ARIS TPC Tilt

Andrew W Watson | 6 March 2017 | Temple U

How to find tilt?

- After S1 and S2 are both z-corrected, plotting $S2_{corr}/S1_{corr}$ over XY shows a high S2/S1 region and a low S2/S1 region
- Plotting $S2_{corr}/S1_{corr}$ vs. theta and fitting allows us to find the tilt angle and perform a tilt correction
- "Height" of tilt in z is currently unknown. Some electrostatics goes into calculating this and I haven't done the calculations
  - (I'm not sure how to do this at the moment.)

Data and cuts

- This is all performed with Run 101076
  - Lyon//sps/nusol/ARIS/data-reconstructed-lite/data-arisana_v1.04_a-lite/raw_101076_arisana_lite.root
    - 10 < tdrift < 120
    - total_s1ID > 0 && total_s2ID > 0
    - 0.2 < total_s1ID_f90 < 1
    - 0.0 < total_s2ID_f90 < 0.05
    - abs(r_barycenter)<2.5)

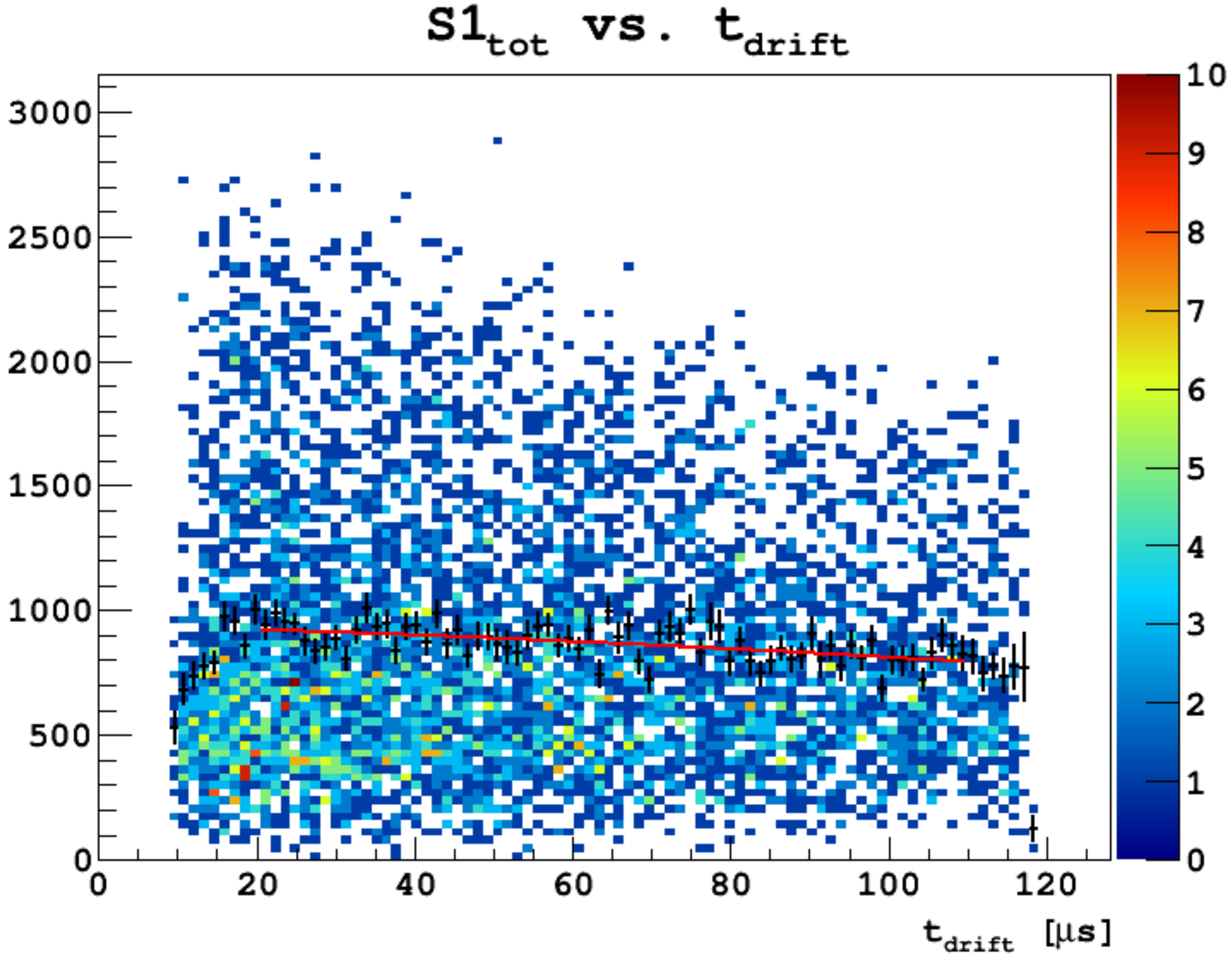
S1 z-correction

To calculate:
plot S1 vs. t_{drift}
fit ProfileX() with pol2
subtract non-constant terms

Note: normalized to top of detector, not center.

