Cold Powering of the Inner Triplets Upgrade Phase 1: Status of Conceptual Design

Amalia Ballarino

Perceived requirements for cold powering

• Power the Inner Triplet magnets via displaced cryostats to free space in the beam area. Inner Triplet: 4 quadrupoles (13 kA) + trims + correctors

•Locate the leads in the underground areas near the power converters

•Electrically link the leads with the LTS bus in the magnets cryostat taking into account the protection of each magnet with a warm diode/thryristor

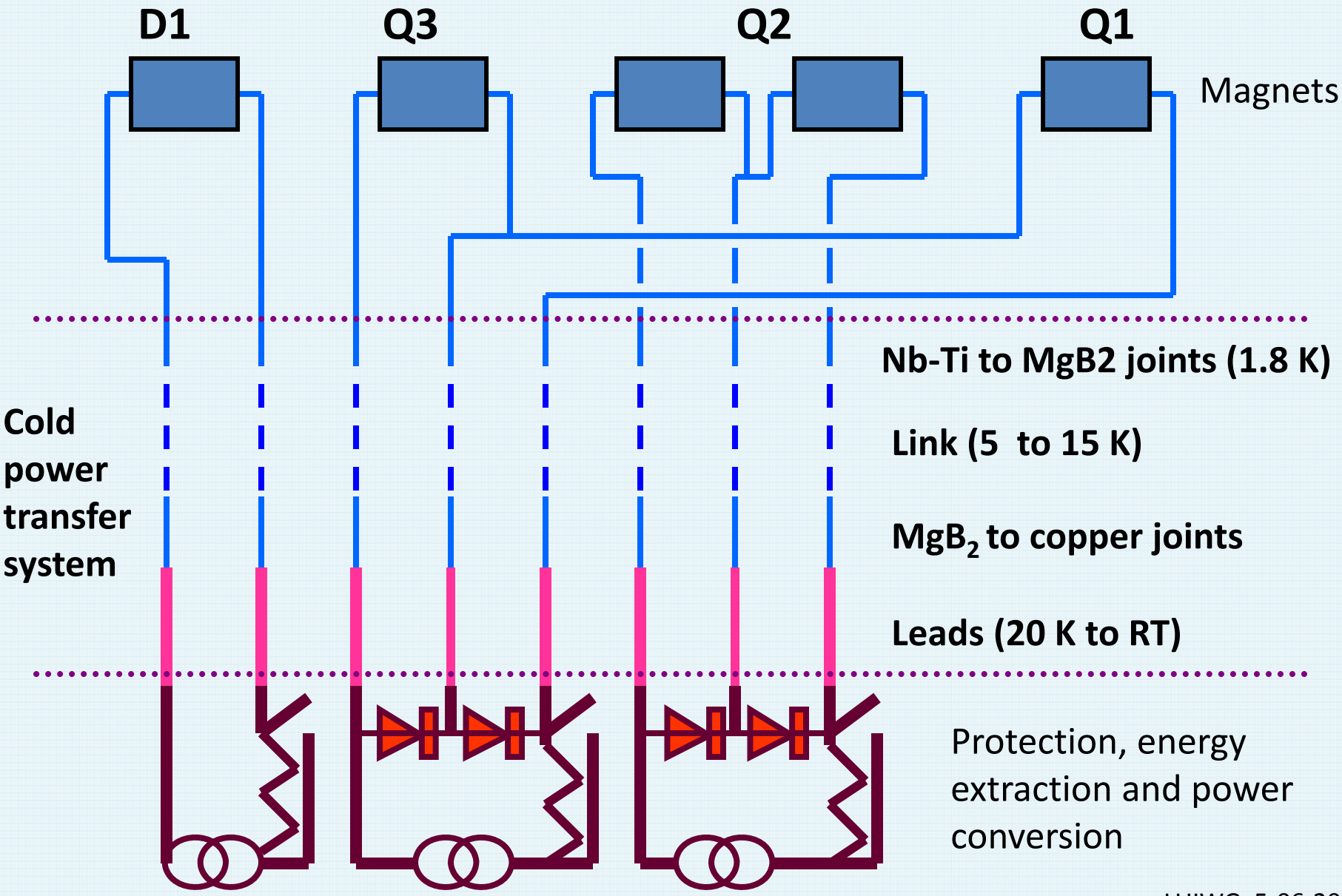
•Provide a design as compact as possible

Cold powering (from RT to 1.9 K):
cryostat + current leads,
superconducting link,
interconnection box to the 1.9 K environment

