



CERN Crash Program for SPS-test DQW Cryomodule

M. Garlasché on behalf of WP4 Team

International Review of Crab Cavity System Design and Production Plan

CERN (Geneva)

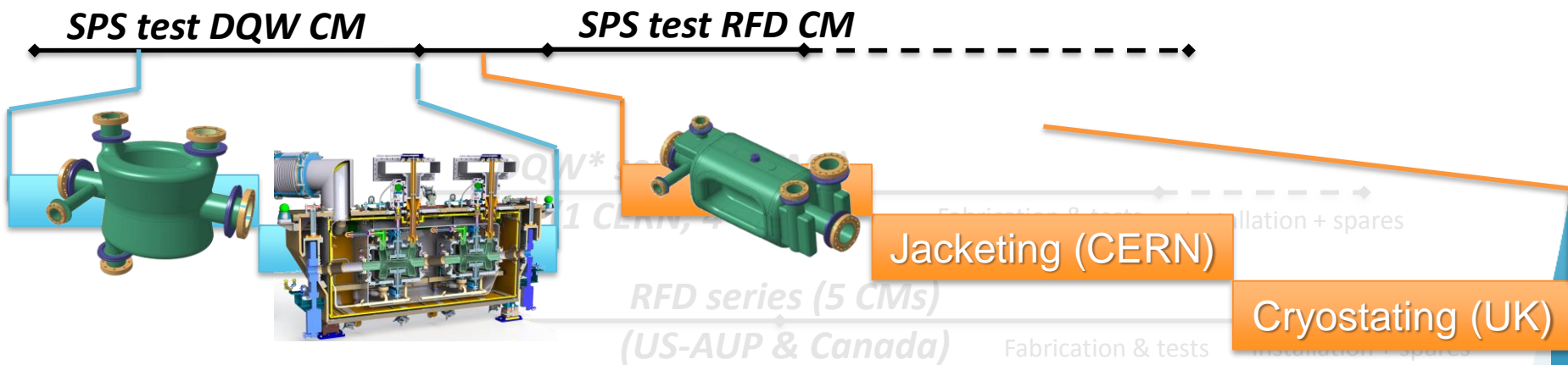
19th ÷ 21st June 2019

Some History and Context

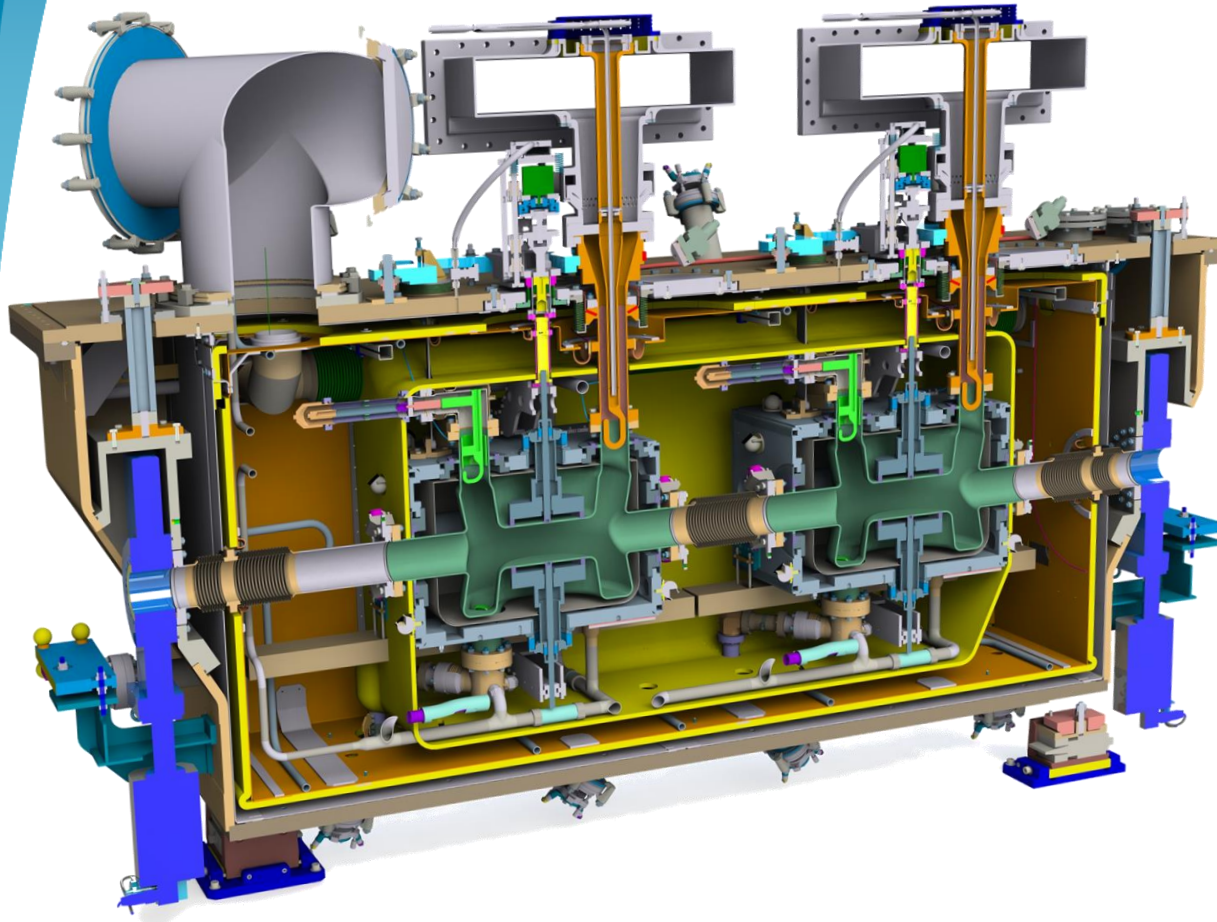
Before October 2015 : tests in SPS to be done using 2 DQW and 2 RFD cavities built in the US

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
- Cavities produced in the US to be extensively tested for thorough understanding of its fundamental behavior



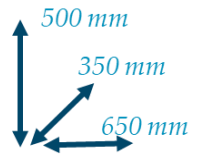
DQW SPS Test Cryomodule



Main Components:

- Dressed Cavity
- Alignment + supports
- Tuning
- Thermal Shield
- Warm Magnetic Shield
- MLI
- Powering
- Cryogenic System
- Vacuum Vessel

