Status of Intra- and Inter-Tower Tracker Alignment

(A preliminary look at the alignment)

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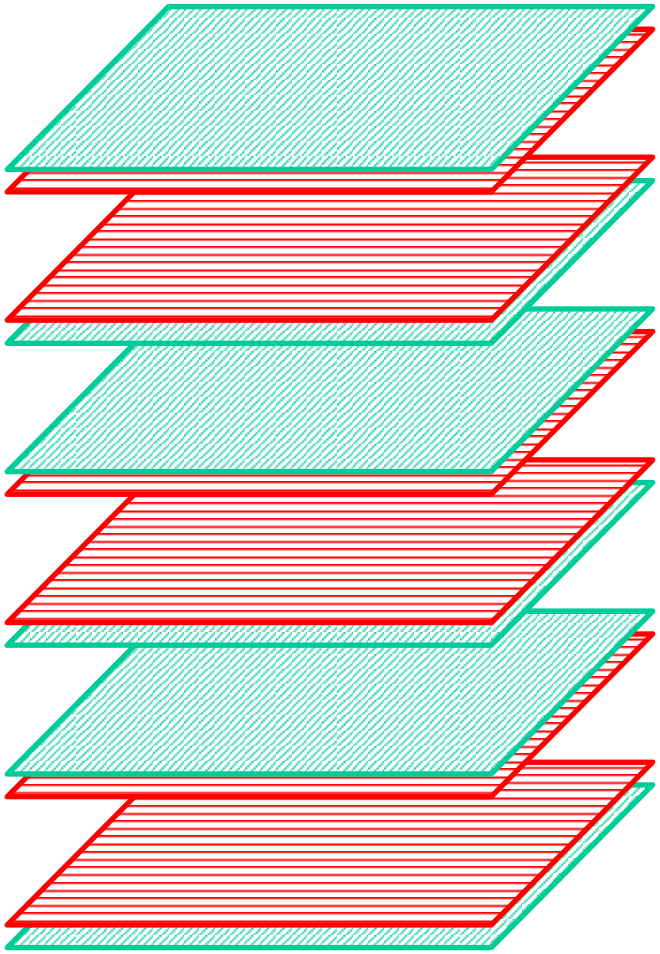
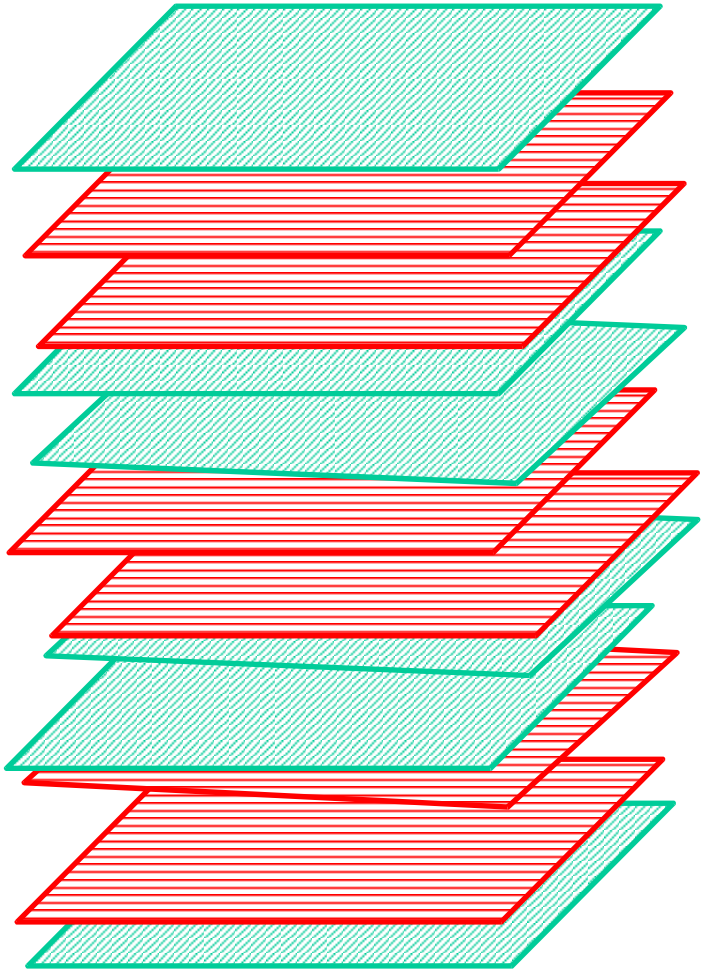
Instrument Analysis Workshop 6
SLAC
28 February 2006

TkrFM …



the ideal TkrFM

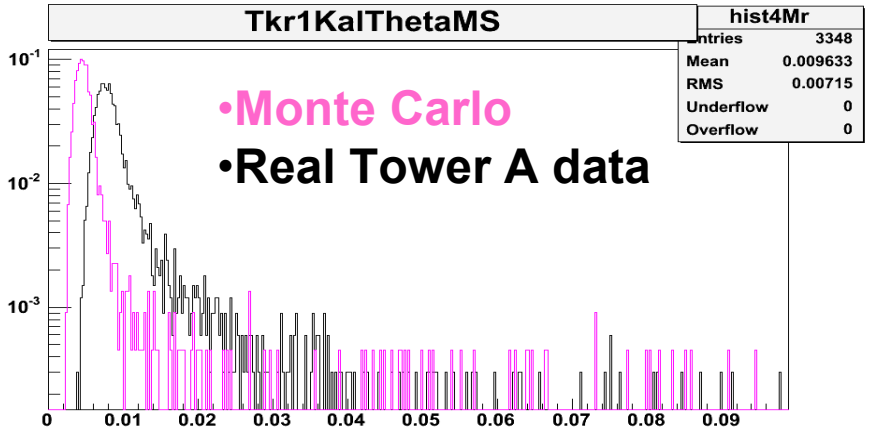


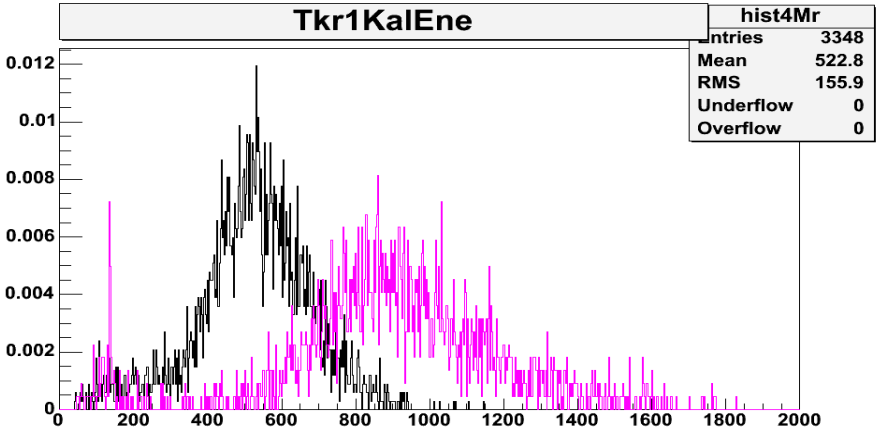
the real TkrFM

It's not an academic exercise only!

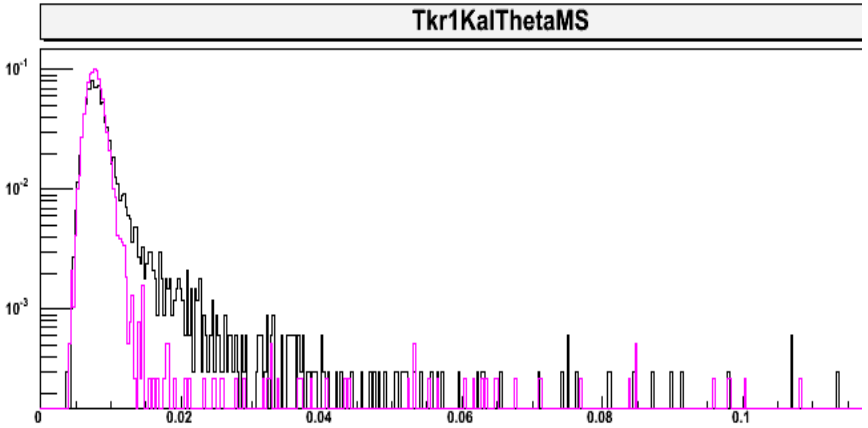
From Sara's presentation at IAWS5:

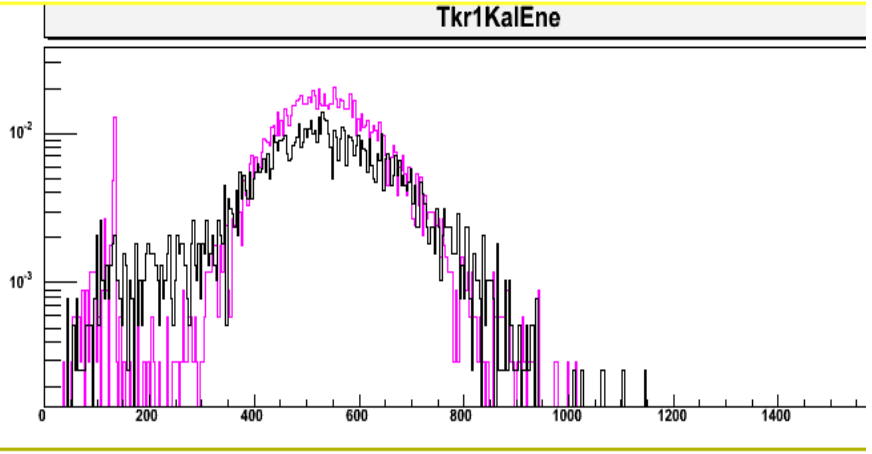
without alignment





with alignment (in MC)





Intra-tower alignment

reference document: my talk at IAWS4

What does it do?

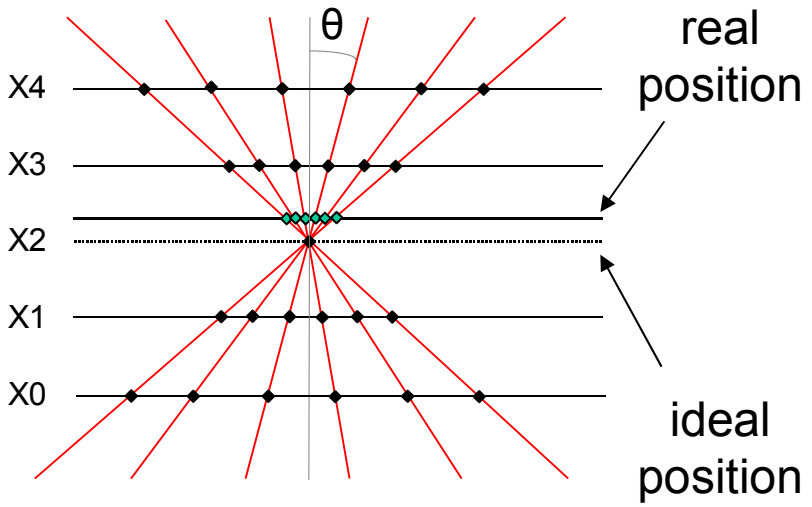
- ✓ aligns planes horizontally, along the measured coordinate
- ✓ aligns planes vertically
- ✓ determines the rotation around z **(NEW!)**

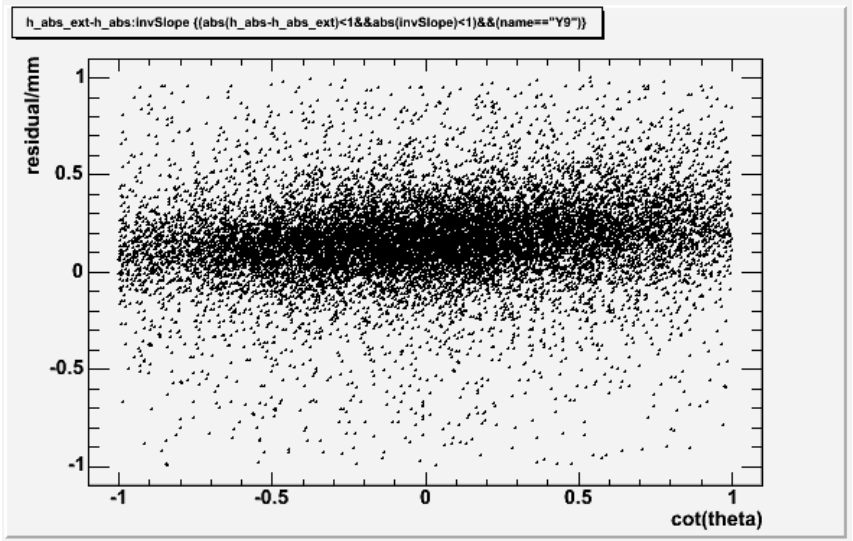
What does it not do?

- ❑ doesn't align planes horizontally, parallel to the strips
- ❑ doesn't determine rotations around x and y
- ❑ doesn't align single ladders or wafers (yet!)

