

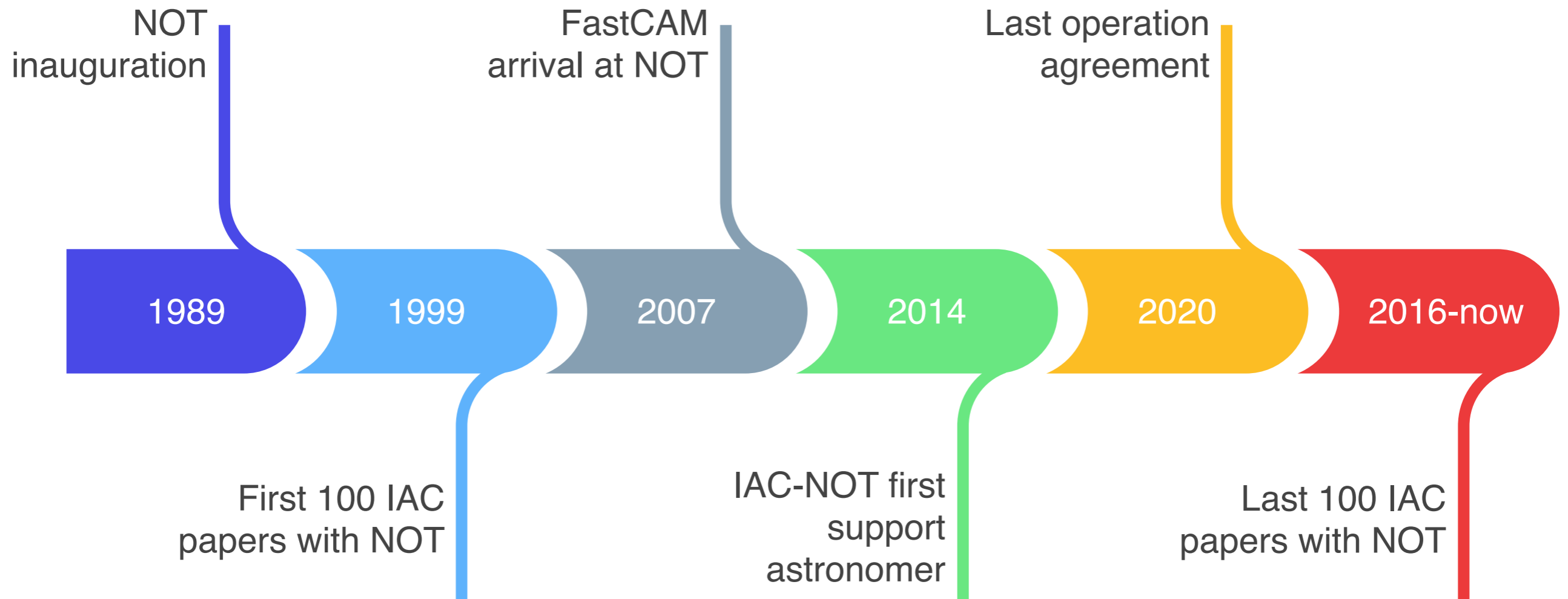
Past, present and future of NOT from the IAC perspective



Jesús Falcón Barroso

NOT - a telescope for the future
La Palma, 7-9 June 2022

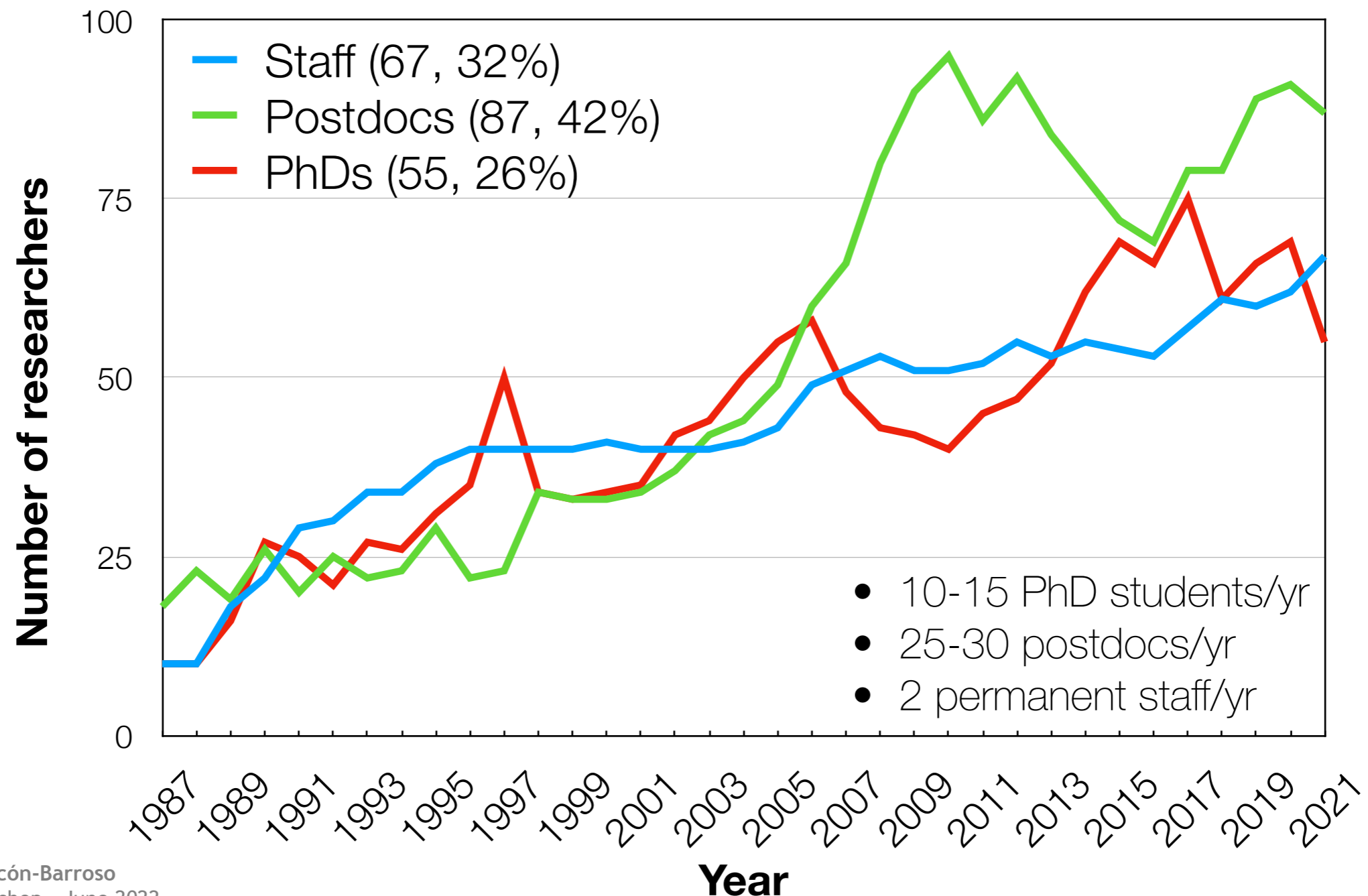
A long journey together ...



