The Design and Construction of the HELIX RICH Detector

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The HELIX Spectrometer

Time of Flight Counters: (Velocity and Charge Measurements)

Two arrays of 8 1.6 m x 20 cm x 1 cm scintillating paddles 2.3 meters apart with an additional 60 cm x 60 cm scintillator paddle at the bore of the magnet. The ends of paddles are instrumented with 8 6x6mm Silicon Photomultipliers (SiPM) and readout with a timing resolution of <50 ps for Z>3.

Magnet: (Particle Rigidity)

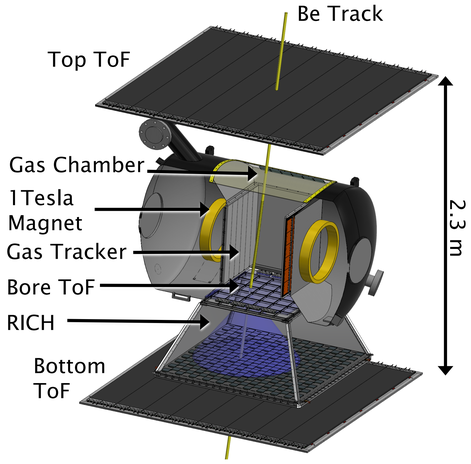
Warm bore superconducting magnet refurbished from the HEAT instrument. The magnet produces a uniform 1 Tesla field across the 50 cm x 50 cm x ~70 cm bore with a hold time of ~ 1 week.

Gas Tracker: (Particle Rigidity)

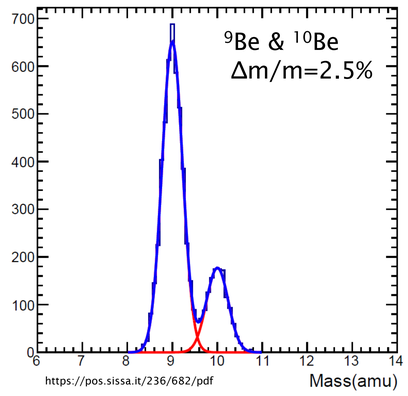
CO_2 multi-wire drift chamber with 72 sense layers used to track the position of isotopes as they bend in the magnetic field to determine the particle rigidity. Tracking layers are read out with a custom ADC system to meet a tracking resolution of better than 200um.

Ring Imaging Cherenkov Detector: (Velocity and Charge Measurement)

Proximity focused RICH used to measure the velocity of particles with energy above 1 Gev/nuc.



$$\left(\frac{\Delta m}{m}\right)^2 = \left(\frac{\Delta R}{R}\right)^2 + \gamma^4\left(\frac{\Delta\beta}{\beta}\right)^2$$

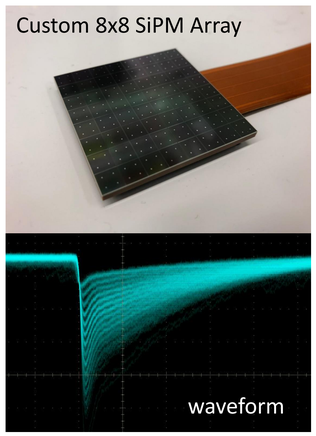


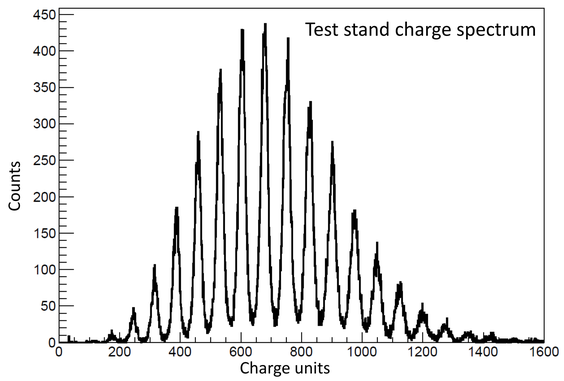
SiPM Modules

The SiPM modules used by the RICH are 8x8 arrays of 6x6mm^2 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.

SiPM Summary

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





RICH Detector

The HELIX RICH 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 a 3 main components that ensure that the geometry of the instrument is correct and that the SiPMs are kept at a consistent temperature.

