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Neutron Scatter Camera: Calibrations and Gain Measurement

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Abstract

A neutron scatter camera aids in the detection of special nuclear material. Neutrons are useful in this detection because they are highly penetrating. The student performed research in the area of gain calibrations, in relation to the camera. Through basic calibrations, the energy spectrum can be viewed, which, in the end, allows for the reconstruction of the initial neutron's energy and direction. Namely, energy responses were calibrated from the detector elements, and then how various adverse conditions such as temperature changes, different orientations, and electronic drifts would affect the detector gains was measured.

The Camera

- Calculates direction and energy of neutron, thereby has the ability to detect the location and energy of a special nuclear material source
- Uses a liquid scintillator
- 7 PMT's (photomultipliers, or light detectors)
  - 4 with 2 inch diameters
  - 4 with 5 inch diameters
  - 3 with 2 inch diameters are separate and act as control

Gain Calibration

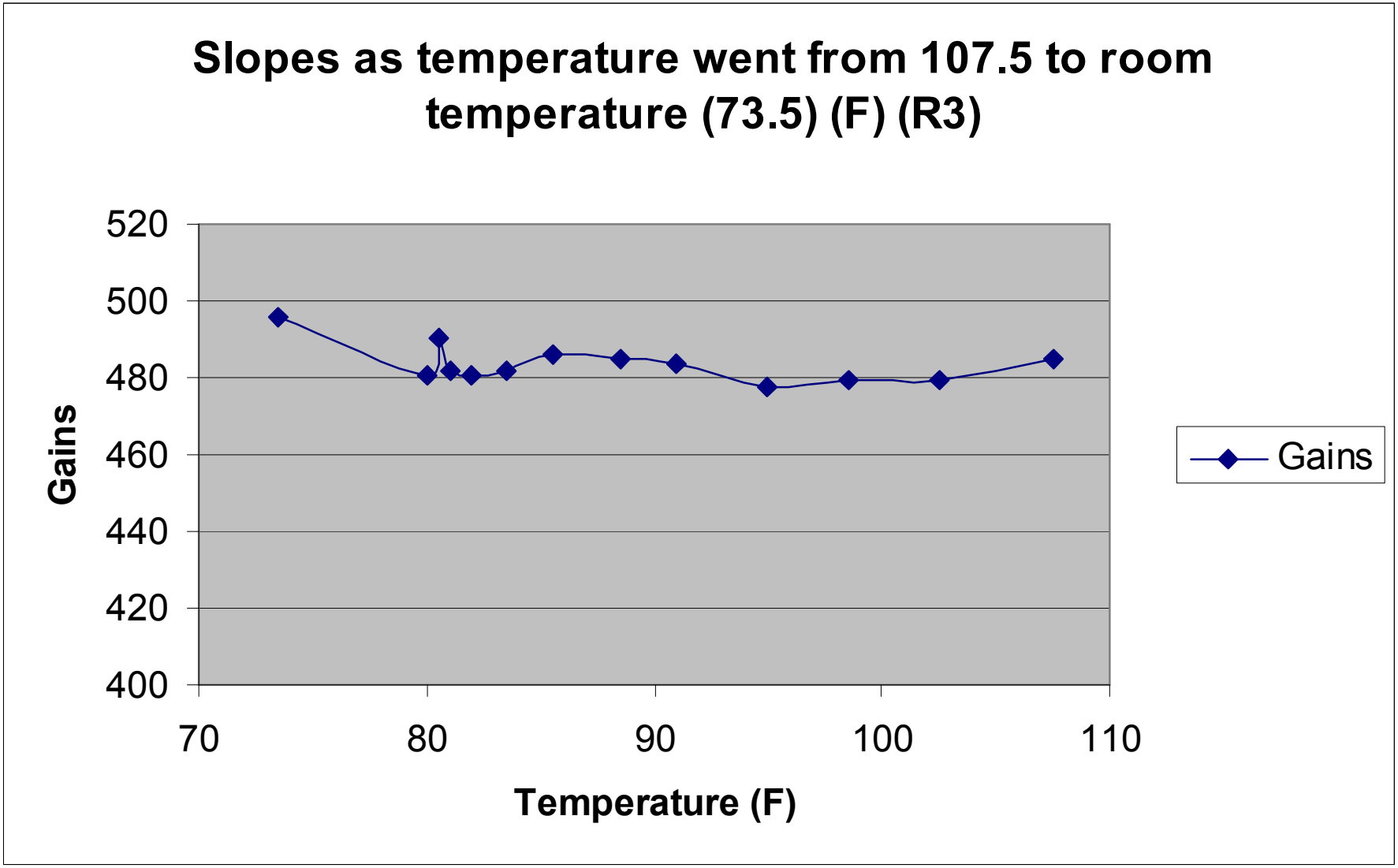
- Allow for the viewing of the energy spectrum of the source
- All gain calibrations were done with a Na22 source (gamma source)
- The histogram received from the calibration gives information regarding the energy of the gammas emitted by the Na22

