CLAS-NOTE 2001-18

General momentum correction form for CLAS: A study of momentum corrections for the Prod-1-9 cooking of e1c data

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Abstract

The general form for momentum corrections is shown to be

$$\Delta(\frac{q\int Bdl}{p}) = \alpha(\theta,\phi) + \beta(\theta,\phi)\frac{q\int Bdl}{p},$$

where α is sensitive to detector misalignments, and β is sensitive to errors is the magnetic field map. For the Prod-1-9 cooking of the e1c data, the above form describes the data well providing a single correction function that can be applied for all beam energies, torus field currents and *all particle types and charges.* A parameterization of the θ and ϕ dependence of α and β measured for this data set has been entered into CVS. Data sets using different alignment or magnetic field maps will need to determine their own values for α and β, but the general technique will still be valid.

1 motivation

Upon completing the analysis of eta electroproduction on the e1b data set, The University of Pittsburgh group turned its attention to the e1c data. The relative size of this data set will lead to much smaller statistical uncertainties allowing us to push the physics reach to a much higher level. The flip side of

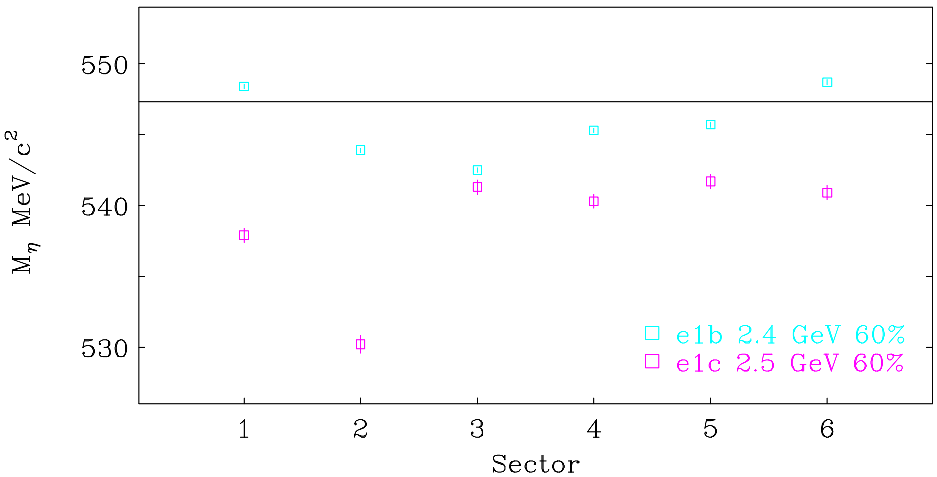


Figure 1: Raw η mass reconstructed via missing mass in e1b and e1c data sets as a function of sector. No momentum corrections were applied for this plot. The horizontal line indicates the known η mass.

this increase in statistics, is that the systematic errors must be understood to much finer detail if we are to reap the benefits of the smaller statistical uncertainties. We first looked at the configuration with $E_{beam} = 2.4$ GeV and $I_{torus} = 2250$ A in order to compare with the e1b data with which we were very familiar. When we looked at the data, we immediately noticed two problems:

1. In sector 2, the η missing mass is substantially shifted from nominal. (see fig 1).

2. The η missing mass showed a larger dependence on ϕ^* than the e1b data.

The e1b data had been recooked with the same code (PROD-1-9), so we looked at it. It showed neither of these features.

Since these data sets used the same torus current and were reconstructed with identical field maps, the difference couldn't be due to the B field. They were cooked with the same code, so it wasn't due to a coding bug. Between these two e1 running periods, however, there had been a maintainance period during which several Region-3 drift chambers had been removed, and reinstalled. The geometry files used in cooking were determined from $I_{torus} = 0$

running done before this maintainance. Is it possible that the Region-3 chambers were not put back in exactly the same spot? The head of the alignment tack force has always claimed that we know the positions of the drift chambers to better than 1 mm. This is probably true for all data taken in 1998, before the maintenance, but we do not yet have a measure of where these chambers are for any data taken in the last two years. Torus off data was taken after this maintainance period, but most of the events contain low momentum tracks which undergo extensive multiple scattering. This has made it difficult to extract accurate alignments from these data.

How would one expect the data to look if reconstructed with the wrong geometry? An infinite momentum particle would result in a straight line track. If, however, one detector is not where we think it is, the hits will not lie on the straight line and we will measure a non-zero curvature leading to a finite momentum track. For a uniform magnetic field, this leads to a shift in the curvature which is proportional to $\frac{qB}{p}$. For this case one expects, in general, the form of the mismeasurement to be

$$\Delta(\frac{qB}{p}) = \alpha + \beta\frac{qB}{p},$$

where α is due to misalignments and β is due to errors in the description of the B field. With the nonuniform field in CLAS, one should use $\int Bdl$ instead of B, but given the number of different ways people do analyses on CLAS, it is not clear that this value is available to everyone. Motivated by this form, we decided to revisit the issue of ad hoc momentum corrections for the e1c data.

2 previous work

The pioneering work on momentum correction in CLAS was performed by Volker Burkert. He assumed that the error was completely due to magnetic field problems and found a scale factor needed to make electrons from elastic scattering yield a missing mass equal to the known proton mass. He parameterized this scale factor as a function of θ and ϕ. He also determined this correction independently for every different configuration of beam energy and torus current for the e1b data. This has since been repeated for the e1c data by several people with various modifications. This technique in general gave good results for the e1b data, however, it didn't remove all systematic correlations for the η events in e1c. It also requires a different set of corrections for every beam energy and torus current setting. This is problematic because:

1. The mismeasurement of an outgoing electron can not depend on the energy of the incoming electron.

2. The mismeasurement of an outgoing electron can only depend trivially on the torus current: in our detectors we really only measure $\frac{B}{p}$.

Using the technique of Volker, we attempted to extend this by removing the assumption of a simple scale factor and tried to fit all the data to a form coming from both misalignments and magnetic field errors.

3 technique

As with the previous studies we use elastic electron scattering off the proton for this measurement. This reaction is over constrained: there are two outgoing particles with 3 unknown momentum components, but there are four constraints from energy and momentum conservation. This leaves us with two independent variables: ϕ of either the electron or proton, from which we determine the other ϕ, and one of the remaining four variables, θ_e, θ_p, p_e, or p_p, from which the other three can be determined. The problem here is that measurement errors can shift all of these from their correct value. While Magnetic field errors will, in general, only effect the momentum measurement, alignment errors will effect both momentum and angle in a correlated way. For this study, we have decided to use the θ_e to determine p_e, and θ_p to determine p_p.

For a given θ, ϕ and sector, we both calculated and measured $\frac{qB}{p}$ for both the electron and the proton. Since not all the myriad of analysis programs and data sets will have access to $\int Bdl$ we decided to try "B"$= I_{torus}/I_{max}$ (with $I_{max} = 3750$ A) in fitting to the straight line define in section 1. Every different setting of beam energy and torus current thus measures two points in $\frac{qB}{/}p$, although the different settings don't cover exactly the same angular range. We used 7 different configurations for this study:

1. $E_{beam} = 1.5$ GeV; $I_{torus} = 750$ A, 1500 A, 2250 A.

