Progress of Interface Design between Test Cell and Lithium Systems in IFMIF-DONES

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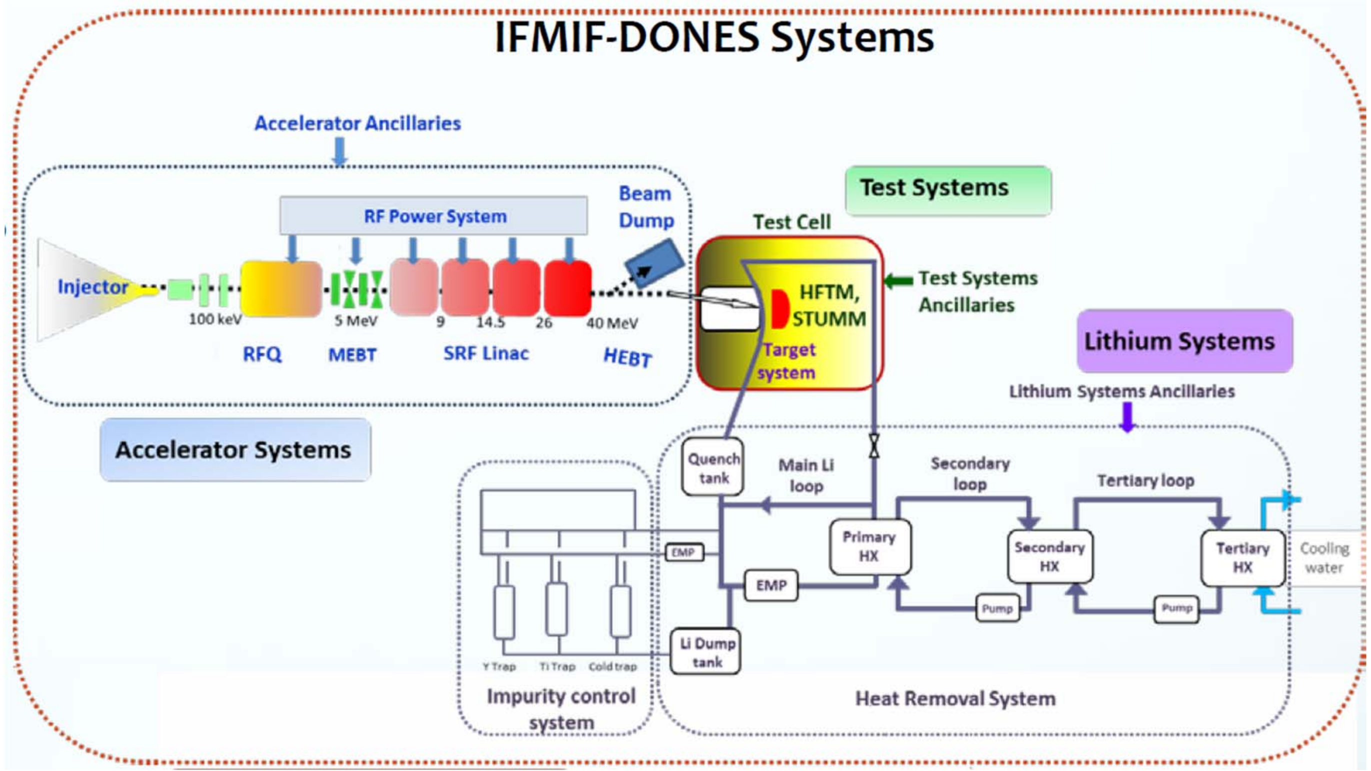
Introduction of IFMIF-DONES

- IFMIF (International Fusion Material Irradiation Facility)-DONES (DEMO Oriented NEutron Source) is a simplification of the full size IFMIF
  - A fusion-like neutron source to qualify structural materials for DEMO fusion reactor

"Full Size" IFMIF	IFMIF-DONES
Two accelerators	***One accelerator***
High, Medium, Low Flux Test Modules for structural/functional materials	***One High Flux Test Module (HFTM) for structural materials***
Full size Test Cell	Full size Test Cell
Full size lithium loop	Full size lithium loop

- IFMIF-DONES will, to a great extent, inherit the design of IFMIF-EVEDA phase

Layout of IFMIF-DONES Major Systems



- IFMIF-DONES major systems
  - Test Systems (TS): including High Flux Test Module (HFTM), Test Cell (TC), Test System Ancillaries
  - Accelerator Systems (AS): one 125mA, 40 MeV, linear D+ accelerator
  - Lithium Systems (LS): lithium loop, lithium target systems(TA)

