5th Joint Hi-Lumi LHC-LARP Annual Meeting 2015

SC Link Protection

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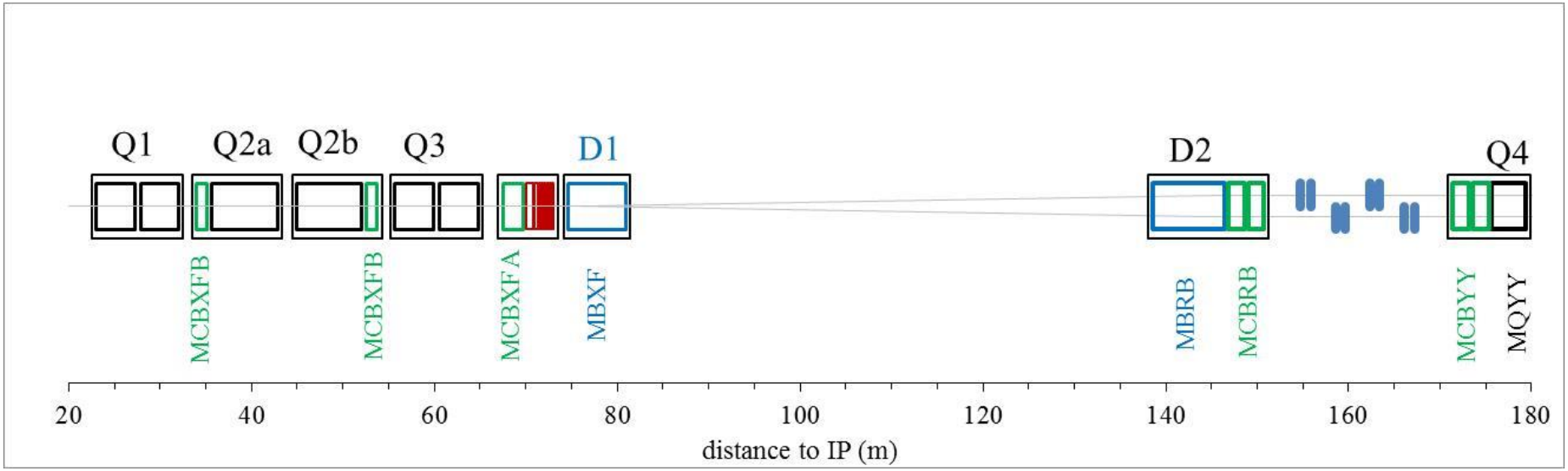
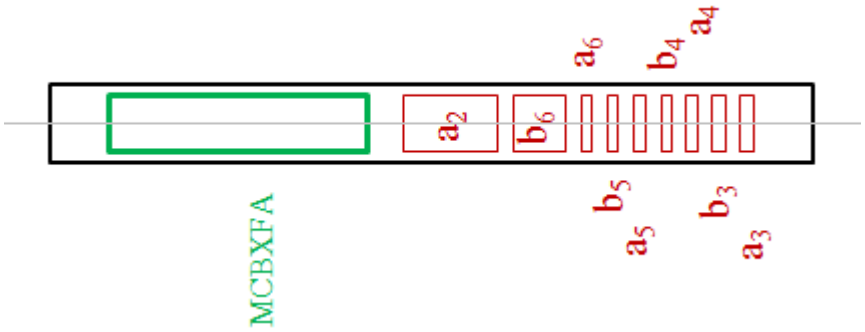
28/10/2015

