GUIDE3 and GUIDE7 desimeter ‘metrology’ with Gaia cross-matches

sample of GFA reductions

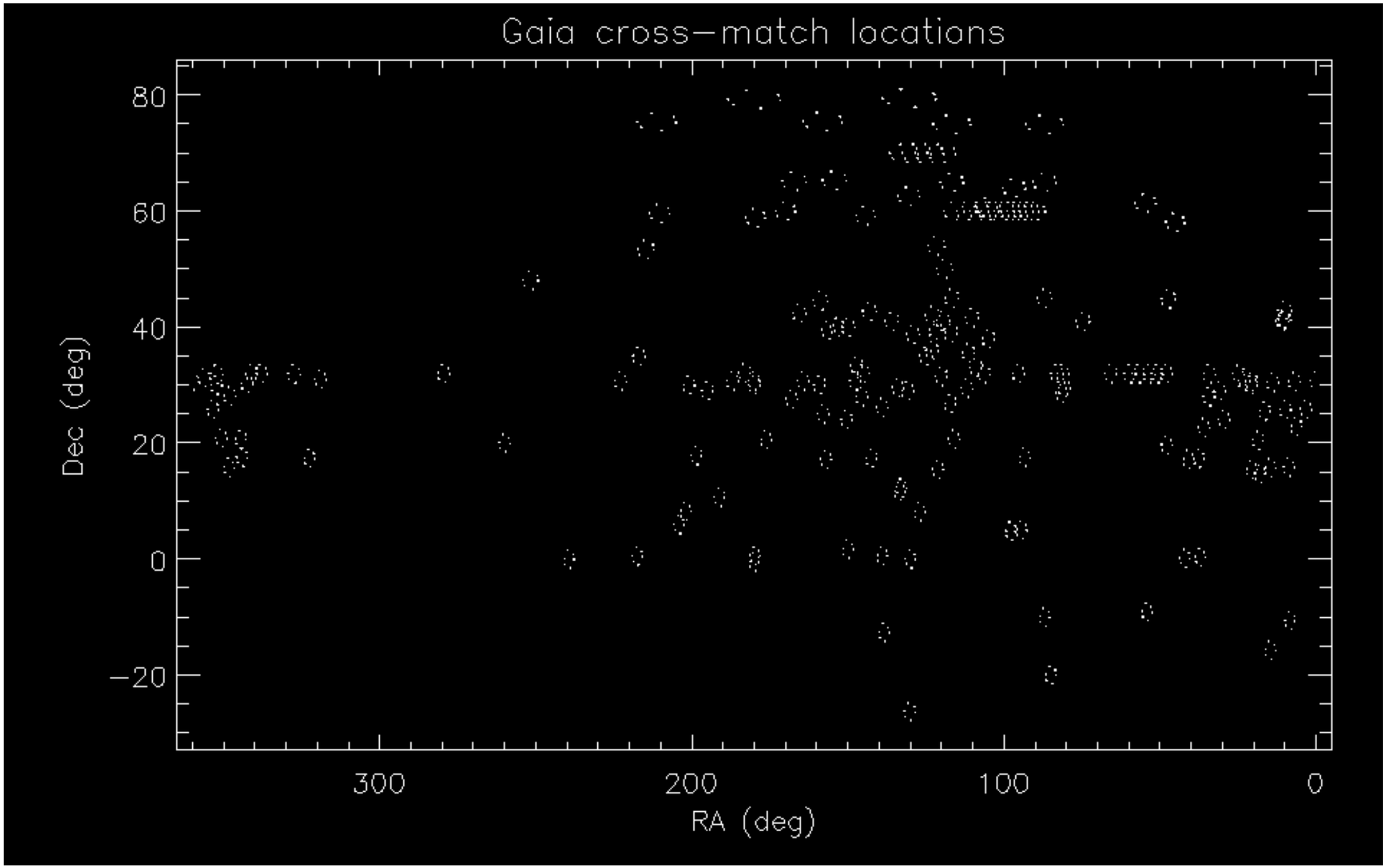
- Use first frame of each guide cube throughout DESI commissioning

- Restrict to the subset with WCS recalibration pattern matching CONTRAST > 2 in all 6 guide cameras

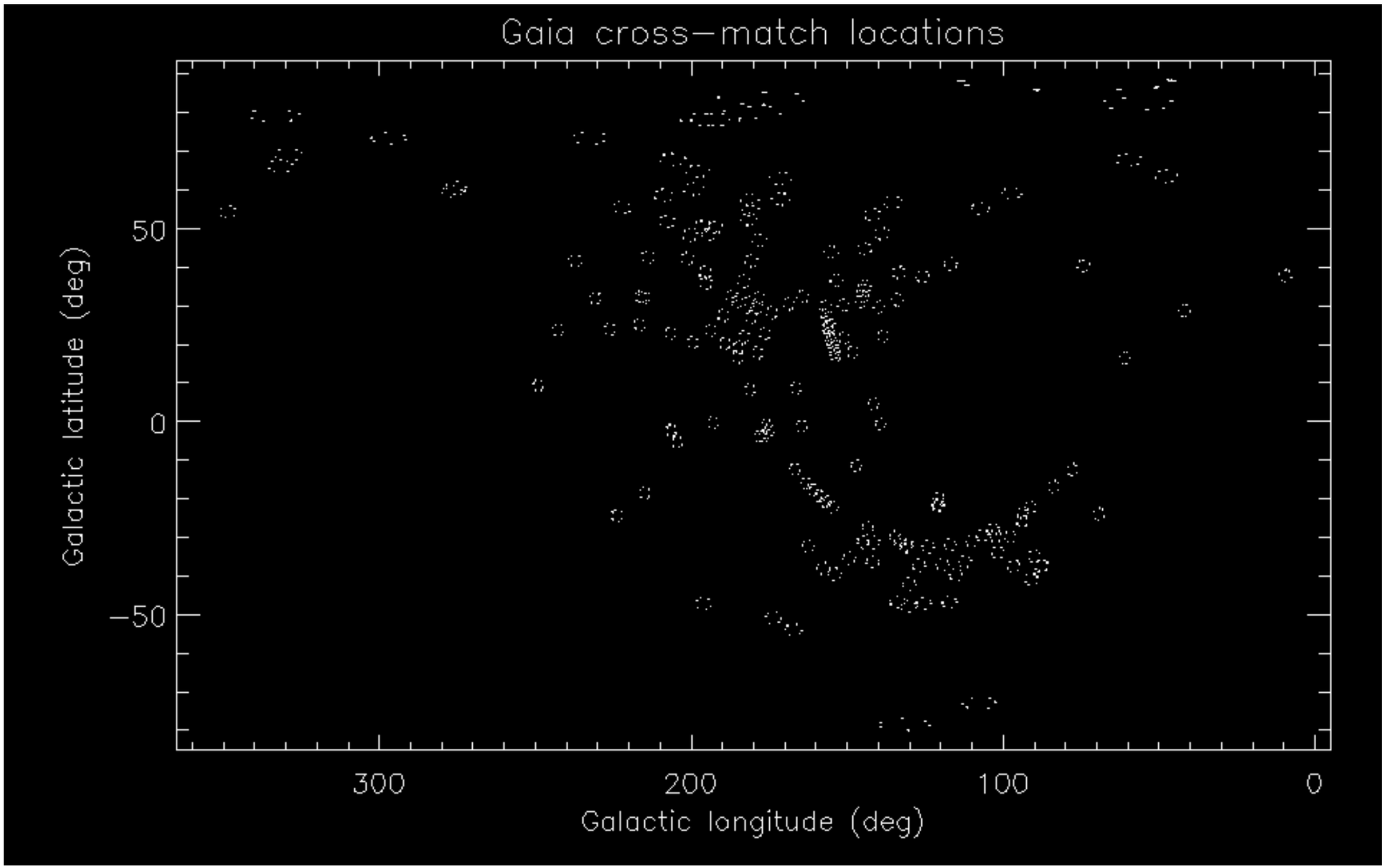
- 2044 GFA exposures from 91 unique DESI observing nights, spanning 20191023 (first night of GFA guiding) to 20200315 (final night of DESI commissioning)

- 8 of these crash in desi_fit_guide_star_coordinates due to missing ADC header information in raw guide cubes

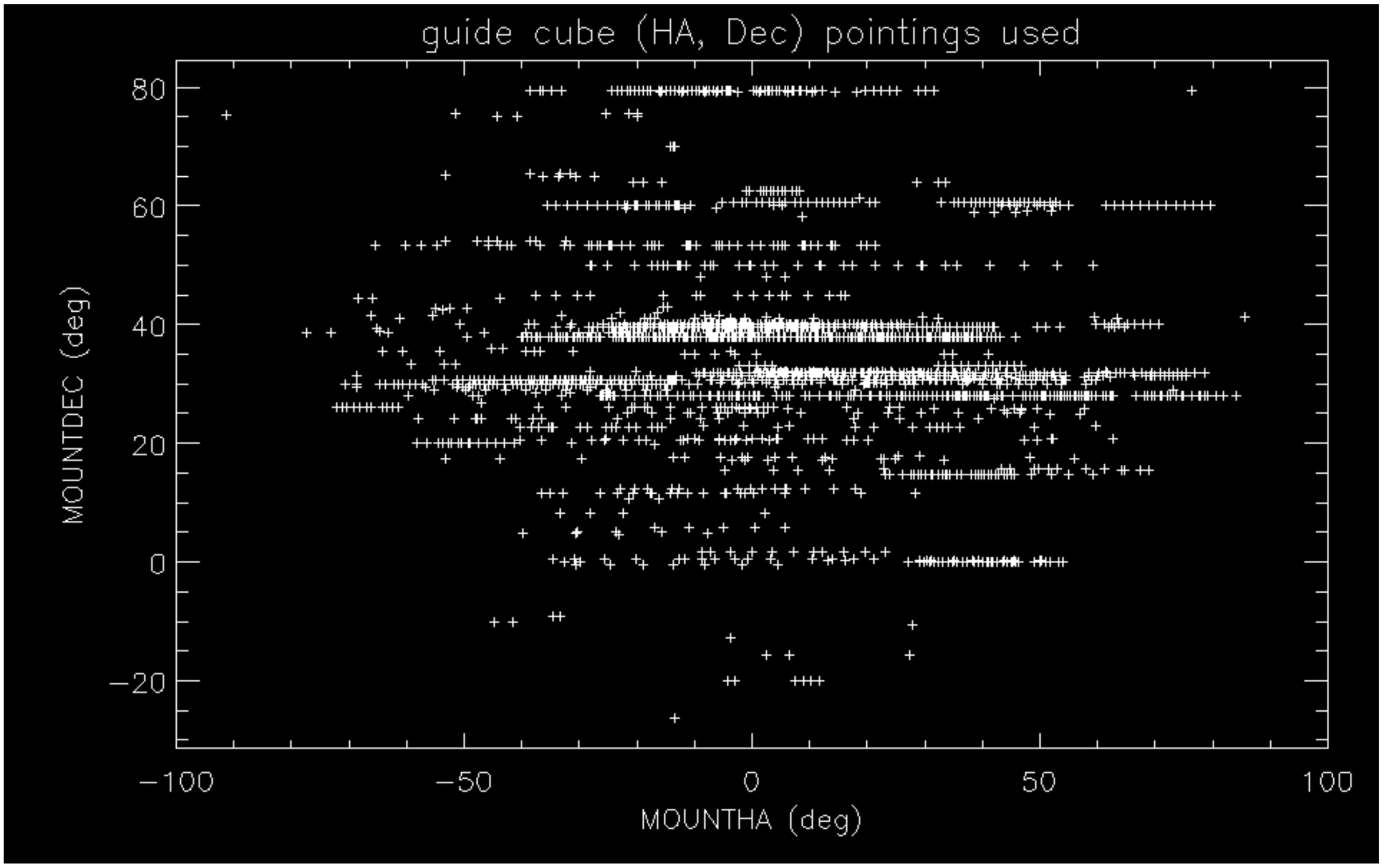
sample of GFA reductions



sample of GFA reductions



sample of GFA reductions



getting focal plane and petal coordinates for Gaia stars

- Created a modified version of Julien's desi_fit_guide_star_coordinates script that fits a FieldModel object using the guide cameras present already in fp-metrology.csv

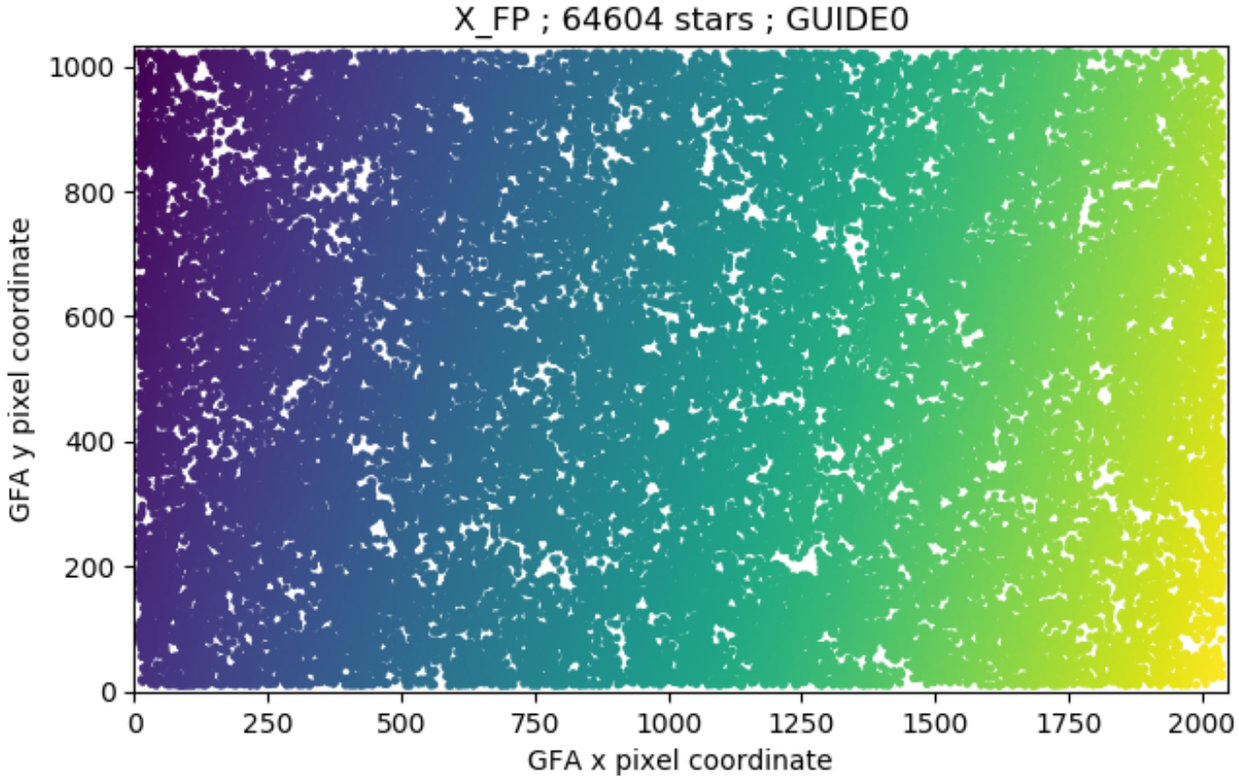
- Use FieldModel object to translate (ra_gaia, dec_gaia) for good cross-matches (< 2 asec) into (X_FP, Y_FP, X_PTL, Y_PTL, Z_PTL) for ***all*** guide cameras, including those without metrology in fp-metrology.csv

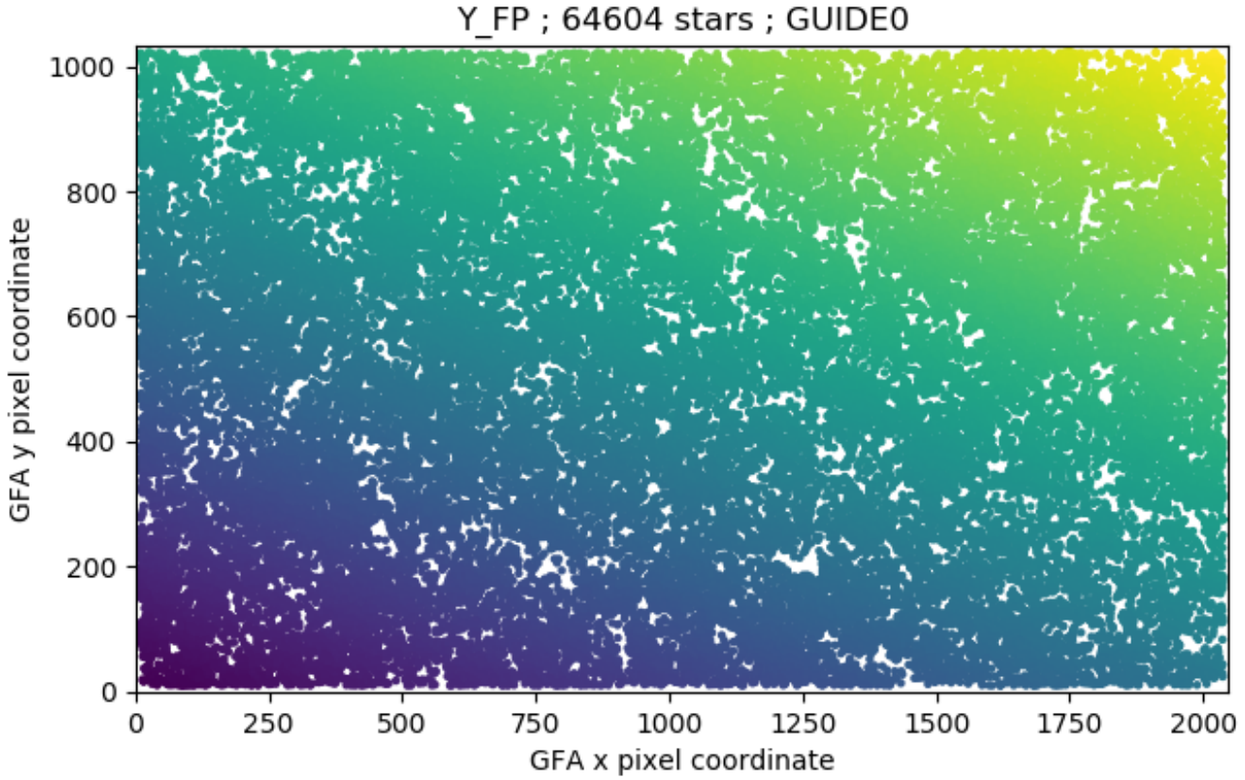
quality cuts

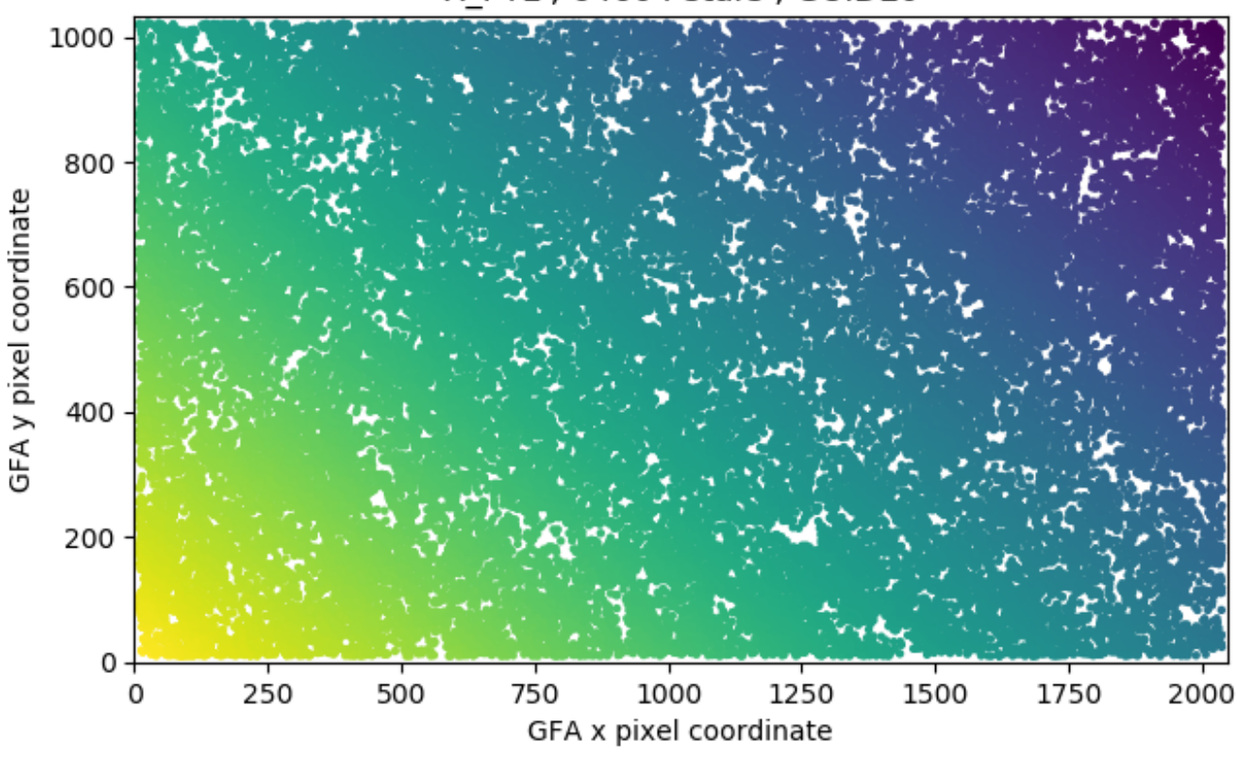
- Initially wanted to make a cut on FieldModel RMS_ARCSEC value but forgot to do this

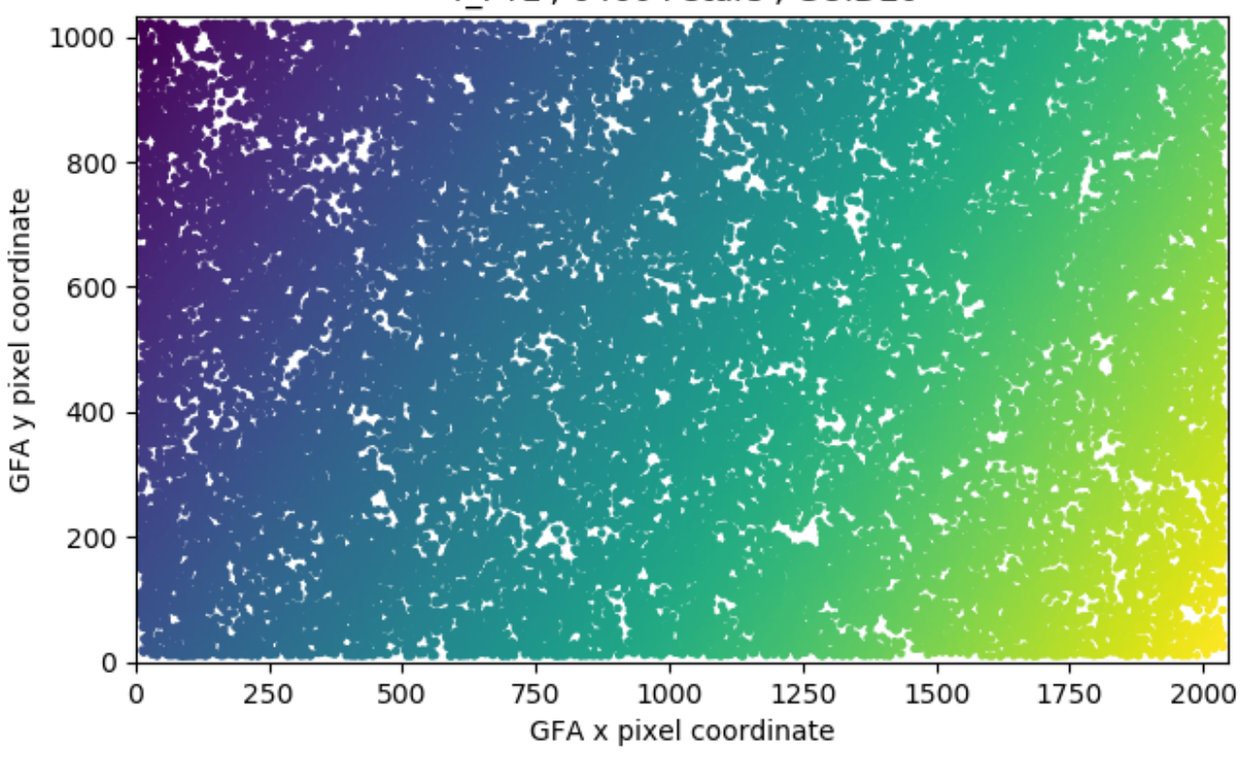
- Require Gaia stars to have gfa_reduce (min_edge_dist_pix > 10) and (dq_flags == 0)

results: FP and PTL coordinates as a function of GFA pixel coordinates [data]

