A possible (big?) plan for synergy between VHE-LHC and TLEP (and VLHeC)

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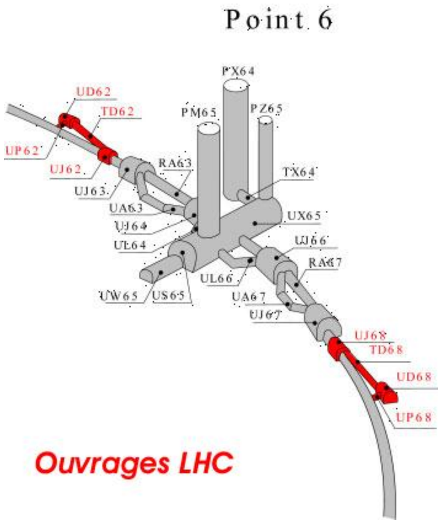
Content

- Avoiding LHC as Injector
- VHE-LHC
  - Injection by means of a LER
  - Synergy with a TLEP and VLHeC

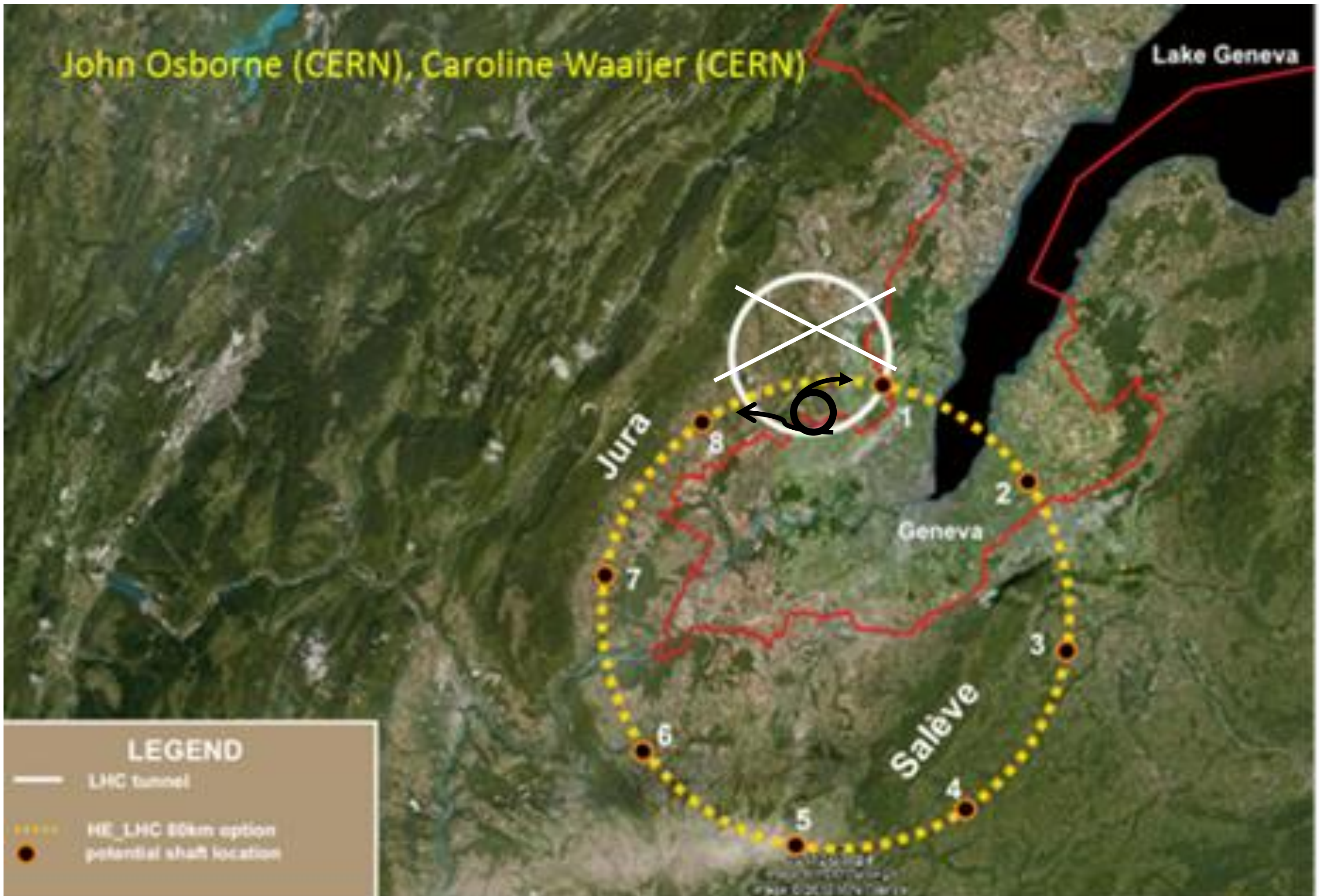
- Purely few preliminary ideas: not real work!!
  $\Rightarrow$ flaws, even basic ones, are possible!