Crash DQW Cavity: Challenges

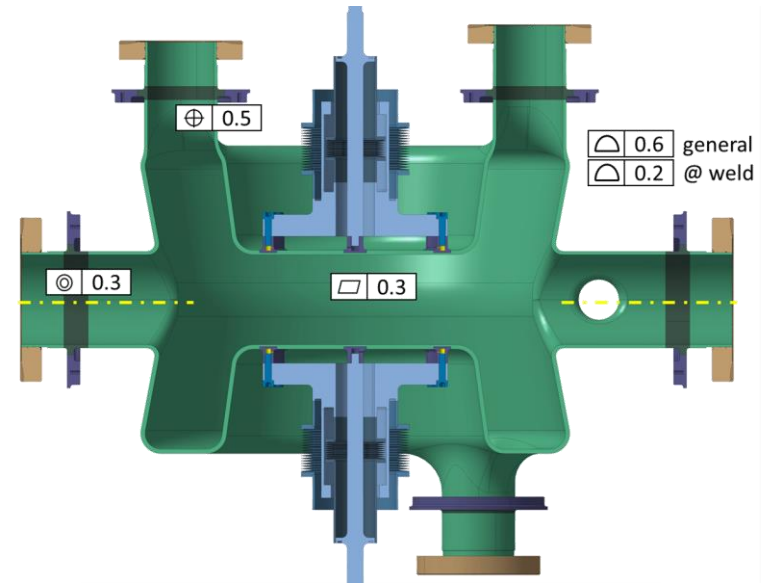


Design & Calculations:

- **Synchronized** (mechanical, RF,..., CERN, AUP, UK)
- **Concurring** with many of the auxiliary systems and with **production**

Manufacturing:

- **Non axi-symmetric** shape
- **High forming ratios** → large deformation processes (deep drawing, extrusion..)
- Multiple fabrication steps on same subcomponent (Shaping + Machining + EB Welding)
- **Tight Schedule**



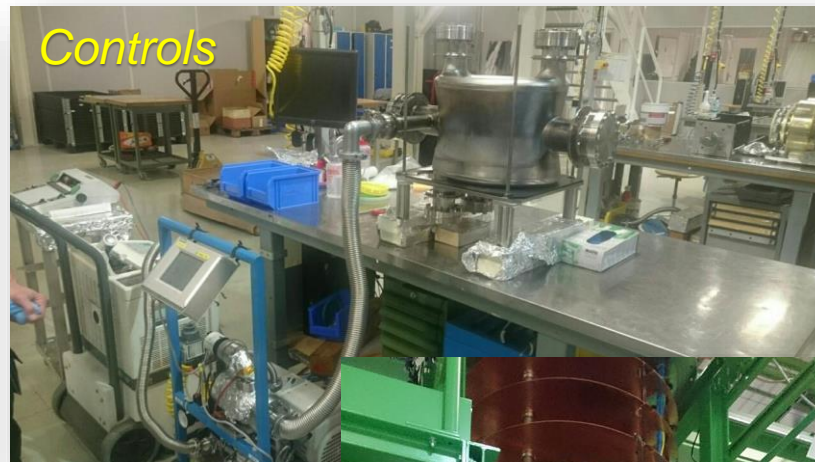
2015	2016				2017			
Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
CAVITY #1					TEST + JACKETING			
CAVITY #2						T+J		



Cavity Readiness

2015	2016				2017			
Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	CAVITY #1				TEST + JACKETING			
	CAVITY #2				T1J			

Cavity Ready?



Surface and Thermal Treatments

Intl. Review C

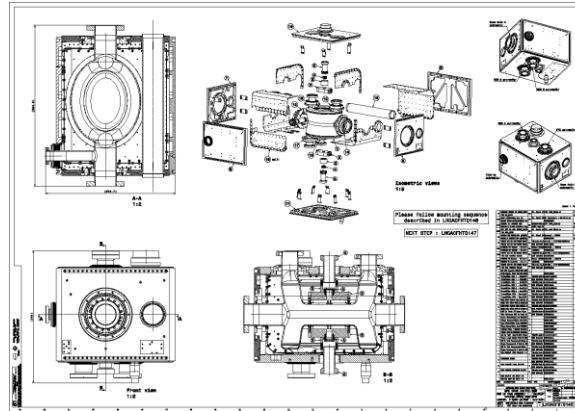
Cold Tests

Cavity Jacketing

Multiple tasks. Synchronized:

- Design & Fabrication
- WP4 Collaboration: components and activities

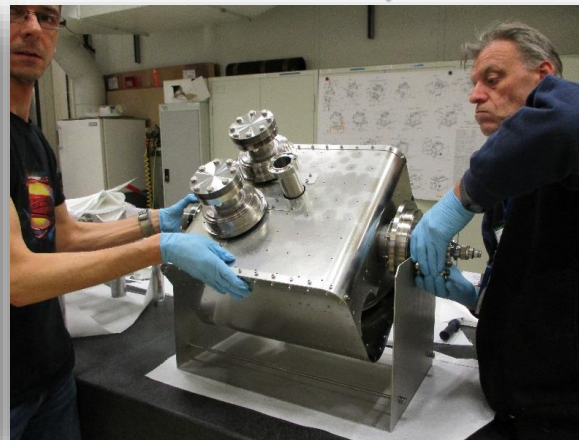
*Assembly study:
feasibility, procedures*



