Integration of collimators in the dispersion suppressors

Status of 11 T cryo-assembly integration

Dec 17, 2013

Delio.Ramos@cern.ch

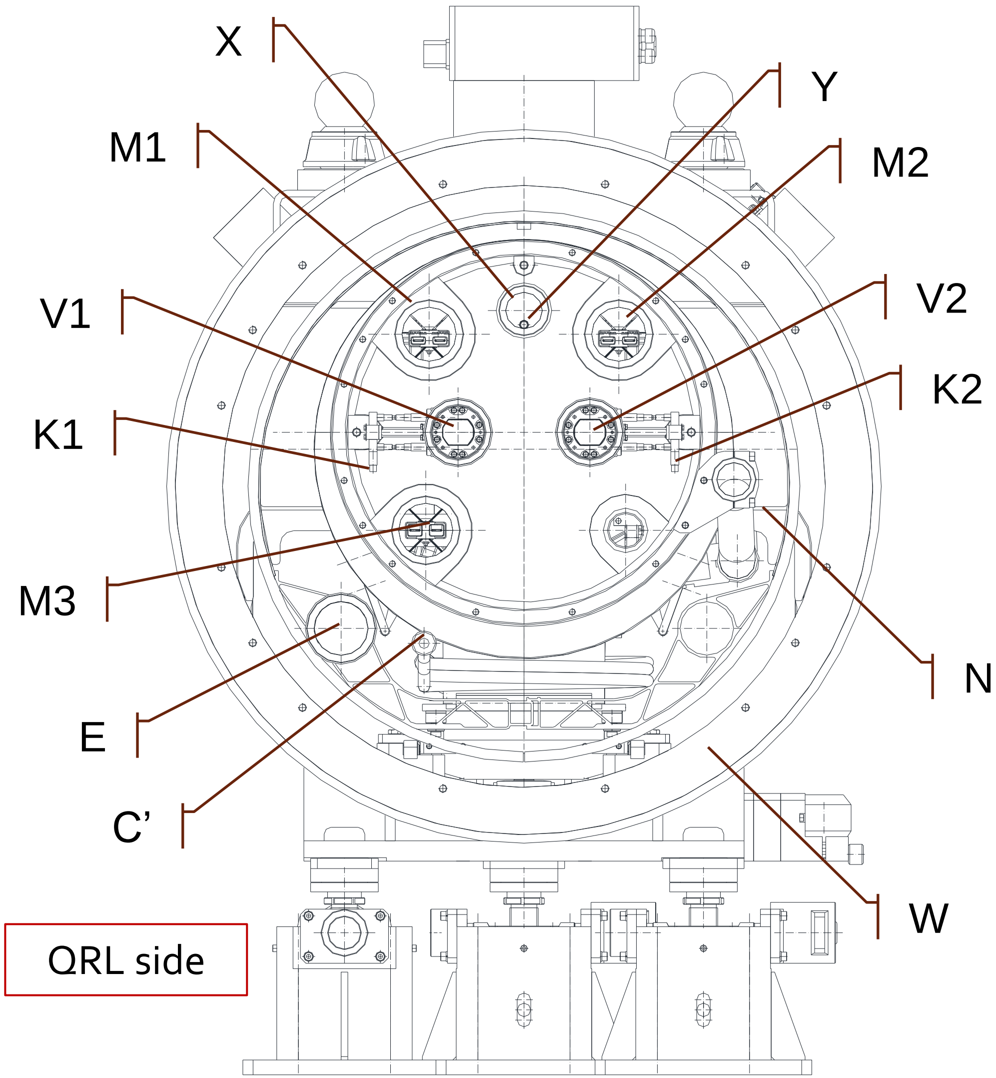
Outline

- (Today's) "Rules of the game" (Some say design constrains, functional specifications, interfaces, etc…)
- 11 T + Collimator cryostat concept
- What's next

Delio.Ramos@cern.ch

Full interchangeability with a standard dipole

(no changes to neighbouring cryomagnets)



- No changes to cryo, electrical or mechanical interfaces (different jack's position is inevitable)
- 15660 mm long, interc. included
- Inside the 11 T cryostat:
  - **X-line remains straight**
  - He II free cross section: 60 cm^2
  - Pressure drop of He II circuit: 4.3 kPa/m (50 mm smooth pipe)
  - Pressures and temperatures acording to LHC-Q-ES-0001 (edms 90032)

Delio.Ramos@cern.ch

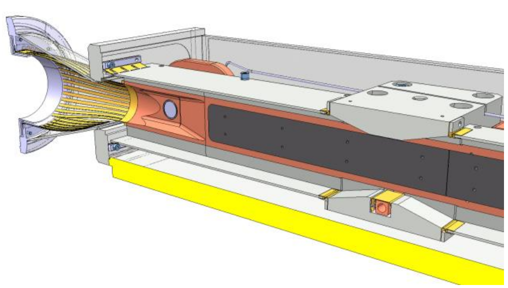
Operation and maintenance

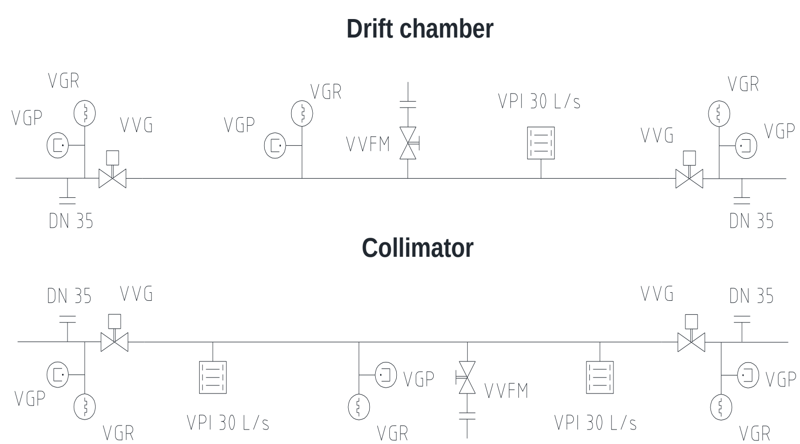
- Mechanical decoupling from cryostat and collimator for removal and alignment of collimator without warming up the arc ⇨ **bellows between collimator tank and cryostat**, **independent supports to the floor**, compatible integration
- One collimator design fits beam 1 and beam 2
- Minimise exposure to residual radiation ⇨ simplify removal/installation of collimator, ex. quick CF flanges, pre-aligned collimator support system, “rapid” electrical and hydraulic connections (but not remote handling), **permanent bakeout insulation**
- **Ports for “RF-ball” test** of new sectors
- Transport constraints: **Stay in the “shadow” of the existing arc cryostat**

