Upgraded SVT Survey

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Stanford/SLAC
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Overview

1. Geometry code investigation
2. Coordinate systems in the SVT
3. hps-align/survey
4. Future plans

Geometry investigation

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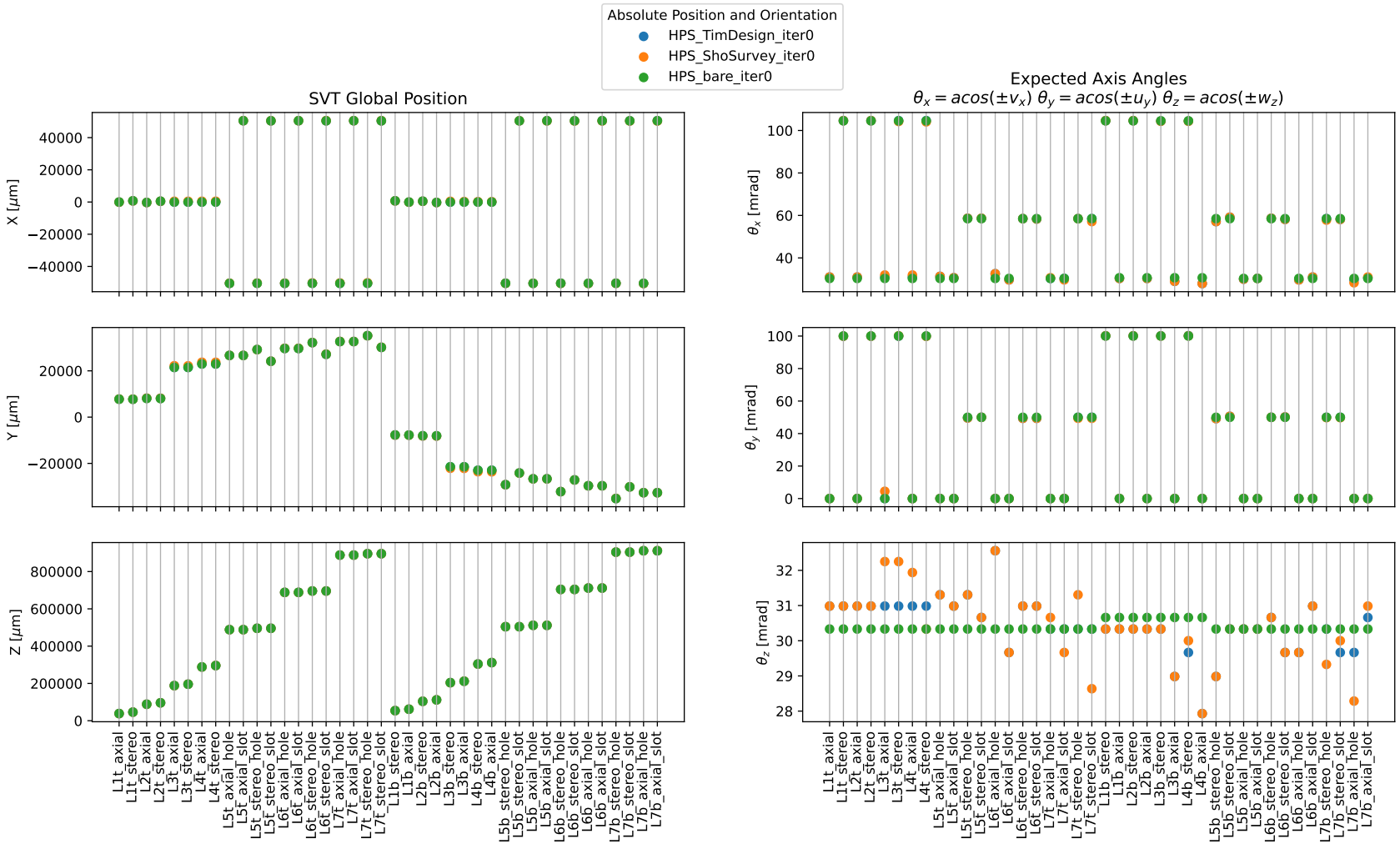
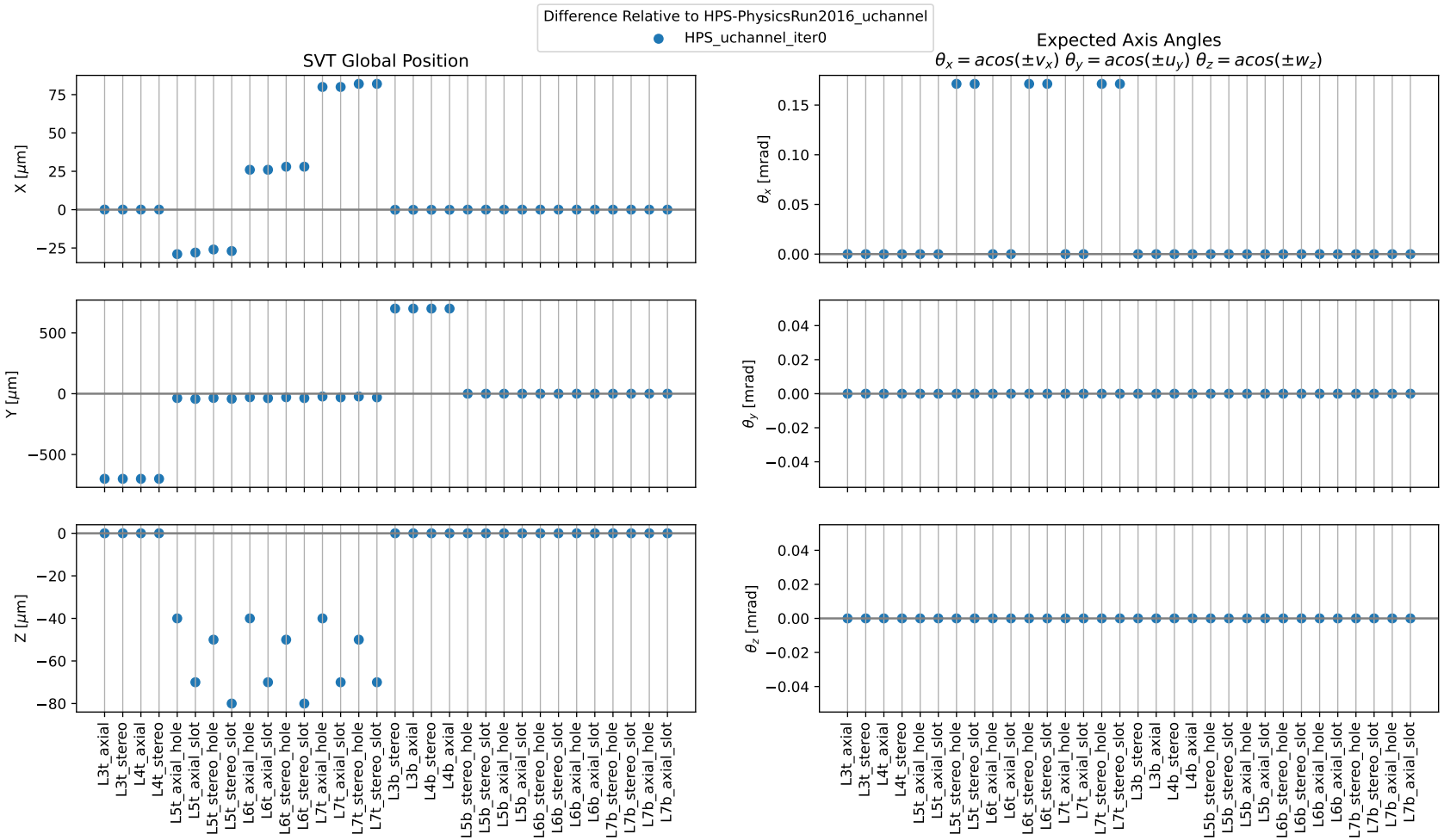
- Look at global positions and orientations of sensors to confirm that they make sense
- Compare different combinations of survey numbers using the two different geometry classes (2016 vs 2019)
  - Same survey numbers should yield same detector
  - Back sensors positions should be about the same for 2016 and 2019
- The following plots are generated using a tool that Tom developed for hps-align

