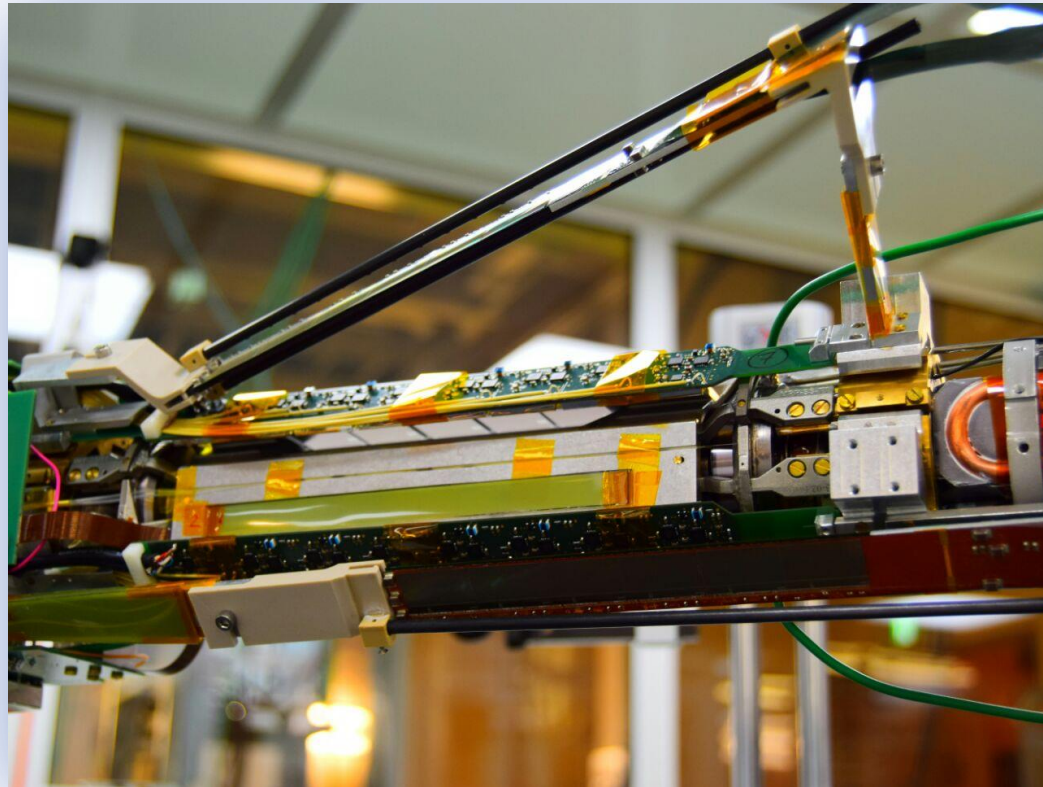


# FOS system phase-2 status report & phase-3 proposal



Belle-2 PXD Workshop  
DESY, January 23, 2017



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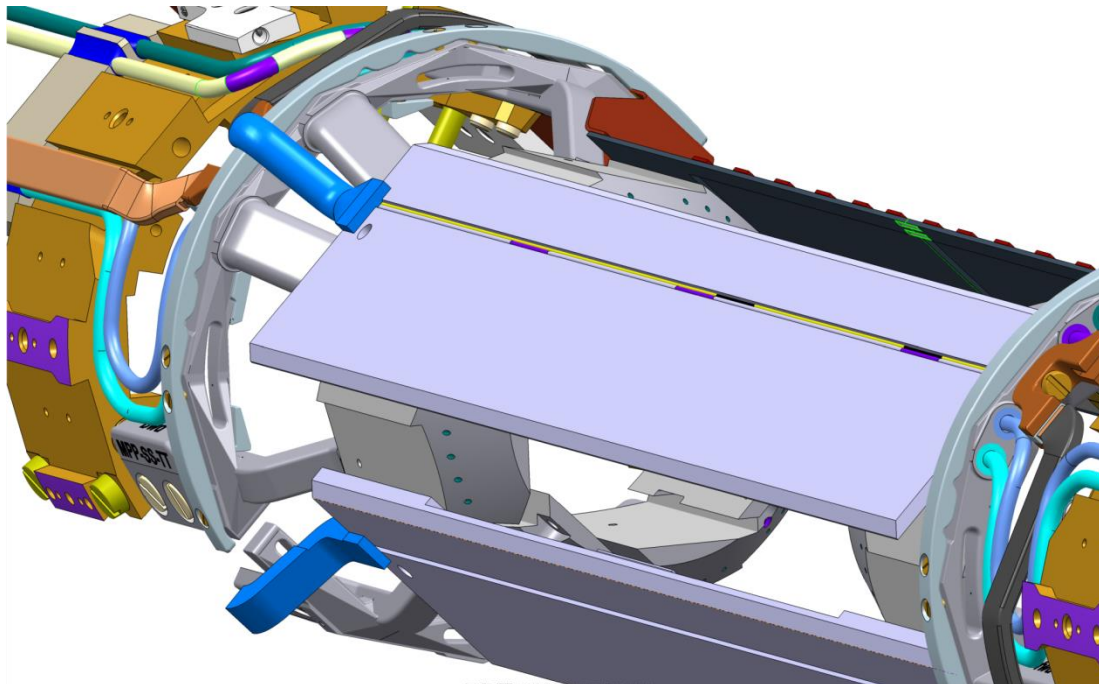
# Outline



- Motivation
- Sensor layout
- Thermal sensors: calibrations and radiation tolerance
- Humidity sensors:
