ITk FOS update - Humidity Monitoring

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MTP-12 connectors

2x for Strips Endcaps - **due now**

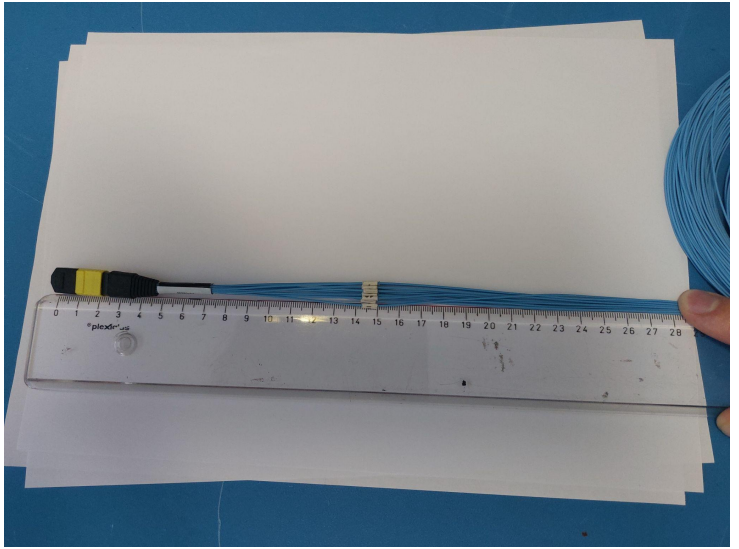
- Spliced, labelled
- QAQC with OTDR
- Ship to Valencia - in progress

10x Pt10k sensors (+6m PEEK twisted pair) to be included with MTP-12s

2x for Strips Barrels - **due end July**

Procured new MTP-12s - label moved 10cm from the boot (enables 90° bend for BSM).

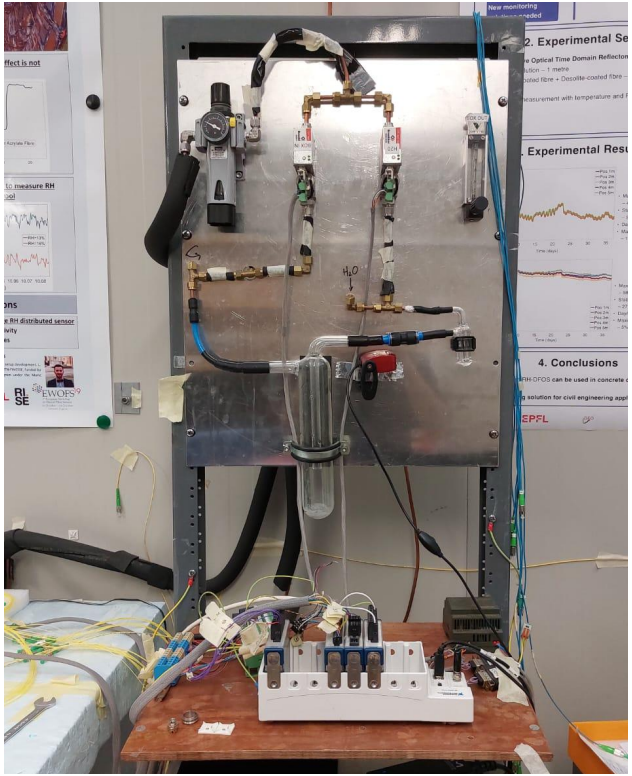
- Spliced
- QAQC and labelling still required (~1 afternoon)
- Deliver to Jason Tarrant (can give to George Iakovidis at CERN)



Standard MTP-12 connector (label @ boot)

QAQC Challenges

- DewMaster (used as high accuracy ref. sensor for RH in lab) is experiencing problems:
  - Requires maintenance (engineer waiting for current test to finish)
  - For now, we use HIH sensors for QAQC
- Humidity control **highly** difficult
  - Industrial sized chambers often see stratification
  - Valves for dry/ humid air input can be unreliable
  - Stable humidity for given valve combination can be different each time



Humidity control setup, 168/R- G14

QAQC Advances I

QAQC procedure expanded to reflect complexity of calibration.

