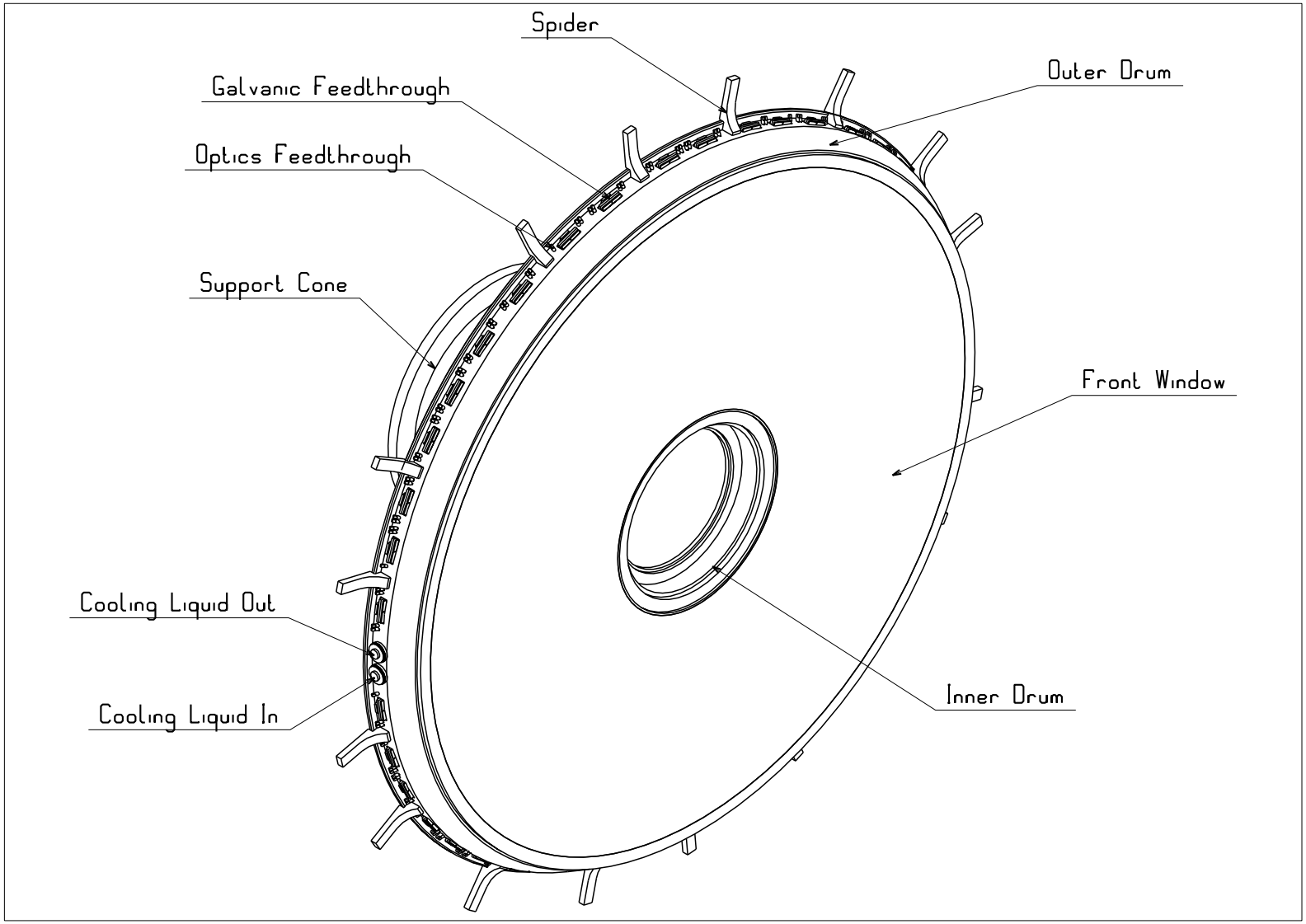
Status report on Preshower (SE) cooling

- on the Preshower and its cooling
- cooling needs and thermal inertia
- coolant transfer pipes on CMS Endcap :
  * foam insulation, condensation, artificial heating
  * pipe routing on Endcap
  * cable chains


