LHCb CO2 cooling meeting
7/10/2019

Istituto Nazionale
di Fisica Nucleare
Sezione di Milano

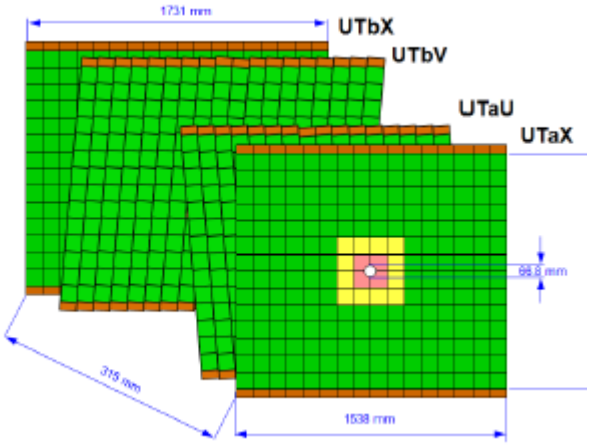
Updates from UT detector

Simone Coelli
For the Milano UT group
INFN milano

SUMMARY:

- ΔT CO_2 – Sensor
- Power and flow
- P&ID

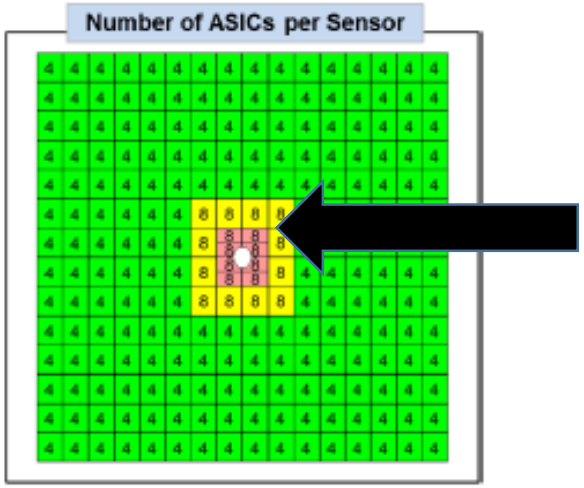
ΔT CO_2 – Sensor



UT detector
4 planes

Dissipated power coming mainly from the ASICs read-out

Requirement: max sensor T < -5°C



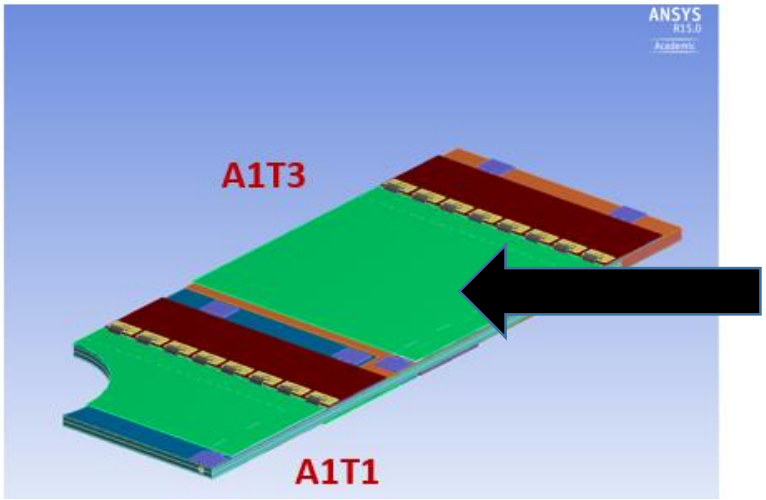
Staves in a plane have modules with 4 ASICs or 8 ASICs read-out

The thermal flow is bigger for modules with 8 ASICs

For these modules the sensor/cooling pipe temperature difference is bigger

These modules drive the coolant T set-point

ΔT CO_2 – Sensor

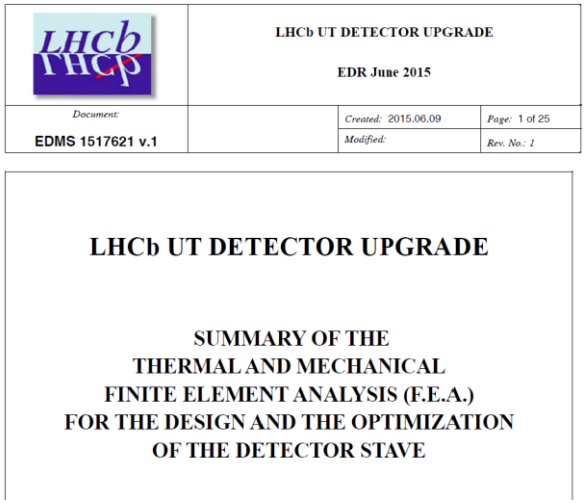


The sensors in the «worst thermal condition»
Are in the Central staves

position A1T3

- 8 ASICs read-out
- Sensors placed over the data-cable

In the design phase
FEA studies have been done
to estimate the temperature field on the sensors



LHCb UT DETECTOR UPGRADE

EDR June 2015

Document: EDMS 1517621 v.1

Created: 2015.06.09 Page: 1 of 25

Modified: Rev. No.: 1

LHCb UT DETECTOR UPGRADE

SUMMARY OF THE
THERMAL AND MECHANICAL
FINITE ELEMENT ANALYSIS (F.E.A.)
FOR THE DESIGN AND THE OPTIMIZATION
OF THE DETECTOR STAVE

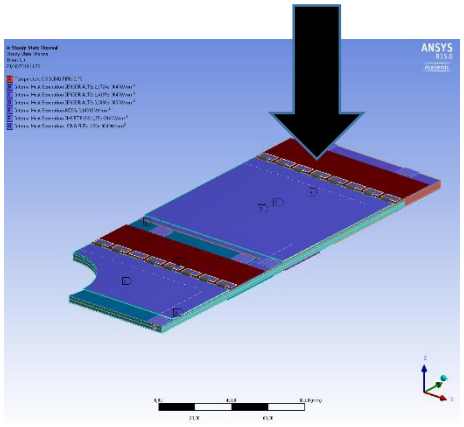
A sum-up of the studies could be find in the report made for the EDR:

SUMMARY OF THE THERMAL AND MECHANICAL FINITE ELEMENT ANALYSIS (F.E.A.) FOR THE DESIGN AND THE OPTIMIZATION OF THE DETECTOR STAVE
https://edms.cern.ch/document/1517621/1

