# Summary of the AO4ASTRO workshop hold at LAM 26th to 28th of March.


Organized by O. Beltramo-Martin

# Motivation

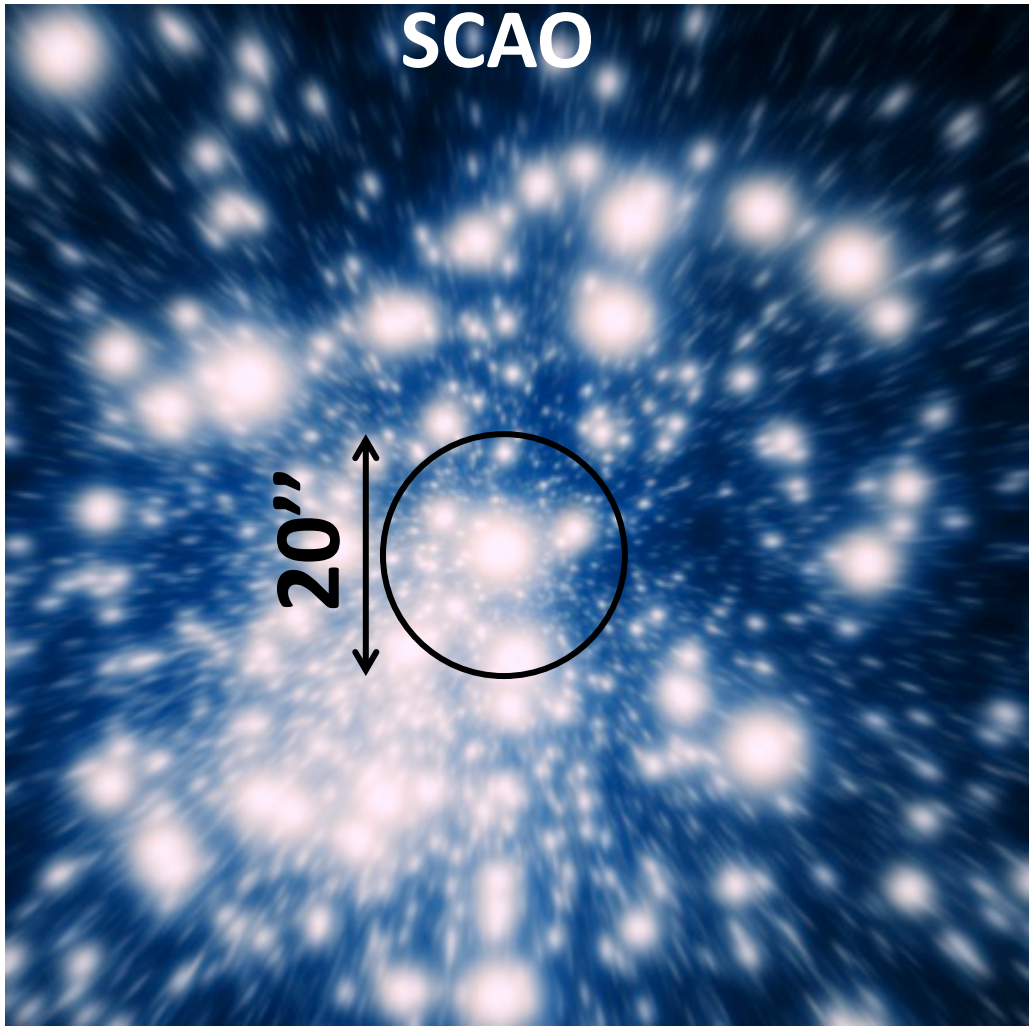
**VLT becomes fully Adaptive**

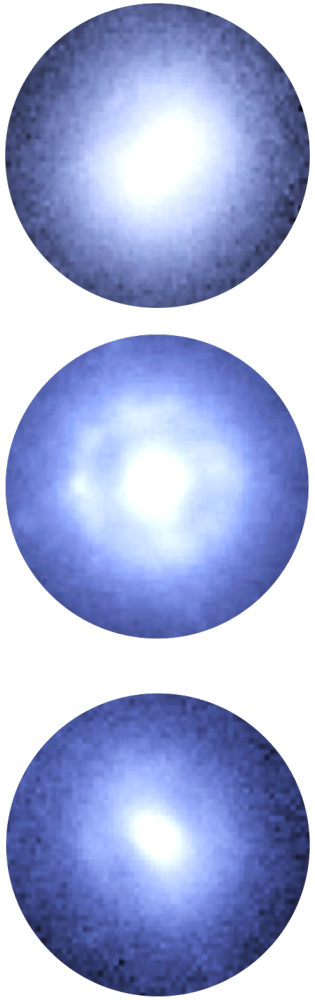
