Small Radius PMT Tests

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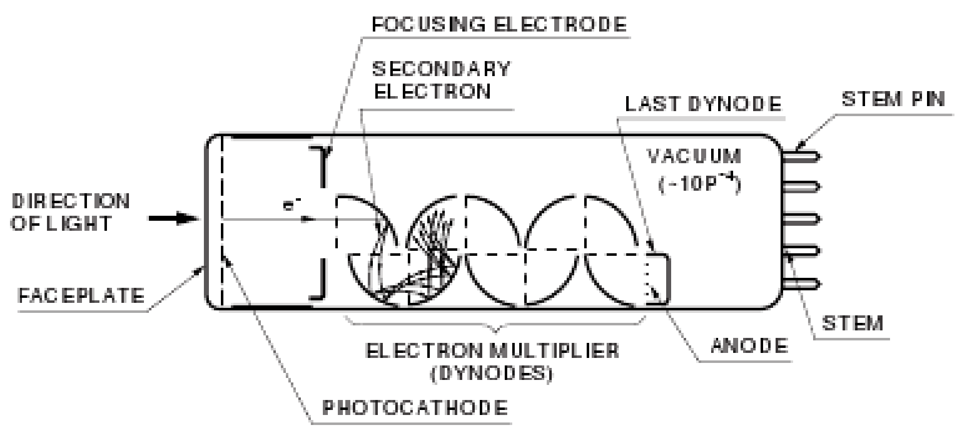
Gain Tests and Calculations

Background: PMT

- How a PMT works
- What the gain is
- What the SEP is
- Why it is important



1. A photon is emitted from an LED and hits the PMT's photocathode
2. A photoelectron is ejected from the photocathode due to the photoelectric effect
3. The electron passes through the dynodes of the PMT and multiplies
4. The electrons become a measurable current when exiting the dynodes

SEP and Gain Tests

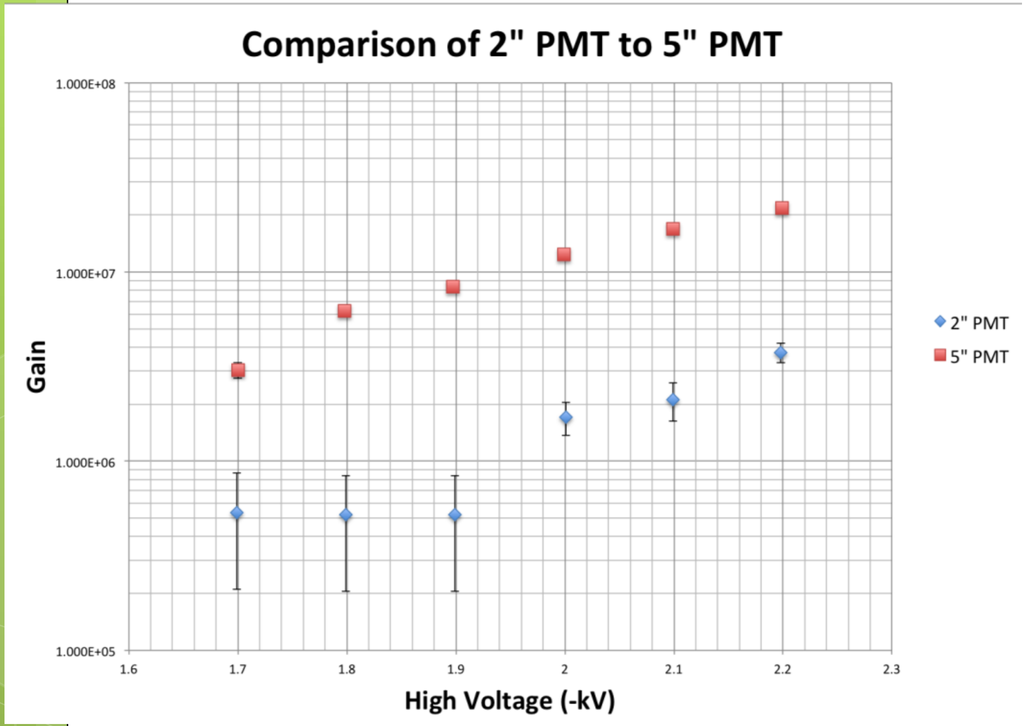
- Finding the single electron peak for the 2-inch PMTs
  - Noise problems
  - Complications
  - Solution
- Calculating the gain for the 2-inch PMTs
- Comparing 2-inch PMT's gain to previously calculated 5-inch PMT's gain

