Dispersion-suppressor upgrade in IR3

V.Parma,

CERN, TE-MSC

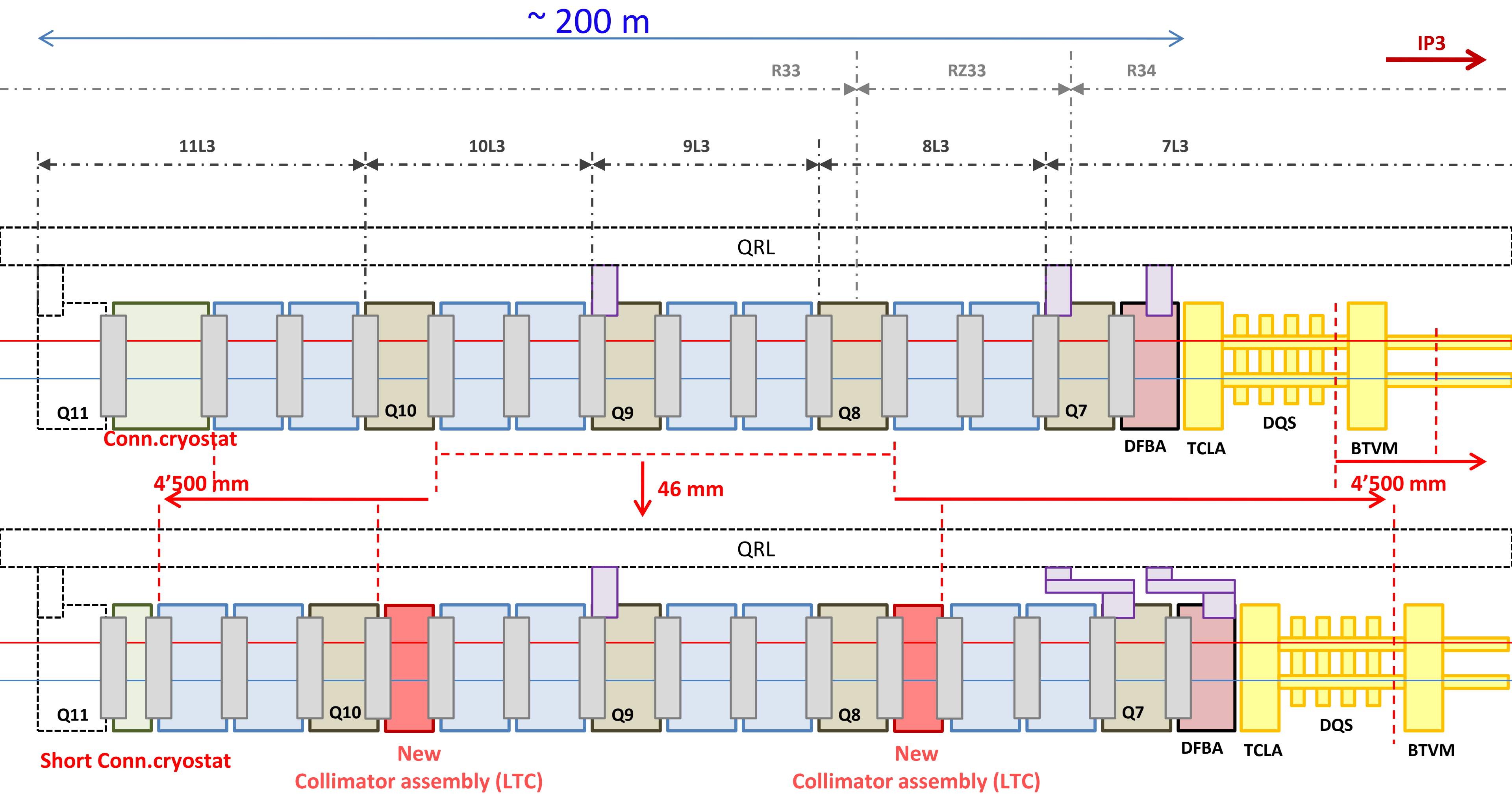
On behalf of the Dispersion Suppressor collimator project team:

R.Assmann, V.Baglin, M.Bajko, P.Bestman, A.Bertarelli, C.Bertone, N.Bourcey, J.Coupard, S.Chemli, K.Dahlerup-Petersen, J.C.Guillaume, Y.Muttoni, D.Ramos, A.Perin, J.Ph.Tock, R.Van Weelderen, A.Vande Craen, R.Principe, A.Rossi, S.Russenchuck, ...and many others

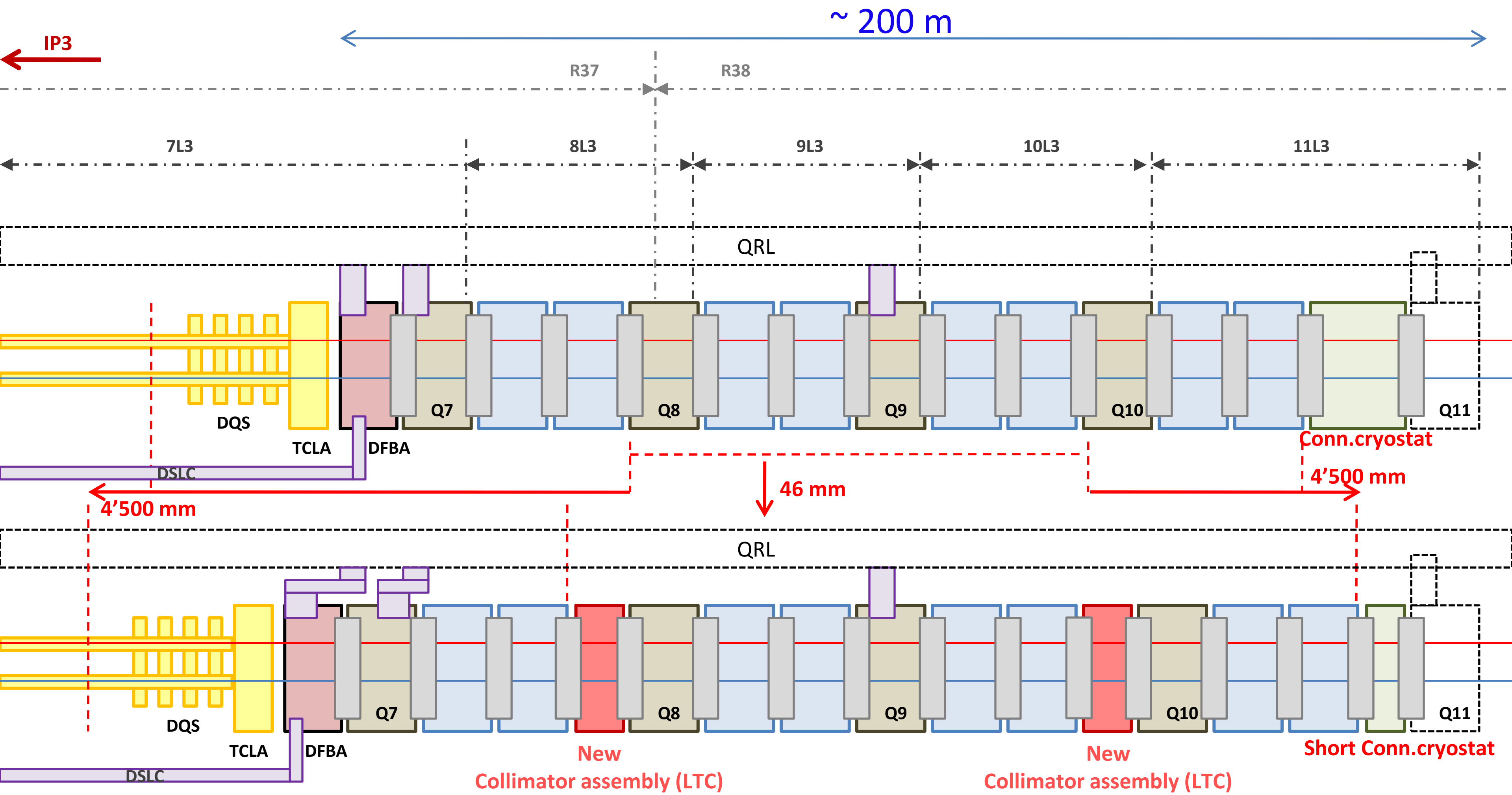
Outline

- DS Collimators in IR3: description, implications
- Organization and cost estimate
- Changes to technical systems (cryogenics, vacuum, powering…)
- Hardware modifications and status:
  - New equipment
  - Tunnel integration issues
- Schedule
- Summary and Outlook

DS collimators: Left side of point 3



DS collimators: Right side of point 3



Work Breakdown Structure

		Responsibles	Auxiliary collimators in DS zone of IR3 TCLD
I	Project Management		
I.1	LHC Collimation Upgrade Management	R.Assmann	x
I.2	LSS Technical coordination	O.Aberle	
I.3	DS Technical coordination	V.Parma	x
I.4	Quality Assurance	A.Rossi	x
I.5	Baseline configuration management and QA	S.Chemli	x
II	Coordination of Installation		
II.1	Scheduling and Coordination	J.Coupard	
II.1.1	Scheduling of surface preparation		x
II.1.2	Scheduling of underground works and installation		x
II.1.3	Coordination on-site		x
II.2	Layout Database	S.Chemli	x
II.3	Integration Office	Y.Muttoni	
II.3.1	Integration studies		x
II.3.2	Installation non conformities		x
II.4	Survey activity	P.Betsmann	
II.4.1	Alignment of machine elements		x
II.4.2	Smoothing of the machine elements		x
II.5	Transport and Handling operation	C.Bertone	x
III	Operation		
III.1	Electrical Quality Assurance	N.Catalan	x
III.2	Hardware commissioning — To be completed ??	O.Aberle & V.Parma	x
III.2.1	Collimators	O.Aberle, A. Masi	
III.2.1.1	10 TCS/TCP		
III.2.1.2	4 TCLD		x
III.2.1.3	2 TCT, removal of 2 TCTVB ?		
III.2.1.4	14 TCTx in IP 1, 2, 5 and 8		
III.2.2	Cryostats & Cryogenics	V.Parma	x
III.3	Remote commissioning / MP tests	A.Rossi & S.Redaelli	x
IV	Safety		
IV.1	Safety Engineering and Environment	C.Colloca	x
IV.2	Radiation Protection	S.Roesler	x

(A.Rossi)

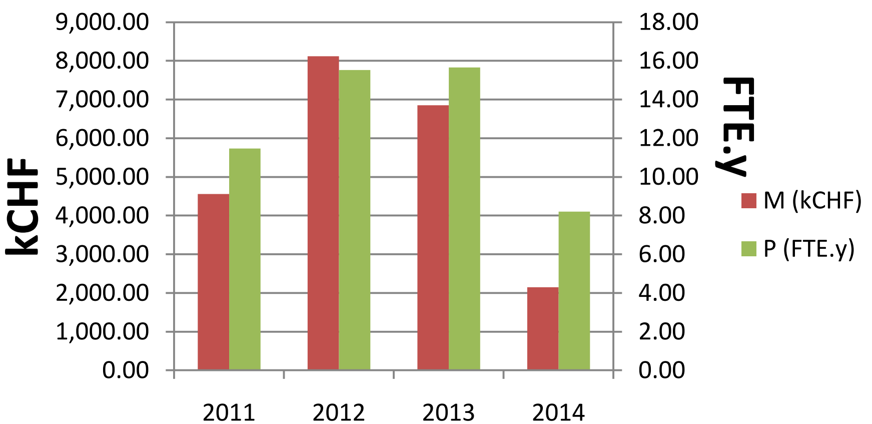
Work Breakdown Organization

V	**Activities**		
V.1	**LHC systems upgrade studies**		
V.1.1	IR3 optics and layout	M.Giovannozzi	x
V.1.2	Impedance from collimators	E.Metral	x
V.1.3	Collimation Performance	A.Rossi	x
V.1.4	Integration and layout studies	Y.Muttoni	x
V.1.5	Cryogenics systems	R.Van Weelderen	x
V.1.6	Vacuum systems	V.Baglin	x
V.1.7	Magnet Electrical systems	K.Dahlerup-Petersen	x
V.2	**LHC equipment Engineering (Design, Production & Testing)**		
V.2.1	**Collimators Engineering and Mfct (before final testing on surface)**	A.Bertarelli	
V.2.1.1	DS collimator module (TCLD with support)		x
V.2.1.2	TCT with integrated BPM (TCTP)		
V.2.1.3	Phase 1+ Collimators (TCP - TCSG)		
V.2.1.4	Phase 2 Collimators (TCSM)		
V.2.1.5	FLUKA studies	F.Cerutti	x
V.2.2	**Collimators manufacturing external to CERN (contracts)**	O.Aberle	
V.2.2.1	Contract for 6 TCSG (plan A)		
V.2.2.2	Contract for 18 TCTP		
V.2.2.3	Contract for 34 TCSM Phase 2 collimators		
V.2.3	**Collimators final assembly and testing before installation (B 252)**	O.Aberle, A. Masi	x
V.2.3.1	10 TCS/TCP + 3 spares		
V.2.3.2	4 + 1 TCLD		
V.2.3.3	2 TCT for Alice		
V.2.3.4	18 TCTP		
V.2.4	**DS Cryostat Equipment Eng & Mfct**		
V.2.4.1	Short Connection Cryostat (LE)	J.Ph.Tock	x
V.2.4.2	DS collimator bypass cryostat (QTC)	A.Bertarelli	x
V.2.4.3	Bus-bars	R.Principe	x
V.2.4.4	Cryo-magnets interconnection components	J.P.Tock	x
V.2.5	**Cold powering tests (SM18)**	M.Bajko	x
V.2.5.1	QTC Cold testing		
V.2.5.2	SCC Cold testing		
V.2.6	**Cryogenics equipment**		
V.2.6.1	Modification of DFBA	A.Perin	x
V.2.6.2	Cryogenic line exstensions	O.Pirotte	x
V.2.6.3	SSS modifications (instrumentation & PID)	R.Van Weelderen	x
V.2.7	**Vacuum equipment**		
V.2.7.1	Beam vacuum	V.Baglin	x
V.2.7.2	Insulation vacuum	P.Cruikshank	x
V.2.7.3	Control	P.Gomes	x
V.2.8	**Transport system**		

