PHOTOMETRY OF SOLAR SYSTEM BODIES WITH SALT

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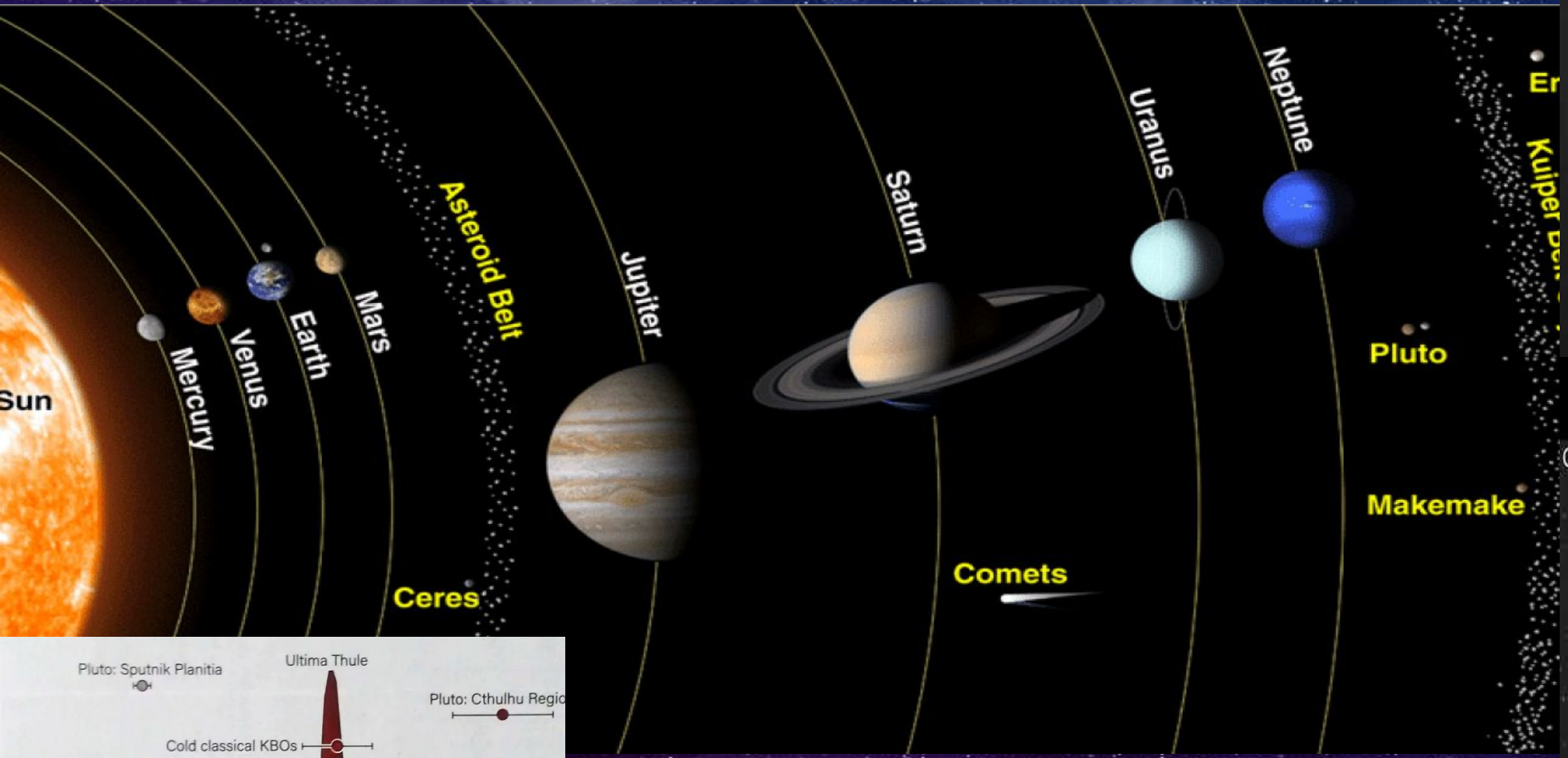
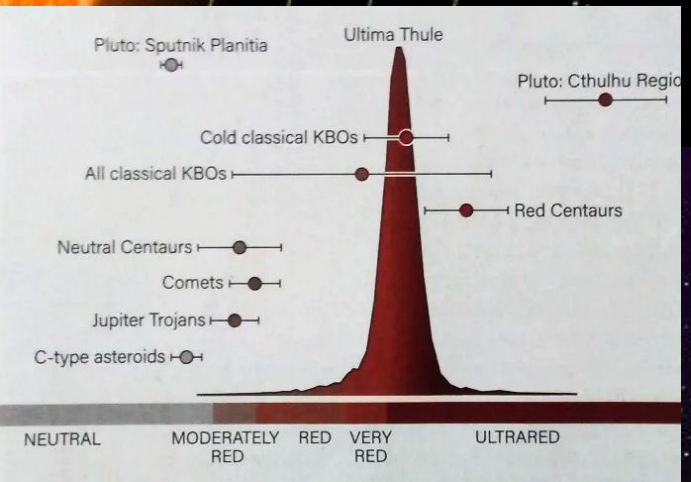
SALT WORKSHOP 2022

Overview

1. Quick Introduction to Centaurs
2. Observing Centaurs
3. Observing Centaurs with SALT+SALTICAM
4. Photometry with SALTICAM
    - SALTICAM vs Illumination Pattern
    - Flat-fielding
    - Let’s count some photons!

What are Centaurs?