Previous QAQC (pre-2024)

1. Constant RH 35%, vary temp. -20->25C
2. *Constant temp. 25C, vary RH 1->60%*

Current QAQC

3. Constant RH 35%, vary temp. -20->25C (same as before)
4. **Constant temp. -20C, vary RH 1->60%**
5. **Constant temp. 0C, vary RH 1->60%**

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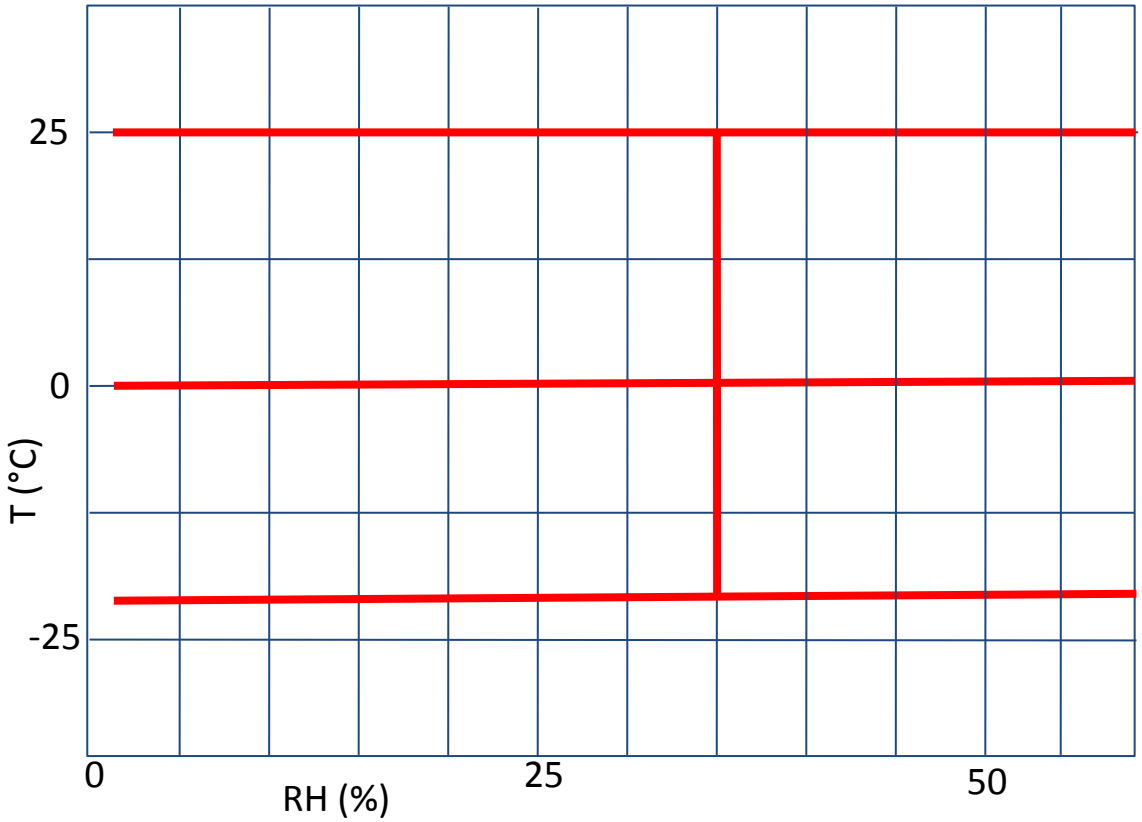


2nd Irradiation Campaign

- Required to pass PRR:
  - Demonstrate the FOS can match reference sensors *even after irradiation*.
  - For this we irradiate another 2 packages (previous 2 were broken)
- PRR must be passed before materials can be ordered to 100%.