Spider
Outer Drum
Galvanic Feedthrough
Optics Feedthrough
Support Cone
Front Window
Cooling Liquid Out
Cooling Liquid In
Inner Drum

Preshower cooling in a nutshell

(detailed discussion : Review ECAL EDR-4)

- keep Si sensors cold enough (-5˚C or lower)

- deal with dissipation of electronics

- SE detector (one on each endcap) has appearance of a freezer :
  - reasonably gas-tight containment
  - walls faom-insulated at the inside
  - container walls at +18˚C (controlled)
  - feedthroughs (looks like a cryostat !)

- cooled by 2x2 large-surface, flat cooling screens (Al , brazed)

- C_6F_{14} (liquid !) ; needed SE entrance temp. = -15˚C

- typical (turbulent) conditions inside cooling screens ($Re \sim 6000$ $Nu \sim 70$)

- no manifolding outside the freezer

- miniumal amount of pipes connected to freezer : 2 inlets (just below beam level) and 2 outlets (just above beam) - see redundancy scheme of M. Jeske

- with this : safe behaviour in case of failure of 1 of the 2 circuits (power off)

- 0.9 ltr/s per pipe

- liquid warming up at SE exit : 2.6 degrees

Refrigeration power for SE (per endcap)

With 'pessimistic' scenarios :

* Dissipation : Si detectors, electronics, voltage regulators :
4 kW per read-out plane (x 2) -> **8 kW**

* Heat inleak through window foam : 0.75 kW (x 2) -> **1.5 kW**
(assumptions : 7 mm , 0.03 W/(m deg) , 18˚C -> -14˚C)

* Heat inleak through (galvanic) feedthrough station :
3.7 W (x 38) -> **0.14 kW**

* Heat inleak through (rest of) outer drum :
very rough estimate : -> **0.5 kW**

* Inner drum : neglected

* Dissipation in cables inside SE : unknown ; most probably not dominant

=> **total : about 10 kW per endcap**

SE tank thermal time constant

Capacitance of cold masses :
713 kg of Pb + 578 kg of Al
C = ($8.56\ 10^4 + 5.18\ 10^5$) J/deg = $6.04\ 10^5$ J/deg = 0.17 kWh/deg

Conductances : per window : 23.6 W/deg (x 2)
feedthrough : 0.01 W/deg (x 38)
outer drum : 17 W/deg
total conductance = 68 W/deg
=> resistance R = 15 deg/kW

Time constant $\tau = RC$ = **2.5 hours** (only !!!!!)

SE coolant transfer pipes : baseline

- pipe itself : austenitic stainless steel ; 32 mm OD ; 30 mm ID
  => v = 1.25 m/s
  => specific pipe loss :

$$\frac{dp}{ds} \approx -10 \cdot \frac{mbar}{m}$$

  => loss per transition (take $\zeta = 1$) :

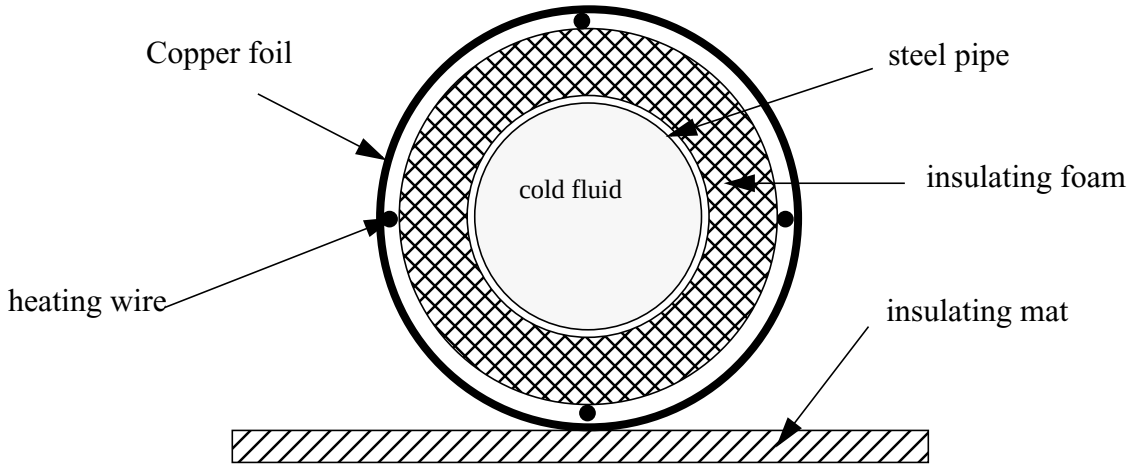
$$\Delta p_{trans} = \zeta \cdot \frac{\rho v^2}{2} = 14\ mbar$$

