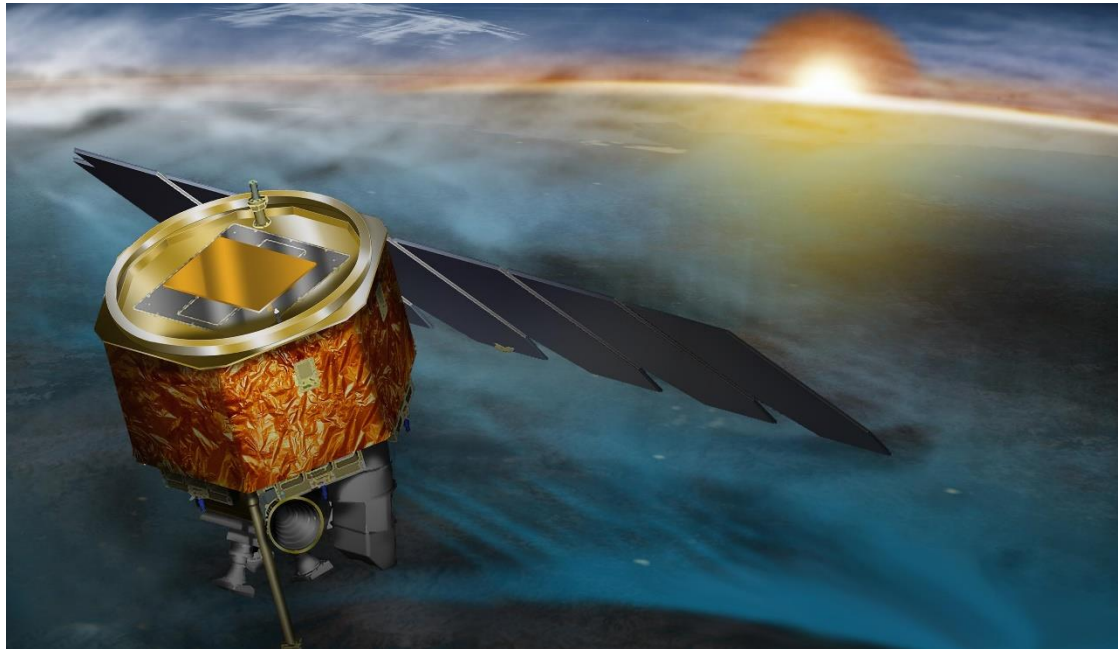


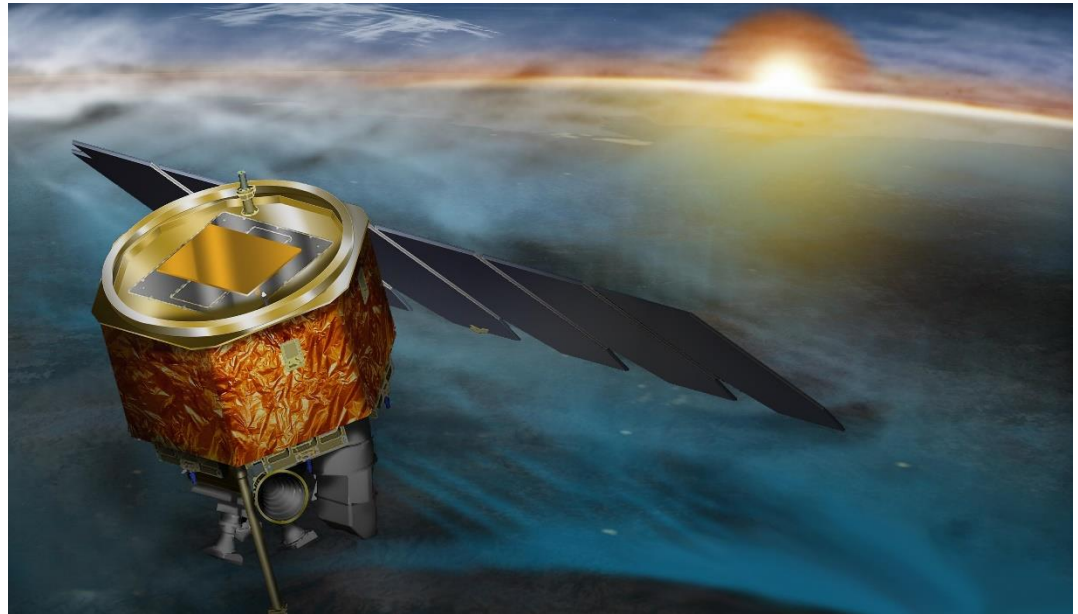
ECE 5554 – Final Project

Calibration of Satellite Cameras using Star Images

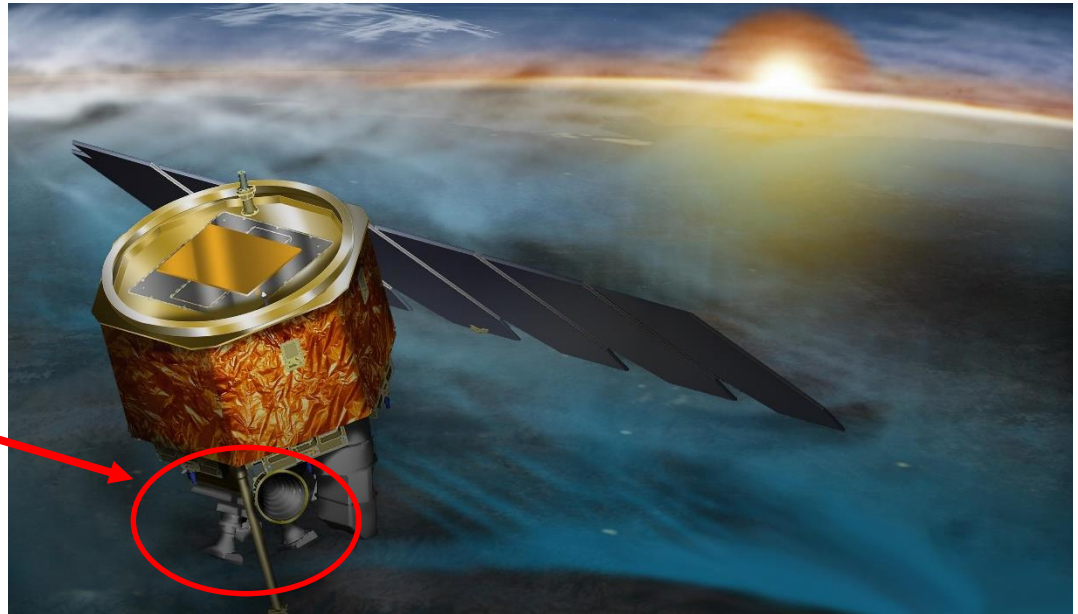


Brett Poché
Maimaitirebike (Muhammad) Maimaiti

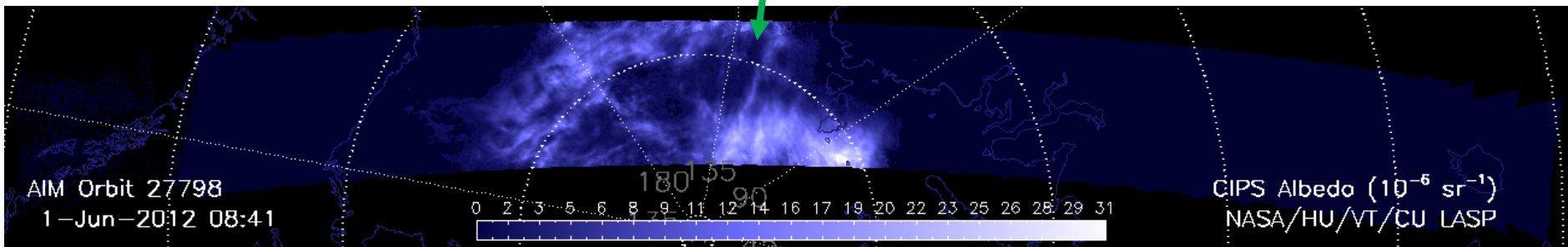
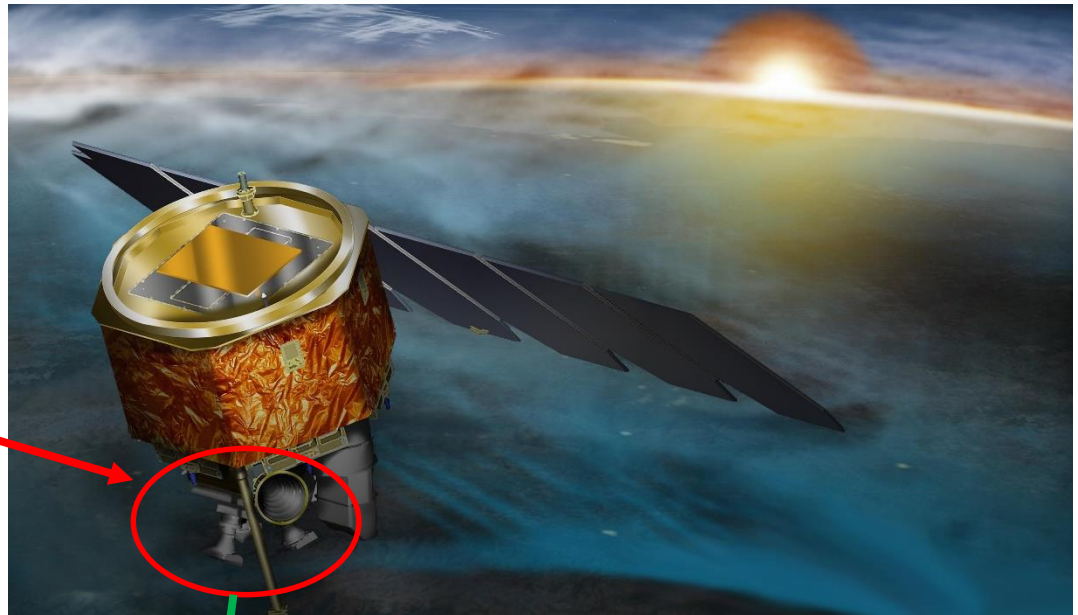
- AIM (Aeronomy of Ice
in the Mesosphere)
Satellite

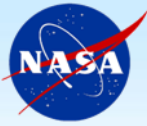


