PQB

Photocathode Analyzing Power Study

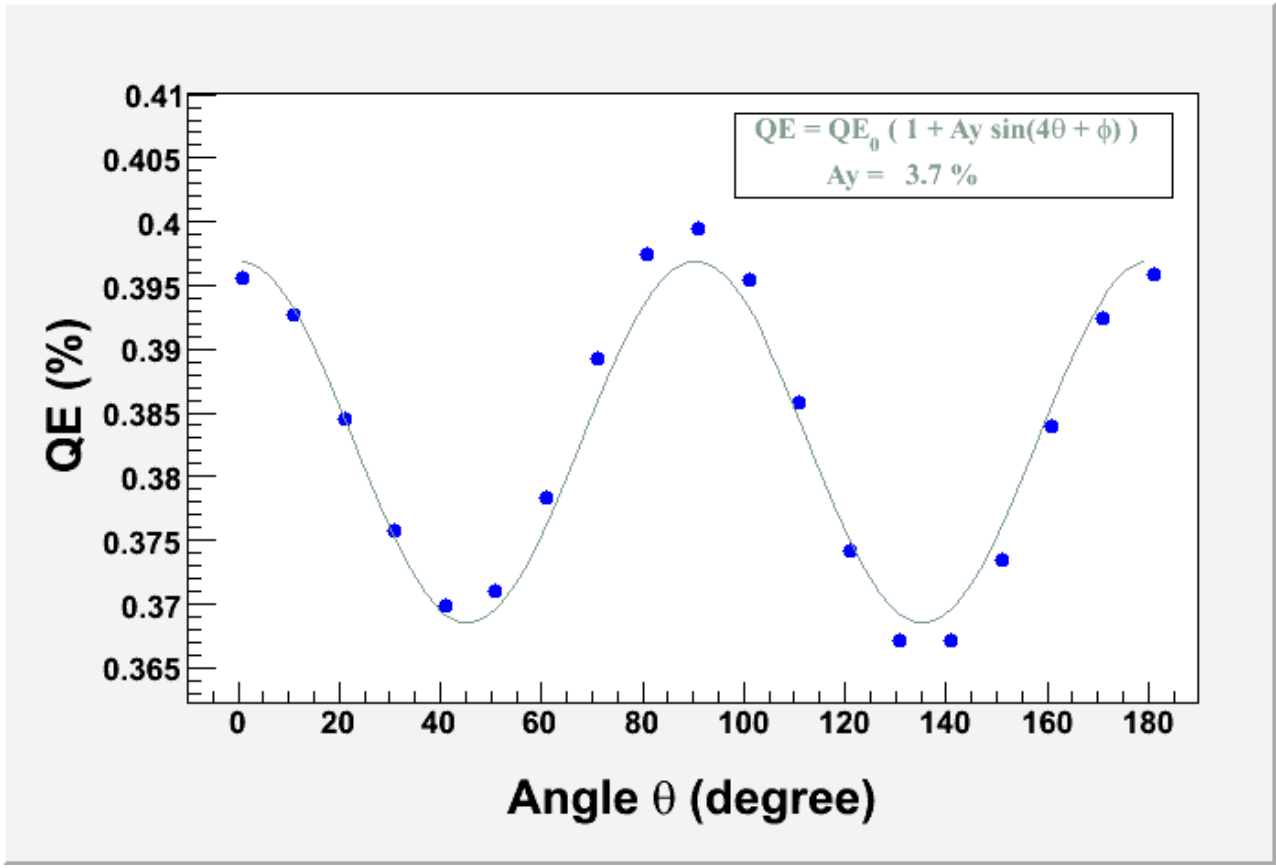
May 19, 2009

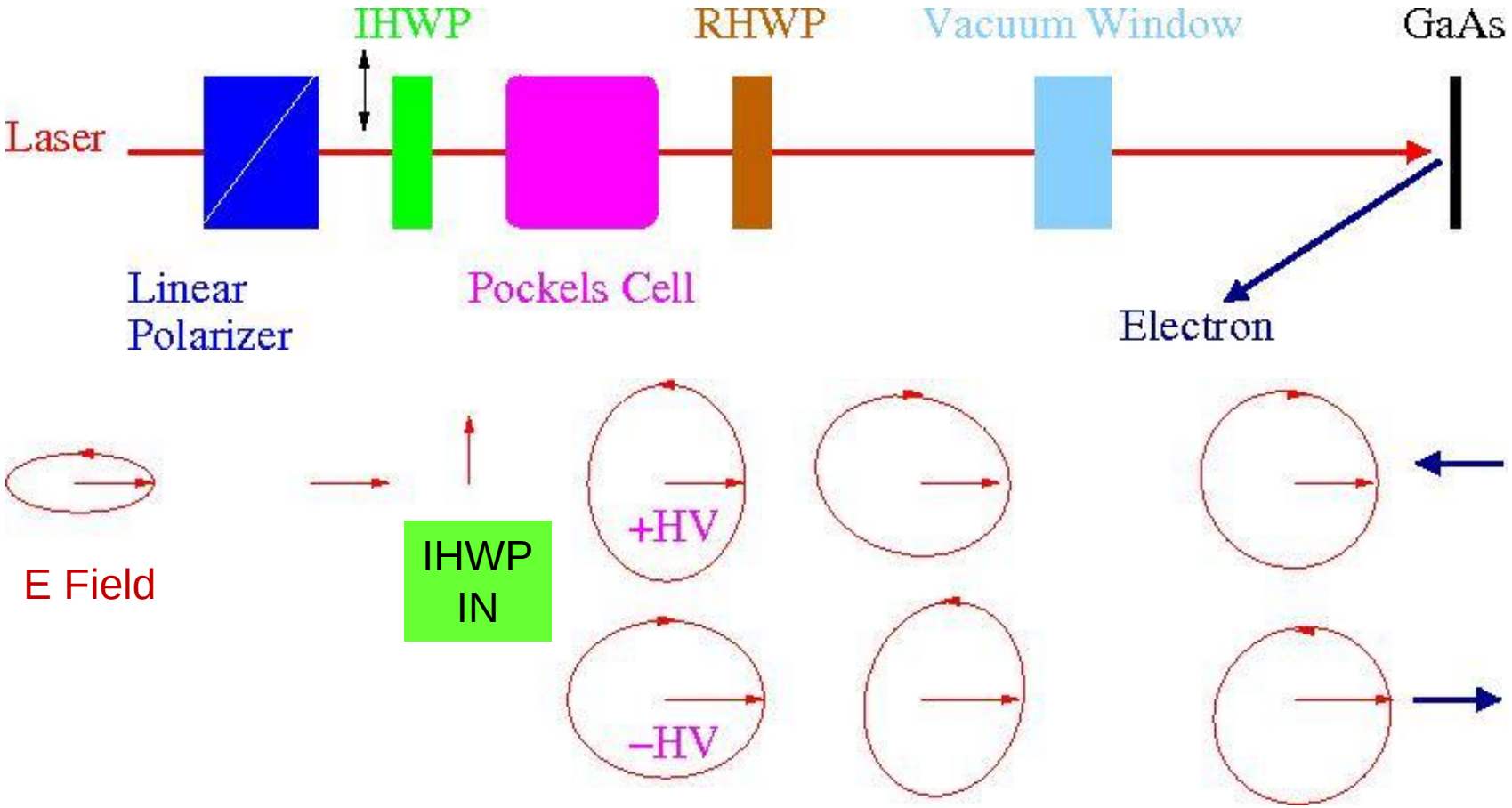
GaAs Analyzing Power

- The GaAs crystal has preferred axis for absorption of linearly polarized light, Linear Dichroism (LD): difference in absorption of light polarized parallel and perpendicular to an orientation axis (Phys. Lett. A **212**, 231 (1996))

- *Circular Dichroism (CD):* difference in absorption of left- and right-handed circularly polarized light. CD is zero for GaAs.

