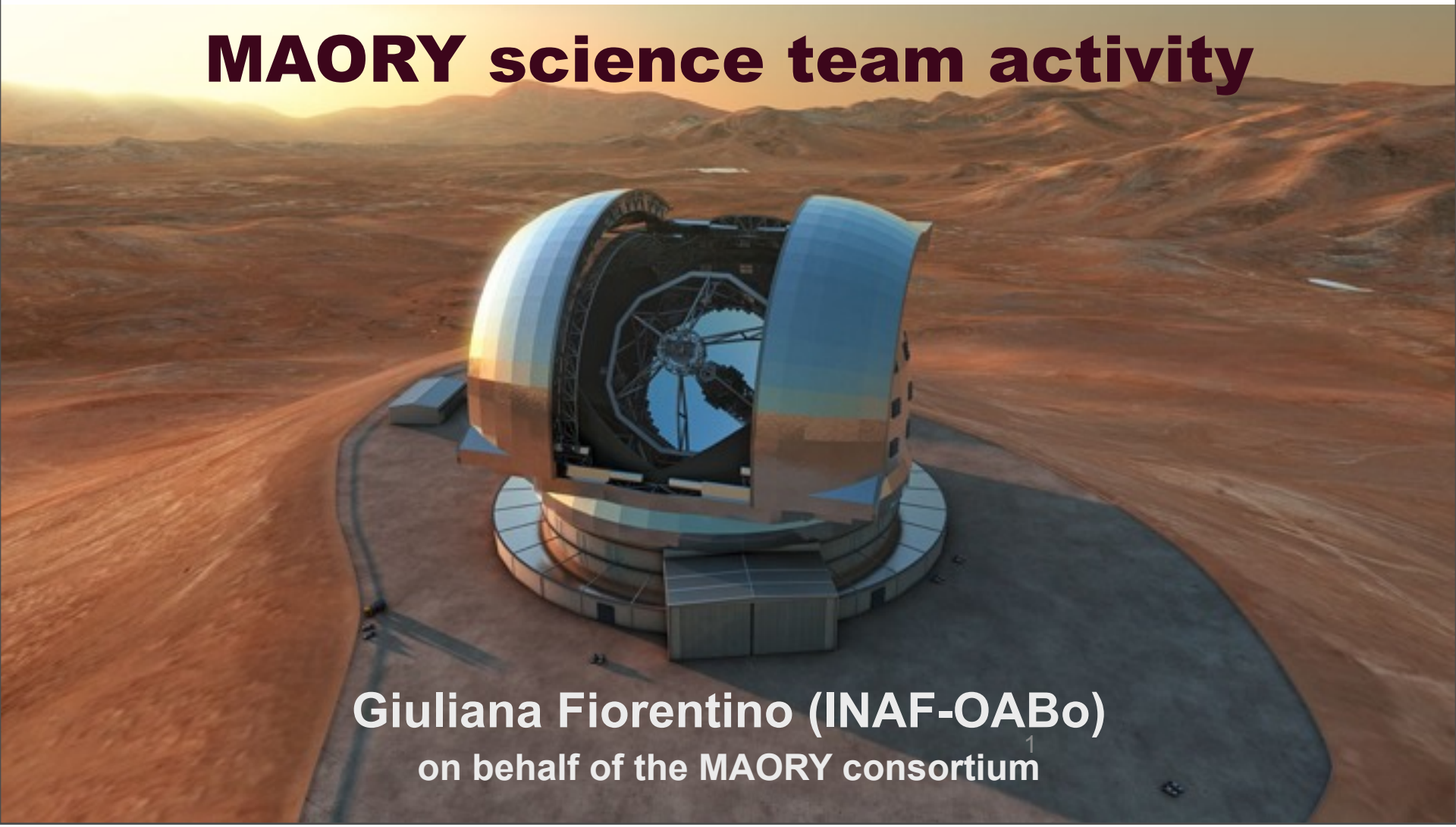
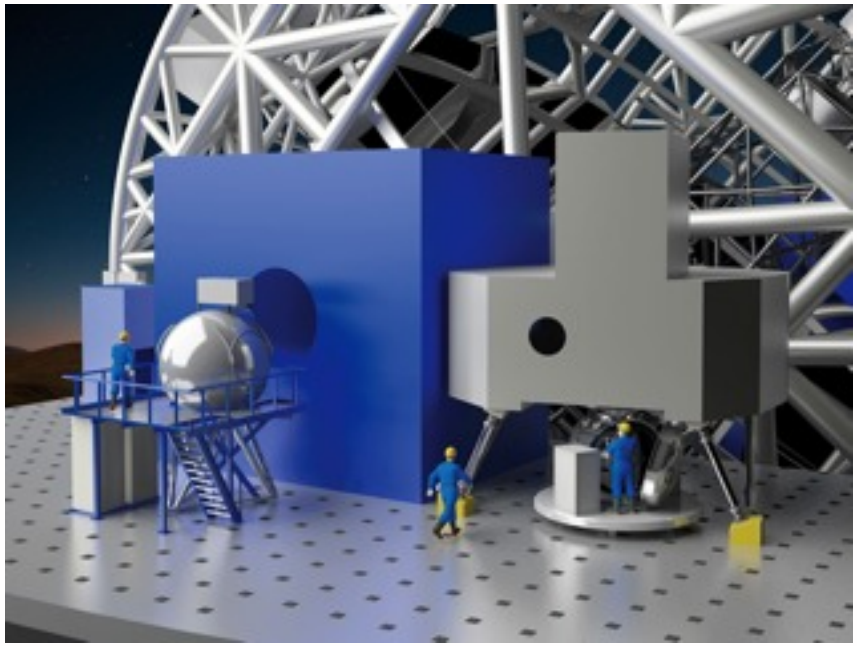
MAORY science team activity



Giuliana Fiorentino (INAF-OABo)
on behalf of the MAORY consortium

MAORY, the PROJECT
the first light AO module for E-ELT
providing a diffraction limit for a 39-m telescope



Designed and to be build by a consortium including several **INAF Institutes** (OA-Bo, IASF-Bo, OA-Arcetri, OAPd, OA-Na, OA-Brera)
+ INSU-IPAG-Grenoble

SCAO mode: high Strehl correction
Over a D~10" FoV with one bright NGS
(7≤V≤16)

MCAO mode: moderate but homogeneous
Strehl correction over a D~180" FoV with
3 NGS (H≤19) + 6 LGS

MAORY will feed the high resolution imager MICADO (that will include a spectrographic mode)

MAORY PI: Emiliano Diolaiti
MAORY PM: Paolo Ciliegi

The SCAO module is a joint project with MICADO consortium

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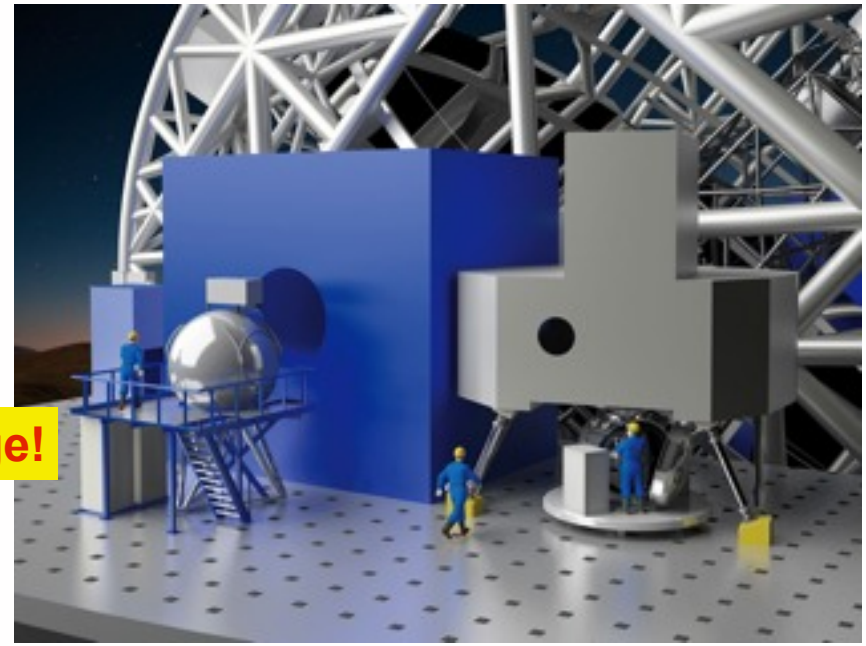

