Performance of SVT
HPS Collaboration Meeting Nov 15, 2021

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Outline

- 2021 slim sensor module production
- Recovering the SVT after ~2 year hibernation at JLab
- Minor issues during run
- Qualitative look at loss of L1/L2 charge collection efficiency over 2021 Run
- Preliminary tracking performance, emphasis on hit efficiencies in L1+L2

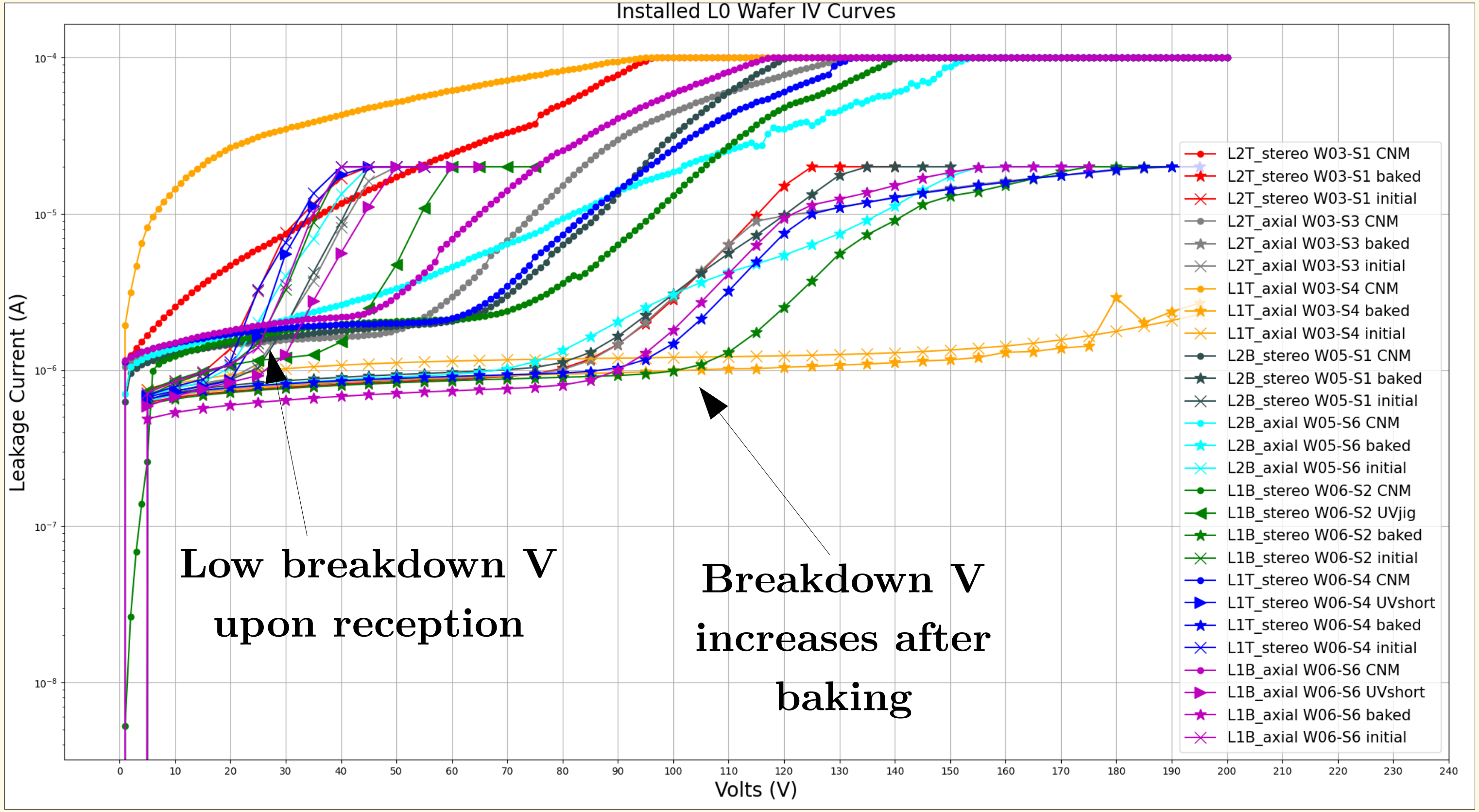
New 2021 Sensor/Module Production

2021 Slim Edge Sensors

- 2019 slim sensors, if manufactured correctly, should be useable for much longer
  - However, **2019 sensors riddled with "pinholes"** (later slide), and had **issues with high surface currents and low breakdown voltages**
- New slim edge sensors manufactured to replace 2019 sensors
- 2021 Wafers had trench etched into silicon to help cleave at 250 um
  - **Slim edges very consistent at 250 um** (improvement over 2019)
- **Trench aluminized before cleaving left aluminum deposit on slim edge**…possible factor in overall lower breakdown voltages for 2021 slim sensors
- IV plots of wafers used in 2021 show initially (CNM + initial) very low breakdown voltages
- **Baking sensors** at 168-172 C for 24-40 hrs (in two separate baking cycles) **increases breakdown voltage**
- UV radiation exposure, and other types of induced radiation (not shown) were tested on other wafers…studies incomplete

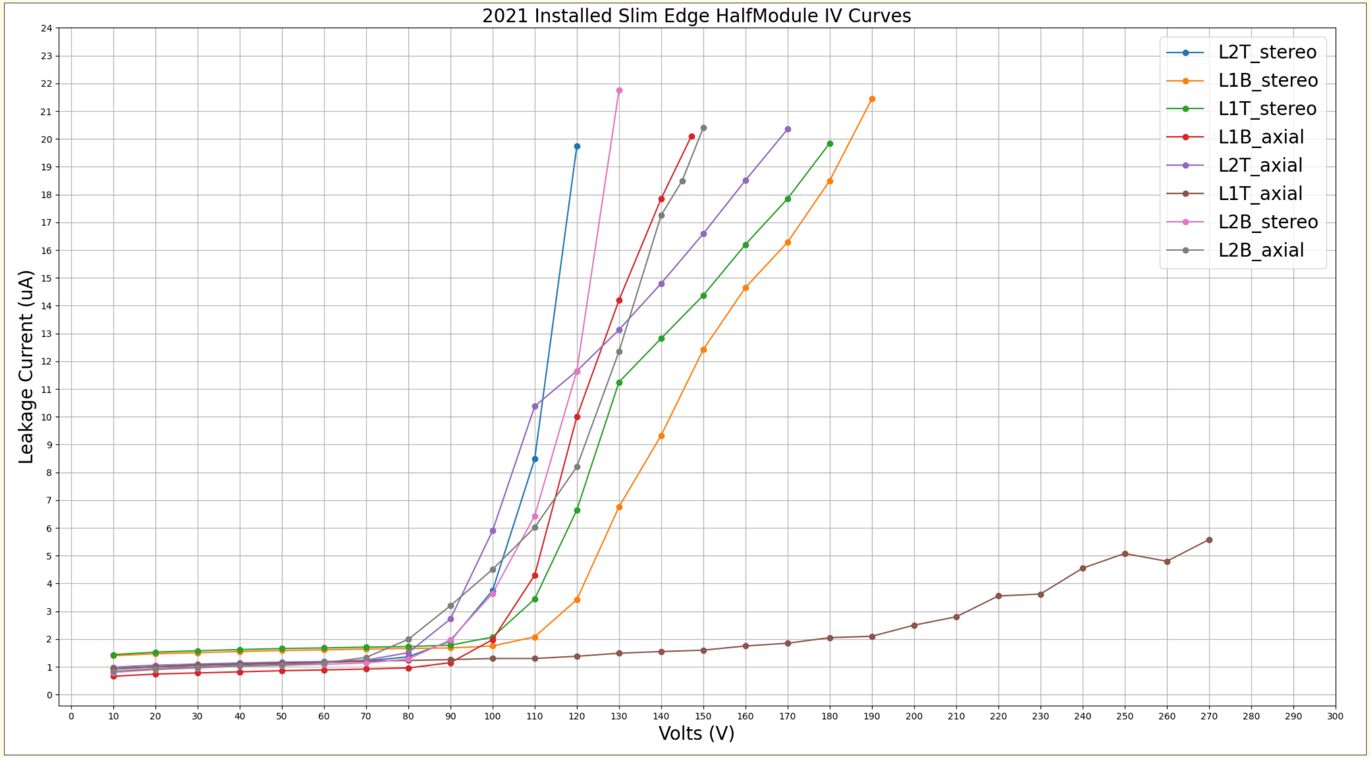
2021 Slim Edge Sensor IV Curves

- Wafer IV curves of 2021 sensors
- Initial testing at UCSC showed very low breakdown
- Post baking, IV data shows significant improvement (from 30-40V to 80-90V)



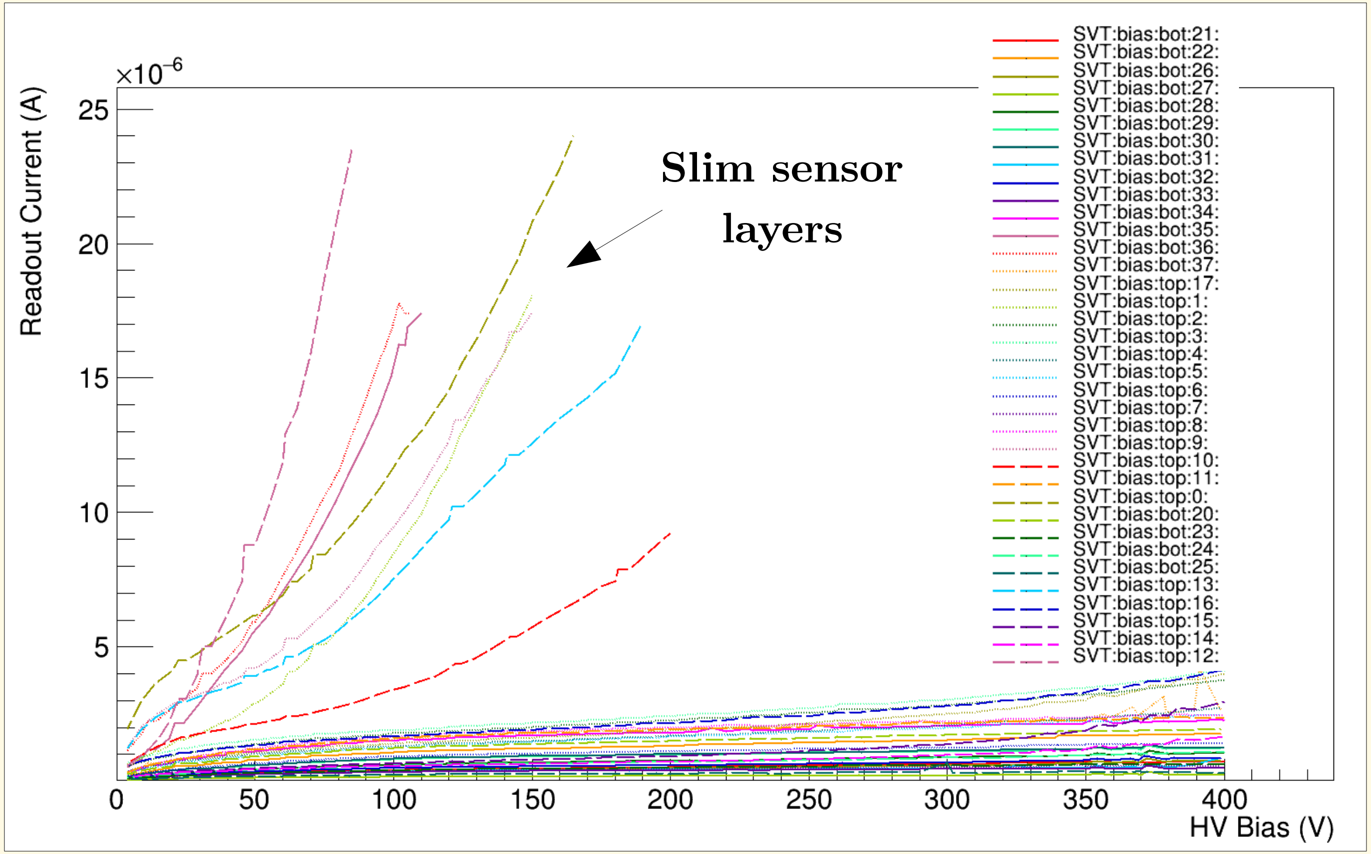
2021 Slim Edge Sensor Halfmodule IV Curves

- Halfmodules built from selected sensors attached to hybrids, wire-bonded to APVs…
- Figure shows **HV IV curves for 2021 slim sensor half-modules**
- L0M06 wafer had very slim edge (178 um) compared to others (250 um), was placed closest to beam

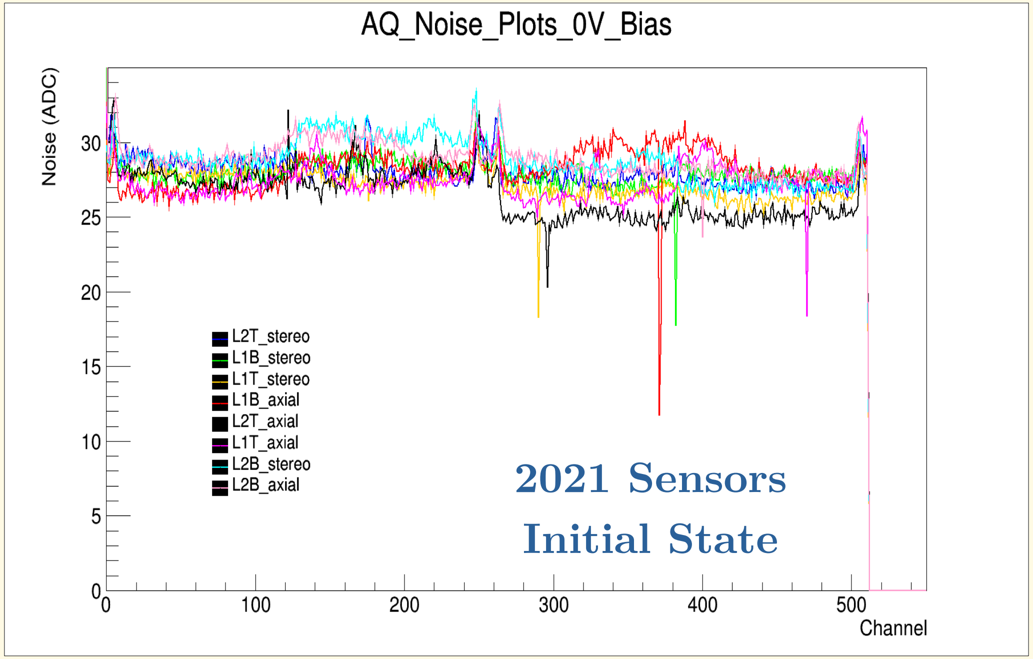


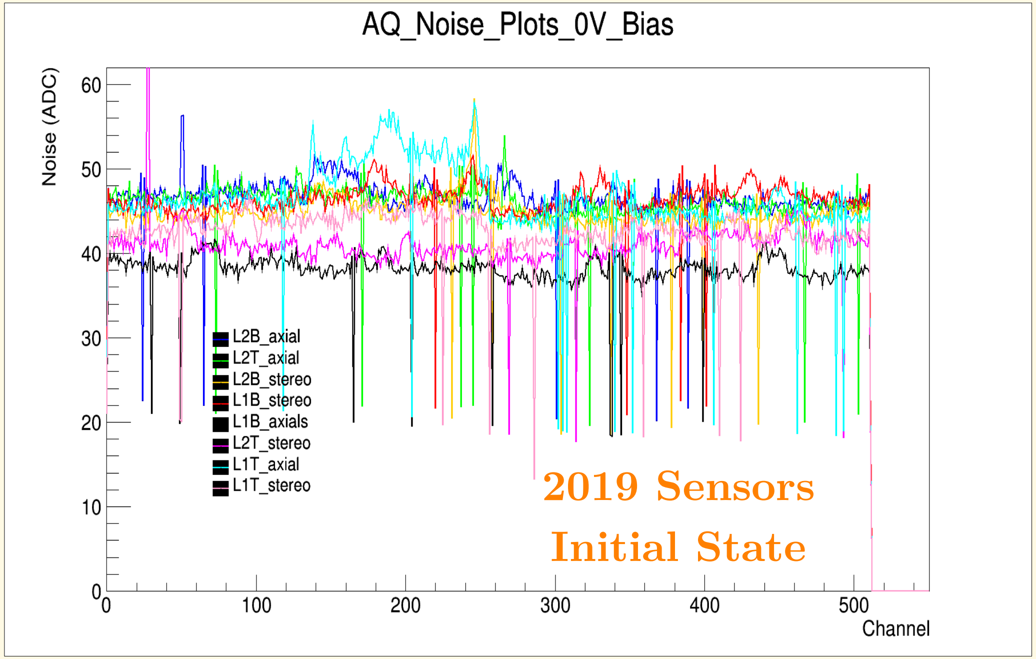
SVT Main Bias HV IV Curve November 5, 2021

- Near end of 2021 Run (11/05/21), IV run taken by scanning through SVT HV bias values
  - Data obtained from Mya
- Will need new slim sensors for future run
  - In contact with CNM already



2021 vs 2019 Slim Edge Sensor Pinholes



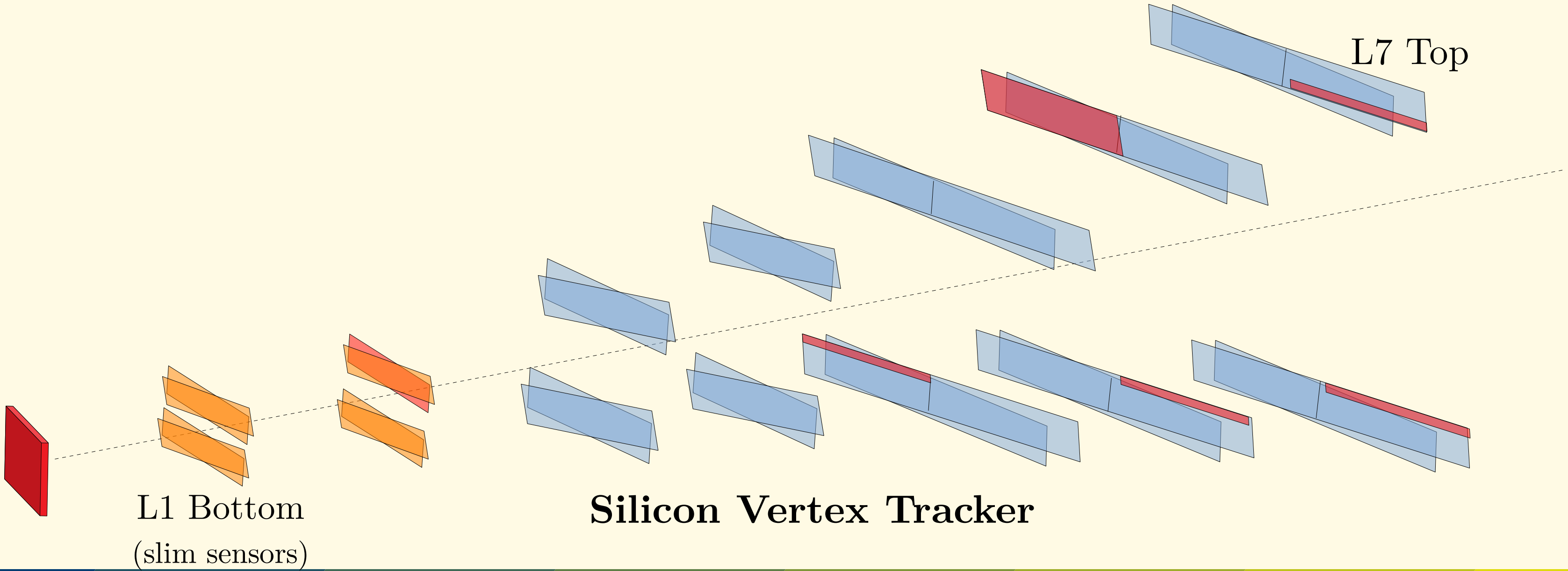


Low noise spikes on physical channel indicate "pinhole" aka bad channel

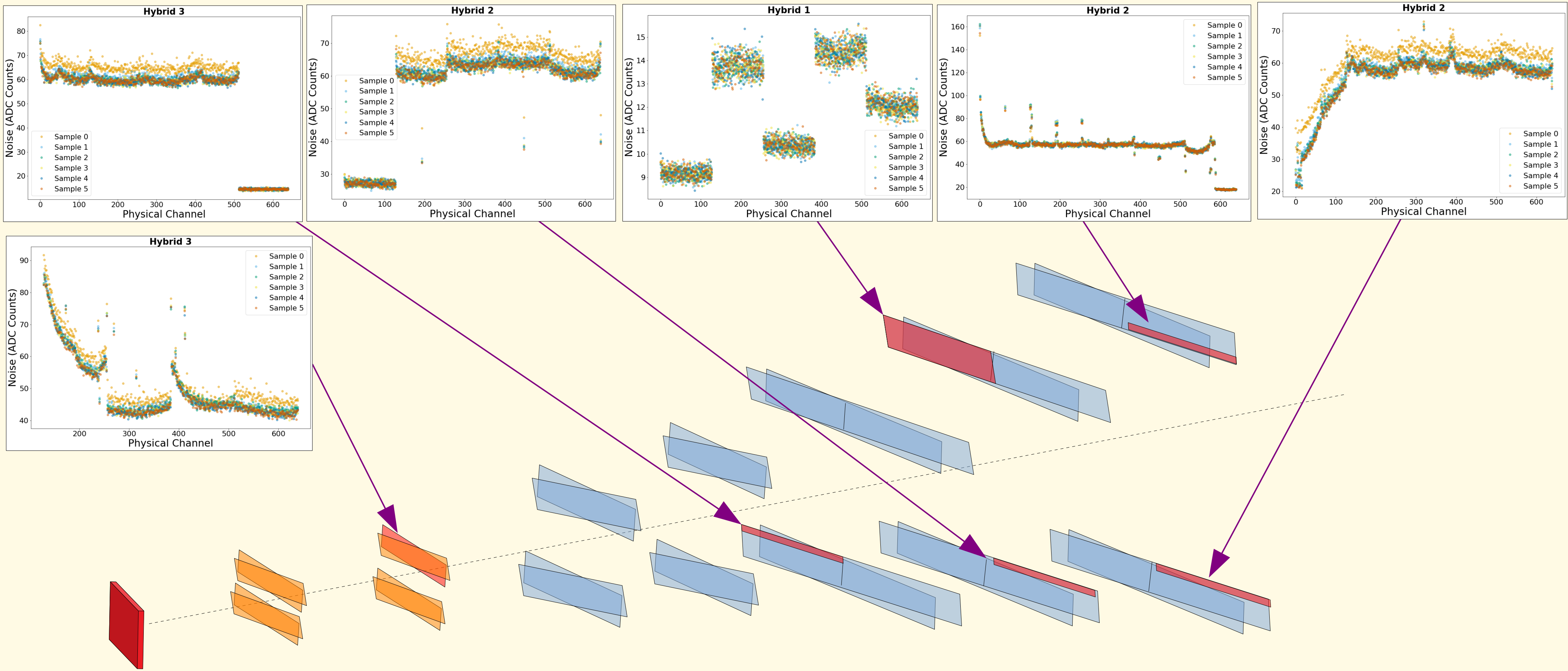
- 2019 slim sensors had many initial pinholes, and grew more during run due to fabrication issues
  - **2021 sensors have significant improvement in fewer pinholes!**

SVT Initial State Summer 2021

- After returning to Jlab July 2021 (late due to covid delay) to inspect state of SVT post 2019 storage...
- **Found some APVs failed, leaving sections of sensor strips dead (shown in red)**
  - **Damage shown NOT present at end of 2019 Run...occurs during hibernation**
- **Degraded halfmodules needed to be replaced**
- **All 2019 slim sensors needed replacement** due to fabrication issues previously mentioned



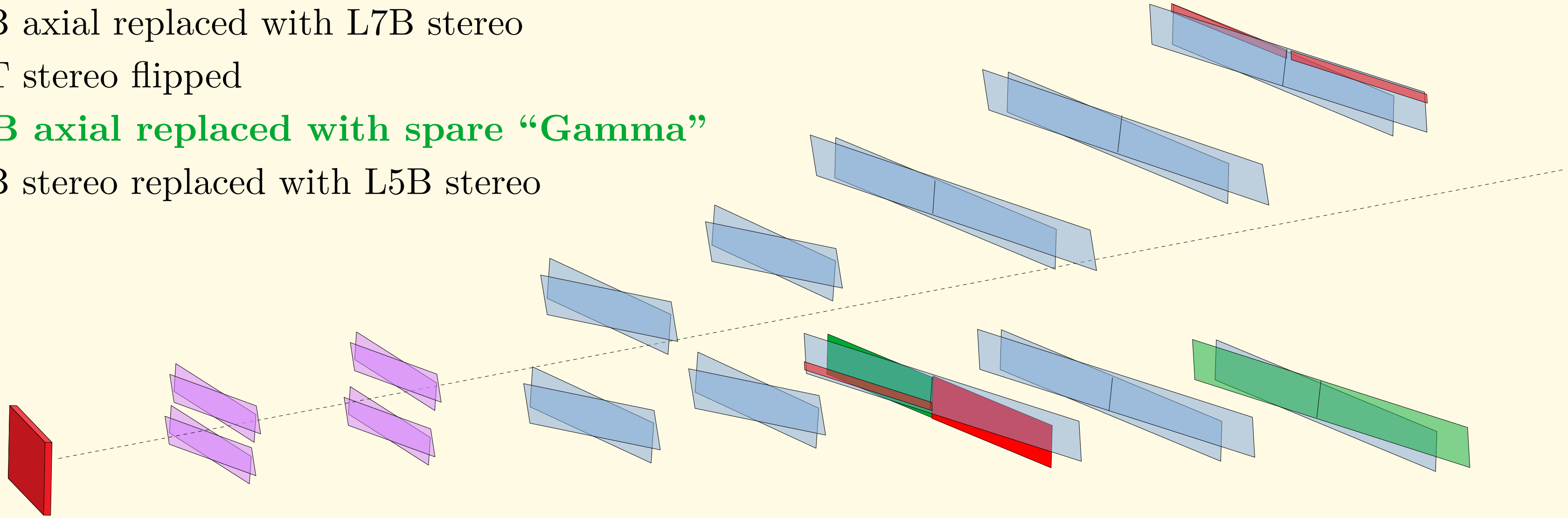
SVT Initial State Summer 2021



SVT Recovered State 2021 Run

- All L1/L2 sensors replaced with 2021 sensors
- L5B axial replaced with flipped L6B axial
- **L5B stereo replaced with spare "Beta"**
  - **Beta electron side failed after install**
- L6T axial swapped with L7T axial
- L6B axial replaced with L7B stereo
- L7T stereo flipped
- **L7B axial replaced with spare "Gamma"**
- L7B stereo replaced with L5B stereo

- **Lacked supply of useable spares for back layers**
- Had to re-organize existing damaged areas to maximize SVT performance with what we have
- Will work on improving supply of spares for future runs

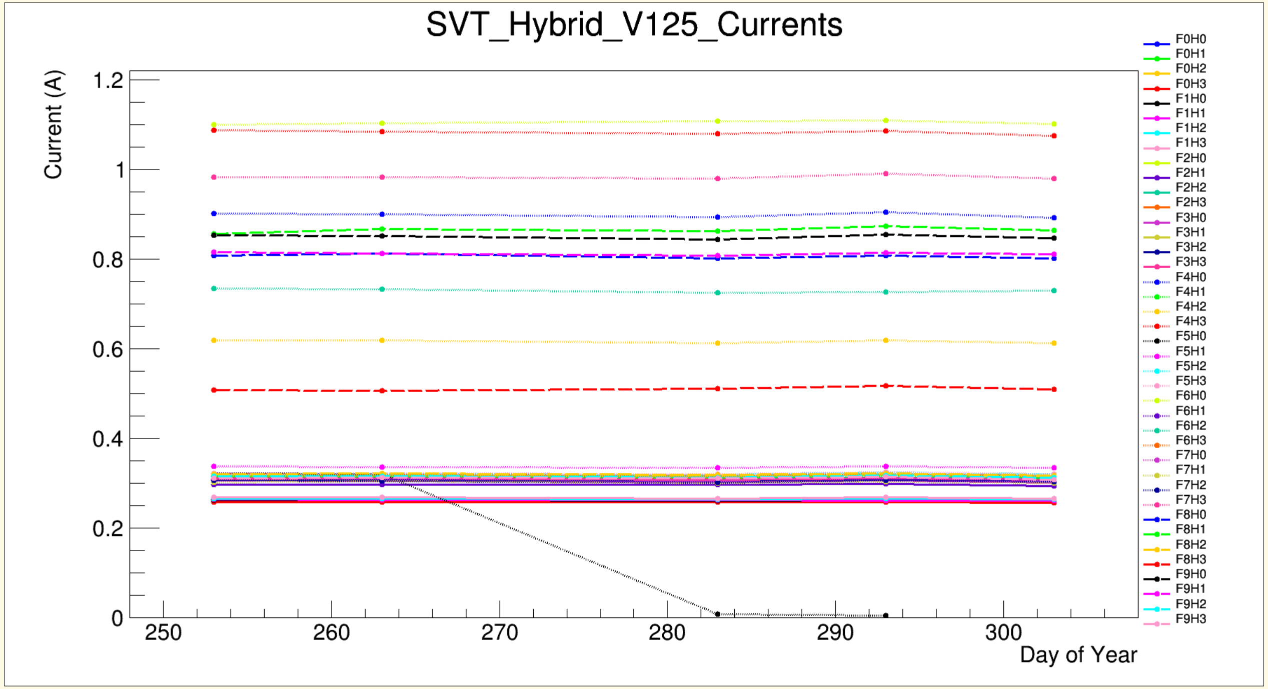


Minor Operations Issues

- Losing clock during "Download"
  - Can only be solved with TI changes
  - Increased average time to reset DAQ
  - Should discuss how to improve for next run
- Monitoring ADC's died from radiation damage in first few layers
  - Intermittent loss of Hybrids before issue understood
- **Possible loss of efficiency due to rad damage in slim sensors**
  - Started raising voltage slowly during run to recover efficiency
  - Later slides will illustrate extent of issue
- Higher than expected V125 currents in back layers (not caught in time due to covid delays)

Hybrid V125 Currents During Run

- **V125 currents** for some hybrids discovered to be **higher than expected**
- **Discovery occurred too late** (due to covid) to fully address issue
- Currents look flat over course of run
- Looking into replacing these hybrids and increasing spare stock



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L1/L2 Charge Collection Efficiency Loss

Cluster-on-Track Charge Collection Efficiency

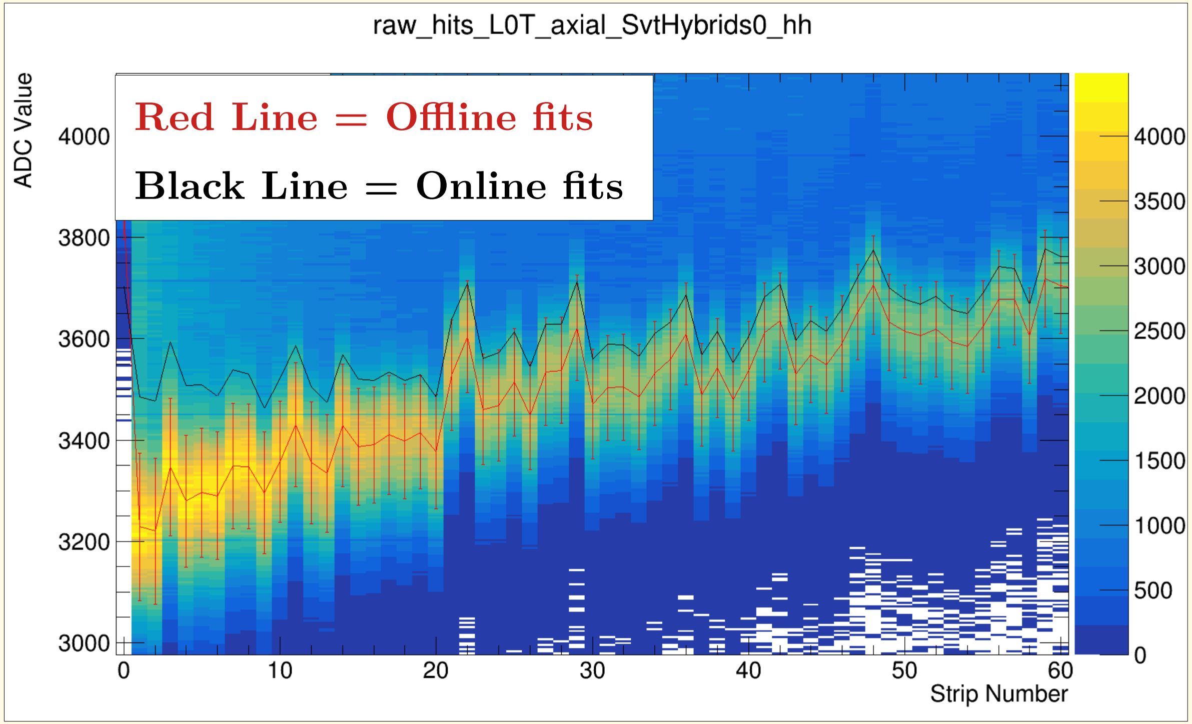
- With radiation exposure, **sensor bias may need to be increased to maintain charge collection efficiency**, especially on high occupancy strips
- **2021 slim sensors have low breakdown voltages and high leakage currents, so increasing bias can be risky**
- 31 days after start of production running, L1/L2 bias voltage had not been increased
  - **Possible that sensors lost hit efficiency** at this voltage (30V)
- Day 35, and again on Day 46, L1/L2 bias voltage was increased in caution of decreased efficiency
- **Will show qualitatively that there was some loss in track hit efficiency…further investigation coming soon**

L1/L2 sensor bias over time

- **Run 14191:** Day 0 (9/10/21)
  - Slim sensor bias = **30V**
- **Run 14552:** Day 31 (10/11/21)
  - Slim sensor bias = **30V**
- **Run 14596:** Day 35 (10/16/21)
  - Slim sensor bias = **45V**
- **Run 14691:** Day 46 (10/27/21)
  - Slim sensor bias = **60V**

Offline Baseline Fitting

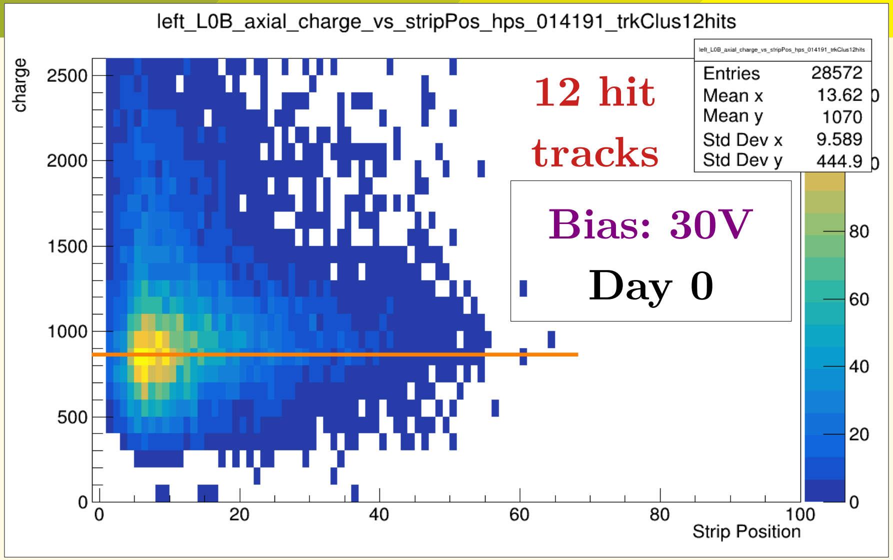
- Before going into charge efficiencies…brief aside on offline baseline fits
- **APV25 channel pedestals change with occupancy**, and can shift significantly especially in strips with high occupancy
- **Online baseline runs done with no beam**
- **Offline baseline fitting extracts pedestals using production conditions**
- Plot shows first of 6 RawSvtHit time samples, which represents readout before passage of charged particle
- **Online baselines can deviate as much as 1*Sigma** of true pedestal value when running production

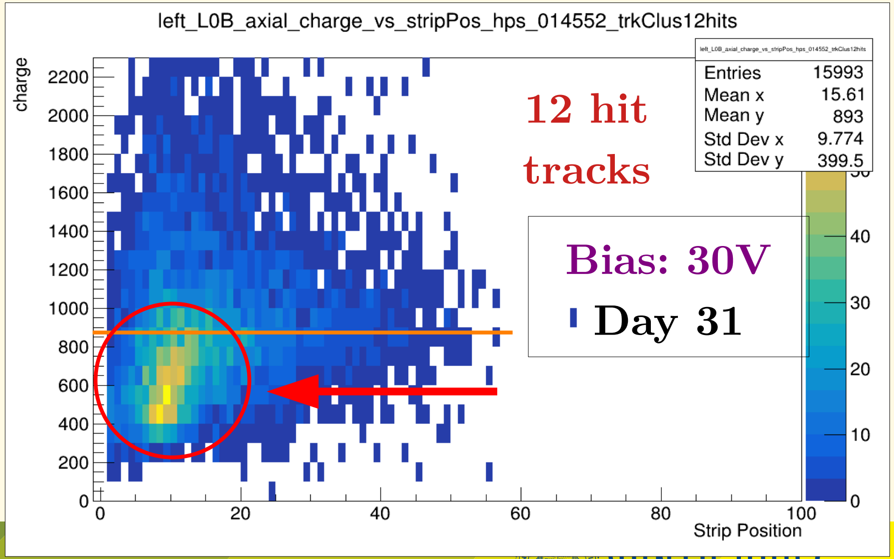


Histogram of Production Data RawSvtHits Time Sample 0

Cluster-on-Track Charge Collection Efficiency

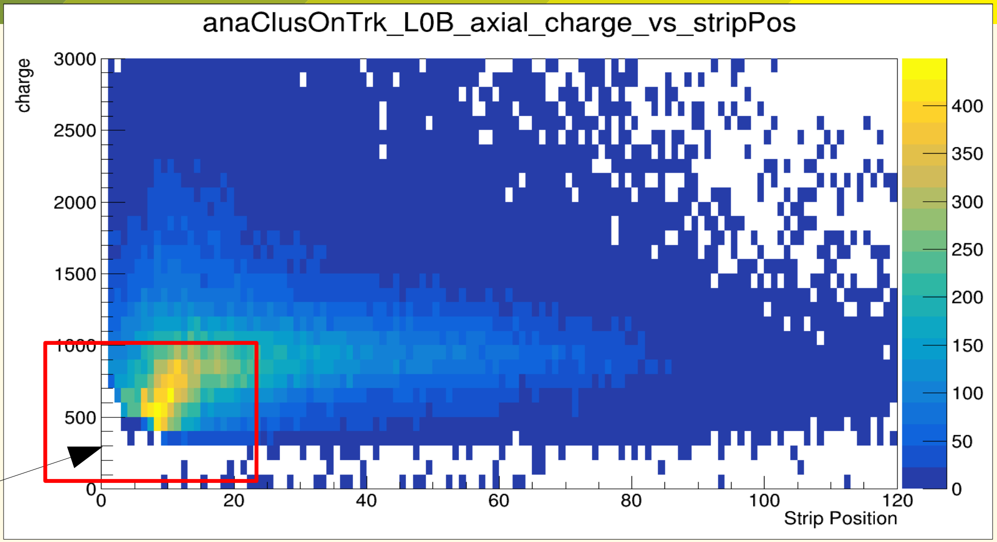
- Back to charge collection efficiency…
- Take **reconstructed tracks**, **break into hit clusters**, and **check charge collected** on clusters of hits
- Strip hits have **Landau charge distribution**, with **most probable value (MPV)** roughly brightest bin **(Right plots)**
- **If strip bias too low, less charge collected from hit on strip (MPV decreases)**
- Since pedestals change with occupancy, charge of fitted hits also shifts…to show changes in charge collection independent of occupancy shifts, **used offline baseline fits in reconstruction**
- Right plots show clusters-on-track charge collected for strips on first bottom layer ("L0 convention used here")
  - Orange line just visual guide for change
- After 31 days at 30V bias, see **clear reduction in charge collected from hit clusters on reco tracks**

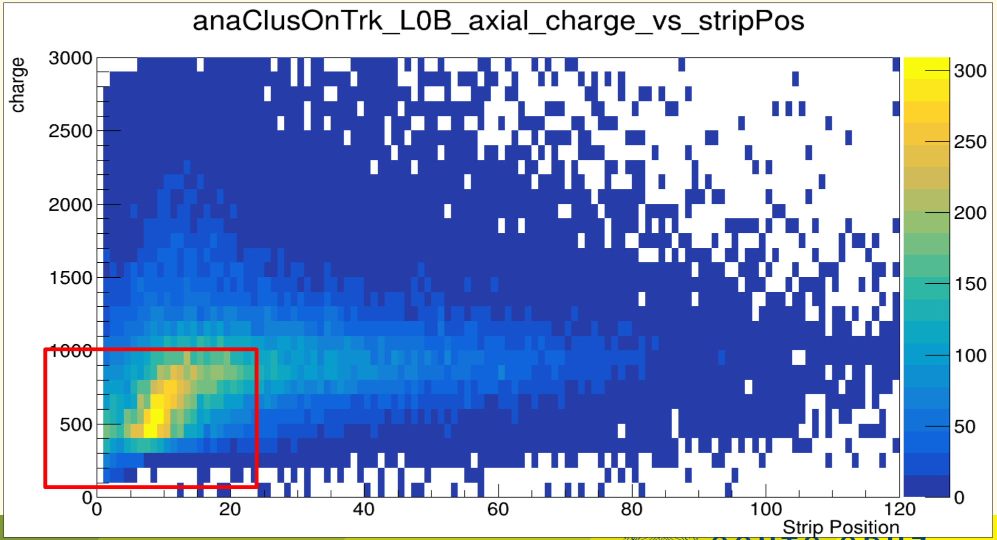




Cluster-on-Track Charge Collection Efficiency

- **Important Note for Charge Plots!**
- (TOP) Standard reconstruction sets cluster amplitude **threshold = 3*noise** from offline baselines
  - Threshold too large in high occupancy strips due to increased noise
  - Lose information on actual charge collection
- (BOTTOM) Reconstruction with cluster amplitude **threshold hardcoded to 100 ADC**
  - Better picture of charge collection independent of hit cluster thresholds

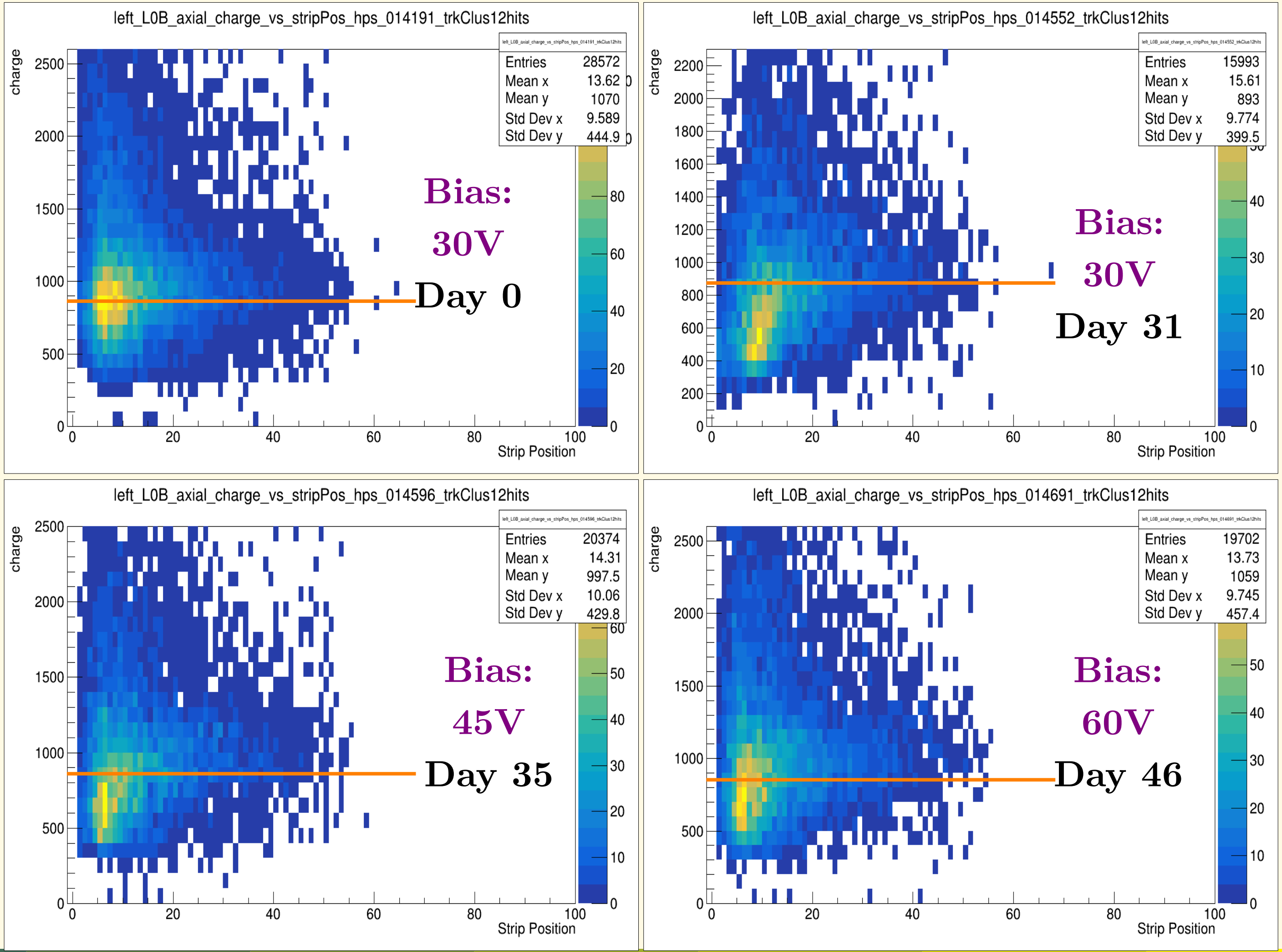




All charge collection efficiency plots in this presentation use this 100 ADC threshold!

