DSG NPS Status Overview

Patrizia Rossi, Aaron Brown, and the Detector Support Group
July 13, 2021
Neutral Particle Spectrometer (NPS) will replace the SHMS in Hall C
- Allows for precision (coincidence) cross section measurements of neutral particles ($\gamma$ and $\pi^0$)

- ~25 msr NPS consists of ~1080 PbWO$_4$ crystals in a temperature-controlled frame including gain monitoring and curing systems
- A sweeping magnet (to remove Moller e-)
- A beam pipe with as large critical angle as possible to reduce beamline-associated backgrounds
DSG Contributions to NPS

- **Humidity Control**
  - Design and Development of the Hardware Interlock System
    (Mary Ann Antonioli, Peter Bonneau, Aaron Brown, Brian Eng)
DSG Contributions to NPS

- **HV System**
  - Fabrication of HV divider cables *(Mindy Leffel)* ✔
  - CAEN A7030TN HV modules testing *(Aaron Brown & George Jacobs)* ✔
  - CSS-BOY Overview screen & PMT setting screen *(Mary Ann Antonioli & Aaron Brown)* ✔

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DSG Contributions to NPS

• **HV System**
  - Fabrication of HV divider cables *(Mindy Leffel)*
  - CAEN A7030TN HV modules testing *(Aaron Brown & George Jacobs)*
  - Fabrication of HV supply cables *(Mindy Leffel)*
  - CSS-BOY Overview screen & PMT setting screen *(Mary Ann Antonioli & Aaron Brown)*

• **Humidity Control**
  - Design and Development of the Hardware Interlock System *(Mary Ann Antonioli, Peter Bonneau, Aaron Brown, Brian Eng)*
Completed Task: HV Supply Cable Fabrication

- Fabricated all forty 145' HV supply cables (Mindy Leffel)
- Terminated Radiall pin connectors
- Terminated the other side with three SAMTEC connectors
HV Supply Cable Testing

- Long-term testing (George Jacobs): 33 of 40 HV cables tested
  - Plots uploaded to DSG NPS Technical Documentation webpage
Cooling System - Crystal & Electronic Zones

- Red and blue squares indicate **tentative locations** where DSG would like to install sensors for monitoring temperature and humidity.

Picture provided by Institut De Physique Nucléaire (IPN) - Orsay
Thermocouples are embedded in the sheet (in front of the crystals) that keeps the crystals in place.
### LabVIEW Keysight Scanning Program

- Crystal zone sensors scanned and temperatures stored in four arrays
  - 28 elements/array
- Two arrays each for front and back thermocouples

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**Aaron Brown**
LabVIEW Hardware Monitoring System Program

• Developed code for front and back crystal zone temperatures (Mary Ann Antonioli) – tested averages, standard deviations, and over/under limits ✓

• Added all-temperatures average to Crystal Main tab ✓

• Completed plotting of averages for both crystal zones ✓
# LabVIEW Hardware Interlock System Program

Mary Ann Antonioli

<table>
<thead>
<tr>
<th>Crystal Zone</th>
<th>Front Crystal Zone Temperatures</th>
<th>Back Crystal Zone Temperatures</th>
<th>Ambient Temperatures</th>
<th>Temperature Map</th>
<th>Plots</th>
<th>Expert Settings</th>
</tr>
</thead>
</table>

## Front Crystal Zone Temperatures [°C]

<table>
<thead>
<tr>
<th>crystal temps avg. std. dev. over limit under limit</th>
<th>crystal temps avg. std. dev. over limit under limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0 18.0 0.8</td>
<td>18.0 18.1 0.8</td>
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<tr>
<td>18.0 18.1 0.8</td>
<td>18.0 18.2 0.8</td>
</tr>
<tr>
<td>17.0 17.9 0.8</td>
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View [full table](#) for complete data.
• Live plot of crystal zone average temperatures (random numbers)
Crystal Zone Temperature Mapping

Temperature map of front crystal array (Aaron Brown)
- Made using randomly generated temperature values $17.5^\circ C \leq T \leq 18.5^\circ C$
- Temperatures between sensor locations estimated using Python bivariate spline interpolation
• ANSYS thermal simulation of 3x3 block of PbWO₄ crystals
  – Surface temperature of central block is set to be 19°C
  – Using thermal conductivity of the crystals (2.4 W/m K in x and y axis, 2.0 W/m K in z-axes)

  “The thermal conductivity is calculated, and it exhibits anisotropy with the values along the [100] axis \( K_x,y \) higher than that along the [001] axis \( K_z \), which is 2.40 W·m\(^{-1}\)·K\(^{-1}\) and 2.00 W·m\(^{-1}\)·K\(^{-1}\) at room temperature, respectively.”

  Specific Heat and Thermal Diffusivity and Conductivity of PbWO₄ Single Crystal Related to Its Crystal Orientation at (300 to 673) K from the Journal of Chemical & Engineering Data
Conclusion

• Currently testing the HV supply cables with load box (George Jacobs, Mindy Leffel, and Marc McMullen)

• Developing LabVIEW Keysight scanning program (Aaron Brown, Peter Bonneau, and Brian Eng)

• Hardware Interlock System (Mary Ann Antonioli)

• Development of the control and monitoring EPICS system for CAEN in progress (Mary Ann Antonioli and Aaron Brown)

• Thermal analysis of crystal zone underway (Aaron Brown)

• Good progress!