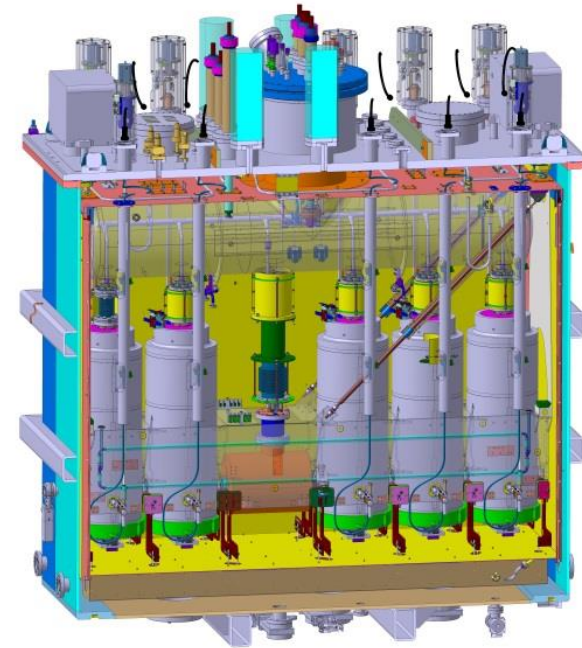


# Status of the assembly of the HIE-Isolde highB Cryomodule

Cathi Final review meeting : 23 Sept. 2014

- **Y.Leclercq, on behalf of the Cryomodule design, procurement, preparation and assembly teams.**

- M.Therasse, W.Venturini, JA. Bousquet, G.Barlow, JB. Deschamps, L.Fabre, F.Vial, Ph.Canard, S.Caille, F.Oddoz. M.Bouhammou, L. Williams, A.Chrul, G.Vandoni, P.Demarest, A.Harrison, JC. Gayde, M.Struik, JA. Ferreira Somoza, P.Zang, D.Smekens, D.Ramos, J.Dequaire, P.Minginette, M.Gourragne, G.Kautzmann, JC. Gayde, N. Delruelle, R.Ferriere, L. Valdarno, V.Parma, L.Mora

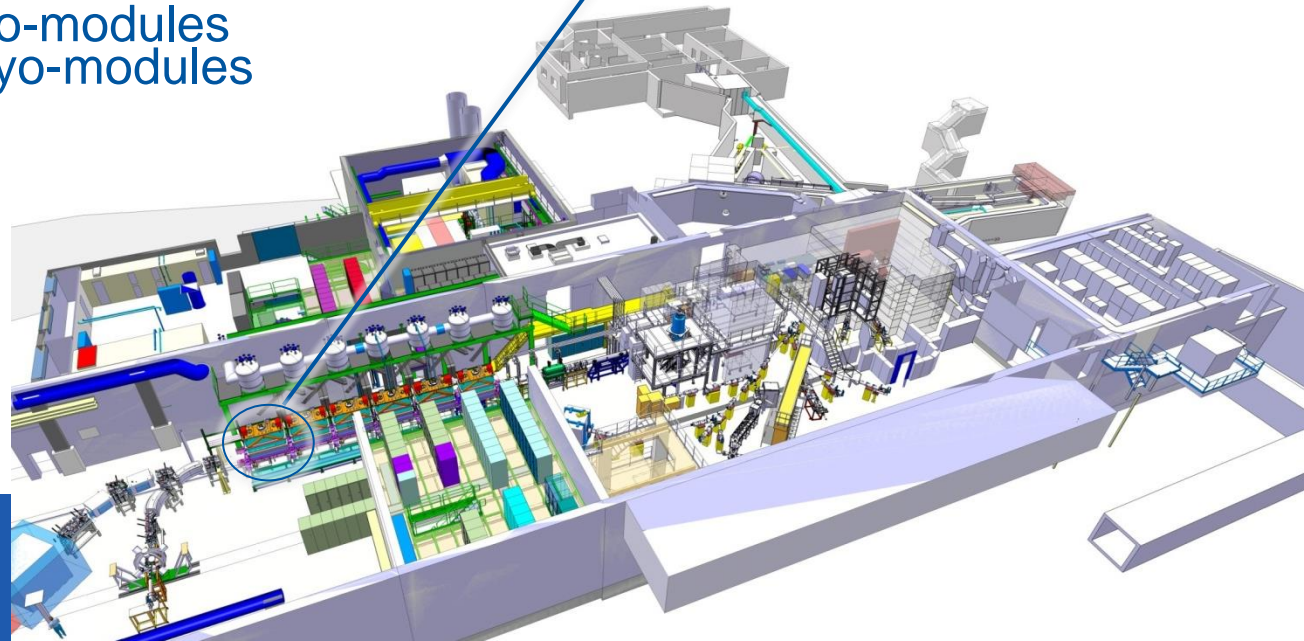
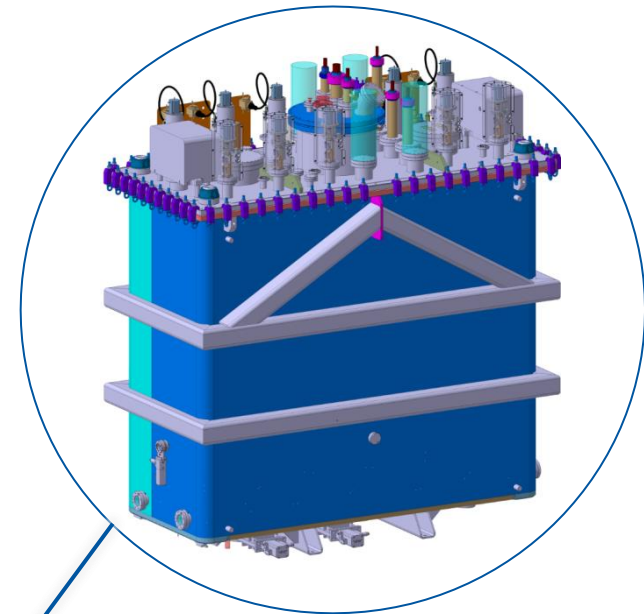


# Outline

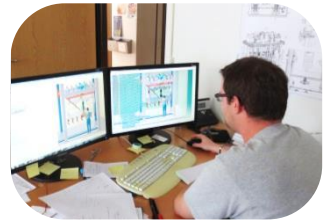
- Context
- Design
- Procurement status
- Assembly organization
- Road map and assembly status

# The HIE-Isolde project

- Upgrade of the REX-Isolde facility
- Linac
  - Phase1 :
    - 2 highB cryo-modules
  - Phase2 :
    - 4 highB cryo-modules
  - Phase3 :
    - 4 highB cryo-modules + 2 lowB cryo-modules



# Cryomodule path to installation



Design  
Specifications  
Detailed design  
Drawing



Procurement

Tech. Spec.  
Follow-up  
Acceptance tests



Parts  
preparation



Reception  
X-ray, leak-tests...  
Blank assembly  
Sorts to procedures  
UHV cleaning



Assembly

Procedures  
Dust cleaning  
Assembly

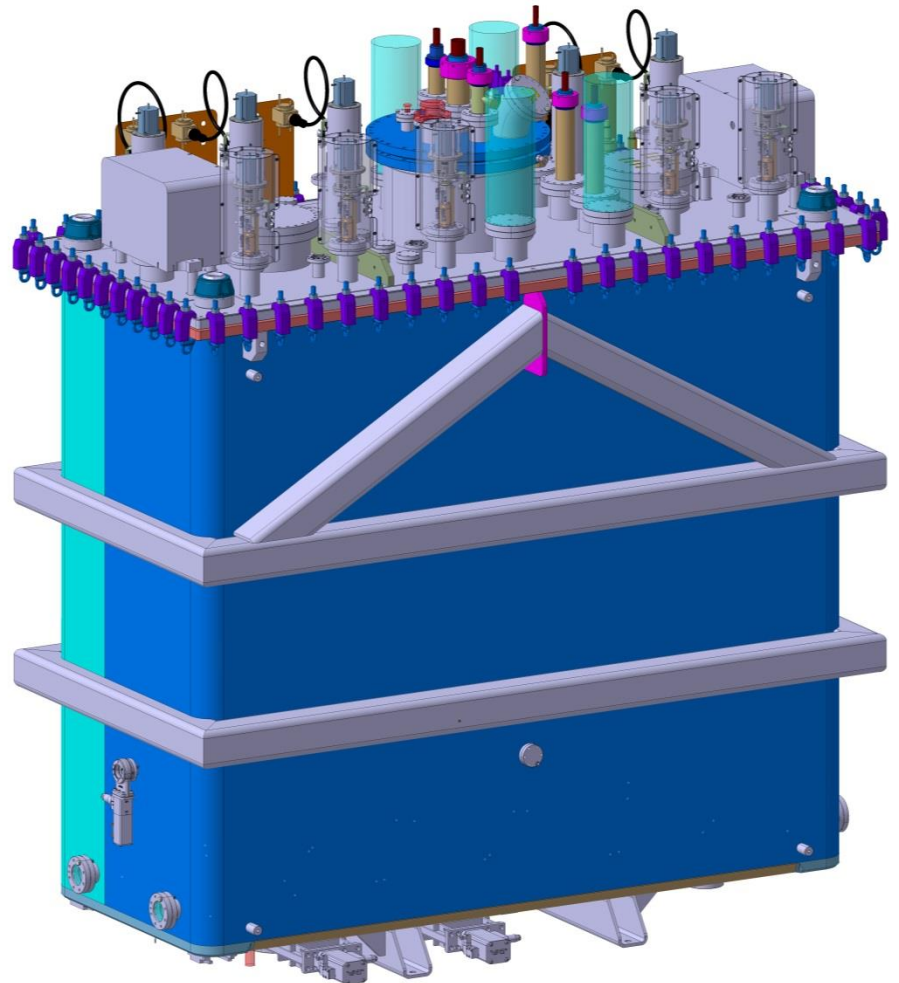


For final testing

Quality Assurance  
Trained resources  
Specific tooling  
Infrastructure  
Logistic

