Study of Beam Offset on Xft Performance

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Abstract

This note describes a series of tests, done to assess the performance of the xft tracking system when a shift in the beam position occurs. This was done by examining oscillation in the ΔCurve Vs. $\Delta\phi$. This oscillation is then fit to a sine curve, and it's amplitude is the watermark through which we compare the dependence of a certain position to another. The results are now being used to create a grid of possible FPGA firmware (linker) so that shifts in the beam position can be adjusted to in a matter of minutes as opposed to a matter of days.

1 Introduction

The XFT Linker Roads have an implicit beam constraint; this means that in the process of fitting circles to the roads to find the curvature of the path, one of the points that the system assumes is on the circle is the beam spot (see figure 1). The default value for the beam spot is (0,0) but has been shifted to accommodate a shift in the beams position (we are currently operating at a radius of 5.1mm and a ϕ shift of 105^o). The XFT hardware can adapt to a shifted beam spot, but it requires a change in the FPGA firmware. The purpose of this study was to determine how close the assumed XFT beam position needs to be to the correct position before performance degrades significantly. This in turn will give us a benchmark for when new linker roads should be downloaded.

2 Impact of Offset

If the Linker Roads have different starting coordinates than the true beam spot, then we see a ϕ dependence in the P_T (curvature) measurement (see figure 2). For some ϕ positions, the XFT P_T measurement will be biased high and at other ϕ biased low. This can lead to a trigger biase. The ΔCurvature vs. $\Delta\phi$ graph can be fit to a sine curve who's amplitude is the quantity to which the dependence was compared. To do this, we first slice the ΔCurvature Vs. $\Delta\phi$ Graph into pieces. Each of these slices is then fit to a Gaussian. We plot the mean of the Gaussian versus the phi slice (See Figure 3). These means are then fit to a sine curve, who's amplitude is ideally zero for a perfect match of XFT to true beam spot.

3 Procedure

In this study, only 4 layer XFT tracks were used. The XFT tracts are first matched to offline tracks. In order for an offline track to be matched to an XFT track, the XFT track has to be within 10 pixels of an offline track for at least 3 of the 4 axial layers. We then compare $\Delta\phi$, ΔP_T, and ΔCurve between it's xft track and it's matching offline track. Those quantities are also put into 3 dimensional histograms for comparison (such as ΔCurve vs $\Delta\phi$). We the use XFLD banks in data files to get XFT track info. In doing this with data through production, XFLD banks are from the hardware. To see what happens when we change the beam spot assumed by the xft, we use the same data set, but first pass it through a simulation of the XFT hardware, using XFTSim package and the XFT roads appropriate for the changed beam spot. This requires using the talk-to for XFTSim to change: 1.) database for roads, 2.)ϕ offset (optionally). After running the simulations, new simulated XFLD banks are created.

4 Data Sample

The data used for the simulations were inclusive electron samples. The run numbers for these samples were 158730, 158799, 158800, and 158894. The number of events used was ~9000.

5 Radial Scan

The Radial scan was a scan outward at 105 degrees starting at board 11 (see Table 1). The points were more concentrated about 5mm because this is near the expected beam position, and more points were desired to try to see a shape for our dependence near the actual beam spot. As expected, a minimum was found at approximately 5 mm in the plot of Radial Offset vs the amplitude of Δ Curve Vs. $\Delta\phi$ (see Figure 4). It should be noted that these coordinates are COT coordinates. Within a half of a millimeter from the beam spot, the dependence appears to be an quadratic, however as we move away from the spot the dependence appears flatten out to be more linear. Amplitude of the ΔCurve is about 4.9×10^{-6} at a radius of 5mm, and is below 1×10^{-5} within .6 mm of the true center (see Table 2 and 3). The significance of this is that width of the P_T bins are around 1.47×10^{-5}, so as long as the road is within .5 mm, the oscillation in the ΔCurve Vs. $\Delta\phi$ will be less than half of the P_T bin width. The consequence of this is that the frequency of binning errors will be drastically reduced, rendering more accurate, reliable data.

