

Gaia eDR3

an Astrometric Global Iterative Solution

Alex Bombrun

HE Space for ESA

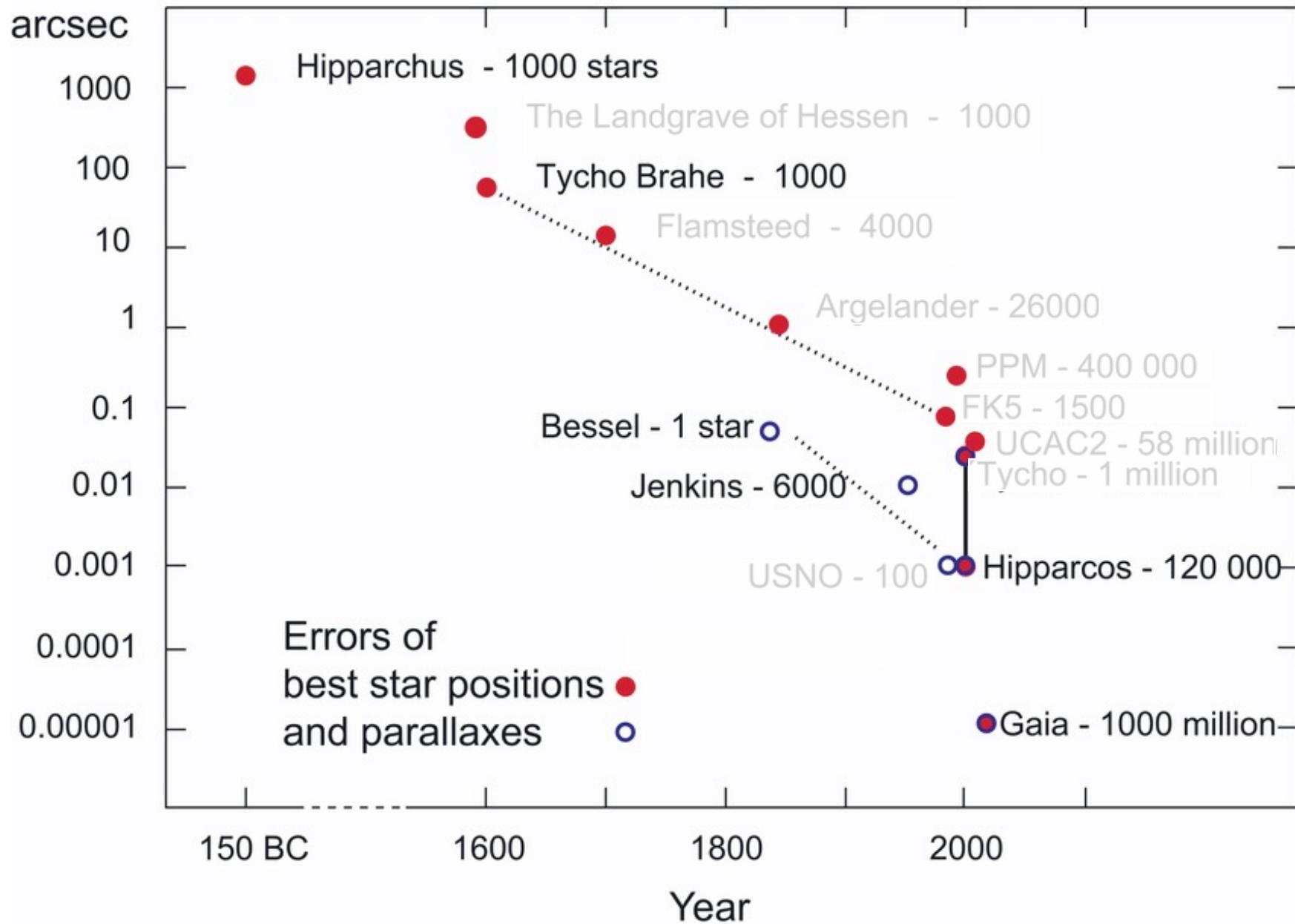
27/09/2022 Athens

Outline

From the first stellar parallax to Gaia

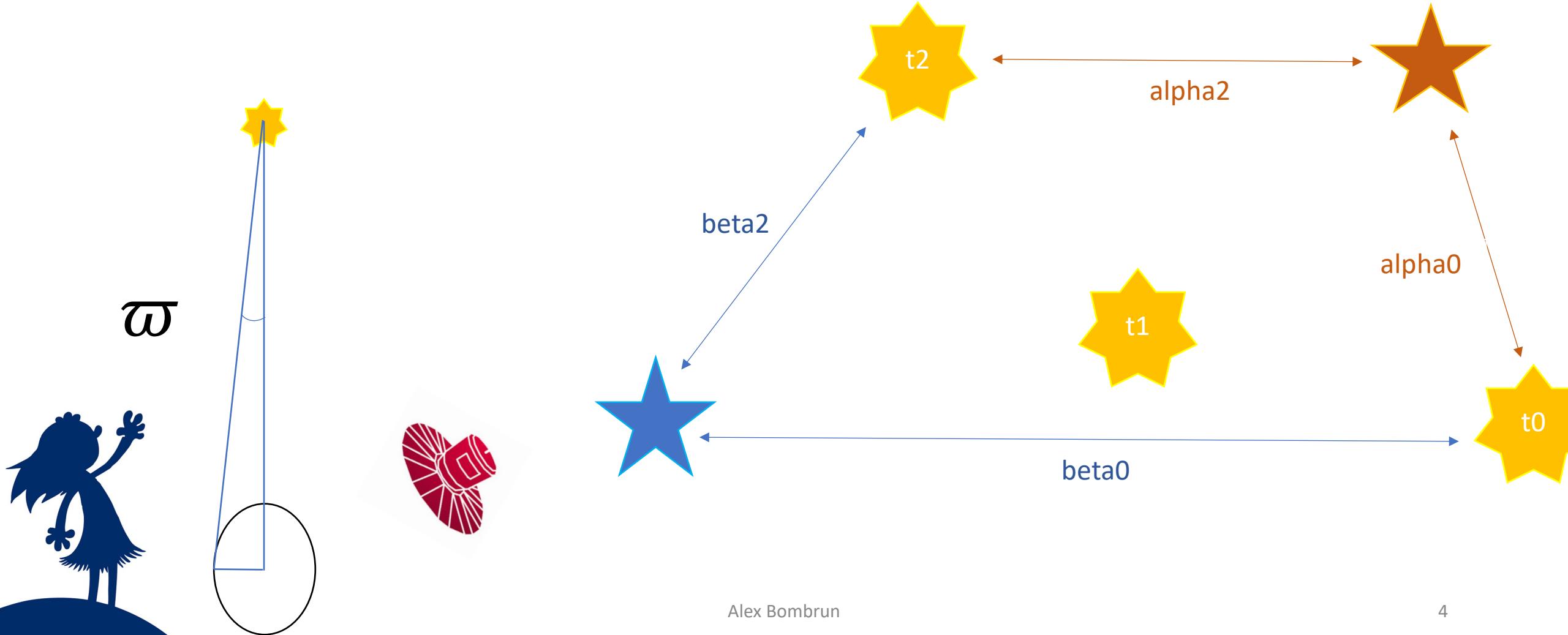
Astrometric Global Iterative Solution

DR3 and some calibration issues



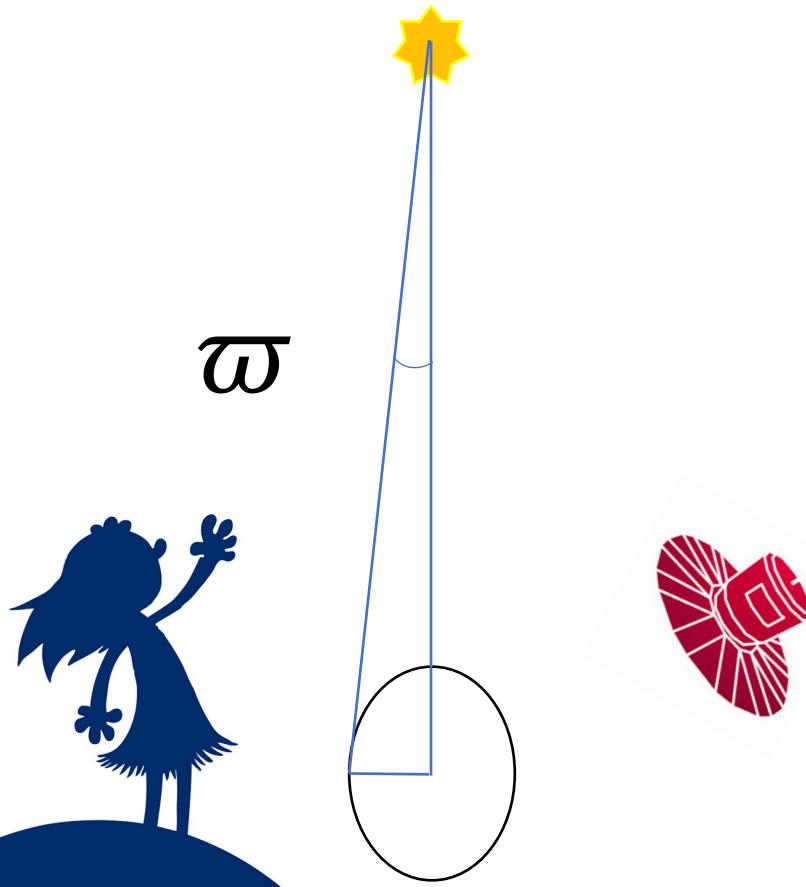


Observations