LHC as Injector of VHE-LHC

- Running LHC at 10% duty cycle is a waste
  - LHC is complex machine not optimized for synchrotron (as one would like for injector) mode
  - The main energy consumption is cryogenics: about 45 MW, half of the LHC power **but working continuously!**
  - Maintaining an «old» (2035-2050) LHC, especially after the HL-LHC run is an effort that is hardly justified as 10% duty cycle injector (especially man-power)
  - The MTBF risk top become too low
- Extraction of beam from LHC will be difficult (buit not impossible). Modifications are needed to extract beam from other LHC points.

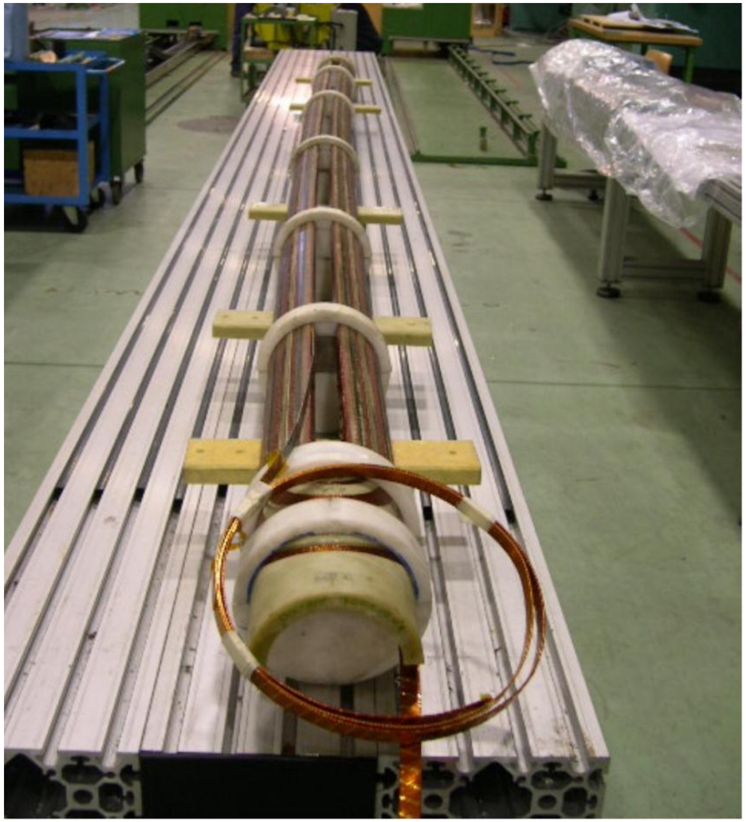


Injection scheme: SC-SPS→VHE-LHC



What we can have from SPS (approx.)

- The SPS+ we are discussing for HE-LHC is based on 4.5 T, 1 T/s
  - Discorap: INFN (FAIR collaboration) 2008-2012, with lenght of 3.5 m: reached **B> 4.5 T and dB/dt > 0.3 T/s** in pool boiling. In SuperCritical He should reach and pass1 T/s with low losses



SPS – Cont.

- Protvino dipoles: 1 m long, **B= 6 T, 1T/s** obtained few years ago (large losses)
- We can assume that with reasonabale R&D a value of 6 T, 1 T/s with low losses can ber obtained. We van assume the magnets can work with a dynamic range of 20
  - Ein = 75 GeV (0.3 T)
  - Eext = 1.5 TeV (6 T)

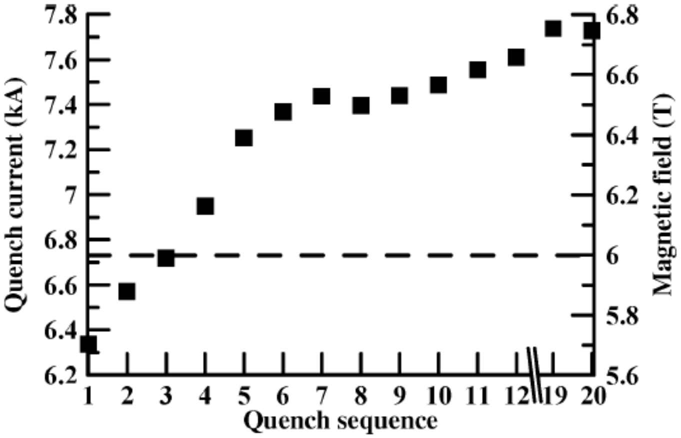


Fig. 4. Training curve of the dipole.

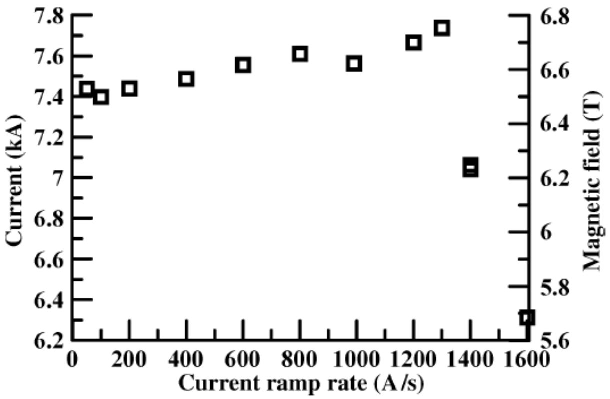


Fig. 5. Ramp rate dependence of the dipole.