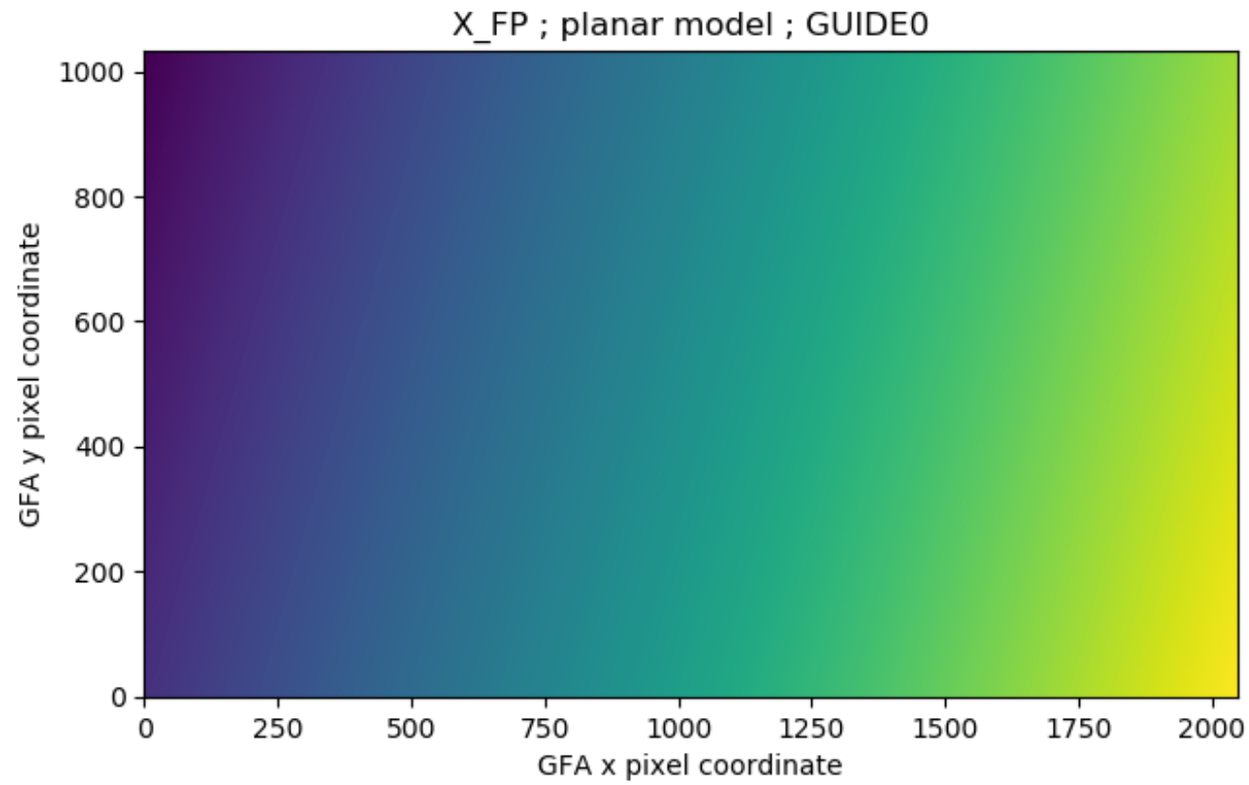


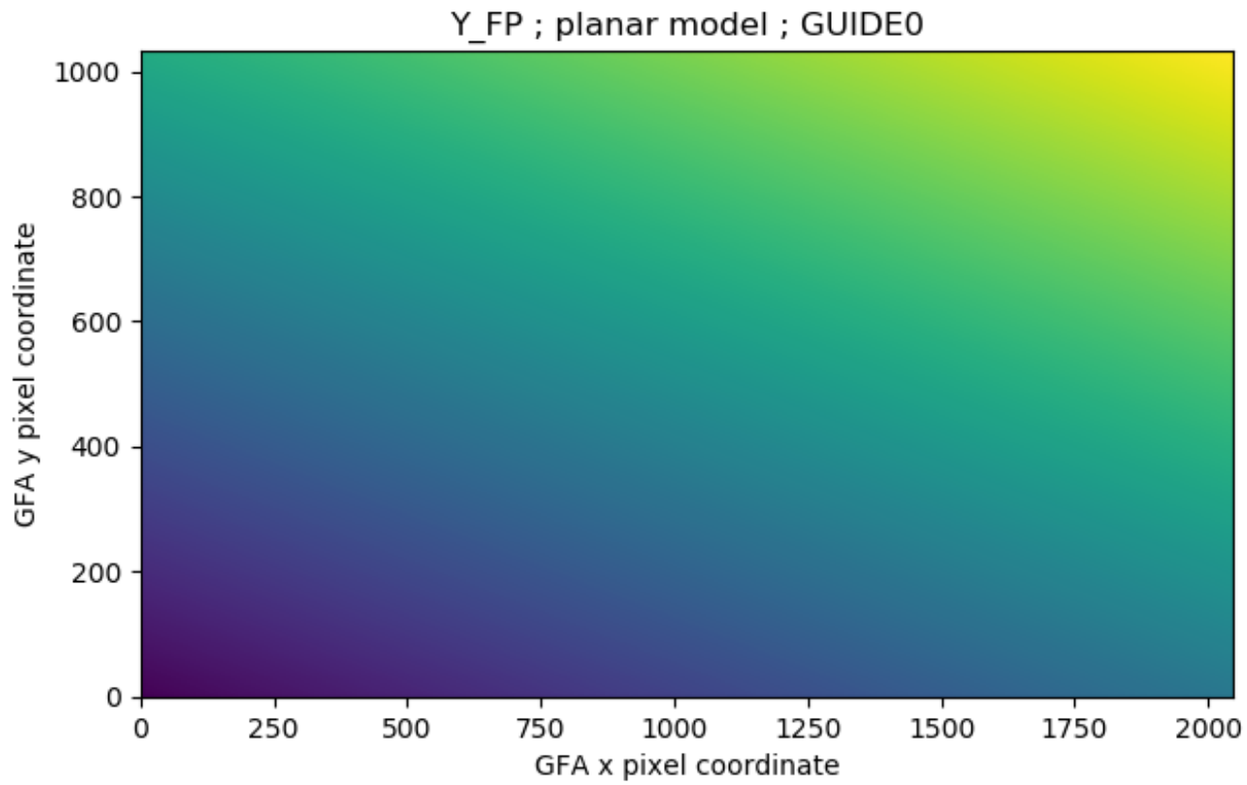


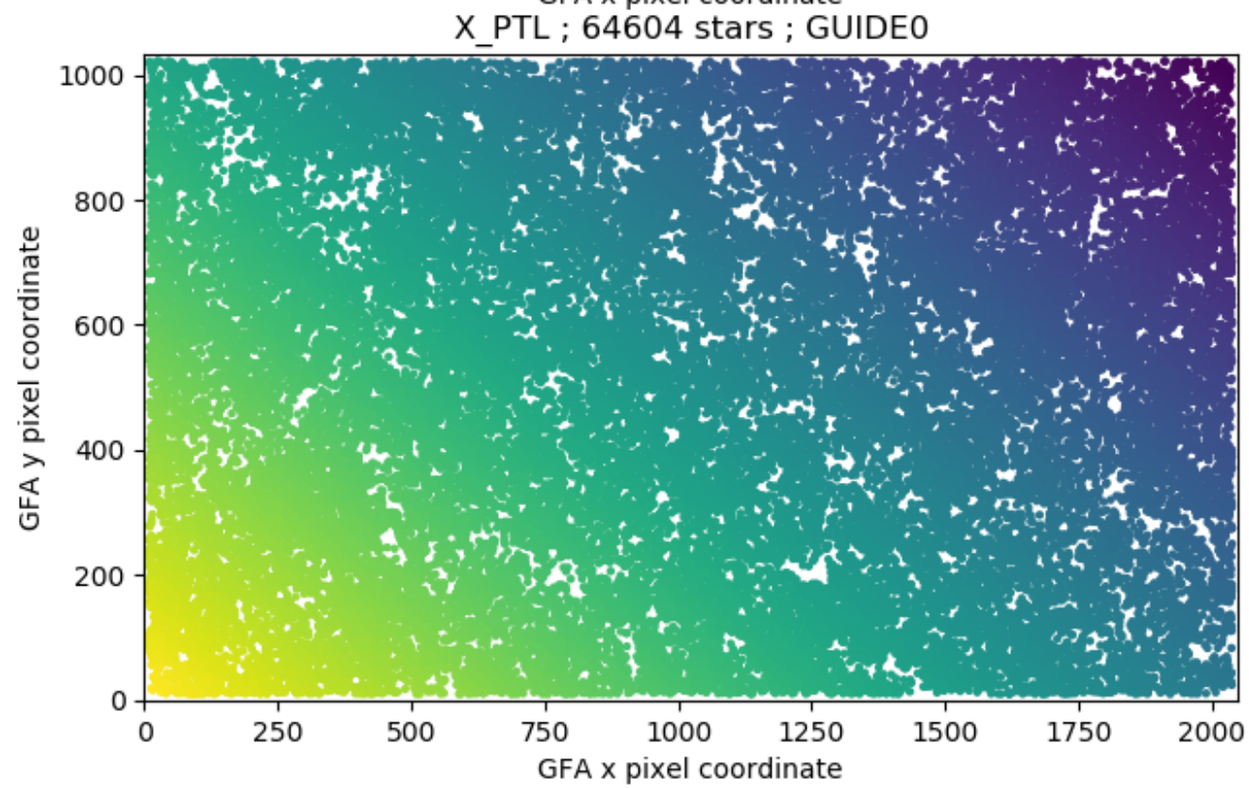


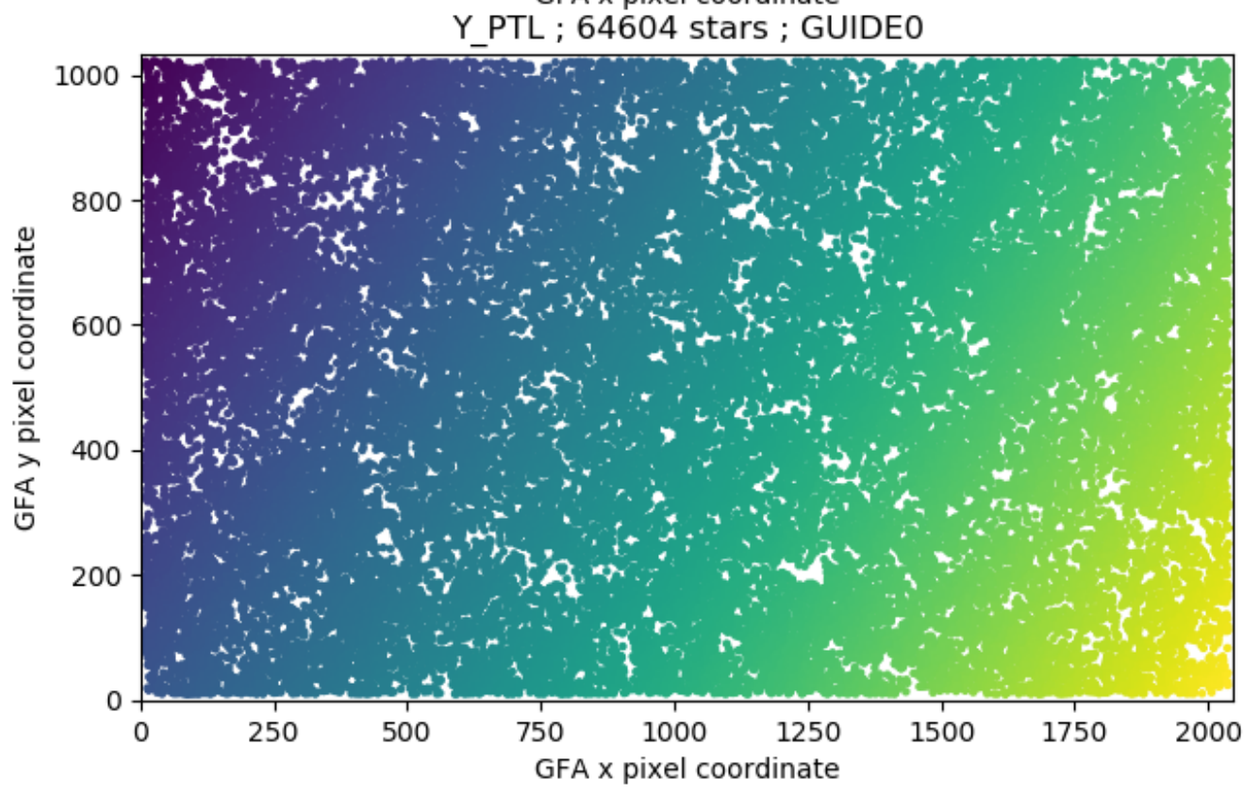


results: FP and PTL coordinates as a function of GFA pixel coordinates [planar model]

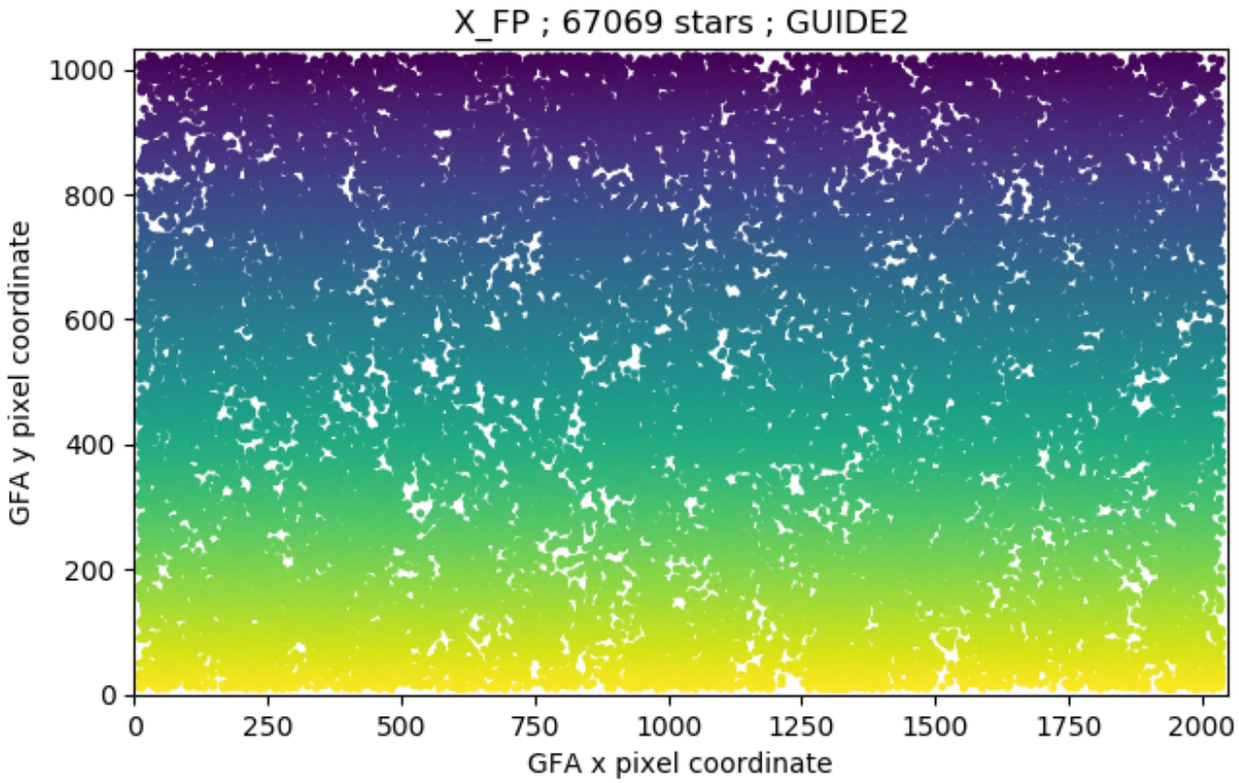


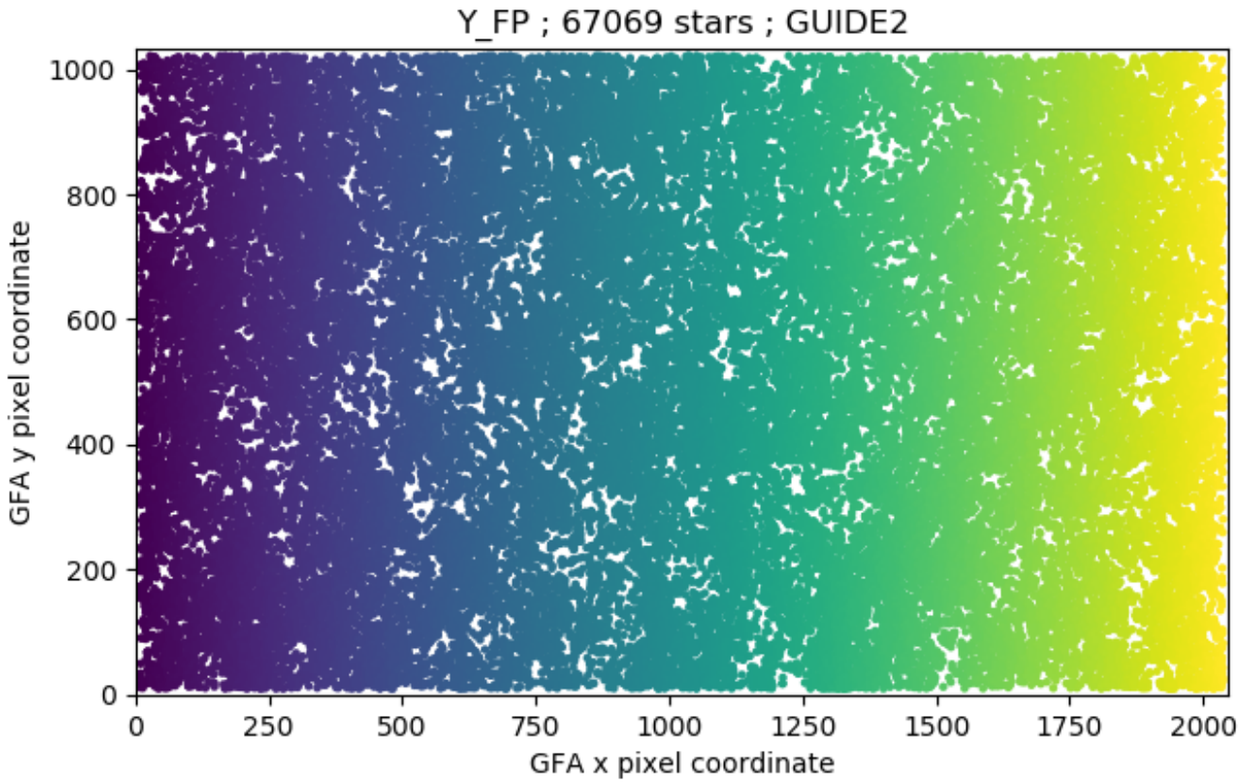


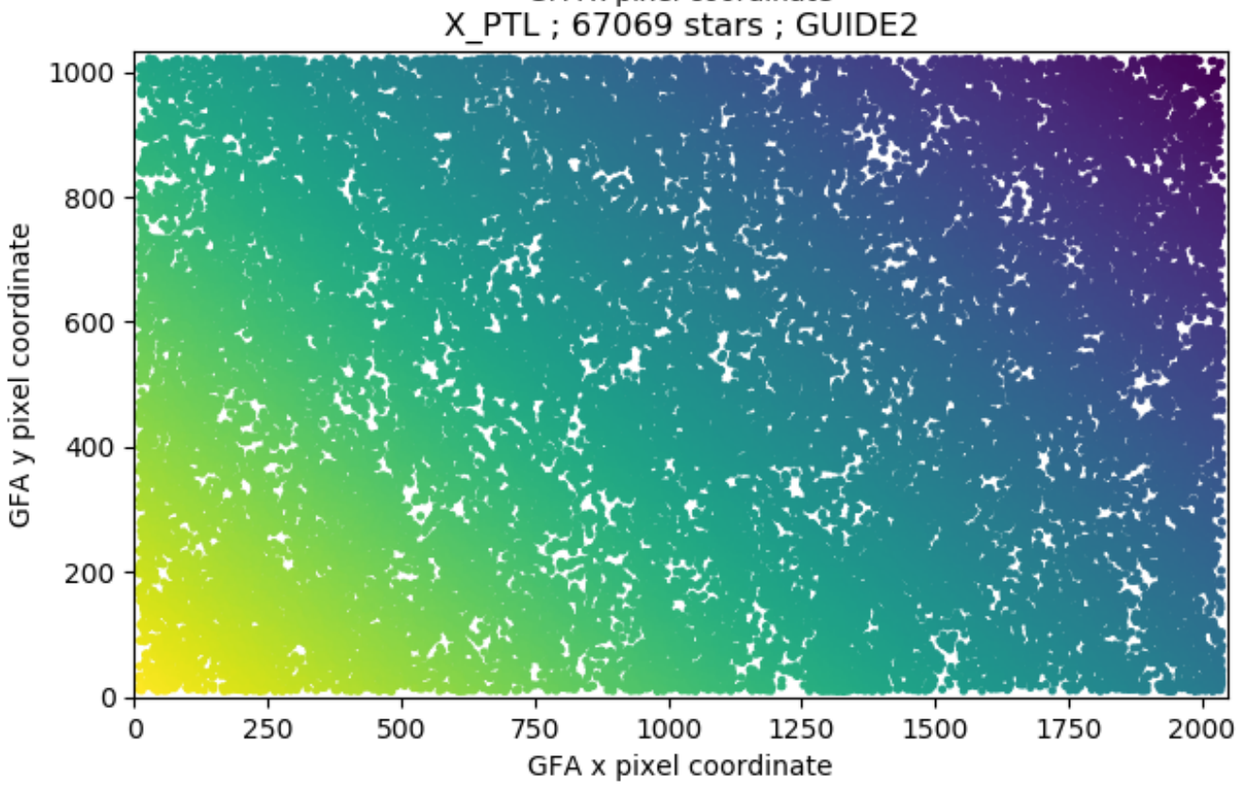


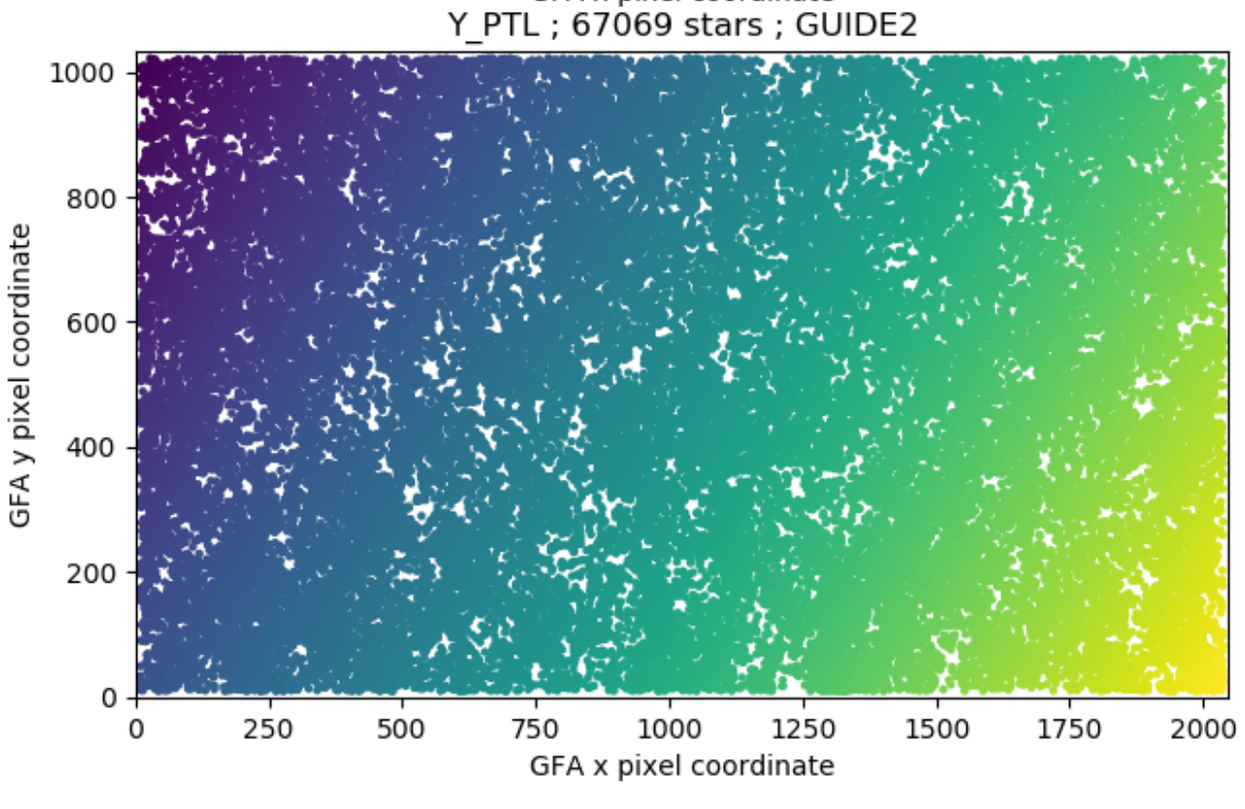


results: FP and PTL coordinates as a function of GFA pixel coordinates [data]

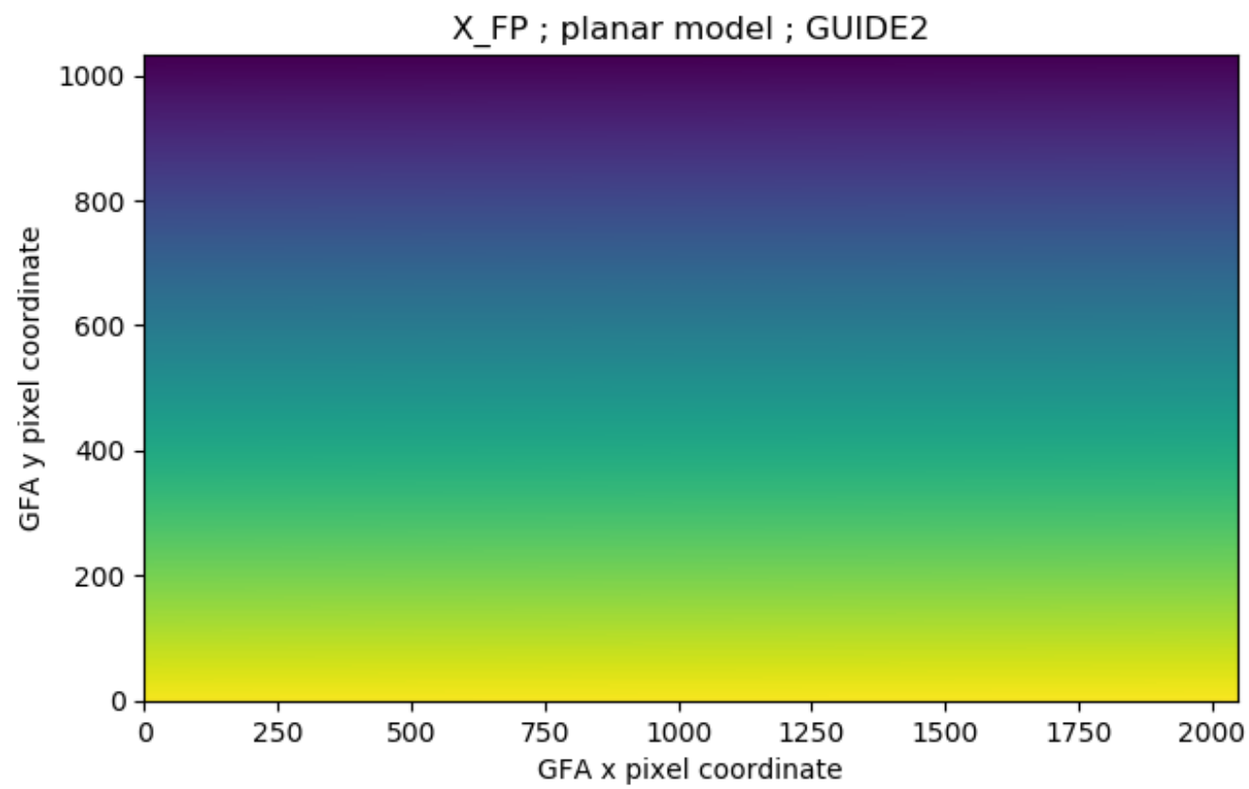


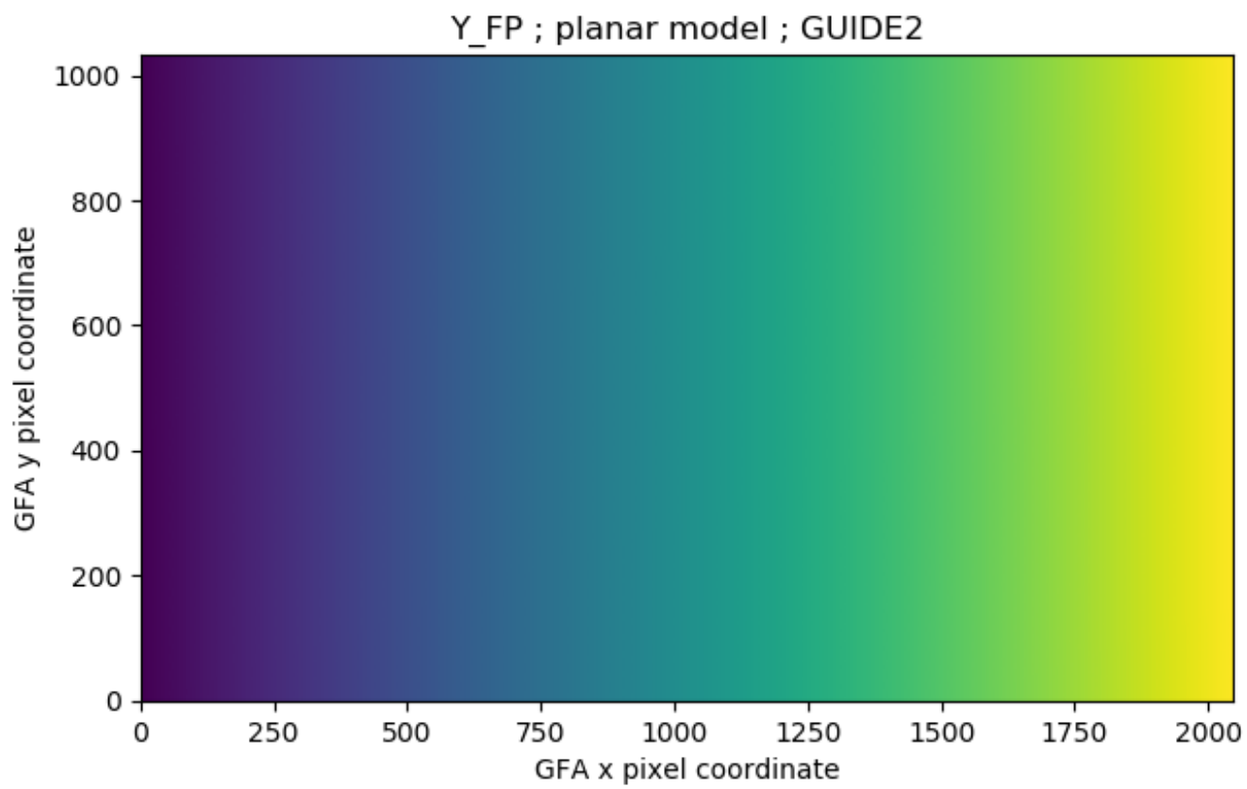


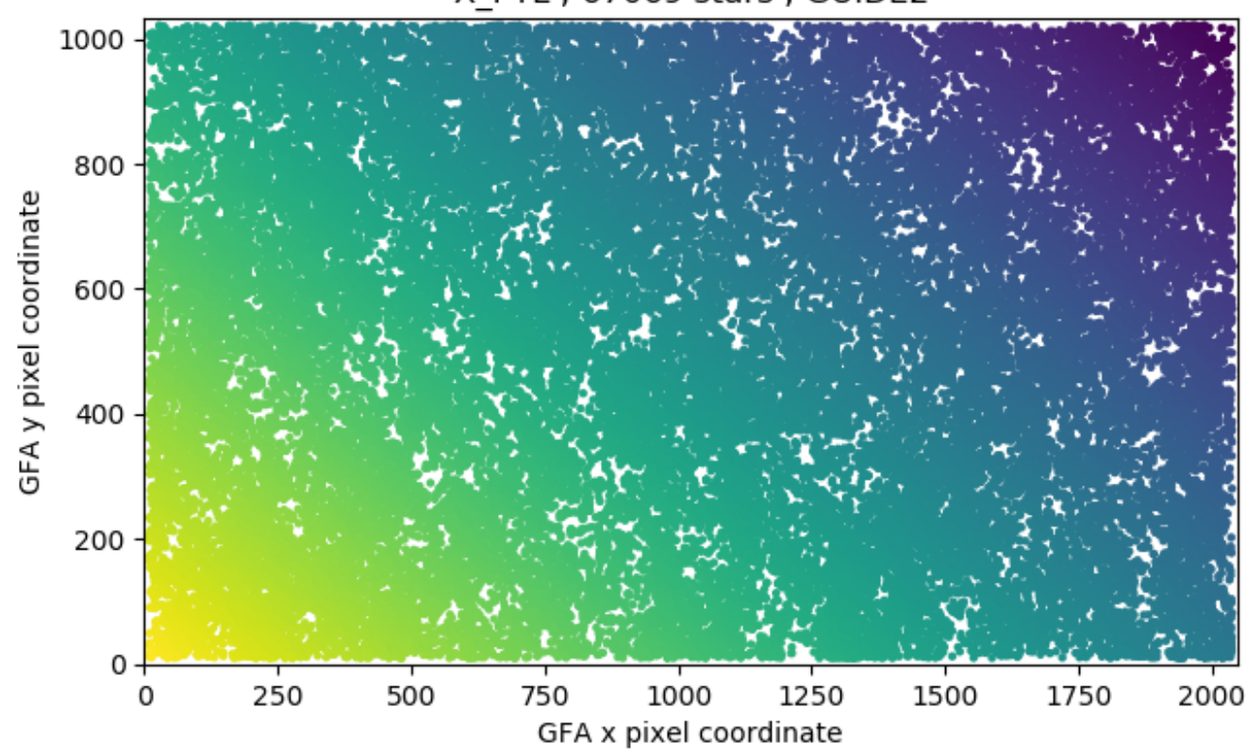


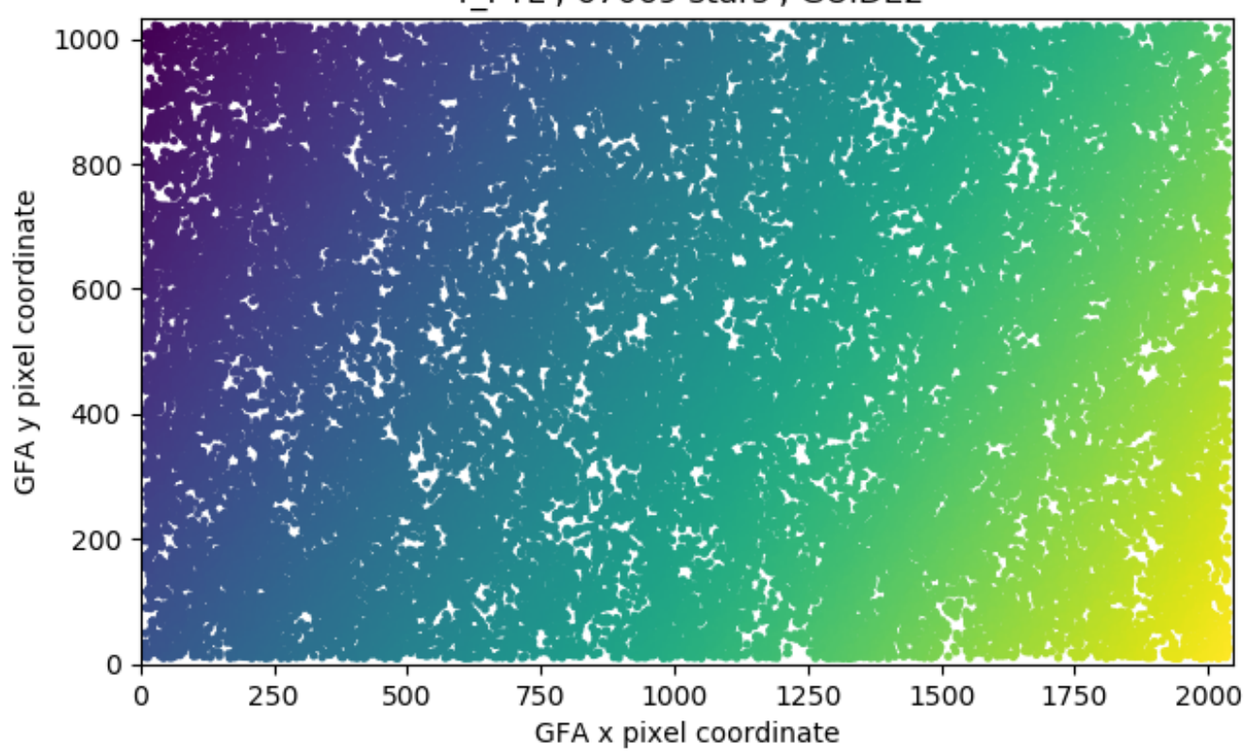


results: FP and PTL coordinates as a function of GFA pixel coordinates [planar model]

