



ITA-INA-S22



Updates on Activities and Progress

Rubin-LSST@Italy 2026

Title: Staff effort in support of Rubin commissioning: Image quality analysis

PI: Giuliana Fiorentino

People involved: L. Schreiber, F. D'Ammando, M. Di Criscienzo, E. Giro, L. Lanteri, D. Massari, D. Paris, V. Ripepi, S. Savarese, P. Schipani, V. Testa, V.F. Braga, R.Z. Sanchez, M. Monelli

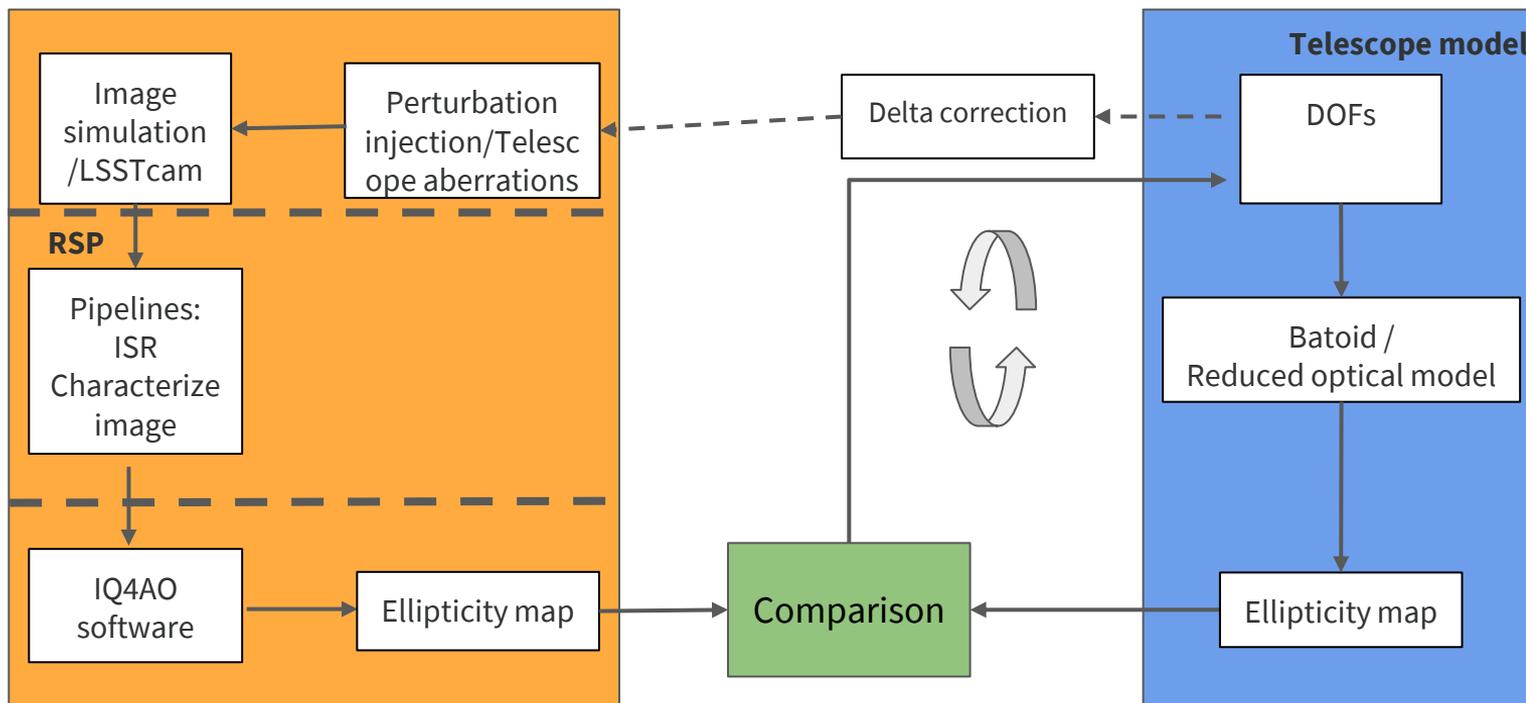
- IQ4AO Method overview
- IQ4AO Method validation
- Saturated stars: science cases and open issues
- Updates and working plan for 2026

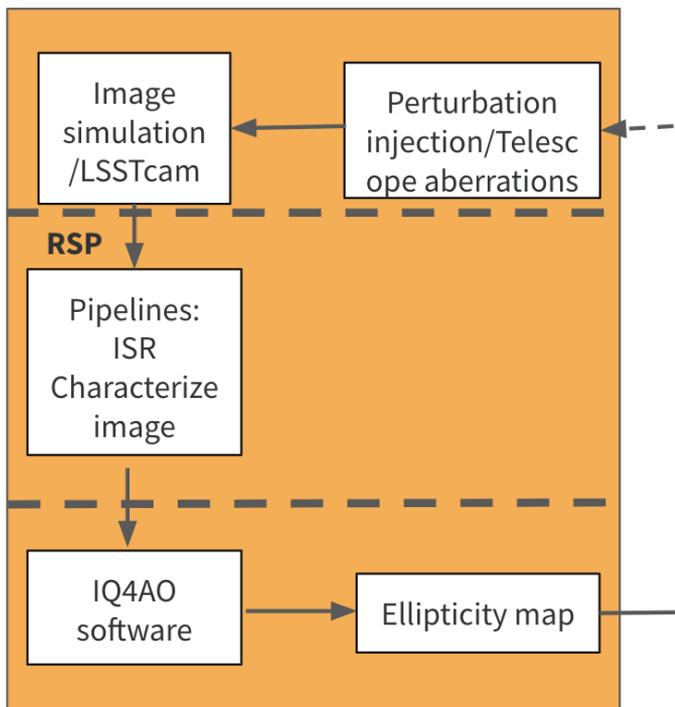


IQ4AO Method overview

IQ4AO Method implementation:

A sanity check for the Active Optics using Focal-plane ellipticity maps



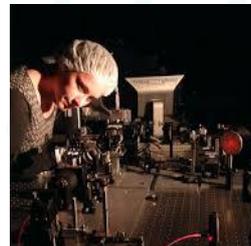


- The input image shall be pre-reduced (background subtracted / flat-fielded etc..)
- The input image shall be associated to a position of the telescope during the observation to retrieve the rotation of the focal plane w.r.t. the telescope coordinates
- The PSF estimation shall be done using the LSST RSP

MAIN CONTRIBUTORS:



Vittorio F. Braga
Scientist/resolved stellar pop.

