Cold Collimator + 11T magnet: cryostat & integration issues

(first thoughts)

V.Parma, J.Ph.Tock

CERN, TE-MSC

Outline

- The Cold Collimator Feasibility Study (CCFS) working group
- From warm collimators (reminder) to cold collimators
- Machine Integration: technical systems affected
- Possible 11 T magnet layouts and consequence on collimator integration
- IR specificities
- Powering
- Summary

Mandate of the CCFS Working Group

(Cold Collimator Feasibility Study)

Scope of the work:

- Verify the feasibility of installing cold collimators, housed in cryo-assemblies, in the continuous cryostat during LHC's Long Shut Down 2 (or later SD), as required by collimation in several machine IR's (pt.1, 2, 3, 5 and 7)

Specific goals:

- Analyze configurations of cold collimators coupled to 11 T magnets;
- Identify potential show stoppers, either related to the implementation of the layout schemes or related to operational aspects of the associated technical systems (vacuum, cryogenics, machine protection, alignment, etc).
- Identify potential needs for R&D with its associated effort and timeline.
- Provide a final recommendation for the opportunity of a cold collimator project, with a draft timeline.

WG composition (by system reponsibility):

- Collimators: A.Bertarelli, EN-MME; F.Cerutti, EN-STI
- Vacuum : V.Baglin, TE-VSC
- Cryogenics : R.Van Weelderen, TE-CRG
- 11 T magnets: M.Karpinnen, TE-MSC
- Machine optics, (R.Assmann, BE-OP)
- Machine Layout, Cryostat & Integration: V.Parma (J.Ph.Tock),TE-MSC

And ex-officio participants:

- Collimator project leader (R.Assmann, BE-OP)
- HL LHC project leader (L.Rossi, TE)

List of topics on the table

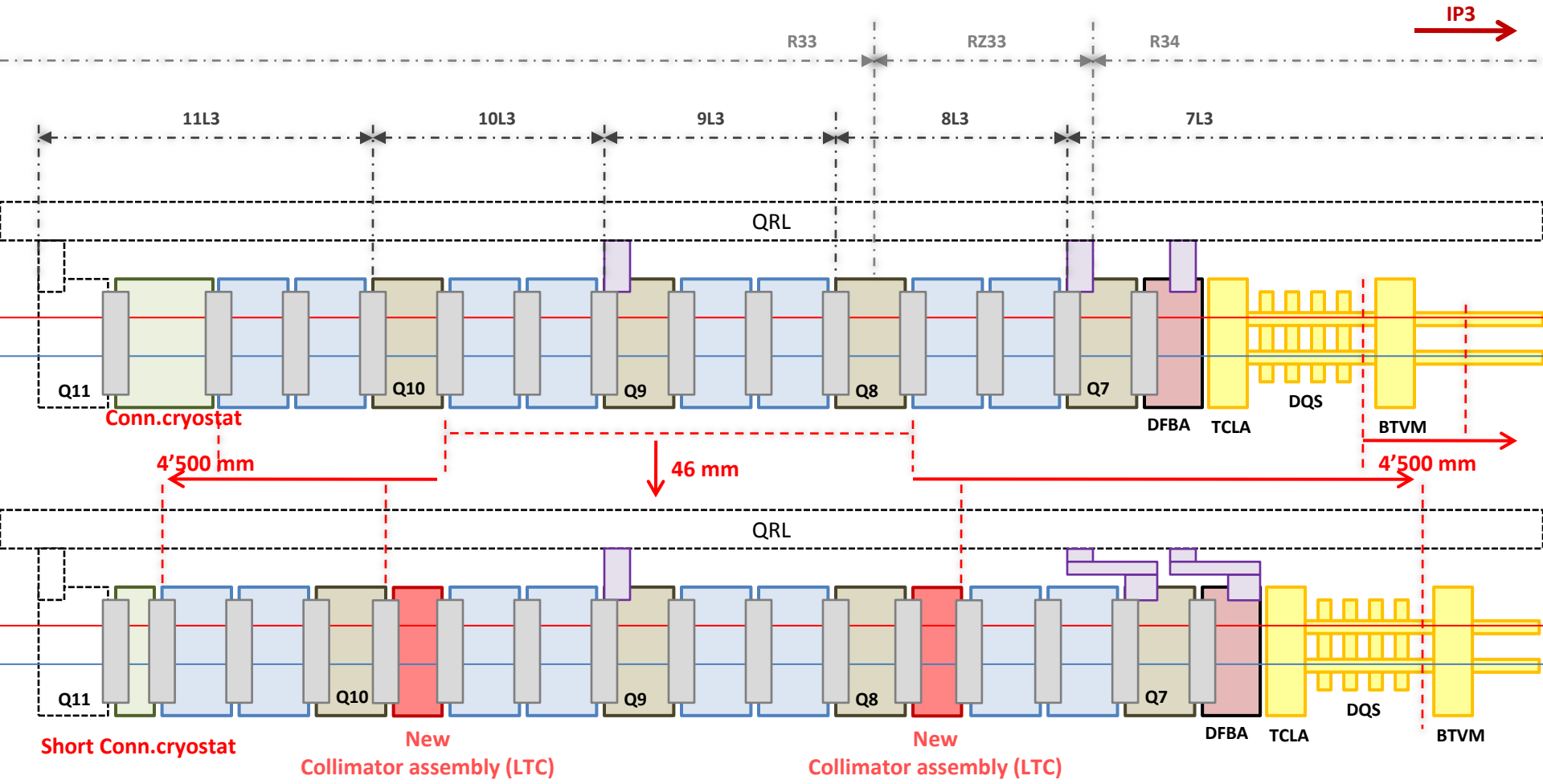
Topics:

- IR Integration specificities (space availability, PC locations,…)
- Collimator length (as function of material, efficiency,…)
- 11 T magnet specificities (strength vs.lenght, trim & powering, quench protection,…)
- Possible cryostat layouts (11 T common integration, individual cryostats,…)
- Vacuum T and operation aspects
- Cryogenic margins (heat load limitations, extraction capacity from 11 T magnet & collimator, operation aspects,…)
- Collimators @ cryo T (materials, RF heat deposition,…)
- Collimator mechanisms @ cryo T (jaws alignment, precision,…)
- Reliability & Maintainability (failure scenarios, down-time,…)
- …

Next meeting on 11th October next:

- Layouts options and IR integration specificities (V.Parma+J.Ph.Tock)
- 11 T magnet main parameters (M.Karppinen)

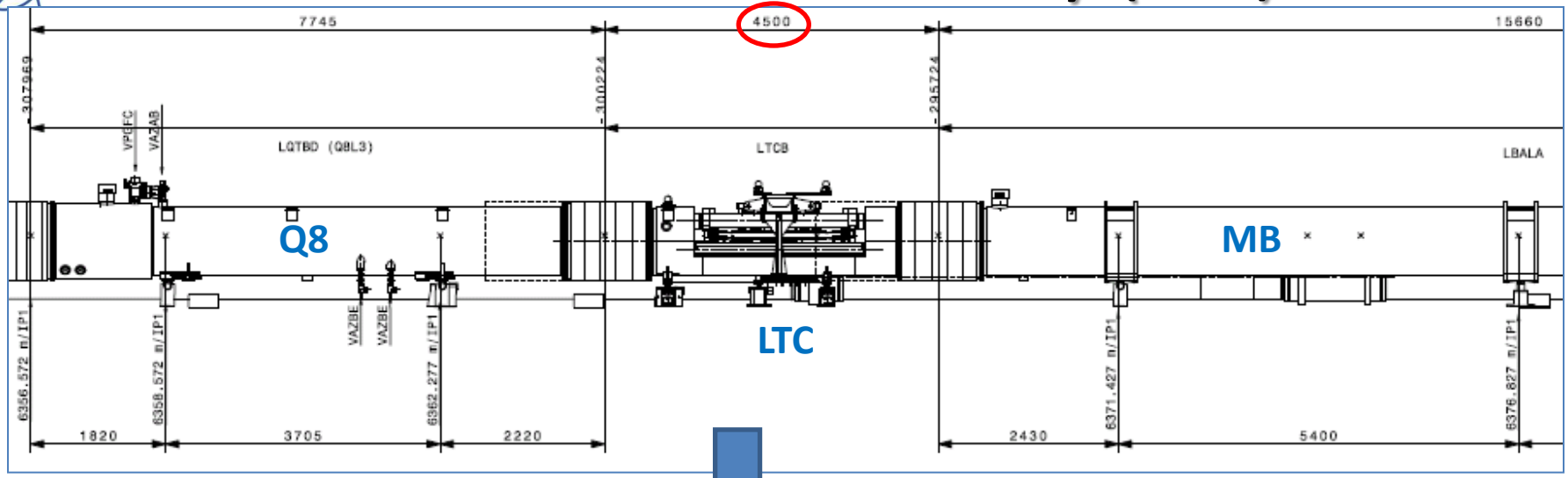
Warm collimators in the DS of IR3: our baseline



- was aimed at Shut-Down 2012-2013 (no time for 11 T magnets!)
- move 24 existing magnets and DFBAs (considered critical but feasible)

→ not needed for SD1 anymore, project postponed

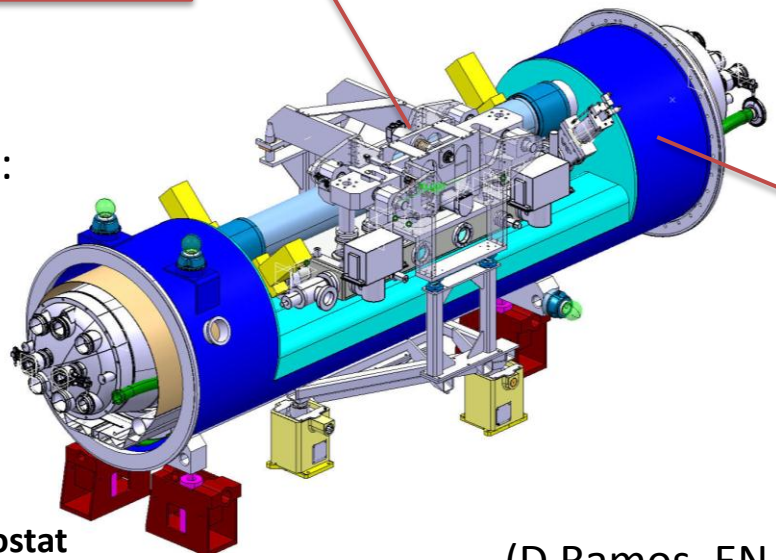
DS Collimator Assembly (LTC)



(Y.Muttoni, EN-MEF)

Collimator Module (TCLD)