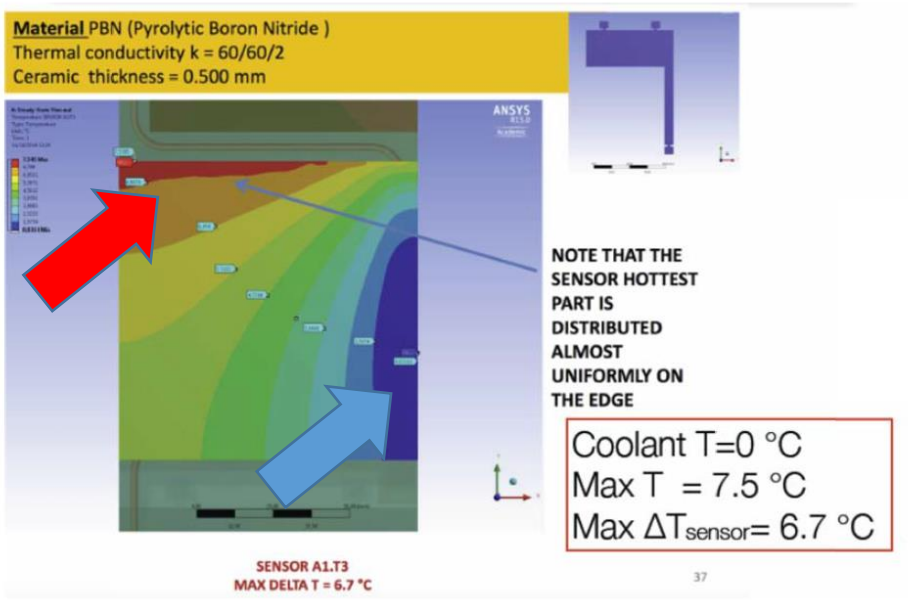
$\Delta T\ CO_2$ – Sensor

A1T3 sensor thermal results
8 ASICs read-out

Basic assumption for the FEAs
Power: 0.768 W/ASIC



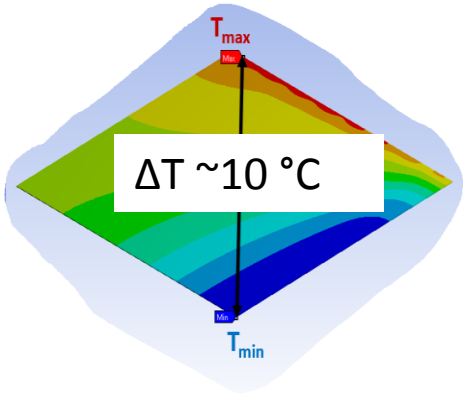
- PBN STIFFENER NO SLITS:



T sensor <-5°C

The sensors operating at nominal power have a temperature field:

- Cold part of the sensor is at a temperature very near to the cooling pipe (negligible thermal flux in this region)
- Hot spot in the silicon located near the sensor edge facing the read-out chips
- The FEA worst case indicated ~7.5°C T difference from the pipe inner surface to the hot spot
- $\Delta T\ CO_2$ to pipe has to be added (internal convection) estimated in ~2°C, in the region under the ASICs, where the hot spot is located



=> The $\Delta T\ CO_2$ - Sensor (max silicon T) was rounded to ~10 °C for these sensors

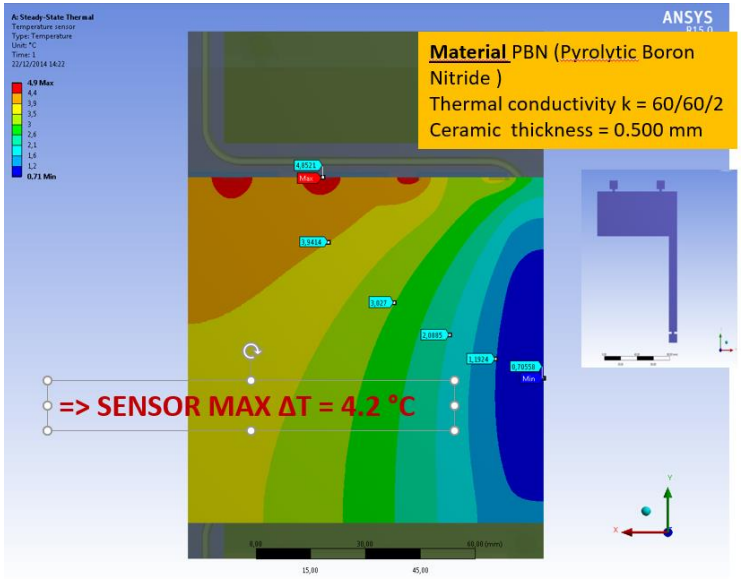
=> T CO2 < -15°C

ΔT CO_2 – Sensor

NOTES:

- The majority of sensors have **4 ASICs read-out**

Having half-power read-out the T differences are a factor 2 lower



- Basic assumption for the FEA

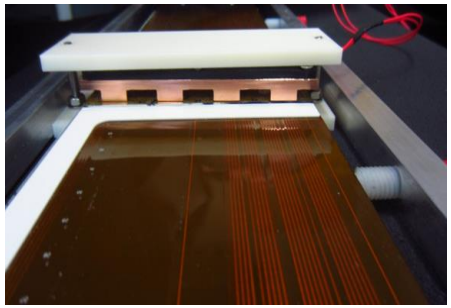
Power: **0.768 W/ASIC**
but real one could be as lo as 0,6 W/ASIC
ΔT in this case will be proportionally lower (~80%)

- The **ASIC chips temperature** is generally higher than that of the Silicon sensor

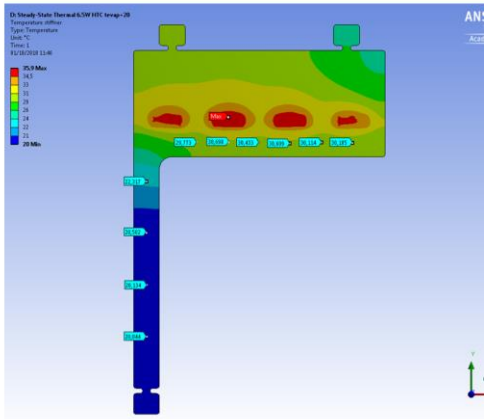
with a max ΔT CO_2 – ASIC estimated around ~25 °C
Acceptable in all working conditions.