(A.Rossi)

Cost Estimate (P+M)

Department/Group	WP name	WP responsible		2011	2012	2013	2014	Totals: M Cost [kCHF]	Totals: Staff [FTE.y]
TE/MSC	DS collimators Technical Coordination	V.Parma	Total M [kCHF]	0.00	0.00	0.00	0.00	0.00	
			Total P [FTE.y] - staff/fellows	0.5	0.5	0.7	0.5		2.2
EN/MEF	Configuration management and QA	S.Chemli	Total M [kCHF]	0.00	0.00	0.00	0.00	0.00	
			Total P [FTE.y] - staff/fellows	0.15	0.15	0.15	0.15		0.6
EN/MEF	Planning, Layout and Integration	J.Coupard	Total M [kCHF]	51.00	34.00	34.00	34.00	153.00	
			Total P [FTE.y] - staff/fellows	0.2	0.4	0.4	0.3		1.3
TE/CRG	Modifications and new cryogenics systems/equipment DS	R.Van Weldereen	Total M [MCHF]	130.00	460.00	560.00	570.00	1,720.00	
			Total P [FTE.y] - staff/fellows	0.6	1.1	1.1	1.1		3.9
TE/VCS	Modifications and new vacuum systems/equipment DS	V.Baglin	Total M [kCHF]	746.87	1,218.06	179.58	42.45	2,186.95	
			Total P [FTE.y] - staff/fellows	0.4	1.4	2.4	1.2		5.4
TE/MPE	QPS modifications and new systems	K.Dahlerup-Petersen	Total M [kCHF]	0.00	0.00	20.00	0.00	20.00	
			Total P [FTE.y] - staff/fellows	0	0.1	0.1	0		0.2
EN/EL	Modifications of Electrical System and Cabling	J.C.Guillaume	Total M [kCHF]	0.00	50.00	800.00	100.00	950.00	
			Total P [FTE.y] - staff/fellows	0.3	0.3	0.3	0		0.9
EN/CV	Modification of CV system	M.Nonis	Total M [MCHF]	0.00	0.00	0.00	0.00	0.00	
			Total P [FTE.y] - staff/fellows	0	0	0	0		0
EN/MME	Engineering, Design & Manufacture of DS collimators (4+1)	A.Bertarelli	Total M [kCHF]	2,167.00	1,601.00	396.00	0.00	4,164.00	
			Total P [FTE.y] - staff/fellows	5.46	4.83	2.45	0		12.74
TE/MSC	Supply of special components to EN/MME	P.Fessia	Total M [kCHF]	544.00	544.00	272.00	0.00	1,360.00	
			Total P [FTE.y] - staff/fellows	1	1	0.5	0		2.5
TE/MSC	Engineering, Design & Manufacture of Short Connection Crystats (2+1)	J.Ph.Tock	Total M [kCHF]	760.00	2,725.00	760.00	0.00	4,245.00	
			Total P [FTE.y] - staff/fellows	1.3	1.8	0.5	0		3.6
TE/MSC	Tunnel IC work and components	J.Ph.Tock	Total M [kCHF]	50.00	326.00	1,281.00	625.00	2,282.00	
			Total P [FTE.y] - staff/fellows	0.5	1.1	3.1	3.1		7.8
TE/MSC	Cold power testing of cryostat assemblies	M.Bajko	Total M [kCHF]	50.00	200.00	200.00	0.00	450.00	
			Total P [FTE.y] - staff/fellows	0	1	1	0		2
TE/MPE	Modifications to magnet electrical circuits, ELQA	N.Catalan Lasheras	Total M [kCHF]	0.00	600.00	600.00	200.00	1,400.00	
			Total P [FTE.y] - staff/fellows	0.5	0.5	0.5	0.5		2
BE/BI	Modification to existing and new beam instrumentation	B.Dehning	Total M [kCHF]	0.00	0.00	0.00	0.00	0.00	
			Total P [FTE.y] - staff/fellows	0	0	0	0		0
GS/SE	Civil engineering modifications	J.Osborne	Total M [kCHF]	0.00	0.00	100.00	0.00	100.00	
			Total P [FTE.y] - staff/fellows	0.15	0.15	0.15	0		0.45
EN/HE	Transport and handling assistance	C.Bertone	Total M [kCHF]	55.00	359.00	1,596.00	558.00	2,568.00	
			Total P [FTE.y] - staff/fellows	0.4	1.2	2.3	1.35		5.25
BE/ABP	Alignment and Survey	P.Bestman	Total M [kCHF]	0.00	0.00	50.00	17.00	67.00	
			Total P [FTE.y] - staff/fellows	0	0	0	0		0
			Overall Total M [kCHF]	4,553.87	8,117.06	6,848.58	2,146.4[illegible]	21,665.95	
			Overall Total P [FTE.y] -	11.46	15.53	15.65	8.2	0	50.84



Up to date, M expenditures:

- < 3 MCHF (estimate)
- Includes design studies (also committed)
- Components/materials ordered (end caps, supports, raw material…)

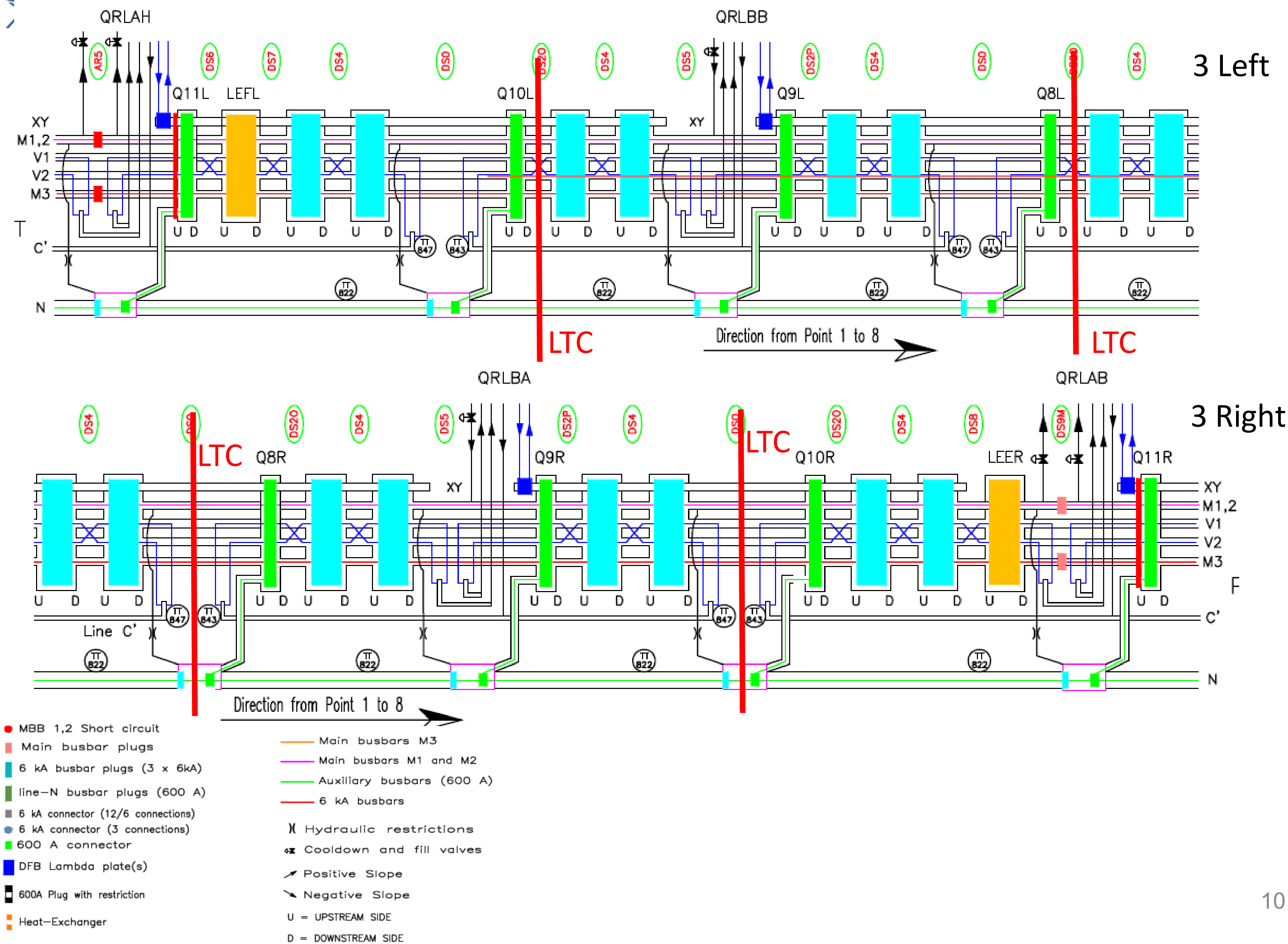
Main H/W implications (3L+3R)

- Disconnect and remove:
  - 16 dipoles, 8 SSS, 2 Connection Cryostats, 2 DFBA
- Displace by 4.5 m:
  - TCLA, DQS, BTVM (3L only)
- Important cable re-layout work:
  - ~600 cables to be shortened, ~800 cables to be extended (warm and cooled cables)
  - Re-routing (through new cable duct UP33/R34); connections
- Civil engineering:
  - Remove, displace and fix jacks to ground
  - Grind passage wall (3-5 cm) on 2x100m length
  - Drilling new cable duct UP33/R34
- Modification of jumpers of Q7, Q9 and DFBAs (on surface or in the tunnel)
- Shortening of DSLC (cryostat+superc.cables) in 3R
- Produce new equipment:
  - 4 (+1) DS collimator assemblies (LTC)
  - 2 (+1) Short Connection Cryostats (SCC)
  - 2 QRL extensions
- Re-install and interconnect DFBA, magnets, SCC, LTC

Strategic choices for new H/W

- Reuse of all possible existing component designs and technology (no R&D!):
  - Minimise risk of unexpected problems
  - Reduce design effort
  - Use *on-the-shelf* LHC spares (cryostat, vacuum, cold mass components)
  - Reduce procurement lead-time
  - Activate options on LHC contracts (e.g. End-caps, support posts)
- Keep interconnects standard
  - Standard tunnel installation (tools, assembly procedures, QA)
- Test both QTC and SCC in operating conditions in SM18 (cold power tests)
- Preparation for tunnel integration in SMI2 (as for magnets)
- Installation of collimators *in-situ* (can be staged) after installation of QTC
- Collimator integration compatible with “fast” removal if faulty (as for other collimators) and bridging with warm beam tubes

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



Systems to be "bridged" and "extended"

Maintain functional continuity to:

Beam lines (beam vacuum):

1. V1, V2

Electrical powering:

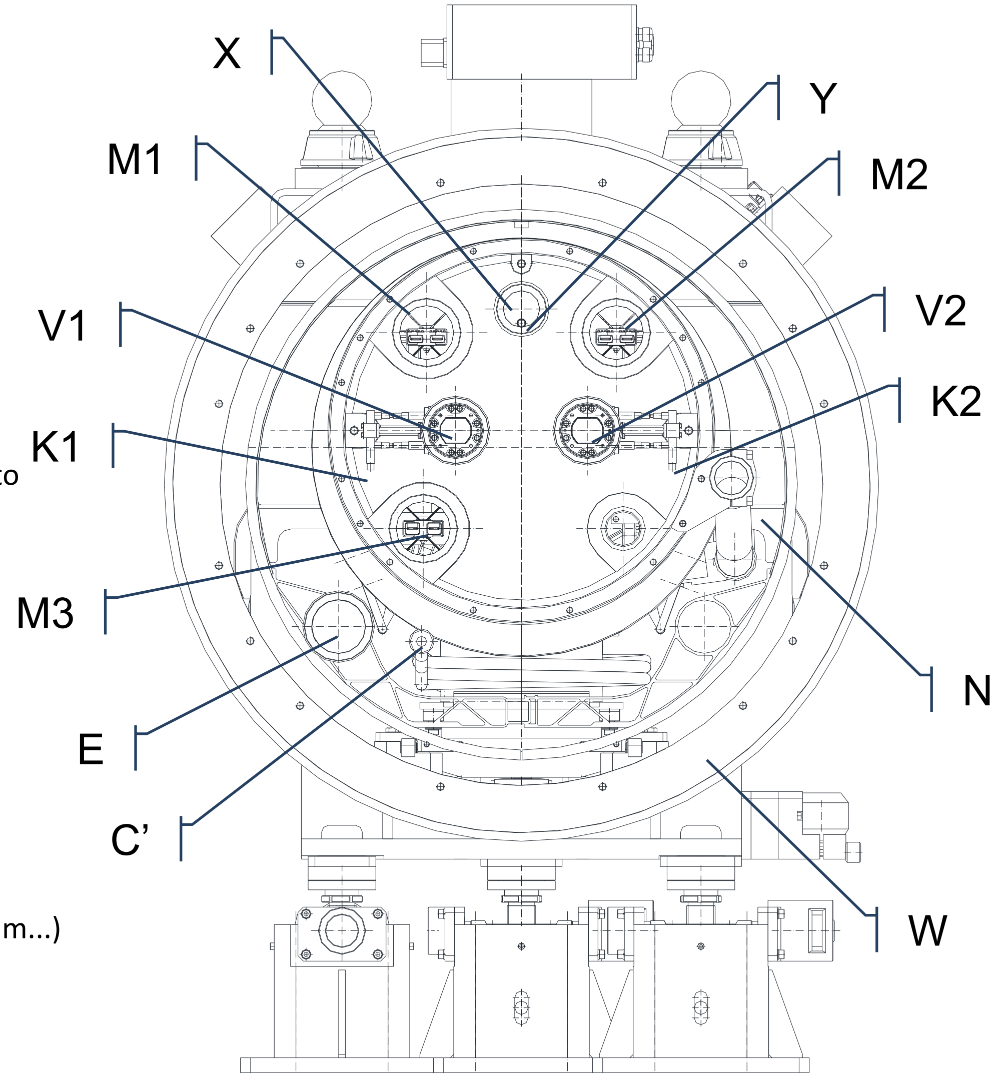
1. M1, M2, M3 and corrector spools (magnet powering)
2. Aux.BB line (line N, only 600 A cables, correctors powering)

