Commissioning of the Fiber-Optical-Sensor (FOS) environmental and structural monitor

AIDA 3nd Annual meeting WP9.4

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Outline

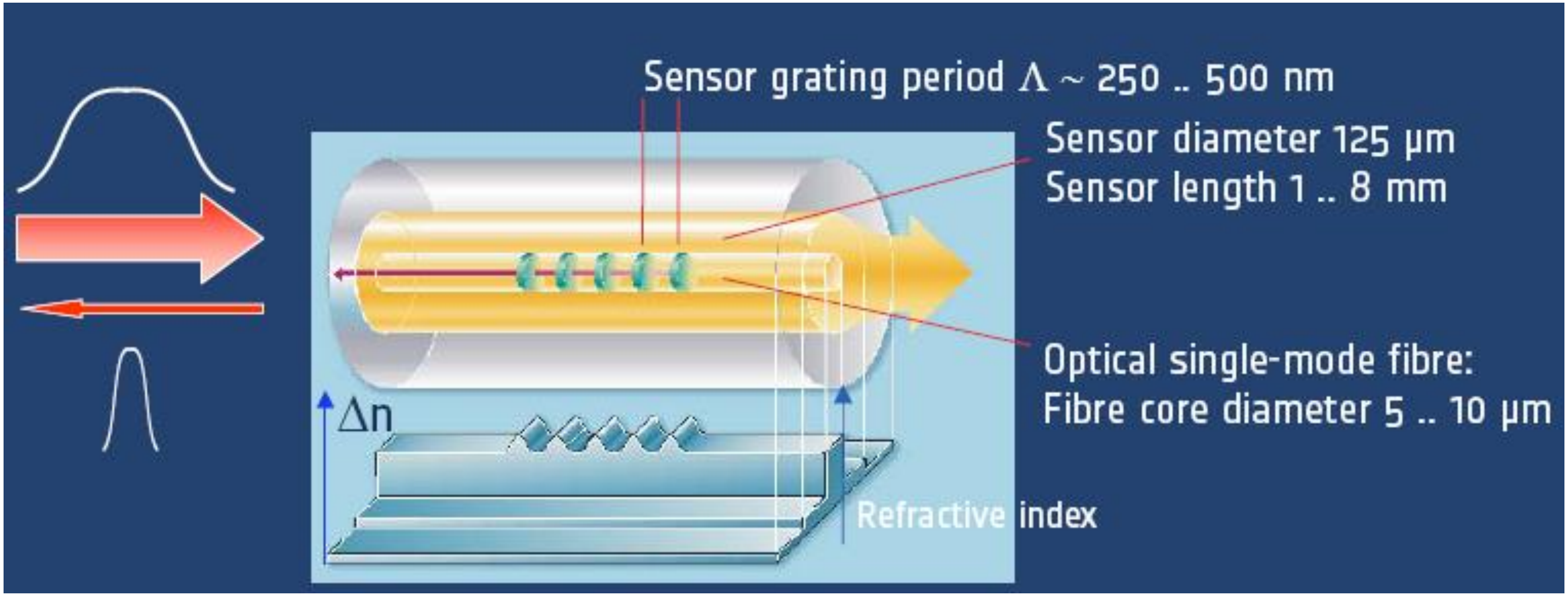
- FOS monitor (basics)
- First cases of use:
  - Temperature, humidity and vibration monitoring of the Belle-II vertex test beam @ DESY (January 2014).
  - Fast (1Khz) thermal monitoring of power pulsed ILD DEPFET dummy ladder (**I.Garcia talk**)
- Summary

FOS Monitor context

- Part of a JRA activity to produced a thermo-mechanical infrastructure.
- Specifically: Temperature, displacement (vibrations) and humidity using Fiber Bragg Gratings sensors.
- Development approach, integration of:
  - Tailored commercial off-the-shelf optical interrogator.
  - Sensing architecture (distribution and multiplexing)
  - Application specific FBG calibrations (temp, HR%, displacements).
  - Dedicated daq software (standalone and integrated in EPICS scada)

