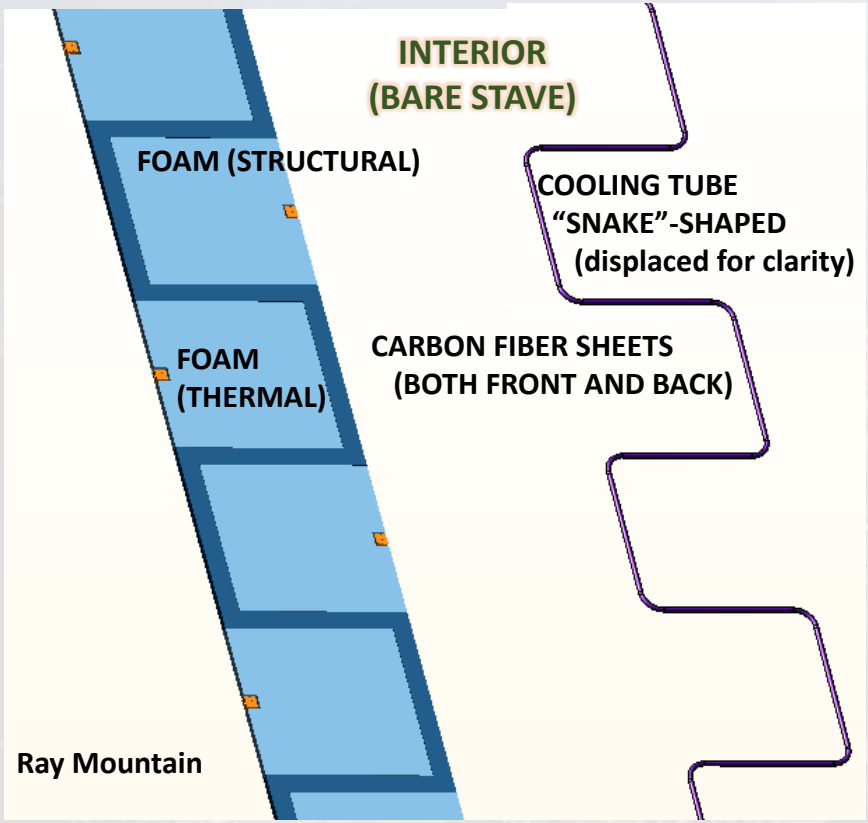
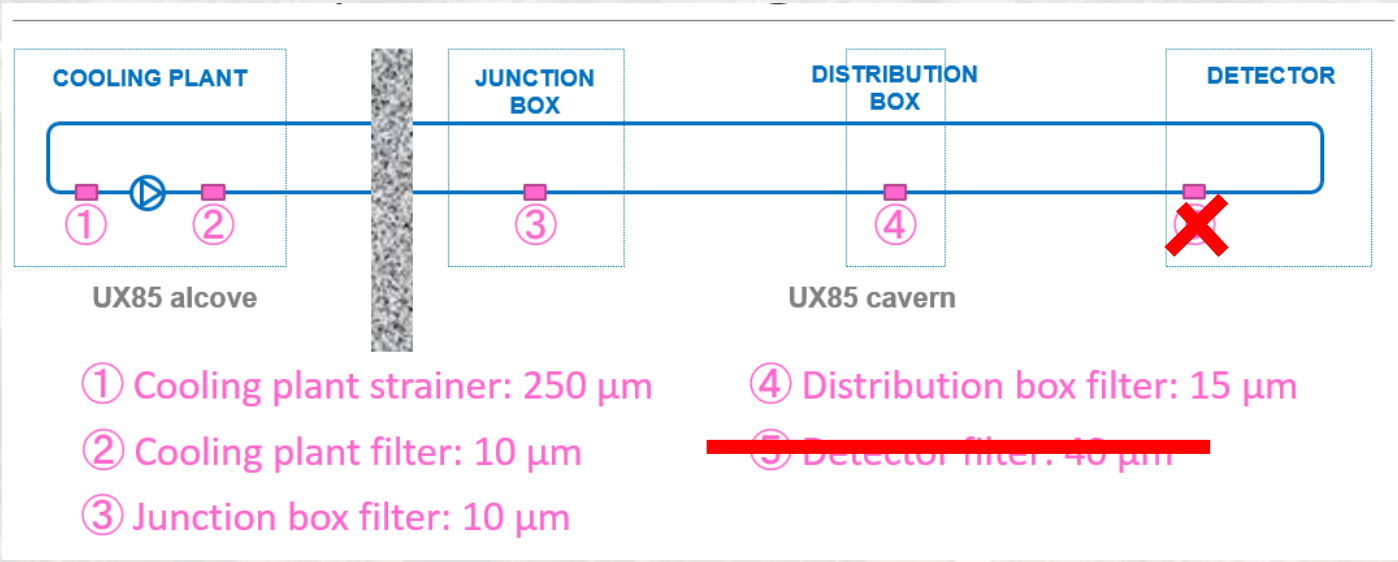
UT CO_2 cooling pipes contamination status

07.10.2019



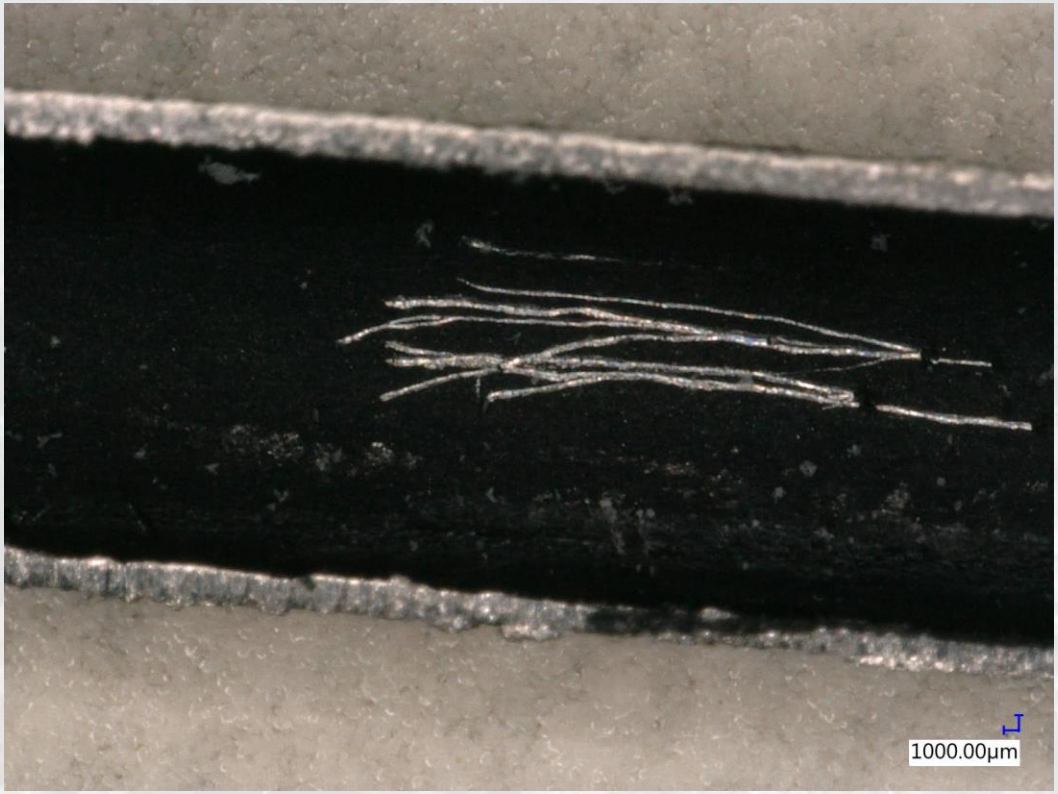
- Titanium snake pipe (OD 2.275mm; ID 2.025mm) 3.1 nominal length
- Electronics are subsequently glued on „bare“ staves
- All bare staves have been produced (68 nominal + 22 spares), small pipe pieces left
- Power consumption is ~0.6 Watt per ASIC -> 35-52Watt per Stave