  - \_ Radiation tolerance.
  - \_ Latency
  - \_ Low-Humidity Induced Off-set
- Phase-3 plans
- Summary

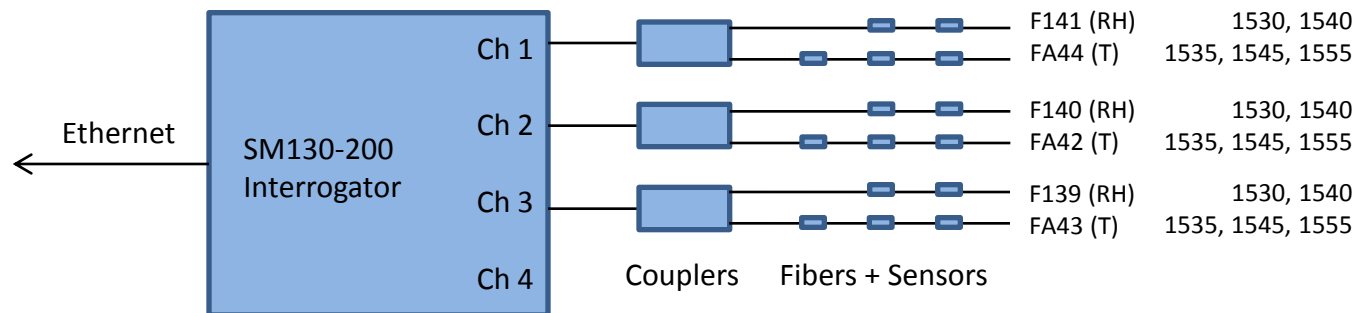
# Motivation

- \_ Installation of pre-irradiated Fiber Bragg Grating sensors on the three FANGS arms for beast-II for temperature and humidity monitoring
- \_ Focus on developing a FBG based humidity sensors.

