Status and Plans for the CRS Test Stand

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Goals

- Establish a test stand with the CRV half module at Fermilab
  - Designed and built at William and Mary (J.Kane, et al) several years ago
  - Never completely read-out or commissioned
- Determine the following
  - Attenuation length of scintillator+WLS
  - Per layer efficiency
  - Total efficiency using a 2-of-3 coincidence
  - Response to neutrons

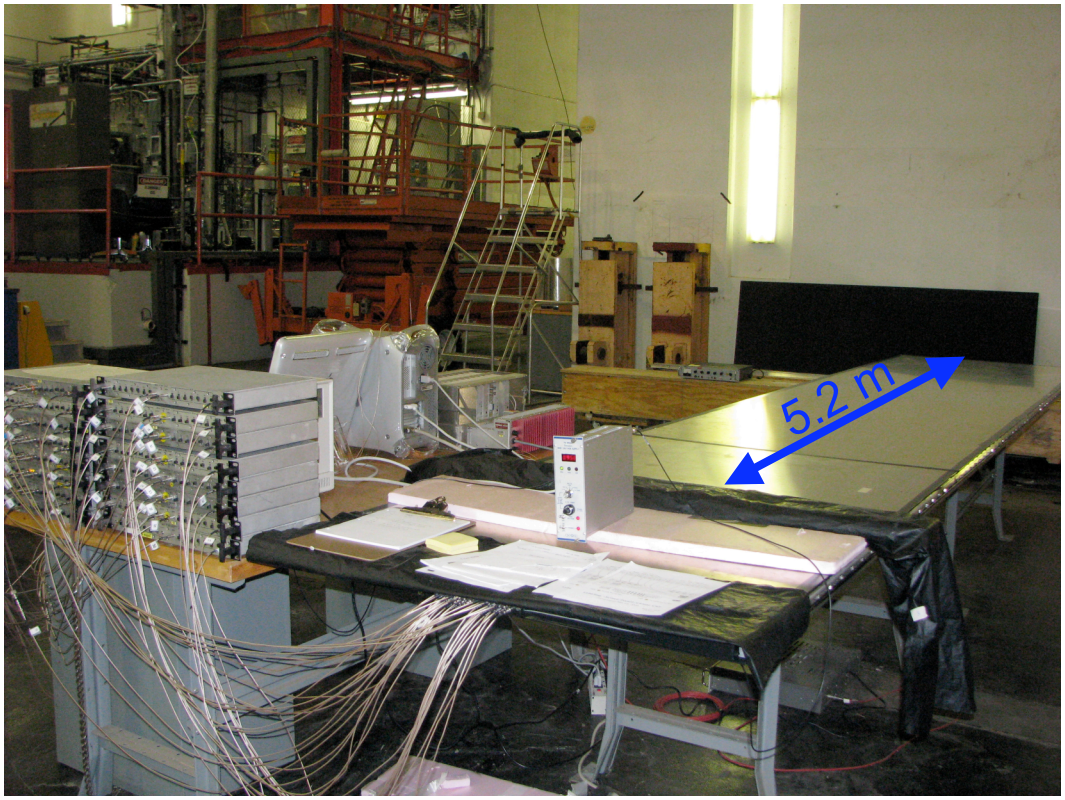
Schedule

- John Kane made a presentation in April 2009 (Mu2e-doc-527) about the design/construction of CRVhm

- Decided to ship to Fermilab and establish a test stand
  - Original schedule: arrive in mid/late May, commission in June, use summer students to collect data
  - Actual schedule: arrived in late June, used summer students to commission, recently began collect decent data

Geometry

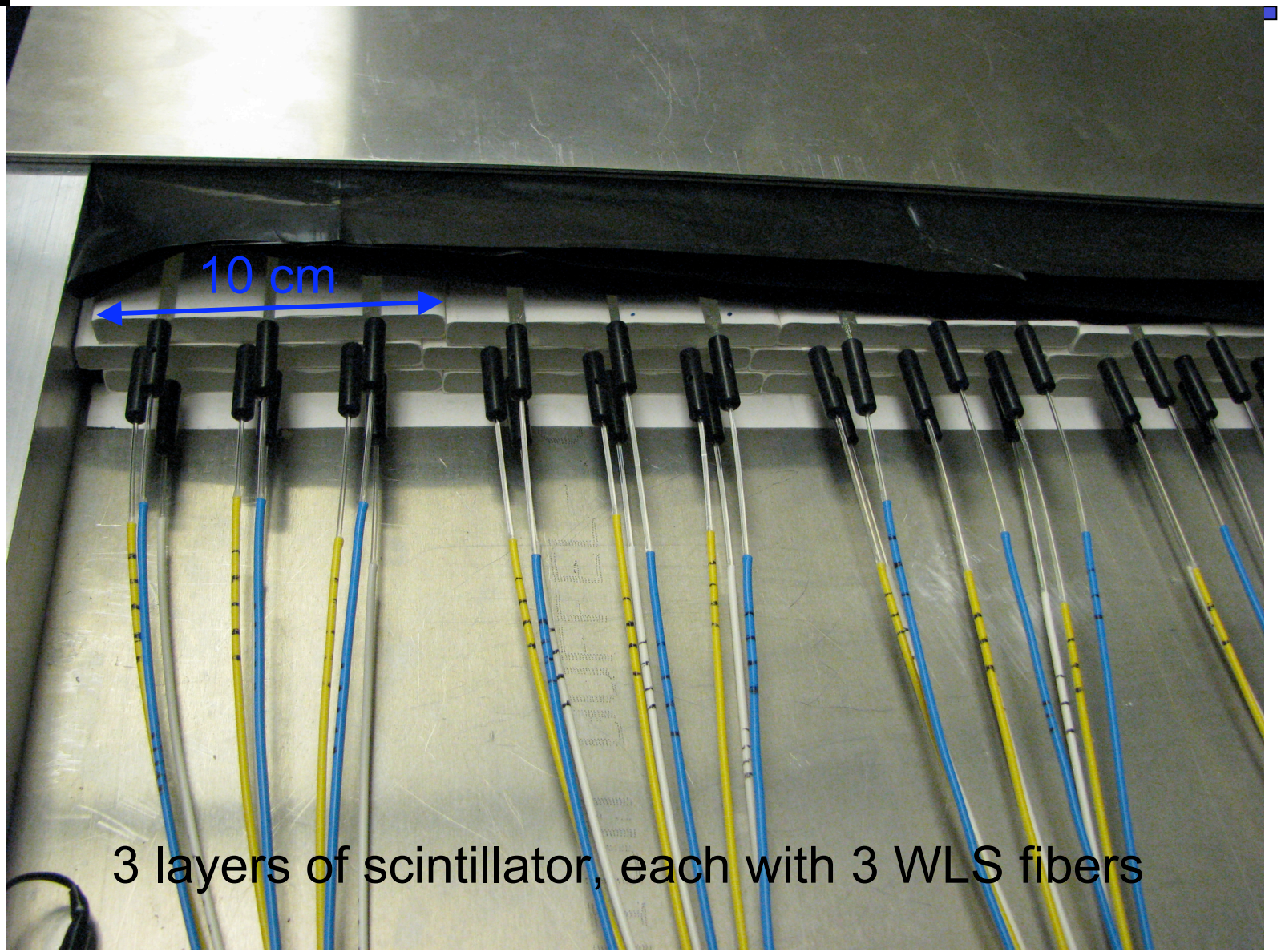
- Dimensions: 1.0 m wide x 5.2 m long x 0.03 m thick



