PIXE-PAN 2007: Calculating the Speed of Light

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Purpose of the Experiment

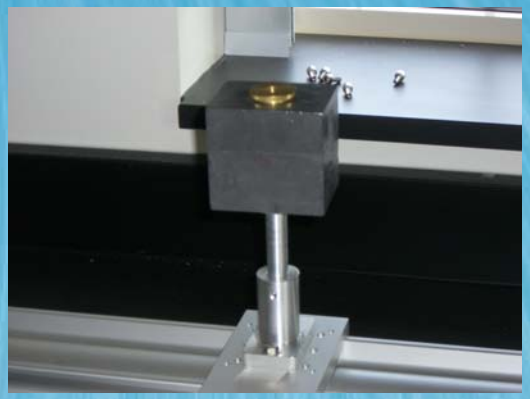
- Determine the speed of light using gamma ray emission
- Learning how to analyze extremely rapid events using precise equipment

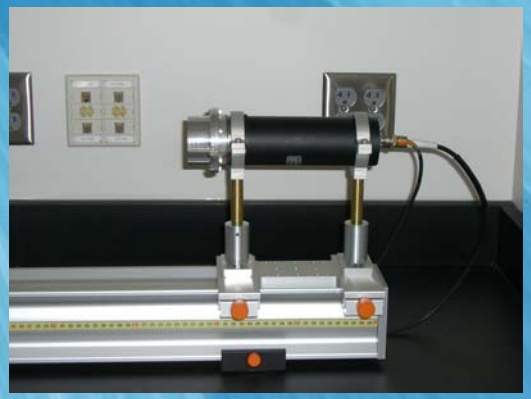
Experimental Setup

- Track with two sensors at each end
- Source between the two sensors which emits gamma rays into them

Procedure

1. Calibrate apparatus using start sensor
2. Collect data pertaining to the different delay increments while calibrating
3. Once calibration is finished, set up source so its distance from each sensor is equal (make this appear as the midpoint on the computer)
4. Select several different points to obtain data