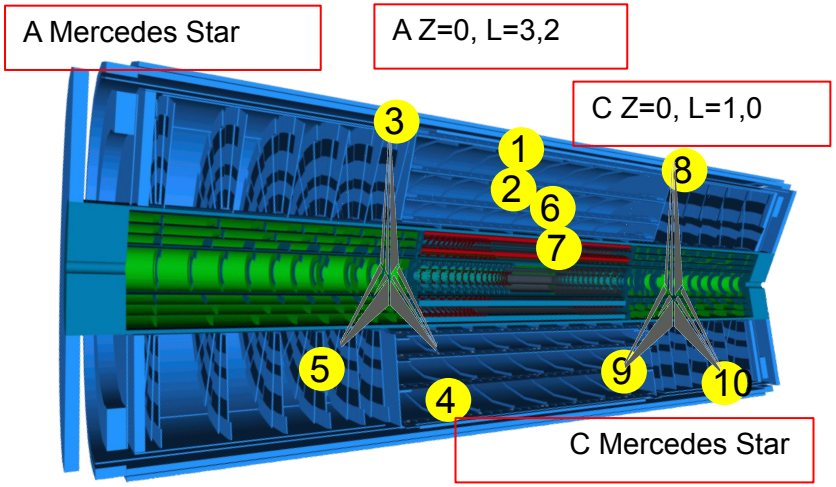
<u>IRRAD</u>

- Plan irradiate to 1.5MGy with protons at IRRAD facility, CERN.
- Date not yet set (focusing on immediate production) - potentially August
- Timeline:
  - Irradiation - 1 week
  - 2-3 weeks before irradiated sensors can be returned to lab
  - 1 week humidity and temperature testing
  - Analysis - depends on results

Labelling

Developed an Auto-Label generator via a script
Label: n1-n2-n3-n4-n5.

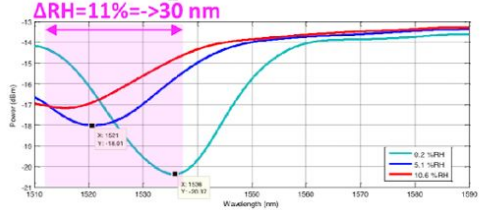
1. **ITk Volume**
   - 1 Strips - Barrel, including z=0 (L=0,1,2,3 go out to different ends of the detector)
   - 2 Strips - Endcap
   - 3 Outer Pixel
   - 4 Inner Pixel
   - 5 OSV
2. **Side of detector**
   - 1 A
   - 2 C
3. **Fixation position**
   - 1 Mapped point 1 : to a drawing, via a map
   - 2 Mapped point 2 : to a drawing, via a map
   - 3 Mapped point 3 : to a drawing, via a map
   - 4 Mapped point 4 : to a drawing, via a map
   - 5 Mapped point 5 : to a drawing, via a map
4. **Pins in MTP or DB25**
   - Pin number
   - for FOS, lower pin of pair is the FBG side of the package
   - for Conventional
     - n+0,1 is for the PT10k, where order does not matter
     - n+2,3,4 is for the HiH4000,order is ground, Supply (+ve), Signal
5. **Overall number**
   - incrementing on the item supplied



Example map … Barrel

Optimization of the LPG- humidity sensor fabrication (2)

- **12 layers of TiO_2 deposited onto the grating**

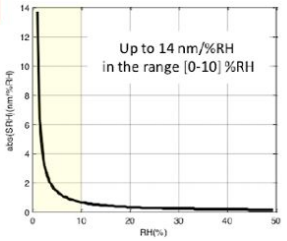


Please note the RH sensitivity of the first generation of RH FOS (FBG) was ~0.001 nm/RH

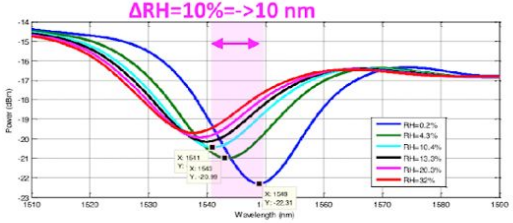
- **Extremely high RH sensitivity**

  Step from 0.2 %RH to 5.1 %RH ⟶ Δλ =~ 15 nm

- **With 3 RH steps in the range [0, 11]% RH, we use 30 nm of bandwidth of the optical interrogator**



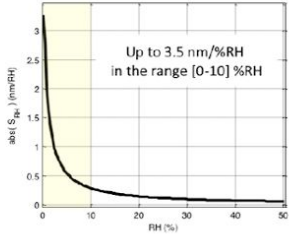
- **11 layers of TiO_2 deposited onto the grating**



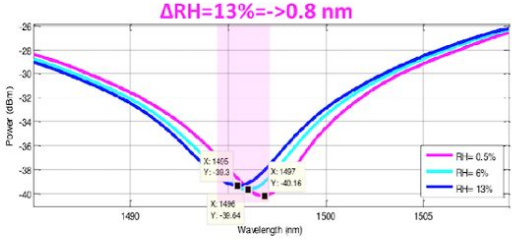
- **Still highly RH sensitive**

  Step from 0.2 %RH to 4.2 %RH ⟶ Δλ=~ 6 nm

- **With 3 RH steps in the range [0, 10]% RH, we use 10 nm of bandwidth of the optical interrogator**