2. $E_{beam} = 2.5$ GeV; $I_{torus} = 1500$ A, 2250 A.

3. $E_{beam} = 4.2$ GeV; $I_{torus} = 2250$ A, 3375 A.

For every two-degree bin in theta and phi we measured

$$\Delta(\frac{qB}{p}) = (\frac{qB}{p})_{measured} - (\frac{qB}{p})_{predicted}$$

and plotted it verses $\frac{qB}{p}$. We then fit these curves to a straight line and parameterized the θ and ϕ dependence of the slope and intercept in each sector.

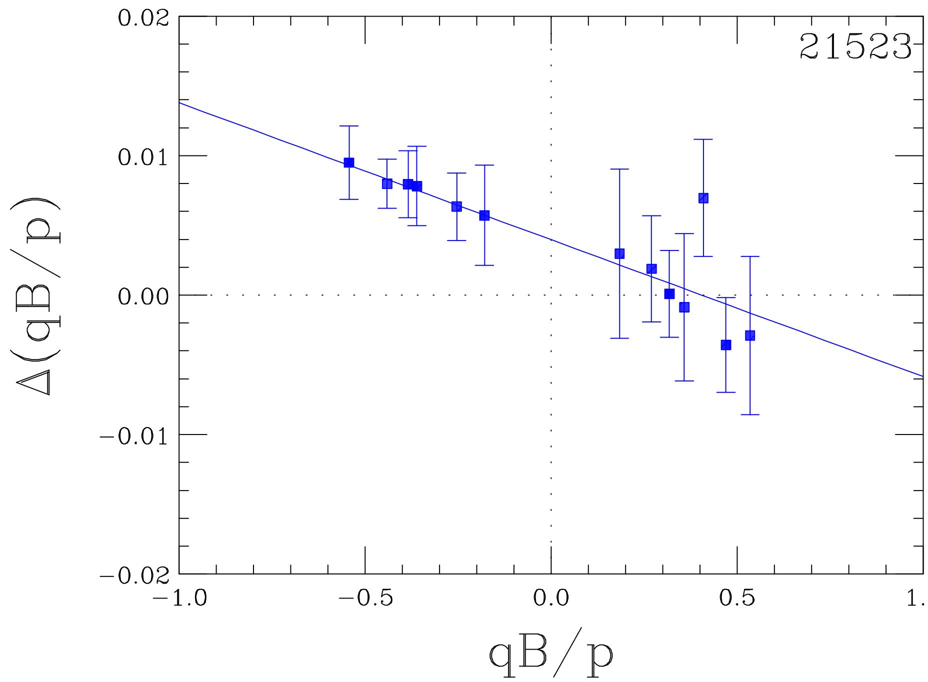


Figure 2: $\Delta(\frac{qB}{p}$ vs $\frac{qB}{p}$ in sector 2 for a particular θ-ϕ bin near 45°. This bin has data for electrons from 6 of the data sets, which (of course) lie at negative $\frac{qB}{p}$. Protons from all seven of the data sets are at positive $\frac{qB}{p}$. The line is the fit to the data from which the slope and intercept are determined for this bin.

4 results

In figure 2 the we plot $\Delta(\frac{qB}{p})$ vs $\frac{qB}{p}$ for a particular bin in θ and ϕ in sector 2. One can see a definite linear relationship for the electrons (negative $\frac{qB}{p}$) and the protons appear to lie on the same curve. This indicates that with one function we can correct the momentum for all tracks, both positive and negative. The line has a significant offset from the origin, indicating a substantial alignment error. All of the angles fit well to a straight line.

The slopes and intercepts for the straight line are shown in figures at the end of this note. (In those plots phi is counted such that 30° is at the midplane of each sector.) The intercepts for sector 2 become large as the lab angle increases. This might be an indication of a z-shift in one of the regions, but the one can not unambiguously determine, from these intercepts, what the actual shifts and rotations are for each of the chambers. We parameterized the θ and ϕ dependence and wrote code to implement this correction. Mark Ito has put the code for this correction in CVS (packages/PittsMomCorr). Any parameterization we have used describe the data where we have measurements, but diverge outside this region. Care must be taken when applying this to tracks at higher angle.

5 conclusions

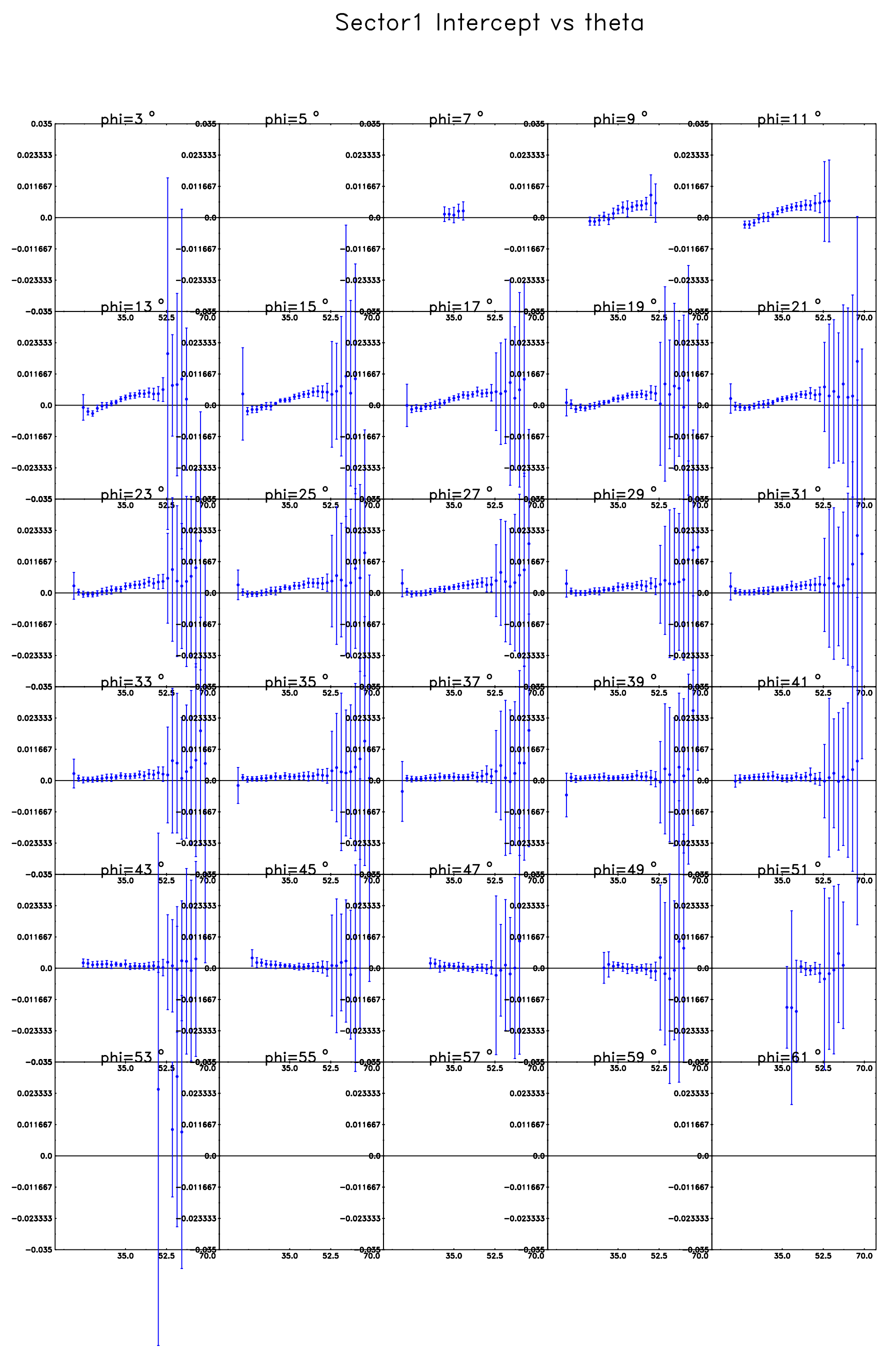
We have examined electrons and protons from elastic scattering and have determined the corrections needed to match the measured momentum to that predicted by the angle of the track. Motivated by possible magnetic field errors *and drift chamber misalignments*, we looked for a linear function in $\frac{qB}{p}$. For a given θ and ϕ, all tracks, both e and p for all magnetic field and beam current settings are found to lie on a single curve. We have determined empirically a function to describe the θ andϕ dependence of this slope and intercept of this line.

