Forward Calorimeter Prototype

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quarks Q2C cosmos APRIL MEETING 2017 January 28-31, 2017 Washington, DC

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LEHIGH UNIVERSITY

NSF

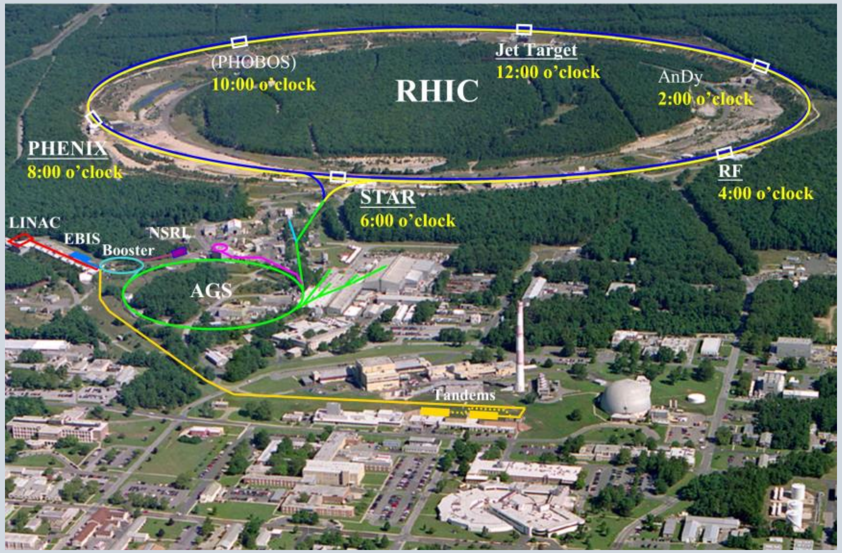
The Prototype

AGS-E864 Collaboration Lead Calorimeter from IP2

Installed for STAR Run16

Specifications

- 2x3 Lead Block Stack
  - 10cmx10cmx117cm blocks
- Spaghetti Calorimetry
- Spatial Resolution – 54 pixels at 3.3cmx3.3cm
  - 9 Fresnel Lenses + Silicon Photomultiplier (SiPM)
  - 18 Fresnel Lenses + Photomultiplier Tube (PMT)
  - 27 Acrylic Light Guides + Photomultiplier Tube
- Nuclear Interaction Length – 7 Interaction Lengths
- Hadronic Resolution – 34%/Sqrt[E]



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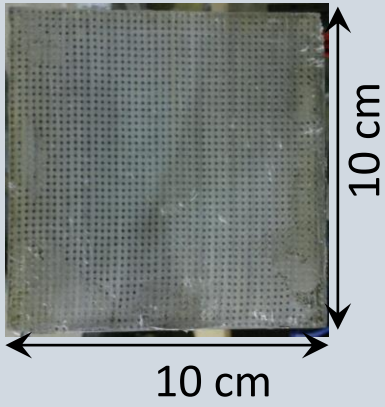
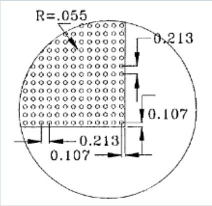
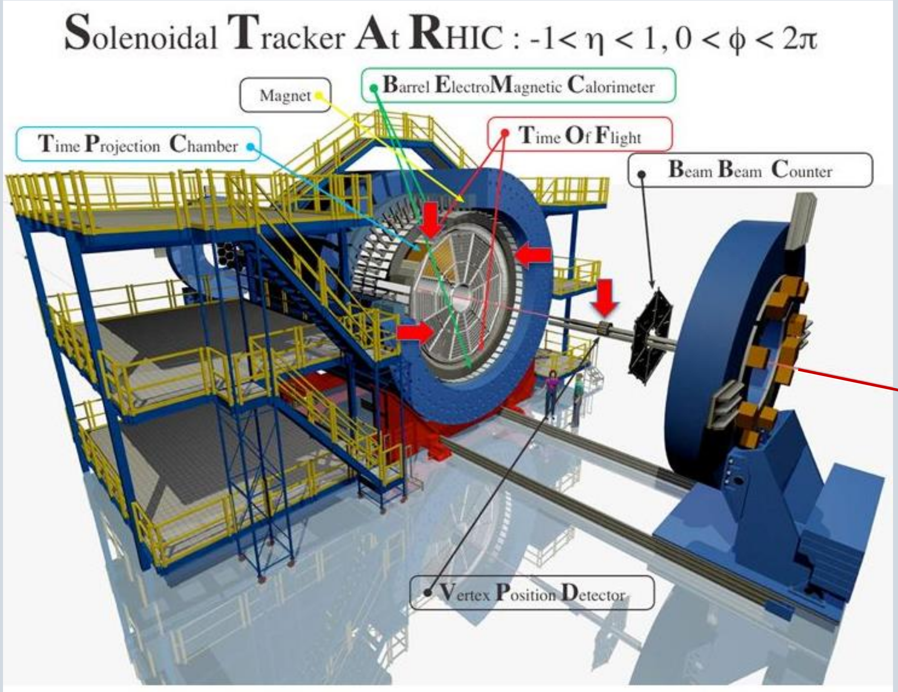




