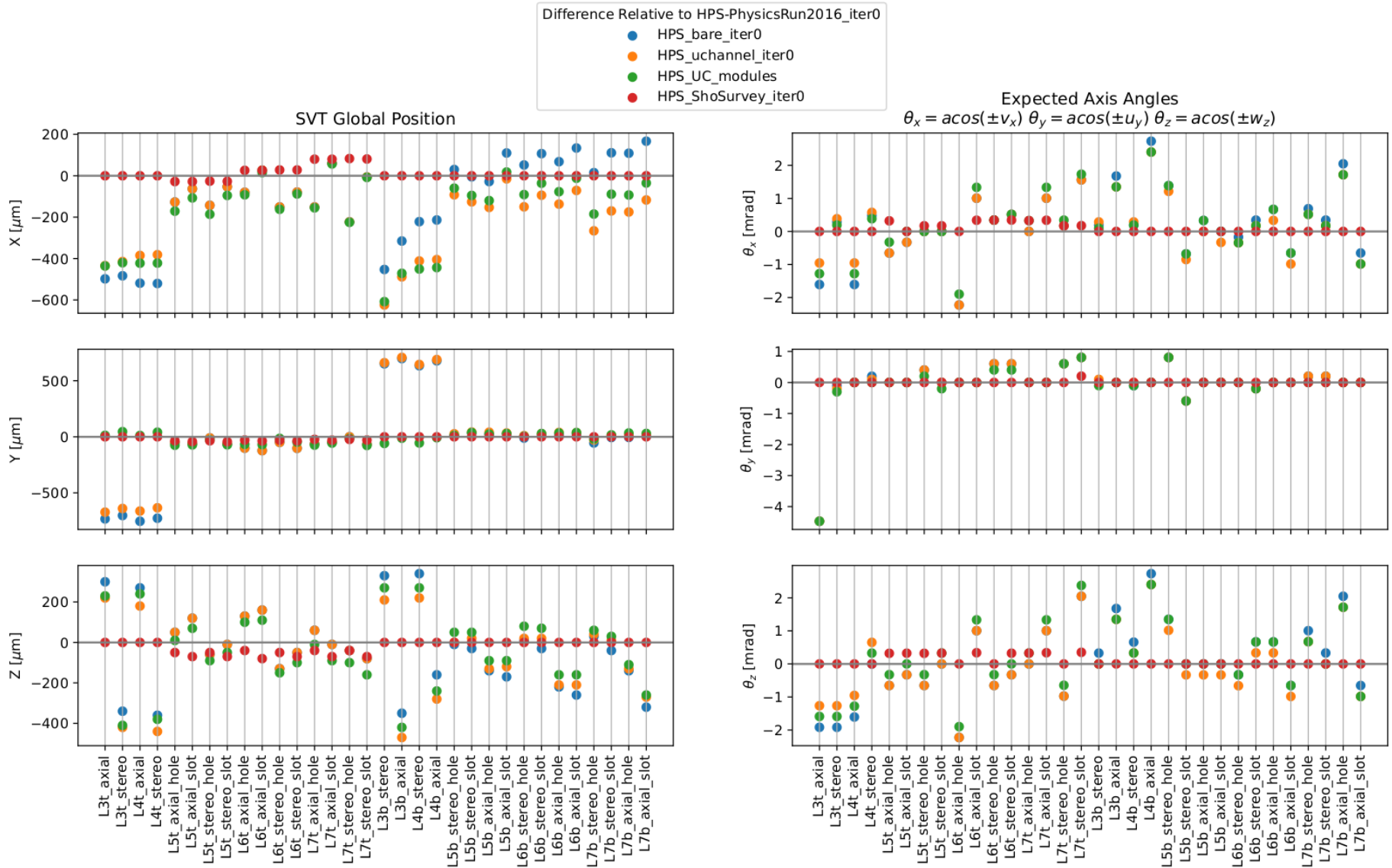


Squashing Bugs and Peeking at 2019 Survey

Cameron Bravo (SLAC)
Sarah Gaiser (Stanford)