Global position in SVT frame



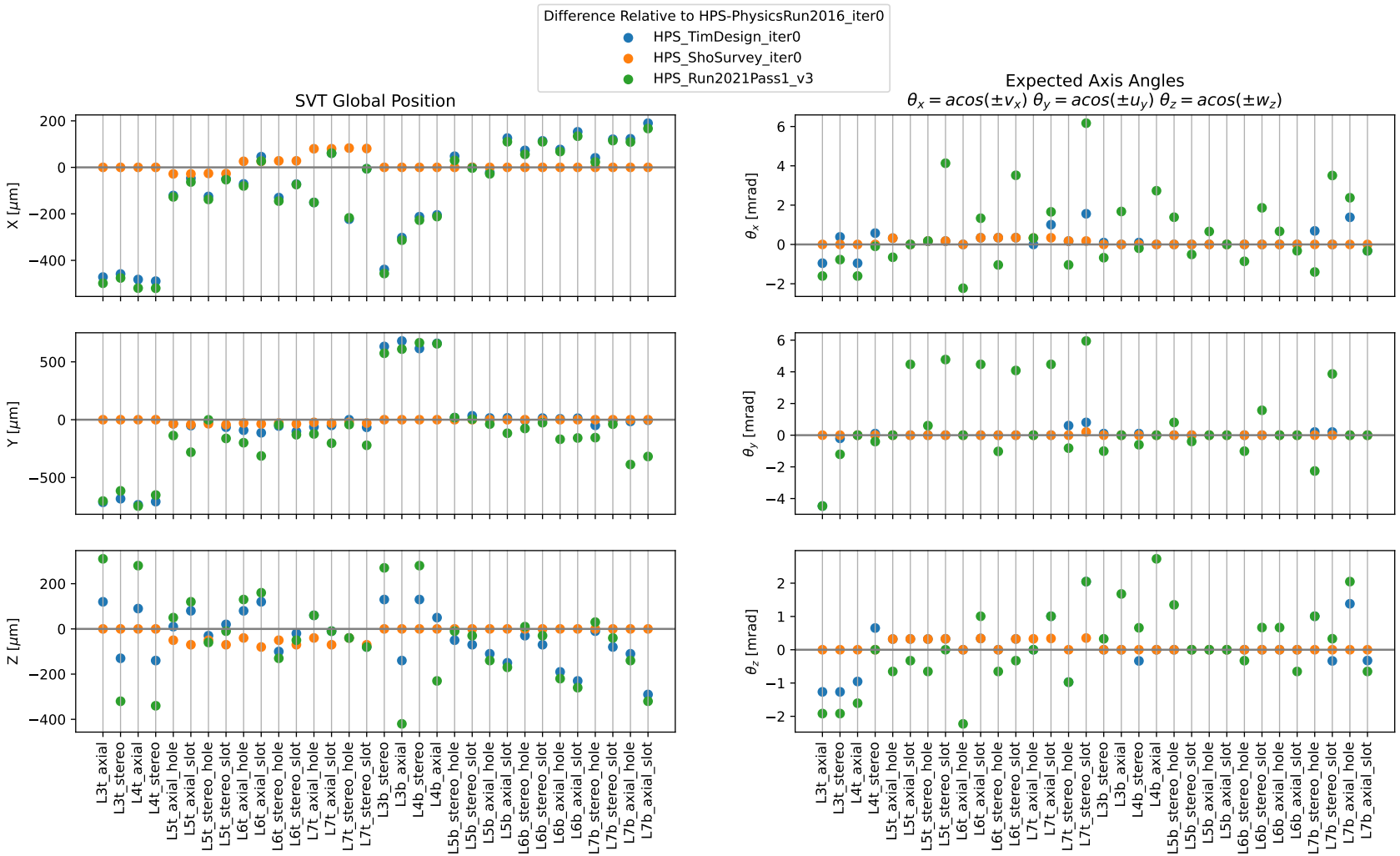
- Global positions of sensors for different SVT versions

Uchannel survey numbers only



- Top back shifted, 700 µm Tu in L3 and L4

Comparing pre-alignment and design



- Only apply survey constants

Summary geometry investigation

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- Plotting tools very helpful for visualization of different geometries
  - Can be found in hps-align
- 700 µm shift in u for L3, L4
  - Shift is not present only when full set of survey data is used
  - Seems to be hard-coded value in 2019 detector classes
- Top back survey constants not applied correctly
  - There seems to be a difference between applying a survey to 2016 and 2019 detectors.
  - Points to bug in detector builder class in hps-java

Structure of hps-java geometry code

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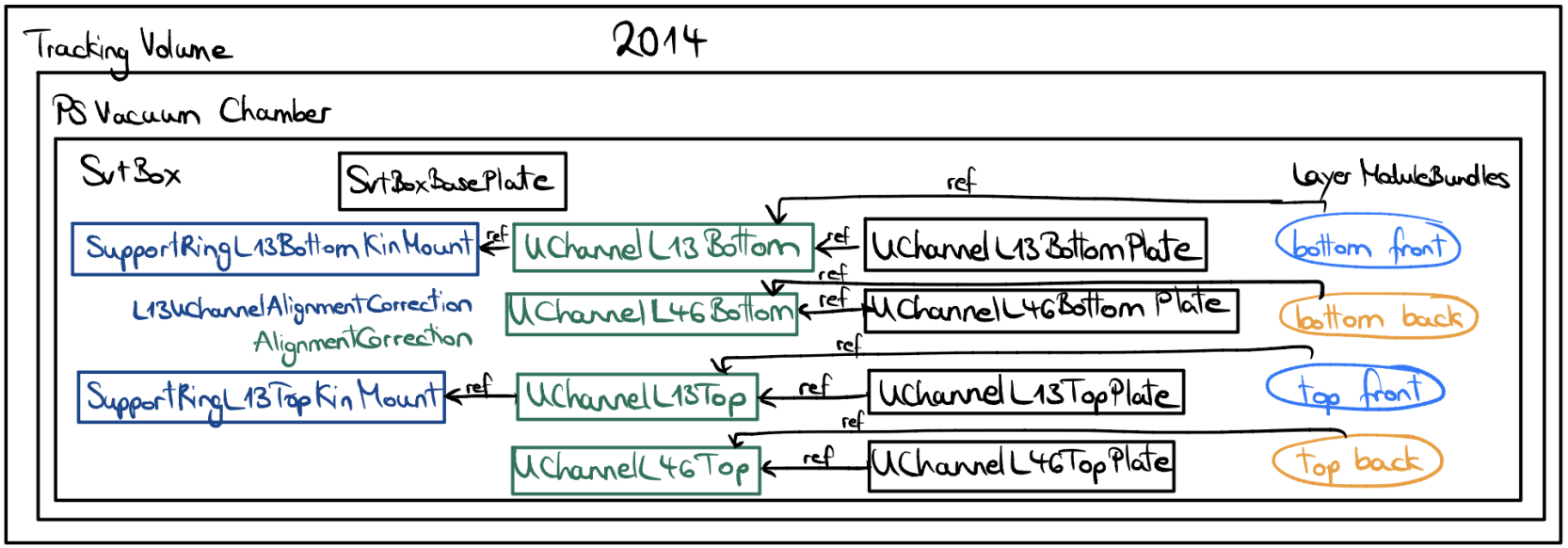
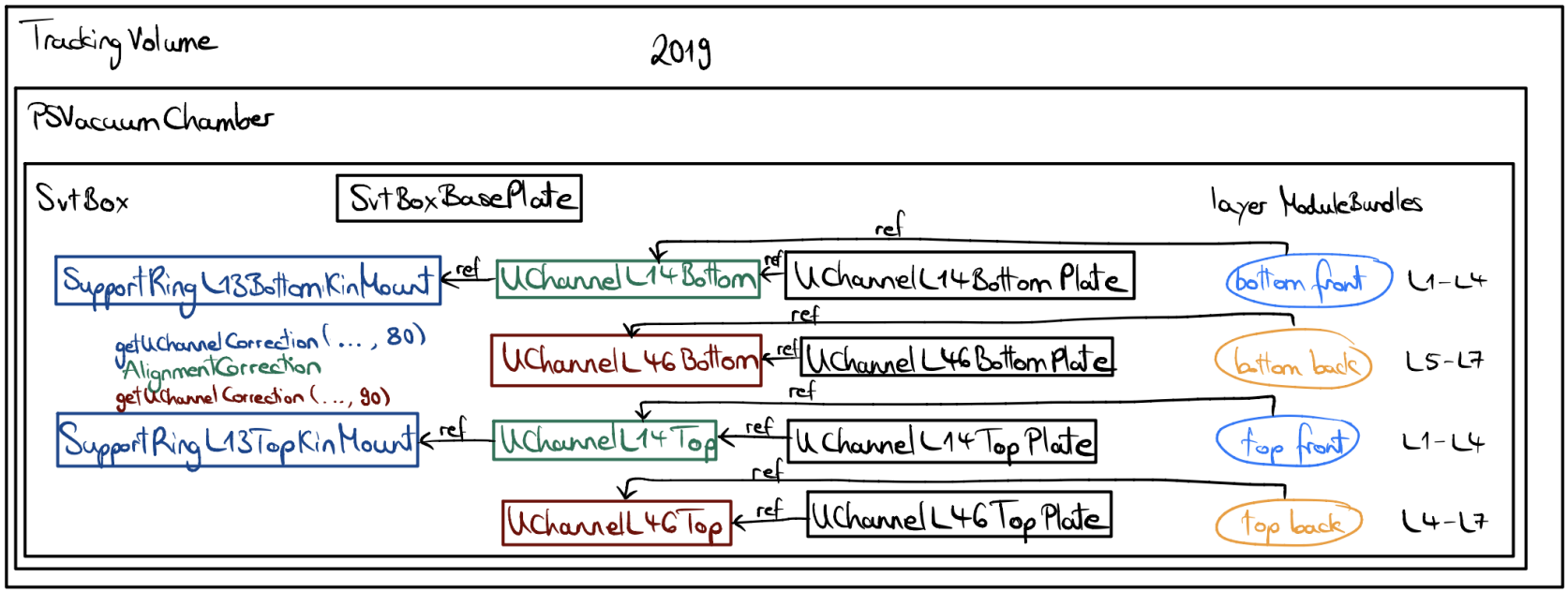
- Relevant code in hps-java/detector-model/src/main/java/org/lcsim/geometry/compact /converter
  - HPSTrackerGeometryDefinition classes generate SVT geometry representation from compact.xml
  - Mother and daughter SurveyVolumes with same logical structure as physical SVT
  - Structure allows AlignmentCorrections for (front and back) uchannel, modules, and individual sensors

