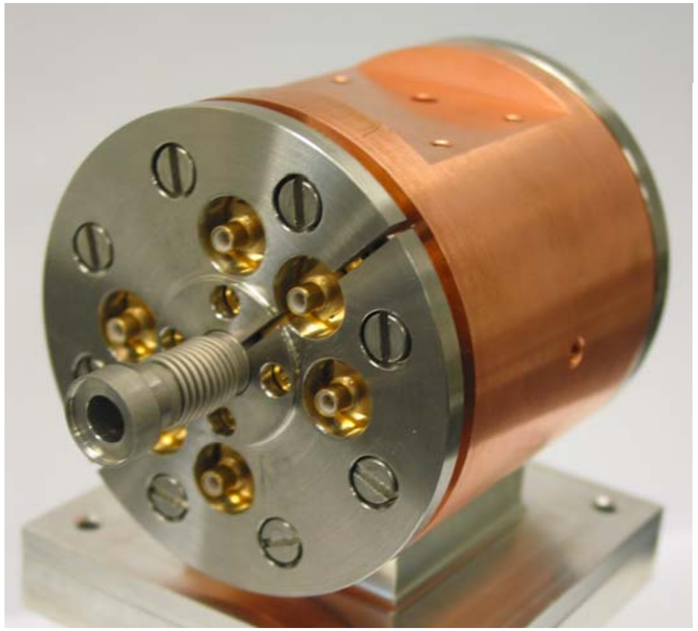
EUROTeV

Precision Beam Position Monitor



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

Outlook

- Deliverables
- Design
- Bench tests
- Beam tests (November 2007)
- Conclusion

PBPM- deliverables

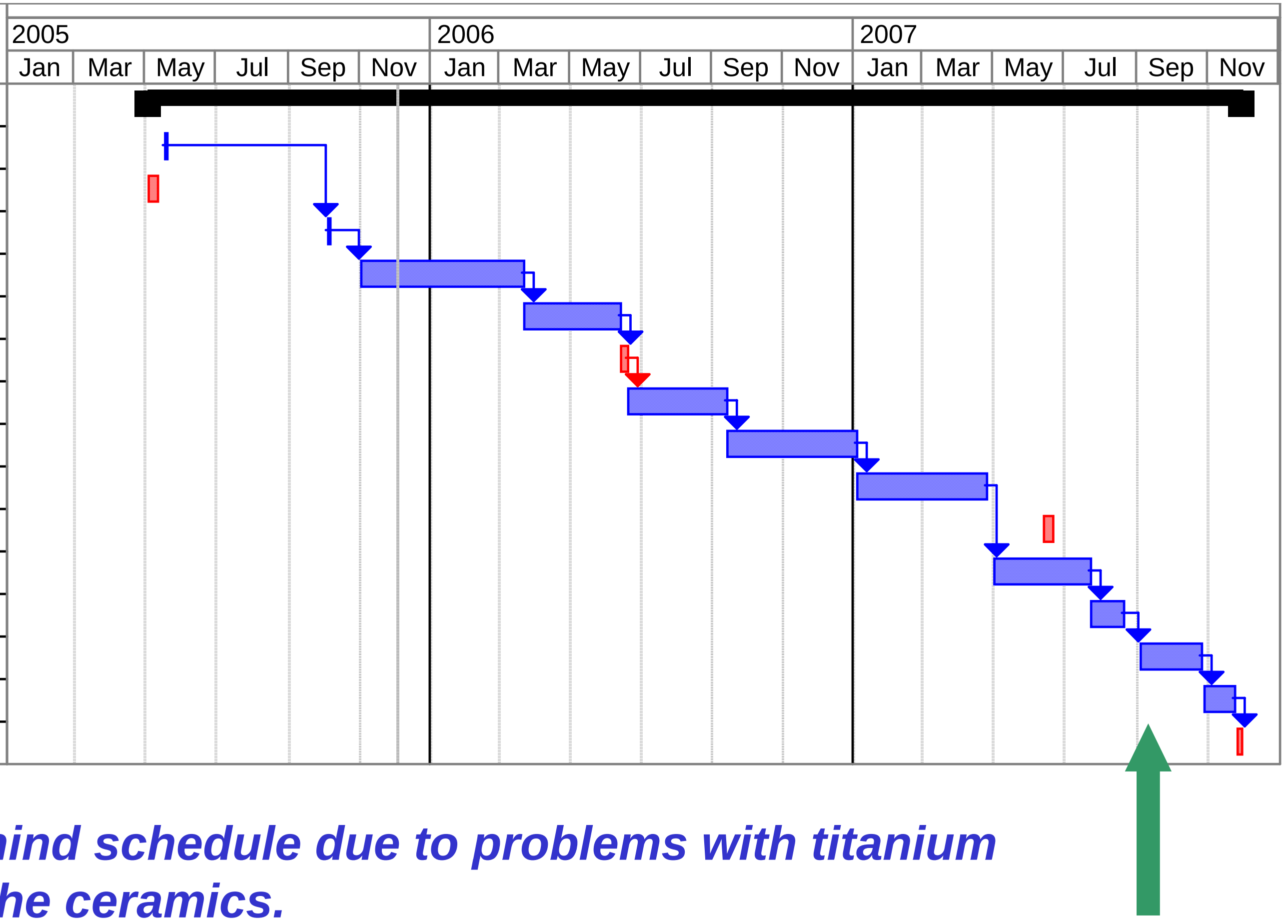
- **Prototype PBPM:**
  - Design and build prototype.

- **Report on bench tests:**
  - Design and build high resolution (100nm). mechanical stable test bench.
  - Measure PBPM.

- **Report on beam tests:**
  - **Build 3 PBPMs and test with CTF3 beam**.

PBPM planning

ID	Task Name
1	**PBPM**
2	Publish fellow post
3	Present work plan for EUROTeV
4	Hire fellow
5	Design PBPM
6	Simulate PBPM
7	Present design for EUROTeV
8	Fabrication drawings
9	Fabrication of 1BPM
10	Tests on bench
11	Present Results for EUROTeV
12	Manufacture 3 PBPMs
13	Tests on bench
14	Tests in CTF3
15	Write report
16	Send report to EUROTeV



Slightly behind schedule due to problems with titanium coating of the ceramics.

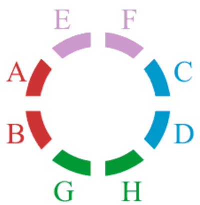
Beam tests will be in November

Specifications

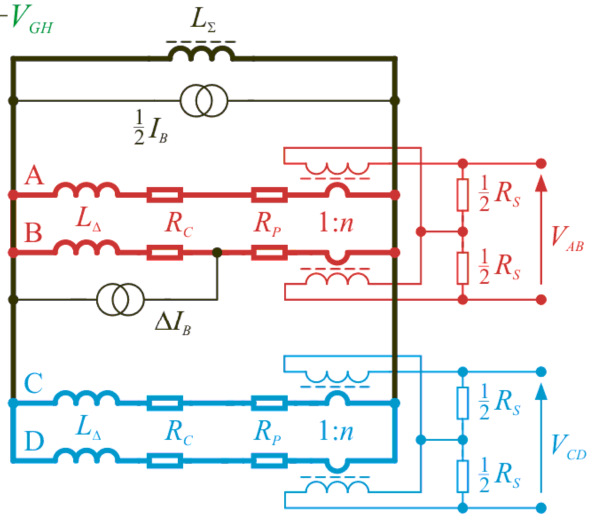
EUROTeV	Aperture	4mm (6mm)
	Resolution	100nm
	Absolute precision	10µm
	Rise time	<15ns
Extended specifications	Dynamic range	±1.5mm (15 bits)
	Linearity error	< 1% (±1.5mm)
	24H stability	1µm
	Droop	< 5%
	Low frequency cutoff	100kHz *(3.6% droop, CLIC 58ns pulse)*
	High frequency cutoff	30MHz
	CMRR	>90dB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

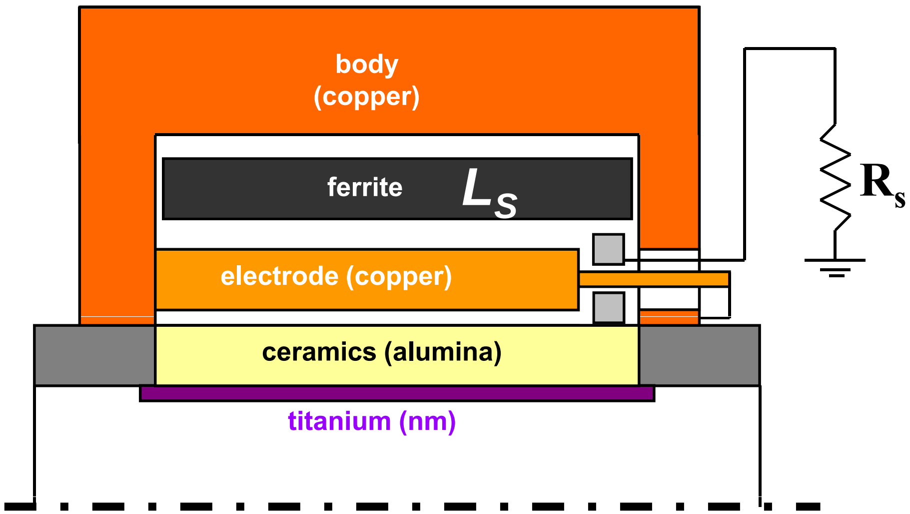
Inductive pick-up: basic scheme

$$V_\Sigma = V_{AB} + V_{CD} + V_{EF} + V_{GH}$$
$$V_{\Delta H} = V_{AB} - V_{CD}$$
$$V_{\Delta V} = V_{EF} - V_{GH}$$



M. Gasior (IPU)





Coupling impedance

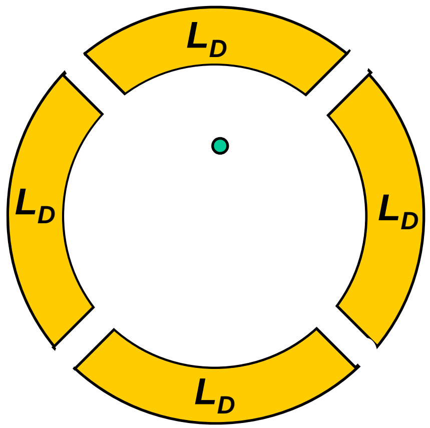
$$V_\Sigma = \frac{R_s}{n} I_B$$

Low cutoff (difference signal)

