DT contributions to LHCb SciFi

Slide by Sune Jakobsen
Presented by Lukas Gruber

LHCb/DT Coordination meeting 28-11-2018

Work packages

Vacuum system for the NOVEC cooling lines

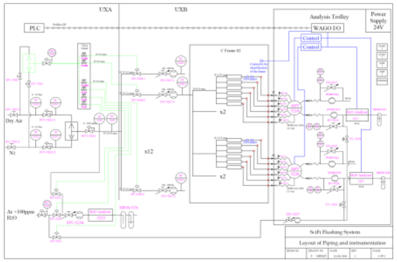
WP: https://edms.cern.ch/document/1974407/1

EP-DT-DI: Xavier Pons, Maciej Stanislaw Ostrega etc.

System for testing C-frame in B3852 build and is operational, but minor modifications will still be needed.

Plan for the underground system is clear.

Dry gas supply and monitoring



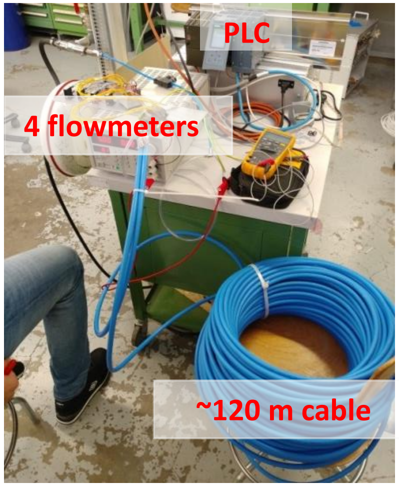
WP: Expected December 2018 by Beatrice Mandelli.

EP-DT-FS: Roberto Guida, Beatrice Mandelli, Frederic Merlet, Patrick Carrie etc.

System for testing C-frame in B3852 foreseen for December 2018.

Plan for the underground system is clear.

Flowmeters for dry gas monitoring on C-frames



WP: Expected December 2018 by Maciej Stanislaw Ostrega.

EP-DT-DI: Xavier Pons, Maciej Stanislaw Ostrega etc.

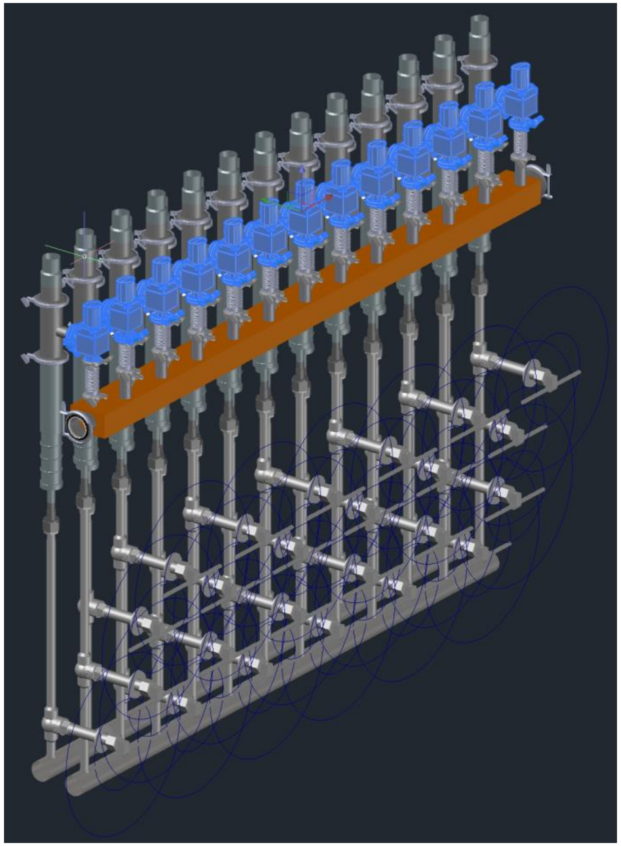
System for testing C-frame in B3852 will come in two stages and first is foreseen for December 2018.

Plan for the underground system is almost clear.

Not covered by current WPs but expected by LHCb SciFi

Vacuum system mechanics, manifold and cabling

- The current WP does in principal not cover anything outside the racks.
- Pipes/bellow needed to connect to the manifold ~10 m from the rack.
- The two manifold needs to be produced (when the design is finished).
- The Piranis on the C-frame need to be cabled.



Dry gas system on C-frame:

- Simple bent stainless steel pipe and simple manifolds needs to be produced and installed.
- EP-DT-FS is assisting the design and will make the first set.
- Agreement needed for production for 12 C-frames.
- Flowmeters and corresponding cables needs to be installed (if not covered by flowmeter WP).

Overall coordination of SciFi assembly at CERN

- => Sune Jakobsen (Not in any WP so far, but should go in the general WP).

SciFi control system development in close collaboration with LHCb online

- => Lukas Gruber (integration of various systems delivered by EP-DT).

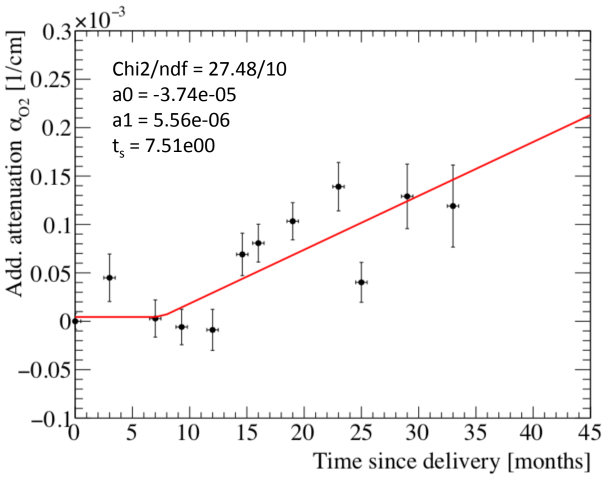
SciFi fibre QA and R&D

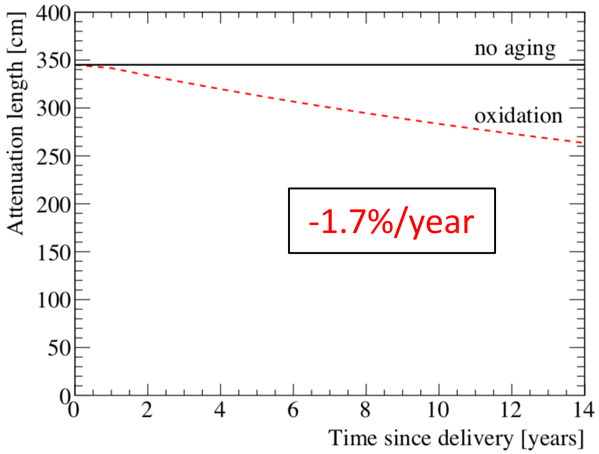
SciFi fibre QA: 12,000 km QA finished March 2018 (*JINST 13 P10025 2018*)

SciFi fibre aging studies:

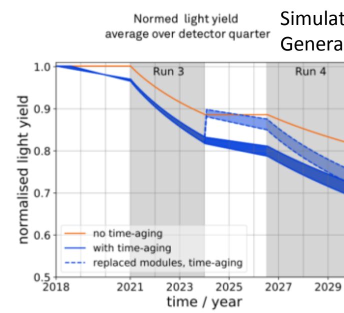
- In March 2018 we have started to perform repeated measurements of stored fibre samples. We observed a slow but systematic reduction of the attenuation length, which is attributed to slow oxidation of Polystyrene (PS) fibre core. N.B. Kuraray experienced similar effect.
- It can be treated as additional damage, like irradiation.

$$\alpha = \alpha_0 + \alpha_{O_2} + (\alpha_{irrad} + ..) = \frac{1}{\Lambda_0} + \frac{1}{\Lambda_{O_2}} + (\frac{1}{\Lambda_{irrad}} + ...)$$





More statistics needed. Measurements every 3-4 months. First study of this kind over such long time period!