Delio.Ramos@cern.ch

Vacuum

- **Room temperature (bakeable) collimator** vacuum operated and maintainded independently from cold beam vacuum ⇨ **sector valves on both lines**
- Beam screens (K-line cooling) with same reliability and performance as rest or the arcs (no helium to beam vacuum welds, testing, etc.)
- No demountable vacuum tight joints in cryogenic system
- Ensure pressure safety of each new beam vacuum “subsectors” ⇨ rupture disks on SSS ports
- Ensure pressure safety of insulation vacuum (DN 200’s)
- Respect current RF-impedance requirements: ex. **shielded sector valves**, **shielded bellows**, **max 15º taper angle**





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Thermo-mechanical

- **Busbar flexibility** must take into account **adjacent magnets**
- Temperature offset between cold mass and beam screen during transient
- Temperature variation between two cold masses during transient
- Cold to warm transitions on the beam lines

CERN
CH-1211 Geneva 23
Switzerland

the
Large
Hadron
Collider
project

LHC Project Document No.
LHC-LVI-ES-0003 rev 1.0

CERN Div./Group or Supplier/Contractor Document No.
LHC-VAC

EDMS Document No.
350950

Date: 2002-10-23

Functional Specification

BEAM VACUUM INTERCONNECTS IN THE DISPERSION SUPPRESSOR AND LONG STRAIGHT SECTIONS OF THE LHC

Abstract

Several different types of Beam Vacuum Interconnects are needed in the Dispersion Suppressor and Long Straight Sections of the LHC. This Functional Specification gives their description, location in the machine, main features and design parameters.

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CH-1211 Geneva 23
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LHC Project Document No.
LHC-VST-ES-0001 rev 1.0

CERN Div./Group or Supplier/Contractor Document No.
LHC/VAC

EDMS Document No.
351092

Date: 2002-12-09

Functional Specification

LONGITUDINAL COLD WARM TRANSITIONS FOR THE LHC BEAM VACUUM SYSTEM

Abstract

This Functional Specification describes the requirements for the LHC longitudinal beam vacuum cold-warm transitions in the LHC cryo-assemblies.

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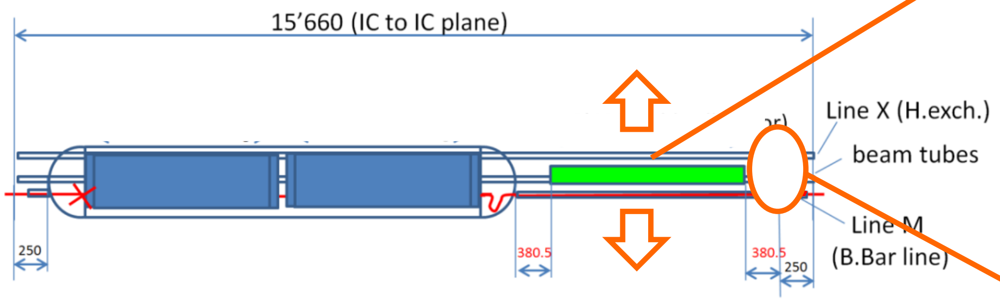
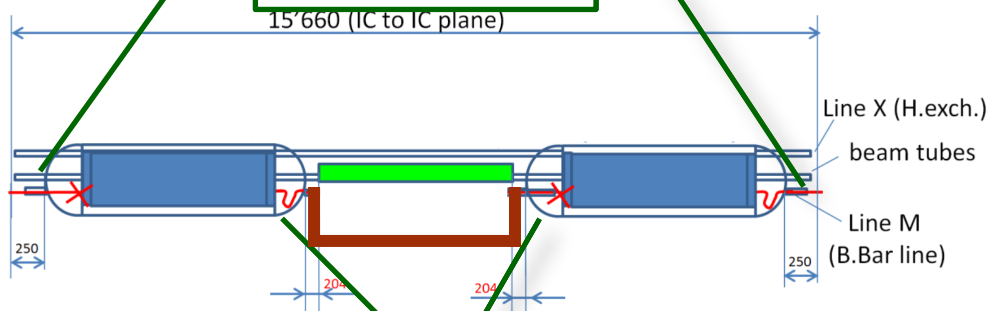
Standard interfaces + fixed length → why the collimator **must be in the middle**



Not possible to fit netiher the collimator nor sector valves between standard bus bar lines. New routing needed to make vertical space for the collimator

Additional module needed to create a standard interconnect interface and thermal compensation. Interference with W sleeve *(ok if collimator on the other side)*.