2-Inch and 5-Inch Gains

H.V. (-kV)	2" Gain	2" Gain Err.	5" Gain	5" Gain Err.
1.700	5.364E05	3.266E05	3.029E06	2.831E05
1.799	5.206E05	3.161E05	6.247E06	4.171E05
1.899	5.206E05	3.161E05	8.361E06	5.406E05
2.000	1.704E06	3.339E05	1.237E07	7.940E05
2.099	2.114E06	4.858E05	1.694E07	1.073E06
2.199	3.755E06	4.454E06	2.169E07	1.374E06
Typical	**1.00E06**		**2.00E07**	

Gain Results

2" vs. 5" Gain Graph



2"/5" Gain Ratios

H.V. (-kV)	Ratio
1.700	0.1771
1.799	0.0833
1.898	0.0623
2.000	0.1378
2.099	0.1248
2.199	0.1731

Further Calculations

- To ensure my experimental process was sound
- The charge of the single electron peak
  - Using two different methods
- The number of channels the signal went into
  - Compared the deltas from my tests with the results from my calculations

Methods to Calculate Charge of SEP Signal

Method 1

Start with delta value from data → Multiply by ADC resolution (2.56*10^-10 Coulombs / 1024 channels) → Result: Charge of SEP signal

Method 2

Start with Gain → Multiply gain by charge of electron (1.6*10^-19 Coulombs) → Result: Charge of SEP signal

Calculation Results

Charge of SEP

H.V. (-kV)	Method 1 (C)	Method 2 (C)
1.700	8.50E-14	8.52E-14
1.799	8.25E-14	8.33E-14
1.899	8.25E-14	8.33E-14
2.000	2.70E-13	2.73E-13
2.099	3.35E-13	3.38E-13
2.199	5.95E-13	6.01E-13
Typical	**N/A**	**1.60E-13**

of Channels

H.V. (-kV)	Delta (#)	Method 2 (#)
1.700	0.34	0.34
1.799	0.33	0.33
1.899	0.33	0.33
2.000	1.08	1.09
2.099	1.34	1.35
2.199	2.38	2.40
Typical	**N/A**	**0.64**

Conclusions of Gain Tests

- Experimental process used was sound
- Determined the signal from the 2-inch PMT to be too weak for the ADC module to effectively measure it
- Result: SEP signal needs to be amplified
  - Amplification factor: 10