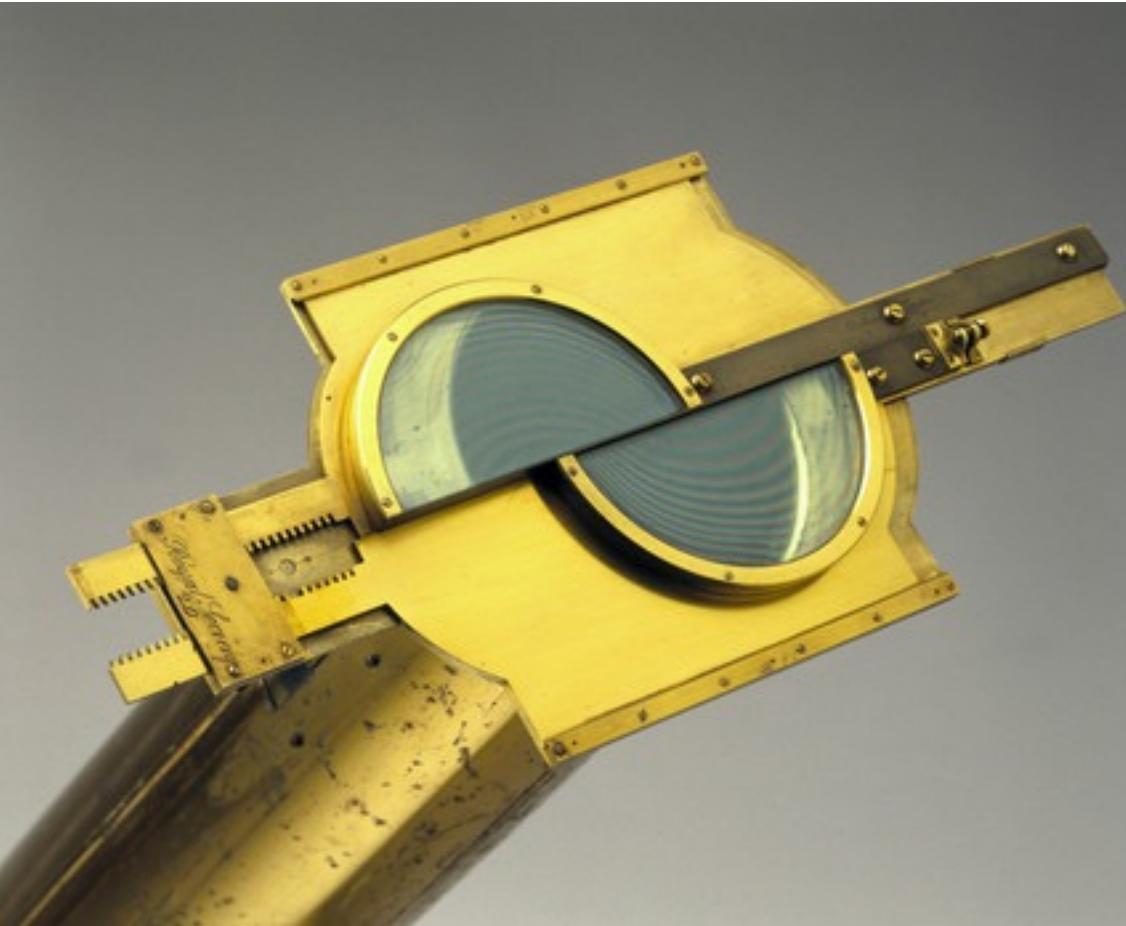


Least squares

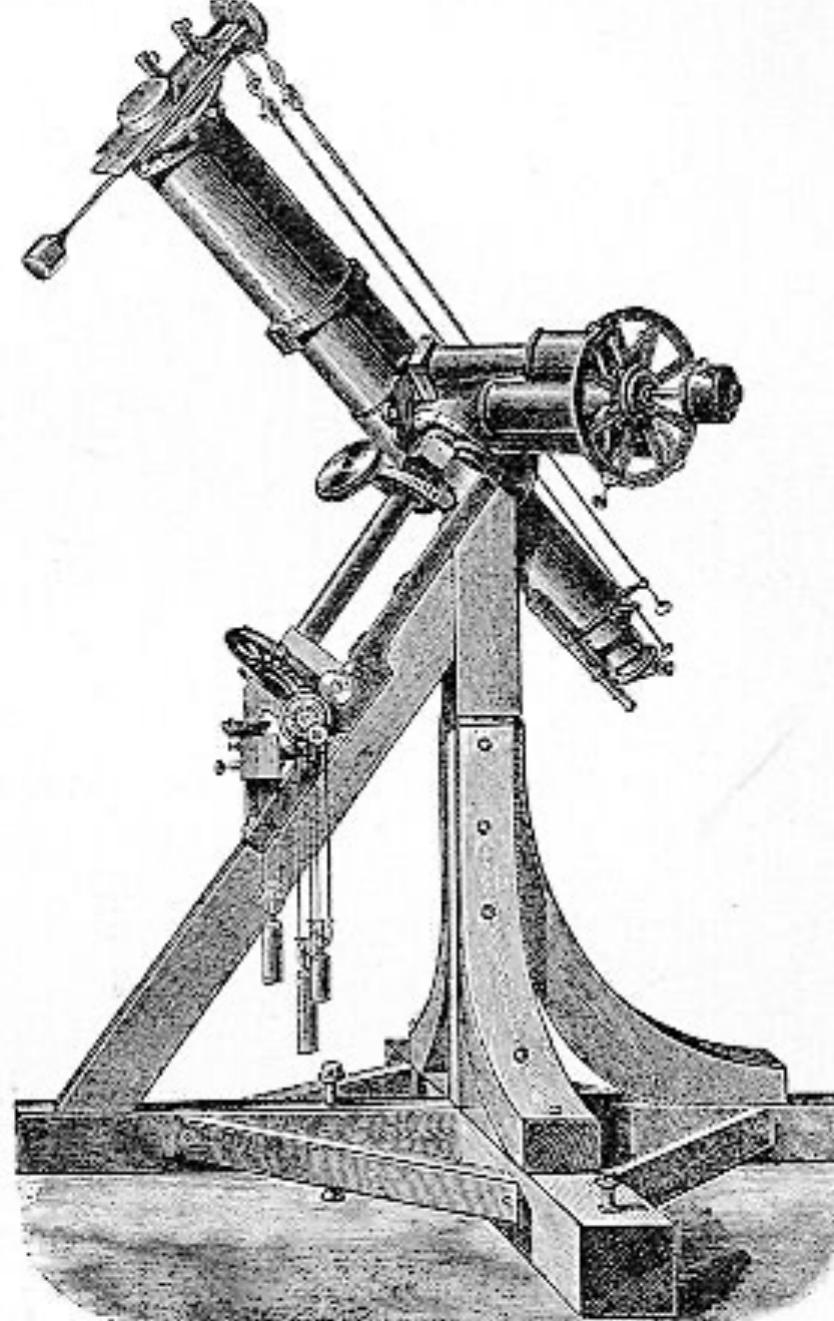


$$\min_{\boldsymbol{\varpi}} \sum \frac{(\alpha_i - f_{\boldsymbol{\varpi}}(t_i) \boldsymbol{\varpi})^2}{\sigma^2}$$

Heliometers



© Science Museum / Richardson, Claire



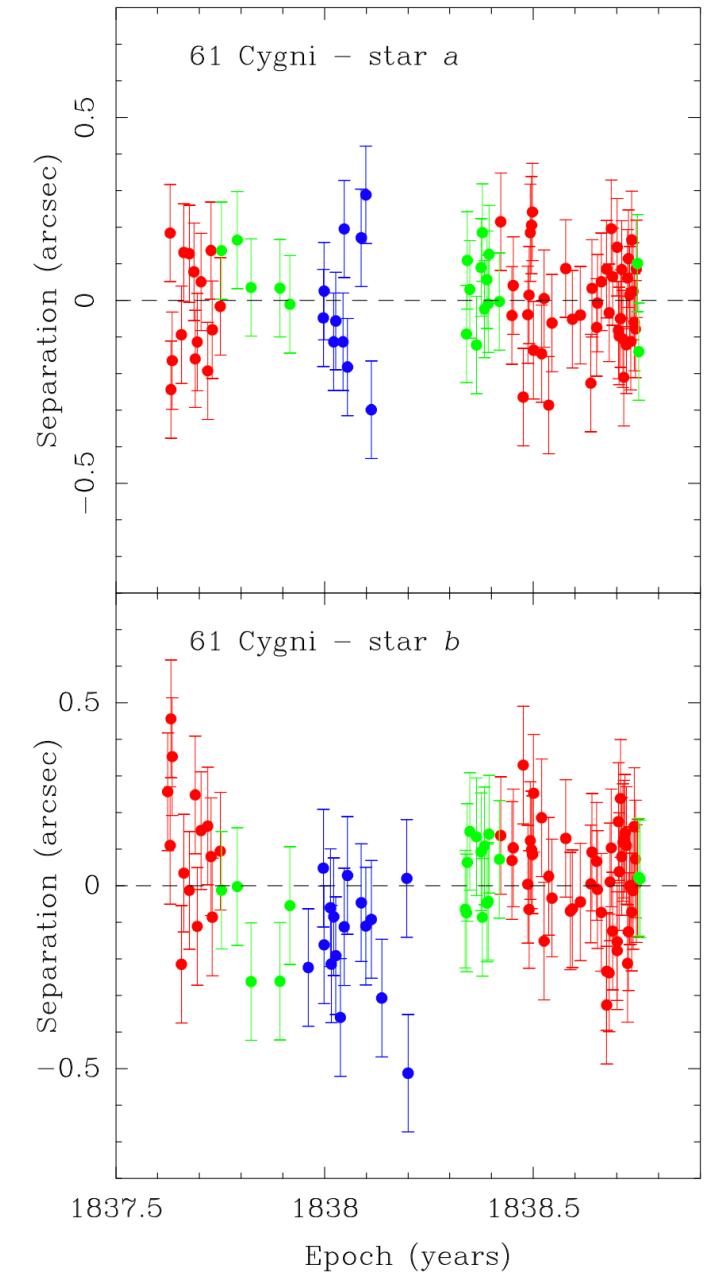
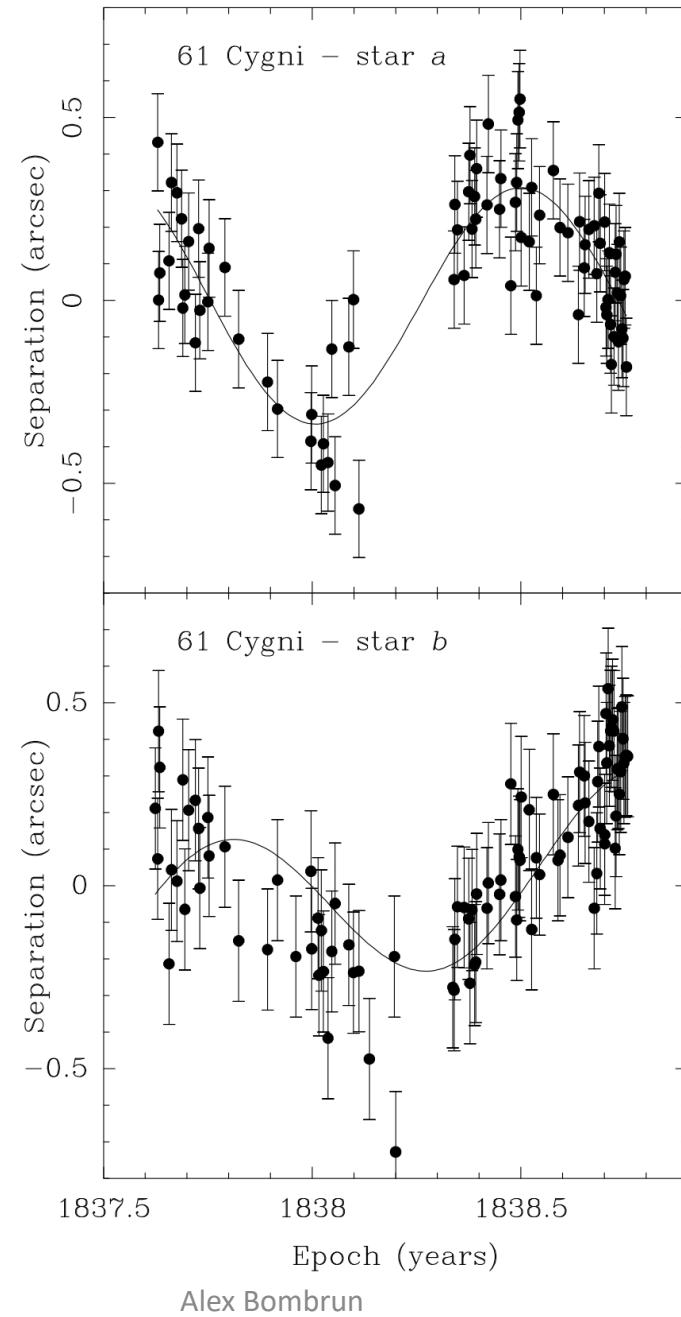
Alex Bombrun