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)



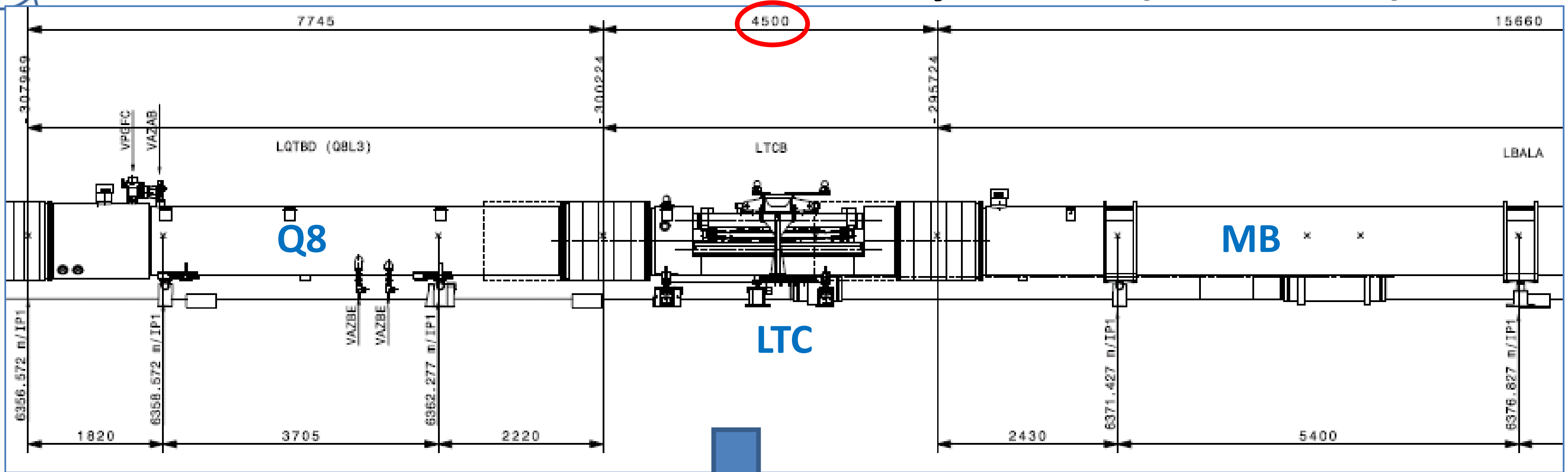
While extending the continuous cryostat:

1. New optics (J.M. Jowett, ABP-LCU meeting, 19/10/2010)
2. Longer and new circuits (electrical, cryogenic, vacuum)
3. Displace interfering equipment (e.g. BTVM)
4. Re-match interfaces with systems (electrical, cryogenic, vacuum...)

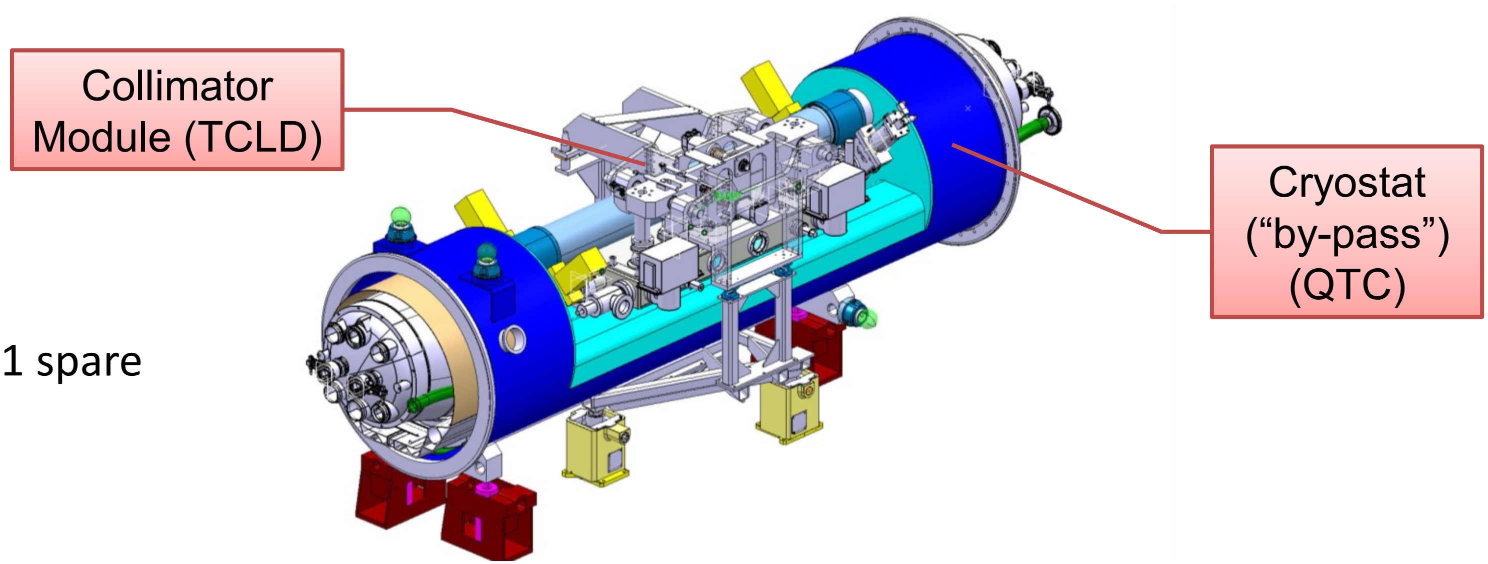
Functionalities reviewed in the **Review of the cryogenic by-pass for the LHC DS collimators (May 2011)**→ **Outcome presented by Ph.Lebrun in the next presentation**

New Equipment

DS Collimator Assembly, LTC (4 units)

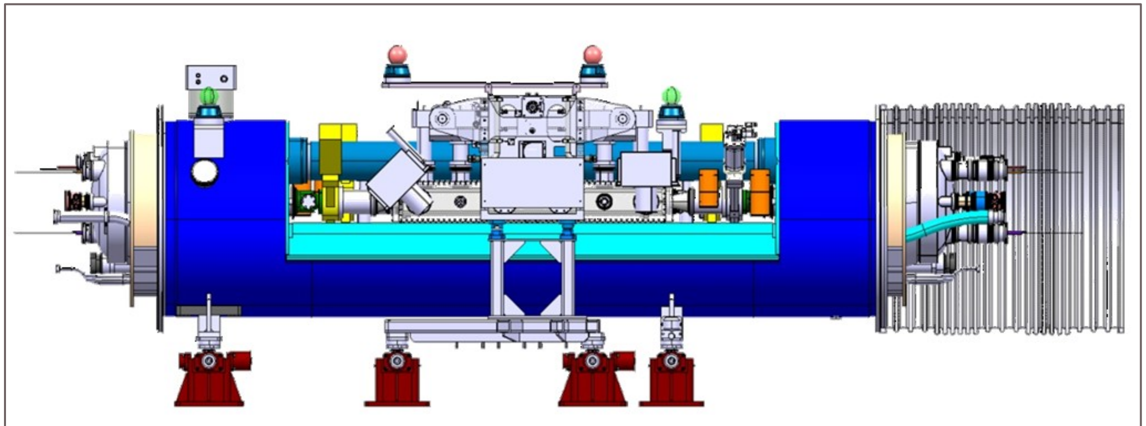


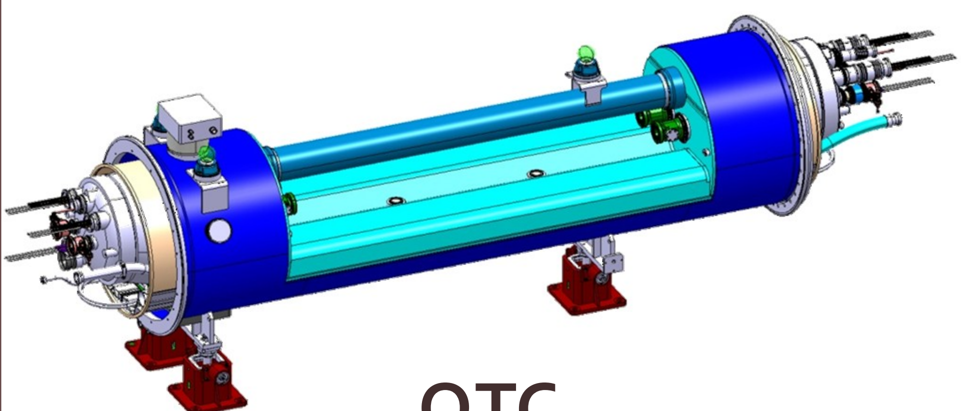
(Y.Muttoni, EN-MEF)



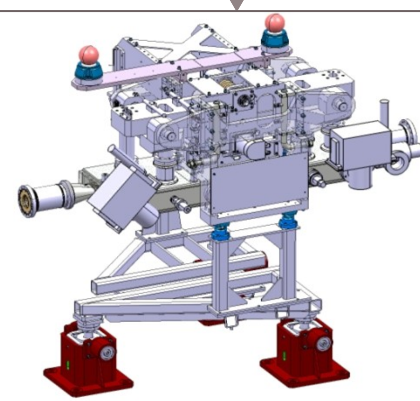
4 units + 1 spare

Equipment breakdown





QTC



TCLD

Vacuum components

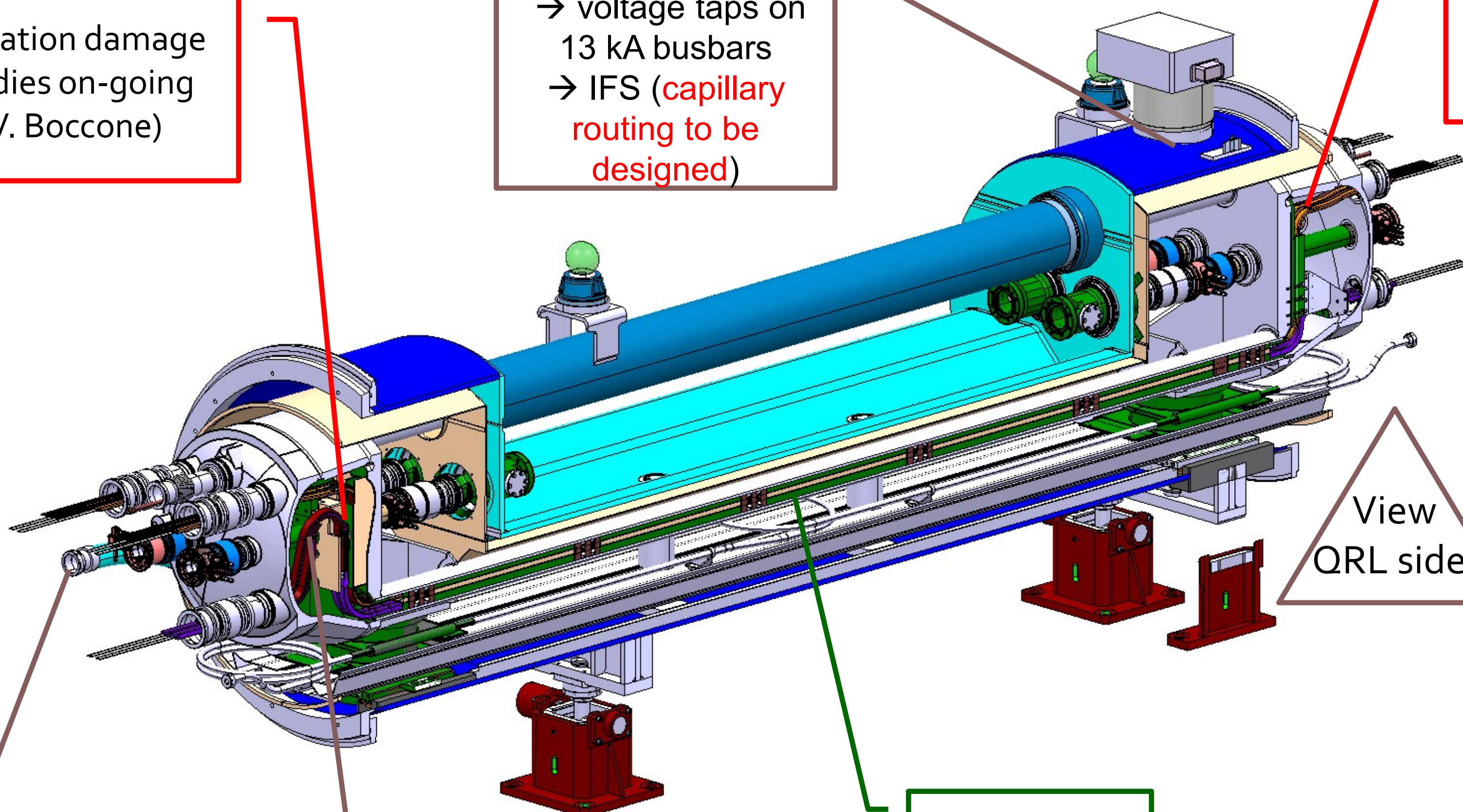
(D.Ramos , EN-MME)

Busbars

Radiation damage studies on-going (V. Boccone)

New equipment:
→ voltage taps on 13 kA busbars
→ IFS (capillary routing to be designed)

Busbar bending in-situ w/ cable already tinned



View QRL side!