Pipetron magnet proposed by Bill Foster (ca. 1996)

Proposed without return cable (i.e. using ground from current return)
First proposed for a super-large ring (Pipetron) even 600 km long;
Then proposed as a cheap stage 1 (low energy) VLHC, at 1.5 T, to be substituted by 10.5 T dipoles for stage 2.

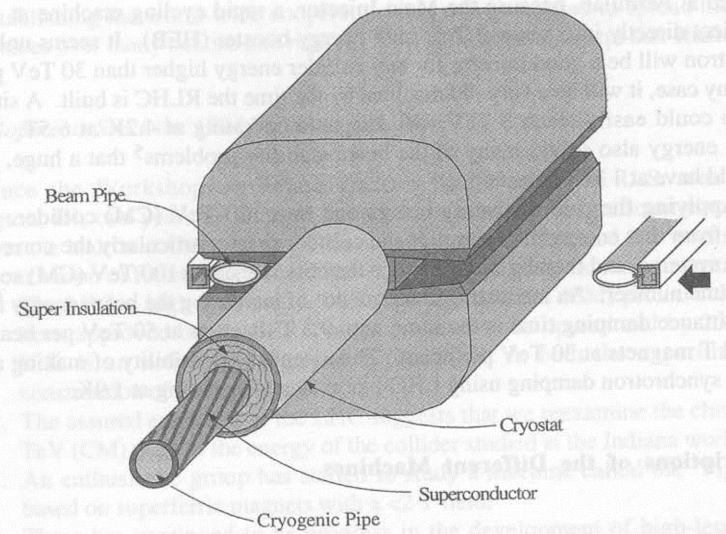
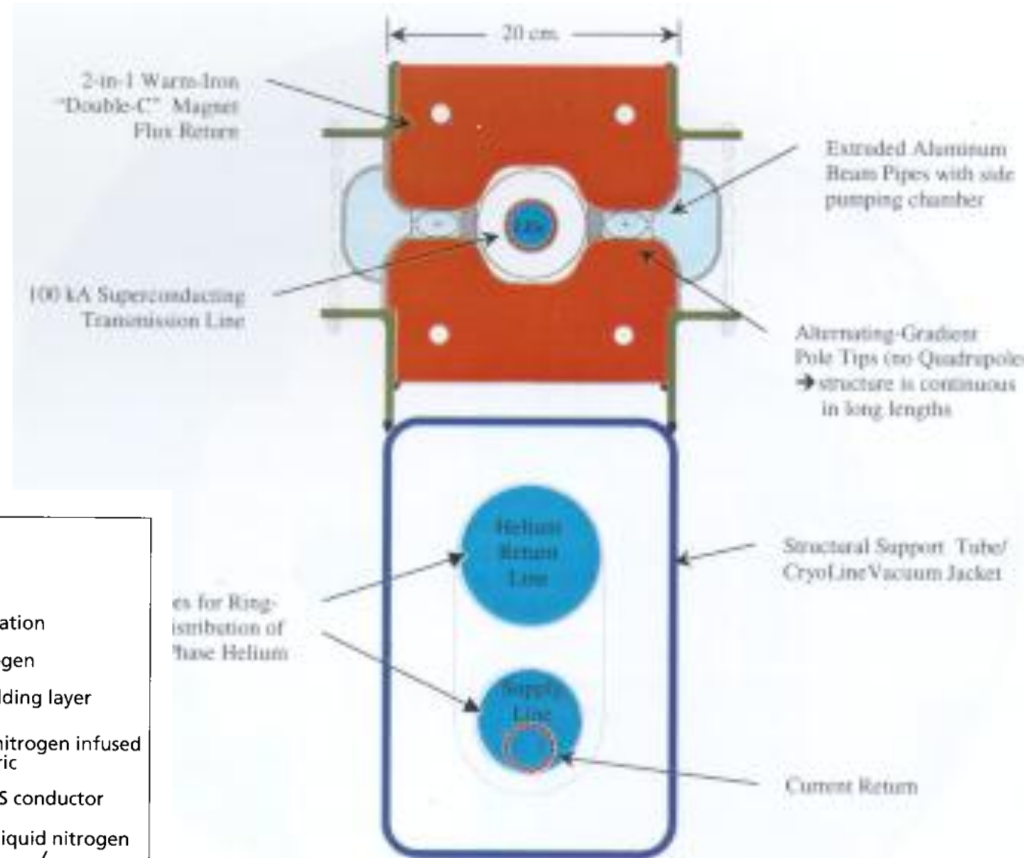