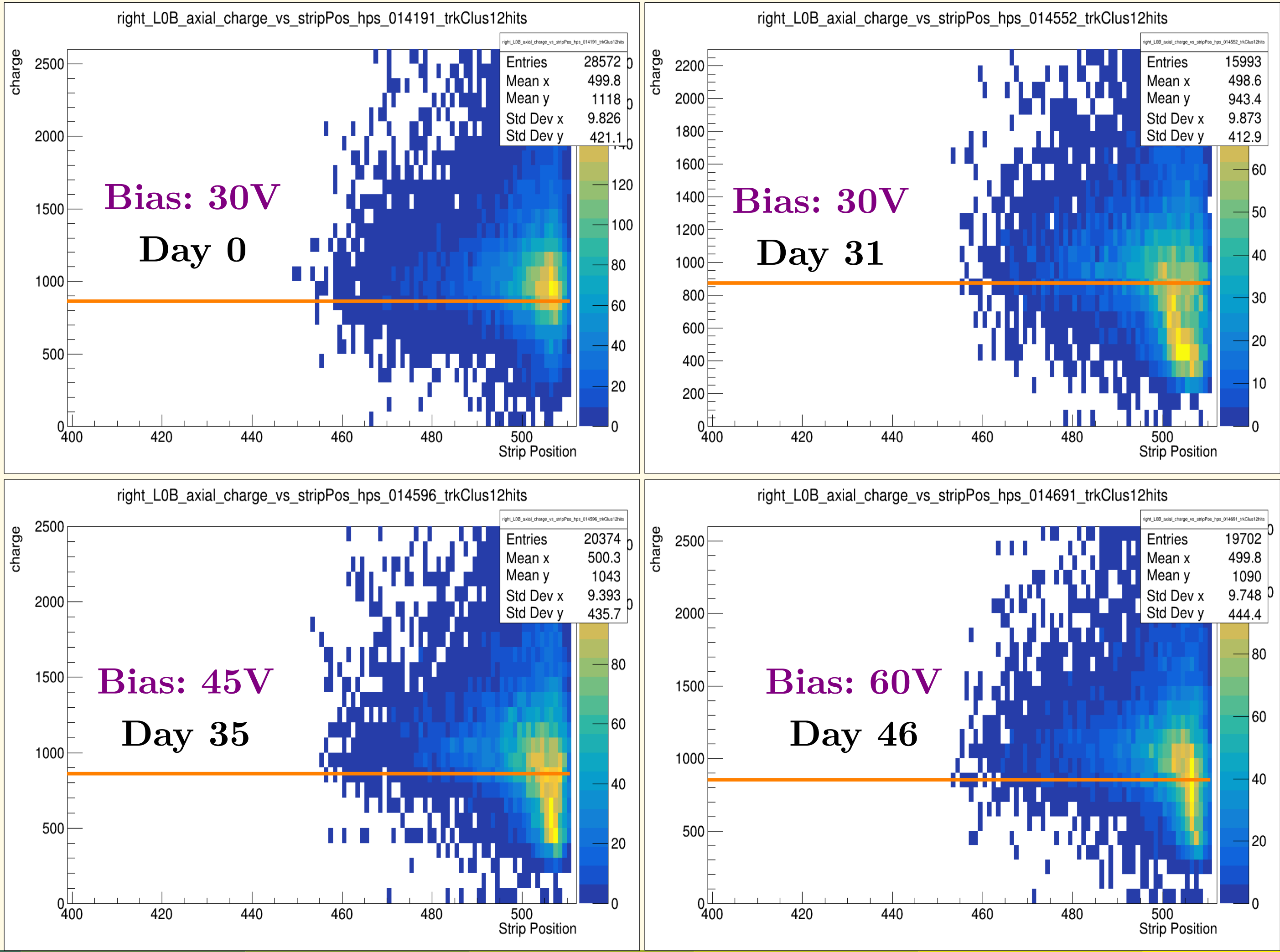
"L0" Charge Collection Over Time

- Plots show charge collection on **left side of L0B axial** over 46 days, with 3 different bias voltages
- Day 31 shows large decrease in peak charge collected on high occupancy strips
- After **bias raised to 45V**, charge collected per strip increases
- At **60V bias**, see charge collected per strip return close to nominal at Day 0



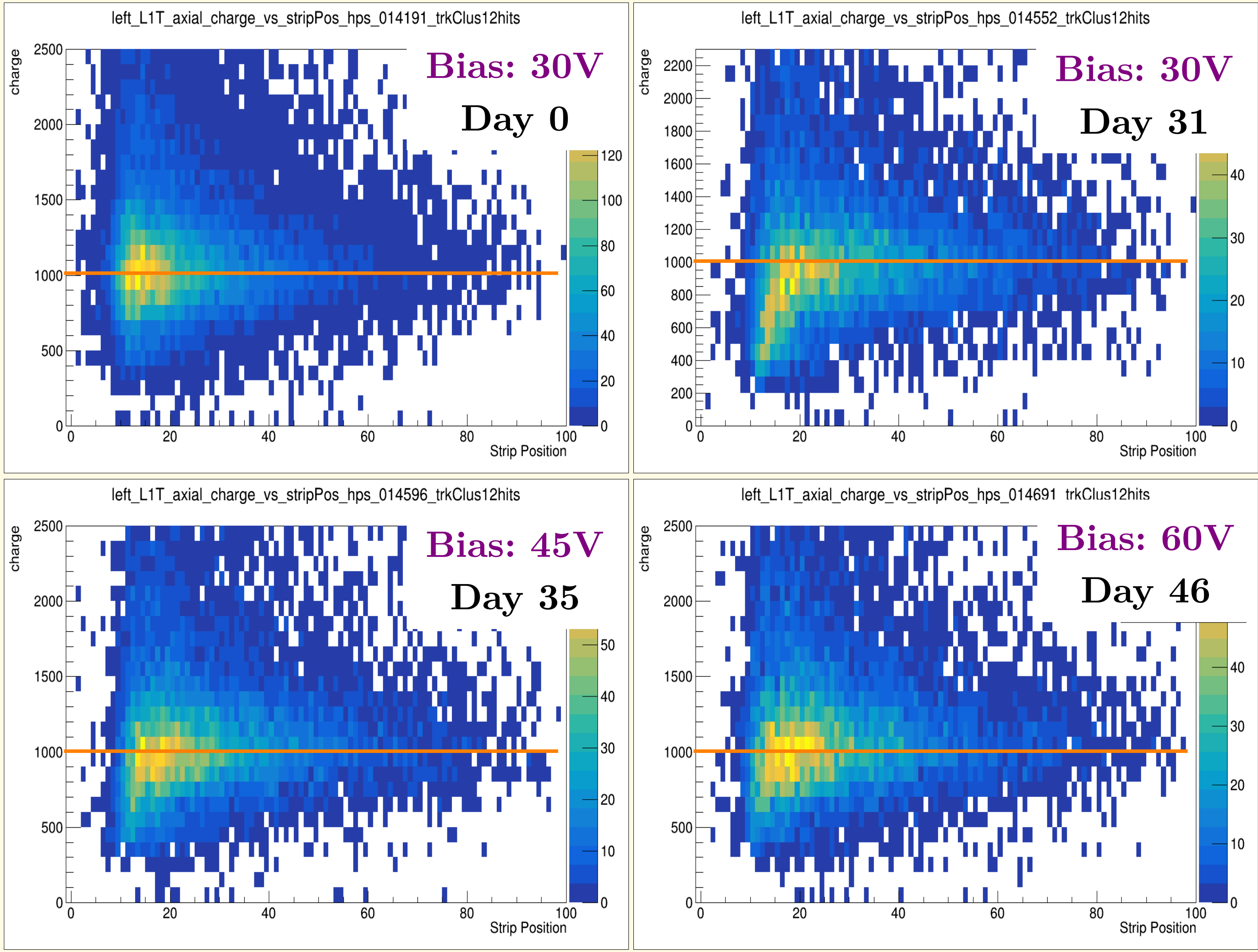
“L0” Charge Collection Over Time

- Find **similar pattern of loss in charge collected for high occupancy strips** on right side of L0B axial
- Less of a recovery at 60V



"L1" Charge Collection Over Time

- L1 (second layer) slim sensor charge collection
- Find **similar decrease in charge collected on high occupancy strips** after 31 days at 30V
- **Pattern continues for all slim sensors** (plots in backup)
- We see qualitatively, **did lose charge collection efficiency during 2021 run in first layers**
- **Efficiency changes with time and SVT HV bias**
- Track efficiency may be highly run dependent due to this
- **Will work to quantify issue and try to recover hits**



Brief Preliminary Tracking (Slim Sensors)

Standard Reconstruction Tracks

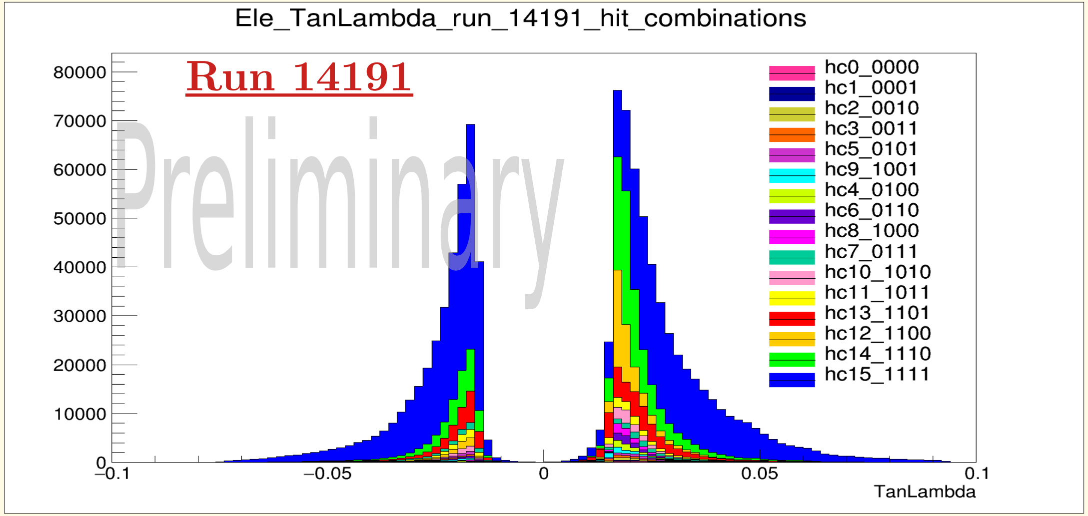
PRELIMINARY

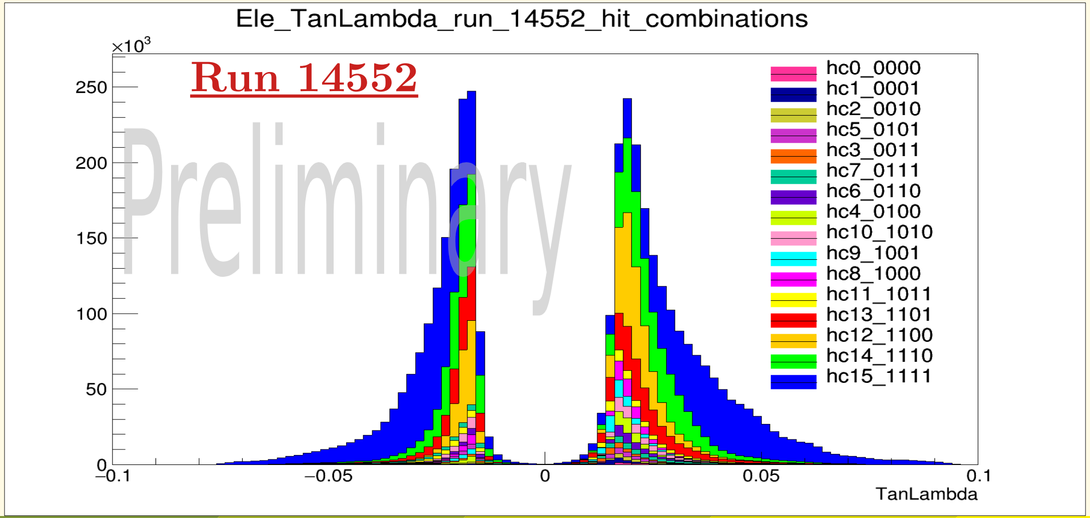
Track Reconstruction Comparison Runs Day 0 and Day 31

- **The following is a *very* preliminary look at tracking with raw data**
- **Run 14522 shows loss in charge collection efficiency in high occupancy regions compared to earlier run 14191, both at same 30V HV bias**
- Ran **standard 2021 reconstruction using Pass1Top Alignment** on run 14191 and 14552
- **Tracks with > 9 hits broken up into 16 hit categories**
  - All combinations of **if hit on track exists in first 4 sensors**
  - "1111" means Track has hit in all 4 first sensors
  - "1110" means Track missing hit in first sensor, has hit in next three sensors, etc…
- Compare track parameters for different hit categories, separated into Ele/Pos, Top/Bottom
- **The following plots do not yet have a clear interpretation**…**they are result of complicated interplay of efficiencies, alignment, geometric acceptance, etc**
- Style of plot may be useful as a standard check on alignment improvements

Electron Track TanLambda

- Plots show stacked histograms of TanLambda for reco tracks with different hit combinations in L1+L2
- **Run 14191**
  - Good charge collection efficiency at 30V
  - More Ele tracks in Top than Bottom at low TanLam
  - **Larger fraction of Top Ele tracks have no L1 hits** (1st and 2nd sensors) **at low TanLambda than Bot**
  - **Note**: One of many possible explanations for raw data, is **angular acceptance of L2 is greater than L1**, so **tracks at edge of L2 can easily miss L1**. **"Missing" hits in L1 not necessarily due to infefficiency (not necessarily "missing" at all)**
- **Run 14552**
  - Saw previously that **charge collection efficiency decreased in high occupancy strips**
  - **Increased fraction of Top Ele Tracks have no L1 hits, especially at low TanLambda**
  - **Bottom Ele Tracks also has less hits in L1**
- **Roles of alignment, acceptance, and hit efficiency in these results is not yet understood! Emphasis on preliminary!**





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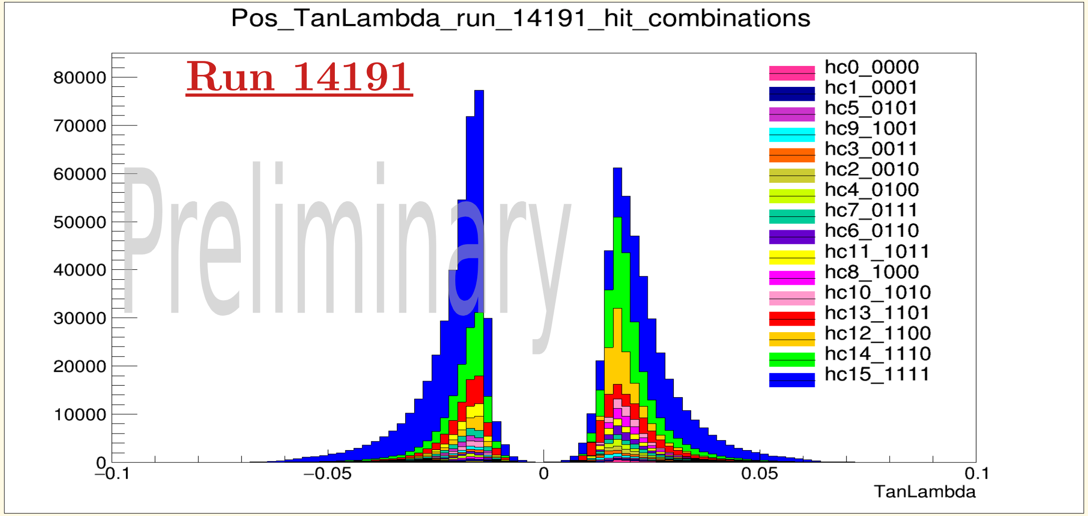
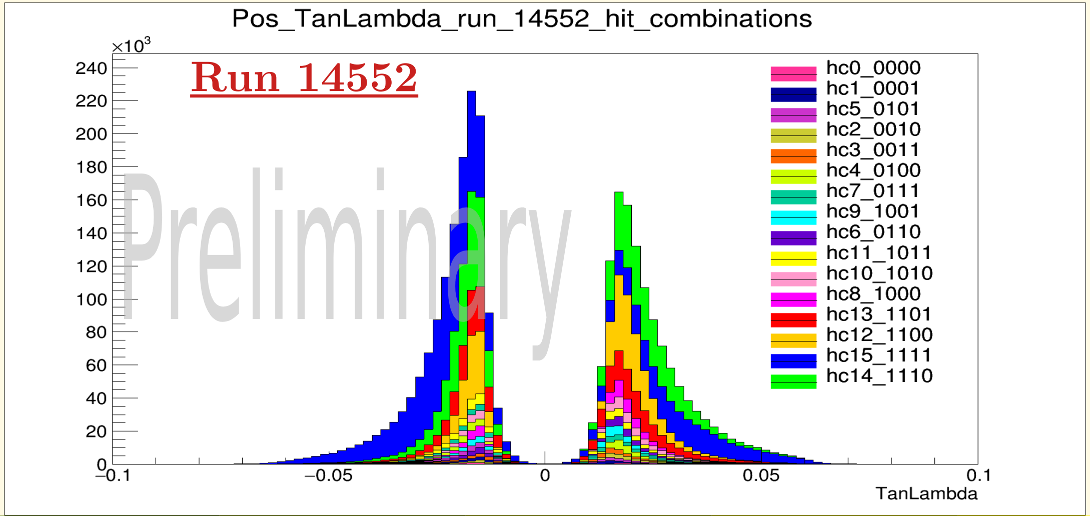
Positron Track TanLambda

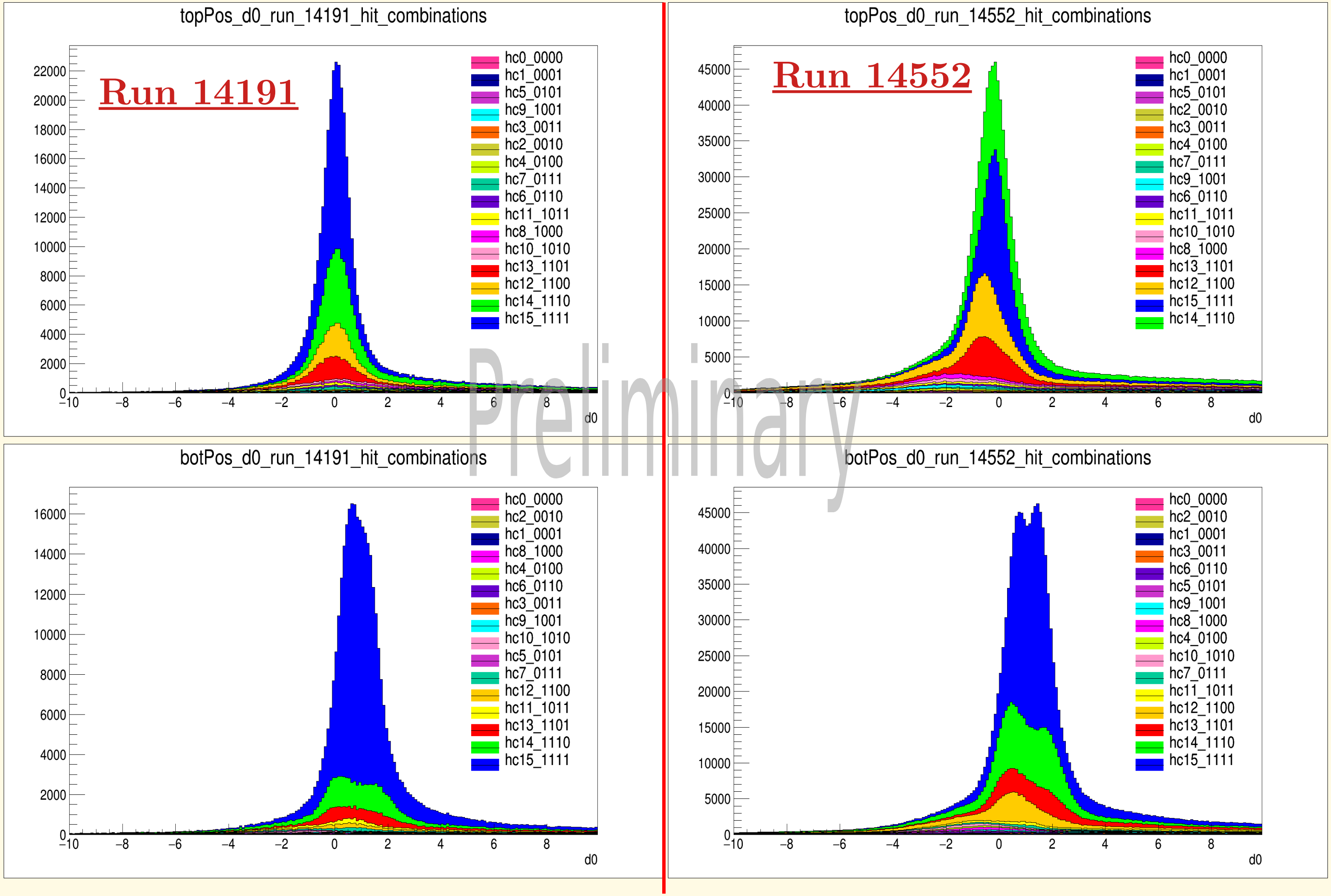
- Plots show stacked histograms of **TanLambda** for **reco tracks with different hit combinations** in L1+L2
- Both runs show many more Pos Tracks in Bottom than Top at low TanLambda
- **Run 14191**
  - Again Top shows larger fraction of Low TanLambda Tracks without hit(s) in L1
- **Run 14552**
  - Increase in fraction of Low TanLambda Tracks that without L1 hit(s) for both Top and Bottom
  - For unknown reasons, Top tracks more often have no hit in very first sensor … (green is now larger than blue)
- Again, **plots are difficult to interpret due to complication of misalignment+acceptance+efficiency, and other factors**
- But **increase in fraction of Tracks without a hit** (or both hits) **in L1 between runs 14191 to 14552** does **motivate taking a closer look at hit efficiency changes** in L1 over the 2021 Run





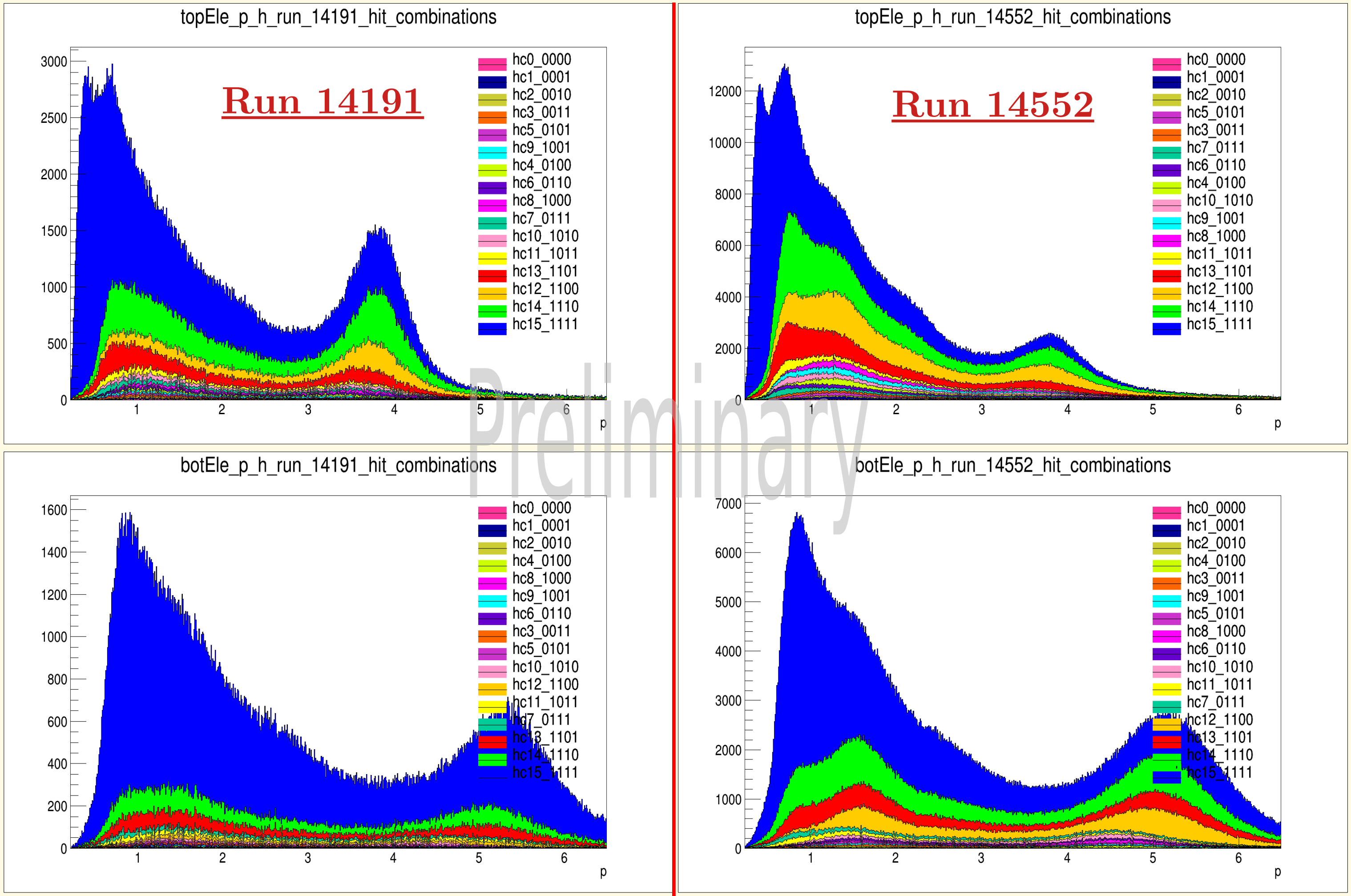
Positron Track d0

- Stacked histograms Pos d0 (Top/Bottom)
- *Maybe* interesting to see how Top Pos **d0 mean shifts based on hits on Track**
- **Run 14191 orange mean roughly 0**, but on **Run 14552, orange mean shifted left**
- These plots, in addition to z0, and Phi (see backup) may find themselves useful for checking alignment in future…



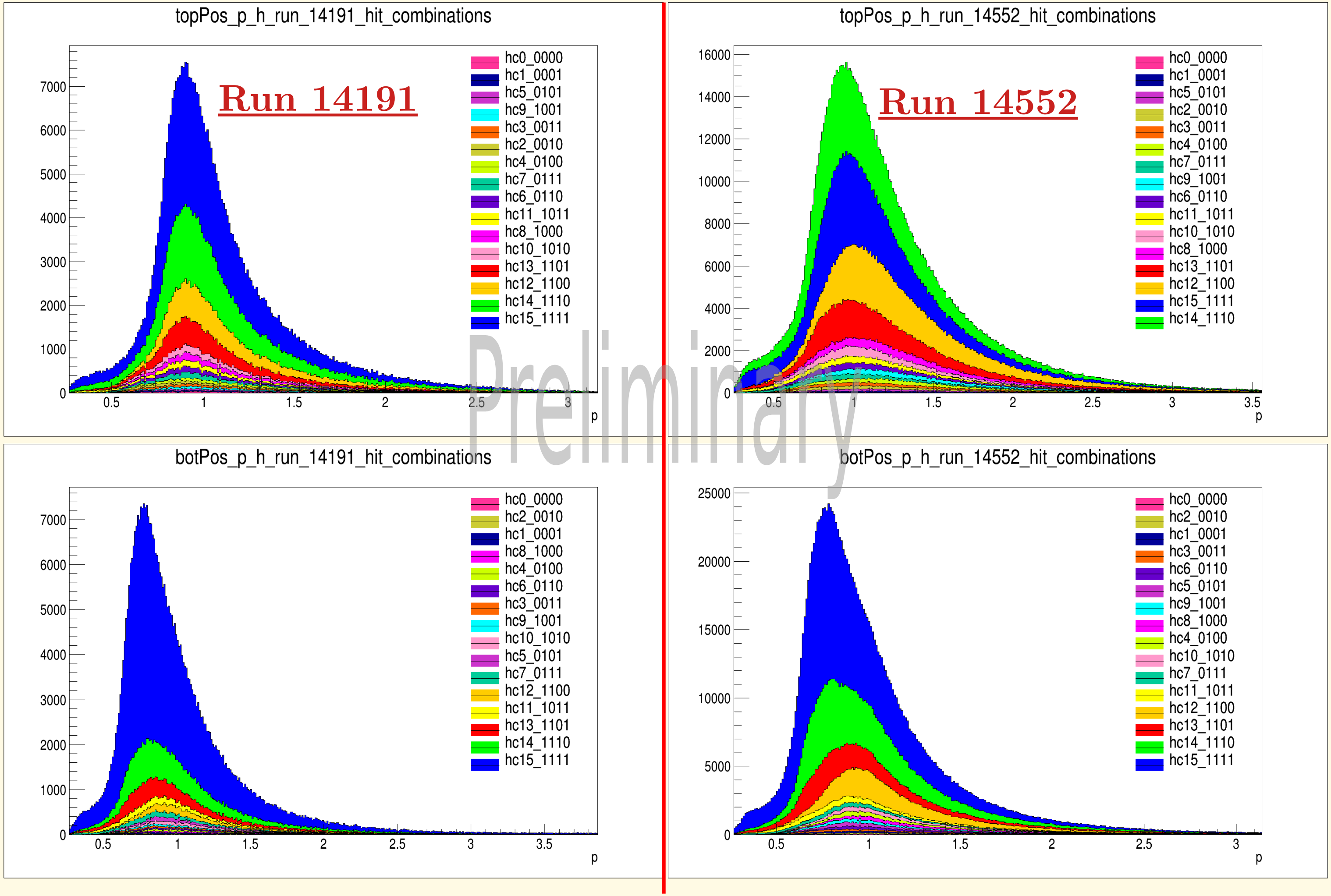
Electron Track Momentum

- Stacked histograms Ele Momentum (Top/Bottom)
- Obviously **Bottom detector not yet FEE aligned**



Positron Track Momentum

- Stacked histograms
  Pos Momentum
  (Top/Bottom)



Conclusion

- **Covid delays led to some late SVT hardware issue discoveries**, but we **still managed to get a solid detector ready for the 2021 Run!**
- **Need more slim sensor layers**, and **more back layer spares** for future runs
  - Slim sensor fabrication still has issues that need to be addressed by CNM to improve quality
- Appears we **did lose some charge collection efficiency** in high occupancy regions of slim sensors over time, to varying degrees based on bias voltage
  - **Severity of this loss not yet quantified**
  - Likely that Track efficiency is more run dependent than we prefer
- **Extremely preliminary tracking plots show fraction of Tracks without hit(s) in L1 increases between Run 14191 and Run 14552** (31 days later)
  - **Not clear how much of this is due to changing hit inefficiencies**, misalignment, or simply complicated acceptance and other subtle details of tracking
- **Need to dig into hit reconstruction** and get a better understanding of the impacts of inefficiencies on tracking

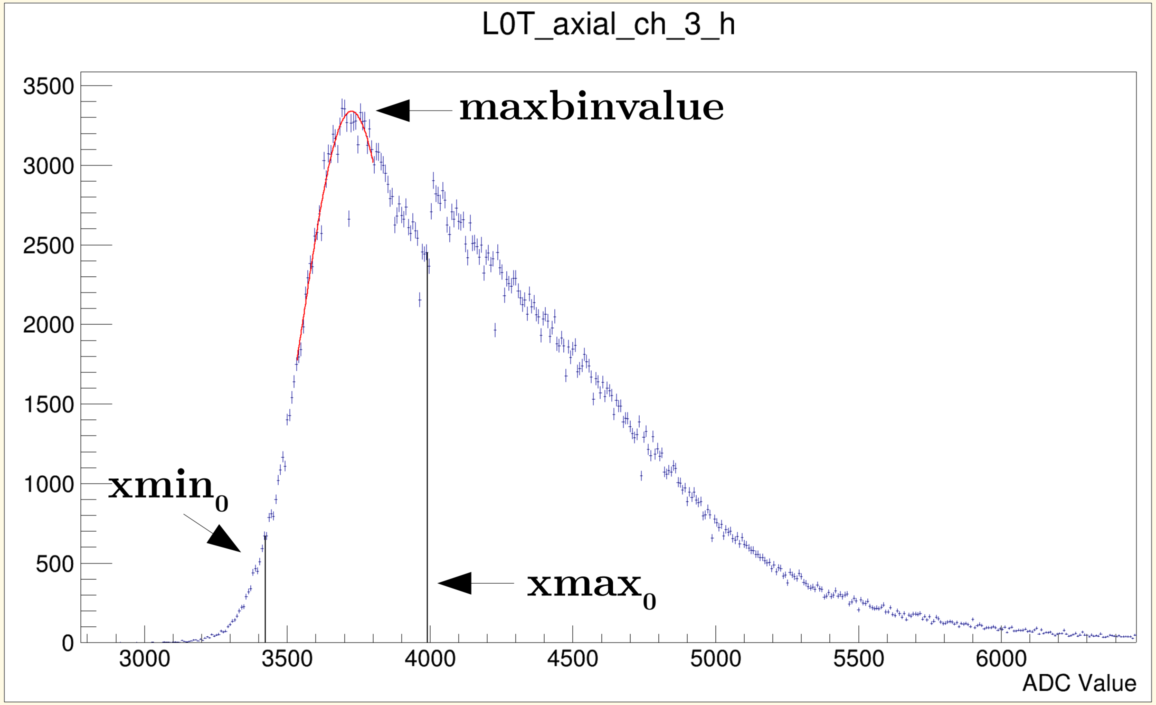
Next Steps

- Estimate loss of hit efficiency by fitting strips with landau distribution
- Review hit clustering algorithm
  - Look into using hit time errors for clustering
  - Try using hit fit error to set cluster thresholds
    - Uses all 6 RawSvtHit time samples, instead of just time sample 0
- Review pulse pileup fitting procedure
  - Can we improve the logic of when to fit a hit with a pile-up pulse
- Calibrate APV-Xtalk filter
- Iterate 2021 alignment forward
- **Suggestions from collaborators?**

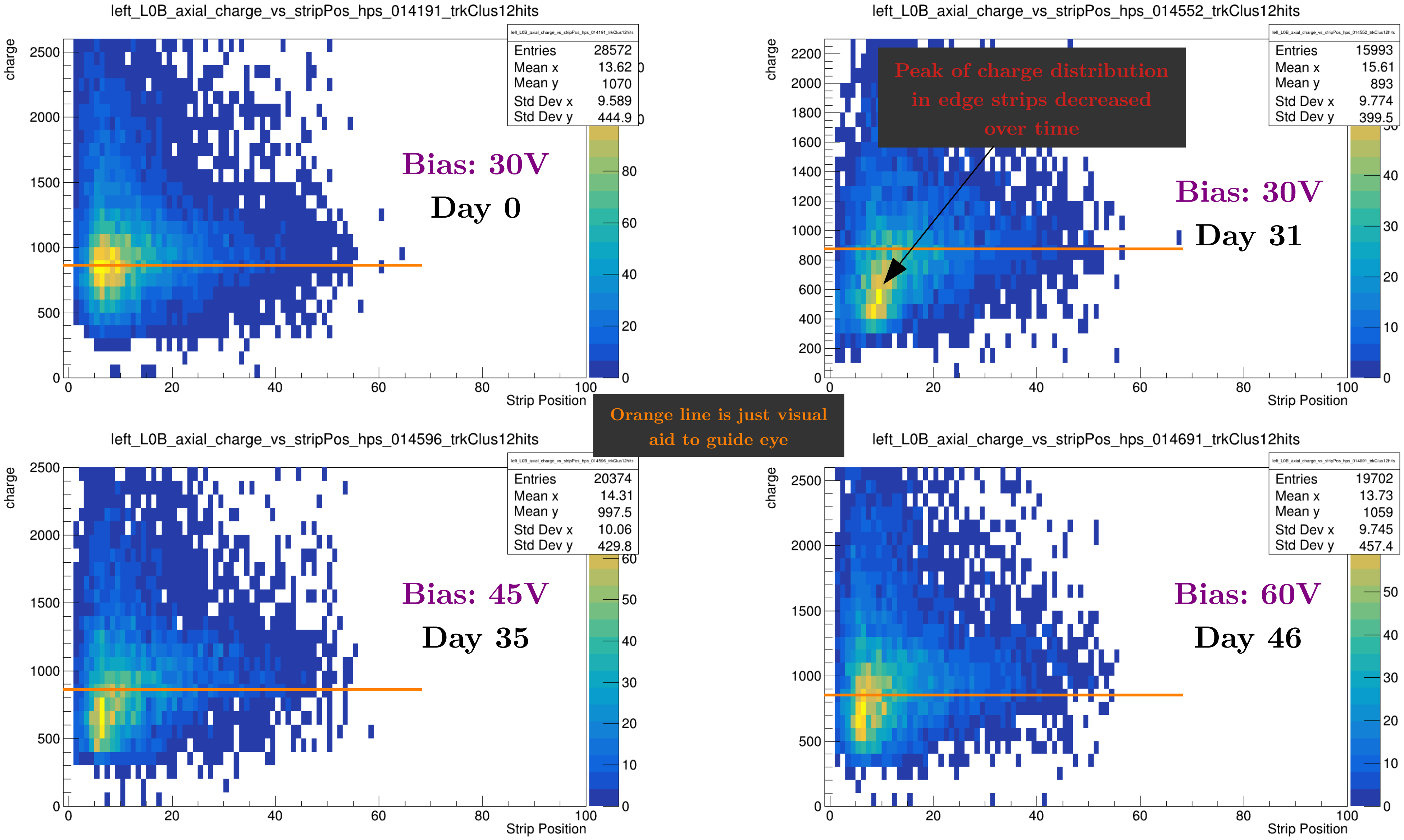
Backup

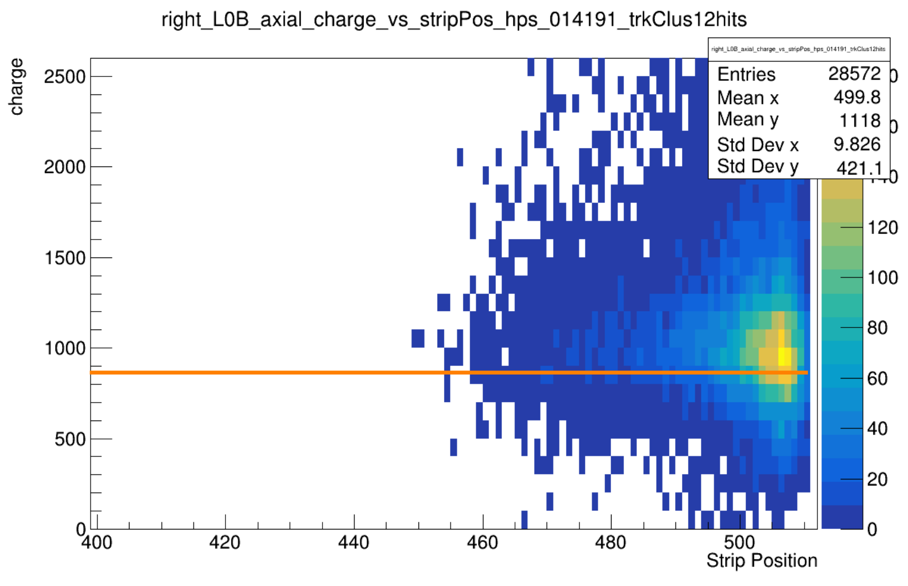
Offline Baseline Fitting

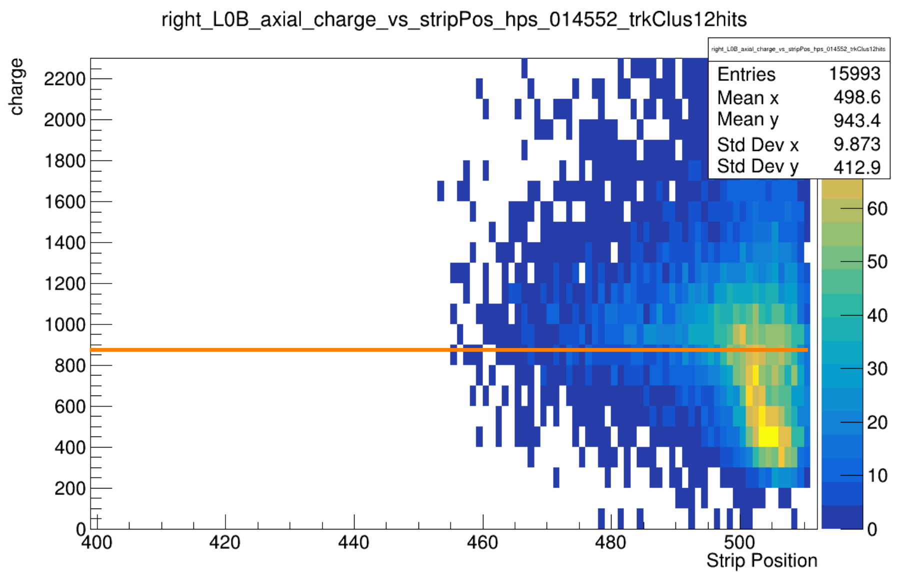
- **Extract pedestal with gaussian fit in window**
- **$xmax_0$** (fit window max ADC) set by reading **thresholds file used to set apv readout thresholds**
- $xmin_0$ initialized as first bin above 0.2*maxbinvalue
- Channel RawSvtHit Sample 0 distribution initial fit with gaussian inside fit window
- Iteratively fit, updating xmin and xmax to be (FitMean + N*Sigma) | (FitMean – N*Sigma)
  - restrict xmax < $xmax_0$ | xmin > $xmin_0$
- Second itertive fit, walking xmax backwards and checking for fit chi2/ndf to improve
  - If FitMean > xmax, break the iterative fit at previous value
  - This recovers fits such as shown Right



L0 Charge vs Run For 12 Hit Tracks


left_L0B_axial_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 28572
Mean x 13.62
Mean y 1070
Std Dev x 9.589
Std Dev y 444.9
Bias: 30V
Day 0
charge
Strip Position
left_L0B_axial_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 15993
Mean x 15.61
Mean y 893
Std Dev x 9.774
Std Dev y 399.5
Peak of charge distribution in edge strips decreased over time
Bias: 30V
Day 31
Orange line is just visual aid to guide eye
left_L0B_axial_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 20374
Mean x 14.31
Mean y 997.5
Std Dev x 10.06
Std Dev y 429.8
Bias: 45V
Day 35
left_L0B_axial_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 19702
Mean x 13.73
Mean y 1059
Std Dev x 9.745
Std Dev y 457.4
Bias: 60V
Day 46


right_L0B_axial_charge_vs_stripPos_hps_014191_trkClus12hits
charge
Strip Position
Entries 28572
Mean x 499.8
Mean y 1118
Std Dev x 9.826
Std Dev y 421.1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Strip Position
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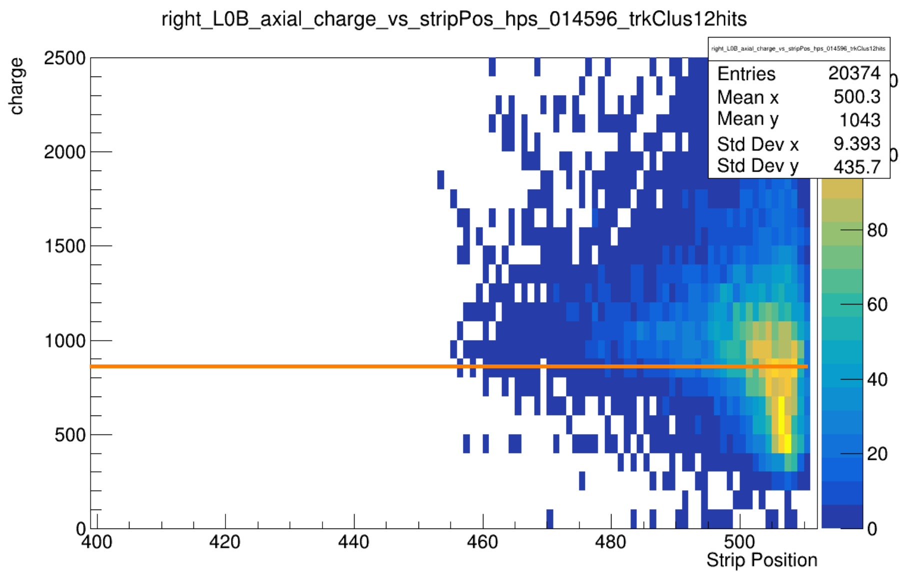
Std Dev x 9.873
Std Dev y 412.9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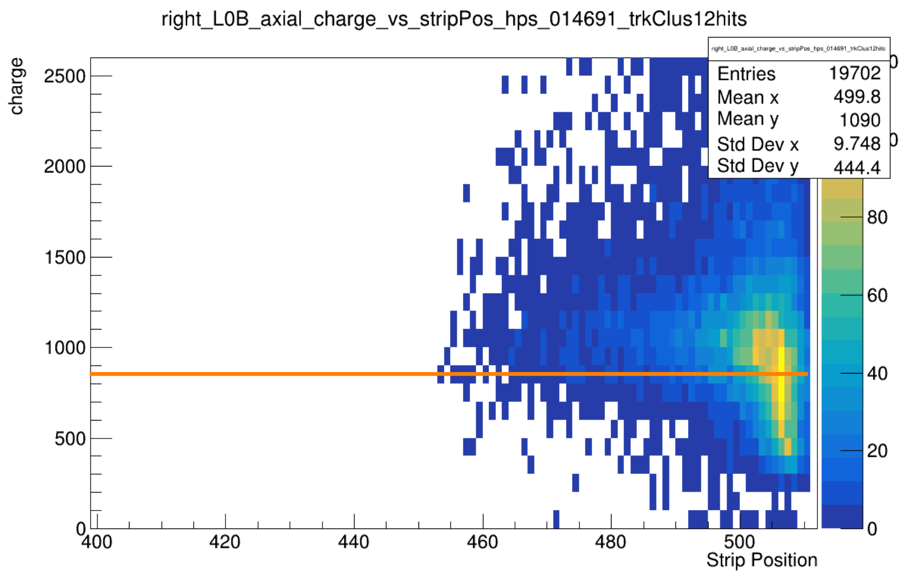
charge
Strip Position
Entries 20374
Mean x 500.3
Mean y 1043
Std Dev x 9.393
Std Dev y 435.7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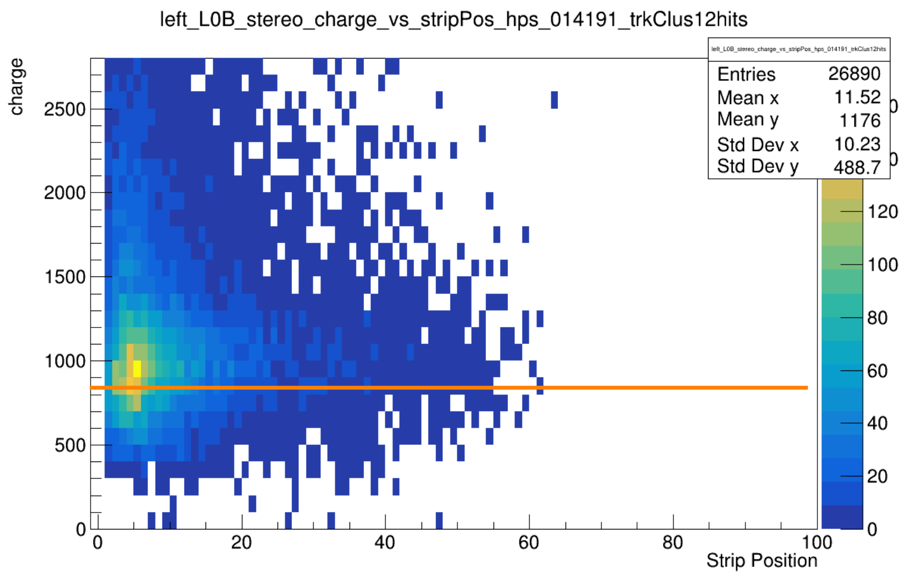
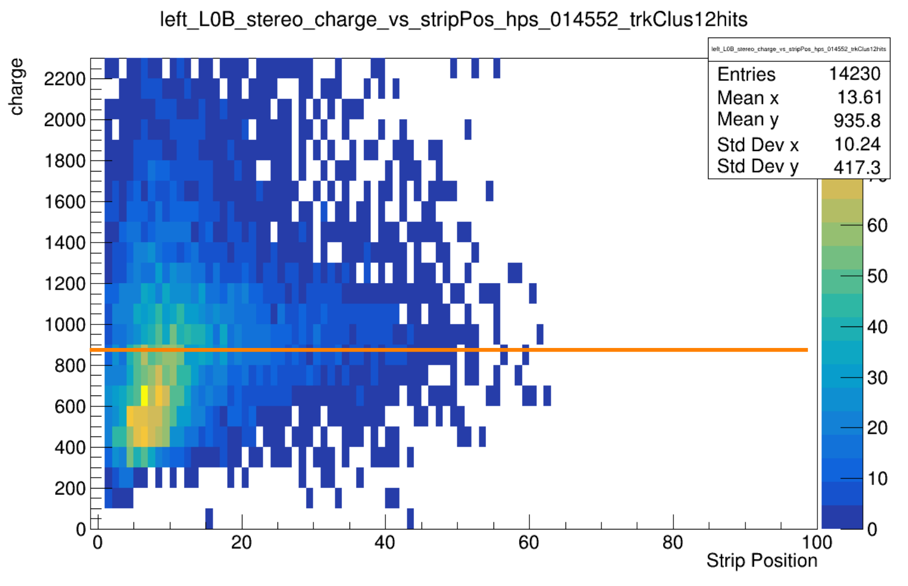
charge
Strip Position
Entries 19702
Mean x 499.8
Mean y 1090
Std Dev x 9.748
Std Dev y 444.4