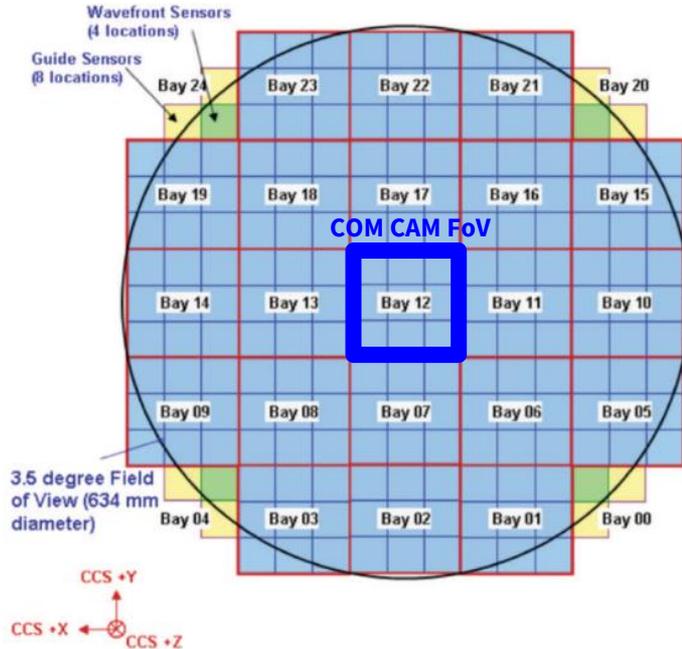


Laura Schreiber
Technologist/
Adaptive Optics

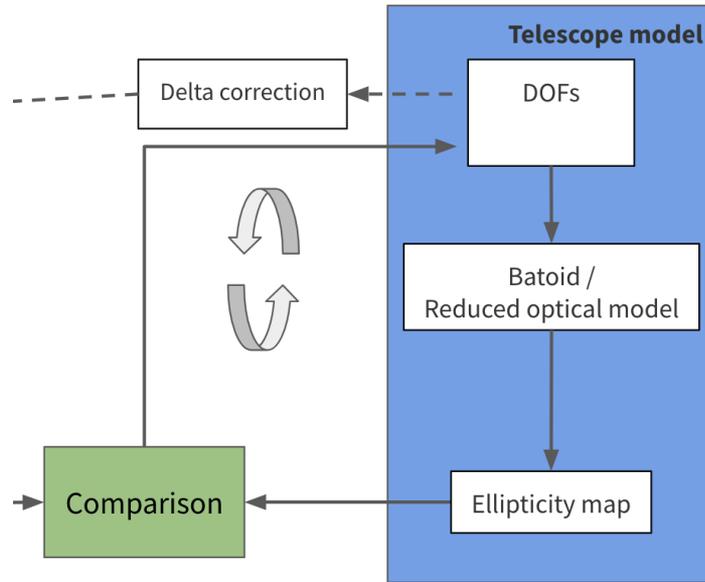


Marcella Di Criscienzo
Scientist/LBT/
resolved stellar pop.

LSSTCam



- 189 detectors on a FoV of 3.5°
- A CalExp Object will be produced for each of the 189 CCDs: this corresponds to a single processed and calibrated image object including metadata and useful methods as, for instance, `getPsf`
- The PSF object can be used to get a realization of a PSF at a specific point by using the method `calexp.getPsf().computeImage(PointD(xp,yp))`
- The adaptive moments I_{xx} , I_{yy} and I_{xy} are computed through the `galsim.hsm` module by estimating the best-fit elliptical Gaussian to the object
- Coordinate transformation and detector orientation angle can be retrieved from the Detector Class Reference in CalExp



- To build a reliable Telescope Model, verified with BATOID with 50 DoF
- An Ellipticity pattern should be produced within the RSP environment
- A Cost minimization function should be built

MAIN CONTRIBUTORS:



Ricardo Z. Sanchez
Technologist/Optics



Salvatore Savarese
Technologist/Active Optics

Rough structure of our Code for VST use

- Standalone code
- Developed in MATLAB
- Interfaced to Zemax for ray-tracing data

Objectives:

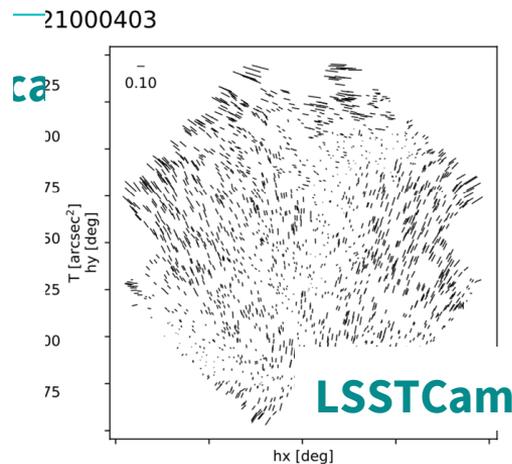
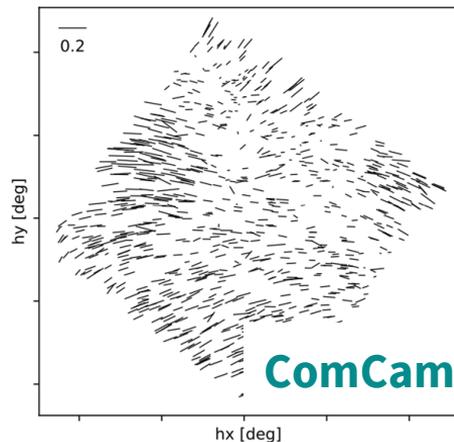
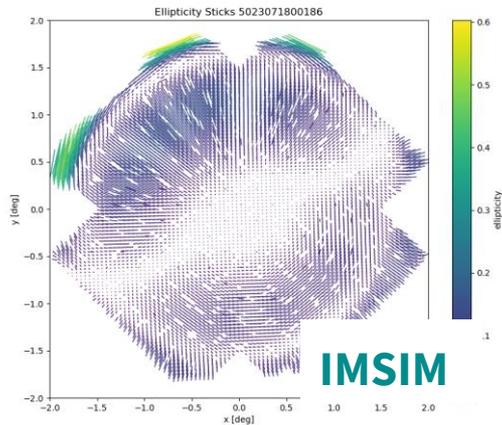
- Python version
- Analytical Telescope model
- Shareable
- Integrated w/ Rubin



IQ4AO Method validation



IO4AO Method validation

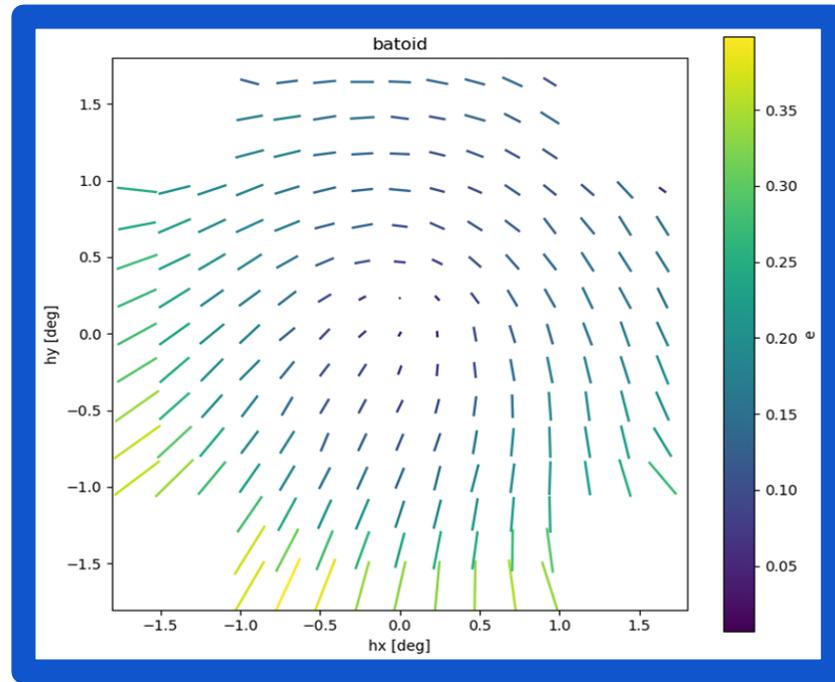
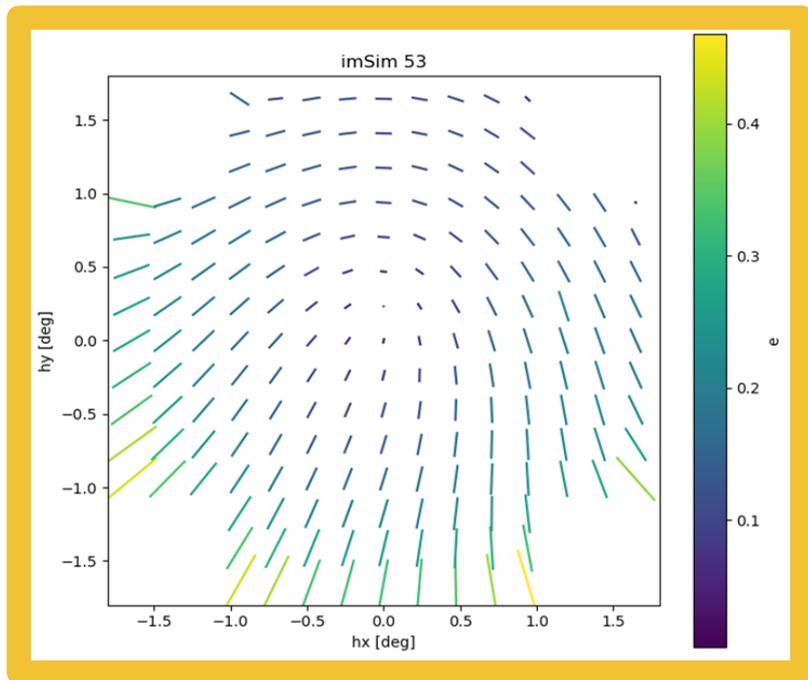


