# Wrap up from WP6

A. Ballarino for the WP6
CERN, Geneva

KEK, 21st November 2014

16th Hi-Lumi LHC Extended Steering Committee

Task leaders: A. Ballarino, U. Wagner (**CERN**)
Y. Yang (**University of Southampton**), F. Broggi (**INFN**)

# Presentations

## Tuesday, 18/11/2014

- Status of project and future milestones, A. Ballarino
- Radiation aspects at LHC P7, P1 and P5 C. Adorisio

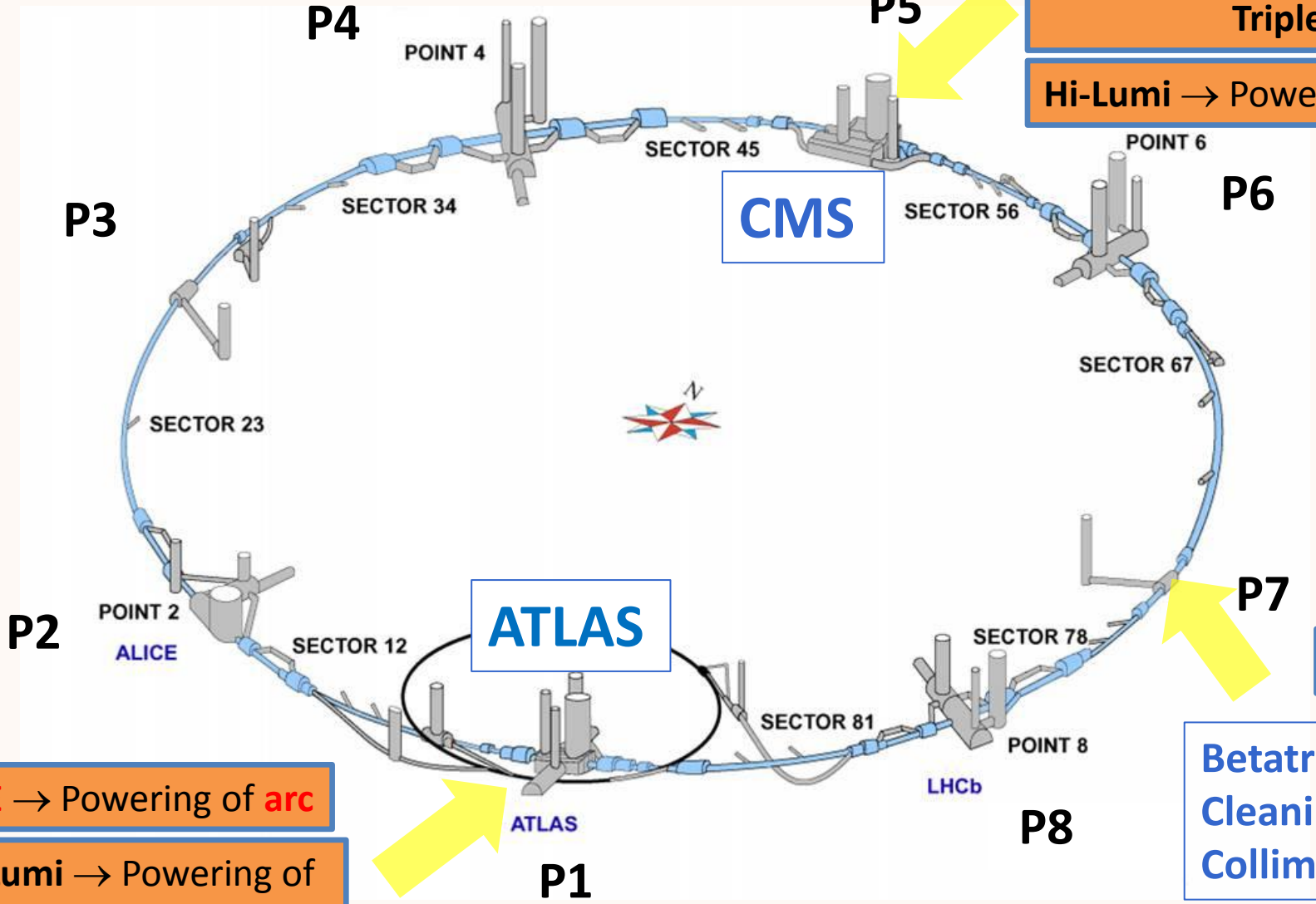
## Wednesday, 19/11/2014

- Cryo for Superconducting Links, S. Claudet
- Progress on cryostat design, Y. Yang
- Update on electro-thermal behaviour of superconducting cables in the links, Y. Yang
- Update on integration studies at LHC P1, P5 and P7, Y. Muttoni

## Thursday, 20/11/2014

- Update on energy deposition studies at IP1, C. Santini
- Preliminary results on energy deposition studies at IP7, A. Bignami

