Software Workshop

HMS/SHMS Drift Chambers Calibration

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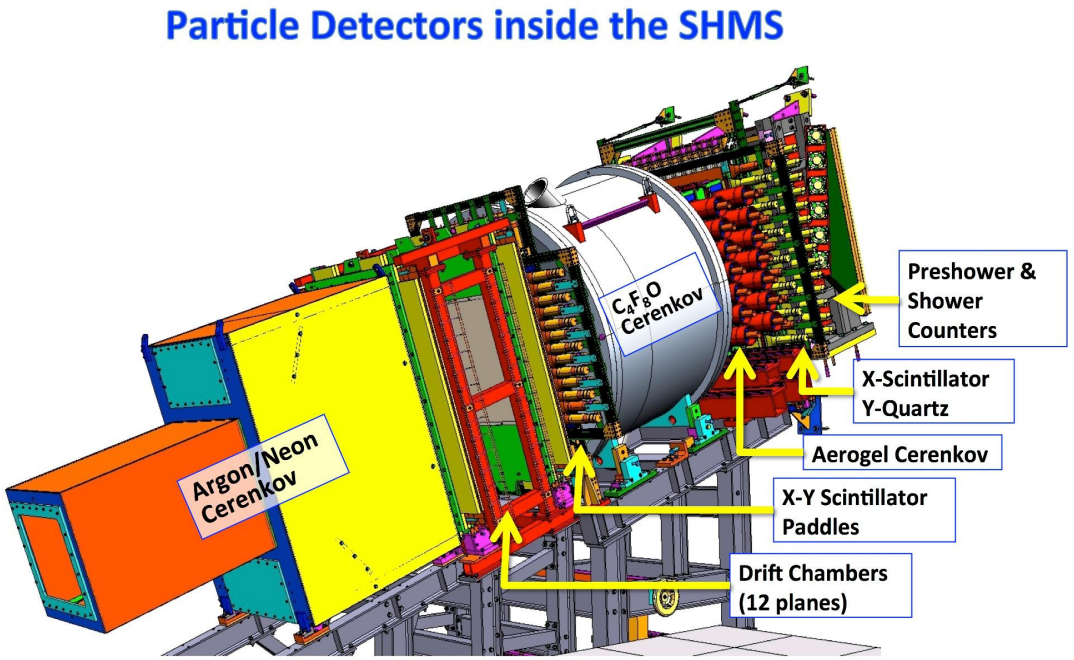
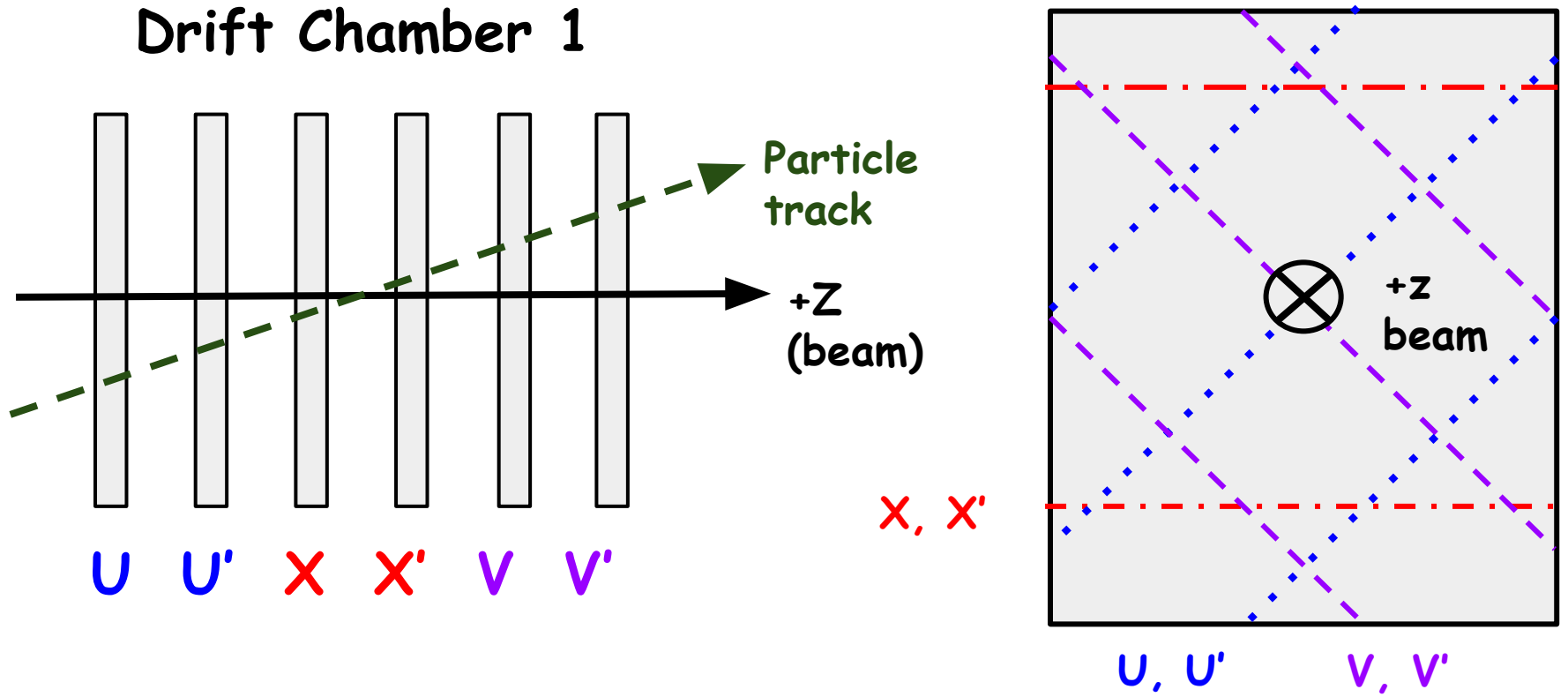
June 26, 2017

SHMS Detector Stack

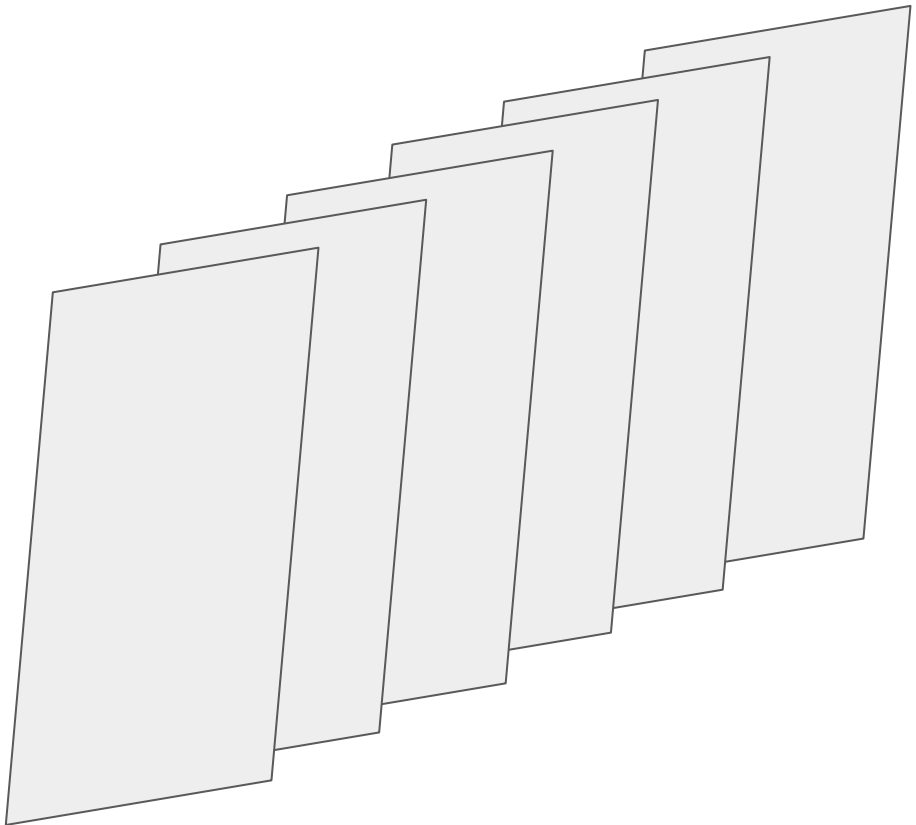
- Drift Chambers are tracking detectors
- Calibration is necessary for high precision particle track reconstruction
- Calibration involves the conversion of drift times to drift distances to obtain accurate track position



SHMS Drift Chamber Planes



How Does Tracking Work?



- Passage of the particle ionizes gas inside chamber
- Electrons from the gas drift towards the sense wire
- Drift times measured by TDC
- Calibration creates a lookup table used to convert drift times to drift distances
- Drift distance represents how far was the track from the sense wire that fired
- A collection of sense wire hits (stubs) are the fitted in each chamber and the best chi2-fit is chosen as best track.

