RICH Status Report

Tyler Lemon
Detector Support Group
Ring-Imaging Cherenkov Detector

• Contents:
  – Mirrors
  – Aerogel
  – Electronics
  – Interlocks
  – Gas System
  – Assembly structure and detector frame
Model of Assembled RICH

Beamline

Detector front
Planar Mirrors

- Spherical Mirrors
- Lateral Planar Mirrors
- Front Planar Mirrors
Spherical Mirror Assembly
Mirrors

• Ten spherical mirrors
  – Six delivered and stored in clean room
    ▪ 2C, 3C, 4C, 5C, 3, and 4
  – Four to be produced and delivered
    ▪ 1, 2, 5, and 6

• Eight planar mirrors
  – Production started
  – Prototype lateral Mirrors A1R and A2R at Instituto Nazionale di Fisica Nucleare (INFN)
Spherical Mirror 2C
Prototype Planar Mirror A1R
Spherical Mirror Analysis

• Measure edges of mirror surface and back surface with CMM
  – JLab Survey Group, Matt Walker

• Analyze data from CMM in AutoCAD and Python
  – Python
    ▪ Amanda, Brian, Pablo, and Tyler
  – AutoCAD
    ▪ Mary Ann, Pablo, and Sahin

• Calculate.
  – Lengths of sides and diagonals
  – Radius of curvature
Python Analysis

• Calculate radius of sphere for mirrors
  – Using all points for a surface
  – Using combinations of four points
• Project CMM points to best fit plane to calculate length
• Check planarity of sides
• Calculate radius of curvature for each individual side
Python Plot for Mirror 5C
AutoCAD Analysis

- Project CMM data to plane created with ideal model
- Measure side and diagonal lengths and thicknesses
- Confirm results from Python algorithms
AutoCAD Plot of Mirror 5C CMM Data

Left

Mirror Surface

Top

Back Surface

Bottom

Right
Best Fit Plane Issues

• Noted that all four corners of a surface in ideal model are not coplanar for 3C and 4C
• One corner is out of plane generated by other three corners
  – Caused by how mirrors are shaped and how they are cut from the sphere
## Lengths of the Sides of 5C

<table>
<thead>
<tr>
<th>Side</th>
<th>Mirror Surface</th>
<th>Back Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Python [mm]</td>
<td>AutoCAD [mm]</td>
</tr>
<tr>
<td>Right</td>
<td>536.75</td>
<td>535.91</td>
</tr>
<tr>
<td>Top</td>
<td>834.36</td>
<td>840.96</td>
</tr>
<tr>
<td>Left</td>
<td>536.55</td>
<td>537.32</td>
</tr>
<tr>
<td>Bottom</td>
<td>834.51</td>
<td>841.16</td>
</tr>
</tbody>
</table>

Error omitted due to debugging of algorithms
### Radius of Sphere for 5C

<table>
<thead>
<tr>
<th>Method</th>
<th>Mirror Surface</th>
<th>Back Surface</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Python [mm]</td>
<td>Ideal [mm]</td>
</tr>
<tr>
<td>All ~100 Points</td>
<td>2696.27 ± 0.07</td>
<td>2700.00</td>
</tr>
<tr>
<td>Four Point Combos (100 C 4)</td>
<td>2704.49 ± 36.96</td>
<td>2700.00</td>
</tr>
</tbody>
</table>

**Diagram:**

The diagram shows a geometric representation of a sphere with marked points indicating the top, right, left, and bottom sections. The coordinates and measurements are used to illustrate the radius and surface properties of the sphere.
Radius of Curvature

Sides of 5C

<table>
<thead>
<tr>
<th>Side</th>
<th>Mirror Surface</th>
<th>Back Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>2700.00</td>
<td>2721.00</td>
</tr>
<tr>
<td>Top</td>
<td>2717.00</td>
<td>2740.00</td>
</tr>
<tr>
<td>Left</td>
<td>2773.00</td>
<td>2720.00</td>
</tr>
<tr>
<td>Bottom</td>
<td>2712.00</td>
<td>2740.00</td>
</tr>
</tbody>
</table>

Error omitted due to debugging of algorithms
Spot Tests of Spherical Mirrors

• Approximation of mirror surface uniformity and radius of curvature

• Uses CCD and fiber-optic light
  – CCD to view image of reflected fiber-optic light
Debian PC for Spot Test

• Researched and installed Debian Linux OS on PC
  – Chief architects
    ▪ Ilaria and Luca (INFN collaborators)
  – Contributors
    ▪ Peter and Tyler on network issues
  – Resolved network issues by using Ilaria’s laptop as Wi-Fi network bridge
Placing CCD and Fiber-Optic Light on Mount for Spot Test
CCD Mount Used for Spot Test

