Some movement monitor systems at DESY

by K. Wittenburg, DESY

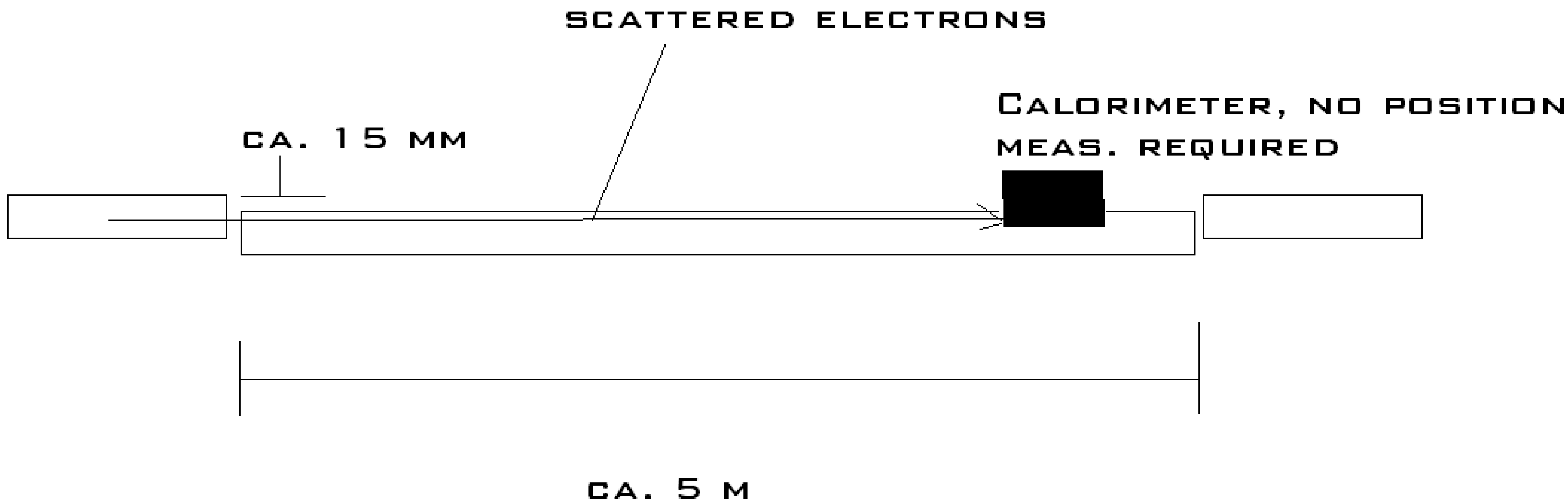
- Introduction/Experience with moving beam pipe in HERA

Some comments and experiences:

1. Commercial System (Eddy current)
2. Hydrostatic Level System (HLS)
3. Stretched Wire (Wire Position Monitor, WPM)
4. PETRAIII: MOMO (Movement Monitor)

5. High resolution BPM System for PETRAIII (very brief)

Moving beam pipe in HERA



NO PROBLEMS DURING 5-10 YEARS OF OPERATION
USING STEP MOTORS LIKE AT THE COLLIMATORS
PRECISION ABOUT 1/10 MM

Introduction

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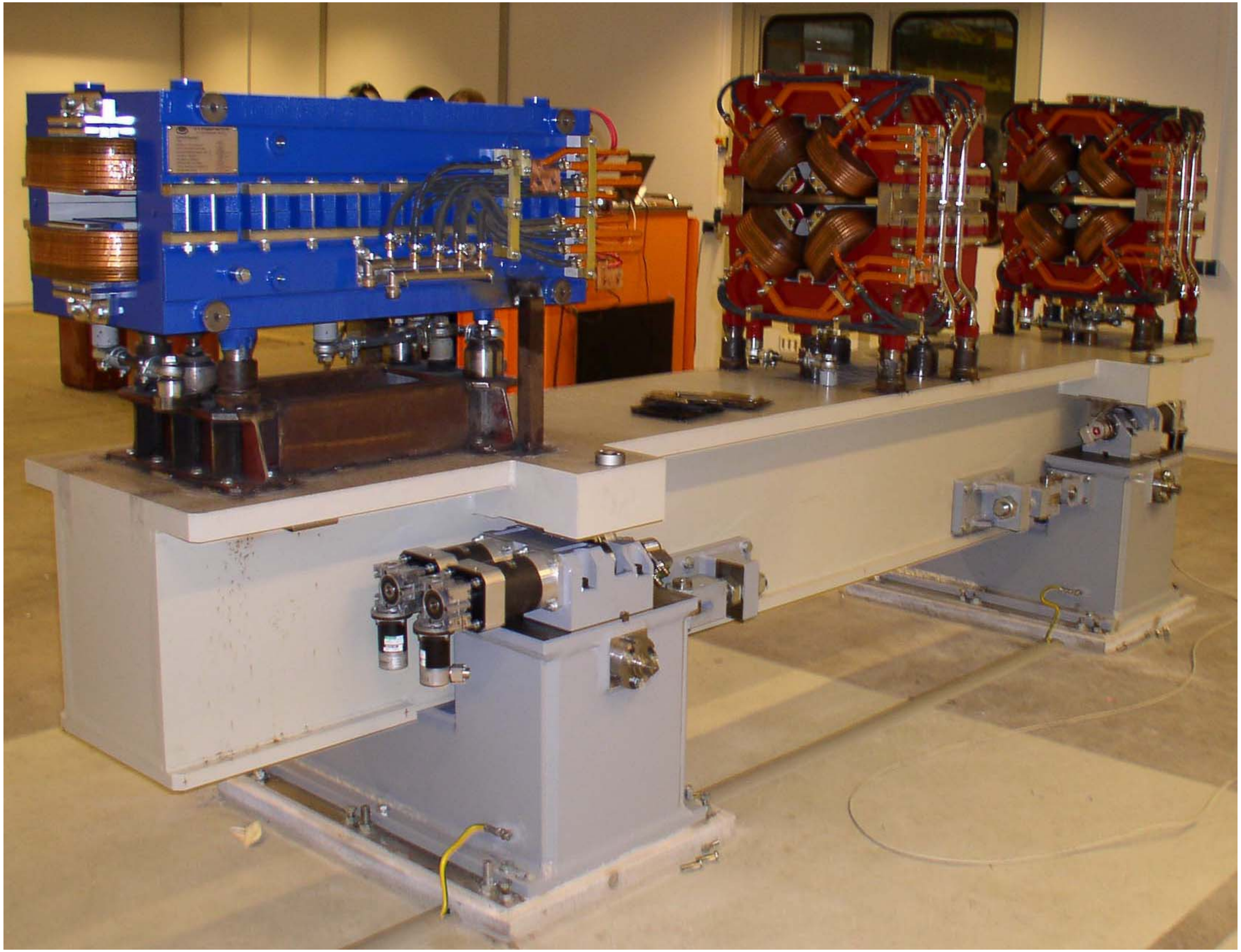
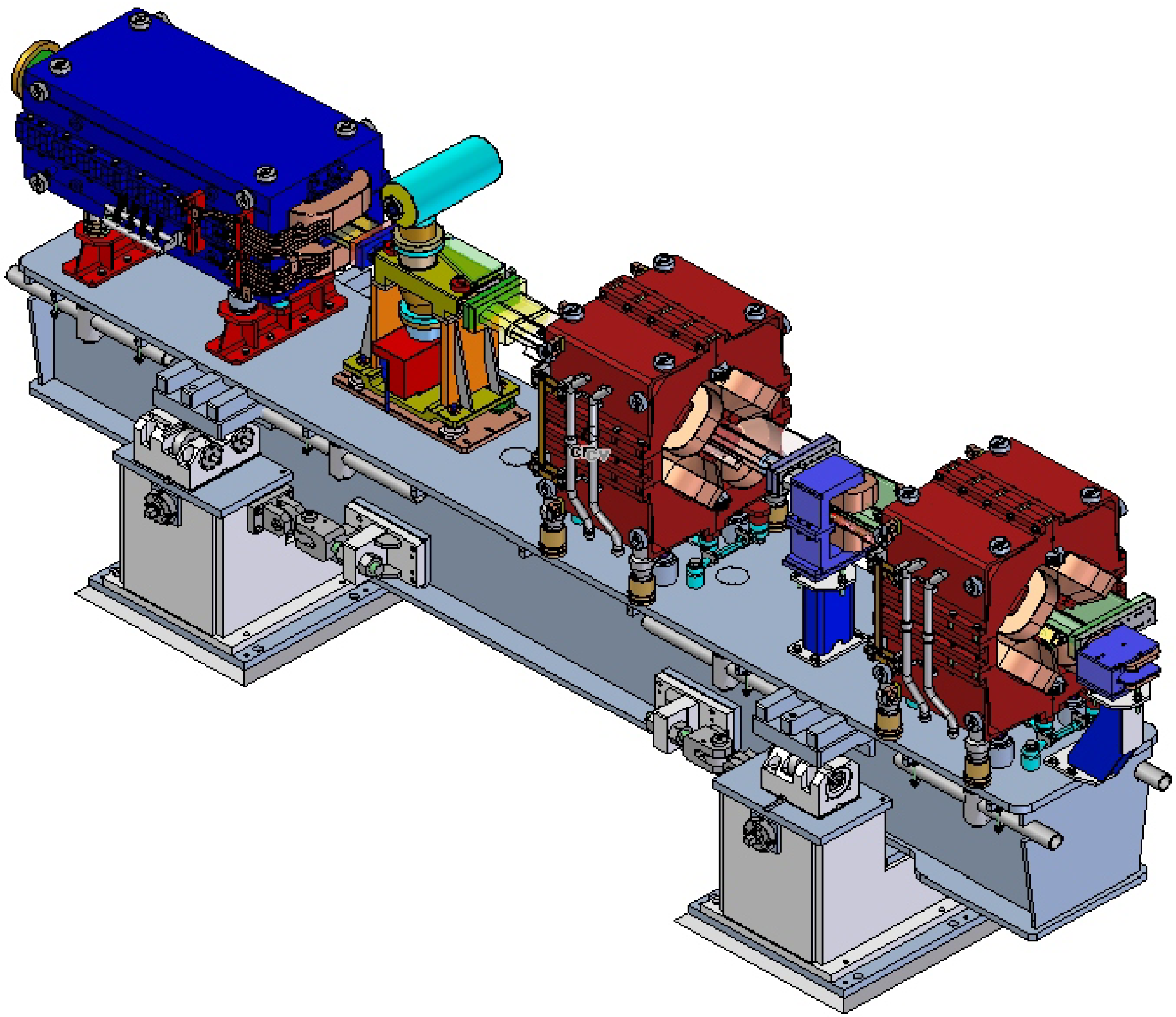
Girder for PETRAIII