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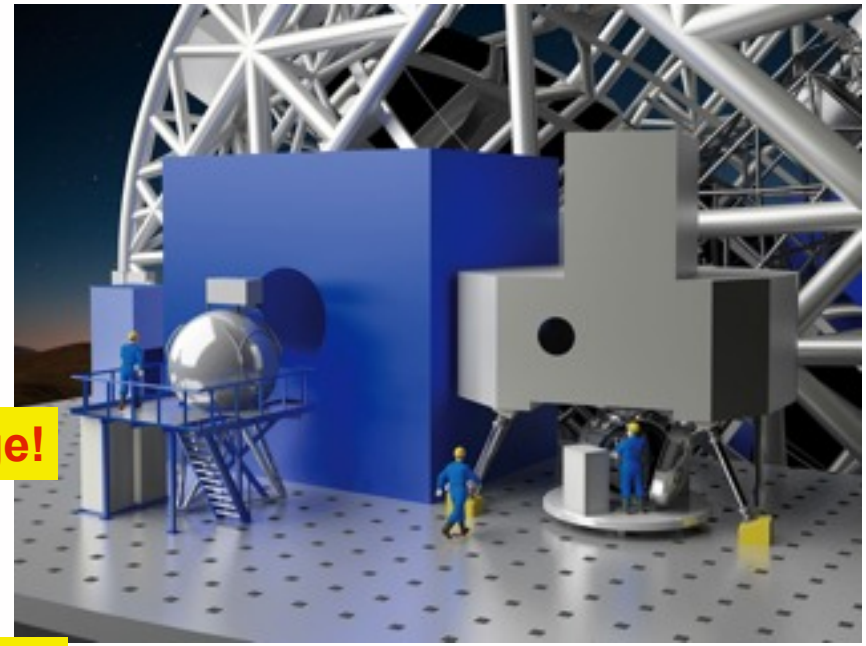

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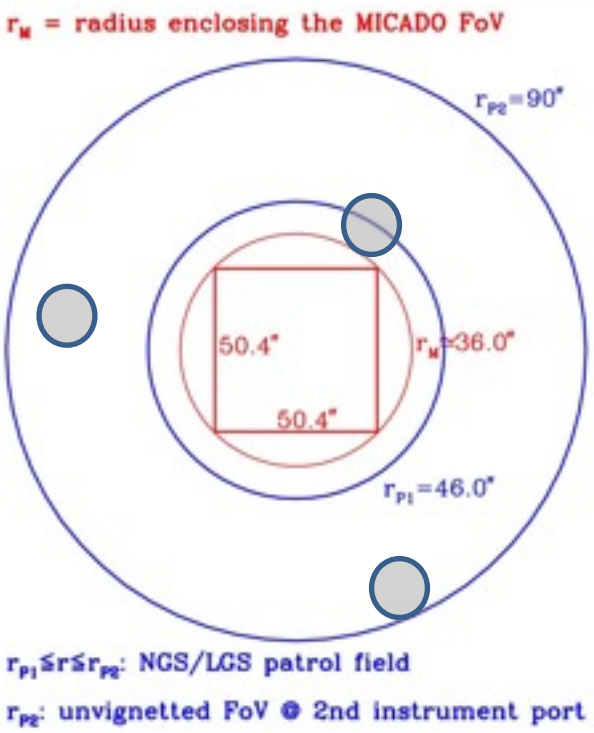
SC≥50% in everywhere, ~100% for b < 30˚

ELT Spatial Resolution: ~6 times better than JWST



λ [μm]	Diffraction limit FWHM θ_{diff} [mas]	Seeing FWHM [arcsec] (best seeing)	Seeing FWHM [arcsec] (median seeing)	Seeing FWHM [arcsec] (sub-optimal)
0.88	4.7	0.39	0.57	0.65
1.22	6.5	0.36	0.54	0.60
1.63	8.6	0.34	0.51	0.57
2.20	11.6	0.32	0.48	0.54

→ 0.6 pc @ D=10 Mpc

λ [μm]	Best seeing conditions 30° from zenith D = 20" FoV		Median conditions close to zenith D = 1' FoV		Sub-optimal conditions 30° from zenith D = 2' FoV	
	Reqs.	Goal	Reqs.	Goal	Reqs.	Goal
0.88	0.01	0.04	-	0.01	-	-
1.22	0.10	0.19	0.02	0.10	-	0.02
1.63	0.28	0.39	0.11	0.28	0.03	0.11
2.20	0.50	0.60	0.30	0.50	0.15	0.30

Table 2. Expected Strehl Ratio for some representative wavelengths in MCAO mode. All values are TBC.

5 mas = 0.005”
10 mas = 0.010”
50 mas = 0.050”

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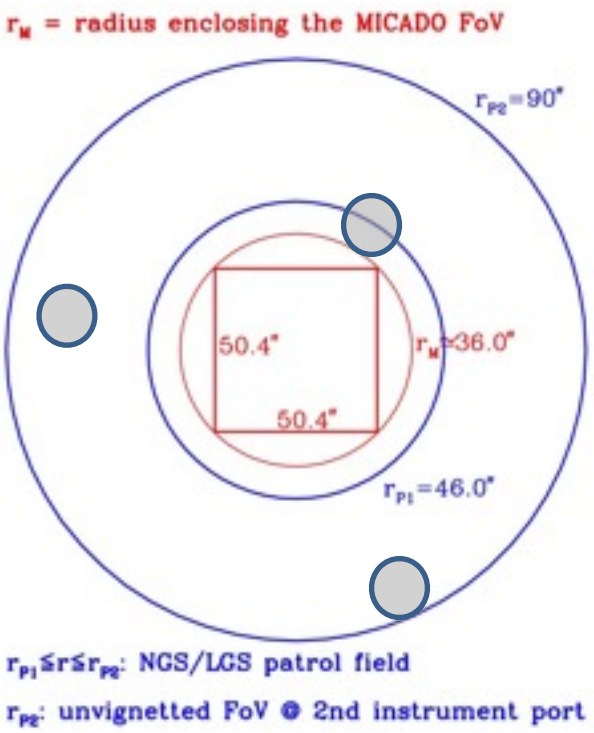

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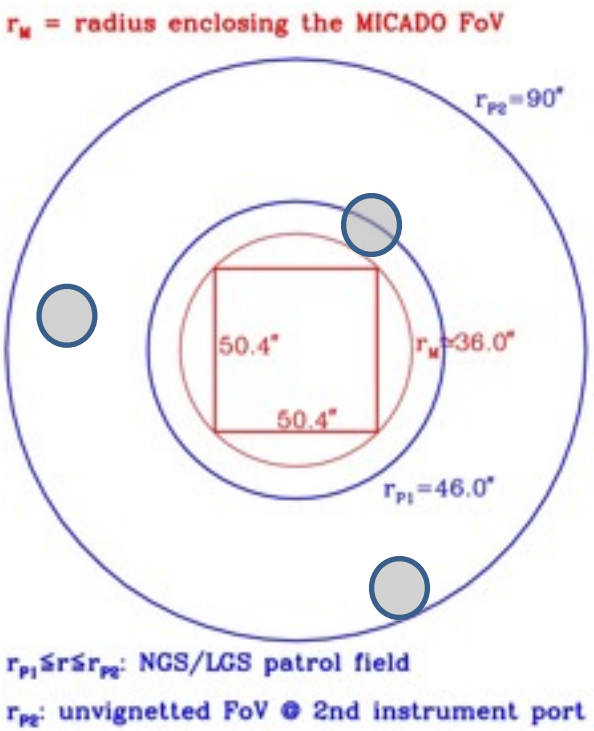

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1.22	6.5	JWST =38.7	0.54	0.60
1.63	8.6	JWST =51.7	0.51	0.57
2.20	11.6	JWST =69.8	0.48	0.54

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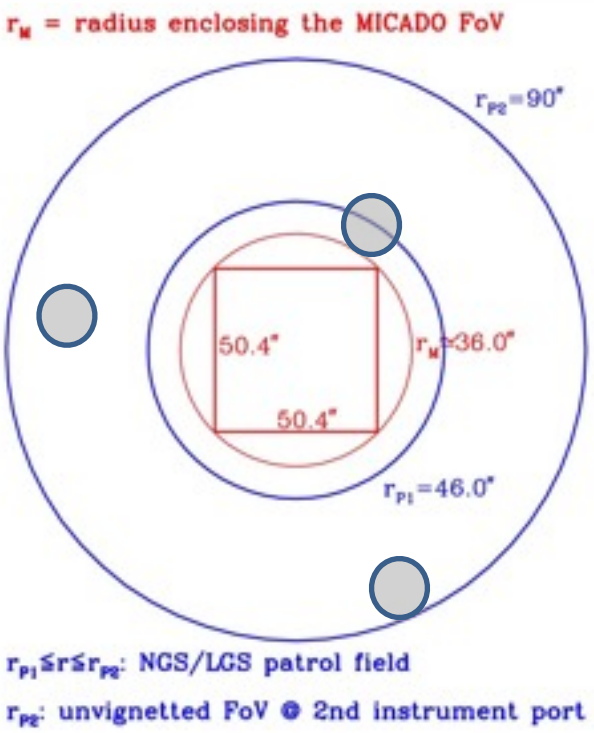