left_L0B_stereo_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 26890
Mean x 11.52
Mean y 1176
Std Dev x 10.23
Std Dev y 488.7
charge
Strip Position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Entries 14230
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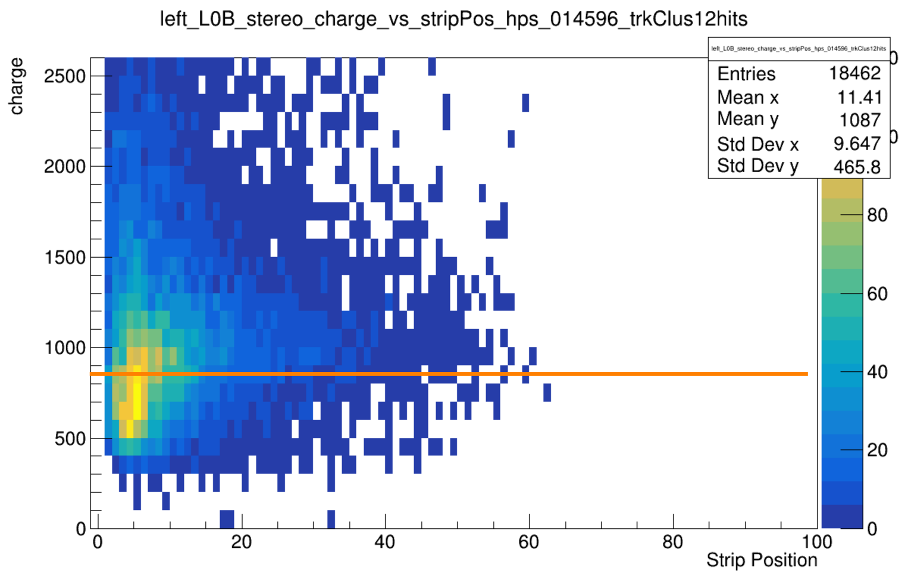
Mean y 935.8
Std Dev x 10.24
Std Dev y 417.3
charge
Strip Position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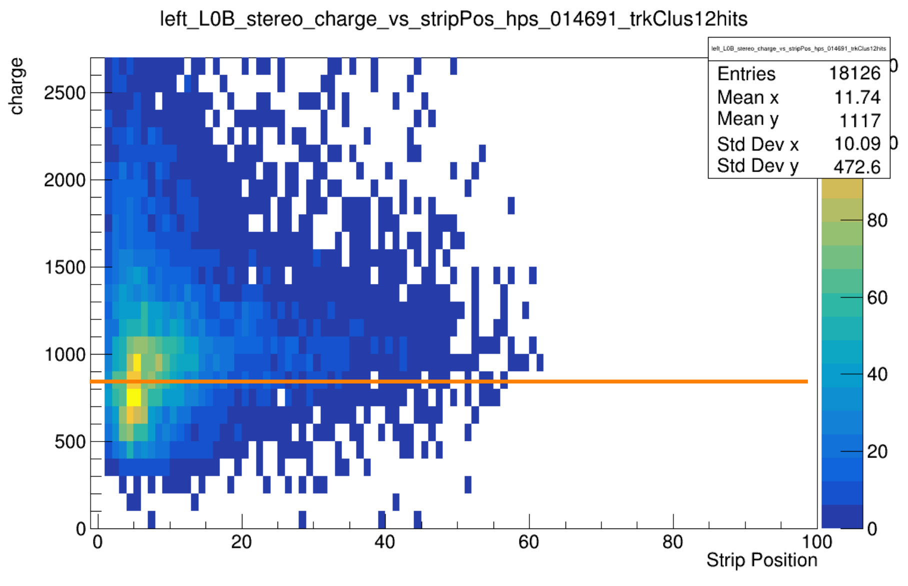
Mean y 1087
Std Dev x 9.647
Std Dev y 465.8
charge
Strip Position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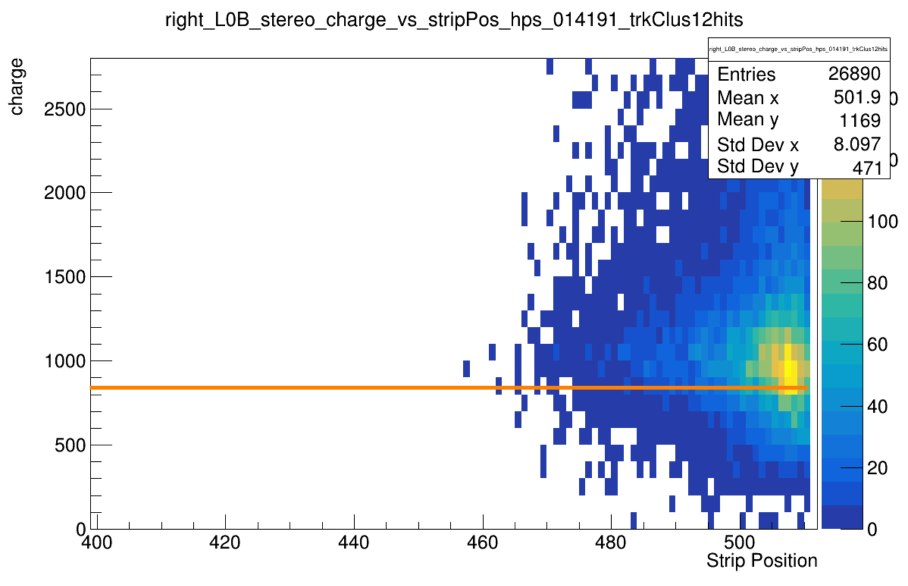
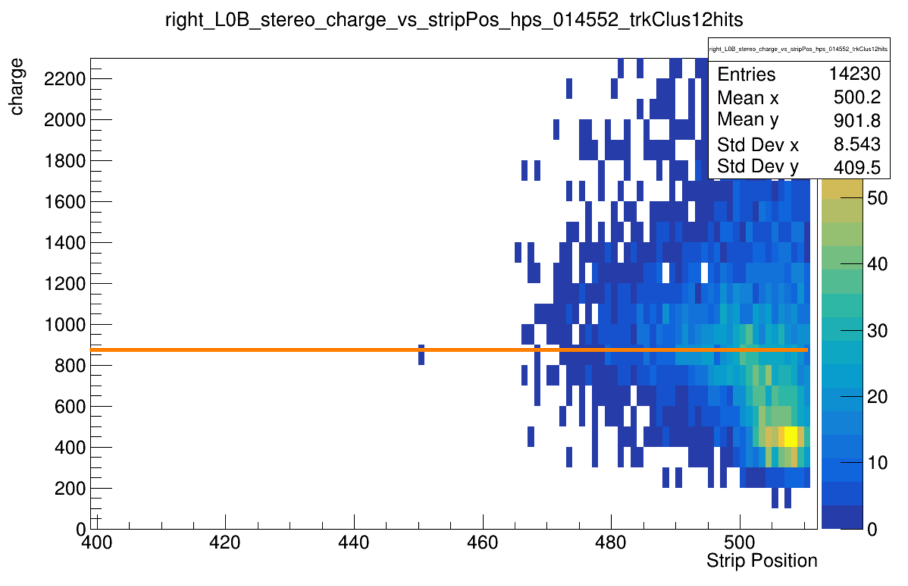
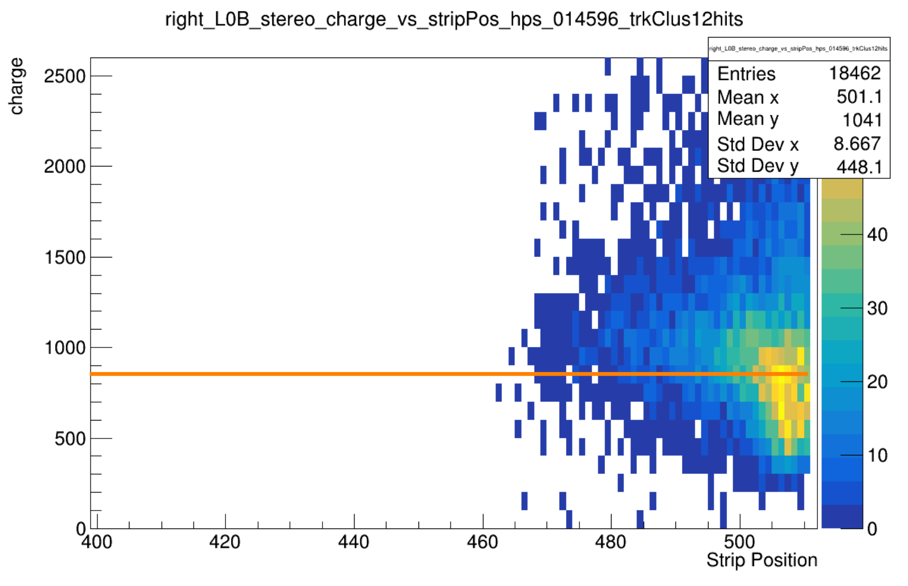
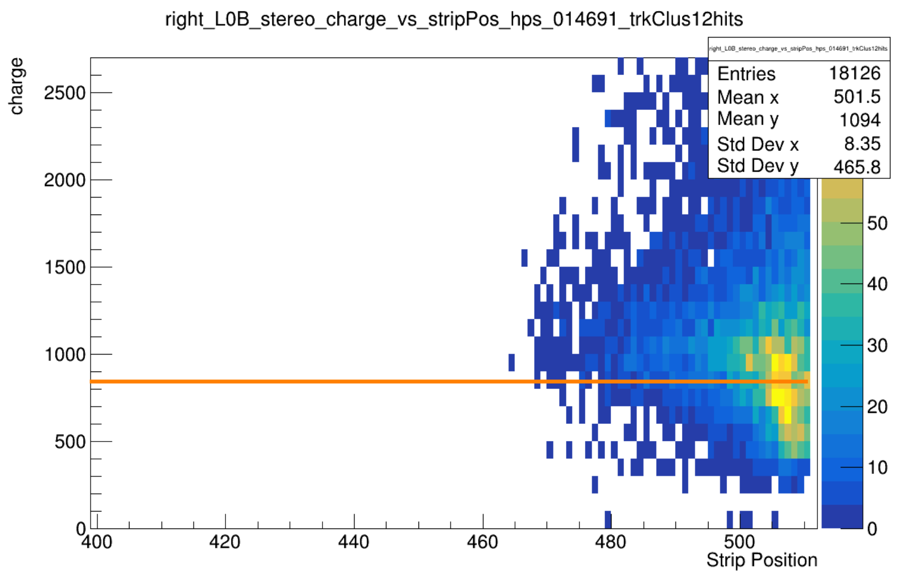
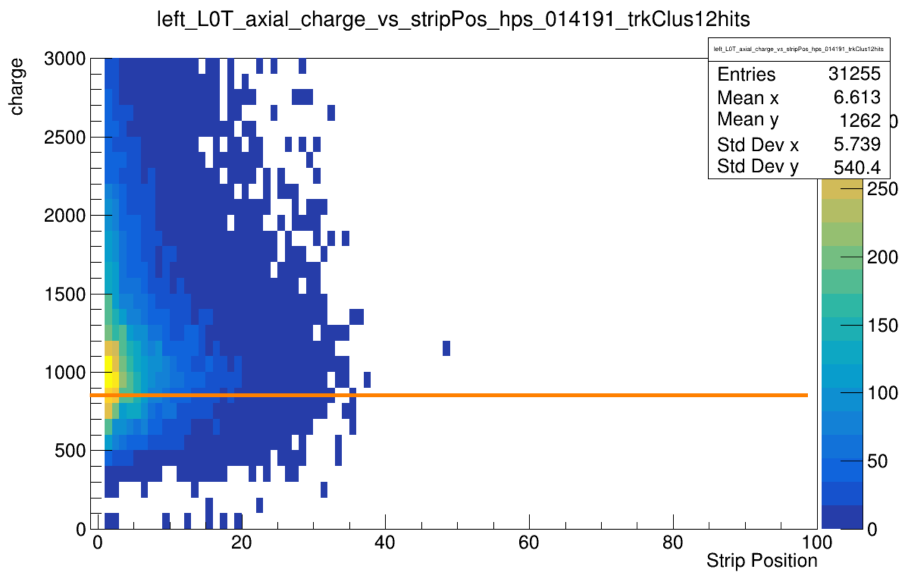
Entries 18126
Mean x 11.74
Mean y 1117
Std Dev x 10.09
Std Dev y 472.6
charge
Strip Position

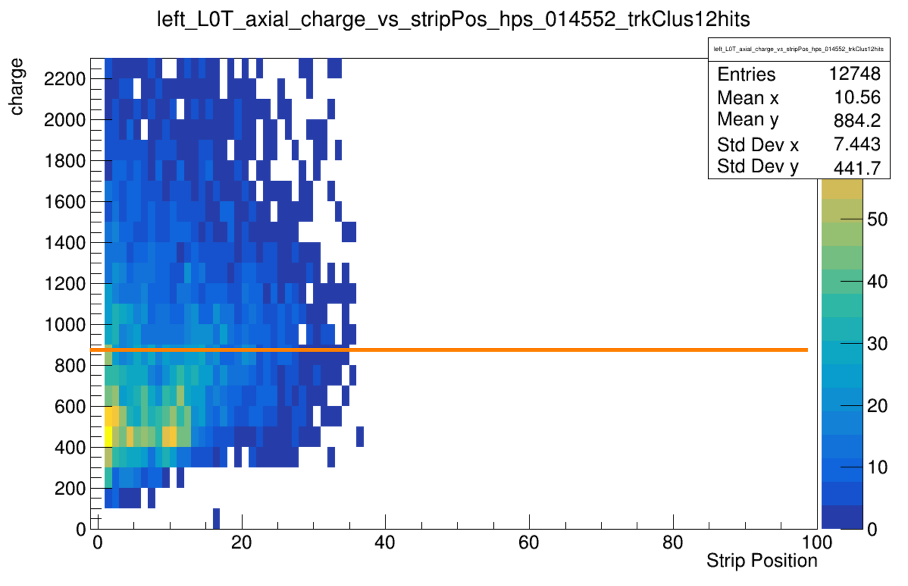

right_L0B_stereo_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 26890
Mean x 501.9
Mean y 1169
Std Dev x 8.097
Std Dev y 471
charge
Strip Position

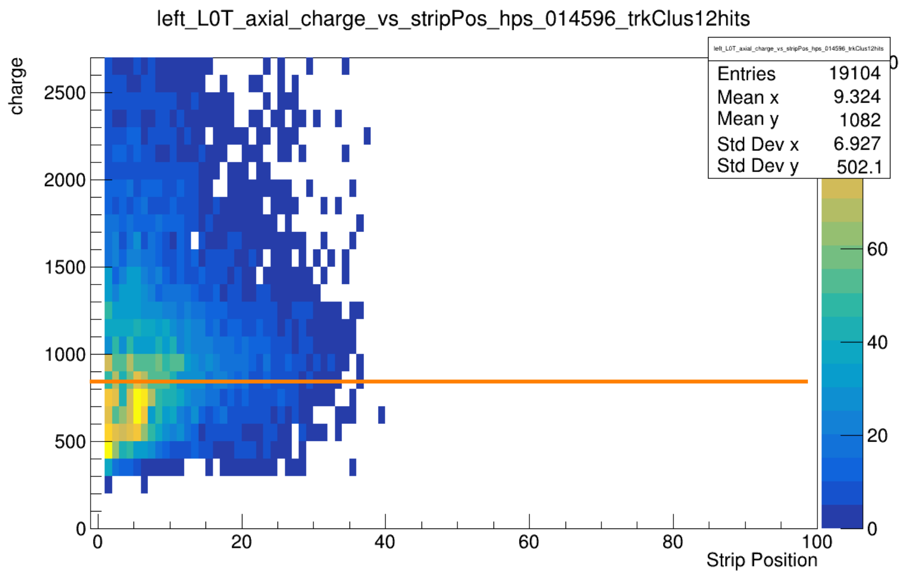

right_L0B_stereo_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 14230
Mean x 500.2
Mean y 901.8
Std Dev x 8.543
Std Dev y 409.5
charge
Strip Position

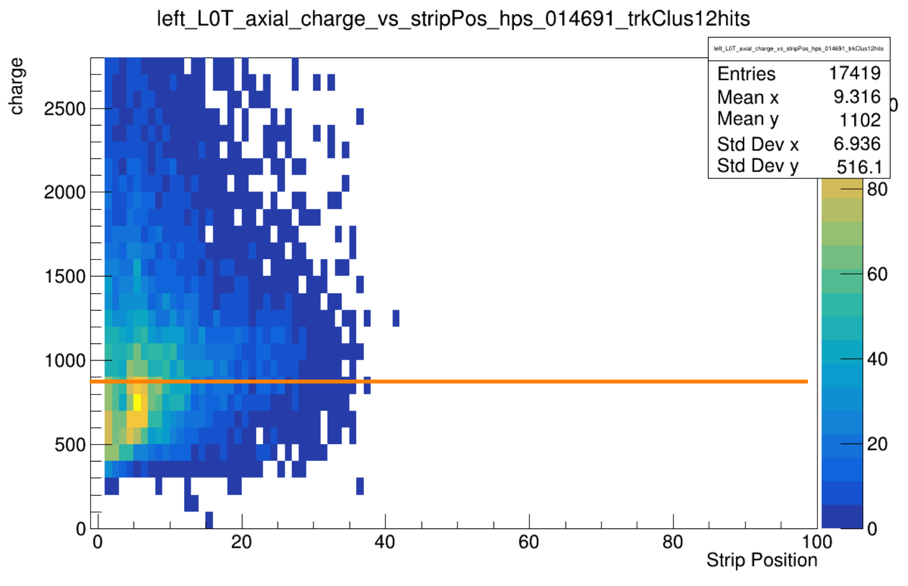

right_L0B_stereo_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 18462
Mean x 501.1
Mean y 1041
Std Dev x 8.667
Std Dev y 448.1
charge
Strip Position

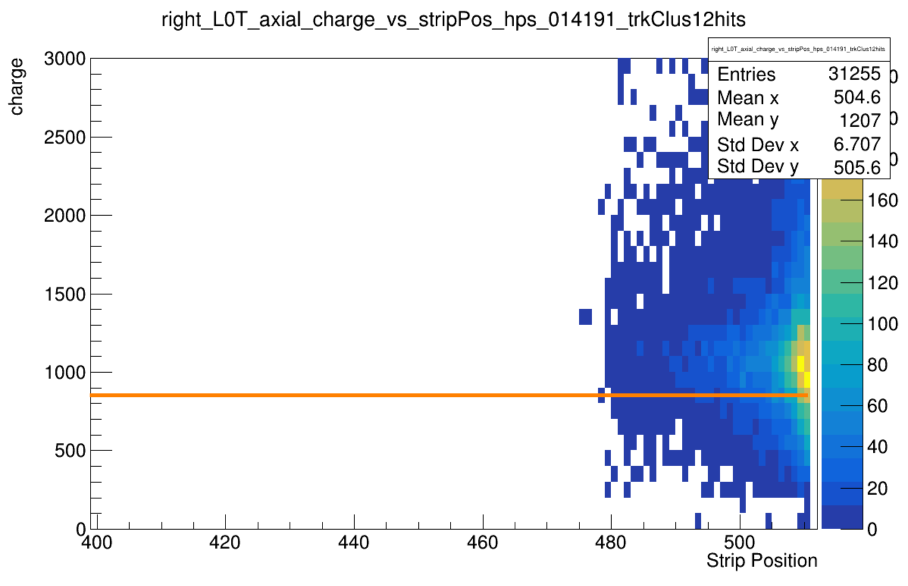

right_L0B_stereo_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 18126
Mean x 501.5
Mean y 1094
Std Dev x 8.35
Std Dev y 465.8
charge
Strip Position

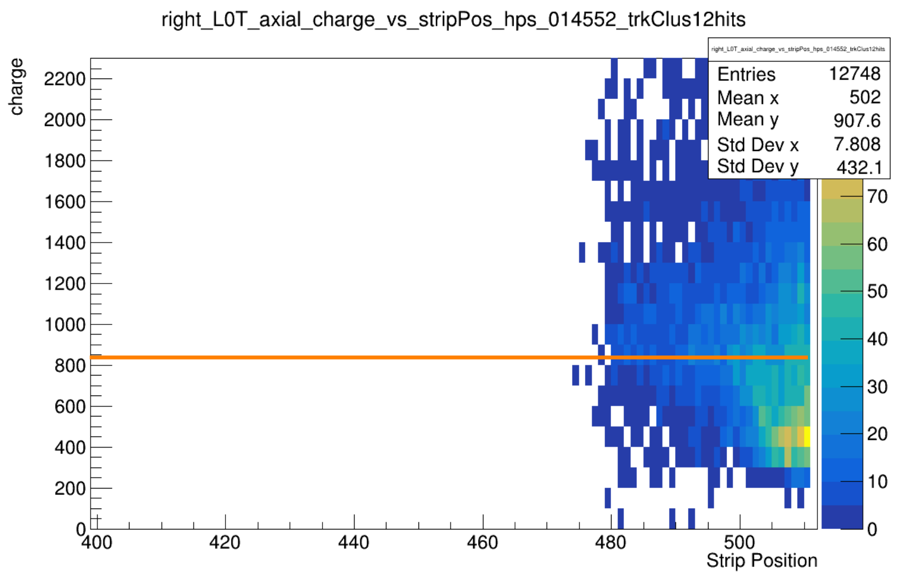

left_L0T_axial_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 31255
Mean x 6.613
Mean y 1262
Std Dev x 5.739
Std Dev y 540.4
charge
Strip Position

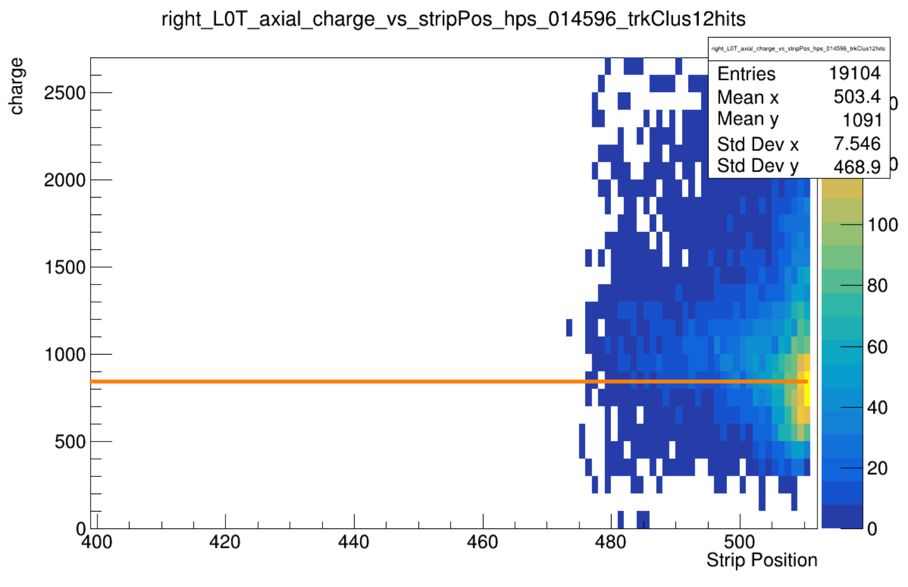

left_L0T_axial_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 12748
Mean x 10.56
Mean y 884.2
Std Dev x 7.443
Std Dev y 441.7
charge
Strip Position

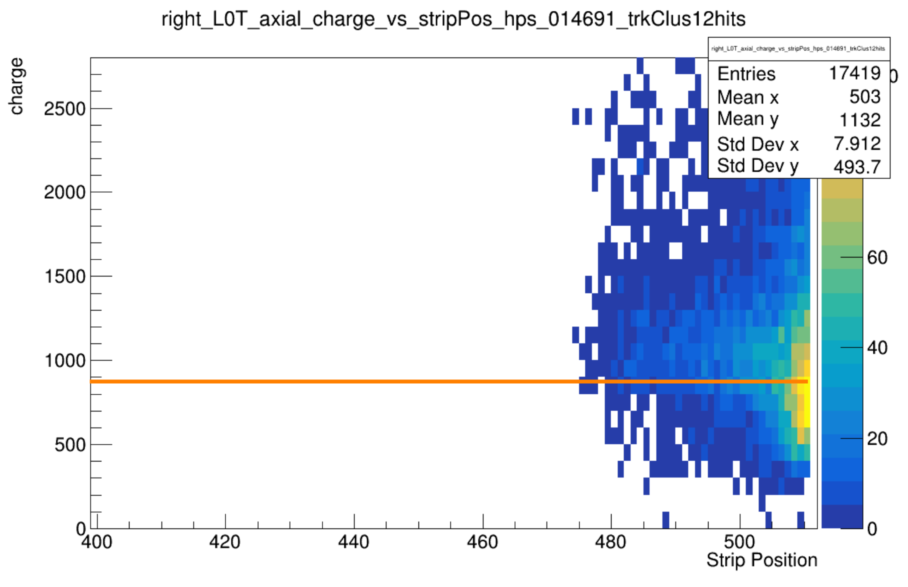

left_L0T_axial_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 19104
Mean x 9.324
Mean y 1082
Std Dev x 6.927
Std Dev y 502.1
charge
Strip Position

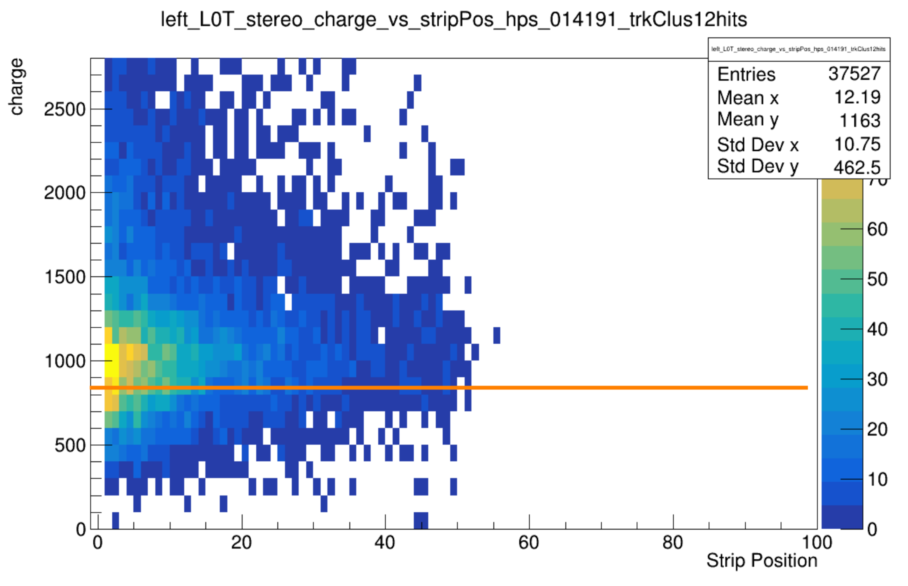

left_L0T_axial_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 17419
Mean x 9.316
Mean y 1102
Std Dev x 6.936
Std Dev y 516.1
charge
Strip Position

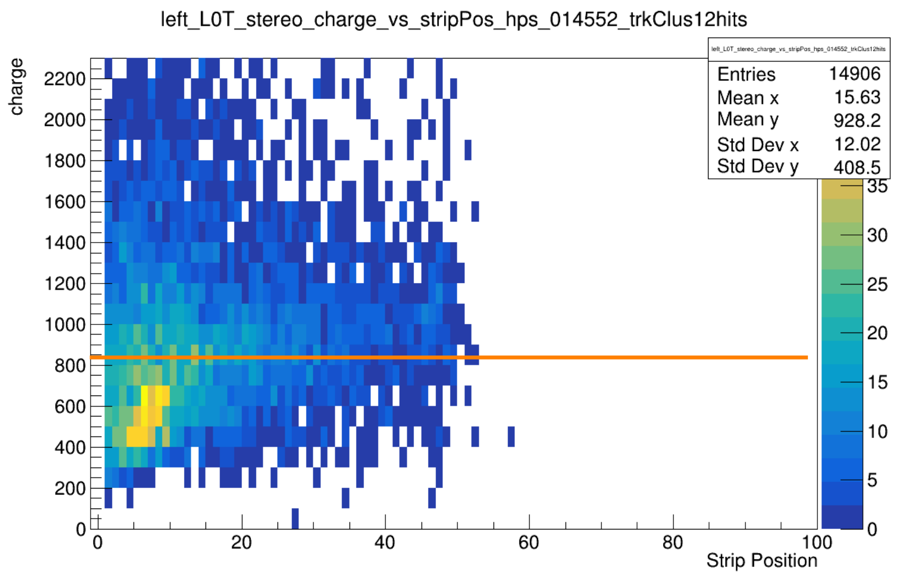

right_L0T_axial_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 31255
Mean x 504.6
Mean y 1207
Std Dev x 6.707
Std Dev y 505.6
charge
Strip Position

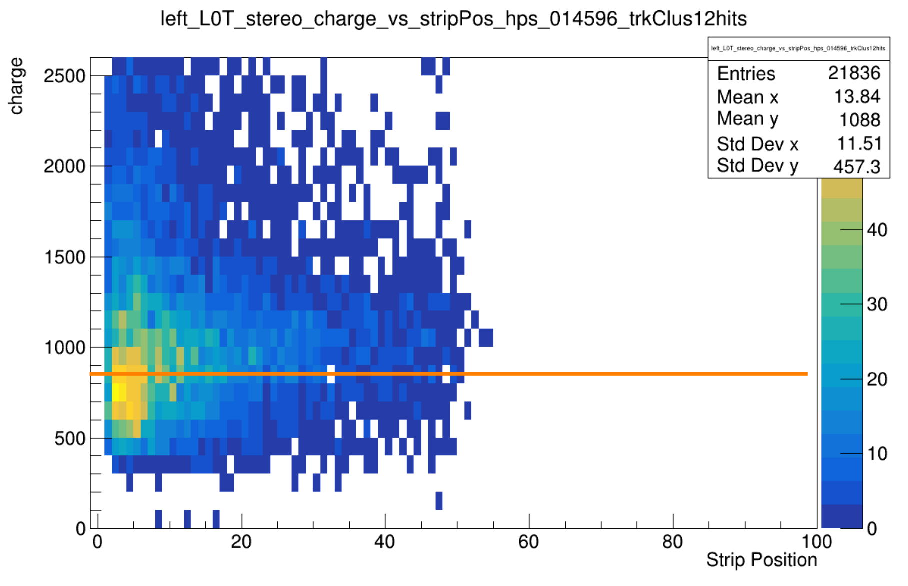

right_L0T_axial_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 12748
Mean x 502
Mean y 907.6
Std Dev x 7.808
Std Dev y 432.1
charge
Strip Position

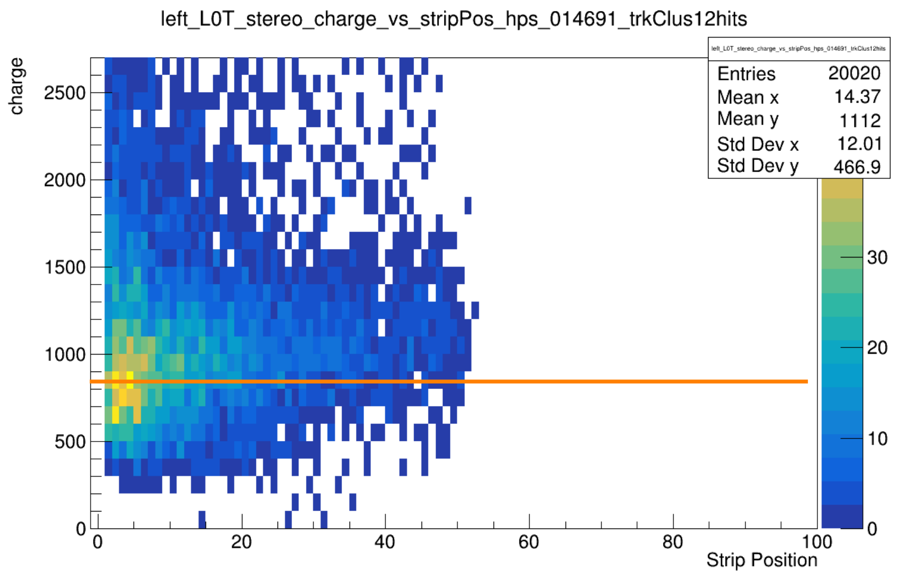

right_L0T_axial_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 19104
Mean x 503.4
Mean y 1091
Std Dev x 7.546
Std Dev y 468.9
charge
Strip Position

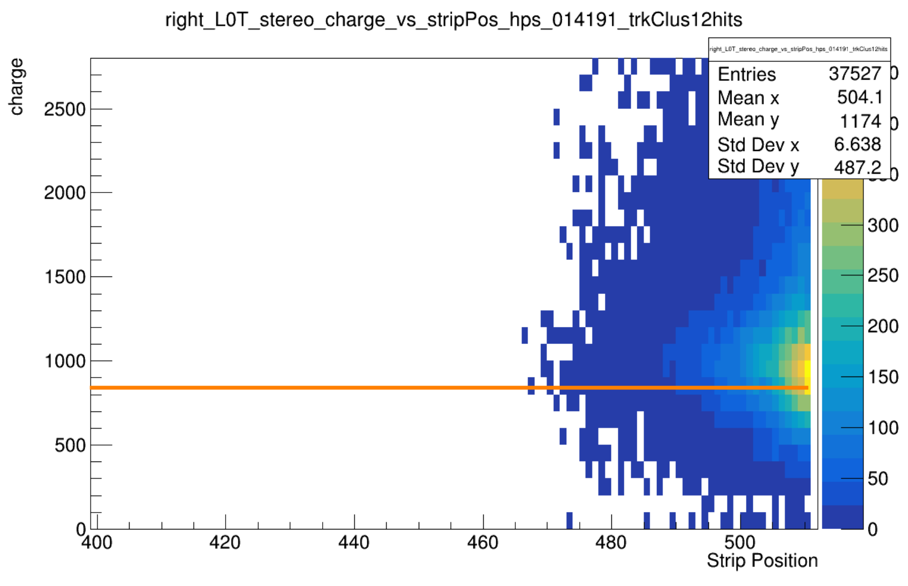

right_L0T_axial_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 17419
Mean x 503
Mean y 1132
Std Dev x 7.912
Std Dev y 493.7
charge
Strip Position

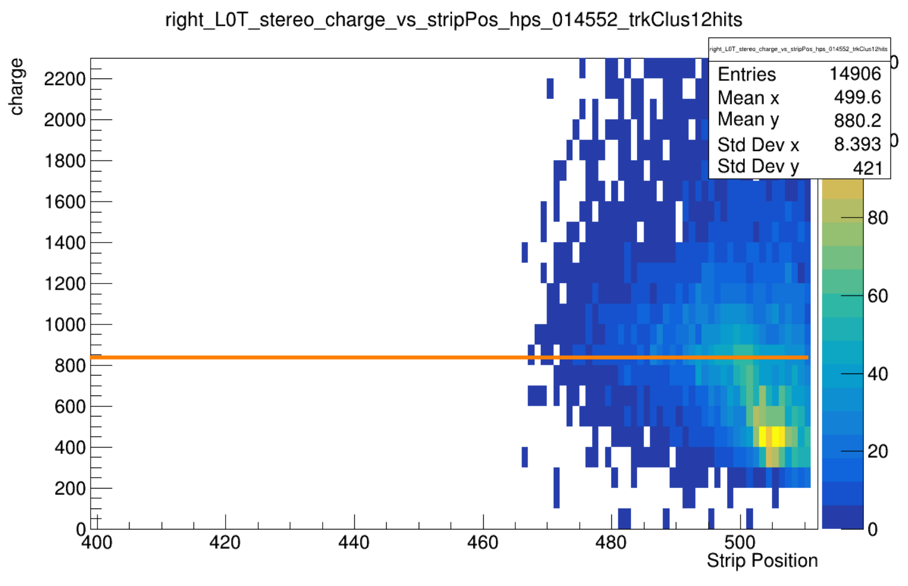

left_L0T_stereo_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 37527
Mean x 12.19
Mean y 1163
Std Dev x 10.75
Std Dev y 462.5
charge
Strip Position

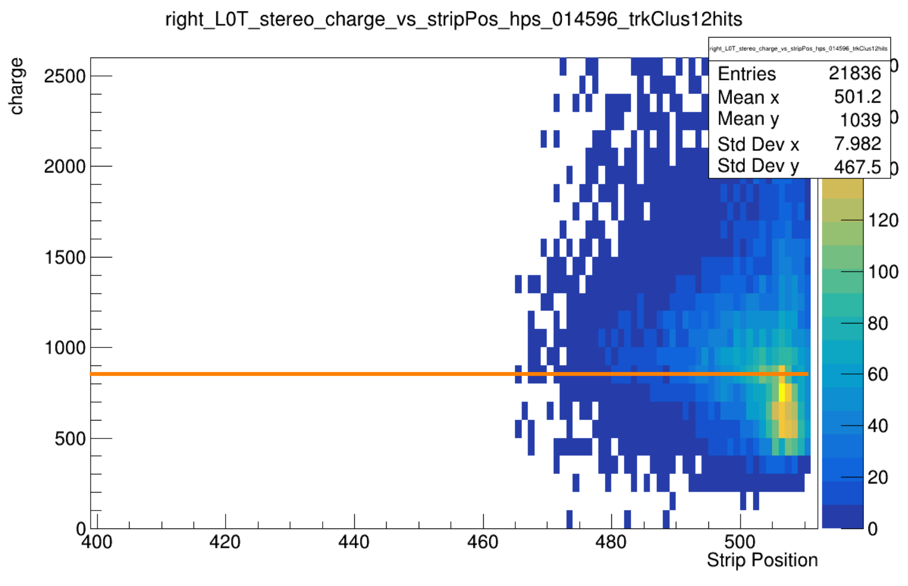

left_L0T_stereo_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 14906
Mean x 15.63
Mean y 928.2
Std Dev x 12.02
Std Dev y 408.5
charge
Strip Position


left_L0T_stereo_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 21836
Mean x 13.84
Mean y 1088
Std Dev x 11.51
Std Dev y 457.3
charge
Strip Position


left_L0T_stereo_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 20020
Mean x 14.37
Mean y 1112
Std Dev x 12.01
Std Dev y 466.9
charge
Strip Position


right_L0T_stereo_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 37527
Mean x 504.1
Mean y 1174
Std Dev x 6.638
Std Dev y 487.2
charge
Strip Position


right_L0T_stereo_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 14906
Mean x 499.6
Mean y 880.2
Std Dev x 8.393
Std Dev y 421
charge
Strip Position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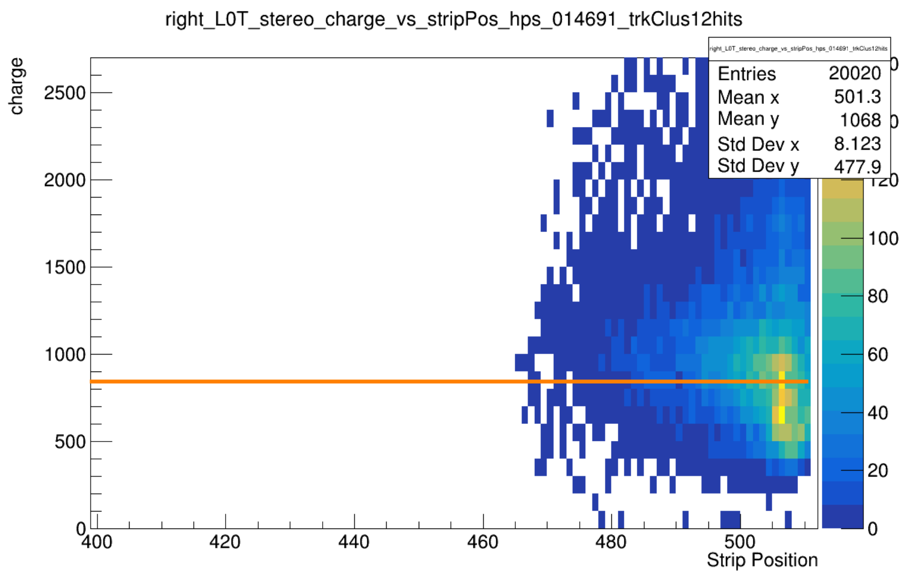
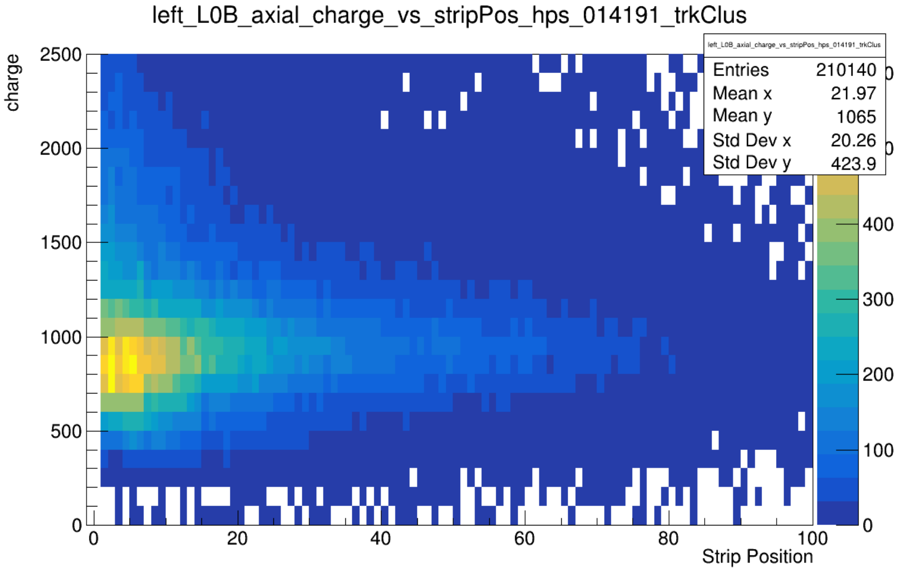
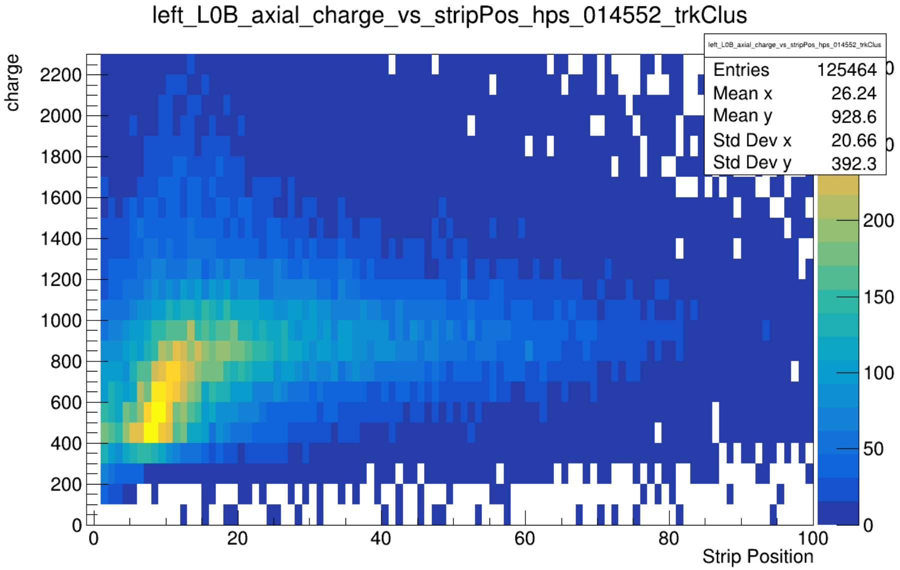
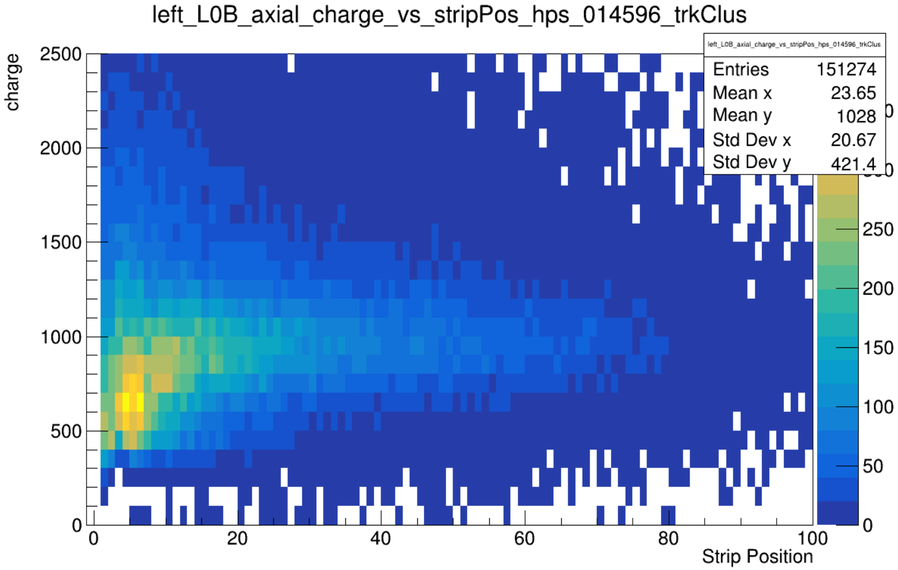
Entries 21836
Mean x 501.2
Mean y 1039
Std Dev x 7.982
Std Dev y 467.5
charge
Strip Position

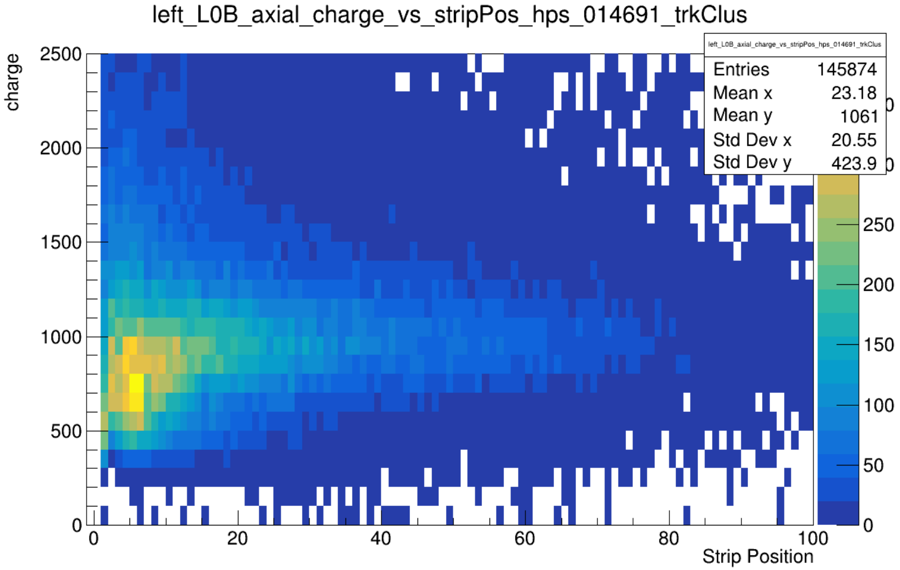

right_L0T_stereo_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 20020
Mean x 501.3
Mean y 1068
Std Dev x 8.123
Std Dev y 477.9
charge
Strip Position

