# RFD SPS-Test Cavity Manufacturing Status

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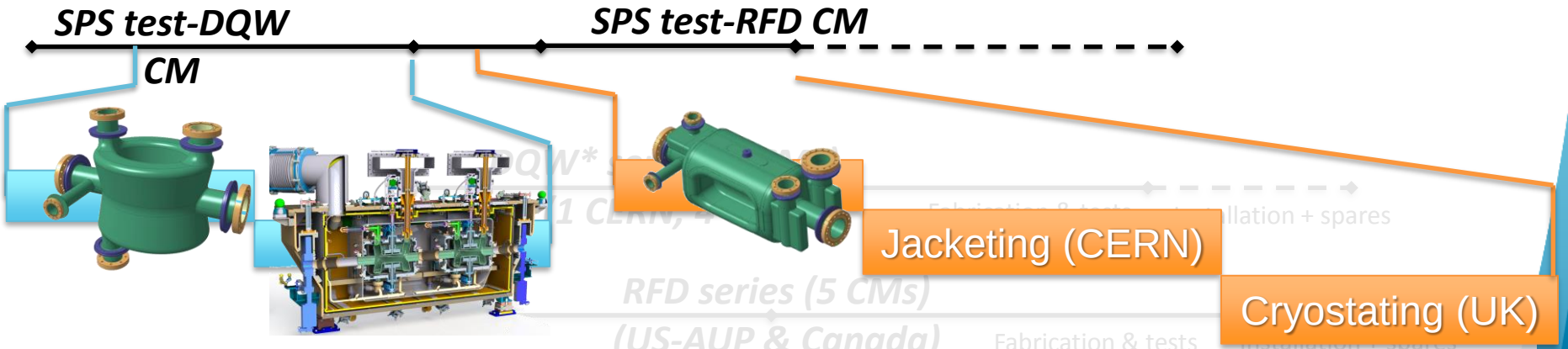
International Review of Crab Cavity System Design and Production Plan
CERN (Geneva), 19-21 June 2019

# Some History

*Before October 2015* : tests in SPS to be done using 2 DQW and 2 RFD cavities built in the US

*October 2015* : start production at CERN of 2 DQW cavities to cope with plans for SPS tests => very tight schedule

- Cavities produced at CERN used to validate the crab cavities behavior with beam in SPS. **RFD to follow DQW fabrication**
- Cavities produced in the US to be extensively tested for thorough understanding of its fundamental behavior

# Fabrication Zeitgeist & Baseline

WP4 context:

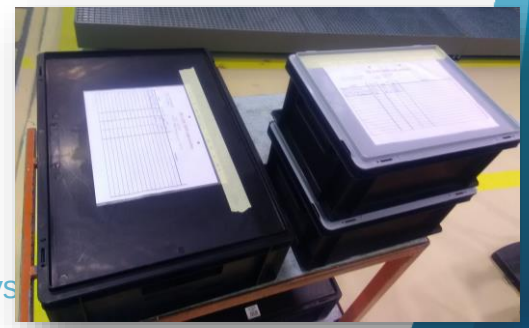
- **Prototype RFD Cryomodule** to be assembled by UK
- **Concurring** fabrication of **series RFD cavity** (outsourced by AUP)
- **Concurring** fabrication of **series DQW cavity** (outsourced by CERN)

CERN context:

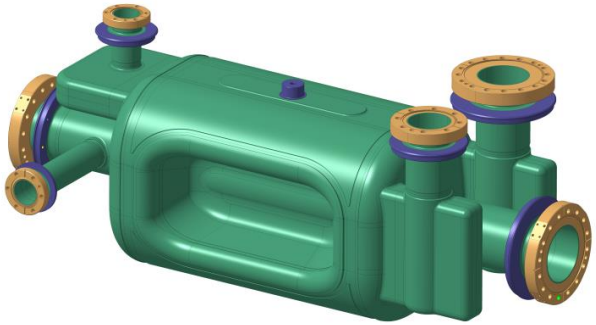
- **LS2 activities** ongoing

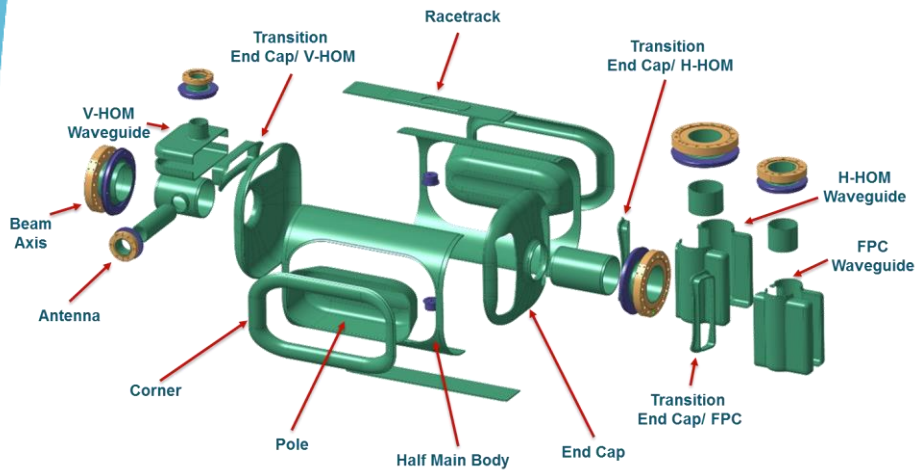
Baseline:

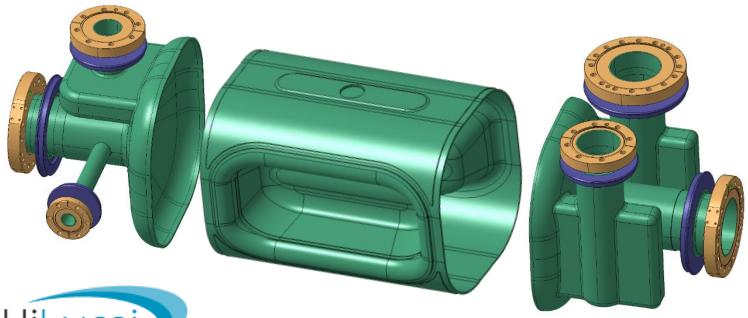
- **No** fabrication **task force** as per DQW. Treat as ‘normal’ activity (both design & fabrication)
- **Sound fabrication folder** (drawings, tools, steps), then production
- All **tests before**, then planning and production
- **Traceability** and Logistics
- **Rationalize** - not reduce! - resources & costs (for tests & tools)
  e.g. RRR40, couple tools
- **Capitalize** from DQW **experience**
  (..shaping processes, clamping, handling…)



# RFD Cavity: Manufacturing Cut Out





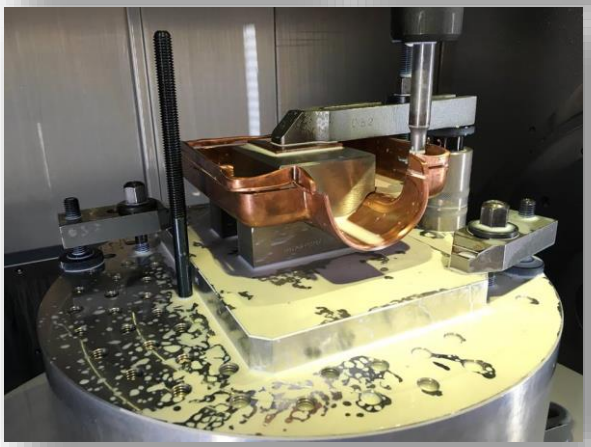
**W.r.t. DQW**:

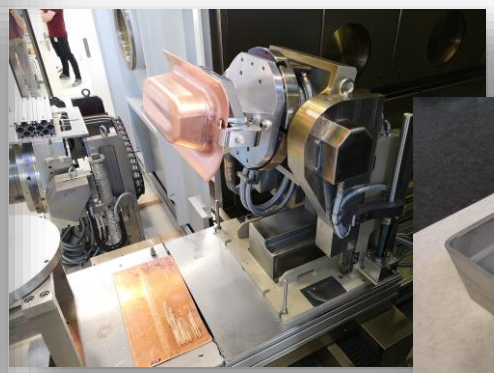
- Multi-technology much more **intertwined** (e.g. waveguides)
- **More** parts. **Bigger** parts (..clamping..)
- Longer **chain of added value**

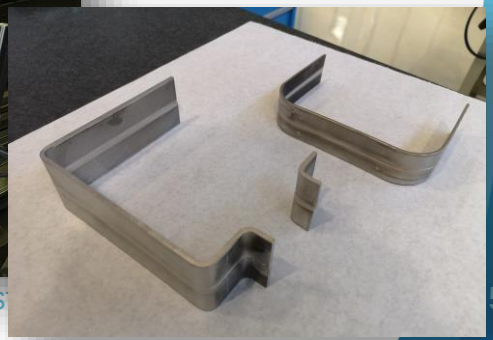
**Rationale** behind RFD prototype **cut out:**

- Favor high-added-value operations (EB welding, trimming)
- Shaping of easiest subcomponents
- Make use of DQW know-how and tooling! (e.g. extremities)
- Optimize raw material cost VS. Process (Memento: 2x cavities)

# DQW Fabrication: Strategy







***<u>Get it right for Niobium</u> !***

Tests: annealed Cu, Al, Nb RRR40
**All processes** involved

**Shaping**:
Some **process parameters**..

- press-pad pressure/position
- niobium initial shape & size

The **imperatives**..

- Account for thickness evolution
- Optimize friction: urethane film
- ~~Circular & Linear tests~~

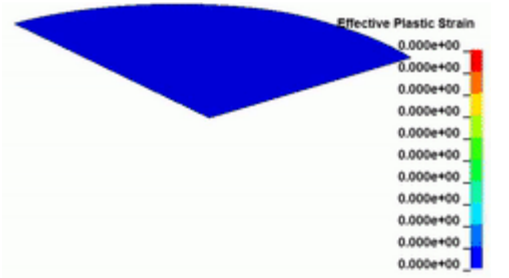
# Finite Element Simulations

## Why?

- Compare different manufacturing choices & steer strategy
- identify forming defects & highly stressed regions
- predict on the final thickness distribution

