Update on the LBNL Pixel Alignment

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Outline

- Pixel Standalone Alignment Strategies
- What's New
- Results and Comparisons
- Conclusion

Pixel Standalone Alignment Strategies

- We use only B-field off data.

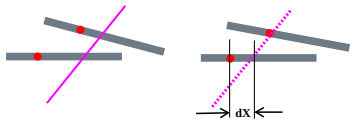
- Pixel Standalone Alignment (PSA)
  - Use only pixel barrel for tracking
  - The constants are simply derived from averages, histograms, and scatter plots.
  - The barrel is aligned in 3 steps: layer, stave, and module.
  - The stave bow alignment is parametrized using a normal parabolic parameters.

- Alternative Procedure using overlaps
  - Use the default tracking and same layer alignment from GX2.7
  - Overlaps are very powerful for neighboring modules, but challenging in cosmics where only top-bottom parts of the detector are well illuminated.
  - Have to rely on some track residual minimization technique to align the modules in different overlaps regions.

What's New ?

- **PSA is stable since last update in April, rededrived the L3 constants starting from GX2.7 so that the constants can be compared directly.**
- **There are significant changes and cross checks in the overlap procedure, but the results seem remain the same.**
- **Better understanding what actually measured misalignment from overlaps.**
- **Validation with Monte Carlo**
- **Comparisons with GX2 pixel only constants**

Alignment with Overlap Residuals



- **Overlap is considered for a track passing through two neighboring modules in the same layer and in the same eta ring.**

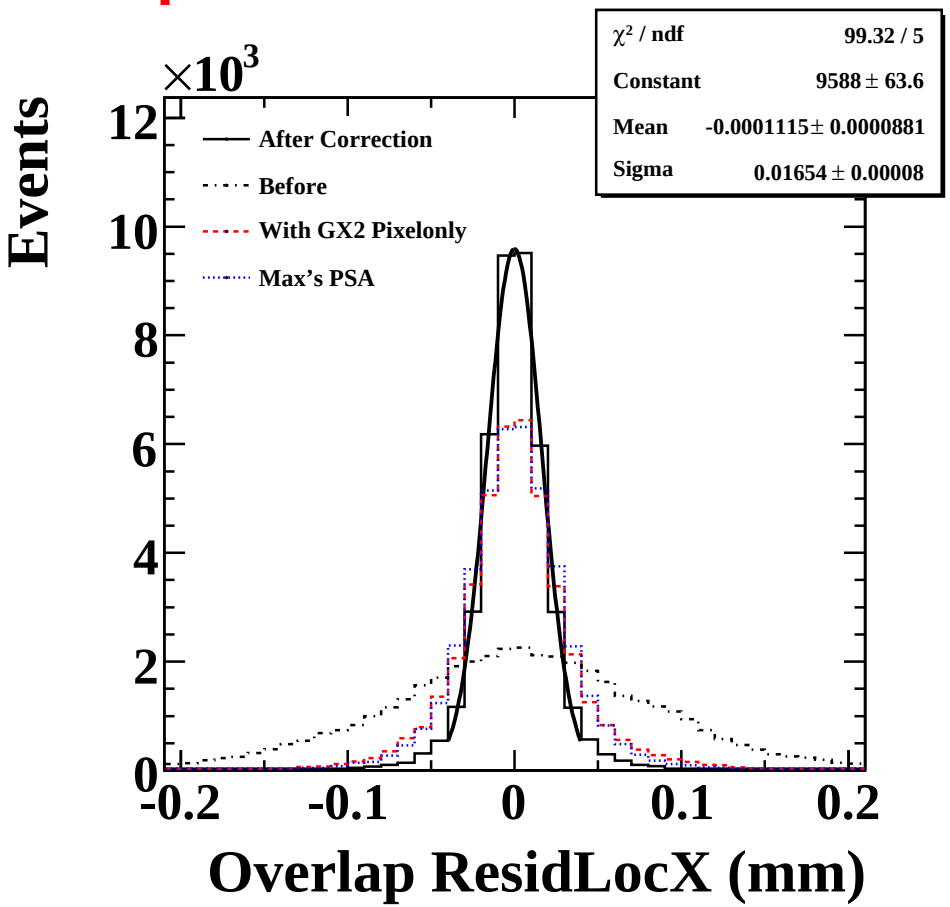
- **Because they are so close to each other, the overlap residual is more sensitive to the misalignment than tracking errors.**