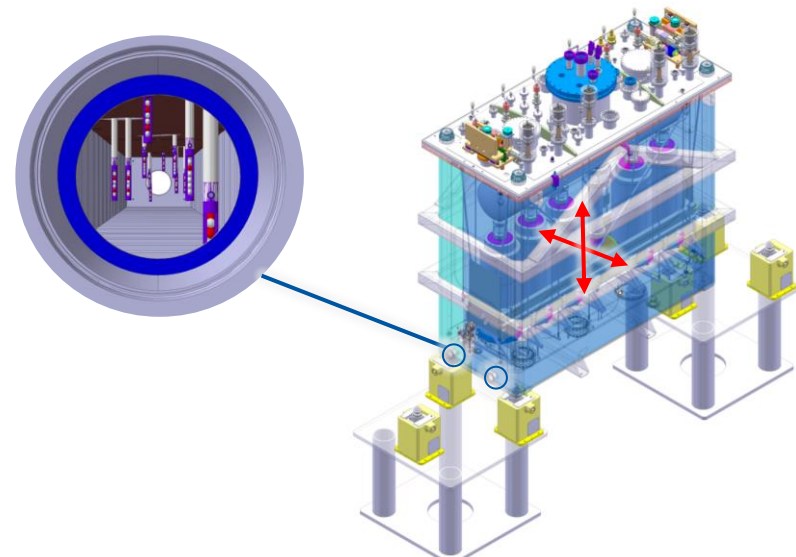
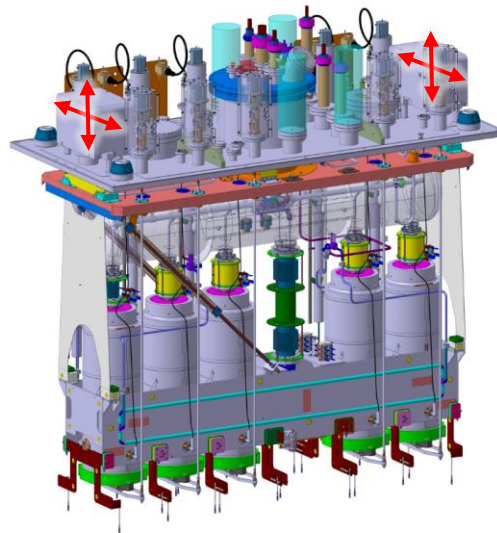
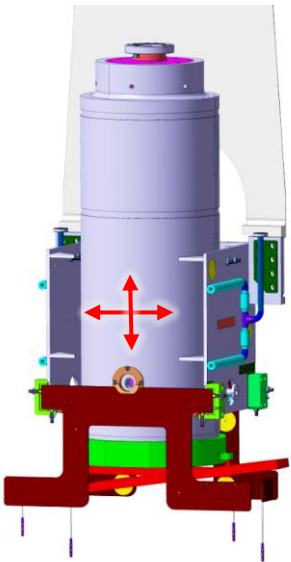
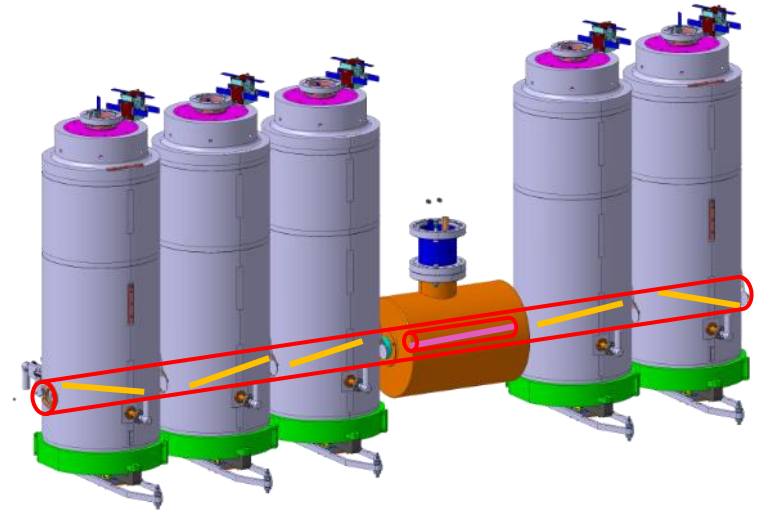
# Design : Cryomodule

- 5 QWR cavities (BE/RF)
  - Tuners, couplers, instrumentation
- 1 solenoid (TE/MS)
  - 116A –  $13.5T^2.m$  – NbTi
  - Immersed in 4.5K LHe 1.5 bara
  - Vapor-cooled current leads
  - Resistive splice
- Supporting frame assembly
  - Actively cooled at 4.5K
  - 316L structure
  - Live monitoring of positions
- Helium reservoir, circuits and interfaces
  - 150l of LHe, 1.5 bara nominal, 4.5K
  - Instrumentation
- Top plate and services
  - Services : 53 ports
  - Seal interface
- Thermal shield
  - Actively cooled to 55-75K Ghe, 13 bara
  - Nickel plated copper
- Vacuum vessel
  - 15mm thick 316L plates
  - Vacuum interfaces
  - 10-8 mbar.l.s-1



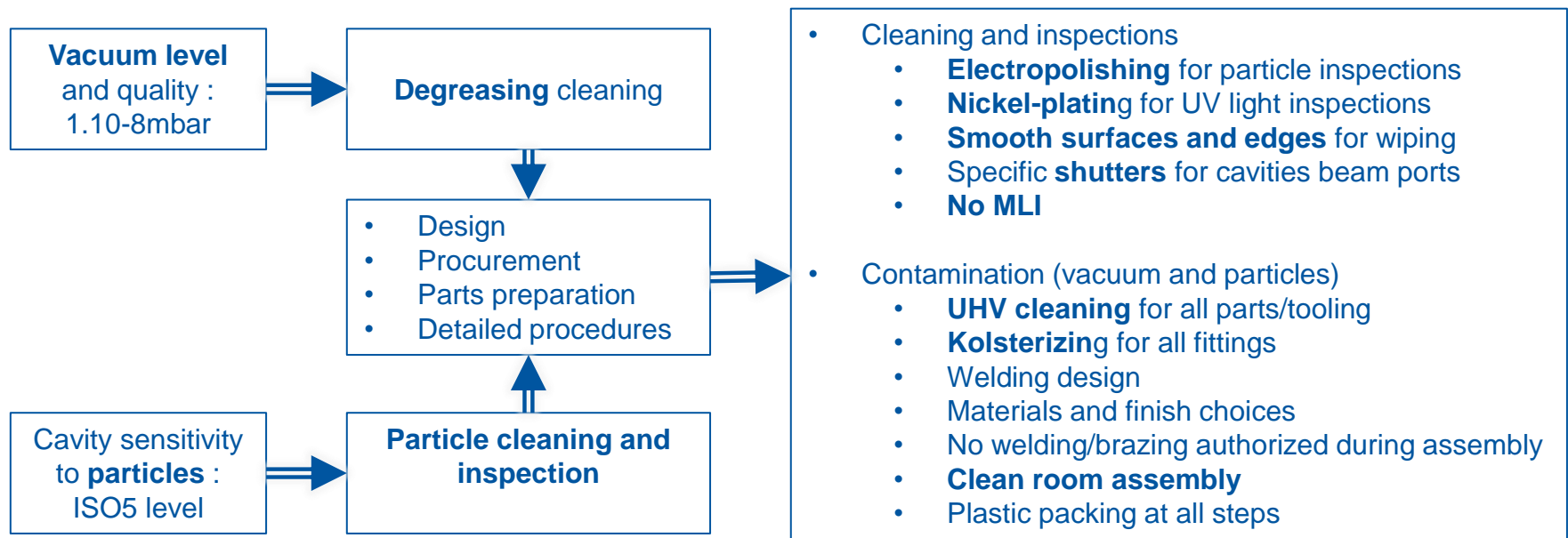
# Design: alignment

- Mechanical Co-axiality with beam axes
  - Cavities beam axis in  $\varnothing$  0.6 mm
  - Solenoid beam axis in  $\varnothing$  0.3 mm
- Technical solution
  - Multi level adjustment systems
    - Individual, frame, cryomodule, solenoid (option for CM1)
  - Live monitoring of components position



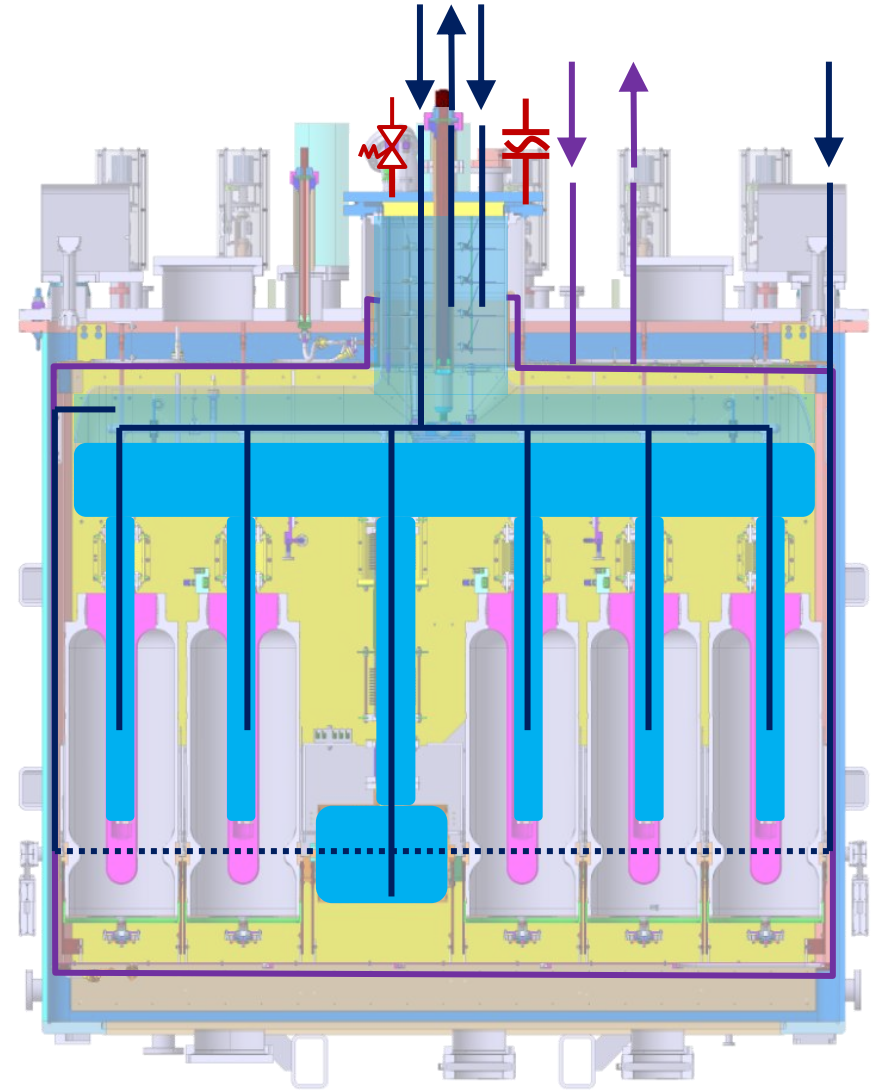
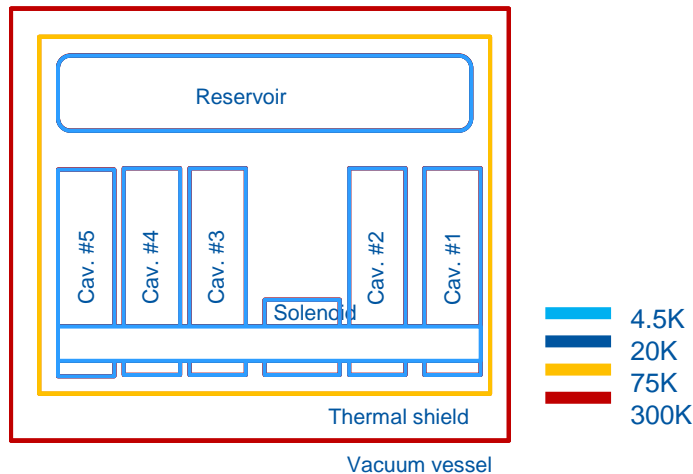
# Design: Vacuum and cleanliness

