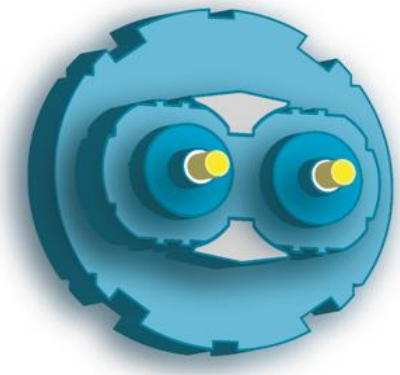


High Luminosity LHC

Crab – RFD prototype:
Production Status Update

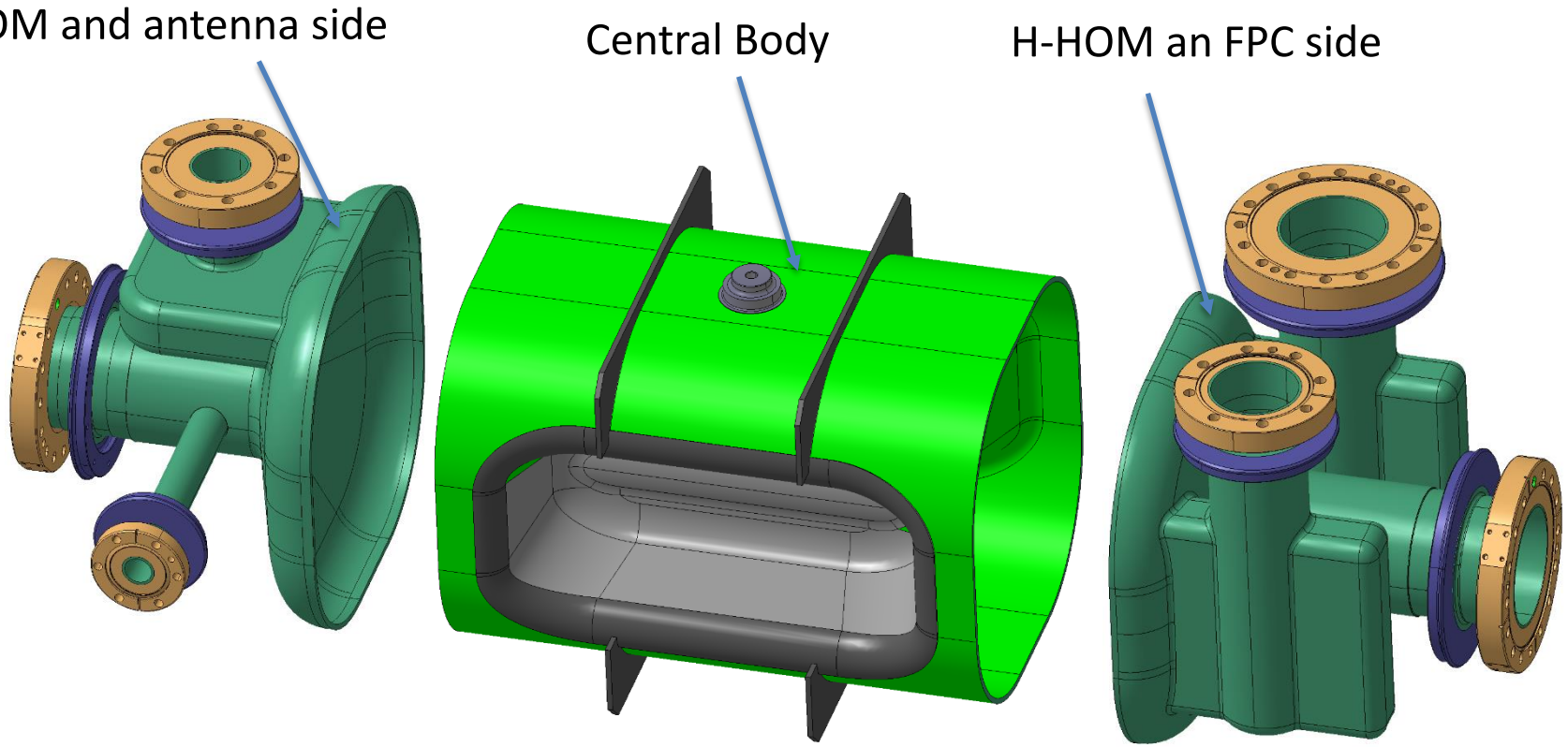
M. Garlaschè & L. Prever-Loiri with contributions from all