Simulation M. Bieker, SciFi General Meeting, Nov. 8

R&D on fibres for SciFi upgrade:

- NOL idea: bind activator and WLS together (non-radiative energy transfer) → **ultimate goal: increase LY**
- Current 10th iteration: use of TPB (= standard WLS) based NOL, attenuation comparable to standard SCSF-78 fibres (Λ = 350 cm), decay time about 2 ns, light yield about 10% lower than SCSF-78 --> discussing next steps with Kuraray and LumInnoTech
- Some new ideas for future developments

Backup

Vacuum system

Maciej Stanislaw Ostrega (CERN EP-DT)
Xavier Pons (CERN EP-DT)
Lukas Gruber (CERN EP-LBD)
Sune Jakobsen

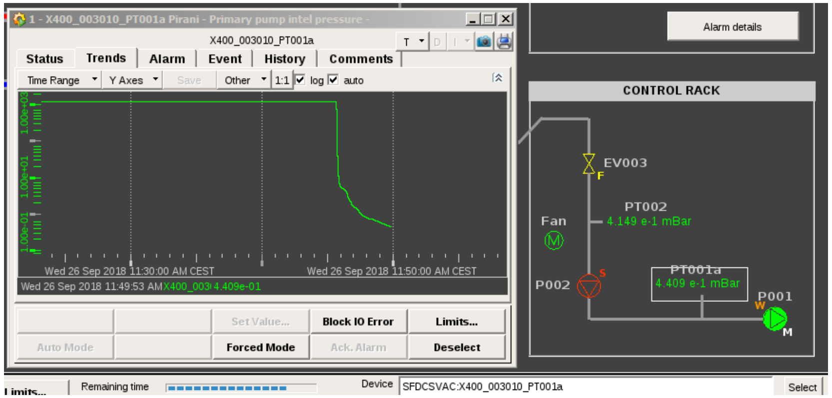
Vacuum system

Rack installed in B3852.

Not connected.

Vacuum internally in the rack looks good.

The connection foreseen as part of the NOVEC distribution lines installation (this week).

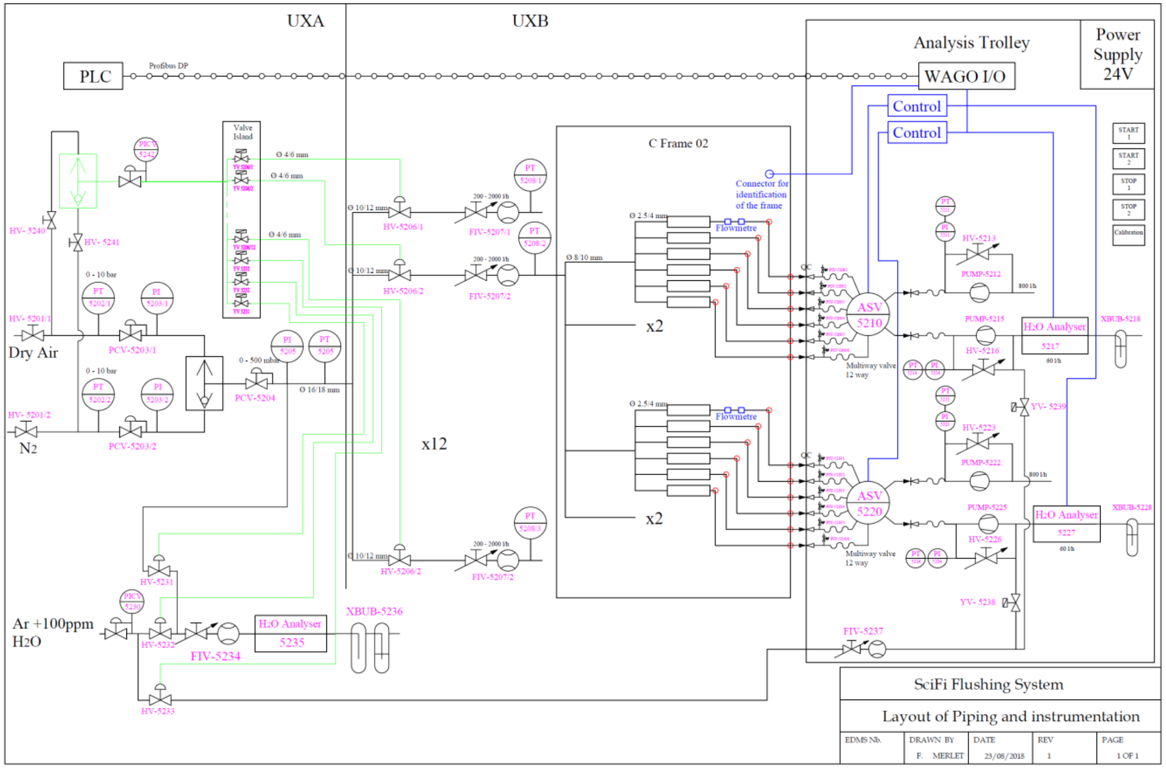


Dry gas system

Roberto Guida (CERN EP-DT)
Frederic Merlet (CERN EP-DT)
Beatrice Mandelli (CERN EP-DT)
Michal Zbigniew Zimny (CERN EP-DT)
Augusto Sciuccati (CERN EP-LBO)
Maciej Stanislaw Ostrega (CERN EP-DT)
Xavier Pons (CERN EP-DT)
Lukas Gruber (CERN EP-LBD)
Karol Kacper Poplawski (CERN EP-LBD)
Mohammed van de Kraats (NIKHEF)
Antonio Pellegrino (NIKHEF)
Sune Jakobsen

Dry gas system - Infrastructure

Final conceptual design for the supply and analysis trolley made:



This includes:

Monitoring of relevant pressures etc. and dew point of incoming.

Automatic change to nitrogen in case of failure of dry gas supply.

Manifold for 12 C-frames.

Remote possibility of turning ON/OFF the flow to a C-frame.

Local pressure regulation for fine tuning between C-frames.

Analysis trolley with multiplexing valves, vacuum pumps and H_2O analysis (one for top and one for bottom).

Price estimate is ~110 kCHF. Parts are being ordered.

This does NOT include anything on the C-frame nor long pipes/cables.

- Likely the long large diameter pipes from OT will be re-used for SciFi.

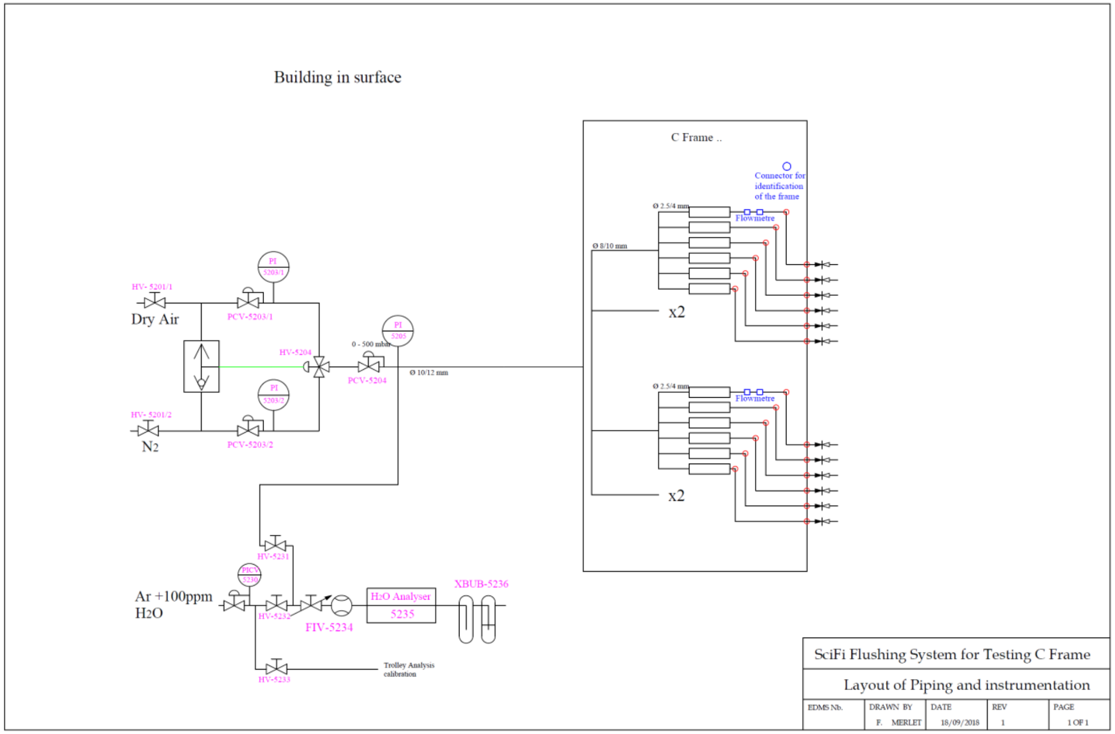
It should be ready by end of September 2019 (aligned to the installation on the first C-frames).

- The analysis trolley should be ready asap (might be start of 2019, but some hope for 2018).

A work packet is being prepared (between EP-DT gas group and LHCb).

Dry gas system - Infrastructure in the assembly hall

A simplified supply system has been designed for the assembly hall:



This includes:

Monitoring of relevant pressures etc. and dew point of incoming.

Automatic change to nitrogen in case of failure of dry gas supply.

Local pressure regulation for fine tuning.

The analysis trolley will be used already in the hall.