1. Using elastic events, we only covered the region from 15-70 degrees. The region from 50-70 degrees is only covered by elastic protons, and thus doesn't constrain the extrapolation beyond this region very well. It is not clear how well our correction function extrapolates outside this region.

2. Although the correction is well described be a linear function in $\frac{qB}{p}$,

Elastic events only probe the high end of our momentum range. A positive 200 MeV particle in the 90% field would have $\frac{qB}{p} = 4.5$, well away from the region probed here where higher order terms could become noticeable. In the future, short runs with low beam energy and a variety of fields from 20% to 90% with both polarities, would provide the ability map any correction out over a larger momentum range. In any case this function is measured over a significant range of momentum and can be more reliably used than the assumption of a simple scale factor.

3. There is a large correction needed for sector 2. One must be careful when applying such a large correction. Applying ad hoc corrections is best done when the corrections are small. The form of the correction indicates a substantial misalignment of this sector for this data. Although the unavoidable presence of low momentum track in the torus-off photon running prevented that straight track analysis from coming to a final conclusion, Rob Fuerbach informs me that the preliminary analysis indicated a large movement of the Region 3 chamber in sector 2 relative to the previous torus off electron data. It is unfortunate that the alignment task force never released even this preliminary alignment for this data before it was cooked. The gross effects we are observing could have probably been removed for this data set as well as all the other data sets taken in the last three years.


Sector1 Intercept vs theta
phi=3 °
phi=5 °
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−0.035
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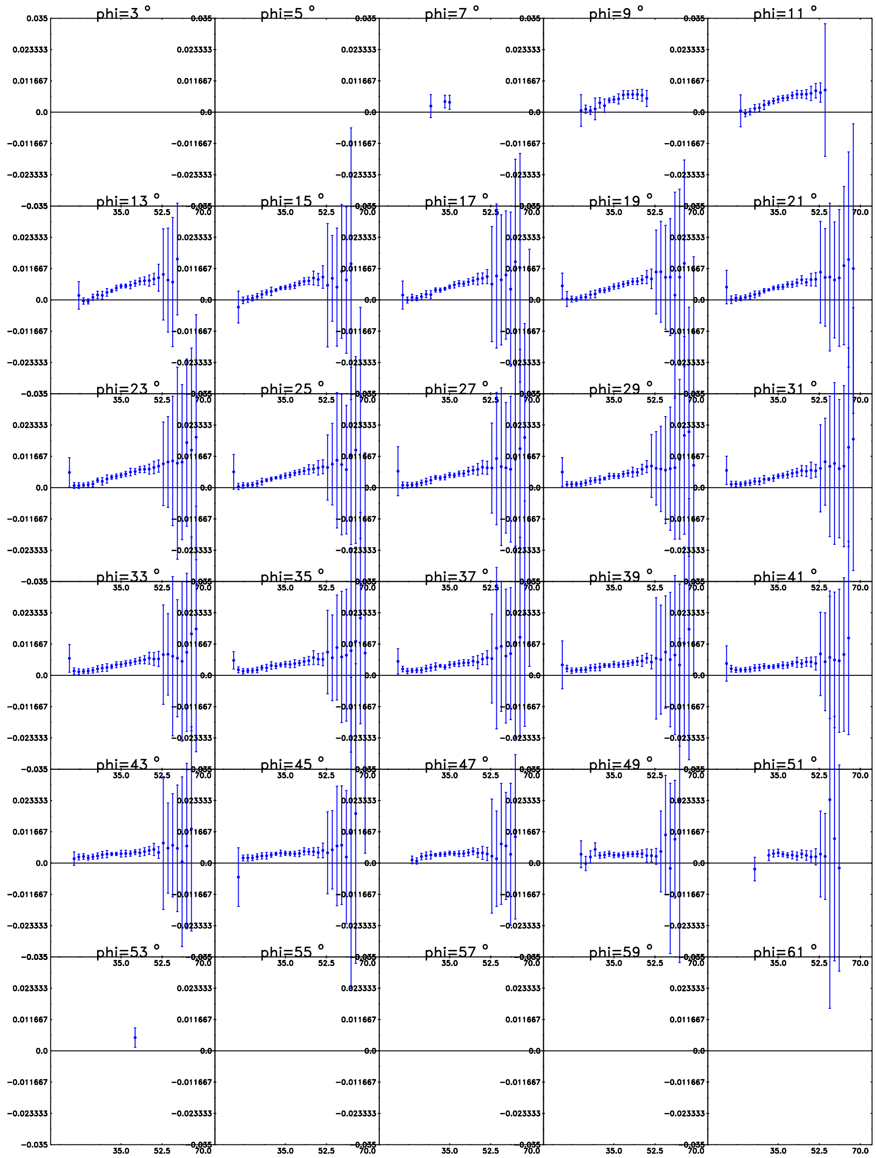
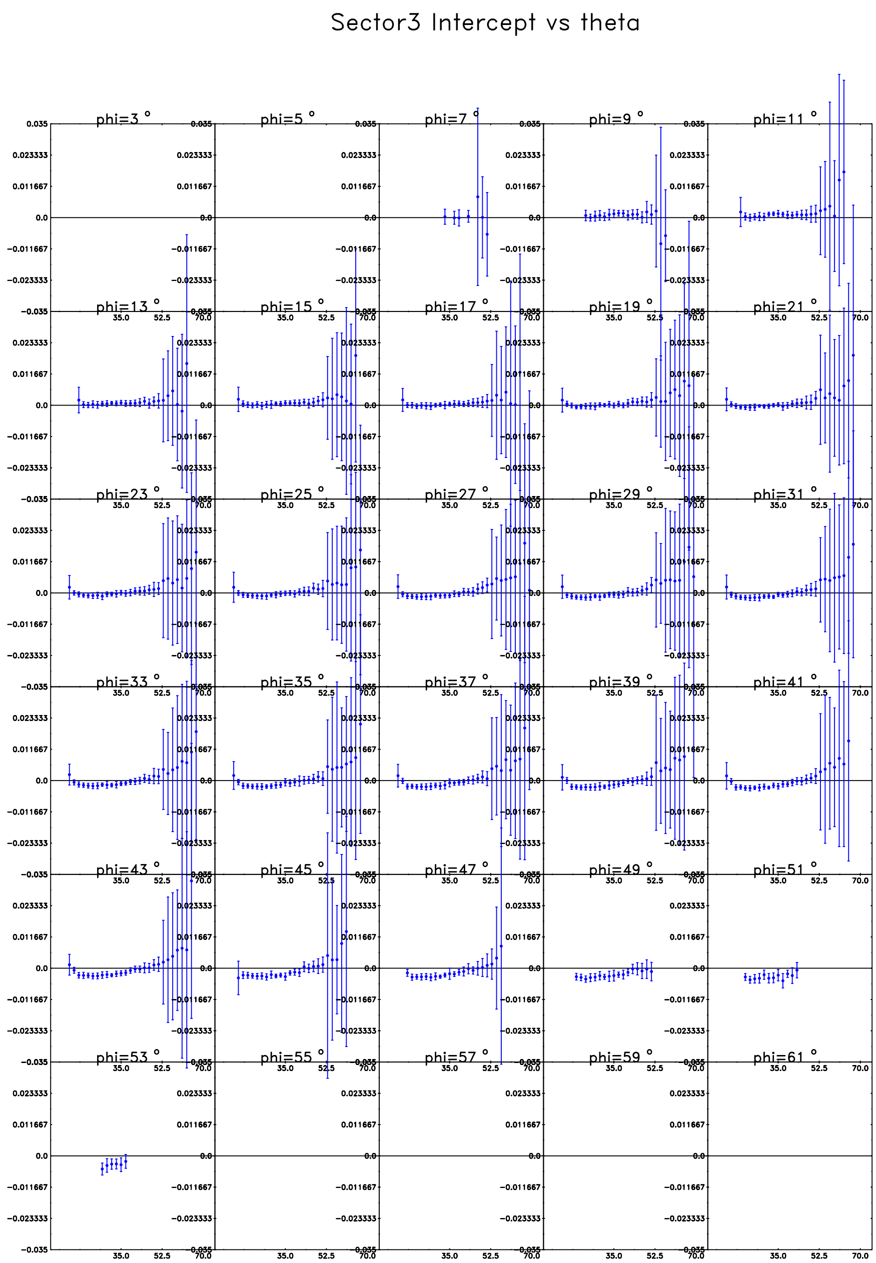
52.5
70.0

