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STATUS OF THE SOLEIL RF SYSTEM
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- SOLEIL Operation September 2009-September 2010
- Booster RF operation
- Storage ring RF operation
- New frequency Tuner
- RF AMPLIFIER operation and R & D
- Summary and conclusion
SOLEIL Operation Sept. 2009/ Sept. 2010

300 mA Top-up until November 2009
400 mA Top up standard operation for users since November 2009
Other available users modes:
   400 mA Hybrid Top-Up
   80 mA 8 Bunches Top-Up
   10 mA Single Bunch Top-Up
500 mA Top-Up validated beginning of 2010, used for machine R&D and Radioprotection test (for users beginning of 2011)
From Sept. 09 until Sept. 2010 ~ 5000 running hours
  • Short Top-up interruption but no beam loss caused by RF booster interlock card fault
  • Amplifier: no failure at all

> 20000 hours operation over 5 years, no real problem
- 580 kW (500 mA) & 4 MV @ 352 MHz
- 2 cryomodules, each containing a pair of single-cell s.c. cavities
- Each cavity powered by a 180 kW solid state amplifier
- Both CM supplied with LHe (4.5 K) from a single cryo-plant
Beam availability during the users and RP sessions

Beam time availability of ~ 96%, 98% before May 2010

Two main RF cryogenic failures impacted beam in 2010

- Breakdown of compressor PLC CPU board ~60 hours of beam downtime failure during weekend + day off, spare board not compatible and spare station under installation.

- Electrical power interruption during the spare compressor test (lost helium) ~ 6 hours of beam downtime
Install of spare compressor station with separate utilities.

- Redundancy in operation (losses of utilities (electric, water) \(\rightarrow\) few hours restart)
- Maintenance transparency

Operational since June 2010
New Tuner Version

1) Standard screw-nut assembly replaced by planetary roller screw

2) Stepper motor + harmonic drive gear box

→ Less friction  \quad \rightarrow \quad \text{More robust} \quad \rightarrow \quad \text{Longer lifetime}

Prototype was successfully tested on a test bench @ cold in CryHolab at CEA

→ 20 years of SOLEIL operation
Installation of New Tuner

Installation of the new cold tuning system for cavity 3&4 during summer shut down (August 2009)
Installation of the new cold tuning system for cavity 1&2 during winter shut down (January 2010)
In May 2010, the tuner of cavity 4 showed signs of malfunctioning.

Before full sticking, use of the backup mode at fixed tuning and variable voltage until next shut down.

Open Cryomodule 2 and investigation during the summer shut down 2010.

The friction between the nut and satellites screw caused the blocking of the system.
→ Double mistake
  • During the preliminary test at warm, without operational soft interlock system, we probably hit the mechanical stop.
  • Mechanical stop not correctly settled → abnormal stress
→ The inspection of the cav 3 system didn’t show any sign of problem and the other tuners on CM1 are still working well
Thermal Fatigue Failure After working for 20000 hrs

Amplifier Performance

- ≈ 20000 hours running, and ≈ 100% operational availability
- Modules failure rate ~ 3,5% per year (AMP 2,3,4~ 2% and AMP1 : 6%)

- Transistor failure
- 2 failures types:
  - Soldering thermal fatigue

About 80% of them can be repaired (preventive repair maintenance on T2 and T3 during the shut down of the last summer)

None of these failures has impacted the operation (modularity & redundancy).
RF AMPLIFIER UPGRADE

- Development a new module with 6th generation LDMOS (50V), much more robust + thermal stress strongly reduced → longer MTBF.