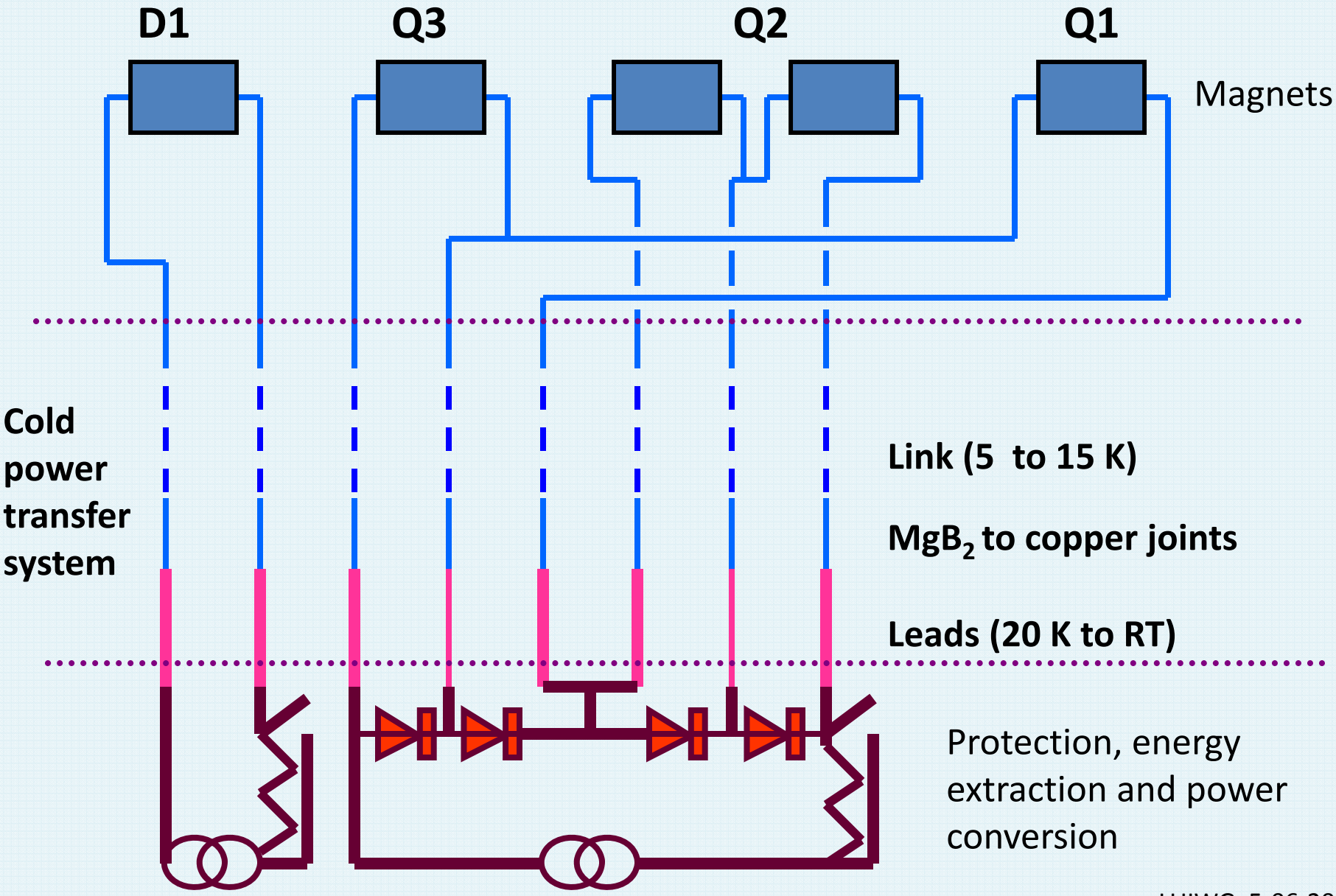
Cold power transfer system

- Proposal for maximum flexibility
  - 8 main (13 kA) cables through the link
  - 6 power leads capable of passing full current in steady state
  - 2 safety power leads capable of passing trim current in steady state and full current during discharge
- This arrangement allows two possible configurations
  - Version 1
    - Q1 in series with Q3, with one or other equipped with a trim supply
    - Q2 with its own power circuit
    - D1 with its own power circuit
  - Version 2
    - Q1, Q2, Q3 in series with two magnets equipped with trim supplies
    - D1 with its own supply
- With regard to tuning, version 1 retains the same functionality as the present scheme.
- If version 2 were to become definitive before work started on the feedbox, the connection between the quadrupole circuits could be made cold, and two of the main power leads could be replaced by a single safety lead.

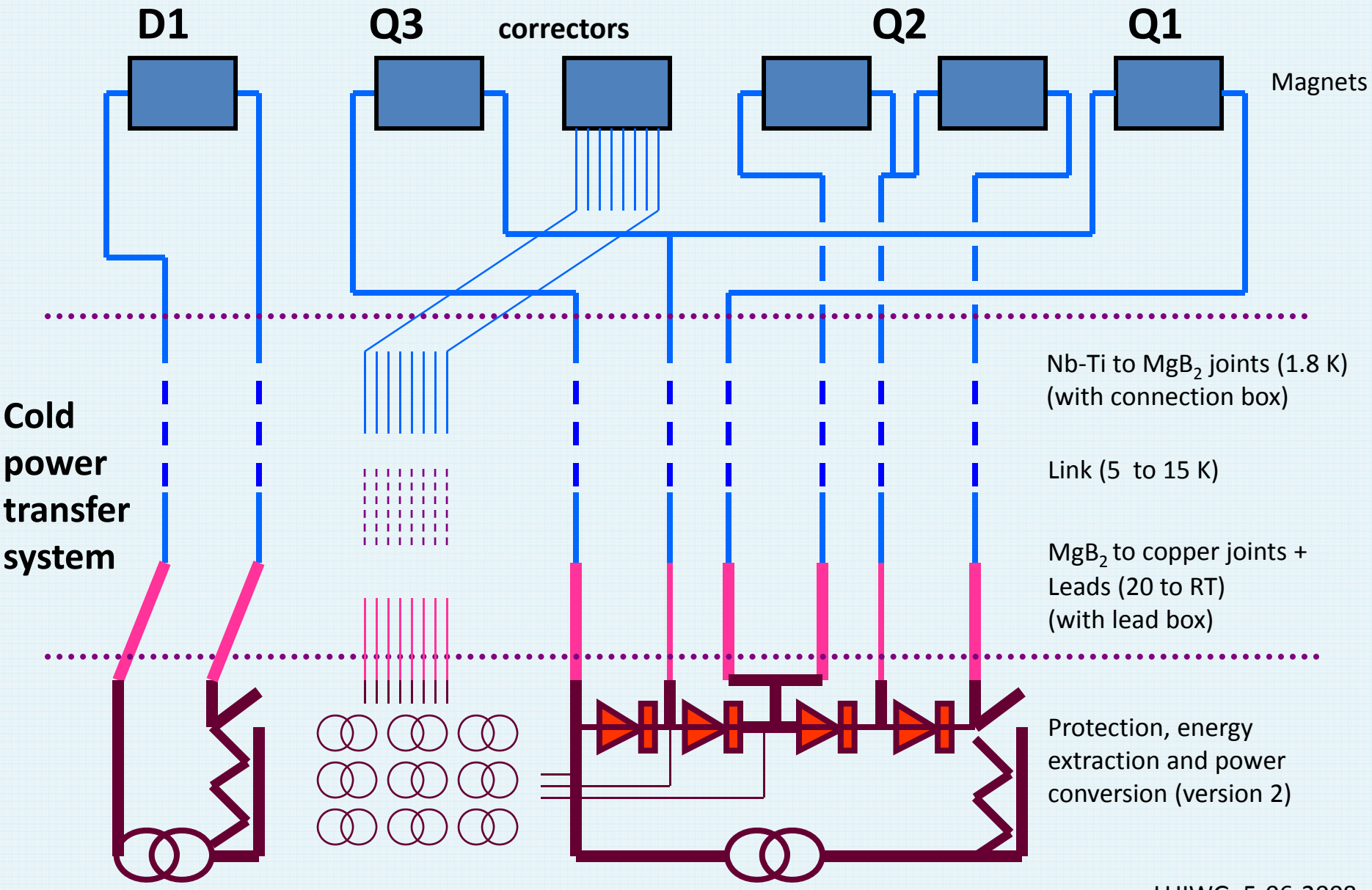
Cold power transfer system (version 1)