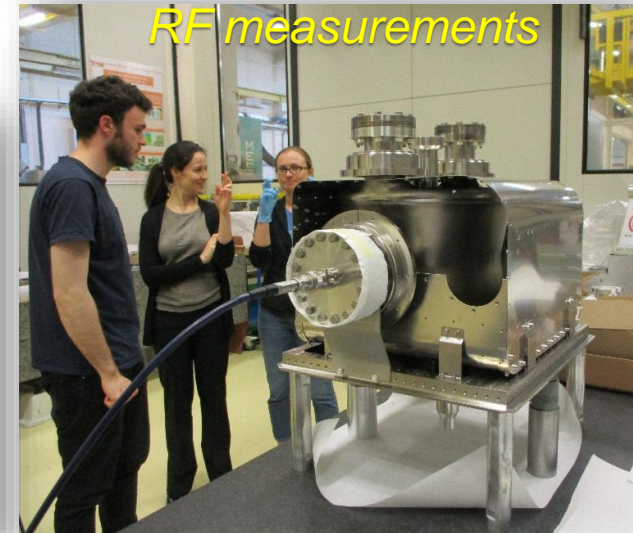
Assembly



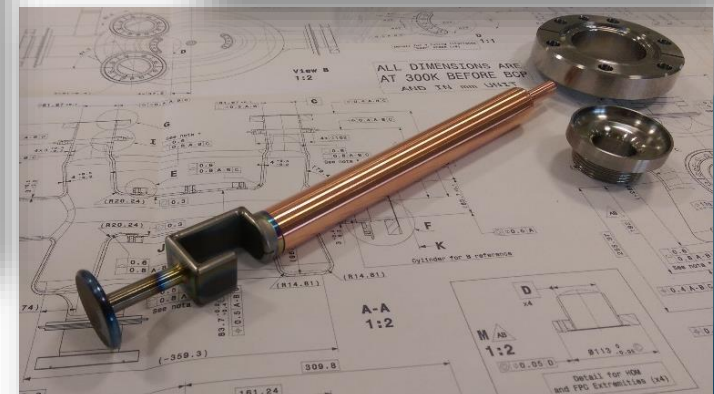
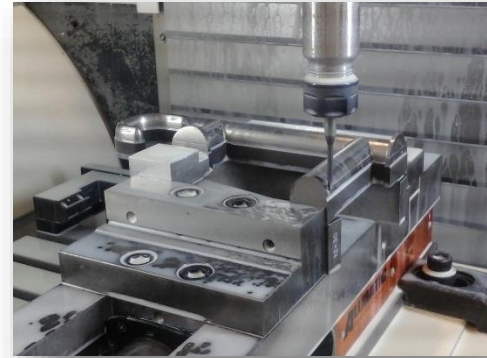
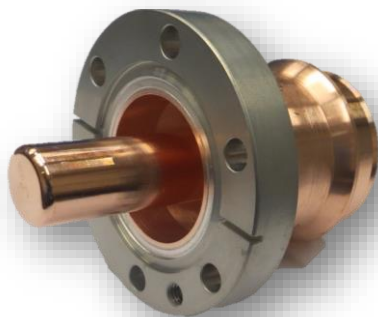
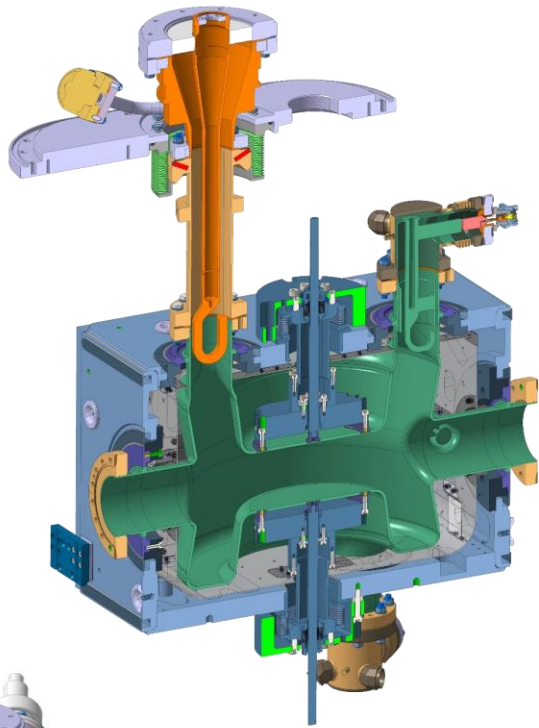
Pretuner & cold μ shield



RF measurements



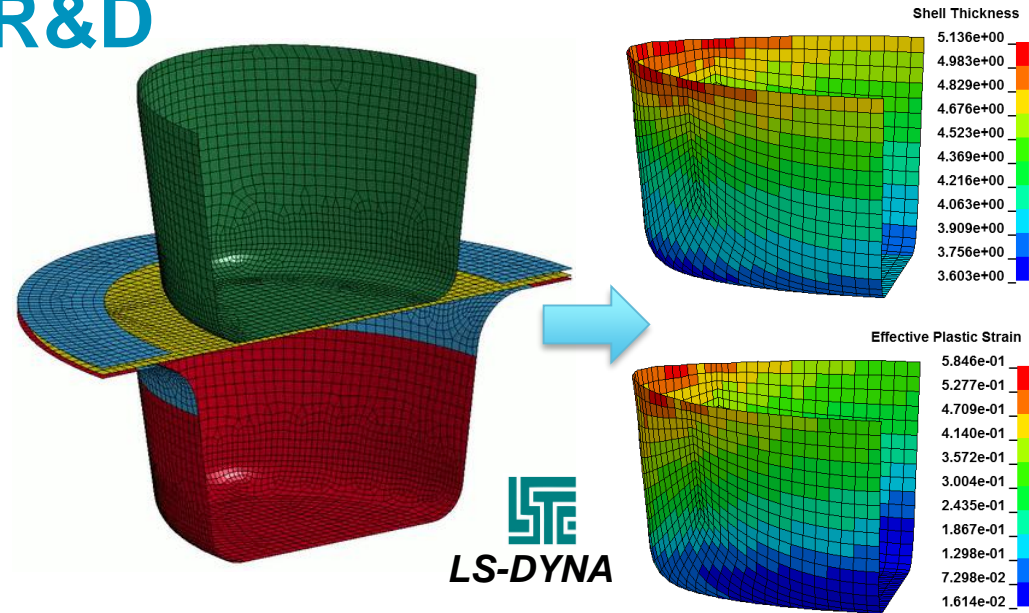
Cavity RF Auxiliaries



Cavity Fabrication R&D

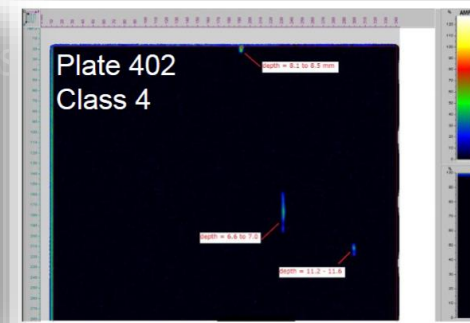
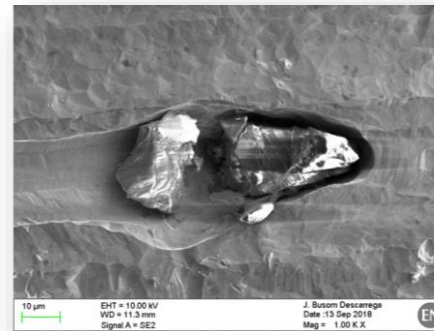
F.E. Simulations of processes:

- Take the **initial trials** out of the workshop.
- Compare different manufacturing choices & steer strategy