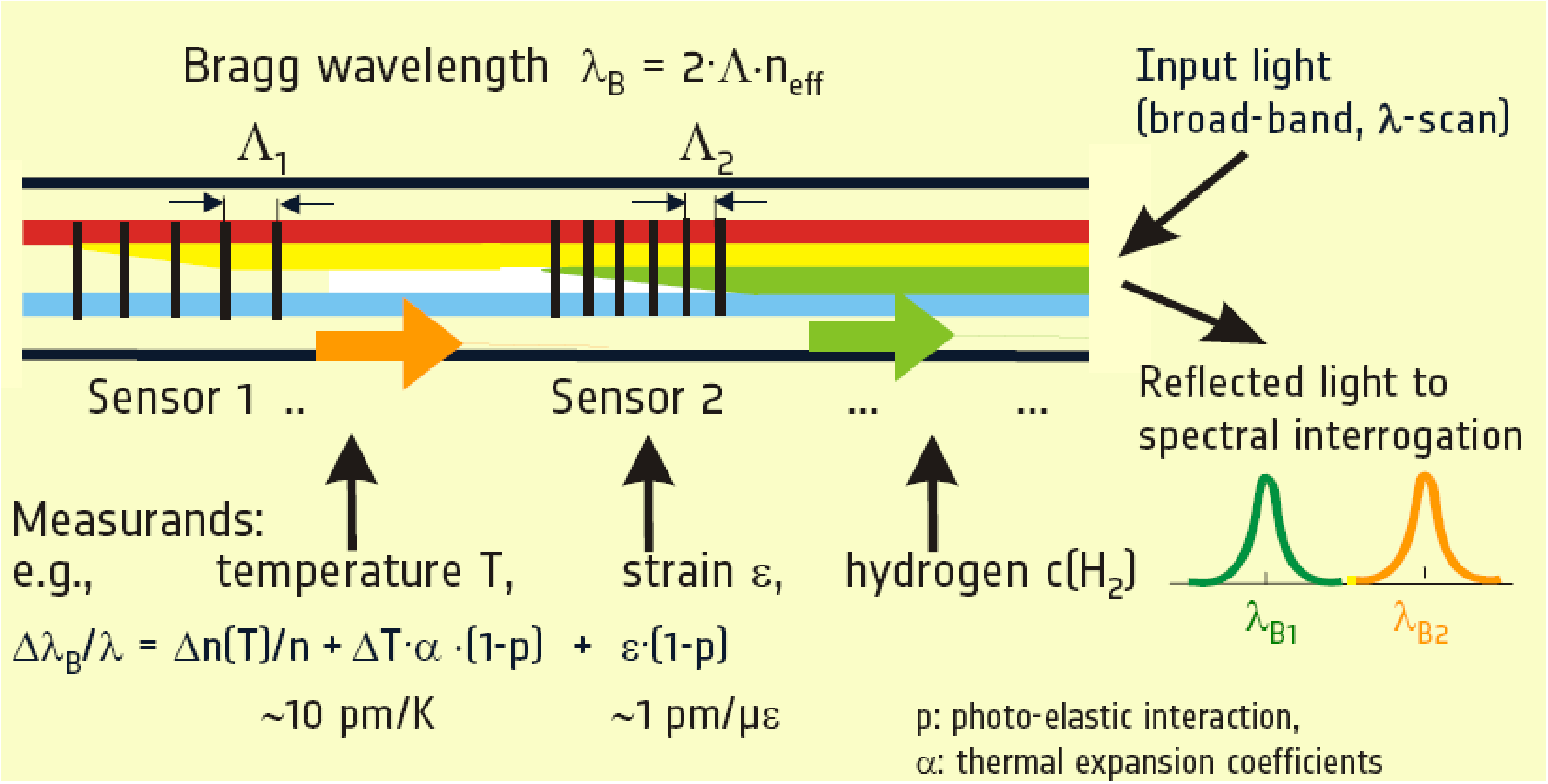
Why FBG sensors:

1. Light, robust, passive, small foot-print = non invasive integration



Why FBG sensors ?

2. Easy to multiplex (tens of sensor per optical fiber)



Why FBG sensors ?

3. Many other advantages with respect with conventional monitoring technologies.

General attributes of fibre optic sensors:

- Immunity against, i.e., applicable in
  - Electro-magnetic fields, high voltage, lightning
  - Explosive or chemically aggressive + corrosive media
  - High and low temperatures
  - Nuclear / ionising radiation environment (to be specified)
- Light-weight, miniaturised, flexible; low thermal conductivity
- Non-interfering, low-loss, long-range signal transmission ("Remote Sensing")

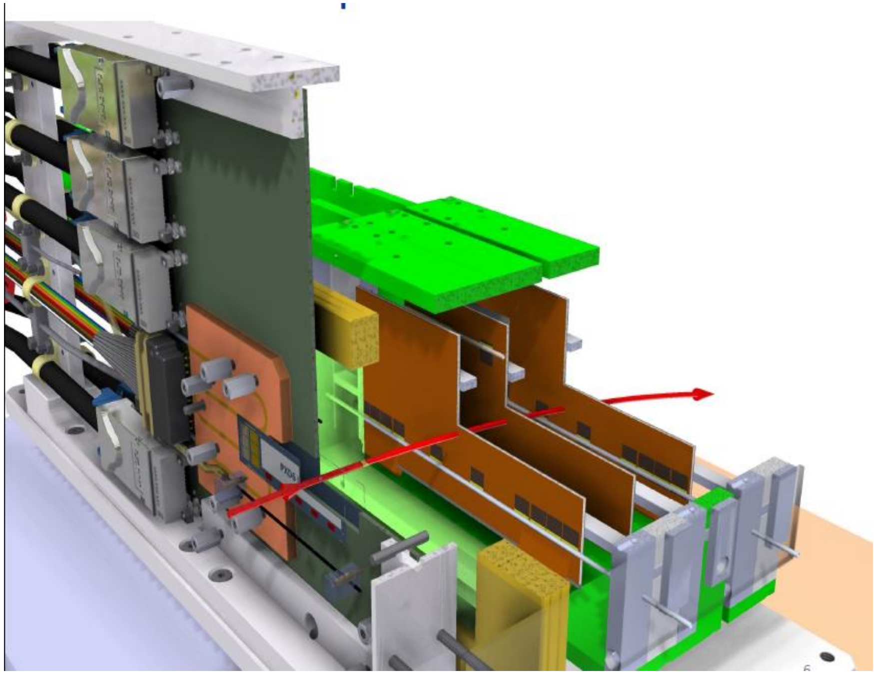
Specific FBG attributes:

- Multiplexing capability ("Sensor Networks")
- Embedding in composite materials ("Smart Structures")
- Wavelength encoded – transferable measurement, neutral to intensity drifts
- Mass producible at reasonable cost
- Durable to high strain 5..6% ("Draw Tower Gratings", with any kind of coating)
- High and low temperatures (4 K .. 900 °C)