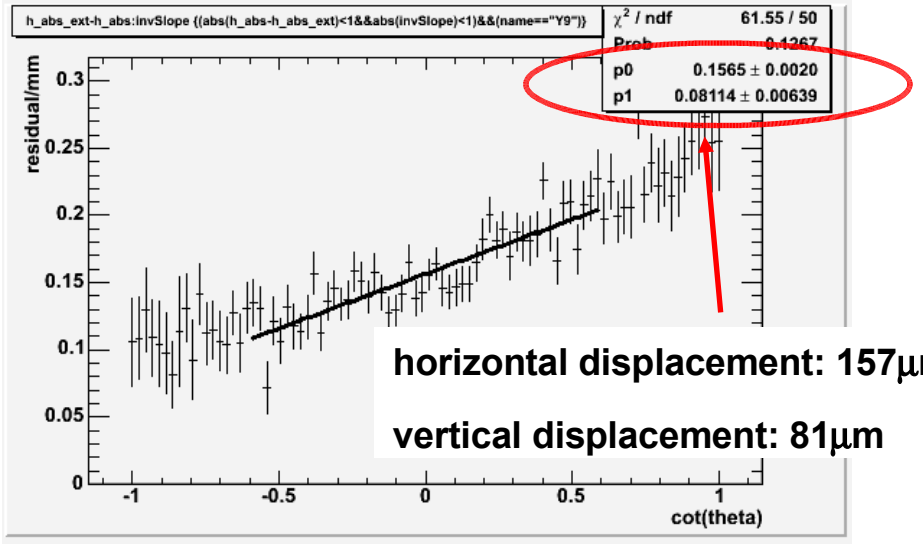
Residuals vs. slope (horizontal and vertical alignment)

```
r->DrawResSlope("Y9", "abs(h_abs-h_abs_ext)<1&&abs(invSlope)<1")
```





$$res = \Delta x + \Delta z \cdot \cot(\theta)$$



Aligns:

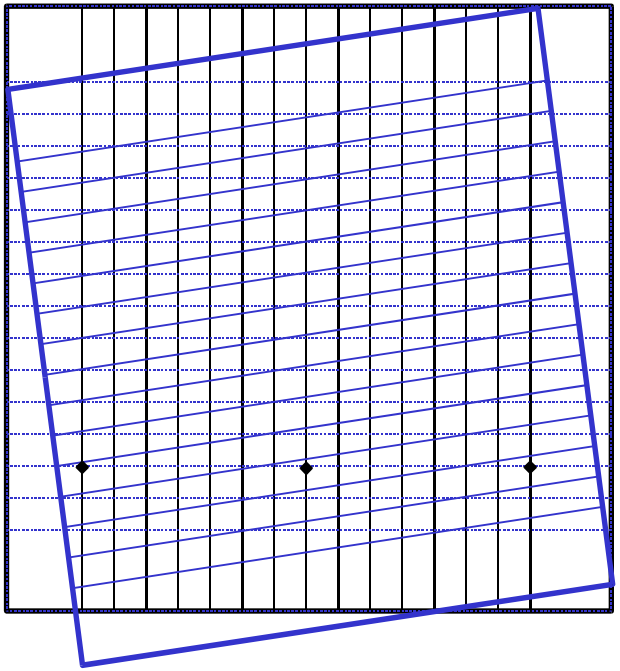
- horizontal (⊥ to strips)
- vertical

horizontal displacement: 157μm

vertical displacement: 81μm

Residuals vs. position in other view

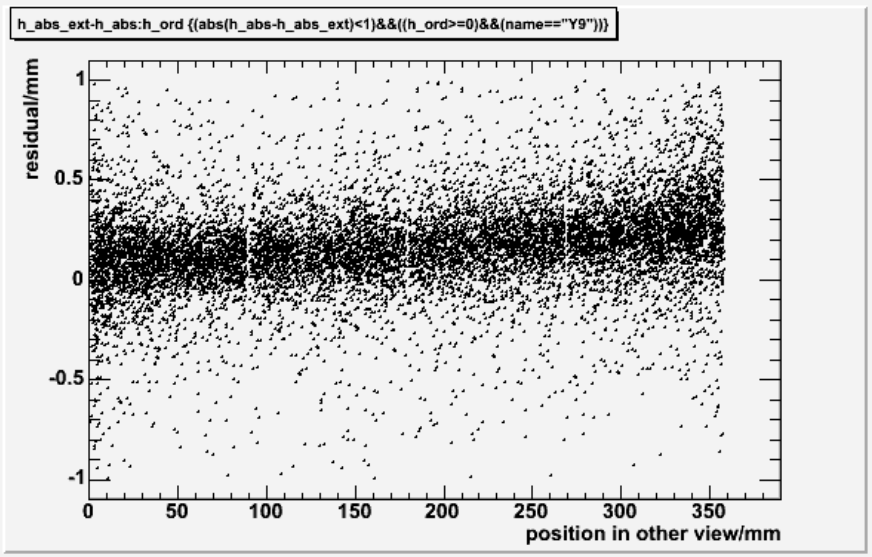
```
r->DrawResOrd("Y9", "abs(h_abs-h_abs_ext)<1")
```

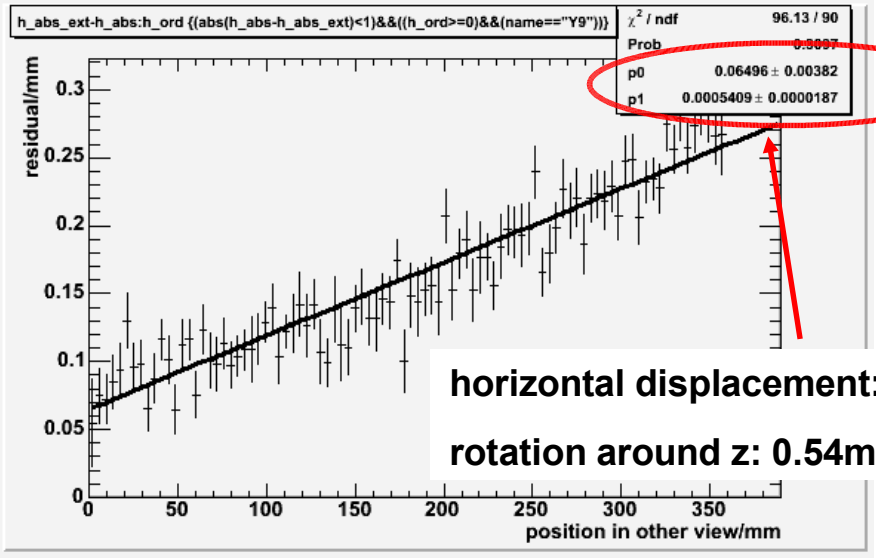


X

Y, ideal position

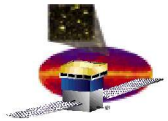
Y, real position





horizontal displacement: 65μm

rotation around z: 0.54mrad

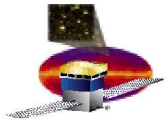


Procedure

Intra-tower alignment is an iterative process!

Since RA v8r3p1: run with 100k events till “real” convergence

- “real” convergence is achieved if a geometry repeats
- 1 iteration for 100k events takes about 6 min CPU
- result is “perfect” geometry



Blindness

Attention

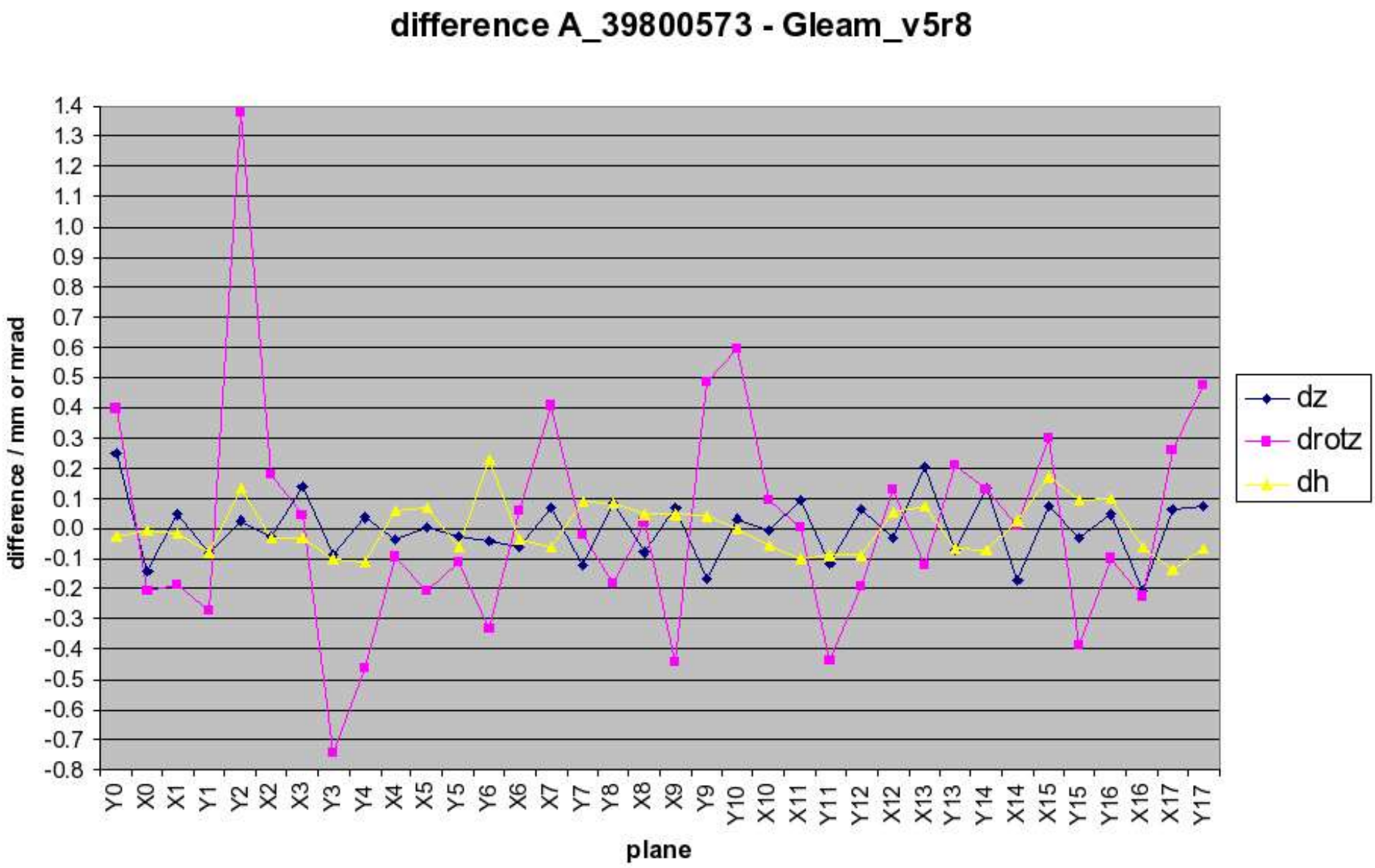
Intra-tower alignment is blind versus:

- **translation**
- **shearing**
- **vertical scaling (horizontal is fixed by strip dimensions, assuming ladders are glued properly)**
- **rotation**
- **translation of the planes of one view vs. the other**
- **rotation of the planes of one view vs. the other**

After every iteration, separately in each view, I *"correct"* for:

- $\sum pos_h = 0$ **(horizontal translation)**
- $\sum pos_h^2$ **min. (shearing)**
- $\sum (pos_v - pos_{v,ref}) = 0$ **(vertical translation)**
- $\sum (pos_v - pos_{v,ref})^2$ **min. (vertical scaling)**
- $\sum rot_z = 0$ **(rotation around z)**

