BETA Detectors

Spin Asymmetries of the Nucleon Experiment

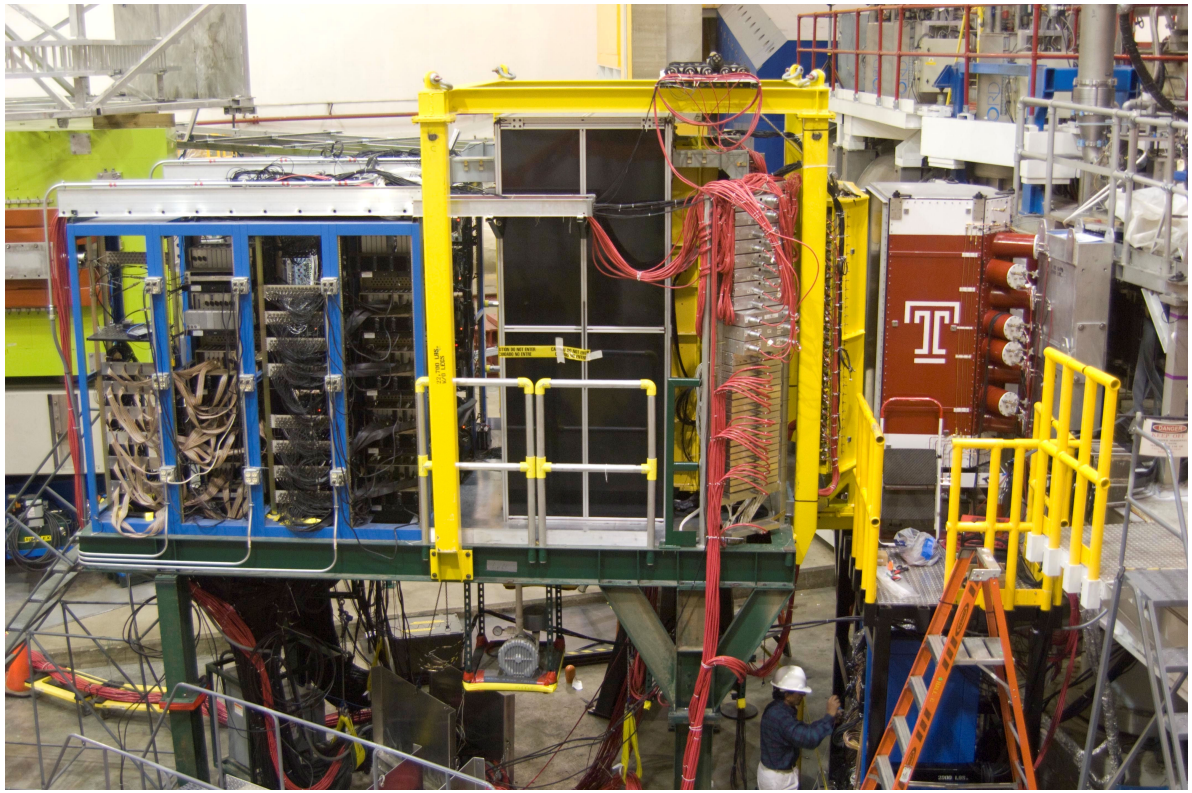
Whitney R. Armstrong

Temple University Physics Department

January 15, 2011

Outline

Big Electron Telescope Array



SANE used BETA to detect inclusive electrons with a large acceptance at angles around 40°for energies above about 1 GeV.

Bigcal

Two Sections

The upper section from Yerevan Physics Institute used during RCS experiment.

- It consists of $4x4x40cm^3$ lead-glass blocks
- They are arranged in a 30x24 array

Lower section from IHEP in Protvino, Russia.

- It consists of $3.8x3.8x45cm^3$ lead-glass blocks
- They are arranged in 32x32 array

1,744 lead glass blocks total.

Figure: Bigcal lead-glass blocks

Bigcal was previously used in the GEp series of experiments

SANE Gas Čerenkov

Gas Čerenkov is from Temple University.

Design

- Filled with nitrogen gas at atmosphere.
- Uses 4 spherical and 4 toroidal mirrors to focus light to photomultiplier tubes.
- Used 3 inch quartz window Photonis PMTs for UV transparency
- Mirror blanks were sent to CERN for special coating for high reflectivity far into the UV.

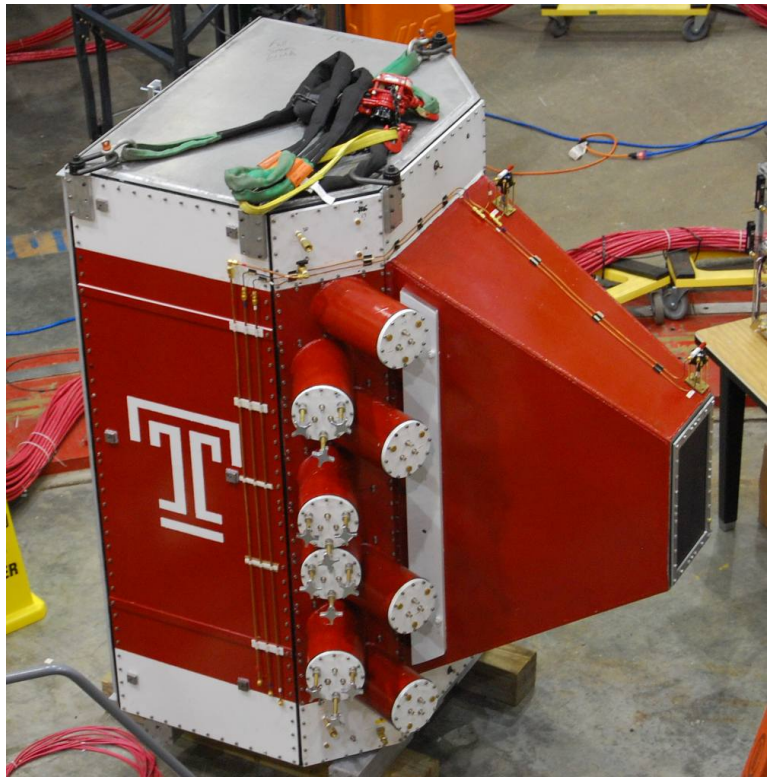


Figure: Gas Čerenkov on Hall C floor

Lucite Hodoscope

Lucite Hodoscope is from North Carolina A&T State University.

Design

- 28 curved Lucite bars with light guides mounted to edges cut at 45°
- PMT with light guide mounted at both ends of each bar.

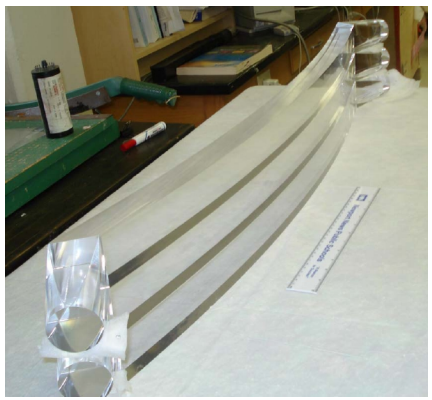


Figure: Lucite Bar

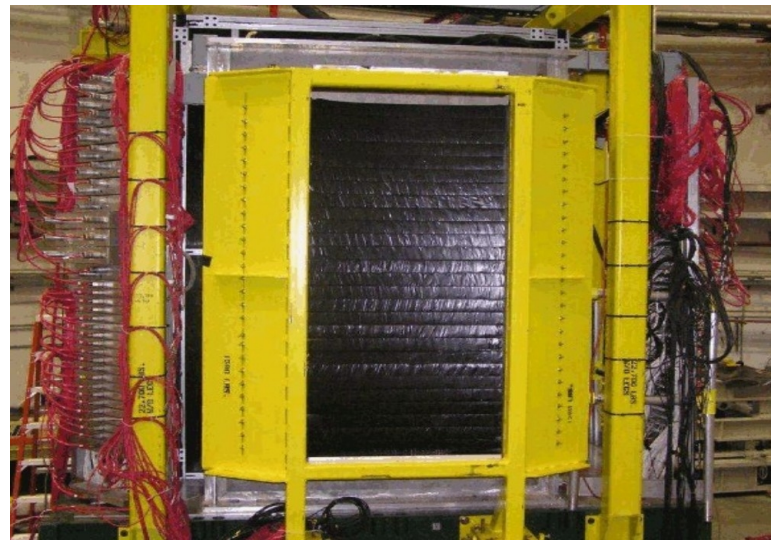


Figure: Lucite Hodoscope in Hall C

Forward Tracker

Forward tracker is from Norfolk State University and University of Regina

Design

- 3 layers of $3mm x 3mm$ scintillators.
- 1 horizontally segmented layer closest to the target consisting of 72 segments
- 2 vertically segmented layers consisting of 128 segments each
- WLS fibers glued to each bar with fibers connected to Hamamatsu 64-Channel PMTs

Figure: Forward tracker in position between Čerenkov snout and target OVC

Outline

Experimental Run

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- Feb. 9, 2009 - Start perpendicular 5.9 GeV production

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- March 6, 2009 - Start parallel 5.9 GeV production
- March 12, 2009 - Start parallel 5.9 GeV production

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- Jan. 30, 2009 - Start perpendicular 4.7 GeV production.
- Feb. 9, 2009 - Start perpendicular 5.9 GeV production
- Feb. 27, 2009 - Resume perpendicular 4.7 GeV production
- March 6, 2009 - Start parallel 5.9 GeV production
- March 12, 2009 - Start parallel 5.9 GeV production
- March 16, 2009 - Experiment finished

Outline

Bigcal

Pedestals and timing

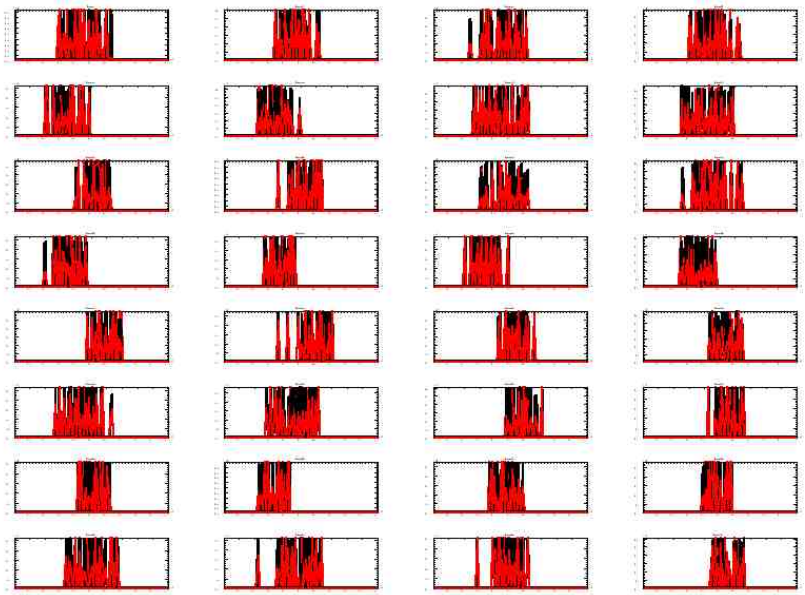


Figure: Bigcal pedestal fits. Each Histogram has a bigcal row containing 32 pedestals

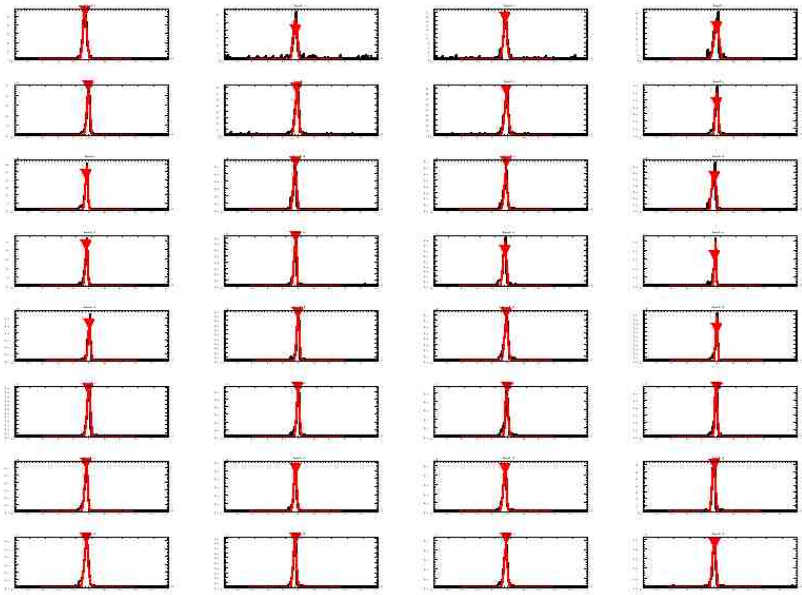


Figure: Bigcal Timing peaks for the smallest sum group (8 blocks in a row).

