



WP DIV IDTT MidTerm Meeting 2022 (Frascati/remote)

DIV-IDTT.S.07-T005-D003

Design, analysis, and integration of not-axial symmetric in-vessel coils

T. Bolzonella on behalf of the DIV-IDTT.S.07-T005-D003 team

23/06/2022



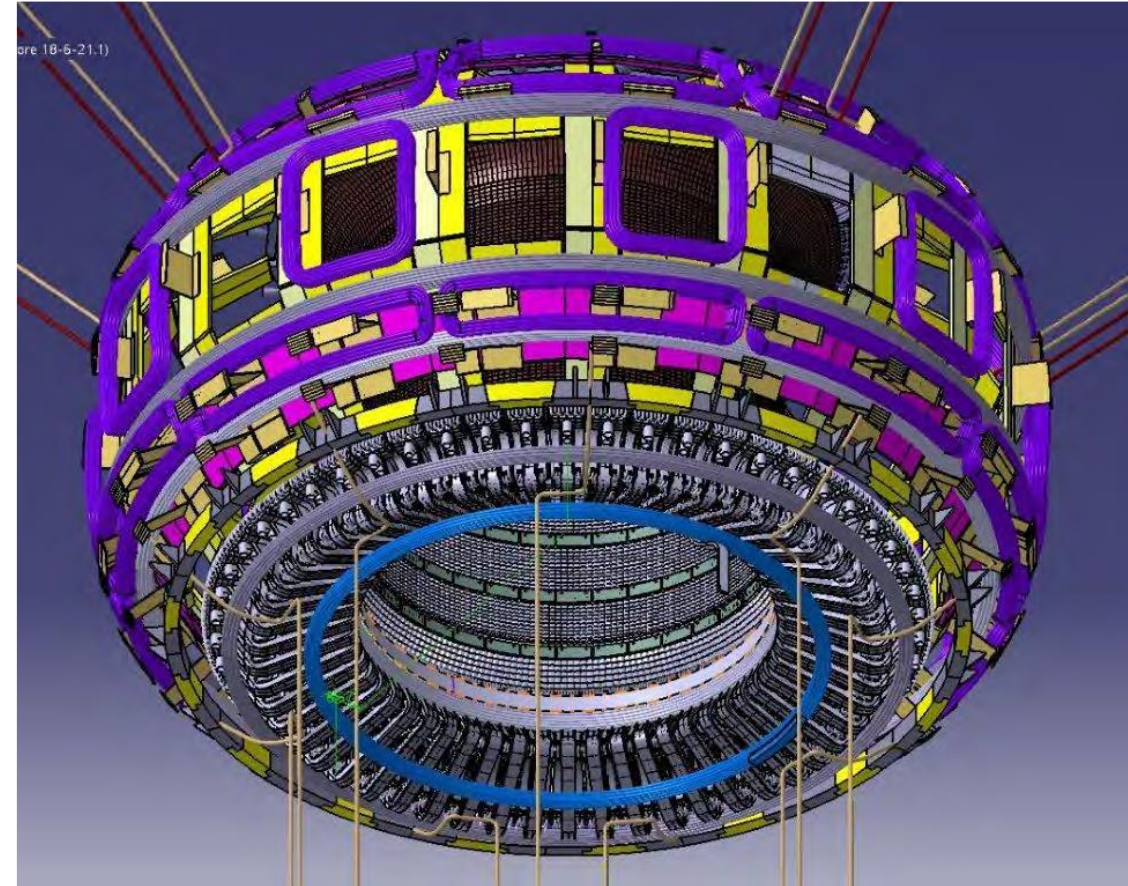
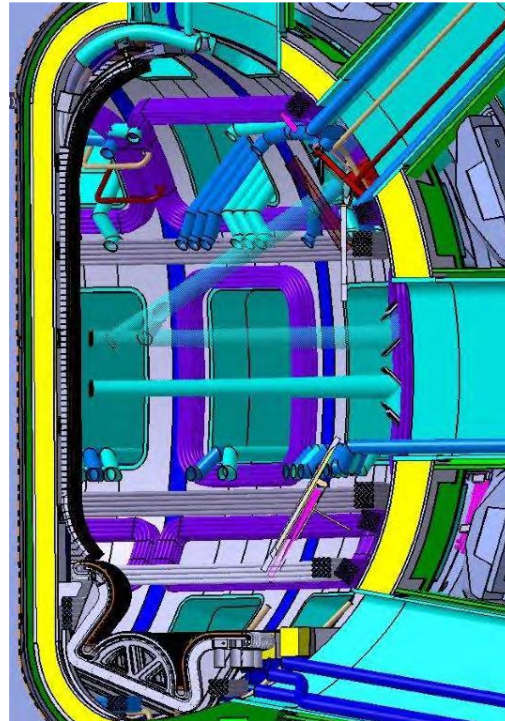
This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.