- Space constraints
  - → Common insulation and beam vacuum at 10<sup>-8</sup> mbar
  - → UHV cleanliness standards



# Design: cryogenics

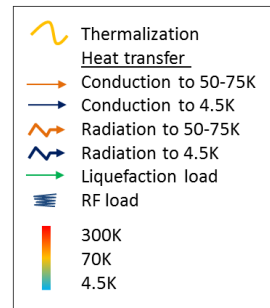
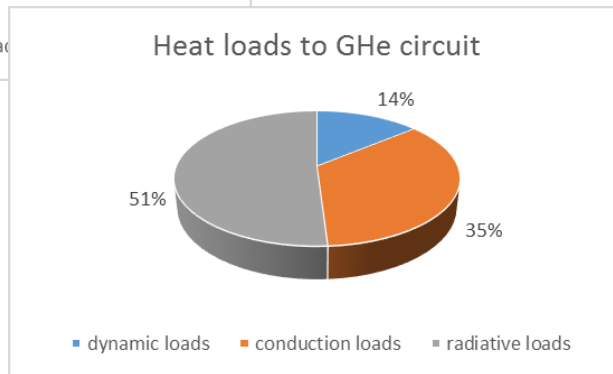
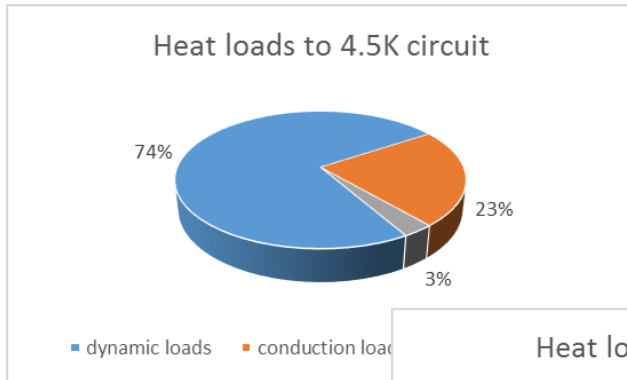
- Cryogenic circuits
  - GHe 55-75K Circuit :
    - 13 bara nominal
  - LHe – Ghe 4.5K
    - 1.3 bara nominal, 150 l of liquid Helium
    - Protected for mass flow up to 4.9 kg/s
- Cool-down procedure
  - Thermal shield cooled first for cryopumping.
  - Cavities cooled at last



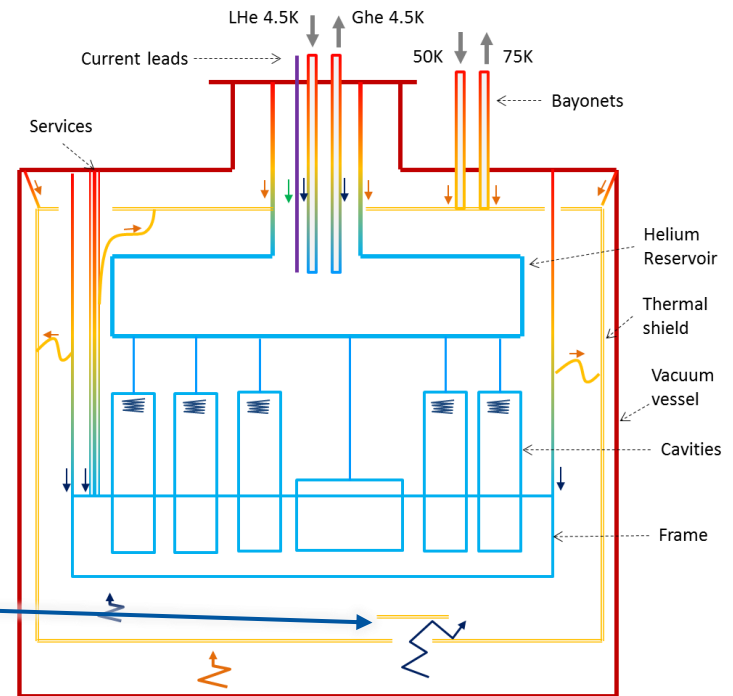


# Design: cryogenics

- Heat loads and thermal paths
- Figures
- Contributions



High emissivity for heat absorbers

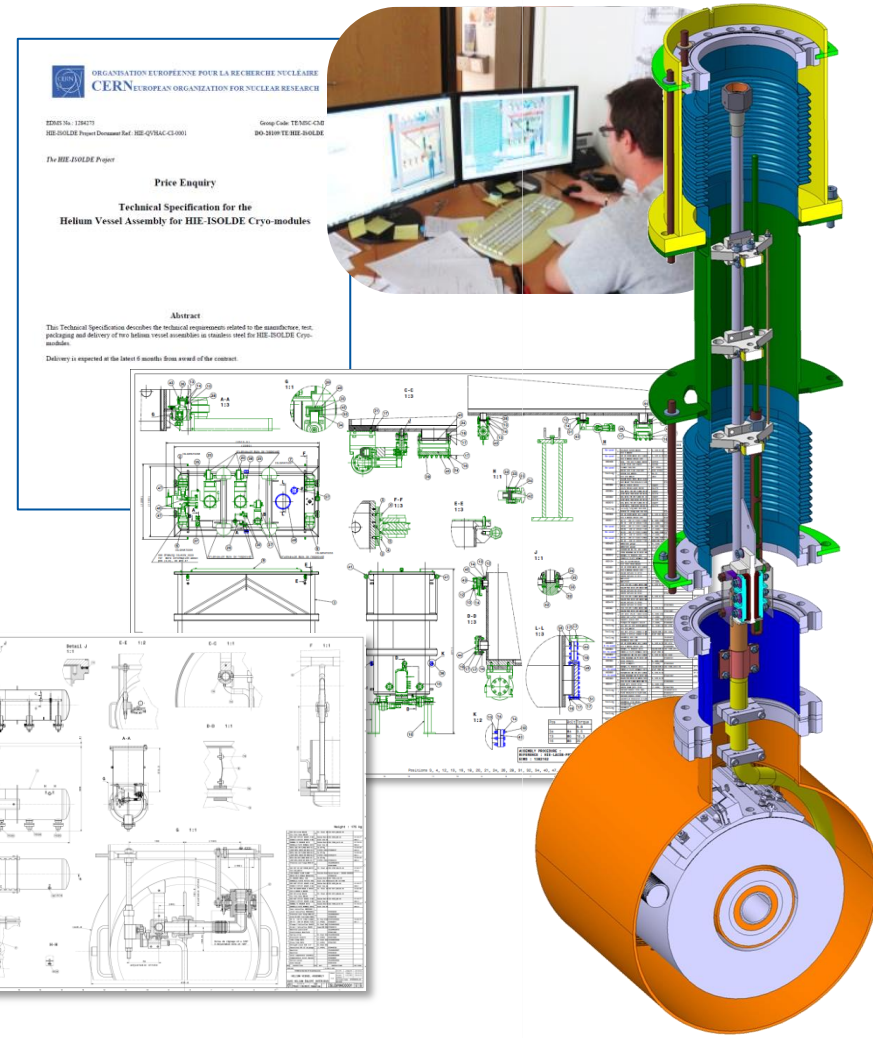


	Min [W]	Max [W]
To GHE circuit 50-75K	367	555
To LHE circuit 4.5K + liquefaction load 0.03 g/s	70	83

Estimations of the dynamic heat loads

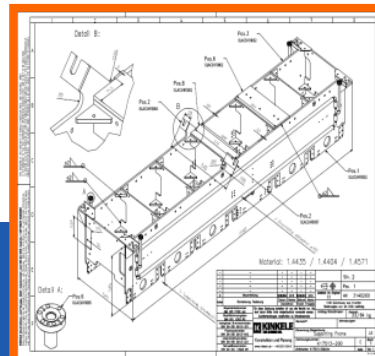
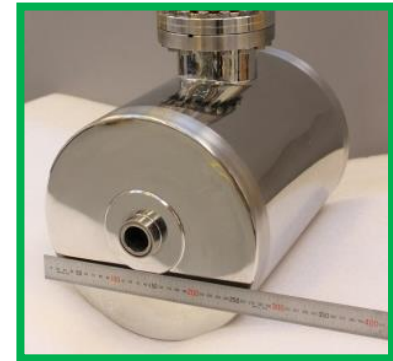
# Design: summary

- Status:
  - Detailed design : **Complete**
  - Technical specifications : **Complete**
  - Procurement drawings : **Complete**
    - Cryomodule : >450 drawings
    - Tooling : >400 drawings
  - Assembly drawings : **in progress**



# Procurement

- Figures:
  - >10 000 parts
  - > 500 references
- Main components status
  - Cavities (see dedicated pres.)
  - Solenoid
  - Vacuum vessel
  - Helium vessel : by w41
  - Thermal shield : by w40
  - Frame : by w42
  - Clean rooms
  - Specific main tooling
- Procurement in line with assembly needs



# Procurement :

- And many others...