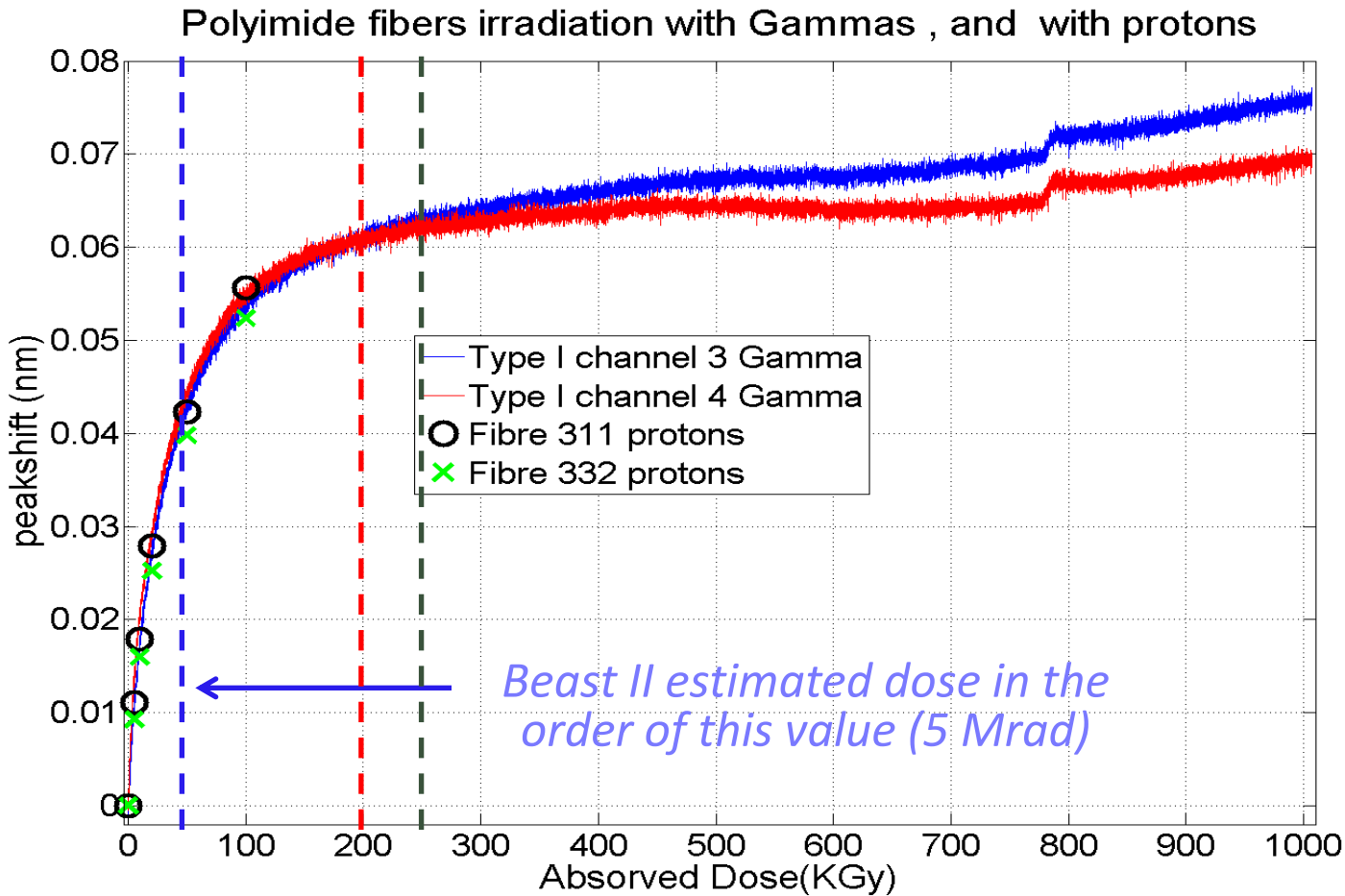


# System Layout

Fiber	Coating	Sensitive	Nº of sensors	Cable length
<b>FA42</b>	acrylate	T	3	3 meters
<b>FA43</b>	acrylate	T	3	3 meters
<b>FA44</b>	acrylate	T	3	3 meters
<b>F139</b>	polyimide	T+RH%	2	3 meters
<b>F140</b>	polyimide	T+RH%	2	3 meters
<b>F141</b>	Polyimide	T+RH%	2	3 meters



