DE LA RECHERCHE À L'INDUSTRIE

CEA – Saclay

www.cea.fr

CRITICAL DESIGN REVIEW #1 FOR MEDIUM BETA CAVITY CRYOMODULES

3-4 APRIL 2017

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CRYOMODULE OVERVIEW, ORGANIZATION AND DEVELOPMENT PLAN

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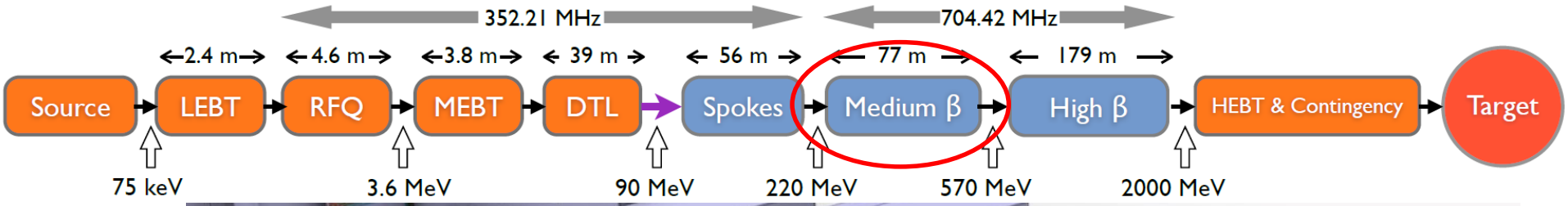
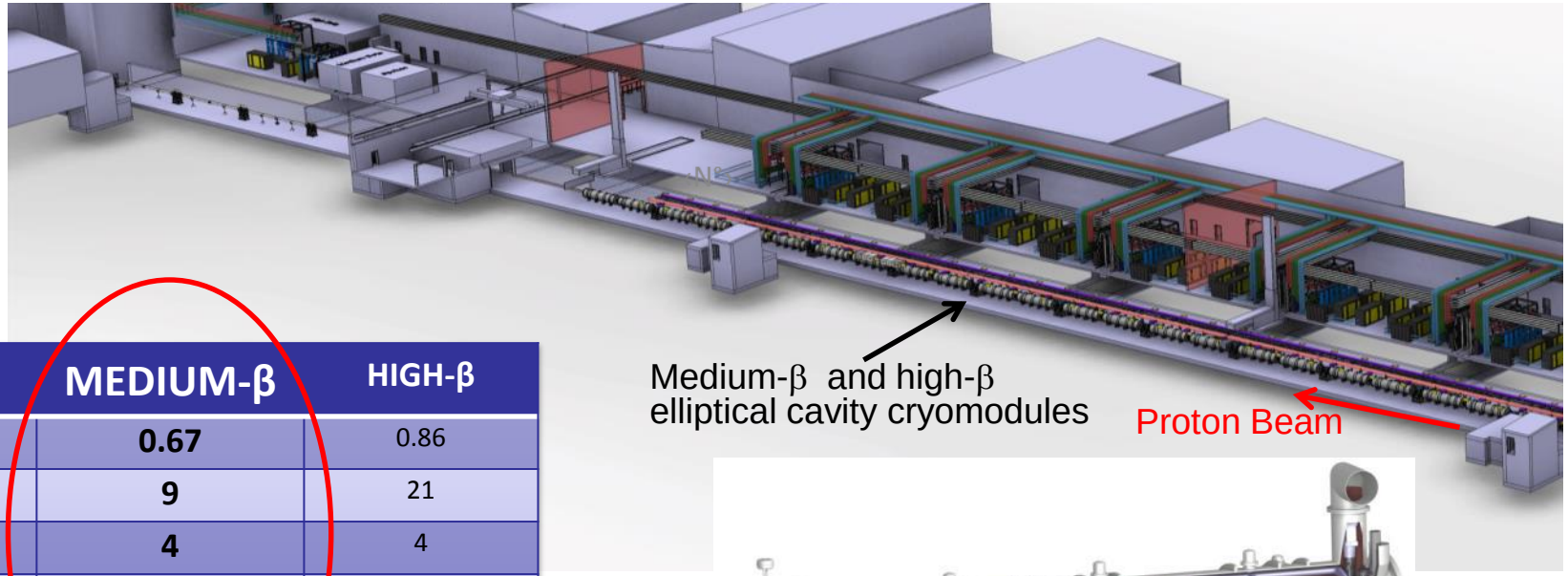
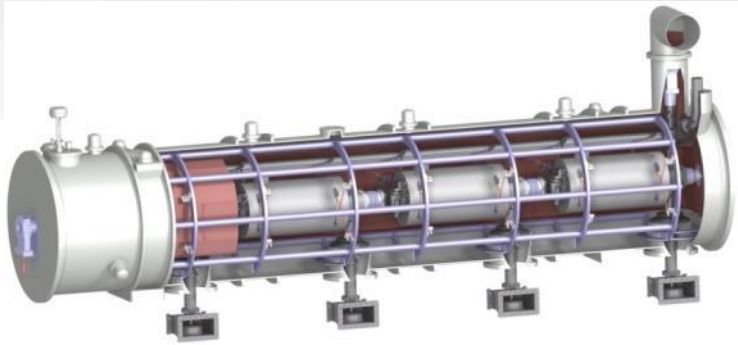
FRANCK PEAUGER

MEDIUM BETA CRYOMODULES IN ESS LINAC





	MEDIUM-β	HIGH-β
β	**0.67**	0.86
# CM	**9**	21
Cav. /CM	**4**	4
# Cav.	**36**	84
CM L [m]	**6.584**	6.584
Sector L [m]	**77**	179