The IAC scientific community

The IAC scientific community

- +200 scientists at all career stages (PhDs, PDs, Staff)
- IAC represents ~25% of the entire Spanish astro community



IAC Scientific Programme

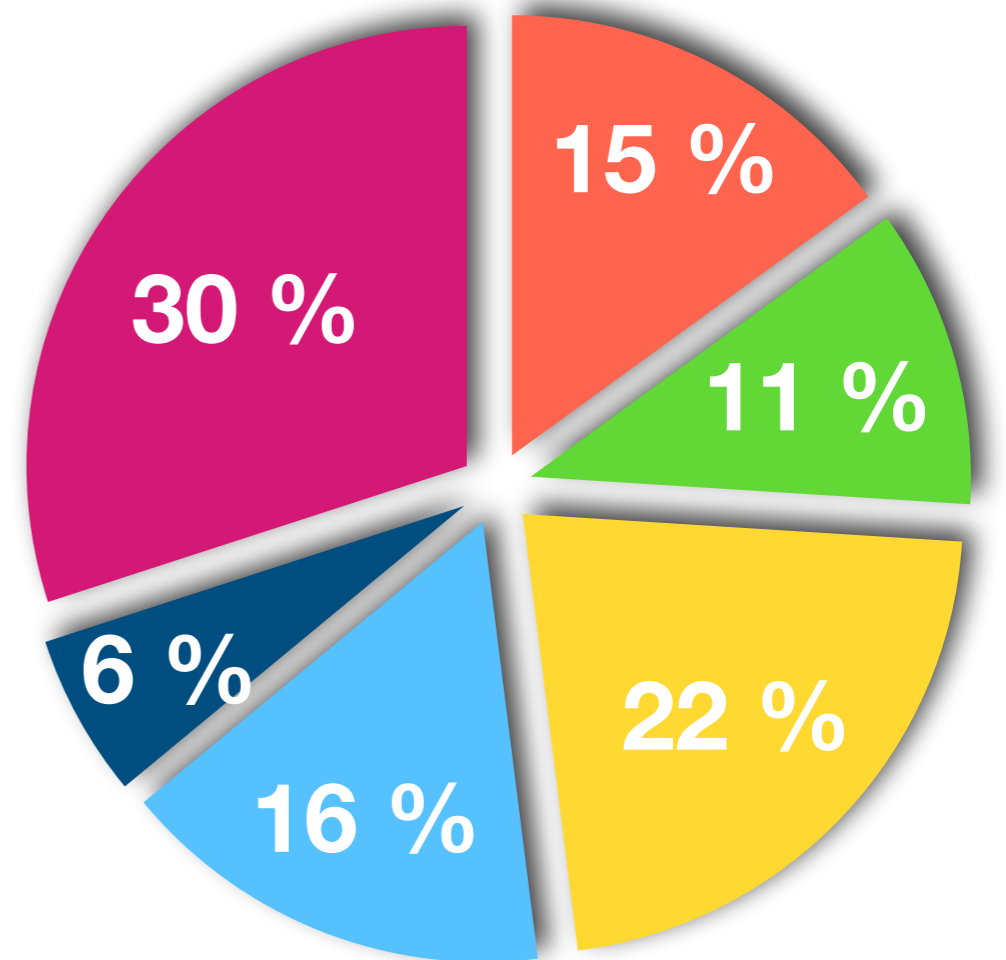


- Wide range of scientific interests
- 6 driving research lines
- Organised in 37 research groups
- Supported by the Severo Ochoa excellence program

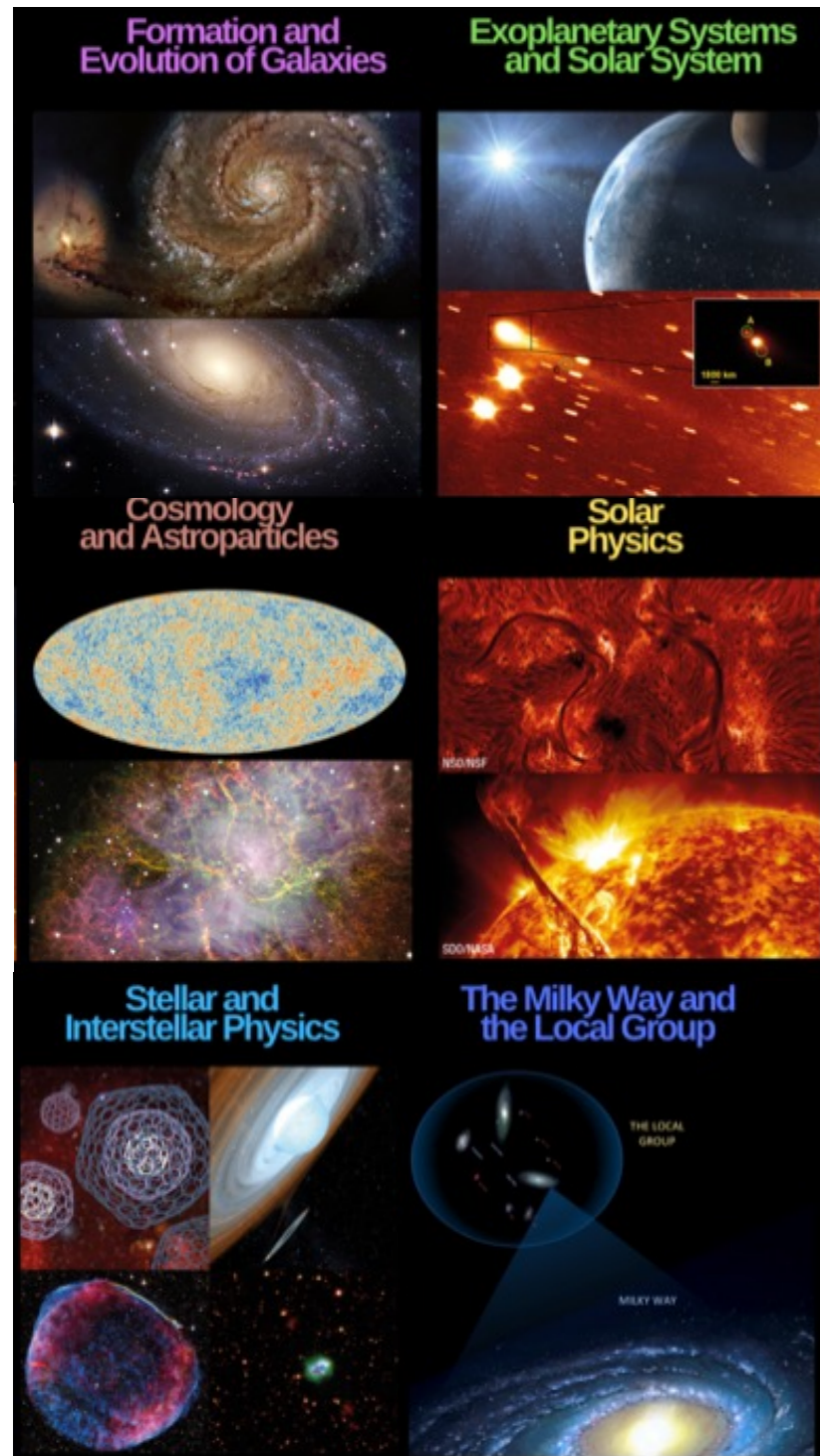


IAC Scientific Programme

- Eminently observational program
- Recently created theoretical groups in:
 - Numerical sims of galaxy formation
 - Astroparticle physics



IAC scientific interests @ NOT



- Tracking and characterisation of small solar system bodies
- Monitoring of exoplanets
- Massive stars & Galactic archaeology
- Magnetars and transient phenomena
- Deep narrow-band imaging
- Optical/IR follow-up of high energy sources

