HTCC update

CLAS12 software workshop

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Outline

- Overview
- Hardware
  - Overview
  - Construction
  - Installation
- Software
  - Slow controls
  - Simulation
  - Calibration
  - Reconstruction
- Performance
- Future steps

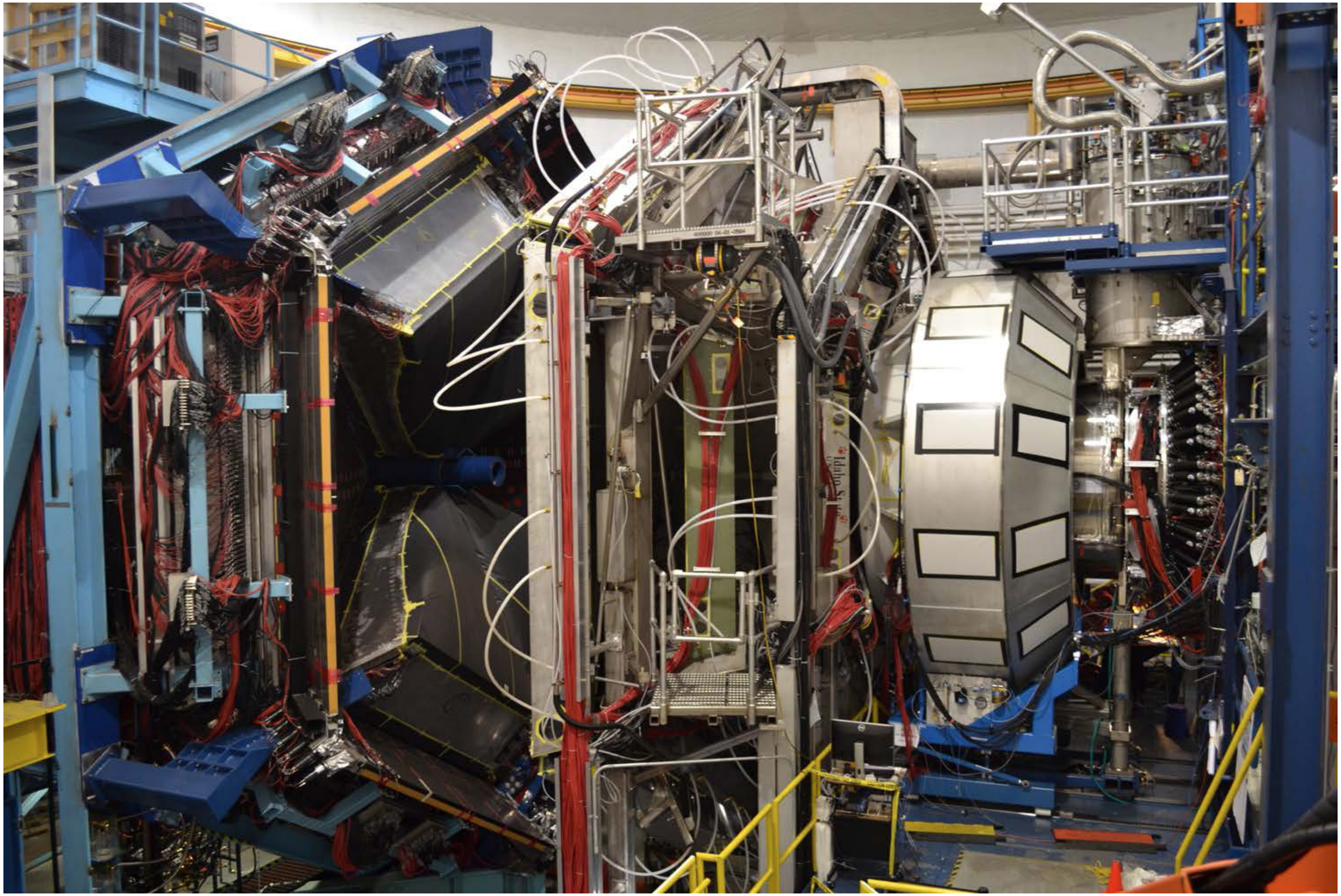
Assembled HTCC

HTCC overview

<u>High Threshold Cherenkov Counter</u>

- Purpose: e/π separation
- Radiator Gas (18.8m^3): CO_2 (1atm)
- Mirror thickness 135mg/cm^2
- Pion threshold: 4.7 GeV/c
- Number of Channels: 48
- Light readout: 5”PMTs (Quartz)
- Coverage in θ & ϕ: $5^o – 35^o$, 360^o.