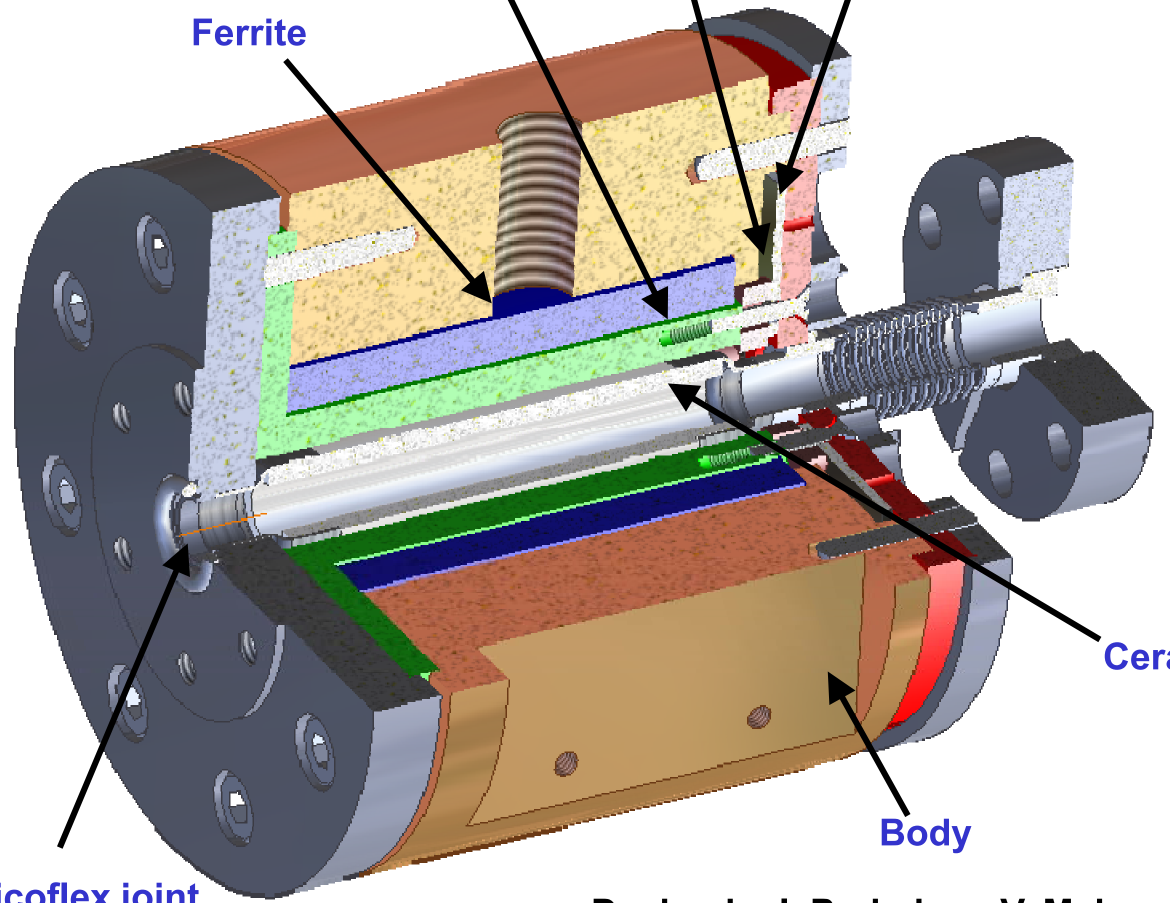
$$f_{L_\Delta} = \frac{R_s / n^2}{2\pi L_\Delta}$$

Low cutoff (sum signal)

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



Final design

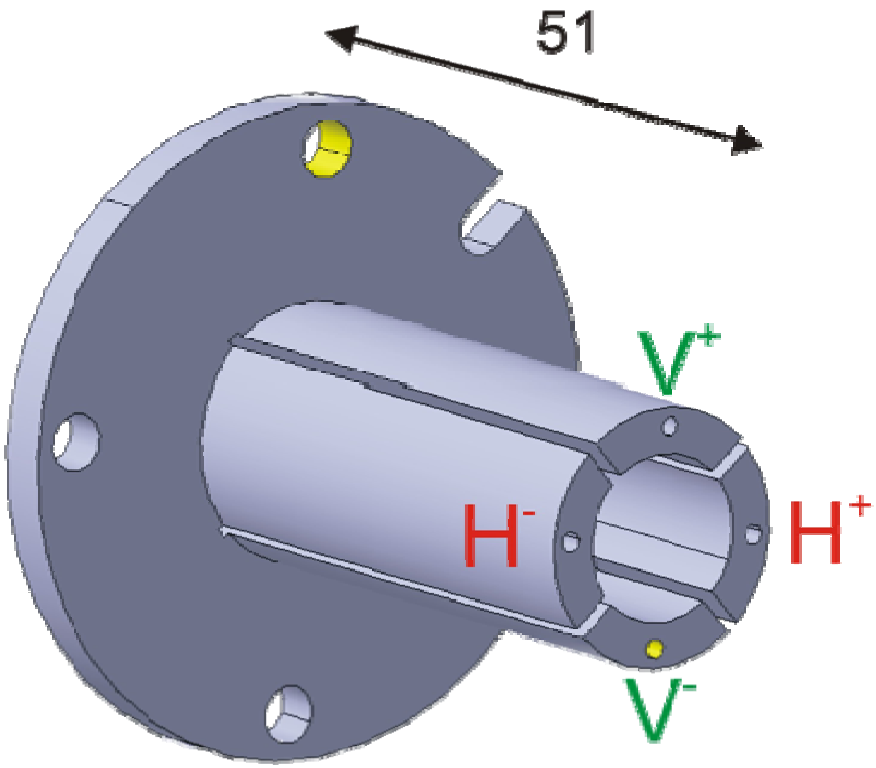


- Length: 95mm
- Overall diameter: 68mm
- Vacuum tube ID: 6mm
- Thickness ceramic: 2mm
- Electrode length: 51mm
- Electrode ID: 12mm
- Electrode OD: 19mm
- Electrode width: 60º
- Ferrite : 46, 21, 30mm

Design by I. Podadera, V. Maire and B. Favrat.