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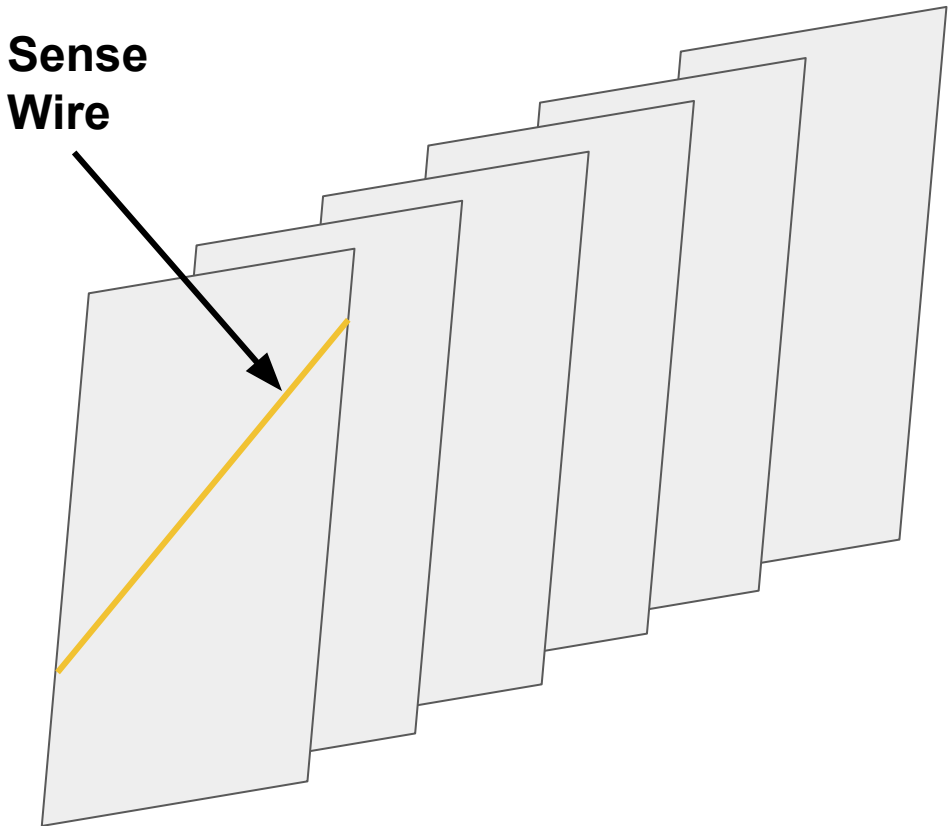

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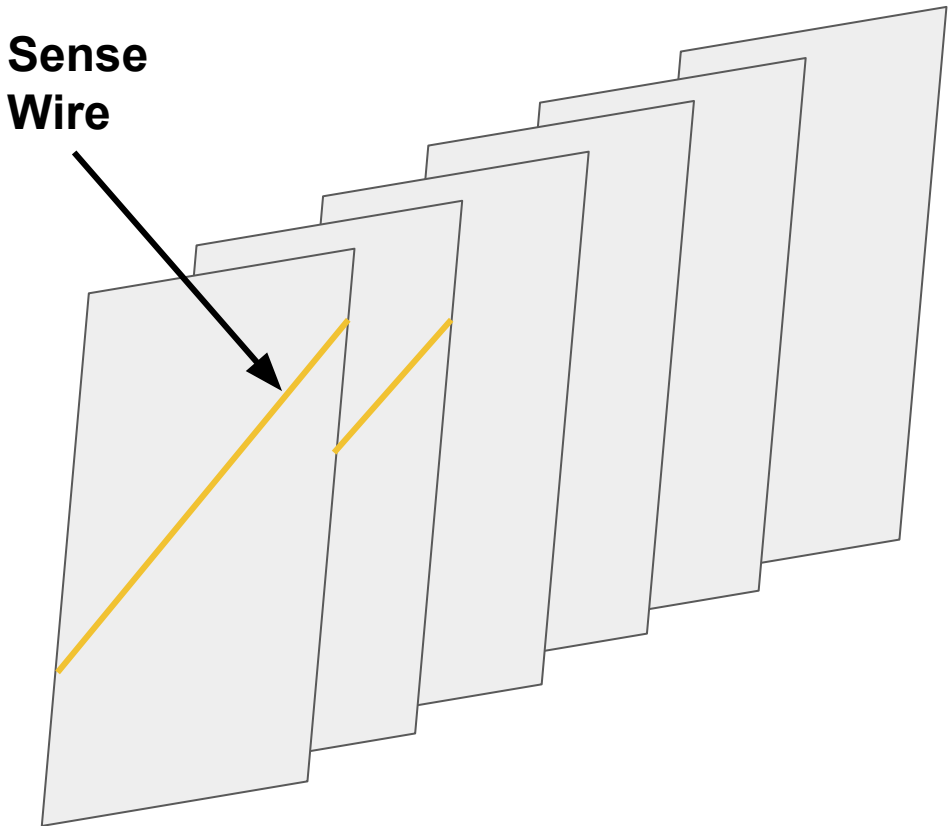

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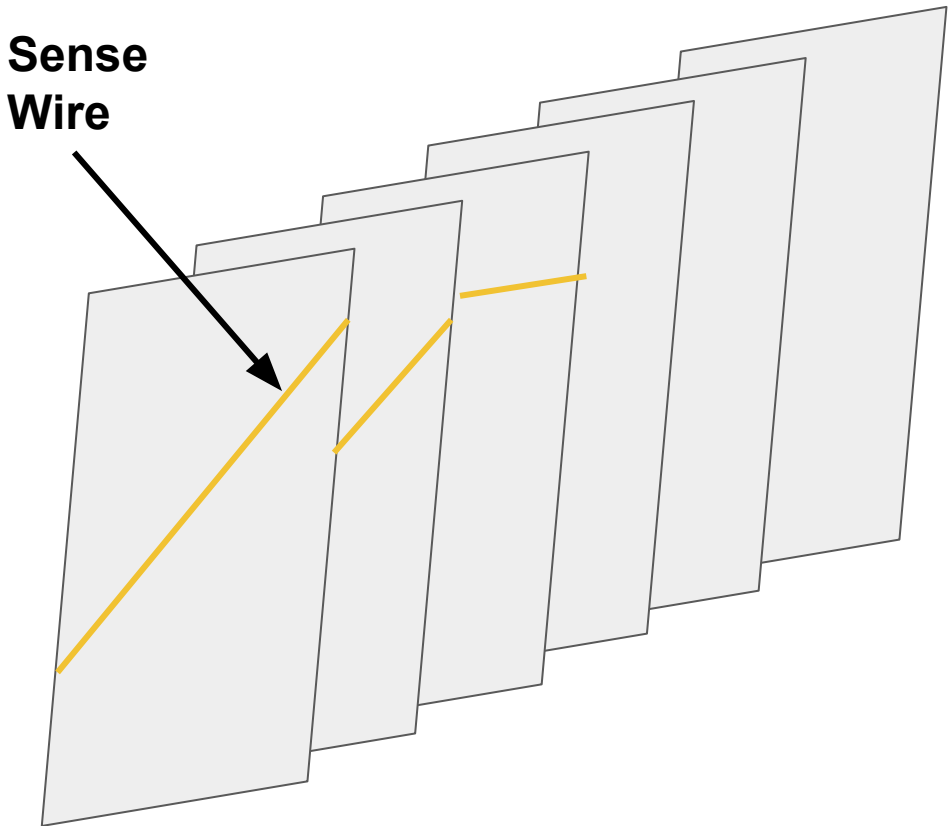

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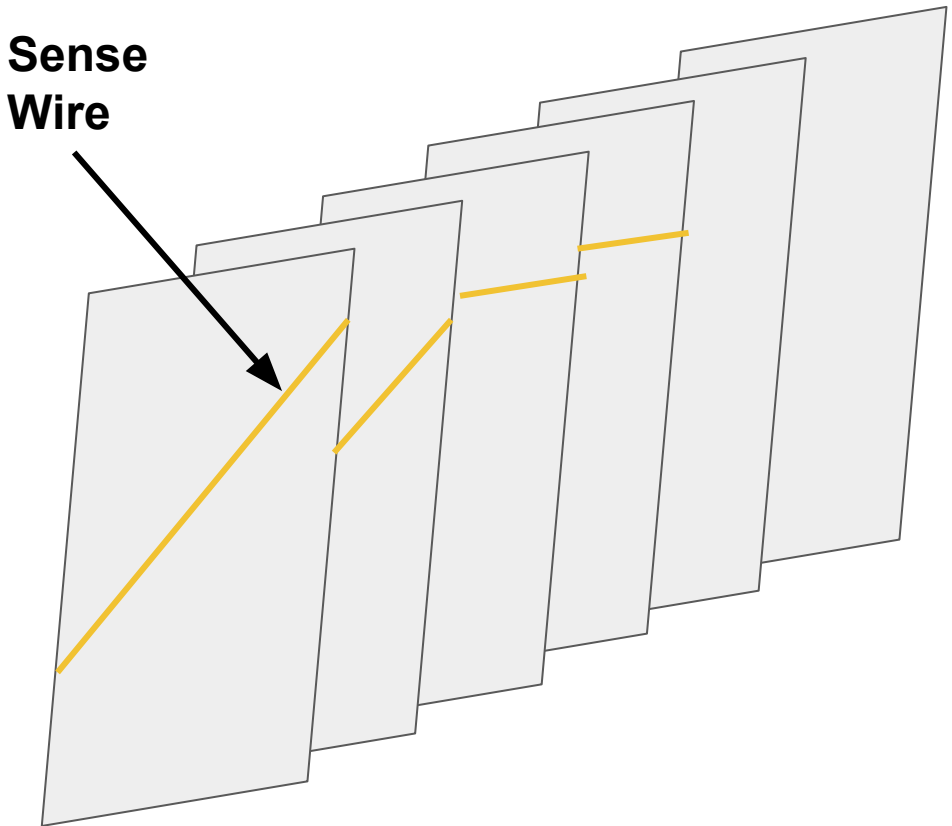