Best Fit:
Chi2/NDf = 81.8807/67

p0 = 942.351 +/- 43.5501
p1 = -0.850101 +/- 1.48561
p2 = -0.00451357 +/- 0.0113047



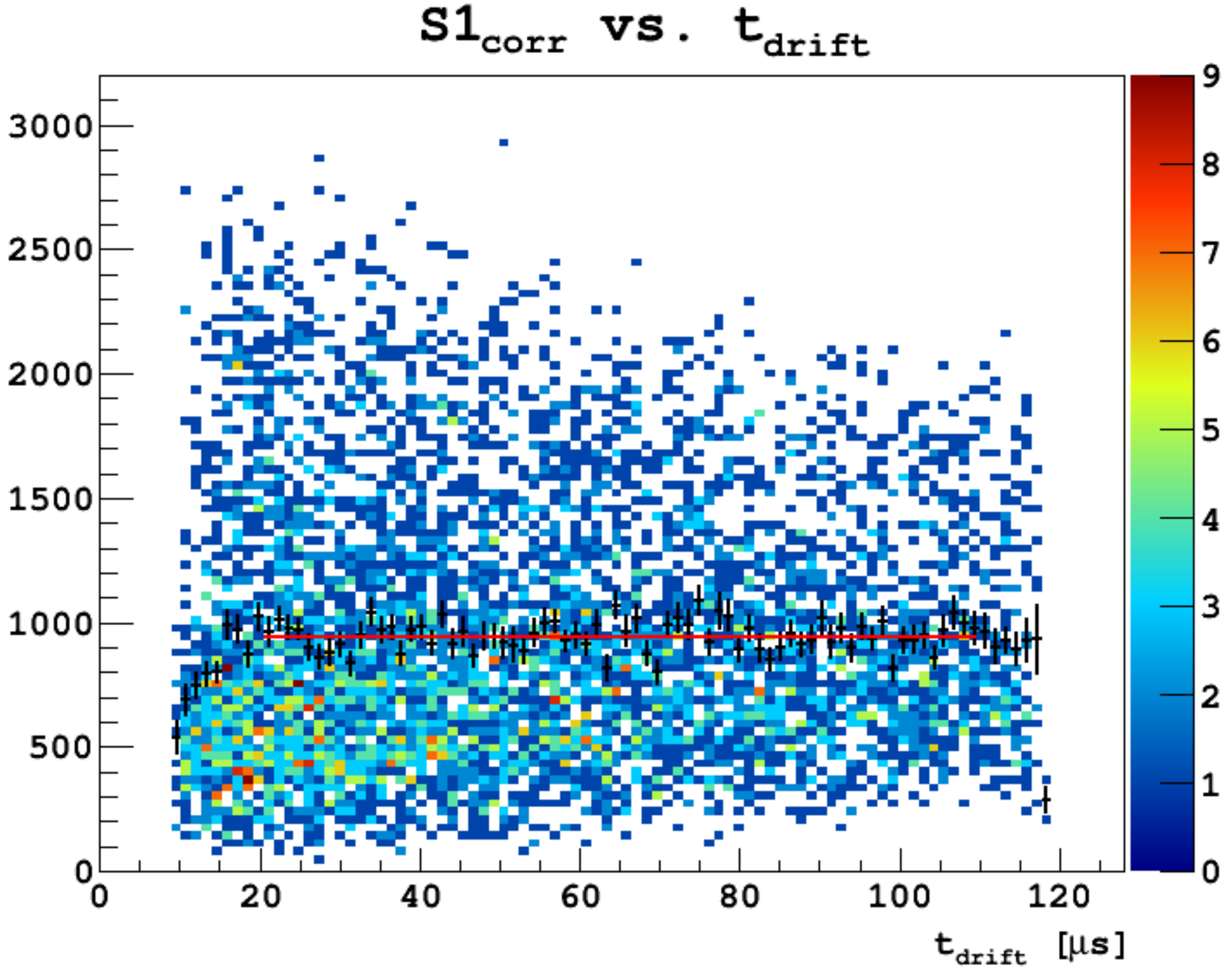
S1 z-correction

To calculate:
plot S1 vs. t_{drift}
fit ProfileX() with pol2
subtract non-constant terms

Note: normalized to top of detector, not center.

Best Fit:
Chi2/NDf = 80.7839/67

p0 = 940.638 +/- 43.56
p1 = 0.0512403 +/- 1.48551
p2 = -0.000413621 +/- 0.0113014