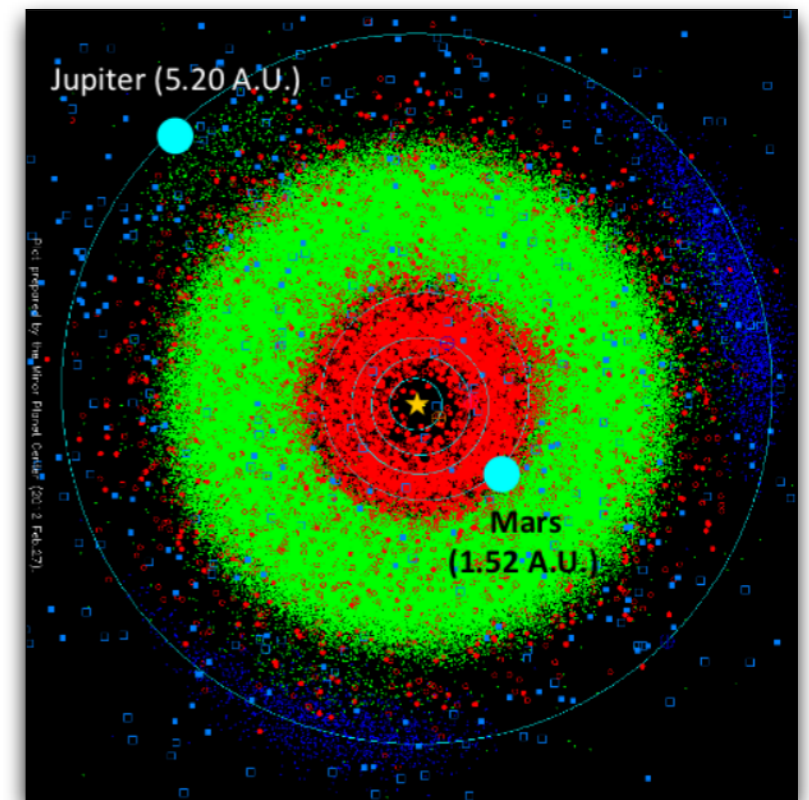
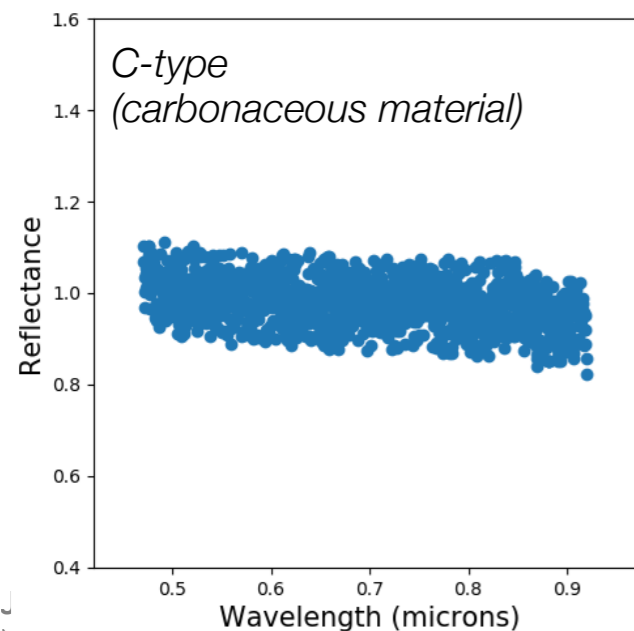
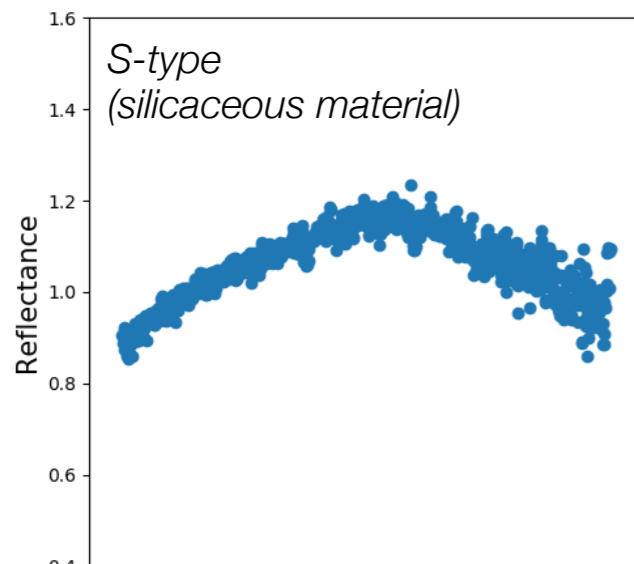
**Running theme:
monitoring or follow-up observations
of transient systems**

Tracking small solar-system bodies

D. Morate, J. de León Cruz, J. Licandro

Visible Near Earth Asteroids Observations Survey

- Spectroscopy (**NOT**, GTC, INT)
- Photometry (TCS)
- Lightcurves (various)



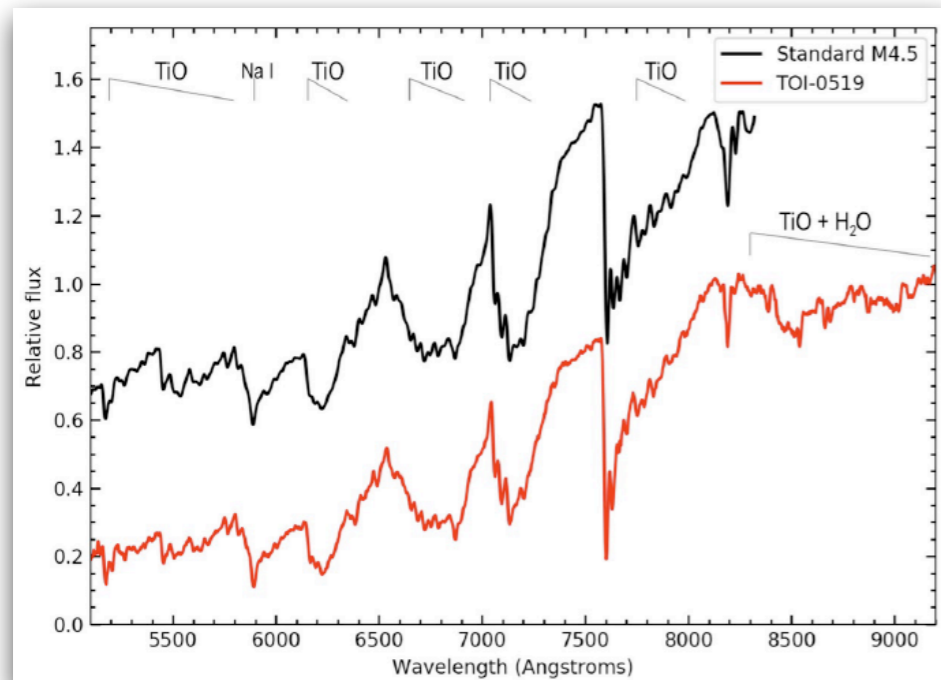
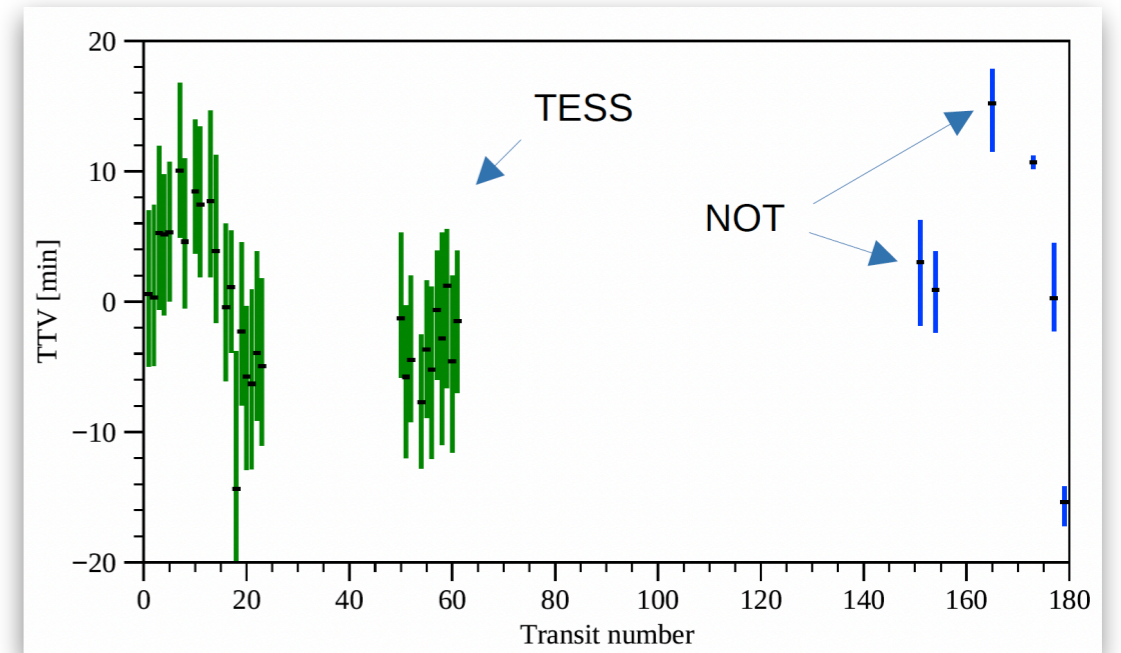
- ~40 observed NEAs (with ALFOSC @ NOT):
 - PHAs (potentially hazardous asteroids)
P3-NEO-1 (ESA program)
 - Low DeltaV (accessible targets for space missions)
NHATS (Near-Earth Object Human Space Flight Accessible Targets Study, NASA)
 - Recently discovered NEAs
NEOROCKS (NEO Rapid Observation, Characterization and Key Simulations, EU Horizon 2020)