Aux. busbars, line N

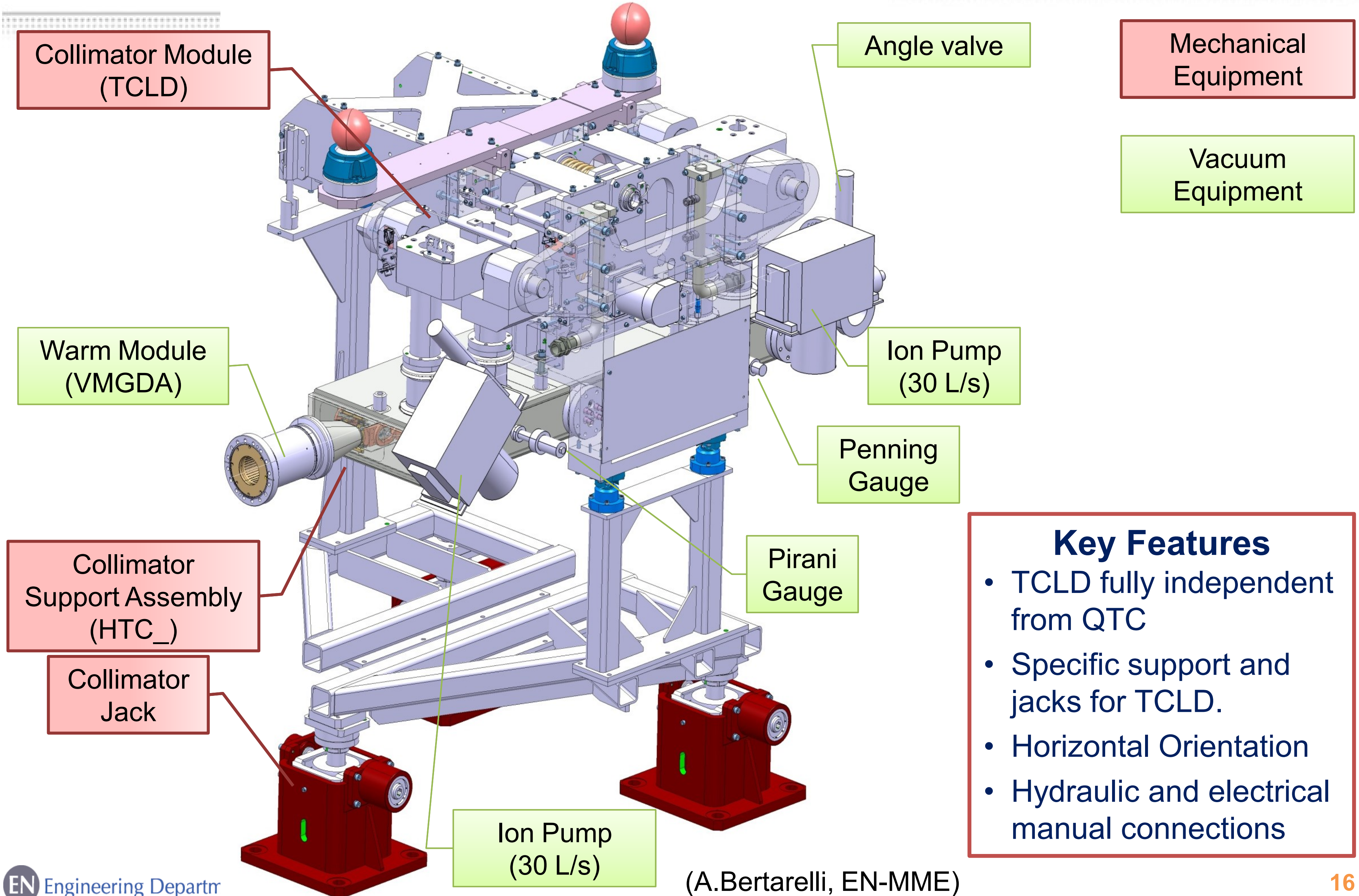
Lyra side pre-assembled before integration

No splices

Weight: ~2.5 ton

(D.Ramos , EN-MME)

COLLIMATOR MODULE (TCLD) LAYOUT

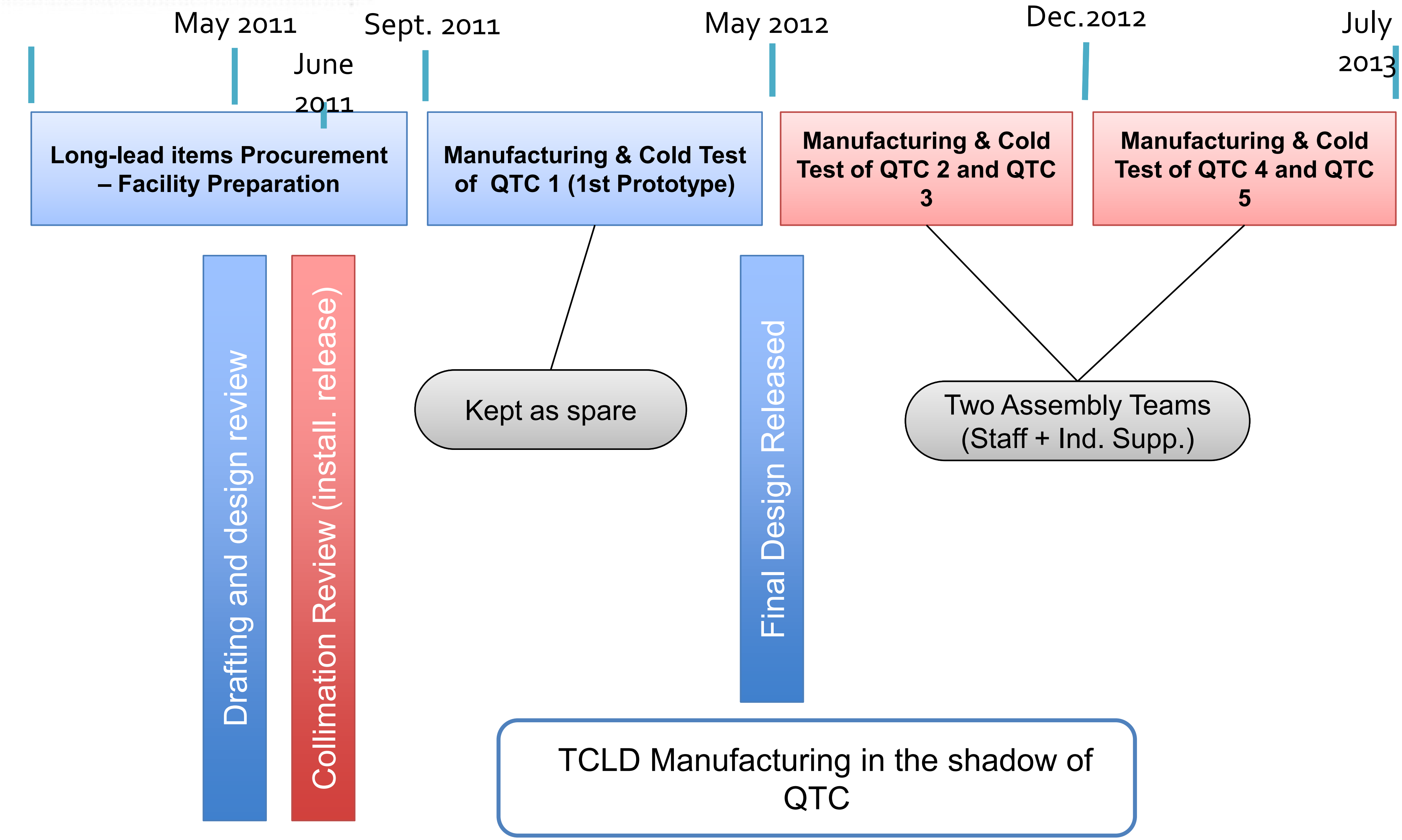


Key Features

- TCLD fully independent from QTC
- Specific support and jacks for TCLD.
- Horizontal Orientation
- Hydraulic and electrical manual connections

(A.Bertarelli, EN-MME)

MANUFACTURING TIMELINE



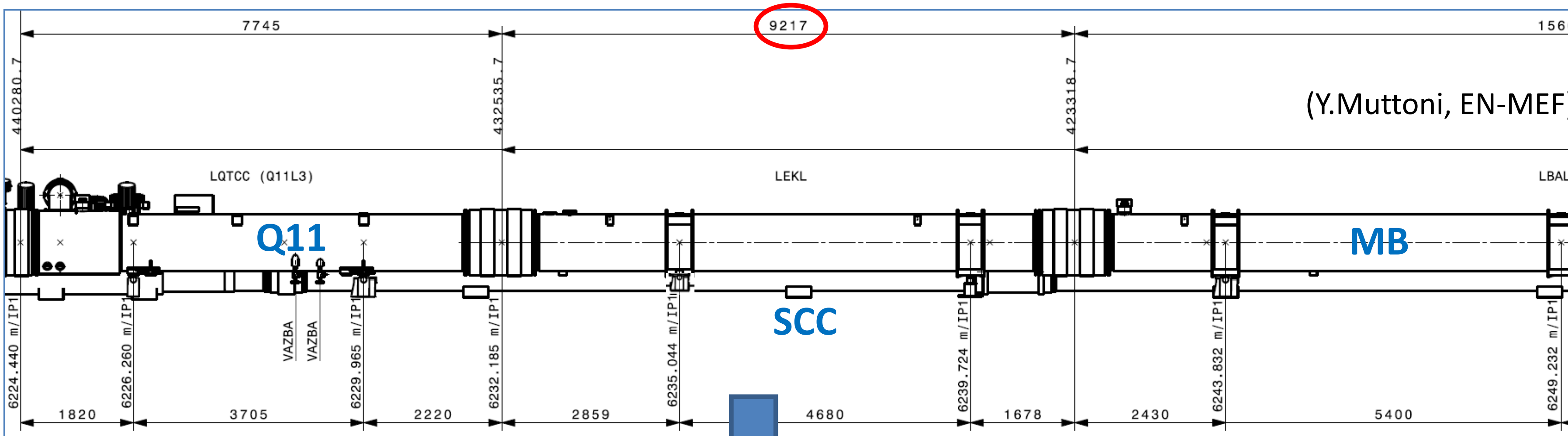
Acknowledged challenges for the QTC

- QTC (cryostat by-pass)
  - New busbars layout, but design thoroughly studied. Radiation heat deposition studies in progress (results in this review? V.Boccone's talk). Some EM Cross-talk checks still pending.
  - Intricate assembly procedure: relying on good craftsmanship
  - Welding distortions during vacuum vessel closure
  - MLI fire hazard during vacuum vessel closure
  - Small gaps between busbars insulation and He vessel walls (electrical insulation, damage during welding) →
  - Access for repairs may imply destruction of the vacuum vessel
  - Beam vacuum lines partly inaccessible after cryostat closure
  - Cold test can reveal some possible defects but not all (wear and fatigue damage, interaction with neighboring magnets...)

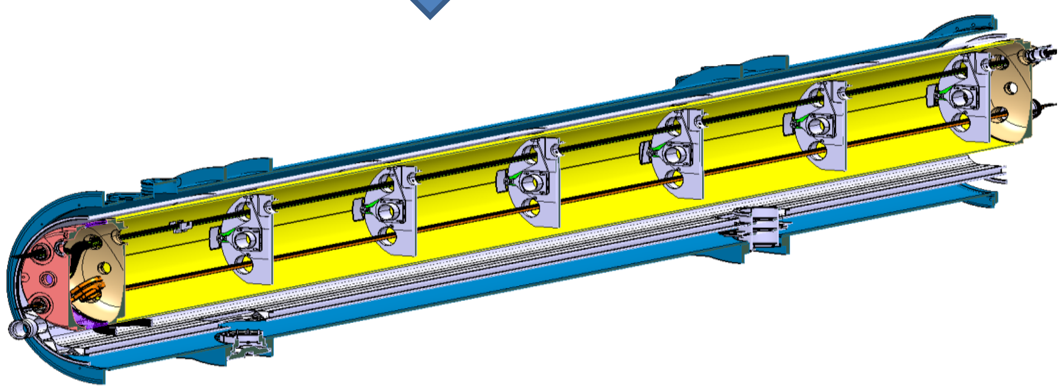
→ The first prototype should answer most of the issues

(input D.Ramos, EN-MME)

Short Connection Cryostats (2 units, 1 per DS)