ΔT CO_2 – Sensor

EXPERIMENTAL MEASUREMENT using a stave prototype were made in 2018



FEA RESULT 6.5 W
TEMPERATURE OVER THE CERAMIC STIFFENER

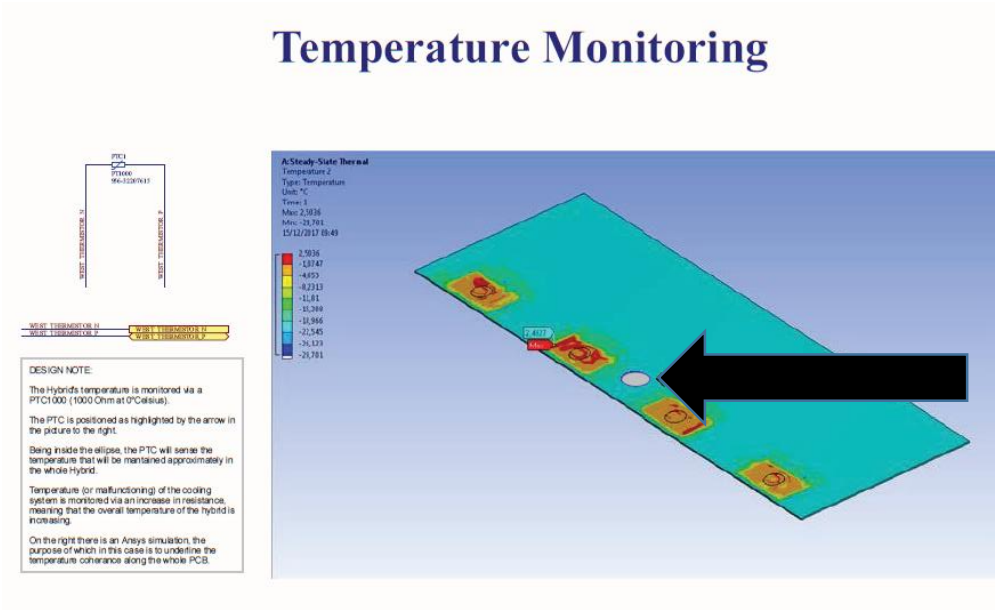


A **validation of the FEA** models was performed:

the conclusion was that for the 8 ASICs configuration (worst case)
the expected ΔT calculated from FEA models
had to be taken with a **3 °C error bar**

measured 13 °C instead of 10.3 °C

ΔT CO_2 – Sensor



All the UT hybrids have a temperature monitoring
=> Useful indication of the detector thermal field

Power and flow

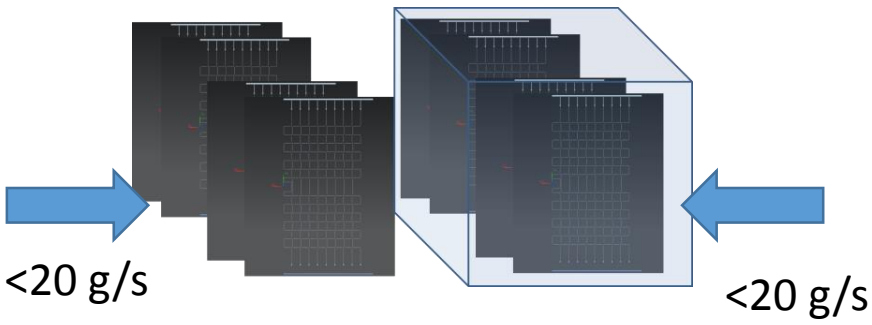
The ASIC power dissipation data
from the 2018 SALT3 chip documentation states:

Table 1: Summary of the specifications of the SALT ASIC.

Variable	Specification
Technology	TSMC CMOS 130 nm
Channels per ASIC	128
Input / Output pitch	80 μm / 140 μm
Total power dissipation	$< 768\,mW$

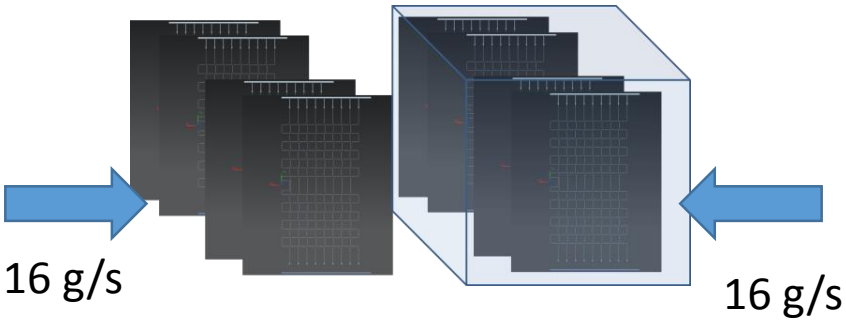
The relevant CO_2 flow calcutation, based on the assumption 1 g/s for 100 W:

1 ASIC DISSIPATION	W	< 0,768
4192 ASICS DISSIPATION	W	3219,456
INCREMENT +10% FOR CABLES	W	3541,4016
HEAT PICK-UP	W	500
TOTAL COOLING POWER	W	4041,4016
TOTAL CO2 FLOW-RATE	g/s	40,41
tot co2 flow-rate one half box	g/s	20,21
flow-rate single stave (1/34)	**g/s**	**0,59**