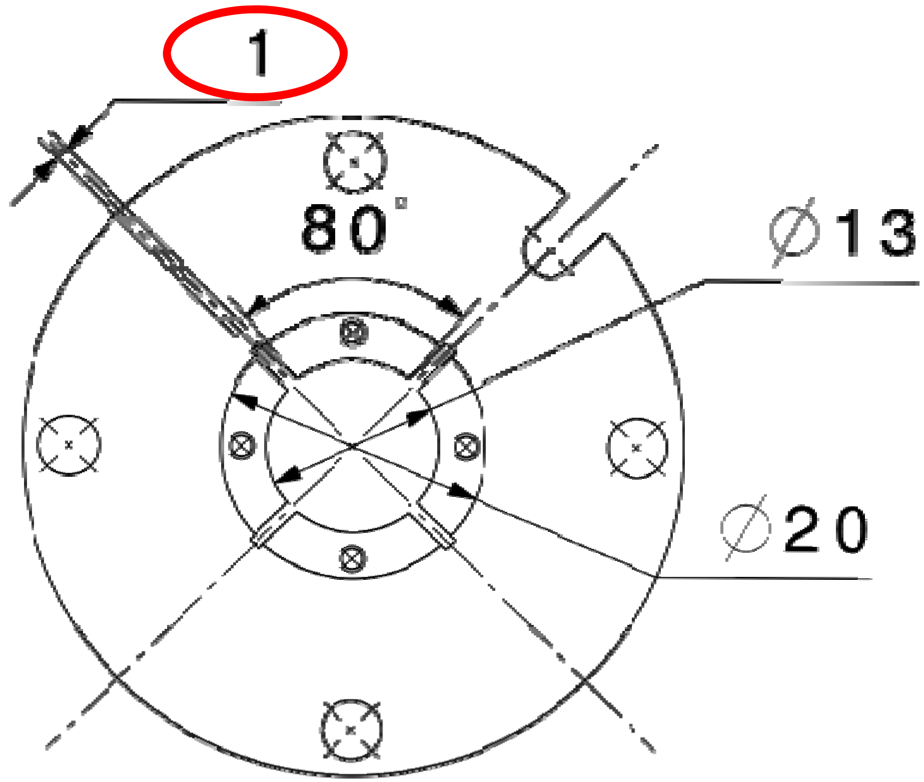
Different electrodes

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



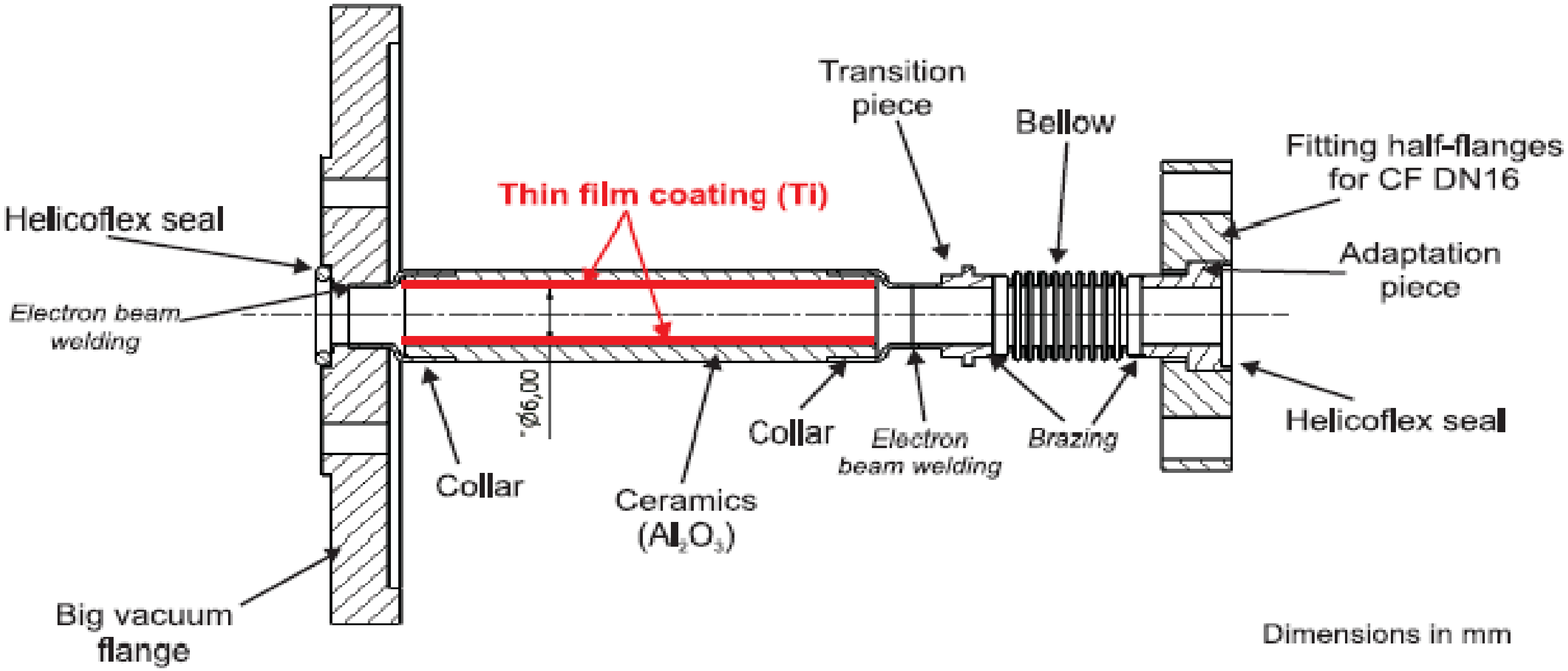
$\Delta_H = H^+ - H^-$

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



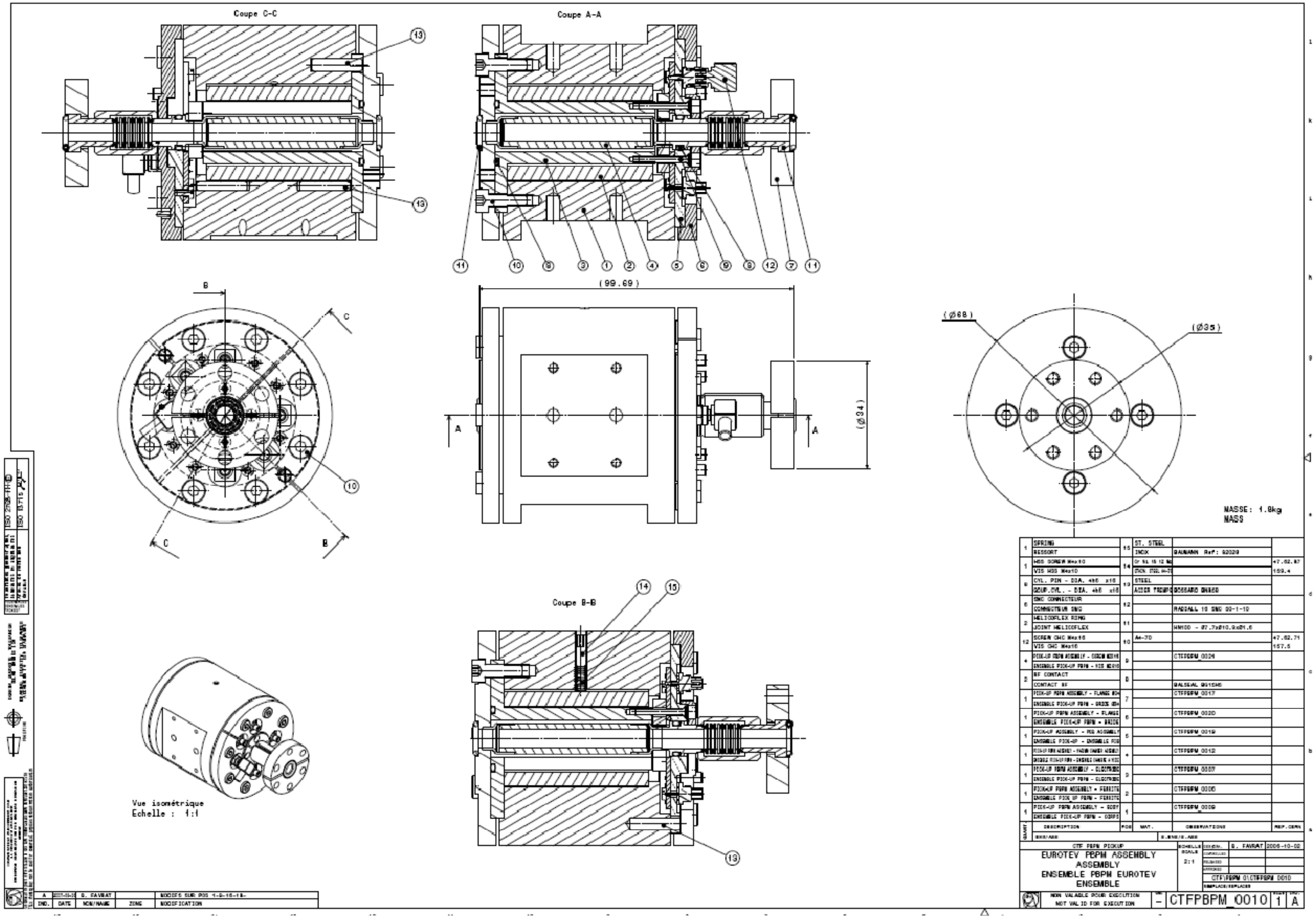
Dimensions in mm

Vacuum assembly



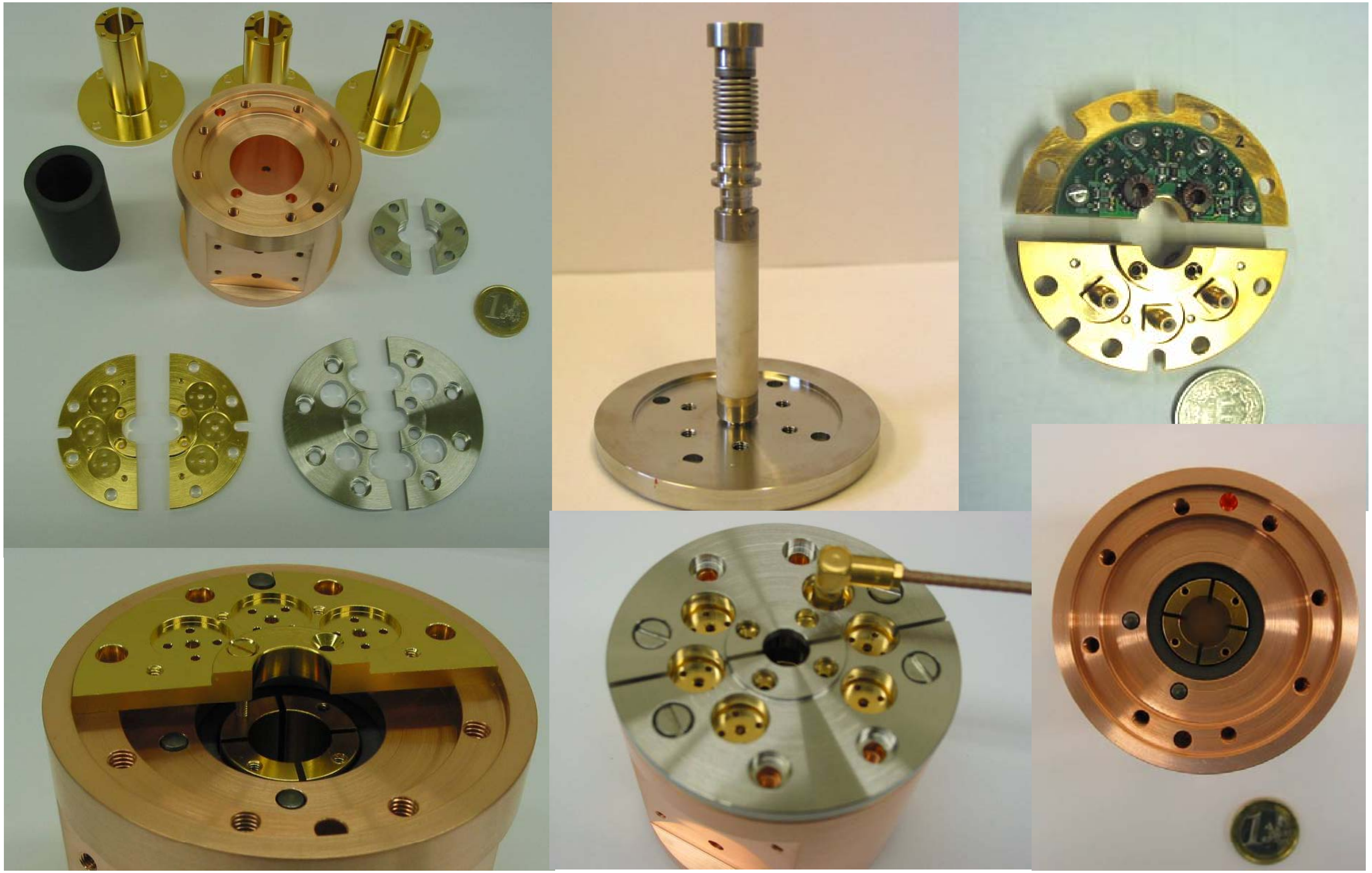
The titanium thin film coating on the inside of the ceramic, which is needed to limit the longitudinal impedance, showed out to be very complicated. Due to the very small dimension a longitudinal magnetic field (magnetron) is needed to create a homogenous plasma inside the tube (sputtering). Due to the Covar (magnetic) collars this was not possible. Ceramics with stain less steel collars have just been ordered.

Final design



EUROTeV PBPM

Preliminary assembly



PBPM bench tests

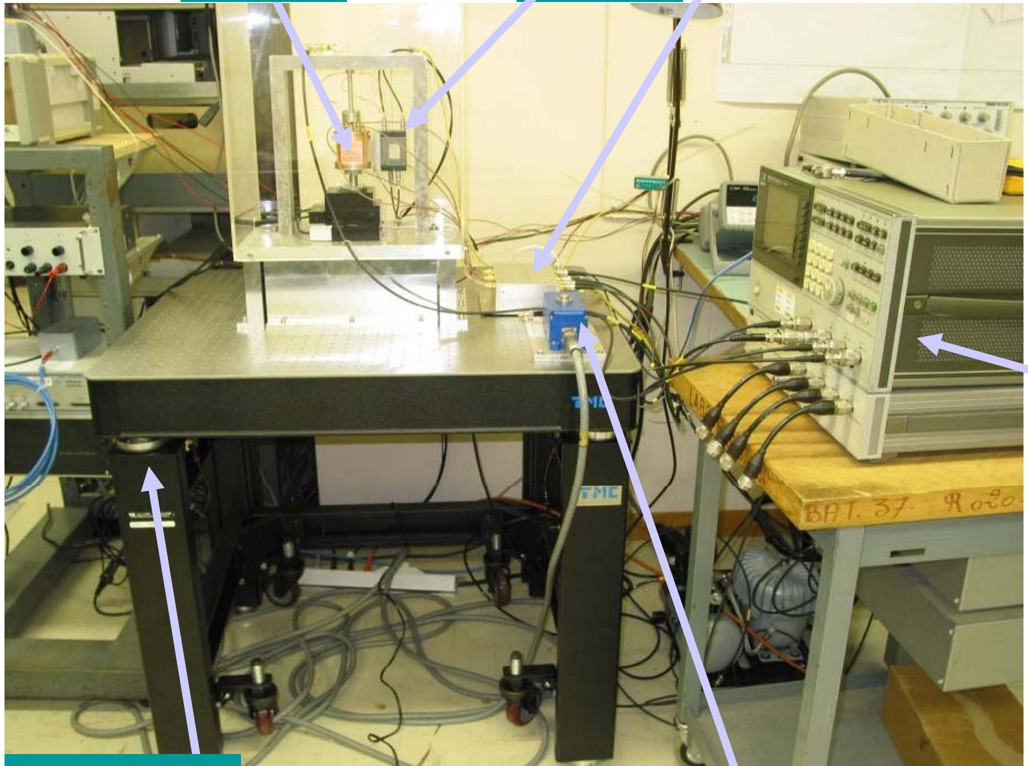
- Sensitivity
- Linearity
- Resolution
- Long-term stability
- Bandwidth
- Electrical offset
- Longitudinal impedance

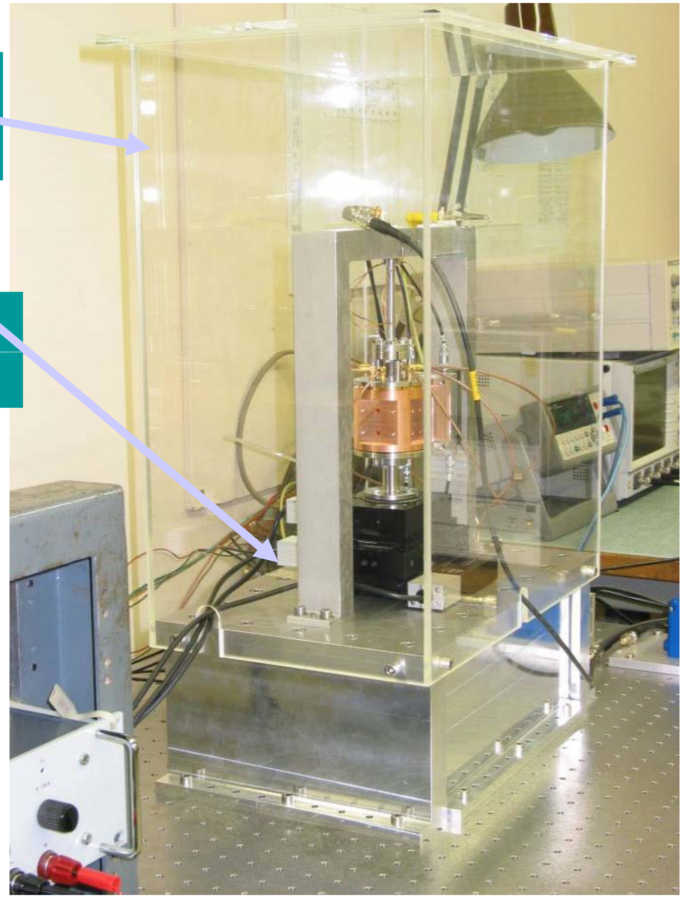
→ **Network analyzer**
CW 1-10MHz, 100mA, narrow band