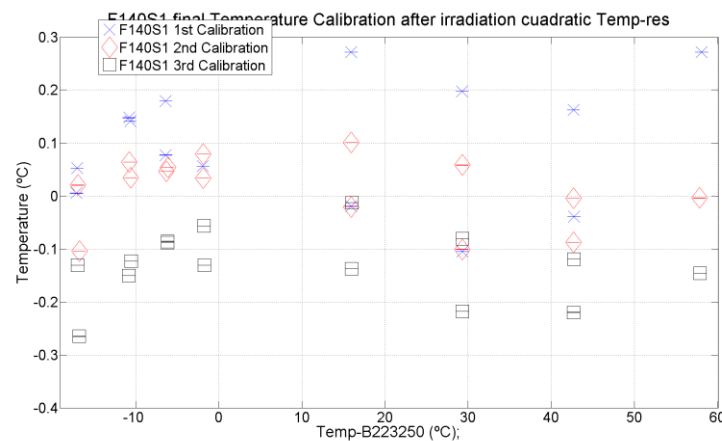
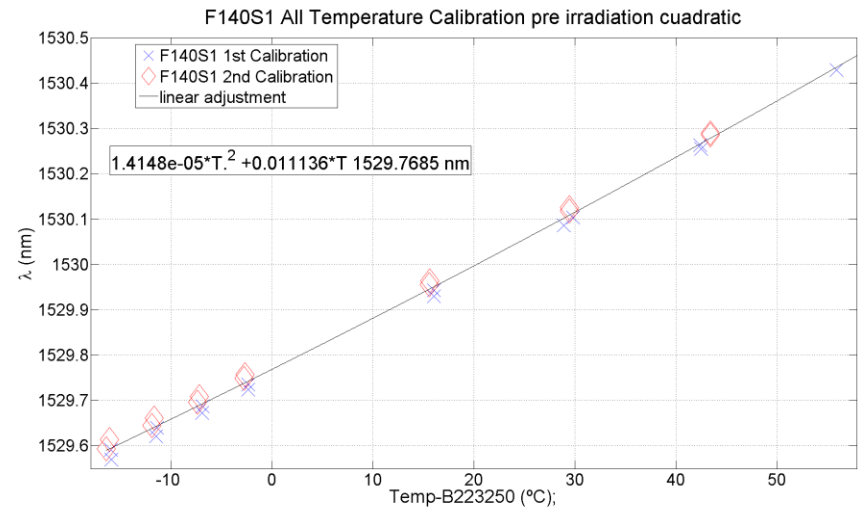
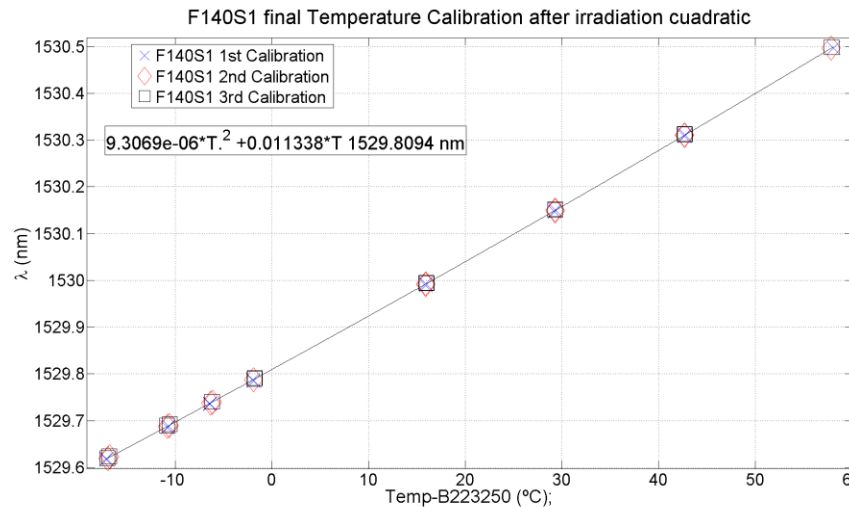
# Pre-irradiation of sensors: motivation