Particle Path

GAMMA RAYS → ELECTRONS → PHOTONS → ELECTRONS → OUTPUT

- Gamma rays scatter off electrons
- Electrons get converted into photons via the scintillator
  - the scintillating energy of the electron is the same as the proton, therefore, this calibration offers information regarding the neutron source as well
  - Information about the scattered proton allows us to reconstruct the situation and find the direction and energy of the neutron
- PMT converts photons into electrons
- Output of flow of electrons

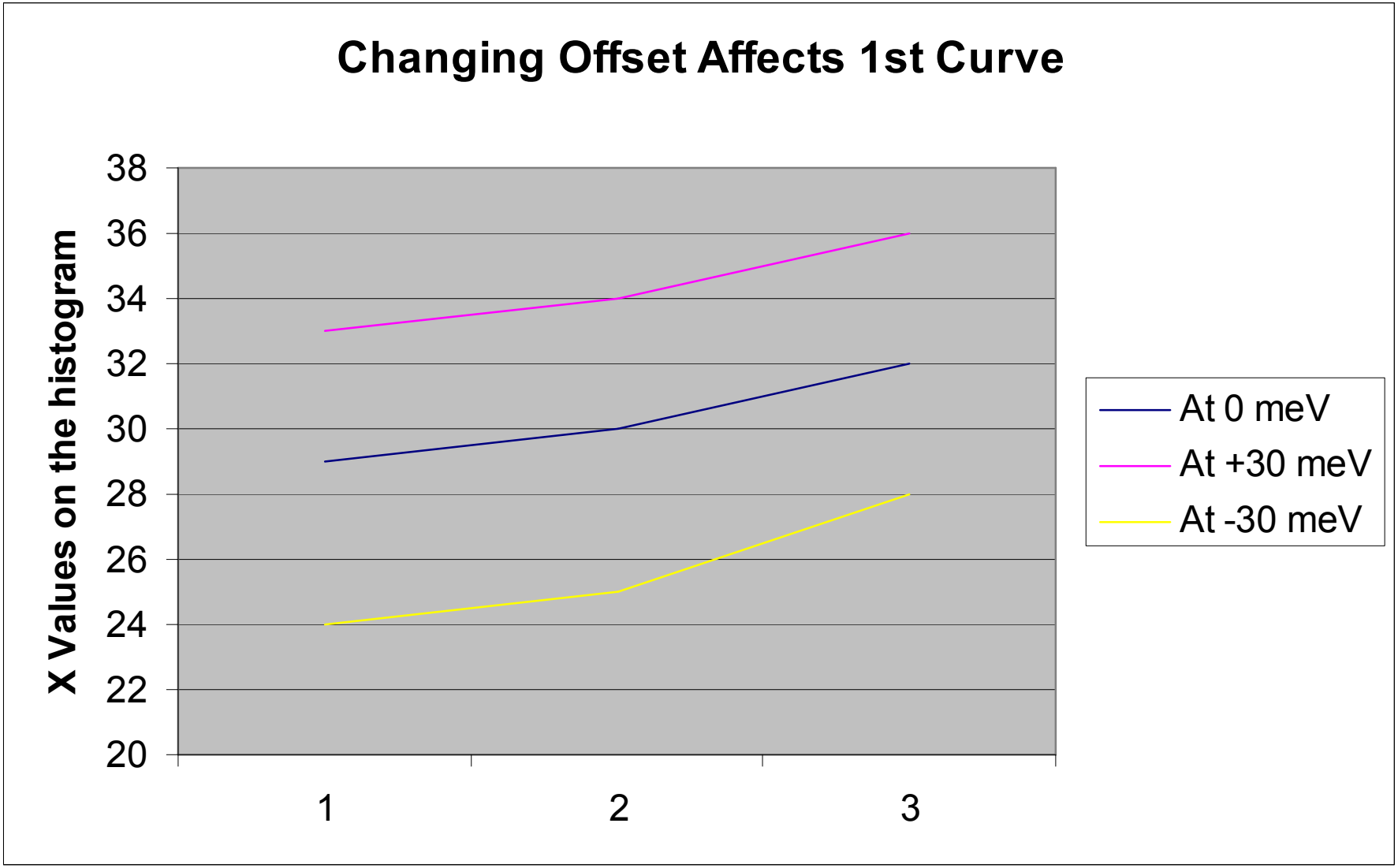
Temperature Tests

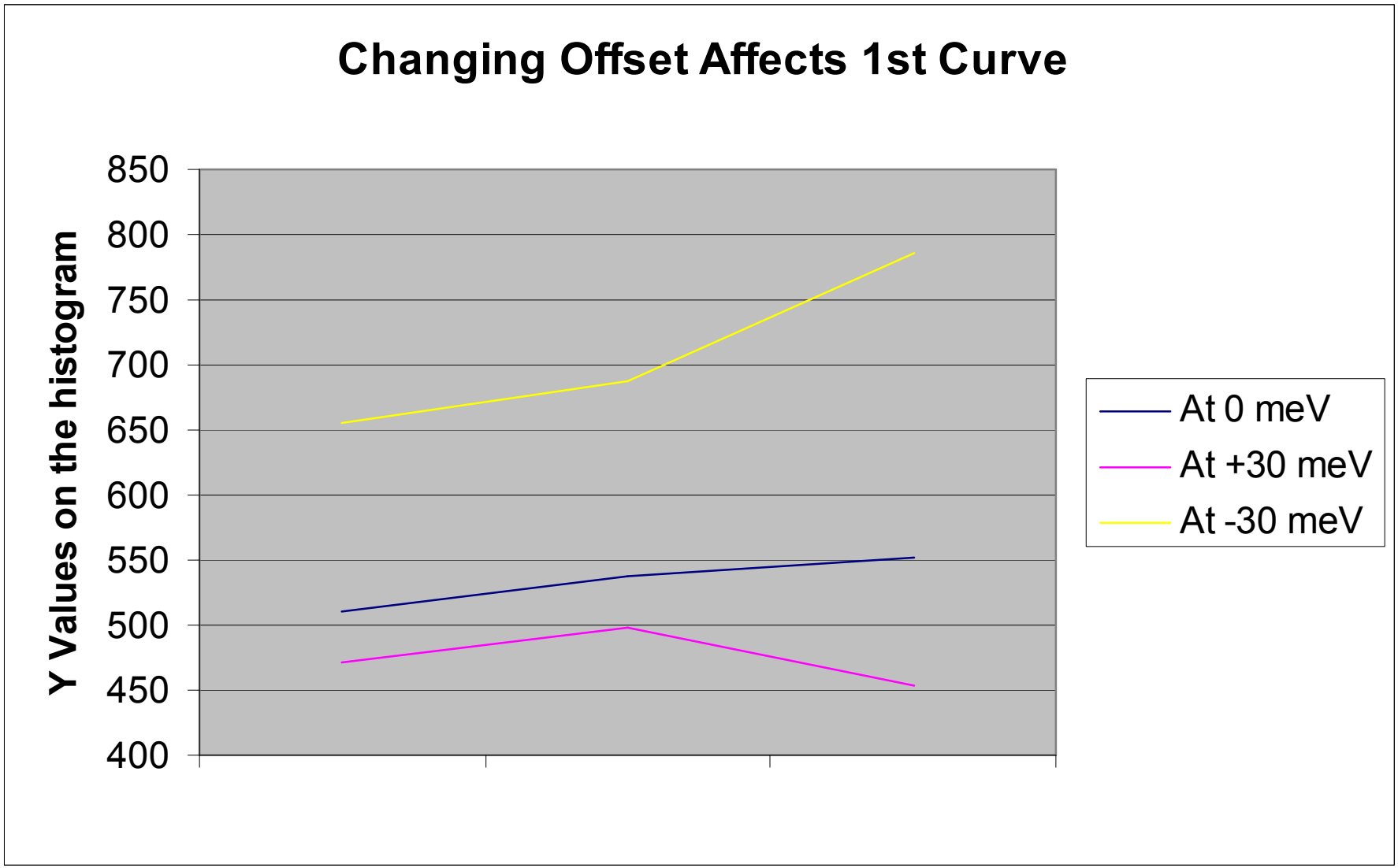


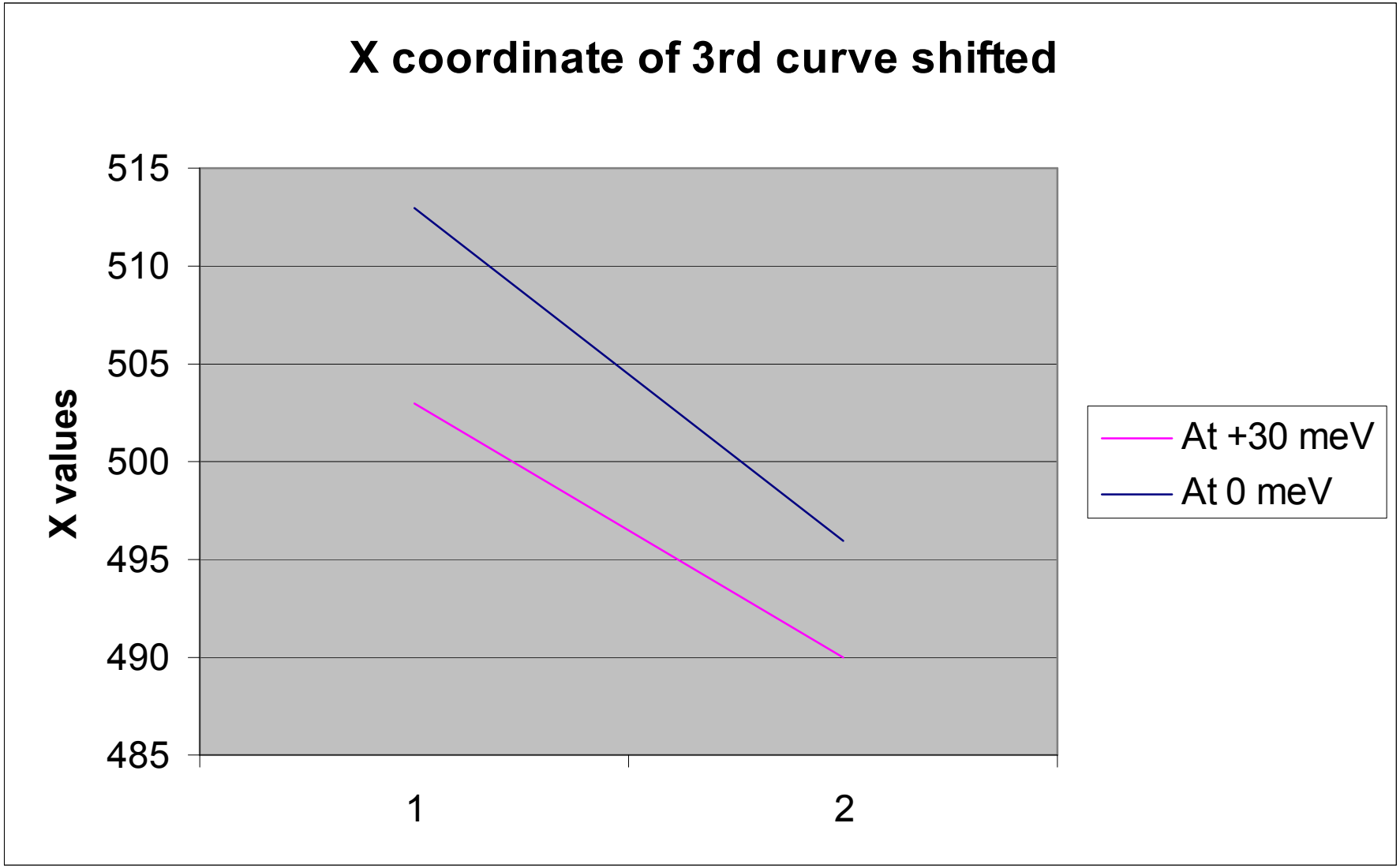
Temperature Conclusions