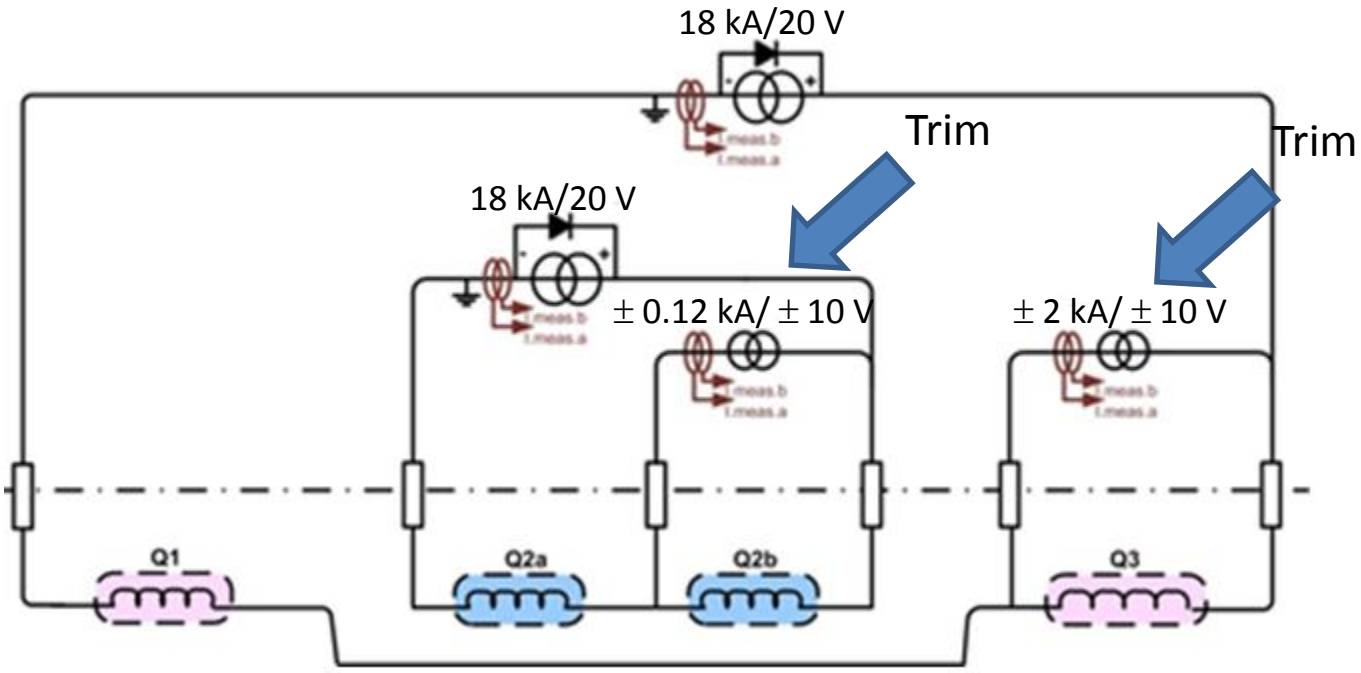
Hi-Lumi Triplets and Matching Section





+ Q5 and Q6

Baseline Powering Layout: MQXF quadrupoles



All other circuits are individually powered

EE still in the present baseline - but convergence on no use of EE

Ramp down time with no EE (~ 1500 s) being optimized by power converters regulation (J. P. Burnet): current control + voltage control

Power Converters for Hi Lumi

Power converter	Current	Voltage	Quantity per IP side	Quantity per UR	Total Quantity
Type 1	18kA	20V	2	4	8
Type 2	13kA	18V	2	4	8
Type 3	6kA	8V	6	12	24
Type 4	±2kA	±10V	7	14	28
Type 5	±600A	±10V	8	16	32
Type 6	±200A	±10V	9	18	36
Type 7	±120A	±10V	9	18	36
Total			43	86	172

J. P. Burnet, updated in Oct 2015

7 Types

172 PCs per IP

Itot (per IP)= 478 kA

Overview of cold powering system
Number of Leads and of SC cables, Current Rating

