Photogrammetry measurements of the SπRIT TPC

Jonathan Barney for the sTPC collaboration
\( S\pi RIT \) Time Projection Chamber

- Built to study the symmetry energy at \(~2\rho_0\)
- Multi-wire proportional chamber
- Large pad plane for particle detection (12,096 channels)
- Designed, constructed and assembled at MSU & TAMU
SπRIT Time Projection Chamber

- Built to study the symmetry energy at $\sim 2\rho_0$
- Multi-wire proportional chamber
- Large pad plane for particle detection (12,096 channels)
- Designed, constructed and assembled at MSU & TAMU
- Shipped to RIKEN (~10,000 km trip)
SπRIT Time Projection Chamber

- Built to study the symmetry energy at \( \sim 2\rho_0 \)
- Multi-wire proportional chamber
- Large pad plane for particle detection (12,096 channels)
- Designed, constructed and assembled at MSU & TAMU
- Shipped to RIKEN (~10,000 km trip)
- Will operate inside SAMURAI magnet at RIKEN
SπRIT Time Projection Chamber

- Thin walled enclosure with angle iron (aluminum) frame
- Field cage made of G10 circuit board
- Thick aluminum plate with ribs designed to keep detection elements fixed
Important measurements

Flatness of the pad plane

- Distance from pads to wires affects gain of detector
- Measure pad plane by measuring top plate

Pad plane is attached to large aluminum plate
Original Laser measurements

- Flatness measured using FARO laser system at NSCL during assembly
- Flat within 125 µm
- Flatness of pad plane within machining tolerances of top plate
Important measurements

• Angle of field cage to pad plane
  • Affects drift path of electrons
  • Also affects simulations
Important measurements

- **Check position inside magnet chamber**
  - Adjust so that E field is parallel to B field
  - Check position of detection elements relative to beam line

TPC inside SAMURAI's magnet
Photogrammetry measurements on the TPC

• Photogrammetry is the measurement method available at RIKEN
• Study performed by Justin Estee, July 2014
• 3 studies:
  • Flatness of top plate
  • How parallel is field cage
  • Changes to TPC on uneven surface

Figure courtesy B. Brophy
How does photogrammetry work?

- Use multiple images to triangulate points on a 3D object
- “Resection” to determine the position of the camera for each photo
- Geodetic V-stars program reconstructs a 3D image of the points
Resection

- Use coded targets as unique points
- Coded targets in picture help identify which face is photographed
- Requires a scale
- Scale bar included in measurements

The size is now evident
Study of accuracy

• Measurement of a granite flat plate (1.35 x 0.9 m)
• Flatness expected to be within 125 μm (or better)
• Measured with photogrammetry

<table>
<thead>
<tr>
<th>Target style</th>
<th>Standard Deviation [μm]</th>
<th>Max/Min [μm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-Single targets</td>
<td>20</td>
<td>+16/-19</td>
</tr>
<tr>
<td>38-tape targets</td>
<td>24</td>
<td>+52/-47</td>
</tr>
<tr>
<td>42-tape targets</td>
<td>23</td>
<td>+57/-46</td>
</tr>
</tbody>
</table>

• Accuracy of photogrammetry measurements is within machining tolerance
Photogrammetry measurements on the TPC
Checking measurements

• The measured points can be analyzed with V-stars program
• Points can also be exported to check against 3D design
• Check position of field cage relative to reference points
Initial location

83% within +/-48μm

• Baseline measurement to see how flatness changes

Deviation from average plane (mm)
Initial location

83% within +/-48µm

Moved across floor

~72% within +/-48µm

Deviation from average plane (mm)
Changes to TPC on unleveled surface

• Lifted one side to determine if warping occurs
• Also check field cage to determine if position changes
Lifting up one side of TPC

• Minimal deviation from original measured plane – within 48 μm
• Overall flatness does not change more than +/- 75 μm
Orientation of field cage

- The exact angle of the field cage determines the electrical field.
- Panels were removed to measure the field cage
- Within 2 miliradians of design value for all measurements
- Provides position of field cage against reference points
Summary

• $S\pi$RIT TPC pad plane is within expected flatness, even when not on a level surface
• Field cage is within 2 miliradians of expected value
• We will be able to position and level detector using photogrammetry
Thank you!

This material is based on work supported by the DOE under Grant No. DE-SC0004835, NSF under Grant No. PHY-1102511 and the Japanese MEXT Grant-in-Aid for Scientific Research on Innovative Area Grant No. 24105004