



Introduction

- Hydrostatic Levelling Systems and Wire Position Systems frequently used in accelerators

- Recent installation of monitoring systems in accelerators
 - Large Hadron Collider (LHC) final focus magnet monitoring (HLS and WPS)
 - Linear Coherent Light Source (LCLS) undulator section (HLS and WPM)
 - Several applications at FNAL (HLS)

- Future accelerators plan to use in monitoring and alignment applications these systems
 - Compact Linear Collider (CLIC)
 - International Linear Collider (ILC)
 - as shown yesterday : KEK / SPring-8

- New sensors were introduced in recent years
 - Budker Institute of Nuclear Physics: capacitive HLS, ultrasound HLS, different types of communication
 - Deutsches Elektronen-Synchrotron: ultrasound HLS

- CLIC prealignment workshop in 2009 at CERN
 - Overview on existing technologies and applications
 - Discuss possibility of intercomparison of the sensors and systems
 - Conclusion on establishing an intercomparison of the sensors presented and institutes that host the tests

Aim

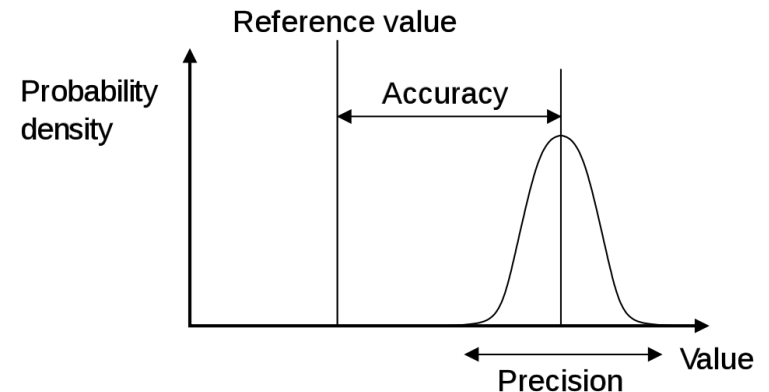
- compare existing
 - HLS with respect to each other
 - WPS with respect to each other

Objectives

- creating same test criteria, conditions and infrastructure
 - institutes hosting the tests
 - same analysis methods
- Investigation into sensor's performance
 - stability, linearity, repeatability, resolution
 - precision, accuracy

and not

- investigate into new technologies, e.g. laser alignment





Aim and Objectives (II)

Steps

- creating same test criteria, conditions and infrastructure
 - institutes hosting the tests
 - Same analysis methods

- Investigation into sensor's performance
 - Longterm stability, linearity, repeatability, resolution
 - Precision, accuracy

- Conclusions on the tests carried out in the „as is“ configuration

- Modification of setup or in sensor
 - Data acquisition module, analysis modes
 - Other references, e.g. interferometer, as external reference

- Final conclusions



Sensors

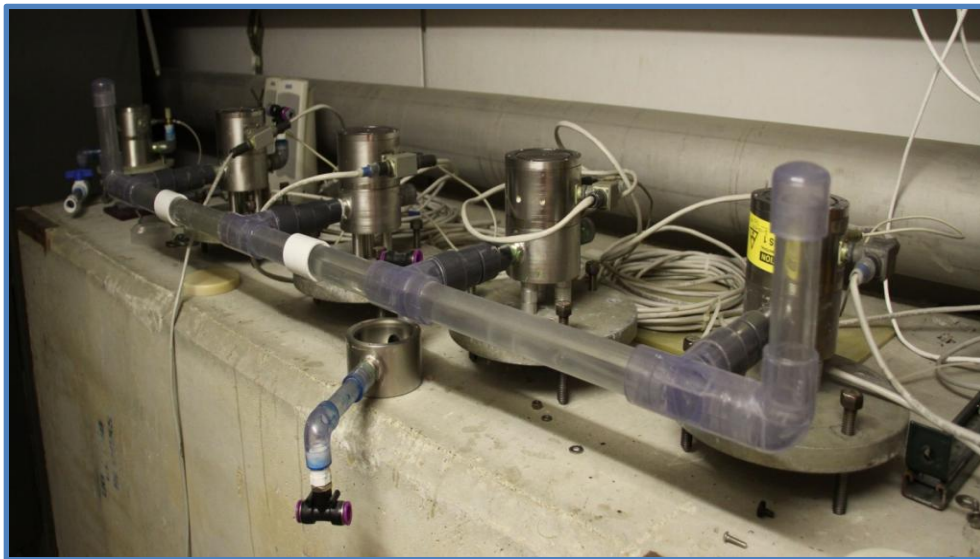
Sensors as they were presented at the CLIC prealignment workshop 2009 at CERN:

Hydrostatic Levelling Sensors

- technology
 - capacitive
 - ultrasound
 - CCD camera / floating device
- Institutes / manufacturers
 - Capacitive FOGALE nanotech (CERN, ESRF, KEK, Soleil, ...)
 - Capacitive BINP SAS and SAS-E (SLAC, FNAL)
 - Capacitive proximity sensors THLS (FNAL)
 - Ultrasound BINP ULSE (SLAC, FNAL)
 - Ultrasound DESY (DESY)
 - CCD camera / floating device (USTC)
 - Capacitive Edi Meier & Partner (PSI)

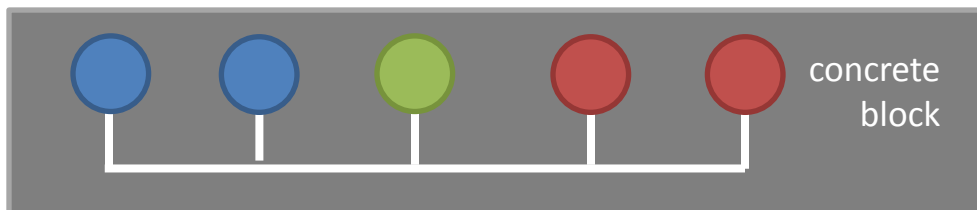
Wire Position Sensors

- technology
 - capacitive
 - optical
 - radio frequency
- Institutes / manufacturers
 - Capacitive FOGALE nanotech (CERN, ESRF, SLAC, DESY, ...)
 - Optical WPS Open Source Instruments (CERN, DESY)
 - Radio Frequency WPM (SLAC, DESY)
- Wires
 - carbon-peek, carbon-pes
 - Vectran
 - Gold coated stainless-steel



FNAL provides as infrastructure:

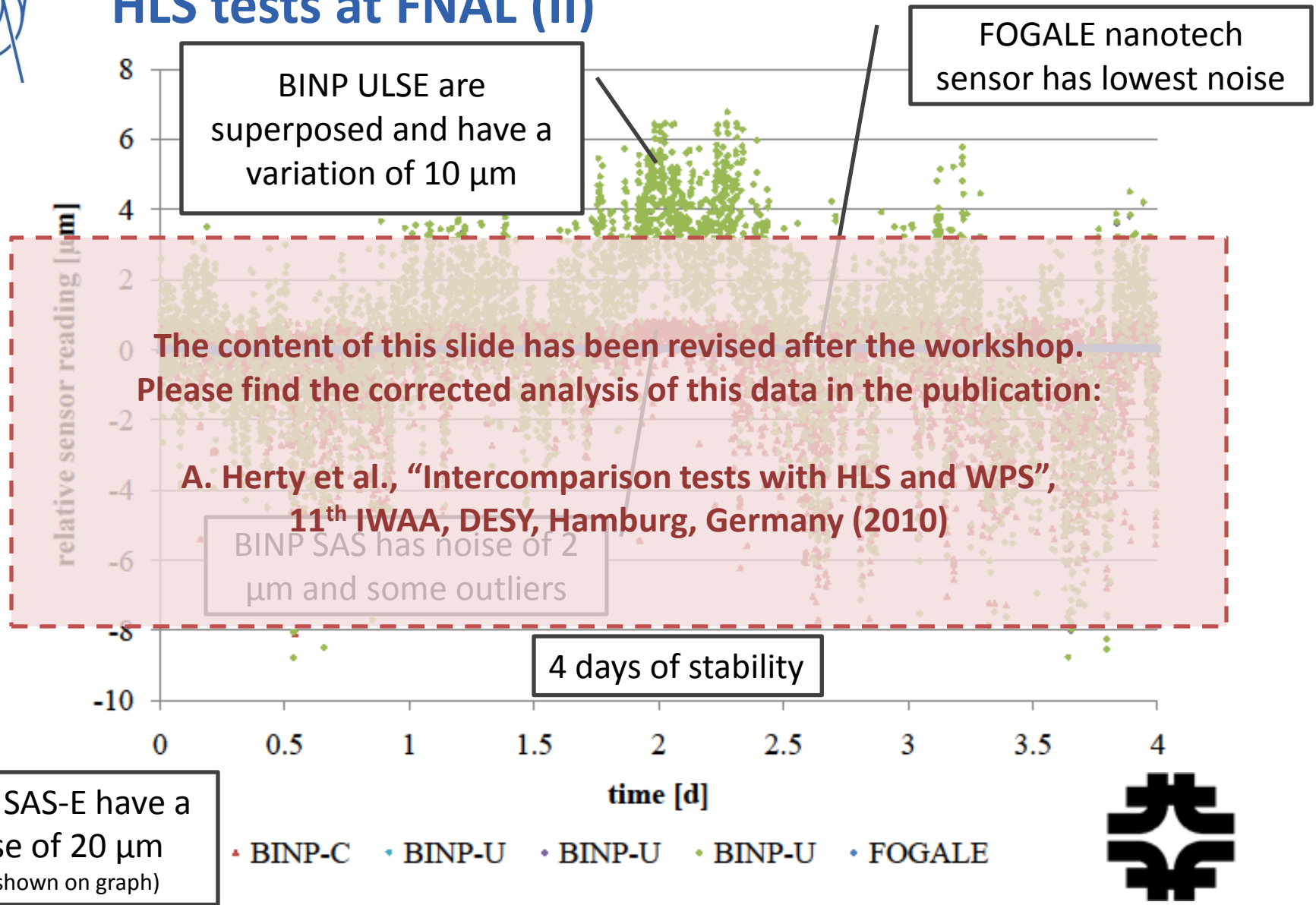
- System installations with the same sensors (Tevatron HLS, BINP SAS, BINP SAS-E, BINP ultrasound ULSE)
- J. Volk will give more details about the tests per type of sensor
- One setup with different types of capacitive sensors, including CERN's Fogale nanotech HLS

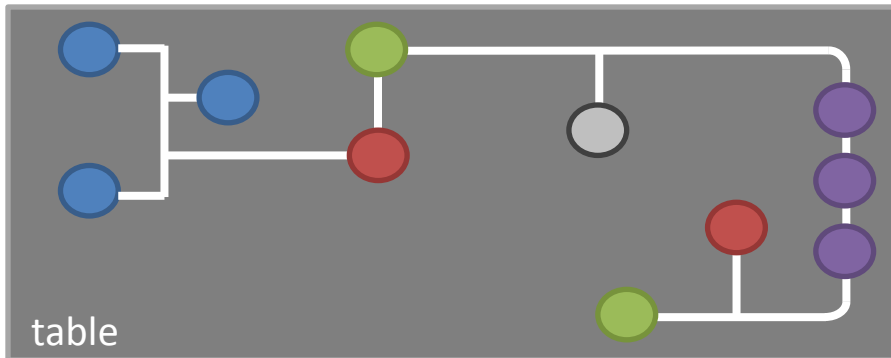


- BINP SAS
- HLS FOGALE nanotech
- BINP SAS-E



HLS tests at FNAL (II)





table

- USTC
- FNAL SAS-E
- FNAL THLS
- CERN CHLS
- Filling and evaporation station

CERN provides as infrastructure:

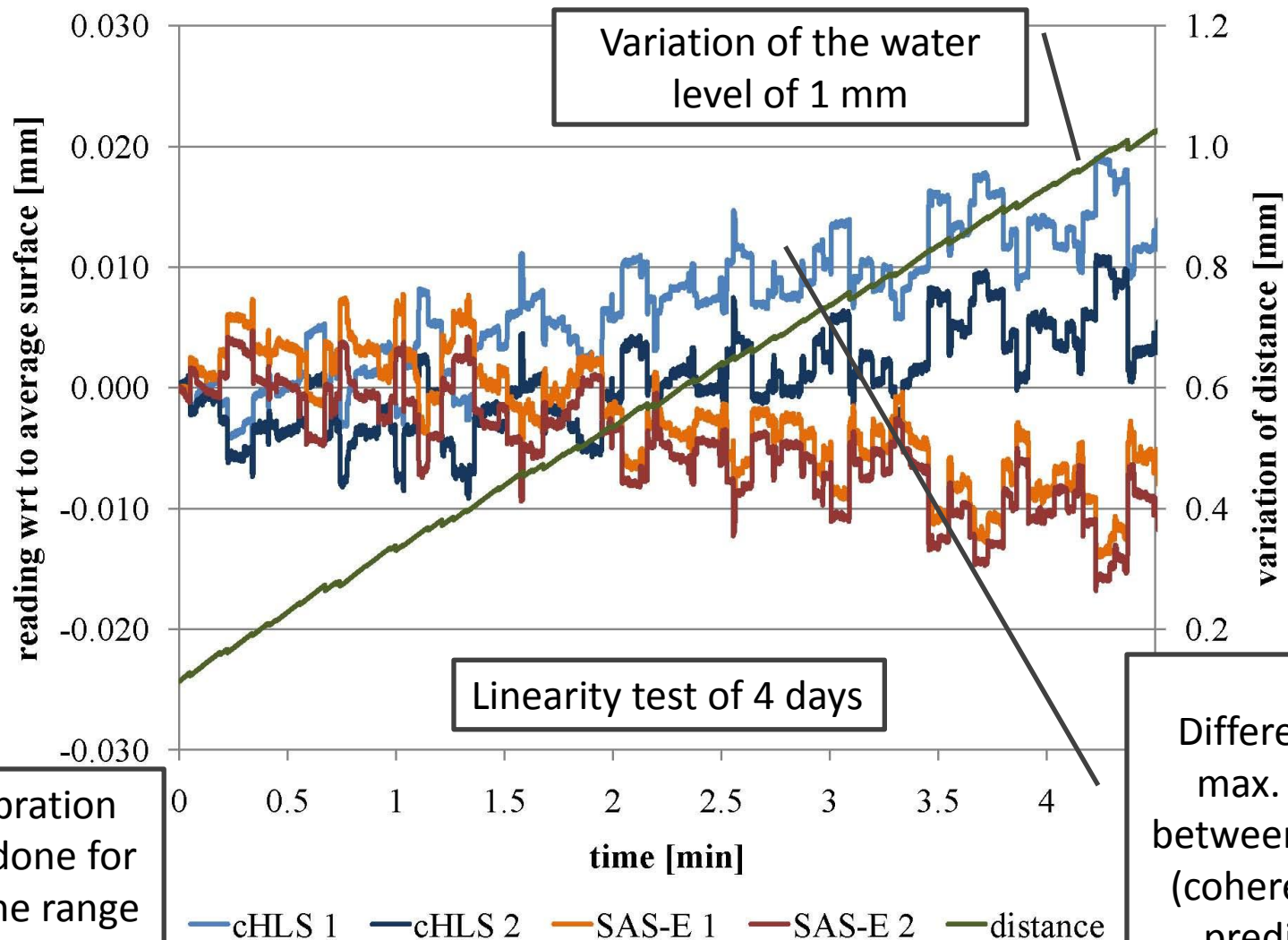
- Variety of sensors provided by the different institutes