- Progressed on treatment after diagnosis **shown last week**
- **PR opened** by Sarah, which fixes bug which eliminates discrepancies observed
- PF has already reviewed the bug found by Sarah and agrees that it is clearly a bug
- Looking into **2019 survey data and analysis from Matt Solt**
- First goal is to prepare module level survey data to account for shims used in layers 3 and 4
- Issues seen in results.txt file
- Progressed in debugging code that produces that file

Comparing to 2016 before fixing bug

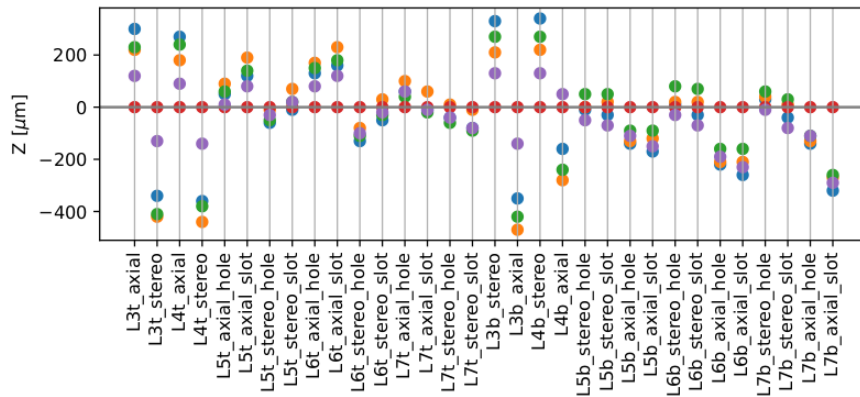
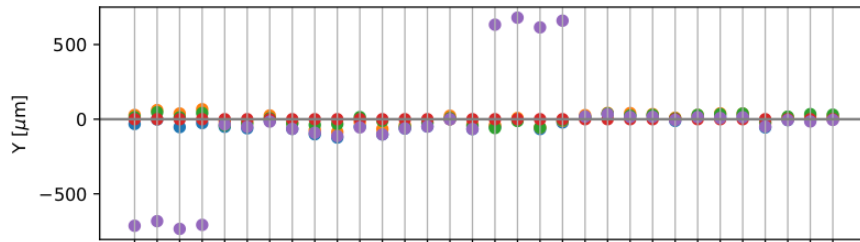
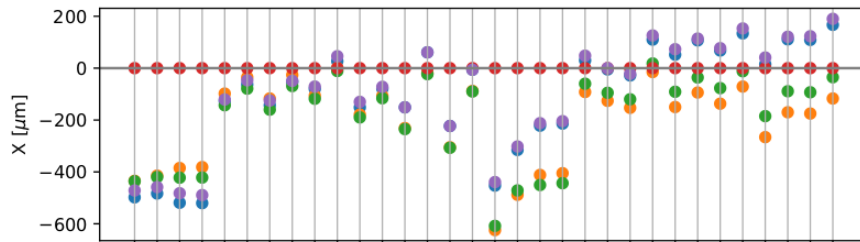