Čerenkov

Pedestals and timing

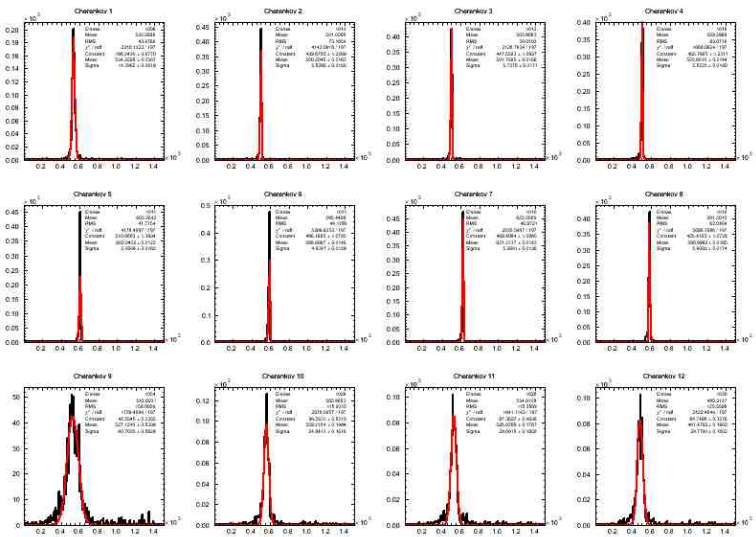


Figure: Čerenkov pedestals for a parallel run

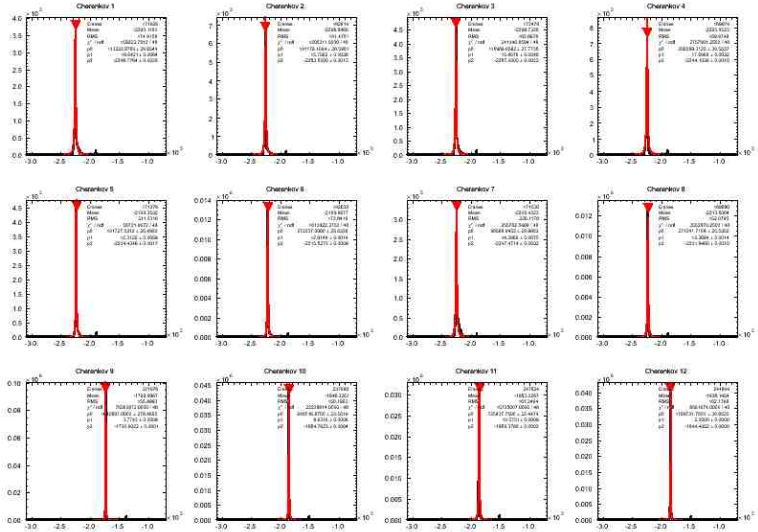


Figure: Čerenkov timing peaks for a parallel run

Lucite Hodoscope

Timing

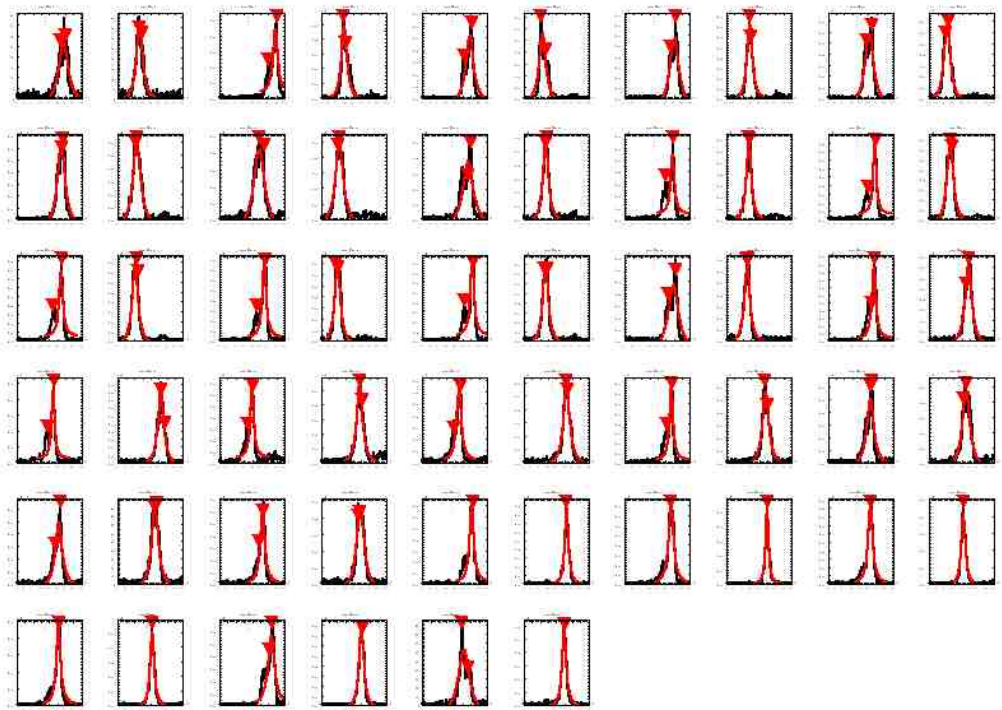


Figure: Hodoscope timing peaks for a parallel run

Forward Tracker

Timing

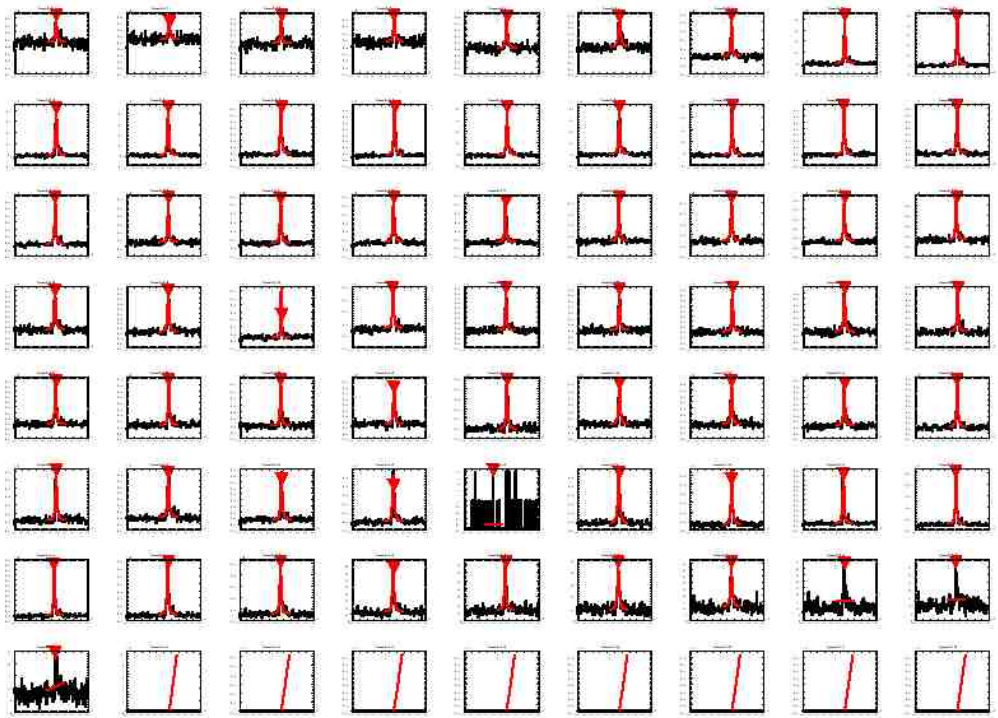
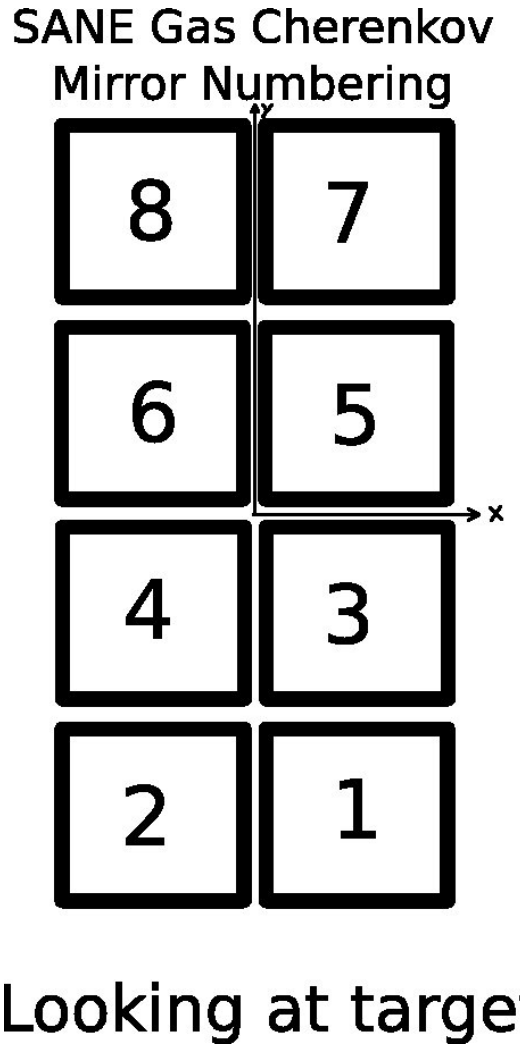


Figure: Tracker timing peaks for a parallel run

Number Conventions



- Number convention for Čerenkov mirrors as seen from behind bigcal looking towards the target
- The toroidal mirrors are the even numbered - on the left
- The spherical mirrors are the odd numbered - on the right.

Bigcal and Gas Čerenkov

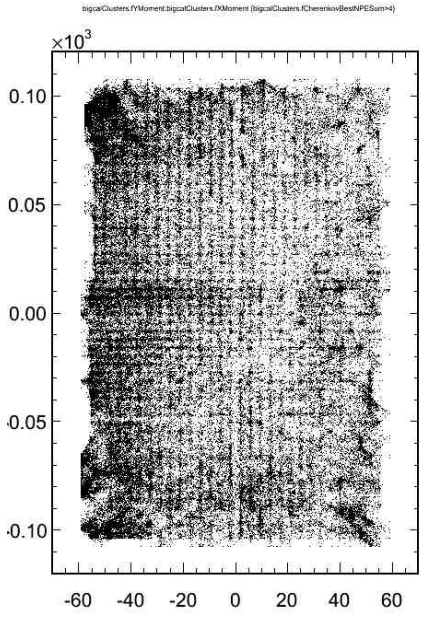


Figure: Scatter plot of simple bigcal clusters, with cut of 4 photo-electrons on gas Čerenkov .

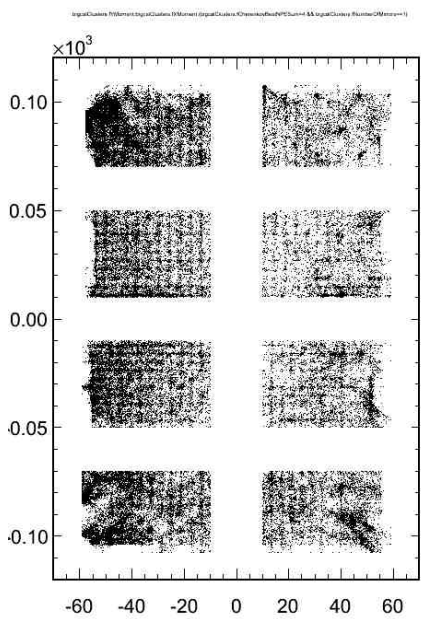


Figure: Mirror cuts such that a full Čerenkov cone is collected by a single mirror.