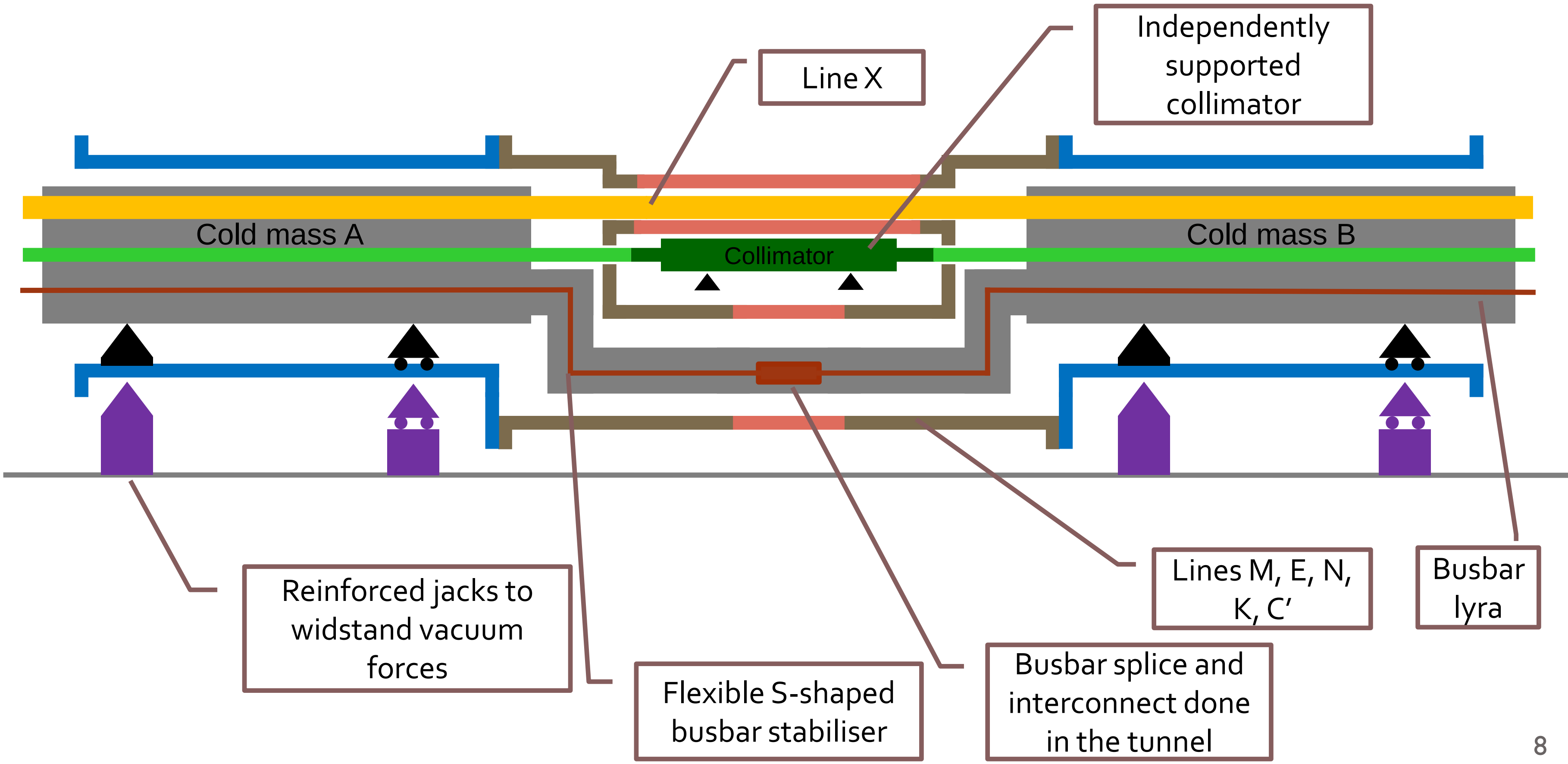
Standard interfaces



New end covers may be made to route the bus bars in a way to provide enough space for the collimator *(no interchangeability between cold masses)*.

Basic concept

- Independently cryostated and handled cold masses, linked through *two short transfer lines*
- Transfer lines with expansion joints mechanically decouple cryostats A and B
- Splice and piping interfonnect in the tunnel, all other work prior to installation
- Can use the existing TCLD collimator design with modified the supports



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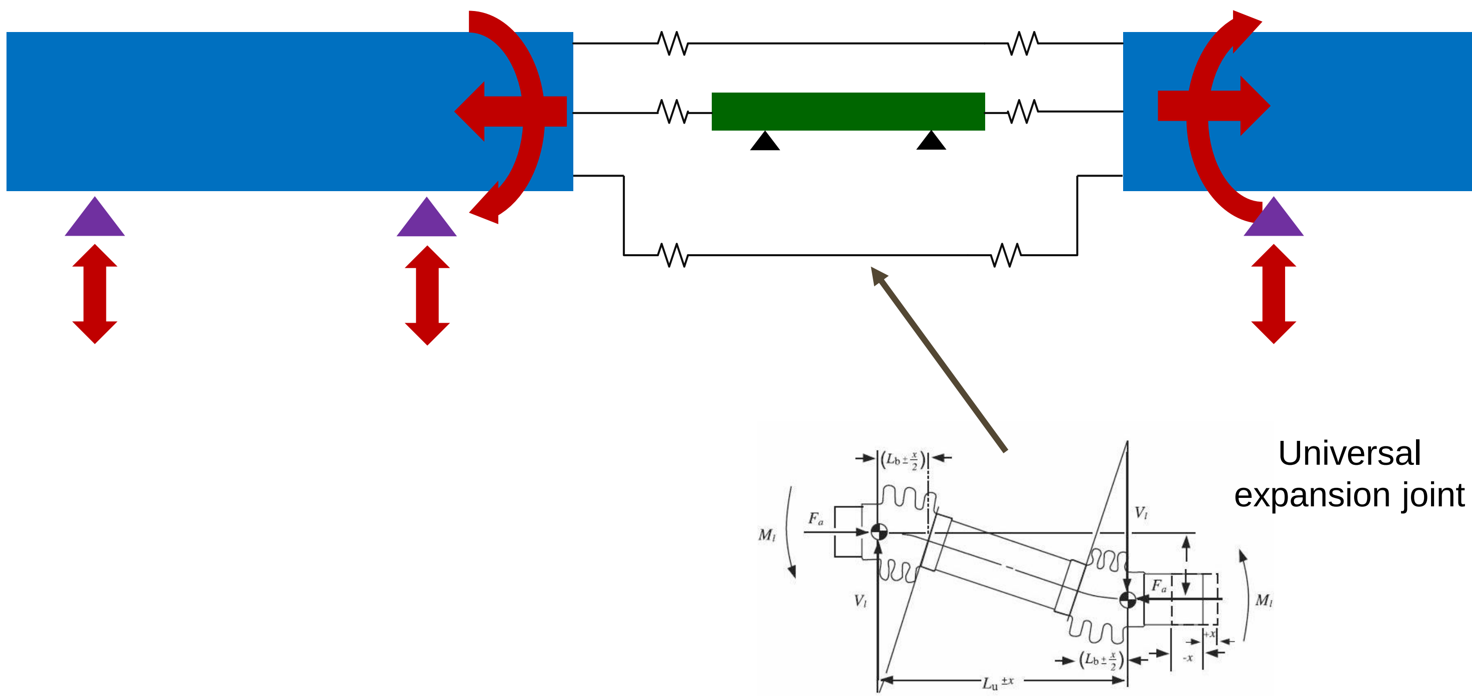
Mechanical alignment decoupled with expansion joints