Monitoring of Exoplanets

Hannu Parviainen

- **Transit Timing Variations (TTVs)**

- TTV analyses combine TESS observations with ground-based ones
- NOT reaches the high photometric precision required for TTV measurements of small exoplanets.
- Used to estimate the masses of planets in extrasolar multi-planet systems (e.g. too low or host star too faint for the planet masses to be measured using RV)



- **Exoplanet characterisation**

- Spec. characterisation exoplanet candidate host stars with ALFOSC
- Used in the validation of exoplanet candidate discovered by the TESS mission
- Backup and filler project to accompany our TTV transit observations
 - Observations can be scheduled freely
 - Less sensitive on the weather

Massive (OB) stars characterisation

Sergio Simón Díaz



Goal: empirical characterisation of a statistically meaningful sample of ~1000 Galactic massive stars covering the full OB stellar domain

FIES@NOT-2.56m:

- 471+ hours (2008-2022+)
- 3820+ spectra
- 770+ Galactic O and B stars
- Largest homogeneous, multi-epoch, high-resolution spectroscopic database of Northern Galactic O and B type stars compiled to date

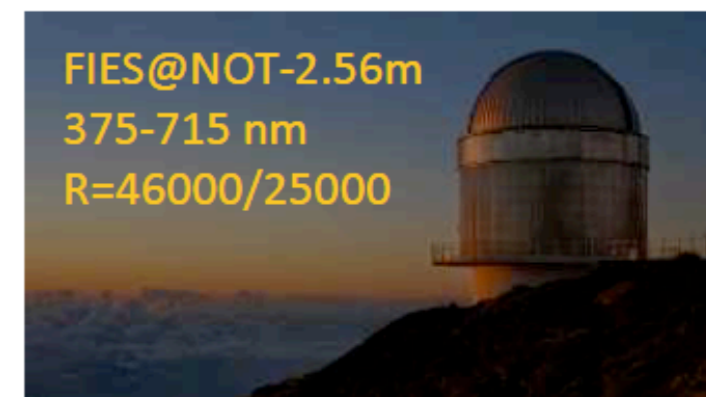
Ground-based optical spectroscopy:

Single snapshot, multi-epoch & time-series

- Spectroscopic parameters
- Surface abundances
- Spectroscopic binaries
- Spectroscopic variability

Importance:

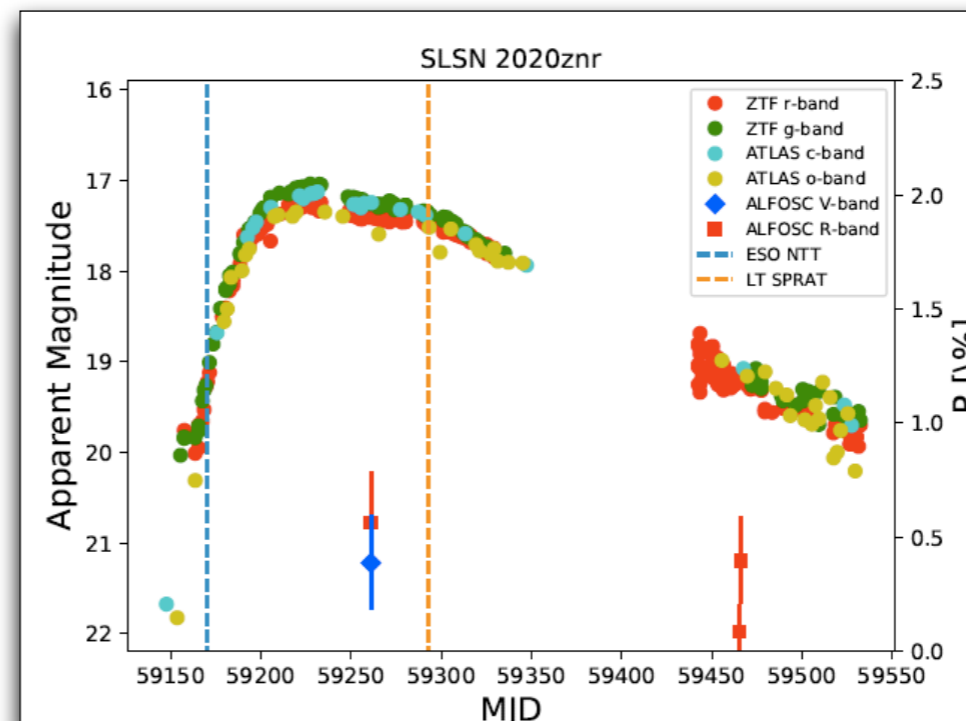
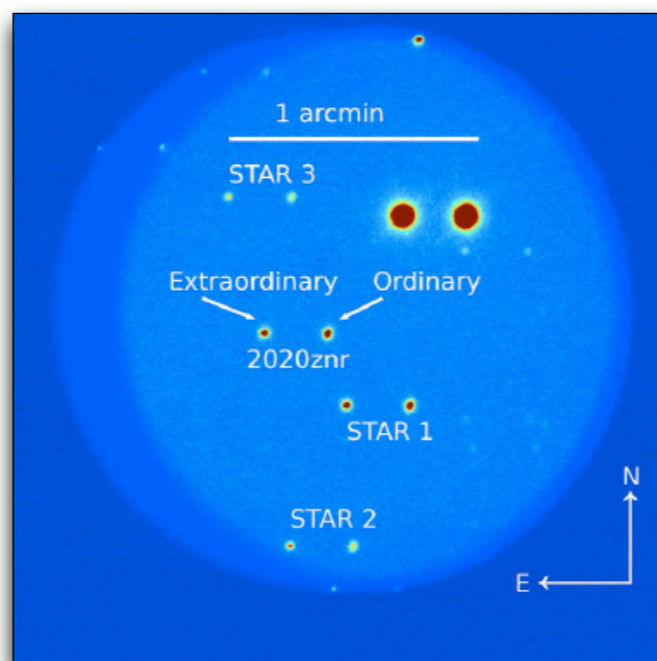
- (i) tracers of star-forming regions,
- (ii) feedback to the interstellar medium,
- (iii) chemo-dynamical evolution of galaxies,
- (iv) Reionization of the Universe,
- (v) extragalactic tools
- (vi) extreme & exotic stellar objects,
- (vii) progenitors of grav. wave emitters