Comparing to 2016 after bug fix

Difference Relative to HPS-PhysicsRun2016_iter0

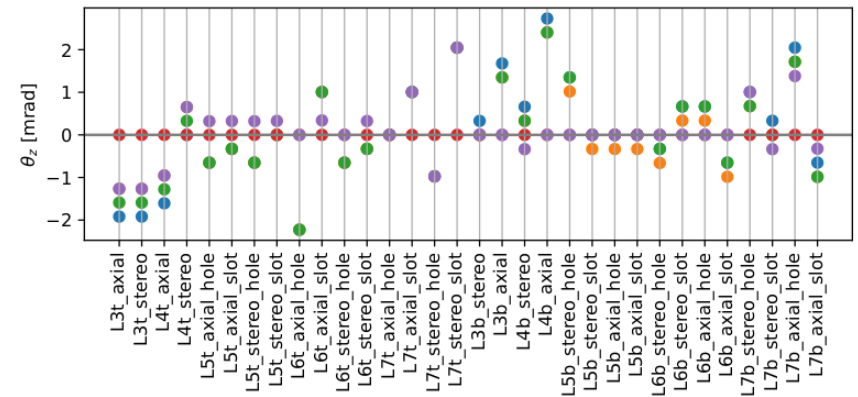
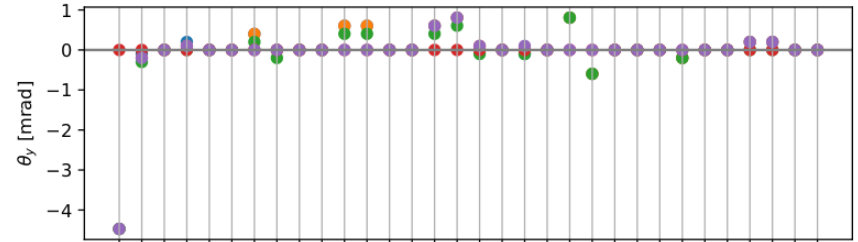
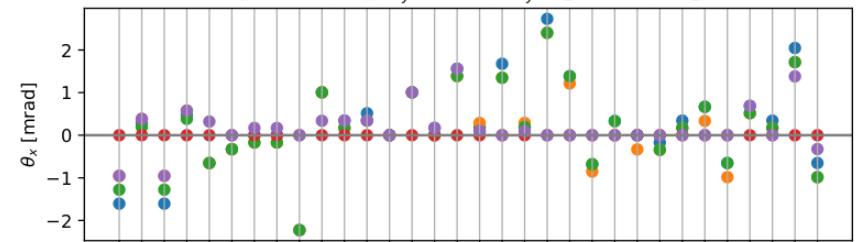
- HPS_bare_iter0
- HPS_uchannel_iter0
- HPS_UC_modules
- HPS_ShoSurvey_iter0
- HPS_TimDesign_iter0

SVT Global Position



Expected Axis Angles

$\theta_x = \text{acos}(\pm v_x)$ $\theta_y = \text{acos}(\pm u_y)$ $\theta_z = \text{acos}(\pm w_z)$



Digging into 2019 Survey

- Sensors in back uchannels of 2019 are the same as 2016 except for layer 7 facing the Ecal
- Code fixed so we can now use survey and alignment from 2016 to fix those sensors in alignment procedure when we get to doing that again
- Need new module level alignment for layers 3 and 4 to account for shims used in these layers
- Survey of empty uchannel taken by Matt Solt in 2019, data never made it into compact though
- Reviewing his results and code to get this survey data into compact for starting point of 2019 alignment

Digging into 2019 Survey

- L1 top in 2016 <origin x="-95.2594" y="51.3976" z="-9.5359" />
 - [-1.80365764e-02, 2.62181815e+01, -3.83293374e+01]
- L2 top in 2016 <origin x="-95.2519" y="52.9069" z="90.4129" />
 - [90.39487321, 95.27831373, -48.11895166]
- L3 top in 2016 <origin x="-95.2881" y="54.3996" z="190.4827" />
 - [190.46632481, 95.3326626 , -50.05499102]
- L1 bot in 2016 <origin x="-95.2795" y="-51.4573" z="9.5403" />
 - [2.96138717e-02, -2.62017431e+01, -3.82222726e+01]
- L2 bot in 2016 <origin x="-95.2388" y="-52.9364" z="109.5866" />
 - [109.5946775 , -95.22904279, -48.30089381]
- L3 bot in 2016 <origin x="-95.2926" y="-54.4158" z="209.5887" />
 - [209.60060705, -95.2746201 , -49.87065427]

