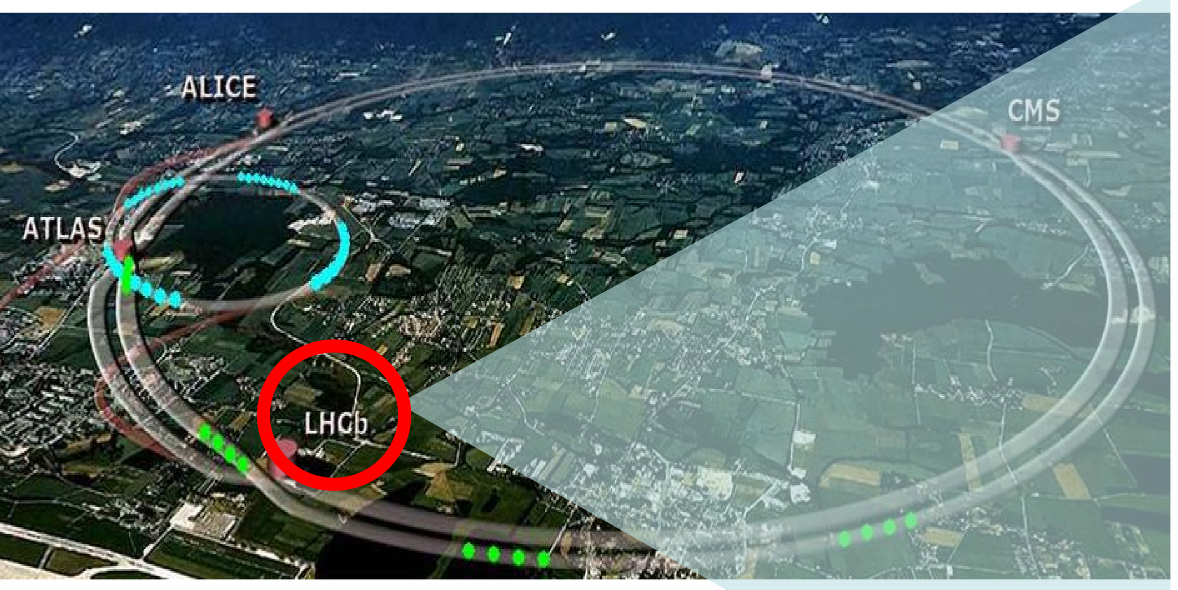
Forum on Tracking Detector Mechanics
31 May-2 June 2023, Tubingen (Germany)

INFN MILANO — Istituto Nazionale di Fisica Nucleare | Sezione di Milano

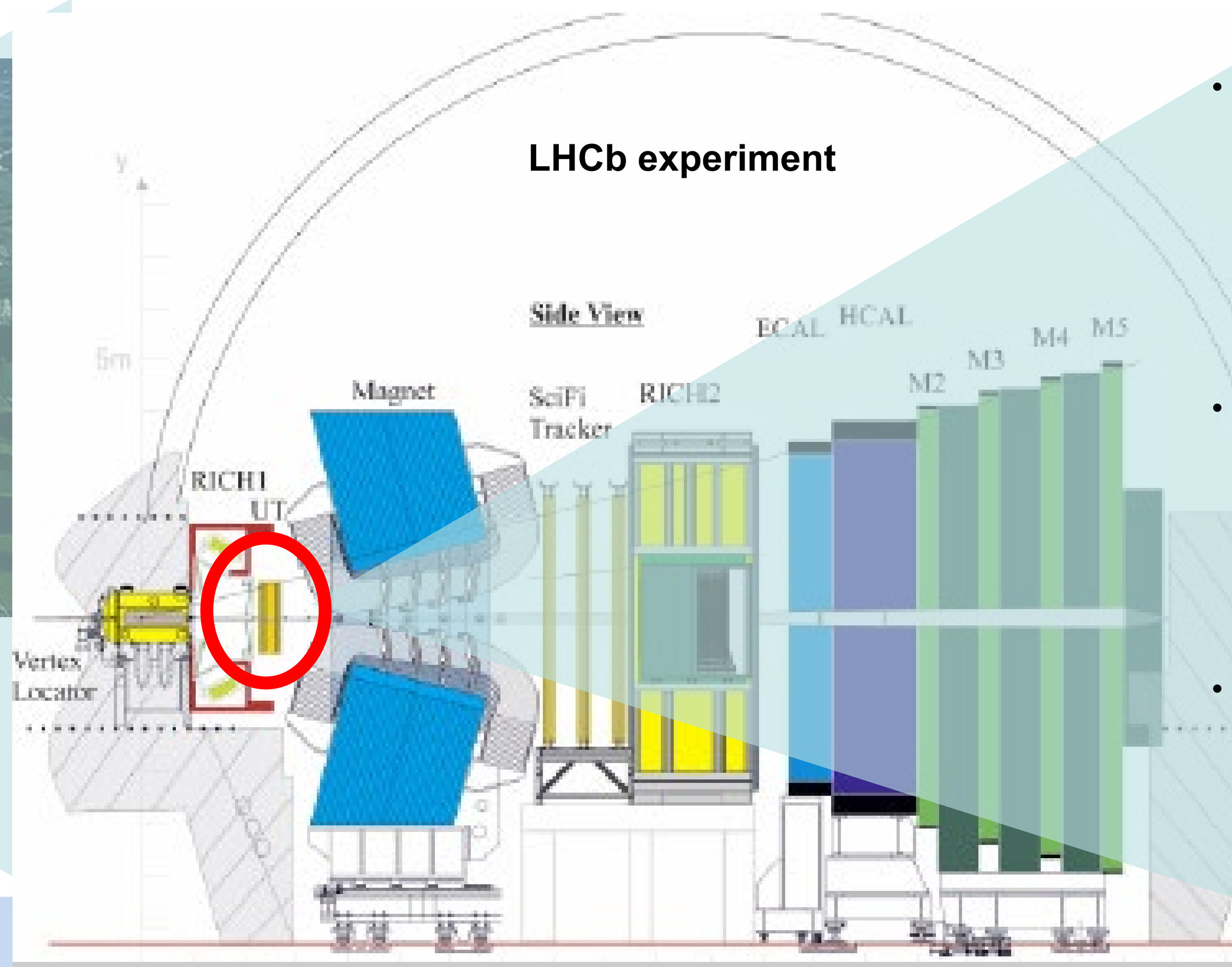
CO_2 evaporative cooling system for the LHCb UT Detector