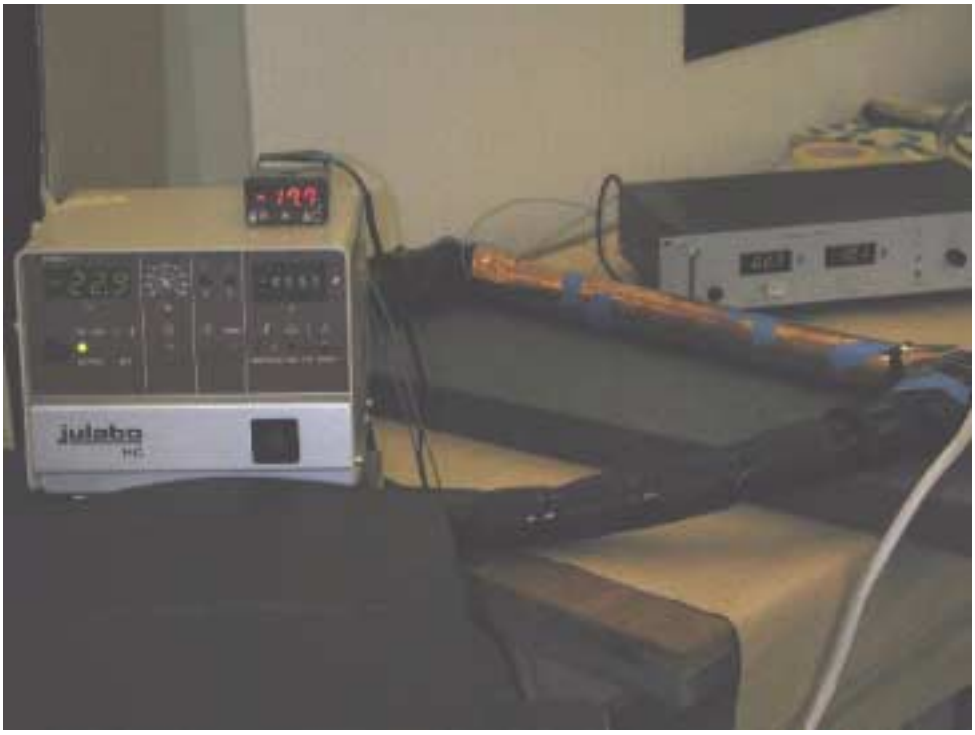
- design guidelines for (Armaflex AF grade) foam : thickness 21 mm necessary to avoid condensation => 74 mm OD over-all !

Problems :

1. **Foam grade** : we think only AF is possible, but only NH allowed by TIS.
   We may need to apply for a derogation.

2. **Foam thickness** : not everywhere is there space for 74 mm OD.
   Wherevere thickness has to be reduced, artificial heating is necessary
   Dedicated testing work : reported upon in CMS IN 2001/036