**ELTs = 100% Adaptive Optics**

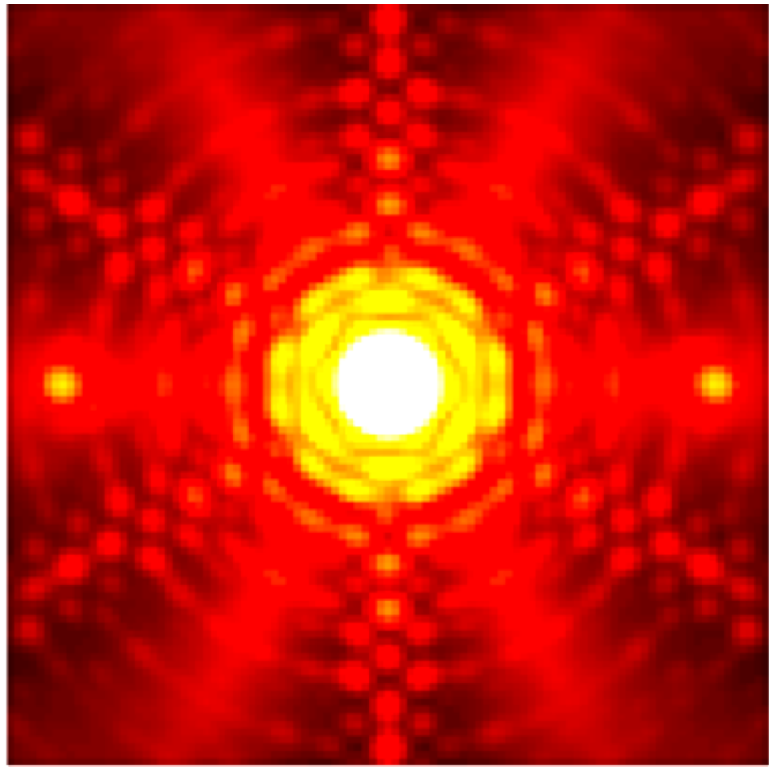
# Motivation

# The AO PSF is complex

Field variations – Time Variations – Highly structured



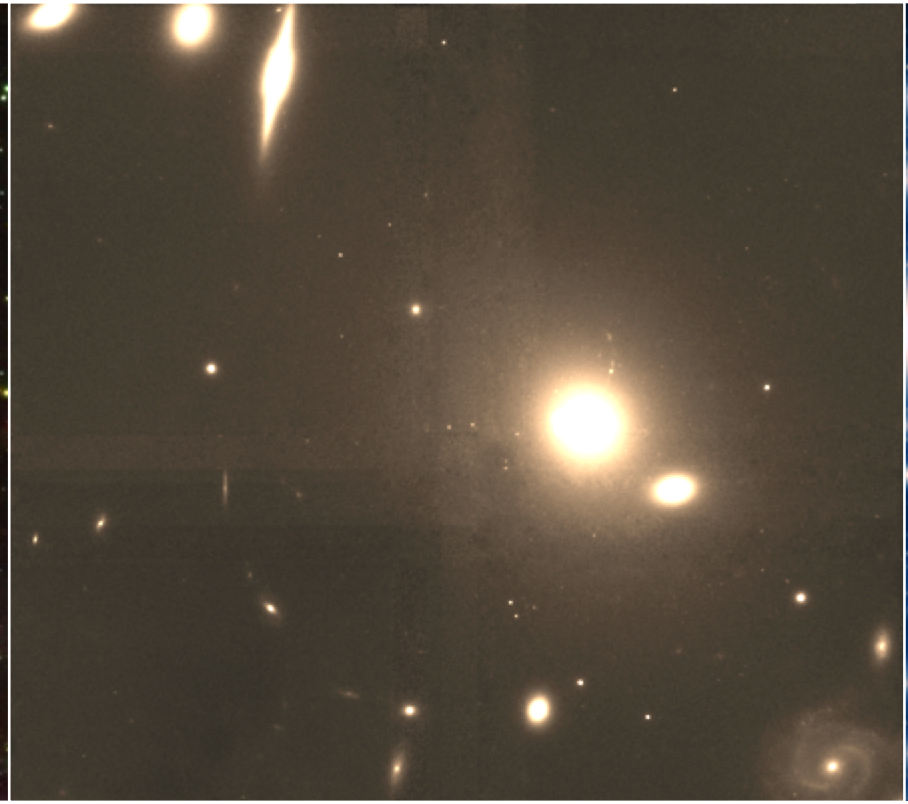
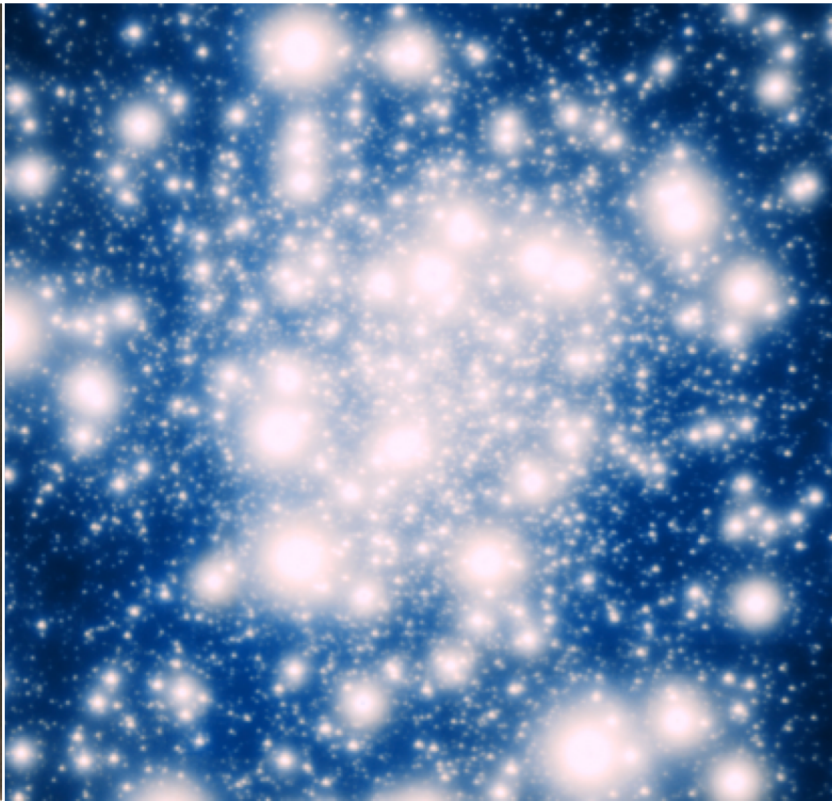