CEA – ESS AGREEMENTS FOR THE ELLIPTICAL CRYOMODULES

- Fr-Sw Agreement:
  - Cooperation Agreement in the field of Neutron Accelerator Science to the ESS Design Phase, Amendment #2, 18 December 2013
    - Medium-Beta Elliptical Cavity Cryomodule Technology Demonstrator (M-ECCTD)

- Schedules of the In Kind Contribution Agreement
  - AIK#1.1: Technical Management Scope of Work to the In-Kind Contribution Agreement signed between ESS-ERIC and CEA
  - AIK#5.1 High-Beta Elliptical Cavity Cryomodule Technology Demonstrator (H-ECCTD)
  - AIK#5.2 Elliptical Medium and High Beta Cryomodule Component Supply
  - AIK#5.3 Elliptical Cryomodules Engineering, Assembly and Test and Technical Assistance in Cavity Design, Manufacturing and Tests
  - AIK#5.5 Elliptical Cryomodules Installation and Commissioning

SCOPE OF THE MEDIUM BETA CRYOMODULES ACTIVITIES

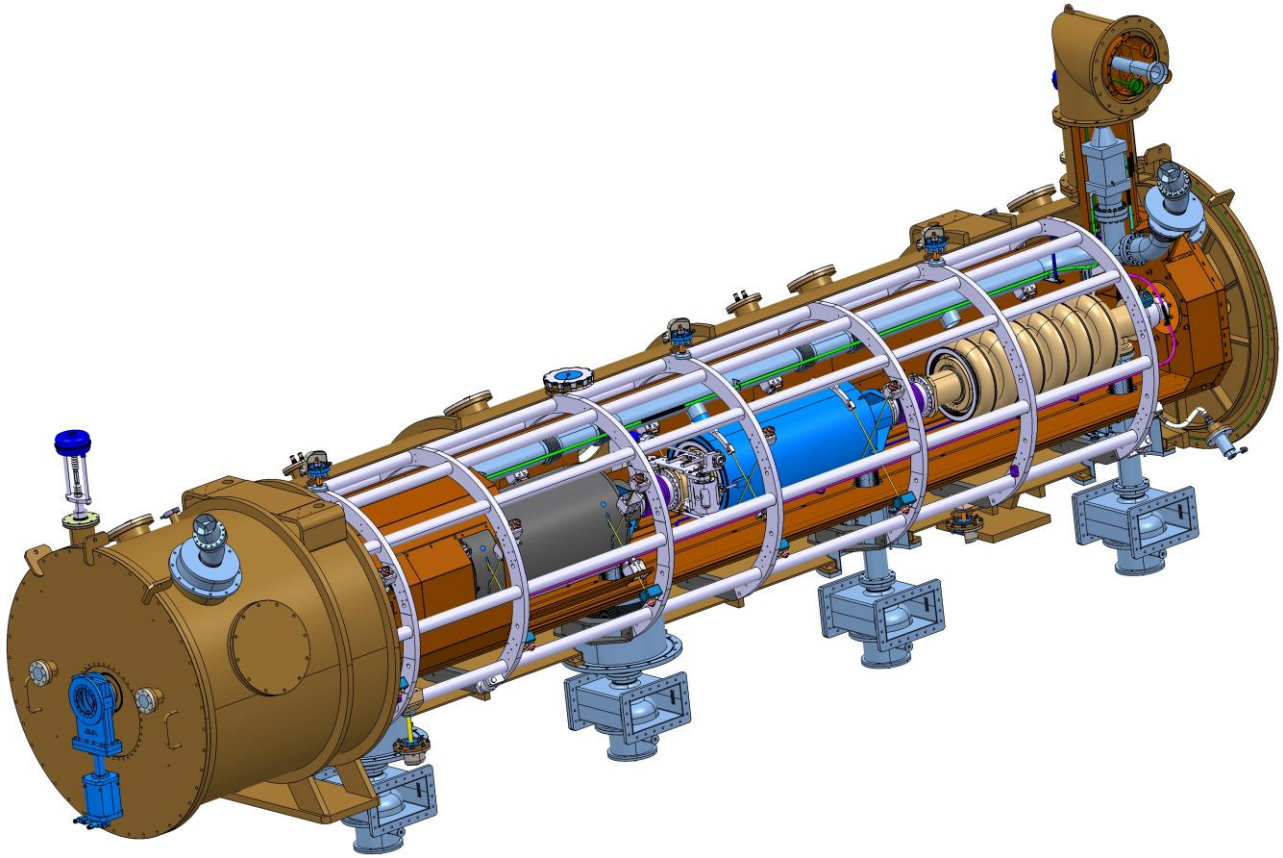
- CEA is charge of all the prototyping activities and series production of the 9 medium beta cryomodules except:
  - The design and prototyping of the cryostat (IPN Orsay)
  - the production of the series medium beta cavities (INFN/LASA)
  - The RF power acceptance tests of the cryomodules at ESS in Lund
- The INFN/LASA proposed a new medium beta cavity design slightly different from the one developed in the prototyping phase by CEA
- **Activities done in two steps:**
  - **Development of a cryomodule demonstrator M-ECCTD**
  - **Delivery of the nine series medium beta cryomodules**

