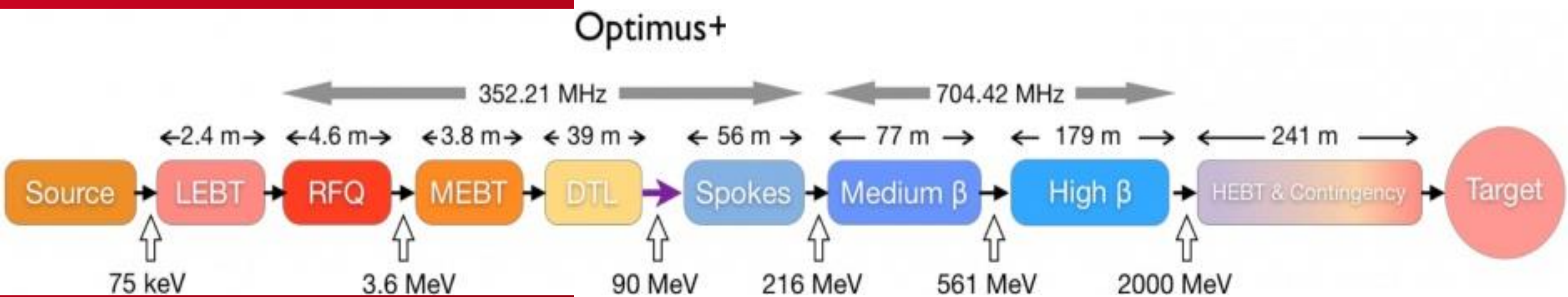
DE LA RECHERCHE À L'INDUSTRIE

THE ESS ELLIPTICAL CAVITIES CRYOMODULES STATUS ON THE CEA SACLAY ACTIVITIES



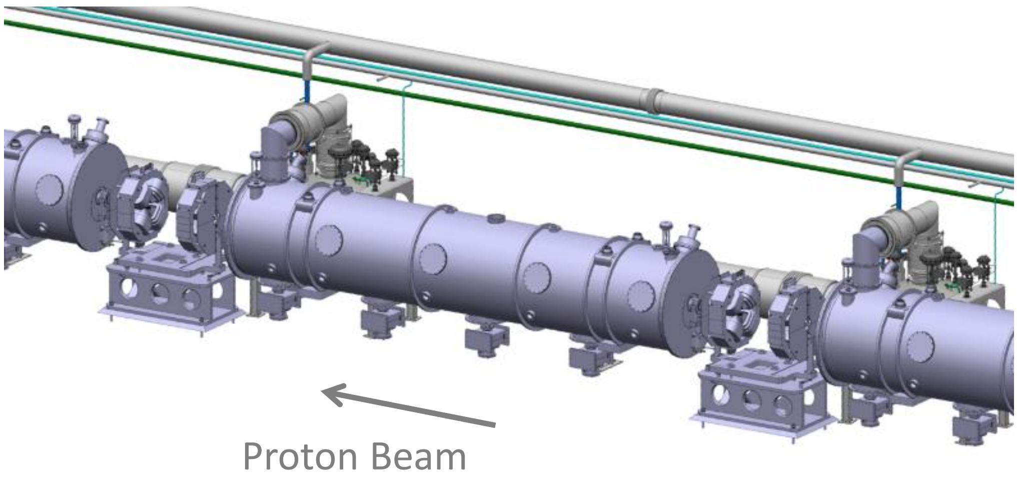
www.cea.fr

P. BOSLAND & F. ARDELLIER TAC13 07th APRIL 2016

CEA SACLAY ACTIVITIES FOR ELLIPTICAL CAVITIES CRYOMODULES

CEA is in charge of the whole activity for the prototyping and the production of the 30 M & H beta cryomodules except =>

	M-ECCTD	M-SERIE	H-ECCTD	H-SERIE
β	0.67	0.67	0.86	0.86
# CM	1	9	1	21
Cav. /CM	4	4	4	4
# Cav.	4 + 2 spares	36	4 + 1 spare	84



Not in the scope of CEA:

- Production & test of the cavities of the series (LASA & STFC)
- Transportation of the cryomodules (Saclay to Lund)
- Acceptance RF power tests of the cryomodules (ESS Lund)

LASA proposes a new design of the Medium beta cavity different from the one developed by CEA during the prototyping phase

Design of the Cryostat of the cryomodule made in collaboration of CEA- IPN Orsay

G. Olivier

A STRONG COLLABORATION ON THE SRF ACTIVITIES IS REQUIRED

ESS	Coordination of the SRF collaboration
CEA	Prototyping, cryomodule assembly and expertise for ESS
INFN	Medium beta cavities
Science & Technology Facilities Council	High beta cavities

⇩

<u>Regular meetings and visits</u>

STATUS OF THE ACTIVITIES ON PROTOTYPES AT SACLAY

Summary

1. Two H-beta prototype cavities

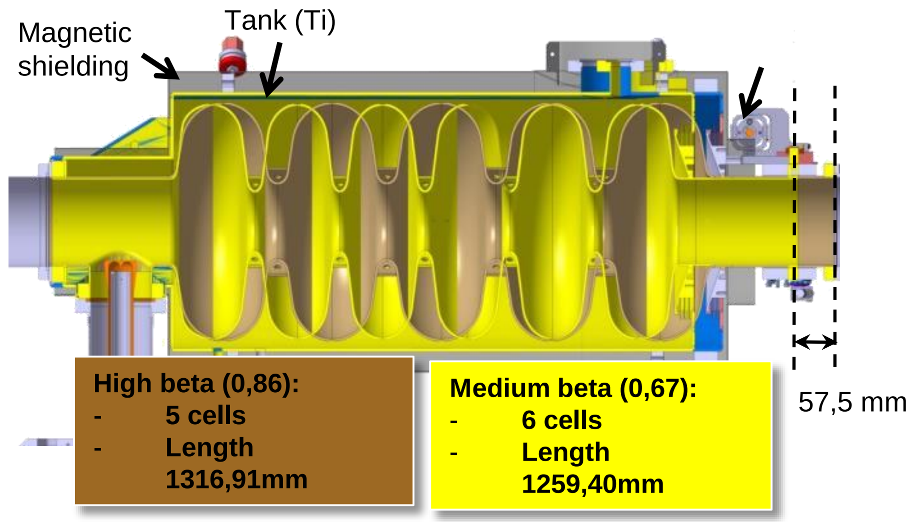
2. M-ECCTD cryomodule
   - 2.1 Procurement of the components:
     - 6 M-beta cavities
     - 6 Power couplers
     - Cryostat components
   - 2.2 Cryomodule assembling
     - Procedures
     - Toolings
   - 2.3 RF power tests of the cryomodules
     - Infrastructure for RF power tests at 2K

3. H-ECCTD
   - 3.1 Status of the procurements
   - 3.2 Change of the development plan: RF power test of a single cavity + coupler + tuner in HNOSS at Uppsala

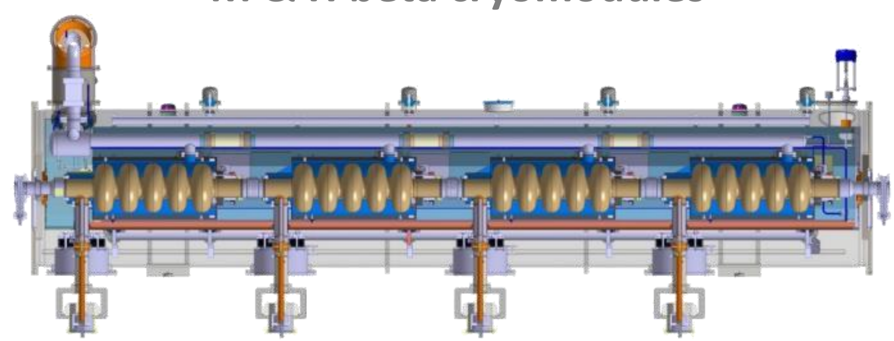
See presentation by Franck Peauger about medium and high beta prototype cavities

MAIN FEATURES OF THE CRYOMODULES

	Medium beta	High beta
Nbre of cavities per cryomodule	4	
Cavity cell number	6	5
Frequency (MHz)	704,42MHz	
Operating temperature (2K)	2	
Geometrical beta	0,67	0,86
Maximum surface field (MV/m)	45	
E_{acc} (MV/m)	16,7	19,9
Nominal accelerating voltage (MV)	14,3	18,2
Q0 at nominal gradient	> 5 E9	
Cavity dynamic heat losses (W)	4,9	6,9
Power coupler Q_{ext}	7,5 E5	7,6 E5
Maximum power (MW)	1,1	
Frequency tuning system	Slow tuner + piezo (2 stacks)	
Thermal shield temperature (K)	50	
Static losses at 2K (W)	12,2	
Dynamic losses at 2 K (W)	19,6	27,6
Static losses at 50 K (W)	46,2	
Overall length from flange to flange (m)	6,584	



One generic design for M & H beta cryomodules



THE ESS COUPLER

Frequency: 704.42MHz

Peak power: 1.1MW

Pulse length: 3,1 ms

F=14Hz

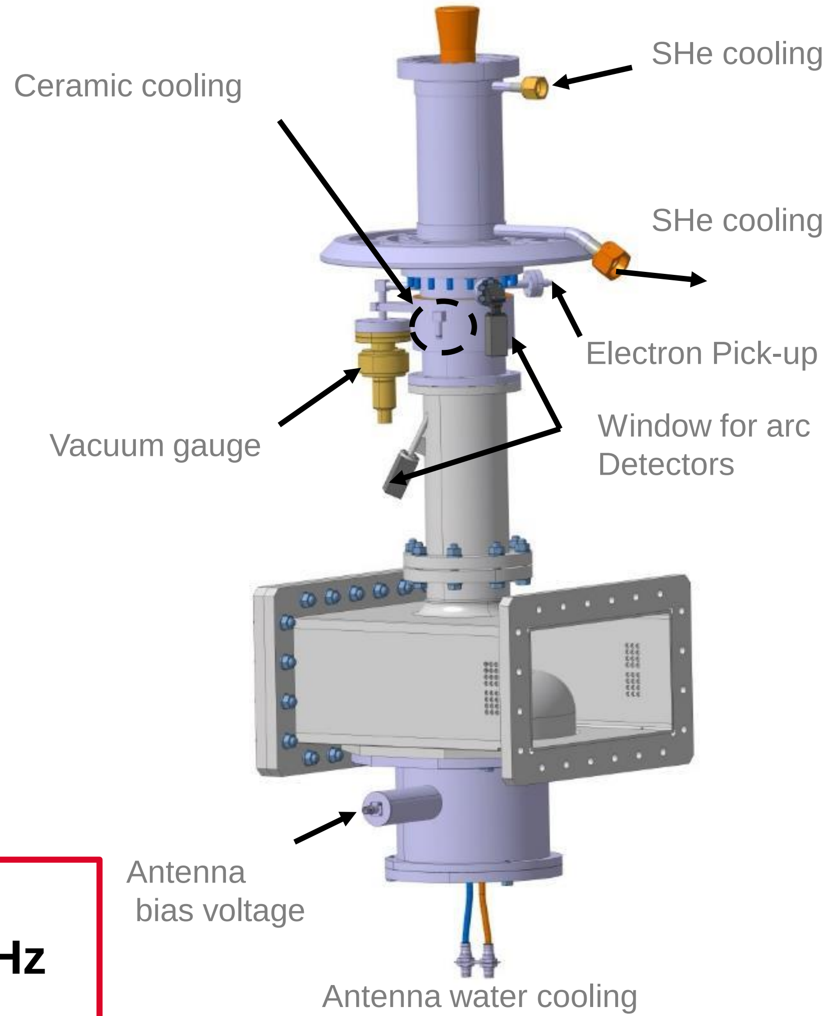
Cooling systems:

- external conductor: SHe at 3bars & 4,5K
- Ceramic window: air or water
- Antenna: water

Bias voltage can be applied to the antenna (10kV max)

Diagnostics

- 1 electron pickup (RF measurements can be made)
- 2 arc detectors (air side + vacuum side)
- 1 vacuum gauge