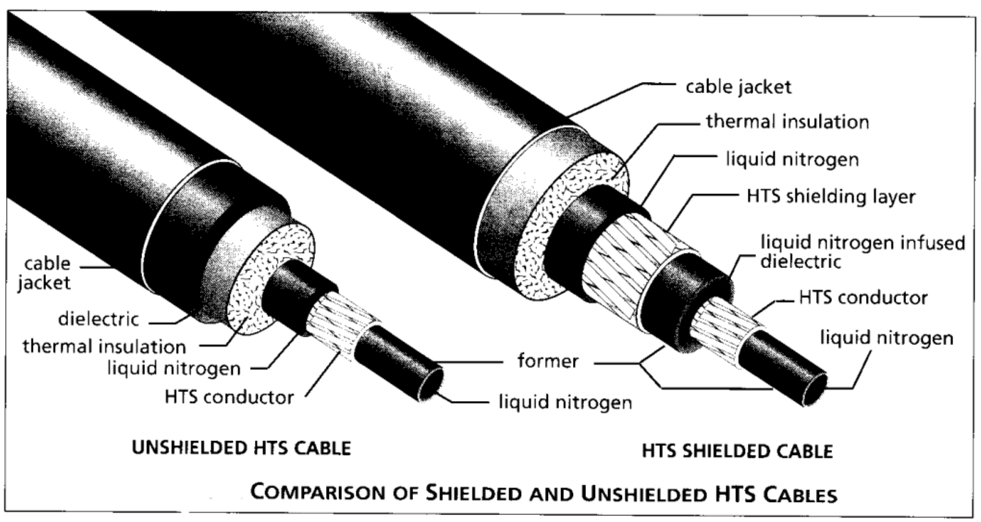
FIG. 1. Double-C twin bore transmission line magnet. The center conductor carries 75 – 100 kA and returns in a separate and nearby cryogenic line. The steel and beam tube are at room temperature. The pole pieces are shaped to provide both bending and alternating gradient focusing.

Even though this ring is very large, the cryogenics system is quite modest.[9] The conductor is at a force null, so the support structure for it has a low heat leak. Furthermore, the yoke steel is not cryogenic and the synchrotron radiation power is removed at room temperature, permitting a much smaller and simpler cryogenic system than for any high-field design. A preliminary design has been presented using NbTi as the conductor and liquid helium as the coolant.[8] Eight refrigerator plants, each roughly the size and power of an SSC plant are located around the ring. It is interesting to note that the transmission-line design is particularly well-suited to either effective use of pre-reacted Nb_3Sn operating at up to 10 K, presently commercially available high-temperature superconductor at 25 K, or, with some development success, the more speculative HTS deposited on structured substrates, operating at 77 K. In all these cases, operating costs would drop dramatically. The wall-plug power, for example, would be less than 5 MW if the transmission line could be operated at LN_2 temperature.

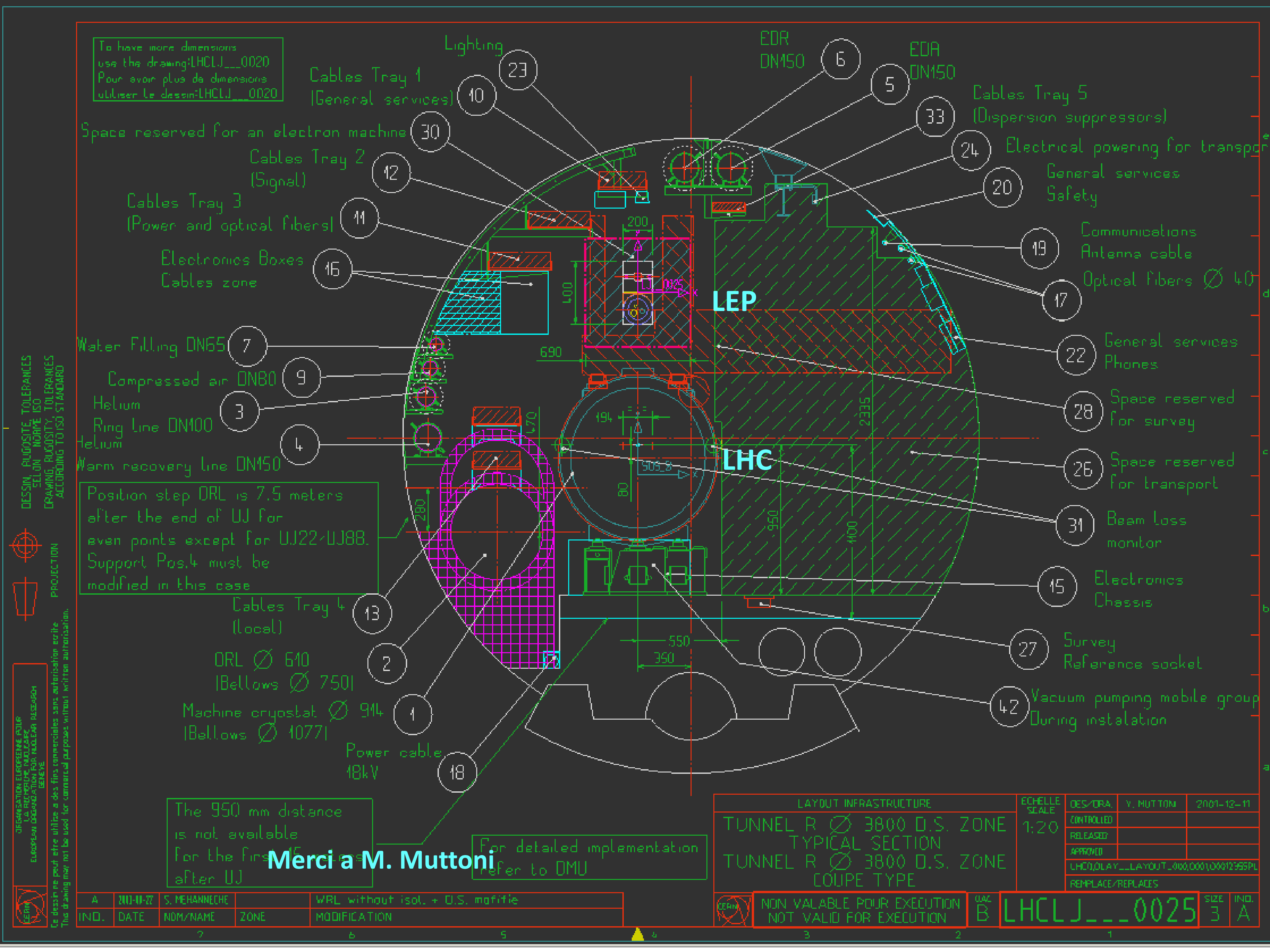
From Nb-Ti to HTS (higher margin, stability and robutstness) for LHC