# SC Links for LHC




**R2E** → Powering of **arc**

**Hi-Lumi** → Powering of **Triplets + D1**

**Hi-Lumi** → Powering **MSs**

**R2E** → Powering of **arc**

**Hi-Lumi** → Powering of **Triplets + D1**

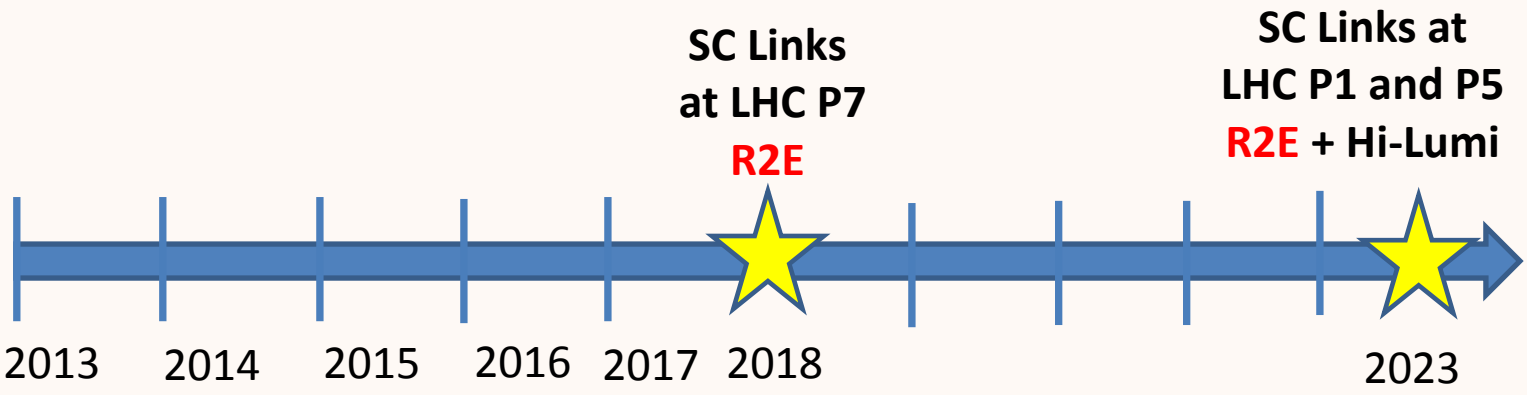
**Hi-Lumi** → Powering **MSs**

**R2E**

**Betatron Cleaning Collimators**

A. Ballarino

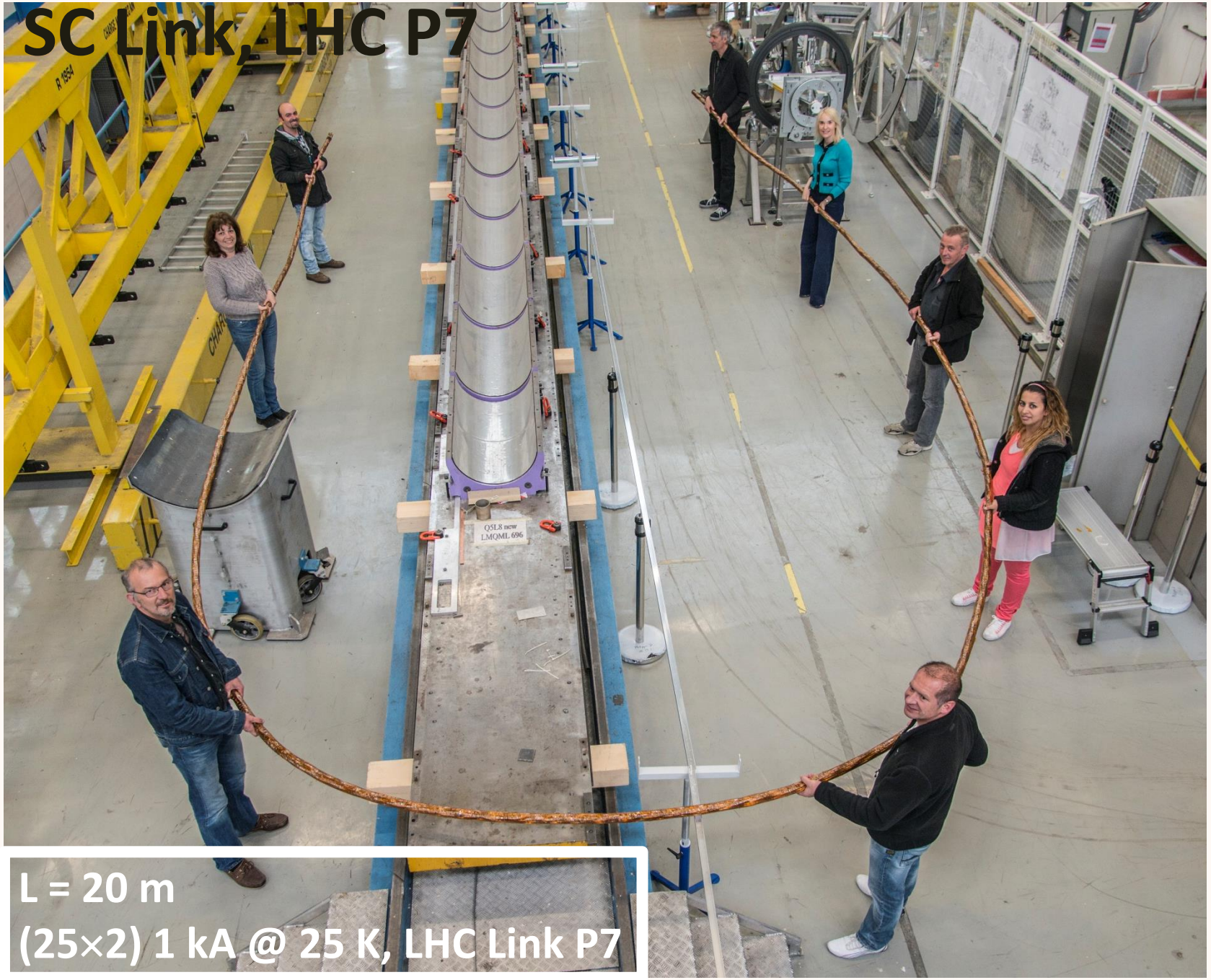
# SC Links for LHC




R2E Workshop at CERN in October 2014

A. Ballarino

# SC Link, LHC P7




L = 20 m
(25×2) 1 kA @ 25 K, LHC Link P7

# High-Current Rating, LHC P1 and P5

## Hi-Lumi Triplets and D1

Cu

$MgB_2$ , Φ = 0.85 mm

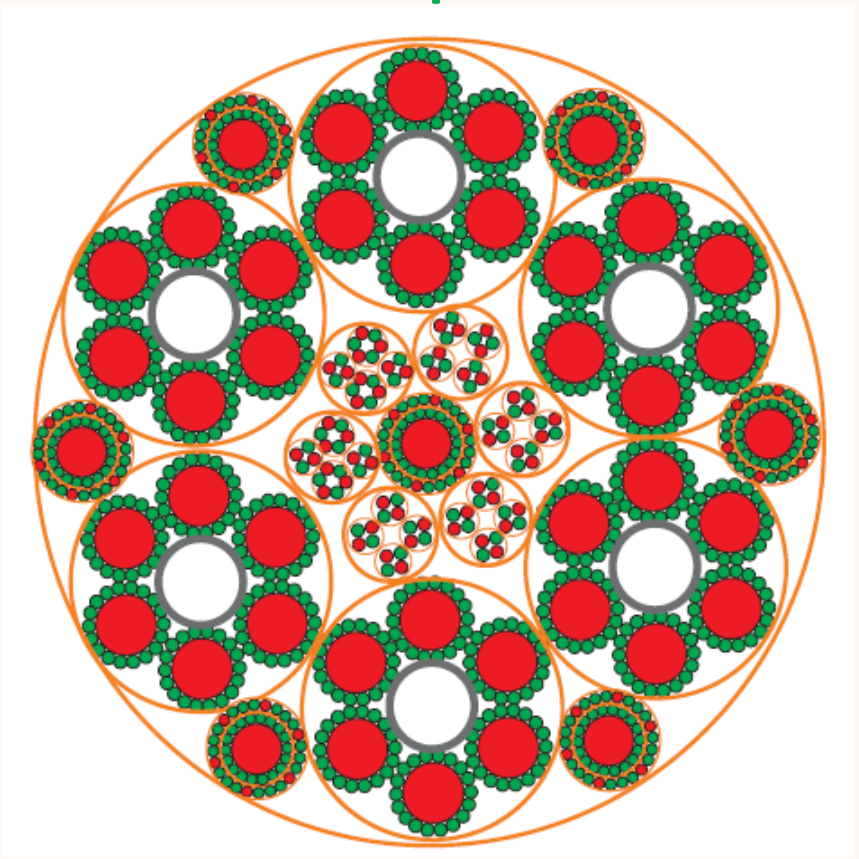
18 $MgB_2$ wires
Φ = 6.5 mm

20 kA
Six cables, Φ = 19.5 mm

Concentric ± 3 kA
Seven cables, Φ = 8.4 mm

0.4 kA
Four cables

0.12 kA
Eighteen cables



Φext ~ 65 mm

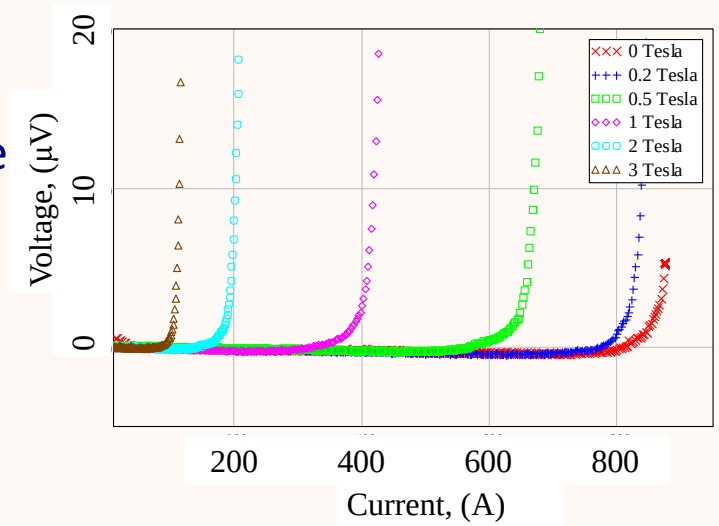
**Mass ~ 11 kg/m**

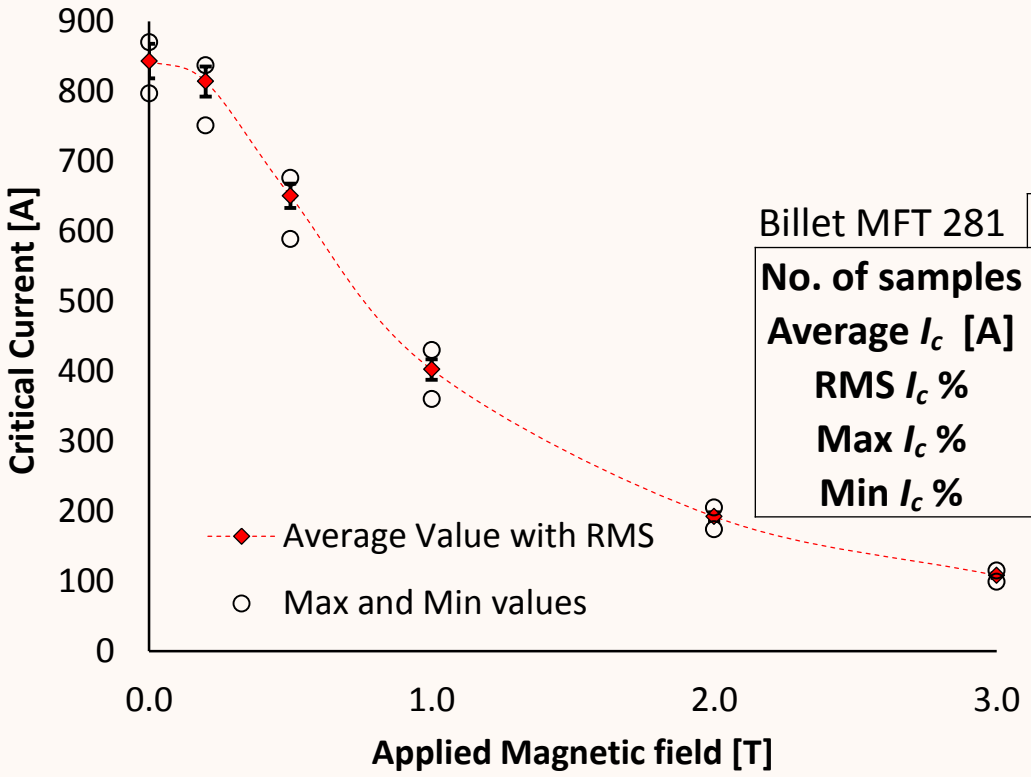
**(880 kg for ΔH=80 m)**

# $I_c$ Measurements

## Short Samples – 4.2 K

- To characterize and qualify the wire, critical current measurements on 15 cm-long samples are carried out in **parallel** magnetic field