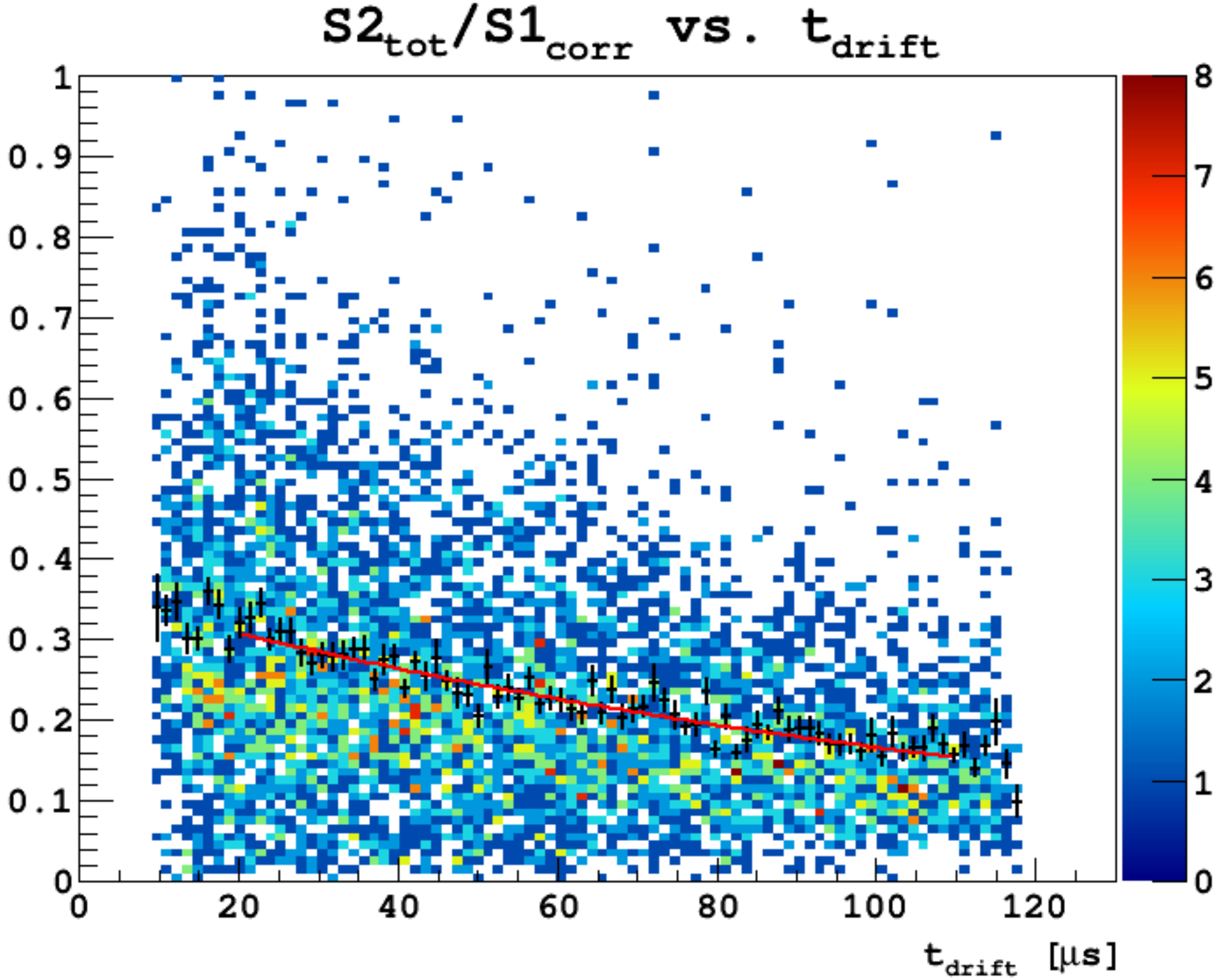
S2 z-correction

To calculate:
plot $S2/S1_{corr}$ vs. t_{drift}
fit ProfileX() with expo
divide by non-constant term

Note: normalized to top of detector, not center.