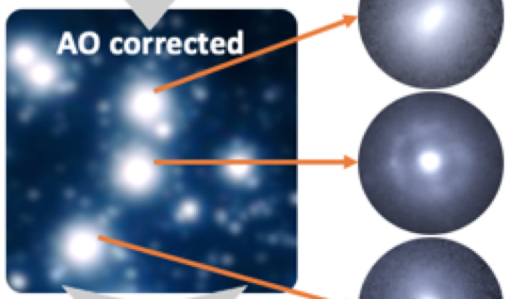
# Motivation

# The AO PSF is complex

**Sometime we can extract an empirical PSF from the data, but sometime not…**

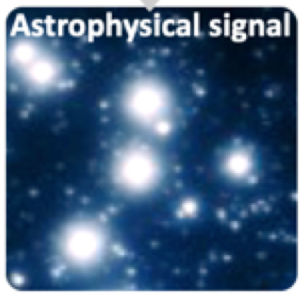




# Rationale

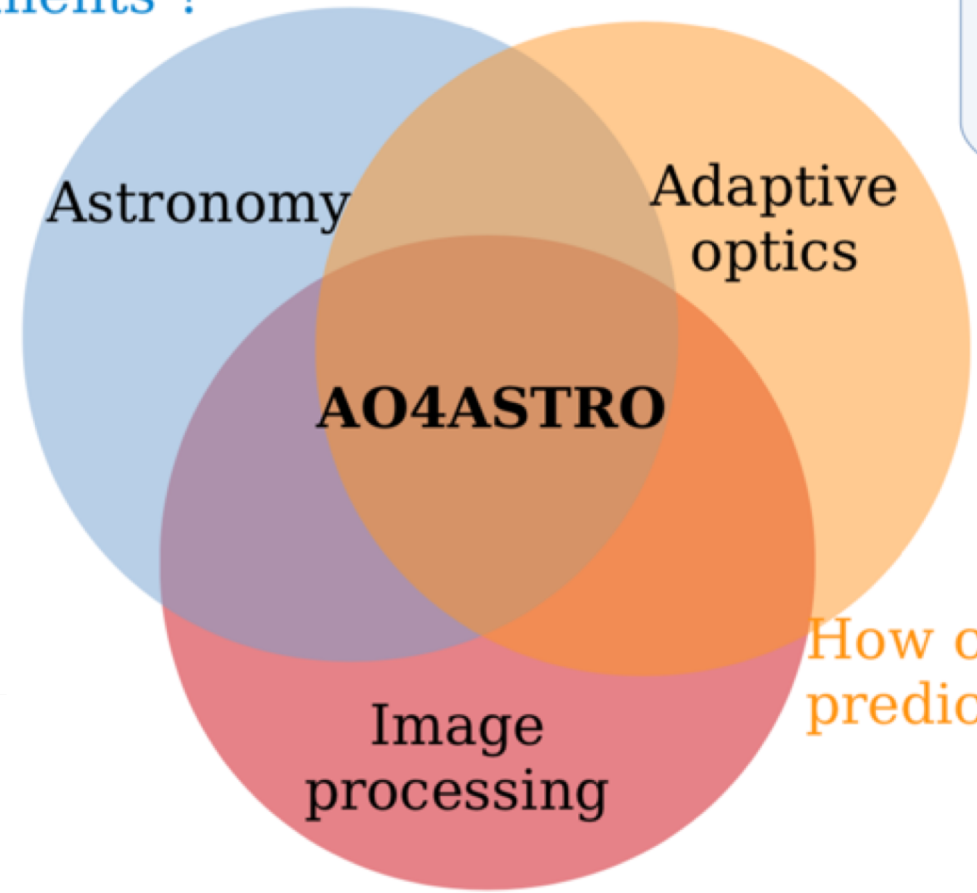


PSF(λ,t,r)




What are the existing limitations in the scientific exploitation of AO-assisted instruments ?

Gather 3 communities to improve the exploitation of AO-assisted instruments




How can we enhance and predict on-sky AO performance ?

What are the state-of-the-art, new paradigms and hot topics in image processing for astronomy ?

# Fact sheets

- More than 60 participants from all around the world


- PI and/or main actors of VLT & ELT instruments present (MUSE, SPHERE, HARMONI, MICADO, MAORY, METIS, MOSAIC, MAVIS, …)
- 30 presentations, all available on-line: https://www.lam.fr/recherche-14/groupe-r-d-optique-instrumentation/workshops/article/ao4astro-marseille-2019

# Big Topics

Needs for PSF knowledge – what are the requirements ?

New AO data processing tools available on the market

High-Contrast (with users already used to AO PSFs, but with very high expectations)

Can Machine learning bring something new in AO data processing ?

What architecture is needed to support AO data reduction and analysis ?

Are they collaborations that can be setup around AO-data processing ?

# Big Topics

**Needs for PSF knowledge – what are the requirements ?**

⇒ Very important topic, and very critical for people developing the algorithms.

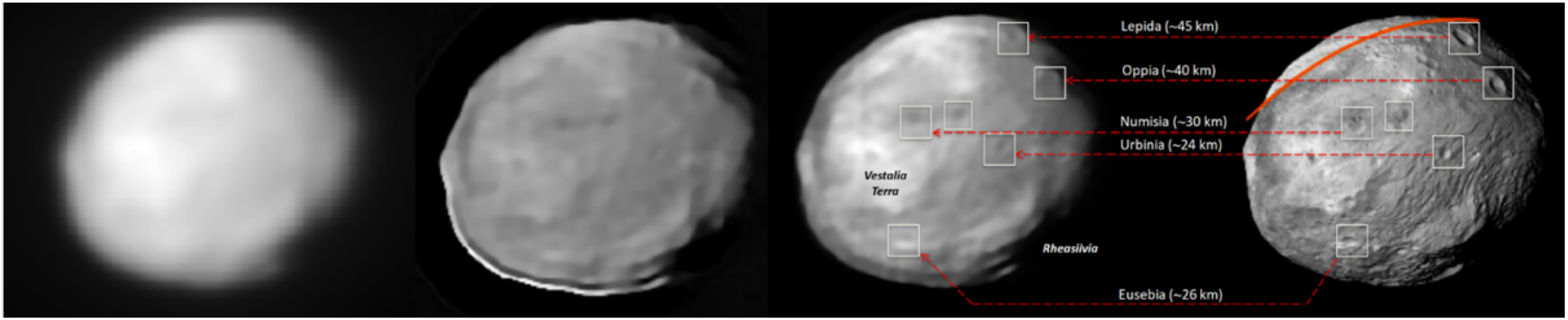
⇒ There is (today) a real lack of clear specifications on requirements for PSF knowledge

⇒ There is no perfect PSF estimation method, so having inputs from users is critical

# Big Topics

**Needs for PSF knowledge – what are the requirements ?**

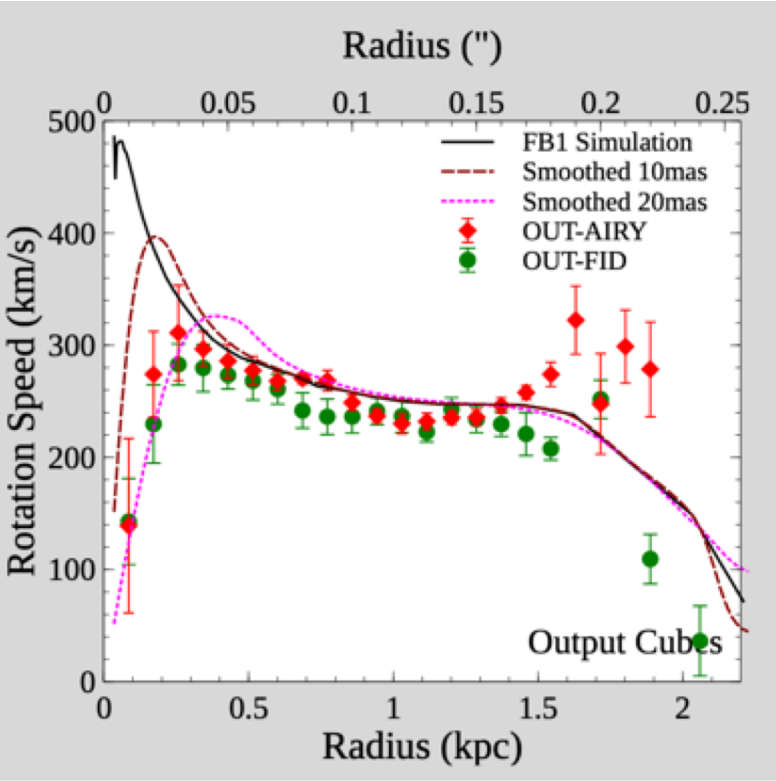
Example with deconvolution (Fétick et al.) :