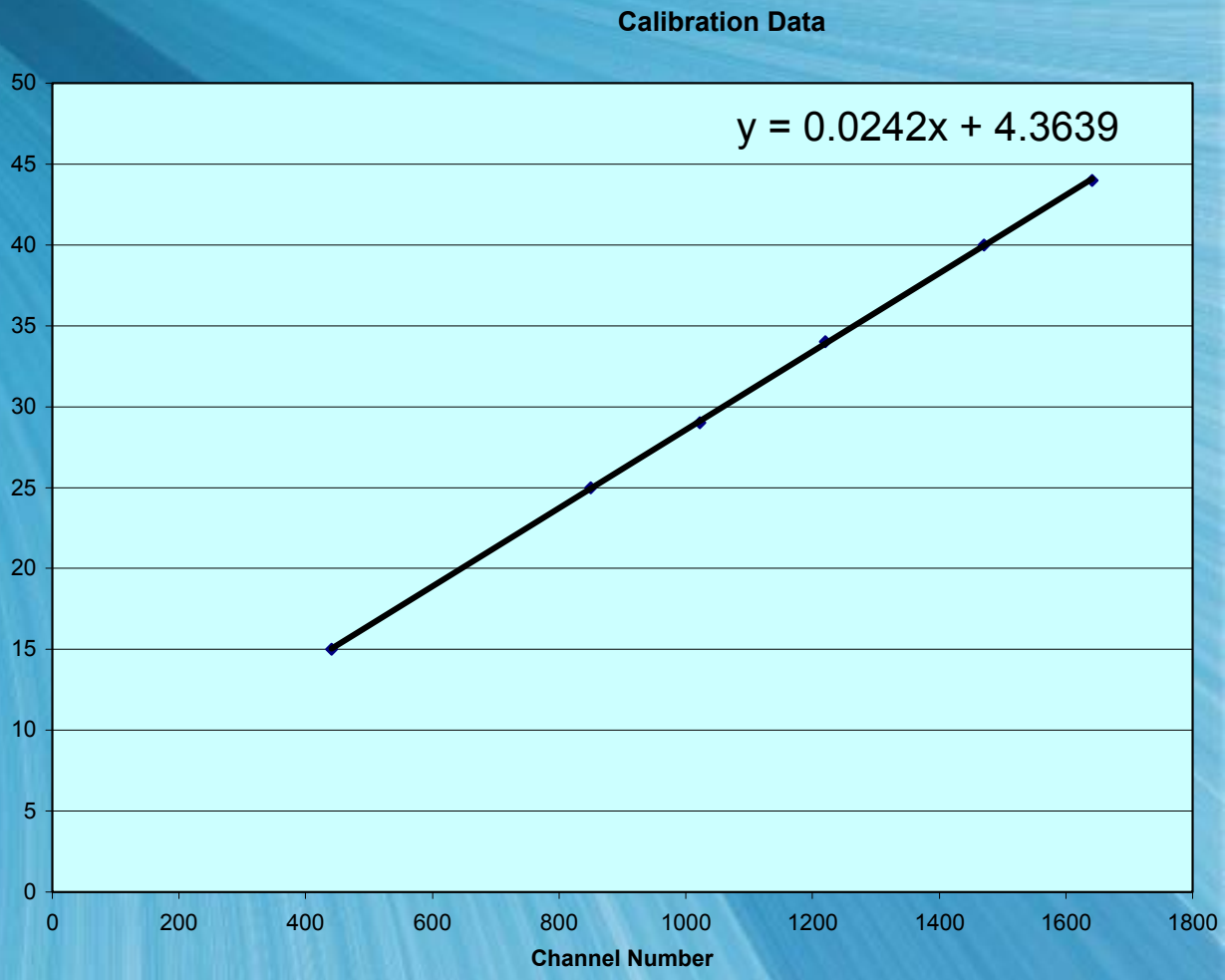




Calibration

- To ensure accuracy, calibrating the detectors was the first step

Delay (nS)	Channel #
22	507
28	754
34	992
40	1246
47	1538



Collecting Data

- Use the difference in the times and distances traveled by the rays to determine the speed of light
- Move the source relative to the detectors

How It Works

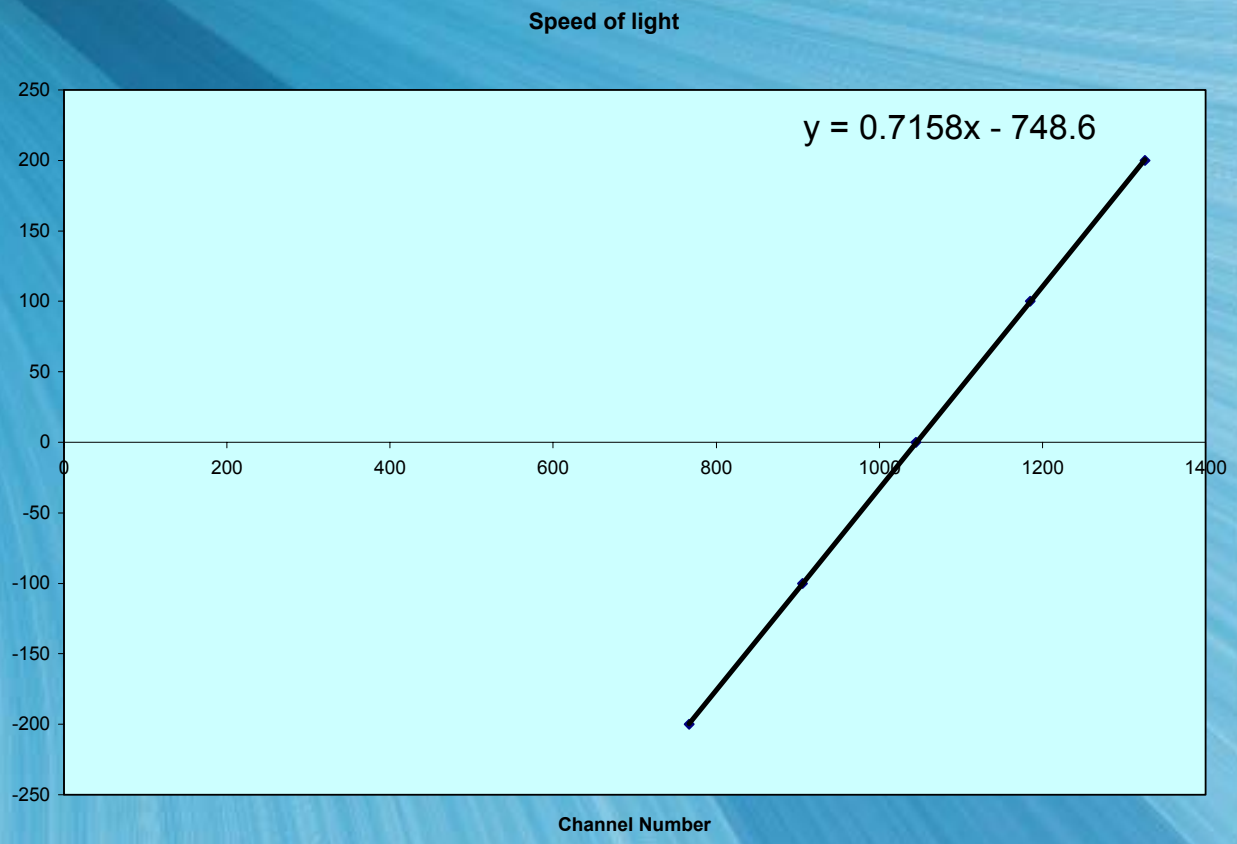
- The source (sodium-22) emits a positron that annihilates an electron in its path, releasing two photons that have 511 keV
- The detectors pick up the photons and sends an analog signal to a converter
- The converter sends a digital signal to the computer
- The computer records the delay from each sensor (start and stop sensors)
- The peak of each signal is determined and recorded as data