Plans for the near future:

- Modify temporary installation (to check sensors function) to a designed bench
- Provide automatic station to vary water level
- Check calibration of capacitive sensors on calibration bench available at CERN
- Cross check calibrations for capacitive sensors at ESRF

→ during a research exchange with USTC for the duration of 3 months

HLS tests at CERN (II)

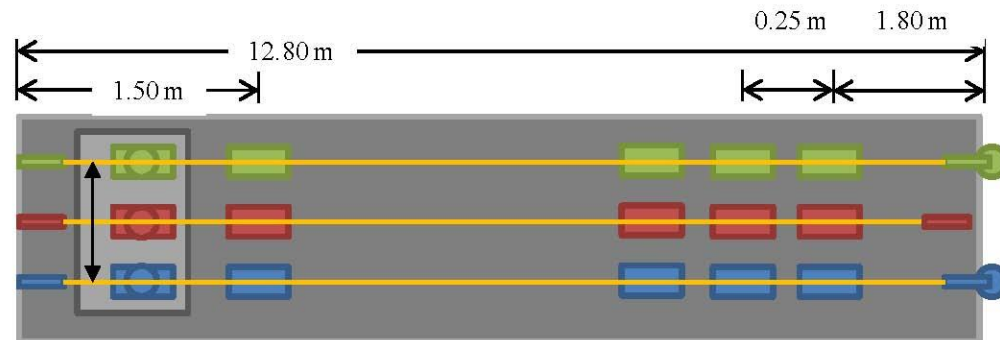
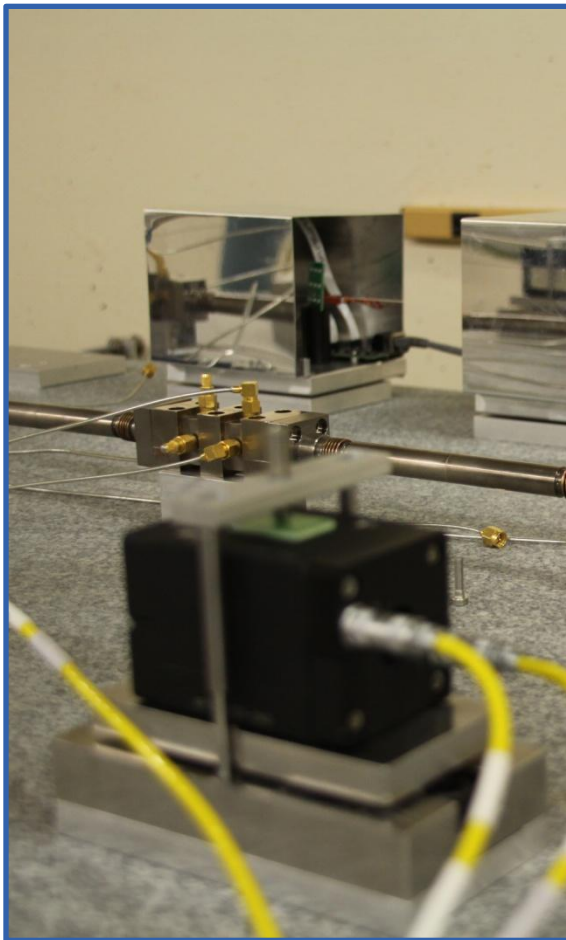


THLS calibration has to be done for knowing the range of the sensor

Differences of max. 15 μm between sensors (coherent with prediction)

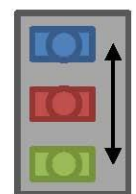
SLAC provides as infrastructure:

- Granite table in air conditioned calibration laboratory
- Wire displacement unit to displace all wires at the same time by the same amount