Girder for PETRAIII



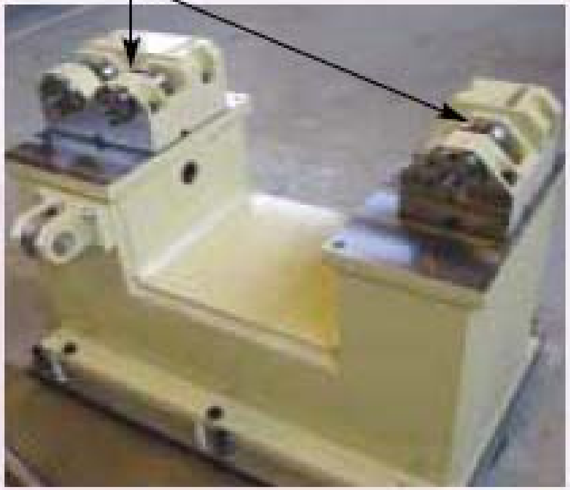
Girder for PETRAIII

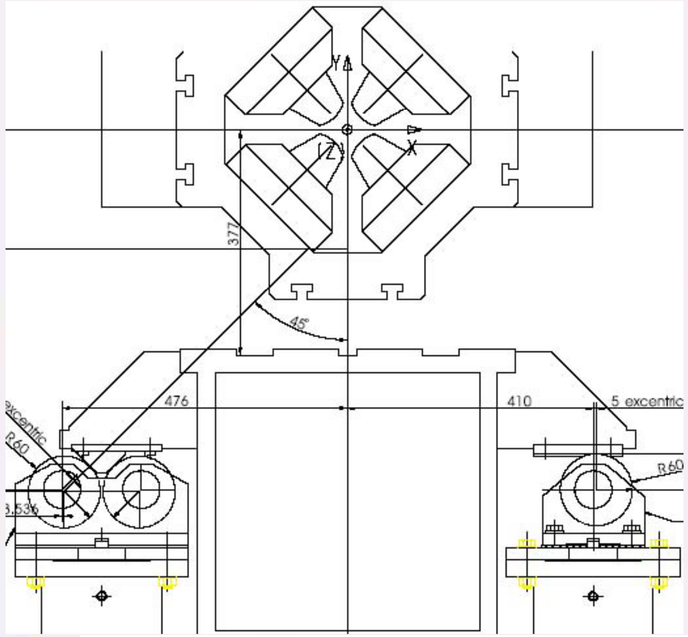
Girders

'Single V' rollers

'Double V' rollers

'Flat' Roller



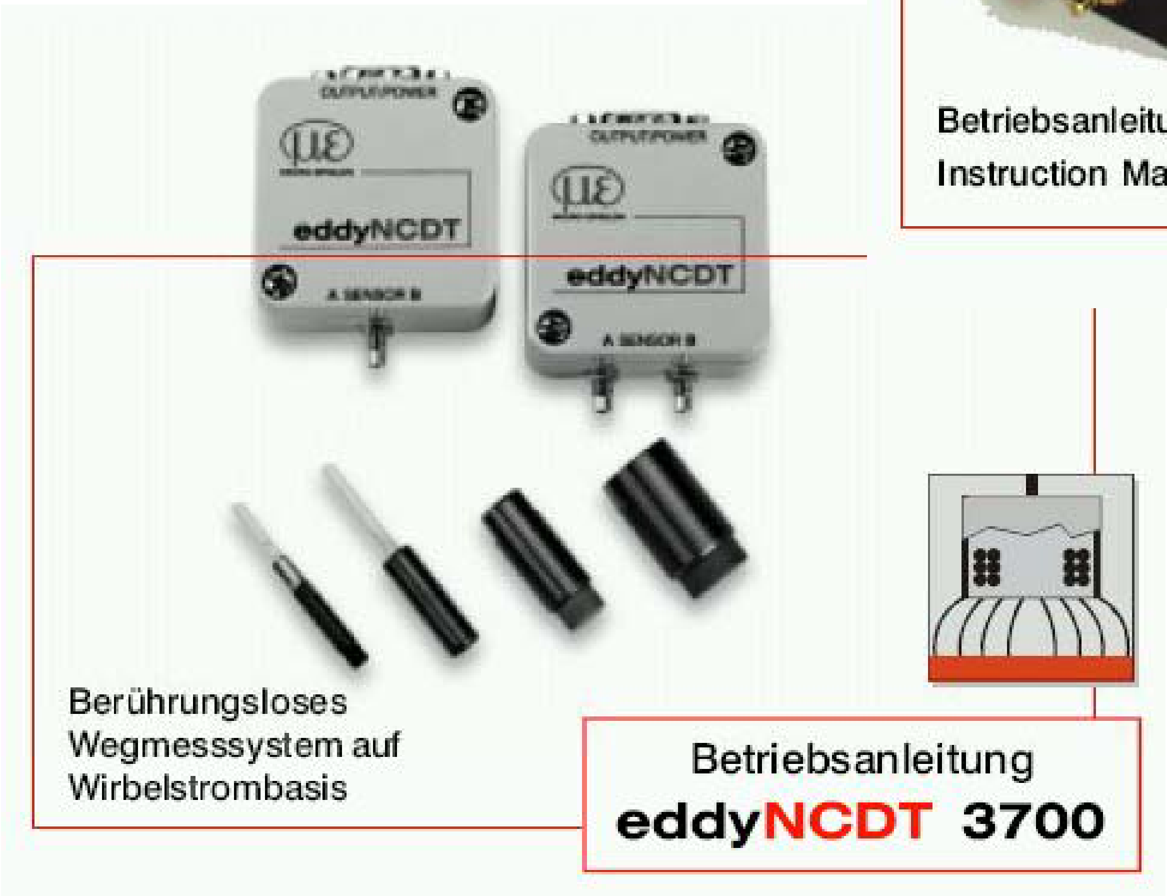


All 72 girders are mounted on motorised cams. The arrangement of cams allows the load-free support of the girder obtained by the use of a kinematic support but with the benefit of 4 point load bearing. These pictures show the motorised cams and housings mounted onto the girder pedestals.

A 6m long girder has been load tested with weights representing magnets. Deflection and vibration measurements have been carried out.

Service routings in modern accelerator installations are always a challenge and this view shows the installation of 4 layers of cable tray alongside an installed girder. The dipole cable installation has had particular attention to ensure that each of the 8 cables is laid alongside an opposite feed or return current carrying cable so as to balance stray magnetic fields.

1) Commercial system



The movement between of the BPMs (relative to ground) should be measured with a resolution of about 1 µm (near undulators). Different technical solutions are under study. Two commercial systems had arrived last week. Test are under way. Also an alternative solution by using a wire alignment system like in HERA will be studied.

Commercial system

2.3 Technische Daten

Modell		S601-0.2	S600-0.5	S600-1	S601-1[1]	CS2	CS3	CS5	CS10
Messbereich MB	mm	0,2	0,5	1	1	2	3	5	10
Linearität		Standard <0,3 % d.M. Einzelabgleich[2] <0,1 % d.M.							
Auflösung		<0,015 % d.M.							
Messwerkstoffe		Elektrisch leitende Werkstoffe, Referenz: Aluminium							
Aktive Sensormessfläche	ø, mm	2,3	3,9	5,5	5,5	7,9	9,8	12,6	17,8
Mindesdurchmesser Messobjekt		5	7	9	9	17	27	37	57
Betriebstemperatur	Sensor	-50 ... +150 °C			bis +200 °C	-50 ... +150 °C			
	Controller	+10 ... +50 °C							
Luftfeuchtigkeit		5 ... 95 %, nicht kondensierend							
Lagertemperatur		-10 ... +75 °C							
Empfindlichkeit	V/mm	50	20	10	10	5	3,33	2	1
Ausgang	Standard	0 ... +10 VDC (kuzschlussfest) Min. Lastwiderstand 1,2 kOhm Max. Lastkapazität 1 nF							
	Option I	4 ... 20 mA, Bürde max. 400 Ohm							

d.M. = des Messbereichs

nische Daten

		Einkanal-System				Zweikanal-System				Differenzsystem			
Modell		DT3701-U1-C3	DT3701-S1-C3	DT3701-U3-C3	DT3701-U6-C3	DT3702-U1-C3	DT3702-S1-C3	DT3702-U3-C3	DT3702-U6-C3	DT3703-U1-C3	DT3703-S1-C3	DT3703-U3-C3	DT3703-U6-C3
Messbereich MB	mm	1	1	3	6	1	1	3	6	0,5	0,5	1,5	3
Messbereichsanfang MBA	mm	0,1	0,1	0,3	0,6	0,1	0,1	0,3	0,6	0,1	0,1	0,3	0,6
Sensormodell		U1	S1	U3	U6	U1	S1	U3	U6	U1	S1	U3	U6
Messprinzip		berühungsloses Wirbelstrom-Verfahren											
Messwerkstoffe		nicht-ferromagnetische Metalle (Referenz: Aluminium)											
Linearität [1]		±6 % d.M.								±1 % d.M.			
Reproduzierbarkeit		< 0,001 % d.M.								< 0,0005 % d.M.			
Auflösung (statisch)		0,000015 % d.M.								0,000008 % d.M.			
	nm	0,15		0,45	0,9	0,15		0,45	0,9	0,08		0,23	0,45
Auflösung (dynamisch) @RMS, fg = 1 kHz		0,00015 % d.M.								0,00008 % d.M.			
	nm	1,5		4,5	9	1,5		4,5	9	0,8		2,25	4,5
Grenzfrequenz (-3 dB)		10 kHz											

1) Abweichung von der idealen Gerade

Commercial system, test results in PETRAII

- No success, no data, system stopped function due to radiation (hot area) within a day.
- Reset-able, but no continuous data taken.
- Decision: Use radiation resistive systems, like in HERA

2) HLS

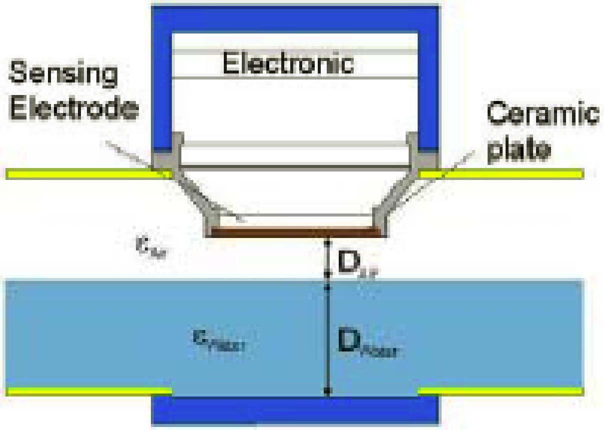


Figure 2: Functional cross section diagram of an HLS capacitive sensor

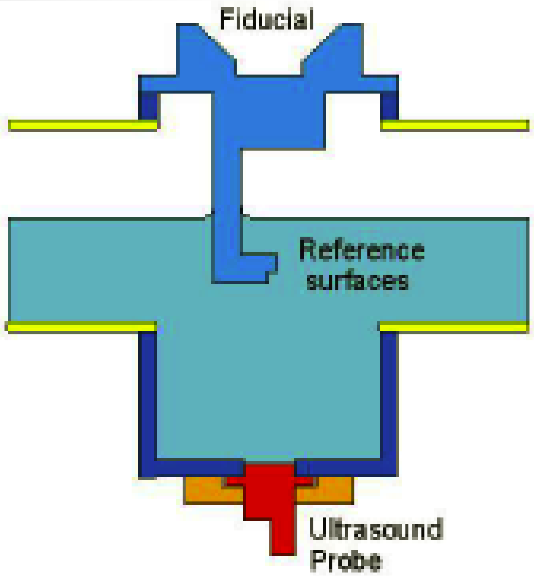


Figure 3: Functional cross section diagram of an HLS ultrasound sensor.