First access

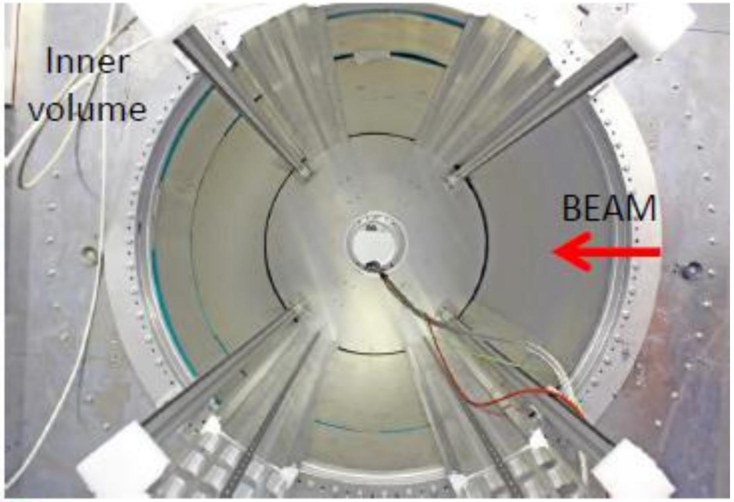
– First access :Belle II PXD-SVD common test beam at DESY
  - Two PXD (DEPFET pixels) Layers+ four SVD (microstrips) layers with a thermal enclosure of nitrogen, all inside PCMAG magnet

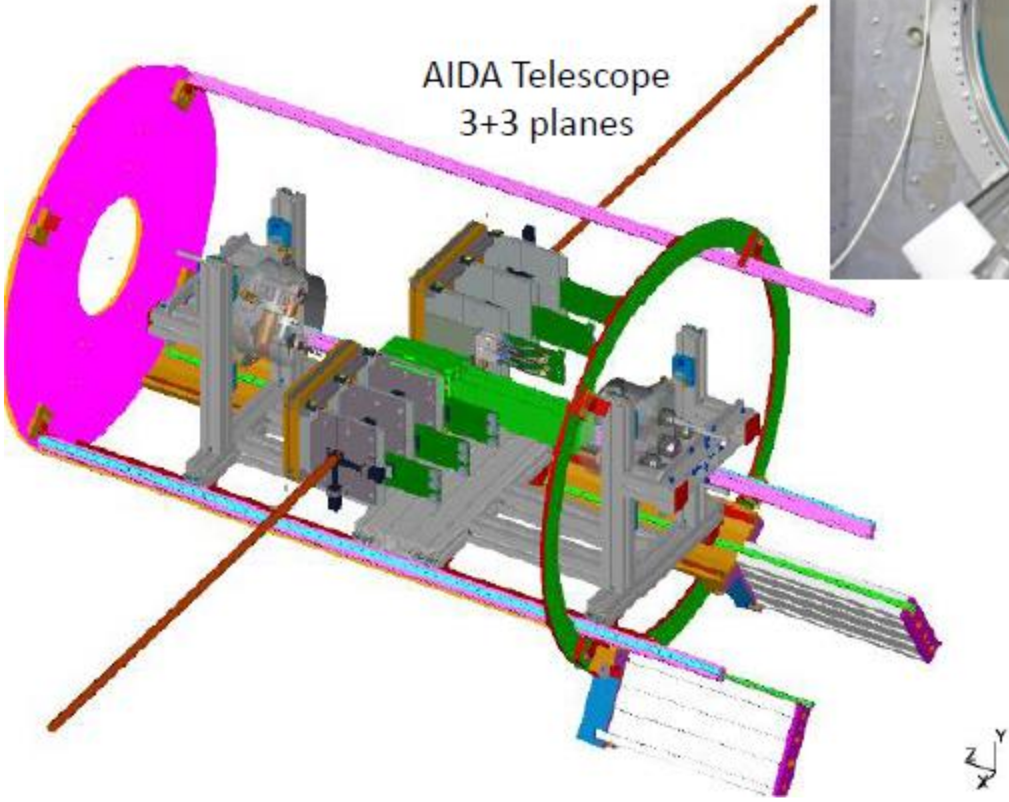
  - SVD sensors CO2 cooled
  - The aim was to measure temperature and humidity within the thermal enclosure and monitor SVD CO2 cooling inlet and outlet pipes temperature.