HTCC overview



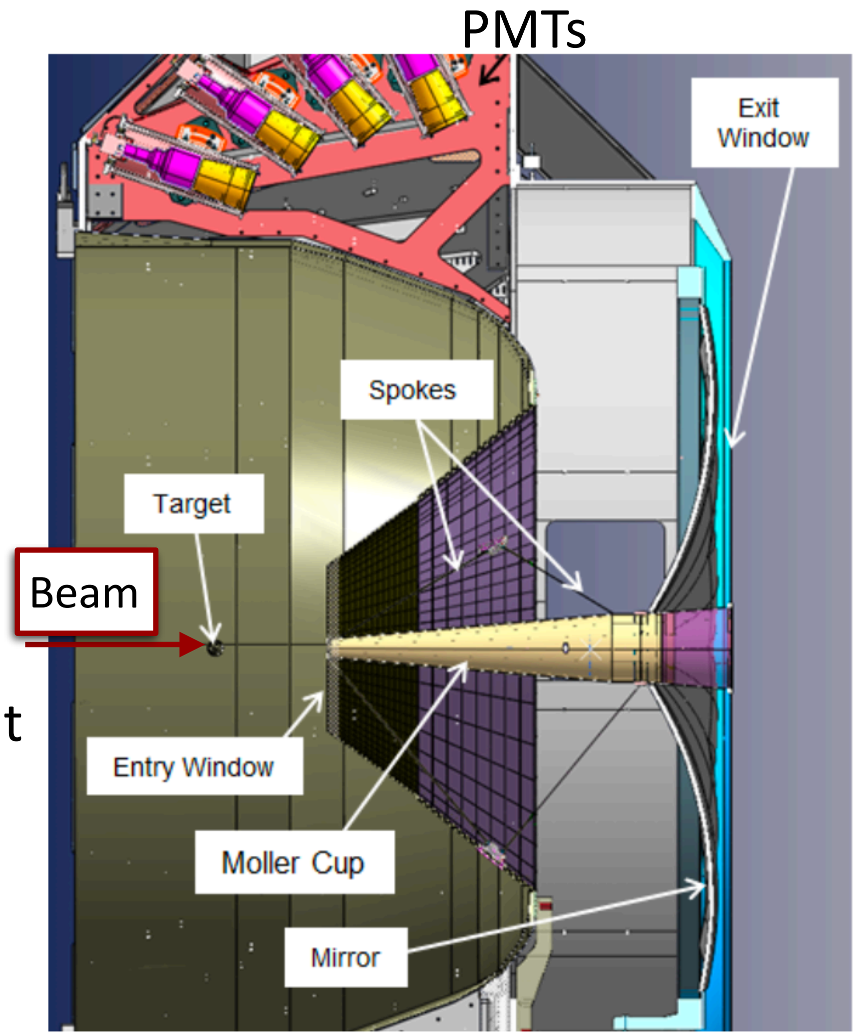
HTCC in data taking

- KPP run (commissioning and initial set up)
- Engineering run (commissioning and initial set up)
- RG-A Spring 2018 production
- RG-A Fall 2018 production
- RG-K production
- RG-A Spring 2019 production
- RG-B production

Hardware

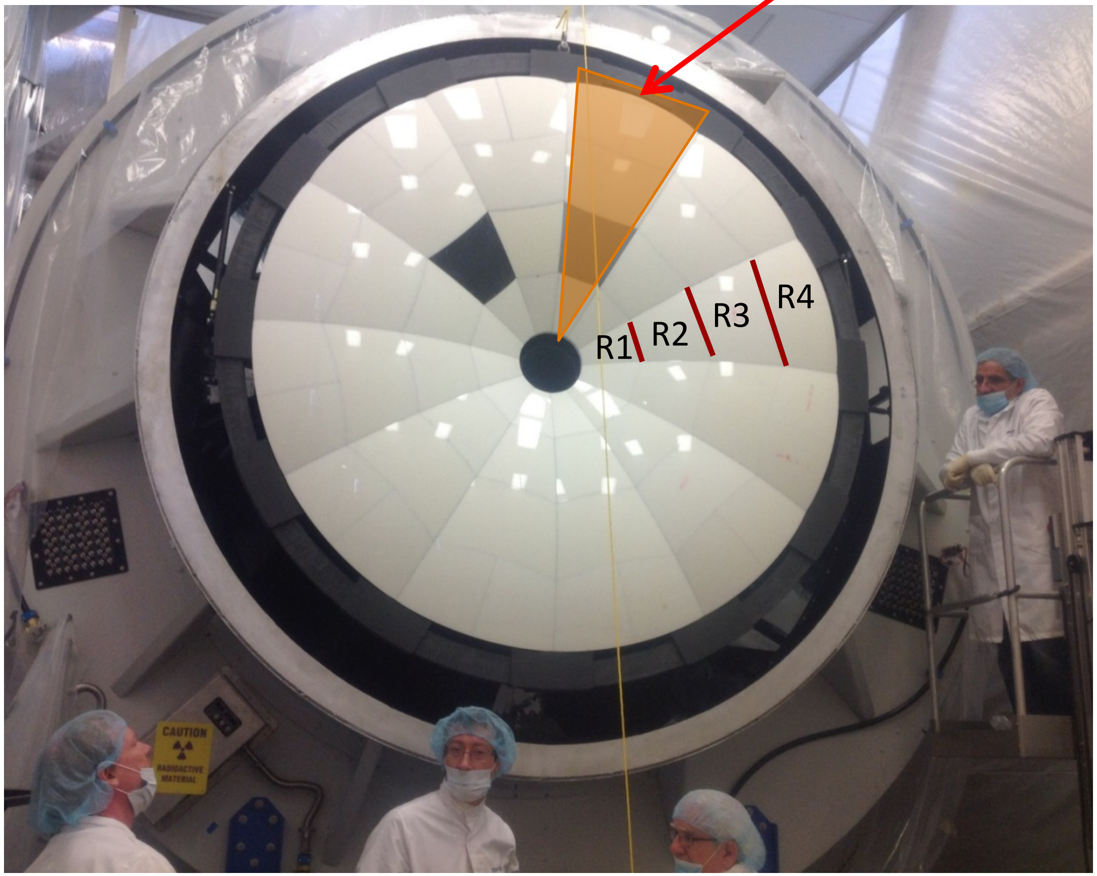
HTCC Cross section

- ET 5 inches quartz window PMTS with active dividers;
- ROHACELL foam mirror with high reflectance in UV and Visible light;
- CO_2 filled volume with controlled humidity;
- TEDLAR/MAYLAR/TEDLAR entry and exit windows;
- Carbon fiber spokes to hold a Moller cup.



