Cryogenic status of the HEL project foreseen at IP4

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On behalf of WP9 Cryogenics

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HL-LHC Hollow Electron Lens (production) kick-off meeting 2021-04-13

Agenda

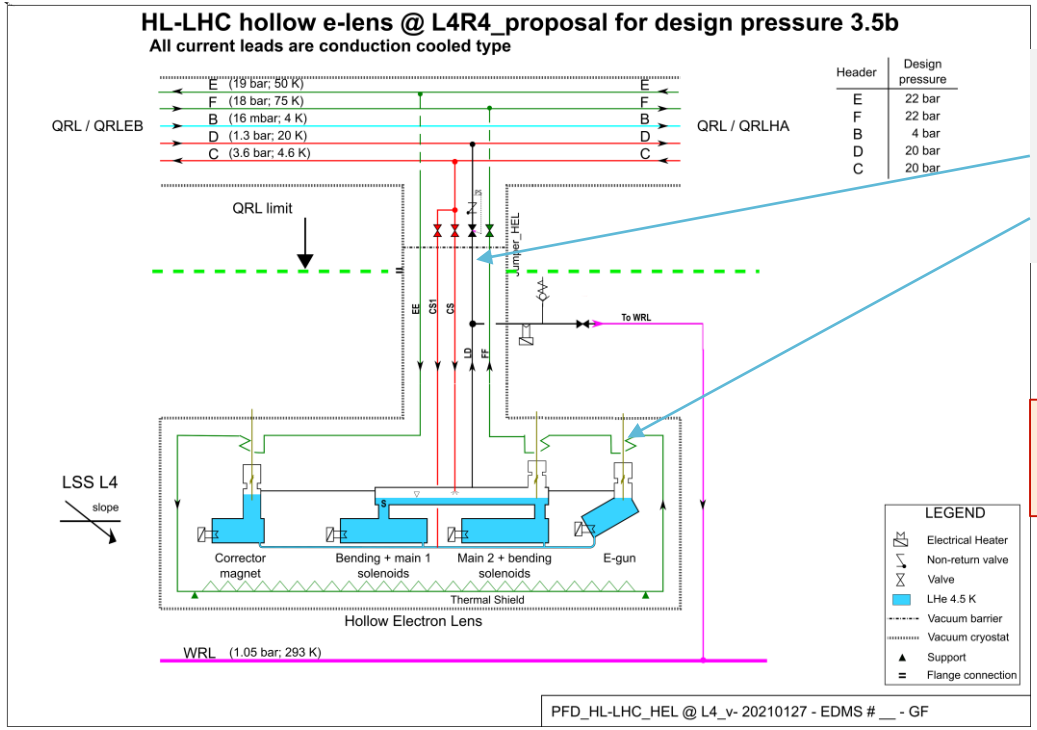
The agenda will be:

- Process flow diagram design, associated studies concerning working pressure and overpressure safety analysis
- Development of the dedicated cryogenic service modules & associated extensions
- What's now
- Budget & Summary
- *The surface commissioning tests at CERN premises are not included in this presentation.*

Last revision of the PFD

At the initial phase of the project, thermal loads were in the range of 10 to 20 W @ 4.5K and up to 500 W @ 70K in case of conduction cooled current leads.
These thermal load are within global sector margin.

An update of these values will help to fix pipes/valves dimensions.



This revision include the design pressure of 3.5 bar and conduction cooled current leads for all circuits

At this point, the energy released during a quench was supposed to be negligible

Decision to use conduction cooled current lead is still pending. The gas cooled current lead system is kept in parallel until final choice. A combined solution (120 A conduction cooled & 350 A gas cooled) is also possible.