- AIM (Aeronomy of Ice in the Mesosphere) Satellite
- CIPS instrument
 - Four **cameras** pointed towards Earth



- AIM (Aeronomy of Ice in the Mesosphere) Satellite
- CIPS instrument
 - Four **cameras** pointed towards Earth
 - Measures PMC (Polar Mesospheric Cloud) properties



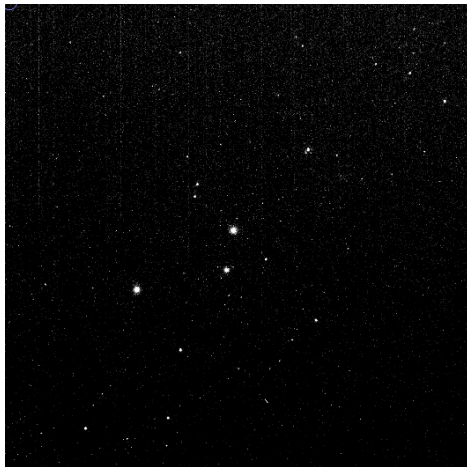


Big Picture

- It was discovered that distortion exists in CIPS cameras which significantly affects our interpretation of the science data.
- As part of initial calibration, in 2007 CIPS was pointed towards the sky and captured a small set of high resolution star images
- **GOAL:** Use these star images to quantify distortion in CIPS and reduce the existing systematic errors

Big Picture

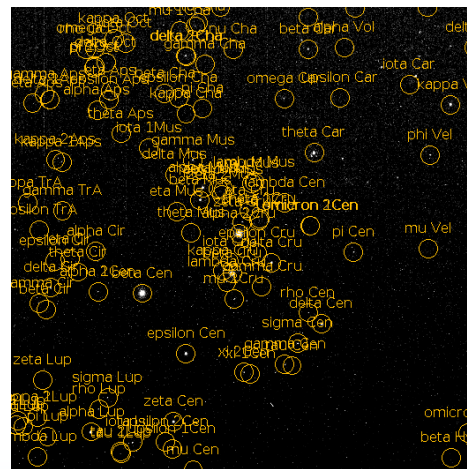
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Input: Raw Star image

