Design of a SiPM-based RICH detector for HELIX.

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HELIX Subsystems

Multiple system detector

- Time of Flight (Top and Bottom)
- 1 Tesla Superconducting Magnet
- Drift Chamber Tracker

The Ring-imaging Cherenkov Detector

- Proximity-focused RICH w/ SiPM readout
- Design goal: $\Delta \beta / \beta \sim 4 \times 10^{-4}$ for $Z > 3$
- Requires detector developments to reach goals
RICH: Ring Imaging CHERENKOV

RICH detectors use the Cherenkov effect to do:

1) Particle charge identification:

\[ N_{pe} \sim Z^2 \sin^2(\theta_c) \]

2) Precise measurement of particle velocity with error:

\[ \frac{\sigma(\beta)}{\beta} = \frac{\sigma(n)}{n} + \tan(\theta) \frac{\sigma(\theta)}{\sqrt{N}} \]

Designing a RICH requires studies and optimizing:
- Detection sensor granularity
- Radiator thickness, index, and uniformity
- Photon emission point uncertainty
- Expansion length
- Optical aberration
- Photon detection efficiency
The HELIX RICH Geometry

- Aerogel Tiles
- 1 cm thick
- 50 cm
- ~60 cm
- 100 cm
- 100 cm

Focal Plane
- 64 Ch SiPM modules (6 mm pixel)
- Thin Aluminum Plate

Readout via Cable
(Flexible Printed Circuit)
Aerogel

Refractive index of $n=1.15$ (produced by M. Tabata at Chiba U)
Threshold $\sim 1 \text{GeV/n}$
2$^{\text{nd}}$ Batch of aerogel is currently drying
Metrology, calibrated, and characterization by McGill
Why Silicon PhotoMultipliers?

Proximity to 1T Magnet makes PMTs problematic
SiPMs insensitive to field, robust, low bias voltage,
good PDE, and good charge resolution

**Evaluated** 10+ models from 3 vendors
Chose: Hamamatsu LVR2-SMP2-75um
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Temperature dependence of devices

Charge Resolution Degrades
Keeping the RICH Cool

**Requirement** to keep RICH plane under 25°C

**Goal** of under 5°C and uniform to ±2°C

**Challenges:**
- Due to 1 Tesla magnet payload, cannot be pointed
- No hot/cold side requires solar blind radiators
- Exploring active cooling to keep temperature uniform

**Material budget**
RICH Electronics

Requirements
- 12800 channel readout
- 10ns hit timing resolution
- Low power consumption
  (< 35 mW/channel)

Layout in progress by Indiana University

CITIROC frontend ASIC as SiPM readout
Functionality with selected SiPM confirmed with Eval Board
Conclusions

The HELIX is on schedule to fly during the 2019/2020 Antarctic Season.

HELIX RICH conceptual design finished and onto prototyping with production in early 2018.

Upcoming work:
- Characterize 8x8 SiPM modules
- Verify (1 meter) FPC cables
- Complete thermal simulation
Backup Slides
Multi Anode PMTs and Magnet fields

Performance of a multi-anode photomultiplier employing a weak electrostatic focusing system (Hamamatsu R8900 series)

X

Y

Z

Field (gauss)
SiPM basics

SiPMs consist of multiple photodiodes with quenching resistors in parallel. The photo diodes are reverse biased and run in Geiger mode.

Pixels avalanche and quench from the inline resistor. Since the device is silicon base the temperature dependencies are a concern.
Coating and Cross Talk

Measured CX Talk Values (at same gain)
Coated: 9.6%  (7% nominal)
nonCoated: 3.4%  (3% nominal)
Temperature and Datarate

![Graph showing the relationship between temperature and data rate for different particle types and time delays.](image)

- **RICH Size**
- **Max Data Rate**
- **Data Rate (MBps)**

**X-axis:** Temperature (°C)
**Y-axis:** RICH Occupancy (Pixels)

**Legend:**
- 30 ns
- 100 ns
- 300 ns

**Particulate Types:**
- Beryllium
- Helium
- Proton

7/15/2017

ICRC 2017 (Busan, Korea)
FrontEnd/CITIROC Evaluation

Tested SiPMs with the CITIROC ASIC to confirm compatibility with readout.

CITIROC allows for different, bias voltage, pre amps gain, and shaping times. Trigger outputs for 32 channels and multiplexed amplitude/charge readout.
The Little Rotator that couldn’t

Technique for keeping items cold in space is to point a radiator away from sun which requires pointing of the payload with Rotator.

Produced simulations of HELIX payload pointing
Taking into account: CREST flight path, sun position, and earths magnetic field*.

*https://ngdc.noaa.gov/geomag/WMM/DoDWMM.shtml