Sector2 Intercept vs theta





Sector3 Intercept vs theta
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phi=21 °
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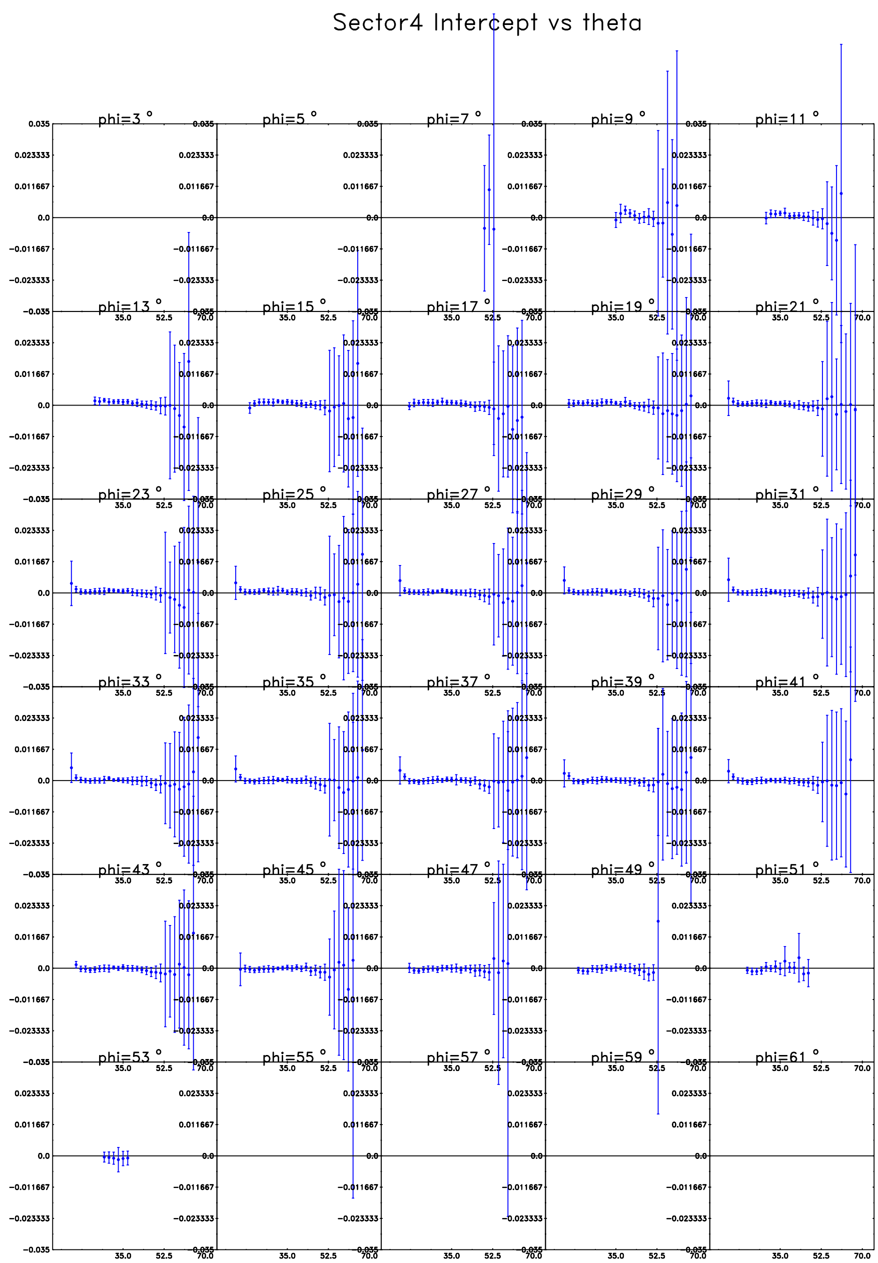