Aerogel Radiator Assembly:

The aerogel assembly consists of 10cm x 10 cm x 1cm 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.

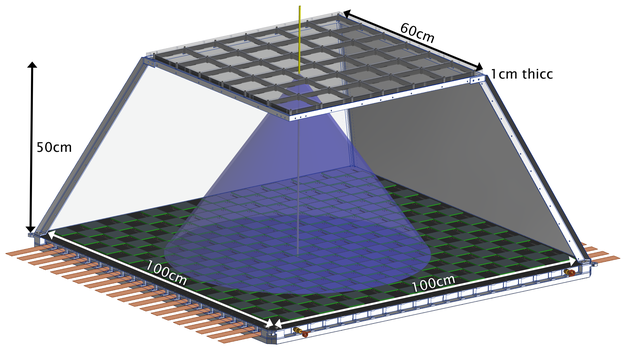
RICH Cone:

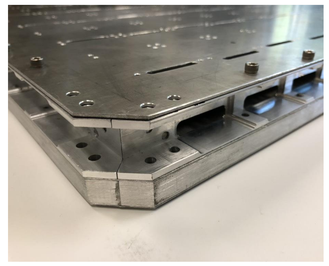
A light-tight aluminum assembly using reinforced corner supports to accurately set the expansion length of 50cm.

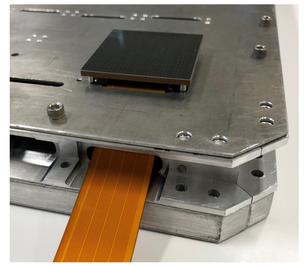
Focal Plane:

Laser cut aluminum sheet with mounting holes for the SiPM modules and slots for feeding cables through. The sheet is supported at the corners with C channels and in the center with 1" standoffs that mount it to the honeycomb base. The thermal control of the SiPMs can be accomplished by holding the edges of the focal plane at a constant temperature due to the low power dissipation in the SiPMs.

The majority of the main mechanical components have been constructed and qualified with mechanical fits and quality control metrology completed.







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.

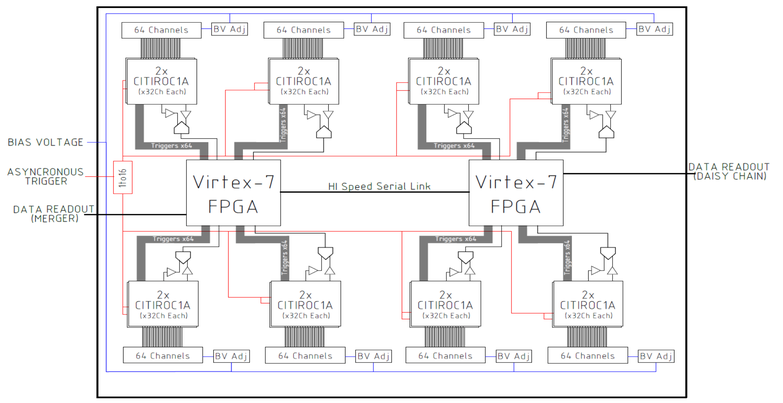
Due to the flight altitude a custom heat sink to cool the FPGAs was designed. This is required to keep the components in the proper operating temperature ranges.

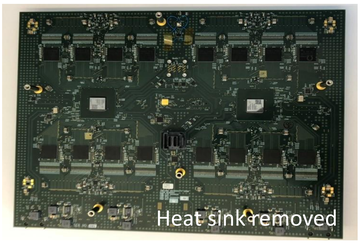
Basic functionality testing was completed for confirmation of the CITIROC performance to ensure the board meets the requirements.

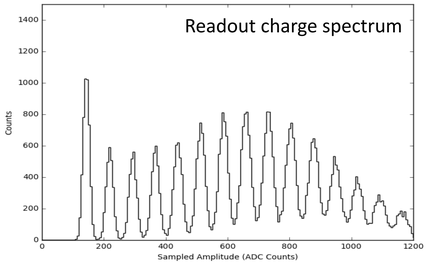
Board Summary

Board Size	240 x 200 mm^2
ASIC	16 x CITIROC1A
Trigger threshold	< 1 PE
FGPA	2 x Virtex-7
Channel Count	512
Power/Channel	~20 mW
Power Consumption	~10 Watts

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.







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