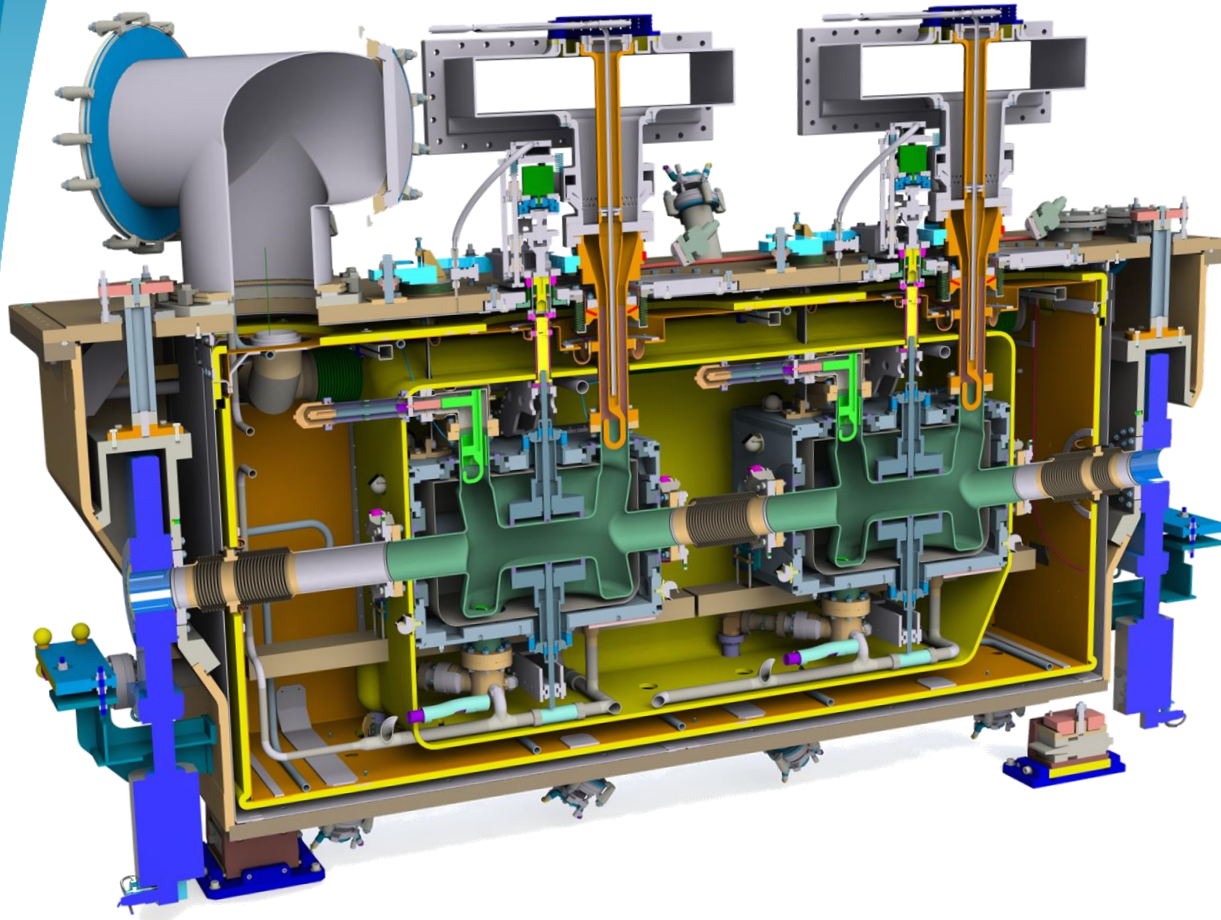
Extensive test campaign on **Niobium contamination sources** and **ability to remove them**:

- Tool materials
- Niobium and NbTi @ reception



Experience is directly translated onto **discussions** with Collaboration, suppliers and into updates of **corresponding CERN specifications** for materials, **processes** (NDT, fabrication, ..)

DQW SPS Test Cryomodule



Main Components:

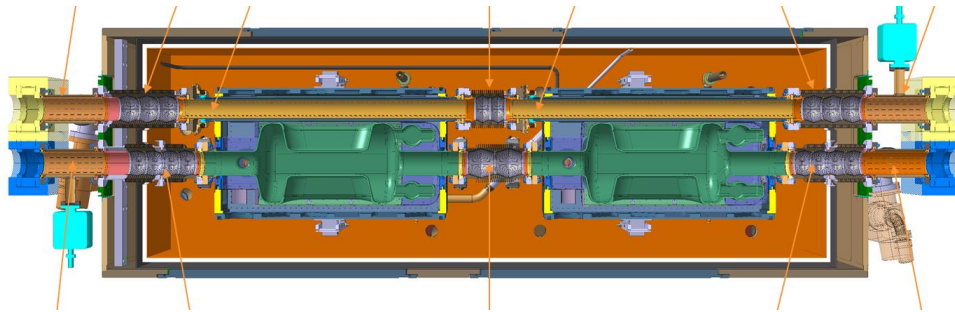
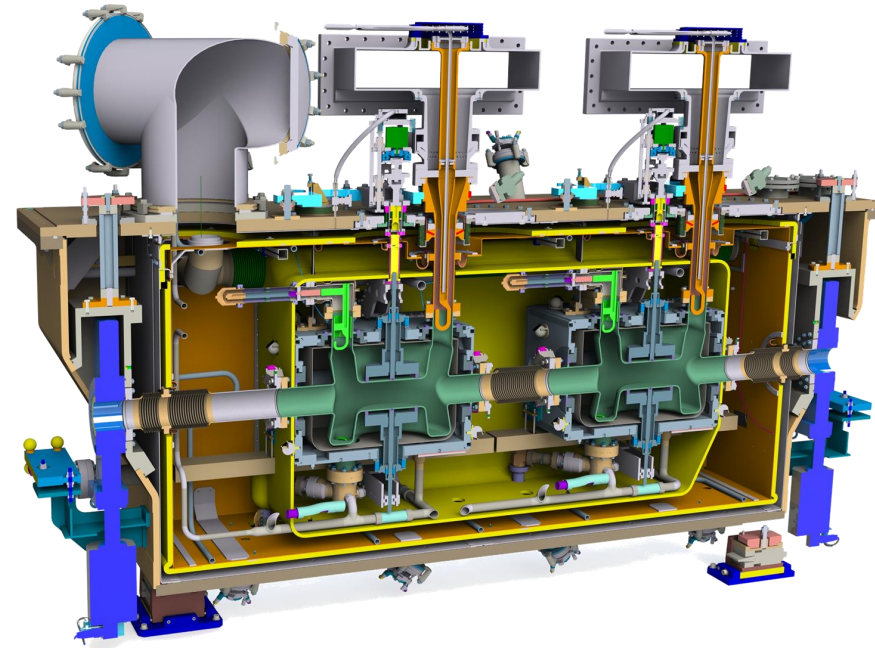
- Dressed Cavity
- Alignment + supports
- Tuning
- Thermal Shield
- Warm Magnetic Shield
- MLI
- Powering
- Cryogenic System
- Vacuum Vessel

Omissis in this Presentation

SPS Test DQW Cryomodule

experience on particular equipment design or activity

- **Cryogenics:** K. Brodzinskij
- **Vacuum:** C. Pasquino
- **Tuning System:** K. Artoos
- **FPC & RF powering:** E. Montesinos
- **Alignment:** M. Sosin
- **Clean Room assembly:** K. Turaj
- **Cryom. Installation:** G. Vandoni



