LNF-CERN X-band test-stand collaboration programme

Alessandro Gallo for
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Mechanical engineers: David Alesini, Enrico Di Pasquale, Andrea Liedl

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Technicians: Graziano Piermarini, Sergio Quaglia, Michele Scampati, Giorgio Scarselletta

INFN-CERN X-band collaboration Meeting
Nov. 26 - 2020
SUMMARY

• Status of TEX, the Frascati X-band test stand
• Short/medium term programme at TEX
• INFN/CERN collaboration/exchange programme
TEX (TEst stand for X-band) Status Report

- The Infrastructure
- The RF power source
- RF Driver and LLRF
- Radiation safety evaluations
- Construction/commissioning schedule
Sketch of LNF bld. #7

The building will host various activities including:

- X-box test stand;
- New oven for brazing;
- THz user end station;
- RF structure tuning and preparation area;
- Meeting area;
- Storage area
Modulator transported in place as for September 24, 2020
MODULATOR SAT - PHASE 1

LNF technical staff with SCANDINOVA remote support
MODULATOR SAT SPLITTED IN TWO PHASES
TEX (TEst stand for X-band) Status Report

ScandiNova K400 SAT setup

XBox EuPraxia/CLIC setup

Courtesy of S.Pioli and E. Di Pasquale
Gain curves for different pulse length and rep.rate

• 1 µs, 10 Hz (first attempt)
• 1.5 µs, 50 Hz (realistic pulse length with pulse compressor)
• 5 µs, 100 Hz (datasheet reference)
• 100 ns, 50 Hz (realistic pulse length)
• 200 ns, 50 Hz (w/o pulse compressor)

Measurement setup

• 3 power meter calibrated probes (S21, S31, S42)
• 200 ns – calibrated RF diode on S31 to cross-check measurements with power meter
• Front panel power indicator
• Internal power meter voltage output
LLRF system based on S-band LIBERA-LLRF by Instrumentation Tecnlogy

- Exploits experience acquired for ELI-NP project
- Possible option for Eupraxia@SPARC_Lab
- Development of the X-band board too expensive and time consuming
- Based on a home-made up/down converter board
- US S-band chosen to be aligned with other in-house applications
up-converter custom cavity filter

unfiltered

filtered

60 MHz

12 GHz
RADIATION SAFETY EVALUATION

CLIC-type structure
L = 20 cm
E = 100 MV/m

<table>
<thead>
<tr>
<th>Parameters</th>
<th>CLIC</th>
<th>EUPRAXIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current [mA]</td>
<td>0.75</td>
<td>1</td>
</tr>
<tr>
<td>Frequency [Hz]</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Period [ns]</td>
<td>250</td>
<td>150</td>
</tr>
<tr>
<td>Energy [MeV]</td>
<td>20</td>
<td>59</td>
</tr>
<tr>
<td>Power [W]</td>
<td>0.1875</td>
<td>0.4425</td>
</tr>
<tr>
<td>Electron per second</td>
<td>$5.8593 \times 10^{10}$</td>
<td>$4.6875 \times 10^{10}$</td>
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</tbody>
</table>

EUPRAXIA-type structure
L = 90 cm
E = 65 MV/m
EUPRAKIA STRUCTURE

no extra shielding

<table>
<thead>
<tr>
<th>Detector</th>
<th>$H_\gamma$ [$\mu$Sv/h]</th>
<th>$H_n$ [$\mu$Sv/h]</th>
<th>$H_{tot}$ [$\mu$Sv/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontale</td>
<td>8.33 · 10³</td>
<td>123</td>
<td>8.49 · 10³</td>
</tr>
<tr>
<td>Laterale</td>
<td>1.36 – 3.13</td>
<td>0.06 – 0.11</td>
<td>1.46 – 3.2</td>
</tr>
<tr>
<td>Sul tetto</td>
<td>2.13 – 3.73</td>
<td>0.20 – 0.22</td>
<td>2.36 – 3.94</td>
</tr>
<tr>
<td>Ingresso sala</td>
<td>3486</td>
<td>370</td>
<td>3857</td>
</tr>
<tr>
<td>Ingresso labirinto</td>
<td>36.7</td>
<td>6.74</td>
<td>44</td>
</tr>
</tbody>
</table>

many mSv/h !!!
EUPRAXIA STRUCTURE with extra shielding:

