Sensitivity to STR variations

Maher Quraan

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Data sets were analyzed using different STR files to investigate the effects of high voltage, temperature, and foil position. The same set was used as a base set and a test set in order to reduce the statistical error and examine the systematic effects closely.

1 Effects of changing the high voltage

A standard set (set3) was analyzed using an STR file generated at a high voltage of 1850 (set3anal2). This set was compared to a standard analysis of set3 (set3anal1). Both sets were analyzed with the same executable and all other settings were identical. Endpoint energy calibrations show a shift of -16 keV, but no deterioration in resolution.

Figure 1 shows a comparison of the 1-dimensional normalized momentum and $\cos(\theta)$ histograms for the two cases. Figure 2 shows the difference between the normalized histograms of figure 1. Maximum deviations are at about 2×10^{-5} for both momentum and $\cos(\theta)$ differences.

Below are the fitting results. The fiducial volume chosen is $20.00 < p < 50.00$ and $0.50 < cos(\theta) < 0.85$.

Data: spectrumStat(fiducial_bins=2160, fiducial_entries=1.66261e+07, min_bin_entries=3435)
Base: spectrumStat(fiducial_bins=2160, fiducial_entries=1.67729e+07, min_bin_entries=3487)

$\chi 2 = 333$
$ndf = 2156$
$confLevel = 1$
$\rho = (0.7 \pm 2.1) \times 10^{-3}$
$\delta = (0.6 \pm 1.9) \times 10^{-3}$
$\xi = (0.4 \pm 2.5) \times 10^{-3}$
$\eta = (59 \pm 118) \times 10^{-3}$

The same standard set (set3) was analyzed using an STR file generated with a high voltage of 1750 (set3anal10). This set was also compared against a standard analysis of set3 (set3anal1). Both sets were analyzed with the same executable and all other settings were identical. Endpoint energy calibrations show a -28 keV shift, but no deterioration in resolution.

Figure 2 shows a comparison of the 1-dimensional normalized momentum and $\cos(\theta)$ histograms for the two cases. Figure 3 shows the difference between the normalized histograms of figure 2. The maximum deviations have now increased to about 4×10^{-5} on the $\cos(\theta)$ distribution, with a statistically significant up wards trend at small angles.

Below are the fitting results. The fiducial volume chosen is $20.00 < p < 50.00$ and $0.50 < cos(\theta) < 0.85$.

Data: spectrumStat(fiducial_bins=2160, fiducial_entries=1.68026e+07, min_bin_entries=3456)
Base: spectrumStat(fiducial_bins=2160, fiducial_entries=1.67729e+07, min_bin_entries=3487)

$\chi 2 = 354$
$ndf = 2156$
$conflevel = 1$
$\rho = (0.2 \pm 2.1) \times 10^{-3}$
$\delta = (0.3 \pm 1.9) \times 10^{-3}$
$\xi = (-0.3 \pm 2.5) \times 10^{-3}$
$\eta = (35 \pm 117) \times 10^{-3}$

2 Effects of changing the temperature

To investigate the effects of temperature variations on the STRs, standard set3 was analyzed using an STR file generated at a temperature of 270 K (set3anal3). This set was compared against a standard analysis of set3 (set3anal1) which used an STR file computed at a temperature of 300 K. Both sets were analyzed with the same executable and all other settings were identical. Energy calibrations show a large -44 keV shift but no deterioration in resolution. Temperature variations in our detector of about 5 degrees will result in shifting the endpoint and therefore deteriorating the endpoint resolution. This is a viable candidate for the 10% resolution decrease observed in data relative to Monte Carlo.

Figure 3 shows a comparison of the 1-dimensional normalized momentum and cos(θ) histograms for the two cases. Figure 4 shows the difference between the normalized histograms of figure 3. The maximum deviations are at about 4×10^{-4} on the cos(θ) distribution, with statistically significant structures particularly at small angles.

Below are the fitting results. The fiducial volume chosen is $20.00 < p < 50.00$ and $0.50 < cos(\theta) < 0.85$.

Data: spectrumStat(fiducial_bins=2160, fiducial_entries=1.69026e+07, min_bin_entries=3492)
Base: spectrumStat(fiducial_bins=2160, fiducial_entries=1.67729e+07, min_bin_entries=3487)

$\chi 2 = 428$
$ndf = 2156$
$conflevel = 1$
$\rho = (0.6 + \pm 2.1) \times 10^{-3}$

$\delta = (0.6 \pm 1.9) \times 10^{-3}$
$\xi = (0.2 \pm 2.5) \times 10^{-3}$
$\eta = (75 \pm 117) \times 10^{-3}$

3 Effects of changing the cathode foil position

To investigate the effects of foil displacement on the STRs, standard set3 was analyzed using an STR file generated with the cathode foil displaced by 200 microns (set3anal4). This set was compared against a standard analysis of set3 (set3anal1). Both sets were analyzed with the same executable and all other settings were identical. Energy calibrations reveal no significant shift in endpoint energy.