15th September, 2017

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

RFD Manufacturing Strategy

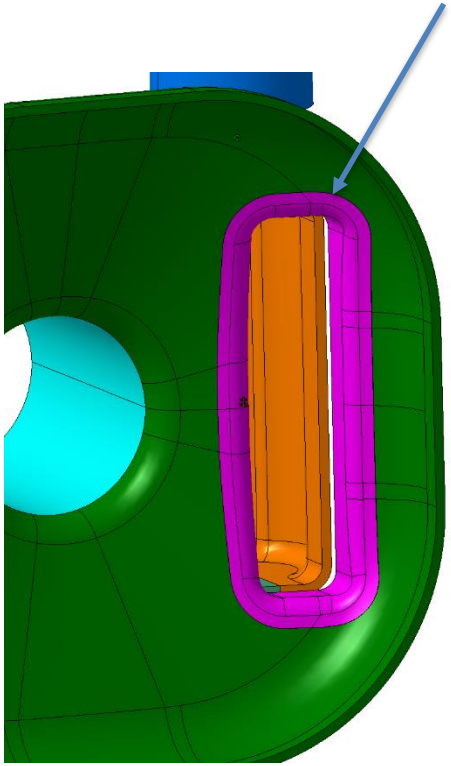
3x main subassemblies

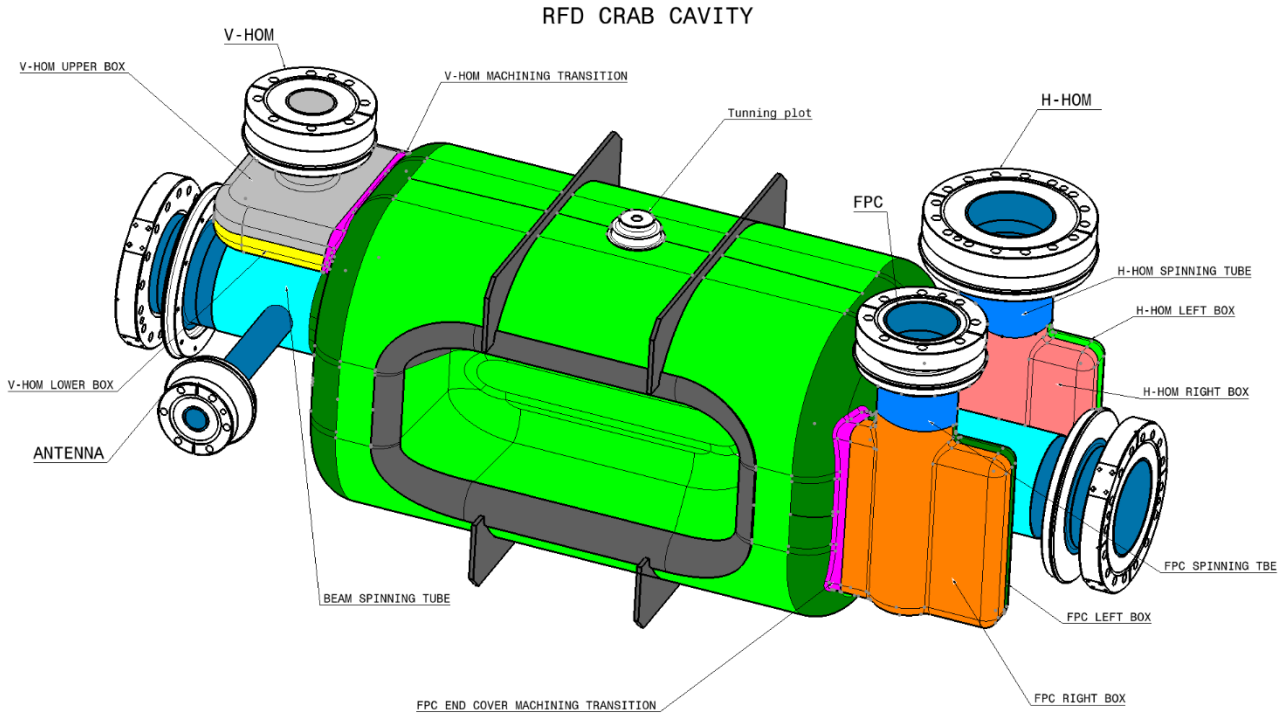


RFD Manufacturing Strategy

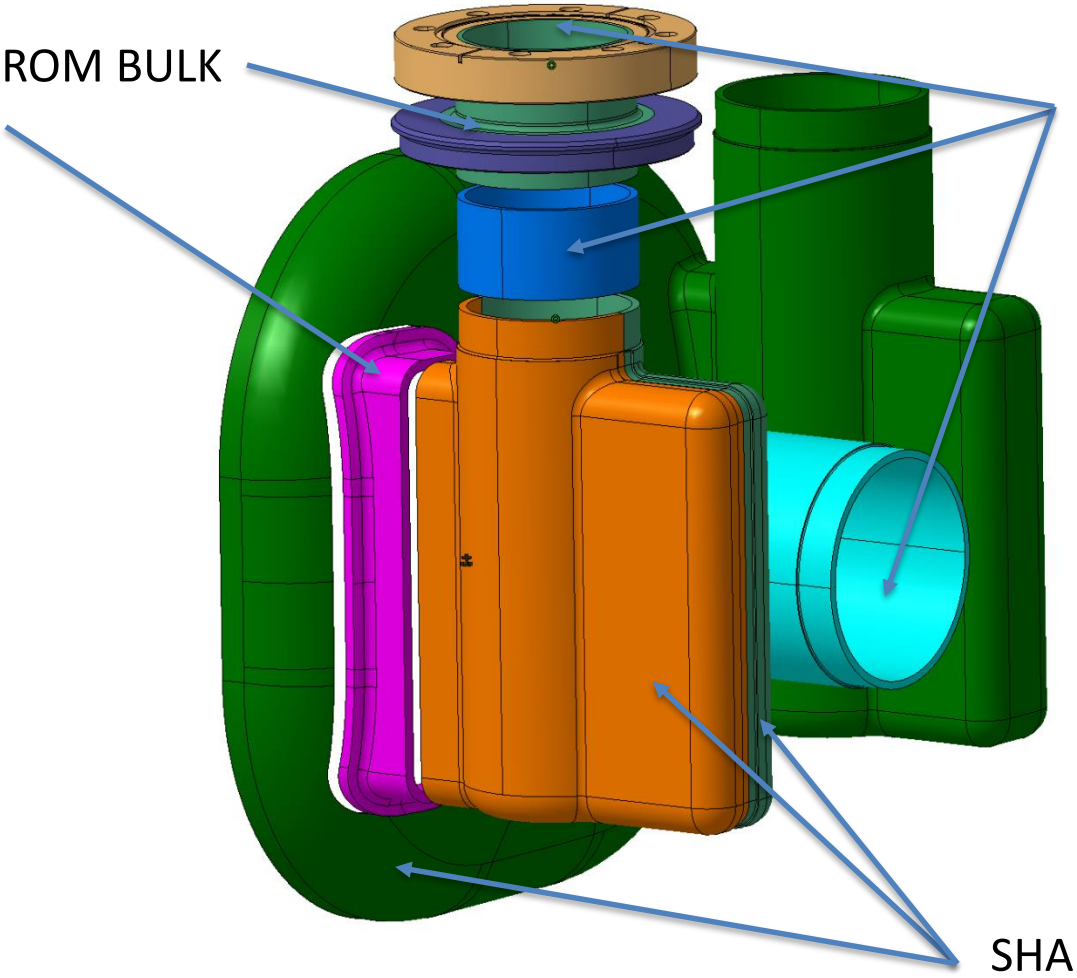
- Initial feasibility well advanced (cut-out & technologies)
- Major Differences (w.r.t. U.S.):
  - **Transitions** between end cover and ports: **machining from bulk**
  - **Welding** interface of **waveguide** on cavity sides