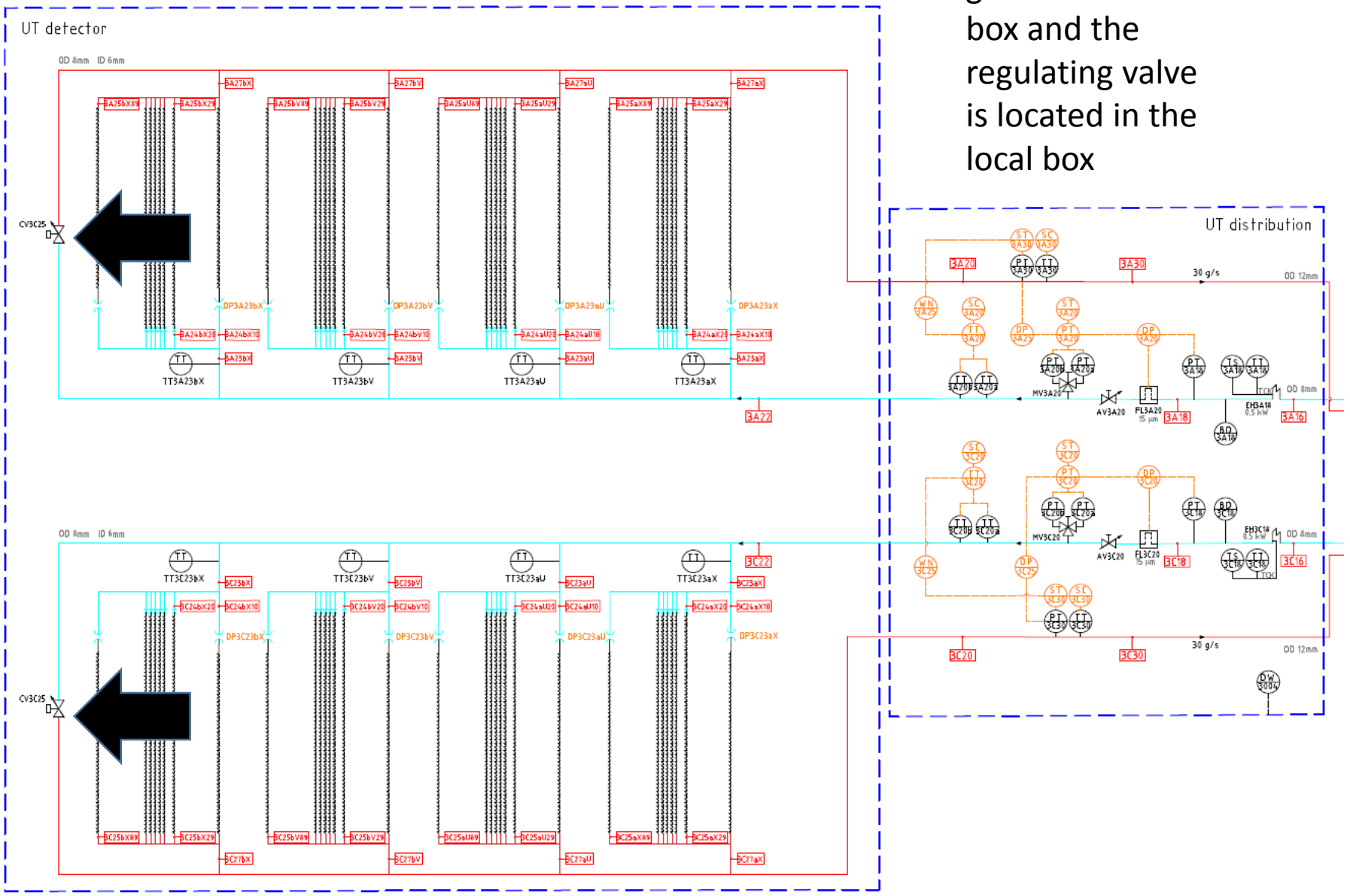
BEST GUESS FROM THE LAST INFORMAL COMMUNICATION

1 ASIC DISSIPATION	W	0,6
4192 ASICS DISSIPATION	W	2515,2
INCREMENT +10% FOR CABLES	W	2766,72
HEAT PICK-UP	W	500
TOTAL COOLING POWER	W	3266,72
TOTAL CO2 FLOW-RATE	g/s	32,67
tot co2 flow-rate one half box	g/s	16,33
flow-rate single stave (1/34)	**g/s**	**0,48**



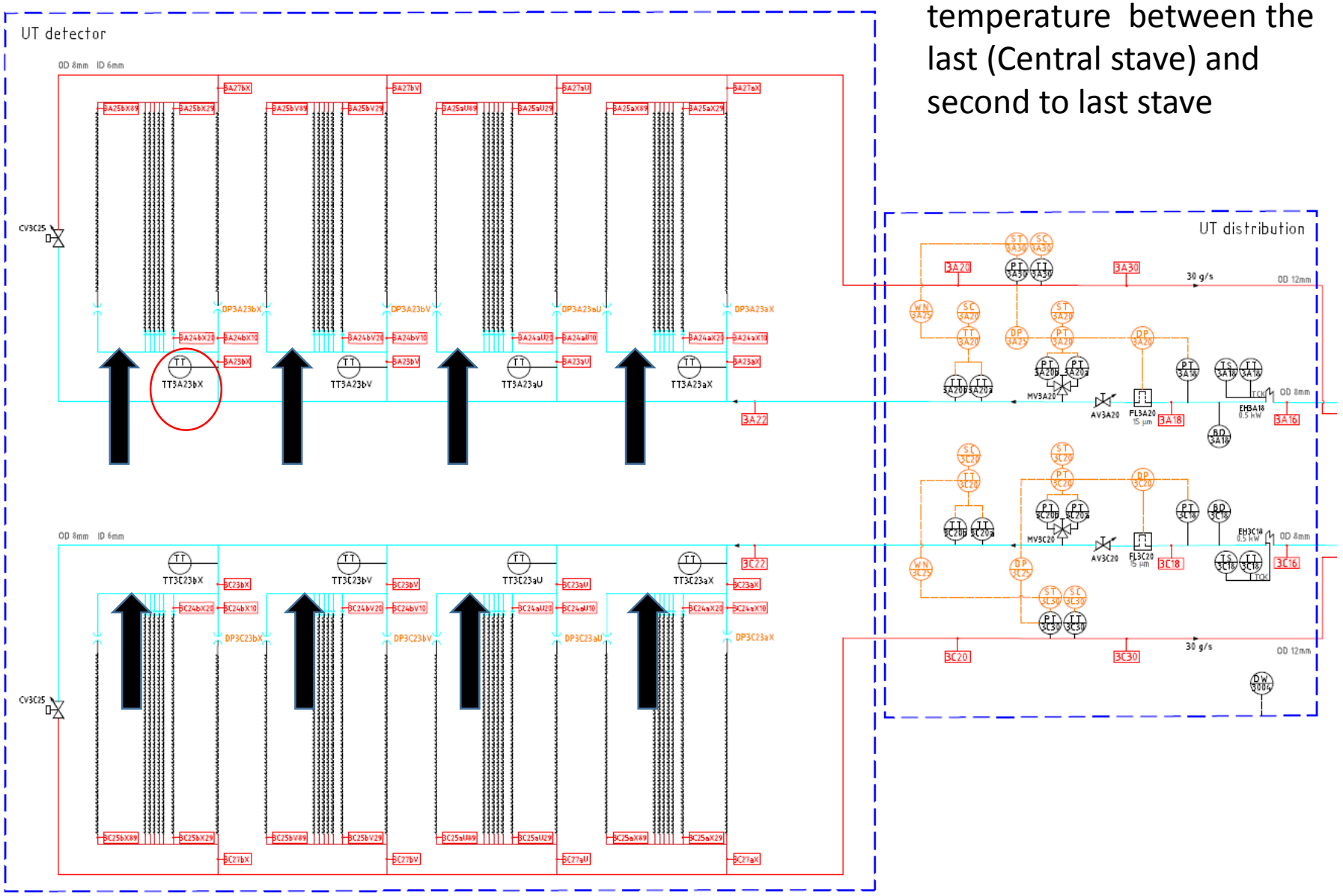
P&ID

By-pass flow goes out the UT box and the regulating valve is located in the local box