Best Fit:
EDM=1.4692e-11

Constant = -1.02138 +/- 0.0203160
Slope = -7.72852e-03 +/- 3.19666e-04



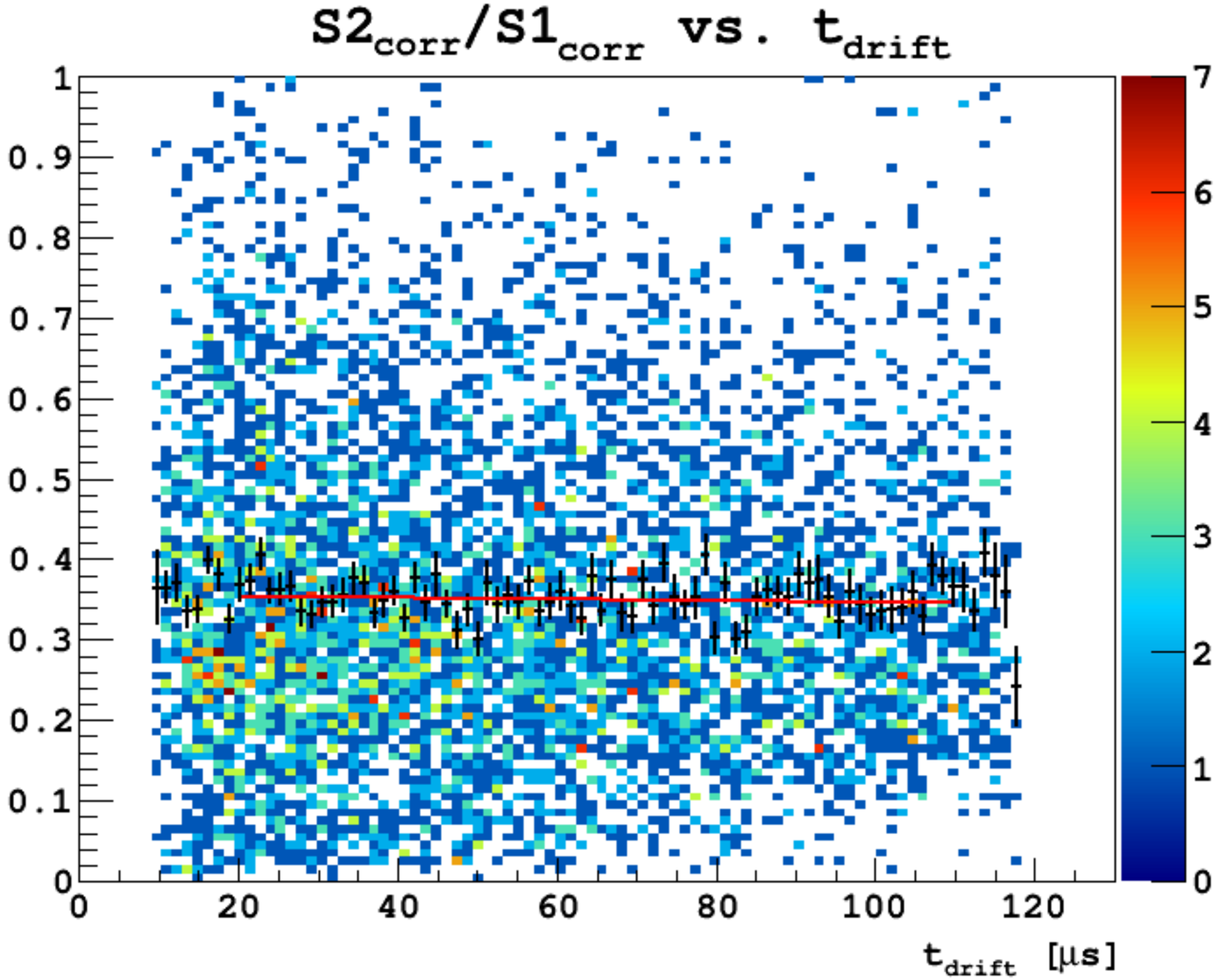
S2 z-correction

To calculate:
plot $S2/S1_{corr}$ vs. t_{drift}
fit ProfileX() with expo
divide by non-constant term

Note: normalized to top of detector, not center.

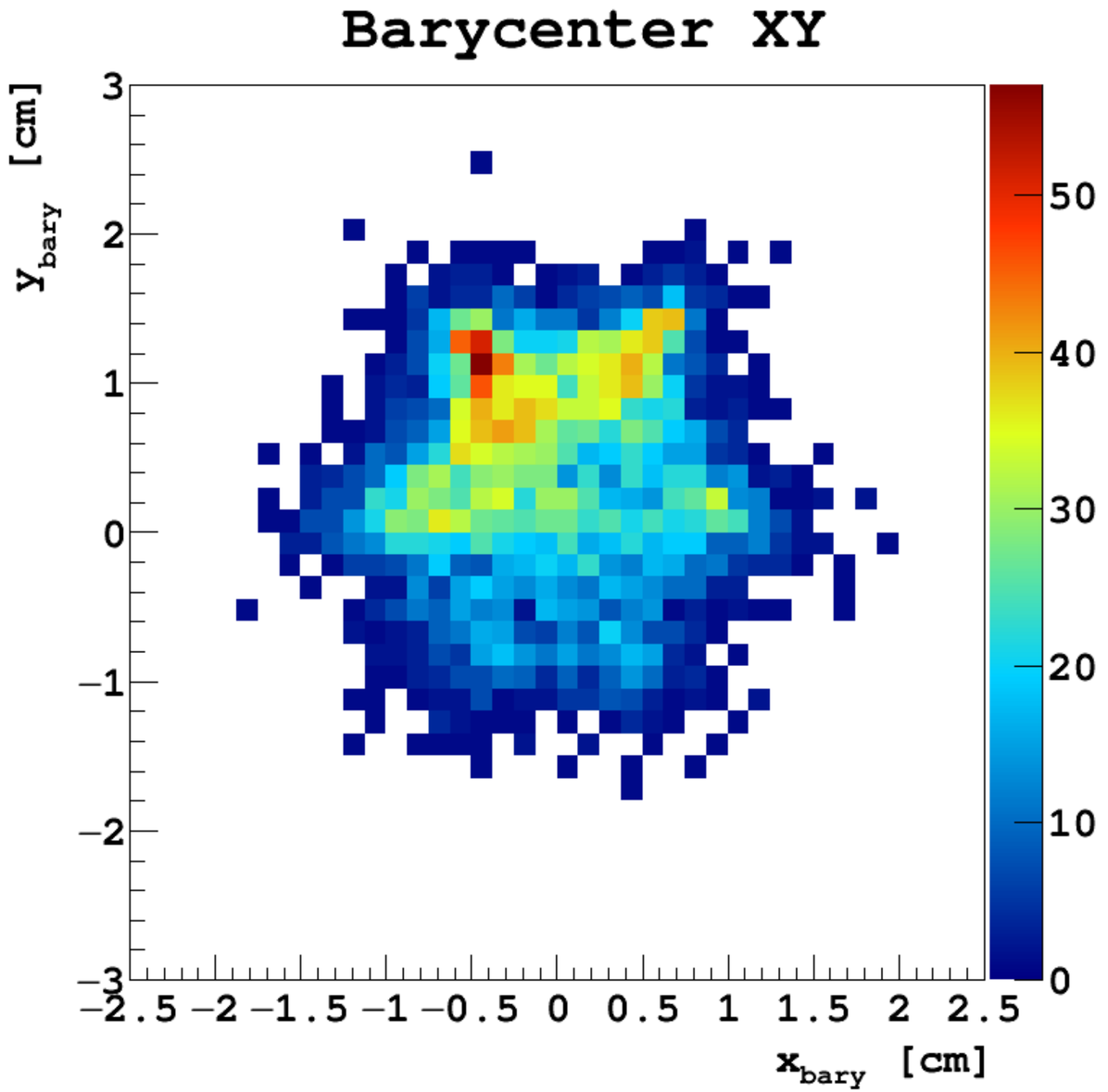
Best Fit:
EDM= 1.36019e-09

Constant = -1.03328 +/- 0.0191445
Slope = -2.62446e-04 +/- 2.92676e-04



Event Distribution in XY (barycenter)

Events concentrated at NW part of TPC. About 4-5x as many events per XY bin compared to SE part of TPC.