Pb = 20 cm
Al = 5 \times \text{Rad Lengths}
Polyethylene = 20 cm

\(< 1 \mu\text{Sv/h}\)

Already acceptable. Simulation needs to be refined, the source has to be better modelled
X-band Test Stand completion schedule
(based on the tentative assumption of having the klystron available by Jan 1\textsuperscript{st} 2021)

<table>
<thead>
<tr>
<th>Task</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power/Fluid plant</td>
<td>5/20 K400@LNF</td>
</tr>
<tr>
<td>Personnel Safety</td>
<td>today</td>
</tr>
<tr>
<td>Modulator SAT *</td>
<td>15/01</td>
</tr>
<tr>
<td>RF/Vac/CS installation</td>
<td>15/01</td>
</tr>
<tr>
<td>Air conditioning plant</td>
<td>30/01</td>
</tr>
<tr>
<td>CPI klystron delivery @LNF originally expected early November 2020</td>
<td>15/11</td>
</tr>
<tr>
<td>CERN (repaired, tested in diode-mode, RF conditioning on going)</td>
<td>31/03</td>
</tr>
<tr>
<td>RF Source ready</td>
<td>-&gt; 15/02/21</td>
</tr>
<tr>
<td>LATINO deadline proposed to be extended to -&gt; 12/21</td>
<td>1/04</td>
</tr>
<tr>
<td>XBOX ready</td>
<td>-&gt; 6/21</td>
</tr>
</tbody>
</table>
TEX: *main items checklist*

- Bunker: built and ready
- **Bunker authorization**: formal request submission by February 2021, answer expected in 90 days
- Cooling and mains: available
- Modulator: positioned, SAT phase 1 successfully done
- **Klystron**: to be delivered (in ≈ 4 weeks?)
- RF driver: available and tested
- LLRF: S-band module available and tested
- LLRF: up/down converter under construction, all components available
- Control room: completed and available
- Control room equipment: available, to be installed
- **Radioprotection shields**: under design
- Radioprotection monitor stations: available, in place
- Machine protection and safety system: ready
- RF components for SAT: available in house
- RF components for cavity test: mostly available, few under delivery (flanged waveguides, vacuum pumps, …)
- **Building #7 air conditioning system installation**: works planned for spring 2021
TEX: short/medium term programme

2021

SAT with klystron
Works
Air conditioning
Waveguide RF line to bunker
LLRF & electronic installation
Commissioning and first tests on cavities (CERN)

2022

Test on borrowed structures and RF components
Test on Eupraxia/XLS accelerating structures and RF components
Eupraxia structures
Borrowed structures

2023

Open access to users (LATINO project)

C-band modulator installation (option not discussed yet)
**Strategic areas of collaboration**

- **RF expertise, components and accelerating structures**
  - LNF has built a consistent RF group, but still need guidance especially in fabrication and test issues
  - Continuation of the CERN support for procurement of special RF parts is extremely important
  - Testing some CLIC structures and special components at TEX would be of mutual benefit
  - LNF RF engineers can support development and design of new or upgraded devices in a collaboration framework

- **Conditioning strategy and algorithms developing**
  - A porting of the CERN-developed automated conditioning tools into the LNF system is crucial

- **Test stand operation**
  - The size of the LNF TEX team is adequate, but personnel need to be trained. CERN expert guest are obviously very welcome especially in the initial phase of operation, but training of LNF personnel at CERN X-box is certainly the most effective way

- **Data and experience sharing**
  - X band is still a territory under exploration. Sharing of the accumulated technical information on devices and high power components, especially those of the power station is essential in view of the construction of a user facility based on this technology.