- No cold support adjustment
- Conventional alignment procedure with adjustment on cryostat jacks and displaced fiducials



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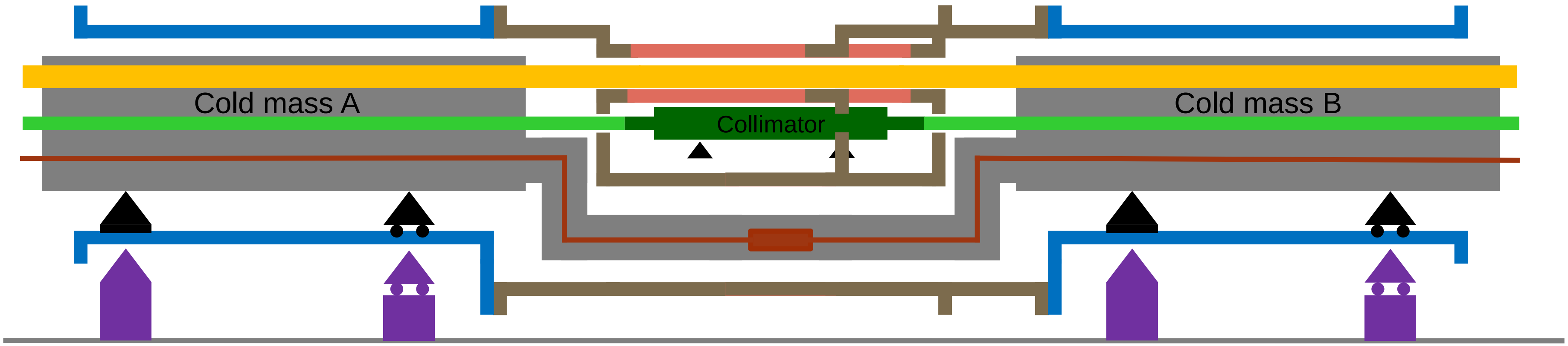
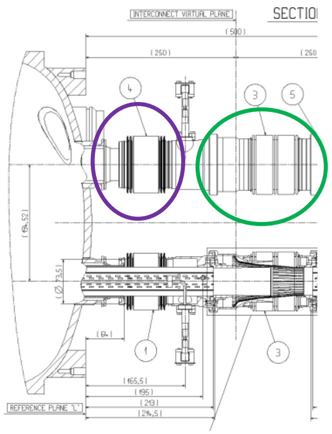
Access for in-situ repair

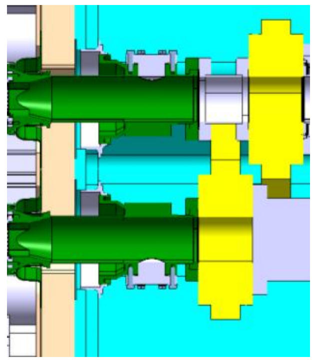


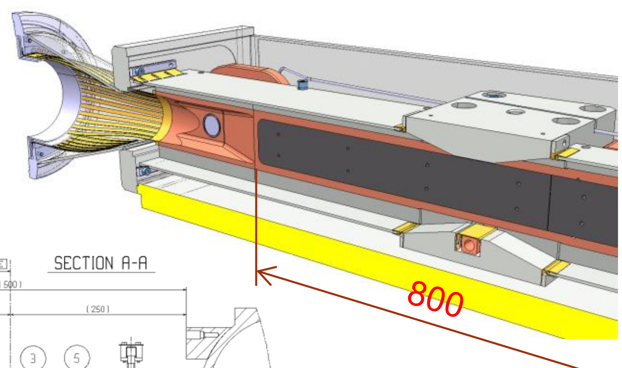
- Once the collimator removed, the vacuum vessel cover can slide open
- In-situ access for repair of «fragile» components:
  - Expansion joints
  - Flexible hoses
  - Diode
  - Instrumentation feedthrough (IFS)
  - Current leads (?)

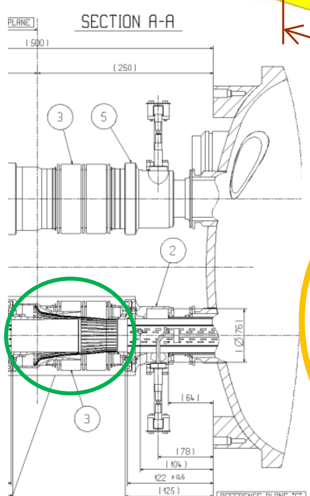
Delio.Ramos@cern.ch

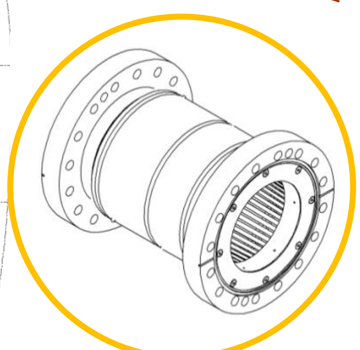
Will it fit in 15660 mm? *(Layout of beam line equipped with collimator)*