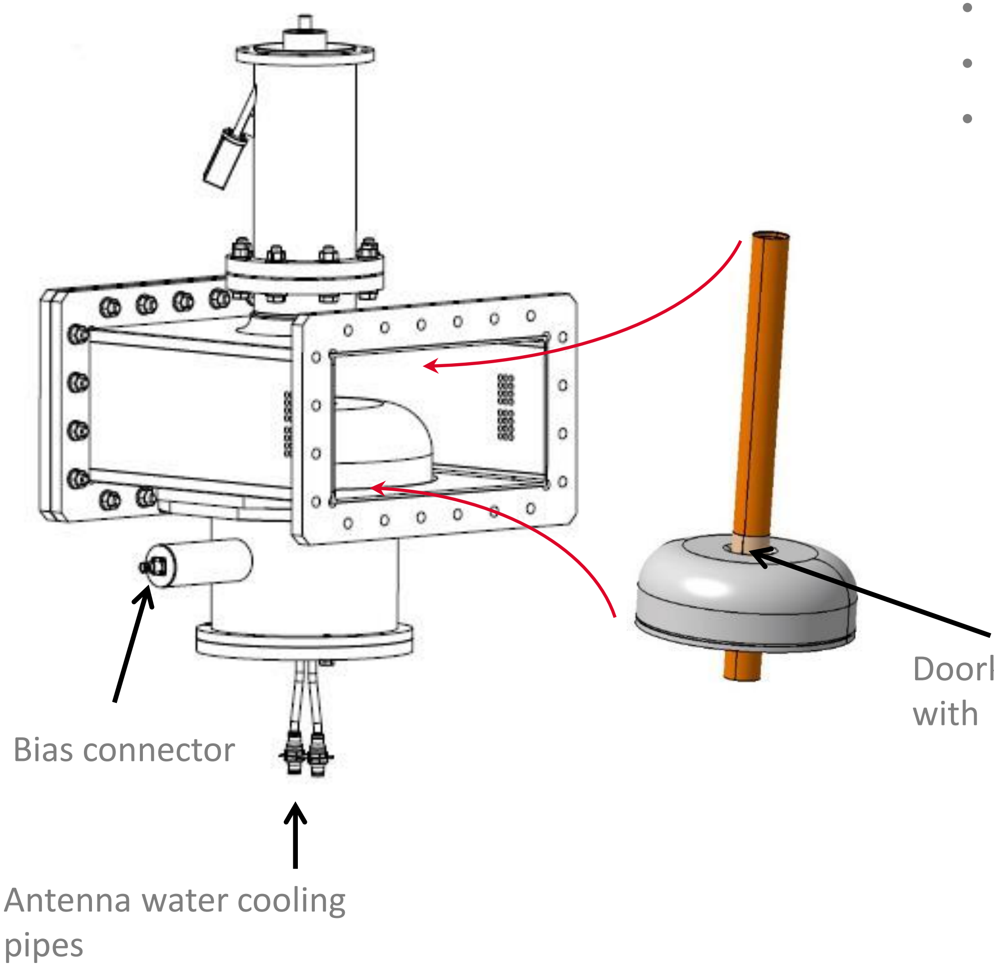
Ceramic window & antenna

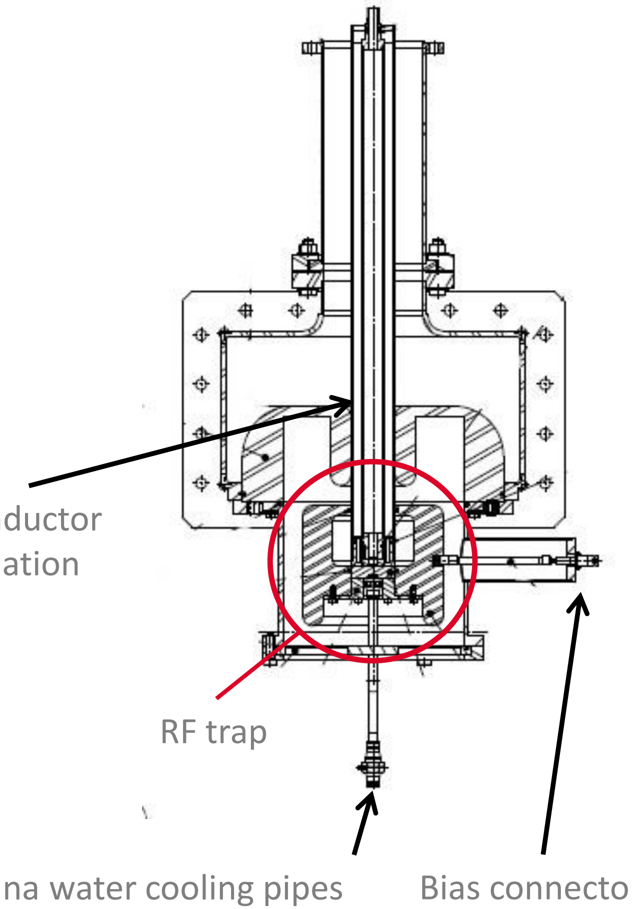
HIPPI type coupler tested at 1.1MW at 50Hz and 10% DC on a 704MHz cavity at 2K

(and 1.2MW for ~1H without any sign of problem)

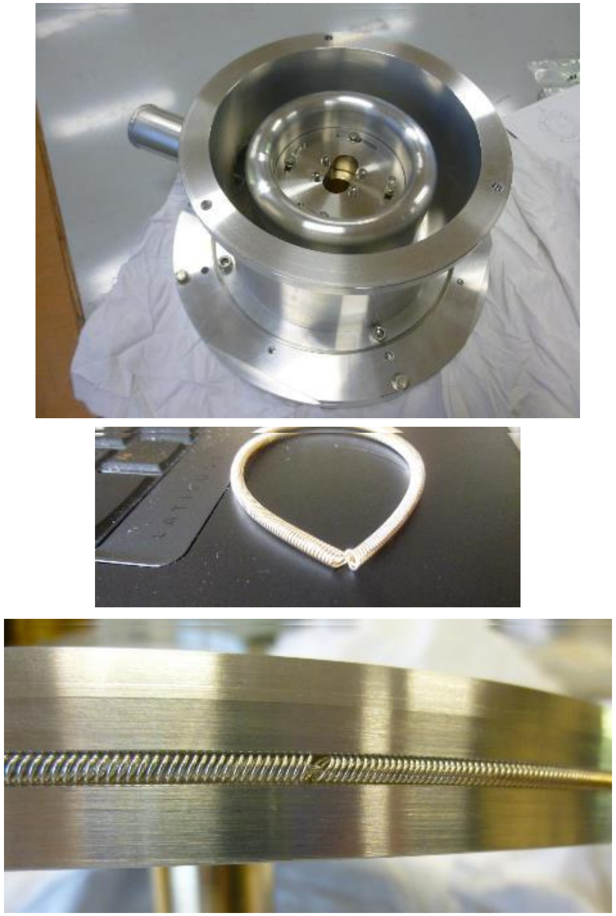
DOORKNOB MODIFIED TO ADD A BIAS ANTENNA SYSTEM

- Transition WG / coax at 704MHz (RF adaptation)
- Bias voltage applied to the antenna: max 10kV
- Water cooling inside the antenna





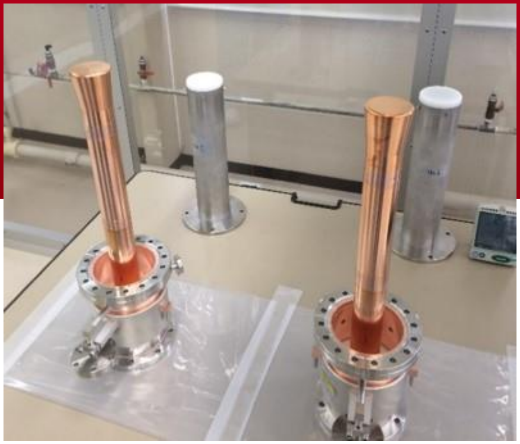
MOCKUP AND TESTS FOR THE DOORKNOB DESIGN OPTIMIZATION



Mockup of the RF trap used for optimizing the grooves of the RF contacts

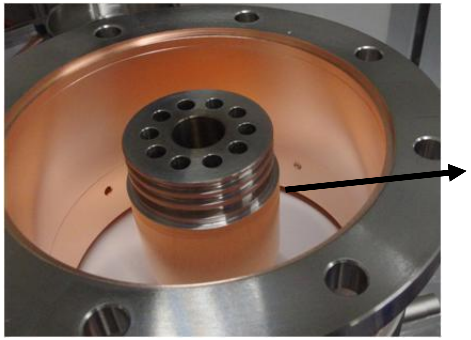
Test of different insulating material to be shrink fitted to the inner conductor

STATUS OF THE PROTOTYPE COUPLERS PRODUCTION



- **6 ceramic windows delivered.**
- **2 last ones expected before end of April**

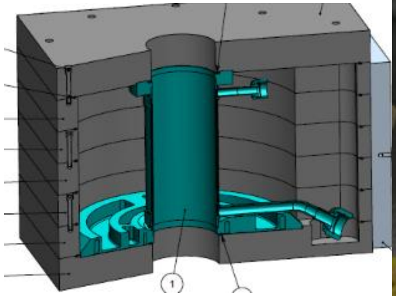
scratches on copper parts



brazing metal alloy melted and filled hole

- **Mechanical manufacturing of the 6 tubes finalized**
- **Delays on the copper deposition:**
  - **RRR = 35 qualified by measurements on samples**
  - Problem of thickness uniformity: modification of the electrode length
  - Protection tool for coating manufactured

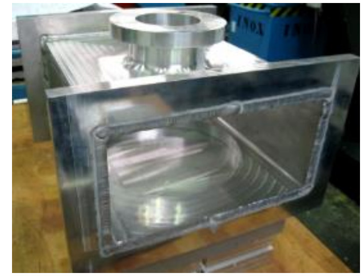
First copper coating on the tube done Tuesday the 5th of April

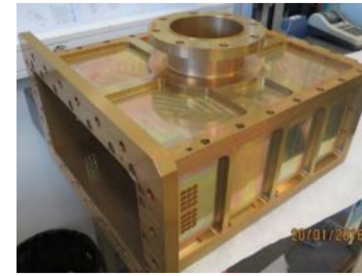


Coating protection system

8 doorknobs ordered to 2 companies (4 + 4):

- Delivery at the beginning of April
- Doorknob box: two versions welded or screwed & welded



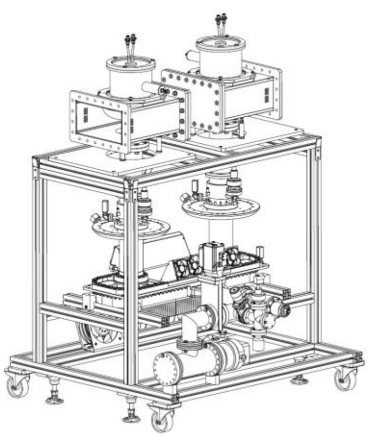


3 conditioning boxes:

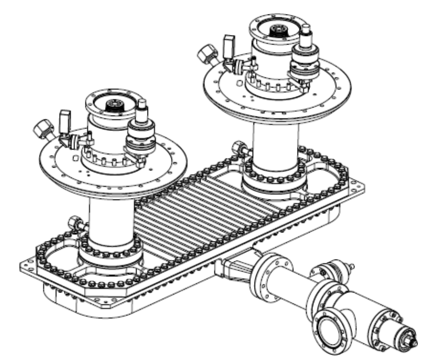
- FAT: 30th of March: some minor modifications are needed

Cover plate

The boxes

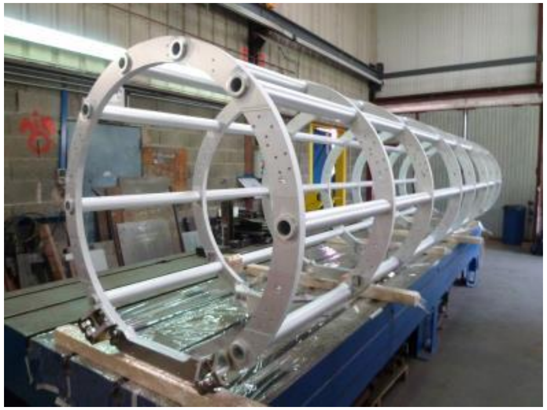


START OF THE RF CONDITIONNING IN MAY



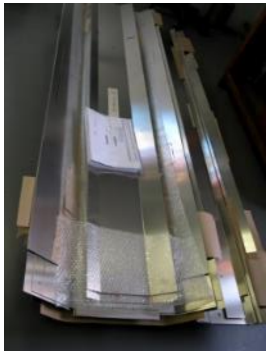
M-ECCTD CRYOSTAT COMPONENTS

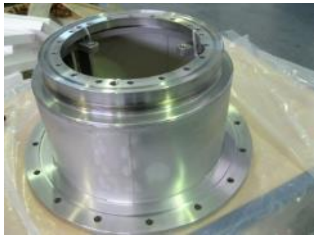


Status of the procurement of the main cryostat components:

- Spaceframe:	Delivered
- Vacuum chamber:	Delivered
- MLI of the thermal shield:	Delivered
- MLI of the cold mass:	Delivered
- Bellows of the couplers:	Delivered
- Thermal screen:	End of April
- Diphasic tube:	End of April
- Cryo pipes:	End of April
- Tubes for rupture discs:	End of April
- Helium heat exchanger:	Delivered
- Helium valves:	Delivered
- Intercavity bellows	July 2016
- Instrumentation:	part is delivered
- Gate valves	Delivered
- …….	