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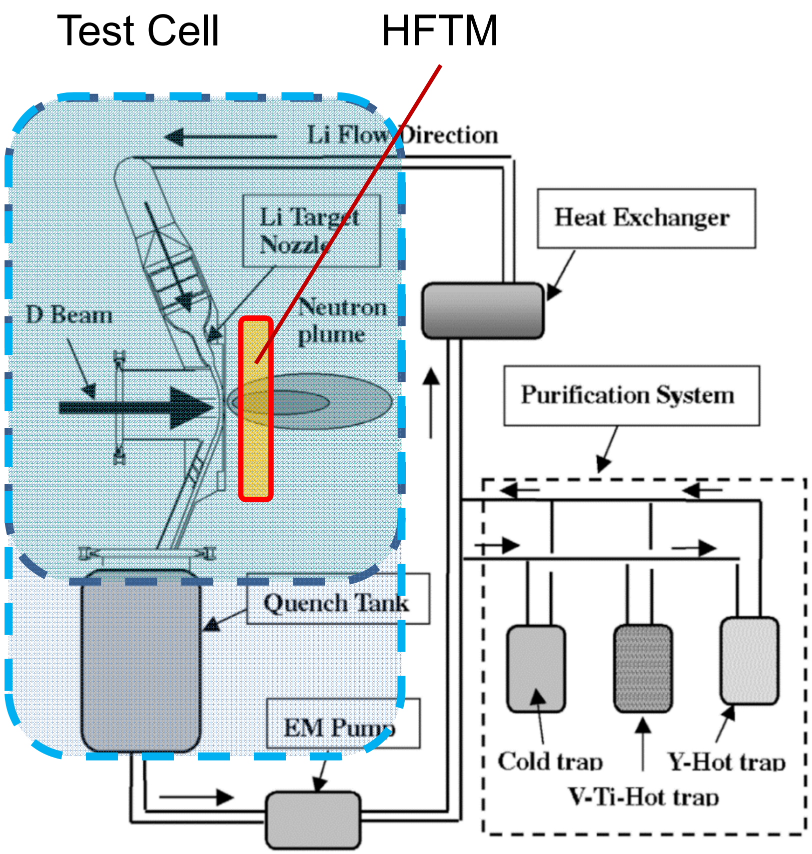
Major Functions of the Test Cell (TC)

- To accommodate TA, end section of accelerator, HFTM, and other LS components;
- To provide sufficient shielding to adjacent rooms and cells;
- To provide convenient access and sufficient space for remote handling tools to perform maintenance operations inside TC;
- To provide variable controlled environments;
- To avoid contact between Li and concrete in case of leakage of lithium inside the TC; and
- To transfer signal, electric power, and media between in-TC components (HFTM, TA, etc.) and ancillary systems
- To assure accurate and durable positioning of the test modules against the target assembly and the back plate;