6 Phi Scan

The Phi scan was done at 5.1mm, and scanned from 105^o to 120^o, at 3^o steps (see talbe 4). The dependence along ϕ did not appear to be as strong as that of the radial dependence, however there was a change that occurred (See figure 5). At 105^o the Amplitude of ΔCurve Vs $\Delta\phi$ was 6.3×10^{-6}, and at it's minimum, which occurred at 111 was 1.6×10^{-6}. Although this graphs minimum was lower than that of the radial scan, the difference over a 6^o change was only 4.7×10^-6. The smaller dependence on ϕ is important, because of the way the boards are programed to recognize the beam roads. The way this is done is by projecting all the possible roads that pass through a certain phi slice on the board, pertaining to the first chip (each chip covers 1.25^o, and there are 12 chips on a board meaning that each board covers

15^o). This chip is then copied for the rest of the chips on the board, so the final chip on the board is a few degrees off in it's beam position. This smaller dependence also tells us that shifts in ϕ require less attention than shifts in radius.

7 Conclusion

In summary, the changing of radius will change the dependence of curvature with respect to ϕ significantly, and changes can be seen in shifts as low as .3mm. The dependence over a range of 15^o is less noticeable, however observable. We are in the process of creating firmware for a grid of beam positions. The grid will consist of radial steps out ward at .5mm steps from 0 to 8mm. For all radii, there will be 3 different ϕ shifts, effectively giving us a grid that will allow us to be within .5mm and 5^o of any shift in the beam that may occur. All comments, questions, and concerns may be emailed to gartner@pacific.mps.ohio-state.edu.

Distance of offset	**Amplitude of ΔCurve Vs. $\Delta\phi$**	**error**
0.0mm	5.802×10^{-5}	$\pm8.384\times10^{-7}$
1.0mm	4.796×10^{-5}	$\pm8.287\times10^{-7}$
2.0mm	3.657×10^{-5}	$\pm8.209\times10^{-7}$
3.0mm	2.464×10^{-5}	$\pm8.436\times10^{-7}$
4.0mm	1.177×10^{-5}	$\pm7.302\times10^{-7}$
4.2mm	9.965×10^{-6}	$\pm7.628\times10^{-7}$
4.4mm	6.986×10^{-6}	$\pm7.941\times10^{-7}$
4.6mm	5.836×10^{-6}	$\pm8.052\times10^{-7}$
4.8mm	5.650×10^{-6}	$\pm8.461\times10^{-7}$
4.9mm	4.838×10^{-6}	$\pm8.494\times10^{-7}$
5.0mm	4.932×10^{-6}	$\pm8.970\times10^{-7}$
5.1mm	6.279×10^{-6}	$\pm9.297\times10^{-7}$
5.2mm	6.507×10^{-6}	$\pm9.030\times10^{-7}$
5.4mm	7.509×10^{-6}	$\pm9.481\times10^{-7}$
5.6mm	8.957×10^{-6}	$\pm8.309\times10^{-7}$
5.8mm	1.141×10^{-5}	$\pm7.941\times10^{-7}$
6.0mm	1.275×10^{-5}	$\pm7.949\times10^{-7}$
7.0mm	2.226×10^{-5}	$\pm8.789\times10^{-7}$
8.0mm	3.380×10^{-5}	$\pm8.960\times10^{-7}$

Table 1: Dependence of Amplitude of ΔCurve Vs $\Delta\phi$ on radial beam offset ($\phi = 105^o$)

P_T	P_T	ΔP_T	**Curvature**	Δ**Curvature**
0	192	****	0.0000110	****
1	64	128.0	0.0000330	0.000022
2	38.4	25.6	0.0000551	0.000022
3	27.428	10.972	0.0000771	0.000022
4	21.333	6.095	0.0000992	0.000022
5	17.454	3.879	0.0001213	0.000022
6	14.769	2.685	0.0001433	0.000022
7	12.8	1.969	0.0001654	0.000022
8	11.294	1.506	0.0001874	0.000022
9	10.105	1.189	0.0002095	0.000022
10	9.142	0.963	0.0002316	0.000022
11	8.347	0.795	0.0002536	0.000022
12	7.68	0.667	0.0002756	0.000022
13	7.111	0.569	0.0002977	0.000022
14	6.62	0.491	0.0003198	0.000022
15	6.193	0.427	0.0003418	0.000022
16	5.818	0.375	0.0003639	0.000022
17	5.485	0.333	0.0003860	0.000022
18	5.189	0.296	0.0004080	0.000022
19	4.923	0.266	0.0004300	0.000022
20	4.682	0.241	0.0004522	0.000022
21	4.465	0.217	0.0004741	0.000022
22	4.266	0.199	0.0004963	0.000022
23	4.085	0.181	0.0005183	0.000022

Table 2: Descriptioin of P_T binning and the corosponding Curvature (part 1).