- W jaw length → 1 m
- overall length 4.5 m
- ineffective length due to:
  - Bus bars routing
  - Cold-Warm transitions

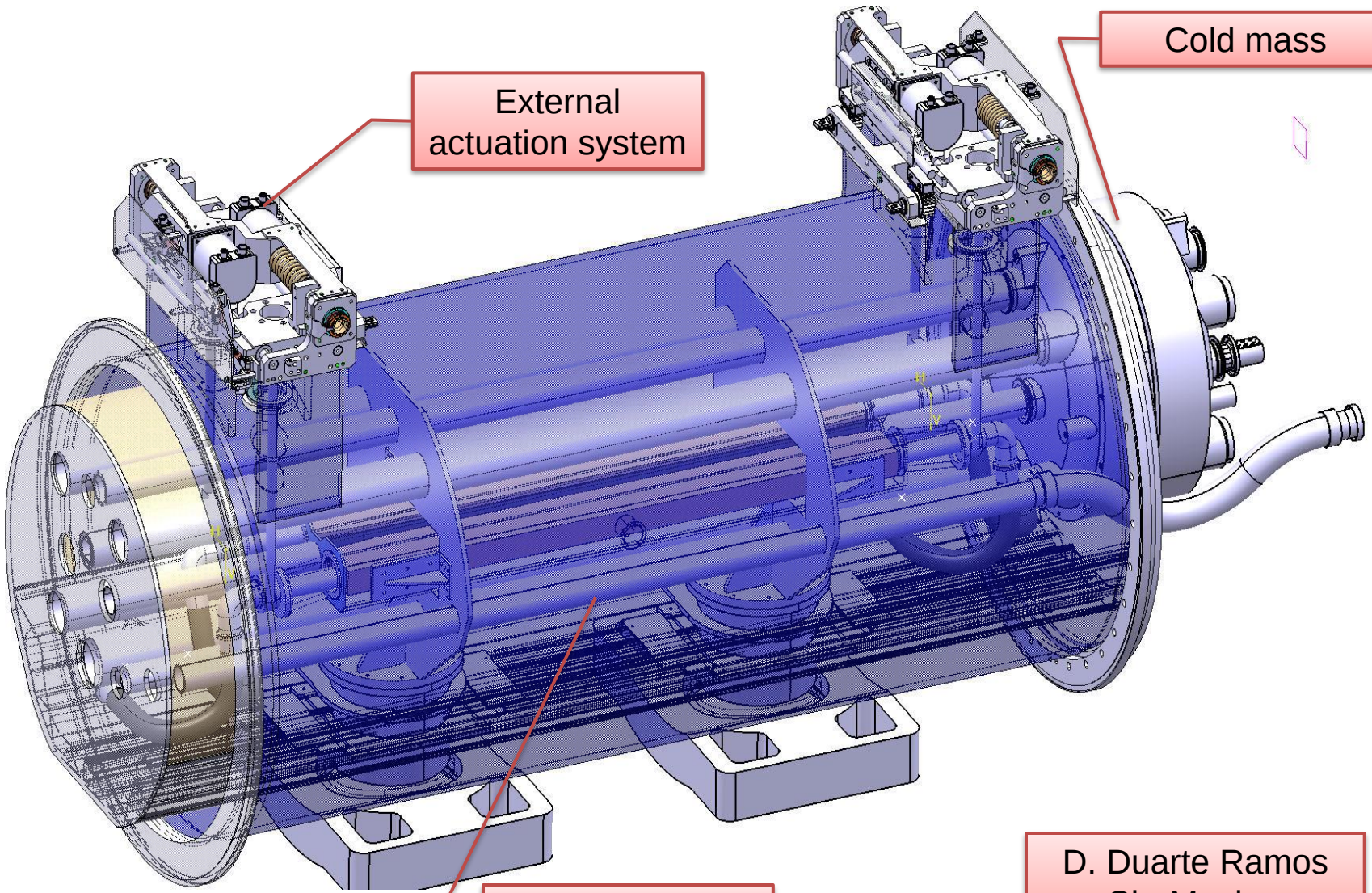


Cryostat ("by-pass") (QTC)

1 prototype cryostat is under construction

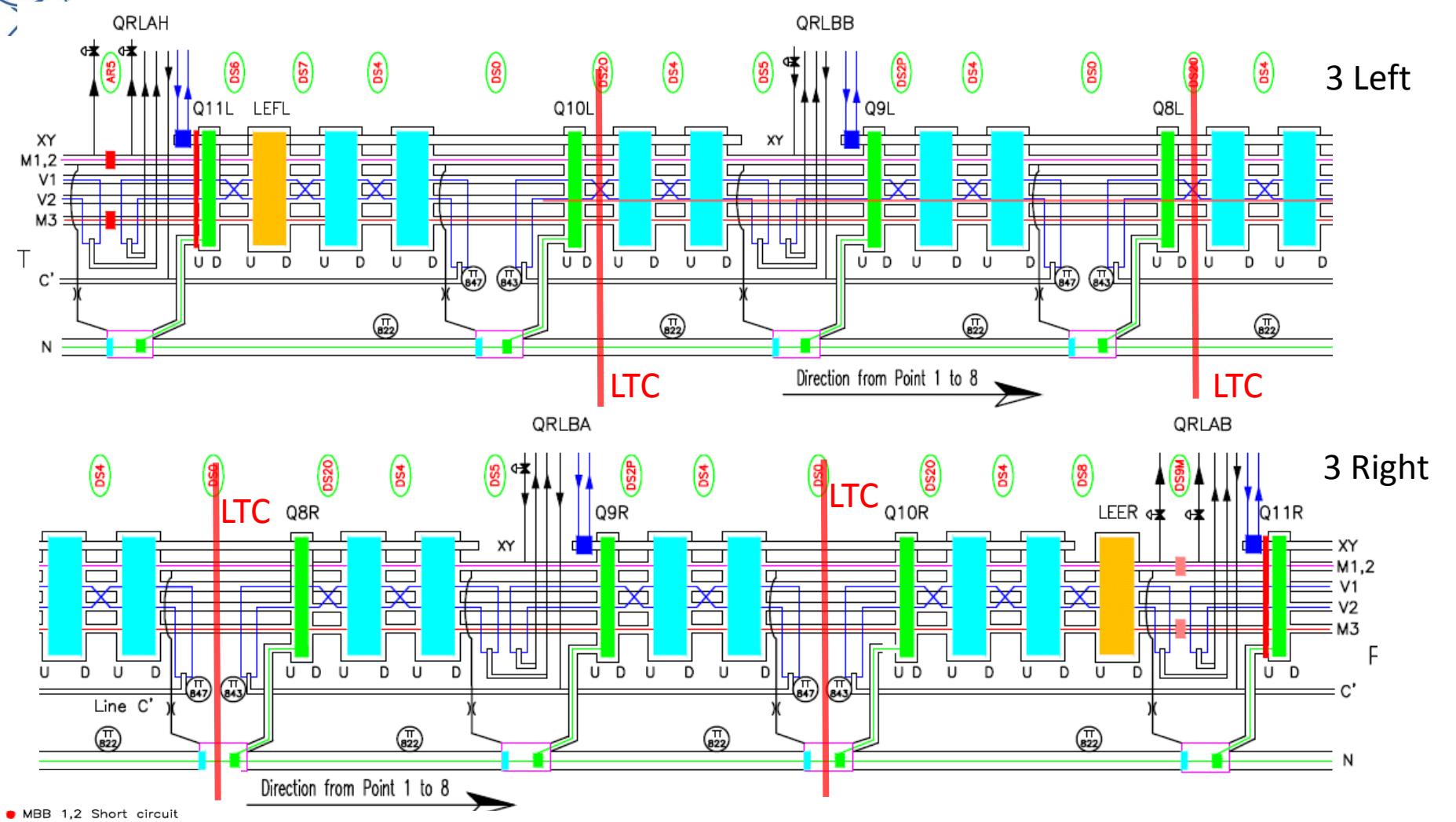
(D.Ramos, EN-MME)

COLD COLLIMATOR PRE-STUDY (2010)



D. Duarte Ramos
Ch. Mucher

Primary technical systems affected by inserting the LTCs (3 L and 3 R)



Systems to be “bridged”

Maintain functional continuity of:

Beam lines (beam vacuum):

1. V1, V2

Electrical powering:

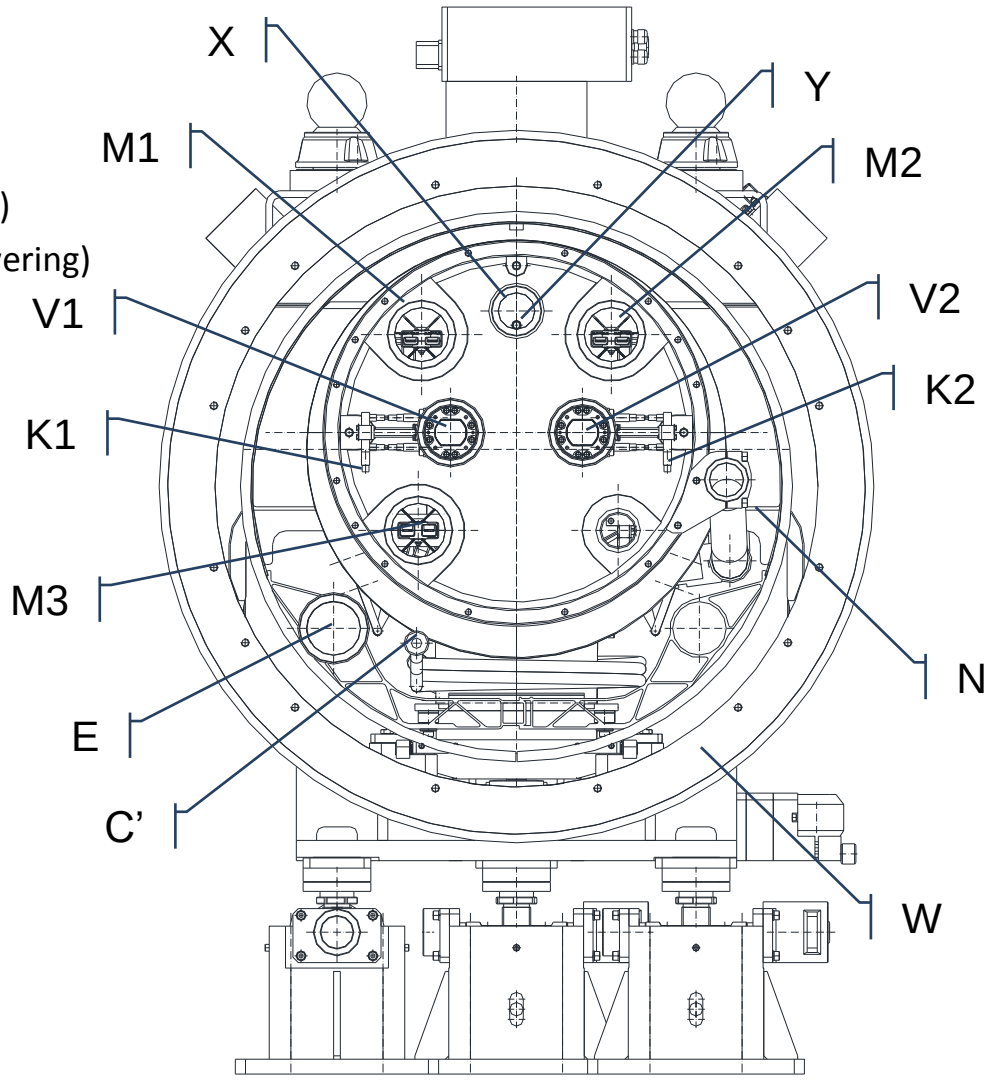
1. M1, M2, M3 and corrector spools (magnet powering)
2. Aux.BB line (line N, only 600 A cables, correctors powering)

