Resolved stellar populations with SWIFT+PALM3K, and prospects for HARMONI @ E-ELT

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Special thanks to S. Zieleniewski & R. Houghton

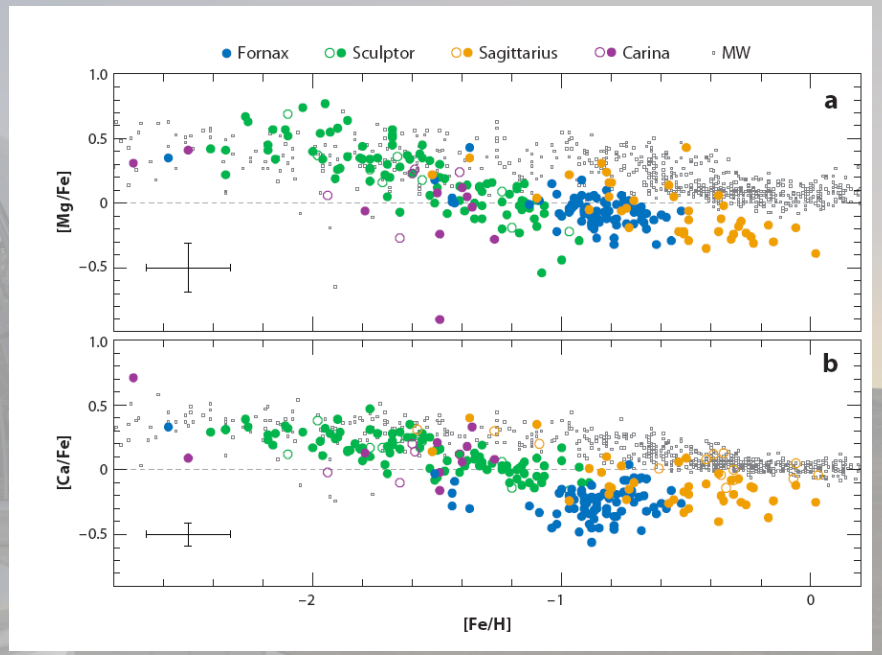
Resolved Stellar Populations

Aim to use abundance patterns in RGB & MS stars to unravel star formation history of each galactic component.

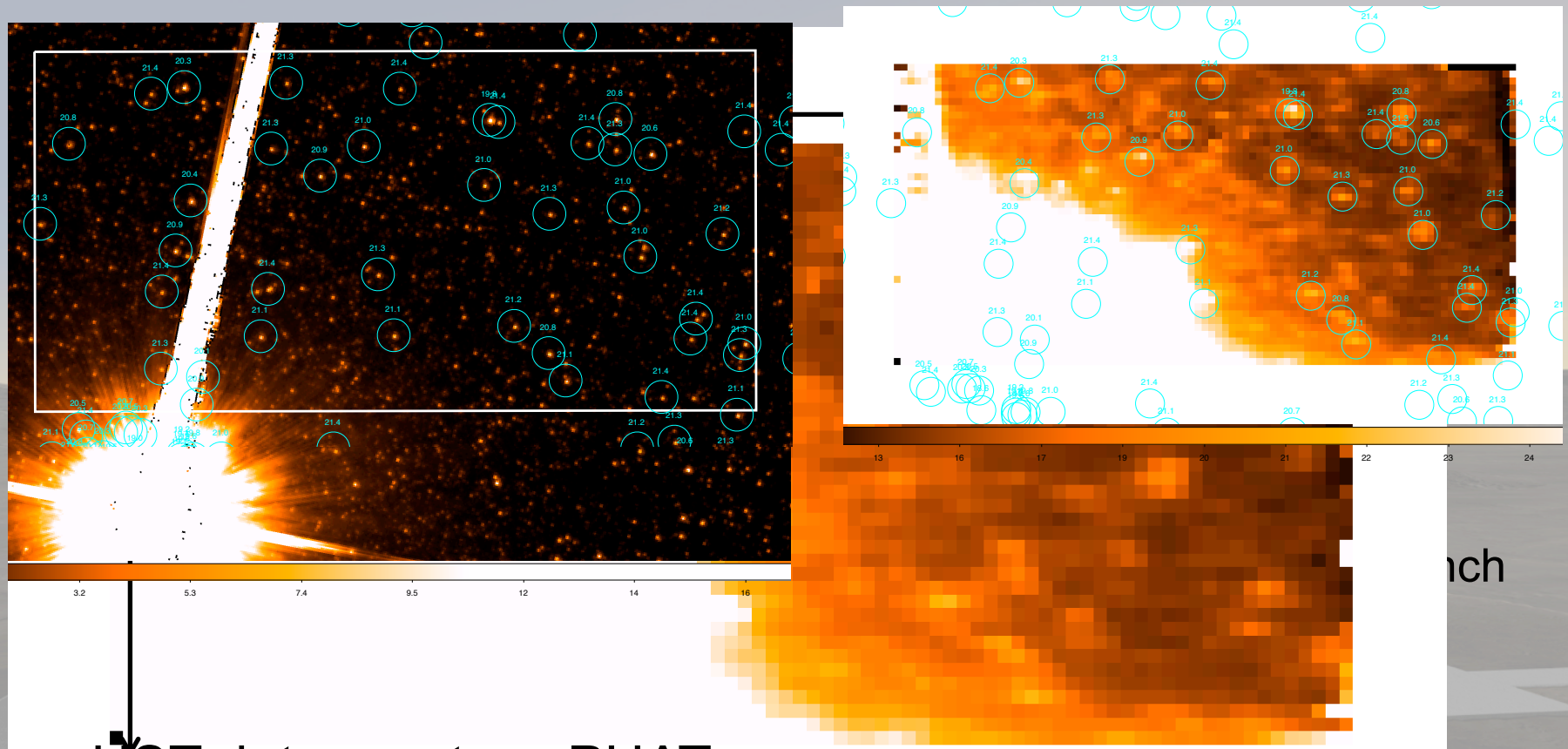
This work is currently only feasible in MW & MC. EELT+HARMONI will probe local groups (eg. Centaurus & Leo groups) and at the limit reach the Fornax and Virgo clusters. **This takes stellar population studies into a completely unexplored realm.**