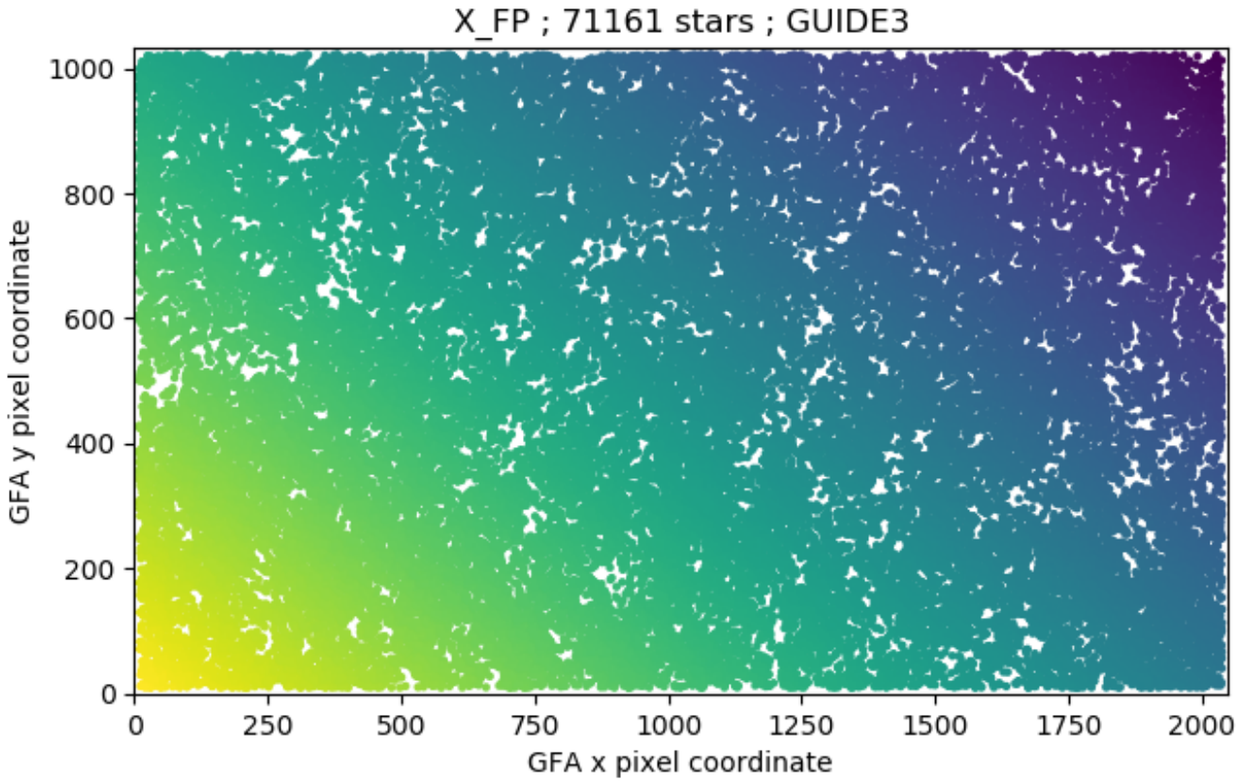


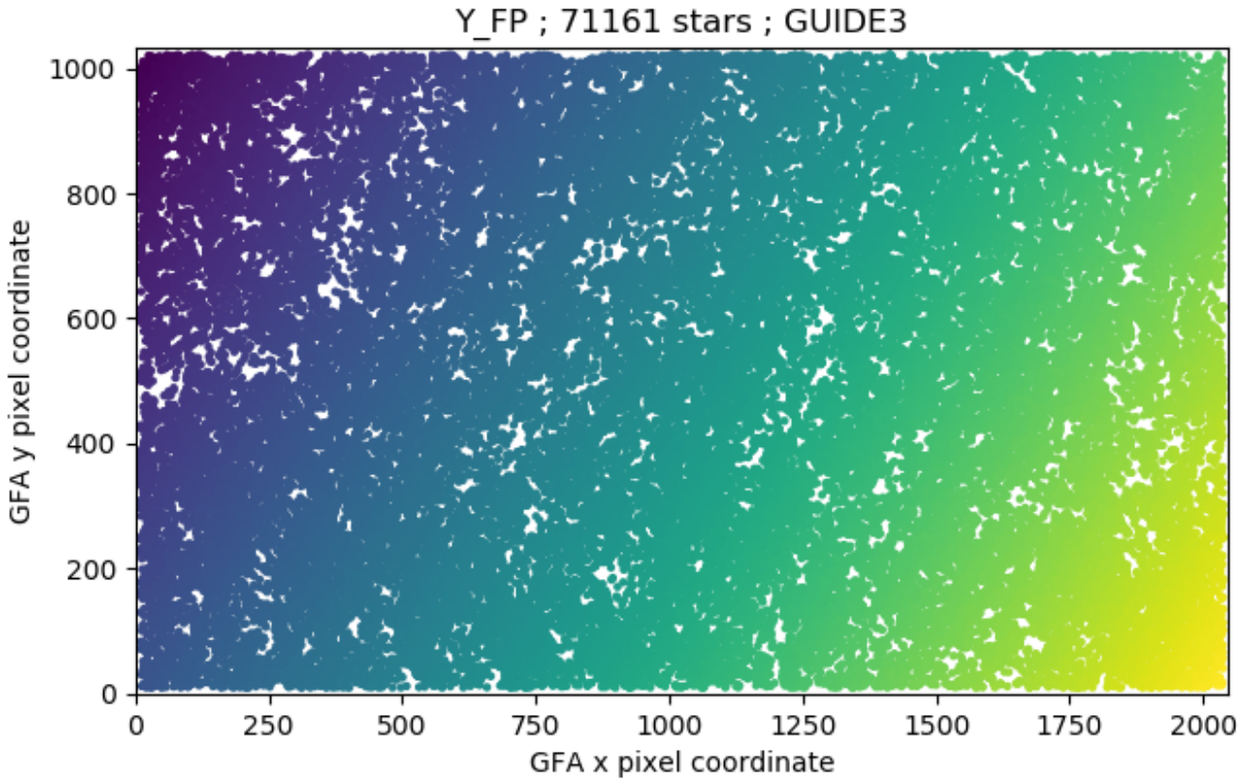


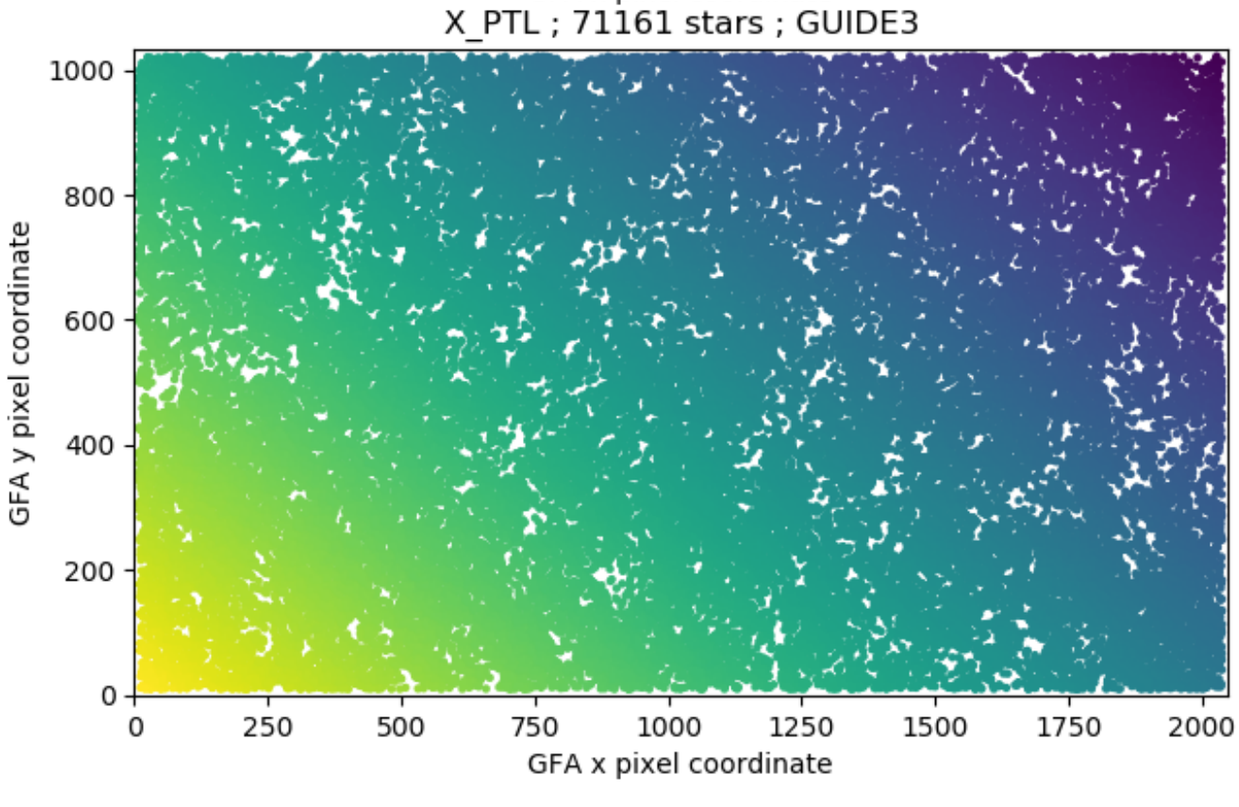


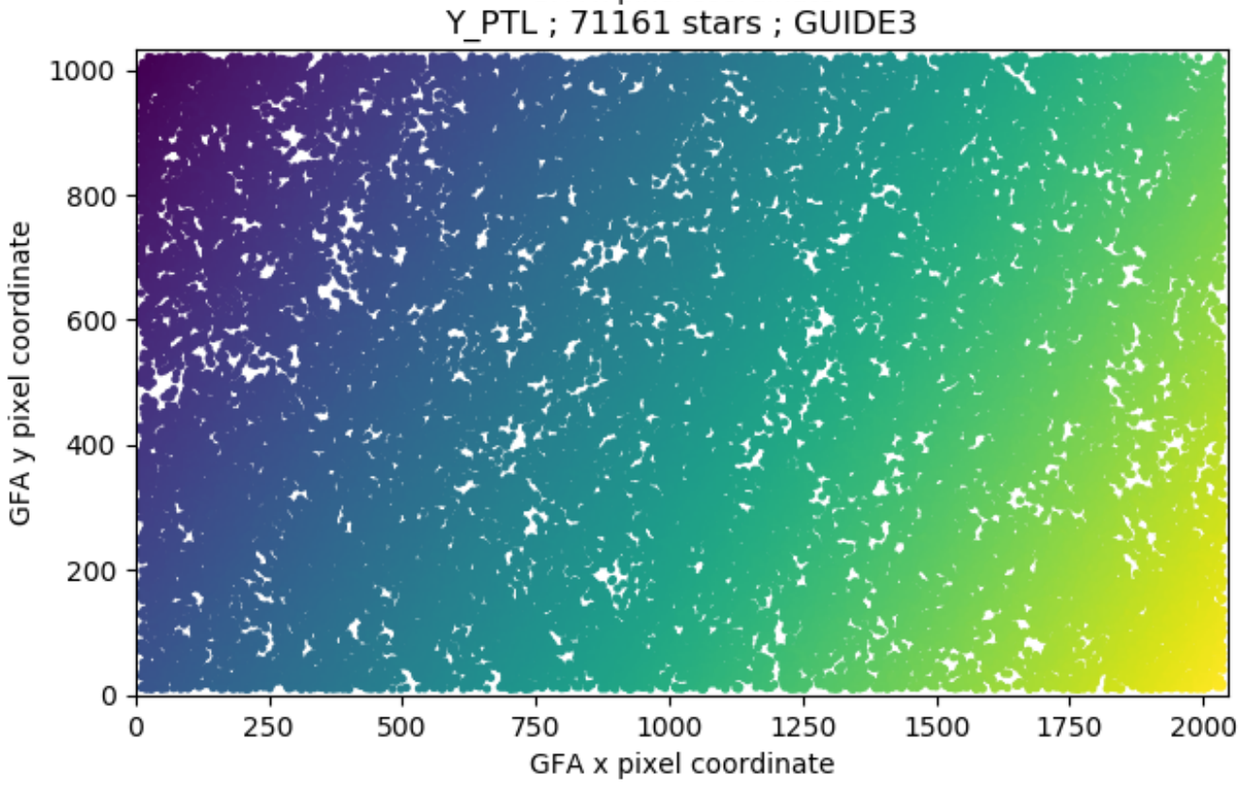


results: FP and PTL coordinates as a function of GFA pixel coordinates [data]

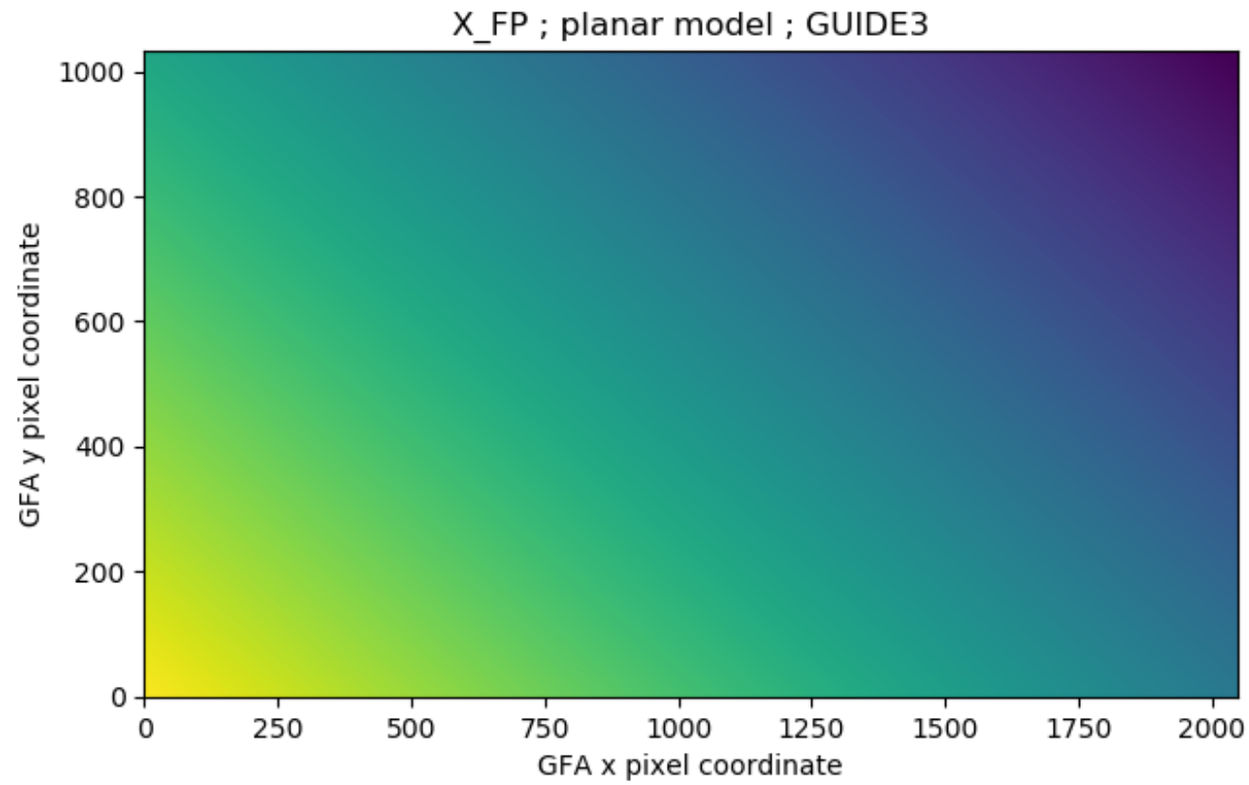


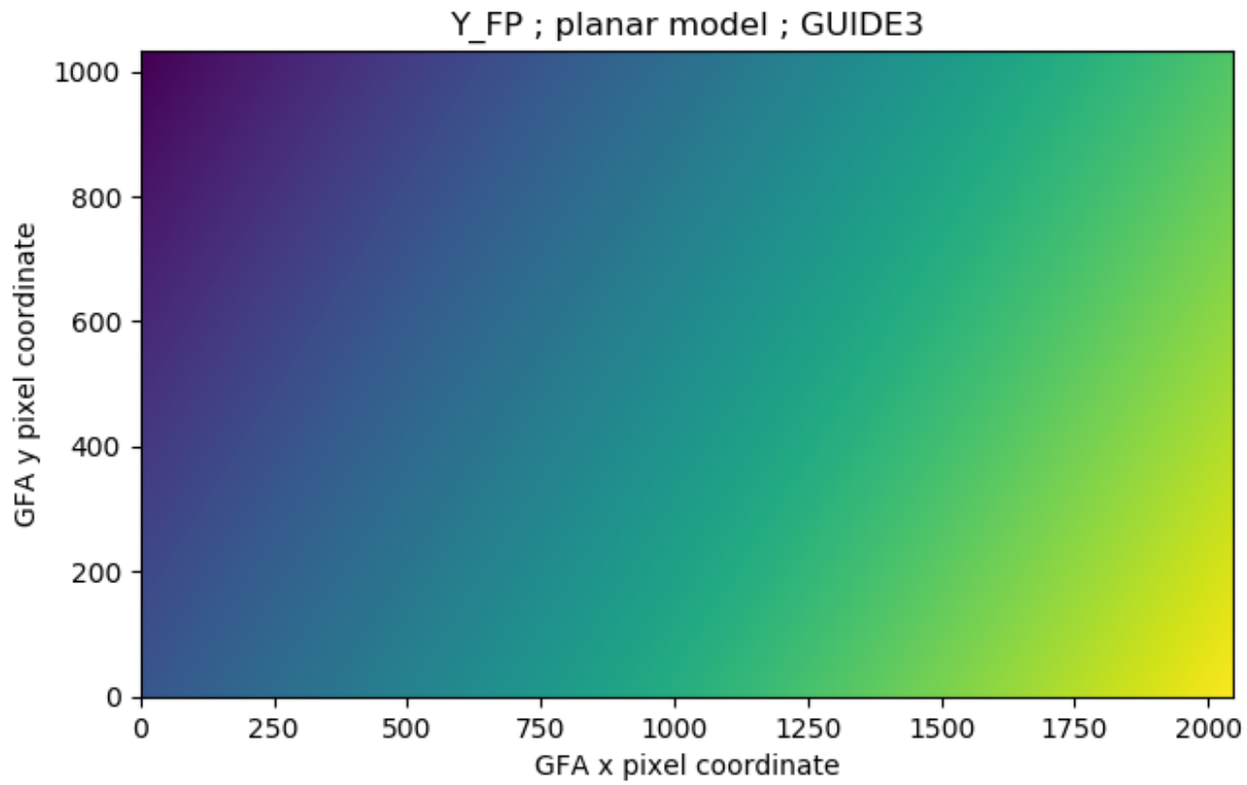


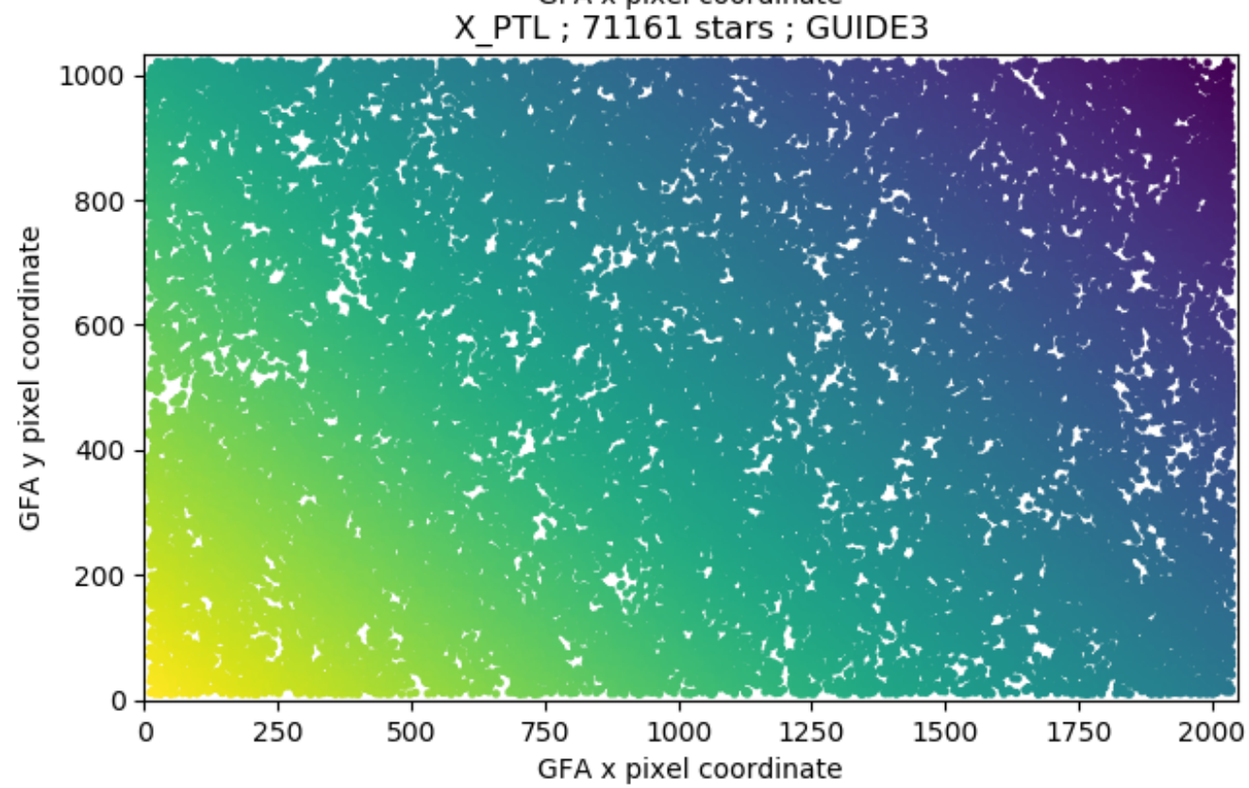


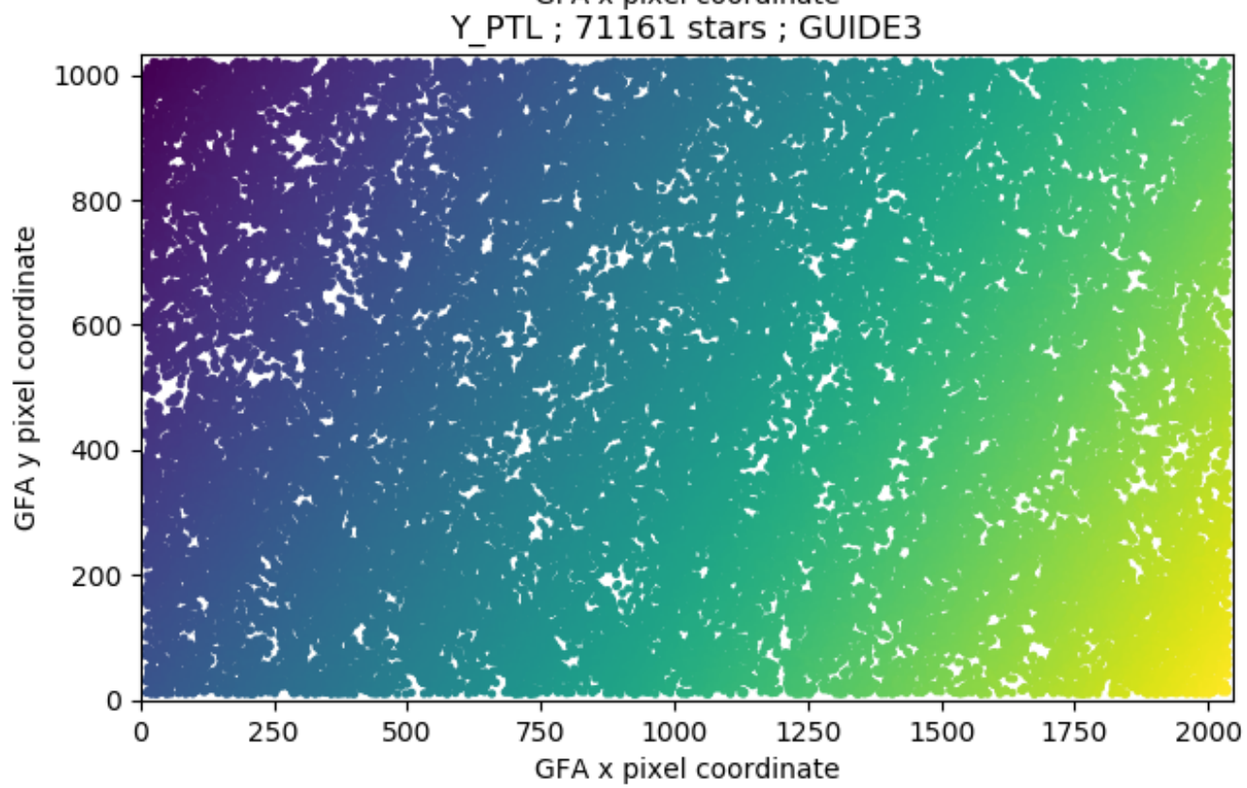


results: FP and PTL coordinates as a function of GFA pixel coordinates [planar model]