Internal welding



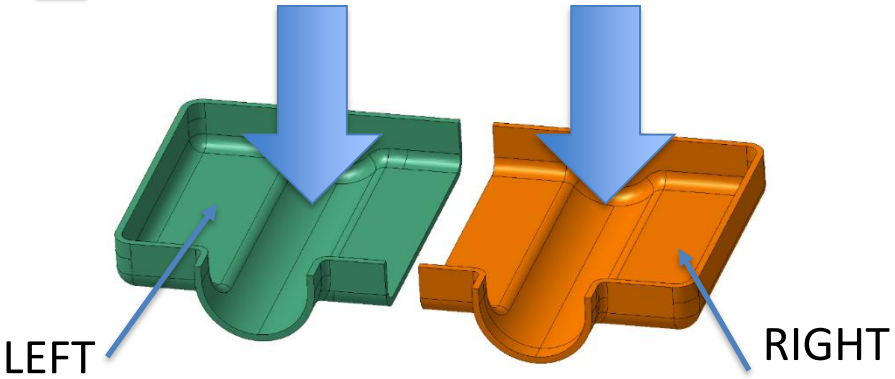


RFD Manufacturing Strategy: Sides



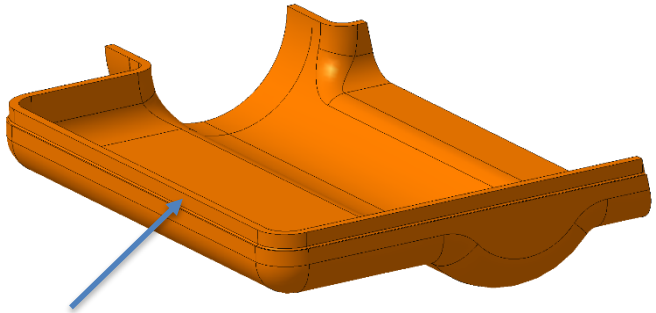
FPC, H-HOM, V-HOM PORTS

1 Shaping + coining

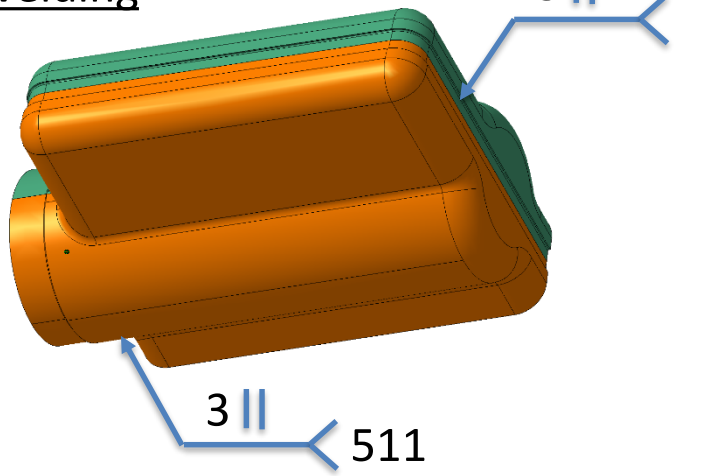


Geometry adjustement

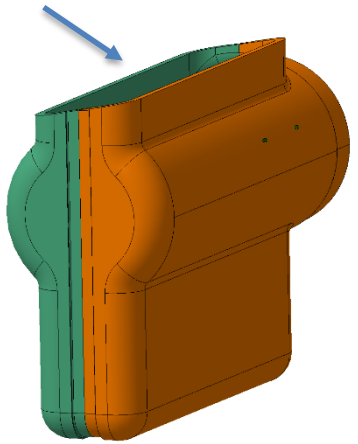
2 Machining half pieces



3 Welding

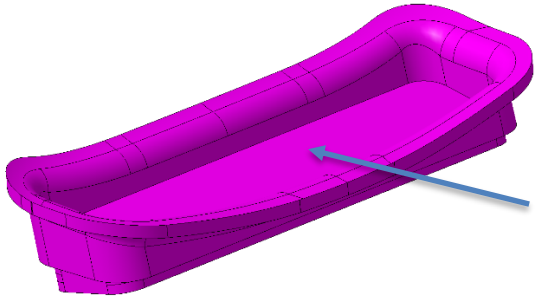


4 Machining of transitions edge



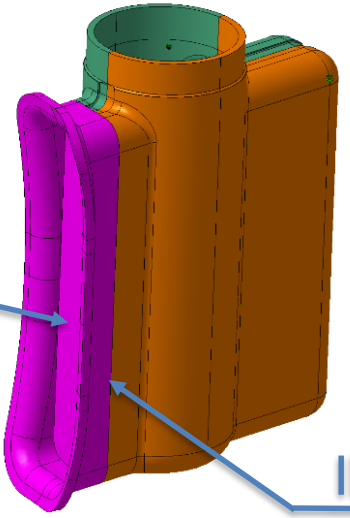
FPC, H-HOM, V-HOM PORT

5 Machining of bulk transitions



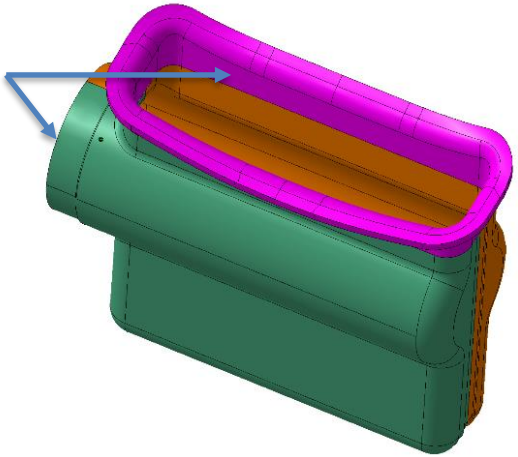
Backing to avoid transversal shrinkage

6 Welding transitions



7 Machining transitions

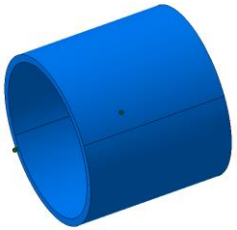
Final machining



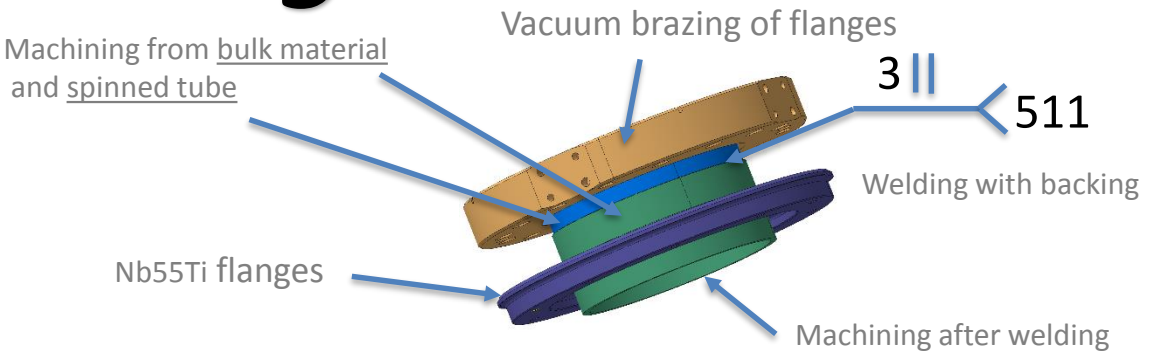
FPC, H-HOM, V-HOM PORT

8 Spinning tube

Machining of:
- External Ø
- Internal Ø
- Length



9 DQW extremities (as per DQW)



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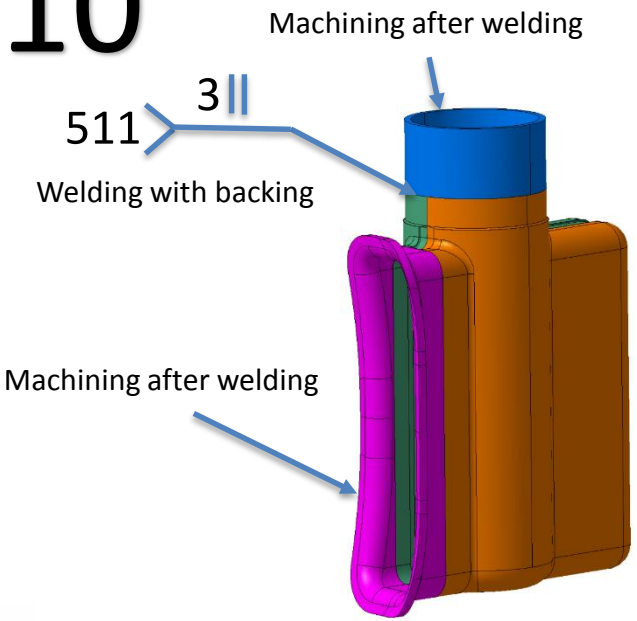
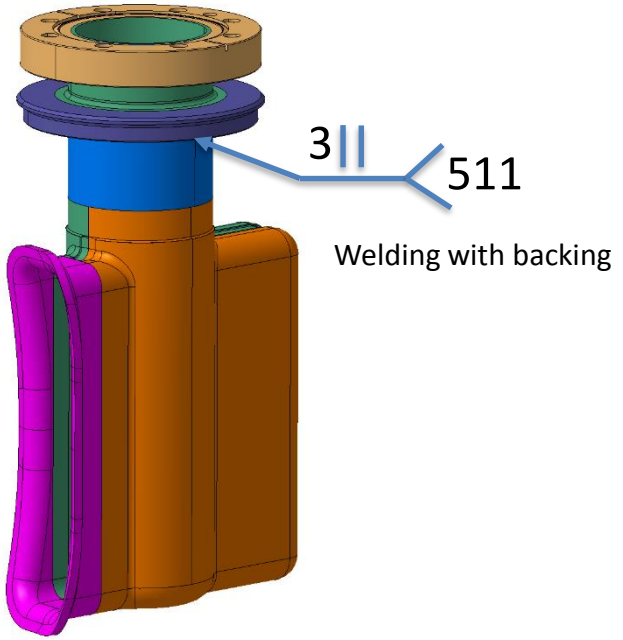
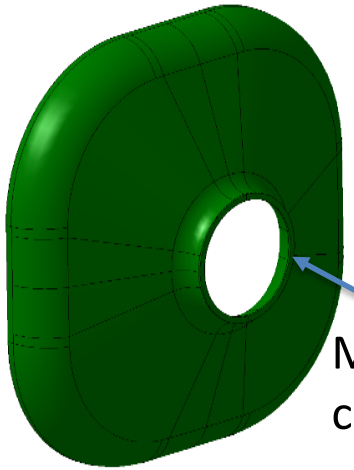