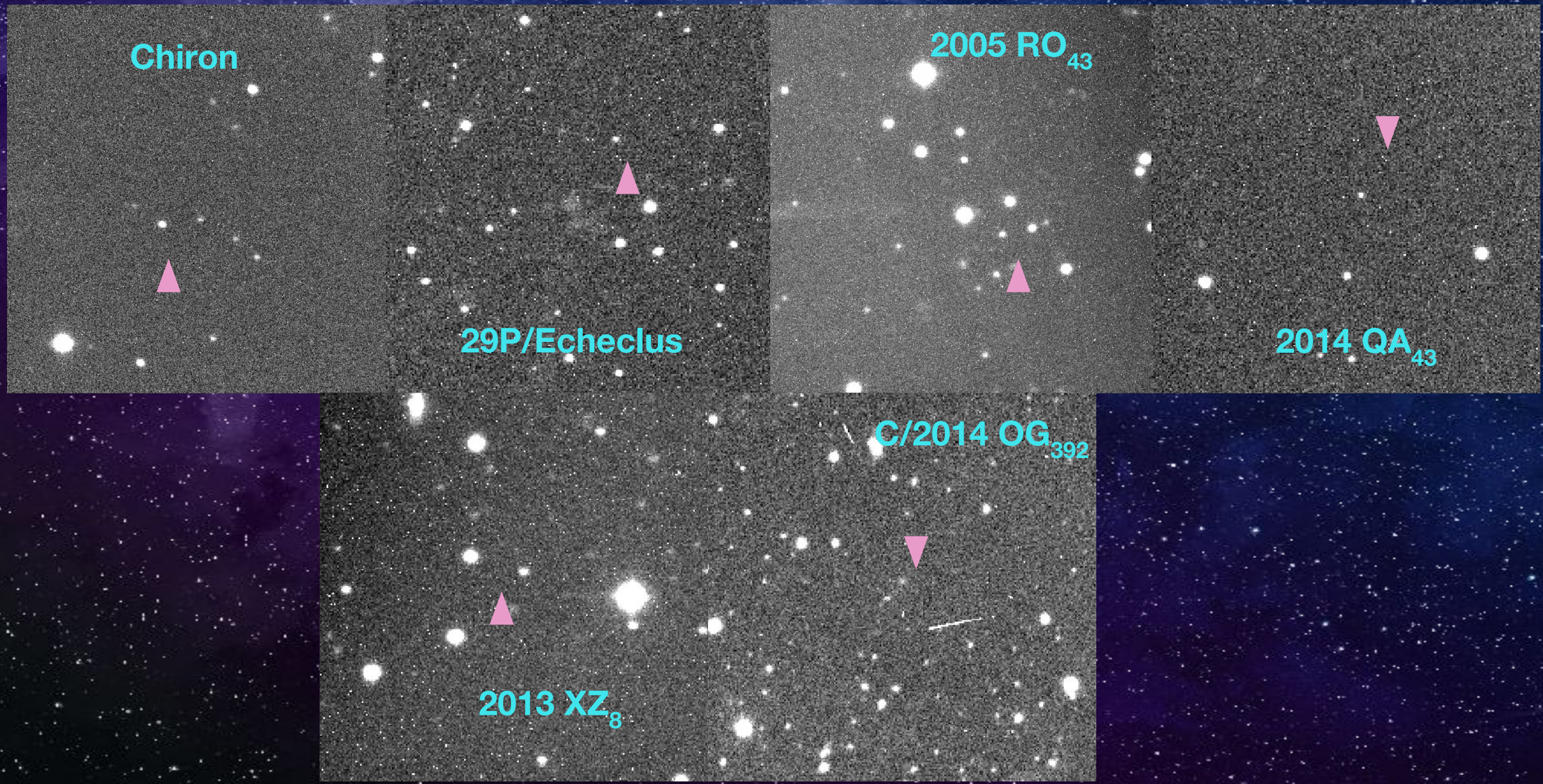


Asteroid-comet hybrid bodies

Found between Jupiter and Neptune

5.5 AU < *a* < 30.1 AU

Just look at them go!



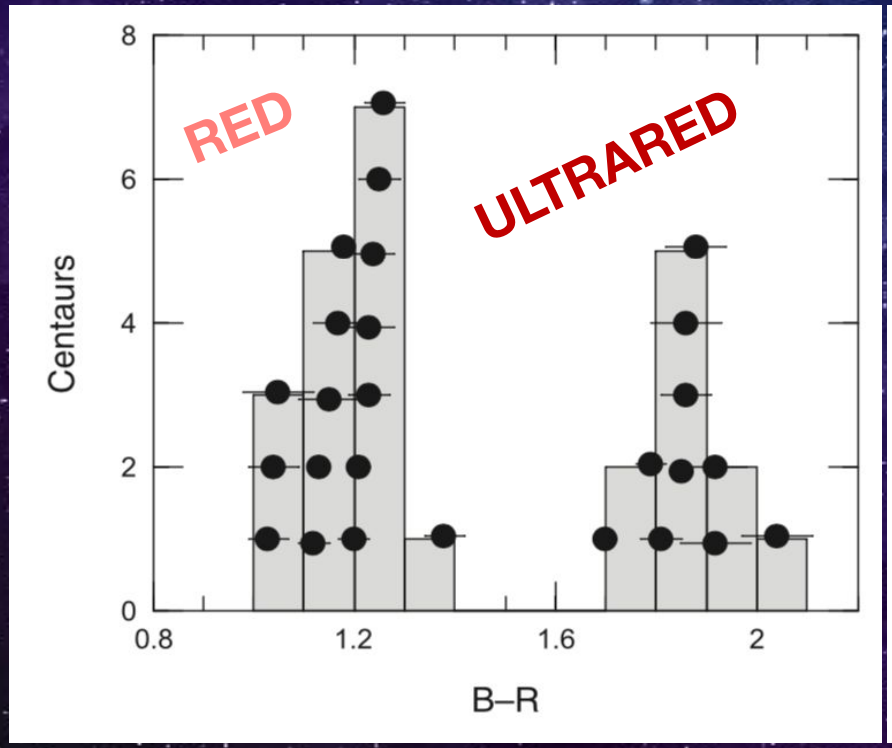
It's a MATCH, SALTICAM!

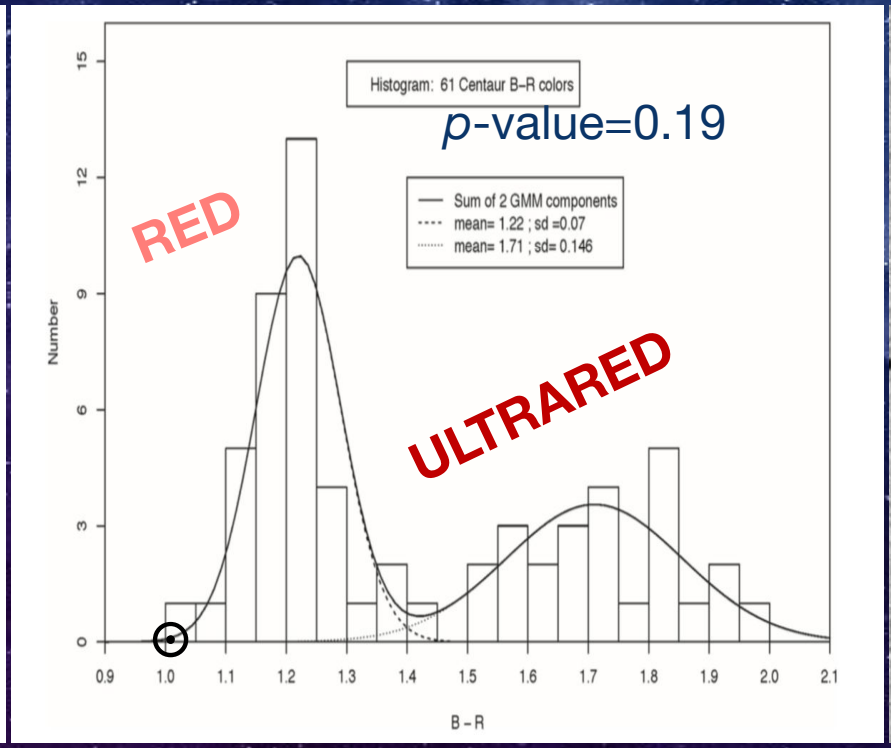
Mag Limit	Movement
✔	✔

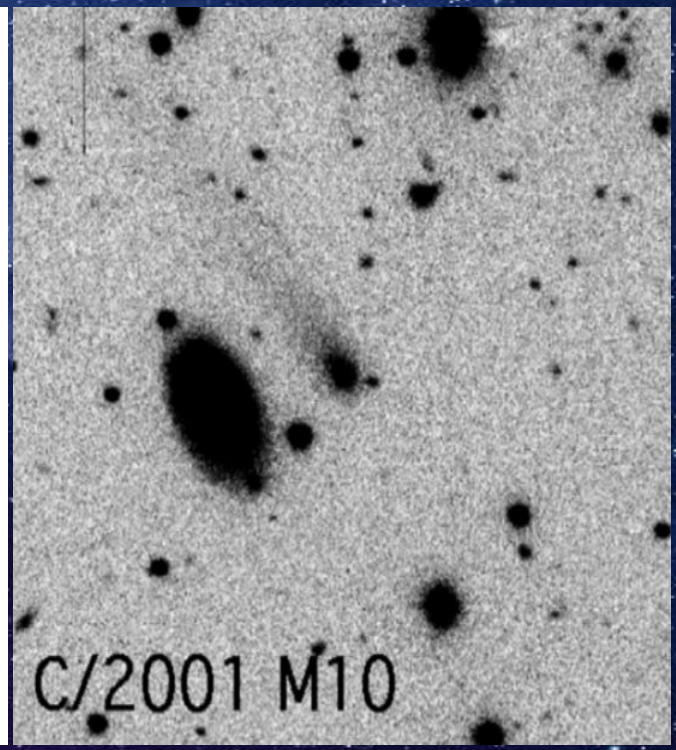
- Centaurs are faint, M_V ~ 21.7
- SALTICAM is the only instrument that can reach this magnitude.
- No need to track the motion of the centaur. SALTICAM CCD has a (unbinned) pixel size of ~0.14".