Figure 5 shows a comparison of the 1-dimensional normalized momentum and cos(θ) histograms for the two cases. Figure 6 shows the difference between the normalized histograms of figure 5. No statistically significant deviations are observed.

Below are the fitting results. The fiducial volume chosen is $20.00 < p < 50.00$ and $0.50 < cos(\theta) < 0.85$.

Data: spectrumStat(fiducial_bins=2160, fiducial_entries=1.67921e+07, min_bin_entries=3470)
Base: spectrumStat(fiducial_bins=2160, fiducial_entries=1.67729e+07, min_bin_entries=3487)

$\chi 2 = 198$
$ndf = 2156$
$conflevel = 1$
$\rho = (0.2 \pm 2.1) \times 10^{-3}$
$\delta = (0.1 \pm 1.9) \times 10^{-3}$
$\xi = (0.1 \pm 2.5) \times 10^{-3}$
$\eta = (7.1 \pm 117) \times 10^{-3}$

4 Conclusions

STR variations result in no significant deviations on any of the Michel parameters, with shifts on ρ, δ and η being less than 1×10^{-3}. This includes shifts due to high voltage variations, temperature variations and foil displacements. It is interesting, however, to note that the large shift of -44 keV observed in the case of lowering the temperature for the STRs from 300 K to 270 K has resulted in no statistically significant deviations of the Michel parameters. A suggested test would be to add the two sets (300K and 270K) in order to obtain a spectrum with a significantly worse endpoint energy resolution, do the energy calibrations, and fit against a standard set. This would reveal how a bad endpoint

energy resolution would reflect on the Michel parameters.

Since temperature, high voltage and foil position changes are correlated in their effect on the STRs, it is logical that only one of these effects should be considered when calculating the systematic error of the final result. The temperature effects were observed to be the most significant when making direct comparisons of the STR files. Furthermore, temperature effects show the maximum shift on endpoint energy. In the final analysis the effect of changing STRs will be considered through a Monte Carlo study instead (gen103). This set consitutes a temperature variation systematic, where the temperature was lowered to 270 K in the ffcards file (to simulate the corresponding change in gas density) as well as through using an STR file computed at 270 K. The set was then analyzed with an STR file computed at 300 K. The results of fitting this set are not available yet. Effects of changing the gas density in the ffcards by lowering the temperature to 270 K alone (no change to STR file) were previously considered, and found to have to significant shift on the endpoint energy, and showed no detrioration in the resolution.