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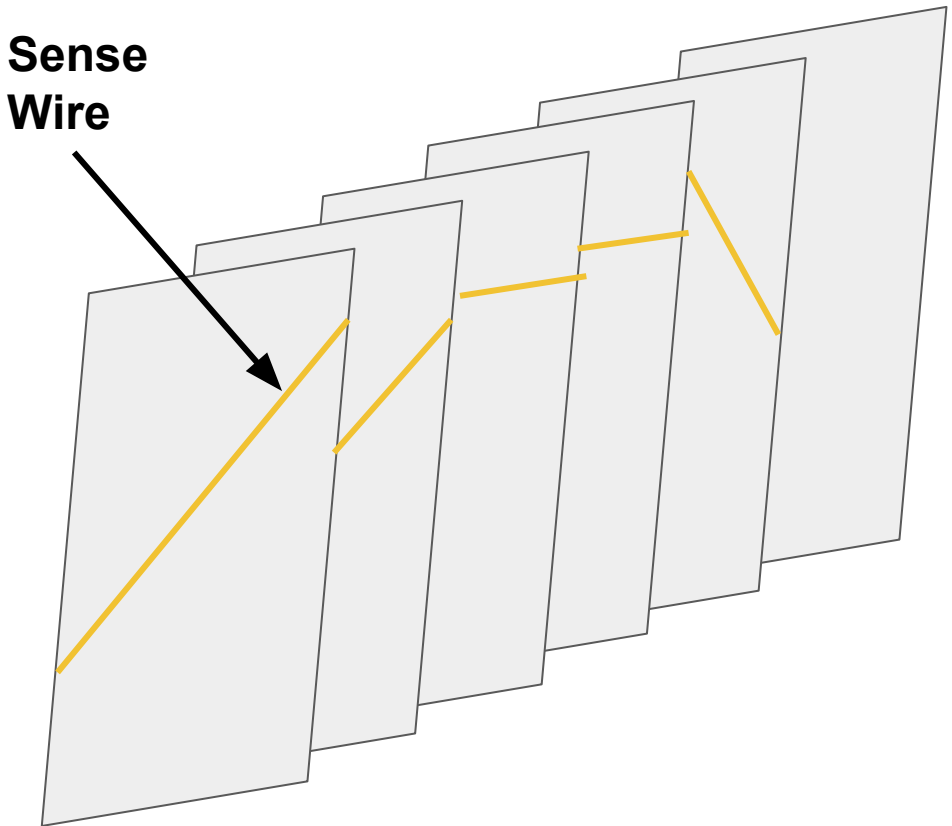

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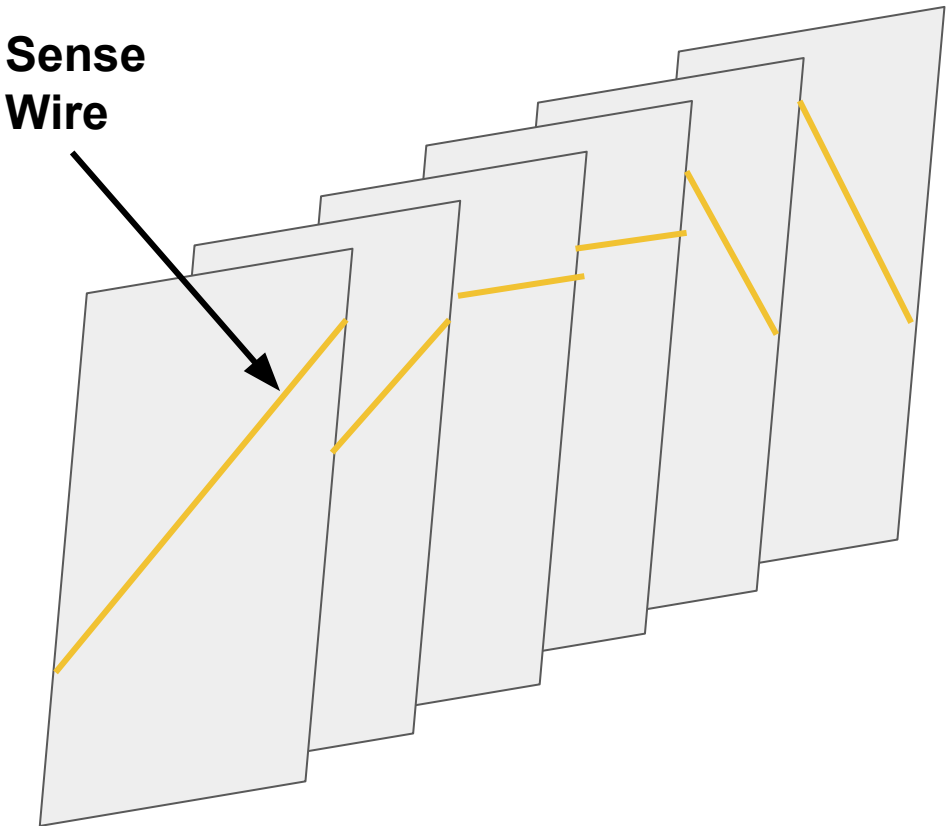

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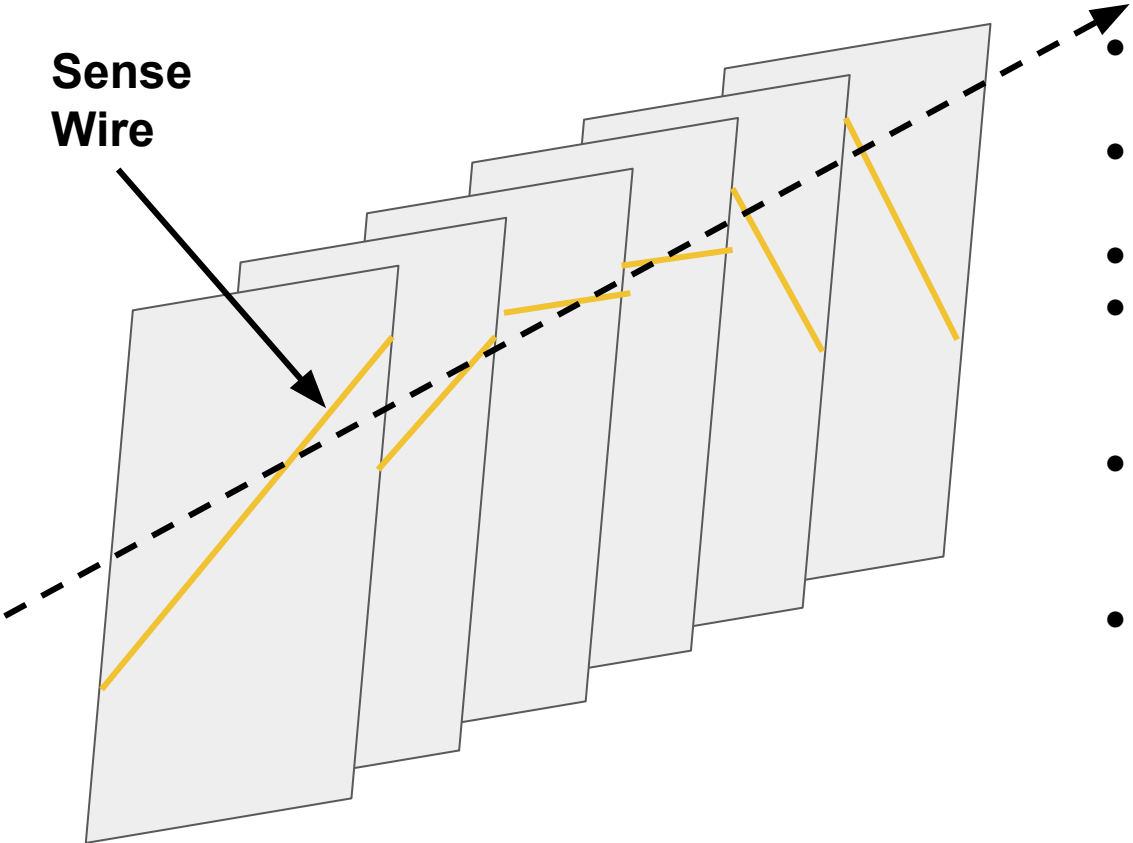

Particle Track

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Interactive Session Begins ….