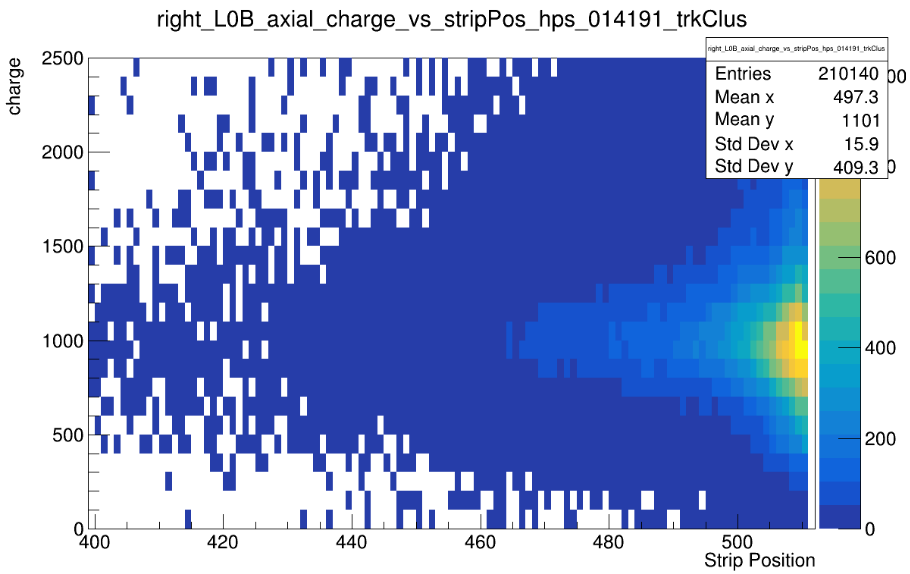
L0 Charge vs Run For All Tracks

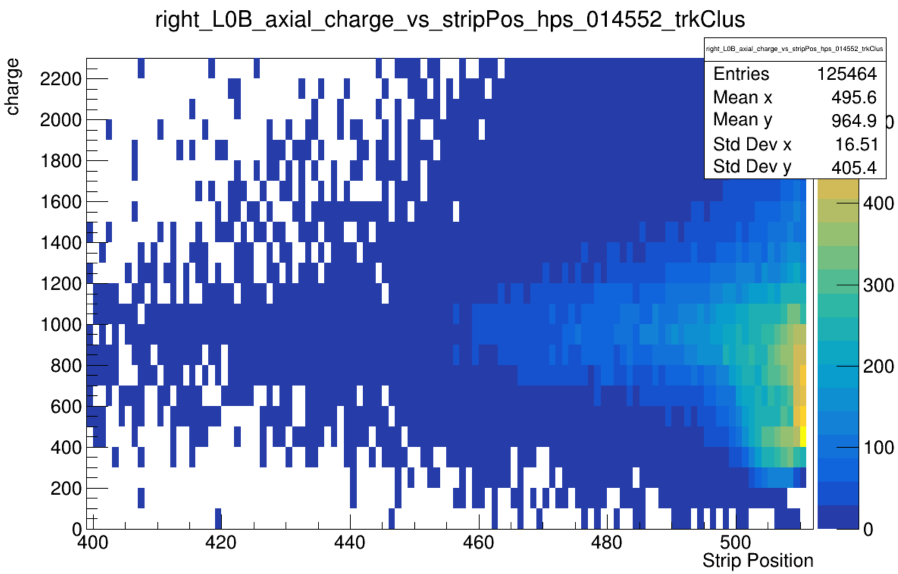

left_L0B_axial_charge_vs_stripPos_hps_014191_trkClus
Entries 210140
Mean x 21.97
Mean y 1065
Std Dev x 20.26
Std Dev y 423.9
charge
Strip Position

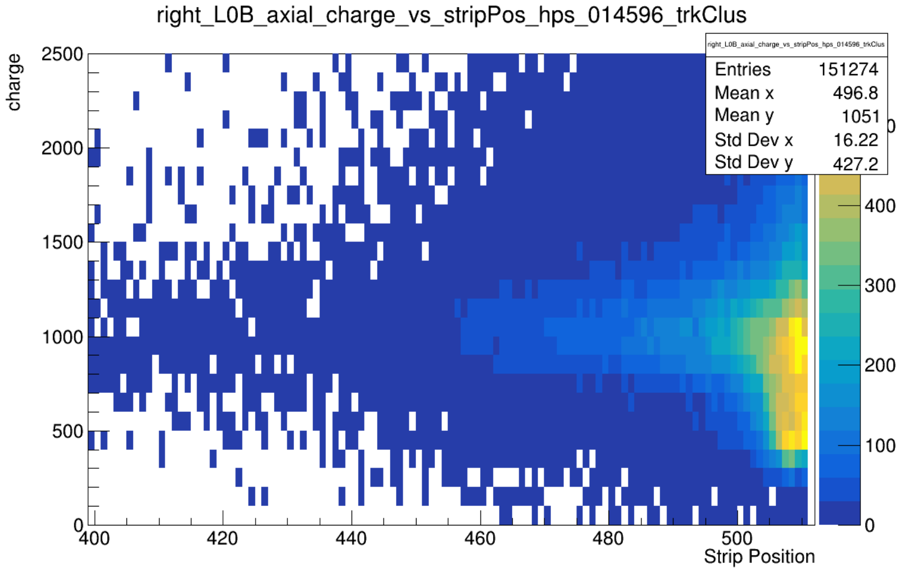

left_L0B_axial_charge_vs_stripPos_hps_014552_trkClus
Entries 125464
Mean x 26.24
Mean y 928.6
Std Dev x 20.66
Std Dev y 392.3
charge
Strip Position

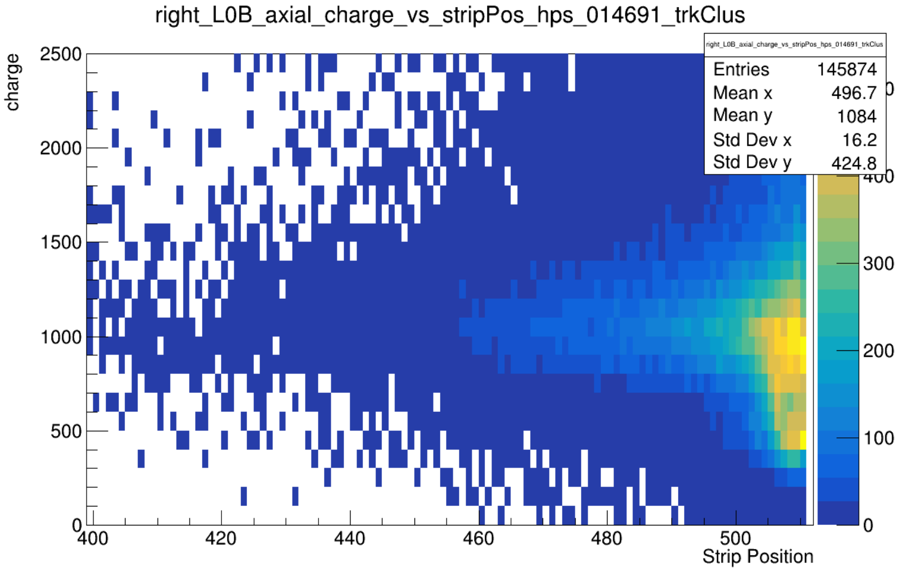

left_L0B_axial_charge_vs_stripPos_hps_014596_trkClus
Entries 151274
Mean x 23.65
Mean y 1028
Std Dev x 20.67
Std Dev y 421.4
charge
Strip Position

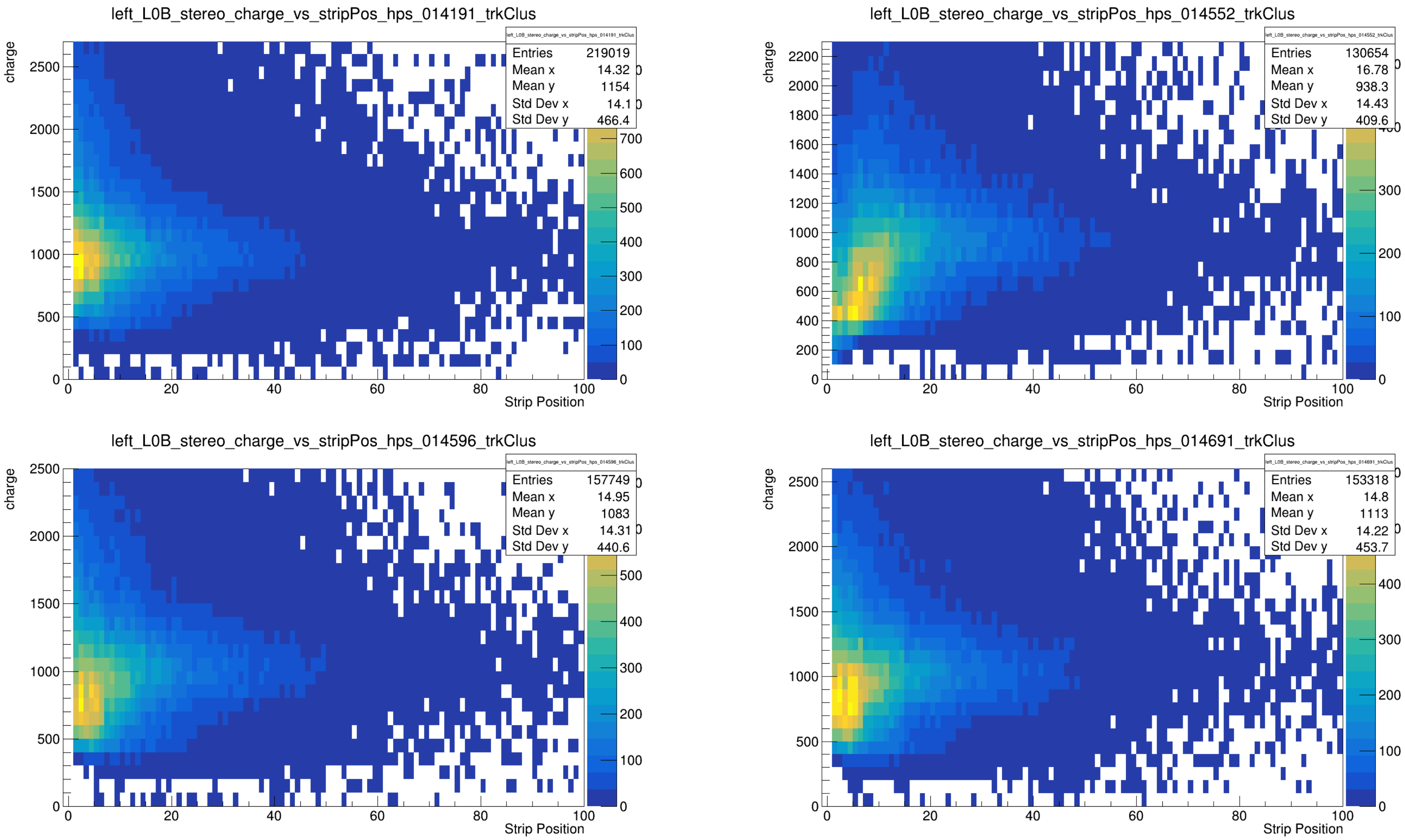

left_L0B_axial_charge_vs_stripPos_hps_014691_trkClus
Entries 145874
Mean x 23.18
Mean y 1061
Std Dev x 20.55
Std Dev y 423.9
charge
Strip Position

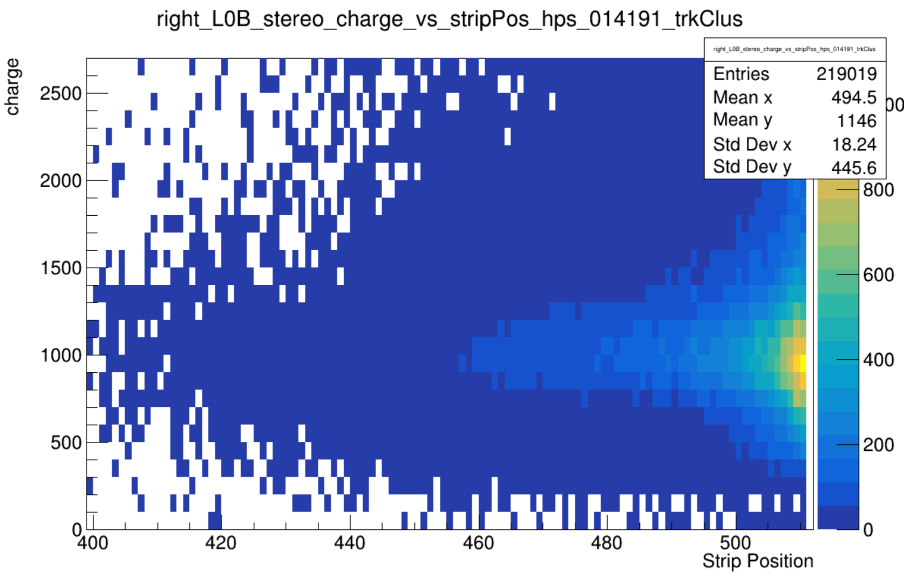

right_L0B_axial_charge_vs_stripPos_hps_014191_trkClus
Entries 210140
Mean x 497.3
Mean y 1101
Std Dev x 15.9
Std Dev y 409.3
charge
Strip Position

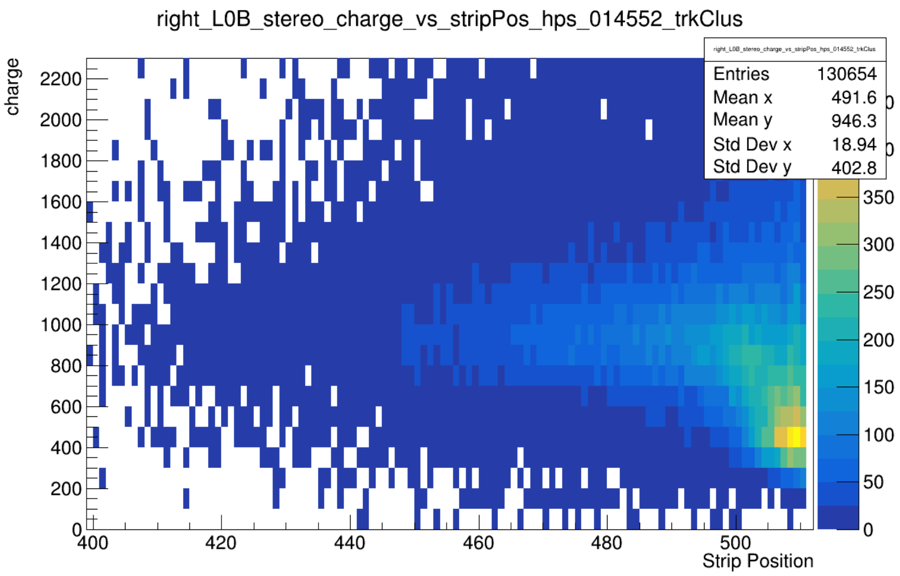

right_L0B_axial_charge_vs_stripPos_hps_014552_trkClus
Entries 125464
Mean x 495.6
Mean y 964.9
Std Dev x 16.51
Std Dev y 405.4
charge
Strip Position

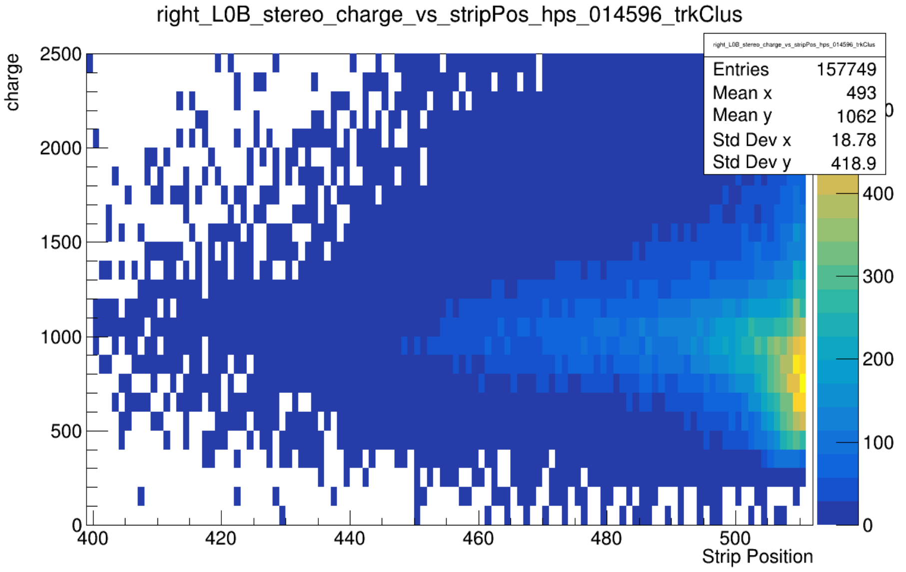

right_L0B_axial_charge_vs_stripPos_hps_014596_trkClus
Entries 151274
Mean x 496.8
Mean y 1051
Std Dev x 16.22
Std Dev y 427.2
charge
Strip Position

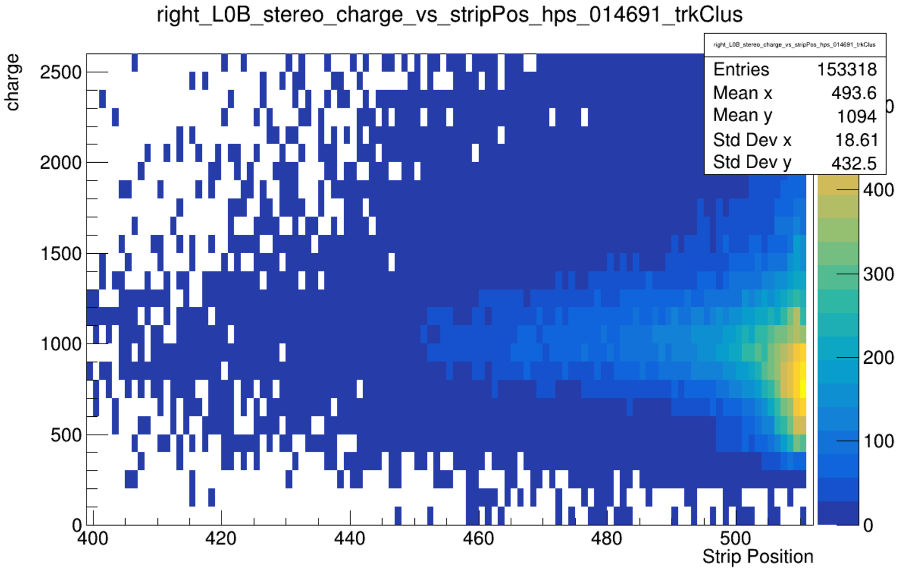

right_L0B_axial_charge_vs_stripPos_hps_014691_trkClus
Entries 145874
Mean x 496.7
Mean y 1084
Std Dev x 16.2
Std Dev y 424.8
charge
Strip Position

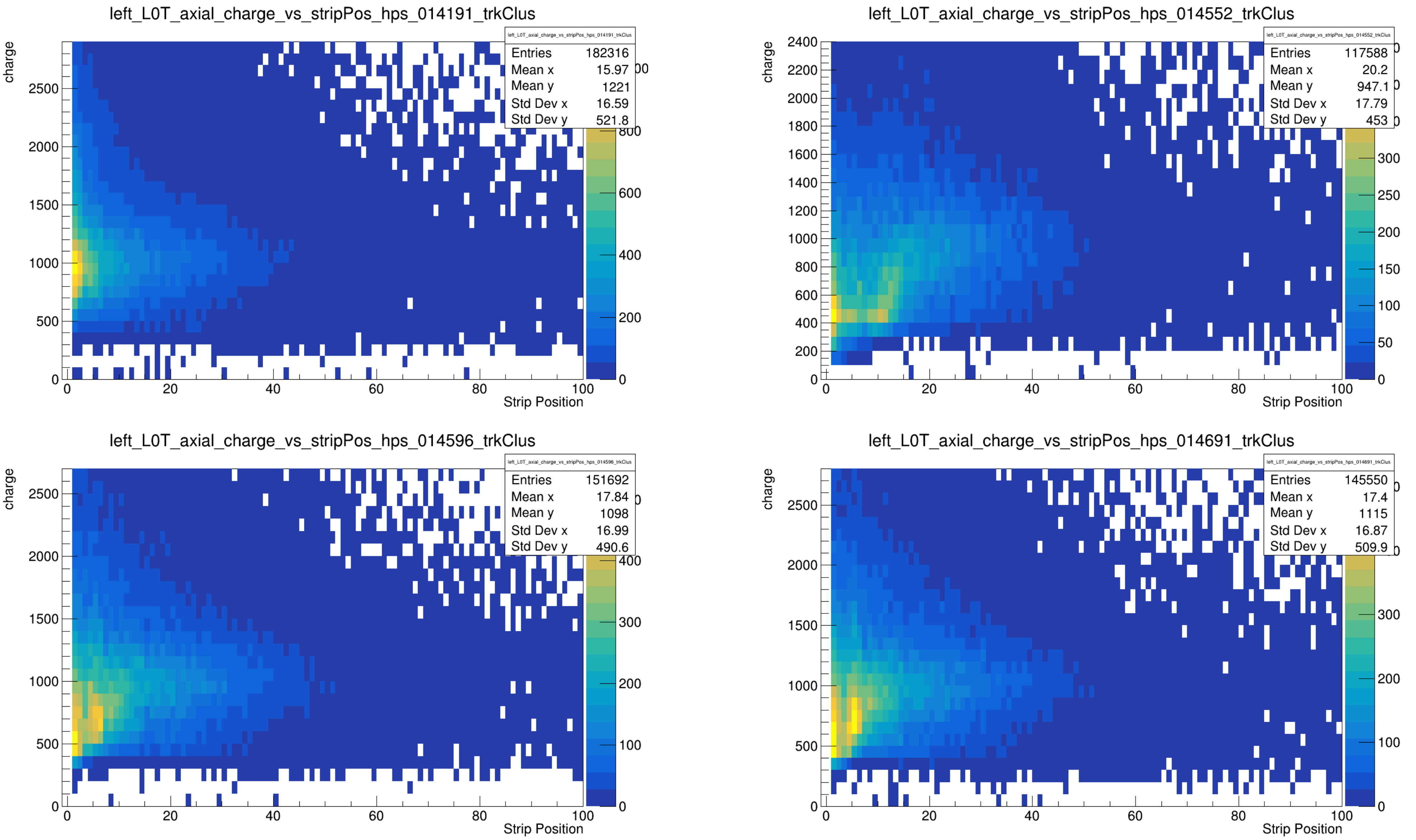

left_L0B_stereo_charge_vs_stripPos_hps_014191_trkClus
Entries 219019
Mean x 14.32
Mean y 1154
Std Dev x 14.1
Std Dev y 466.4
charge
Strip Position
left_L0B_stereo_charge_vs_stripPos_hps_014552_trkClus
Entries 130654
Mean x 16.78
Mean y 938.3
Std Dev x 14.43
Std Dev y 409.6
charge
Strip Position
left_L0B_stereo_charge_vs_stripPos_hps_014596_trkClus
Entries 157749
Mean x 14.95
Mean y 1083
Std Dev x 14.31
Std Dev y 440.6
charge
Strip Position
left_L0B_stereo_charge_vs_stripPos_hps_014691_trkClus
Entries 153318
Mean x 14.8
Mean y 1113
Std Dev x 14.22
Std Dev y 453.7
charge
Strip Position


right_L0B_stereo_charge_vs_stripPos_hps_014191_trkClus
Entries 219019
Mean x 494.5
Mean y 1146
Std Dev x 18.24
Std Dev y 445.6
charge
Strip Position

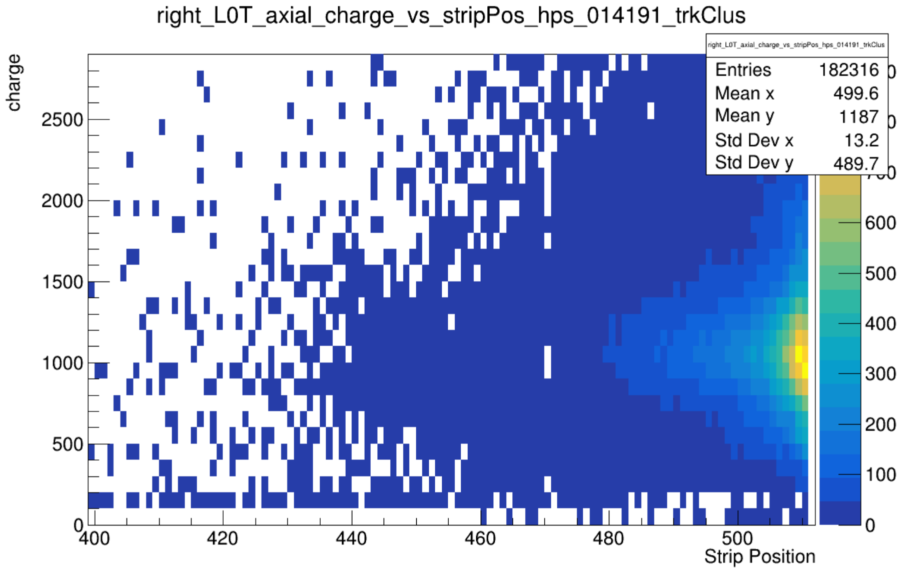

right_L0B_stereo_charge_vs_stripPos_hps_014552_trkClus
Entries 130654
Mean x 491.6
Mean y 946.3
Std Dev x 18.94
Std Dev y 402.8
charge
Strip Position

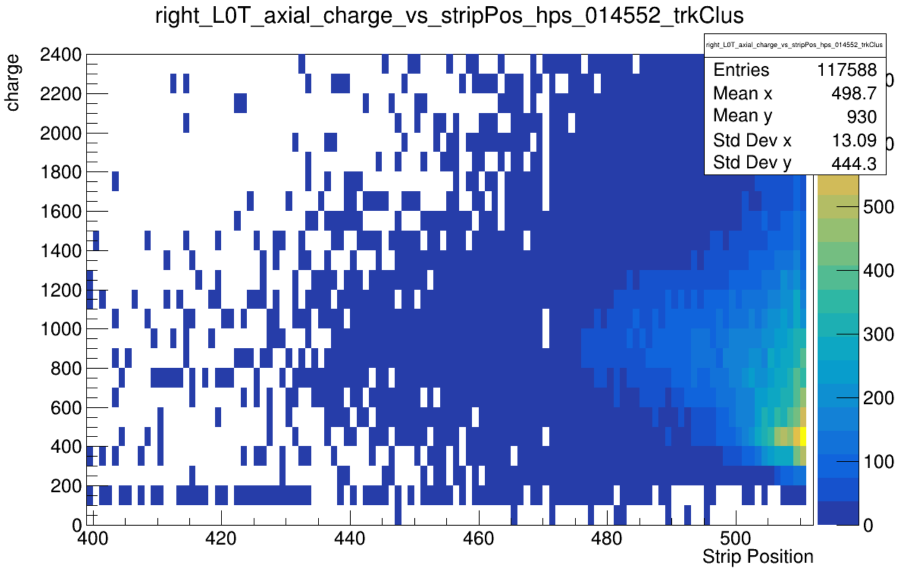

right_L0B_stereo_charge_vs_stripPos_hps_014596_trkClus
Entries 157749
Mean x 493
Mean y 1062
Std Dev x 18.78
Std Dev y 418.9
charge
Strip Position


right_L0B_stereo_charge_vs_stripPos_hps_014691_trkClus
Entries 153318
Mean x 493.6
Mean y 1094
Std Dev x 18.61
Std Dev y 432.5
charge
Strip Position



left_L0T_axial_charge_vs_stripPos_hps_014191_trkClus
Entries 182316
Mean x 15.97
Mean y 1221
Std Dev x 16.59
Std Dev y 521.8
charge
Strip Position
left_L0T_axial_charge_vs_stripPos_hps_014552_trkClus
Entries 117588
Mean x 20.2
Mean y 947.1
Std Dev x 17.79
Std Dev y 453
charge
Strip Position
left_L0T_axial_charge_vs_stripPos_hps_014596_trkClus
Entries 151692
Mean x 17.84
Mean y 1098
Std Dev x 16.99
Std Dev y 490.6
charge
Strip Position
left_L0T_axial_charge_vs_stripPos_hps_014691_trkClus
Entries 145550
Mean x 17.4
Mean y 1115
Std Dev x 16.87
Std Dev y 509.9
charge
Strip Position


right_L0T_axial_charge_vs_stripPos_hps_014191_trkClus
Entries 182316
Mean x 499.6
Mean y 1187
Std Dev x 13.2
Std Dev y 489.7
charge
Strip Position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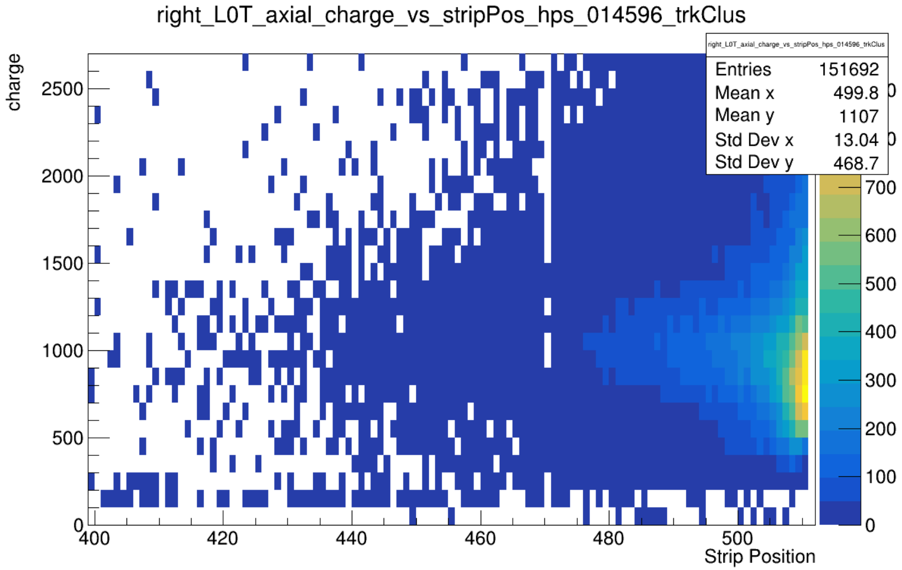
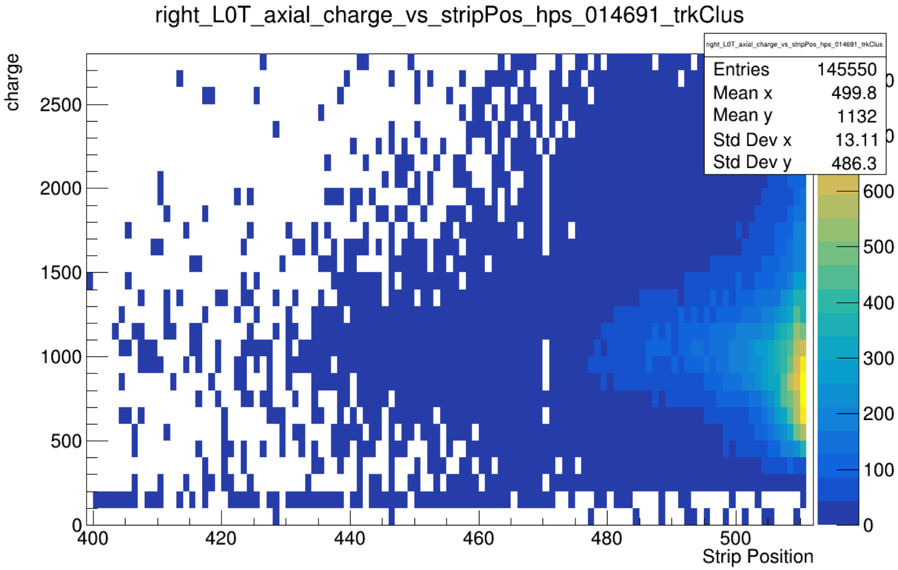
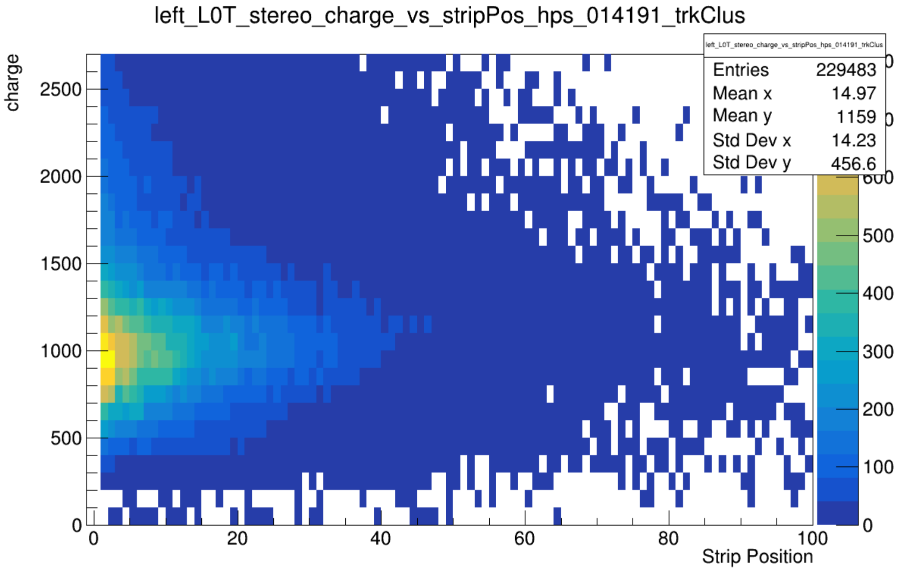
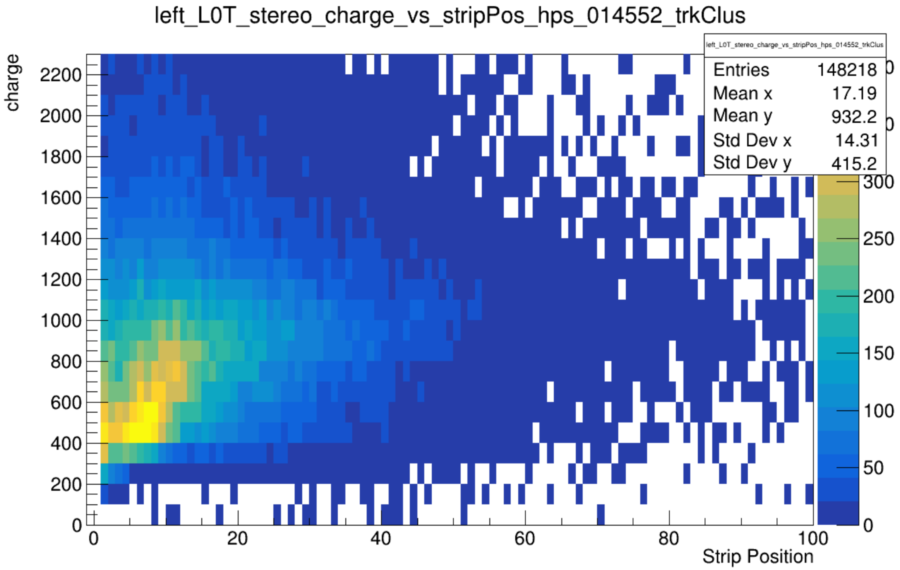
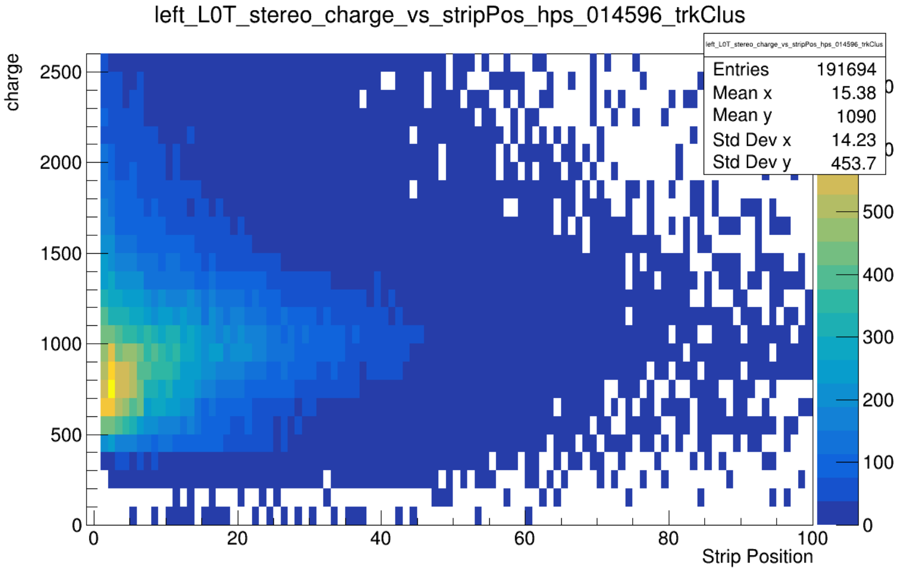
Entries 117588
Mean x 498.7
Mean y 930
Std Dev x 13.09
Std Dev y 444.3
charge
Strip Position

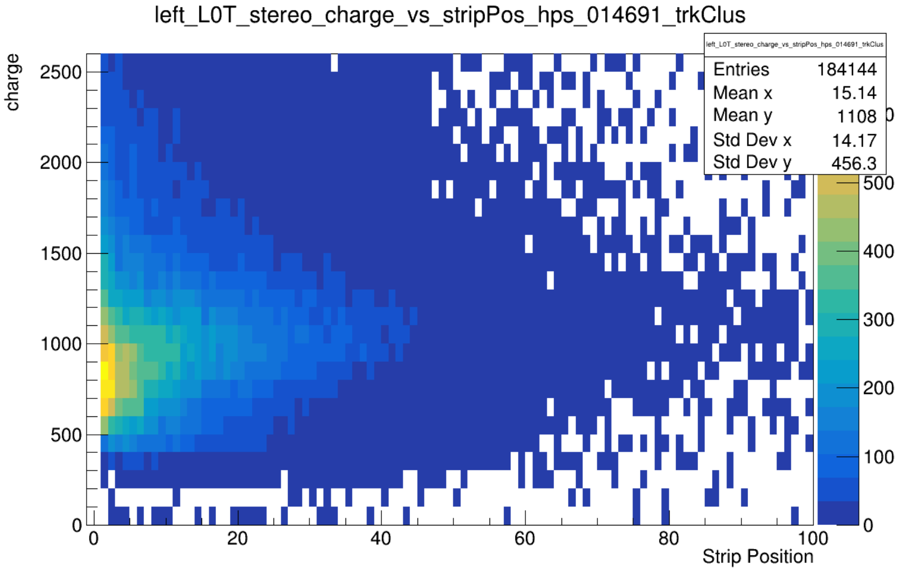

right_L0T_axial_charge_vs_stripPos_hps_014596_trkClus
Entries 151692
Mean x 499.8
Mean y 1107
Std Dev x 13.04
Std Dev y 468.7
charge
Strip Position


right_L0T_axial_charge_vs_stripPos_hps_014691_trkClus
Entries 145550
Mean x 499.8
Mean y 1132
Std Dev x 13.11
Std Dev y 486.3
charge
Strip Position


left_L0T_stereo_charge_vs_stripPos_hps_014191_trkClus
Entries 229483
Mean x 14.97
Mean y 1159
Std Dev x 14.23
Std Dev y 456.6
charge
Strip Position


left_L0T_stereo_charge_vs_stripPos_hps_014552_trkClus
Entries 148218
Mean x 17.19
Mean y 932.2
Std Dev x 14.31
Std Dev y 415.2
charge
Strip Position


left_L0T_stereo_charge_vs_stripPos_hps_014596_trkClus
Entries 191694
Mean x 15.38
Mean y 1090
Std Dev x 14.23
Std Dev y 453.7
charge
Strip Position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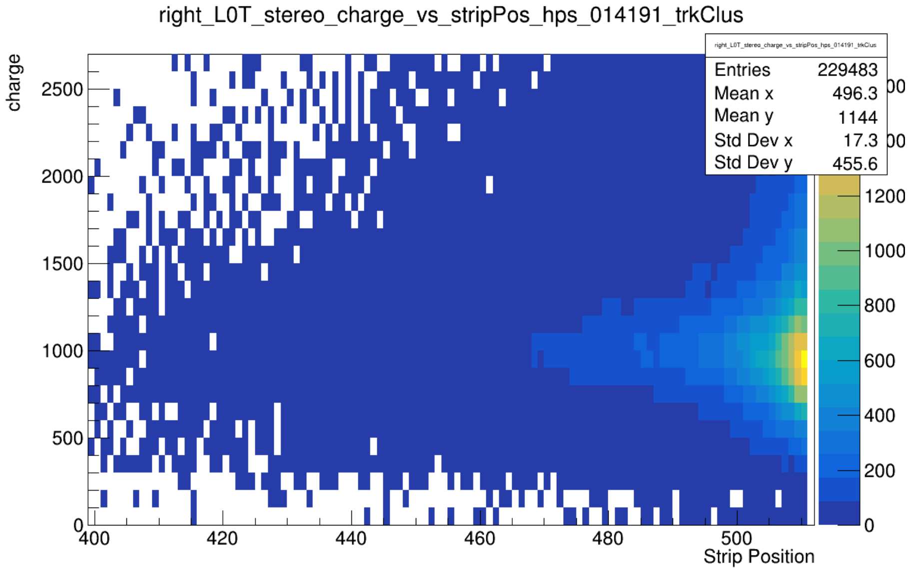
Entries 184144
Mean x 15.14
Mean y 1108
Std Dev x 14.17
Std Dev y 456.3
charge
Strip Position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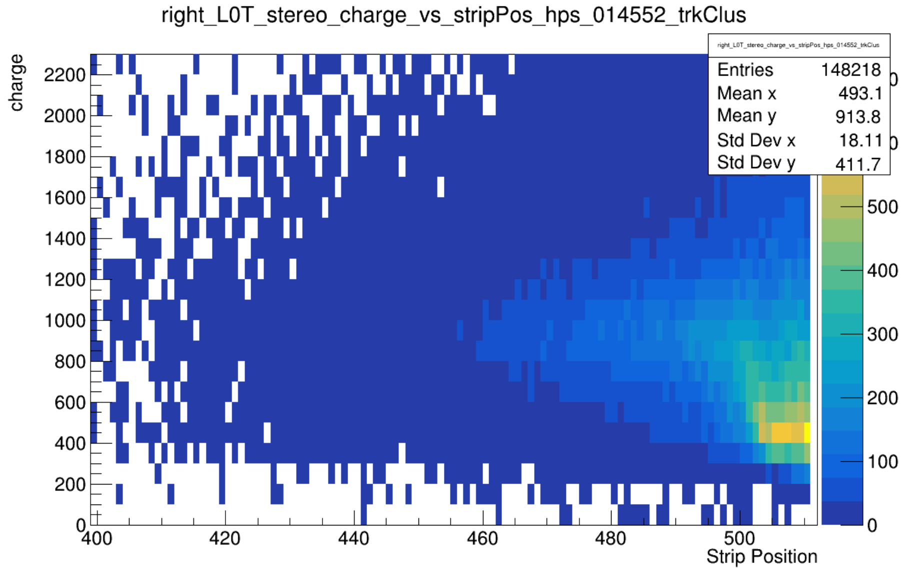
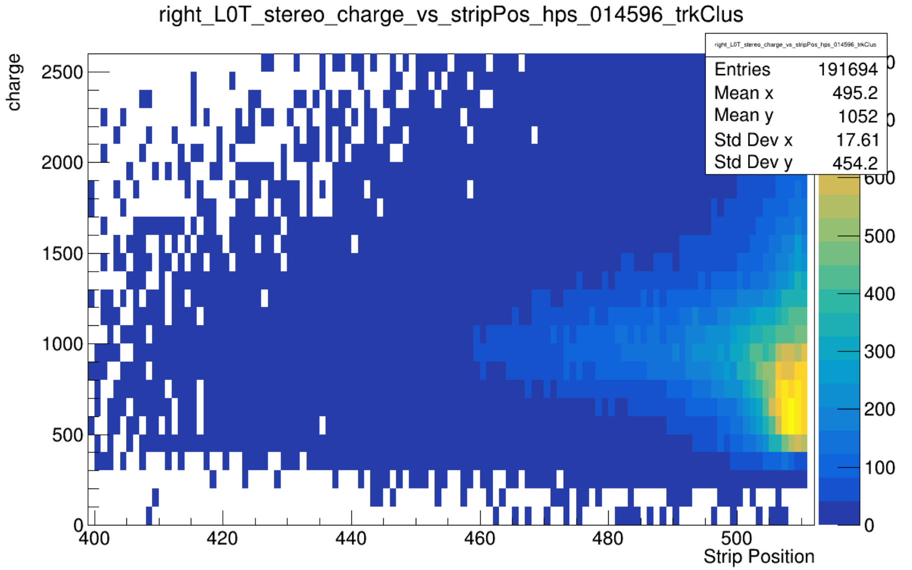
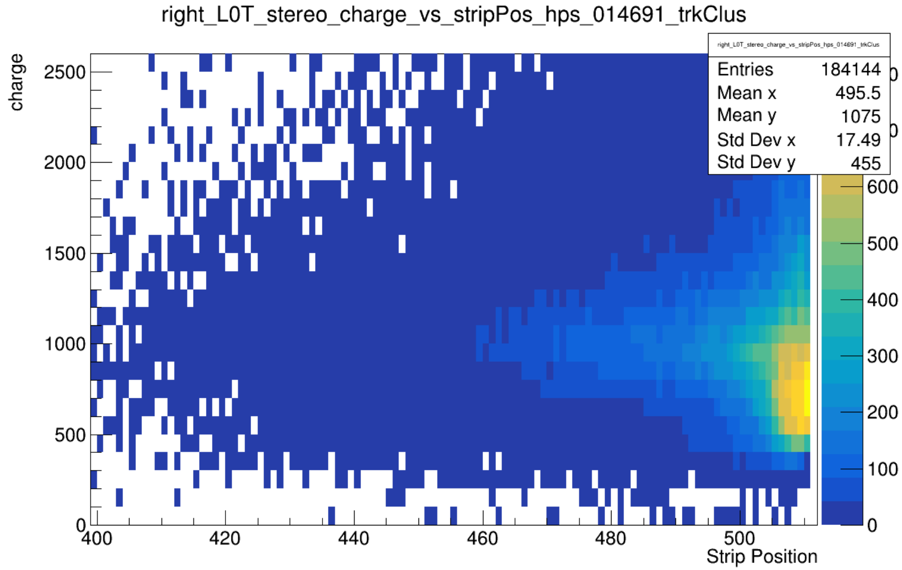
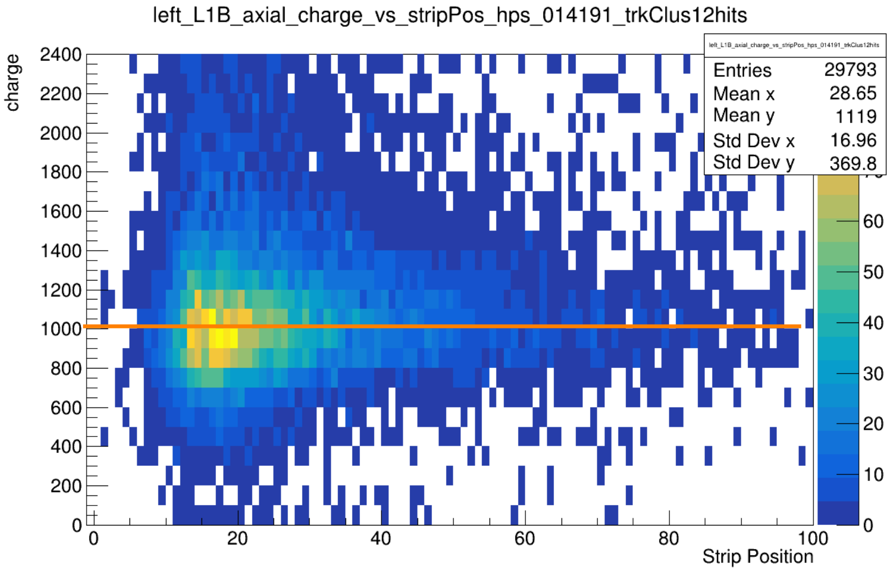
Entries 229483
Mean x 496.3
Mean y 1144
Std Dev x 17.3
Std Dev y 455.6
charge
Strip Position