- Major effort concentrated in end 2021
- Present conceptual design is integrated in the global machine model (including central array)
- Some interface issues still need to be monitored carefully

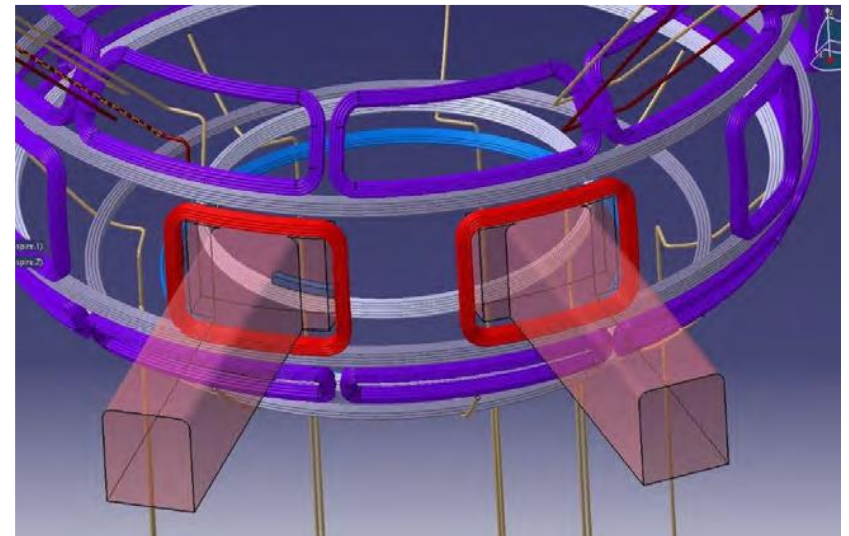
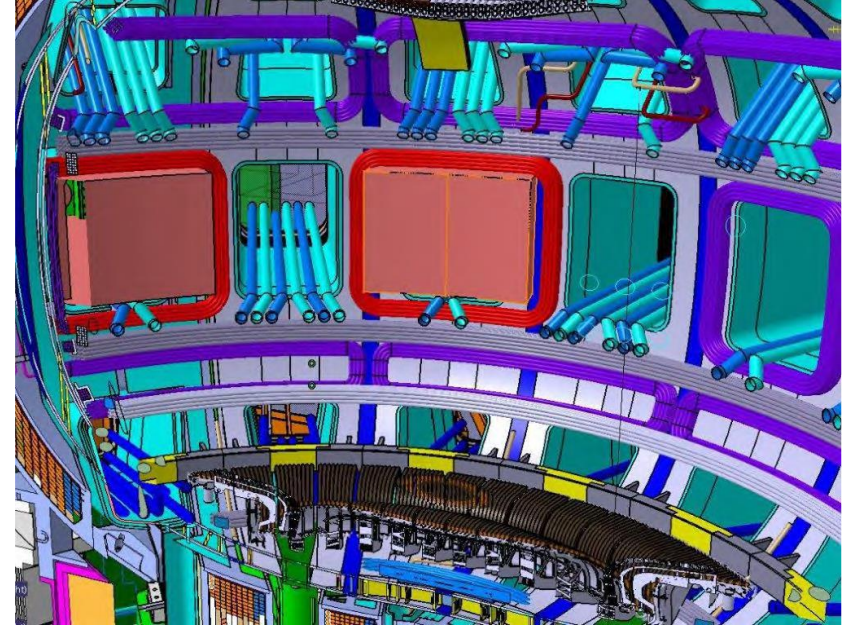
Baseline layout:

27 saddle coils (9x3)
fed by independent
power supplies



Some special solutions had to be adopted

- 25 coils can be manufactured outside the vessel and then inserted through the ports
- 2 middle coils have to be enlarged due to the interference with the ICRH antennas and have to be mounted before the assembly of the last sector of the vacuum vessel
- Another middle coil should have a slightly different set-up due to the inclination of the NBI port



2022 sub-deliverables

- Conceptual design support (physics requirements)
- Technical specification support (coil positioning and dimensions, cable identification, cooling strategy, ...)
- Joining and testing of multi-material components
- Static structural analyses on in-vessel coils under EM loads - Engineering design of the attachments to the VV of the divertor coils with static EM loads analysis
- Sharing of results, in particular EM forces, obtained from global model analyses (outsourcing from integration in the global model)

2022 team is made up by an effective mix of groups and competences!