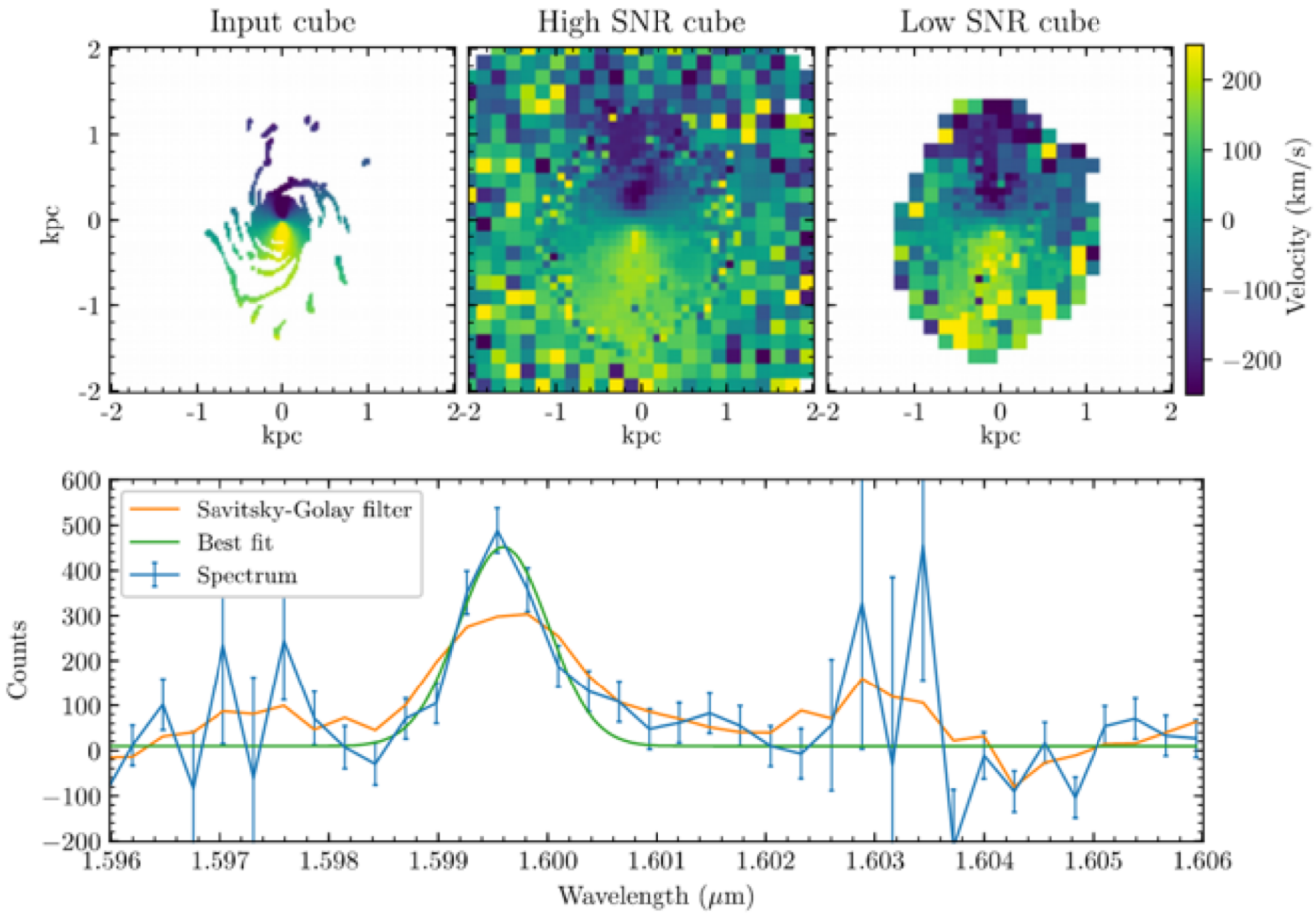



⇒ « Simple » moffat models are enough (even better than calibration star), the most important being the PSF core. **Requirements would be FWHM <5%**

# Big Topics

**Needs for PSF knowledge – what are the requirements ?**




Ex. Thatte et al., Bouché et al., Bacon et al.

⇒Shape of the PSF less critical, as errors are dominated by the galaxy models , **requirement is FWHM <10%**