Superluminous Supernovae

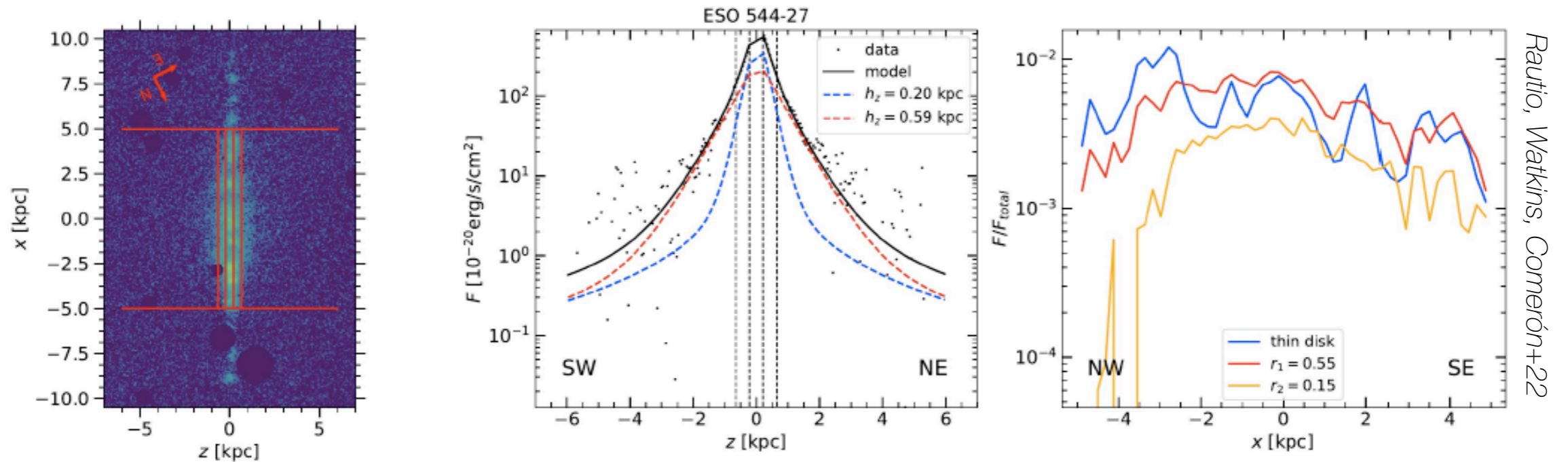
F. Poidevin & I. Pérez-Fournón

- **2021 Polarimetry Survey**
 - 10h of ToOs program to test polarimetry properties of magnetars
 - Magnetars are the best progenitor candidates for super luminous supernovae (2 to 4 magnitudes brighter than type Ia supernovae)
 - Other possibilities include: pair-instability model, ejecta-circumstellar material interaction model
 - Polarimetry of 5 super luminous supernovae in different phases
 - 1 published article (Poidevin+2022) + 3 more in preparation
- ALFOSC imaging polarimetry reduction pipeline developed by F. Poidevin
- Pipeline tests with NOT archive data (see Poidevin+2022)



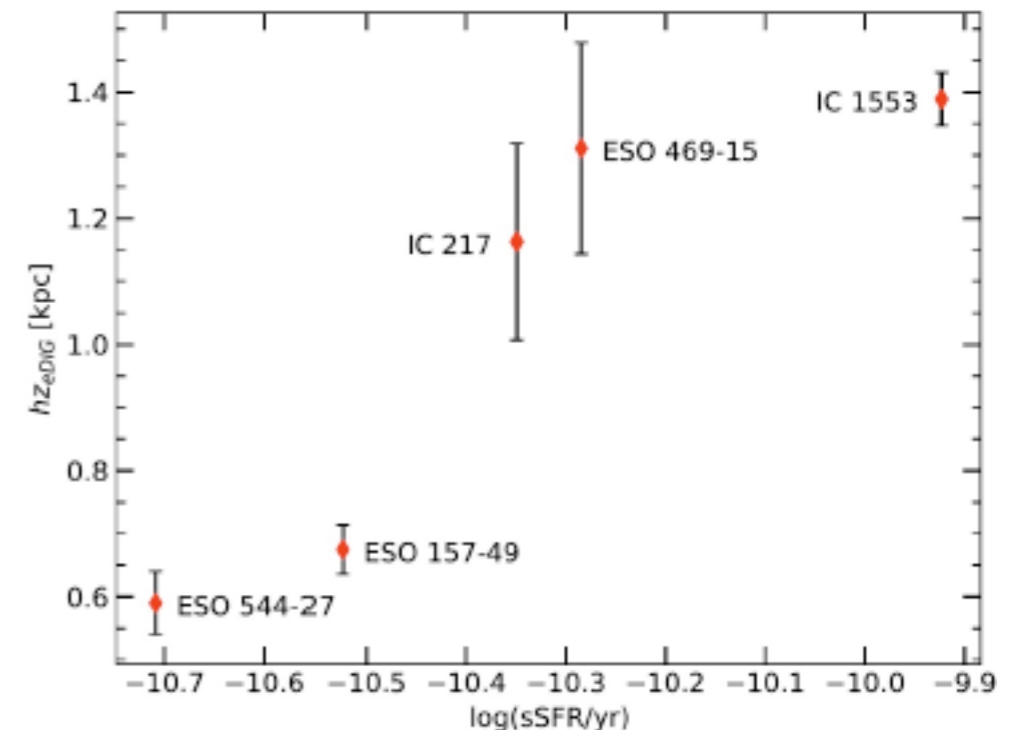
Extraplanar Diffuse Gas (eDIG)

S. Comerón



Raito, Watkins, Comerón+22

- Deep narrow-band H α imaging
- Relatively wide-field imagers in mid-size telescopes key to obtain deep imaging of narrow lines over large areas
- Positive correlation between the vertical scale-height of the eDIG and the specific star formation in the disc, indicating that the latter is one of the drivers of the properties of the eDIG



IAC interests at NOT

- **High resolution stellar spectroscopy**
 - Radial velocities, parameters and abundances
- **Follow-up of space-based observations (TESS, GAIA, PLATO,...)**
 - Exoplanets searches & monitoring
 - Galactic archaeology (to complete other samples)
- **Time domain astronomy**
 - Imaging, spectroscopy and polarimetry to follow up sources of interest identified in large surveys (MAGIC, CTA, LSST)
- **Narrow-band, deep (wide-field) imaging**
 - Important to study extragalactic, extended sources not easy to get in future facilities at ORM

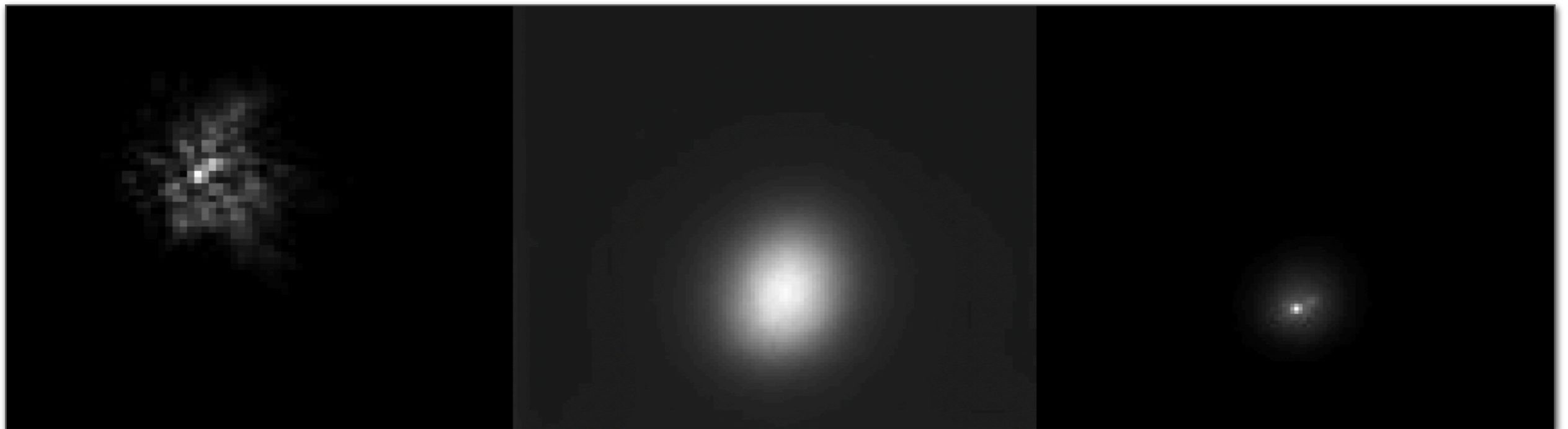


IAC instruments @ NOT

FastCAM

A lucky imaging instrument for medium-size telescopes

- FastCam developed by IAC in collaboration with other institutions to obtain high spatial resolution images in the optical
- High speed EMCCD camera is used with exposure times 30-50 ms, to minimise the effect of atmospheric turbulence during the exposures



