

Comparison of HRS+septum optics for APEX comparing parallel to anti-parallel fields in the septum

APEX_R_dir.dat is the APEX configuration with parallel fields in the septum (i.e. the way it will run for the experiment)

APEX_Rb_dir.dat is the same but now the fields in the septum are anti-parallel (i.e. PREX configuration)

First Order Matrices

	x_0	θ_0	y_0	ϕ_0	δ	
APEX_R_dir.dat	-2.174	-0.0043	-0.0360	-0.036	13.397	x
	-0.231	-0.460	0.001	0.004	2.320	θ
	0.020	0.024	0.008	-1.746	-0.241	y
	0.018	0.021	0.576	-0.722	-0.229	ϕ

	x_0	θ_0	y_0	ϕ_0	δ	
APEX_Rb_dir.dat	-2.198	-0.0548	-0.0620	-0.102	13.381	x
	-0.229	-0.459	0.002	0.002	2.317	θ
	0.033	0.062	0.009	-1.749	-0.225	y
	0.030	0.060	0.575	-0.729	-0.232	ϕ

Already one sees small differences, but these can easily be the result of the grainy nature of the maps used. (1st order matrix elements are determined by looking at very small differences between axial and paraxial rays all going through a rather limited range of the map.)

Raytracing/mufit analysis

Use SNAKE to create two sets of rays. These are random rays spanning the acceptance of the spectrometer. One set is from APEX_R_dir.dat, set “a”. The other is from APEX_Rb_dir.dat, set “b”. Use set “a” to create a reconstruction tensor for δ_0 , θ_0 , y_0 , & ϕ_0 . Set “a” gives figure 1. Set “b” using the same tensor gives figure 2. Achieved resolution is degraded and there are some small shifts in the reconstructed values. The effect of adding detector errors, $\sigma_x = \sigma_y = 100 \mu\text{m}$, $\sigma_\theta = \sigma_\phi = 0.5 \text{ mrad}$, to the same analysis produces figures 3 and 4. The results are summarized in table 1.

Summary: In general the situation is not as bad as it could have been. Resolution including “generic” detector errors is at worst almost a factor of two worse (ϕ_0) using the set “a” reconstruction on set “b” rays. The observed offsets are the result of slightly different bend angles achieved with each of the septa and can be eliminated by a more carefully balanced tuning of one vs. the other in the model¹. In practice the offsets are a calibration issue in any case.

¹ This was verified by changing the septum field by ~1%, which gave almost the same y and ϕ values at the VDC, a 2 mm shift in y_f . Then the observed offsets in y_0 and ϕ_0 were significantly reduced. ($\Delta\phi_0 = 2.7 \times 10^{-5}$, $\Delta y_0 = -9 \times 10^{-4}$) Uncertainties were essentially unchanged.

	APEX_R_dir.dat		APEX_Rb_dir.dat	
	σ	mean	σ	mean
No Errors				
δ	1.27×10^{-5}	0	8.70×10^{-5}	-8.6×10^{-5}
θ	8.61×10^{-5}	0	5.6×10^{-4}	-5.3×10^{-4}
y	4.78×10^{-4}	0	7.6×10^{-4}	-3.2×10^{-3}
φ	1.47×10^{-4}	0	3.69×10^{-4}	1.32×10^{-3}
With Errors ($\sigma_x = \sigma_y = 100 \mu\text{m}$, $\sigma_\theta = \sigma_\varphi = 0.5 \text{ mrad}$)				
δ	5.32×10^{-5}	0	1.02×10^{-4}	-8.62×10^{-5}
θ	1.08×10^{-3}	0	1.21×10^{-3}	-5.29×10^{-4}
y	9.72×10^{-4}	0	1.11×10^{-3}	-3.16×10^{-3}
φ	2.47×10^{-4}	0	4.18×10^{-4}	1.33×10^{-3}

Table 1: Summary of achieved resolutions comparing reconstruction based on set “a” with reconstruction of set “b” rays using the set “a” reconstruction.