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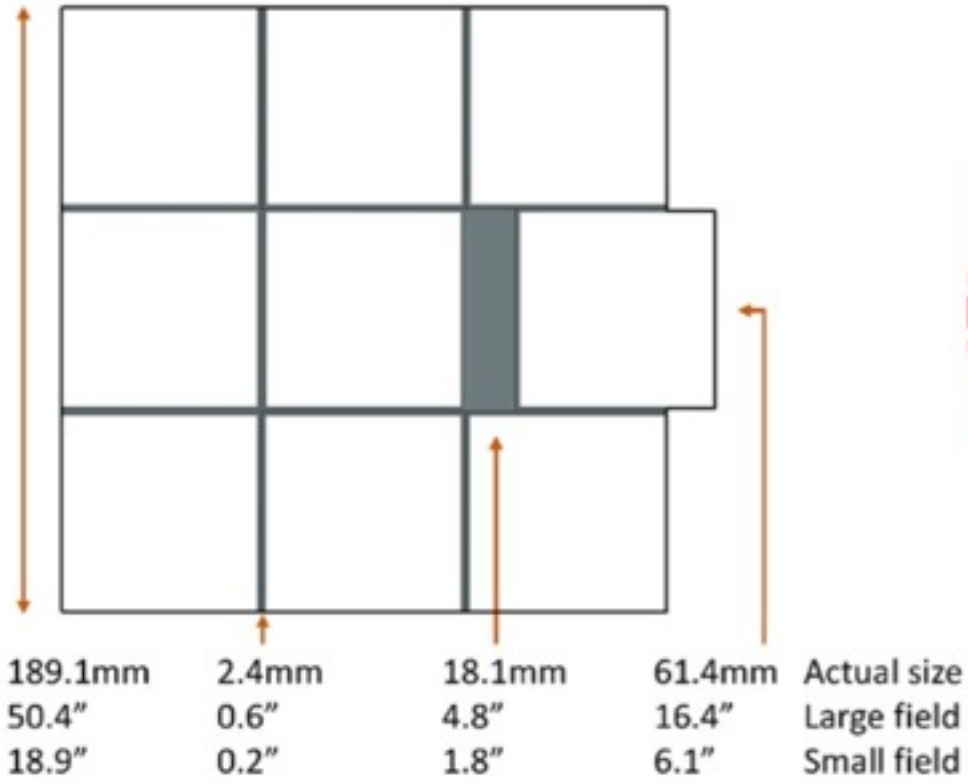
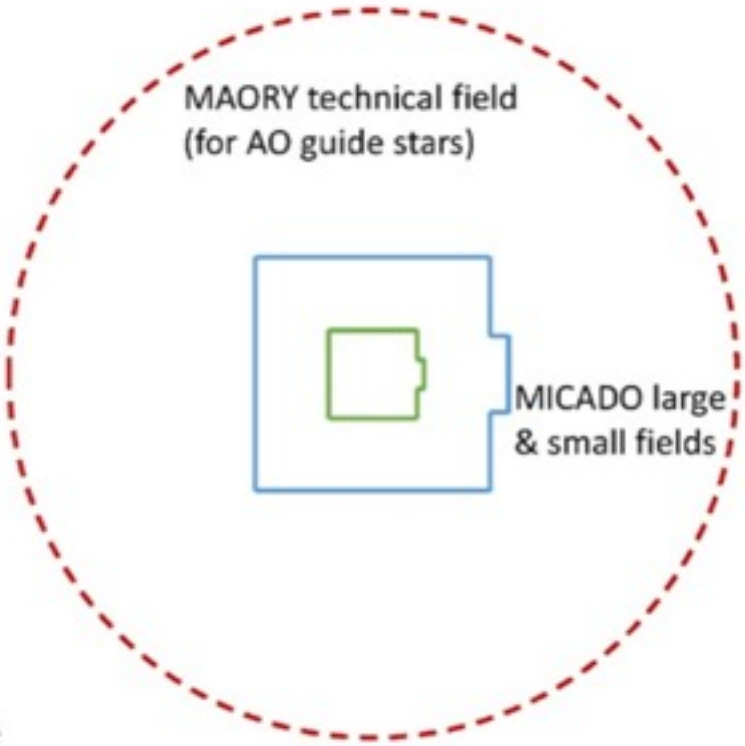
Feeding MICADO: the imager