P_T	P_T	ΔP_T	**Curvature**	**ΔCurvature**
24	3.918	0.167	0.0005403	0.000022
25	3.764	0.154	0.0005625	0.000022
26	3.622	0.142	0.0005845	0.000022
27	3.490	0.132	0.0006066	0.000022
28	3.368	0.122	0.0006286	0.000022
29	3.254	0.114	0.0006506	0.000022
30	3.147	0.107	0.0006727	0.000022
31	3.047	0.100	0.0006948	0.000022
32	2.909	0.138	0.0007278	0.000033
33	2.742	0.167	0.0007721	0.000044
34	2.594	0.148	0.0008162	0.000044
35	2.461	0.133	0.0008603	0.000044
36	2.341	0.120	0.0009044	0.000044
37	2.232	0.109	0.0009485	0.000044
38	2.133	0.099	0.0009926	0.000044
39	2.042	0.091	0.0010368	0.000044
40	1.959	0.083	0.0010807	0.000044
41	1.882	0.077	0.0011250	0.000044
42	1.811	0.071	0.0011691	0.000044
43	1.745	0.066	0.0012133	0.000044
44	1.684	0.061	0.0012572	0.000044
45	1.627	0.057	0.0013013	0.000044
46	1.573	0.054	0.0013460	0.000044
47	1.523	0.050	0.0013901	0.000044

Table 3: Descriptioin of P_T binning and the corosponding Curvature (part 2).

Phi	**Amplitude of ΔCurve Vs. $\Delta\phi$**	**error**
105^o	6.279×10^{-6}	$\pm9.290\times10^{-7}$
108^o	2.478×10^{-6}	$\pm1.508\times10^{-6}$
111^o	1.604×10^{-6}	$\pm8.870\times10^{-7}$
114^o	2.554×10^{-6}	$\pm8.302\times10^{-7}$
117^o	5.750×10^{-6}	$\pm8.080\times10^{-7}$
120^o	6.910×10^{-6}	$\pm8.870\times10^{-7}$

Table 4: Dependence of Amplitude of ΔCurve Vs $\Delta\phi$ on ϕ beam offset (radius = 5.1mm).