- Filters are installed on the MAUVE plant
- Both UT and VELO can run off the same plant (JB level)



Cooling pipe contamination studies

- Titanium snake cooling pipes have a layer of oxide on the inner surface
- Knife scratches can remove this layer as shown
- Investigation of the surface together with EN-MME (metallurgy/materials)



The pipes are already embedded into the bare staves. In case the oxide layer from the pipes inner surface detaches, it can be a danger (for UT and VELO).

Possible consequences & solutions

- If these particles detach, they **can possibly clogg the MAUVE filters** (10 µm mesh) -> stop of cooling operation and/or **clogg VELO (60x60 µm) microchannel inlets** (if in backup joint operation)

- Two possibilities of cleaning are being investigated:

1. „Mechanical cleaning“ – running CO2 through the staves (Slide 6)
2. Chemical cleaning – running a special cleaning detergent through the staves (Slide 10)

- The cleaning method needs to be validated:

1. A sufficient amount of spare pipes – the only way to establish a working cleaning procedure
2. Chemical analysis of the spare pipe surface
3. LUCASZ filter inspection – decreasing amount of trapped particles after CO2 circulation inside a real stave
4. Pipe inspection inside the stave seems impossible (?)

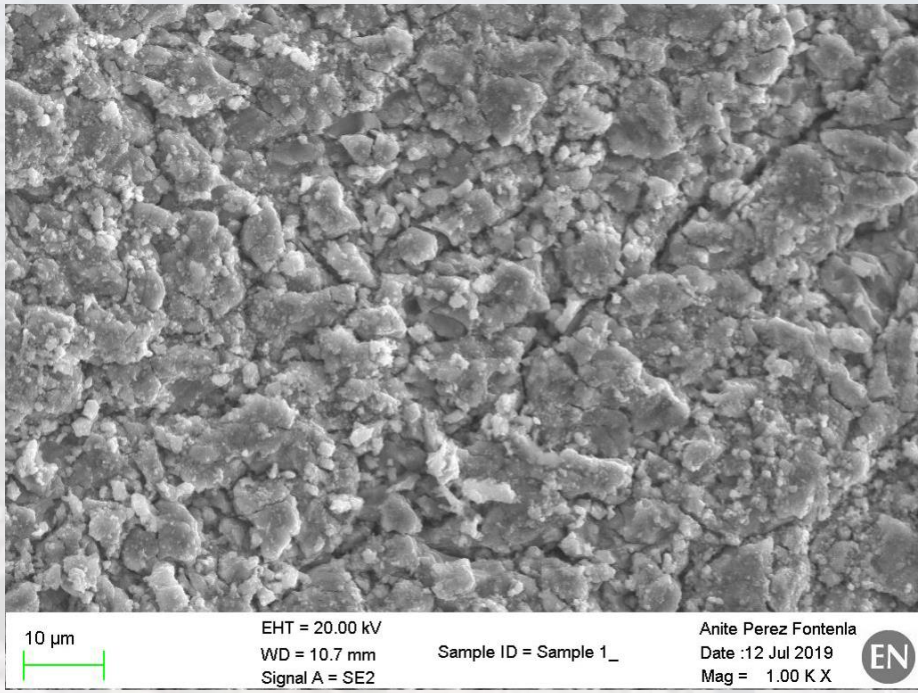
Safety of the chosen method for the pipes must be ensured!

EDMS: 2208046

Contamination studies: Pipe Surface Analysis

Grade II Titanium tubes inner surface;
study performed with Scanning Electron Microscope (full report in EDMS)

Element	Sample 1 (%)	Sample 2 (%)	Ref. (%)
Ti	62.6	61.9	Rest
O	28	32.8	0.25
Fe	9.1	4.9	0.3