from the MICADO Operational Concept Description



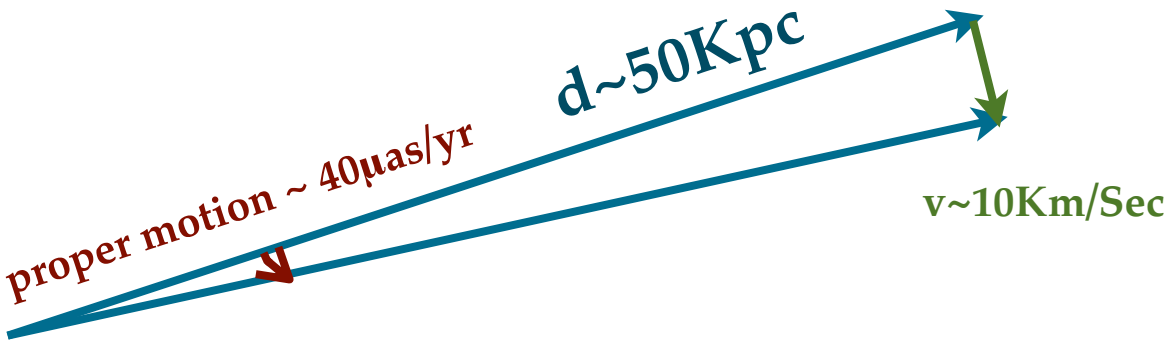


Large- Pixel Scale=4 mas/px Nyquist sampling H,K

Narrow- Pixel Scale=1.5 mas/px Nyquist sampling down to I

There is also a coronographic mode

Astrometric requirements for the E-ELT

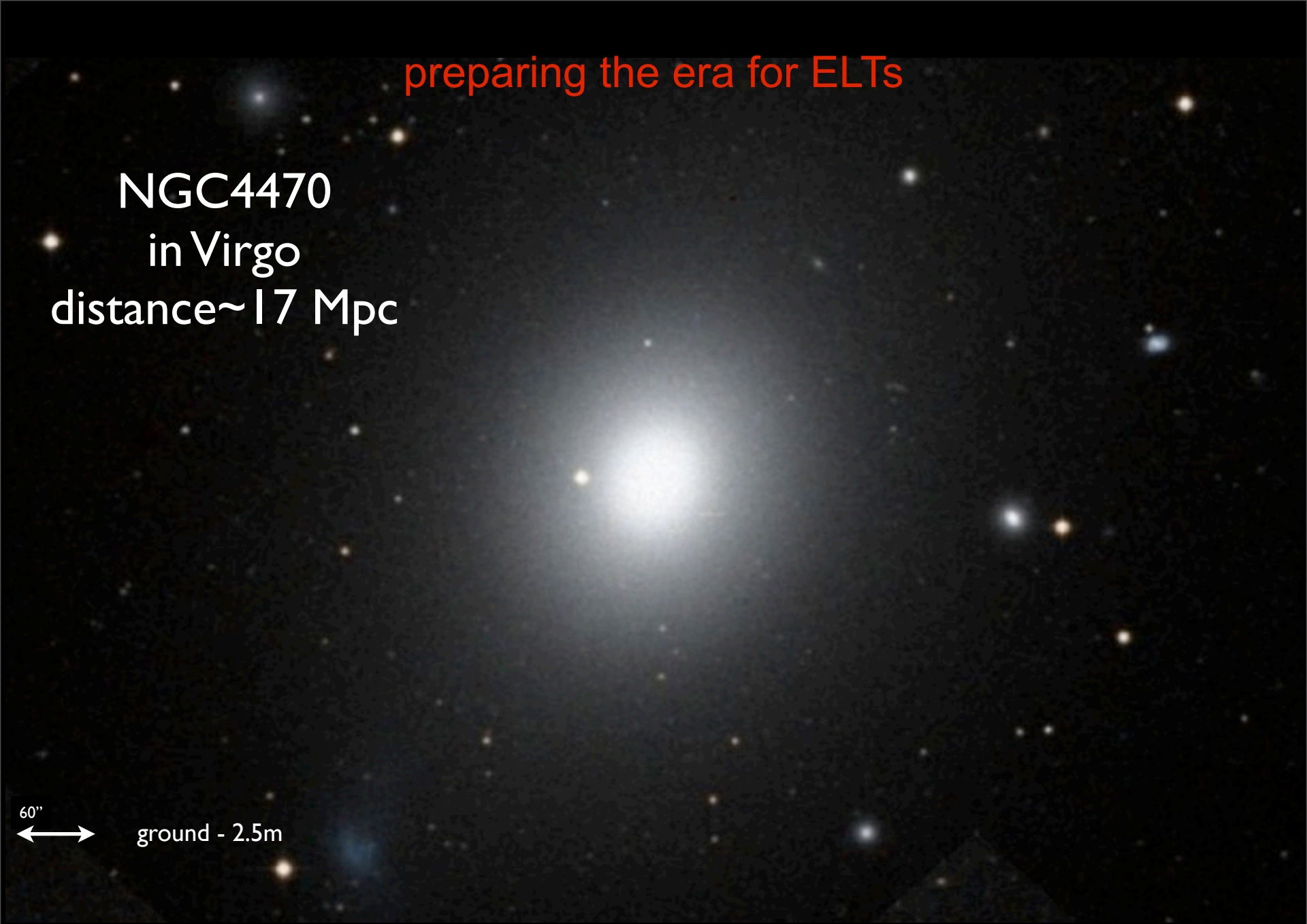


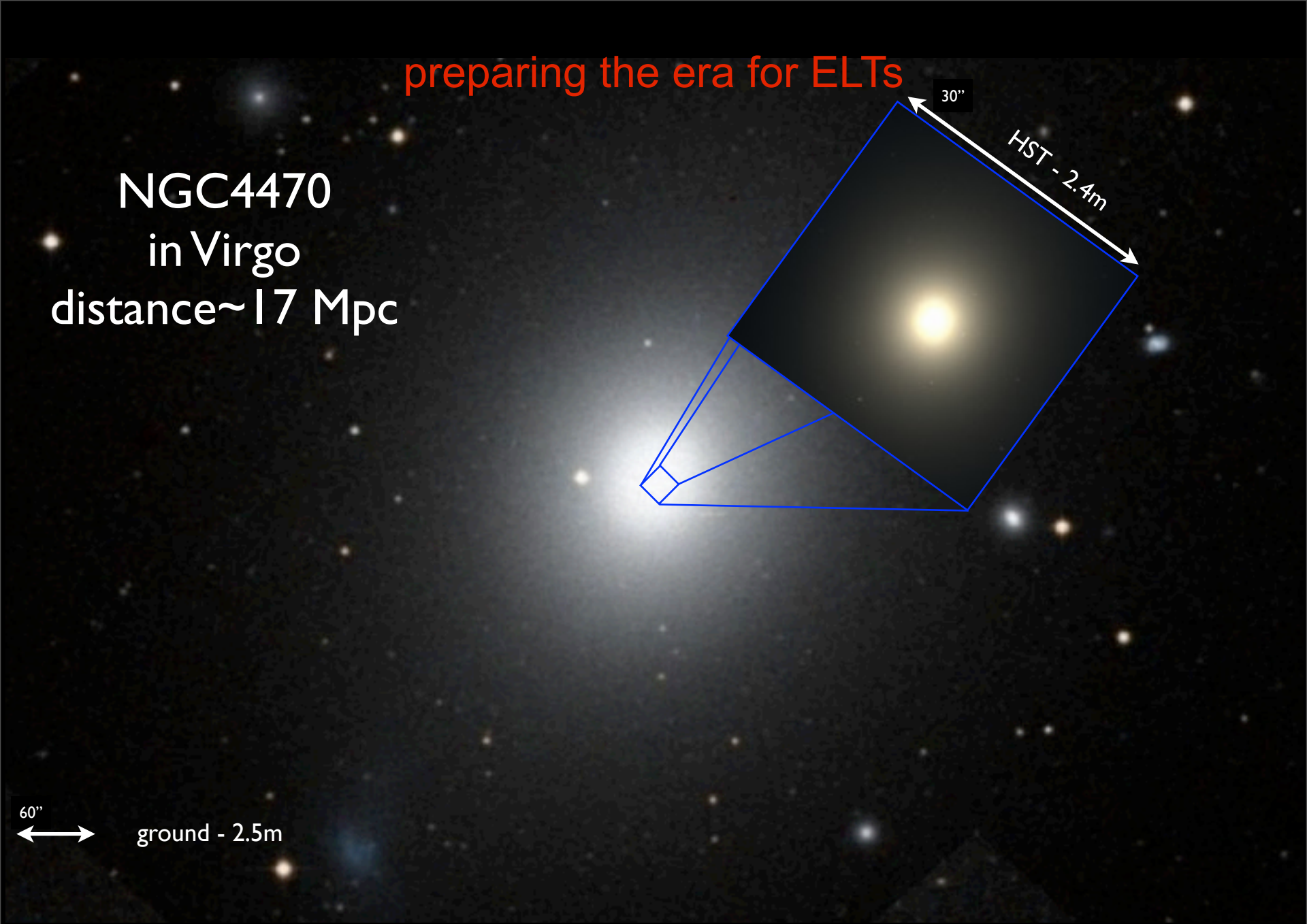
ASTROMETRY of internal proper motions in:
p.m. (mas/yr) = v(km/sec)/d (Kpc) * 0.206265

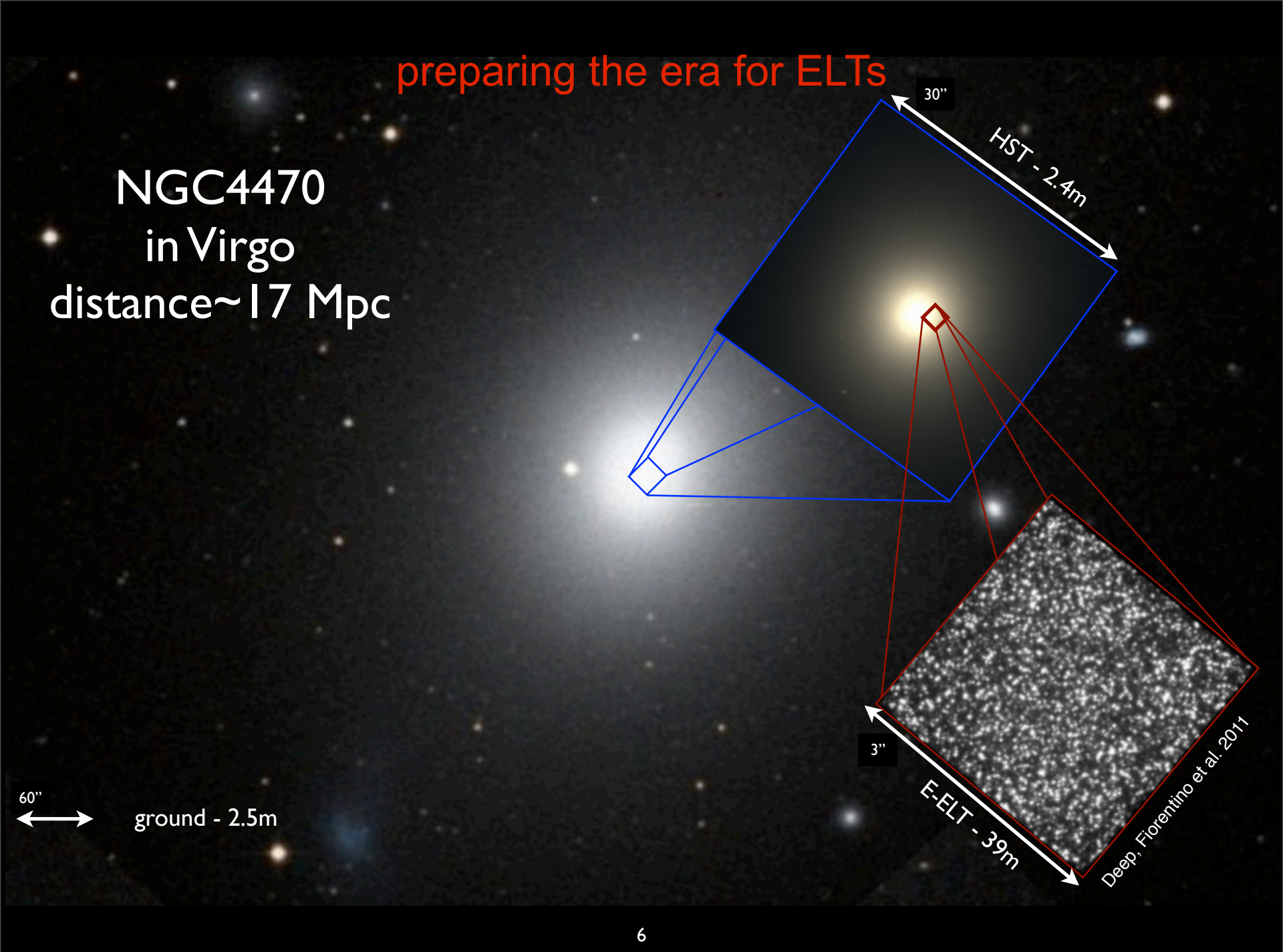
Globular clusters at 50Kpc and v~10Km/sec -> 40μas/yr, in 5 yr for a sample of > 100 stars the relative accuracy is **50 μas/(200 μas*√100) = 2%**

Dwarf galaxies at 1Mpc and v~10Km/sec -> 2μas/yr, in 10 yr for a sample of >100 stars, the relative accuracy is **50 μas/(20 μas*√100) = 20%**