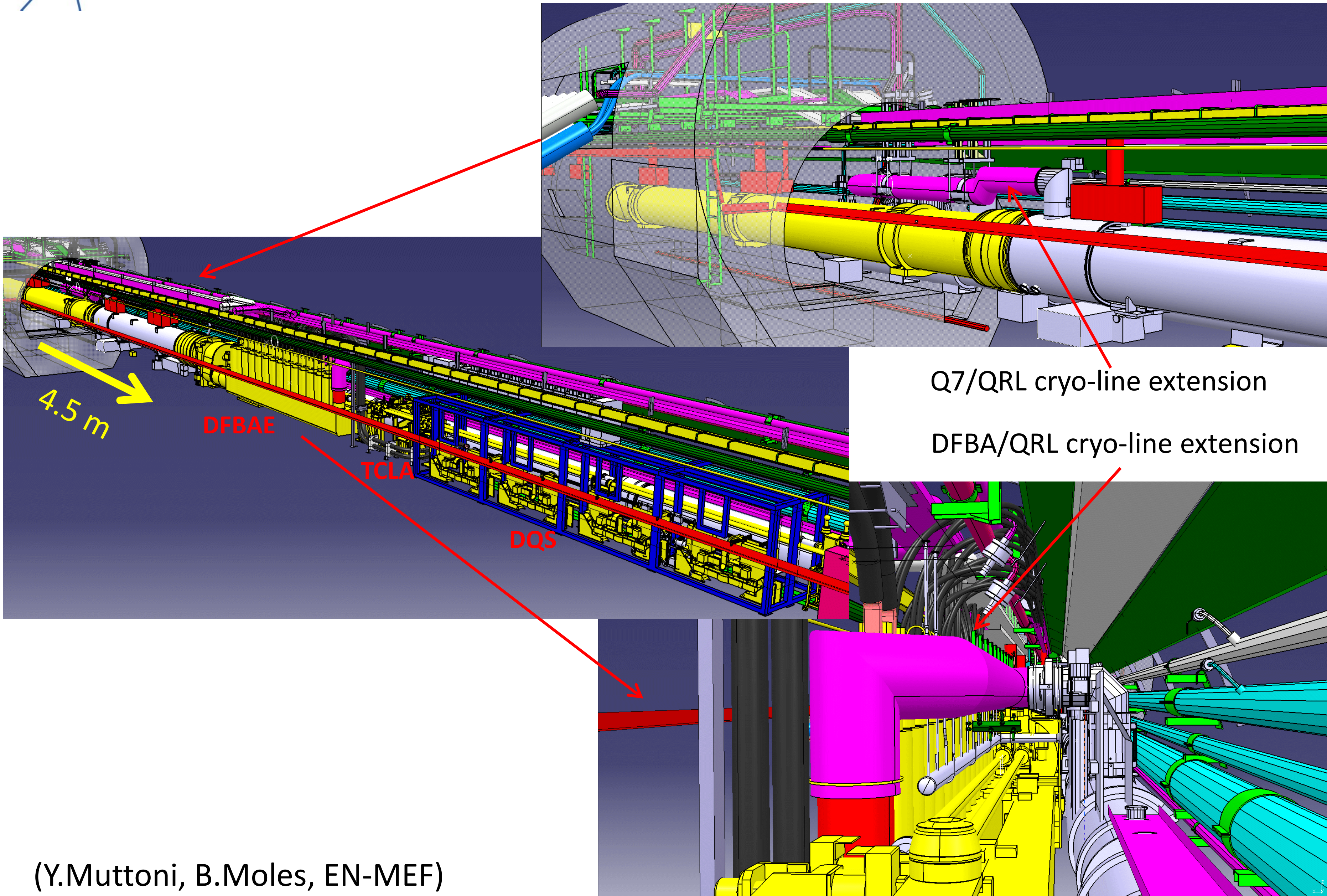
2 units + 1 spare



(J.Ph.Tock, A.Vande Craen, TE-MSC)

Tunnel integration and H/W modifications

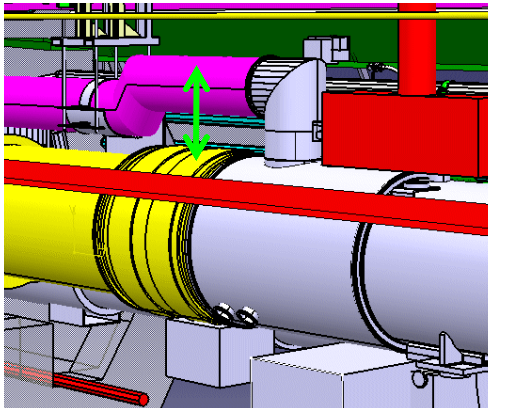
Integration studies, 3L



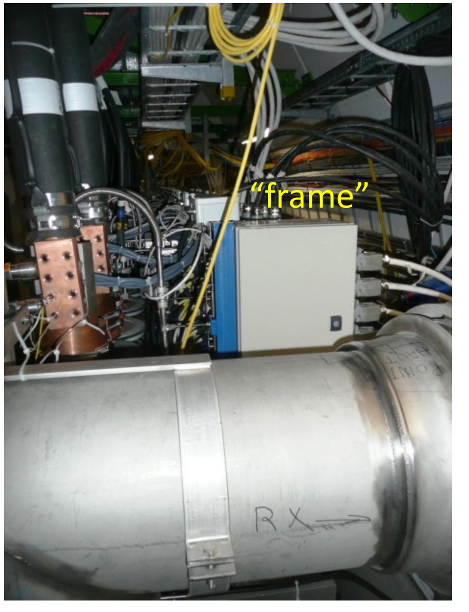
(Y.Muttoni, B.Moles, EN-MEF)

Integration studies

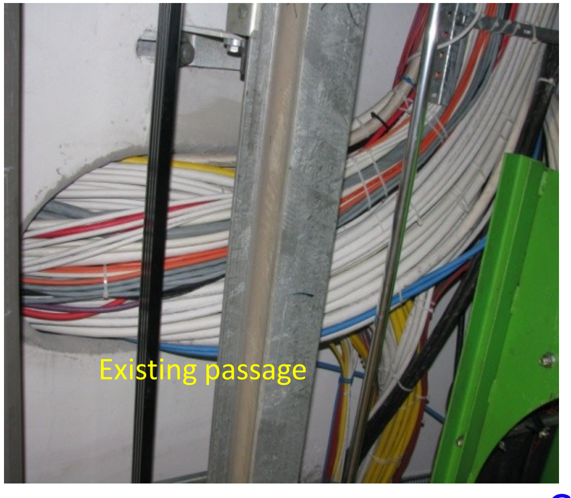
- Issues:
  - Densely populated zone around the DFBAs
  - Limited space for accessing Q7 interconnect (A)
  - Proximity equipment difficult to place (B)
  - Need to drill a new cable duct for cables re-routing (~1'400 cables) (C)

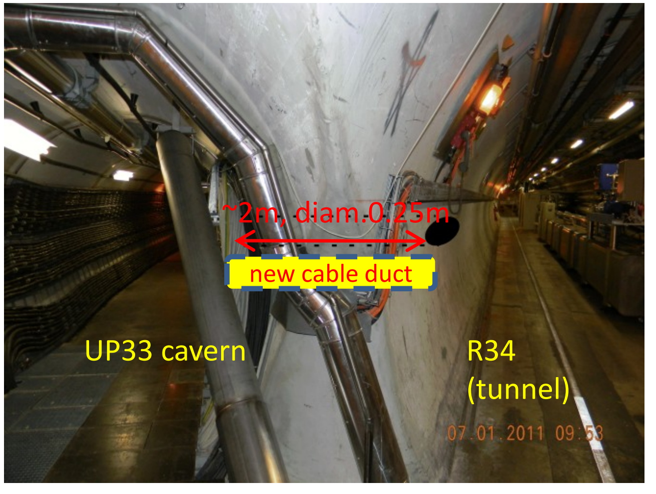


A)



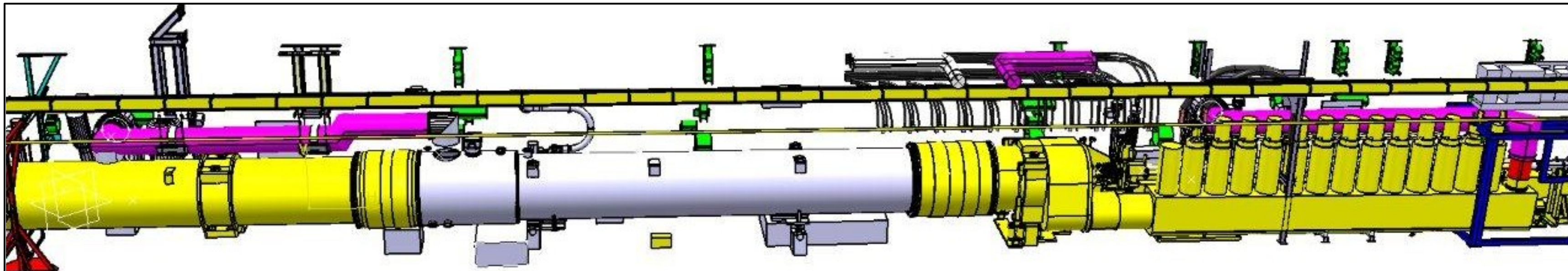
B)



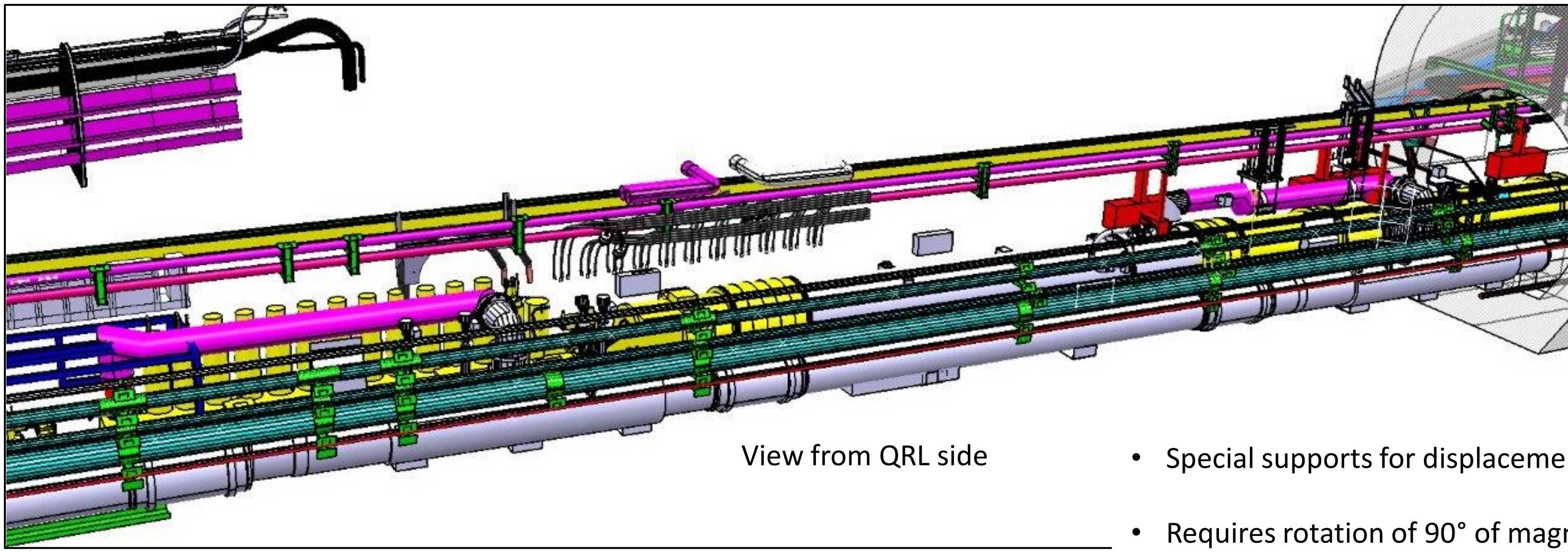


C)