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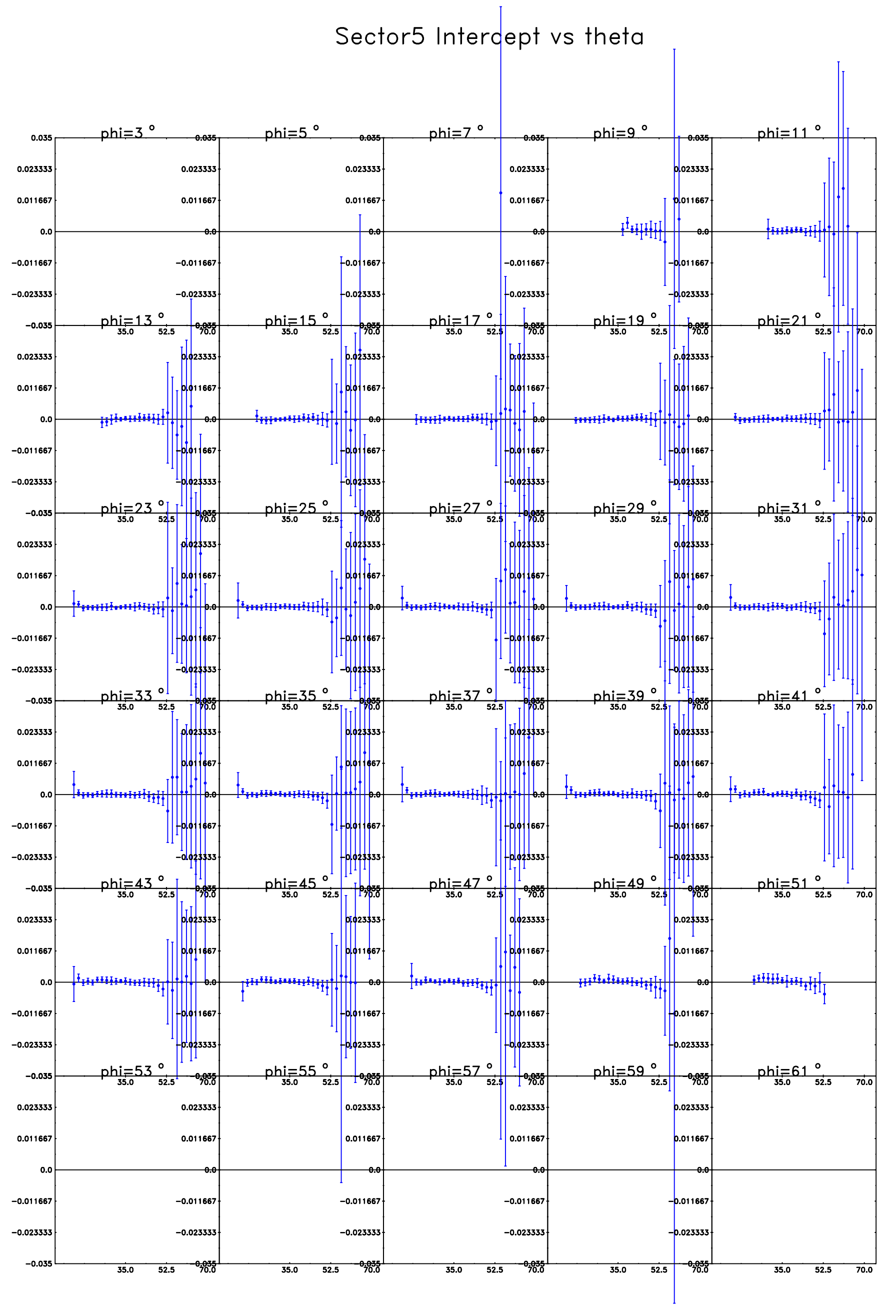
Sector5 Intercept vs theta
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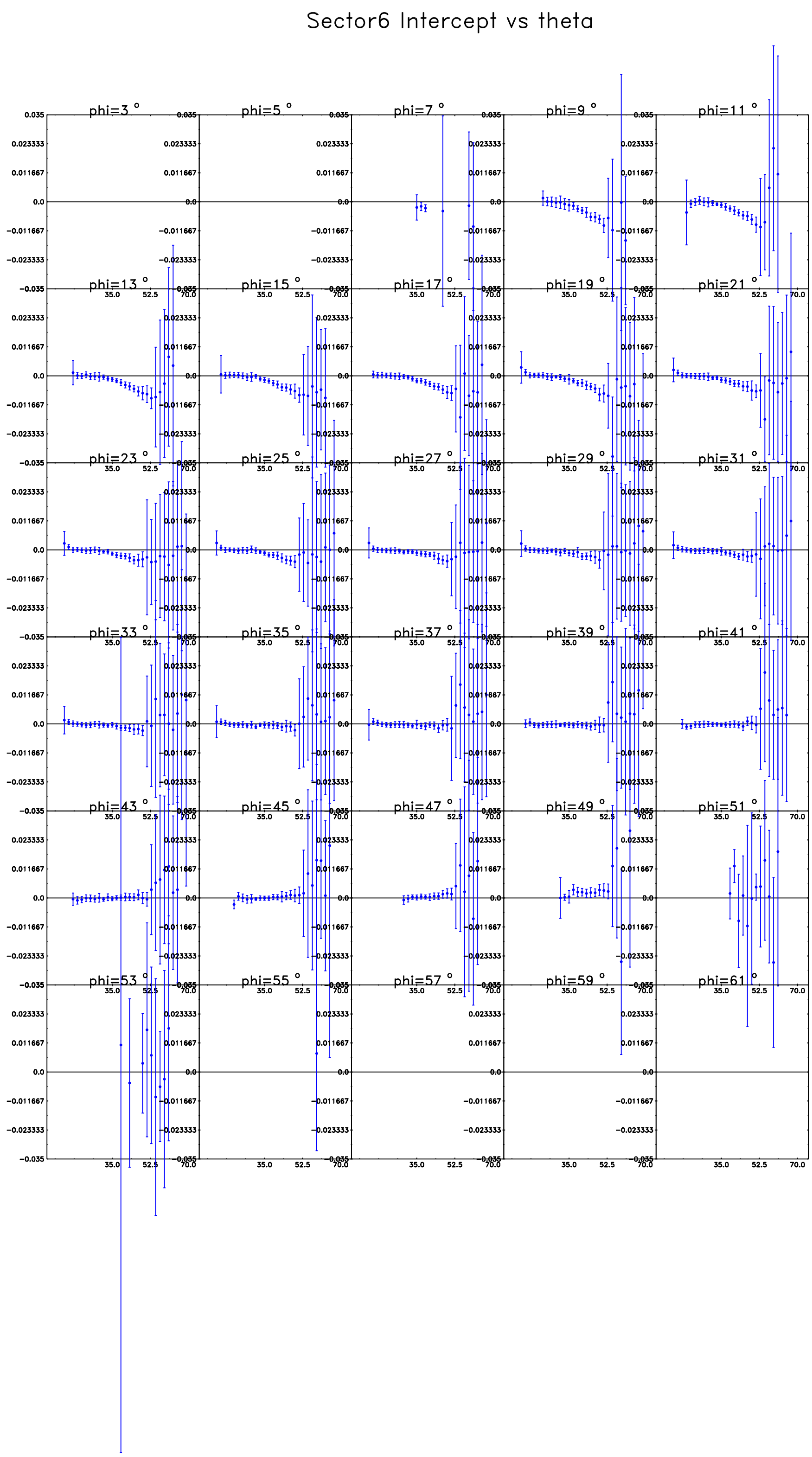
Sector6 Intercept vs theta
phi=3 °