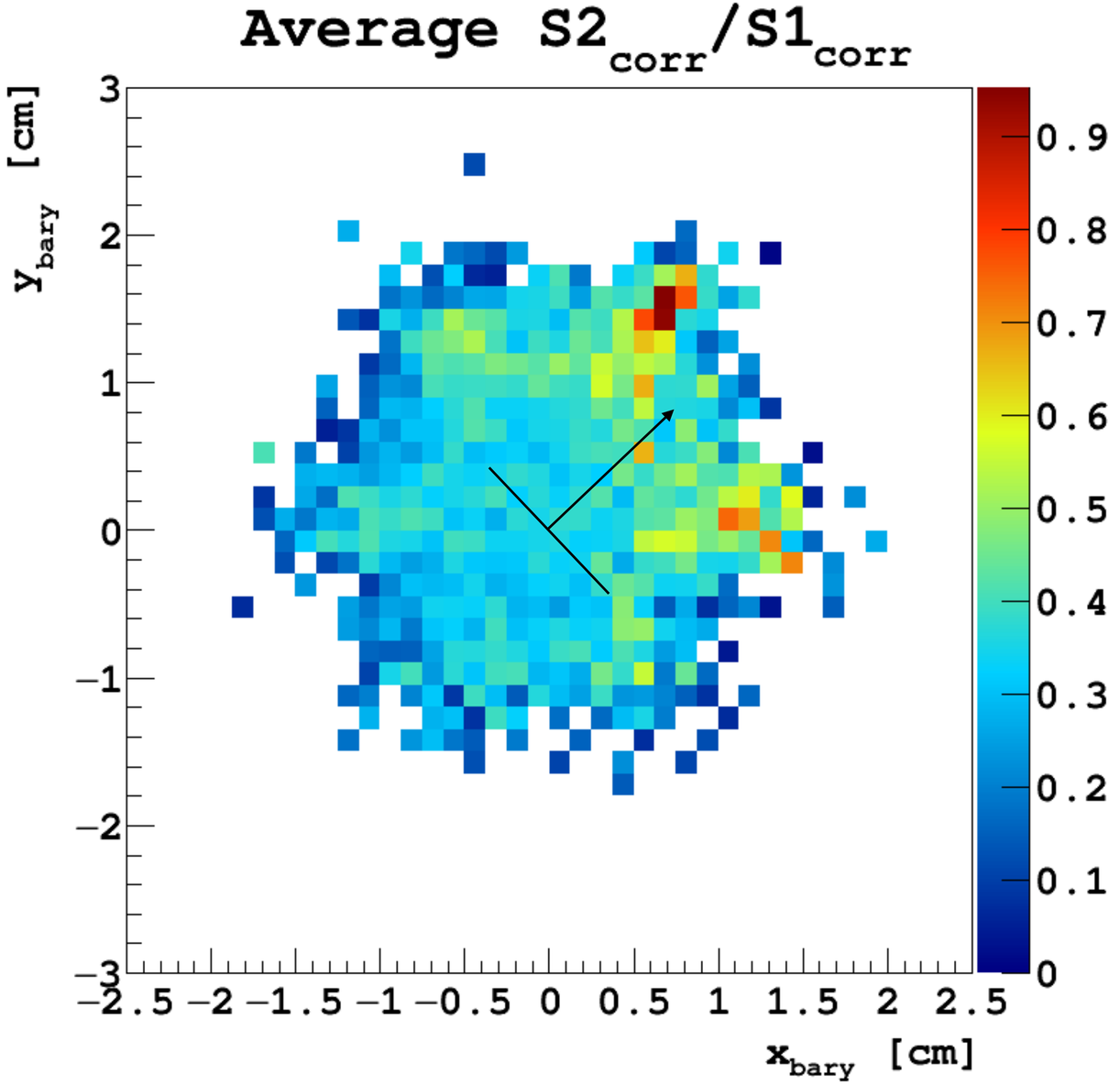


$S2_{corr}/S1_{corr}$ Distribution in XY (barycenter)

Events in the NE part of the detector have much larger $S2_{corr}/S1_{corr}$ ratios compared to events in the SW.

Evidence of detector tilt!

How to remove…?