Triplets, D1 and CP – per IP Side

6 × 18 kA
13 × 2 kA
18 × 0.2 kA
1 ×0.12 A

→ 38 Units
2×68.5 kA

Matching Sections – per IP Side

2 × 13 kA
12 × 6 kA
16 × 0.6 kA
18 × 0.12 kA

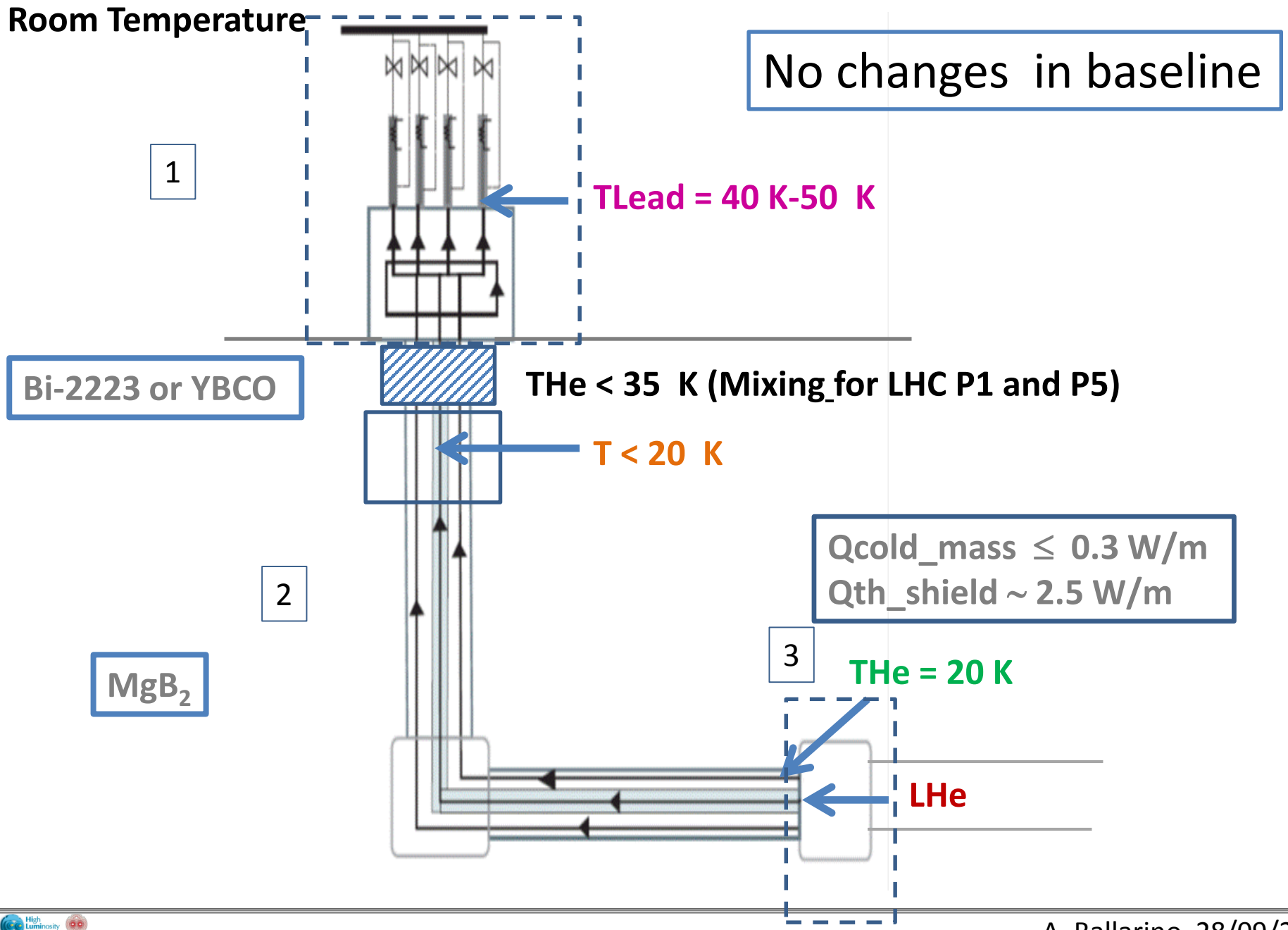
→ 48 Units
2×54.8 kA

Type	N_IPside
18 kA	6
13 kA	4
6 kA	12
2 kA	13
0.6 kA	16
0.2 kA	18
0.12 kA	19

Per IP side : **2×123 kA** , 86 Leads/SC Cables

Hi-Luminosity Upgrade: **2×492 kA,** 344 Leads/SC Cables