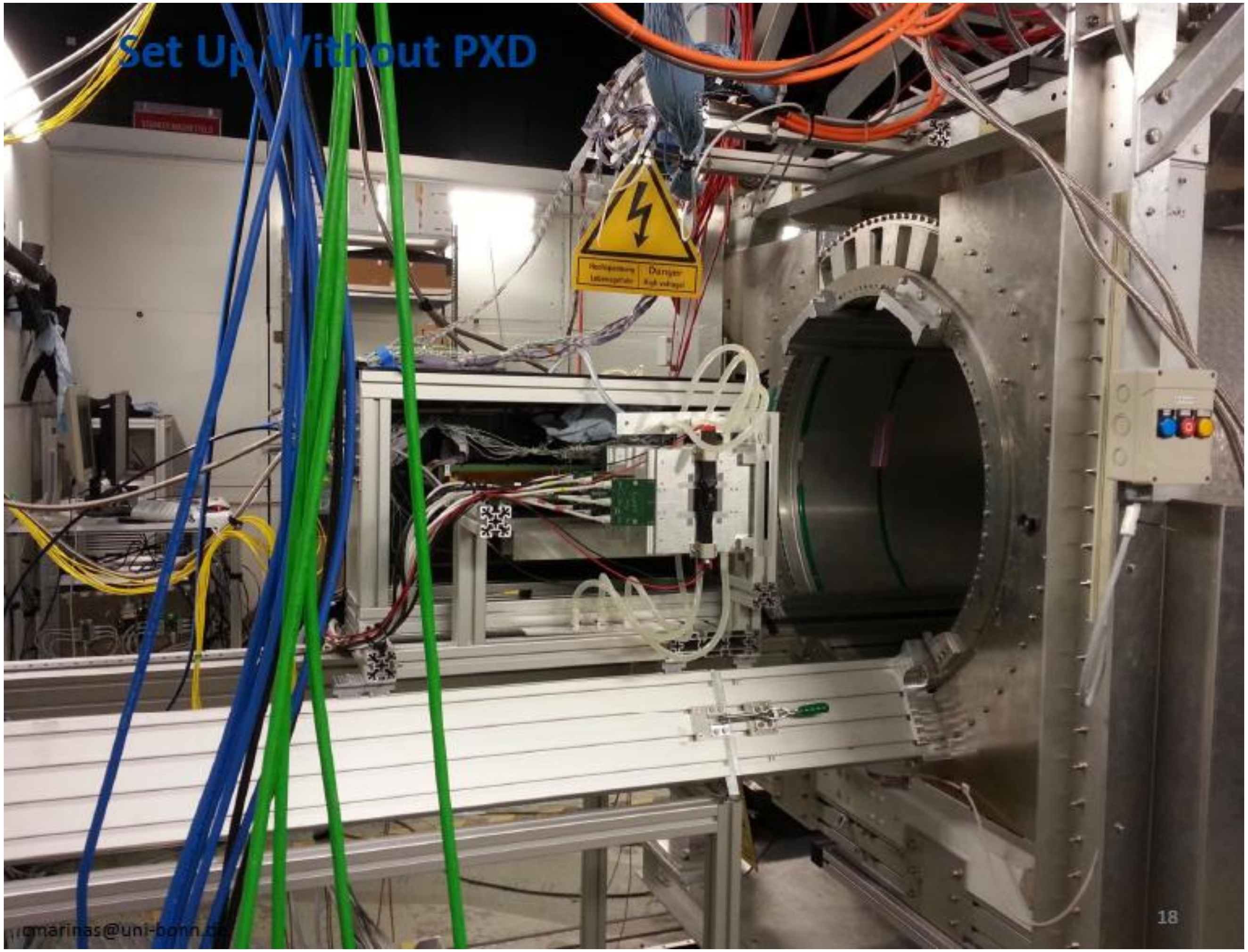
PXD – SVD Integrated test beam set-up

Integration into the PCMAG

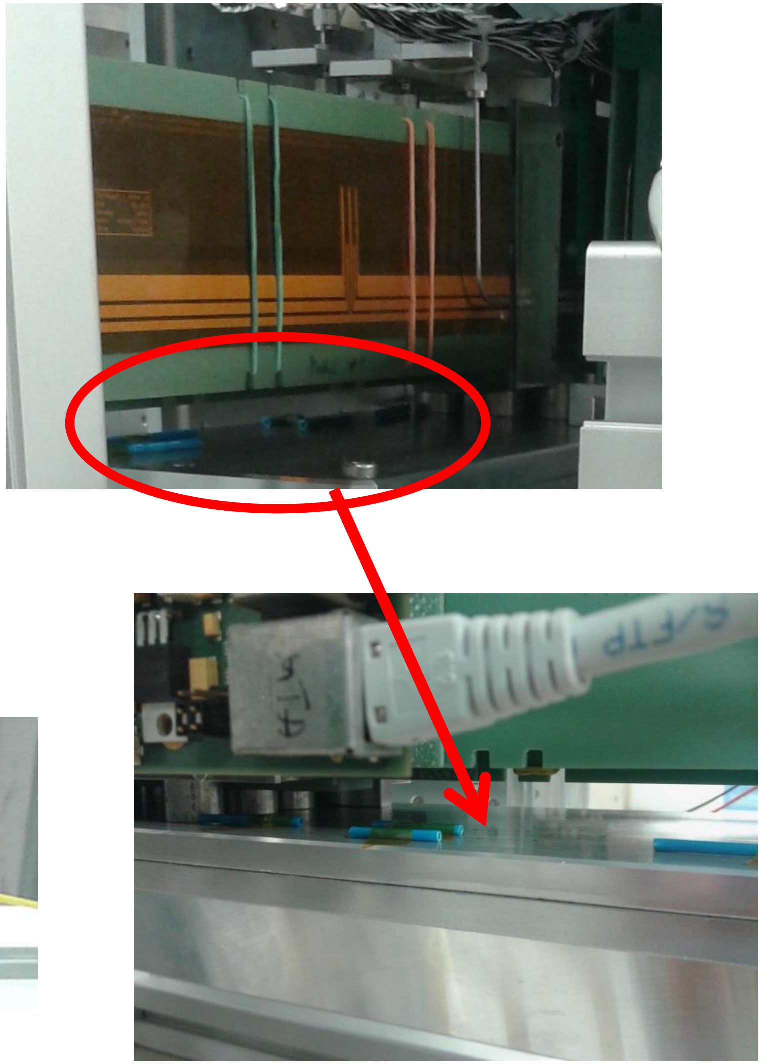


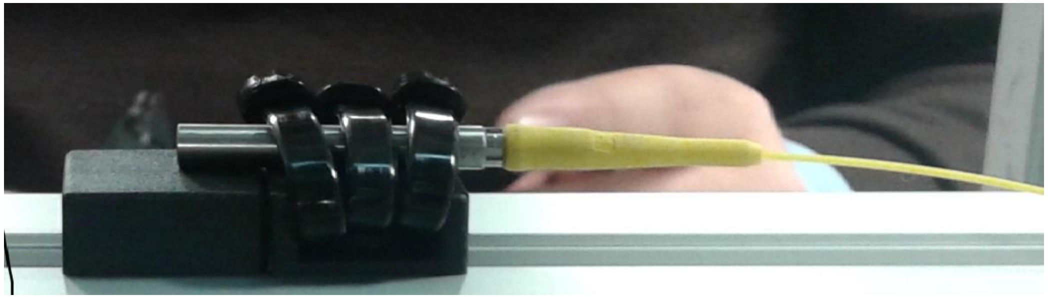


PXD – SVD Integrated test beam



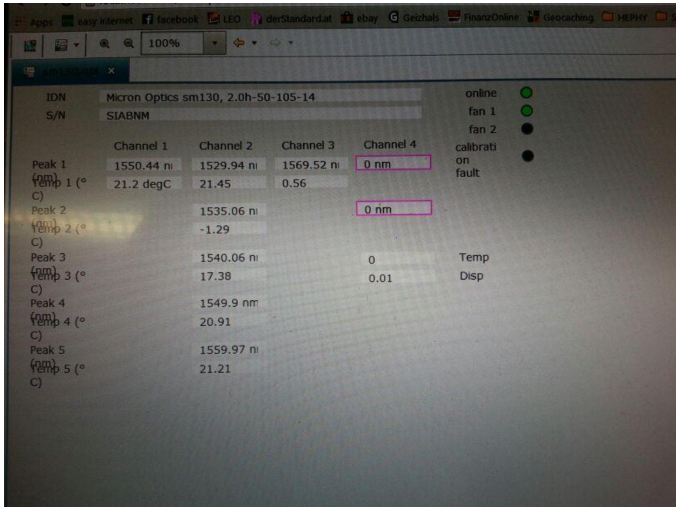
FOS Monitor: FOS Packing



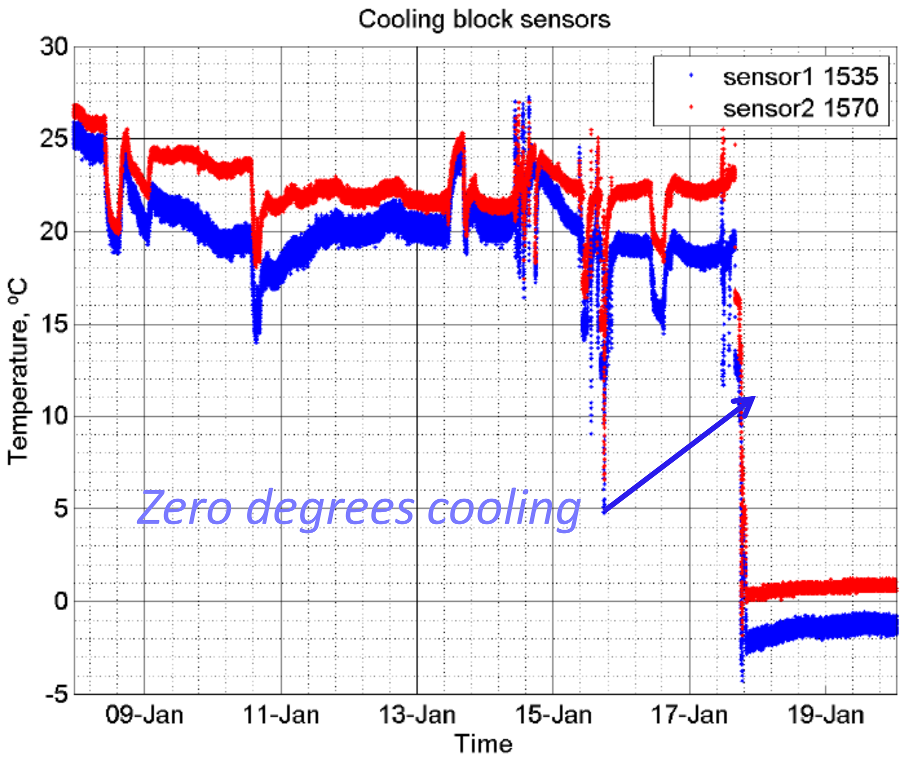