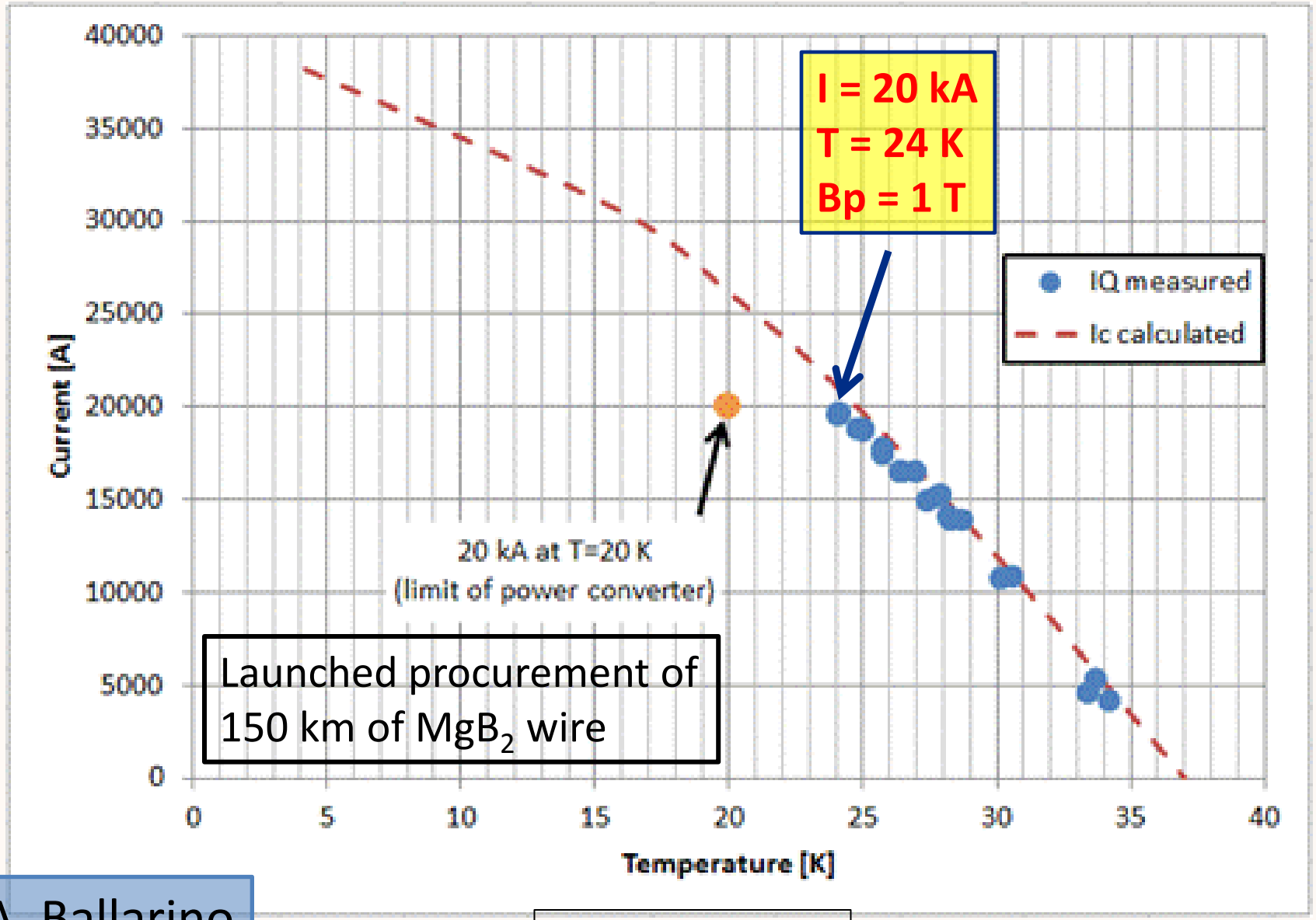



| Billet MFT 281 | 0 T | 0.2 T | 0.5 T | 1 T | 2 T | 3 T |
|---|---|---|---|---|---|---|
| **No. of samples** | 13 | 24 | 39 | 69 | 69 | 69 |
| **Average $I_c$ [A]** | 841 | 811 | 649 | 402 | 192 | 108 |
| **RMS $I_c$ %** | 3 | 3 | 3 | 4 | 3 | 3 |
| **Max $I_c$ %** | 3.4 | 3.2 | 4.2 | 7.0 | 6.6 | 6.4 |
| **Min $I_c$ %** | -5.1 | -7.2 | -8.9 | -9.7 | -9.0 | -7.9 |

B. Bordini, EUCAS 2013

# $MgB_2$ Cables developed and tested at CERN



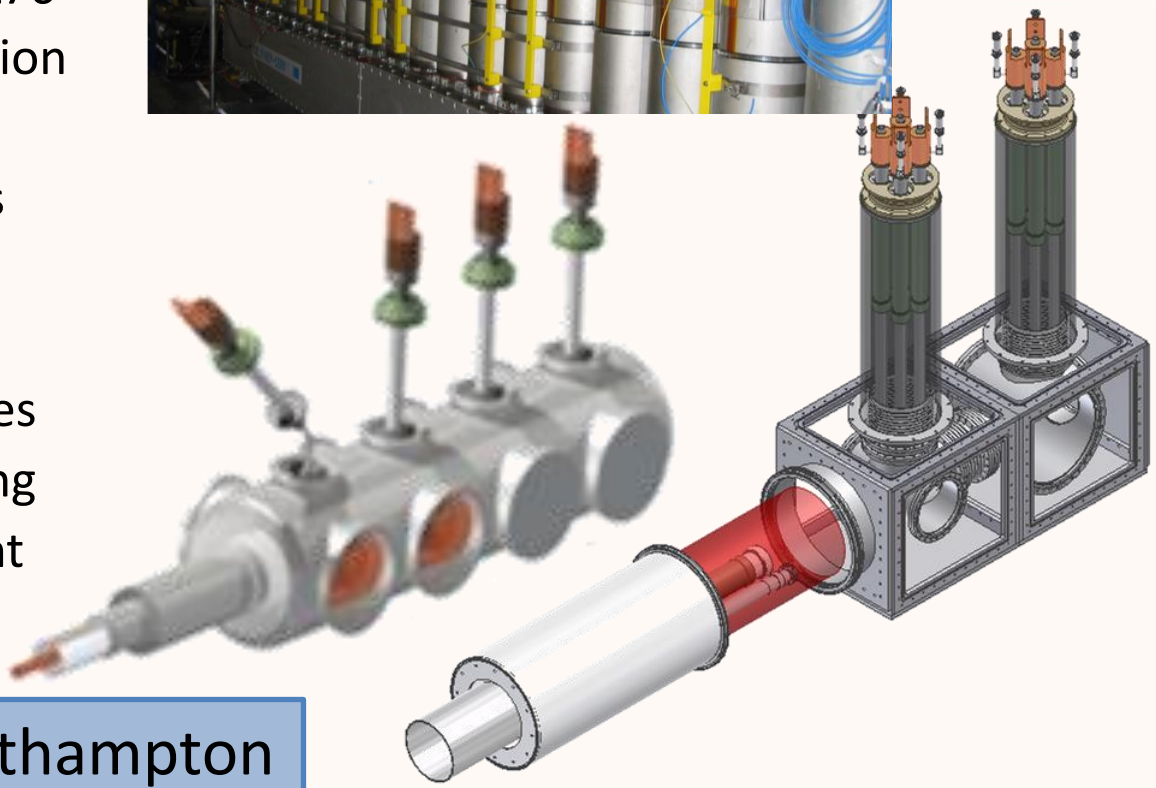

A. Ballarino

**ΔT along line < 1 T**

# Problems for a Single DFH with Multiple Chimneys of Current Leads

The chimney assembly of LHC DFC becomes difficult for DHF of SC link:

1. Constraints of transport to TZ76 require the in-tunnel integration of current leads.
2. Installation of current leads is tricky due to limited height in TZ76.
3. Splice of SC link in situ requires substantial side access, leading to oversized cryostat, too tight for the TZ75 width.