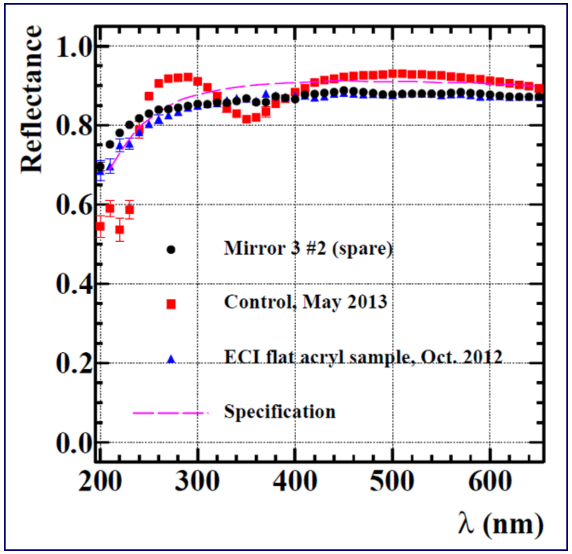
Mirror structure

One of 12 Halfsectors



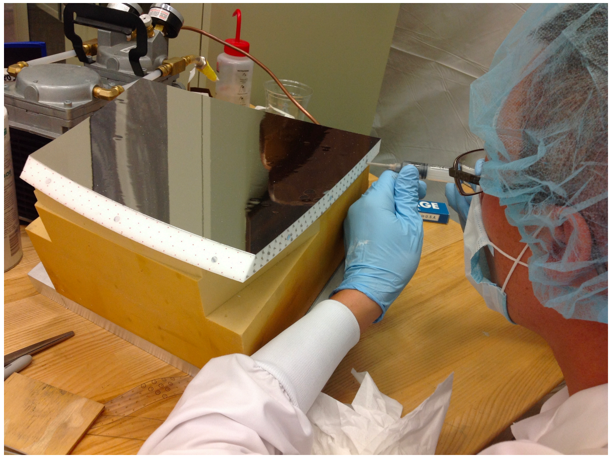
- 48 logical mirror segments (monitored by 48 PMTs);
- 60 physical mirror segments (largest mirror, mirror 4, is made of 2 pieces due to its large dimensions).

Construction



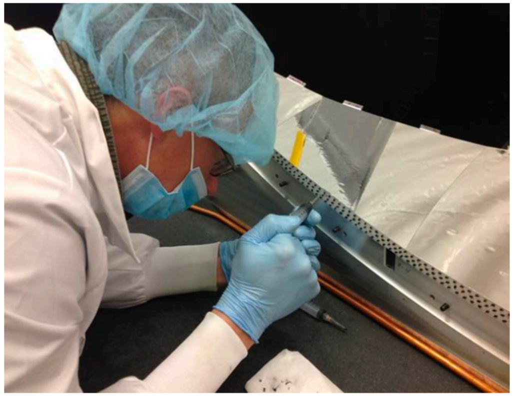
Each mirror was tested for the reflectance in both UV and Visible spectrums and 12 best mirrors for each facet were chosen.

Unfinished half sector on the half sector assembly table



Each mirror was glued with epoxy glue using the special glue dot pattern to prevent mirror shrinkage while assuring the glue strength.

Construction



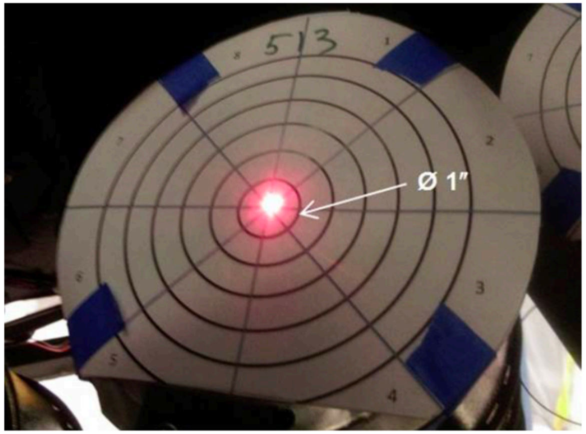
Epoxy dots were applied to one side of the mirror half sectors in the specific pattern.

Two halves of the mirror were assemblec on the table and then glued together to form a full mirror.

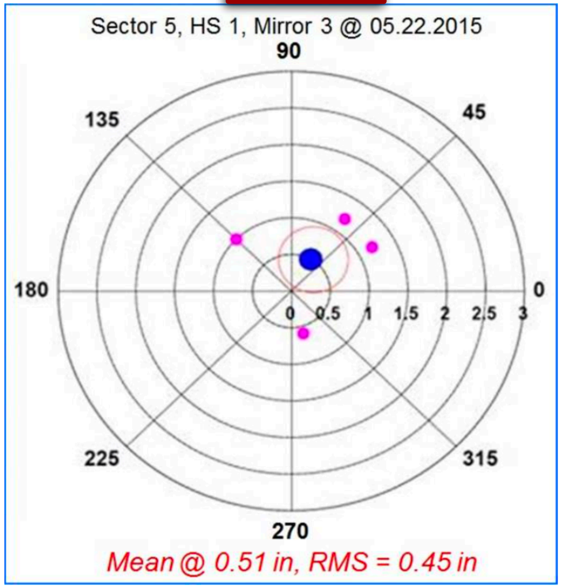
Individual half sectors were glued together on the special mirror assembly tool where they are held in place by a low pressure.

Construction

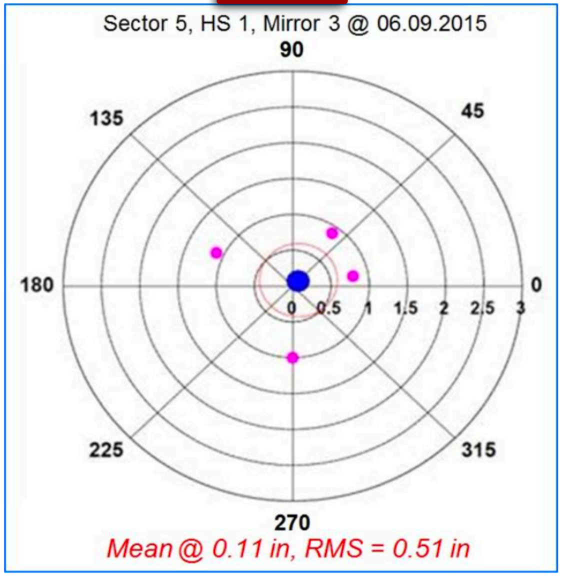
Using the laser installed in the position of the target we illuminated each mirror facet in 5 points (all 4 corners and a center) and recorded the reflection point near the face-off the PMT.
PMT position was adjusted so that the reflection would be centered.