11



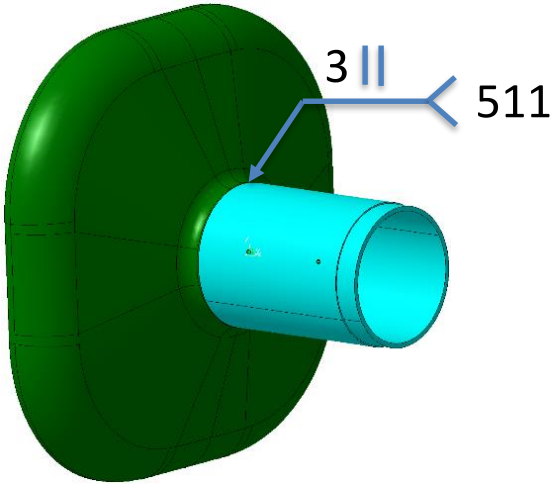
End Caps

1 Shaping + coining

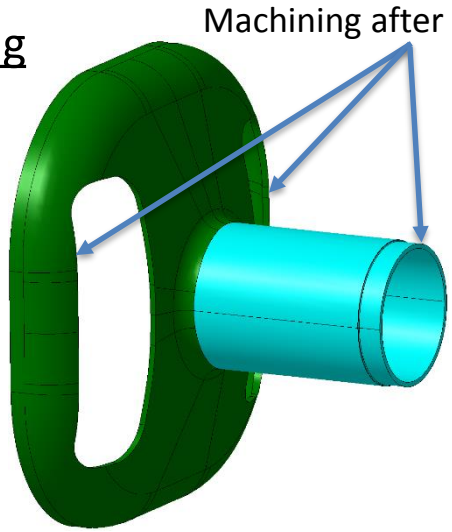


Geometry adjustement

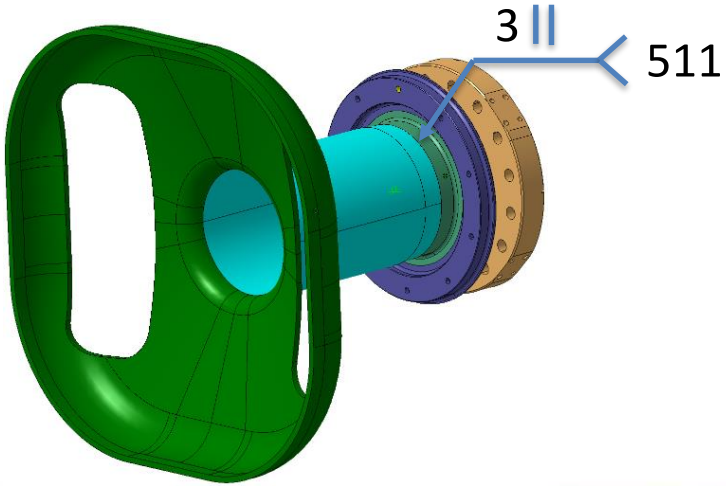
2 Welding spinned tubes



3 Machining Edges



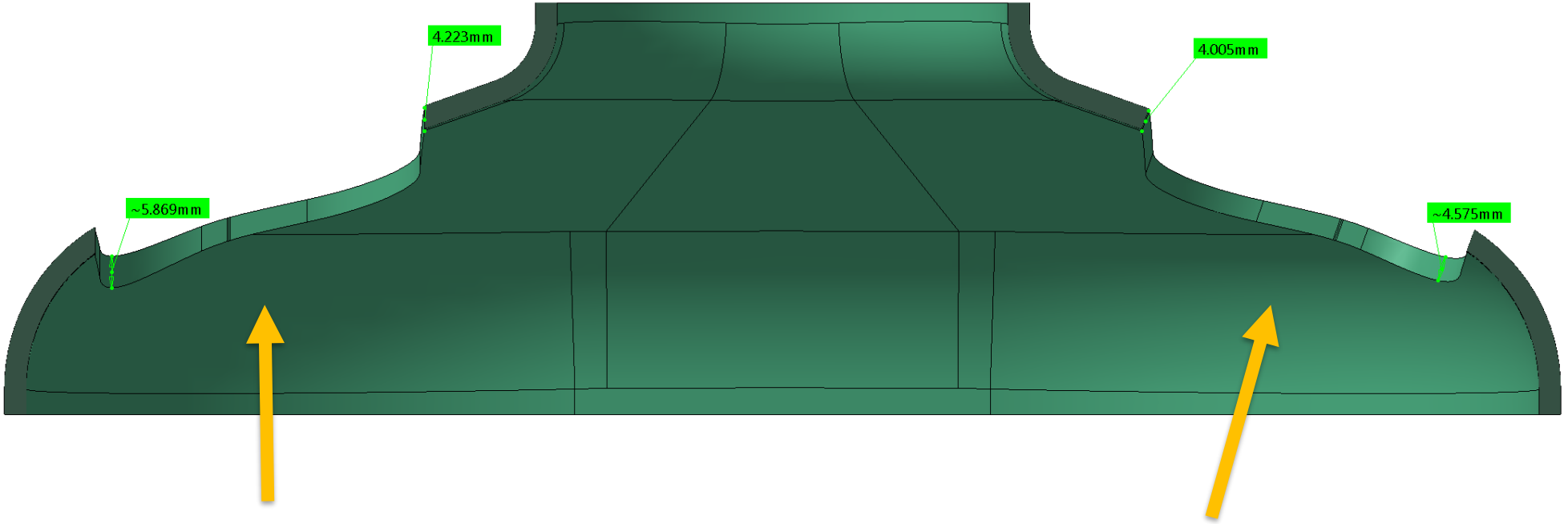
4 Welding extremities



End Caps: Aperture Machining

OPTION 1 : *Vertical cut*
Thickness variation 4.2mm to 5.9mm

OPTION 2: *20° cut*
Thickness variation 4mm to 4.6mm

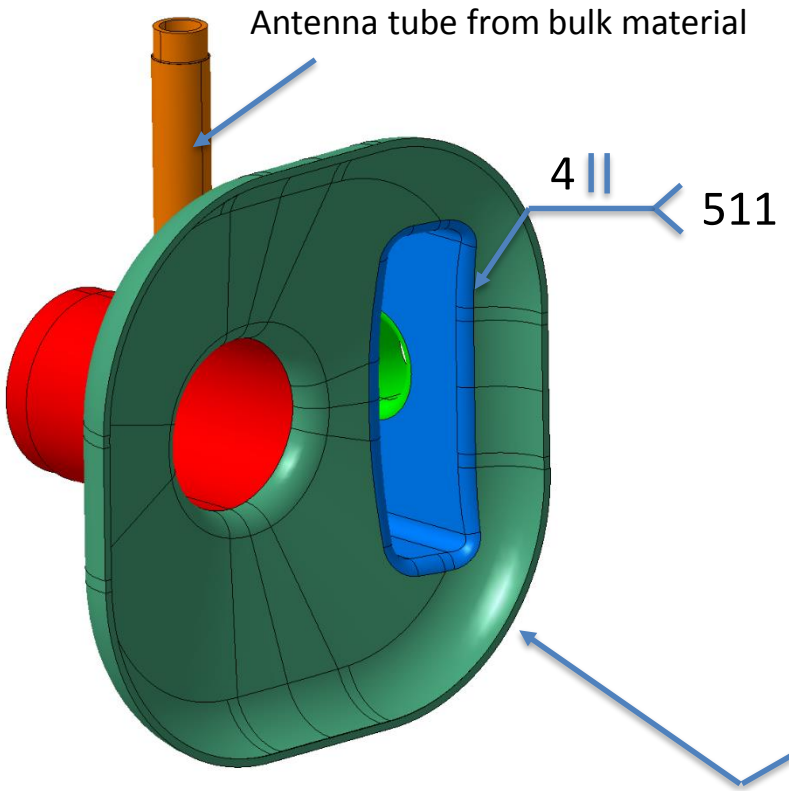


EBW direction

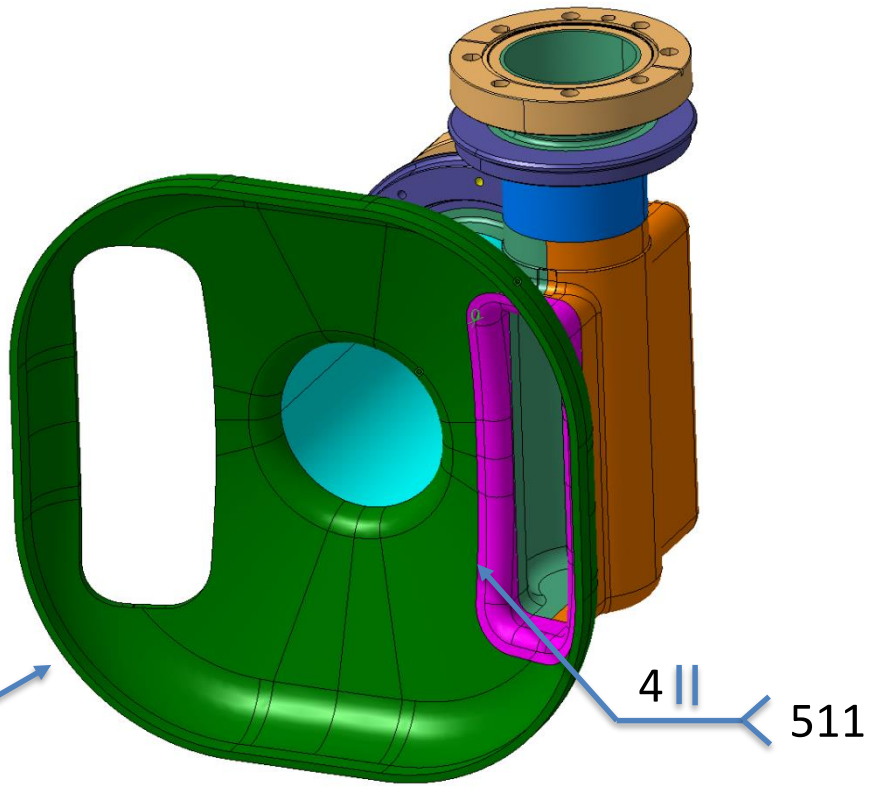
EBW direction

Welding Ports to End Caps

Welding V-HOM

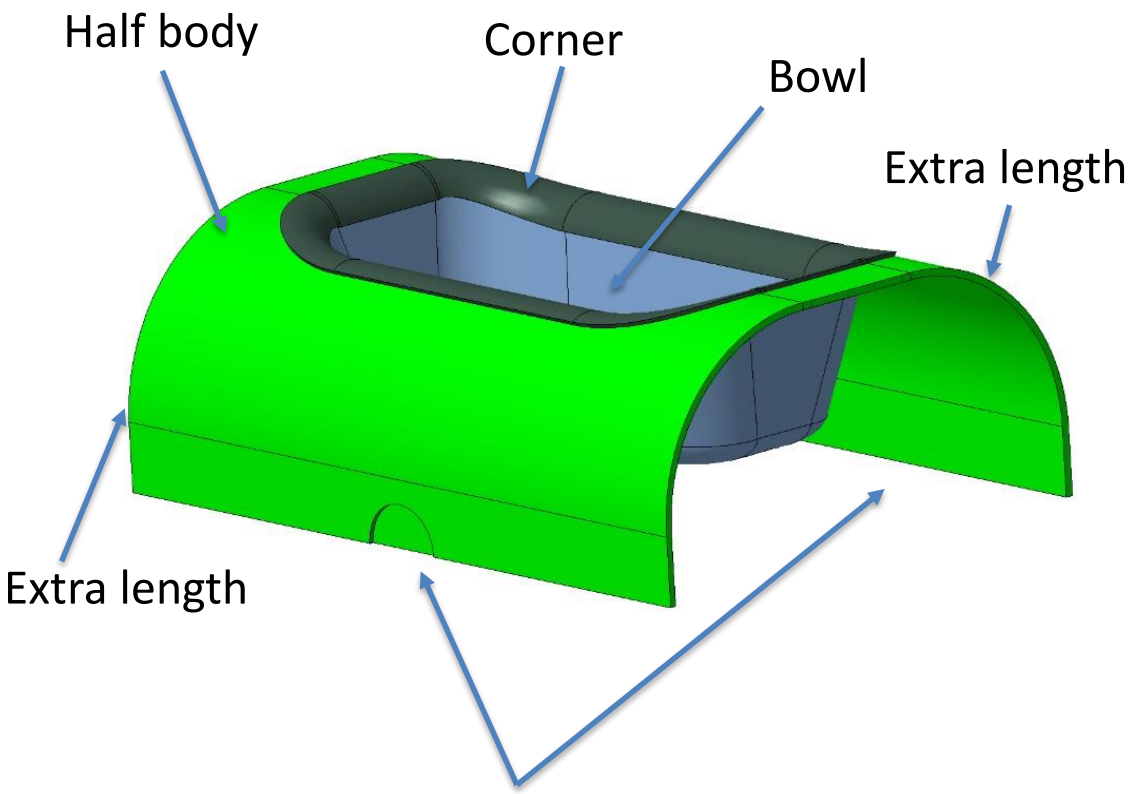