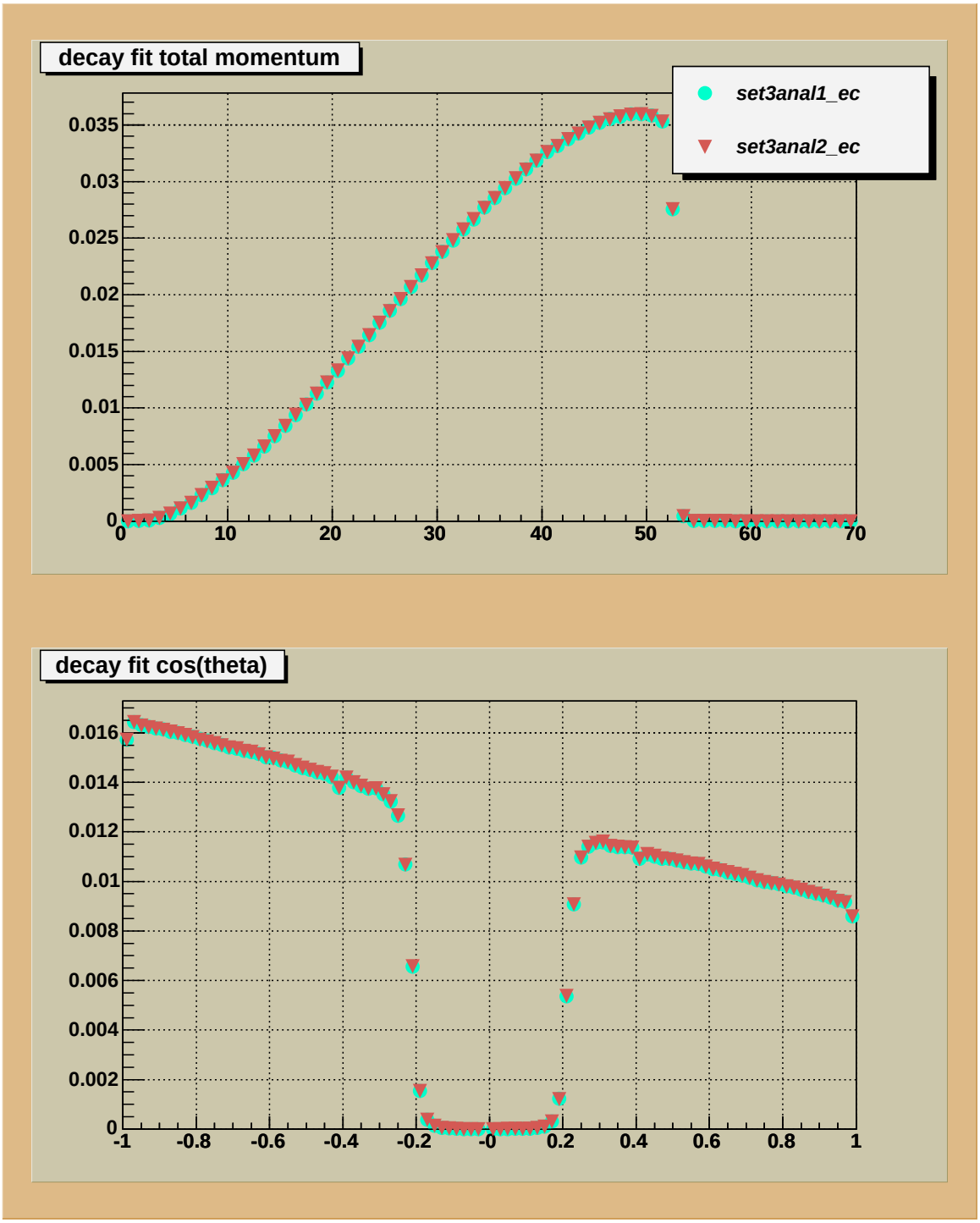

Figure 1: Momentum (top) and cos(θ) (bottom) distributions for the analysis of set3 using an 1850 V and 1950 V STR file.

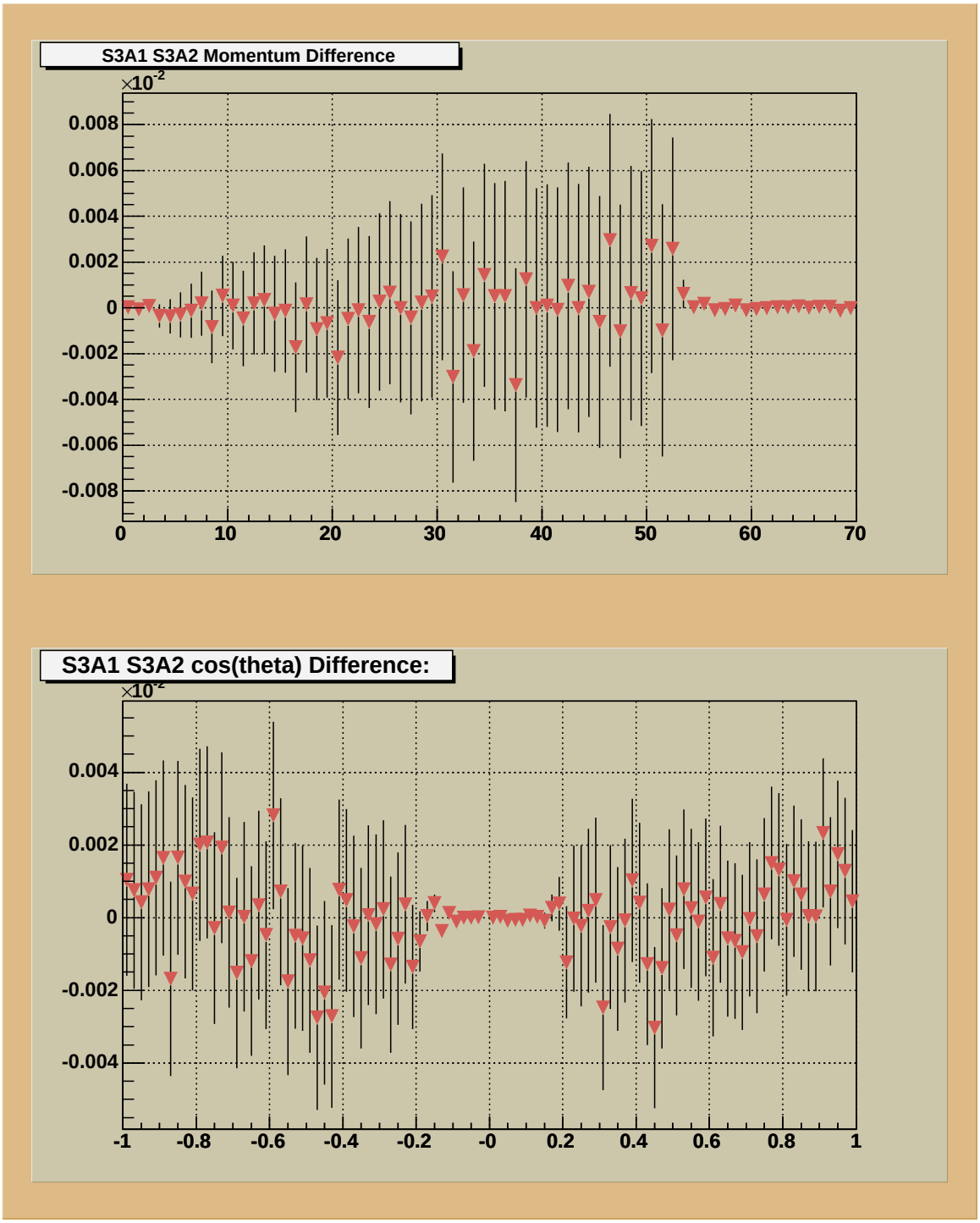

Figure 2: Momentum difference (top) and cos(θ) difference (bottom) distributions for the analysis of set3 using an 1850 V and 1950 V STR file.