Geometry

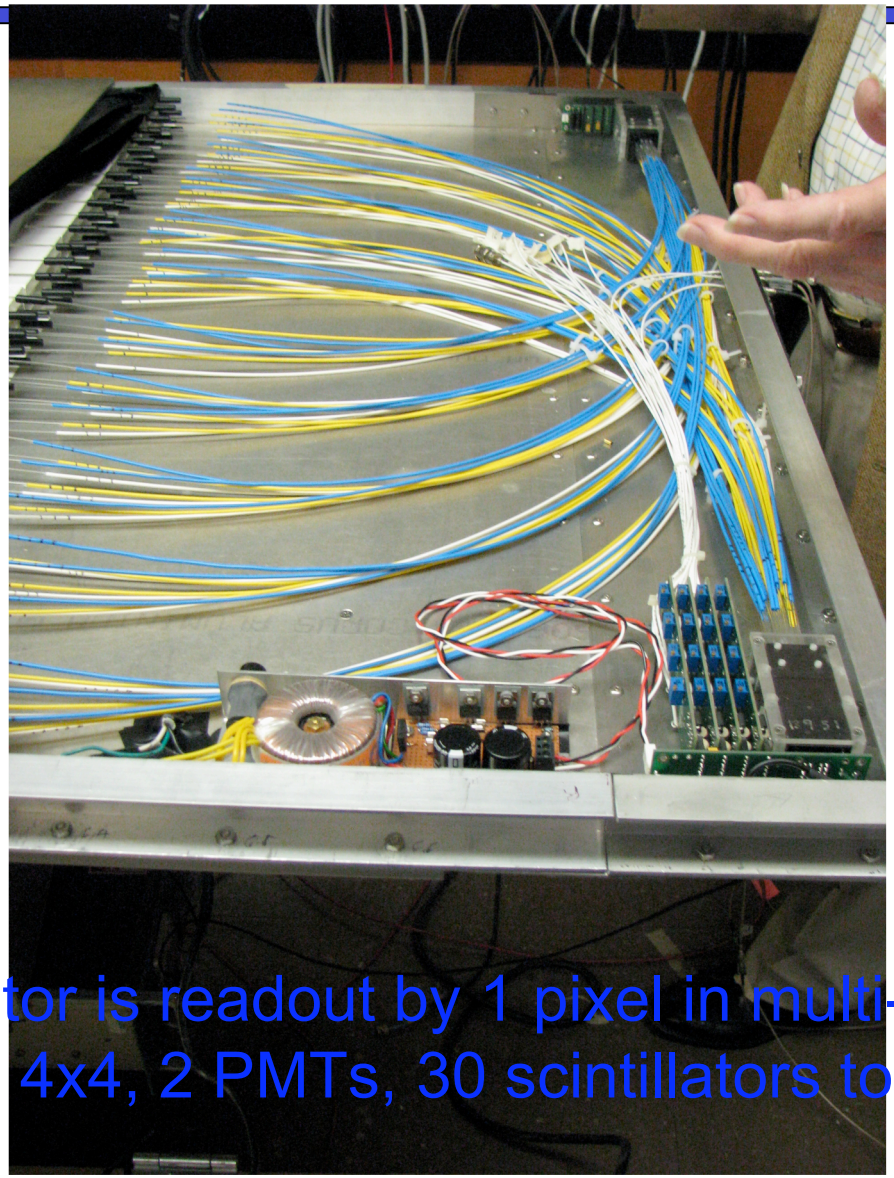
- 3 layers of scintillator
  - Middle layer offset by 0.01 m relative to top/bottom
- 10 scintillator bars per layer
  - 0.01 m thick x 0.10 m wide x 5.2 m long
  - Three WLS glued to grooves on top
  - Each bar wrapped in tevlar
- This gives 30 scintillator bars total
- Encased in Aluminum frame and box
- Design/construction courtesy of John Kane, and Jonathan Stevens of College of William and Mary