- **After minimizing the χ^2 of overlap residuals, we get the relative constants from neighboring modules.**

  - $\Delta x_{overlap} = x_{odd} - (x_{even} * cos(\delta\phi) - sin(\delta\phi) z_{even})$
  - $\Delta z_{overlap} = z_{odd} - (x_{even} * sin(\delta\phi) + cos(\delta\phi) z_{even})$

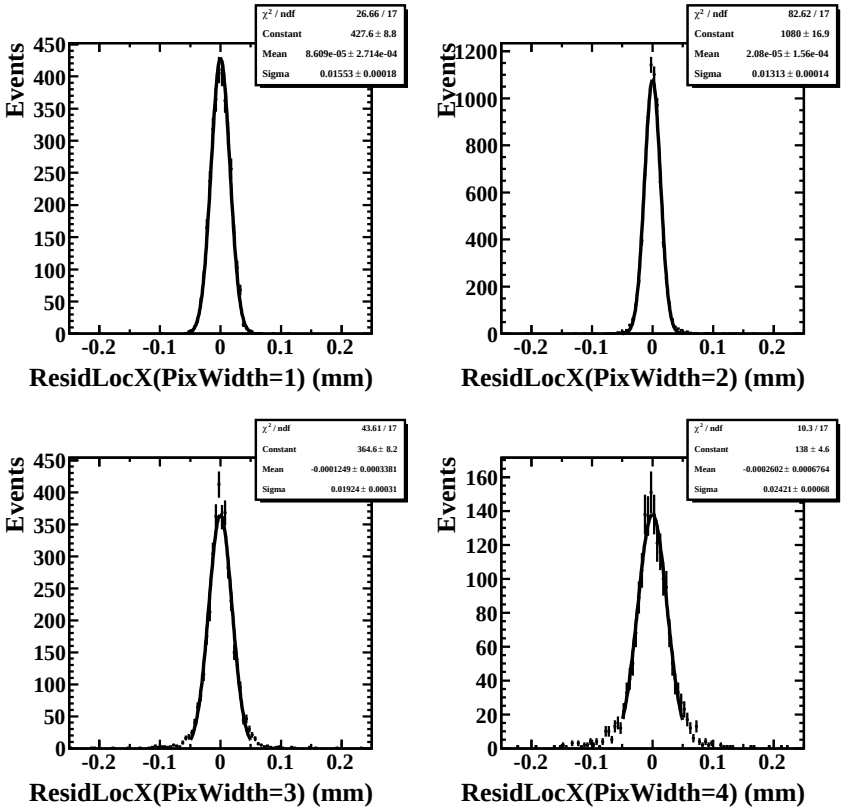
- **If assuming the module misalignment in z is small, we can estimate the module misalignment in x from both left and right side modules.**

Overlap Residuals after Correction



- The overlap residual has significantly improved after correction.
- Work is in progress to understand the systematic due to tracking and clustering.