Ing. Simone Coelli - INFN Milano
on behalf of the LHCb UT Collaboration

The LHCb experiment at the Large Hadron Collider uses a silicon strip detector for the Upstream Tracker (UT), part of its tracking system

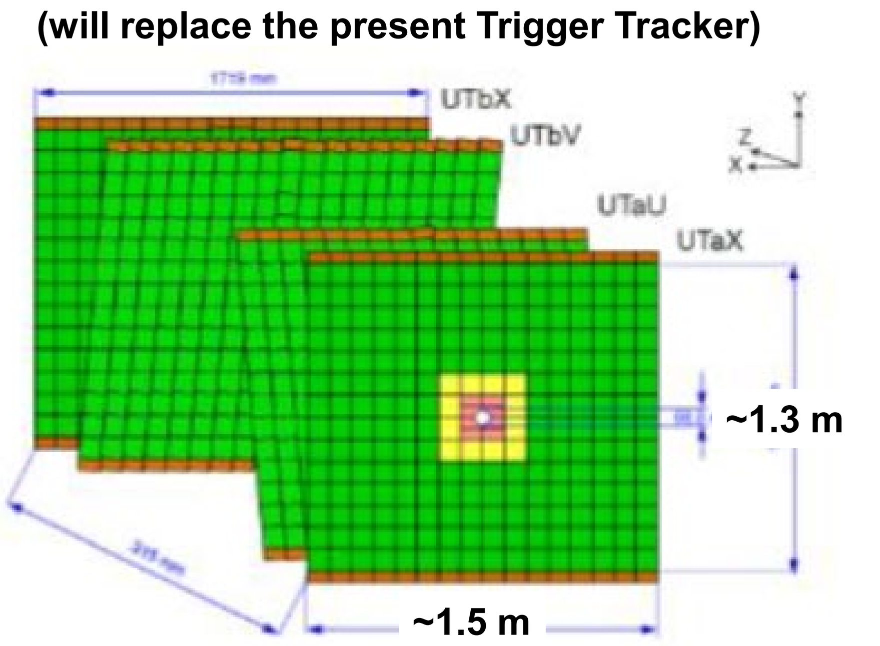


Large Hadron Collider at CERN



- the full read-out of the front-end electronics, currently limited by a Level-0 trigger to 1 MHz, will be changed to a readout at 40 MHz followed by a software based event selection
- detector designed to cope with an increase of the nominal operational luminosity by a factor 5 compared to the current detector
- silicon strip tracker detector with improved performance in charged particle tracking and triggering

UT Detector
(will replace the present Trigger Tracker)



- 4 planar detector layers
- Total area 8.5 m^2
- High granularity silicon micro-strip sensors
- Read-out by ASICs
- Signals processed at the sensor level

Detector thermal design and cooling system tasks:

- extract the thermal power dissipated by read-out chips
- keep ASIC max temperature < 40 ° C
- prevent thermal runaway in presence of radiation damage

=> keep the sensor temperature T max < - 5 ° C

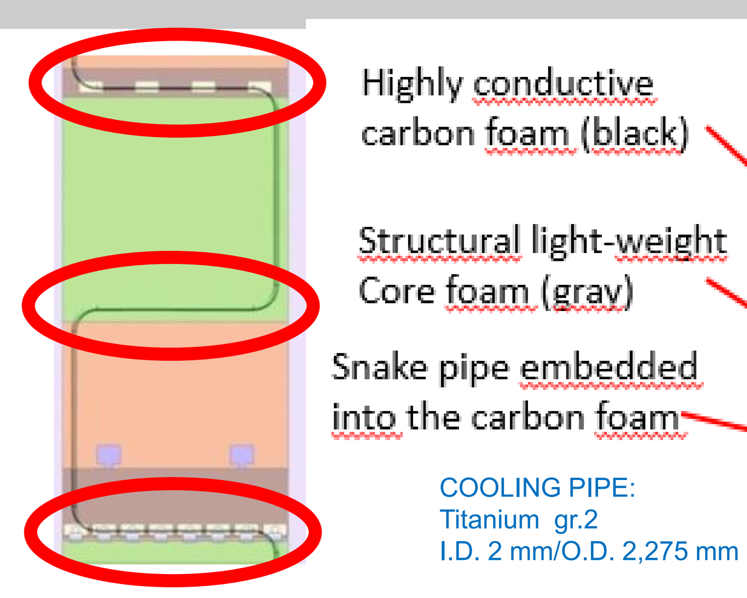
- minimize the temperature difference over the silicon sensors

