CO_2 cooling requirements Update for UT

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UT cooling requirements

- Documented in EDMS 1487284
- Extract:

4.A. Major Detector Thermal Requirements

The main thermal requirements for the UT Tracker are stated here.

1. **Temperature difference within a given sensor: Not to exceed ΔT of 5 °C**

   This is a constraint to limit both the deformation of the sensor due to thermal contraction, and the relevant stresses induced on the sensor by cooling it down.

2. **Maximum temperature for any sensor: To be maintained below –5 °C**

   This is a functional requirement for the sensor operation under the worst conditions foreseen in the detector, after maximum irradiation, at the end of its life.

3. **Maximum ASIC temperature: Not to exceed +40 °C**

   The electronics readout ASICs should be maintained at the lowest possible temperature compatible with other requirements of the system. The ASIC are the most powerful local heating source in the detector, so that their temperature is the maximum figure present in the detector.

- We say nothing in the specifications about the lowest temperature in the box for the various operating modes; we only define the dew-point of the dry air.
- The box has been validated for a temperature of about -10°C. Down to this temperature the aerogel interface between the beam-pipe and the box has also been validated, but not for lower temperatures.
- It seems now that this cannot be guaranteed for all operating modes

UT cooling requirements

- Extract:

OPERATIONAL MODES			
T_evap, Normal operation	-30 ± 5	°C	cold, max power 5 kW
T_evap, Partial power operation	-30 ± 5	°C	cold, max power 2.6 kW
T_evap, Maintenance	-30 to +15	°C	cold or warm, max power 1.5 kW

1. UT NORMAL OPERATING (DATA-TAKING) MODE,

   COLD: T_op = –30 ± 5 °C

   Conditions. Box halves joined and sealed, electronics fully powered, full cooling to maintain the sensors temperature under –5 °C. For normal data-taking.

2. UT PARTIAL-POWER (STAND-BY) MODE,

   COLD: T_op = –30 ± 5 °C

   Conditions. Box halves joined and sealed, with electronics on but operating at partial power, i.e., from 10% to 50% of nominal power. For electronics testing of digital readout alone, analog readout alone, power distribution, and slow control.

   Note. The sensors should be kept at a nominal temperature, under –5 °C. Although the temperature remains the same here as in normal operating mode, the power load is less. Hence the cooling power required is less, and the mass flow rate can be reduced, if needed, based upon the actual power load in the range given above.

3. UT MAINTENANCE (INSTALLATION/COMMISSIONING) MODE,

   COLD OR WARM: T_op = –30 °C TO +15 °C (Room Temp., above Dew Point)

   Conditions. Box halves retracted and sealed (or retracted and unsealed), electronics and cooling on for one half-plane at a time only (refers to in-pit, not on-surface operational modes). For maintenance/commissioning in pit.

We only specify the lowest temperature on the sensors, Not inside the box.

Clearly, in particular when the electronics are off and we have a CO_2 temperature of -30^{o}C, the air temperature inside the box will drop to < -10^{o}C.

UT cooling requirements

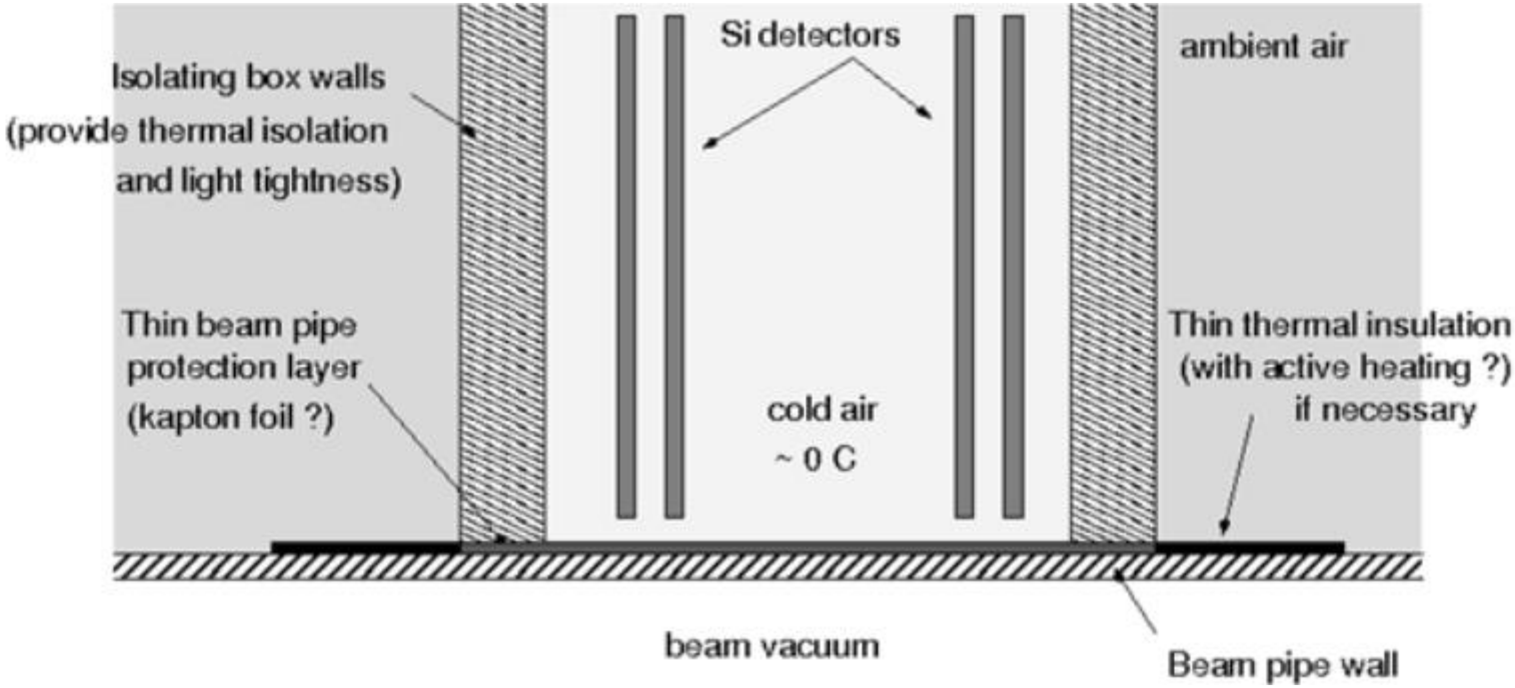
- This is in particular delicate in the exceptional case where VELO and UT are powered by the same plant and the set-point cannot be changed to a value of about -10^{o}C.