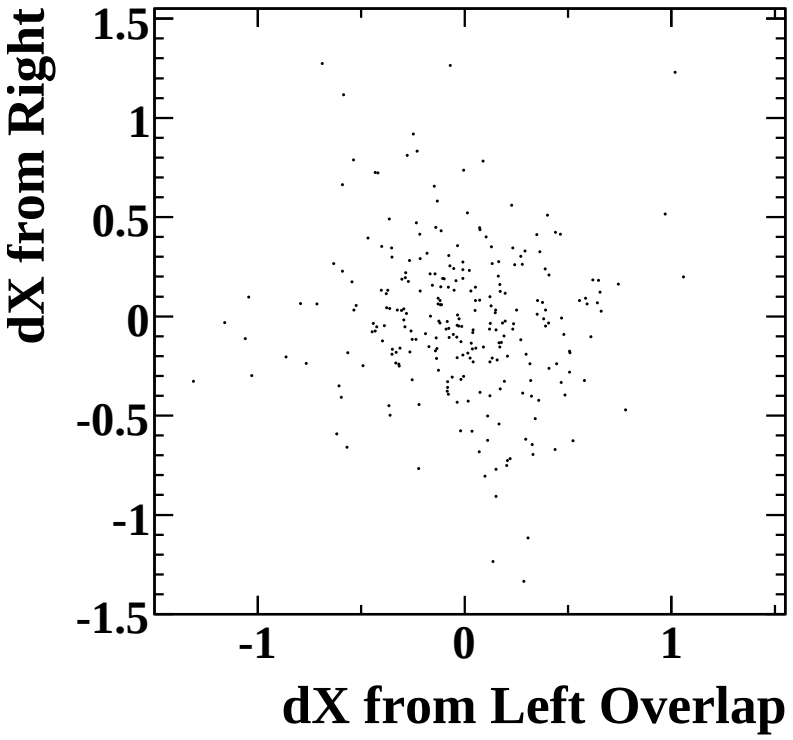
Pixel Cluster Resolutions

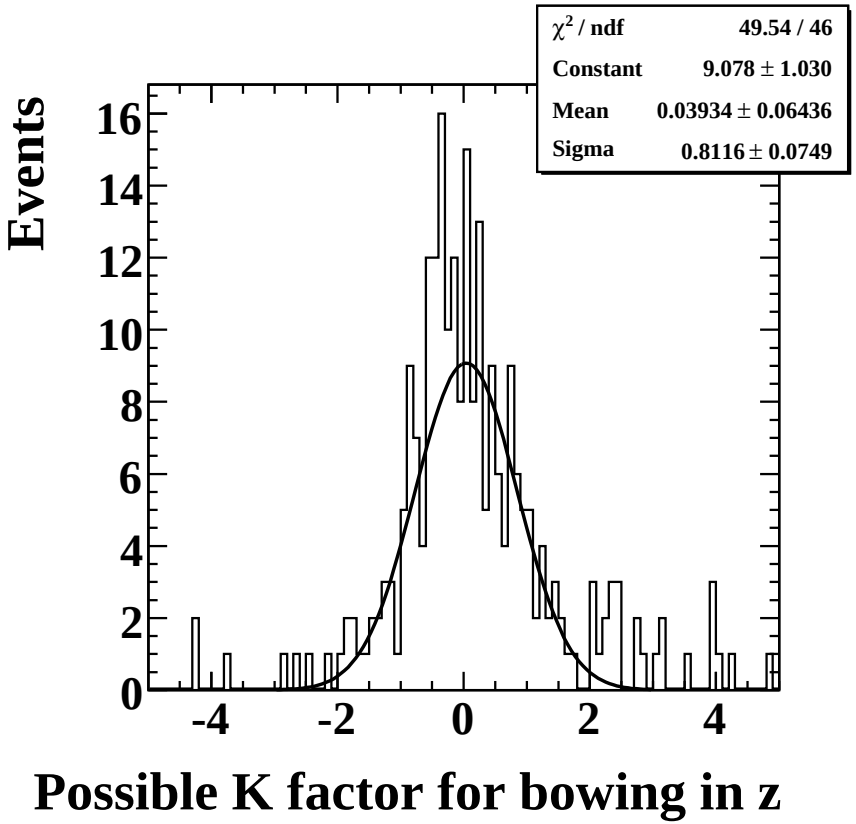


- **Break overlaps that consist of one, two, three and four pixels in LocX to measure the resolution.**
- **Close to what expected from test beam results.**

