The Design and Construction of the HELIX RICH Detector

The HELIX detector uses a radiator of aerogel tiles and a detector plane of SiPMs to accurately measure the velocity of particles with energy above 1 GeV/nuc. The detector is composed of 3 main components that ensure that the geometry of the instrument is correct and that the SiPMs are kept at a consistent temperature.

Magnet: (Particle Rigidity)
A warm bore superconducting magnet is supported at the corners with an additional 60 cm x 60 cm silicon paddle at the bore of the magnet. The ends of paddles are instrumented with 8 SiPMs and readout with a timing resolution of ~50 ps for Z=3.

Aerogel Radiator Assembly:
The aerogel assembly consists of 10 cm x 1 cm aerogel tiles arranged in a 6x6 grid and held in an aluminum frame. Holes located on the radiator assembly locate and reference the RICH to the magnet and the rest of the payload.

Gas Tracker: (Particle Rigidity)
Gas Tracker is a 72 layer drift chamber with 72 sense layers used to track the position of isotopes as they bend in the magnetic field. The ends of paddles are instrumented with 8 6x6mm SiPMs designed in collaboration with Hamamatsu. The pixels all share a common cathode and are manufactured by Hamamatsu. The pixels all share a common cathode and are manufactured by Hamamatsu. The pixels all share a common cathode and are manufactured by Hamamatsu. The pixels all share a common cathode and are manufactured by Hamamatsu.

ToF Counters: (Velocity and Charge Measurements)
The SiPM modules used by the RICH are 8x8 arrays of 6x6mm² SiPM pixels designed in collaboration with and manufactured by Hamamatsu. The pixels all share a common cathode and are read out individually by their anodes. Each array also has two integrated LMT70 sensors for monitoring temperature so the temperature dependent effects can be compensated for.

Basic functionality testing was completed for confirmation of the CITIROC1A performance to ensure the board meets the requirements.

RICH Electronics

The RICH electronics are custom boards designed to meet the unique requirements of the HELIX RICH detector. The boards each read 8 SiPM arrays with 16 CITIROC1A chips each, requiring 25 boards total to instrument the 12,800 pixels of the focal plane.

Due to the flight altitude a custom heat sink to cool the FPGAs was designed. This is required to keep the components in the proper operating temperature ranges.

Basic functionality testing was completed for confirmation of the CITIROC performance to ensure the board meets the requirements.

Board Summary

<table>
<thead>
<tr>
<th>Board Size</th>
<th>240 x 200 mm²</th>
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</thead>
<tbody>
<tr>
<td>ASIC</td>
<td>16 x CITIROC1A</td>
</tr>
<tr>
<td>Trigger threshold</td>
<td>&lt; 1 PE</td>
</tr>
<tr>
<td>FPGA</td>
<td>2 x Virtex-7</td>
</tr>
<tr>
<td>Channel Count</td>
<td>512</td>
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<tr>
<td>Power/Channel</td>
<td>~20 mW</td>
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<tr>
<td>Power Consumption</td>
<td>~10 Watts</td>
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</tbody>
</table>

The boards, cables, and downstream readout have gone through prototyping and initial characterization of the readout performance. With testing completed the full 25 RICH boards and 200 cables will be manufactured in the Fall of 2019.

SiPM Modules

The SiPM modules used by the RICH are 8x8 arrays of 6x6mm² SiPM pixels designed in collaboration with and manufactured by Hamamatsu. The pixels all share a common cathode and are read out individually by their anodes. Each array also has two integrated LMT70 sensors for monitoring temperature so the temperature dependent effects can be compensated for.

The SiPM Summary table shows:
- Dark Count Rate: ~ 2 MHz @ 25 °C
- Cross Talk Rate: ~ 15%
- Operating Voltage: 42 V
- PDE @ Vop: 55%
- Cell Size: 75 um
- Array Coating: Silicone
- Test stand charge spectrum
- Waveform
- Readout charge spectrum

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