The system consists of two types of HLS sensors, which complement each other. One sensor type is based on capacitive measurements, which has the advantage of being widely used and having a lower purchase cost, see Figure 2. **The repeatability of the sensor is 1 µm with an accuracy of 5 µm over the 5 mm measurement range**. A disadvantage of this sensor type is that capacitive sensors drift by about 1 – 2 µm per month due to aging of electronic components.
The second type of sensor is based on ultrasonic runtime measurements, see Figure 3. The measurements are self calibrating and therefore no drifts are expected. The repeatability of the sensor **is 1 µm with an accuracy of 5 µm over the 5 mm measurement range**. Since the ultrasound sensors provide actual height differences to the water surface they can be used to calibrate the capacitive sensors.

SLAC-PUB-12098

ELECTRON BEAM ALIGNMENT STRATEGY IN THE LCLS UNDULATORS *

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2.2.1. HLS Test

To fulfil the high alignment requirements for a linear collider at the TeV range a free surface hydrostatic levelling system with in situ calibration has been developed in cooperation with the Bauhaus-University Weimar. First tests of this system have taken place in a water adit near Katzhütte in the Thuringian Forest [1]. For a test under real accelerator conditions with ground motion and vibrations two of these systems were mounted in the HERA tunnel (Fig.5). One at the highest place under a road with heavy traffic the other at the lowest part under the groundwater level in a quiet place. No significant movements have been seen yet (Fig. 6).

Fig. 5 HLS Sensor in HERA

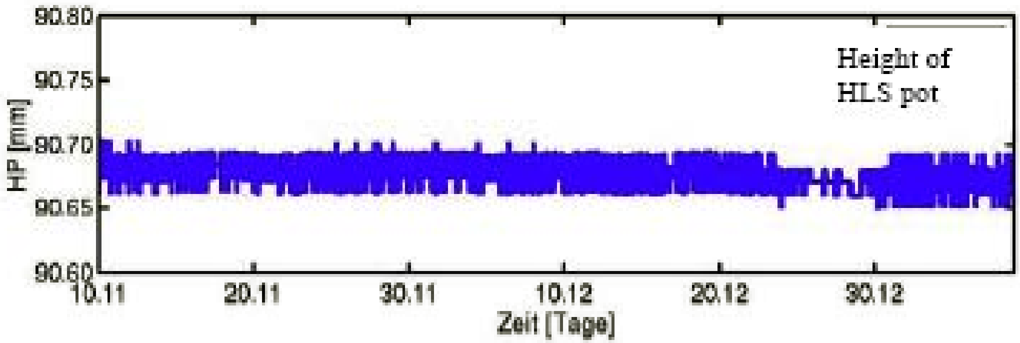


Fig. 6 First HLS Results at HERA

IWAA2004, CERN, Geneva, 4-7 October 2004

STATUS REPORT ON SURVEY AND ALIGNMENT EFFORTS AT DESY

Johannes J. Prenting, Gerhard Neubauer, DESY, 22607 Hamburg, Germany

HLS in PETRA II

HLS in PETRA II

There was corrosion in the test
System at PETRAII.
Lots of synchrotron radiation!?!

HLS

- This system should detect vertical movements of the PETRAIII girders

In CTF2, six HLSs monitor the stability of the concrete girder supporting the accelerator.

In CTF2, 34 WPS-sensors are installed on the girders and the quadrupoles.

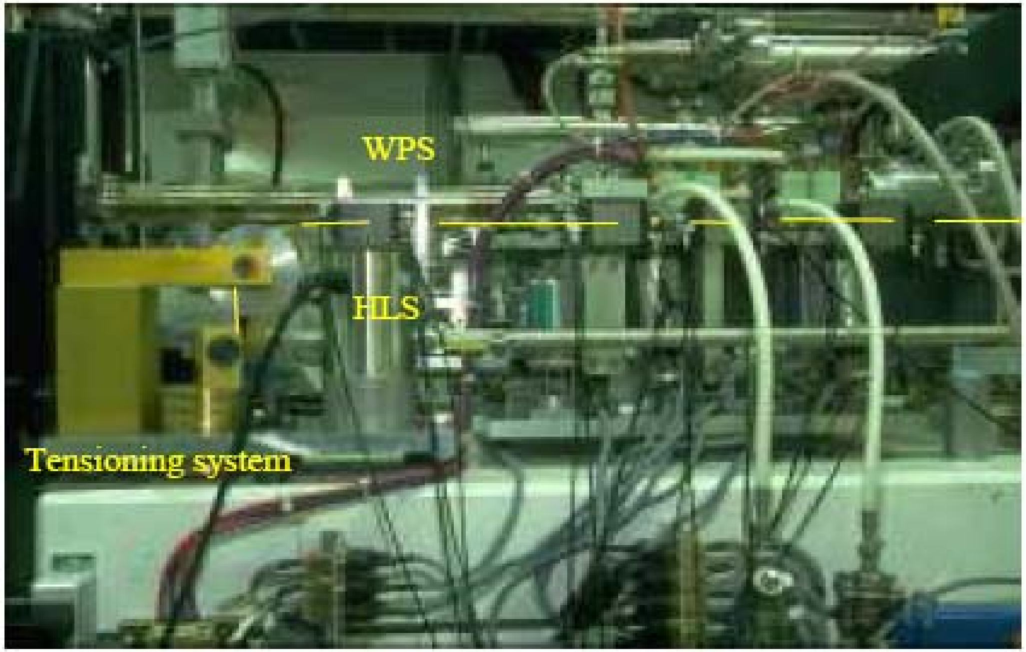


Fig. 10: Instrumentation in CTF2 (photo 1)

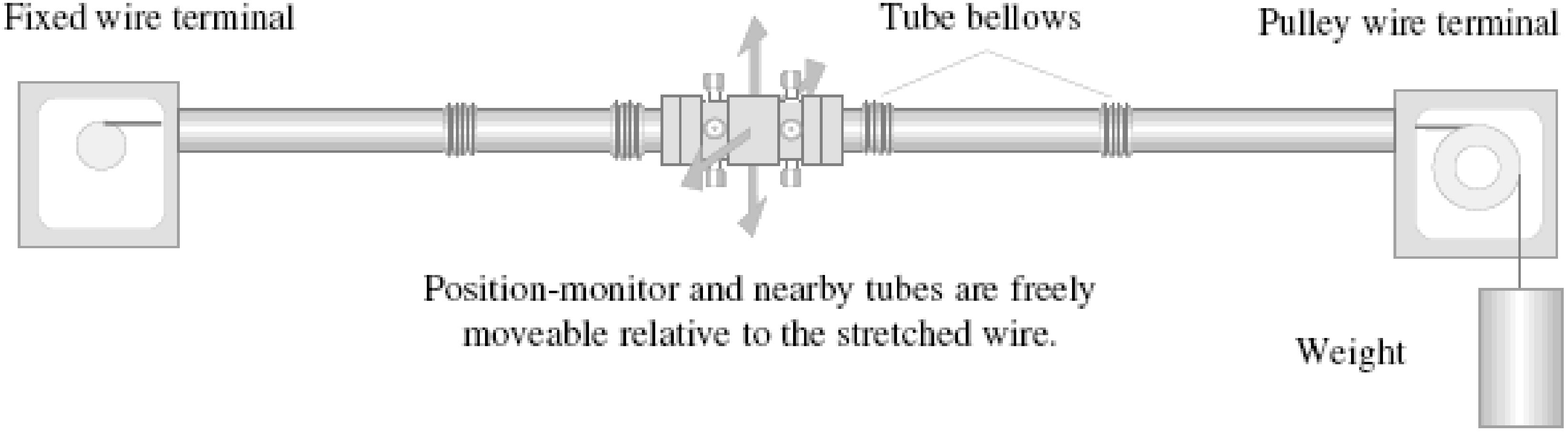


Figure 2 Principle scheme of the stretched wire position system.

3) WPM

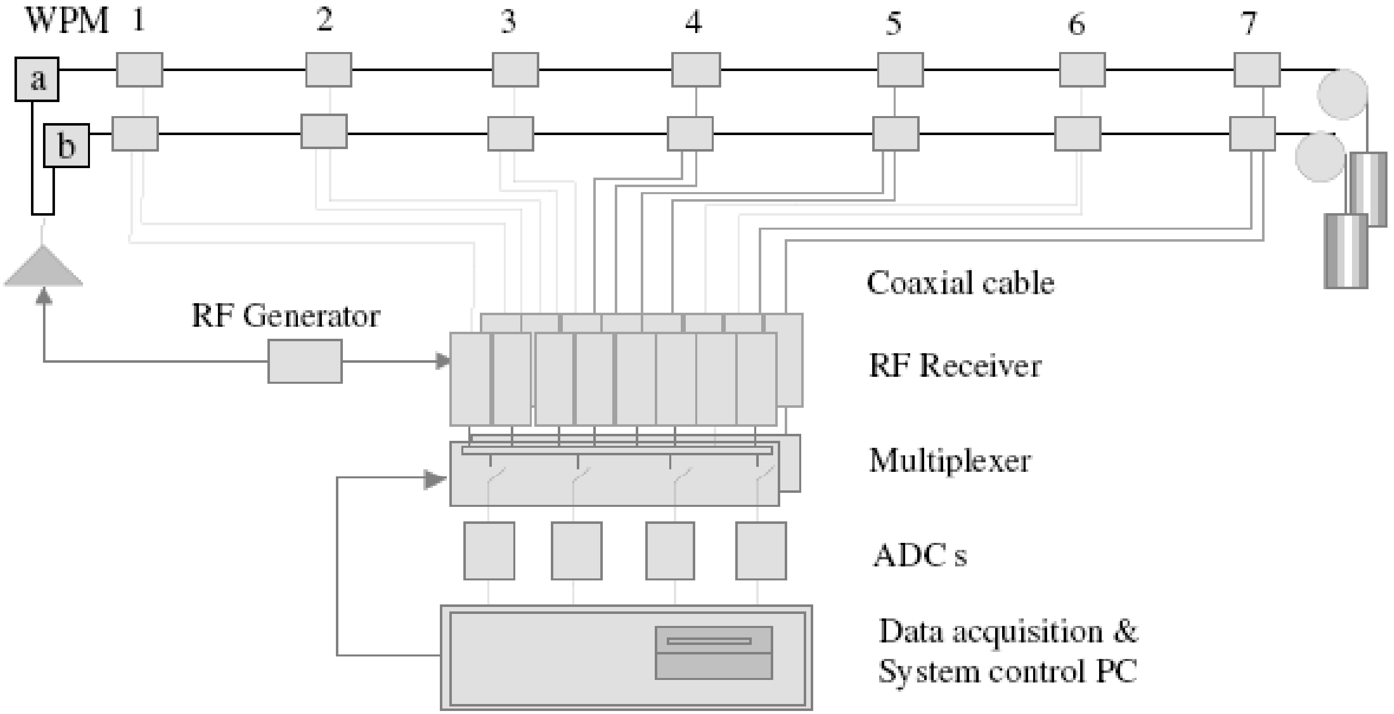


Figure 4 Wire system test set up - electrical layout and control -

LCLS-TN-05-7
First Measurements and Results With a Stretched Wire Test Setup
Franz Peters, Georg Gassner, Robert Ruland
February 2005
SLAC

WPM

Transverse position of quadrupoles can be determined within 0.5 µm (rms) by measurements of support temperatures within ±0.1 K. As extensive test measurements have shown [11], the readout resolution of the WPM system is much better than 100 nm and instrument drifts are lower than 100 nm per day. Due to the unavoidable large sag of long wires, the uncertainty of the wires in vertical direction will be higher than one micrometer, which is the required design objective for the quadrupoles. Therefore, the vertical position of both wires will be correlated to the horizontal plain defined by the Hydrostatic Leveling System.

