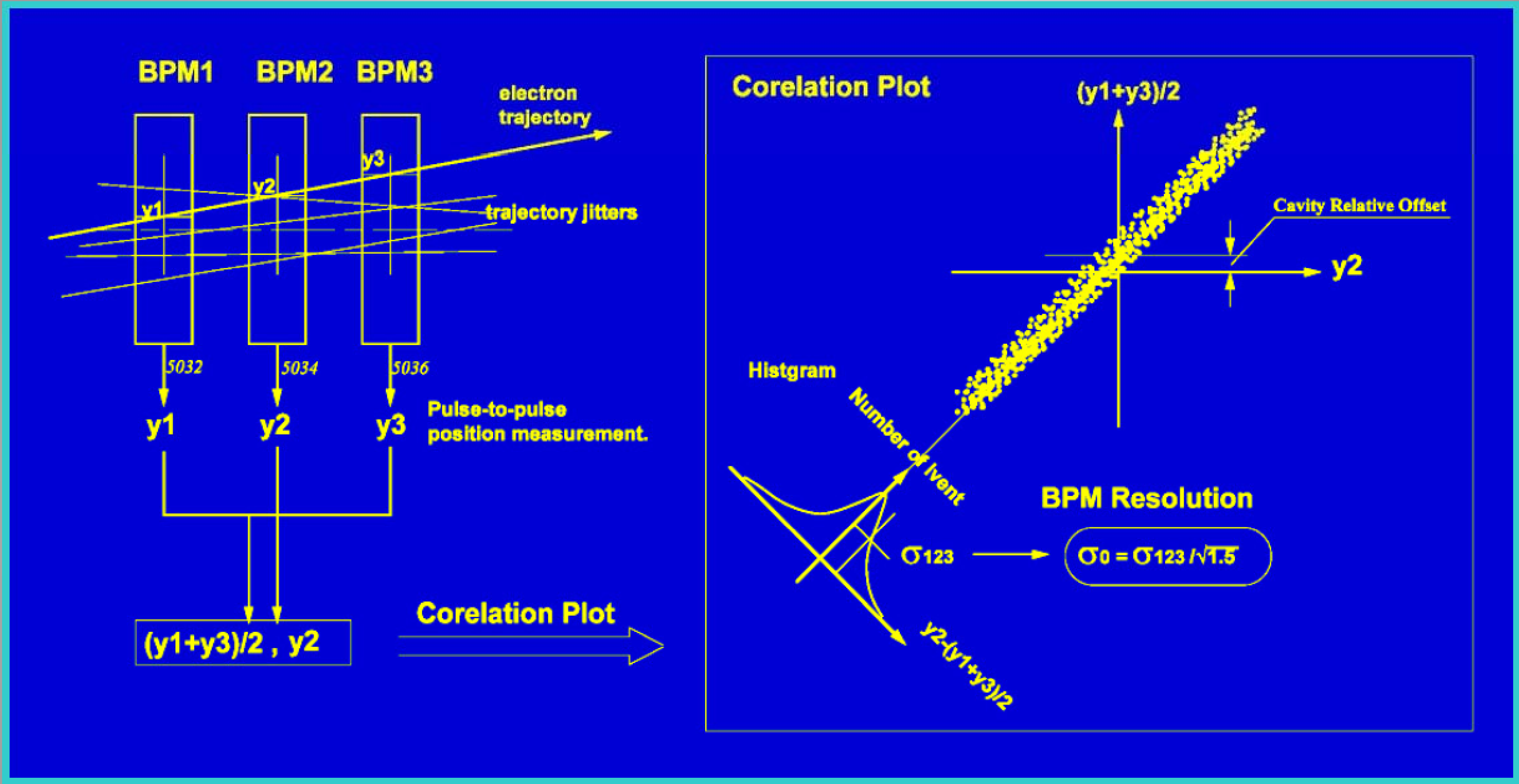
Real impedance

Imaginary impedance

Bench test-results

BPM Sensitivity Δ=Σ	11.8mm
Linearity error [±500µm]	1%
Electrical offset	~50µm
Meas. resolution (100mA, 3kHz BW)	σ = 36nm
Resolution CLIC (1.5A, 25MHz BW)	σ = 160nm / 220nm
Resolution ILC (55mA , σ=14ns, 25MHZ BW)	σ = 5.8um
24H stability/ 5 deg. C	2µm
BPM bandwidth	Δ = 300kHz-80MHz Σ = 5kHz-80MHz