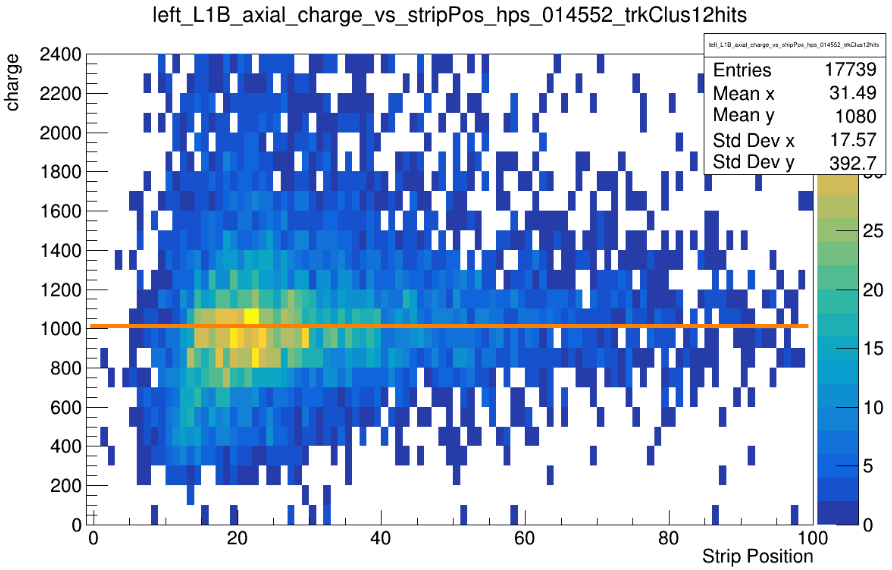

right_L0T_stereo_charge_vs_stripPos_hps_014552_trkClus
Entries 148218
Mean x 493.1
Mean y 913.8
Std Dev x 18.11
Std Dev y 411.7
charge
Strip Position

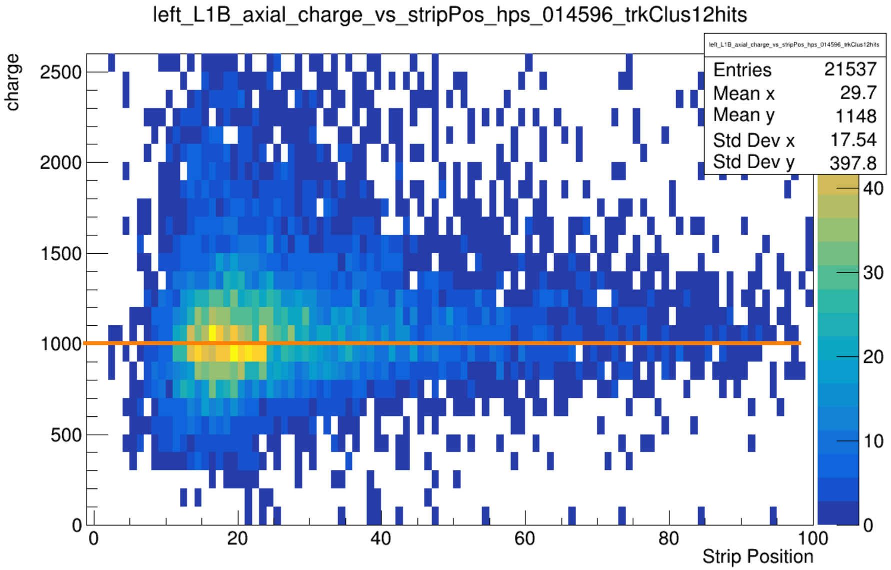

right_L0T_stereo_charge_vs_stripPos_hps_014596_trkClus
Entries 191694
Mean x 495.2
Mean y 1052
Std Dev x 17.61
Std Dev y 454.2
charge
Strip Position

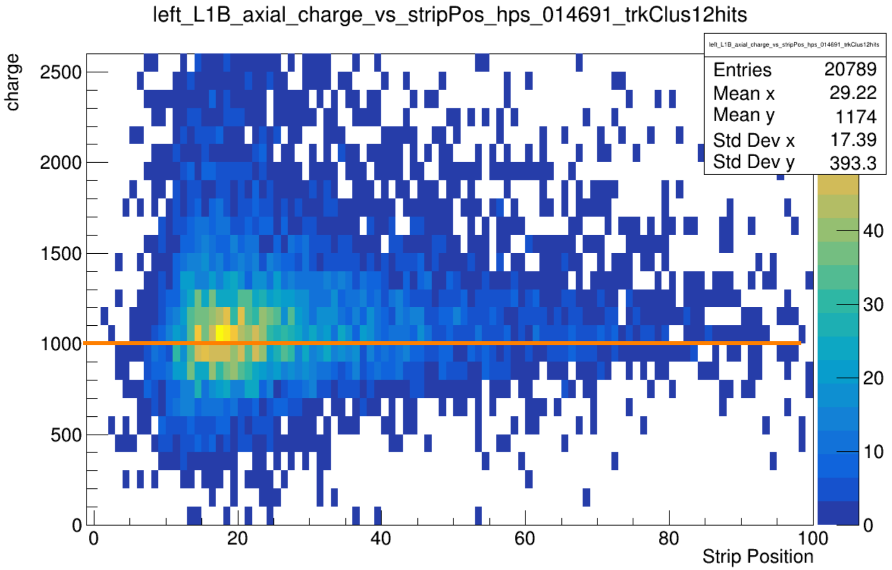

right_L0T_stereo_charge_vs_stripPos_hps_014691_trkClus
Entries 184144
Mean x 495.5
Mean y 1075
Std Dev x 17.49
Std Dev y 455
charge
Strip Position

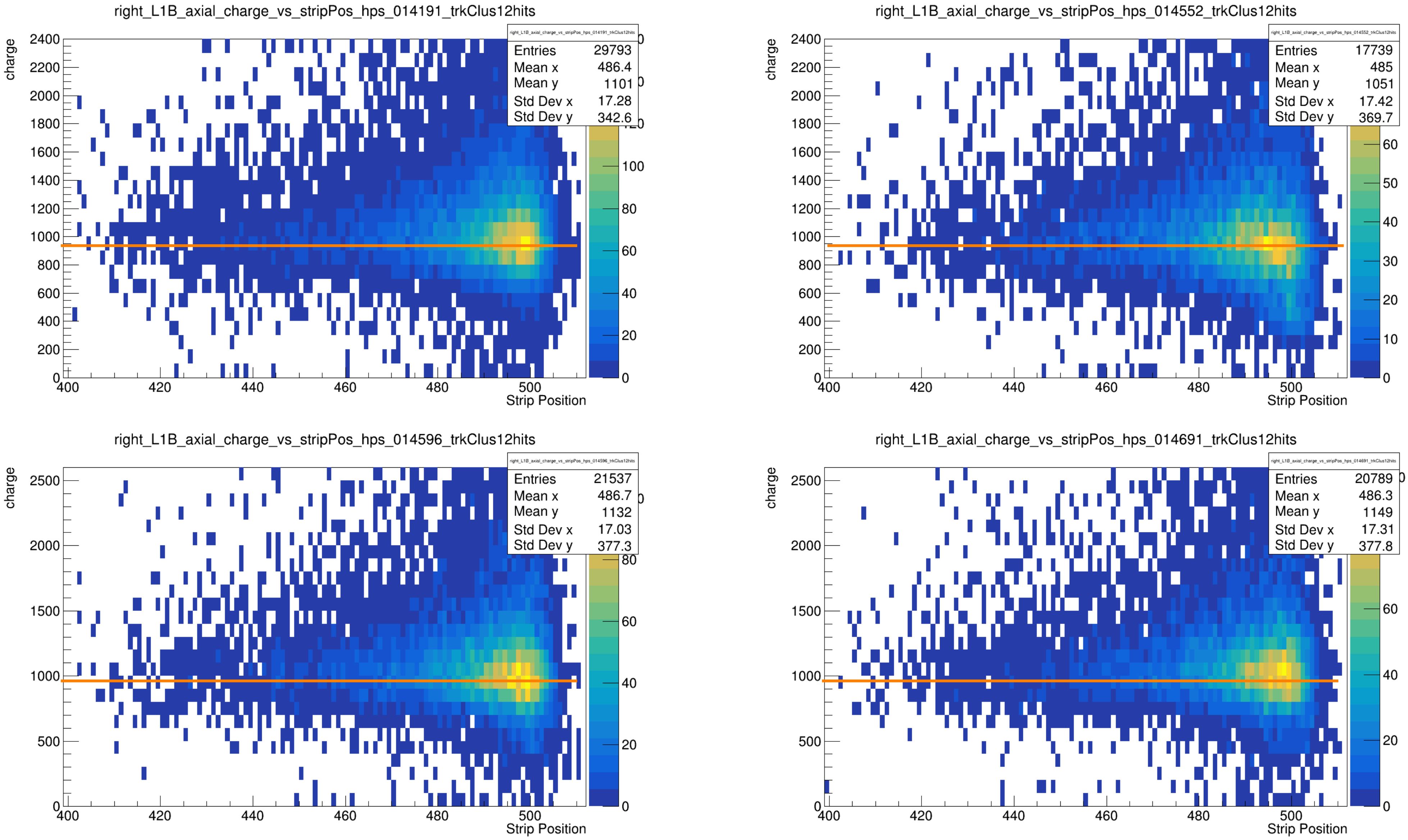
L1 Charge vs Run For 12 Hit Tracks

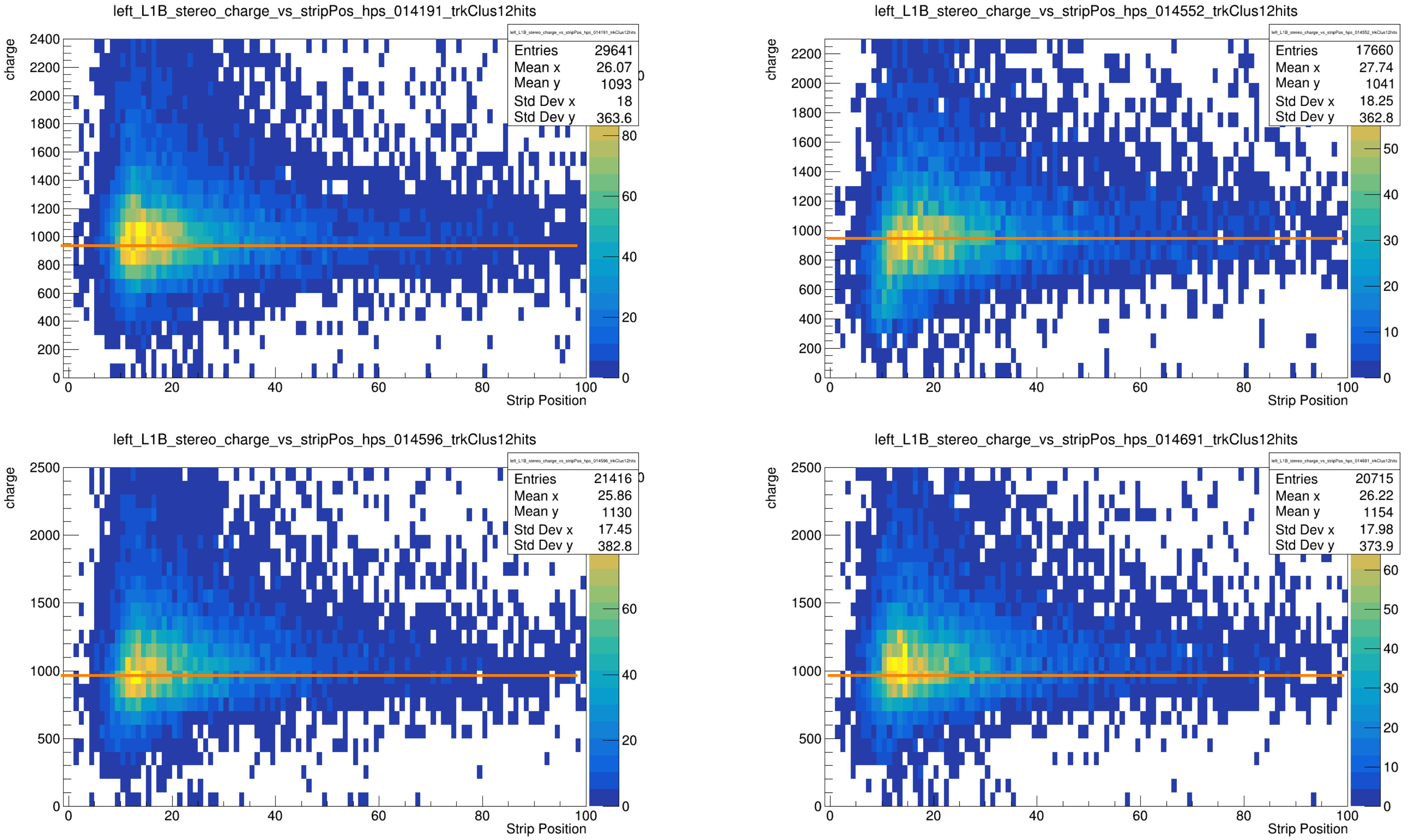

left_L1B_axial_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 29793
Mean x 28.65
Mean y 1119
Std Dev x 16.96
Std Dev y 369.8
charge
Strip Position

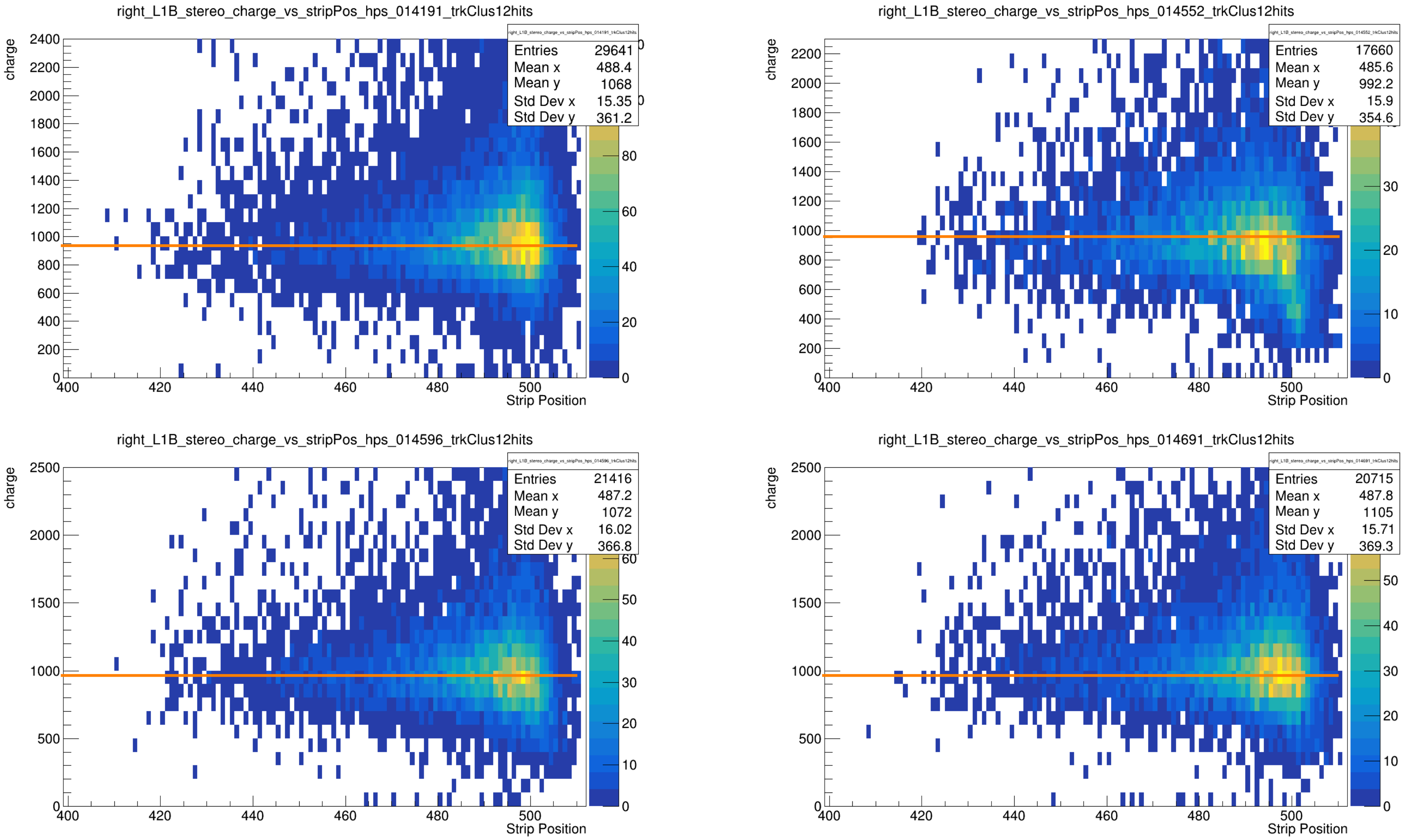

left_L1B_axial_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 17739
Mean x 31.49
Mean y 1080
Std Dev x 17.57
Std Dev y 392.7
charge
Strip Position

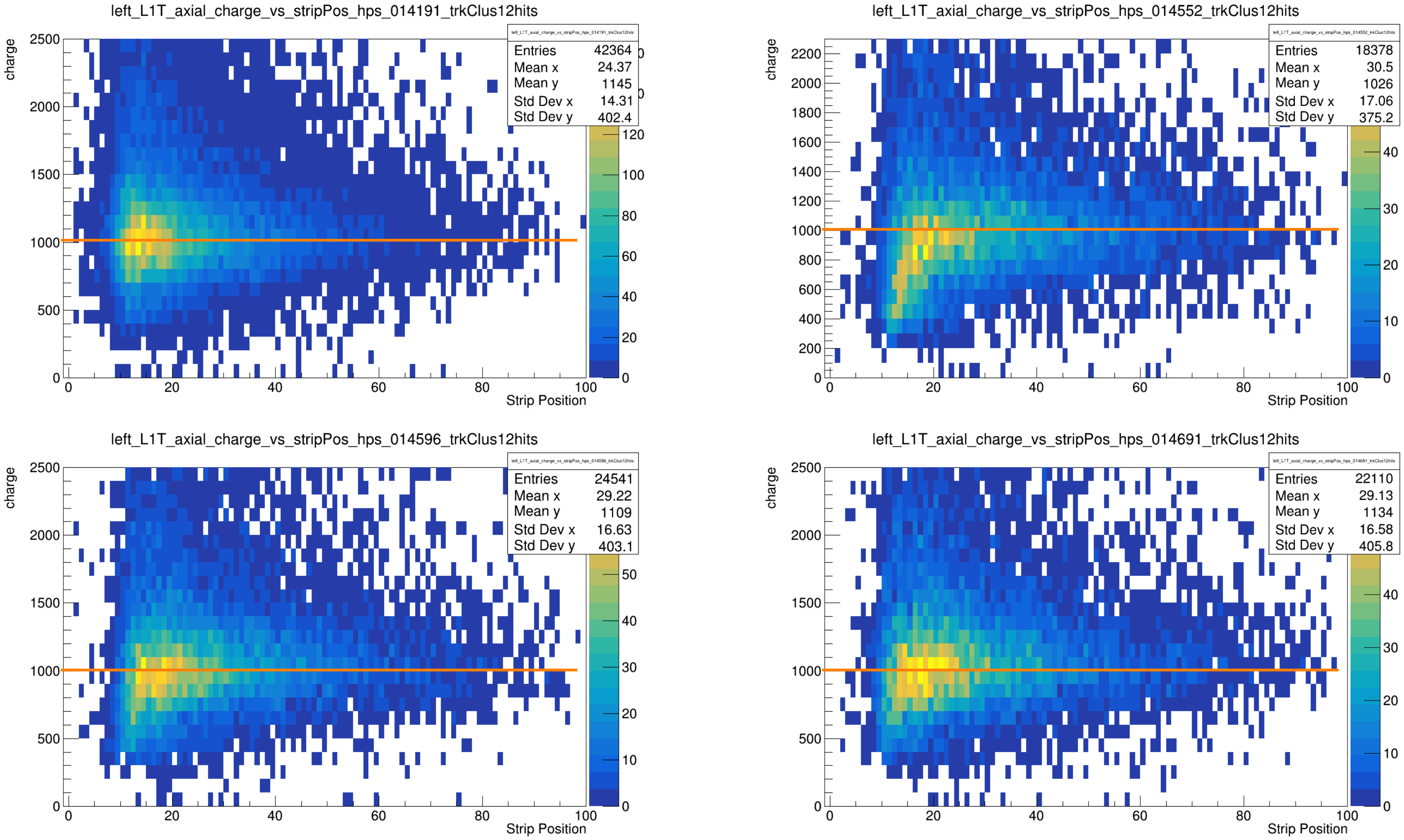

left_L1B_axial_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 21537
Mean x 29.7
Mean y 1148
Std Dev x 17.54
Std Dev y 397.8
charge
Strip Position

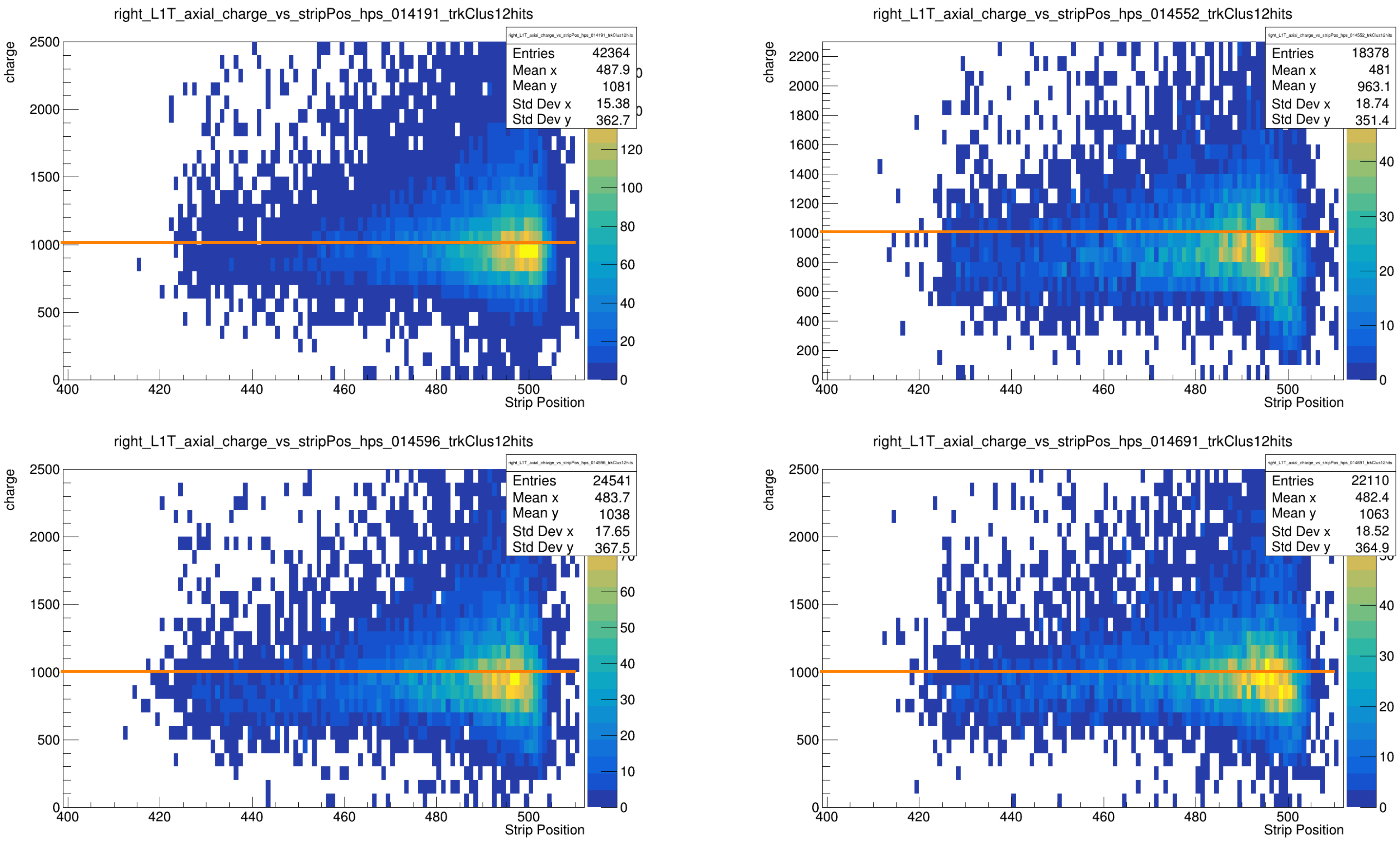

left_L1B_axial_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 20789
Mean x 29.22
Mean y 1174
Std Dev x 17.39
Std Dev y 393.3
charge
Strip Position

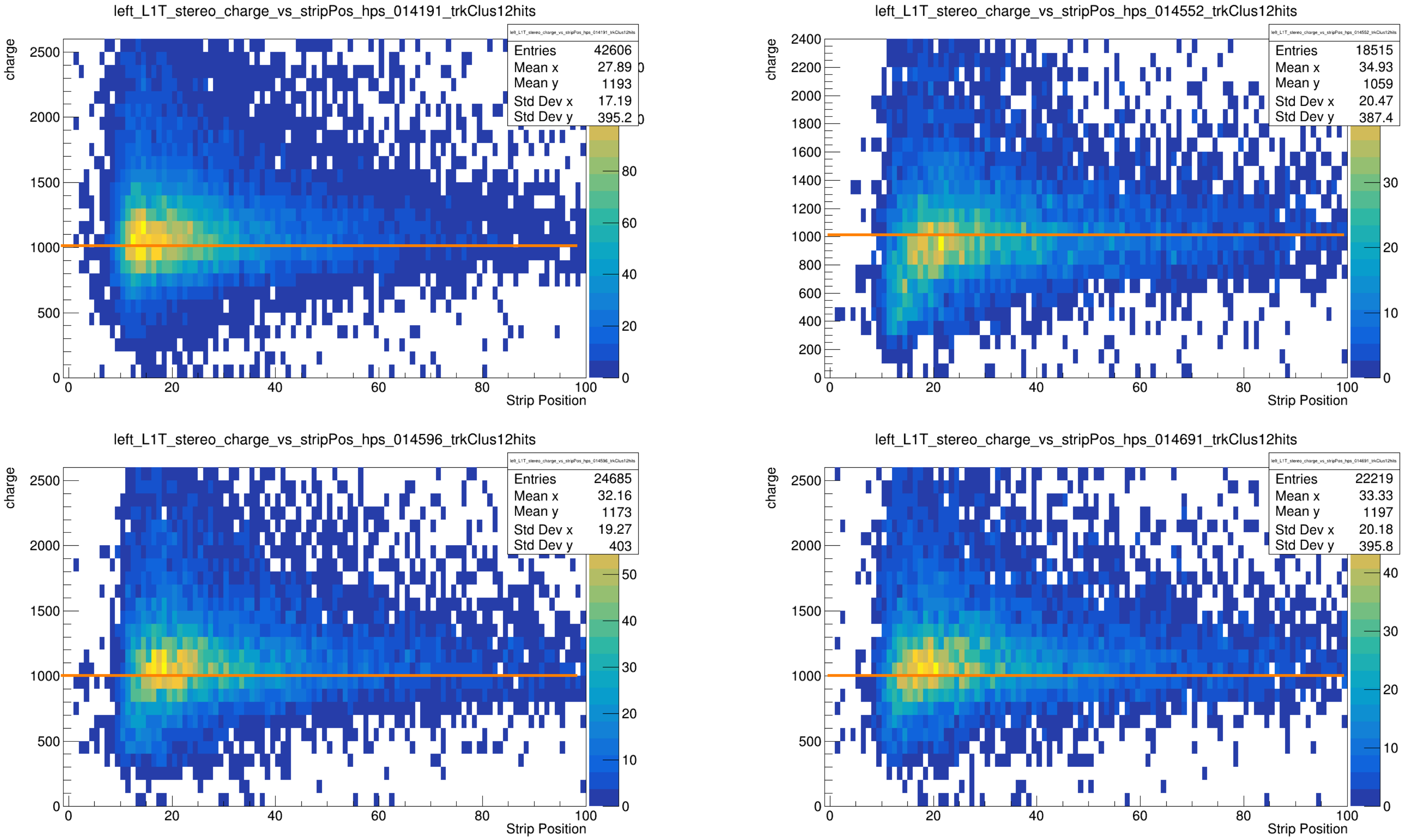

right_L1B_axial_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 29793
Mean x 486.4
Mean y 1101
Std Dev x 17.28
Std Dev y 342.6
charge
Strip Position
right_L1B_axial_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 17739
Mean x 485
Mean y 1051
Std Dev x 17.42
Std Dev y 369.7
charge
Strip Position
right_L1B_axial_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 21537
Mean x 486.7
Mean y 1132
Std Dev x 17.03
Std Dev y 377.3
charge
Strip Position
right_L1B_axial_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 20789
Mean x 486.3
Mean y 1149
Std Dev x 17.31
Std Dev y 377.8
charge
Strip Position

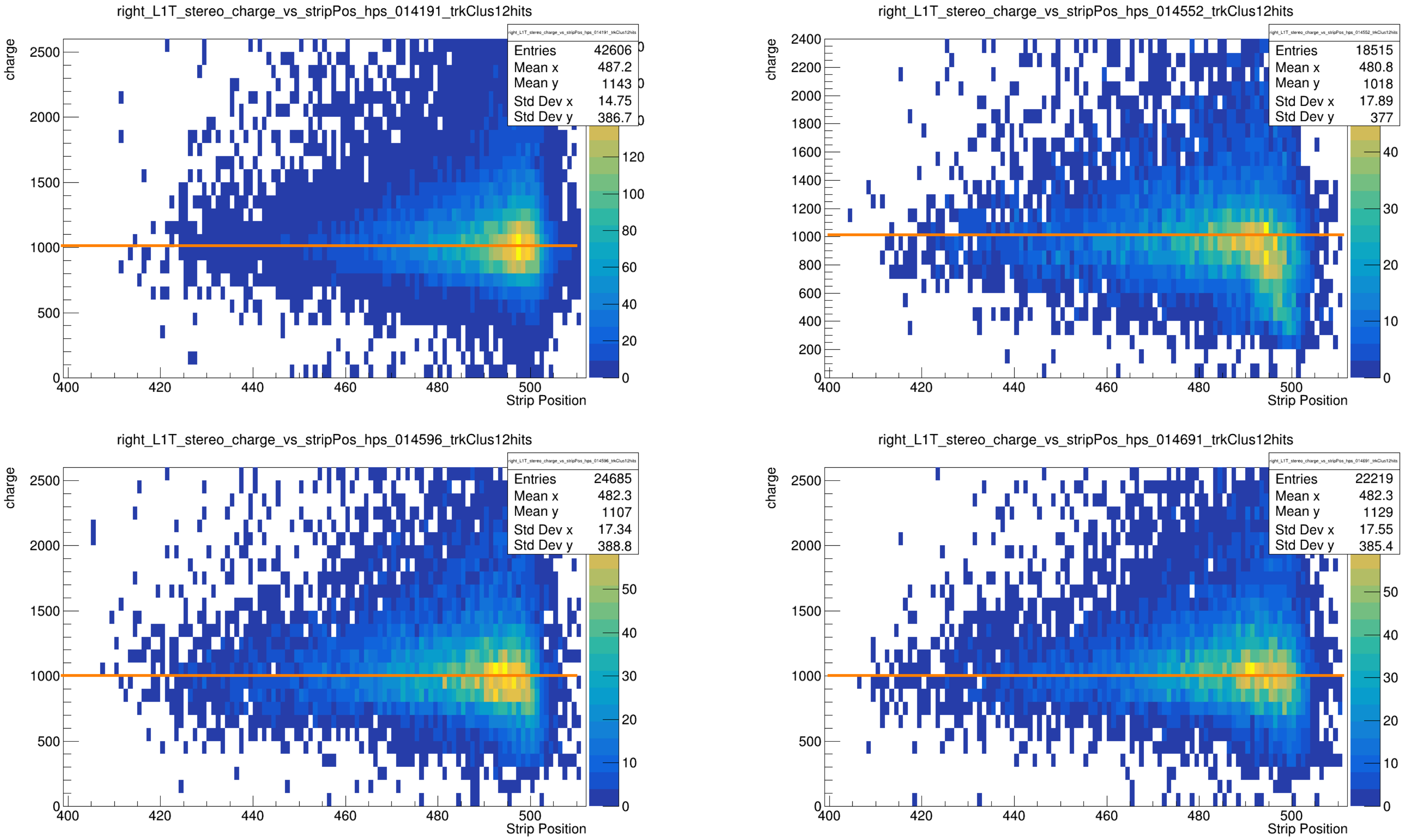

left_L1B_stereo_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 29641
Mean x 26.07
Mean y 1093
Std Dev x 18
Std Dev y 363.6
charge
Strip Position
left_L1B_stereo_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 17660
Mean x 27.74
Mean y 1041
Std Dev x 18.25
Std Dev y 362.8
charge
Strip Position
left_L1B_stereo_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 21416
Mean x 25.86
Mean y 1130
Std Dev x 17.45
Std Dev y 382.8
charge
Strip Position
left_L1B_stereo_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 20715
Mean x 26.22
Mean y 1154
Std Dev x 17.98
Std Dev y 373.9
charge
Strip Position


right_L1B_stereo_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 29641
Mean x 488.4
Mean y 1068
Std Dev x 15.35
Std Dev y 361.2
charge
Strip Position
right_L1B_stereo_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 17660
Mean x 485.6
Mean y 992.2
Std Dev x 15.9
Std Dev y 354.6
charge
Strip Position
right_L1B_stereo_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 21416
Mean x 487.2
Mean y 1072
Std Dev x 16.02
Std Dev y 366.8
charge
Strip Position
right_L1B_stereo_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 20715
Mean x 487.8
Mean y 1105
Std Dev x 15.71
Std Dev y 369.3
charge
Strip Position

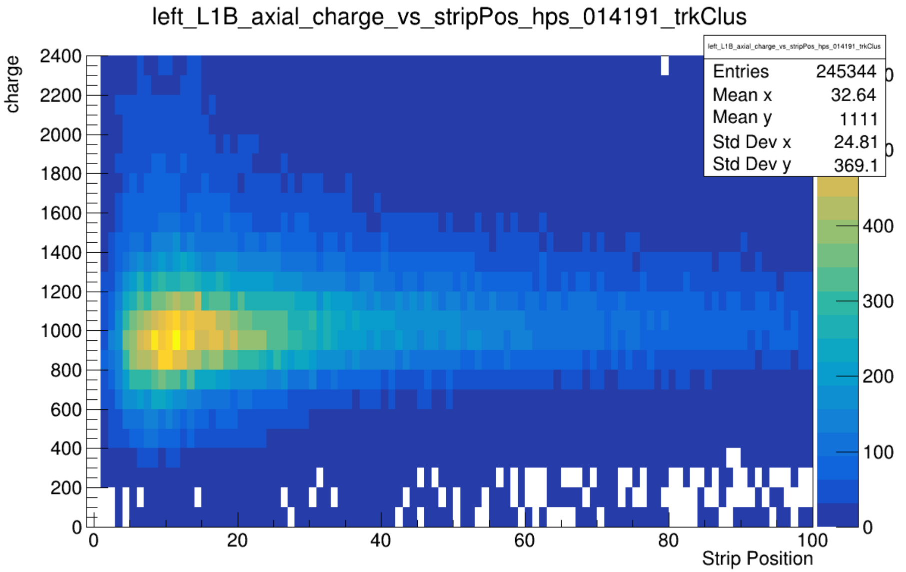

left_L1T_axial_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 42364
Mean x 24.37
Mean y 1145
Std Dev x 14.31
Std Dev y 402.4
charge
Strip Position
left_L1T_axial_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 18378
Mean x 30.5
Mean y 1026
Std Dev x 17.06
Std Dev y 375.2
charge
Strip Position
left_L1T_axial_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 24541
Mean x 29.22
Mean y 1109
Std Dev x 16.63
Std Dev y 403.1
charge
Strip Position
left_L1T_axial_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 22110
Mean x 29.13
Mean y 1134
Std Dev x 16.58
Std Dev y 405.8
charge
Strip Position

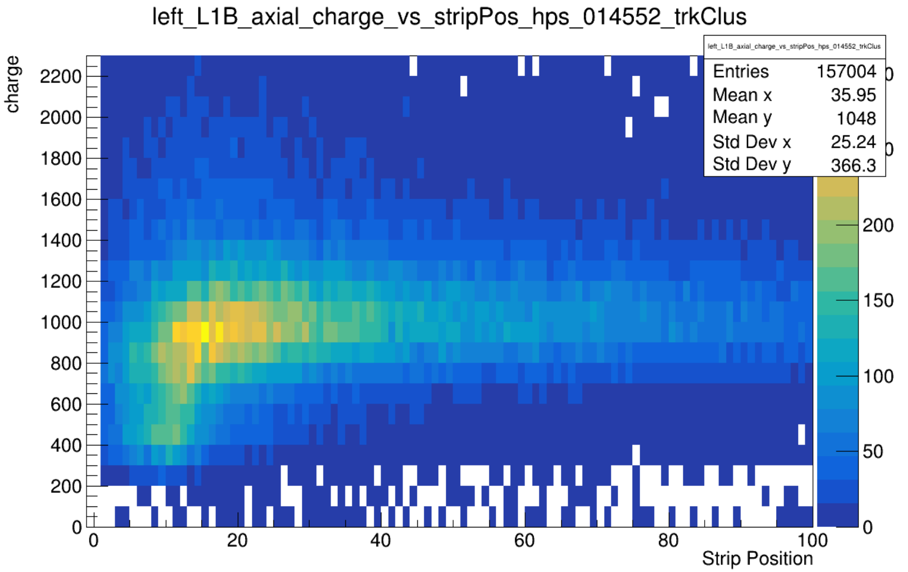

right_L1T_axial_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 42364
Mean x 487.9
Mean y 1081
Std Dev x 15.38
Std Dev y 362.7
charge
Strip Position
right_L1T_axial_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 18378
Mean x 481
Mean y 963.1
Std Dev x 18.74
Std Dev y 351.4
charge
Strip Position
right_L1T_axial_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 24541
Mean x 483.7
Mean y 1038
Std Dev x 17.65
Std Dev y 367.5
charge
Strip Position
right_L1T_axial_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 22110
Mean x 482.4
Mean y 1063
Std Dev x 18.52
Std Dev y 364.9
charge
Strip Position

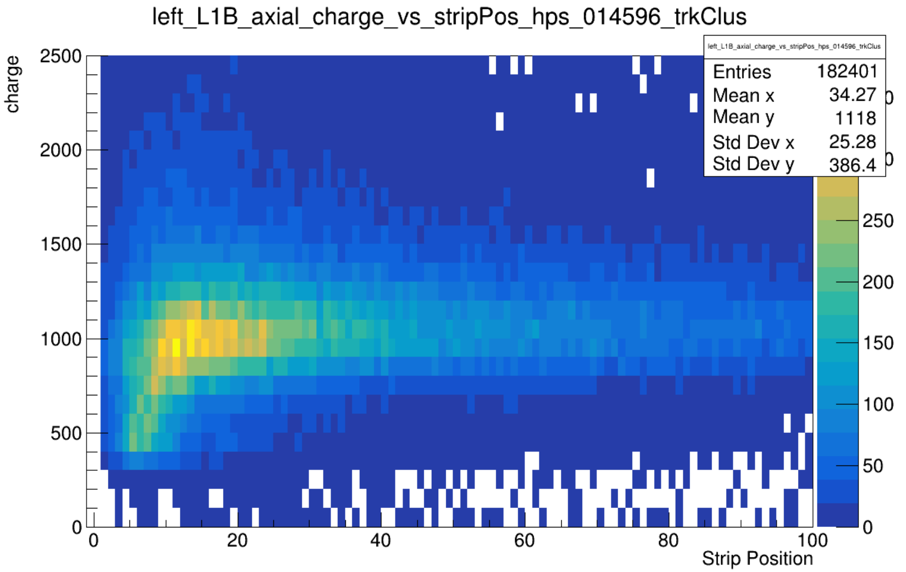

left_L1T_stereo_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 42606
Mean x 27.89
Mean y 1193
Std Dev x 17.19
Std Dev y 395.2
charge
Strip Position
left_L1T_stereo_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 18515
Mean x 34.93
Mean y 1059
Std Dev x 20.47
Std Dev y 387.4
left_L1T_stereo_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 24685
Mean x 32.16
Mean y 1173
Std Dev x 19.27
Std Dev y 403
left_L1T_stereo_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 22219
Mean x 33.33
Mean y 1197
Std Dev x 20.18
Std Dev y 395.8

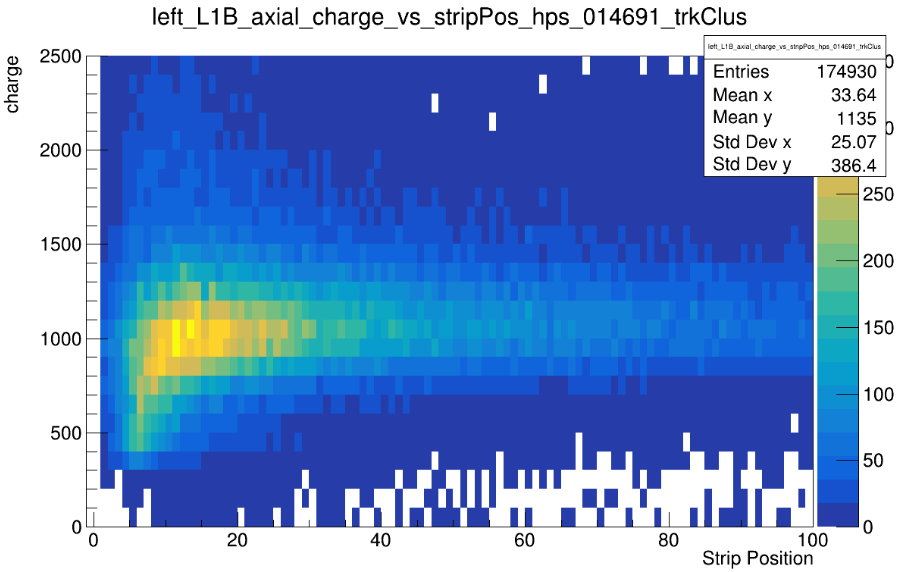

right_L1T_stereo_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 42606
Mean x 487.2
Mean y 1143
Std Dev x 14.75
Std Dev y 386.7
charge
Strip Position
right_L1T_stereo_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 18515
Mean x 480.8
Mean y 1018
Std Dev x 17.89
Std Dev y 377
charge
Strip Position
right_L1T_stereo_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 24685
Mean x 482.3
Mean y 1107
Std Dev x 17.34
Std Dev y 388.8
charge
Strip Position
right_L1T_stereo_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 22219
Mean x 482.3
Mean y 1129
Std Dev x 17.55
Std Dev y 385.4
charge
Strip Position

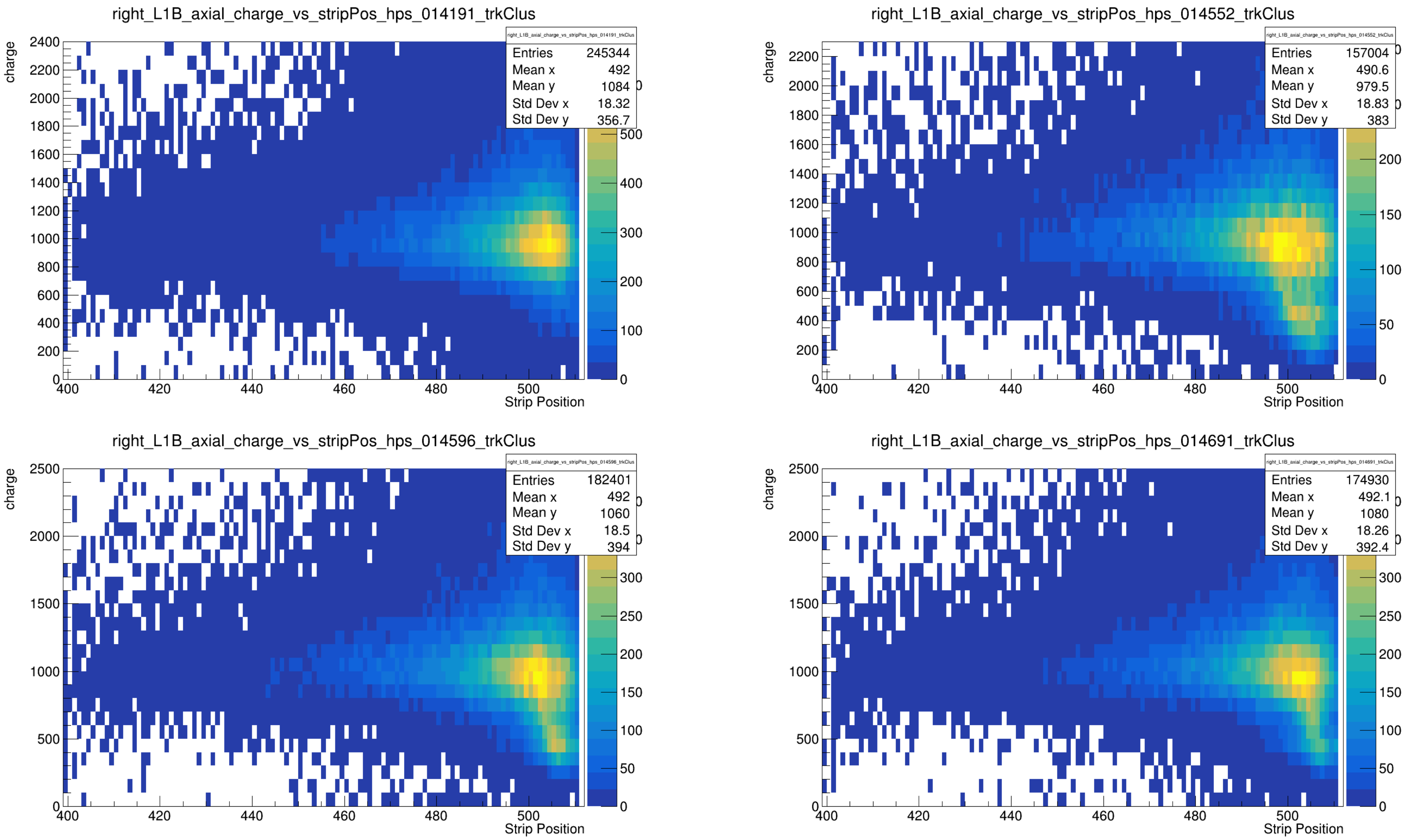
L1 Charge vs Run For All Tracks


left_L1B_axial_charge_vs_stripPos_hps_014191_trkClus
Entries 245344
Mean x 32.64
Mean y 1111
Std Dev x 24.81
Std Dev y 369.1
charge
Strip Position