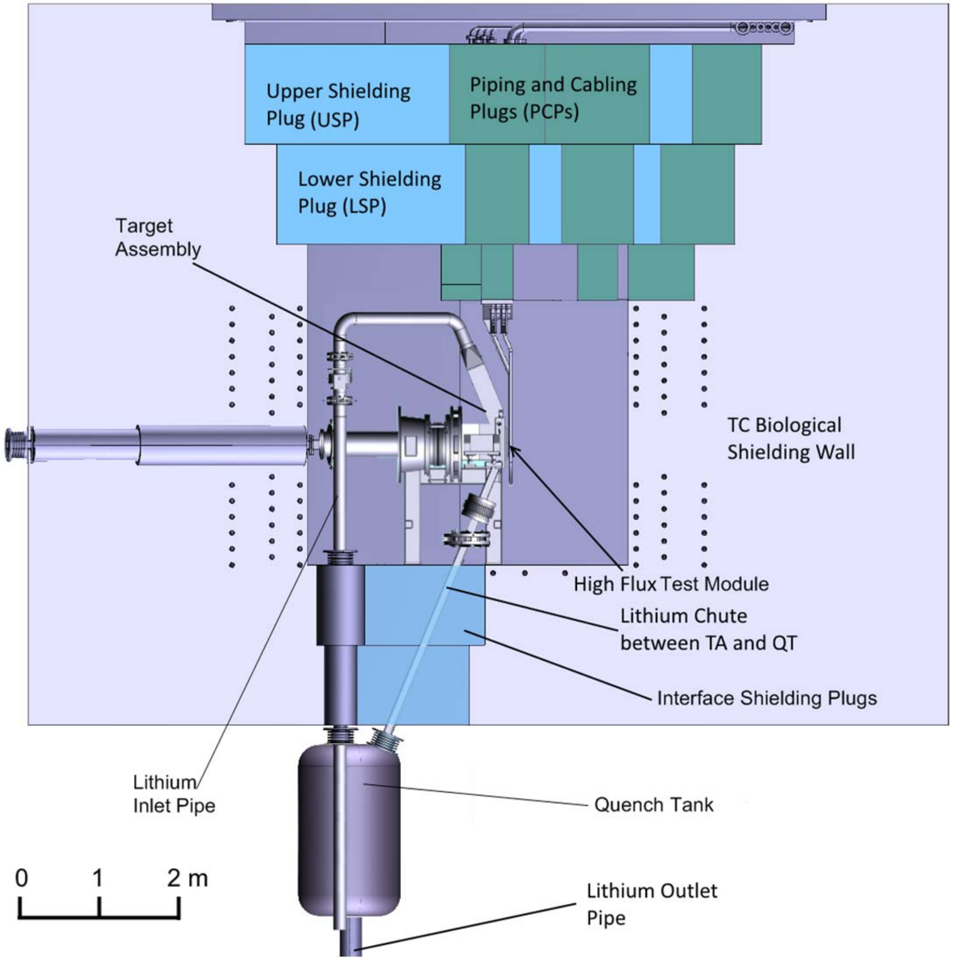
Interfaces between TC and LS



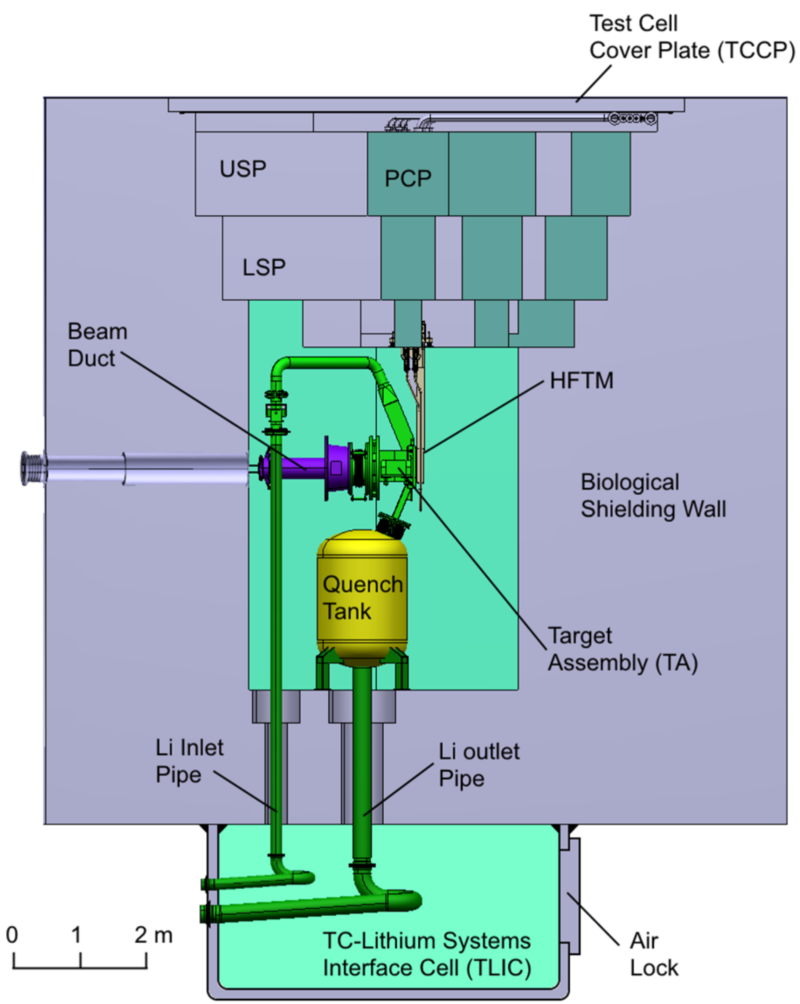
- Lithium is provided to TA through an inlet pipe
- In TA, lithium flow meets deuteron beam to generate neutrons (up to $10^{14}cm^{-1}s^{-1}$) for irradiation experiments
- After the TA, lithium must be slowed down and cooled down in a Quench Tank (QT) before returning to EM Pump
- Location of QT is one of the key decisions to be made for TC design

TC design based on IFMIF-EVEDA Concept

- Surrounding walls, plugs, and TC floor provide major shielding function
- Remote handling (RH) access to in-TC components from top (removing two plugs)
- QT is located below the TC floor, connects TA with a long chute
- *Major Issues:*
  - High cavitation risk in chute
  - QT requires RH in LS area
  - Transient heat shock on chute