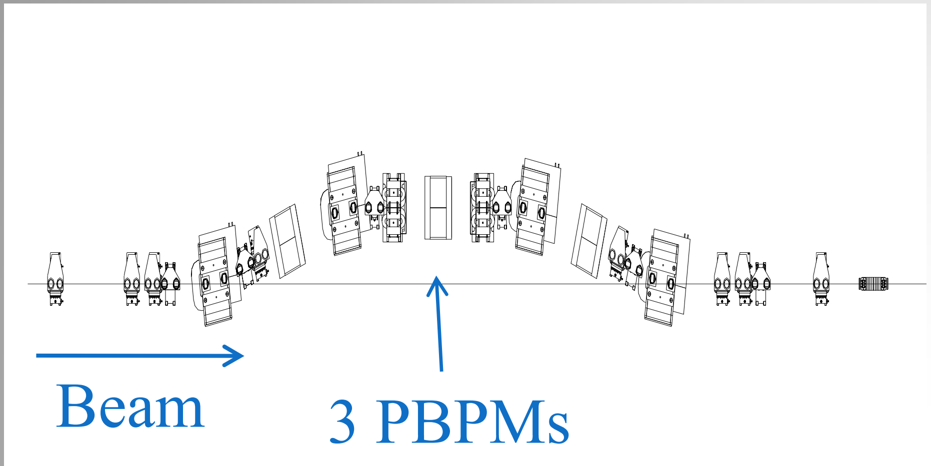
Beam tests



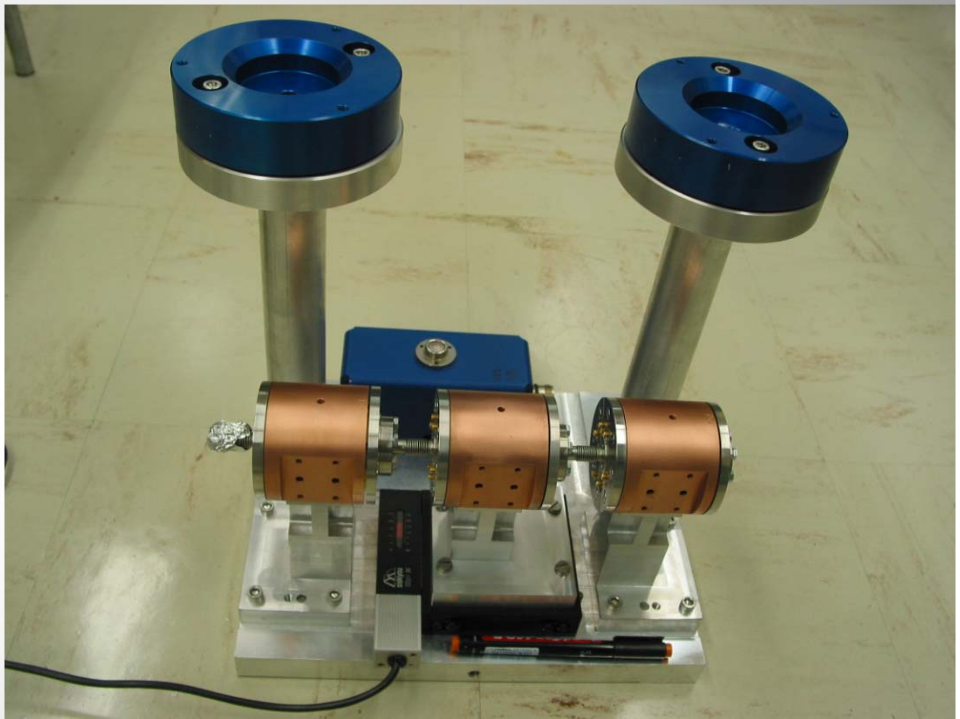
Courtesy T. Shintake

Beam tests in CTF3

Magnetic chicane CTF3 Linac



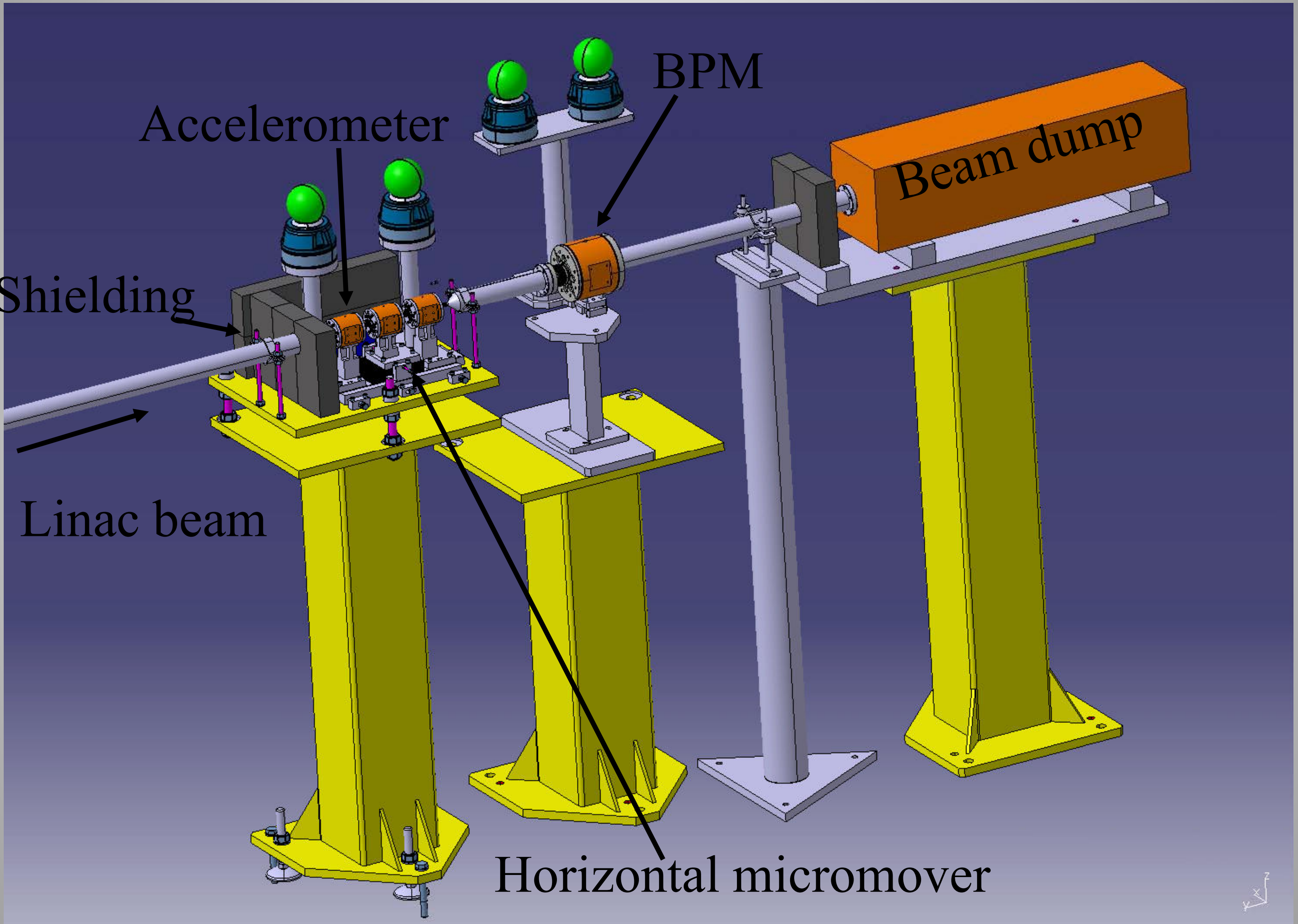
Installation of 3 PBPM in CTF3
November 2007



CTF3 beam parameters

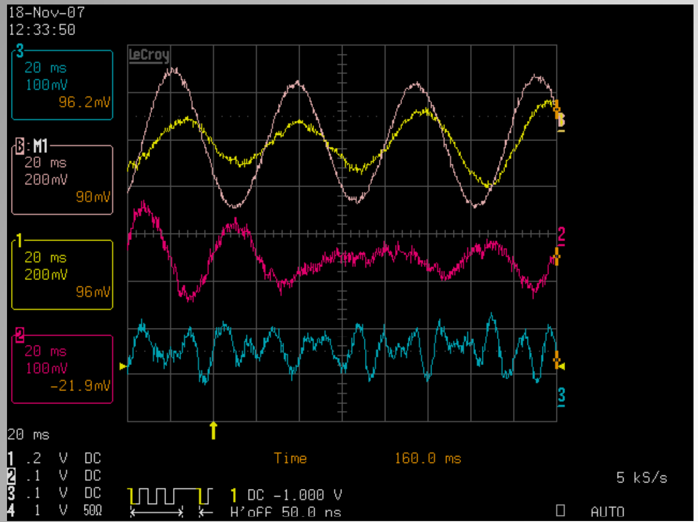
Beam current	**1 A**
Pulse width	**400 ns**
rms-Transverse beam size	**0.7 mm**
Beam angle	**1.25 mrad** *(0.5 mm offset at 400 mm length)*
Tranversal position jitter	**100 to 200 µm**

Beam tests



BPM
Accelerometer
Beam dump
Shielding
Linac beam
Horizontal micromover

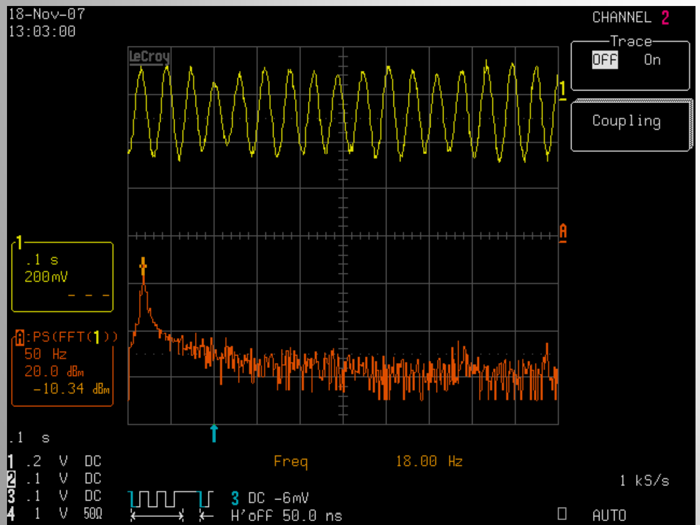
Beam tests-vibrations



Longitudinal =Yellow, Violet = **± 1µm**

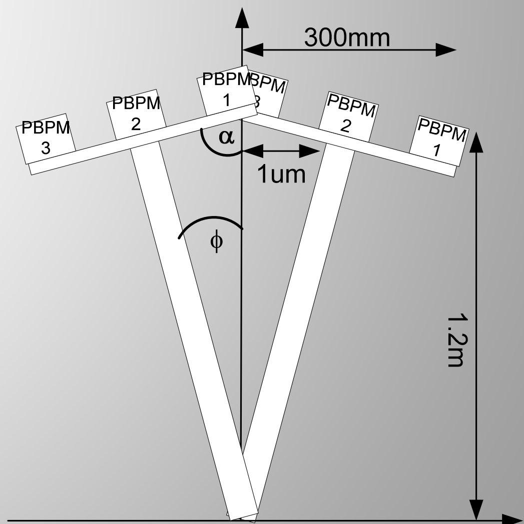
Horizontal=Red = **± 500nm**

Vertical=Blue = **± 50nm**



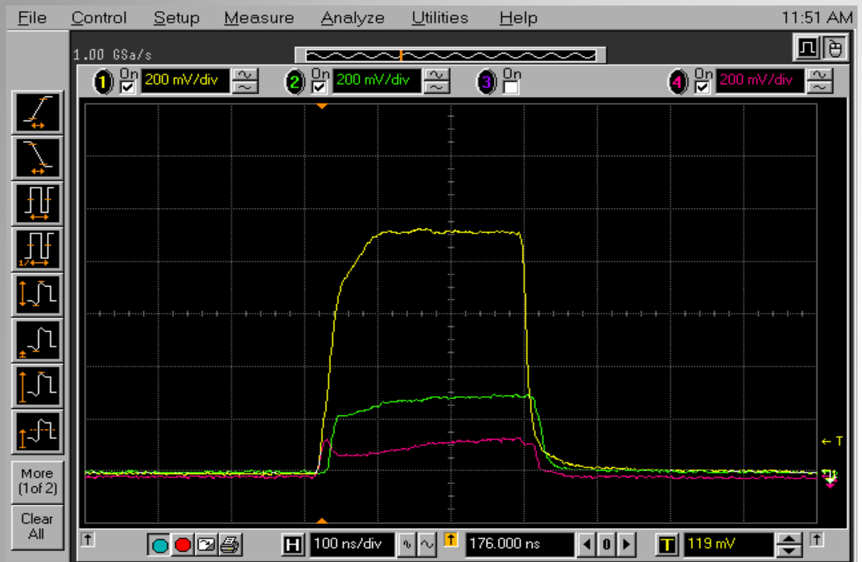
Longitudinal movement ~18Hz

Longitudinal movement, gives vertical displacement of 125nm, of opposite signs on PBPMs 1 and 3, and zero on center PBPM.