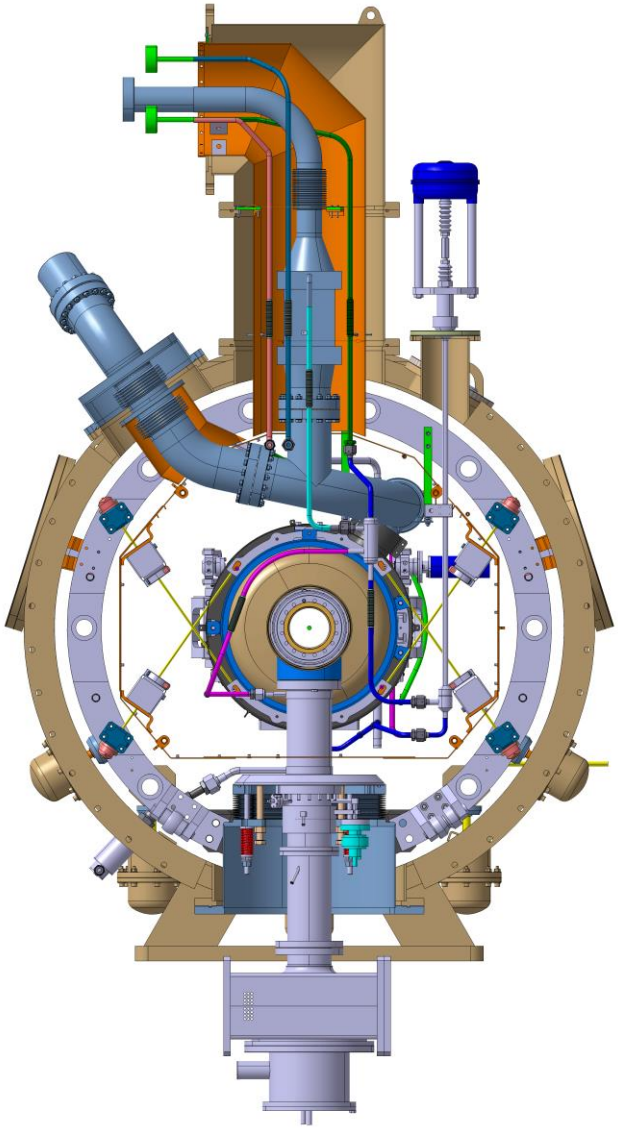
	M-ECCTD	M-SERIE
β	0.67	0.67
# CM	1	9
Cav. /CM	4	4
# Cav.	3 + 1 LASA + 3 spares	36

DETAILED SCOPE

- For the prototype phase M-ECCTD :
  - design and procurement of the cavities, couplers, tuners, magnetic shieldings (CEA)
  - Design and procurement of the vacuum vessel, spaceframe, thermal shielding, cryogenic circuits (IPNO)
  - Preparation and tests of the cavities and couplers (CEA)
  - design and fabrication of the cryomodule assembly toolings (CEA)
  - Development of the high power test stations (for couplers and cryomodules) (CEA)
  - assembly and high power RF tests of the cryomodule (CEA)
- For the series phase:
  - CEA is responsible for:
    - the procurement of the cryomodule components (except cavities)
    - the clean room preparation and RF conditioning of the power couplers
    - the assembly of the nine cryomodules
    - the high power RF tests of the three first cryomodules at CEA
    - The prepare the cryomodule for shipment to Lund
  - INFN is responsible for the procurement, preparation and tests of the cavities
  - IPNO is responsible for the update of the cryostat components design and drawings

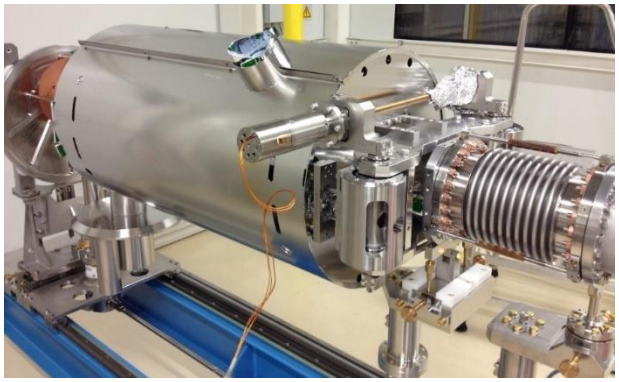
ESS MB CRYOMODULE 3D VIEW AND CROSS SECTION