- **Pipetron! The cheap Sc magnet for 2 T**
- **Iron excited by a transmission line of HTS (LN!!!)**

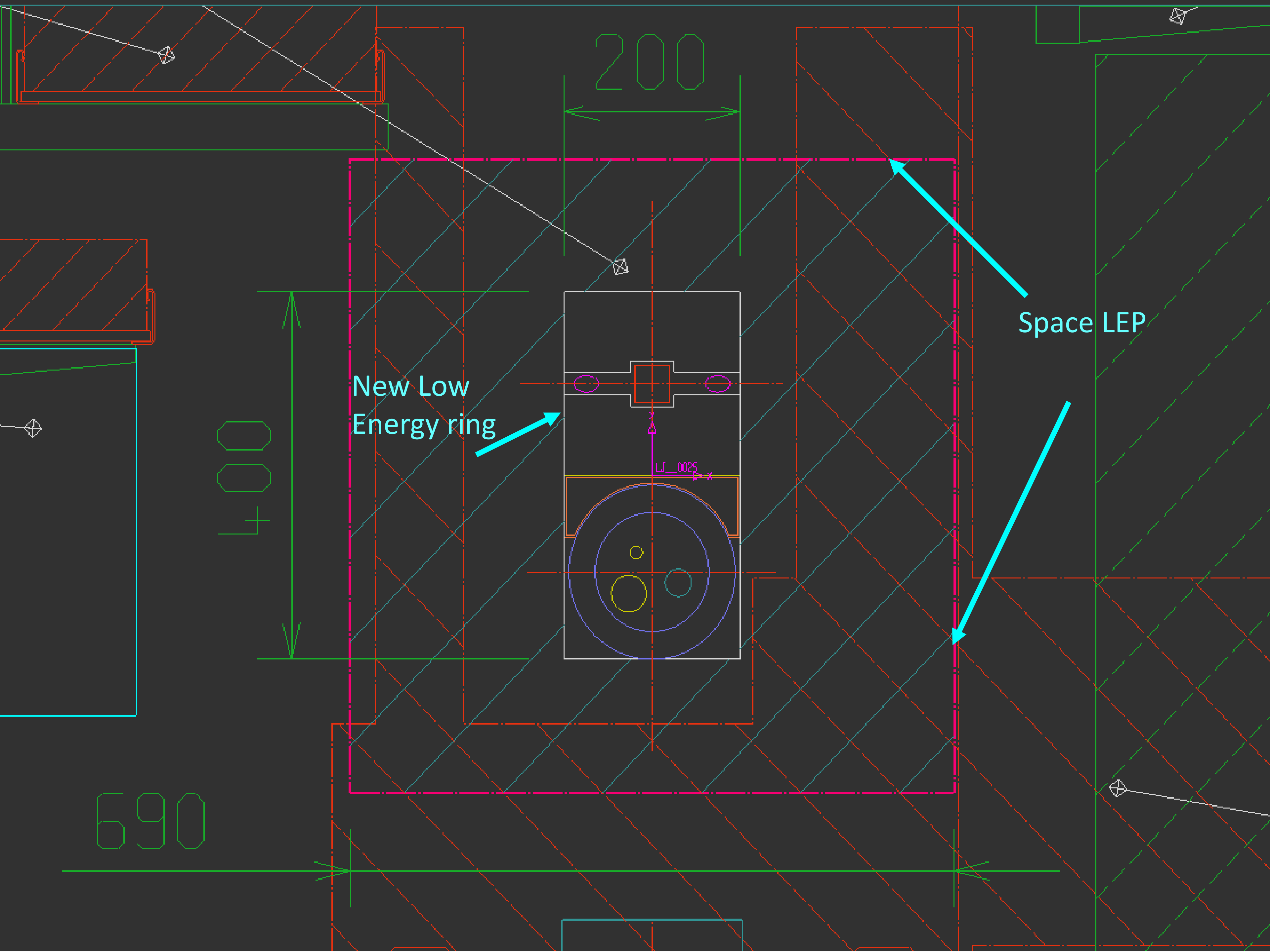




Collaboration with H. Piekarz, Fermilab, that has done design and prototype based on a Nb-Ti 100 kA in 2007