Simulations needed to determine the distances and depths to which metallicities and line-of-sight velocities can be measured with sufficient accuracy in reasonable exposure times.

Challenge: the main metallicity indicators are in the visible. Thus this work does not take full advantage of the AO. Can infrared diagnostics be identified that will give reliable metallicities for RGB stars?

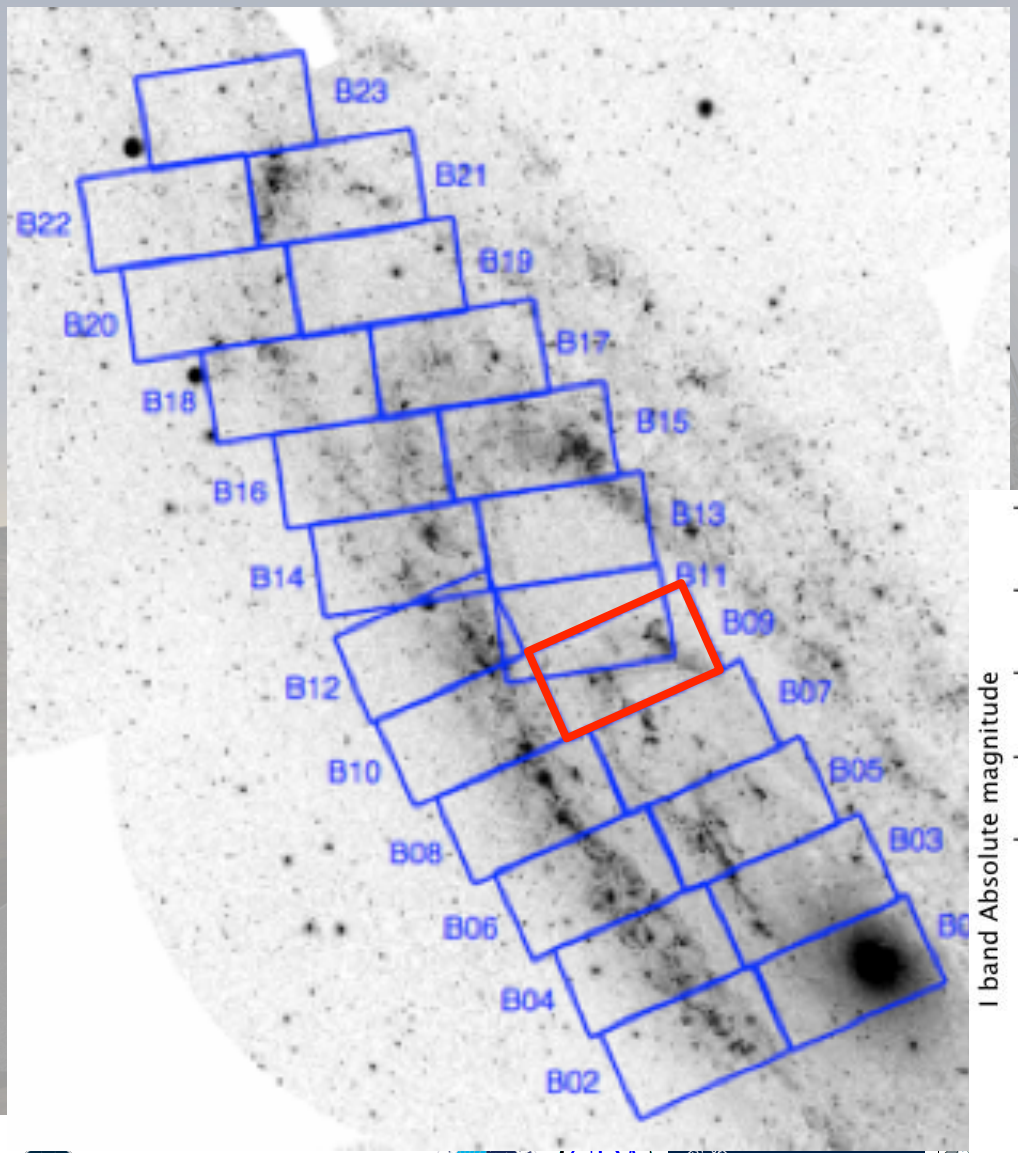


Resolved Stellar Pops in M31



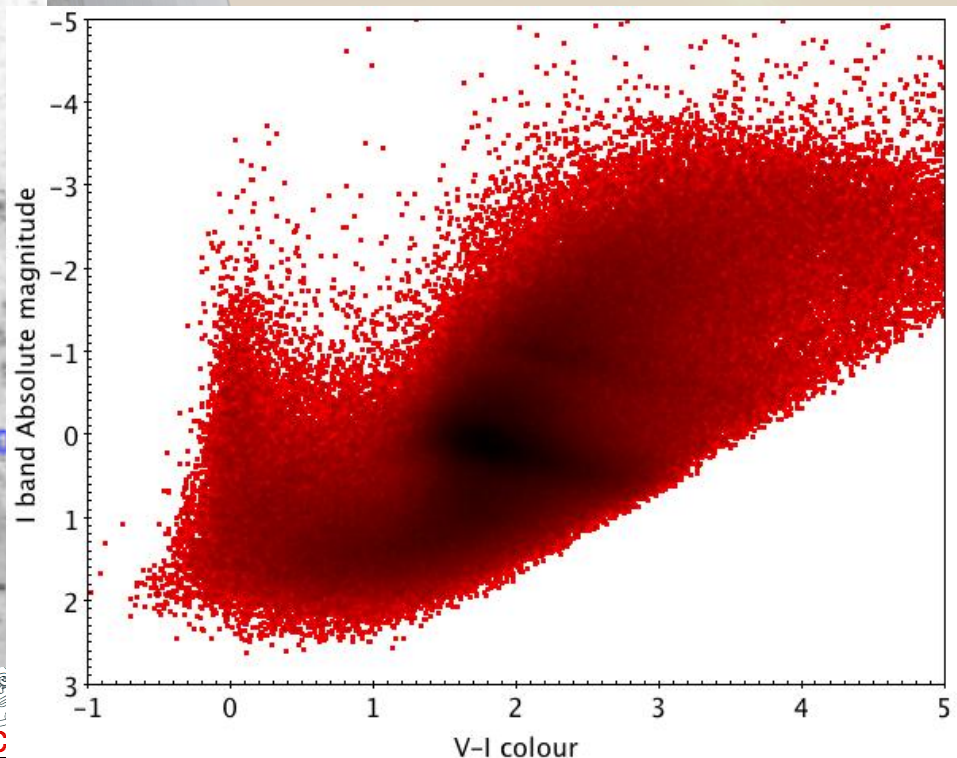
HST data courtesy PHAT survey
Dalcanton et al. 2012

M31 Pointing Brick 9

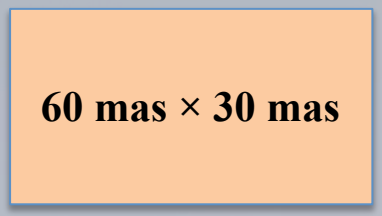


Reference Target for PALM3K NGS ExAO

V = 9.3 mag star in foreground



HARMONI – SPATIAL SETUP



For non-AO & visible observations

For optimal sensitivity (faint targets)