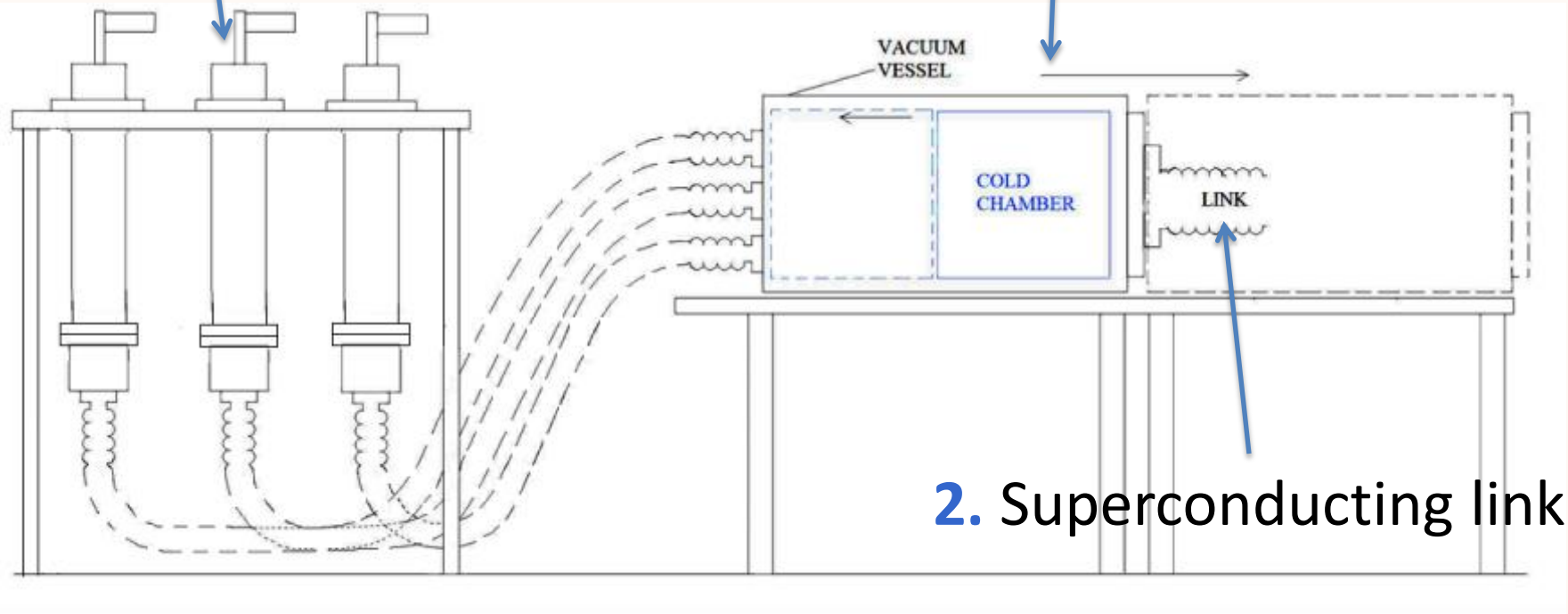


Y. Yang, University of Southampton

# WP6.3 New DHF Design for P7

**1.** Individual current leads

**3.** Electrical interconnection box

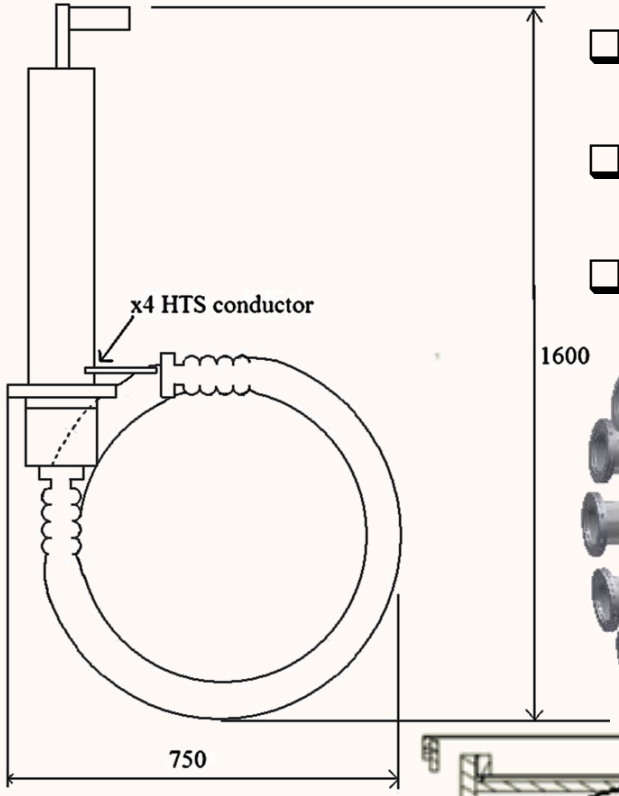


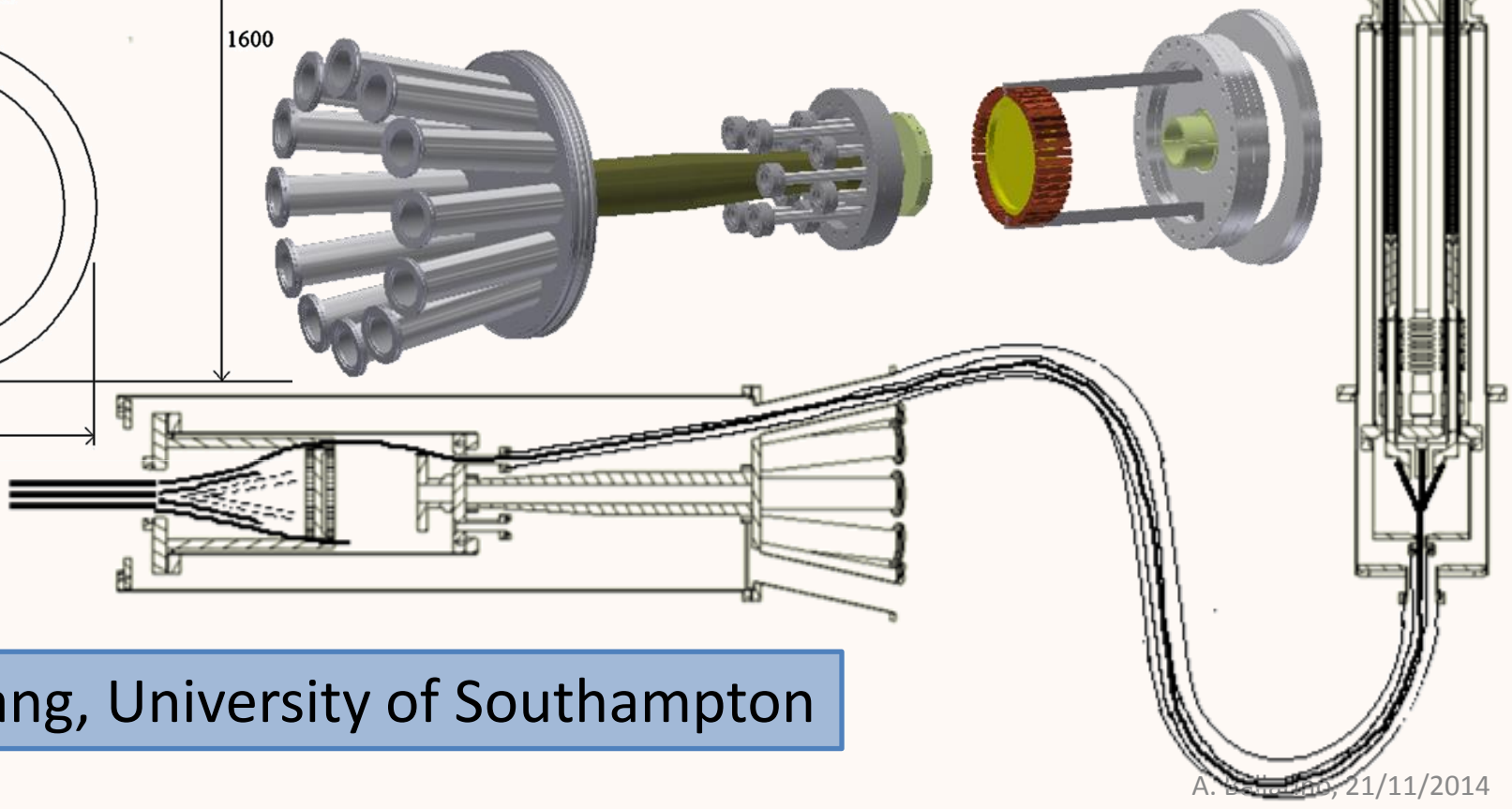

**2.** Superconducting link

Y. Yang, University of Southampton

# WP6.3 New DHF Design for P7

- Compact DFH design assembled in tunnel with fully open access for inter-connection to SC link
- Discrete current lead units flexibly attached to DHF via HTS cables in transfer-line
- Easily transported within the tight constraints in TZ76.

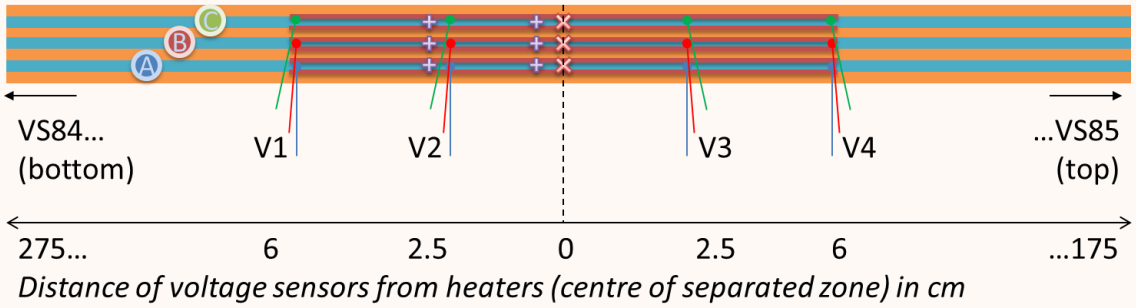


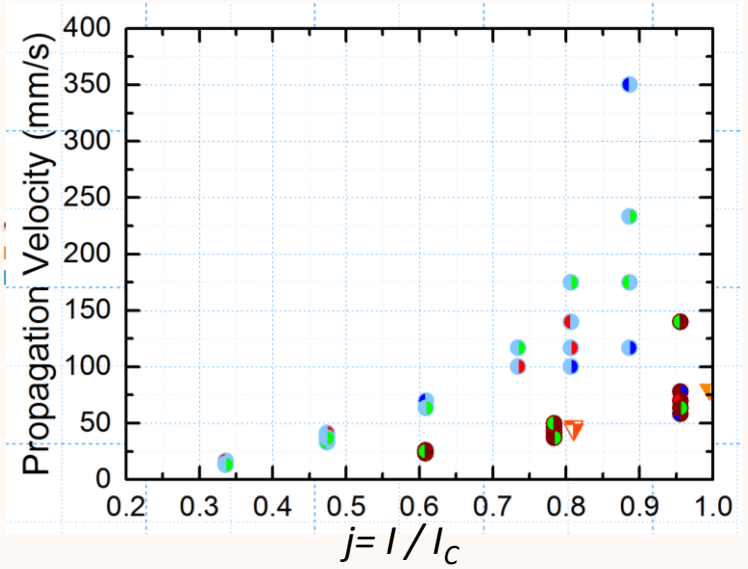
Y. Yang, University of Southampton

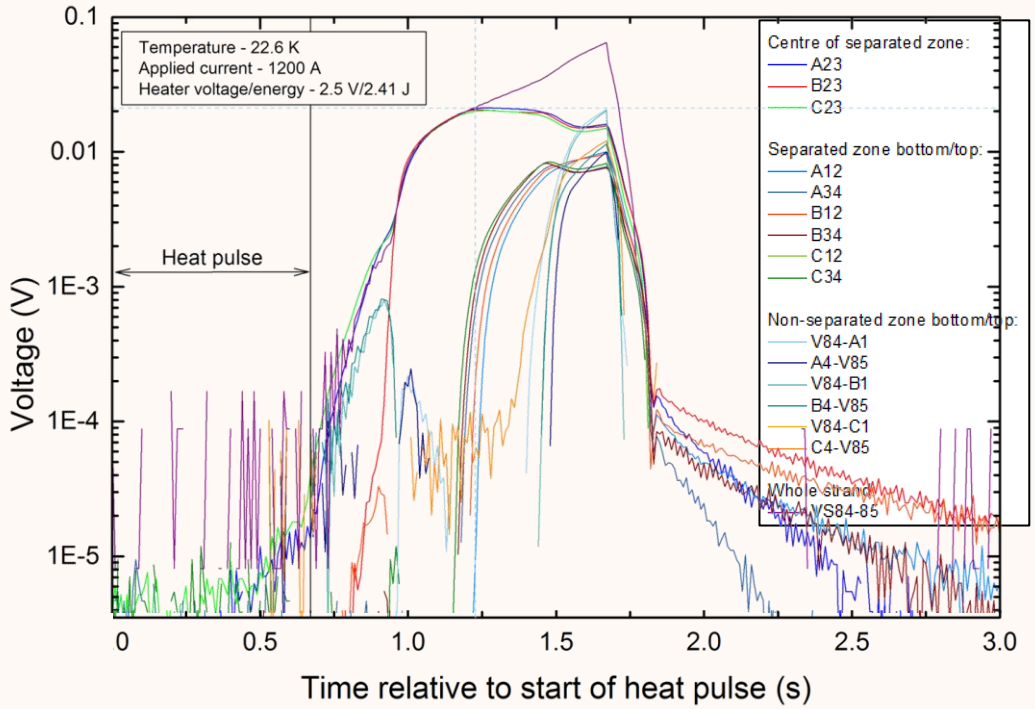
# WP6.4 Measurements on the Quench Characteristic of $MgB_2$ Twisted-Pair Cables