To have more dimensions use the drawing:LHCLJ___0020
Pour avoir plus de dimensions utiliser le dessin:LHCLJ___0020
Lighting 23
Cables Tray 1 (General services) 10
Space reserved for an electron machine 30
Cables Tray 2 (Signal) 12
Cables Tray 3 (Power and optical fibers) 11
Electronics Boxes Cables zone 16
Water Filling DN65 7
Compressed air DN80 9
Helium Ring line DN100 3
Helium Warm recovery line DN150 4
Position step DRL is 7.5 meters after the end of UJ for even points except for UJ22/UJ88. Support Pos.4 must be modified in this case
Cables Tray 4 (local) 13
DRL Ø 610 (Bellows Ø 750) 2
Machine cryostat Ø 914 (Bellows Ø 1077) 1
Power cable 18kV 18
The 950 mm distance is not available for the first 15 m after UJ
EDR DN150 6
EDA DN150 5
Cables Tray 5 (Dispersion suppressors) 33
Electrical powering for transport 24
General services Safety 20
Communications Antenna cable 19
Optical fibers Ø 40 17
General services Phones 22
Space reserved for survey 28
Space reserved for transport 26
Beam loss monitor 31
Electronics Chassis 15
Survey Reference socket 27
Vacuum pumping mobile group During instalation 42
LEP
LHC
200
400
690
194
470
280
80
950
1100
2335
550
350
For detailed implementation refer to DMU
Merci a M. Muttoni
LAYOUT INFRASTRUCTURE
TUNNEL R Ø 3800 D.S. ZONE TYPICAL SECTION
TUNNEL R Ø 3800 D.S. ZONE COUPE TYPE
ECHELLE SCALE 1:20
DES/DRA. Y. MUTTON 2001-12-11
CONTROLLED
RELEASED
APPROVED
REMPLACE/REPLACES
NON VALABLE POUR EXECUTION
NOT VALID FOR EXECUTION
B
LHCLJ___0025
SIZE 3
IND. A
A 2003-11-27 S. MEHANNECHE WRL without isol. + D.S. modifie
IND. DATE NOM/NAME ZONE MODIFICATION
PROJECTION
DESSIN, RUGOSITE, TOLERANCES SELON NORME ISO
DRAWING, RUGOSITY, TOLERANCES ACCORDING TO ISO STANDARD


200
400
690
New Low
Energy ring
Space LEP

From H. Piekarz
Malta proceedings (CERN-2011-003) pag 101)