- Measure the super-lattice photo-cathode analyzing power (QE anisotropy), turn off Pockels Cell (PC) and do a Rotatable Half Wave Plate angle (θ) scan:

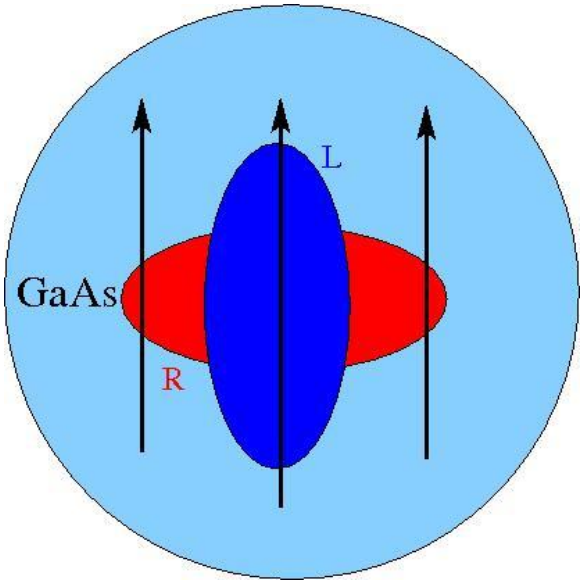


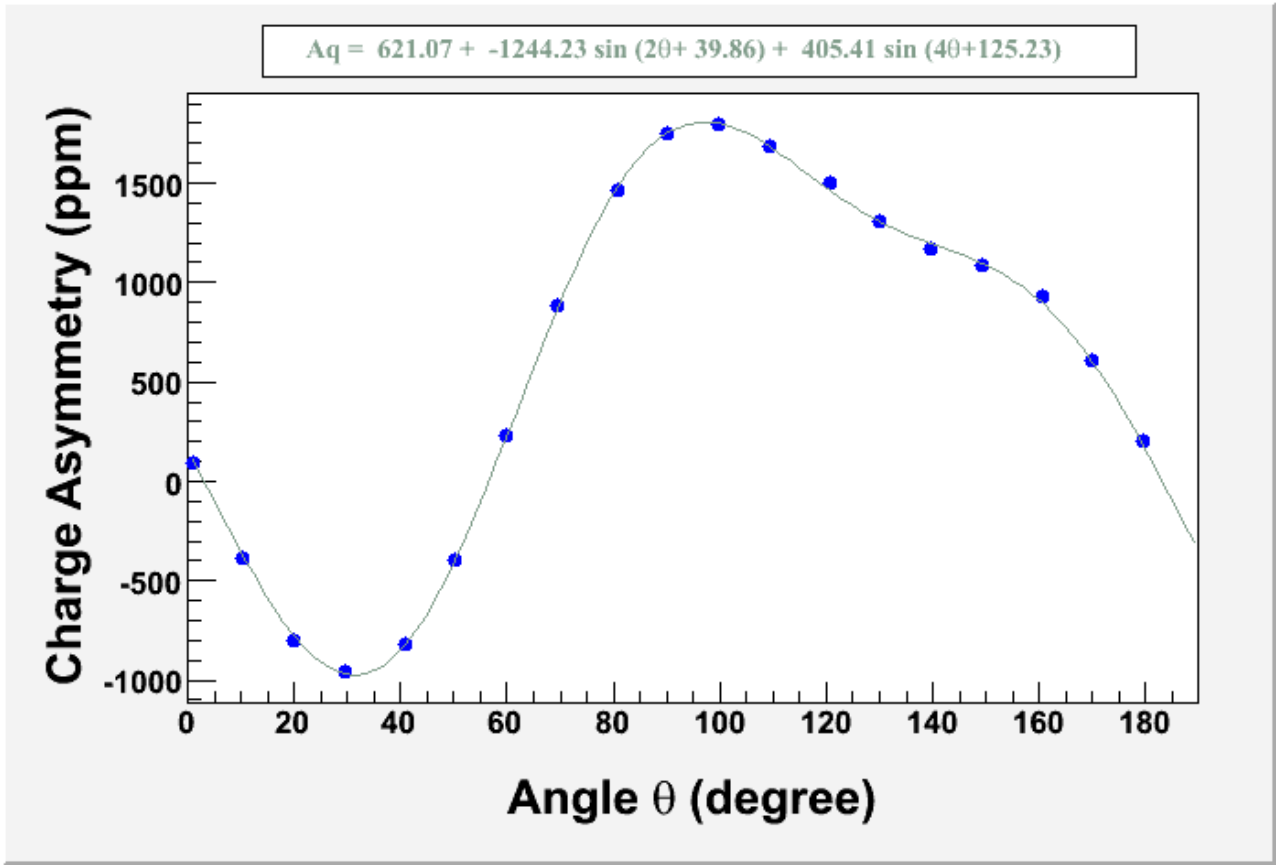

IHWP
RHWP
Vacuum Window
GaAs
Laser
Linear Polarizer
Pockels Cell
Electron
E Field
IHWP IN
+HV
–HV
E Field
IHWP OUT
–HV
+HV

Not Perfect Circular Polarization?

- Residual linear polarization causes charge asymmetry when coupled to photocathode analyzing power

- Measure the charge asymmetry (turn on Pockels Cell and do a RHWP scan)





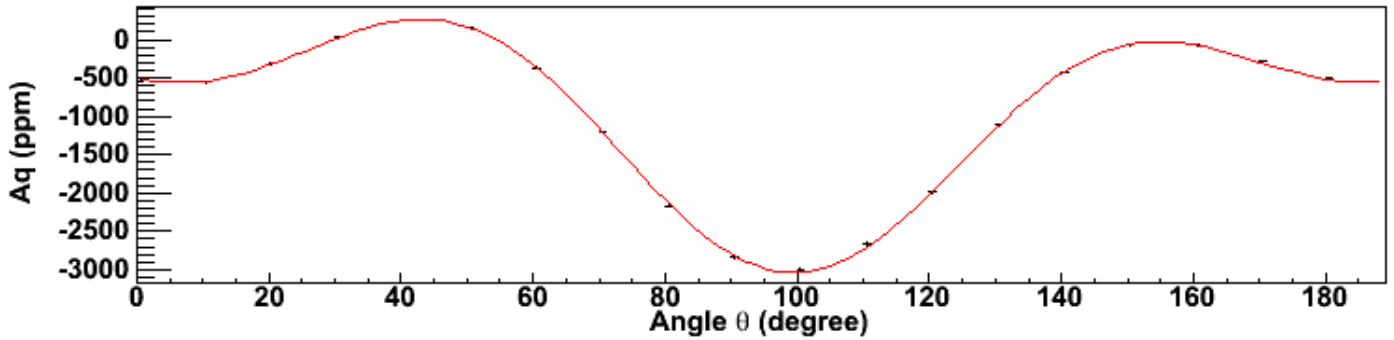
RHWP Scans

$$A_q = A_y\left[c_0 + c_1 \sin(2\theta + \phi_1) + c_2 \sin(4\theta + \phi_2)\right]$$