Directory structure

* hallc_replay/CALIBRATION/shms_dc_calib/**run_Cal.C** **(steering code)**

* hallc_replay/CALIBRATION/shms_dc_calib/**scripts** **(calibration codes)**

* hallc_replay/CALIBRATION/shms_dc_calib/**root_files** **(produced by calib.)**

* hallc_replay/CALIBRATION/shms_dc_calib/**data_files** **(produced by calib.)**

Running the code

1. First set the parameter 'p_using_tzero_per_wire = 0' in the parameter file located at:

   hallc_replay/PARAM/SHMS/DC/pdc.param

2. Replay the data to produce the uncalibrated root file to be used as input in the Calibration

   From the hallc_replay execute: ./hcana SCRIPTS/SHMS/replay_shms.C

3. Run the calibration script with the newly produced root file as input. The script is located at:

   hallc_replay/CALIBRATION/shms_dc_calib/

From this directory,type:

>> root -l run_Cal.C

Running the code ...Continued

Once you run run_Cal.C, you will be asked to input:

Replay root file name (without the .root extension): ex. shms_replay_488_500000

The run number: ex. 488

The number of events to be calibrated: ex. 100000

Due to limited time, use 200,000 events for the calibration.

While you wait ...Brief Description of Calibration Scripts

The steering script (run_Cal.C) runs a series of scripts that work together to perform the calibration.

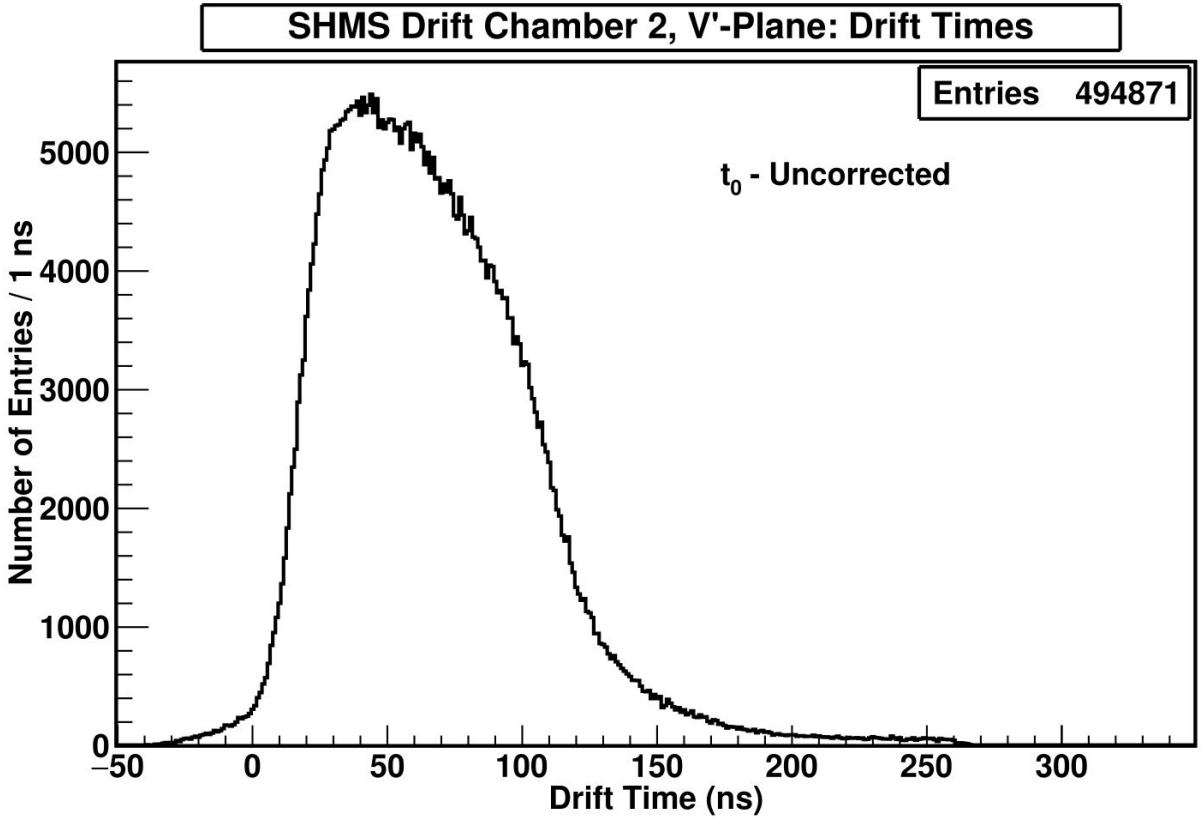
The scripts are located in: hallc_replay/CALIBRATION/shms_dc_calib/scripts

The scripts are executed by the steering script in the following order:

- get_pdc_time_histo.C
- wire_drift_times.C, wire_drift_times.h (using "Make Class")
- get_wire_tzero.C
- get_tzero_per_wire_param.C
- get_pdc_time_histo_tzero_corrected_v2.C
- get_LookUp_Values.C

In the following slides, we will go over the output of each script mentioned above.

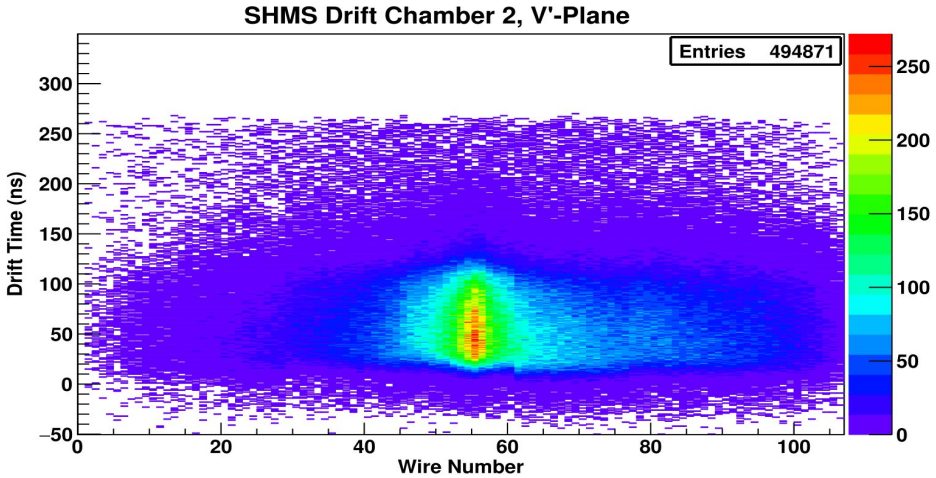
❑ get_pdc_time_histo.C



Output:
'shms_dc_time_run#.root'

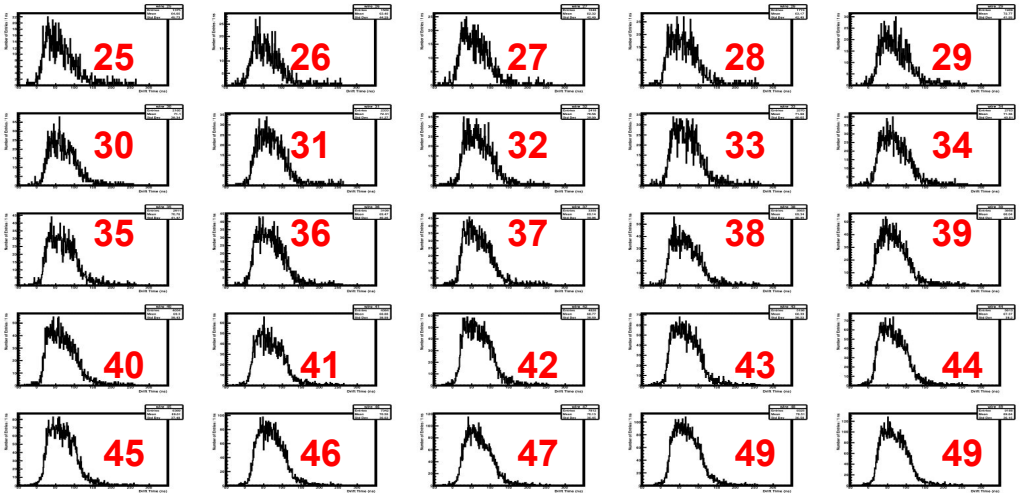
--contains re-binned per-plane drift time histograms