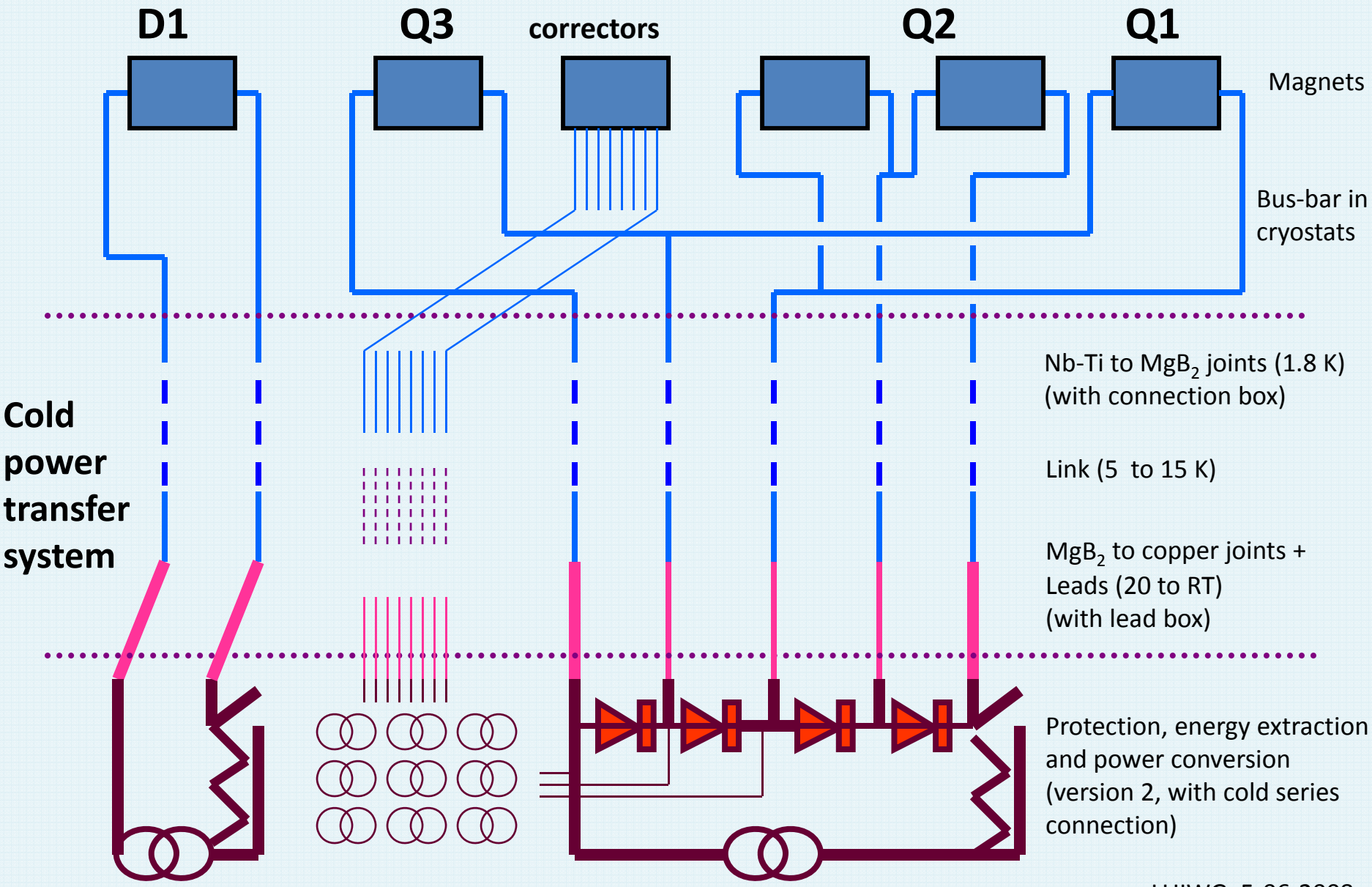
Cold power transfer system (version 2)