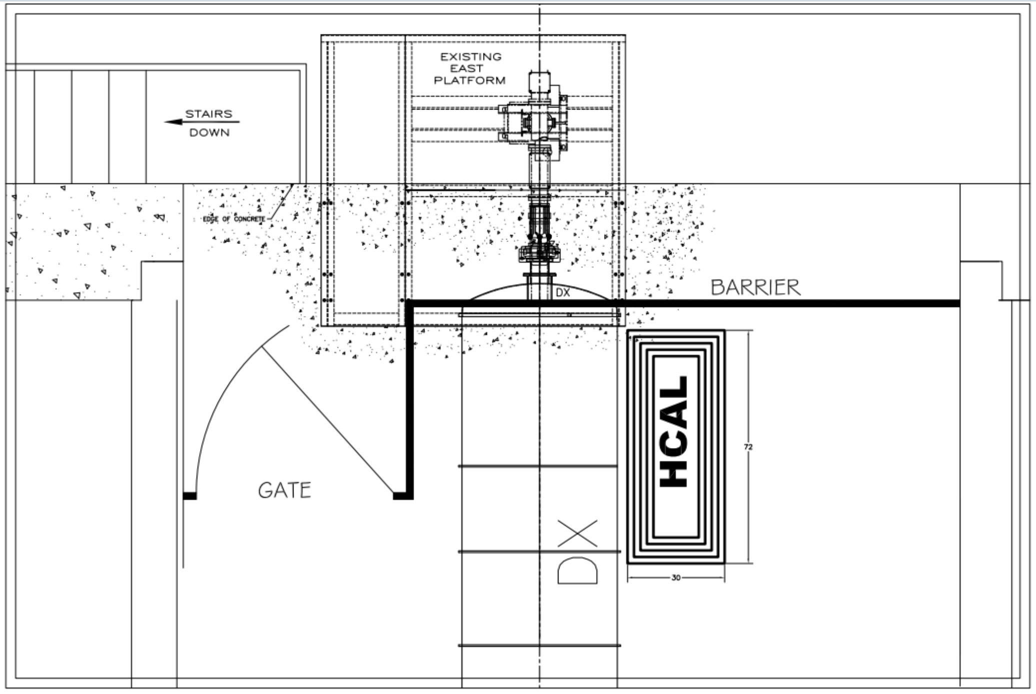
Prototype Detector Location

North side of the east tunnel

Less iron → lower fringe field effects



FCal



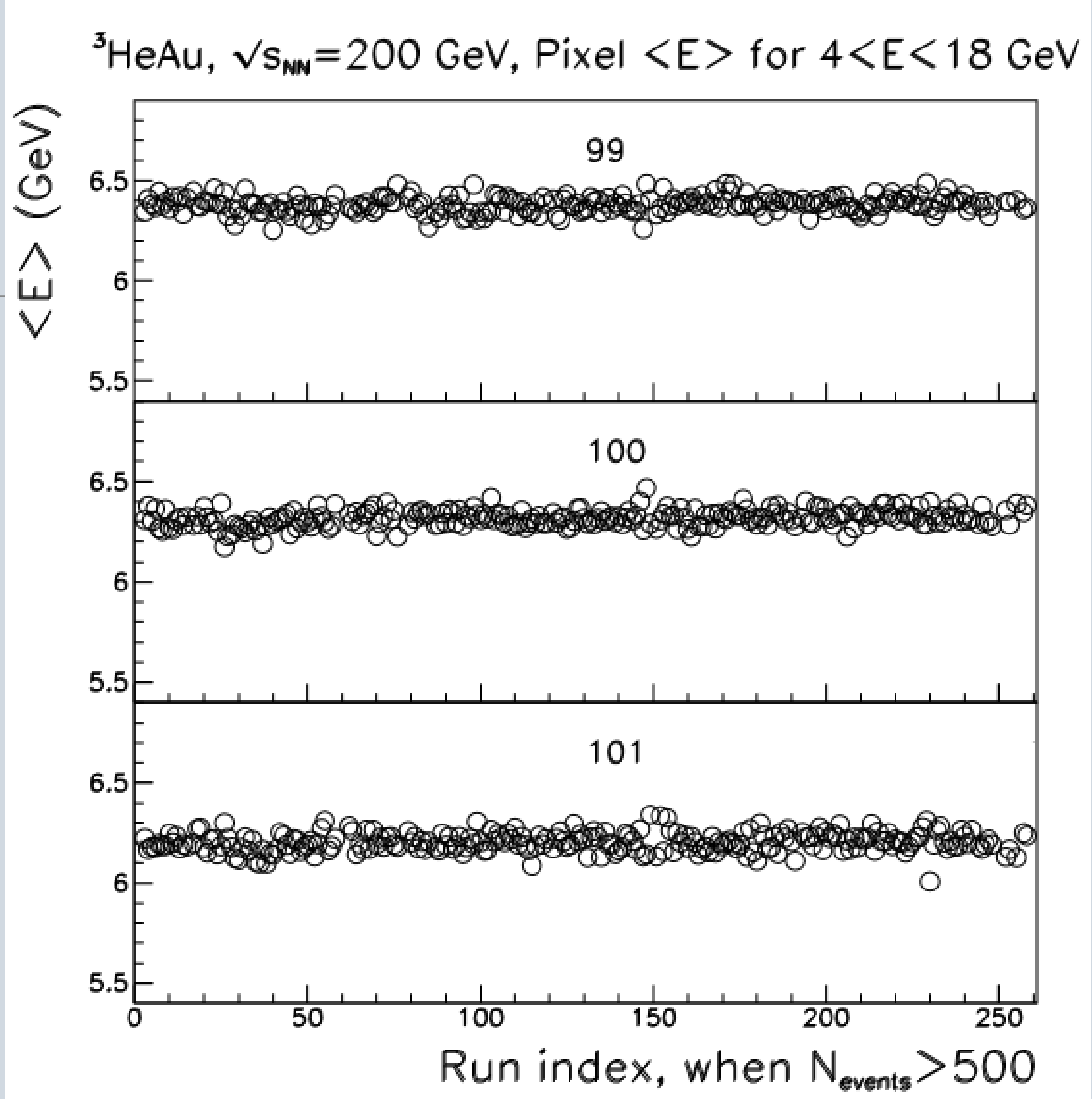
Prototype Goals

Reaffirming Run 14 Data
- 2014 Run Data Shown – Highly Stable
- Retain Stability – “Set it and forget it”

Hardware Tests
- Mu-Metal Shielding
- Fresnel Light Guides
- Silicon Photomultipliers

Neutral Pion Finding
- Calibration

Average energy deposition per run, for entire 200 GeV 3He+Au operation as a function of run number, for three selected pixels which are close to beam pipe.