Before



After

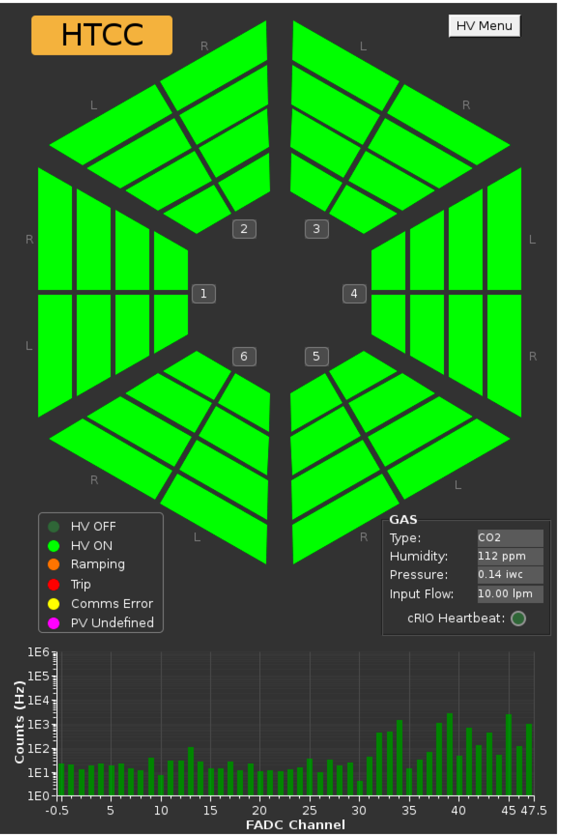


Software

- Slow controls
- Simulation
- Reconstruction
- Calibration

Slow controls

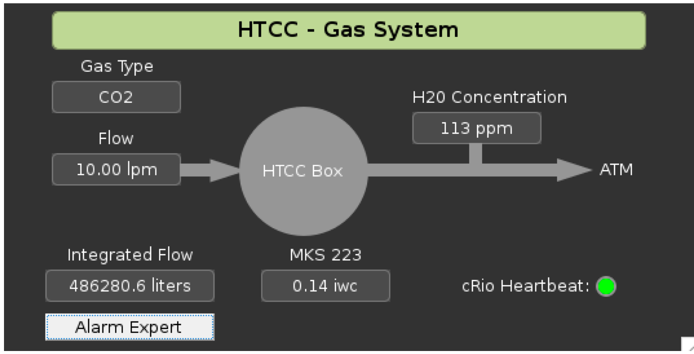
HV Controls

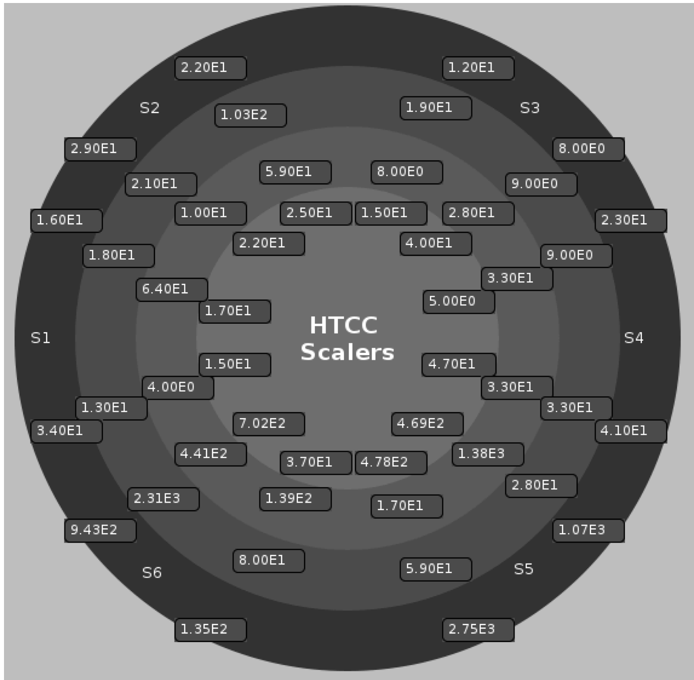


Full set of the Slow Controls control and detector monitoring was developed and implemented including