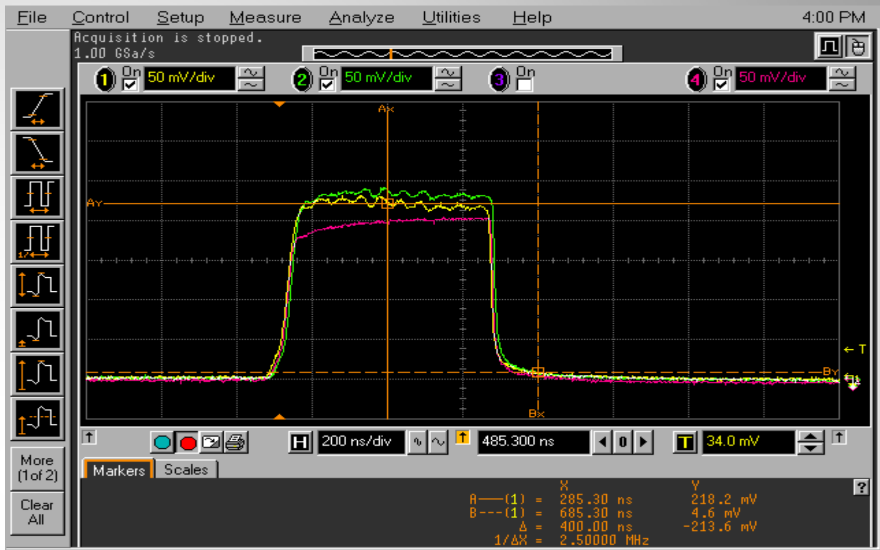


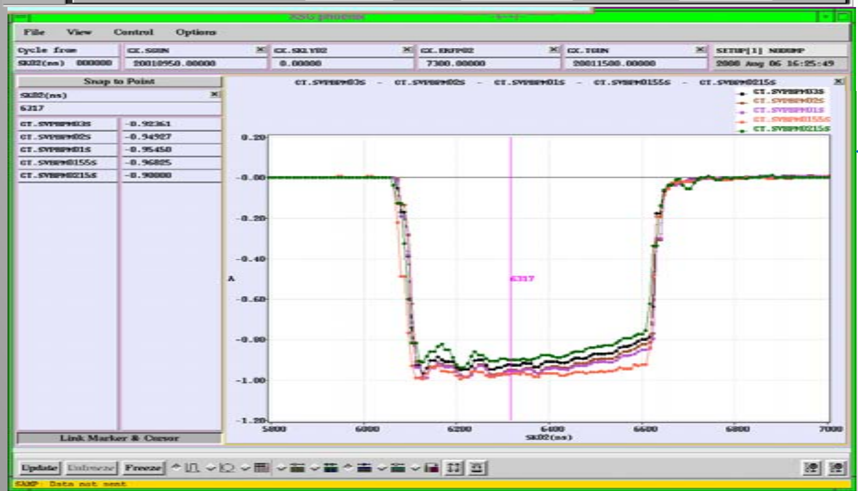
Beam tests

1A beam current, May 2008



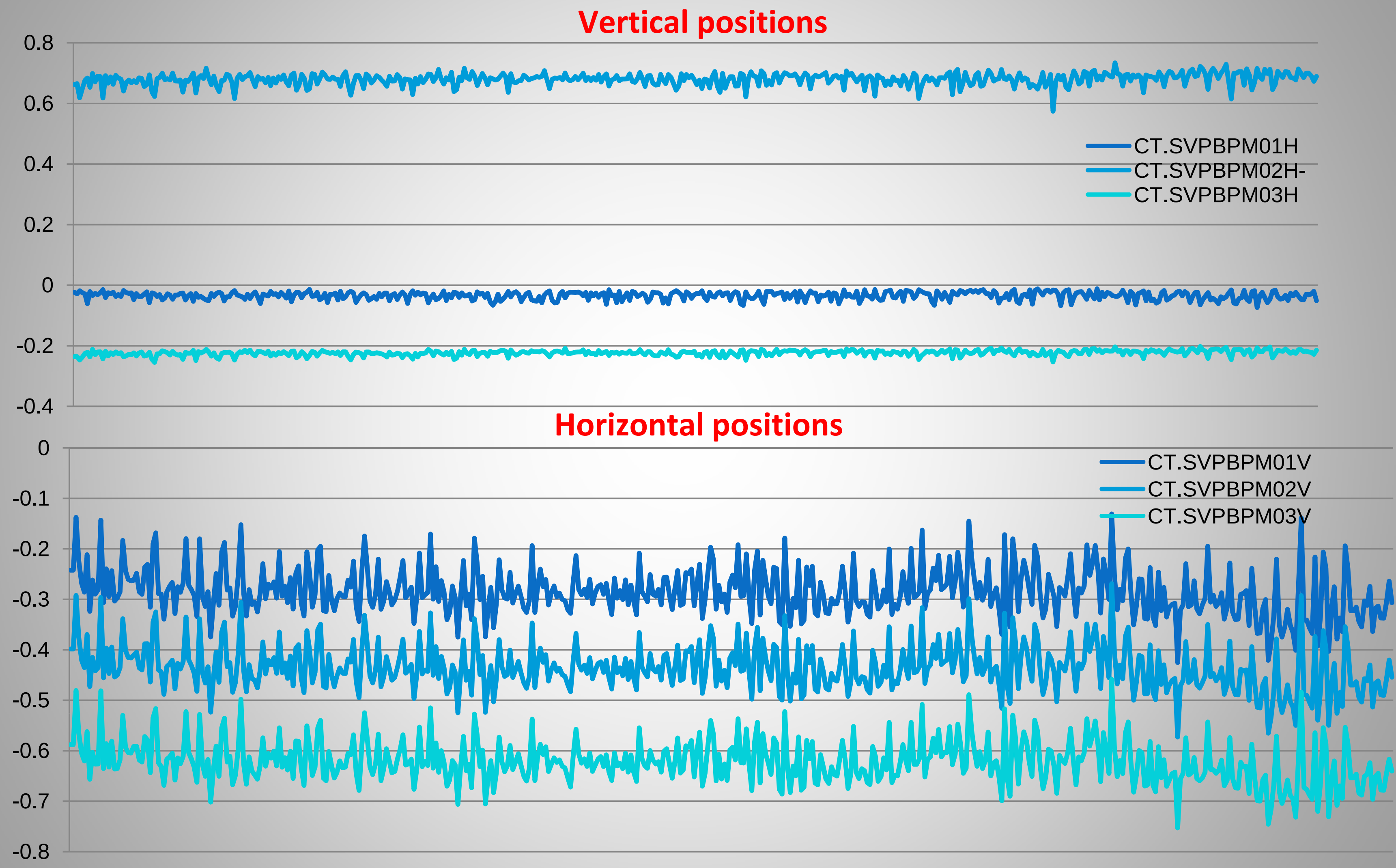
0.2A beam current, May 2008



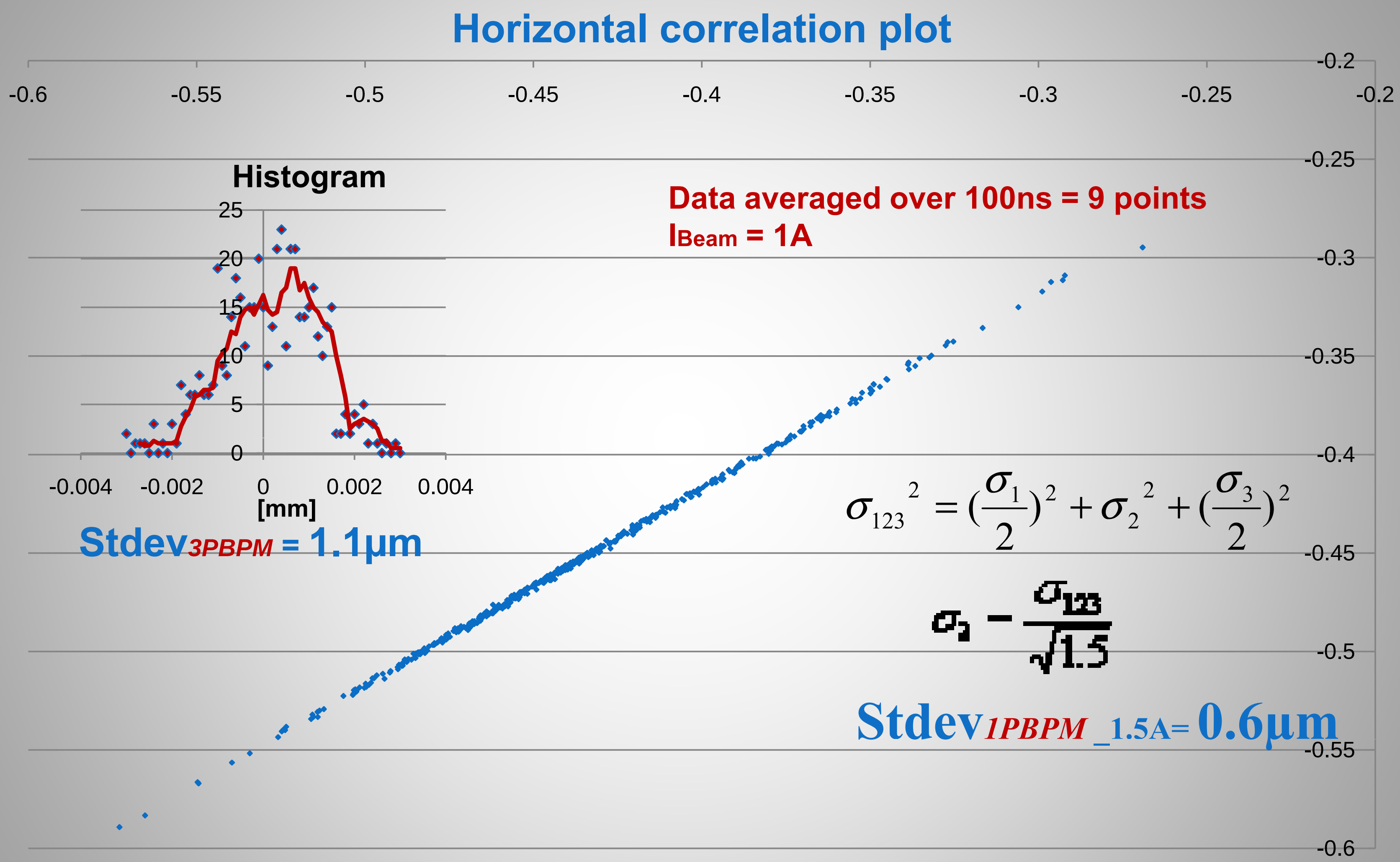


←1A beam current, August 2008, 95% transmission.