Cryogenics:

1. Pressurised HeII bath (line L)
2. Sub-cooled HeII (lines X, y)
3. C’, KD1, KD2 lines (4.5 K) for IR3L; none for IR3R (but needed to thermalise cryostat components)
4. Thermal shield line (line E)

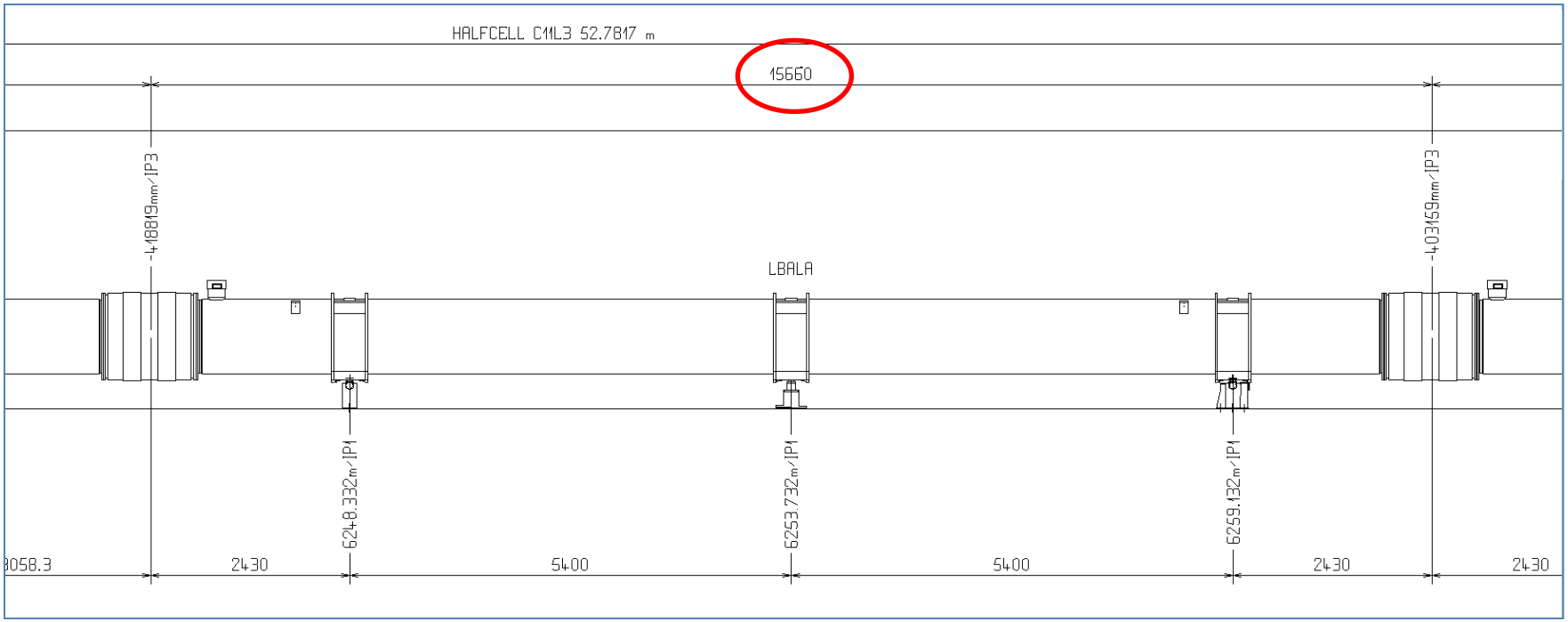
Insulation vacuum:

1. Insulation vacuum (line W)



(courtesy: D.Ramos)

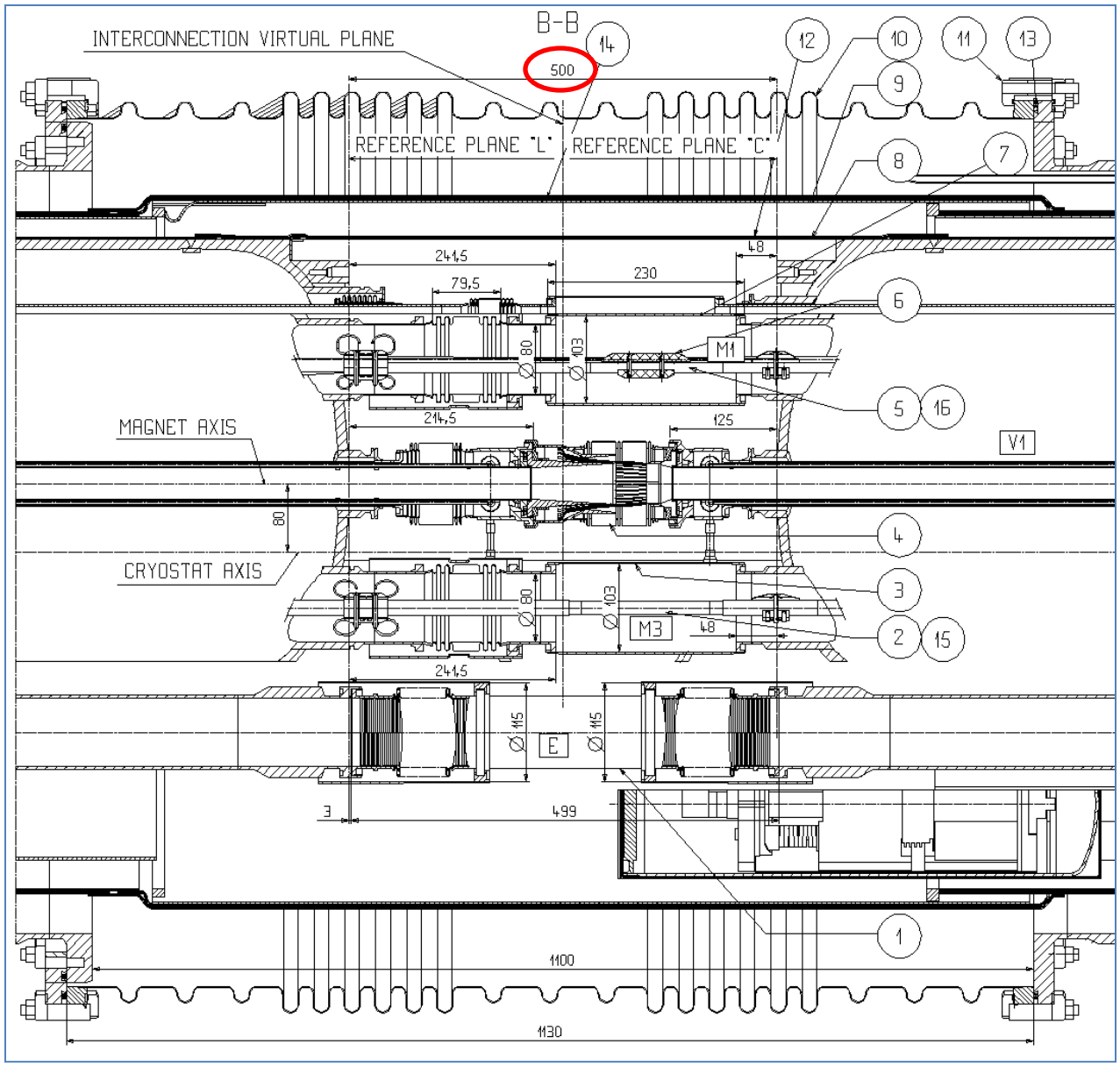
Dipole tunnel integration layout



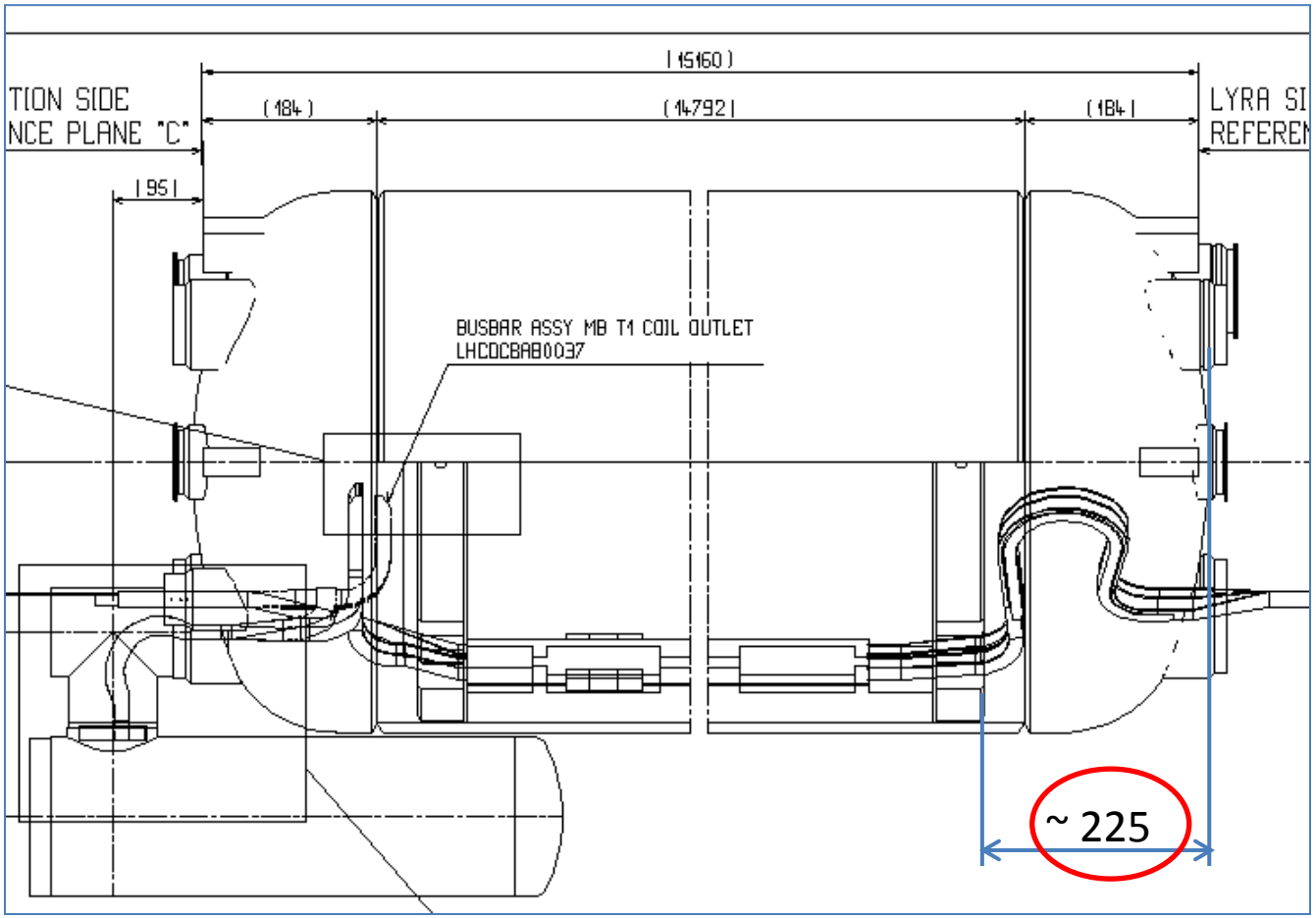
- Remove and replace 1 (or 2) MB
- Possibly preserve standard interconnect