- High Voltages
- Low Voltages
- Gas
- LED
- Scalers

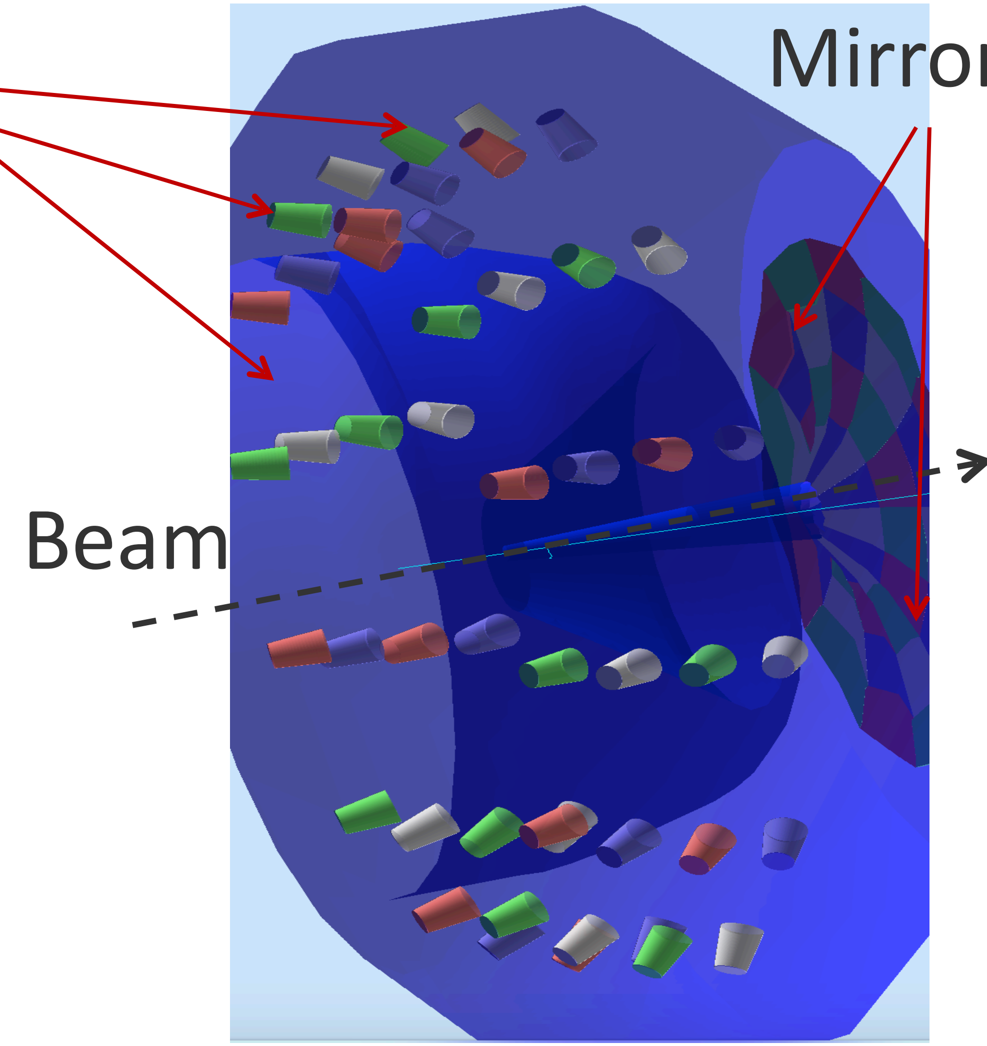
Gas controls





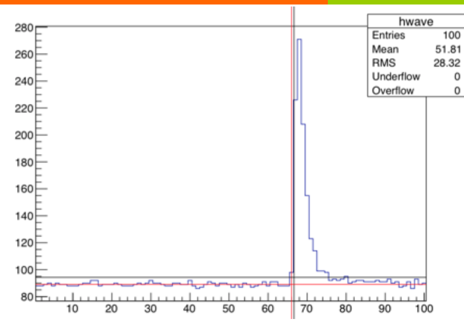
GEMC

- Full HTCC geometry
- Measured mirror and Winston cone reflectance
- Realistic Quantum Efficiency of the PMT with Quartz Entry Window
- Realistic $C0_2$ gas transparency
- Realistic $C0_2$ gas refraction index



Data processing

FADC channel



T, ns

FADC spectrum in time (read from 3 ADC cards, total of 48 channels)

Decoding

Sector, halfsector, ring

```
   sector (      BYTE) :          4
    layer (      BYTE) :          2
component (     SHORT) :          4
    order (      BYTE) :          0
      ADC (       INT) :       3060
     time (     FLOAT) :    136.000
      ped (     SHORT) :        103
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```

Calculating pulse size and time based on threshold value

```
--------------------------+-------------------
      id (     SHORT) :          0
   nhits (     SHORT) :          3
    nphe (     SHORT) :         44
    time (     FLOAT) :    136.632
   theta (     FLOAT) :      0.196
  dtheta (     FLOAT) :      0.038
     phi (     FLOAT) :      1.136
    dphi (     FLOAT) :      0.151
       x (     FLOAT) :     13.473
       y (     FLOAT) :     29.031
       z (     FLOAT) :    164.051
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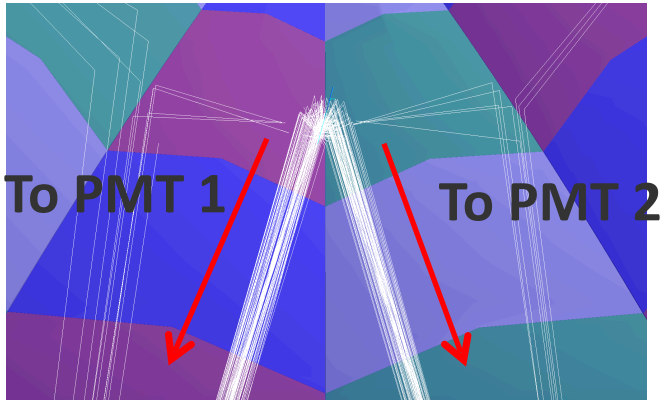
Reconstruction

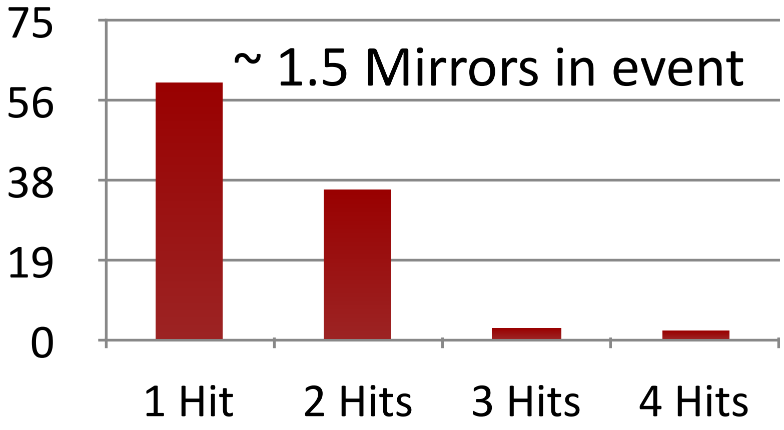
θ, ϕ
(x, y, z)

