

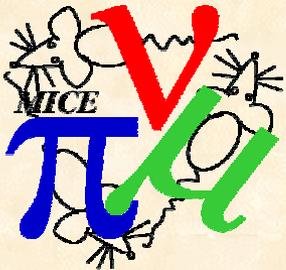
The Mechanical and Thermal Design for the MICE Detector Solenoid Magnet System



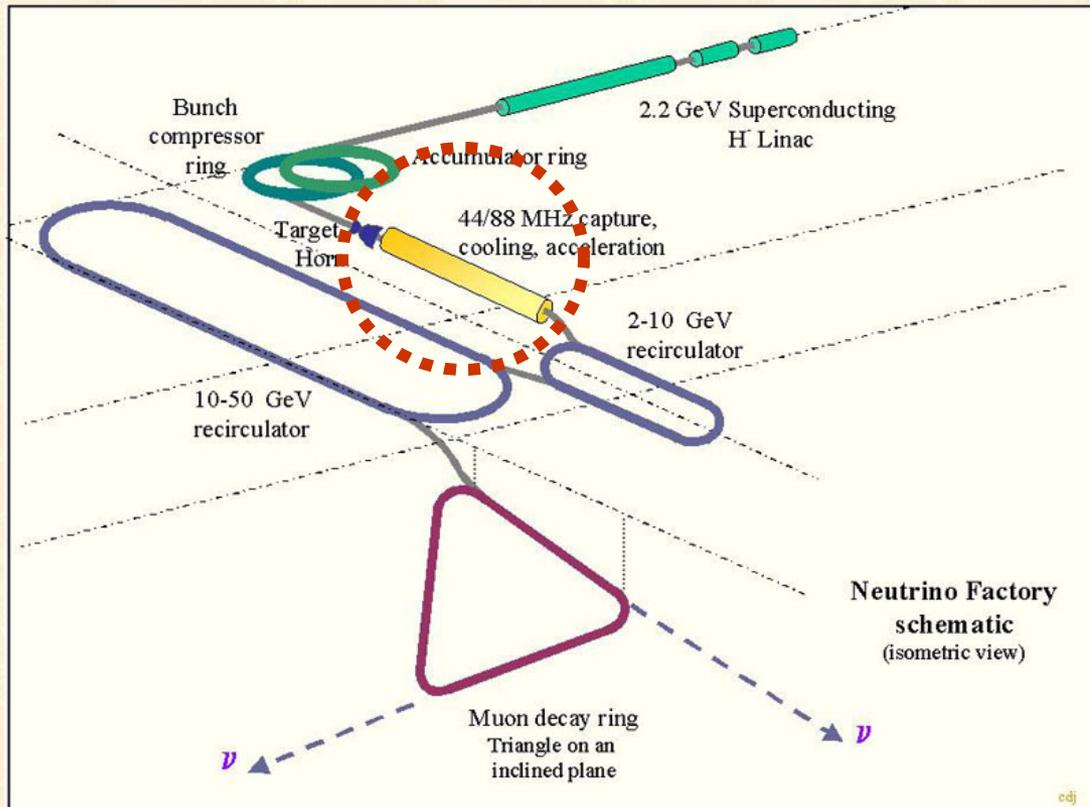
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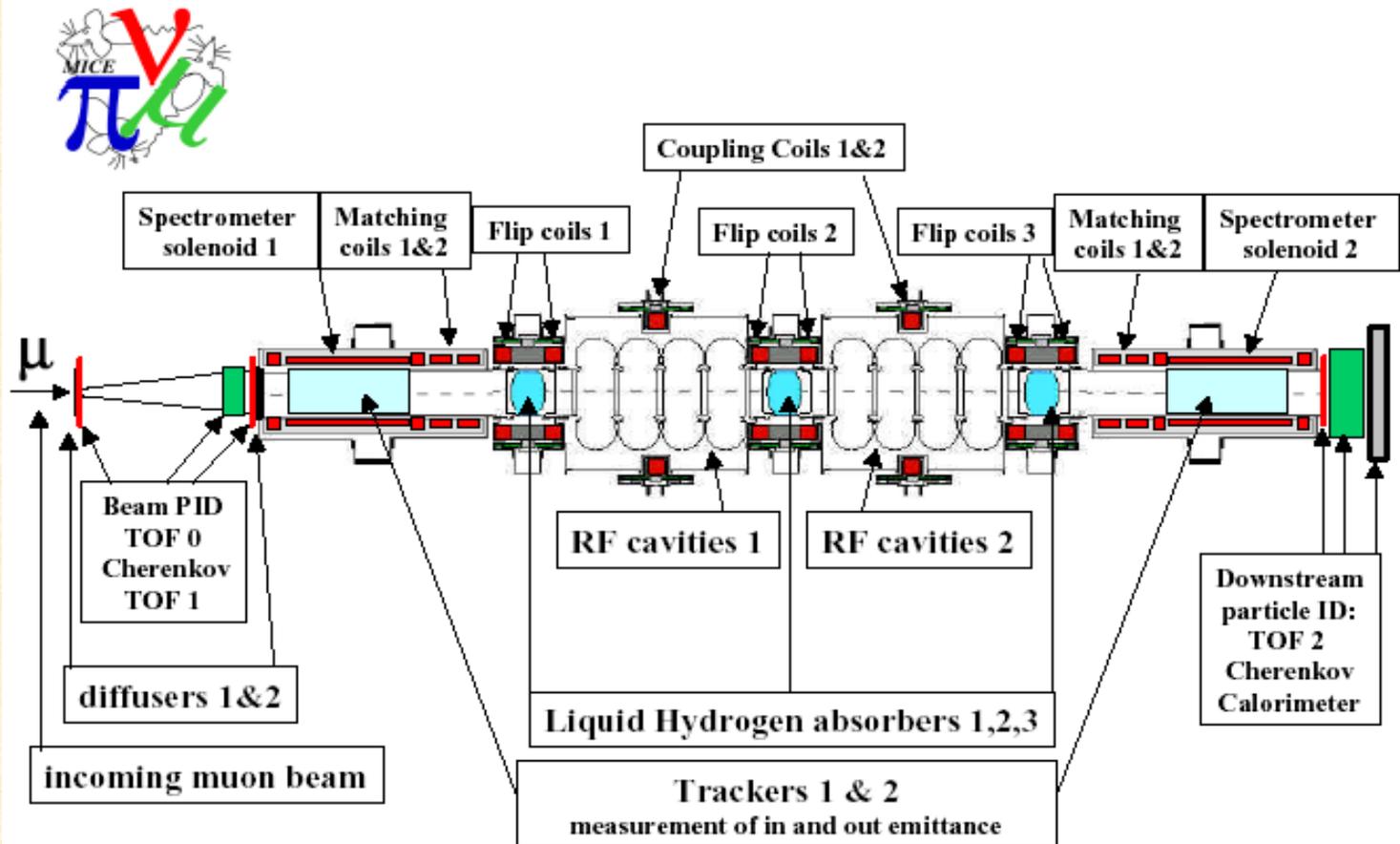
In the frame of a Neutrino Factory Complex, a key role is played by the muon ionization cooling channel