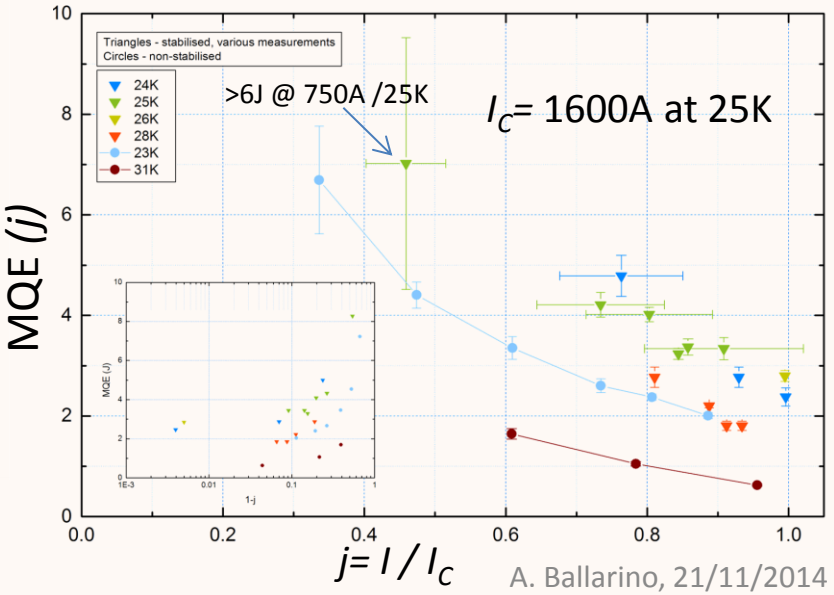
Y. Yang, University of Southampton



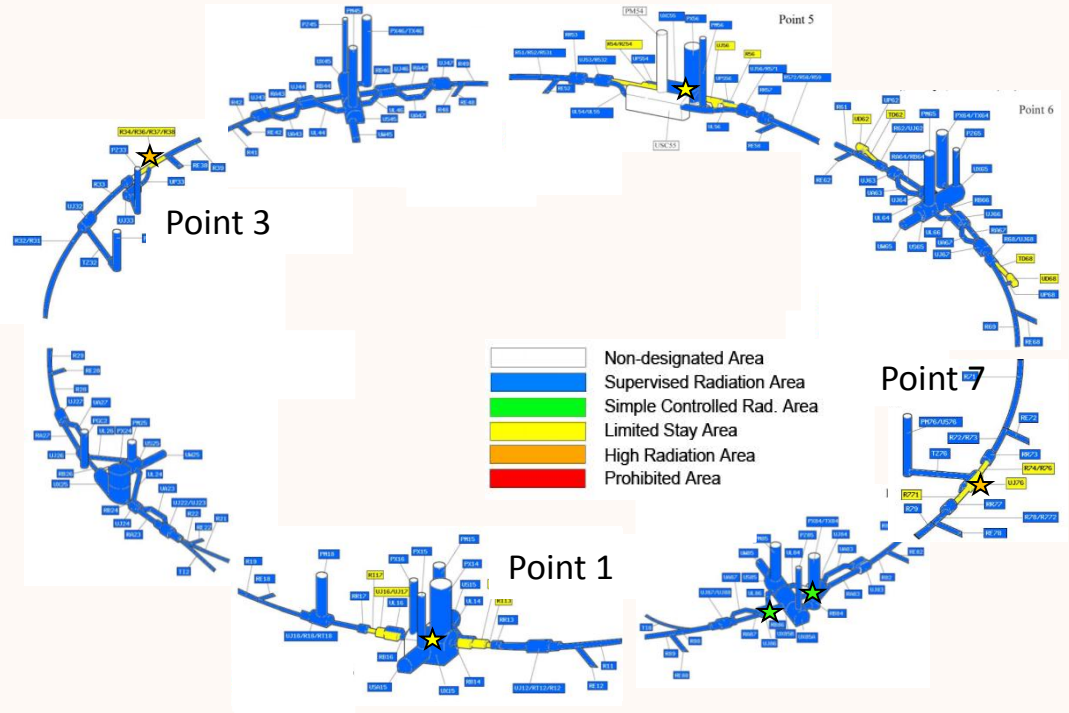

*Distance of voltage sensors from heaters (centre of separated zone) in cm*



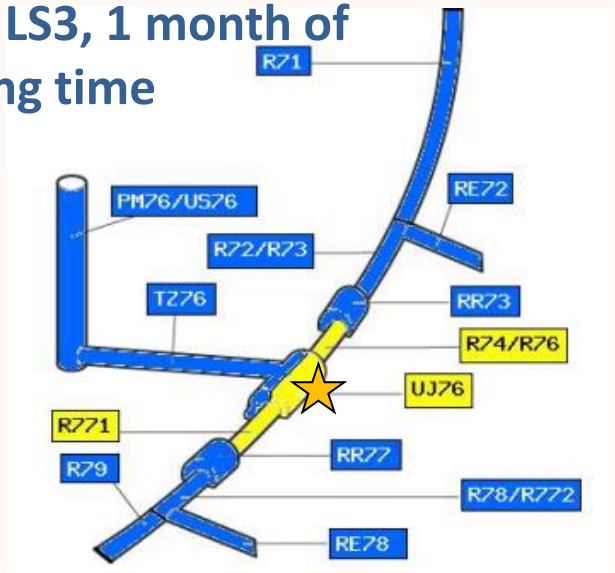



# Radiation aspects at P7, P1 and P5




**IR7 – LS3, 1 month of cooling time**




C. Adorisio, CERN

- **Installation of the Super Conducting Link passing through the LSS7**: evaluation of detailed Work and Dose Planning is needed to optimize the intervention
- For the **removal of the DFBX** and the installation of the SC links the evaluation of detailed Work and Dose Plannings is needed to optimize the interventions (working and passaging through activated area (inner triplet area) and activated equipment (e.g. TCL collimators, TAN)