Big Picture

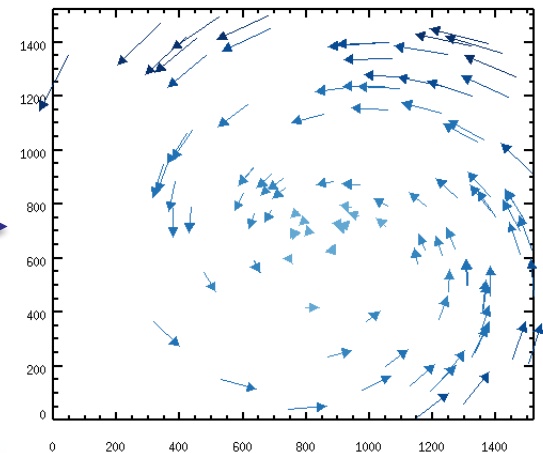
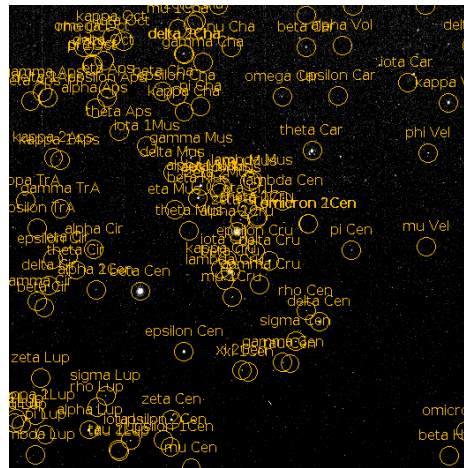
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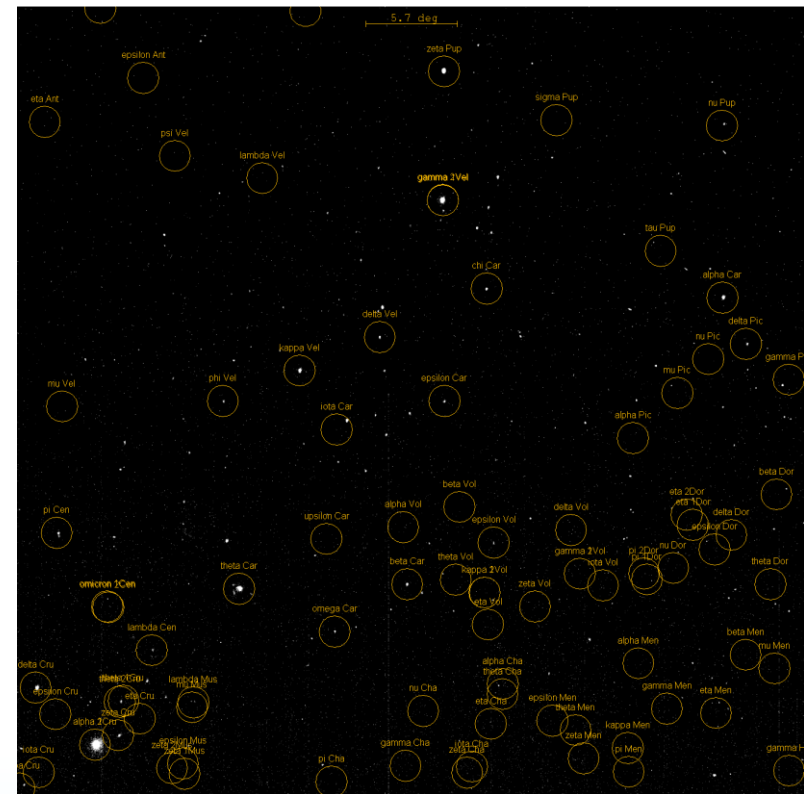


