Status of TCLD design and integration

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4th Joint HiLumi LHC-LARP Annual Meeting
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Outline

- Context
- Status of the integration
- Status of the design
- Summary

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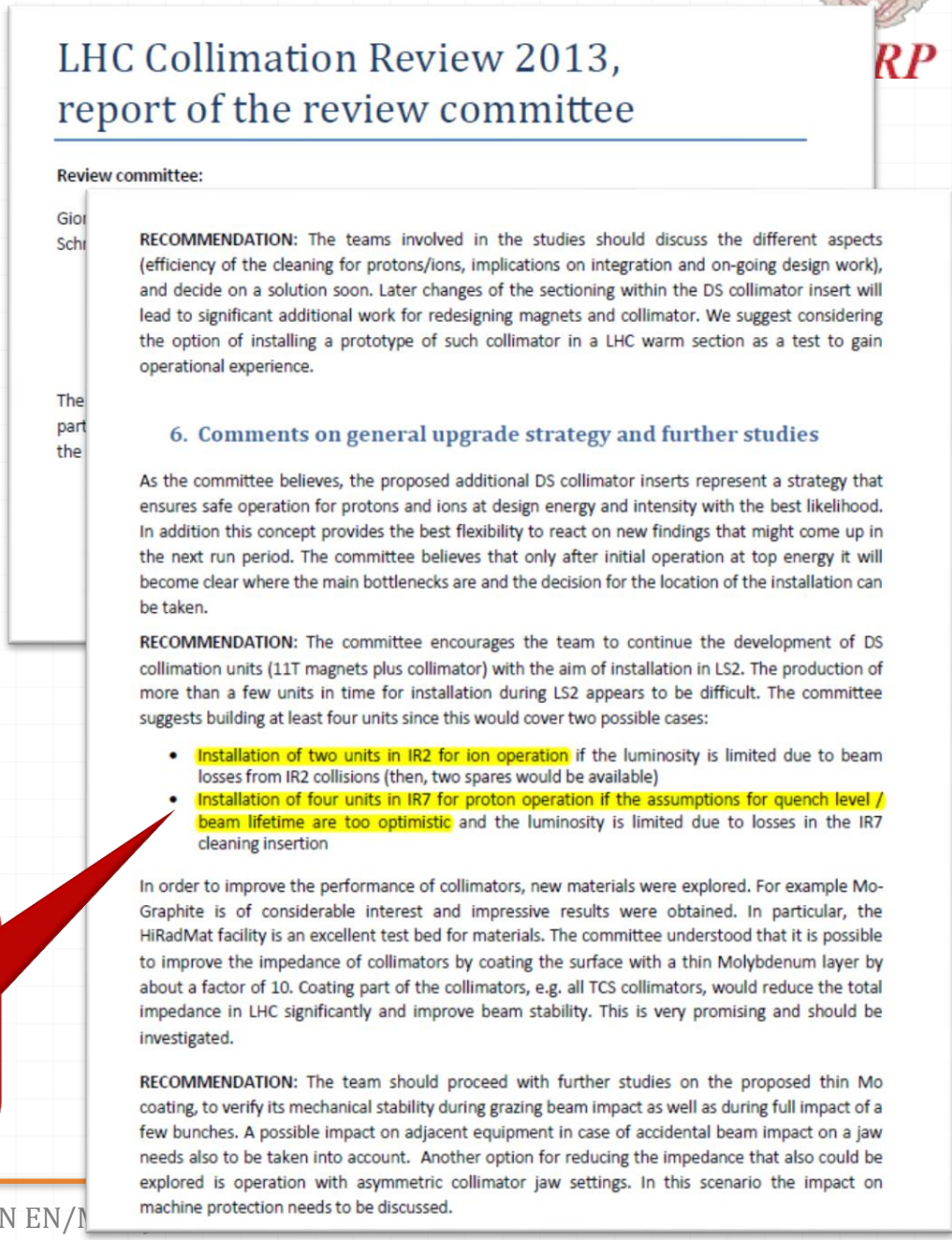
Context

- DS Collimators are **mandatory** for **Ion Operation** after LS2 (**2 units** to be installed at **IR2** during **LS2**).
- In **Proton Operation**, DS Collimators **reduce local losses by a factor 10.** Installation timing depends on actual **Quench Limits** for **SC magnets** (in worst scenario, **4 units** at **IR7** during **LS2**).
- DS Collimators **very likely required** in all **IRs** after **LS3.**

Report from 2013 Collimation Review Committe May 2013



LHC Collimation Review 2013, report of the review committee

Review committee:

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RECOMMENDATION: The teams involved in the studies should discuss the different aspects (efficiency of the cleaning for protons/ions, implications on integration and on-going design work), and decide on a solution soon. Later changes of the sectioning within the DS collimator insert will lead to significant additional work for redesigning magnets and collimator. We suggest considering the option of installing a prototype of such collimator in a LHC warm section as a test to gain operational experience.