Beam tests, August 2008



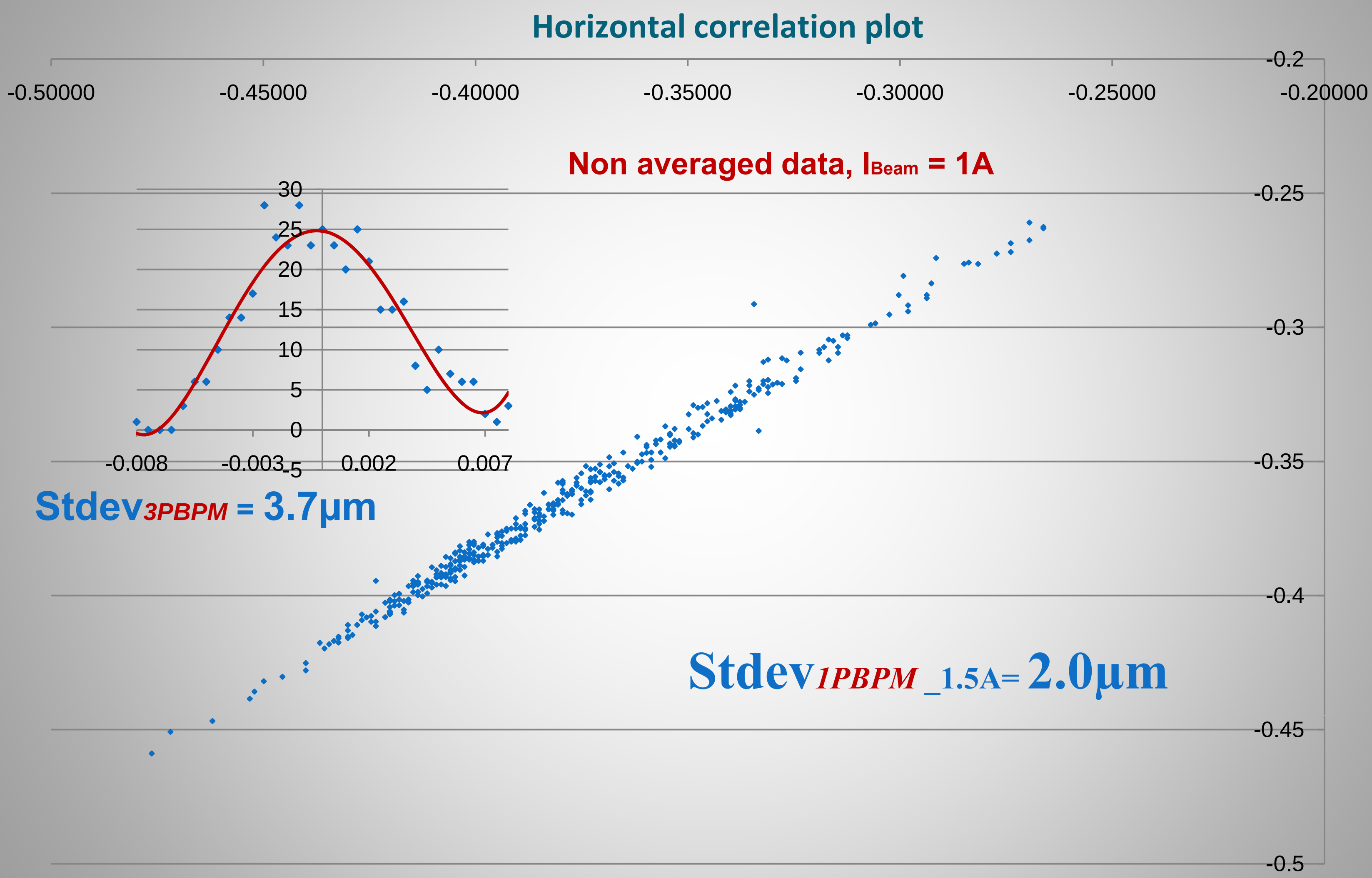
Beam tests, August 2008



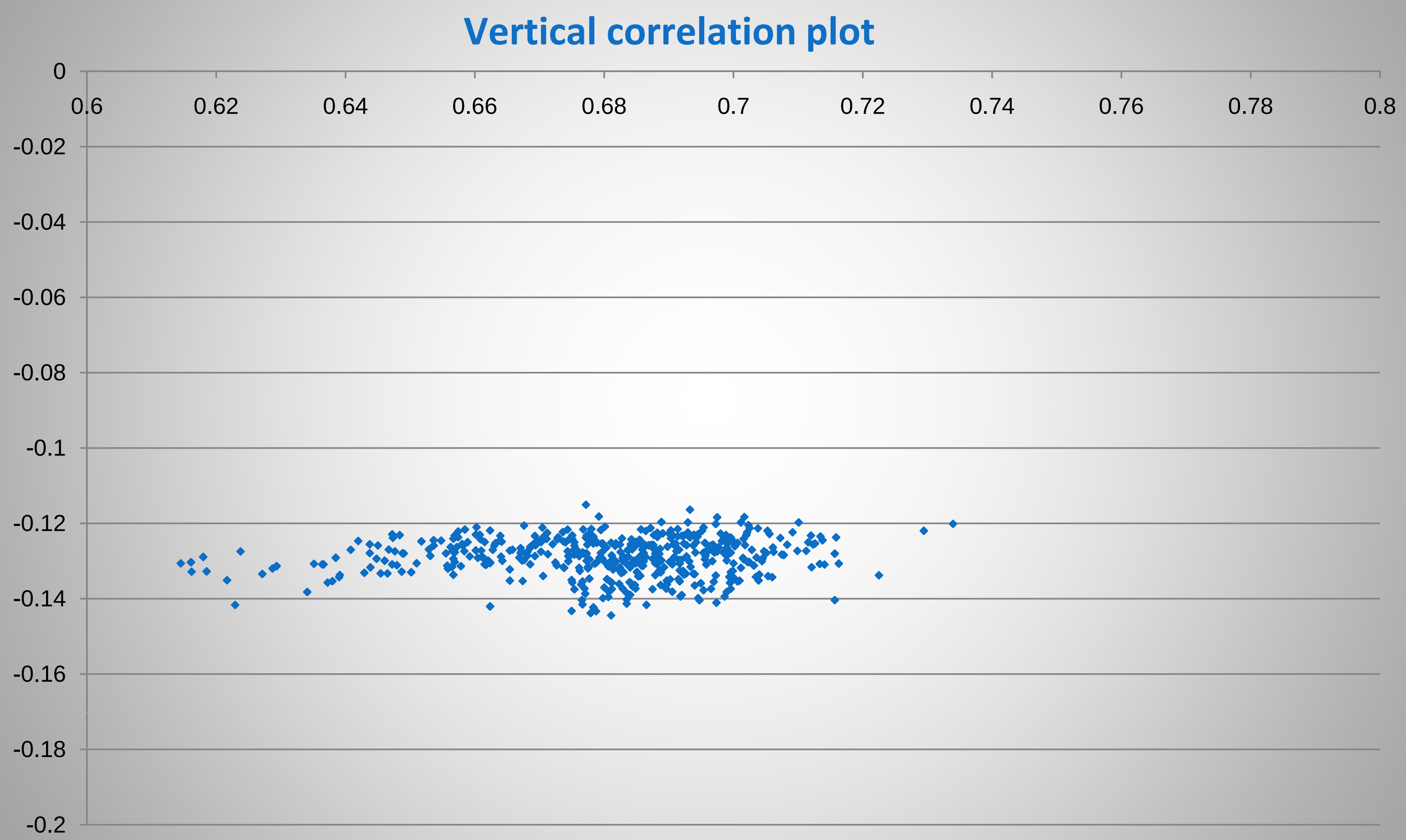
$$\sigma_{123}^{2} = \left(\frac{\sigma_1}{2}\right)^2 + \sigma_2^{2} + \left(\frac{\sigma_3}{2}\right)^2$$