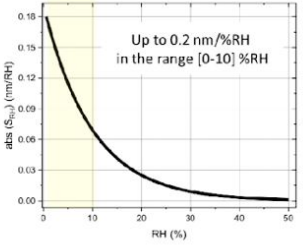
- **8 layers of TiO_2 deposited onto the grating**



- **Still highly RH sensitive**

  Step from 0.5 %RH to 5.5 %RH ⟶ Δλ=~ 0.8 nm

- **With 3 RH steps in the range [0, 13]% RH, we use 1.3 nm of bandwidth of the optical interrogator**



Trade-off between sensing performance and wavelength range available for the sensors readings

The choice of the number of layers should be fixed considering the operational RH range of the sensor and the max bandwidth variation assigned to the sensor itself

LPG sensor issue

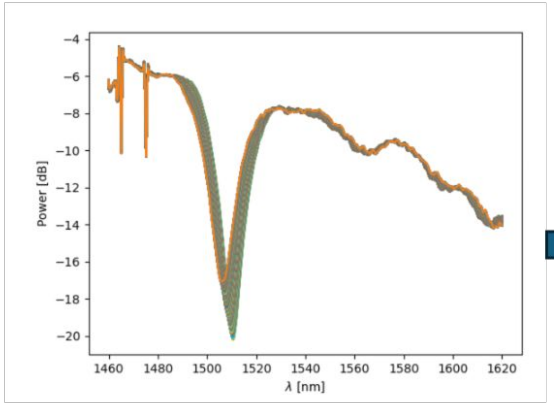
- Conducted RH test on two packages at -20˚C with 19 data points
  - Use labview to acquire temperature, RH & DP from various sensors
  - Currently fixing analysis code.
- We ordered a batch of LPG sensors with modified Ti_20 layers
  - LPG initially had 8 Ti_20layers according to specification. Sannio changed layers to 10 at a very late stage to get more sensitivity.

  → Dip gets wiped out as Dose increases

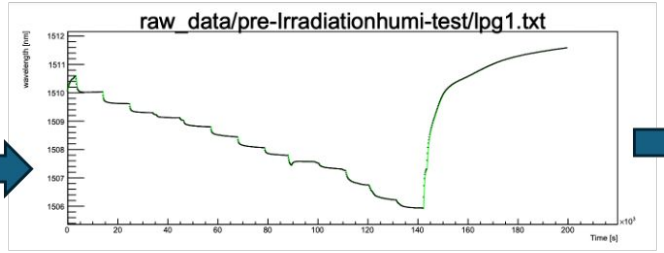
Issue with LPG's

- Now these sensors are showing too low sensitivity. However they are also showing 10 times to high noise. This seems to be a setting on the interrogator DAQ that could improve this, and we are following up.
- According to slide [layers], we should have about 1 nm for 5% RH, so at least 100 distinct steps in RH from the LPG and interrogator