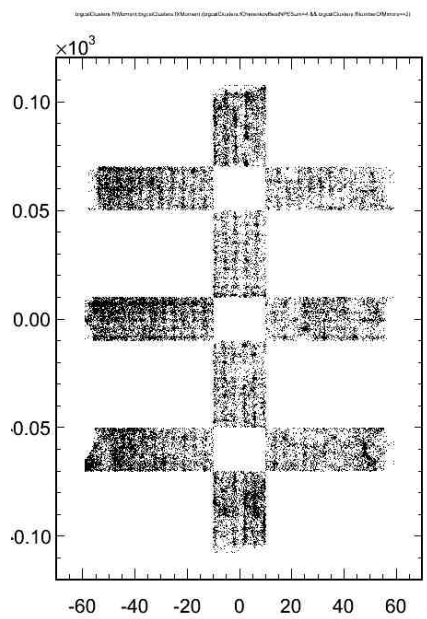
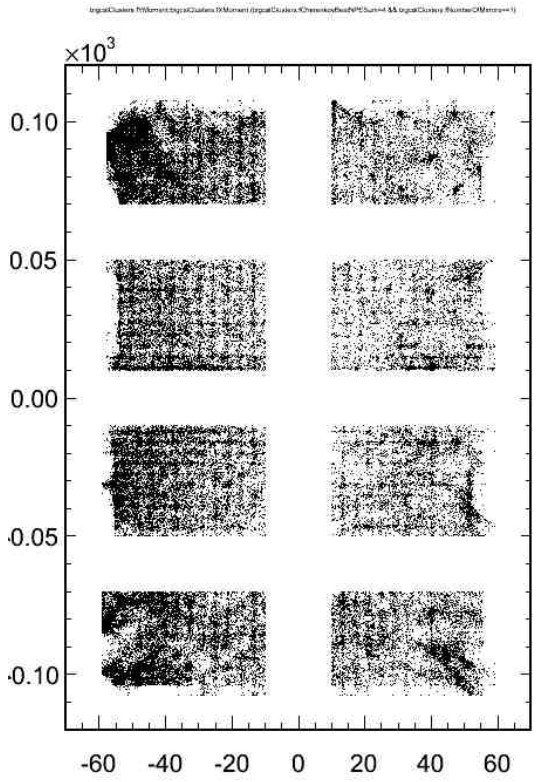


Figure: Mirror cuts such that the Čerenkov cone is divided among 2 mirrors.

Bigcal and Gas Čerenkov



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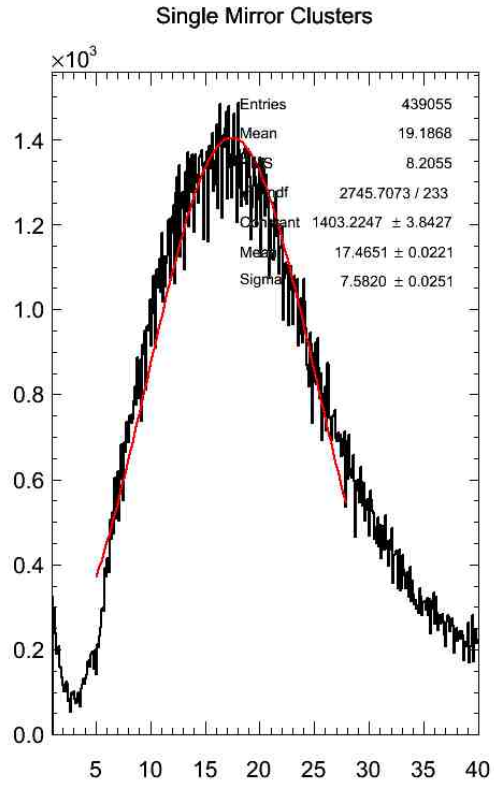
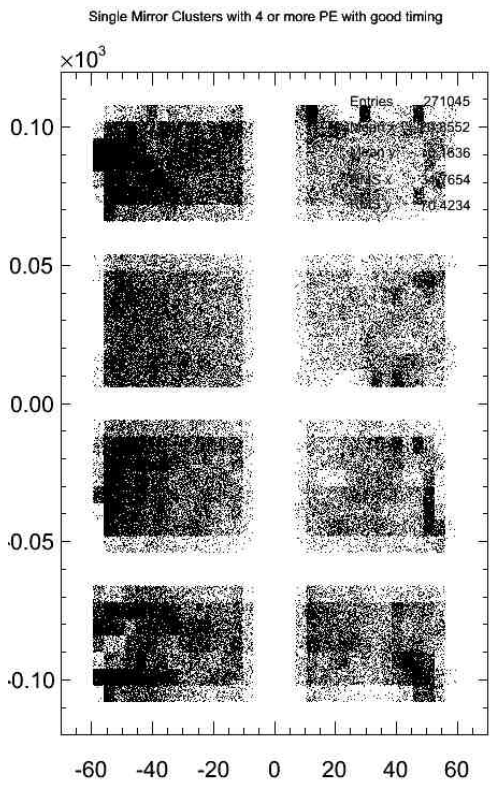


Figure: Gas Čerenkov performance when full Čerenkov cone is collected on one mirror. During the parallel running there was 18 photo-electrons for a good Čerenkov signal.

Note: No timing or energy cuts have been applied yet

Bigcal and Gas Čerenkov



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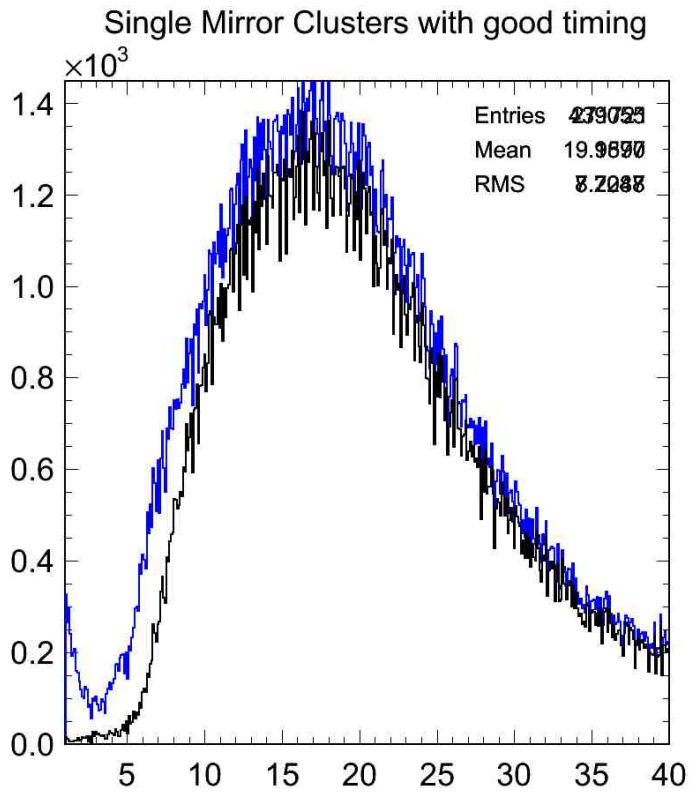
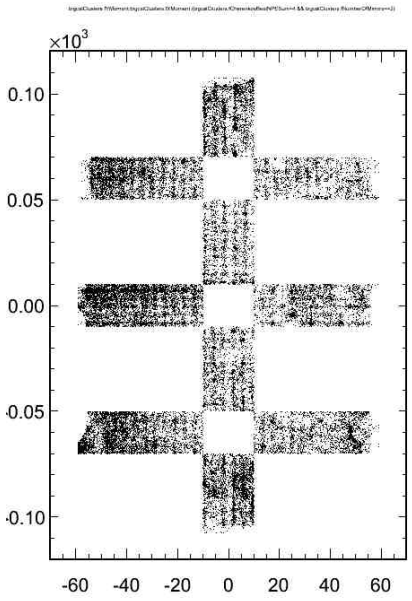


Figure: Gas Čerenkov performance when full Čerenkov cone is collected on one mirror now with an energy and timing cut.

Bigcal and Gas Čerenkov



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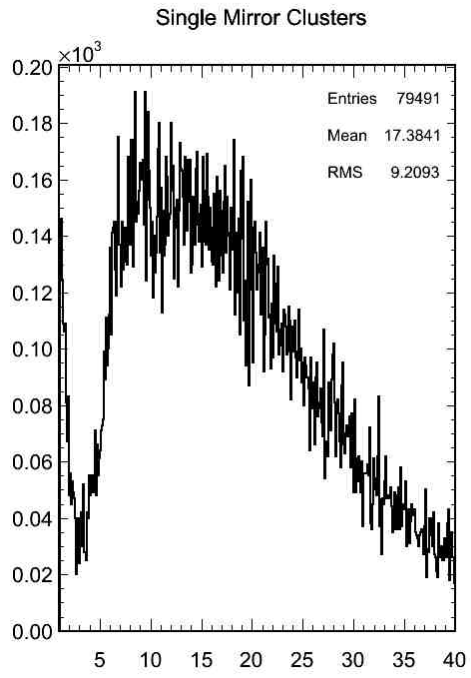
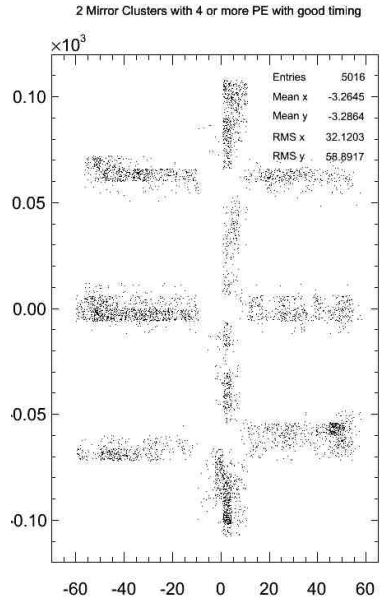


Figure: Gas Čerenkov performance when the Čerenkov cone is split between two mirrors.

Note: No timing or energy cuts have been applied yet
Shape of Čerenkov sum suggests that the geometry definitions could use improvement.

Bigcal and Gas Čerenkov



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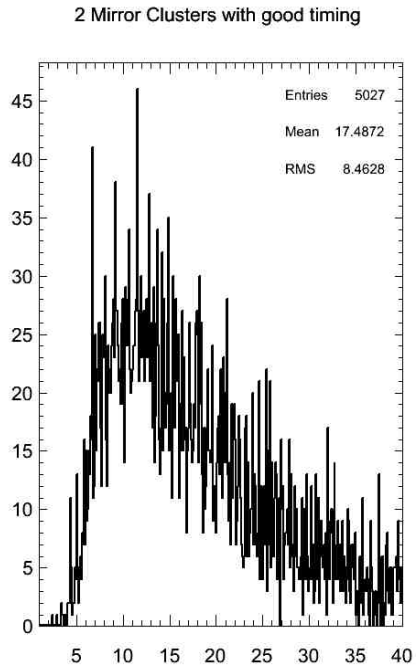


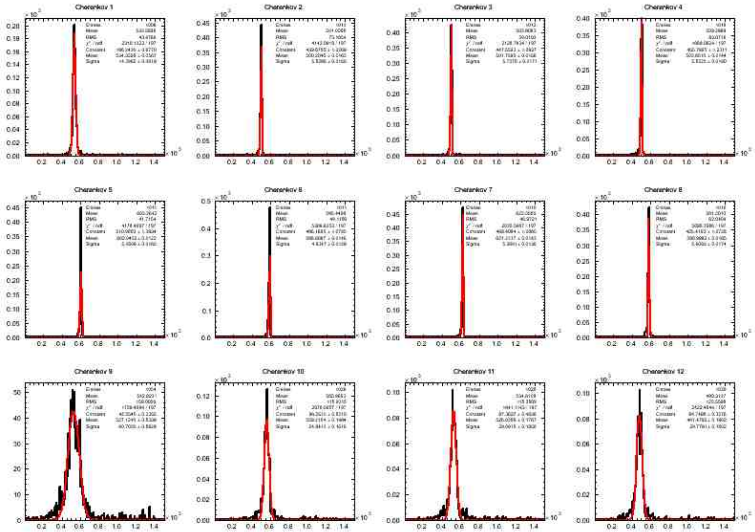
Figure: Gas Čerenkov performance when the Čerenkov cone is split between two mirrors.

Shape of Čerenkov mirrors comes out of timing cuts by requiring every mirror in the sum have a tdc hit. It is probably better to only requrire one tdc hit at the extremes of the 2 mirror geometry cut to not loose events from an ADC cut.