SALTICAM for Science

Goal: Color and activity



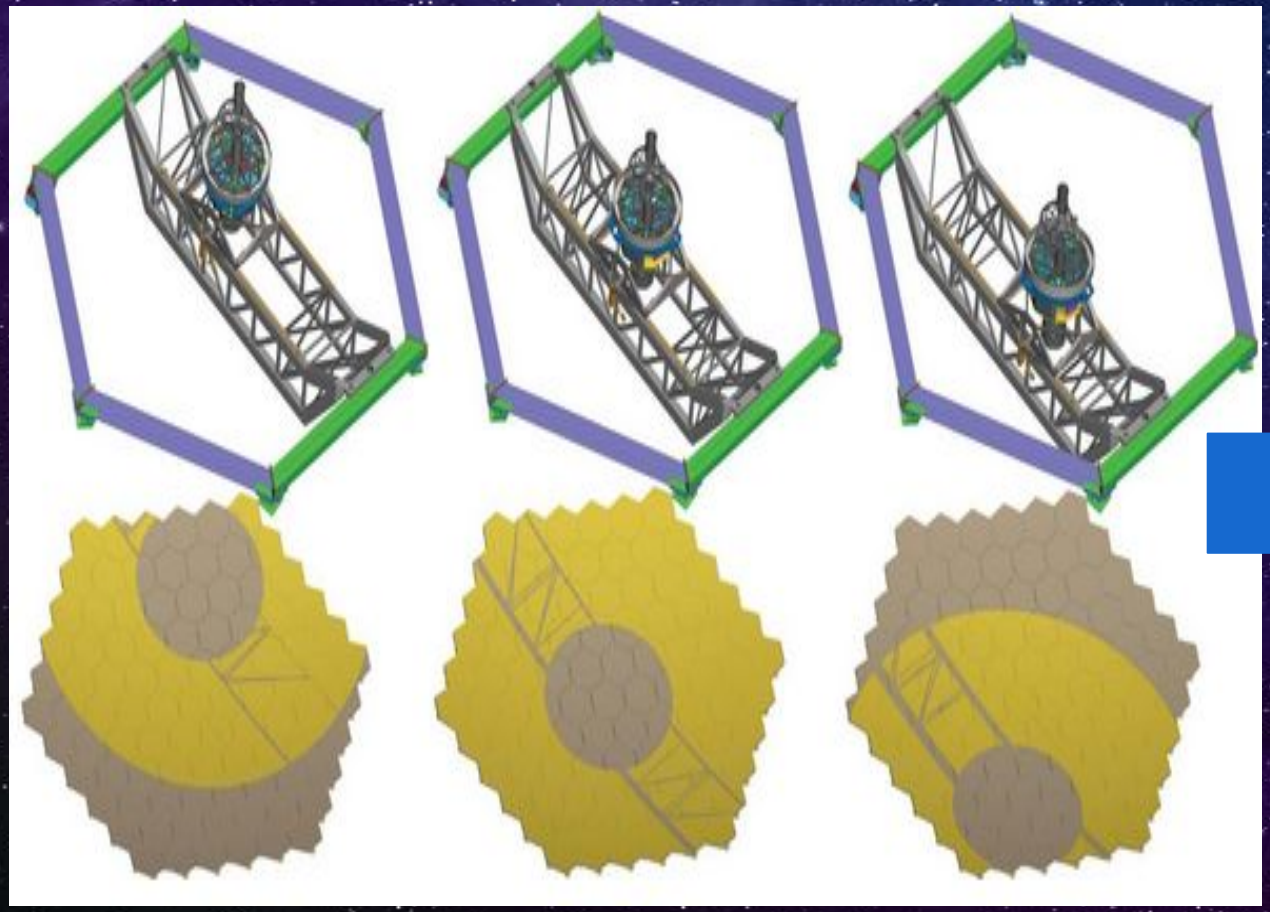


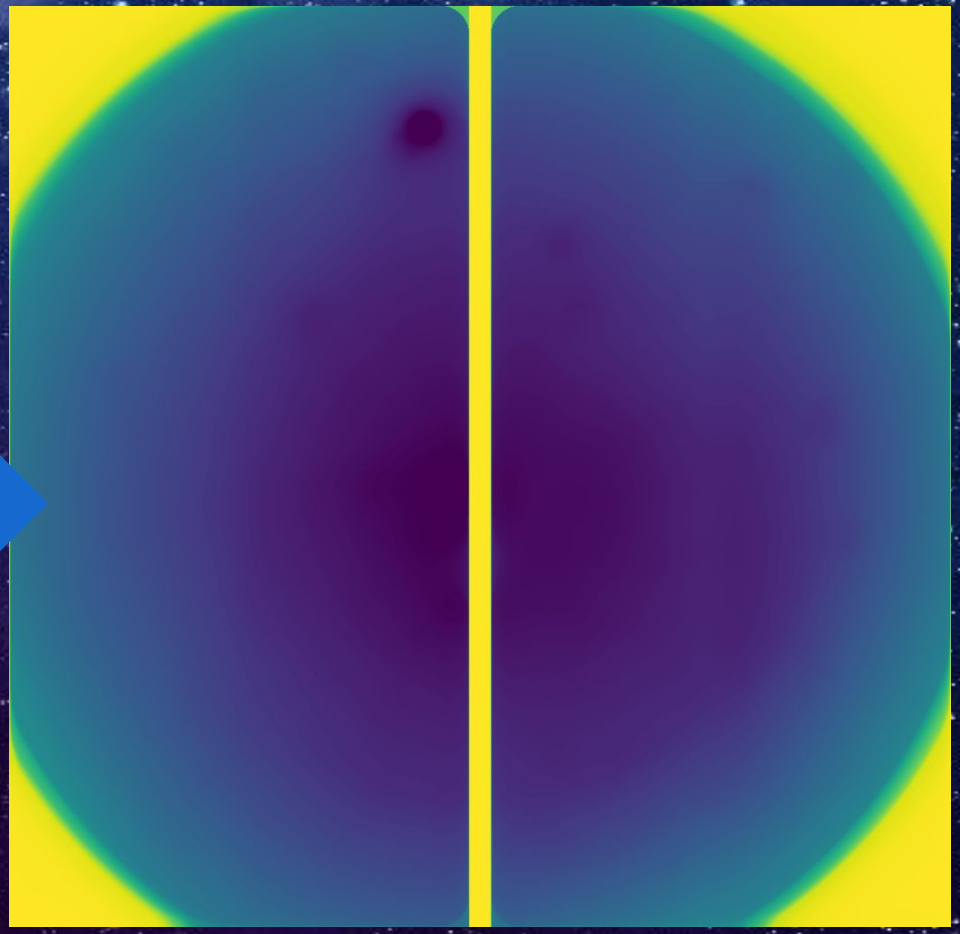


Tegler (2008) Tegler et al. (2016) Jewitt (2009)

Accurate absolute photometry with SALTICAM is difficult.