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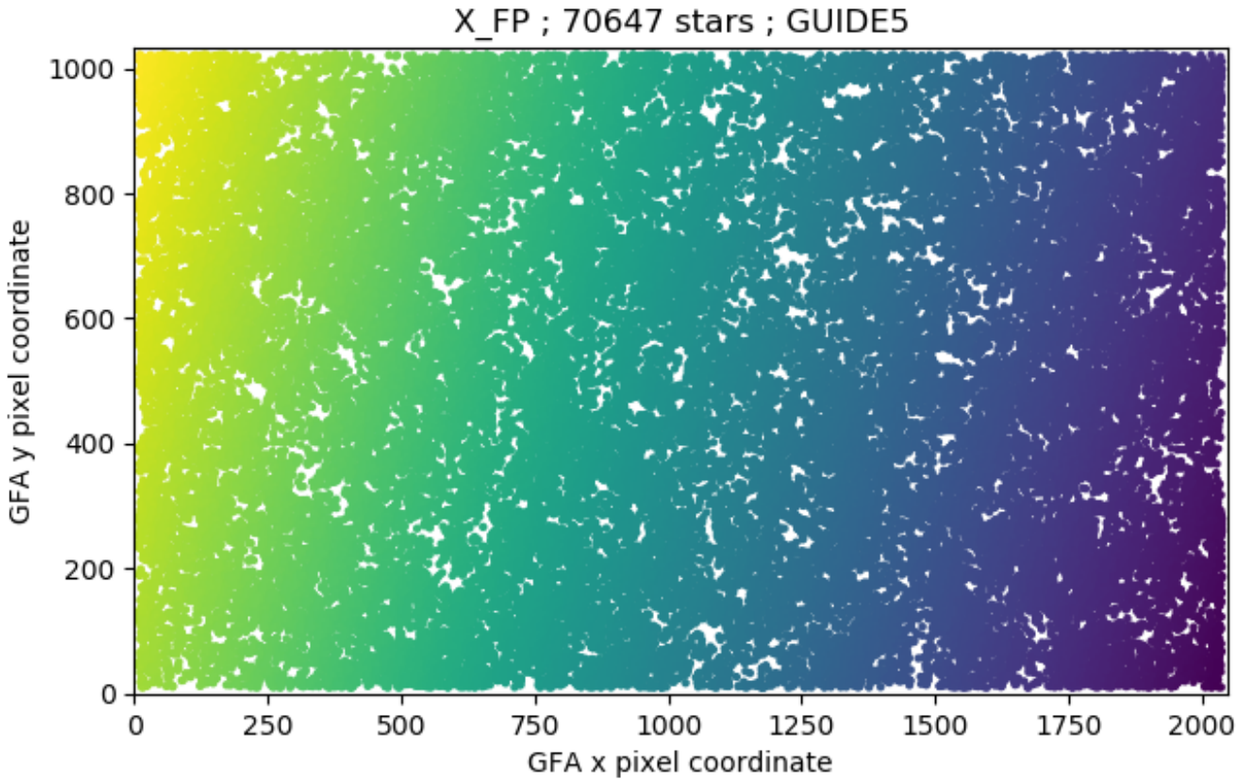
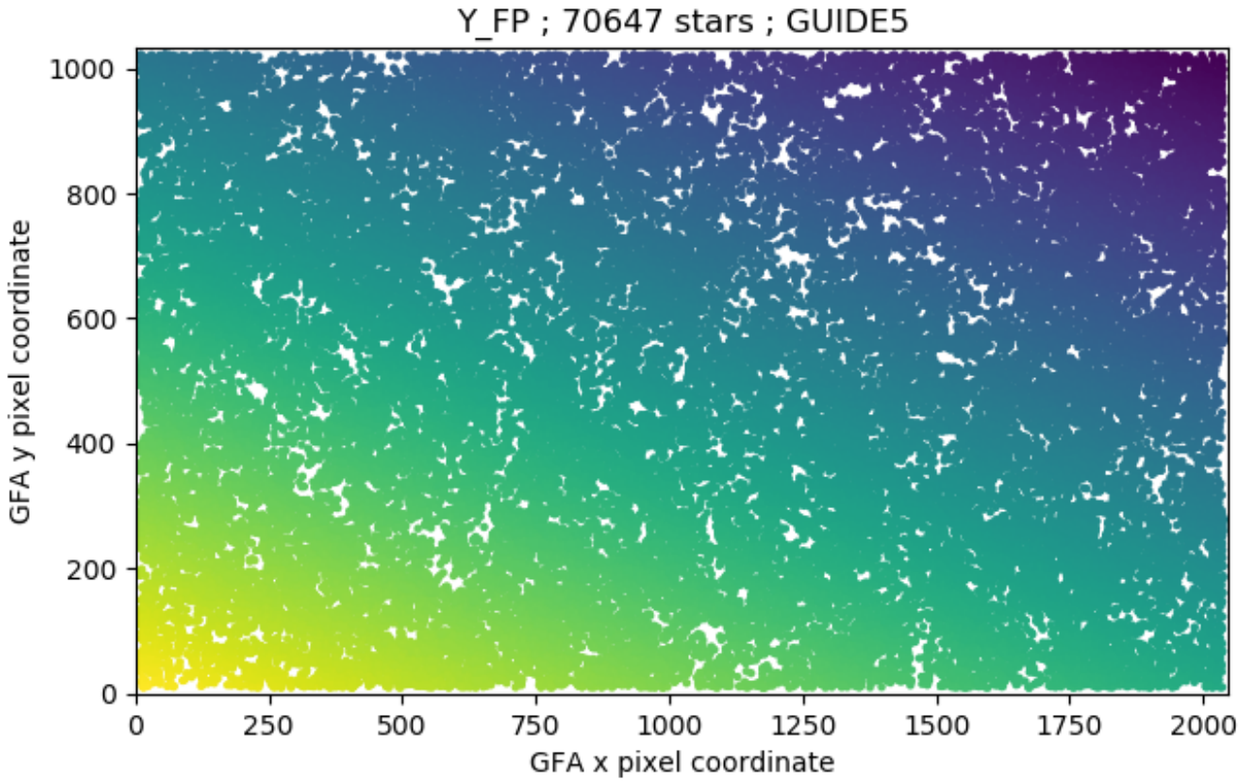
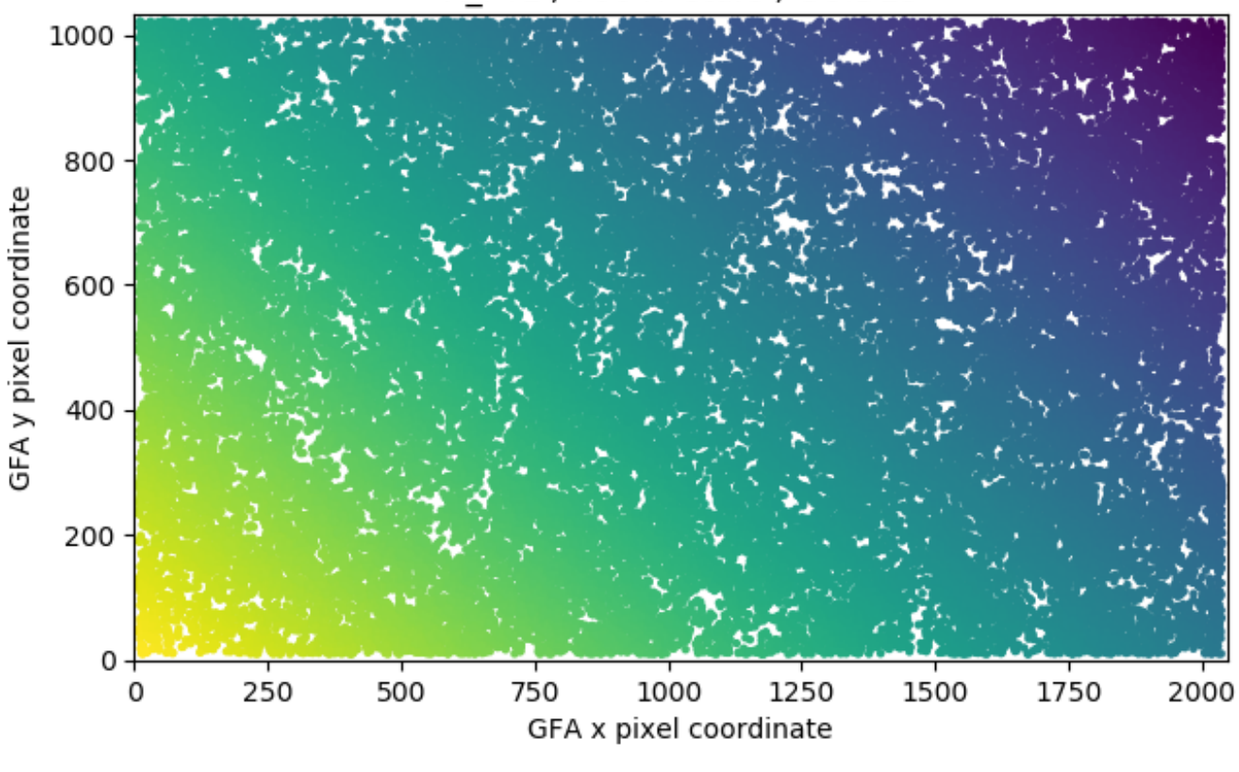
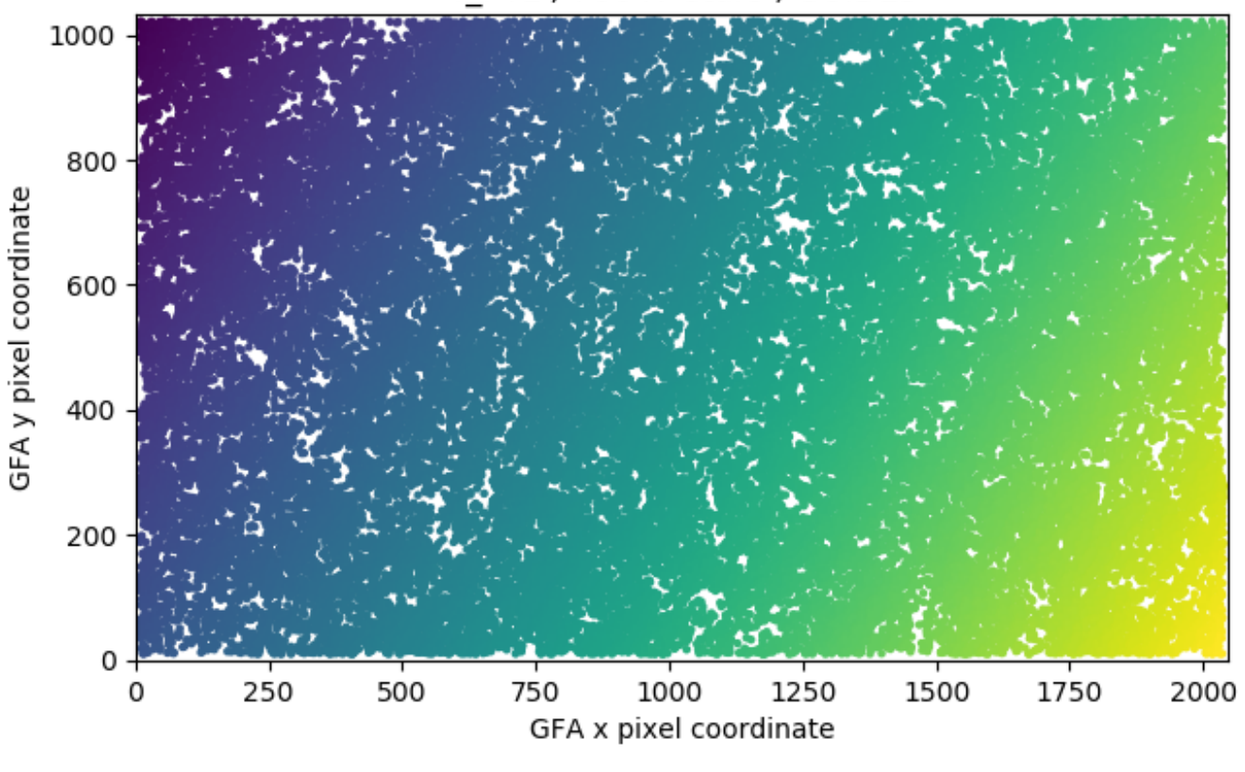
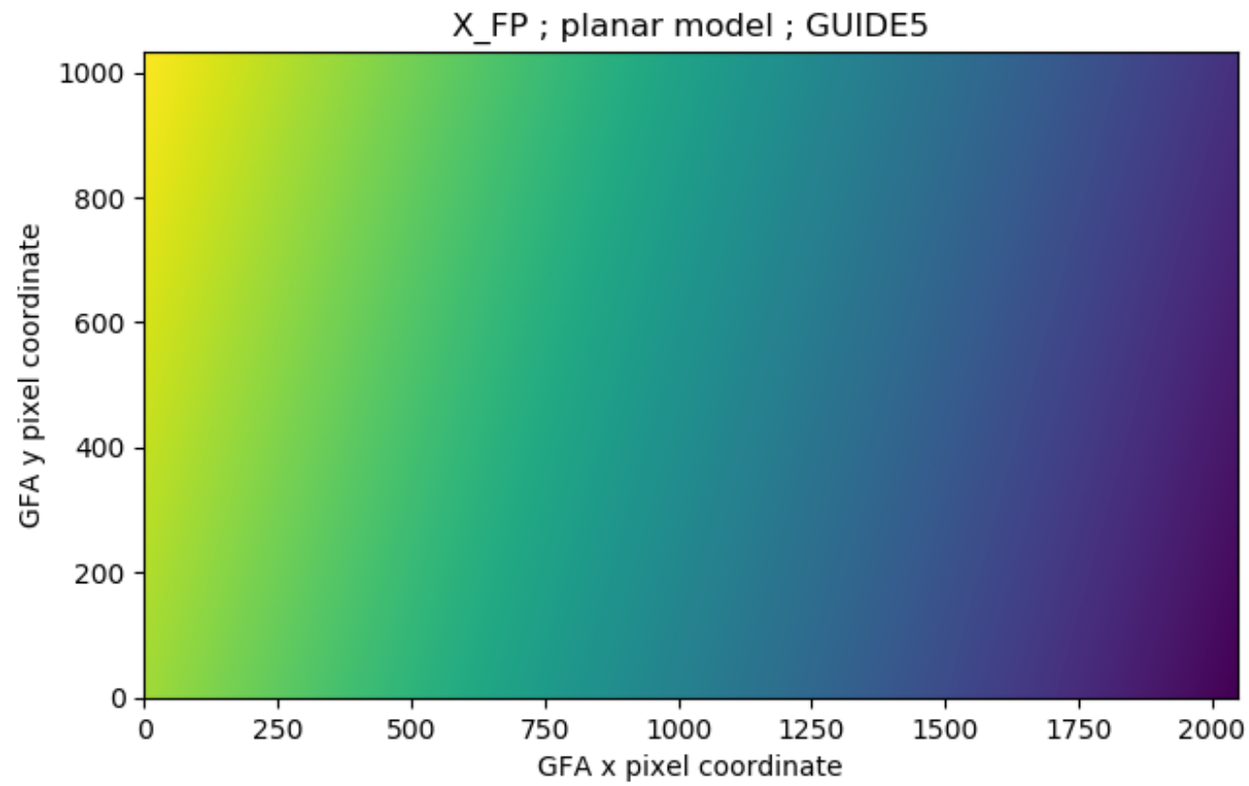


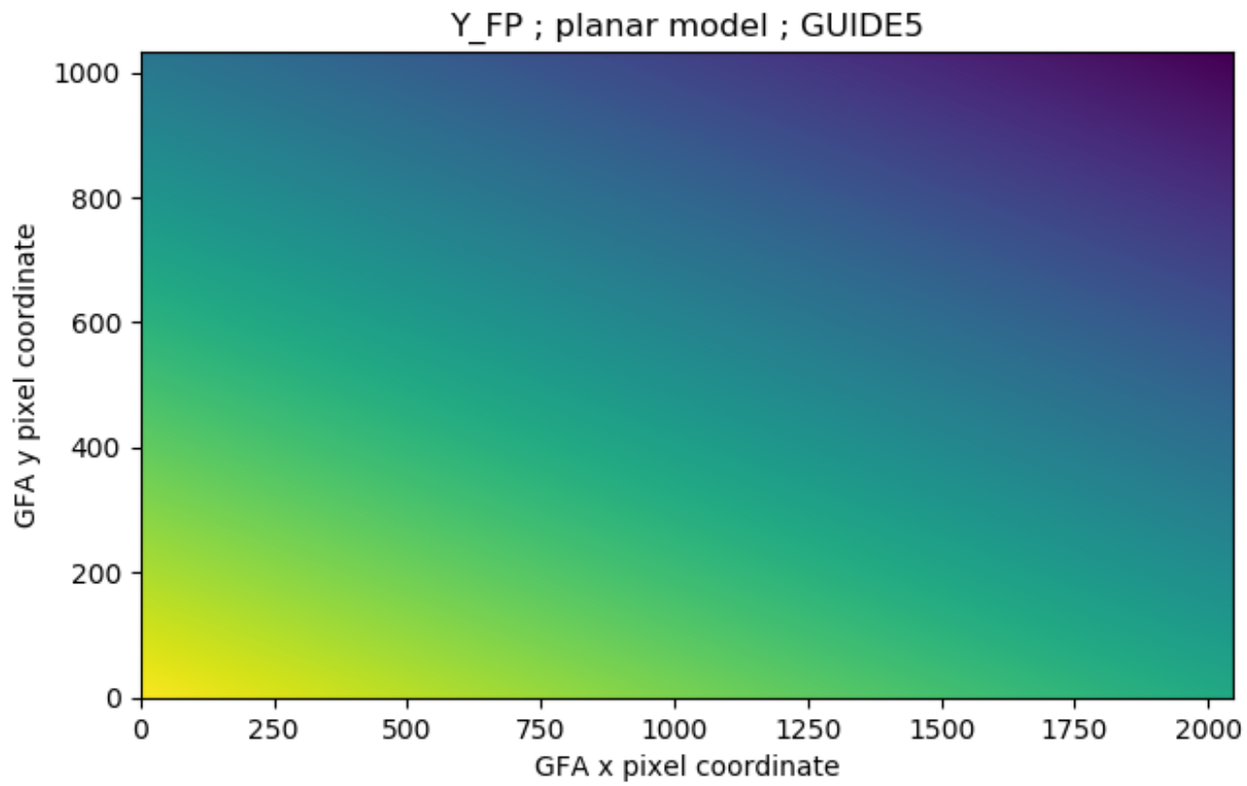


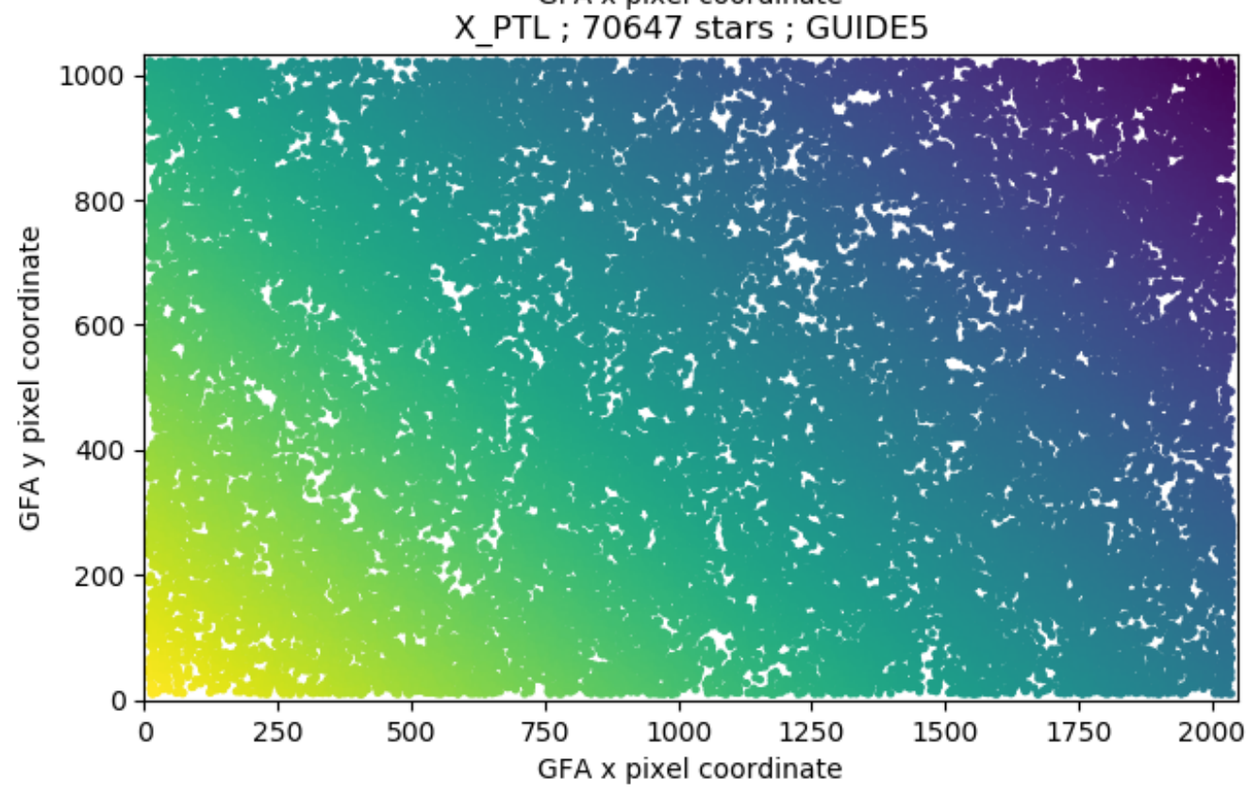


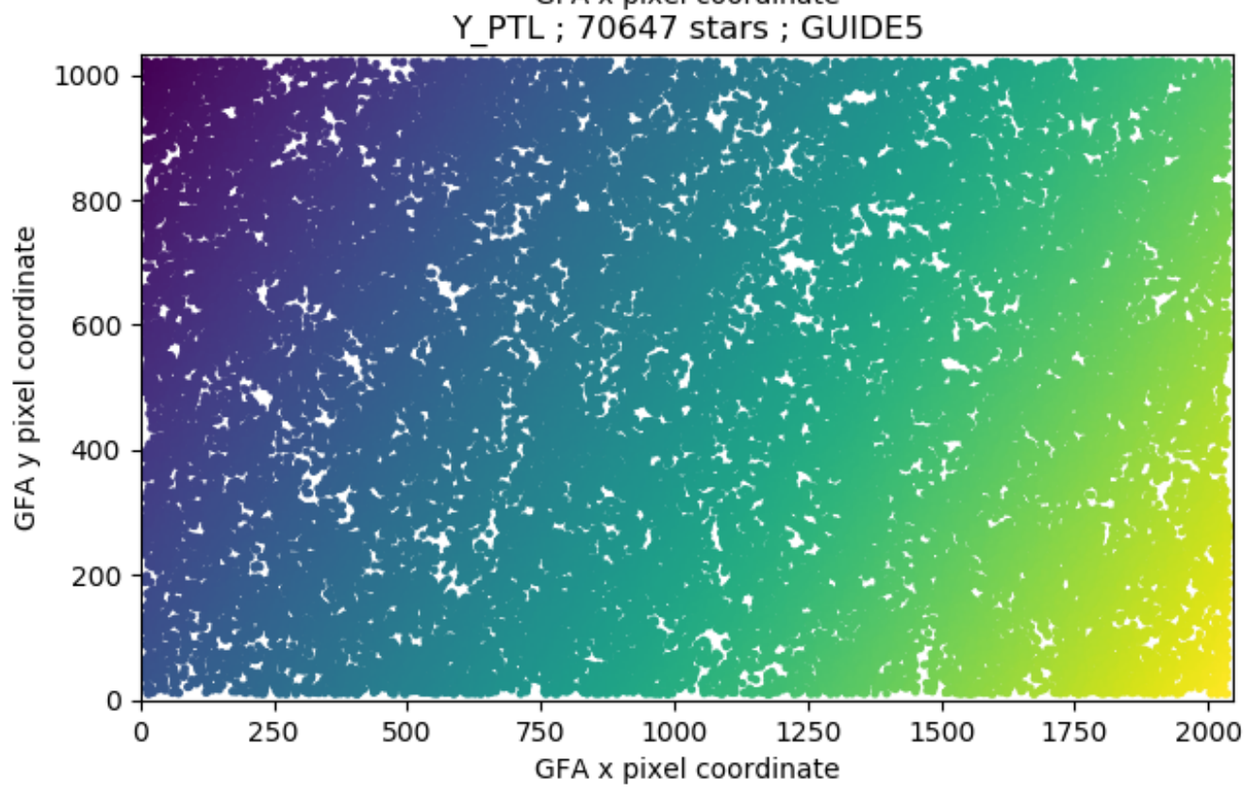


results: FP and PTL coordinates as a function of GFA pixel coordinates [planar model]

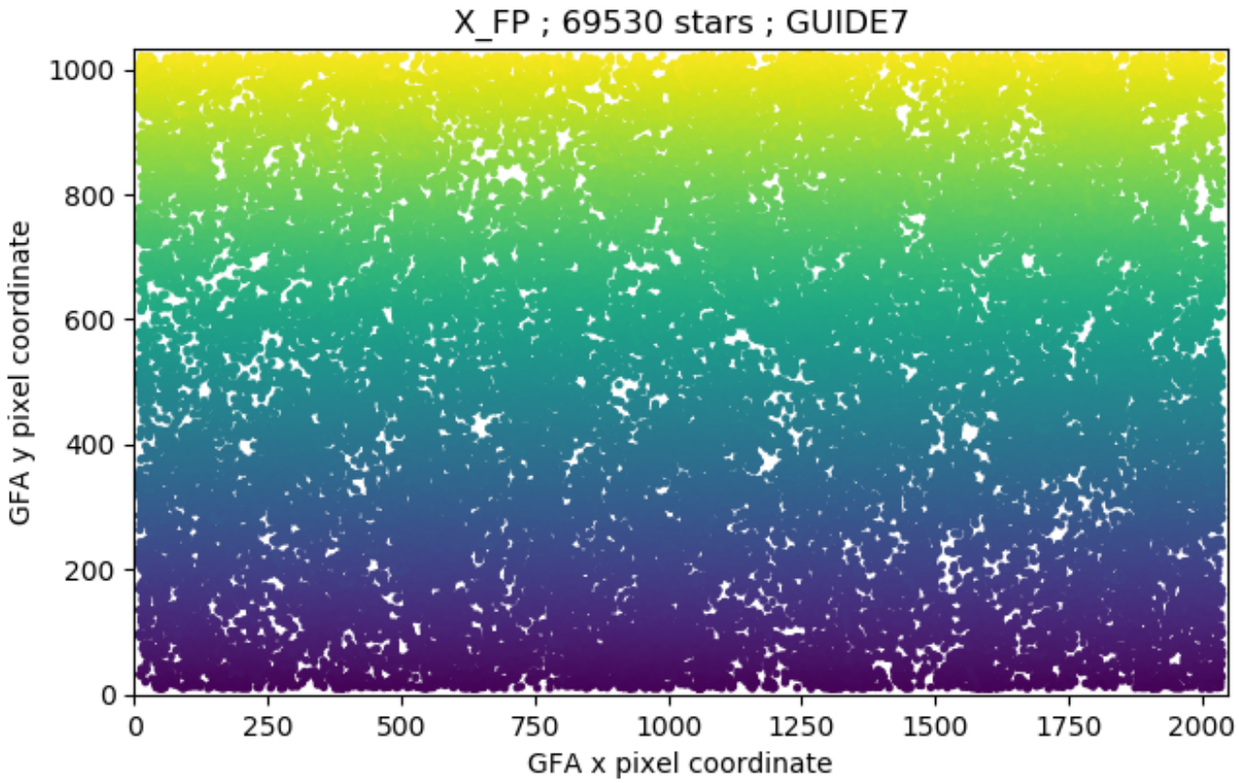


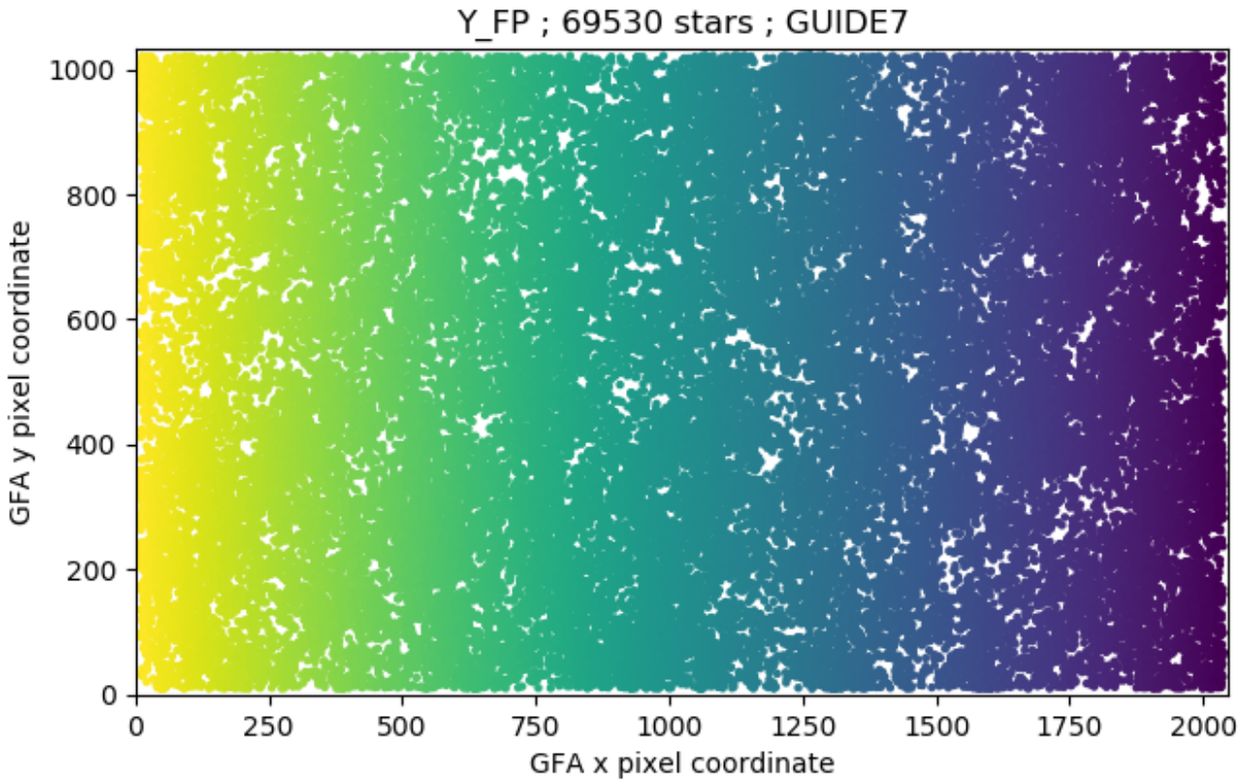


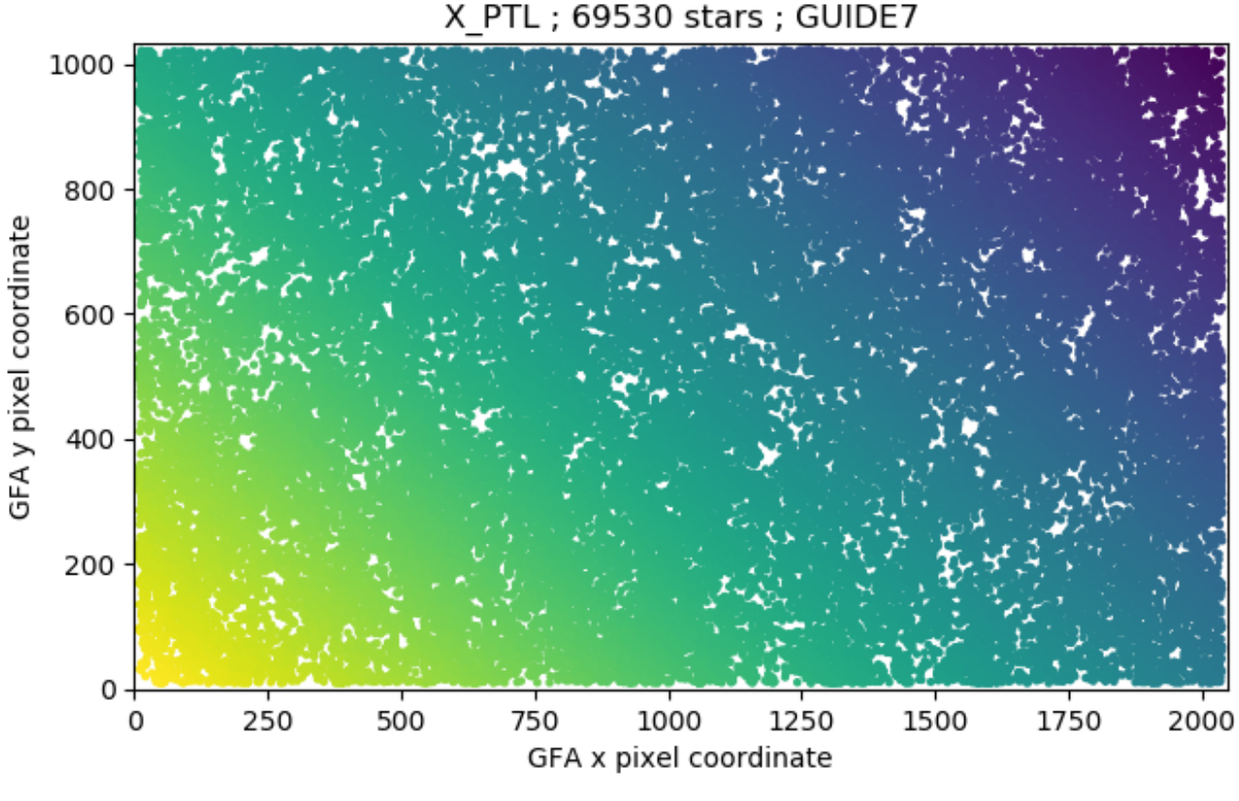


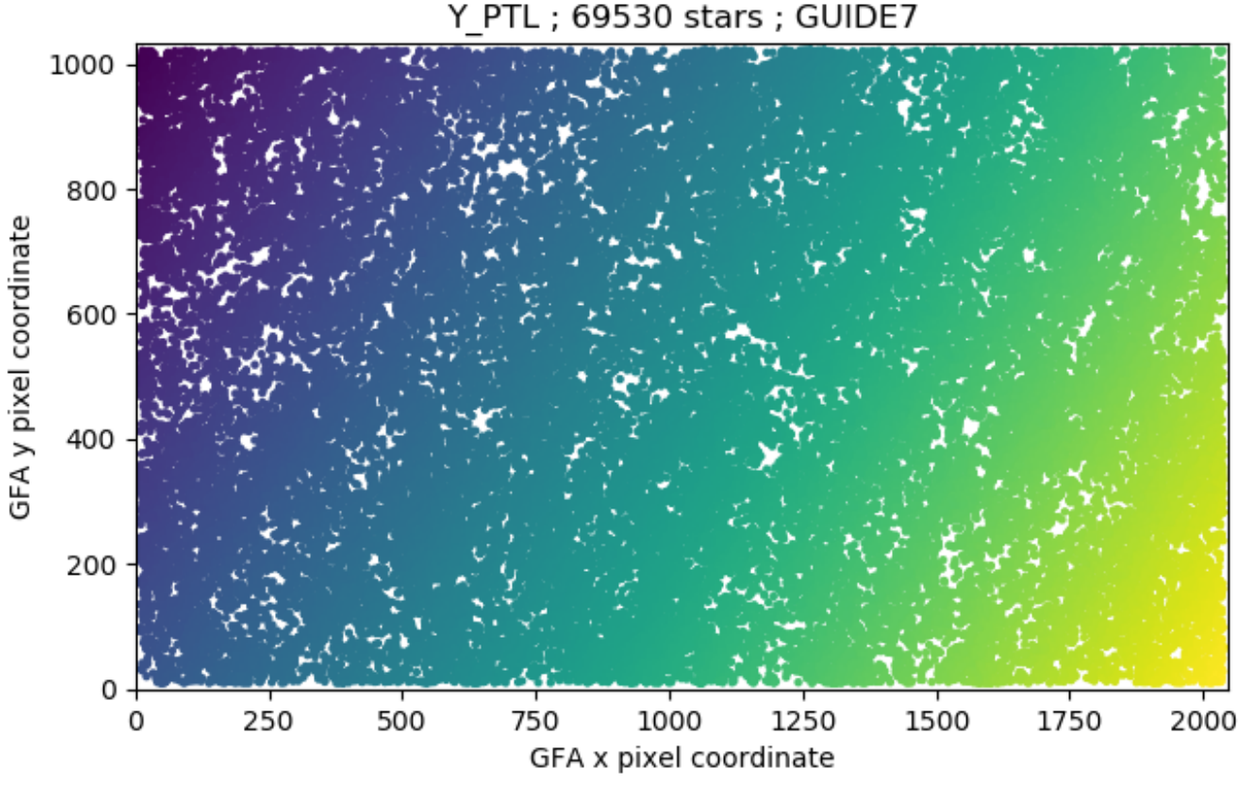


results: FP and PTL coordinates as a function of GFA pixel coordinates [data]