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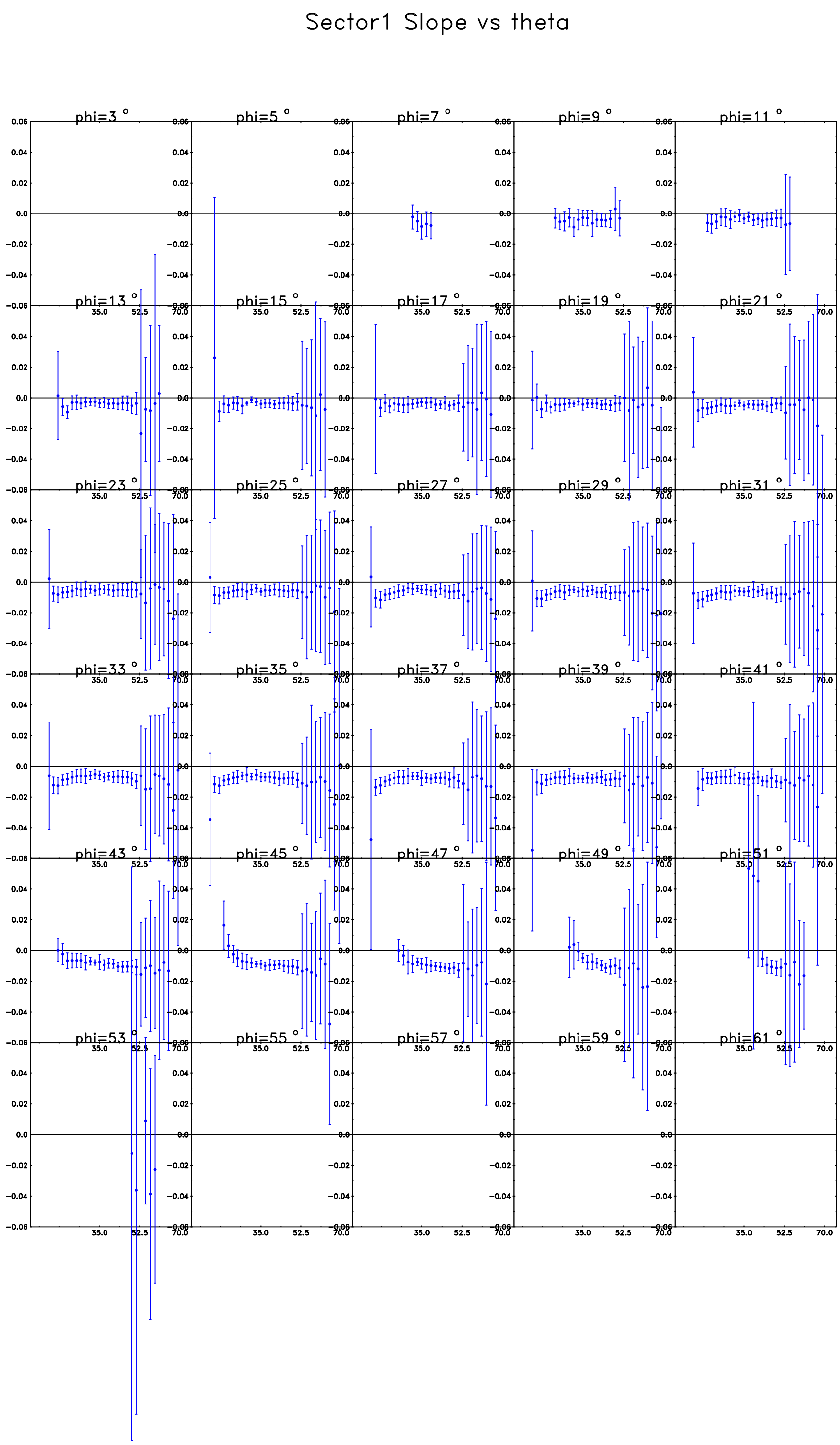
Sector1 Slope vs theta
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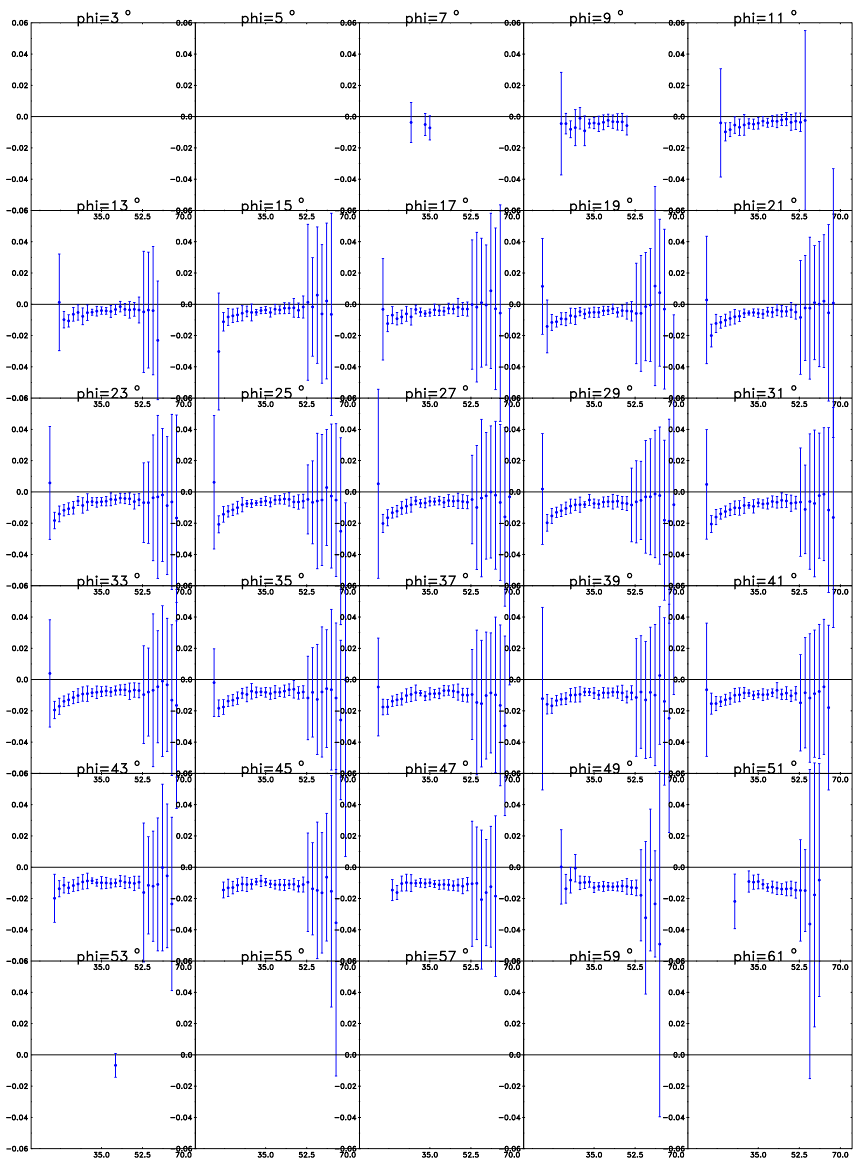
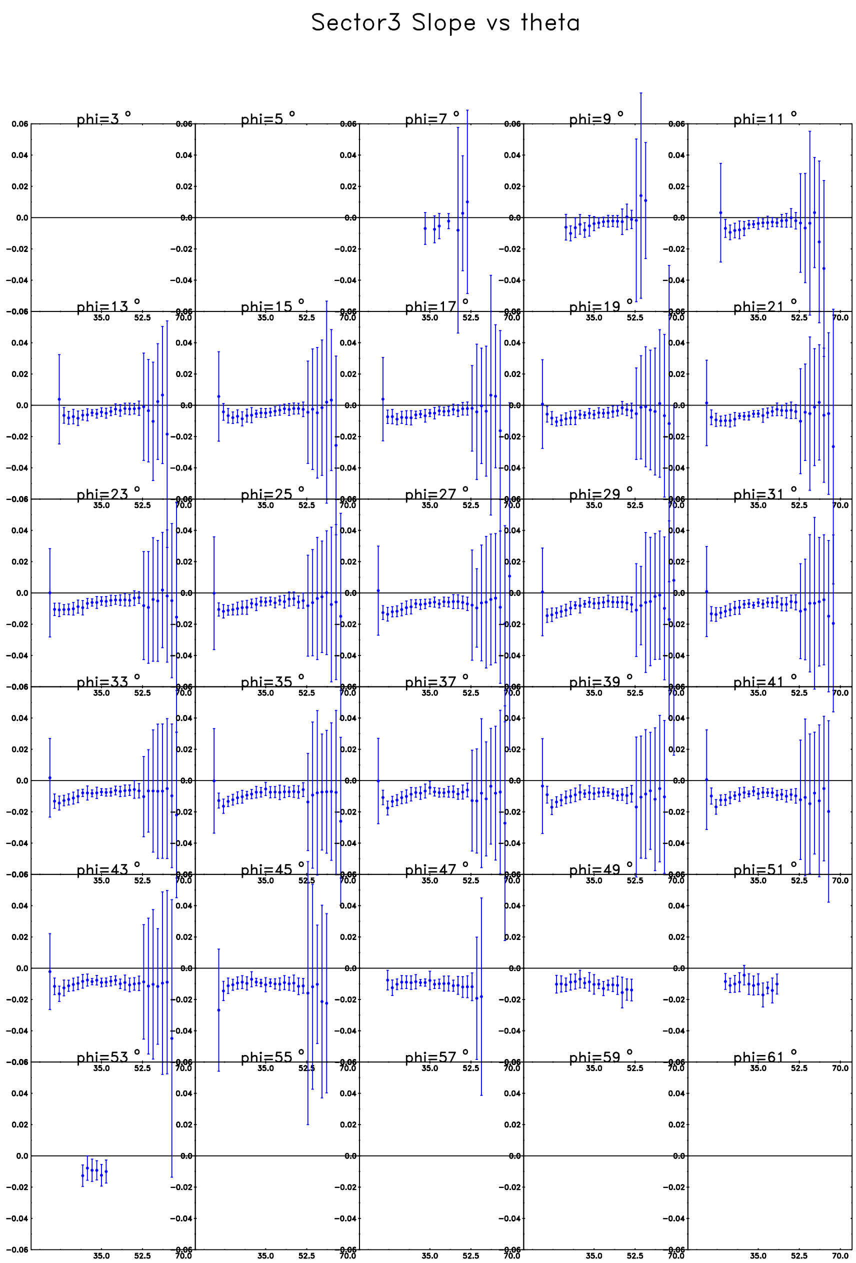
Sector2 Slope vs theta