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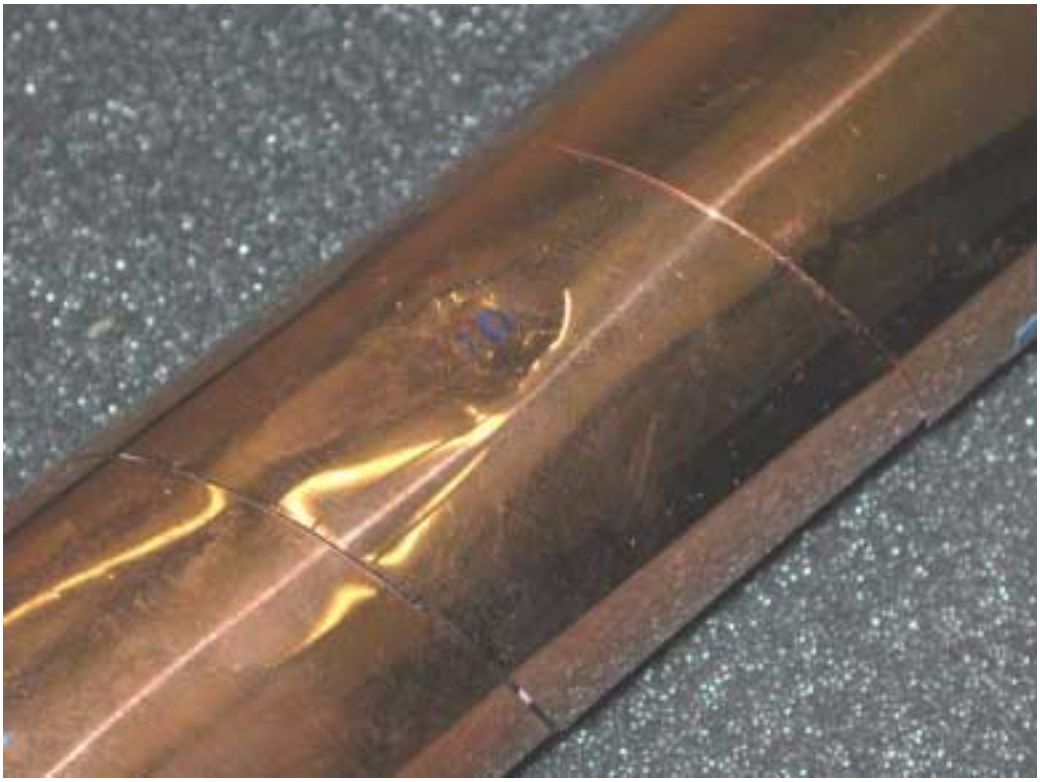