The use of ionization cooling increases the density of muons within the volume of phase-space that can be accelerated and improves the performance of the Neutrino Factory by a factor that ranges from **4 to 10** depending on the design. Although it saves considerably on the cost of the accelerating devices, cooling as is presently envisaged is itself expensive, representing as much as **20%** of the Neutrino Factory cost.

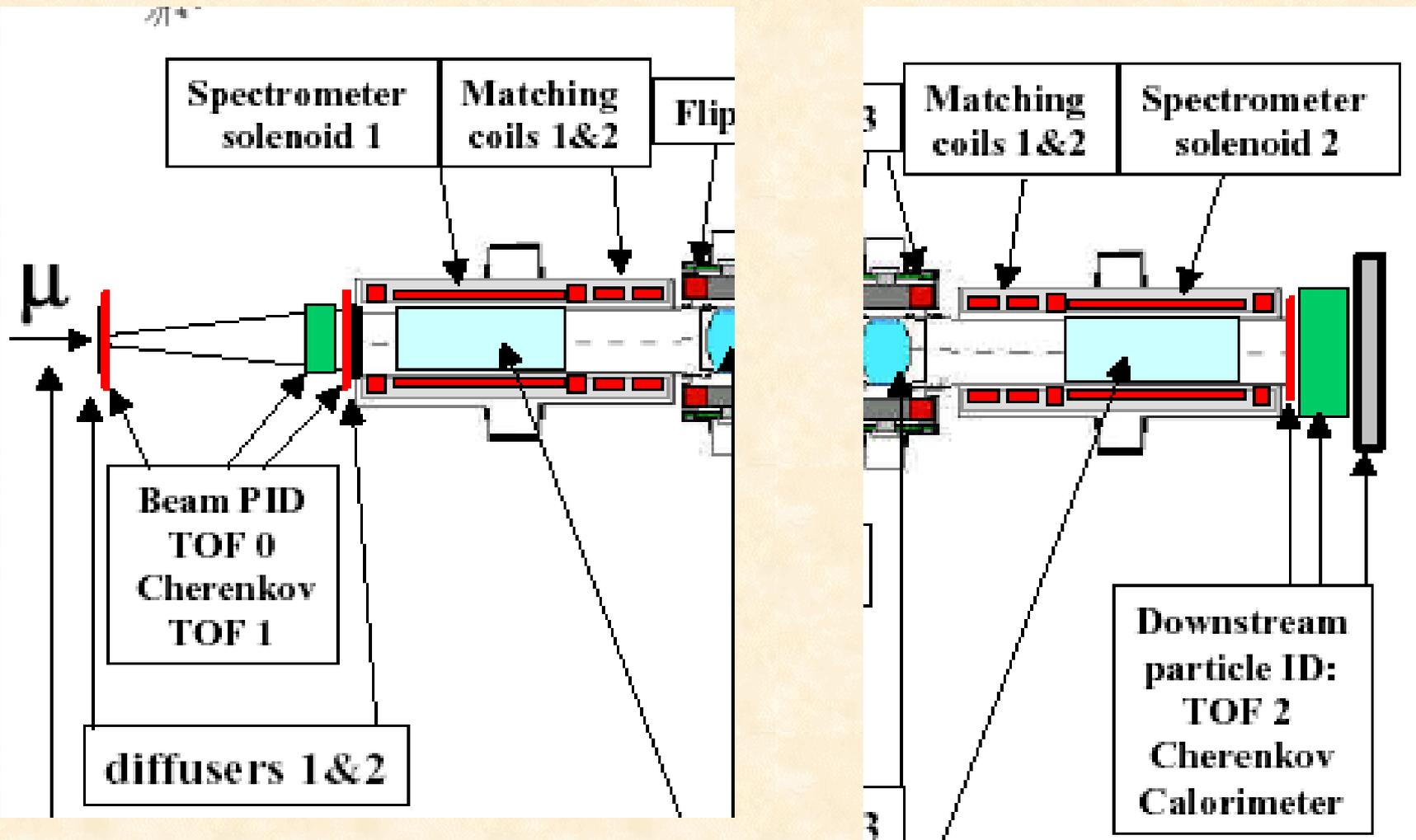
Then we need to study the capability for cooling a muon beam, i.e. how reduce and control the beam emittance

MICE is an experimental line for testing the ionization cooling of muon. Cooling means that muons have their momentum reduced in both the longitudinal direction and the transverse direction by passing them through a low Z absorber. RF cavities are used to re-accelerate the muons to their original momentum