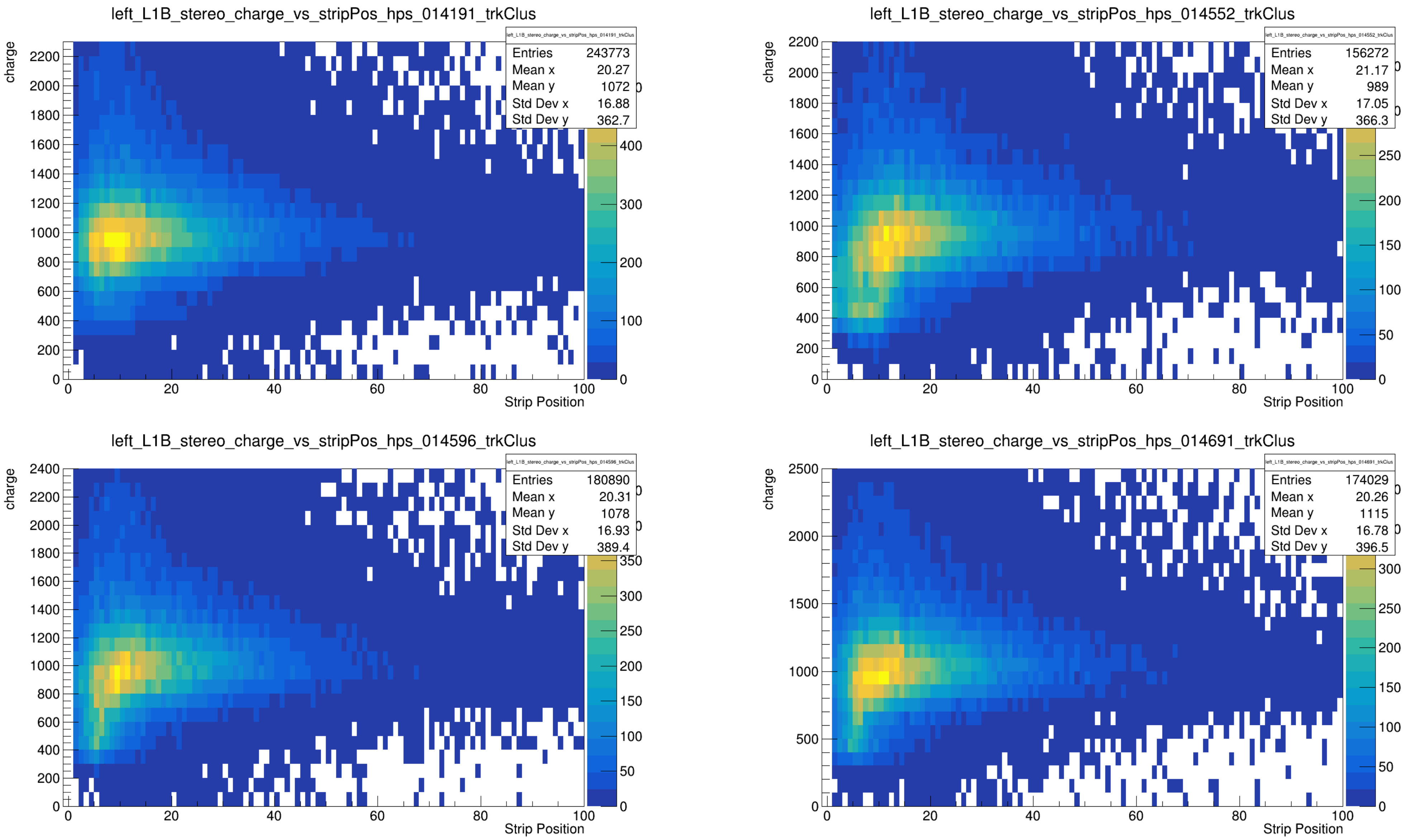

left_L1B_axial_charge_vs_stripPos_hps_014552_trkClus
Entries 157004
Mean x 35.95
Mean y 1048
Std Dev x 25.24
Std Dev y 366.3
charge
Strip Position


left_L1B_axial_charge_vs_stripPos_hps_014596_trkClus
Entries 182401
Mean x 34.27
Mean y 1118
Std Dev x 25.28
Std Dev y 386.4
charge
Strip Position

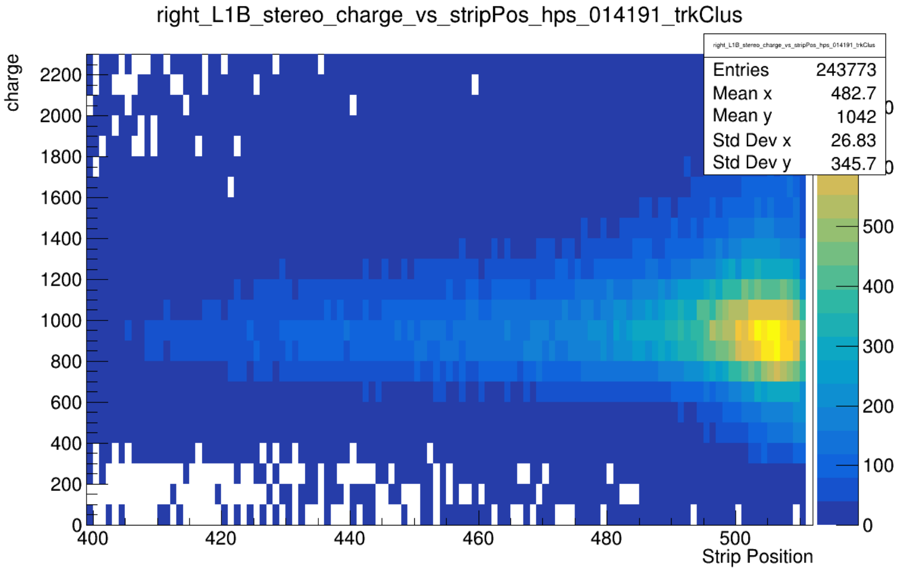

left_L1B_axial_charge_vs_stripPos_hps_014691_trkClus
Entries 174930
Mean x 33.64
Mean y 1135
Std Dev x 25.07
Std Dev y 386.4
charge
Strip Position

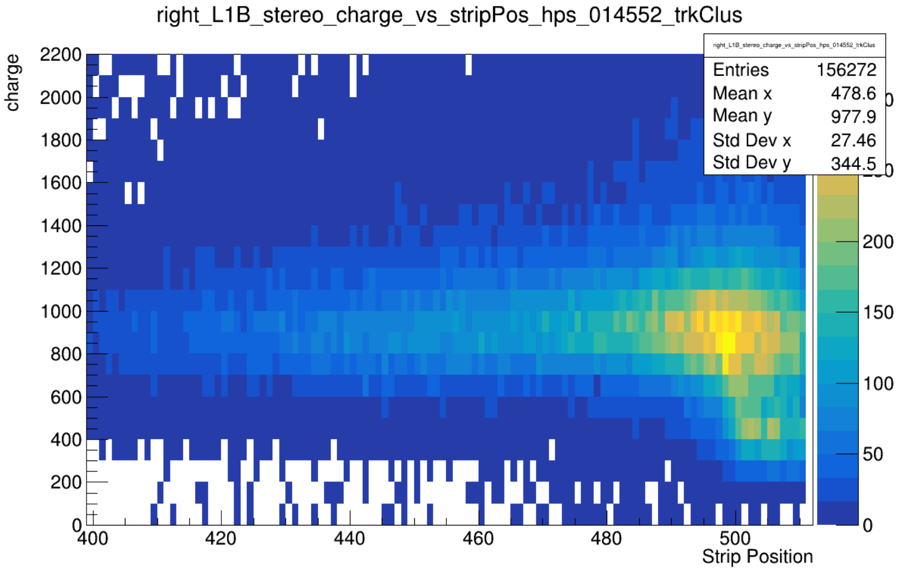


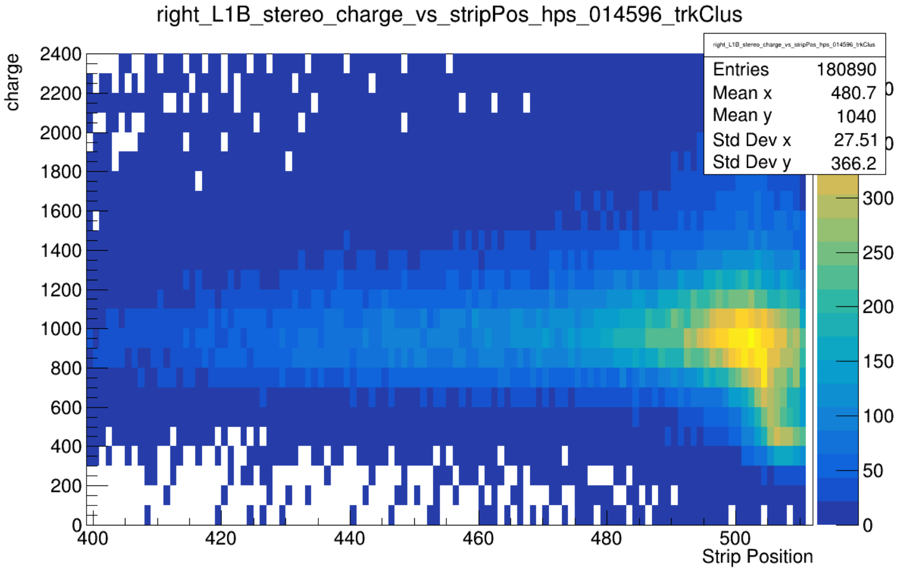
right_L1B_axial_charge_vs_stripPos_hps_014191_trkClus
Entries 245344
Mean x 492
Mean y 1084
Std Dev x 18.32
Std Dev y 356.7
charge
Strip Position
right_L1B_axial_charge_vs_stripPos_hps_014552_trkClus
Entries 157004
Mean x 490.6
Mean y 979.5
Std Dev x 18.83
Std Dev y 383
charge
Strip Position
right_L1B_axial_charge_vs_stripPos_hps_014596_trkClus
Entries 182401
Mean x 492
Mean y 1060
Std Dev x 18.5
Std Dev y 394
charge
Strip Position
right_L1B_axial_charge_vs_stripPos_hps_014691_trkClus
Entries 174930
Mean x 492.1
Mean y 1080
Std Dev x 18.26
Std Dev y 392.4
charge
Strip Position

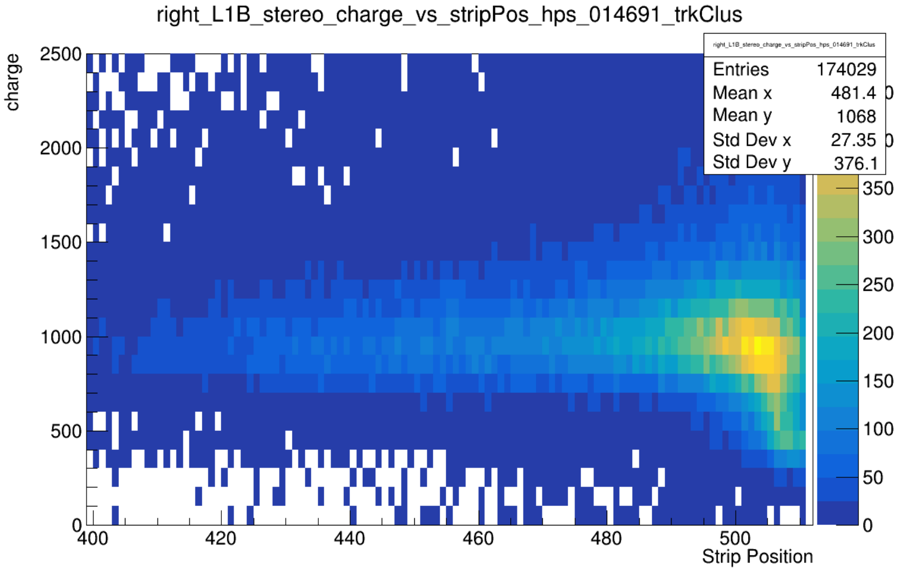


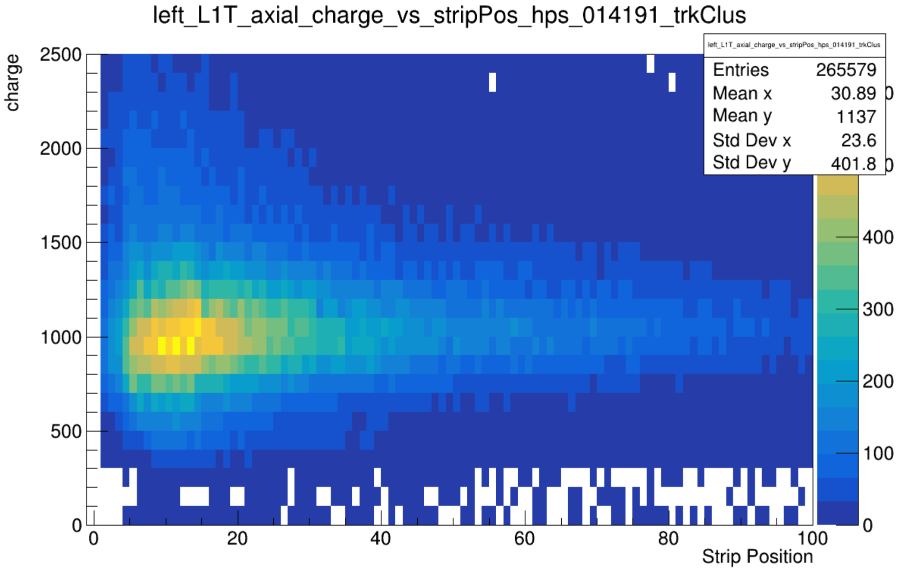
left_L1B_stereo_charge_vs_stripPos_hps_014191_trkClus
Entries 243773
Mean x 20.27
Mean y 1072
Std Dev x 16.88
Std Dev y 362.7
charge
Strip Position
left_L1B_stereo_charge_vs_stripPos_hps_014552_trkClus
Entries 156272
Mean x 21.17
Mean y 989
Std Dev x 17.05
Std Dev y 366.3
charge
Strip Position
left_L1B_stereo_charge_vs_stripPos_hps_014596_trkClus
Entries 180890
Mean x 20.31
Mean y 1078
Std Dev x 16.93
Std Dev y 389.4
charge
Strip Position
left_L1B_stereo_charge_vs_stripPos_hps_014691_trkClus
Entries 174029
Mean x 20.26
Mean y 1115
Std Dev x 16.78
Std Dev y 396.5
charge
Strip Position

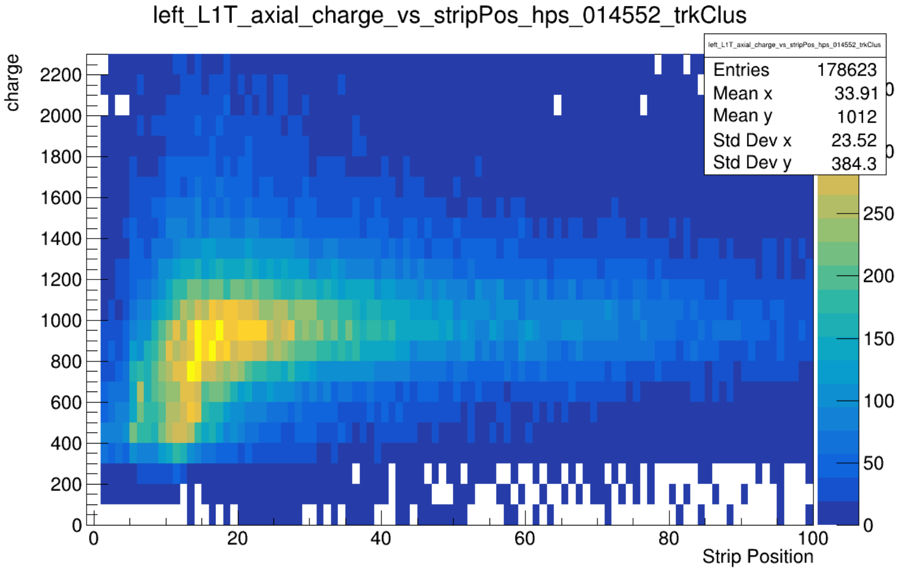

right_L1B_stereo_charge_vs_stripPos_hps_014191_trkClus
Entries 243773
Mean x 482.7
Mean y 1042
Std Dev x 26.83
Std Dev y 345.7
charge
Strip Position

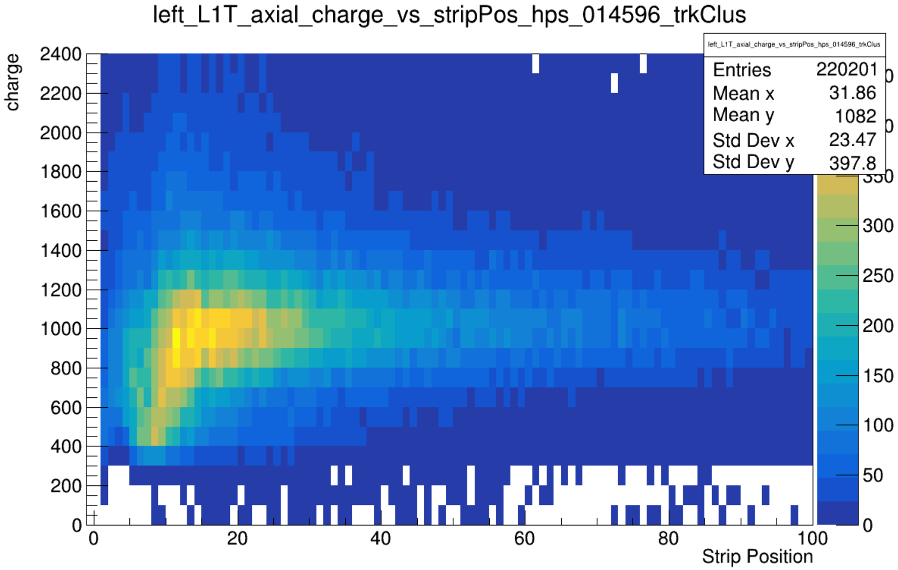

right_L1B_stereo_charge_vs_stripPos_hps_014552_trkClus
Entries 156272
Mean x 478.6
Mean y 977.9
Std Dev x 27.46
Std Dev y 344.5
charge
Strip Position

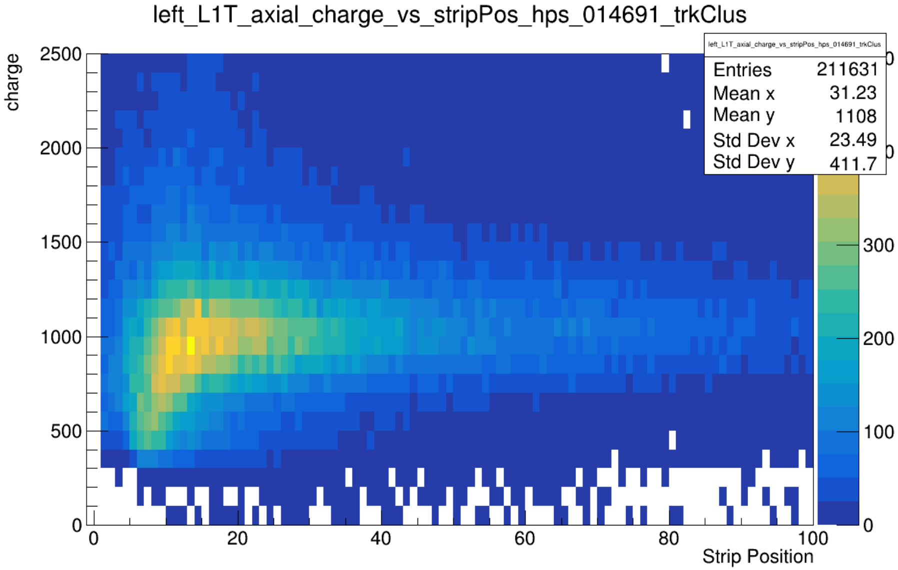

right_L1B_stereo_charge_vs_stripPos_hps_014596_trkClus
Entries 180890
Mean x 480.7
Mean y 1040
Std Dev x 27.51
Std Dev y 366.2
charge
Strip Position

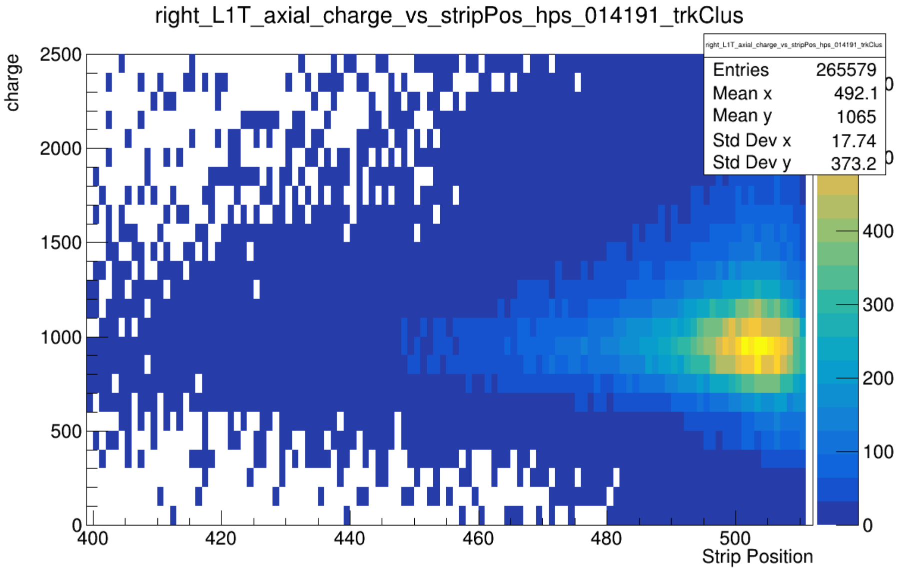

right_L1B_stereo_charge_vs_stripPos_hps_014691_trkClus
Entries 174029
Mean x 481.4
Mean y 1068
Std Dev x 27.35
Std Dev y 376.1
charge
Strip Position

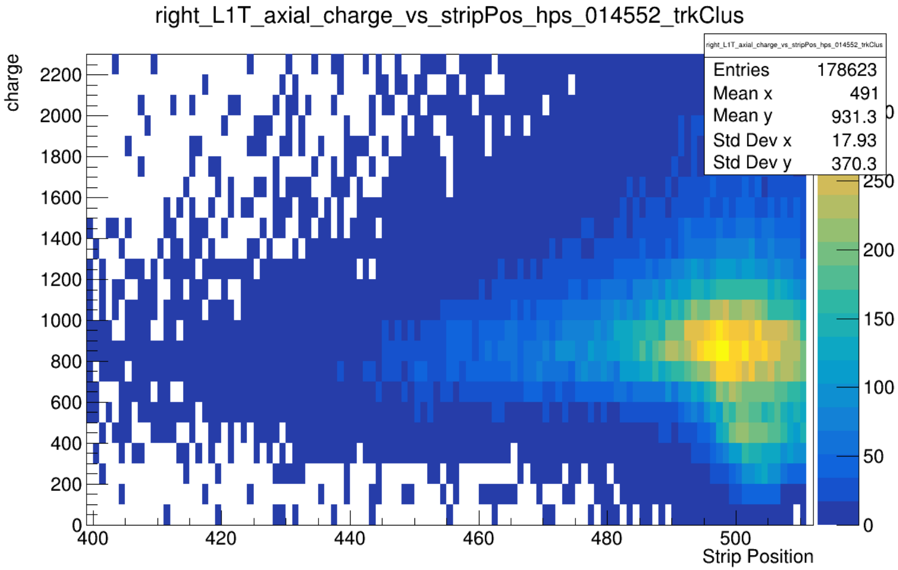

left_L1T_axial_charge_vs_stripPos_hps_014191_trkClus
Entries 265579
Mean x 30.89
Mean y 1137
Std Dev x 23.6
Std Dev y 401.8
charge
Strip Position

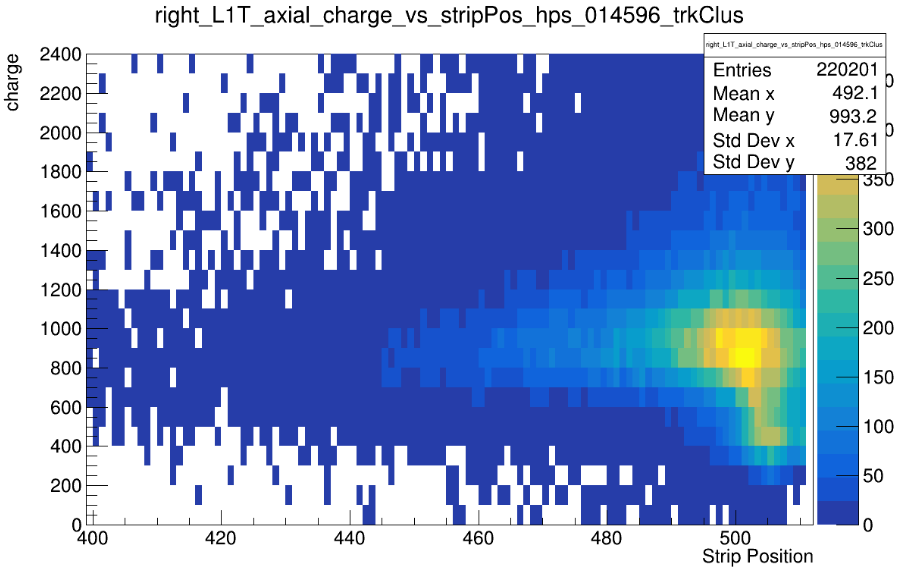

left_L1T_axial_charge_vs_stripPos_hps_014552_trkClus
Entries 178623
Mean x 33.91
Mean y 1012
Std Dev x 23.52
Std Dev y 384.3
charge
Strip Position

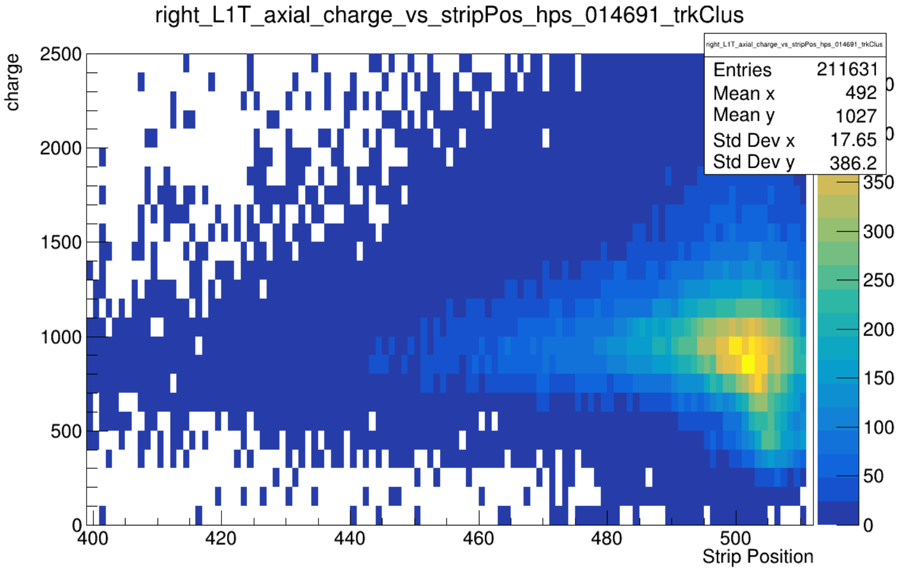

left_L1T_axial_charge_vs_stripPos_hps_014596_trkClus
Entries 220201
Mean x 31.86
Mean y 1082
Std Dev x 23.47
Std Dev y 397.8
charge
Strip Position

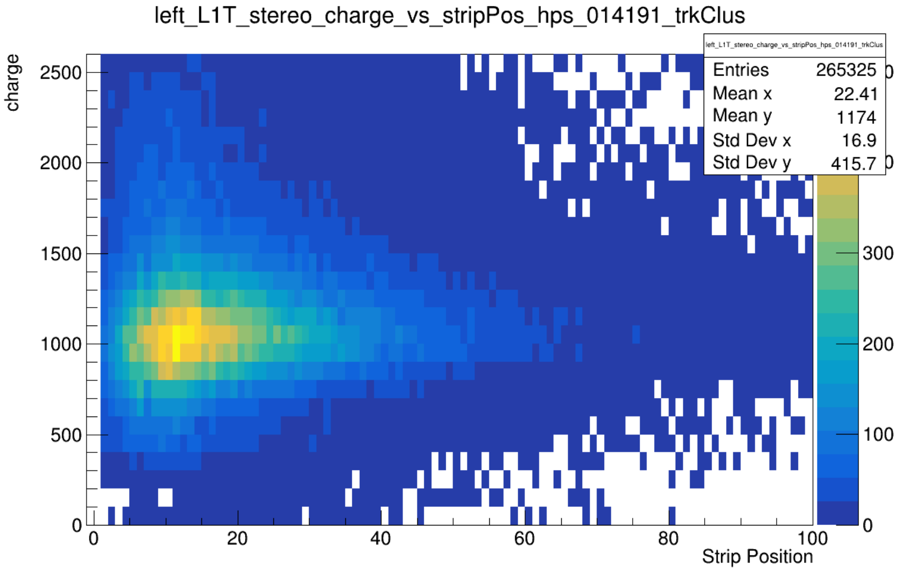
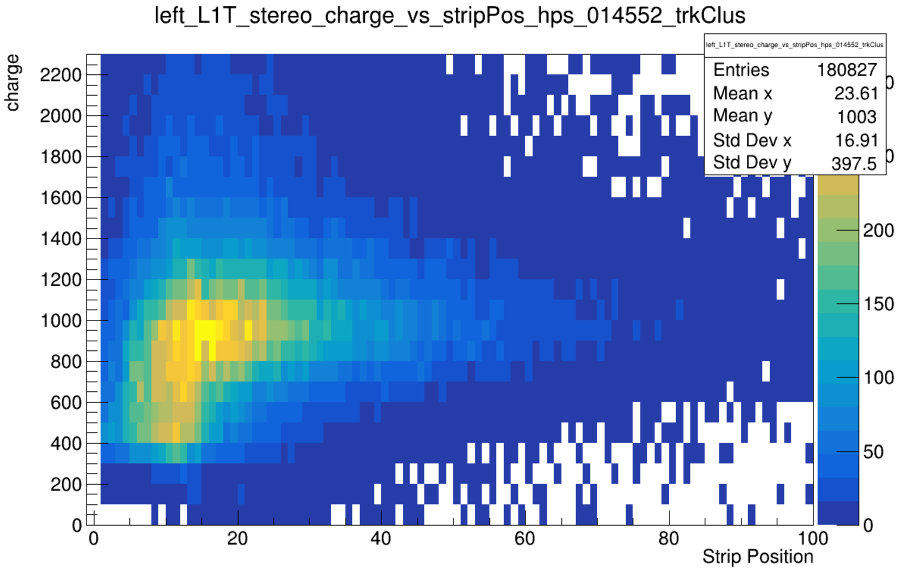
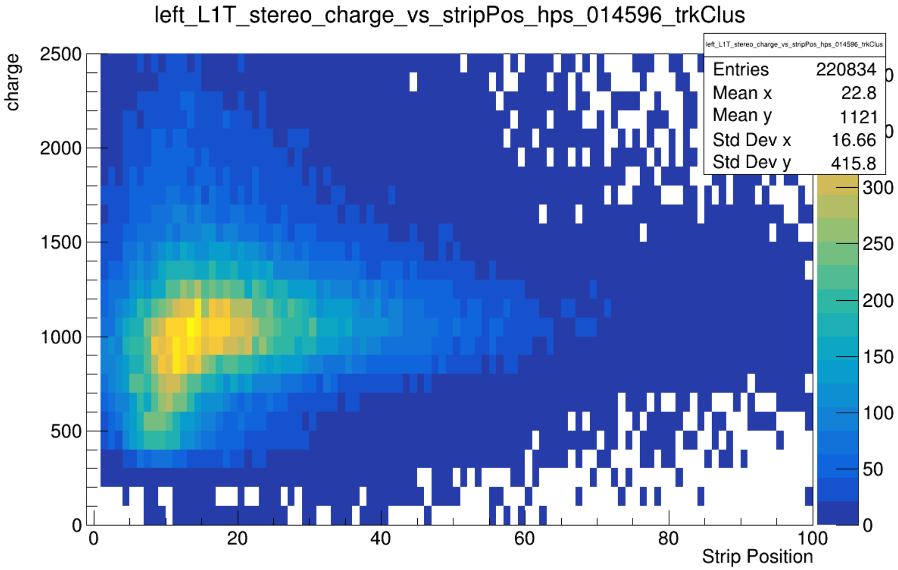
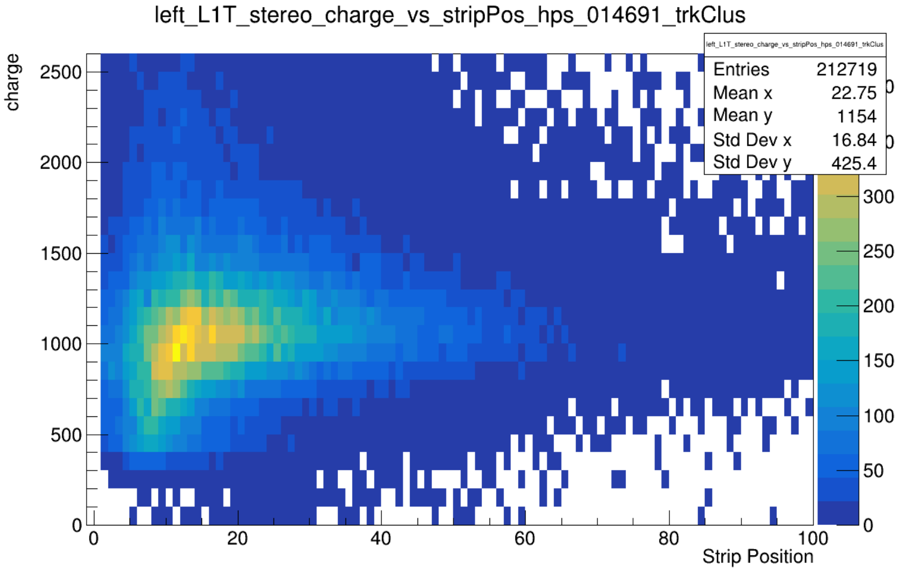

left_L1T_axial_charge_vs_stripPos_hps_014691_trkClus
Entries 211631
Mean x 31.23
Mean y 1108
Std Dev x 23.49
Std Dev y 411.7
charge
Strip Position

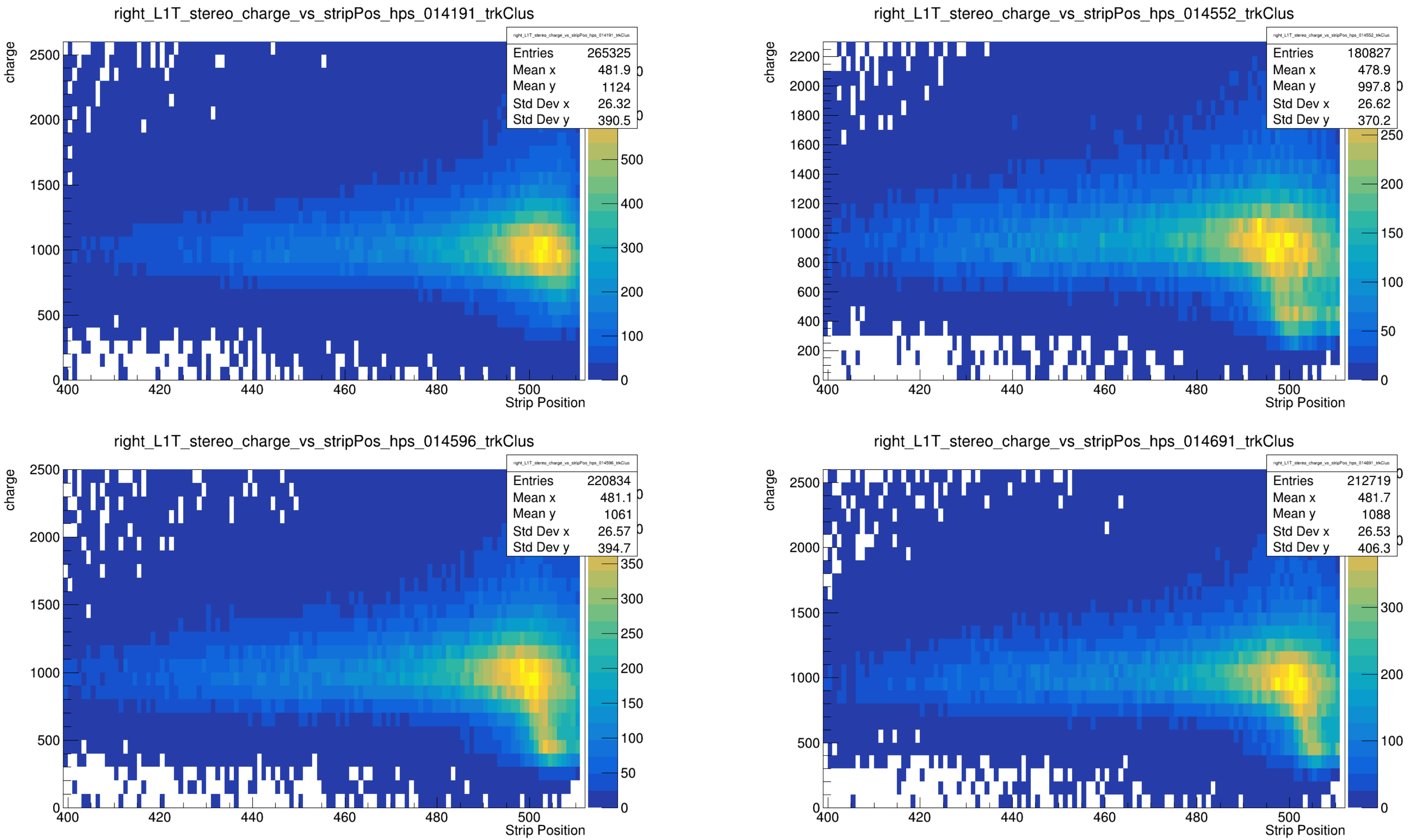

right_L1T_axial_charge_vs_stripPos_hps_014191_trkClus
Entries 265579
Mean x 492.1
Mean y 1065
Std Dev x 17.74
Std Dev y 373.2
charge
Strip Position

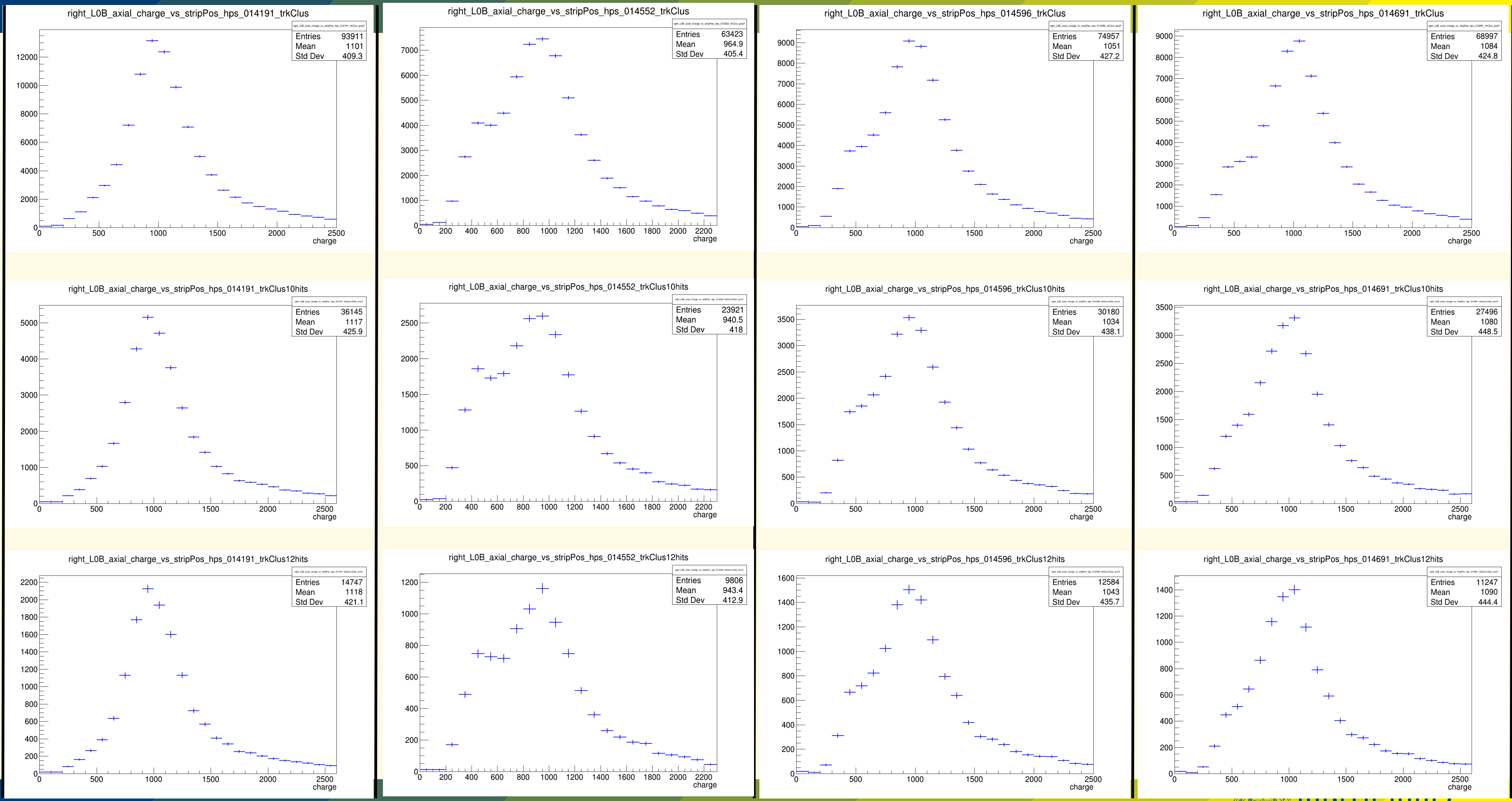

right_L1T_axial_charge_vs_stripPos_hps_014552_trkClus
Entries 178623
Mean x 491
Mean y 931.3
Std Dev x 17.93
Std Dev y 370.3
charge
Strip Position