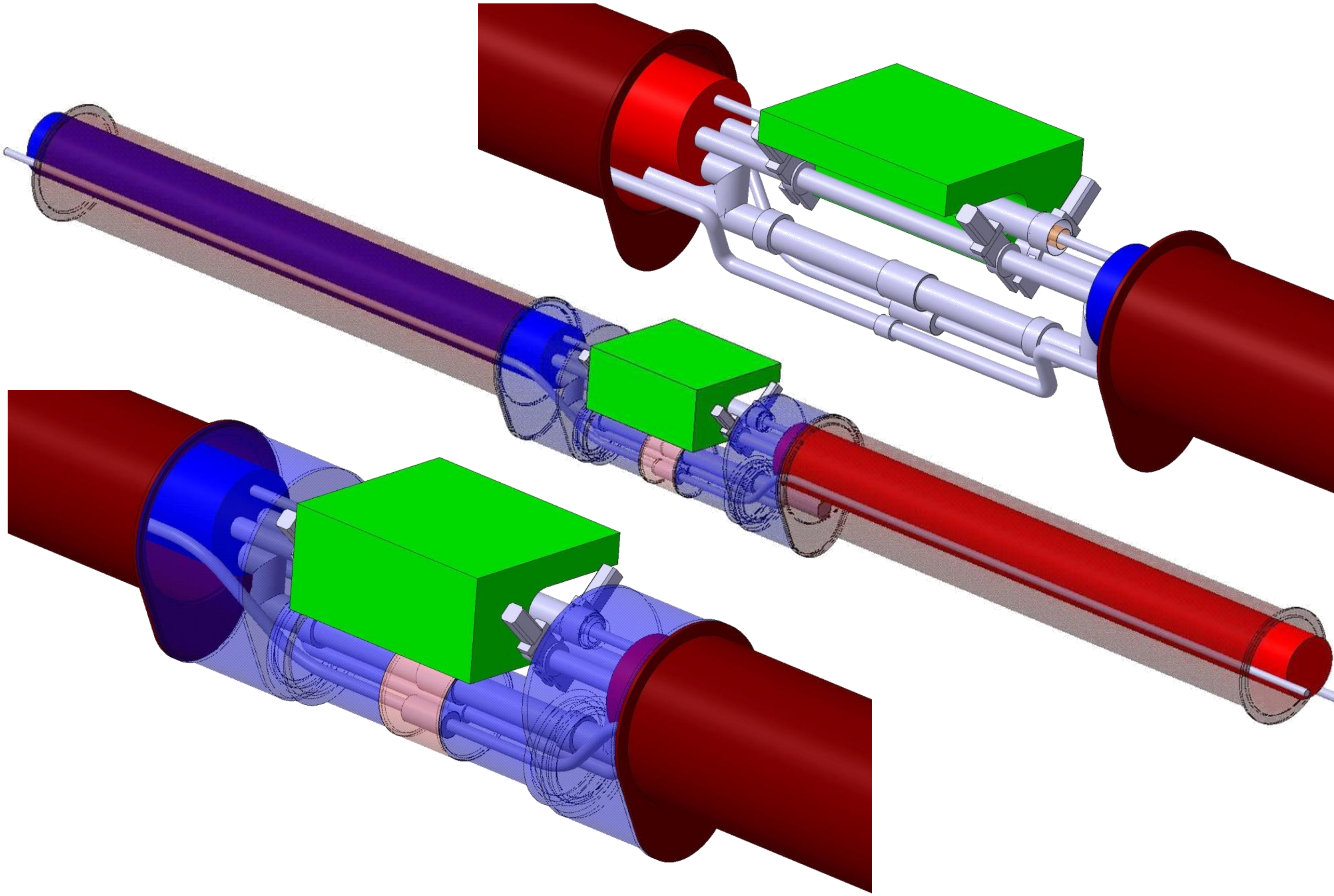


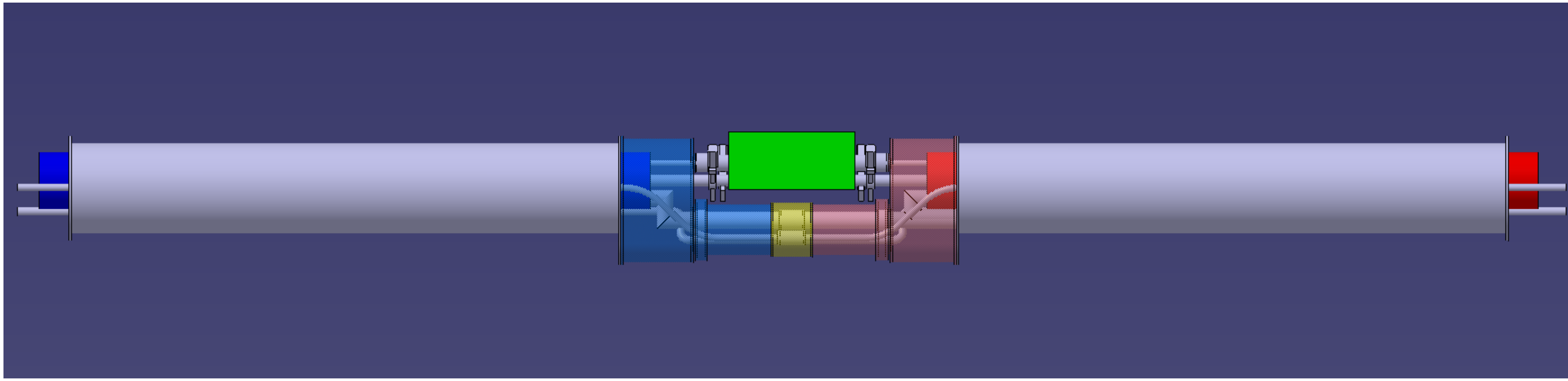


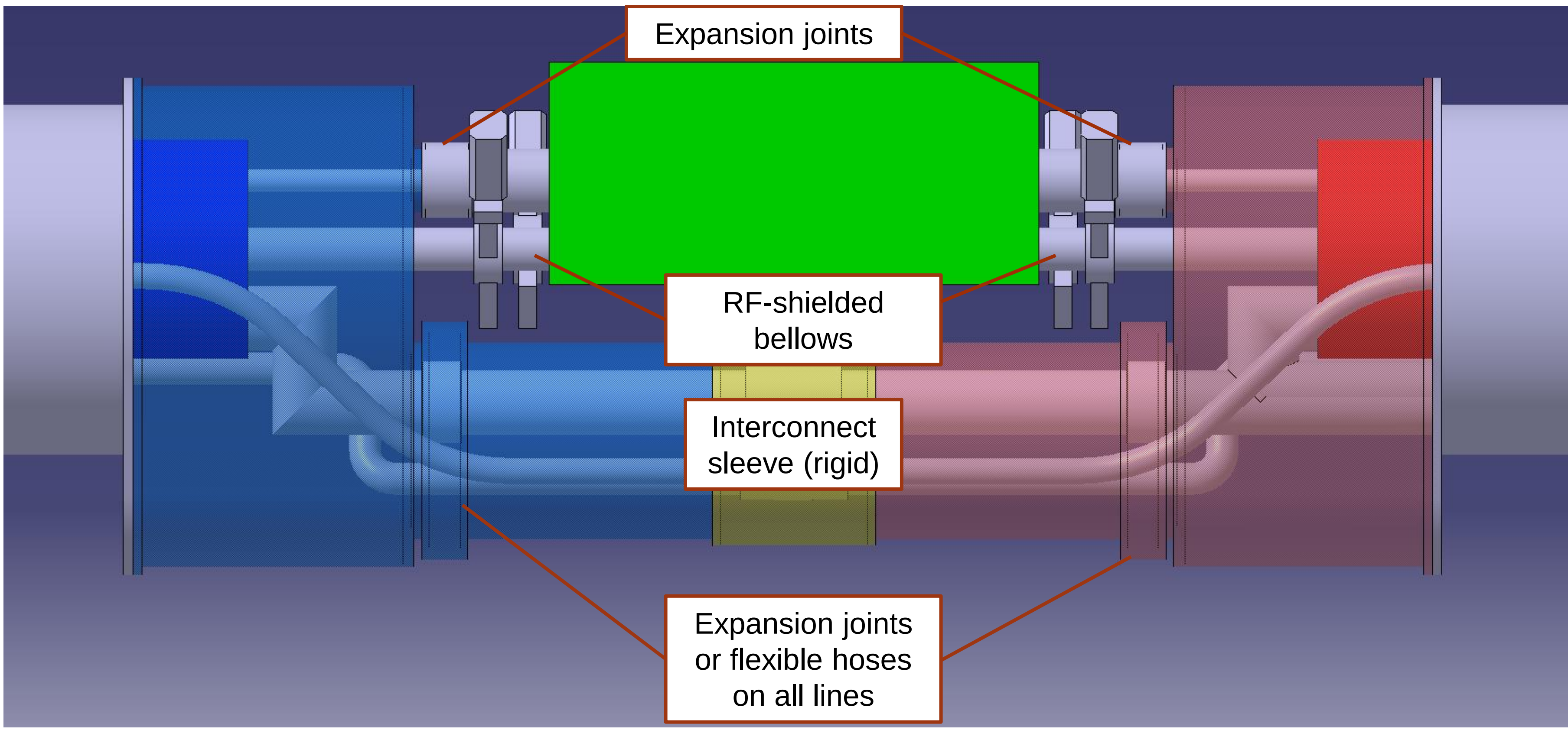


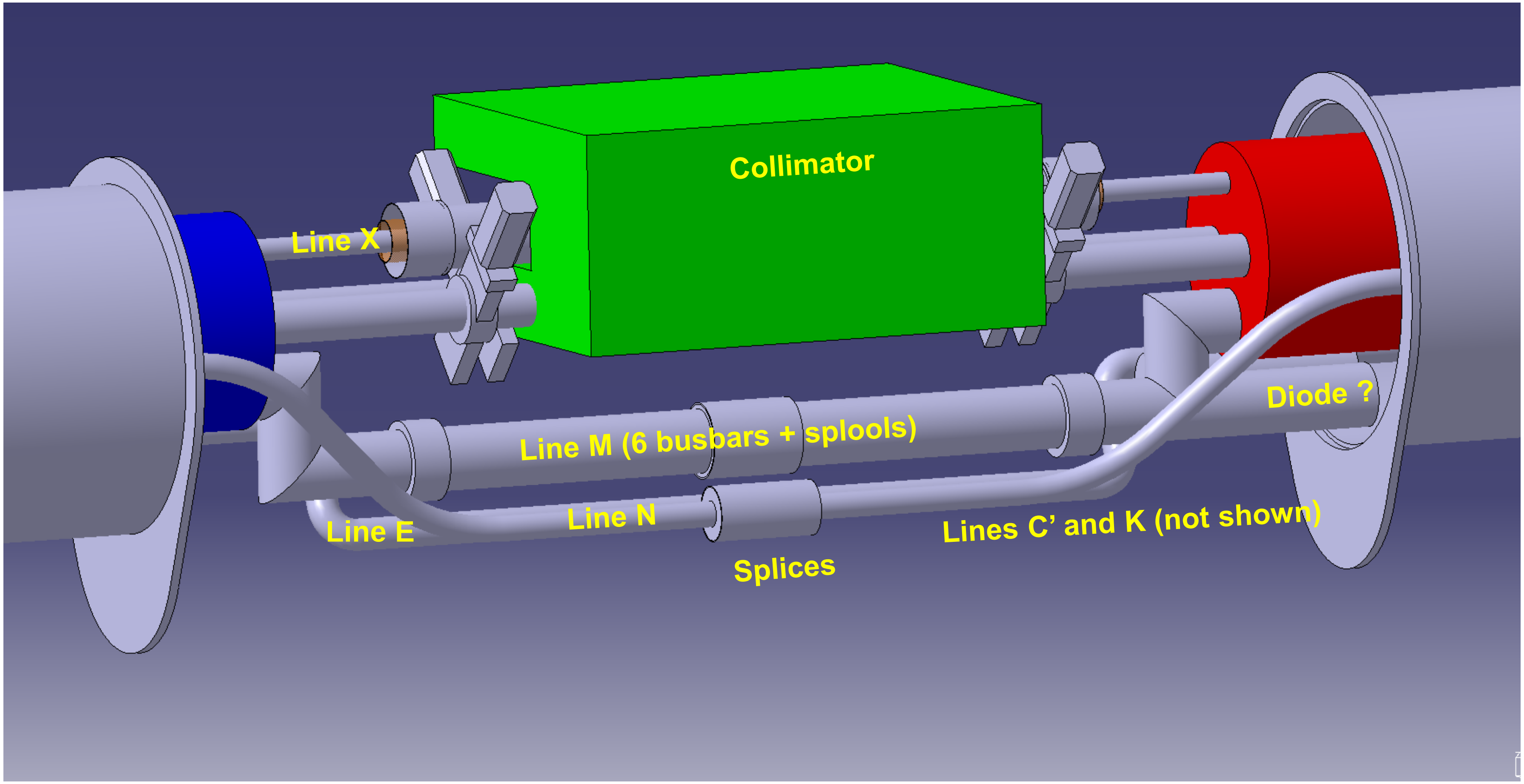
Section	Element	Length standard	Length optimised
Interconnect upstr.	Interconnect	250	250
Interconnect upstr. Total		**250**	**250**
Cold mass A	Cold mass A		
Cold mass A	End cover	154	154
Cold mass A	Outer shell extension	56	56
Cold mass A	End plate	75	70
Cold mass A	Coil	5622	5622
Cold mass A	End plate	75	70
Cold mass A	Outer shell extension	56	56
Cold mass A	End cover	154	154
Cold mass A Total		**6192**	**6182**
Cold line A	beam screen termination with nested bellows	213	181
Cold line A	Plug-in module	165	147
Cold line A	Cold warm transition with RF ball insertion port	263.5	263.5
Cold line A Total		**641.5**	**591.5**
Warm line A	Sector valve	75	75
Warm line A	RF-shielded bellows	163	121
Warm line A Total		**238**	**196**
Collimator	RF transition and flange	140	140
Collimator	Jaw tapering and pick-up	100	100
Collimator	Tungsten	1000	800
Collimator	Jaw tapering and pick-up	100	100
Collimator	RF transition and flange	140	140
Collimator Total		**1480**	**1280**
Warm line B	RF-shielded bellows	163	121
Warm line B	Sector valve	75	75
Warm line B Total		**238**	**196**
Cold line B	Cold warm transition with RF ball insertion port	263.5	263.5
Cold line B	Plug-in module	165	147
Cold line B	beam screen termination fixed side	122	122
Cold line B Total		**550.5**	**532.5**
Cold mass B	End cover	154	154
Cold mass B	Outer shell extension	56	56
Cold mass B	End plate	75	70
Cold mass B	Coil	5622	5622
Cold mass B	End plate	75	70
Cold mass B	Outer shell extension	56	56
Cold mass B	End cover	154	154
Cold mass B Total		**6192**	**6182**
Interconnect downstr.	Interconnect	250	250
Interconnect downstr. Total		**250**	**250**
Grand Total		**16032**	**15660**
Dipole length		**15660**	**15660**
Margin		**-372**	**0**