Light to mirror

Reflected light from mirror
Placing Mirror 3 on Table for Spot Test
Mirror 4
Spot Test Results

Distance Between CCD and Mirror = 2709 mm
Mirror 4
Spot Test with CCD

Spot distortion because spot is not at focal plane

D0 = 4.290 mm
Aerogel

• Received all 3-cm-thick tiles
  – Whole and partial tiles
• Tiles stored in dry-boxes at 0.5% RH
• Visually inspected each tile upon delivery
Model Showing Aerogel in Relation to Spherical Mirrors
Partial Aerogel Tile
Partial Aerogel Tile

Cracked in corner
Electronics

• Front End Electronics
  – MAPMTs (64 anodes)
  – MAPMT adapter board
  – ASIC board
  – FPGA board
Front View of Model with Front Panel Removed
Model of Electronics Panel

391 MAPMTs
~25,000 channels

Two MAPMT board

Three MAPMT board
Test Setup for Electronics Panel
Back Side of Electronics Panel Test Setup
Electronics

• Back End Electronics
  – CAEN SY4527 mainframe (8 U)
  – CAEN R649 HV distribution (5 U)
  – LV distribution at patch panel
  – Fiber Distribution Panel (4 U)
  – VXS crate with SSP cards (11 U)
Electronics Racks
Forward Carriage Level 3

Interlocks and Gas System
cRIO Chassis

CAEN Mainframe
HV Distribution
Racks C3-4, C3-5, C3-7
Forward Carriage Level 3
Electronics Rack
Forward Carriage Level 2

VXS Crate

Fiber Distribution
Rack C2-4
Forward Carriage Level 2
Interlocks

• Developing cRIO-based interlock system
  – Mindy, Marc, George, Brian, Peter
  – Monitor
    ▪ Internal temperature
    ▪ Humidity
    ▪ Air cooling status

• All PRs submitted

• All cRIO modules and rack mounts received
  – Controller to be delivered
cRIO Chassis and Controller
Gas System

• Developing gas system
  – George, Brian, Marc, Mindy, Sahin

• Nitrogen purge system
  – Maintain low internal humidity for aerogel

• Air cooling system
  – Prevent electronics overheating
  – <100°F to prevent FTOF damage
Nitrogen Purge System Diagram

RICH Detector N2 Purge Gas System Diagram
Hall B Fwd Carriage

RICH #1

Pressure Control Bubbler

EPICS
cRio Chassis

RICH #2

Pressure Control Bubbler

0-20 slm Flow Transducer

MFT

2-23 slm Flow Rotameter

VALVE

45 psig Relief Valve

Activated Charcoal Filter

PR

VALVE

15 psig

N2 Gas 99.998% Purity
O2 < 5ppm
H2O < 3 ppm
Odor: None

PRESSURE REGULATOR

Bldg 96B Gas Pad

1500 Gal LN2 Dewar

RICH Detector N2 Purge System Diagram
George Jacobs 05/24/2016
Physics DSG group
Air Cooling System

• Two Atlas Copco compressors
• Air cooling system located on top deck of Forward Carriage
Air Cooling System Location

Sahin Arslan
Detector Support Group
Air Cooling System Diagram

RICH Cooling Circuit Diagram with PS Interlocks (Preliminary)

Cooling Circuit Interlocks for RICH HV and LV Power to be Enabled
Air Compressor Power ON Interlock – 11 and/or 12 or PS Power is Disabled
Air Pressure Interlock – 13 > 100 psi (TBD) or Power Disabled
Air Flow Interlock RICH #1 Power – 14 > 250 s/lm (TBD) or Power to RICH #1 Disabled
Air Flow Interlock RICH #2 Power – 15 > 250 s/lm (TBD) or Power to RICH #2 Disabled
Assembly Structure and External Frame

• Assembly test in progress at INFN facility in Italy
Assembly Tests at INFN
Assembly at JLab

- Detector assembled in EEL 124
- Assembly structure will be bolted to cleanroom floor
  - Bolt size will be determined by INFN collaborators
- Start as soon as possible
  - Depends on space in clean room
EEL 124 Layout
Upcoming Events

• Deliveries
  – August 2016
    ▪ Last spherical mirrors
    ▪ Aerogel (2-cm-thick)
  – September 2016
    ▪ Electronics boards
  – October 2016
    ▪ Assembly structure
    ▪ External frame
Upcoming Events

