The Hall A Coordinate Detector at Jefferson Lab:
Adventures in Construction, Assembly and Testing

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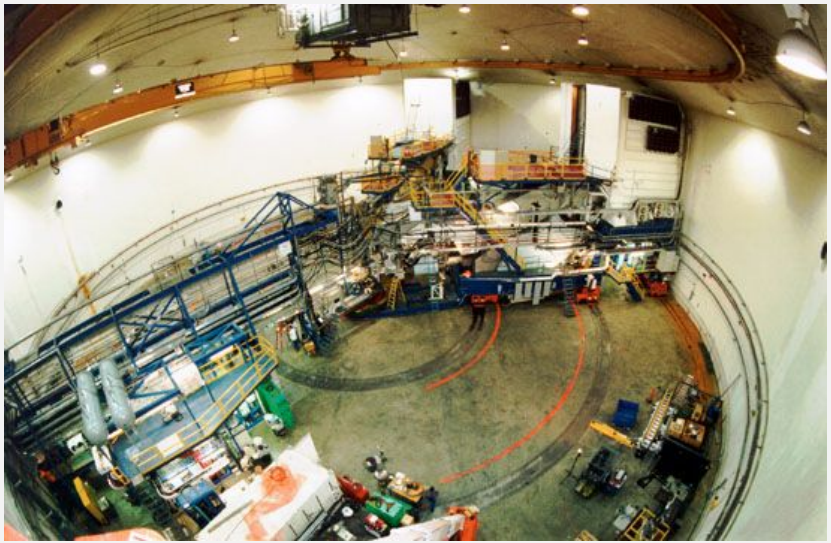
Jefferson Lab: A Brief Overview

- Located in Newport News, Virginia
- Particle Physics lab
- In the process of a 12GeV upgrade for its synchrotron accelerator
- Working specifically for Hall A (1 of 4 Halls)

Courtesy: Google Maps

Hall A and the Super Bigbite Spectrometer

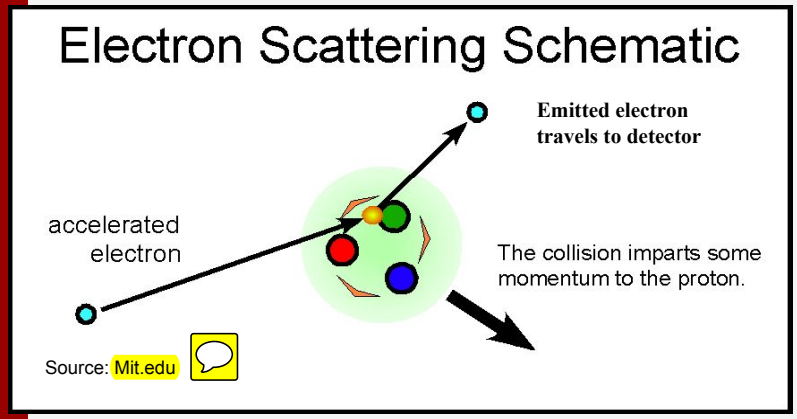


Source: https://physics.fiu.edu/research-groups/nuclear-physics-experiment/

- Takes high energy electrons from the Continuous Electron Beam Accelerator Facility (CEBAF)
- Bigbite is currently under construction
- Designed to function with the CEBAF upgrade to 12 GeV
- Spectrometer to have a very high acceptance rate.

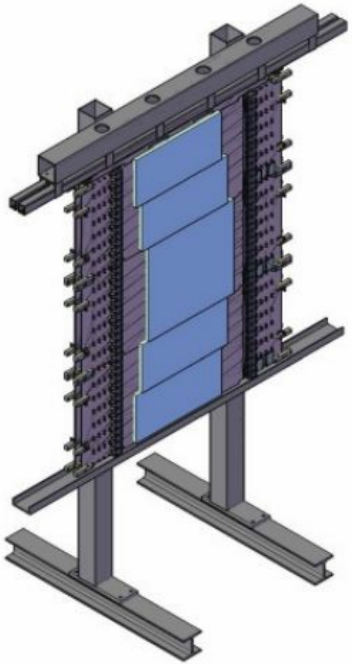
Electron Scattering in an Electron-Proton collision

- High Energy Electron collides with a Proton (Target) at some position
- Electron is emitted with a different energy and a scattering angle
- The goal is to determine the position of the collision and the scattering angle



The Coordinate Detector (CDET)