- Resolution

→ **Function generator and oscilloscope**
200ns, 100mA pulse, 25MHz BW

Test bench assembly





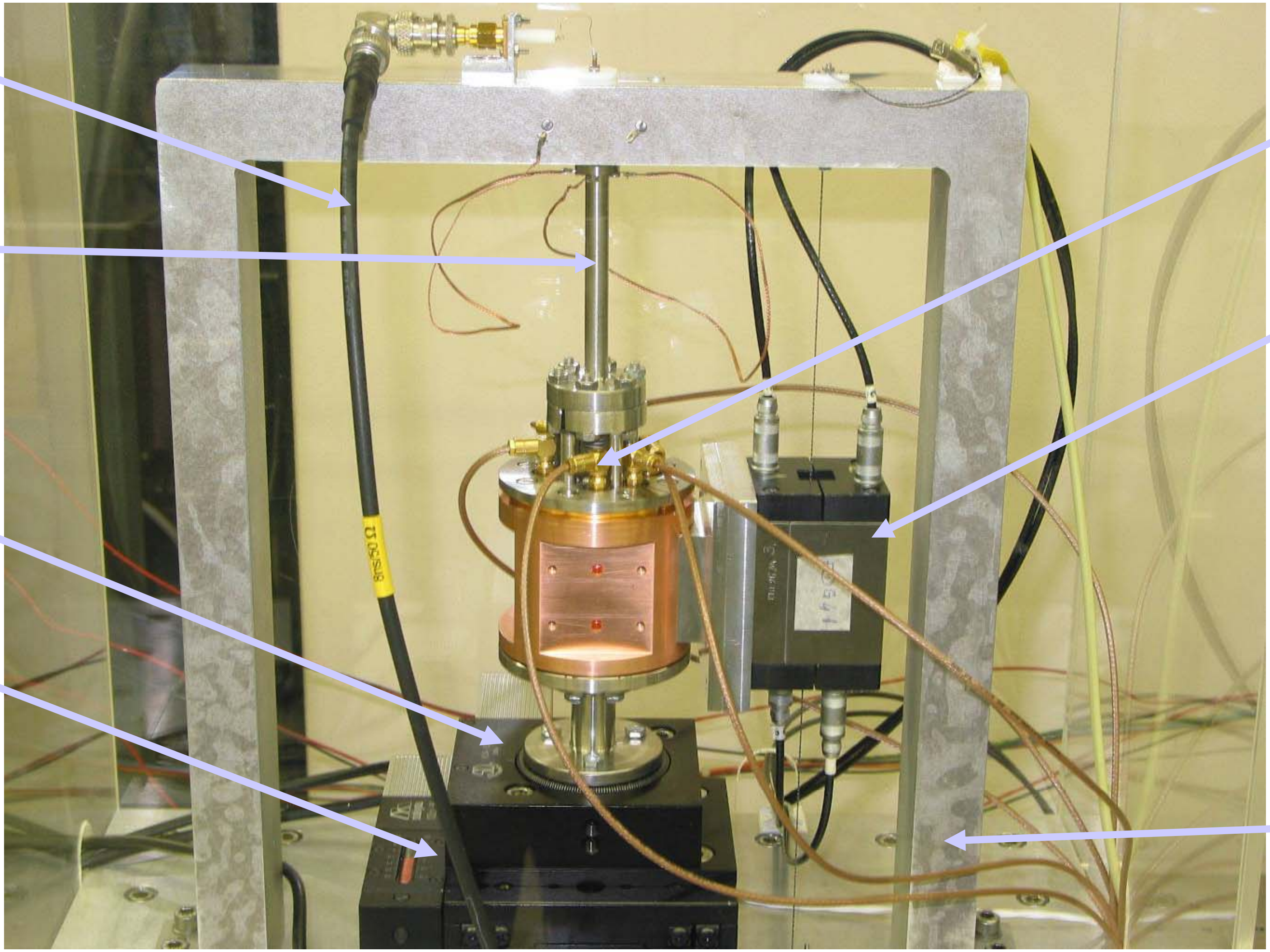
Test bench assembly

From RF-generator

Coaxial 0.2mm wire

Rotary stage

Linear stages (X, Y)



Electrode signals

WPS

support

Tesy bench specifications

Antenna:
Fixed wire of 0.2mm terminated in 50 Ω.
Fixed wire of 2,6mm (50 Ω system), for longitudinal impedance measurements.

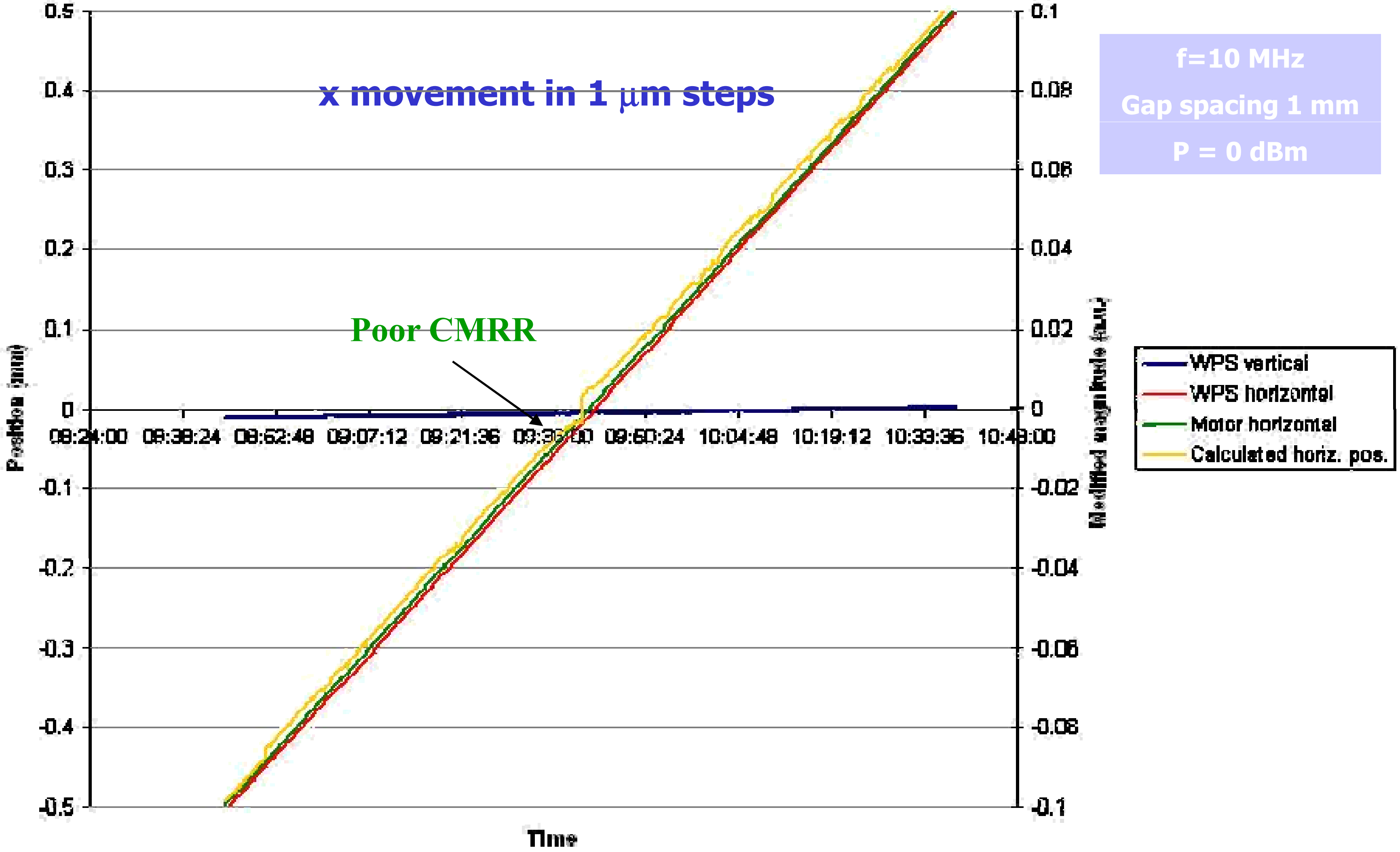
Vibrations:
TMC 63-530 damping table
Natural frequency <2Hz
Isolation efficiency @10Hz ≈95%

Environment:
“Stabilized” around room temperature (20 ºC).
Wind shield

Linear motion:
X, Y : Siskiyou 100 CRI M
Displacement: 25 mm.
Resolution: 100 nm.
Repeatability: 500 nm.
Accuracy ~2 µm.

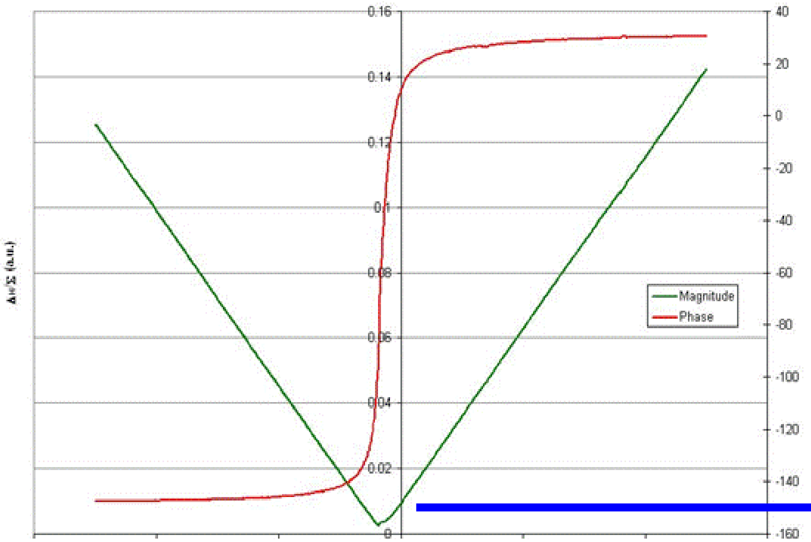
Rotary motion:
Siskiyou RSA -1.0i
Resolution: 0.03mrad
Repeatability: 0.03mrad
Accuracy: 0.1mrad.