SALTICAM vs Illumination Pattern





Standard Data Reduction

BIAS

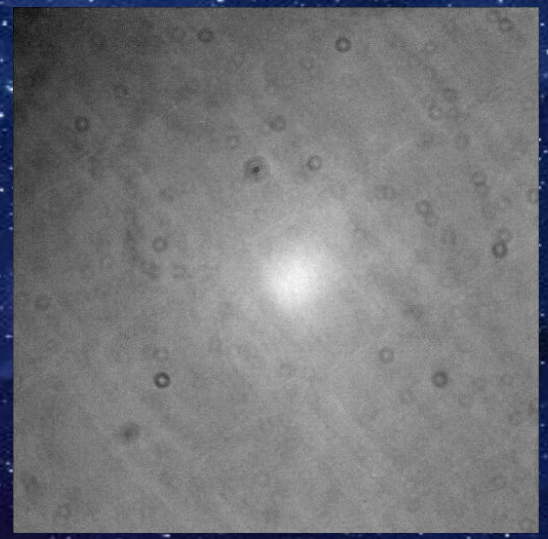
According to SALT Proposal Call Document, test show that biases cannot be used. Data is corrected using the overscan level with the standard pipeline.

DARK

For SALTICAM:

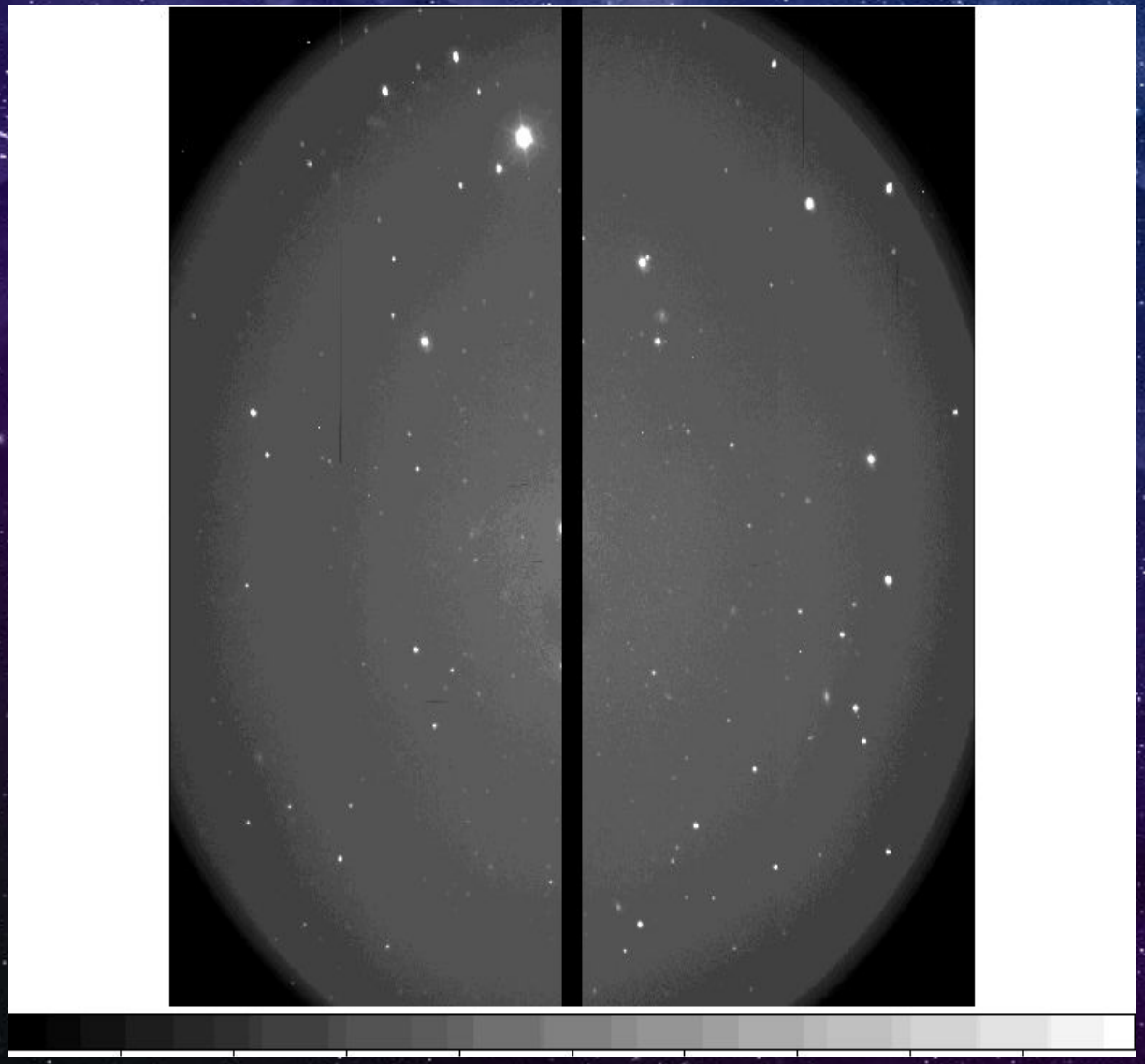
Dark current < 1 e^- per pixel per hour.