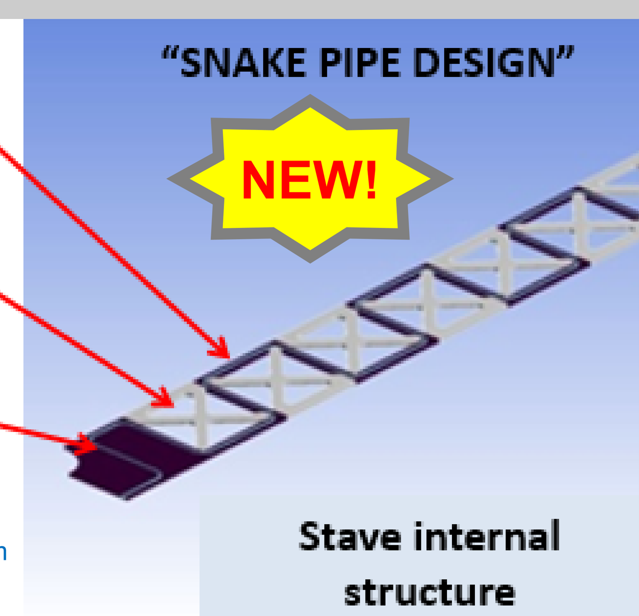
=> Delta T < 10° C

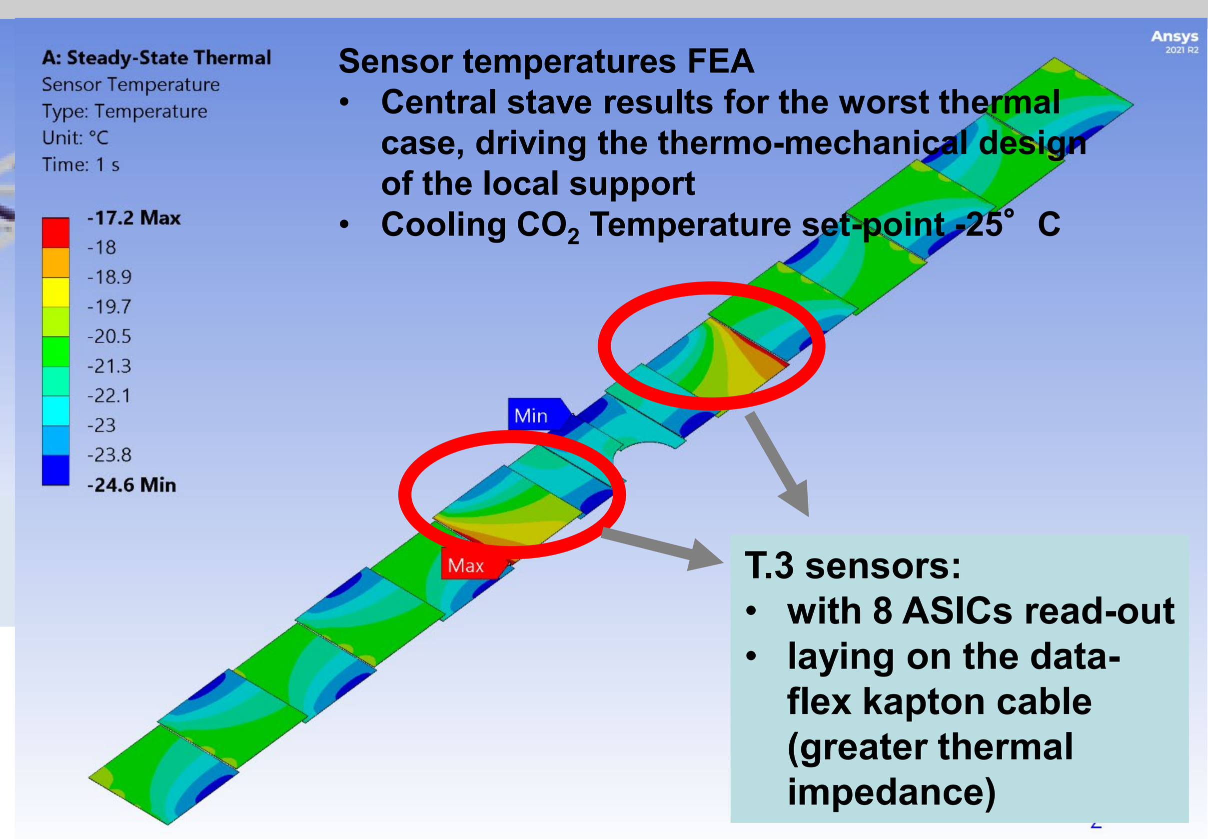
=> Design exploiting a cooling system based on CO_2 evaporation

Detector total power:
4192 ASICs ~ 0,8 W/each
+ cables + sensors + heat pick-up
⇒ **~ 4 kW power to be extracted**

Sensor modules are mounted on:
- lightweight carbon fiber mechanical structure
- embedding a SNAKE SHAPED EVAPORATOR cooling pipe
- passing underneath the read-out ASICs (thermal power sources to be cooled down)

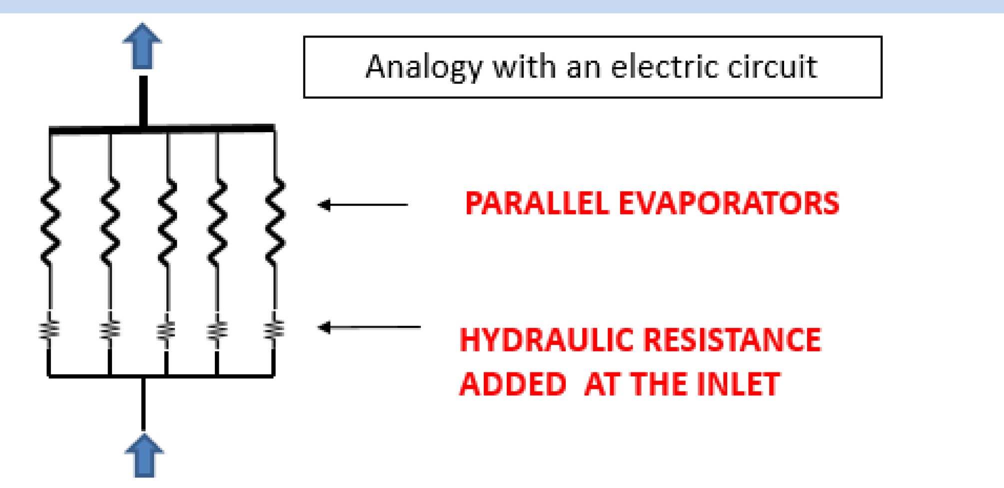






Sensor temperatures FEA
- Central stave results for the worst thermal case, driving the thermo-mechanical design of the local support
- Cooling CO_2 Temperature set-point -25° C

T.3 sensors:
- with 8 ASICs read-out
- laying on the data-flex kapton cable (greater thermal impedance)

