MODULE ASSEMBLY:

FROM ESS TO PIP-II
PREPARATION OF THE PRODUCTION OF THE 30 ESS ELLIPTICAL CRYOMODULES IN CEA SACLAY
INTRODUCTION

- As part of the ESS project CEA is in charge of assembling 32 elliptical Cryomodules including 2 demonstrators

  - 2 Demonstrators
    - 1 cryomodule medium beta
    - 1 cryomodule high beta

  - 30 series cryomodules
    - 9 cryomodules medium beta
    - 21 cryomodules high beta

- MB cavity accelerating gradient = 16.7 MV/m (6 cells)
- HB cavity accelerating gradient = 19.9 MV/m (5 cells)
THE ACTORS OF THE CM PRODUCTION

CEA
- 3 MB Cavities from RI
- Cavity package

IPN
- Cryostat (inspired from JLAB/SNS)

INFN
- 1 MB Cavity

ZANON
- 1 MB Cavities from RI

CEA Saclay
- MB Demonstrator assembly

1 MB PROTOTYPE

CEA
- CM RF power test stand At Saclay

CEA
- High Power RF Test Stand for coupler conditioning at Saclay

1.2 MW 704 MHz
CEA provides all the CM components.

CEA Saclay
And partially
a sub contractor

HB Demonstrator assembly

1 HB PRE-SERIES

CEA
CM RF power test stand
At Saclay

CEA
High Power RF Test Stand for
coupler conditioning at Saclay

1.2 MW
704 MHz

4 HB Cavities from RI
THE ACTORS OF THE CM PRODUCTION

CEA provides all the CM components except the cavities

CEA Saclay sub contractant

MB Series CM assembly

High Power RF Test Stand for coupler conditioning at Saclay

CEA

1.2 MW 704 MHz

ESS Lund

CEA

9 MB Series Elliptical Cryomodules

ESS preliminary Acceptance

ESS 2K RF POWER TEST at Lund

ESS final Acceptance

CEA

CM RF power test stand
At Saclay

36 MB Cavities

ZANON

INFN

ESS Cavity acceptance

ESS 2K RF POWER TEST at Lund

CEA

3 first CM
CEA provides all the CM components except the cavities

STFC
84 HB Cavities

ESS 2K RF POWER TEST at Lund

ESS final Acceptance

ESS Lund

21 HB Series Elliptical Cryomodules

CEA
CM RF power test stand
At Saclay

CEA Saclay
sub contractant
MB Series CM assembly

CEA
High Power RF Test Stand for coupler conditioning at Saclay

1.2 MW
704 MHz

ESS preliminary Acceptance

ESS 2K RF POWER TEST at Lund

CEA
CEA Saclay/Irfu projet ESS

Date

CEA

STFC
STFC subcontractant

MB Series CM assembly

CM RF power test stand
At Saclay

CEA
CEA provides all the CM components except the cavities

High Power RF Test Stand for coupler conditioning at Saclay

1.2 MW
704 MHz

ESS
preliminary
Acceptance

ESS
final
Acceptance

ESS Lund

21 HB Series Elliptical Cryomodules
The CDR2 will be held after the RF power test at Saclay on the MB Demonstrator (this summer)

The 2\textsuperscript{nd} cryomodule will be a MB CM for the series. Assembly is expected to take 4 months

The 3\textsuperscript{rd} CM will be the HB demonstrator. Assembly will also take 4 months

The 4\textsuperscript{th} CM will take 3 months and will start 1.5 months before the end of the 3\textsuperscript{rd} CM.

Afterwards, production will enter the nominal series phase where CM assembly will take 2 months, for a throughput of one CM every month

9 MB CMs will be produced in March 2020

21 HB CMs will be produced by the end of 2021
CEA has nearly finished launching 60 manufacturing contracts.

CEA has taken the risk of launching pre-series production before finalising all the RF tests on the demonstrator.

At the end of each pre-series, an inspection is conducted before launching series production.

For good schedule management of the cryomodule assembly process, we plan to store 2 sets of each component at Saclay.

Stock will be managed using bar codes and most of the components will be identified by a serial number.

A CEA team oversees the schedule, checks product quality at the manufacturing site (for the pre-series) and again at CEA Saclay.
An industrial integrator will be in charge of CM assembly with a contract based on a performance agreement.

Once CEA has trained the team, the contractor is then responsible for managing assembly.

CEA ensures quality control and expertise.

All assembly operations will be performed by the integrator in the same hall.

CEA keep in charge the coupler assembly and conditioning.
Assembly hall for the MB demonstrator will be used for assembling the series coupler and acceptance of cavity tuners.

Test stand for coupler conditioning.

2 Klystrons:
- 704 MZH – 1.2 MW
- 704 MZH – 1.5 MW (partially delivered)
Ultra-sonic bath cleaning
Industrial washer
Cavity - coupler assembly
Cavity string assembly
Cavity string dressing / spaceframe insertion
Spaceframe preparation / cryostating
Coupler bell assembly
Cryomodule loading
ASSEMBLY HALL – WORKSTATION LAYOUT
For the integrator, the CM assembly process prepared is a line of 7 WS.

1) Coupler assembly to the cavity (in clean room ISO4)
2) Cavity string assembly (in clean room assembly ISO4)
3) Cavity string dressing
4) Spaceframe insertion (cavity string hanging in the equipped spaceframe)
5) Cryostat assembly (introduction of cold mass into the vacuum vessel)
6) Coupler bell assembly to cryostat
7) Preparation of the shipment

Most of WS are redundant or have a second set of tooling in case of incident

During assembly ramp-up (~first four modules), total assembly duration is 4 months. After ramp-up, assembly duration = 8 weeks (40 working days !)

Breakdown is roughly 1/3 duration in clean room (WS1-WS2) and 2/3 duration in assembly hall (WS3-WS6).

Preparation for RF test and/or for shipment (WS7) is done in another building (XFEL Shipment building, not shown).
The assembly duration of PIP-II should match that of ESS ramp-up, from 4 months down to 2 months.

For PIP-II, an extension to assembly of three modules at all time, is feasible within the same hall. It should bring more flexibility.

The two Rail systems in Clean Room and Roll-Out are separated by 1.8 m, while ESS cold mass is about 1.3 m wide: two assembly lines fit (hardly) in parallel.

Two parallel assembly lines is not foreseen for ESS, but it could be envisaged as an accelerated production mode for PIP-II, if needed by the end of production.
Thank you for your attention