Analysis

- After recording the data, it is transferred to a table in excel
- Use the table to make graphs of the data
- Create the trend-line of the graphs
- Two graphs: one for the calibration data and one for the experiment data
- Use the slopes of the two graphs to find the speed of light

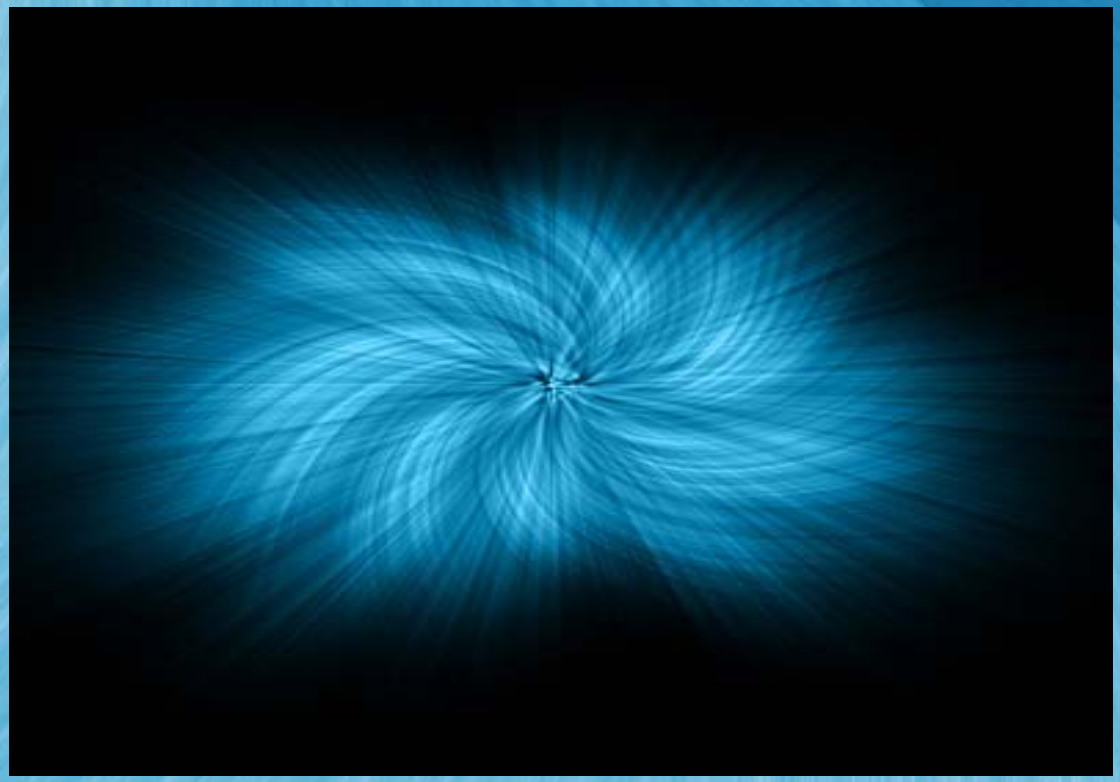
The Results

Path Difference	Channel Number	Time (nS)
220 cm	1342	42.3
140 cm	1229	39.6
80 cm	1145	37.5
0 cm (center)	1035	34.9
-80 cm	921	32.1
-110 cm	838	30.1
-220 cm	727	27.4



Error in the Experiment

- Measured speed: 2.95×10^8 m/s
- Accepted speed: 2.99×10^8 m/s
- Percent Error: 1.34%



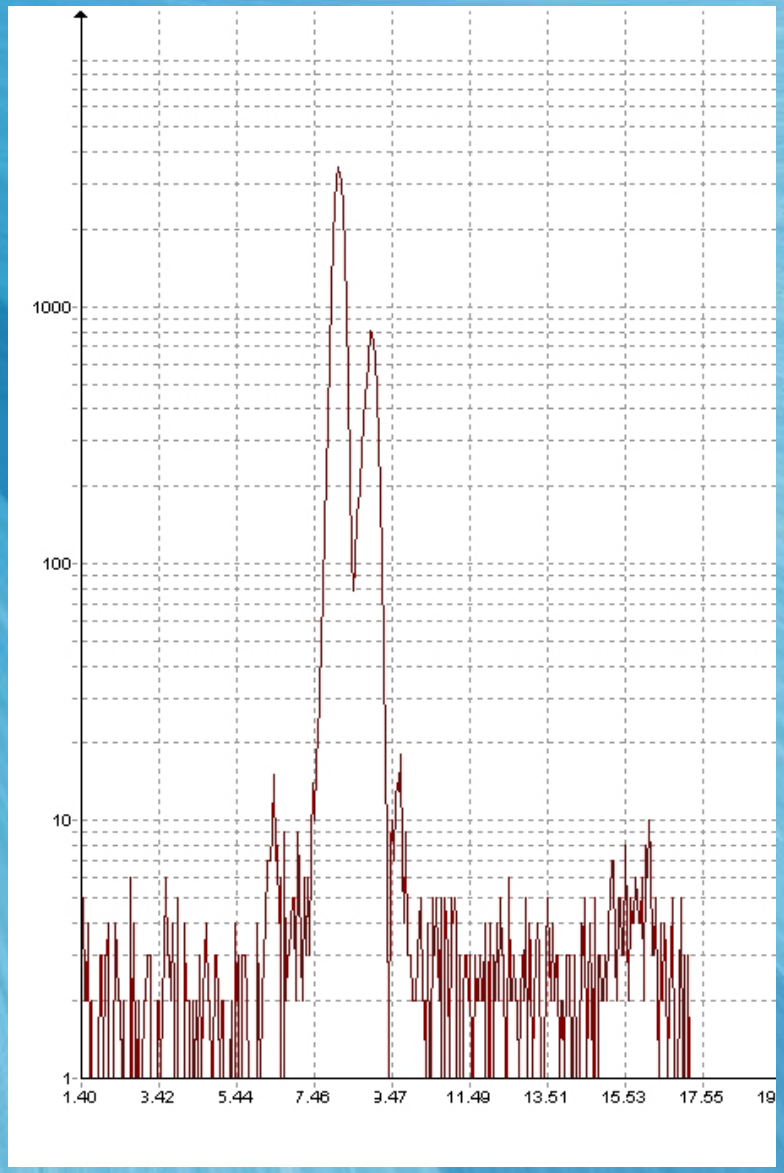
Picture: http://www.webdesign.org/img_articles/239/step_5.jpg