30ms speckles

Natural seeing star

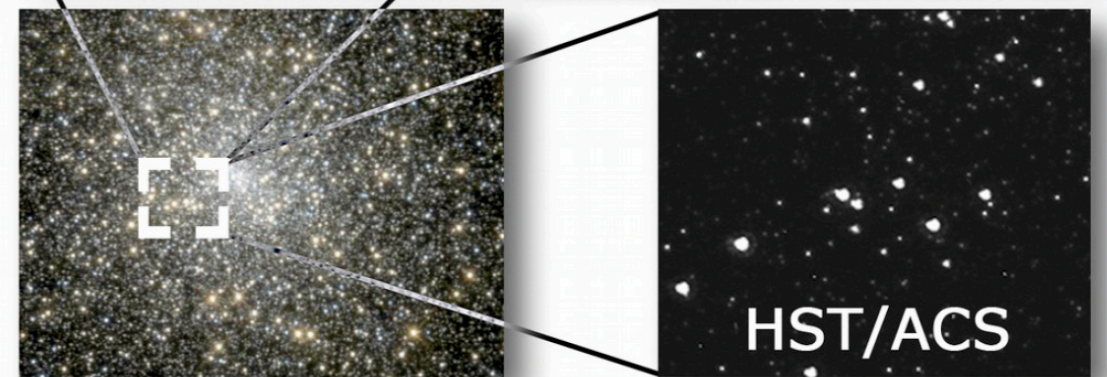
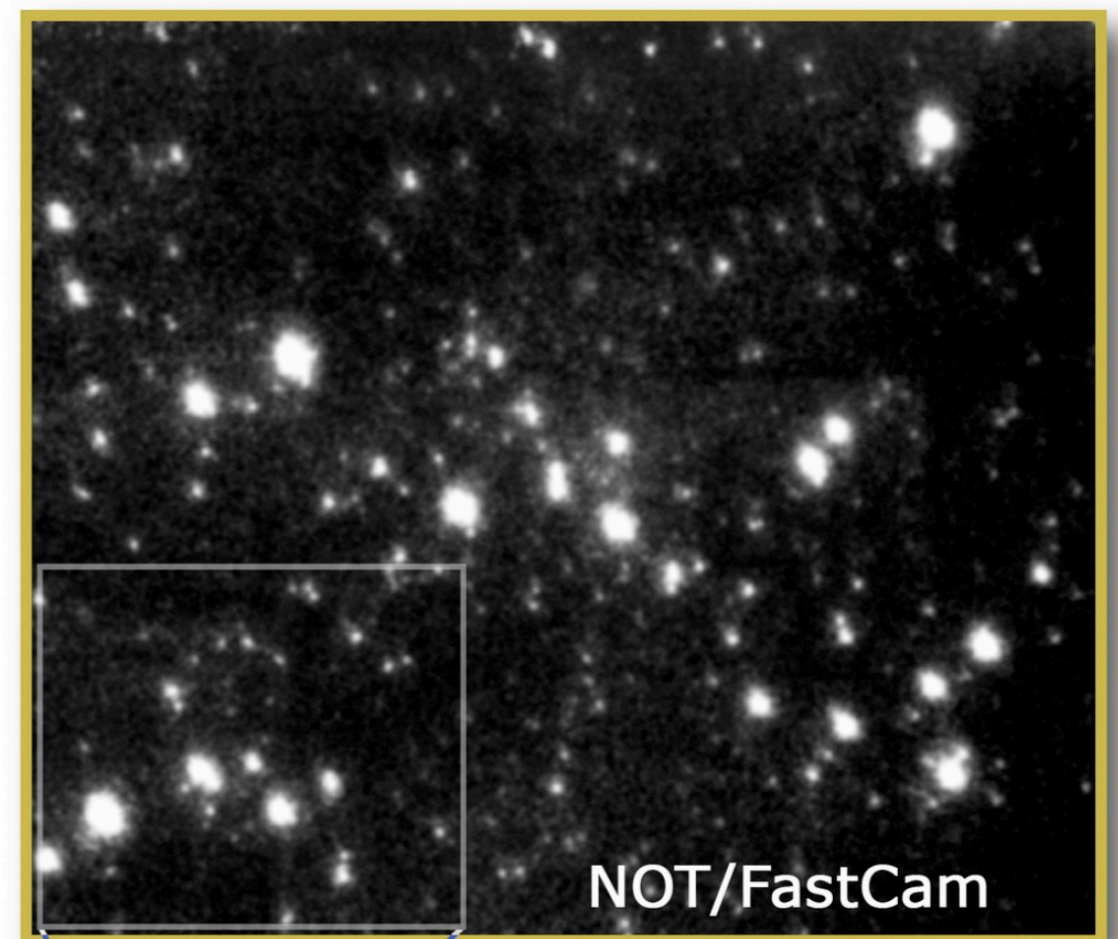
Shift and add 1% of
4000 images

FastCAM

A lucky imaging instrument for medium-size telescopes

- FastCam FastCam has been installed at four telescopes:
 - 1.5m TCS
 - 2.5m NOT
 - 4.2m WHT
 - 10.4m GTC
- Best resolution attained for first 3 was close to the diffraction limit in I-band.

TCS (1.5m)	0.15"
NOT (2.5m)	0.09"
WHT (4.2m)	0.07"



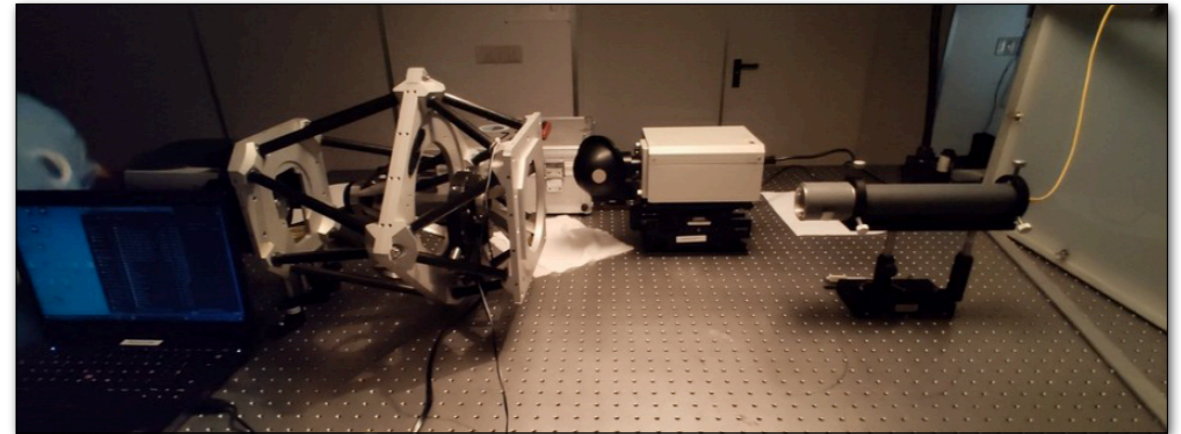
FastCAM

A lucky imaging instrument for medium-size telescopes

- **FastCam has been completely upgraded:**

- A new EMCCD camera
- Full characterisation of the detector both in the laboratory and on test nights at the Carlos Sánchez Telescope (TCS).
- New acquisition and control software
- More robust user interface
- Optimisation of the reduction software