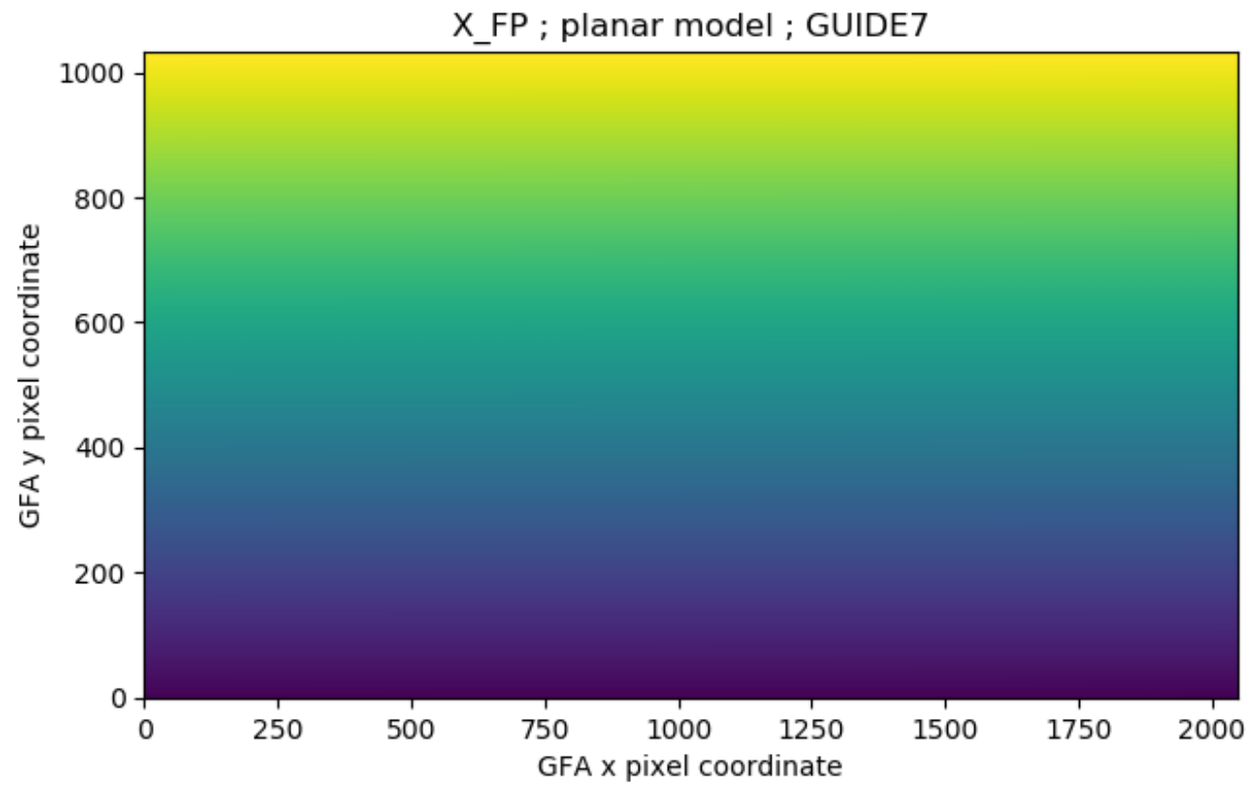


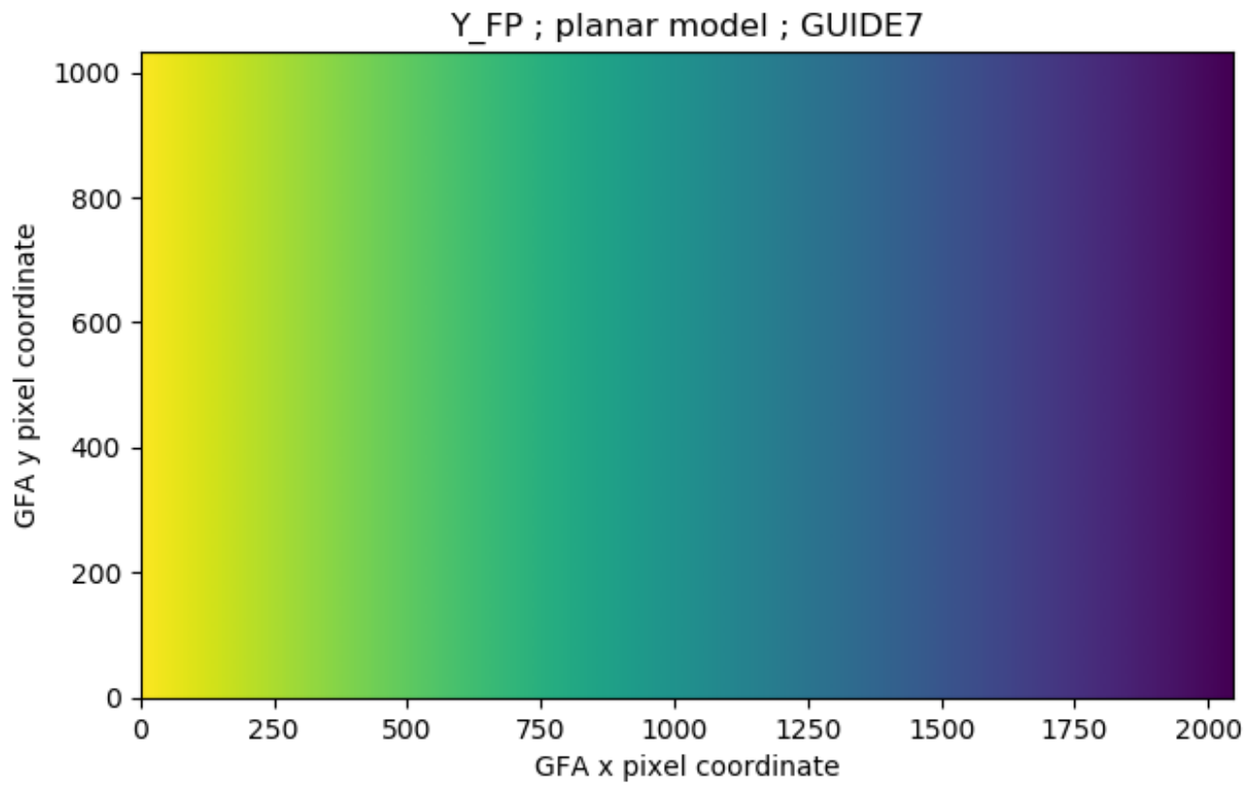


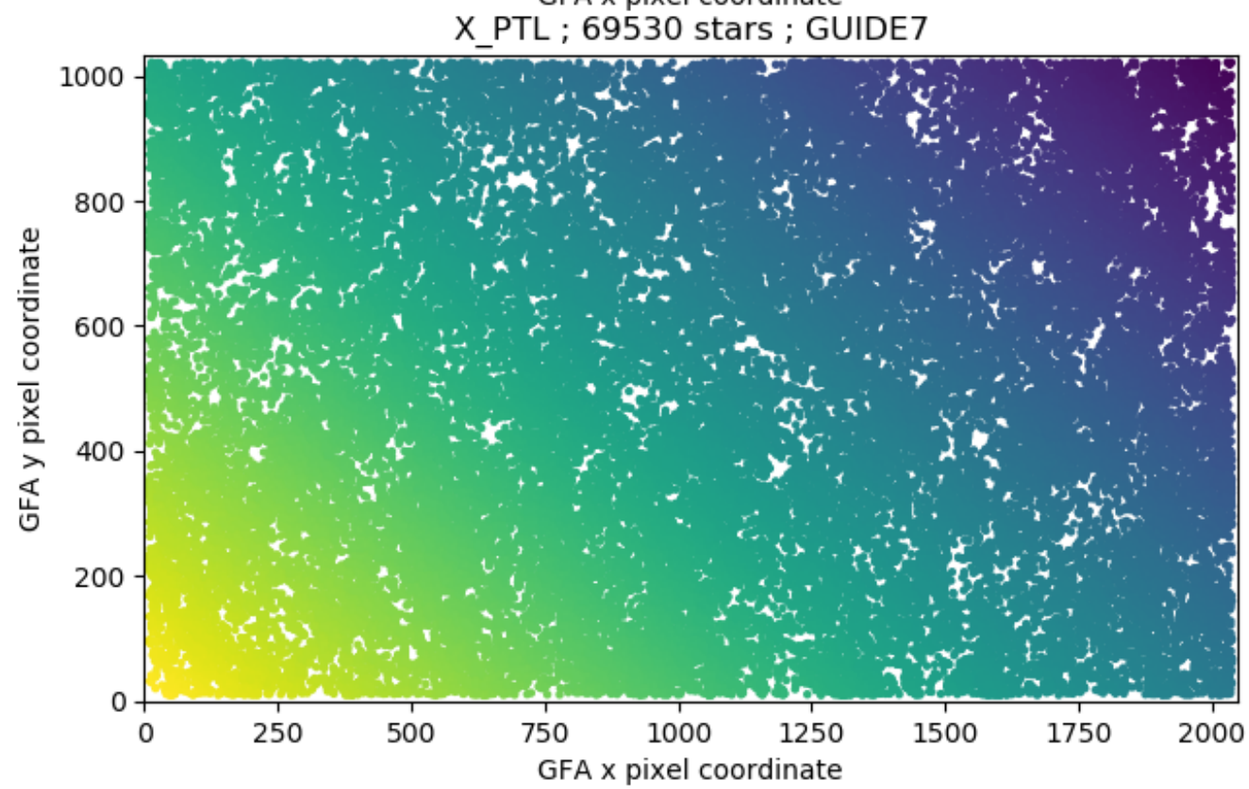


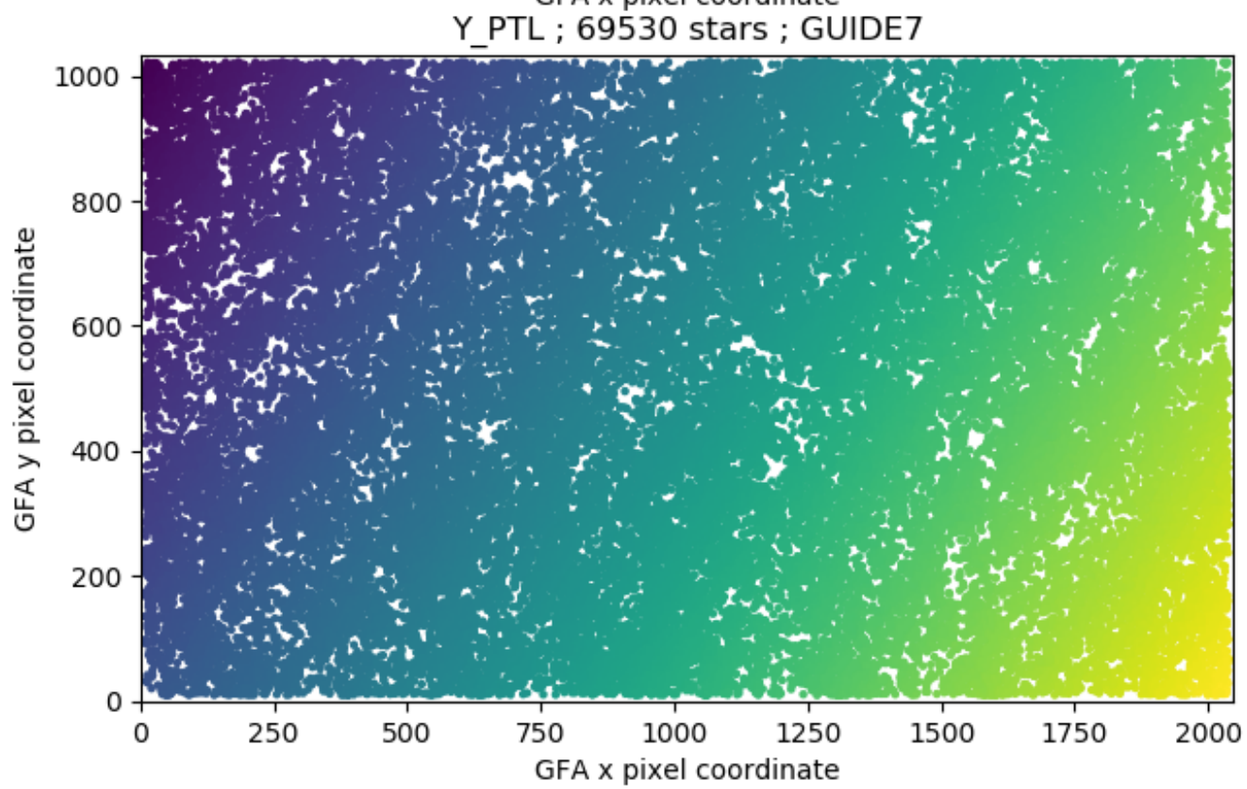


results: FP and PTL coordinates as a function of GFA pixel coordinates [planar model]

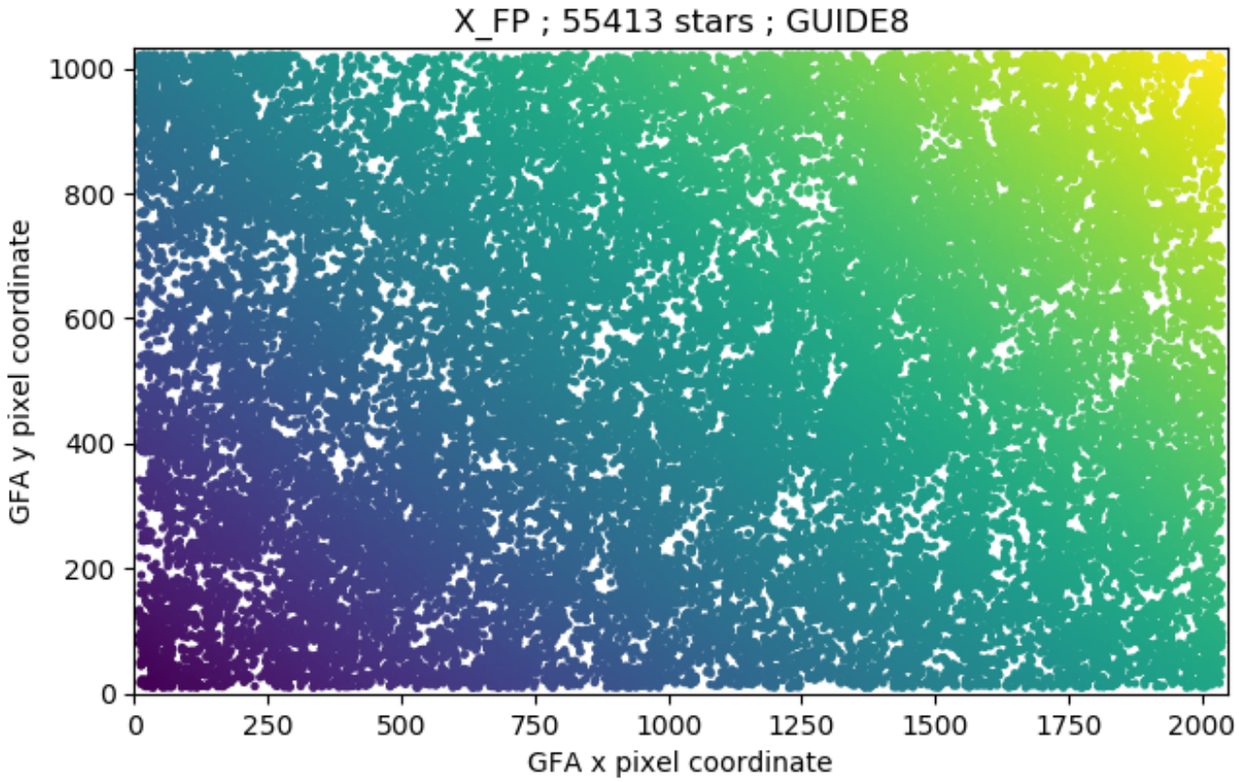


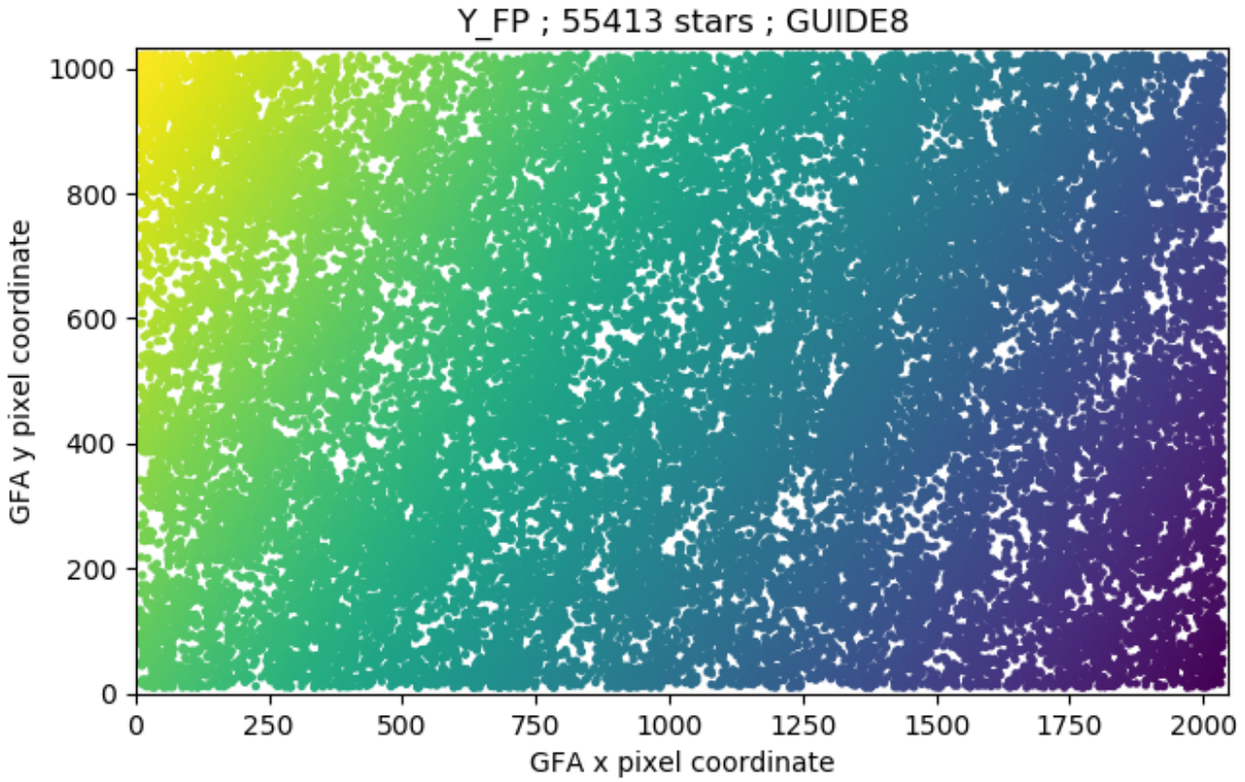


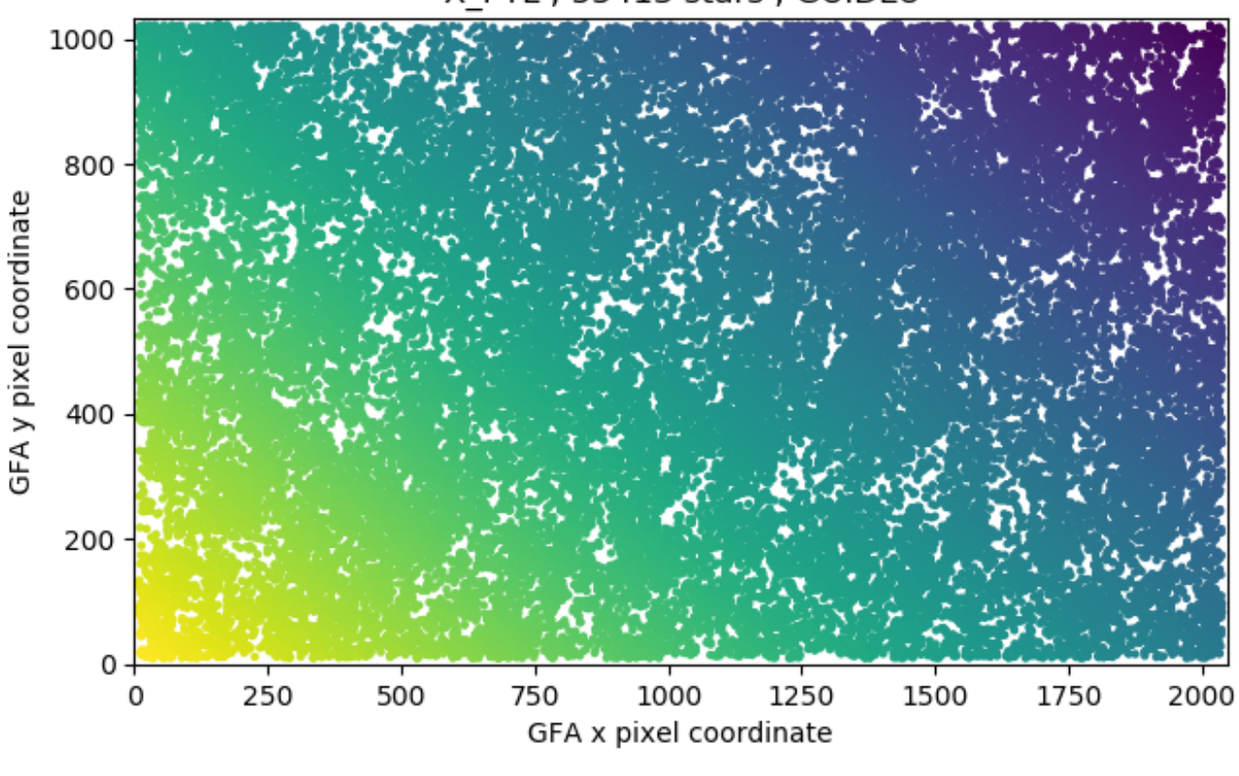


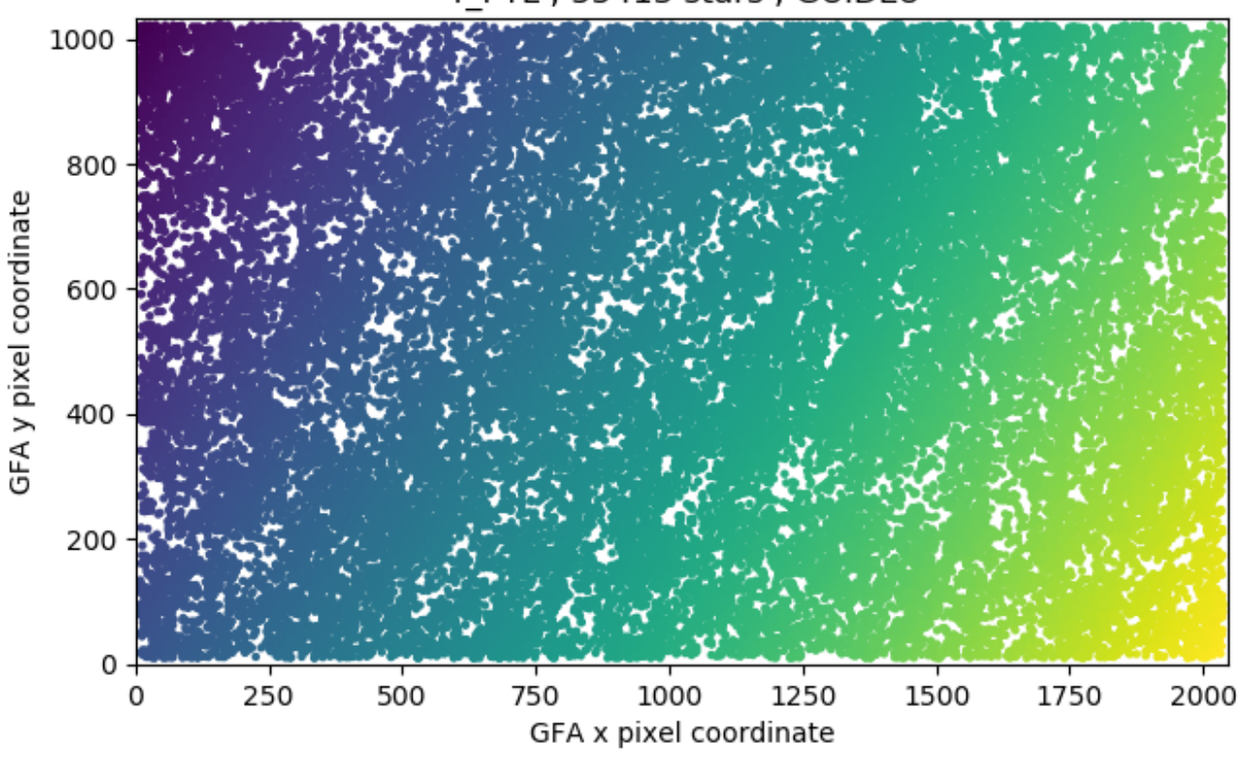


results: FP and PTL coordinates as a function of GFA pixel coordinates [data]