LocX Size	1	2	3	4
LocX res.(μm)	11	9.5	14	17

Alignment between Left/Right Overlaps



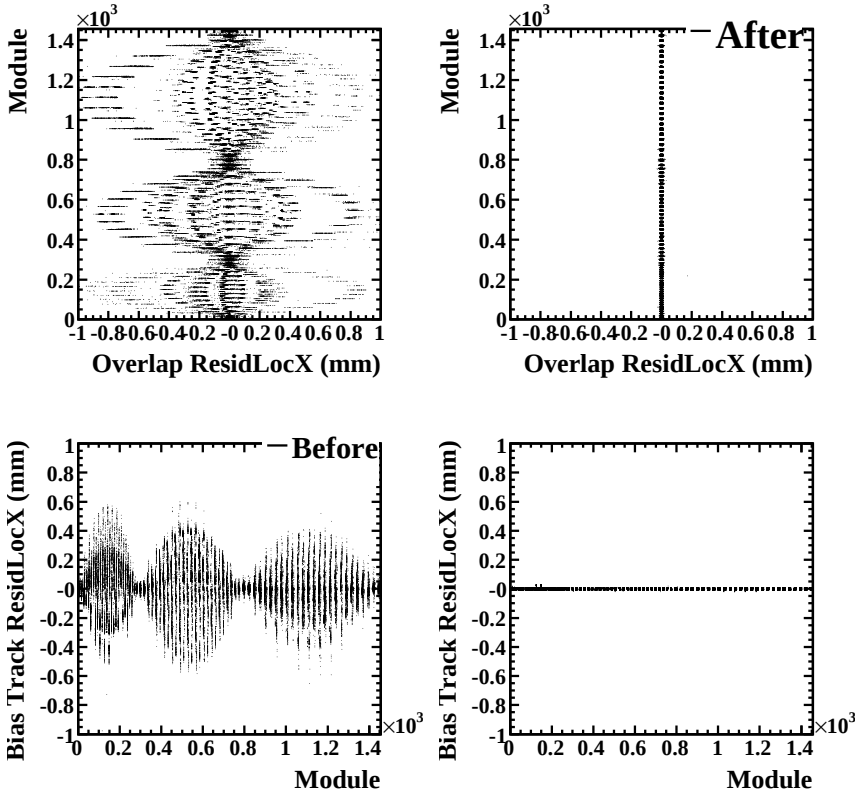


- As mentioned, the module misalignment can be estimated using measured ΔZ from left/right overlaps if misalignment in z is small.
- Unfortunately the correlation seems small in the data.
- Assuming the bow in x and z has similar shape for all modules and by forcing the left and right value equal, we could estimate the bow direction ($z = k \cdot x$).