6. Comments on general upgrade strategy and further studies

As the committee believes, the proposed additional DS collimator inserts represent a strategy that ensures safe operation for protons and ions at design energy and intensity with the best likelihood. In addition this concept provides the best flexibility to react on new findings that might come up in the next run period. The committee believes that only after initial operation at top energy it will become clear where the main bottlenecks are and the decision for the location of the installation can be taken.

RECOMMENDATION: The committee encourages the team to continue the development of DS collimation units (11T magnets plus collimator) with the aim of installation in LS2. The production of more than a few units in time for installation during LS2 appears to be difficult. The committee suggests building at least four units since this would cover two possible cases:

- Installation of two units in IR2 for ion operation if the luminosity is limited due to beam losses from IR2 collisions (then, two spares would be available)
- Installation of four units in IR7 for proton operation if the assumptions for quench level / beam lifetime are too optimistic and the luminosity is limited due to losses in the IR7 cleaning insertion

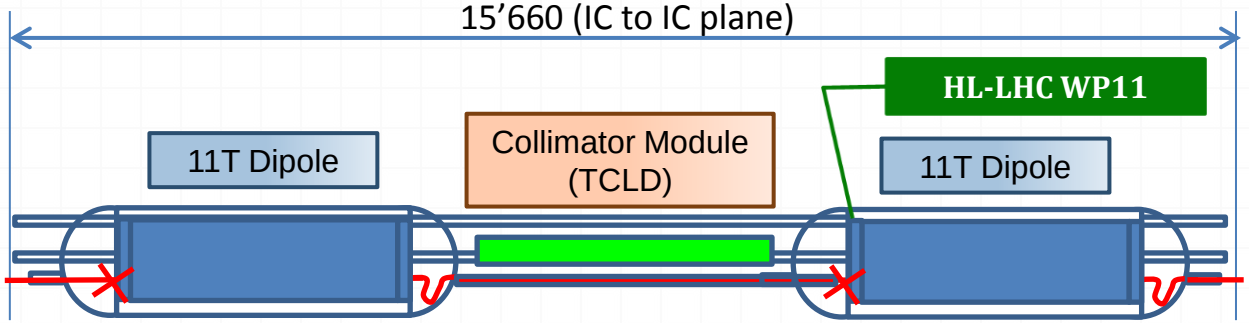
In order to improve the performance of collimators, new materials were explored. For example Mo-Graphite is of considerable interest and impressive results were obtained. In particular, the HiRadMat facility is an excellent test bed for materials. The committee understood that it is possible to improve the impedance of collimators by coating the surface with a thin Molybdenum layer by about a factor of 10. Coating part of the collimators, e.g. all TCS collimators, would reduce the total impedance in LHC significantly and improve beam stability. This is very promising and should be investigated.

RECOMMENDATION: The team should proceed with further studies on the proposed thin Mo coating, to verify its mechanical stability during grazing beam impact as well as during full impact of a few bunches. A possible impact on adjacent equipment in case of accidental beam impact on a jaw needs also to be taken into account. Another option for reducing the impedance that also could be explored is operation with asymmetric collimator jaw settings. In this scenario the impact on machine protection needs to be discussed.