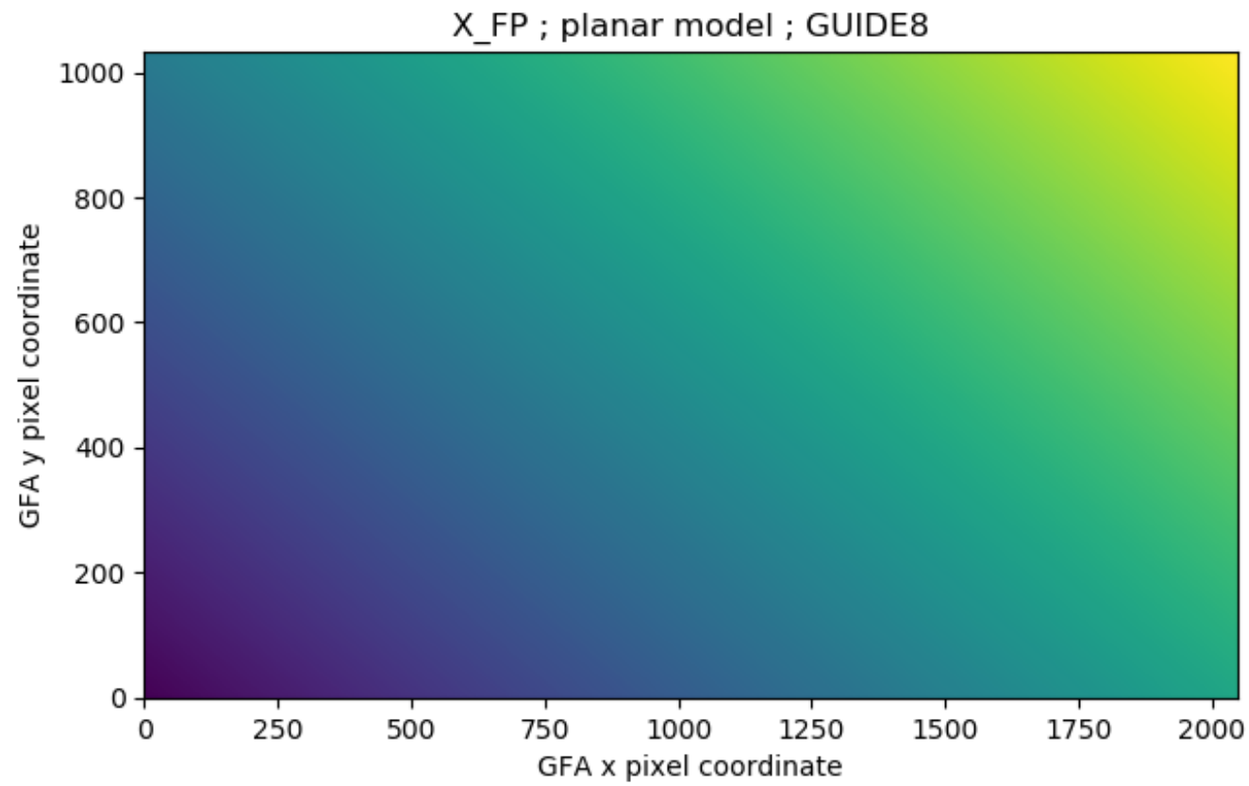


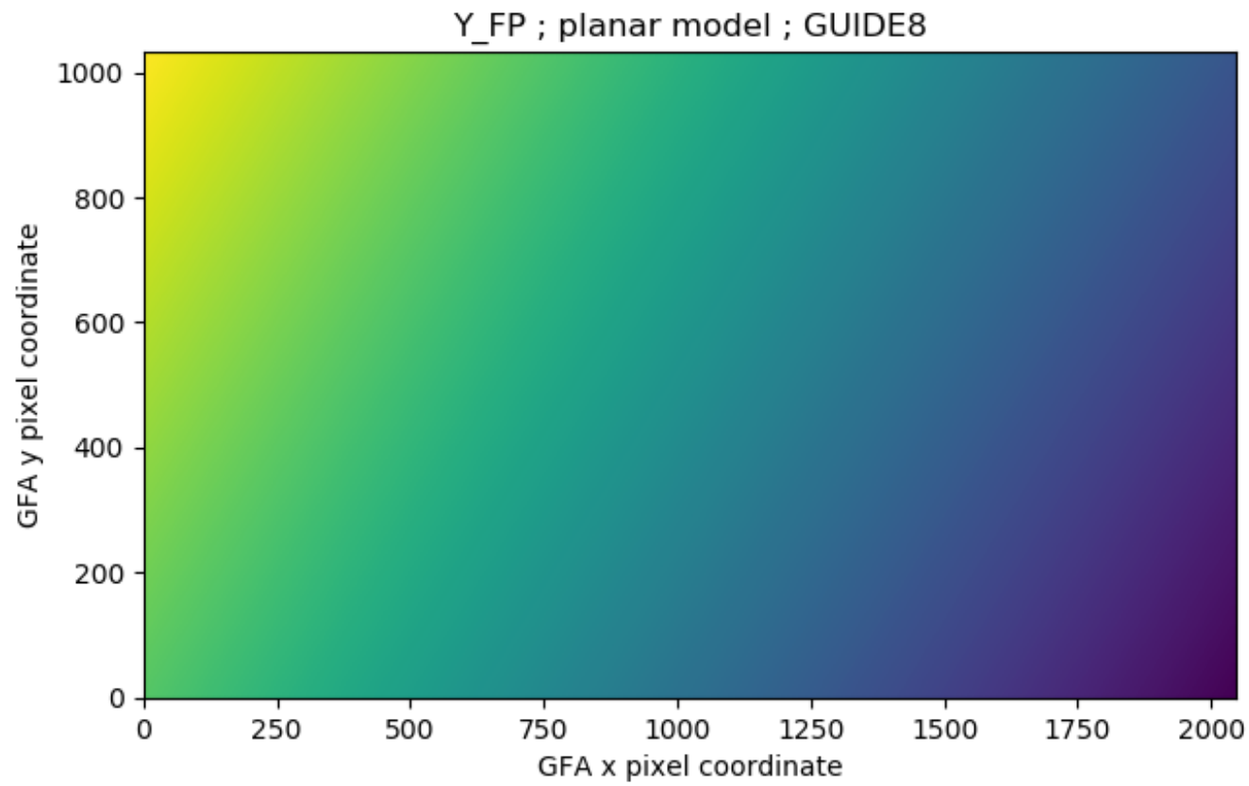


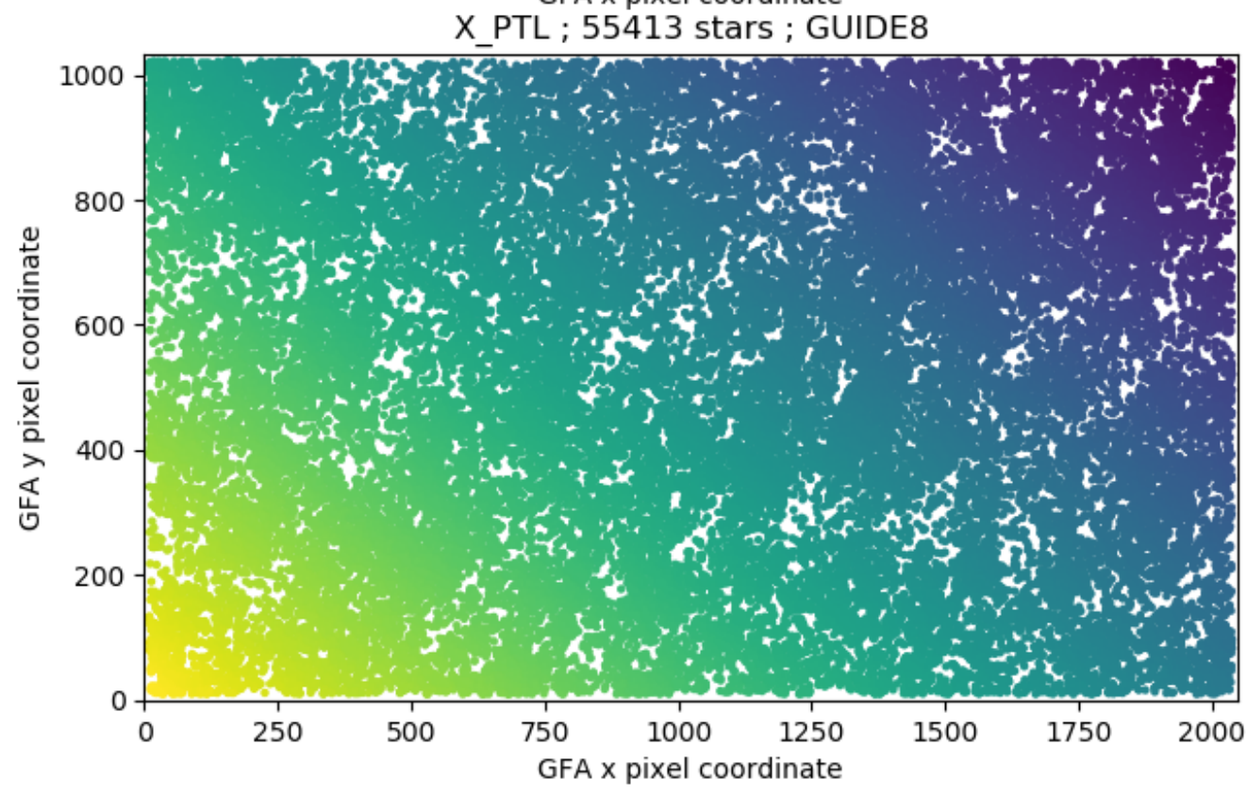


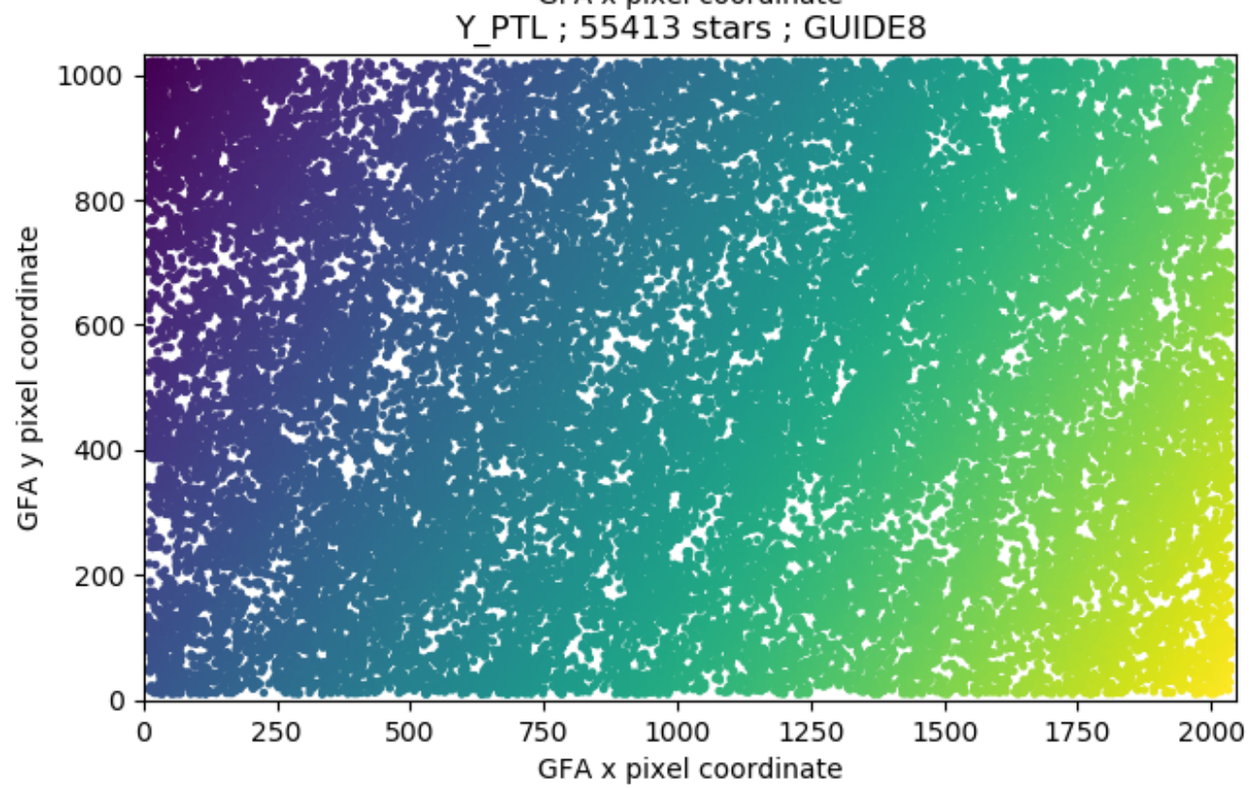


results: FP and PTL coordinates as a function of GFA pixel coordinates [planar model]

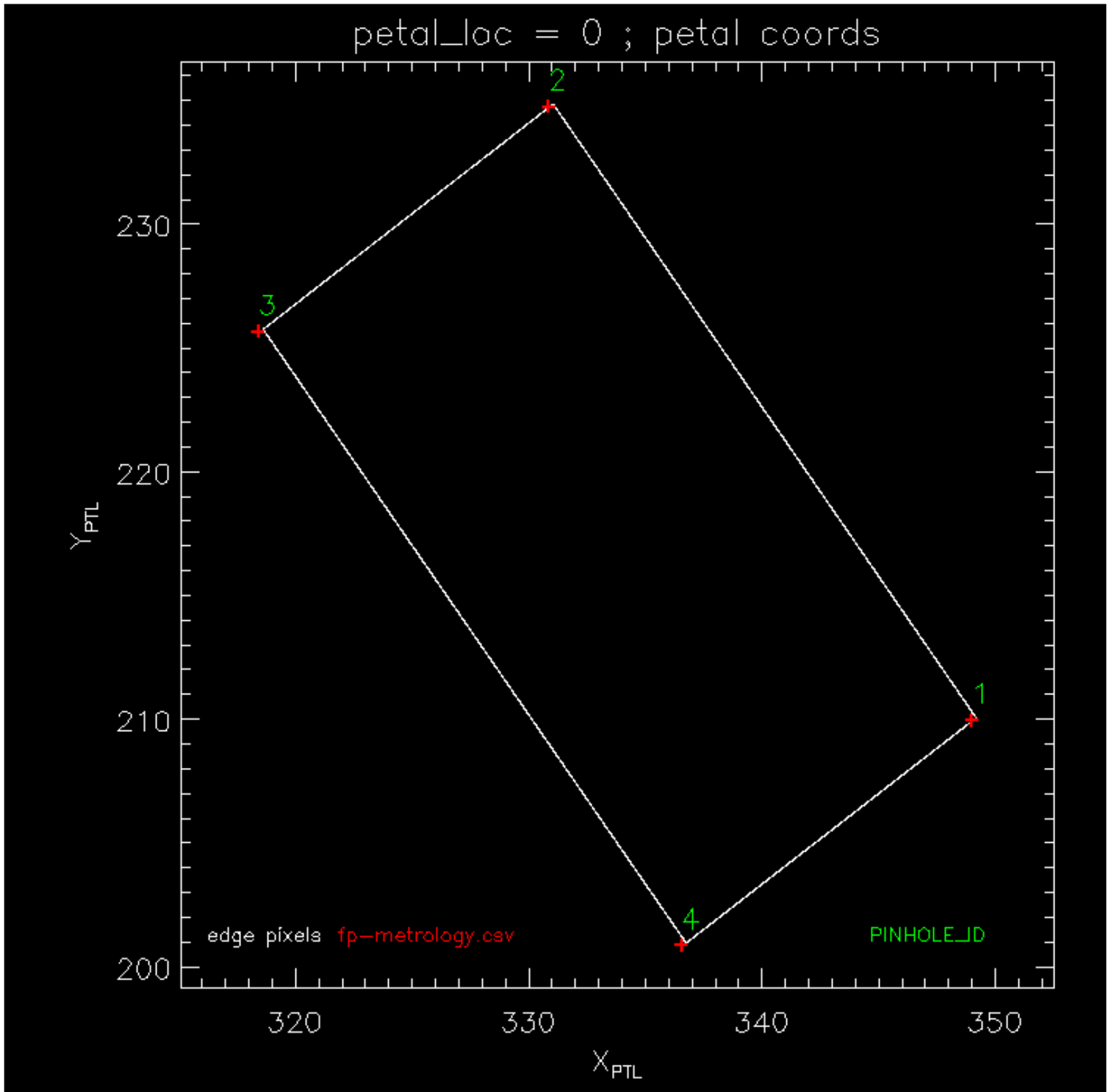




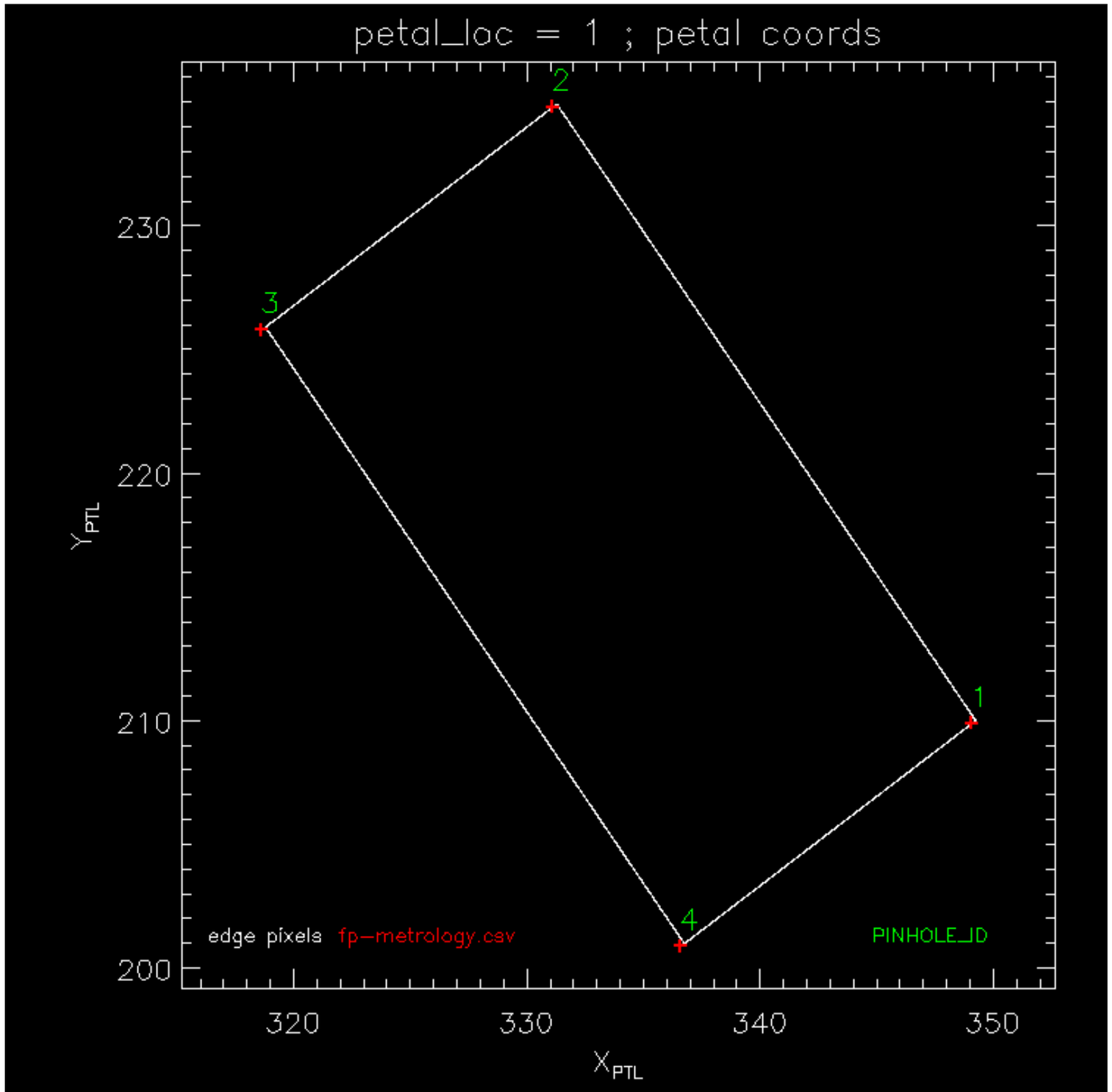




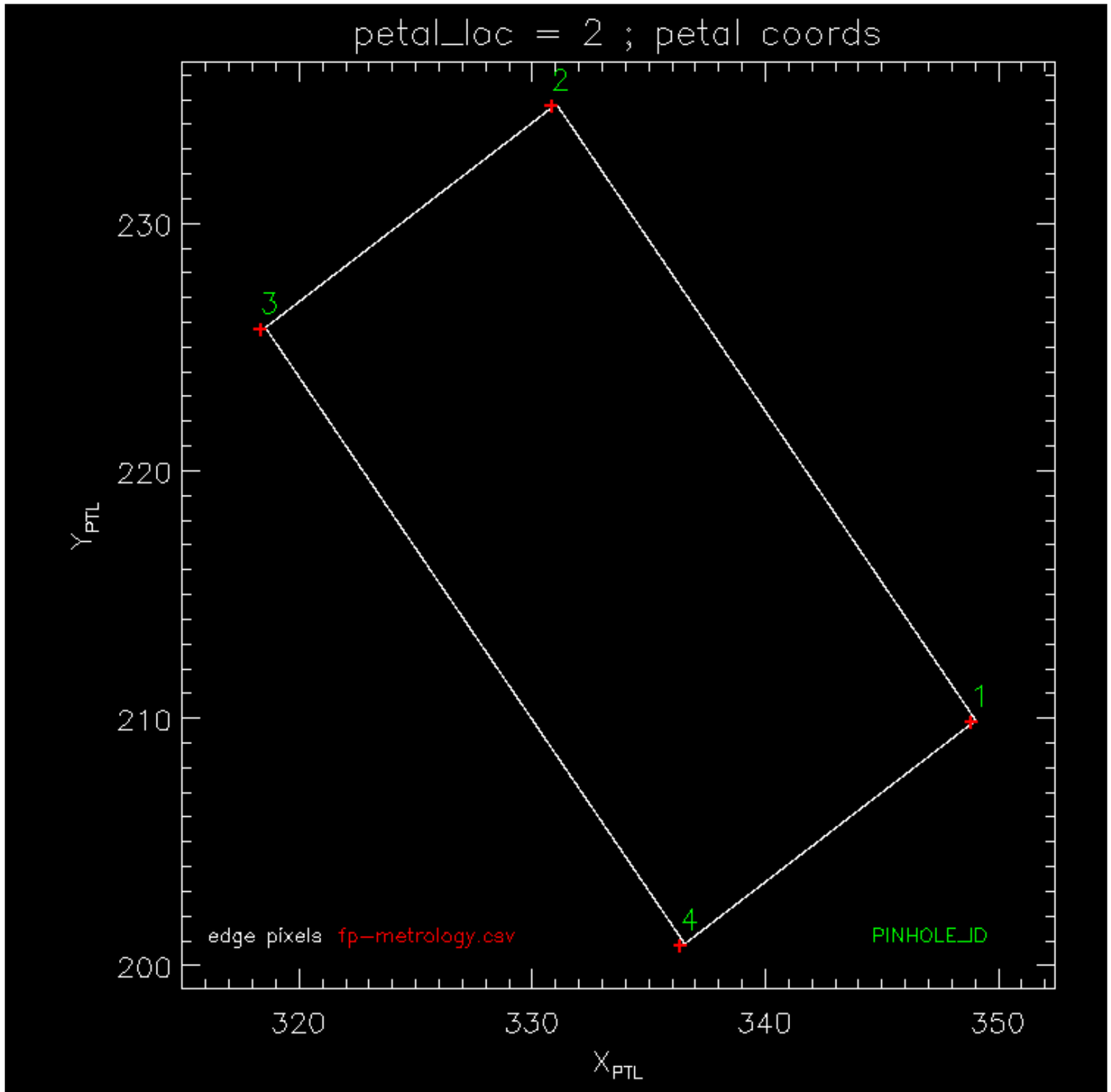
At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



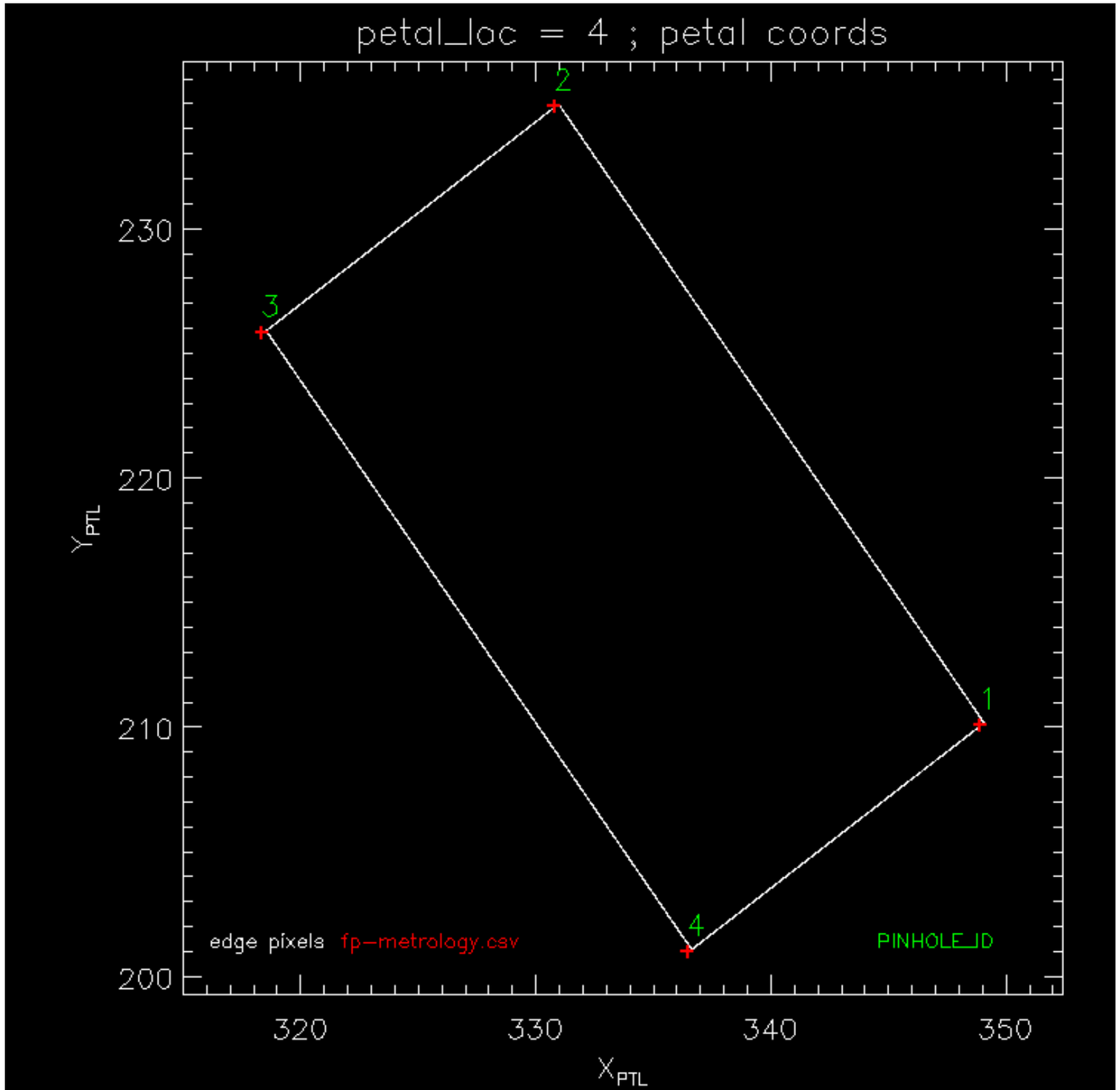
At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



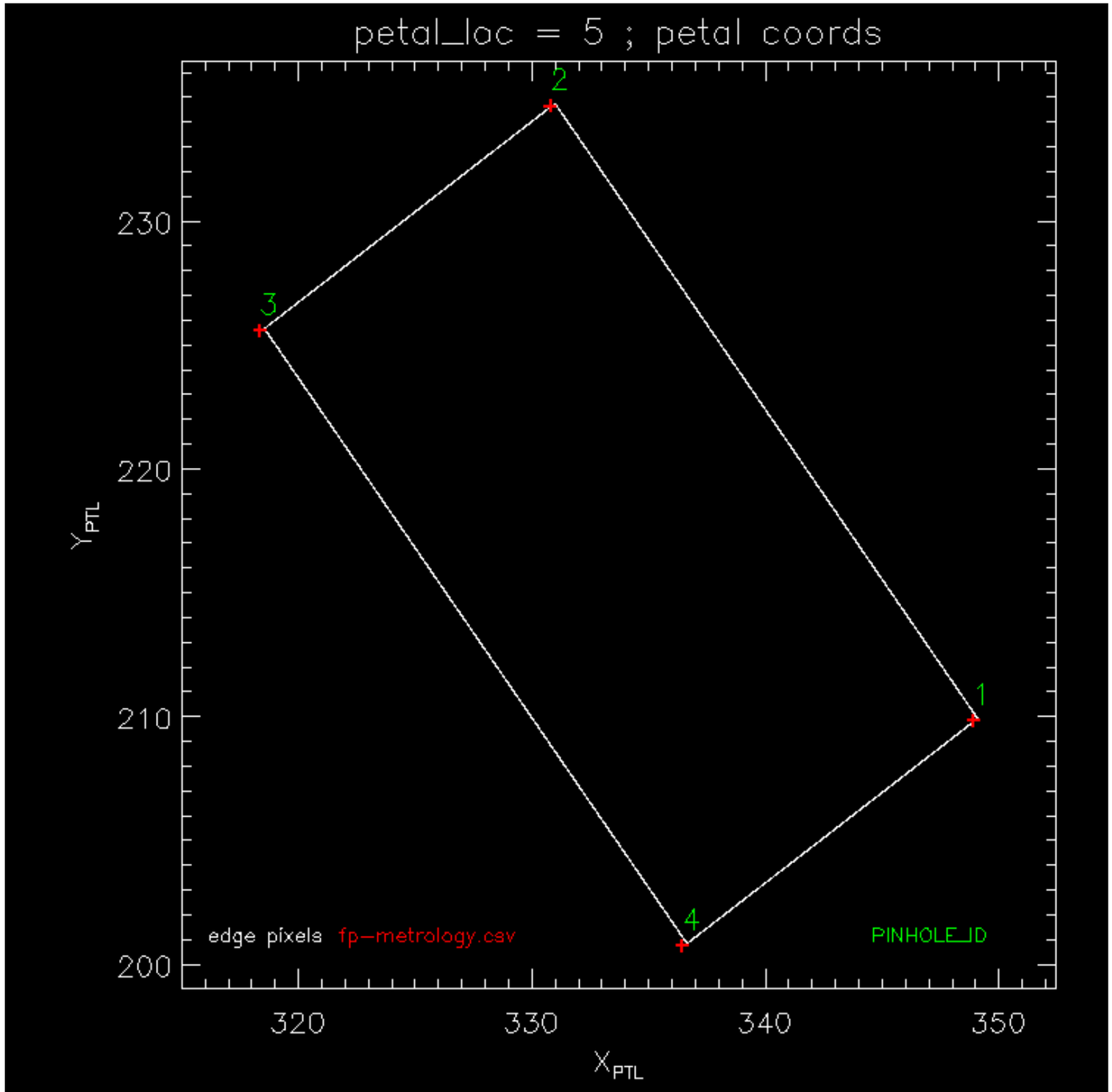
At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



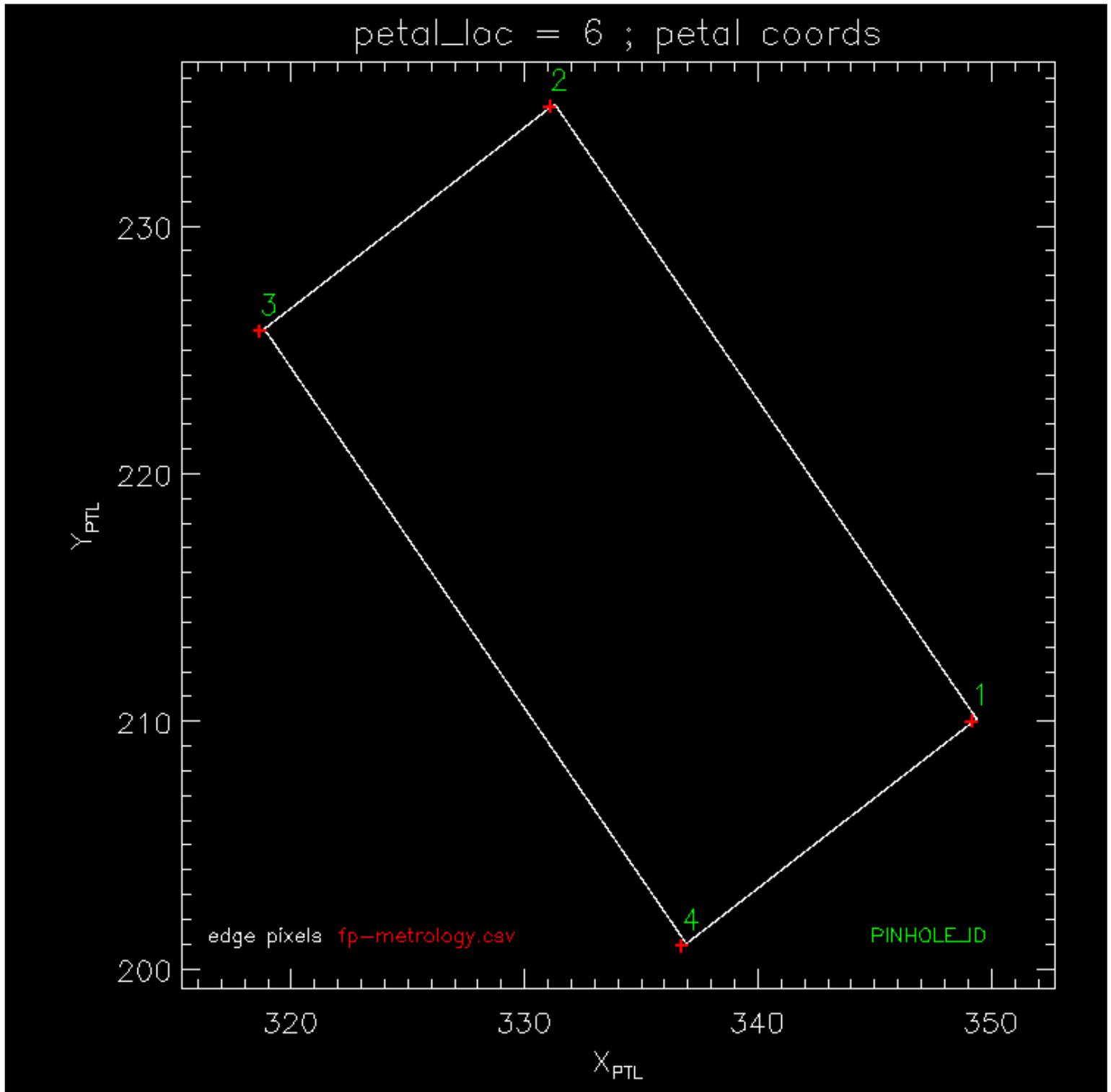
At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