IR3 Left: jumper and QRL extensions



View from transport side

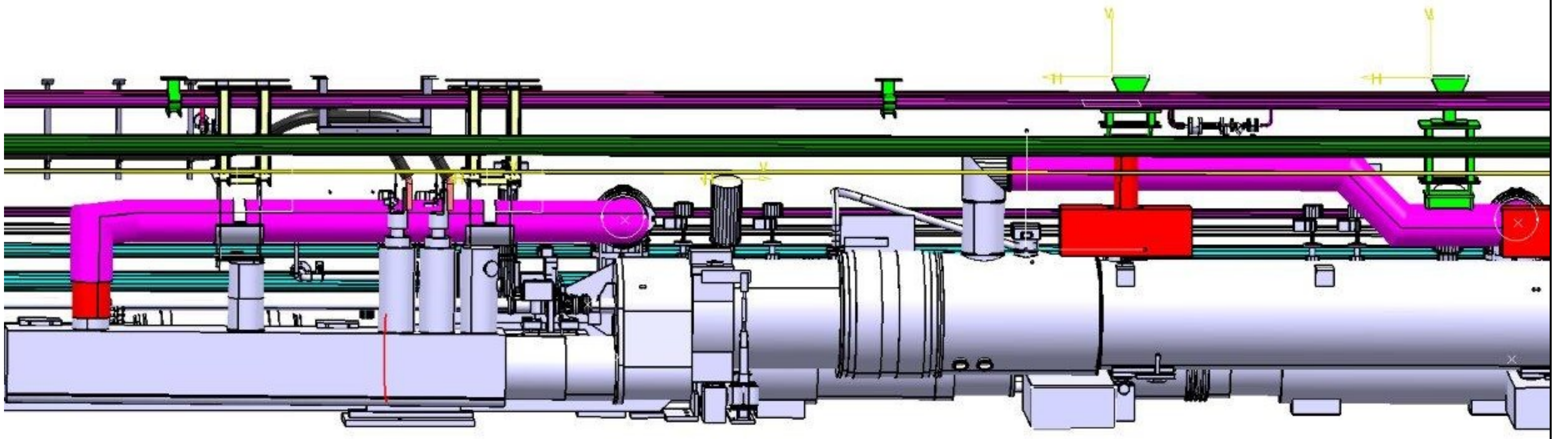


View from QRL side

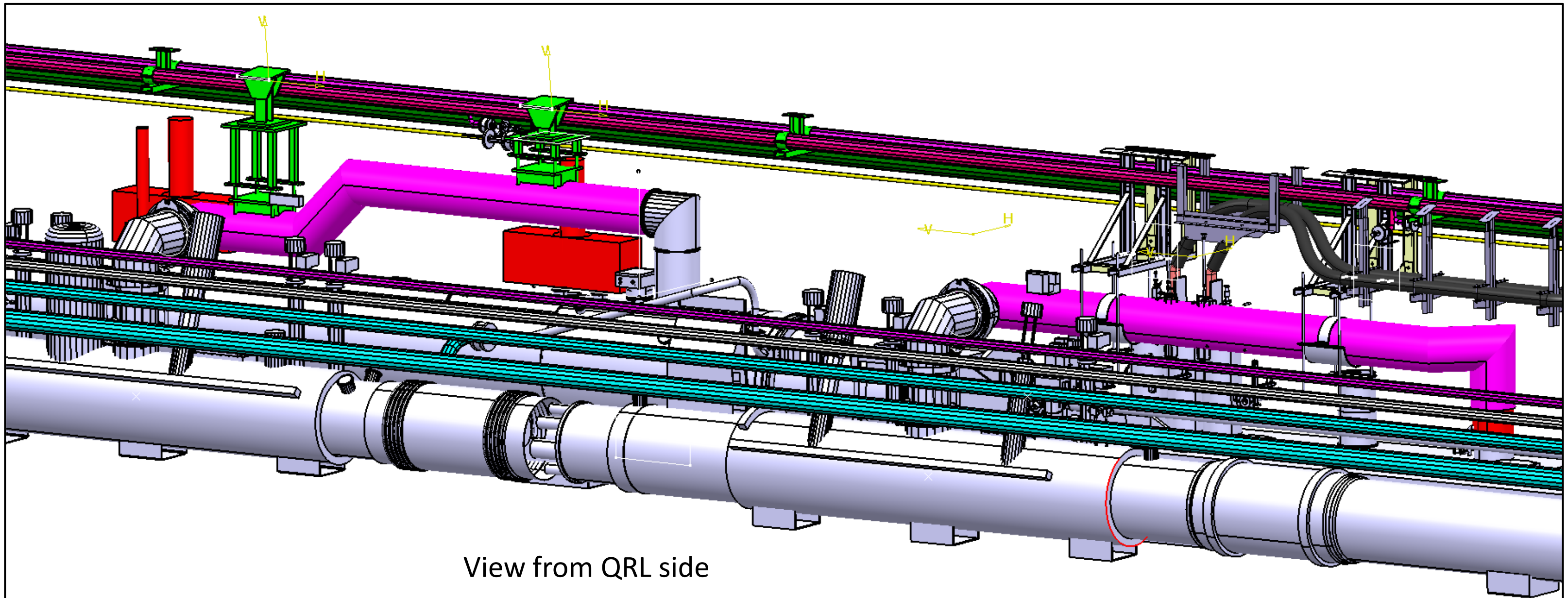
- Special supports for displacement
- Requires rotation of 90° of magnet jumper with respect to original.
- Magnet jumper also higher by about 300 mm
- In IR3L, the jumper extension will be installed after the interconnection work in order to guarantee the best access for the intervention.

(Y.Muttoni, B.Moles, EN-MEF)

IR3 Right: jumper and QRL extensions



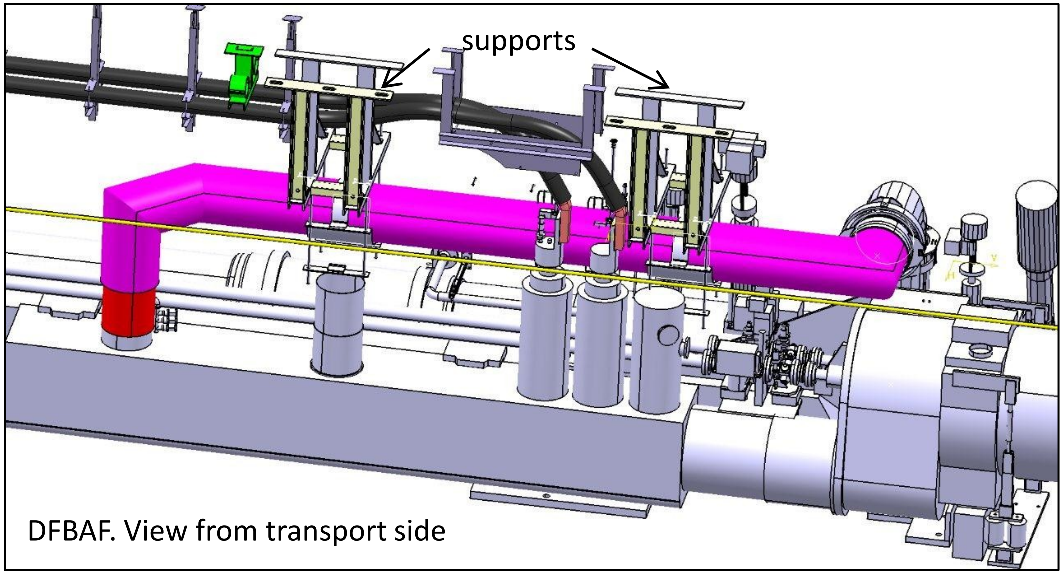
View from transport side



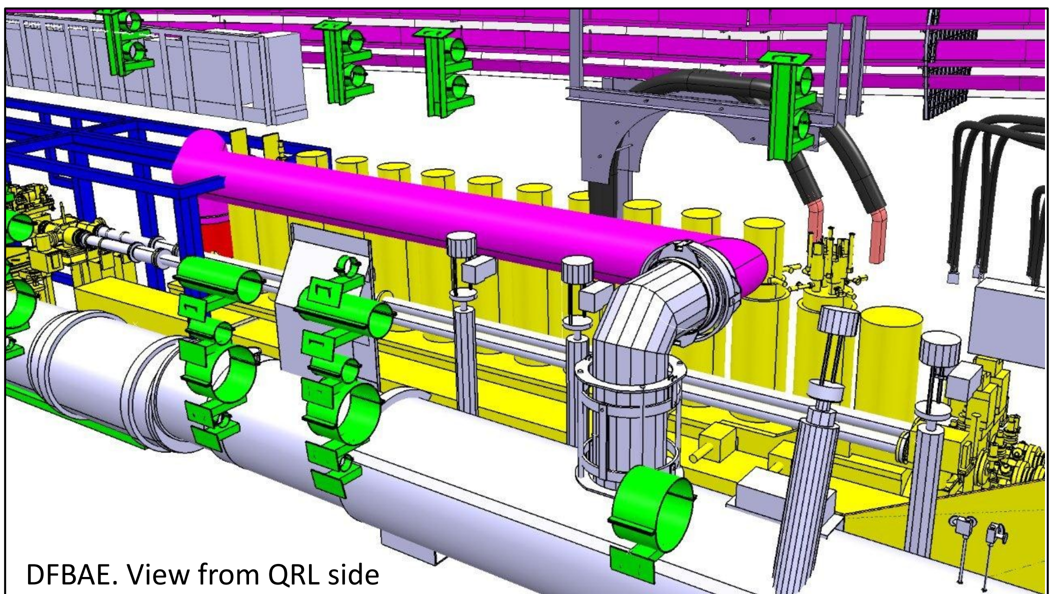
View from QRL side

(Y.Muttoni, B.Moles, EN-MEF)

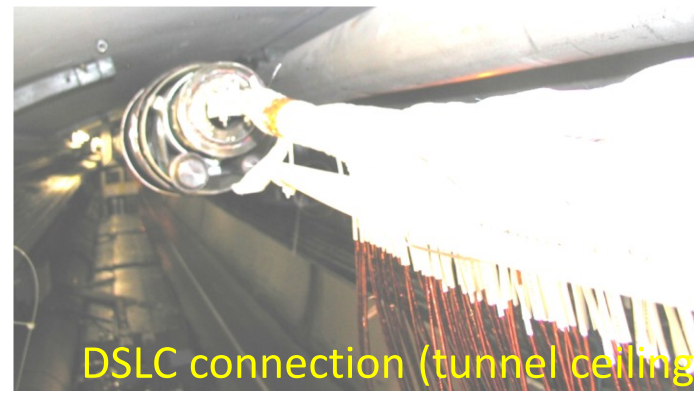
IR3 Right: DFBA jumper and QRL extensions, DSCL shortening



DFBAF. View from transport side

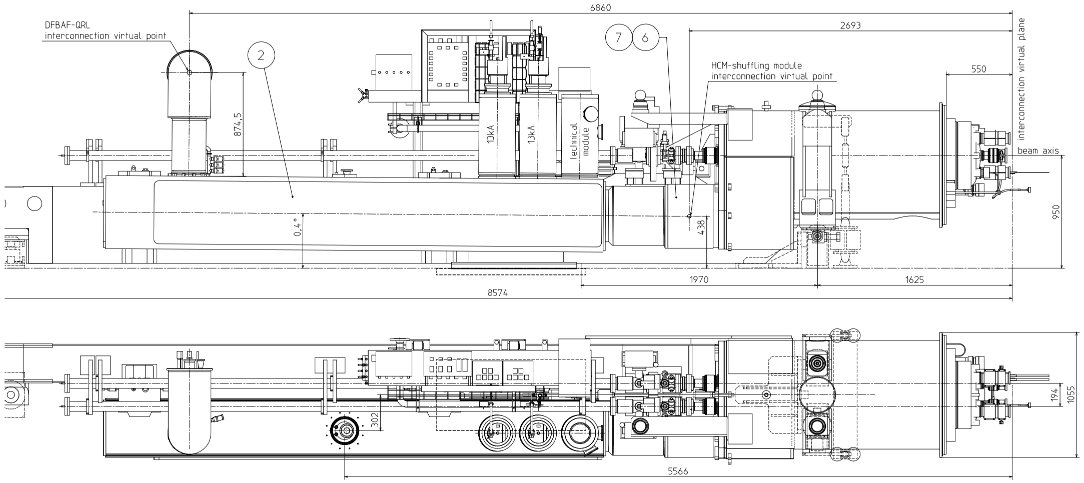

DFBAE. View from QRL side

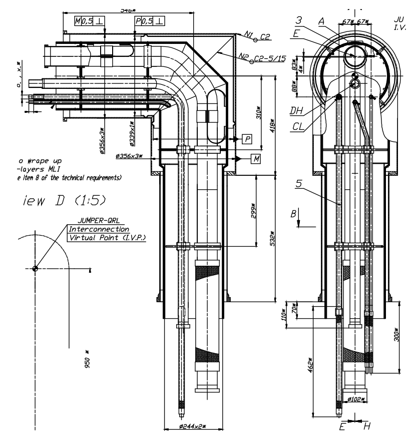
- Special supports for displacement
- Requires rotation of 45° of DFBA jumper with respect to original.
- Interference with “proximity equipment”: transformers, connection boxes, etc.
- Superconducting link (DSLC) to be shortened (tunnel ceiling work)


DSLC connection (tunnel ceiling)

(Y.Muttoni, B.Moles, EN-MEF)

Moving the DFBAs





Impact on the DFBAs

- Needs to be moved by 4.5 m
- Connection to the jumper extension requires a rotation of 45° of the DFBA jumpers an internal piping with respect to original: essentially completely rebuild the jumper.
- Interference with “proximity equipment”: transformers, connection boxes, etc: displacement of the proximity equipment
- **No spare DFBA!**

Tentative sequence of interventions

- Open interconnection to Q7, disconnect the DFBA from the QRL, from WL and cabling
- Move DFBA in a safe place (possibly IP4). Re-use the installation tooling.
- Perform all modifications on the DFBA jumper
- Full leak and pressure test of the modified piping on the DFBA (+ electrical qualification)
- Transport the DFBA in the new location and reconnect

(A.Perin, TE-CRG)

Acknowledged tunnel integration challenges

- Regions around DFBAs are densely populated zones:
  - Integration studies based on 3D models: fully representative of reality?
  - limited working space: installation work correctly analyzed? Need for special tooling and procedures? **Potential risk of unforeseen interference and impact on installation schedule**
  - Coactivity between various teams: needs accurate preparation and coordination. **Potential risk on installation schedule**