TRAINING FOR THE ASSEMBLY OF THE M-ECCTD IN PROGRESS



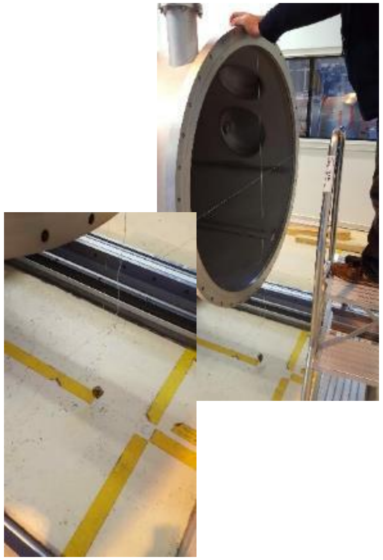






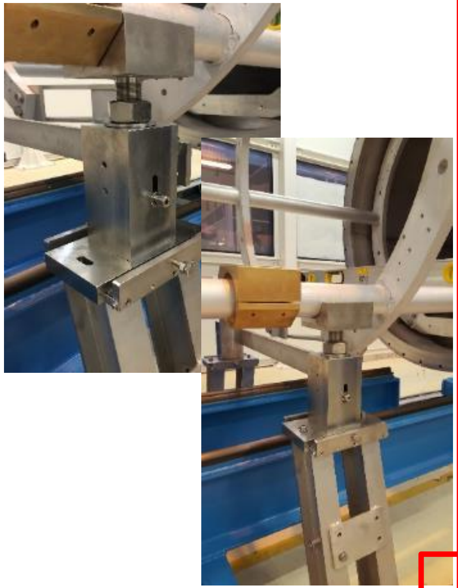

EXAMPLE: MAIN STEPS OF THE SPACEFRAME INSERTION

Vessel axis adjustment **1**

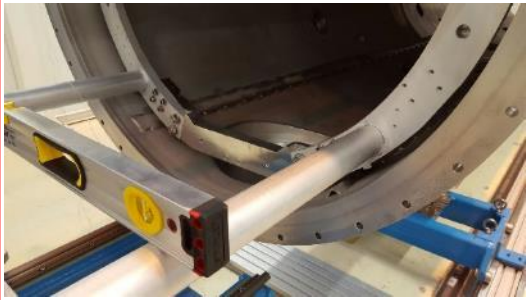


Height of the vessel adjustment **2**

Spaceframe height adjustment **3**

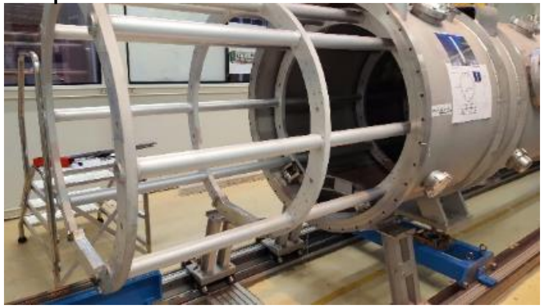


Strat of the insertion of the spaceFrame **4**



Spaceframe in contact with the rails of the vessel **5**

Insertion of the spaceframe **6**

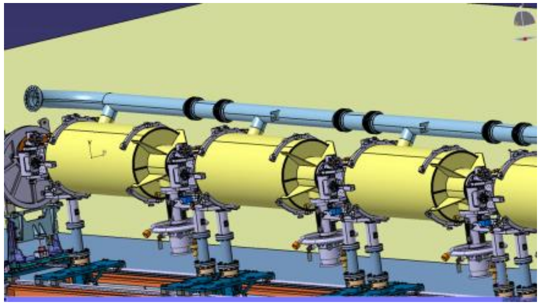


7 Last tooling removed before final insertion

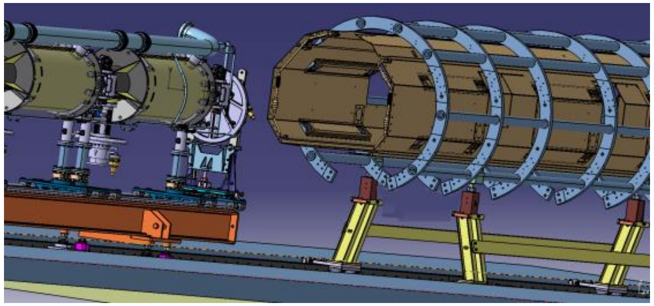
ASSEMBLY OF THE M-ECCTD

XFEL assembly lessons learned

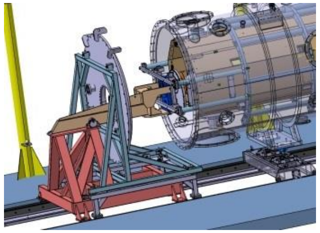
Assembling of the cavity string with a N2 flow for protection against dust particles



Welding the titanium diphasic tubes

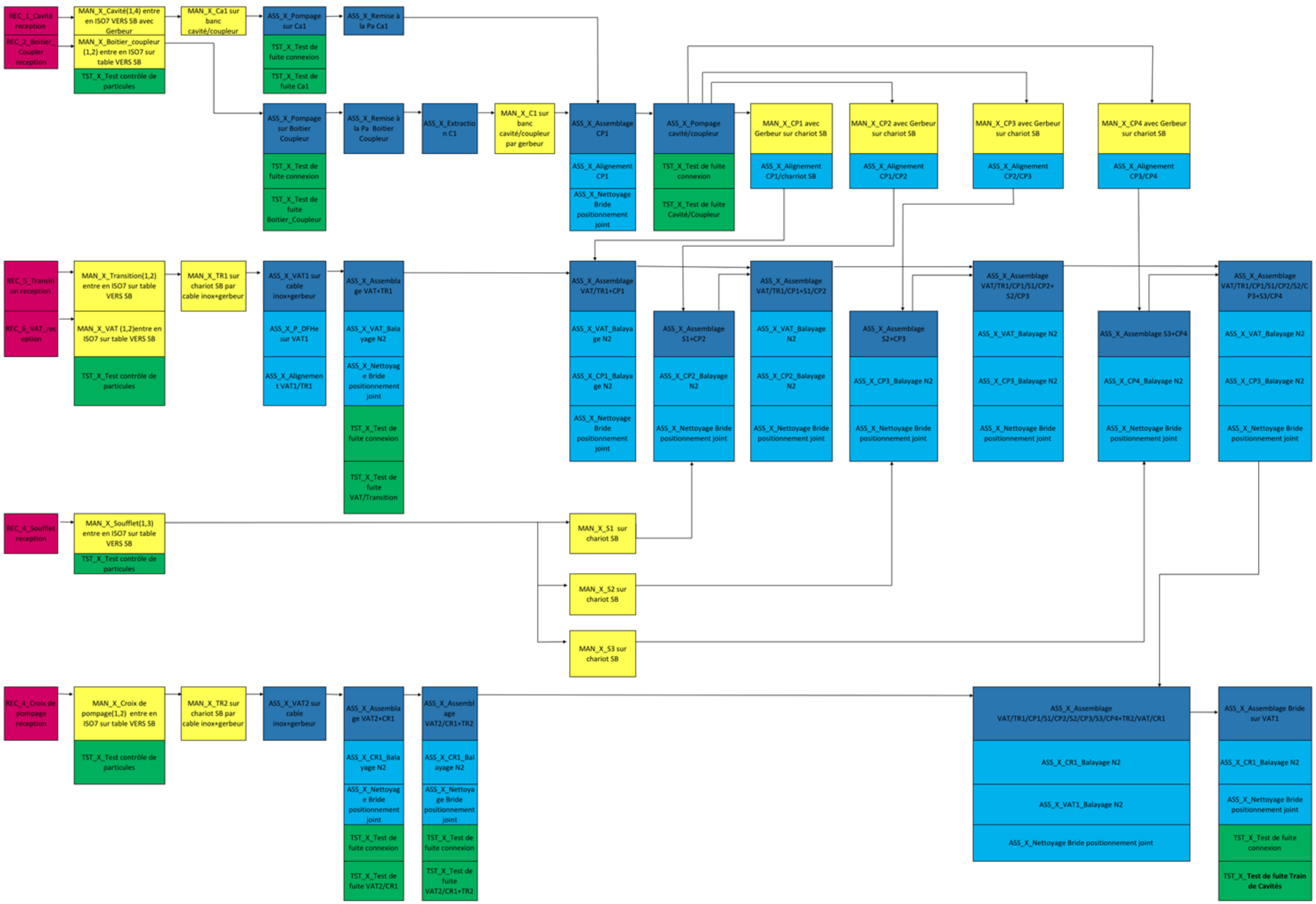


The cavity string is inserted in the spaceframe already eaquipped with the thermal shield



Closing the vacuum

Assembly process inside the clean room



Assembly process outside the clean room

Sortie salle blanche

- Manutention train de cavité hors salle blanche 5001/6001
  - transfert du train de cavité sur 6001
  - Mise à niveau 5001 et 6001 par chandelles 6006 et pied carré 6001
  - fixe chassis 6001 et chariot 5001
- Mesure laser tracker position des cavités
- Manutention train de cavité HALL 124 vers Böth
  - transfert du train de cavité sur remorque
  - Soulève le chassis 6001 avec le palan
  - Retrait des chandelles 6006
  - Dépose sur remorque

Fixation du train de cavité au Spaceframe dans la Böth

- Both: Mise à niveau chassis 6001 avec rail 6002
- Assemblage écran sur support écran 6002003
  - Demi flan G
  - Demi flan D
  - MLI sur demi flan G et D
- Assemblage Spaceframe sur pied 6002012
  - Place gabarit contrôle hauteur et coté 6002022*2 6002023*4
- Fixe l'écran sur Space frame
  - Demonte 2 plaques 6002013
  - Glisse le Space frame sur écran
  - Fixe 16 équerres 6002020 et 6002021
  - démonte 6002022, 6002023 et 6002003
- Réception train de cavité dans la Böth
  - Dépose 6001 sur 6002
  - Mesure laser tracker contrôle transport/palan
  - Caractérisation des bras de mires par rapport au référentiel de la Böth

- Soude les lignes dyphasiques
  - Maintien ligne avec 6009
- Fixe 2 demi coquilles par cavités 0300003 0300004
- Fixe SAF
  - Utilise outillage 6008
  - Demonte équerres 0020001
- Fixe 4 demi anneaux par cavités
  - Colle MLI sur tank hélium
- Fixe fût SAF sur 4 cavités
  - 2 demi fond SAF 0300005 0300006
  - 2 demi fût 0300001 et 0300002
  - fond haut 0300007 et 2 colliers 0300008 0300009
- Ligne Cryogénique coupleur et cavité
  - Soudure, bridage, et fixation des différents raccords et tubes

- Coulisse space frame sur train de cavité
- Place les tirants
  - Visser dans les anneaux cavités
  - Retire équerre 6002020 6002021
- Laser tracker contrainte liés aux tirants
- Ferme bas du Space frame
- Place outils reprise de charge 6003
- Retire poteaux au milieu et sur les cotés et rigidificateur soufflet
  - Laser tracker contrainte liés reprise de charge, rigidificateur
- Fixe longueur basse écran thermique
  - Raccordement circuit hélium écran thermique
  - fixe ligne de pompage des coupleurs

Assembly process outside the clean room

Cryostating

- Place le cryomodule sur 6004?
- Ajuste hauteur et niveau par rapport à Space frame
- Fixe sur les rails

- Installe roulettes sur Space frame

- Glisse le Space frame
- Retire les barres de pieds 6002014
- Retire les pieds 6002012 pas à pas

- Retire chassis transfert 6001

- Centre le cryomodule dans la Böth

- Alignement du train de cavité par rapport à l'enceinte à vide
- Fixe les bras de report de mires
- Laser tracker train de cavité et coupleur
- Laser tracker enceinte à vide (défini son axe)
- Fixe les chandelles en place des vérins verticaux
- Positionne l'enceinte
- Contraint le train de cavité avec vérins latéraux
- Démonte les chandelles et bride les 3 ouvertures
- Laser tracker train de cavité par rapport à l'enceinte à vide

- Installe les deux disques de rupture
- Trouver outil de portage pyrell

- Installe le jumper
- Fixe manchette verticale
- Colle MLI sur écran verticale et fixe écran
- Soude coude BP à l'échangeur, colle MLI et positionne l'ensemble
- Soutient l'ensemble avec cales et on bride l'échangeur
- Vis l'écran thermique
- Colle MLI, fixe ligne hélium et thermalise partie verticale écran
- Colle MLI sur écran coudé et fixe écran
- Fixe le coude Jumper, thermalise l'écran coudé
- Soude embout extérieur tube

- Installe vanne VK
- ligne cryogénique échangeur, vannes, écrans

- Positionne portes cryomodule
- fixe outil support vannes 6005
- fixe outil support portes 6007
- retire outil reprise de charge 6003

- Ferme écran latéral
- MLI sur 3 parties pour chaque cotés

- Installe 4 cartouches réchauffemnt d'hélium

- Installe cloches coupleurs
- Spécifier outils

- Ferme portes cryomodule
- Positionne joint étanchéité
- Aligne porte, transition, enceinte et bride les portes
- Laser tracker train de cavité par rapport à

ASSEMBLING PROCEDURES IN PREPARATION

Irfu cea			
	Assemblage banc cavité coupleur		

Procédure d'assemblage du coupleur sur la cavité

Cette Fiche d'Instructions définit les opérations d'alignement et d'assemblage d'une cavité avec son coupleur VAT1 sur la transition1.