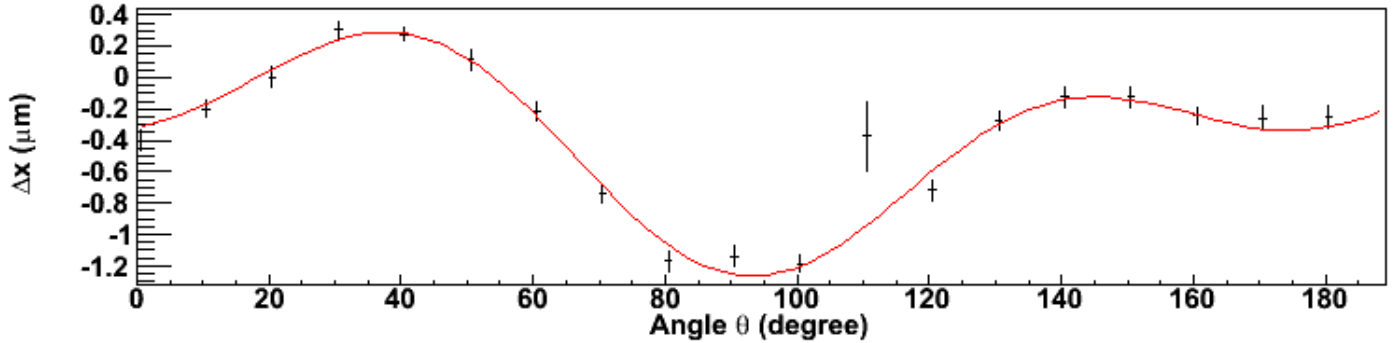
Term	Caused by
c_0	Vacuum Window Phase Shift
c_1	RHWP Phase Shift
c_2	Pockels Cell Residual Phase Shift & Imperfect Initial Linear Polarization

- Did RHWP Scans with:
  - I. Insertable Half-Wave Plate: IHWP IN or IHWP OUT
  - II. Insertable Linear Polarizer: ILP IN or ILP OUT
    - I. ILP OUT: Spot 900/900
    - II. ILP IN: Spot 850/800, to run from same spot as OUT; ILP moved the beam by about 2 mm
  - III. Pockels Cell HV set for maximum circular polarization (PITA = 0 V) or set for elliptical polarization (PITA = -120 V)

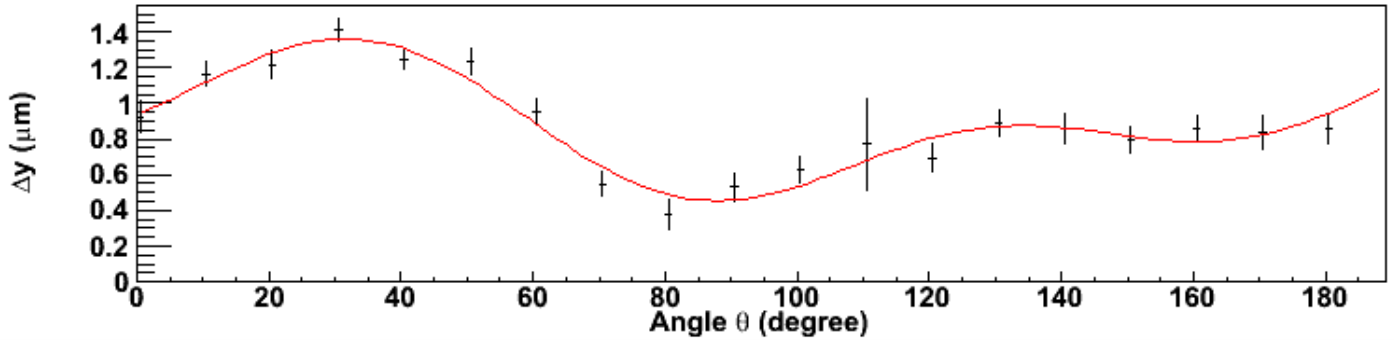
Run 689, PITA = 0, IHWP OUT, ILP OUT, QWK_1I02



Aq = -952.43 + 1252.02 sin (2θ+ 65.86) + -841.07 sin (4θ+ 66.39)

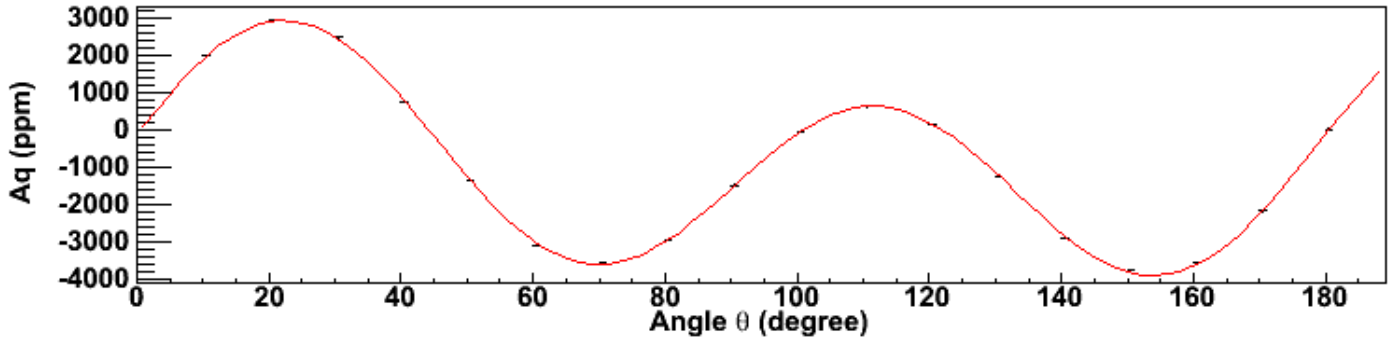


Δx = -0.39 + 0.52 sin (2θ+ 64.99) + -0.40 sin (4θ+ 89.46)

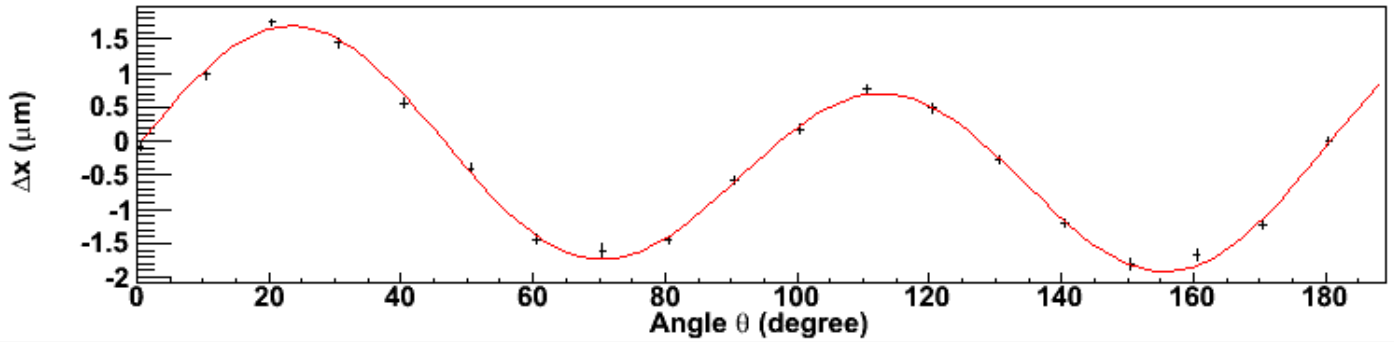


Δy = 0.88 + 0.30 sin (2θ+ 52.80) + -0.22 sin (4θ+ 125.73)

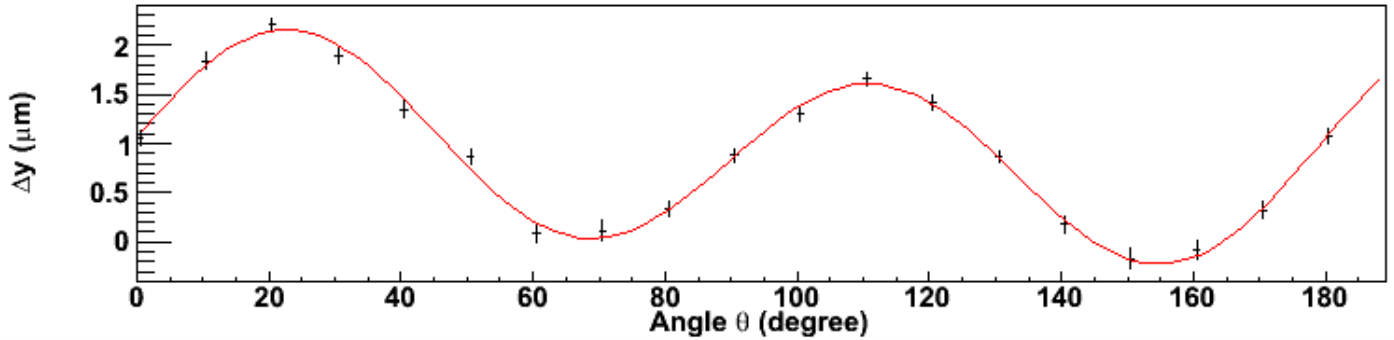
Run 690, PITA = -120, IHWP OUT, ILP OUT, QWK_1I02