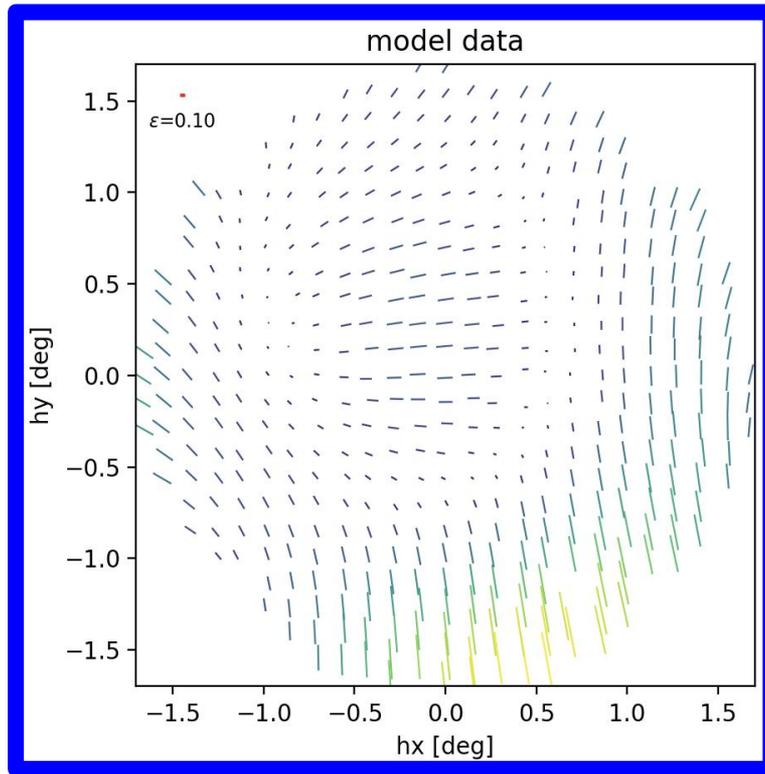
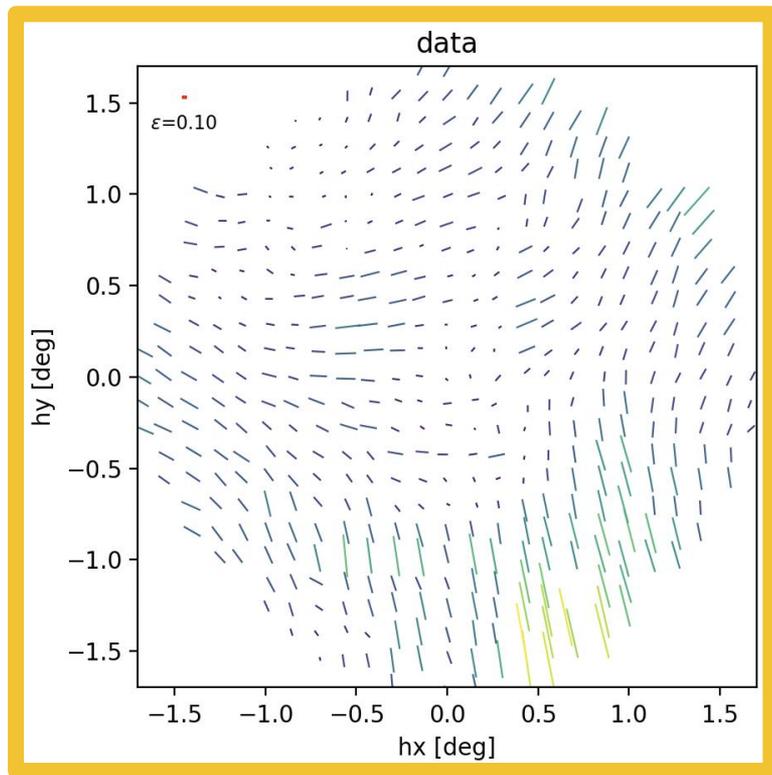
Validation datasets

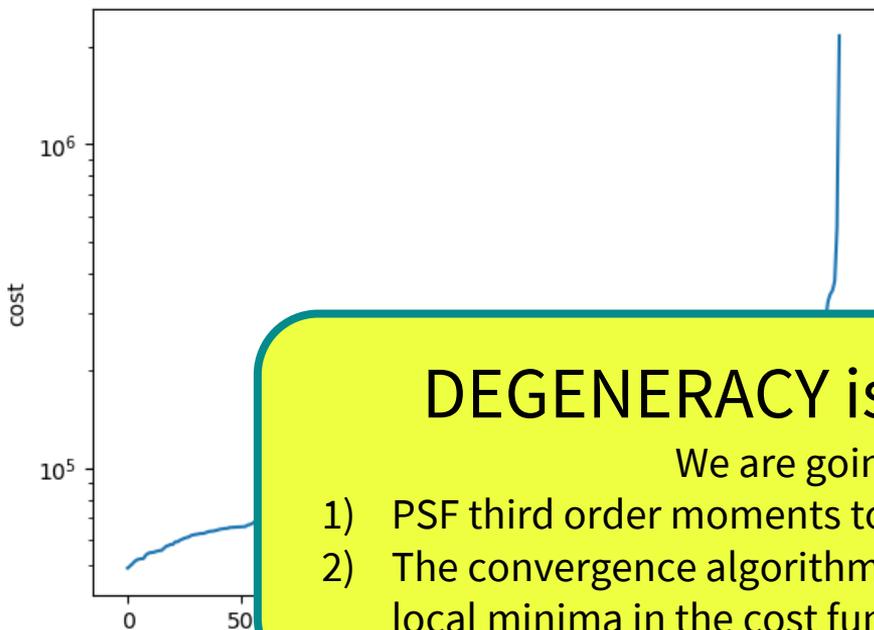
- Through simulations → DP0, Rehearsal images and ImSim - **pro** we know inputs; **cons** not real
- AOS commissioning ComCAM datasets - **pro** first real images; **cons** small FoV
- **Application to LSSTcam images** - **pro** real images (real problems, e.g. vignetting, temperature); **cons** not known the zero point of the alignment

First tests on simulated images: Ellipticity maps - IMSim VS Batoid

M2: $(dz, R_x, R_y) = (30 \text{ } \mu\text{m}, 20'', 10'')$







DEGENERACY is a MAJOR ISSUE!!