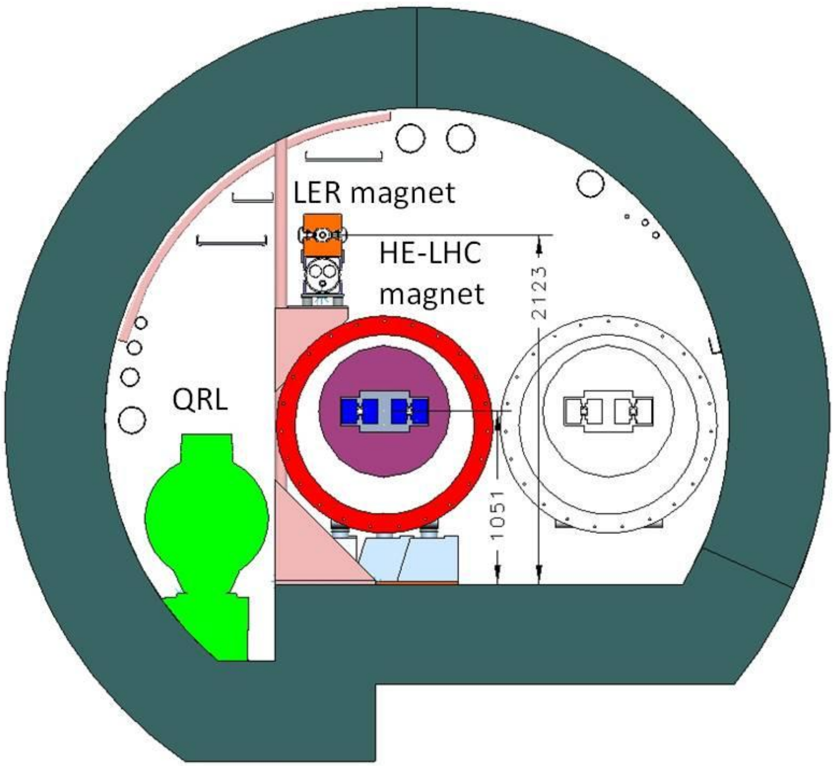


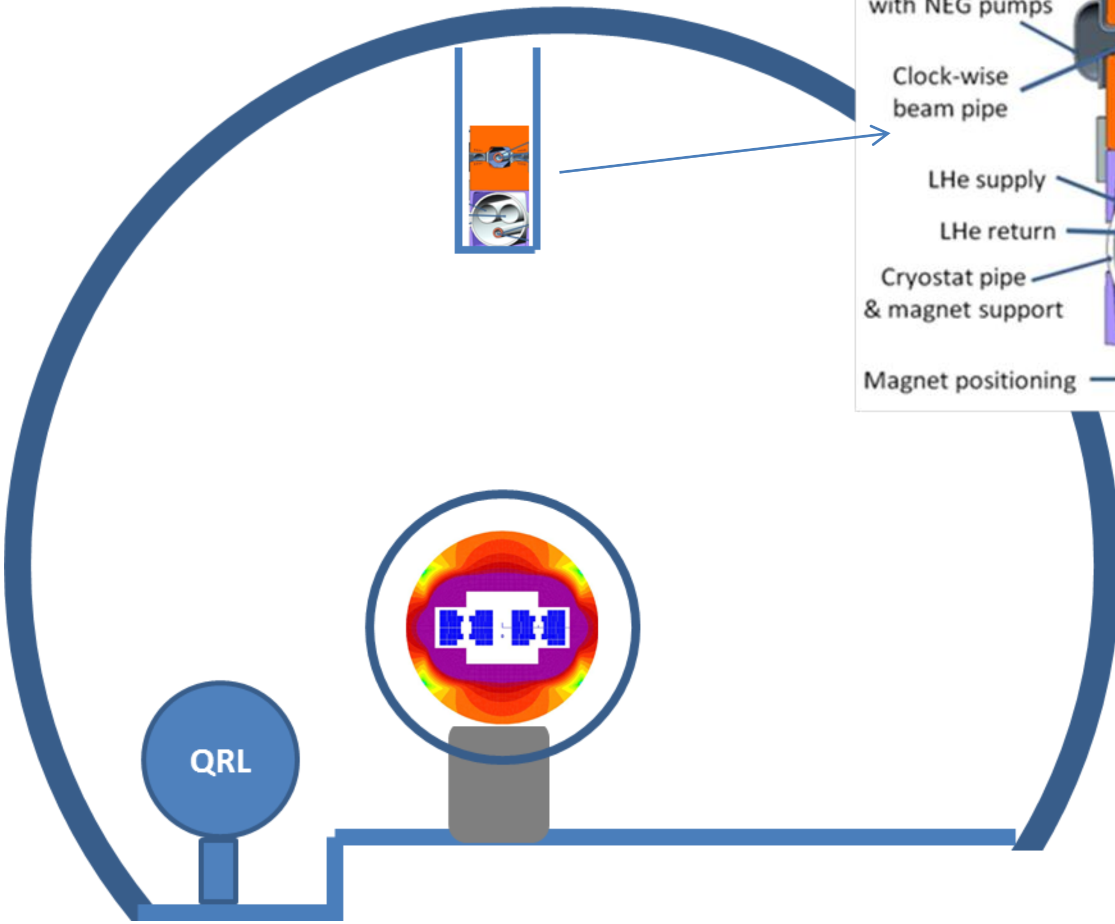
Fig. 8: Possible arrangement of LER and HE-LHC magnet rings in the LHC tunnel and position of a second HE-LHC magnet in transportation through the tunnel.

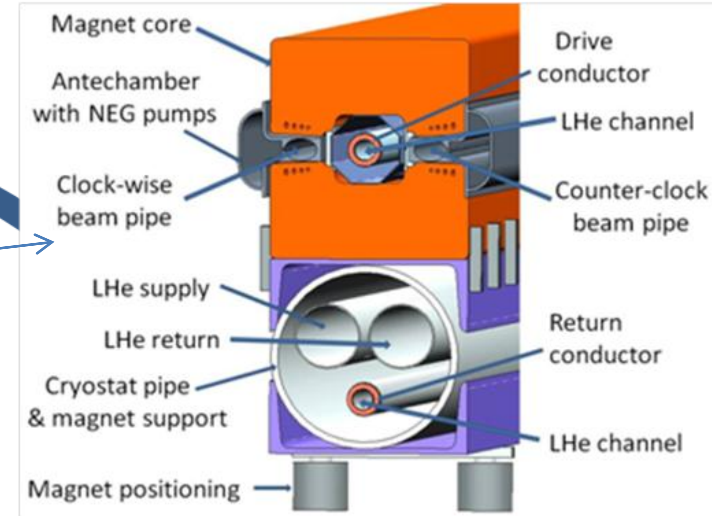
The idea here was to compare SC-SPS + Sc transfer beam lines TI2, TI8 witjh an injection from today SPS into a LER in the LHC tunnel, transferring beam to HE-LHC in a single turn.

The results was that cost of LER is much less wrt to SC-SPS option.