Cold Powering System

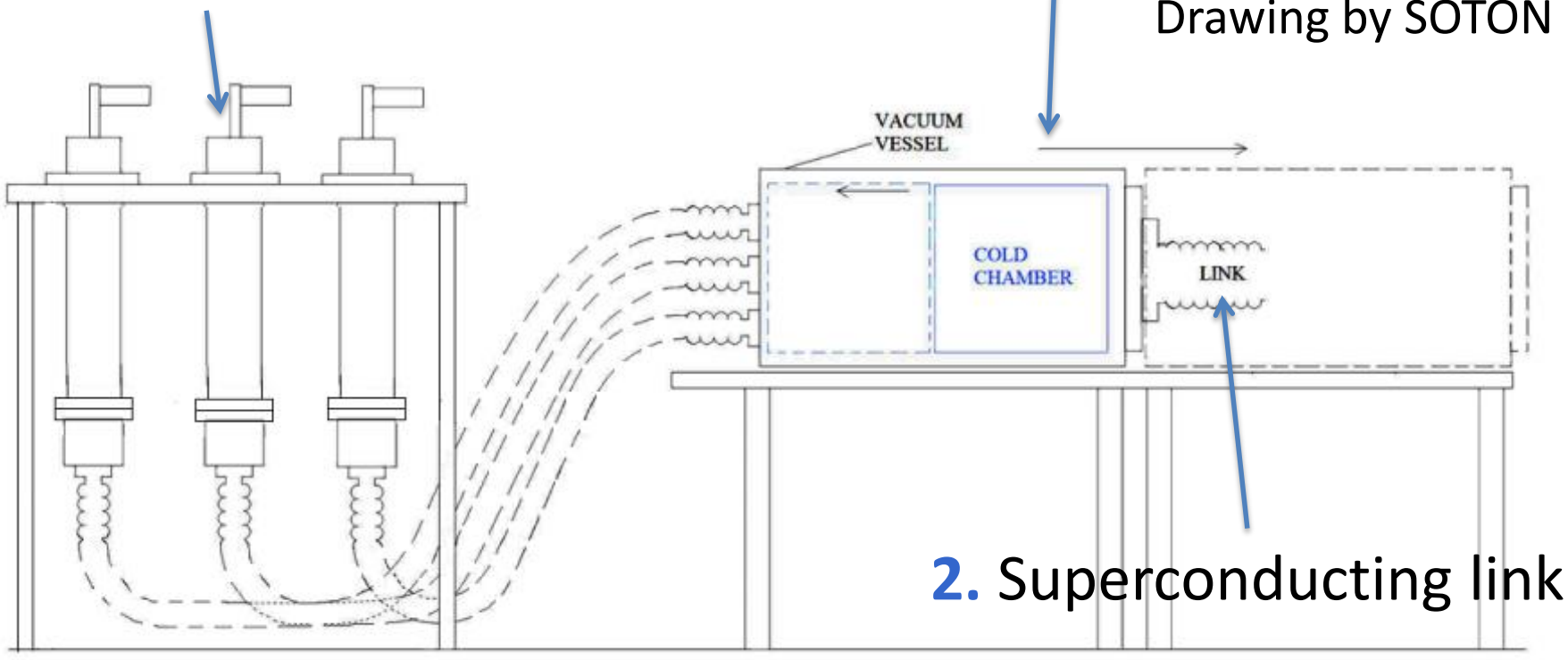


System design

1. Current leads

3. Electrical interconnection box

Drawing by SOTON

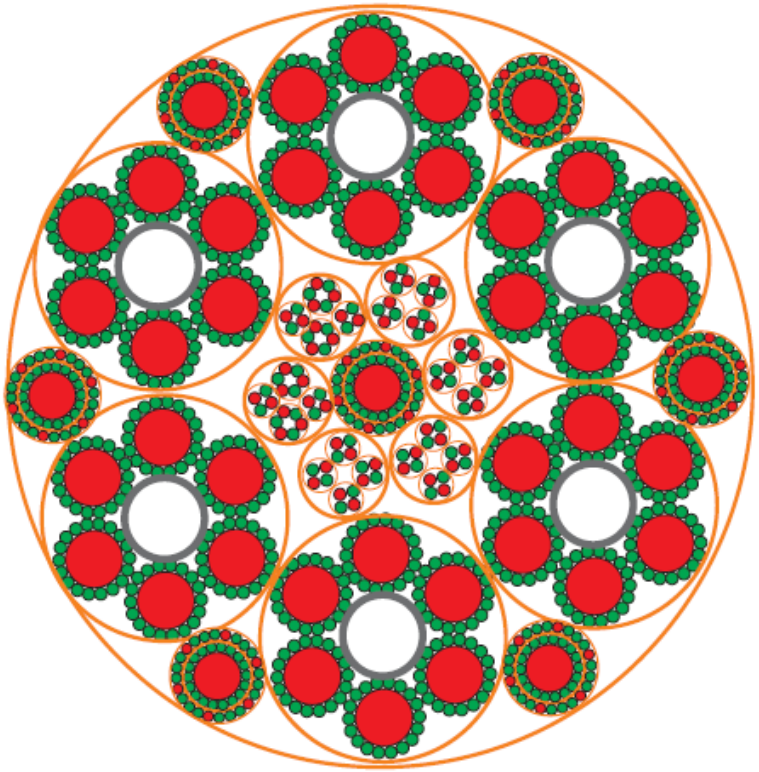


2. Superconducting link

Concept developed for LHC P7 and being studied for LHC P1 and P5

Superconducting Cable Assembly

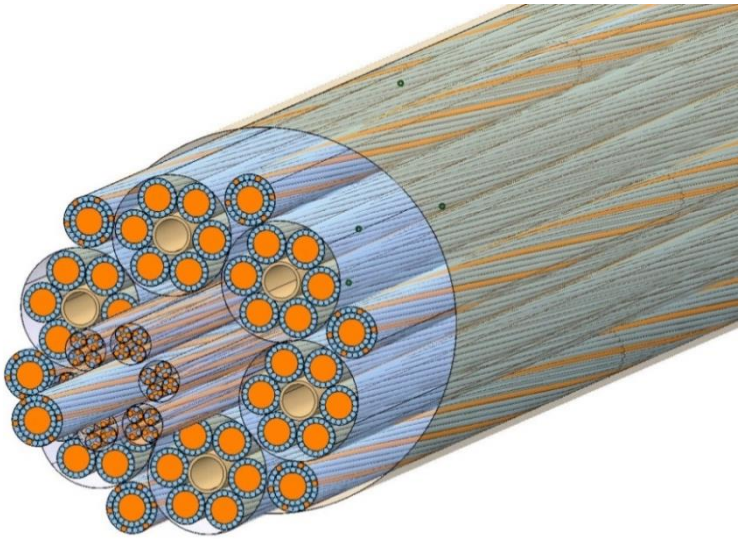
Hi-Lumi Triplets and D1

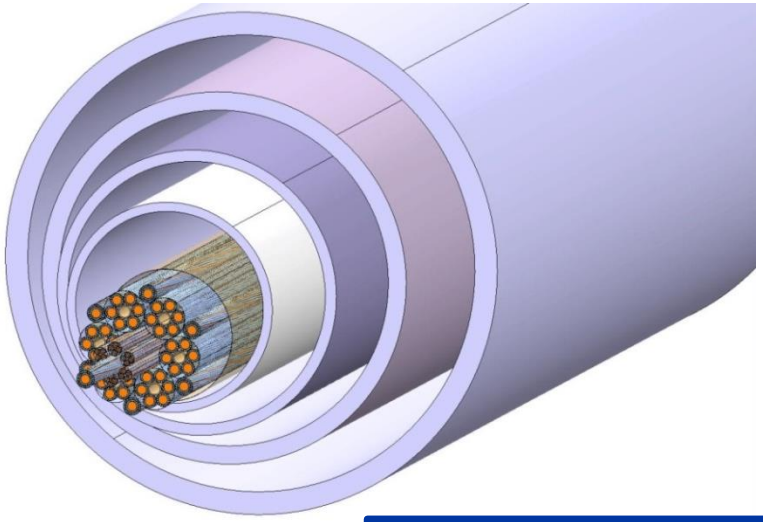


Φext ~ 65 mm