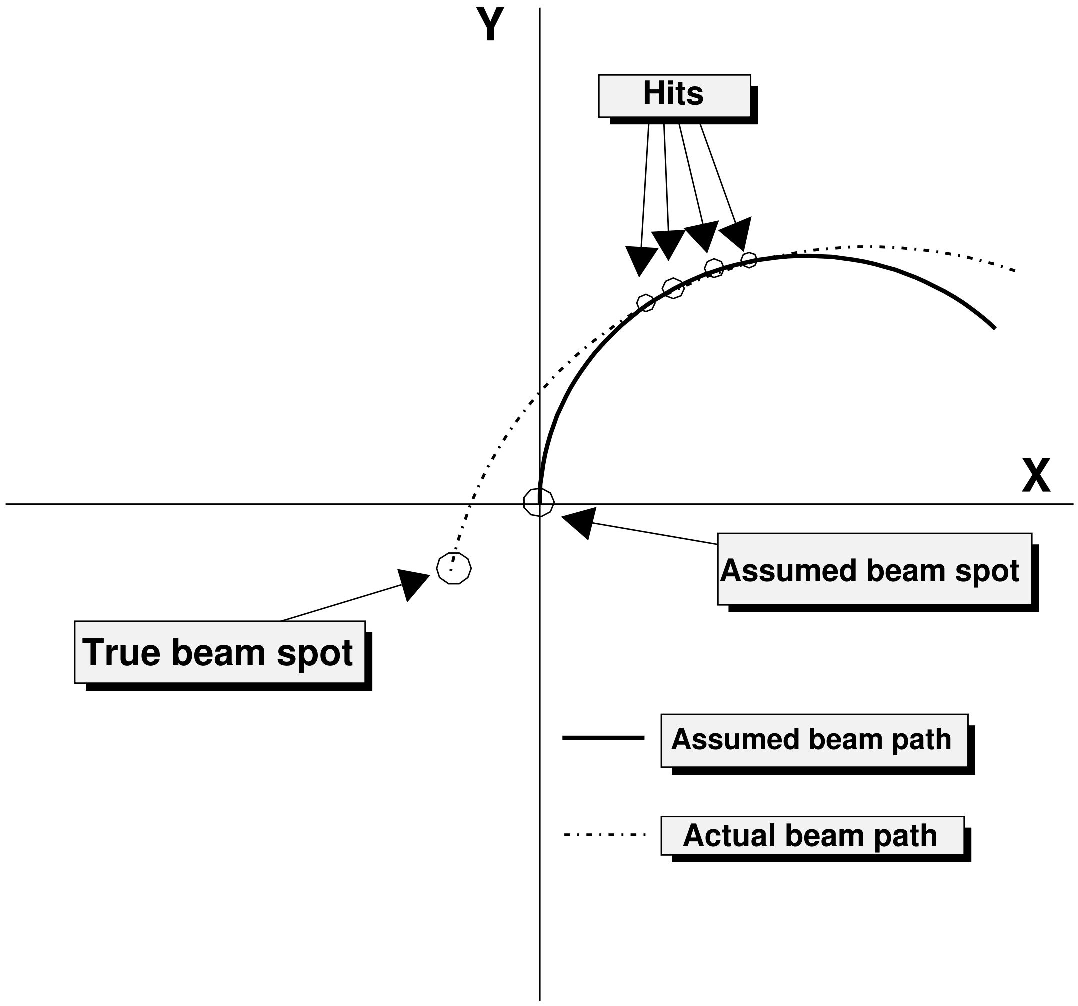

Figure 1: The difference in curvature found when the beam position differs from the road origin. The difference in curvature will create a difference in measured P_T

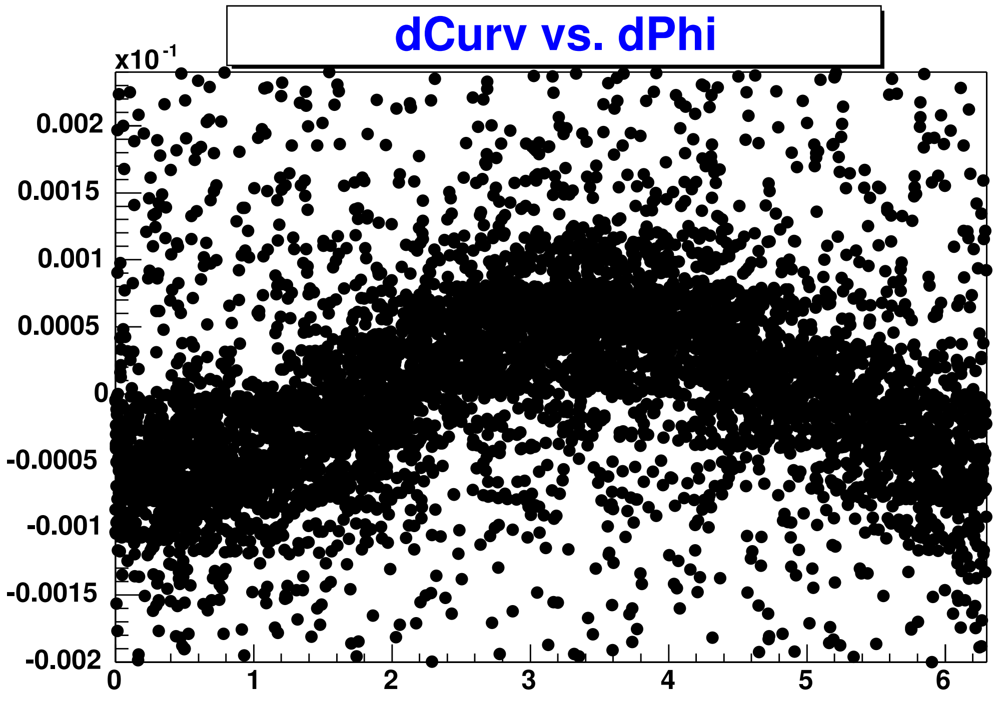

Figure 2: ΔCurve Vs. $\Delta\phi$ on a radial offset of 0mm.