We are going to investigate

- 1) PSF third order moments to break the degeneracy;
- 2) The convergence algorithm could be improved to optimize the local minima in the cost function.

Image quality: Saturated STARS

- **O3 IMAGE QUALITY EVALUATION.** Assist image quality and calibration performance evaluation as needed by the Rubin team. Here we propose a study on saturated stars.
- **DO3.1** Data reduction procedure for saturated stars. Development of a dedicated software to manage the photometry of saturated sources using the wings of the point spread function and the photometry of sources in star trail images.

LL worked in the first here to the Fortran software for doing this fit using PSF wings. He was planning to use DECam images to test the software. He participated to the weekly meetings but He could work only little time, however He left officially the project mid-2024.

In September 2024 MM join the project as TD, nowadays He got the staff position in Teramo, still helping but not full time.

In October 2025 VB moved on the Saturated STARS working package, thus He we expect to to carry-out the program

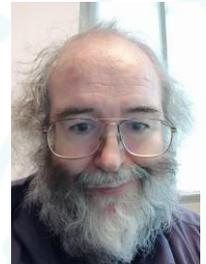
MAIN CONTRIBUTORS:



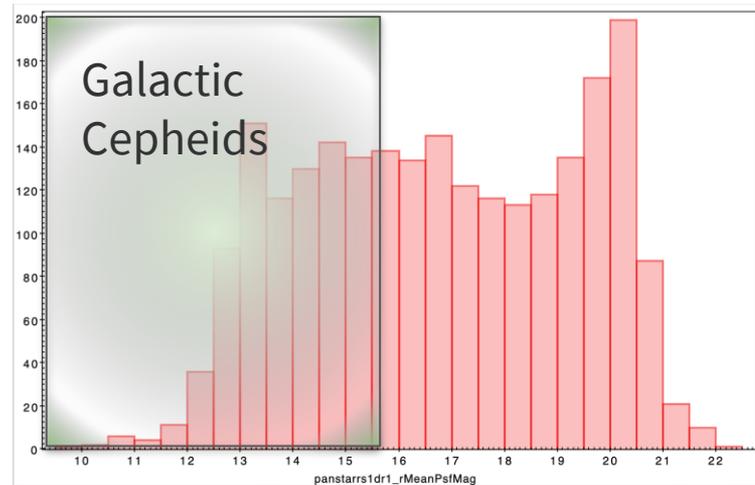
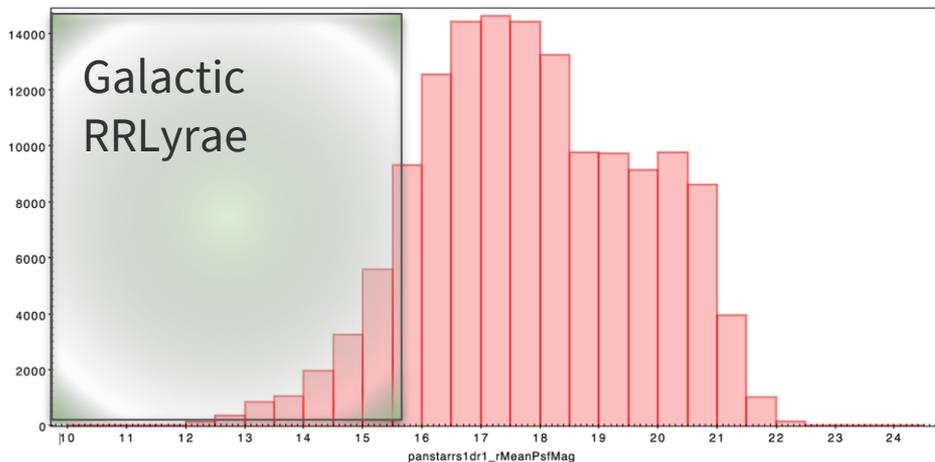
Vittorio F. Braga
Scientist/resolved stellar pop.



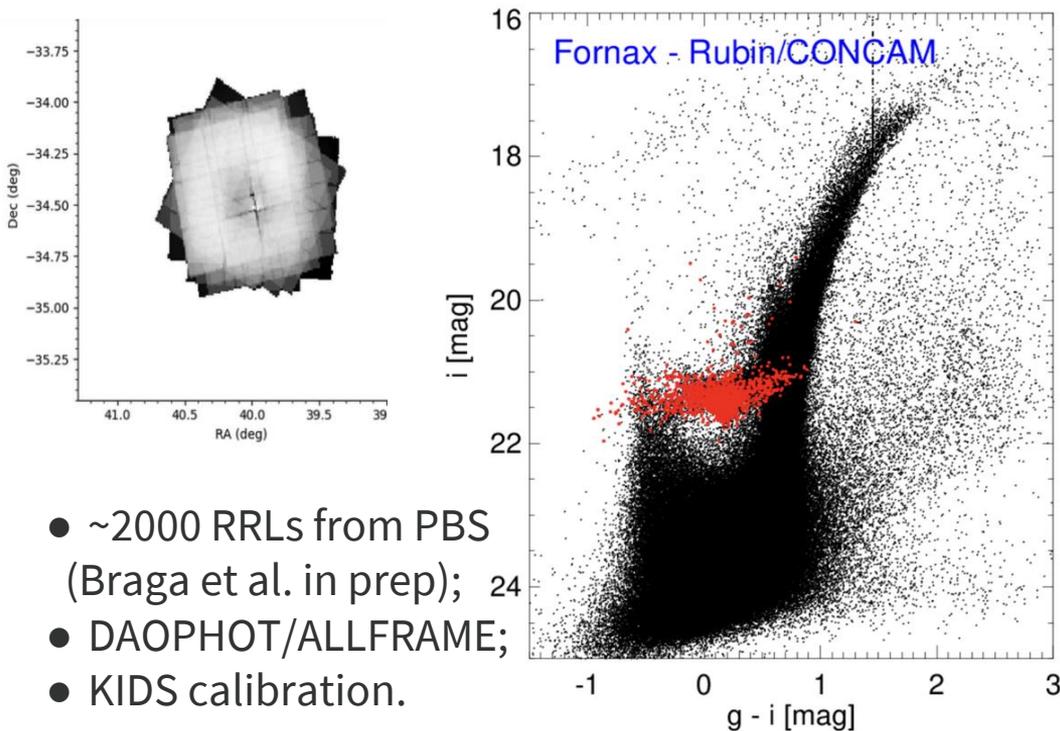
Matteo Monelli
Scientist/resolved stellar pop/photometry.