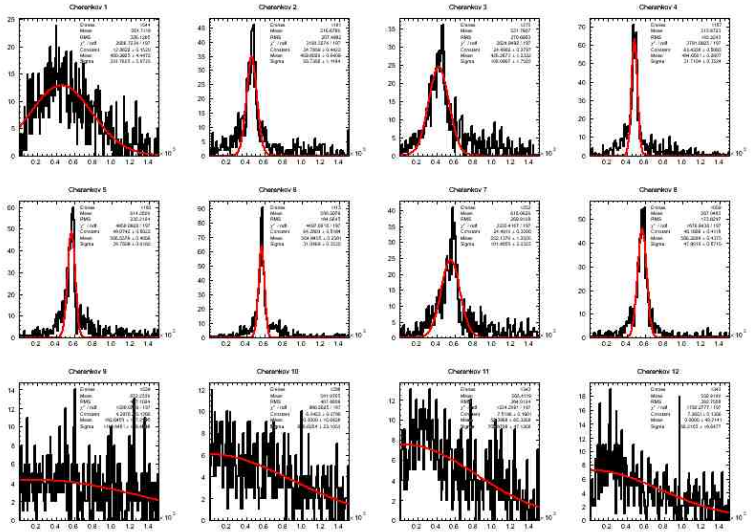
Outline

Čerenkov pedestals

During parallel



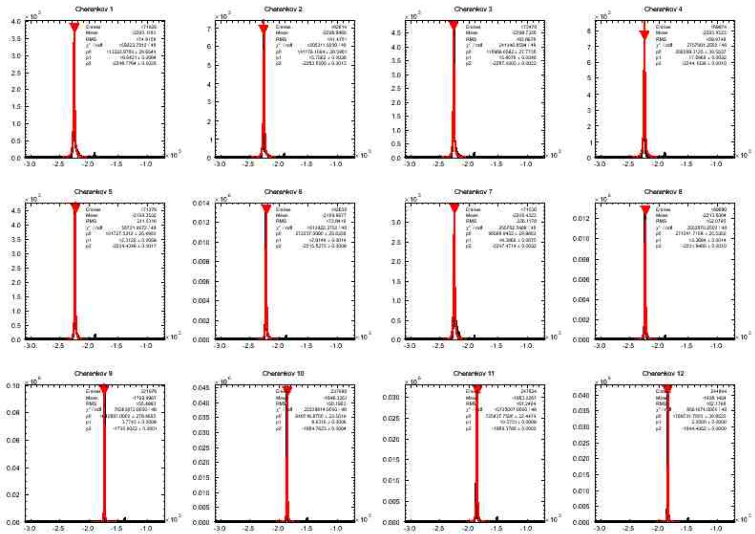
During perpendicular



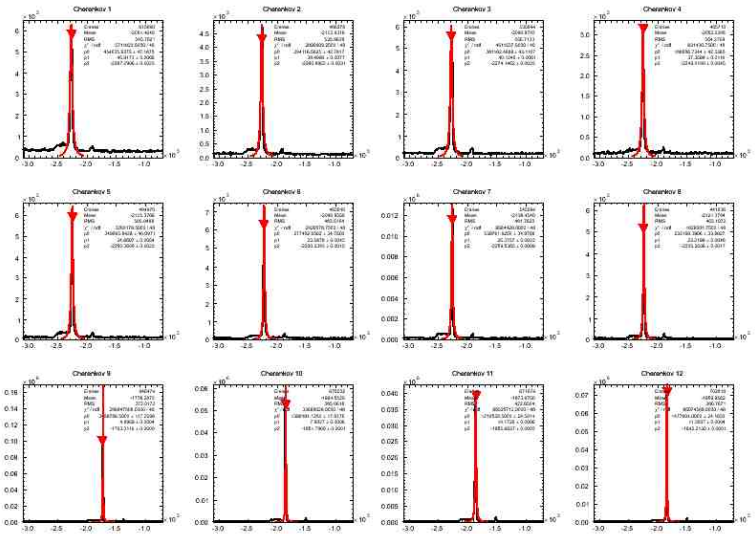
There was a much larger background during the perpendicular running.

Čerenkov TDCs...

During parallel



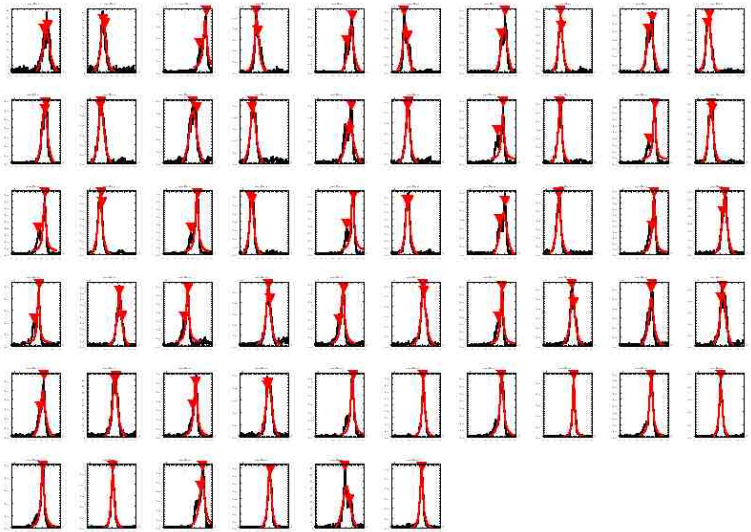
During perpendicular



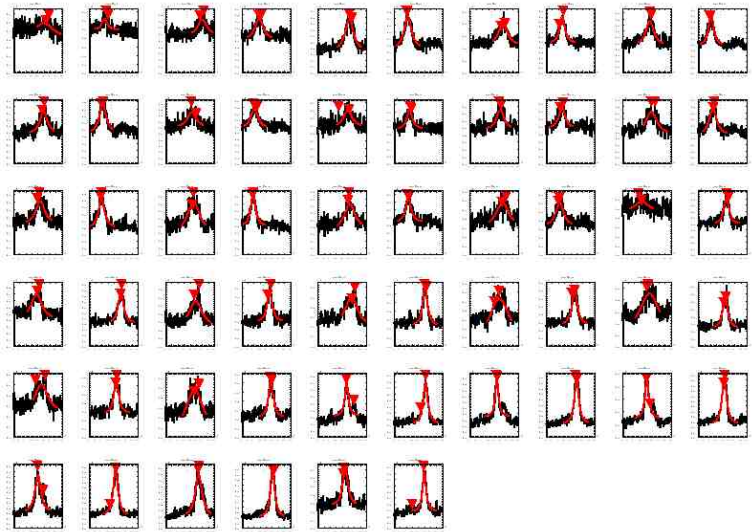
This noise added to the background of the TDC cuts.

Lucite Hodoscope TDCs...

During parallel



During perpendicular



This noise added to the background of the TDC cuts.

Bigcal and Gas Čerenkov

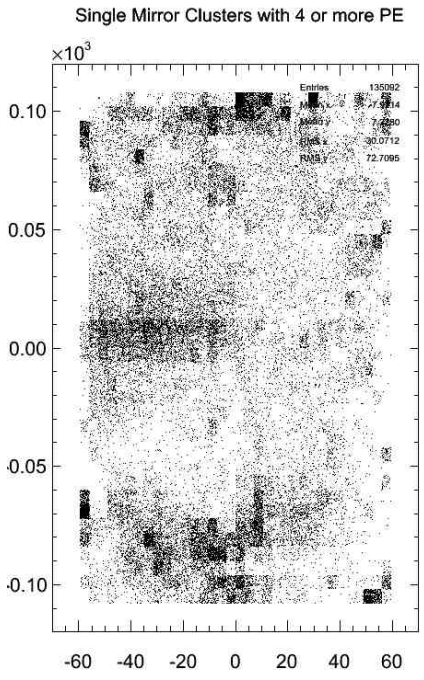
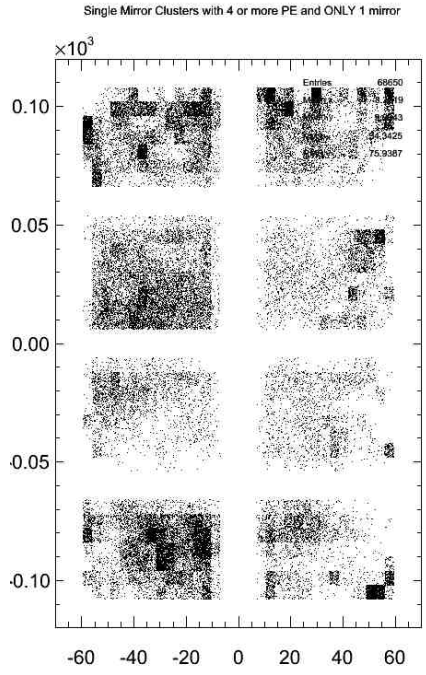


Figure: Scatter plot of simple bigcal clusters, with cut of 4 photo-electrons on gas Čerenkov .



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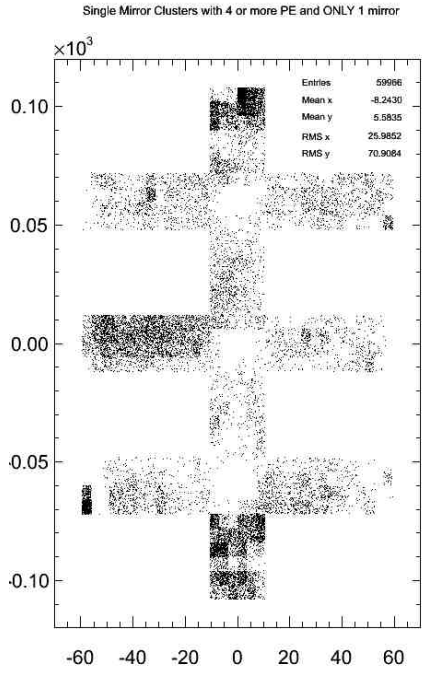
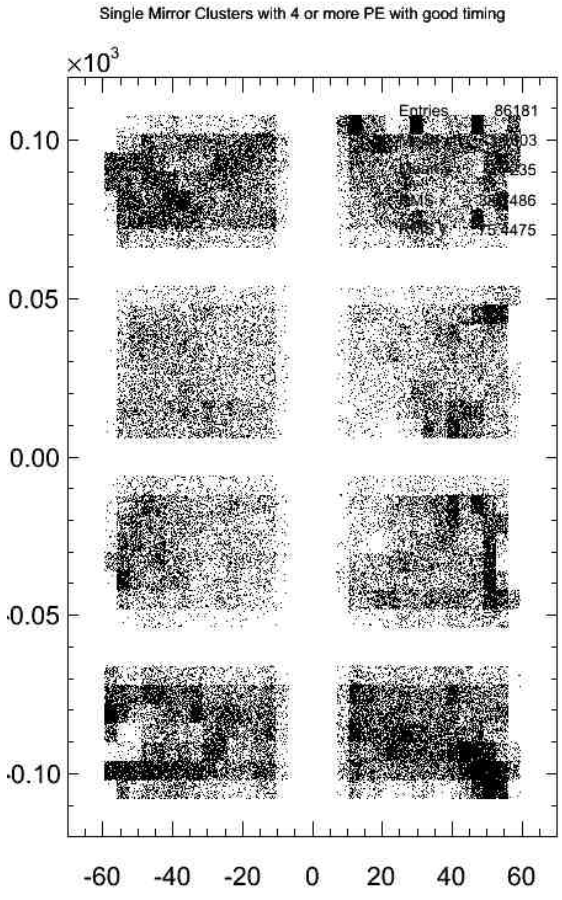


Figure: Mirror cuts such that the Čerenkov cone is divided among 2 mirrors.

Note: Only the addition of the energy cut has been added. No timing cuts have been applied.

Bigcal and Gas Čerenkov



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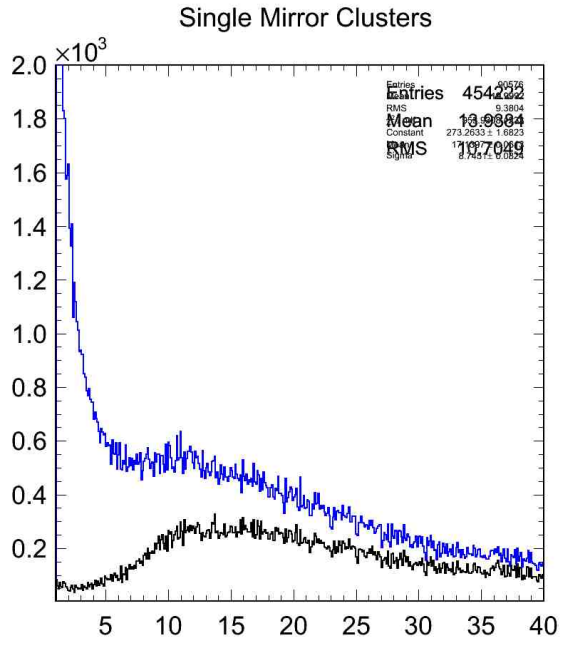
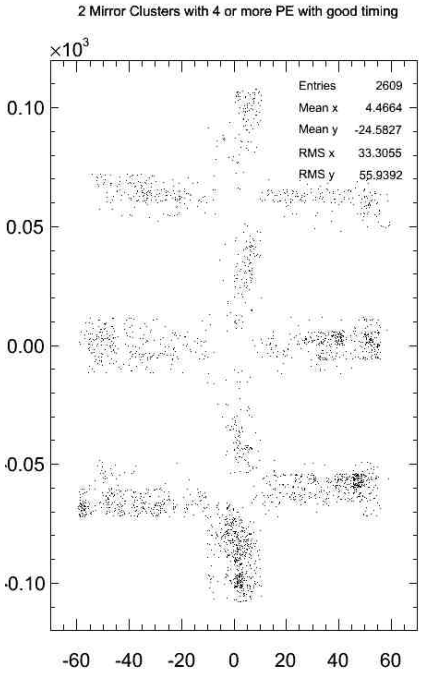


Figure: Gas Čerenkov performance when full Čerenkov cone is collected on one mirror. During the perpendicular running there was 17 photo-electrons from a good Čerenkov signal.