Upper suspension



Frame fixing plates



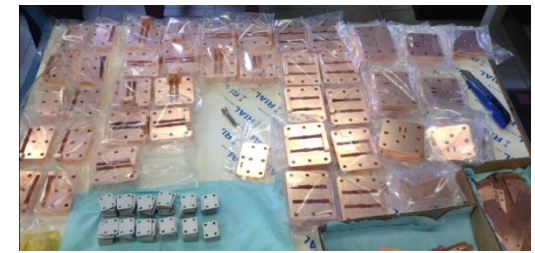
Mechanical adjusters



Valves



Cavity shutters



$\Omega$  plates supports and thermalization



LHe level gauges



Instr. connectors



Hydroformed bellows



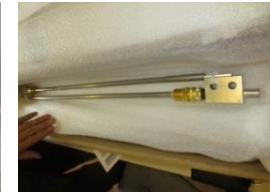
$\Omega$  plates



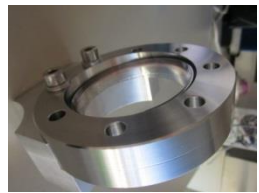
Chimney



Stratification screens



Current leads



Viewports



Target thermalization



Bayonets fittings



Cavity supports



Supporting jacks



Spread loaders



Cryogenic piping

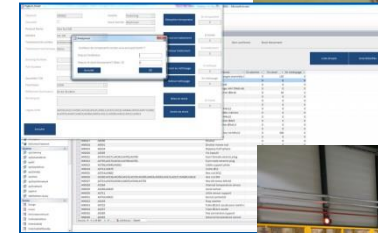
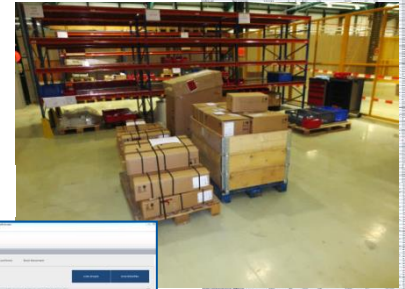
# Parts preparation

- Key to successful assembly
- Infrastructure available
- Team in place
- Still optimizing the organization

Preparation area



Part reception



Part identification  
Part inspection



General checks and blank assy

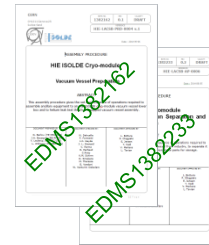
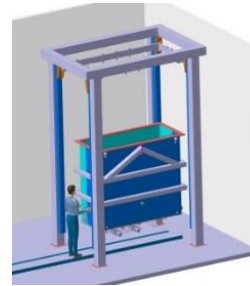
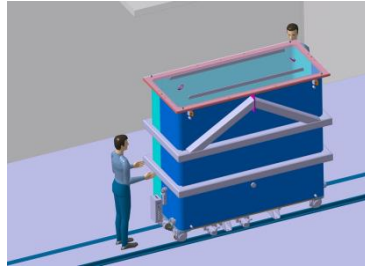
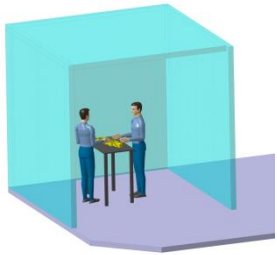


Storage after  
UHV cleaning

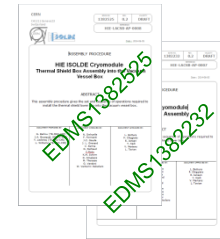
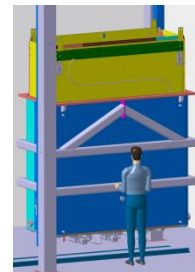
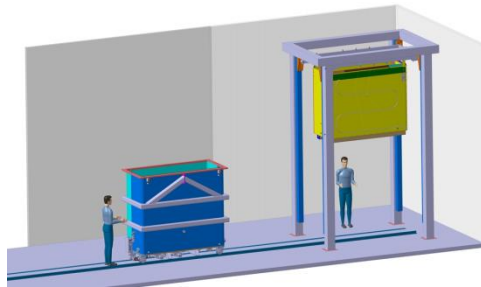
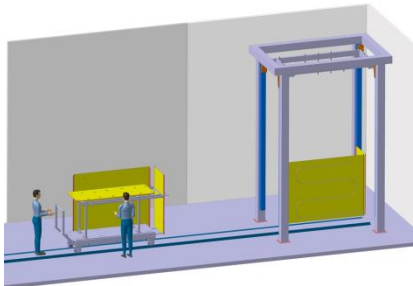


Parts list for cryomodule  
procurement and preparation

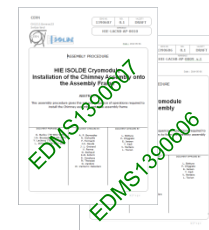
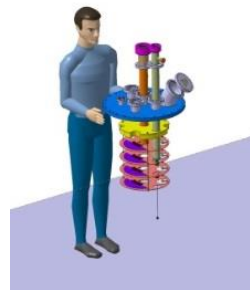
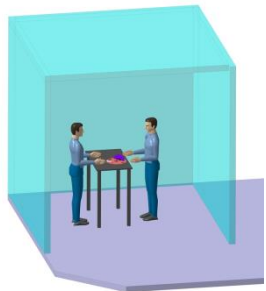
# Assembly : procedure



## 1. Vacuum vessel assembly

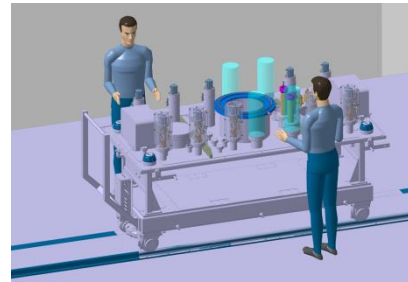
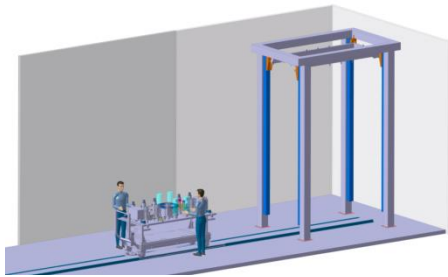


## 2. Thermal shield and vacuum assembly

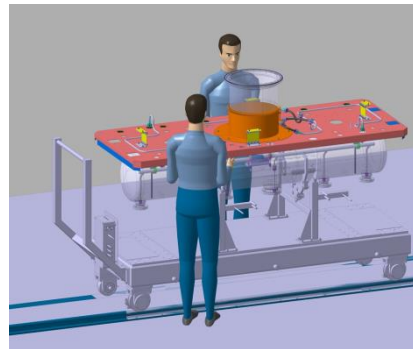
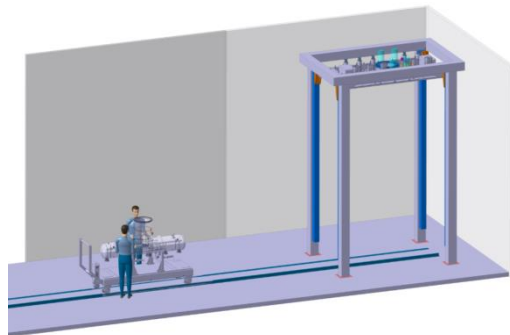


## 3. Chimney Assembly

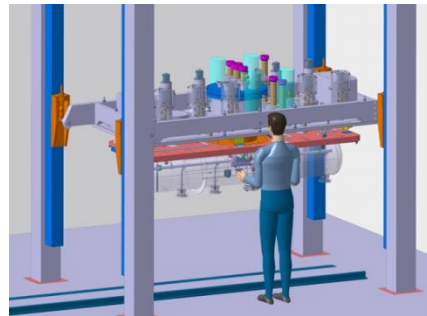
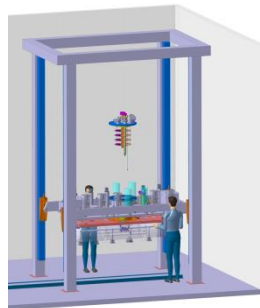
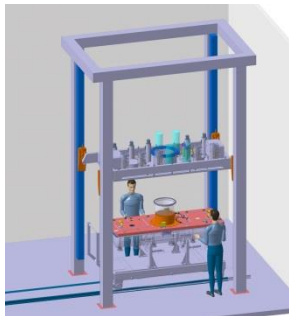
# Assembly procedure : main steps



4. Top plate assembly



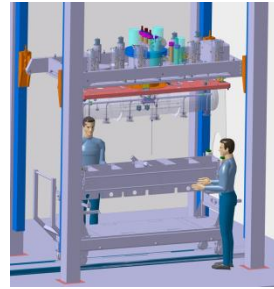
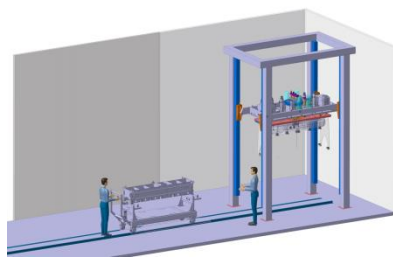
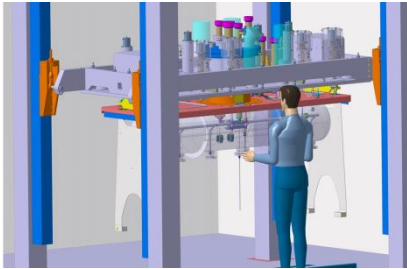
5. Upper thermal shield and helium tank



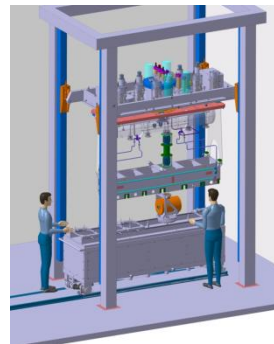
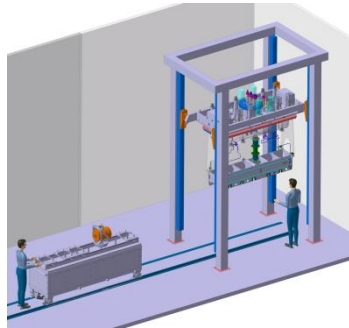
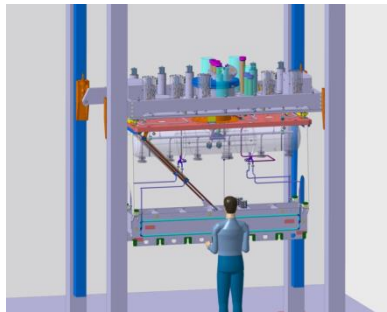
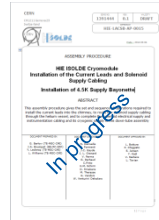
6. Helium tank, top plate and chimney assembly