IAC looking for formulas to keep FastCAM permanently at ORM

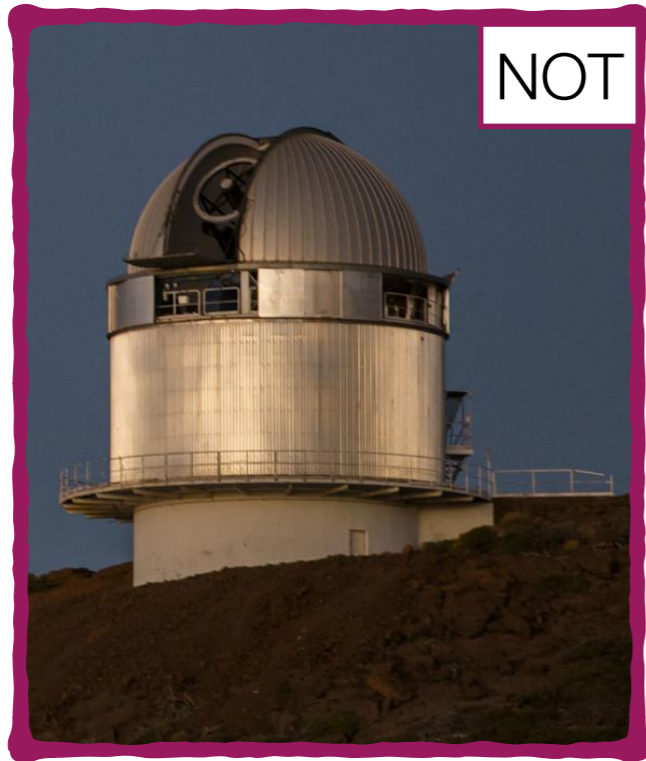


The Andor iXon Ultra 888:

- 1024 x 1024 active pixels
- 13 μm pixel size
- 30 MHz max readout time
- $< 1e$ readout noise
- 26 fps full frame
- 93 fps @ 512 x 512
- $> 95\%$ QE