❑ wire_drift_times.C, wire_drift_times.h



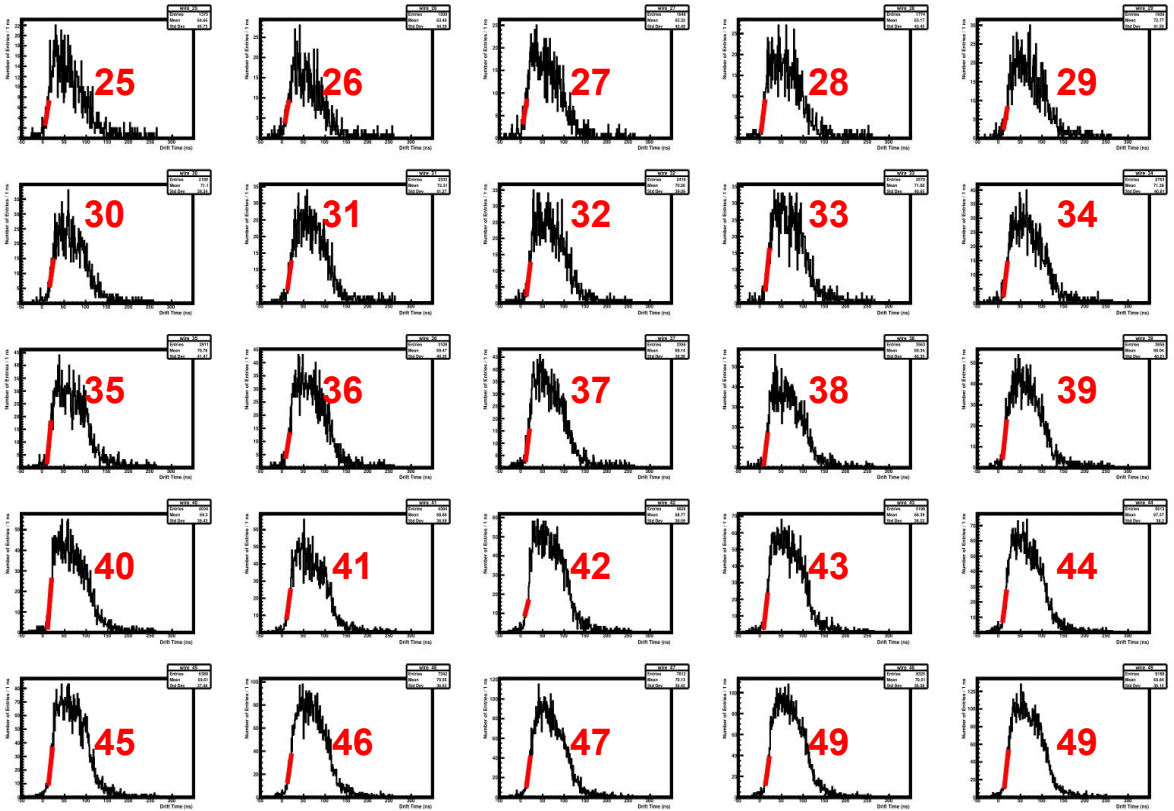
Outputs root_file:
'shms_DC_plane_run#_wire_histos.root'

-- contains a 2-D histo of "drift time vs. Wire Number" and drift time spectra for all wires in the plane



Drift time spectra for wires 25-49 (107 wires in total for the V'-Plane)

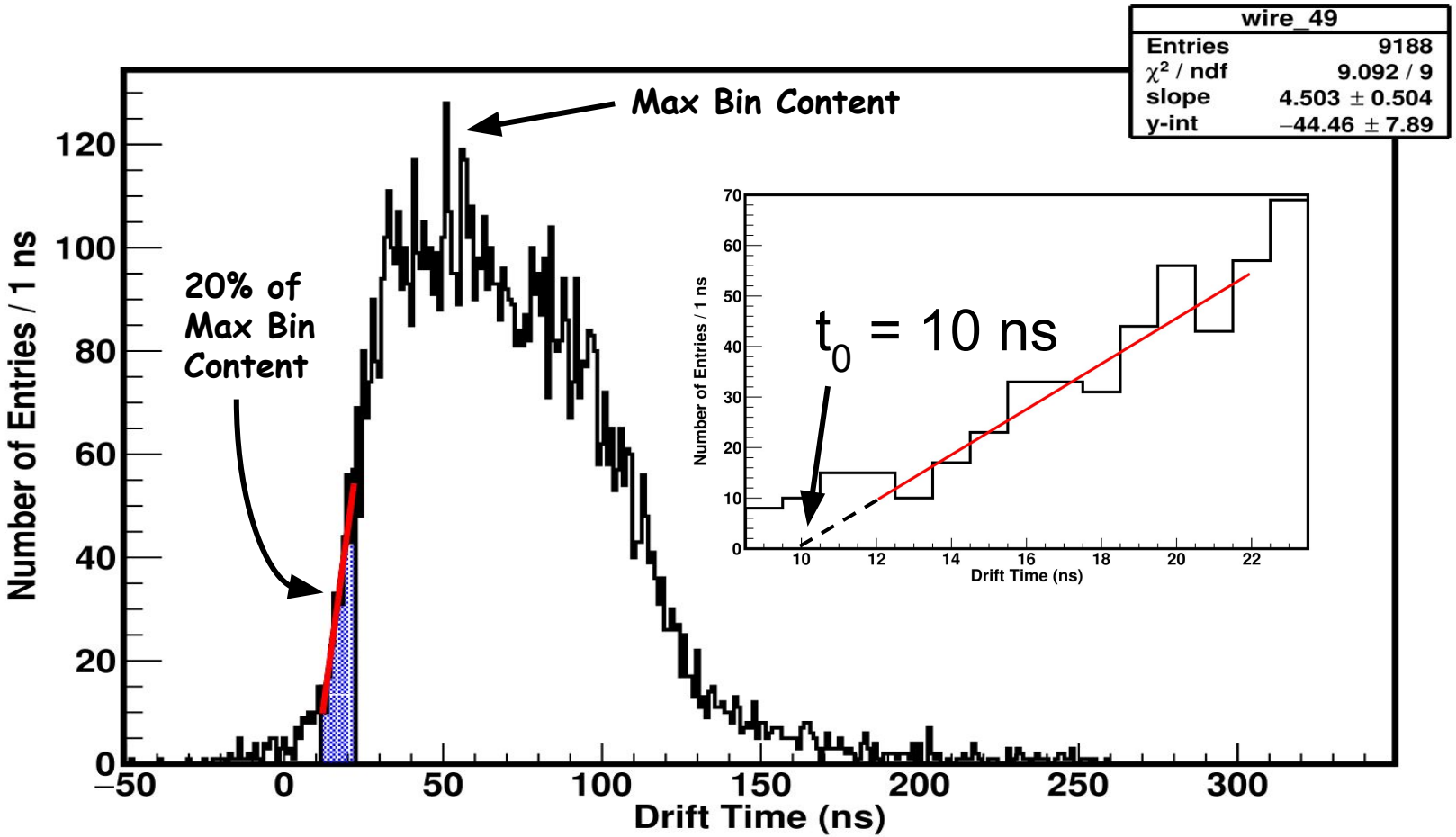
❑ get_wire_tzero.C



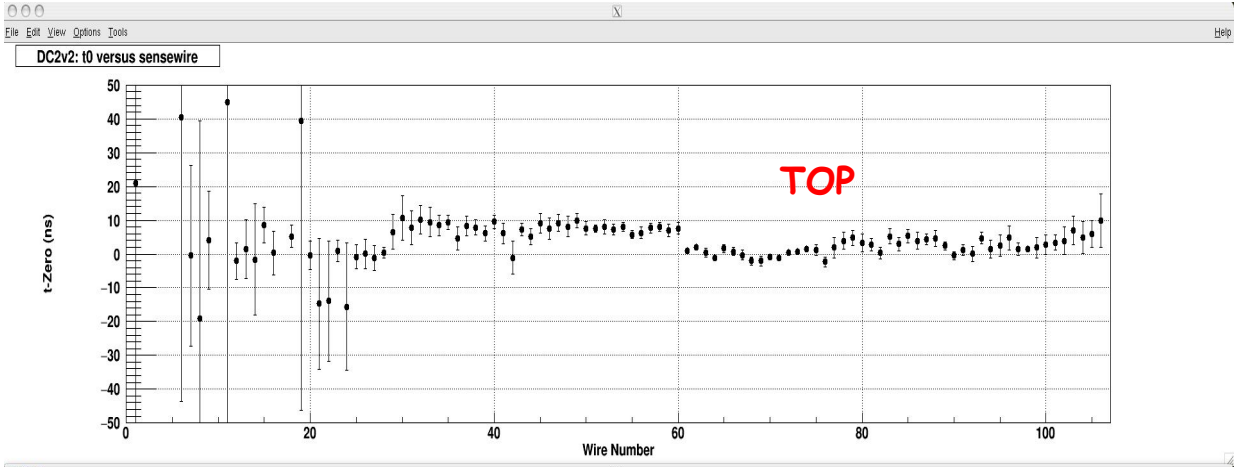
-- outputs root_file:
'shms_DC_plane_run#_fitted_histos.root'