Structure of hps-java geometry code



- HPSTracker2014GeometryDefinition: used for 2016 detector
- Two types of sensors and modules that bundle sensors

Structure of hps-java geometry code



- HPSTracker2019GeometryDefinition: used for 2019 and 2021 detectors
- Three types of sensors and modules that bundle sensors

Structure of hps-java geometry code

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- Relevant code in hps-java/detector-model/src/main/java/org/lcsim/geometry/compact /converter
  - HPSTrackerGeometryDefinition classes generate SVT geometry representation from compact.xml
  - Mother and daughter SurveyVolumes with same logical structure as physical SVT
  - Structure allows AlignmentCorrections for (front and back) uchannel, modules, and individual sensors
- Bug fixes already merged:
  - Remove hard-coded 700 µm shift in HPSTracker2019GeometryDefinition
  - Typo in name of AlignmentCorrection for top back uchannel
- This changes existing detectors:
  - Open PR: modified detectors to preserve 'original' state
  - Important exception HPS_Nominal_iter0: geometry output by code with no survey or alignment

Motivation for survey study

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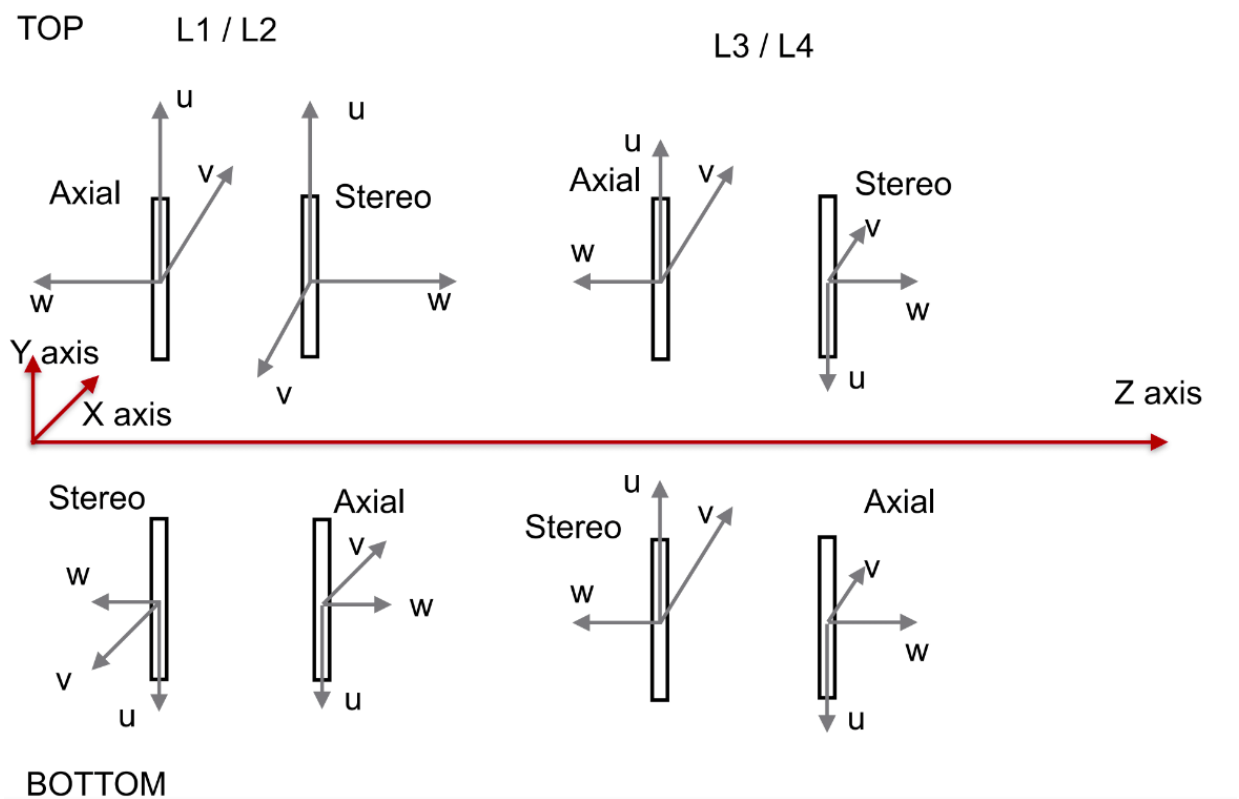
- Matt Solt's 2019 survey data is not used at the moment
  - OGP measurement data has to be transformed to correct coordinate system to be used in compact
  - Coordinate transformations Matt used are not the same as for Sho's 2016 survey
- Need a robust way to transform measured points to correct coordinate systems
  - Create a framework for handling SVT survey data and coordinate transformations that can be reused for future surveys
  - Documentation should include necessary measurements and how they are transformed to uchannel coords
  - All functions should be (unit) tested to ensure that they're working as intended

Overview of relevant coordinate systems

- Sensor frames – defined by strips and sensor normal



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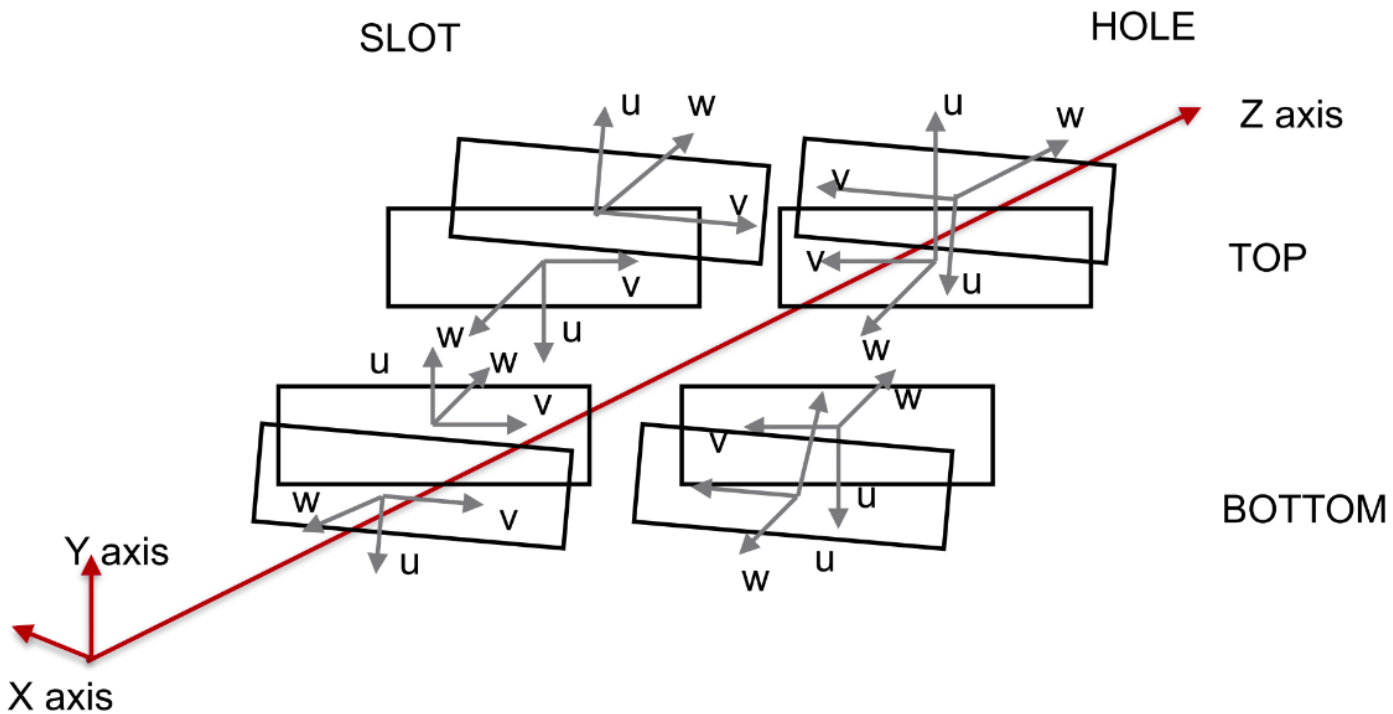
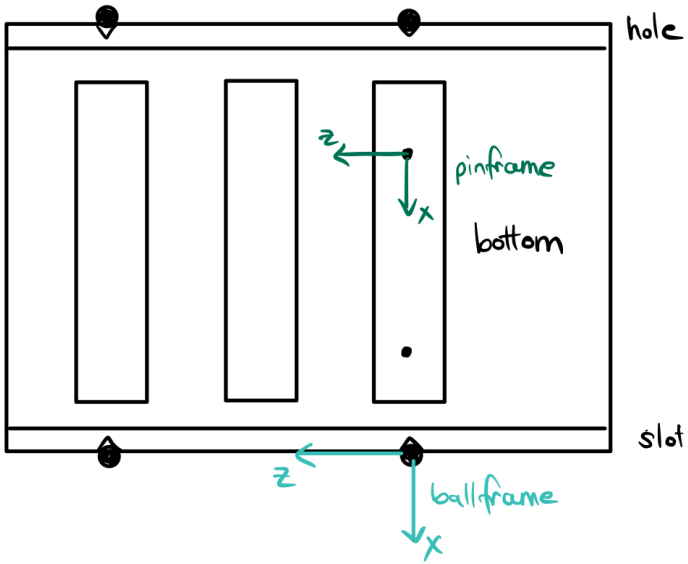
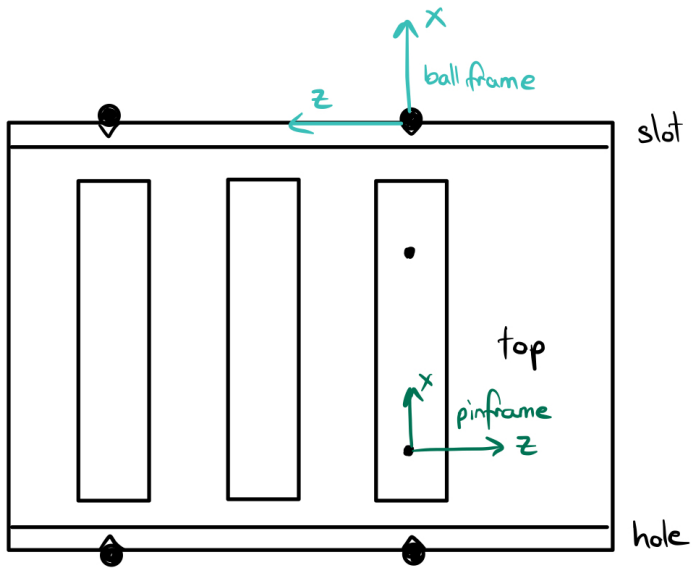