Welding H-HOM and FPC



Machining after welding and geometry adjustement
Sides + thickness 3.0 mm

Manufacturing Strategy: Central Body



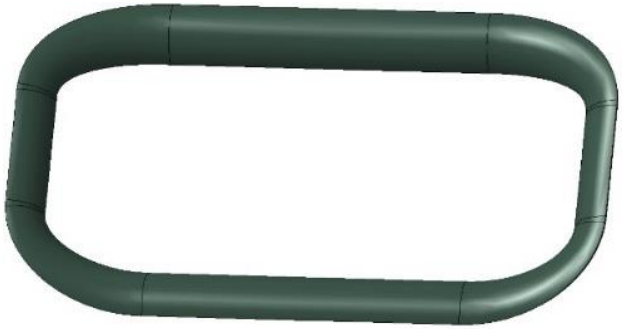
Manufacturing process:

1. Bowl forming and machining
2. Corner forming and machining
3. Bending of Central body (extra length)
4. Machining aperture of half body
5. Welding Bowl/Corner (internal)
6. Geometry adjustement and machining
7. Welding Corner/Central Body (internal)
8. Geometry adjustement
9. Machining of linear welding seam

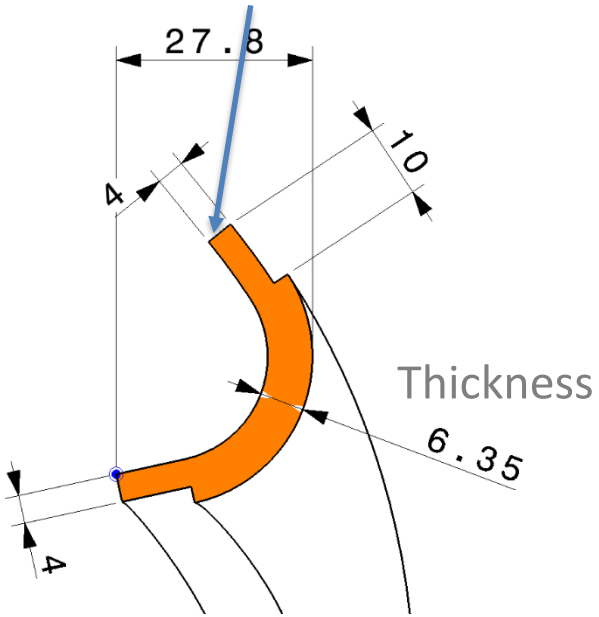
Manufacturing Strategy: Corner Transition

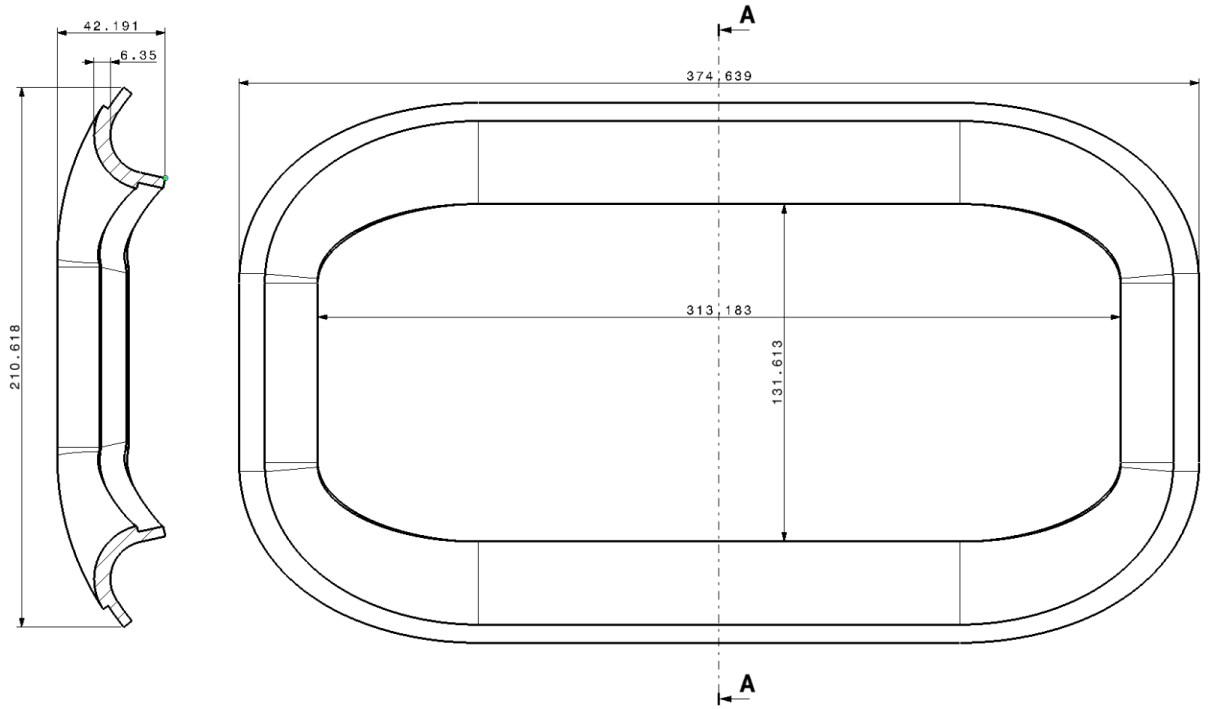
Manufacturing process:

- External edge Bending
- Internal edge: extrusion
- Coining
- Edges machining

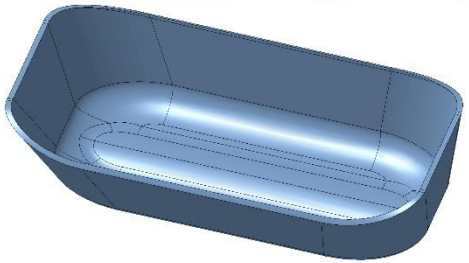


Butt weld welding seam

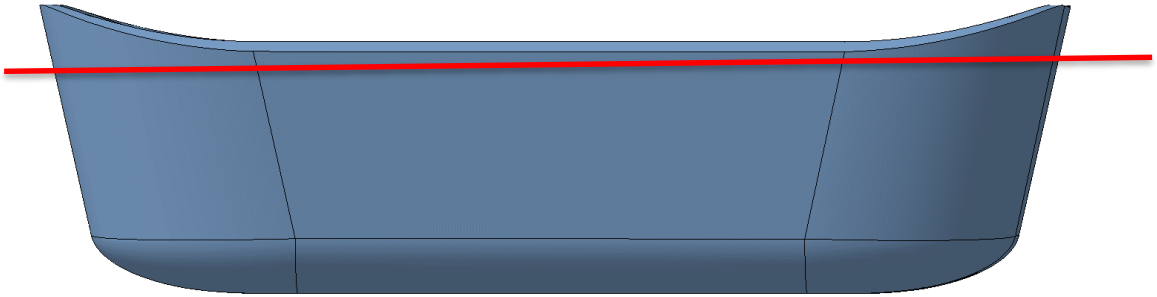




Manufacturing Strategy: Bowl

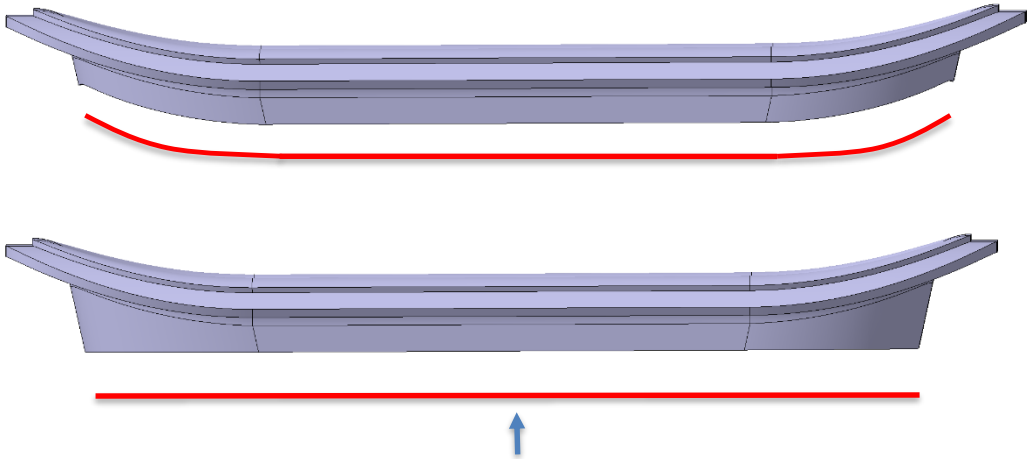


Geometry of welding seam to be defined



Manufacturing Process:

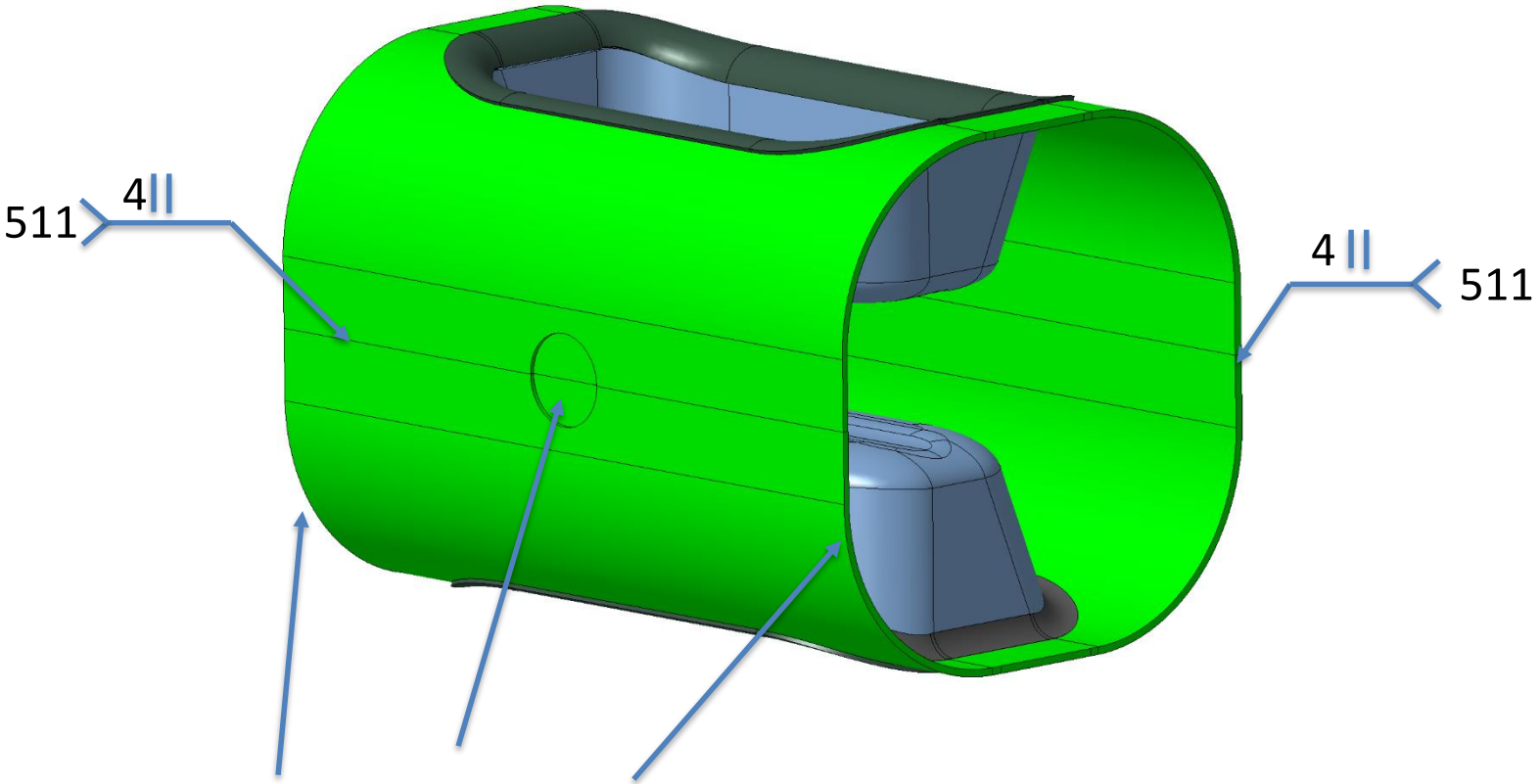
- deep drawing
- Coining
- Machining (edges plus eventual features)