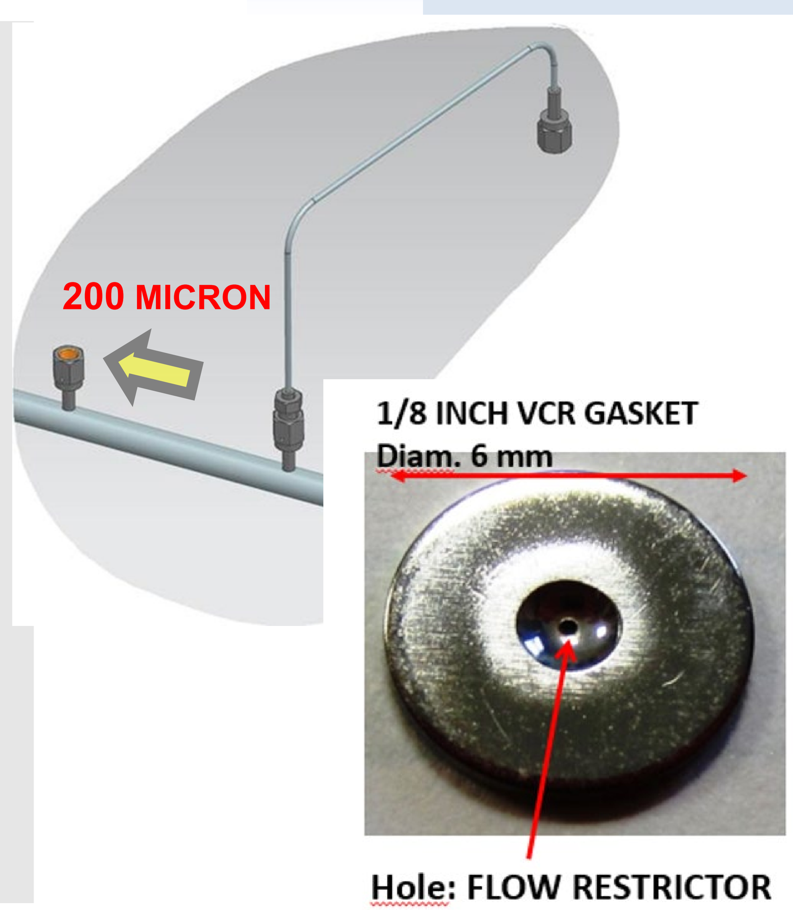


COOLING DISTRIBUTION SYSTEM WITH FLOW RESTRICTORS INSTALLED AT THE EVAPORATOR INLET: 200 MICRON CALIBRATED ORIFICES

FLOW RESTRICTORS

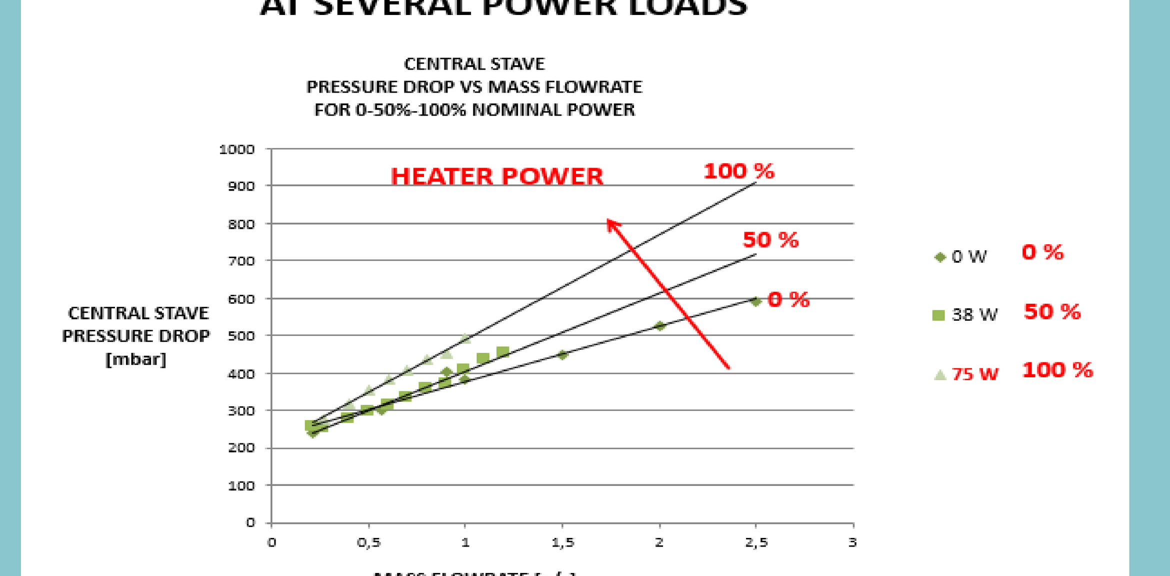
- Less used in present tracker detectors
- A gasket (VCR) can become a restrictor
- Small diameter orifice => risk of clogging

IMANDATORY:
- To use proper filtering elements
- To use a pure fluid (no moisture)
- Take care of the cleanness of the plant lines
- Vacuum the lines before filling