Input: Raw Star image

Output: Distortion Map

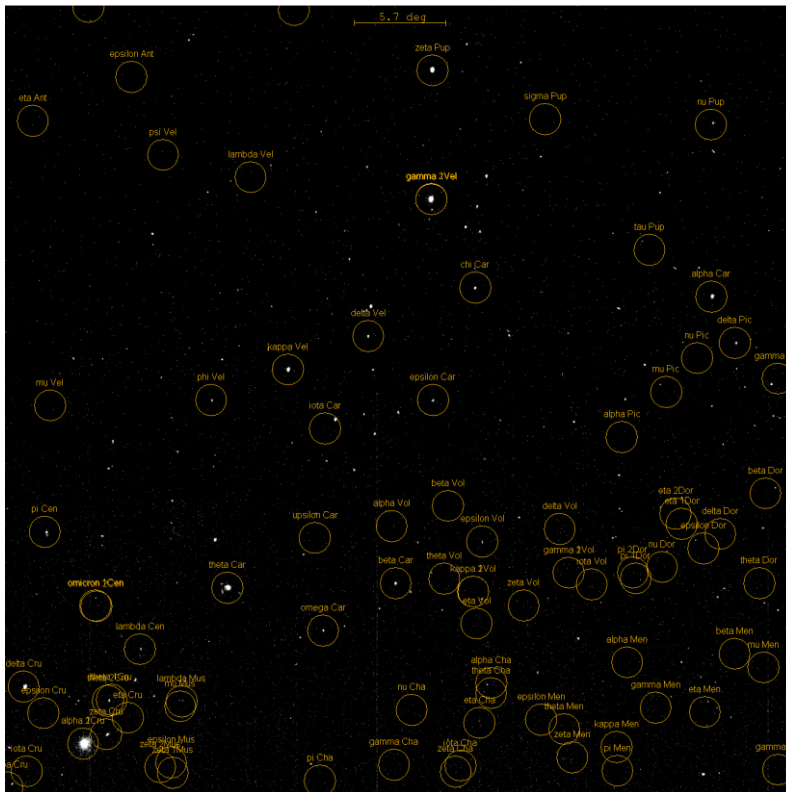
Steps

- Step 1) Identify Stars using Astrometry.net



Steps

- Step 2) Lookup Star coordinates (RA/DEC) in Star Catalog



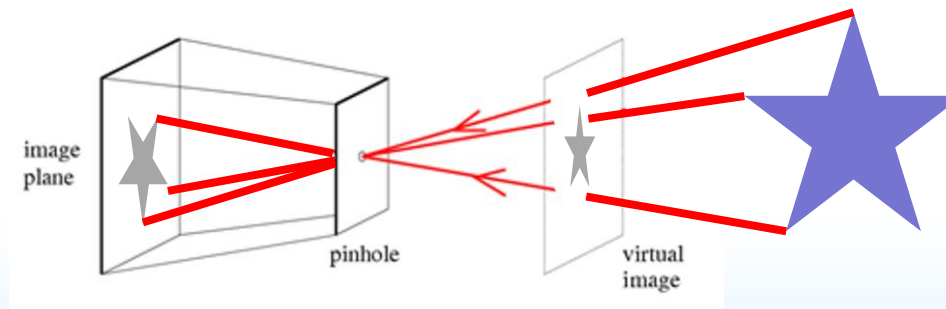
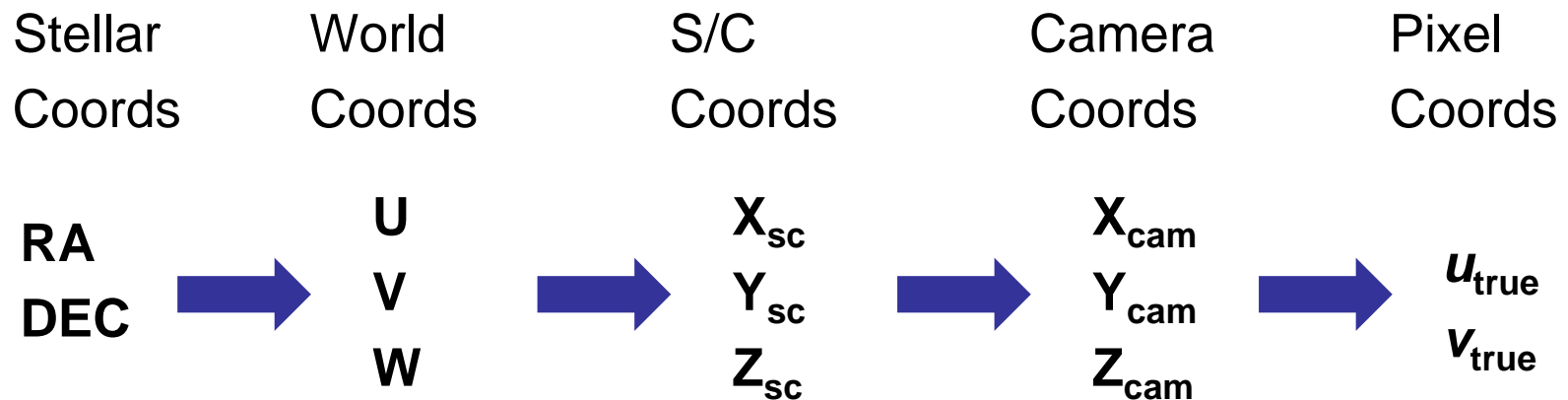
data - DataFrame