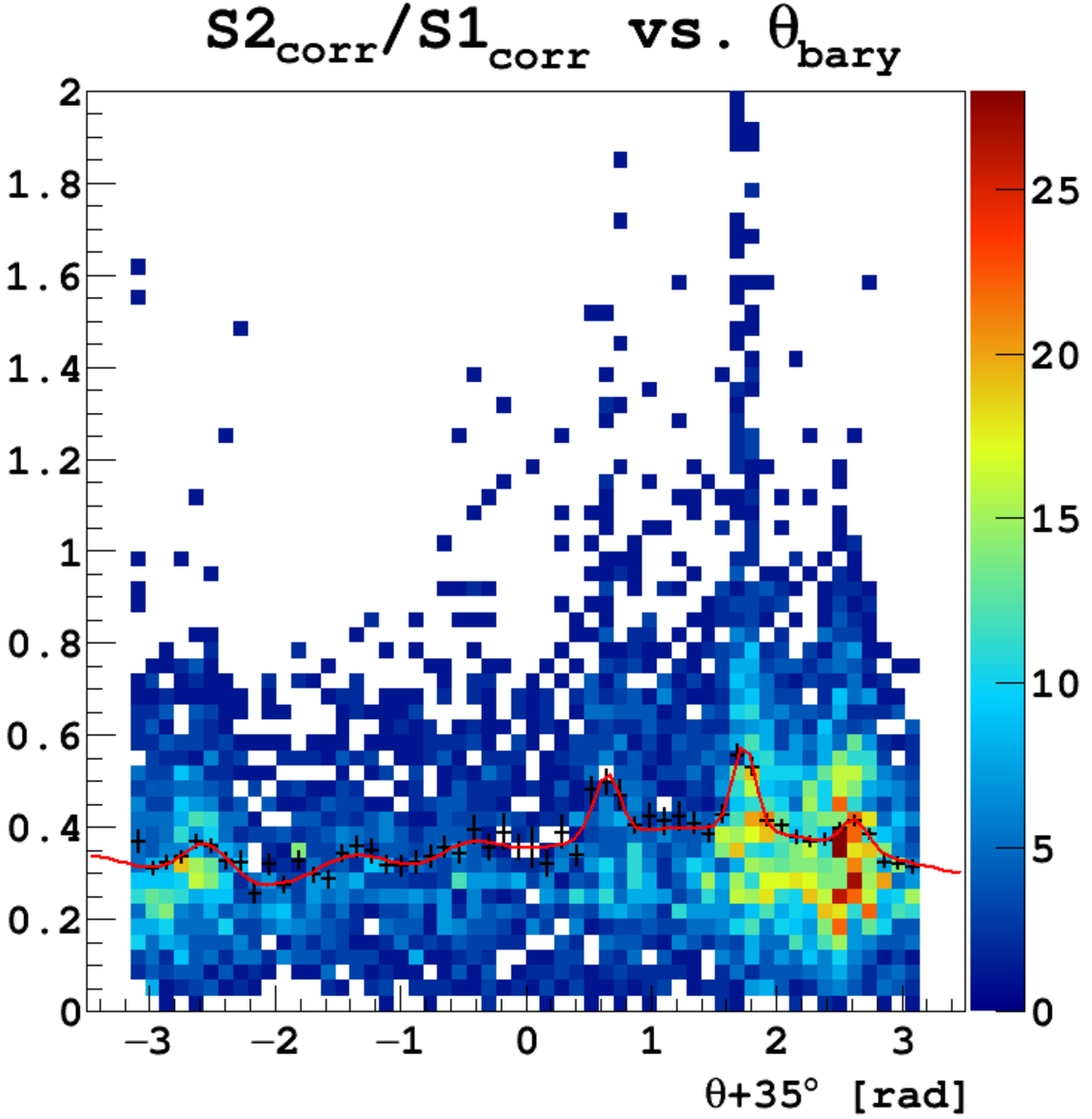


Finding the tilt angle

Plot $S2_{corr}/S1_{corr}$ vs. theta and fit.

Fit is 6 independent Gaussians, plus a cosine. The Gaussians fit the peaks under the outer PMTs, and the cosine fits the change in $S2_{corr}/S1_{corr}$ as we move around the TPC.

The peak of the cosine gives the angle at which the average $S2_{corr}/S1_{corr}$ is highest.



Fit

```
TF1* fit = new TF1("fit", "[0]*exp(-0.5*pow((x-[1])/[2],2))+[3]*exp(-0.5*pow((x-[4])/[5],2))+[6]*exp(-0.5*pow((x-[7])/[8],2))
+[9]*exp(-0.5*pow((x-[10])/[11],2))+[12]*exp(-0.5*pow((x-[13])/[14],2))+[15]*exp(-0.5*pow((x-[16])/[17],2)) + [18]*cos(x+[19])+ [20]");
```

Green boxed terms are the 6 Gaussians, red boxed term is cosine. (Also, constant [20].)

Parameter Initialization and Limits

```
fit->SetParameter(0,   0.1);
fit->SetParameter(3,   0.1);
fit->SetParameter(6,   0.1);
fit->SetParameter(9,   0.2);
fit->SetParameter(12,  0.2);
fit->SetParameter(15,  0.1);

fit->SetParameter(1,  -2.6); fit->SetParLimits(1,  -2.6, -2.5);
fit->SetParameter(4,  -1.3); fit->SetParLimits(4,  -1.6, -1.0);
fit->SetParameter(7,  -0.3); fit->SetParLimits(7,  -0.5, -0.1);
fit->SetParameter(10,  0.6); fit->SetParLimits(10,  0.5,  0.8);
fit->SetParameter(13,  1.8); fit->SetParLimits(13,  1.7,  1.8);
fit->SetParameter(16,  2.7); fit->SetParLimits(16,  2.5,  2.8);

fit->SetParameter(2,   0.1); fit->SetParLimits(2,  0, 0);
fit->SetParameter(5,   0.1); fit->SetParLimits(5,  0, 0.3);
fit->SetParameter(8,   0.2); fit->SetParLimits(8,  0, 0.3);
fit->SetParameter(11,  0.2); fit->SetParLimits(11, 0, 0.3);
fit->SetParameter(14,  0.1); fit->SetParLimits(14, 0, 0);
fit->SetParameter(17,  0.1); fit->SetParLimits(17, 0, 0);

fit->SetParameter(18, 0.10);
fit->SetParameter(19, 0.10);
fit->SetParameter(20, 0.15);
```