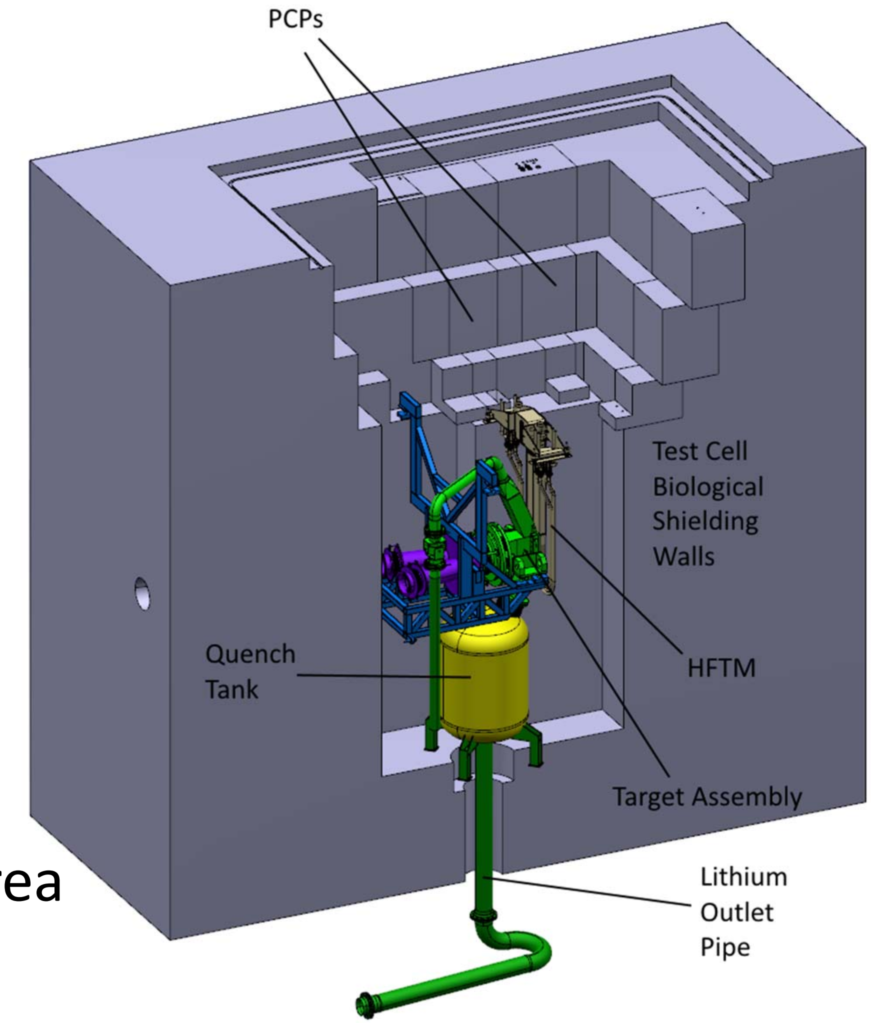
TC Design update: QT being arranged in TC



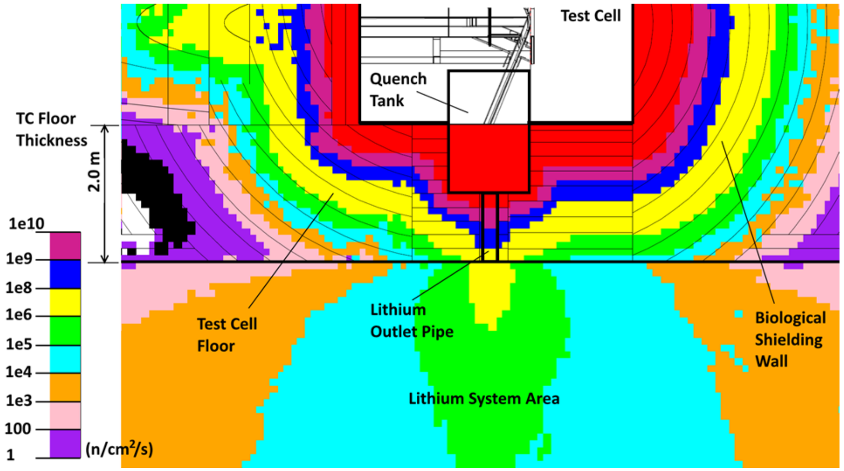
- Configuration of shielding walls and plugs keep unchanged
- QT is located inside the TC
  - QT directly below the TA
  - Supported from TC floor
  - Bottom check possible
- TC internal dimension expands 1.8 meters
- Li pipes vertically penetrates TC floor
- Test Cell-Lithium Systems Interface Cell (TLIC) is arranged to accommodate thermal expansion pipes