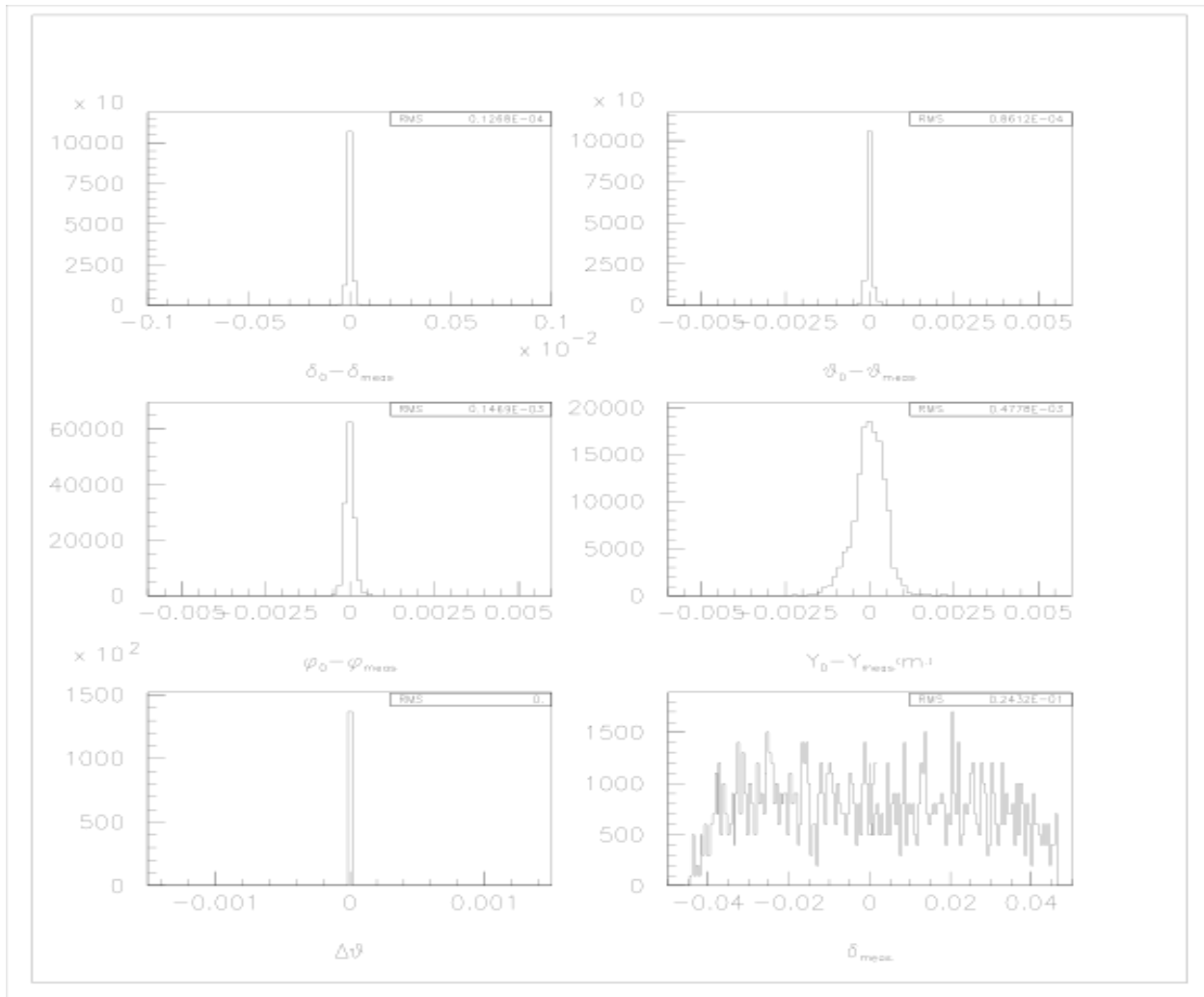


Figure 1: Set "a" reconstruction with no detector errors. Bottom plots illustrate the detector errors, on the left, and the δ range used.