Fit Result

```
FCN=33.2844 FROM MIGRAD    STATUS=CONVERGED    3232 CALLS        3233 TOTAL
                EDM=6.74081e-07    STRATEGY= 1  ERROR MATRIX UNCERTAINTY   2.5 per cent
 EXT PARAMETER                                   STEP         FIRST
 NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
  1  p0           7.86344e-02   1.45068e-02  -5.06973e-06  -7.90191e-04
  2  p1          -2.54841e+00   3.54931e-02  -2.21413e-04  -4.24904e-04
  3  p2           1.81627e-01   6.22172e-02  -9.32806e-05  -1.32939e-02
  4  p3           6.79917e-02   2.34919e-02  -6.39907e-05  -2.50551e-02
  5  p4          -1.37408e+00   7.70901e-02   1.45851e-04  -2.69675e-04
  6  p5           3.00000e-01   5.87435e-04   9.35376e-06  -2.32044e-03
  7  p6           5.19989e-02   2.26877e-02  -3.28749e-05  -2.56693e-02
  8  p7          -4.62299e-01   8.28588e-02   5.46412e-04  -3.37782e-04
  9  p8           2.46105e-01   8.01839e-02  -2.08282e-04  -3.15616e-04
 10  p9           1.32270e-01   2.79892e-02  -7.12571e-06  -3.37465e-02
 11  p10          6.42349e-01   2.83985e-02  -1.18080e-04  -2.44033e-03
 12  p11          1.05138e-01   2.16882e-02  -2.07765e-05   1.33280e-04
 13  p12          1.85742e-01   2.33674e-02  -3.21570e-06  -9.77237e-03
 14  p13          1.74209e+00   1.13209e-02   6.38633e-05  -1.54876e-03
 15  p14          8.95908e-02   1.35019e-02   1.12994e-05   7.34886e-03
 16  p15          6.29997e-02   1.24638e-02  -1.09902e-05   5.46611e-02
 17  p16          2.61911e+00   2.26321e-02   1.26083e-04  -1.05786e-03
 18  p17          1.02794e-01   2.05357e-02   1.56999e-05   3.23281e-02
 19  p18          6.62158e-02   9.99630e-03  -2.01265e-05   9.63994e-02
 20  p19         -1.37027e+00   1.27822e-01   2.21451e-04  -1.28416e-02
 21  p20          3.32718e-01   8.20272e-03   1.49424e-05   5.97092e-02
```

[19] is -(tilt angle)

(Must subtract 35 degrees from this though. See previous plot.)

Calculating the tilt correction

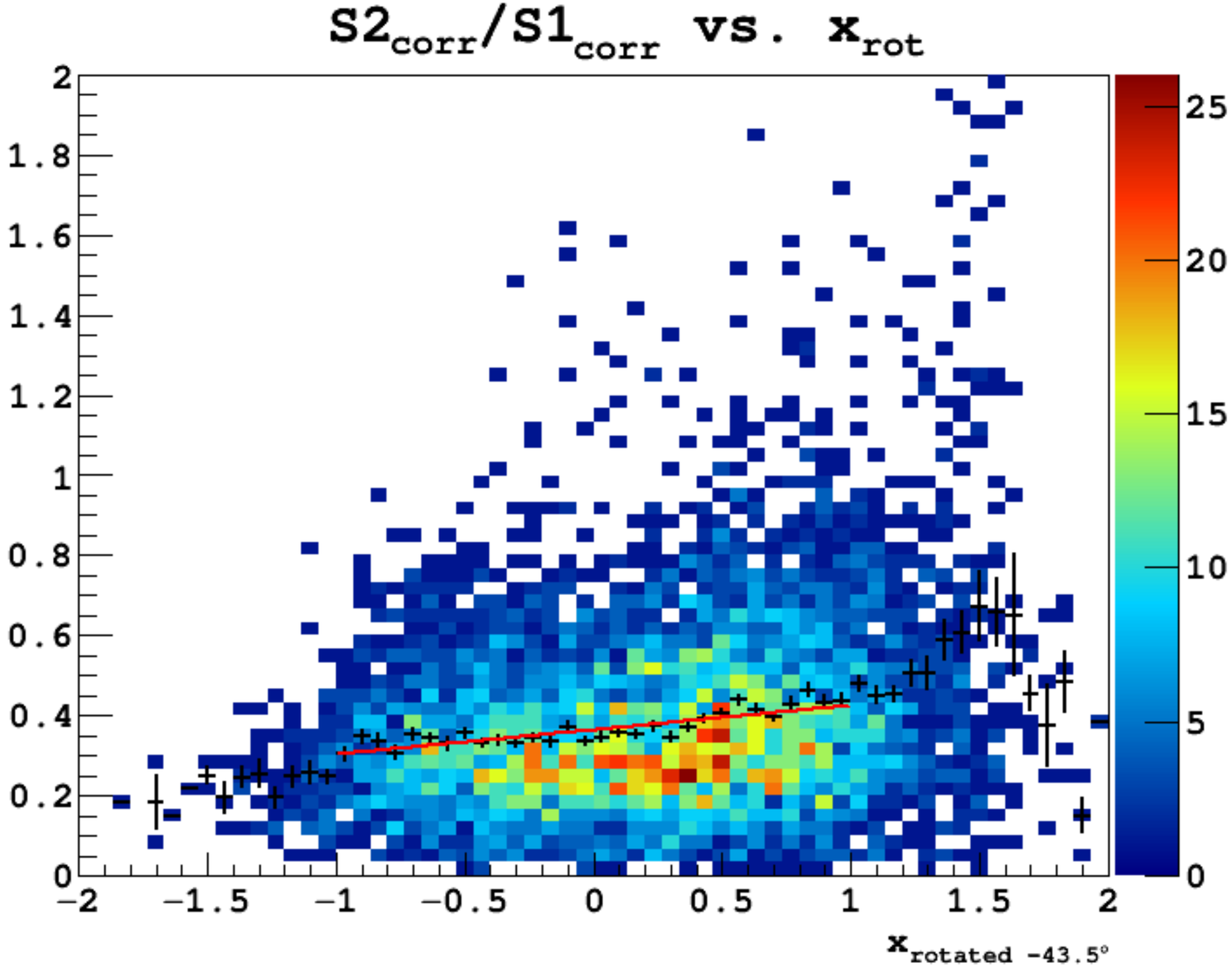
Tilt angle is 43.5 degrees.