- On the other hand, from the UT-side we have to be avoid problems with the (silica aerogel) interface to the beam-pipe and the resulting temperatures, if the temperature on the inside drops to about -25^{o}C.

➢ We have to address this issue soon in a dedicated meeting with all the experts involved.

Backup

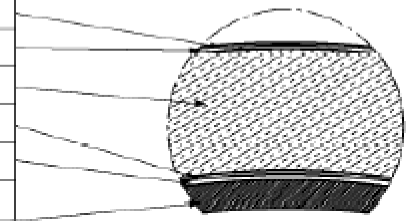
Proposed insulation of UT to the beam-pipe



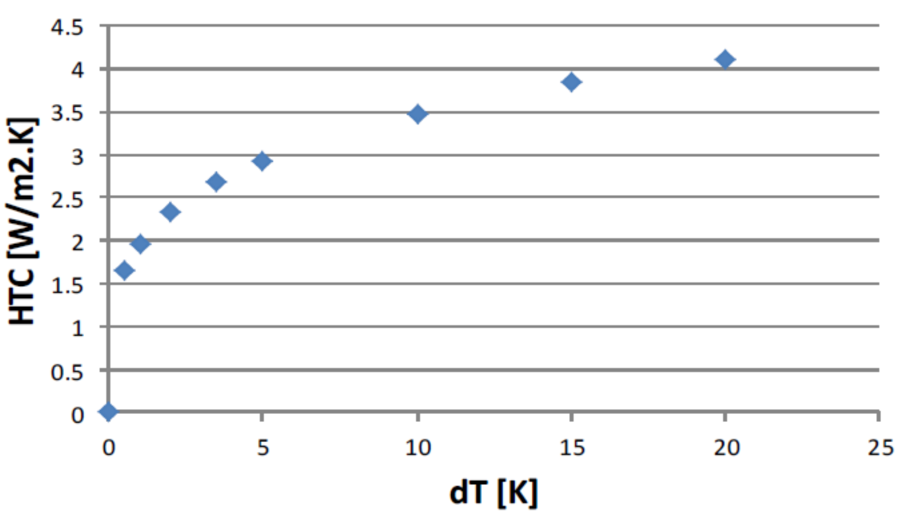
- Advantages of this proposal are:
- It minimizes the distance between detector modules and the beam-pipe.
- It minimizes the amount of material and thus interactions and multiple scattering
- ➢ This proposal has been summarized in the upgrade Tracker TDR