Impact of QT in-TC configuration

- Tritium generation increased
- Re-configuration of DONES building (TC shape changed)
- QT size being limited
- Re-design of TA supporting structure required
- Re-design of penetrations of lithium pipes in TC floor
- Thermal expansion for pipes compensation required
- High neutron streaming to LS area
- RH on QT from Access Cell required (accident condition)



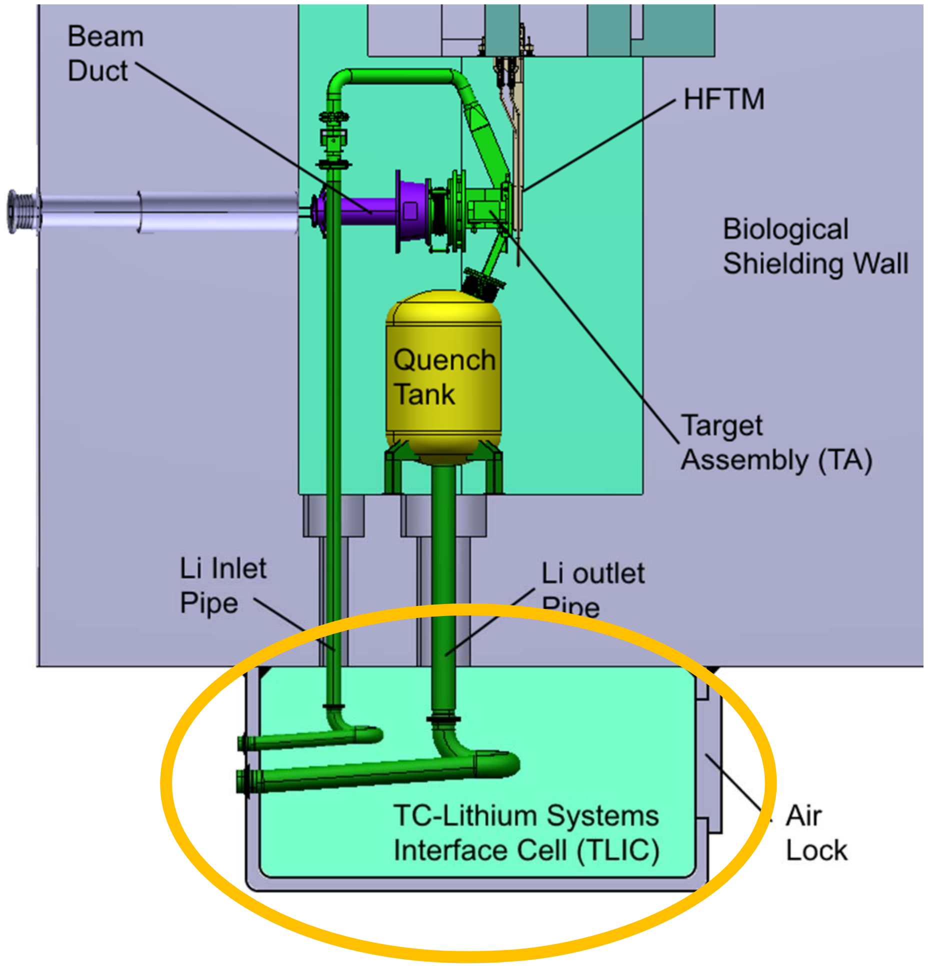
Neutron Flux Through Li Pipe



Neutron steaming calculation on a QT half-buried in TC floor configuration

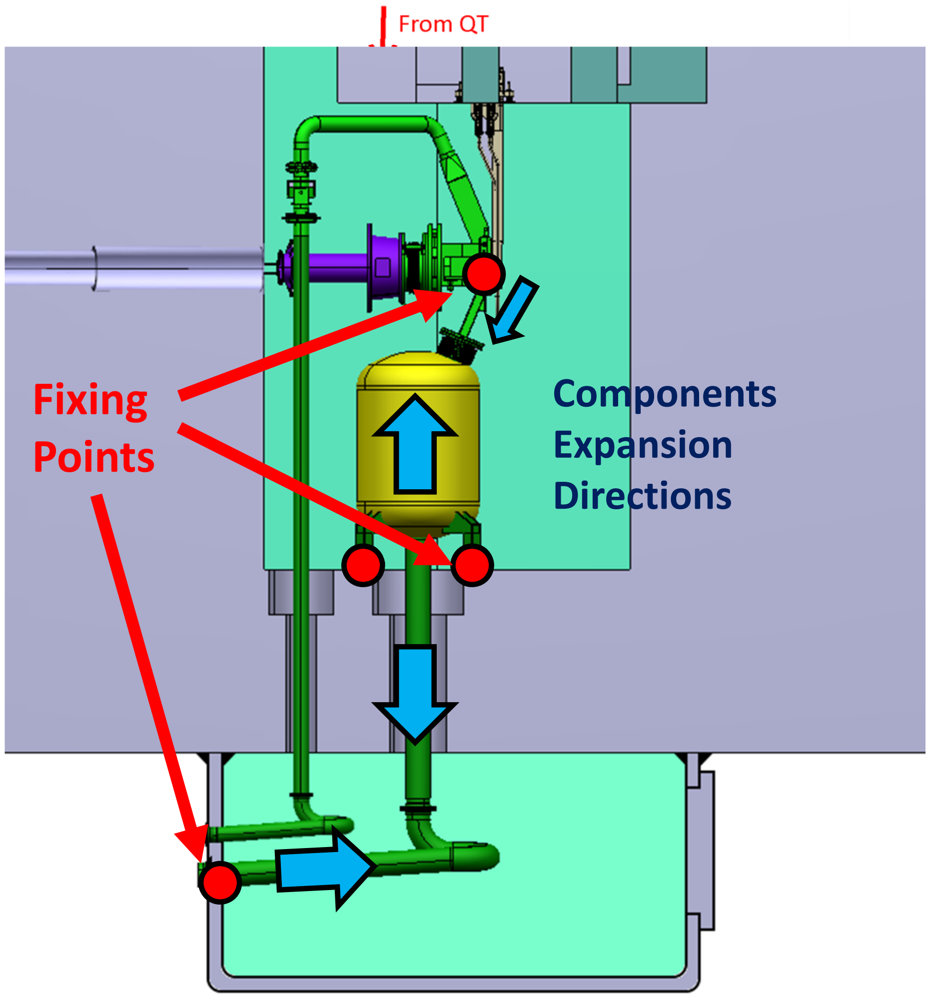
- Lithium outlet pipe (DN 250) and thermal insulations lead to strong neutron steaming