$Aq = -938.92 + 1160.79 \sin(2\theta + 38.98) + 2740.88 \sin(4\theta + 12.66)$

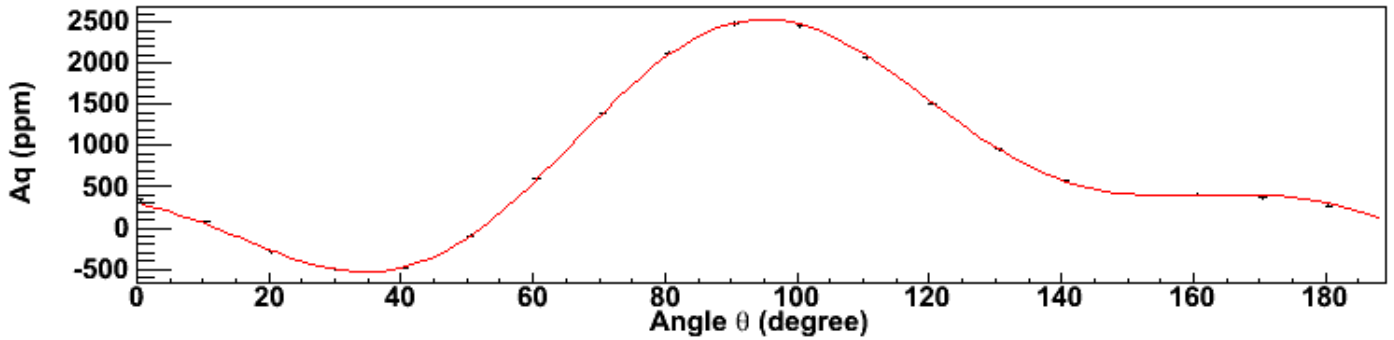


$\Delta x = -0.30 + 0.50 \sin(2\theta + 33.64) + -1.50 \sin(4\theta + 177.87)$

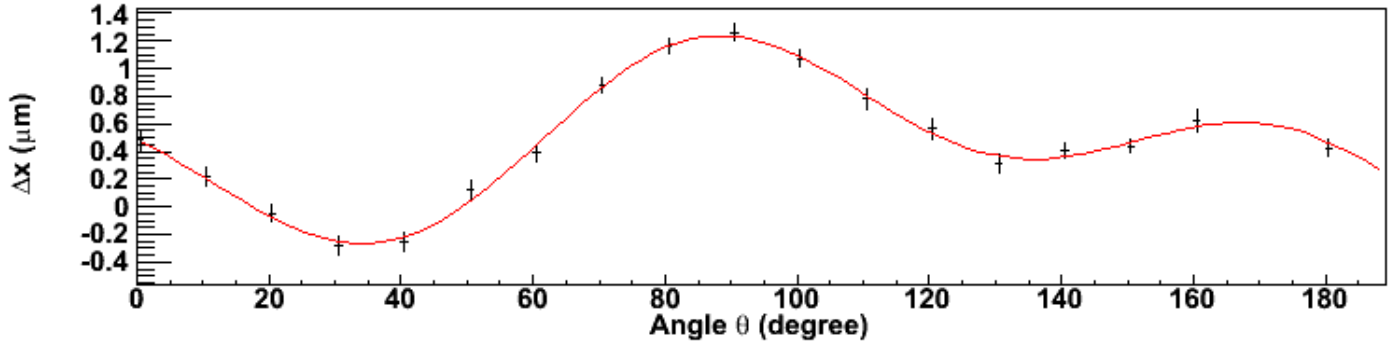


$\Delta y = 0.90 + 0.30 \sin(2\theta + 21.32) + 0.98 \sin(4\theta + 3.05)$

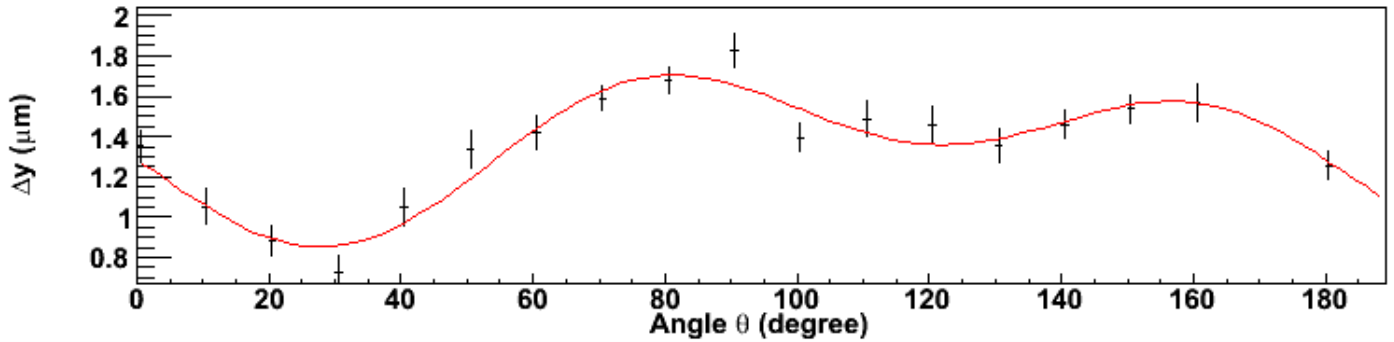
Run 691, PITA = 0, IHWP IN, ILP OUT, QWK_1I02



Aq = 799.62 + -1220.48 sin (2θ+ 63.16) + 595.06 sin (4θ+ 97.69)

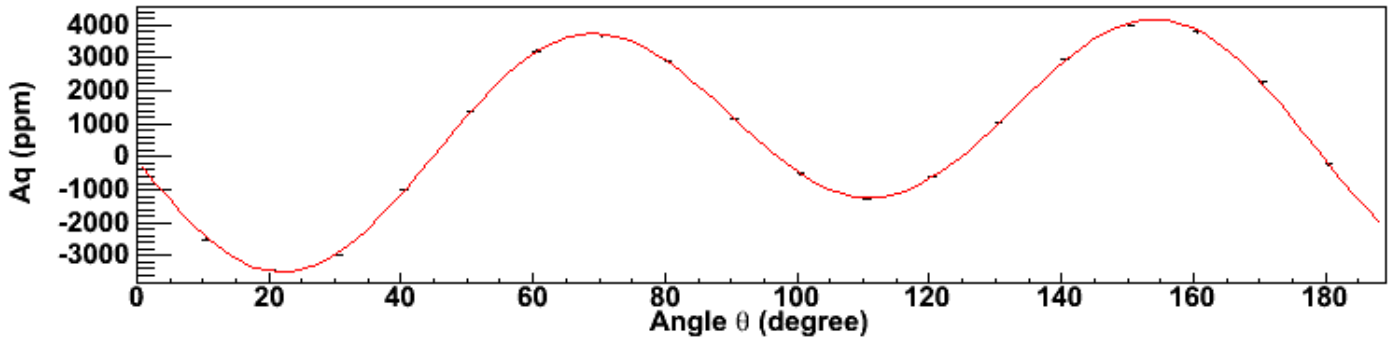


Δx = 0.48 + -0.45 sin (2θ+ 57.87) + 0.41 sin (4θ+ 114.58)