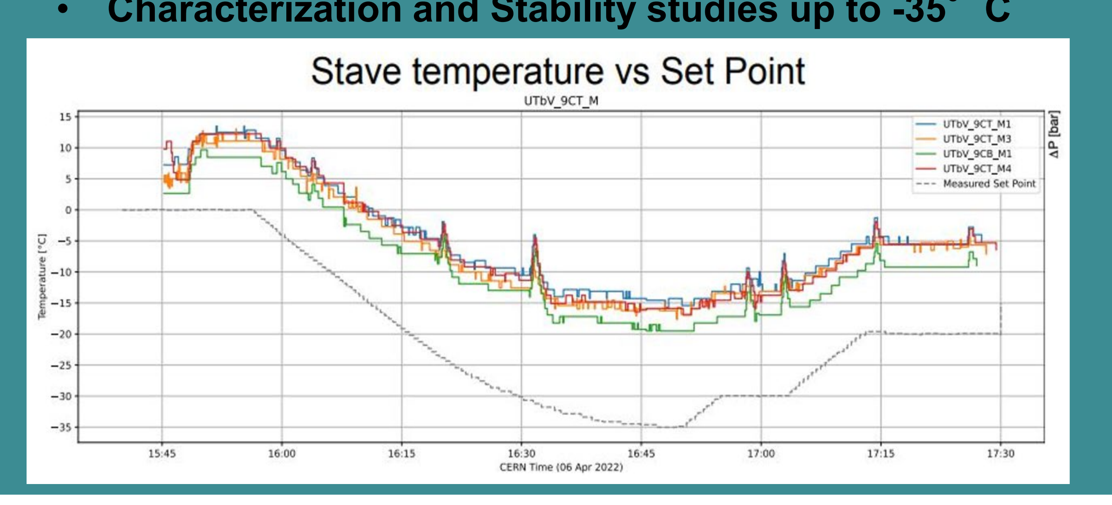


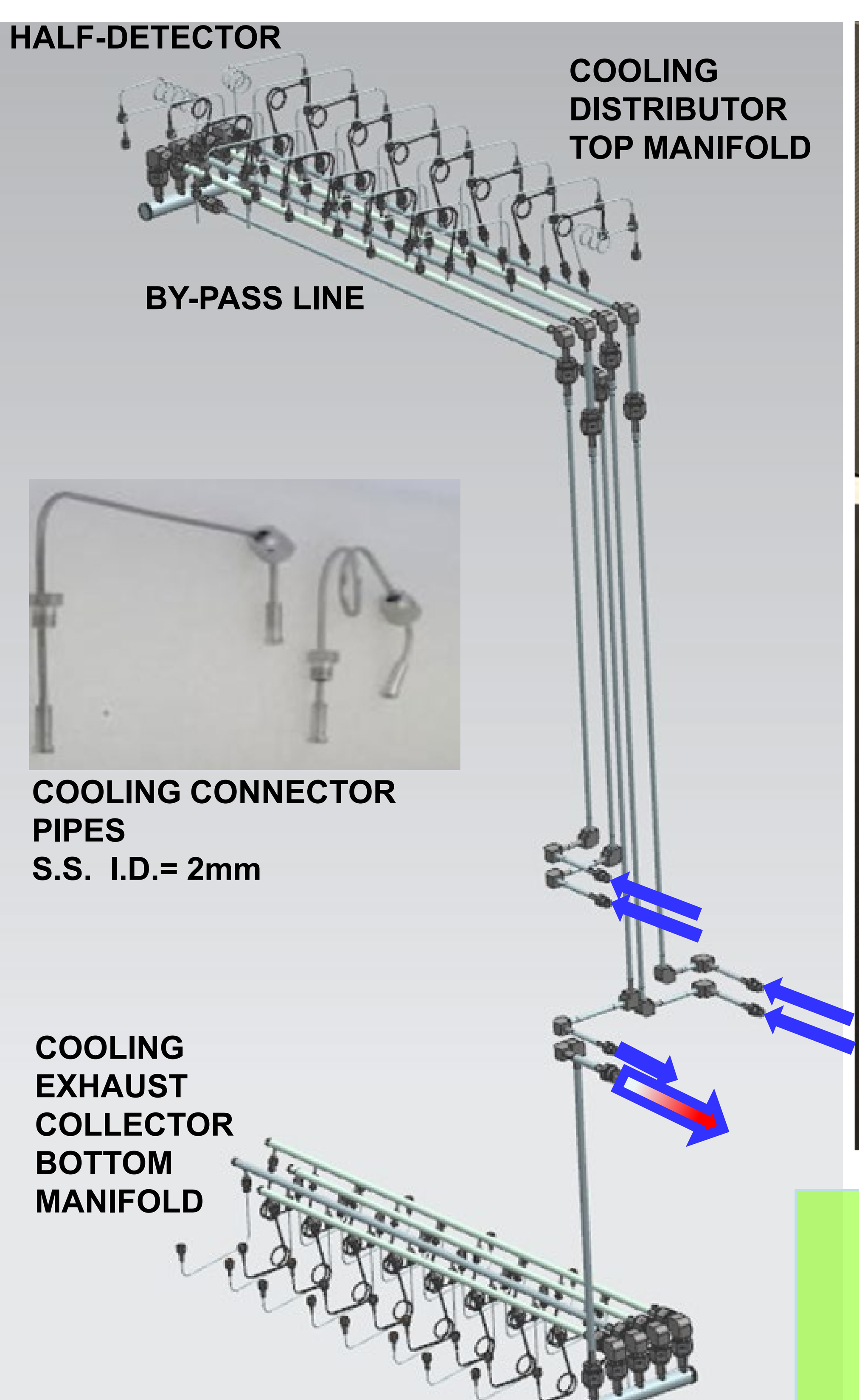
To demonstrate the correct operation of the cooling, 2014-2020
- experimental measurements on full scale prototypes
- thermal-hydraulic characterization of dummy staves