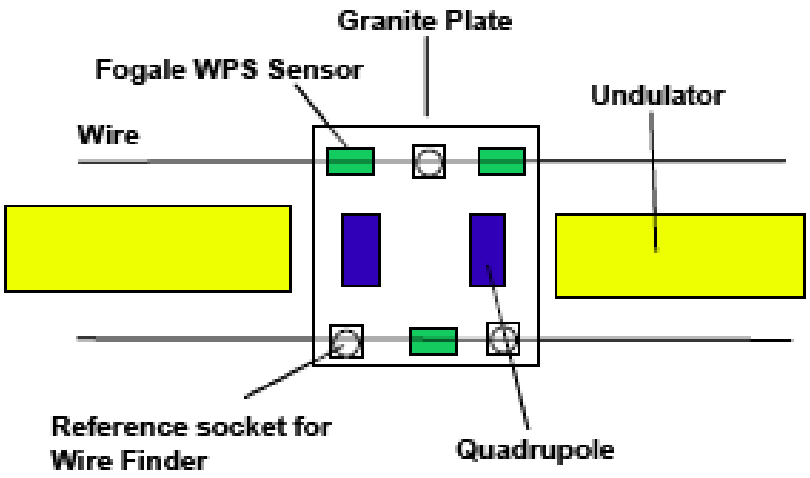


Fig. 21 Concept of the TTF Wire Measurement System

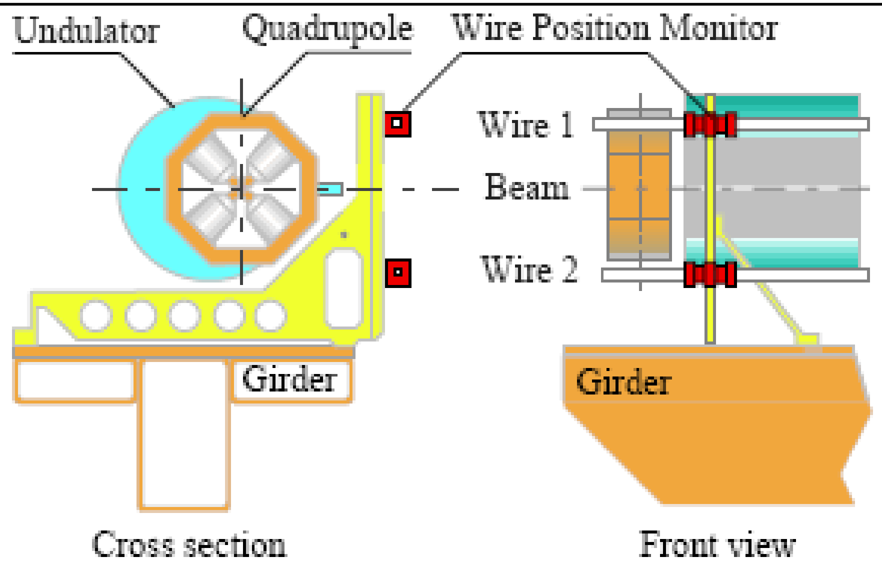
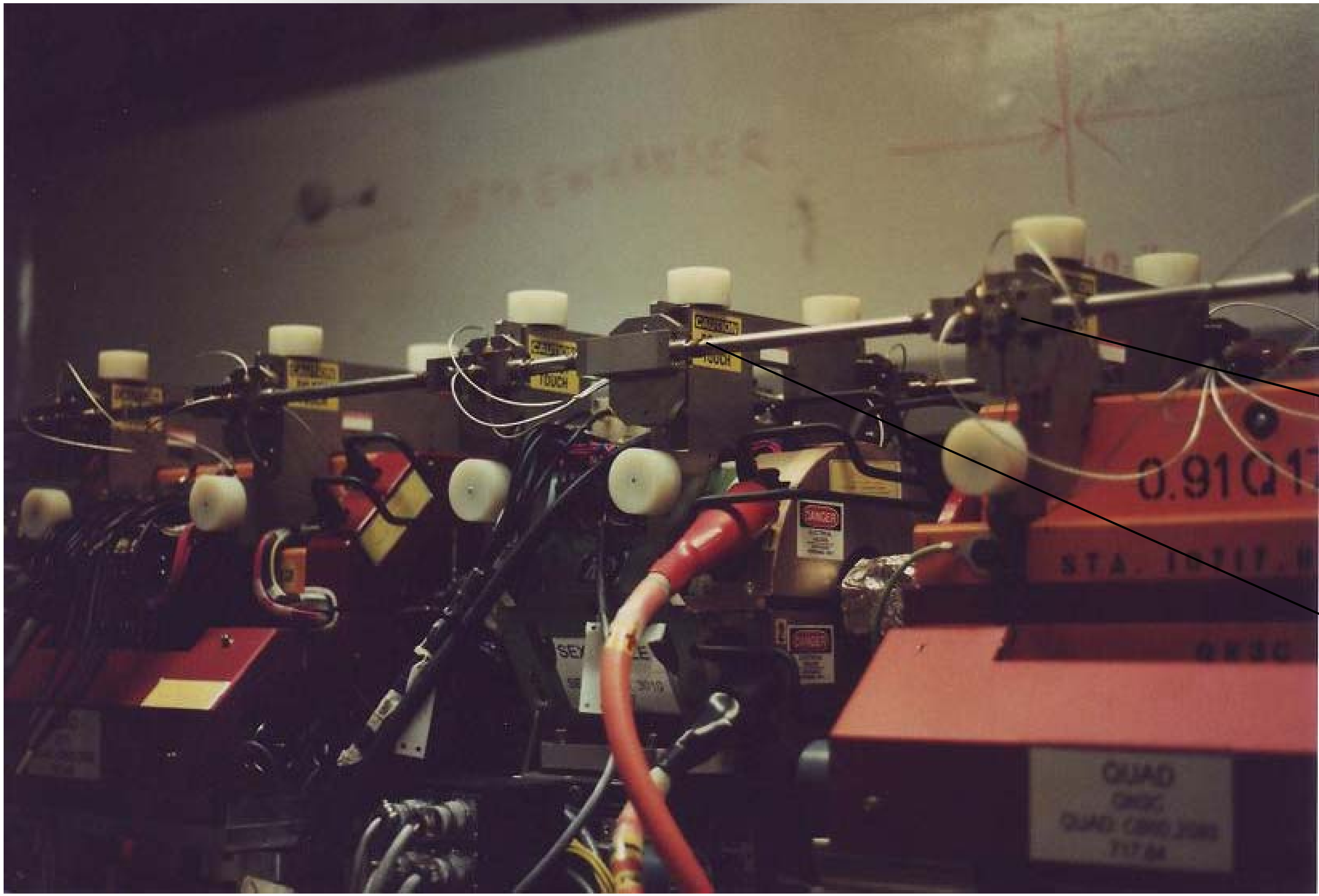


Figure 1: Functional cross section diagram of wire arrangements for the WPM system

LCLS

FFTB WPM



Sensor mounted on magnet

Wire

FFTB / SLAC

WPM

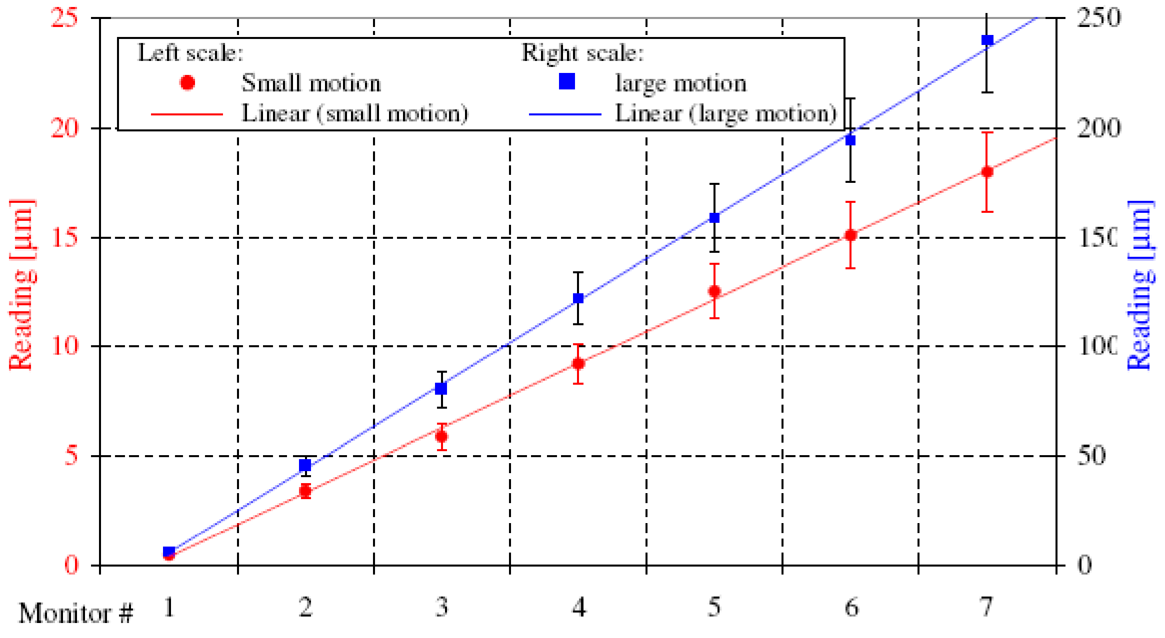


Figure 5 Wire system test set up - overall system test by dedicated movements of end station e2 -

0.5 µm/div

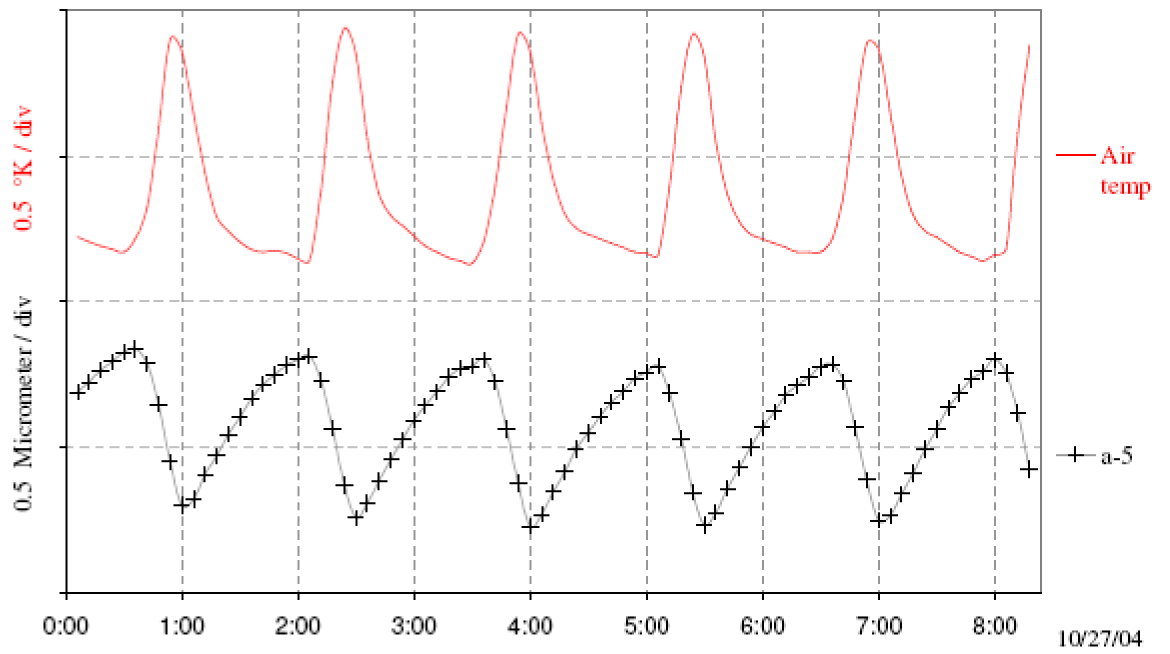


Figure11 Correlation of wire position with air temperature swings, generated by air condition duty cycles.