→ 15’660 mm (IC plane to IC plane) space constraint

Dipole-Dipole interconnect

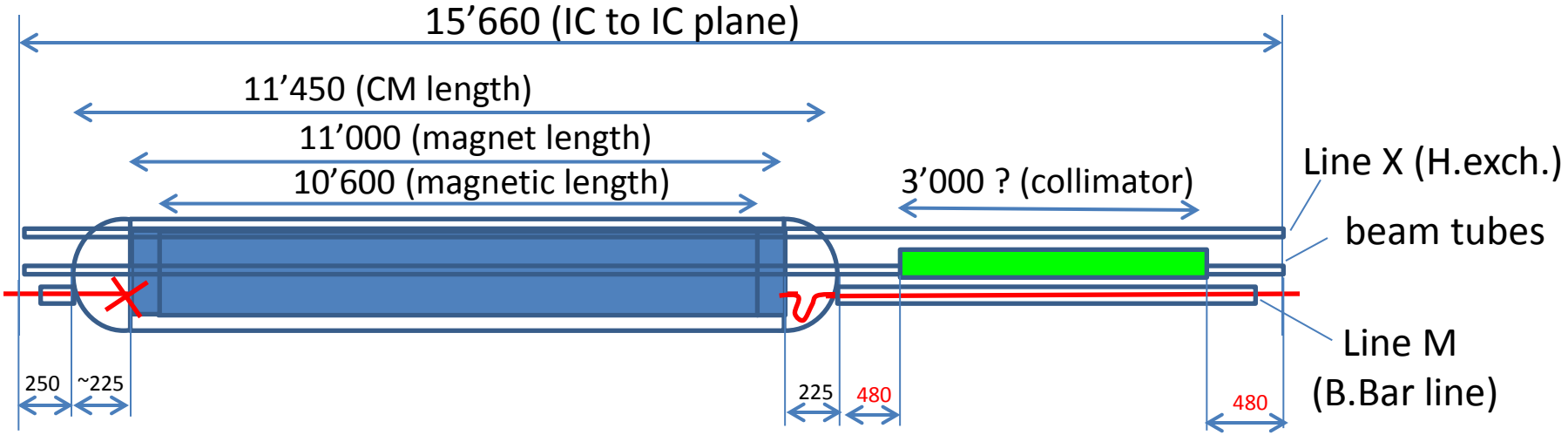


Typical bus bars arrangement in MB



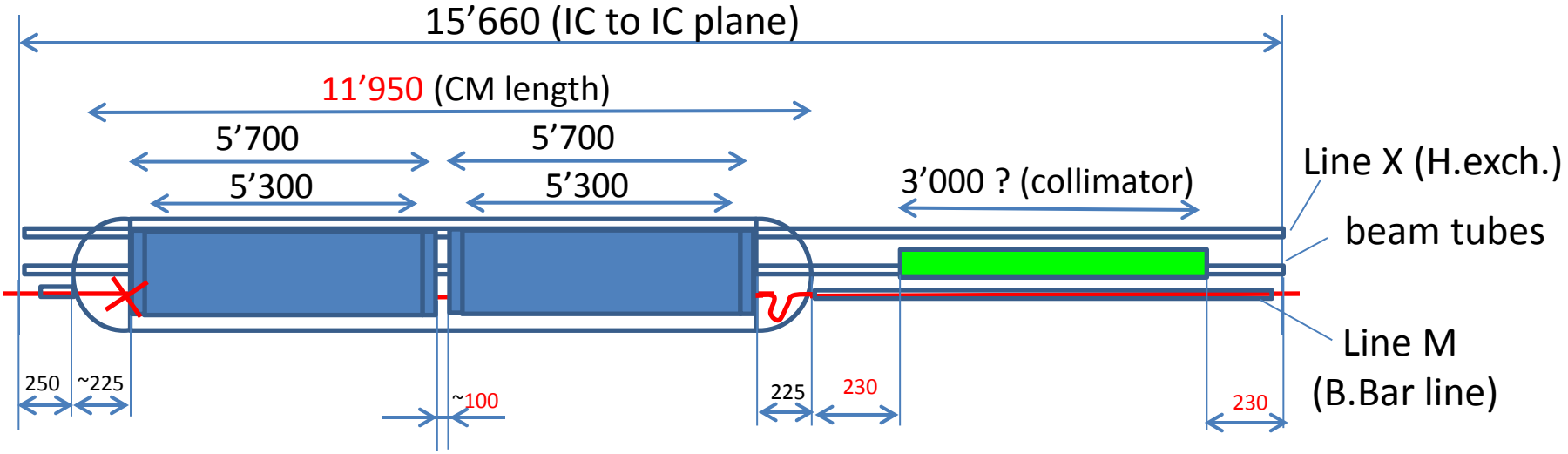
Drwg LHCDCBAB0001

Longitudinal layout (Option 1)



Note: no space included for correctors

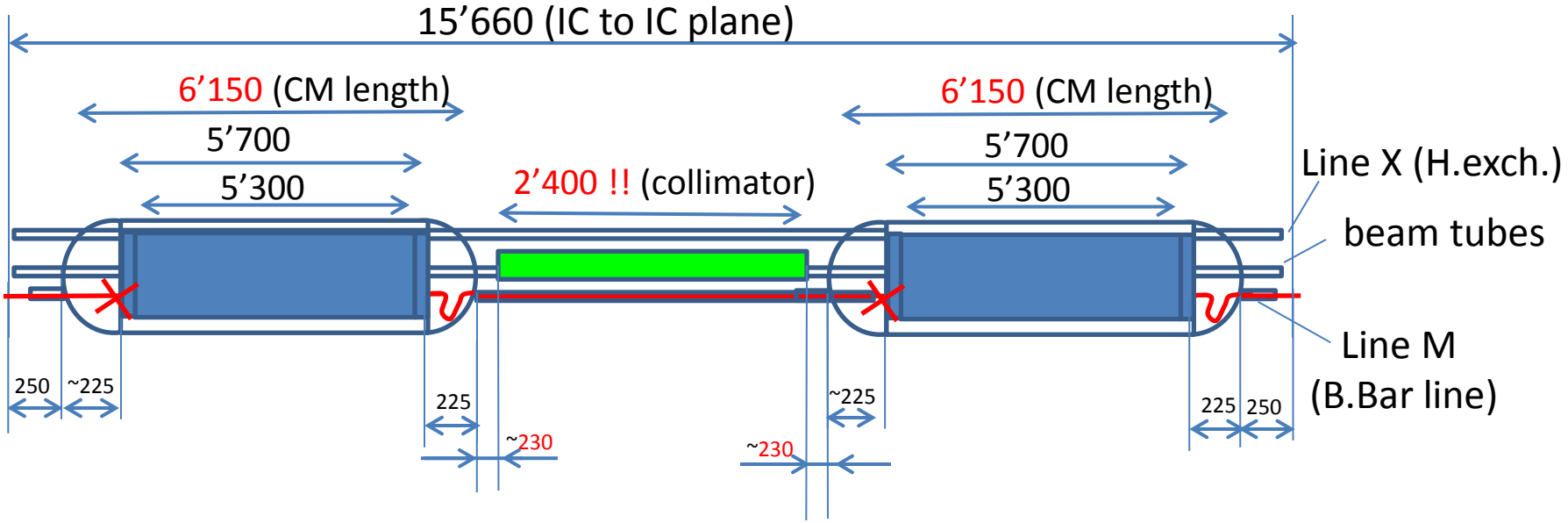
Longitudinal layout (Option 2)



CM is 500 mm longer (2 end plates+connection space)

Note: no space included for correctors

Longitudinal layout (Option 3)