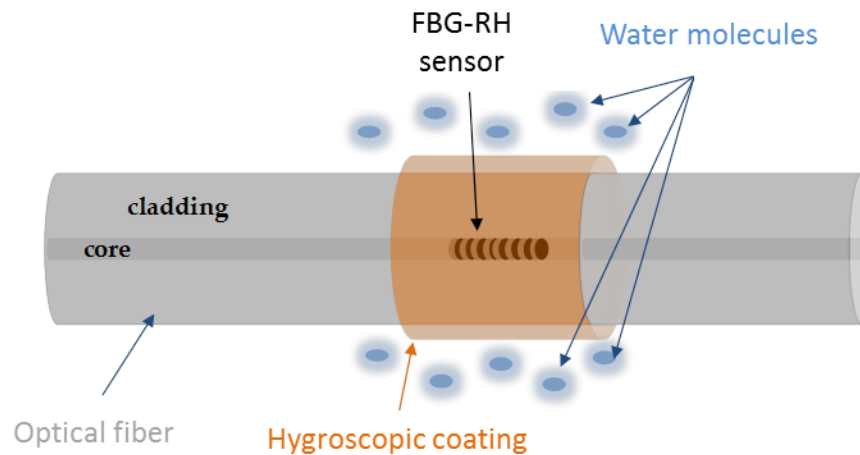
# Temperature calibration



- Temperature calibration carried out before and after the irradiation.



# Humidity with FBGs 101



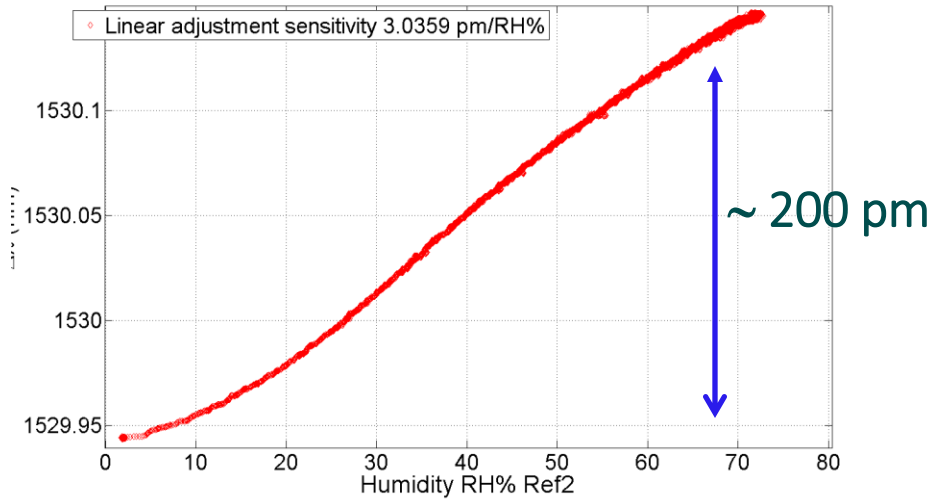
$$\Delta\lambda_B = f(\Delta T, \Delta RH) = S_T(T, RH) \cdot \Delta T + S_{RH}(T, RH) \cdot \Delta RH$$

- A temperature compensation scheme is required to extract RH measurements from the sensor readings

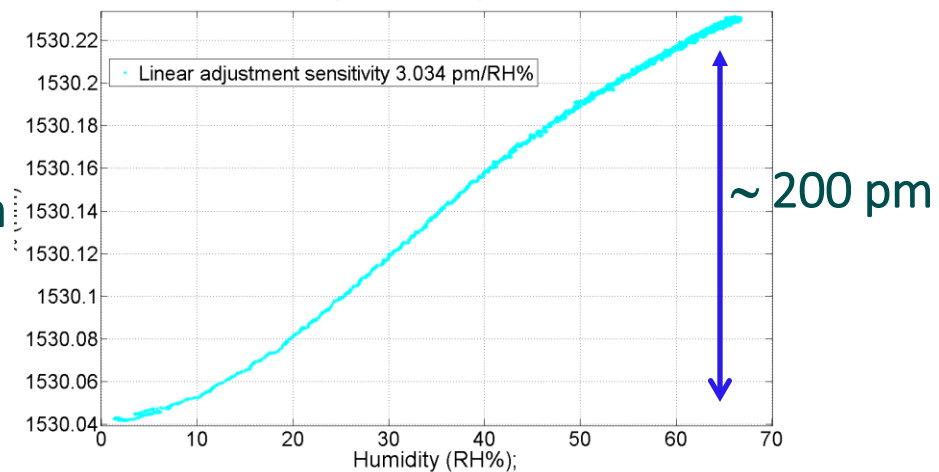
# Radiation tolerance of the FBG sensitivity to the humidity.