Geometry



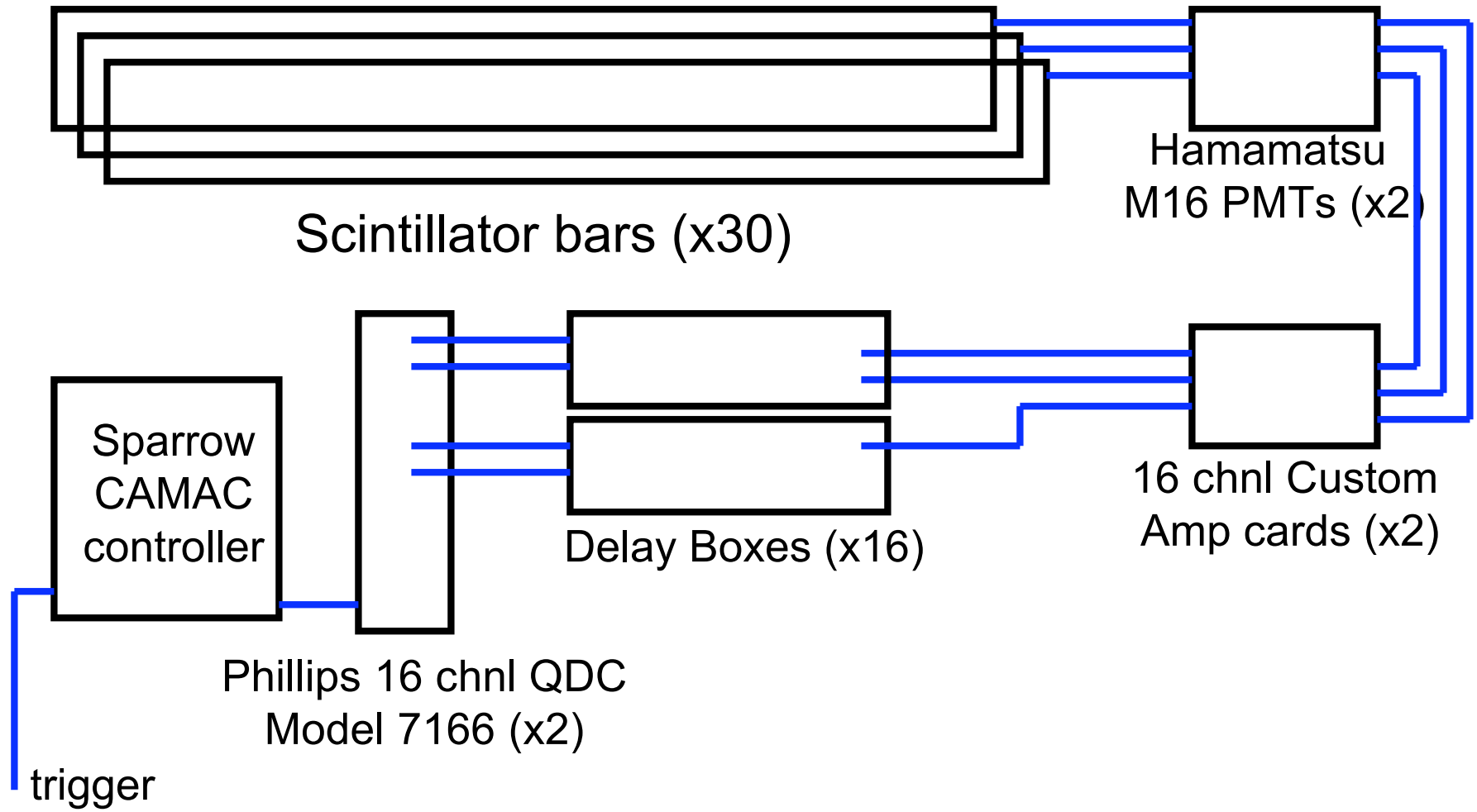
3 layers of scintillator, each with 3 WLS fibers