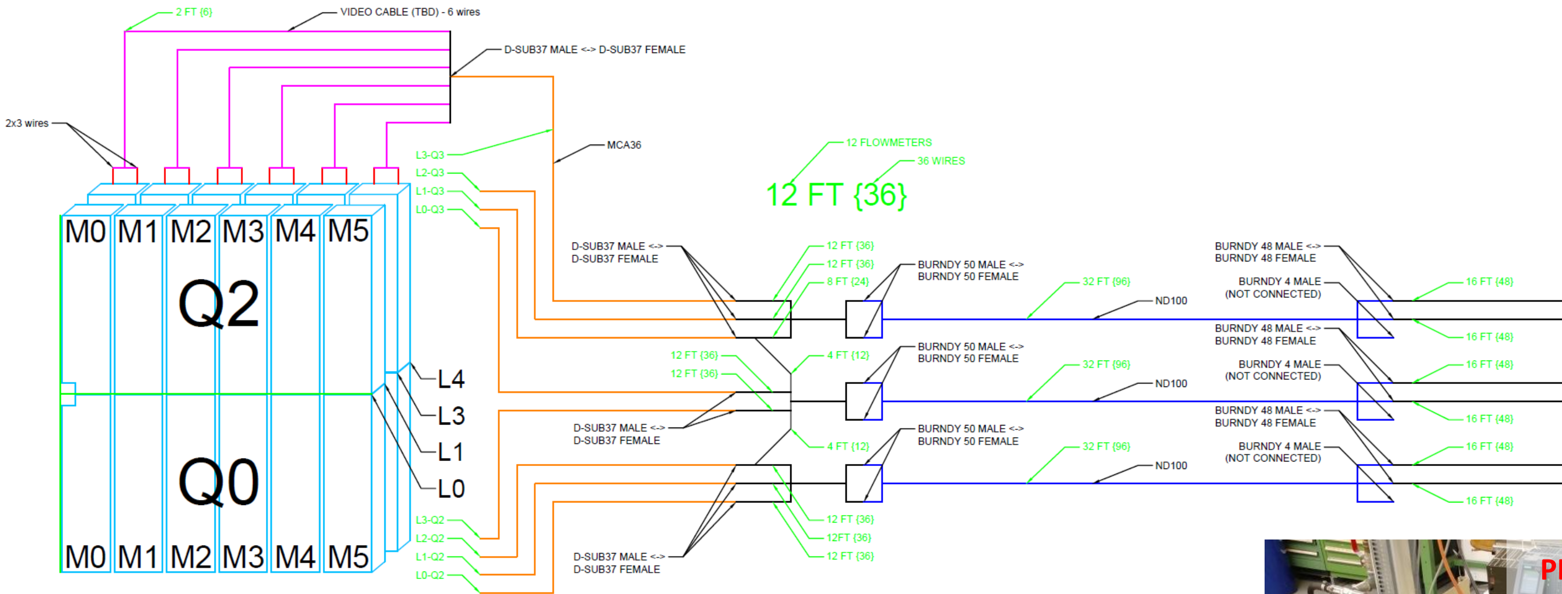
Price estimate is ~10 kCHF. Parts ordered.

To be delivered asap. (should be this year)

A small rack is foreseen next to the dry gas supply in B3258.

Dry gas system - Flowmeters

The details of the cabling has been worked out:



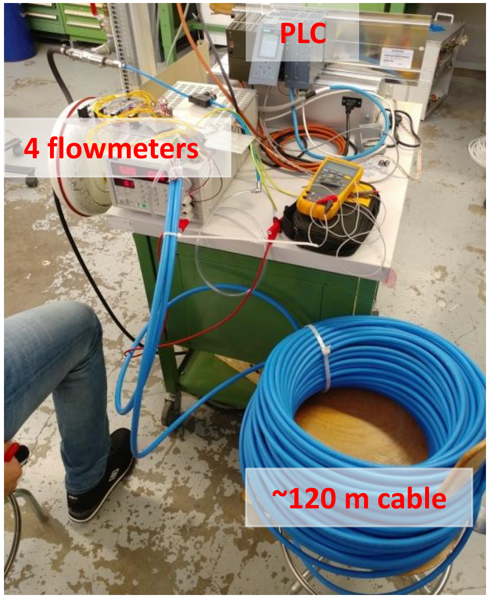
The long cables (ND100) has been reduced to 18 + 1 spare (before it was 25).

The flowmeter prototype has been upgraded with long cables (~120 m).

A significate offset (10-15 %) is observed with the long cables, but overall it works.

The tests continues and the goal is to calibrate the offset away.

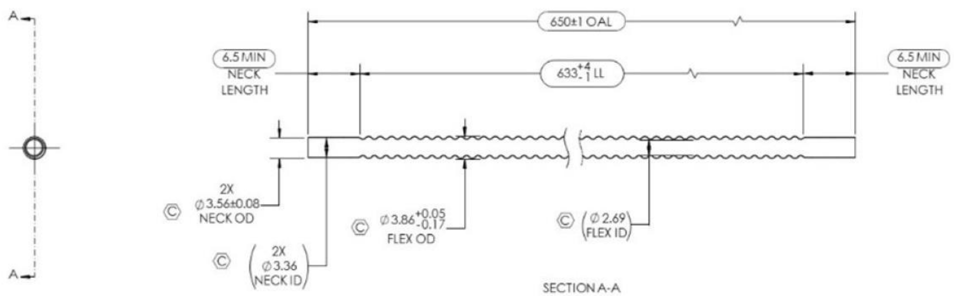
A work packet covering flowmeter readout is being prepared (between EP-DT and LHCb).



Dry gas system – connection to coldbox

Small bellows for destitution should be ordered via NIKHEP.

- Pre-production of 30 pieces foreseen for the prototype.
- 570 pieces foreseen for the full production.



The first 60 custom connector for the coldbox end will be made at CERN.

- Production of the remaining 1200 pieces to be planed.

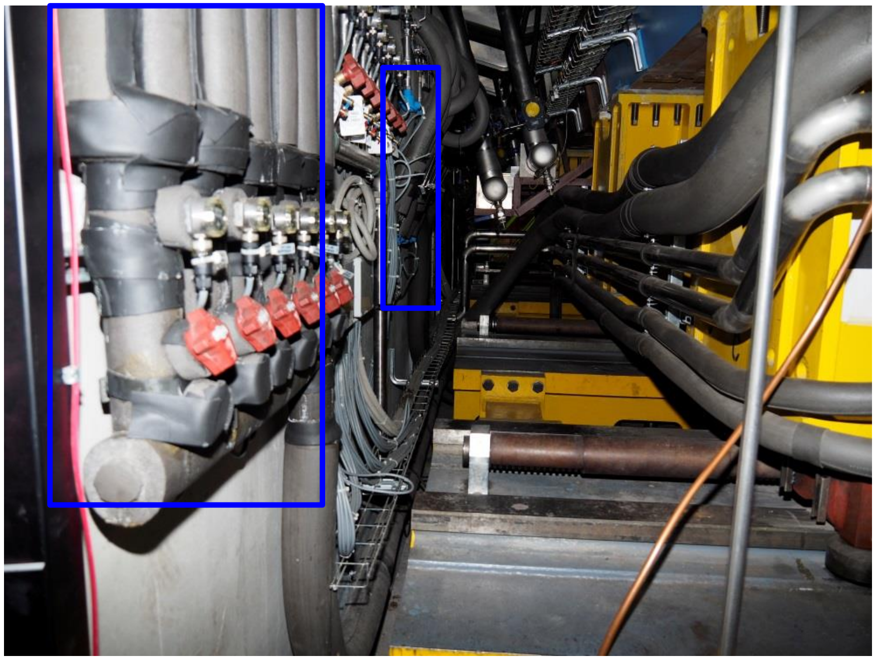
Integration of services outside the C-frame

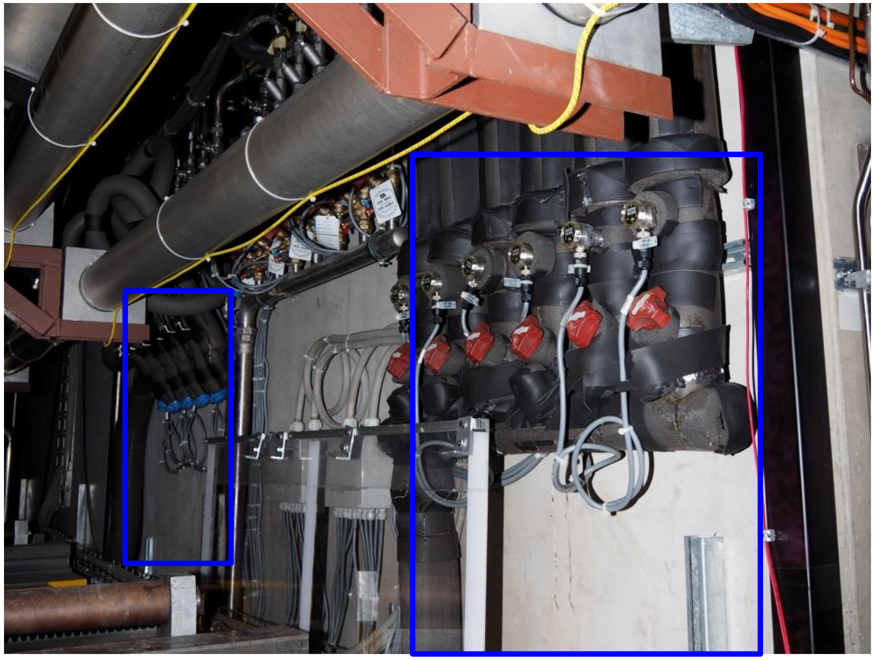
Martin Doubek (CERN EN-CV)
Maciej Stanislaw Ostrega (CERN EP-DT)
Xavier Pons (CERN EP-DT)
Sune Jakobsen

NOVEC and vacuum - Manifolds

NOVEC manifold (by EN-CV):

Installation position foreseen:





A vacuum manifold (by EP-DT) are needed in the direct vicinity for the vacuum isolation of the NOVEC distribution lines.