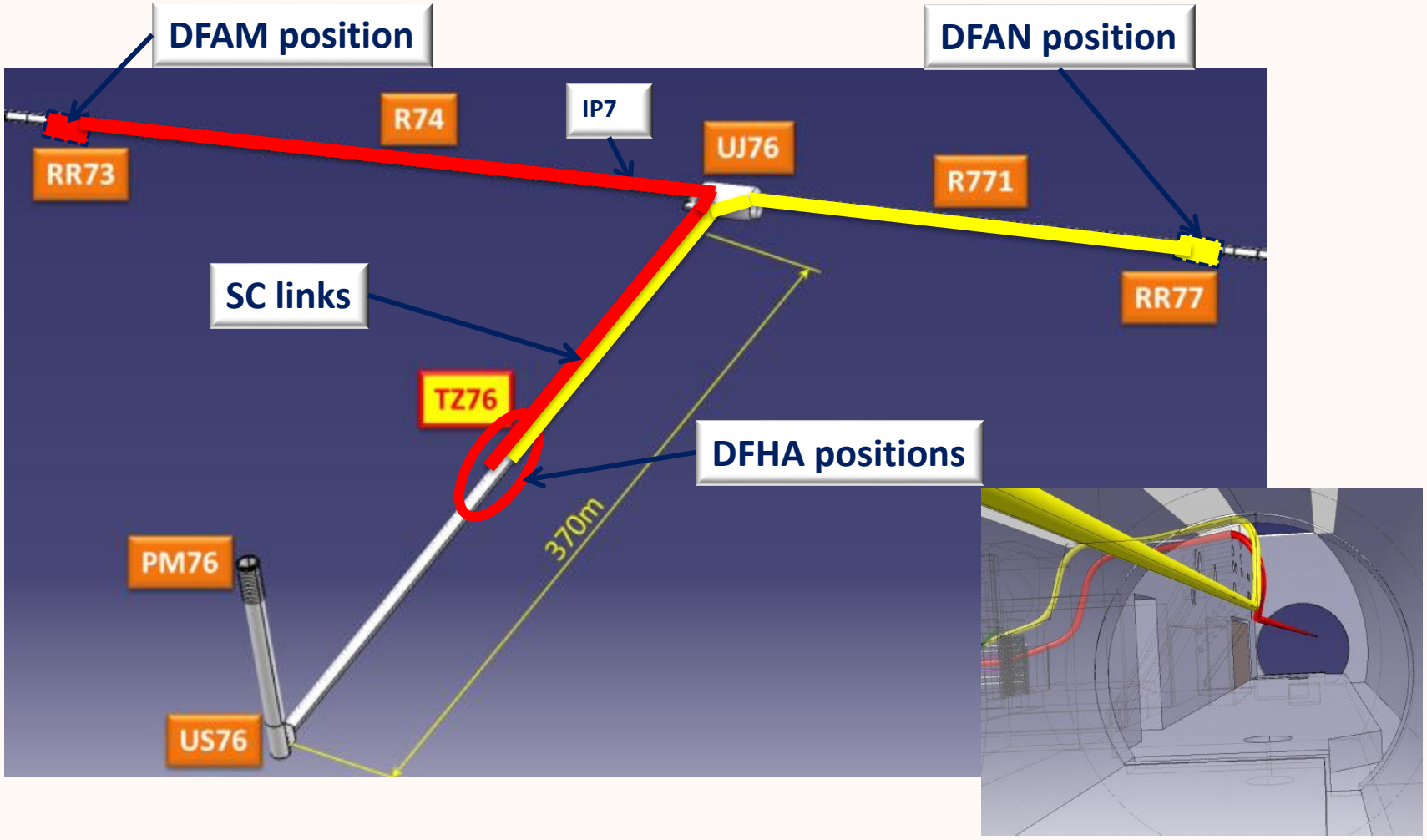
# Cryogenics for SC Links

- For P1 & P5, a completely new cryogenic distribution system will be studied and implemented: the needs for the sc links will surely be part of the design and associated optimisation. The potential vertical part might need specific study (transient, stability)

- For P7, a cooling process compatible with existing constraints exists since spring'14, we would be ready to proceed with definition of piping & valve requirements