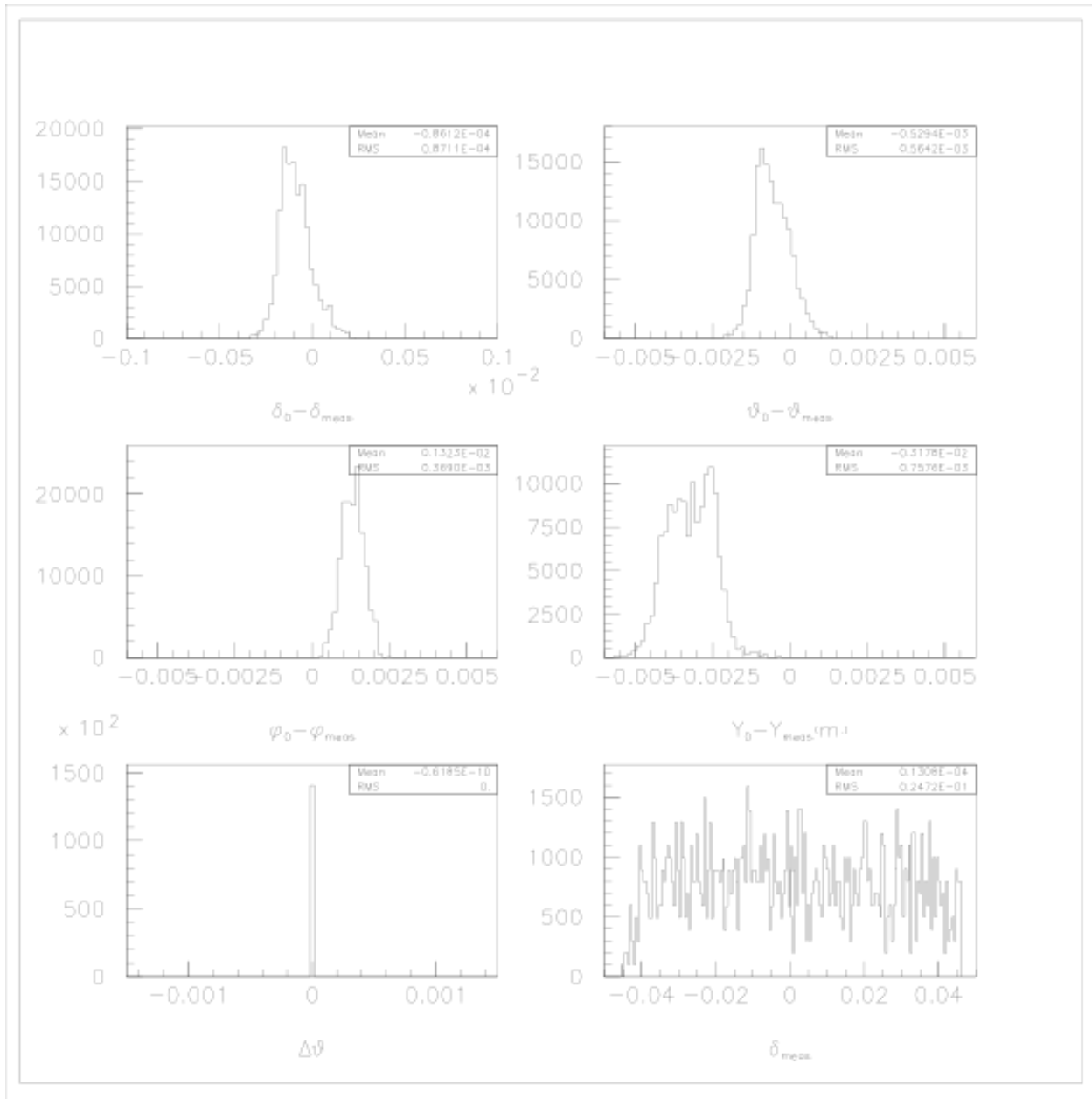


Figure 2: Set “b” reconstruction using the tensor developed from set “a”.