PIXE

- Three different pennies

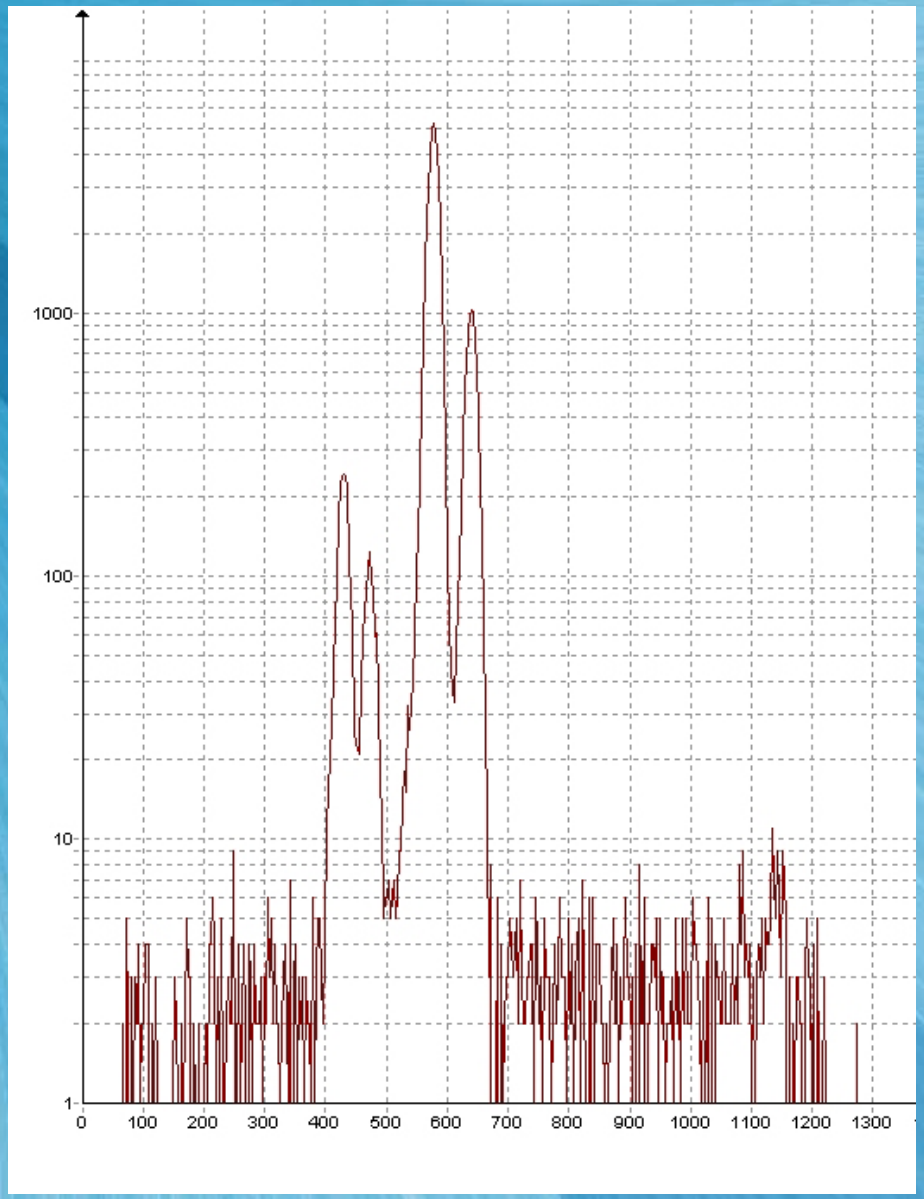
Penny One: 1941

- Mainly composed of copper
- Also found zinc



Penny Two: 1943

- Steel penny: had mostly iron and zinc
- Reason for this change: the copper was needed for the war effort



Penny Three: 2007

- Composed of mainly zinc (the core)
- Copper coating
- Reason for this change: rising cost of copper