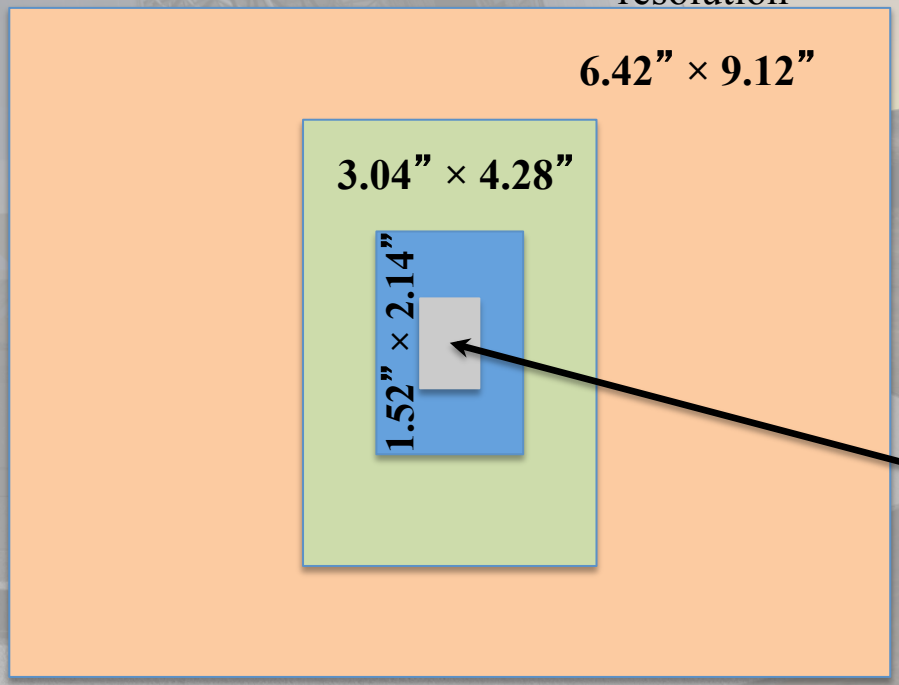
Best combination of sensitivity and spatial resolution

Highest spatial resolution (diffraction limited)

Equivalent slit length: 16 arcmin

or

3.2 metres in ELT focal plane



~152 × 214 (32000) spaxels at all scales

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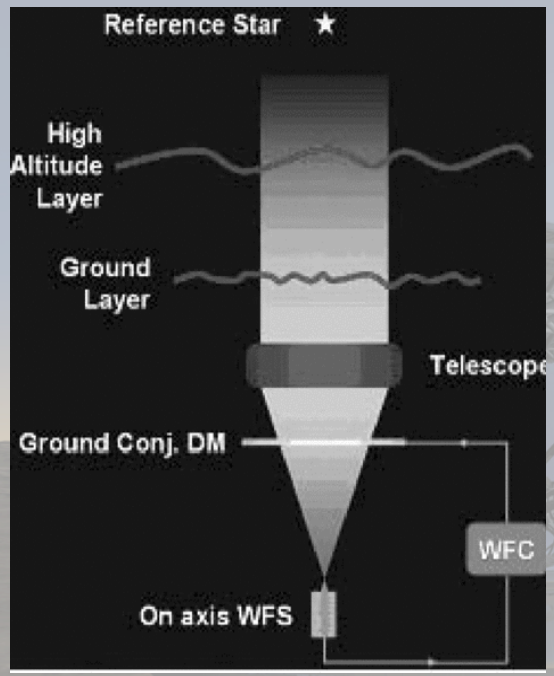
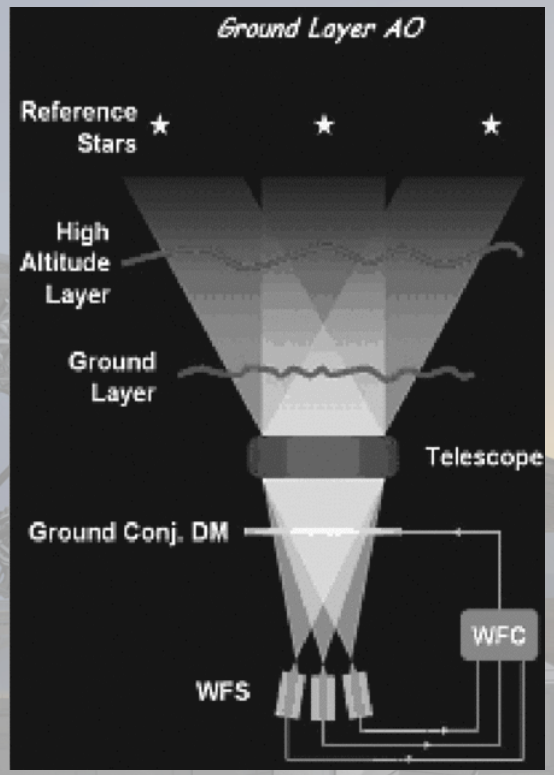
HARMONI - SPECTRAL SETUP