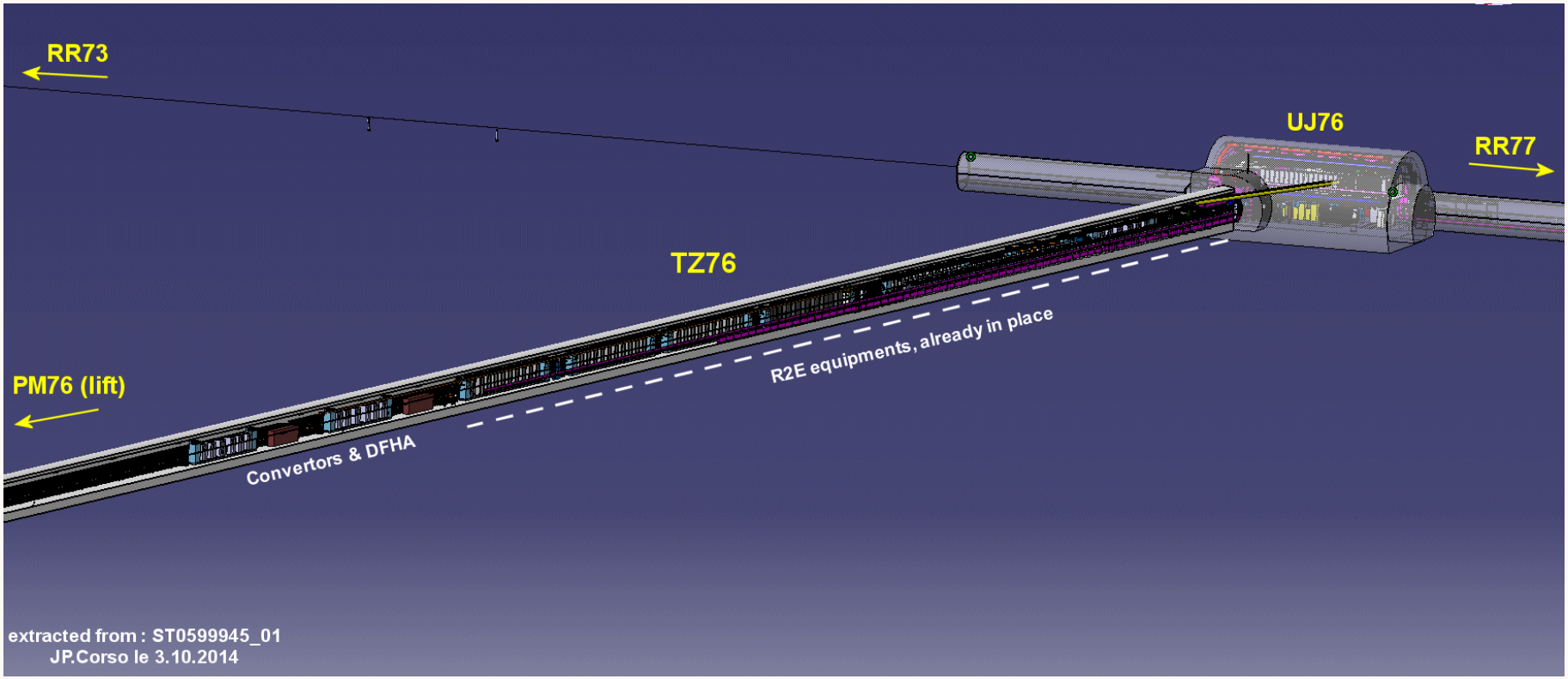
S. Claudet, CERN

# Overview of Point 7



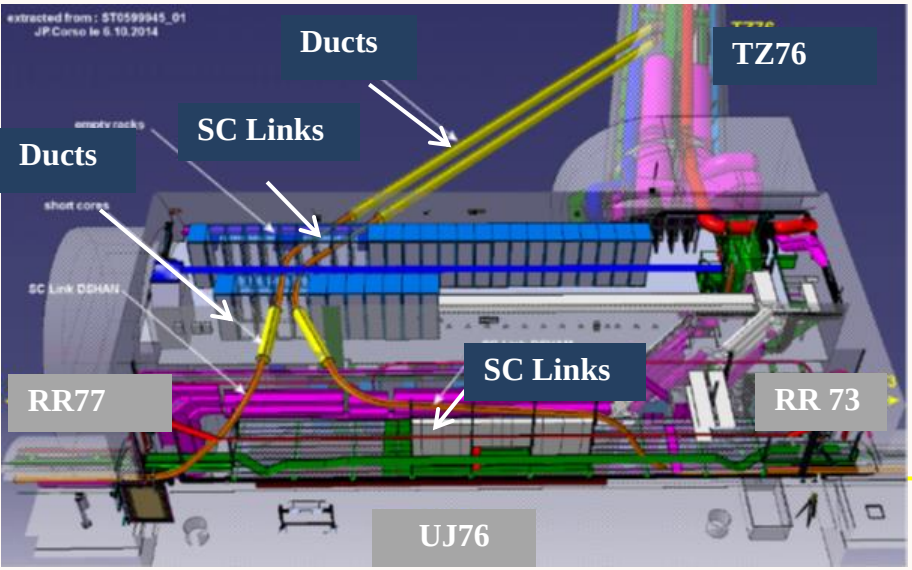

Y. Muttoni, CERN

# Integration at LHC Point 7

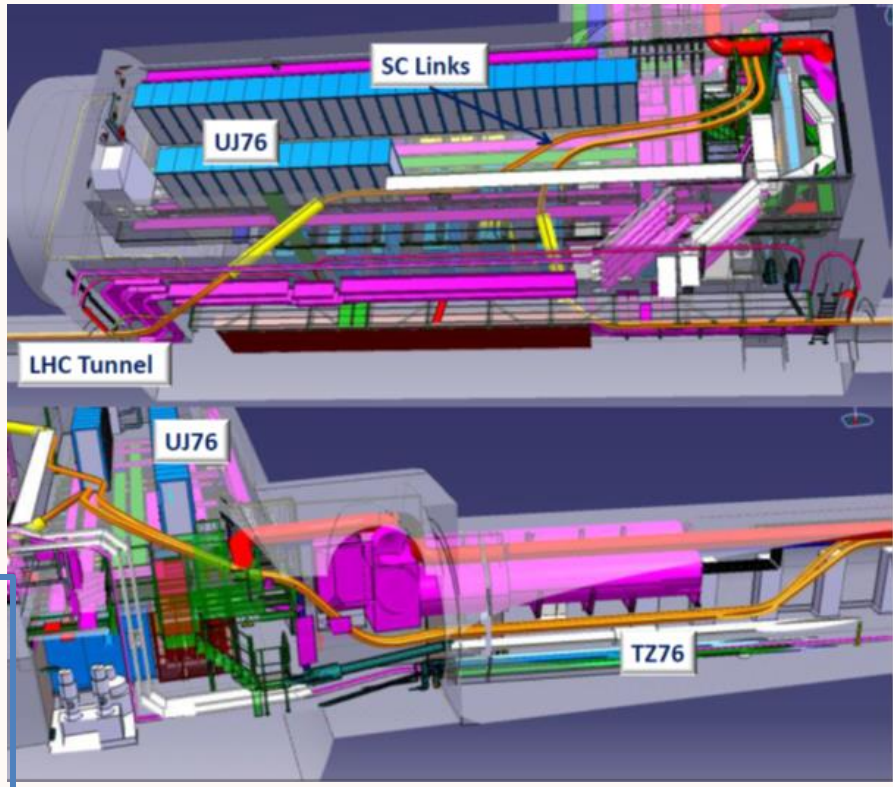



Y. Muttoni, CERN

# Integration of Cold Powering System at LHC P7




Option 2: more complex routing routing

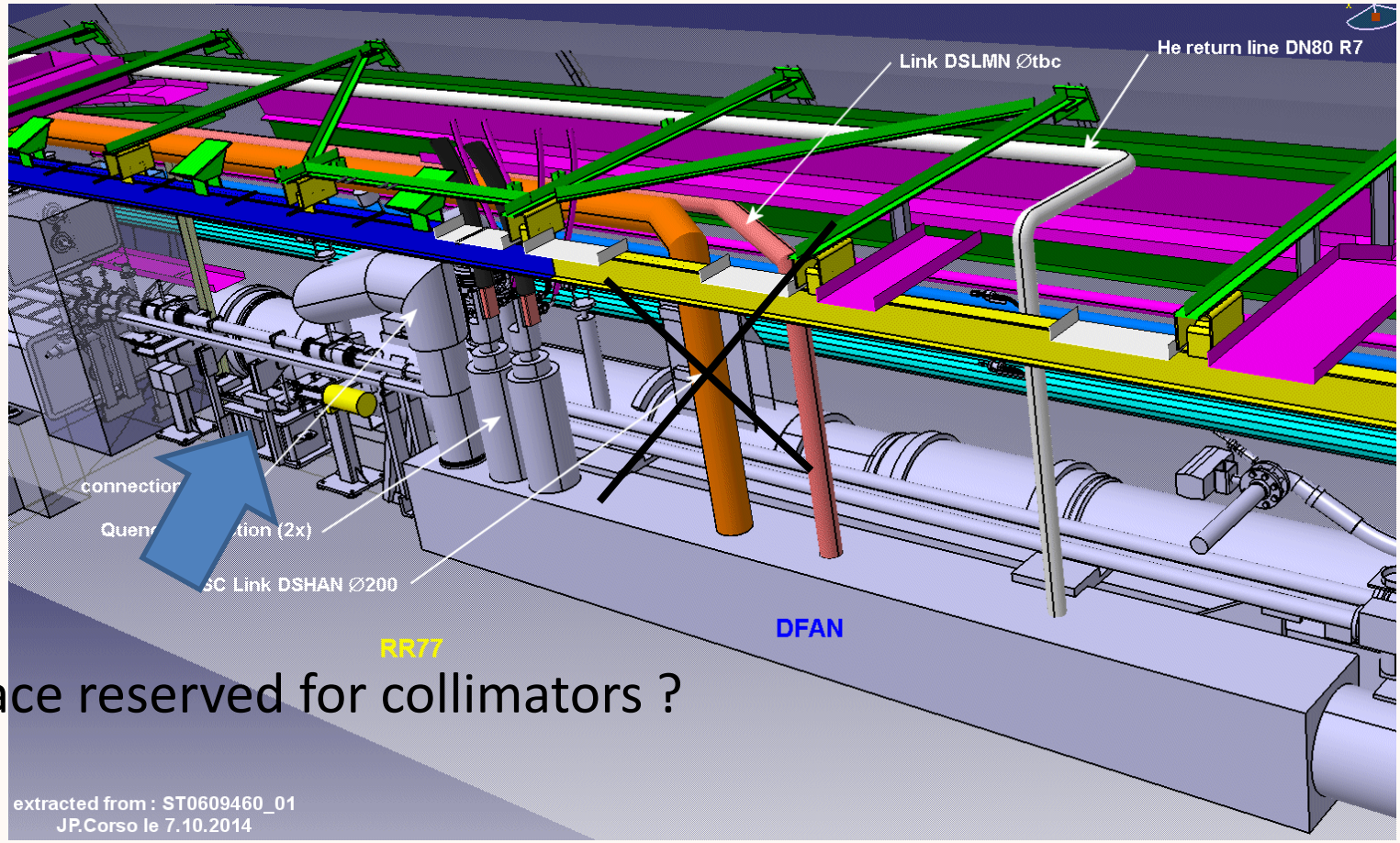



Option 1: simplified routing

**Integration tests at CERN in Spring 2015 using a 60 m long SC Link (cryostat + cable) to verify the two options – and select the most convenient**

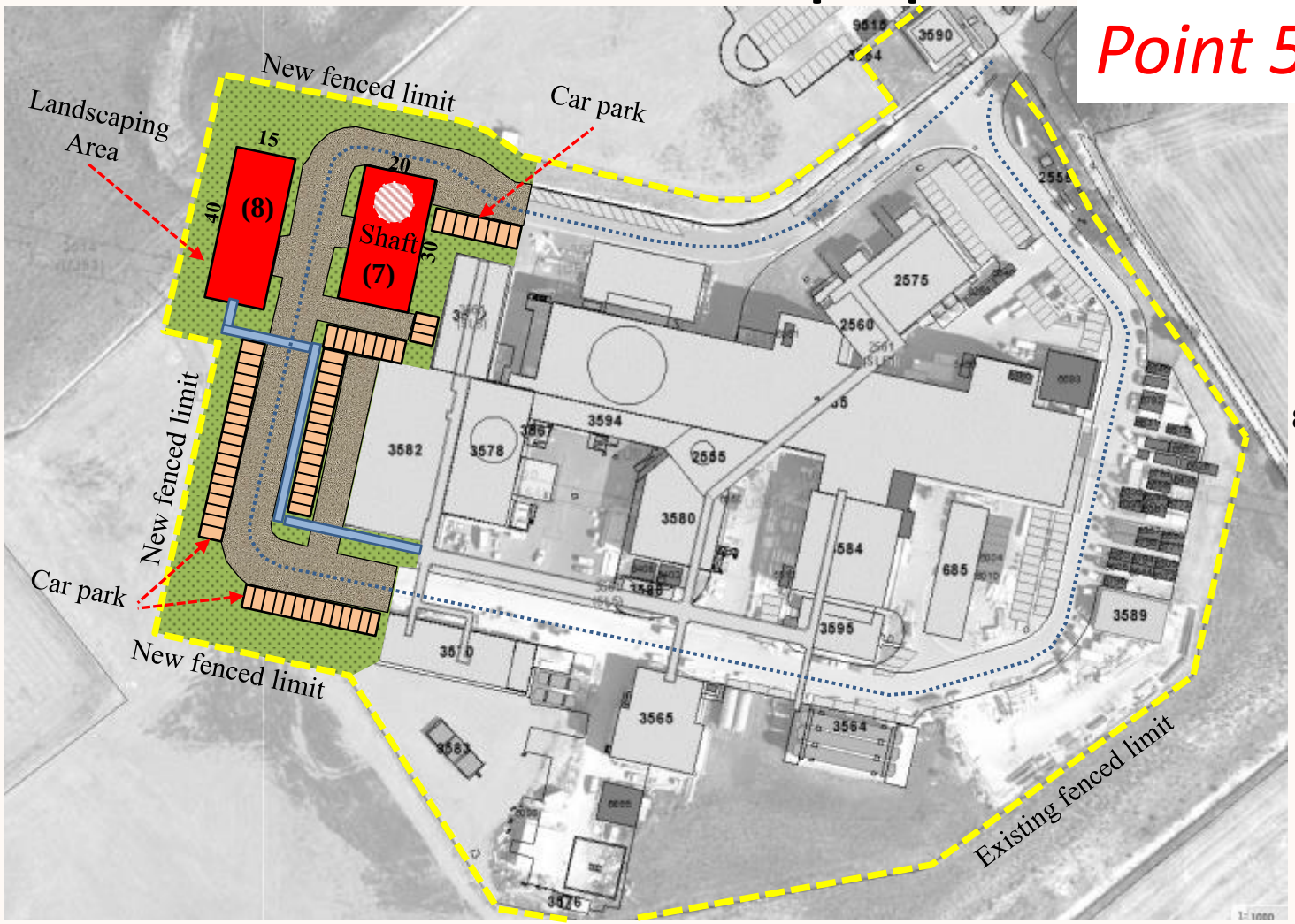
Y. Muttoni, CERN

# Integration of Cold Powering System at LHC P7




Space reserved for collimators ?

# Option surface: all other equipment




**MACHINE SIDE, WITH NEW SHAFT + PC**

**7) SD (Steel)**

- Dimension: 20 x 30 = 600m2
- Hmax = 12.0m
- Services (in;out): HV, water, SC Links ; ?
- Crane not costed (20t ?)

**8) WARM COMPRESSOR (Conc)**

- Dimension: 15 x 40 = 600m2
- Hmax = 9m
- Services (in;out): HV, water, Cryo pipes ; ?
- 20t crane not costed

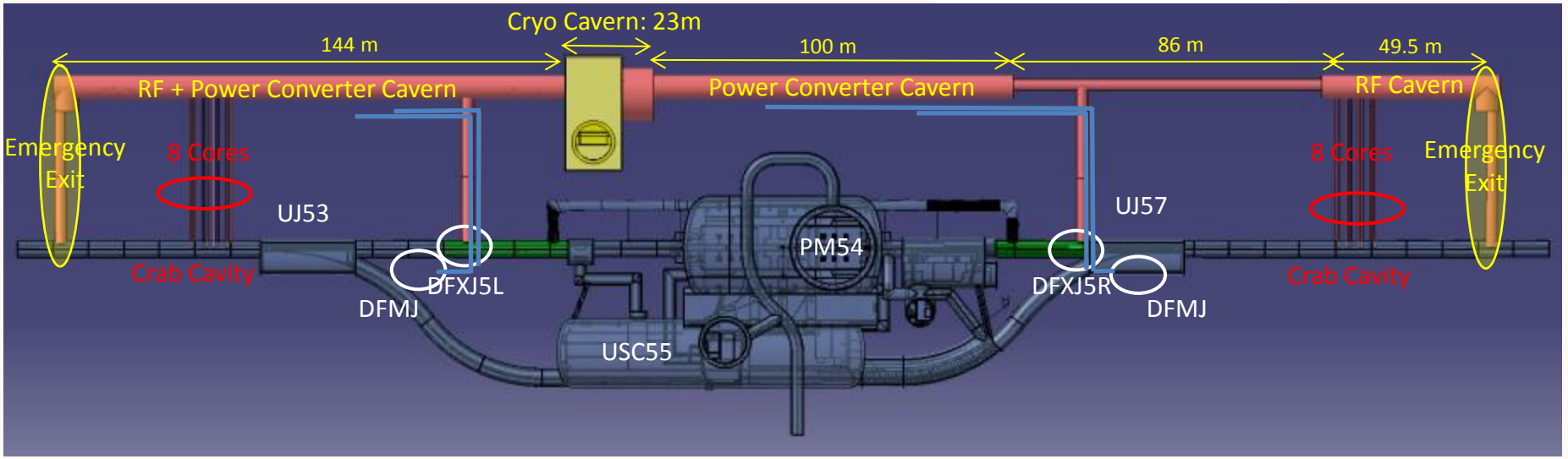
**10) PARKING, ROADS, GALLERIES**

- Car Park: 20 places added
- New Road: 180m(L), 8m(W)
- New Access road: 70m(L), 6.5m(W)
- Galleries for services: 110m(L), Cross section2.0m(W) by 2.5m(H)
- Landscaping: 6,600m2