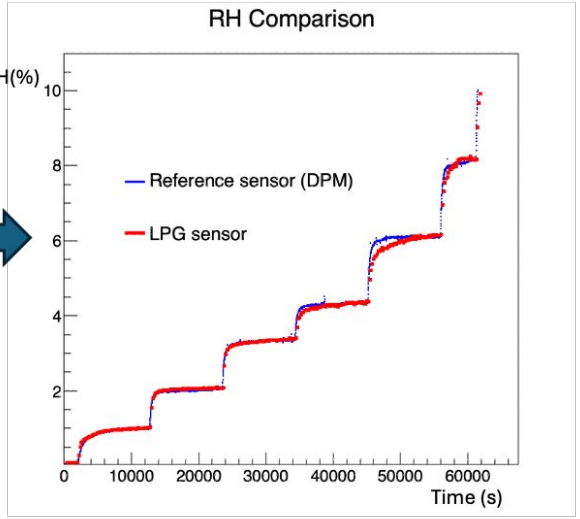
Typical characterization at 25 ° C



Observed wavelength spectra shift



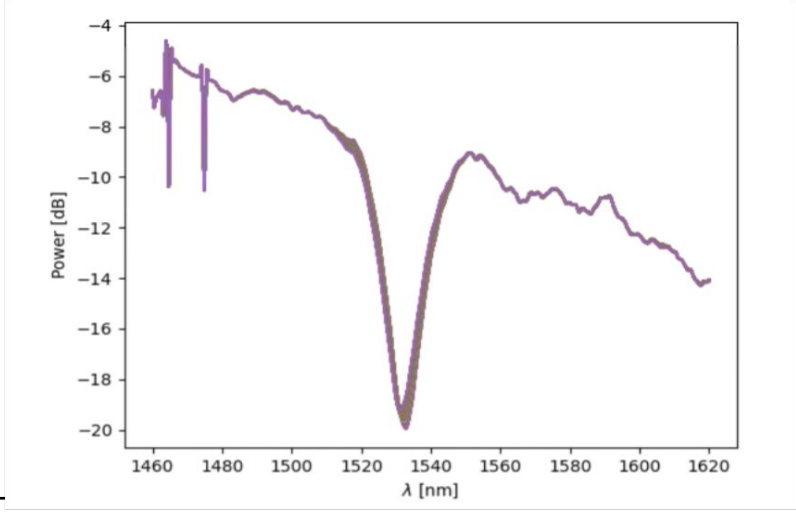
Power spectrum plot



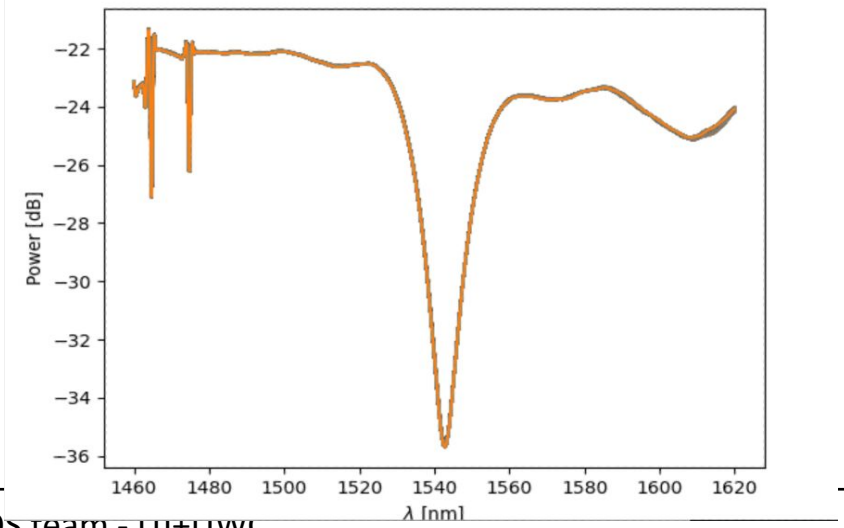
Readout comparison

Comparison in wavelength shift of LPG's at -20 ° C

10 Layers

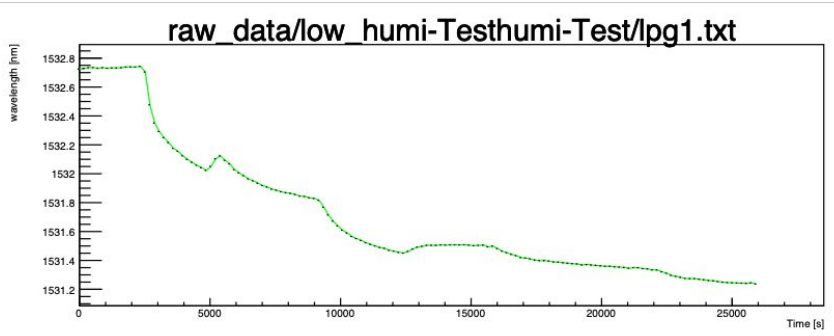


8 Layers

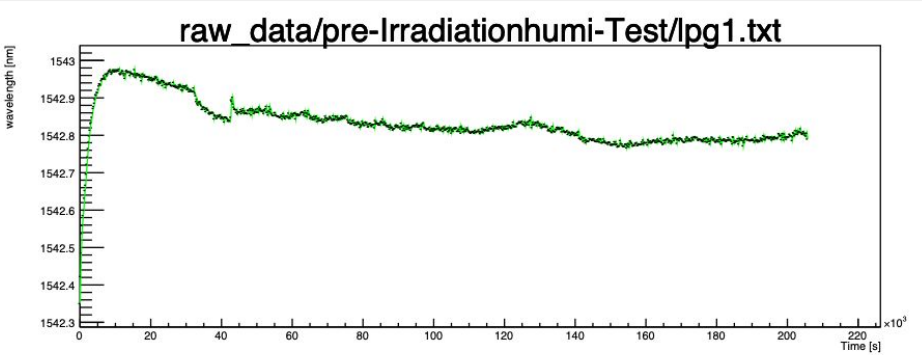


Comparison in centroid extraction of LPG's at -20 °C

10 Layers

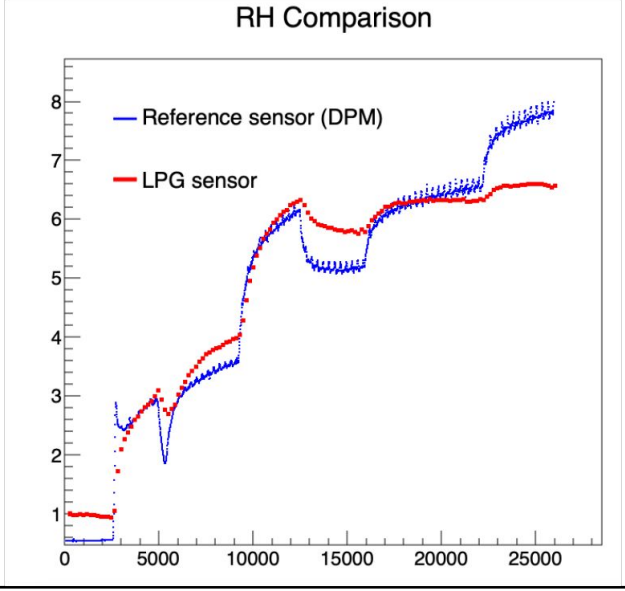


8 Layers

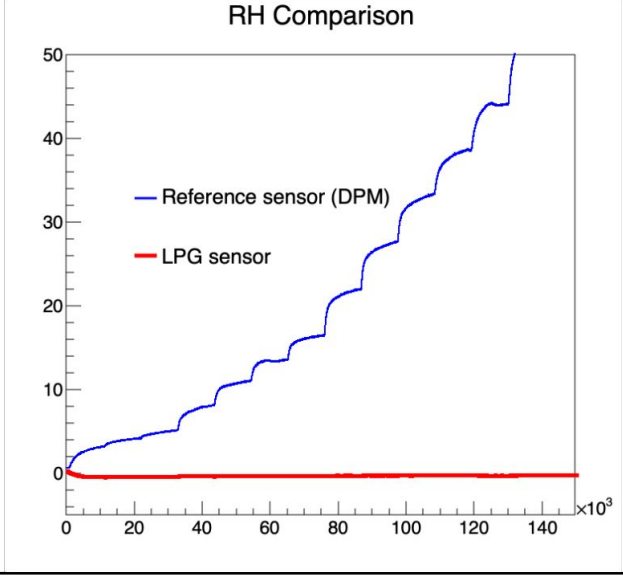


Comparison Reference sensor readout vs LPG readout at -20˚C

10 Layers



8 Layers