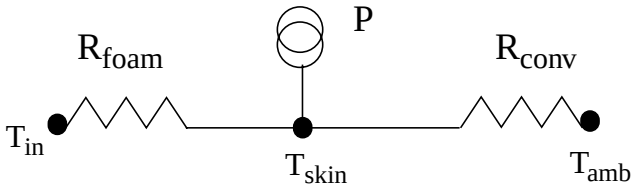
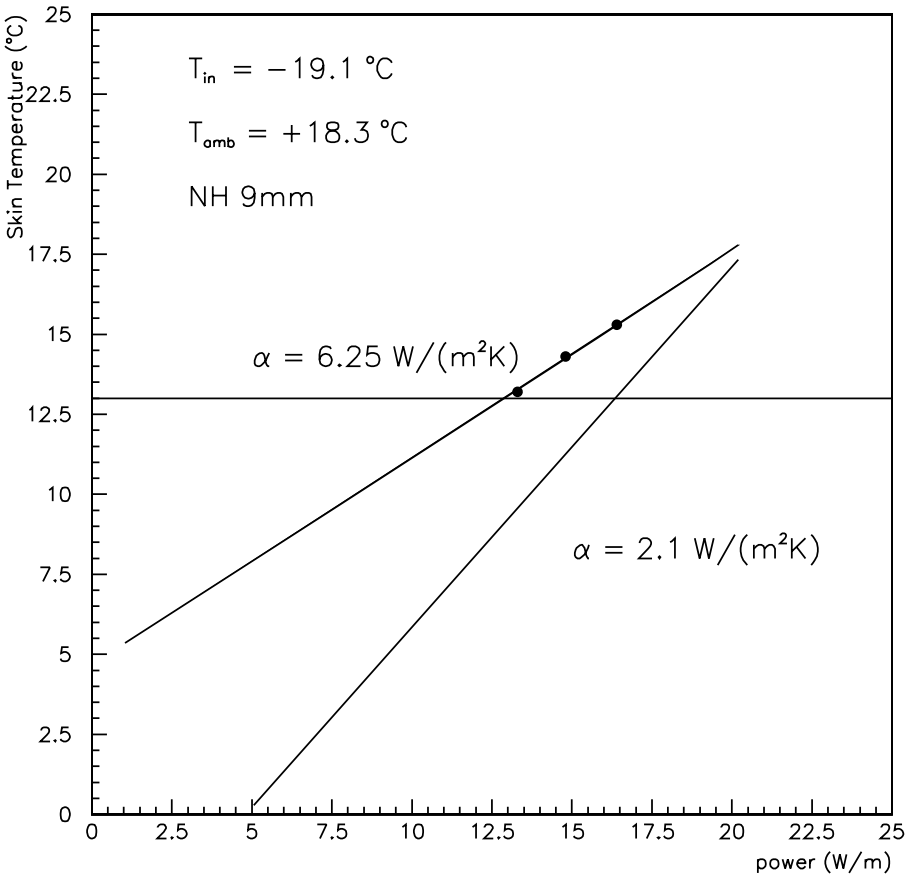
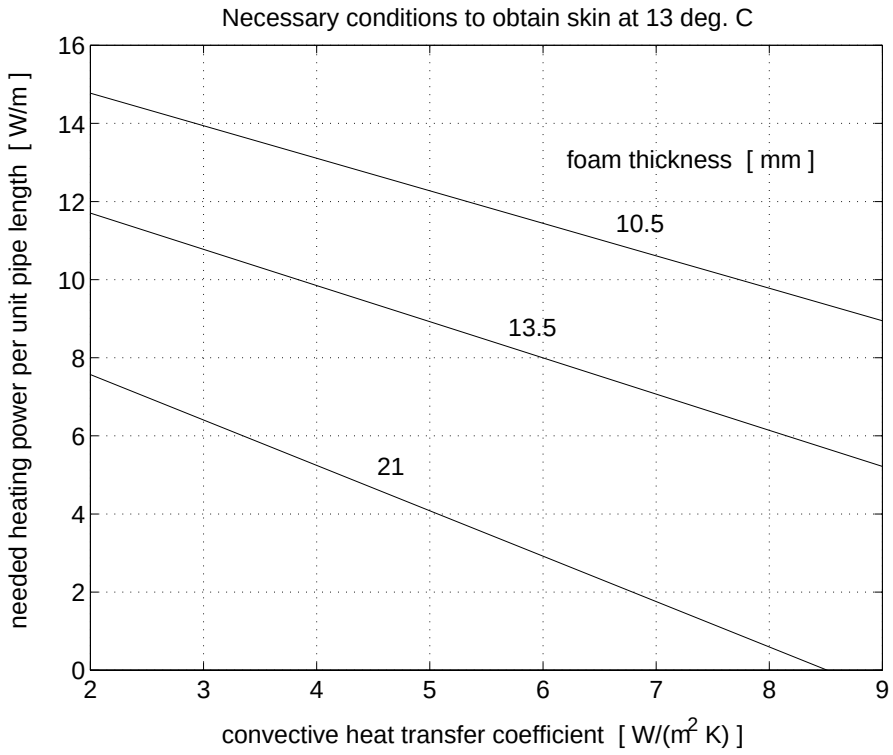