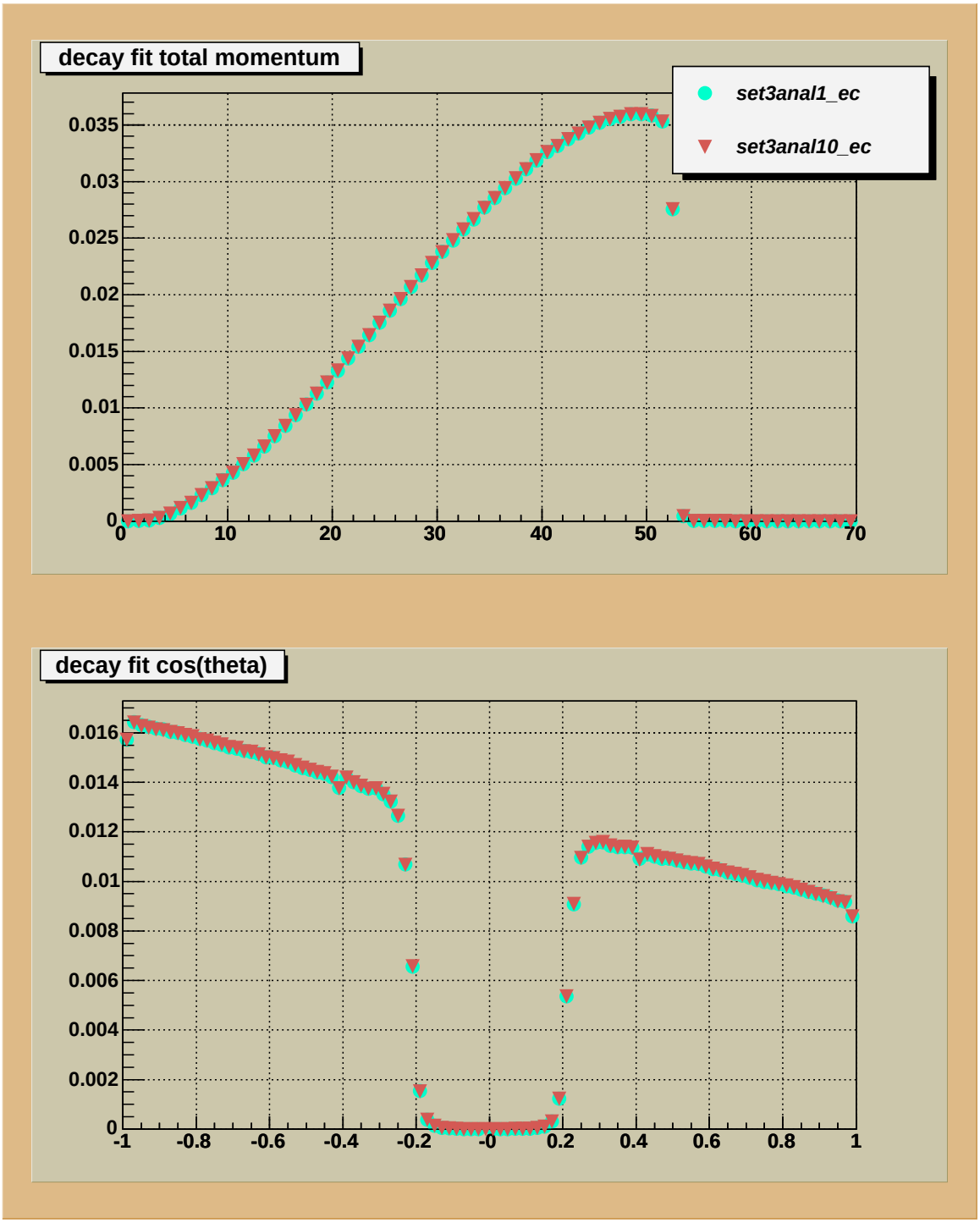

Figure 3: Momentum (top) and cos(θ) (bottom) distributions for the analysis of set3 using an 1750 V and 1950 V STR file.