Readout

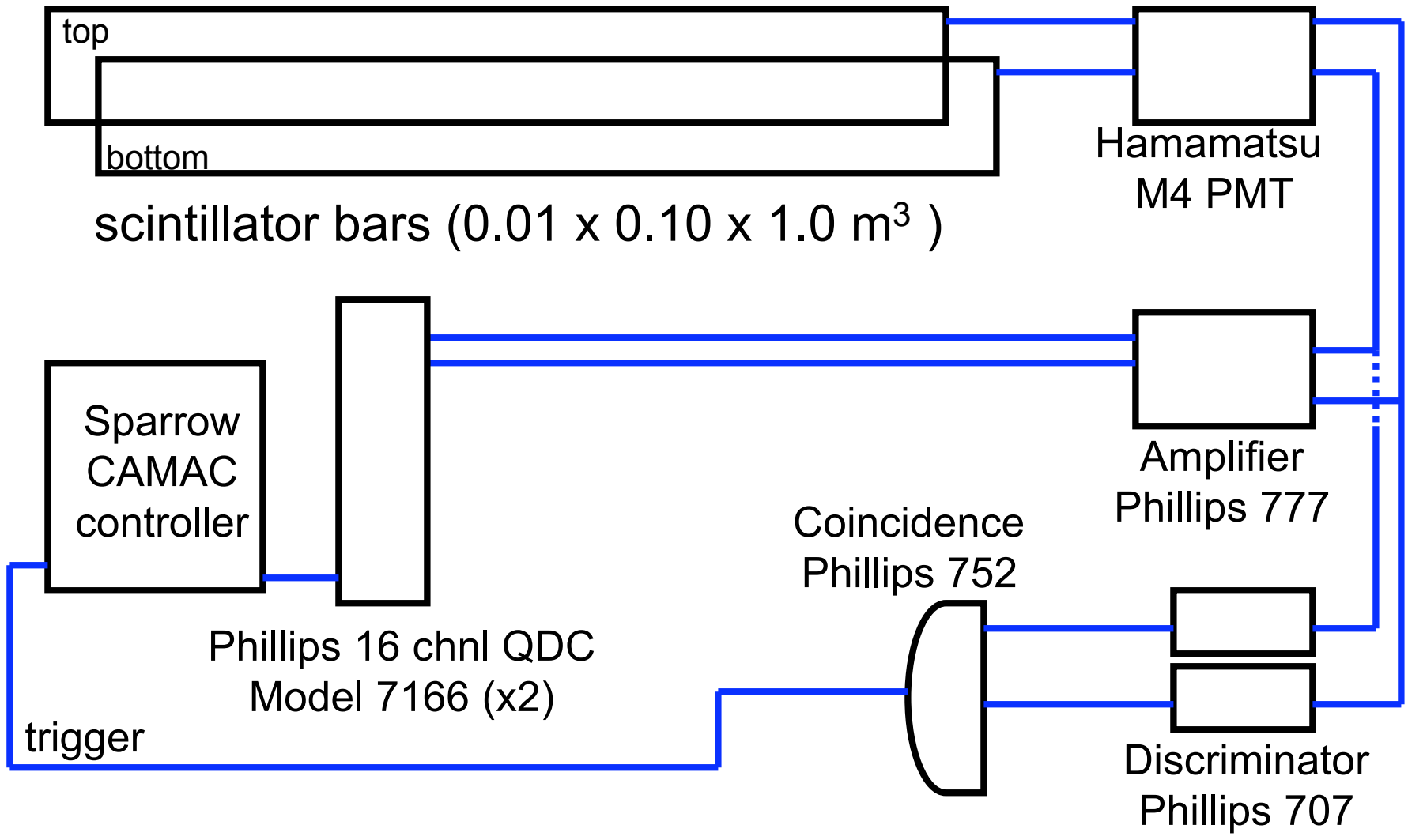


Each scintillator is readout by 1 pixel in multi-anode PMT
Each PMT is 4x4, 2 PMTs, 30 scintillators total+2 empty

Readout


Scintillator bars (x30)
Hamamatsu
M16 PMTs (x2)
Sparrow
CAMAC
controller
Delay Boxes (x16)
16 chnl Custom
Amp cards (x2)
Phillips 16 chnl QDC
Model 7166 (x2)
trigger

Trigger


top
bottom
scintillator bars (0.01 x 0.10 x 1.0 m^3)
Hamamatsu
M4 PMT
Sparrow
CAMAC
controller
Phillips 16 chnl QDC
Model 7166 (x2)
Amplifier
Phillips 777
Coincidence
Phillips 752
trigger
Discriminator
Phillips 707

Trigger Configuration

- The trigger uses same scintillator but just 1m long

- Fixture made at W&M and brought to Fermilab
  - Paddles right on top of each other
  - Rest them on top of CRVhm in various orientations
    A. Transverse to 30 scint bars
    B. Parallel to a given column of bars
    C. Off to the side

Trigger Configurations

- Take runs in orientation A along length to measure attenuation and efficiency vs distance from PMT
- Take runs in orientation B along width to debug
- Take runs in orientation C for pedestals, accidental coincidences, common mode noise, etc studies

The Team

- John Kane, Frank Kane, Jonathan Stevens came for a week to re-assemble CRV-hm in the CDF assembly pit and establish data taking
  - Left lots of equipment, tools, and some documentation
  - Eventually need to return their equipment
  - Took a set of runs in orientation A in 7 positions along length
- They handed-off to us:
  - DG, Craig Group (pdoc,Fermilab), Jo-Anne Butt (middle school teacher), Amy Allen (HS student), Keegan Freiburger (HS student), Jamie Ray (HS student)
  - Aimed to first repeat their measurements, then extend program

Commissioning Trigger

- Initially data rate erratic
  - Re-wrapped trigger, replaced frayed wire, and strain relieved wires. Data rates constant since then.
- In orientation A expect the occupancy of a given scintillator to be ~10%, but observed ~0.01%
- Coincidence rate exceeded what expected from cosmic flux given surface area of trigger
- Deadtime about 50%
  - Raising discriminator TH so that the singles rate per paddle ~10-15 Hz (expected cosmic flux) fixed all three

Commissioning Trigger

- Initially histogram of trigger ADC shoved to the far left
  - John reminded us to introduce a delay
- Plateau-ed the trigger PMT

- Occupancies now sensible (~10%), dead time small (<5%), trigger rate stable

Commissioning Readout Order

- Plan to use offline analysis to determine efficiency
  - Mapping of readout order to physical location of scintillator bar necessary to accomplish this
- One of the students wrote an event display
  - Complete non-sense at first (cf. next page)
- Students initiated a set of tests to debug
  - Took runs with various scint. bars unplugged
  - Took runs with trigger in orientation B