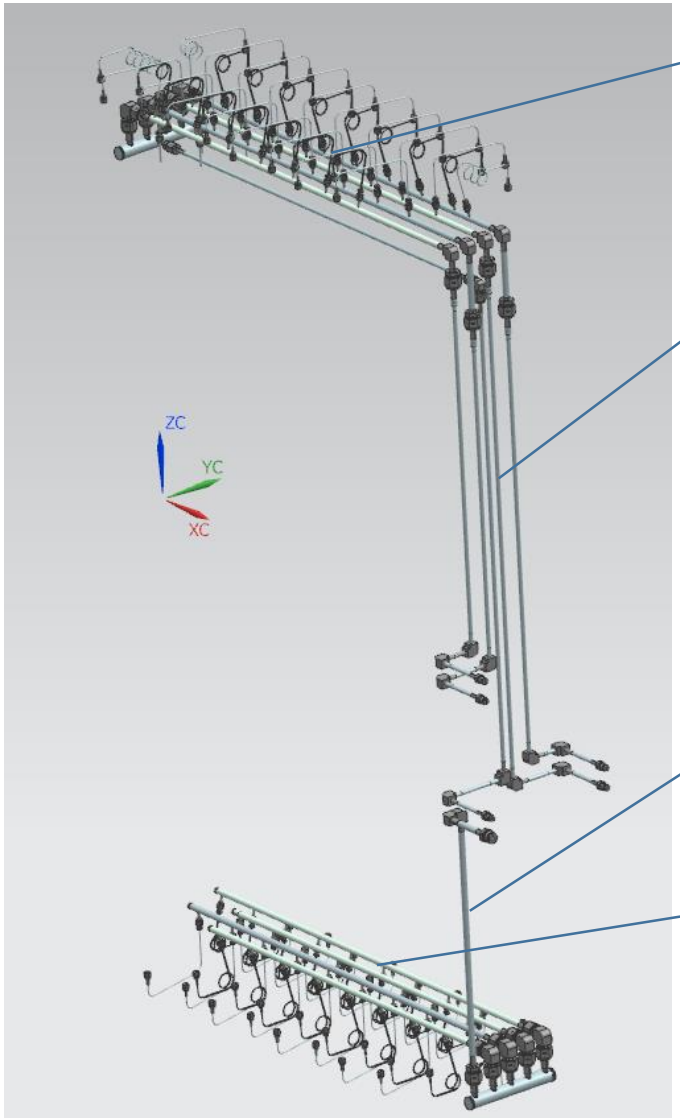


P&ID

TT monitoring manifold CO2 temperature between the last (Central stave) and second to last stave