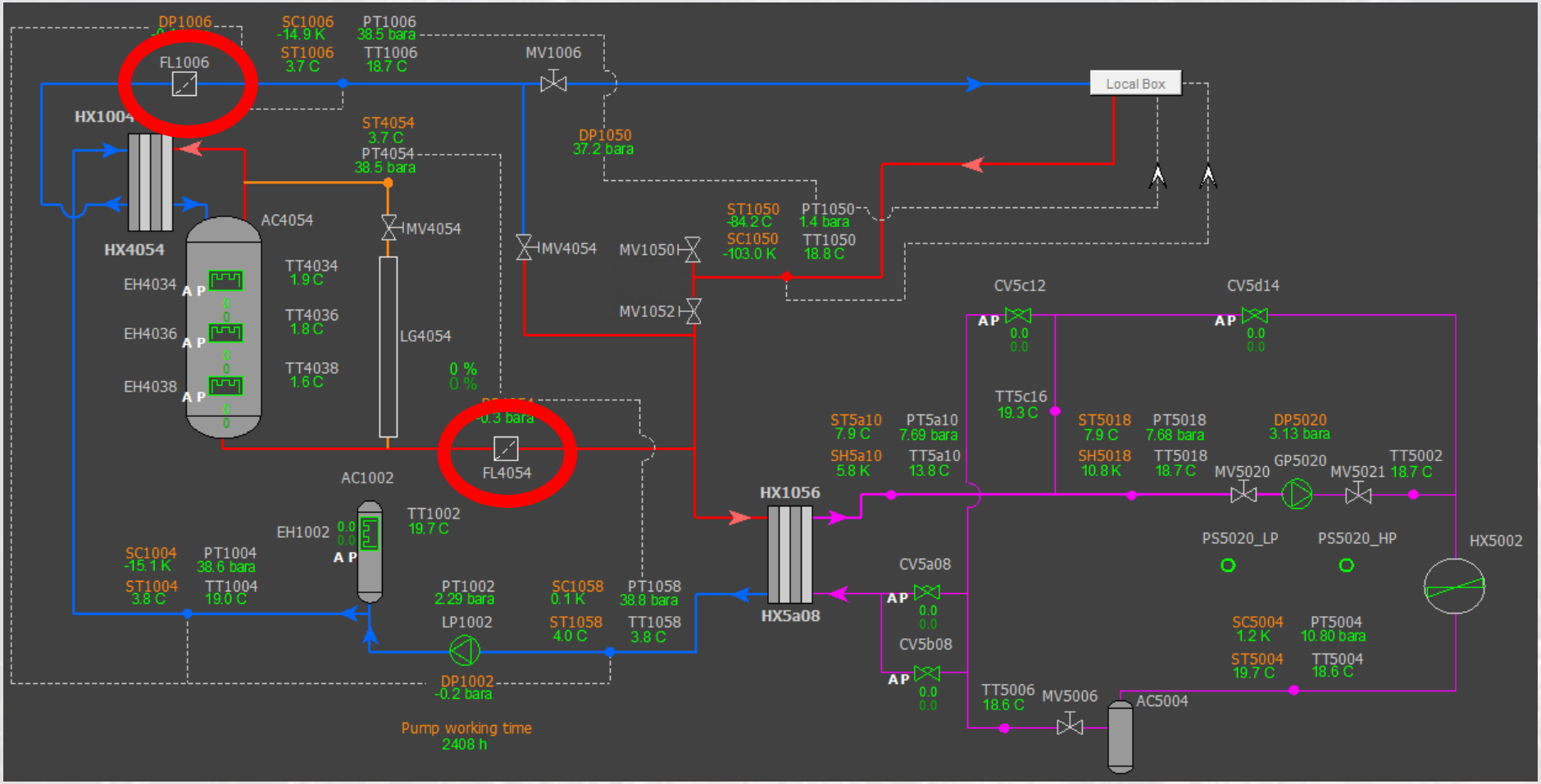


These amounts of Fe and O are not within the specs for Ti II grade
Particle sizes between 100 nm to few microns and **slightly attached** to inner surface have been observed

Cleaning by CO2 circulation

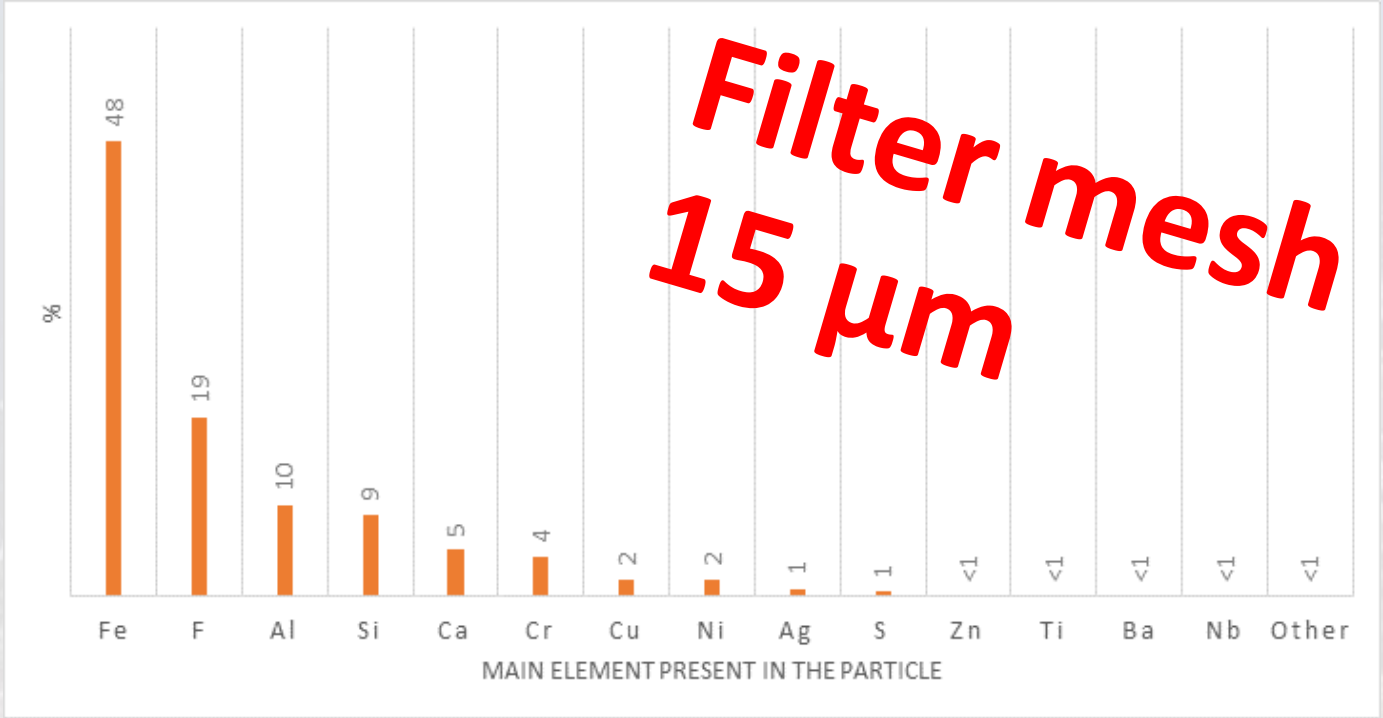
- LUCASZ: Plant has been running previously with „fresh“ Swagelok pipes and flexibles only – however, a filter contamination from them is still possible
- LUCASZ: Circulated CO2 through a test stave for 1 week with high flow (~10 g/s) whereby design flow is at ~0.5 g/s per stave (The time scale needs to be validated as well)
- Two filters – 90 µm for pump protection and 15 µm for main supply line to stave extracted for analysis