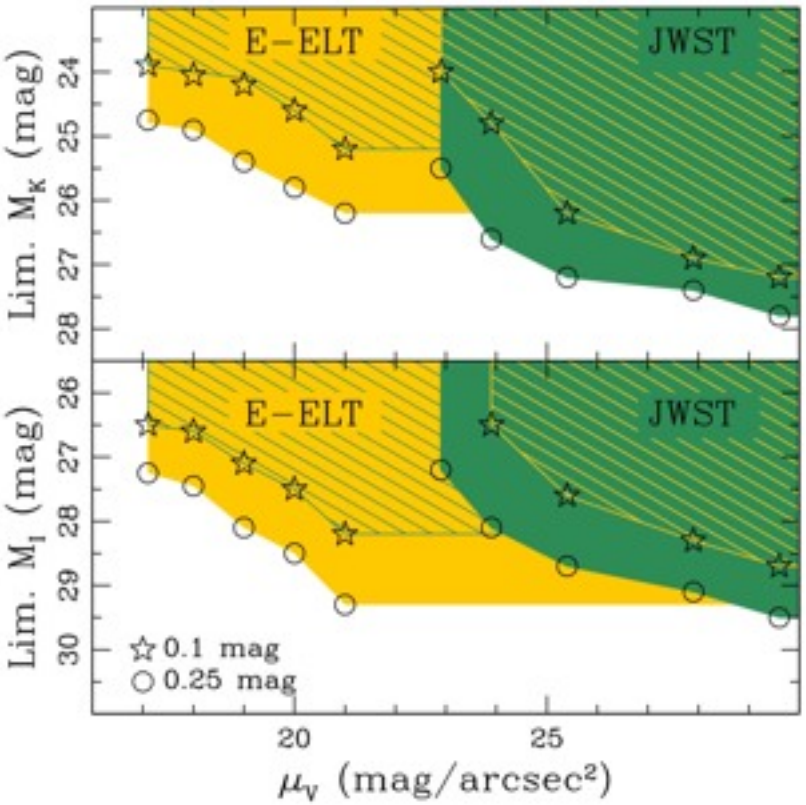
the requirement is an astrometric precision of 50 μas (goal 10 μas) on bright stars 20x20 MICADO FoV.

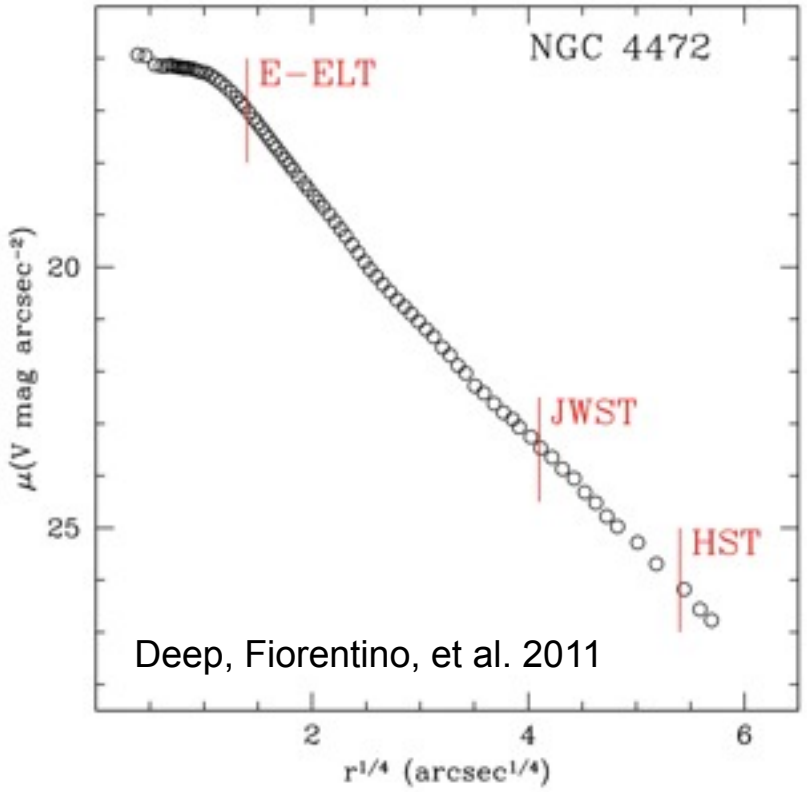

NGC4470
in Virgo
distance~17 Mpc
60”
ground - 2.5m


NGC4470
in Virgo
distance~17 Mpc
30”
HST - 2.4m
60”
ground - 2.5m


preparing the era for ELTs
NGC4470
in Virgo
distance~17 Mpc
30”
HST - 2.4m
3”
E-ELT - 39m
Deep, Fiorentino et al. 2011
60”
ground - 2.5m

Photometric requirements for the E-ELT into the crowd of ELLIPTICALs





Deep, Fiorentino, et al. 2011

PHOTOMETRY of Elliptical galaxies:

"The ultimate goal is to study the resolved stellar populations in giant elliptical galaxies, of which there is no example in the LG, and we have to look at Cen A to find the closest example of a peculiar elliptical. **However, the best place to look at the properties of a range of elliptical galaxy types is the Virgo cluster which contains thousands of large galaxies and tens of giant ellipticals of a range of size and position in the cluster.** Of particular interest are the crowded central regions of galaxies where most of the stellar mass lies."

The requirement is a photometric precision of few 0.01 mag over the full MICADO FoV.

MAORY Science Team

- Definition of MAORY+MICADO Science Cases
- Definition of the scientific drivers constraining MAORY (+MICADO) final design
- To provide support to the technical team in defining and fulfilling specifications
- To prepare the exploitation of the ELT GTO awarded to INAF for building MAORY: 54 E-ELT nights (MICADO +HARMONI)

Chair: M. Bellazzini (INAF-OA Bo)
Deputy: G. Fiorentino (INAF-OA Bo)

P. Ciliegi (INAF-OA Bo)
E. Maiorano (INAF-IASF Bo)
F. Mannucci (INAF-OA Arcetri)
M. Mapelli (INAF-OA Pd)
P. Saracco (INAF-OA Brera)
M. Spavone (INAF –OA Na)
S. Douté (IPAG)
G. Chauvin (IPAG)

TB extended!!

Started activity in phase B, kick off February 2, 2016 (2 meetings so far)

MAORY Science Cases: assembling the MAORY SC book

Programme: E-ELT

Project: ELT MCAO Construction – MAORY

MAORY Science Case Template

1.1 Title of the case

Authors: *names*

Brief description of science case: *[one page maximum]*

MICADO Pixel Scale / FoV: *1.5mas/px and 20arcsec FoV or 4mas/px and 53arcsec FoV*

MICADO Spectral set-up:

Filters required: *and brief justification*

Estimate Survey Area/Sample Size/ Number of Images/Epochs:

Average Integration time per image (magnitude of targets; S/N required):

Observation requirements: *dithering patterns, how important is precise positioning, rotation, scale stability?Non-sidereal tracking*

Strehl or EE required: *what drives this requirement*

Image Stability Required: *what drives this requirement*

Astrometric Accuracy:

SCAO vs. MCAO:

Comparison with JWST or other facilities: *specify the advantage of using MAORY+ MICADO/HARMONI*

Synergies with other facilities (4MOST/MOONS, LSST/ALMA/HARMONI/METIS, HIRES/MOSAIC), but also VLT or other smaller telescope instruments: are additional data required or desirable, if so from which facility. Are preparatory observations needed?

Simulations made/needed to verify science case or feasibility:

Origin of the targets: catalogs / *observations still to be performed, etc*

NGS: *availability, average surface density, etc.*

Acquisition: *how precise pointing is required? Can the pointing be verified with a finding chart?*

Calibrations: *'Standard' or something more; day-time vs. night-time; flat-fields; standard stars or star fields; astrometric; at what level do image distortions matter; are there calibrators in the field? Or might you need calibrators in other fields (this might motivate the need for fainter standard fields than are currently available. How accurate is photometry and astrometry required (be clear if this is absolute or relative).*

Data Processing Requirements: *detailed PSF knowledge? Special issues/requirements? What are the desired final data products as starting point for the scientific analysis? Including the crucial metadata.*

MAORY Science Cases: assembling the MAORY SC book

MAORY Science Cases: assembling the MAORY SC book
Take what you need:

24 ‘resolved’ 18 ‘unresolved’

1 Osservatorio di Torino
2 Osservatorio di Brera
3 IASF Milano
4 Osservatorio di Padova
5 Osservatorio di Trieste
6 Osservatorio di Bologna
7 IRA Bologna
8 IASF Bologna
9 Osservatorio di Arcetri (FI)
10 Osservatorio di Teramo
11 Osservatorio di Roma
12 IAPS Roma
13 Osservatorio di Capodimonte (NA)
14 Osservatorio di Cagliari
15 Osservatorio di Palermo
16 IASF Palermo
17 Osservatorio di Catania