Alignment with Track Residuals

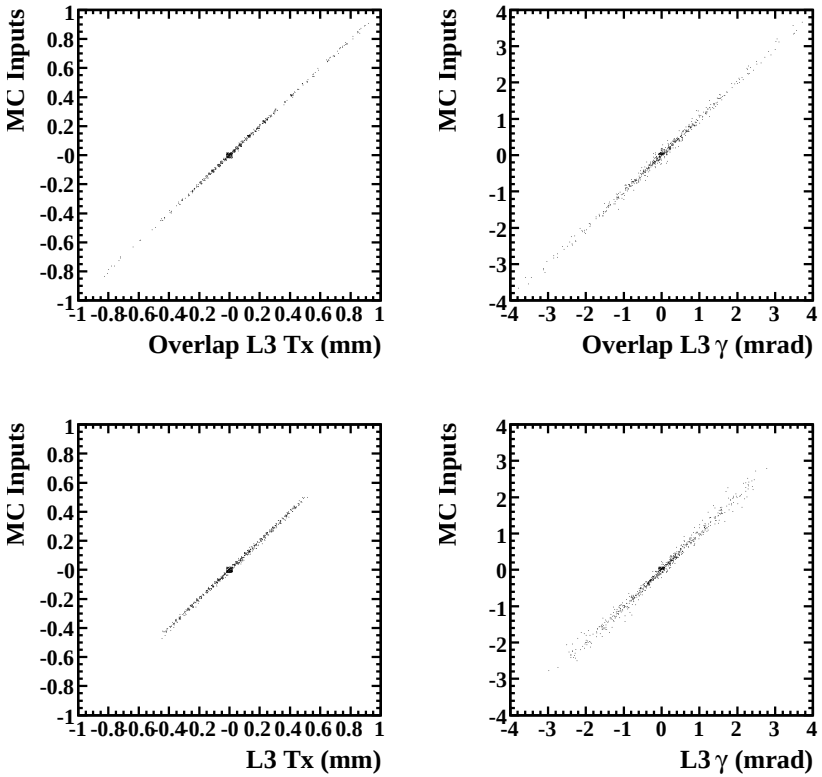
- **Rely on some consistency check using the hits on the track.**
- **In each overlap region, we select the odd module with most overlap hits as a reference module, so the alignment of the rest modules in the same region are computable.**
- **Fit a line in terms of module misalignemt of hits attached.**
- **Minimizing overall $\chi^2 = \sum (x_{exp} - x_{hit})^2/\sigma_x^2 + (y_{exp} - y_{hit})^2/\sigma_y^2$ and there are 92 regions with 2 dof each that gives a 184^2 matrix to solve in the χ^2 fit.**
- **The fit is sensitive to weak mode, such as bow...**

MC Test: Sagittas Uniform To +/- 500 μm



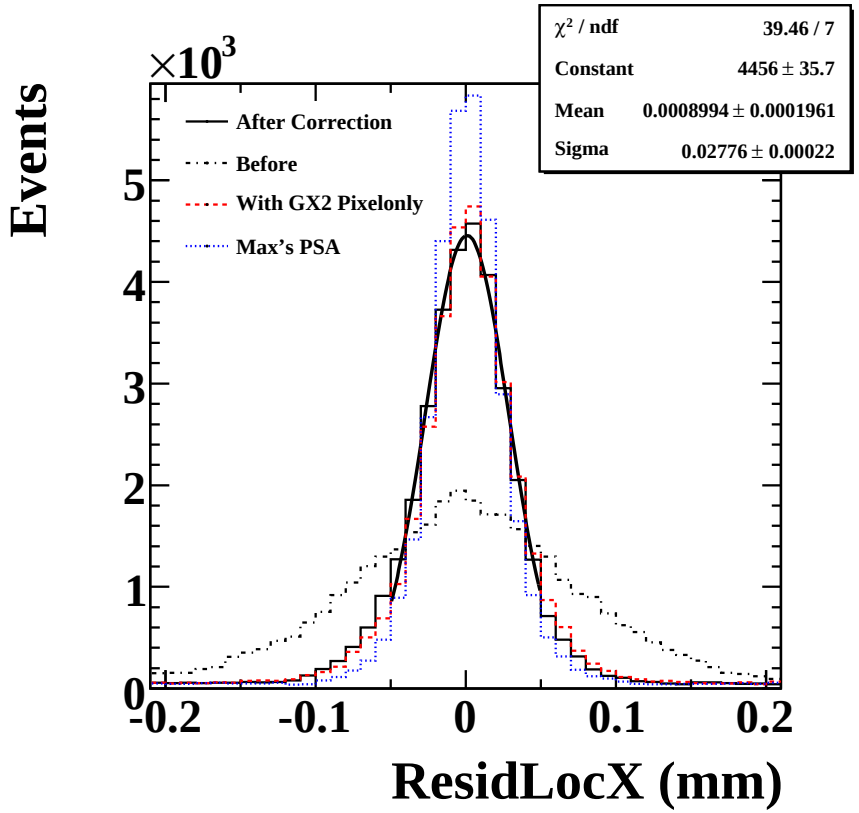
- **Each stave is misaligned using the random bow as the sagitta.**
- **With the initial estimation of misalignment from overlaps, the fit converages nicely.**