Bigcal and Gas Čerenkov



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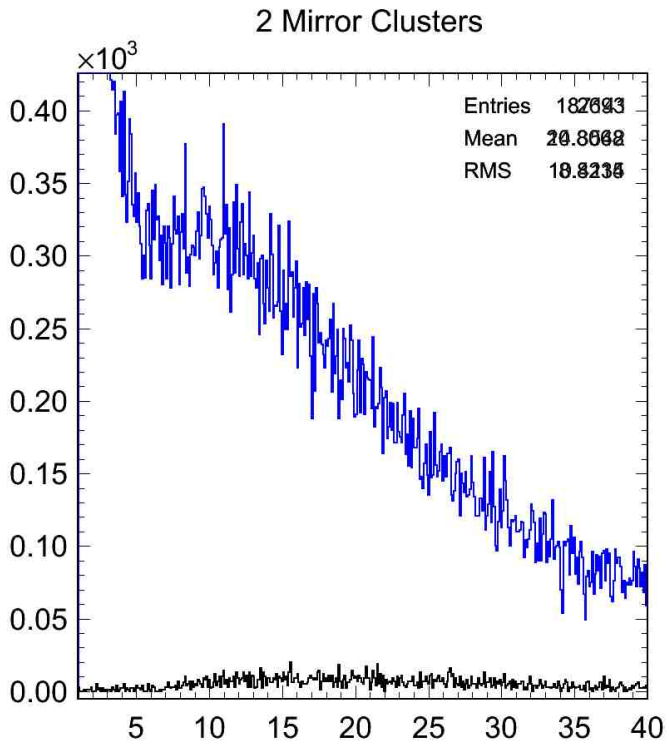
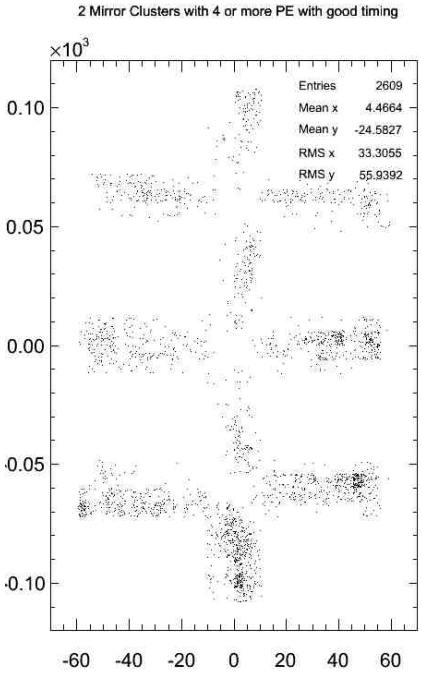


Figure: Gas Čerenkov performance when the Čerenkov cone is split between two mirrors. Blue requires a tdc hit for both mirrors.

Again, it Probably best to sum both mirrors, but require only one good tdc hit.

Bigcal and Gas Čerenkov



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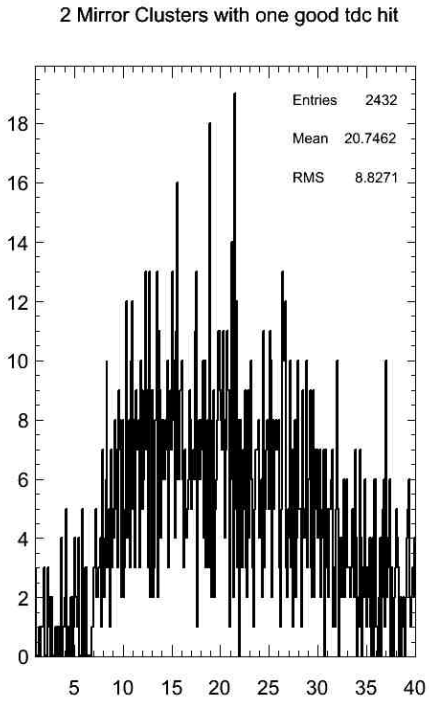
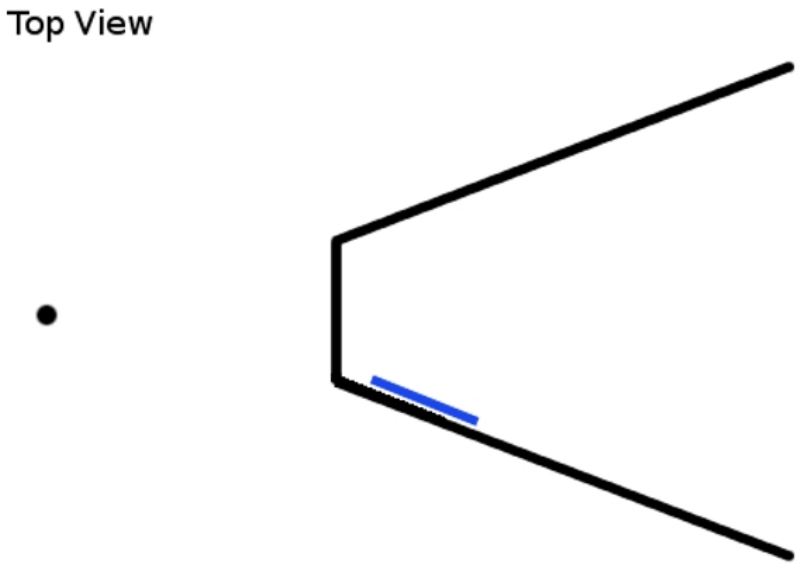


Figure: Gas Čerenkov performance when the Čerenkov cone is split between two mirrors. Now only requiring a single tdc hit.

Again, it Probably best to sum both mirrors, but require only one good tdc hit.

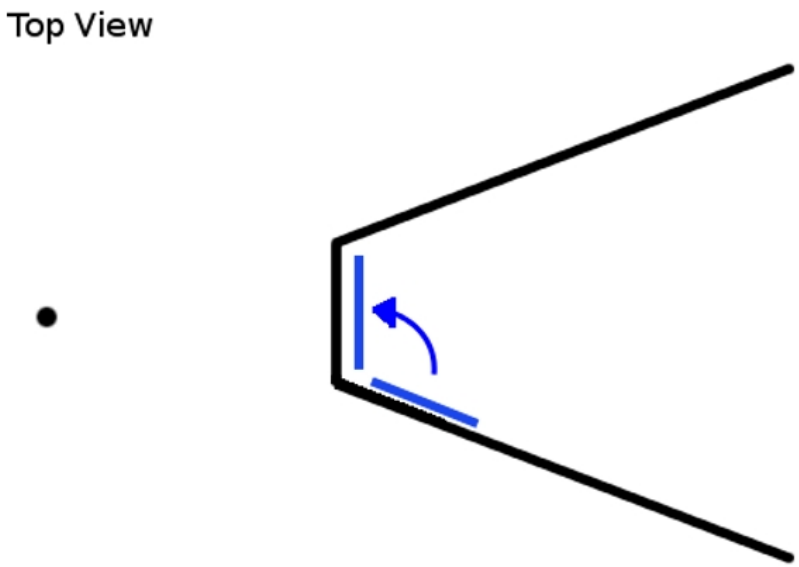
Outline

SANE Gas Čerenkov LED System



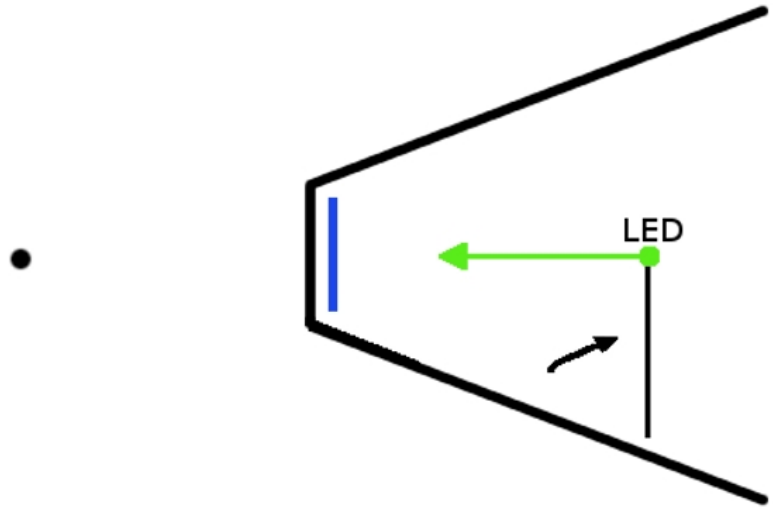
When turned off, the Mirror and LED are held inside the tank against the skin of the snout.

SANE Gas Čerenkov LED System



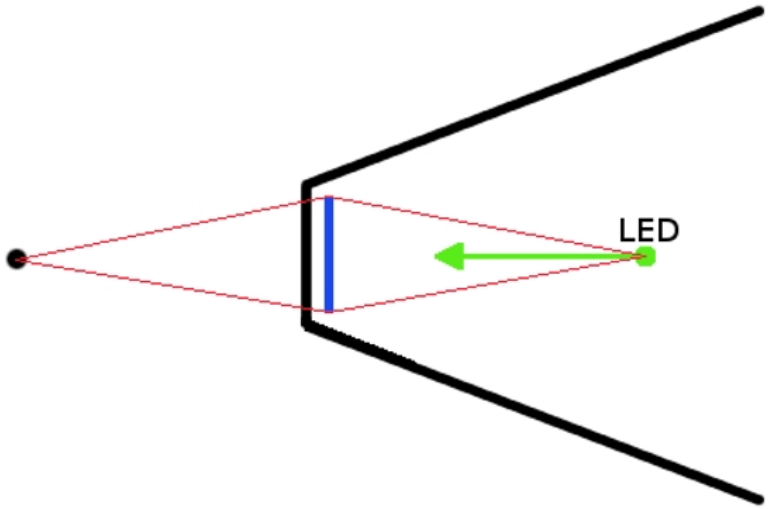
Activating the first rotary actuator swings out a mirror just behind the front window.

SANE Gas Čerenkov LED System



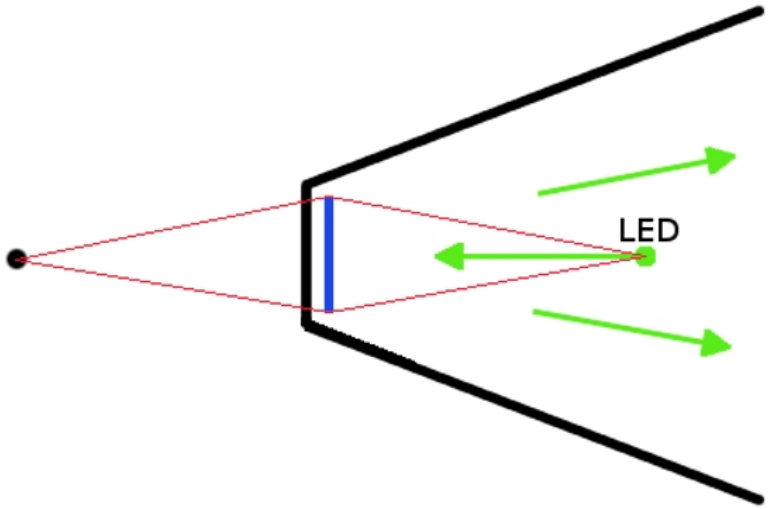
Activating the second rotary actuator causes the LED to swing into position.

SANE Gas Čerenkov LED System



The LED position was selected to mirror the targets position with line of sight to mirrors obstructed.

SANE Gas Čerenkov LED System



The LED pulses now have very similar optics to the Čerenkov light produced.

