SPIRAL 2 CRYOMODULES
TEST RESULTS AND
STATUS

Guillaume OLRY - IPN ORSAY
On behalf of cryomodules A and B teams
OUTLINE

- SPIRAL2 Linac layout & parameters
- Cryomodule A and B tests
  - Cryogenic losses
  - Power coupler & cavity performances
  - Tuning system
- Production status
  - Cryostats
  - Cavities
  - Power couplers
### Cryomodule Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value Cryomodule A</th>
<th>Value Cryomodule B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve-to-valve length [mm]</td>
<td>610</td>
<td>1360</td>
</tr>
<tr>
<td># cavities</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>$f$ [MHz]</td>
<td>88.05</td>
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</tr>
<tr>
<td>$\beta_{\text{opt}}$</td>
<td>0.07</td>
<td>0.12</td>
</tr>
<tr>
<td>$\text{Epk/Ea}$</td>
<td>5.36</td>
<td>4.76</td>
</tr>
<tr>
<td>$\text{Bpk/Ea [mT/MV/m]}$</td>
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</tr>
<tr>
<td>$r/Q$ [$\Omega$]</td>
<td>599</td>
<td>515</td>
</tr>
<tr>
<td>$\text{Vacc @ 6.5 MV/m} &amp; \beta_{\text{opt}}$</td>
<td>1.55</td>
<td>2.66</td>
</tr>
<tr>
<td>$L_{\text{acc}}$ [m]</td>
<td>0.24</td>
<td>0.41</td>
</tr>
<tr>
<td>Beam tube $\varnothing$ [mm]</td>
<td>38</td>
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### Cryomodule Locations

- **Beta 0.07 energy section**
- **Beta 0.12 energy section**
- **Cryomodule A**
- **Cryomodule B**
- **Power coupler**

### Cryomodule Manufacturers

- **CEA Saclay**
- **IPN Orsay**
- **LPSC Grenoble**

### Lattice Lengths

- **Beta 0.07**
  - Beam tube $\varnothing$: 1190 mm
  - **Beta 0.12**
    - Beam tube $\varnothing$: 1940 mm

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**Image Description**

- The image shows the layout of the SC LINAC with cryomodule sections labeled as Beta 0.07 and Beta 0.12.
- The cryomodule sections are connected by power couplers labeled CEA Saclay, IPN Orsay, and LPSC Grenoble.
- The axial length of the LINAC is approximately 35 meters.

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**Table of Values**

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Cryomodule A

Specifications:
- \( T = 4.5 \) K
- \( E_{\text{acc}} = 6.5 \text{MV/m} \) & \( P_{\text{cav}} < 7 \text{W} \)
- Cryomodule static losses < 8.5 W
- \( P_{\text{coupler}} = 10 \text{kW max} \)

Test stand @ CEA/Saclay
Cool down

- Thermal shield cooled down first during 1 day
- Cavity cool down 250K → 4K: < 1 hour (excepted cavity bottom)
- Tuning system: $T_{\text{final}} = 20$K within 4 days
- Static losses: 6.5 W (SPIRAL2 specs <8.5W)
- Losses during continuous LH$\text{e}$ transfer losses (w/o RF): 35 W

![Cool down of the cryomodule A](chart.png)

- Copper breads
- Cavity bottom at ~15 K
- 1.5 W
RF performances

- Power coupler conditioned up to 10 kW CW at 300K and 4K
- Multipacting barriers at 4, 26, 131 and 220 W (passed but not processed)
- External Q: $5.3 \times 10^5$ (calculated: $5.5 \times 10^5$)
- Cavity AZ1 with low $Q_o \rightarrow 35W \at 6.5 \text{ MV/m}$
- $E_{acc\text{ max}} = 10.3 \text{ MV/m}$ at low duty cycle (5 Hz). $P_{cav} > 70 \text{ W}$
Tuning system in contact before cool down \(\rightarrow\) -5 kHz (SS shrinkage) \(\Rightarrow\) Shifted away (1.3 mm) from the cavity
- good linearity: 0.15 Hz/motor step
- Sensitivity: \(\sim\)28 kHz/mm (25 kHz/mm calculated)
- Small backlash
- Tested over 10kHz amplitude (full range: +25 kHz)
**Cryomodule B**

**Specifications:**
- $T = 4.5$ K
- $E_{\text{acc}} = 6.5$ MV/m & $P_{\text{cav}} < 10$ W
- Cryomodule static losses < 11 W
- $P_{\text{coupler}} = 10$ kW max

**Components:**
- Copper thermal shield (upper part)
- LHe buffer
- Beta 0.12 QWR
- Magnetic shield
- Beam axis
- Power coupler
- Cryomodule
- Valves box
- Test stand @ IPN Orsay
Cool down

- Thermal shield cooled down first: 300K → 80K in 10h
- Cavities cool down 250K → 4K: < 5h (~1h between 150K an 50K)
- He bath pressure variation: +/- 2 mbar
- Static losses: 16 W (SPIRAL2 specs <11W) → extra heat load from couplers + bad contacts on copper thermal shield
- Losses during continuous LHe transfer (w/o RF): 32 W
RF performances

- Power coupler conditioned up to 10 kW CW at 300K and 4K
- Multipacting barriers & vacuum deterioration only up to 150W
- $E_{acc}$ max = 7 MV/m & 8 MV/m (~9 MV/m in vertical cryostat) → tuning system with SC plunger (chemical treatment of only 20 µm → defect → quench)
Coarse tuning: introducing the plunger ⇒ from +20kHz to +50kHz

Fine tuning: moving the plunger (+/- 4mm)
- Sensitivity: ~1 kHz/mm (1.15 kHz/mm calculated)
- Good linearity: 0.12 Hz/motor step
- Small backlash (70Hz)

Compensation up to ΔP=30mbar and variation rate of 0.4 mbar/s
Status on components production

Cryomodule A

- Fabrication started in June 2009 (11 cryostats)
- First cryostat delivered in January 2010
- Cryostats #2-#10: from July to December 2010 (3 batches)

Cavities A

- Fabrication in 2 phases (2 +10 cavities) started in June 2008
- The first two cavities (AZ2 & AS3) tested and validated this year
- 10 remaining cavities between May and July 2010
Cryomodule B

- Fabrication started in March 2009 (6 cryostats)
- First cryostat in November 2009
- Cryostats #2-#5 every 2 months

Cavities B

- 10 cavities delivered
- 7 cavities tested and validated
- 1 cavity repairing: frequency too high → local chemistry in H field area
- 6 more cavities in October/November 2009
Fabrication of 30 couplers started in September 2008
First batch (5 couplers) delivered and tested
  - 2 TiN coating (30nm): break at 4kW & 7kW
  - 1 TiN coating (1nm): ok up to 35kW
  - 2 non-coating: ok up to 35kW
2nd batch of 5 couplers (non-coated) in October 2009
End of conditioning: mid-2011
Thank you

- Pierre Bosland (CEA)
- Yolanda Gomez-Martinez (LPSC)