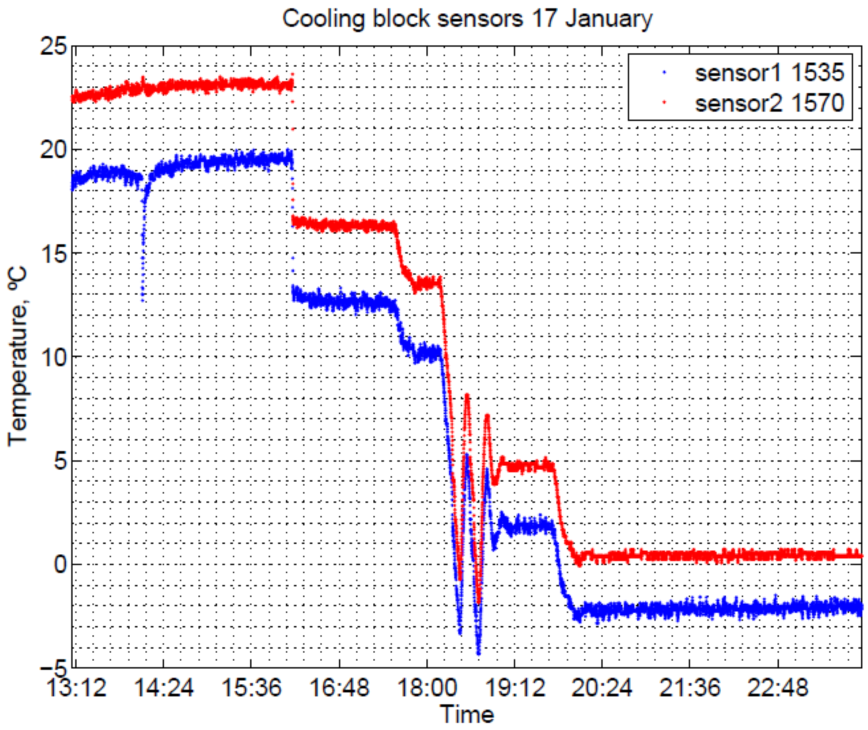
FOS Monitor: DAQ – SC integration

- For the read out , AIDA thermo mechanical set-up dynamic interrogation unit at DESY (SM130-200) used
- Readout integrated in EPICS (dedicated driver over Ethernet). The integration went very smooth ready since the January 6th