John Osborne, Martin Manfredi GS-SE-PAS

# Option: underground

*Point 5*

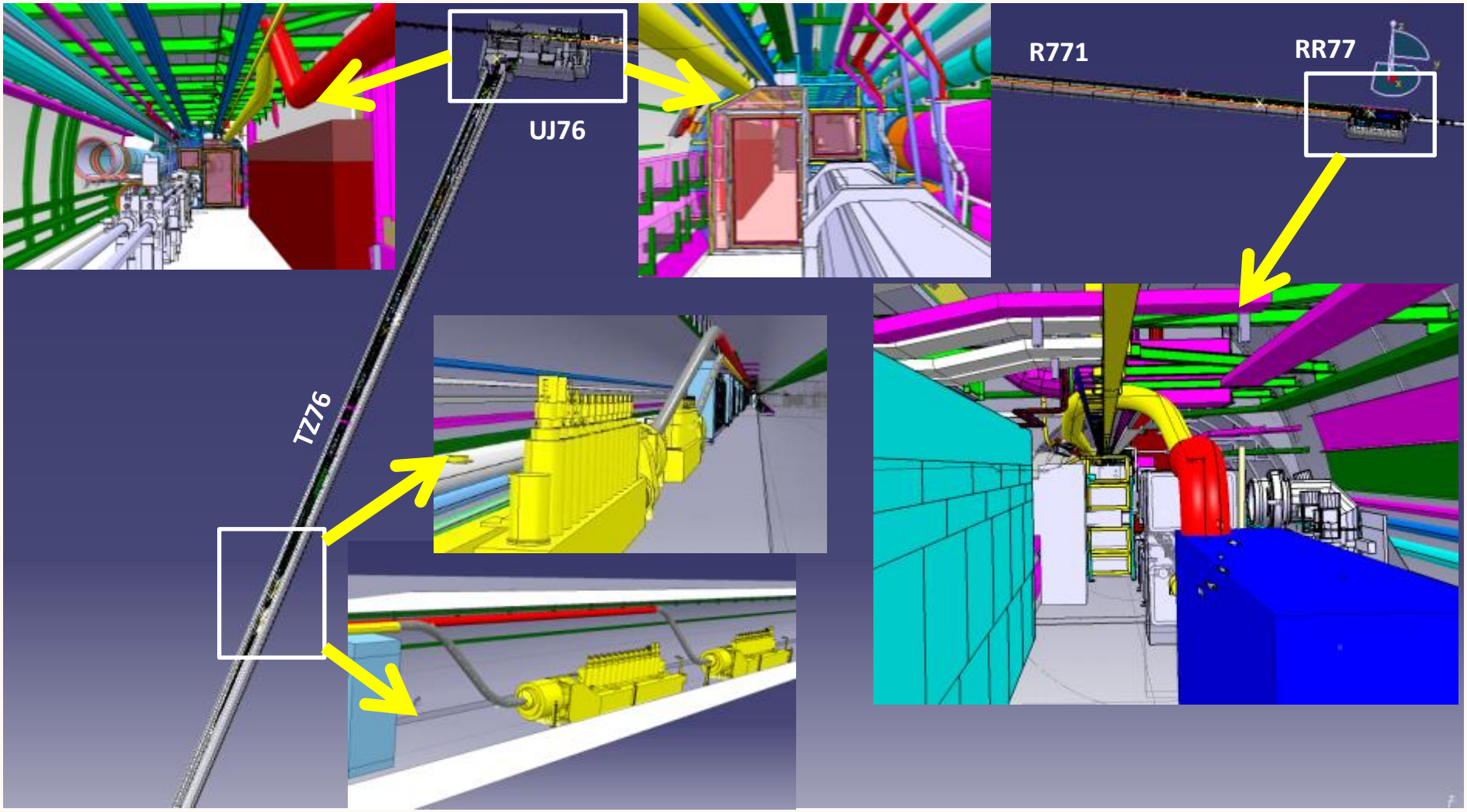




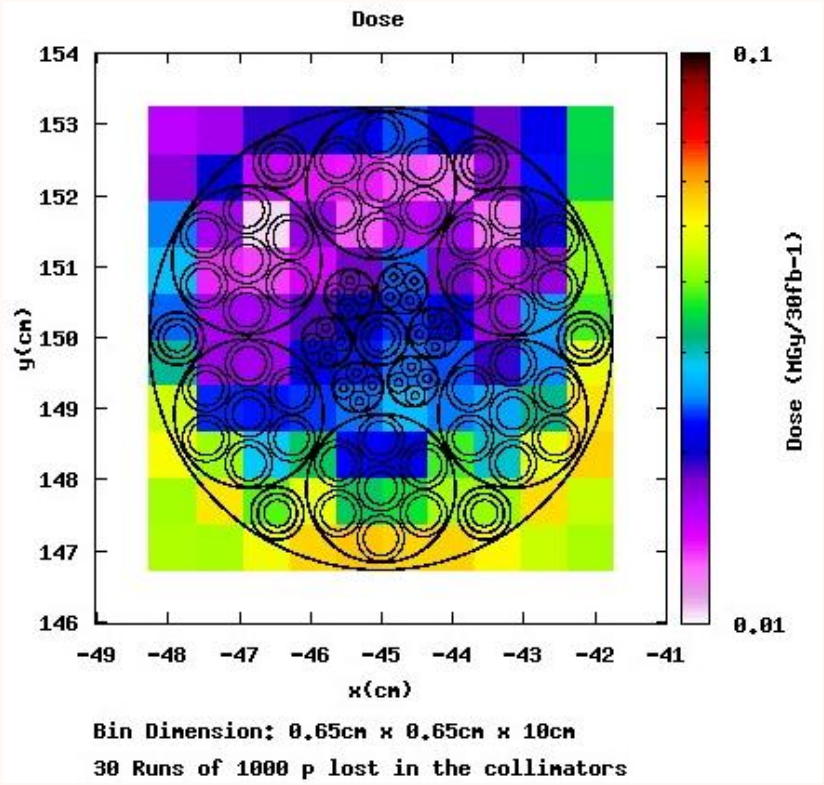
Surface or underground installation: huge implication on system design

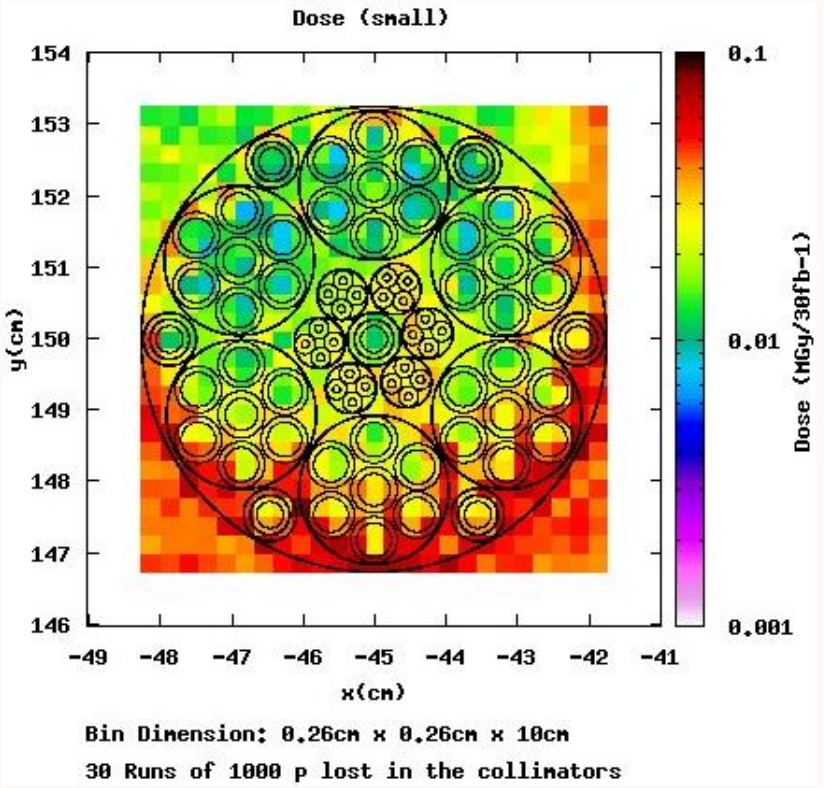
Activity on test of vertical SC-Link start in Jan 2015

# Sc Link in P7 – Radiation aspects



# Dose at LHC P7




The maximum dose is about 40 kGy integrated over a period of 30 $fb^{-1}$

If also we extrapolate proportionaly to 3000 $fb^{-1}$ we will obtain only **4 MGy** over the whole period of exercise