FICHE D'INSTRUCTIONS OPERATIONNELLES					
	CEA				
	Rédigé par	Vérifié par	Autorisé par	Vérifié par	Approuvé par
Fonction					

Irfu cea			
	Assemblage banc cavité coupleur		

Procédure d'assemblage de la vanne VAT 1 sur transition 1

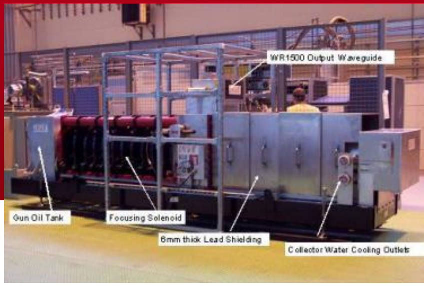
Couverture

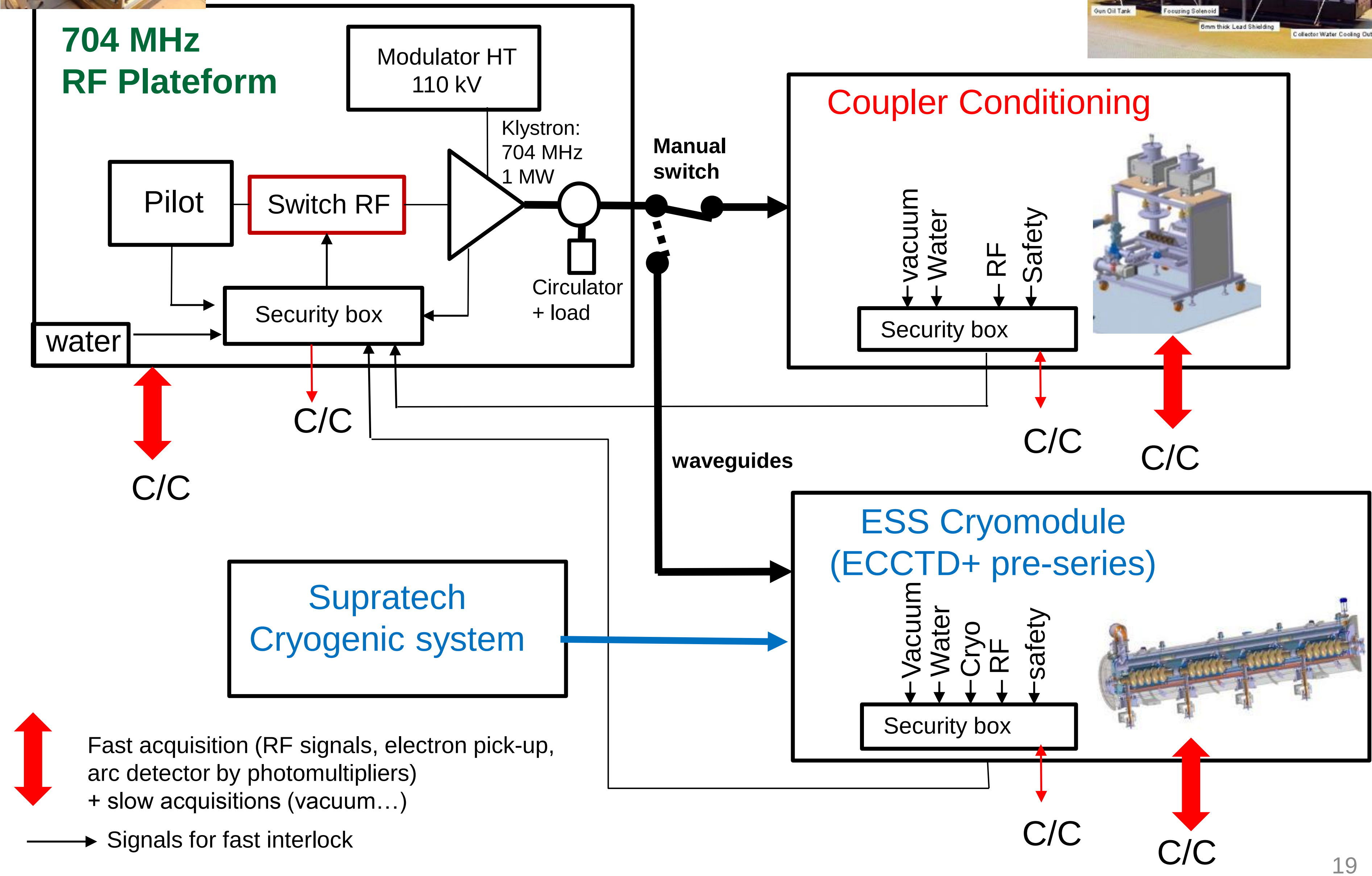
1

Cette Fiche d'Instructions définit les opérations d'alignement, d'assemblage et de test de fuite en ligne de la vanne VAT 1 sur la transition 1.

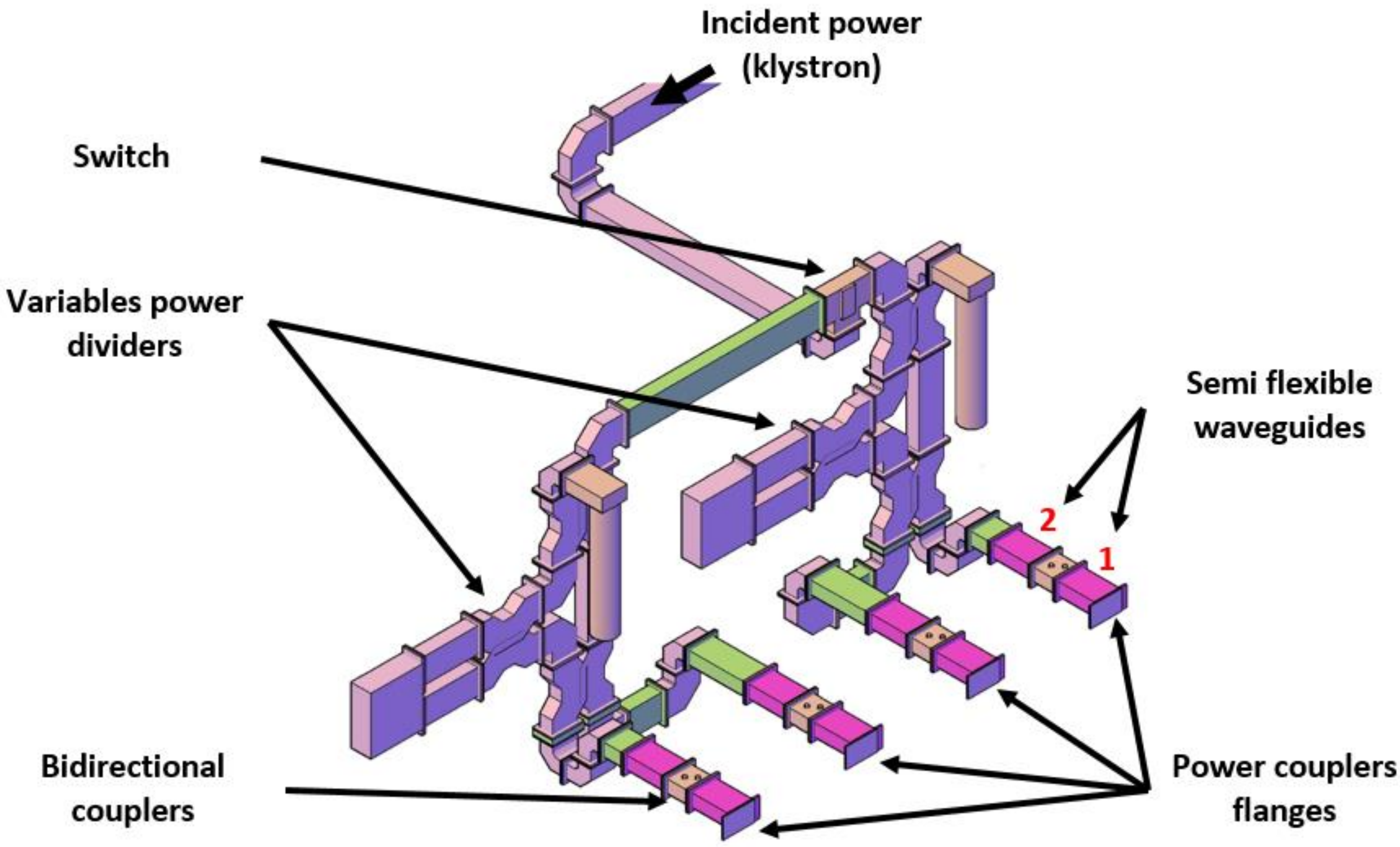
FICHE D'INSTRUCTIONS OPERATIONNELLES					
	CEA				
	Rédigé par	Vérifié par	Autorisé par	Vérifié par	Approuvé par
Fonction					

704MHZ RF POWER TEST STANDS

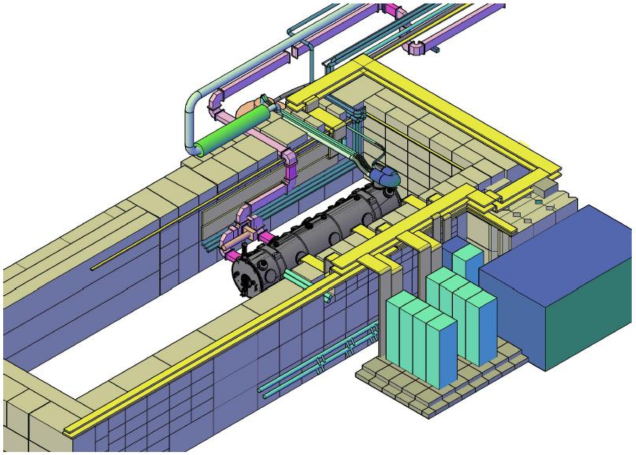


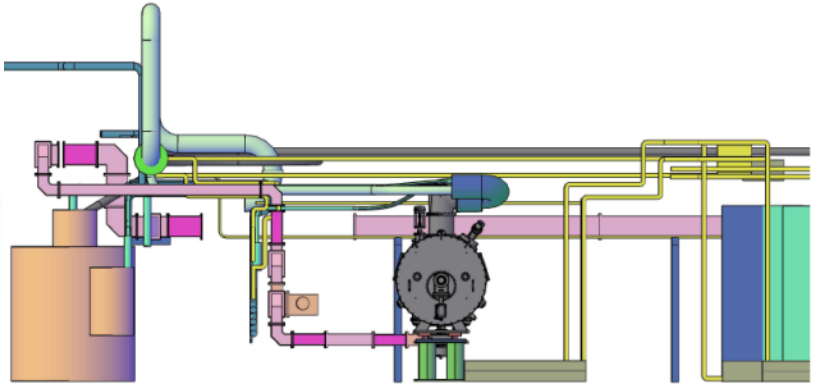


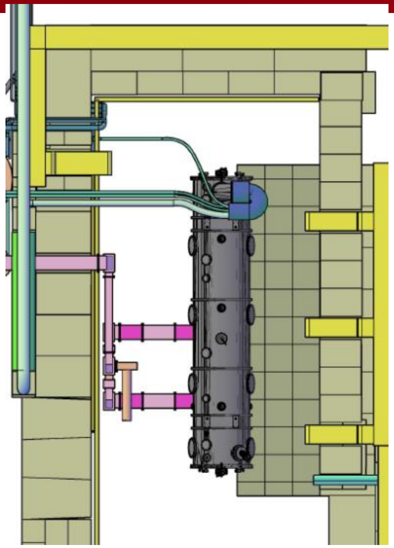
RF DISTRIBUTION FOR THE TESTS OF THE CRYOMODULES AT SACLAY