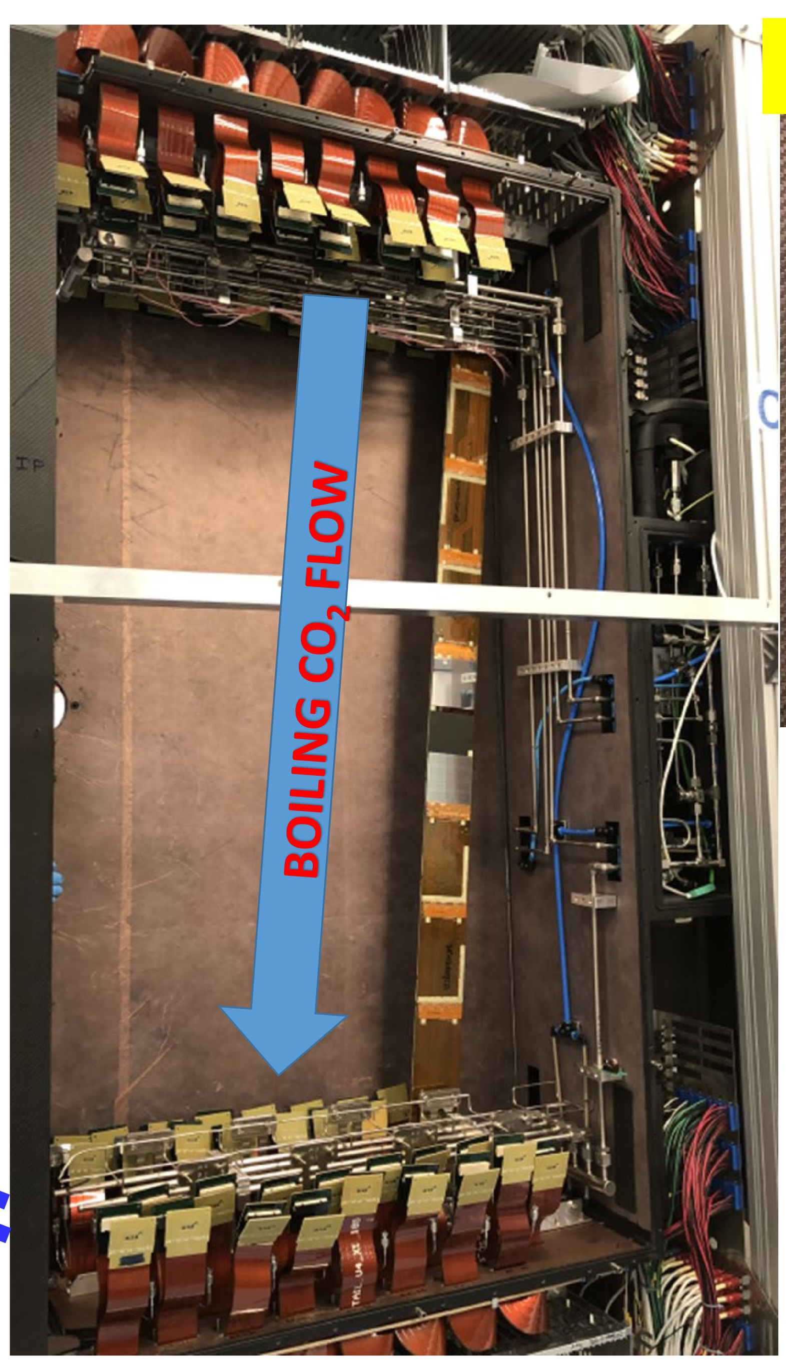
STAVE PRESSURE DROP VS MASS FLOW-RATE AT SEVERAL POWER LOADS