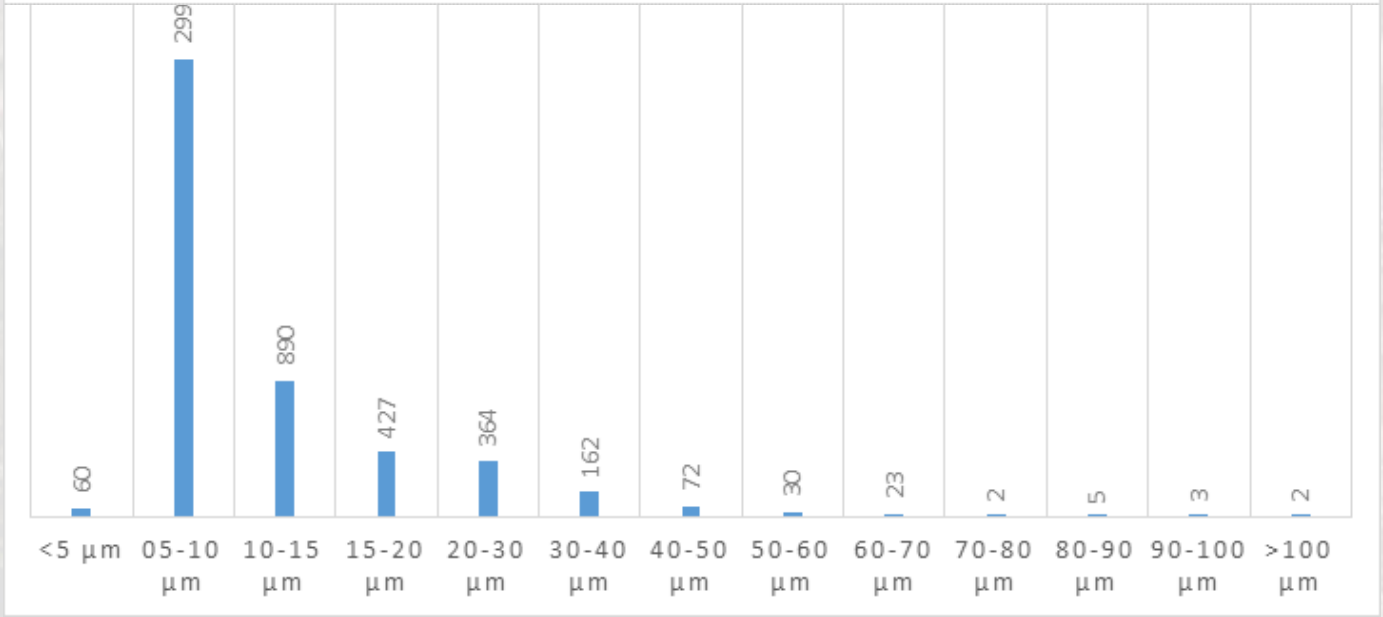
LUCASZ P&ID


DP1006
FL1006
SC1006
-14.9 K
ST1006
3.7 C
PT1006
38.5 bara
TT1006
18.7 C
MV1006
Local Box
HX1004
ST4054
3.7 C
PT4054
38.5 bara
DP1050
37.2 bara
HX4054
AC4054
MV4054
ST1050
-84.2 C
PT1050
1.4 bara
SC1050
-103.0 K
TT1050
18.8 C
MV1050
MV1052
EH4034
EH4036
EH4038
TT4034
1.9 C
TT4036
1.8 C
TT4038
1.6 C
LG4054
0 %
0 %
FL4054
CV5c12
CV5d14
TT5c16
19.3 C
ST5a10
7.9 C
SH5a10
5.8 K
PT5a10
7.69 bara
TT5a10
13.8 C
ST5018
7.9 C
SH5018
10.8 K
PT5018
7.68 bara
TT5018
18.7 C
DP5020
3.13 bara
MV5020
GP5020
MV5021
TT5002
18.7 C
AC1002
EH1002
TT1002
19.7 C
HX1056
HX5a08
PS5020_LP
PS5020_HP
HX5002
SC1004
-15.1 K
ST1004
3.8 C
PT1004
38.6 bara
TT1004
19.0 C
PT1002
2.29 bara
LP1002
SC1058
0.1 K
ST1058
4.0 C
PT1058
38.8 bara
TT1058
3.8 C
CV5a08
CV5b08
SC5004
1.2 K
ST5004
19.7 C
PT5004
10.80 bara
TT5004
18.6 C
TT5006
18.6 C
MV5006
AC5004
DP1002
-0.2 bara
Pump working time
2408 h

Filter contamination studies: **Preliminary**

Particle identified by 51% of its content!





Particle identified by 51% of its content!

Filter contamination studies

Follow up with Anité Perez Fontenla

- Does it mean there is no Iron Oxide present in the filter?
- Does it mean there is no Ti Oxide present in the filter?

↓

- *More than 2000 particles presented Fe as main element.*
- *Into those Fe particles, 1153 presented also stainless steel alloy elements like Cr (thus we can consider them SS particles) and* ***1100 particles were only presenting Fe and O****.*
- *I cannot tell which type of oxide of iron, just the present elements.*

↓

1. We are urgently waiting for further analysis to understand the elements found on the filter and whether we can link those to the inner surface ot UT cooling pipes
2. We now have a clean filter which we will use to study trapped particles with future staves
3. We are consulting with chemical experts to try chemical cleaning

Chemical cleaning

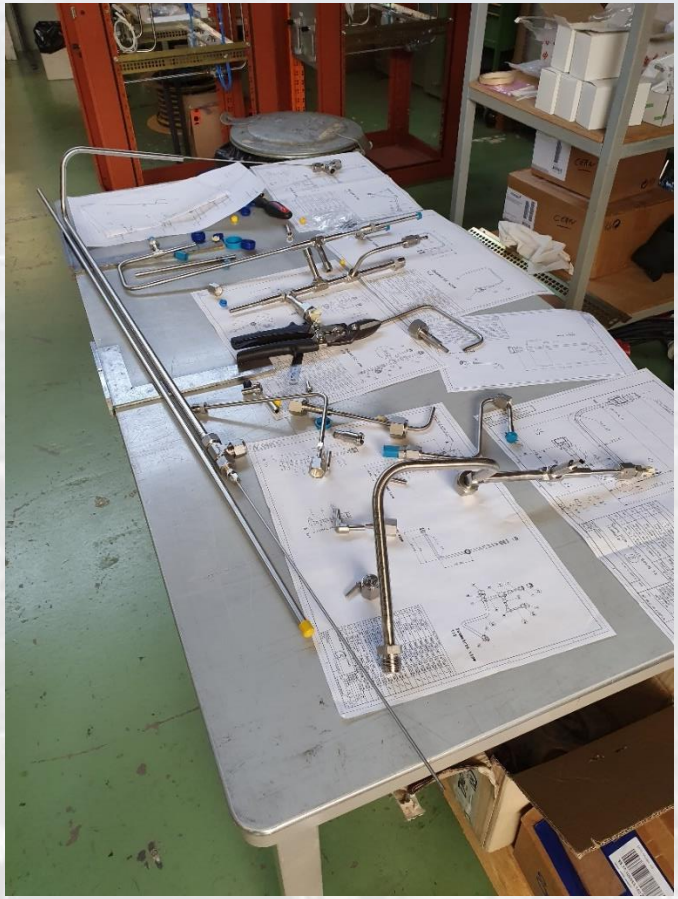
Received the bare stave for tests last week and met with the expert:

- Suggestion is to use Net Inox [Specs in backup] – a mix of nitric and fluorine acides

- Need a spare pipe pieces to test before applying to the bare stave (Simone is urgently shipping his pipes from Milano)
- Need to understand whether the remnants of Net Inox (or other?) would be a danger for the cooling system and the detectors:

1. Running detergent (can be done is special lab) – time to be determined
2. Cleaning with demineralized water
3. Drying

Slice test setup for orifice and cold tests



We need to study the DP behavior in normal operating conditions for the final geometry and power:

Up to two stave can be operated simulataneously, but we can only power up one of them. It would be interesting to circulate CO2 through two fully powered staves (bricolage?)