$$\sigma_1 = \frac{\sigma_{123}}{\sqrt{1.5}}$$

Beam tests, August 2008



Beam tests, August 2008

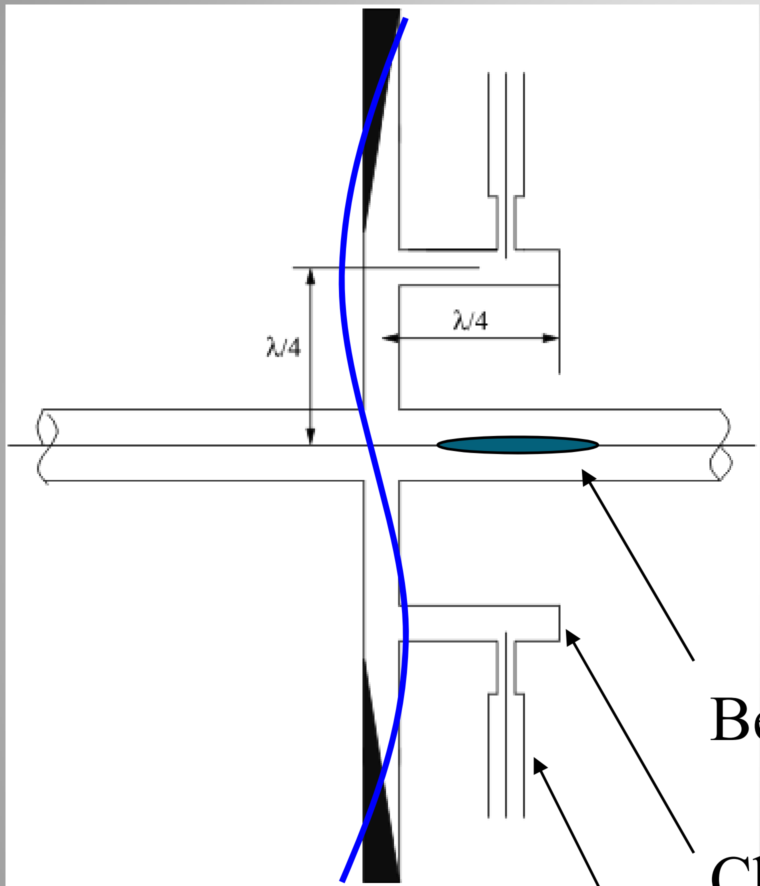


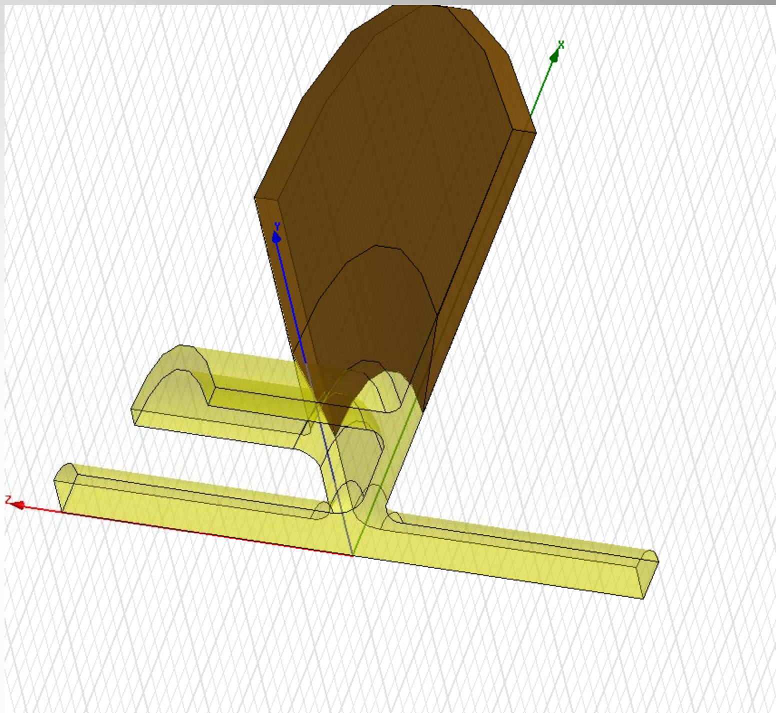
Precision BPM for CLIC

Raquel Fandos & Igor Syratchev

EUROTeV-Report-2008-033

Choke BPM by Shintake, 1995





Beam

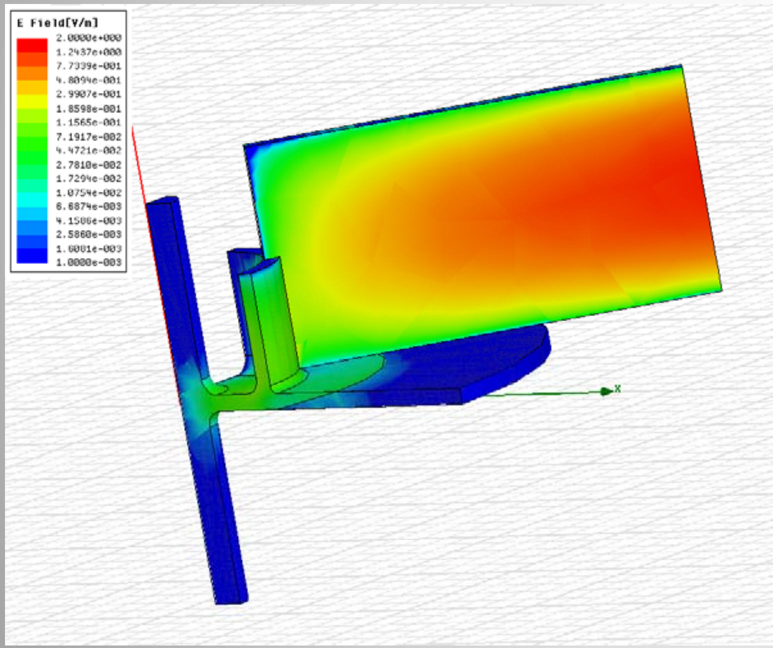
Choke where the TM11 mode is trapped

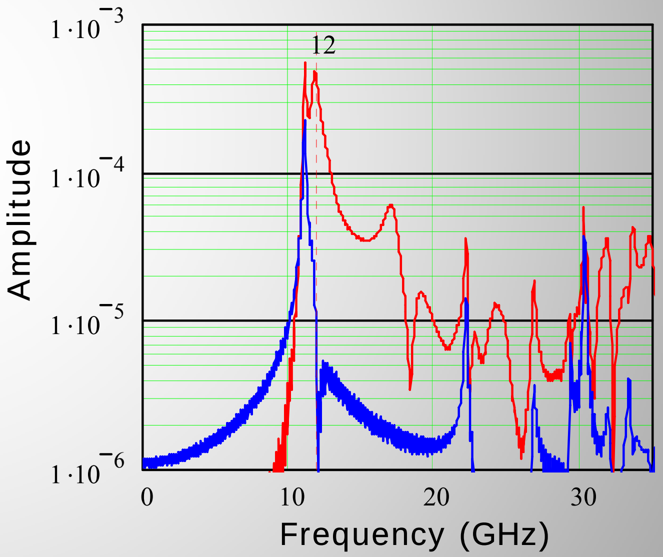
Damping material

Coaxial antenna pickup