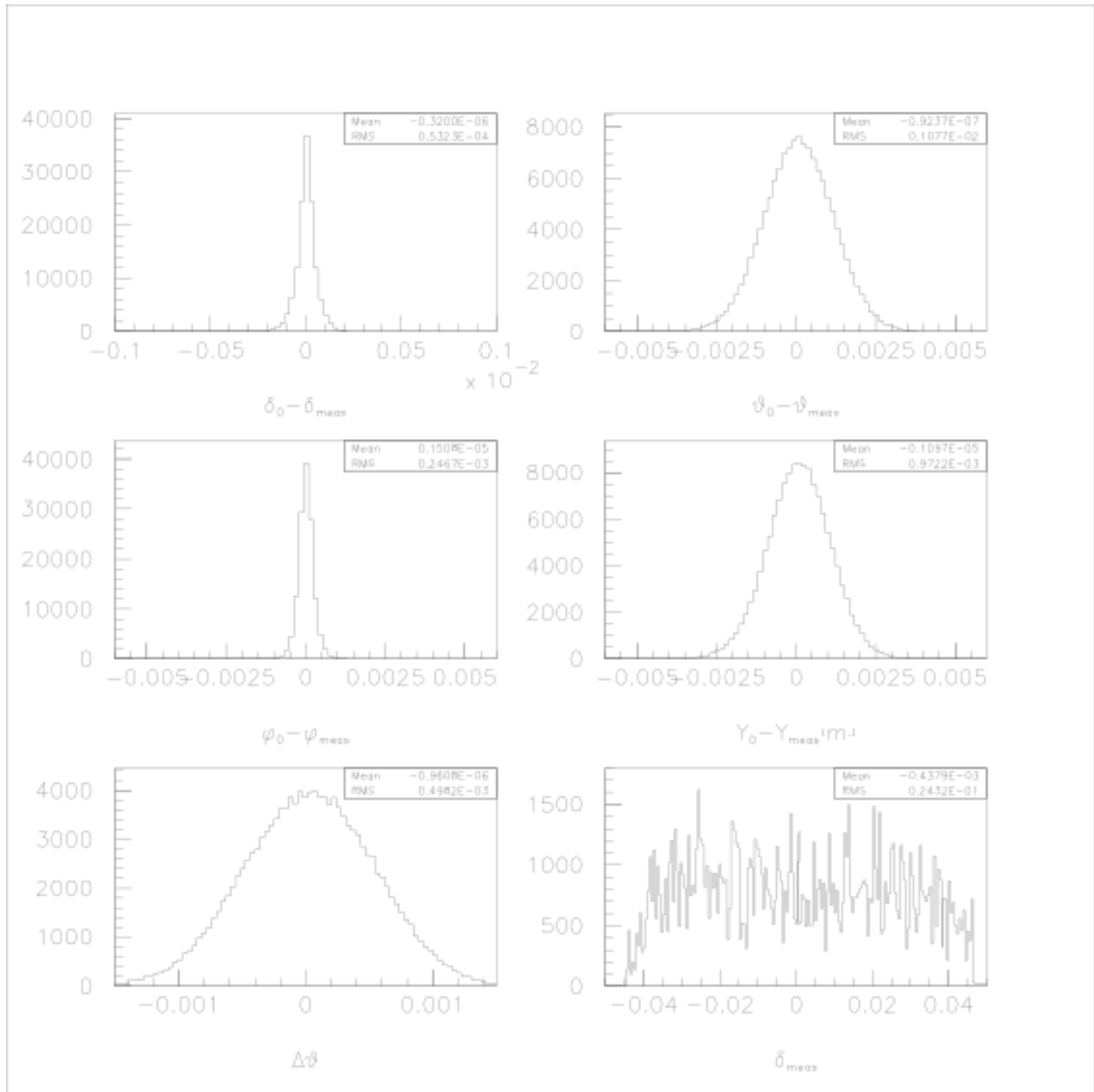


Figure 3: Same as figure 1 but now including “generic” detector errors. ($\sigma_x = \sigma_y = 100 \mu\text{m}$, $\sigma_\theta = \sigma_\phi = 0.5 \text{ mrad}$)