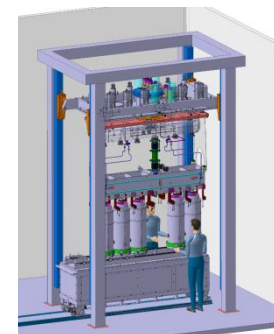
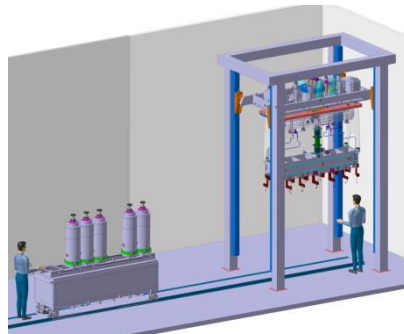
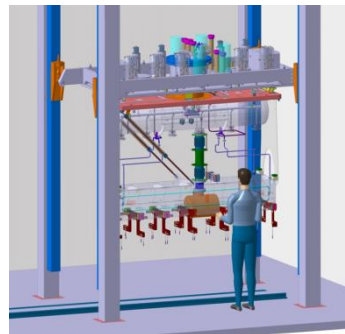
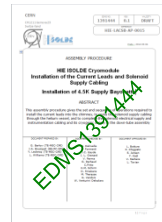
# Assembly procedure : main steps



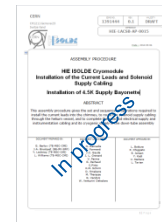
7. Installation of the support frame



8. Installation of the solenoid

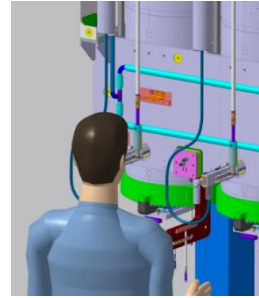
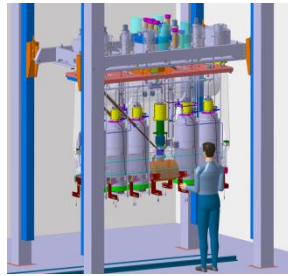
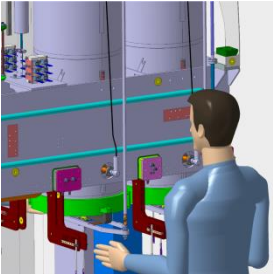


9. Installation of cavities





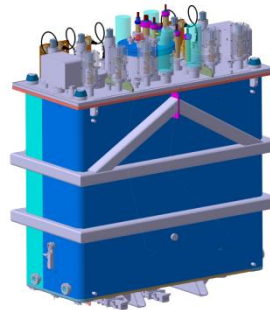
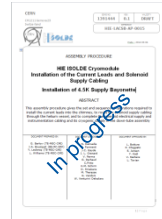
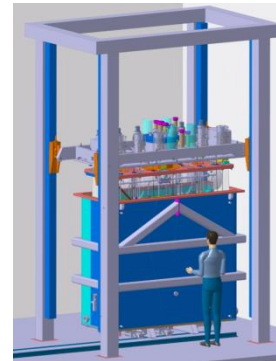
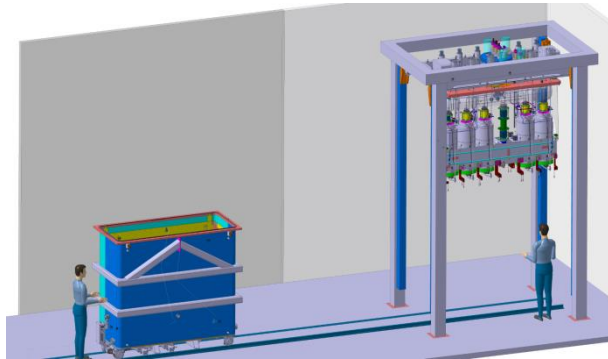
# Assembly procedure : main steps



10. Installation of cavities aux.



11. Cryomodule vessel closure

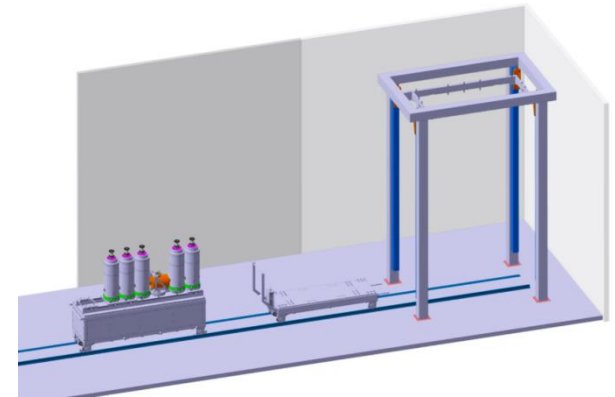


12. Final assembly qualification before delivery to RF testing



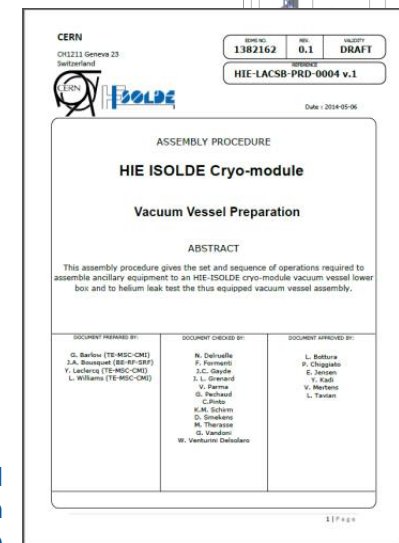
# Assembly area

- 3 clean rooms areas available
  - “Baldaquin”: Class ISO5
  - “Main clean room” : Class ISO7 and ISO5
- Equipped with specific tooling



# Assembly work

- **Support team**
  - Procedures in progress
  - Assembly drawings in progress
- **Clean room team**
  - 2+1 per clean room
  - Acquiring experience



Vacuum vessel preparation procedure

Chimney assembly in the baldachin



# CM1 Assembly Roadmap

*(in work)*

planned
in progress
Achieved

#	Assembly steps (including QA)	Sep-14			Oct-14				Nov-14				Dec-14				Jan-15				Feb-15					
		wk36	wk37	wk38	wk39	wk40	wk41	wk42	wk43	wk44	wk45	wk46	wk47	wk48	wk49	wk50	wk51	wk52	wk1	wk2	wk3	wk4	wk5	wk6	wk7	wk8
1	Vacuum vessel assembly																									
2	Thermal shield and vacuum vessel assembly																									
3	Chimney assembly																									
4	Top plate assembly																									
5	Upper thermal shield and helium tank																									
6	Insertion of chimney																									
7	Install. of the support frame																									
8	Install. of the solenoid																									
9	Install. of the cavities																									
10	Install. of the cavities's aux.(tuner, coupler, RF cables)																									
11	Cryo-module vessel closure																									
12	Final assembly qualification testing																									

- Late start of assembly
- 20w : need close steering
- Work started in August, so far on schedule.

Today

Baseline end of assembly  
Provisional end of assembly



Completion of Chimney assembly



Start of Vacuum vessel assembly

# Summary

- Design
  - Design complete, Assembly drawings synchronized with assembly procedures
  - Now support to components production and CM assembly
- Procurement (components and tooling)
  - 10 000 items delivered or being procured in line with need
  - Most of main components delivered
- Preparation of components before clean room
  - Key to successful assembly (blank assemblies, cleaning...)
  - Components preparation & storage is essential (limit clean-room work, identify NC ahead...)
- Assembly
  - Started in August, still in running-in phase (need to acquire experience)
  - Clean rooms available, new clean room technicians learning the job
- Assembly roadmap
  - Objective is assembly of CM1 in 20 weeks (challenging)
  - Strong organization and partnership in place at CERN: responding well
  - Experience in the coming weeks will provide us confidence