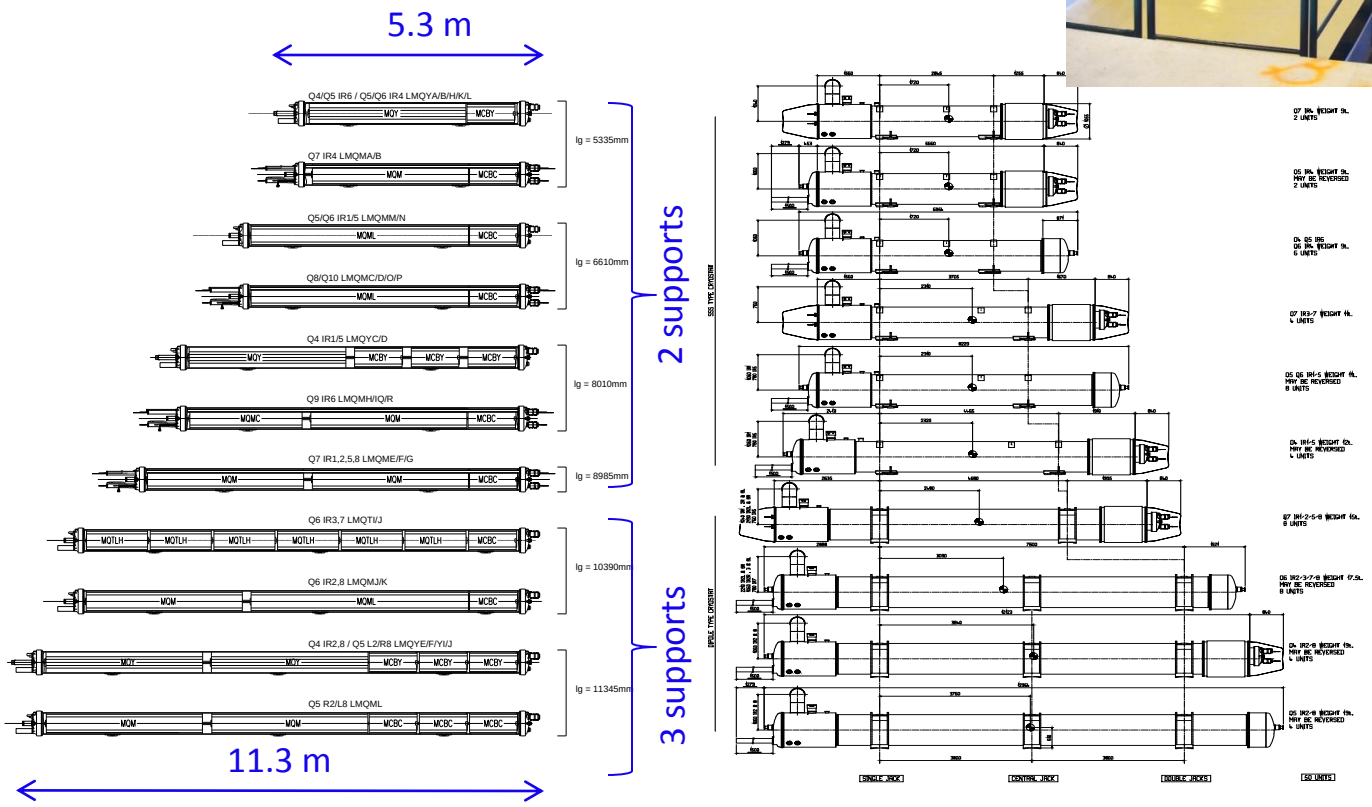


Collimator space reduced by 600 mm (w.r.t option 2)

Note: no space included for correctors

LHC “cryostating” methods

- SSS-type for shorter/lighter cold masses (up to ~ 9 m long):
  - Can be lifted from cold mass ends
  - Cryostat vacuum vessel on 2 cold supports posts
- Dipole-type for longer units (>9m):
  - Cannot be lifted from cold mass ends
  - 2 support posts preferred, whenever possible (isostatic)
  - 3 support posts inevitable for very long cold masses



IR specificities

(J.Ph.Tock)

For Pts 1,3,5,7 : The DS zones are very similar in terms of layout (not studied in details)

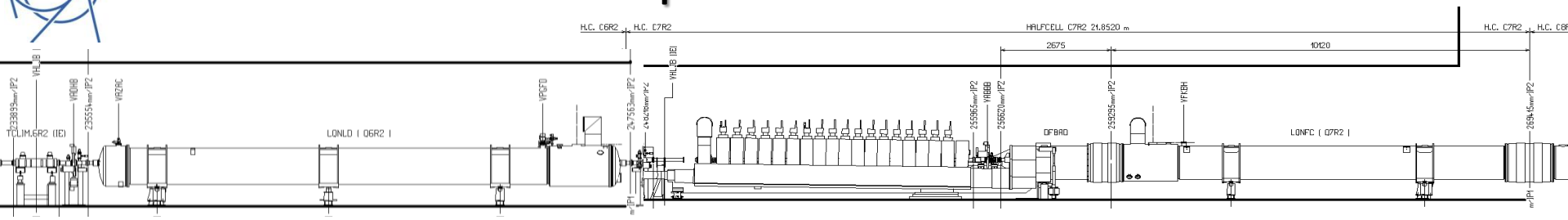
IR3 : Checked and validated ;
See drawings LHCLJ_3U0035 to 0045

IR2 could necessitate a different collimation optics : only one collimator

Left of IR2, there is the injection line and the QRL that are constraining differently the available space

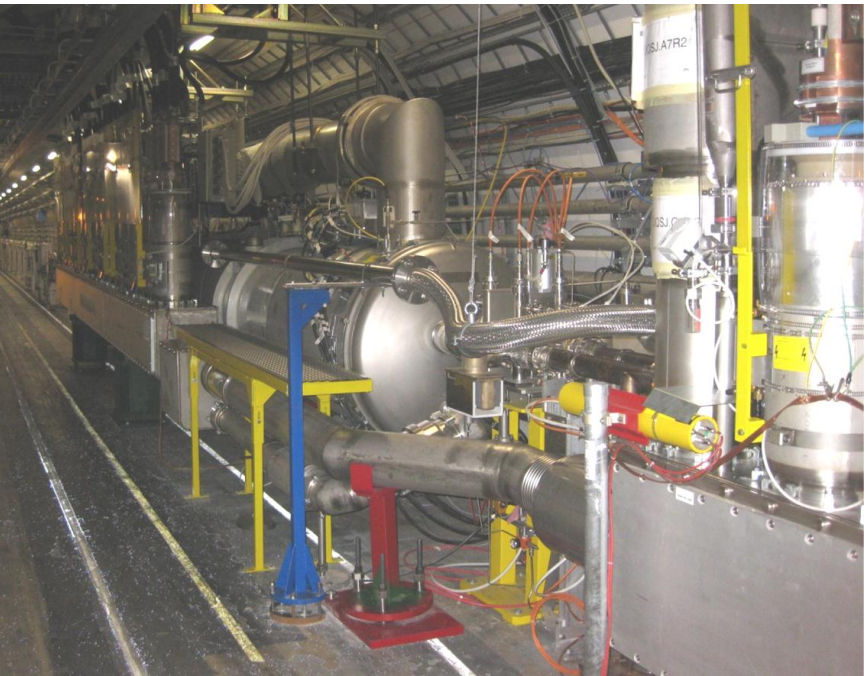
Differences in design, tooling, procedures, …

IR2 specificities



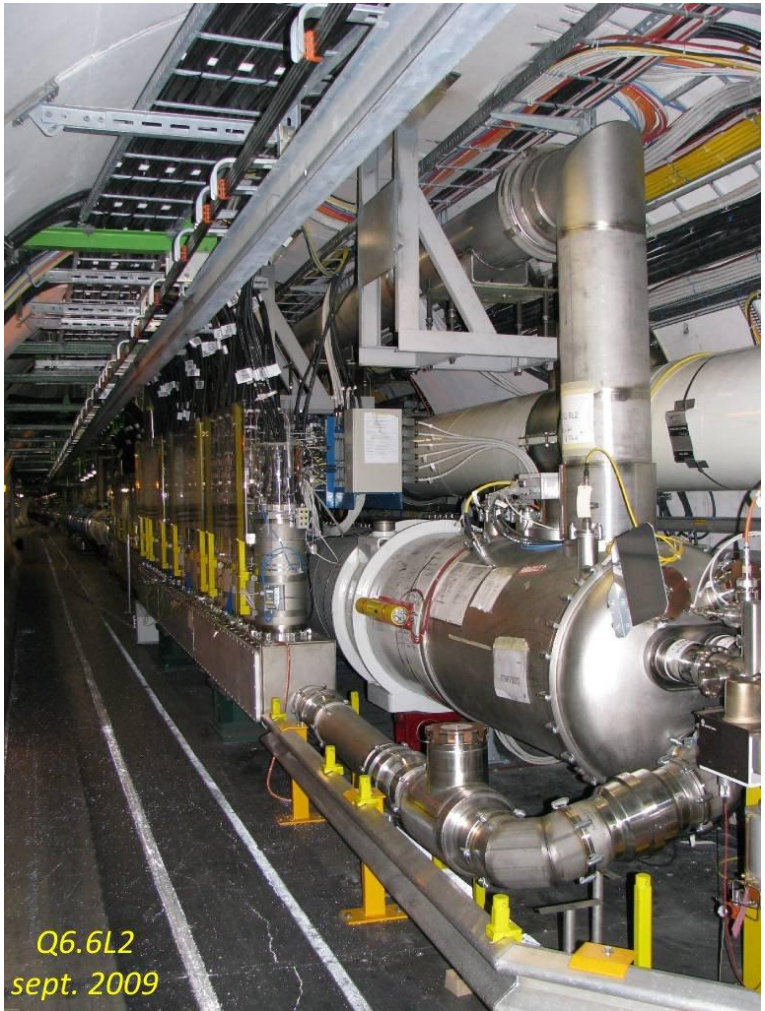
DFBAs at P2 are also feeding Q6 so if cryomagnets have to be displaced, this would be heavier

DSR2



(J.Ph.Tock)