LCLS-TN-05-7
First Measurements and Results
With a Stretched Wire Test Setup
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Robert Ruland
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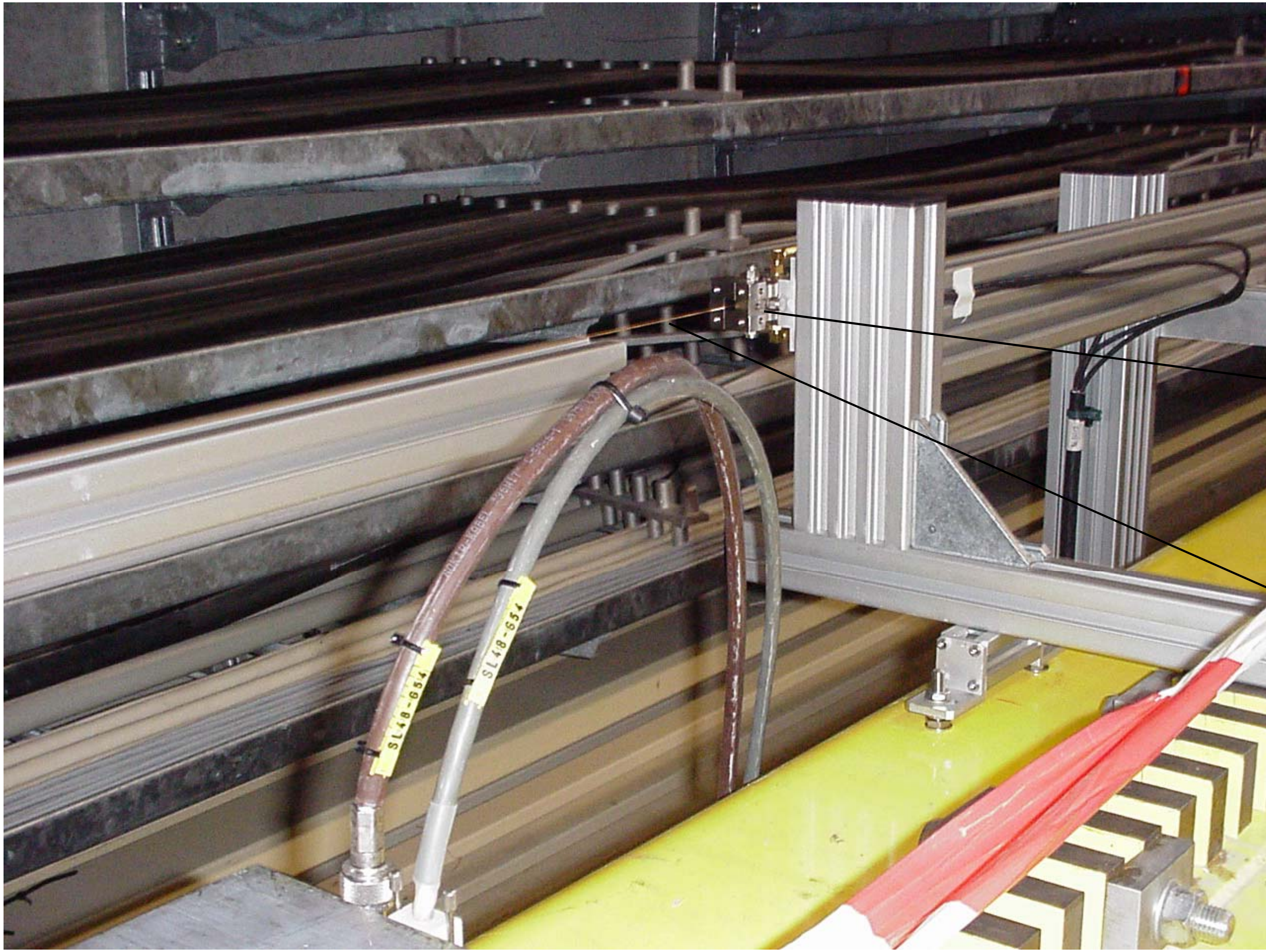
SLAC