FLAT

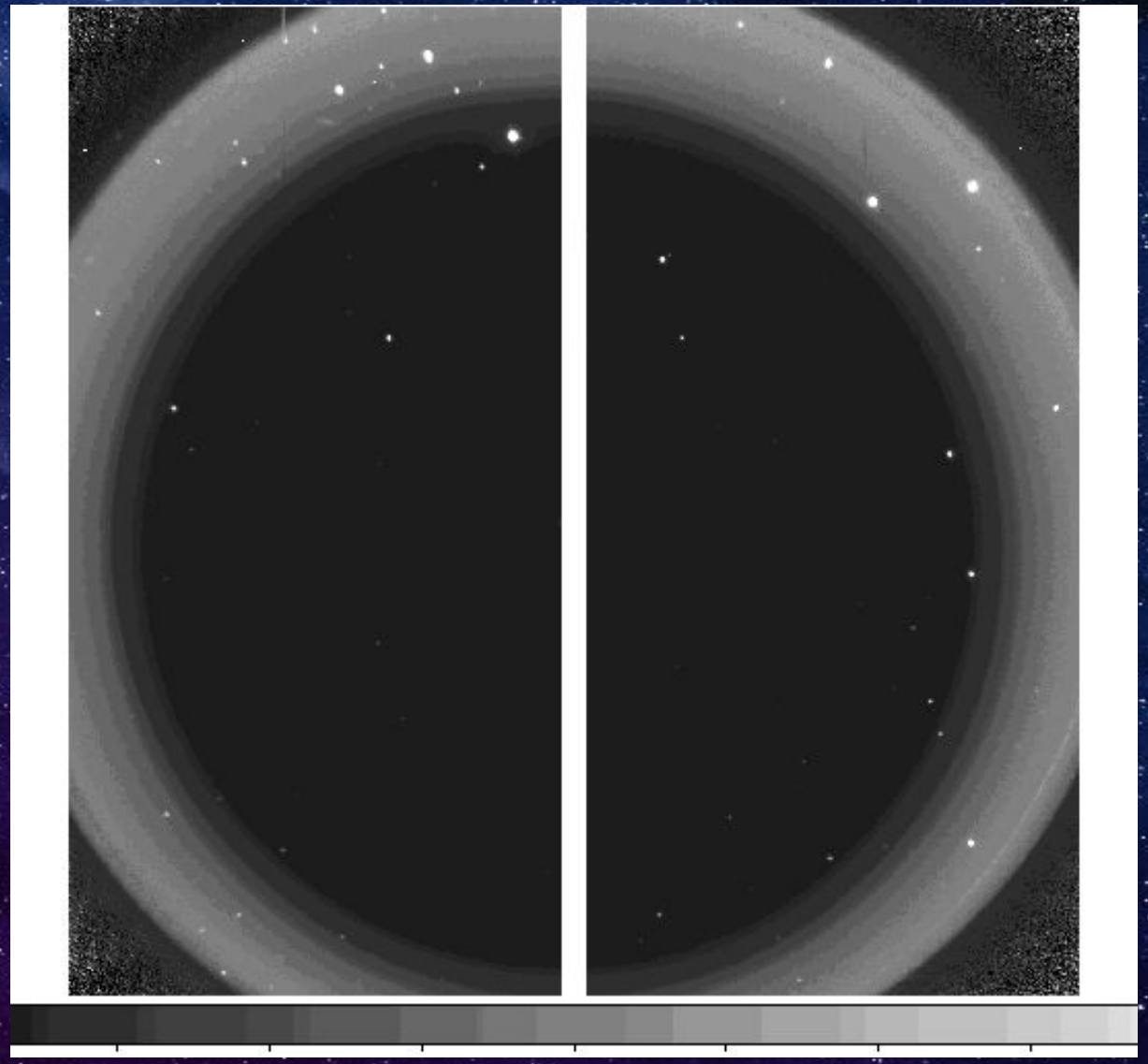


Calibration screen flats
OR
Twilight flats

Raw Image



Raw Image/Master Flat



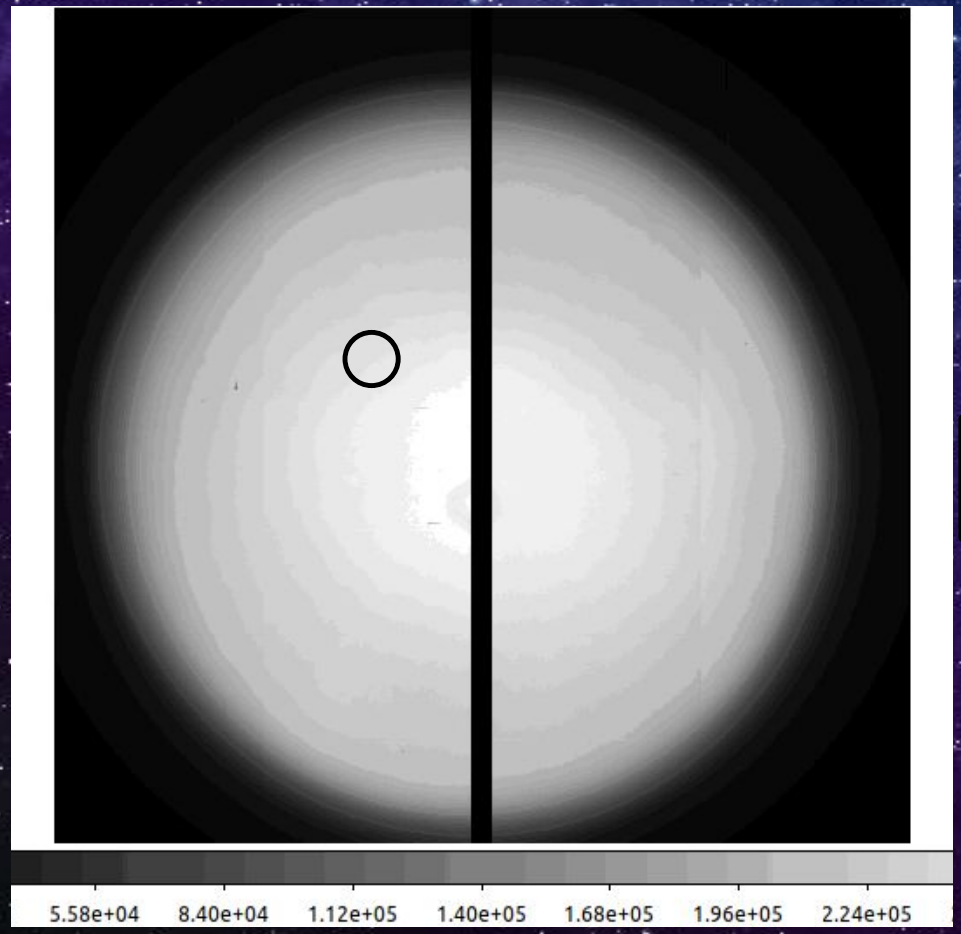
HOW TO FLAT-FIELD

According to Kniazev & Vaisanen, 2011

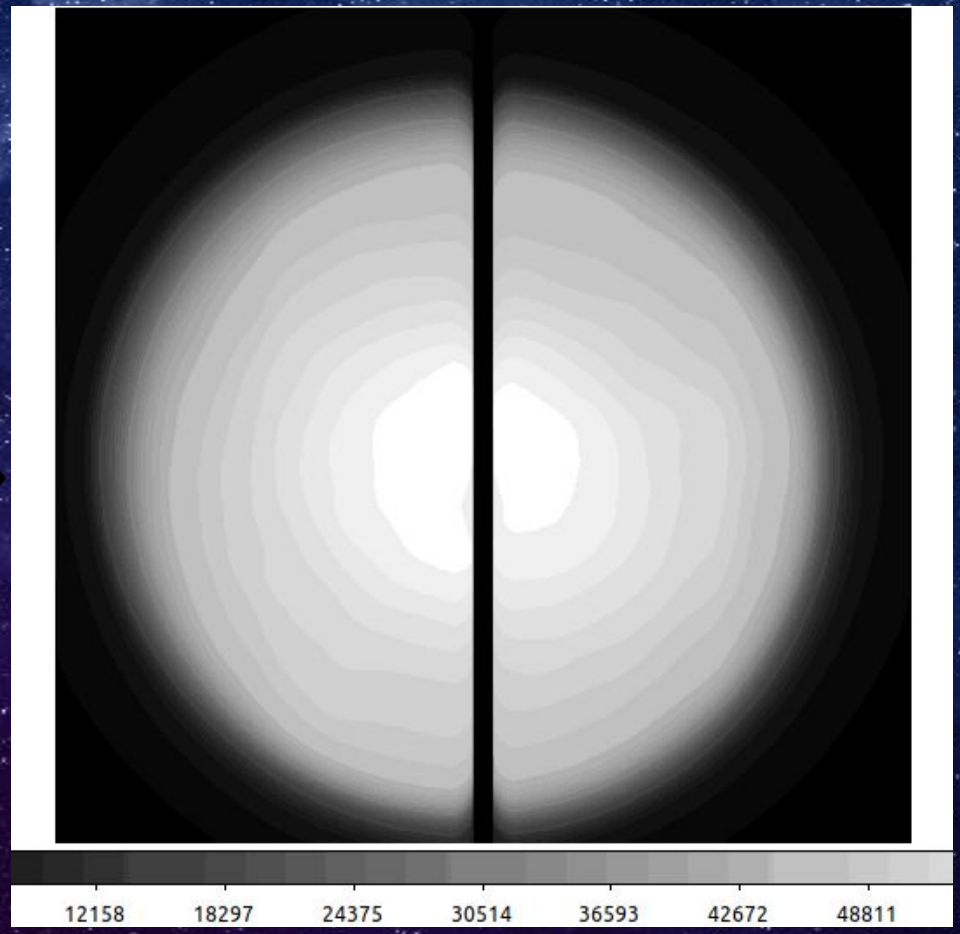
For best results (0.05 ≤ magnitude accuracy ≤ 0.1 mag), two-step flat-fielding is suggested:

1. Low-frequency flats to correct for illumination pattern
2. High-frequency flats to correct for pixel-to-pixel variations