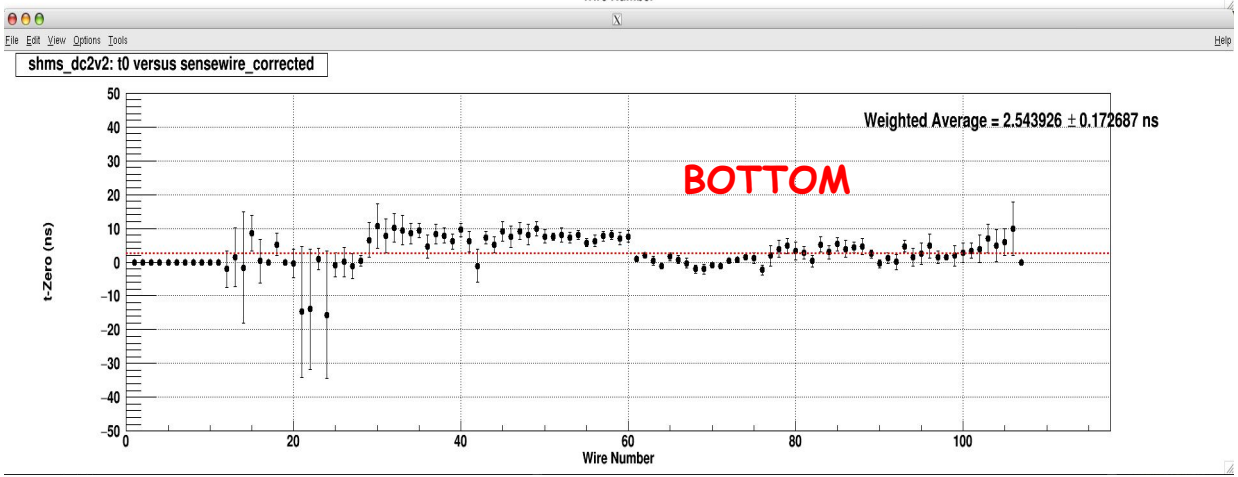
-- contains line-fitted wire drift time histos. The extrapolation of the fit to the x-axis is defined as "tzero" and represents the time at which the electron has come in contact with the sense wire. Therefore, the drift time spectra must be offset to align the "tzero" with a drift time of zero nanoseconds.

- get_wire_tzero.C



❑ get_wire_tzero.C





The root file

'shms_DC_plane_run#_fitted_histos.root'

also contains two "tzero vs. wire number" plots:

TOP: 'tzero' values vs. Wire Number

BOTTOM: for wires that did not have enough statistics for a good quality fit, the 'tzero' was set to 0 ns.

The 'tzero' weighted average was calculated for all planes.

(In the past, this weighted avg. was applied to each chamber plane, but now the offset is done wire by wire)

❑ get_wire_tzero.C

```
#WIRE            t0          t0_err        entries
1                21          254.86             33
2    -1.63767e+14     1.89644e+28             58
3    -1.27677e+14      5.5373e+27             72
4    -6.38808e+13     4.45248e+26             94
5     9.16111e+11     1.18689e+24            119
6         40.3774         84.1182            167
7        -0.504854         26.7054            207
8         -19.0116         58.5082            227
9          4.02222         14.5508            290
10          -174.25         3221.35            344
11               45         280.815            413
12             -2.1         5.29451            434
13          1.34033         8.71093            463
14         -1.59667         16.5133            518
15          8.57056         5.25803            643
16         0.276423          6.4461            672
17         -89.8462         562.525            751
18          5.22418         3.32222            784
19           39.535         85.7869            877
20        -0.311936         4.26604            980
21         -14.6467         19.3815           1047
22          -13.937         17.8237           1131
23         0.956811          3.1991           1275
24         -15.6571         18.8585           1335
25        -0.825362         3.64092           1375
26       0.00725091         4.27683           1509
27          -1.1311         3.71947           1648
28         0.421375         1.51935           1774
29           6.5395         5.14957           1909
-:---   shms_dc_2v2tzero_run488.dat    Top L1     (Fundam
menu-bar buffer C-c
```

```
#Wire        t_zero      t_zero_err        entries
1                 0               0             18
2                 0               0             37
3                 0               0             48
4                 0               0             57
5                 0               0             85
6                 0               0             65
7                 0               0            118
8                 0               0            148
9                 0               0            162
10                0               0            188
11                0               0            218
12                0               0            257
13                0               0            261
14          4.13281         12.3221            341
15          4.80894         16.1101            327
-:---   shms_dc_2v2tzero_run484_updated.dat    Top L6     (Fundar
```

```
 #weighted_AVG       DC plane: 1u1
2.33729
 #weighted_AVG       DC plane: 1u2
1.99103
 #weighted_AVG       DC plane: 1x1
-0.728702
 #weighted_AVG       DC plane: 1x2
-0.539862
 #weighted_AVG       DC plane: 1v1
d_AVG                DC plane: 1v2
d_AVG                DC plane: 2v2
```

tzero data file

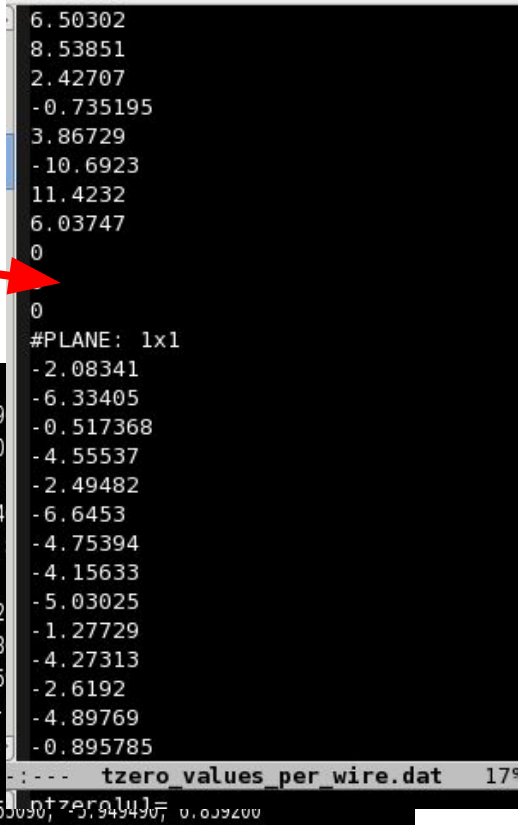
tzero weighted avg. per plane

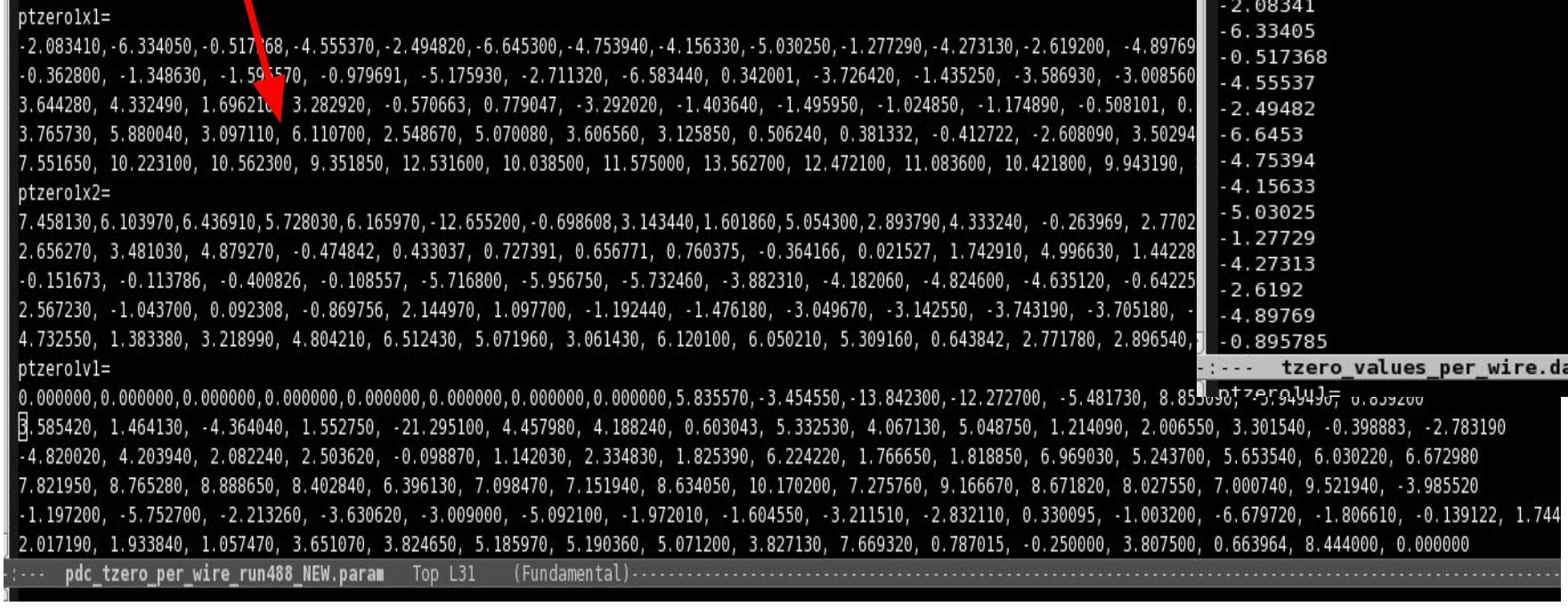
tzero updated data file (only for entries>300)