HERA WPM

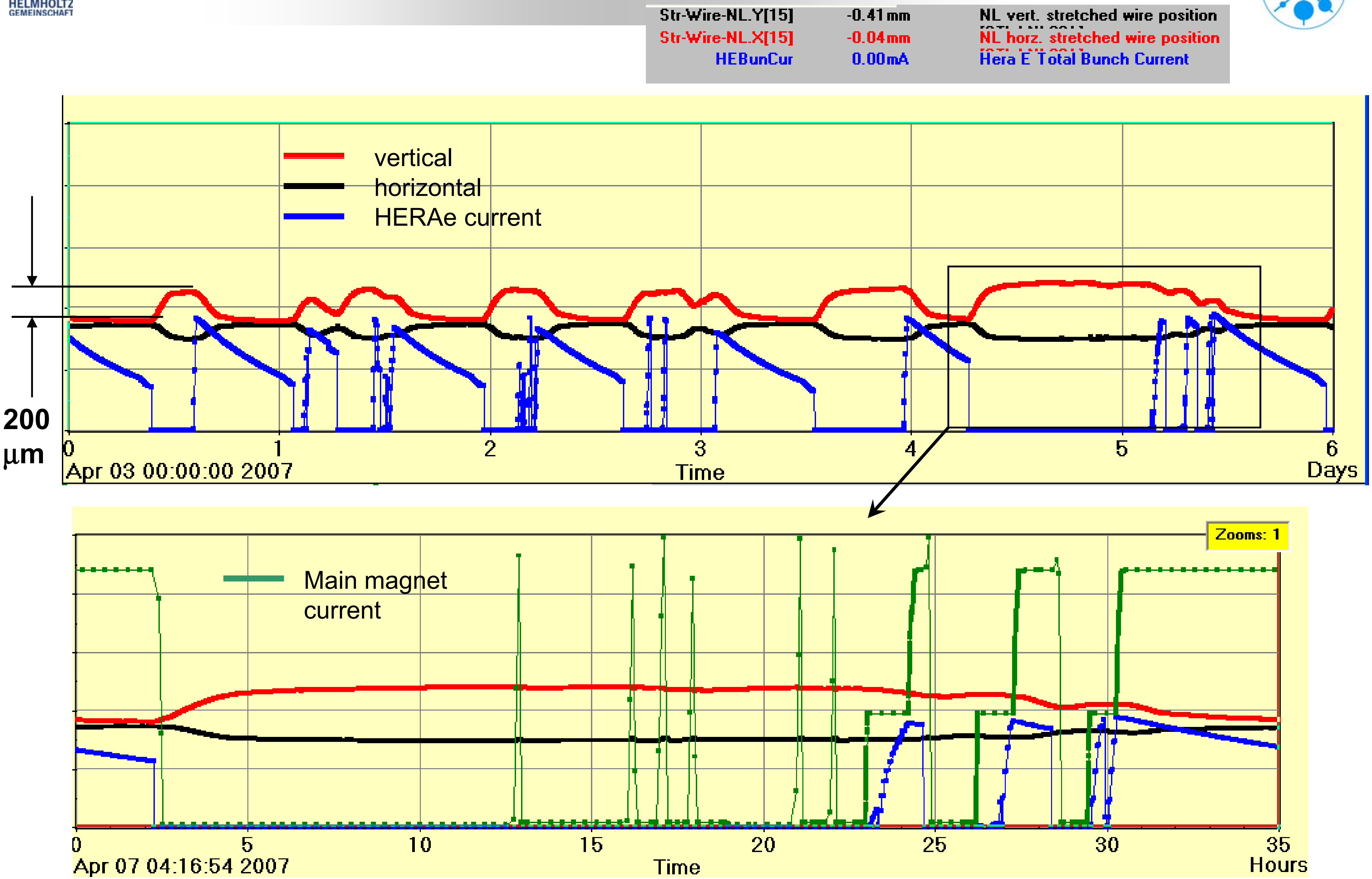


Sensor mounted on magnet

Wire

HERA

HERA WPM



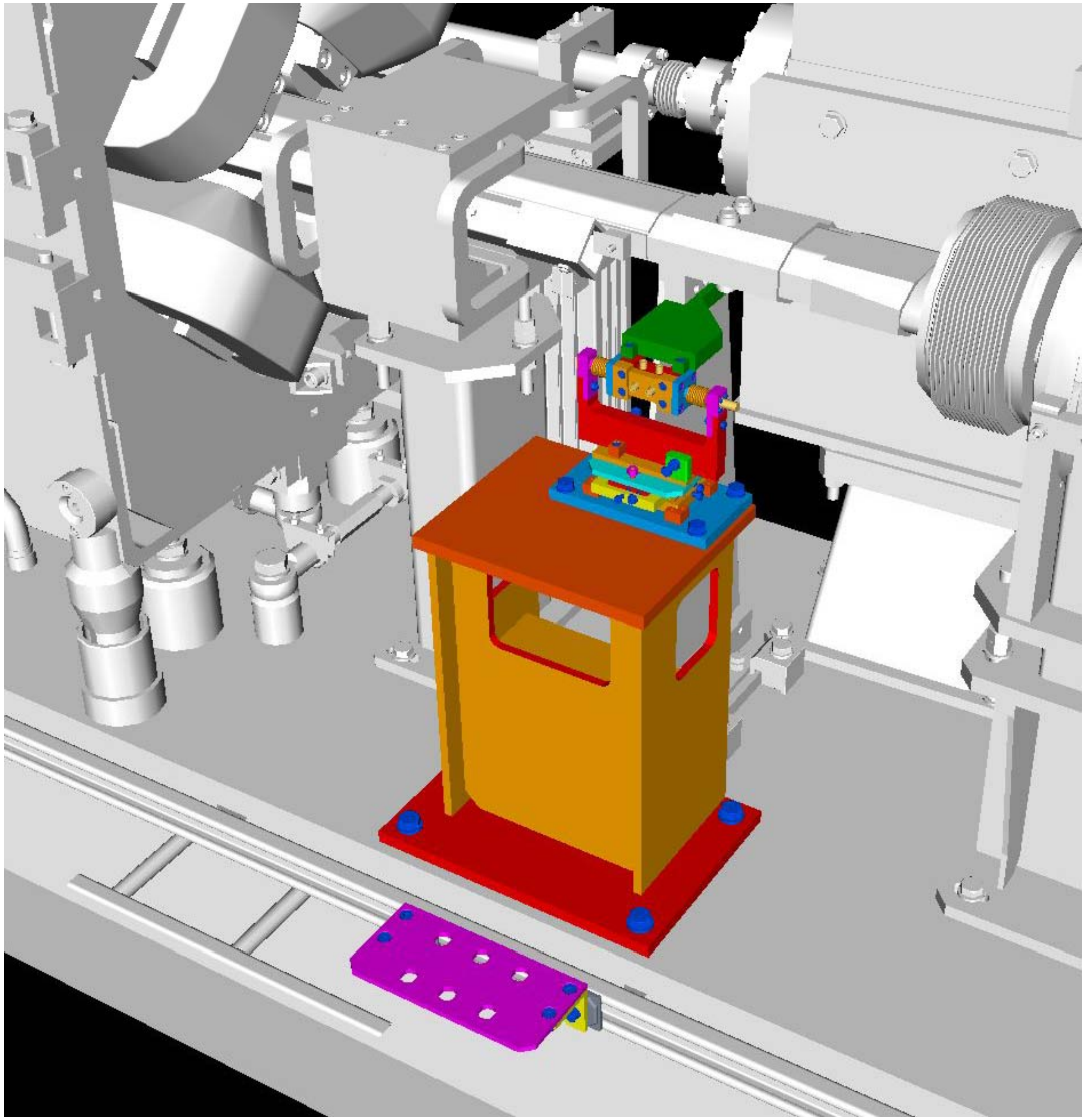
Str-Wire-NL.Y[15] -0.41mm NL vert. stretched wire position
Str-Wire-NL.X[15] -0.04mm NL horz. stretched wire position
HEBunCur 0.00mA Hera E Total Bunch Current
vertical
horizontal
HERAe current
200
µm
0
1
2
3
4
5
6
Apr 03 00:00:00 2007
Time
Days
Zooms: 1
Main magnet
current
0
5
10
15
20
25
30
35
Apr 07 04:16:54 2007
Time
Hours

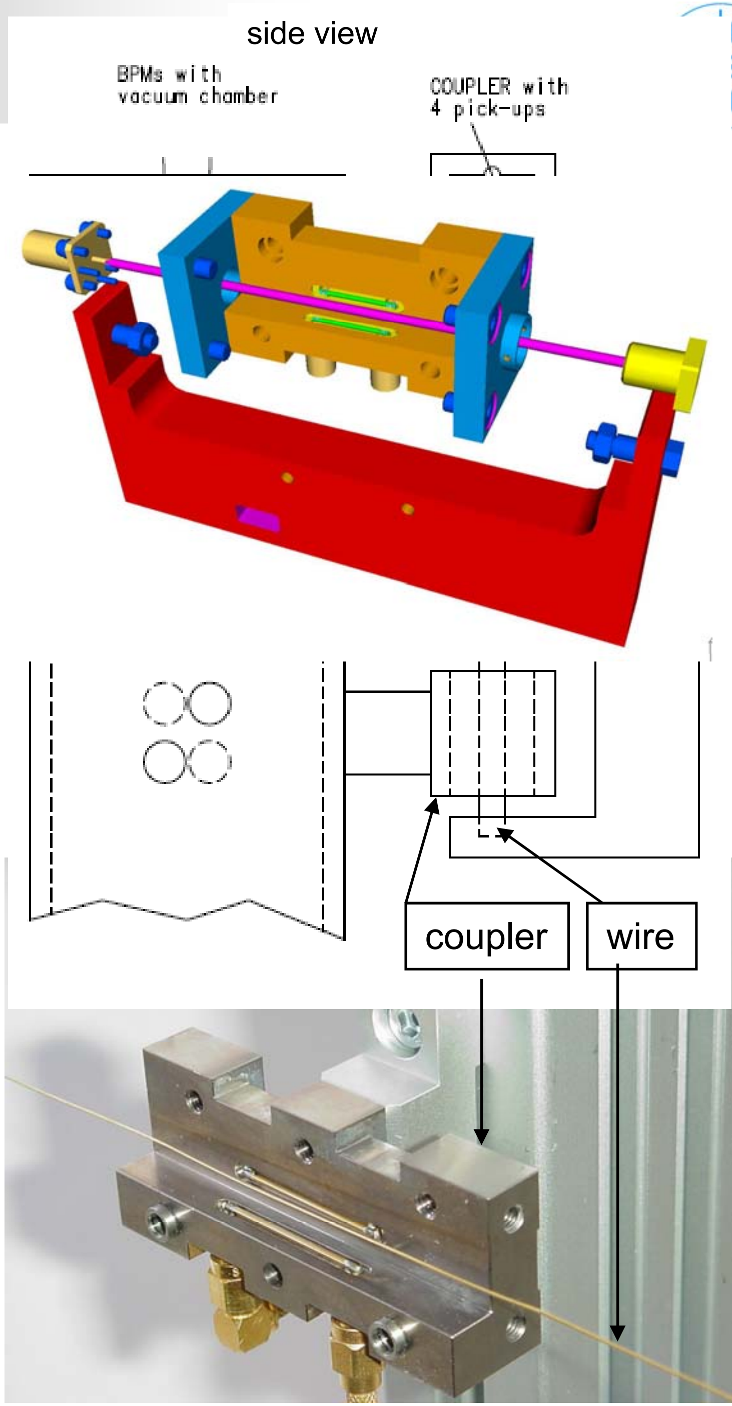
WPM

- Experience from HERA:
  - Long wires disturbed always any kind of service on magnets, water, cables, …
  - due to services, wires often got huge offsets, shorts, dismounted, …