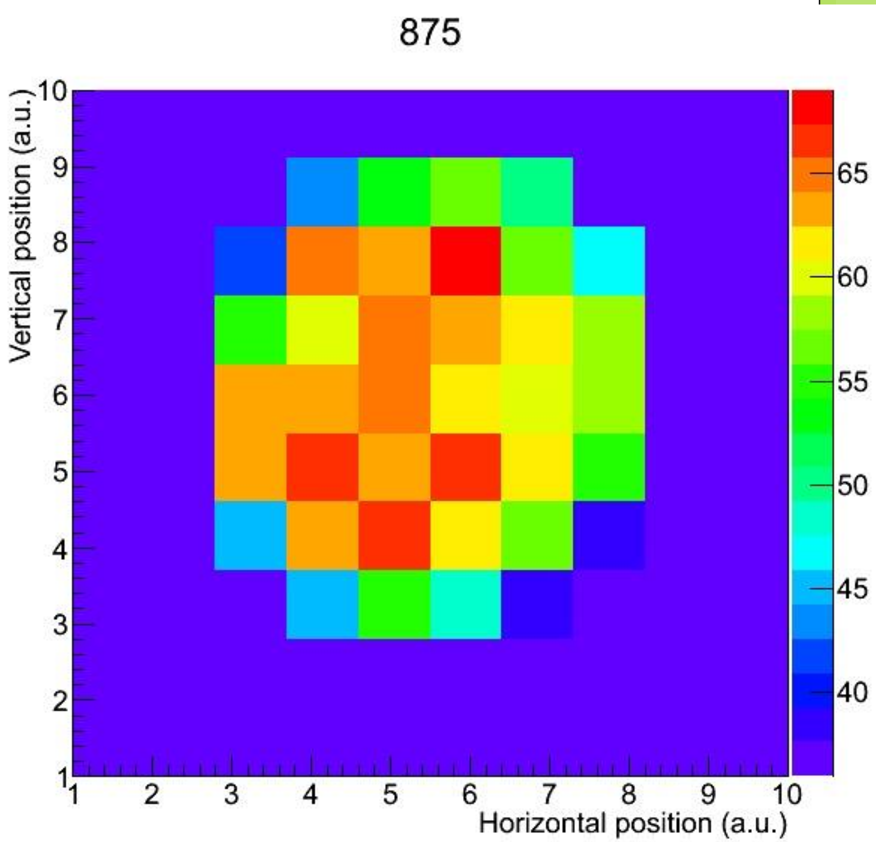
Scanning 2-Inch PMTs

Scanning Background

- Why
  - To determine where on the photocathode the PMT is the most receptive to light
- How
  - Using a step motor and a pulsing LED
    - Only pulses at each data point
  - Creates a matrix of a preprogrammed number of data points