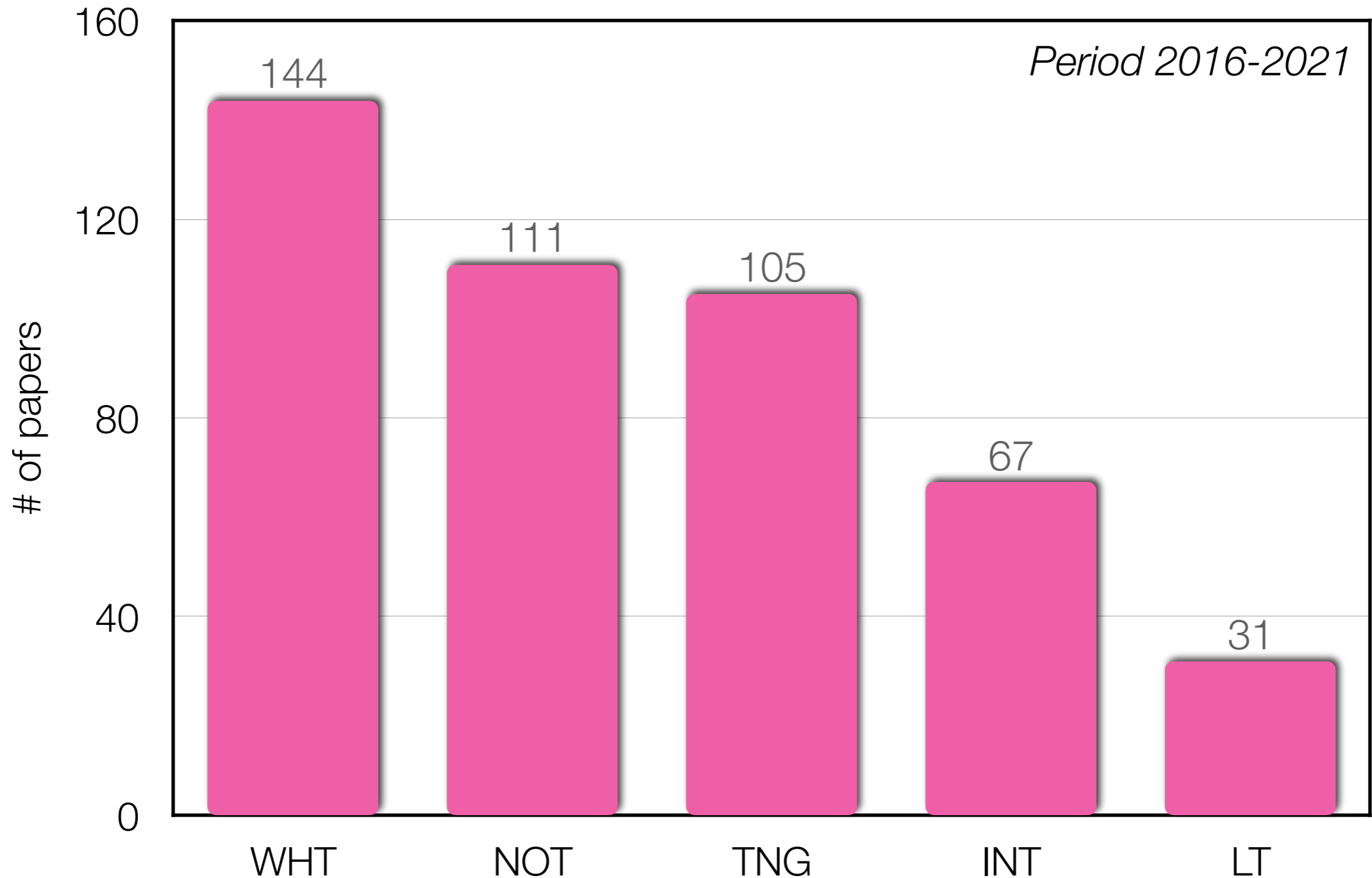


OPTICON Telescopes



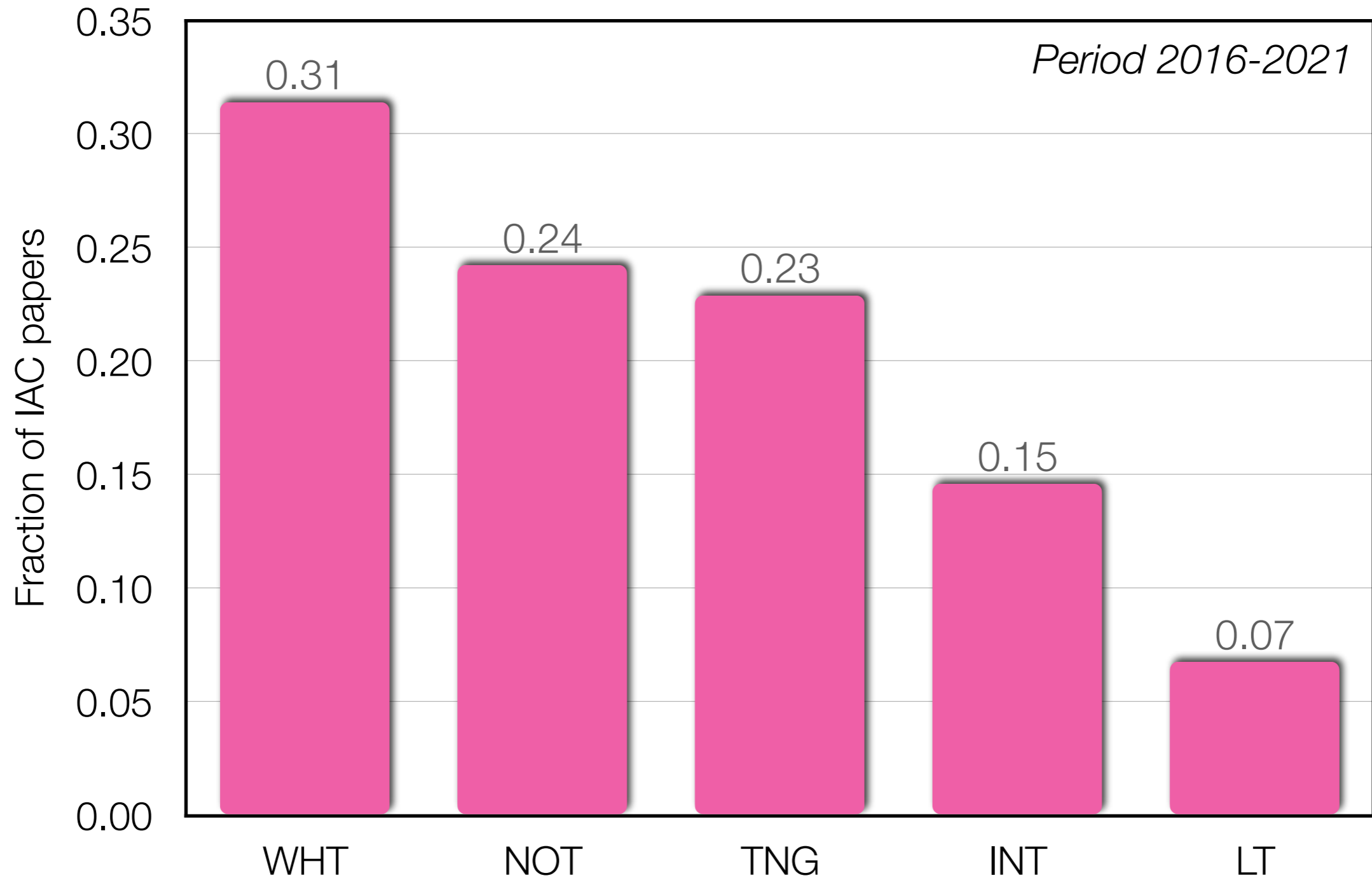
IAC pubs @ ORM

OPTICON telescopes



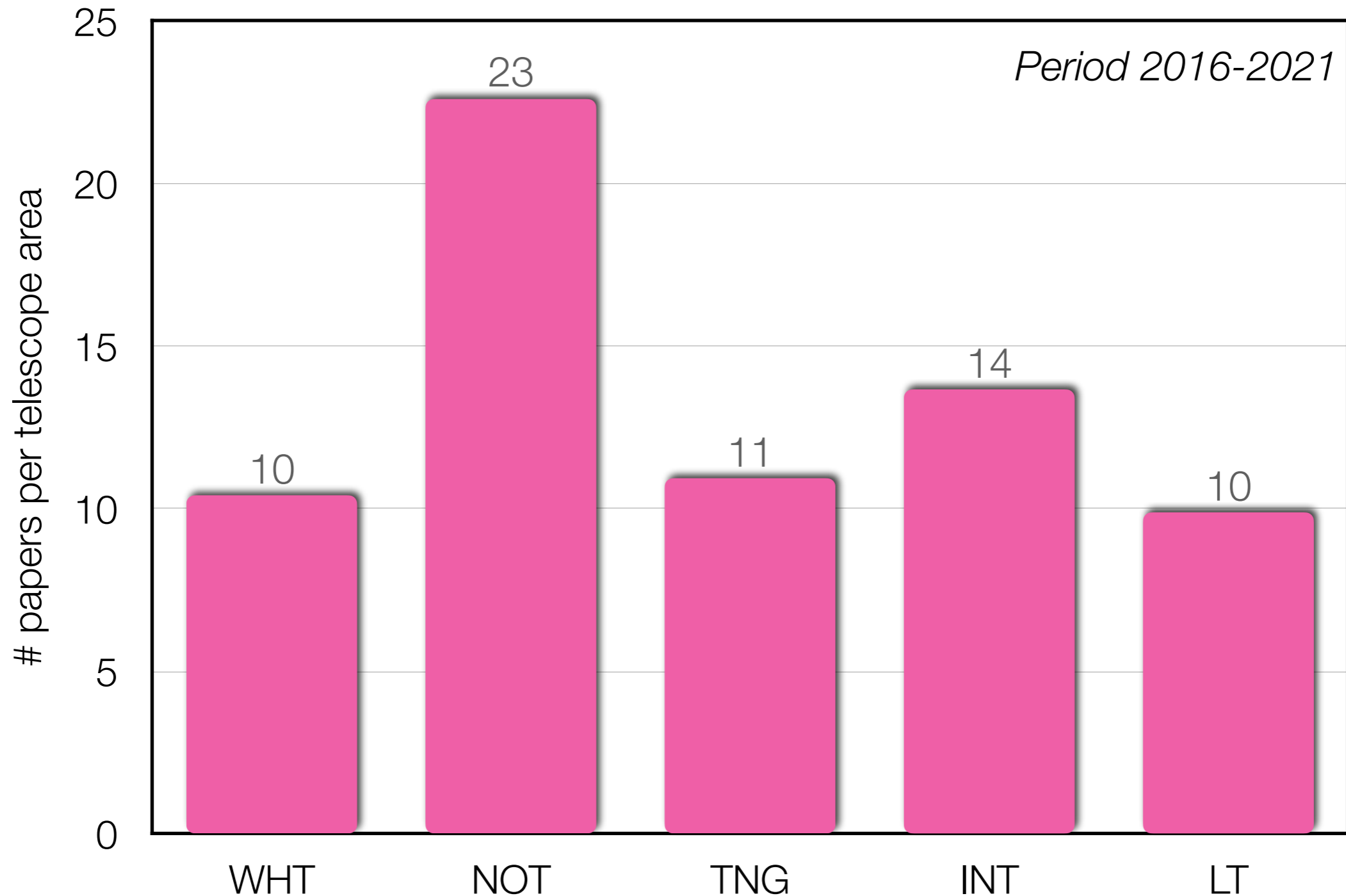
IAC pubs @ ORM

OPTICON telescopes



IAC pubs @ ORM

OPTICON telescopes



**NOT in the ORM
landscape**

NOT in the ORM landscape

	Optical			Near IR			Med IR		Special							
	Img	MRS	HRS	Img	MRS	HRS	Img	MRS	AO	Opt WFI	IR WFI	WF Spec	Polar Img	Polar Spec	Fast Phot	Coro
GTC	X	X	X	X	X	X	X	X					X	X	X	X
WHT	X	X	X	X	X								X			
TNG	X	X	X	X	X	X									X	
NOT	X	X	X	X	X								X	X		
INT	X	X								X						
LT	X	X											X			
Mercator	X	X	X													
Stella	X		X							X						
JKT	X															

Img: image, MRS: med-res. spec., HRS: high-res. spec., AO: adapt. Opt., WFI: wide field image, Polar: polar., Phot: photom., Coro: coronagraphy



NOT and OPTICON telescopes

	Optical			Near IR			Med IR		Special							
	Img	MRS	HRS	Img	MRS	HRS	Img	MRS	AO	Opt WFI	IR WFI	WF Spec	Polar Img	Polar Spec	Fast Phot	Coro
WHT	X	X	X	X	X								X			
TNG	X	X	X	X	X	X									X	
NOT	X	X	X	X	X	X							X	X		
INT	X	X	X							X						
LT	X	X											X			

Img: image, MRS: med-res. spec., HRS: high-res. spec., AO: adapt. Opt., WFI: wide field image, Polar: polar., Phot: photom., Coro: coronagraphy

- Most OPTICON telescopes are specialising in MOS and HRS
- NOT, with upgraded instrumentation, still competitive providing broad range of options for both imaging, intermediate/high resolution spectroscopy and spectro-polarimetry



NOT and OPTICON telescopes

	Optical			Near IR			Med IR		Special							
	Img	MRS	HRS	Img	MRS	HRS	Img	MRS	AO	Opt WFI	IR WFI	WF Spec	Polar Img	Polar Spec	Fast Phot	Coro
WHT		X	X													
TNG			X			X										
NOT	X	X	X	X	X	X								X		
INT			X													
LT	X	X											X			

Img: image, MRS: med-res. spec., HRS: high-res. spec., AO: adapt. Opt., WFI: wide field image, Polar: polar., Phot: photom., Coro: coronagraphy

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Take away messages

- Nordic Optical Telescope great asset for the ORM and IAC community!!
- Versatility allows a wide range of science topics/community
- Current instr. allows forefront science, complementing other facilities at ORM
- One of the most effective telescopes for IAC community (papers/area)
- The IAC-NOT support programme key to maintain IAC productivity / use
- Future developments (e.g. NTE, FIES upgrade) expected to open the door to new exciting new scientific ventures.
- New NOT developments in line with IAC general interests



¡Gracias!

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