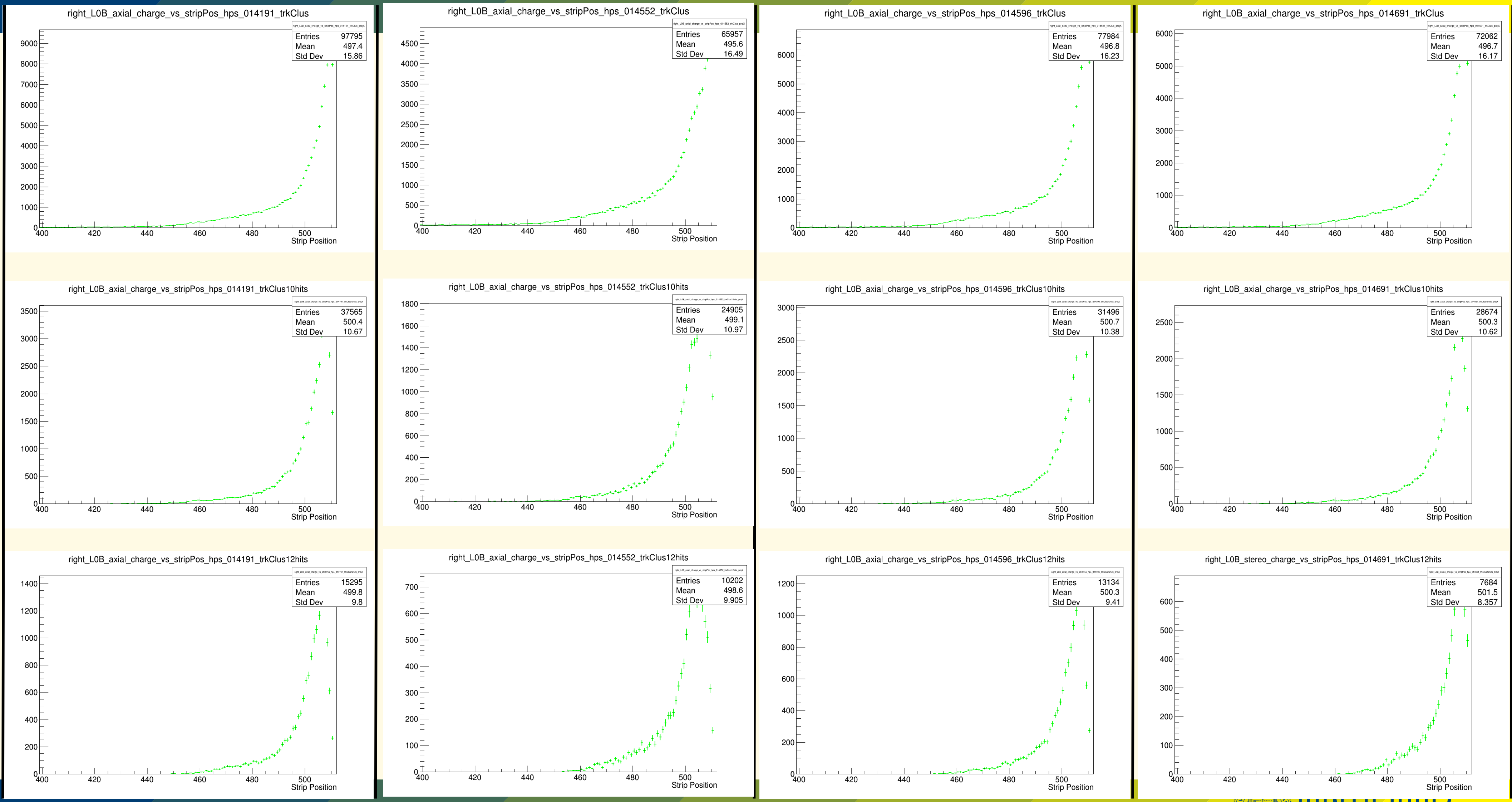

right_L1T_axial_charge_vs_stripPos_hps_014596_trkClus
Entries 220201
Mean x 492.1
Mean y 993.2
Std Dev x 17.61
Std Dev y 382
charge
Strip Position


right_L1T_axial_charge_vs_stripPos_hps_014691_trkClus
Entries 211631
Mean x 492
Mean y 1027
Std Dev x 17.65
Std Dev y 386.2
charge
Strip Position


left_L1T_stereo_charge_vs_stripPos_hps_014191_trkClus
Entries 265325
Mean x 22.41
Mean y 1174
Std Dev x 16.9
Std Dev y 415.7
charge
Strip Position

left_L1T_stereo_charge_vs_stripPos_hps_014552_trkClus
Entries 180827
Mean x 23.61
Mean y 1003
Std Dev x 16.91
Std Dev y 397.5
charge
Strip Position

left_L1T_stereo_charge_vs_stripPos_hps_014596_trkClus
Entries 220834
Mean x 22.8
Mean y 1121
Std Dev x 16.66
Std Dev y 415.8
charge
Strip Position

left_L1T_stereo_charge_vs_stripPos_hps_014691_trkClus
Entries 212719
Mean x 22.75
Mean y 1154
Std Dev x 16.84
Std Dev y 425.4
charge
Strip Position


right_L1T_stereo_charge_vs_stripPos_hps_014191_trkClus
Entries 265325
Mean x 481.9
Mean y 1124
Std Dev x 26.32
Std Dev y 390.5
charge
Strip Position
right_L1T_stereo_charge_vs_stripPos_hps_014552_trkClus
Entries 180827
Mean x 478.9
Mean y 997.8
Std Dev x 26.62
Std Dev y 370.2
charge
Strip Position
right_L1T_stereo_charge_vs_stripPos_hps_014596_trkClus
Entries 220834
Mean x 481.1
Mean y 1061
Std Dev x 26.57
Std Dev y 394.7
charge
Strip Position
right_L1T_stereo_charge_vs_stripPos_hps_014691_trkClus
Entries 212719
Mean x 481.7
Mean y 1088
Std Dev x 26.53
Std Dev y 406.3
charge
Strip Position


right_L0B_axial_charge_vs_stripPos_hps_014191_trkClus
Entries 93911
Mean 1101
Std Dev 409.3
charge
right_L0B_axial_charge_vs_stripPos_hps_014552_trkClus
Entries 63423
Mean 964.9
Std Dev 405.4
charge
right_L0B_axial_charge_vs_stripPos_hps_014596_trkClus
Entries 74957
Mean 1051
Std Dev 427.2
charge
right_L0B_axial_charge_vs_stripPos_hps_014691_trkClus
Entries 68997
Mean 1084
Std Dev 424.8
charge
right_L0B_axial_charge_vs_stripPos_hps_014191_trkClus10hits
Entries 36145
Mean 1117
Std Dev 425.9
charge
right_L0B_axial_charge_vs_stripPos_hps_014552_trkClus10hits
Entries 23921
Mean 940.5
Std Dev 418
charge
right_L0B_axial_charge_vs_stripPos_hps_014596_trkClus10hits
Entries 30180
Mean 1034
Std Dev 438.1
charge
right_L0B_axial_charge_vs_stripPos_hps_014691_trkClus10hits
Entries 27496
Mean 1080
Std Dev 448.5
charge
right_L0B_axial_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 14747
Mean 1118
Std Dev 421.1
charge
right_L0B_axial_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 9806
Mean 943.4
Std Dev 412.9
charge
right_L0B_axial_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 12584
Mean 1043
Std Dev 435.7
charge
right_L0B_axial_charge_vs_stripPos_hps_014691_trkClus12hits
Entries 11247
Mean 1090
Std Dev 444.4
charge



right_L0B_axial_charge_vs_stripPos_hps_014191_trkClus
Entries 97795
Mean 497.4
Std Dev 15.86
Strip Position
right_L0B_axial_charge_vs_stripPos_hps_014552_trkClus
Entries 65957
Mean 495.6
Std Dev 16.49
Strip Position
right_L0B_axial_charge_vs_stripPos_hps_014596_trkClus
Entries 77984
Mean 496.8
Std Dev 16.23
Strip Position
right_L0B_axial_charge_vs_stripPos_hps_014691_trkClus
Entries 72062
Mean 496.7
Std Dev 16.17
Strip Position
right_L0B_axial_charge_vs_stripPos_hps_014191_trkClus10hits
Entries 37565
Mean 500.4
Std Dev 10.67
Strip Position
right_L0B_axial_charge_vs_stripPos_hps_014552_trkClus10hits
Entries 24905
Mean 499.1
Std Dev 10.97
Strip Position
right_L0B_axial_charge_vs_stripPos_hps_014596_trkClus10hits
Entries 31496
Mean 500.7
Std Dev 10.38
Strip Position
right_L0B_axial_charge_vs_stripPos_hps_014691_trkClus10hits
Entries 28674
Mean 500.3
Std Dev 10.62
Strip Position
right_L0B_axial_charge_vs_stripPos_hps_014191_trkClus12hits
Entries 15295
Mean 499.8
Std Dev 9.8
Strip Position
right_L0B_axial_charge_vs_stripPos_hps_014552_trkClus12hits
Entries 10202
Mean 498.6
Std Dev 9.905
Strip Position
right_L0B_axial_charge_vs_stripPos_hps_014596_trkClus12hits
Entries 13134
Mean 500.3
Std Dev 9.41
Strip Position
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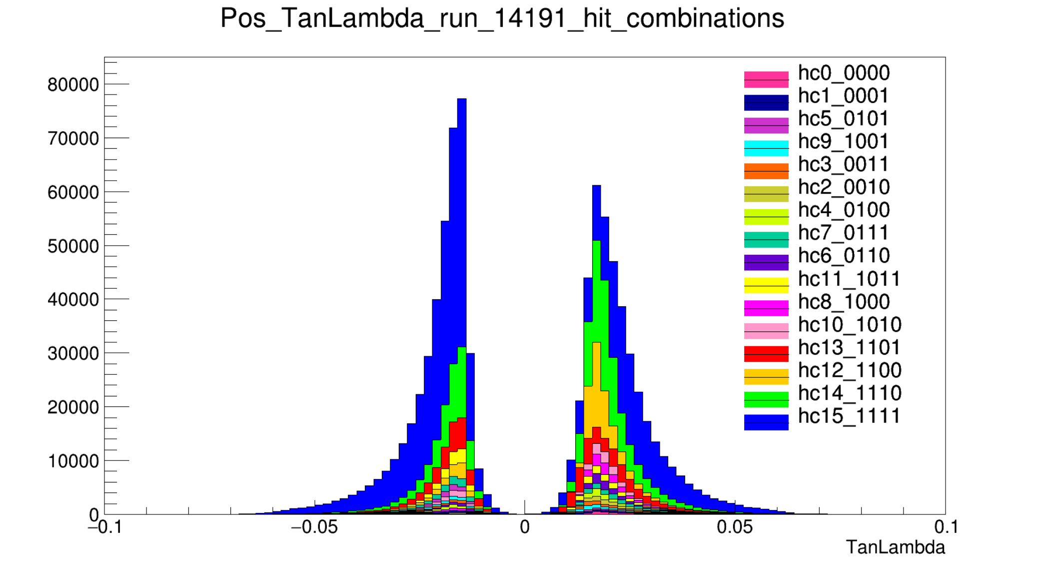
Entries 7684
Mean 501.5
Std Dev 8.357
Strip Position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hc1_0001
hc5_0101
hc9_1001
hc3_0011
hc2_0010
hc4_0100
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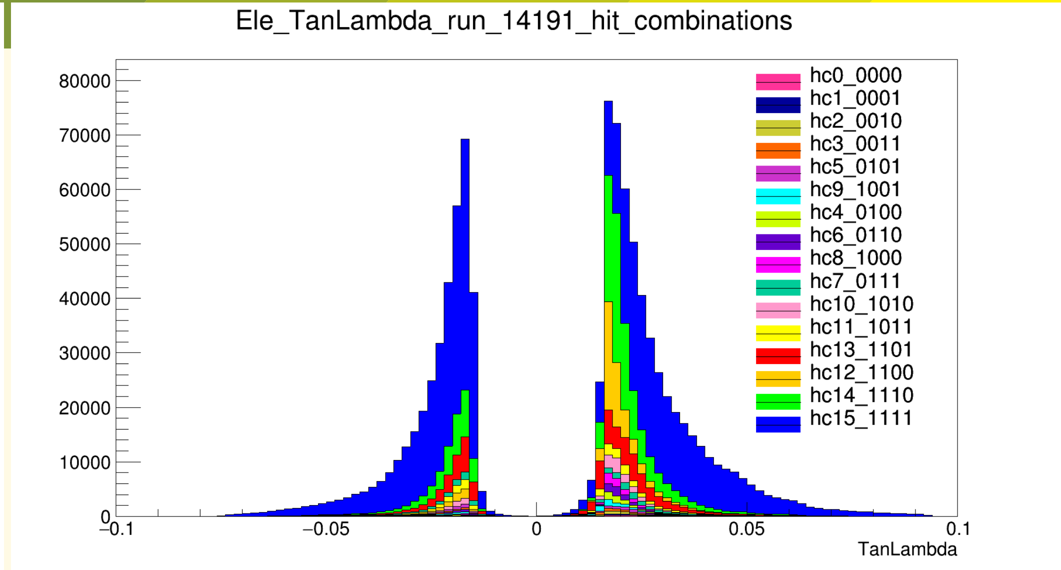
hc8_1000
hc10_1010
hc13_1101
hc12_1100
hc14_1110
hc15_1111
TanLambda


Ele_TanLambda_run_14191_hit_combinations
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hc1_0001
hc2_0010
hc3_0011
hc5_0101
hc9_1001
hc4_0100
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hc10_1010
hc11_1011
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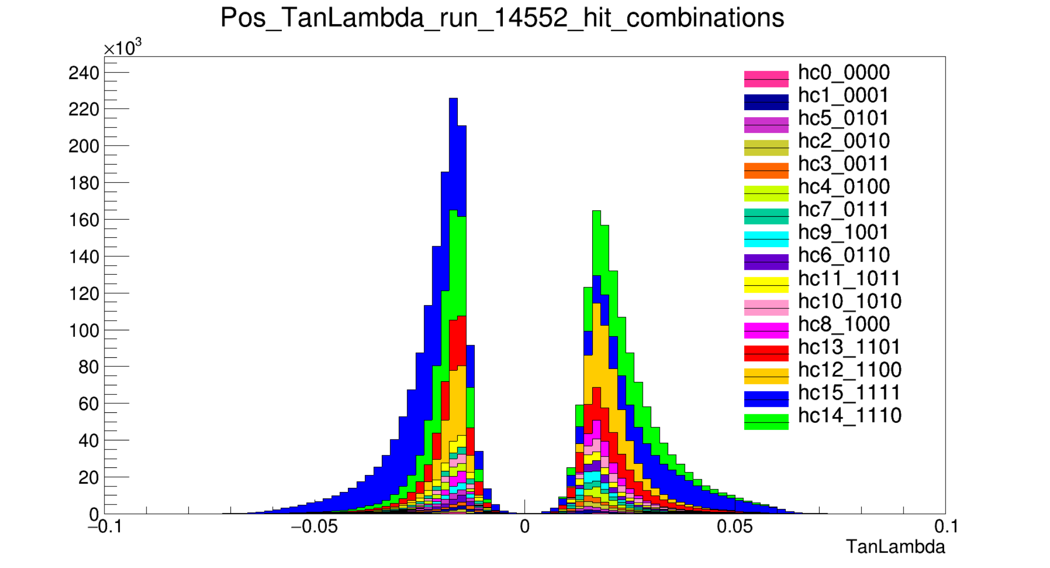
hc12_1100
hc14_1110
hc15_1111
TanLambda


Pos_TanLambda_run_14552_hit_combinations
×10³
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hc1_0001
hc5_0101
hc2_0010
hc3_0011
hc4_0100
hc7_0111
hc9_1001
hc6_0110
hc11_1011
hc10_1010
hc8_1000
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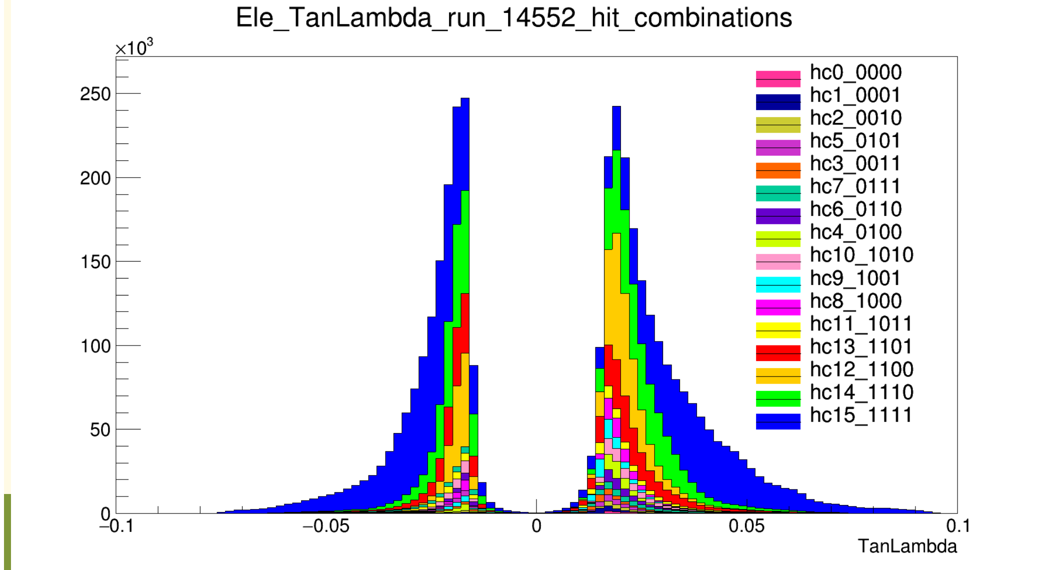
hc12_1100
hc15_1111
hc14_1110
TanLambda


Ele_TanLambda_run_14552_hit_combinations
×10³
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hc1_0001
hc2_0010
hc5_0101
hc3_0011
hc7_0111
hc6_0110
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hc10_1010
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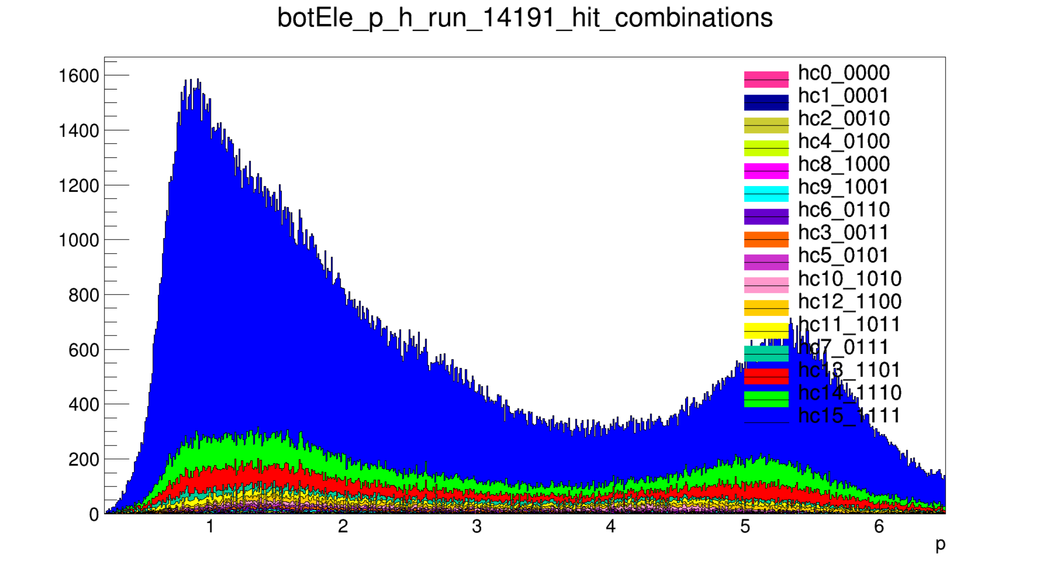
hc15_1111
TanLambda


botEle_p_h_run_14191_hit_combinations
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
6
p
hc0_0000
hc1_0001
hc2_0010
hc4_0100
hc8_1000
hc9_1001
hc6_0110
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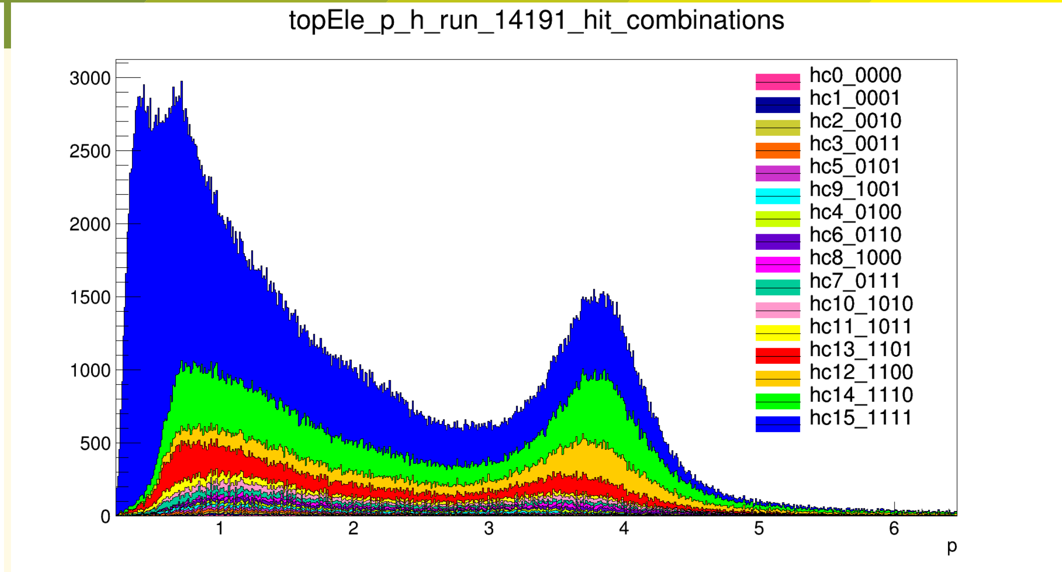
hc14_1110
hc15_1111


topEle_p_h_run_14191_hit_combinations
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
p
hc0_0000
hc1_0001
hc2_0010
hc3_0011
hc5_0101
hc9_1001
hc4_0100
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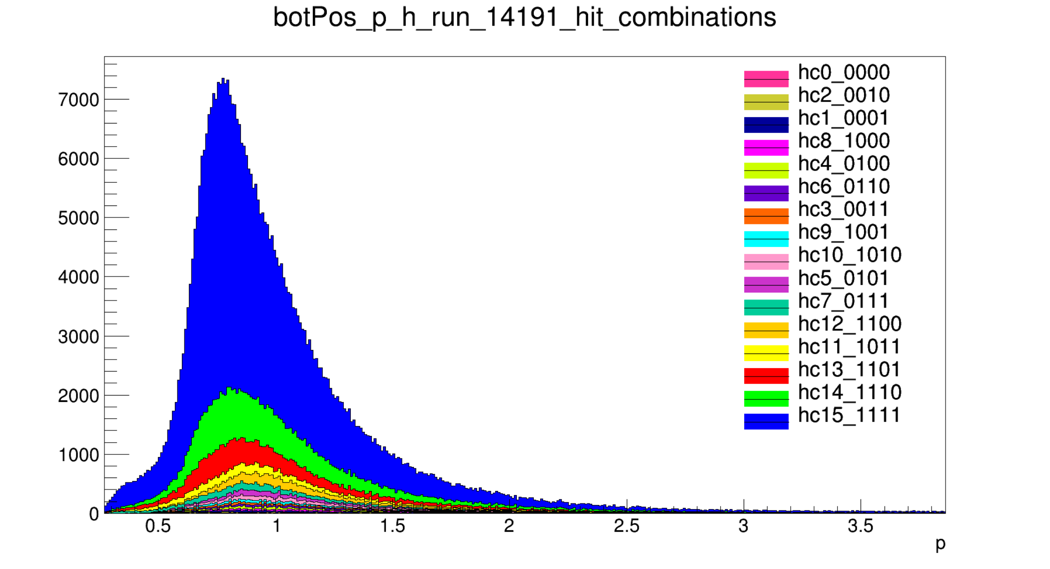
hc15_1111


botPos_p_h_run_14191_hit_combinations
7000
6000
5000
4000
3000
2000
1000
0
0.5
1
1.5
2
2.5
3
3.5
p
hc0_0000
hc2_0010
hc1_0001
hc8_1000
hc4_0100
hc6_0110
hc3_0011
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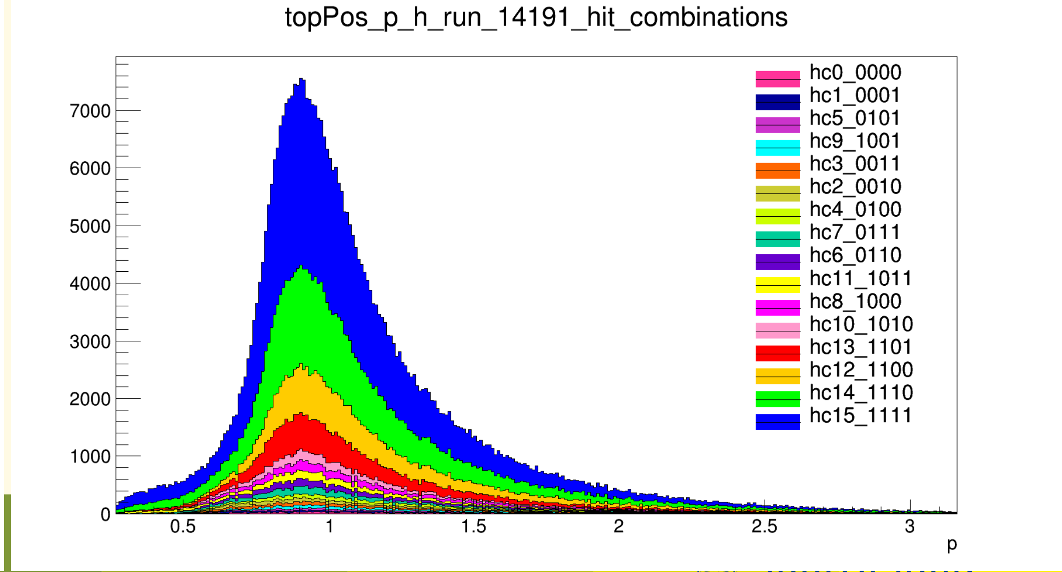
hc15_1111


topPos_p_h_run_14191_hit_combinations
7000
6000
5000
4000
3000
2000
1000
0
0.5
1
1.5
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3
p
hc0_0000
hc1_0001
hc5_0101
hc9_1001
hc3_0011
hc2_0010
hc4_0100
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hc8_1000
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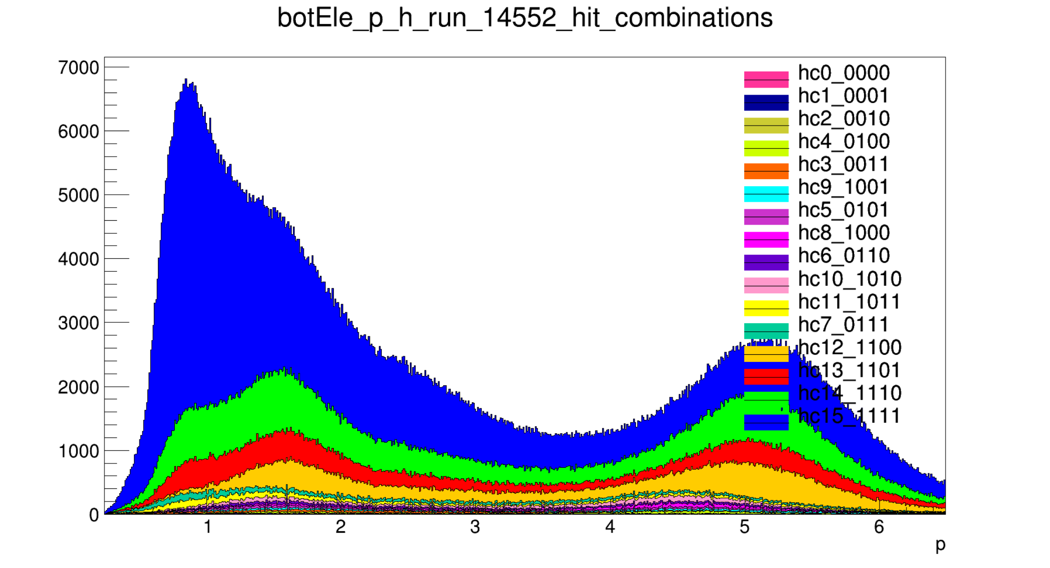
hc15_1111


botEle_p_h_run_14552_hit_combinations
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hc1_0001
hc2_0010
hc4_0100
hc3_0011
hc9_1001
hc5_0101
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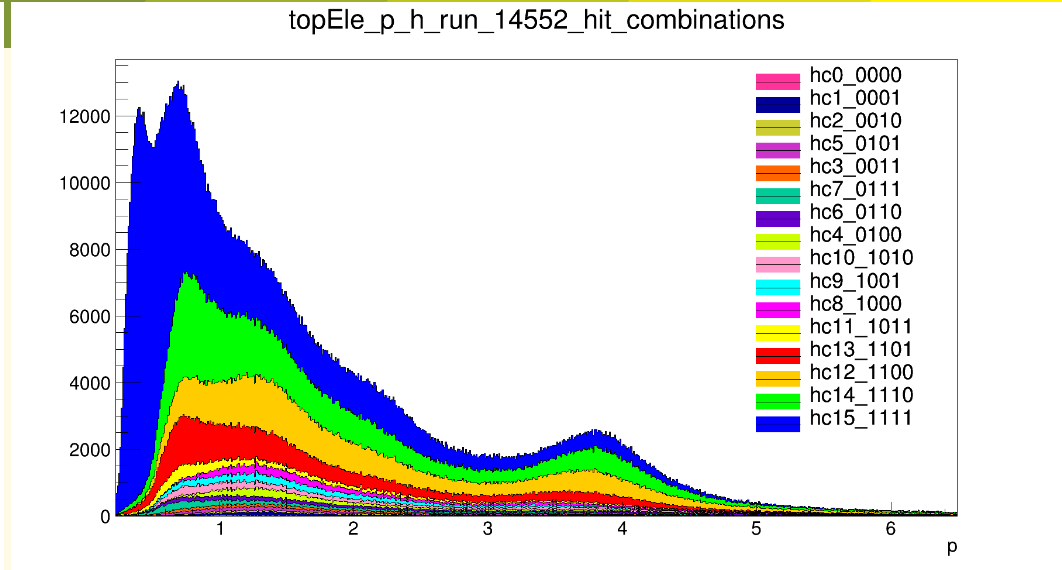
hc14_1110
hc15_1111
p


topEle_p_h_run_14552_hit_combinations
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hc1_0001
hc2_0010
hc5_0101
hc3_0011
hc7_0111
hc6_0110
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hc8_1000
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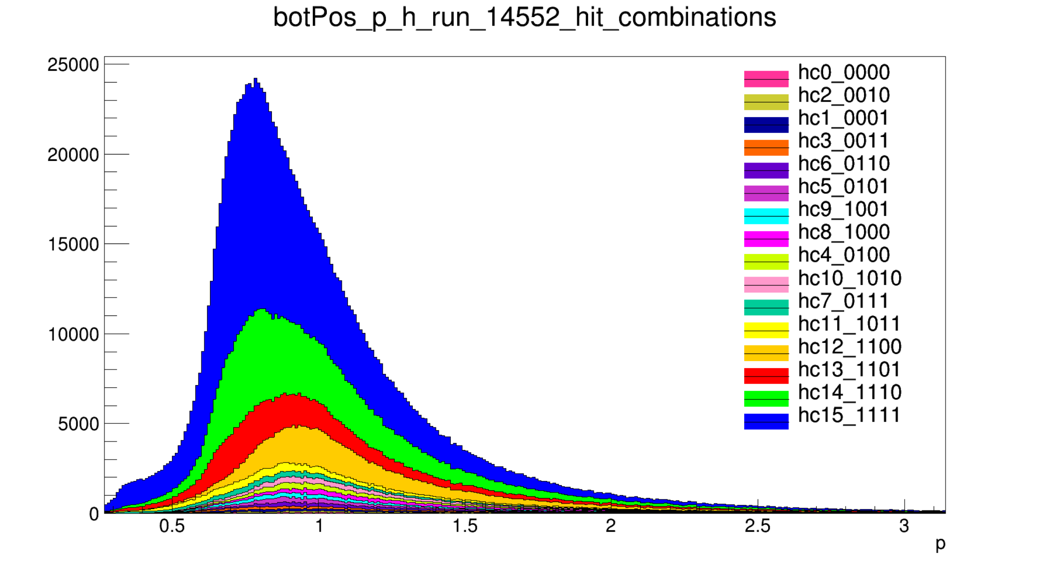
p


botPos_p_h_run_14552_hit_combinations
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hc2_0010
hc1_0001
hc3_0011
hc6_0110
hc5_0101
hc9_1001
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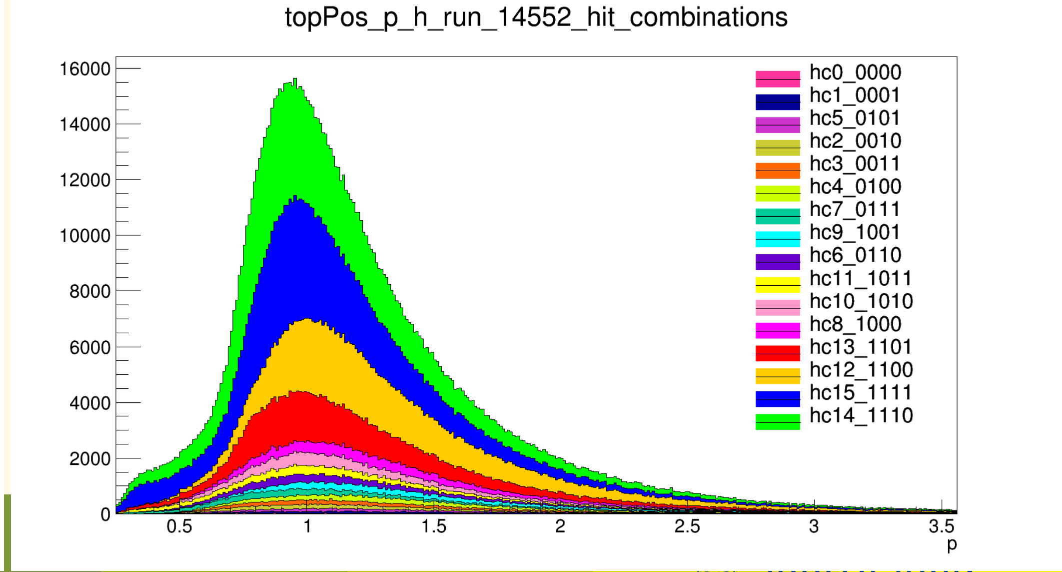
p


topPos_p_h_run_14552_hit_combinations
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hc4_0100
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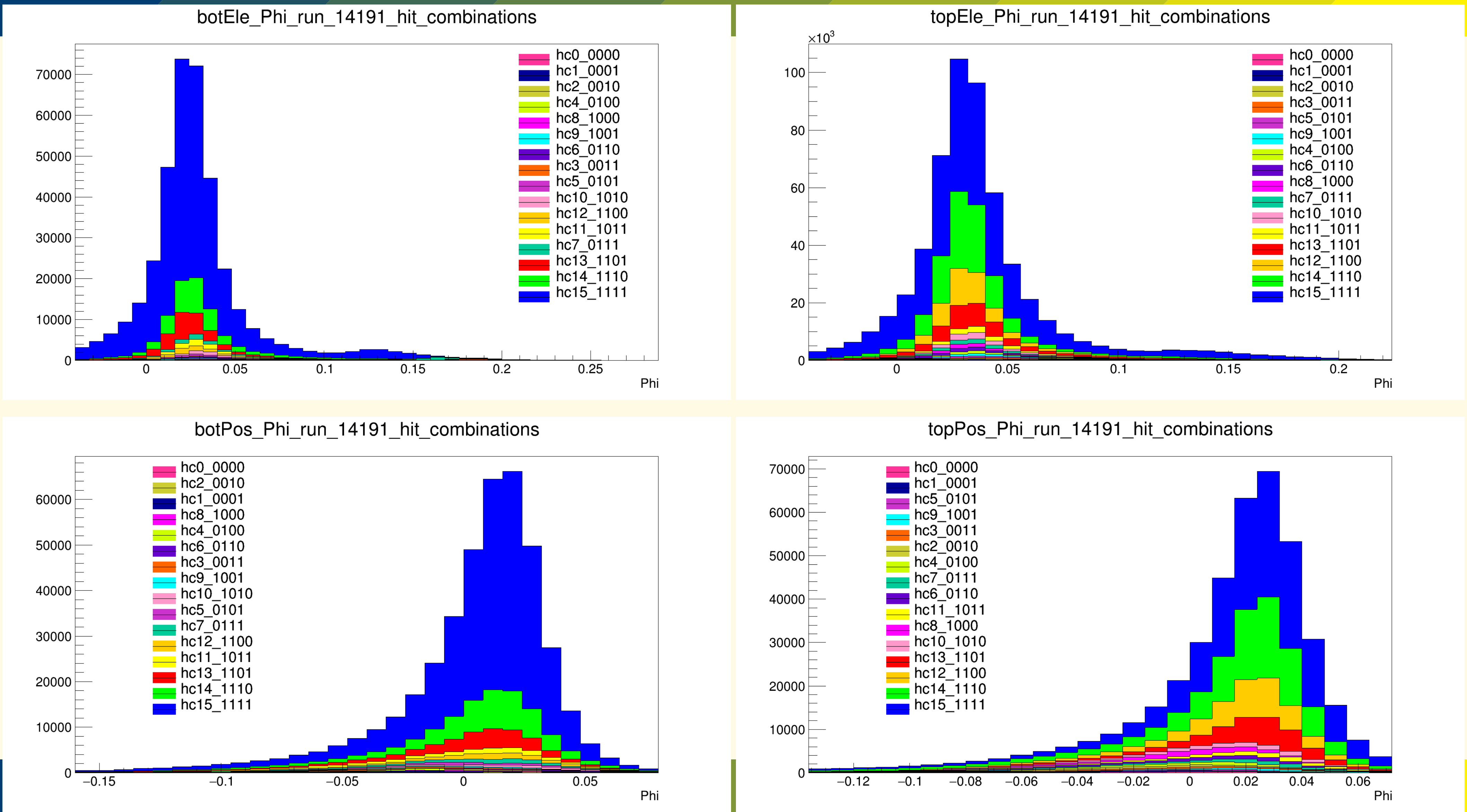

botEle_Phi_run_14191_hit_combinations
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hc2_0010
hc4_0100
hc8_1000
hc9_1001
hc6_0110
hc3_0011
hc5_0101
hc10_1010
hc12_1100
hc11_1011
hc7_0111
hc13_1101
hc14_1110
hc15_1111
Phi
topEle_Phi_run_14191_hit_combinations
×10^3
hc0_0000
hc1_0001
hc2_0010
hc3_0011
hc5_0101
hc9_1001
hc4_0100
hc6_0110
hc8_1000
hc7_0111
hc10_1010
hc11_1011
hc13_1101
hc12_1100
hc14_1110
hc15_1111
Phi
botPos_Phi_run_14191_hit_combinations
hc0_0000
hc2_0010
hc1_0001
hc8_1000
hc4_0100
hc6_0110
hc3_0011
hc9_1001
hc10_1010
hc5_0101
hc7_0111
hc12_1100
hc11_1011
hc13_1101
hc14_1110
hc15_1111
Phi
topPos_Phi_run_14191_hit_combinations
hc0_0000
hc1_0001
hc5_0101
hc9_1001
hc3_0011
hc2_0010
hc4_0100
hc7_0111
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hc8_1000
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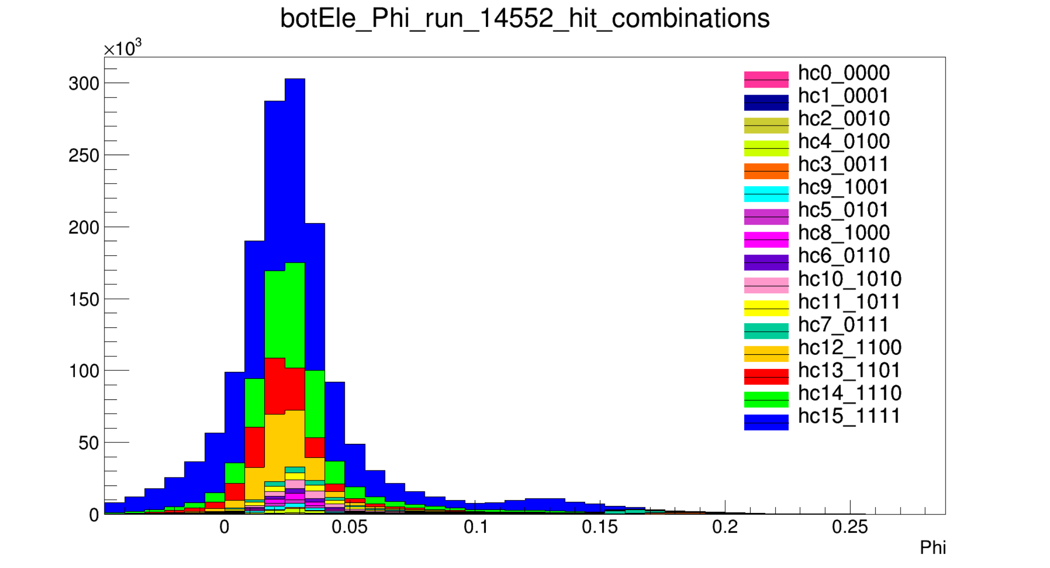
hc15_1111
Phi


botEle_Phi_run_14552_hit_combinations
×10^3
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hc1_0001
hc2_0010
hc4_0100
hc3_0011
hc9_1001
hc5_0101
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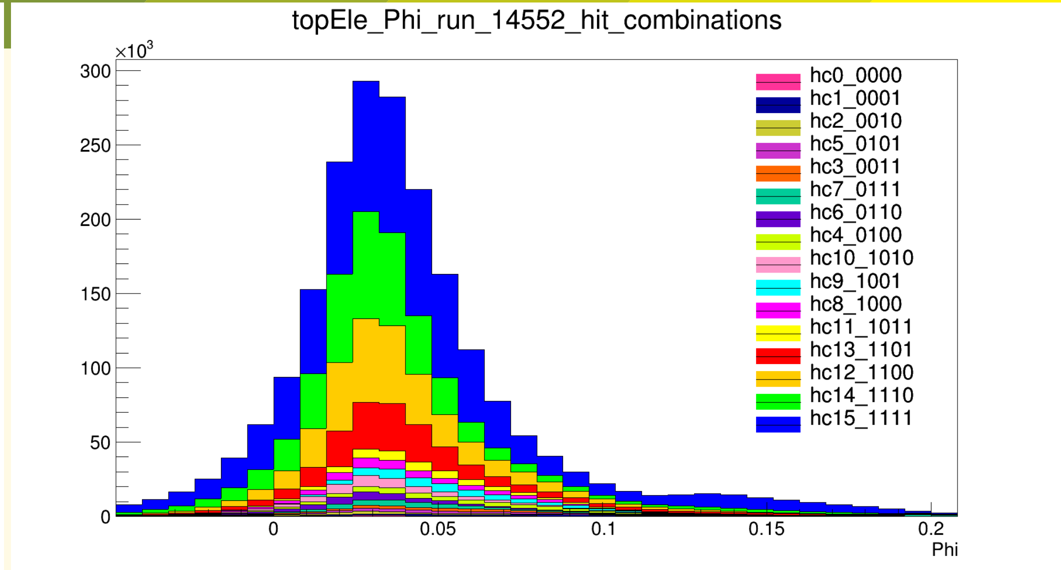
Phi


topEle_Phi_run_14552_hit_combinations
×10^3
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hc1_0001
hc2_0010
hc5_0101
hc3_0011
hc7_0111
hc6_0110
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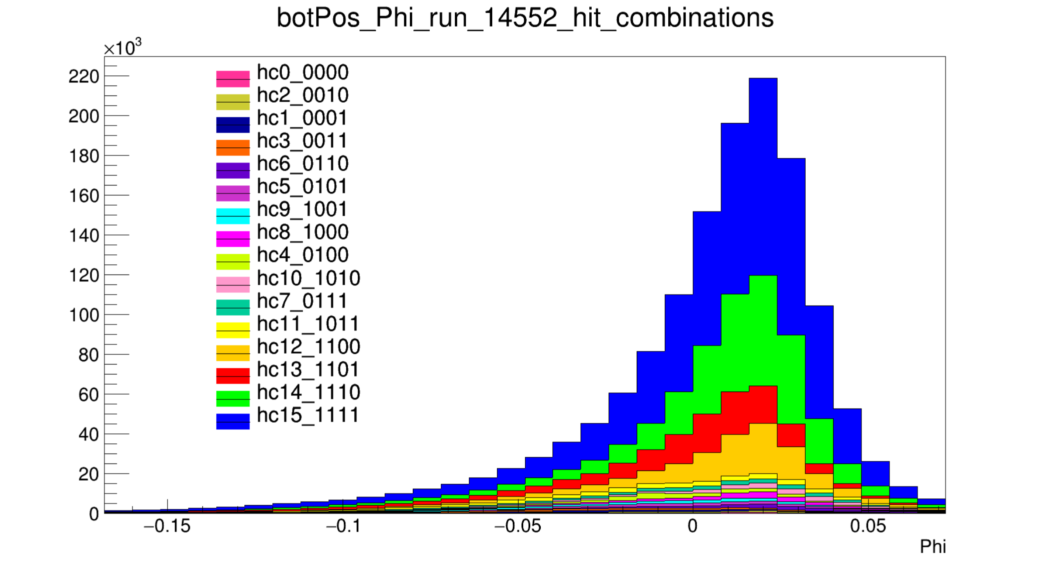
Phi


botPos_Phi_run_14552_hit_combinations
×10^3
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hc2_0010
hc1_0001
hc3_0011
hc6_0110
hc5_0101
hc9_1001
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hc12_1100
hc13_1101
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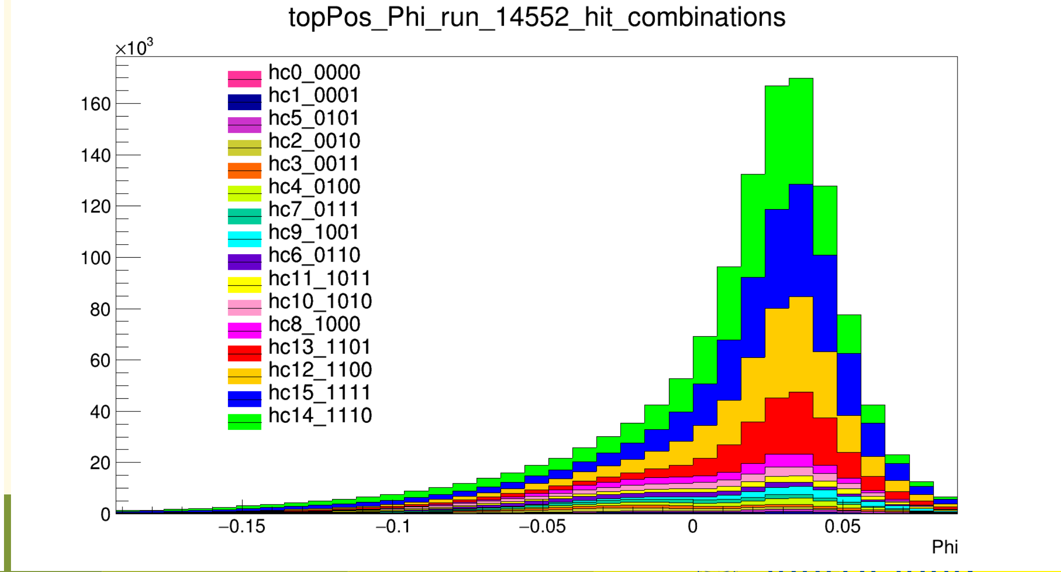
hc15_1111
Phi


topPos_Phi_run_14552_hit_combinations
×10^3
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hc1_0001
hc5_0101
hc2_0010
hc3_0011
hc4_0100
hc7_0111
hc9_1001
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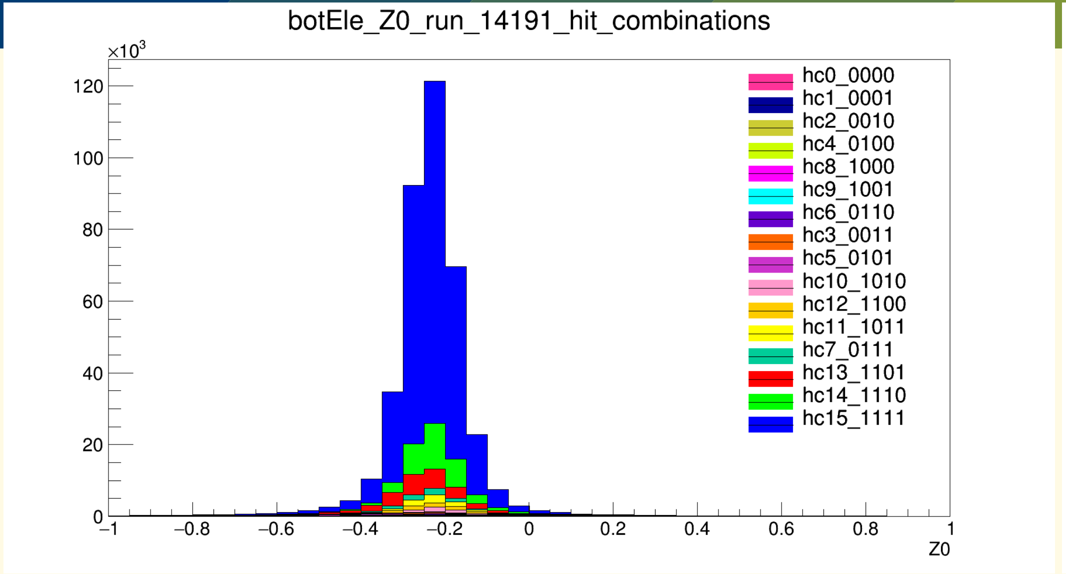
hc13_1101
hc12_1100
hc15_1111
hc14_1110
Phi


botEle_Z0_run_14191_hit_combinations
×10^3
0
20
40
60
80
100
120
−1 −0.8 −0.6 −0.4 −0.2 0 0.2 0.4 0.6 0.8 1
Z0
hc0_0000
hc1_0001
hc2_0010
hc4_0100
hc8_1000
hc9_1001
hc6_0110
hc3_0011
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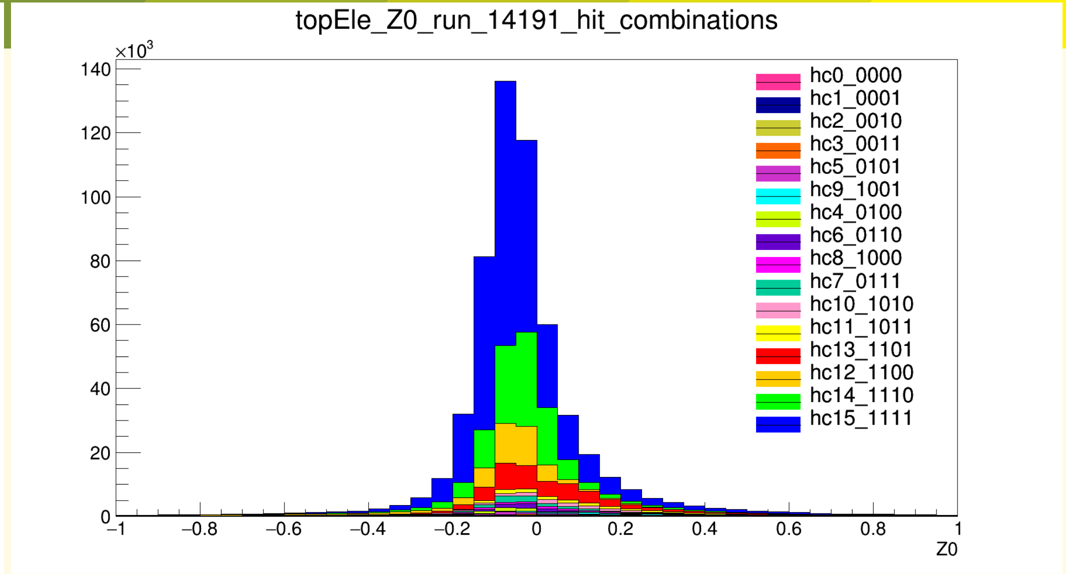
hc14_1110
hc15_1111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×10^3
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60
80
100
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140
−1 −0.8 −0.6 −0.4 −0.2 0 0.2 0.4 0.6 0.8 1
Z0
hc0_0000
hc1_0001
hc2_0010
hc3_0011
hc5_0101
hc9_1001
hc4_0100
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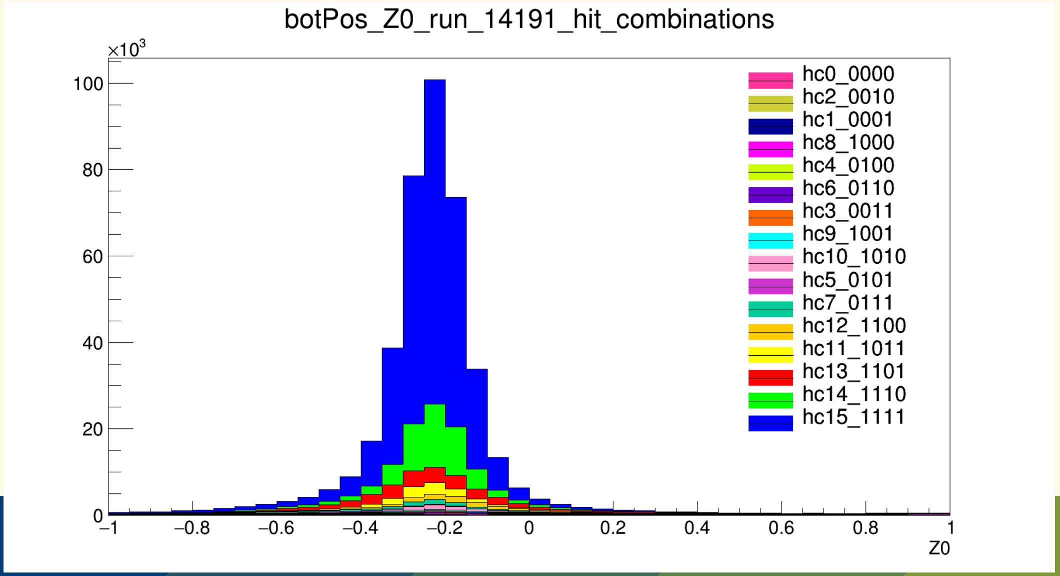
hc15_1111