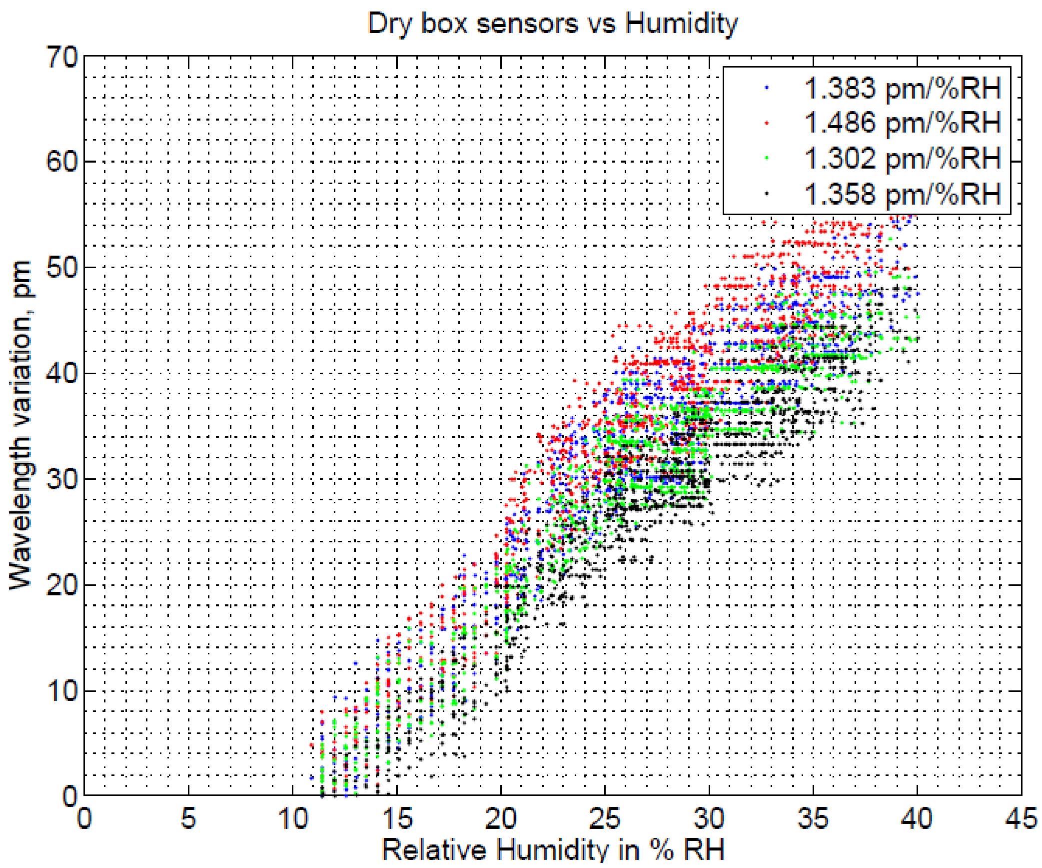
FOS Monitor: Data: MARCO in-let & out-let lines





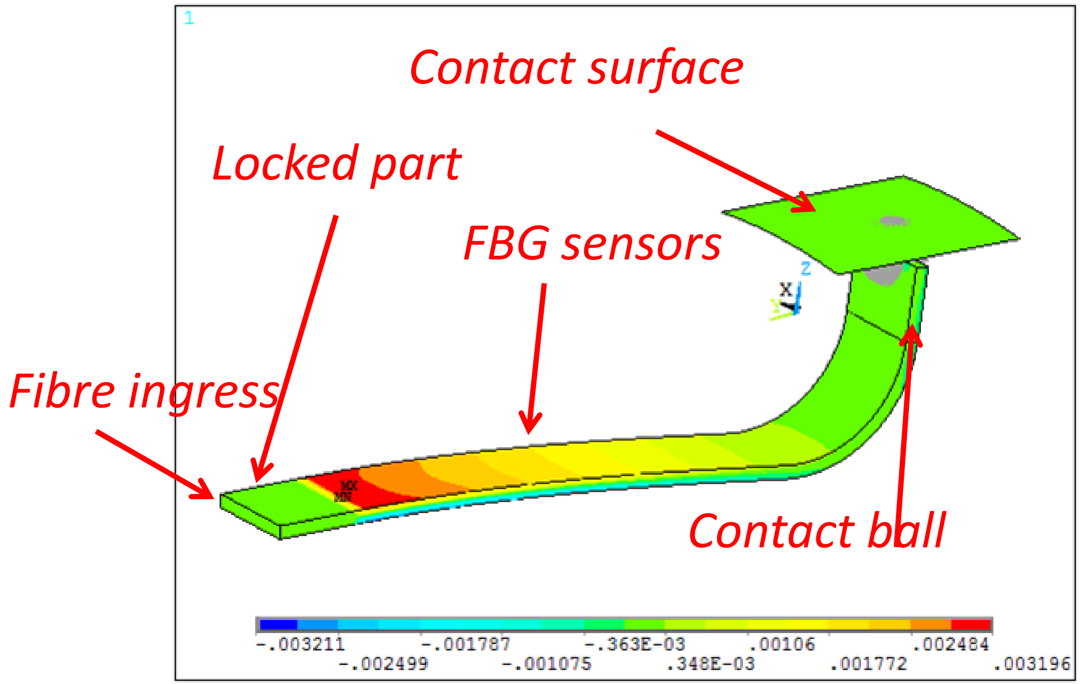
FOS Monitor:Humidity measurements

- Comparing the wavelength shift of ambient sensors (naked fibers) vs. commercial Humidity sensors inside the dry box.
- Excellent linearity and sensibility after temperature compensation