Finding a Bug

- <https://github.com/mrsolt/HPS/blob/master/OGP/Measurements/Results.py#L269>
 - top_L1_pinbasis written to file, top_L1_pinbasis_ubasis is data in uchannel basis
 - Same bug for all modules in front uchannels
- L1 top <origin x="-95.2594" y="51.3976" z="-9.5359" />
 - [26.08833752, 38.4177797 , -0.06571338]
- L2 top <origin x="-95.2519" y="52.9069" z="90.4129" />
 - [95.01298776, 48.48791817, 90.47694528]
- L3 top <origin x="-95.2881" y="54.3996" z="190.4827" />
 - [95.17130438, 50.10862859, 190.5329046]
- X and Z look pretty reasonable (ignoring sign error)
 - Y is off by over 4 mm
 - Layer 1 is way off
- Similar situation in bottom

Hard-coded data?

- Data is hard coded into python, copy pasted from ogp data files
- https://github.com/mrsolt/HPS/blob/master/OGP/Measurements/Top_uchannel_measurements.py
- Cross-checked source of all hard-coded numbers with grep
- L1 data comes from different file than L2 and L3
- Changed hard-coded numbers to data from same file that L2 and L3 came from (uchannel_empty_top_1.rtf and uchannel_empty_bottom_1.rtf)
- After this fix, situation in L1 is similar to L2 and L3
- Next looked into ~4 mm discrepancy in Y (for all 6 modules)

Another Bug Found

- Followed the trail of how module level survey numbers are calculated
- Several utilities functions used in calculations
- https://github.com/mrsolt/HPS/blob/master/OGP/Measurements/AI_utils.py

```
def project_point_to_plane(point,plane_point,normal):  
    t = (normal[0]*(point[0]-plane_point[0])+normal[1]*(point[1]-plane_point[1])  
+normal[2]*(point[2]-plane_point[2]))/(normal[0]**2+normal[1]**2+normal[2]**2)  
    newpoint = np.array([normal[0]*t+point[0],normal[1]*t+point[1],normal[2]*t+point[2]])  
    return newpoint
```

- newpoint has a sign error, should subtract $t \cdot \text{normal}$, not add
- Fixed this bug and reran Results.py

Survey Data after Bugs Fixed

- L1 top <origin x="-95.2594" y="51.3976" z="-9.5359" />
 - [95.26046662, 51.39564762, -9.51851844]
- L2 top <origin x="-95.2519" y="52.9069" z="90.4129" />
 - [95.20589964, 52.8849686, 90.47694528]
- L3 top <origin x="-95.2881" y="54.3996" z="190.4827" />
 - [95.20487904, 54.39062631, 190.5329046]
- L1 bot <origin x="-95.2795" y="-51.4573" z="9.5403" />
 - [95.27097981, 51.46187495, -9.57081759]
- L2 bot <origin x="-95.2388" y="-52.9364" z="109.5866" />
 - [95.23986652, 52.91635215, -109.59259304]
- L3 bot <origin x="-95.2926" y="-54.4158" z="209.5887" />
 - [95.29808244, 54.5026018, -209.57016535]

Discussion of Survey Software

- Data hard-coded into software
 - Some of the numbers clearly came from wrong place
 - Data from multiple measurement cycles averaged in OGP coordinates
- Multiple utility functions found to be wrong
 - Projecting point to a plane
 - `make_basis` returns identity always
 - `UchannelToJlabVec` just returns input vector
- Wrong coordinate system used for module pinbases
- We feel it is a better use of time to write this software from scratch rather than fixing it
 - Being poorly commented makes it difficult to diagnose
 - Being poorly factorized makes it difficult to work on

Discussion and Next Steps

- Y numbers in L1 now match after fixing multiple issues
 - Validates code and data used for module pin-frame calculations
 - Comparing to survey data from Sho/Pelle
- Y numbers in L2 and L3 also match within OGP error
 - This shouldn't be the case, shims should be in
 - There are two more files of empty uchannel survey data, Sarah checked them both and they also don't have shims
- After L2 and L3 survey with shims ironed out next step will be to move focus to slim edge modules/sensors
- Long term plan after following through on survey data is to restart alignment from surveyed starting point