Calculating absolute signal strength and coordinate based on the PMT calibration

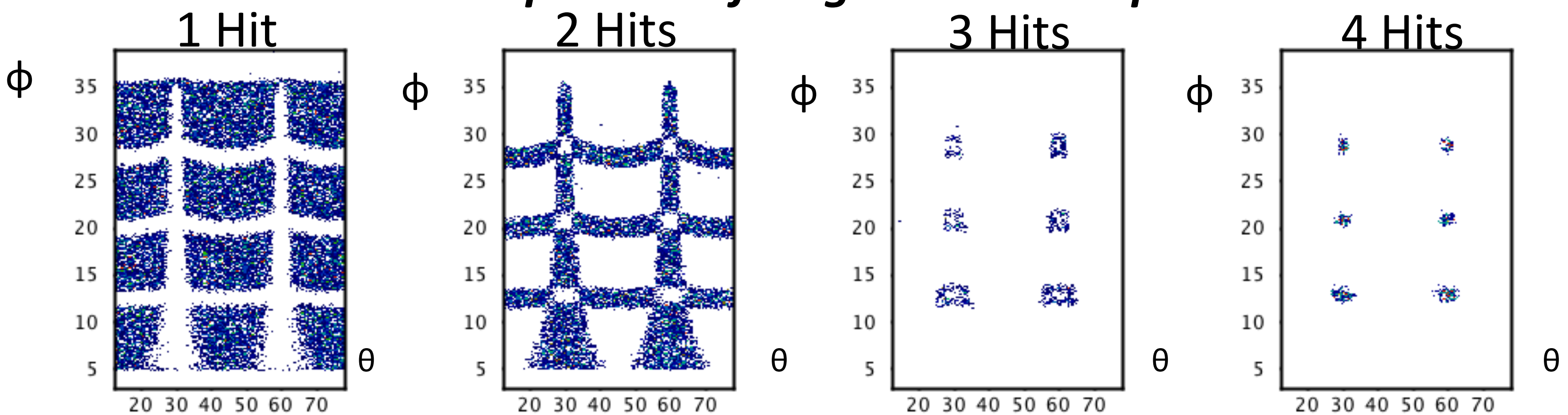
Reconstruction: clusters



Cerenkov radiation from single electron may split between mirrors and is collected by different PMTs

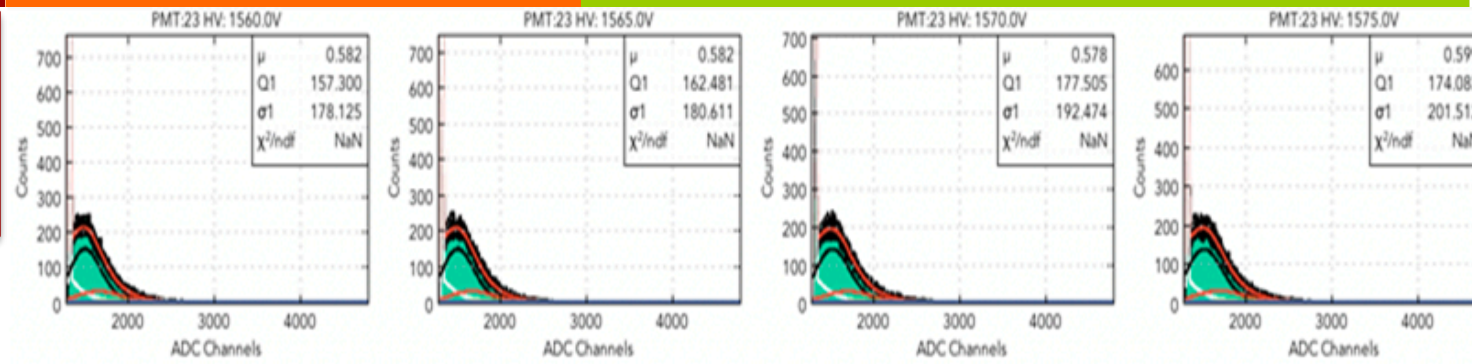


Geometrical pattern of single- and multiple hit events:



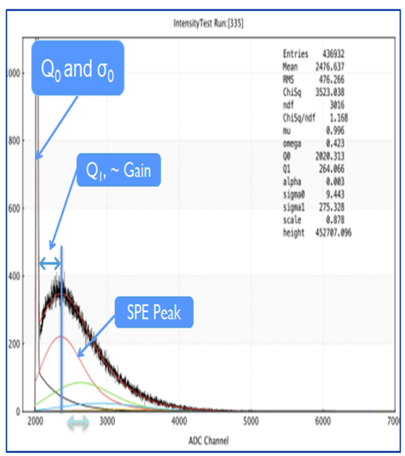
Calibration procedure

Perform the HV sweep of all 48 PMTs at the same LED luminosity



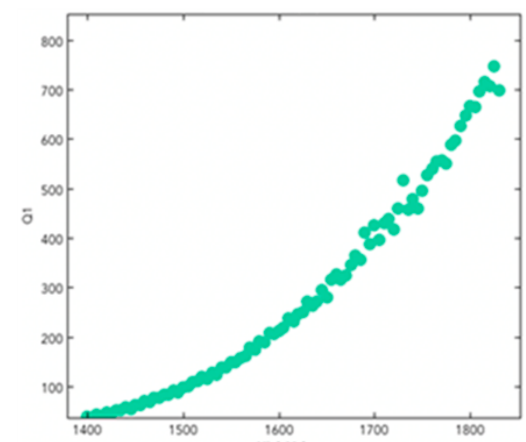
Fitting of individual responses

Find position of the SPE peak by fitting a response of the PMT to the LED illumination