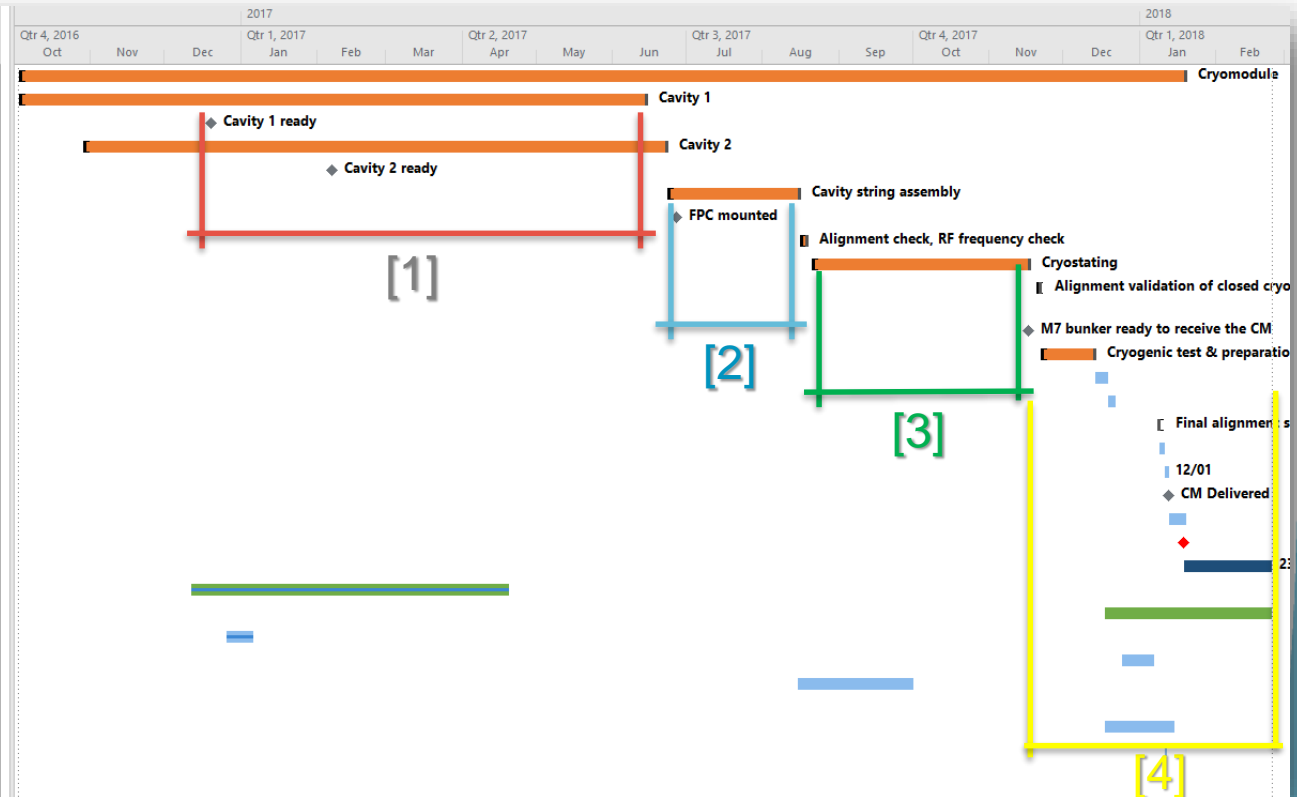
See **LHC Cryomodule Design** T.Capelli

Some additional components:

- Second Beam Pipe
- Beam Screening

Crash Assembly Planning

Task Name	Durati	Start	Finish
► Cryomodule	316 days	Mon 03/10/16	Fri 19/01/18
► Cavity 1	170 days	Mon 03/10/16	Wed 14/06/17
Cavity 1 ready	0 days	Mon 19/12/16	Mon 19/12/16
► Cavity 2	156 days	Fri 28/10/16	Thu 22/06/17
Cavity 2 ready	0 days	Mon 06/02/17	Mon 06/02/17
► Cavity string assembly	38 days	Fri 23/06/17	Tue 15/08/17
FPC mounted	0 days	Mon 26/06/17	Mon 26/06/17
Alignment check, RF frequency check	3 days	Wed 16/08/17	Fri 18/08/17
► Cryostating	63.5 days	Mon 21/08/17	Fri 17/11/17
Alignment validation of closed cryomodule (M7 bunker)	2 days	Mon 20/11/17	Tue 21/11/17
M7 bunker ready to receive the CM	0 days	Thu 16/11/17	Thu 16/11/17
► Cryogenic test & preparation	16 days	Wed 22/11/17	Wed 13/12/17
Cold test buffer time	3 days	Thu 14/12/17	Mon 18/12/17
Cryomodule warmup	3 days	Tue 19/12/17	Thu 21/12/17
Final alignment steps	1 day	Mon 08/01/18	Mon 08/01/18
Cutting lines jumper	2 days	Tue 09/01/18	Wed 10/01/18
Transport preparation	2 days	Thu 11/01/18	Fri 12/01/18
CM Delivered	0 days	Fri 12/01/18	Fri 12/01/18
Buffer time	7 edays	Fri 12/01/18	Fri 19/01/18
Cryomodule RTI in BA6	0 days	Fri 19/01/18	Fri 19/01/18
CM installation in SPS tunnel	26 days	Fri 19/01/18	Fri 23/02/18
EYETS 2016/17	83 days	Mon 12/12/16	Wed 19/04/17
YETS 17/18	40 days	Mon 18/12/17	Fri 23/02/18
Christmas 2016	11 edays	Mon 26/12/16	Fri 06/01/17
Christmas 2017	13 edays	Mon 25/12/17	Sun 07/01/18
CRG shutdown	46.38 edays	Tue 15/08/17	Sat 30/09/17
CRG Christmas stop (No He available)	28 edays	Mon 18/12/17	Mon 15/01/18
AUG test in SM18	1 day	Thu 11/01/18	Thu 11/01/18



[1] Jacketing & Co (BCP, Thermal Treatment, jacketing, conditioning & cold testing)