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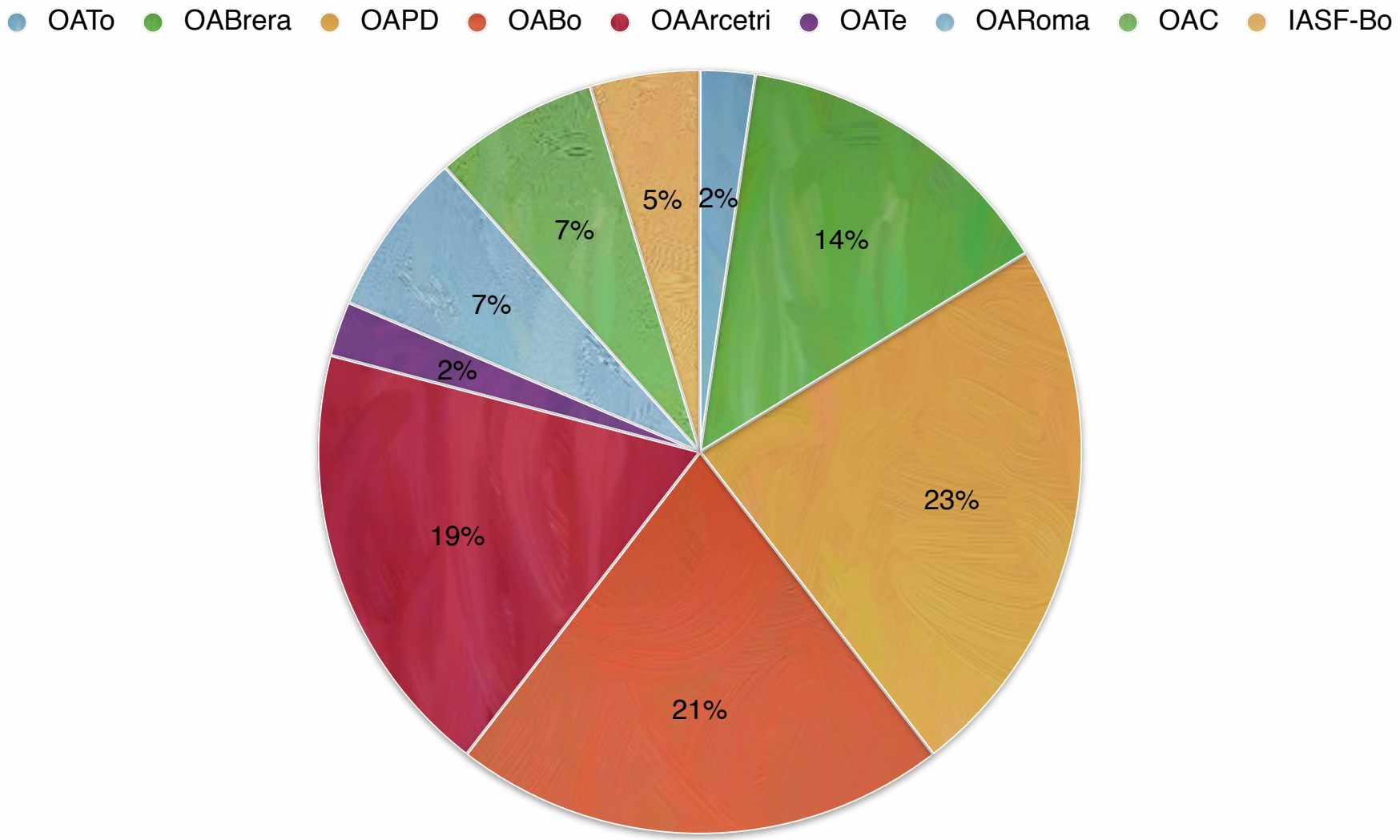
Collected MAORY Science Cases



9/17 INAF Institutes so far replied to the MAORY SC call

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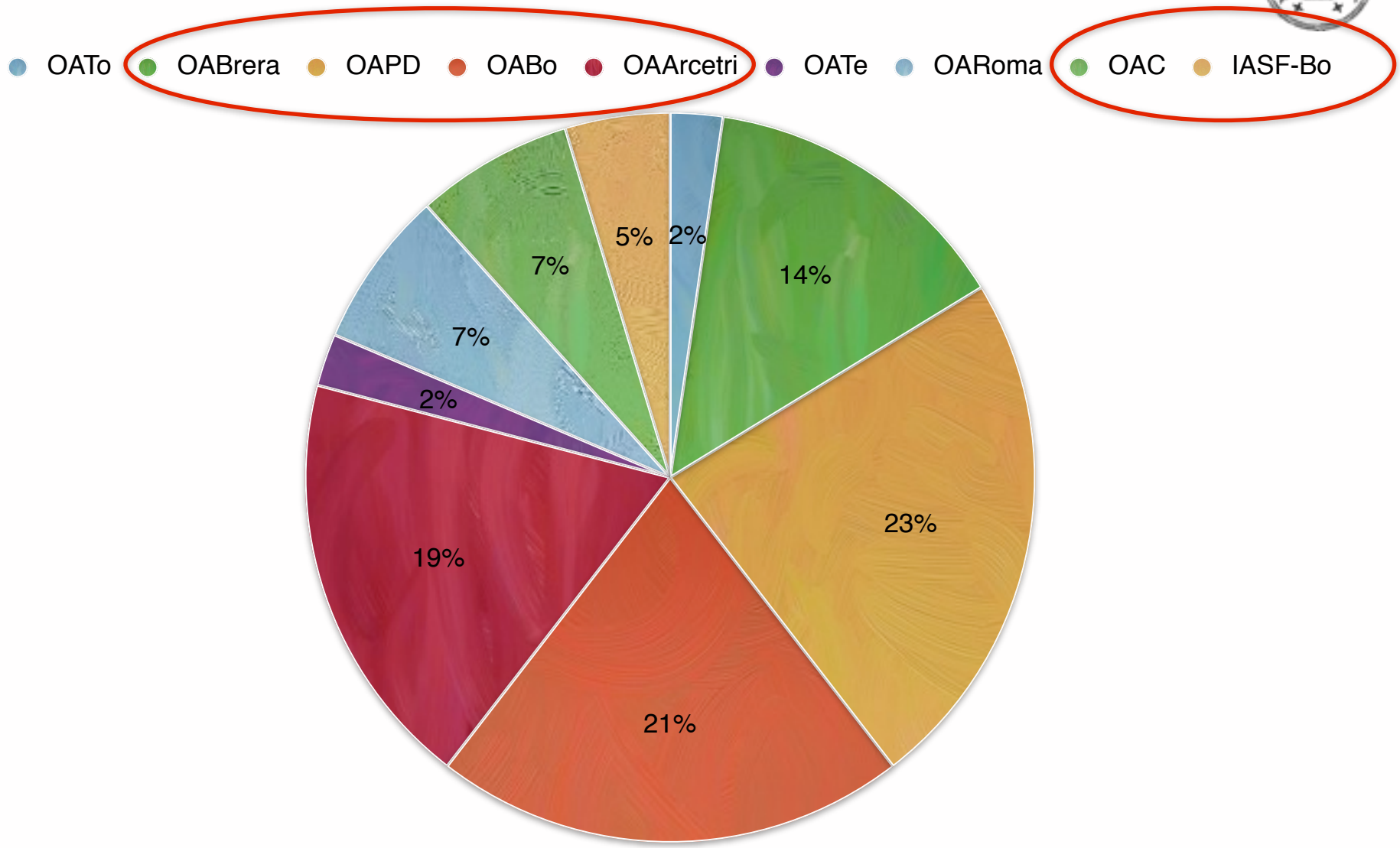