Original readout ordering

- Some example event displays with original ordering

Commissioning Readout Order

- Eventually tracked it down to a couple goofs:
  - A few sets of wires swapped between output of CRVhm and Phillips QDC (fixed the right half)
  - Found PMT and guideblock holding the WLS rotated relative to each other

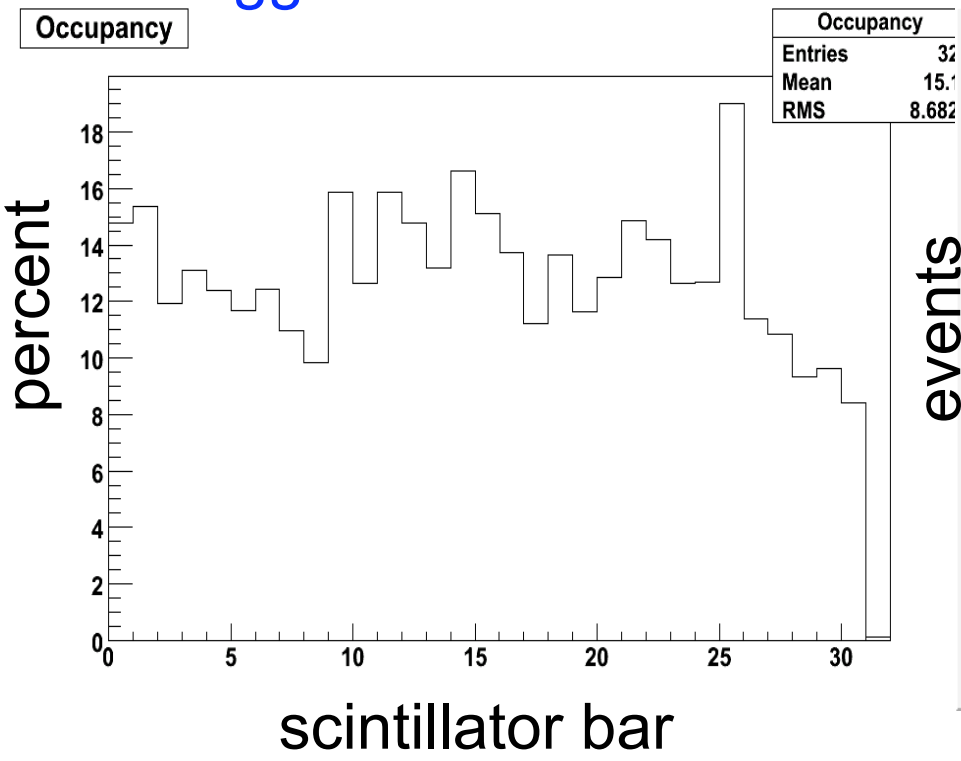
- After these fixes, event displays sensible (cf. next slide)

Fixed Readout Ordering

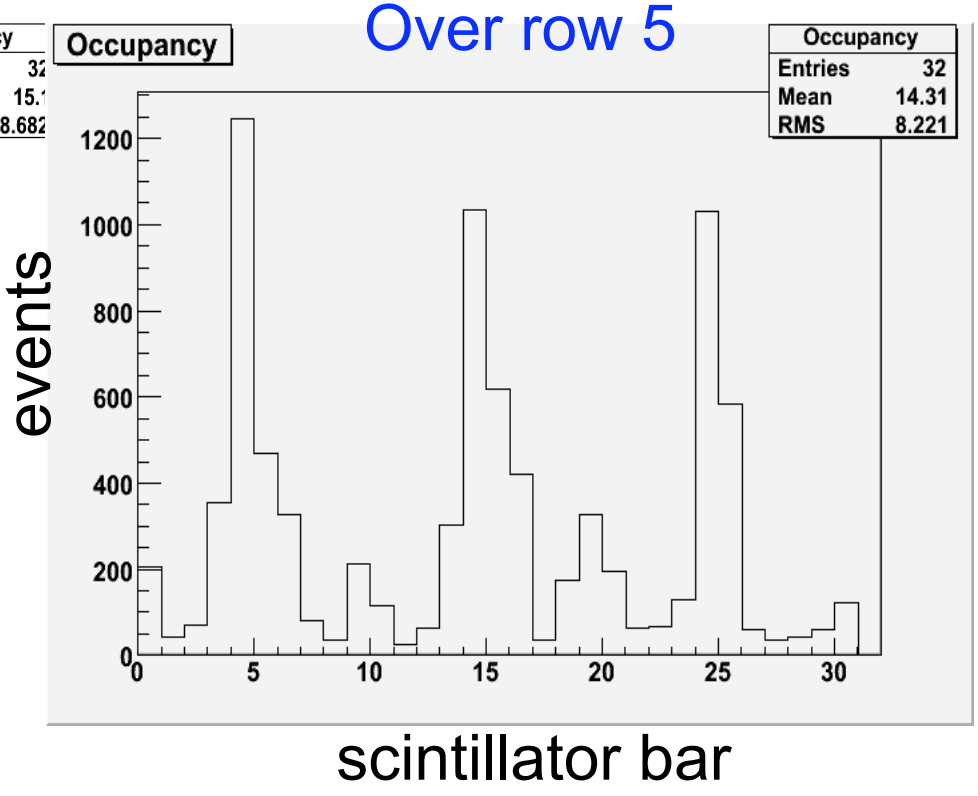
- Some example event displays after debugging