Overview of relevant coordinate systems

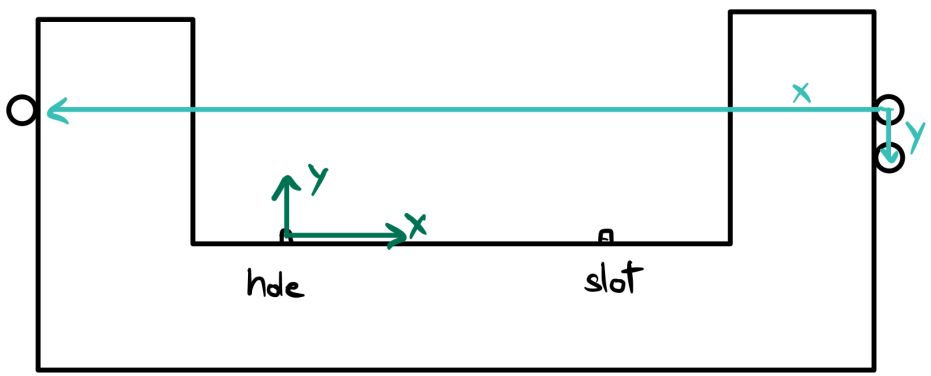
- Sensor frames – defined by strips and sensor normal
- Uchannel ballframe and pinframe





Overview of relevant coordinate systems

- Sensor frames – defined by strips and sensor normal
- Uchannel ballframe and pinframe
- Fixture ballframe and pinframe



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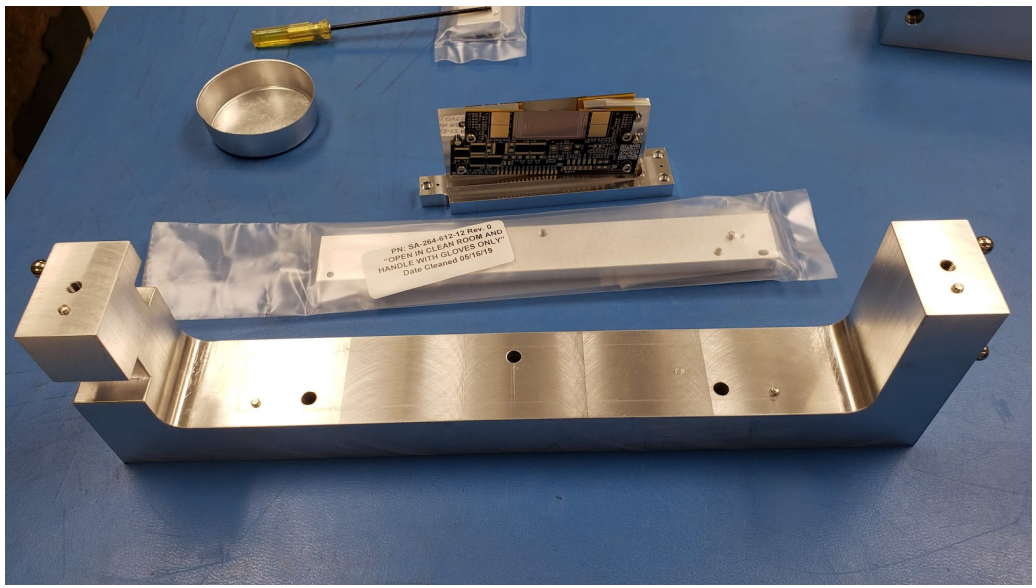
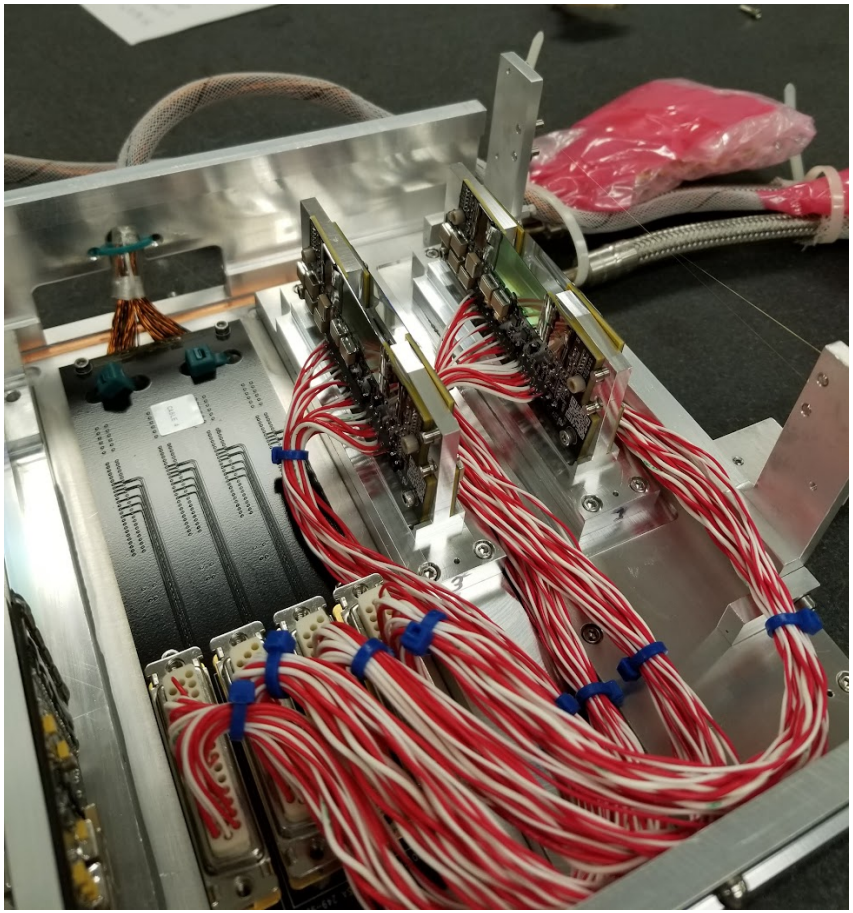


Uchannel



Necessary measurements and transformations

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- Measure sensors in fixture
  - Transform measurement to fixture ballframe
  - For L1, L2: need measurement with transition piece
- Empty fixture: measure position of pins
  - Transform measurement to fixture ballframe
  - Combine with sensor in fixture ballframe measurement to get sensor position in pinframe
- Empty uchannel: measure position of pins
  - Transform measurement to uchannel ballframe
  - Combine with sensor position in pinframe to get sensor position in uchannel ballframe

hps-align/survey

- New module hps-align/survey
  - Built to work with Tom's underlying python structure
  - Contains coordinate transformations and tests thereof
  - Currently work in progress
- General structure:
  - _parser: reads measurement data from OGP output text file
  - _utils: utility functions – find normal vectors, make basis, ...
  - _uchannel: transformations between uchannel _pinframe and _ballframe
  - _fixture: generates fixture ballframe and pinframe
  - _sensors: measurement of sensor in fixture

Preliminary results – pin basis in uchannel

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- Matt0: results from Matt Solt's original code
- Matt: results from Matt Solt's code with some bug fixes

Sho	-95.2594	51.3976	-9.5359
Matt0	-0.0180	26.2182	-38.3293
Matt	95.2598	51.3949	-9.5212
Sarah	-95.2635	51.3832	-9.5551