The two manifold and the NOVEC distribution lines will have to be integrated closely together

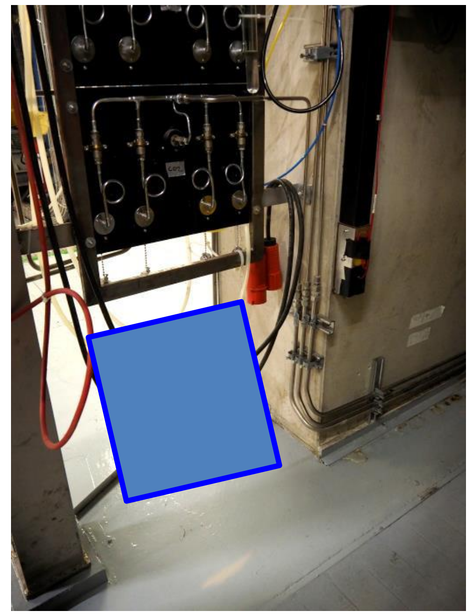
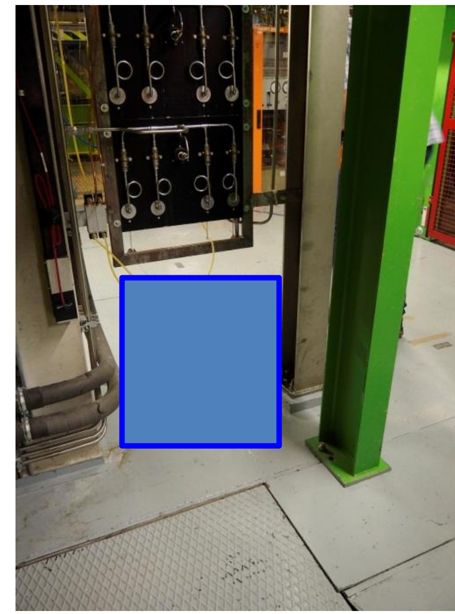
First meeting last week:

- A first idea was found after a long brainstorming.
- There is still a long way to go and modifications might be needed to the NOVEC destitution line design.
- Design help from outside CERN would be highly appreciated.

NOVEC and vacuum – vacuum infrastructure

A single rack is foreseen for the vacuum system:

- Installation position foreseen next to the gas racks.
- One ~50 mm pipe/bellow connecting to the vacuum manifold and continuing to the other manifold.
- 7 cables going to rack D3E06 (or one of the neighbors).

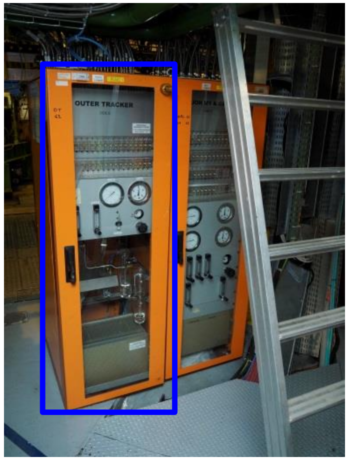
A readout/patch panel is needed for the Piranis.

- Installation foreseen below the gas panels.
- 6 cables will arrive from the C-frames to each position.
- 2 cables going to rack D3E06 (or one of the neighbors).

Dry gas

Dry gas supply destitution (Manifold, valves, flow controls etc.):

- Installation position foreseen in the top part of current OT gas racks.
- About 2*~2/3 of a rack.
- 12 bellows (~18 mm OD) going to the C-frames.
- Minimum one (22 mm OD) pipes going to rack A3B06 (or one of the neighbors). 2 Pipes needed in case the location is shared between A and C side. Discussion ongoing to re-use the OT pipes (current baseline).
- 4-6 multichannel pipes (~22 mm OD) for valve control going to A3B06 (or one of the neighbors).



Patch panel for flowmeters:

- Installation position in the lower part of the current OT gas racks.
- About ~2*1/3 of a rack if split between A and C side.
- Due to the large number of channels, the patch panel will be made of PCBs housed in crates.
- 12*4 cables (MCA 36 P, 12.3 mm OD) arriving from C-frames.
- 19 cables (ND100, 24 mm OD) going to D3E06 (or one of the neighbors).

Activities in B3852 – clean up, wooden boxes and C-cage

The scaffolding have been moved to the still unfinished tent.

This cleared space for the wooden boxes with modules from B2885, which are now on the mezzanine.

The work to finish the C-cage has continued.

Activities in B3852 – Vacuum and NOVEC tests

The vacuum manifold have been installed (after many modifications).

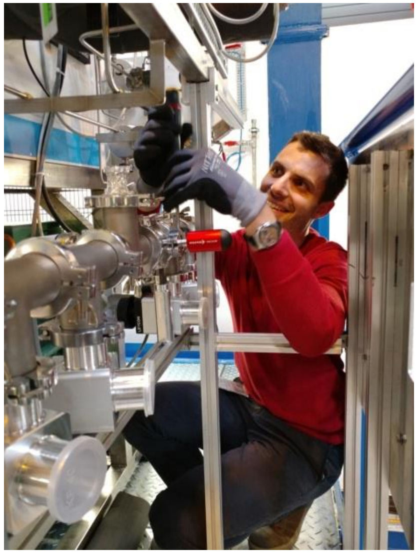
A vacuum of about 10^{-4} mbar has been achieved at the pumping station, but it is clear that the system still have leaks.

- 4 leaks from the NOVEC to the vacuum found and repaired (3 on the new coldbox connection and the largest on a VCR blind flange in the NOVEC manifold).

NOVEC has been filled in the bottom system (yesterday).

First try of circulating warm NOVEC shows low flow even at 8 bar – commissioning will continue.

Notice: On Wednesday the 14th the NOVEC system will be pressure validated, so no people will be allowed in B3852 between 9:30 and 10:30.



Activities in B3852 – Other activities

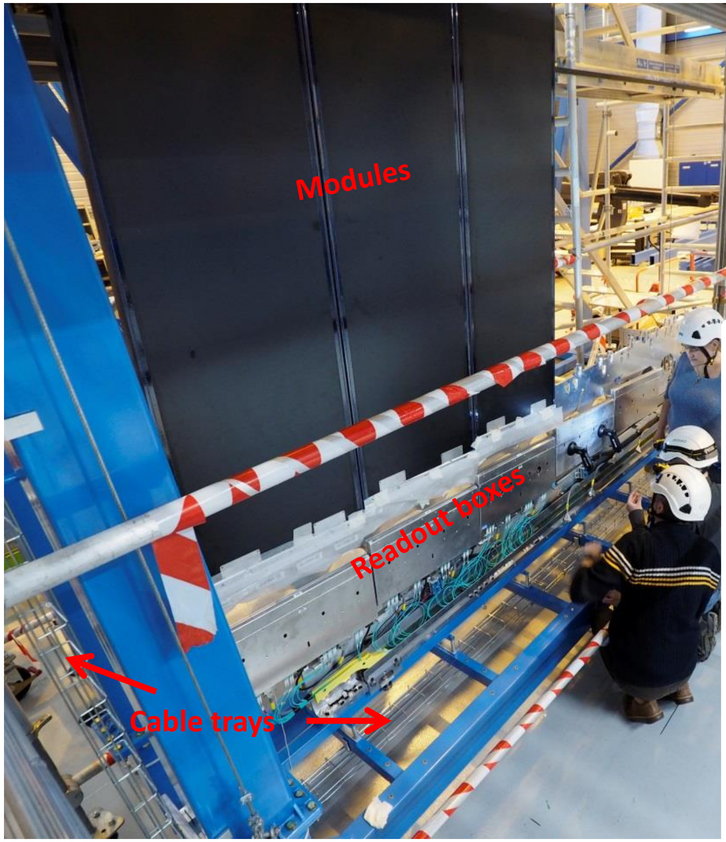
A safety net have been installed at the top level to catch materials (not persons).