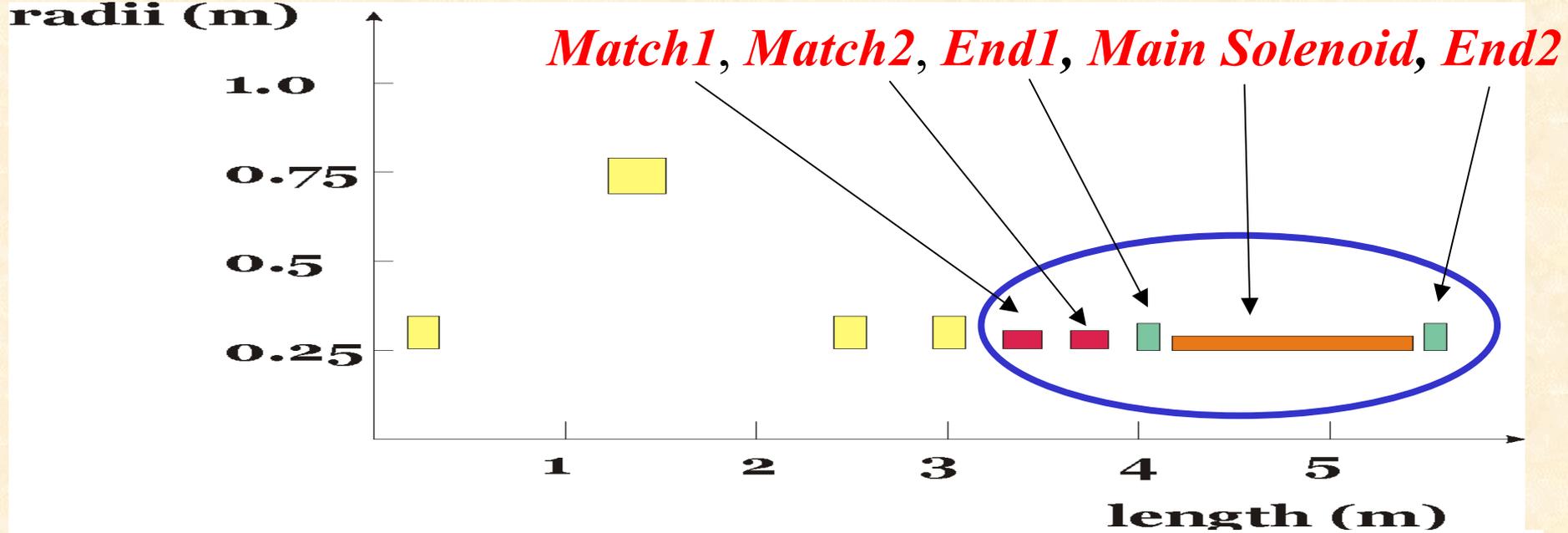
More details
about MICE
line in papers

4RL05 and
5LF-01

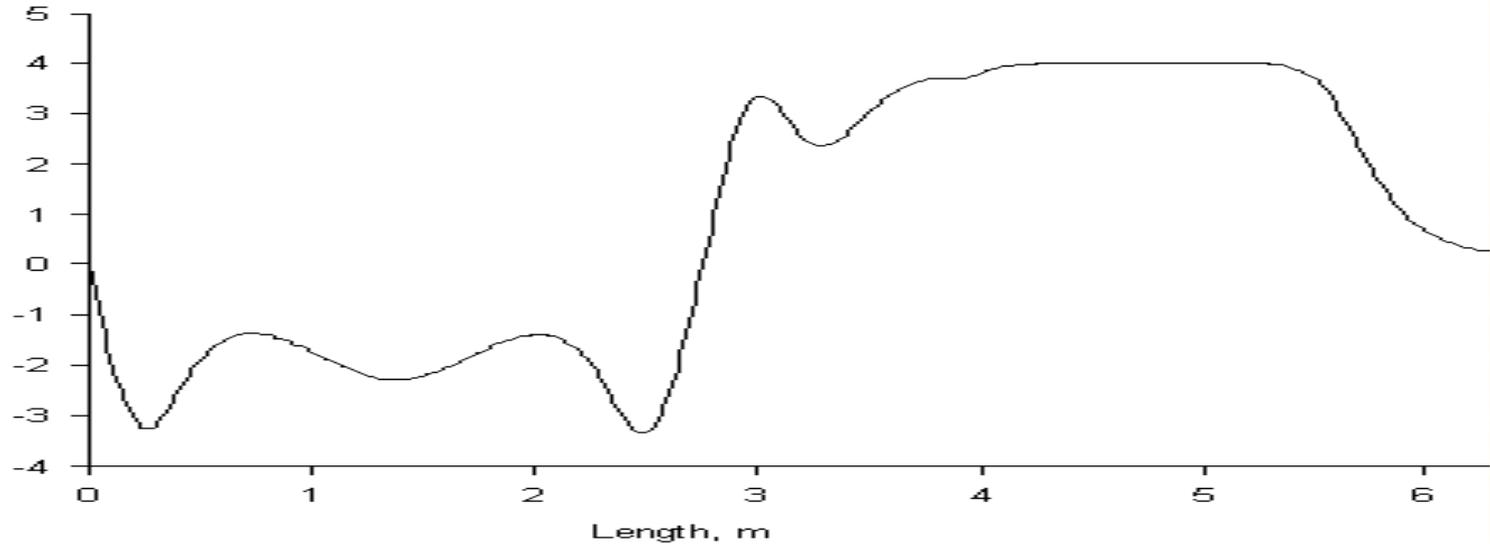


The muon emittance will be measured, before and after ionization cooling by four planes of scintillating fibers that are in a uniform solenoidal magnetic field from 2.8 to 4 T (400 mm warm bore)

MAGNETIC FIELD OF SPECTROMETER SOLENOID



Field (T)



BASIC CONCEPTS OF SPECTROMETER SOLENOIDS

The very basic choice is that both the spectrometers shall operated at working temperature (4.5 K) through cryocoolers. Furthermore each coil shall have an independent current feeding