Welding seam simplified

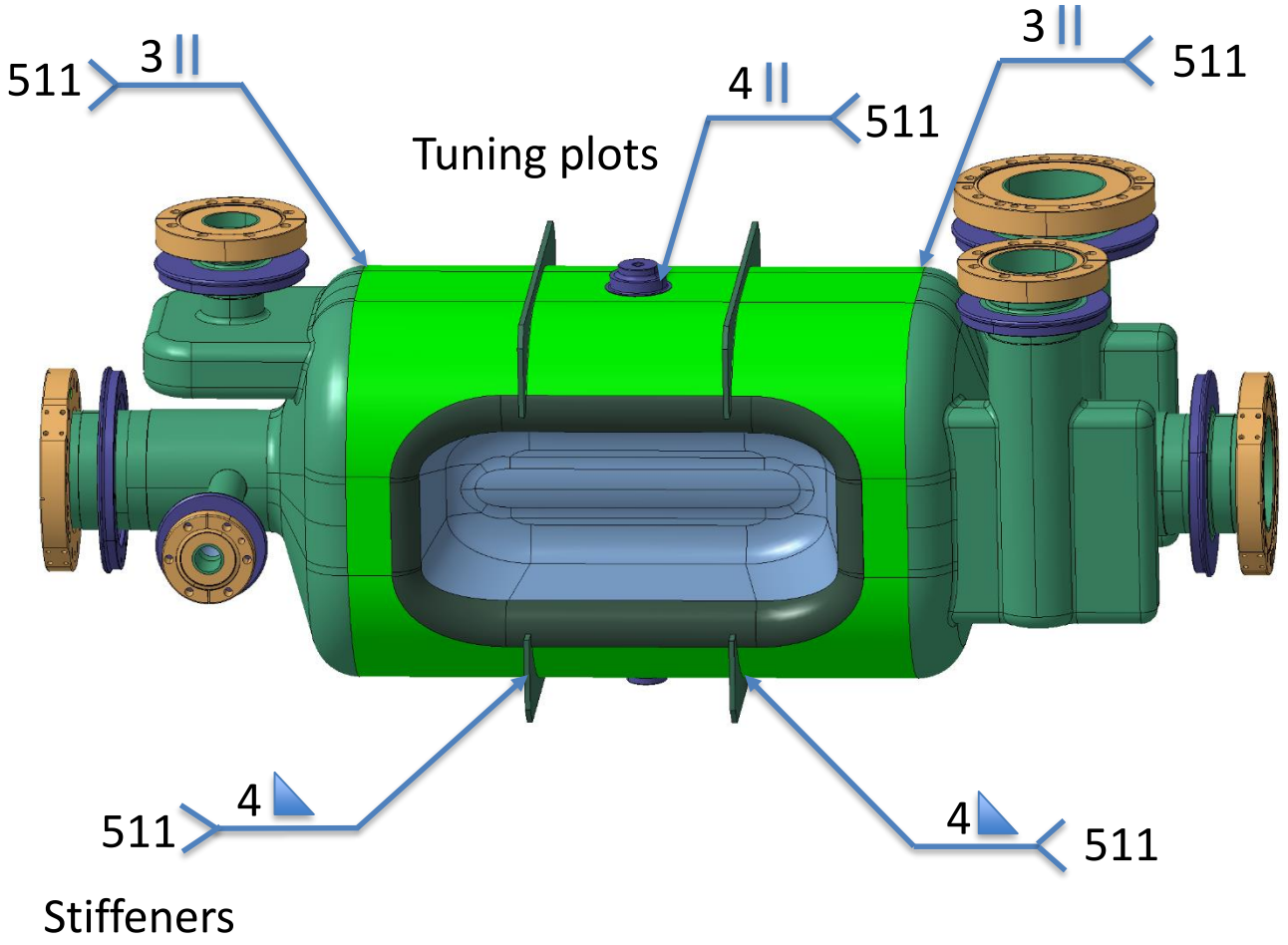
Body Assembly

Two linear welds with possible internal re-welding (RF surface improvement)



Machining after welding and geometry adjustement
Length + thickness reduction to 3.0 mm

RFD Final Assembly

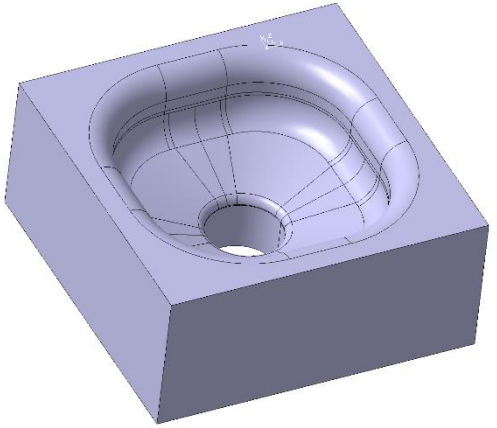


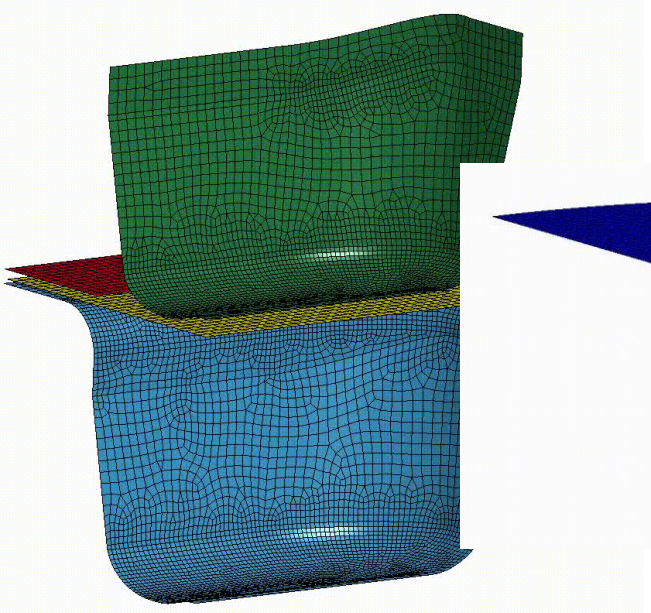
RFD-Shaping

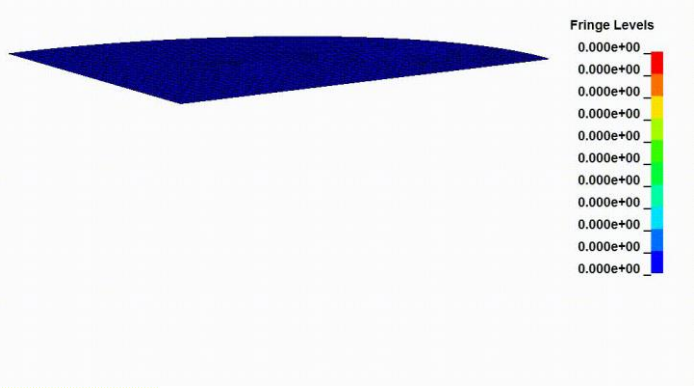
- Shaping philosophy & draft tools finished (thanks to DQW experience)
- Initial FE analyses started (max stress strain, indicative sheet size, pleating, forces...)