Rotate (x,y) by this amount and draw $S2_{corr}/S1_{corr}$ vs. x_{rot} to find tilt correction.

Note: normalized to minimum $S2_{corr}/S1_{corr}$ value, not average.

Best Fit:
Chi2/NDf = 47.051/28

p0 = 0.364666 +/- 0.00286177
p1 = 0.0610921 +/- 0.00542845



Calculating the tilt correction

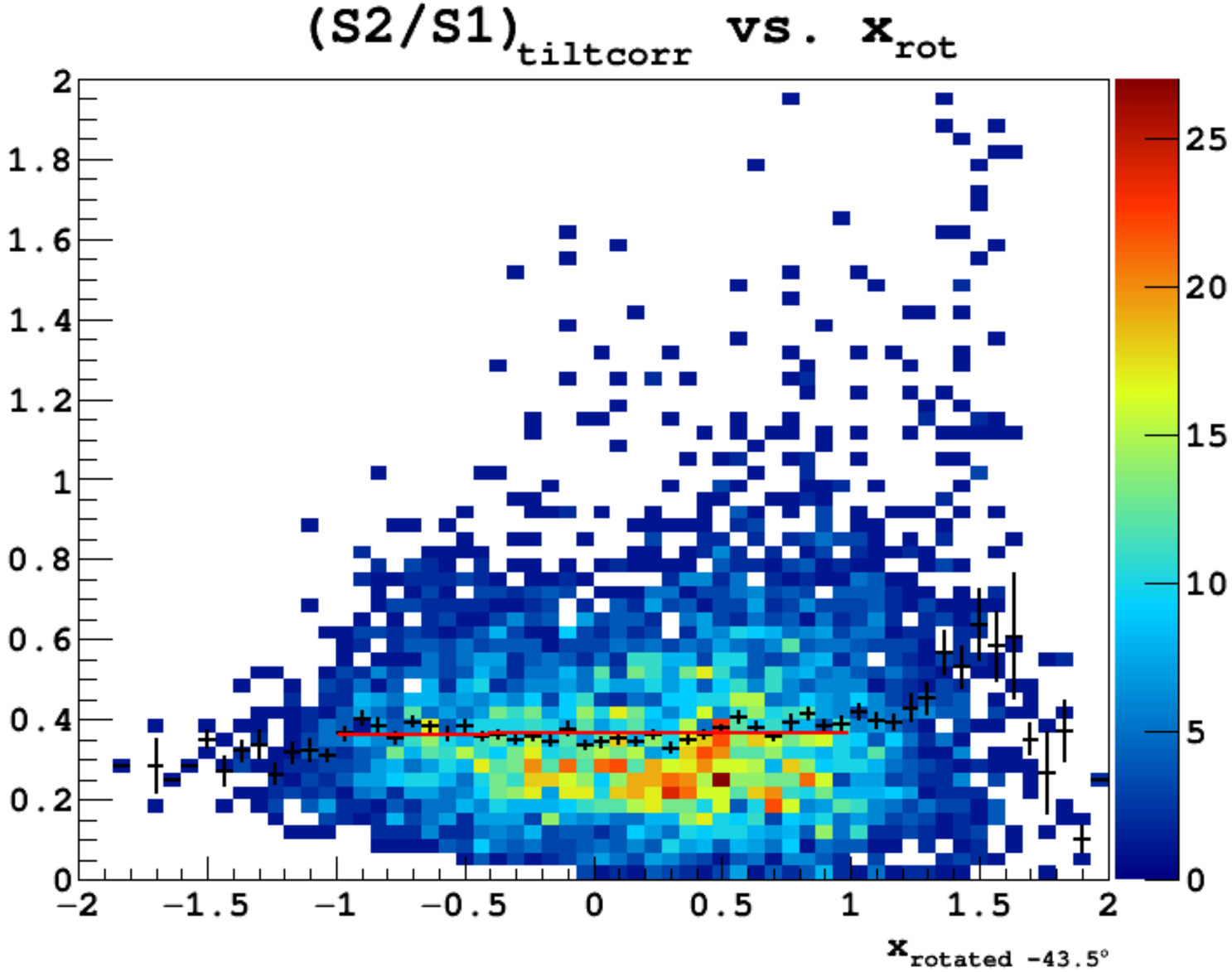
Tilt angle is 43.5 degrees.

Rotate (x,y) by this amount and draw $S2_{corr}/S1_{corr}$ vs. x_{rot} to find tilt correction.

Note: normalized to minimum $S2_{corr}/S1_{corr}$ value, not average.

Best Fit:
Chi2/NDf = 50.3078/28

p0 = 0.365191 +/- 0.00286659
p1 = 0.00252112 +/- 0.00544048



Tilt-corrected S2/S1

There are still very high bins at the NE part of the TPC, but the overall tilt is now removed.

Flip back and forth between this slide and slide 9 to see the improvement.

To include this in g4DS, we need the "height" of the tilt, which I have not calculated.