- get_tzero_per_wire_param.C

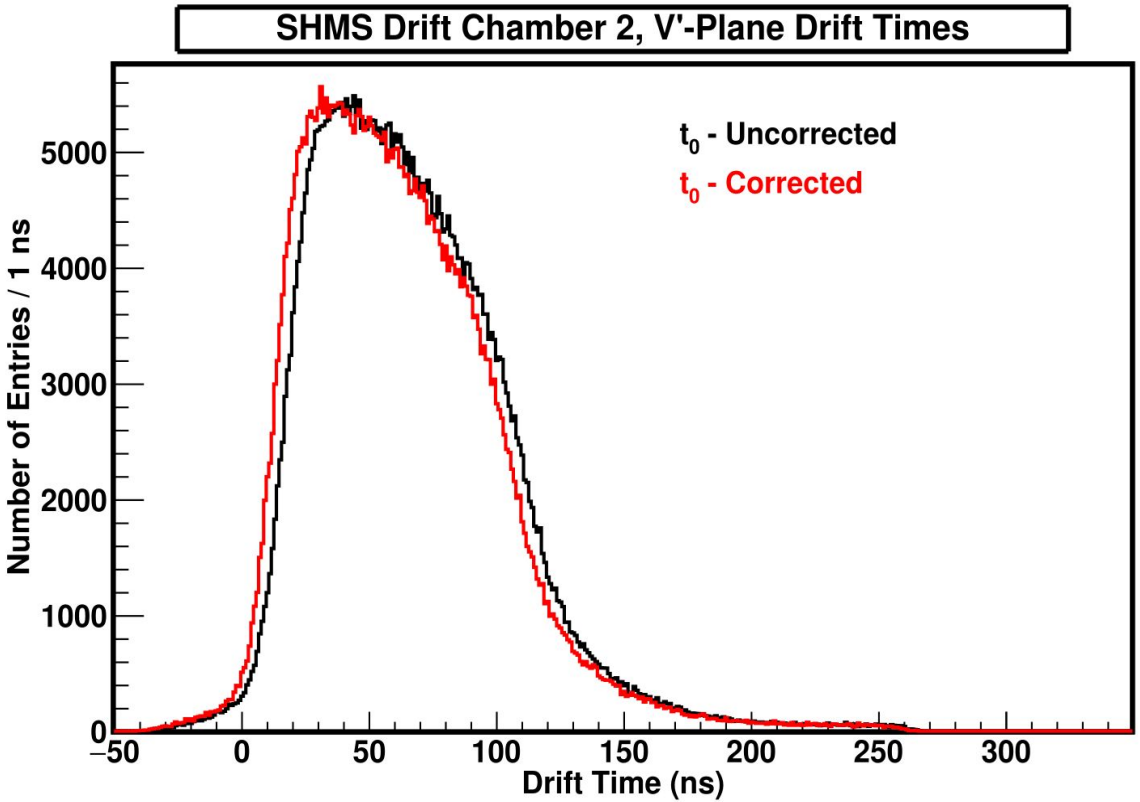
tzero values for all wires in all planes

tzero parameter file





❑ get_pdc_time_histo_tzero_corrected_v2.C



--outputs root_file:

'shms_tzero_corr_histo.root'

--contains 'tzero' corrected per-plane drift times

This script reads tzero data file, and applies the tzero-offset to each plane on an event by event basis.

❑ get_LookUp_Values.C

```
; Lookup Table: RUN 488
; number of bins in time to distance lookup table
pdriftbins = 275
; number of 1st bin in table in ns
pdrift1stbin=0
; bin size in ns
pdriftbinsz=1
pwc1u1fract=0.0010211,0.00213,0.00345,0.00498,0.00681,0.00913,0.01182,0.01518,0.01900,0.02323,0.02795,0.03334,0.03902,0.04521,0.05188,0.05898,0.06665,0.07458,0.08280
0.09150,0.10068,0.10987,0.11943,0.12920,0.13917,0.14933,0.15940,0.16972,0.18072,0.19111,0.20212,0.21304,0.22395,0.23489,0.24592,0.25677,0.26799,0.27894,0.28986
0.30103,0.31197,0.32317,0.33399,0.34477,0.35573,0.36684,0.37769,0.38864,0.39944,0.41040,0.42121,0.43199,0.44279,0.45397,0.46463,0.47530,0.48599,0.49645,0.50724
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0.72025,0.72949,0.73873,0.74753,0.75642,0.76536,0.77397,0.78266,0.79114,0.79957,0.80781,0.81593,0.82393,0.83147,0.83892,0.84652,0.85378,0.86063,0.86762,0.87419
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0.97566,0.97636,0.97712,0.97783,0.97847,0.97914,0.97986,0.98045,0.98101,0.98152,0.98208,0.98260,0.98311,0.98357,0.98407,0.98446,0.98487,0.98539,0.98578,0.98617
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0.99372,0.99383,0.99397,0.99407,0.99416,0.99426,0.99435,0.99445,0.99456,0.99464,0.99475,0.99487,0.99498,0.99507,0.99517,0.99527,0.99539,0.99549,0.99562,0.99573
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0.99979,0.99985,0.99988,0.99991,0.99992,0.99995,0.99997,0.99998,0.99998,0.99999,1.00000,1.00000,1.00000,1.00000,1.00000,1.00000
pwc1u2fract=0.00092,0.00195,0.00317,0.00468,0.00667,0.00882,0.01136,0.01442,0.01800,0.02224,0.02690,0.03202,0.03756,0.04367,0.05022,0.05738,0.06491,0.07306,0.08149
0.09065,0.09983,0.10927,0.11905,0.12880,0.13900,0.14920,0.15953,0.17028,0.18092,0.19170,0.20238,0.21304,0.22423,0.23532,0.24632,0.25708,0.26826,0.27922,0.29018
0.30110,0.31223,0.32363,0.33462,0.34554,0.35646,0.36718,0.37826,0.38901,0.39987,0.41062,0.42140,0.43192,0.44266,0.45354,0.46390,0.47437,0.48492,0.49586,0.50627
0.51651,0.52686,0.53723,0.54765,0.55792,0.56822,0.57864,0.58870,0.59887,0.60889,0.61892,0.62924,0.63893,0.64857,0.65822,0.66774,0.67711,0.68667,0.69595,0.70540
0.71466,0.72395,0.73293,0.74191,0.75090,0.75988,0.76898,0.77762,0.78634,0.79476,0.80279,0.81098,0.81908,0.82696,0.83431,0.84161,0.84878,0.85578,0.86271,0.86936
0.87582,0.88193,0.88788,0.89336,0.89878,0.90397,0.90855,0.91303,0.91727,0.92122,0.92486,0.92833,0.93161,0.93447,0.93736,0.93997,0.94236,0.94476,0.94680,0.94893
0.95075,0.95262,0.95422,0.95584,0.95750,0.95901,0.96047,0.96164,0.96286,0.96406,0.96524,0.96639,0.96744,0.96853,0.96945,0.97036,0.97123,0.97204,0.97286,0.97377
0.97472,0.97552,0.97627,0.97697,0.97761,0.97824,0.97894,0.97957,0.98018,0.98071,0.98132,0.98184,0.98239,0.98288,0.98339,0.98387,0.98434,0.98473,0.98511,0.98555
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0.99087,0.99105,0.99120,0.99135,0.99148,0.99161,0.99178,0.99192,0.99205,0.99218,0.99230,0.99242,0.99256,0.99270,0.99282,0.99290,0.99302,0.99314,0.99327,0.99335
0.99346,0.99358,0.99368,0.99376,0.99387,0.99400,0.99412,0.99422,0.99431,0.99442,0.99450,0.99463,0.99474,0.99484,0.99492,0.99502,0.99513,0.99525,0.99536,0.99549
0.99561,0.99571,0.99582,0.99593,0.99606,0.99617,0.99628,0.99638,0.99656,0.99667,0.99677,0.99686,0.99698,0.99709,0.99720,0.99732,0.99740,0.99748,0.99759,0.99770
0.99782,0.99791,0.99801,0.99815,0.99826,0.99836,0.99848,0.99858,0.99871,0.99880,0.99891,0.99904,0.99913,0.99923,0.99933,0.99944,0.99953,0.99961,0.99967,0.99974
0.99980,0.99984,0.99991,0.99995,0.99997,0.99998,0.99999,0.99999,0.99999,0.99999,0.99999,1.00000,1.00000,1.00000,1.00000,1.00000
pwc1x1fract=0.00107,0.00226,0.00362,0.00522,0.00725,0.00973,0.01267,0.01613,0.02001,0.02486,0.02994,0.03544,0.04152,0.04811,0.05535,0.06299,0.07106,0.07946,0.08873
0.09812,0.10783,0.11761,0.12768,0.13821,0.14884,0.15938,0.17017,0.18074,0.19160,0.20229,0.21331,0.22450,0.23552,0.24657,0.25761,0.26851,0.27962,0.29038,0.30107
0.31206,0.32291,0.33383,0.34490,0.35573,0.36644,0.37739,0.38823,0.39882,0.40953,0.42029,0.43089,0.44156,0.45233,0.46285,0.47351,0.48404,0.49462,0.50531,0.51564
0.52598,0.53629,0.54672,0.55723,0.56749,0.57808,0.58806,0.59848,0.60854,0.61838,0.62811,0.63791,0.64768,0.65706,0.66662,0.67587,0.68513,0.69481,0.70421,0.71325
0.72241,0.73136,0.74012,0.74917,0.75785,0.76662,0.77539,0.78383,0.79204,0.80037,0.80848,0.81640,0.82440,0.83214,0.83970,0.84699,0.85401,0.86075,0.86705,0.87330
0.87914,0.88488,0.89049,0.89579,0.90087,0.90558,0.90985,0.91390,0.91789,0.92151,0.92493,0.92808,0.93111,0.93409,0.93677,0.93926,0.94165,0.94374,0.94580,0.94786
0.94963,0.95142,0.95301,0.95454,0.95597,0.95749,0.95881,0.96018,0.96143,0.96272,0.96381,0.96490,0.96593,0.96695,0.96799,0.96900,0.96990,0.97089,0.97177,0.97254
0.97335,0.97420,0.97499,0.97583,0.97663,0.97738,0.97804,0.97873,0.97939,0.98004,0.98062,0.98114,0.98175,0.98226,0.98281,0.98329,0.98375,0.98416,0.98461,0.98500
0.98538,0.98584,0.98623,0.98657,0.98688,0.98721,0.98752,0.98780,0.98811,0.98837,0.98865,0.98891,0.98911,0.98933,0.98954,0.98974,0.98997,0.99018,0.99035,0.99053
0.99070,0.99085,0.99102,0.99120,0.99132,0.99148,0.99162,0.99176,0.99191,0.99206,0.99227,0.99237,0.99250,0.99263,0.99277,0.99287,0.99300,0.99311,0.99323,0.99334
0.99348,0.99360,0.99371,0.99385,0.99395,0.99405,0.99415,0.99424,0.99435,0.99443,0.99455,0.99466,0.99480,0.99493,0.99505,0.99515,0.99526,0.99539,0.99550,0.99561
0.99571,0.99583,0.99594,0.99605,0.99613,0.99626,0.99636,0.99648,0.99659,0.99670,0.99681,0.99691,0.99703,0.99712,0.99722,0.99729,0.99741,0.99754,0.99767,0.99779
0.99788,0.99799,0.99808,0.99819,0.99827,0.99840,0.99850,0.99861,0.99872,0.99881,0.99892,0.99902,0.99911,0.99918,0.99926,0.99933,0.99942,0.99949,0.99956,0.99964
0.99970,0.99974,0.99980,0.99984,0.99987,0.99989,0.99992,0.99995,0.99996,0.99998,0.99998,0.99999,0.99999,1.00000,1.00000,1.00000
```