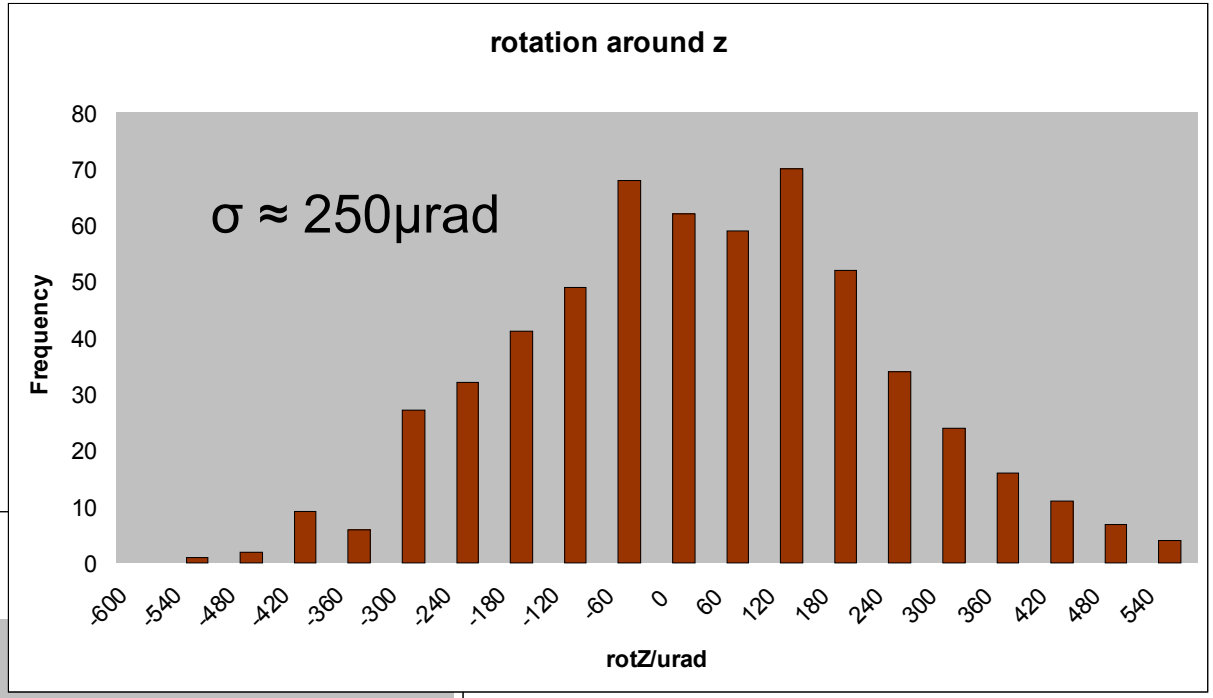
Typical result

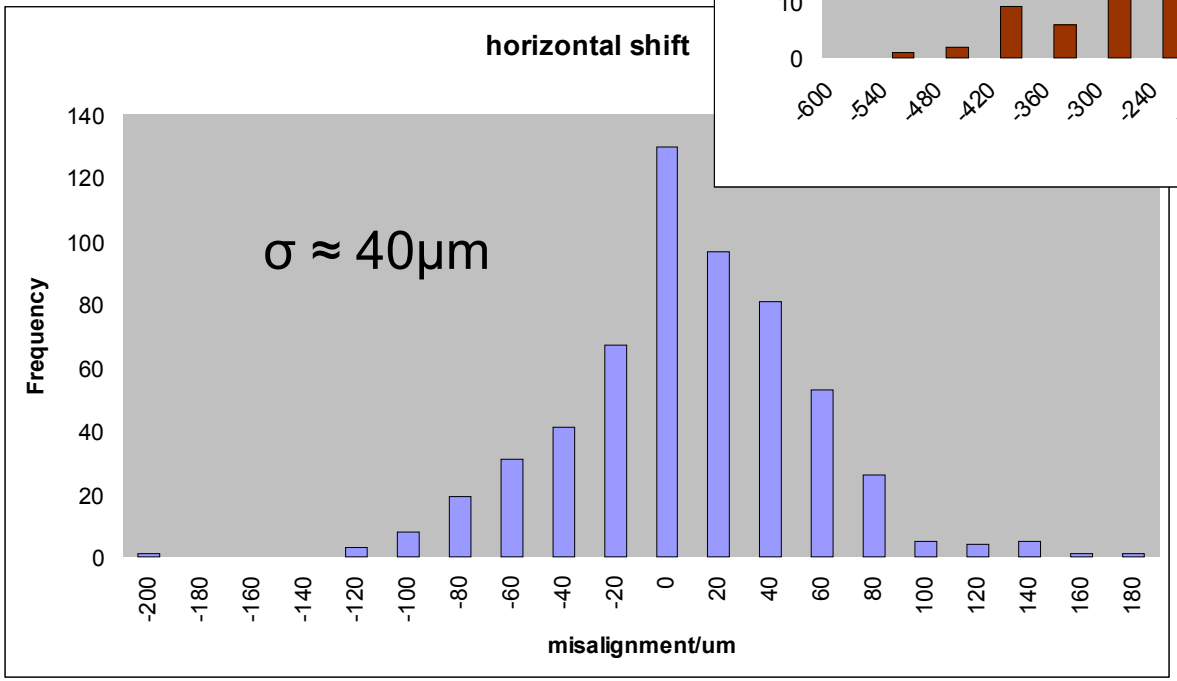


Intra-tower alignment: summary

Tower 0 (TkrFMA) Y2: 1.33mrad

Tower 5 (TkrFM1) Y12: 1.38mrad





Tower 6 (TkrFM12) Y13: -358μm

Tower 9 (TkrFM3) Y8: 394μm

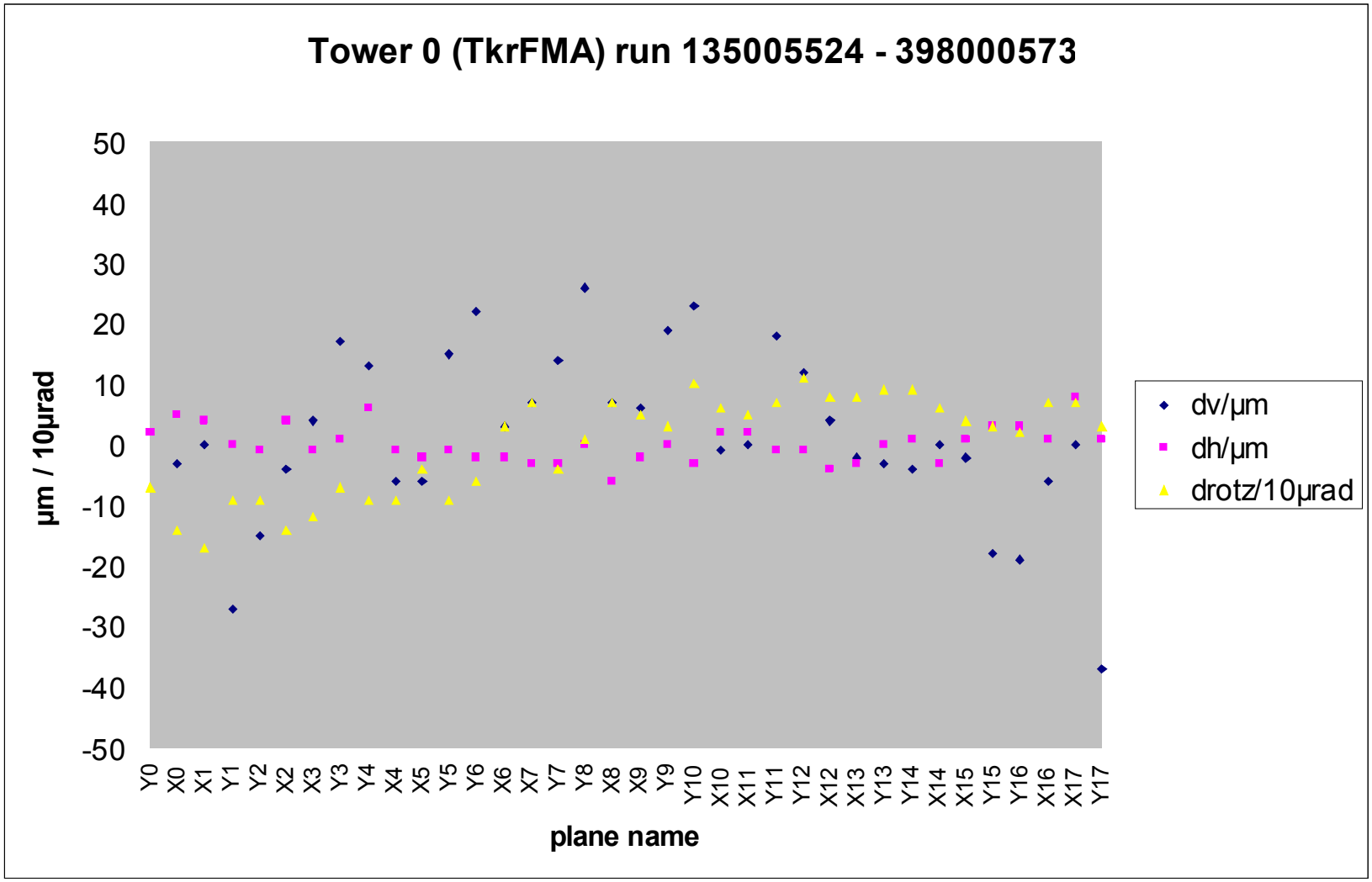
Check of mechanical stability (trending)

- reference data: single-tower runs taken at Alenia, Pisa, or SLAC before October 2005 (used 100k events each)

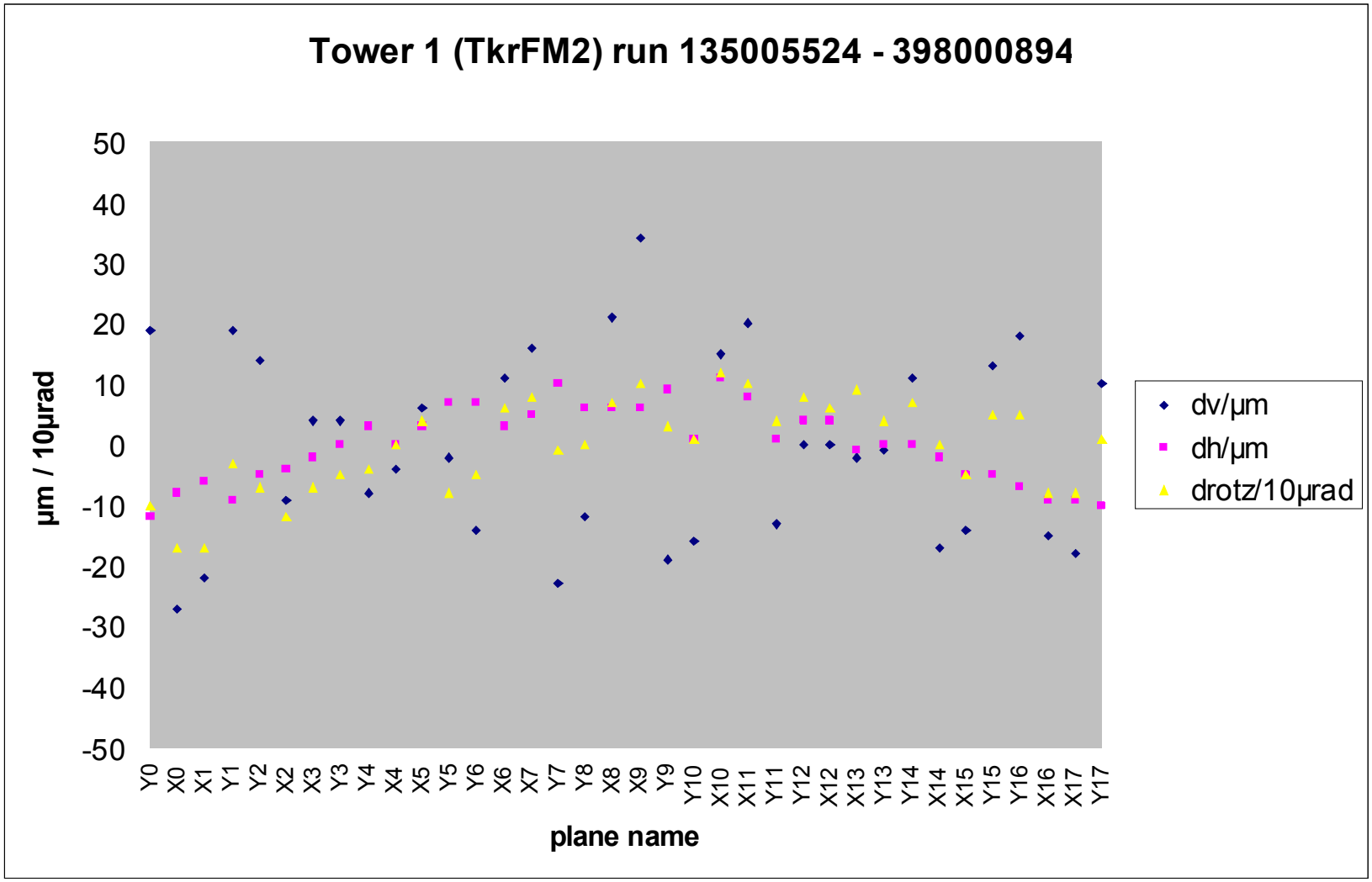
- new data: 16-tower (B30) runs 135005518/20/22/24 (1.75M events) taken January 16 2006 at SLAC

The following plots show the difference of the two geometries obtained for a particular tower.