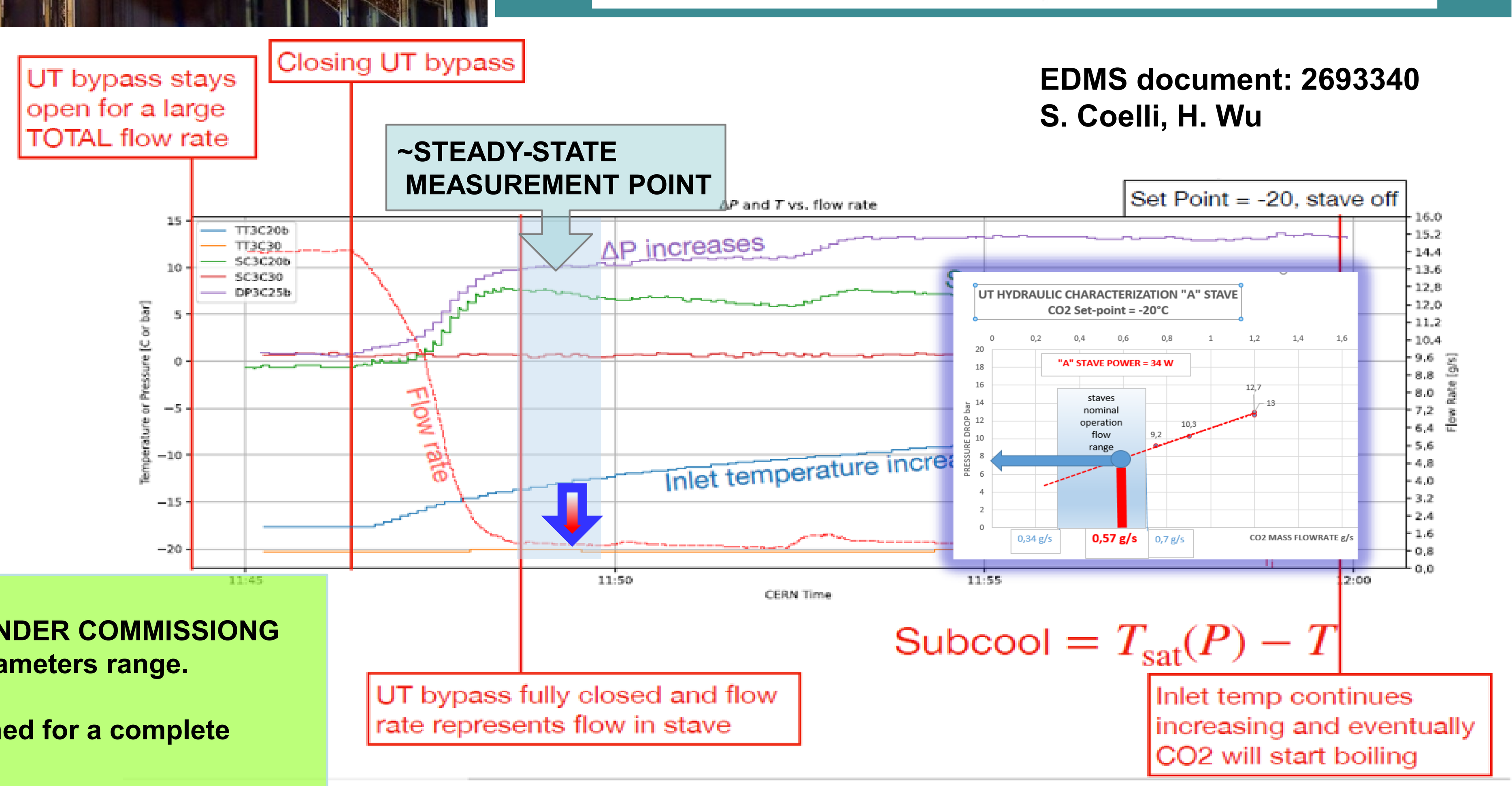
COMMISSIONING MEASUREMENTS, LUKASZ cooling unit
- Characterization and Stability studies up to -35° C







2023: DETECTOR INSTALLED AND COMMISSIONED IN THE LHCb CAVERN



$$\text{Subcool} = T_{sat}(P) - T$$

EDMS document: 2693340
S. Coelli, H. Wu

WORK IN PROGRESS:
DETECTOR INTEGRATED AND COOLING SYSTEM UNDER COMMISSIONG
- UT cooling system is working within expected parameters range.
- Thermo-hydraulic behaviour is under control.
- Commissioning in progress. Further test are planned for a complete characterisation.