botPos_Z0_run_14191_hit_combinations
×10^3
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20
40
60
80
100
−1 −0.8 −0.6 −0.4 −0.2 0 0.2 0.4 0.6 0.8 1
Z0
hc0_0000
hc2_0010
hc1_0001
hc8_1000
hc4_0100
hc6_0110
hc3_0011
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hc5_0101
hc7_0111
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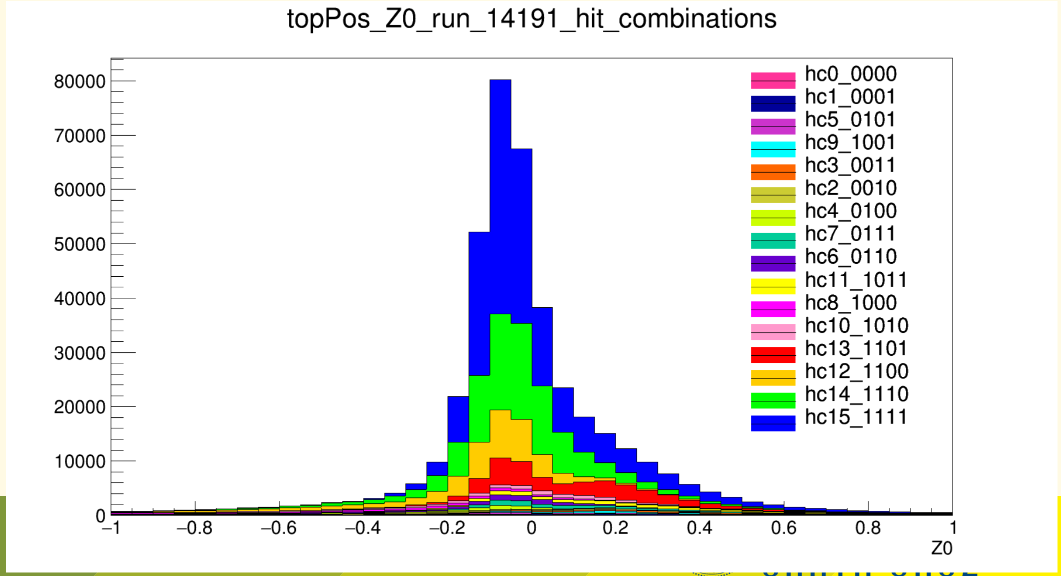
hc15_1111


topPos_Z0_run_14191_hit_combinations
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30000
40000
50000
60000
70000
80000
−1 −0.8 −0.6 −0.4 −0.2 0 0.2 0.4 0.6 0.8 1
Z0
hc0_0000
hc1_0001
hc5_0101
hc9_1001
hc3_0011
hc2_0010
hc4_0100
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hc11_1011
hc8_1000
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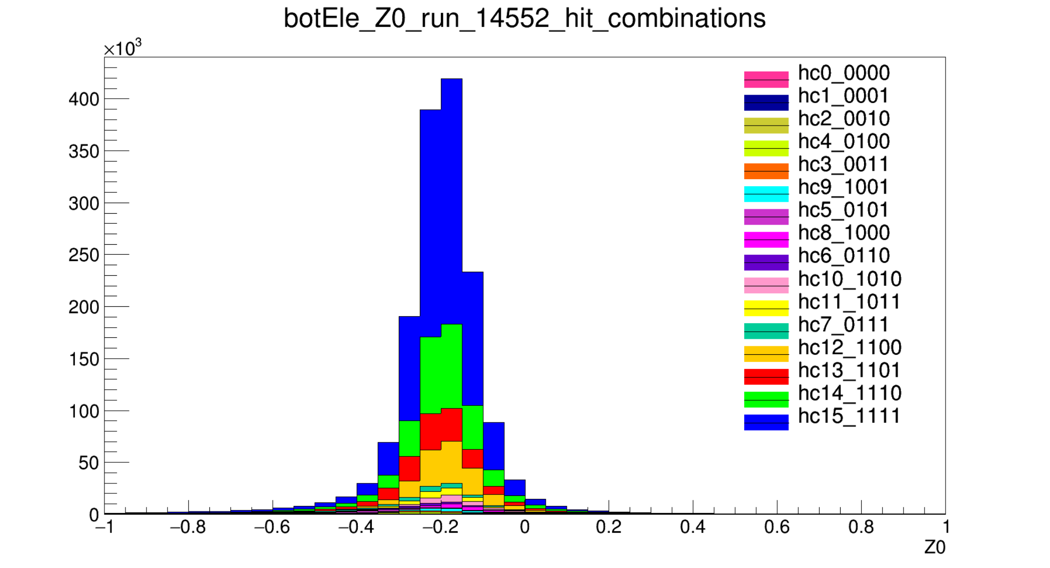
hc15_1111


botEle_Z0_run_14552_hit_combinations
×10^3
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100
150
200
250
300
350
400
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1
Z0
hc0_0000
hc1_0001
hc2_0010
hc4_0100
hc3_0011
hc9_1001
hc5_0101
hc8_1000
hc6_0110
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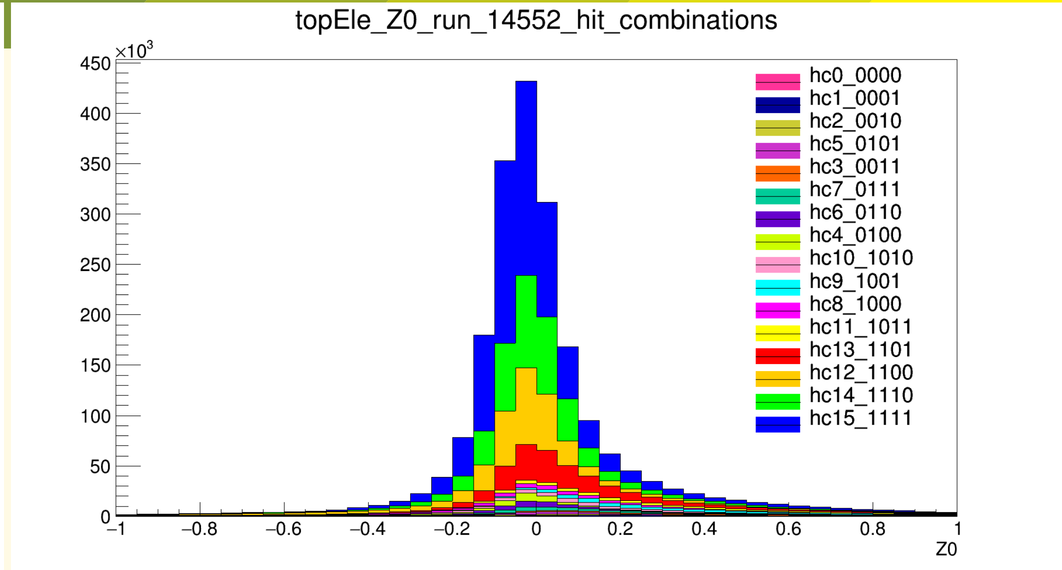
hc14_1110
hc15_1111


topEle_Z0_run_14552_hit_combinations
×10^3
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200
250
300
350
400
450
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−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1
Z0
hc0_0000
hc1_0001
hc2_0010
hc5_0101
hc3_0011
hc7_0111
hc6_0110
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hc13_1101
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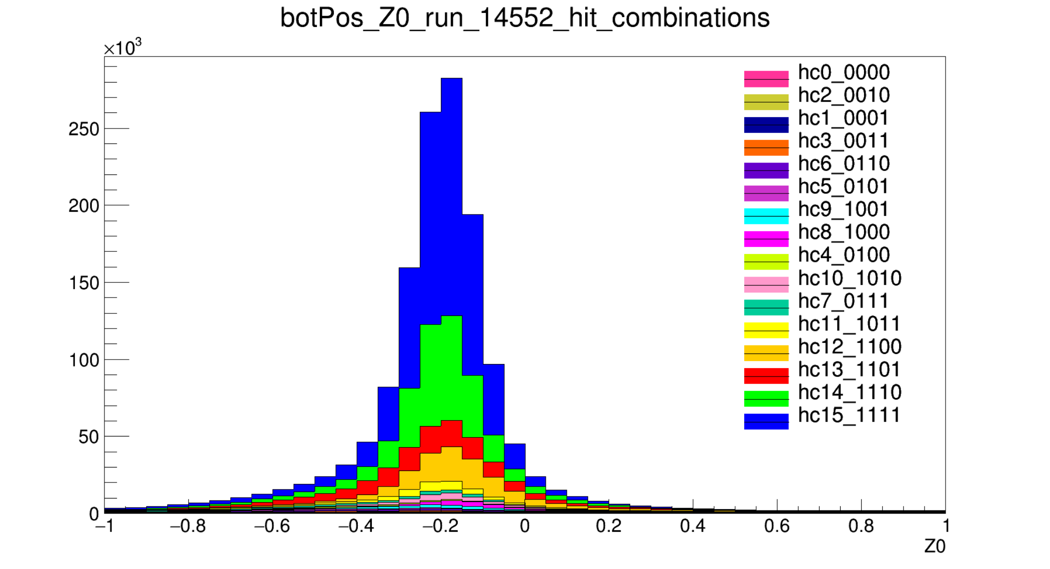
botPos_Z0_run_14552_hit_combinations
×10^3
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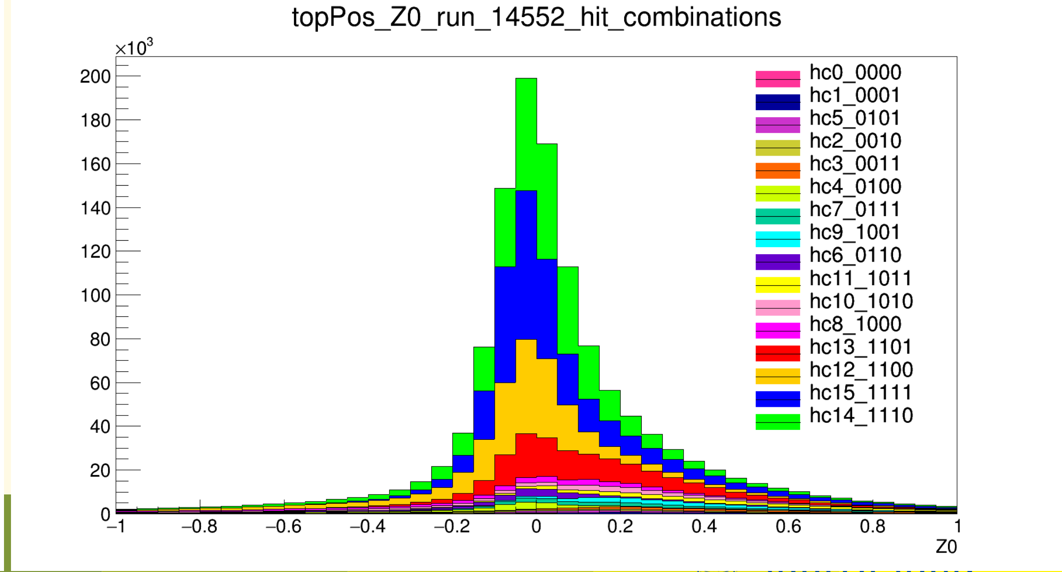
100
150
200
250
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1
Z0
hc0_0000
hc2_0010
hc1_0001
hc3_0011
hc6_0110
hc5_0101
hc9_1001
hc8_1000
hc4_0100
hc10_1010
hc7_0111
hc11_1011
hc12_1100
hc13_1101
hc14_1110
hc15_1111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×10^3
0
20
40
60
80
100
120
140
160
180
200
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1
Z0
hc0_0000
hc1_0001
hc5_0101
hc2_0010
hc3_0011
hc4_0100
hc7_0111
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hc6_0110
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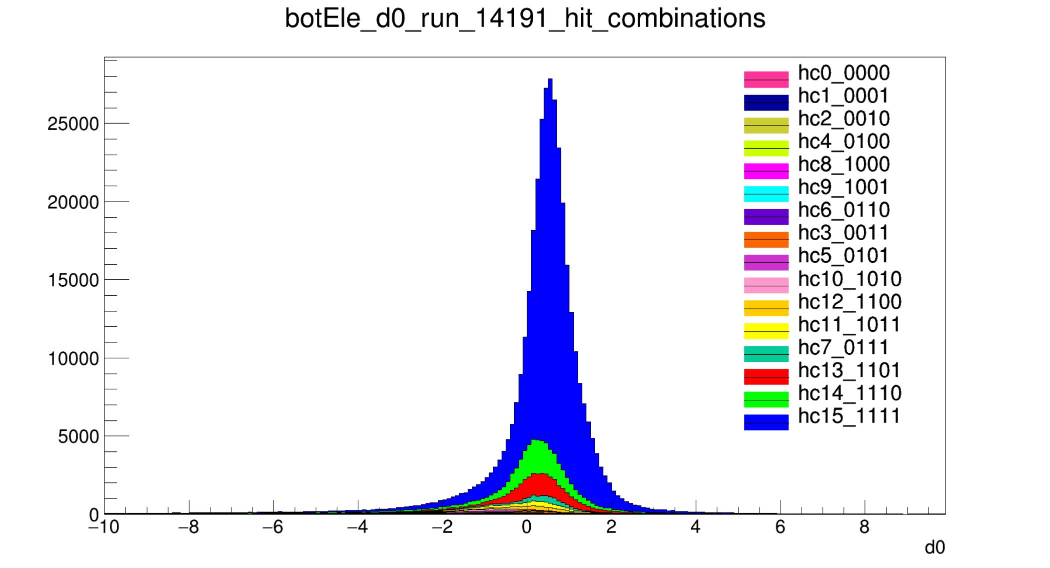
hc10_1010
hc8_1000
hc13_1101
hc12_1100
hc15_1111
hc14_1110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hc6_0110
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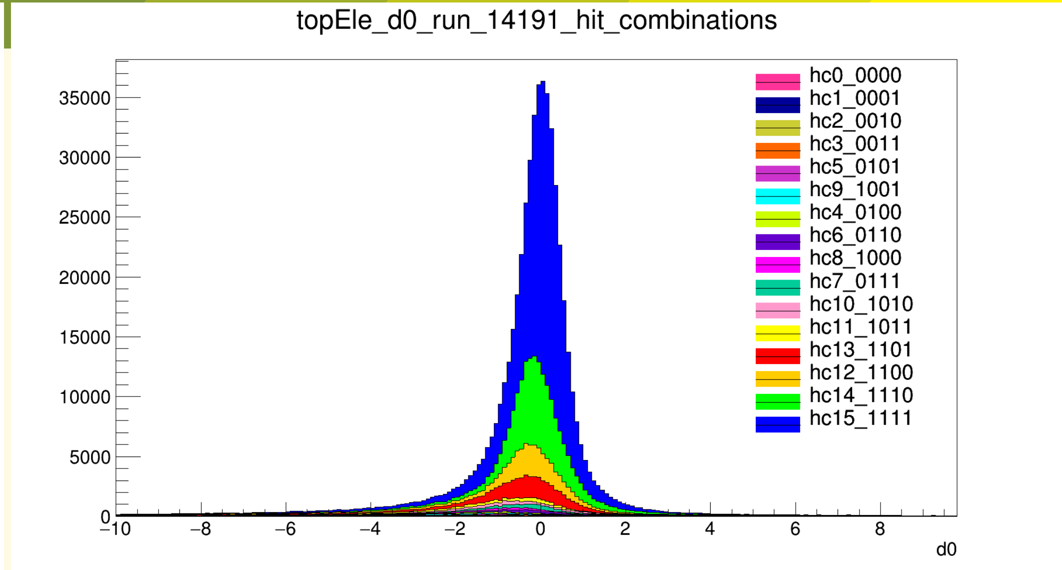
hc10_1010
hc12_1100
hc11_1011
hc7_0111
hc13_1101
hc14_1110
hc15_1111
d0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hc2_0010
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hc4_0100
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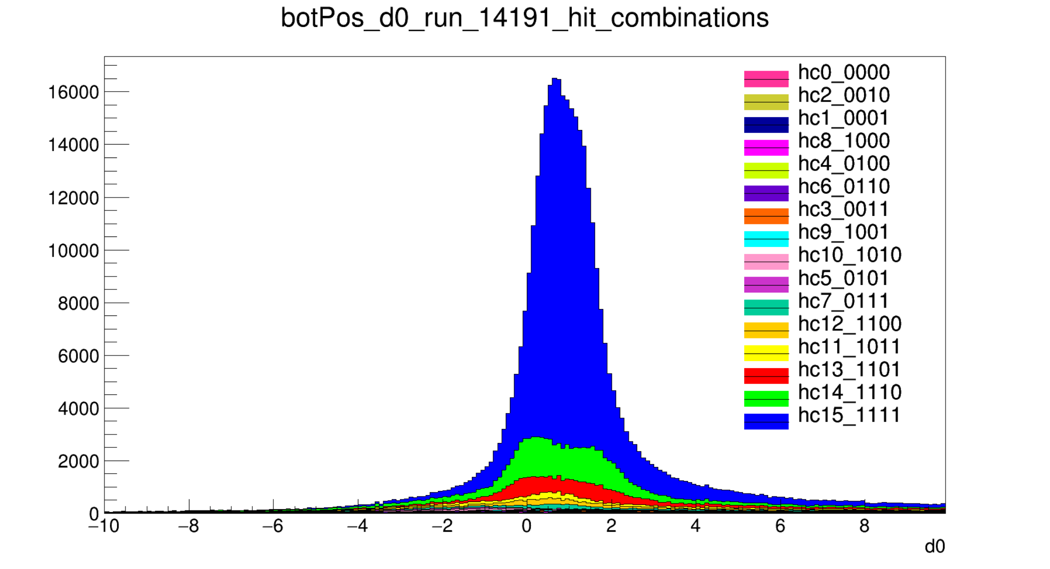
hc8_1000
hc7_0111
hc10_1010
hc11_1011
hc13_1101
hc12_1100
hc14_1110
hc15_1111
d0


botPos_d0_run_14191_hit_combinations
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hc2_0010
hc1_0001
hc8_1000
hc4_0100
hc6_0110
hc3_0011
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hc10_1010
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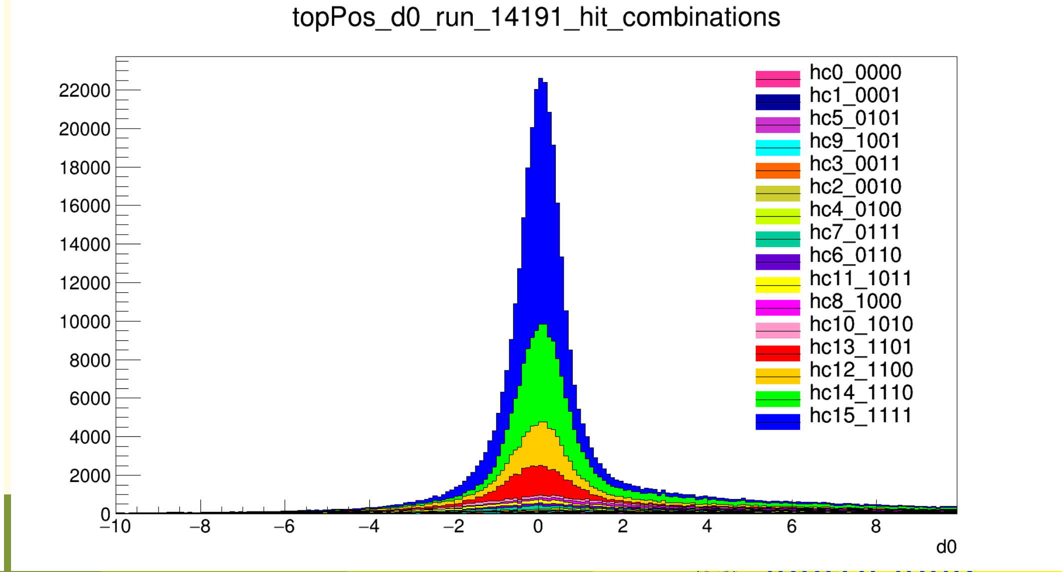
hc7_0111
hc12_1100
hc11_1011
hc13_1101
hc14_1110
hc15_1111
d0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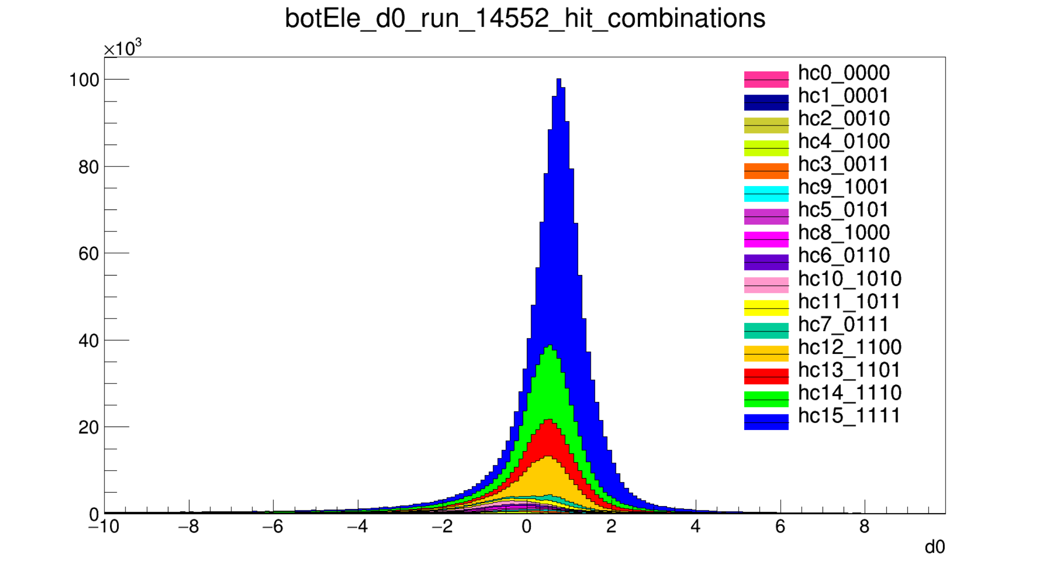
hc5_0101
hc9_1001
hc3_0011
hc2_0010
hc4_0100
hc7_0111
hc6_0110
hc11_1011
hc8_1000
hc10_1010
hc13_1101
hc12_1100
hc14_1110
hc15_1111
d0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×10^3
100
80
60
40
20
0
−10
−8
−6
−4
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0
2
4
6
8
d0
hc0_0000
hc1_0001
hc2_0010
hc4_0100
hc3_0011
hc9_1001
hc5_0101
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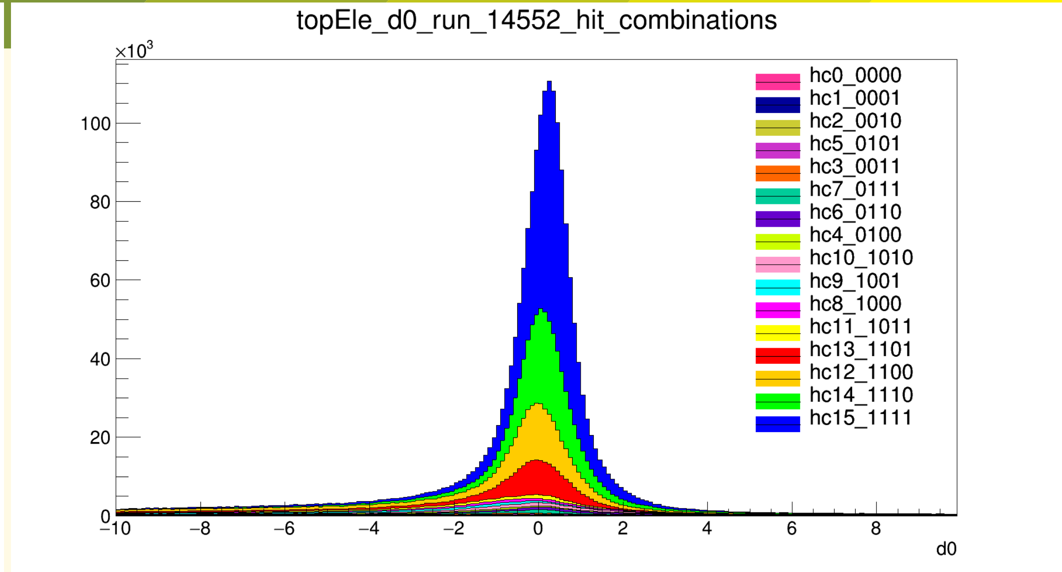
hc14_1110
hc15_1111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×10^3
100
80
60
40
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0
−10
−8
−6
−4
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4
6
8
d0
hc0_0000
hc1_0001
hc2_0010
hc5_0101
hc3_0011
hc7_0111
hc6_0110
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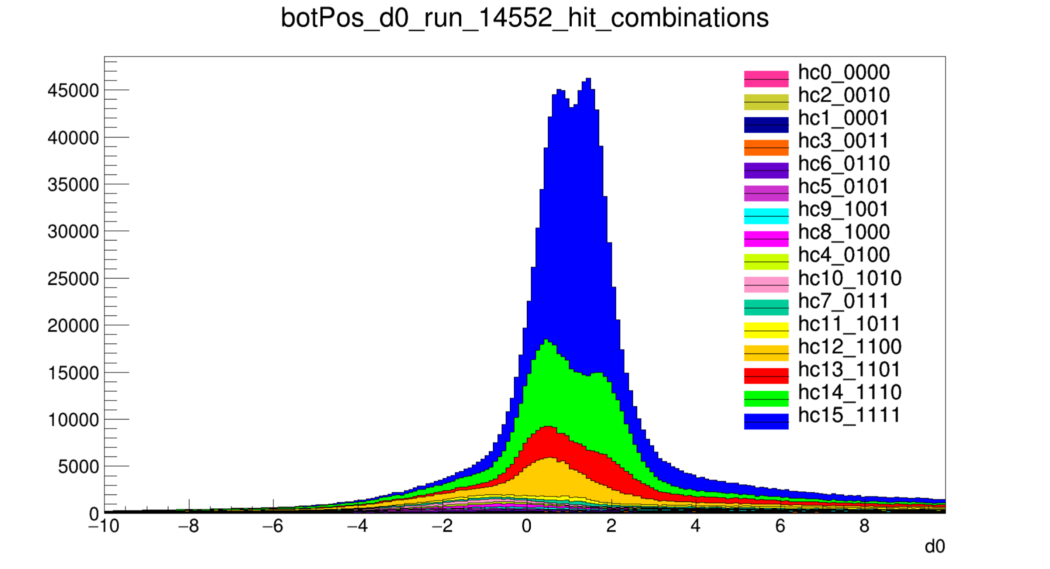
hc13_1101
hc12_1100
hc14_1110
hc15_1111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45000
40000
35000
30000
25000
20000
15000
10000
5000
0
−10
−8
−6
−4
−2
0
2
4
6
8
d0
hc0_0000
hc2_0010
hc1_0001
hc3_0011
hc6_0110
hc5_0101
hc9_1001
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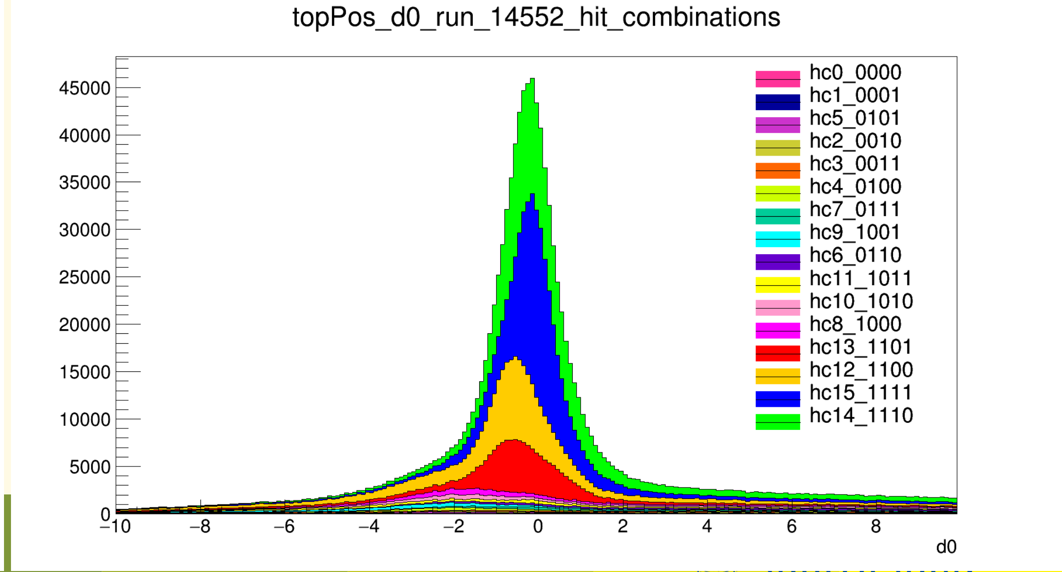
hc14_1110
hc15_1111

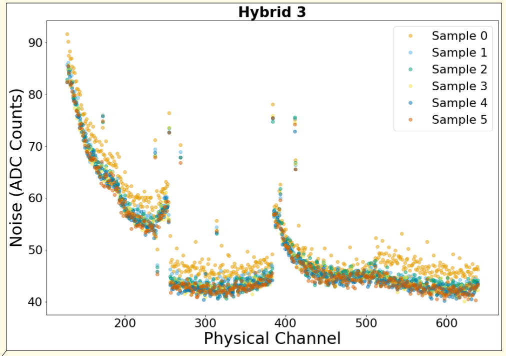

topPos_d0_run_14552_hit_combinations
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
−10
−8
−6
−4
−2
0
2
4
6
8
d0
hc0_0000
hc1_0001
hc5_0101
hc2_0010
hc3_0011
hc4_0100
hc7_0111
hc9_1001
hc6_0110
hc11_1011
hc10_1010
hc8_1000
hc13_1101
hc12_1100
hc15_1111
hc14_1110

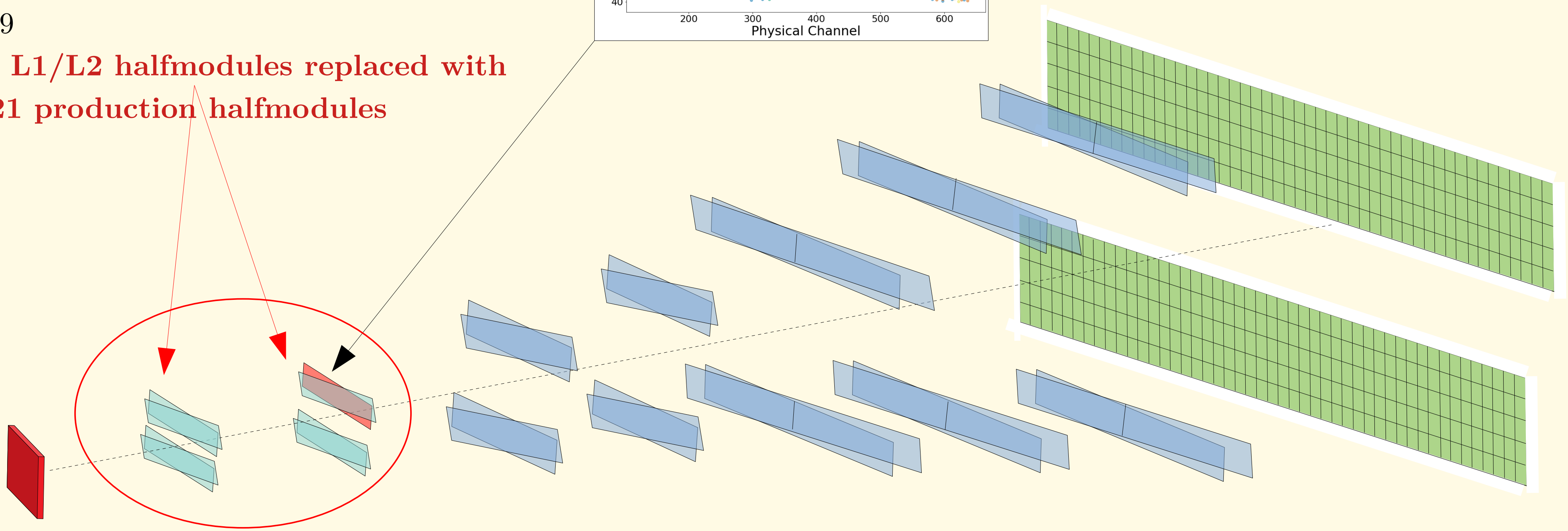
Draft Slides

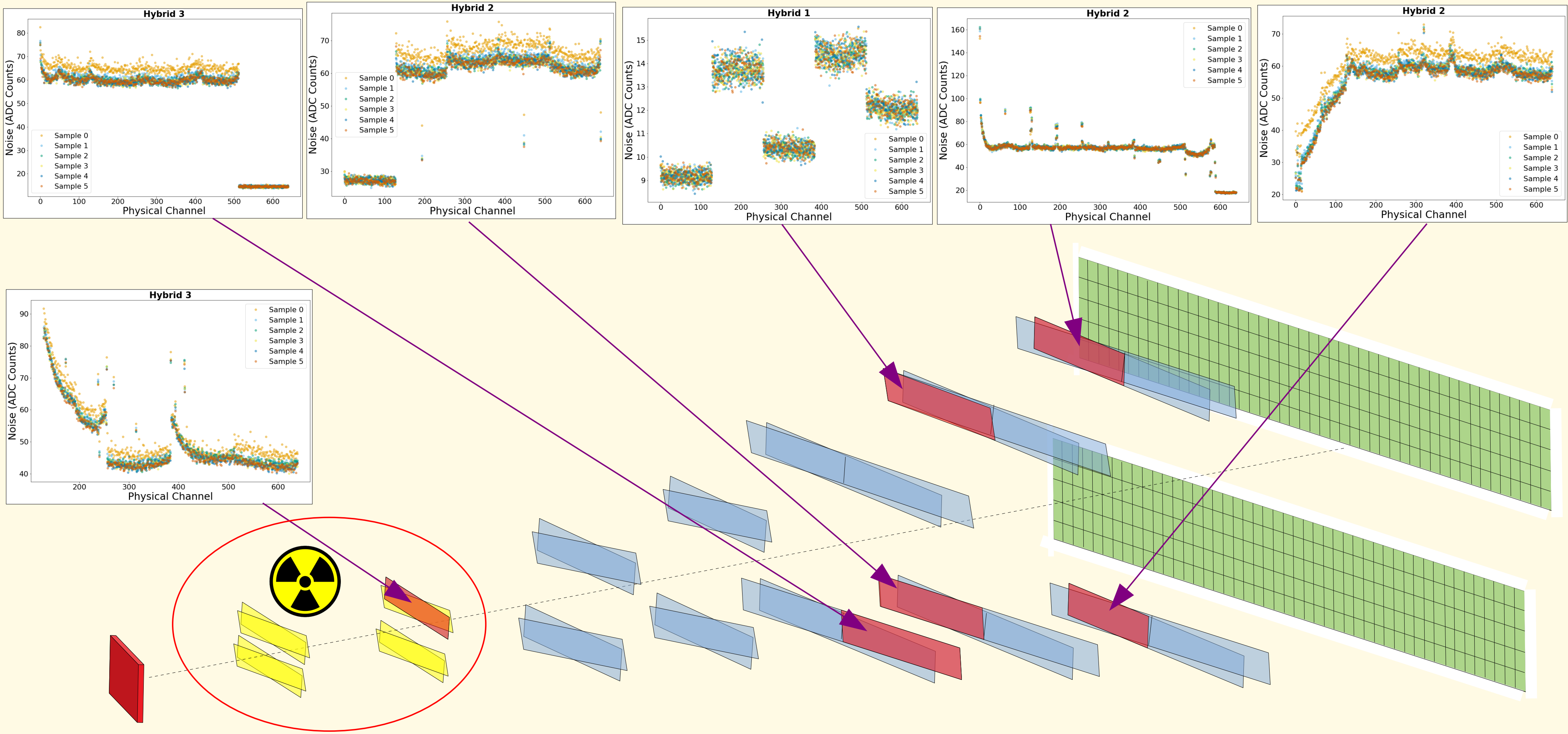
Cluster-on-Track Charge Collection Efficiency

- Reconstruct tracks on production data using **offline fitted baselines**
  - Important that baselines are correct. Any unaccounted shift in baselines will also shift charge(ADC) of clusters on track
- Loop over 3d hits on track and fill histograms with rawhit amplitude vs strip number
- **Split L1 and L2 sensors into "left" and "right"** halves for better scaling in histograms
- **Compare Strip Position vs Charge for the same sensor across different runs** (14191, 14552, 14596, 14691 will be in plot title)
- Some plots have different requirements for the Tracks being looped over…
  - **Tracks can require 12 hits, 10 hits, and all hits** (will say in plot title… "TrkClus12hits" for example)
- If a sensor strip number appears to have little/no charge efficiency, could be due to geometric acceptance for Tracks…check "all hits" plots to confirm that there is still charge collection efficiency in those strips
- If strip appears to have low/no charge efficiency, may be due to geometric acceptance…check "all hits" to minimize this acceptance effect

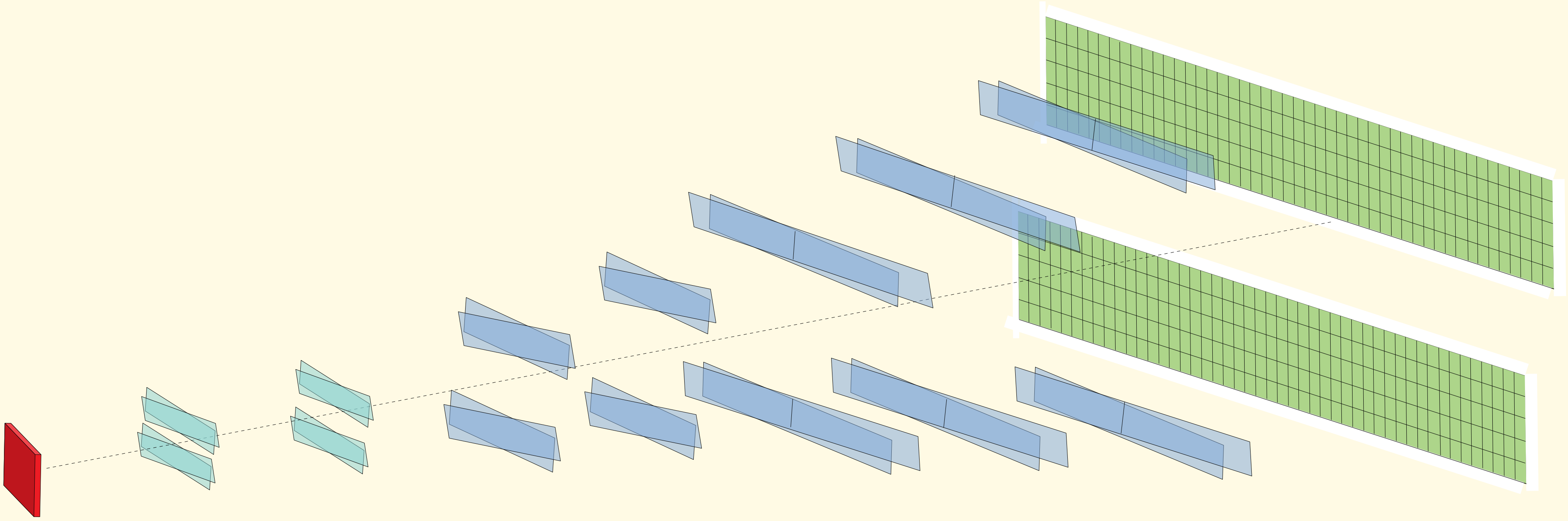
- 2019 slim-edge sensors received damaging radiation
  - Example: 2019 L2 Top Stereo
- 2021 sensor production drastically improved number of pinholes compared to 2019
- **All L1/L2 halfmodules replaced with 2021 production halfmodules**

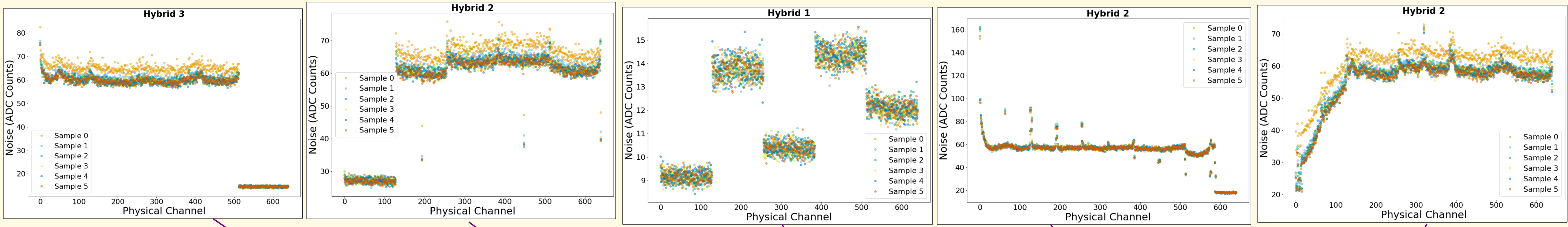




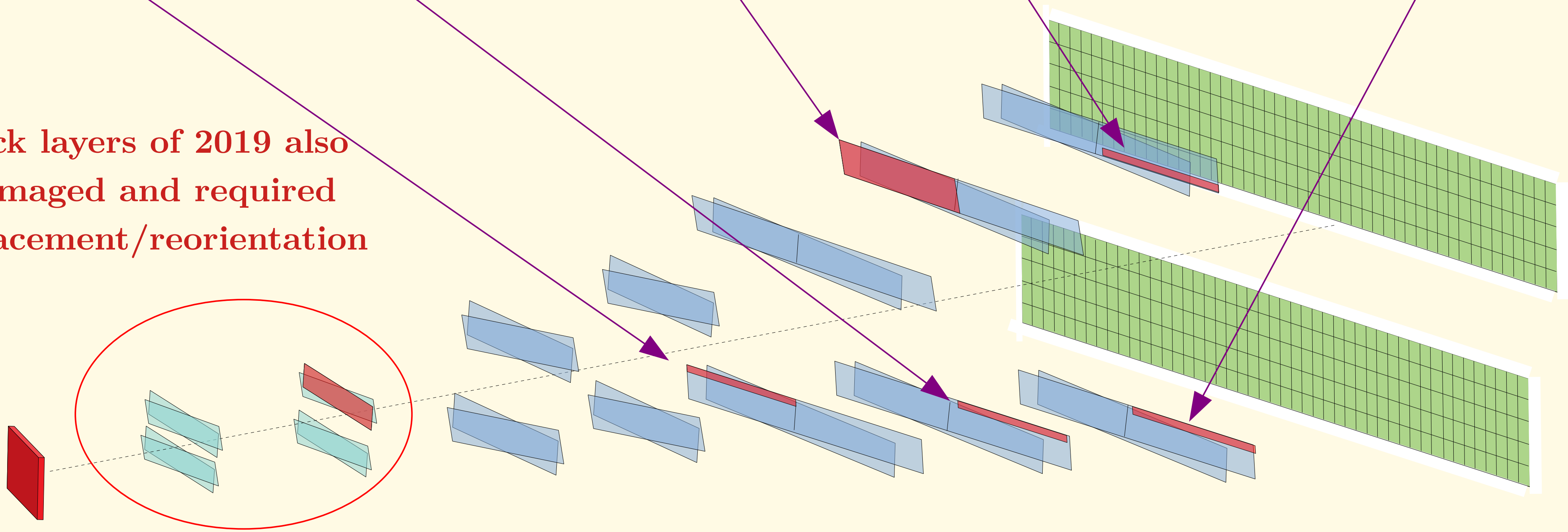

Hybrid 3
Hybrid 2
Hybrid 1
Hybrid 2
Hybrid 2
Hybrid 3
Noise (ADC Counts)
Physical Channel
Sample 0
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5

2019 Detector Diagram





Back layers of 2019 also damaged and required replacement/reorientation



[redacted]

MEASURED CURRENTS

Layer	FEB		Hybrid	Type	Side	ON/OFF	DVDD	AVDD	V125	Temp (C)
L0-1t	0	Off On	0	Axial	Electron	Off On	0.316	0.299	0.245	0.000
			1	Stereo	Electron	Off On	0.292	0.298	0.243	0.000
			2	Axial	Electron	Off On	0.260	0.299	0.245	0.000
			3	Stereo	Electron	Off On	0.262	0.297	0.242	0.000
L0-1b	1	Off On	0	Stereo	Electron	Off On	0.266	0.300	0.245	0.000
			1	Axial	Electron	Off On	0.262	0.302	0.243	0.000
			2	Stereo	Electron	Off On	0.268	0.300	0.246	0.000
			3	Axial	Electron	Off On	0.319	0.303	0.249	0.000
L2-3t	2	Off On	0	Axial	Electron	Off On	0.311	0.362	0.293	77.346
			1	Stereo	Electron	Off On	0.285	0.358	0.283	19.250
			2	Axial	Electron	Off On	0.290	0.366	0.298	19.566
			3	Stereo	Electron	Off On	0.291	0.360	0.294	19.634
L2-3b	3	Off On	0	Stereo	Electron	Off On	0.283	0.364	0.290	19.544
			1	Axial	Electron	Off On	0.284	0.370	0.298	20.019
			2	Stereo	Electron	Off On	0.287	0.365	0.291	20.245
			3	Axial	Electron	Off On	0.302	0.363	0.294	64.347
L4t	4	Off On	0	Axial	Electron	Off On	0.285	0.371	0.876	44.643
			1	Axial	Positron	Off On	0.278	0.364	0.293	20.455
			2	Stereo	Electron	Off On	0.278	0.361	0.593	21.366
			3	Stereo	Positron	Off On	0.284	0.371	1.060	840.528

MEASURED CURRENTS

Layer	FEB		Hybrid	Type	Side	ON/OFF	DVDD	AVDD	V125	Temp (C)
L4b	5	Off On	0	Stereo	Electron	Off On	0.294	0.142	0.001	0.000
			1	Stereo	Positron	Off On	0.281	0.408	0.315	20.206
			2	Axial	Electron	Off On	0.283	0.377	0.301	21.096
			3	Axial	Positron	Off On	0.286	0.371	0.301	20.801
L5t	6	Off On	0	Axial	Electron	Off On	0.282	0.370	1.083	22.506
			1	Axial	Positron	Off On	0.279	0.364	0.284	18.104
			2	Stereo	Electron	Off On	0.278	0.373	0.703	21.862
			3	Stereo	Positron	Off On	0.281	0.374	0.299	21.619
L5b	7	Off On	0	Stereo	Electron	Off On	0.281	0.366	0.291	20.666
			1	Stereo	Positron	Off On	0.281	0.363	0.282	21.477
			2	Axial	Electron	Off On	0.277	0.365	0.285	21.249
			3	Axial	Positron	Off On	0.279	0.377	0.956	20.274
L6t	8	Off On	0	Axial	Electron	Off On	0.281	0.400	0.775	21.943
			1	Axial	Positron	Off On	0.280	0.368	0.841	21.897
			2	Stereo	Electron	Off On	0.279	0.370	0.300	21.261
			3	Stereo	Positron	Off On	0.282	0.518	0.492	21.880
L6b	9	Off On	0	Stereo	Electron	Off On	0.279	0.375	0.823	20.977
			1	Stereo	Positron	Off On	0.281	0.374	0.780	21.012
			2	Axial	Electron	Off On	0.281	0.364	0.295	22.691
			3	Axial	Positron	Off On	0.288	0.374	0.294	19.771