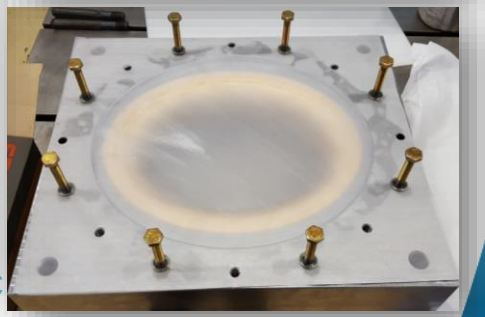

## What?

Shaping of: Pole, Main Body, H-HOM waveguide, End Cap, Corner

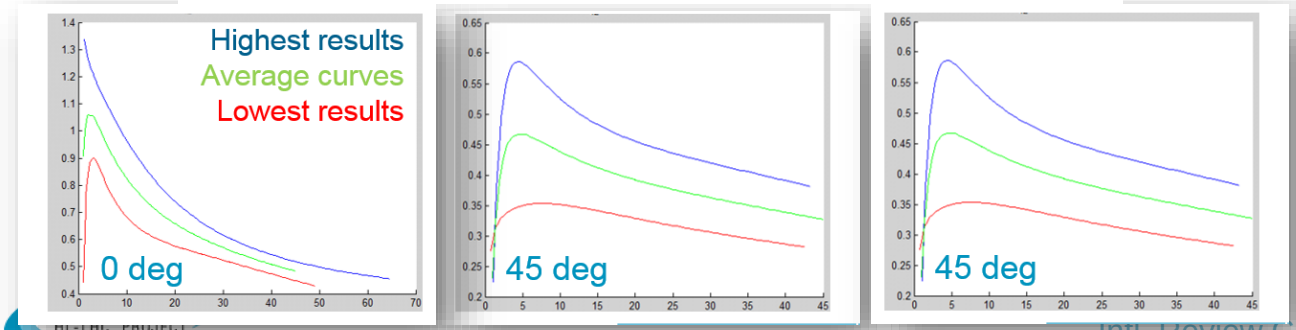



Working on **Springback** modelling, plastic failure and ongoing **material characterizations**:

- Anysotropy
- Niobium Frictional behavior



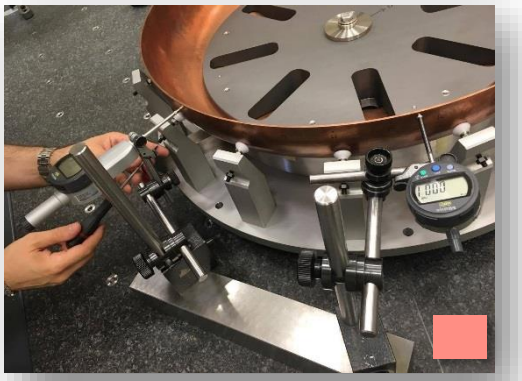
**r values curves for each direction and their averages**

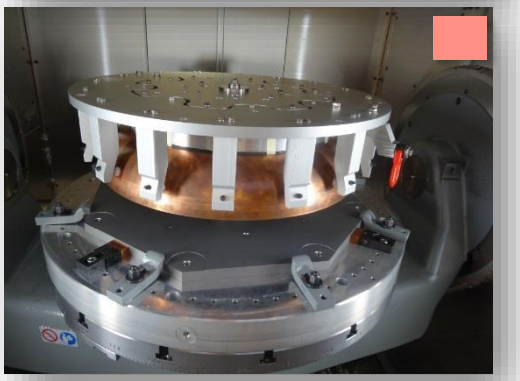


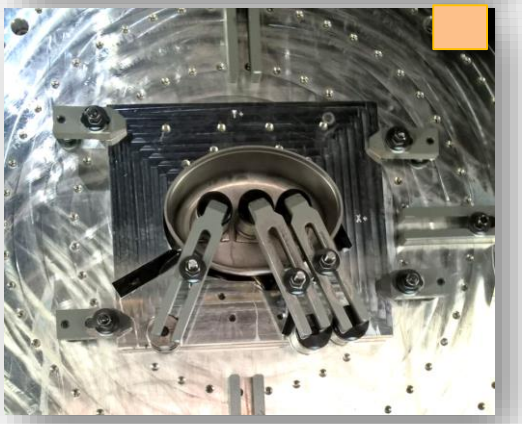
# Manufacturing: Machining Strategy

*How to handle unconventional shapes?*

*The real world...*







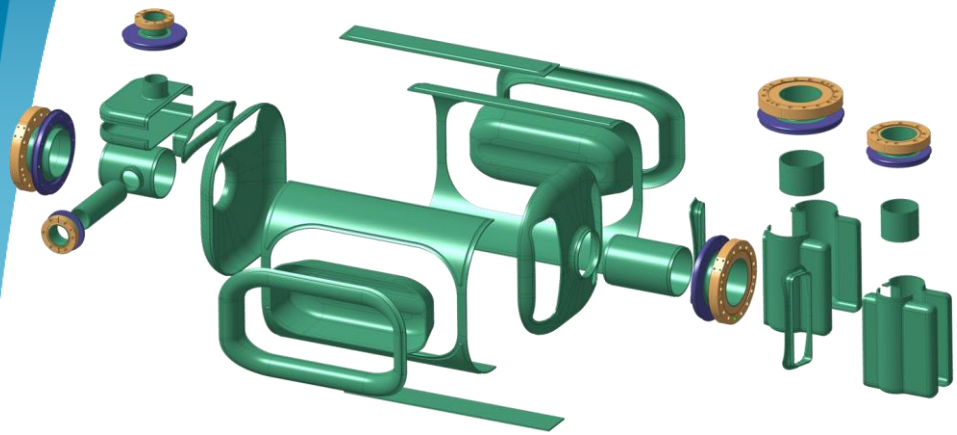
...**theoretical-shape** clamping…

- More indulgent on shaping and machining
- Advanced tools needed down to last weld

…VS. **free-state** (stress-free)clamping…

- Forming: must yield best shape possible (→ coining!)
- Machining: no easy referencing.. must go hand in hand with metrology
- Welding: no last minute surprises