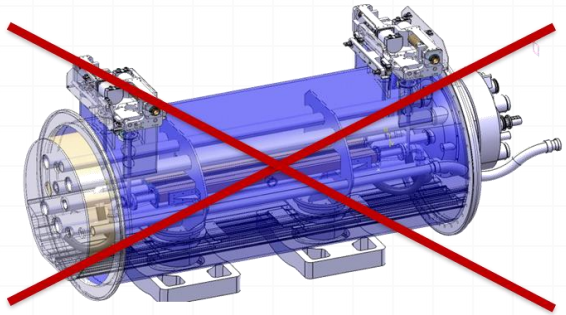
TCLD collimator

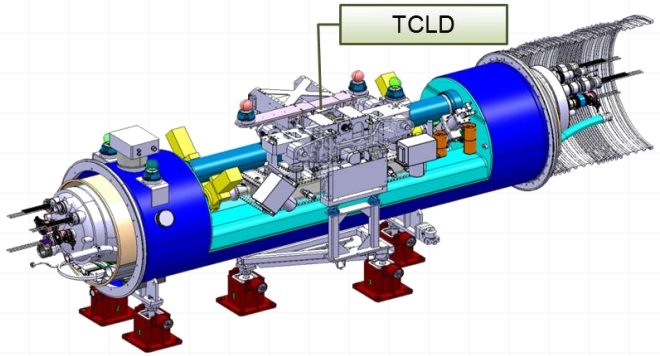
Challenge 1: How to create space for a DS Collimator Unit in the LHC Continuous Cryostat (Dispersion Suppressor region)?

Replacing LHC dipoles **with shorter High Field (11 T) magnets**



Challenge 2: Cold or warm DS Collimator Module?





Cold collimator

- Many open issues.
- Possible showstoppers exist.
- Only limited advantage as to overall length (200÷300 mm).

Warm collimator

- Slightly longer, but no showstoppers.
- Can profit from experience with 4.5 m cryo-bypass (**QTC** for LS1)

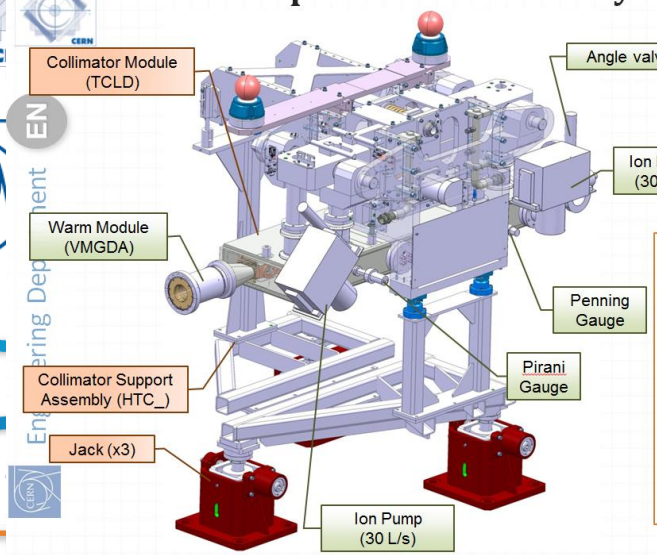
TCLD collimator

- May 2013 **review committee** wholly **endorsed the proposal of a warm collimator module between two 11T magnets** replacing a standard dipole
- A design effort was launched to adapt the **2010 TCLD design** to **a completely different environment** (see A. Bertarelli's talk at 3rd Joint HiLumi LHC-LARP Annual Meeting)

RECOMMENDATION:

- The committee strongly encourages the development and prototyping of one 11 T (5.5 m) dipole magnet, and the cryogenic bypass collimator unit. An early cold test of the almost complete cryogenic bypass may be elucidating alignment issues that could be important for the final application.
- Build at least 4 units (1 unit consists of 2 magnets + bypass + collimator) since this would cover 2 possible cases, as described in section 6 of this report.
- For an LS2 deployment it is clear that serial «learning curves» for making Nb_3Sn coils at CERN and later in EU industries cannot be accommodated. The committee agrees with the early involvement of industrial partners in the assembly of CERN Nb_3Sn prototypes.
- In the US, the continued development of 11 T Nb_3Sn dipoles is being challenged by the needs of IR quadrupole development within the LARP program. However the knowledge acquired in the Nb_3Sn dipole and quadrupole programs are synergetic and can support each other. Develop alternative plans for the first 5.5 m long prototype taking into consideration potential prioritizations in the US Nb_3Sn program.