Timeline

During perpendicular target configuration running, which was also the first use of the Čerenkov with the target field, a magnetic field component longitudinal to the PMT axes strongly degrading the Čerenkov PMT performances.

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Sequence of Events

1. Jan. 22 - Target Tests
2. Jan. 24 - 71882-71891 : First Čerenkov HV on with a perpendicular target field.
3. Jan. 24 - Hall Access
4. Jan. 25 - Moller runs 71937-71956
5. Jan. 25 - First LED run with perpendicular target field
6. Jan. 26 - Target quench late night
7. Jan. 27 - It was suggested that we mount some of the 3/4“ iron plates that were laying on hall floor.
8. Out of plane bigcal calibrations begin at 85 uA (which required no cherenkov due to high rates)
9. Tried using a bucking coil mounted on μ-metal shield with no success
10. Jan. 29 - Iron sheet installed *thanks to quick work of Hall C staff.* Run 72099
11. LED runs just after field is ramped up show great improvement.
12. Jan. 30 - Began 4.7 GeV Perpendicular production runs

Gas Čerenkov in Perpendicular Field

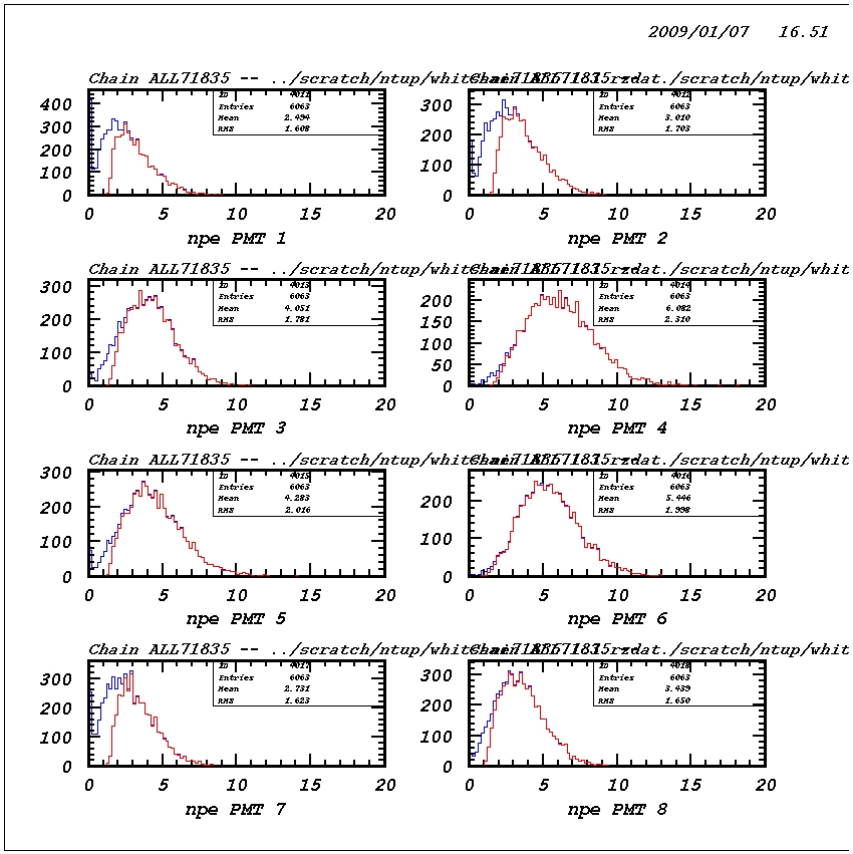


Figure: LED run before any perpendicular field.

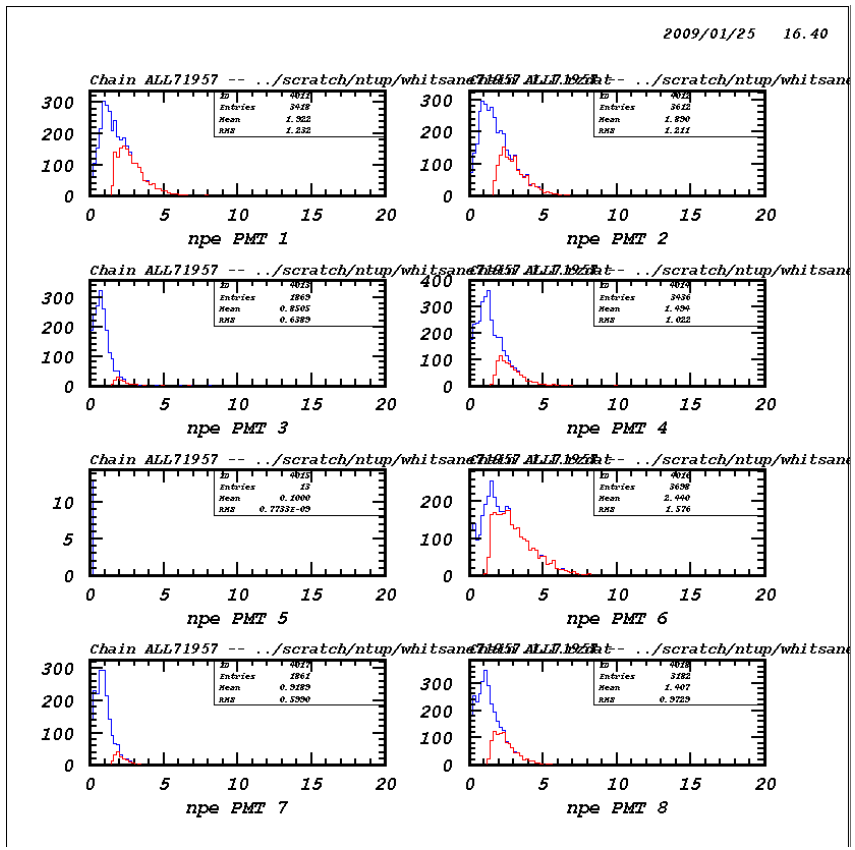
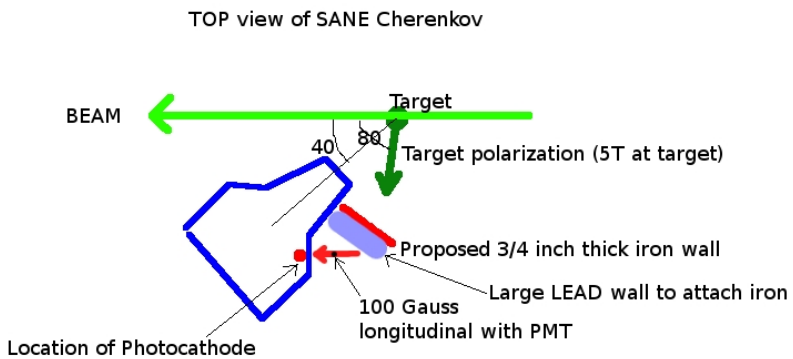
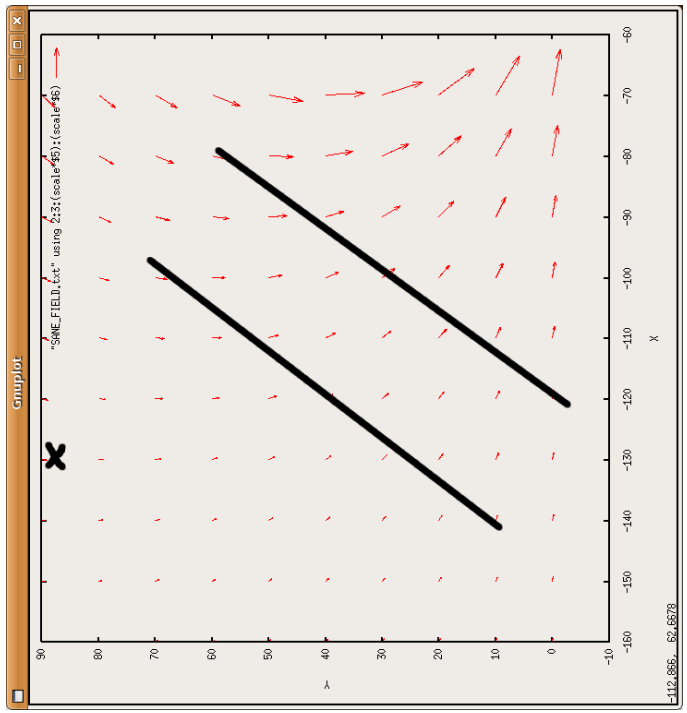


Figure: First LED run with perpendicular field.

Target Magnetic Field Near Čerenkov

Since the magnetic field was not saturating the tubes, the installed iron plate successfully reduced field.





Again, many thanks to the Hall C staff and technicians for the prompt installation of the plate!

Comparing no field and full perpendicular field LED runs

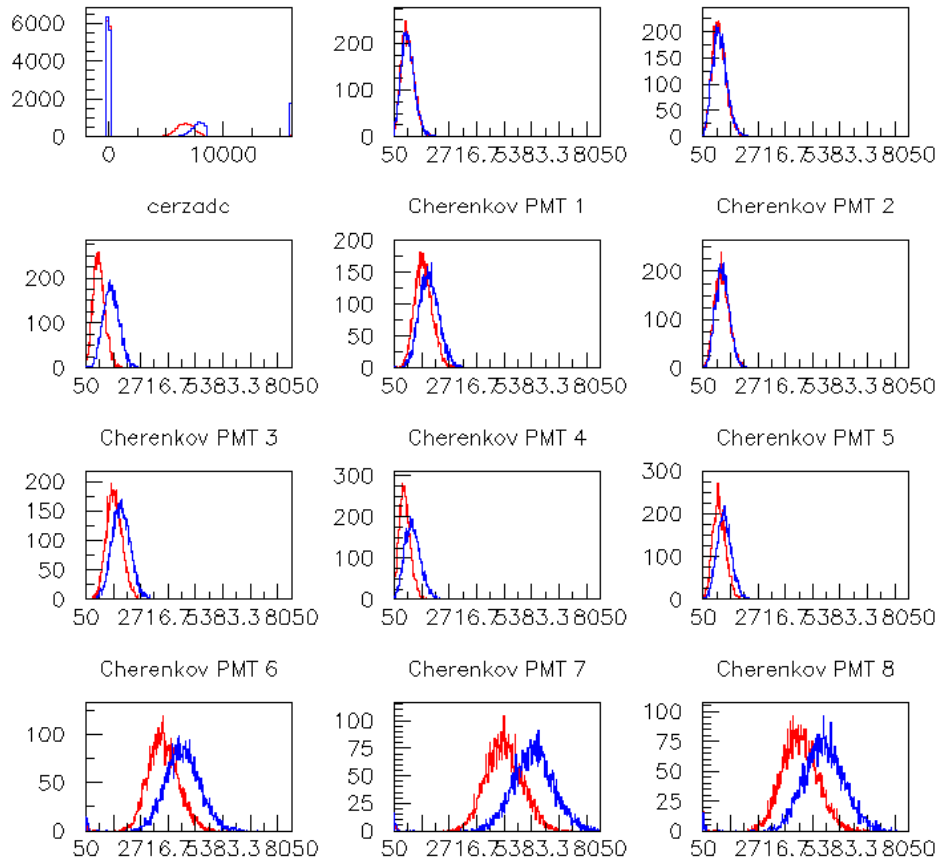


Figure: Here is a direct comparison of just after we installed the iron plate. The blue is with no field and the red is with full field. Run 72138: With iron plate installed, pmts 3 and 7 still had lowest performance (50-60%)

Outline

Conclusions and Future Work

- Iron plate was quite successful at shielding Čerenkov PMTs during perpendicular running.
- Magnetic shielding problem was compounded by high background rates during perpendicular running.
- Large background during perpendicular running likely complicates analysis cuts.
- Great Čerenkov performance during parallel running provided clean trigger.