Top L1 pin basis in U-channel fiducial frame

Sho	-95.2795	-51.4573	9.5403
Matt0	0.0296	-26.2017	-38.2223
Matt	95.2710	51.4608	-9.5718
Sarah	-95.2683	-51.4648	9.5839

Bottom L1 pin basis in U-channel fiducial frame

Preliminary results – pin basis in uchannel

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Sho	-95.2519	52.9069	90.4129
Matt0	90.3949	95.2783	-48.1190
Matt	95.2062	52.8827	90.4765
Sarah	-95.2805	52.8964	90.3917

Top L2 pin basis in U-channel fiducial frame

Sho	-95.2388	-52.9364	109.5866
Matt0	109.5947	-95.2290	-48.3009
Matt	95.2400	52.9167	-109.5932
Sarah	-95.1902	-52.9322	109.6281

Bottom L2 pin basis in U-channel fiducial frame

Preliminary results – pin basis in uchannel

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Sho	-95.2881	54.3996	190.4827
Matt0	190.4663	95.3327	-50.0550
Matt	95.2064	54.3859	190.5334
Sarah	-95.3340	54.4062	190.4639

Top L3 pin basis in U-channel fiducial frame

Sho	-95.2926	-54.4158	209.5887
Matt0	209.6006	-95.2746	-49.8707
Matt	95.2981	54.5002	-209.5724
Sarah	-95.2003	-54.4160	209.6371

Bottom L3 pin basis in U-channel fiducial frame

Preliminary results with bug fix

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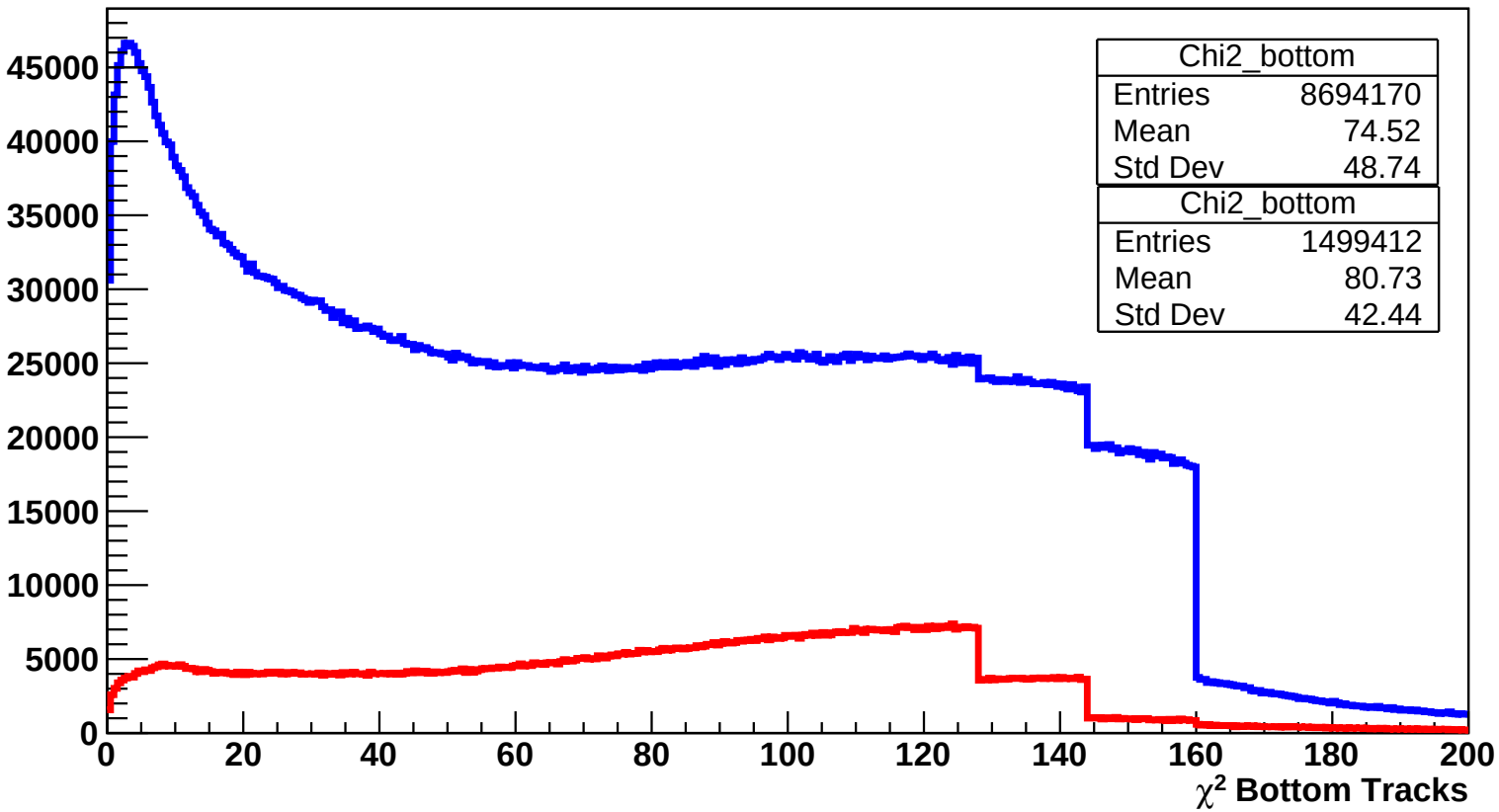
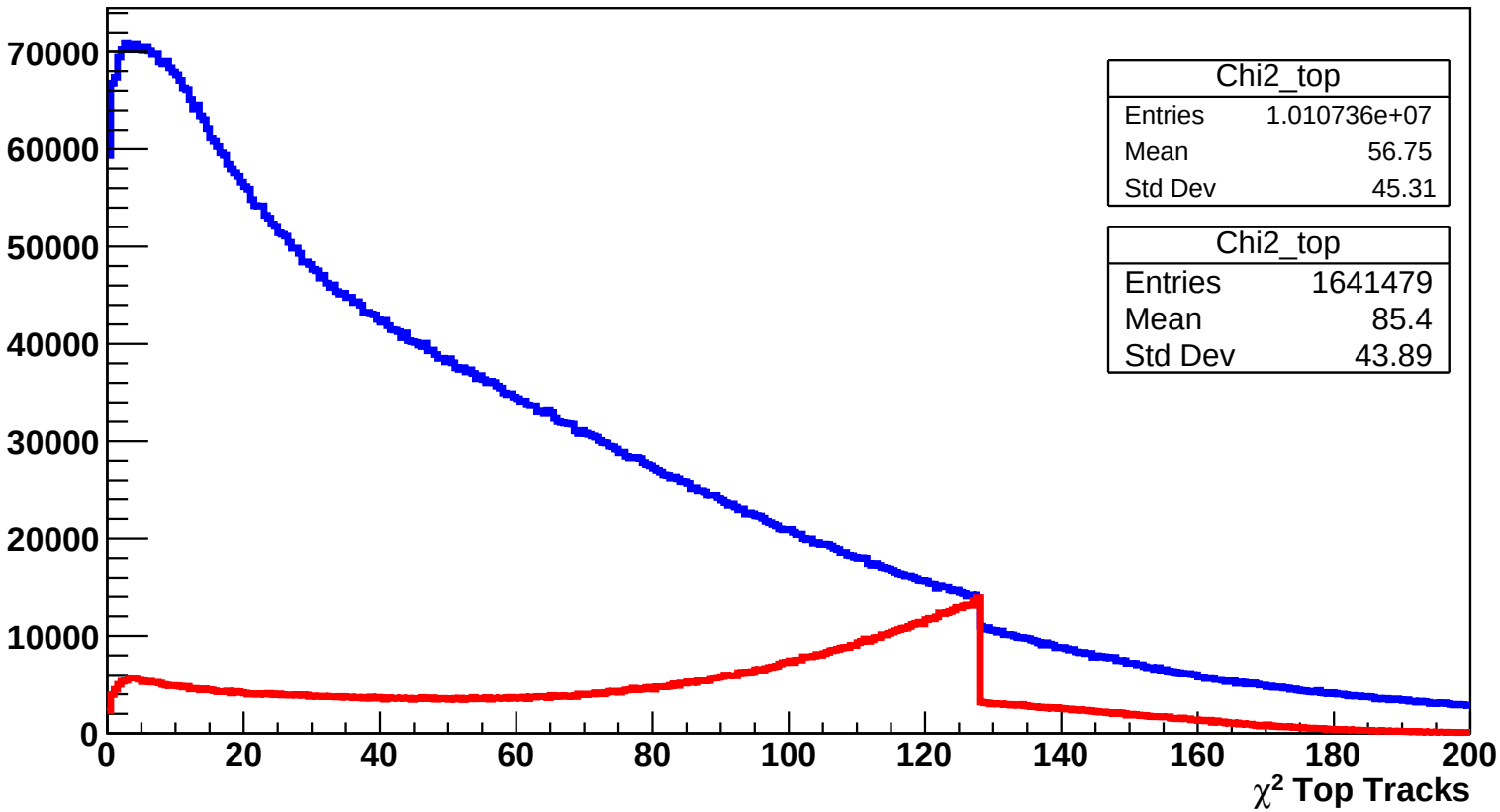
- Run reconstruction with and without 700 µm shims in L3, L4
- Reconstruction with L1 and L2 hits removed
- Requiring at least 8 hits on track
  - Top only has 8 layer hits because layer 7 is missing
- Looking at alignment monitoring plots