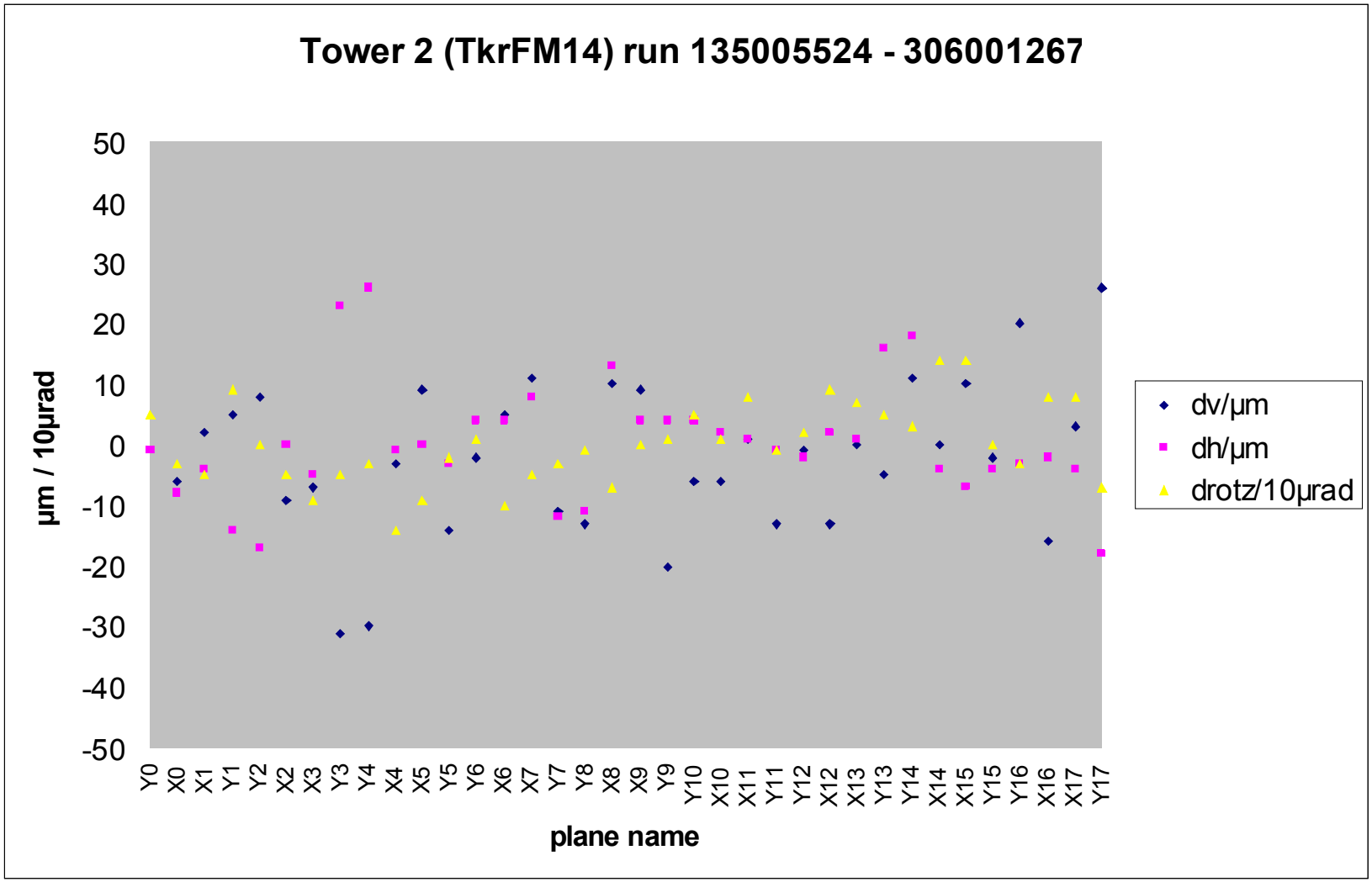
Intra-tower alignment results tower 0



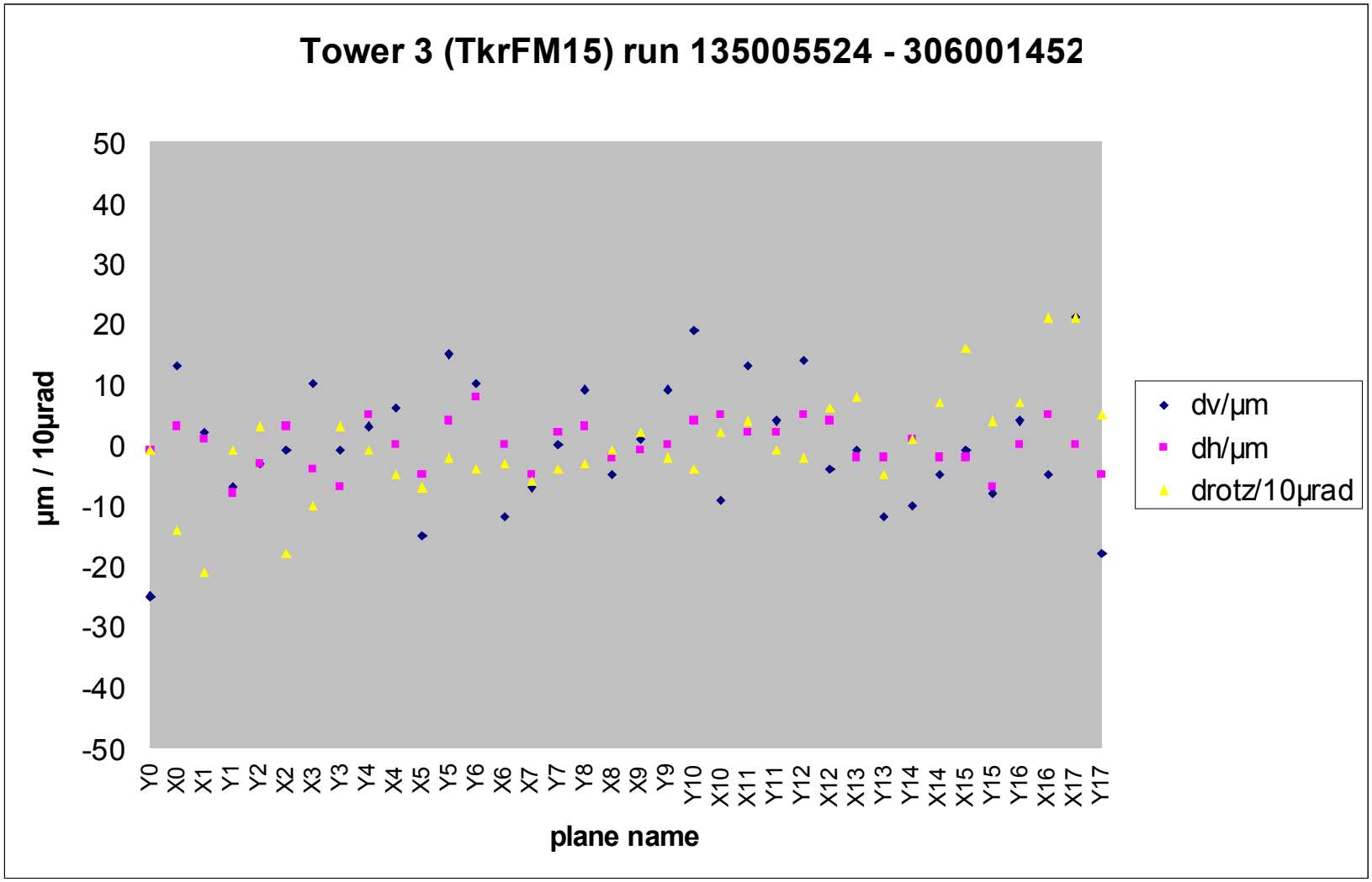
Intra-tower alignment results tower 1



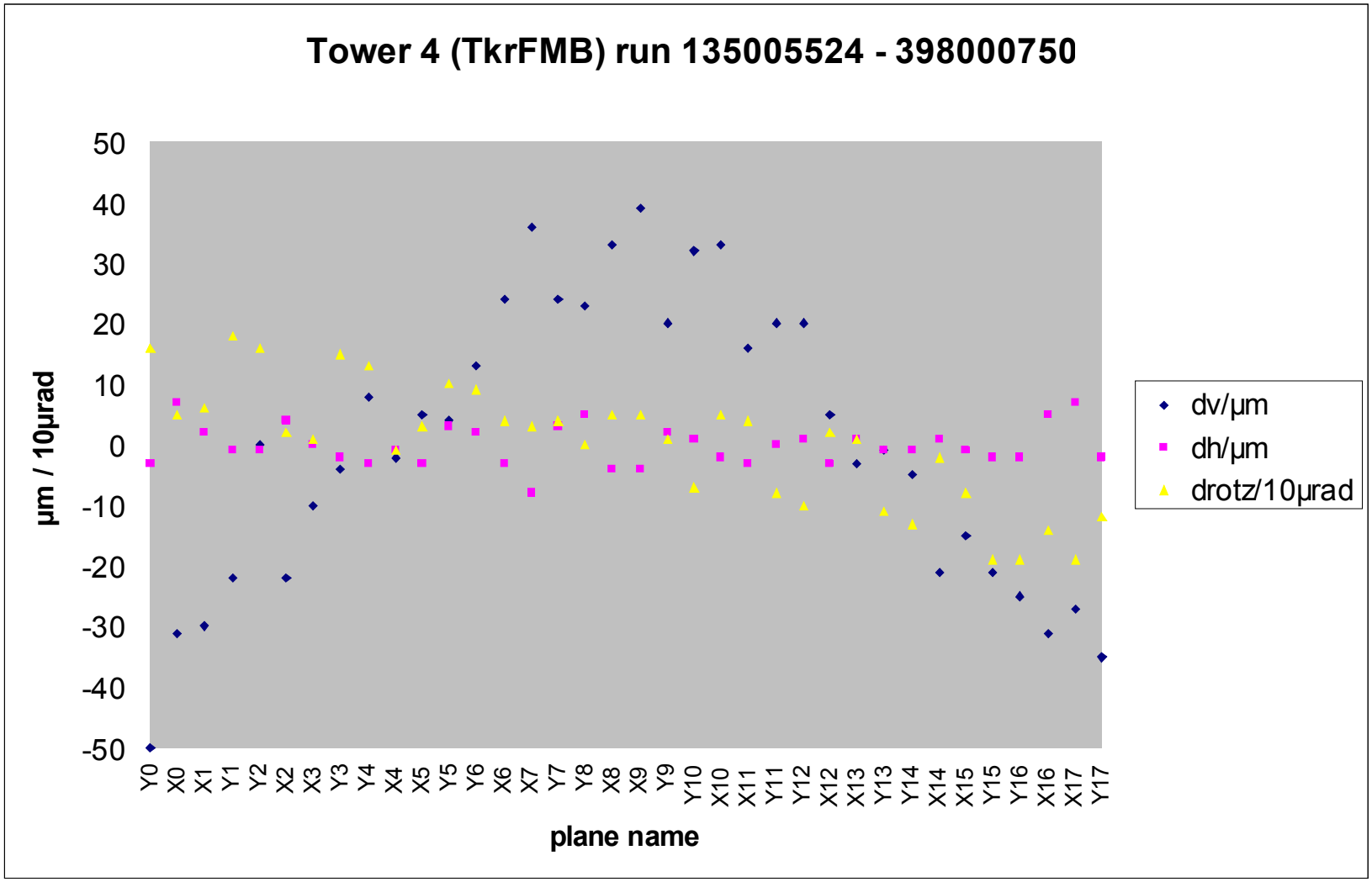
Intra-tower alignment results tower 2



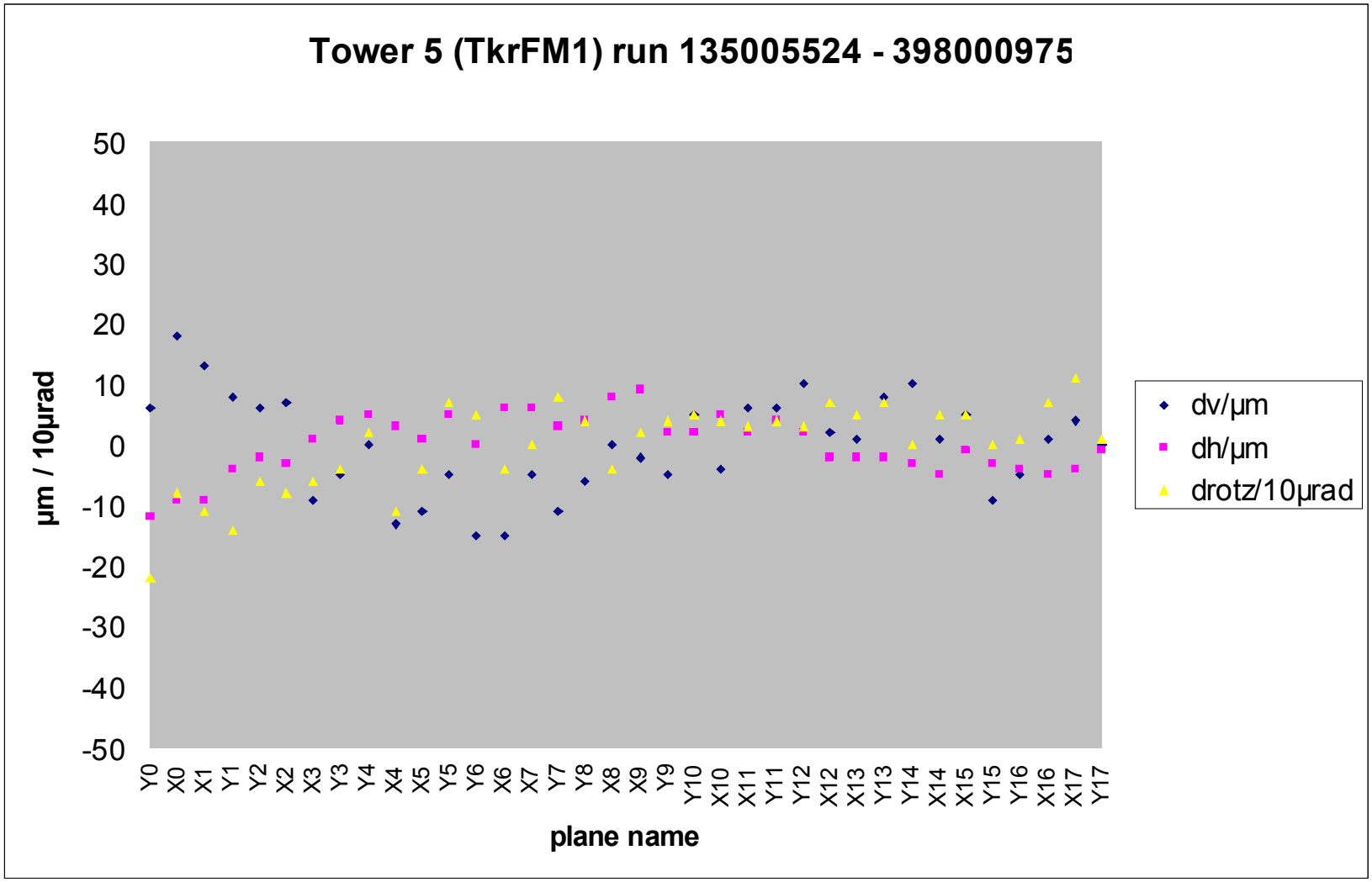
Intra-tower alignment results tower 3



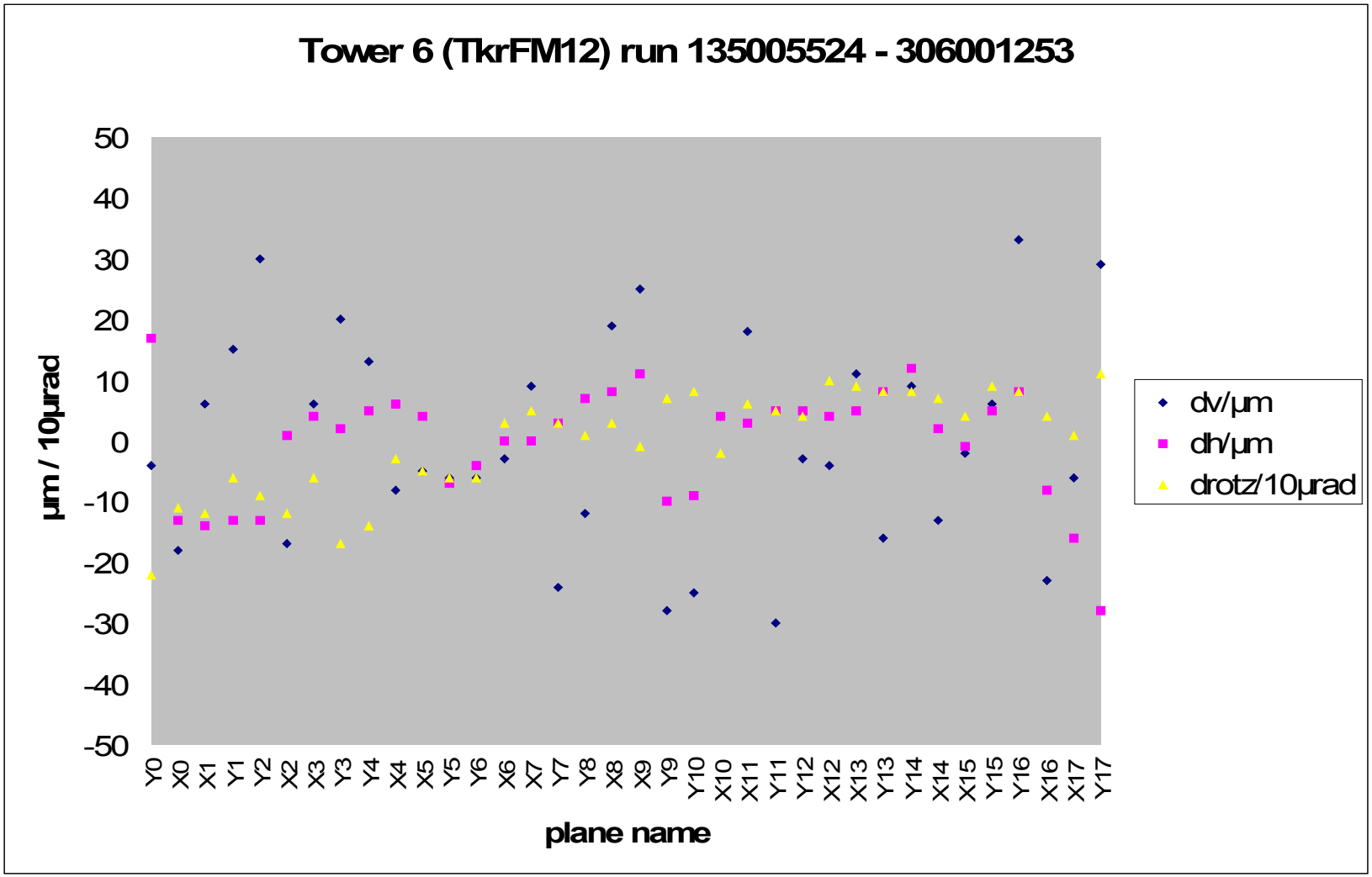
Intra-tower alignment results tower 4