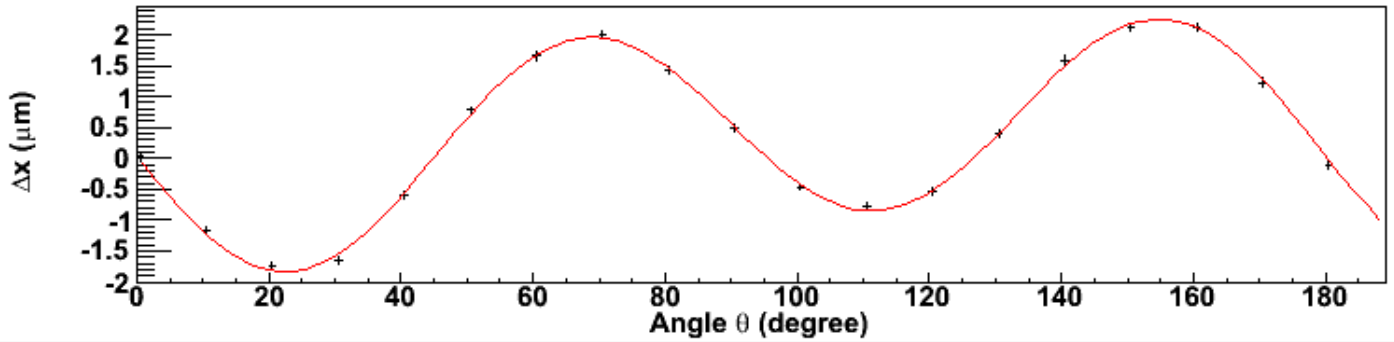


Δy = 1.36 + -0.26 sin (2θ+ 46.04) + 0.25 sin (4θ+ 152.48)

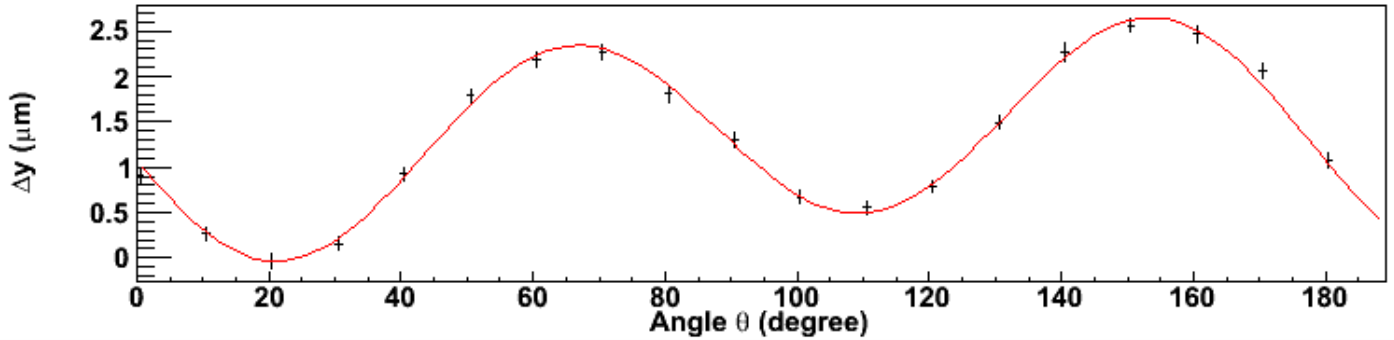
Run 692, PITA = -120, IHWP IN, ILP OUT, QWK_1I02



Aq = 776.38 + -1145.43 sin (2θ+ 36.03) + -3131.25 sin (4θ+ 13.94)

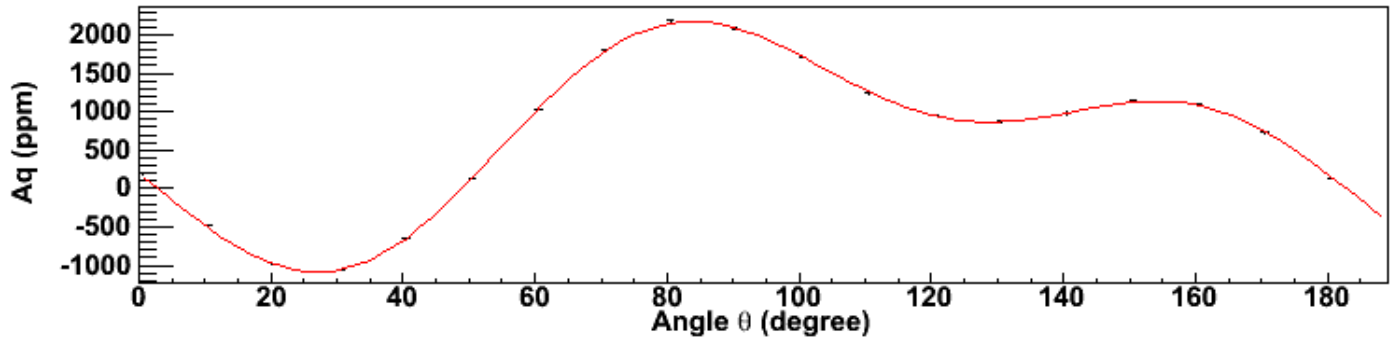


Δx = 0.38 + -0.51 sin (2θ+ 29.90) + -1.71 sin (4θ+ 2.77)

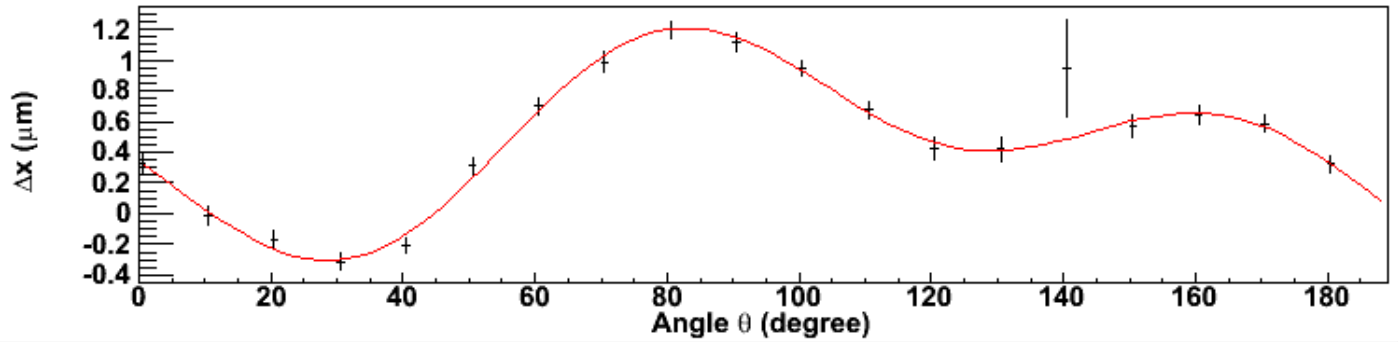


Δy = 1.36 + -0.30 sin (2θ+ 19.77) + -1.13 sin (4θ+ 9.48)