Mass ~ 11 kg/m

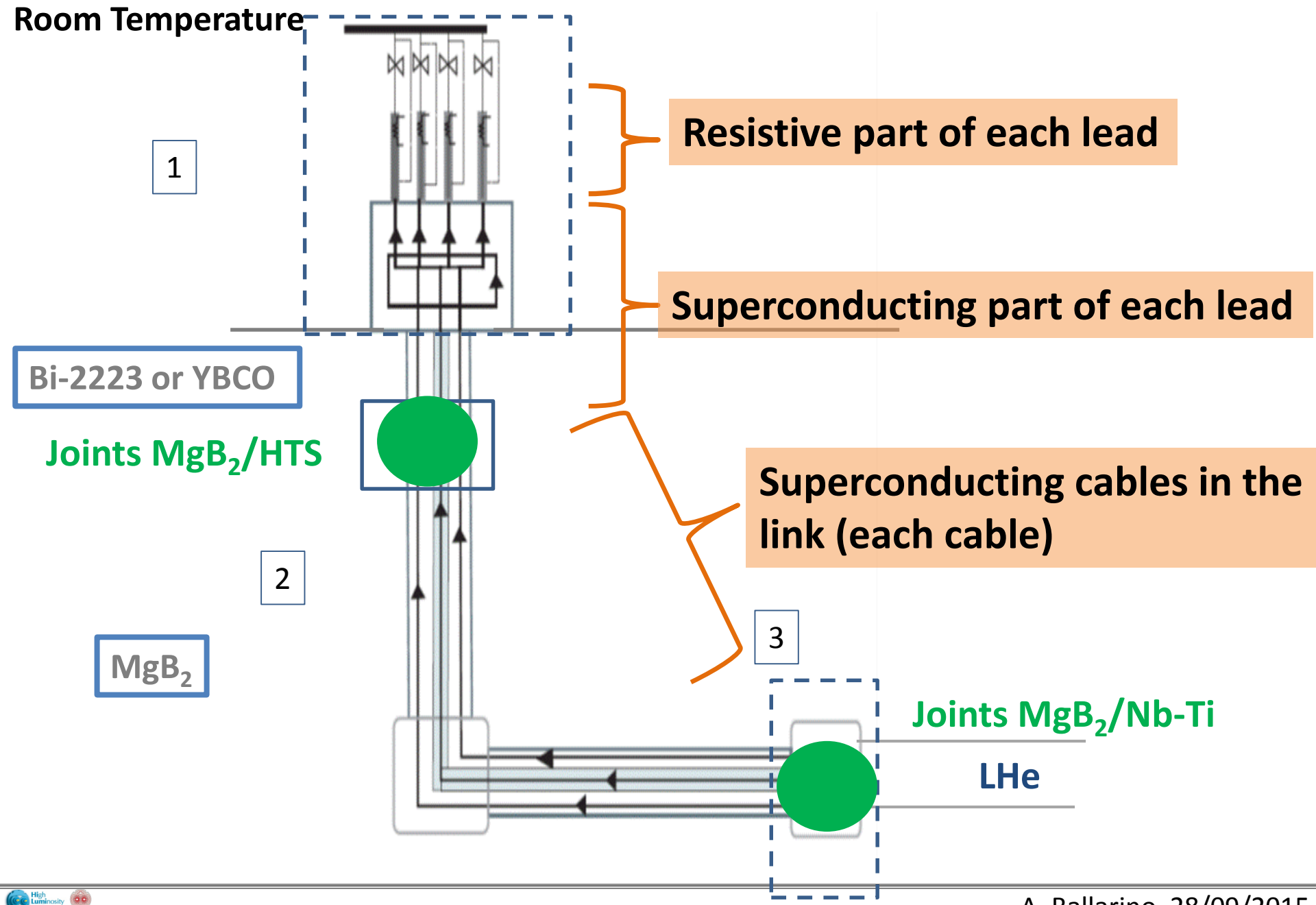
(880 kg for ΔH=80 m)





Φext ~ 220 mm

Protection


Room Temperature
1
Resistive part of each lead
Superconducting part of each lead
Bi-2223 or YBCO
Joints MgB2/HTS
Superconducting cables in the link (each cable)
2
3
MgB2
Joints MgB2/Nb-Ti
LHe

Protection

Resistive part of each lead

As for LHC: voltage detection. Detection threshold ~ 100 mV
Long integration times permitted

Superconducting part of each lead

As for LHC: voltage detection. Detection threshold ~ 1-5 mV
Integration times of ~ 100 ms (depending on final choice of material)

Superconducting cables in the link cryostat

Long (~ 100 m) cables. Work on-going. Aiming at detection thresholds in the range from 50 mV-100 mV, with τ of the circuits of 3 s (present boundary condition based on protection of magnets with EE system)