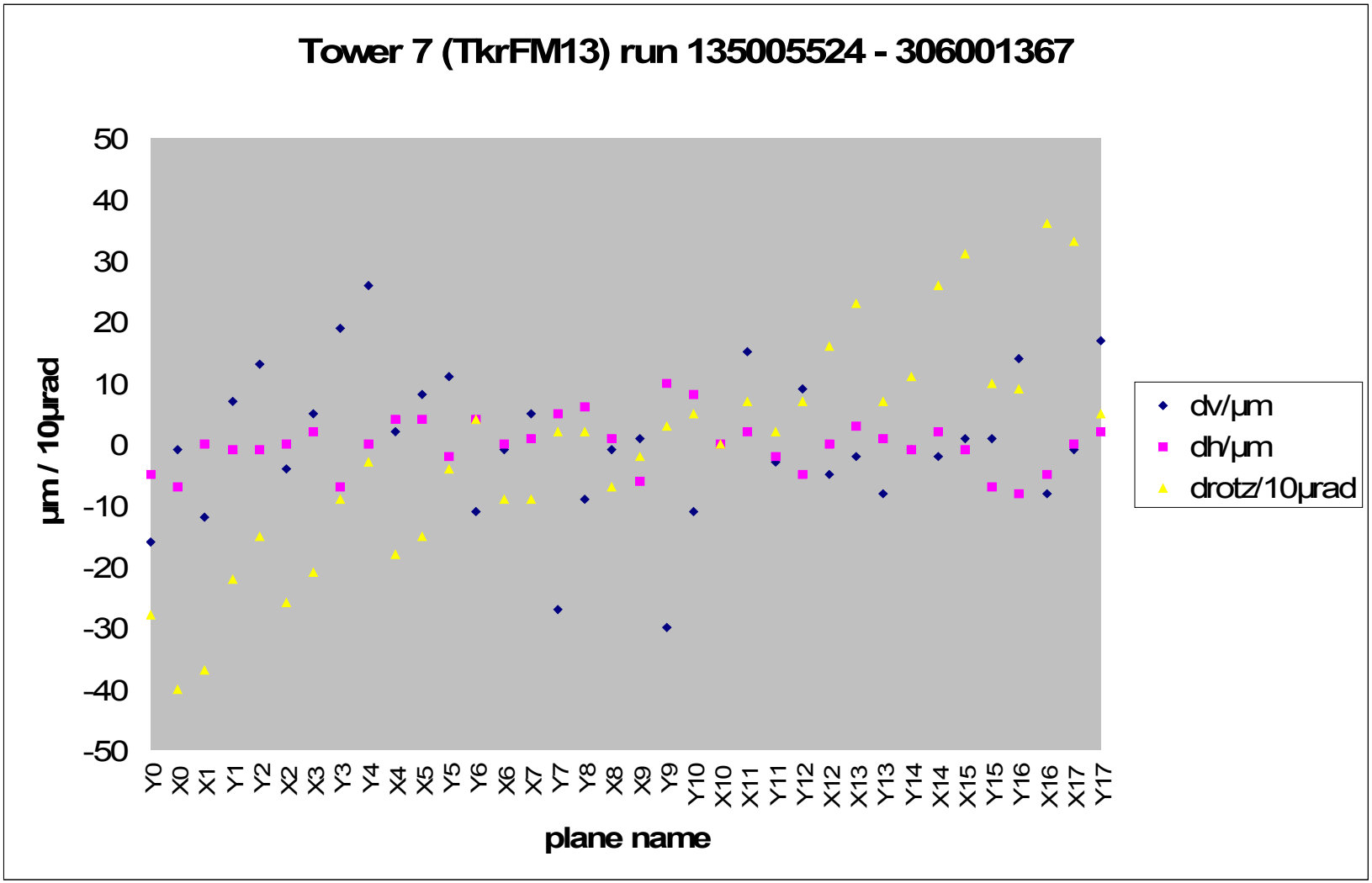
Intra-tower alignment results tower 5



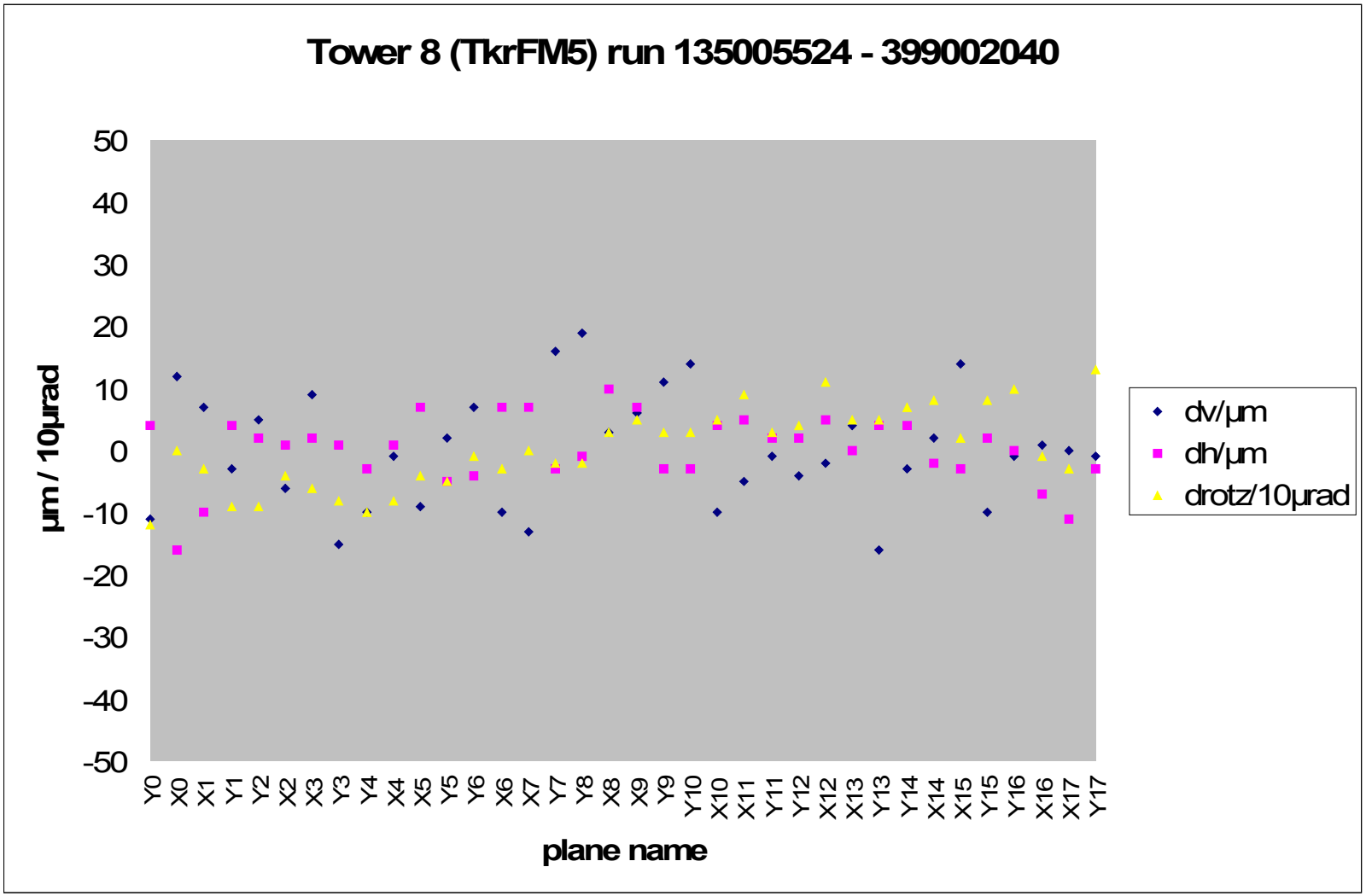
Intra-tower alignment results tower 6



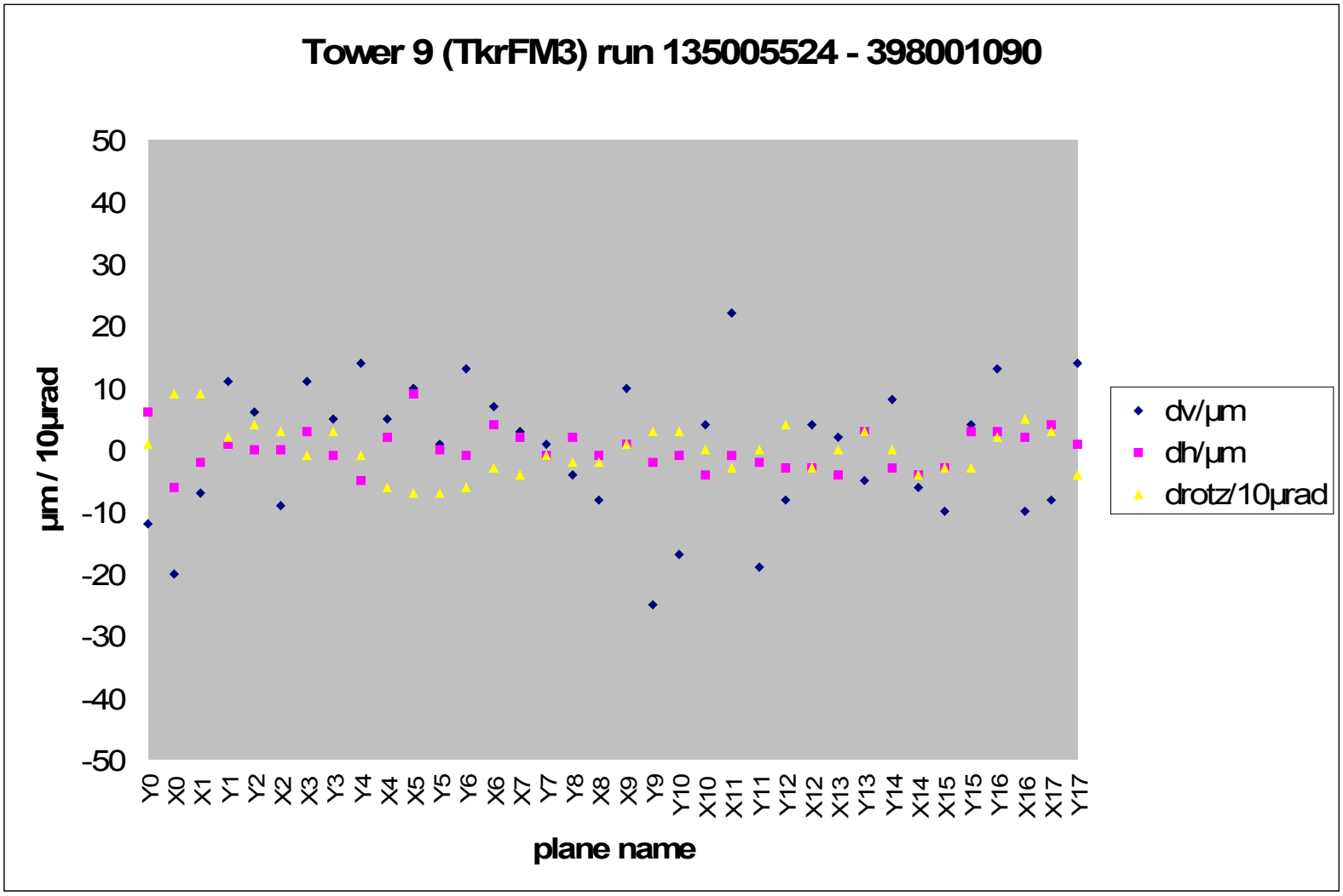
Intra-tower alignment results tower 7



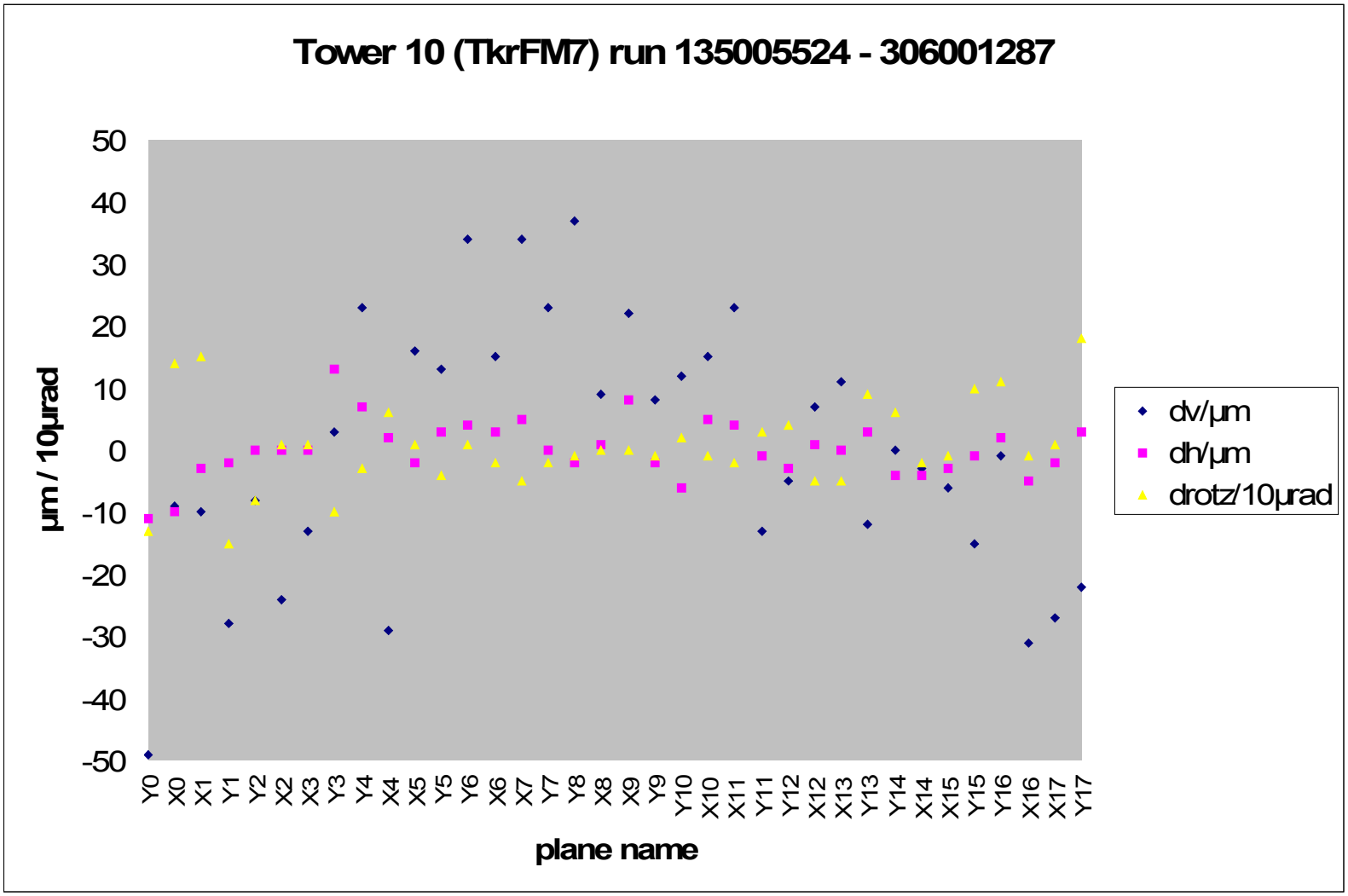
Intra-tower alignment results tower 8



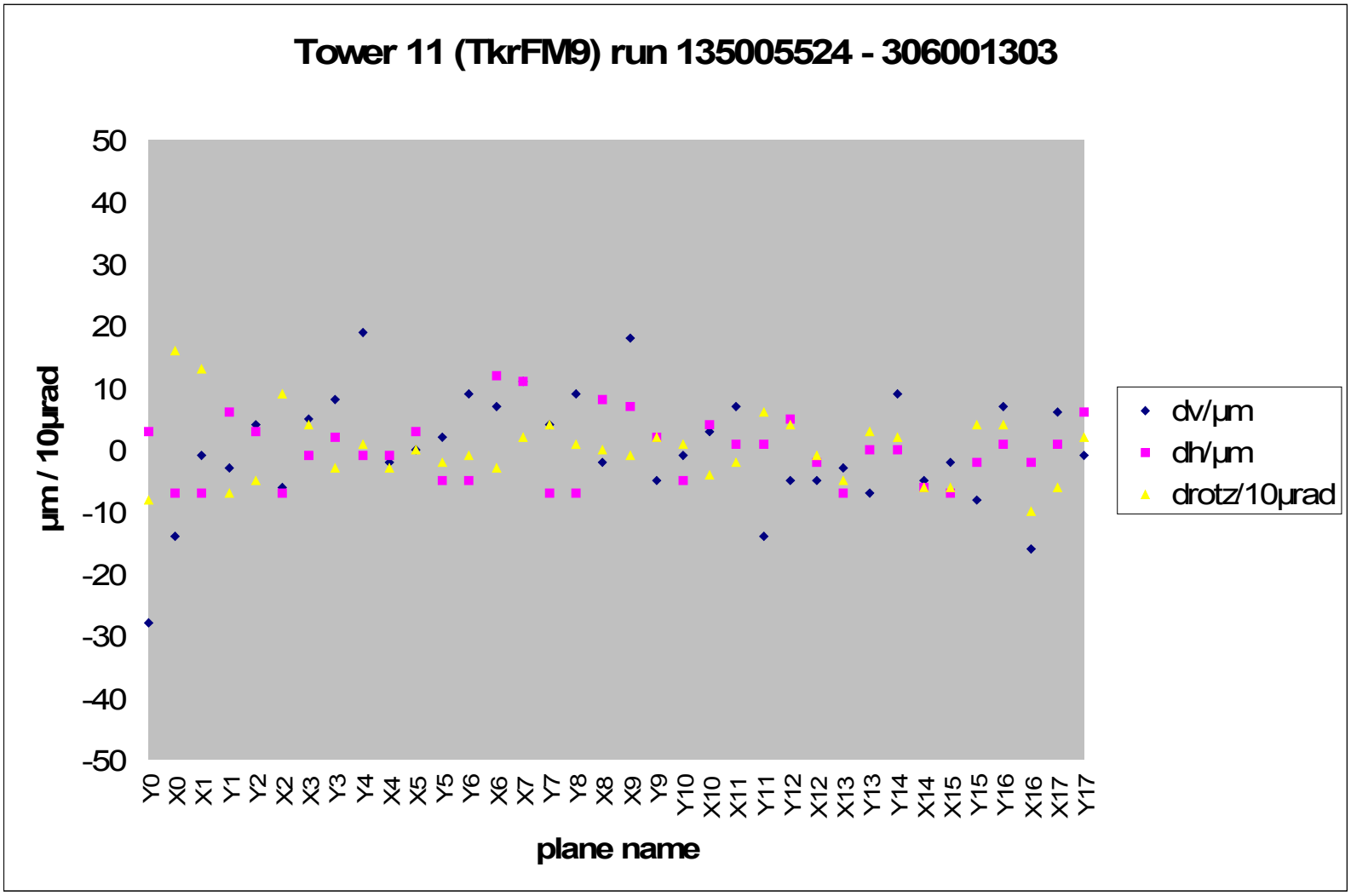