NO LONG WIRES IN PETRAIII

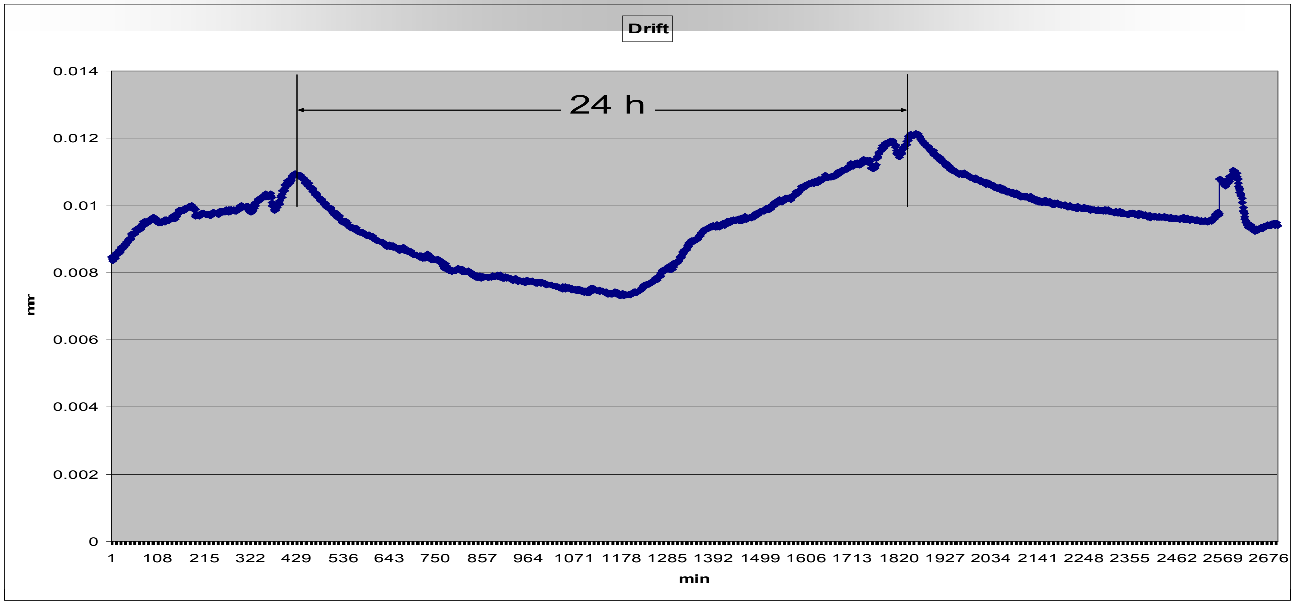
4) MOMO



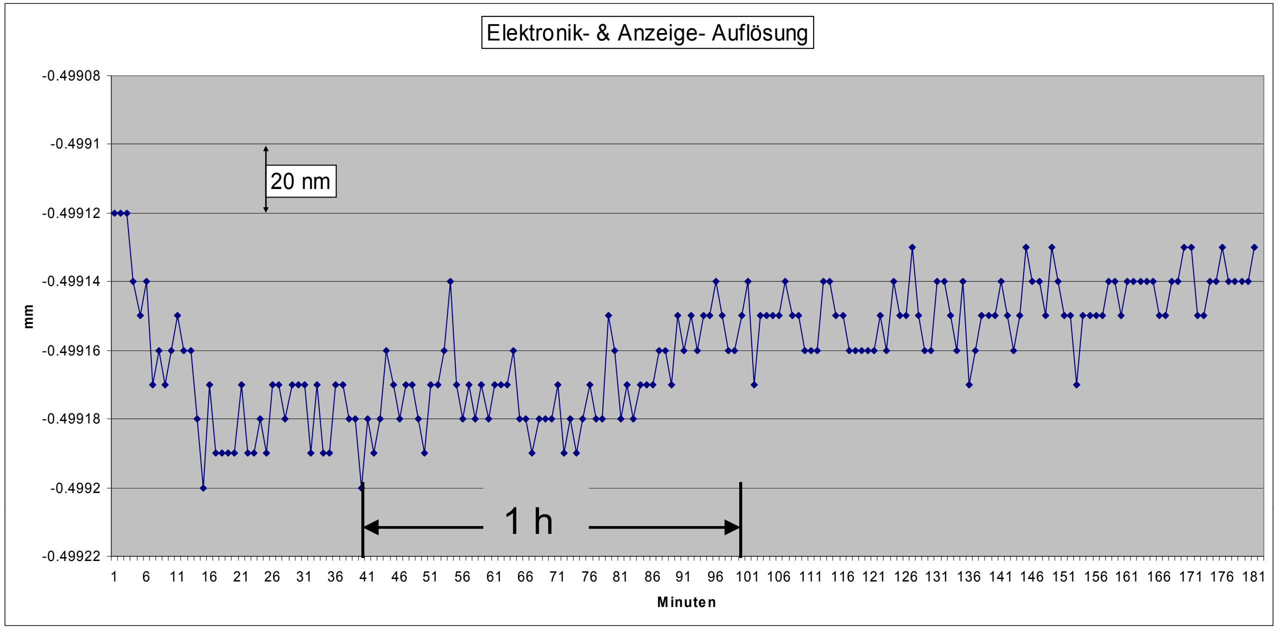

side view
BPMs with
vacuum chamber
COUPLER with
4 pick-ups
coupler
wire

Laboratory-measurements on MOMO prototype

20 µm/div



20 nm/div



5) BPM requirements for fast orbit correction

=> Sub micron orbit stability
=> 0.2 µm resolution at 300 Hz bandwidth

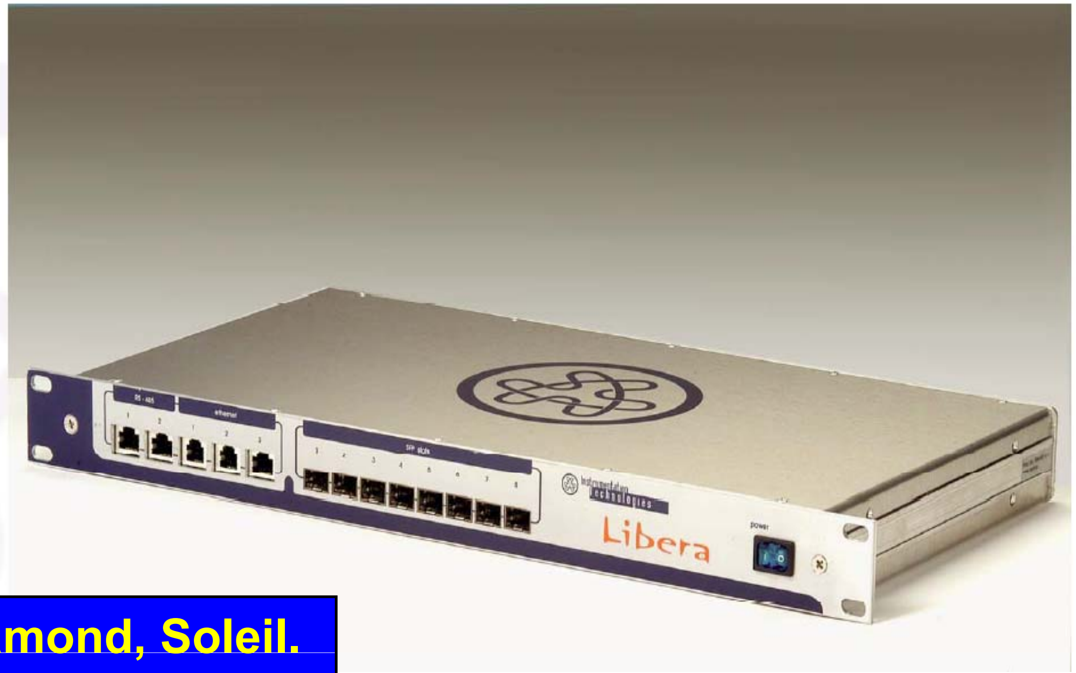
Part I: Readout electronic

Libera

Very close cooperation with WP Feedback.

Decision: Before buying extensive tests of electronic necessary:

- Slow orbit resolution
- Fast data readout for fast orbit feedback.



Same system also used in Diamond, Soleil. Planned for ALBA, ESRF…

Absolute accuracy

1) Regular beam based alignment foreseen

2) Small electronic drifts:

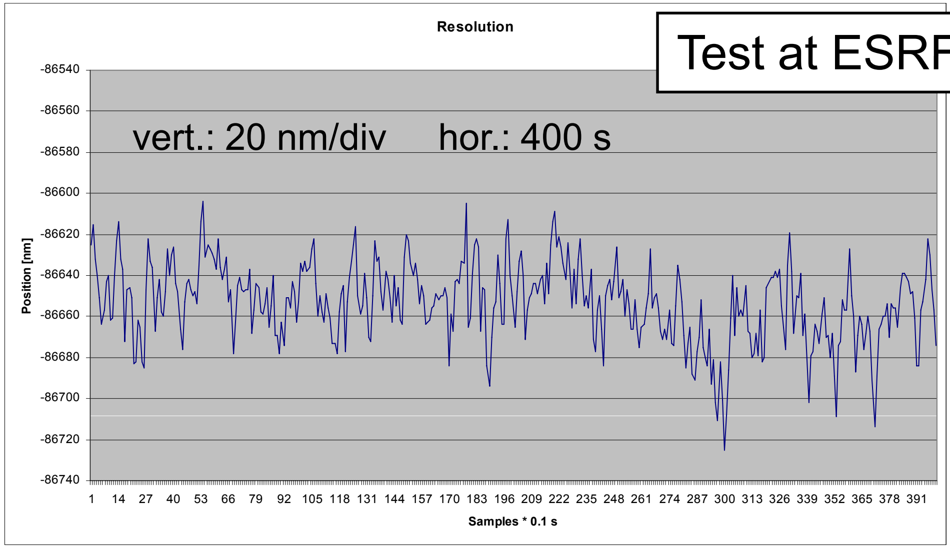
8-hour stability (Ambient temp. = T ± 1°C)	≤ 1µm peak-peak (pp) or max. -80dB for **Δ/Σ**
Temperature drift (Ambient temp. range: 10 to 35°C, Input power = -20dBm)	≤ 0.2 µm/°C or max. -94dB/°C for **Δ/Σ**

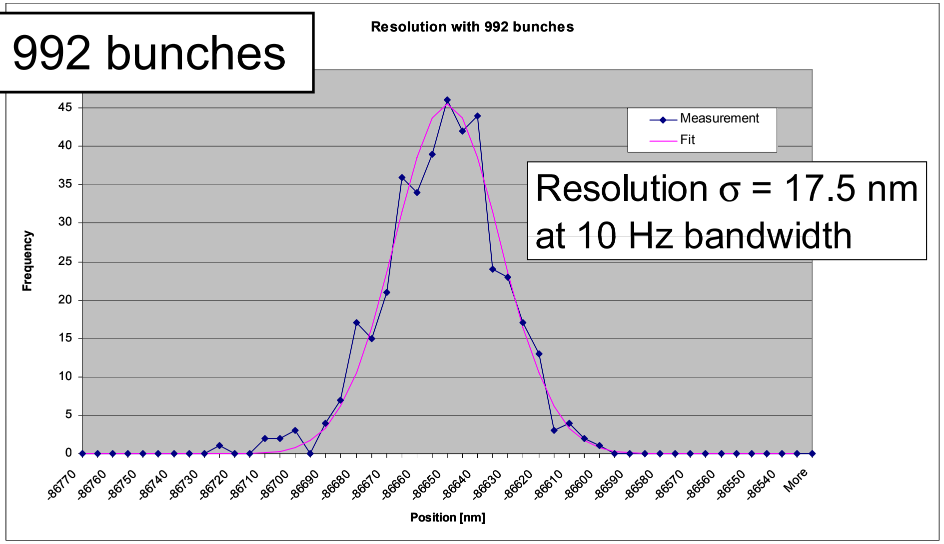
- 8 hour stability: The position reading has to be constant within a 1 µm band during an 8 hour period at constant ambient temperature (stabilized to 24±1 °C) and constant input power.
- Temperature stability: The position reading has to be constant within a 5 µm band during an 8 hour period with a ramp of the ambient temperature from 20 °C to 30 °C and constant input power.

Status BPM Electronic:

✓ Many successful tests in laboratory, PETRAII and ESRF.
✓ Extensive communication with I-Tech, Soleil, DIAMOND, ESRF and Libera users
✓ Useful firmware exist since middle 2006. Startup was troublesome.
✓ Latest version fulfills our requirements on slow orbit resolution and stability.

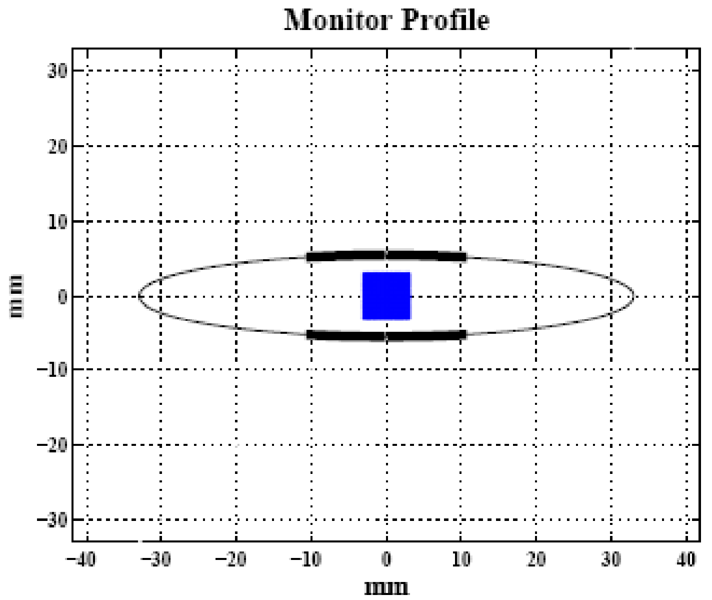
Test at ESRF: 992 bunches

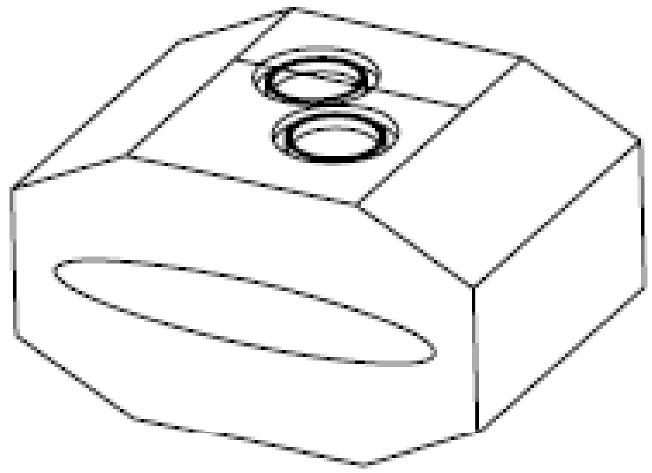


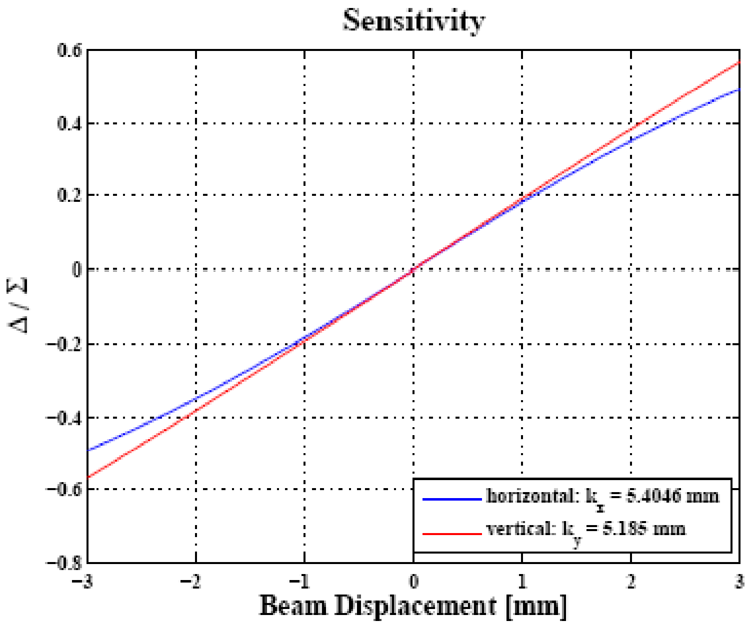


✓ Fast Data transfer (**turn by turn = 130 kHz**) exists since July 2006. Tests were very promising.
✓ Detailed specifications are in preparation
• Additional electronics necessary for distribution of triggers, clocks, alarms, etc.
• Test of temperature stabilized 19"racks (≈ ±1 0C) ongoing.