Index	ra_act	dec_act
alpha1 Cen	219.901	-60.8354
alpha1 centaurus	219.901	-60.8354
alpha1 crucis	186.65	-63.099
alpha1_cen	219.902	-60.834
alpha2 cru	186.65	-63.099
alpha2_cen	219.896	-60.8372
alpha2_cen	219.896	-60.8372
alpha_cru	186.65	-63.0991
alpha_cru	186.65	-63.0991
alpha_mus	189.296	-69.1356
alpha_mus	189.296	-69.1356
beta Aps	250.77	-77.5175
beta Car	138.3	-69.7172
beta Cen	210.956	-60.373
beta Cen	210.956	-60.373
beta Cha	184.586	-79.3122

Format Resize ☒ Backgrot ☒ Column i OK Cancel

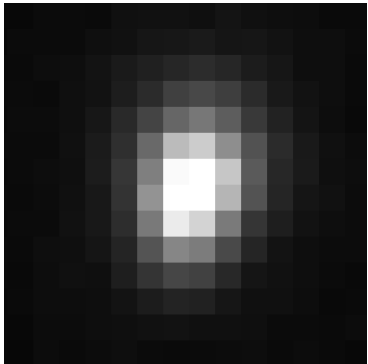
Steps

- Step 3) Use pointing information from satellite and ideal camera model to transform from star coordinates to “true” pixel coordinates



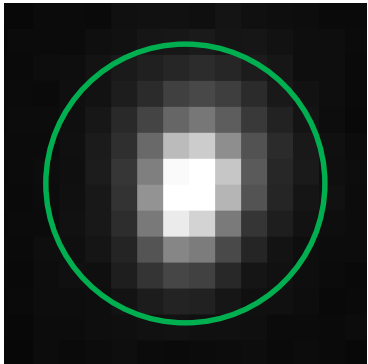
Steps

- Step 4) Quantify distortion by comparing centroid location of stars in original image to “true” pixel coordinates



Steps

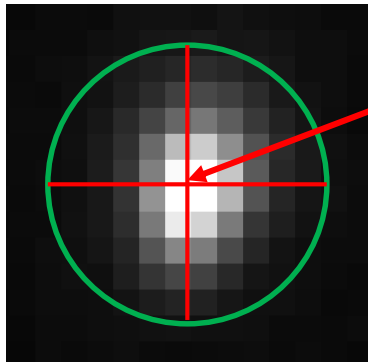
- Step 4) Quantify distortion by comparing centroid location of stars in original image to “true” pixel coordinates



Star: Alpha Crucis

Steps

- Step 4) Quantify distortion by comparing centroid location of stars in original image to “true” pixel coordinates



Centroid pixel coords:

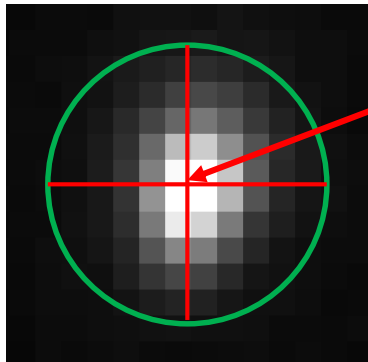
$$u_{act} = 155.34$$

$$v_{act} = 435.68$$

Star: Alpha Crucis

Steps

- Step 4) Quantify distortion by comparing centroid location of stars in original image to “true” pixel coordinates