61 Cygni A-B vs stars a & b

F Bessel
angular separations
and residuals

M. Reid, K. Menten 2020

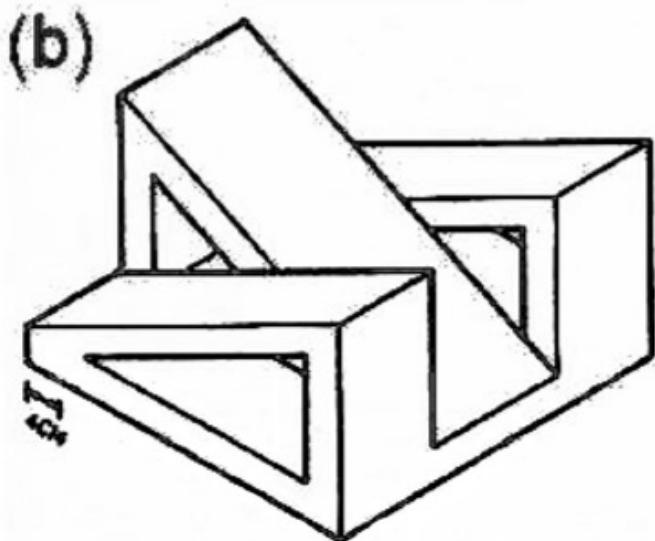


61 Cygni parallax

F. Bessel 314 \pm 20 mas
(A-B 1838)

Gaia DR3 286.00 \pm 0.06 mas
61 Cygni A

A brief history of space astrometry



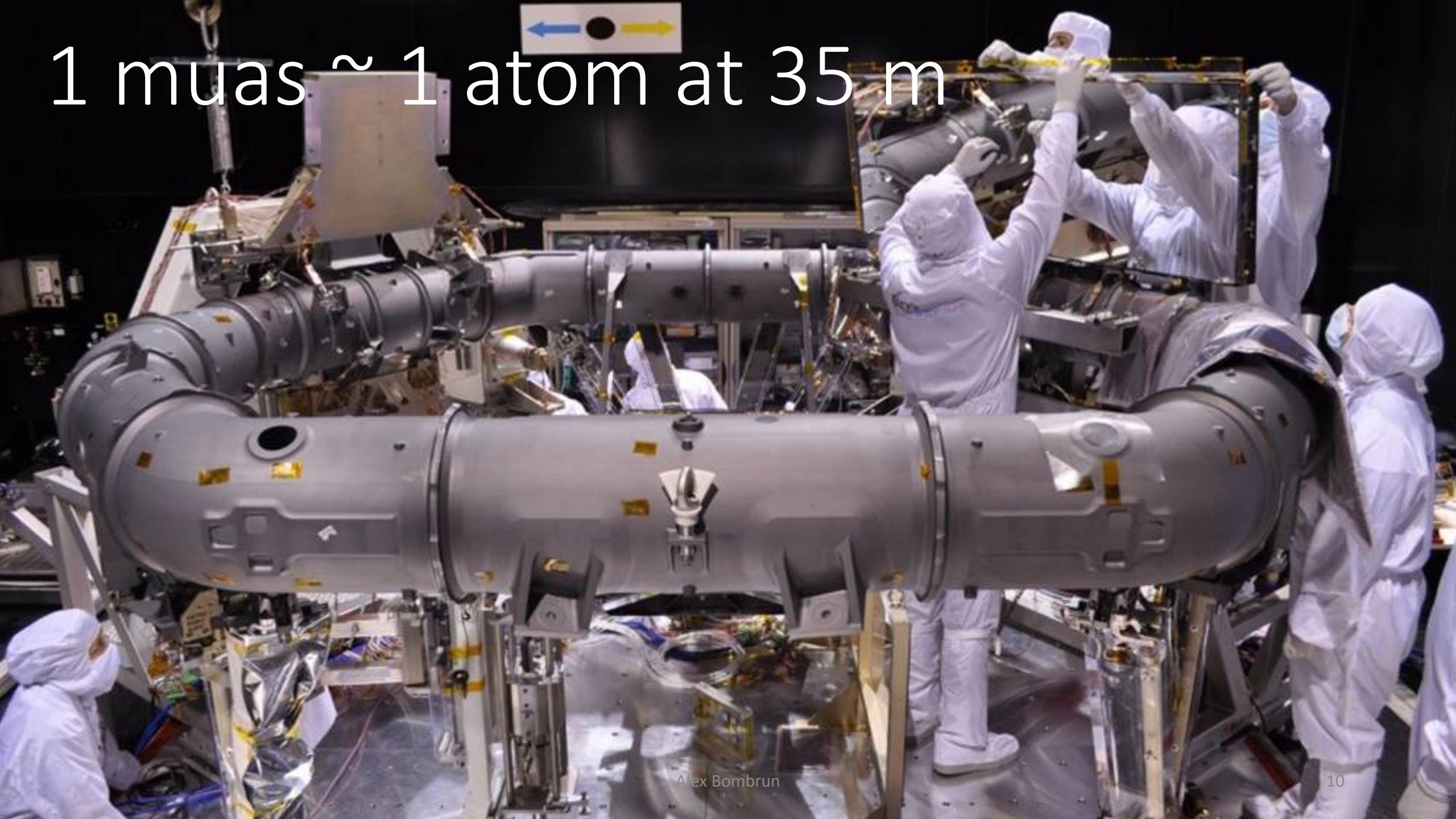
1964



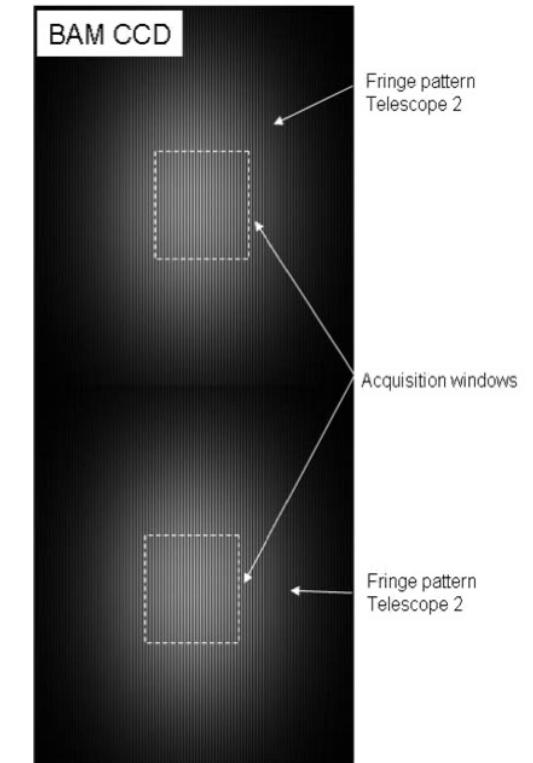
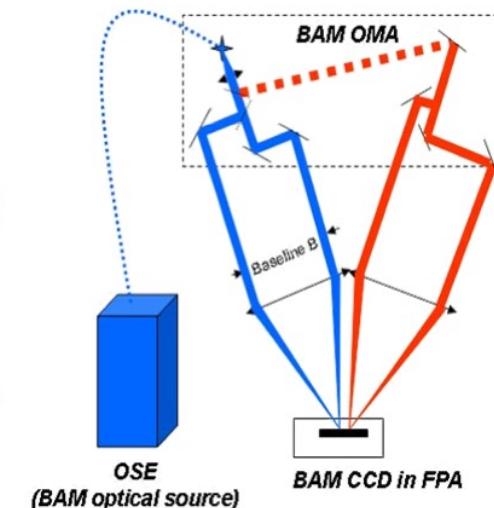
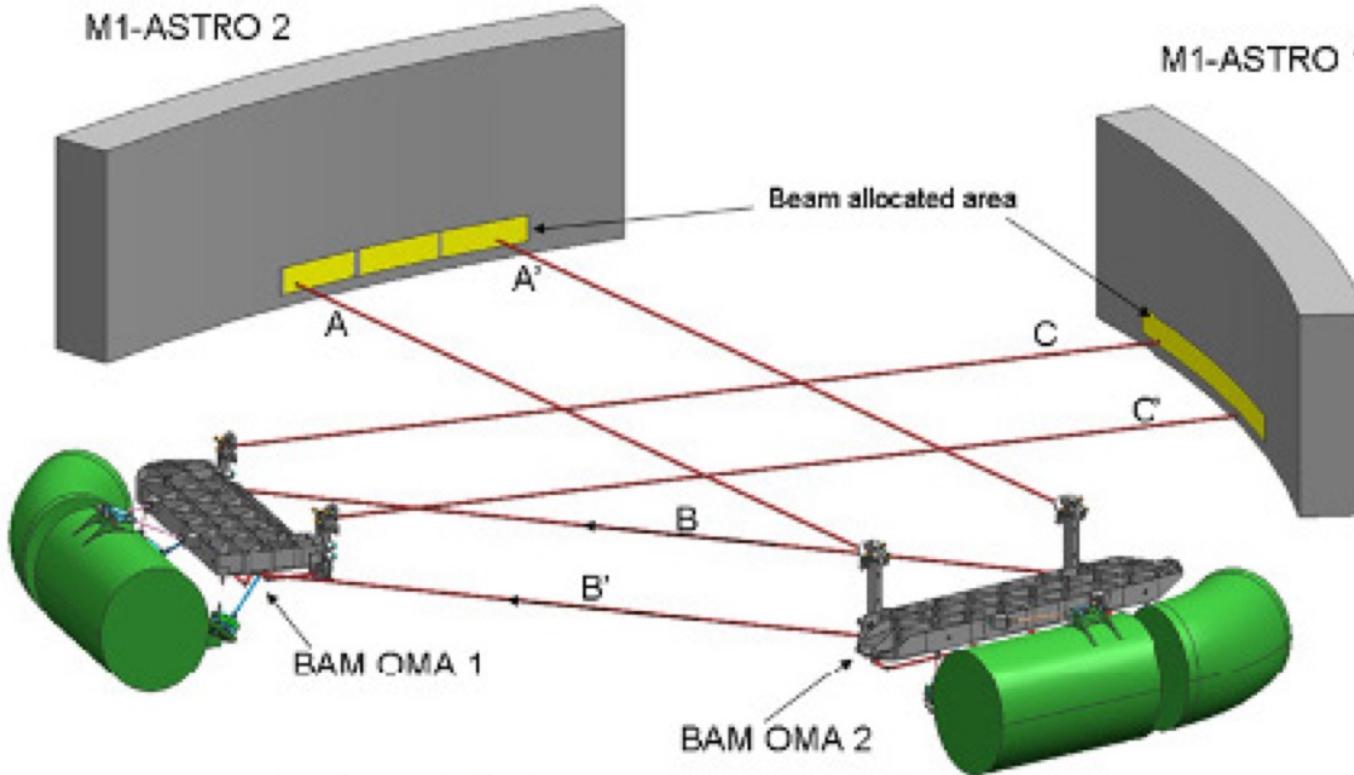
1975



1 muas \sim 1 atom at 35 m

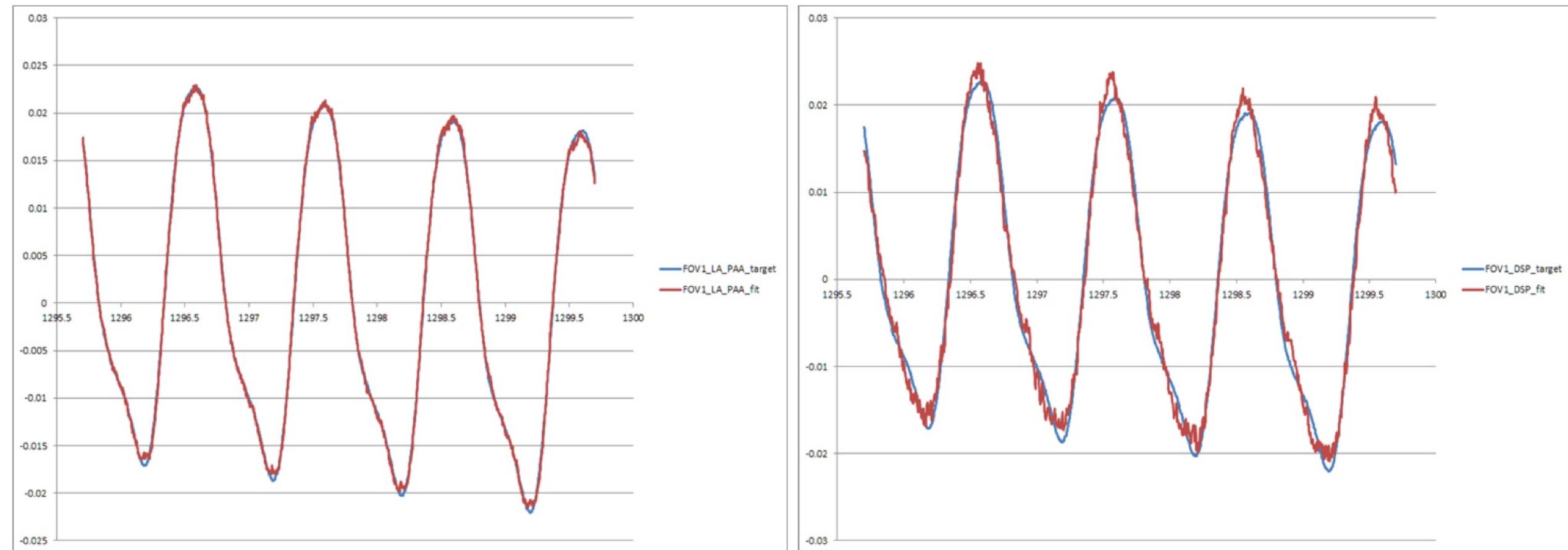


Basic Angle Monitor



A. Mora 2016

Basic Angle Monitor & temperature!