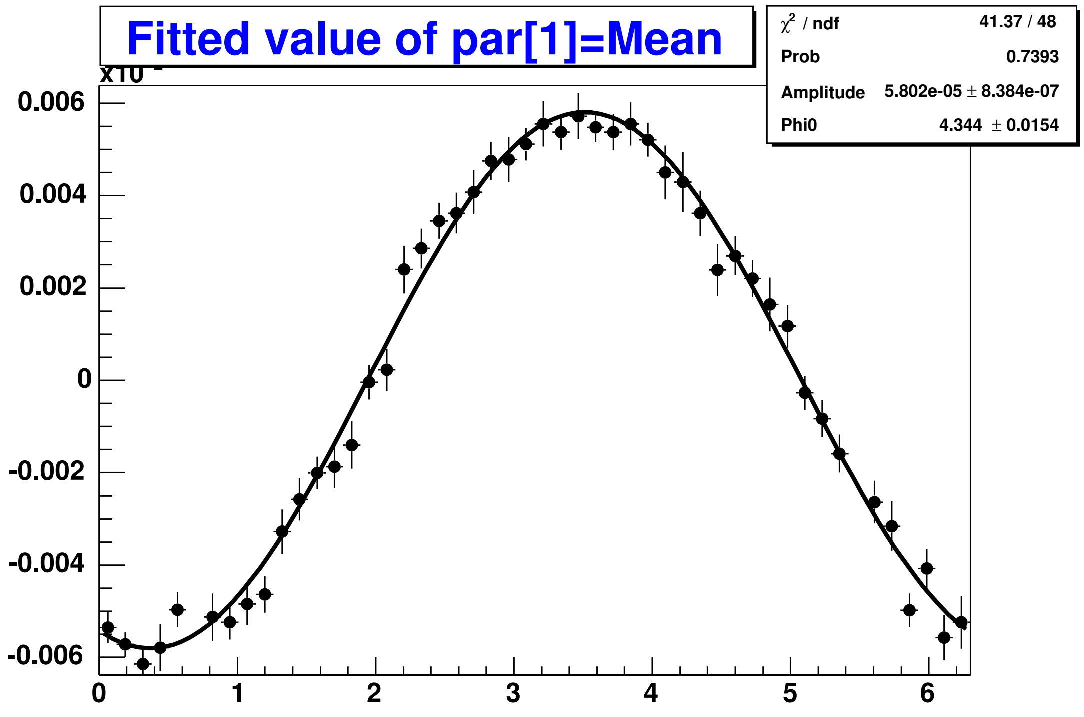

Figure 3: Fit of ΔCurve Vs. $\Delta\phi$ with no radial offset.