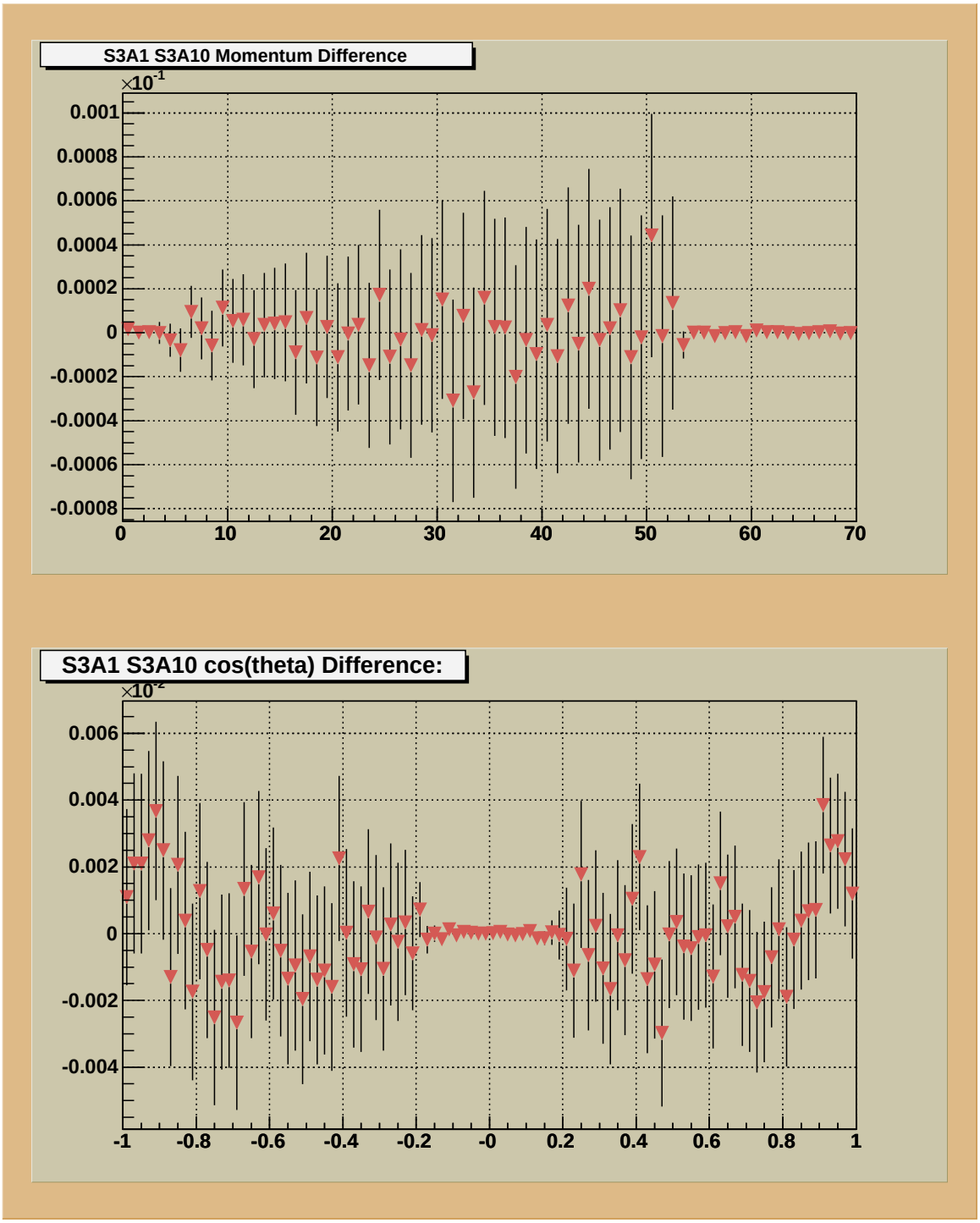

Figure 4: Momentum difference (top) and cos(θ) difference (bottom) distributions for the analysis of set3 using an 1750 V and 1950 V STR file.