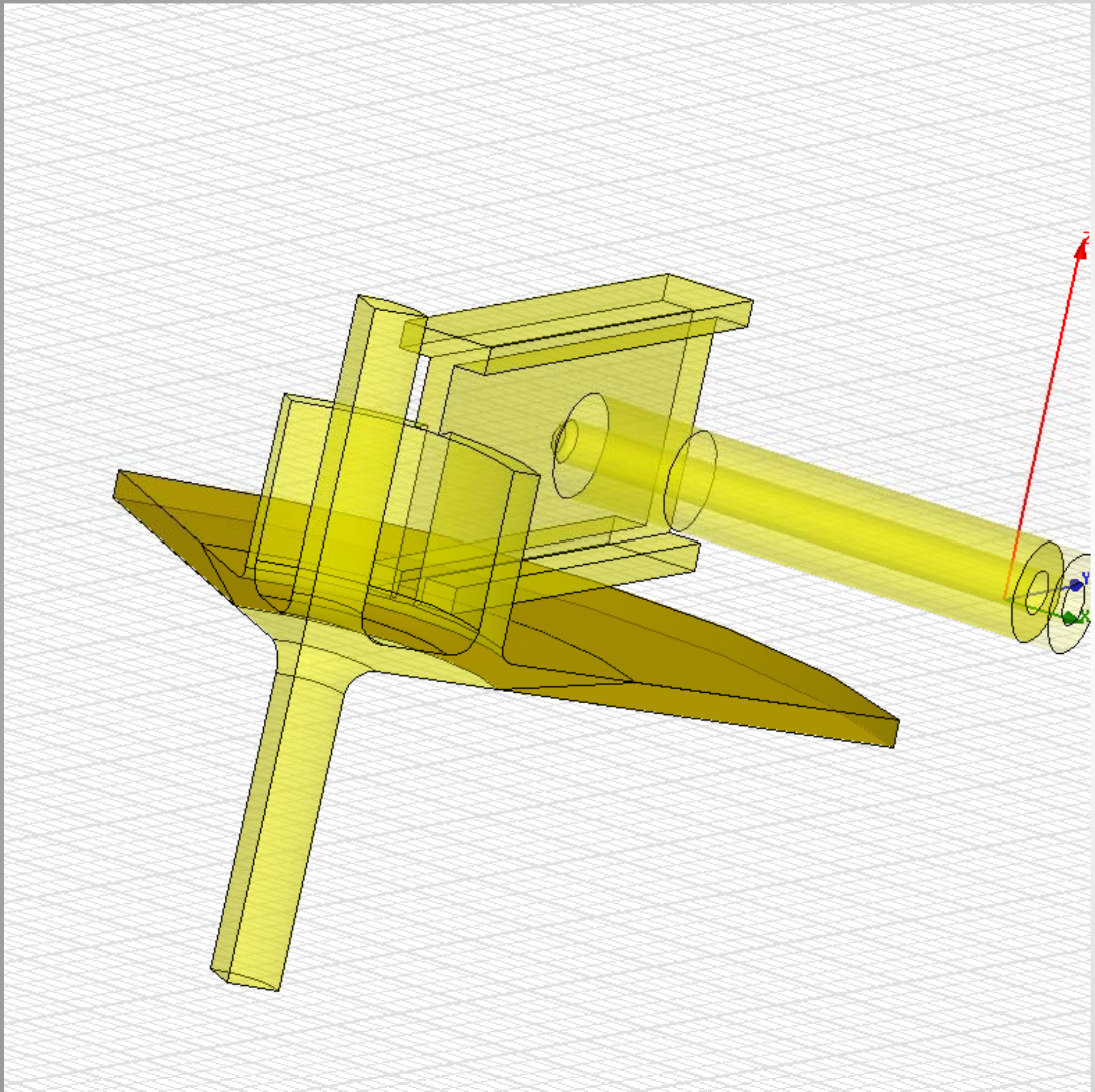
Choke BPM

Ridge WG avoids resonance at WG cutoff (10.7GHz) that appears for rectangular slot.





Improving the Choke BPM: Damping Sectors



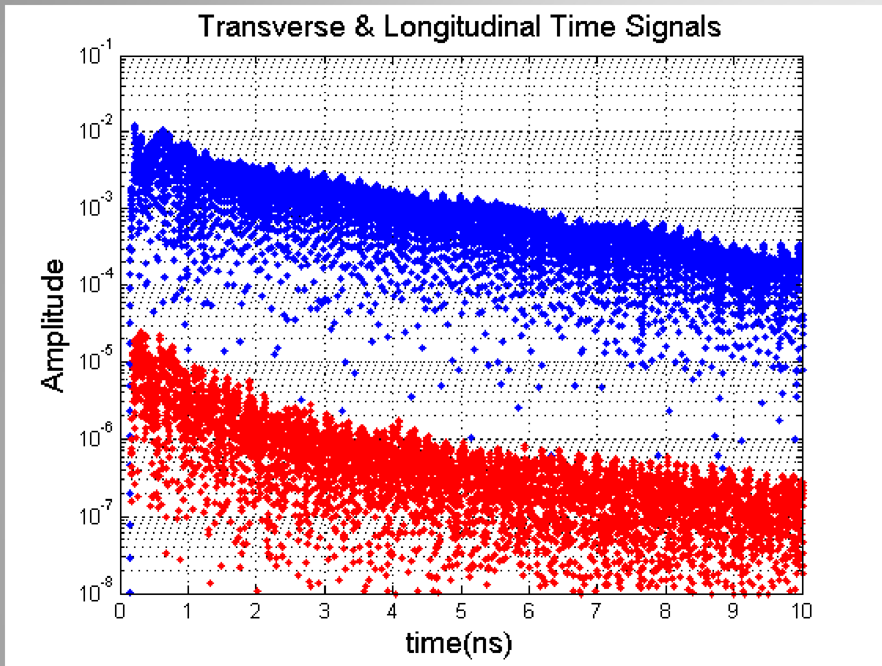
Still a few HOM's couple to the choke

Damping sectors

- respect the TM11
- absorb HOM's not damped in the cavity

Choke BPM

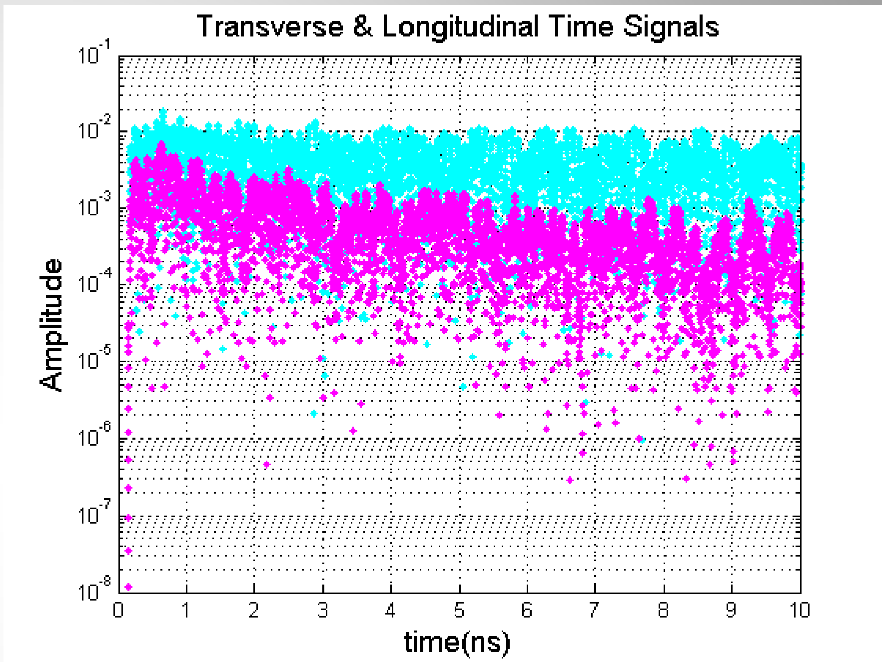
Choke cavity BPM



- Transverse modes (TM11 + HOMs), 1mm offset
- Longitudinal modes (TM01 + HOMs)