CRYOMODULE TESTS STAND



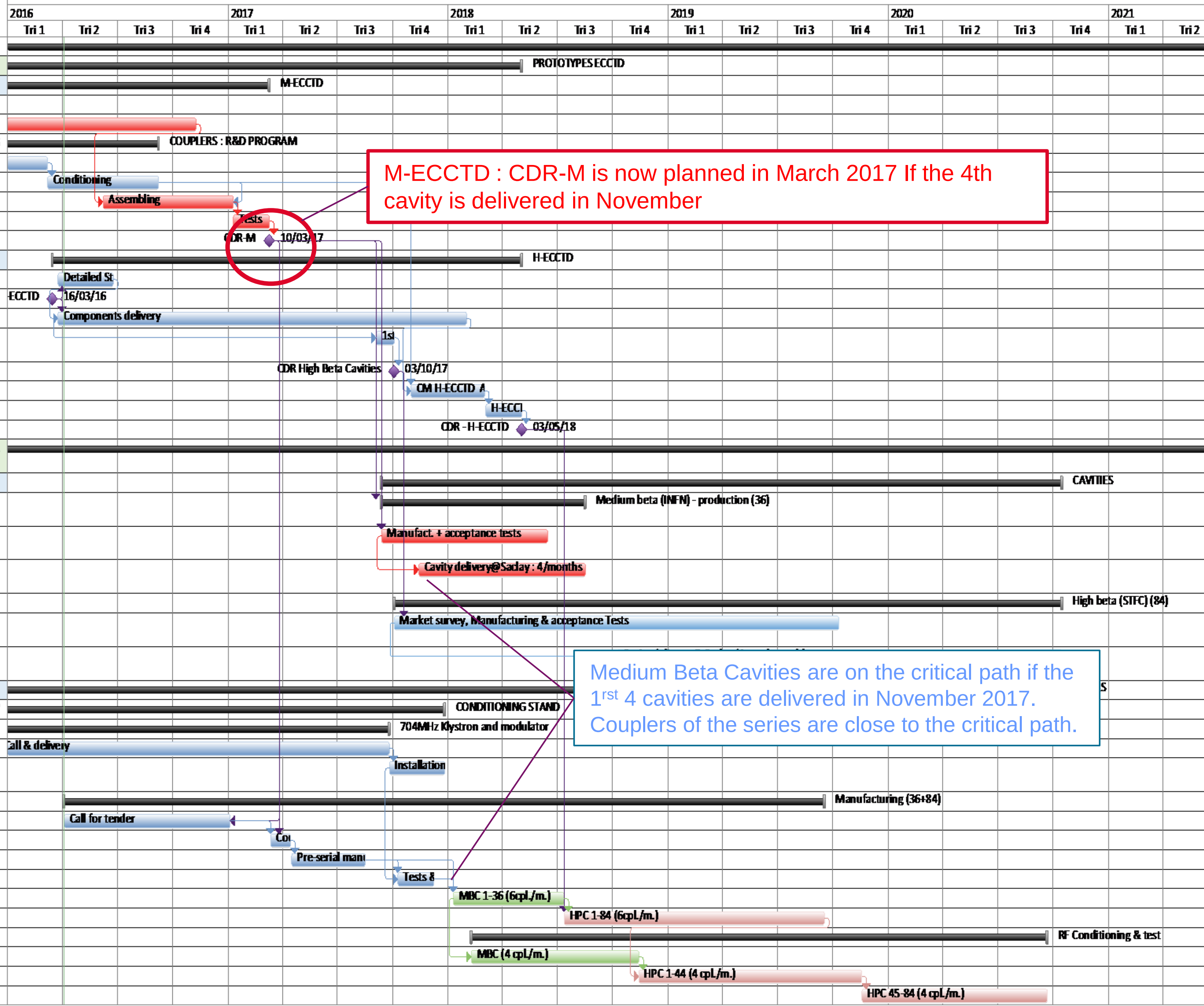




Parameters	ESS operation	ECCTD tests at CEA
Acc gradients	16,7 (Mbeta) and 19,9 (Hbeta) MV/m	
RF peak power	1,1MW max	
Max nbre of cavity running together	4	2
RF pulse rate	14Hz	16,7Hz
Cavity cooling	She at 4,5K & 3bars	LHe at 4,5K & 1 bar
coupler cooling	She at 4,5K & 3bars	Ghe at 4,6K & 1,2bara
Thermal shield	Ghe at 50K & 19bara	LN2 at 77K

CRYOMODULES TIME SCHEDULE (BASELINE)
CRYOMODULES ASSEMBLY & TESTS

Nom de la tâche	Durée	Début	Fin
ELLIPTICAL CRYOMODULES	77 ms	Jeu 01/01/15	Mar 29/06/21
PROTOTYPES ECCTD	39,59 n	Jeu 01/01/15	Jeu 03/05/18
M-ECCTD	26 ms	Jeu 01/01/15	Ven 10/03/17
Studies	6 ms	Jeu 01/01/15	Ven 03/07/15
Components Delivery	19 ms	Ven 03/04/15	Mar 08/11/16
COUPLERS : R&D PROGRAM	20 ms	Jeu 01/01/15	Mer 07/09/16
Prototyping	14 ms	Jeu 01/01/15	Lun 07/03/16
Conditioning	6 ms	Mar 08/03/16	Mer 07/09/16
Assembling	7 ms	Mer 08/06/16	Lun 09/01/17
Tests	2 ms	Mar 10/01/17	Ven 10/03/17
CDR-M	0 ms	Ven 10/03/17	Ven 10/03/17
H-ECCTD	25,32 n	Mer 16/03/16	Jeu 03/05/18
Detailed Studies	3 ms	Ven 25/03/16	Ven 24/06/16
Kick Off Meeting H-ECCTD	0 ms	Mer 16/03/16	Mer 16/03/16
Components delivery	22 ms	Ven 25/03/16	Mer 31/01/18
1st High Beta cavity + coupler tests (@ Uppsala ?)	1 ms	Lun 04/09/17	Mar 03/10/17
CDR High Beta Cavities	0 ms	Mar 03/10/17	Mar 03/10/17
CM H-ECCTD Assembling	4 ms	Mer 01/11/17	Ven 02/03/18
H-ECCTD Tests	2 ms	Lun 05/03/18	Jeu 03/05/18
CDR - H-ECCTD	0 ms	Jeu 03/05/18	Jeu 03/05/18
Cryomodules - Production of serie	65,59 ms	Ven 18/12/15	Mar 29/06/21
CAVITIES	36,68 n	Mer 13/09/17	Jeu 15/10/20
Medium beta (INFN) - production (36)	11 ms	Mer 13/09/17	Jeu 16/08/18
Manufact. + acceptance tests	9 ms	Mer 13/09/17	Ven 15/06/18
Cavity delivery@Saclay : 4/months	9 ms	Mar 14/11/17	Jeu 16/08/18
High beta (STFC) (84)	36 ms	Mer 04/10/17	Jeu 15/10/20
Market survey, Manufacturing & acceptance	24 ms	Mer 04/10/17	Ven 11/10/19
Cavity delivery @ Saclay (4 cav / month)	24 ms	Mar 09/10/18	Jeu 15/10/20
COUPLERS	56,45 n	Ven 18/12/15	Lun 21/09/20
CONDITIONING STAND	24 ms	Ven 18/12/15	Mar 26/12/17
704MHz Klystron and modula	21 ms	Ven 18/12/15	Lun 25/09/17
Call & delivery	21 ms	Ven 18/12/15	Lun 25/09/17
Installation and Commissioning	3 ms	Mar 26/09/17	Mar 26/12/17
Manufacturing (36+84)	41 ms	Lun 04/04/16	Mar 17/09/19
Call for tender	9 ms	Lun 04/04/16	Mer 04/01/17
Couplers contract awarded	5 sm	Lun 13/03/17	Ven 14/04/17
Pre-serial manufacturing (4)	4 ms	Lun 17/04/17	Mer 16/08/17
Tests & condtitioning of pres	2 ms	Mar 10/10/17	Ven 08/12/17
MBC 1-36 (6cpl./m.)	6 ms	Mer 10/01/18	Jeu 12/07/18
HPC 1-84 (6cpl./m.)	14 ms	Ven 13/07/18	Mar 17/09/19
RF Conditioning & test	31 ms	Ven 09/02/18	Lun 21/09/20
MBC (4 cpl./m.)	9 ms	Ven 09/02/18	Mar 13/11/18
HPC 1-44 (4 cpl./m.)	12 ms	Mer 14/11/18	Lun 18/11/19
HPC 45-84 (4 cpl./m.)	10 ms	Mar 19/11/19	Lun 21/09/20

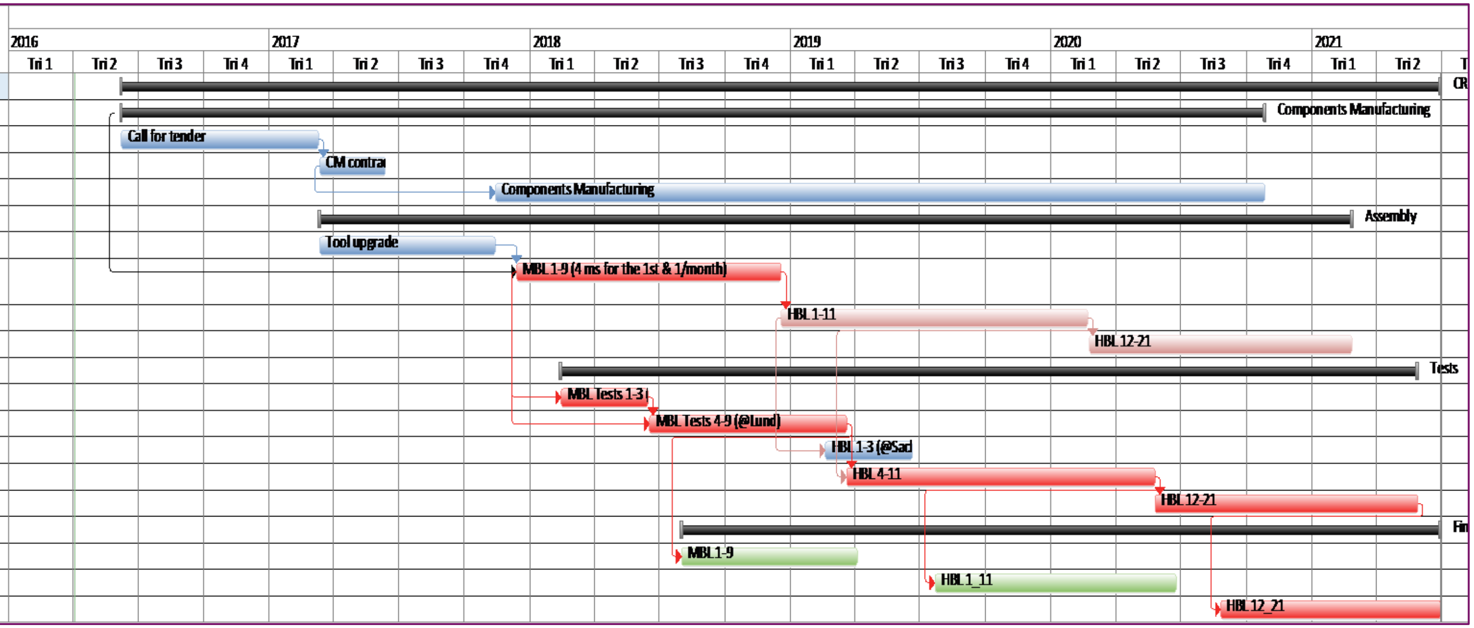


M-ECCTD : CDR-M is now planned in March 2017 If the 4th cavity is delivered in November

Medium Beta Cavities are on the critical path if the 1rst 4 cavities are delivered in November 2017. Couplers of the series are close to the critical path.

CRYOMODULES TIME SCHEDULE (BASELINE) CRYOMODULES ASSEMBLY & TESTS

Nom de la tâche	Durée	Début	Fin
CRYOMODULES REALISATION	60 ms	Mer 08/06/16	Mar 29/06/21
Components Manufacturing	52 ms	Mer 08/06/16	Lun 26/10/20
Call for tender	9 ms	Mer 08/06/16	Ven 10/03/17
CM contract awarded	3 ms	Lun 13/03/17	Lun 12/06/17
Components Manufacturing	35 ms	Mar 14/11/17	Lun 26/10/20
Assembly	47 ms	Lun 13/03/17	Jeu 25/02/21
Tool upgrade	8 ms	Lun 13/03/17	Lun 13/11/17
MBL 1-9 (4 ms for the 1st & 1/month)	12 ms	Jeu 14/12/17	Mar 18/12/18
HBL 1-11	14 ms	Mer 19/12/18	Ven 21/02/20
HBL 12-21	12 ms	Lun 24/02/20	Jeu 25/02/21
Tests	39 ms	Mer 14/02/18	Ven 28/05/21
MBL Tests 1-3 (@Saclay)	4 ms	Mer 14/02/18	Ven 15/06/18
MBL Tests 4-9 (@Lund)	9 ms	Lun 18/06/18	Mer 20/03/19
HBL 1-3 (@Saclay)	4 ms	Mar 19/02/19	Jeu 20/06/19
HBL 4-11	14 ms	Jeu 21/03/19	Lun 25/05/20
HBL 12-21	12 ms	Mar 26/05/20	Ven 28/05/21
Final installation	34,5 ms	Jeu 02/08/18	Mar 29/06/21
MBL 1-9	8 ms	Jeu 02/08/18	Jeu 04/04/19
HBL 1_11	11 ms	Mar 23/07/19	Mer 24/06/20
HBL 12_21	10 ms	Mer 26/08/20	Mar 29/06/21



Some data inputs & analysis :

- Minimum delay expected after the delivery at Saclay of the 4th cavity and the completion of the cryomodule assembly: 2 months for the M-ECCTD and first cryomodules of the series

Cavities & couplers are closed on the critical path for the medium beta cryomodules:

- Delivery rate for cavities : 4 items / month
  - 1st batch of 4 Medium-β cavities delivery : nov 2017
  - 1st batch of 4 High-β cavities delivery : nov 2018

Risks :

- No margin for technological and procurement issues
- The 2nd Mbeta cryomodules is assembled without waiting the tests results of the 1rst one. No time for lessons learned at the beginning of the series production process.
- **M-ECCTD is built and tested with « Saclay prototype cavities ». LASA cavities have to be tested in real conditions before launching the production of the series => see presentation from INFN**

CHANGE OF THE DEVELOPMENT PLAN FOR THE M-ECCTD ?

Testing a LASA cavity with new design in the M-ECCTD in order to limit the risks before launching the cavities of the series ?

The second prototype cryomodule H-ECCTD

Kick off meeting: 16th March

A modification of the development plan has been proposed.