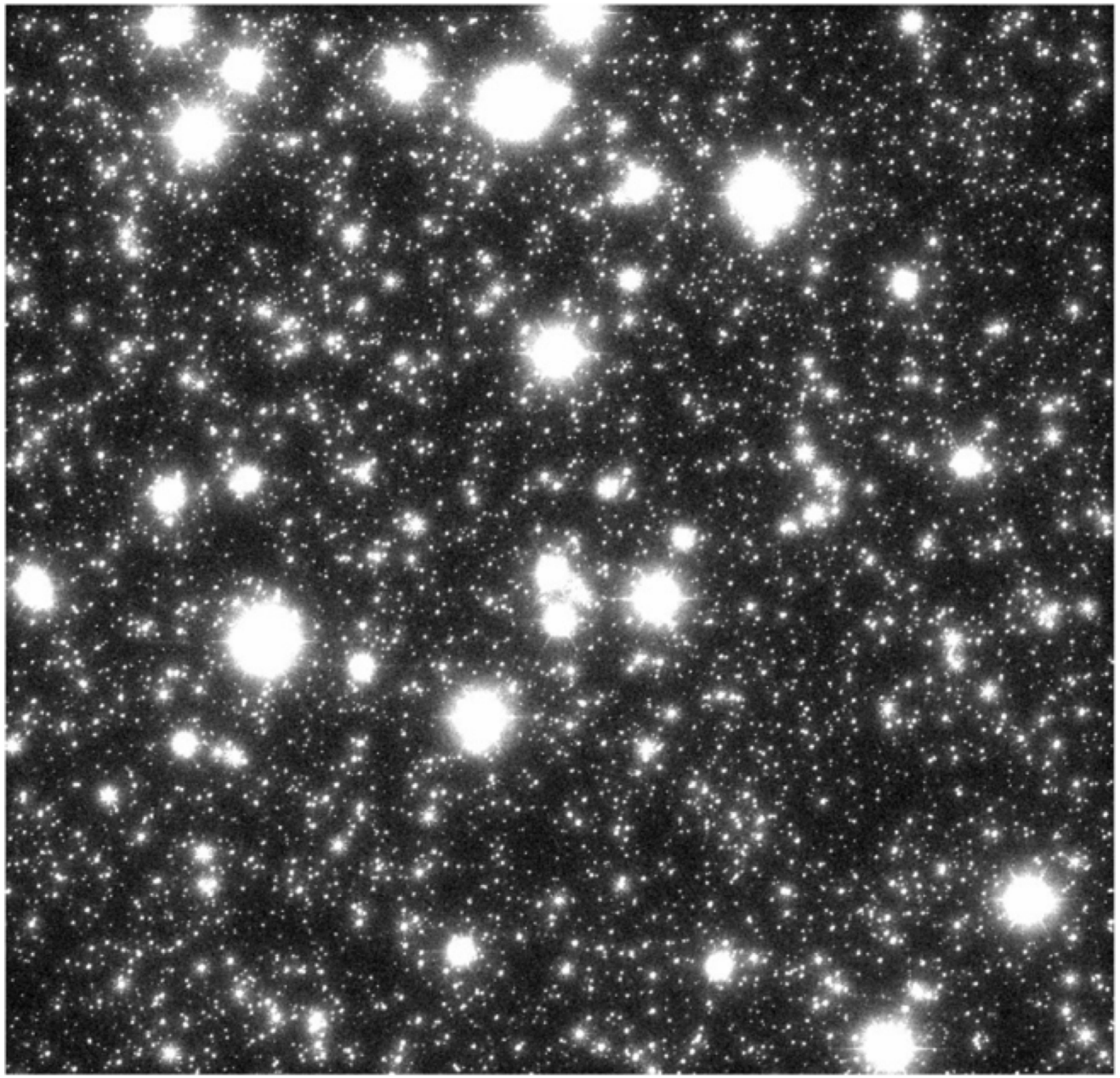
# Big Topics

**Needs for PSF knowledge – what are the requirements ?**

Ex. Massari et al., Fiorentino et al., Moraux et al.

50 micro-arcsec, 0.01magnitude
**=> FWHM to better than 2%**

Astro-Photometry of densed environements



# Big Topics

**Needs for PSF knowledge – what are the requirements ?**

**=> Some on-going work, but more is needed !**

| | Solar system objects | Physics of distant galaxies | Intermediate Mass Black Holes | Galactic Center |
|---|---|---|---|---|
| **Post-processing method** | Deconvolution [MISTRAL] | Model convolution [GalPack3D] | PSF fitting [PampelMuse] | PSF fitting [AIROPA-PRIME] |
| **State-of-art** | > 30km resolution | Kinematics @ 20% | Kinematic biases > 10km/s | Astrometry: 150µas<br>Photometry: 0.1mag |
| **Science requirements** | < 15km resolution | Kinematics @ <10% | Kinematic biases < 3km/s | Astrometry: < 80µas<br>Photometry: < 0.05mag |
| **PSF requirements** | FWHM < 5% | FWHM < 10% | FWHM < 2% | FWHM < 2% |
| **PSF constraints** | No PSF available | No PSF available<br>Temporal variability<br>Spectral variability | Source confusion<br>Spatial variability<br>Spectral variability | Source confusion<br>Spatial variability<br>Spectral variability |

# Big Topics

**Needs for PSF knowledge – what are the requirements ?**

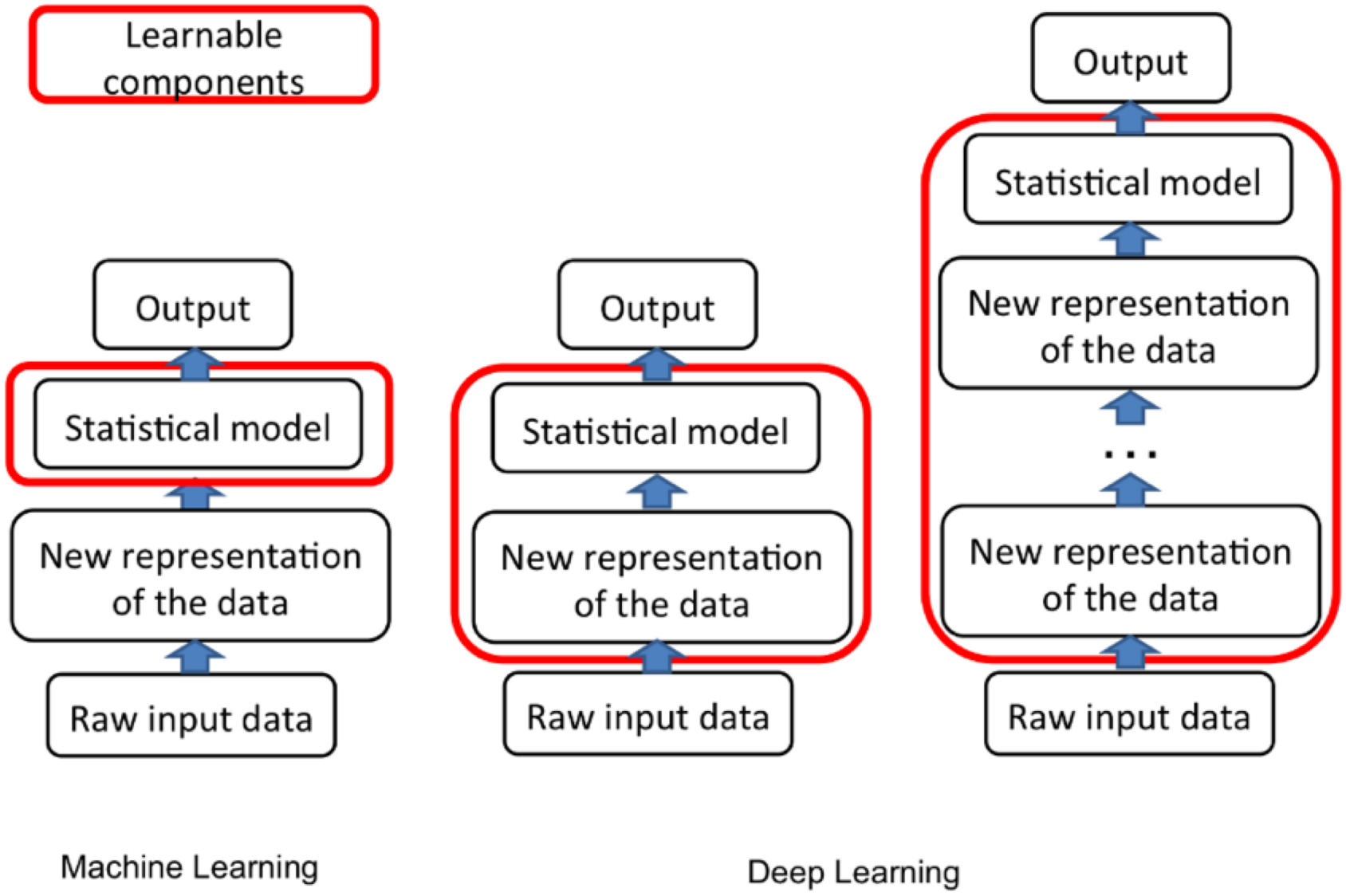
**=> Some on-going work, but more is needed !**