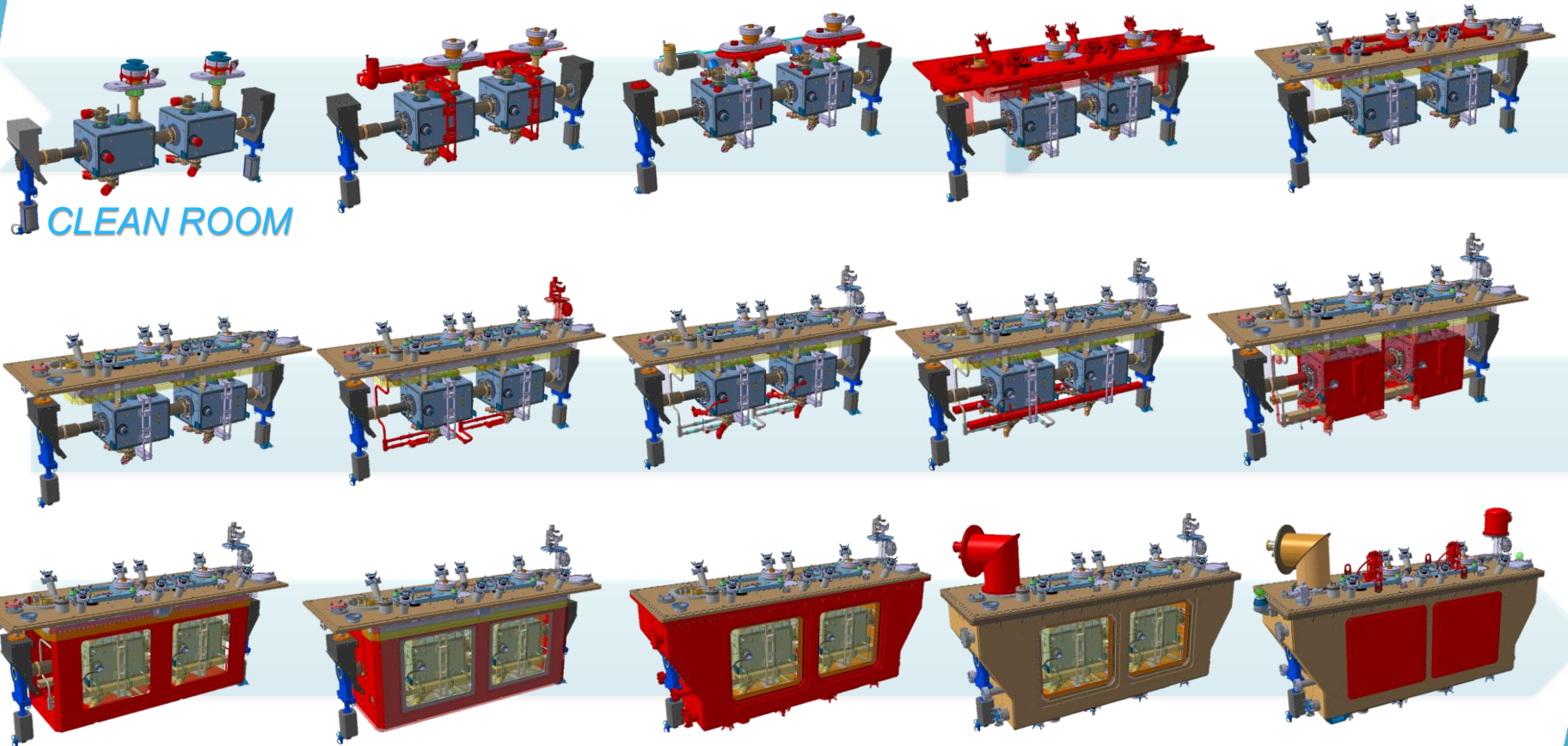
[2] Dressing + String Assembly

[3] Cryomodule Assembly

[4] Cold Testing, Logistics, Installation in SPS

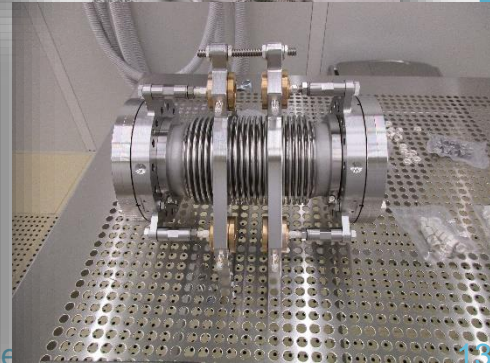
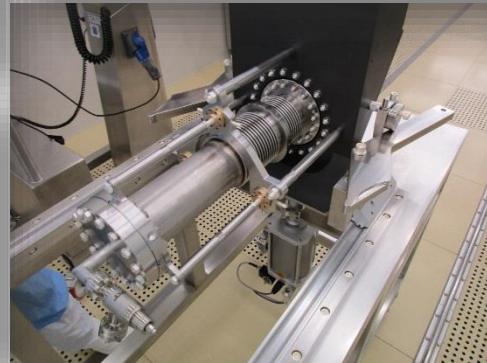
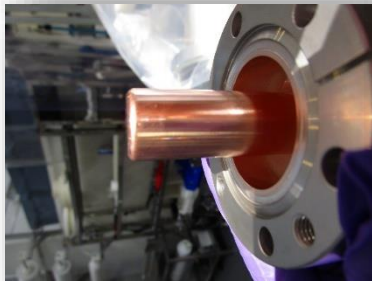
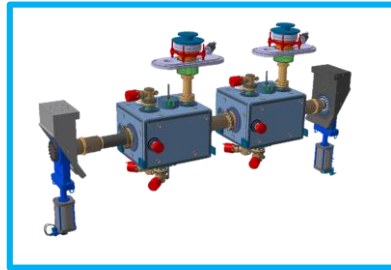
Cryomodule Assembly Sequence

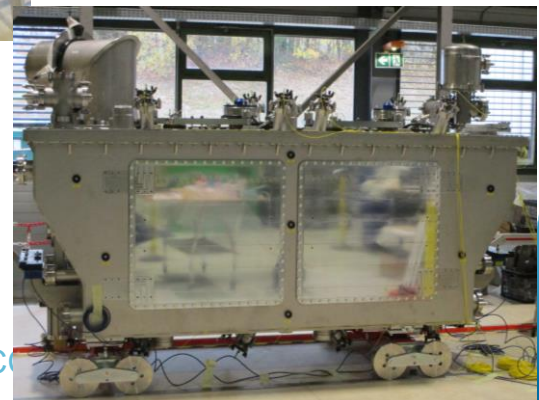
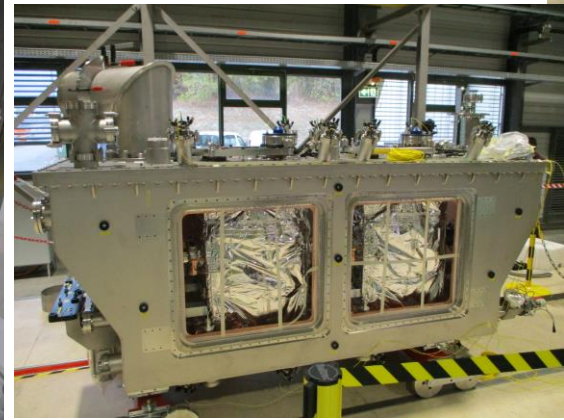
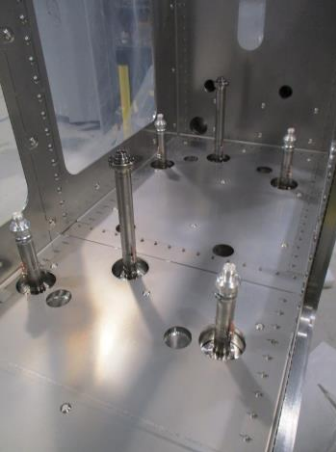
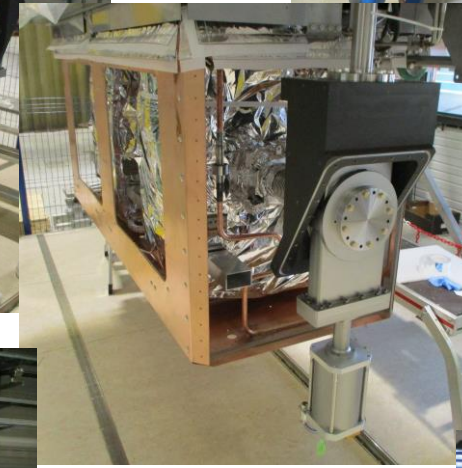
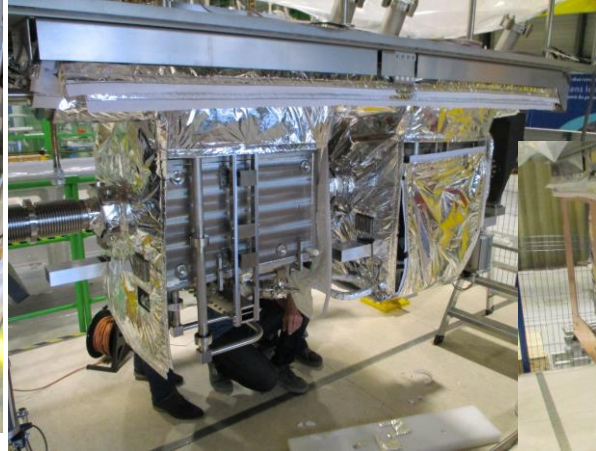
Macro assembly steps from JC, to string line, to cryomodule
Same philosophy for LHC Cryomodule