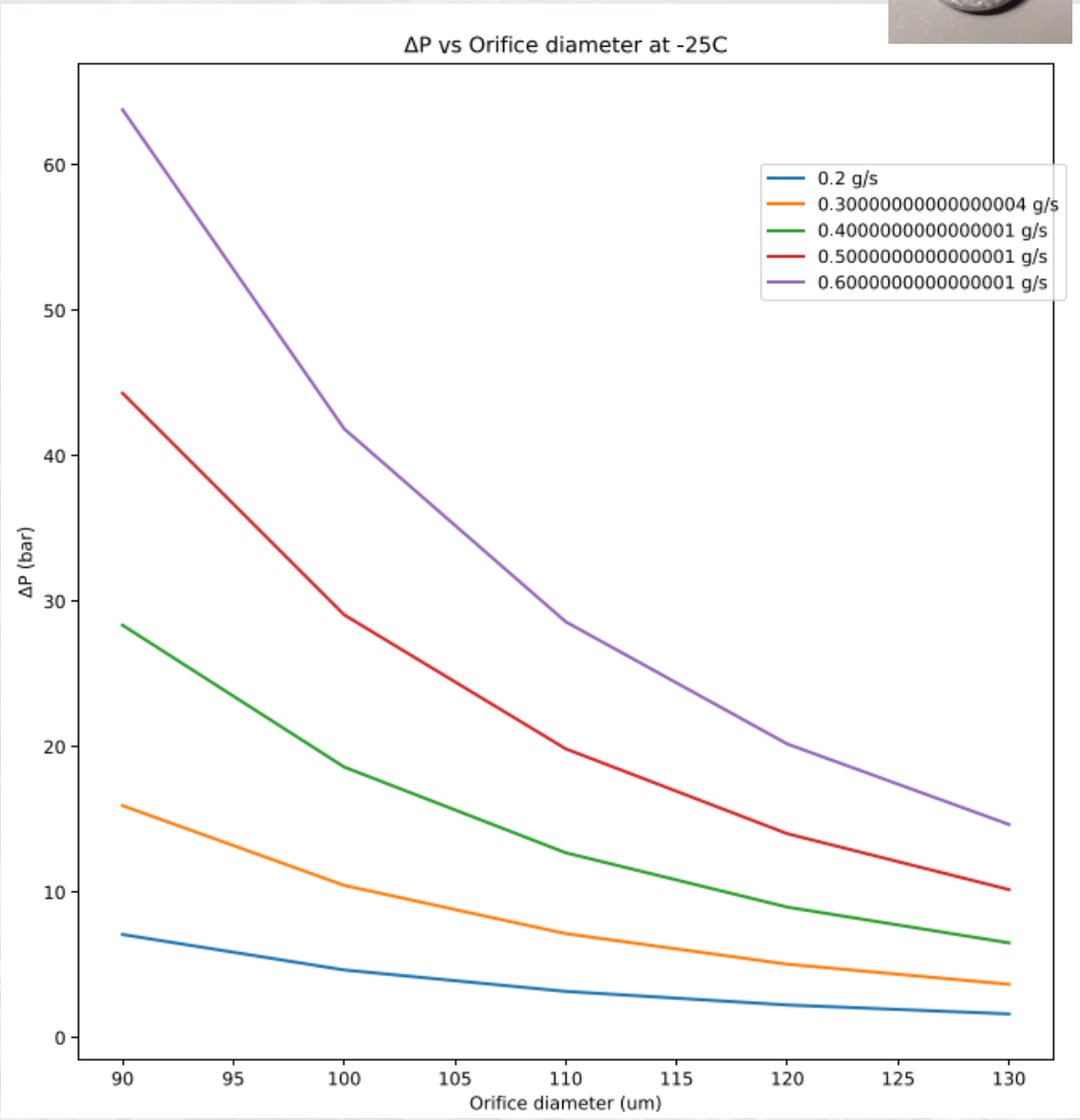
Orifice tests for understanding the DP are first priority once this setup is installed (foreseen for upcoming week)!

Slice test setup at P8

- Can house up to 2 staves, 14 hybrids can be powered at the moment (1 full non-central stave)
- Flowmeter, two PTs, two TTs will be installed, so the pressure difference over the stave can be studied (both with and without an orifice)
- One would need to bricolage in order to add an improvised heater on the second stave (only on a bare stave)

Orifice DP from simulations

- Several orifices available for testing (100µm, 125 µm and 150 µm)
- Simulations show that and 125µm delivers a DP which is close to the design requirements
- The choice of the orifice size should be done as soon as possible; however, a change is possible „rather quickly“