Luciano Lanteri
Technologist/Saturated stars



- 1- Galactic RRLyrae, Cepheid, Local Group LP (Mira and Semi regular) variable stars: Saturated stars or nonlinear regime.
- 2- Recovering magnitudes around saturated stars for stellar population studies.

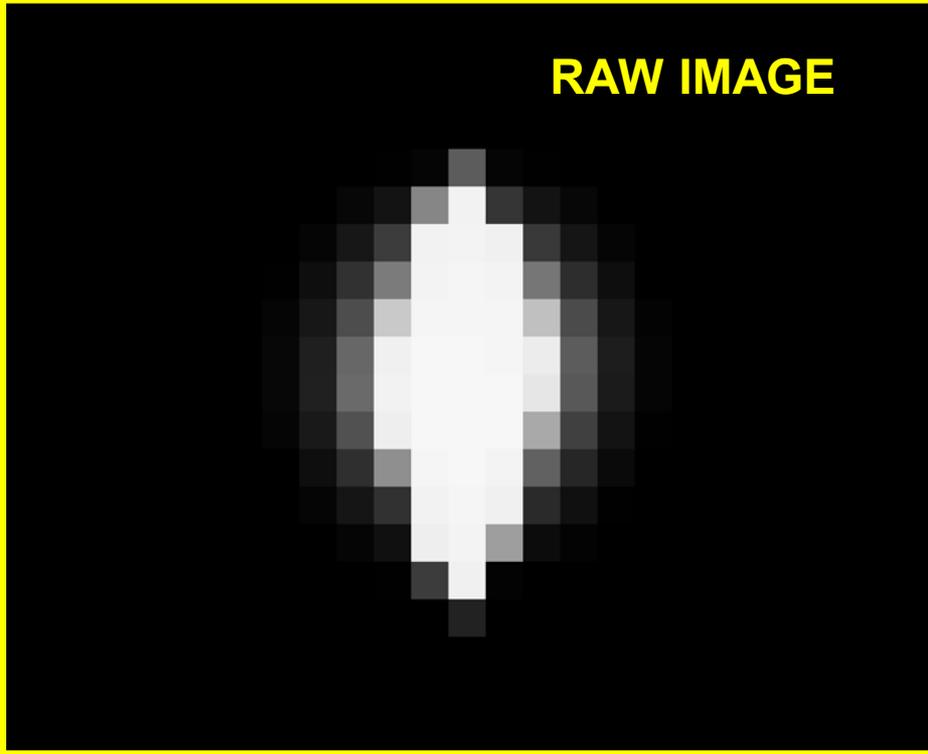


- ~2000 RRLs from PBS (Braga et al. in prep); 24
- DAOPHOT/ALLFRAME;
- KIDS calibration.

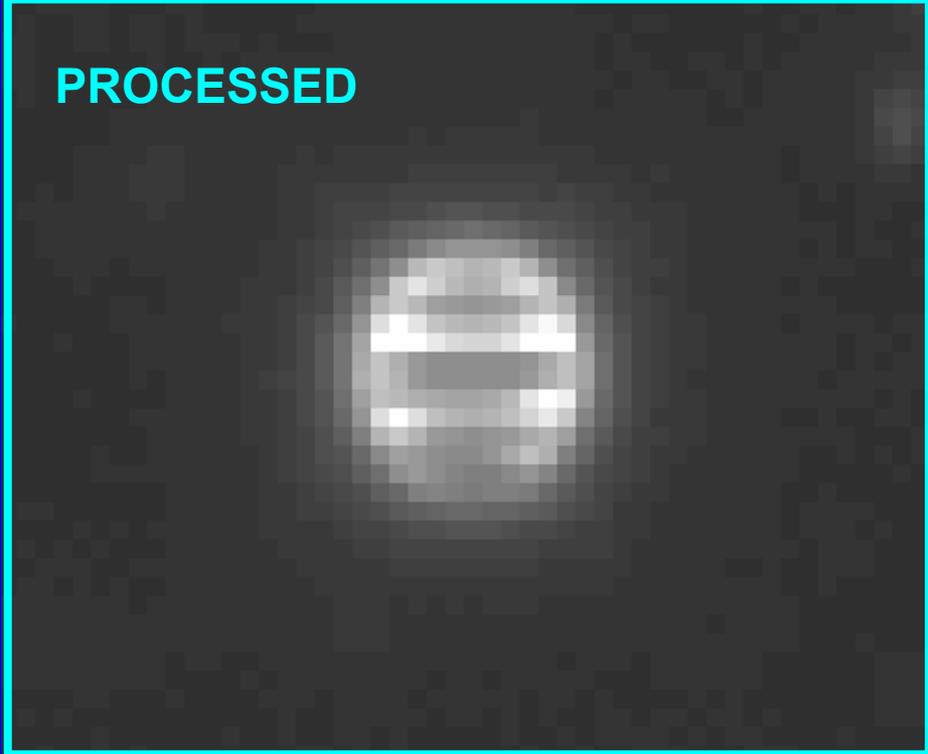
Target	u	g	r	i	z	y
47 Tuc	6	10	33	19	0	5
Rubin SV 38 7	0	44	55	57	27	0
Fornax dSph	0	5	26	13	0	0
ECDFS	53	230	257	177	177	30
EDFS ComCam	20	61	90	42	42	20
Rubin SV 95 -25	33	86	97	29	60	11
Seagull	10	37	49	3	13	0