- Working point has been optimised for 46V @ 330W (G=21, η =72%)

<table>
<thead>
<tr>
<th>P (W)</th>
<th>Gain (dB)</th>
<th>Idc1 (A)</th>
<th>Idc2 (A)</th>
<th>Idc (A)</th>
<th>Phase (°)</th>
<th>S11 (dB)</th>
<th>Po (W)</th>
<th>E (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>330</td>
<td>20,82</td>
<td>4,8</td>
<td>5,10</td>
<td>9,92</td>
<td>-127,0</td>
<td>-50,0</td>
<td>456,3</td>
<td>72,3</td>
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<tr>
<td>315</td>
<td>21,20</td>
<td>4,70</td>
<td>4,90</td>
<td>9,60</td>
<td>-126,7</td>
<td>-51,0</td>
<td>441,6</td>
<td>71,3</td>
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<tr>
<td>300</td>
<td>21,48</td>
<td>4,58</td>
<td>4,72</td>
<td>9,30</td>
<td>-126,3</td>
<td>-51,7</td>
<td>427,8</td>
<td>70,1</td>
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<tr>
<td>250</td>
<td>21,95</td>
<td>4,18</td>
<td>4,21</td>
<td>8,39</td>
<td>-126,0</td>
<td>-43,7</td>
<td>385,9</td>
<td>64,8</td>
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<tr>
<td>200</td>
<td>22,10</td>
<td>3,75</td>
<td>3,74</td>
<td>7,49</td>
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<td>-39,0</td>
<td>344,5</td>
<td>58,0</td>
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<tr>
<td>150</td>
<td>22,14</td>
<td>3,25</td>
<td>3,2</td>
<td>6,47</td>
<td>-128,0</td>
<td>-36,0</td>
<td>297,6</td>
<td>50,4</td>
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</tbody>
</table>

- Replace progressively the actual modules with LR301 by new ones with BLF574 transistor (typically 1 tower/year)

- The choice of this solution will minimize the modifications

- Option for higher power (380W) @ 50V
New generation modules developed at SOLEIL for different projects and collaborations.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Output Power</th>
<th>Gain (1 dB)</th>
<th>Efficiency</th>
<th>projects</th>
</tr>
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<tbody>
<tr>
<td>MHz</td>
<td>W</td>
<td>dB</td>
<td>%</td>
<td></td>
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<tr>
<td>476</td>
<td>400</td>
<td>20</td>
<td>69</td>
<td>LNLS</td>
</tr>
<tr>
<td>352</td>
<td>700</td>
<td>20.5</td>
<td>73</td>
<td>ESRF</td>
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<tr>
<td>500</td>
<td>700</td>
<td>18</td>
<td>67</td>
<td>SESAME</td>
</tr>
<tr>
<td>88</td>
<td>1000</td>
<td>26</td>
<td>87</td>
<td></td>
</tr>
</tbody>
</table>

Possibility of designing modules of intermediate frequency such 100 MHz (Astrid) 200 MHz (CERN) and up to L band (1.3-1.5 GHz)
Transfer of technology agreement concluded with ELTA-AREVA

→ ESRF contract for 7 amplifiers of 150 kW (14 towers of 75 kW)
  - Module validated → P = 700 W, G > 20 dB, η > 70% @ 350 MHz
  - Integration test and validation for one unity of 10kW combination of 16 modules”
  - 75 kW tower → next year
2 amplifiers of 50 kW with RF modules of 400 W @ 476MHz were successfully tested.

AVRIL 2010, “SOLEIL – LNLS team in Campinas BRAZIL”
Area test with high power voltage, water and spare BOOSTER Cavity
→ LLRF and amplifier test
→ Conditioning the spare BOOSTER cavity (ready to be installed, if necessary)

New digital LLRF BOOSTER
(R. Sreedharan presentation)
For the BO RF, no operation problem at all
For SR RF, after 4 years of running, the operational experience proved to be fully satisfactory, but in 2010 significant downtime due to 2 long cryogenics failures
Installation of a spare He compressor station
Confirm the good reliability of the new CM frequency tuners
Upgrade of the power couplers (collab. with CERN & ESRF), able to store 500mA with one Cryomodule (redundancy)
Progressive replace of the actual modules by the new generation (1 tour/year) → increase MTBF
Continue the development of LLRF for Booster and Storage ring and others projects.