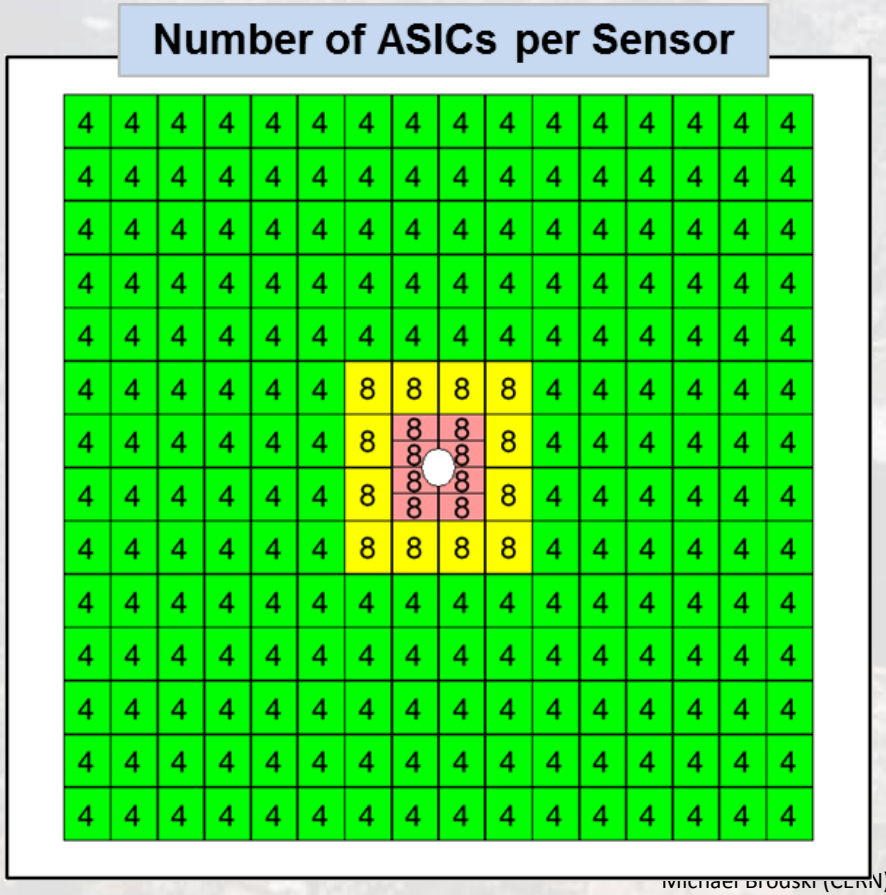
Conclusions

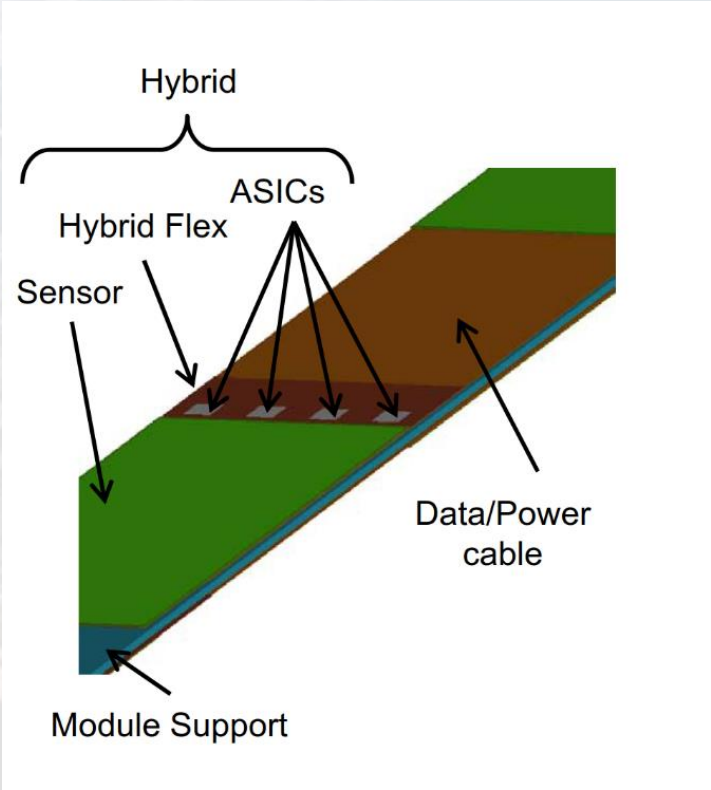
- Pipe contamination studies ongoing with full steam – stay tuned in the next few weeks
- Final decision on cleaning to be taken by UT management
- Orifice characterization studies to start asap
- Final CO2 system manufacturing/procurement has begun

BACKUP

Sandwich stave structure

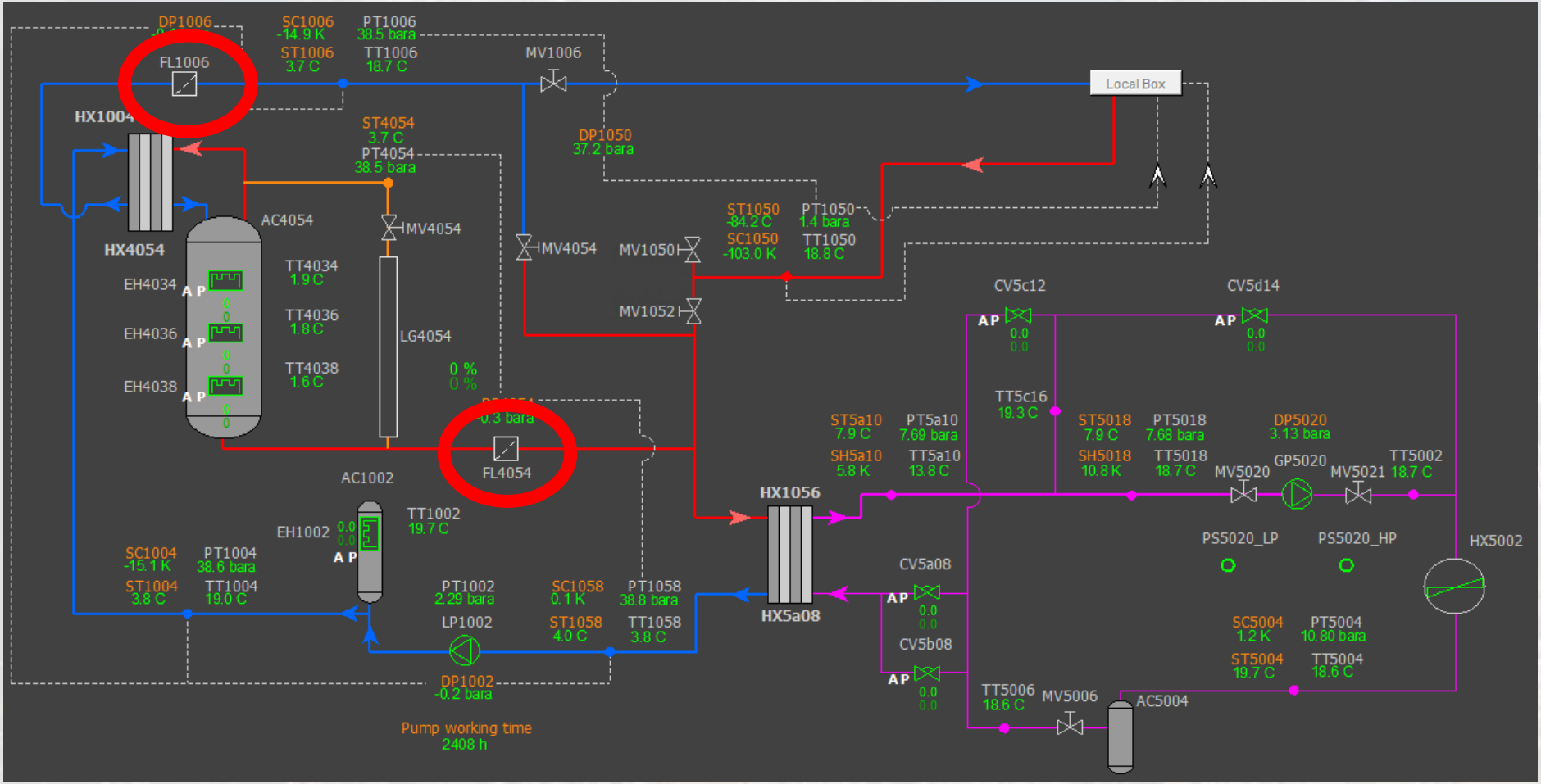
- ASICs are the main heat producers with about ~2.4 Watt per 4ASICs (preliminary; sensor contribution is negligible)