A. Mora 2016

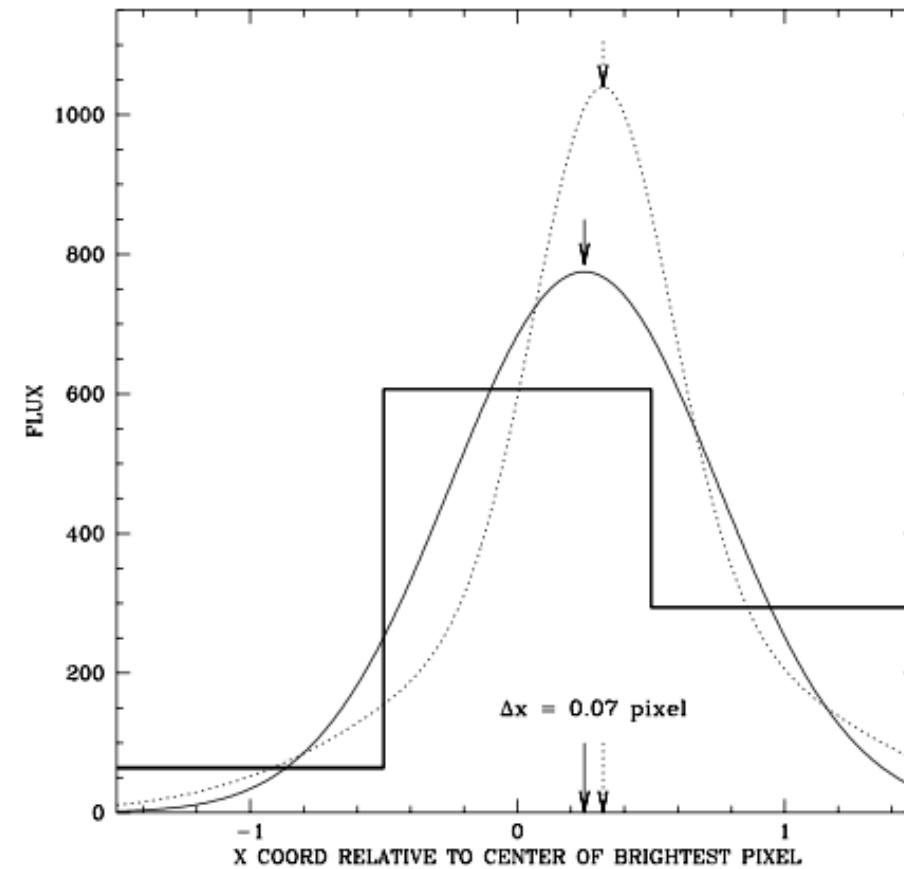
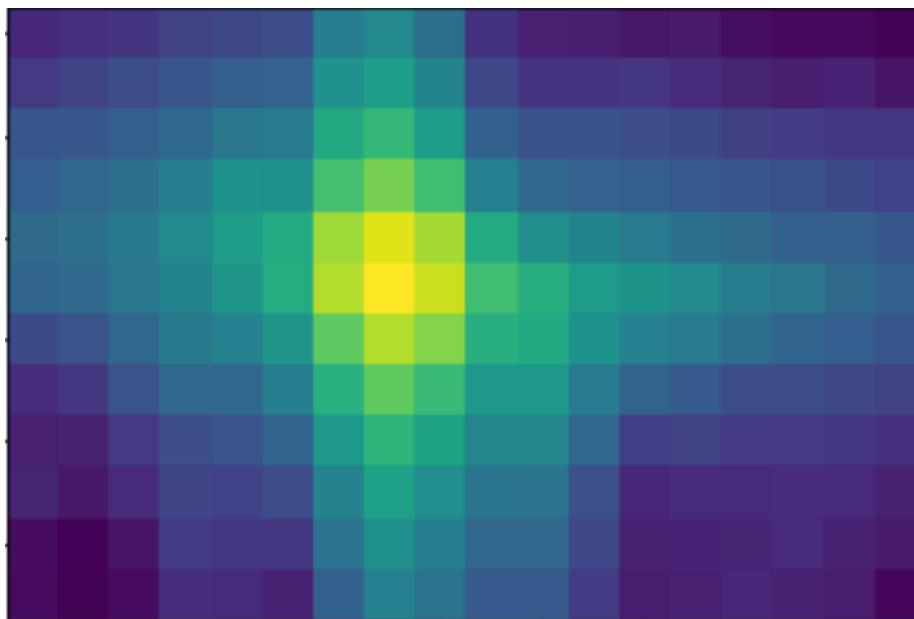
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Astrometric Global Iterative Solution

Some calibration issues

Accurate PSF calibration



Anderson, J., King, I.R., 2000

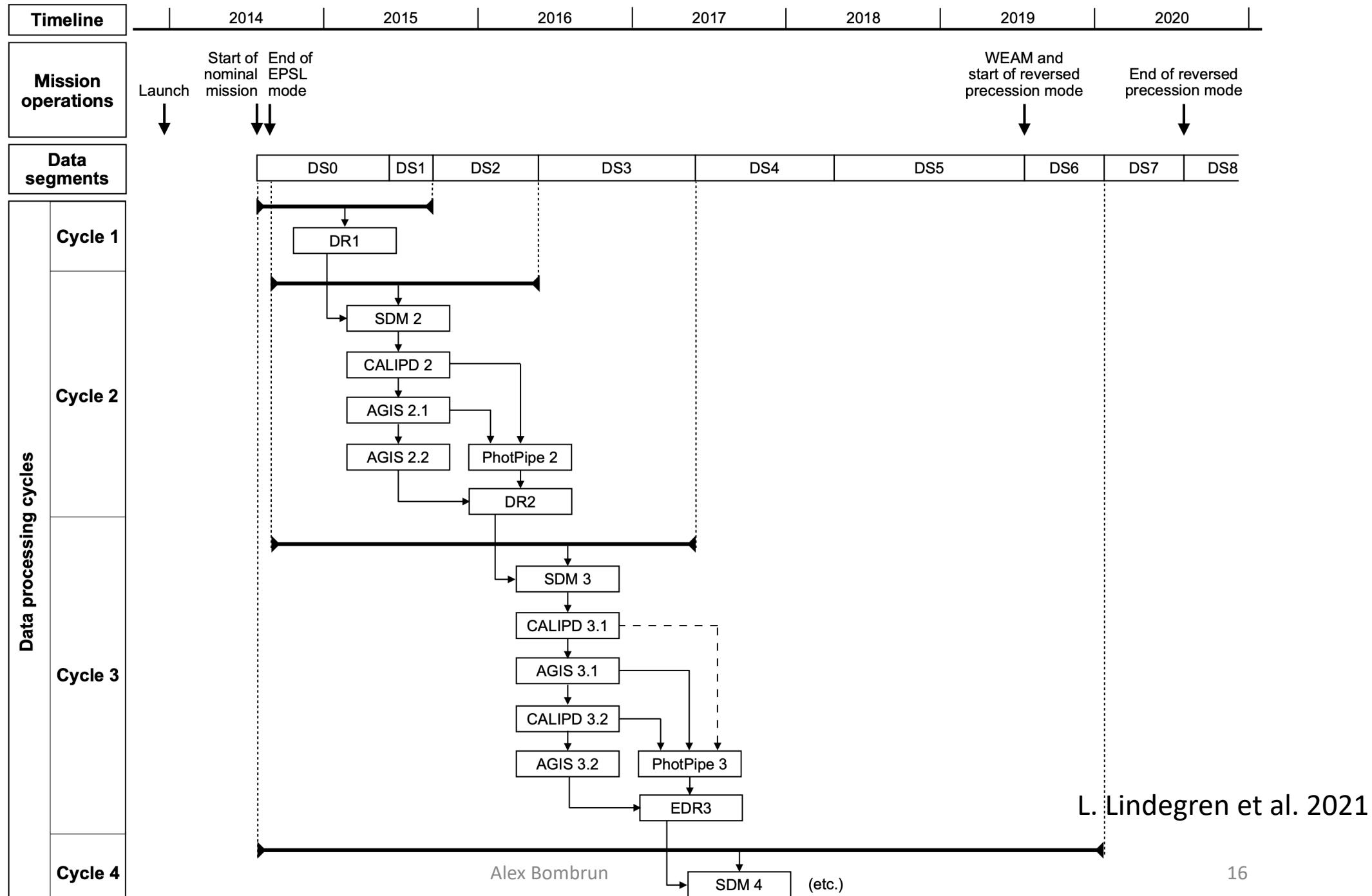
See also L. Lindegren 2010 TN A generic LSF/PSF model

AGIS : an ad-hoc least squares solver

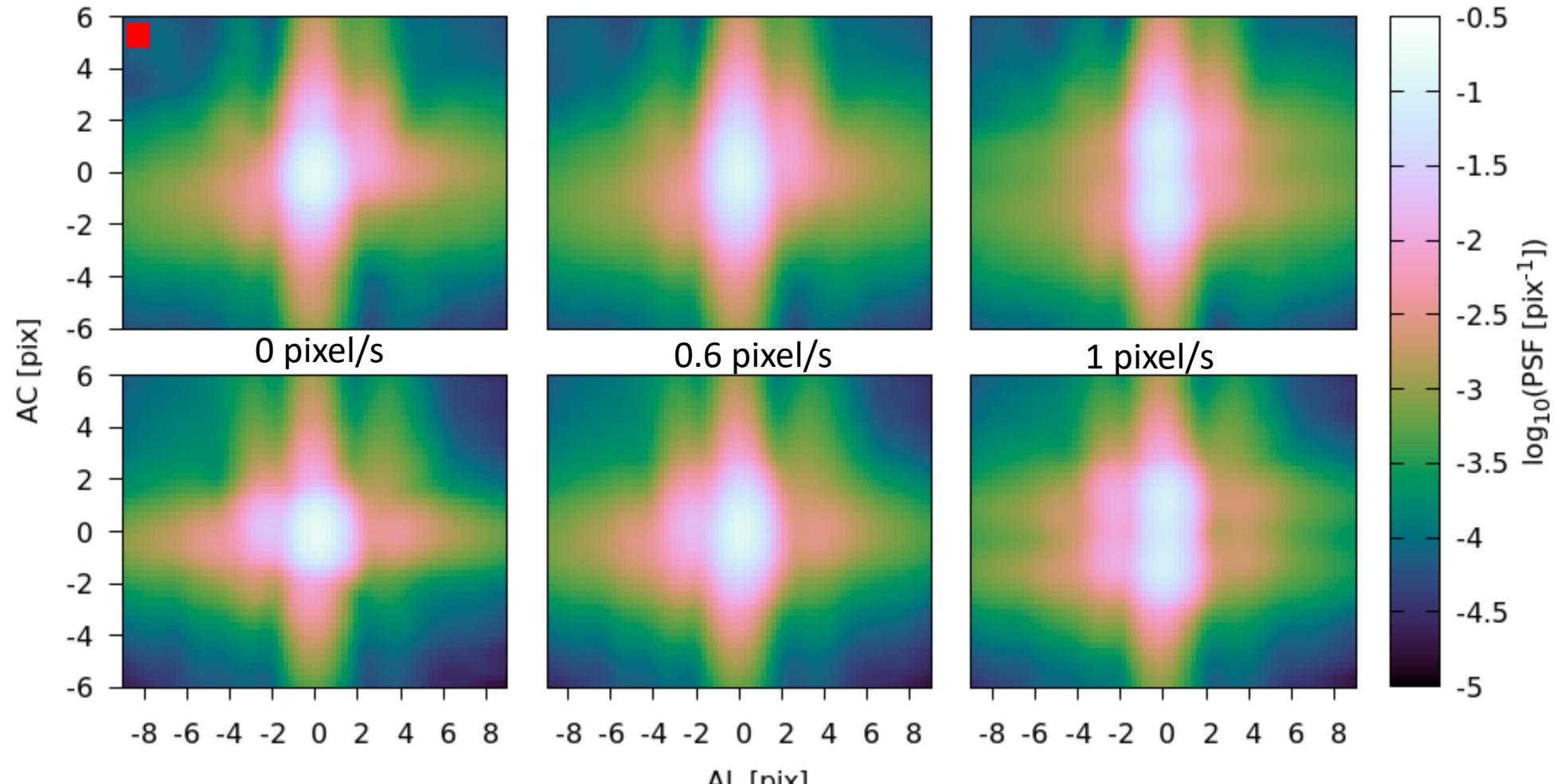
$$\min_{s,a,c,g} \sum u_o \frac{(o - C)^2}{\sigma_o^2 + \epsilon_i^2 + \epsilon_a^2}$$