After these efforts

Trigger orientation A

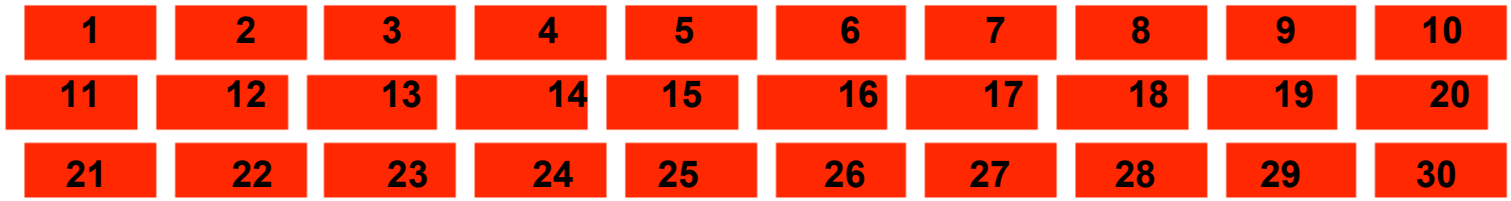


Trigger orientation B
Over row 5



- Occupancy and readout reasonable

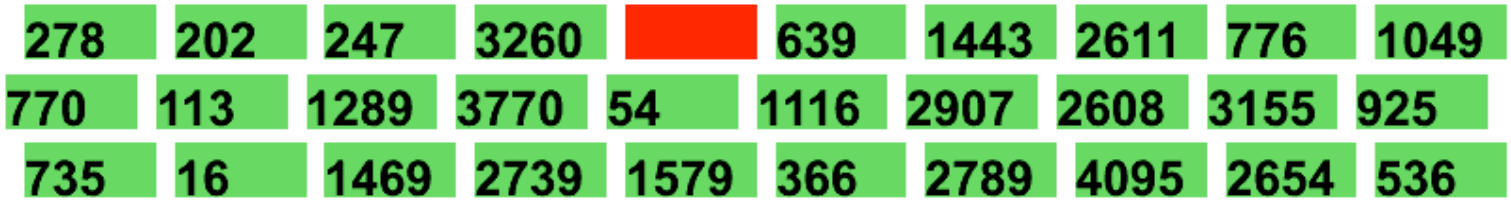
Scintillator Numbering



- Here's how the scintillator bars are numbered

Oddities

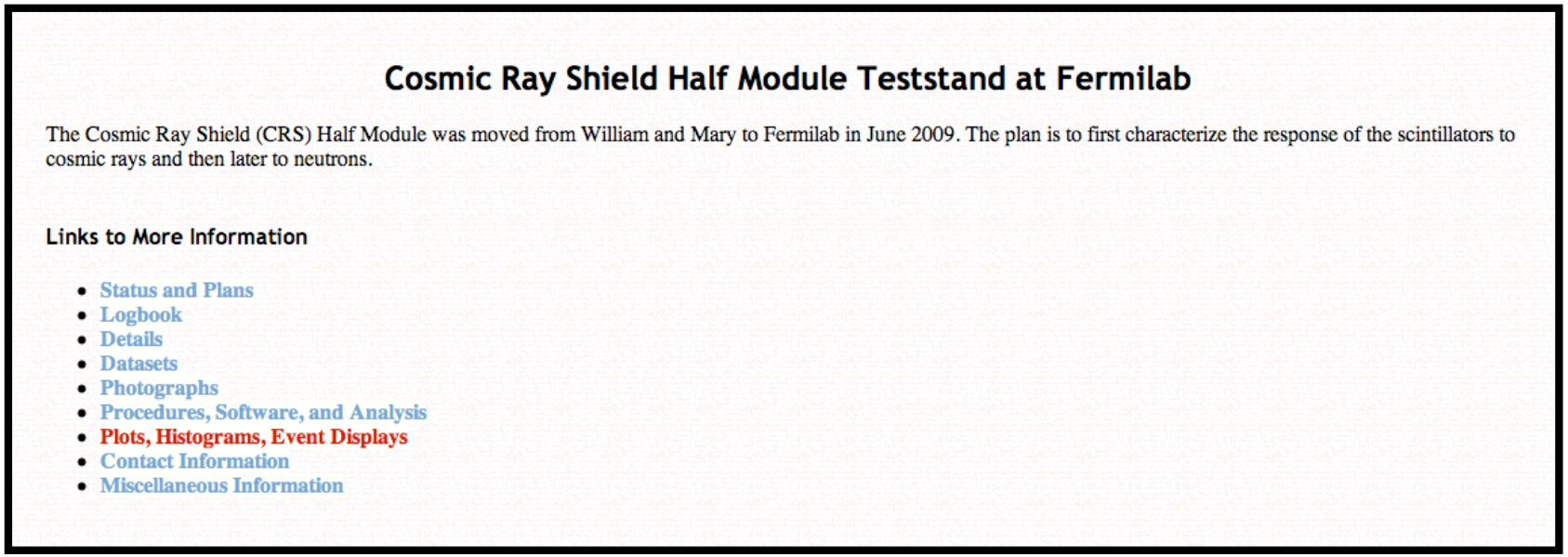
- About 7% of triggered events empty - μ stopped in trigger? Real inefficiency? Other?



- About 0.5% of triggered events “full” - Air shower? Common mode noise? Other?

Documentation

- Jo-Anne, Keegan, Amy, and Jamie made a beautiful set of web pages with lots of information
  - http://www-cdf.fnal.gov/~douglasg/mu2e/crs.html
  - Check it out! Some examples in next pages



Cosmic Ray Shield Half Module Teststand at Fermilab

The Cosmic Ray Shield (CRS) Half Module was moved from William and Mary to Fermilab in June 2009. The plan is to first characterize the response of the scintillators to cosmic rays and then later to neutrons.