3 modules without coldboxes have been installed on the C-frame prototype.

A cable tray is being installed from the racks to the C-frame for the Pirani cables, but others are naturally welcome to add cables to it.

(Dummy) readout boxes have been installed on several location (see electronics talk).

A setup of the FrontEnd tester is being commissioned on the mezzanine next to the test beam setup.



Activities in B2885 - “gray room”

Activities in B2885 – Transformation into a useful workplace

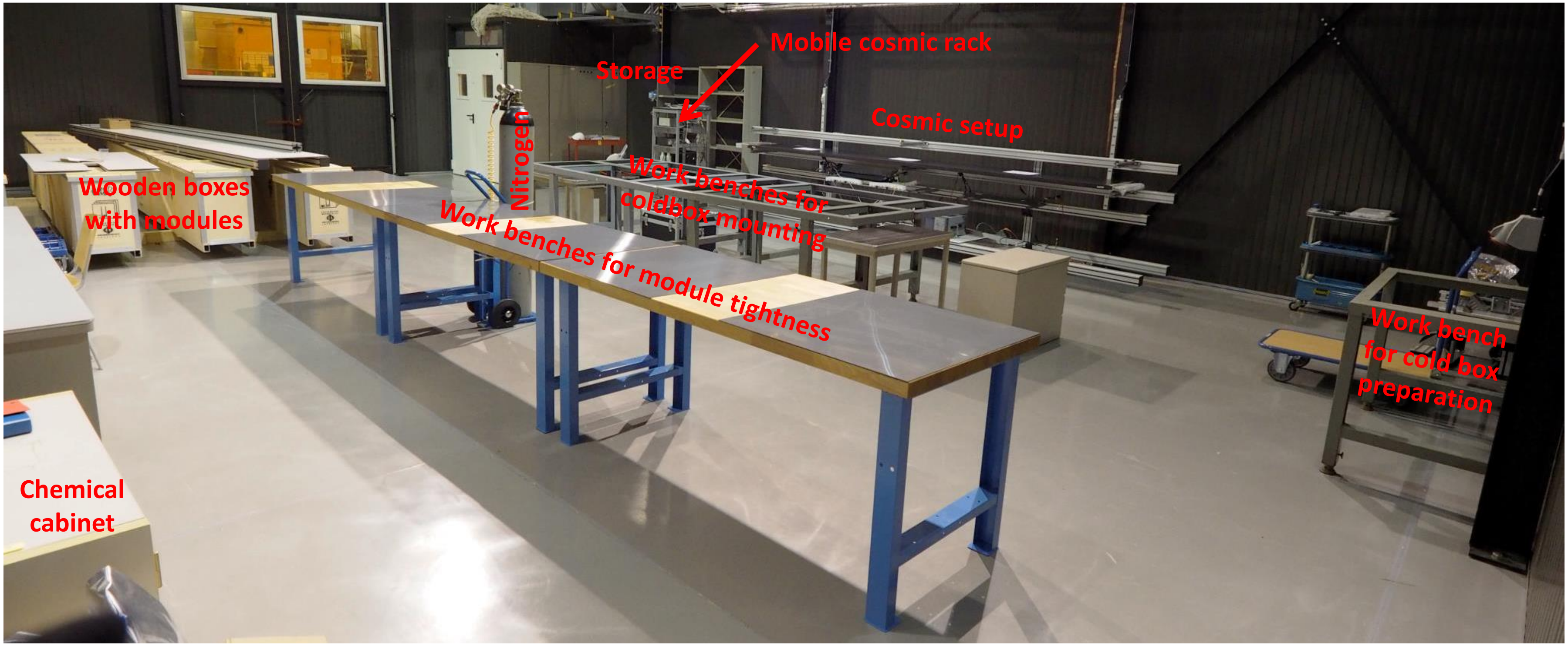
Most of the wooden boxes with the modules have been moved to B3852.

All have been prepared to start the leak tightness modification to the first 20 modules.

The cosmic setup have been prepared and is to first order operational.

The room have in general been prepared including a place to install coldboxes on modules.

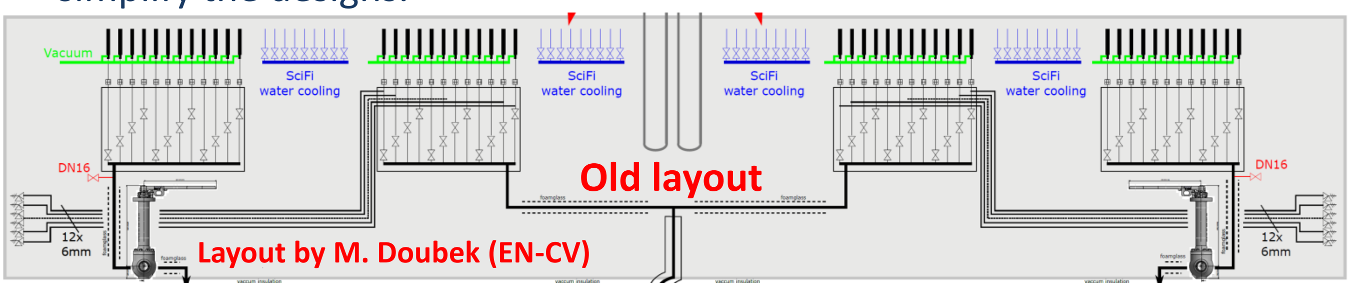
- New tables tops are being prepared in Heidelberg.
- Some activities still ongoing to make the room fully operational (cleaning, additional work lights, conversion into semi-clean room etc.)

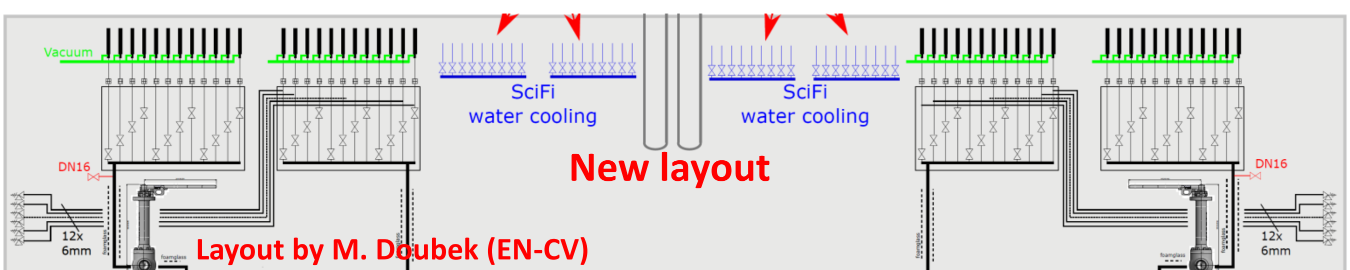


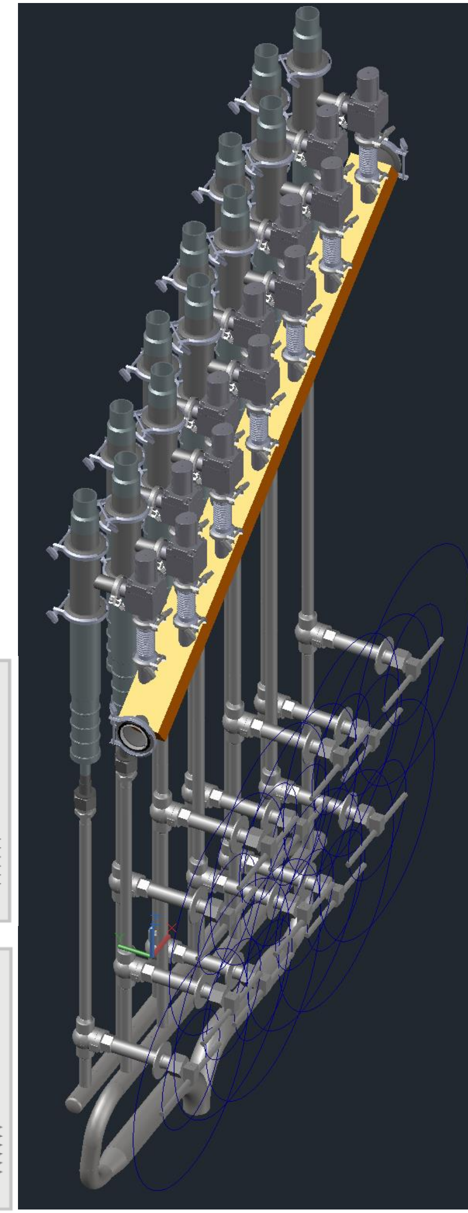
Manifolds for water, NOVEC and vacuum for the cavern at P8

Manifolds for water, NOVEC and vacuum

- A sketch of a possible vacuum manifold have been made and it shows that it is possible to keep the current design of the NOVEC distribution line and of the NOVEC manifold.
  - Now we can wait for a real design when a designer becomes available.
- Due to the constrains from the cable carrier etc., it is needed to modify the OT water manifold.
- It was been decided to rearrange the water and NOVEC manifolds to NOT split them.
  - This significantly ease the design of the NOVEC and vacuum manifolds with only minor implication for the water manifold as it would have to be updated anyway.
- The integration work continues and there are already new ideas to simplify the designs.