Conclusion

BACKUP

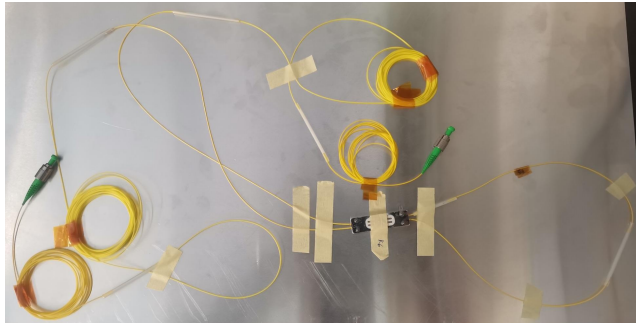
OTDR analysis

OTDR Models

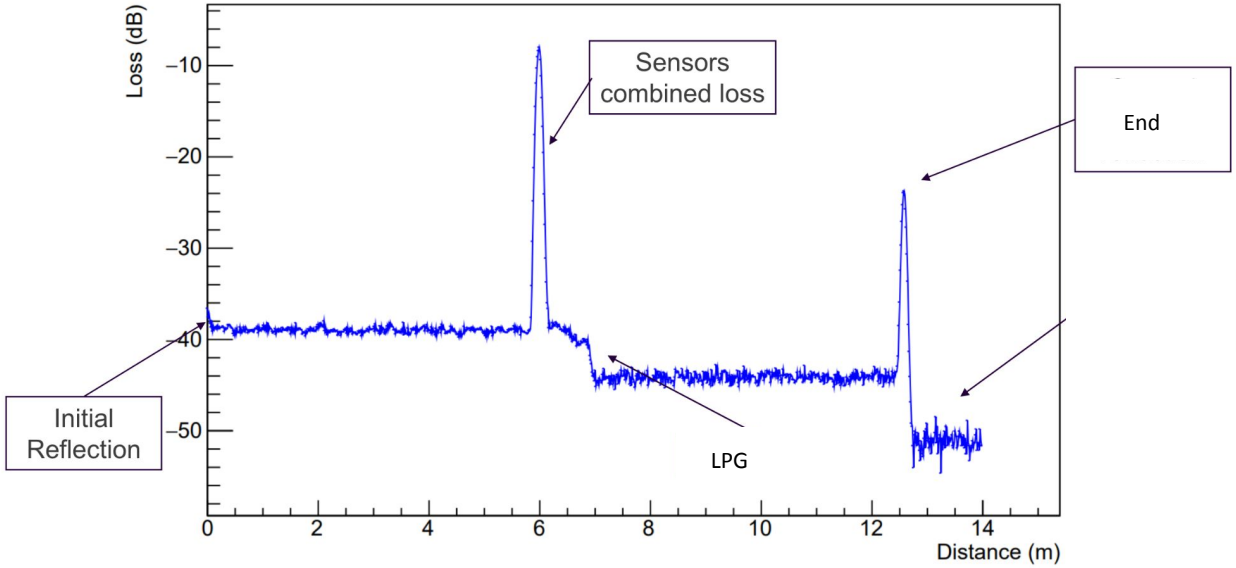
- **Current:** Luciol v-OTDR, rented from electronics pool, 10CHF/ day
- **Desired:** FOTR-201 handheld OTDR, €1152

At installation:

- Health check each fibre
- Compare against spectra recorded in the lab



OTDR – FOS Packages



Above: Example spectrum from OTDR
Right: FOS package with full 6m leads

2x Packages for Strips Barrels Z=0, L=2 and L=3

1st package due **July 8th** (next Monday), 2nd due **July 15th**

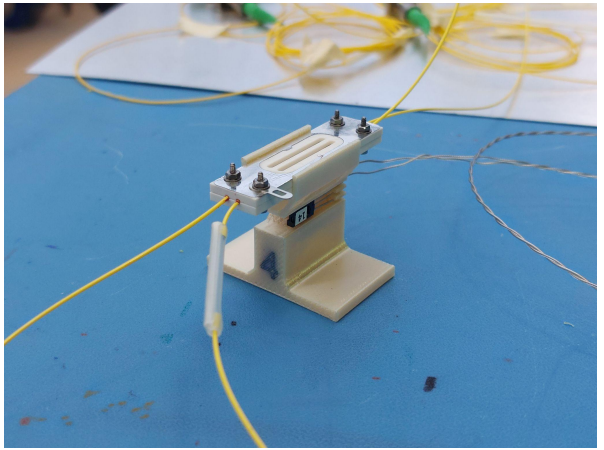
Status - under QAQC testing (had to be lengthened)

Schedule

1. Test varying RH at -20C **-> finished yesterday, 17:00 CERN time**
2. Flush chamber, run test varying temperature at 35% RH **-> until Wednesday 17:00**
3. Flush chamber, run test varying RH at 0C **-> until Friday 17:00**
4. Final steps: add last grounding components and check connection, glue reference sensors to bracket, package all **-> until Saturday 17:00**

Both packages on track for Monday 8th

Explanation of grounding



Example FOS package in bracket

To deliver (2 each):

- Ultem bracket
- HIH sensor + 6m PEEK twisted triplet
- Pt10k sensor + 6m PEEK twisted pair
- Neoceram package, with 2x FBG and 1x LPG sensors