• Assembly
  – October 2016
    ▪ Spherical mirror mounting and coating
    ▪ Electronic panel
  – November 2016
    ▪ Assembly structure
    ▪ Detector structure
Upcoming Events

• Testing
  – August 2016
    ▪ Pre-production electronic boards
  – November 2016
    ▪ Electronic panel

• Installation
  – September 2017
Conclusion

• Contributions by *all* DSG members
  – Measurements
    ▪ CMM-based
  – Analysis using Python and AutoCAD
    ▪ Mirror dimensions
  – Research and Design
    ▪ Interlocks
    ▪ Gas system
  – Procurement
    ▪ Interlocks
    ▪ Gas system
  – Safety
    ▪ THA and OSP
Conclusion

• Delivery of components underway
• Performing acceptance tests
  – Mirrors
  – Aerogel
  – Electronics
• Finalized location and layout for assembly and testing
THANK YOU
Backup Slides
Air Cooling Compressor Specs

Model: SF 11-100 AFF Multi (includes 3 x SF4 modules)

<table>
<thead>
<tr>
<th>Inlet conditions</th>
<th>100 psi</th>
<th>Unit</th>
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<tbody>
<tr>
<td>1. Barometric pressure</td>
<td>14.5</td>
<td>psi(g)</td>
</tr>
<tr>
<td>2. Ambient air temperature</td>
<td>68</td>
<td>°F</td>
</tr>
<tr>
<td>3. Relative humidity</td>
<td>0</td>
<td>%</td>
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<table>
<thead>
<tr>
<th>Performance</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1. Maximum discharge pressure*</td>
<td>112</td>
<td>psi(g)</td>
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<tr>
<td>2. Operating pressure*</td>
<td>196</td>
<td>psi(g)</td>
</tr>
<tr>
<td>3. Capacity delivered*</td>
<td>43</td>
<td>cfm</td>
</tr>
<tr>
<td>4. Shaft power input – loaded</td>
<td>11.1</td>
<td>bhp</td>
</tr>
<tr>
<td>5. Shaft power cooling fan</td>
<td>2.0</td>
<td>bhp</td>
</tr>
<tr>
<td>6. Drive Arrangement</td>
<td>Belt Drive</td>
<td></td>
</tr>
<tr>
<td>7. Dryer – FF only</td>
<td>7</td>
<td>bhp</td>
</tr>
<tr>
<td>8. Package power input – Loaded</td>
<td>12</td>
<td>kW</td>
</tr>
<tr>
<td>9. Sound level*</td>
<td>60</td>
<td>dBA</td>
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<tr>
<td>10. Pressure dew-point</td>
<td>37</td>
<td>°F</td>
</tr>
<tr>
<td>11. Minimum ambient temperature</td>
<td>32</td>
<td>°F</td>
</tr>
<tr>
<td>12. Maximum allowable inlet temperature</td>
<td>104</td>
<td>°F</td>
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<table>
<thead>
<tr>
<th>Cooling data</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cooling air flow – Unit canopy total cfm with dryer included</td>
<td>1363</td>
<td>cfm</td>
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<tr>
<td>2. Cooling air flow – Dryer only</td>
<td>106</td>
<td>cfm</td>
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<tr>
<td>3. Discharge air temperature (Ambient +)</td>
<td>180</td>
<td>°F</td>
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<table>
<thead>
<tr>
<th>Electrical data</th>
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<tbody>
<tr>
<td>1. Motor</td>
<td>3 x 4 / 3 x 5</td>
<td>kW / Hp</td>
</tr>
<tr>
<td>2. Motor type</td>
<td>Induction</td>
<td></td>
</tr>
<tr>
<td>3. Enclosure</td>
<td>TEFC</td>
<td></td>
</tr>
<tr>
<td>4. Service Factor</td>
<td>1.15</td>
<td></td>
</tr>
<tr>
<td>5. Efficiency</td>
<td>85.5</td>
<td>%</td>
</tr>
<tr>
<td>6. Speed</td>
<td>3505</td>
<td>rpm</td>
</tr>
<tr>
<td>7. Insulation</td>
<td>F w/B rese</td>
<td></td>
</tr>
<tr>
<td>8. Bearing</td>
<td>Antifriction</td>
<td></td>
</tr>
<tr>
<td>9. Starter type</td>
<td>Press Switch - Stop/Start</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical data</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dimensions L x W x H</td>
<td>66 x 30 x 48</td>
<td>inches</td>
</tr>
<tr>
<td>2. Weight</td>
<td>1136</td>
<td>lbs</td>
</tr>
<tr>
<td>3. Air discharge</td>
<td>1/2</td>
<td>inch NPT</td>
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