Cold power transfer system

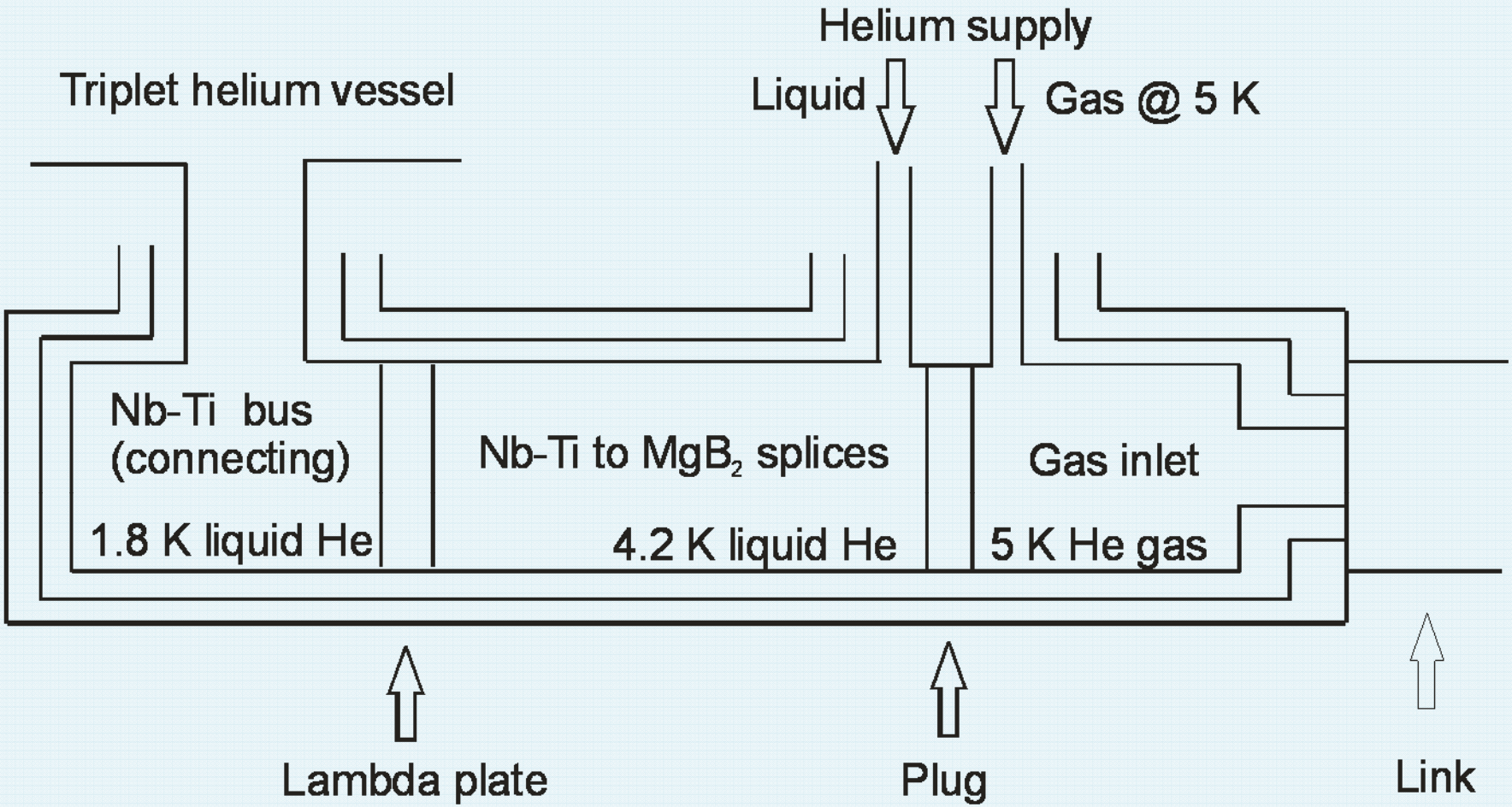


Cold power transfer system



LUIWG, 5-06-2008

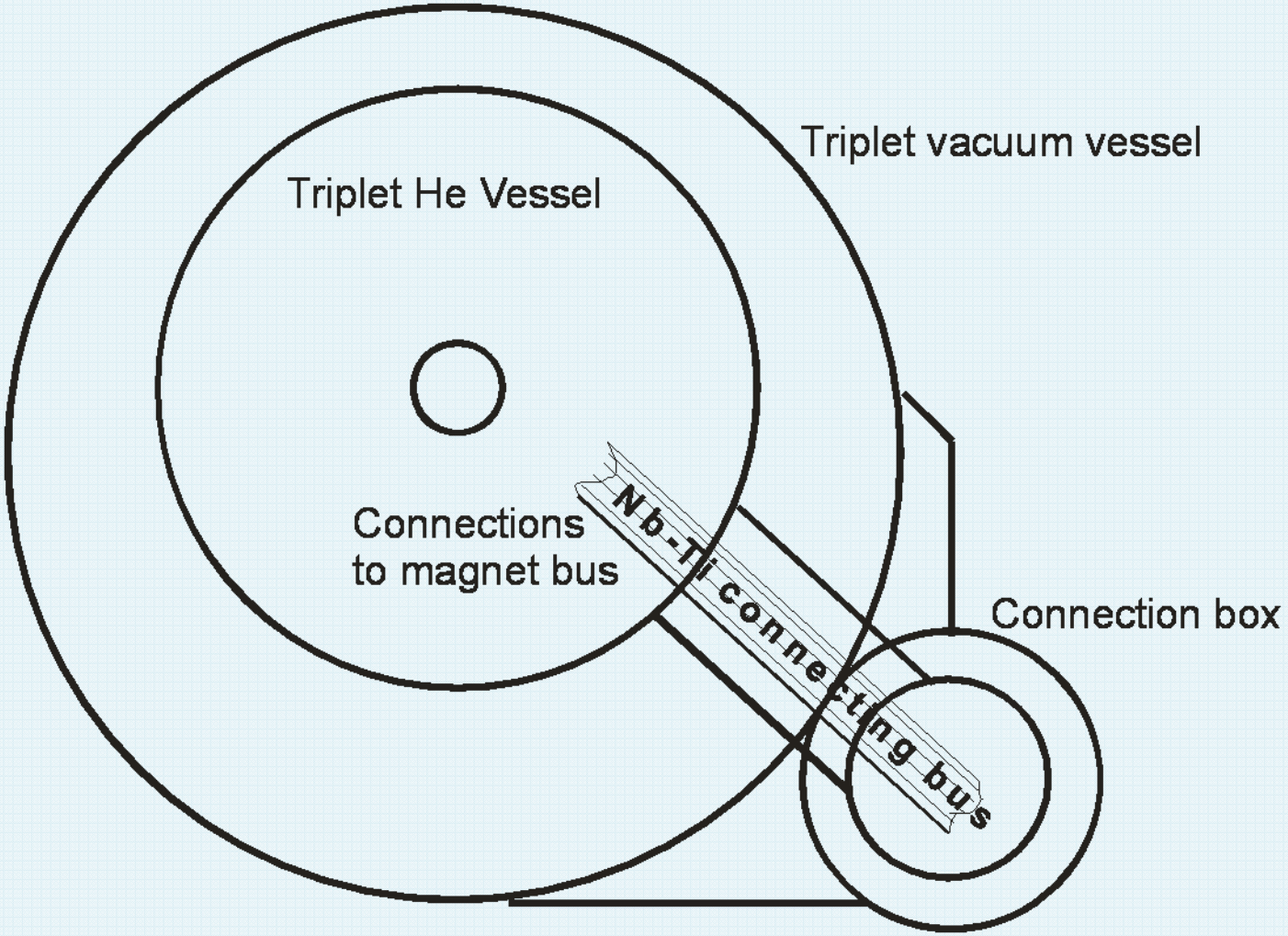
From the magnet to the link



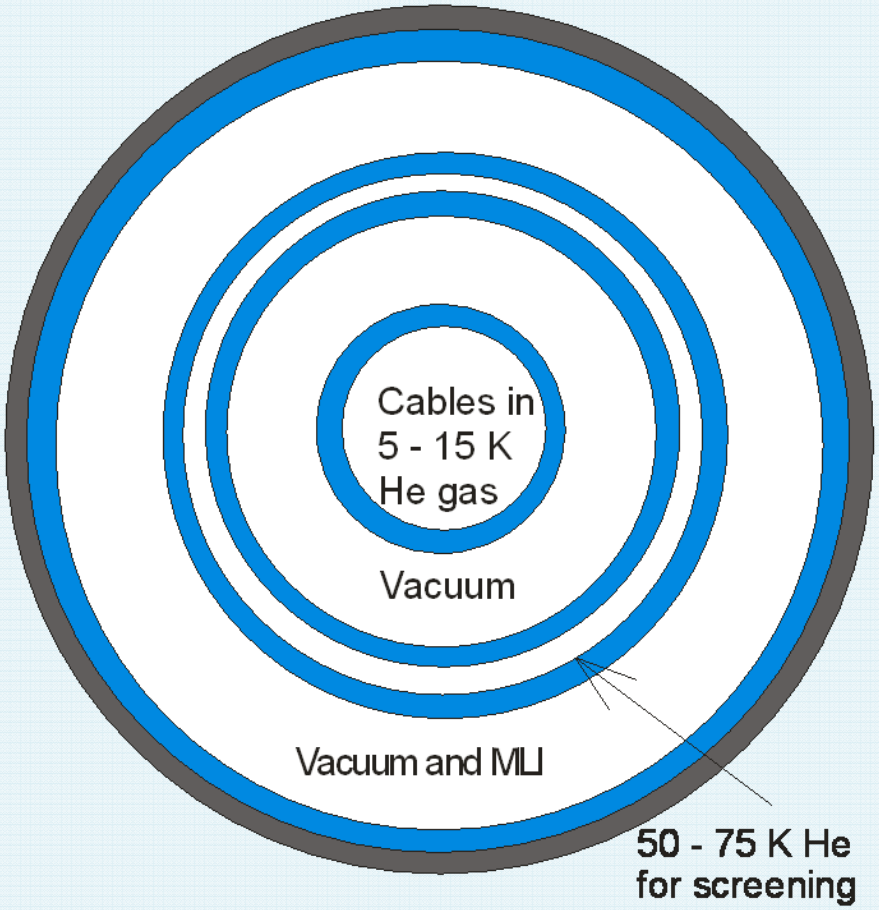
Connection box - schematic

External diameter ~ 350 mm Total length ~ 1.5 m

From the magnet to the link



The link