# Manufacturing : Welding Strategy



**Butt welds** (no key/slotted configuration):

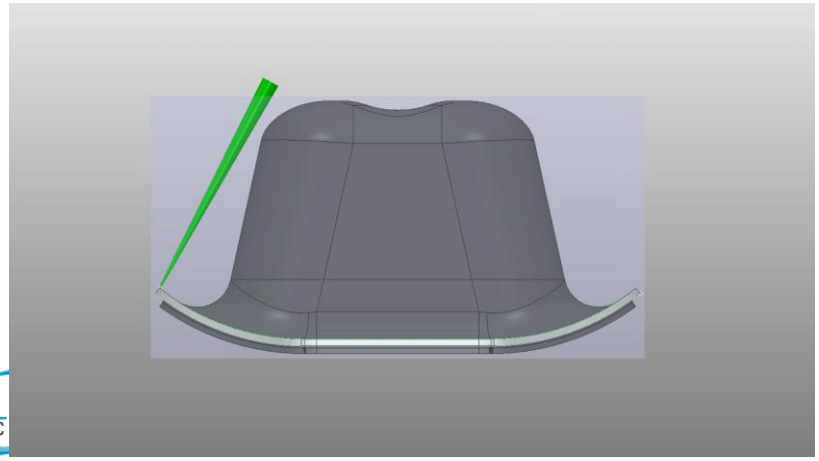
- Easy check for alignment and defects
- Easy RF trimming
- Multi-axis milling

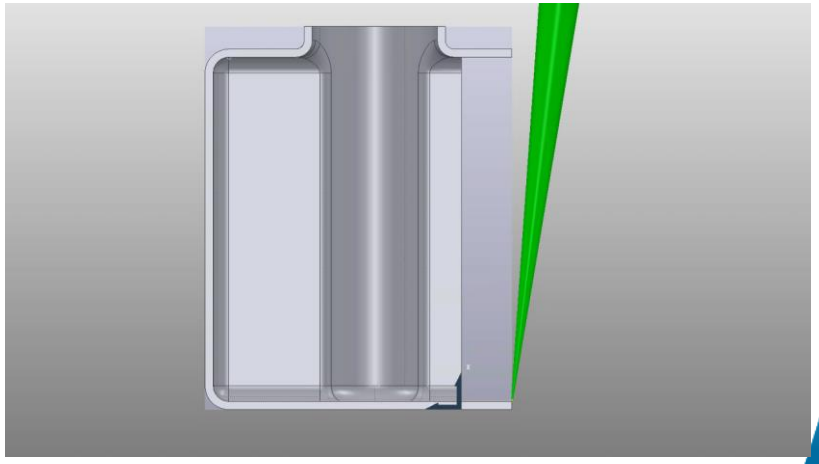
If **RF surface visible**:
4mm weld, smoothing on RF side.

If **RF surface not visible**: thickness reduction for critical welds (→lower energy input, less risky,..)

**Backing Ring** when remachining feasible

**Corner-Pole smoothing**

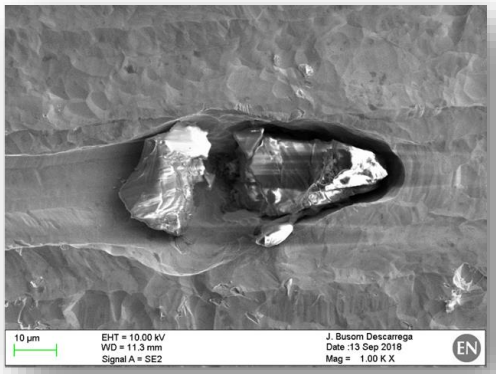




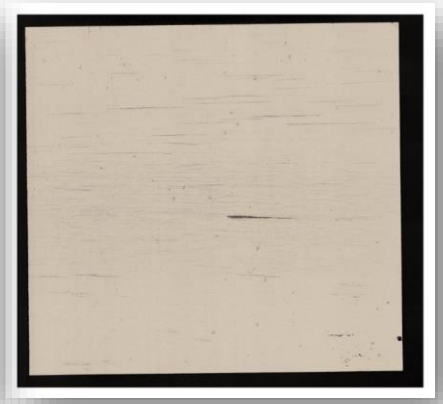
# RFD Cavity Manufacturing: Strategy

**Material**:

- Stainless Steels, Bronze (CuSn12), EN 1.2343, …
- Highly attentive to Niobium and NbTi condition @ reception







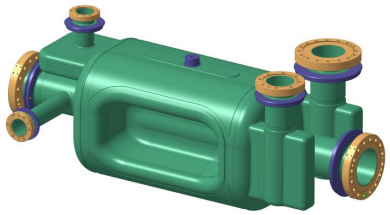
***Niobium***:

- *Alumina inclusions*
- *Automatic inspection on samples of incoming material*

***NbTi***:

- *Niobium inclusions, not detected during supplier NDT*

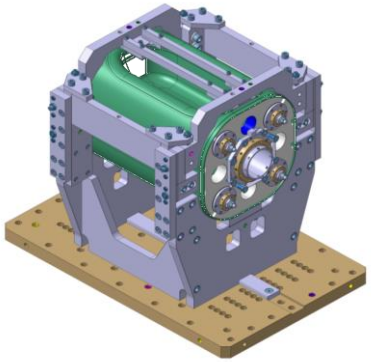
# The Truth is Out There

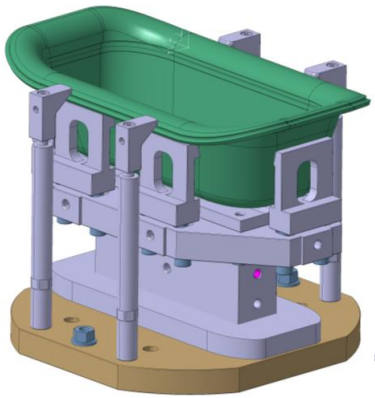


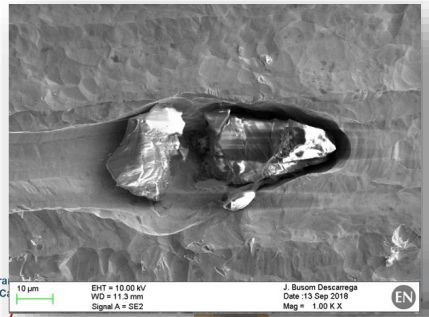
CERN **experience on prototype** fabrication is directly translated onto:

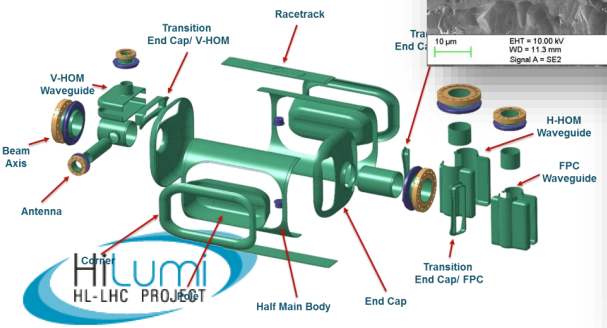
- **feedback** & view exchange within **WP4** Collaboration
- **dialogue** with **suppliers**
- updates on **processes** & CERN **specifications**

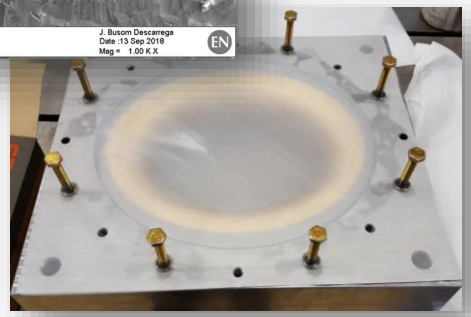
*Strategy for fabrication*
*Process parameters and tips*
*Tools design*