Links to More Information

- Status and Plans
- Logbook
- Details
- Datasets
- Photographs
- Procedures, Software, and Analysis
- Plots, Histograms, Event Displays
- Contact Information
- Miscellaneous Information

On the Web: Datasets

List of datasets available for the CRS Half Module at Fermilab

(All the files can be found on fcdflnx2:/cdf/home/douglasg/public_html/mu2e/docs)

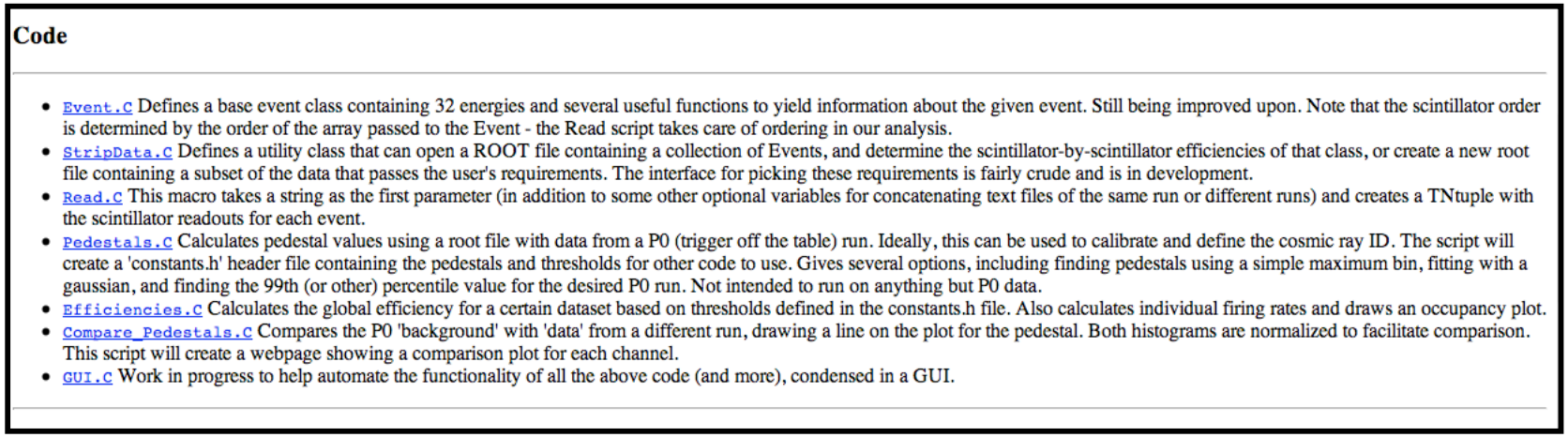
We have listings for these data taking configurations: Trigger at 870V, Trigger at 800V, Revised Readout Mapping, Initial Investigations,

Revised Trigger Voltage 870V

Date	Who	What	Nevents on Coincidence Counter	Nevents in textfile	Filename
2009-Aug-06	aa/jb	870volts	28558	27911	090806P1TtOnB01106.txt
2009-Aug-05	aa/jb/kf	870volts	23875	23386/TD>	090805Verticaltrigger50cm1120.txt
2009-Aug-05	aa/jb/kf	870volts	8084	7790	090805Verticaltrigger50cm0934.txt
2009-Aug-04	aa/jb	870volts	38968	38153	090804P0TtOnB010574hours.txt
2009-Aug-03	aa/jb	870volts	11901	11525 (11530 on DAC)	090804P7TtOnB00844.txt
2009-Aug-03	aa/jb	870volts	12696	12332	090803P2TtOnB00854.txt
2009-Aug-03	aa/jb	870volts	9950	9705	090803P3TtOnB01029.txt
2009-Aug-03	aa/jb	870volts	10316	10093	090803P4TtOnB01207.txt
2009-Aug-03	aa/jb	870volts	9745	9527	090803P5TtOnB01205.txt
2009-Aug-03	aa/jb	870volts	9898	9712	090803P6TtOnB01519.txt
2009-Jul-31	jb	870volts P0 1.5 hrs	16695	16086	090731P0TtOnB00856.txt
2009-Jul-31	jb	870volts P1 1.5 hrs	12839	12426	090731P1TtOnB01029.txt
2009-Jul-31	jb	870volts P4 4 hrs	38163	37007	090731P4TtOnB01202.txt