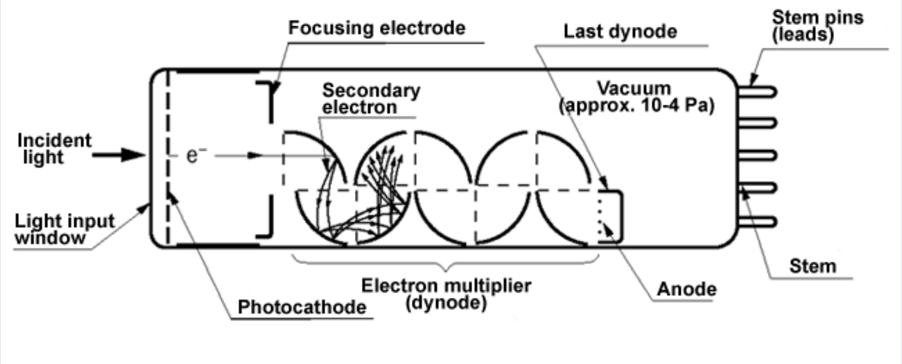
Mu-Metal Shielding

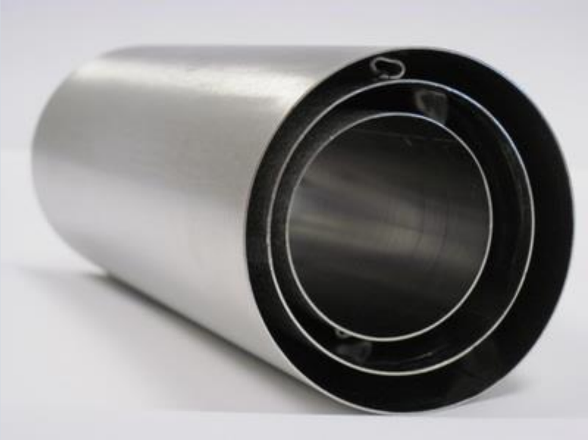
Magnetic field effects on photomultiplier tubes (PMTs)

- Magnetic field alters cascade in PMTs

Magnetic field shielding

- Known passive shielding
- Amount required
- Interaction with optical system





Fresnel Lens Light Guides

Alternative to acrylic light guide

Replaceable parts

- Commercial item
- Can be machined to fit
- Can be installed after stacking

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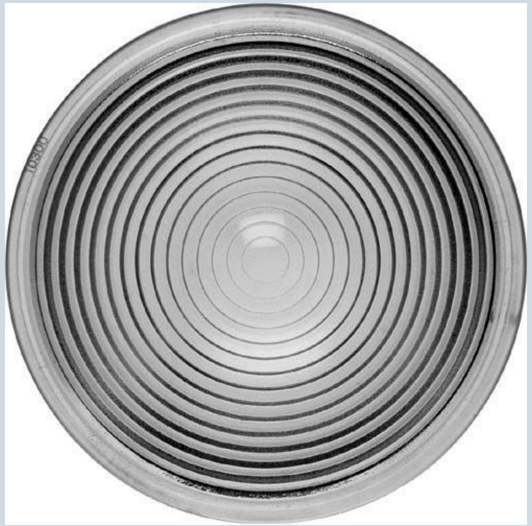