DSL2

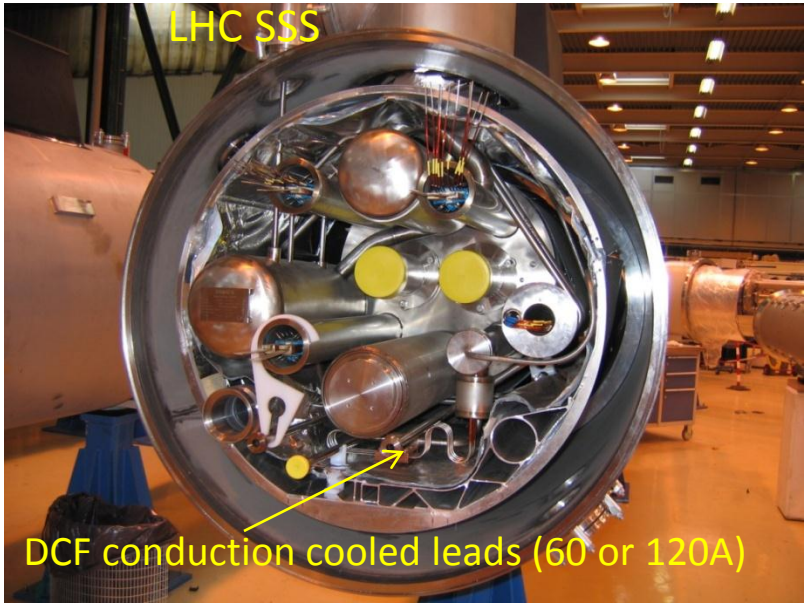


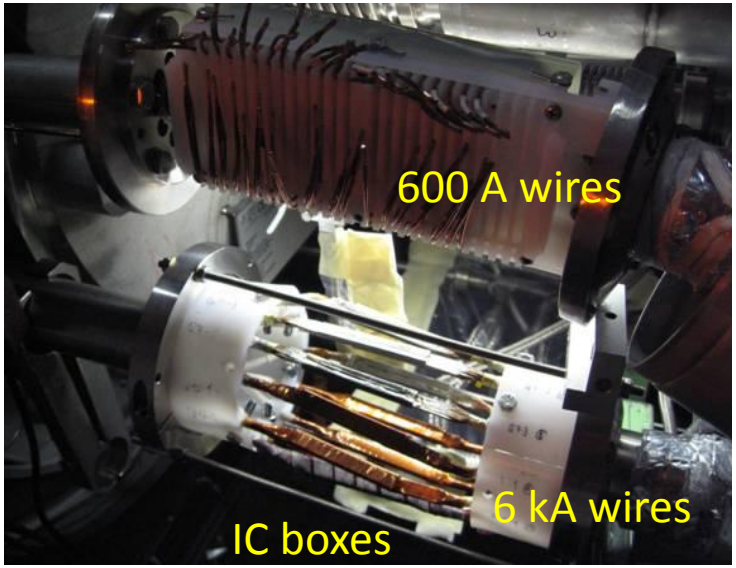
Powering of correctors/trims

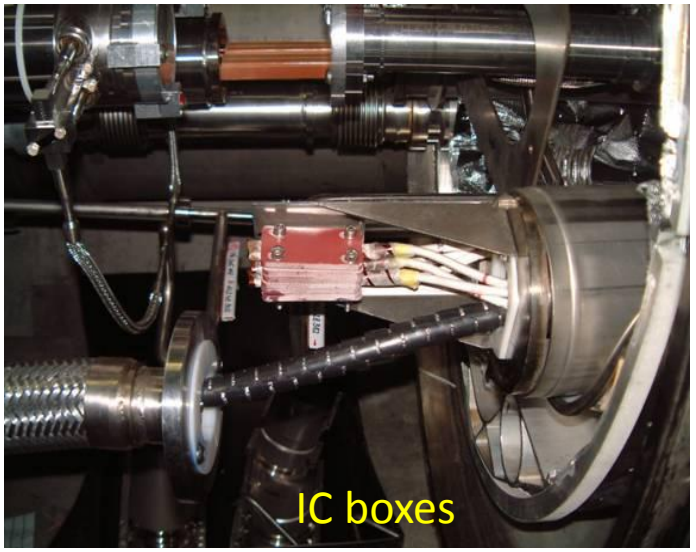
Powering of correctors / trim. 300 to 600 A (?):

- Local feeding (as for DCF in SSS):
  - Conduction cooled leads?
  - Other solutions?

- Via DFBs (or future SC link in IR1,5,7) ?
  - Line N (up to 1 pair of 600 A spares), new IC boxes or new line N bundle
  - or Line M (3 pairs of 600 A spare spool wires)



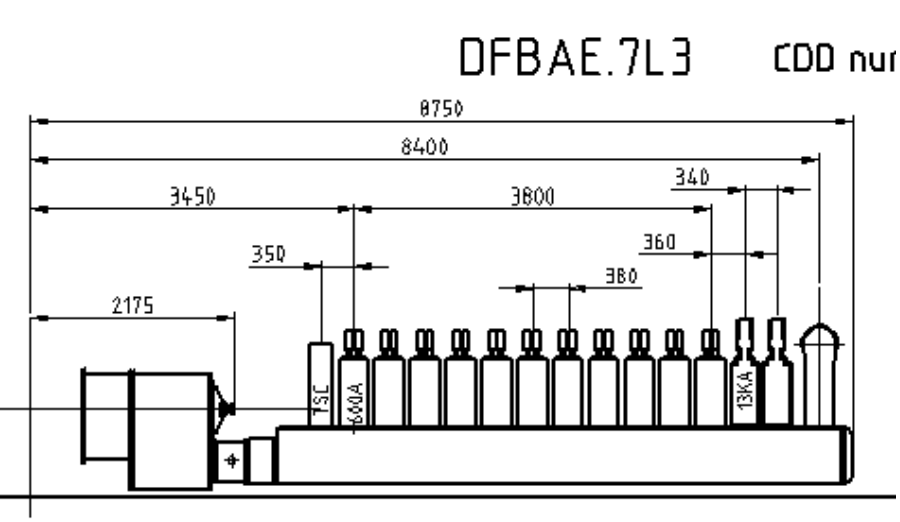


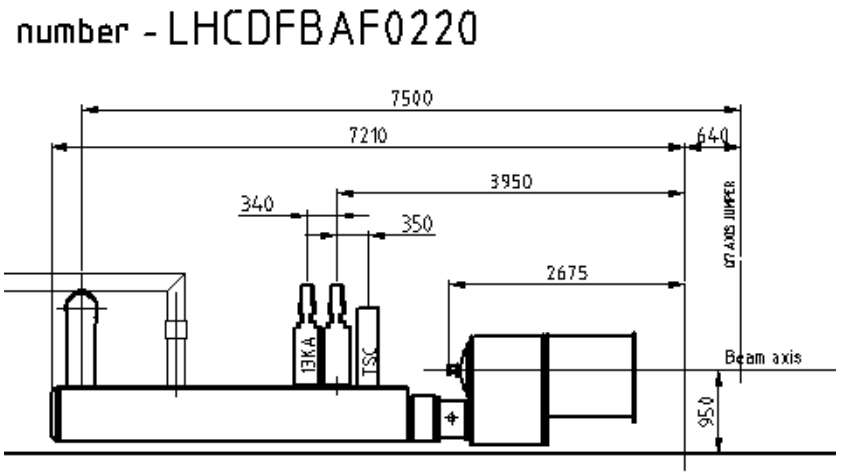


(input J.Ph.Tock)

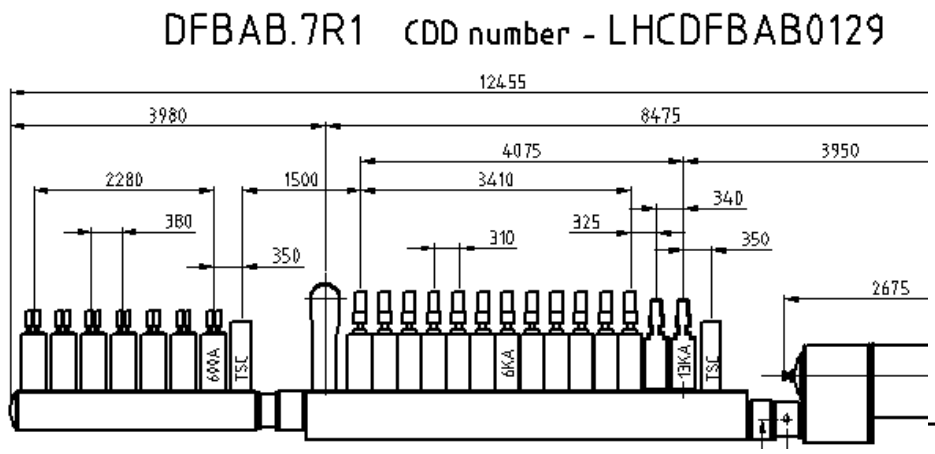
Differences are coming from the DFBA type and the elements on the IR side.

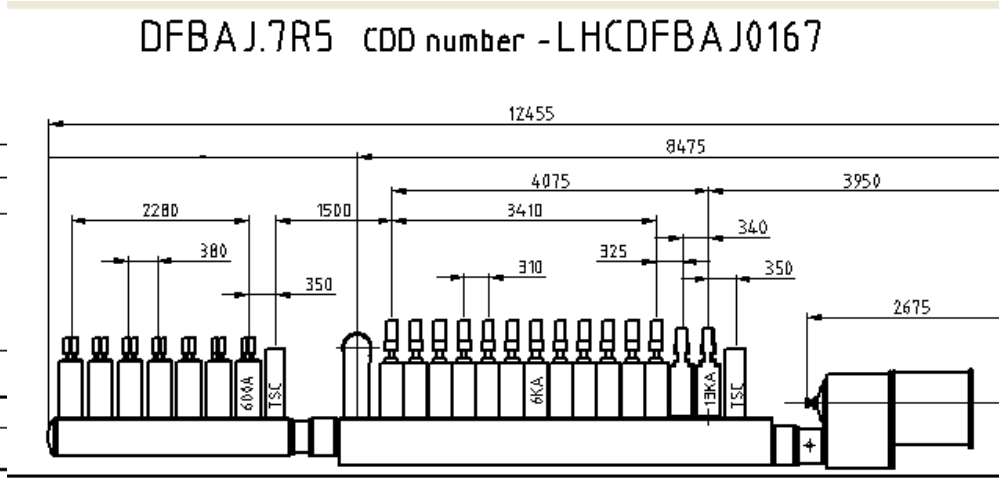
P3 for reference:





P1 (5):