Some Future Work:

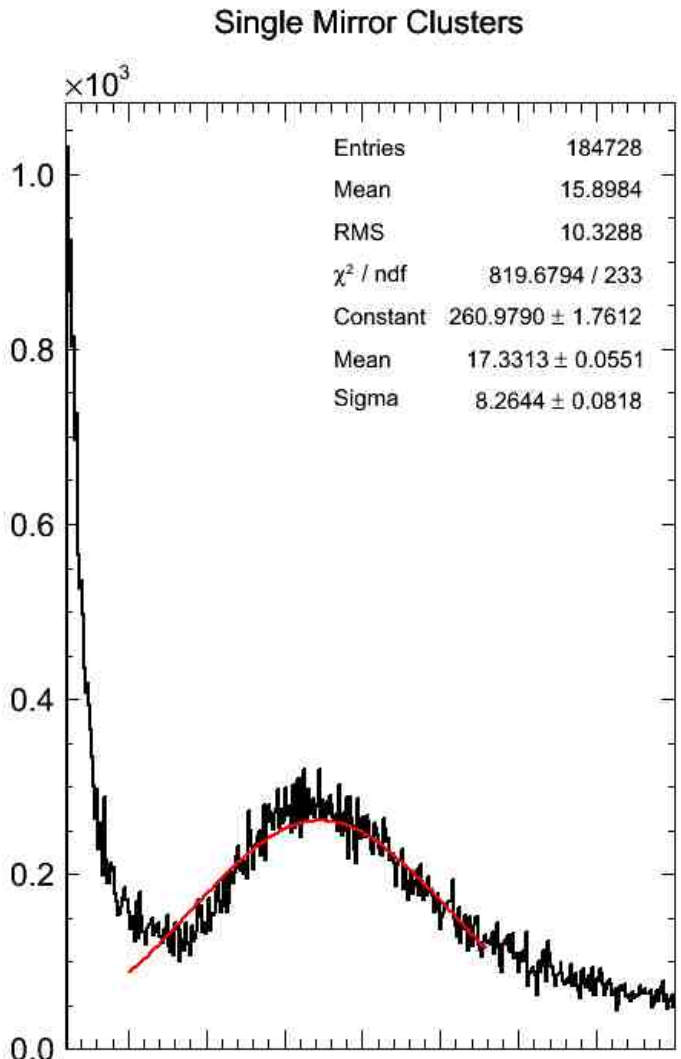
- Systematic study of detector performances against time since (and possibly degree of) target magnet quenches.
- Perform regular calibrations during perpendicular running
- Continue to investigate sources of systematic errors.
- Do quenches change the magetic shielding?

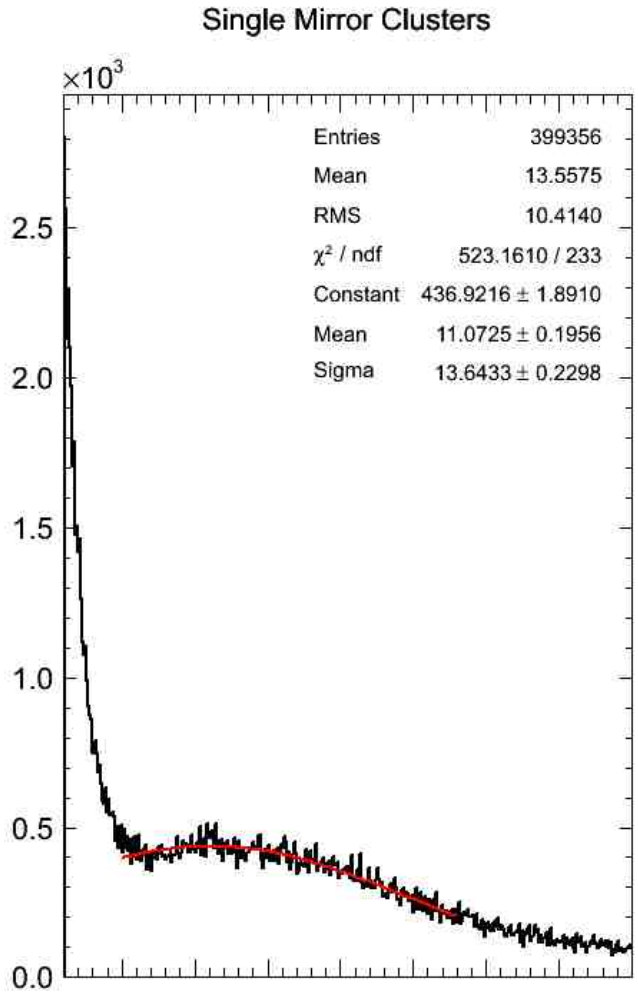
Thank You!

Backup Slides

Quenches

A quench late night February 2 occured. Here is before and after.





Ramping Target Field

Runs 72016 to 72047.

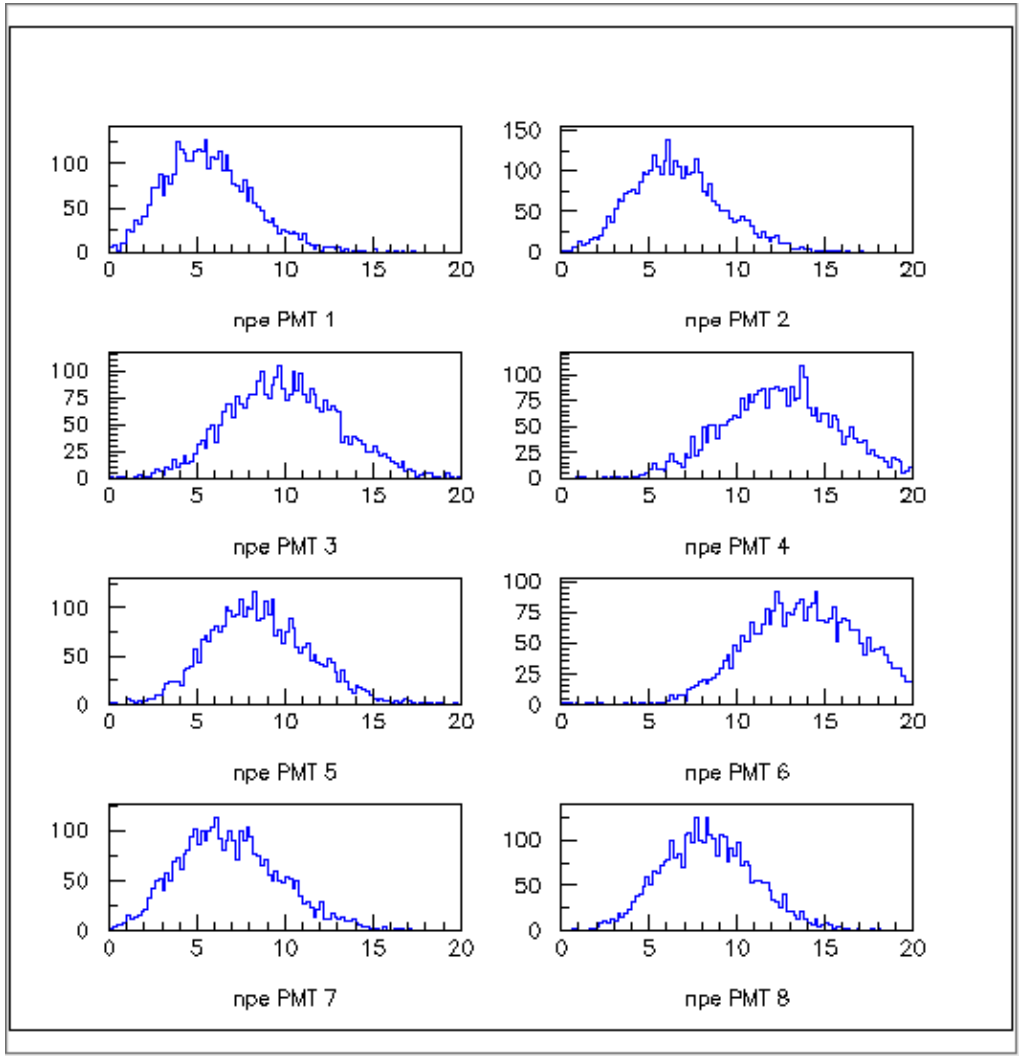


Figure: Target current: 0 A

Ramping Target Field

Runs 72016 to 72047.

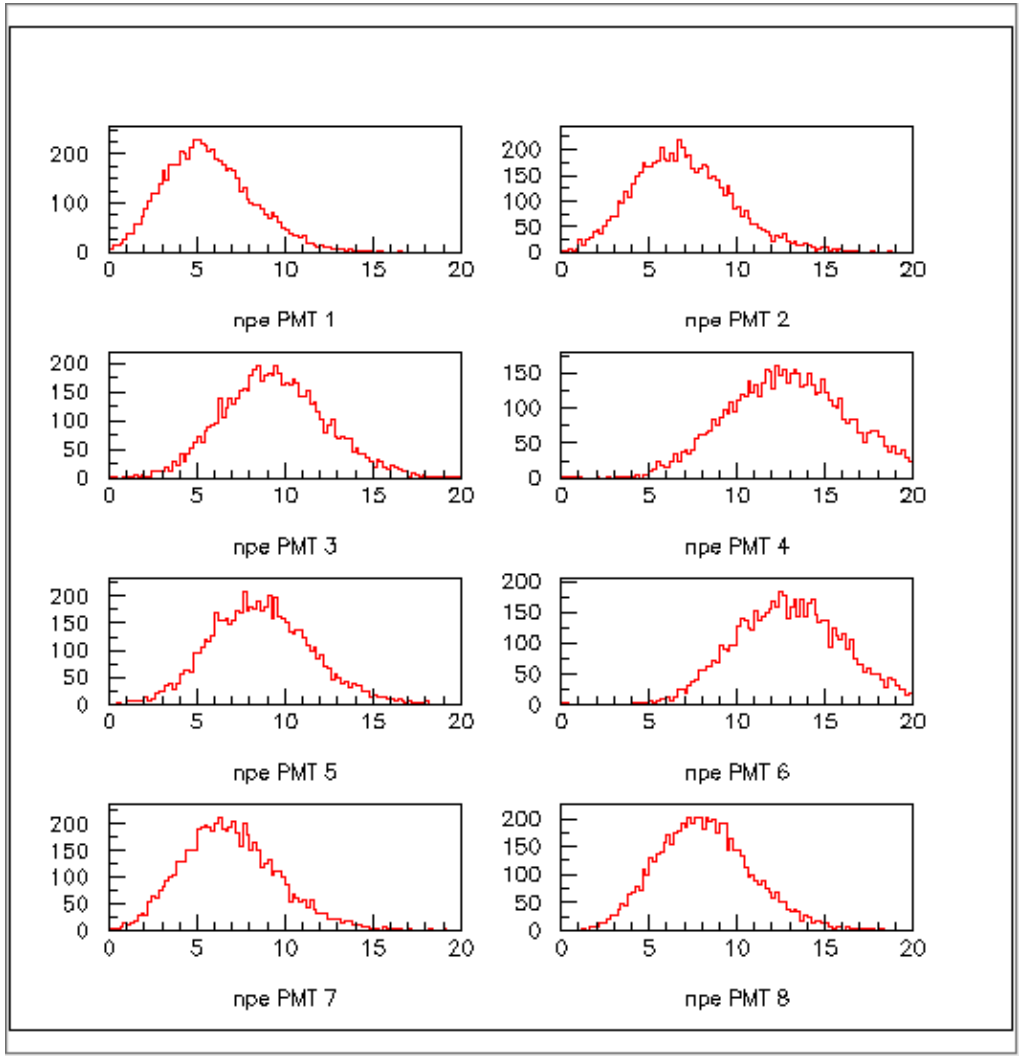


Figure: Target current: 11.5 A

Ramping Target Field

Runs 72016 to 72047.