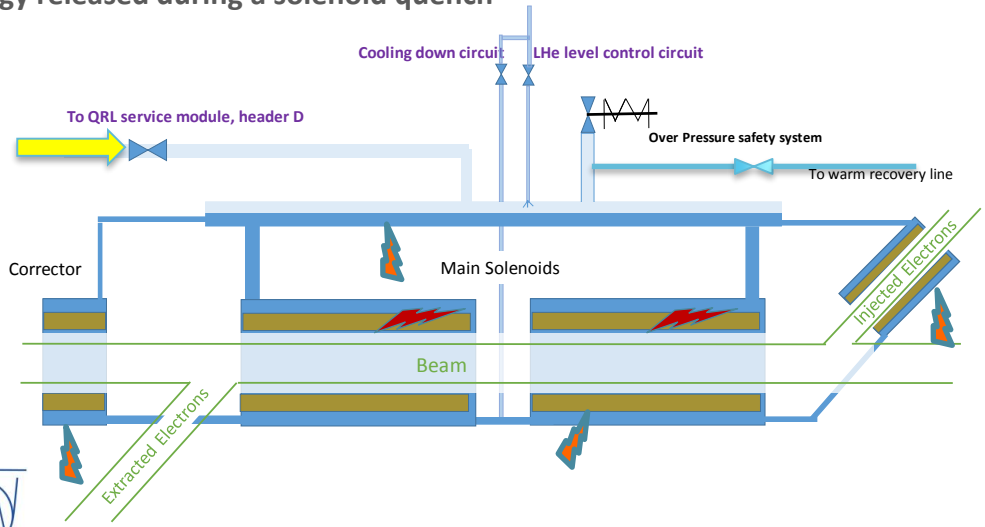
Pressure safety analysis

After an update of the solenoid quench protection study, the energy released during a quench is estimated about 1.2 MJ released in 2 s.

At this stage of the studies, a first round of pressure safety evaluation must be performed to validate the chosen safety concept.

There are 3 major type of overpressure incidents possible in this cryostat

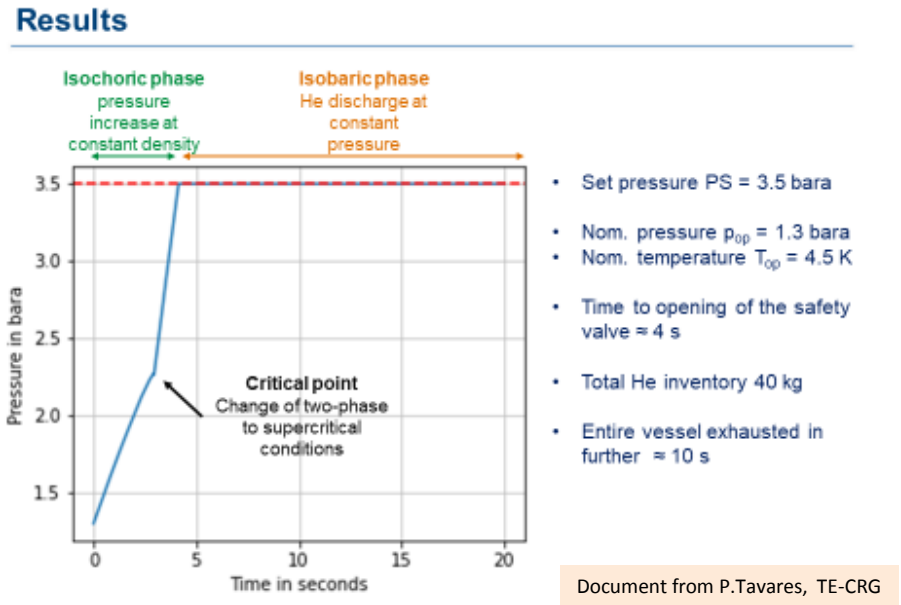
- **Lost of vacuum insulation after an accident on the vacuum envelope**
- **Back-filling of the cryostat by QRL-header D after sector quench**
- **Energy released during a solenoid quench**



All these possible incidents are addressed by design, if the cryostat is PN 20 and connected to the LHC QRL

Pressure safety evaluation

From overpressure point of view, the sizing case will be generated by a solenoid quench. The energy stored is in the range 1.2 MJ. This will generate up to 4.4 kg/s of helium mass flow.



Document from P.Tavares, TE-CRG

Depending on the QRL status, this helium mass flow will be expelled to the QRL header D in most of the cases.