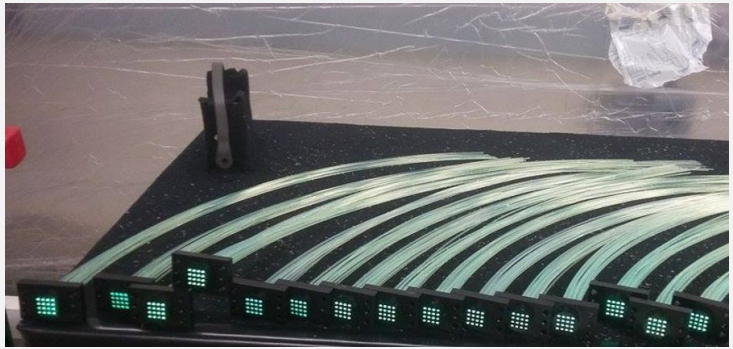
- Consists of 6 Modules
- 3 Modules on each side of mount (See figure)
- Each Module contains 28 scintillation bars
- All Scintillation bars angled towards expected collision area
- Expected vertical resolution of ~<2mm



Courtesy SBS collaboration

CDET Continued

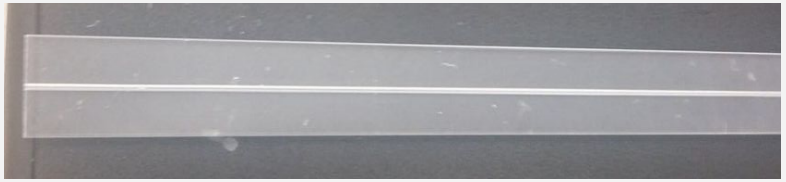
- Scintillation bar contains 14 thin scintillation paddles
- Fiber optic cable threaded through each paddle



Several Bundles of Fiber optic cables

- Every bar is connected to a Photomultiplier tube (**PMT**)
- The PMT outputs the signal that data acquisition requires

★ Problem! These PMTs are being **Re-used**. Some may not be fit for purpose



Thin Scintillation paddle

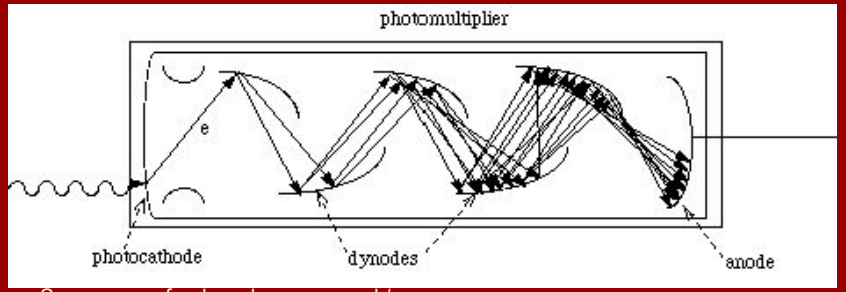
PhotoMultiplier Tubes

- Take advantage of high voltage and the photoelectric effect
- Single photons interact with the 1st layer and release electrons
- These electrons travel to the next layer and release more, etc. Until a usable signal is generated

What we noticed:

1. A single PMT only has 1 High Voltage connection
2. Each scintillation bar contains 14 paddles, while each PMT contains 16 usable pixels

This still gives an opportunity to optimize!