L. Lindegren et al. 2012

Gaia cyclic processing

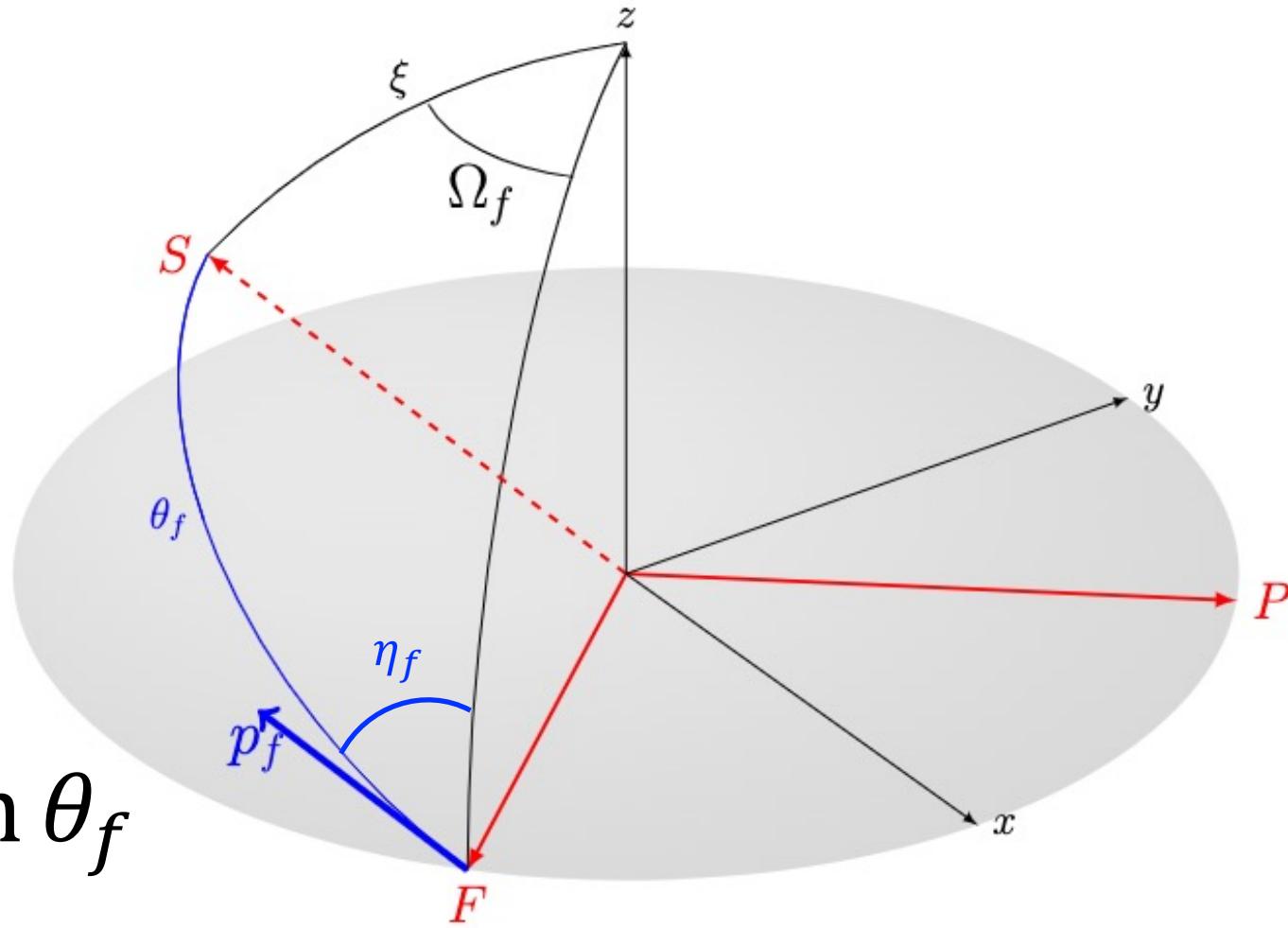


EDR3 Point Spread Function vs AC rate



Global astrometry degeneracies

$$p_f = \varpi R \sin \theta_f$$



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See
L. Lindegren et al. 2012
A. G. Butkevich et al. 2017
L. Lindegren et al. 2021

Parallax & basic angle degeneracy

$$\Omega_f = \Omega - \Gamma/2$$

$$\cos \xi = \cos \eta_f \sin \theta_f$$

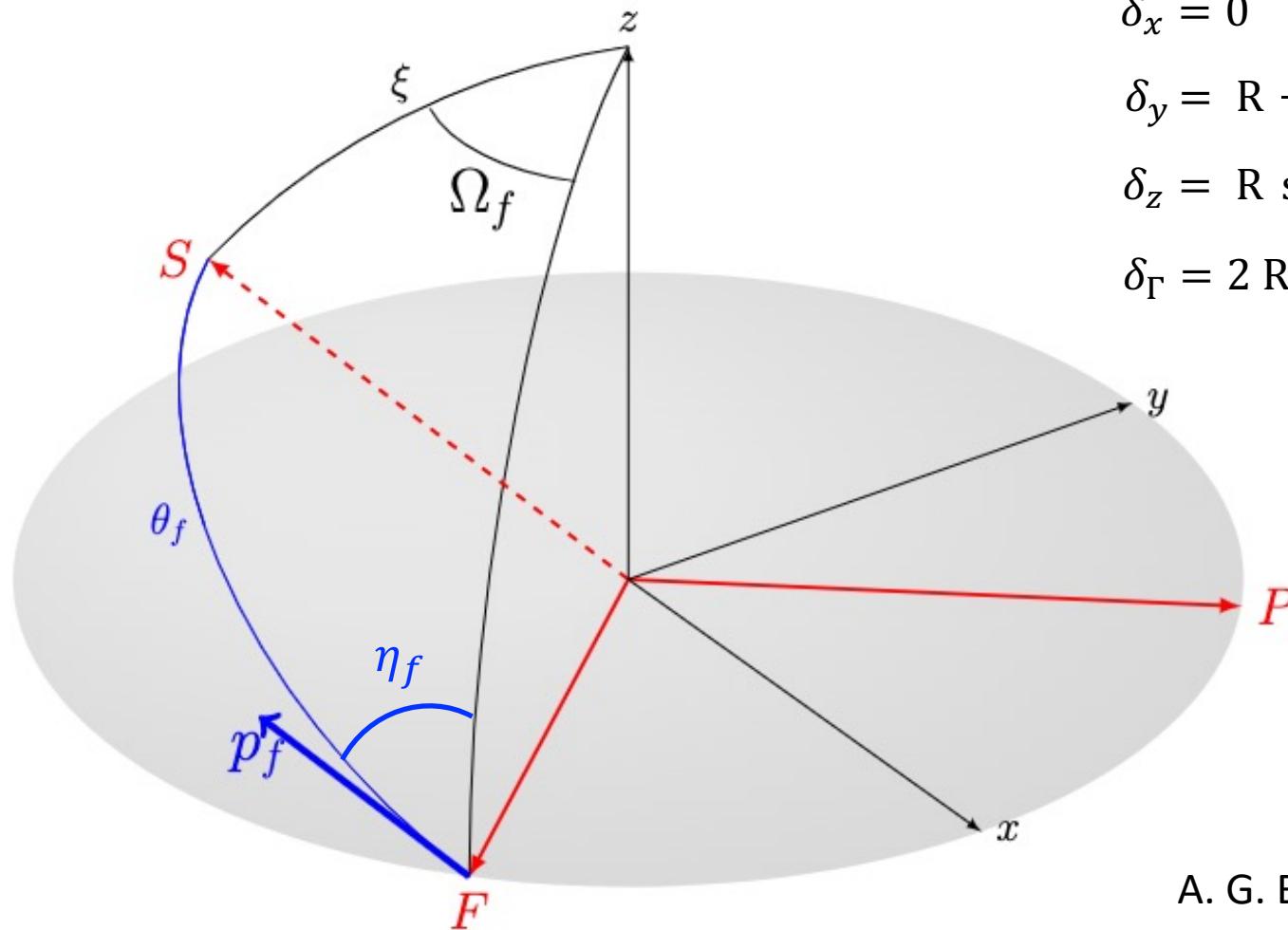
$$\frac{\sin \Omega_f}{\sin \theta_f} = \frac{\sin \eta_f}{\sin \xi}$$