χ^2 distribution – bottom



- blue: with shims; red: without shims

χ^2 distribution – top



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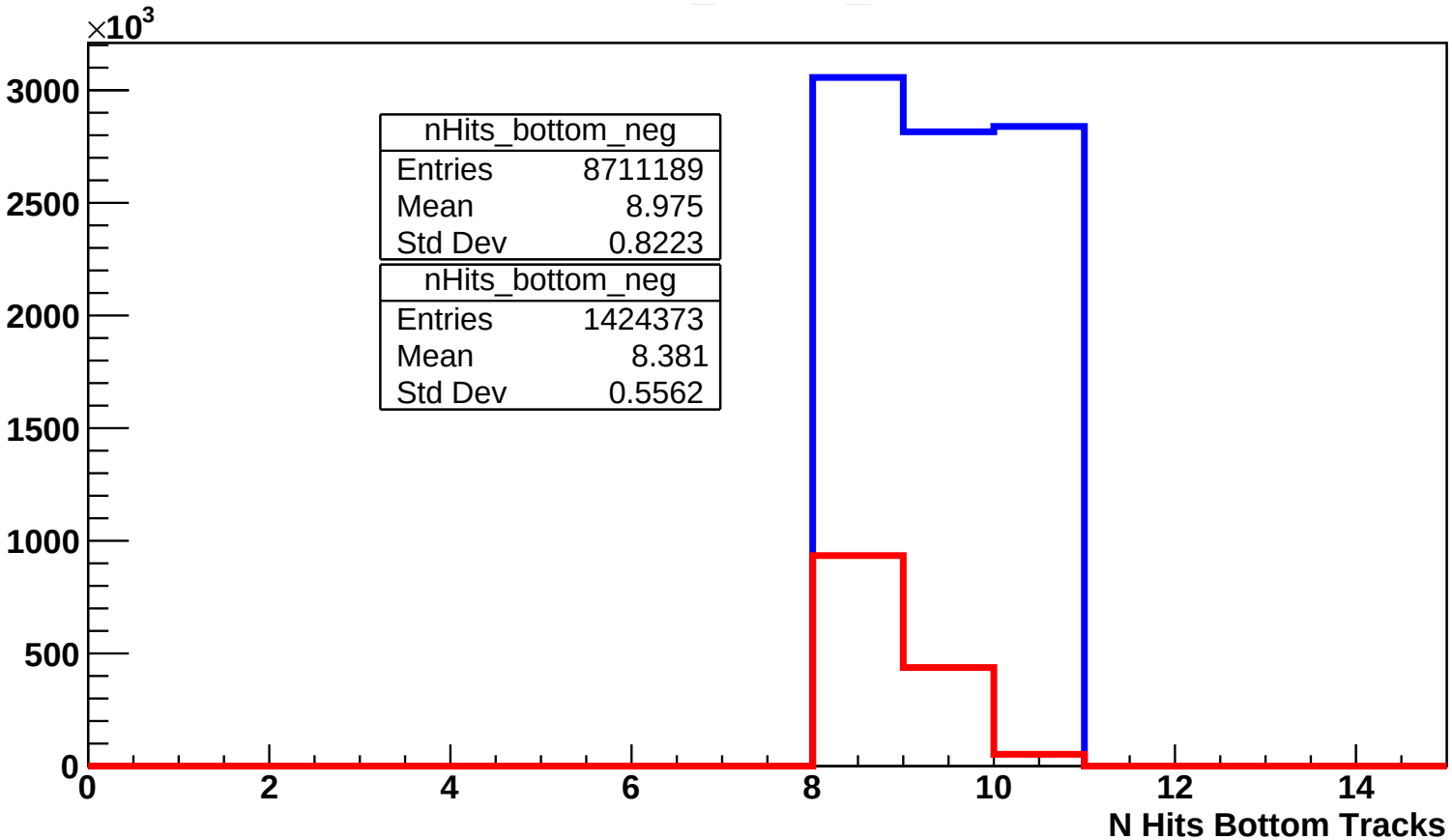
nHits distribution – bottom, electrons



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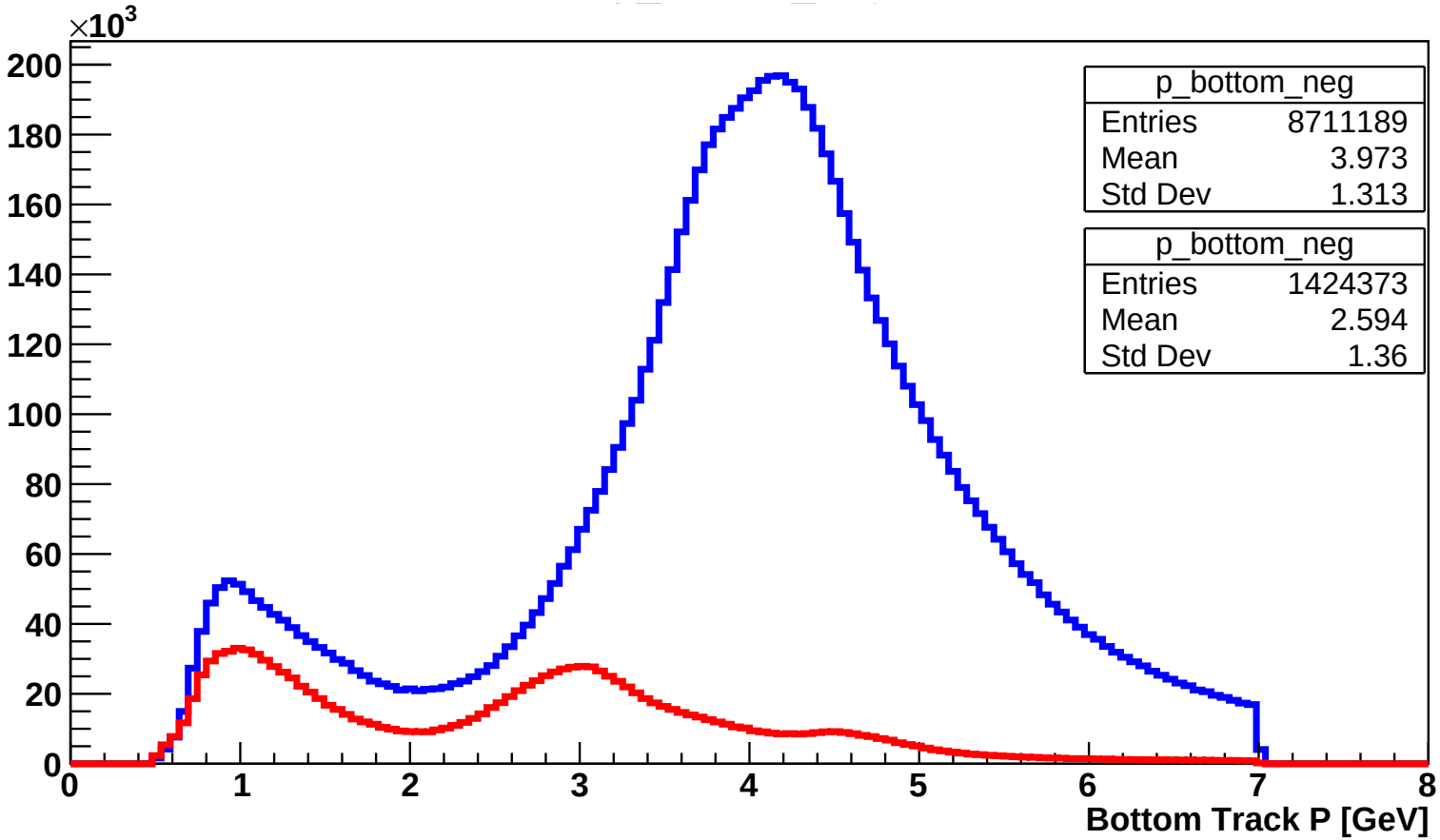
Momentum distribution – bottom, electrons