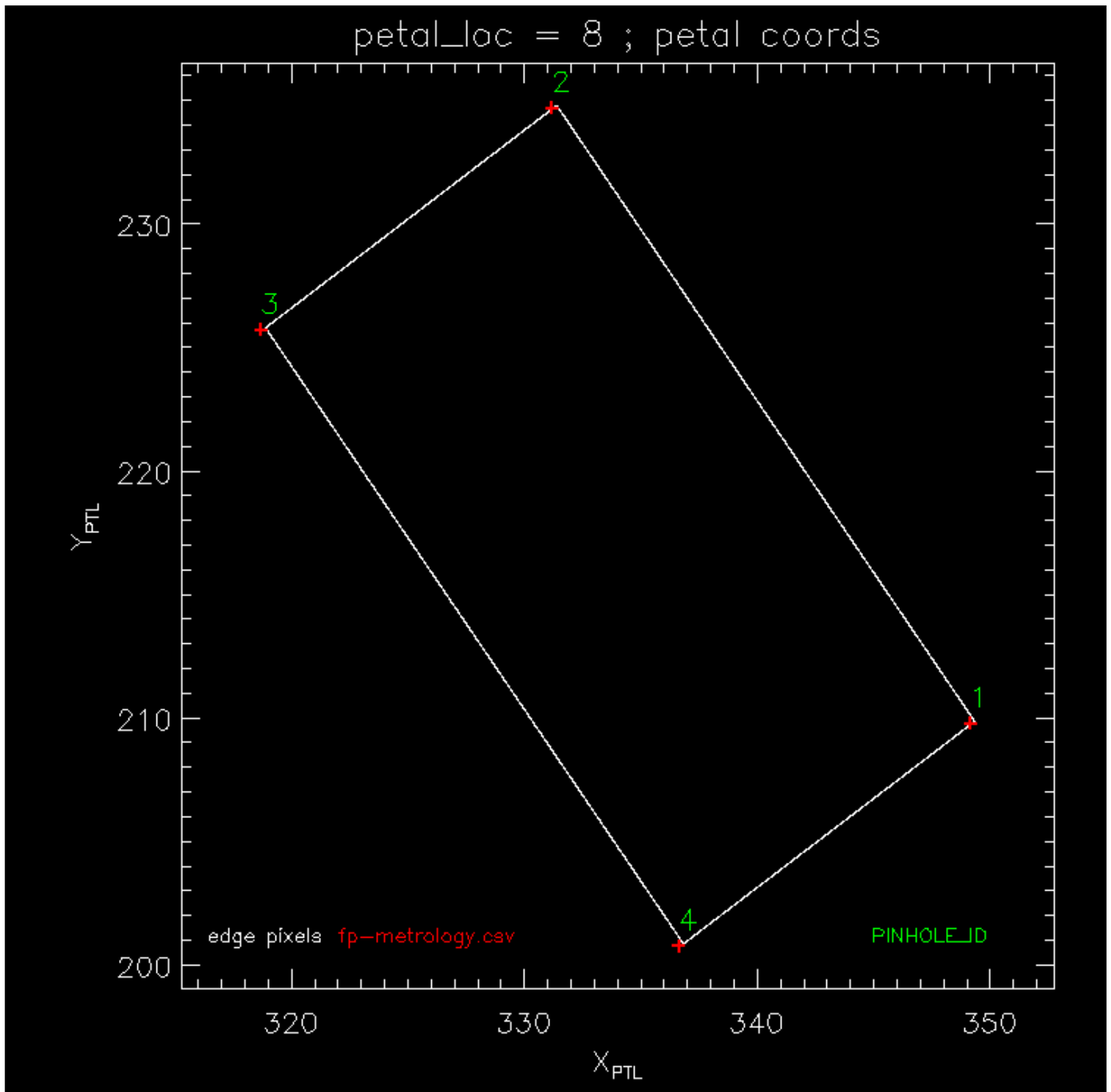
At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



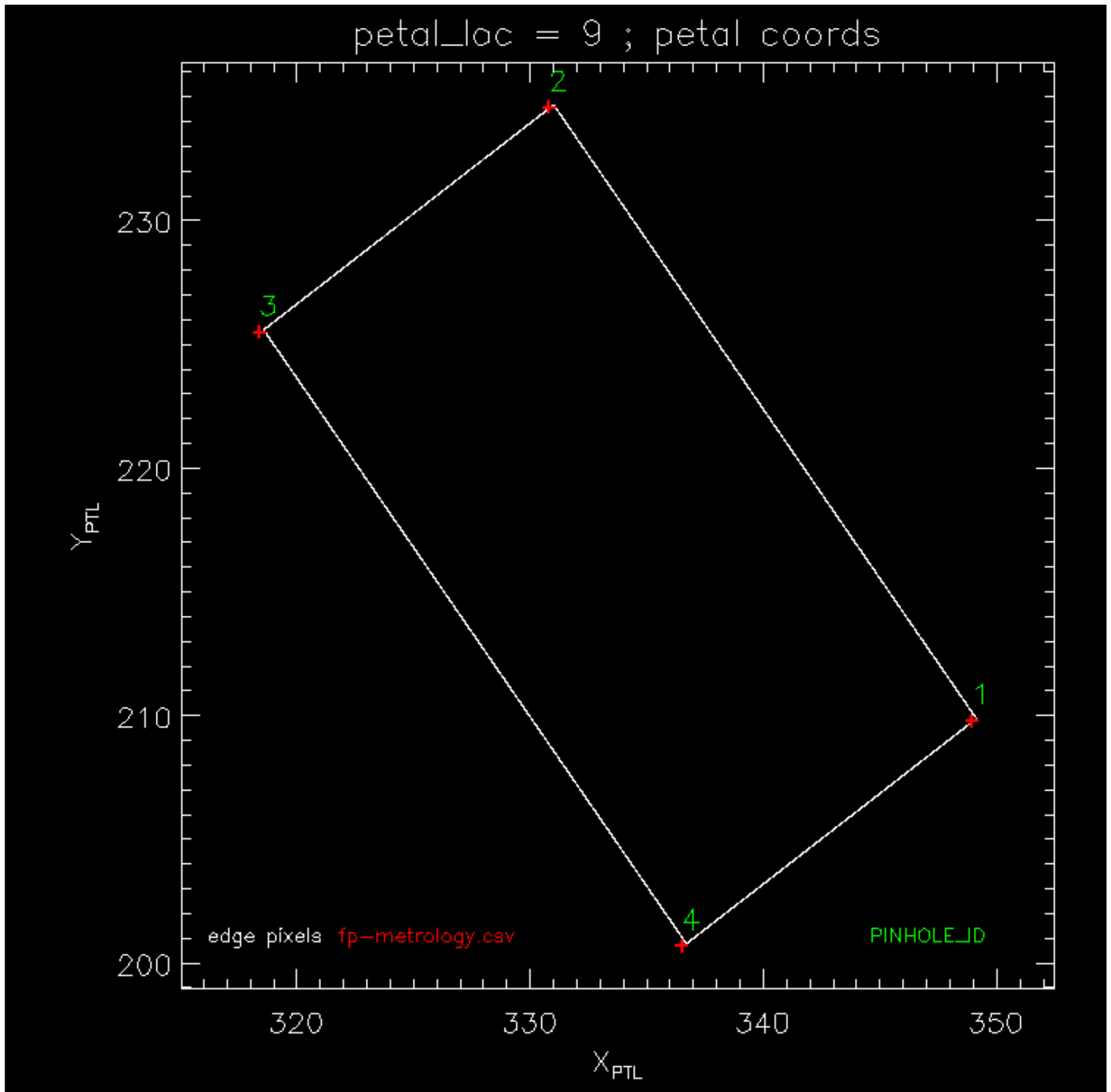
At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



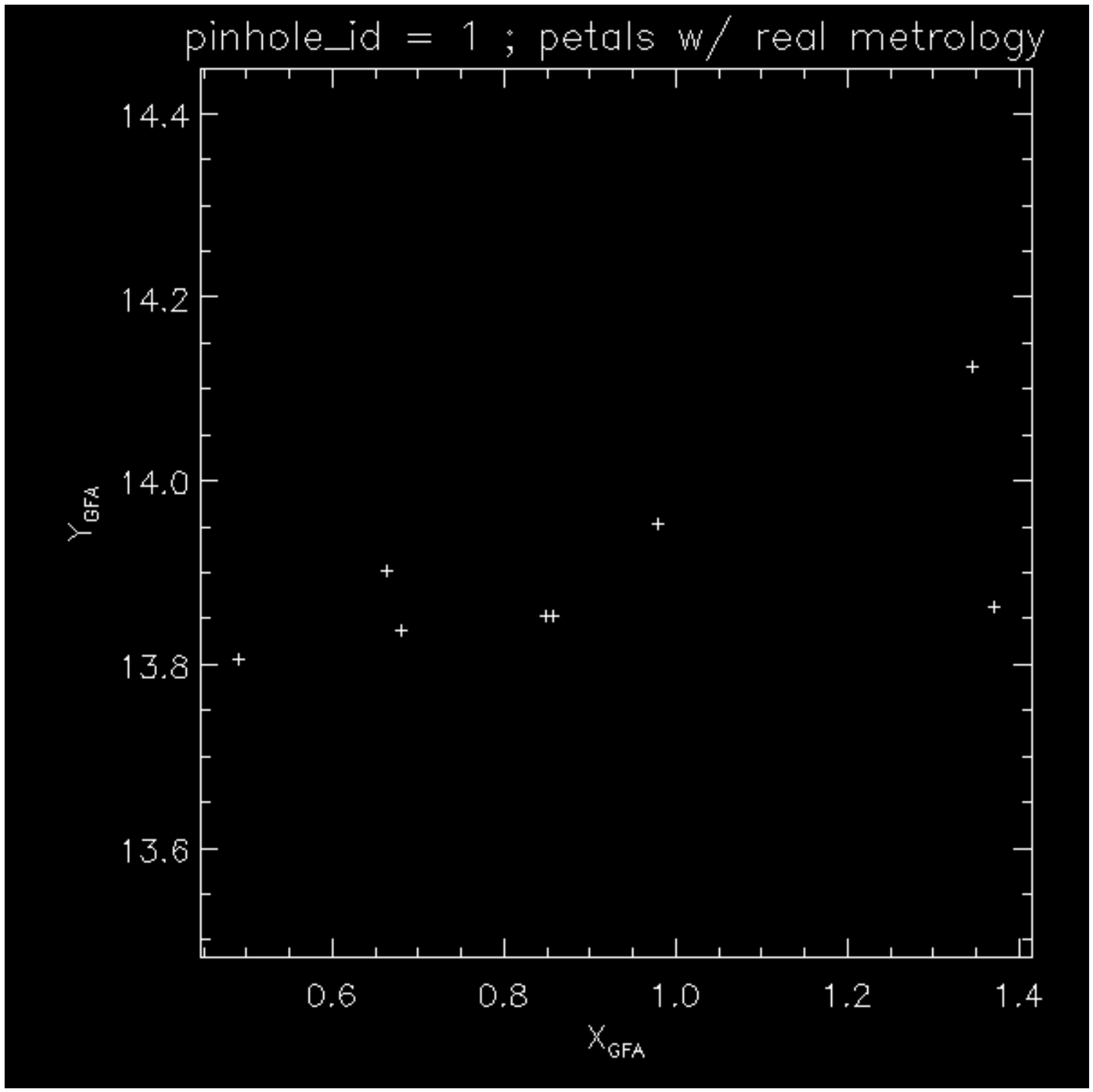
At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?

- The previous 8 plots show that for the 8 GFA cameras with fp-metrology.csv metrology available, the pinholes consistently fall close to, but not exactly at, the 4 corners of each GFA camera's image area

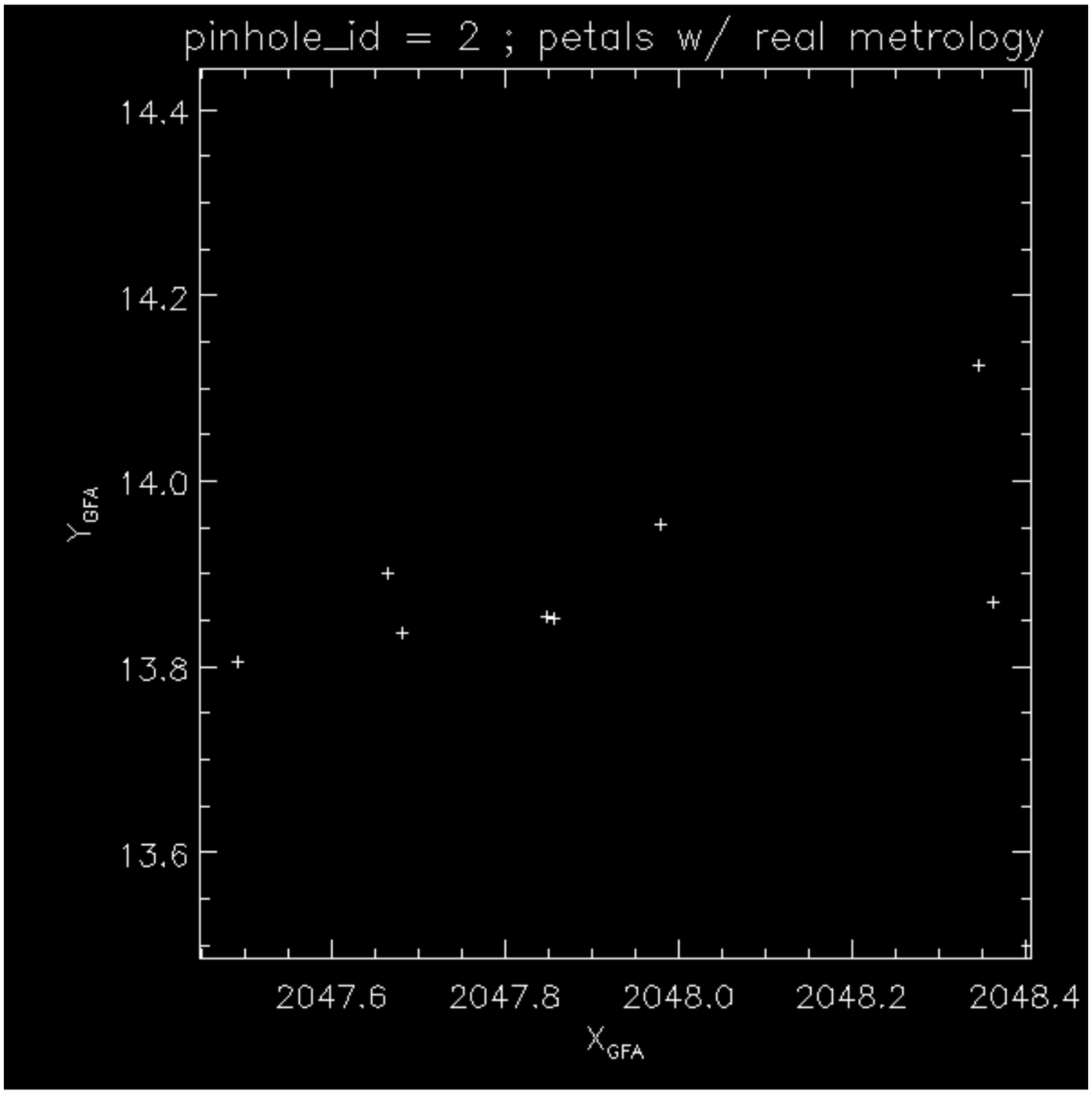
- So it's worth figuring out the exact (x_gfa, y_gfa) values in each case

- The following four plots show that the (x_gfa , y_gfa) values of each PINHOLE_ID are consistent at the ~0.3 (~0.1) GFA pixel RMS level across cameras with existing metrology in fp-metrology.csv

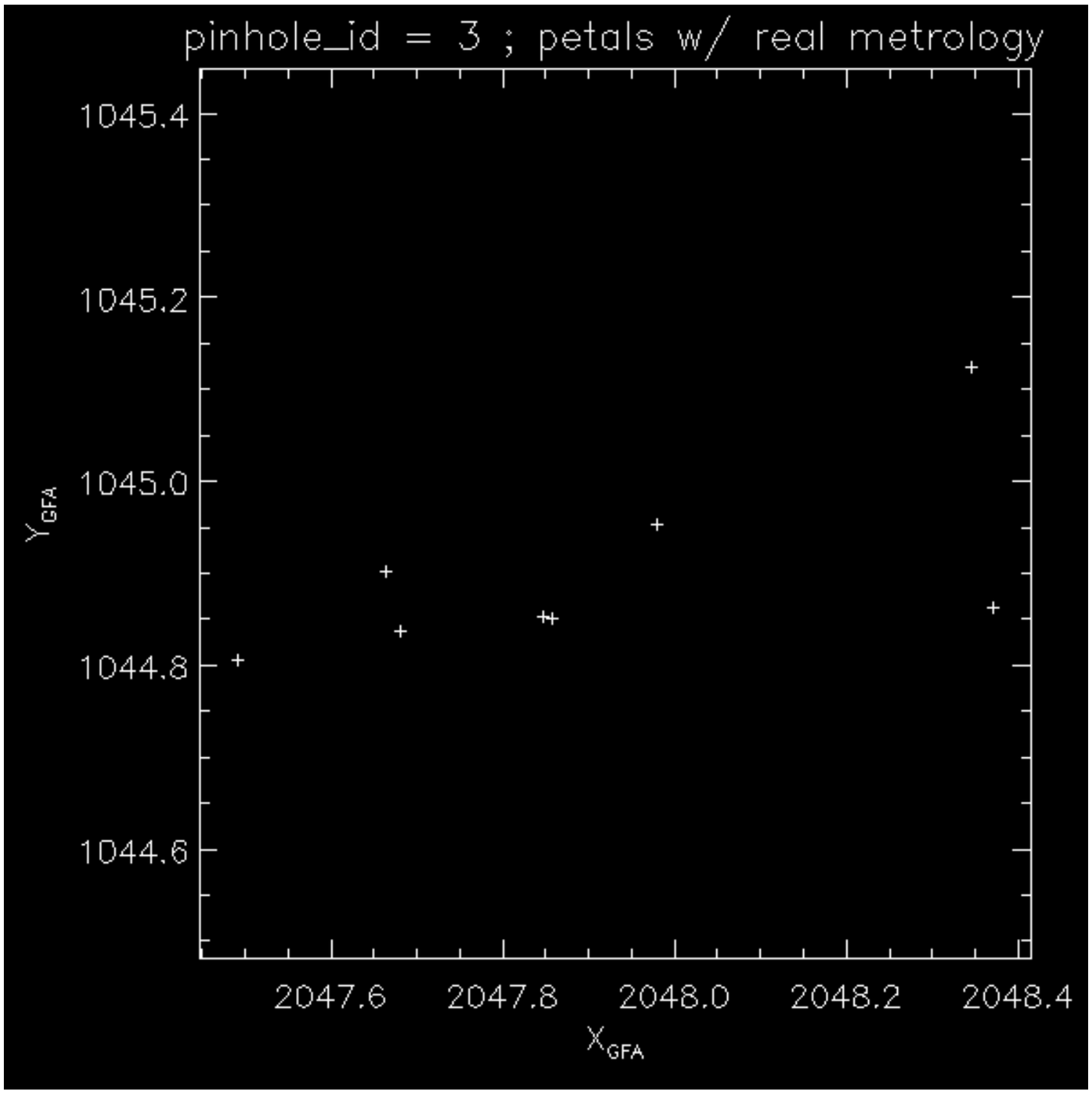
At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



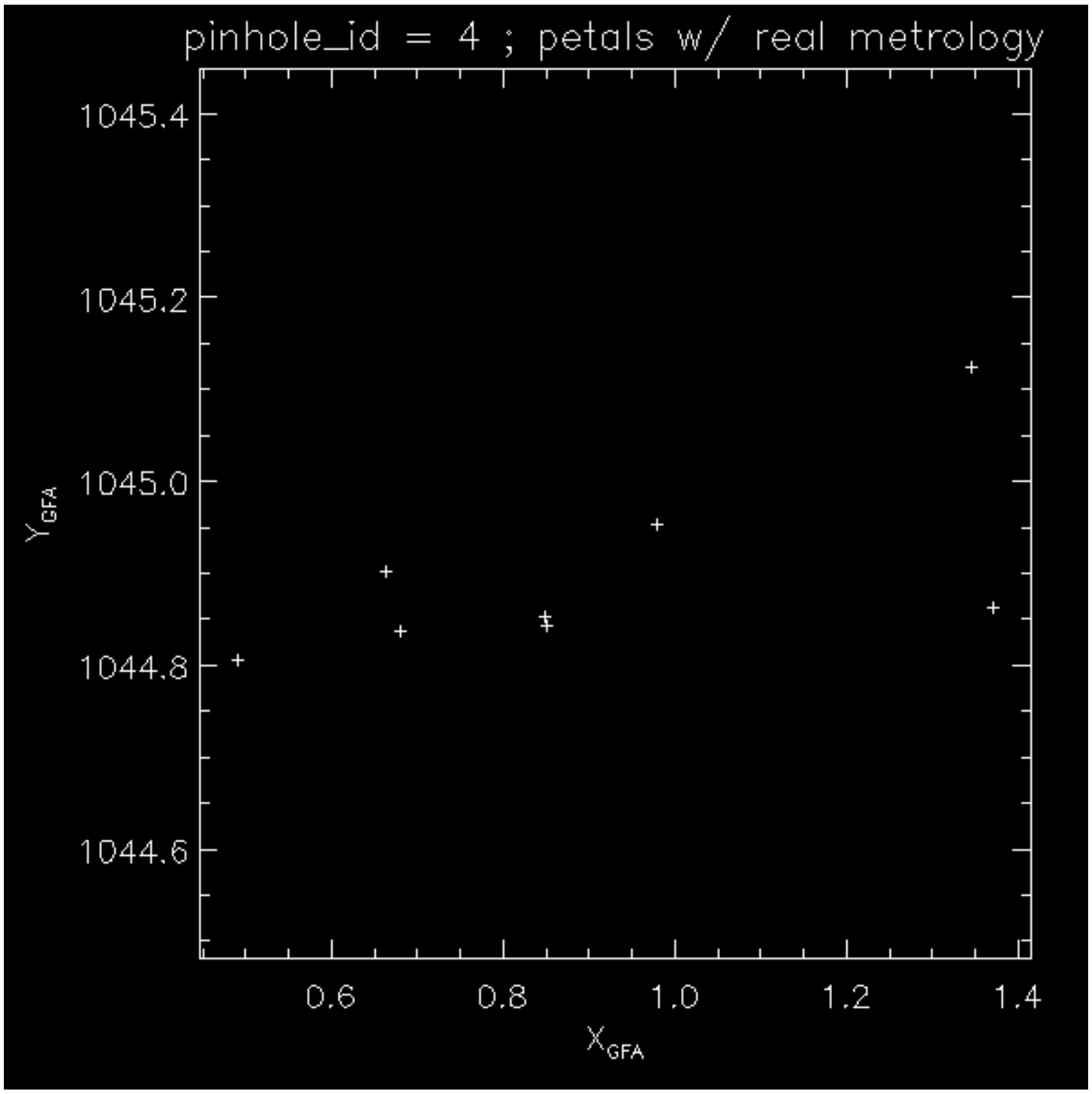
At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?



At what (x_gfa, y_gfa) should the planar models be evaluated to fill in the missing GUIDE3 and GUIDE7 metrology?

Evaluate the planar models X_FP(x_gfa, y_gfa) and Y_FP(x_gfa, y_gfa) for each guide camera at the mean (x_gfa, y_gfa) per PINHOLE_ID:


```
{
   PINHOLE_ID: 1,
   MEAN_X_GFA: 0.90445804595947266,
   MEAN_Y_GFA: 13.898725032806396
}
{
   PINHOLE_ID: 2,
   MEAN_X_GFA: 2047.9033813476562,
   MEAN_Y_GFA: 13.899508476257324
}
{
   PINHOLE_ID: 3,
   MEAN_X_GFA: 2047.9044799804688,
   MEAN_Y_GFA: 1044.8986511230469
}
{
   PINHOLE_ID: 4,
   MEAN_X_GFA: 0.90369510650634766,
   MEAN_Y_GFA: 1044.8976745605469
}
```


Then translate (X_FP, Y_FP) to (X_PTL, Y_PTL) using desimeter fp2ptl. fp2ptl gives Z_PTL off by ~2.3 mm relative to the metrology file, so for Z_PTL in GUIDE3 and GUIDE7 just take the average of Z_PTL per PINHOLE_ID for the 8 cameras with existing metrology

Sanity check: how well is fp_metrology.csv data for GUIDE0, GUIDE2, GUIDE5, GUIDE8 reproduced by this procedure?

PETAL_LOC : 0 ; RMS 1D in XY : 10.534562 micron
PETAL_LOC : 0 ; RMS in Z : 6.9103197 micron
PETAL_LOC : 2 ; RMS 1D in XY : 7.7207323 micron
PETAL_LOC : 2 ; RMS in Z : 78.458377 micron
PETAL_LOC : 5 ; RMS 1D in XY : 8.6773615 micron
PETAL_LOC : 5 ; RMS in Z : 16.545197 micron
PETAL_LOC : 8 ; RMS 1D in XY : 9.1428214 micron
PETAL_LOC : 8 ; RMS in Z : 35.625449 micron

~10 microns RMS or better (1D) in X, Y (where I used the Gaia cross-matches) ; can be substantially worse in Z where I just averaged existing metrology across petals

Sanity check: how well is fp_metrology.csv data for GUIDE0, GUIDE2, GUIDE5, GUIDE8 reproduced by this procedure?