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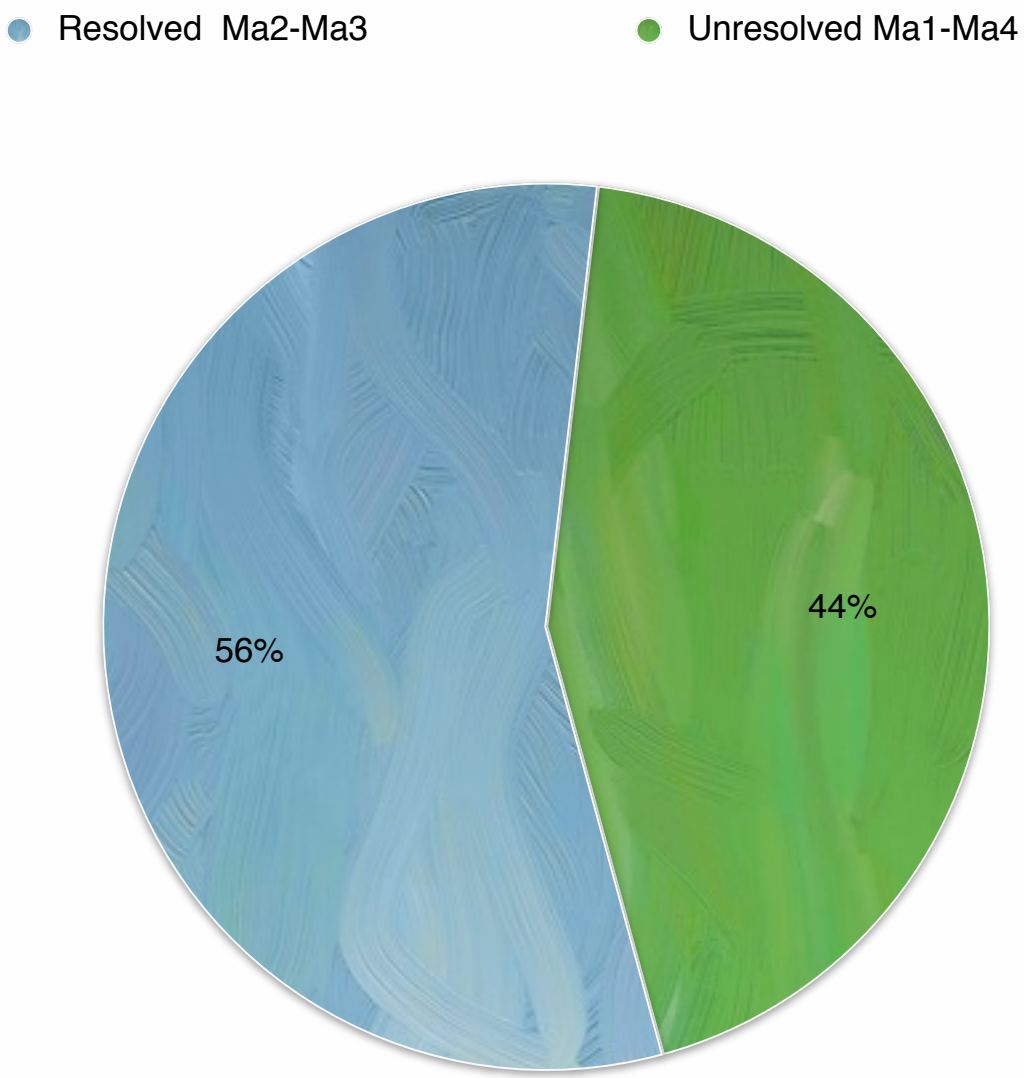
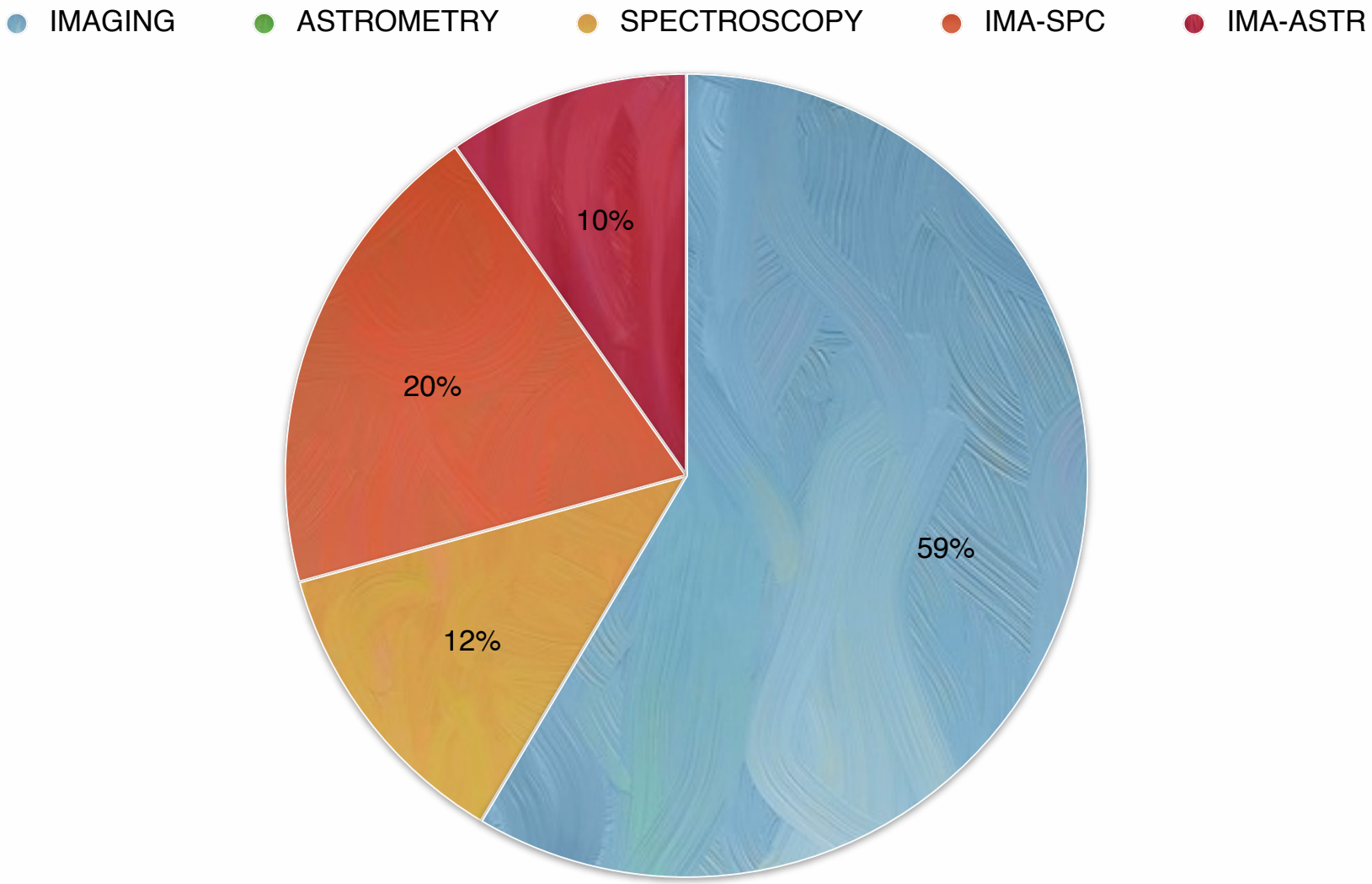


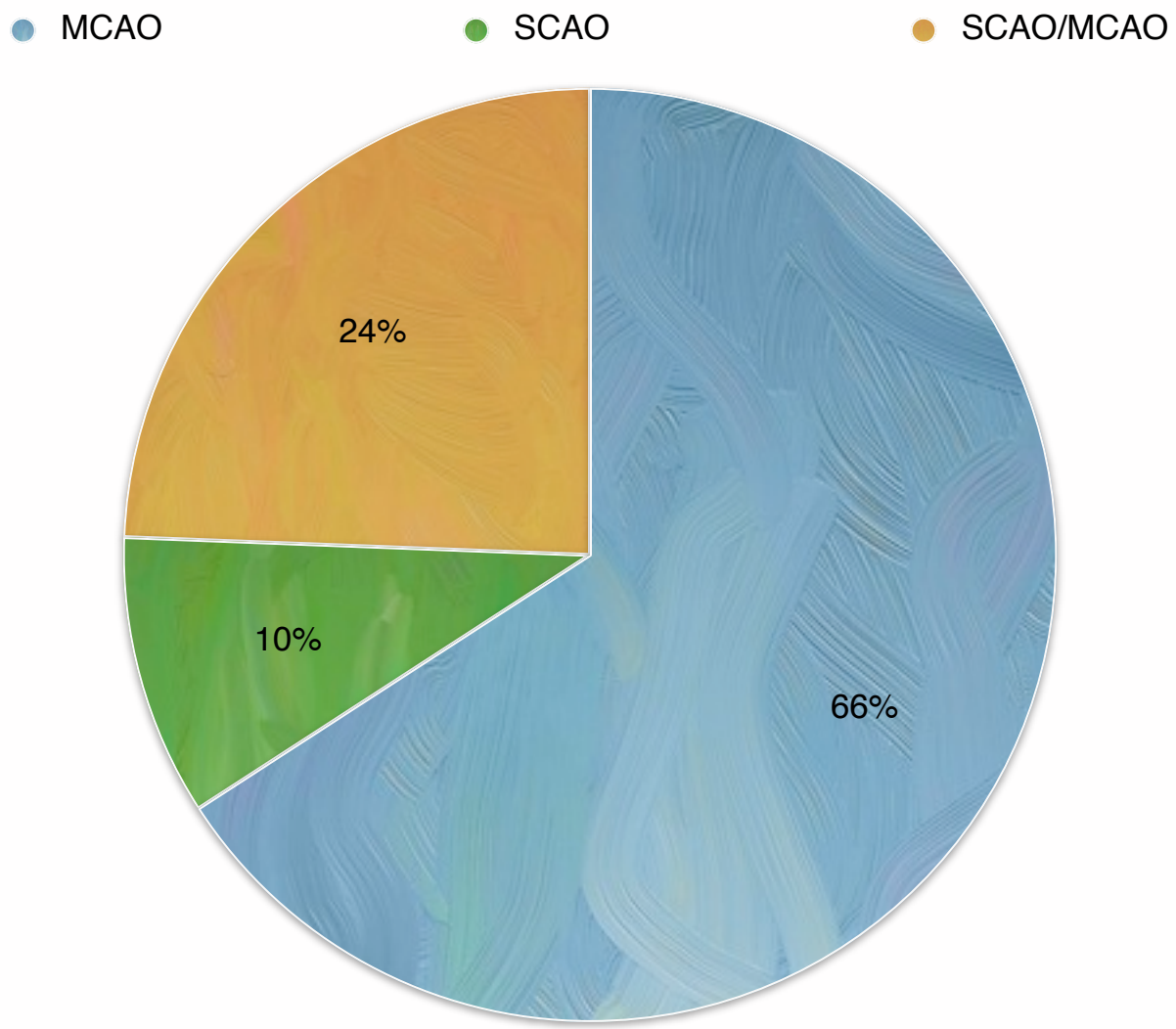
more science cases are likely to be collected...