$$p_f^{\parallel} = \delta\varpi R \sin \theta_f \sin \eta_f$$

$$p_f^{\perp} = \delta\varpi R \sin \theta_f \cos \eta_f$$

$$p_f^{\parallel} = \delta\varpi R \sin \xi \sin \Omega_f$$

$$p_f^{\perp} = \delta\varpi R \cos \xi$$



$$\delta_x = 0$$

$$\delta_y = R \frac{\cos \xi}{\cos \Gamma/2} \delta\varpi$$

$$\delta_z = R \sin \xi \sin \Omega \cos \Gamma/2 \delta\varpi$$

$$\delta_\Gamma = 2 R \sin \xi \cos \Omega \sin \Gamma/2 \delta\varpi$$

A. G. Butkevich et al. 2017

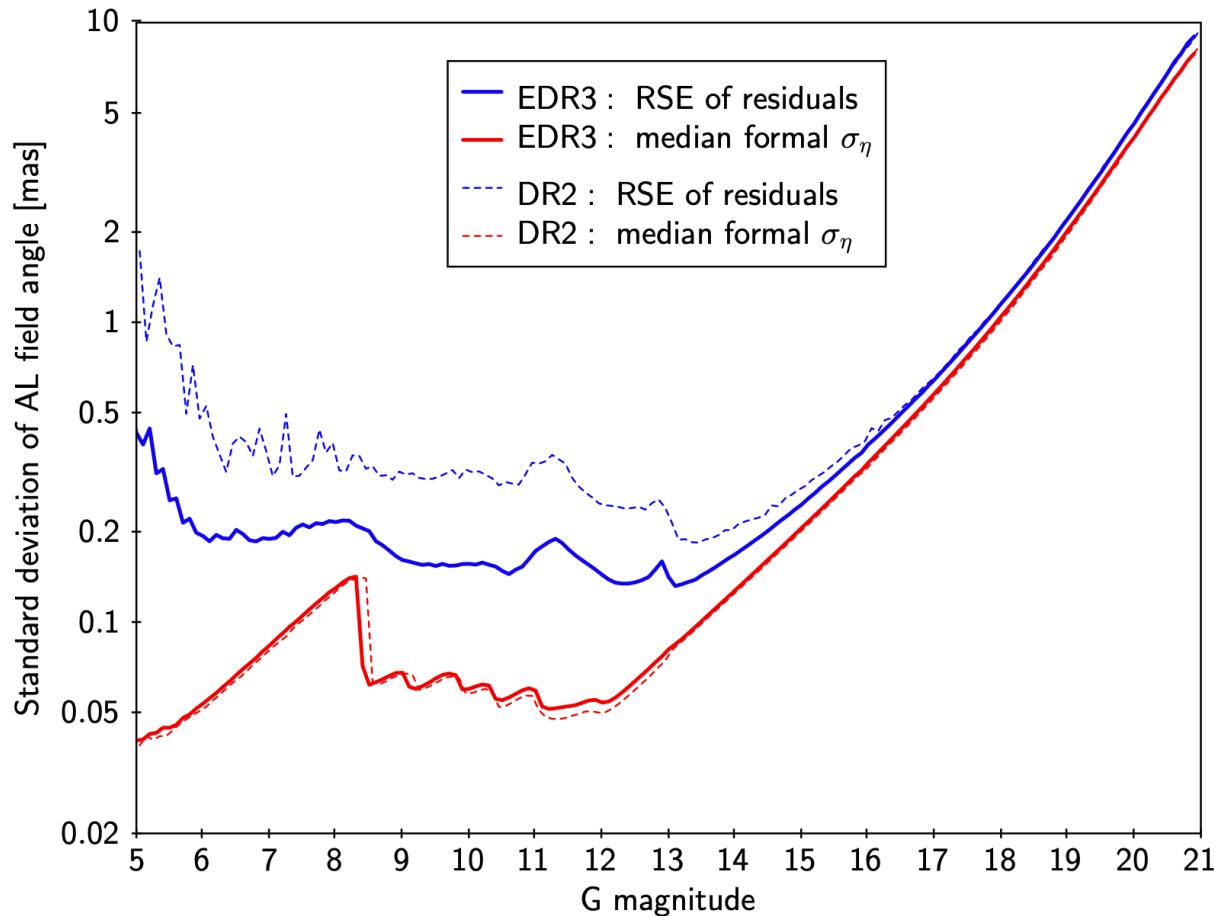
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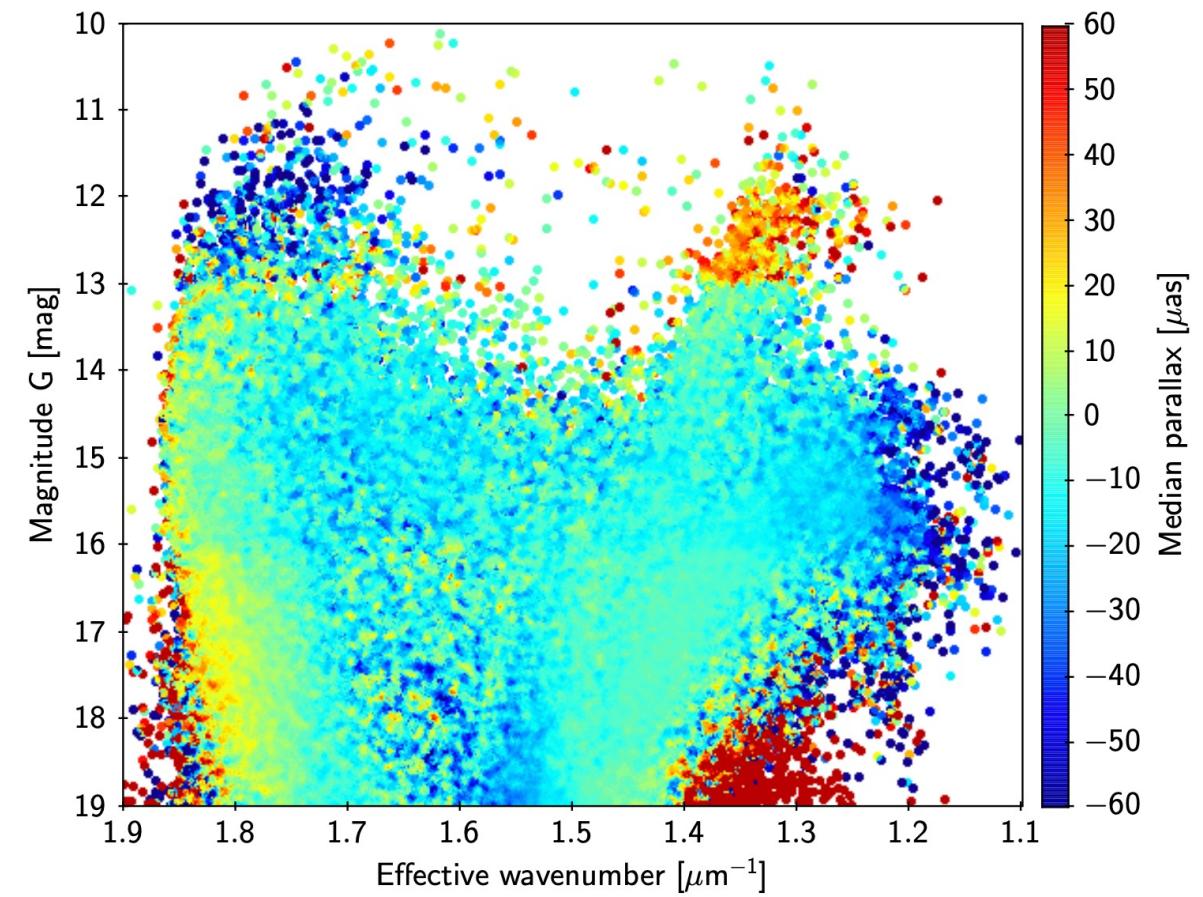
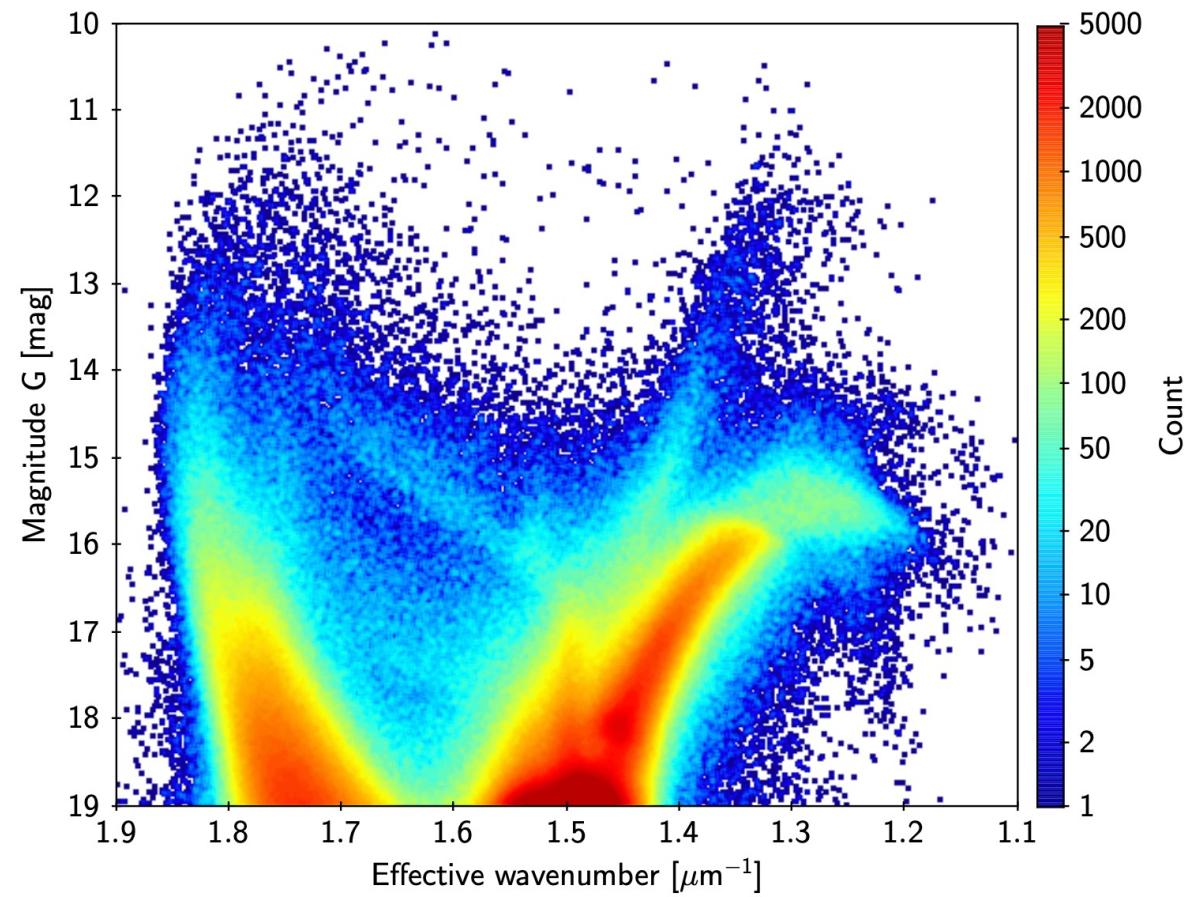
Some calibration issues

DR3 vs DR2 astrometric precision



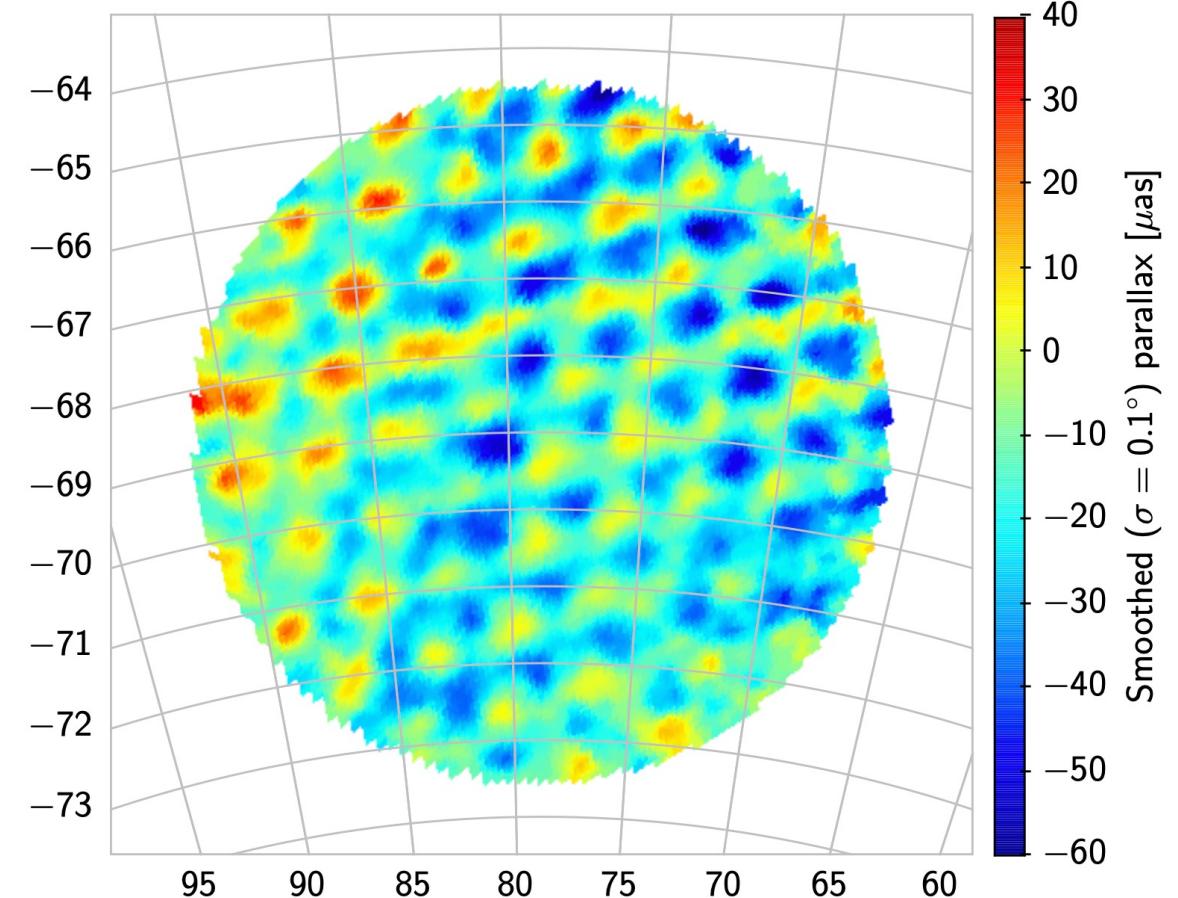
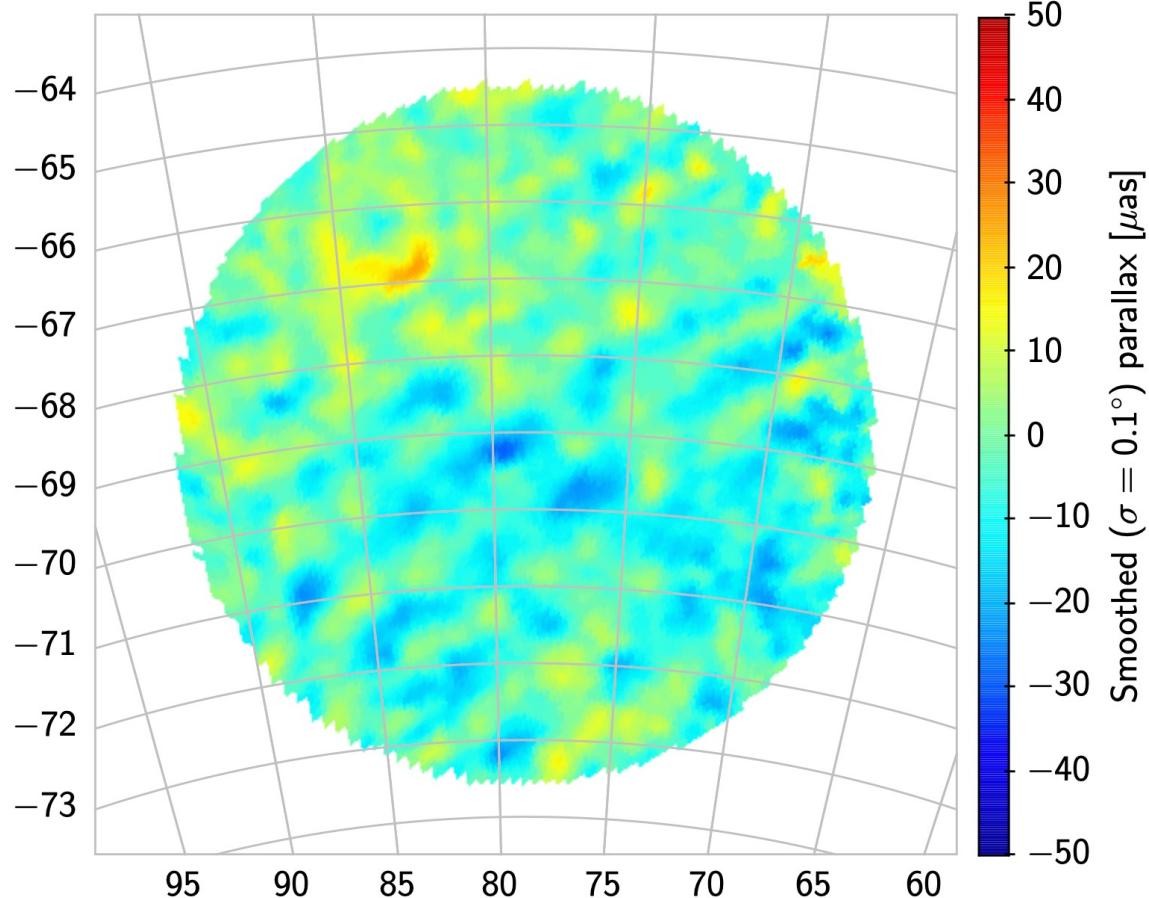
L. Lindegren et al. 2021