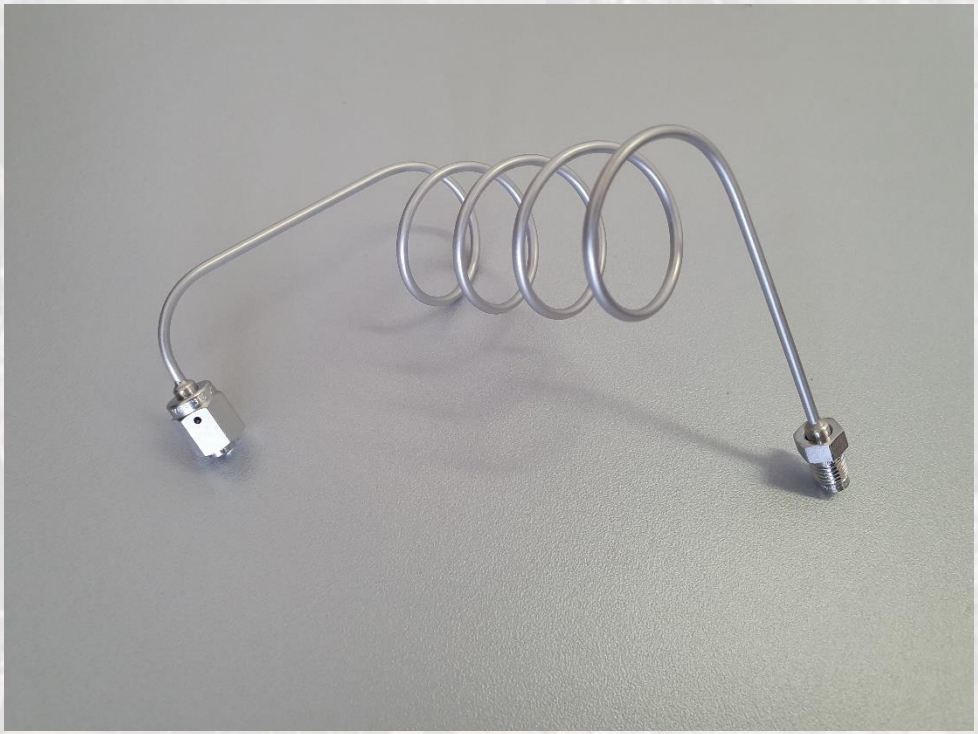
- Denser arrangement around the beam pipe due to higher particle flux

LUCASZ P&ID


DP1006
SC1006
-14.9 K
ST1006
3.7 C
PT1006
38.5 bara
TT1006
18.7 C
FL1006
MV1006
Local Box
HX1004
ST4054
3.7 C
PT4054
38.5 bara
DP1050
37.2 bara
HX4054
AC4054
MV4054
ST1050
-84.2 C
PT1050
1.4 bara
SC1050
-103.0 K
TT1050
18.8 C
MV4054
MV1050
MV1052
EH4034
TT4034
1.9 C
EH4036
TT4036
1.8 C
EH4038
TT4038
1.6 C
LG4054
0 %
0 %
FL4054
CV5c12
CV5d14
TT5c16
19.3 C
ST5a10
7.9 C
PT5a10
7.69 bara
SH5a10
5.8 K
TT5a10
13.8 C
ST5018
7.9 C
PT5018
7.68 bara
SH5018
10.8 K
TT5018
18.7 C
DP5020
3.13 bara
MV5020
GP5020
MV5021
TT5002
18.7 C
AC1002
EH1002
TT1002
19.7 C
HX1056
HX5002
PS5020_LP
PS5020_HP
SC1004
-15.1 K
PT1004
38.6 bara
ST1004
3.8 C
TT1004
19.0 C
PT1002
2.29 bara
SC1058
0.1 K
PT1058
38.8 bara
LP1002
ST1058
4.0 C
TT1058
3.8 C
HX5a08
CV5a08
CV5b08
SC5004
1.2 K
PT5004
10.80 bara
ST5004
19.7 C
TT5004
18.6 C
TT5006
18.6 C
MV5006
AC5004
DP1002
-0.2 bara
Pump working time
2408 h