LHCb fibre QA: fibre aging

Fibre aging (w/o radiation)

- In March 2018 we have started to perform repeated measurements of stored fibre samples. We observed a slow but systematic reduction of the attenuation length, which increases in time.
- Effect is attributed to slow oxidation of Polystyrene (PS) fibre core.

  $PS + O_2 = PS^*$ ("colour centre")

- It can be treated as additional damage, like irradiation.

$$\alpha = \alpha_0 + \alpha_{irrad} + \alpha_{O_2} = \frac{1}{\Lambda_0} + \frac{1}{\Lambda_{irrad}} + \frac{1}{\Lambda_{O_2}}$$

$$\alpha_{O_2} \propto [\mathrm{PS}^*] = k \cdot t \quad \text{where } k = \mathrm{f}(\mathrm{T},[\mathrm{PS}][O_2])$$

$$k = k_0 \cdot \exp(-\frac{\Delta E}{RT})$$

Literature:
Aging of plastic scintillating fibers, H. Blumenfeld and M. Bourdinaud, APPLIED OPTICS, 1992, Vol. 31, No. 15.

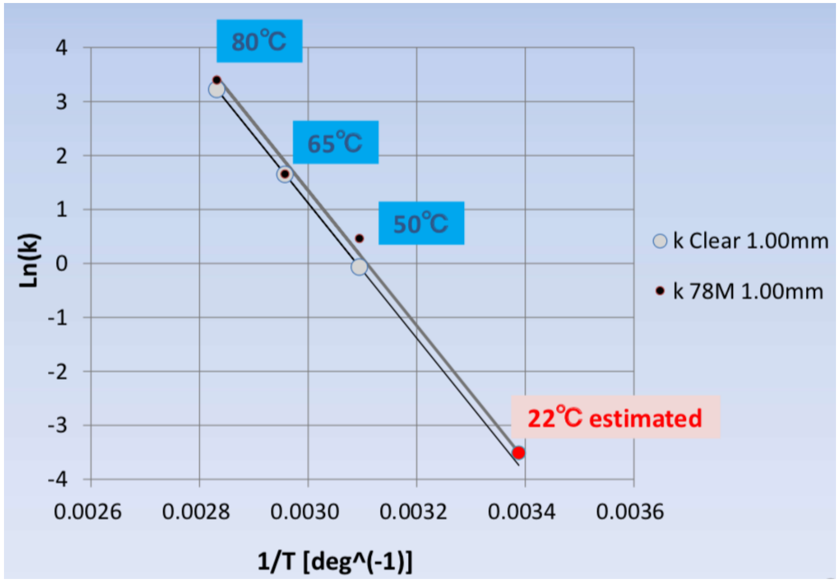
V. Senchishin et al., New Radiation Stable and Long-Lived Plastic Scintillator for the SSC, FERMILAB-TM-1866, 1993.

A. Artikov et al., Properties of the Ukraine polystyrene-based plastic scintillator UPS 923A, Nucl. Instrum. Meth. A (2005), 555, 125-131.

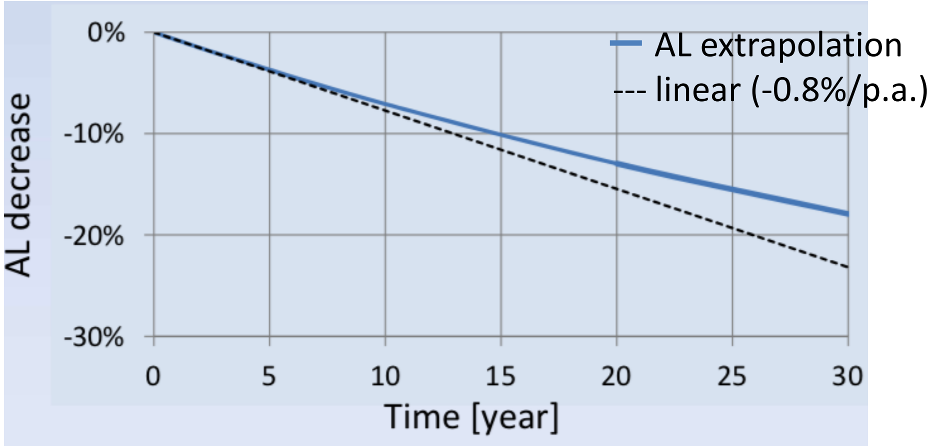
Arrhenius plot of *ln k* vs *1/T* allows to determine ΔE and to make a prediction for any *T*.

Kuraray study

- Our observations were discussed with Kuraray. They are aware of the effect and recently made a high temperature acceleration test to estimate the aging effect at room temperature (measurements at 50°C, 65°C and 80°C with 1 mm SCSF-78 fibre).



Kuraray data (for internal use only)

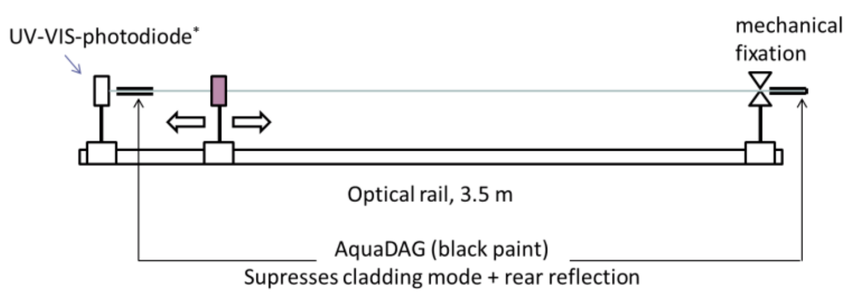


- They find that there is almost no change in transmission loss during the first 2-3 weeks (*) after the initial measurements. After that they estimate a 0.8% attenuation length decrease per year at 22°C. For 0.25 mm fibre it is difficult to give a precise estimation but the magnitude of the effect is expected to be similar.

**at high temperature. Will be much longer at room temperature.*

Our measurement procedure

- Since March we have also done additional measurements.
- The very same 3.5 m long single-fibre samples have been repeatedly measured on the very same set-up. Repeatability is within about 2 %.
- It was checked that measurement procedure itself (incl. unpacking, mounting, demounting, repacking) doesn't degrade fibre.

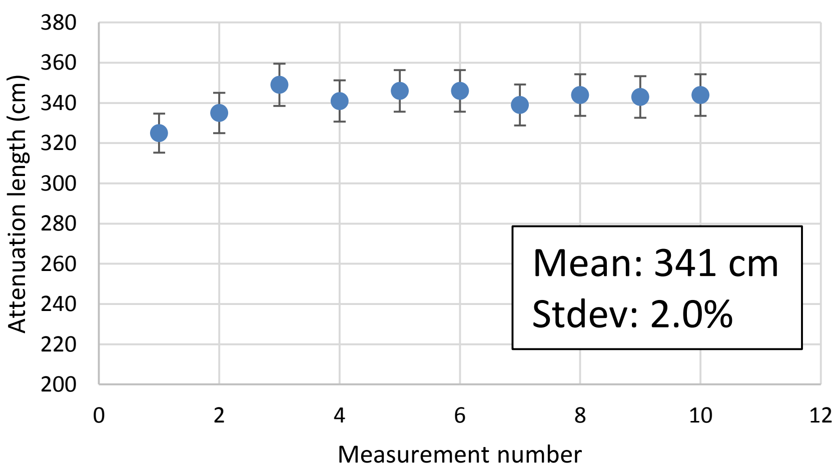


Λ is determined by a single-exponential fit to the data from d = 100 – 300 cm

$I = I_0 \cdot \exp(d/\Lambda)$ Λ: Attenuation length

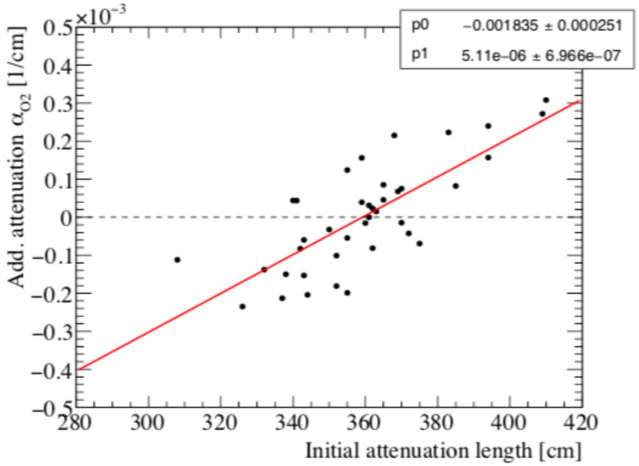
$\alpha = 1/\Lambda$ α: Attenuation factor

