SPOKE CRYOMODULES
CONCEPTUAL DESIGNS FOR ESS & MYRRHA

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SLHIPP-2 - Catania - 3&4 May 2012
Goal:
Design and construct a technological demonstrator: a full-scale prototype cryomodule

Motivations:
• Demonstrate the construction capability of a $\beta=0.5$ cavities cryomodule
• Learn from the critical assembly phases (from the clean room to a cryomodule)
• Enable RF testing of a double Spoke cavity; of a multi-cavity assembly in real operating conditions
• Validate operation issues cryogenic cooling principles
• Improve design and construction features
• Support cost estimates
**WP4** ⇒ design and construct:
- 2 cavities, 2 couplers, 2 tuners, **1 cryostat**
- the related assembly tooling: in and outside the clean room
- a dedicated RF supply line for the tests
- a dedicated **cold box** for the tests

⇒ *Very constrained time line!!*

⇒ *suggested time line:*

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The Goal of MAX Task 3.3 (IPNO) of the WP3 is to give a detailed design of a complete Spoke Cryomodule (2 spoke cavities, $b=0.35$, 350 MHz) for the end of 2013. The ACS company has in charge the study of the cryogenic installation (Plant and distribution).

Budget is available, outside the framework of MAX, to start the manufacturing of a complete prototype Cryomodule from the end of 2013.
Cold Tuning System

Based on the CEA Cold Tuning System for ‘Soleil’

On a 350MHs, $\beta=0.15$, spoke cavity

Cold stepping motor and gear reductor, Piezo fast tuning, ceramic balls nut-screw...

The MAX CTS will be adapted from the one Designed for ESS

First design for ESS

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POWER COUPLER

MAX

Power Coupler 350 MHz, 20 kW CW (designed), ~10kW CW Operation 50 Ω.

WARM WINDOW

Prototype manufactured and tested at 8 kW CW on a 350 MHz, beta 0.15 Spoke cavity.

2 CF16 (Vacuum) + 1 CF 16 pick up

Window water cooled.

Outer Conductor : CF 63, 300 mm L.

Thermal Interception @60K and 10K

Simulations to do :
→ Mechanical behaviour of the antenna (Static and eigen modes)
→ Thermal interception and eventually cooling of the antenna.

ESS

Power Coupler 350 MHz, ~ 400 kW pic.

WARM WINDOW

EM design in course

2 CF16 (Vacuum) + 1 CF 16 pick up

Outer Conductor : CF 100, ~ 300 mm L.

→ Mechanical behaviour of the antenna (Static and eigen modes)
→ Thermal interception and eventually cooling of the antenna.
Conceptual design goal:

• Define the layout of the cryomodule:
  - Mechanical layout
  - Cryogenic layout

• taking into account the following criteria:
  - Assembly phases (in and out of the clean room)
  - Thermal budget
  - Manufacturing
  - Alignment method
  - General dimensions
  - Tunnel environment
  - Budget

Conceptual design strategy:

• Define different configurations for the cavities, couplers and tuners positions within the cryomodule;

• Define different technical solutions for:
  - the \{cavity+tuner+coupler\} support;
  - the thermal shield support;
  - the vacuum vessel
  - the interfaces: couplers/vacuum vessel, beam vacuum/vacuum vessel...

• Compare those solutions
  ⇒ Definition of an analysis grid for this comparison
Assembly of the magnetic shielding (actively cooled)

Assembly of the space frame

Warm valve

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**ESS Cryogenic Distribution Layout**

<table>
<thead>
<tr>
<th>Heat Loads</th>
<th>Milestone</th>
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<tbody>
<tr>
<td><strong>Cryomodule</strong></td>
<td></td>
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<tr>
<td>Conceptuel</td>
<td>03/2012</td>
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<tr>
<td>Detailed Design</td>
<td>07/2012</td>
</tr>
<tr>
<td><strong>Cryomodule cold box</strong></td>
<td></td>
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<tr>
<td>Conceptuel design</td>
<td>05/2012</td>
</tr>
<tr>
<td>Detailed design</td>
<td>07/2012</td>
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</tbody>
</table>

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Inside Clean Room: Warm Valves, Couplers and supporting frame...

Cavity train Shutting Valves. Warm Valves. Valve command dismounted.

Cavity position adjustment Blocs using needle bearings. X-FEL Solution

Vacuum Vessel connection Flanges

Vacuum Vessel connection Flanges

Power Couplers + Vacuum gauges (only Penning..to be confirmed)
MAX Cryomodule Mechanical Design

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**Assembly Outside Clean Room**

- **Cryogenic circuitry**
- **Magnetic Shielding**
- **Cold Tuning Systems**
- **Thermal Shield**

+ MLI (30 Layers @ 60 K, 10 Layers @ 10/2 K)

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MAX Cryomodule Mechanical Design

CRYOSTATING 1

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Inside Clean Room

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