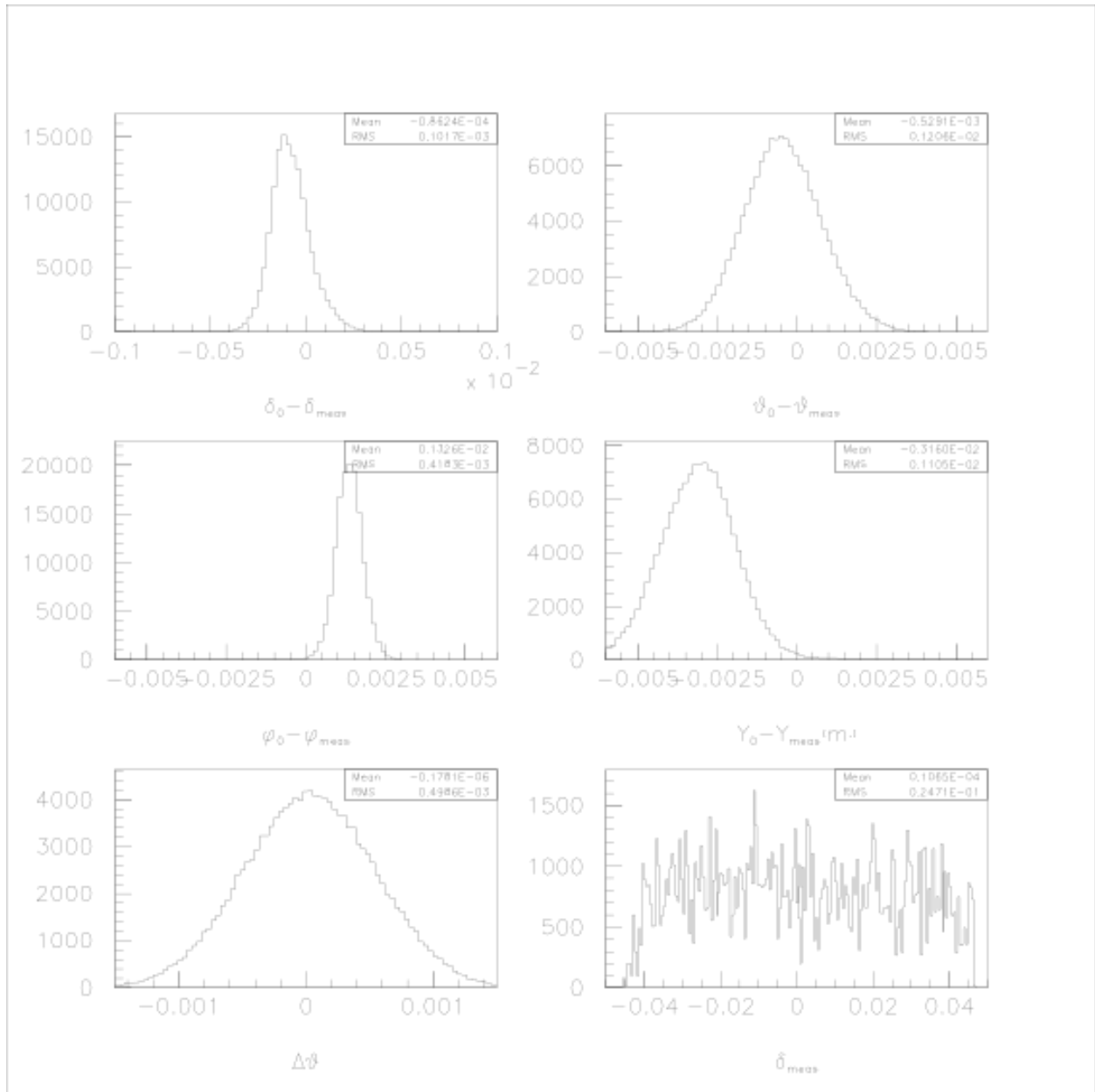


Figure 4: Same as figure 2 but with detector errors included. ($\sigma_x = \sigma_y = 100 \mu\text{m}$, $\sigma_\theta = \sigma_\phi = 0.5 \text{ mrad}$)