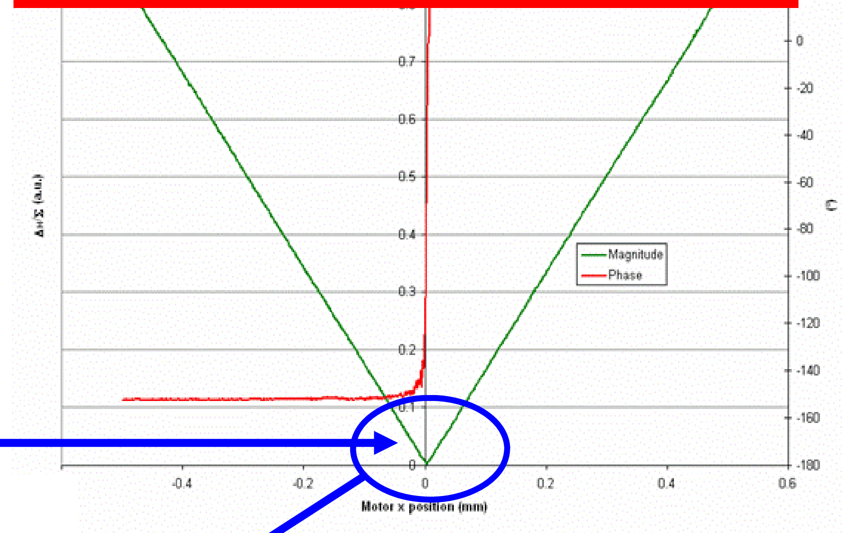
Validation movements: WPS

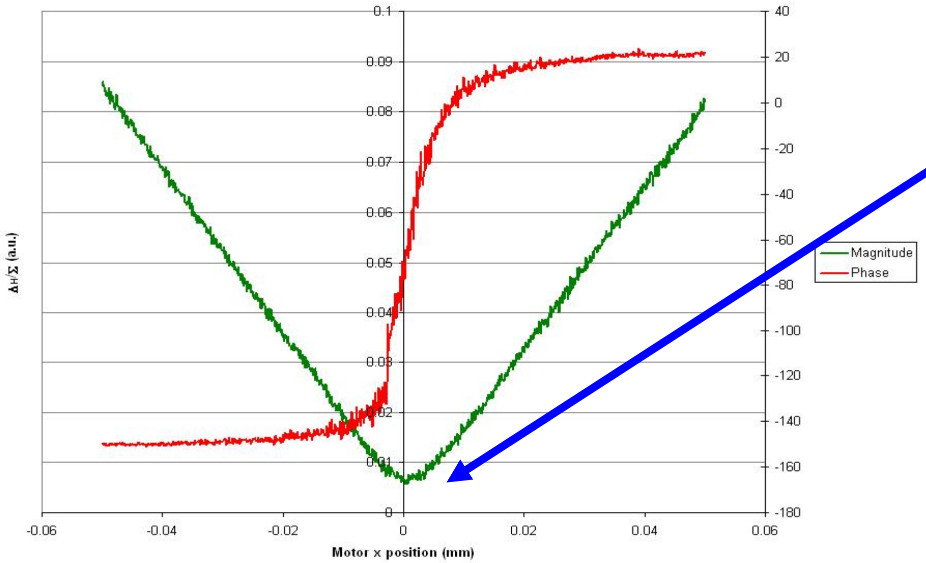


Bench test - Sensitivity

Bigger gain, higher CMRR





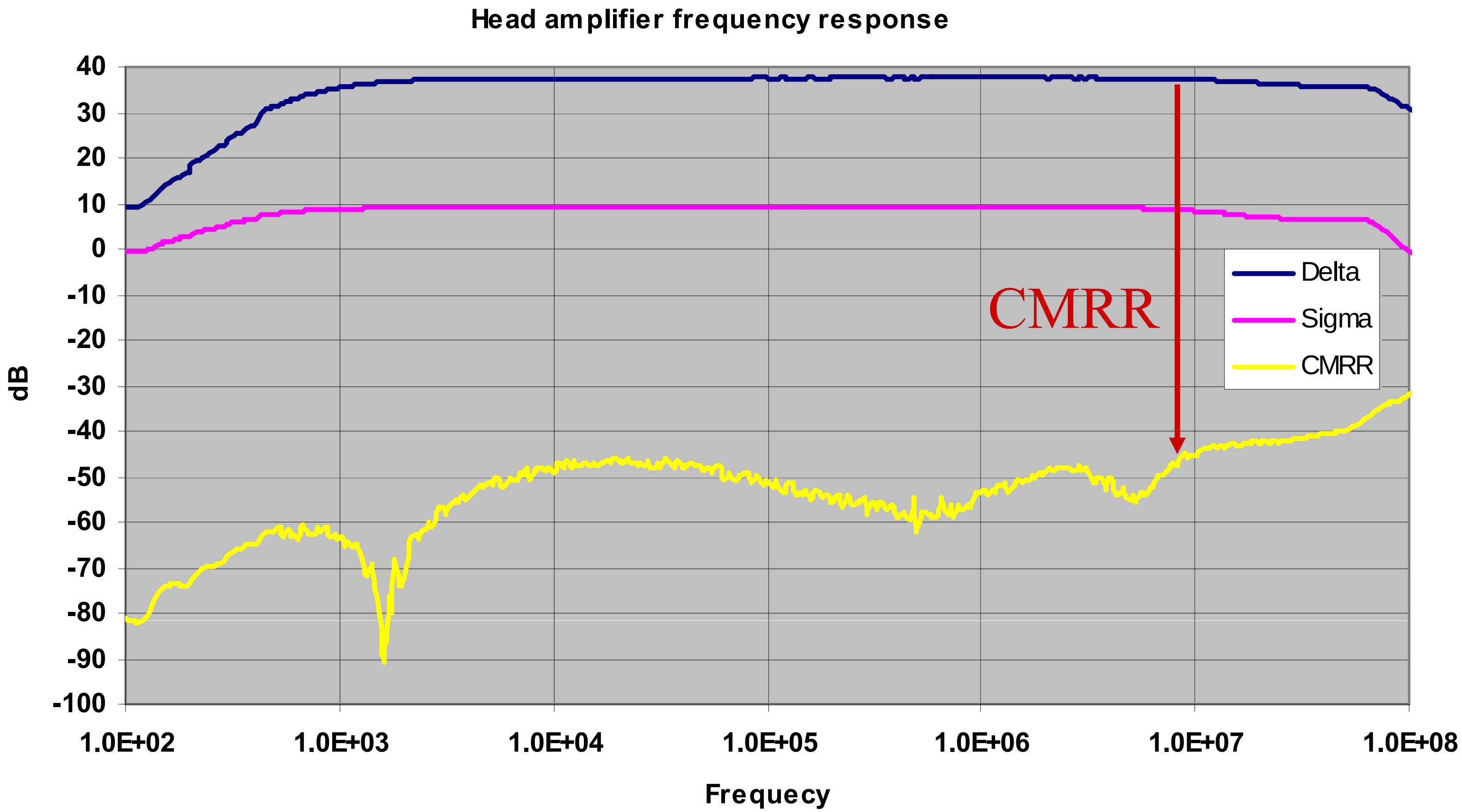


CM-signal in-phase results in electrical offset, while CM in quadrature phase reduces the sensitivity to zero in a region of d/CMMR around the centre