MC Test: Sagittas Uniform To +/- 500 μm



- **The fit also recovers the input misalignment completely.**
- **However, without the initial input, the fit converages, but does not remove the bow completely.**

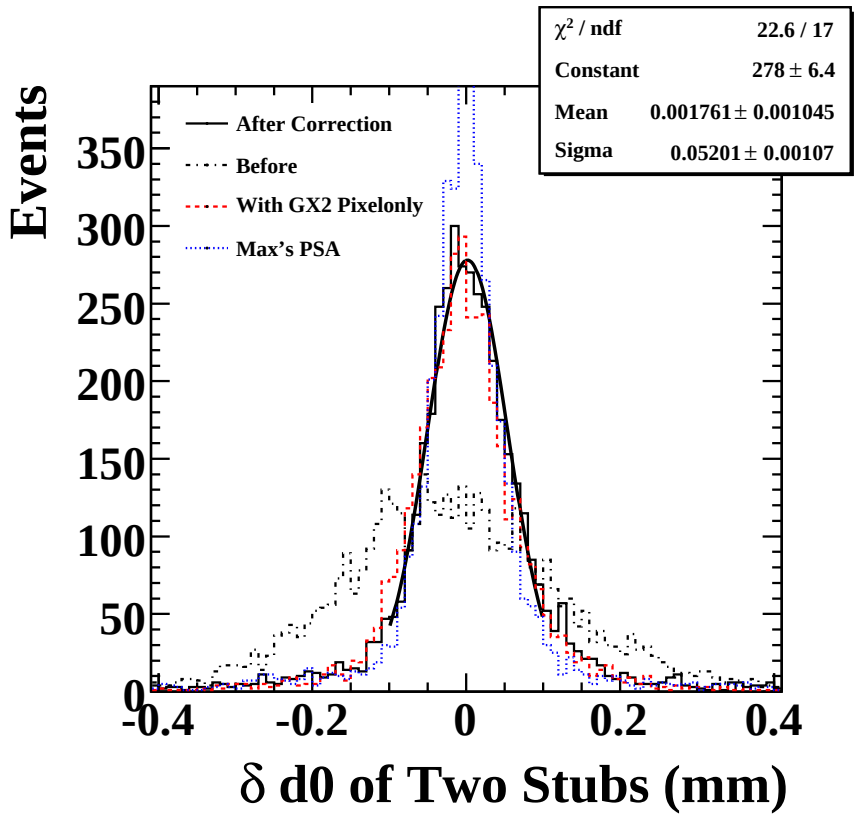
Track Residuals After Correction



- Track residual is calculated for hits on layer 0 and 1 respect to the fit using hits only on layer 2.

- PSA seems give much better overall residuals than other methods.