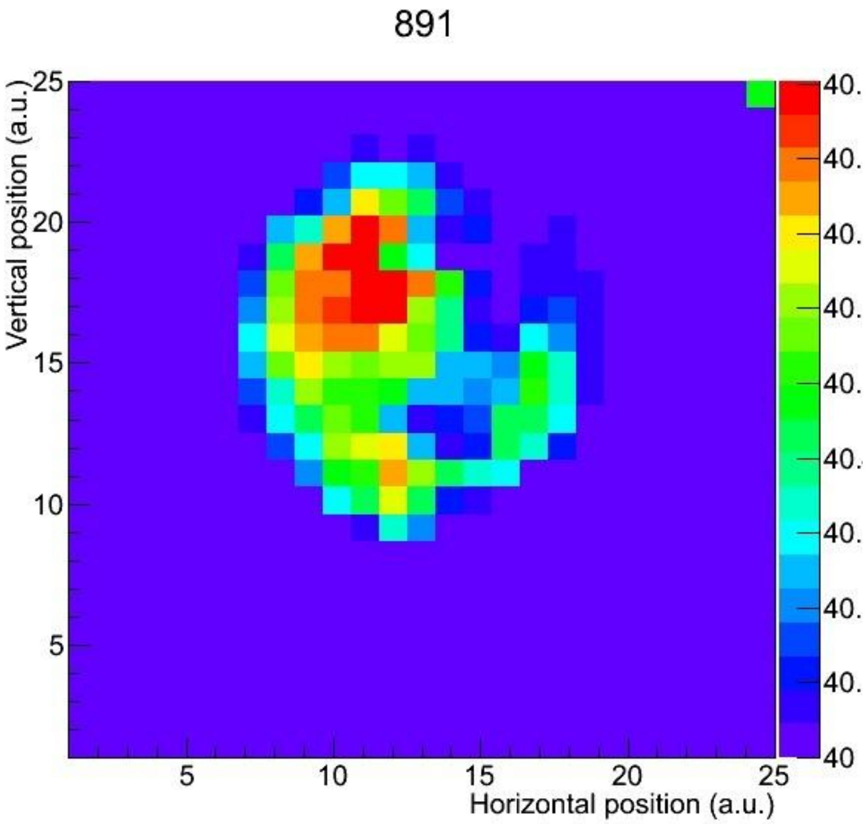
Procedure

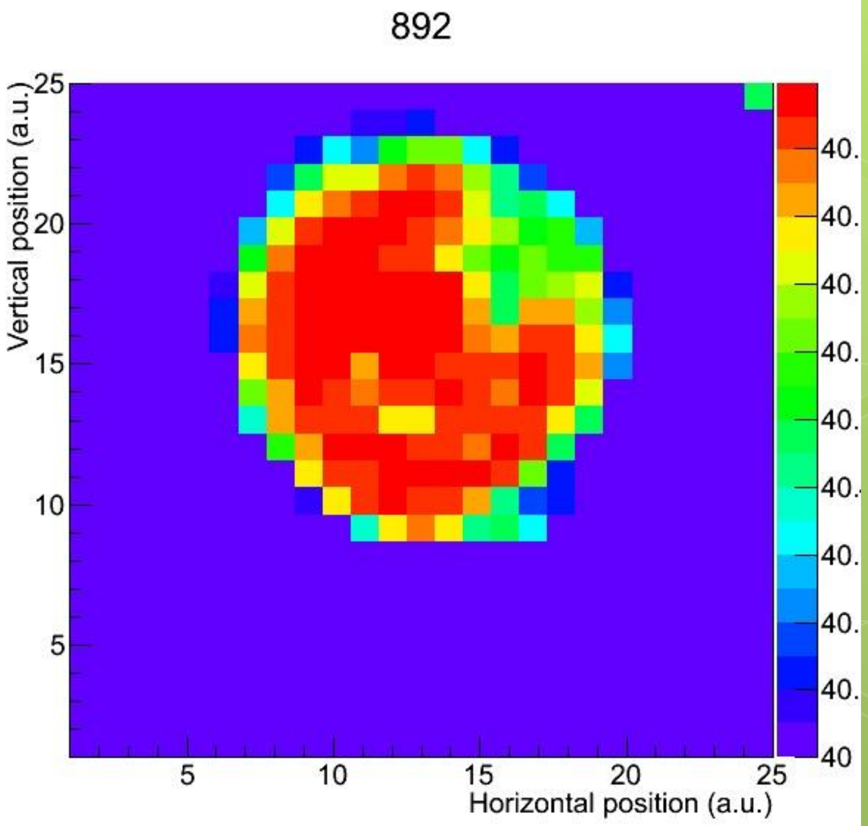
- First took a 10 X 10 matrix, with 1000 events per data point
  - To ensure positioning was completely inside range of step motor
- Second took a 25 X 25 matrix, again with 1000 events per data point, using a range of high voltages
  - ~ -1.600 kV to ~ -2.000 kV