P
R_{foam}
R_{conv}
T_{in}
T_{skin}
T_{amb}


Skin Temperature (°C)
power (W/m)
T_{in} = −19.1 °C
T_{amb} = +18.3 °C
NH 9mm
α = 6.25 W/(m²K)
α = 2.1 W/(m²K)
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25

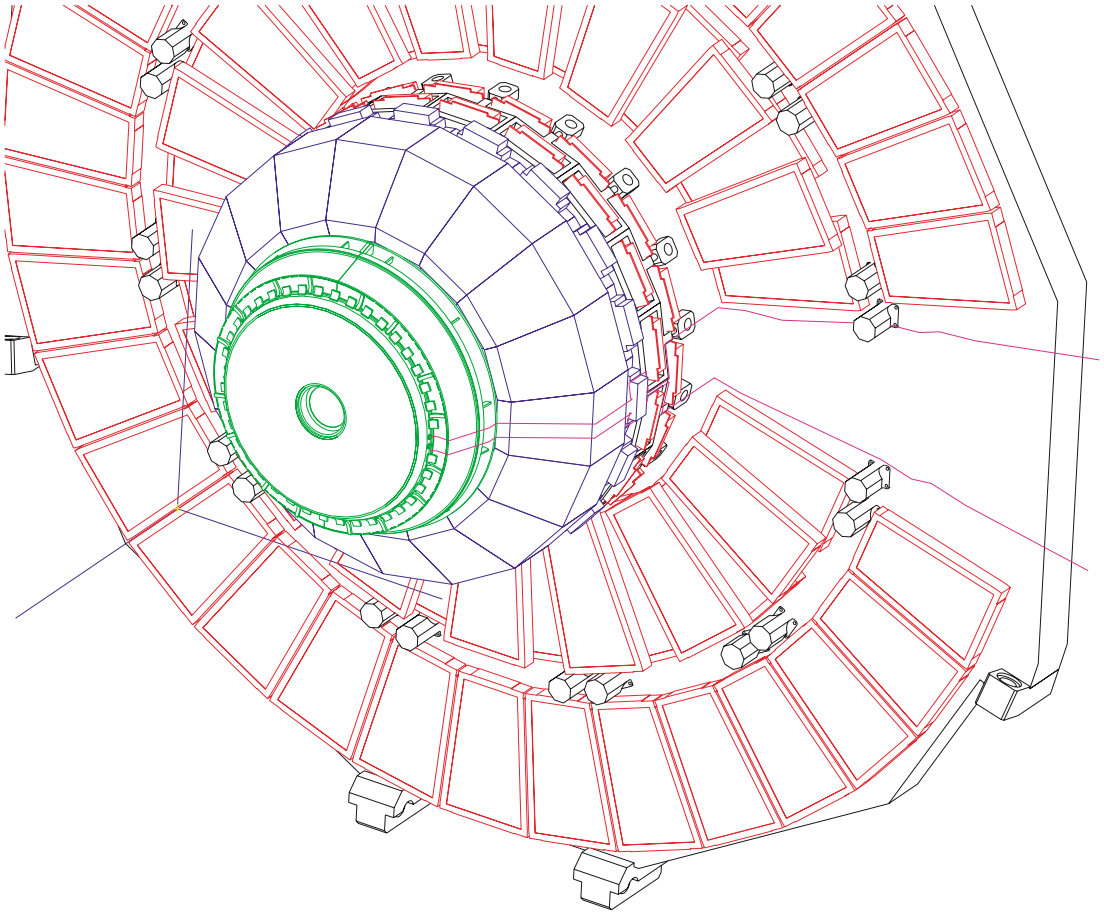


What we intend to do :
- design foam thickness wherever possible
- reduced foam thickness wherever required
- heating wires and Cu foil all along
- tune wire gage (resistance) to foam thickness
- the same 32/30 steel pipe all along except from 53˚ crack (see further)

3. Difficult pipe routing

From SE connection to CMS outside :
- avoid clash with TK support bracket
- allow EE to move in/out (with SE gone)
- in 53˚ crack : avoid HE connectors
- on cylindrical part of Endcap nose : avoid HE readout boxes
- buried behind ME/1/2 and ME/1/3
- no space for intermediate disconnections => **welded construction all along**

We try to replace the stiff pipe by a **DN32 flexible line in the 53˚ crack**, in order to free (transverse) space for EE motions. Reduced foam thickness (14.5 mm) resulting in over-all diam. ~ 72 mm . Trying to find Cu braid to put around foam.



SE coolant transfer through Endcap cable chains

Current baseline, under discussion with Integration :
- cryogenic transfer line (simplified , no superinsulation necessary)
- inner hose DN32
- over-all diameter ~ 90 mm