In 2022 we are working to reach some important milestones

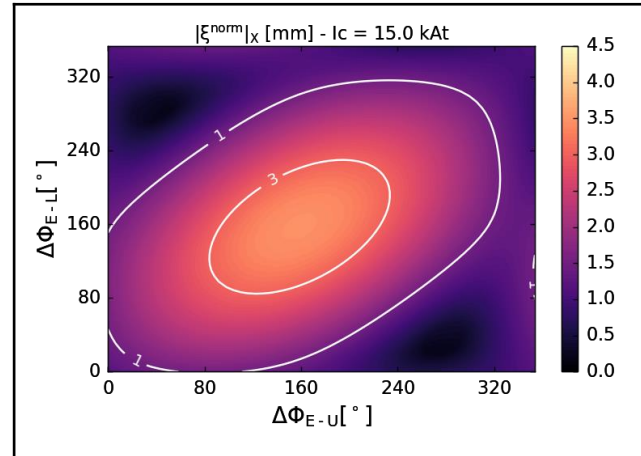
- Revise and stabilize ICN requirements (→ kAt, potential waveforms)
- Identification of parameters for cable design and manufacturing. Identification of the cable insulation technologies for coils and implications on joining of coils to feeder
- R&D of the joints between coils and feeders, manufacturing-installation sequence of the system
- Load specification for analysis and verification of the system
- Design of supports on vacuum vessel consistent with system installation sequence. Mechanical analysis and verification of supports on vacuum vessel
- Keep monitored all interfaces for integration in the global model

→ By the end of the year:

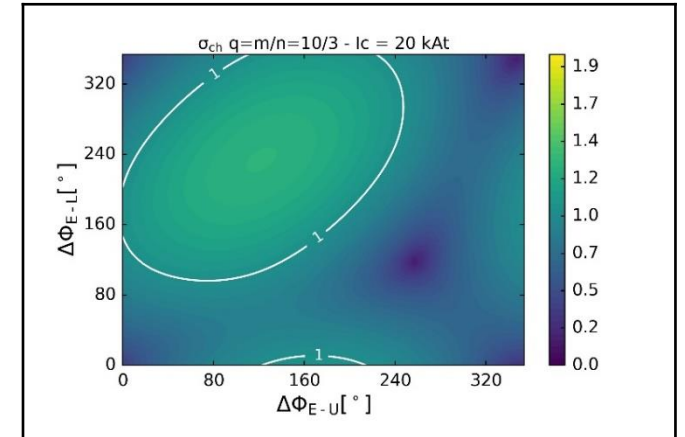
- Technical specification for procurement of the cable for ICA and ICN
- Technical specification for the procurement of ICN

Recent results on current (field) requests for

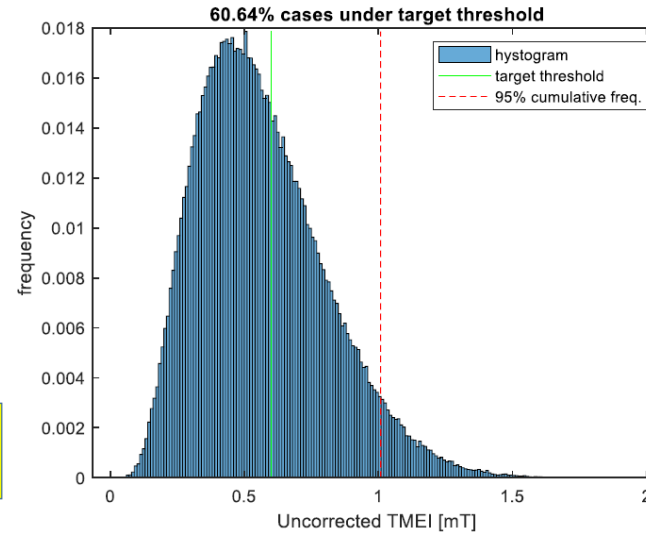
- ELM control: different metrics implemented and compared. (poster EPS contribution next week)
- EF control: several EF sourced considered for parametric analysis. New parameters to be implemented in 2022 (vacuum (TMEI) → plasma response, synergy with DEMO activities)