Sector3 Slope vs theta
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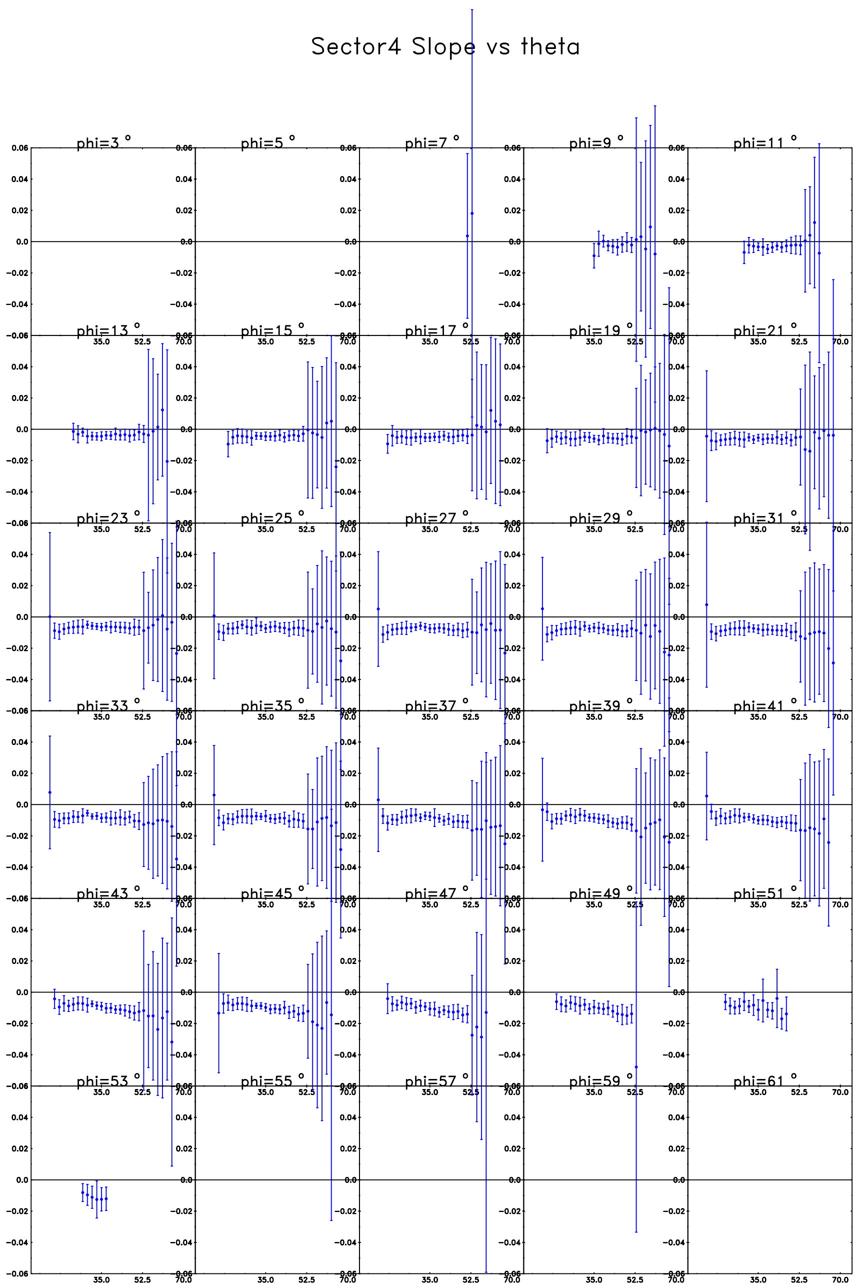
Sector4 Slope vs theta
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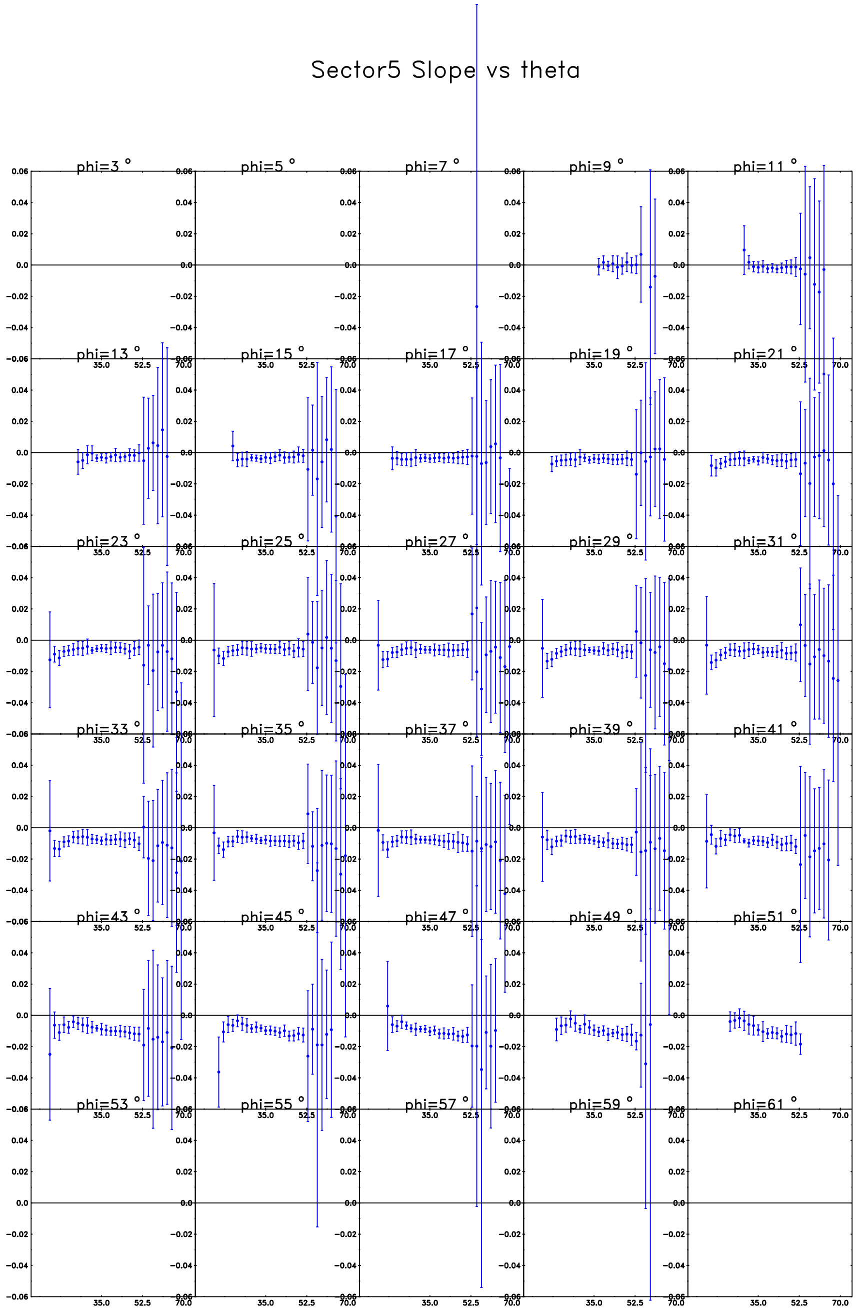