Step 1: Illumination Pattern



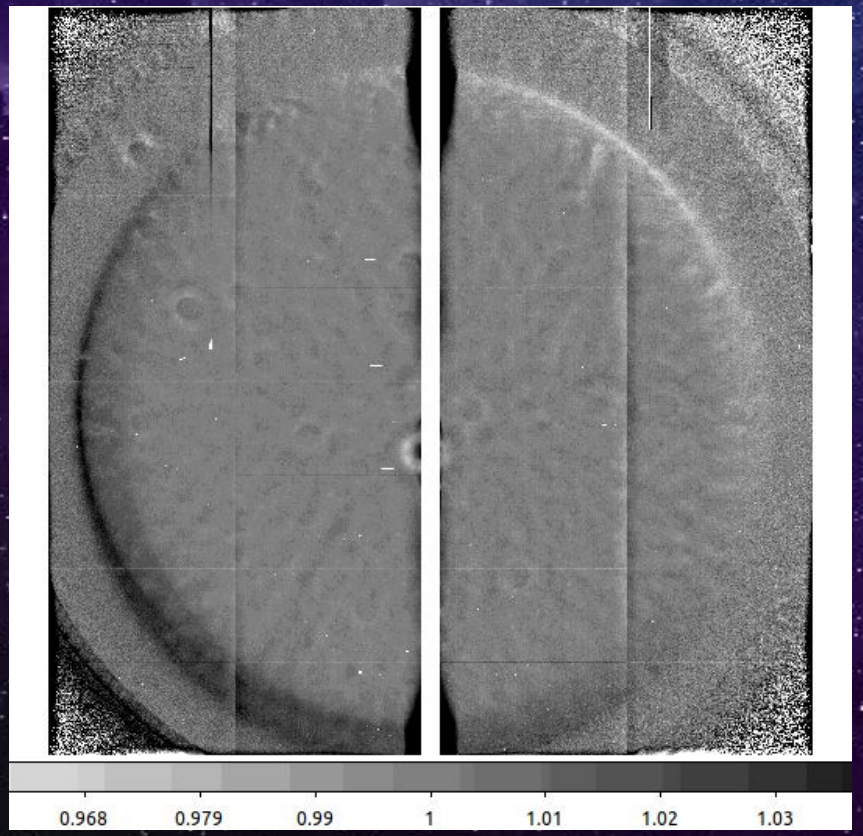
Image



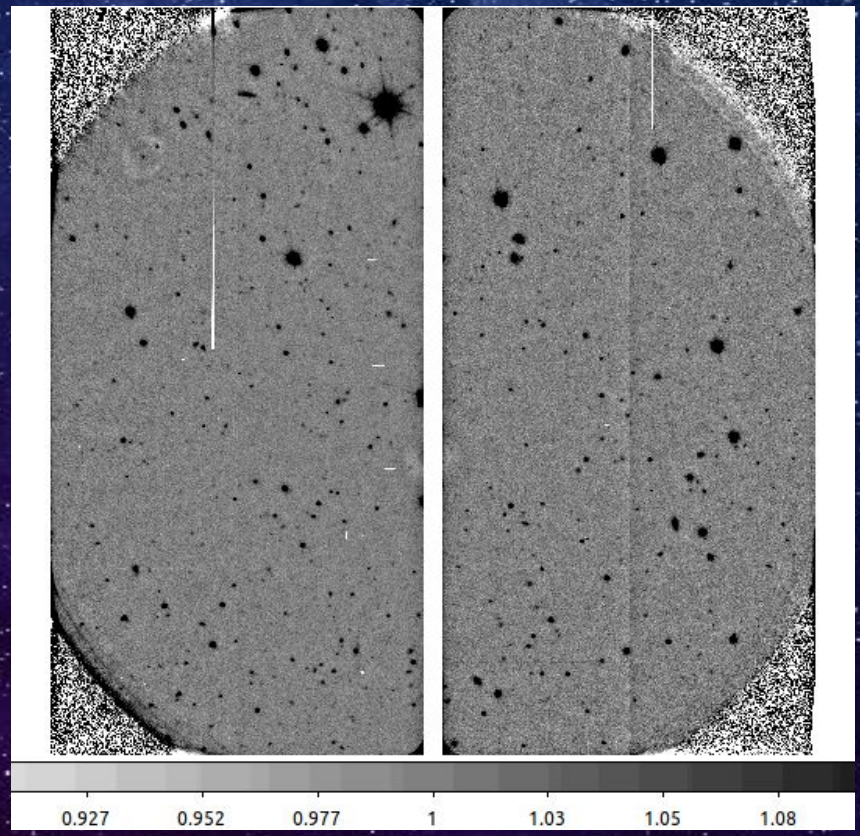
Illumination Pattern

Step 2: Illumination Pattern Correction

$$\frac{\text{IMAGE}}{\text{median(IMAGE, radius=25.5 px)}}$$

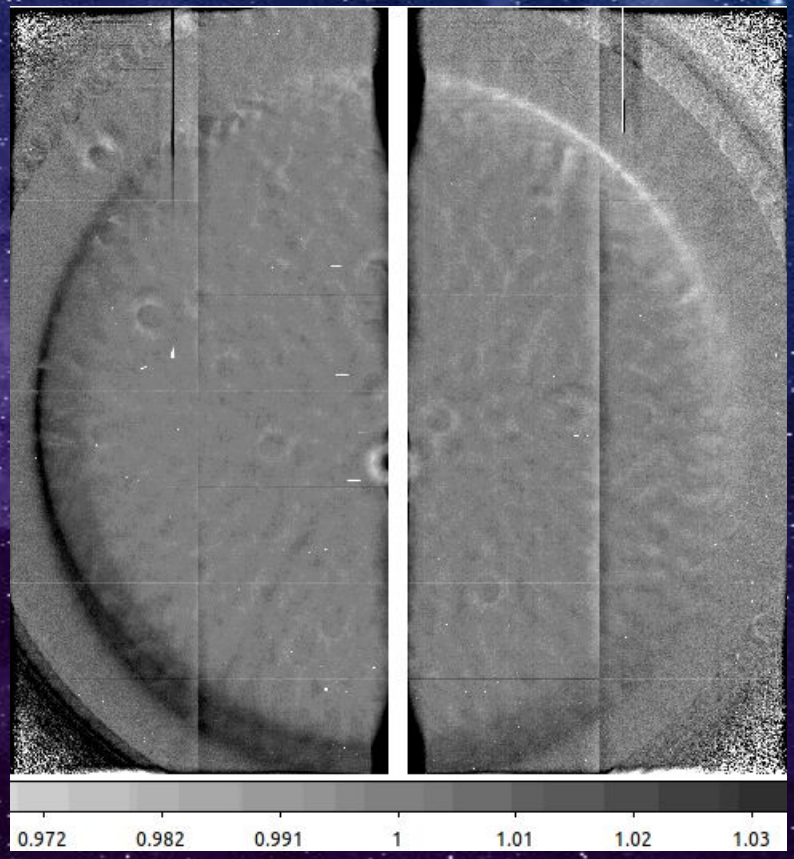