PROCUREMENT FOR H-ECCTD

Components already ordered

- Niobium for 5 cavities [Tokyo Denkai]
- Coupleur antenna and RF ceramic window [Toshiba]
- Doorknob transitions [PMB]
- Magnetic shielding [Meca magnetic]
- Cold tuning system [Gavard]
- Motors [Phytron]
- Piezo actuators [Noliac]
- Cavity pick-up antennas [Solcera]
- Coupler pick-up antenna [Solcera]
- Coupleur vacuum gauges [Pfeiffer]

Next procurements

- Five cavities (within a single supplier)
- Couplers: six external conductors for Qext adjustment
- Vacuum vessel, spaceframe, thermal shielding
- Cavity supports, inter-cavity belows and cold-warm transitions
- Diphasic tubes and cryogenic circuits, MLI
- Instrumentation
- New assembly toolings (if needed)

New procurement strategy!

PROCUREMENT STRATEGY

- About **40 big contracts** for the procurement of components of the 30 series cryomodules
- Contracts must be prepared **in 2016** and launched in **2017** in order to meet the ESS time schedule.
- **CEA proposal: include the H-ECCTD cryostat components procurements in the series cryomodule contracts**:
  - Preparation of the CEA teams for the series cryomodule activities
  - Reduce the number of calls for tender
  - Same manufacturer for the prototype and series components

This may induce delays for:

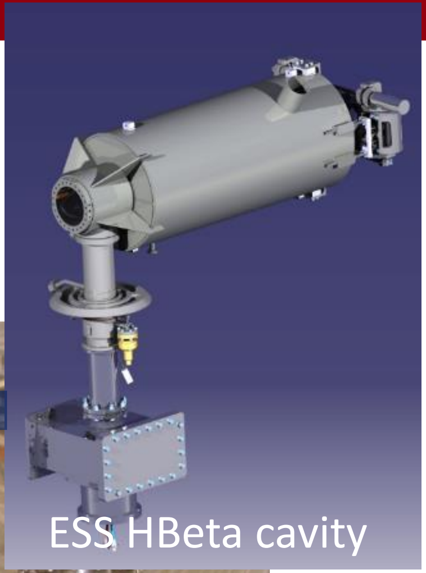
- **procurement of the H-ECCTD components**
- **CDR H-ECCTD**
- **Launch of the production of the H beta cavities of the series**

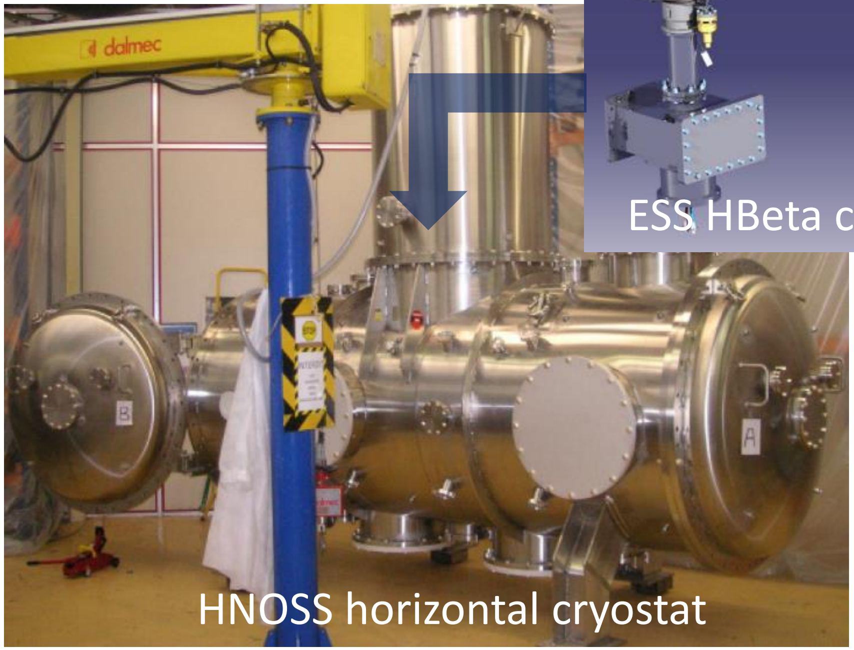
Possible mitigation = RF power test of a single cavity with power coupler and piezo tuner

TEST IN HNOSS @UPPSALA

- The HNOSS horizontal cryostat can host a Hbeta ESS elliptical cavity equipped with a power coupler, a tuner and a magnetic shield
- Uppsala will also have a 704 MHz RF source (klystron + modulator)

CEA, UU and ESS are interested in such a collaboration



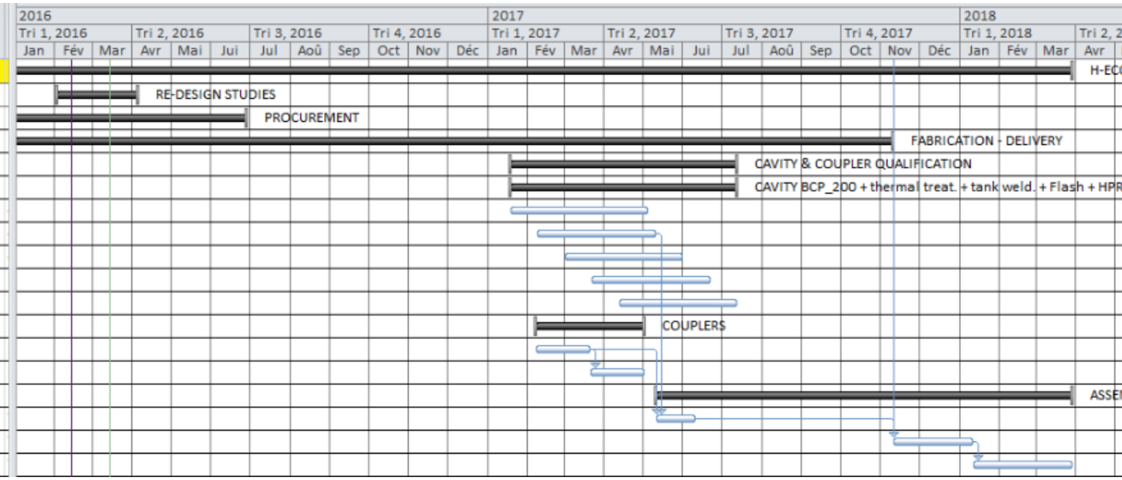


The analysis of the needed components is in progress

- Circulator, waveguide line (30 m)
- LLRF
- …

H-ECCTD PLANNING

om de la tâche	Durée	Début	Fin
H-ECCTD	**31.5 ms?**	**Lun 03/08/15**	**Mer 28/03/18**
RE-DESIGN STUDIES	**2 ms**	**Mer 03/02/16**	**Lun 04/04/16**
PROCUREMENT	**10.73 ms?**	**Lun 03/08/15**	**Lun 27/06/16**
FABRICATION - DELIVERY	**22.05 ms**	**Ven 01/01/16**	**Jeu 09/11/17**
CAVITY & COUPLER QUALIFICATION	**5.73 ms**	**Mer 18/01/17**	**Mer 12/07/17**
CAVITY BCP_200 + thermal treat. + tank weld. + Flash + HPR + CV-test	5.73 ms	Mer 18/01/17	Mer 12/07/17
Cavity ESS086-P03 (+ cv-test before thermal treat.)	3.5 ms	Mer 18/01/17	Jeu 04/05/17
Cavity ESS086-P04	3 ms	Mer 08/02/17	Mer 10/05/17
Cavity ESS086-P05	3 ms	Mer 01/03/17	Mer 31/05/17
Cavity ESS086-P06	3 ms	Mer 22/03/17	Mer 21/06/17
Cavity ESS086-P07	3 ms	Mer 12/04/17	Mer 12/07/17
COUPLERS	2.73 ms	Mar 07/02/17	Lun 01/05/17
Couplers #5-6 assembly & conditioning	6 sm	Mar 07/02/17	Lun 20/03/17
Couplers #7-8 assembly & conditioning	6 sm	Mar 21/03/17	Lun 01/05/17
ASSEMBLY & QUALIFICATION TEST	**10.45 ms**	**Jeu 11/05/17**	**Mer 28/03/18**
Cleanroom assembly	1 ms	Jeu 11/05/17	Ven 09/06/17
Cryostating assembly (vacuum vessel !)	2 ms	Ven 10/11/17	Mer 10/01/18
Power test qualification H-ECCTD	2.5 ms	Jeu 11/01/18	Mer 28/03/18



- 2016: procurement process and start of the components fabrication
- 2017: cavity and coupler preparation and tests
- Nov. 2017 -> Mars. 2018: Cavity string integration and cryostating
- May 2018: High power tests (first main results)

The “high beta H-ECCTD CDR” planned in Oct. 2017 would be delayed in April 2018 or late in 2018

Mitigation proposed: RF power test of a single cavity/coupler/tuner in the horizontal cryostat HNOSS in October 2017

THANK YOU for your attention

Extra slides

FRAMEWORK OF THE ACTIVITIES
ESS – CEA – INFN - STFC

WP5:

External WPL: P. Bosland - ESS deputy WPL: C. Darve

1. **Two prototype cryomodules:**
    2. medium beta: M-ECCTD <= **FR-SW** agreement
    3. High beta: H-ECCTD <= **CEA** FR In Kind Contribution

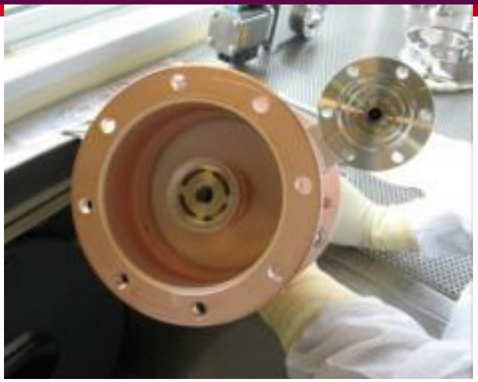
2. **Production of cavities of the series with RF tests**:
    3. medium beta cavities <= **LASA** - IT In Kind Contribution
    4. High beta cavities <= **STFC** - UK In Kind Contribution

3. **Production of all other components**: <= **CEA** FR In Kind Contribution
(including coupler production with RF power processing)

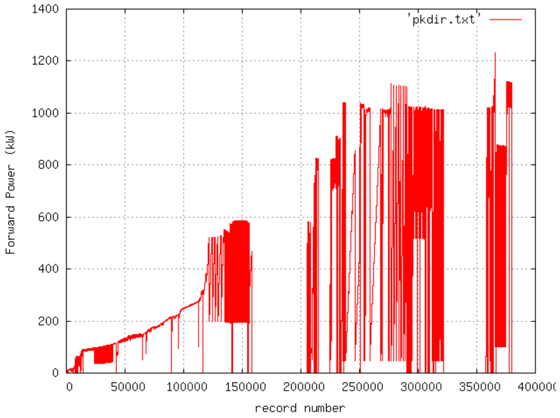
4. **Cryomodule assembling** : <= **CEA** FR In Kind Contribution

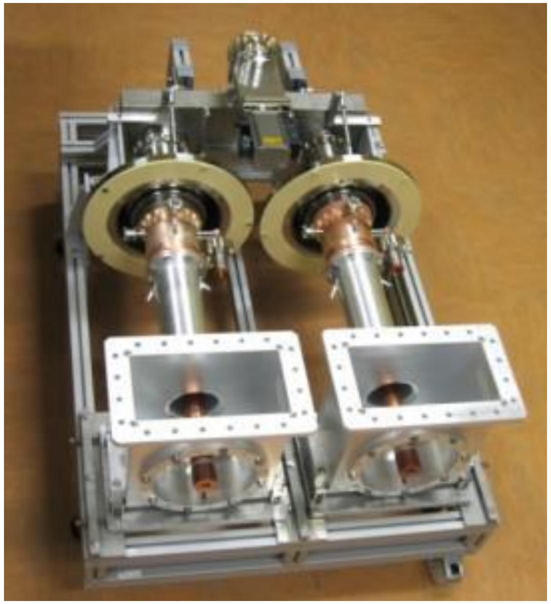
5. **RF power tests of the cryomodules** <= **ESS** Lund

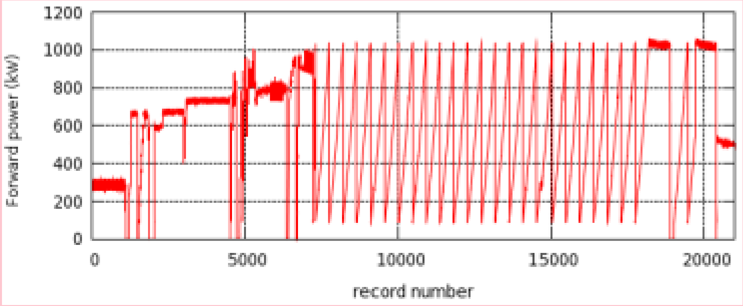
EXPERIENCE OF THE HIPPI POWER COUPLER AT SACLAY



HIPPI power coupler (KEK-type window) tested to 1.2 MW, 10% Duty factor at Saclay