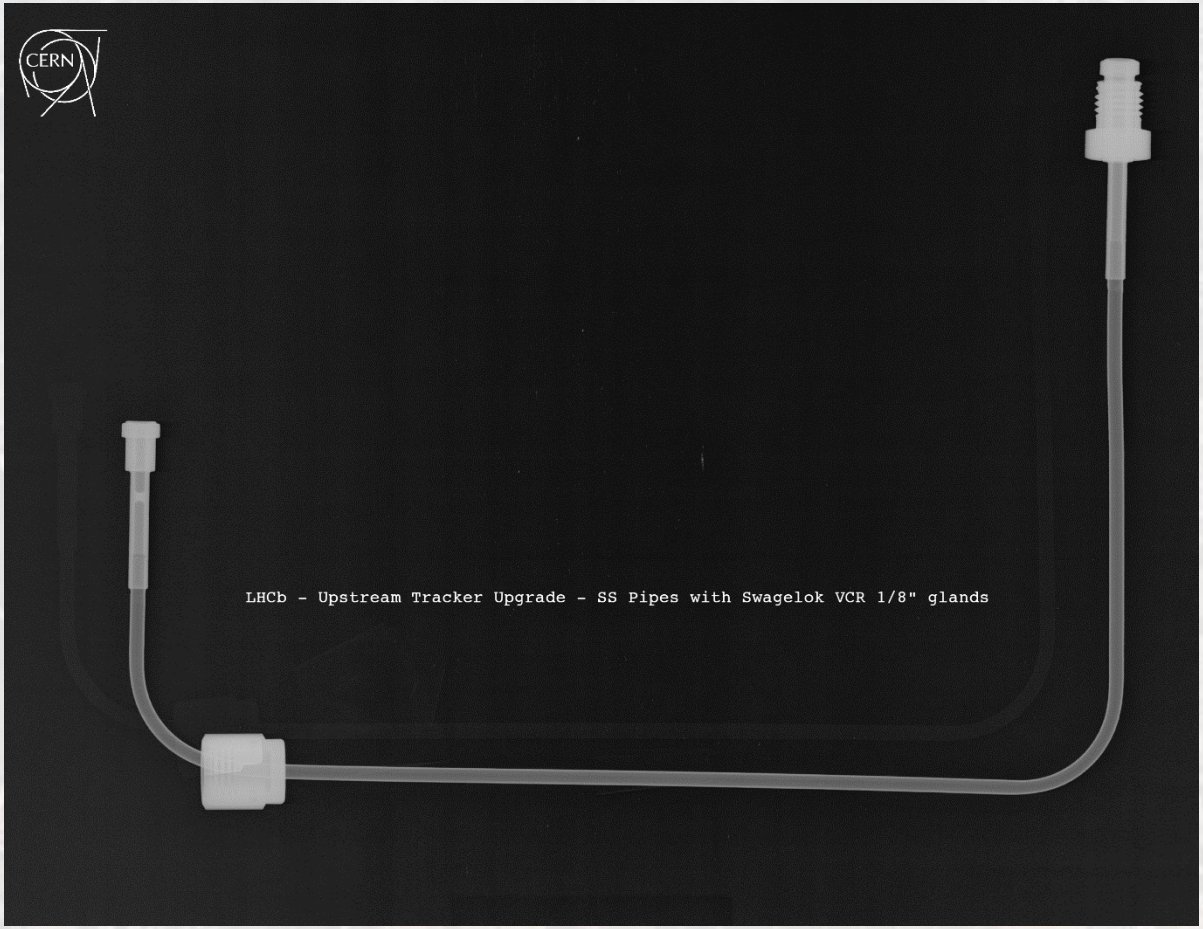
UT Box CO2 and further stuff

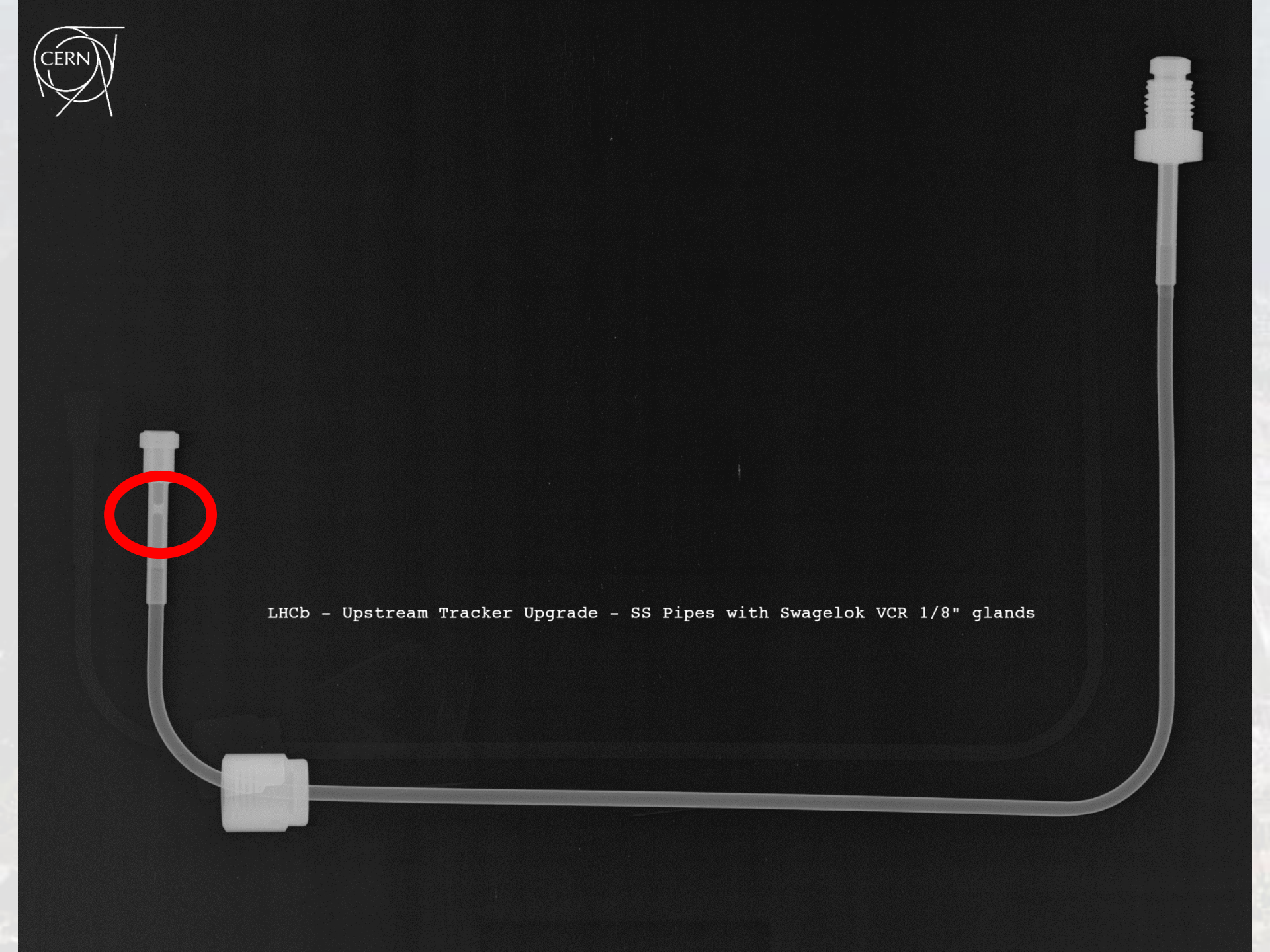
- VCR 1/8‘‘ glands drilling will be done by the **end of October**
- In the mean time, a manifold has been prepared as a pilot
  2.4mm ID after brazing point
  for now
  -> will be 2.0mm as in final drawings for final brazing
- Will send this manifold to qualification pressure test



Quality follow up of vacuum brazing

- X-ray inspection reveals that brazing alloy might have been the cause of clogging
- Images from metallurgy (open and look) expected beginning of this week




LHCb - Upstream Tracker Upgrade - SS Pipes with Swagelok VCR 1/8" glands

Net Inox data sheet

2 IDENTIFICATION DES DANGERS

Effets néfastes sur la santé

Toxique par inhalation, par contact avec la peau et par ingestion
Corrosif ; provoque des brûlures

Effets sur l'environnement

Produit fortement acide. Il est corrosif et toxique.

Dangers physico-chimiques

En cas d'incendie, peut former des gaz toxiques (NOx).

Classification du produit

Toxique ; Corrosif

PRINCIPAUX SYMPTÔMES:

Brûlures par contact avec la peau et les muqueuses
Irritation des voies respiratoires.

3 COMPOSITION/INFORMATION SUR LES COMPOSANTS

COMPOSANTS APPORTANT UN DANGER:

NOM	N° Einecs	N° CAS	CLASSIFICATION	RISQUES	CONCENTRATION
Acide nitrique	231-714-2	7697-37-2	C corrosif	R 8-35	30-50%
Acide fluorhydrique	231-634-8	7664-39-3	T+ très toxique C corrosif	R 26/27/28 R 35	5%

Final CO2 setup procurement & Misc

- Final offer received from Swagelok
- EDH finalized 1.5 weeks ago – waiting for it to pass through the system

- RH studies ongoing -> how to measure RH inside the box (meeting with Petr, Jana and Carlos last week)
- Need to see with Carlos about electronical integration
- Discussion about clean room and/or controlled RH tent in the assembly hall in 3852