Protection

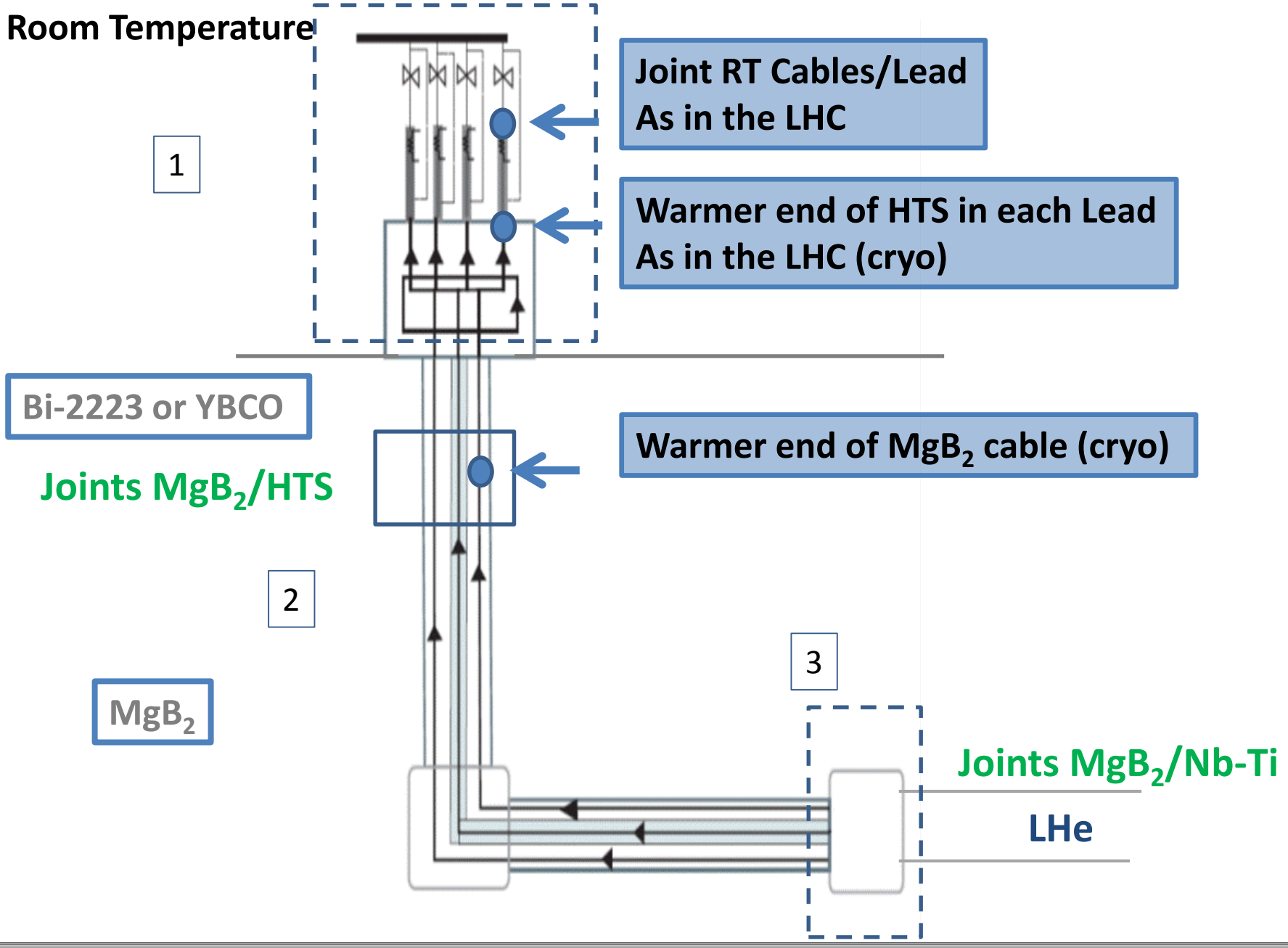
Electrical joints (MgB_2 to Nb-Ti and HTS to MgB_2)

Required availability of individual signals for post-quench analysis (need to identify location - and circuit – for interventions in case of performance degradation).

The design of the cold powering system takes as boundary condition the need of accessing and repairing individual joints at the level of the electrical interconnection box (MgB_2-HTS) or at the magnets interface (MgB_2 – Nb-Ti)

In case of quench of any superconducting element of the Cold Powering System, time constants of maximum 3 seconds can be accepted (need of quenching the magnets if no EE system ?)

Temperature Interlocks



Conclusions

- Test of prototype Cold Powering System (possibly re-used in the String 2 Test) in the SM-18 (2017). This prototype will include all current leads needed for powering the Triplets + D1.

- Final validation of protection system for full Cold Powering System (Triplets + D1) connected to the magnets during String 2 Test.