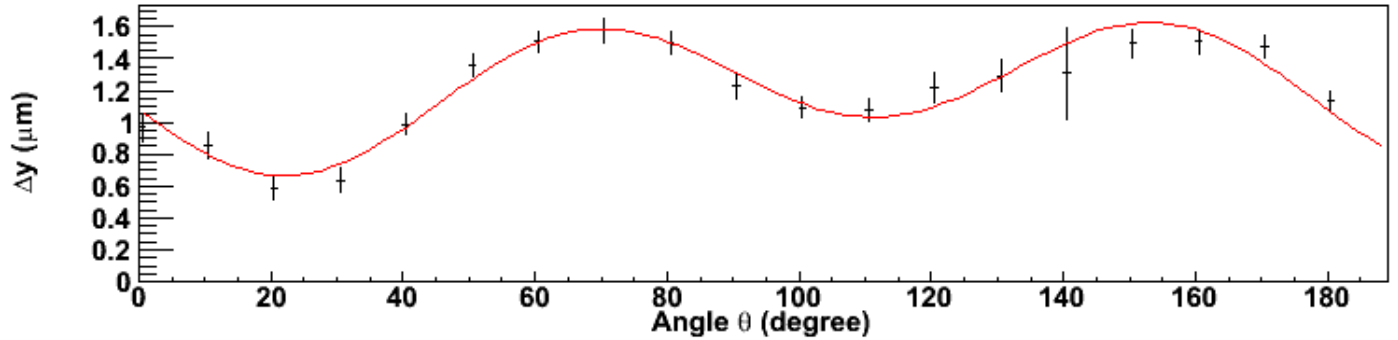
Run 693, PITA = 0, IHWP IN, ILP IN, QWK_1I02



Aq = 716.63 + -1135.11 sin (2θ+ 57.07) + 771.17 sin (4θ+ 156.63)

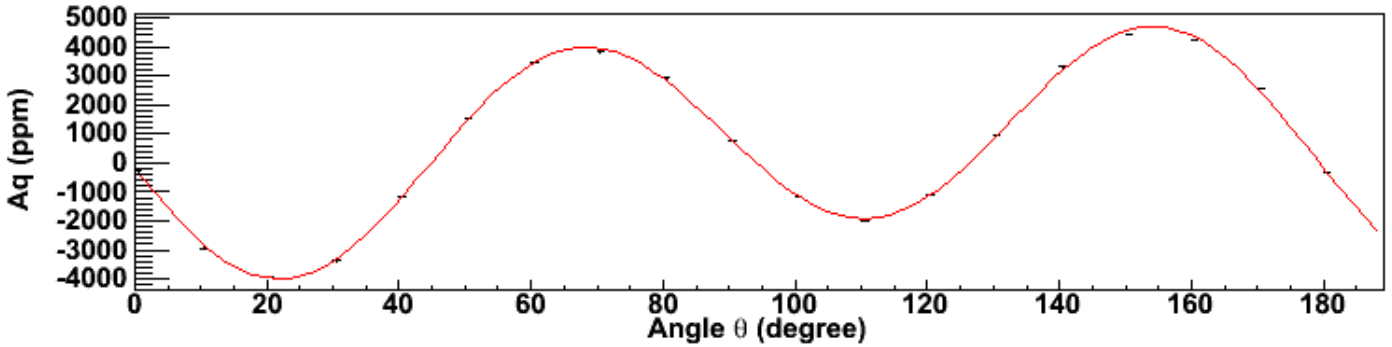


Δx = 0.48 + -0.46 sin (2θ+ 62.91) + 0.41 sin (4θ+ 139.95)

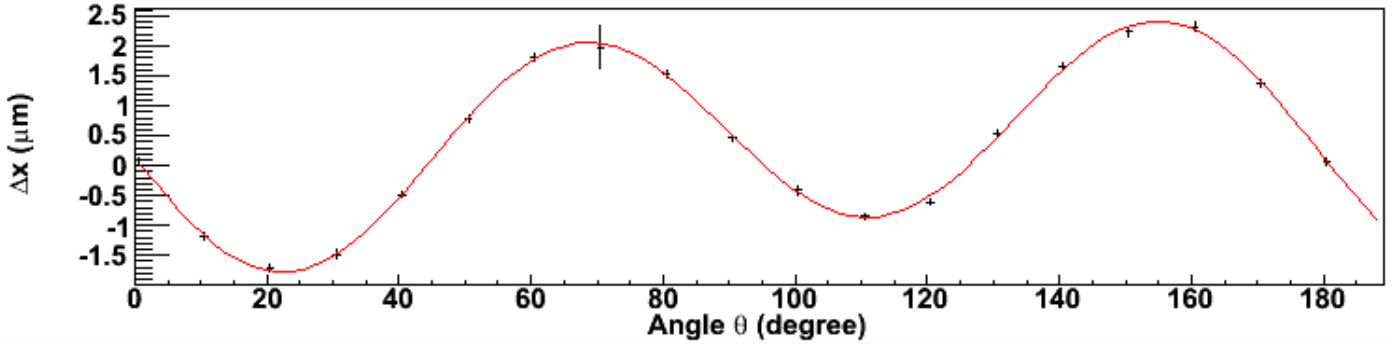


Δy = 1.22 + -0.18 sin (2θ+ 40.38) + -0.37 sin (4θ+ 3.60)

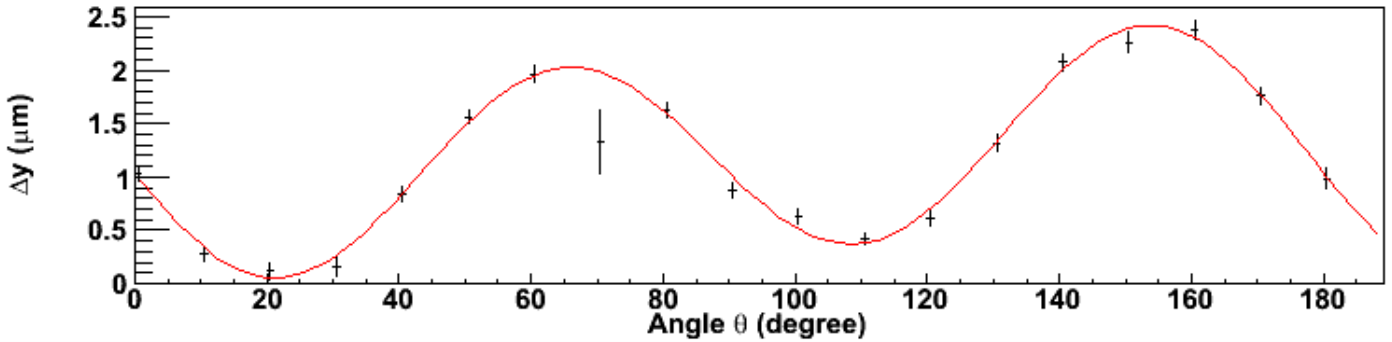
Run 694, PITA = -120, IHWP IN, ILP IN, QWK_1I02



Aq = 685.19 + -1101.51 sin (2θ+ 28.65) + -3632.83 sin (4θ+ 15.45)

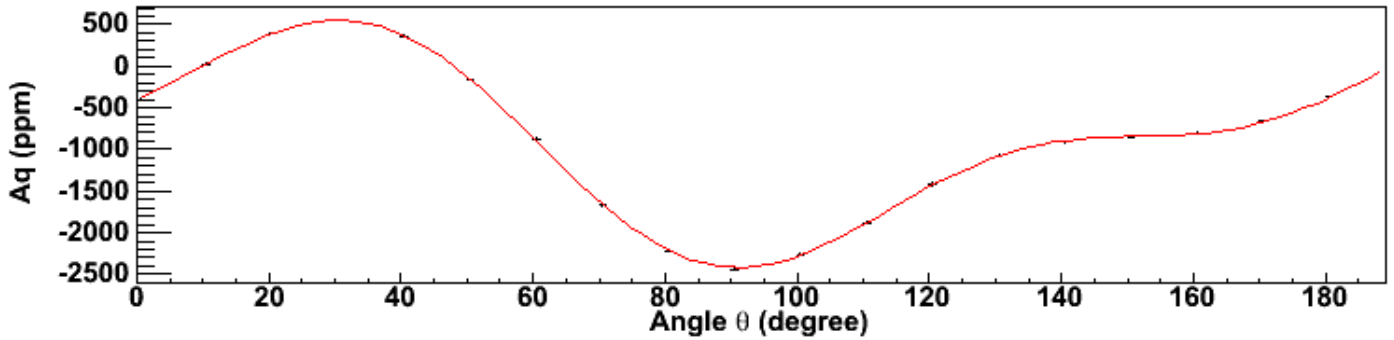


Δx = 0.45 + -0.49 sin (2θ+ 25.19) + -1.77 sin (4θ+ 3.38)