Concept of 11T cryo-assembly





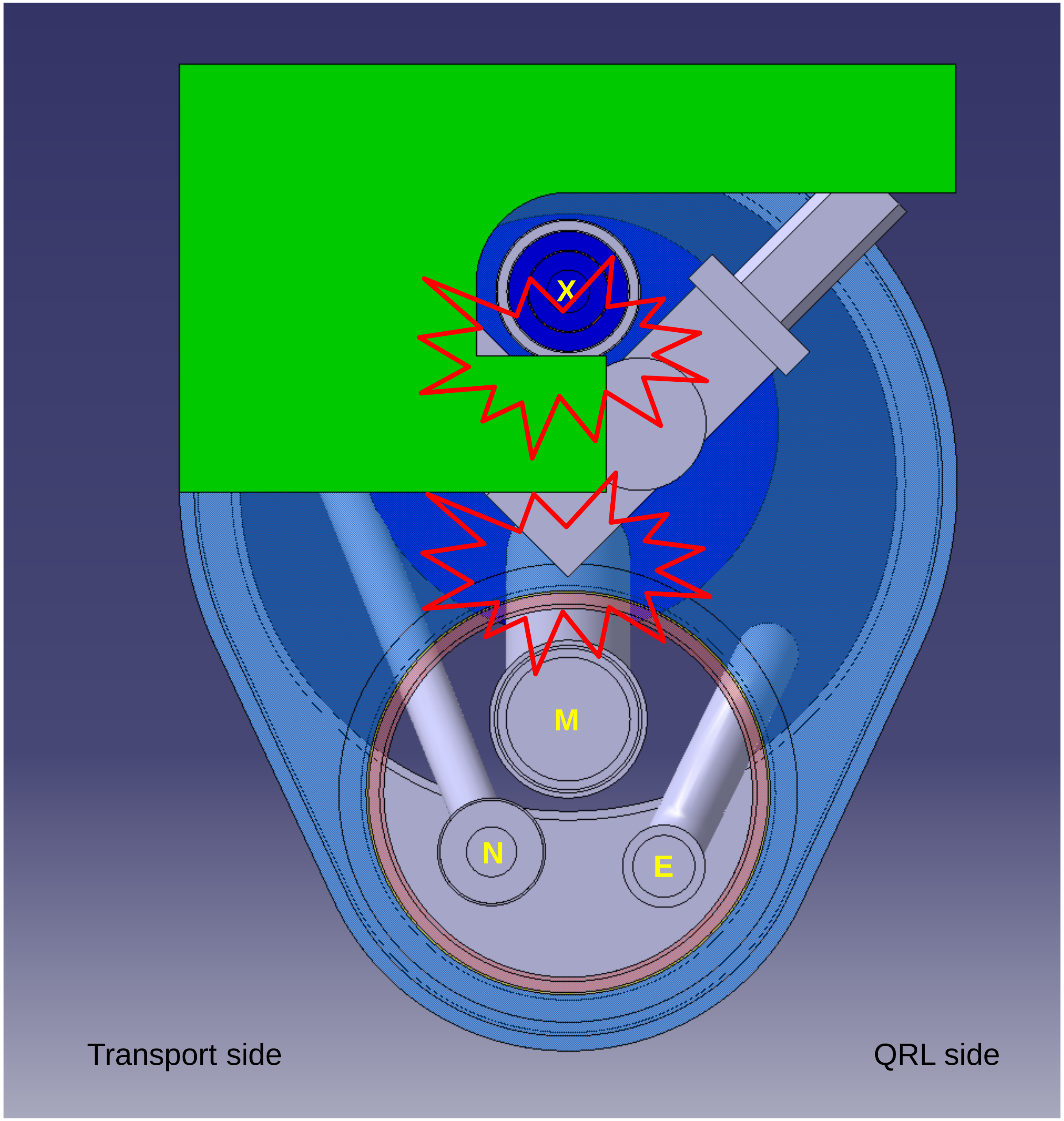

Expansion joints
RF-shielded bellows
Interconnect sleeve (rigid)
Expansion joints or flexible hoses on all lines