- Will move data to somewhere everyone can get to it

On the Web: Software

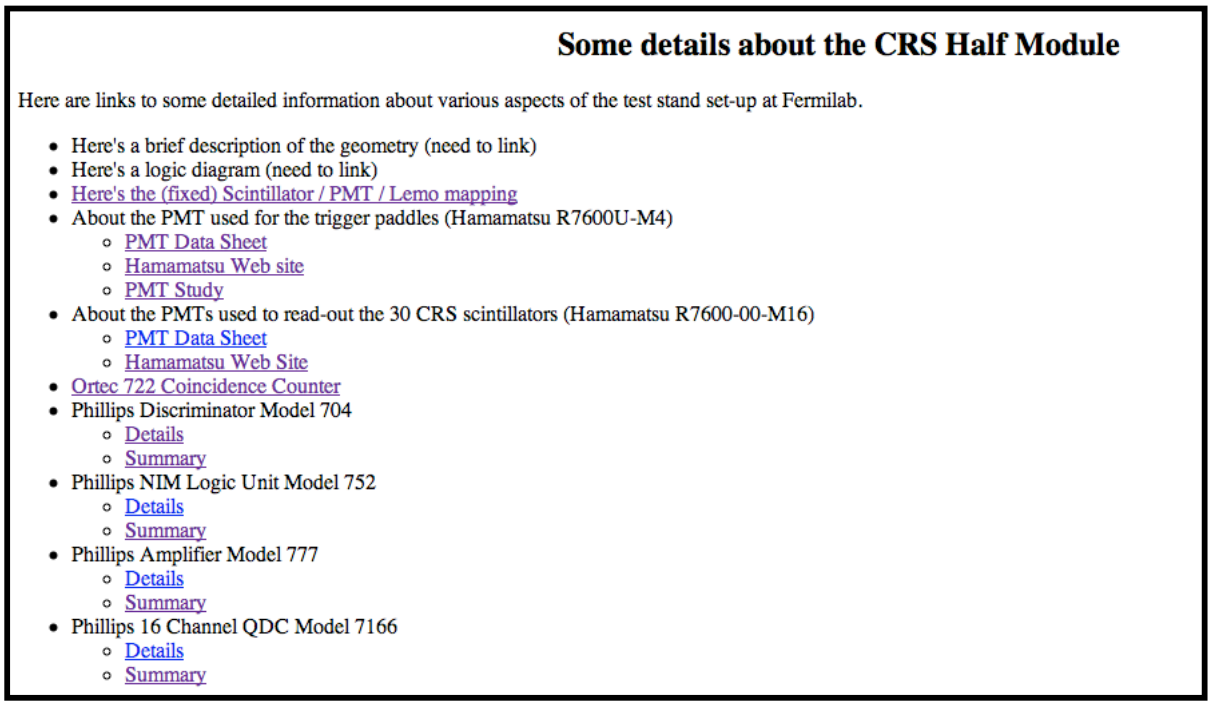


Code

- Event.C Defines a base event class containing 32 energies and several useful functions to yield information about the given event. Still being improved upon. Note that the scintillator order is determined by the order of the array passed to the Event - the Read script takes care of ordering in our analysis.
- StripData.C Defines a utility class that can open a ROOT file containing a collection of Events, and determine the scintillator-by-scintillator efficiencies of that class, or create a new root file containing a subset of the data that passes the user's requirements. The interface for picking these requirements is fairly crude and is in development.
- Read.C This macro takes a string as the first parameter (in addition to some other optional variables for concatenating text files of the same run or different runs) and creates a TNtuple with the scintillator readouts for each event.
- Pedestals.C Calculates pedestal values using a root file with data from a P0 (trigger off the table) run. Ideally, this can be used to calibrate and define the cosmic ray ID. The script will create a 'constants.h' header file containing the pedestals and thresholds for other code to use. Gives several options, including finding pedestals using a simple maximum bin, fitting with a gaussian, and finding the 99th (or other) percentile value for the desired P0 run. Not intended to run on anything but P0 data.
- Efficiencies.C Calculates the global efficiency for a certain dataset based on thresholds defined in the constants.h file. Also calculates individual firing rates and draws an occupancy plot.
- Compare_Pedestals.C Compares the P0 'background' with 'data' from a different run, drawing a line on the plot for the pedestal. Both histograms are normalized to facilitate comparison. This script will create a webpage showing a comparison plot for each channel.
- GUI.C Work in progress to help automate the functionality of all the above code (and more), condensed in a GUI.

- Simple ROOT scripts available to look at data, alternatively one of the students is developing a GUI

On the Web: Hardware Manuals



Some details about the CRS Half Module

Here are links to some detailed information about various aspects of the test stand set-up at Fermilab.

- Here's a brief description of the geometry (need to link)
- Here's a logic diagram (need to link)
- Here's the (fixed) Scintillator / PMT / Lemo mapping
- About the PMT used for the trigger paddles (Hamamatsu R7600U-M4)
  - PMT Data Sheet
  - Hamamatsu Web site
  - PMT Study
- About the PMTs used to read-out the 30 CRS scintillators (Hamamatsu R7600-00-M16)
  - PMT Data Sheet
  - Hamamatsu Web Site
- Ortec 722 Coincidence Counter
- Phillips Discriminator Model 704
  - Details
  - Summary
- Phillips NIM Logic Unit Model 752
  - Details
  - Summary
- Phillips Amplifier Model 777
  - Details
  - Summary
- Phillips 16 Channel QDC Model 7166
  - Details
  - Summary

- More complete operating manuals obtained in paper copies as well for most components

Plans

- Spend some time looking at the data we have in hand
  - First crack at efficiencies and attenuations
- Normalize the gains across the 30 scintillator bars
  - Gain variations across pixels can be compensated with the variable amplifiers on the amp cards
  - Use single-photo-electron peak?
- Plateau M16 tubes
- Split trigger paddles and put one below the table
  - Anticipate eliminating the empty events that way
- Introduce a neutron source
  - Look for hits in 2 CRV layers with no hits in trigger paddles

Plans

- Eventually need to return most electronics to W&M
  - Replace with something of our choice
  - Is there a Mu2e standard for test stands? If not will go with an option that has support from local (ie. CDF) expertise

- Timescale
  - By January 2010 collaboration meeting would like to have at least gotten efficiency and attenuation measurements we have confidence in
  - A first look at response to neutrons using a source may be possible by then too

Conclusions

- CRV half module test stand nearly commissioned
- First data available for first looks
  - Will move data to public Mu2e space
- Webpages available with lots of documentation
  - Photographs, analysis scripts, hardware manuals, HowTos, etc.
  - http://www-cdf.fnal.gov/~douglasg/mu2e/crs.html
  - Need to move to Mu2e web area and link
- Over the next couple months further improve performance and understanding based on the data in hand, perhaps even first look at neutron response