- TC floor is constrained by the building design (increasing of thickness is desired)
- Additional removable neutron shielding materials below TC floor required
- Optimized arrangement of thermal insulation material around pipes may reduce neutron streaming

Test Cell-Lithium System Interface Cell (TLIC)



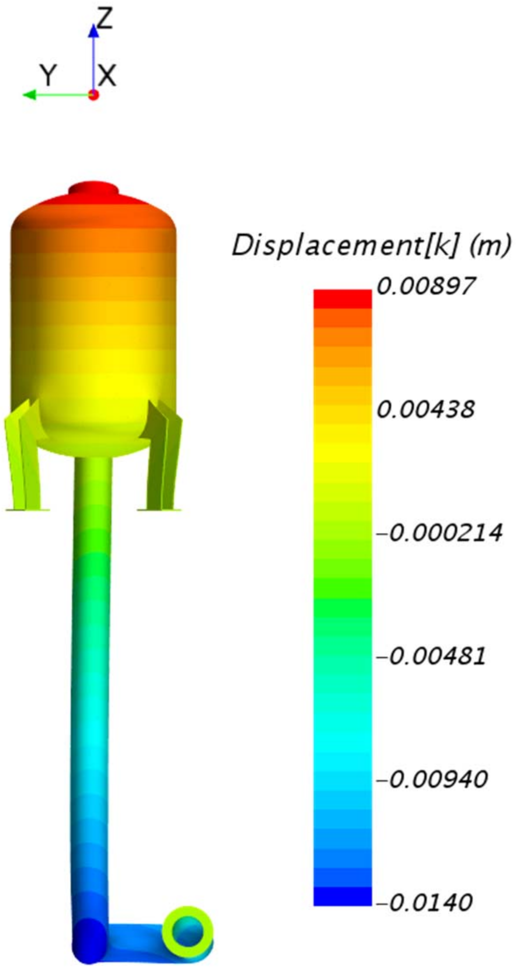
- Location: below the TC floor, in Lithium Systems Area
- Functions:
  - Accommodating stress compensation pipe sections (no bellows)
  - Accommodating removable neutron shielding materials (not shown)
  - Acting as part of the TC vacuum boundary
  - Providing RH access to Li inlet / outlet pipes
- First proposal: metal based attachment cell
- Detailed dimension to be defined