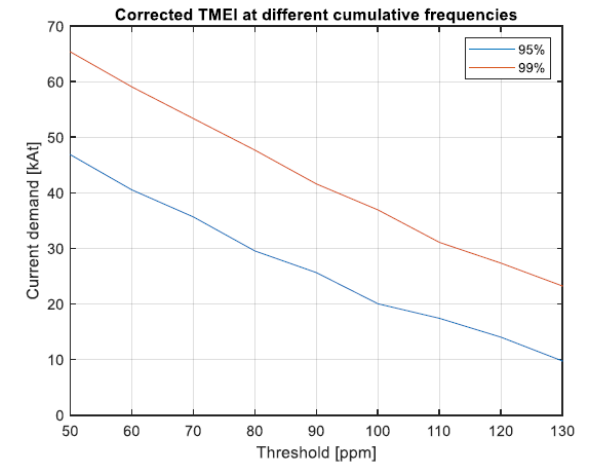
Normal displacement of the plasma surface near the X-point for an n=3 field distribution and a current of 15 kA on each coil.



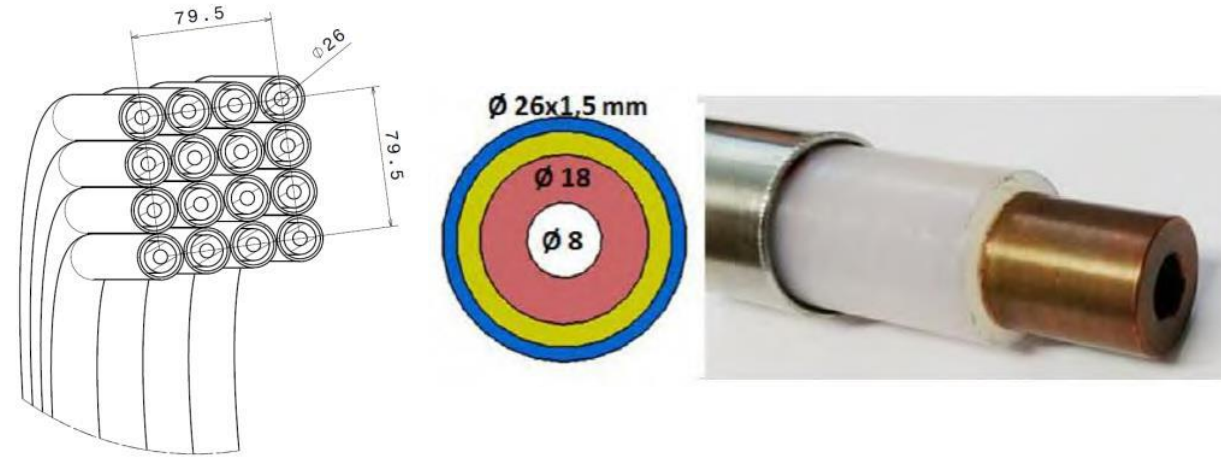
Chirikov parameter for an n=3 field distribution calculated with the total perturbed field (plasma response + vacuum) and a current of 20 kA on each coil.



20 kAt needed to correct the TMEI below the 100 ppm threshold in 95% of the cases



Present design assumes 16 turns cables: reference ASDEX-U-like conductor layout: 26 mm diameter, active cooling, TEFZEL electric insulation and vacuum containment liner. Presently assumed max current: 2.5 kA (i.e. 40 kAt total peak current on each coil).



Cable critical points:

- TEFZEL insulation might give issues for joints and small curvature radius design
- Mineral insulation (MgO, ITER solution) is also under consideration, it could also solve some issue for joints between coils and feeders although its hygroscopic properties might be a problem.
- Cooling: in case of max kAt increase, active cooling also during operations (not only in between shots) might be necessary.

Joints: expertise from Department of Applied Science and Technology of PoliTo on characterization of joints and joining material is extremely welcome!