As consequences →

1. Indirectly cooling design → Large enthalphy margins

Avoid mechanical disturbances

2. Current limited at 300 A → Large inductance

3. Robust but low losses supporting system

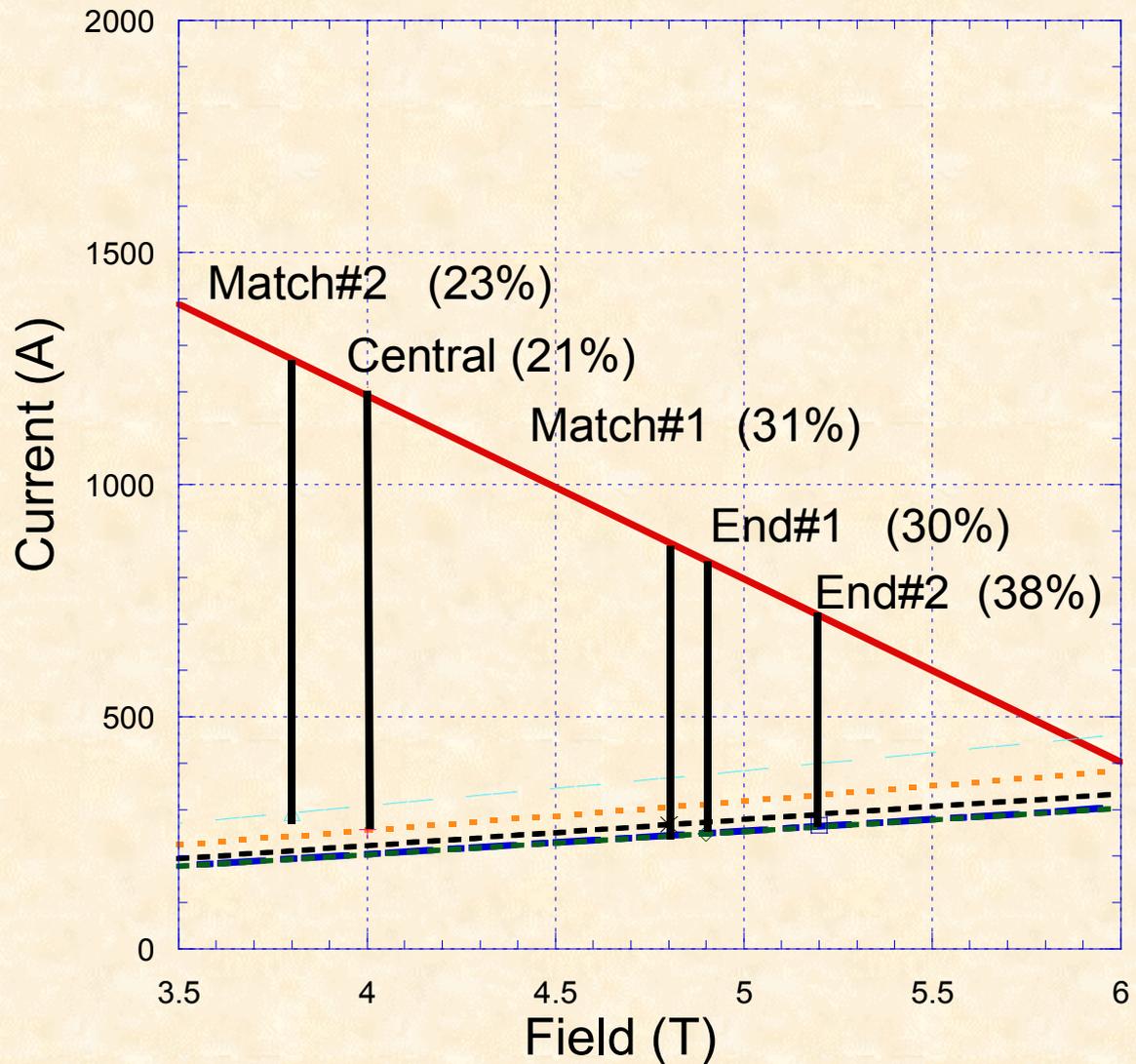
THE CONDUCTOR

OCSI CONDUCTOR CHARACTERISTICS:

Dimensions (bare):	1.52×2.28 mm ²
Dimensions (insulated):	1.65×2.40 mm ²
Number of filaments:	92
Filament diameter:	80 μm
Critical current:	2000 A @ 2 T 1550 A @ 3 T 1210 A @ 4 T
Required length	60 km

Note: Some time ago the projects involving S/C wires demanded for special conductors for the specific design. At present time we are looking for some standard conductors (often for RMI) fitting our needs as fine as possible

LOAD LINES AND TEMPERATURE MARGINS



With respect the current sharing temperatures we have:

End#2 1.55 K

End#1 1.84 K

Match#1 1.85 K

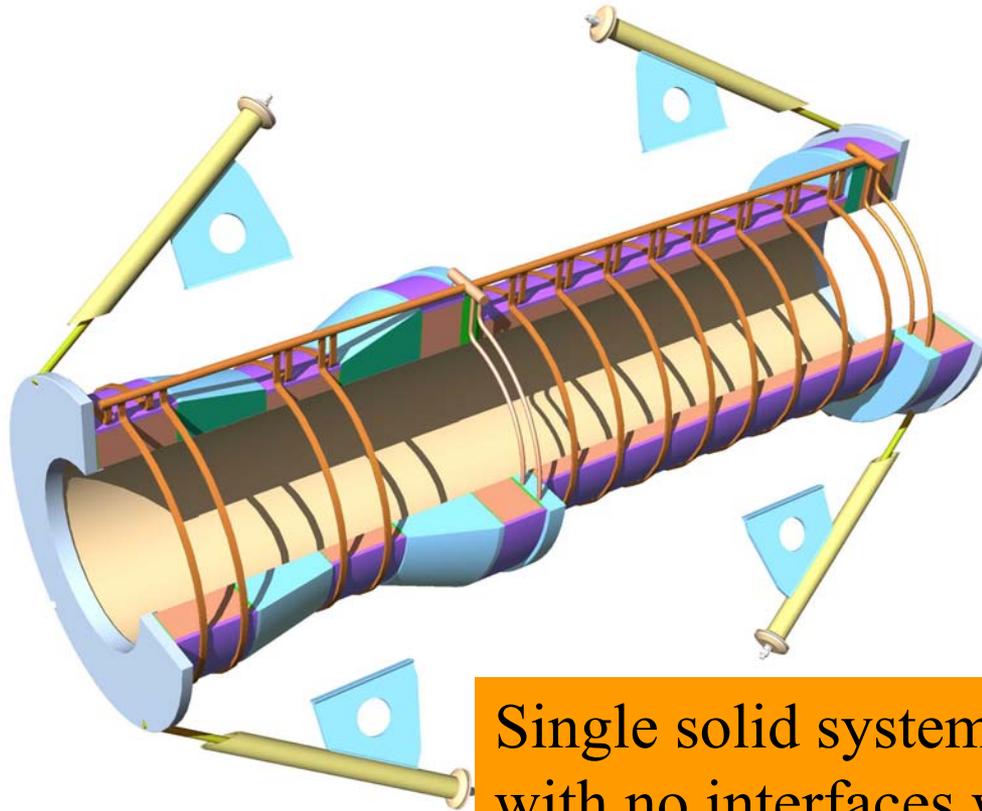
Central 2.40 K

Match#2 2.41 K

$\Delta E = 1650 \text{ J/m}^3$

THE COLD MASS

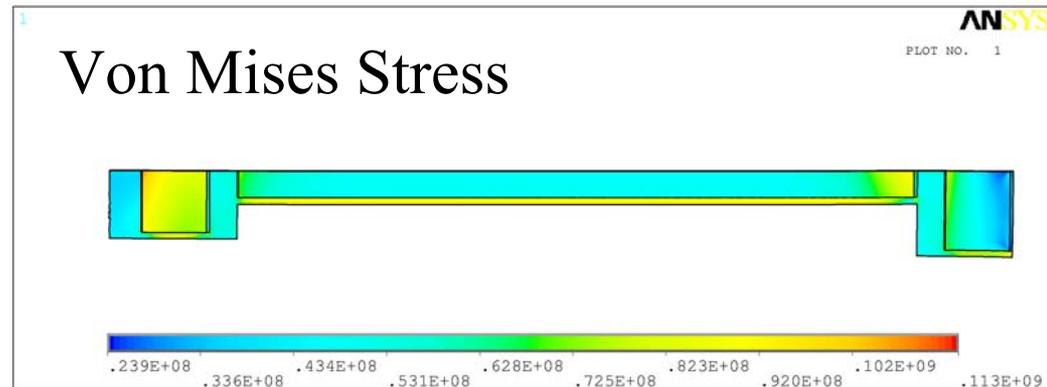
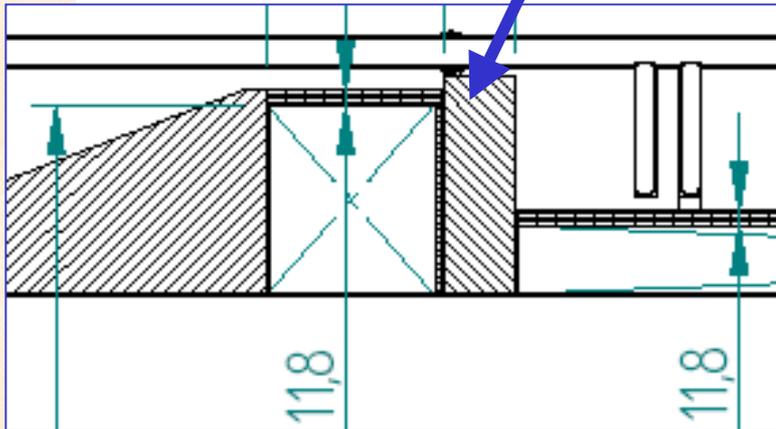
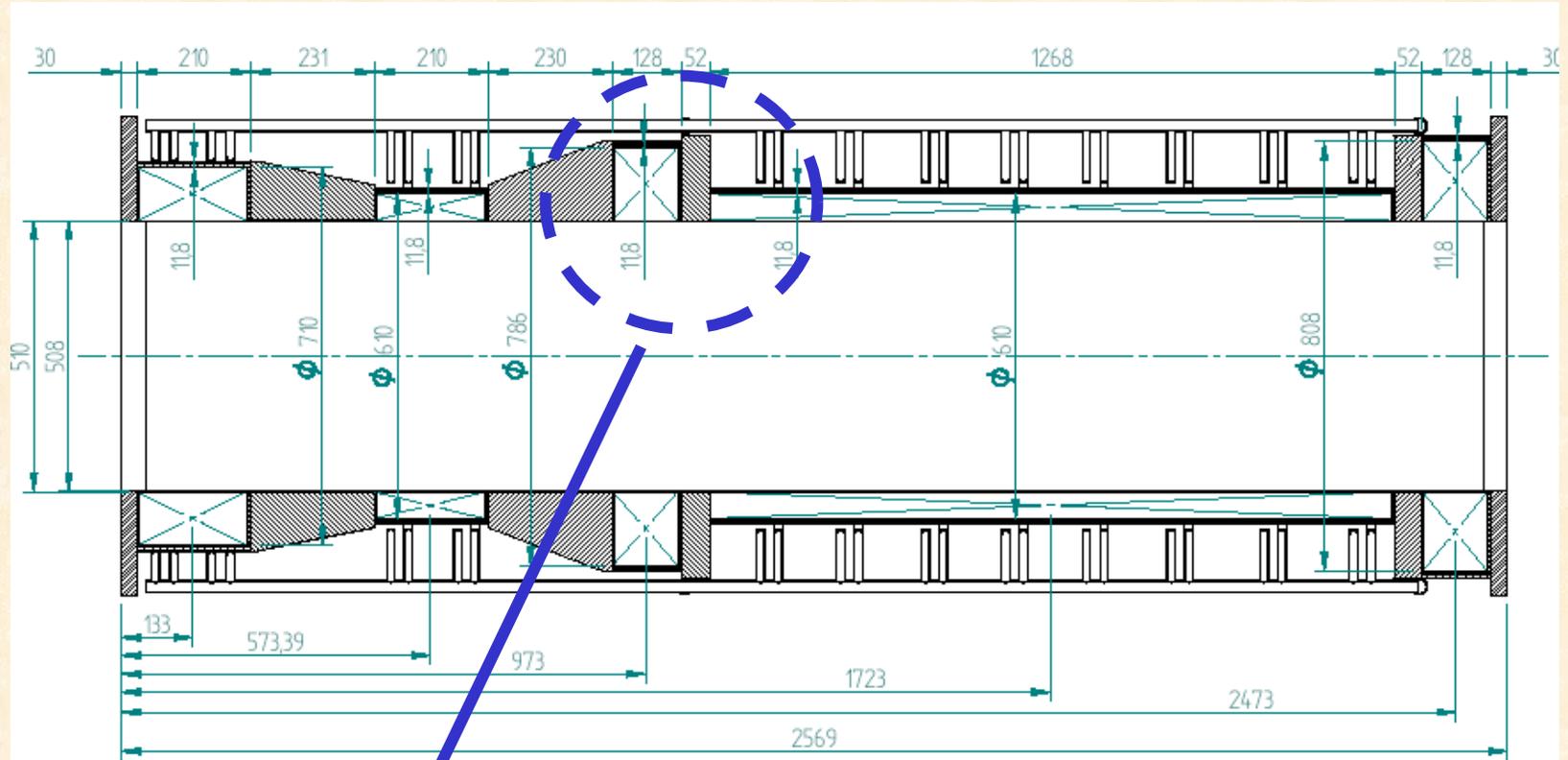
The coils are supposed to be wound on a demountable bobbin. Each coil is axially contained by two fiberglass epoxy (G10) thin flange and the remaining space between coils is filled with aluminum alloy (5083) block rings