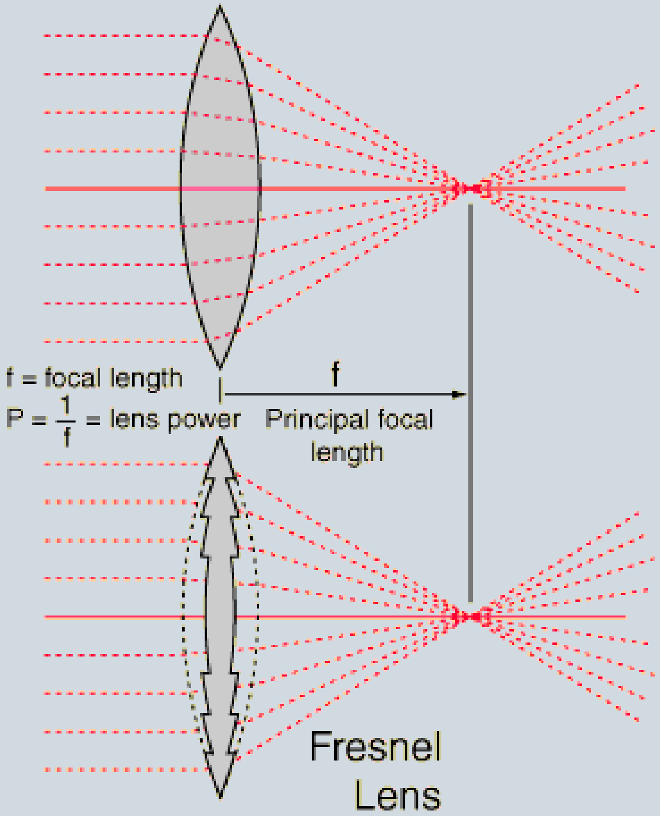

Fresnel Lens Light Guides

Alternative to acrylic light guide

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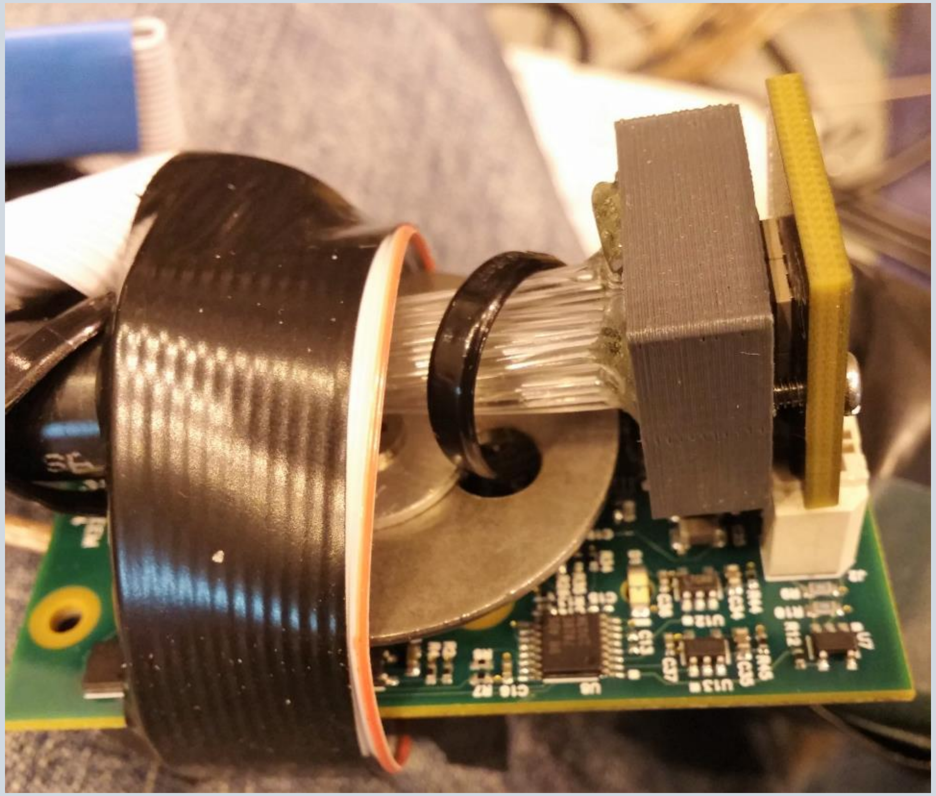
Silicon Photomultipliers (SiPMs)