Cooling distribution system: piping dimensions inside the UT detector



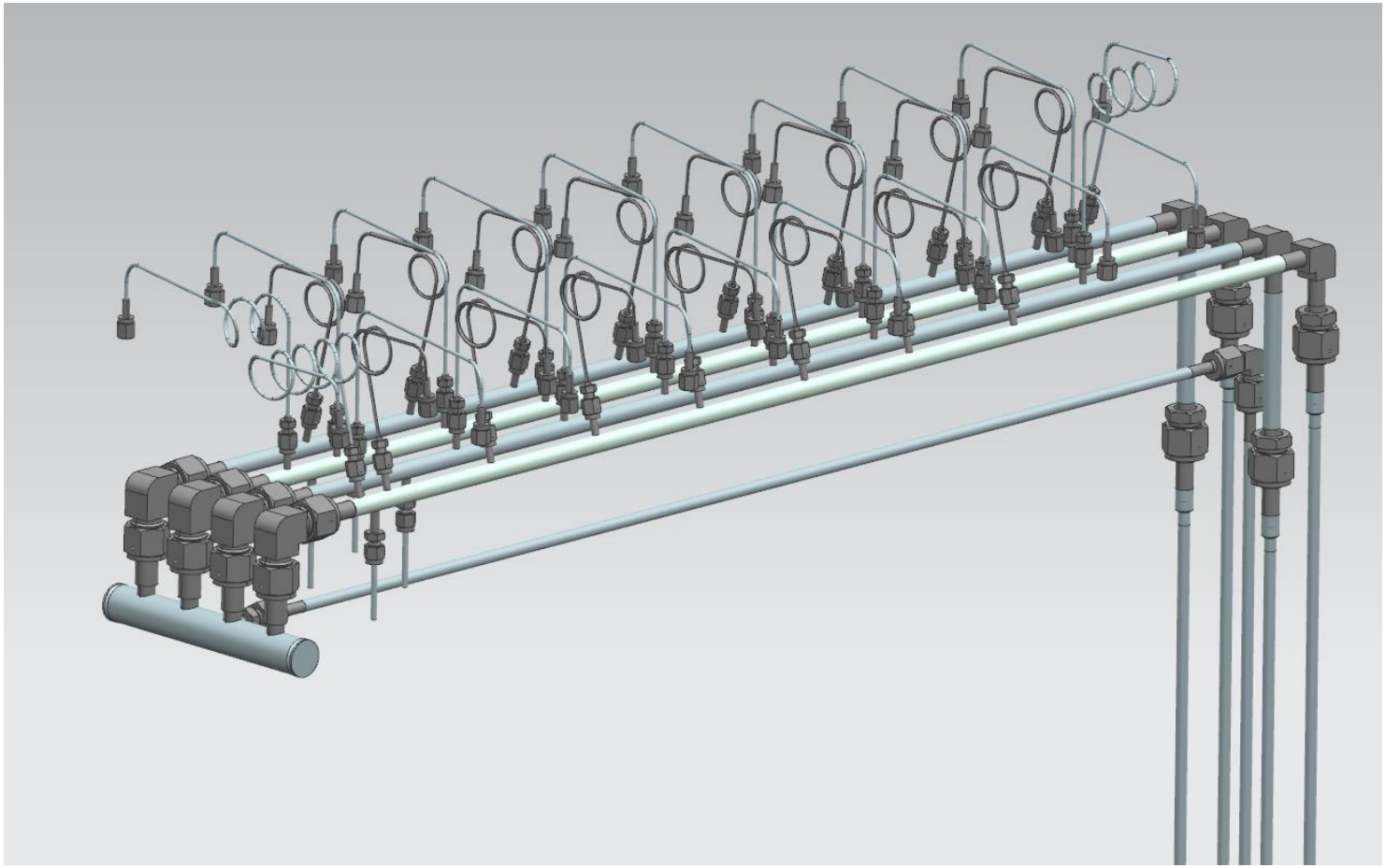
4 Manifolds
OD 12 mm ID 10 mm

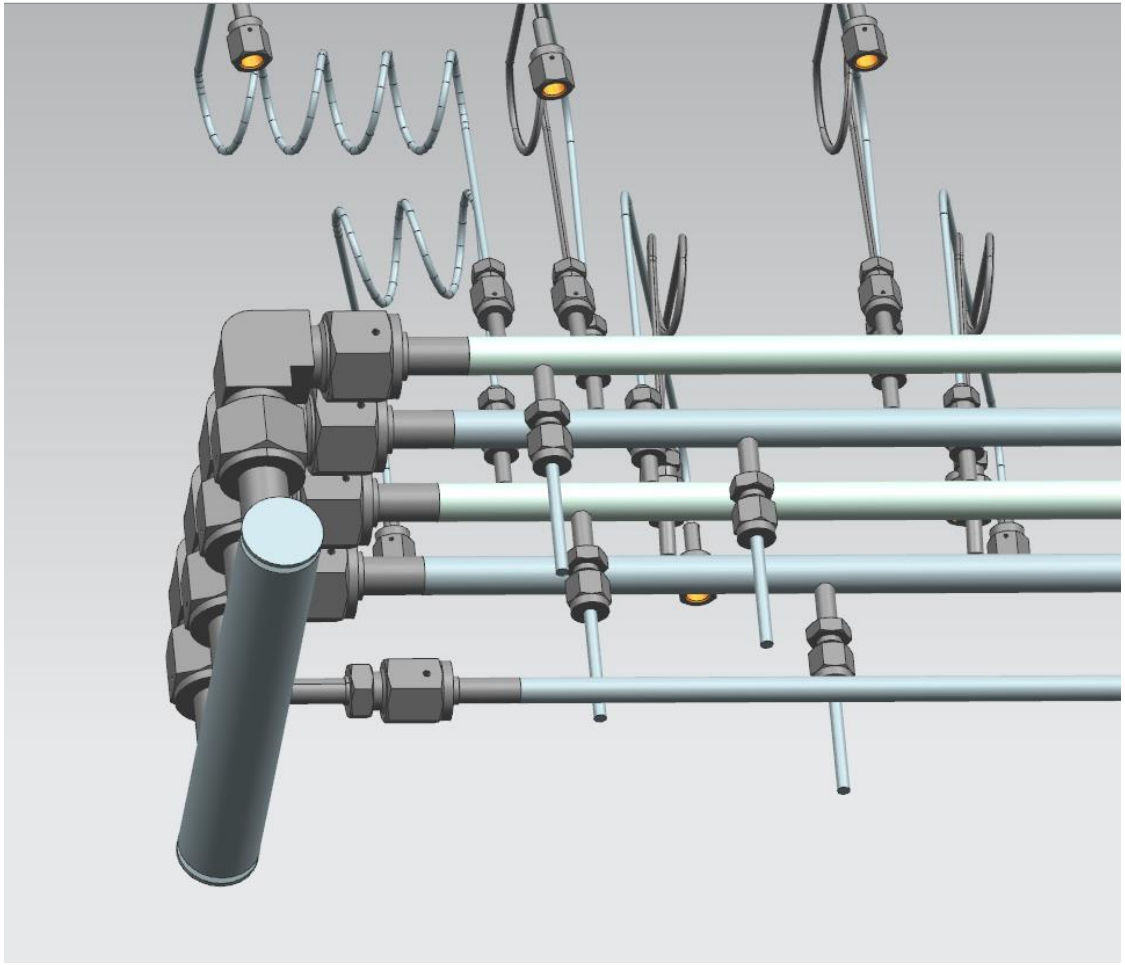
4 Inlet lines and 1 bypass
OD 8 mm ID 6 mm