Use SIMCADO, HSIM, and test your science cases !

# Big Topics

e.g. Francois-Xavier Dupé (LIS)

**Can Machine learning bring something new in AO data processing ?**



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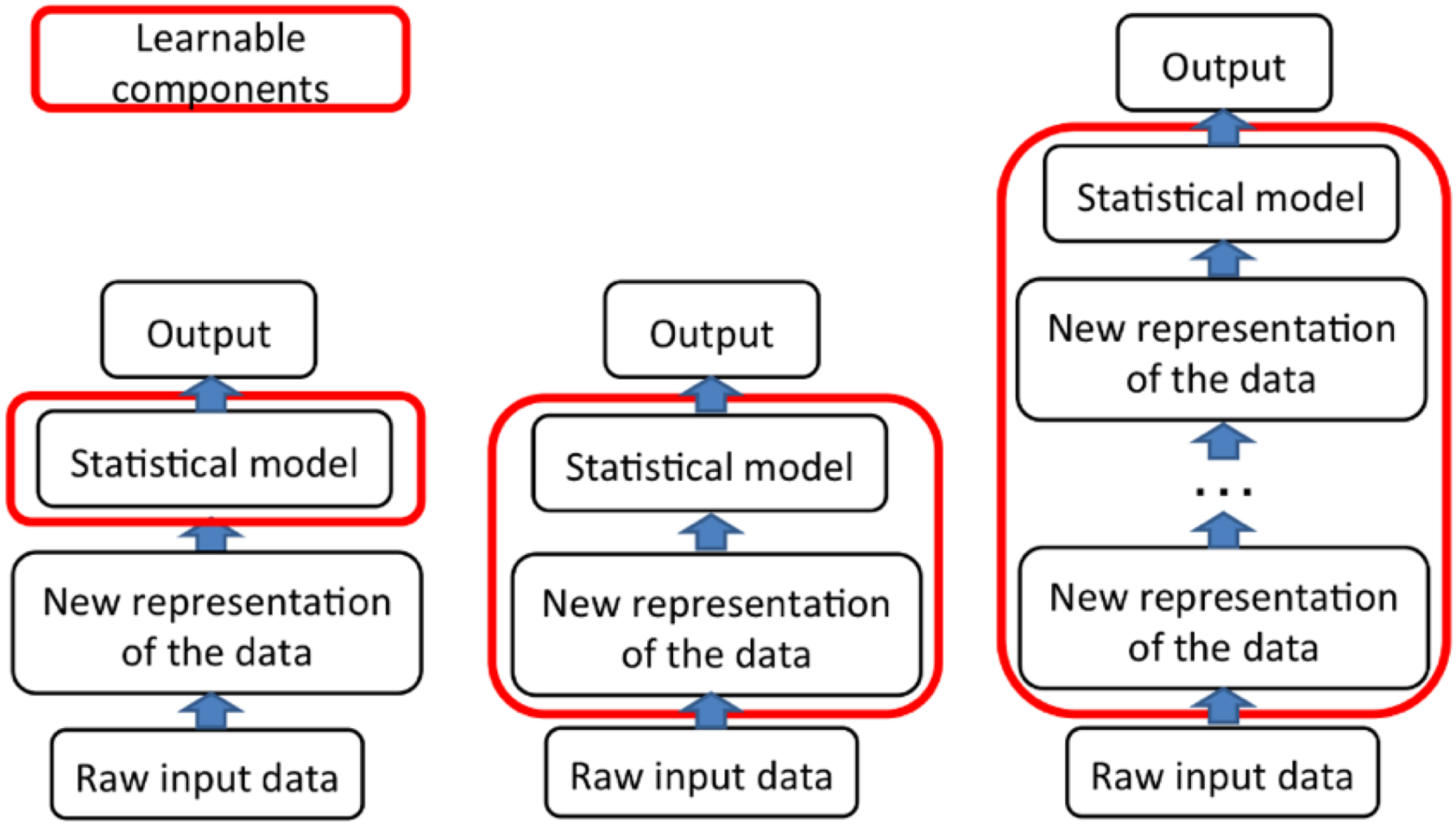