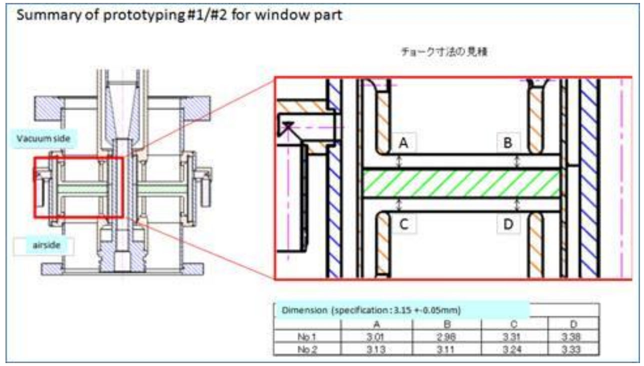






Test of the HIPPI power coupler on the HIPPI cavity at 1.8 K, full reflection

MANUFACTURING OF THE CERAMIC WINDOWS AT TOSHIBA

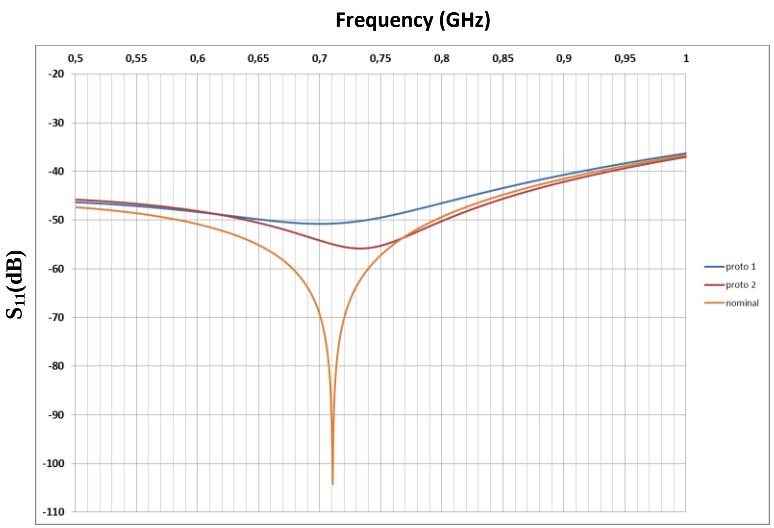


Non conformities on the distance from the chokes to the ceramic surfaces

	Vacuum side (external/internal choke)	Air side (external/internal choke)
Nominal	3.15 (mm)	3.15 (mm)
Proto 1	3.01/2.98 (mm)	3.31/3.38 (mm)
Proto 2	3.13/3.11 (mm)	3.24/3.33 (mm)

Design of the coupler +/- 0.05mm

Measurement of the chock-ceramic gaps

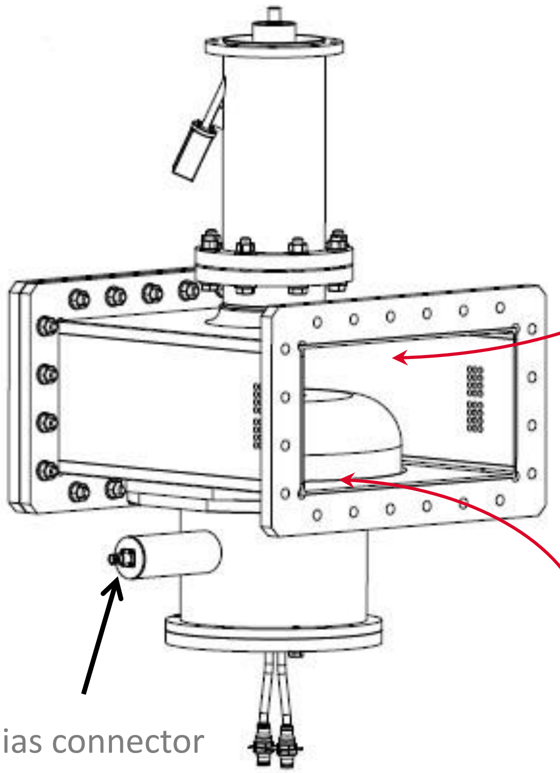


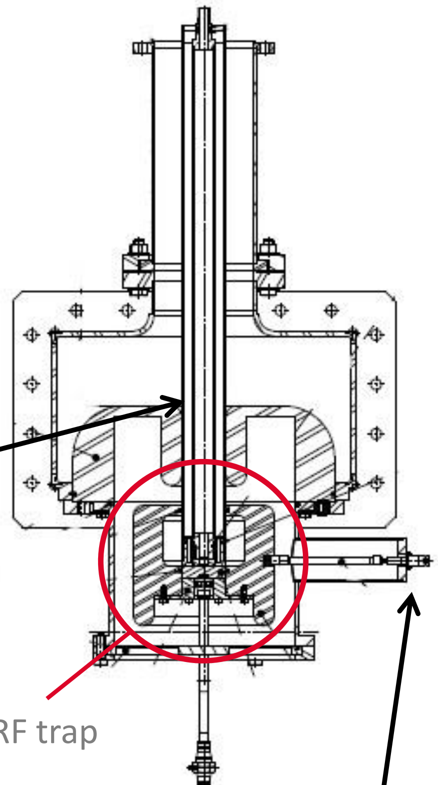
Simulation of the S_{11} parameters for different chocke defects measured on the real ceramic windows of the 2 first couplers

The simulation showed that the ceramic windows can be accepted.

DOORKNOB MODIFIED TO ADD A BIAS ANTENNA SYSTEM

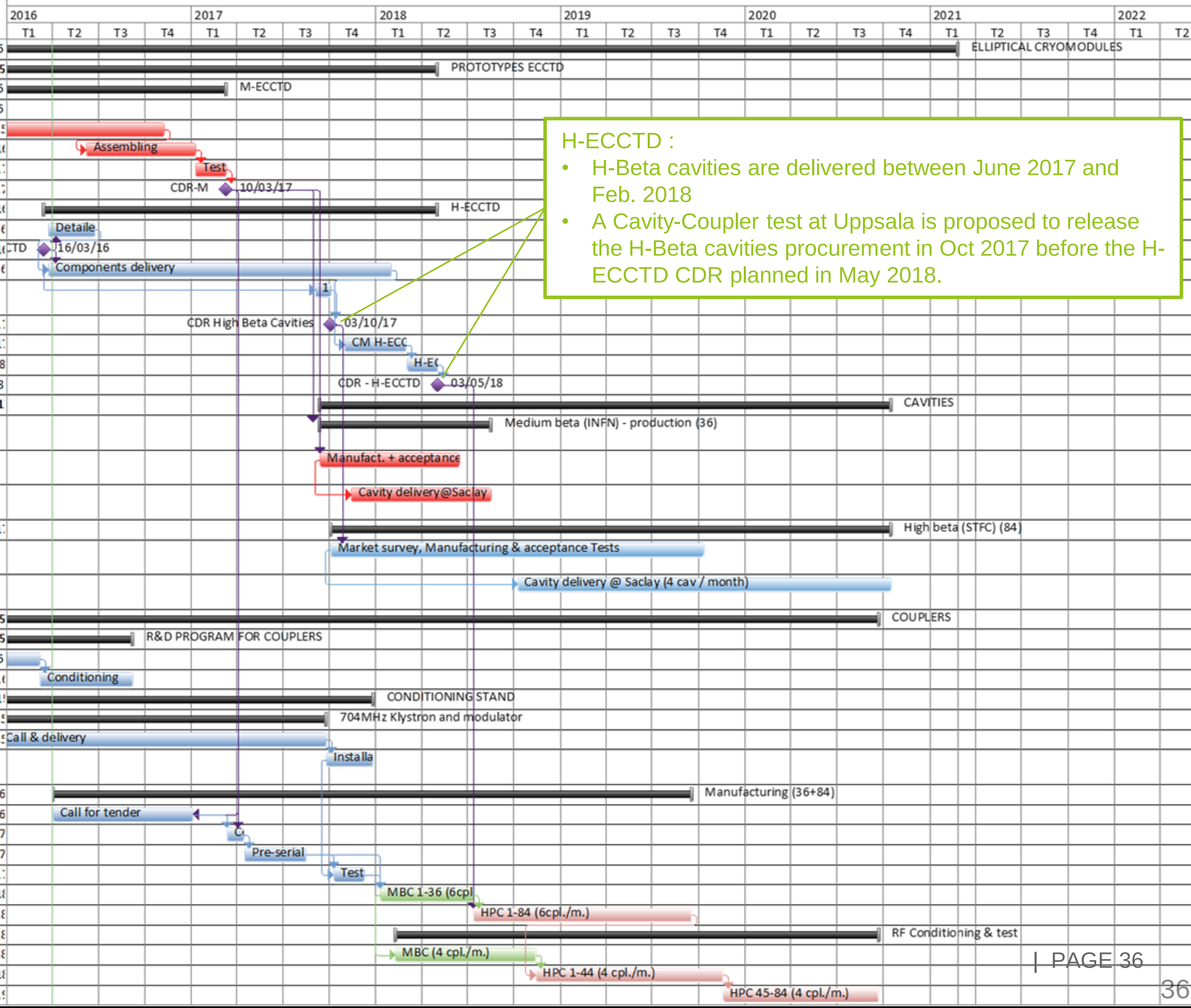
- Transition WG / coax at 704MHz (RF adaptation)
- Bias voltage applied to the antenna: max 10kV
- Water cooling inside the antenna





CRYOMODULES TIME SCHEDULE (BASELINE) COMPONENTS PROCUREMENTS

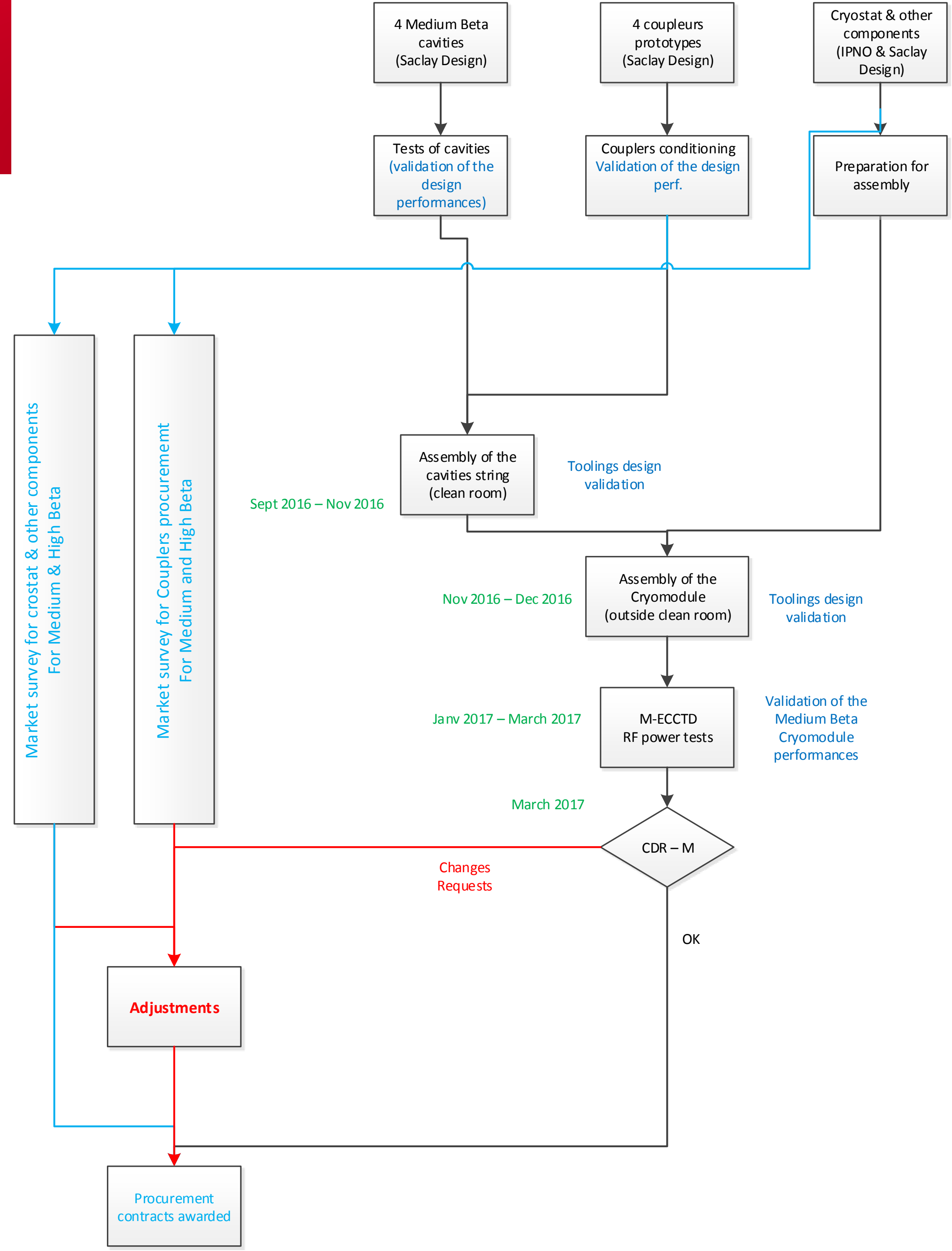
Nom de la tâche	Durée	Début
ELLIPTICAL CRYOMODULES	73 ms	Jeu 01/01/15
PROTOTYPES ECCTD	**39,59 ms**	**Jeu 01/01/15**
M-ECCTD	26 ms	Jeu 01/01/15
Studies	6 ms	Jeu 01/01/15
Components Delivery	19 ms	Ven 03/04/15
Assembling	7 ms	Mer 08/06/16
Tests	2 ms	Mar 10/01/17
CDR-M	0 ms	Ven 10/03/17
H-ECCTD	25,32 ms	Mer 16/03/16
Detailed Studies	3 ms	Ven 25/03/16
Kick Off Meeting H-ECCTD	0 ms	Mer 16/03/16
Components delivery	22 ms	Ven 25/03/16
1st High Beta cavity + coupler tests (@ Uppsala ?)	1 ms	Lun 04/09/17
CDR High Beta Cavities	0 ms	Mar 03/10/17
CM H-ECCTD Assembling	4 ms	Mer 01/11/17
H-ECCTD Tests	2 ms	Lun 05/03/18
CDR - H-ECCTD	0 ms	Jeu 03/05/18
CAVITIES	**36,68 ms**	**Mer 13/09/17**
Medium beta (INFN) - production (36)	11 ms	Mer 13/09/17
Manufact. + acceptance tests	9 ms	Mer 13/09/17
Cavity delivery@Saclay : 4/months	9 ms	Mar 14/11/17
High beta (STFC) (84)	36 ms	Mer 04/10/17
Market survey, Manufacturing & acceptance Tests	24 ms	Mer 04/10/17
Cavity delivery @ Saclay (4 cav / month)	24 ms	Mar 09/10/18
COUPLERS	**67,86 ms**	**Jeu 01/01/15**
R&D PROGRAM FOR COUPLERS	**20 ms**	**Jeu 01/01/15**
Prototyping	14 ms	Jeu 01/01/15
Conditioning	6 ms	Mar 08/03/16
CONDITIONING STAND	**24 ms**	**Ven 18/12/15**
704MHz Klystron and modulato	21 ms	Ven 18/12/15
Call & delivery	21 ms	Ven 18/12/15
Installation and Commissioning	3 ms	Mar 26/09/17
Manufacturing (36+84)	41 ms	Lun 04/04/16
Call for tender	9 ms	Lun 04/04/16
Couplers contract awarded	5 sm	Lun 13/03/17
Pre-serial manufacturing (4)	4 ms	Lun 17/04/17
Tests & condtitioning of preseri	2 ms	Mar 10/10/17
MBC 1-36 (6cpl./m.)	6 ms	Mer 10/01/18
HPC 1-84 (6cpl./m.)	14 ms	Ven 13/07/18
RF Conditioning & test	31 ms	Ven 09/02/18
MBC (4 cpl./m.)	9 ms	Ven 09/02/18
HPC 1-44 (4 cpl./m.)	12 ms	Mer 14/11/18
HPC 45-84 (4 cpl./m.)	10 ms	Mar 19/11/19