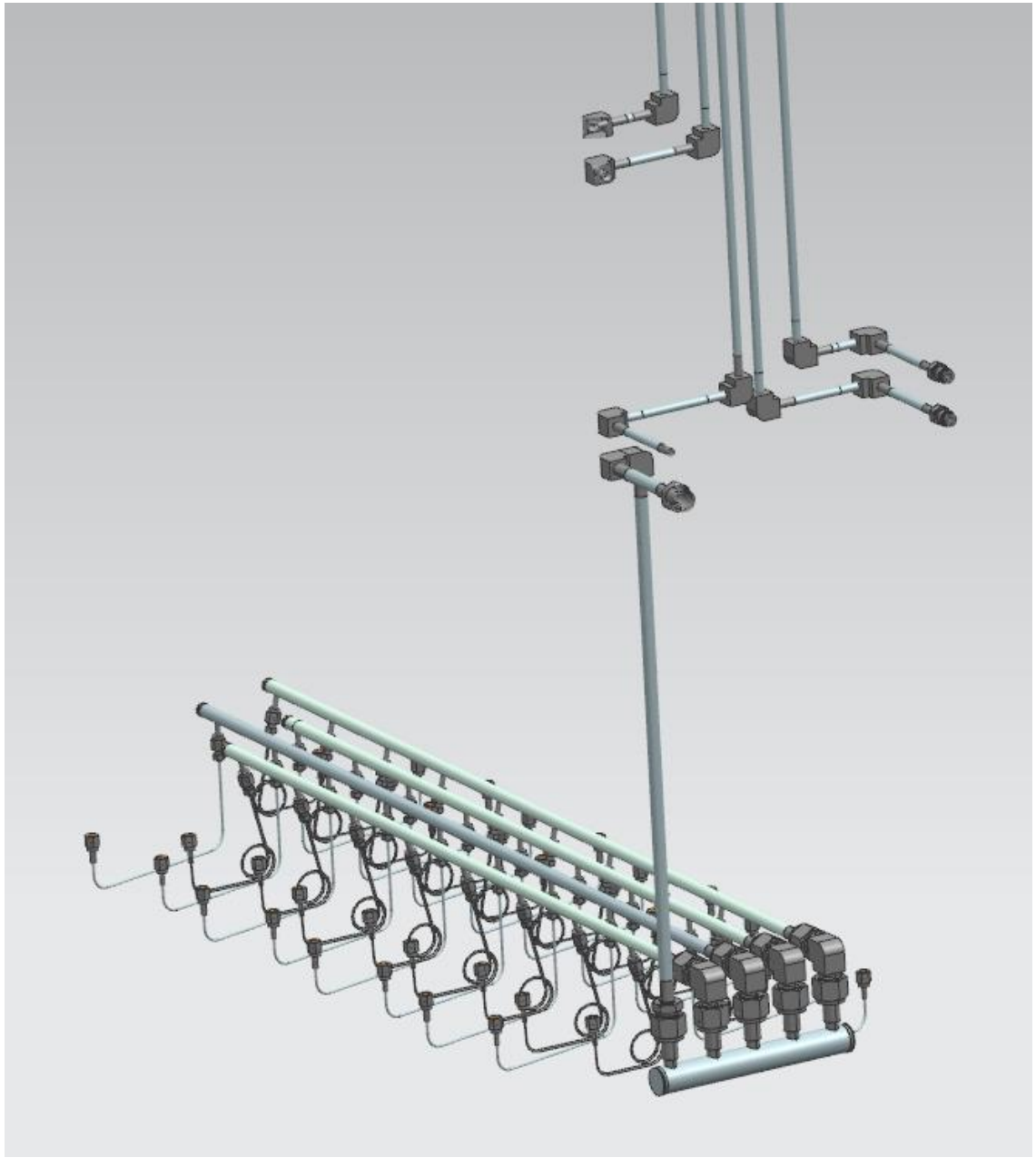
Outlet line
OD 12 mm ID 10 mm

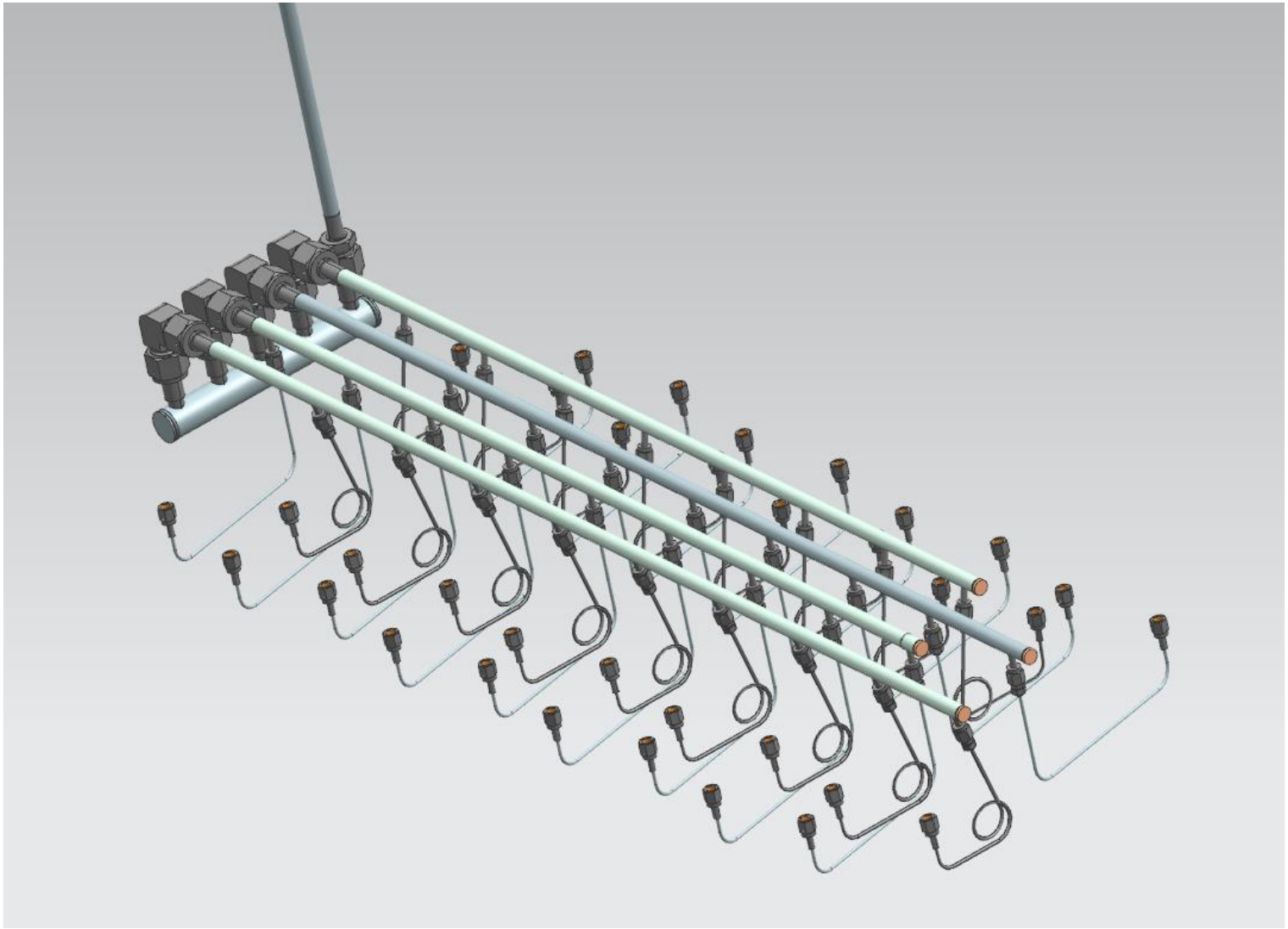
4 Manifolds