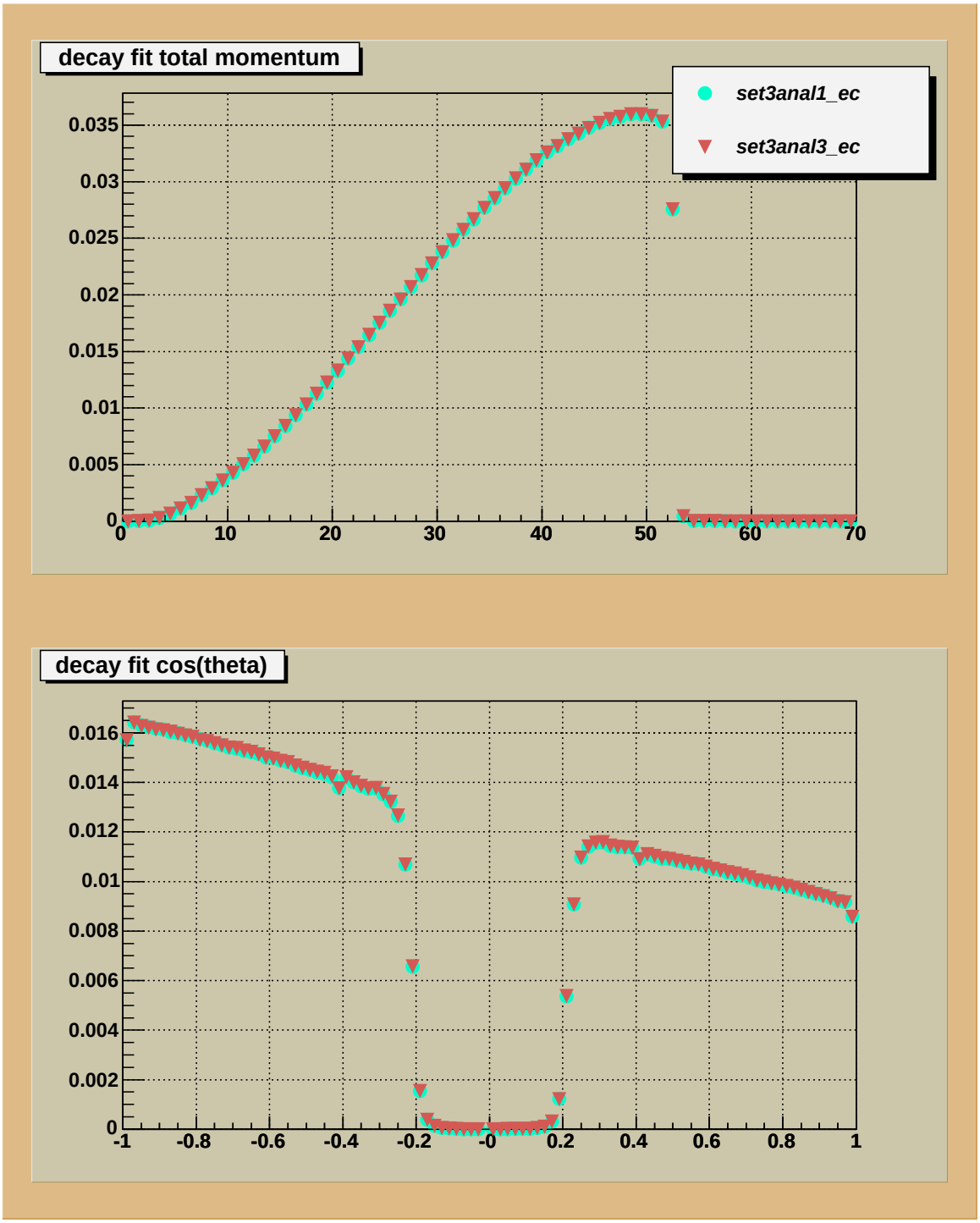

Figure 5: Momentum (top) and cos(θ) (bottom) distributions for the analysis of set3 using an STR file computed at 270 K and 300K.