$\alpha_{O_2}(t) = \alpha(t) - \alpha_0$ $\alpha(t)$ measured now
α_0 at delivery

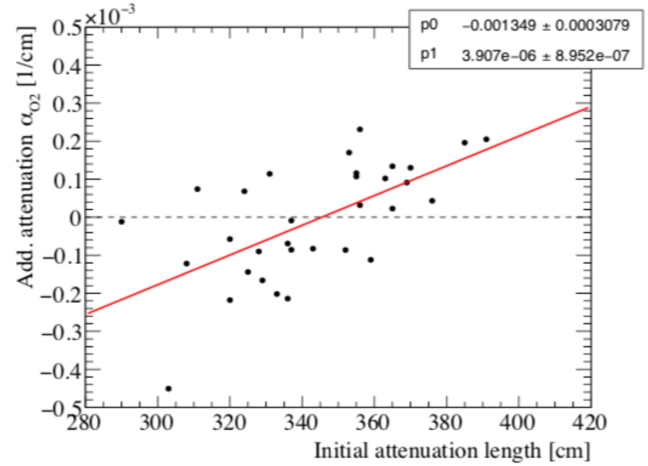


Repeatability measurement of the same AL sample: removed fibre from the set up and put it back into plastic bag between individual measurements

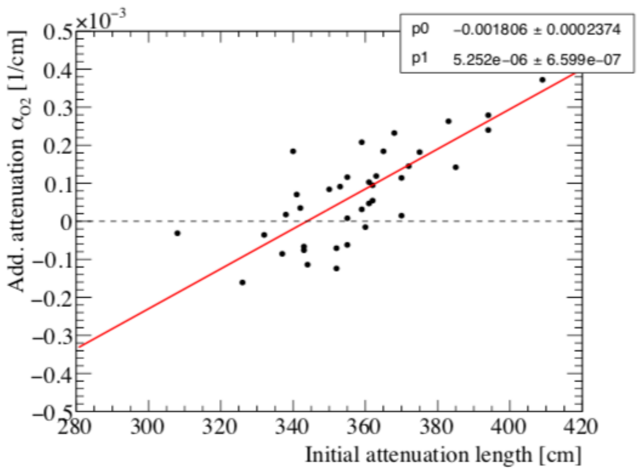
Add. Att. α_{O2} vs. initial AL



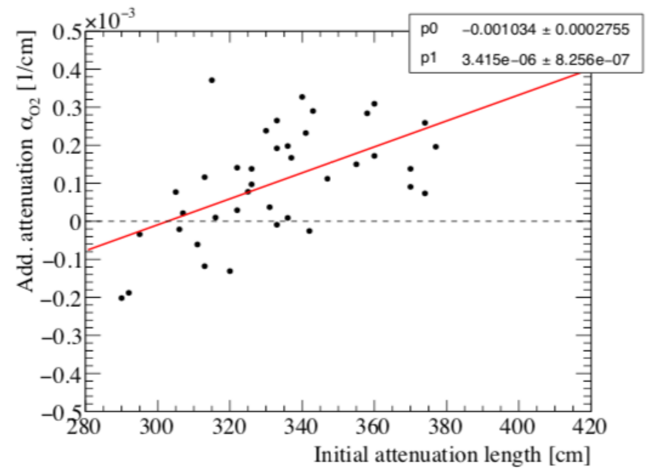
(a) After 7 months.



(b) After 12 months.



(c) After 16 months.



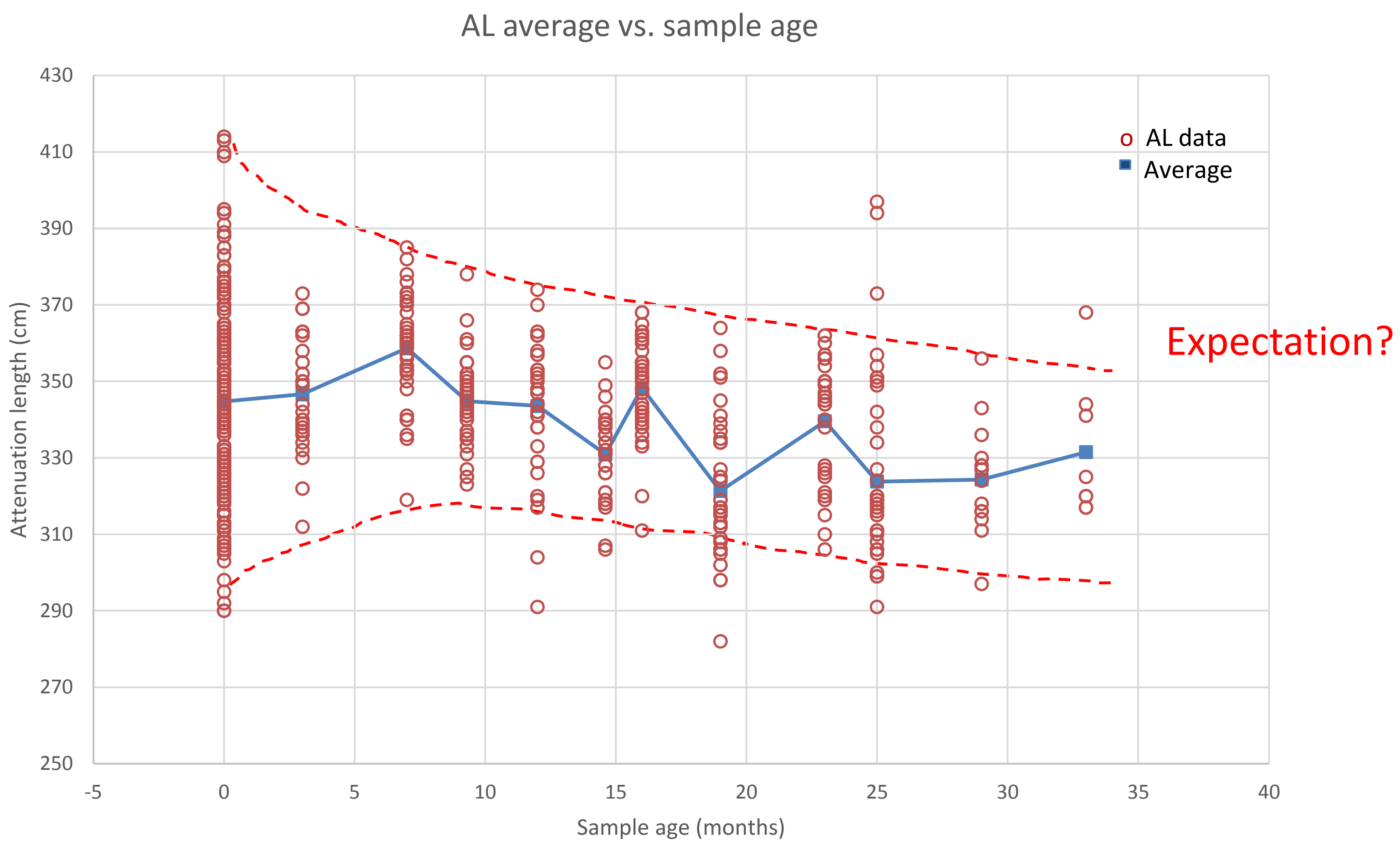
(d) After 19 months.

Add. Att. α_{O2} vs. initial AL

- **Add. attenuation (α_{O2}) and initial AL show a clear correlation.** We see this correlation for all measured times.
- **Initially low AL fibres** ($\Lambda < 350$ cm) tend to improve and show a **negative additional attenuation**, while **initially high AL fibres** ($\Lambda > 350$ cm) tend to degrade, i.e. **show large additional attenuation**.
- However, at a certain age (~ 1 year), the positive trend is over and fibres degrade.
- We think that there are fibres which had **initially high mechanical stress = large Rayleigh scattering = low initial AL**. Those fibres will loose the stress over time(*) and **improve in AL in the beginning**, until the oxidation effect dominates and they start to loose.
- Other fibres had **low stress = high initial AL**. These fibres start to **loose AL from the beginning**.