Sector5 Slope vs theta
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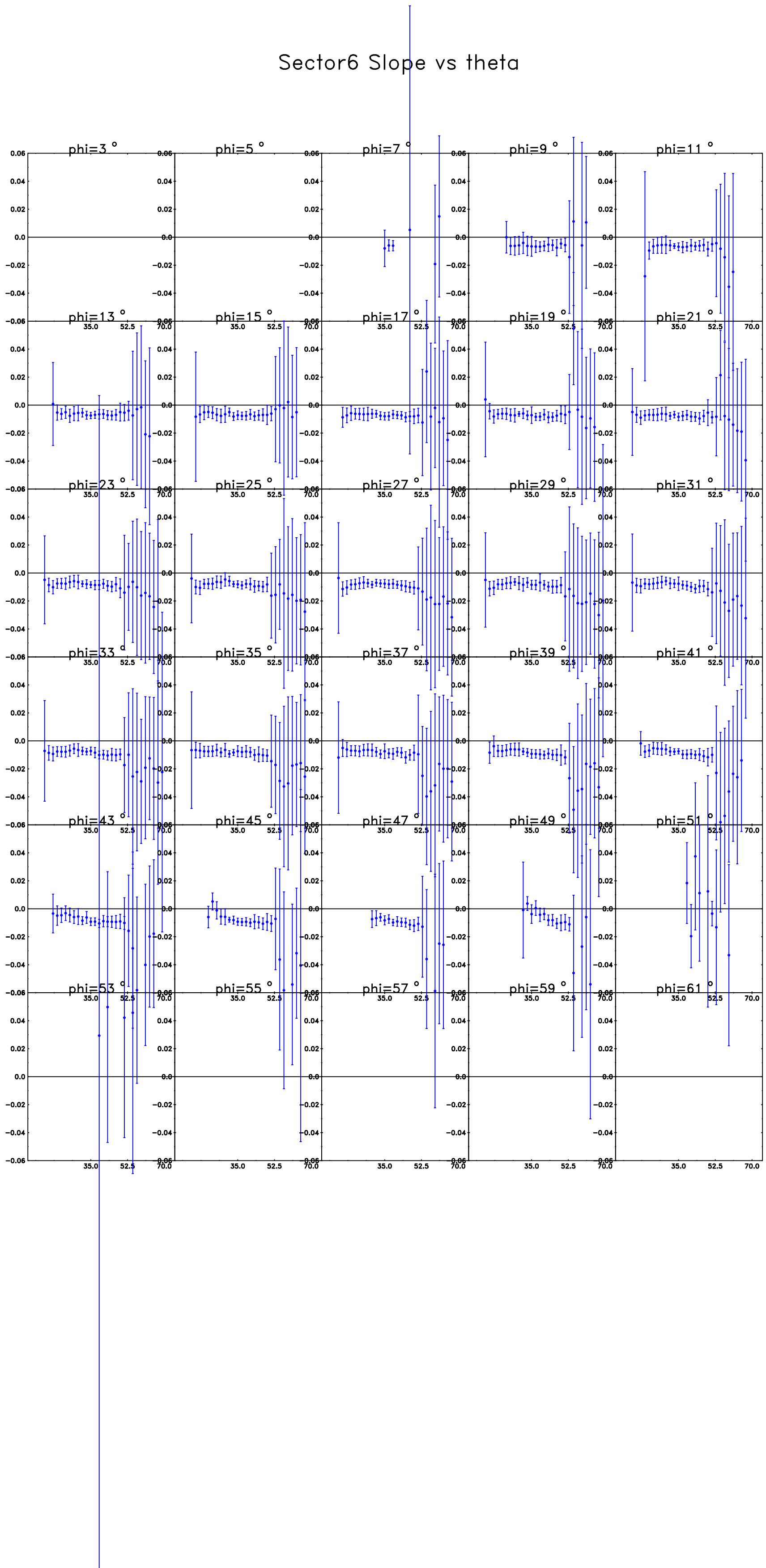
Sector6 Slope vs theta
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