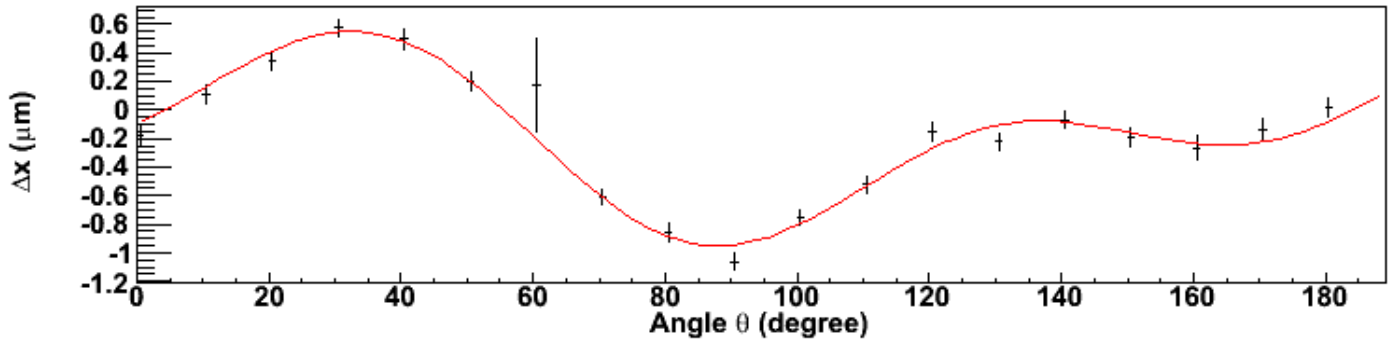


Δy = 1.22 + 0.25 sin (2θ+ 179.31) + -1.00 sin (4θ+ 10.56)

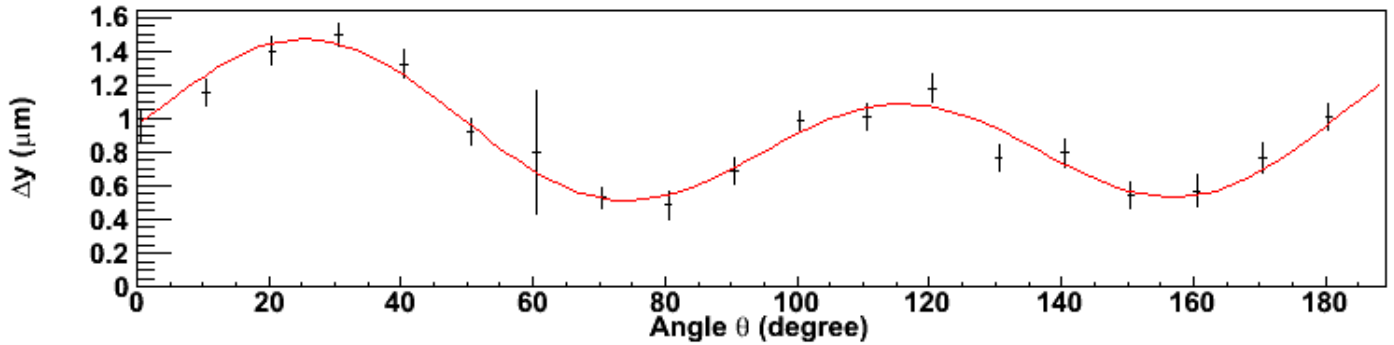
Run 695, PITA = 0, IHWP OUT, ILP IN, QWK_1I02



Aq = -902.07 + 1159.96 sin (2θ+ 60.47) + -552.36 sin (4θ+ 125.06)

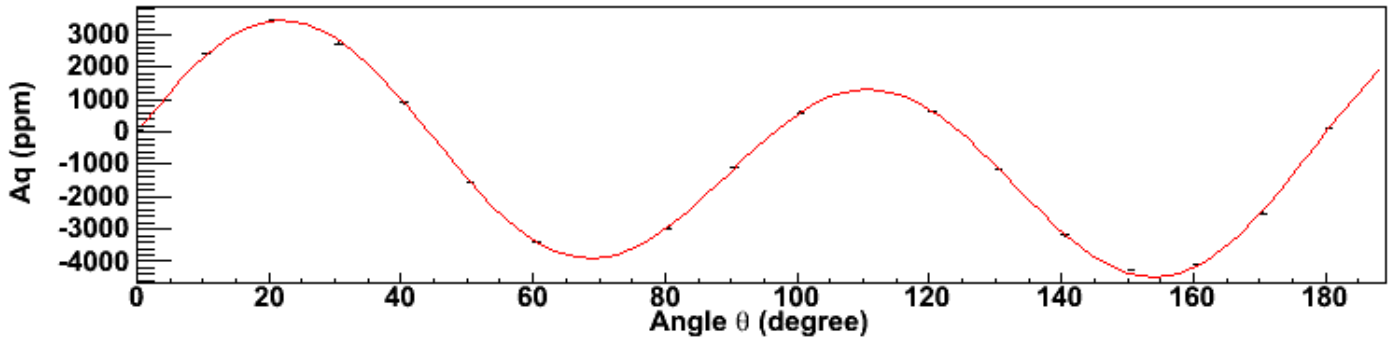


Δx = -0.18 + 0.48 sin (2θ+ 61.78) + -0.38 sin (4θ+ 117.80)

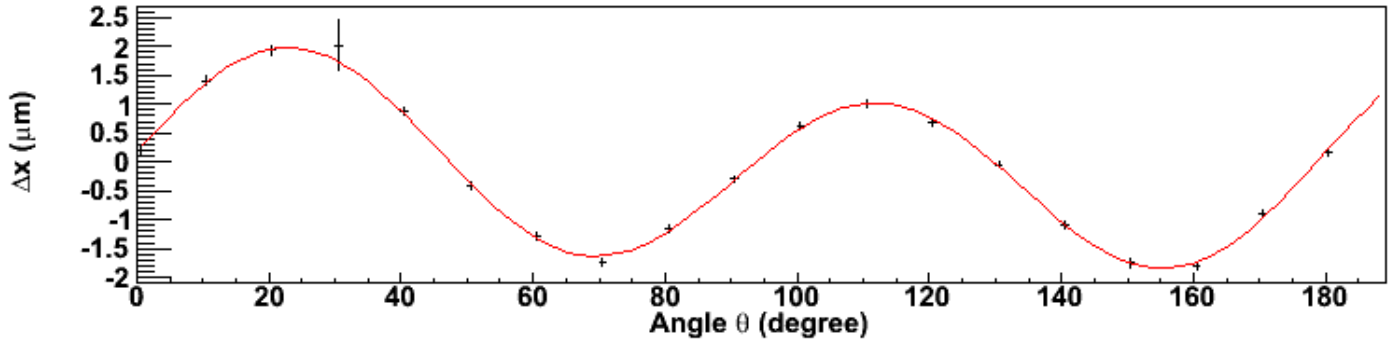


Δy = 0.91 + 0.19 sin (2θ+ 41.58) + -0.37 sin (4θ+ 167.70)