**In S-type fibres the styrene chains are aligned along the fibre axis while they are randomly oriented in non-S-type fibres. S-type fibres are mechanically stronger, however show a reduced attenuation length. Fibres of 0.25 mm diameter are produced only in a single quality which corresponds to semi-S-type.*

Attenuation length vs. sample age

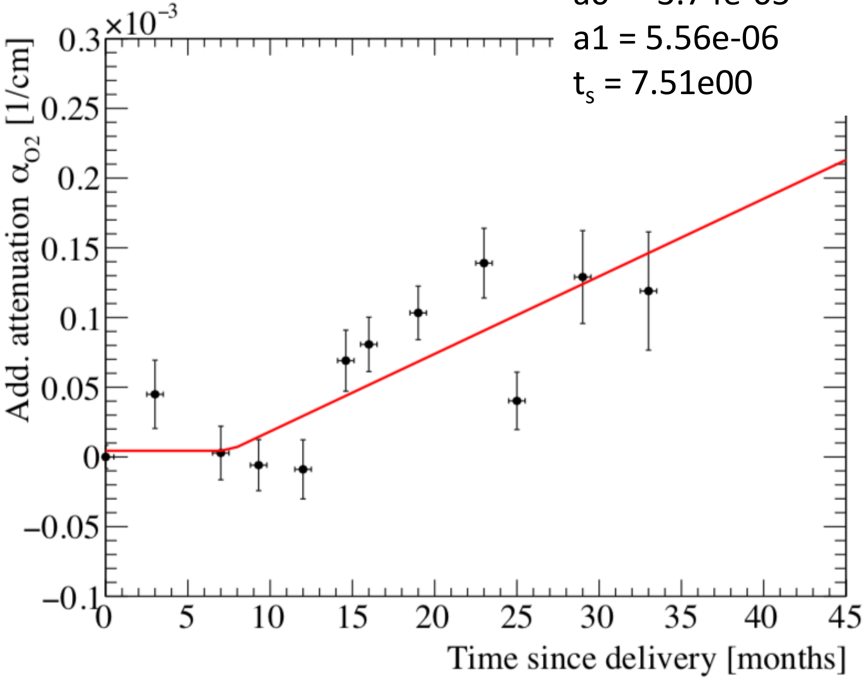


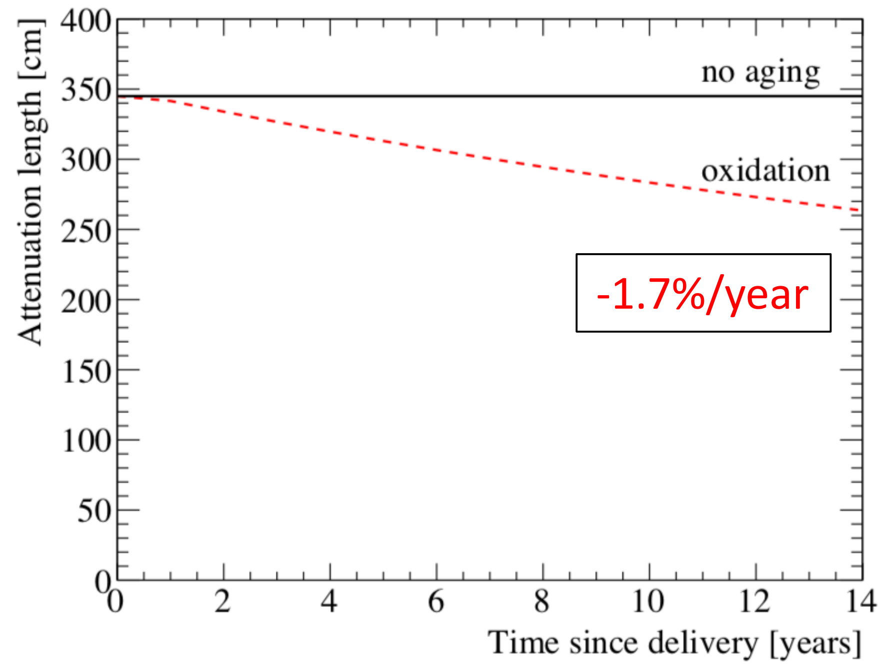
Extrapolation of add. attenuation

… if we assume a constant α_{O_2} up to a certain time t_s (t_s as additional fit parameter), then linear degradation starts:

If ($x < t_s$): $y = a0 + a1*t_s$
Else: $y = a0 + a1*x$

Chi2/ndf = 27.48/10
a0 = -3.74e-05
a1 = 5.56e-06
t_s = 7.51e00



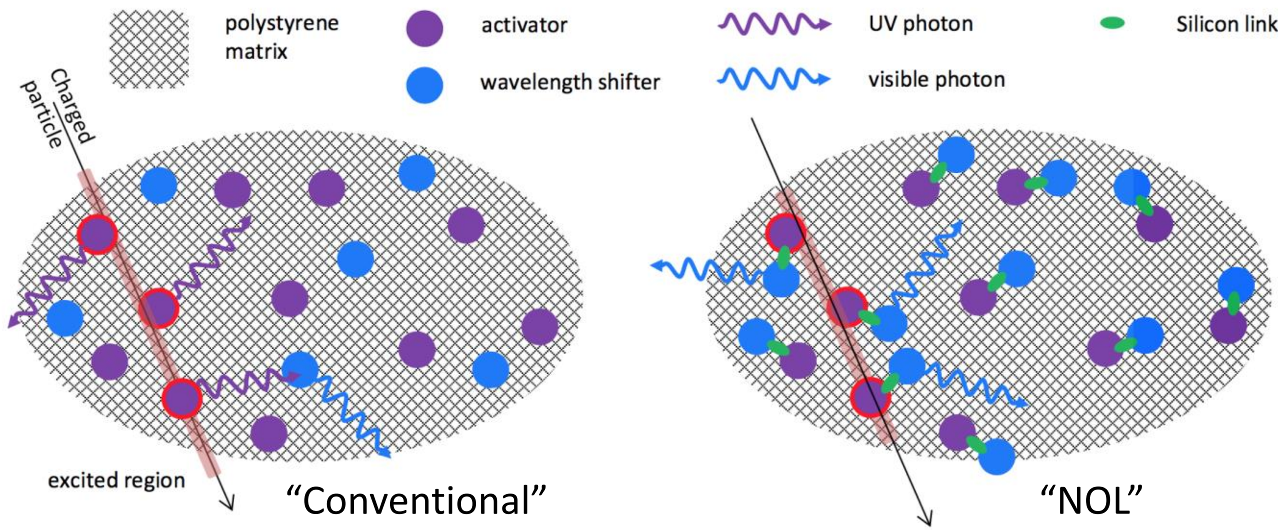


LHCb SciFi fibre R&D: NOL fibres

The NOL idea

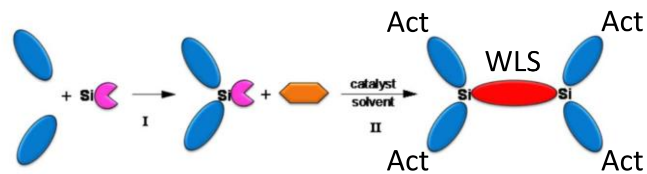
S.A. Ponomarenko et al., Nature Sci. Rep. 4 (2014) 6549

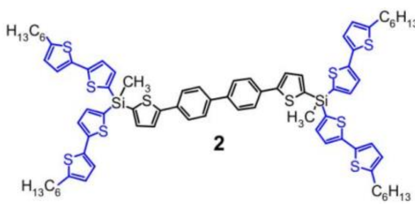
NOL: Nanostructured Organo-silicon Luminophores



Activator and WLS are chemically coupled using silicon links

- → Non radiative energy transfer (Förster mechanism)
- → Faster and more efficient
- → Higher light yield





2

NOL fibres

Applying the NOL idea to fibres puts some constraints on the content of material components

- **Activator content ~ 1-2%**: efficient energy transfer from solvent to activator and high light yield (Förster energy transfer)
- **WLS content < 1000 ppm:** avoid large self absorption (incomplete Stokes shift) and short attenuation length, should be fast and efficient (high QE)
- **Emission in the blue to green wavelength region** to match photodetector's PDE
- NOLs typically have an activator to wavelength ratio of 4/1 or 6/1 → **non-NOL activator has to be added and NOL serves as efficient and fast spectral shifter**

Components and contents need to be carefully selected and adjusted! The used materials must be of high purity!

NOL fibre R&D among 3 institutes/companies

- Kuraray CO., Japan
- CERN, Switzerland
- ISPM, Russian Academy of Sciences, Russia

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