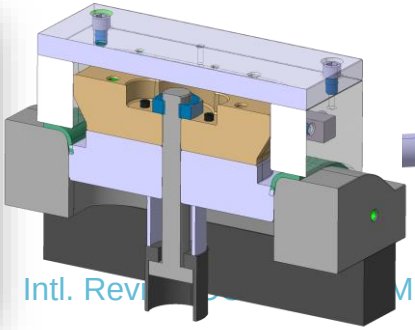


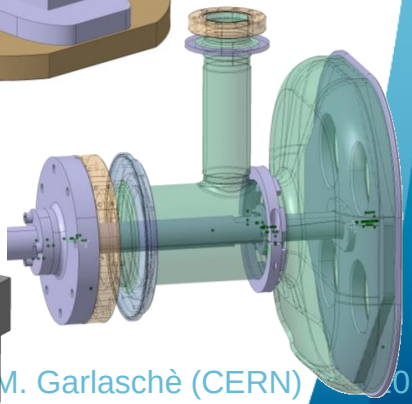




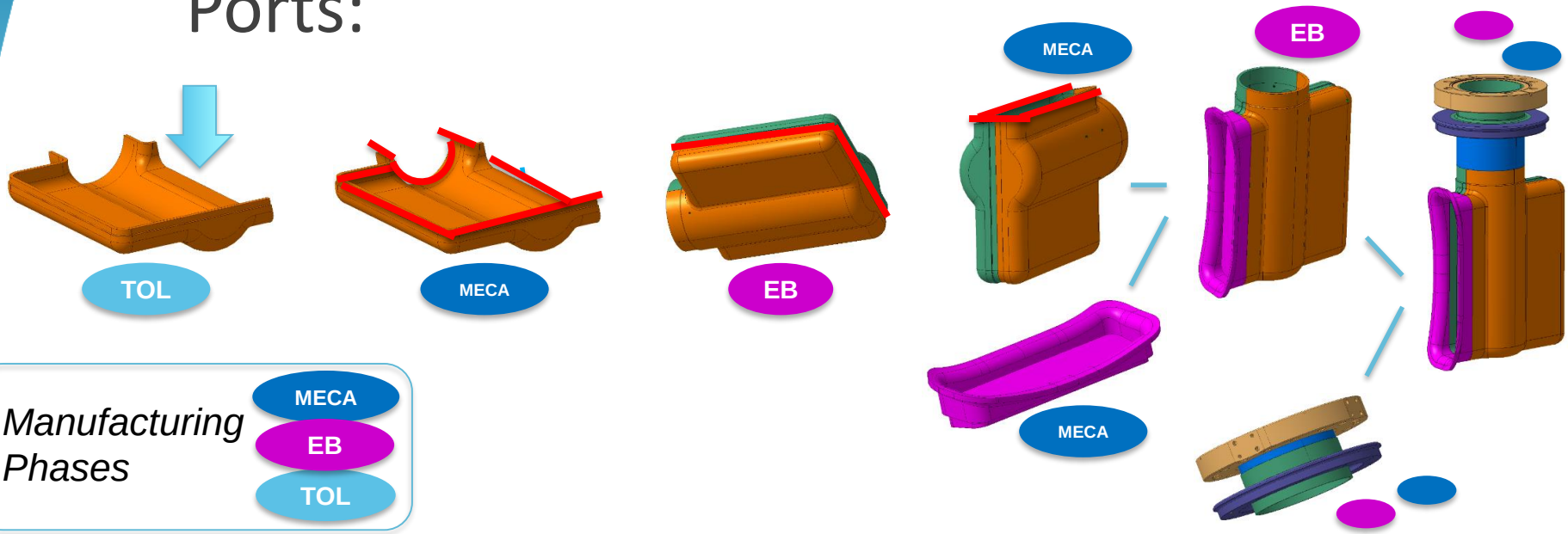







# Cavity Build Up

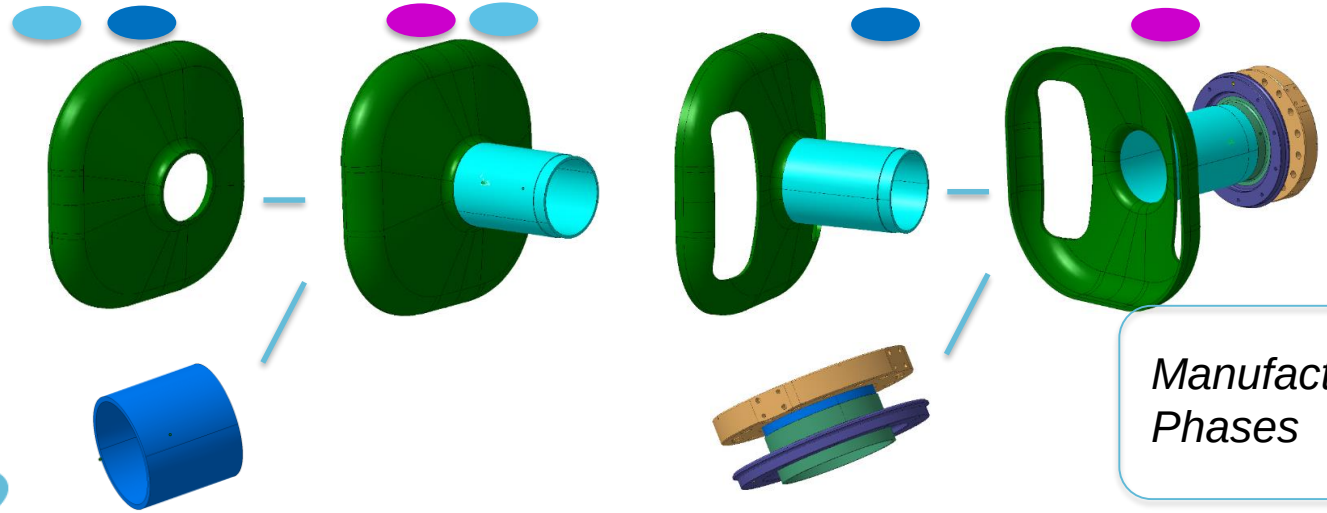
## Ports:




*Manufacturing Phases*

MECA
EB
TOL

## Cap:



*Manufacturing Phases*

MECA
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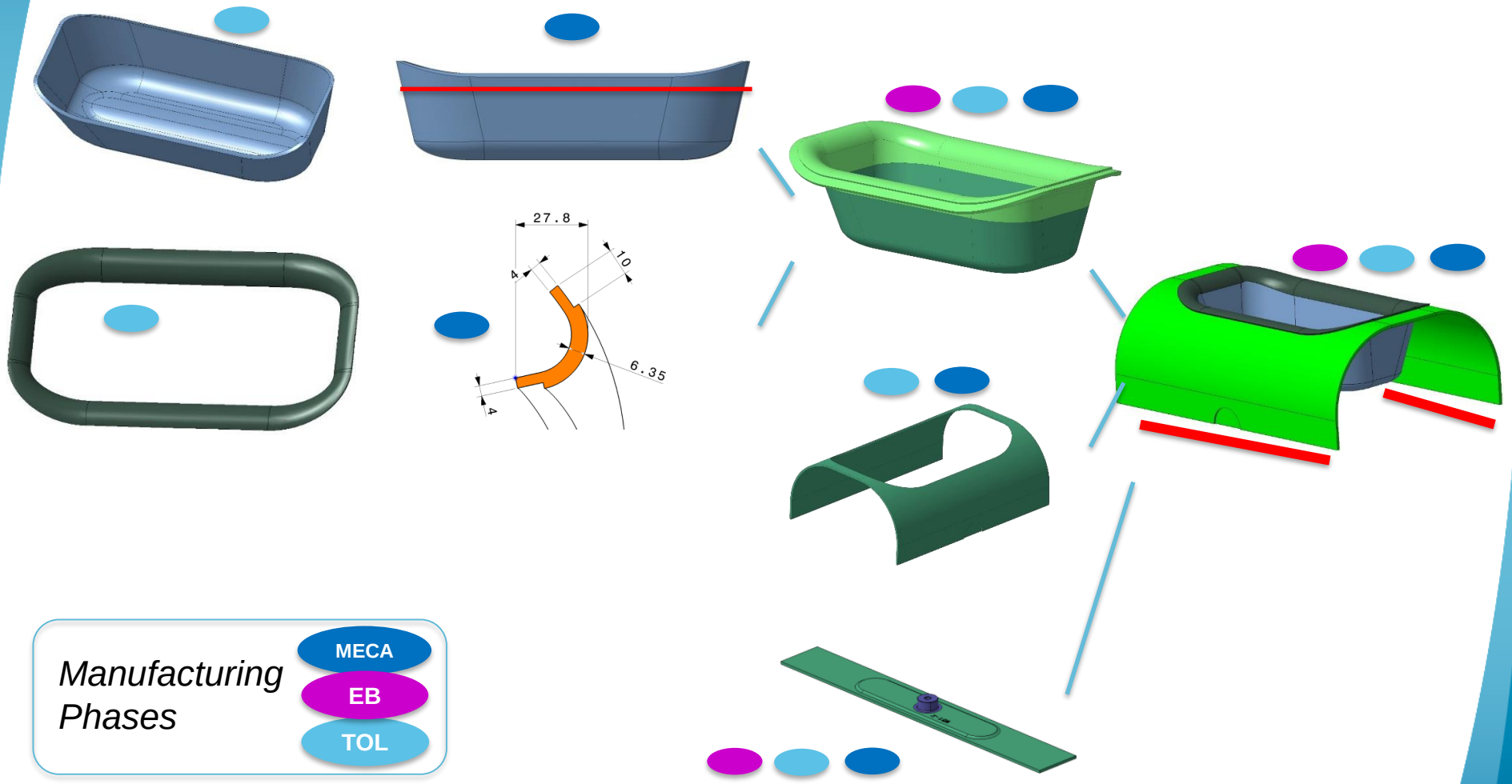
# Cavity Build Up