TCLD Specification and Layout



Key Features

- 2 jaws on 1 beam
- TCLD fully independent from Cryostat
- Pre-aligned TCLD Support for rapid positioning
- Horizontal Orientation
- Hydraulic and electrical manual connections
- On-collimator vacuum equipment

Conclusions

- DS collimators seem to be a very promising way of decreasing proton losses to cold magnets in the LHC.
- Present design proposal: assembly with warm DS collimator between 2 short 11T dipoles can replace existing long dipole
- MAD lattice with DS collimators in IR7 created, both for nominal optics and for ATS. Used for SixTrack input
- SixTrack simulations of cleaning in nominal optics show a very significant loss reduction in cold magnets from DS collimators
  - Gain factor 10-20 in global inefficiency, and even more in local losses in the IR7 DS
  - Results consistent with results from ATS simulations (A. Marsili) and previous studies with different layout (T. Weiler)
- Installing 2 DS collimators seems as a better option: shields the whole IR7 DS and reduced losses also in other parts of the ring.
- Decreasing the length of the TCLD from 1m to 80cm has no visible impact on the losses
- Detailed energy deposition studies needed to quantify gain in dose and quench margin – SixTrack output forwarded to FLUKA team (see A. Lechner in next talk)

2013.09.27 R. Bruce

R. Bruce, 27/09/13

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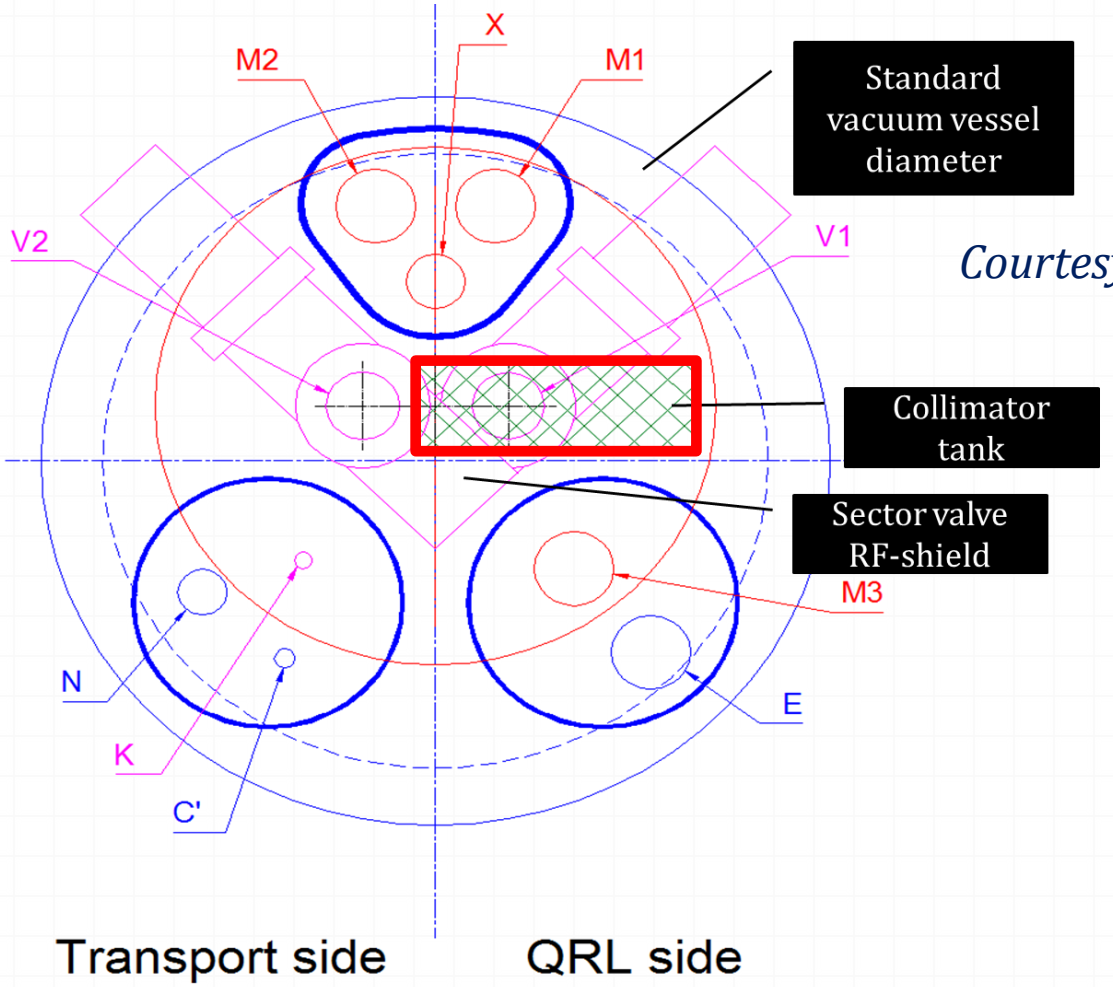
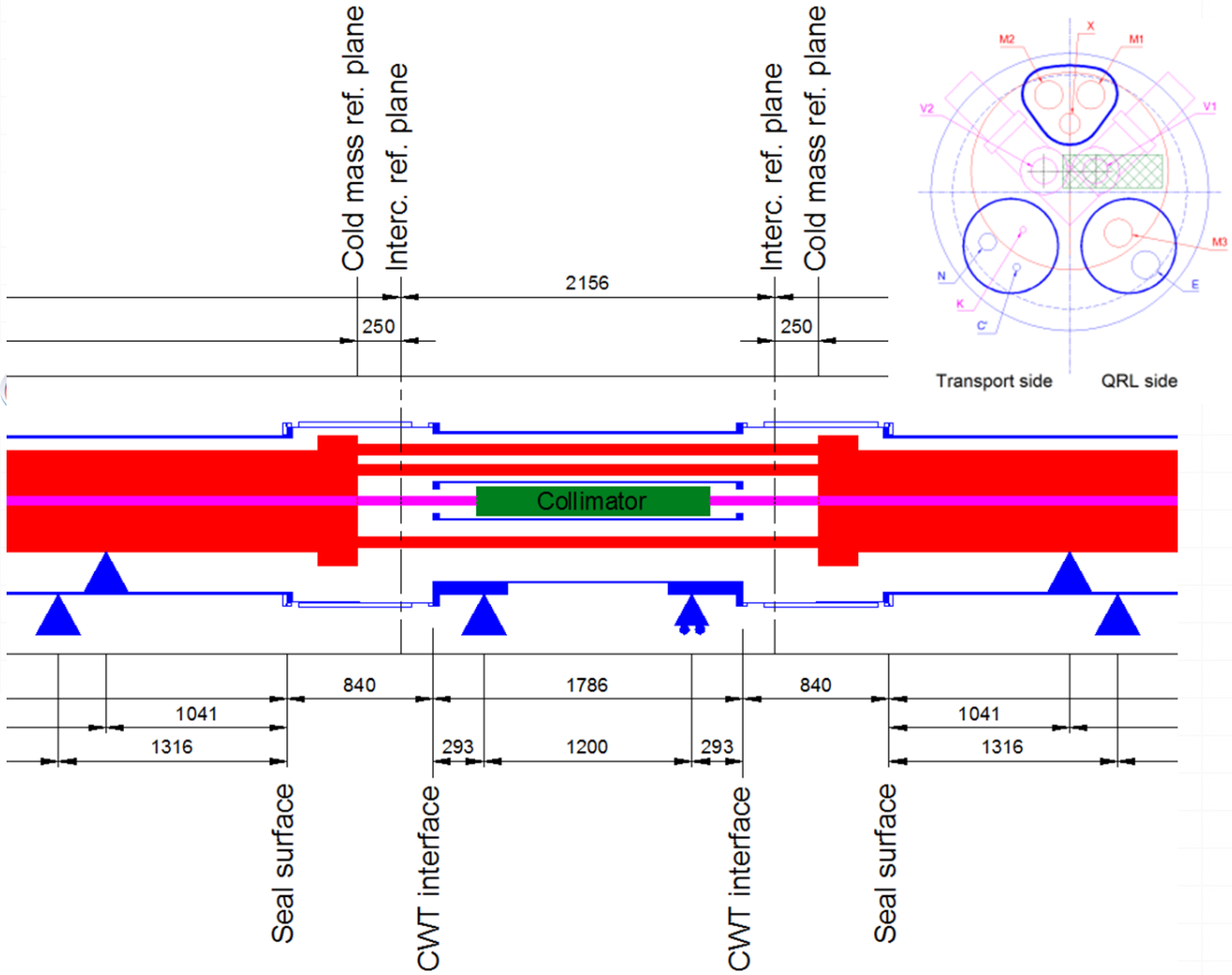
Status of the Integration

- Routing scheme proposed in 2010 is not compatible with 11 T magnet layout
- HL-LHC WP11 presented a possible solution for the integration (D. D. Ramos, 24.10.14):