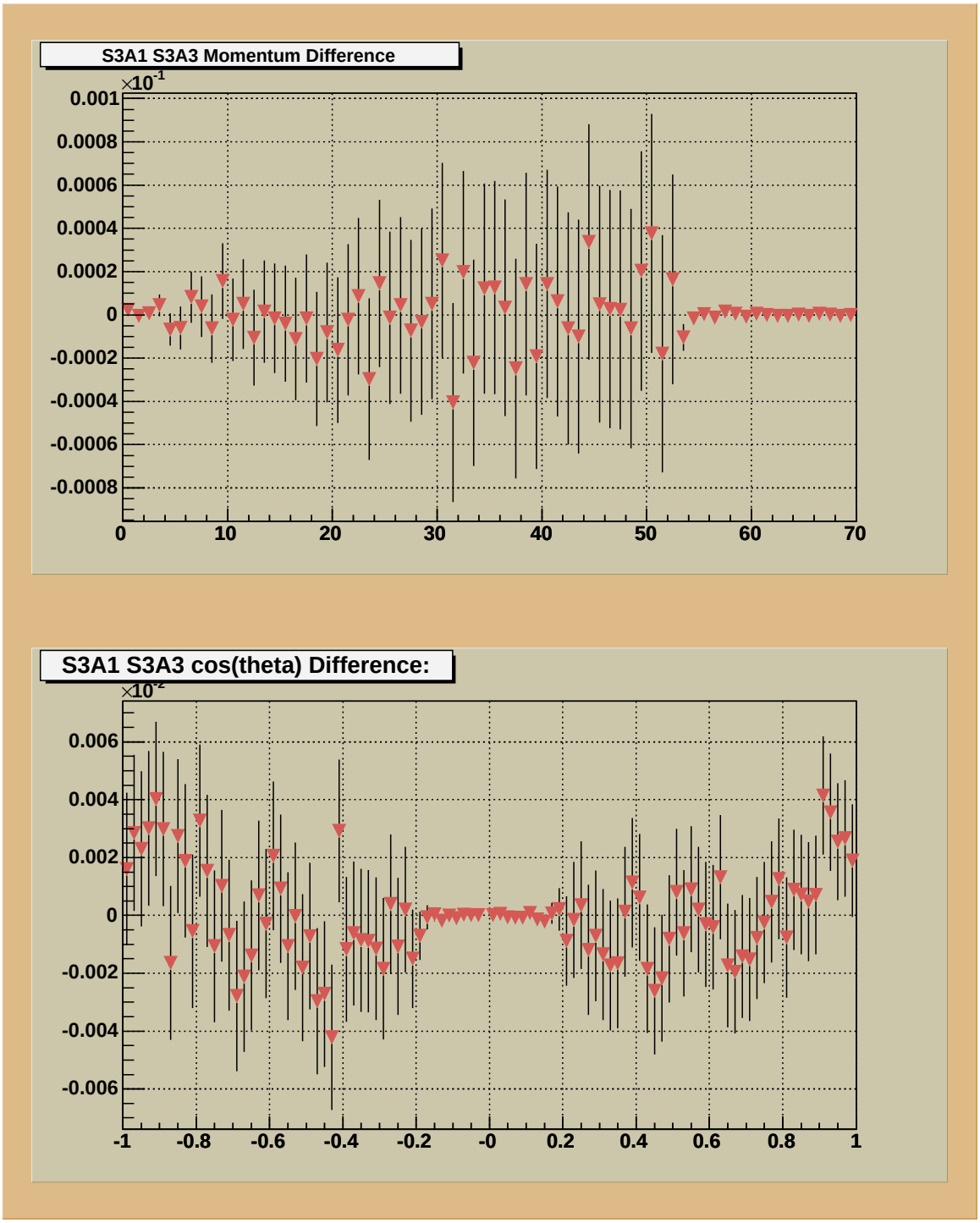

Figure 6: Momentum difference top and cos(θ) difference (bottom) distributions for the analysis of set3 using an STR file computed at 270 K and 300K.