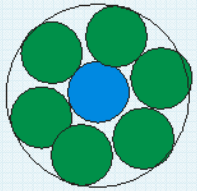


Four concentric corrugated tubes (Nexans)
The innermost tube (ID ~ 60 mm) contains cables.
The overall OD is about 200 mm.

$Q \leq 1.5$ W/m
$m_{min} \sim 2$ g/s

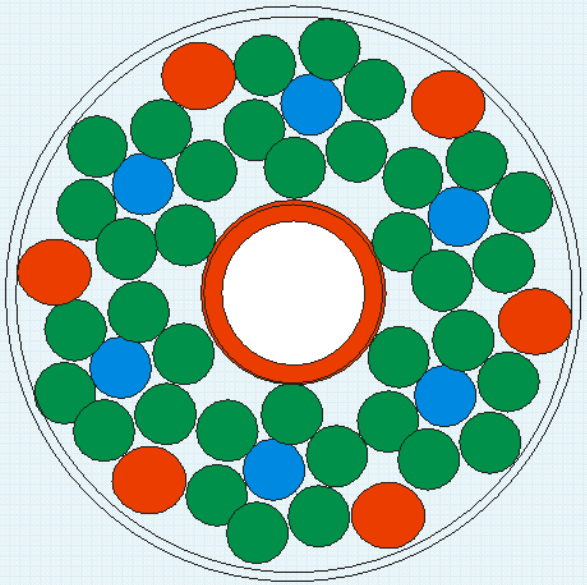
The link

Insulated MgB2 strand



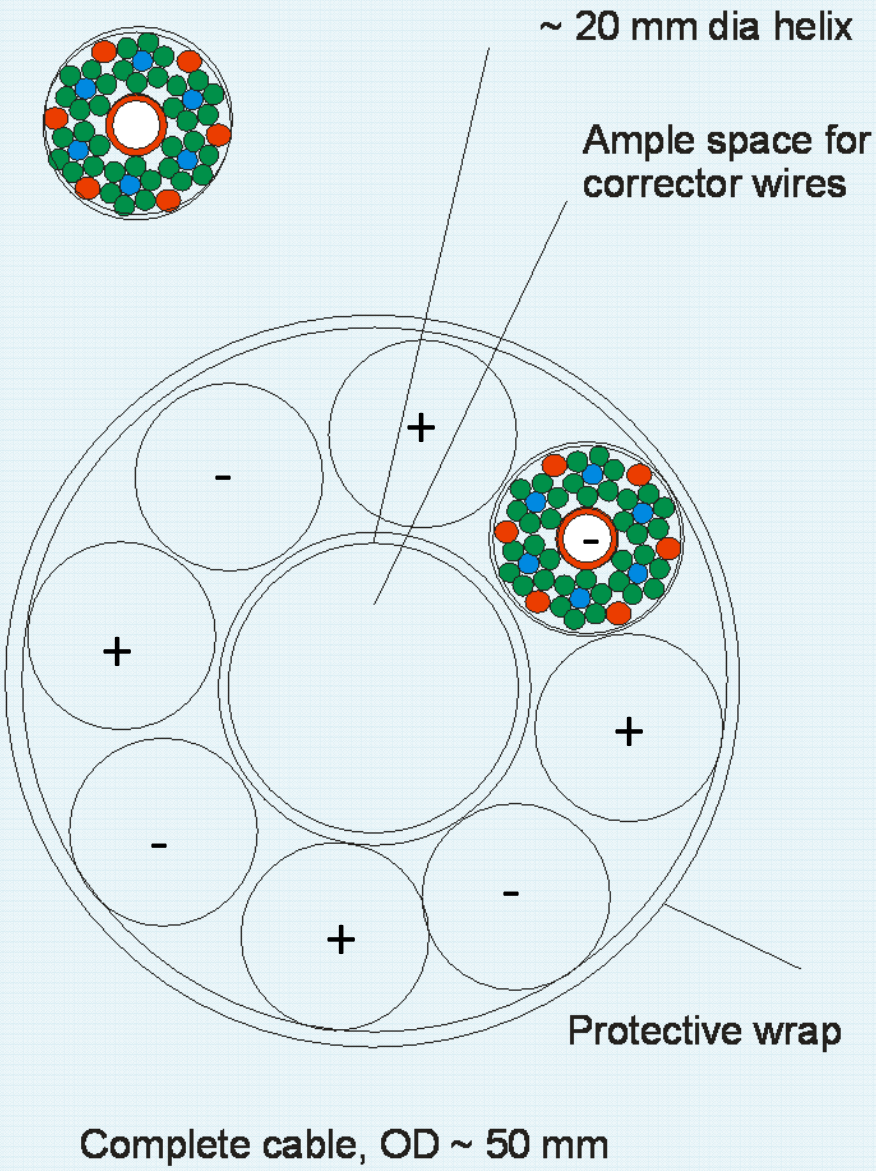
6-strand sub -cable,
twist pitch 300 mm.
The core is SS or Cu.