DR3 LMC parallax



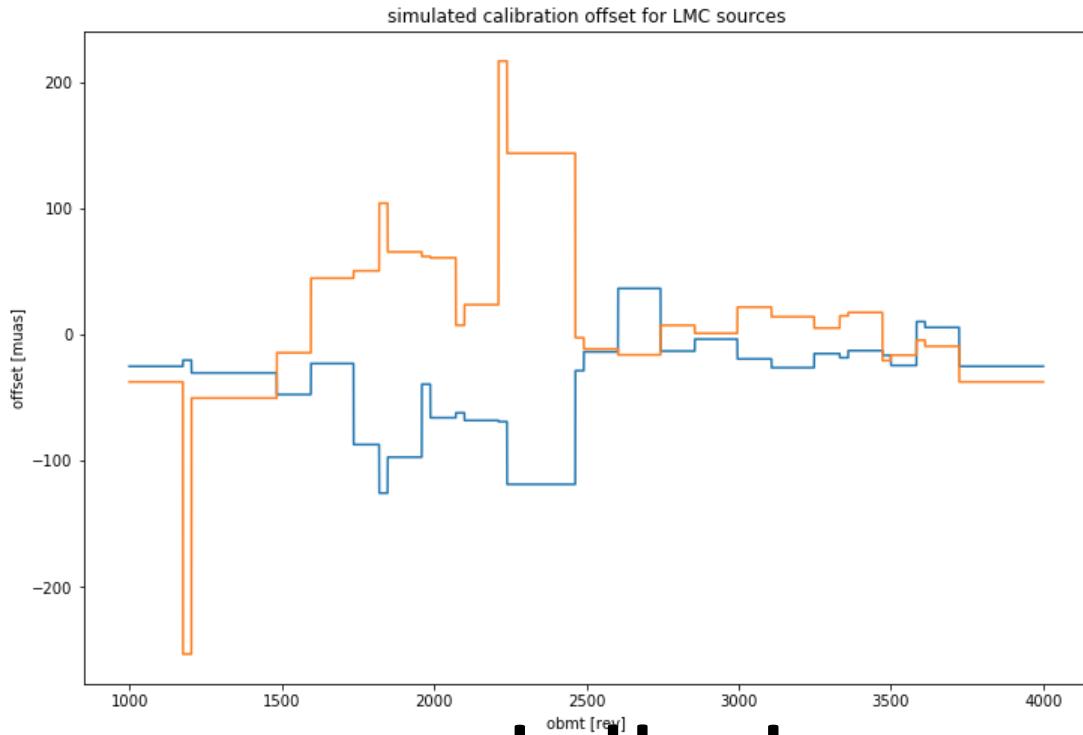
L. Lindegren et al. 2021

DR3 vs DR2 LMC parallax

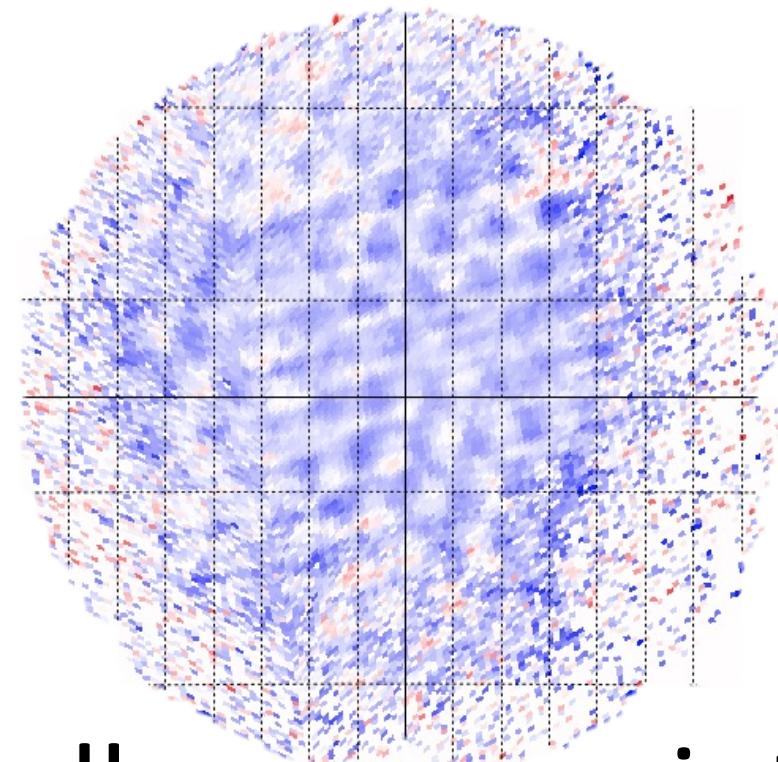


L. Lindegren et al. 2021

When the model does not match the data

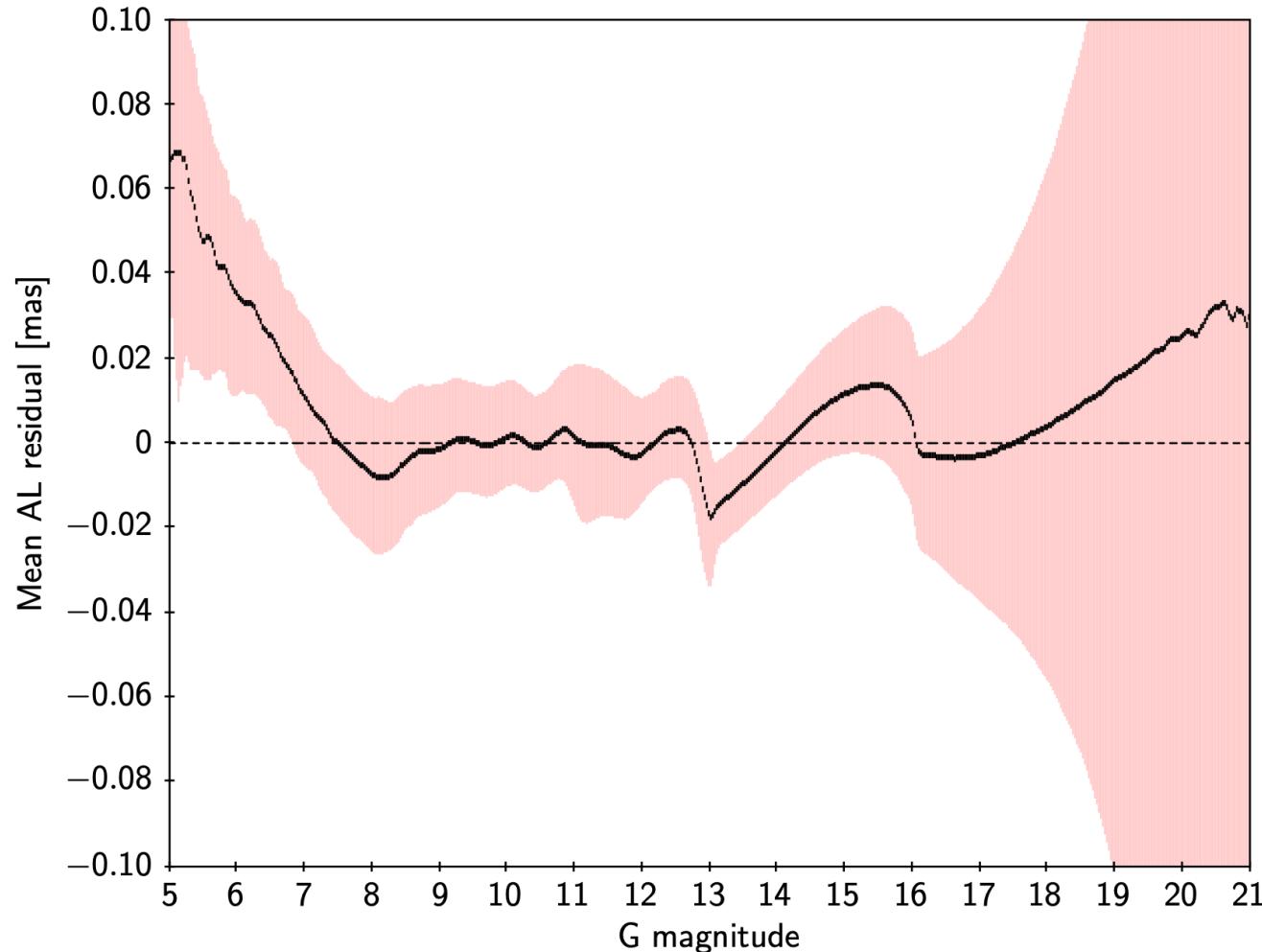


un-modelled
signal



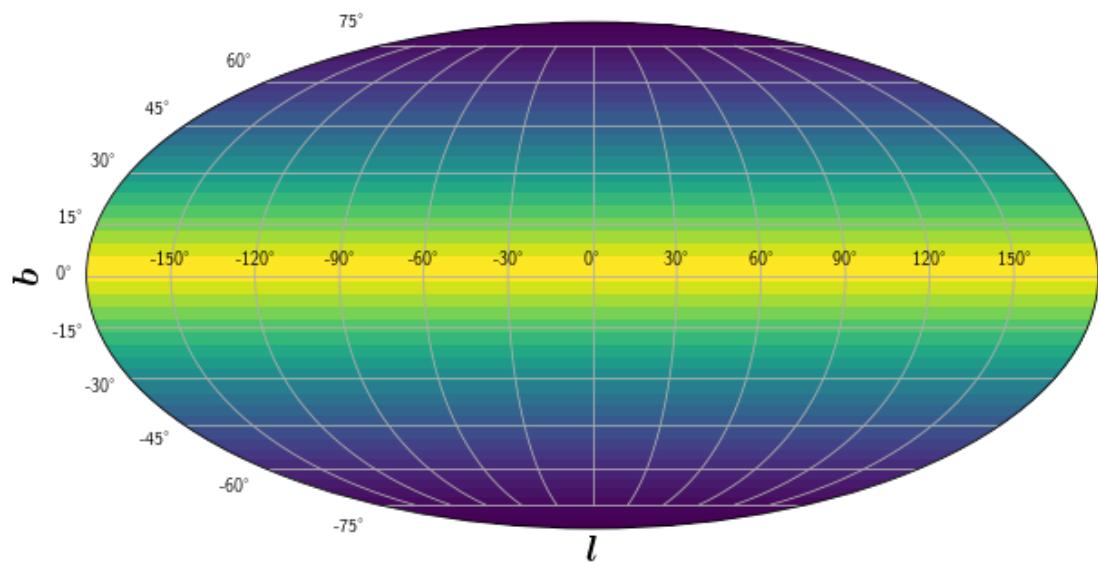
parallax zero-point errors
(simulation)