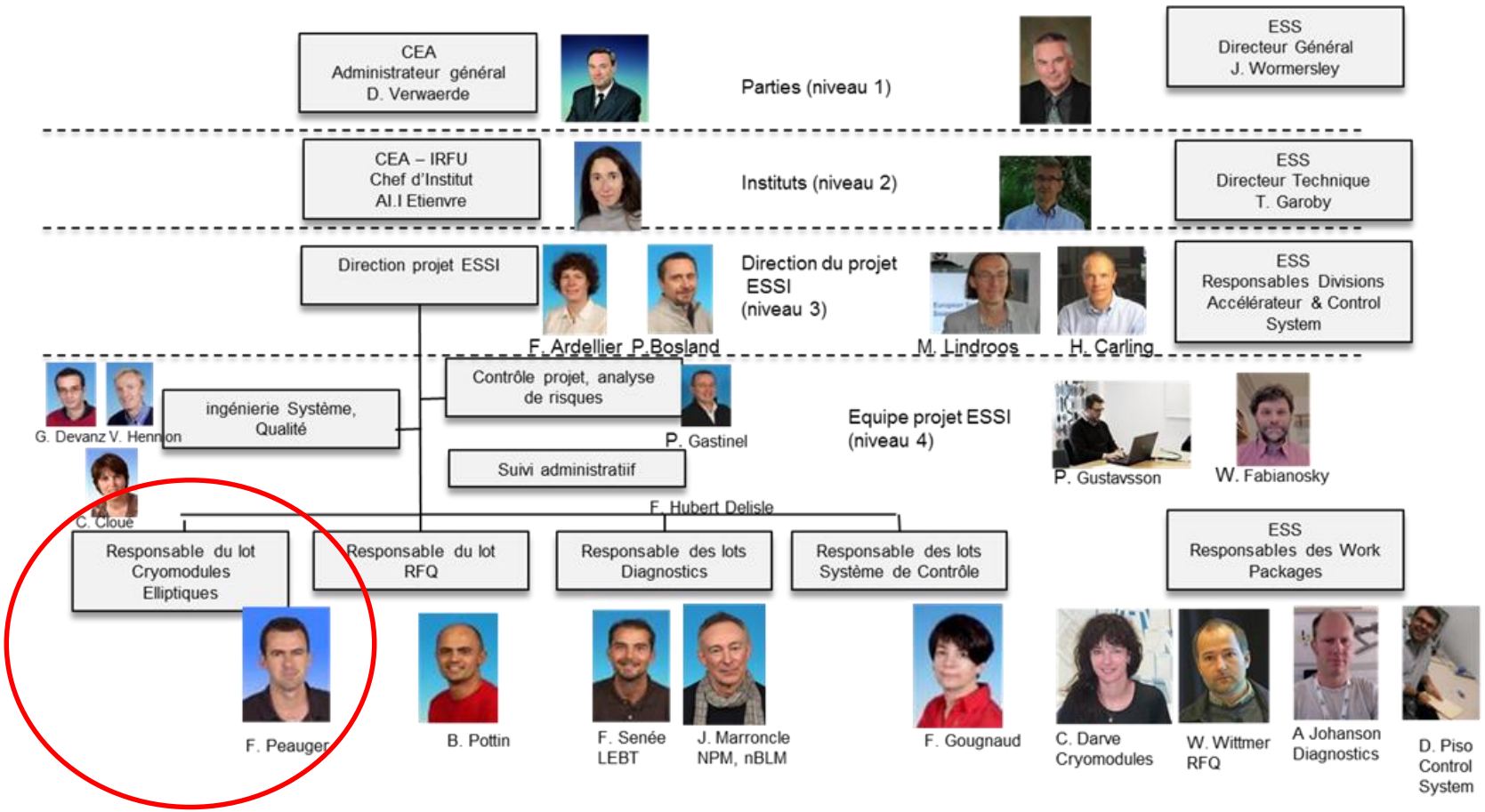


MEDIUM BETA CRYOMODULE MAIN SPECIFICATIONS

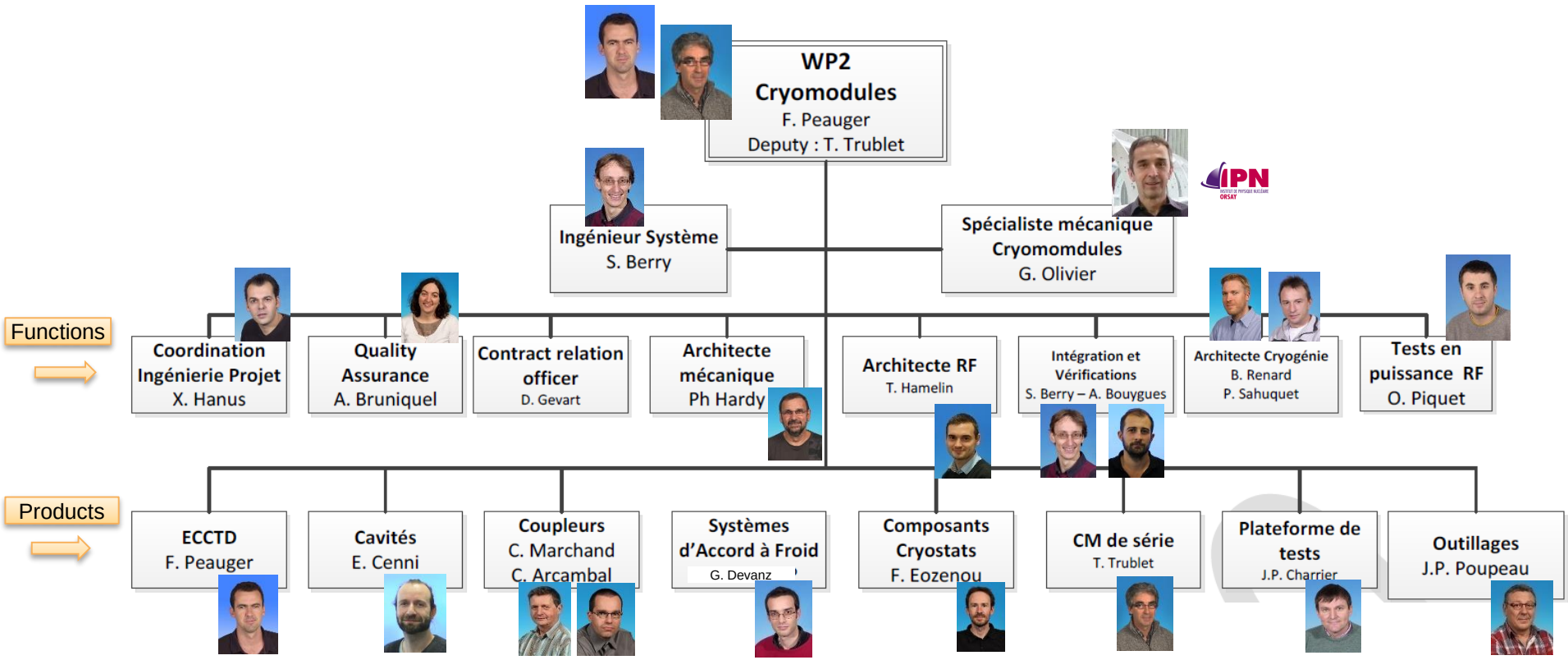
- **Four superconducting cavities in pure bulk niobium (RRR>250)**
  - Frequency: 704.42 MHz
  - 6 cells at β=0.67
  - Beam pulse: 2.86 ms at 14 Hz
  - No HOM couplers (decided at the PDR)
- Accelerating gradient
  - E_{acc} max = **16.7 MV/m**, $Q_0 > 5.10^9$
  - Power coupler: **1.1 MW max**
  - External coupling: $Q_{ext} = 7.5.10^5$
- Slow tuning system: ± 300 kHz
- Fast tuning system (LFD) : 1+1 piezo
- Cavity cooling: LHe at 2 K
- Coupler cooling: SHe at 4.5 K, 3 bars
- Thermal shielding cooling: LHe 50 K
- Overall length: 6584 mm from flange to flange
- Thermal losses (for MB):
  - Static losses at 50 K: 46.2 W
  - Static losses at 2 K: 13.2 W
  - Dynamic losses at 2 K: 23.2 W
- Pressure vessel: good engineering practice (article 4.3 of PED)