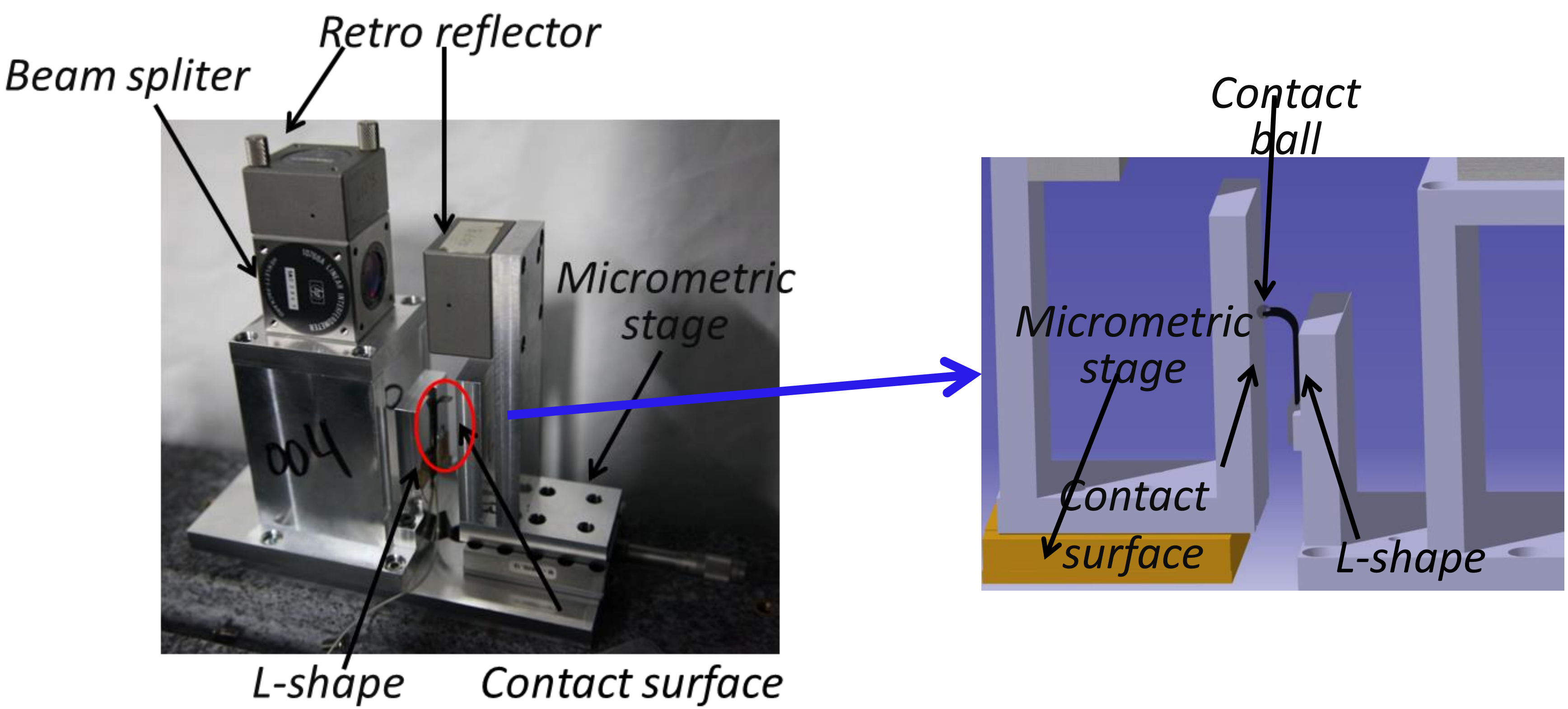
Position transducer: The L-shape

- The idea is to monitor online PXD-SVD relative displacement using an application custom tiny CFRP structure with FBG sensors embedded.