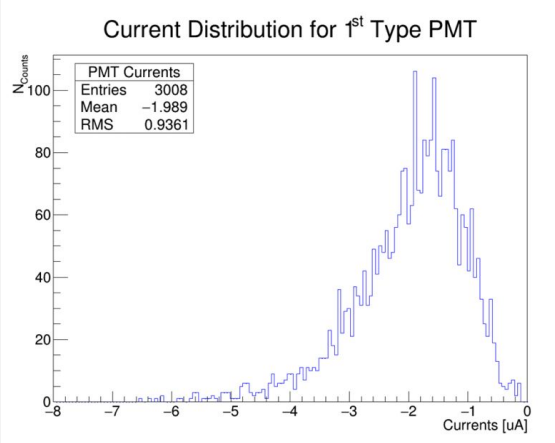


Source:www.frankswebspace.org.uk/

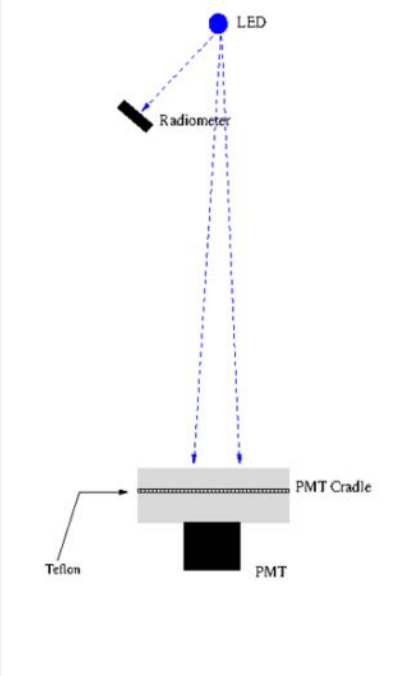
Front and back of PMT used in CDET

PMT Data: Summer 2015

- Using PMT data from Nathan Murtha during summer 2015
- For each pixel:
  Measured output current given a constant voltage and photon source
- Mean currents compiled into a text document for analysis



Example of data for a single pixel

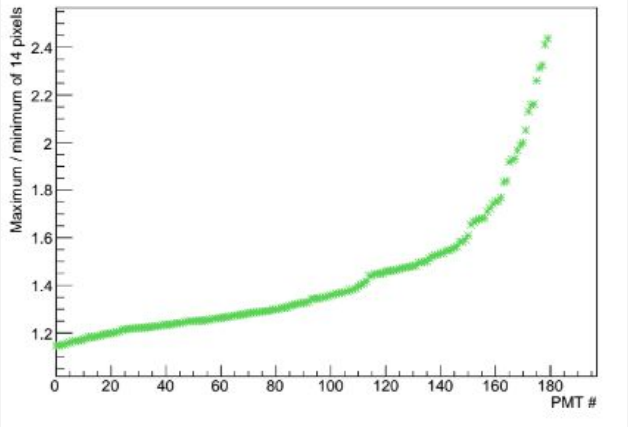


Source:Mahbub Khandaker, Idaho State University. SBS collaboration meeting 2015

Optimizing the Photomultiplier Tube Output Signal

- 2 Pixels with the largest deviation from the mean were removed
- The ratio of the largest and smallest current of the remaining pixels is calculated
- Define as Maximum Scaling Factor
- Use as a basis for optimal PMT selection
- Module maps followed

Maximum Scaling Factor of each PMT (sorted)