360 A/wire @ Tmax=20 K



36-strand fully transposed 13 kA cable.
The core is an helical Cu or SS tube.
Inside the core are routed the instrumentation wires (V taps + thermometers) for this cable.
Insulated copper shunt wires help to make finished cable round. Overall OD ~ 12mm.

The link


~ 20 mm dia helix
Ample space for corrector wires
+
-
-
+
+
-
+
-
Protective wrap
Complete cable, OD ~ 50 mm

MgB_2 conductor for the link

Collaboration with Columbus, where a person is working full-time on this project. The collaboration started in April 2008.

Goal: MgB_2 wire with Ic(25 K, 0.4T)=725 A

Two wires were developed by Columbus, and are today available in long (up to 3 km) lengths:

- D1=1.6 mm. Ic(24 K, 0.4 T)>550 A. Jce>240 A/mm^2
- D2=1.1 mm, Ic(24 K, 0.4T)=436 A. Jce=357 A/mm^2

f= 14 %

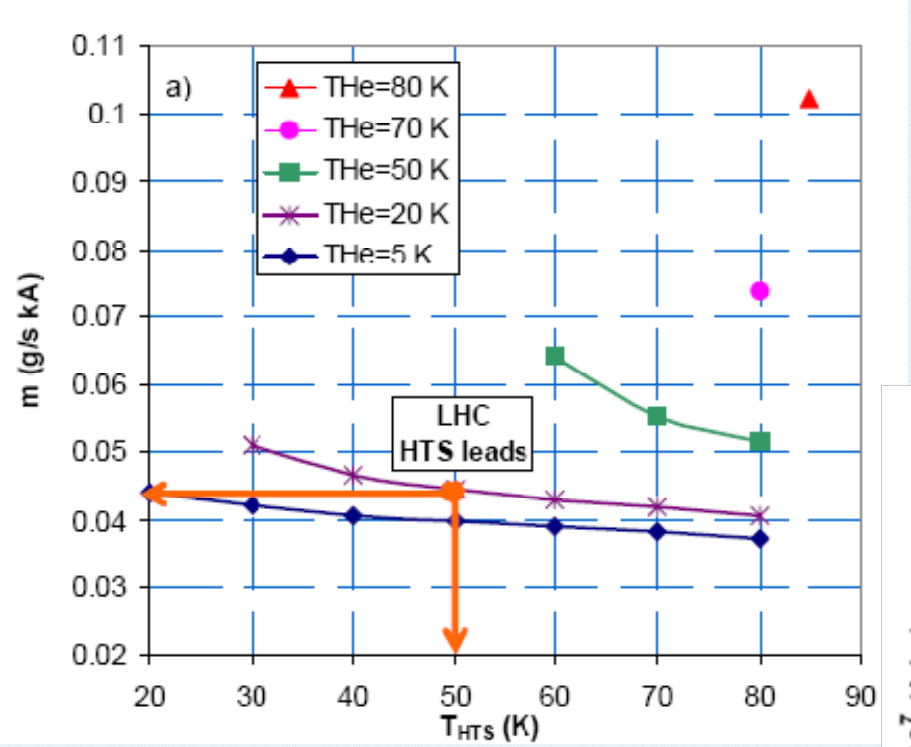
12 MgB_2 filaments (Each filament ~ 0.019 mm^2 for D1 and ~0.03 mm^2 for D2)