Flat

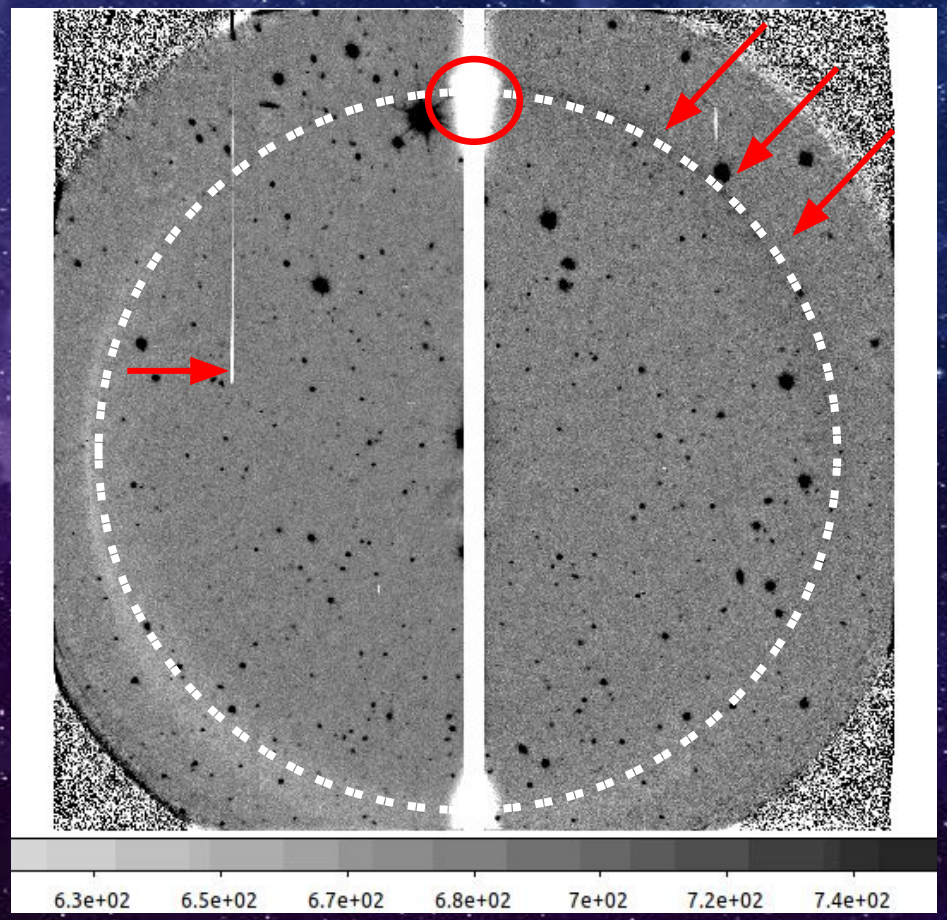


Science image

Step 3: Master Flat

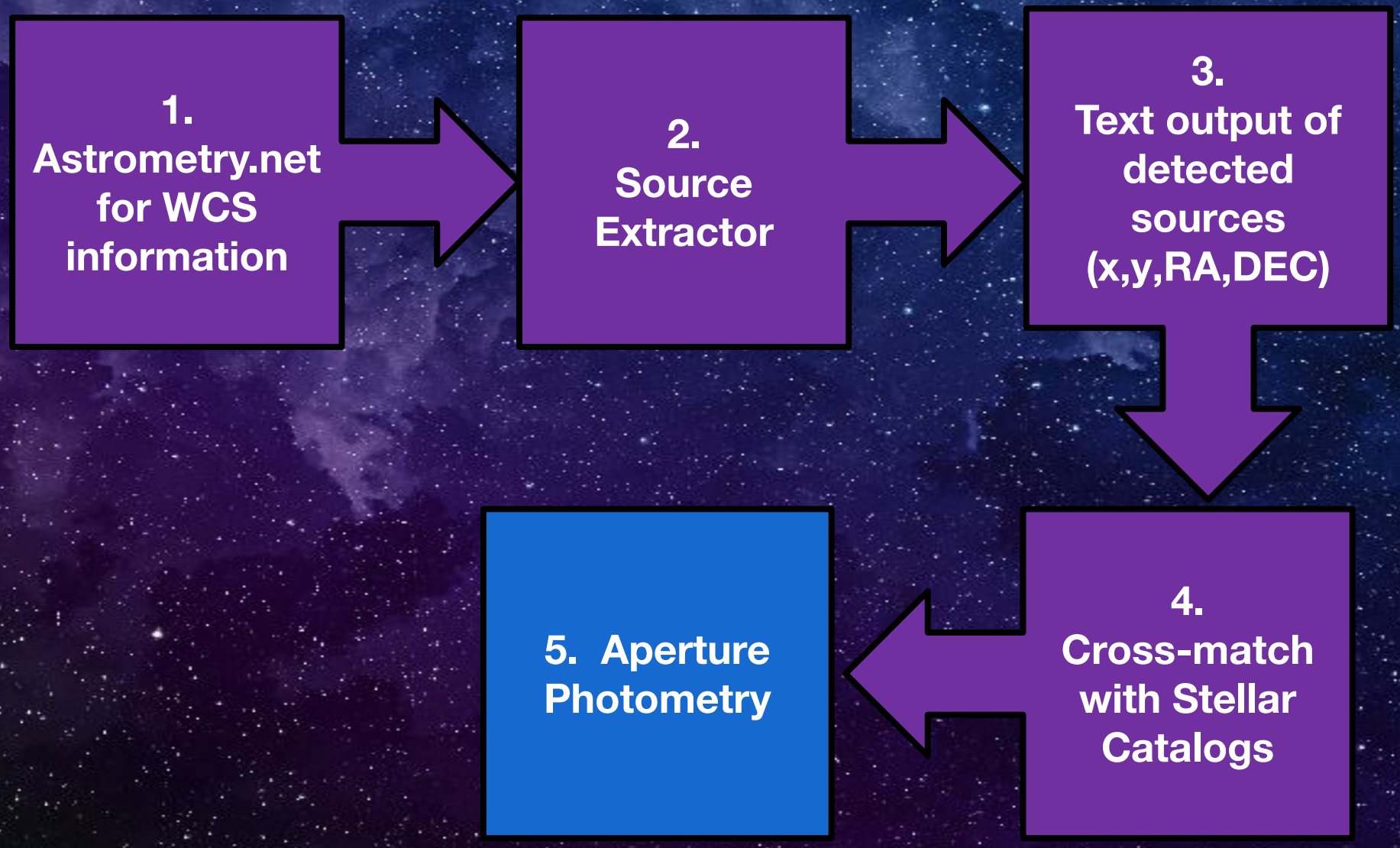


Result

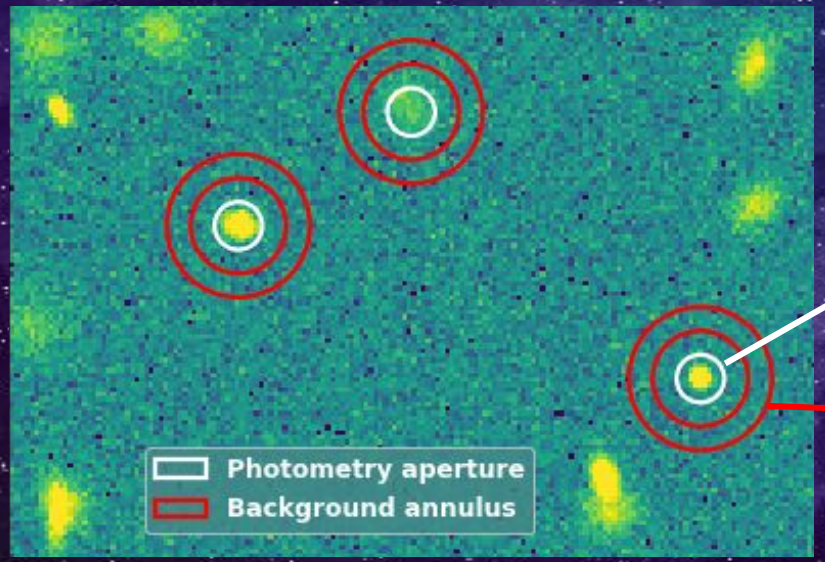


Remnants are still visible, but the majority of the background gradient is now smooth.