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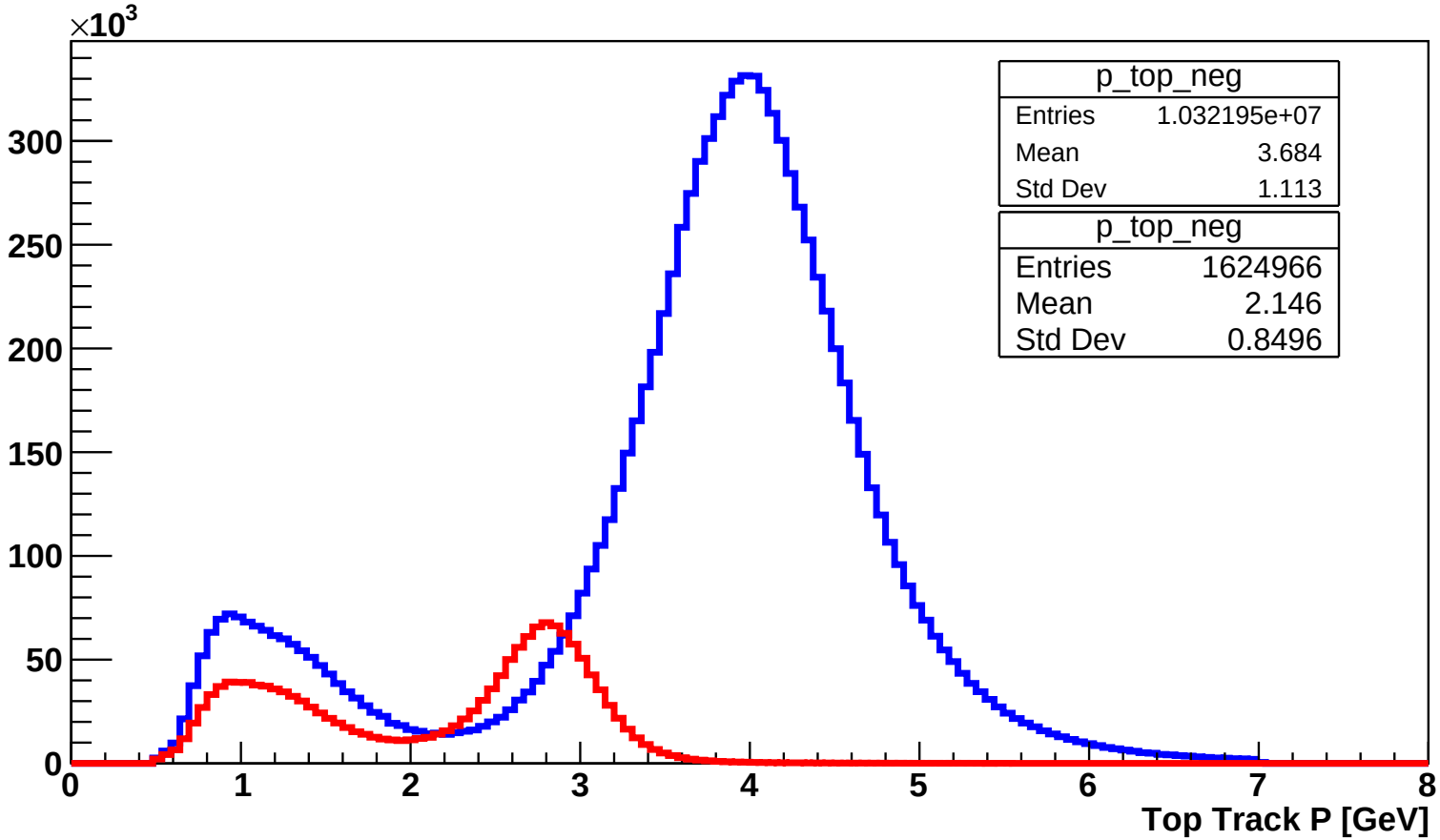
Momentum distribution – top, electrons



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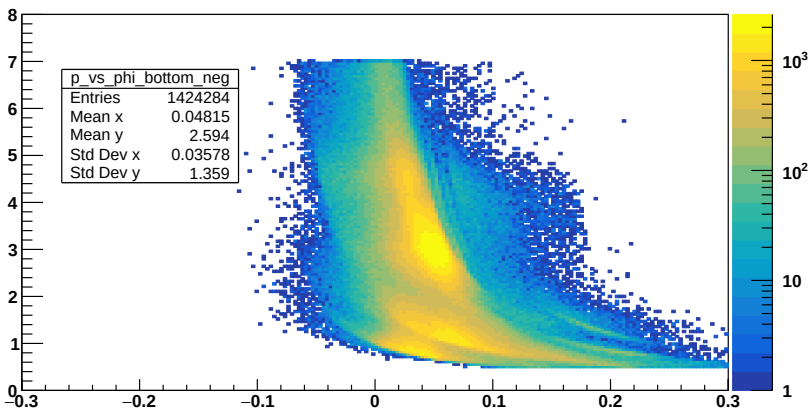
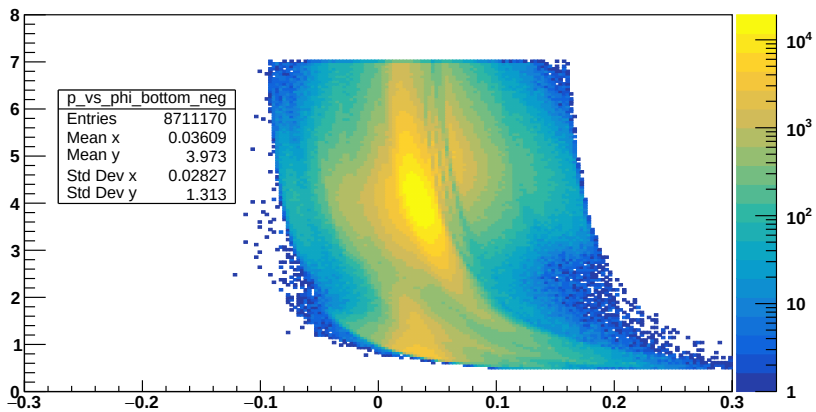
p vs ϕ – bottom, electrons



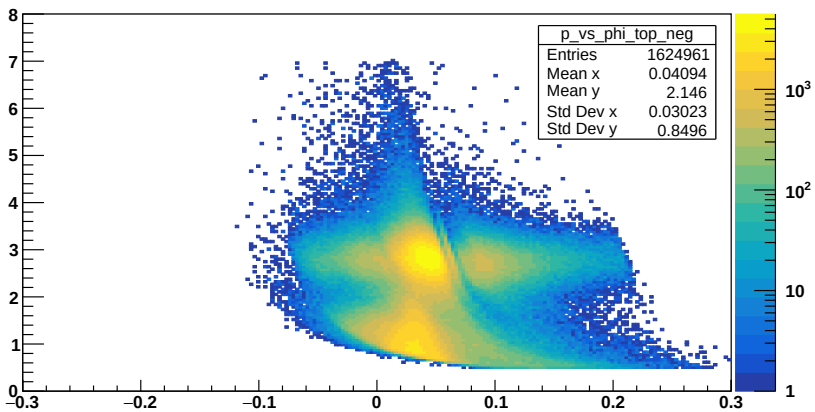
without shims



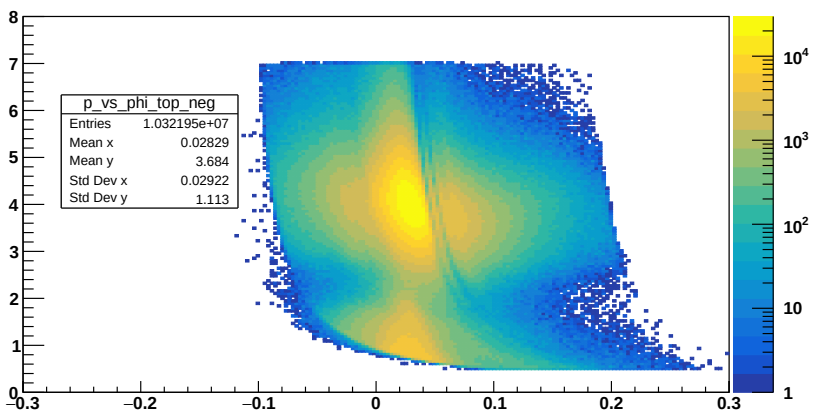
with shims

- Lose relatively more tracks on the positron side compared to the electron side

p vs ϕ – top, electrons



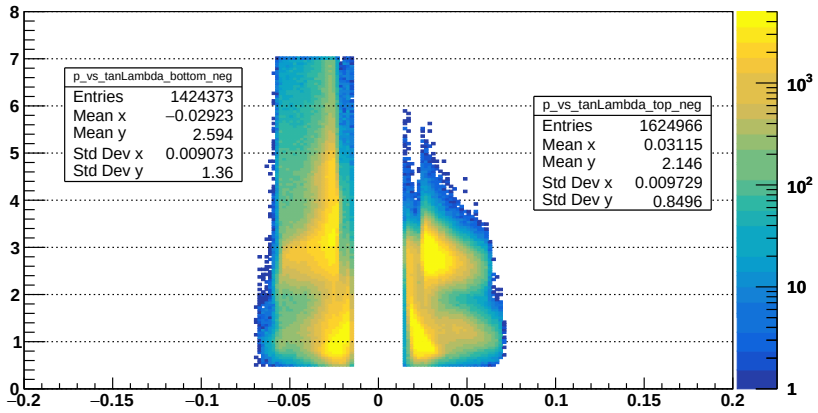
without shims



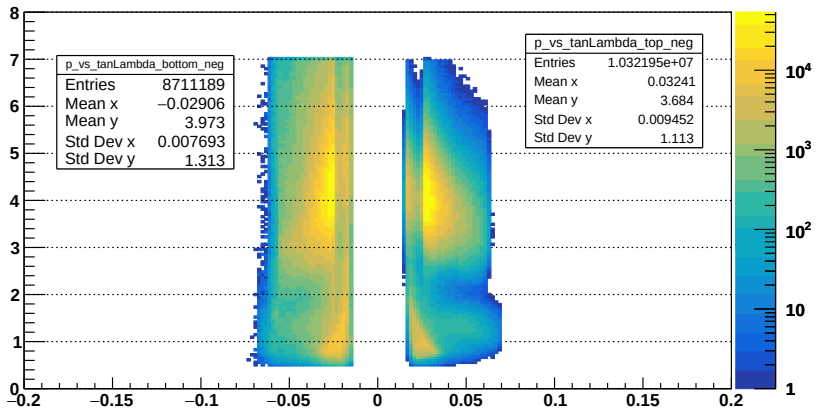
with shims

- Shape of distribution without shims looks nice but is shifted in momentum

p vs tanλ – electrons



without shims



with shims

- Flatter distribution without shims
- Lose relatively more tracks on the positron side compared to the electron side