C' and K lines not shown

Elements defining the design in the transverse plane

- Line X insulation
- RF-shield module of gate valve



Delio.Ramos@cern.ch

Main features

- Seen by neighbouting magnets as standard dipole: Staightforward **replacement in case of major problem**
- Can be **cold tested as a single unit** in a dipole test bench and split in two for handling and transport
- **Standard alignment** procedures
- Completely **independent operation** of collimator and cryogenic systems
- Access for some **in-situ repairs**
- **Simplified construction**
- **Non-compromised functionality** wrt existing arcs
- Passed a first iteration with simplified CAD model
- Minimised impact on the collimator design (assuming 800 mm long TCLD)

Delio.Ramos@cern.ch

The short term "to do list"

- ~~Cold bore diameter?~~ → **50 mm, as the other magnets, standard beamscreens**
- ~~Are M1 and M2 busbars needed?~~ → **yes**
- Do we need spools? → **Start busbar routing as if we do**
- **Routing the busbars** inside the cold mass end covers is the next challenge → **Just started**
- Re-design components that can be optimised in length
- Detail pipe dimensions and routing
- Can we pull the line N cable? Can the line N splice be avoided?
- Do we need diodes? One unit enough for both cold masses?
- Trim powering? (Use line N? Compatibility with DFBA?)
- Cold tests done prior to beam screen installation?
- Determine position of supports for compatibility with special SSS cryostating tool and dipole anchors
- Do we need to shield the collimator from busbar magnetic field as in the QTC? (stainless or carbon steel covers?)
- Do we need more DN200's on adjacent magnets?
- <u>Draft and approve interface specification</u>

June 2014?

Delio.Ramos@cern.ch

Steps towards "valid for installation" cryostats

2014-15

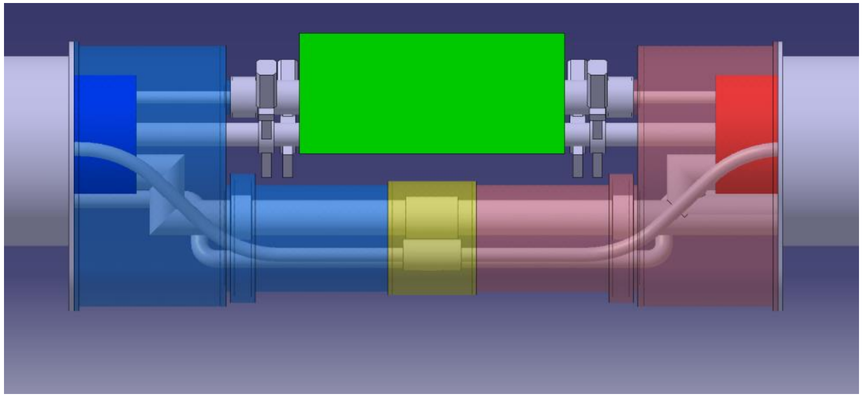
- Mockup of the bypass subassembly (**asap!**)
  - Validate integration of all components
  - Measure fabrication tolerances
  - Test alignement flexibility
  - Train personnel on assembly procedures
  - Exercise installation, alignment and removal of collimator
  - Simulate repair interventions
  - Develop tooling
  - Feedback for design improvements
- Iterate on drawings, specifications, tooling design

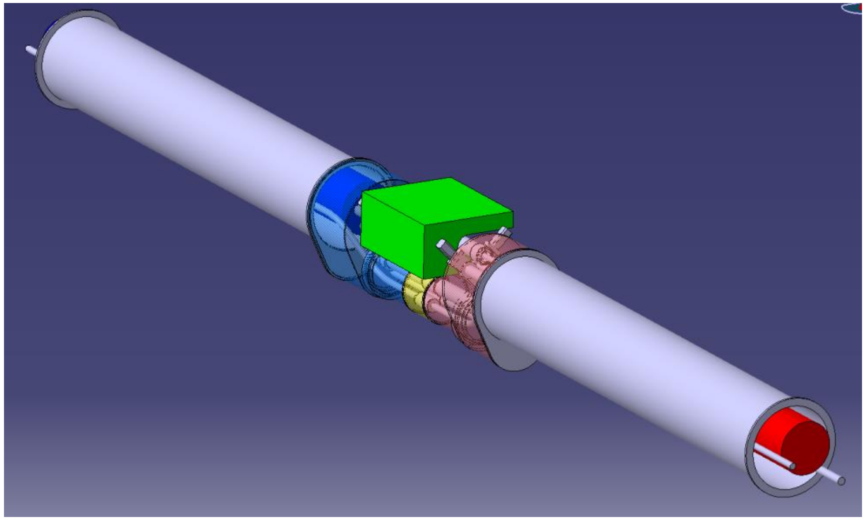
2016?

- Fabricate and cold test full scale prototype (*i.e. 2 cold masses*)

2017-18?

- Fabricate series





Delio.Ramos@cern.ch

Final remarks

- Making it all fit in 15660 mm is not yet guaranteed -> let's **optimise all we can**
- One should aim for a design at least as **robust** as existing arc cryostats, **demonstrated** by testing
- Let's stick to **common practices** as much as we can
- We need only 2 units for IR2 but more may follow: **industrialisation and standardisation** of the design are justified from the beginning
- Good designs require time for testing and re-iteration, let's give ourselves the chance to do it by answering **open questions** as soon as possible!

Delio.Ramos@cern.ch