ORGANISATION CHART (ESSI PROJECT LEVEL)



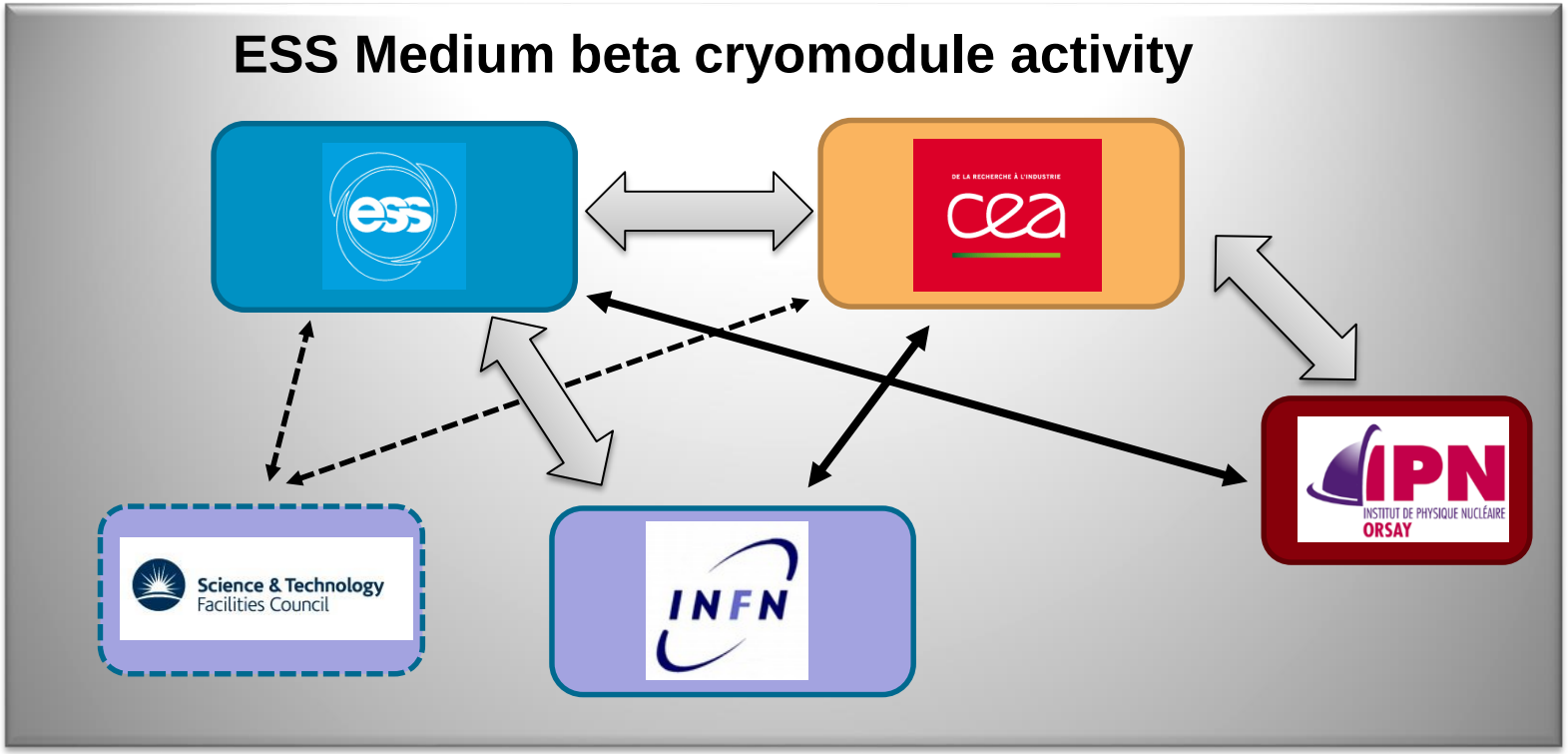
ORGANISATION CHART (CRYOMODULE LEVEL)