- CWPS
- WPM
- OWPS

- wire termination
- wire pulleys
- wire (different types)



moveable plate

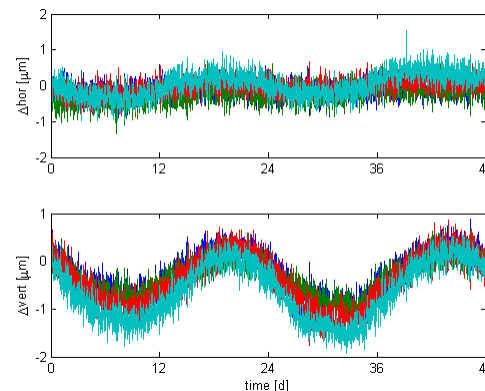
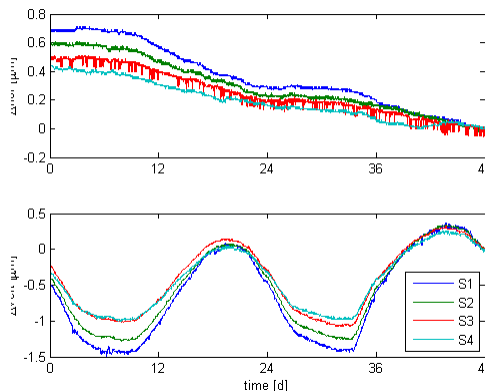
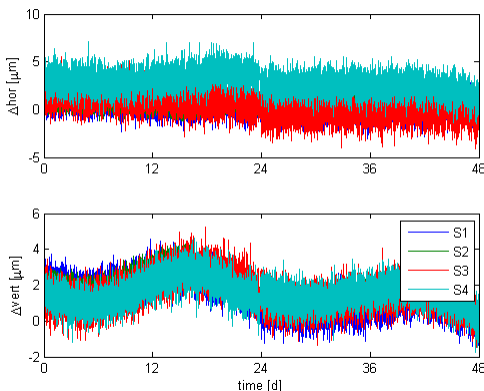
WPS tests at SLAC (II) – RESOLUTION

Open Source Instruments

SLAC RF WPM

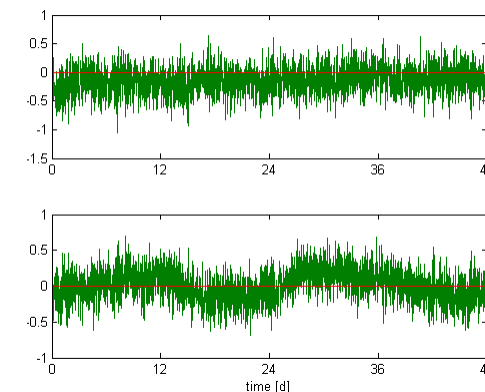
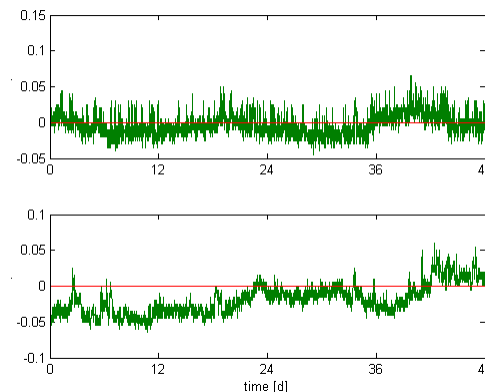
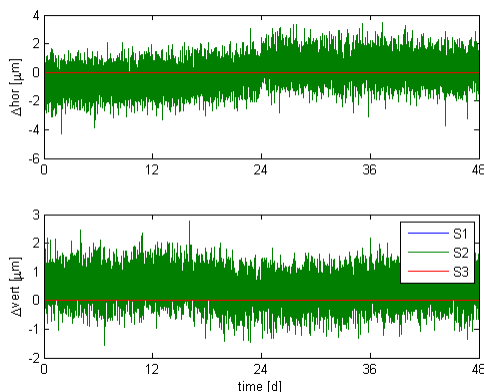
FOGALE nanotech