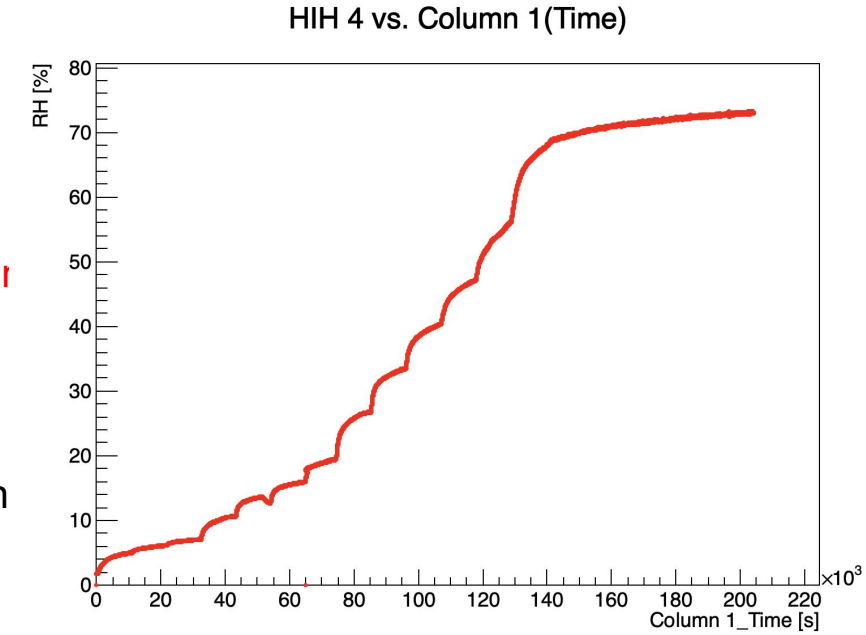
QAQC Advances II

PID control - in progress

- Currently humidity control is done in 2 ways:
  - Manually adjust valve opening %, check humidity by eye - slow, noisy data
  - Script to adjust valve opening % - inconsistent RH values
- Goal: develop a system to automatically adjust humidity
- Required move from LabVIEW to C++ and Python

Optical switch

- Previously only 2 packages could connect to Hyperion interrogator at once (only 4 channels)
- Optical switch allows up to 12
- Greatly speeds up QAQC



Example reference sensor output for QAQC, showing humidity steps

Questions from FOS for Strips

FOS need by dates doc

- MTP-12s for Strips Barrels
  - Due when? By end July (can be done after Strips packages)
  - Need more HIH and Pt10k??
  - Do we supply the F-F MTP-12 coupler?
- Further packages
  - Strips Endcaps - 6 due during 2024? Need to wait for PRR
  - Strips Barrels - due March 2025? Yes this date should be fine
- OTDR
  - How will it be shared - just for a day? Can only be at CERN - Should be fine
- Brackets for packages
  - We only have 4 brackets for Strips Barrels
  - New design? Already made, can be sent by Jason Tarrant (waiting on finalizing labelling)
- Labelling
  - Question about the ATLAS Accredited label
    - Is there a specification ? - G. Iaokvidis: change ‘Fixation position’ numbers to match e.g. Barrel level 0, 1, 2, 3
    - Must it be Rad Hard ?
  - Apparently the TC Co-ordination also maintain a DB., in addition to the Production DB (called ACES).

Inventory

1. MTP-12 Connectors
   a. **9** regular
   b. **2** MTP couplers - 16 ordered
2. Pt10k: **61**
3. HIH: **10**
4. Ceramic packages: **74**
5. PEEK wire: **6.5km** twisted double, **1km** twisted triple
6. **300e** Titanium Screws (order 200 more each)
7. Grounding
   a. Goodfellows Aluminized Kapton **300mm x 300mm**
   b. Araldite – **2x 15ml** tubes
   c. Non-woven mesh – **0.14m^2**
   d. **100** Solder tags
   e. **70e** PEEK nuts and washers
8. Fibre connectors
   a. LC/APC - ?
   b. FC/APC - 50 ordered
9. Labelling machine - need to place order
10. FBGs:
    a. **11** Radsoft
    b. **11** Radhard
11. LPGs: **11**

Produced

1. MTP-12 Connectors
   a. **2** spliced for Strips Endcaps
   b. **2** spliced for Strips Barrels
2. **8** Packages
3.

Items in bold are in the lab (168-R-G14)

Not procured

25% procured

100% procured