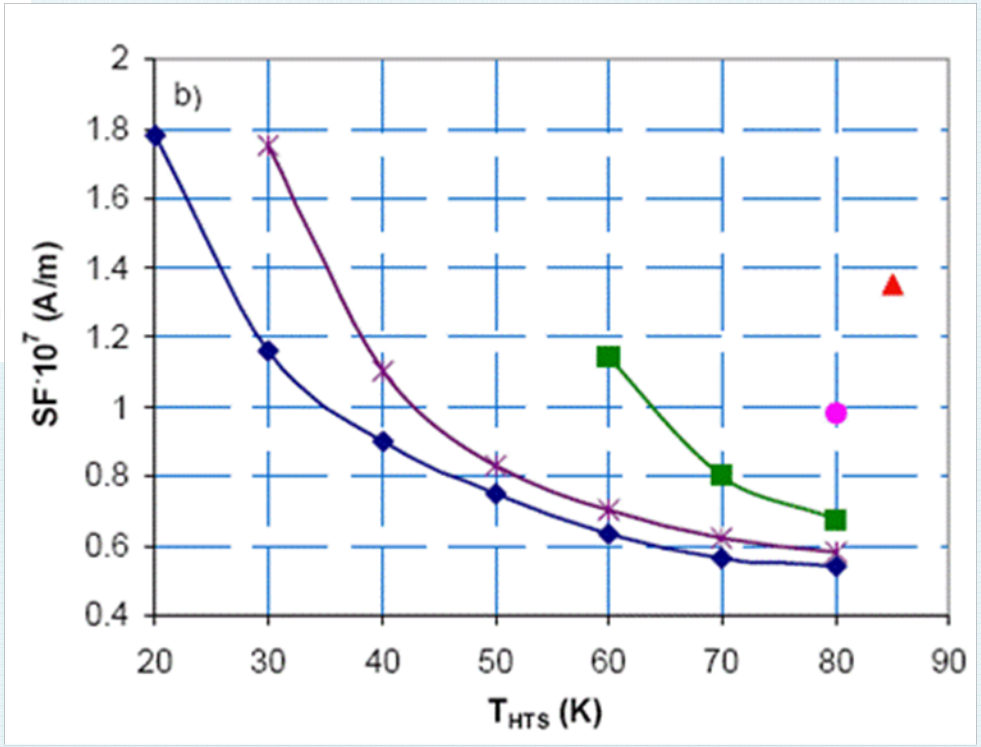
Twist pitch=300 mm

Inner core of copper (~ 15%)

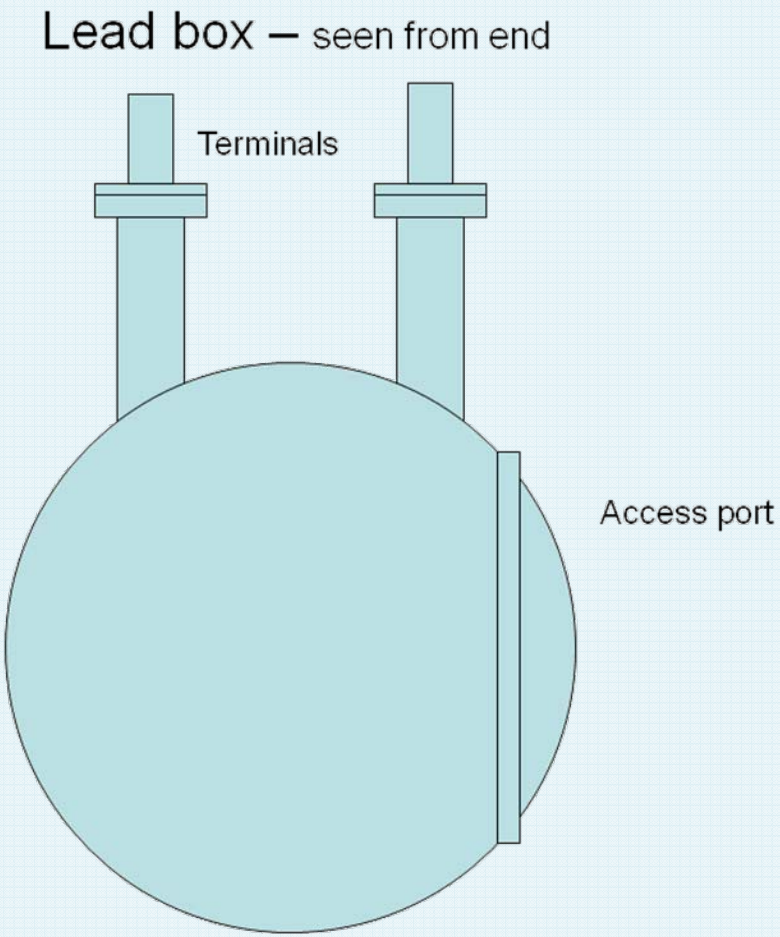
•Electrical (Ic(B-T), ρ(T)), thermal (K(T)) and mechanical properties (Rb) of the wires were also measured