Machine Learning

Deep Learning

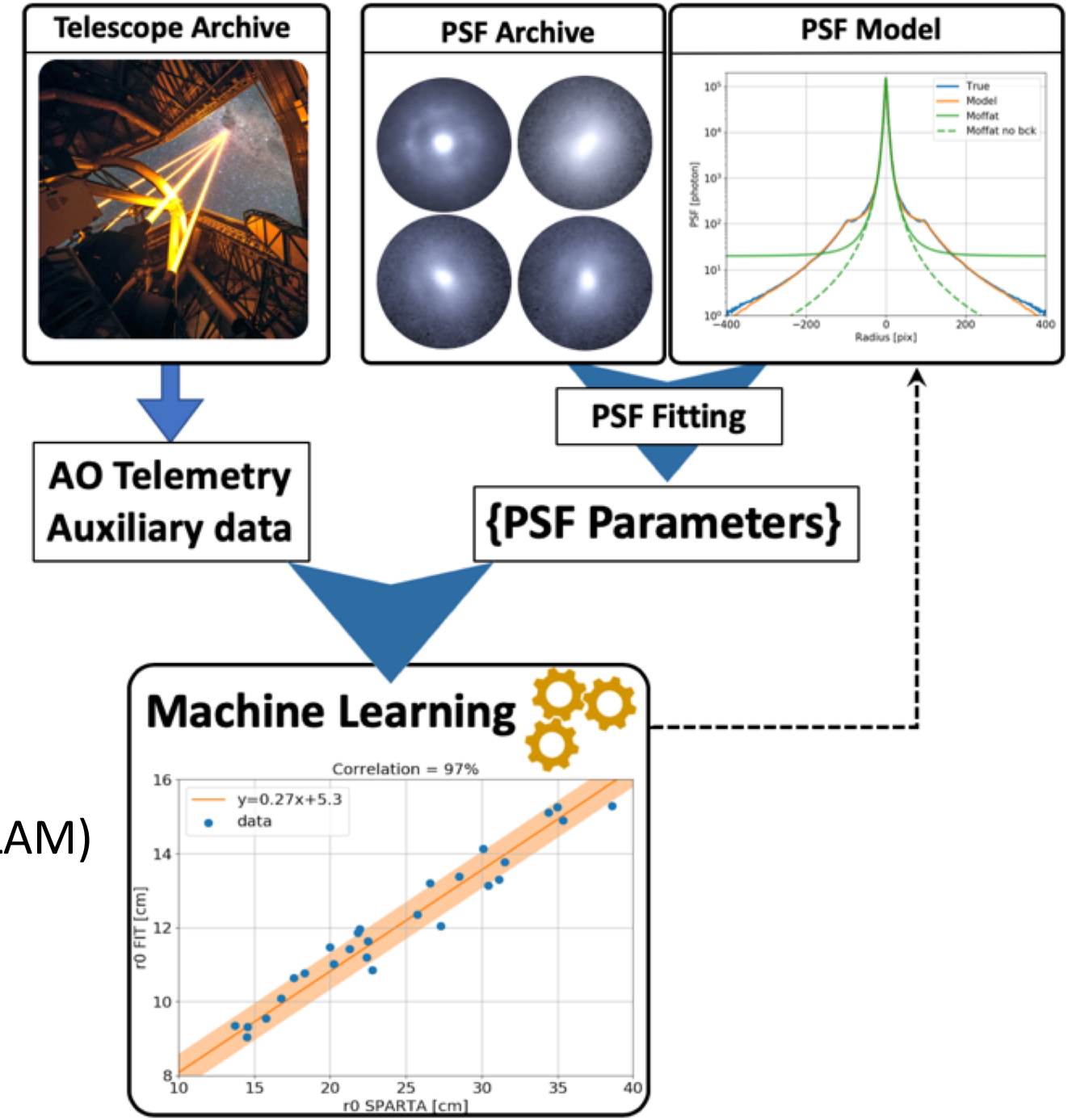
# Big Topics

**Can Machine learning bring something new in AO data processing ?**

e.g. Francois-Xavier Dupé (LIS)

Alavro Menduina (Oxford)

Neichel et al., Beltramo-Martin et al. (LAM)