Intra-tower alignment results tower 9



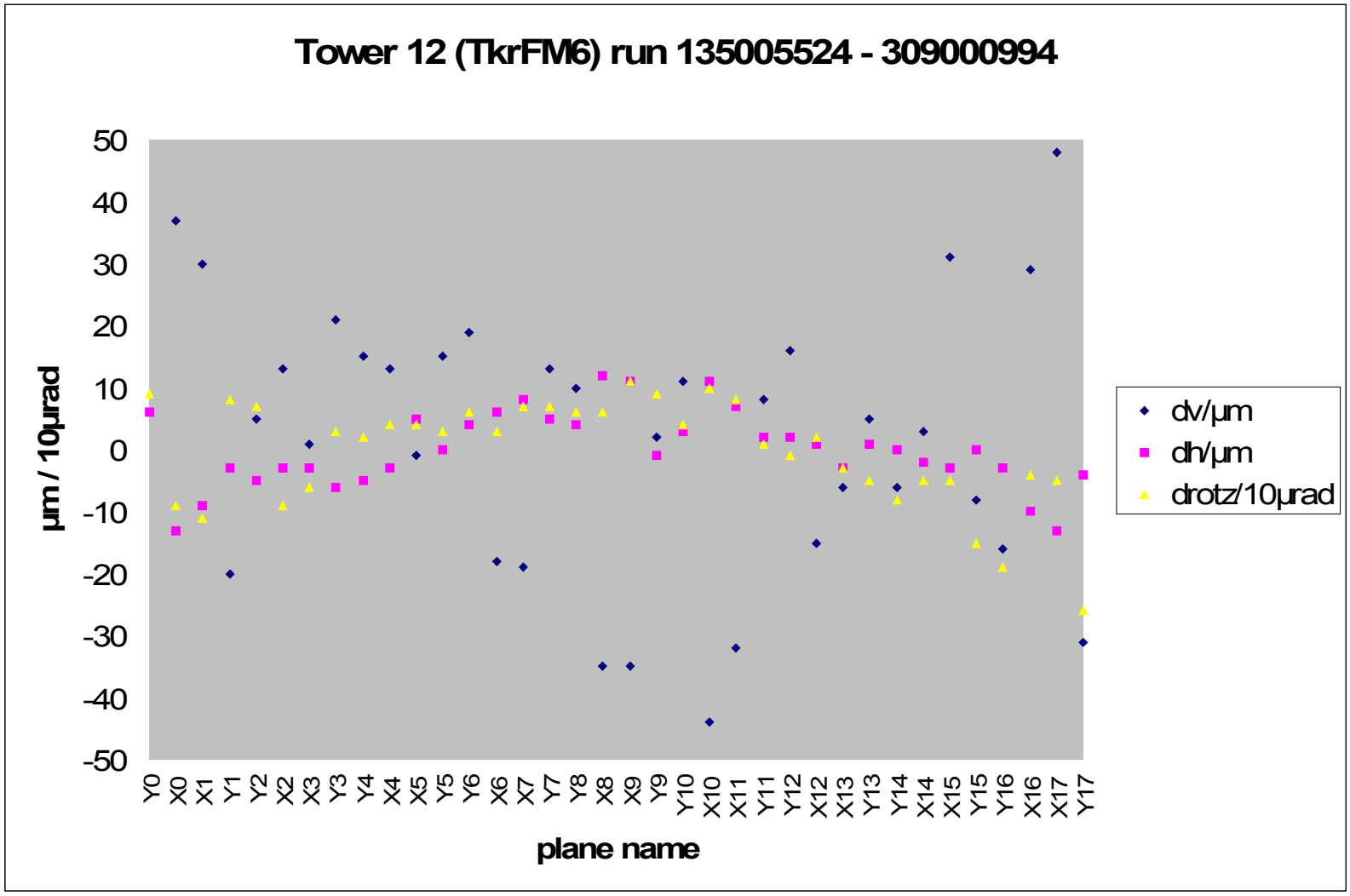
Intra-tower alignment results tower 10



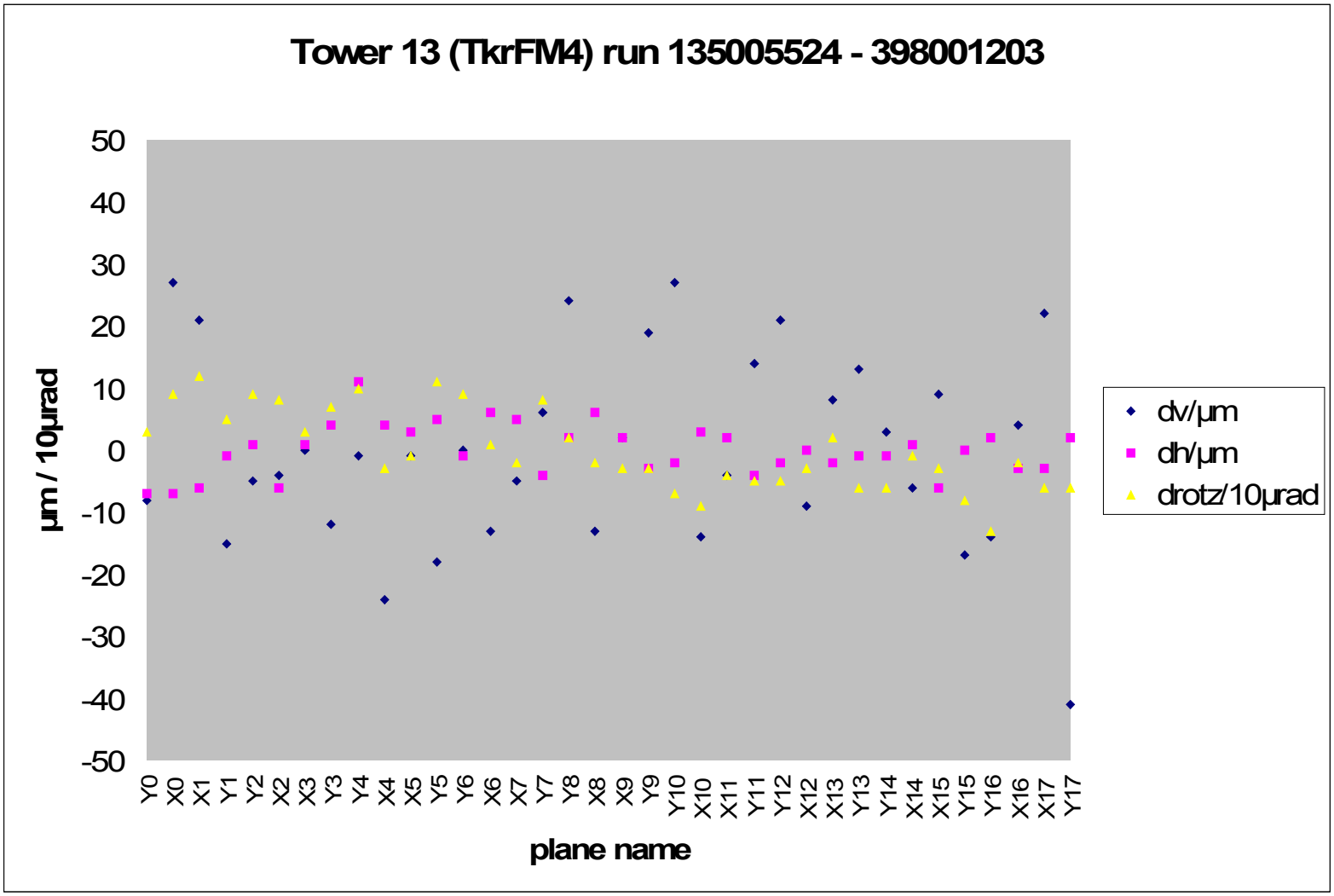
Intra-tower alignment results tower 11



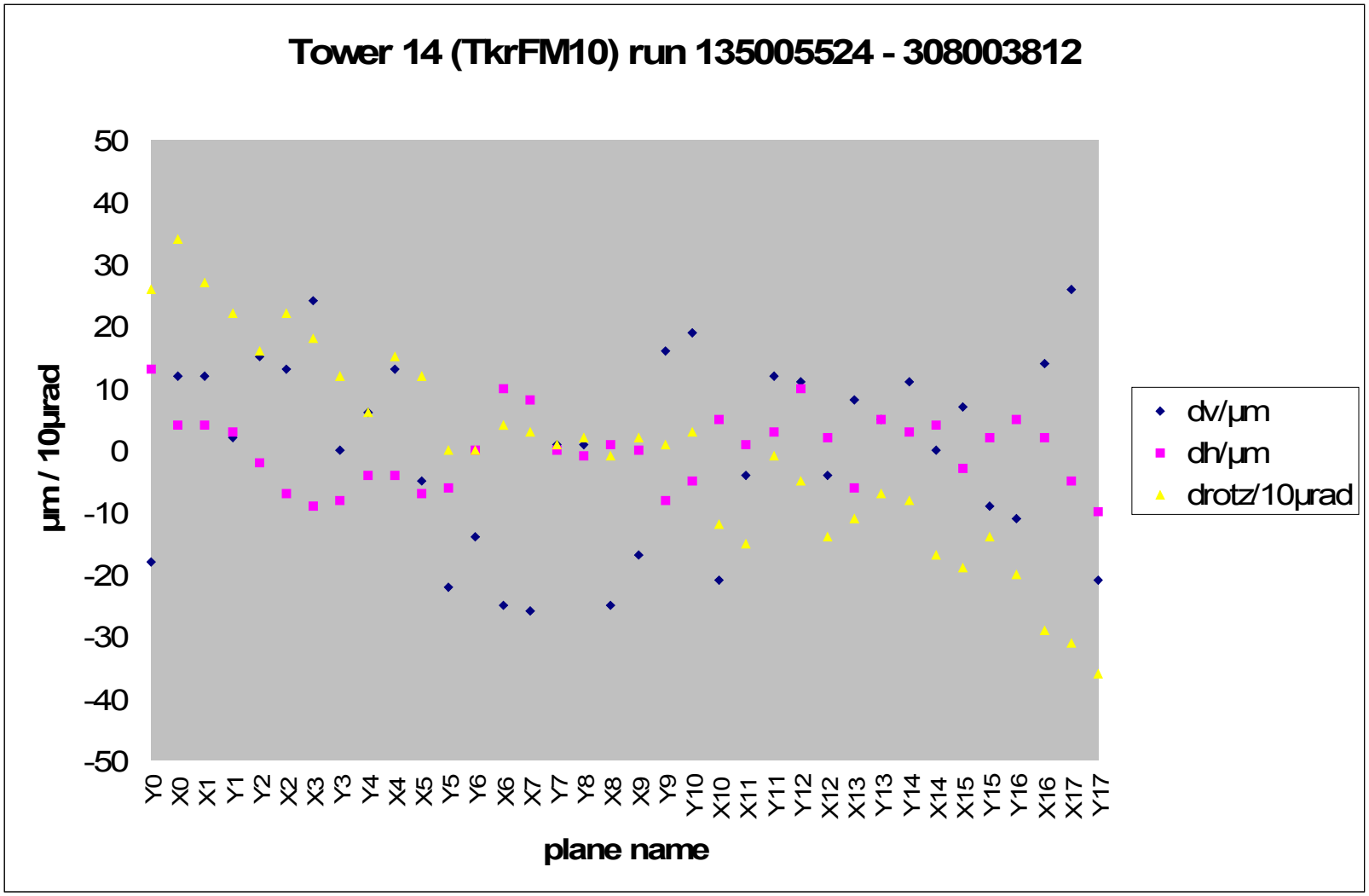
Intra-tower alignment results tower 12



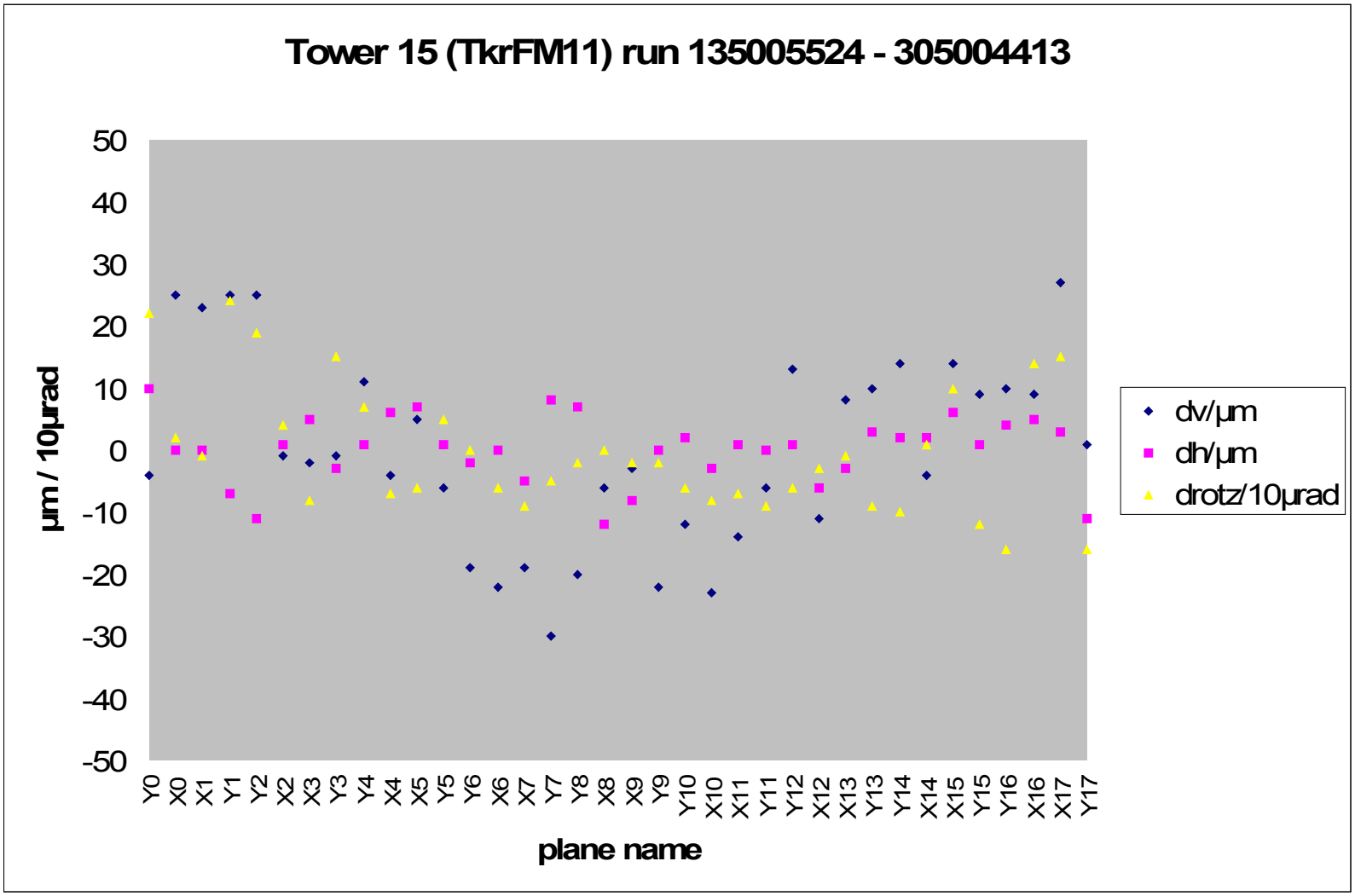
Intra-tower alignment results tower 13



Intra-tower alignment results tower 14



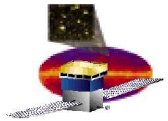
Intra-tower alignment results tower 15



The future of LeaningTower

- **(NEW!)** can handle multi-tower runs
- **(NEW!)** determines rotations properly
- doesn't handle single ladders/wafers
- introduces ambiguities for the resulting geometry
- people don't like it anyway

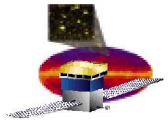
⇨ merge with AlignmentContainer!