Summary – results with bug fix

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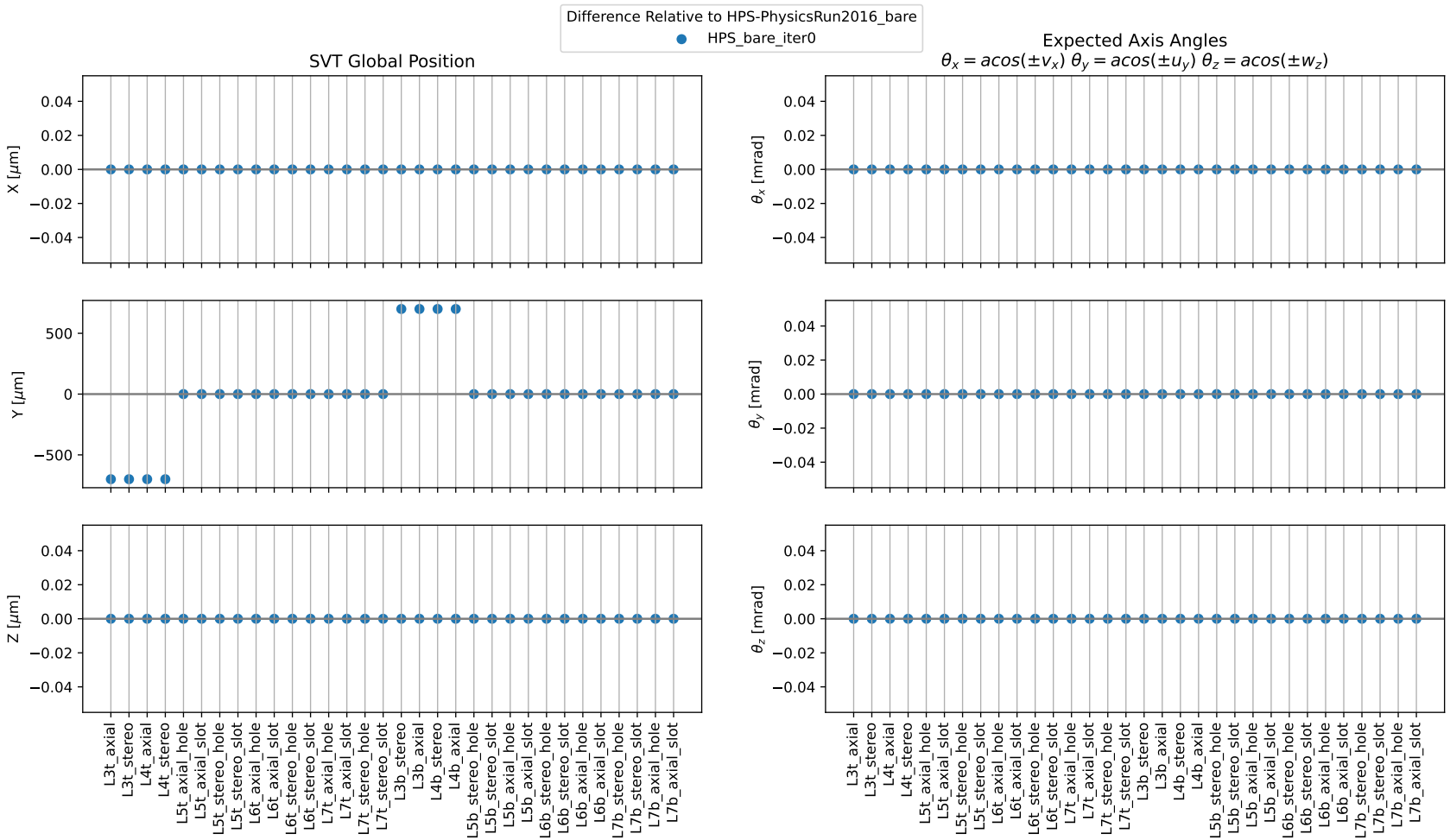
- Top vs bottom: for 2D plots change in shape is related to having more hits on track in the bottom
- p vs tanλ:
  - Flatter distribution without shims
  - Lower rate at lower phi are accidentals, fee trigger in tanλ edge is higher than the SVT acceptance
- p vs *phi*: lose relatively more tracks on the positron side compared to the electron side

Outlook

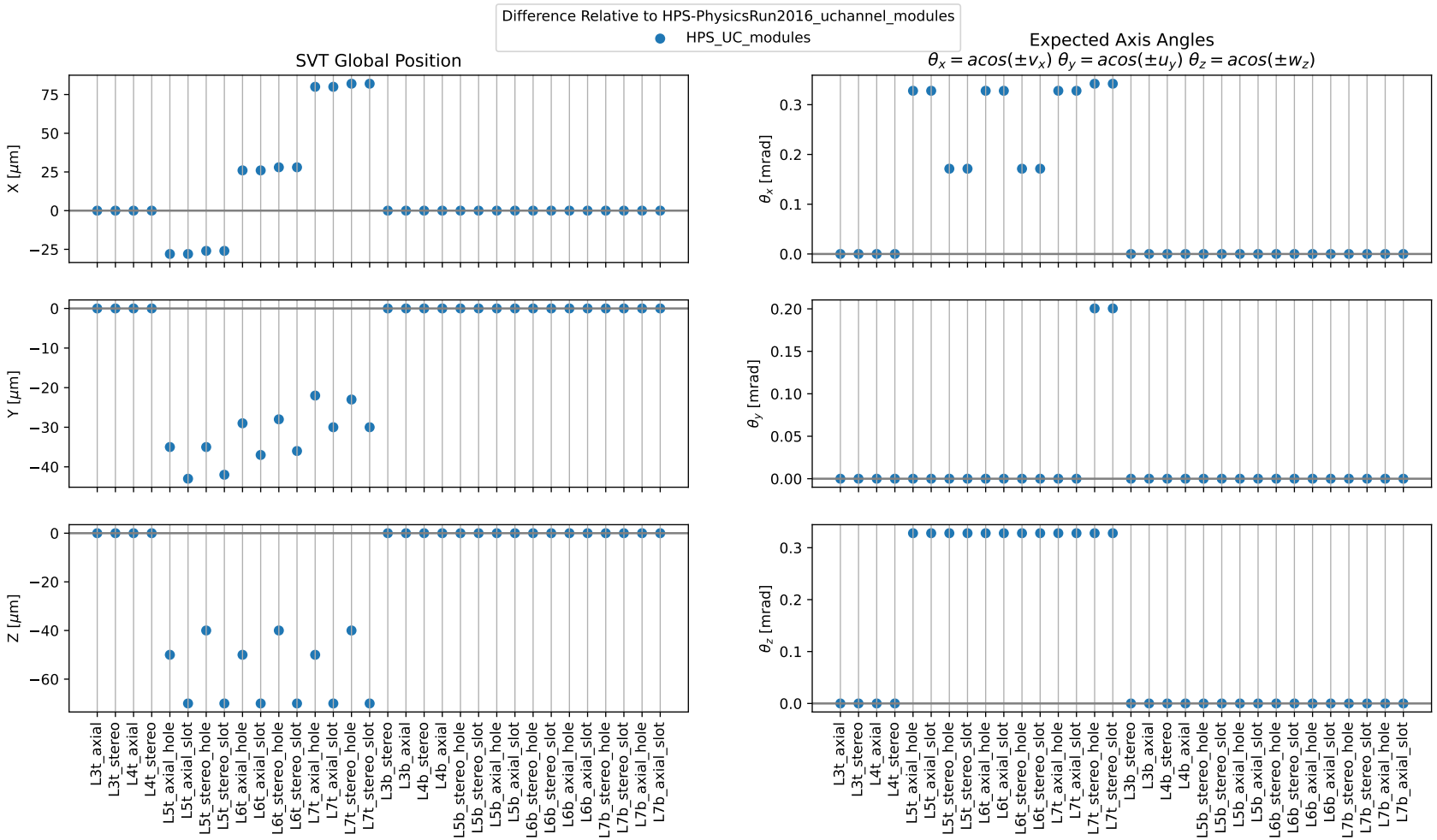
- Finish evaluating and integrating Matt Solt's survey data for the 2019 detector
  - Success for getting pin position in uchannel frame
  - Next: validate fixture to uchannel transformation pipeline
  - Goal: get L1 and L2 survey numbers into a compact
- Investigation of shim thickness
  - Scan of the shim thicknesses from 650 µm to 900 µm in 50 µm steps
  - Try using a momentum constraint and making the shim thickness a free parameter, excluding L1 and L2 hits

Remove all survey and alignment constants



- 700 µm shift in L3 and L4

Uchannel and module survey numbers only



- Shift gone, systematic effect in top back