	Nov. 24 2024	Dec 05 2024	<seeing>
g		5 (5 min)	1.15"
r	17 (14 min) + 2 (2 min, 28 min later)	5 (5 min)	0.8"
i	5 (5 min)	7 (6 min)	0.7"-1.05"

RAW IMAGE



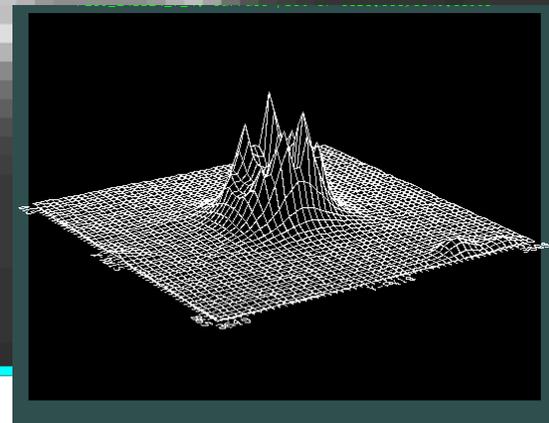
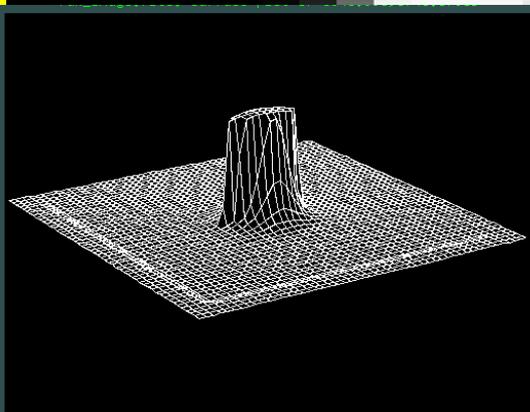
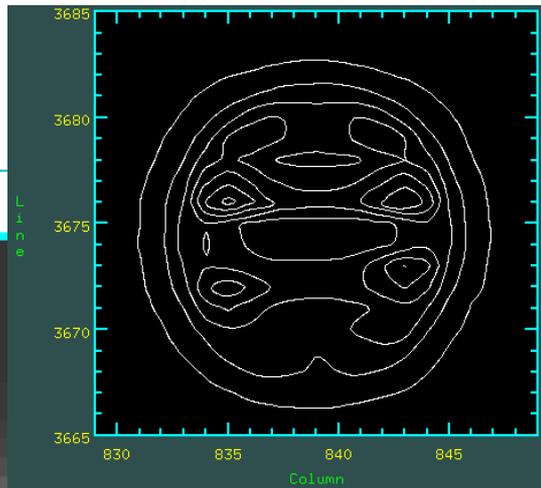
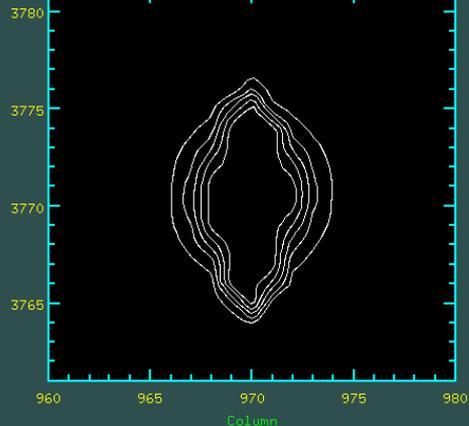
PROCESSED



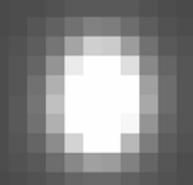
Saturated star treatment

RAW IMAGE

PROCESSED

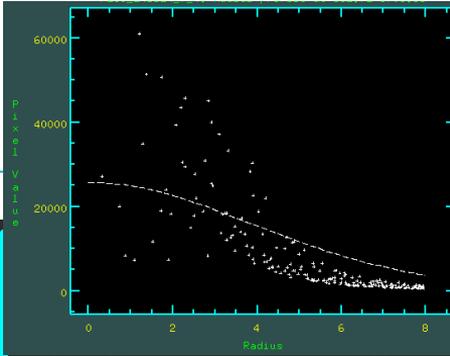
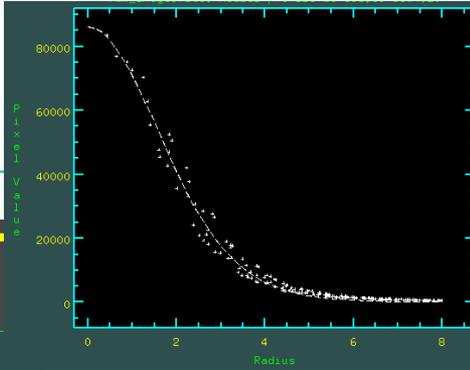