+ CEA/DRF purchase department (« Service Commercial »)

+ CEA/DRF/IRFU/SACM Infrastructures and Safety managers

PROJECT ORGANISATION AND COLLABORATIONS

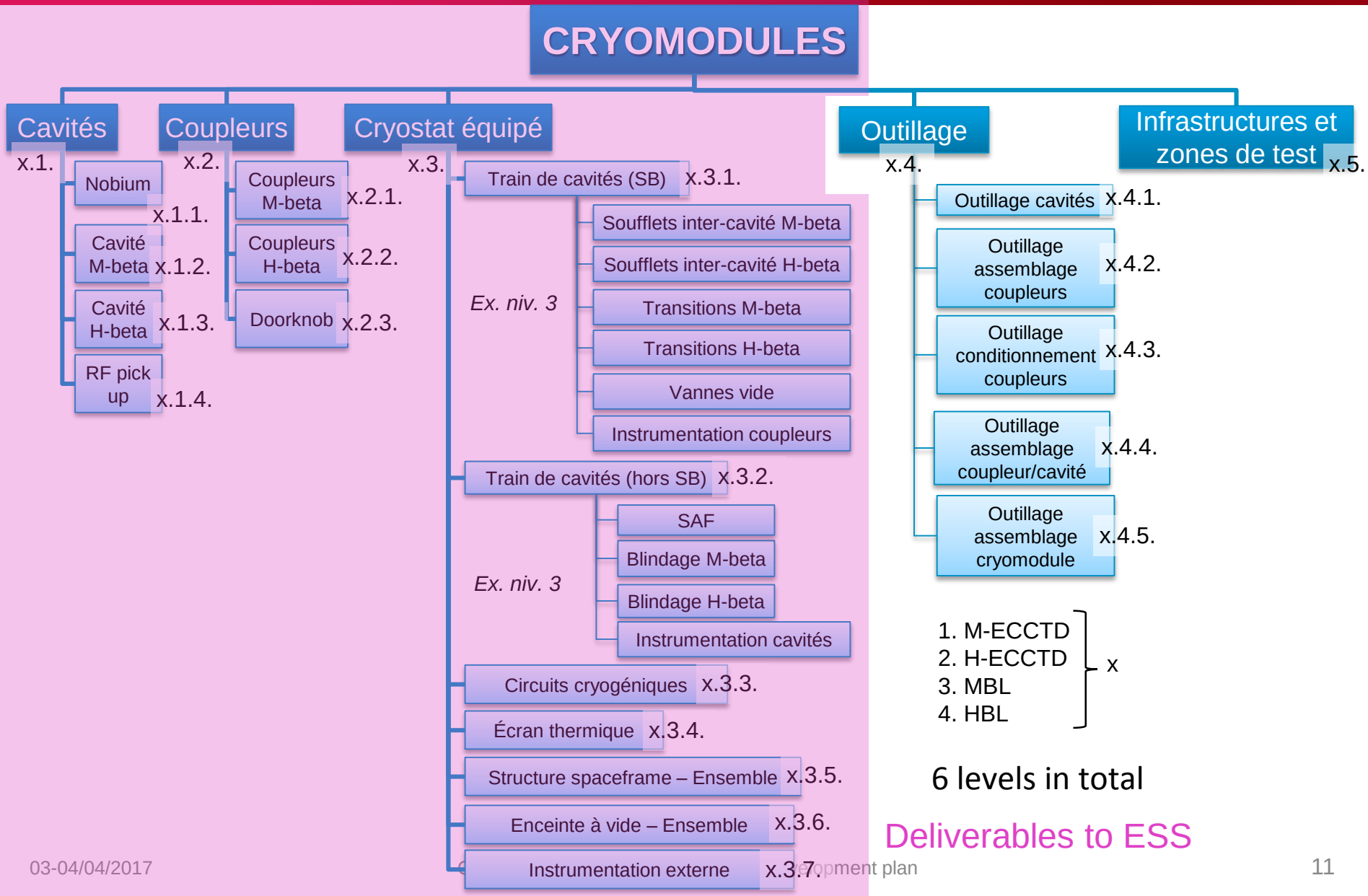


Contractual links

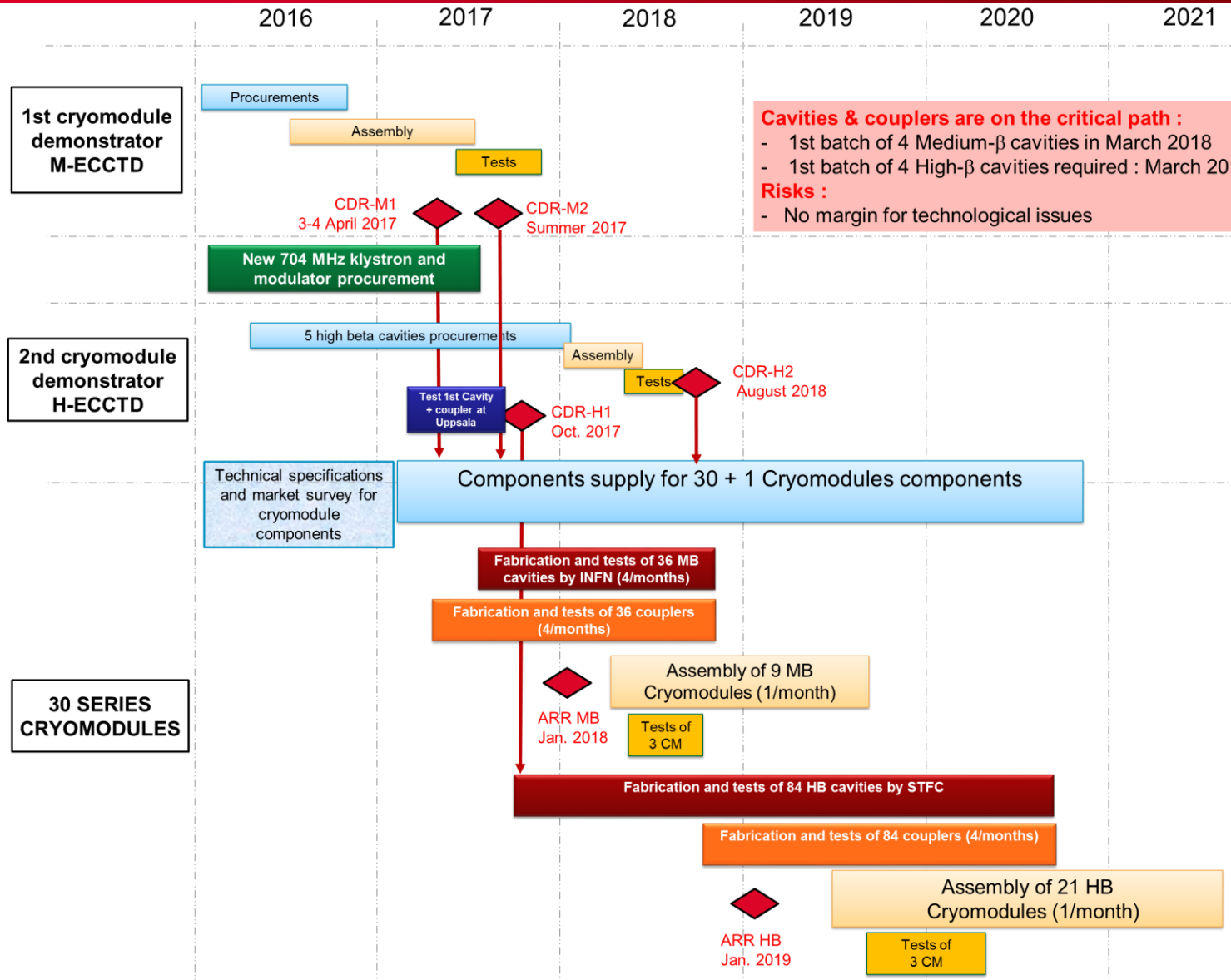
"short links" for technical exchanges
(with ESS and CEA always in copy)

"Observers"

PRODUCT BREAKDOWN STRUCTURE (PBS)



OVERALL ESS CRYOMODULE DEVELOPMENT PLAN



MEDIUM BETA CRYOMODULES DEVELOPMENT PLAN AND REVIEWS

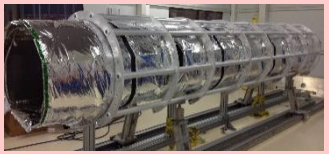
Fabrication, surface preparation and test of medium beta cavities

Fabrication and test of power couplers

Development and fabrication of assembly toolings

Assembly of a cryomodule mock-up

Procurement of cryostat components



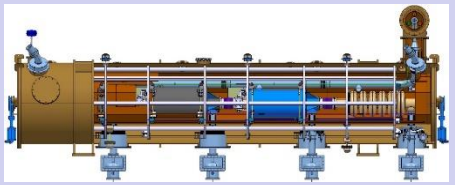
Clean room assembly of the M-ECCTD cavity string

CDR-M1

03&04/04/2017

Final assembly and high power test of the M-ECCTD

- **Cavity performances in a cryomodule configuration**
- Validation of the cryogenic circuits operation