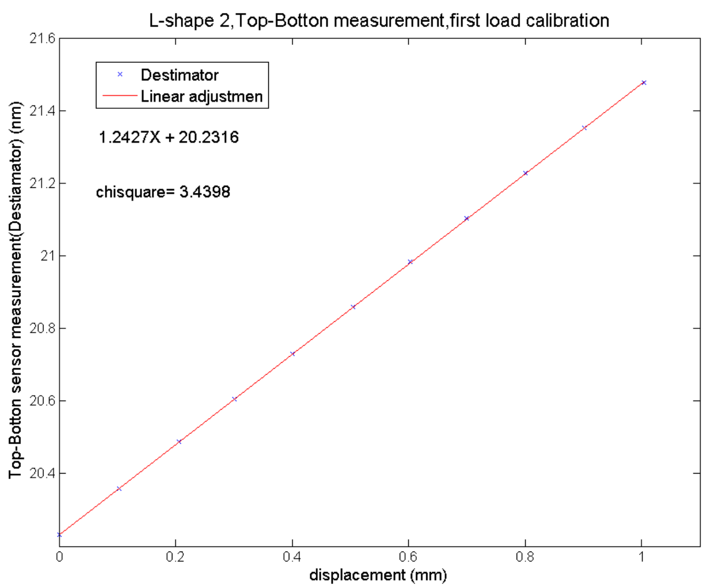
Displacement Calibration

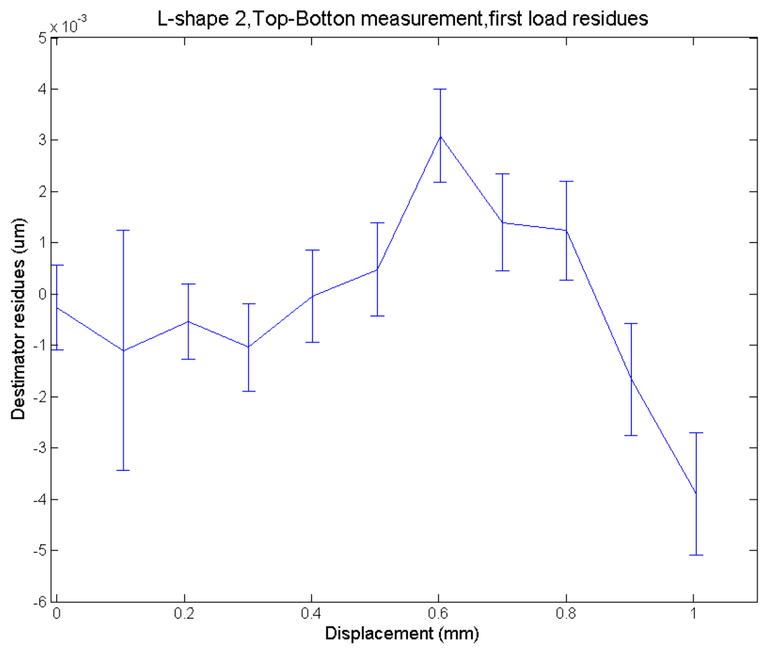
– An specific calibration set-up at IFCA using a Michelson interferometer.
– Readout of L-shape compared with true position (interferometer)



L-shape Linearity vs. Displacement

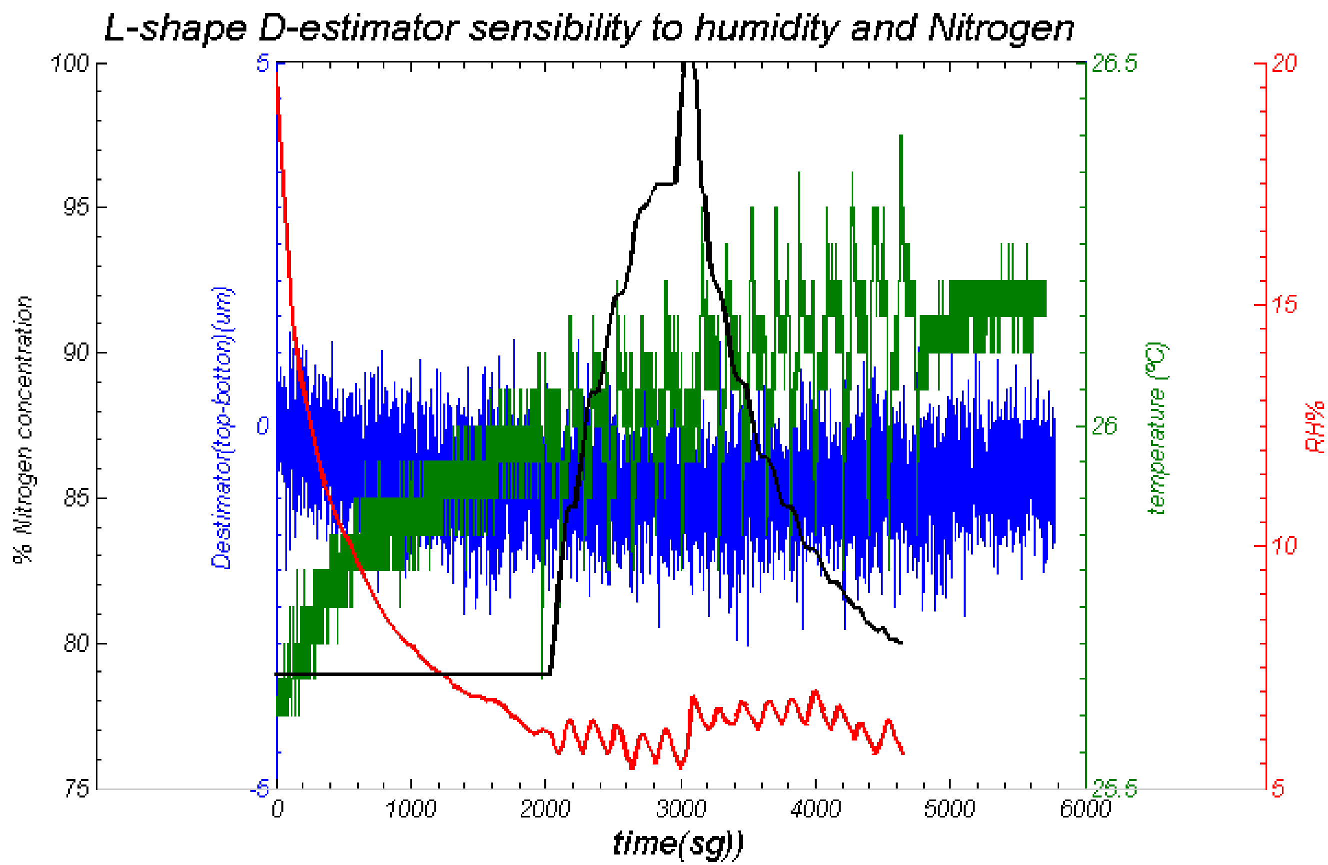
- Calibration over a range of 1mm
- Resolution (readout resolution) 0.5 um.
- Accuracy (diff. Between inter & L-shape) ≈ 2 um
- Simple temperature compensation





L-Shape sensitivity to environmental conditions: HR%, T, N_2

No sensitivity to environmental conditions



Summary

– The FBG-based FOS structural and environmental monitor delivered.
– Able to monitor temperature, humidity, vibrations, displacements.
– First cases of use for the Belle-II and ILC community
– Will be used on the monitoring of integrated Belle-II vertex mock-up (June and September)
– Available to the community (please contact us)

THANK YOU!