Special BPM chamber for high sensitivity







As already noticed, a slight touch of the cables may have led to jumps in the position value. This was proved online by watching the readout values, but no dedicated experiment was recorded. However, in the data one can find these kinds of jumps but we can correlate it no more with touches. Fig. 12 shows such a jump of 0.135 μm but offline observations had shown some μm jumps, too.

…

Fig. 12 shows also some kind of slow oscillations, which are also visible in other samples. The setup was done in a way to avoid influenced from real beam oscillations, but this might be an residual effect of real beam oscillations or effects from LIBERA itself (1/f noise?). Note that the amplitude of these oscillations is very small (≈ 0.01 μm).

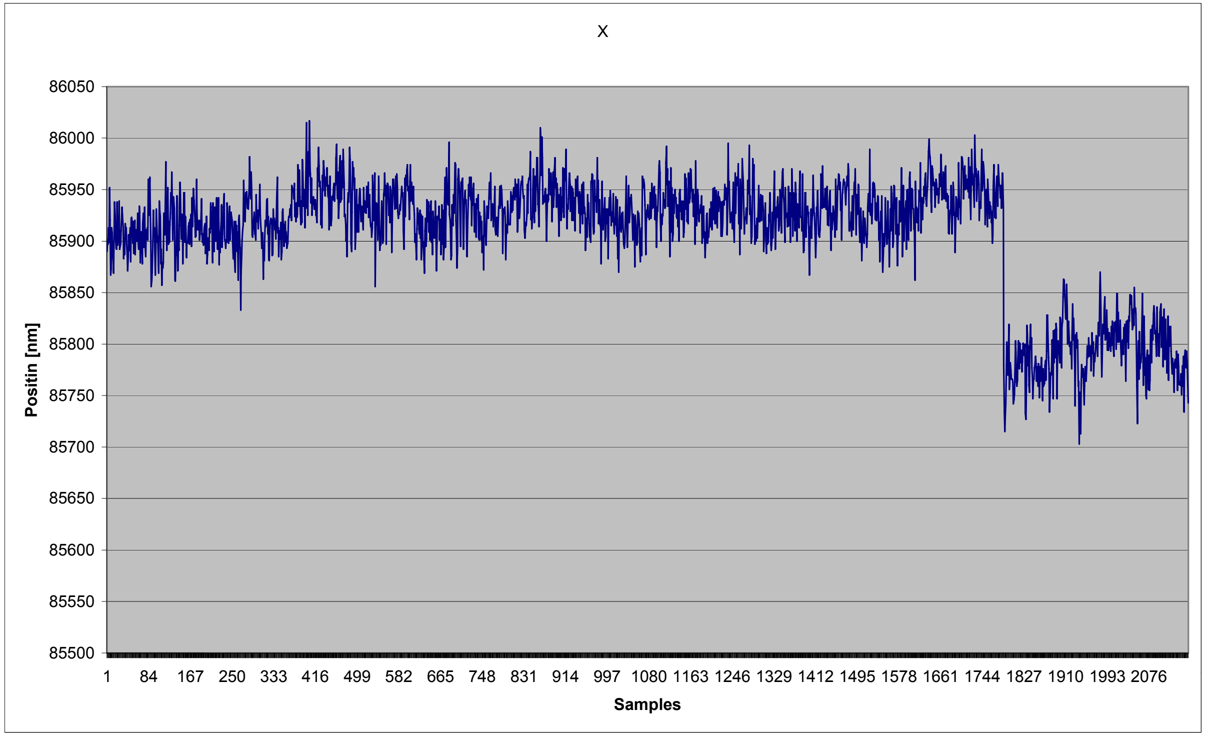
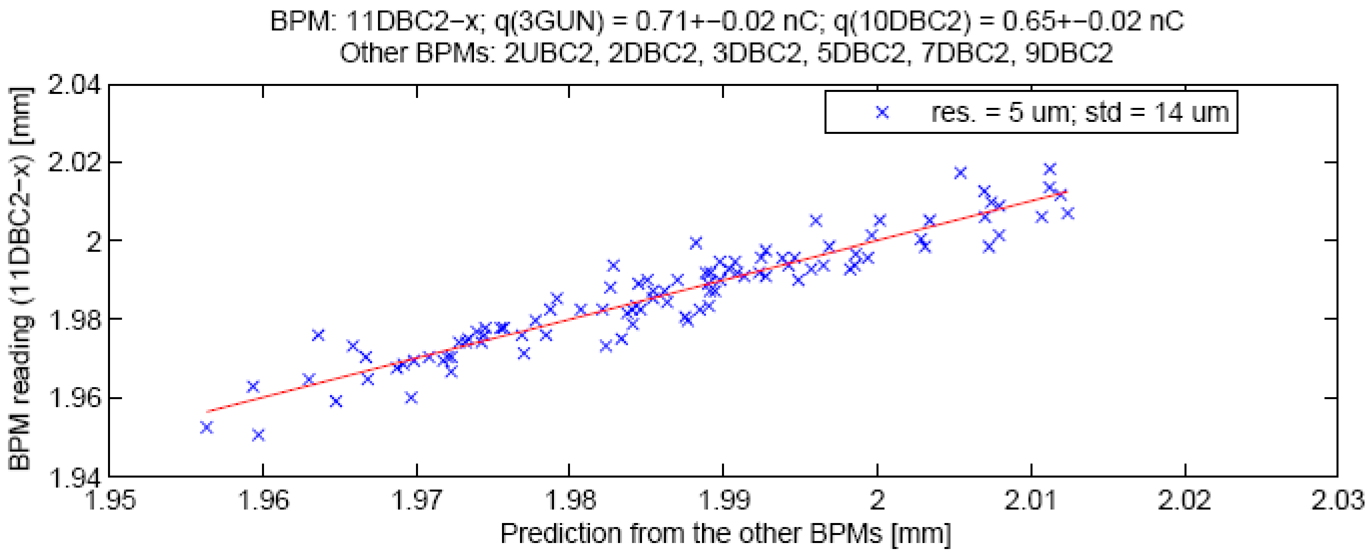
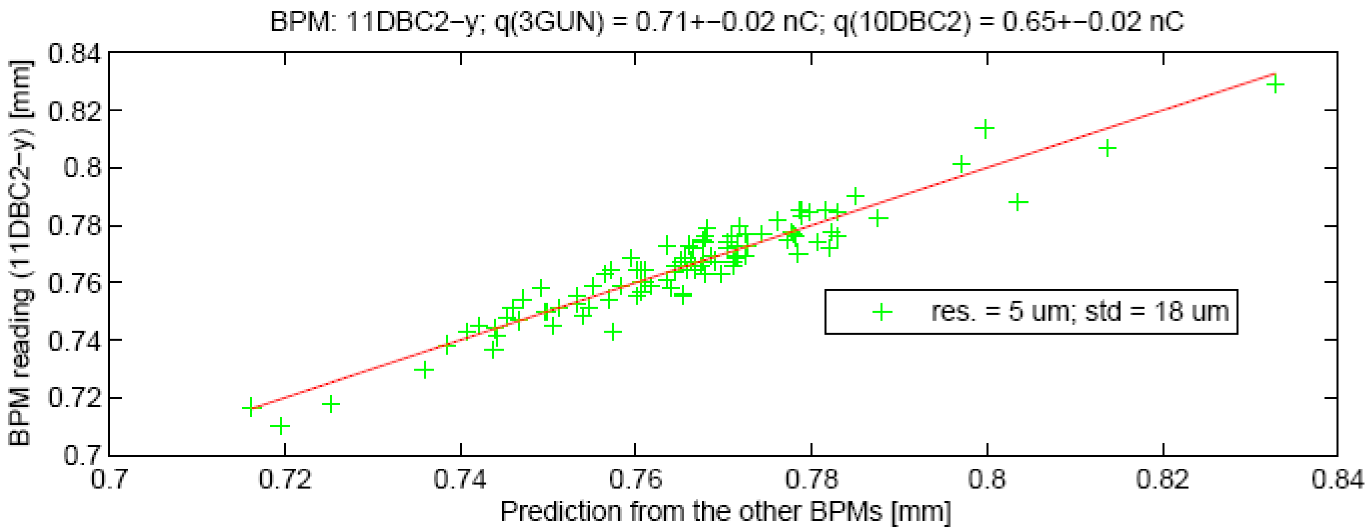


Fig. 12: Jump of x-position

FASH experience





Stripline BPM:

Bunch distance: 100 ns

Will work with ≈50 ns without any changes


The End
now open for
discussion

WPS

CLIC NOTE 553
January 2003
AN ACTIVE PRE-ALIGNMENT SYSTEM AND METROLOGY NETWORK FOR CLIC
F. Becker, W. Coosemans, R. Pittin, I. Wilson

The first?

TN-65-74
September 1965

PART I

THE USE OF A MAGNETIC PICKUP AS AN ALIGNMENT INDICATOR WITH A STRETCHED-WIRE TECHNIQUE

W. K. H. Panofsky

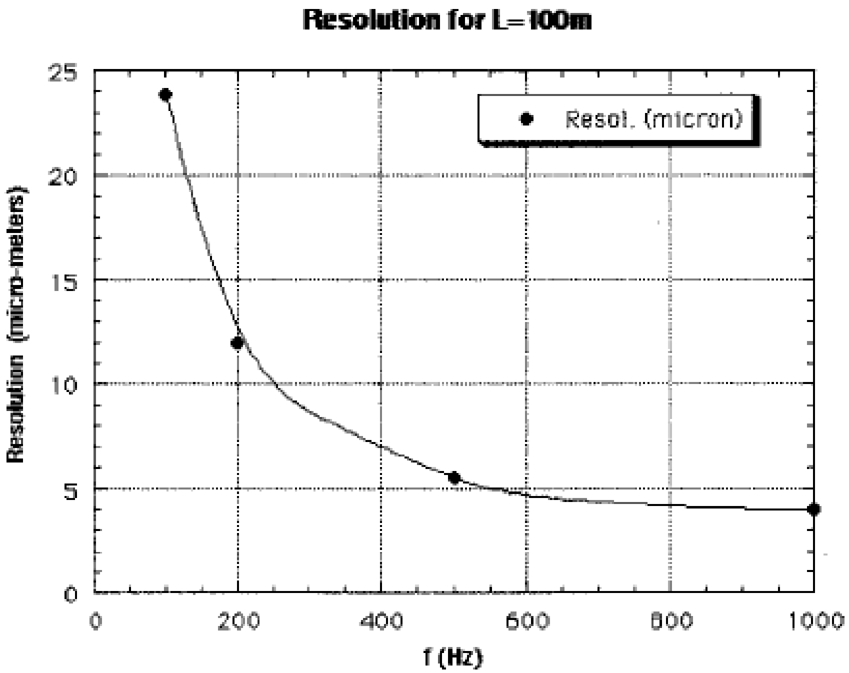


Fig.2: Resolution for L=100m

STRETCHED WIRE METHOD FOR MAGNET ALIGNMENT WITH MEDIUM FREQUENCY CURRENT

Ryuhei Sugahara, Yasunobu Ohsawa, Norihito Ohuchi and Masato Yoshida
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Oho 1-1, Tsukuba-shi, Ibaraki 305-0801, Japan