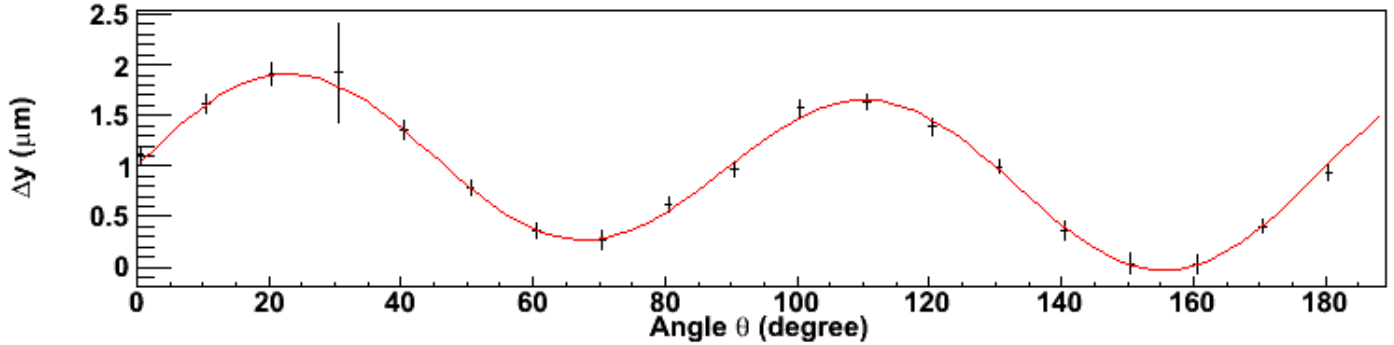
Run 696, PITA = -120, IHWP OUT, ILP IN, QWK_1I02



$Aq = -881.34 + 1104.97 \sin(2\theta + 32.29) + 3267.84 \sin(4\theta + 14.76)$



$\Delta x = -0.11 + 0.49 \sin(2\theta + 32.79) + 1.61 \sin(4\theta + 0.68)$



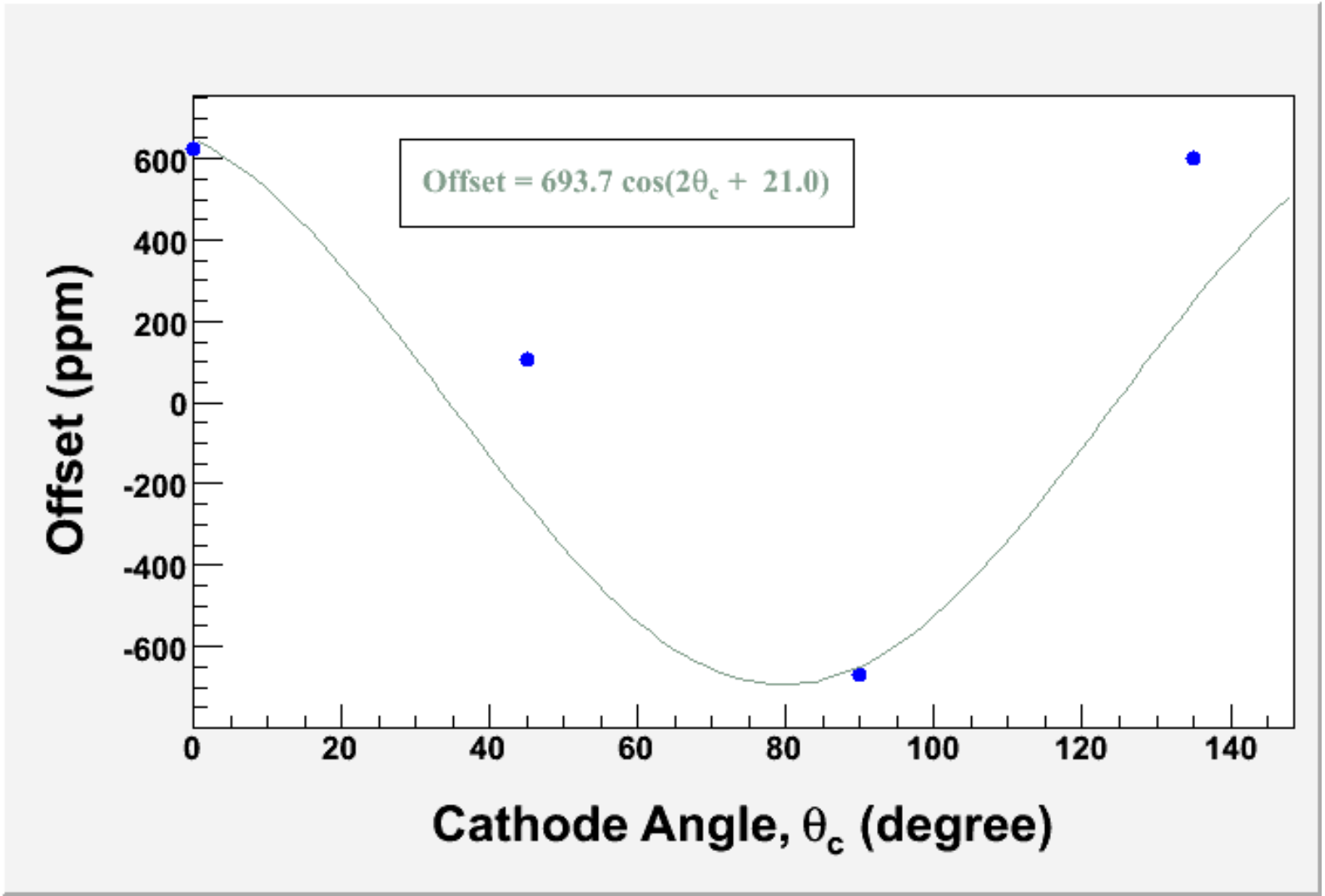
$\Delta y = 0.95 + -0.20 \sin(2\theta + 177.41) + 0.83 \sin(4\theta + 3.75)$

Summary of RHWP Scans

- IHHWP IN → IHWP OUT: $A_q \rightarrow -A_q$
  - IHWP does not cancel helicity correlated effects caused by residual linear polarization
- ILP has small effect
  - The initial polarization is highly linear
  - Because of the way the three laser beams are combined, ILP can only be used during beam studies
- How to zero charge asymmetry?
  - Use c_2 to compensate for offset term or
  - Zero offset term by rotating photocathode

Photocathode Rotation

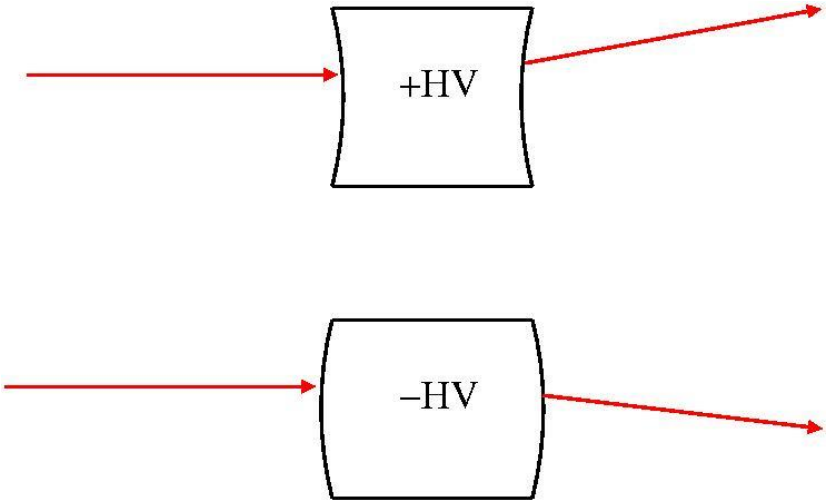
- Measure Offset term (c_0) as a function of photocathode angle (θ_c)
- Choose angle where Offset is zero



Why use IHWP?

- IHWP cancels helicity-correlated changes due to:

1. Position differences caused by Pockels Cell steering
   - PC alternately pulsed to +HV and -HV to change from right to left circularly polarized light and vice-versa
   - PC behaves alternately as converging and diverging lens
   - If beam is off-center, it can be steered
   - Induces helicity-correlated position differences



2. Electronic cross talk