- This scenario will be used to size the return gas connection to QRL-Header D

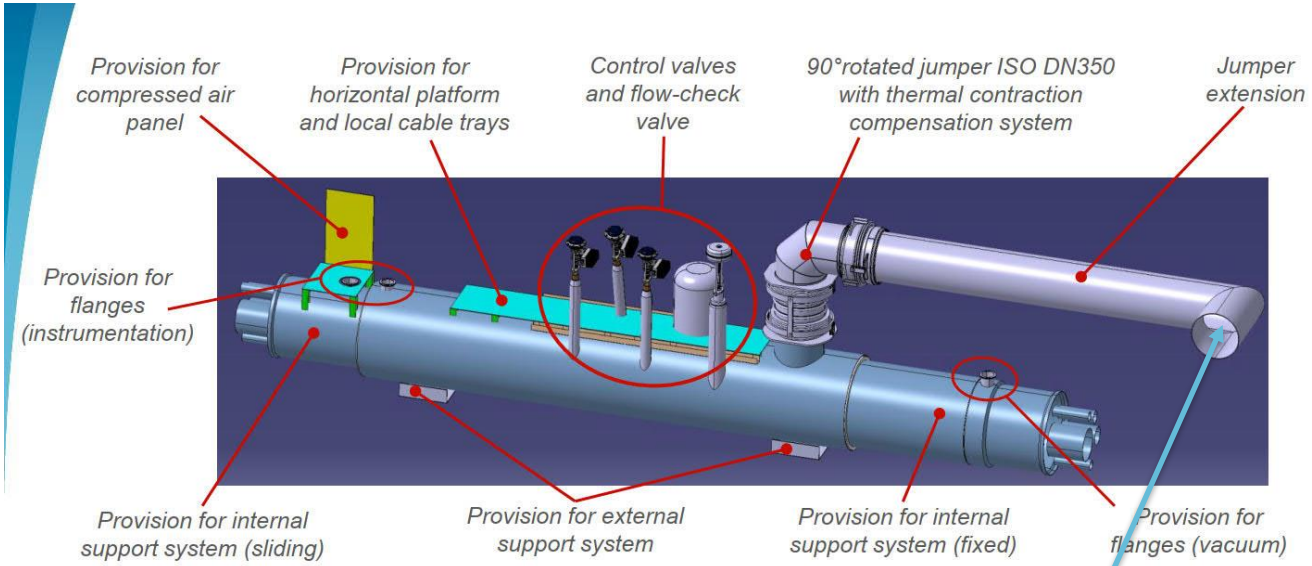
If the quench occurs while QRL-Header D is pressurized, the overpressure safety system must be able to handle the full mass flow.

- This scenario will be used to size the overpressure safety valves.
- The ODH risk assessment must be reviewed.

A re-evaluation of the design pressure up to 4.5 bara is undergoing. This should ease helium management in case of solenoid quench with no external equipment involved to release helium to tunnel and decrease associated downtime.

Service modules studies

A feasibility studies has been generated edms 2061800 by TE-CRG design office. Then a more detailed study with an adequate sizing of the service module and advanced space & installation study has been done. A 3D model is now released for integration purposes.



Documents from M. SISTI & J. METSELAAR, TE-CRG

So far with typical cryostat typical interconnection interface

This service module 3D model concern left of P4.

A similar model is generated for right side of P4.