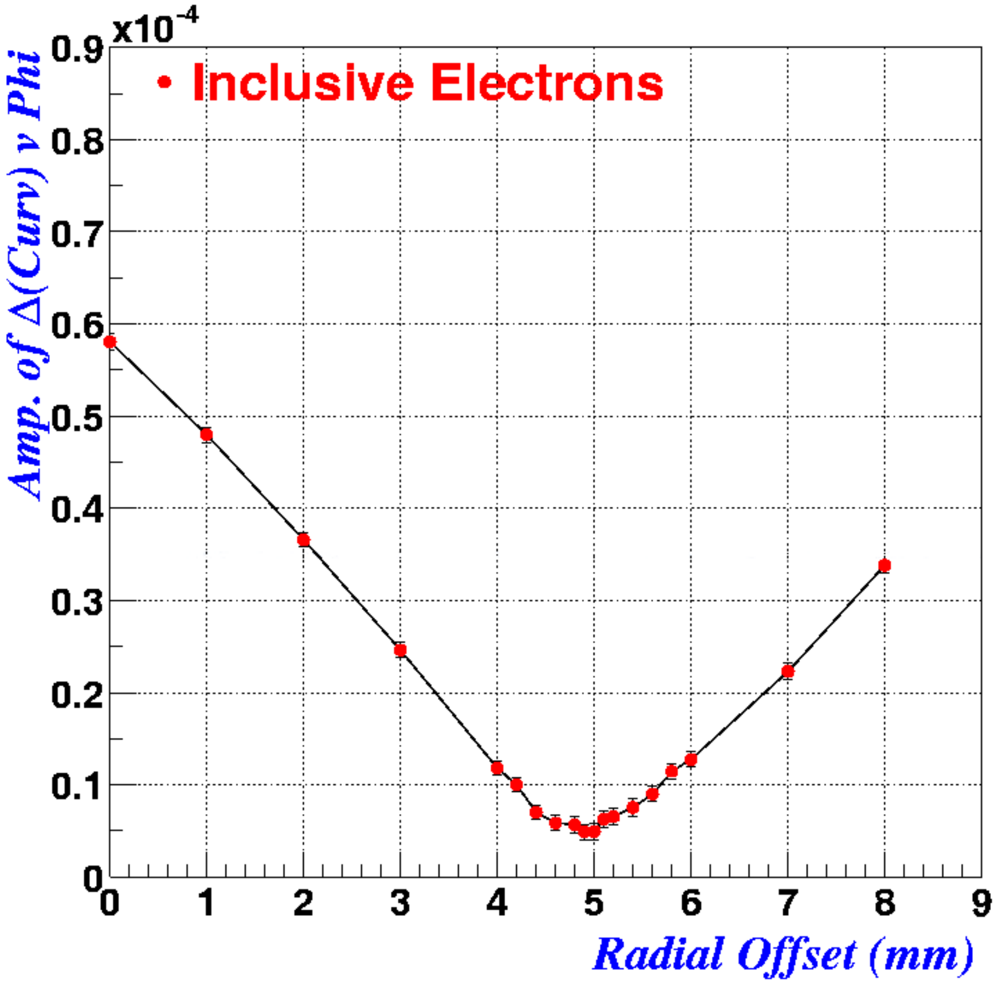

Figure 4: Dependence of Amplitude of ΔCurve Vs $\Delta\phi$ on radial offset ($\phi = 105^0$). The Blue line represents the width of the scatter on the ΔCurve Vs. $\Delta\phi$.

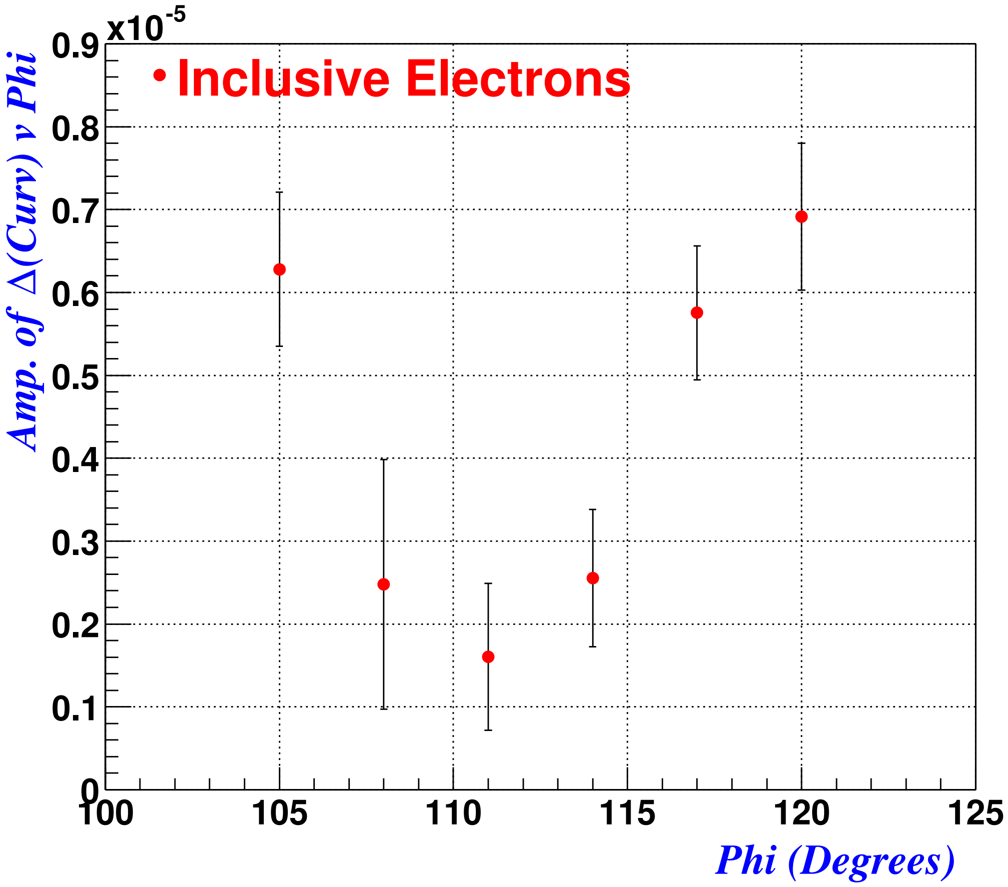

Figure 5: Dependence of Amplitude of ΔCurve Vs. $\Delta\phi$ on ϕ offset.(radius = 5.1mm)