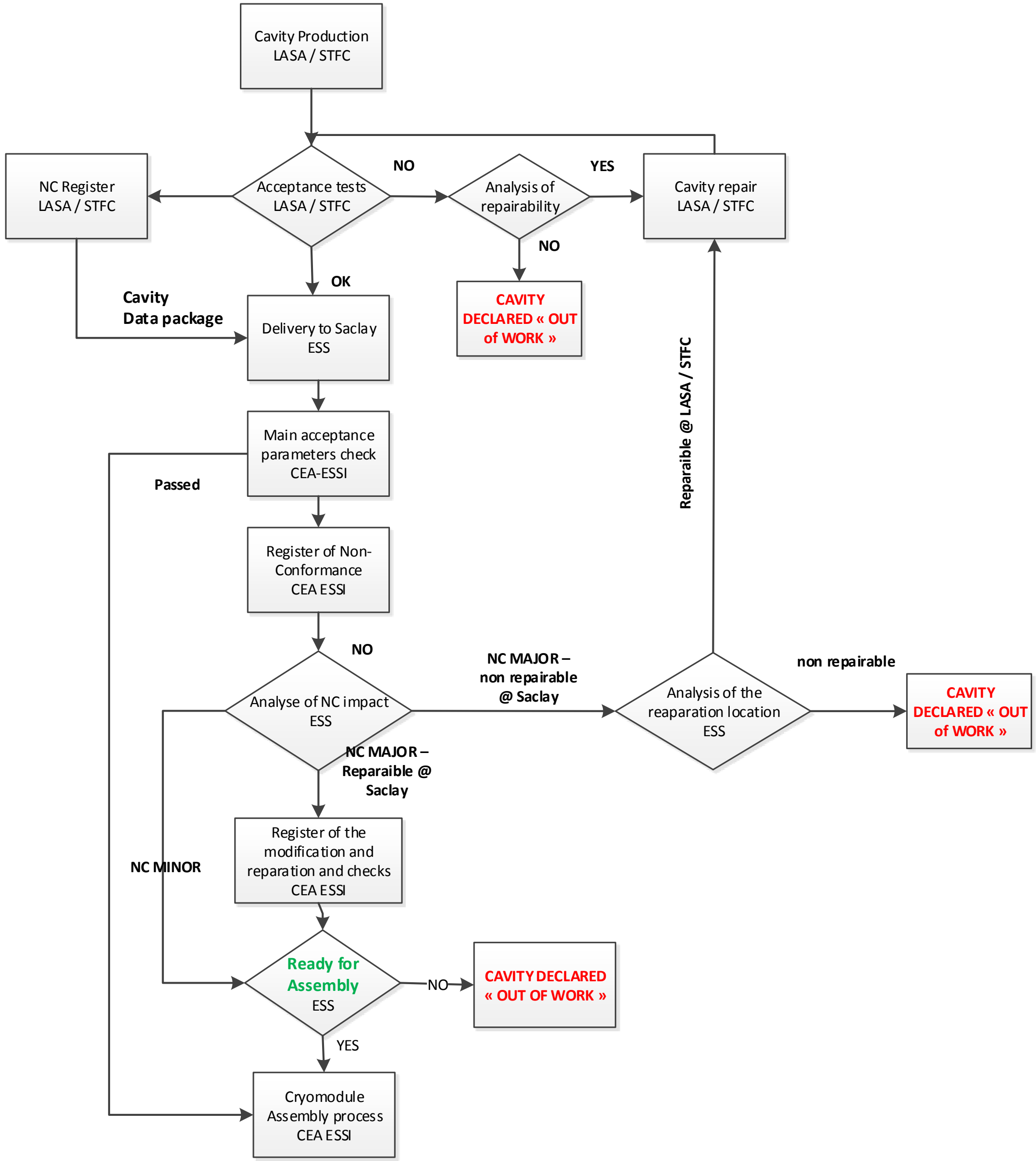
H-ECCTD :

- H-Beta cavities are delivered between June 2017 and Feb. 2018
- A Cavity-Coupler test at Uppsala is proposed to release the H-Beta cavities procurement in Oct 2017 before the H-ECCTD CDR planned in May 2018.

DEVELOPMENT PLAN FOR M-ECCTD (BASELINE)



PROPOSED FLOW CHART FOR THE ACCEPTANCE OF THE CAVITIES BEFORE CRYOMODULE ASSEMBLY

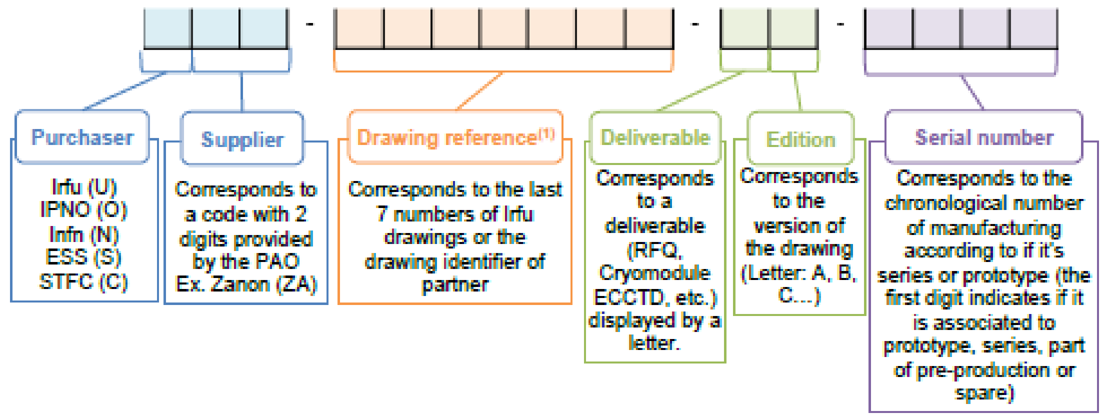


IDENTIFICATION AND MARKING OF ESSI PROJECT'S DELIVERABLES | CEA-ESS-PJT-NT-0001 A | Page 1 / 7

Technical note

IDENTIFICATION AND MARKING OF ESSI PROJECT'S DELIVERABLES

	Edited by	Reviewed by		Approved by
Name	Anaïs BRUNIQUEL	Vincent HENNION	Christelle CLOUÉ	Florence ARDELLIER
Function	Quality Engineer	Configuration management responsible of ESSI Project	Product Assurance Officer of ESSI Project	CEA Project leader for ESSI
Date and visa	18/03/16	18-03-2016	18-03-2016	18.03.2016



(1) If there is no drawing reference, a unique identification code can be proposed by the purchaser and apply after the approval by the configuration manager of ESSI project and the PAO. It shall be a group of letters which is representative of the component. For example: Multi-Layer Insulation (MLI) with JUMPVER for the MLI of the Jumper thermal screen (for ECCTD).

Figure 1 – Identification code

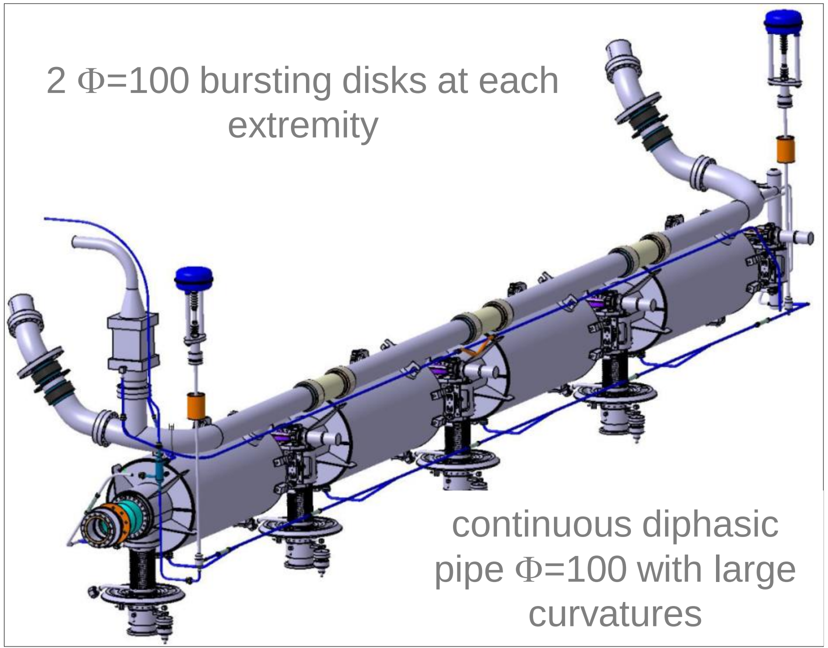
For example: cavity of the cryomodule H-ECCTD

U Z A - 0 0 2 1 0 0 1 - R C - 0 0 0 1

The Purchaser is Irfu (U)
The supplier is Zanon (ZA)
The identifier of irfu Drawing is "71 HAAV DM- 0021 001 RC" where "R" of "RC" is for "ECCTD" and C of "RC" is the C version
It's the first prototype of cavity (0001).

Compliance with European PED 97/23/EC

Cryo pipes designed to reduce the overpressure in case of beam vacuum failure



TUV Nord analysis report: The elliptical cryomodules are classified according to PED article 3.3

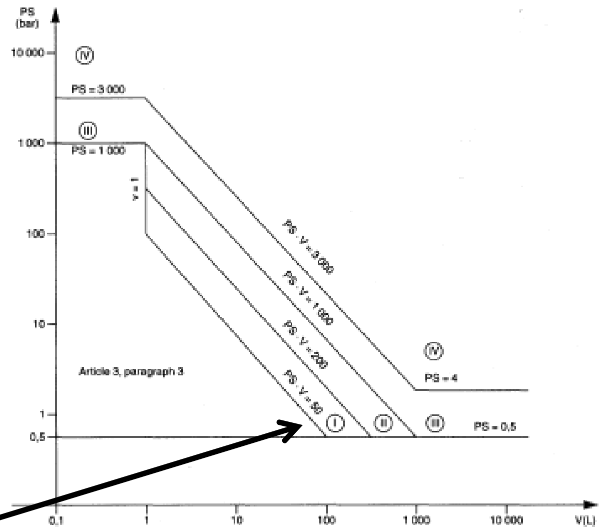


Table 2

Vessels referred to in Article 3, Section 1.1 (a), second indent

- Volumes of the helium circuits and vessels < 50 l
- 1,431 bars< Working pressure
- Ps = 1,9 bars

CEA IRFU CRYOMODULE TEAM