LookUp values are generated from tzero-corrected drift times per plane. (previous slide)

These values are calculated on a bin-by-bin basis for each plane corrected drift time spectra, and represent scaling factors that hcana uses to convert the drift time to drift distance.

Running the code ...Continued

4. After the calibration is finished, two parameter files are created in hallc_replay/PARAM/SHMS/DC/

   - pdc_tzero_per_wire_run#_NEW.param
   - pdriftmap_run#_NEW.param

From the directory mentioned above, copy these files to the parameter files that will actually be read by hcana as follows:

```
>> cp pdc_tzero_per_wire_run#_NEW.param pdc_tzero_per_wire.param

>> cp pdriftmap_run#_NEW.param pdriftmap.param
```

Running the code ...Continued

5. In the parameter file located at:

hallc_replay/PARAM/SHMS/DC/

Open the "pdc.param", locate the following parameter, and make sure it reads as follows:

p_using_tzero_per_wire = 1

6. Replay the data with the updated parameters to produce the new calibrated root files with the corrected drift times and drift distances.

From hallc_replay directory type:

>> ./hcana SCRIPTS/SHMS/replay_shms.C

Running the code ...Continued

7. Compare the calibrated an uncalibrated root files located at:

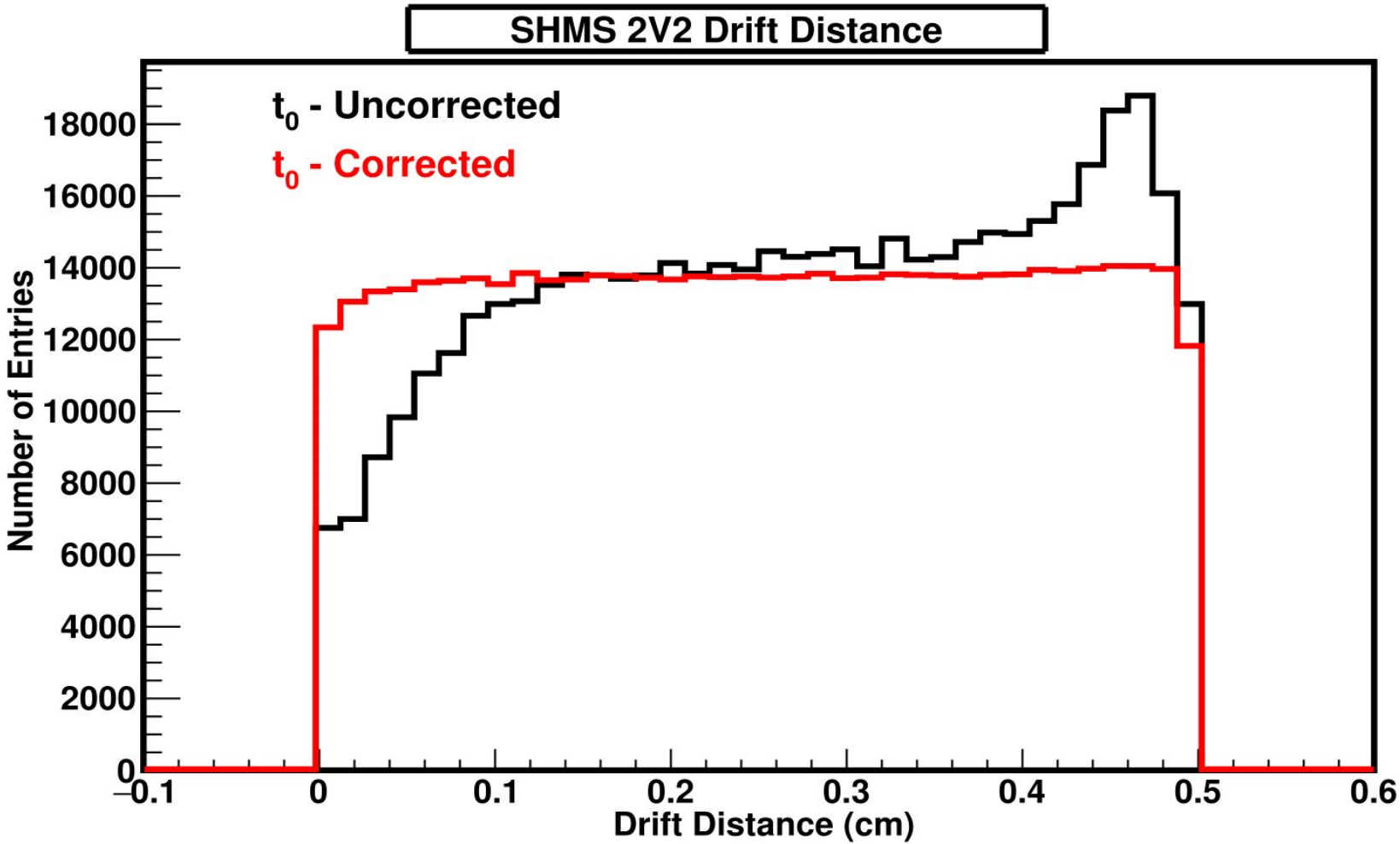
    hallc_replay/ROOTfiles/

The files generic name will be:

    shms_replay_run#_#events.root

    shms_replay_run#_#events_dc_uncal.root

HINT: Compare the drift distances, the calibrated drift distances should be flat.


SHMS 2V2 Drift Distance
t_0 - Uncorrected
t_0 - Corrected
Number of Entries
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
−0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
Drift Distance (cm)

QUESTIONS?