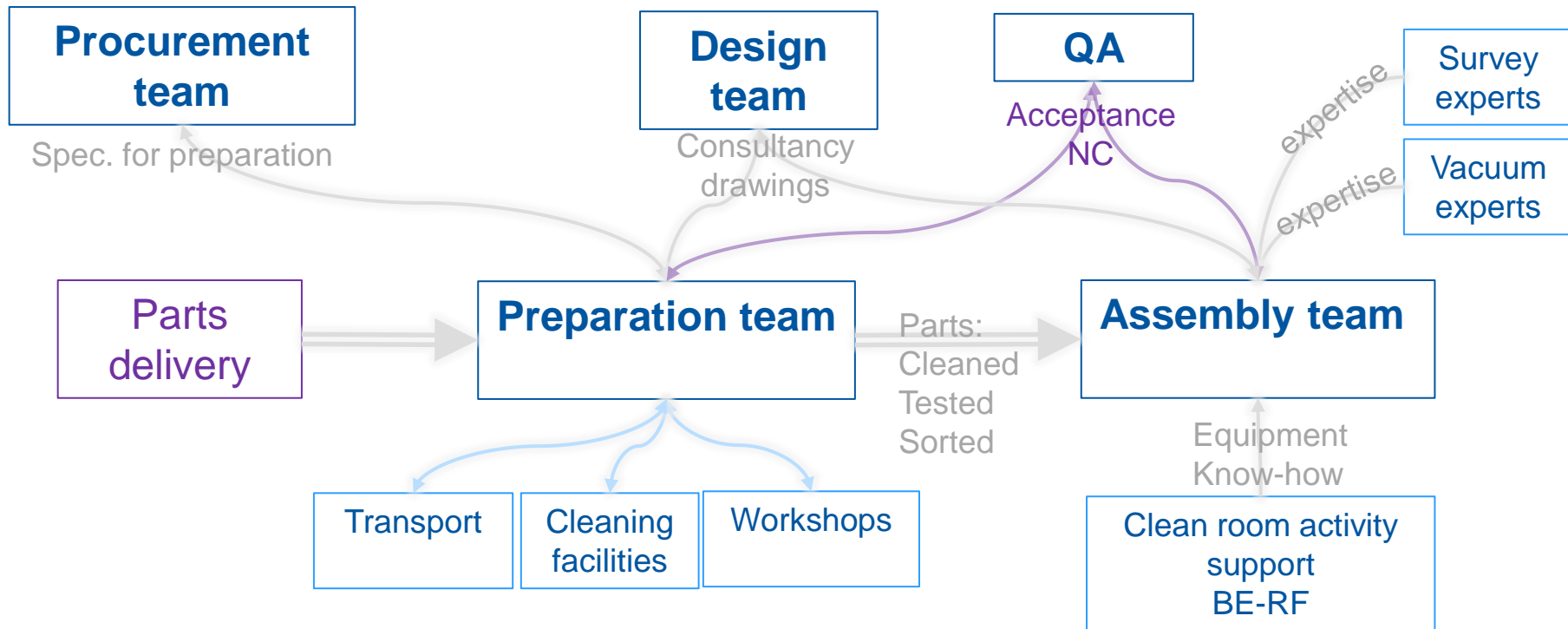
# Questions



# Spare slides

# Assembly coordination

- Two main poles : Preparation area / Assembly area





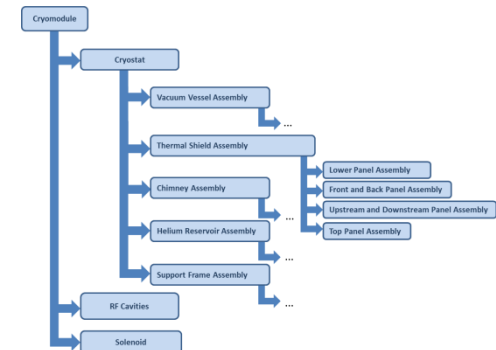
# Quality assurance

- Procurement
  - Follow-up during manufacturing
  - Wide manufacturing file
    - (welding qualifications, material certificate...)
- Assembly
  - Control sheets during assembly
  - MTF structure (in progress)
    - To the scale of the project
    - NC's attached to MTF steps
- Industrial Travellers being developed

Control sheet for Chimney and vacuum vessel assembly



Instrumentation control during manufacturing



Draft of MTF structure in progress

# Procurement : other tooling

- Main components
  - Vacuum vessel cover
    - Received
  - Chevre
    - Received and HSE approved
  - Leak test tool
    - Manufacturing in progress
    - Delivery by w41
  - Elevator
    - Received



Vacuum vessel cover



Chevre / Chimney-MPT



Leak test tool



Feet



Elevator

# Procurement requirements

- Size dependent:
  - For parts >2m
    - Vacuum
      - Tightness :  $1 \cdot 10^{-9}$  mbar.l.s-1
      - Cleanliness
        - Degreasing : ultrasonic bath
        - Dust cleaning : at Cern
        - Delivery packing : 3 plastic layers
  - For parts <2m
    - Vacuum
      - Leak tightness :  $<1 \cdot 10^{-9}$  mbar.l.s-1
      - Cleanliness
        - Degreasing : at Cern (TE-VSC)
        - Dust cleaning : at Cern
        - Delivery packing : 1 layer
- Delivery exceptions
  - Instrumentation cabling/connectors
    - ISO5 cleanliness level
  - Hydroformed bellows
    - ISO5 cleanliness level

Helium vessel cleaning at manufacturer's premises



Delivery packing for Vacuum vessel



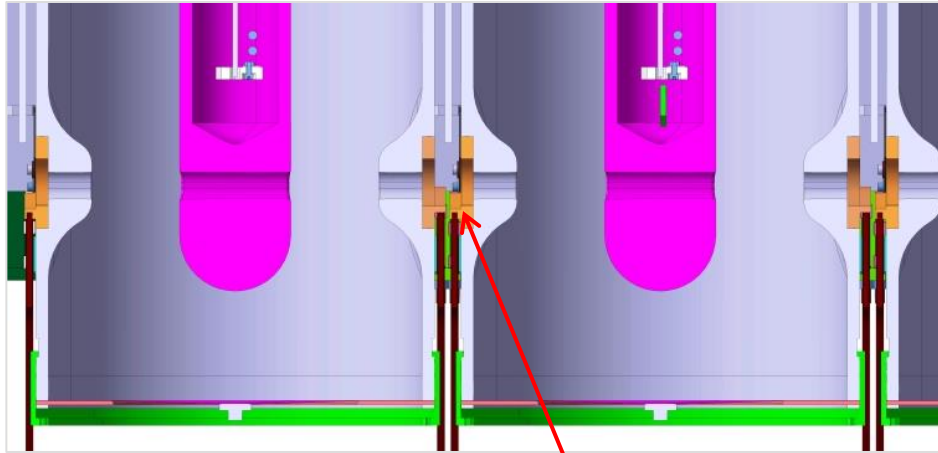
Industrial cleaning for standard parts; <2m



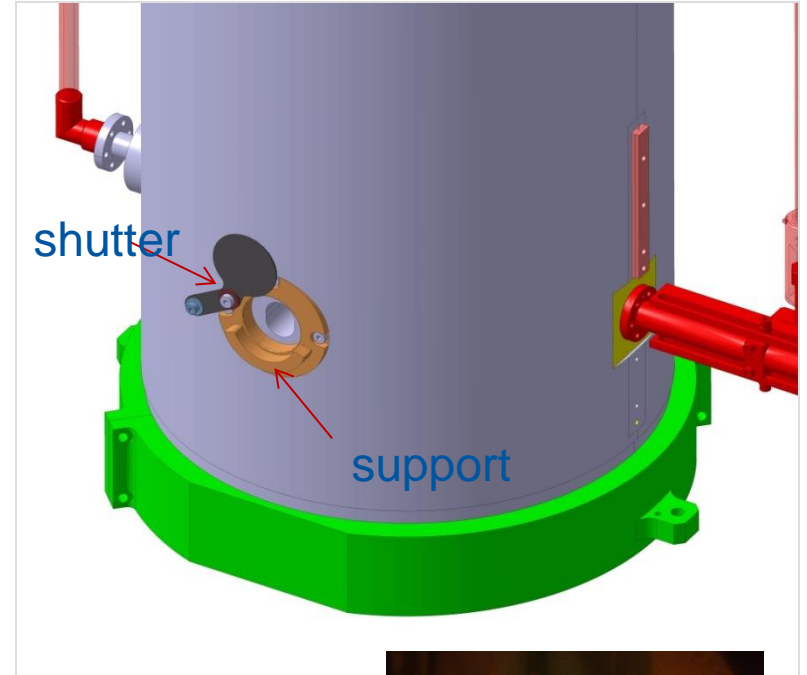
ISO5 cleanliness delivery for specific parts