Courtesy of D. D. Ramos

Status of the Integration



3 Cryo-assemblies interconnected in the tunnel

- M lines are moved away from the beam lines by the implementation of enlarged cold mass end covers
- Conventional busbar work (lyras..), support scheme and splices
- Two short interconnects
- **Less available space than previous proposal but with better accessibility**

Courtesy of D. D. Ramos

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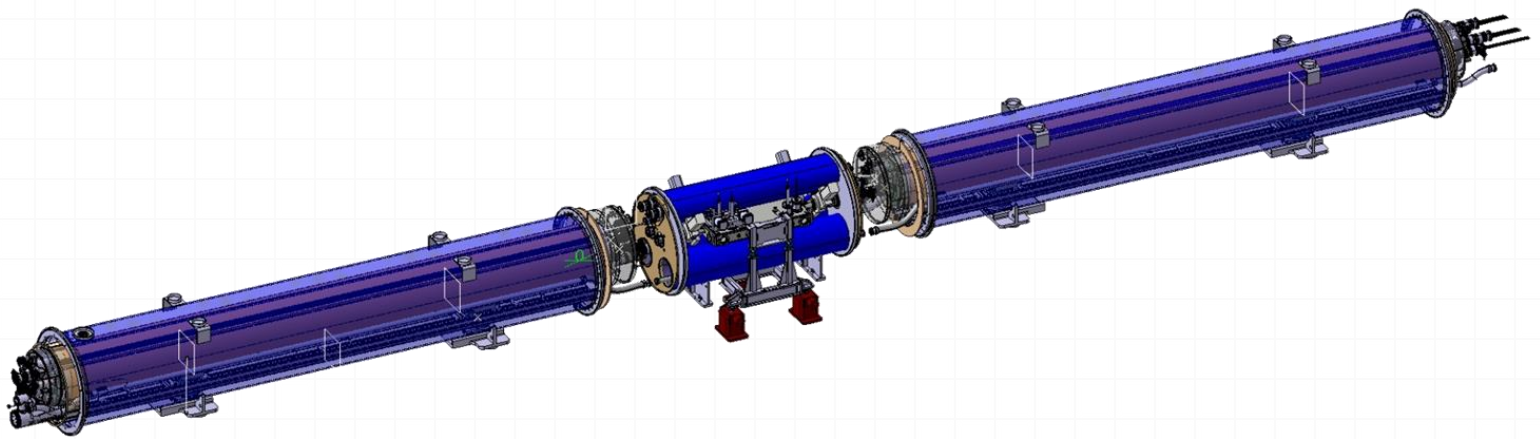
Status of the Design

- The collimator design completed in 2010 to meet the collimation specifications **cannot be adapted to this different environment → drastic design modification required!**
- The new **mechanical design of the collimator** has started at EN/MME, after the last inputs from the integration
- The maximum acceptable length of the jaw required for the integration is **not defined yet**. This is driven by the beam vacuum equipment.