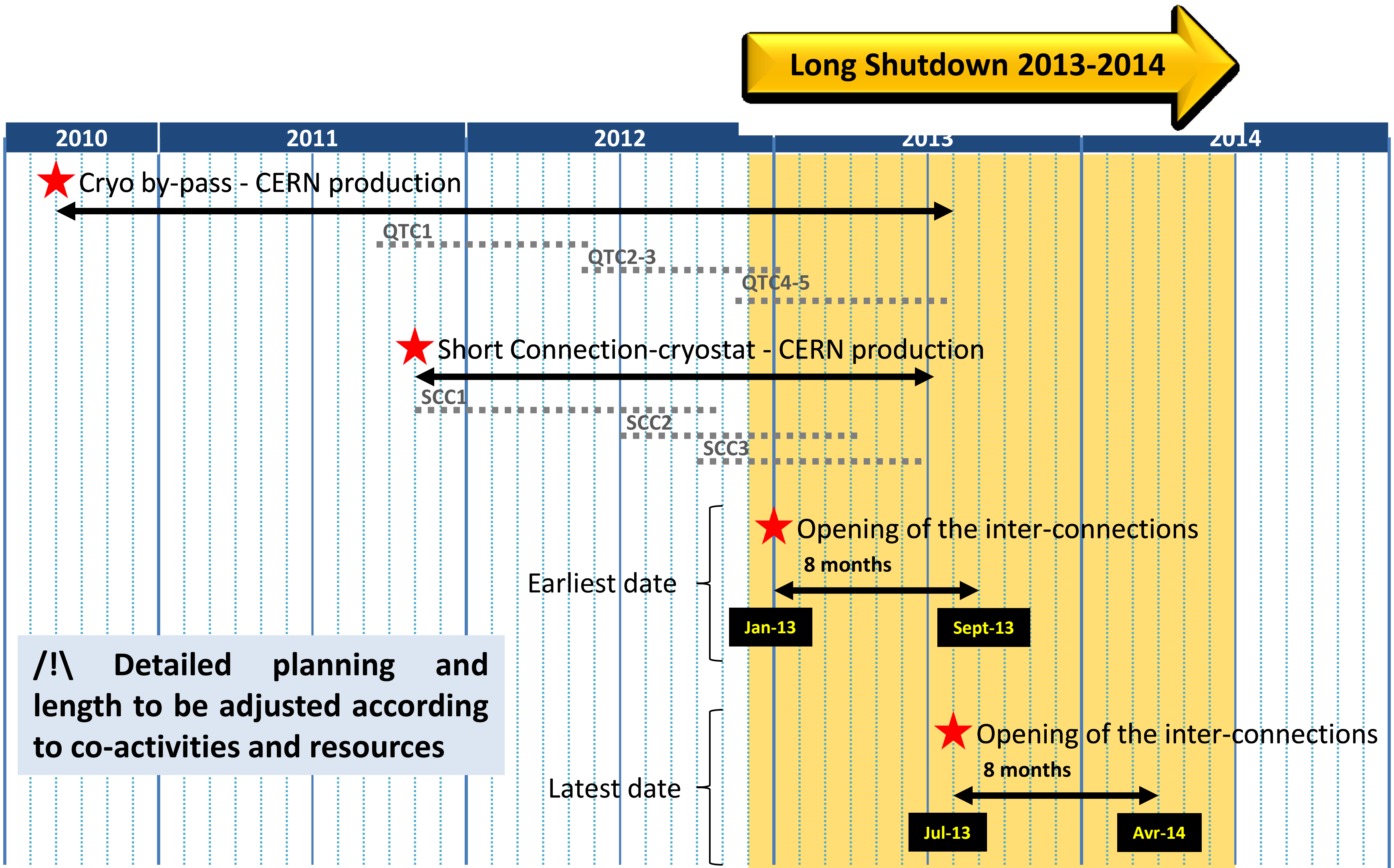
  → **Accurate installation sequence to be studied; still risk of facing unplanned work. Potential risk on installation schedule**
- Heavy re-cabling work with risk of errors and mishaps:
  - lengthy troubleshooting/repair. **Potential risk on installation/commisionning schedules**
- Modification of in-situ equipment:
  - Can be technically complex (e.g. DSLC mods) → **risk of damaging unique equipment.**
- Handling/Transport of heavy equipment (DFBA):
  - **risk of damage of unique equipment (no spares)**
- Coactivity with other shut-down activities. Handling/Transport:
  - Free transport passage. **Potential risk on installation schedule**
  - Share transport resources. **Potential risk on installation schedule**

Summary of main H/W activity

- Status of DS Collimators
  - Design of Cryostat and Collimator Module well advanced (manufacturing drawings being released)
  - Long-lead components and material procurement under way
  - Manufacturing and assembly of first unit to start in coming weeks
- Status of Short Connection Cryostats
  - Short Connection Cryostat engineering almost completed
  - Schedule and budget are under control
  - No show stopper identified
- Modifications of other equipment:
  - Q7 jumpers not critical
  - DFBA jumpers not critical but on unique equipment
  - Cryo-links not critical (existing design in LHC) but complex integration
  - In-situ modification of DSCL complex and critical (unique installed equipment)
- Still in progress:
  - Study of cold testing and bench connections (SM18) for power testing of Collimator by-pass and Short Connection Cryostats

Schedule

Schedule



/!\ Detailed planning and length to be adjusted according to co-activities and resources

Tunnel work assumptions

- Working assumptions:
  - All magnets up to surface (dipoles from PMI2, quads from P4)
  - Works on one (extended) shift, with night transport
  - 3L and 3R mostly parallel work
  - DFBAs moved and stored in P4 (underground)
  - 4 teams for cabling (DS, LSS&DFBA, connections, water-cooled cables)
- Limitations:
  - Planning not merged with other activities/projects
  - No resource sharing with other activities/projects (especially interconnects!)
  - No transport sharing with other activities/projects
  - …no contingency!

→ Minimum of 8 months of tunnel activity

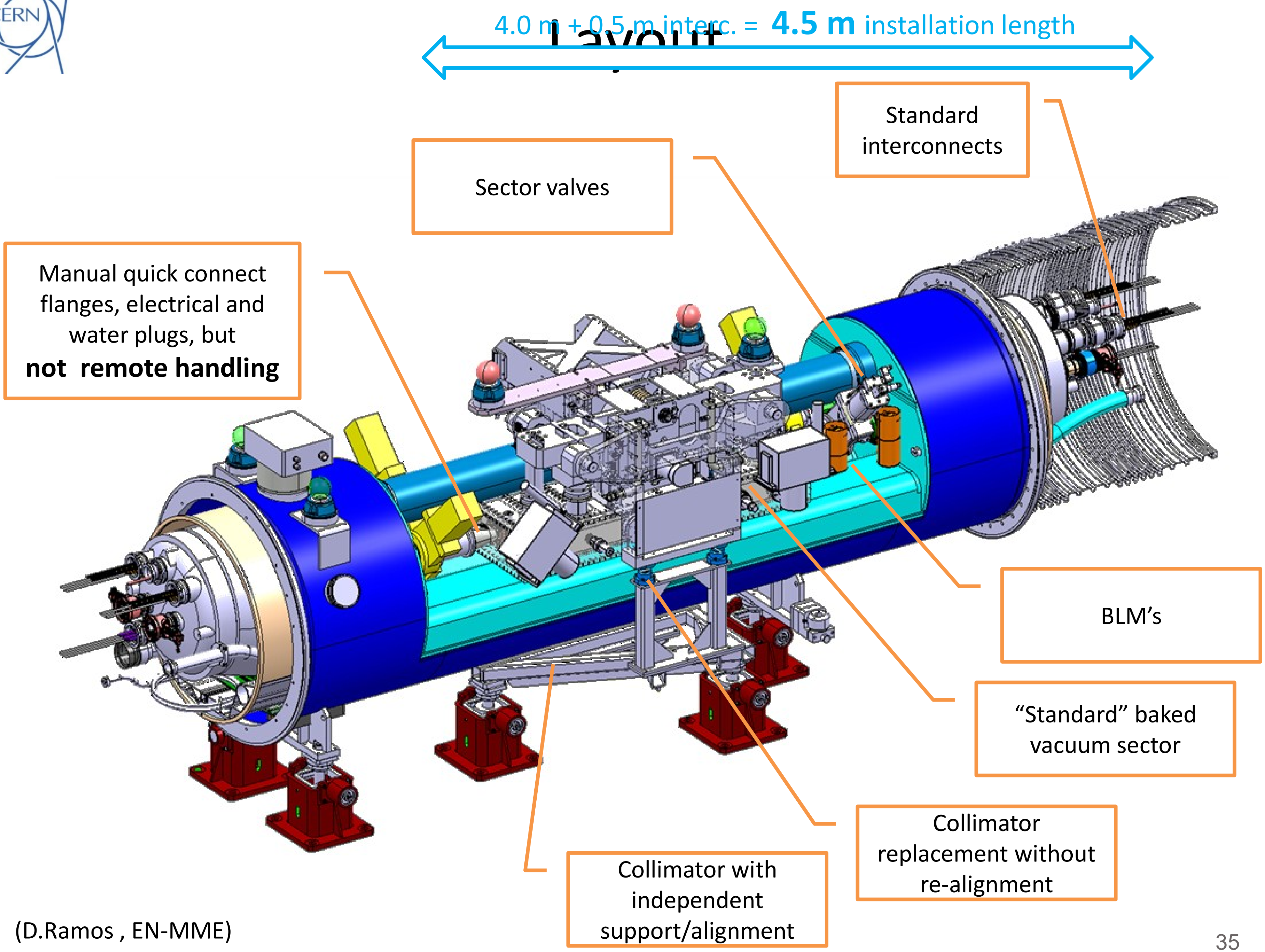
Summary and Outlook

- The DS collimator project in IR3, aimed at improving collimation efficiency (factor 5-10), is now structured and progressing full steam for the next log shut-down
- The DS collimators requires a challenging re-layout and integration study, which is almost completed and no technical show-stopper have been identified so far
- Considering the complex integration and densely populated area around the DFBAs, there is a certain risk of having underestimated the work. A detailed installation sequence should be studied
- In-situ modifications of highly integrated equipment (e.g. DSLC) and transport/handling of unique equipment (DFBAs), remain critical issues justifying a dedicated risk analysis
- The design of the new DS equipment (DS collimators, and Short Connection Cryostats) is close to completion and was reviewed recently (May review)
- Procurement of other long-lead components in industry is launched
- Construction of the first units (QTC and SCC) is to start (summer 2011)
- Planned availability dates of the QTC and SCC: mid 2012-mid 2013
- First draft schedule for 2013 shut-down, yields a ~8 months minimum installation for the DS collimators
- This preliminary schedule needs consolidation and matching with those of other shut-down projects (resources allocation, co-activity, transport sharing, etc.) so its duration could be considerably longer (up to 3 months?).

Thank you
for your attention!

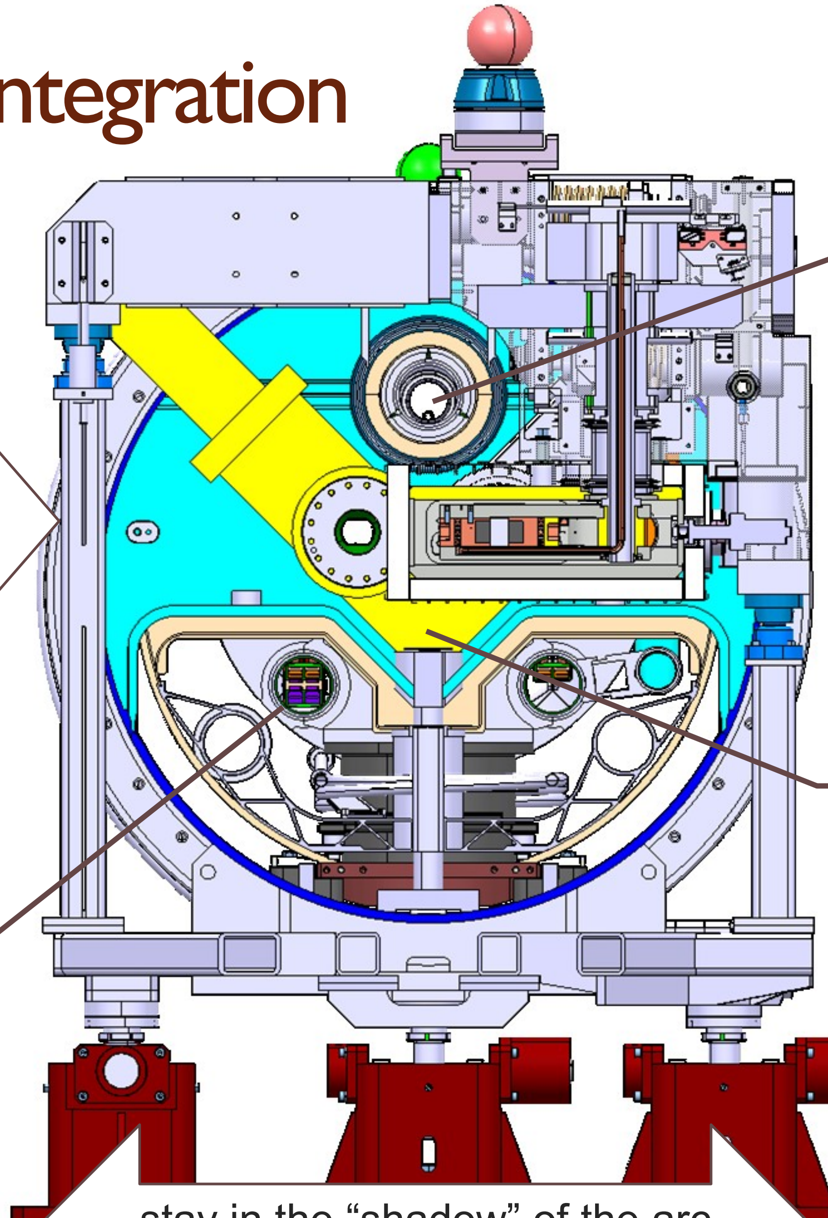
Spare slides

Layout



(D.Ramos , EN-MME)