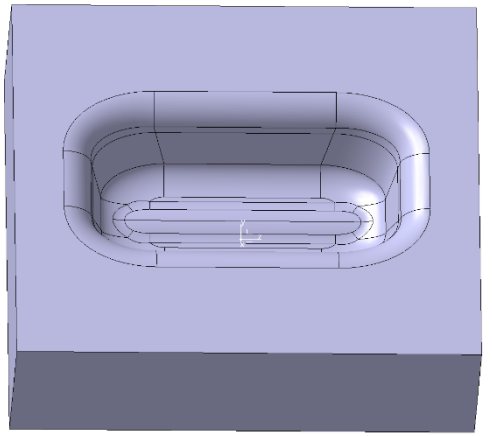
BOWL: deep drawing + coining

End cap:
Deepdrawing (w. central hole)
Trimming
Extrusion
coining



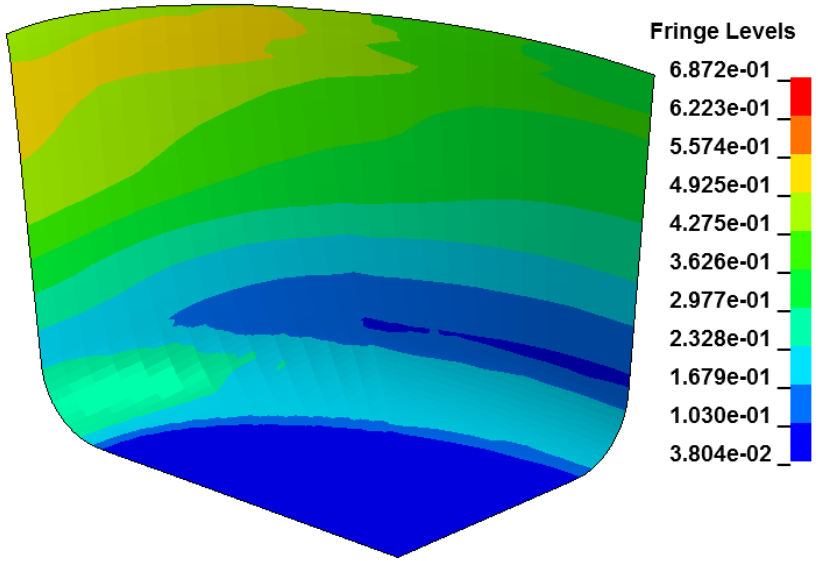






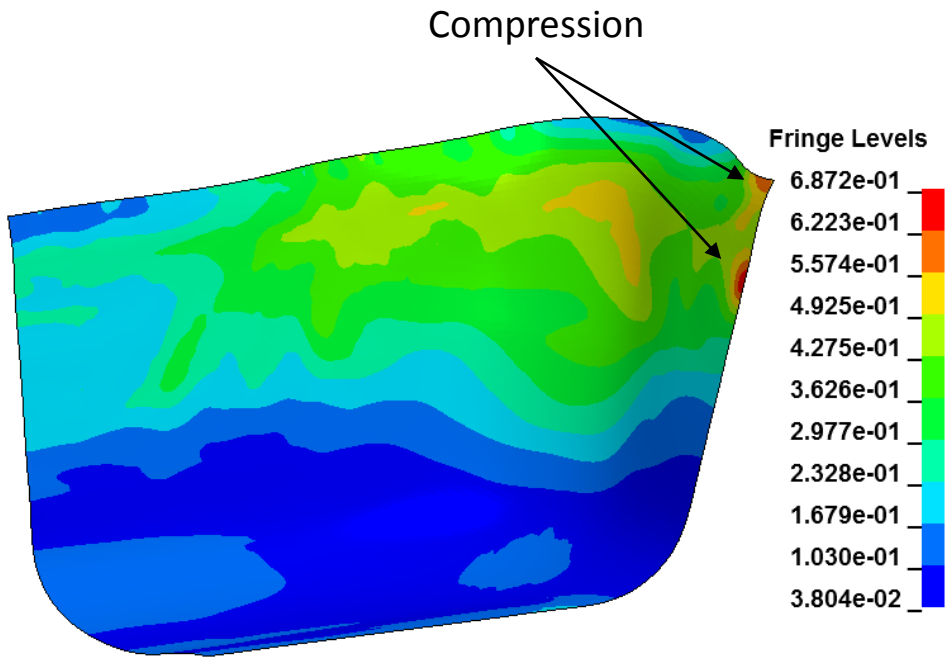
Finite Elements Analyses

Effective Plastic strain $\varepsilon_{plastic}$ distributions



DQW bowl

Max. Effective Plastic strain: 0.56



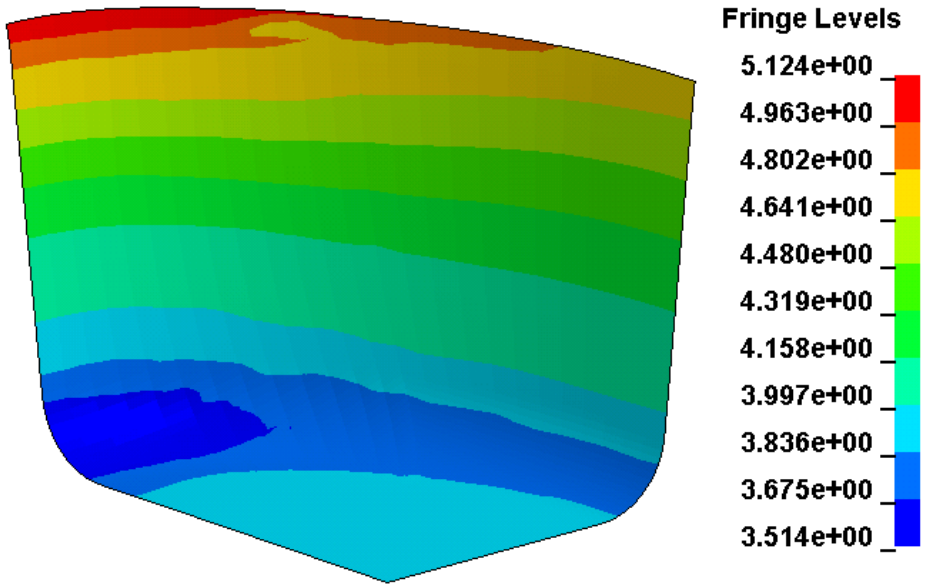
RFD bowl (Radius 15mm)

Should we worry about these peaks in strain?

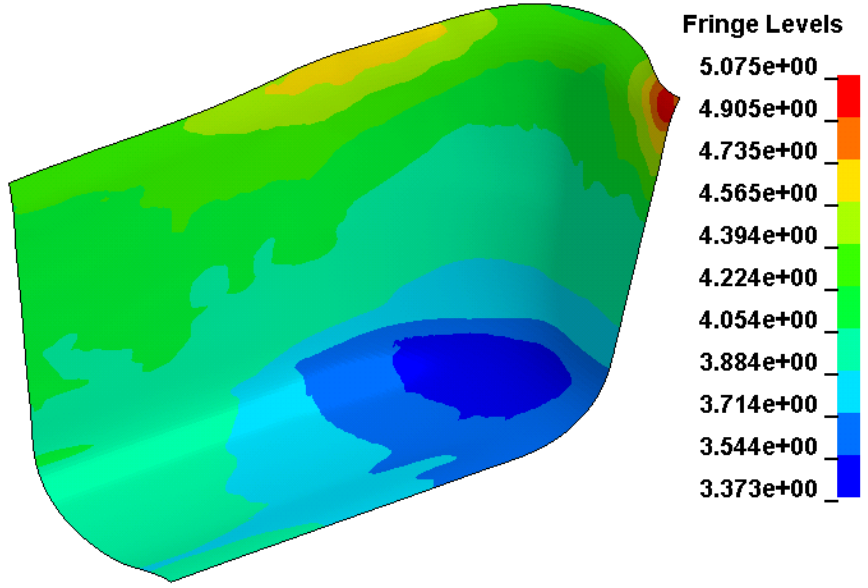
- ε_{UTS} is 0.5 – 0.8 in unidirectional tests – but considering the triaxility, there is a larger margin
- Peak is due to compression on surface opposite to RF
- We have already observed some buckling of the material in the DQW bowl (rather than compression-driven failure)

Finite Elements Analyses

Thickness distribution Comparison



DQW bowl



RFD bowl (Radius 15mm)

Conclusions

- Initial **feasibility study** well **advanced** (cut-out & technologies)
- **Shaping**:
  - Bowl & End Caps: philosophy of tools **finished** (thanks to DQW experience)
  - Ports: philosophy of tool **to be defined**
  - Initial FE analyses on going (max stress strain, indicative sheet size, pleating, forces...)
- **NEXT**:
  - Purchase Nb & Nb55Ti
  - launch 'standard' manufacturing (extremities)
  - Cavity design (cut out, components definition…)
  - Tools design

Thanks for your attention!