The leads

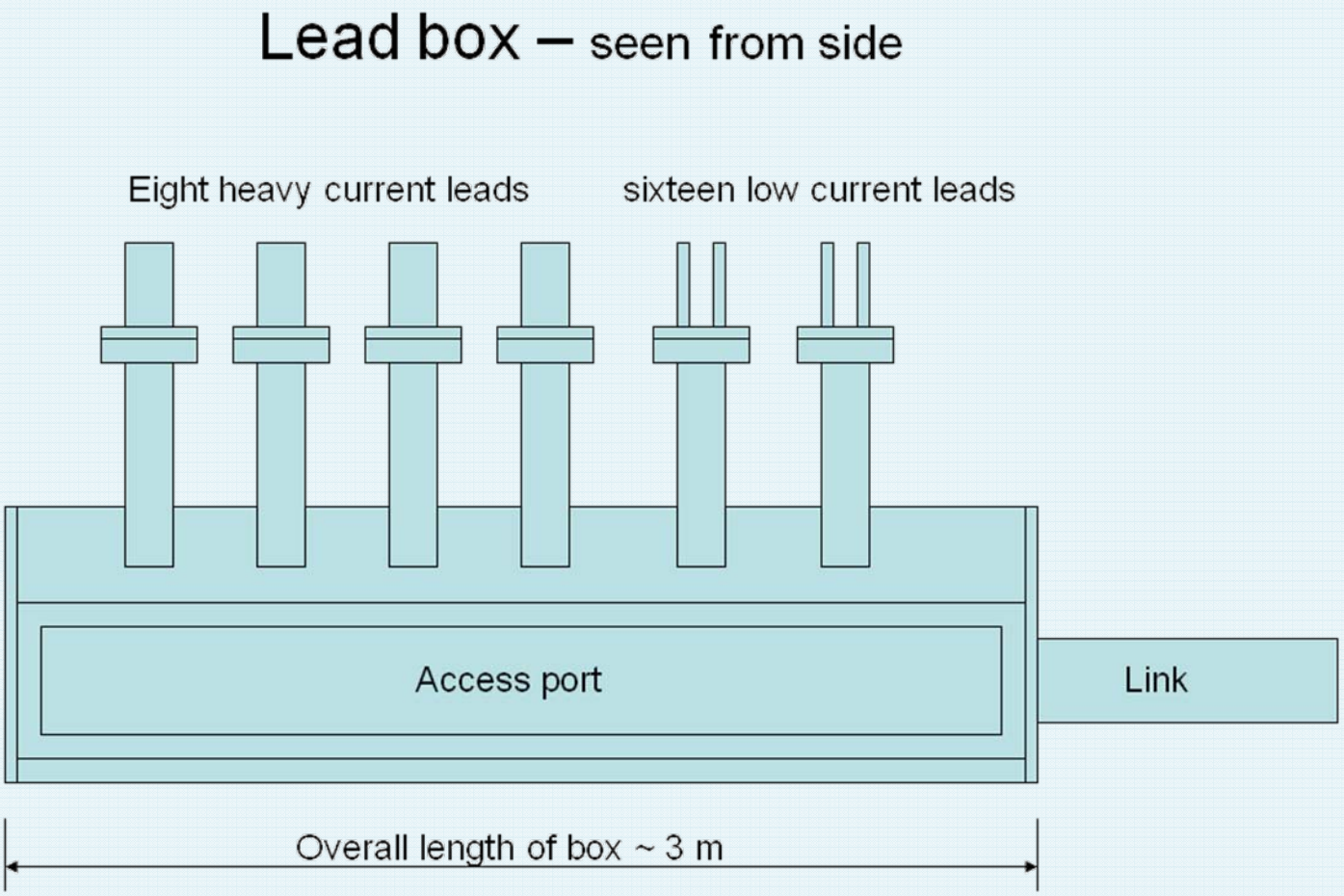

a)
THe=80 K
THe=70 K
THe=50 K
THe=20 K
THe=5 K
LHC
HTS leads
m (g/s kA)
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
20
30
40
50
60
70
80
90
T_HTS (K)


b)
SF·10^7 (A/m)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
20
30
40
50
60
70
80
90
T_HTS (K)

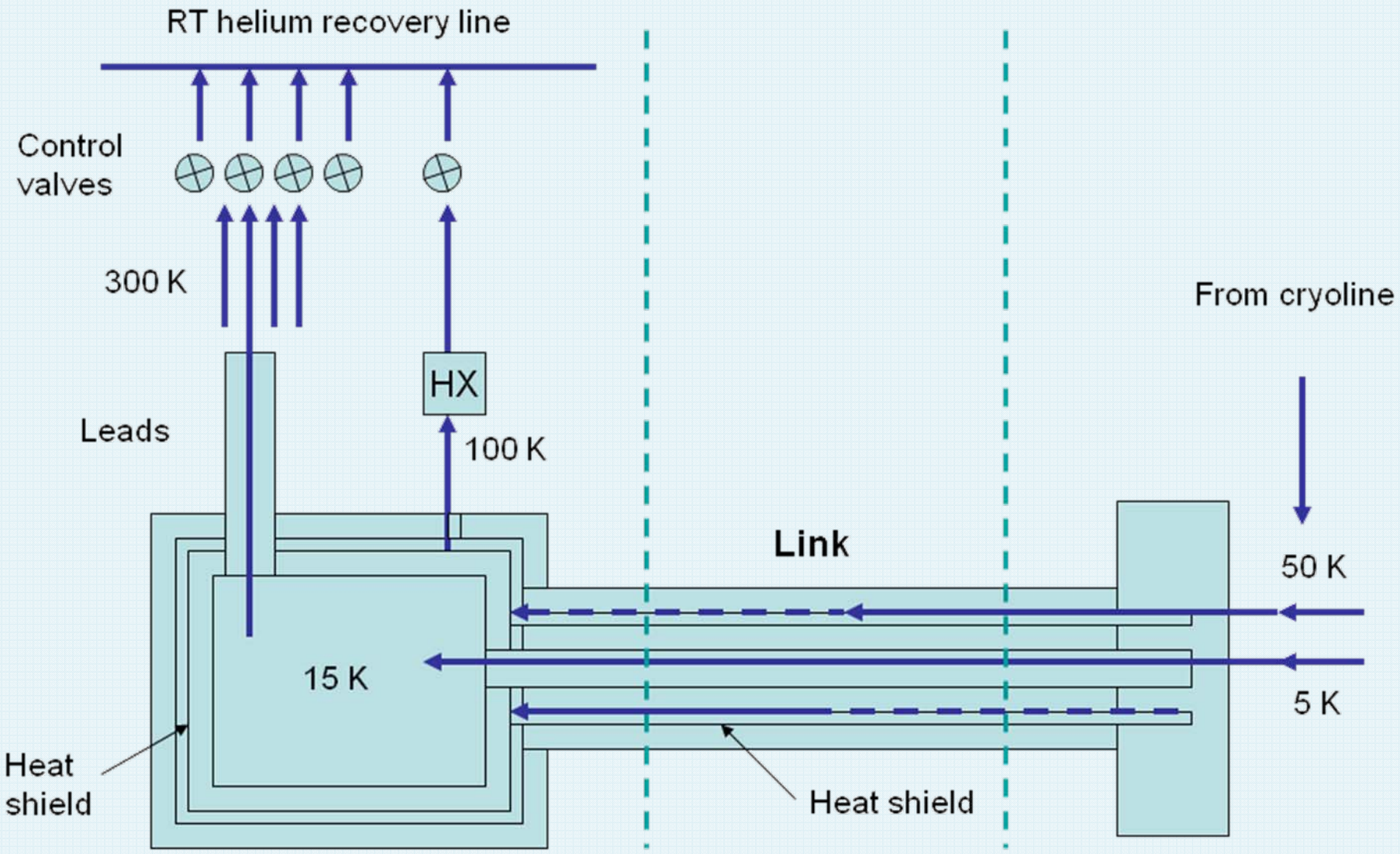
The leads



The leads


Lead box – seen from side
Eight heavy current leads
sixteen low current leads
Access port
Link
Overall length of box ~ 3 m

The system


RT helium recovery line
Control valves
300 K
HX
Leads
100 K
From cryoline
Link
50 K
15 K
5 K
Heat shield
Heat shield

Conclusion

• A preliminary conceptual design study was made. A more detailed study and validation tests should be carried out in the next months

• The use of MgB_2 brings a number of advantages in the cold powering scheme:
higher temperature margin;
simplified cryostat (no LHe);
no need of cold cryogenic lines in the caverns (only recovery of He gas at room temperature)

• A collaboration has been established with Columbus for the production and test of the MgB_2 wire suitable for this application