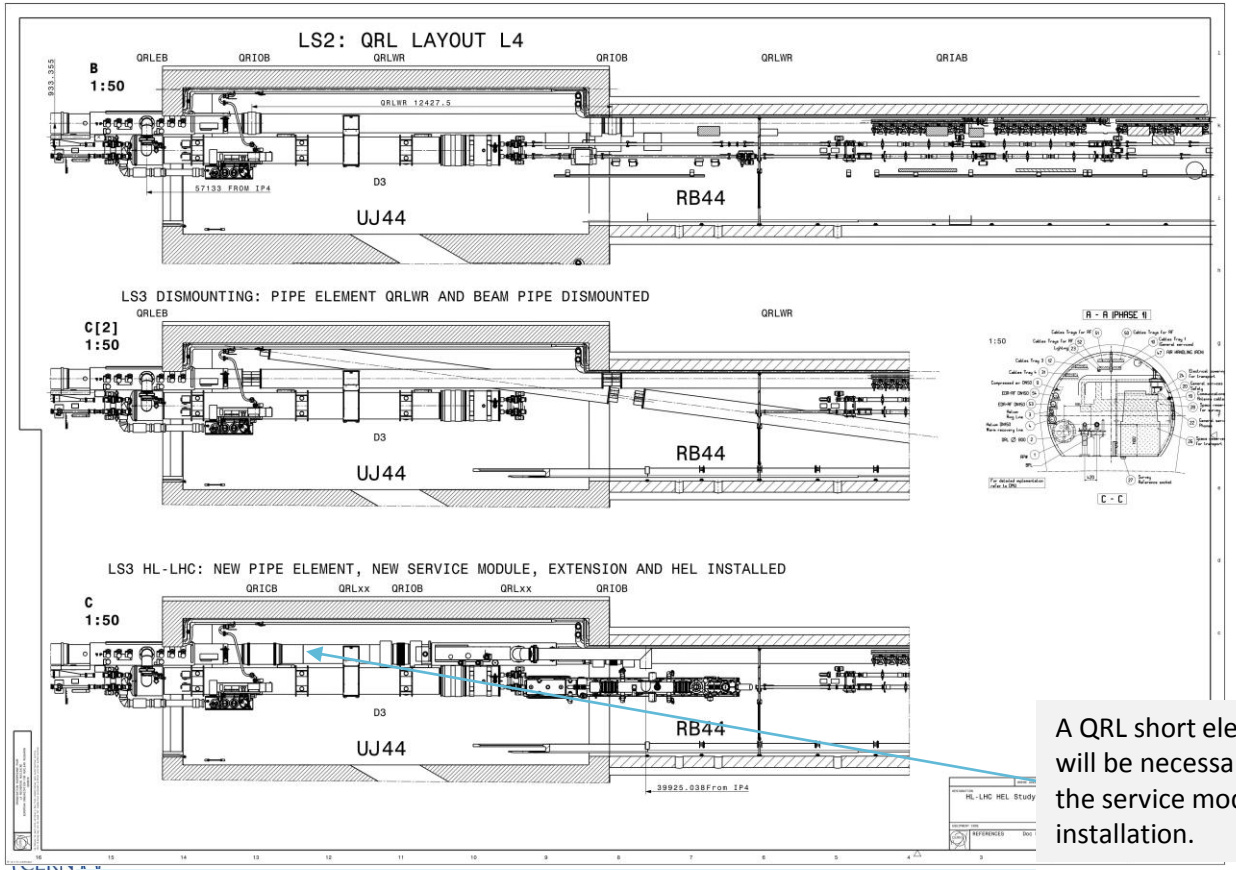
The jumper extension is compatible with header D enlargement depending on the overpressure studies

Service modules Installation studies without D3 removal

Present layout

Dismounting

HL-LHC layout



A QRL short element will be necessary for the service module installation.

On request of the integration team, Cryo support team has launched a study to install service modules without D3 removal.

This studies use the standard handling margins.

To be noted: this area is a flat floor zone!

Endorsement will be discussed with the transport team.

A similar simulation has been generated for right side of P4.

What's now, What's next

Support for the cryostat design

- After confirmation of the design pressure, an updated consolidation of the cryogenic design will be generated
- Update/follow-up of the cryogenic instrumentation
- Cryogenic functional requirements and follow-up of the cryogenic part of the project

Development of the dedicated cryogenic service modules & extensions

- Updated consolidation of the design after confirmation of design pressure
- Validation of the integration studies with integration & transport teams to be done

After validation of this portion of the project, it would be possible to transfer this fraction to WP9 with corresponding resources. There could be some synergy with other QRL rework activities at P1-P5

Summary

- The HEL project is close to the pre-design validation for cryogenic items.
- Fixation of the design pressure at, if possible, an higher PN (~4.5 bara) will allow to fix the design of the pressure safety system and of the connections pipes to QRL.
- The constraint of keeping D3 + Undulator in position has an important impact on the dismounting of the QRL service module, on his design adaptation and on the final installation with potential over-cost.
- There is a possibility after complete validation to transfer the QRL service module task to WP9 with corresponding resources.