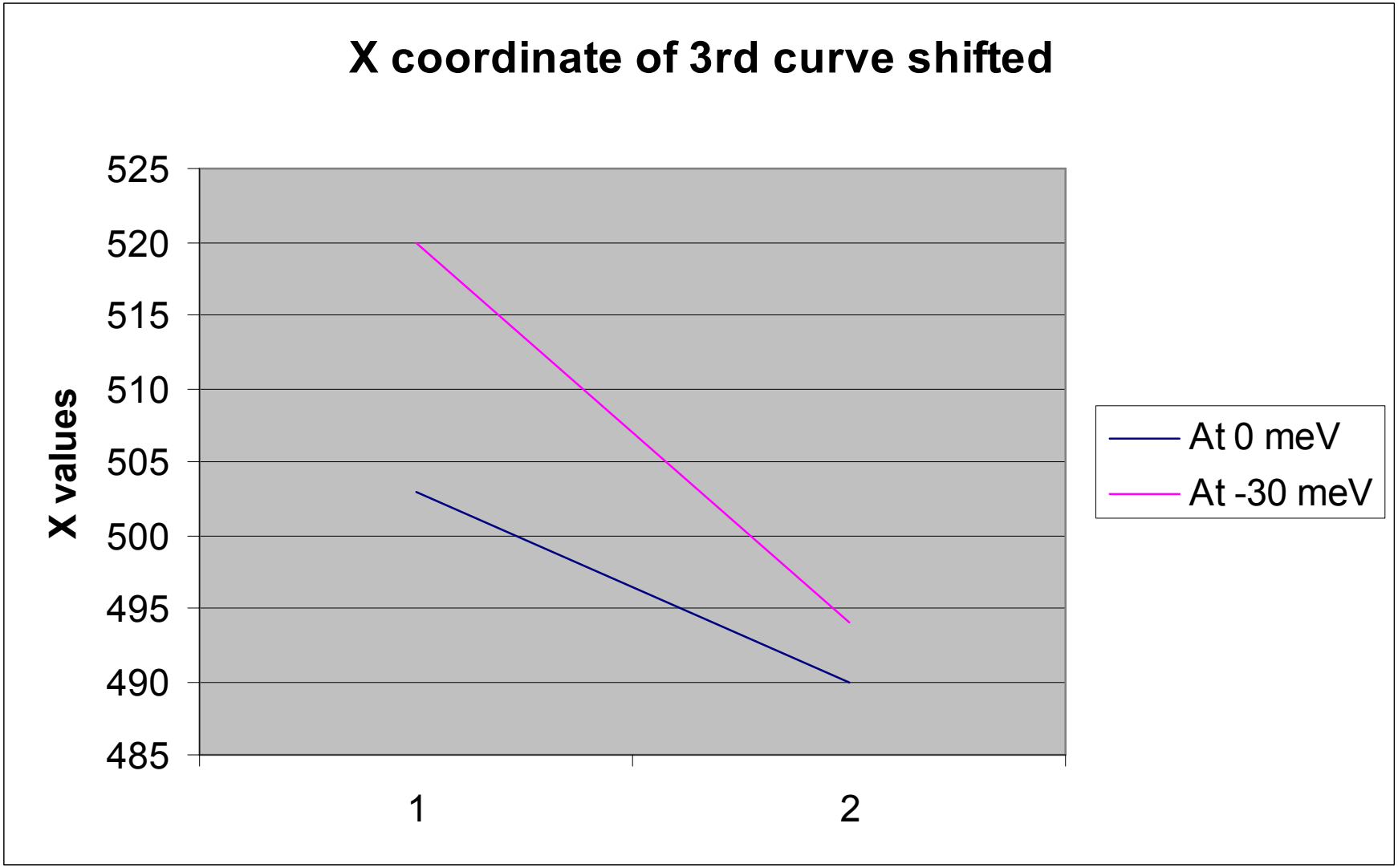
- Cell was heated to 107.5 degrees F, and gains were measured at small increments until it cooled down back to 73.5 degrees F
- Gains were barely affected by temperature changes.