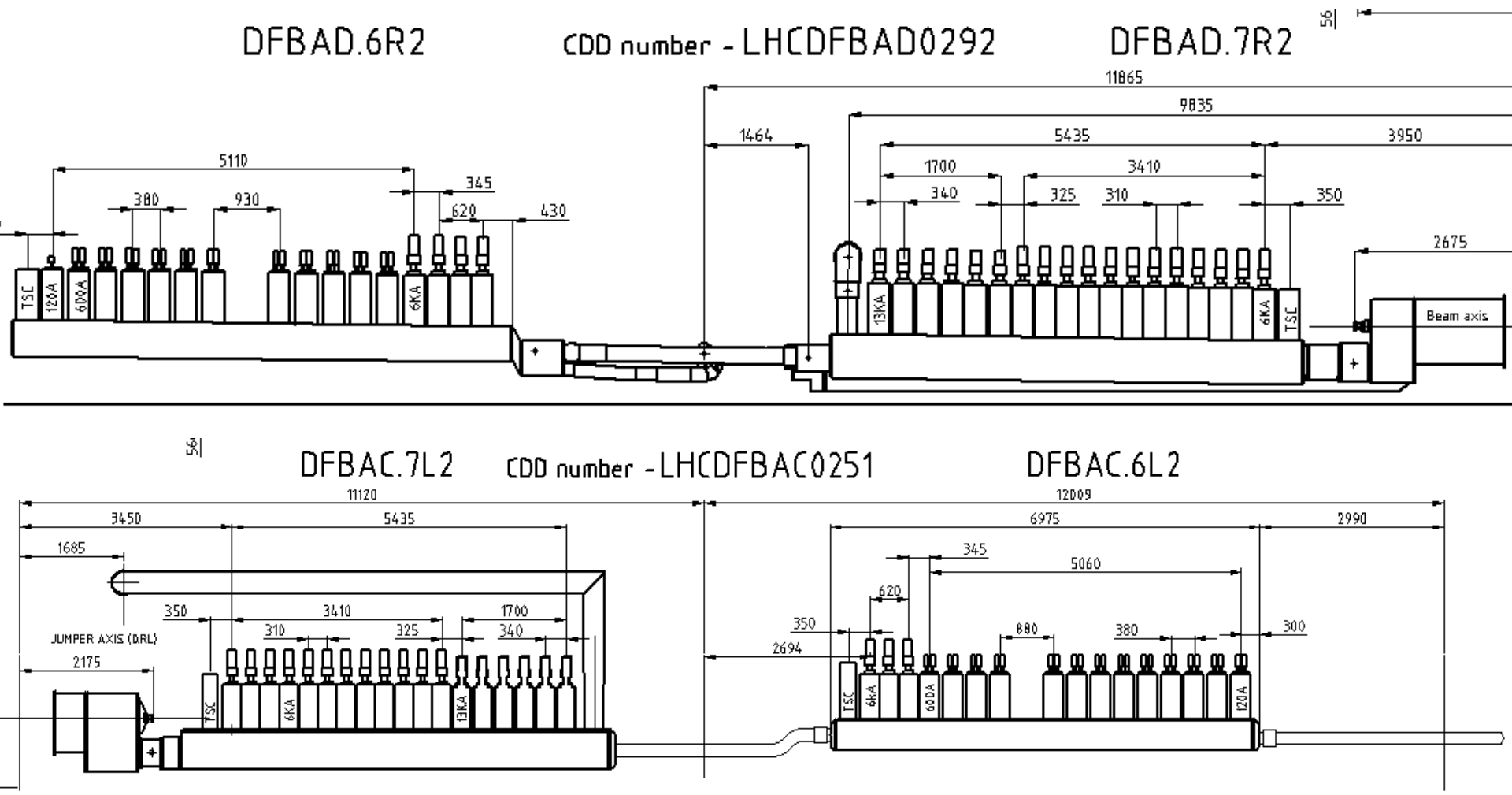




(J.Ph.Tock)

Differences are coming from the DFBA type and the elements on the IR side.

P2 (Very different):



DFBAs at P2 are also feeding Q6 so if cryomagnets have to be displaced, this would be heavier

(J.Ph.Tock)

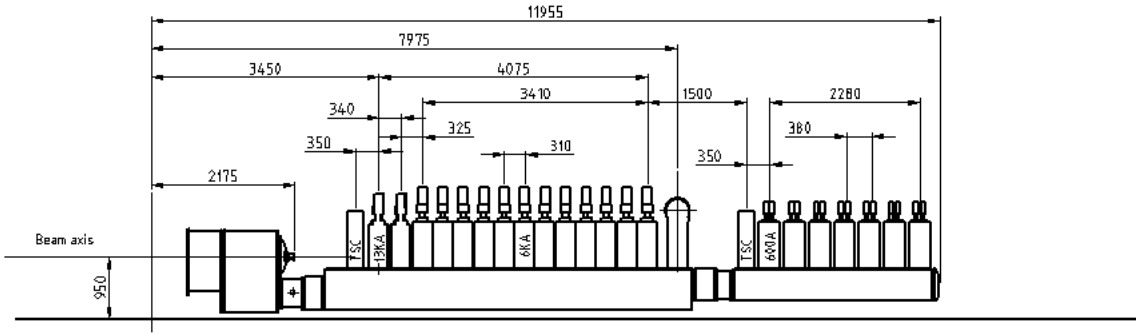
Summary

- CCFS working group has just started (give us time!)
- 5-6 months time to identify (or rule out!) possible show stoppers
- Warm collimator remains an option, to be coupled with 11 T magnet
- Replacement of 1 (or 2) MB → preserve IC to IC space
- Preliminary 11T+collimator layouts show a more compact arrangement with a single CM, but none can be excluded so far
- IR 1,3,5 and 7 are comparable in terms of layout, IR2 is special (QRL and injection line)
- Powering of trims/correctors (300-600A?). Need must be clarified, but options with local feedthroughs or using existing spools and DFBA (modified,or SC links in IR1,5,7), can be investigated

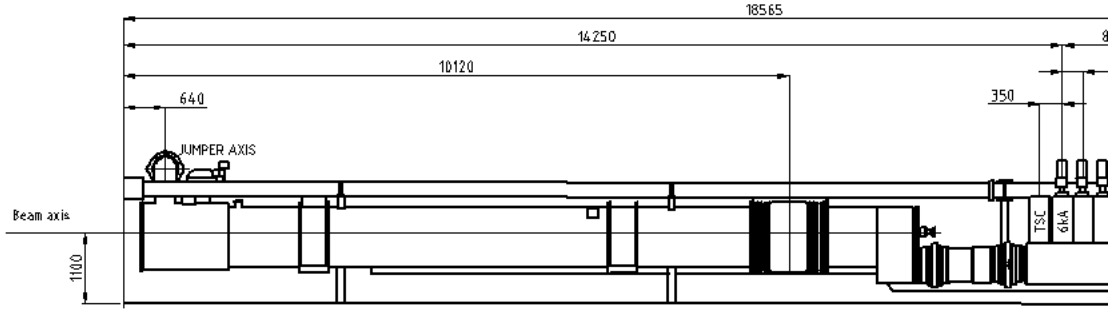
Spare slides

Differences are coming from the DFBA type and the elements on the IR side.

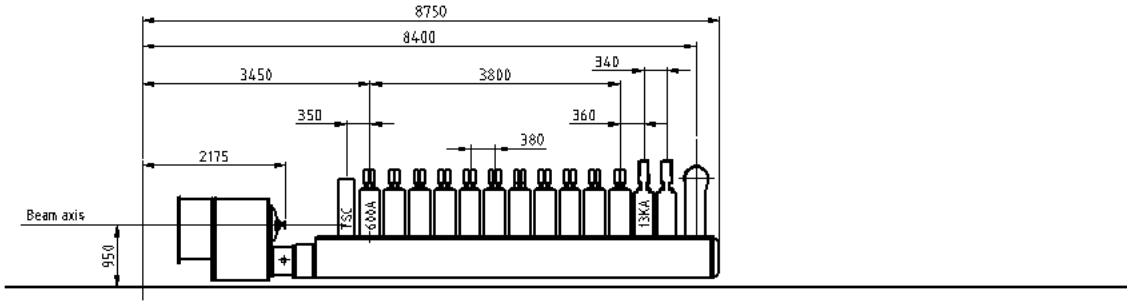
DFBAI.7L5 CDD number - LHCDFBAI0137



DFBAK.5L6 CDD number - LHCDFBAK0328



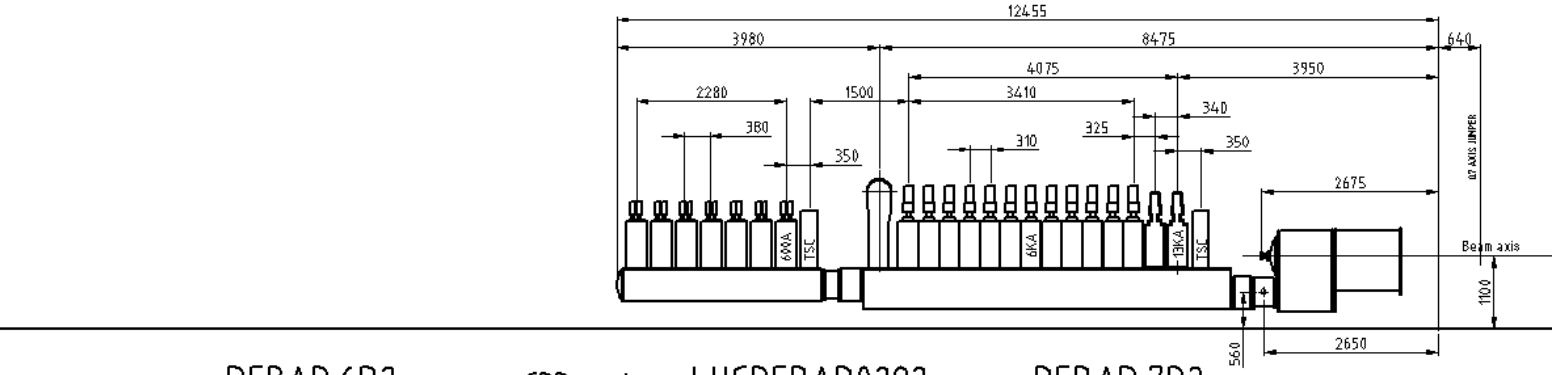
DFBAM.7L7 CDD number - LHCDFBAM0119



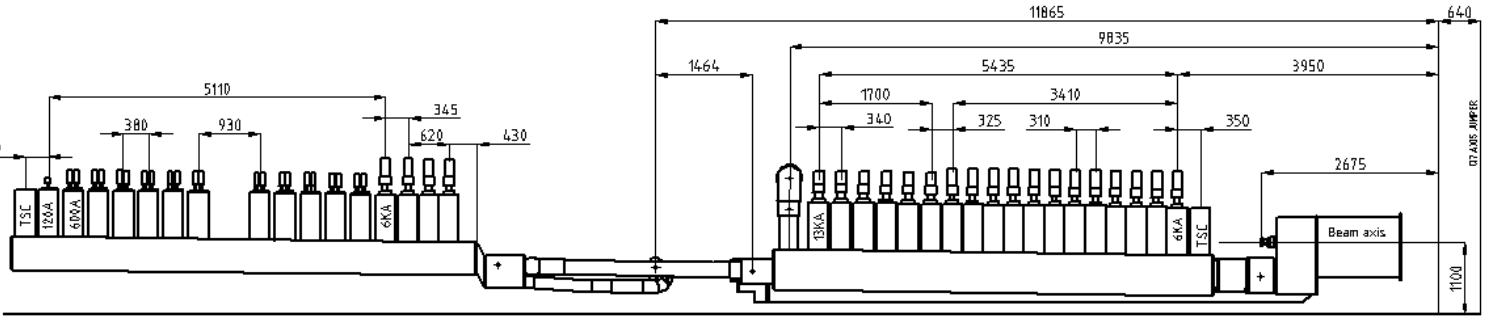
(J.Ph.Tock)

Differences are coming from the DFBA type and the elements on the IR side.