AlignmentContainer

Johann started to code:

- tool filters recon files
  - 1 track
  - track contained in one tower (currently)
  - at least 36 hits on track
  - tries to select high-energy muons (based on `KalThetaMS` and `KalEne`)
  - residual calculated from TkrRecon results: `TkrHit::Measured-TkrHit::Predicted` (problem: residual for first plane of the track is always 0)
  - saves residual and slope to a root file
- python script reads the root file, and performs the alignment (cloned from LeaningTower)
- doesn't iterate yet



Comparison of methods

- Pisa: uses 100k events (35k good tracks), 1h for TkrRecon, alignment iterative (6min), typically 30 – 40 iterations
- Johann/AlignmentContainer: should use 100k events, alignment iterative (1h for TkrRecon, some mins for alignment)
- Hiro: fits tracks from the data stream, not iterative, no extra time required, surprisingly good

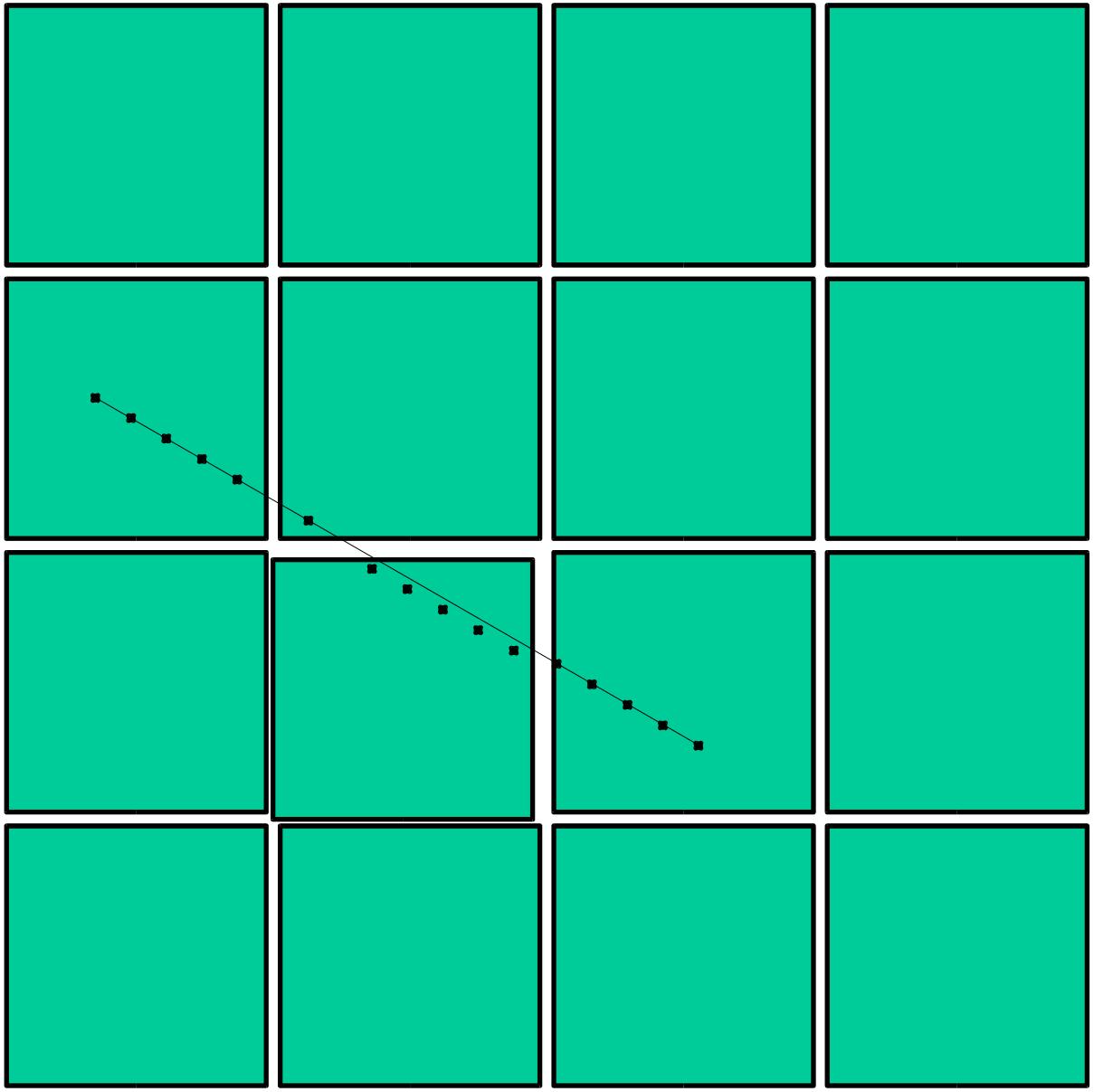
Intra-tower alignment blindness (revisited)

Intra-tower alignment is blind versus:

- translation
- shearing
- vertical scaling (horizontal is fixed by strip dimensions)
- rotation
- translation of the planes of one view vs. the other
- rotation of the planes of one view vs. the other

⇨ Inter-tower alignment

Translation



Intra-tower alignment:

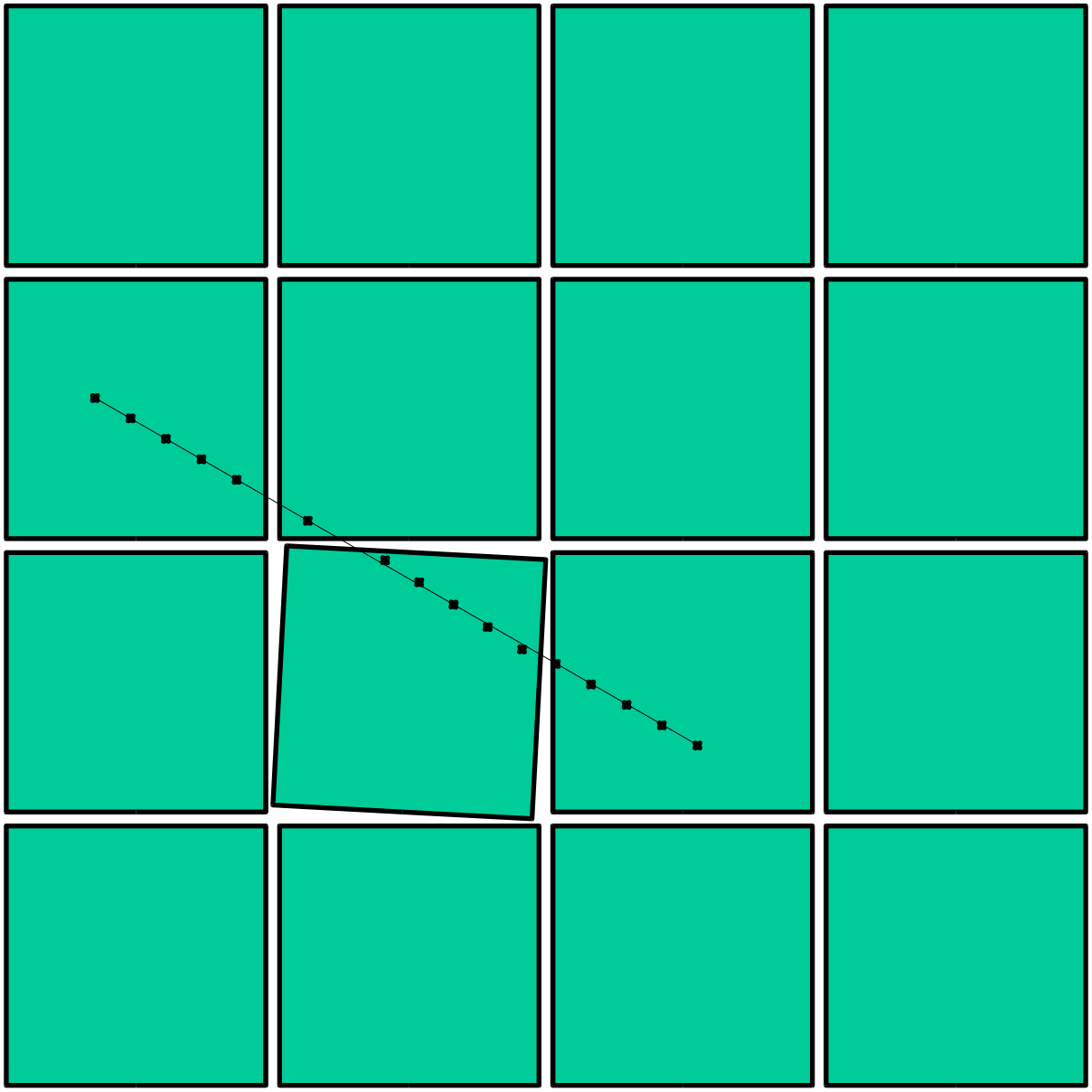
absolute position of a single tower is ambiguous

Inter-tower alignment:

tracks passing tower gaps fix the relative positions

⇨ **SOLVED**

Rotation



Intra-tower alignment:

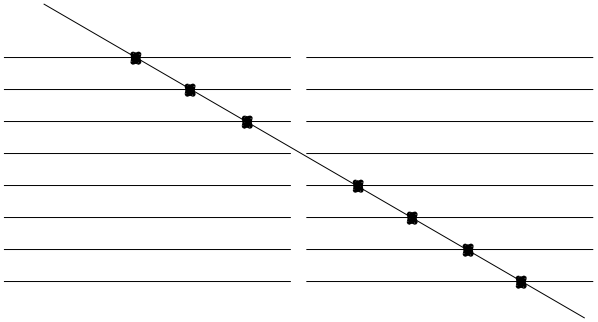
rotation of a single tower with respect to some coordinate system is ambiguous

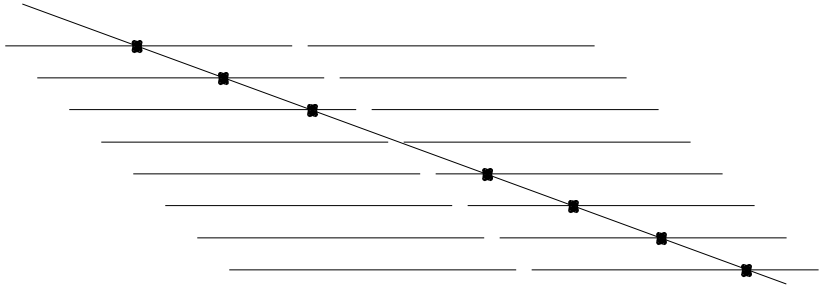
Inter-tower alignment:

tracks passing tower gaps fix the rotation of one tower vs. the others

⇨ **SOLVED**

Shear

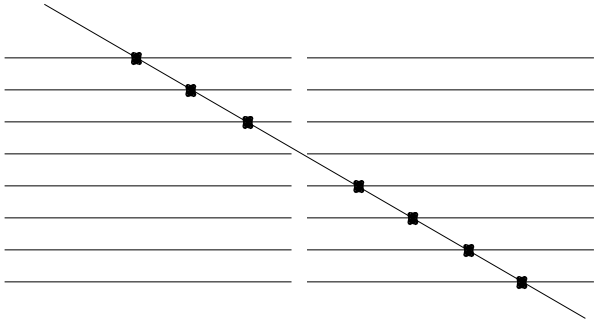


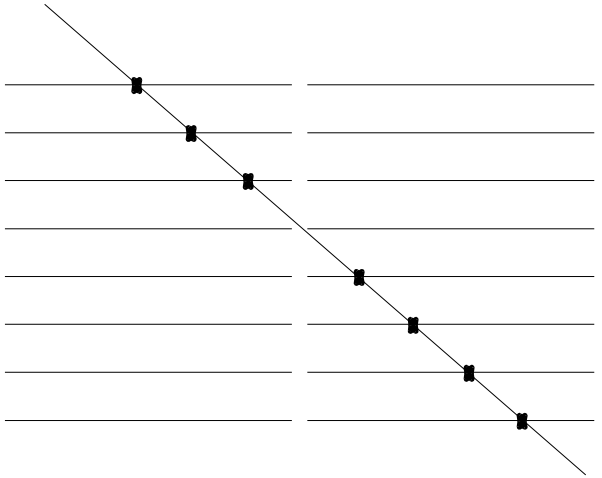


There is no way to correct for common shear from data!

- Metrology measurements?
- Average over all TkrFM's?
- Do we care? 50μm vs. 554mm for a perpendicular track = 0.1mrad (20arcsec)

Vertical Scale





There is no way to correct for a common vertical scale from data!

- Metrology measurements?
- Average over all towers?
- Do we care? 70μm vs. 554mm for a 45° track = 0.1mrad
- Can we look at some bright sources (Crab et al.)?

Intra-tower alignment blindness (re-revisited)

Intra-tower alignment is blind, but inter-tower alignment …

gives:

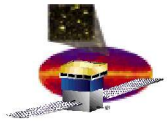
- ✓ translation
- ✓ rotation

gives more or less:

- ✓ shearing
- ✓ vertical scaling

but it doesn't say anything about:

- ❑ translation of the planes of one view vs. the other
- ❑ rotation of the planes of one view vs. the other

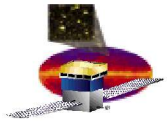


Inter-tower alignment

- started long time ago by Hiro (intra-tower too)
- restarted by Tracy (AlignmentContainer)
- recently revived by Johann

- handles only two towers at a time (a reference tower, and a second tower to be aligned)
- track through both towers gets split into two
- track segment in reference tower gets refit
- new track is compared to track segment in the second tower

Status: does something, but results are not consistent when switching reference and second tower



Conclusions

- **Misalignment has an impact on data analysis!**
- LeaningTower:
  - aligns planes vertically and horizontally with high accuracy
  - determines rotations around z properly **(NEW!)**
  - can handle multi-tower runs **(NEW!)**
  - doesn't do some things (yet)
  - needs help from inter-tower alignment
  - TkrAlignmentSvc files are available, and **(NEW!)** the signs are validated
- **Actions items:**
  - Intra-tower: implement the method of LeaningTower in a proper way
  - Inter-tower: fix the bugs in the code
  - How do we feed the alignment constants into the analysis? Calibration database?