Gain equalization

For each PMT, plot a SPE position vs High Voltage value



Setting up voltages based on the peak position

Based on the calibration curves, select a HV for each of the PMT such as that we have a single photoelectron peak at the same position across all 48 PMTs

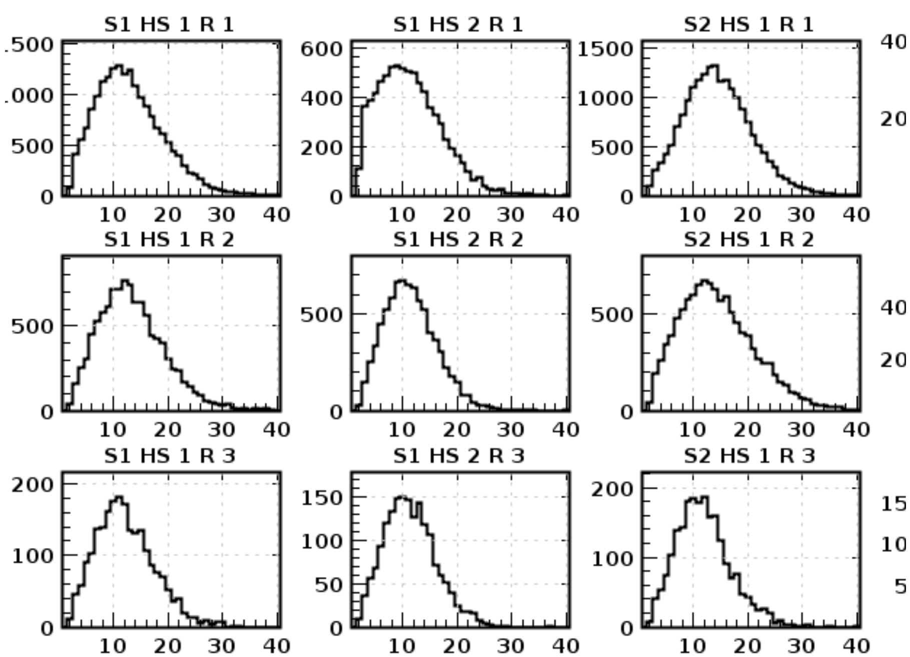
Calibration procedure

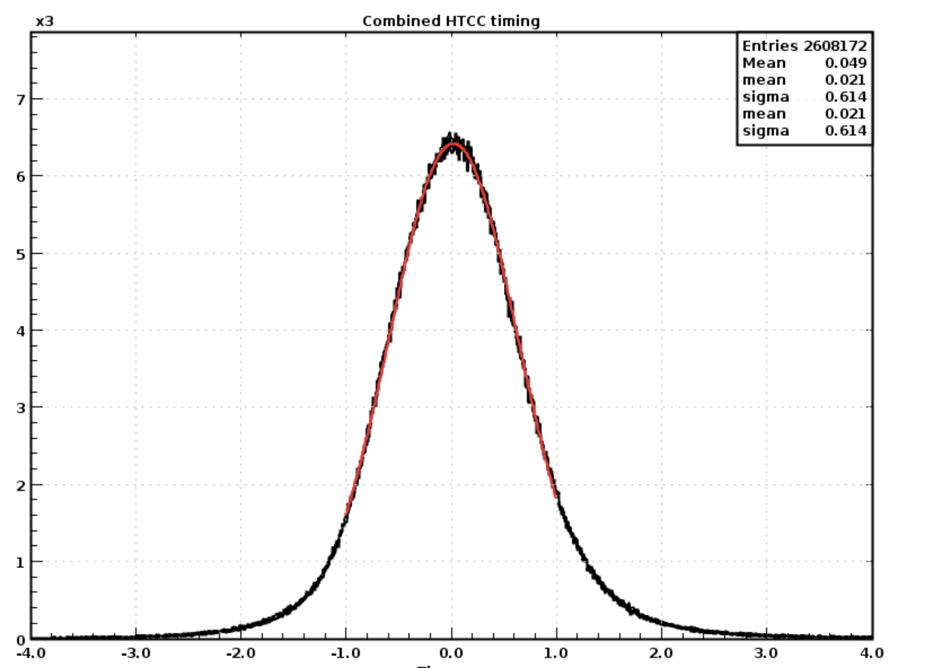
Signal Strength

- Estimate the signal strength in each of the 48 channels;
- Develop corresponding correction factors, which align the signals between individual channels.

Timing

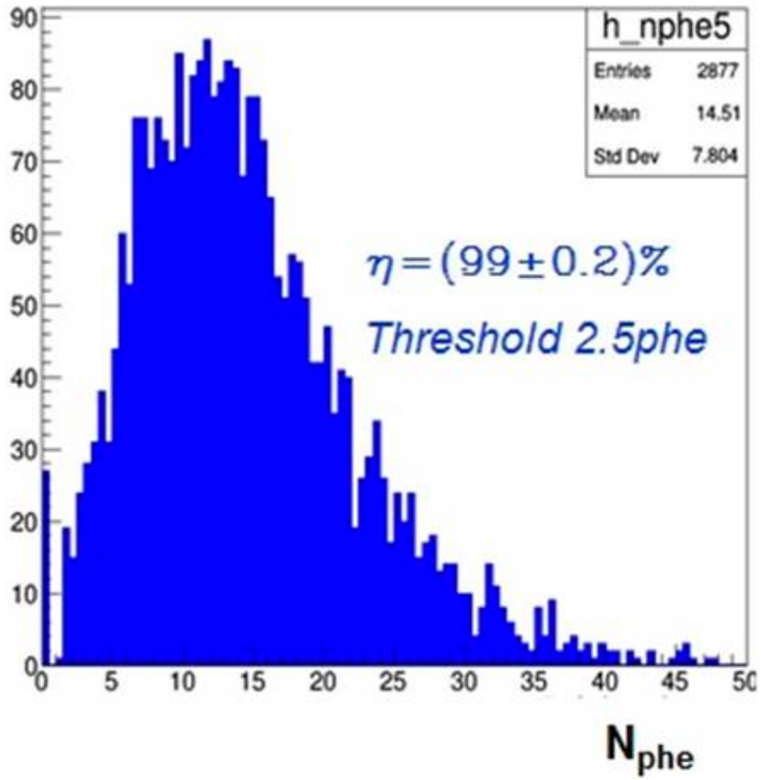
- **Online** : Timing of all 48 HTCC channels is aligned in the FADC configuration files by setting appropriate delays with the precision of the 4 *ns* (best available using the FADC);
- **Offline**: calculate time at the vertex for each of 48 channels and estimate the time shift between individual channels.