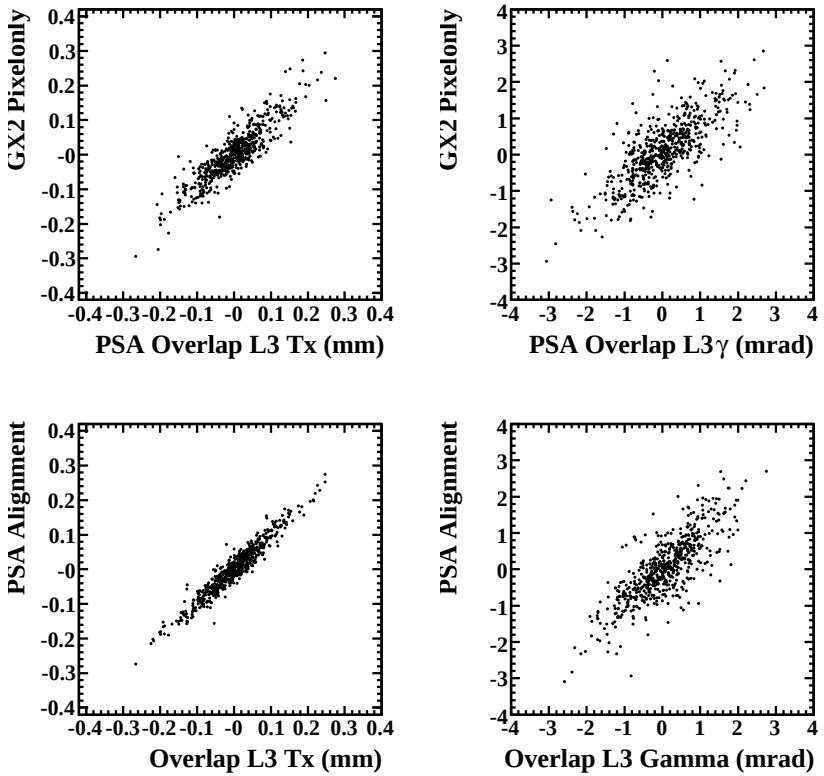
Impact Parameter between Two Stubs



- Measure the impact parameter resolution using top and bottom cosmic stubs.

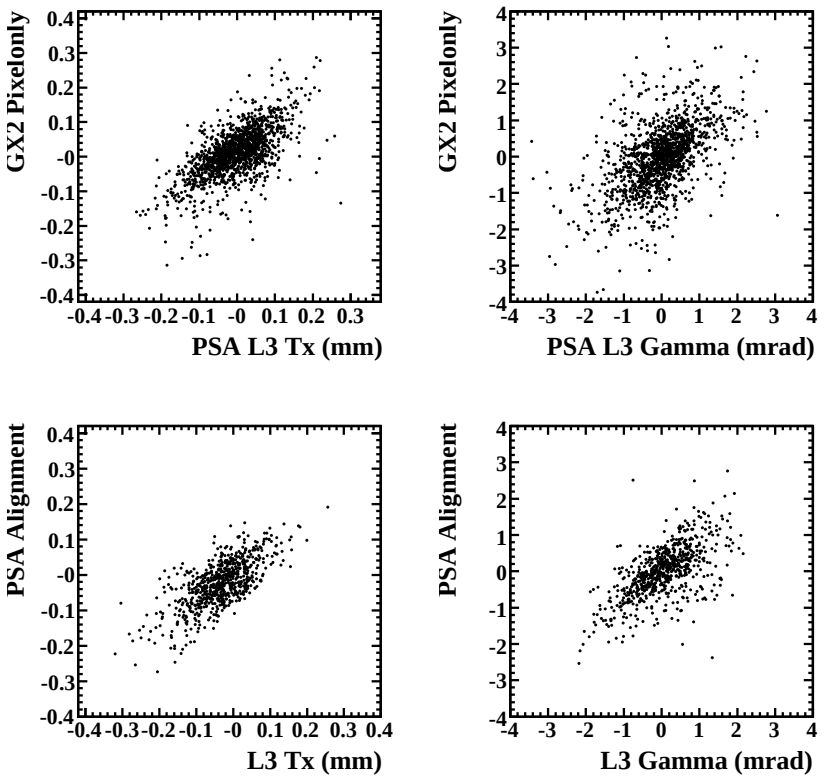
- As expected, PSA has a better impact parameter resolution than others.

Comparison of Overlap Alignment Constants



- **Compared overlap alignment constants and there seem strong correlation among three methods.**

Comparison of L3 Constants



- **Compared L3 alignment constants.**
- **Again there are some correlations, but not strong as in overlap case.**

Conclusion

- **The Pixel Standalone procedure has changed very little in the last several months, but with the use of MC its strengths and weaknesses are now known better.**
- **The PSA alignment seems have smaller track residual than other methods and there are some correlations among them, but not strong as hoped.**
- **How to deal with bow correction could be source of discrepancy.**
- **There are still some work to understand the systematic of overlap residuals.**