Thank you

Spare slides

Service modules Installation studies without D3 removal

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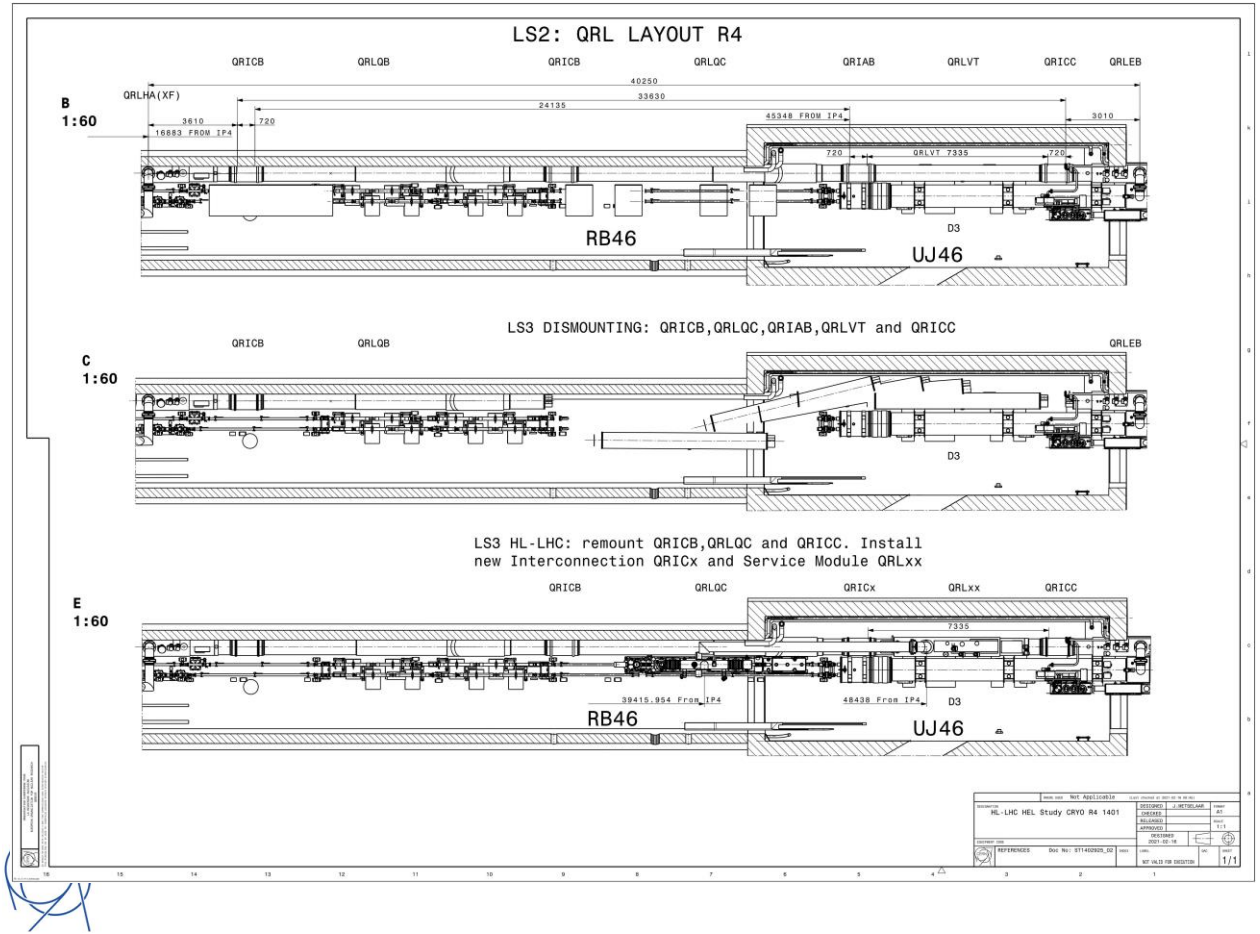

R4 side