PINHOLE_ID : 1 ; RMS 1D in XY : 8.5868611 micron
PINHOLE_ID : 1 ; RMS in Z : 5.8293296 micron
PINHOLE_ID : 2 ; RMS 1D in XY : 9.1102248 micron
PINHOLE_ID : 2 ; RMS in Z : 55.457016 micron
PINHOLE_ID : 3 ; RMS 1D in XY : 9.5483475 micron
PINHOLE_ID : 3 ; RMS in Z : 66.180151 micron
PINHOLE_ID : 4 ; RMS 1D in XY : 9.0317873 micron
PINHOLE_ID : 4 ; RMS in Z : 16.034697 micron

~10 microns RMS or better (1D) in X, Y (where I used the Gaia cross-matches) ; can be substantially worse in Z where I just averaged existing metrology across petals

GUIDE3 and GUIDE7 values to be inserted into fp-metrology.csv

```
{
    PETAL_LOC: 3,
    PINHOLE_ID: 1,
    X_FP: 348.70699575513720,
    Y_FP: 210.11802993715563,
    X_PTL: 348.76464892711920,
    Y_PTL: 210.07021109845599,
    Z_PTL: -20.952542536599914,
    Z_FP: -20.952542536599914
}
{
    PETAL_LOC: 3,
    PINHOLE_ID: 2,
    X_FP: 330.57150438728377,
    Y_FP: 234.89812275263509,
    X_PTL: 330.63438899134030,
    Y_PTL: 234.85413172773400,
    Z_PTL: -20.767164722593968,
    Z_FP: -20.767164722593968
}
{
    PETAL_LOC: 3,
    PINHOLE_ID: 3,
    X_FP: 318.15089930452552,
    Y_FP: 225.79936047015394,
    X_PTL: 318.21186345482175,
    Y_PTL: 225.75799161285633,
    Z_PTL: -19.332358573025797,
    Z_FP: -19.332358573025797
}
{
    PETAL_LOC: 3,
    PINHOLE_ID: 4,
    X_FP: 336.28640949159791,
    Y_FP: 201.01924682358572,
    X_PTL: 336.34214220542185,
    Y_PTL: 200.97405014851731,
    Z_PTL: -19.517736387031739,
    Z_FP: -19.517736387031739
}
```

```
{
    PETAL_LOC: 7,
    PINHOLE_ID: 1,
    X_FP: -405.57258141850389,
    Y_FP: 35.467524790740441,
    X_PTL: 349.04426046270368,
    Y_PTL: 209.67278762408259,
    Z_PTL: -20.952542536599914,
    Z_FP: -20.952542536599914
}
{
    PETAL_LOC: 7,
    PINHOLE_ID: 2,
    X_FP: -405.59430628339862,
    Y_FP: 4.7577098591934925,
    X_PTL: 331.00747481975247,
    Y_PTL: 234.52771809612071,
    Z_PTL: -20.767164722593968,
    Z_FP: -20.767164722593968
}
{
    PETAL_LOC: 7,
    PINHOLE_ID: 3,
    X_FP: -390.19620774869713,
    Y_FP: 4.7556586699079277,
    X_PTL: 318.55025108389907,
    Y_PTL: 225.47680546331711,
    Z_PTL: -19.332358573025797,
    Z_FP: -19.332358573025797
}
{
    PETAL_LOC: 7,
    PINHOLE_ID: 4,
    X_FP: -390.17448574829149,
    Y_FP: 35.465501529813451,
    X_PTL: 336.58705546316378,
    Y_PTL: 200.62185408316890,
    Z_PTL: -19.517736387031739,
    Z_FP: -19.517736387031739
}
```

*existing DEVICE_TYPE = GFA entries in fp-metrology.csv have Z_FP = Z_PTL, so I've done the same for GUIDE3 and GUIDE7

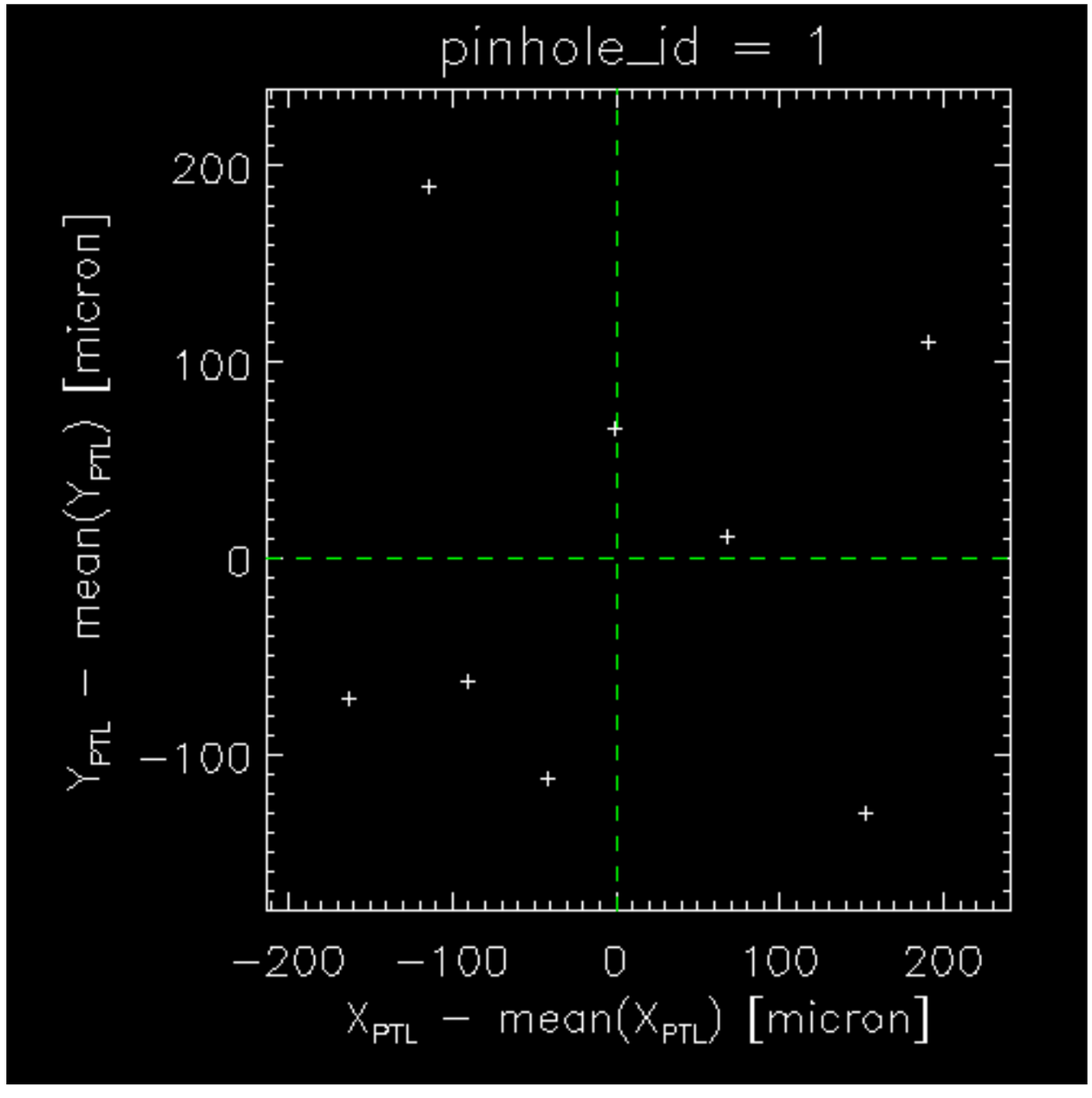
GUIDE3 and GUIDE7 values to be inserted into fp-metrology.csv

```
{
    PETAL_LOC: 3,
    PINHOLE_ID: 1,
    X_FP: 348.70699575513720,
    Y_FP: 210.11802993715563,
    X_PTL: 348.76464892711920,
    Y_PTL: 210.07021109845599,
    Z_PTL: -20.952542536599914,
    Z_FP: -20.952542536599914
}
{
    PETAL_LOC: 3,
    PINHOLE_ID: 2,
    X_FP: 330.57150438728377,
    Y_FP: 234.89812275263509,
    X_PTL: 330.63438899134030,
    Y_PTL: 234.85413172773400,
    Z_PTL: -20.767164722593968,
    Z_FP: -20.767164722593968
}
{
    PETAL_LOC: 3,
    PINHOLE_ID: 3,
    X_FP: 318.15089930452552,
    Y_FP: 225.79936047015394,
    X_PTL: 318.21186345482175,
    Y_PTL: 225.75799161285633,
    Z_PTL: -19.332358573025797,
    Z_FP: -19.332358573025797
}
{
    PETAL_LOC: 3,
    PINHOLE_ID: 4,
    X_FP: 336.28640949159791,
    Y_FP: 201.01924682358572,
    X_PTL: 336.34214220542185,
    Y_PTL: 200.97405014851731,
    Z_PTL: -19.517736387031739,
    Z_FP: -19.517736387031739
}
```

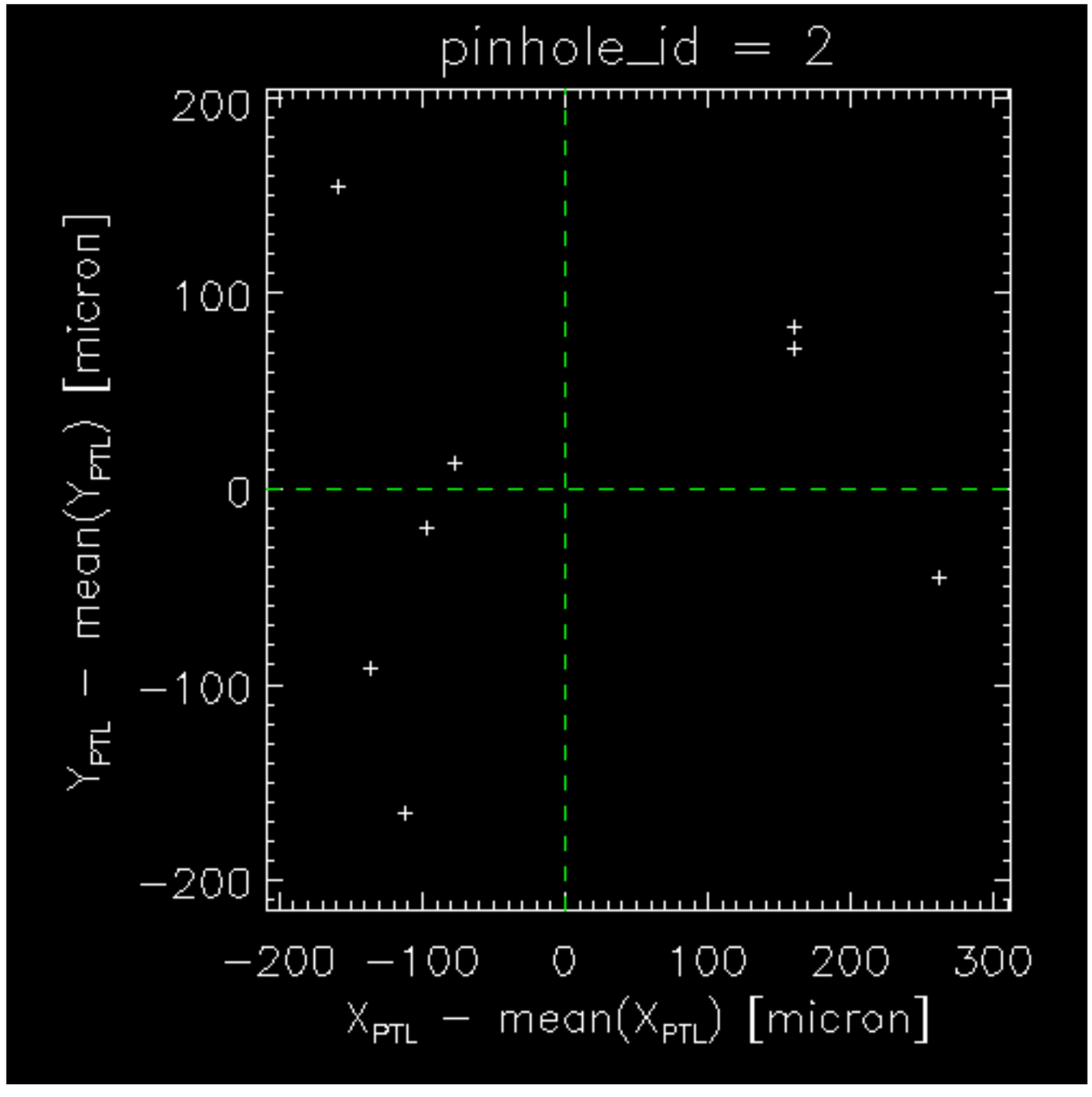
```
{
    PETAL_LOC: 7,
    PINHOLE_ID: 1,
    X_FP: -405.57258141850389,
    Y_FP: 35.467524790740441,
    X_PTL: 349.04426046270368,
    Y_PTL: 209.67278762408259,
    Z_PTL: -20.952542536599914,
    Z_FP: -20.952542536599914
}
{
    PETAL_LOC: 7,
    PINHOLE_ID: 2,
    X_FP: -405.59430628339862,
    Y_FP: 4.7577098591934925,
    X_PTL: 331.00747481975247,
    Y_PTL: 234.52771809612071,
    Z_PTL: -20.767164722593968,
    Z_FP: -20.767164722593968
}
{
    PETAL_LOC: 7,
    PINHOLE_ID: 3,
    X_FP: -390.19620774869713,
    Y_FP: 4.7556586699079277,
    X_PTL: 318.55025108389907,
    Y_PTL: 225.47680546331711,
    Z_PTL: -19.332358573025797,
    Z_FP: -19.332358573025797
}
{
    PETAL_LOC: 7,
    PINHOLE_ID: 4,
    X_FP: -390.17448574829149,
    Y_FP: 35.465501529813451,
    X_PTL: 336.58705546316378,
    Y_PTL: 200.62185408316890,
    Z_PTL: -19.517736387031739,
    Z_FP: -19.517736387031739
}
```

TODO: patch these values into fp-metrology.csv by editing write_focal_plane_metrology script

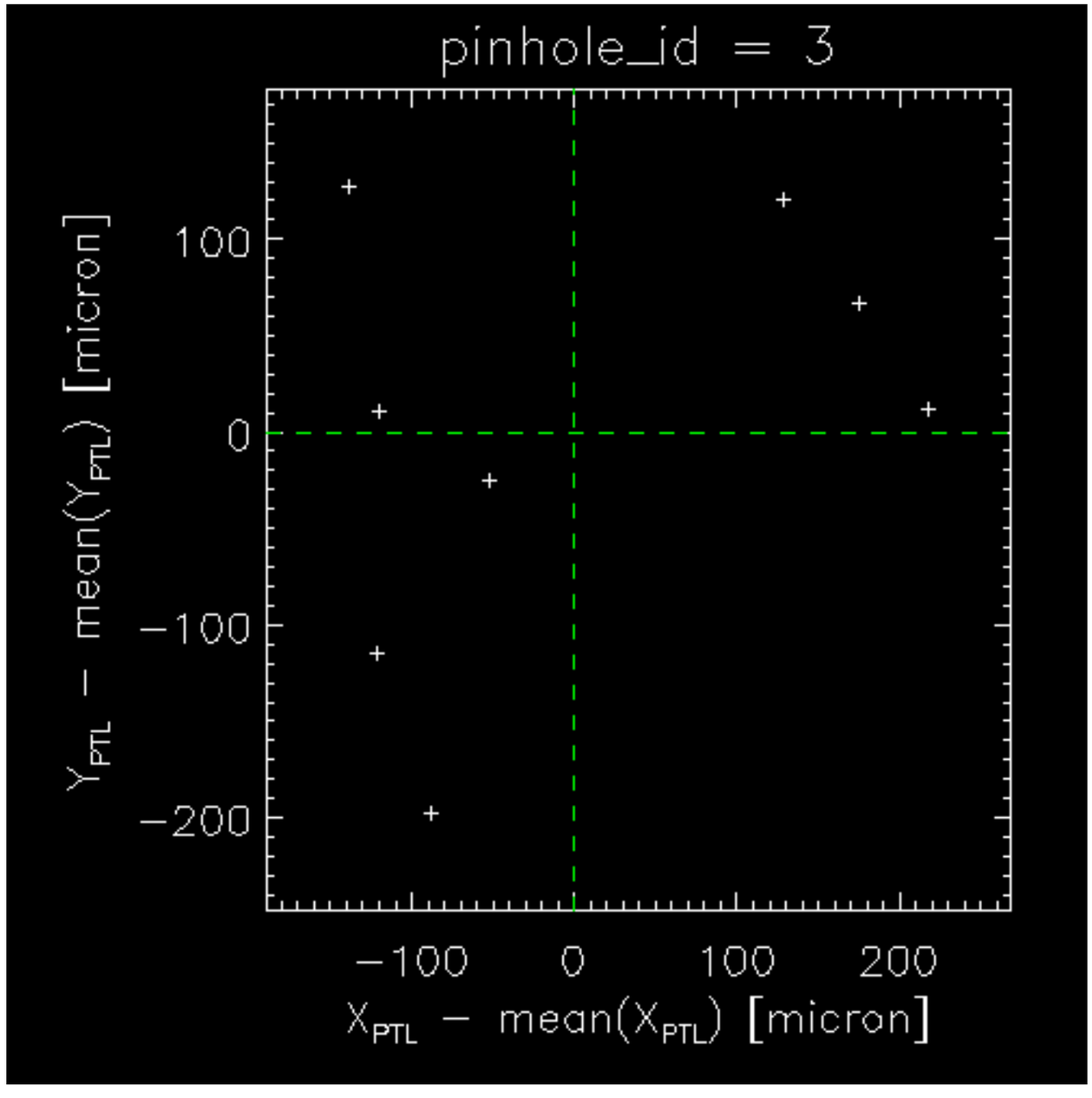
How much was gained by using Gaia for GUIDE3/GUIDE7 (X_PTL, Y_PTL) rather than just averaging those values for 8 petals with existing metrology?



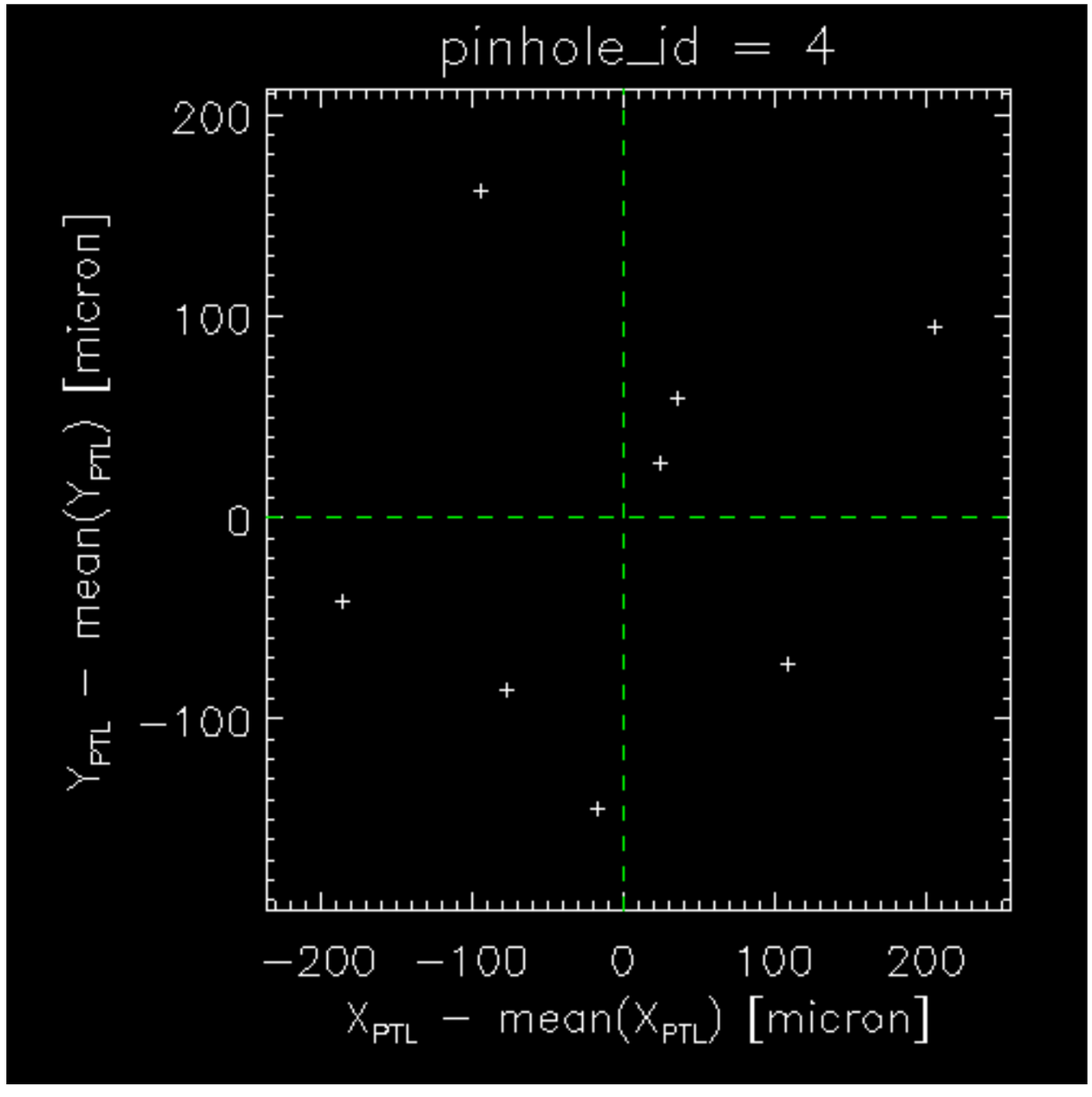
How much was gained by using Gaia for GUIDE3/GUIDE7 (X_PTL, Y_PTL) rather than just averaging those values for 8 petals with existing metrology?



How much was gained by using Gaia for GUIDE3/GUIDE7 (X_PTL, Y_PTL) rather than just averaging those values for 8 petals with existing metrology?



How much was gained by using Gaia for GUIDE3/GUIDE7 (X_PTL, Y_PTL) rather than just averaging those values for 8 petals with existing metrology?

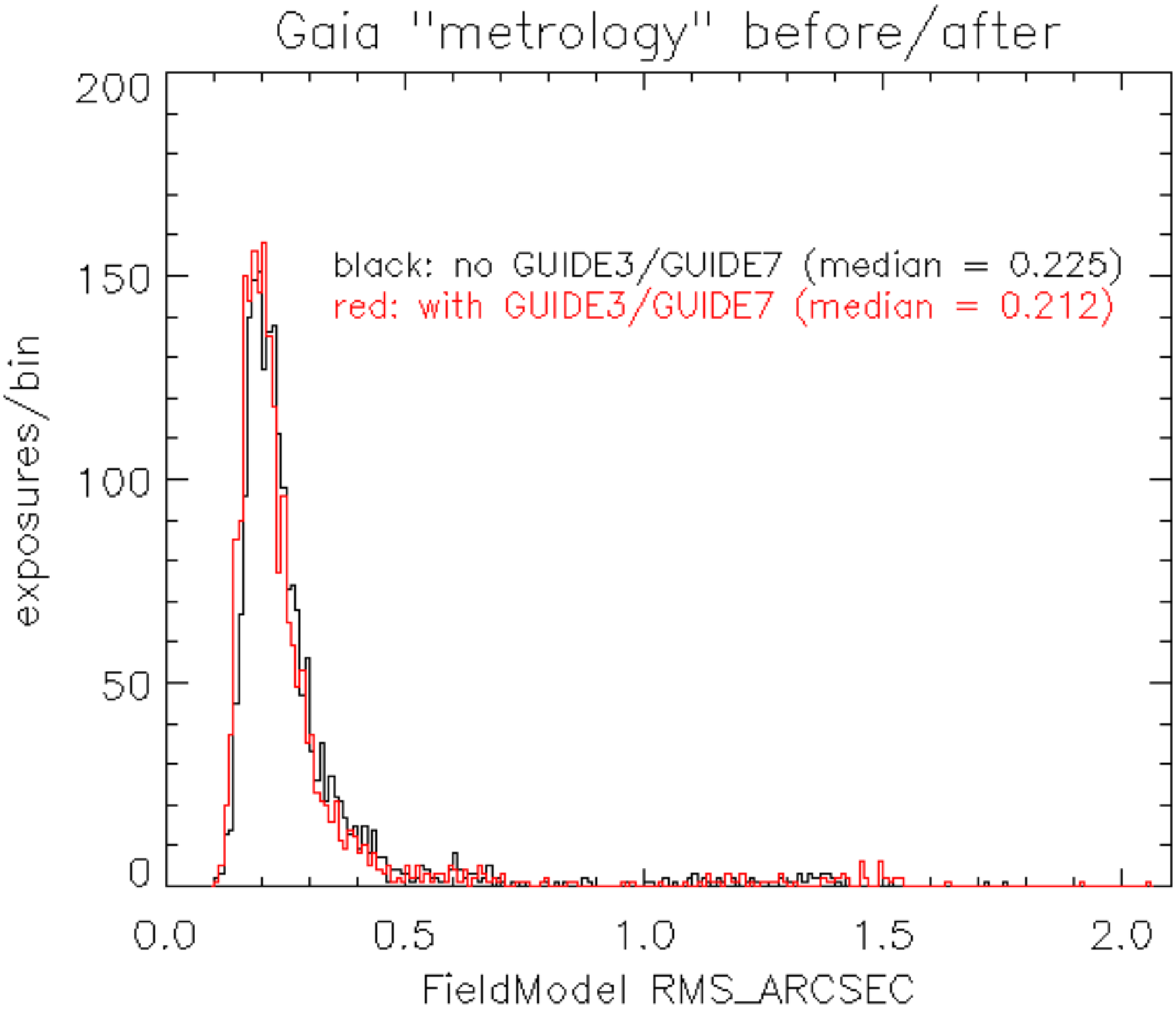


How much was gained by using Gaia for GUIDE3/GUIDE7 (X_PTL, Y_PTL) rather than just averaging those values for 8 petals with existing metrology?

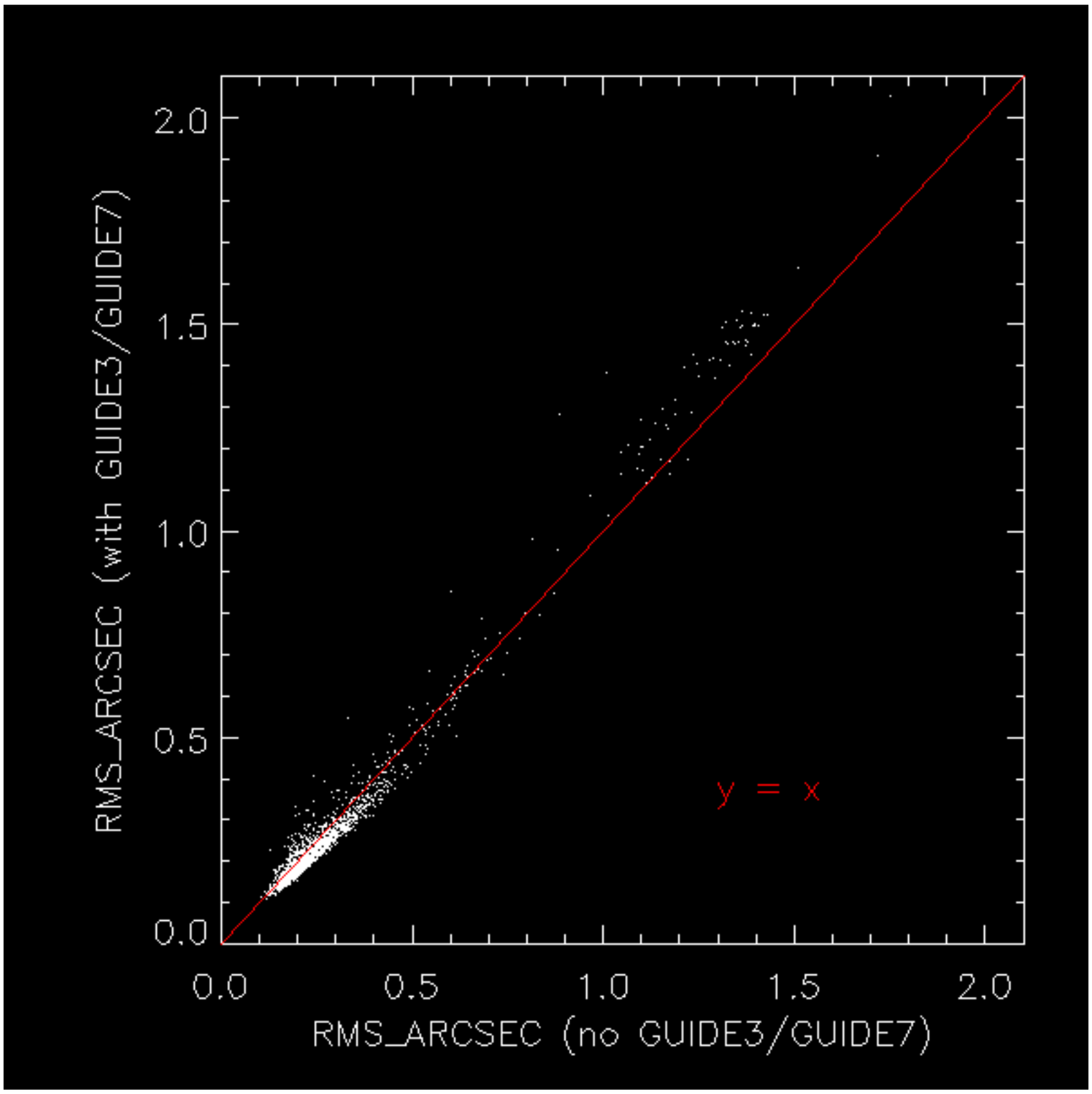
```
RMS X_PTL(Gaia) shift relative to mean of GFA's w/ real metrology :        187.78971 micron
RMS Y_PTL(Gaia) shift relative to mean of GFA's w/ real metrology :        174.27949 micron
```

given that the typical 1D RMS of my Gaia-based procedure relative to fp-metrology.csv truth for PETAL_LOC=[0, 2, 5, 8] is ~9 microns, the gain is up to a factor of ~20x

end-to-end validation

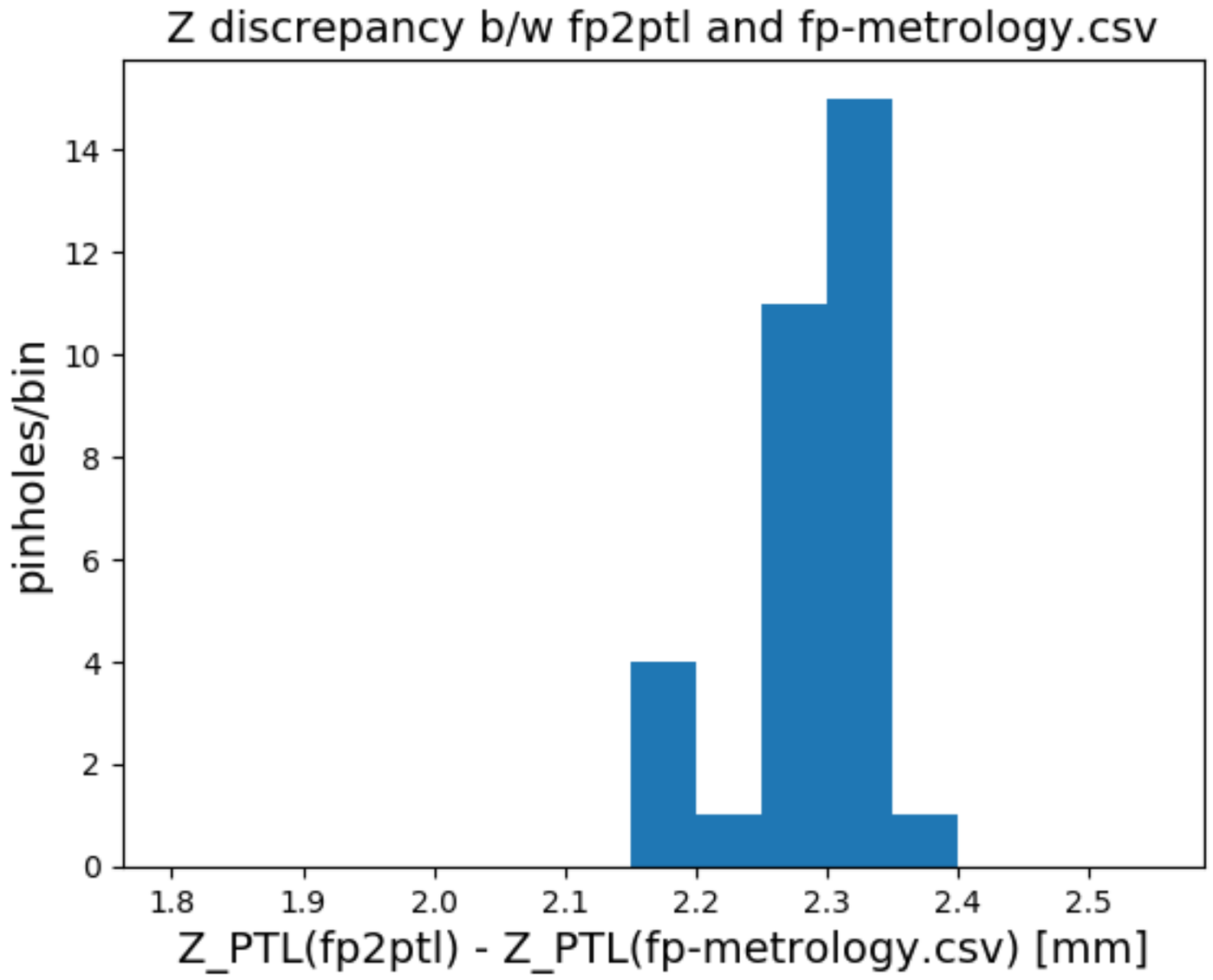


end-to-end validation



appendix: miscellaneous

2+ mm Z_PTL discrepancy



When I convert (X_FP, Y_FP) from fp-metrology.csv to (X_PTL, Y_PTL, Z_PTL) using fp2ptl, I get agreement within roundoff for (X_PTL, Y_PTL) for all DEVICE_TYPE=GFA pinholes. But the Z_PTL values from fp2ptl disagree with those in fp-metrology.csv by ~2+ mm (see above histogram)

Code: https://gist.github.com/ameisner/1173899bbd6a0c44d317fd6a80b2ff99.