## Humidity sensitivity not affected by irradiation

F140S1 humidity ref2 calibration pre irradiation



F140S1 All humidity Calibration post irradiation quadratic





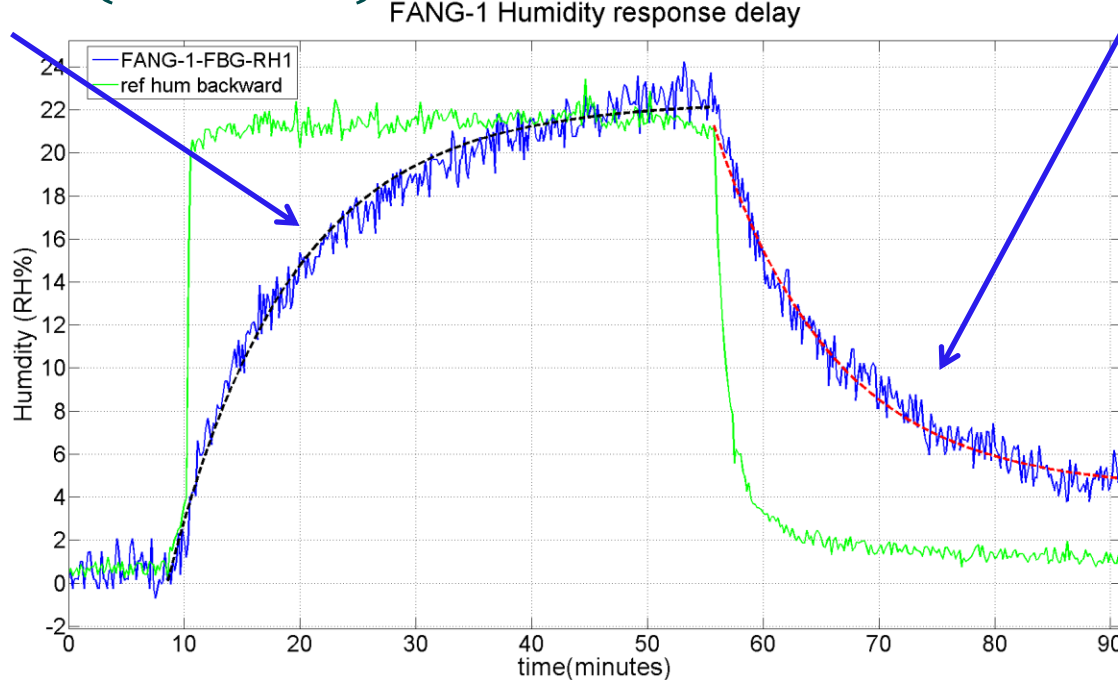
# Humidity systematics: Response latency

- Dynamic equilibrium of the water molecules in air and in the polyimide.