CDR-M2

Summer 2017

Procurement of the series cryomodule components

End March 2018

SAR

System Acceptance Review for Medium-beta pre-series components

Mars 2019

SAR

System Acceptance Review for Medium-beta series components

Jan 2018

ARR

Assembly Readiness review

First 4 MB cavities arrives 2 months later

→ **March 2018 (from LASA)**

Acceptance for shipment to Lund

Oct. 2018	*Jan 2019*	*Apr. 2019*
SAR1	SAR1	SAR1
CM1,2,3	**CM4,5,6**	**CM7,8,9**

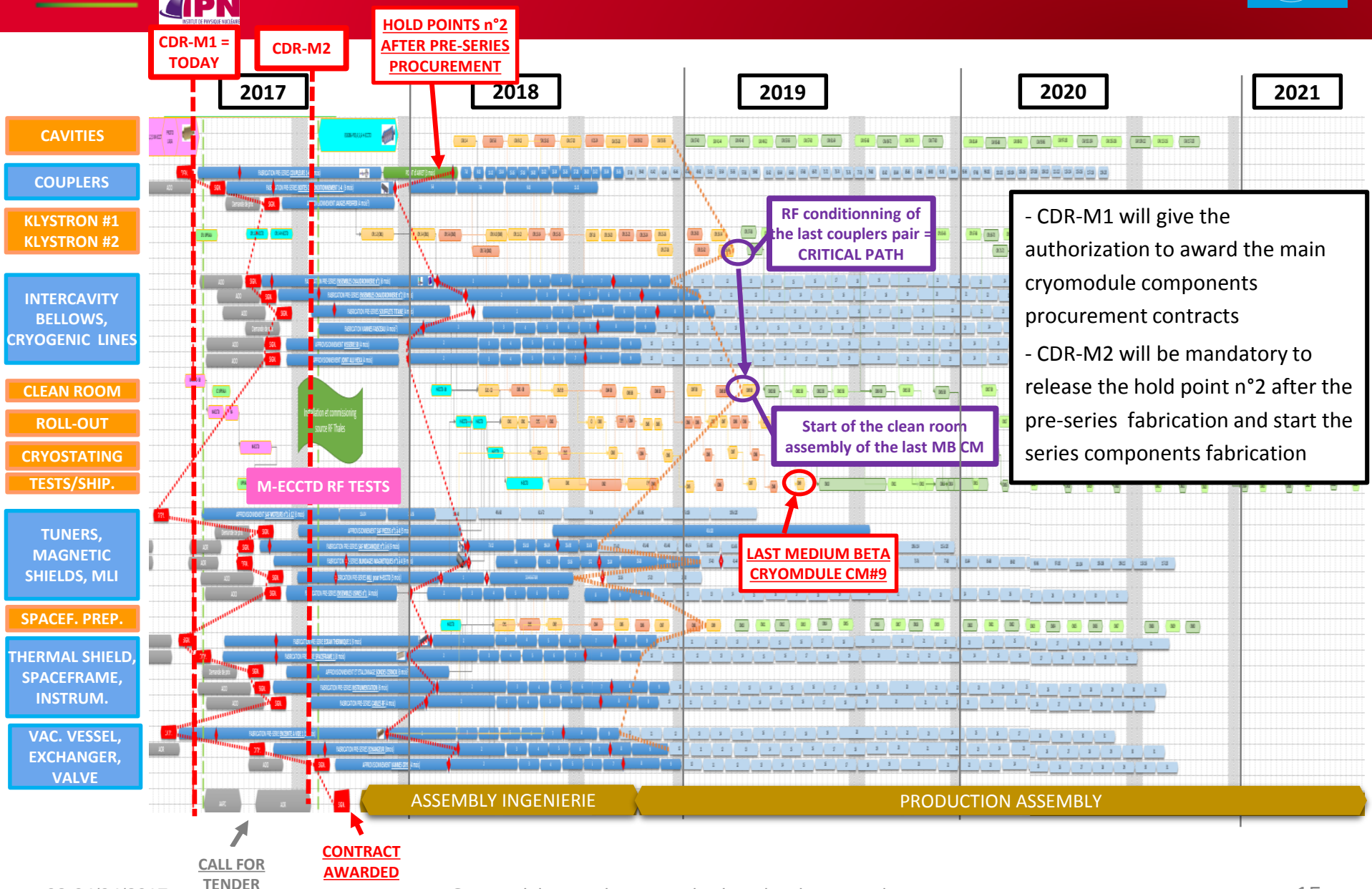
Acceptance after RF test at Lund

Dec 2018	*March 2019*	*July 2019*
SAR2	SAR2	SAR2
CM1,2,3	**CM4,5,6**	**CM7,8,9**

KEY POINTS

- Cryomodule components procurement:
  - Divided in several procurement contracts adapted to the skills of the companies
- Cryomodule assembly :
  - Assembly rate of one cryomodule per month
  - Will be performed in the former “XFEL Village” which becomes officially now the “ESS Village”
    - Fully dedicated to the ESS cryomodule (no interference with other projects at Irfu)
  - Will be done by an industrial partner on CEA Saclay site, under the supervision of CEA team
    - Include clean room cavity string assembly, rool –out activities, alignment and cryostating (XFEL like)
    - Include also power coupler clean room preparation (same clean room) (new!)
- Cryomodule tests at CEA:
  - Will be done on the three first series MB cryomodules only
  - These tests are mandatory to have a fast feedback on the quality of the cryomodule assembly

PROCUREMENT AND ASSEMBLY ROADMAP



CONCLUSION

- Cryomodule scope and development plan well defined
- Organization in place and structured within the ESSI project and within an international collaboration
- Procurement process anticipated and fully optimized to limit technical risks and to “fine-tune” the cryomodule delivery schedule

Thank you

•Commissariat à l'énergie atomique et aux énergies alternatives
•Centre de Saclay ¦ 91191 Gif-sur-Yvette Cedex
•T. +33 (0)1 69 08 76 11 ¦ F. +33 (0)1 69 08 30 24
•Etablissement public à caractère industriel et commercial ¦ RCS Paris B 775 685 019

ORGANISATION: MEETINGS

Internal CEA meetings

- ESSI Project meeting
  - with all the workpackage + CEA purchase department
  - Every month (Thursday morning)
- ESS cryomodules meeting:
  - with all the workpackage + CEA purchase department
  - Every month (Thursday morning)
- Non-conformity/modification meeting:
  - Internal meeting at CEA with workpackage leaders, Quality team and system engineer
  - Tuesday afternoon every 2 weeks
- Infrastructures meeting:
  - Internal meeting at CEA with infrastructures leaders and other project leaders
  - Agree on short term schedule for chemical treatment, clean rooms, testing activities
  - Every Friday afternoon

Organized by ESS

- SRF meeting :
  - Visio
  - ESS / CEA / INFN / STFC
  - every Friday morning
- Interface meeting:
  - Visio
  - ESS / CEA / IPNO
  - Every Tuesday afternoon
- SRF collaboration meeting
  - ESS / CEA / INFN / STFC
  - every 3 months