# Under design: cavity protection shutter

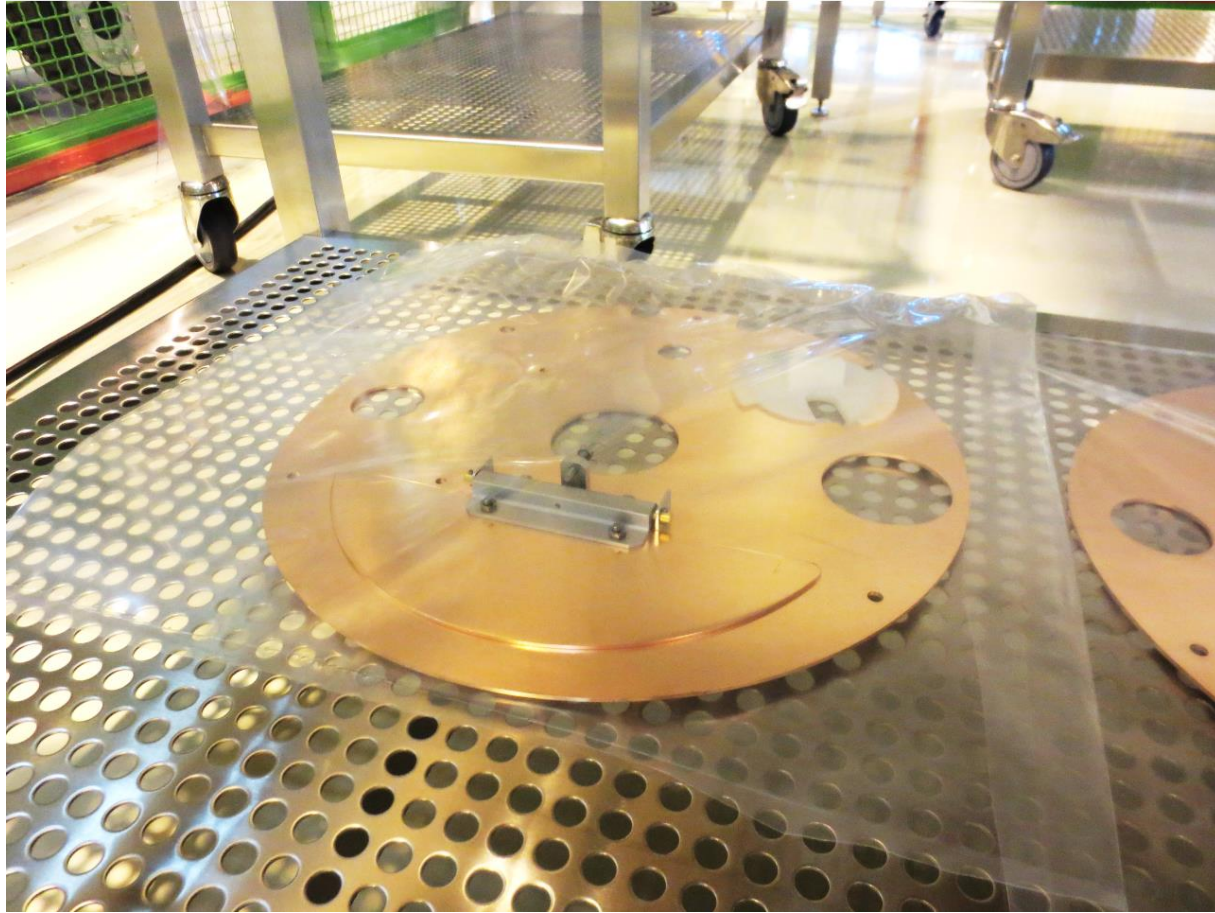


Inter-cavity space



# Storage and preparation area SMA18

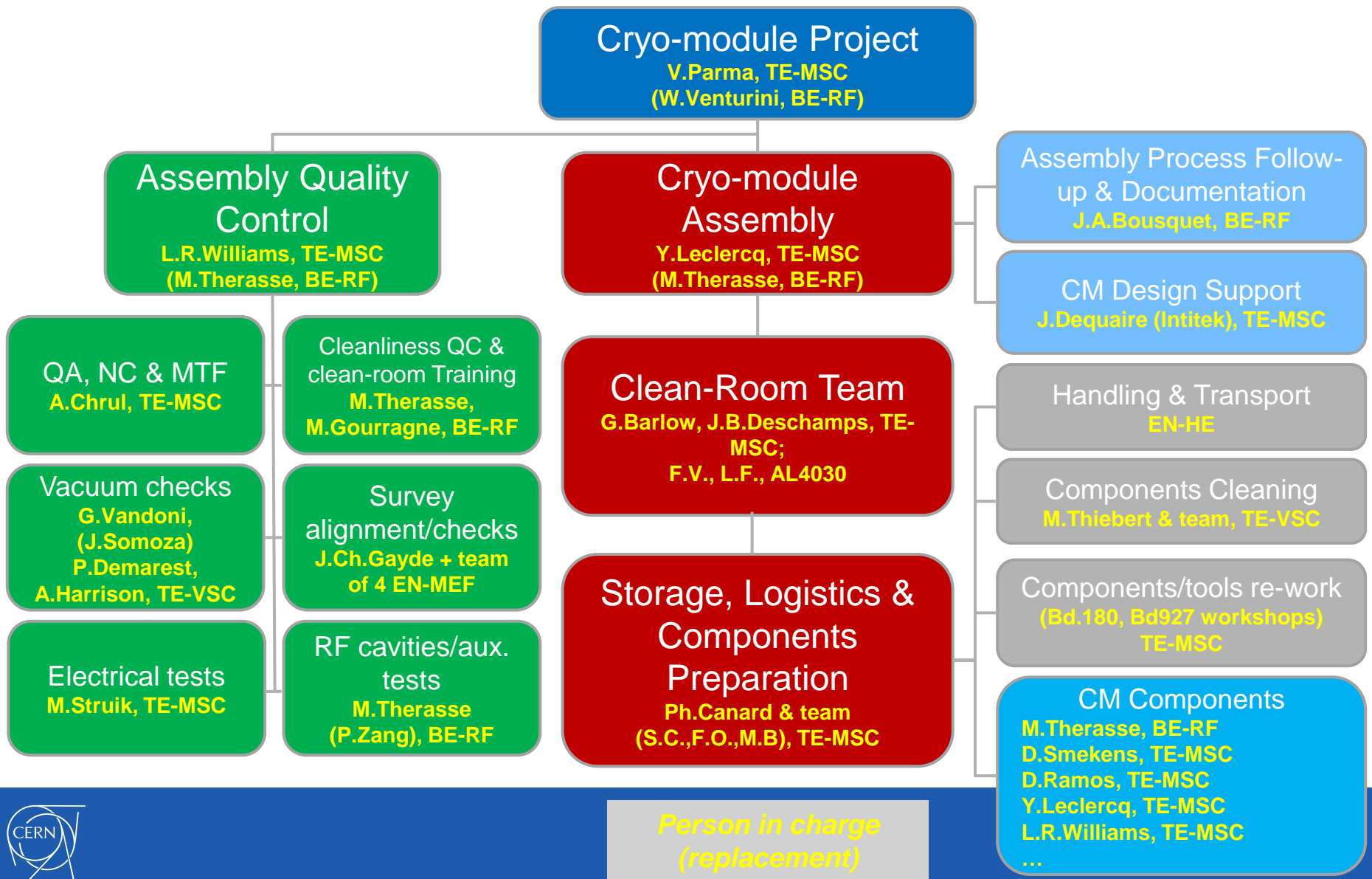




# Procurement status summary

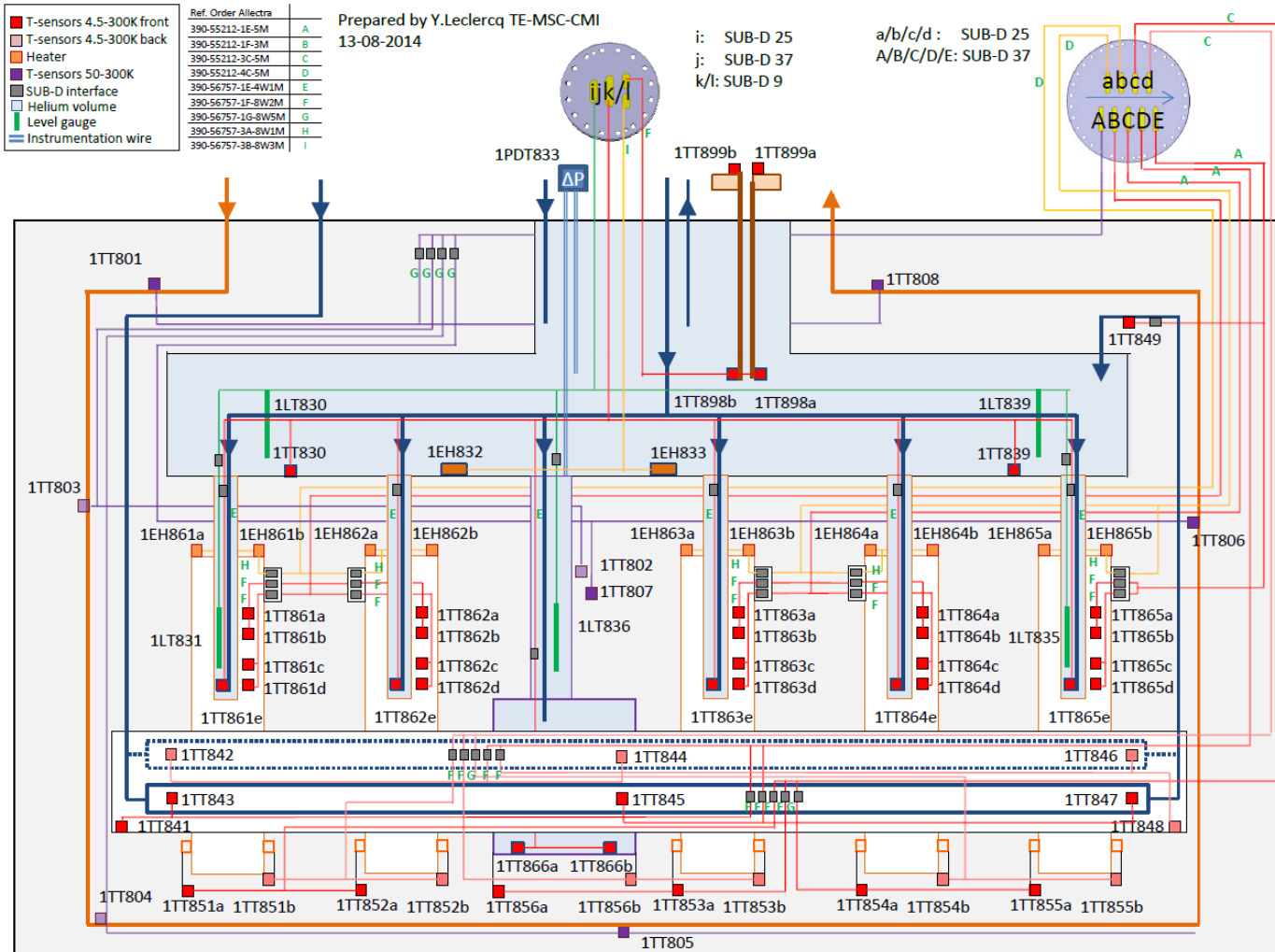
Component	Quantity	Status	Component	Quantity	Status
<b>Cryomodule</b>			<b>Tooling</b>		
Vacuum vessel	For 2CM	1 <sup>st</sup> received	Ω plates thermalization	For 2CM	2CM received
Thermal shield	For 2CM	Manufacturing w40	Solenoid extension	For 2CM	Manufacturing w44
Helium reservoir	For 2CM	Manufacturing w41	Helium fittings	For 2CM	Manufacturing w44
Mech. Adjusters	For 3CM	1CM received	Omega plate supports	For 2CM	2CM received
Suspension system	For 2CM	2CM received	Current leads	For 2CM	2CM received
Load spreaders	For 2CM	2CM received	Jacks	For 6CM	6CM received
Bellows	For 3CM	3CM received			
Thermal shield flexibles	For 3CM	3CM received	Clean room		Cleaning w38
Bayonets (TE-CRG)	For 6CM	6CM received	Baldachin		Available
Chimney	For 2CM	2CM received	Railing system		Available
Frame	For 2CM	Manufacturing w42	Lifting Frame		Cleaning w37
Coupler ancillaries	For 1CM	Manufacturing w40	Cavities/solenoid Trolley		Manufacturing w40
Tuners ancillaries	For 1CM	Manufacturing w40	Multi Purpose Trolley		Received
Cavities	For 1CM	see W.Venturini presentation	Top plate leak test tooling		Manufacturing w41
RF power cables	For 1CM	Manufacturing w43	Plaque test en charge		Received
RF pick-up cables		Information pending	Chimney support assy. for trolley		Received
Solenoid	For 4CM	1CM received	Lifting support for chimney eq.		Received
Fittings, bolts...	For 3CM	3CM received	He tank insertion blocks		Drawing ready w41
O-rings, Helicoflex, Cu gaskets	For 2CM	2CM received	Double targets support for V plate		Manufacturing w41
Current leads	For 2CM	2CM received	Target L support		Manufacturing w41
Splice parts	For 2CM	Manufacturing w44	sets of wheels for v-vessel		Received
Cryogenic piping	For 2CM	2CM received	set of wheels for Cavity trolley		Manufacturing w40
Cryogenic sensors/gauges	For 2CM	2CM received	Motorization v-vessel/CST		Received
Cryogenic instrumentation	For 2CM	2CM installed	Vacuum vessel feet		Received
Omega alignment plates	For 2CM	2CM received	Vacuum vessel cover		Received
Suspension system	For 2CM	2CM received	Thermal shield onto lifting frame fixation system		Received
Cavities supporting spheres	For 2CM	2CM received	Crow's foot spanner set (for VCR connection)		Received
Survey viewports	For 2CM	Testing @Cern w38	Steps (for work in height into the cleanroom)		Received
Monitoring targets	For 2CM	Manufacturing w43	Personal elevator		Received
Cryogenic safetydevices (TE-CRG)	For 2CM	Order out w43	Cleanroom harness		Received
Vacuum safety devices		Information pending	Chimney frame pre assembly		Received
Vacuum valves	For 2CM	80% received	Cavity crane (Chevre)		Received
Vacuum gauges	For 2CM	2CM received	Survey targets supports for assembly		Testing @ Cern
Vacuum cryo T-sensors	For 2CM	2CM received	Survey targets supports M12		Received
Vacuum instrumentation	For 2CM	Manufacturing w40	Consumable for clean room		Received
Bellows ancillaries	For 2CM	Manufacturing w44	Ultrasonic bath		Received
Helium vessels ancillaries	For 2CM	2CM installed	Hand tools		Received
RF cable thermalization	For 2CM	Manufacturing w44	Laser tracker (EN-MEF)		Received
Diagonal rods thermalization	For 2CM	Manufacturing w44	Vacuum test equipment (TE-VSC)		Procuring