Integration is difficutlt but not impossible since there si new lay-out (HE-LHC are bigger than LHC ones, but we might eliminate QRL)

Possible arrangement in VHE-LHc tunnel

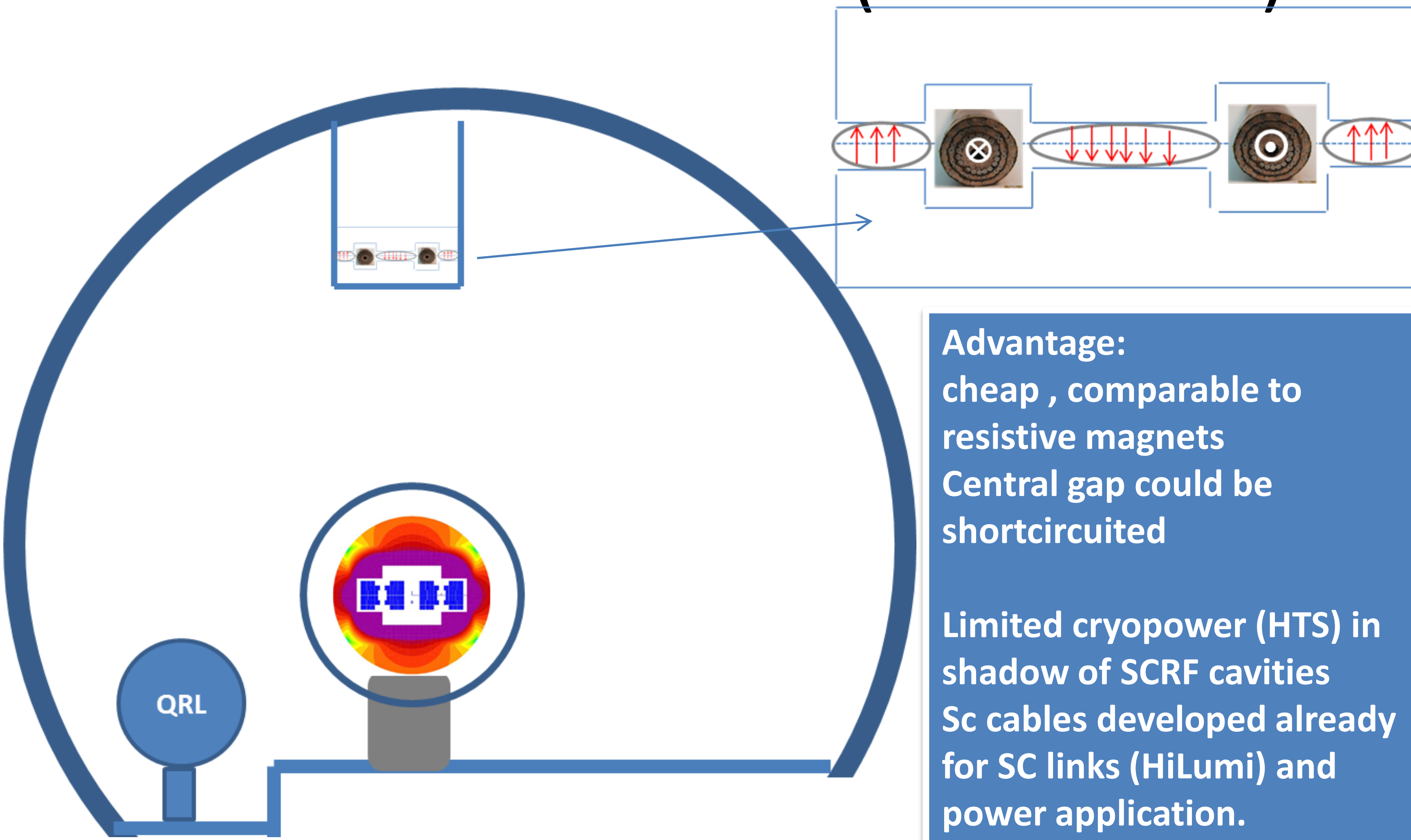




From H. Piekarz
Malta Prooc. Pag. 101

30 mm V gap
50 mm H gap
Bin = 0.5 T
Bextr = 1.5 T

Possible VHE-LHC with a LER suitable also for e^+-e^- collision (and VLHeC)



Advantage:
cheap , comparable to resistive magnets
Central gap could be shortcircuited

Limited cryopower (HTS) in shadow of SCRF cavities
Sc cables developed already for SC links (HiLumi) and power application.
SR taken at 300 K

Possible steps for a technical synergy between TLEP and VHE-LHC

- Build the SC-SPS (by 2030 to be installed in a long shutdown:may be a benefit also for final phase of HiLumi?)
- Build the 80 km tunnel and the LER (by 2030)
- To be exploited for e+e- (beginning of 2030s?)
- Meanwhile build the 16-20 T dipoles for the hadron collider (on the momentum of the 12-13 T magnets we are prototyping for HiLumi)
  - If it is worth: install in HE-LHC the first 35% of the magnets to have 30 TeV c.o.m. «quick» collision (2035?)
  - Complete the magnets for the VHE-LHC to be installed after 2040?
  - The curvature of the LHC is moderate (and is formed at magnet assembly) and the magnet can be made to be retrofitted in the 80 km tunnel
- Or, once stopped HiLumi, abandon LHC tunnel and go for VHE-LHC (80-100 TeV c.o.m.) directly, with TLEP and VLHeC
- Cryogenics for SCRF cavities e+e- and magnets for LER and VHE-LHC (and other infrastructure) is COMMON