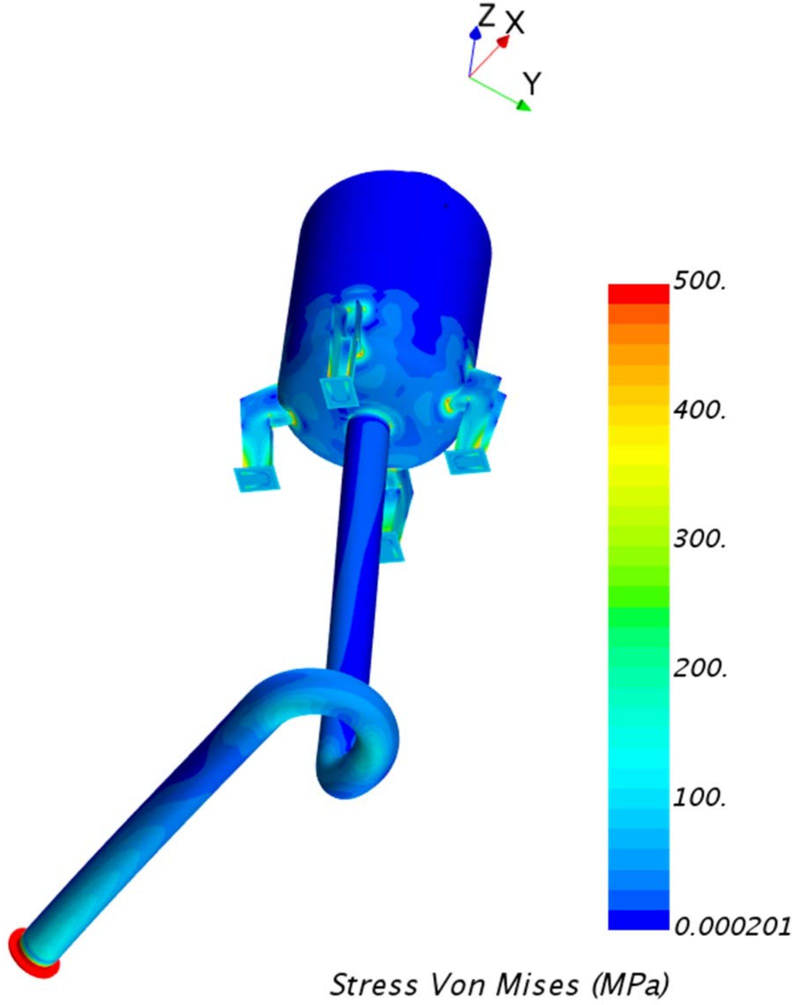
Thermal Expansion Compensation



- High temperature differences between installation and operation lead to expansion of metal components
  - Connections between TA and QT
  - Quench Tank
  - Lithium Pipes
- Fixing points are required for steady irradiation experiments
- Quench Tank can expand freely upwards (bellow compensation)
- U shaped outlet pipe sections compensate thermal expansion of inlet/outlet pipes