Electron Drift Effects

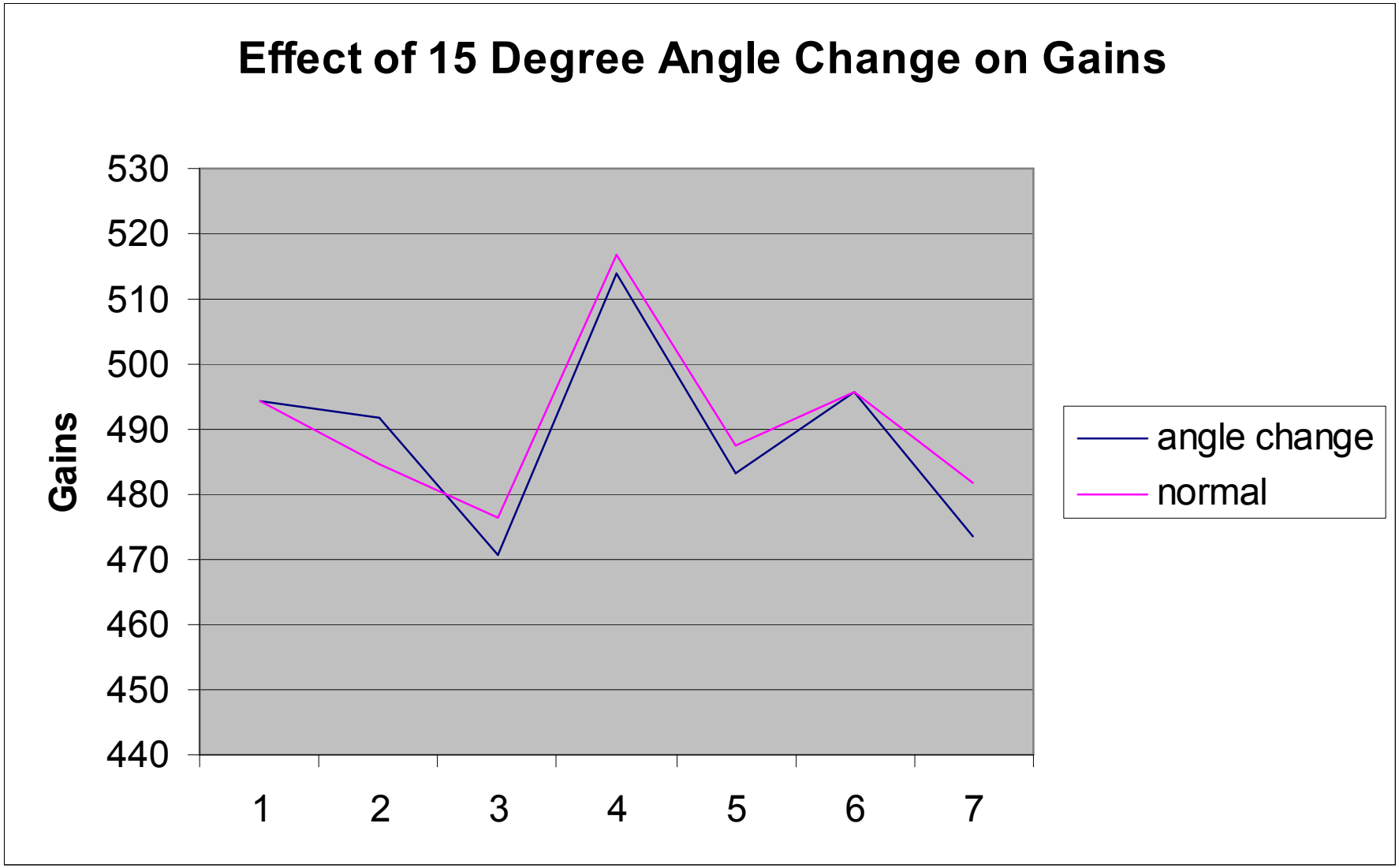



Changing Offset Affects 1st Curve
Y Values on the histogram
850
800
750
700
650
600
550
500
450
400
At 0 meV
At +30 meV
At -30 meV


X coordinate of 3rd curve shifted
X values
515
510
505
500
495
490
485
1
2
At +30 meV
At 0 meV


X coordinate of 3rd curve shifted
X values
525
520
515
510
505
500
495
490
485
1
2
At 0 meV
At -30 meV

Angle Changes



Results

- Changing the temperature does effect the gain
- The electronic drifting, or changing of offsets does effect the gain
- Change in temperature does not effect the gain
- …