DR3 mean AL residual per source

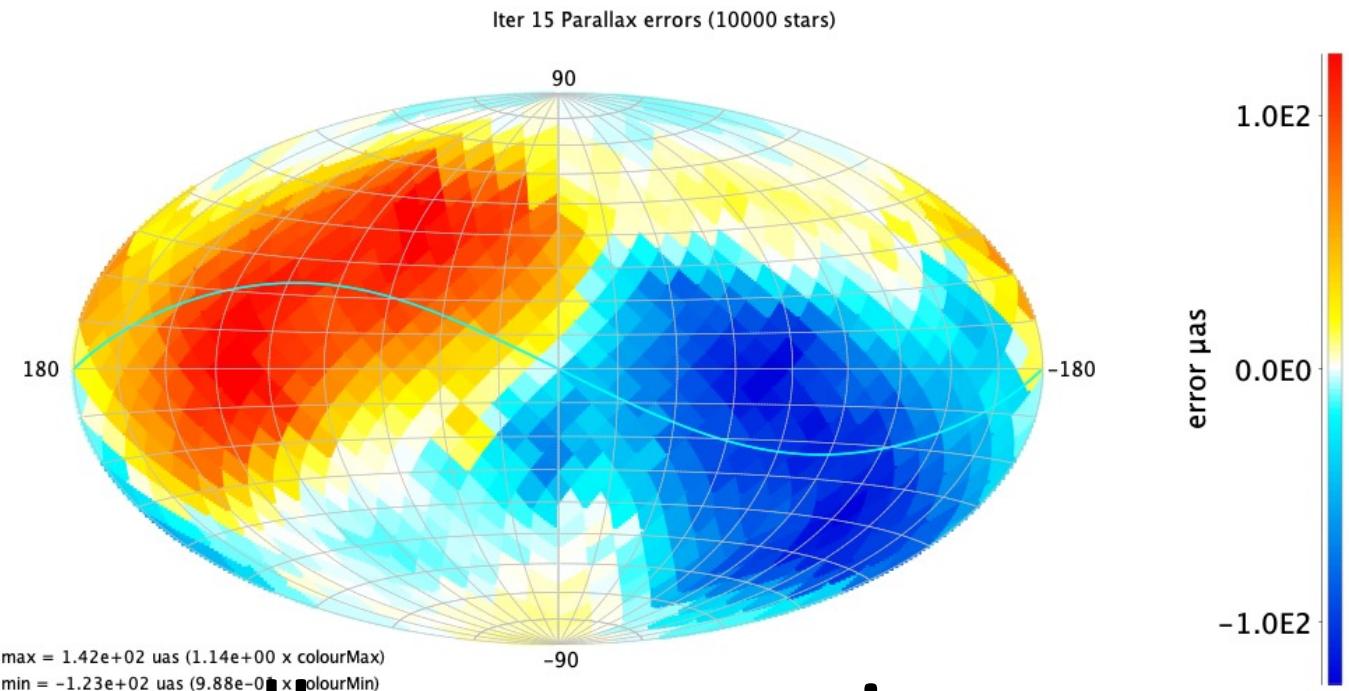


L. Lindegren et al. 2021

Calibration error proportional to magnitude



non uniform sky



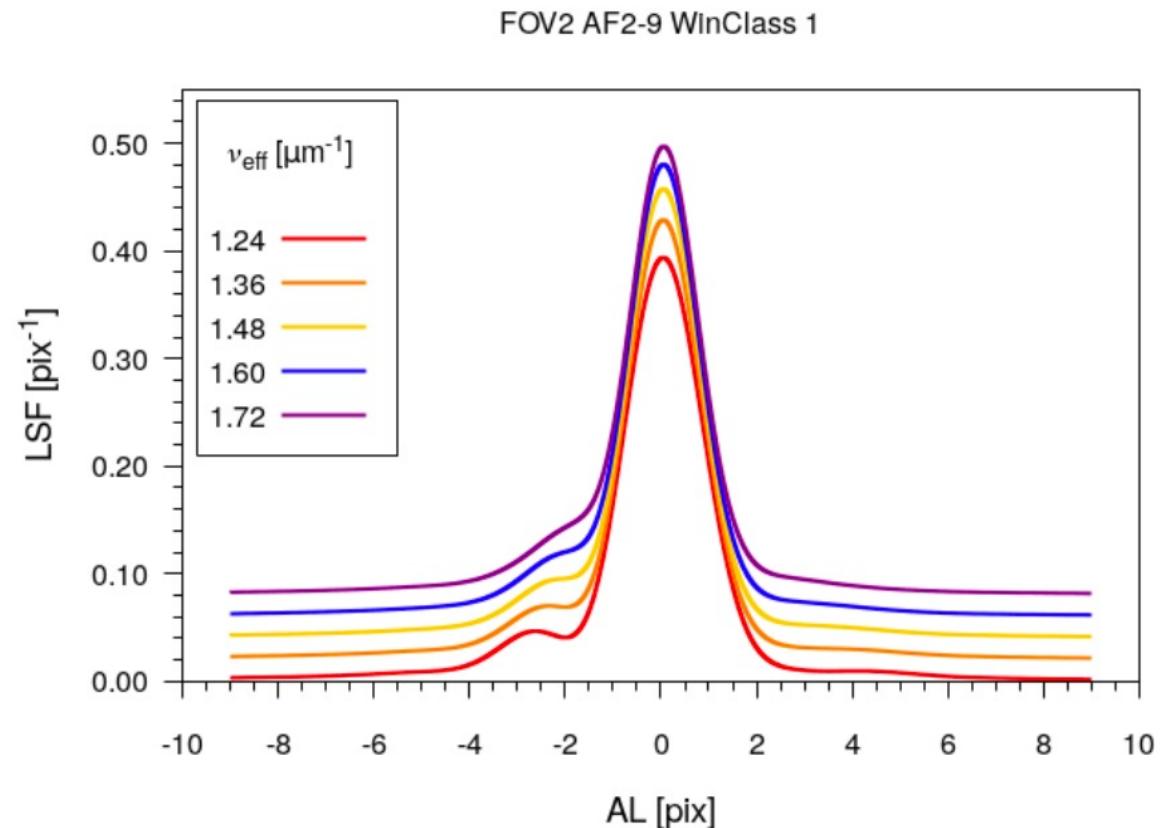
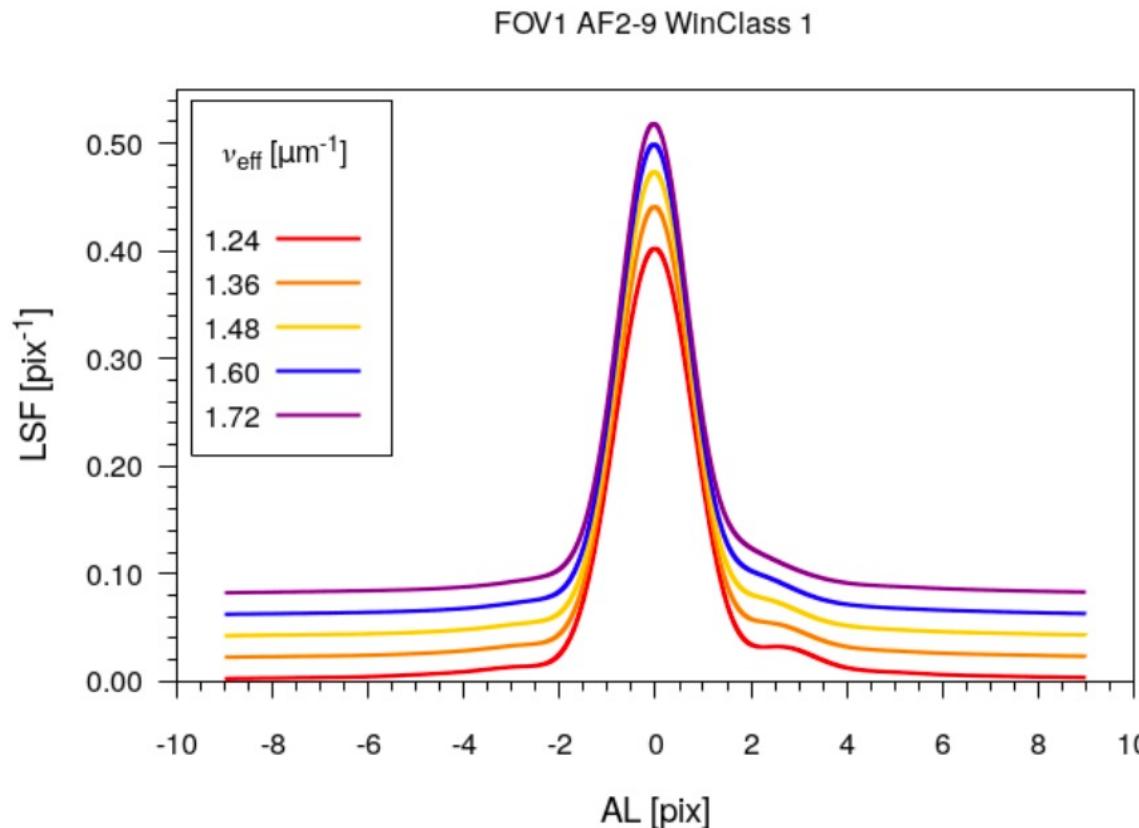
parallax zero-point errors
(simulation)

My work for DR4

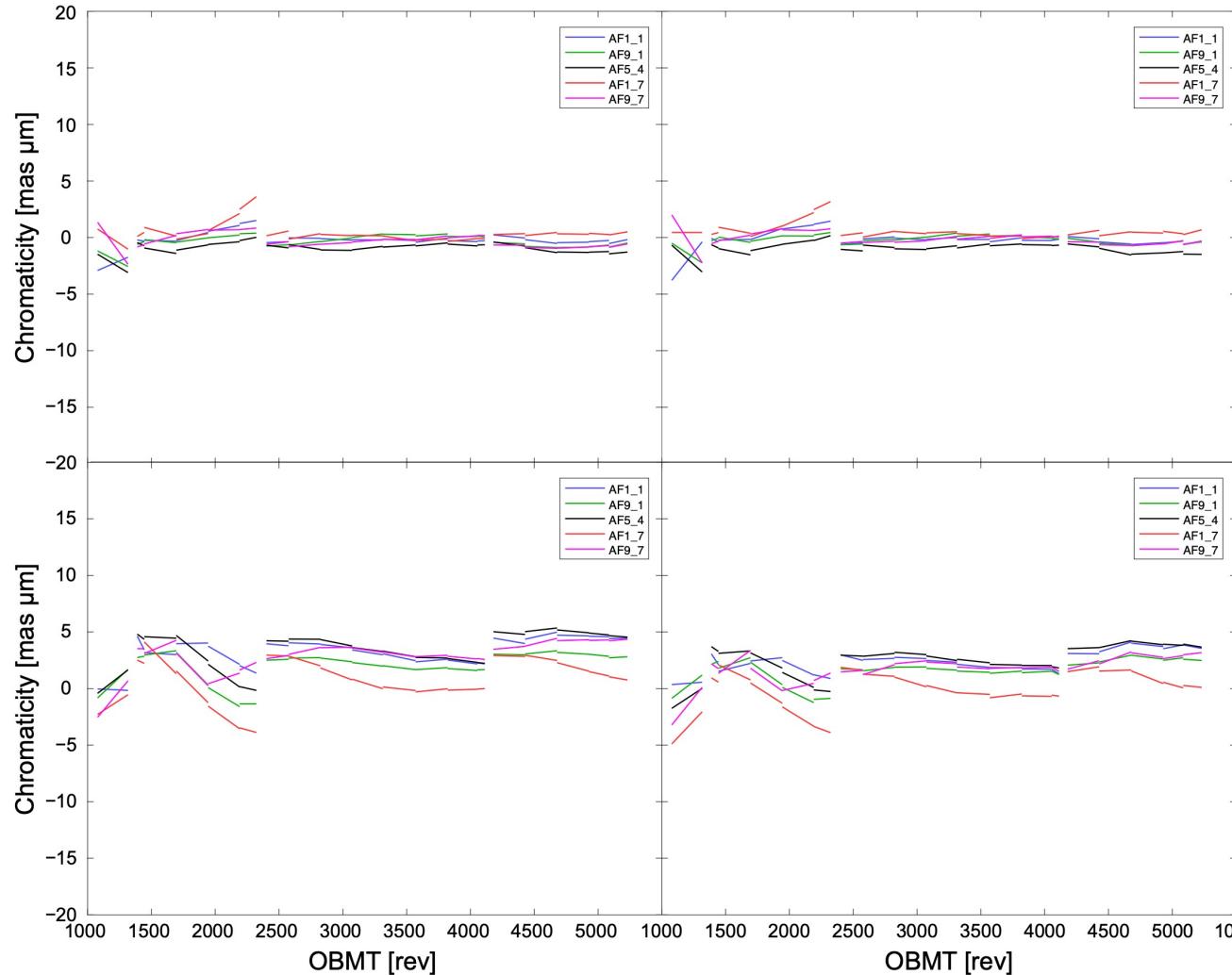
- Alignment of AGIS and PSF calibration
- Constraining degeneracies
- Calibration excess noise
- Calibrate magnitude dependencies
- Test ac rate calibration (reverse precession)



EDR3 Light Spread Function vs color



DR3 astrometric colour correction



Alex Bombrun

L. Lindegren 2021