1micron single bunch resolution

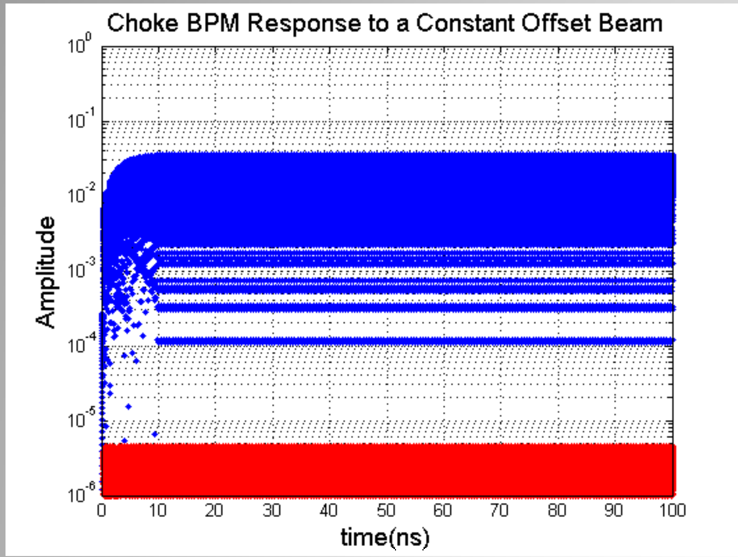
Circular cavity BPM

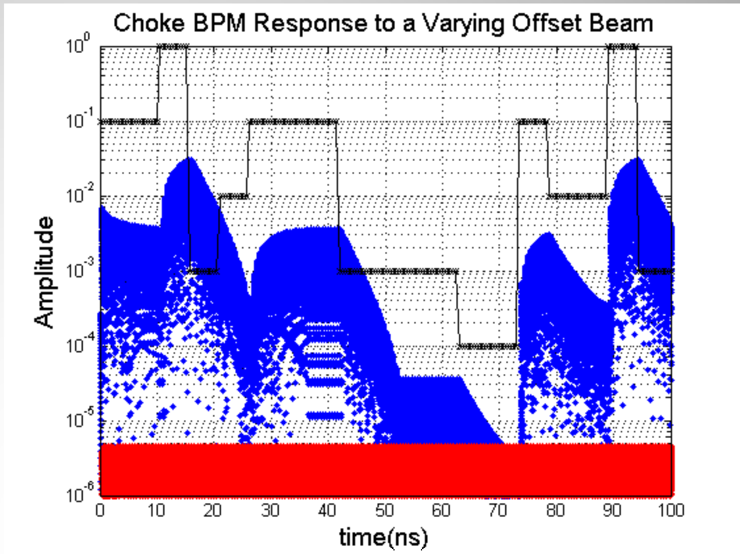


- Transverse modes (TM11 + HOMs), 1mm offset
- Longitudinal modes (TM01 + HOMs)