CM → Delta

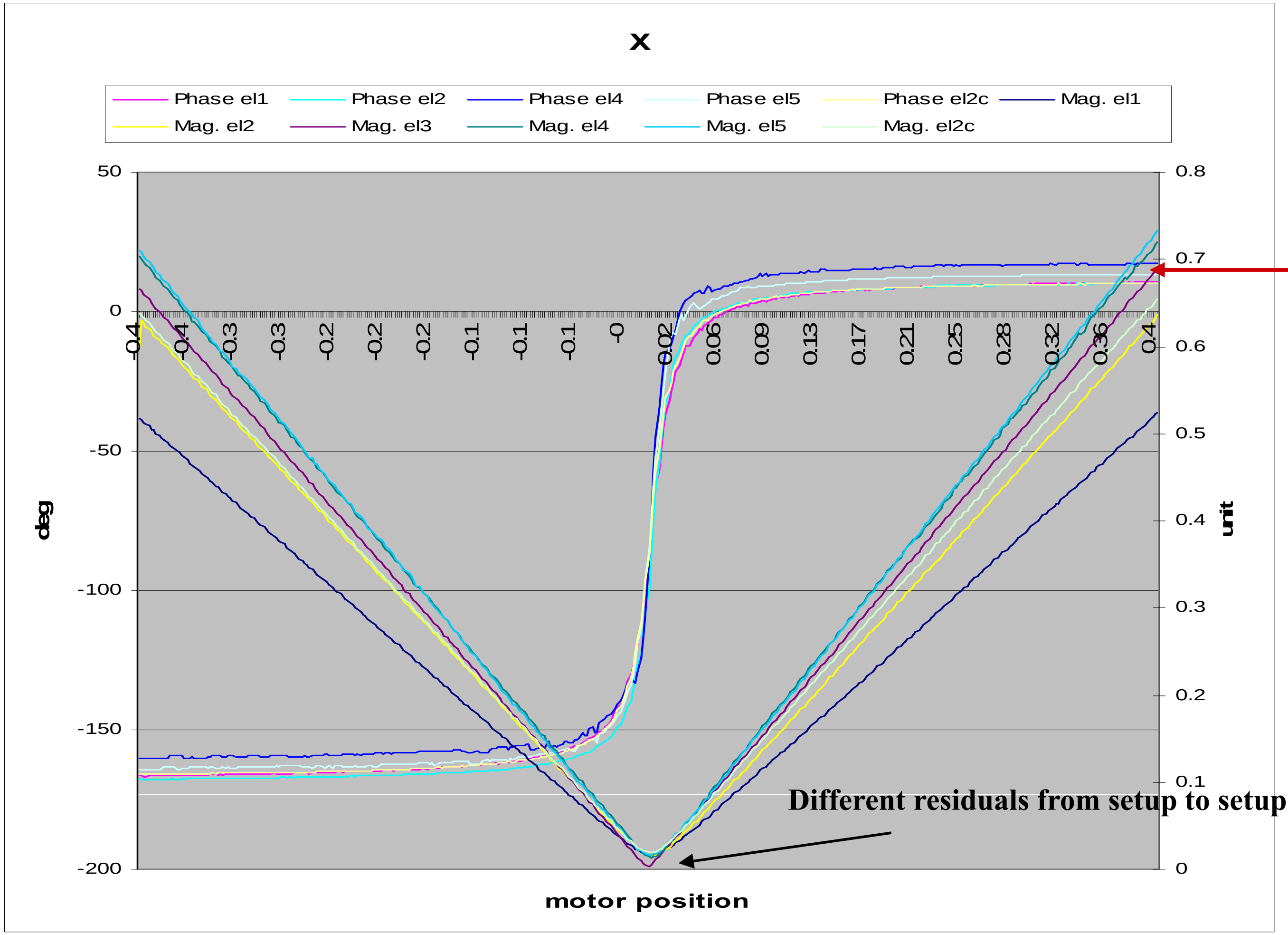
→ Delta CM

Difference amplifier



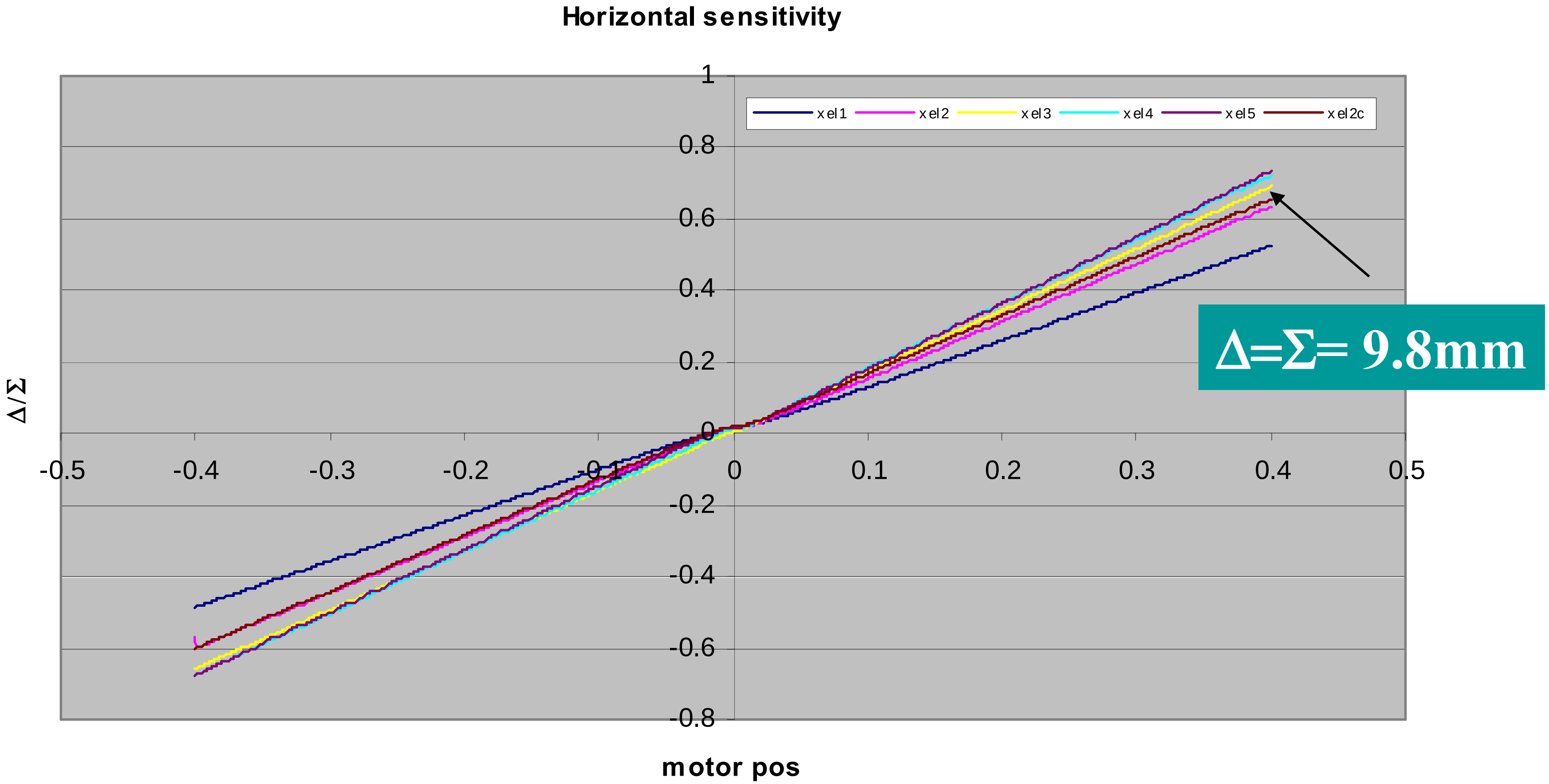
CMRR ~ 83dB @ 10MHz

Sensitivity



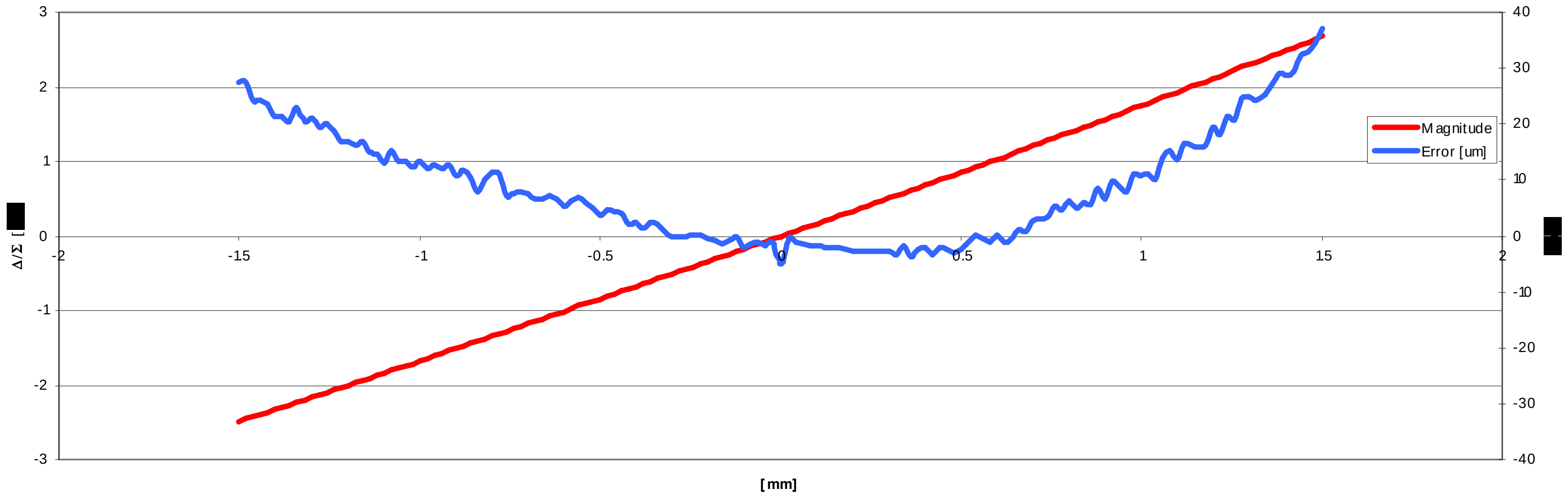
60 deg electrode
(3mm spacing)

Sensitivity



Bench tests-Linearity

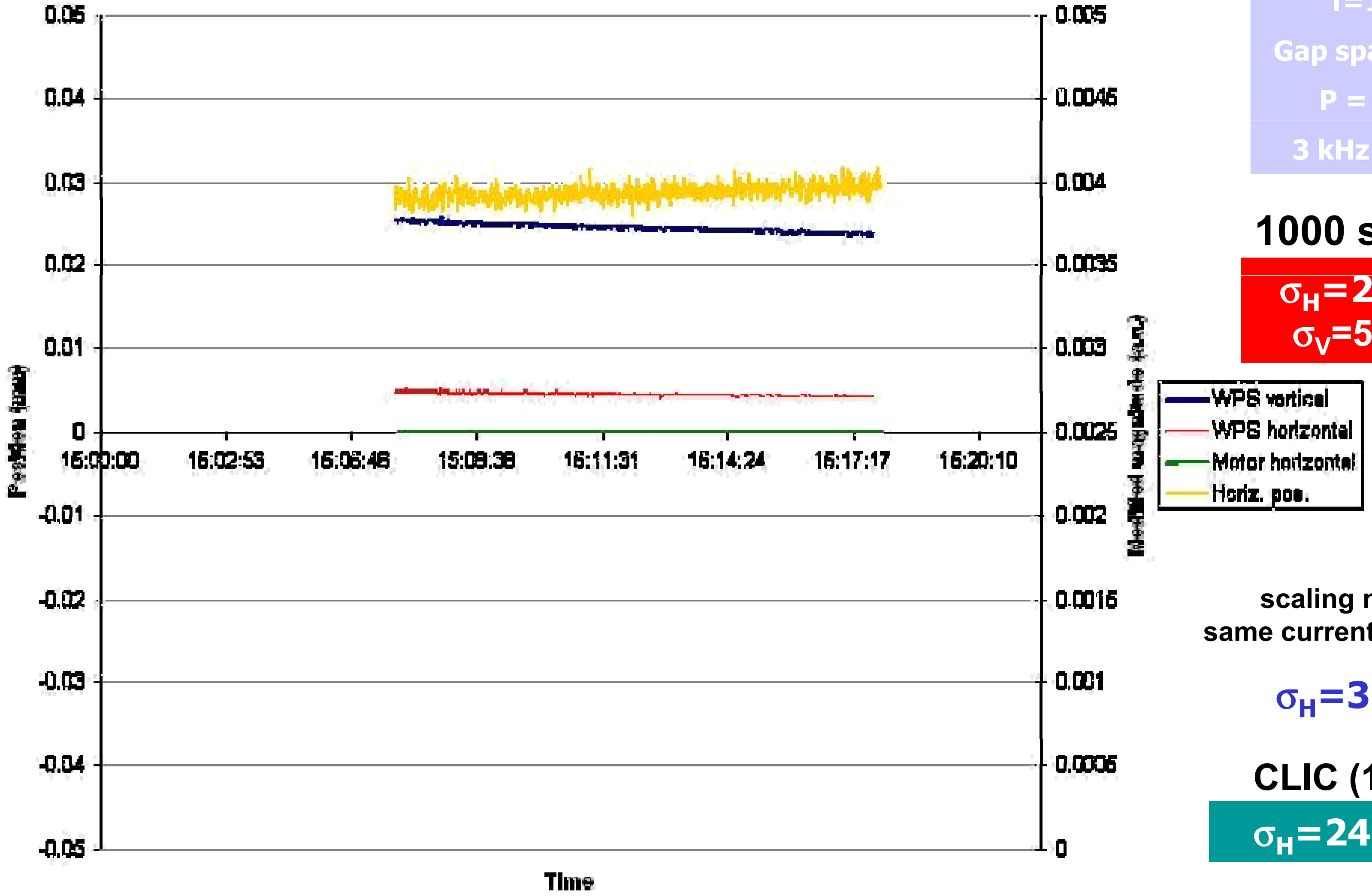
+- 1.5mm Linearity measurement



Error: <1% for ± 500µm

Resolution

center



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

1000 samples

σ_H=27.8 nm
σ_V=52.3 nm

scaling noise to
same current at 30 MHz...

σ_H=3.6 μm

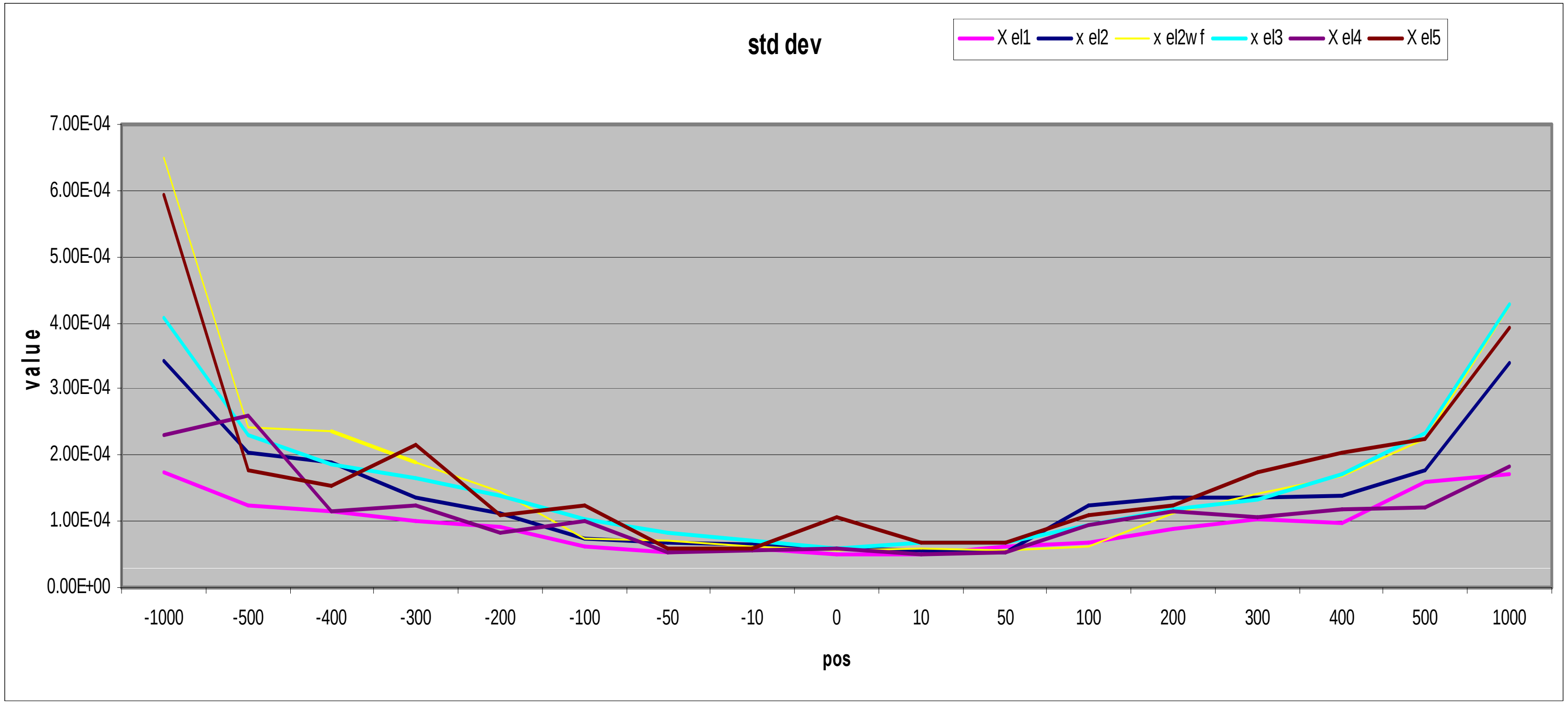
CLIC (1.5 A)

σ_H=240 nm

New head amplifier

Resolution

Standard deviation of 250 measurements a different positions

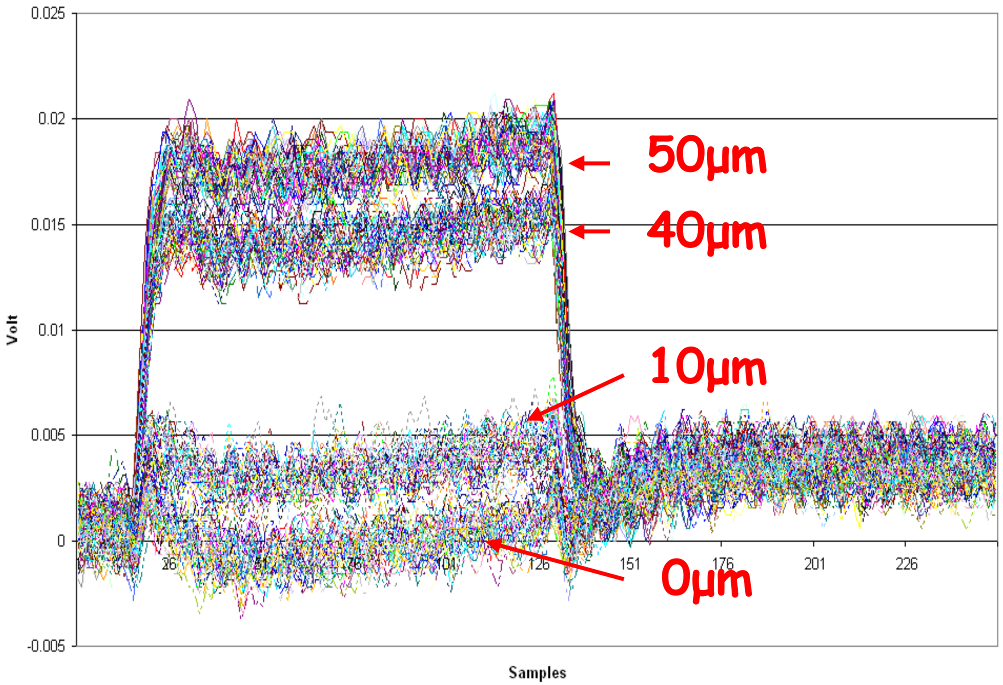


Different values at different positions, is believed to be due to vibrations of the wire. A linear dependency with wire current was found