Performance

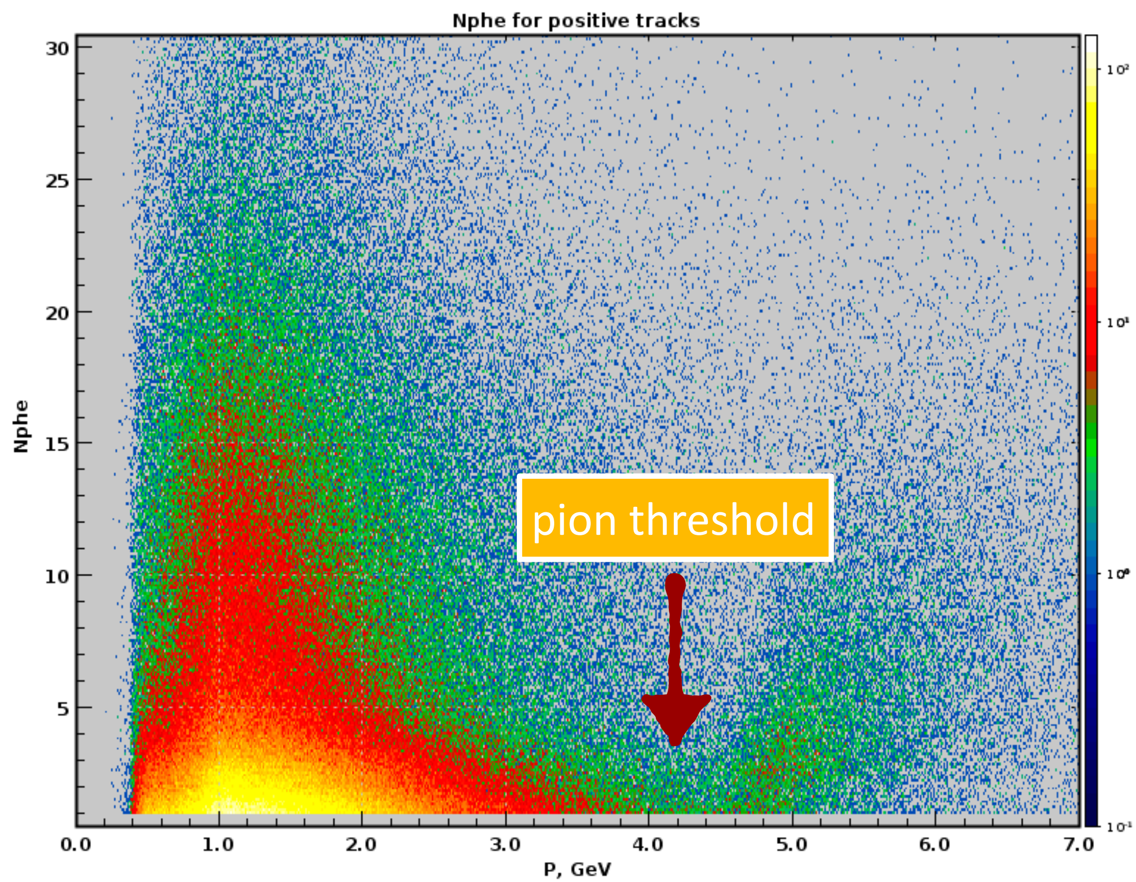
Using elastic events from 2 GeV run data, HTCC efficiency was determent to be around 99%. The threshold on the FADC at that moment was significantly higher then it should be, so it is a lower border of the efficiency.



plot form R. Paremuzyan

Performance

- Number of photoelectrons versus momentum for positive tracks.
- We clearly see pions with higher momentum above the threshold.



Future plans and issues

- Helium in the Hall B and gas content of the HTCC vessel:
  - Magnet quench releases helium in atmosphere (~350L for both magnets). Might affect quartz phototube lifetime;
  - Oxygen/ozone will absorb UV Cherenkov light and significantly affect the signal strength;
  - Installing residual gas analyzer to constantly monitor gas content of the HTCC vessel;
- HV crate replacement (CAEN->Wiener):
  - Earlier studies found that the CAEN HV PS make the pedestal peak width ~ 8 channels. Using single channel NIM PS or Wiener PS reduce it to 2-3 channel. Make a fit more stable;
- Replacement of the active dividers with passive bases:
  - Second output of the base (supposed to be TDC) is not used as we use FADC for both timing and signal strength. Installing the passive base will allow us to bring up voltage on the first dinode to reduce the noise.
- Replacement of ET PMTs with Hamamatsu PMTs or LTCC PMTs:
  - ET PMTs are rather noisy, installing Hamamatsu PMTs with UV transparent glass coated with wave shifter or LTCC PMTs might reduce noise. Studies are under way.
- Minor modification of calibration and reconstruction software.

Summary

- HTCC was working effectively as a part of the CLAS12 generating trigger signal and serving as a part of PID;
- HTCC met the performance requirements;
- Calibration and reconstruction software properly works;
- Tighter monitoring of the internal conditions of the detector vessel is planned and installation of the system is under way;
- Upgrades in electronics are planned.