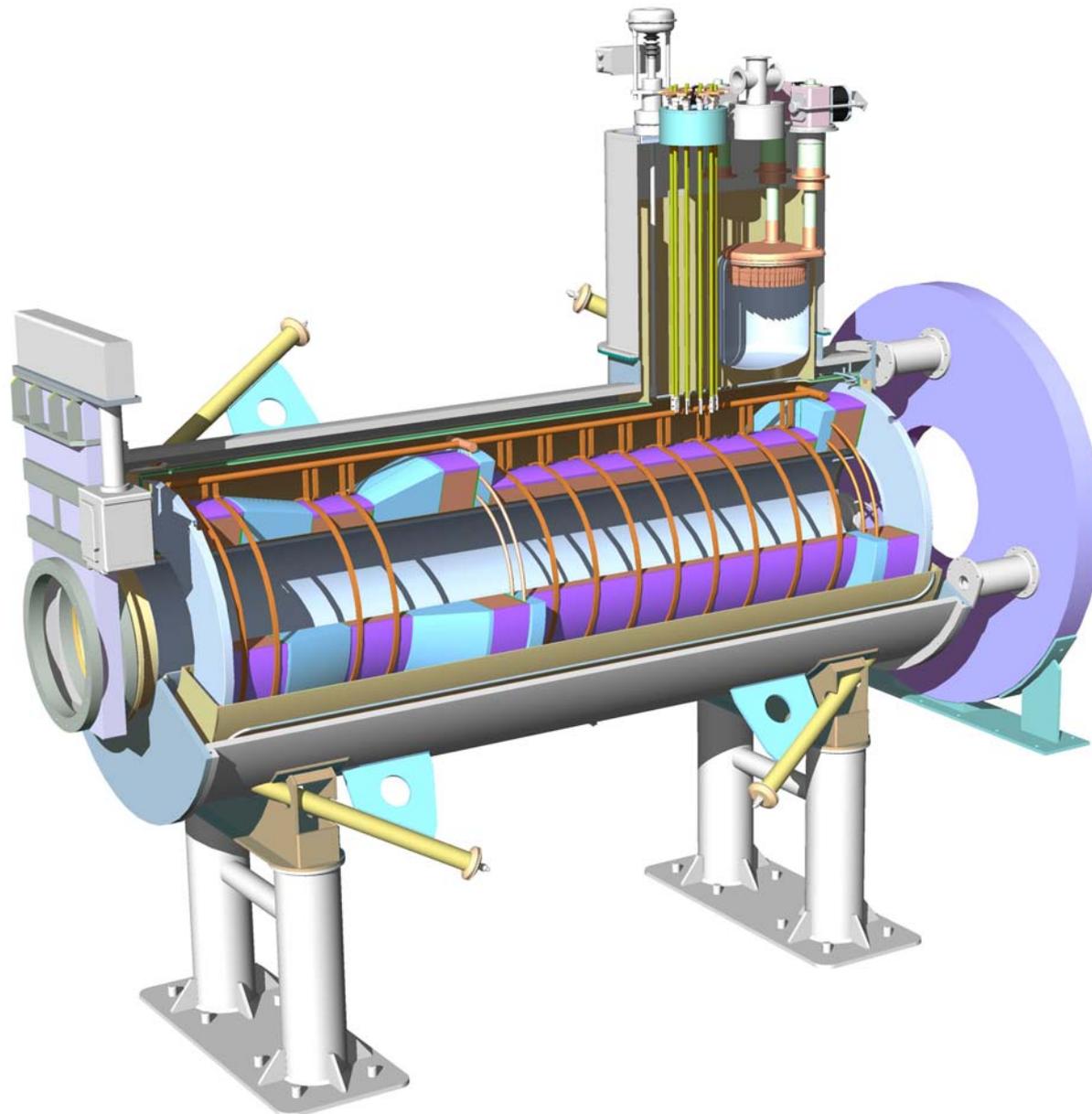
After the winding of each coil, a 2-3 mm thick strip in aluminum alloy is wound onto the coil, so to form an external structure providing the hoop strength.