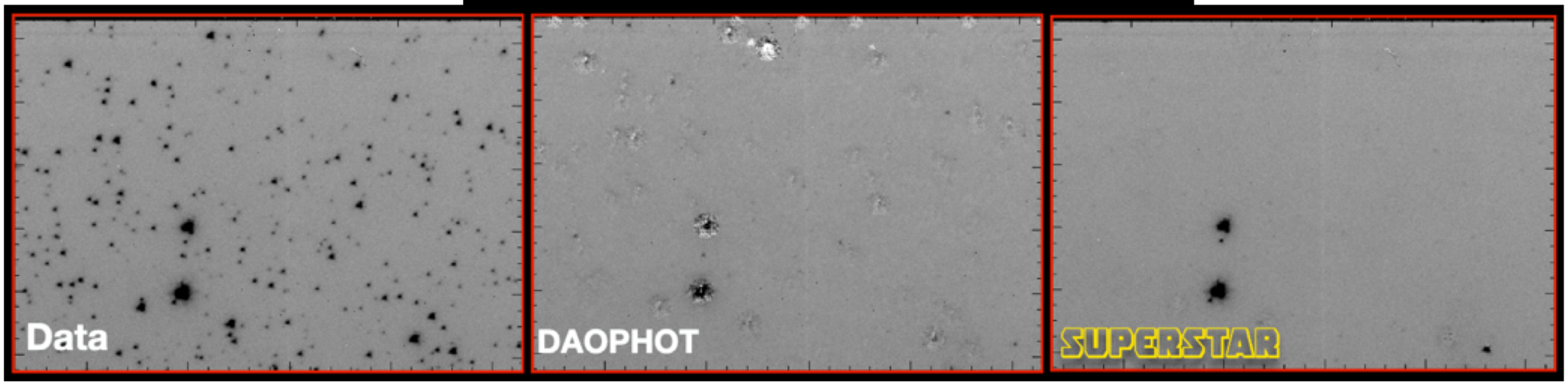
# Big Topics

New AO data processing tools available on the market

## A new software for astrometry and photometry in the AO era

**Antonino Marasco**
(Kapteyn Institute & ASTRON, Netherlands)

## SUPERSTAR



# Big Topics

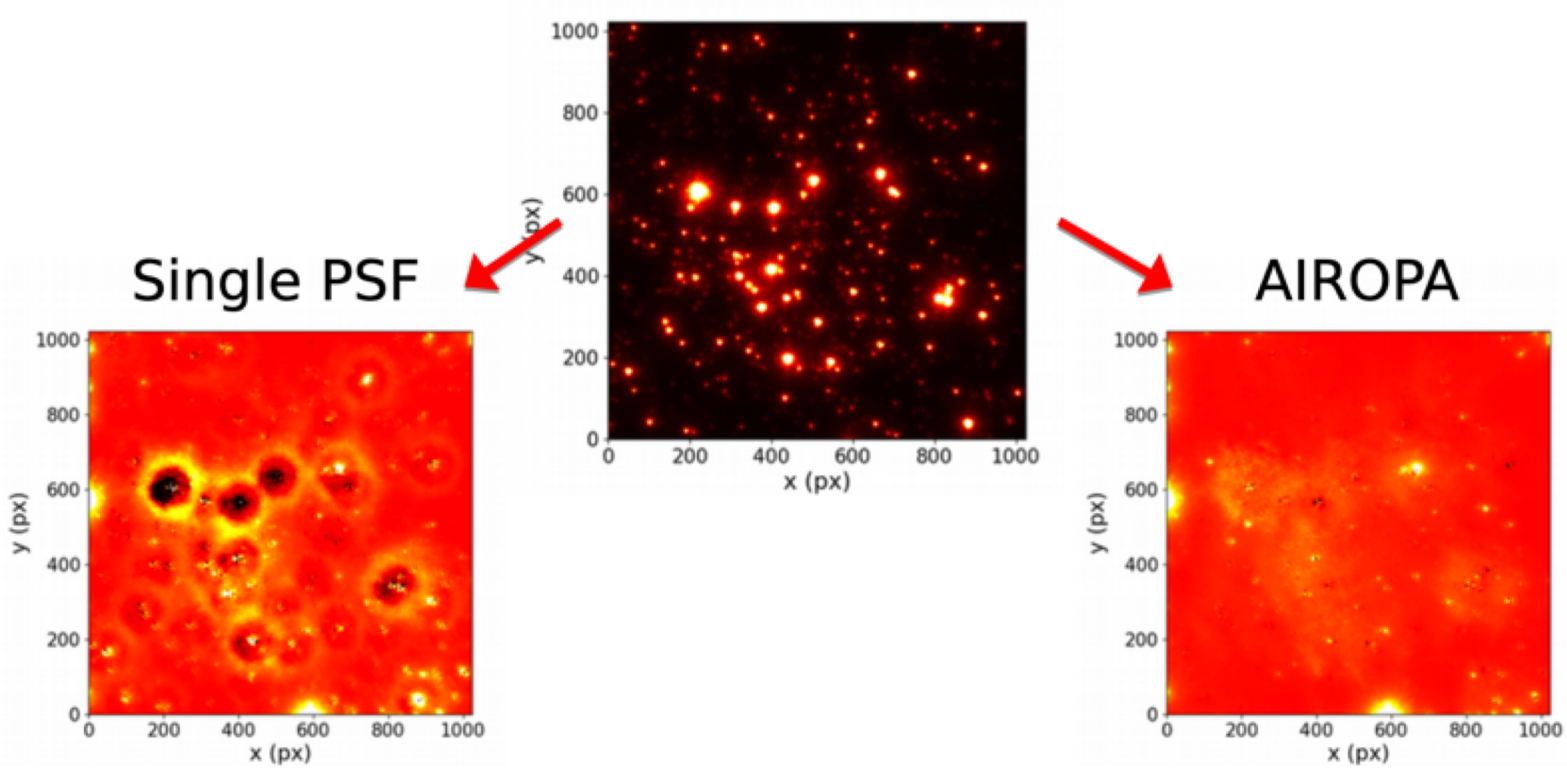
**New AO data processing tools available on the market**

P. Turri et al.

# AIROPA

## A PSF-reconstruction program for NIRC2

GALACTIC CENTER SIMULATION

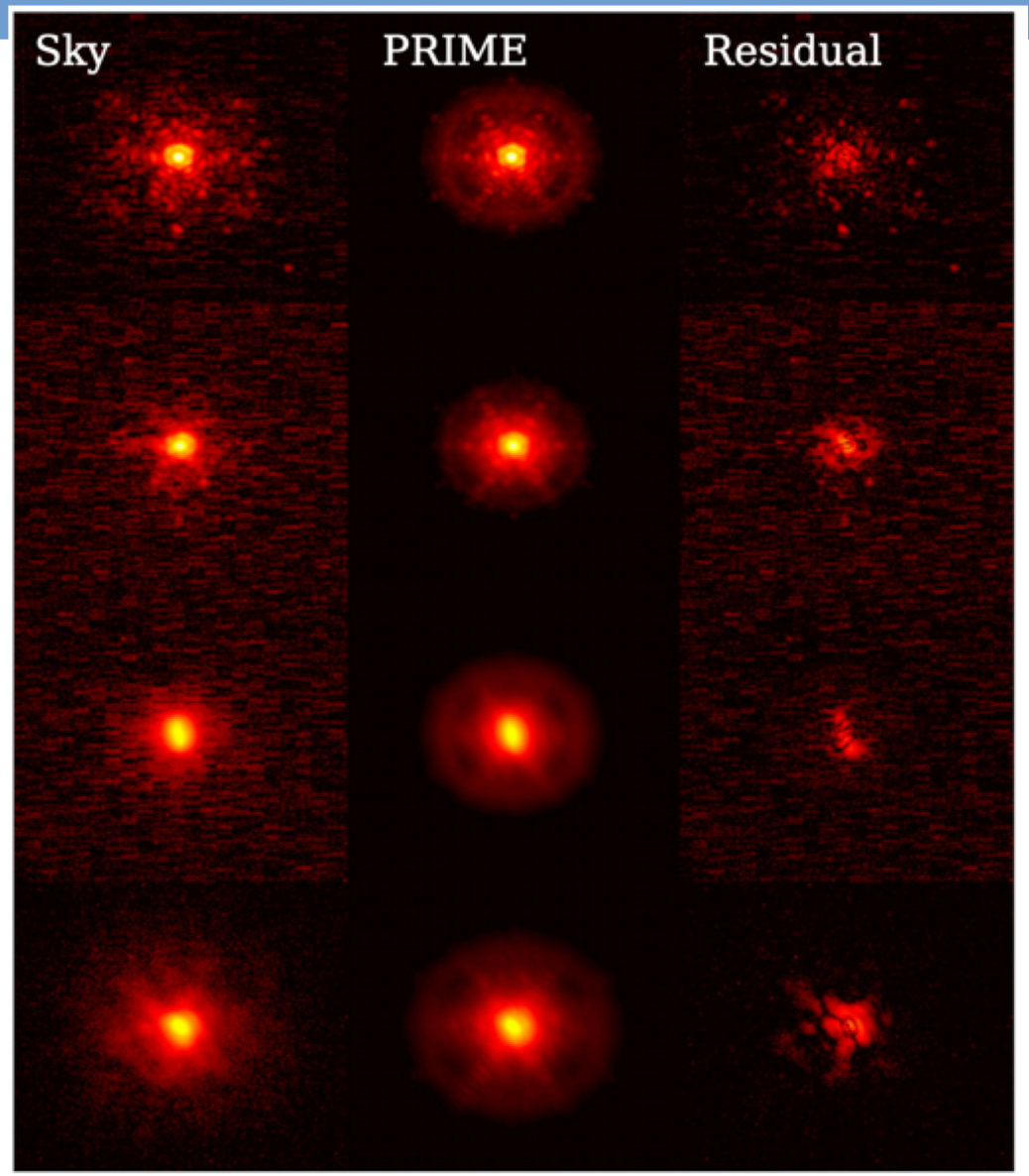


# Big Topics

**New AO data processing tools available on the market**

O. Beltramo-Martin et al.

## PSF reconstruction with PRIME



# Conclusions

- There is only 1 ELT, each photon counts !!
- AO data processing may not be as trivial as expected
- It is important to start thinking about optimized AO data processing today.