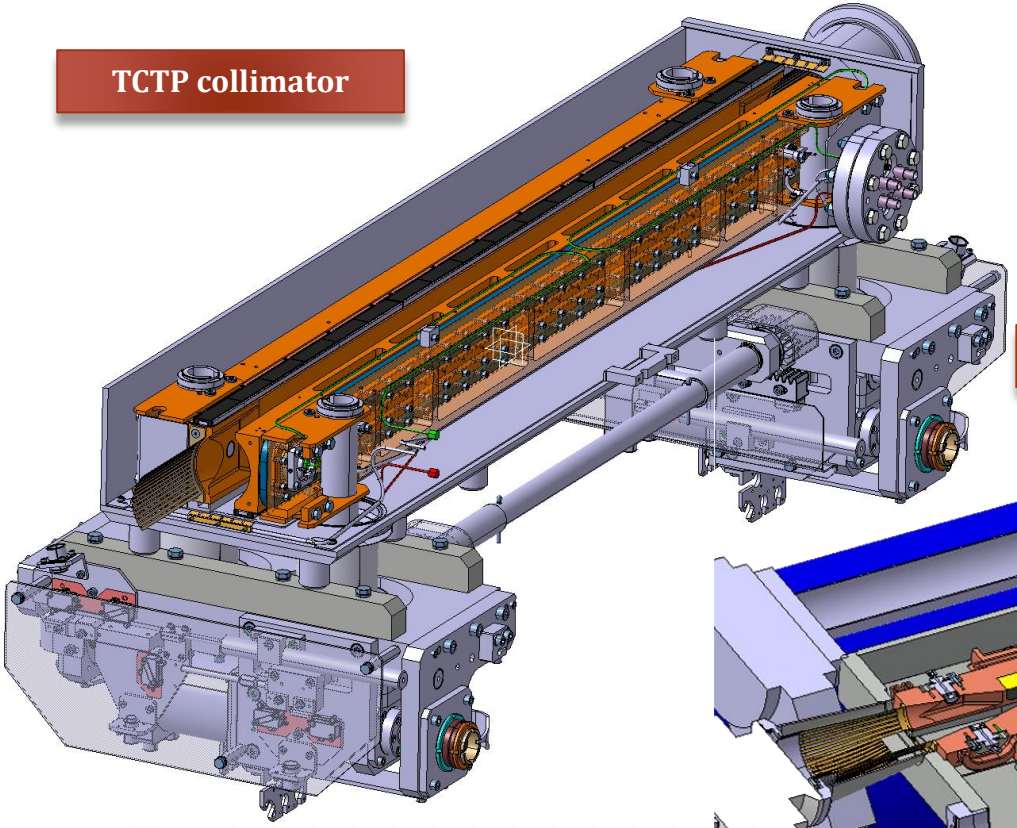


Courtesy of L. Gentini

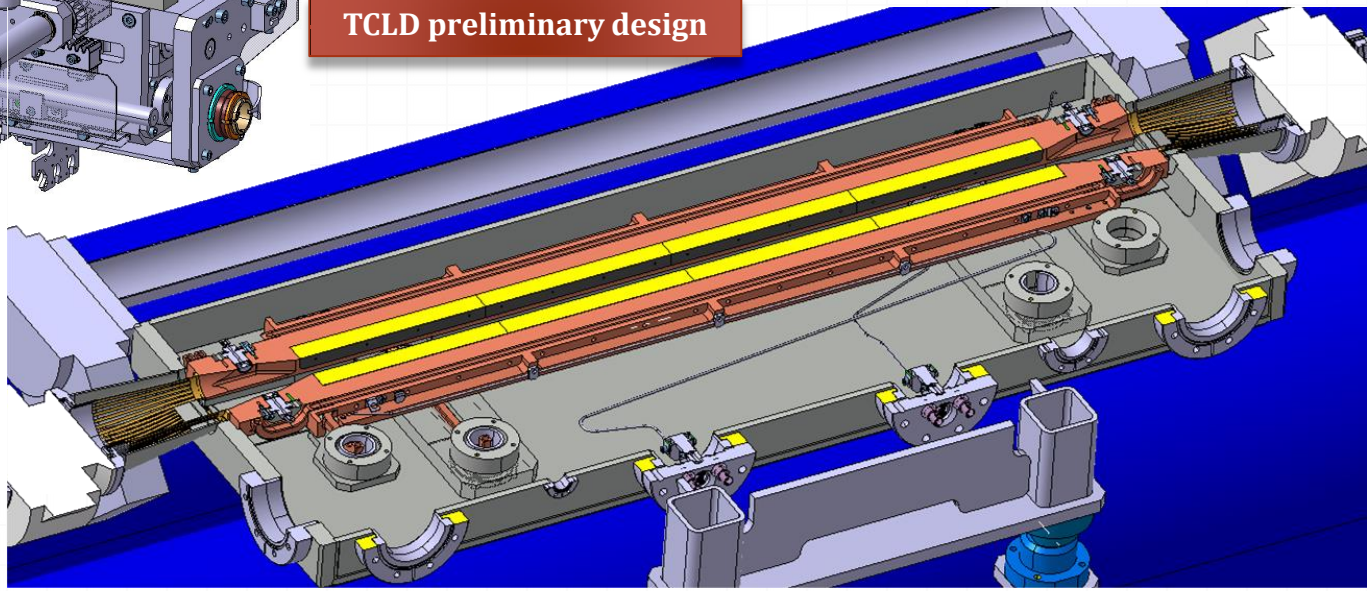
Status of the Design

- Main difference with a standard collimator (e.g. TCTP): **all axes on the same side** → cantilever supporting system for the jaws, different collimator supports and movable tables