Single solid system mechanically self-consistent with no interfaces with mechanical structures

THE COLD MASS: some details



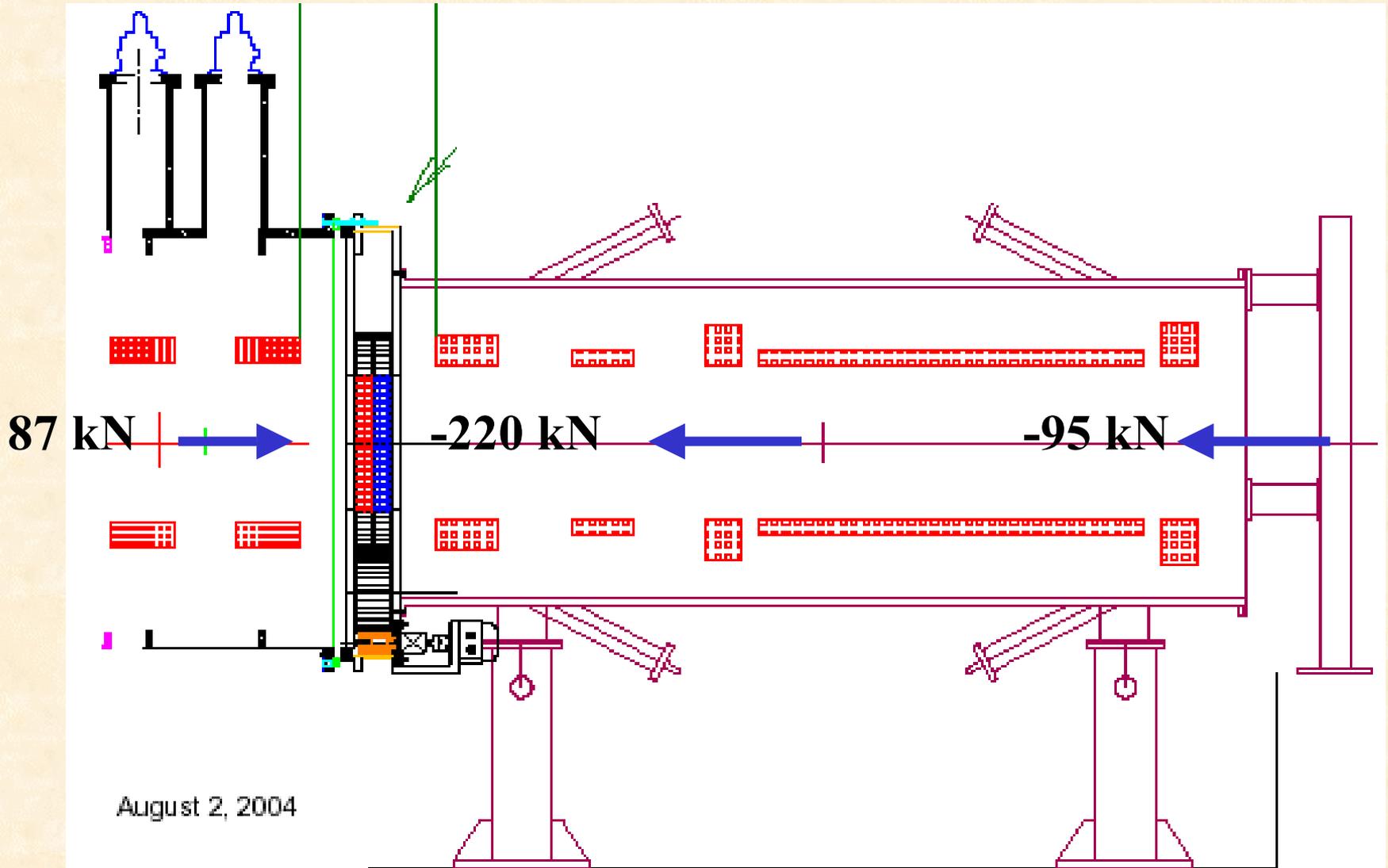
THE COMPLETE SYSTEM



THE NOMINAL DESIGN PARAMETERS FOR THE MICE DETECTOR SOLENOID COILS

Parameter	Match 1	Match 2	End 1	Center	End 2
Z distance from MICE Center* (mm)	3510	3951	4391	4571	5891
Coil Length (mm)	202	202	120	1260	120
Coil Inner Radius (mm)	255	255	255	255	255
Coil Thickness (mm)	100	57	138	50	149
Number of Layers	60	34	82	30	90
Number of Turns per Layer	84	84	50	525	50
Coil Overall Current Density (A mm ⁻²)	66.82	73.25	61.59	64.44	67.11
Coil Current (A)	267.8	293.8	248.8	257.8	266.7
Coil Self Inductance (H)	15.9	5.0	12.6	47.0	15.1
Peak Induction in the Coil (T)	4.8	3.8	4.9	4.0	5.2
Coil Stored Energy at Current above (MJ)	0.57	0.22	0.39	1.56	0.54
			92 H	3.6 MJ	