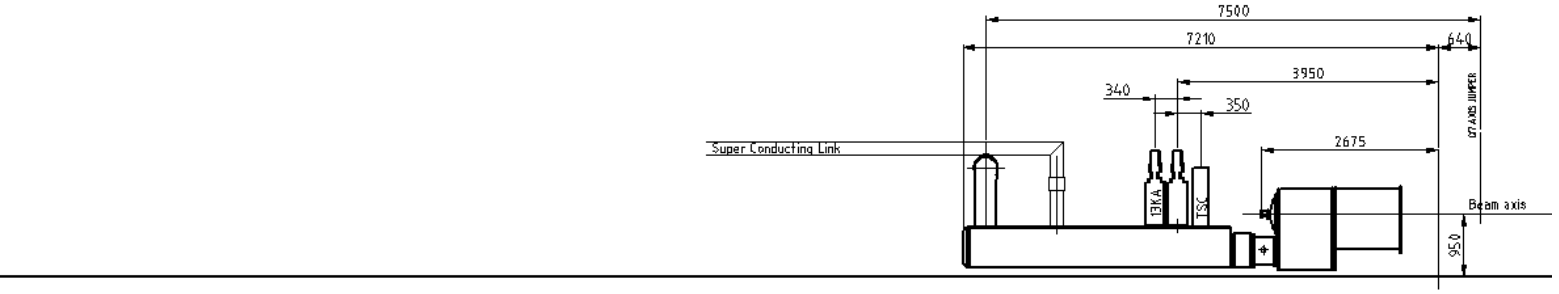
DFBAB.7R1 CDD number - LHCDFBAB0129



DFBAD.6R2 CDD number - LHCDFBAD0292 DFBAD.7R2



DFBAF.7R3 CDD number - LHCDFBAF0220



(J.Ph.Tock)

Differences are coming from the DFBA type and the elements on the IR side.

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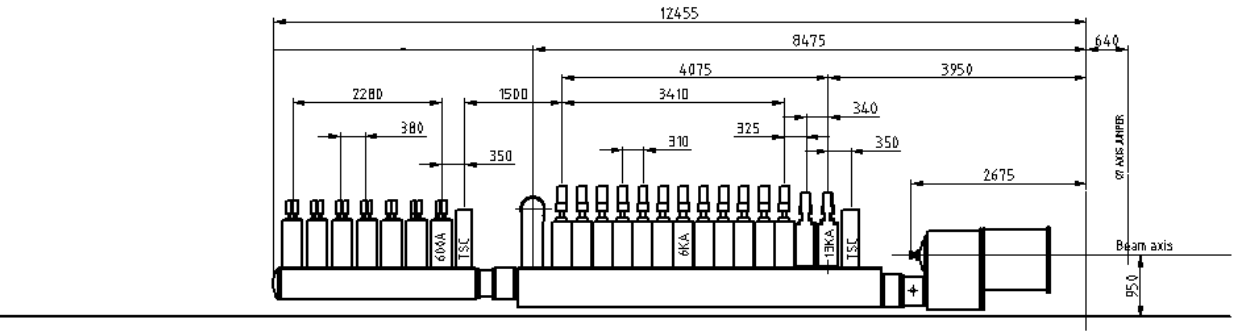
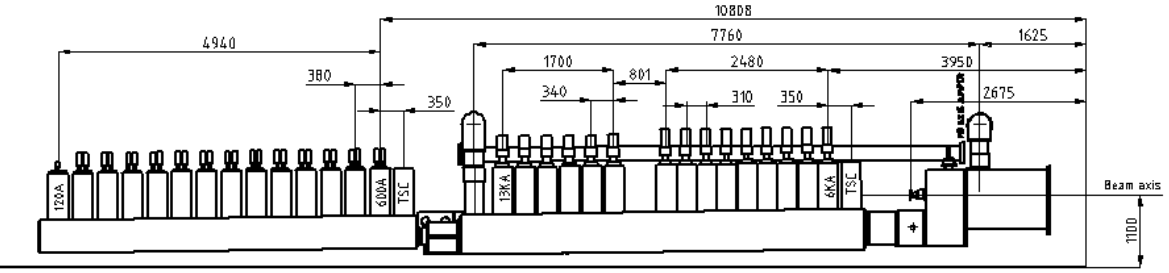
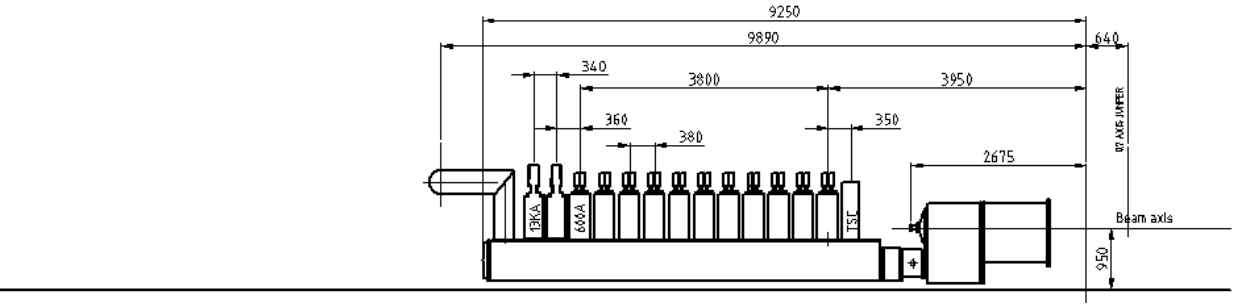


DFBAL.5R6 CDD number - LHCDFBAL0245



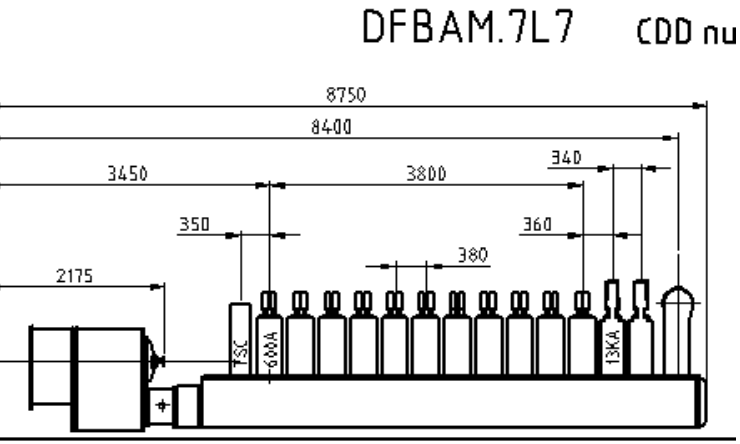
DFBAN.7R7 CDD number - LHCDFBAN0315

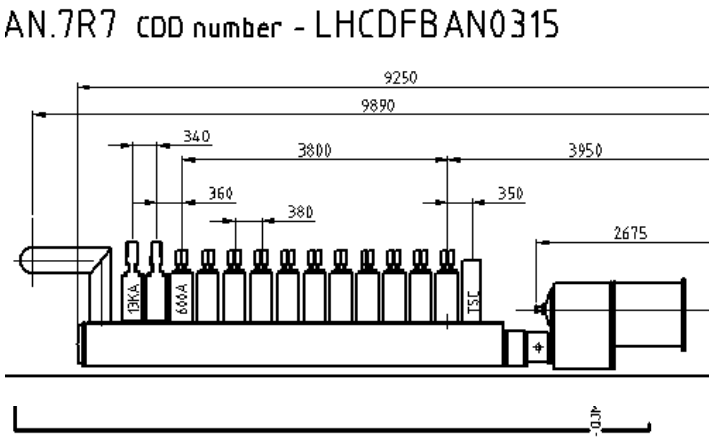


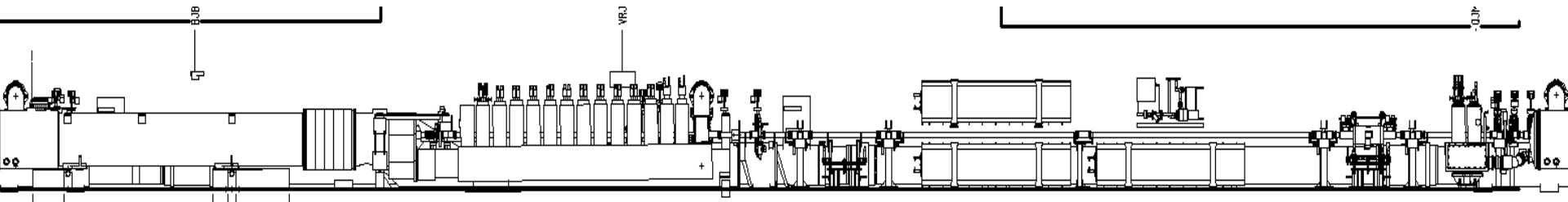
(J.Ph.Tock)

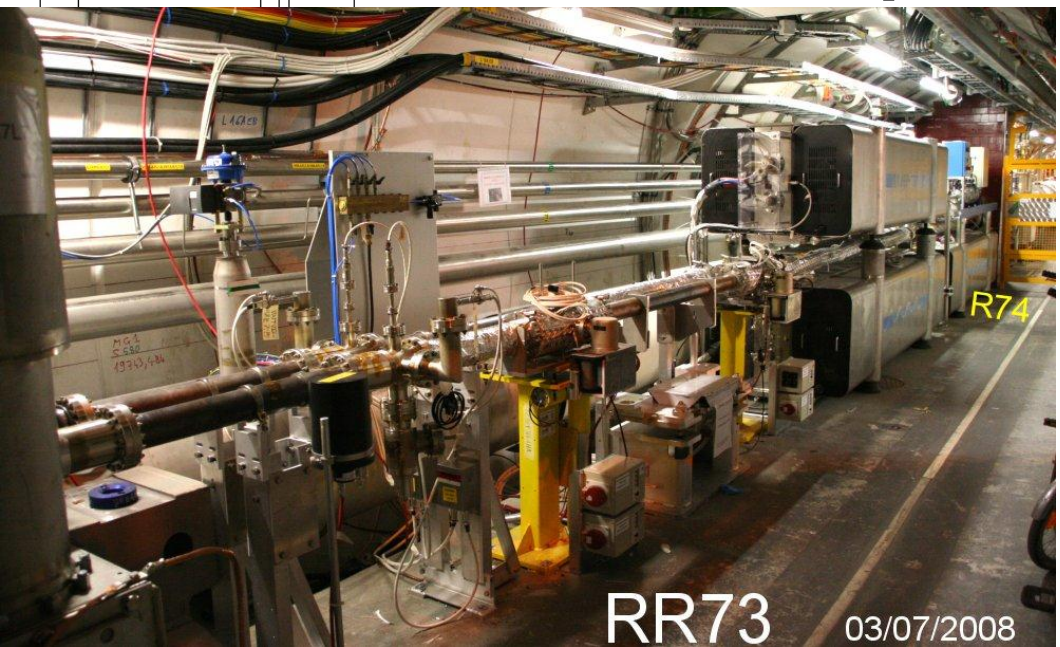
Differences are coming from the DFBA type and the elements on the IR side.

P7 : DFBA OK but space available …









(J.Ph.Tock)