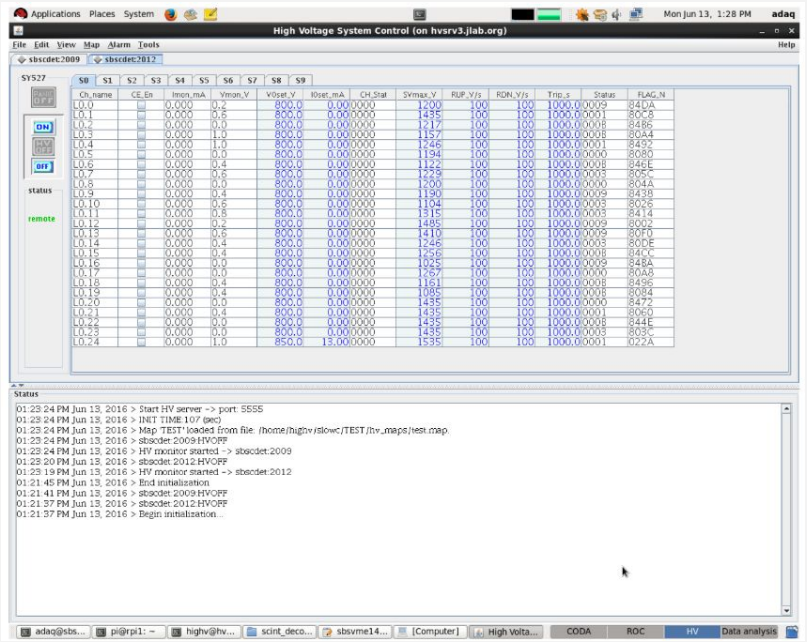


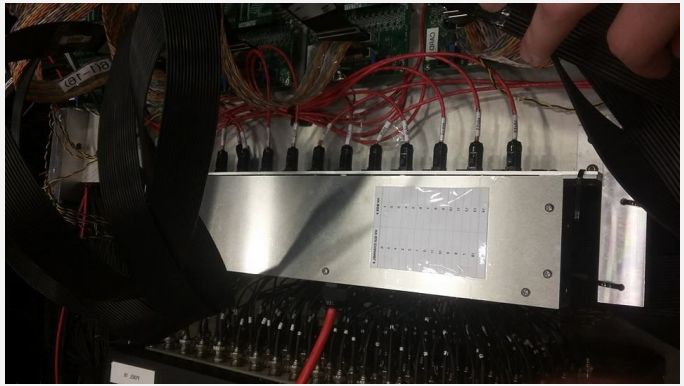
		TOP LEFT				TOP RIGHT		
Pixels NOT Used	Bar Label	PMT SERIAL #	Notes		Notes	PMT SERIAL #	Bar Label	Pixels NOT Used
1, 15	M3-8DL	154				52	M3-8DR	4, 14
1, 4	M3-9DL	102				108	M3-9DR	2, 16
2, 6	M3-10DL	33				99	M3-10DR	1, 4
2, 6	M3-11DL	31				107	M3-11DR	13, 16
14, 16	M3-12DL	150				181	M3-12DR	1, 4
1, 13	M3-13DL	46		MODULE 3		73	M3-13DR	13, 16
1, 4	M3-14DL	35				38	M3-14DR	3, 16
1, 13	M3-15DL	65				159	M3-15DR	4, 14
4, 12	M3-16DL	152				1	M3-16DR	1, 14
6, 13	M3-17DL	51				12	M3-17DR	5, 14
11, 14	M3-18DL	53				39	M3-18DR	2, 3
2, 13	M3-19DL	131				42	M3-19DR	4, 15
7, 11	M3-20DL	72				129	M3-20DR	4, 16
2, 4	M3-21DL	83				165	M3-21DR	1 ,10
		BOTTOM LEFT				BOTTOM RIGHT		
		PMT #				PMT #		

High Voltage System: CDET HV CAEN SY527N

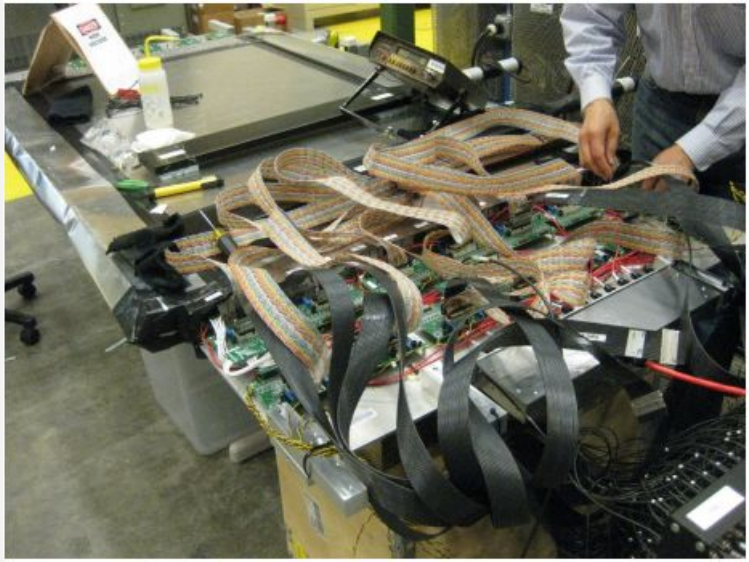
High Voltage Control

- Previously no dedicated HV for CDET
- Designed HV test cables
- New HV switchboard
- Designed a map from HV remote control GUI to CDET
- Control on Linux based computer, operable from anywhere