Complete Assembly and checks performed in 6x + 11x Weeks

String Assembly





Cryo Assembly: Manpower & Coordination



Daily Coordination:

- Many units working simultaneously. Up to 4x tasks at the same time
- Granular Weekly Planning

Entities involved for assembly:

Surface treatments *

Vacuum *

Cryogenics *

Electrics & electronics *

RF *

Alignment *

Mechanical assembly

Qualified Welders

Clean room

Subcontracting *

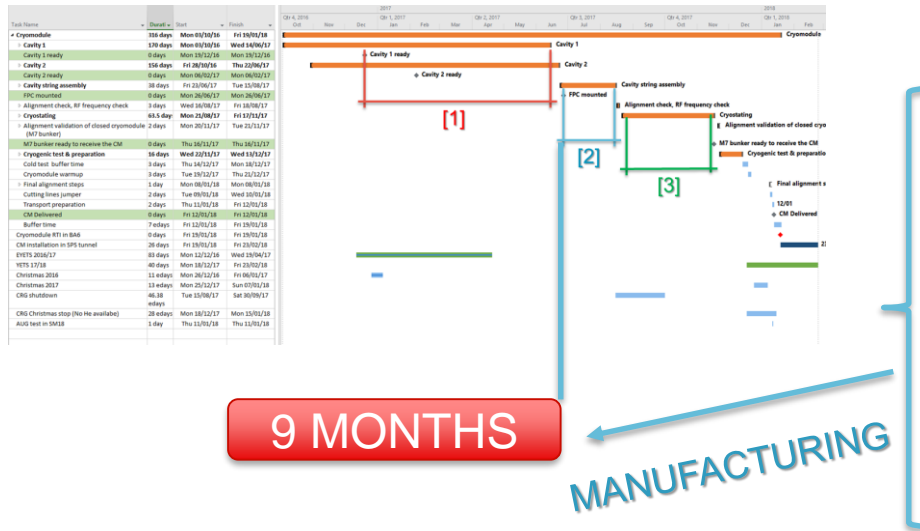
Transport & logistics *

Crash Program

* On call availability

What the Planning Doesn't Show

Cryomodule Assembly Readiness



- Assembly Strategy, Drawings & Procedures
- Conditioning of assembly areas
- Tools
- Thermal Shield
- Magnetic Shield
- MLI
- Cryo. Lines
- Vacuum Vessel
- Tuning system
- Beam Lines
- RF Lines and systems
- Consumables (low μ , surface treatments,..)

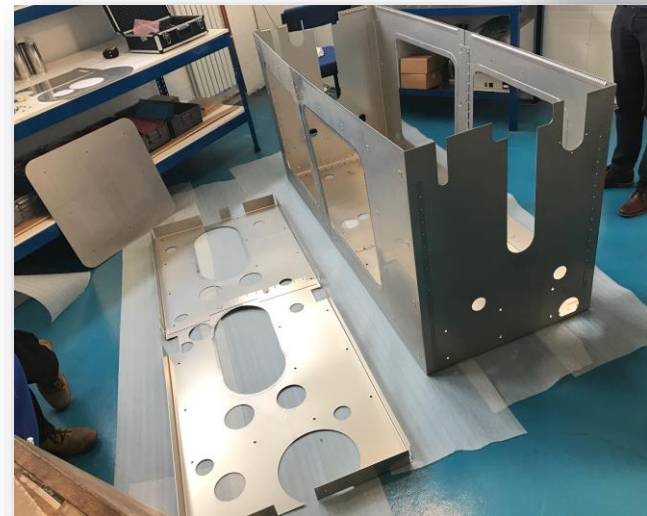
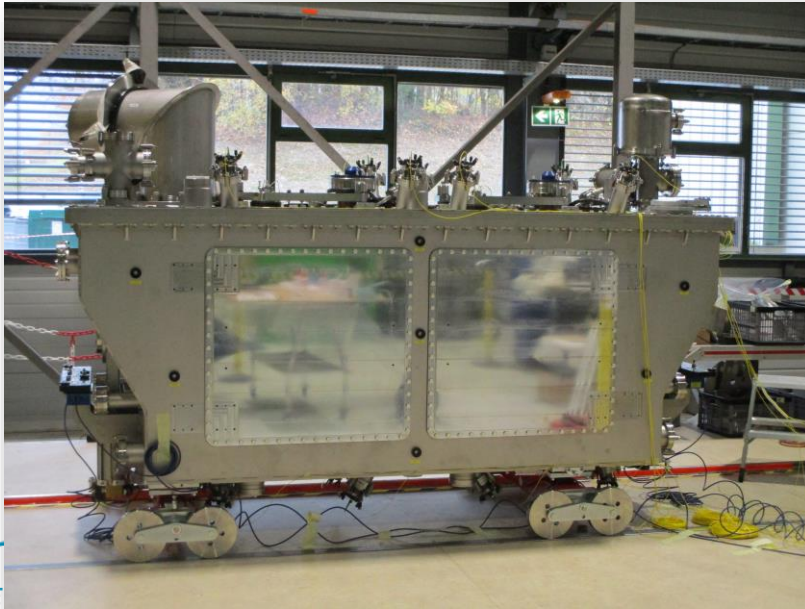
Fabrication Criticalities

- Long Lead Materials & Long Lead components (UHV bellows, non standard consumables)
- Components with few suppliers (μ -shields, Ti-SS Transitions,..)
- Components entailing multi-technological manufacturing + treatments
- Manufacturing in compliance with required traceability and controls