Sensor relative measurements



horizontal
vertical

Reduced by wire movements

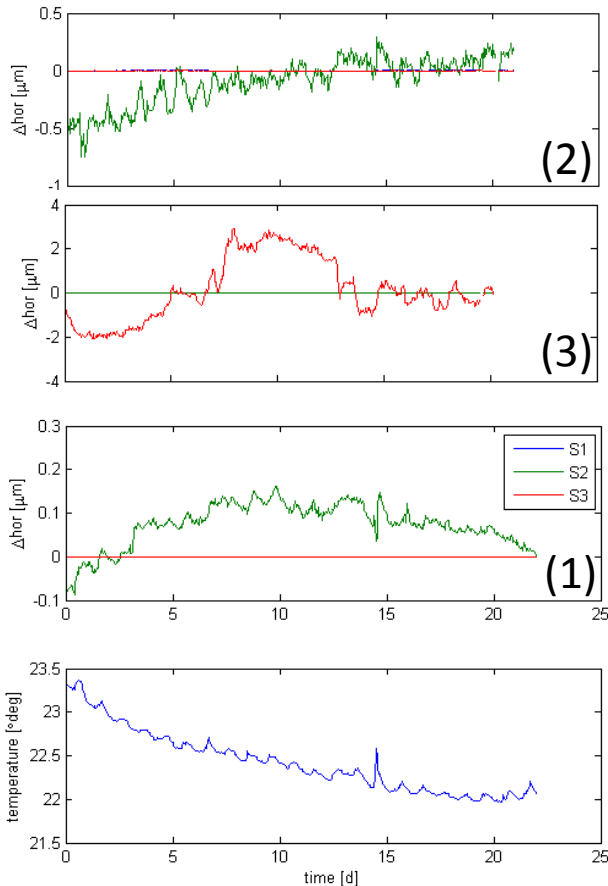


horizontal
vertical

$\pm 1.0 \mu\text{m} \cdot 1 \text{ sample}$

$\pm 0.02 \mu\text{m} \cdot 3.000 \text{ samples}$

$\pm 0.2 \mu\text{m} \cdot 30 \text{ samples}$



	RF WPM (1)	FOGALE nanotech (2)	Open Source Instruments (3)
Resolution horizontal	0.02	0.24	0.99
Resolution vertical	0.02	0.23	0.53
Stability (3weeks)	< 0.20	< 0.75	< 3.00

measurements in μm

- Stability does not take into account parameter changes in the wire
- Resolution different in X and Y for OSI sensor due to configuration of sensor



Future steps

Hydrostatic Levelling Sensors

- Complete installation of test benches
 - CERN: In collaboration with USTC; three months technical exchange
 - FNAL: Modification of installation for multi-sensor network
- Check calibration of capacitive sensors
 - CERN: on automated calibration bench
 - ESRF: cross check of CERN results on their automated calibration bench
- Long term stability measurements (FNAL)

Wire Position Sensors

- Complete installation of test benches
 - SLAC: install wire displacement unit and HLS sensors to monitor bench
 - CERN: continue validation of optical WPS (Open Source Instruments)

All sensors

- Validate their calibration function
- Compare resolution, precision and accuracy of sensors
- New ideas for comparison of the sensors and analysis of the measurements



Summary

- existing sensors and technologies have been identified at CLIC-PRAL workshop 2009
 - HLS: capacitive, ultrasound, CCD array
 - WPS: capacitive, optical and radio frequency
- Intercomparison has been agreed on
 - to provide sensors
 - to host test installations
- Concepts for tests have been evaluated between the hosting institutes
- Installation of benches took place in summer 2010 at FNAL, SLAC and CERN
- Evaluation of results is starting as shown in this presentation
- Discussion of the results
- Making results available for alignment community