Compared to photomultiplier tubes

- Magnetic field effects
- Lower cost
- Smaller

Stability over time

- Radiation resistance



Results

Mu-Metal Shielding

- Acrylic light guides limit length
- Fits into Fresnel lens system
- 8 degree tilt reduces field effects
- Optimal minimal recess of 5.8cm
- Reduces magnetic field effects to <5%

Fresnel Lens Light Guides

- Greater light levels than acrylic light guides
- More secure photomultiplier tubes
- Allows for proper recession distance

Results

Silicon Photomultipliers

- Changes due to radiation – Not stable
- Not suitable for this application due to placement

Testing over 28 days

Blue: PMT

Magenta: SiPM

Results

Neutral pion finding

- Early results
- Used for calibration
- $\pi^0 \rightarrow \gamma + \gamma$
- Further calibration needed

STAR Trigger used

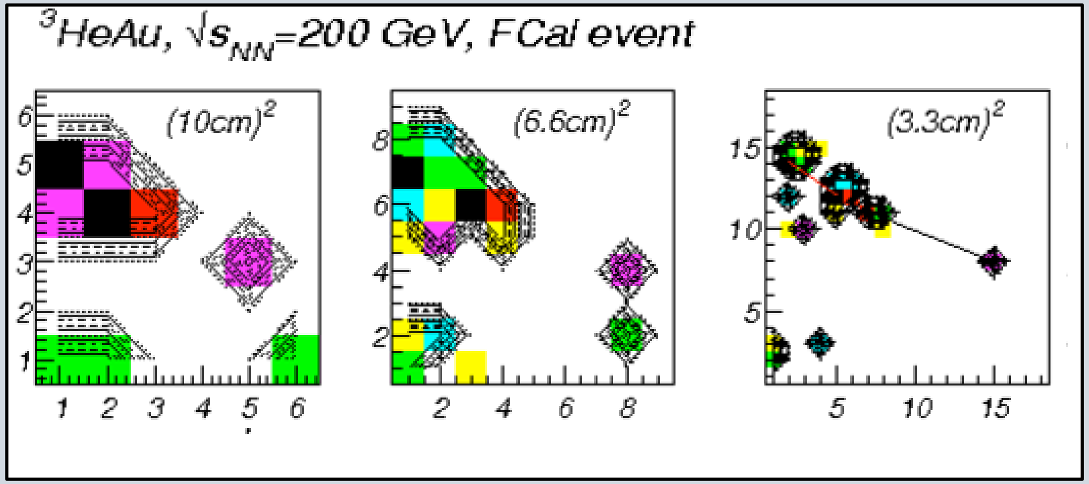
Au+Au Collisions used

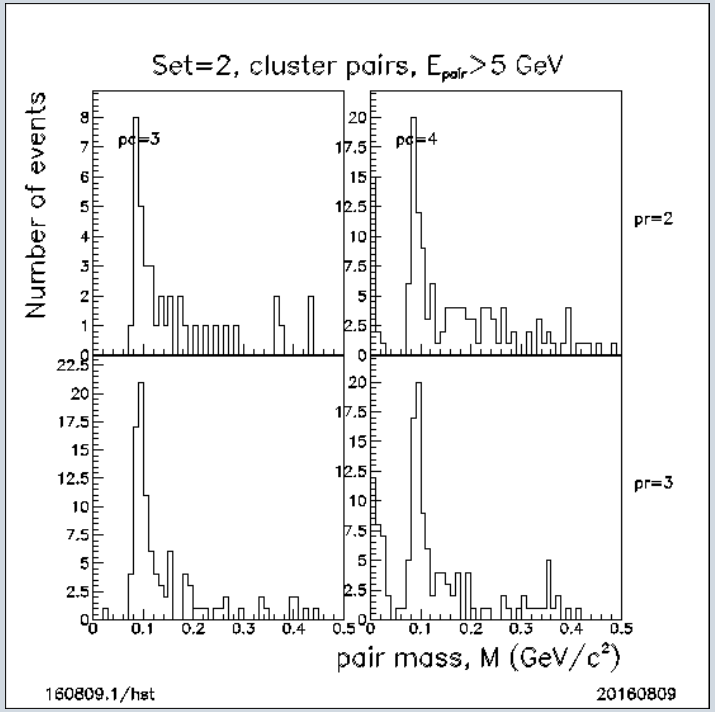
No Centrality explicitly selected

12% of available data used

4 Cells of Run16 data

Pixelization





Conclusions

Mu-Metal
- Provides adequate shielding
- Gain shifts reduced to <5%
- Allows use of PMTs close to the beam pipe

Fresnel Lens Light Guides
- Increase light levels
- Allows easy installation of components
- Allows easy replacement of components
- More secure PMTs

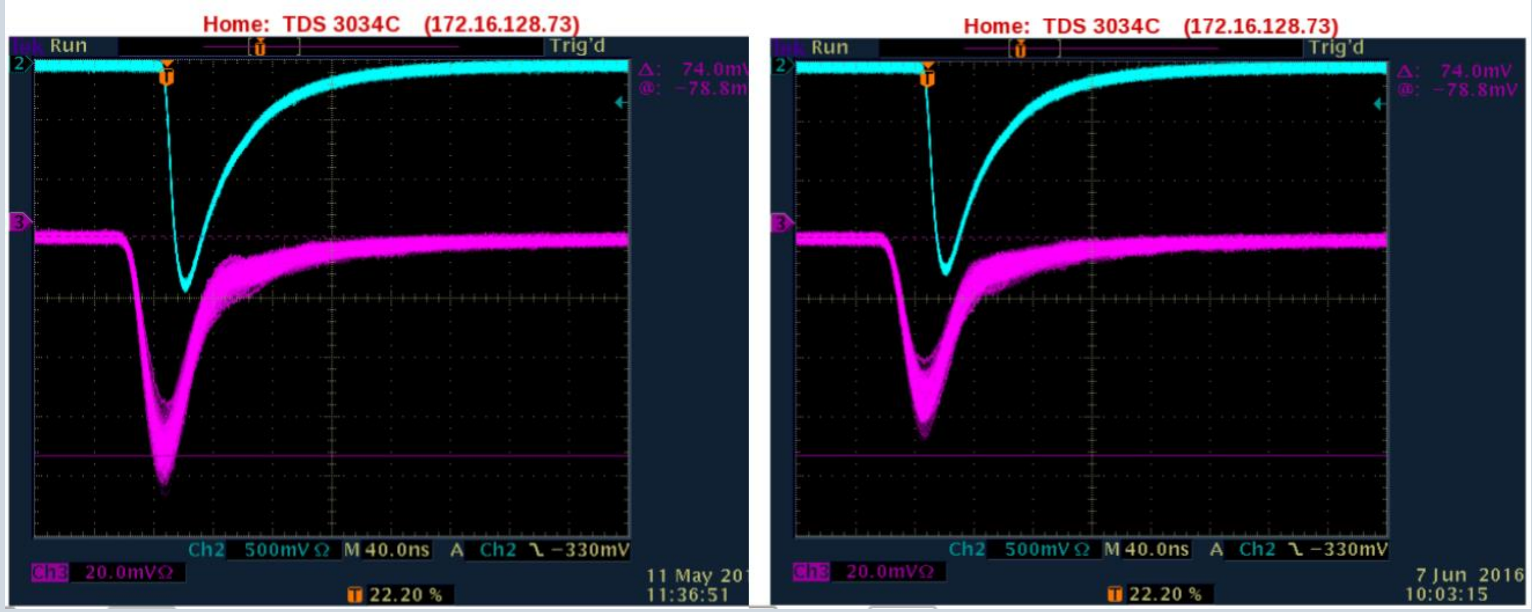
Silicon Photomultipliers
- Gain changes over time
- Not suitable