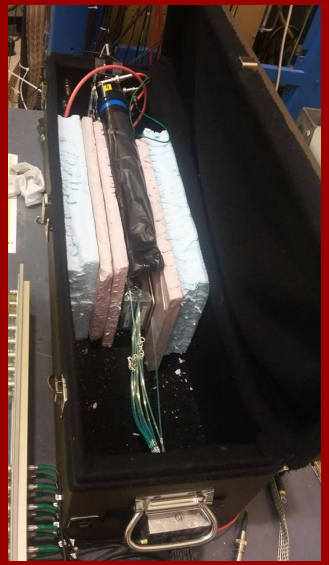


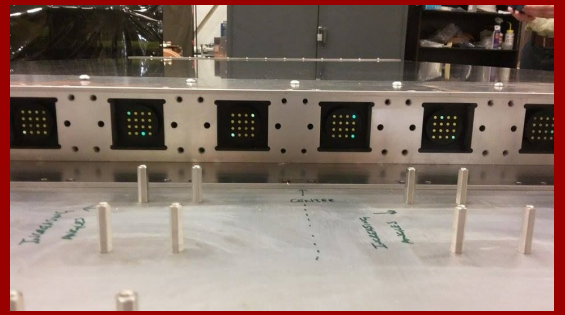
Construction of the Coordinate Detector



Scintillator installation

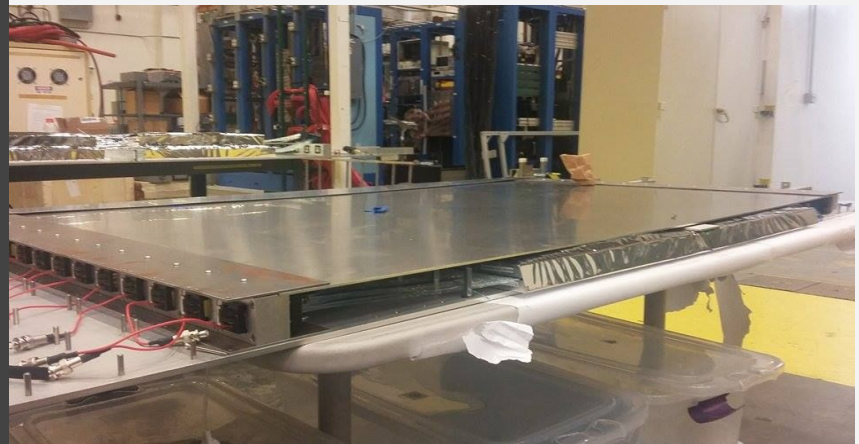
- Tested with cosmic rays prior to installation (top left)
- Rejected pixels selected from prior analysis (top right)
- Fiber optic cables threaded through each bar
- Bars installed on bottom panel (bottom)





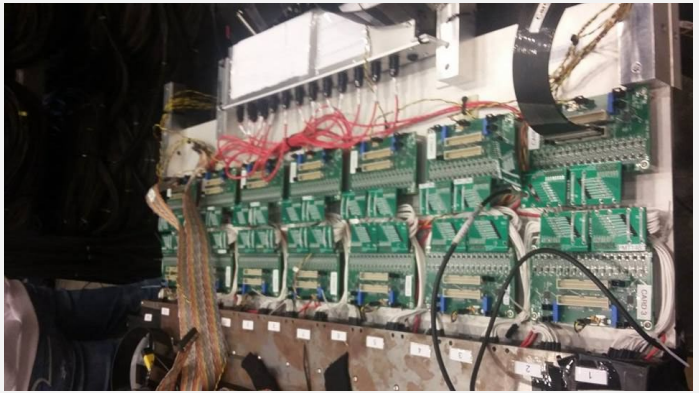
Installing Plates

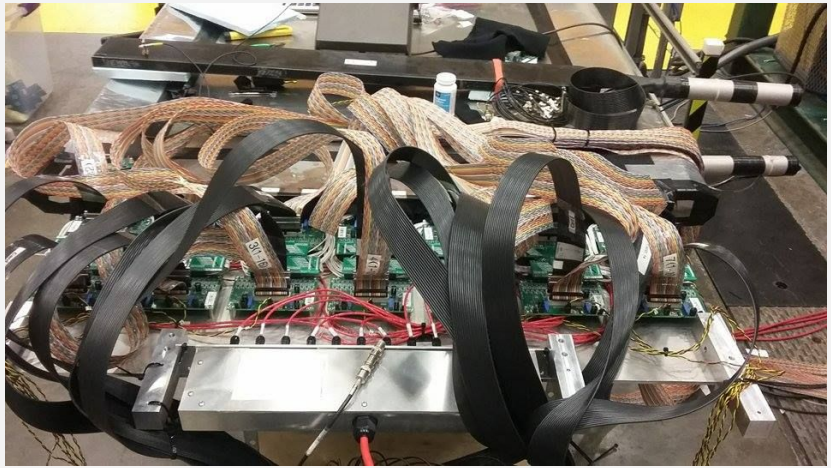
- Aligned scintillation bars (top right)
- Installed top and side plates
- Taped overlapping areas with Electric tape (bottom right)



Finishing Touches

- Connect HV cables to PMT's
- Install discriminator cards
- Use HV to probe for light tightness
  700V → <30nA
- Connect the remaining signal cables to data acquisition modules





Thank you

Questions?