OD 12 mm ID 10 mm

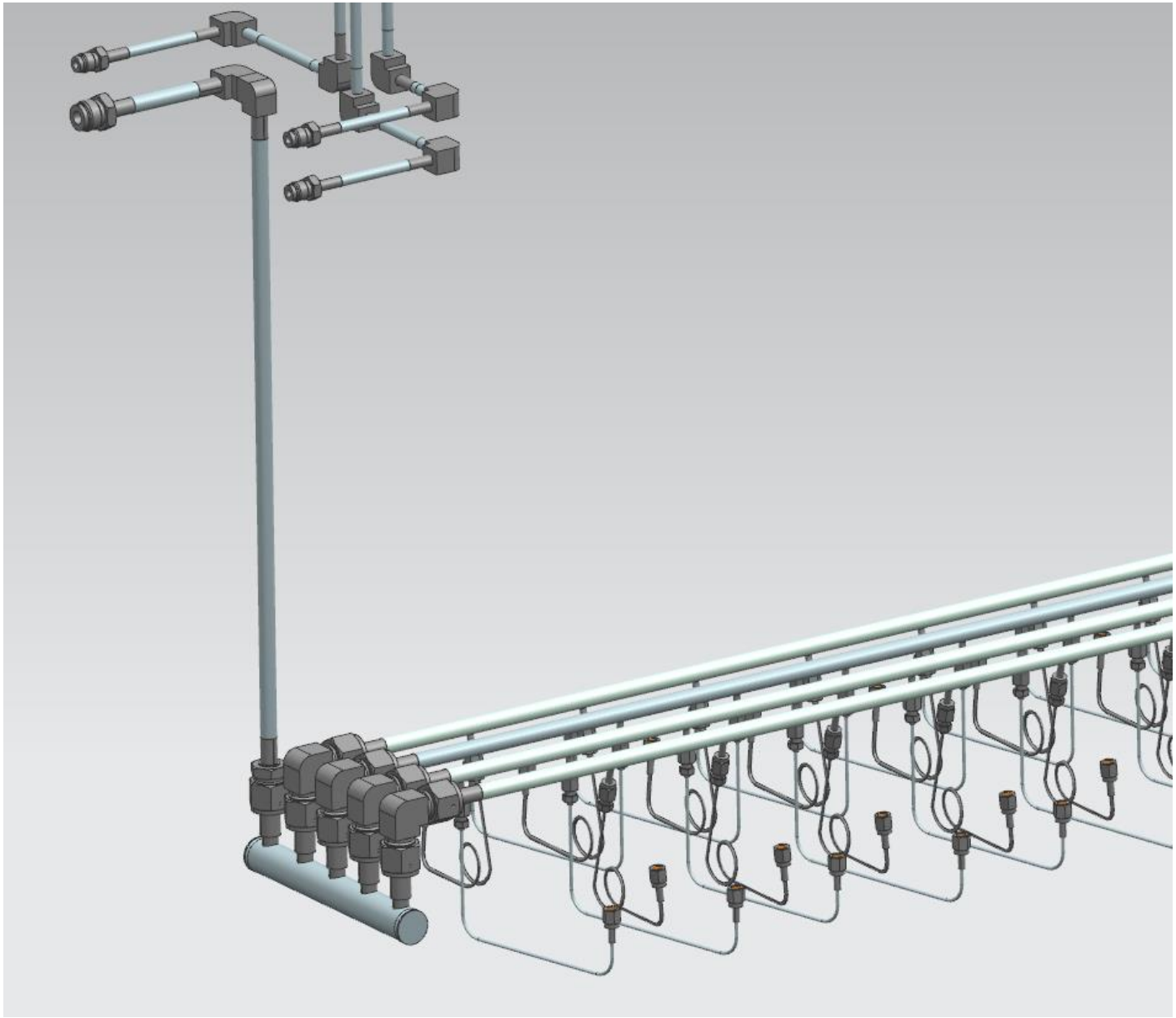
BACK-UP

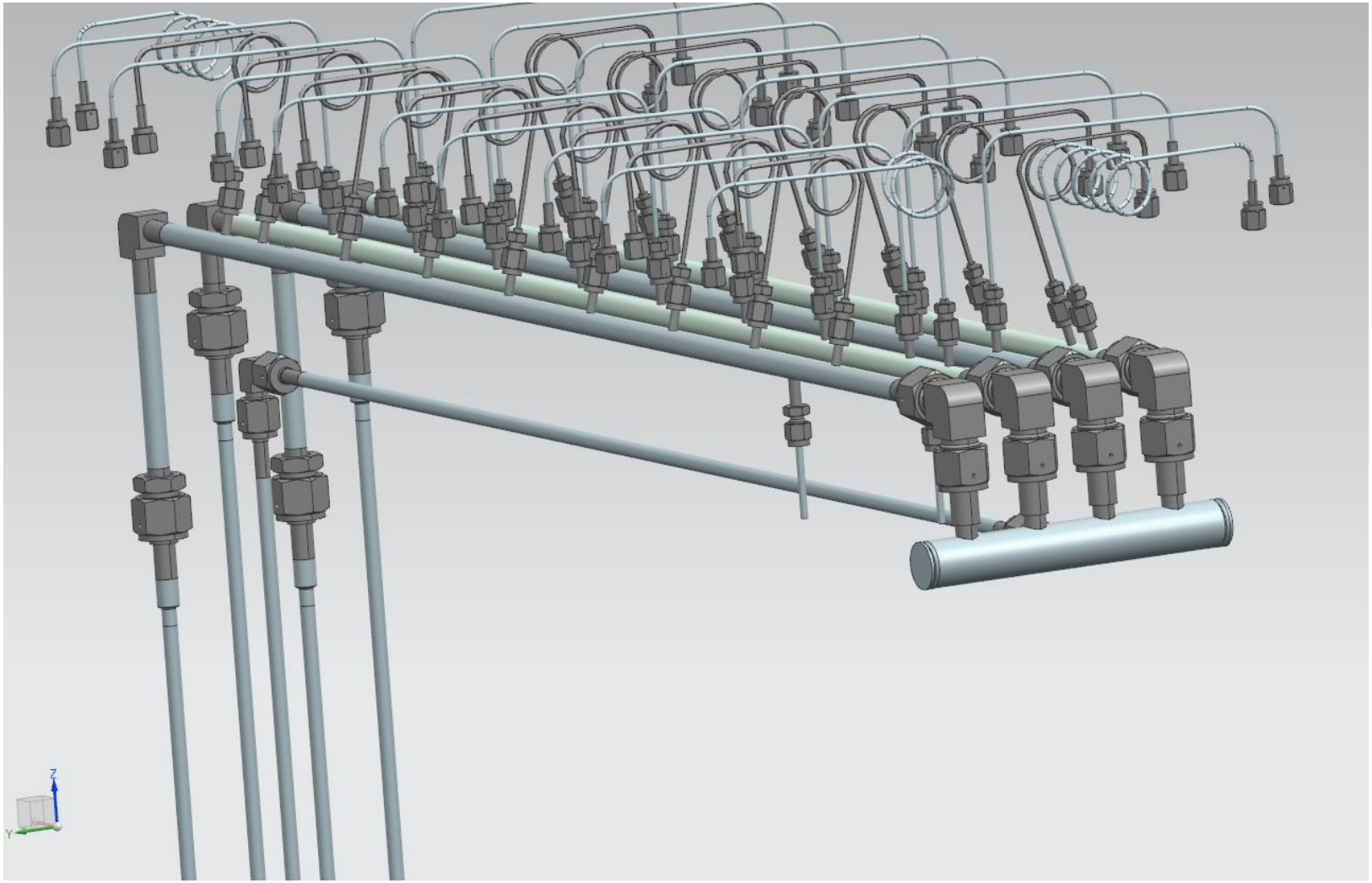











Z
Y