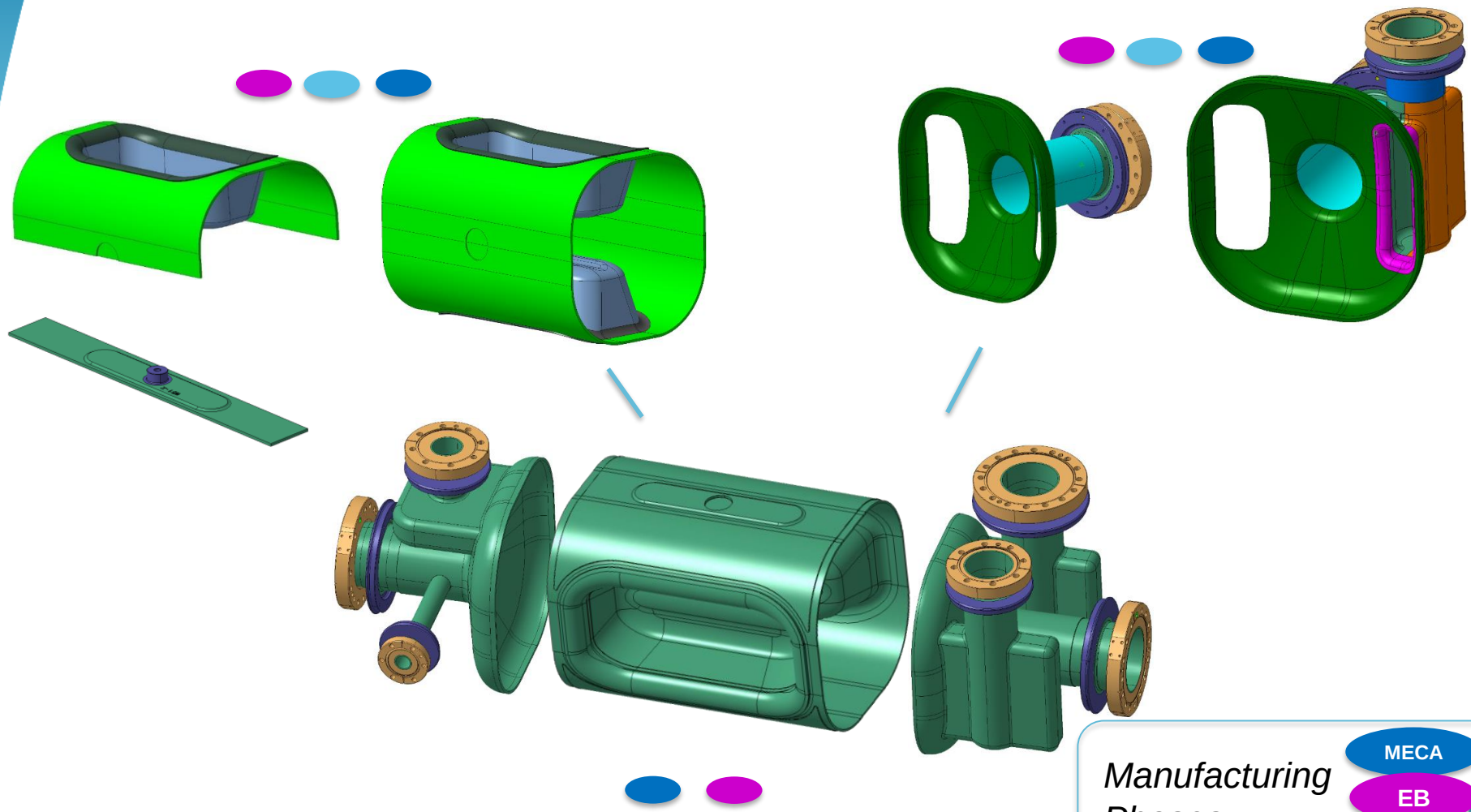

*Manufacturing Phases*

MECA

EB

TOL

# Cavity Build Up



*Manufacturing Phases*

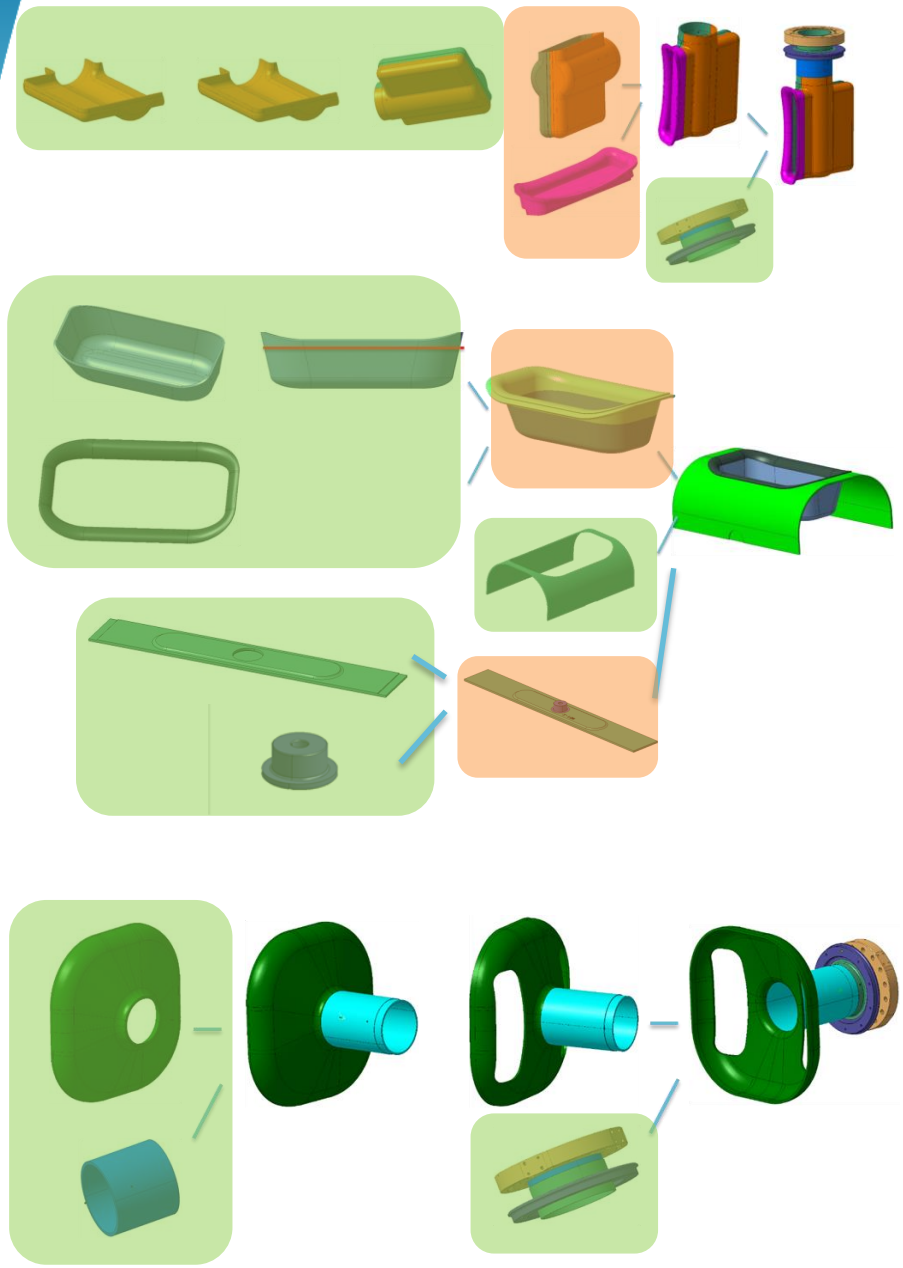
MECA

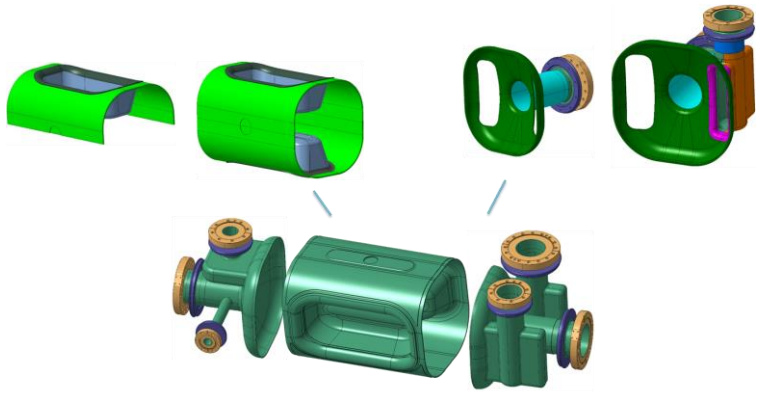
EB

TOL

# Fabrication Status

DONE
ONGOING





# Some Pics









# Conclusions

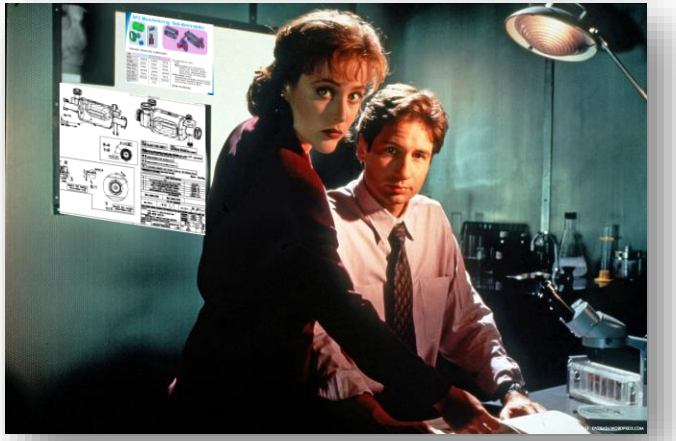
Great **capitalization of experience** from DQW.

Experience is spread onto current activities and onto **feedback to WP4 Collaboration.**

As per DQW, experience and support of collaboration is paramount.

**Planning:**

- No major technical showstoppers. Cavities well on the way.
- LS2 & other CERN urgent programs have an impact on activities.
- Current expected deadlines for cavity delivery:
  - CAV#1 – Mid of Q4 2019
  - CAV#2 – End of Q4 2019



***Thank you!***