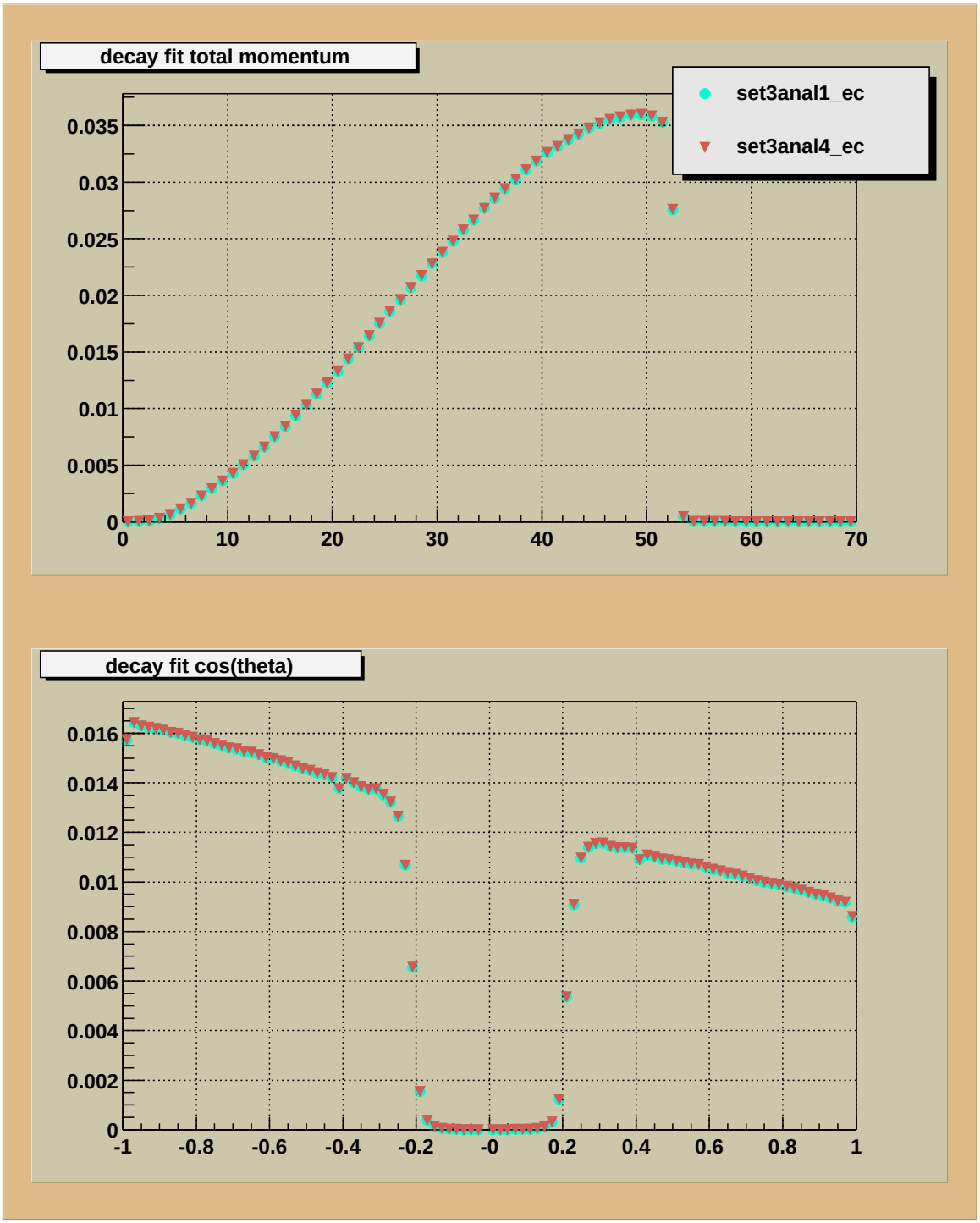

Figure 7: Momentum (top) and cos(θ) (bottom) distributions for for the analysis of set3 using an STR file computed with the foils shifted by 200 microns in one case and shifted by 200 microns in the other.

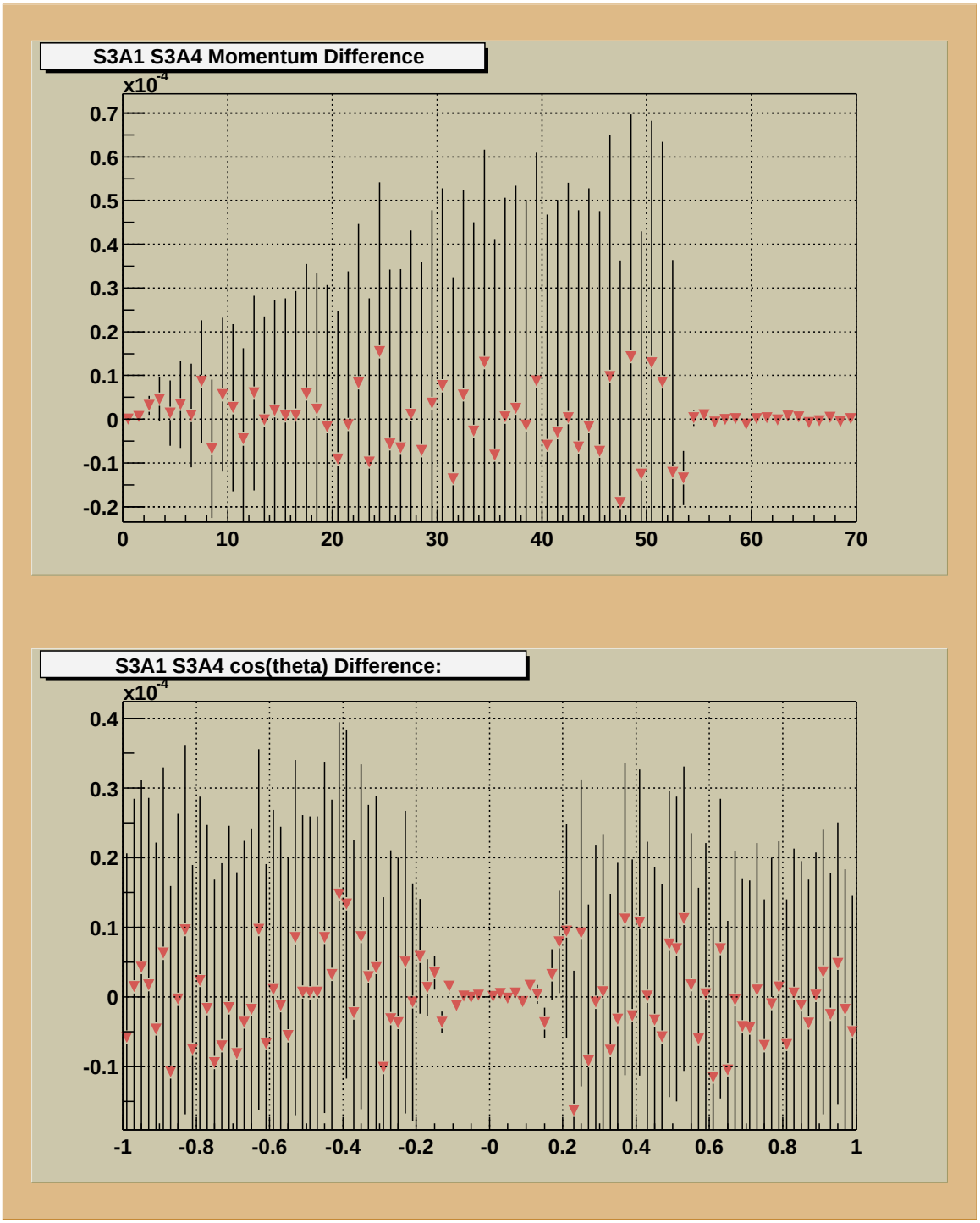

Figure 8: Momentum difference (top) and cos(θ) difference (bottom) distributions for for the analysis of set3 using an STR file computed with the foils shifted by 200 microns in one case and shifted by 200 microns in the other.