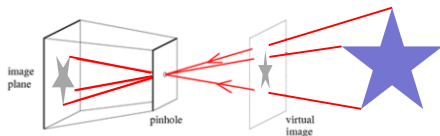


Star: Alpha Crucis

Centroid pixel coords:

$$u_{act} = 155.34$$

$$v_{act} = 435.68$$



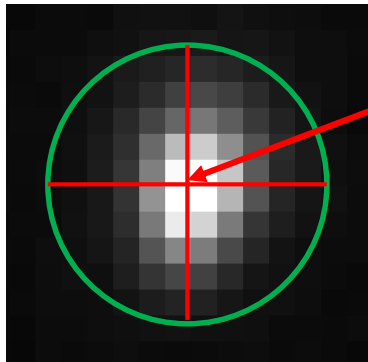
True pixel coords:

$$u_{true} = 157.34$$

$$v_{true} = 433.68$$

Steps

- Step 4) Quantify distortion by comparing centroid location of stars in original image to “true” pixel coordinates



Star: Alpha Crucis

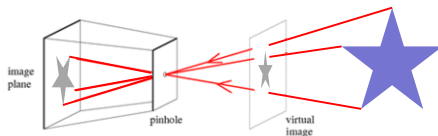
Centroid pixel coords:

$$u_{act} = 155.34$$

$$v_{act} = 435.68$$

$$u_{off} = u_{true} - u_{act}$$

$$v_{off} = v_{true} - v_{act}$$



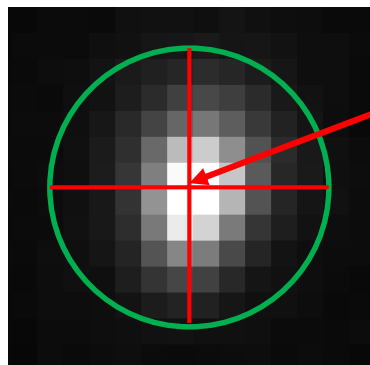
True pixel coords:

$$u_{true} = 157.34$$

$$v_{true} = 433.68$$

Steps

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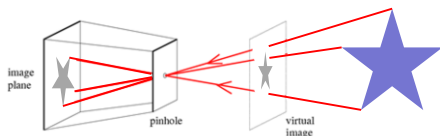


Star: Alpha Crucis

Centroid pixel coords:

$$u_{act} = 155.34$$

$$v_{act} = 435.68$$



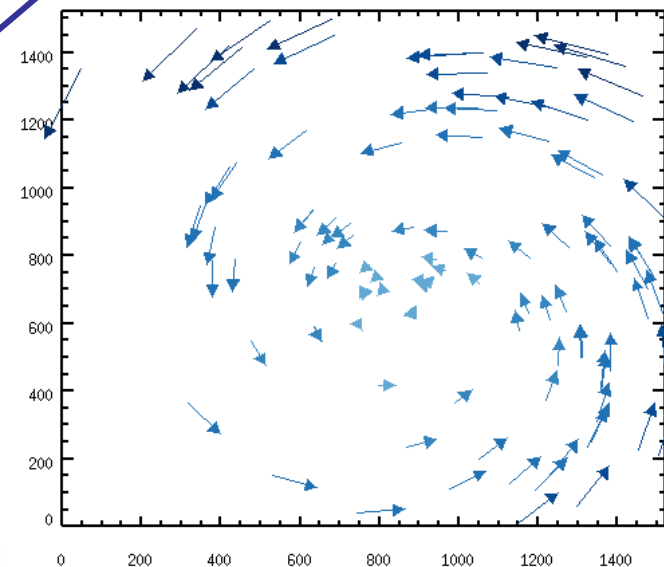
True pixel coords:

$$u_{true} = 157.34$$

$$v_{true} = 433.68$$

$$u_{off} = u_{true} - u_{act}$$

$$v_{off} = v_{true} - v_{act}$$





Summary

- **Current Progress:**

- Identified all stars in images
- Looked up star coordinates from star catalogs
- Transformed star coordinates to pixel coordinates
- Quantified errors for each camera

- **Future Work:**

- Find a transformation for each camera that fixes the error in a systematic way
- Test proposed transformation matrices on a test dataset