RAW IMAGE

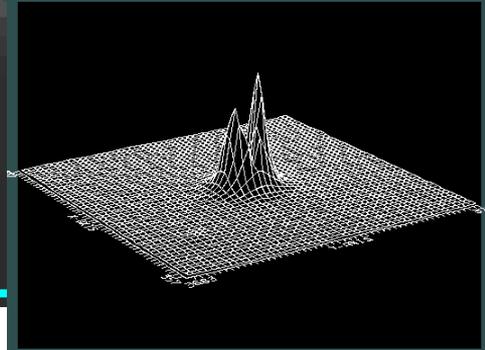
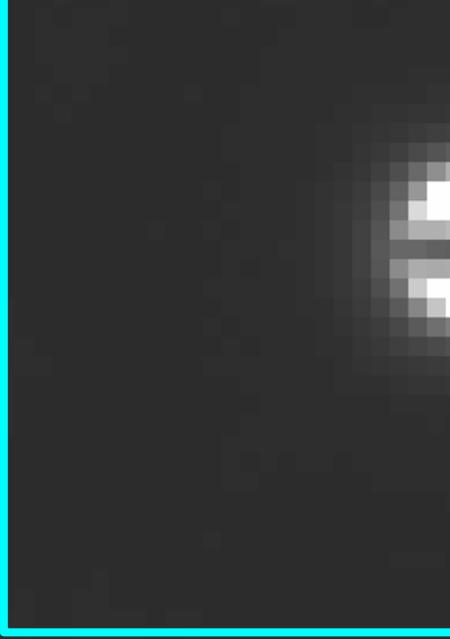
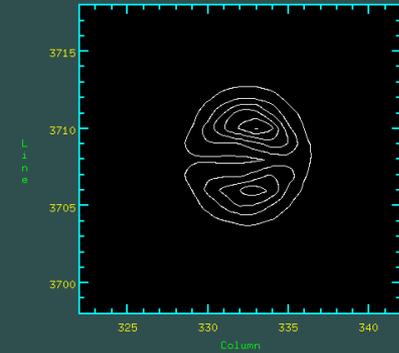
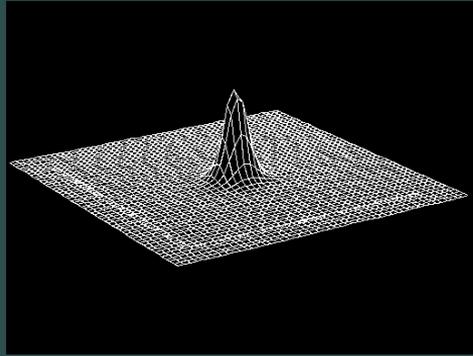
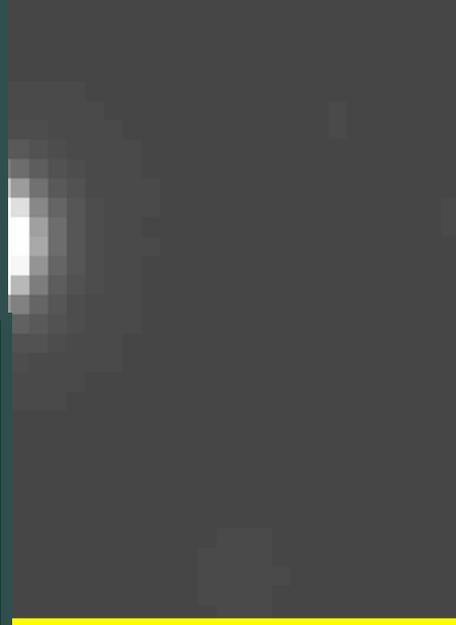
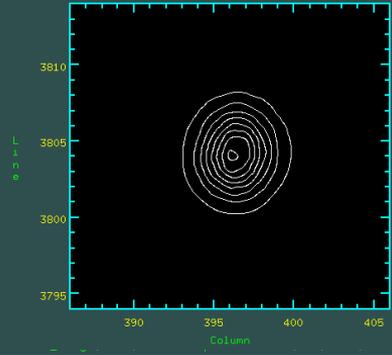


PROCESSED





G(Gaia)=15.9
sloan:
g=16.159
r=15.704





Deliverables and working plan for 2026

- **IQ4AO Deliverables – GitHub Repositories:** The source code has been uploaded to GitHub. We are currently refining the scripts to ensure they are well-documented, commented, and user-friendly: ellipticity map notebook, analytical telescope model, cost function- **early 2026 (end of march)**.
- **Saturated STARS** - ComCam images with saturated stars are analysed in detail to recover their true magnitudes and the stellar pop around them. We are studying parallel Australian in-kind to understand possible synergy (Bright Star Subtraction pipeline).

NEXT-STEPS:

- **IQ4AO:** We plan to introduce the third order moments (ASYMMETRY) of the PSF to remove aberration degeneracy - **July 2026**
- **IQ4AO: Deliverable – Documentation:** final IQ4AO method - **October-December 2026**
- **Saturated STARS-** Software to extract a better magnitude estimation for stars close to the saturation limit - **October-December 2027**.

t0=01/10/2021

FY22: 1 New hire (postdoc, 0.7 FTE), + Staff, 2.0 FTE (**O1, O3**)

FY23: ~~3~~ 2 New hire (postdoc, ~~2.1~~ 1.4 FTE), + Staff, 2.0 FTE (**O1, O3**)

FY24: 3 New hire (postdoc, 2.1 FTE), + Staff, 2.0 FTE (**O1, ~~O2~~, O3**)

FY25: 3 New hire (postdoc, 1.4 FTE), + Staff, 2.0 FTE (**O1, ~~O2~~, O3**)

FY26: 2 New hire (postdoc, 1.4 FTE), + Staff, 2.0 FTE (**~~G1~~, O1, O3**)

FY27: 1 New hire (postdoc, 0.7 FTE), + Staff, 2.0 FTE (O3)

OBJECTIVES:

O1 = IQ4AO method

O2 = Impact of Geometric Distortion on IQ4AO

O3 = Saturated stars treatment

GOAL:

G1 = IQ4AO method on-line