$$HR = K \left(1 - e^{-\frac{t}{\tau}}\right)$$

FANG-1 Humidity response delay

$$HR = e^{-\frac{t}{\tau}}$$

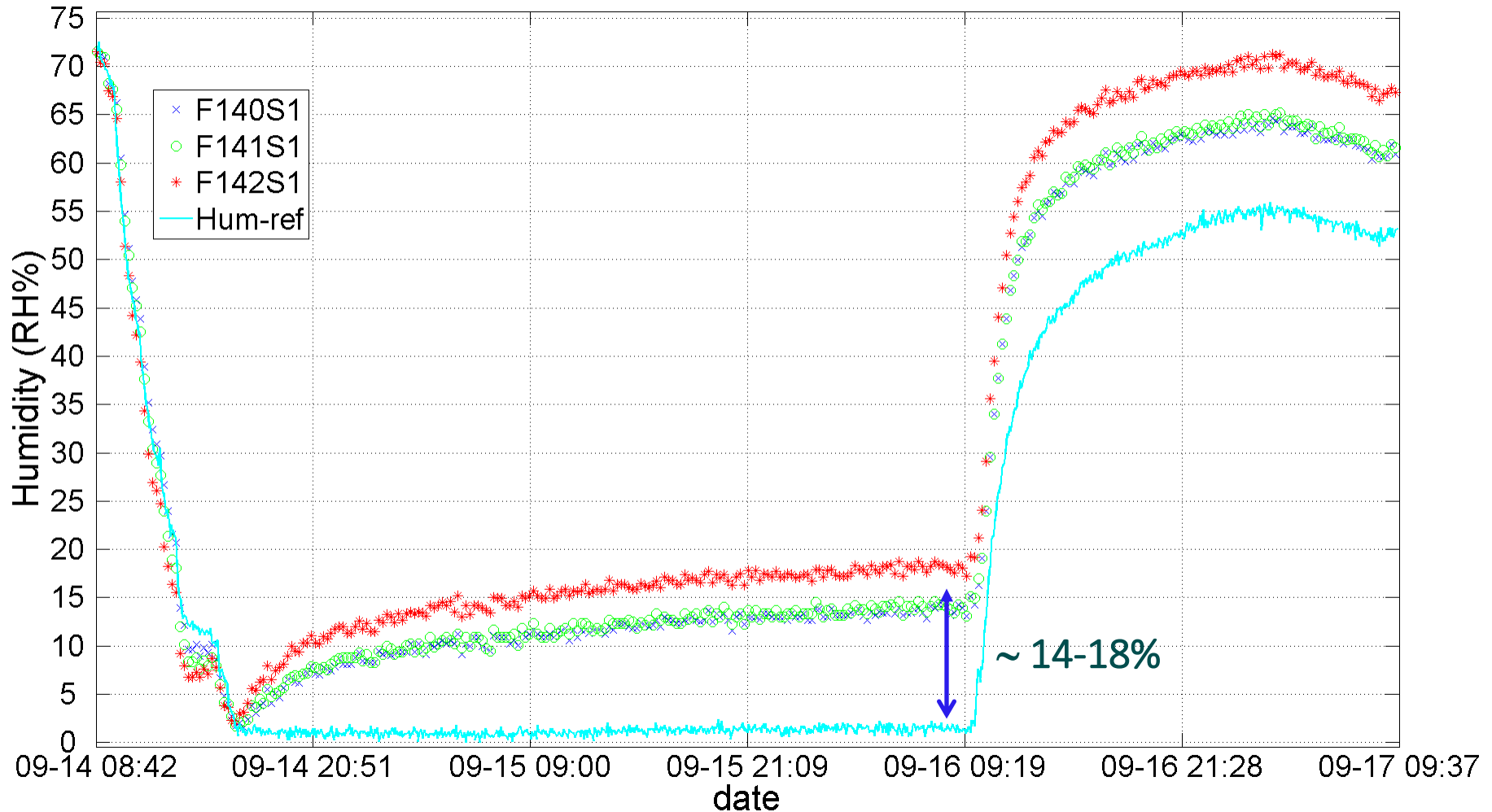


Time characteristics  
 $\tau \sim 10$  minutes

# Humidity systematics: Low-Humidity-Induced Off-set (LHIO)



F140 F141 F142 2nd humidity Calibration post irradiation linear



# Phase-3 proposal



- \_ 8 monitoring fibers in the PXD envelop (4 temperature & 4 for humidity) + one additional spare pair
- \_ Fixation in PXD volume following Tcharly proposal.
- \_ Time line:
  - \_ Fibers procurements (8 weeks)
  - \_ Irradiations (3 weeks)
  - \_ Re-calibration (3 weeks)
- Sensors should be ready on the third week of May.

# Summary



- FOS Installation and commissioning at Beast-II completed: all sensors alive and responsive.
- Temperature read-out smoothly.
- As expected: absolute measurement of the humidity requires in-situ resetting of the off-set after LHIO saturation reached.
- Beast-II will allow for a detailed performance evaluation under real conditions.