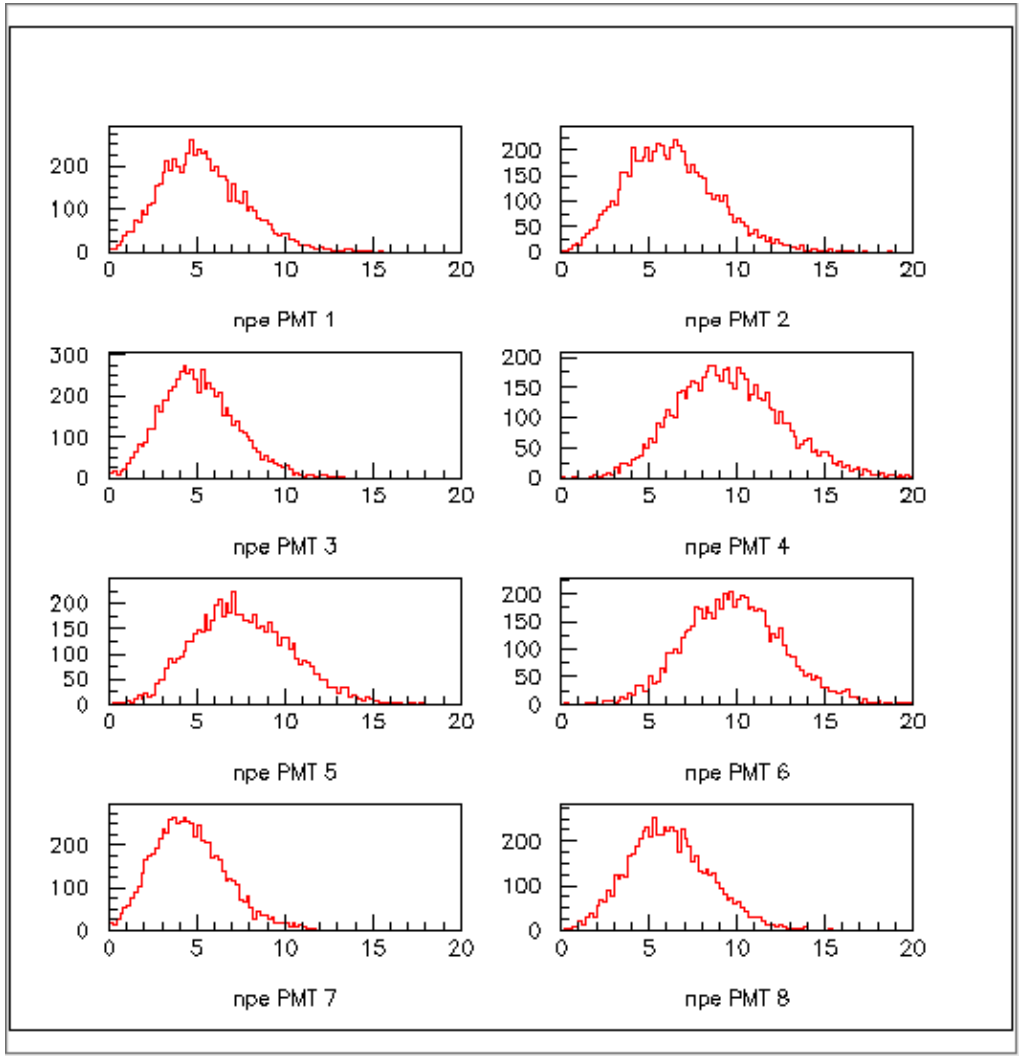


Figure: Target current: 37.9 A

Ramping Target Field

Runs 72016 to 72047.

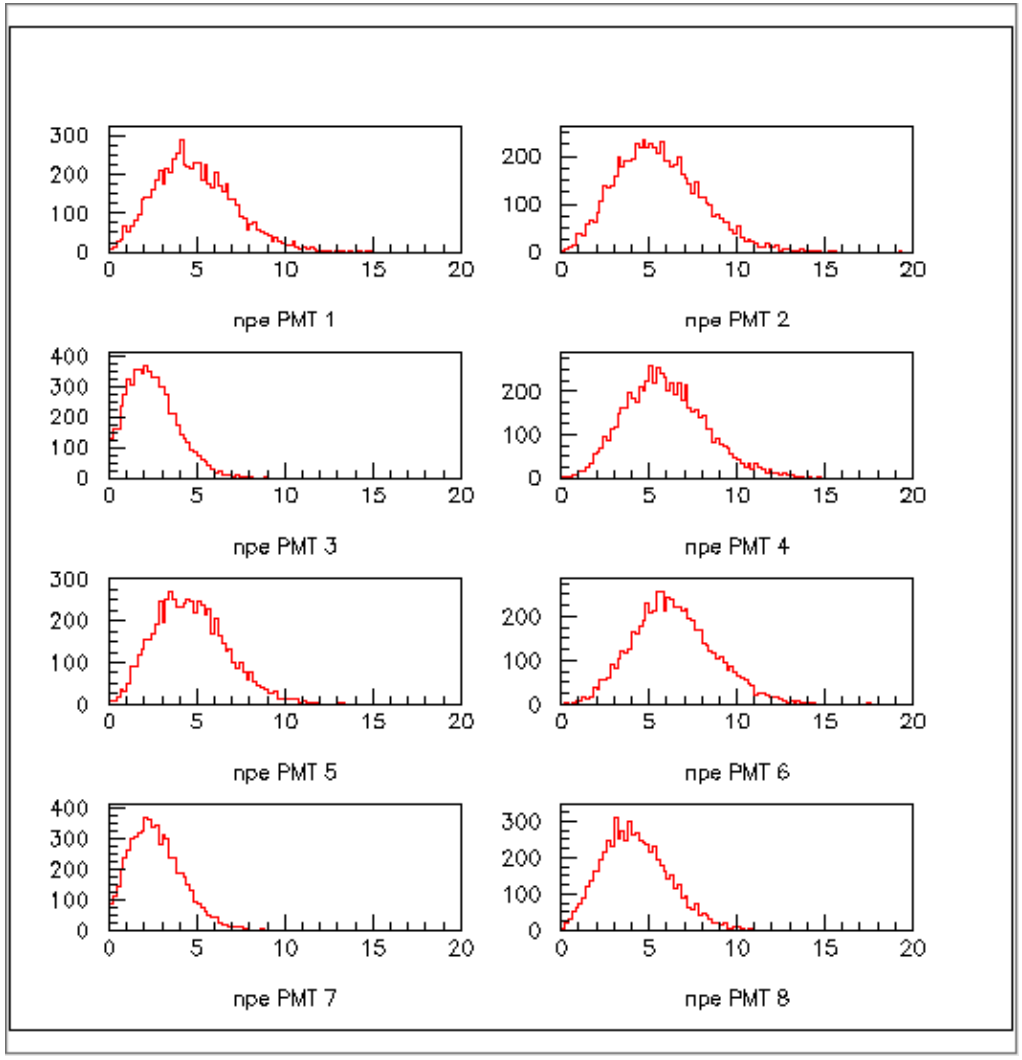


Figure: Target current: 59.7 A

Ramping Target Field

Runs 72016 to 72047.

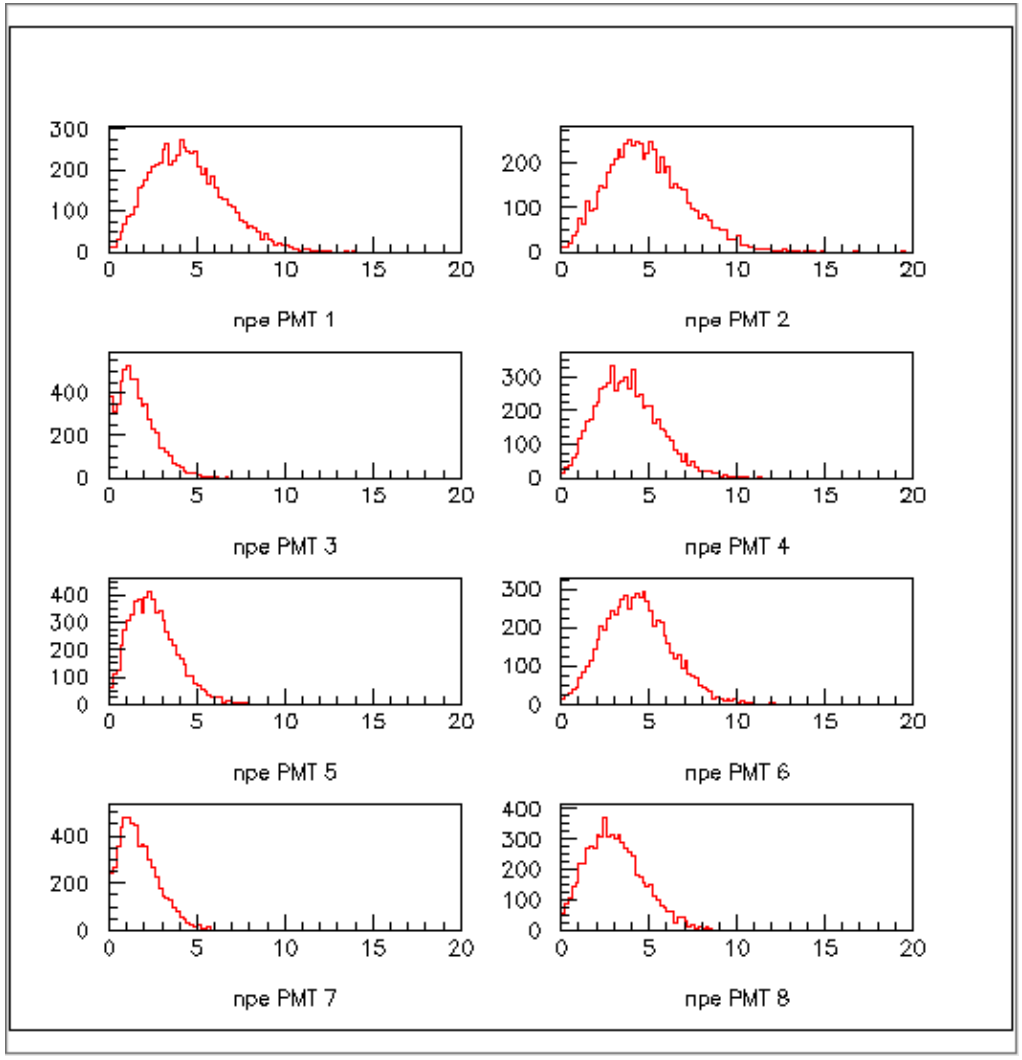


Figure: Target current: 73.8 A

Ramping Target Field

Runs 72016 to 72047.

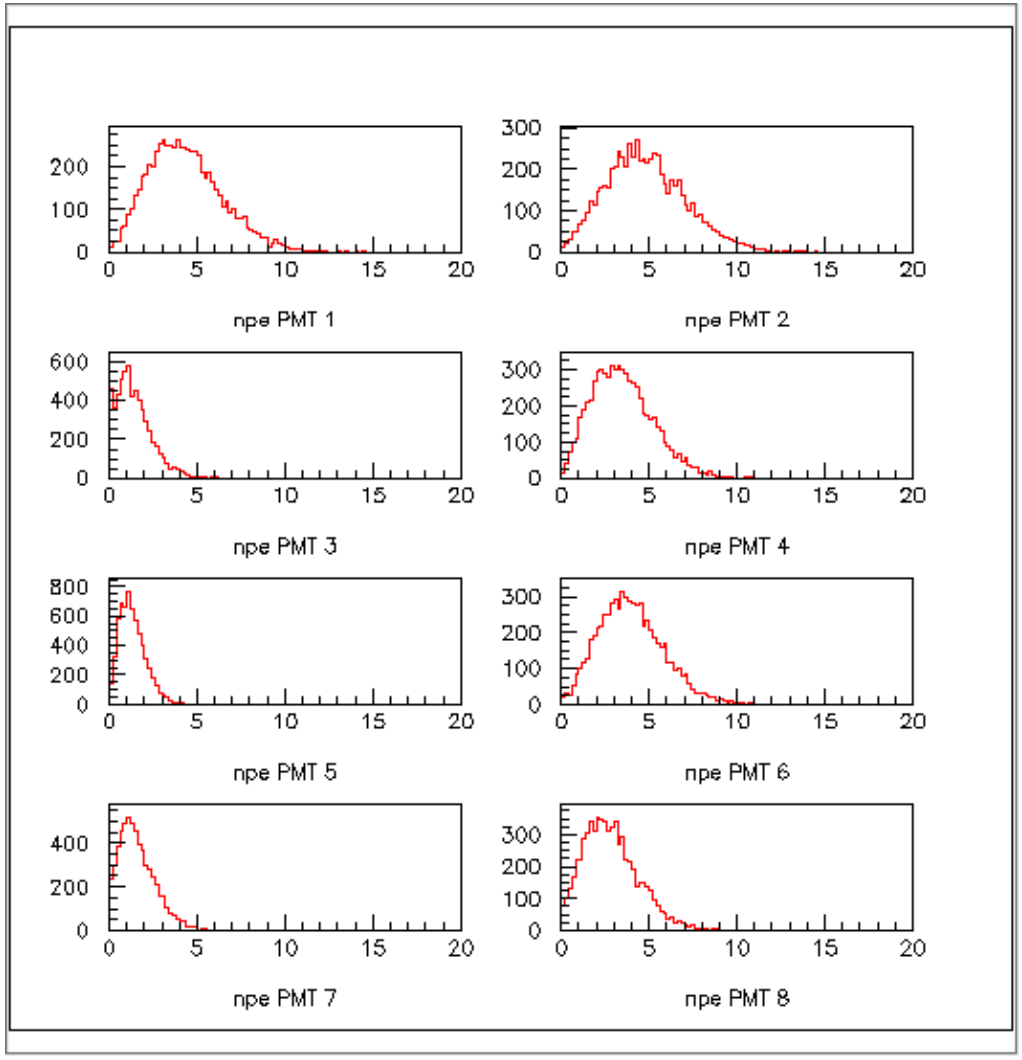


Figure: Target current: 77.1 A - Full Field