$\sigma_{Center}=6*10^{-5}$

Bench tests

Mean=17.4mV
σ=0.87mV
σ=2.5µm



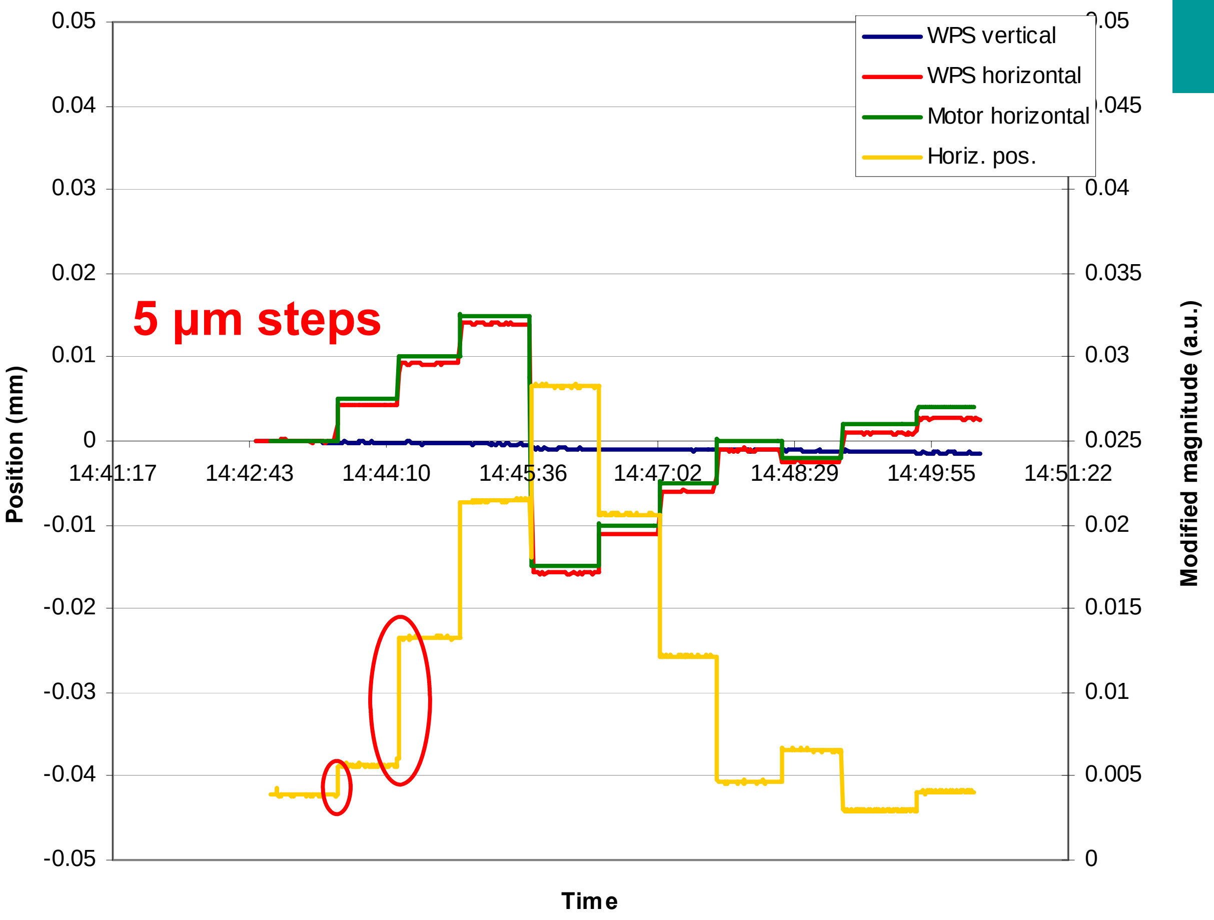
Mean=2.9mV
σ=0.90mV
σ=3.1µm

Wire current 100mA

Resolution with movement

Correlation between x movements and monitoring signals

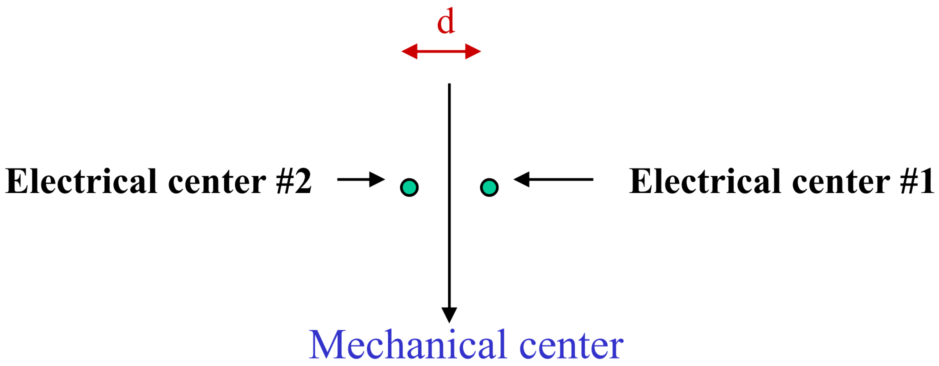
f=10 MHz
Gap spacing 3 mm
P = 25 dBm
3 kHz bandwith



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

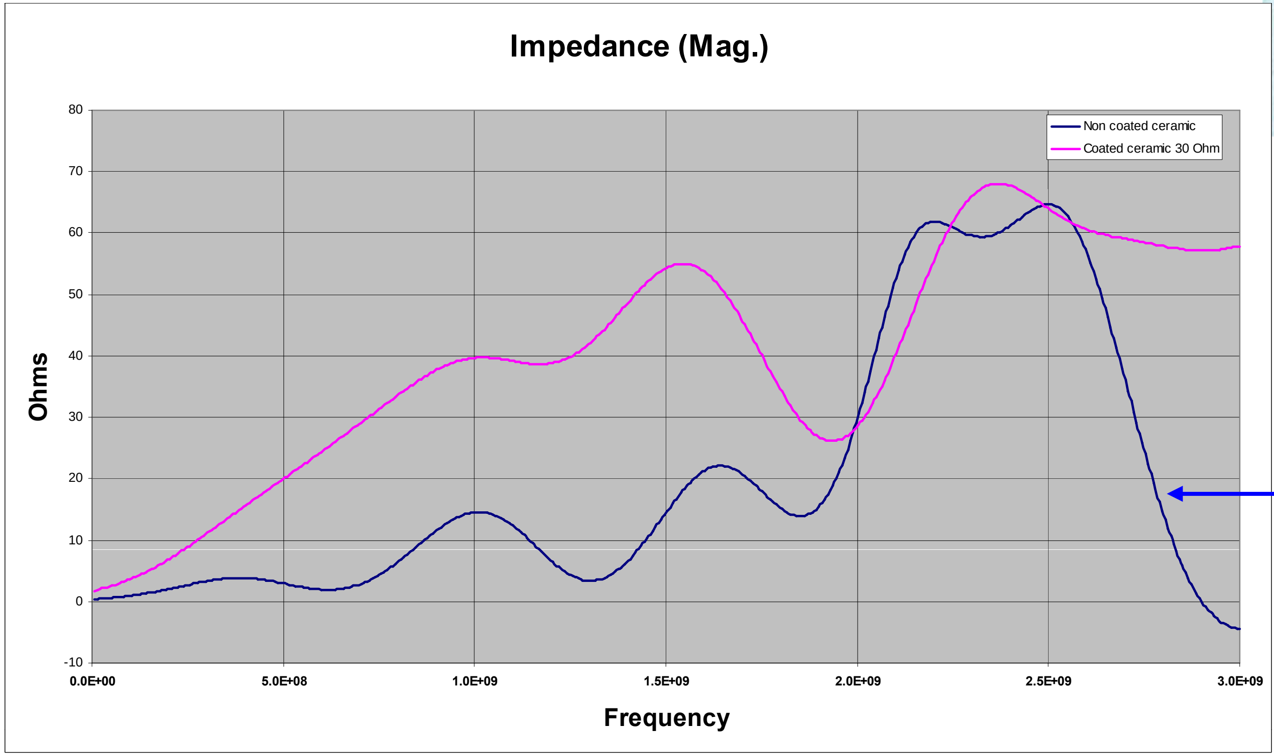


The electrical offset was measured to 50µm.

The reason for this was due to in precise alignment of the PBPM
on the rotation stage. Better alignment has been foreseen for the future PBPMs.

Impedance measurement

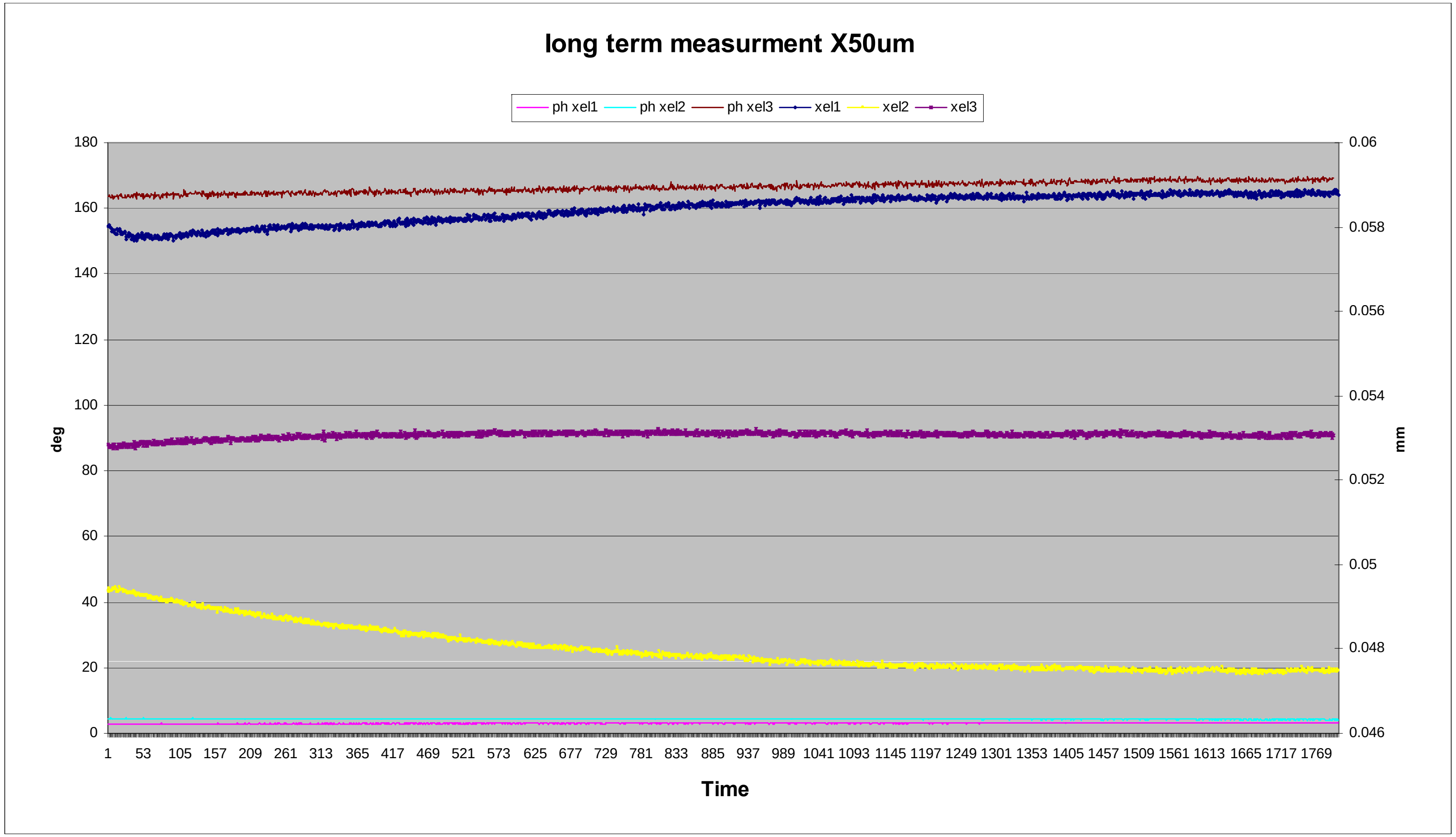
$$Z_{//} = -2 Z_L \ln\left(\frac{S_{21}}{S_{21R}}\right)$$



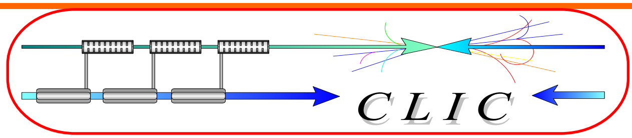
Stabilizing at 60 Ohm, but a factor 2 too high?