Photometry Pipeline



Aperture Photometry



$$m \pm \delta m_{inst} = -2.5 log(S \pm N)$$

$$S = \left(F_{targ} - \left(F_{Sky}.A_{ap}\right)\right)/t_{exp}$$

$$N = \sqrt{St_{exp} + A_{ap}\left(1 + \frac{A_{ap}}{A_{an}}\right)\left(F_{Sky} + RN^2\right)}$$

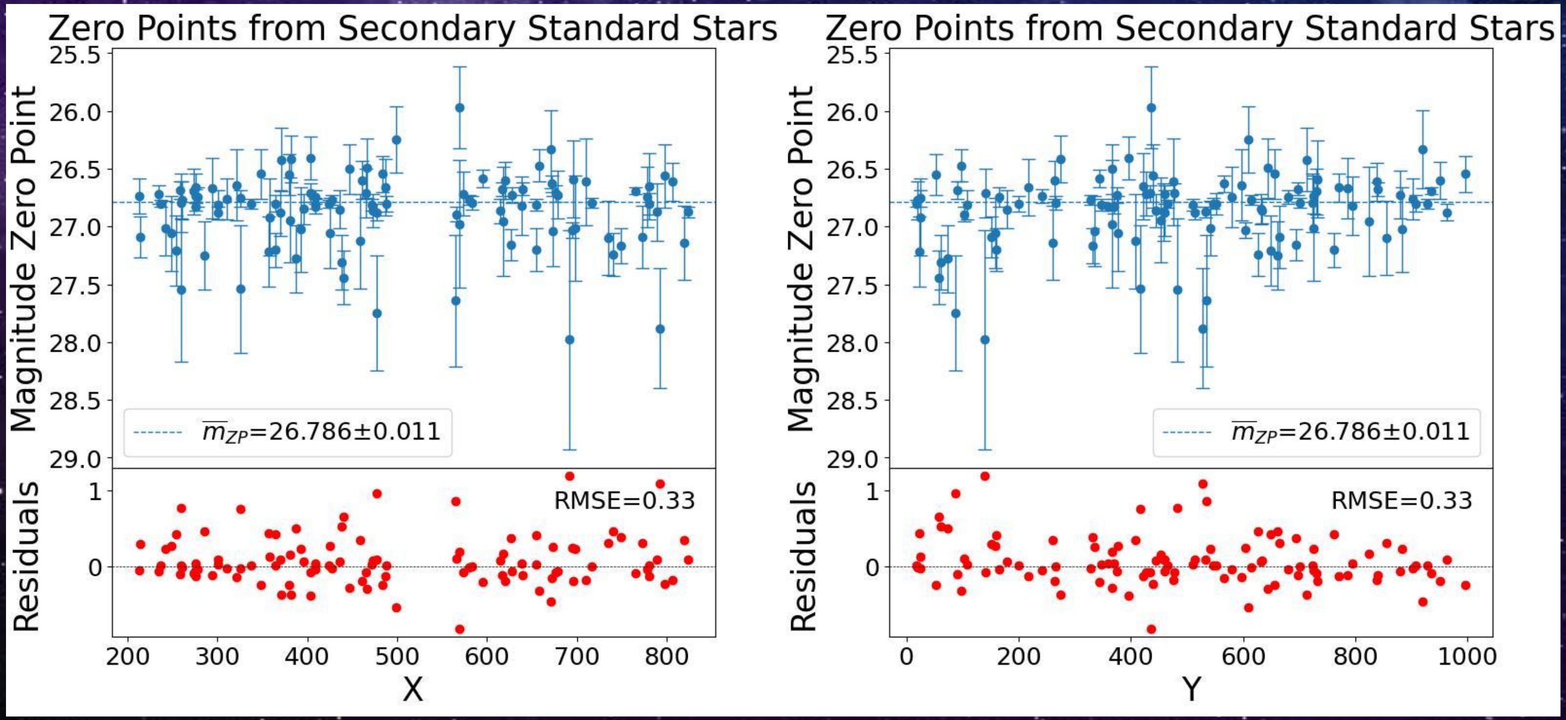
$$ZP = M_{Cat} - m_{inst}$$

Average Zero Point

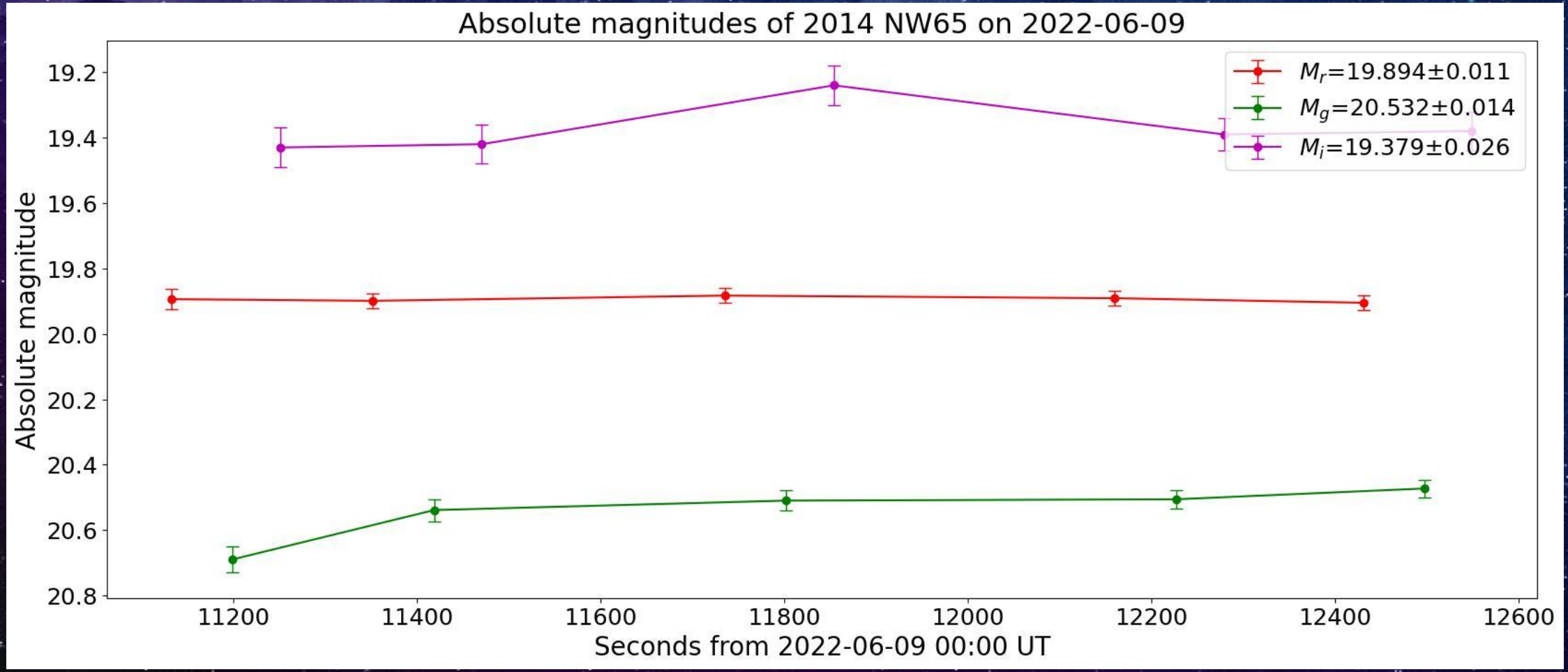
Use photometry of point sources to determine zero points across the science FoV

FILTER- — — — — — — — — — — — — — — — —FILTER

< 8'x8' FoV | Sigma-clip ZPs | Only bright stars



Photometric Calibration



Thank you!