Above: 10 X 10 Scan; -1.821 kV

PMT Scanning

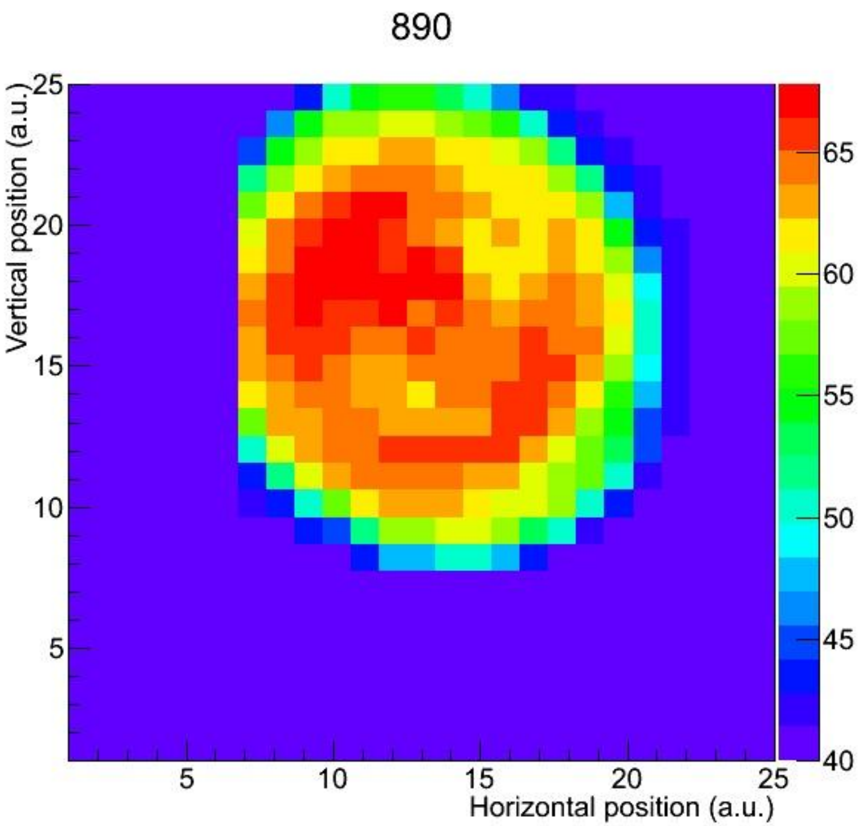




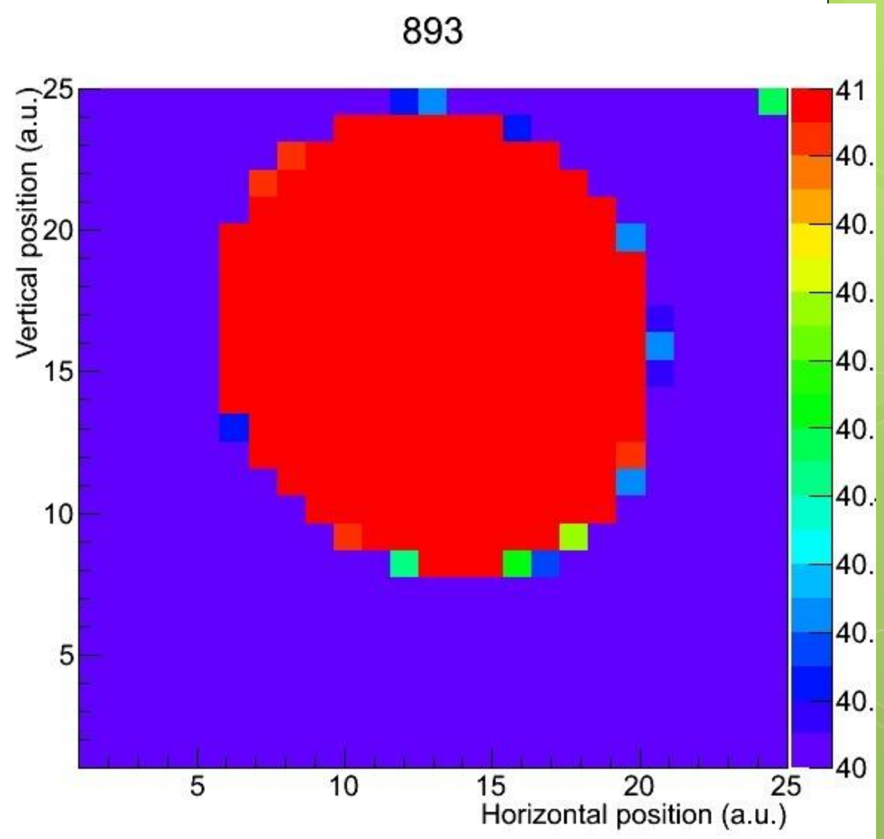
High Voltage: -1.619 kV

High Voltage: -1.707 kV

PMT Scanning

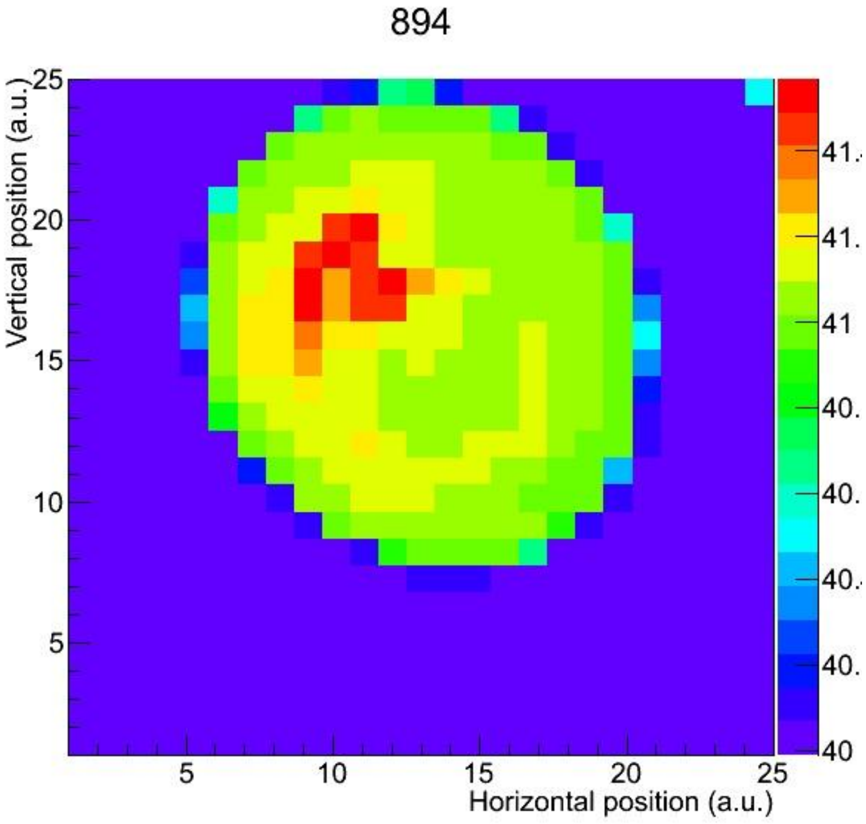


High Voltage: -1.787 kV



High Voltage: -1.898 kV

PMT Scanning



High Voltage: -2.007 kV

Results

- The PMT needs to be repositioned slightly to be completely inside the 2.5 inch X 2.5 inch range the step motor covers
- Scanning needs to continue, using the high and low ends of the range used with the 2-inch PMTs (~ -1.500 kV and ~ -2.100 kV)