Stress and Deformation of Li Outlet Pipe





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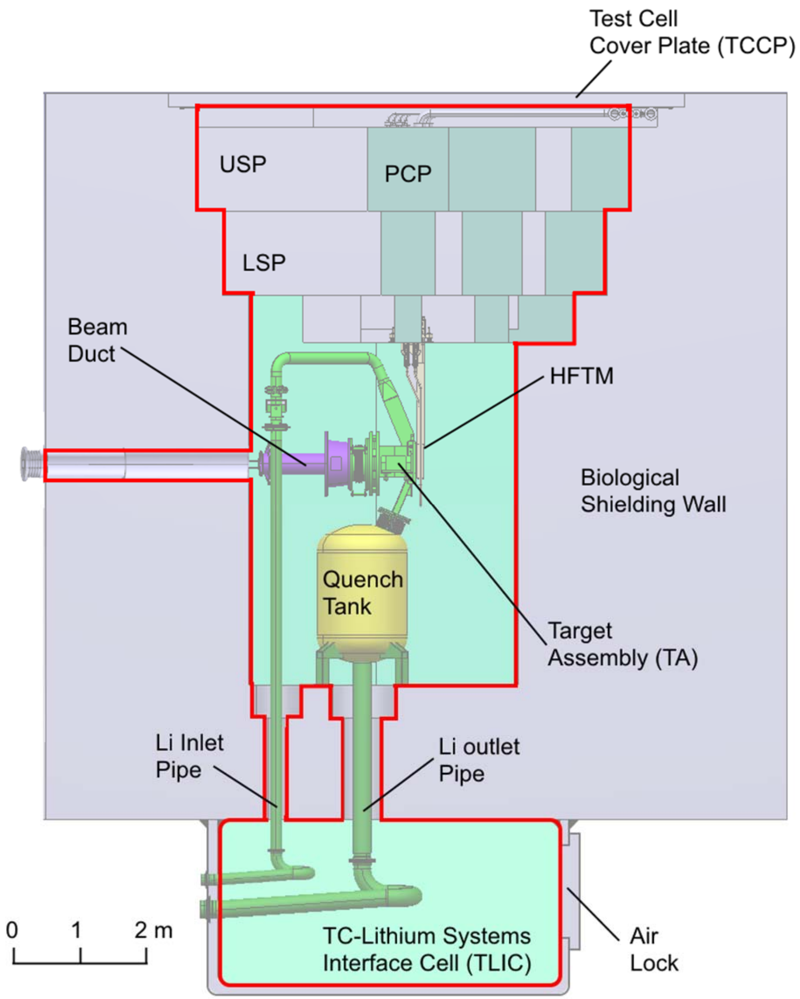
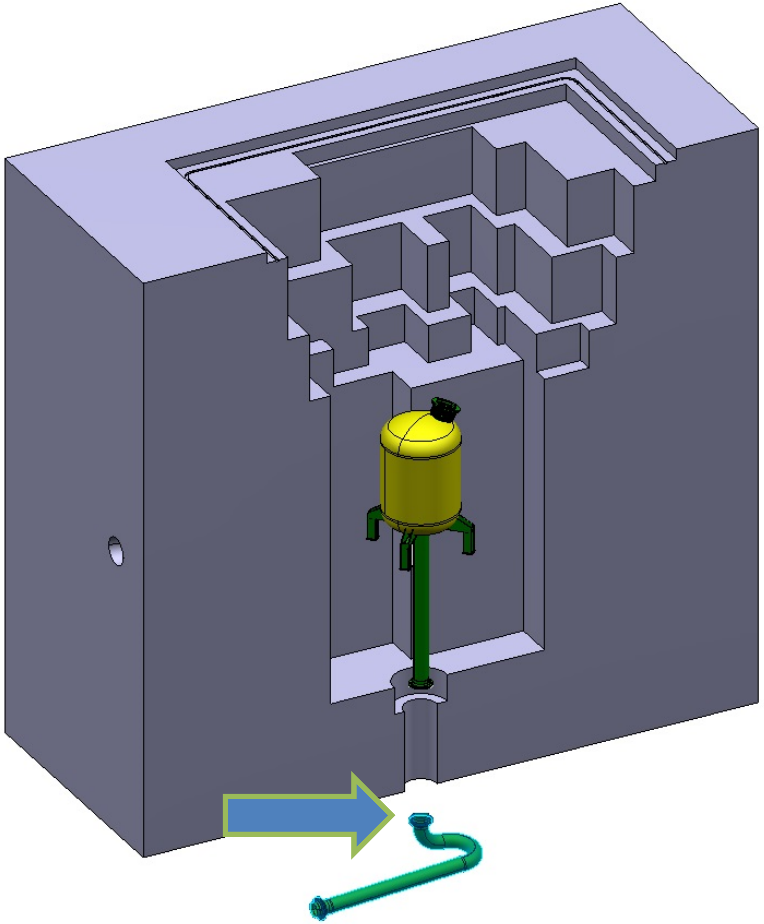
Test Cell Vacuum Boundary



- Major Functions:
  - Keep controlled TC internal atmosphere
  - Avoid contact between Li and Concrete in accident
- TC vacuum boundary includes:
  - Test Cell Cover Plate (TCCP)
  - Sealing between TCCP and TC internal atmosphere
  - Closed liner covering internal surfaces of biological shielding
  - Extension of the liner to beam duct
  - Extension of the liner to Li loop penetrations
  - Internal surfaces of TLIC
  - Airlock hatch of TLIC

Maintenance scenarios of QT

- TA is replaced after each irradiation campaign (~ 1 Year)
- QT/Lithium pipes also require maintenance in case of damage
- Replacement of QT and Li pipes inside TC is the major maintenance operation
- During maintenance Li compensation pipe can be disconnected with QT from inside of TLIC
- QT is removed through AC together with Li outlet pipe



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Summary

- IFMIF-DONES TC has been updated by arranging lithium QT from outside TC to inside TC
- Test Cell-Lithium Systems interface is updated by introducing an interface cell below the TC
  - TLIC acts as part of TC vacuum boundary
  - TLIC houses lithium pipe thermal expansion compensation sections and removable neutron shielding
  - TLIC provides access to RH operation on Li pipes
- QT replacement operation scenarios are preliminary defined

Acknowledgment

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