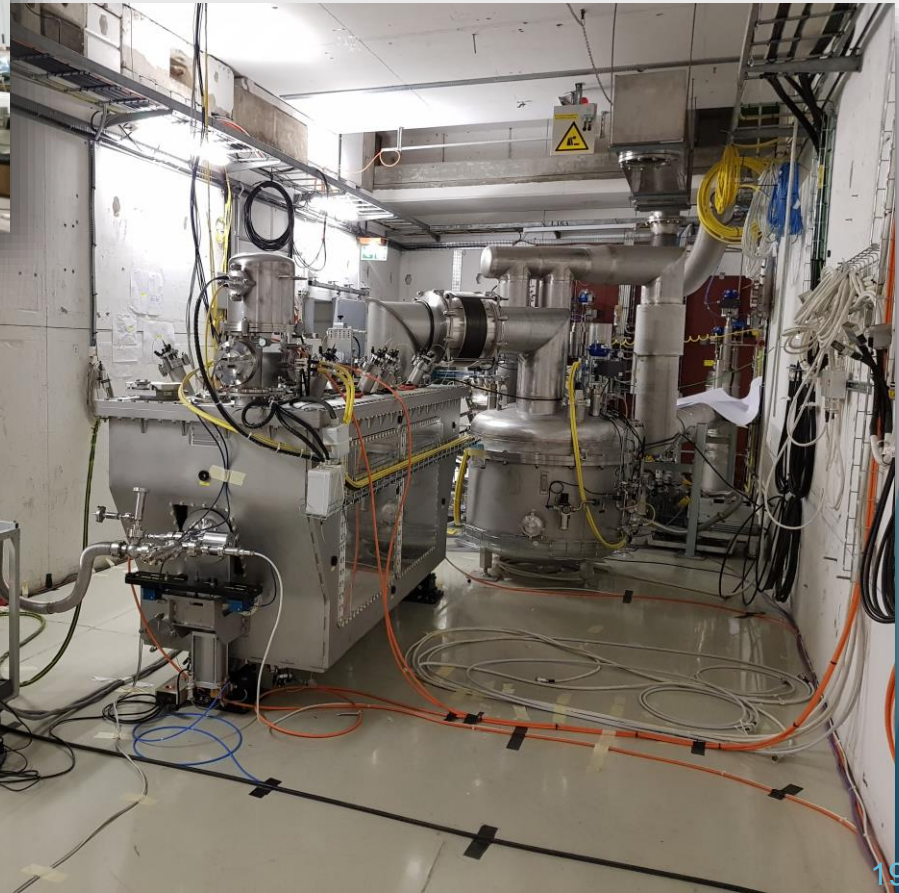
Components



Components



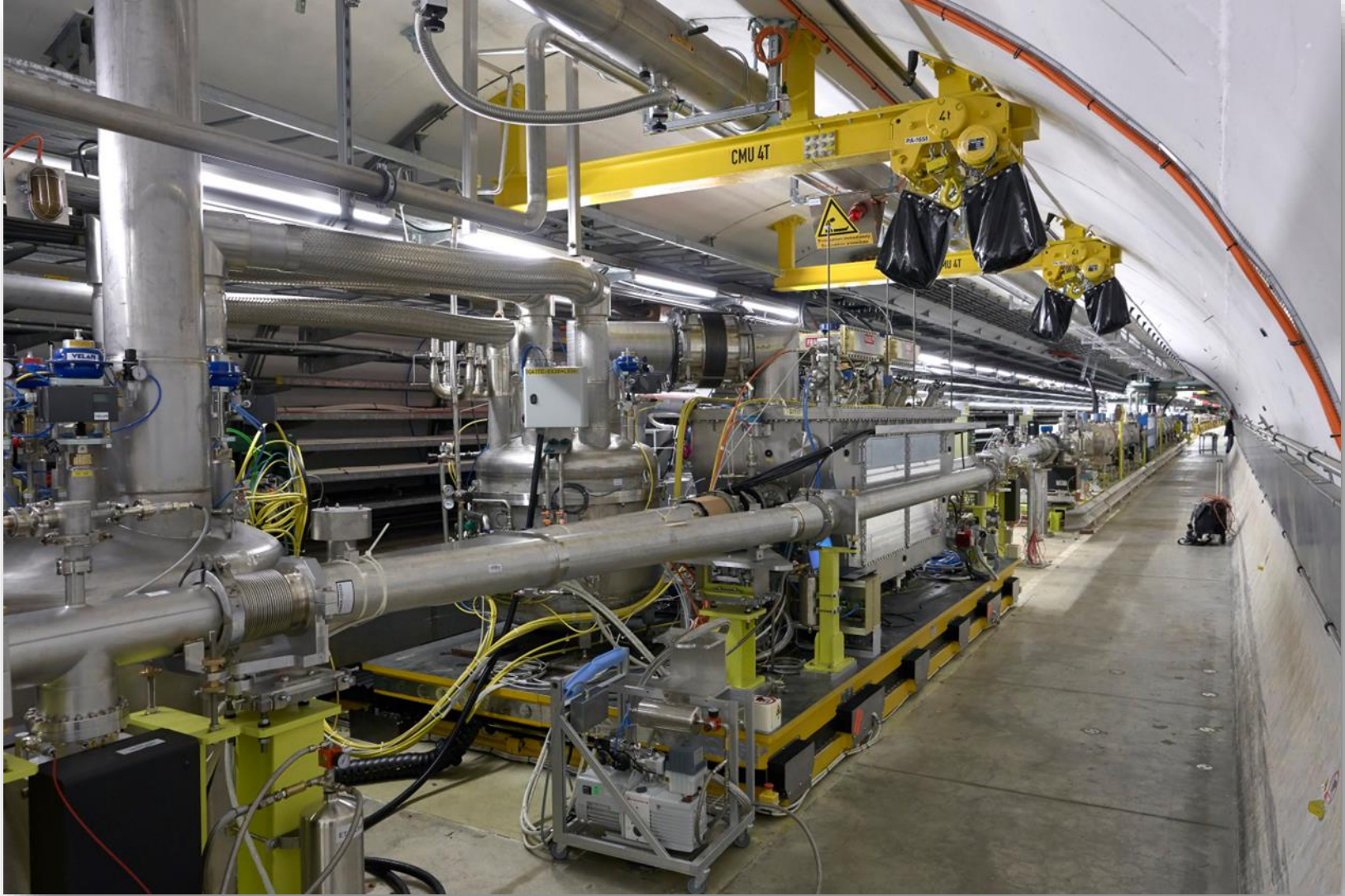
DQW for SPS Test : CM cold tests in SM18 bunker



DQW for SPS Test: Installation in SPS



DQW for SPS Test: Installation in SPS



Conclusions

SPS-Test DQW Crash program successful!

- Tight **schedule respected**
- **Cryomodule works as expected**

Crash = High resource consumption

- Concurrent Design & Fabrication
- On-call resources
- Numerous resources. Fabrication + Assembly team: see image..

Fundamental WP4 Collaboration community missing from pic !



Many **lessons learnt and implemented** on...

...LHC cryomodule design, on feedback to collaboration and suppliers, ongoing CERN fabrication activities



Thank you!