Collimator integration



Σ jaw,
vacuum tank,
bakeout jacket,
assy. tolerances,
installation gap

No bypass for two-phase He flow

RF-shielded sector valves

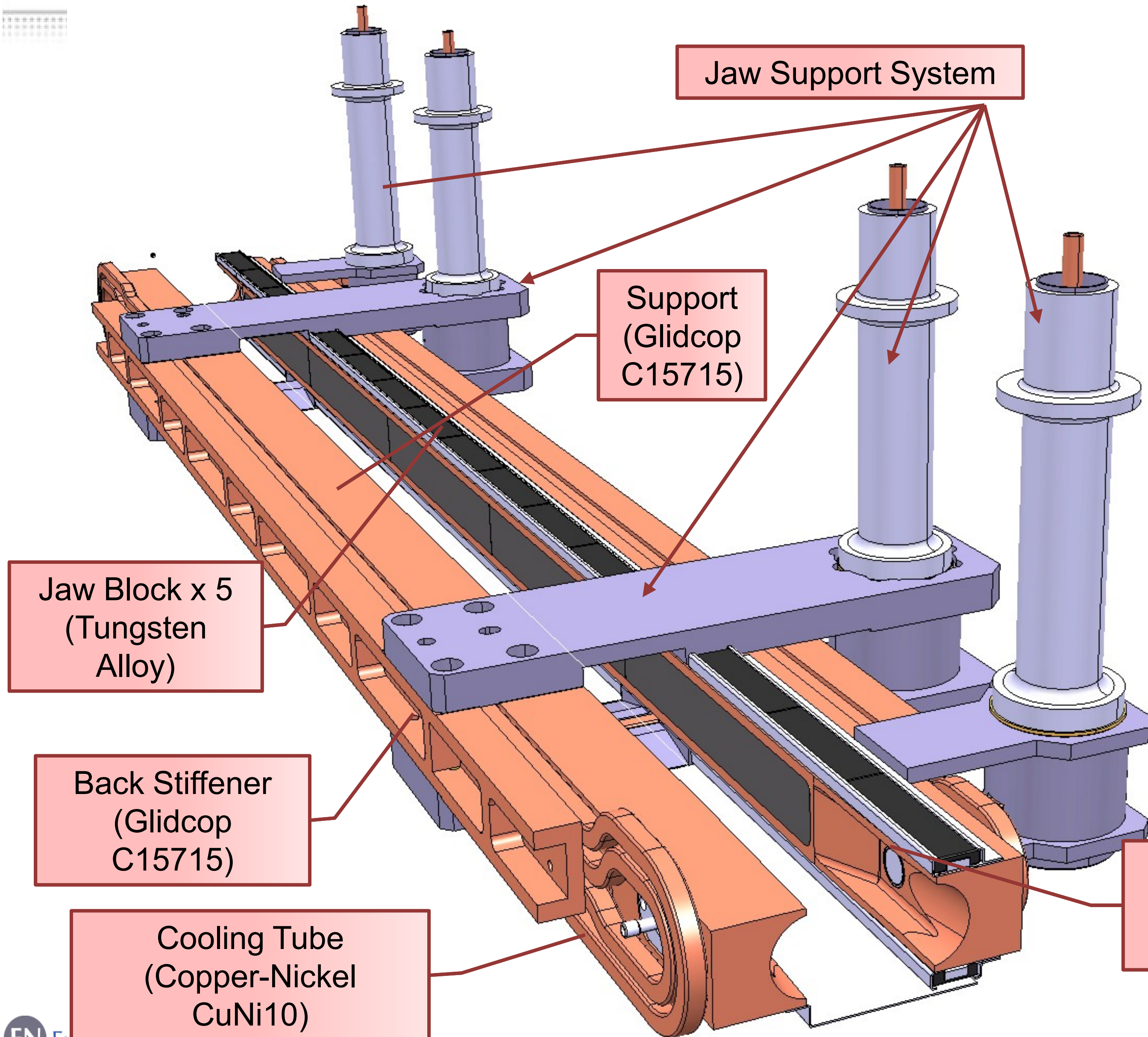
Room for only two bypass tubes
→M1& M3 grouped.

Cross-talk addressed

stay in the "shadow" of the arc cryostat

(D.Ramos , EN-MME)

TCLD JAW DESIGN (1/2)

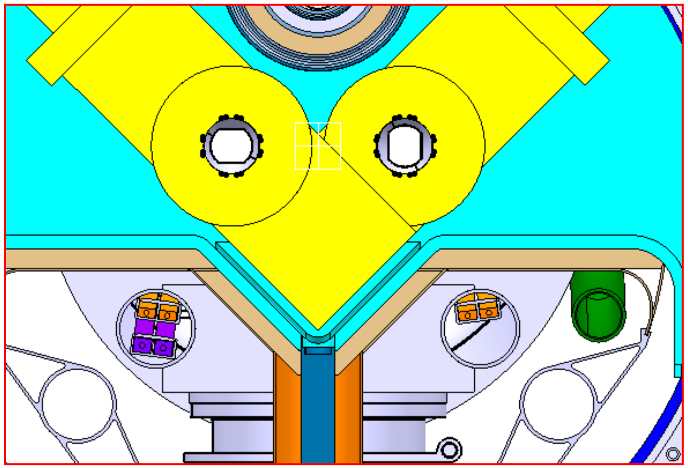


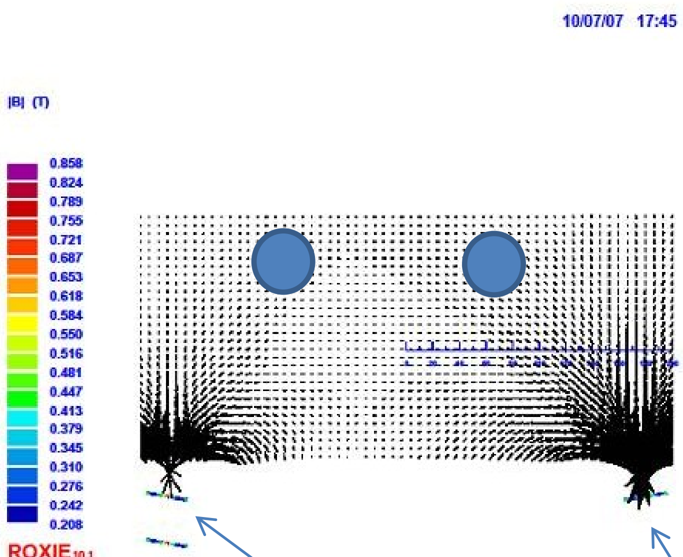
Key Features

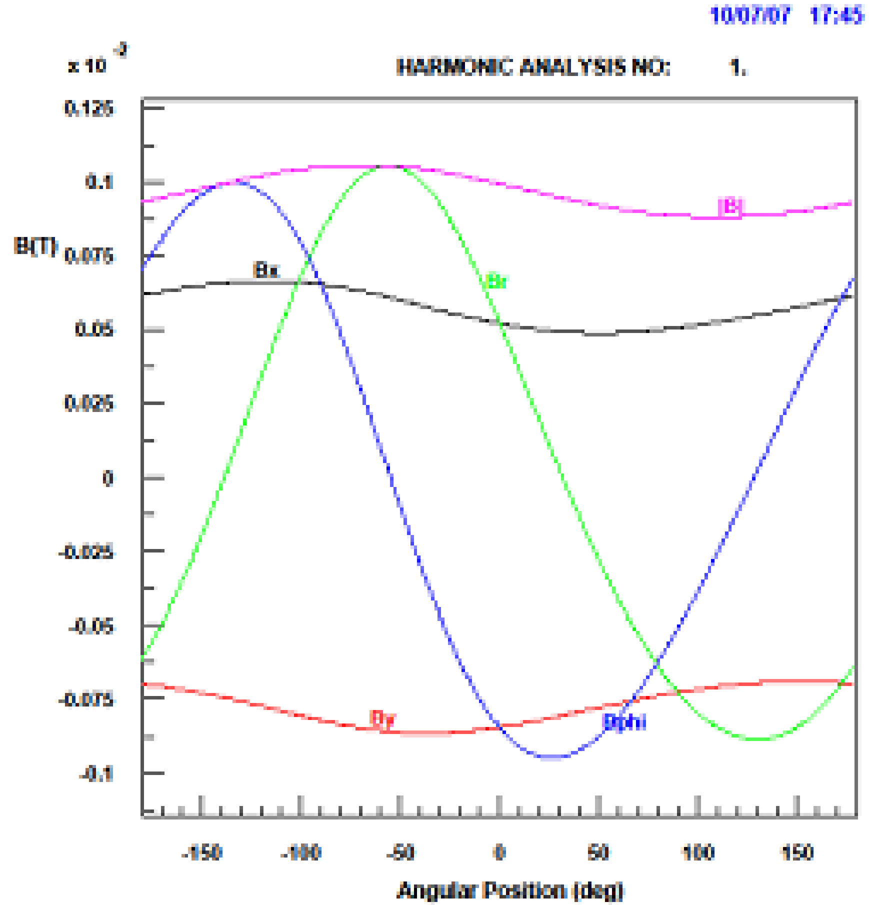
- Total length: 1200 mm (including 100m tapering)
- Active length: 1000 mm (5 blocs x 200 mm)
- Asymmetric jaw supporting system
- Continuous cooling circuit
- Contactless RF shielding
- BPM pickups: 2 per jaw
- T ure
  cs (2 PT100

BB stray field to beam

Roxie calculations: S.Russenschuck







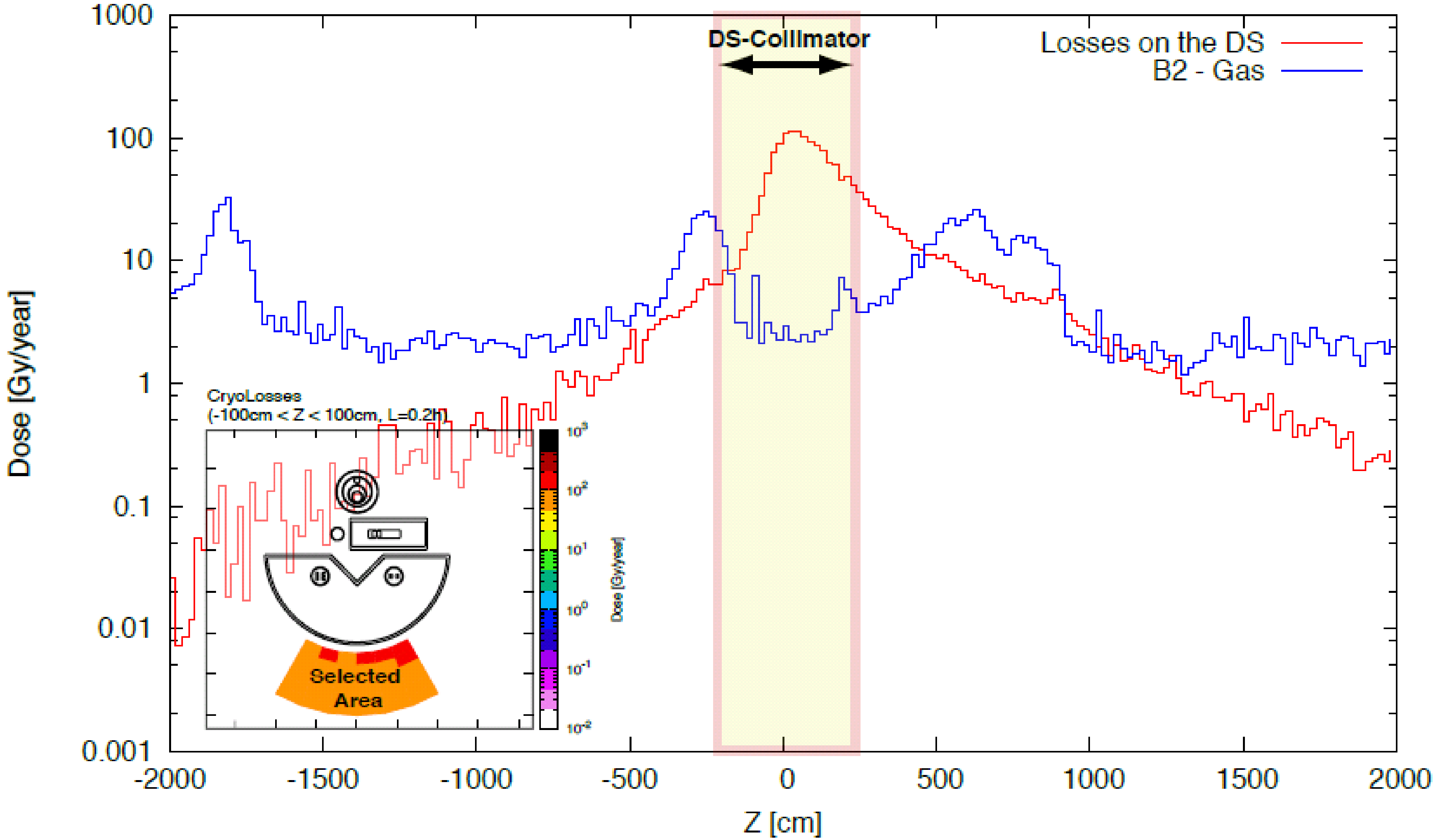
D Quad+dipole BB

F Quad BB

Negligible effect on beam

(LHC Collimation Working Group, July 2010)

Comparison of DOSE below LHC cryostat around the DS-Collimator



Testing of QTC and SCC

- Construction testing:
  - Pressure test (construction integrity)
  - Dimensional checks (mechanical interfaces)
  - Leak tests
  - Electrical tests (@RT): continuity, HV
  - ...
- Qualification testing @ cold (SM18):
  - Envisaged tests:
    - Leak-tightness @ cold (insulation+beam vacua)
    - HV tests (before CD, @cryo)
    - Continuity and splices measurements
    - RRR measurements
    - Powering tests of all circuits (connected in series) @ ultimate current
    - Magnetic measurements (SCC only)
    - Thermal cycle(s)
    - Cryostat T measurments on QTC prototype
    - ...
  - Diagnostics instrumentation (T gauges, Vtaps...) needed

Modifications to the DSLC (superconducting link)

- The DSLC needs to be shortened by 4.5 m
- Cable is 44 x 600A busbars
- Delicate operation but experience exists. Unique system.

Tentative sequence (details being studied):

- Open and disconnect at the DLSC-DFBAF connection
- Open and disconnect at ceiling connection 40 meters from DFBAF
- Shorten the helium piping while preserving the SC cable on the DFBAF segment
- Reconstruct the interface flanges on the piping
- Install temporary sliding supports on the DSLC vacuum envelope
- Shift the DFBAF segment by 4.5 m to the new position
- Reconnect the DSLC
- Perform leak tighness & Hi Voltage tests on the DSLC before reconnection to the DFBAF
- Reconnect to the DFBAF + leak tests + electrical test