TCTP collimator

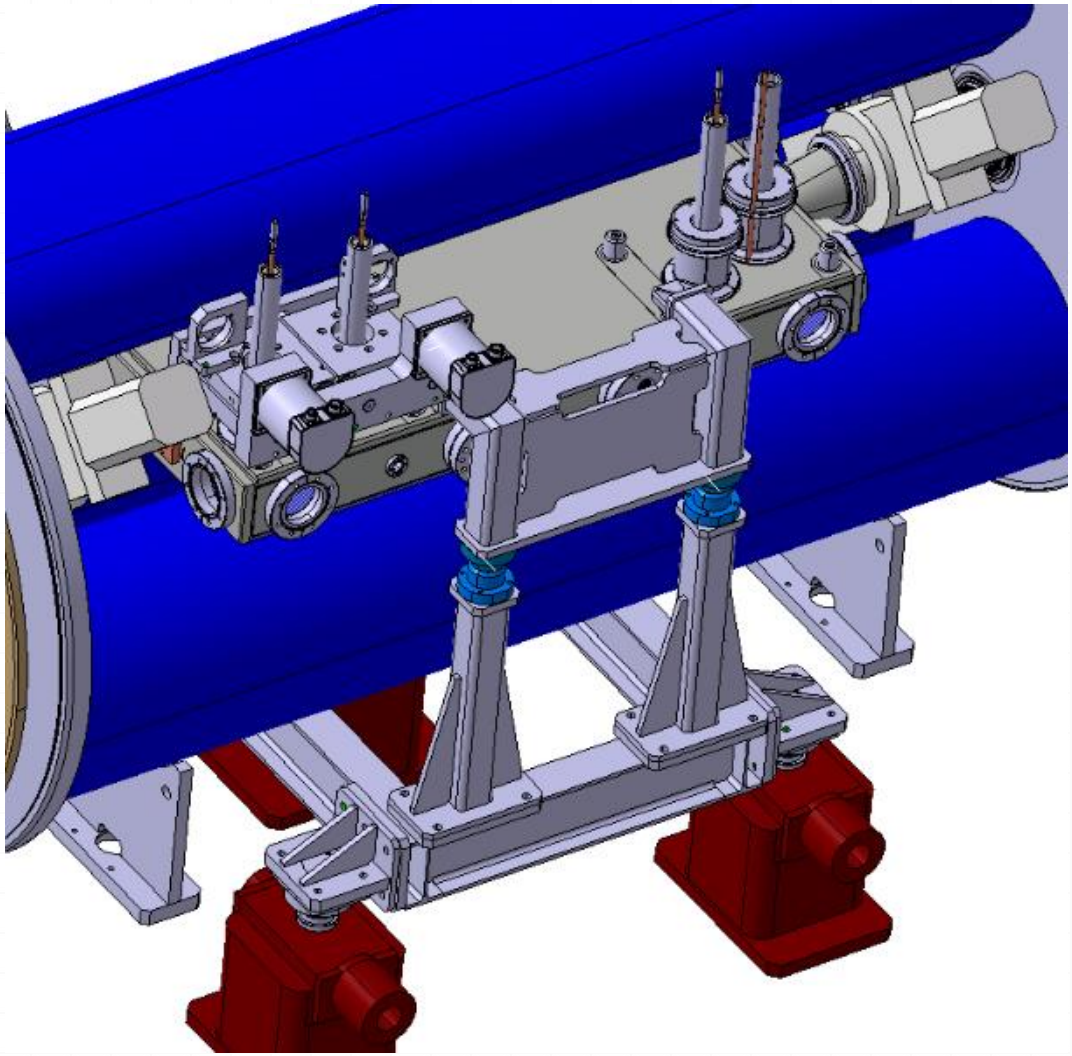


TCLD preliminary design



Courtesy of L. Gentini

Status of the Design



- **New collimator supports design well advanced!**
- **Re-design of the actuation system ongoing**

Courtesy of L. Gentini

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- A solution for the introduction of a collimator between two 11T magnets in the DS region has recently been proposed by HL-LHC WP11 (**end of October 2014**)
- The new layout introduces significant changes with respect to 2010 layout and **reduces available space for collimator**
- **The new mechanical design has already started**, and preliminary solutions have been proposed for some of the components (e.g. collimator supports)
- An important input for the design is the **maximum acceptable jaw length** for integration, which depends on the beam vacuum equipment and is under definition

Thank you for your attention!