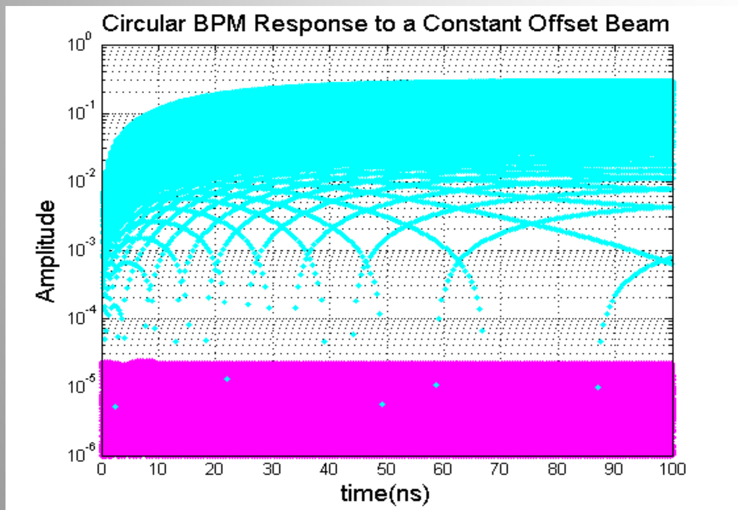
500micron single bunch resolution

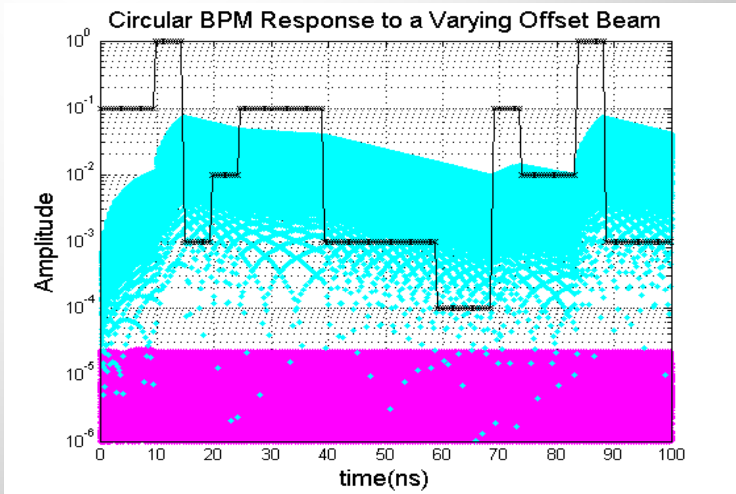
Multibunch Resolution





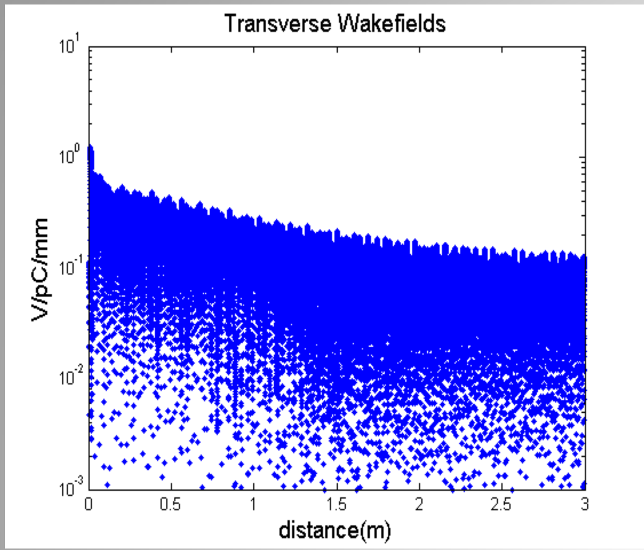
Q=100
Res.=200nm

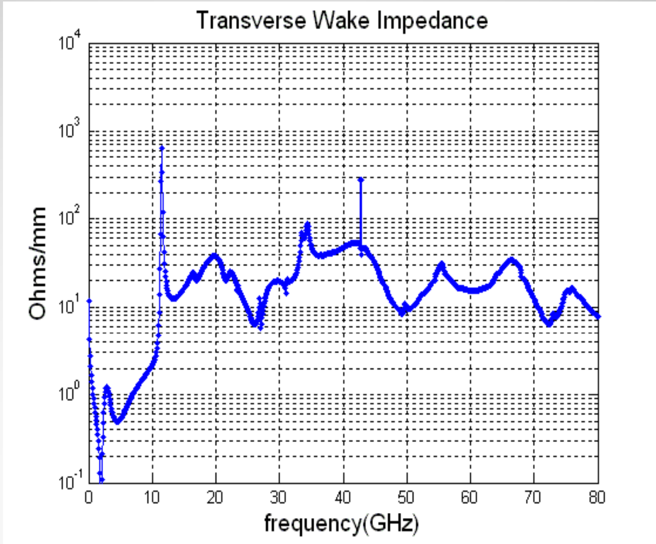


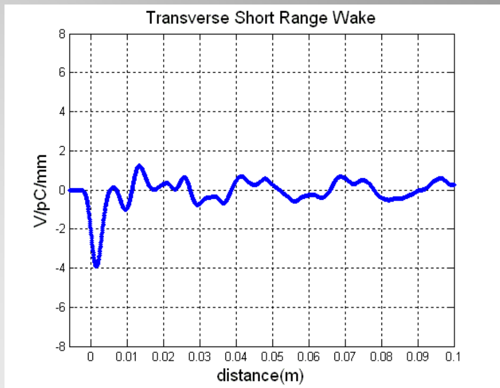


Q=1000
Res.=200nm

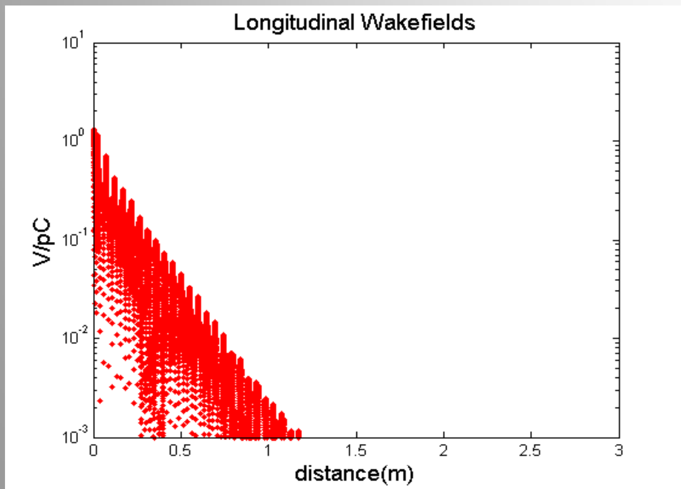
Wakefields

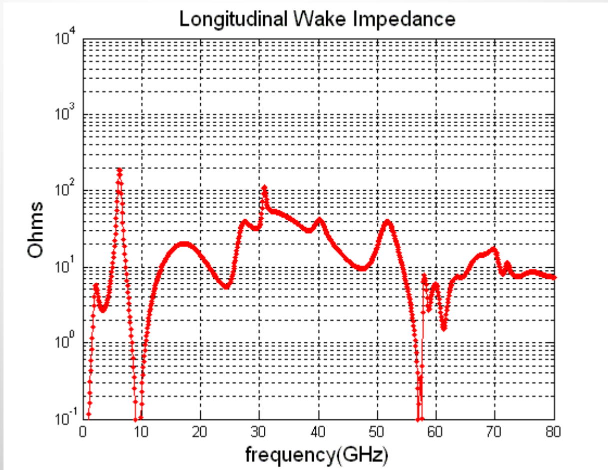


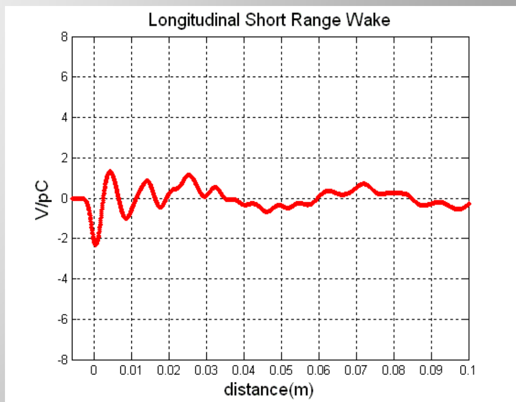




W_T<<13V/pC/mm

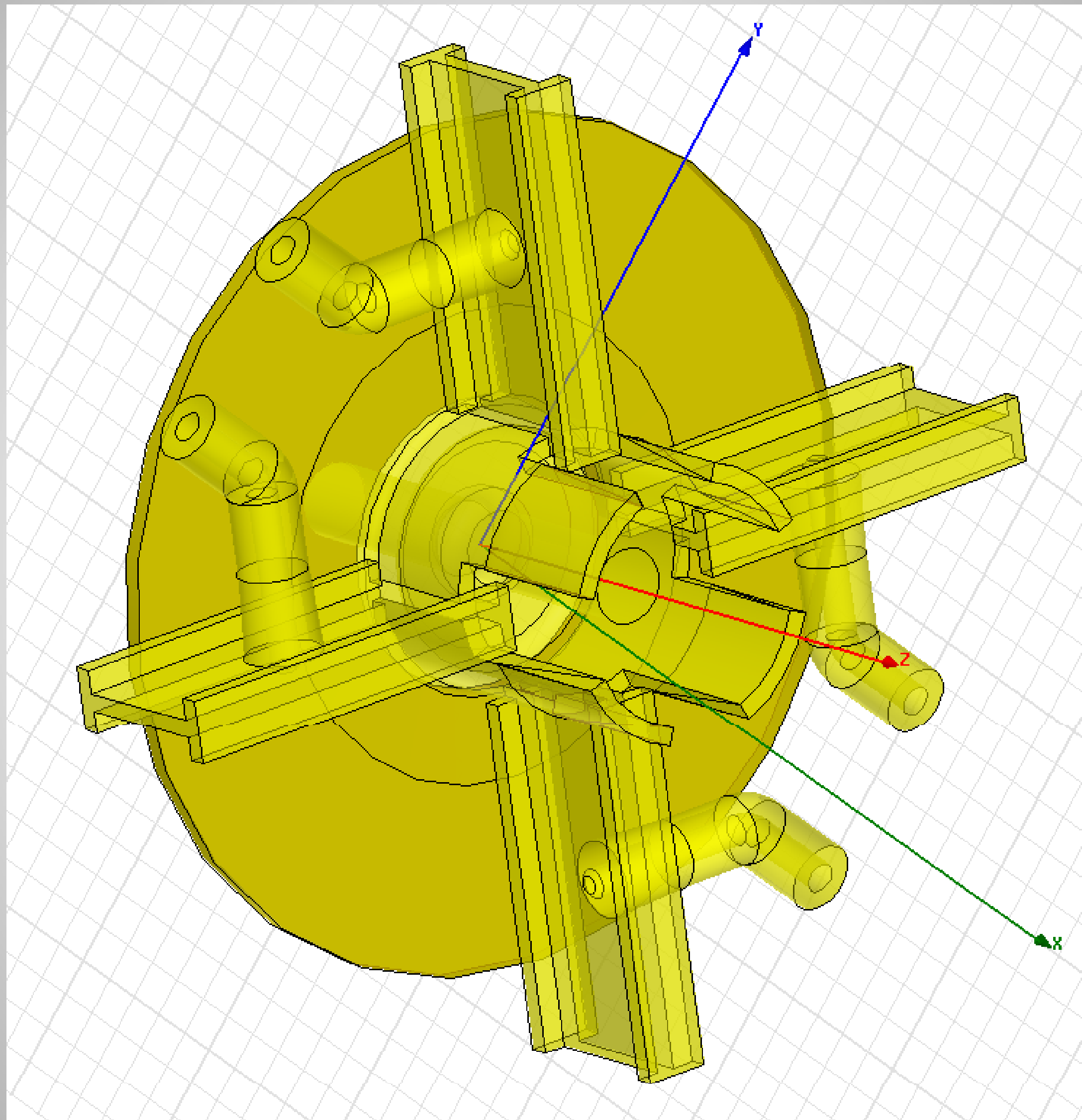






W_L<< <46V/pC

Choke BPM



Conclusion and outlook

- The design of the PBPM has been reported in : EUROTeV-Report-2007-008
- Bench measurements are just finished and will be reported on in an EUROTeV Report in November 2008. Preliminary results were reported in: EUROTEV-Report-2007-046, DIPAC TUPB03
- The bench measured resolution for CLIC (1.5A) of 160nm / 220nm is close to the calculated one of 130nm.
- Big electrical offset has been measured, as well as a big centre residuals (CW only). This hampers the centre sensitivity and precision. This will be studied in the coming months.
- Beam tests in CTF3 has showed promising results, but beam losses in the vertical plane still has to be understood and corrected. A resolution down to 600nm has been measured. Further beam tests are foreseen before the end of the year. An EUROTeV Report will be published in November
- A cavity choke BPM designed and simulated and shows promising results. EUROTeV-Report-2008-033.