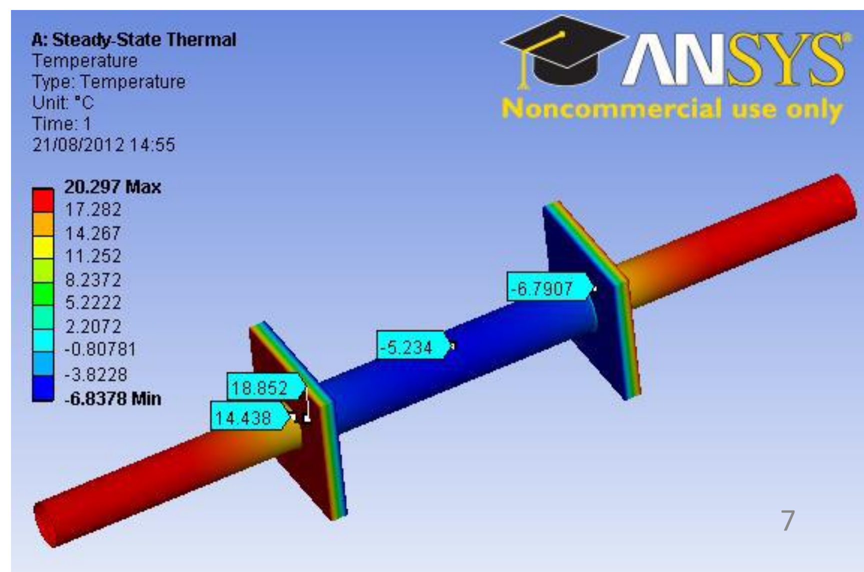
Silica aerogel based insulation

Description	tickness (mm)	density (g/cm3)
Aluminium Foil	0.05	2.7
2 layers polyimide tape (Kapton)	2*0.06	1.53
Aerogel insulation (compressed)	4	0.11
2 layers polyimide tape (Kapton)	2*0.06	1.53
heaters	0.2	1.73
vac.chamber wall		



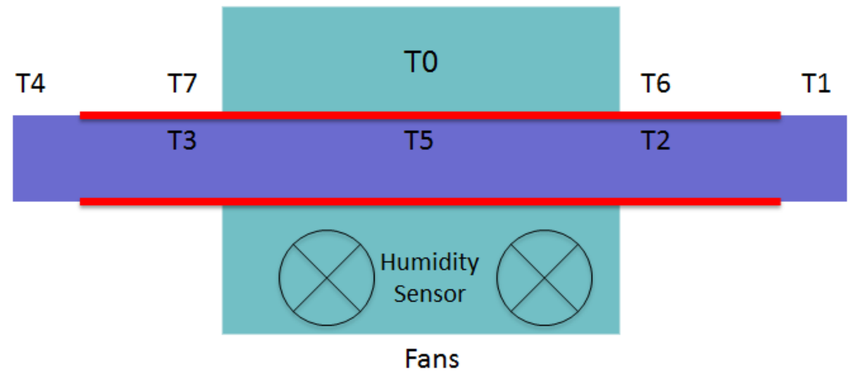
- Calculation of the Heat Transfer Coefficient:
- Thermal conductivity *K* of aerogel 14.7 mW/mK, and of beryllium 190 W/mK
- Assuming -10°C in the box and 20 °C for the beam-pipe, thus a dT of 30 °C, the HTC approaches a value of $5 W/m^2K$
- 4mm of aerogel have been determined to avoid condensation outside the box through heat-transfer via the beam-pipe (compressed thickness 3.5mm)



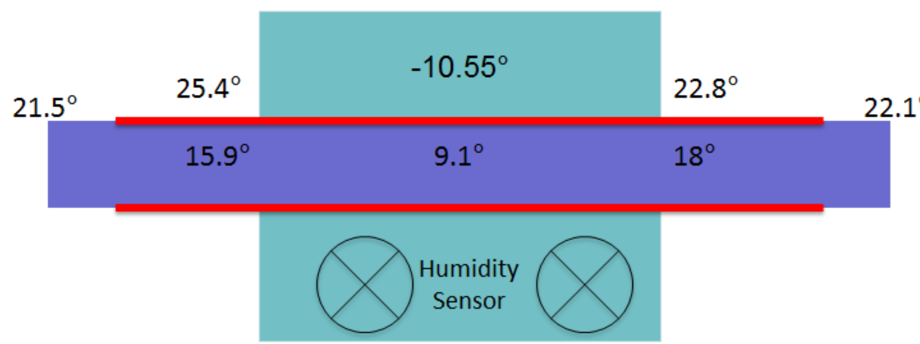


Experimental validation

- Location of temperature sensors
  - T0 temperature inside the box
  - T1, T4 temperature outside the box
  - T2, T3 and T5 on the beam-pipe
  - T6 and T7 on the insulation



Results with RH=17% and $T_{box\text{-}air}$ = -10°C



Redundancy approach for cooling plants

- How to make the system fully redundant?
  - Taking into account:
    - Simplicity (both use and production)
    - Rely on past experiences
    - Cost
    - Minimal interference between UT and Velo operation.
  - Basic idea:
    - 2 identical plants with over capacity
    - Use 1 plant for Velo and UT together in case 1 system is out of order (in case of maintenance or problems)
  - First a basic concept must be worked out further
    - How to interlink the CO_2 units
      - Mixing up content of 2 systems, influencing filling content
      - How to separate?