Required MAORY observing modes



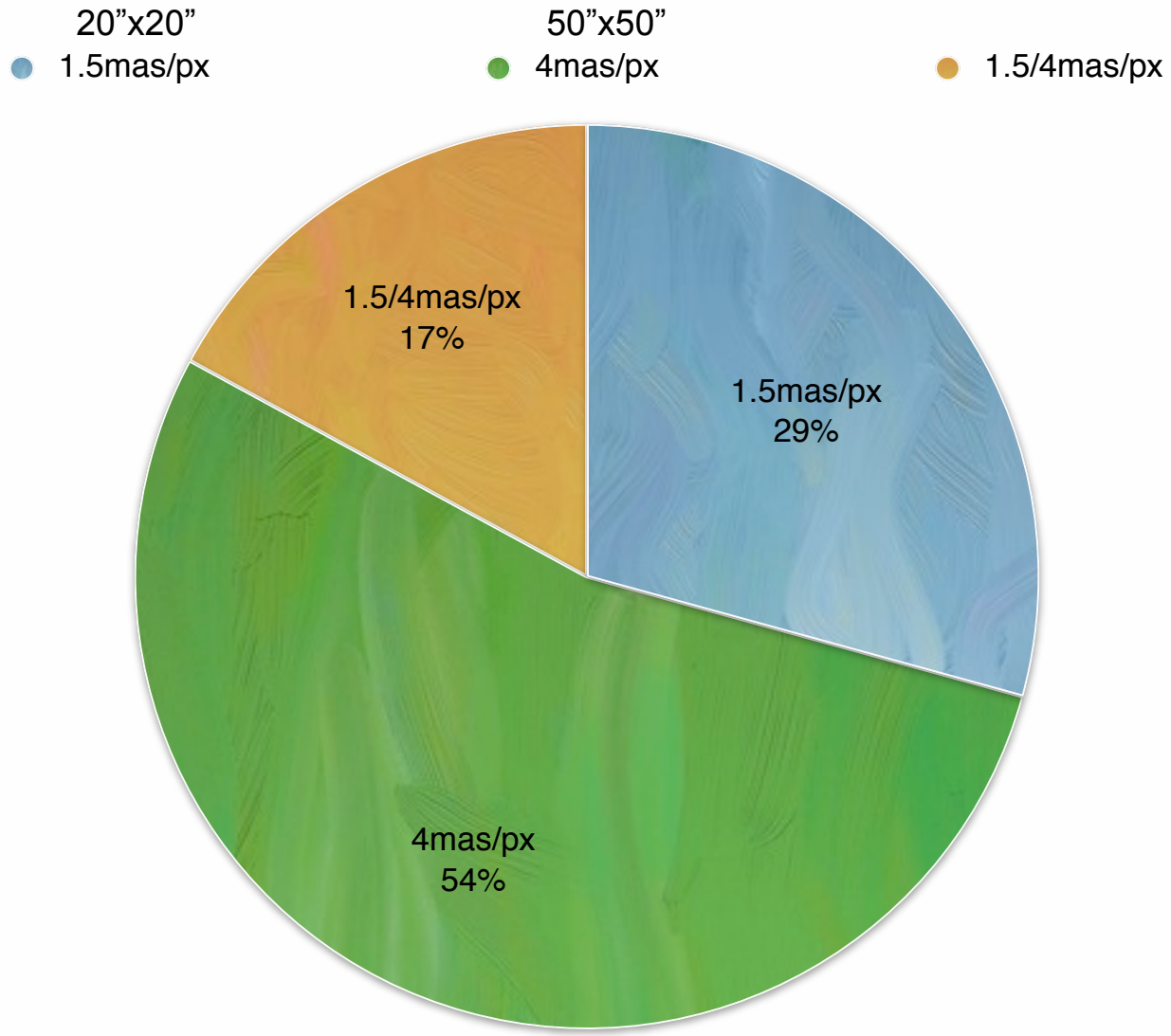
so far MAORY SC mainly require the imaging mode

Required AO observing modes



so far MAORY SC mainly require the imaging mode

Required FoV/ Pixel scale



so far MAORY SC mainly require the imaging mode

Focus on resolved stellar populations

Young stars

- Jets characterization and disk/accretion interaction (narrow band photometry)
- Search for proto-planets (≥ 1 M_{Jup}) in proto-planetary disks (photometry)

Compact star clusters within our galaxy

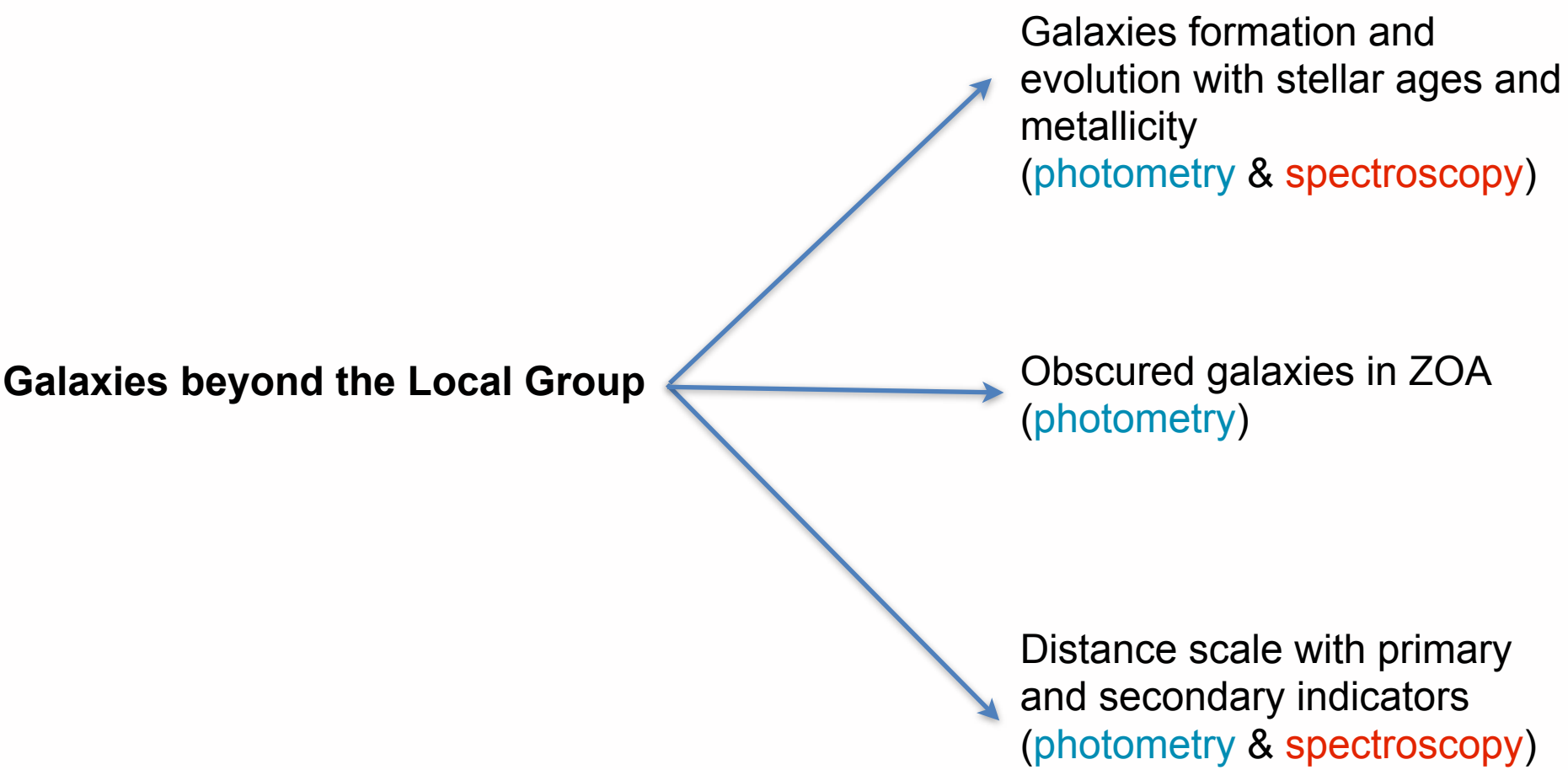
- dark matter content of old and young clusters (astrometry & photometry)
- origin of multi pop in GCs (astrometry & photometry)
- Bulge formation and evolution (photometry)

Focus on resolved stellar populations

Compact star clusters beyond the MW

- Nuclear Star Clusters in 30 Doradus (astrometry & photometry)
- Nuclear Star Clusters beyond the Local Group (photometry & spectroscopy)
- GCs as age and metallicity stellar tracers (photometry & spectroscopy)
- IMF in low metallicity environments (photometry)
- Star Formation in merged galaxies (photometry)

Focus on resolved stellar populations



next steps...

- Interaction with PI-s in particular to help with the technical form and to suggest possible merge;
- Detailed simulations (SCAO PSFs are already available, MCAO coming soon), so far are mainly based on Phase-A study;
- next meeting within autumn 2017;
- White book assembling, authorship will be recognized and properly advertised (on astro-ph);
- February 2 2018, end of Phase-B activity.

Thanks!