# Work organization : organigram



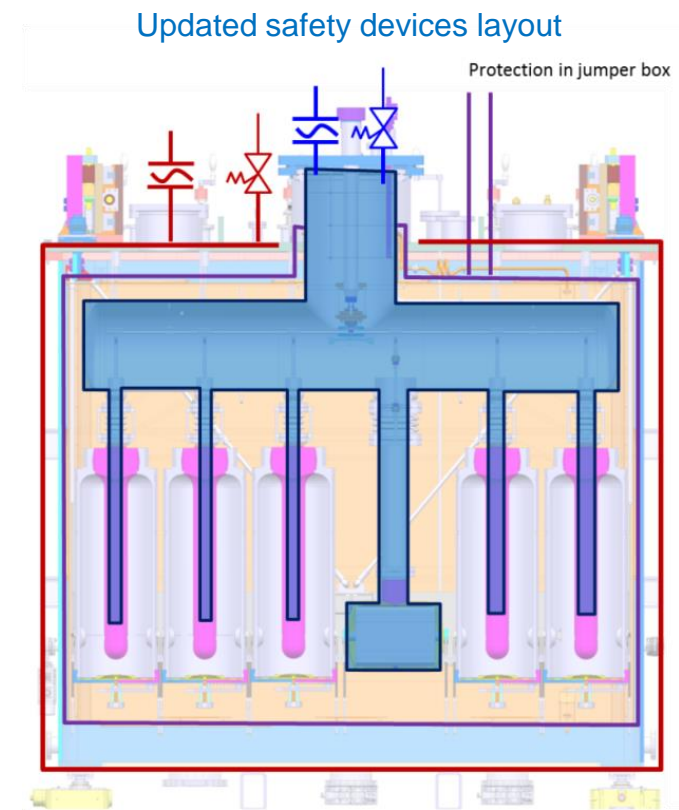


# Design: Instrumentation



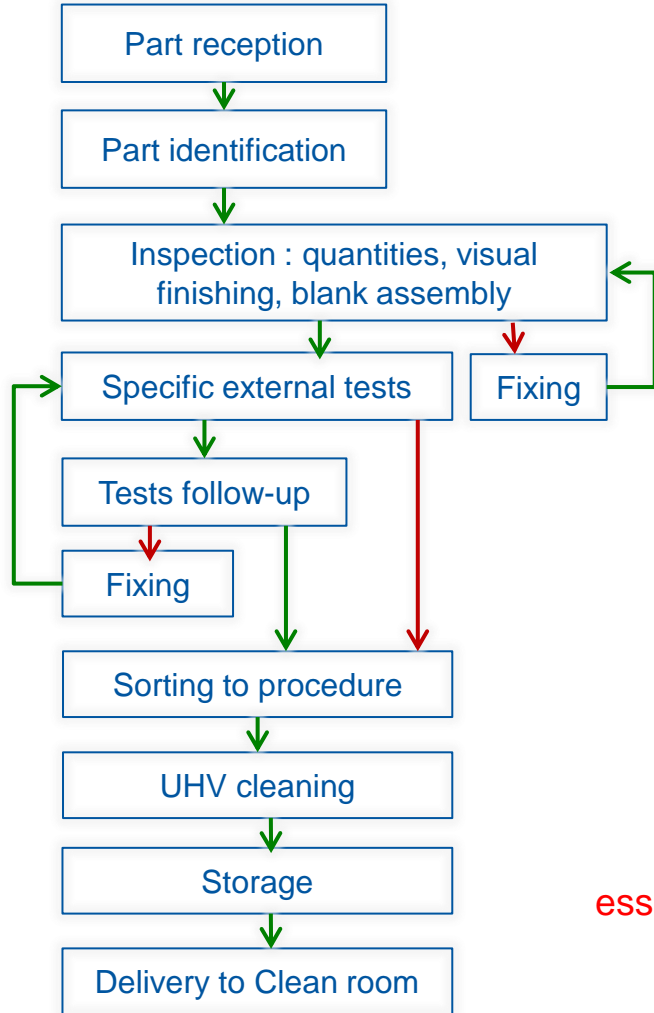
# Design: safety pressure devices

- Vacuum vessel protection
  - $P < 1.5 \text{ bar}$
  - He mass flow : 4,7 kg/s
- Helium volume protection
  - $PS = 3.5 \text{ bar}$
  - Heat load : 76 kW
  - He mass flow: 4.9 kg/s



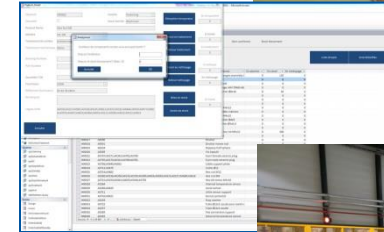
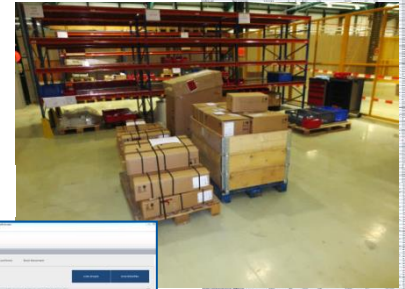
# Work organization :

## 3. preparation team : SMA18



**Logistic/Storage in SMA18 is essential for efficient assembly work in clean room !**

Part reception



Part identification  
Part inspection



General checks and blank assy



Storage after  
UHV cleaning

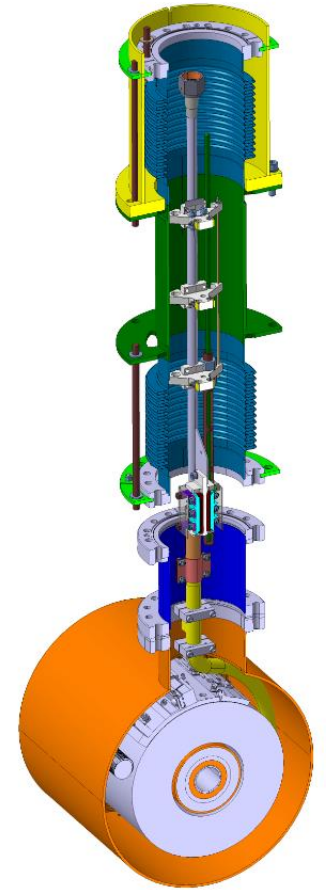


Parts list for cryomodule  
procurement and preparation

Part No.	Description	Quantity	Unit	Material	Supplier	Status
1001	...	...	...	...	...	...
1002	...	...	...	...	...	...
1003	...	...	...	...	...	...
1004	...	...	...	...	...	...
1005	...	...	...	...	...	...
1006	...	...	...	...	...	...
1007	...	...	...	...	...	...
1008	...	...	...	...	...	...
1009	...	...	...	...	...	...
1010	...	...	...	...	...	...
1011	...	...	...	...	...	...
1012	...	...	...	...	...	...
1013	...	...	...	...	...	...
1014	...	...	...	...	...	...
1015	...	...	...	...	...	...
1016	...	...	...	...	...	...
1017	...	...	...	...	...	...
1018	...	...	...	...	...	...
1019	...	...	...	...	...	...
1020	...	...	...	...	...	...
1021	...	...	...	...	...	...
1022	...	...	...	...	...	...
1023	...	...	...	...	...	...
1024	...	...	...	...	...	...
1025	...	...	...	...	...	...
1026	...	...	...	...	...	...
1027	...	...	...	...	...	...
1028	...	...	...	...	...	...
1029	...	...	...	...	...	...
1030	...	...	...	...	...	...
1031	...	...	...	...	...	...
1032	...	...	...	...	...	...
1033	...	...	...	...	...	...
1034	...	...	...	...	...	...
1035	...	...	...	...	...	...
1036	...	...	...	...	...	...
1037	...	...	...	...	...	...
1038	...	...	...	...	...	...
1039	...	...	...	...	...	...
1040	...	...	...	...	...	...
1041	...	...	...	...	...	...
1042	...	...	...	...	...	...
1043	...	...	...	...	...	...
1044	...	...	...	...	...	...
1045	...	...	...	...	...	...
1046	...	...	...	...	...	...
1047	...	...	...	...	...	...
1048	...	...	...	...	...	...
1049	...	...	...	...	...	...
1050	...	...	...	...	...	...

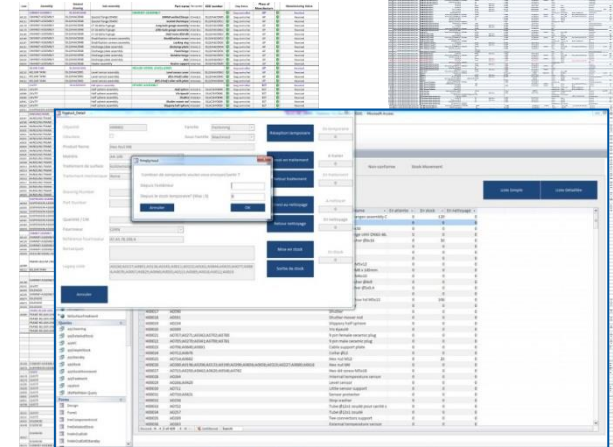
# Design : Cavities & Solenoid

- Cavities and ancillaries
  - See dedicated presentation for details
- Solenoid and ancillaries
  - Properties: 116 A – 13.5 T2.m - NbTi
  - Self protected
  - Supplies:
    - Vapor-cooled current leads
    - Resistive splice
    - Lhe 4.5K



# Procurement : summary

- Still in progress
- In line with assembly planning
- Figures
  - **>10 000 parts**
  - > 500 references



Software developed at TE-MSC  
for parts database management

Custom parts manufacturing  
follow up



Welding of helium  
and vacuum  
vessels



Machining leak test  
tool



Acceptance test for  
adjusters

Parts list for cryomodule  
procurement and preparation

# Parts preparation

- Key to successful assembly
- Dedicated area
- Blank assemblies
- Fixing
- UHV cleaning
- Storage and delivery