Inductive impedance

24H stability



~ 2um over 24H and 5ºC



Bench test-results

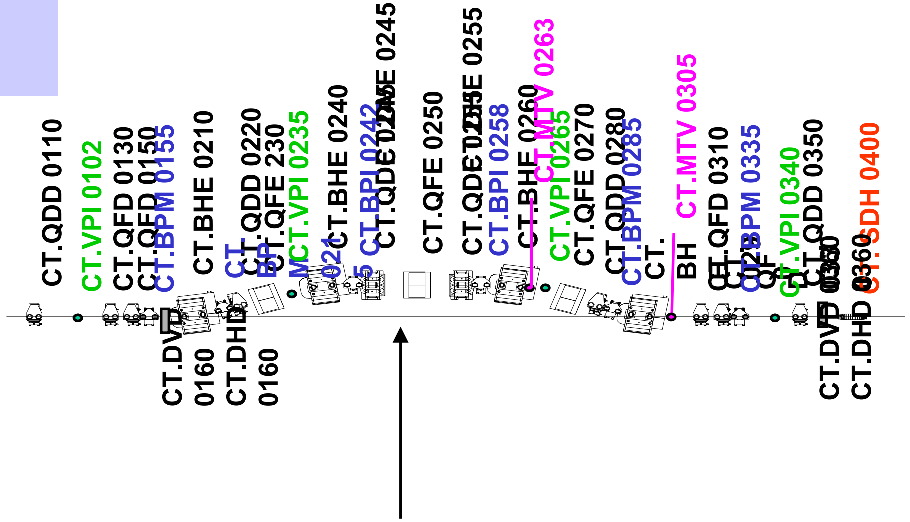
Sensitivity Δ=Σ	9.8mm
Linearity error [±500µm]	1%
Electrical offset	50µm
Meas. Resol. (100mA, 3kHz BW)	σ_H=28nm σ_V=52nm
Resolution CLIC	σ_H=180nm σ_V=350nm
Resolution ILC	σ_H=2.8um σ_V=5.5µm
24H stability/ 5 deg. C	2µm
Bandwidth	Δ = 300kHz-80MHz Σ = 5kHz-80MHz

Beam tests in CTF3

Installation of 3 PBPM in CTF3 during first week of September 2007 (disentangle position and angle jitter).

Each PBPM with individual micromovers.

Magnetic chicane (CT)



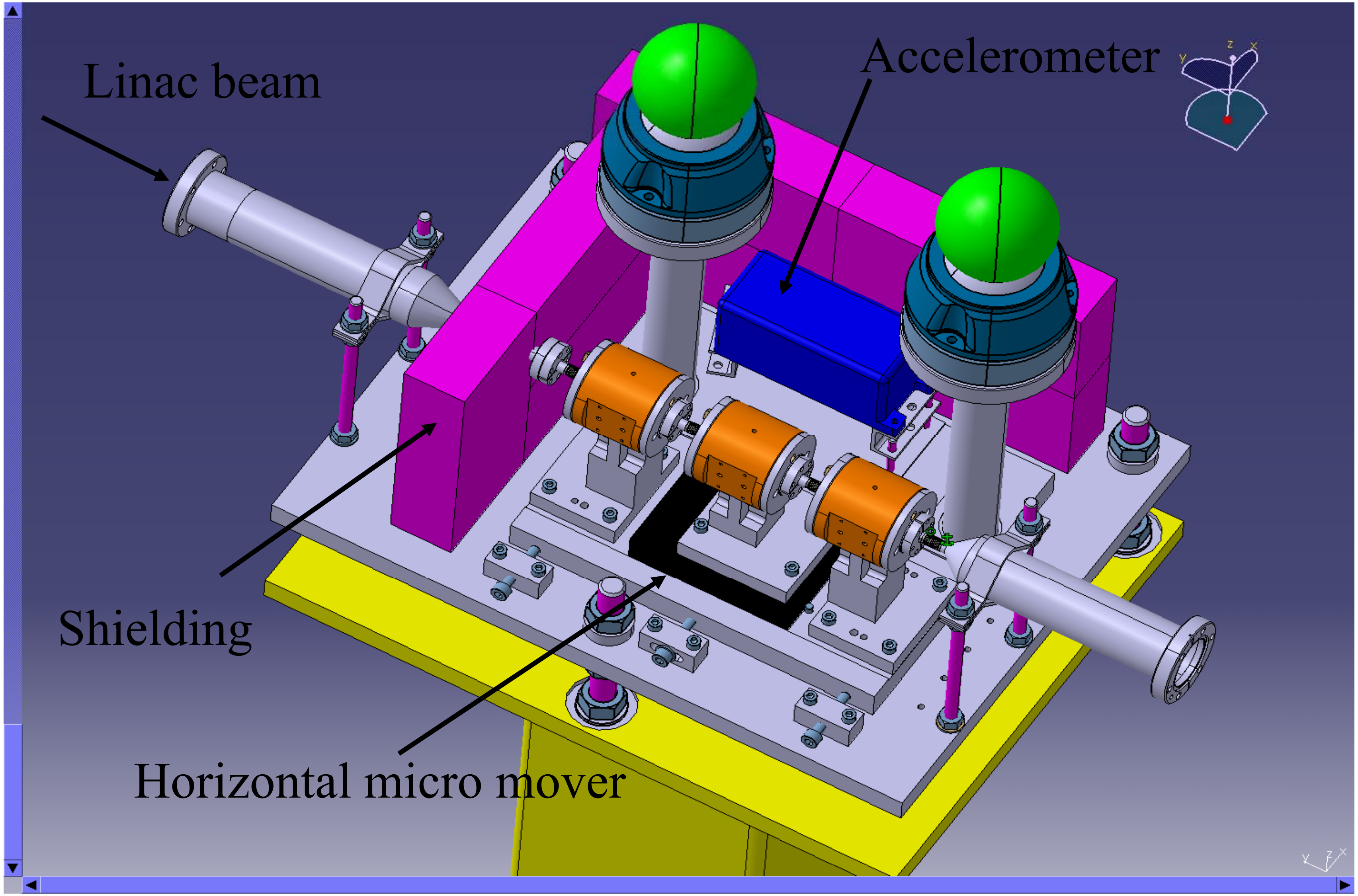
3 PBPM,s

Can be left in place

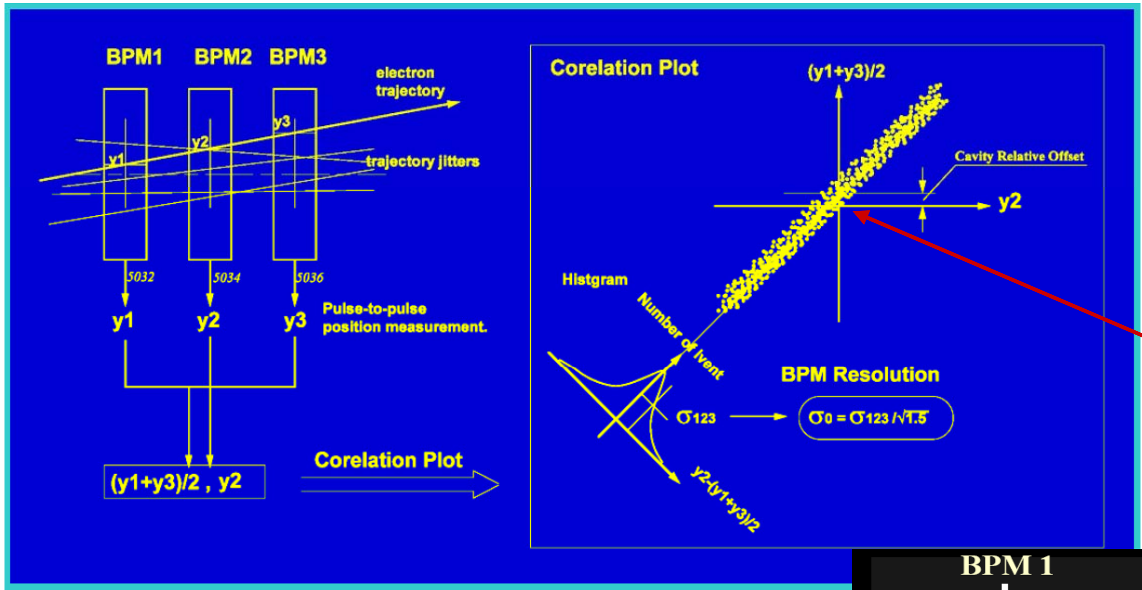
CTF3 beam properties

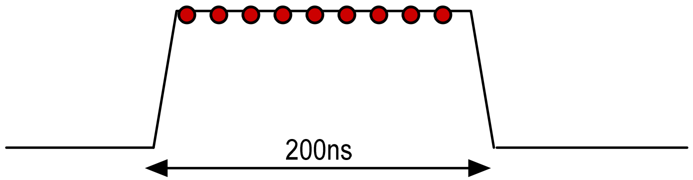
Beam current	1.5 A
Pulse width	200 ns
rms-Transverse beam size	0.7 mm
Beam angle	1.25 mrad *(0.5 mm offset at 400 mm length)*
Tranversal position jitter	100 to 200 µm

Beam tests

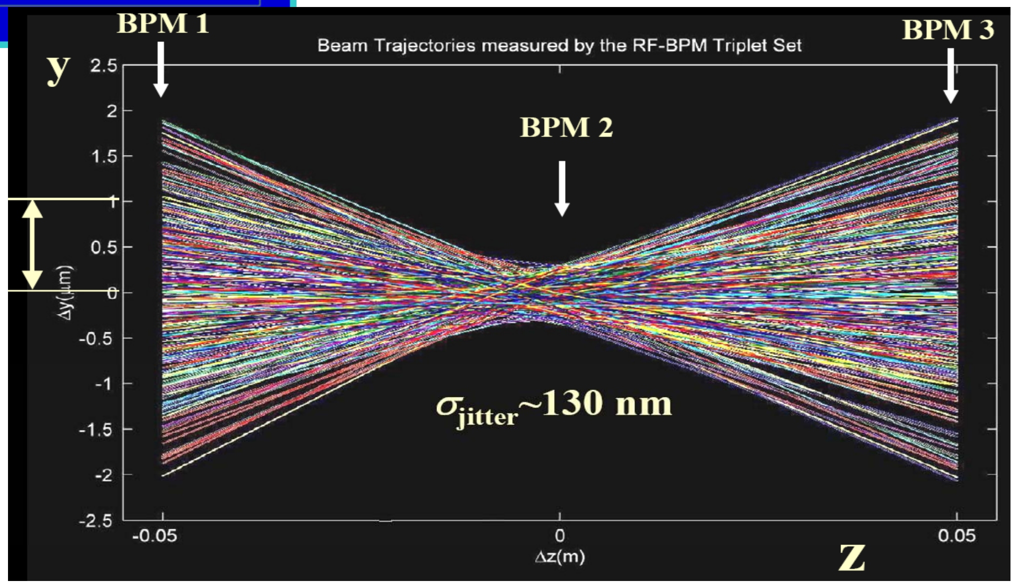

Linac beam
Accelerometer
Shielding
Horizontal micro mover

Beam tests





For different center PBPM positions



Courtesy T. Shintake

EUROTeV PBPM

Conclusion

- The design of the PBPM has been reported in :
  EUROTeV-Report-2007-008

- Bench measurements are just finished and will be reported on in a EUROTeV note in November 2007. Preliminary results were reported in:
  EUROTEV-Report-2007-046

- The measured resolution for CLIC for the two planes (~250nm) is ~ 2 times bigger than calculated one. The reason for this is not yet understood

- The front end electronics used in the tests had a CMRR of ~80dB and we hope for further improvement to increase the sensitivity in the centre.

- The relatively big electrical offset is due to lack of precision in the alignment of the PBPM on the rotational stage. Improvement of this has been done.

- Beam test are planned for November 2007 and will be reported on in December.