AXIAL MAGNETIC FORCES

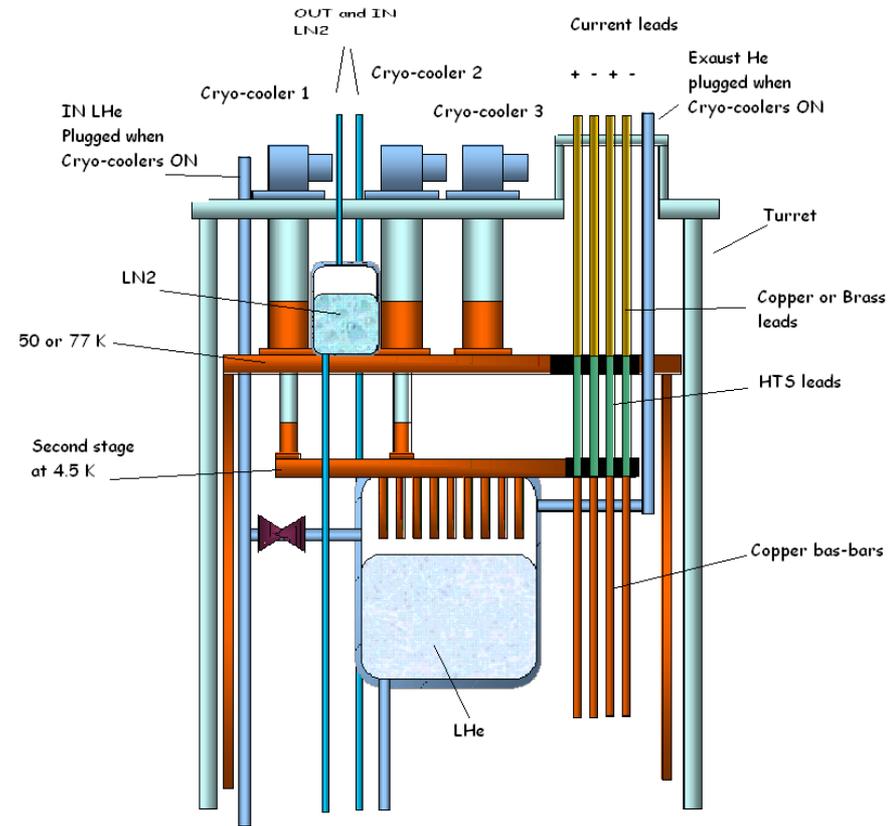
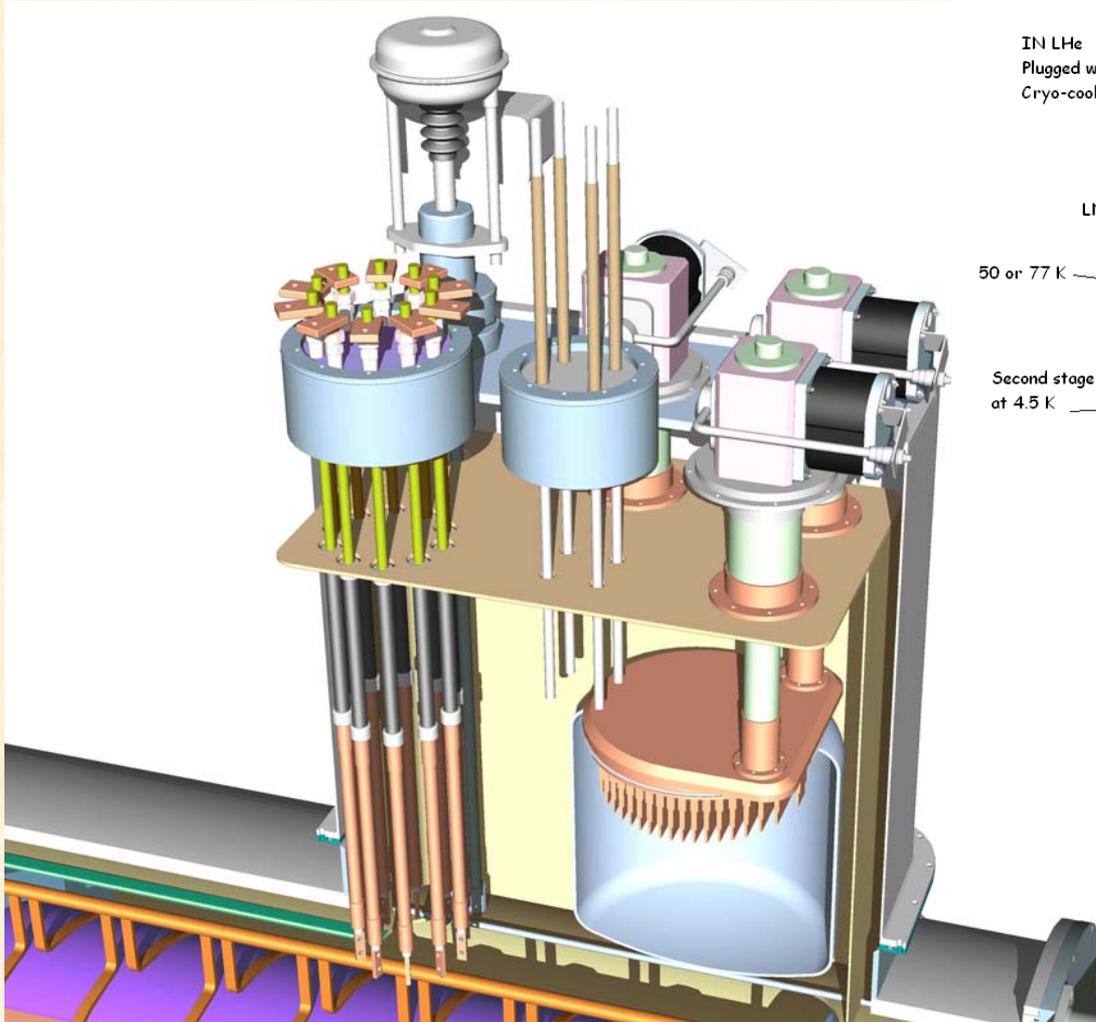


COOLING SYSTEM

The cooling system presently under study is based on three main concepts:

- The cooling power is provided by cryo-coolers directly connected to the cold-mass
- The cryo-coolers do not cool the coil and the thermal shields by conduction, but through an exchange gas. This choice comes from the need to cool efficiently a long coil. The cooling by thermal conduction starting from an extremity may result in unacceptable temperature gradient inside the cold mass. The LHe coolant can better distribute the cooling power.
- With cryo-cooler off the coil cool-down shall be possible though direct feeding of cryogenes.

Cooling with cryocoolers



Heat load at 4.5 K 1.85 W

at 50 K 178 W

CONCLUSIONS

- The superconducting detector solenoids for **MICE** can be built with existing niobium titanium conductors.
- There is enough margin in the detector magnet design to allow for tuning of the MICE magnets and still have reasonably large temperature margins for each of the detector coils
- The forces within the magnet can be handled by the proposed coil and aluminum spacer structure
- The detector solenoid can be cooled using three coolers. At least two of those coolers must provide cooling at 4.2 K. The third cooler may provide extra cooling at 40 K to handle the large heat load coming down the copper leads from room temperature.