Neutral Pion Finding
- Reconstruction possible
- Used for calibration
- Further calibration needed

Results
- Results were positive
- Investigation of installation possibilities underway

SiPM Test Procedure

"A blue LED is pulsed continuously at ~100 Hz. Both an xp2262 and a 36x1-mm diameter fiber bundle view the pulsed LED. The phototube is ch=2 and the SiPM array is ch=3 on the escope. A script acquires e-scope images every ~20min [I do not recall the precise "sleep" time in the script], and stamps the acquired file with UNIX time. A separate script records your readable I2C values from your SiPM FEE every ~20min, and stamps a log file with UNIX time. From that we get leakage current."



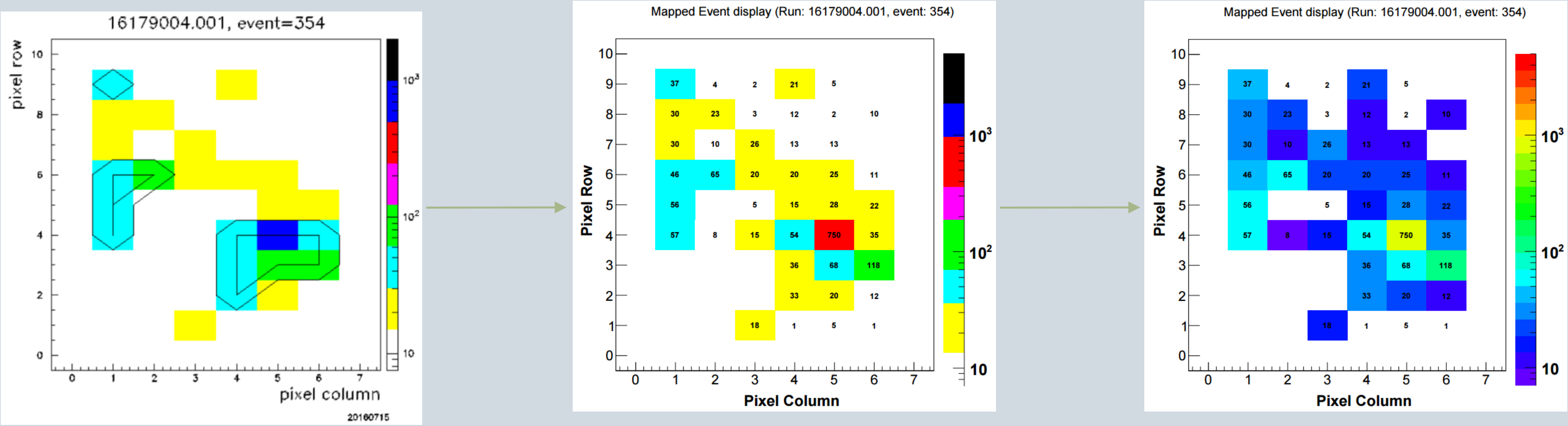
Code Conversion and Data Analysis

Finishing converting code to C++ / ROOT

- Open analysis to everyone

2016 Prototype data analysis

- Side by side comparisons
- Reaffirm 2014 data



Data Acquisition

Electronics designed/built by Berkeley group [H. Crawford, et al.] for STAR digital trigger

DAQ written for IP2 effort by C. Perkins

DAQ/digital trigger system previously used at IP2 In 2011-13. Last used at FermiLab for T1064

All items powered from 108VAC

Installed in Wide Angle Hall east side

All components remotely controlled via CANBUS (VME) or network-power switch