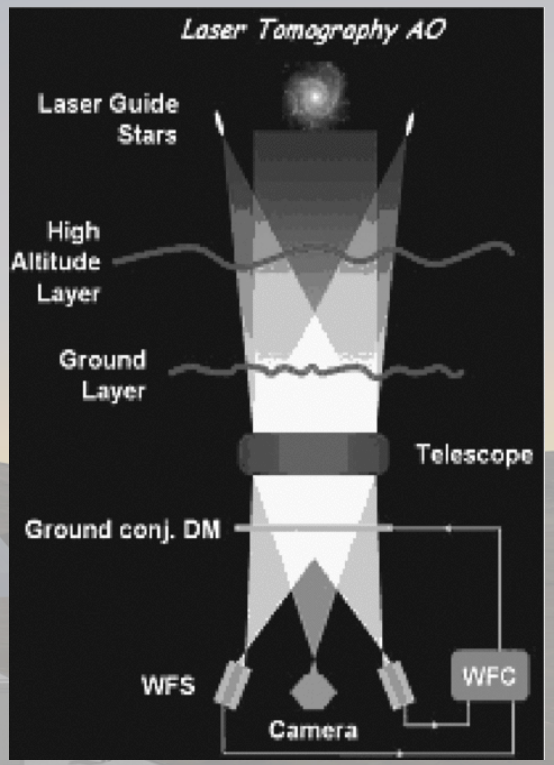
Bands	Wavelengths (µm)	R
Simultaneous V to K	0.45 to 2.45	~500*
"V+R" or "I+z+J" or "H+K"	0.45-0.8, 0.8-1.35, 1.45-2.45	~3500
"I+z" or "J" or "H" or "K"	0.8-1.0, 1.1-1.35, 1.45-1.85, 1.95-2.45	~8000
"Z" or "J_high" or "H_high" or "K_high"	0.9, 1.2, 1.65, 2.2 (TBD)	~20000

*Simultaneous V to K achieved by combining I to K (0.8 to 2.45 µm) at R~500 with visible wavelength range (0.45 to 0.8 µm) at R~3500

HARMONI Adaptive Optics Flavours

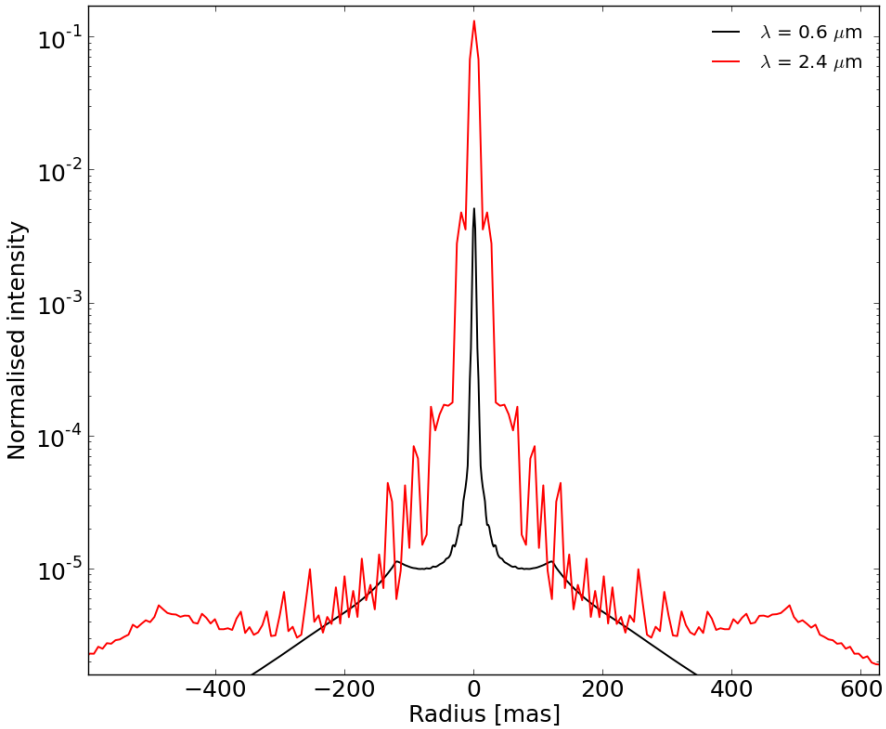


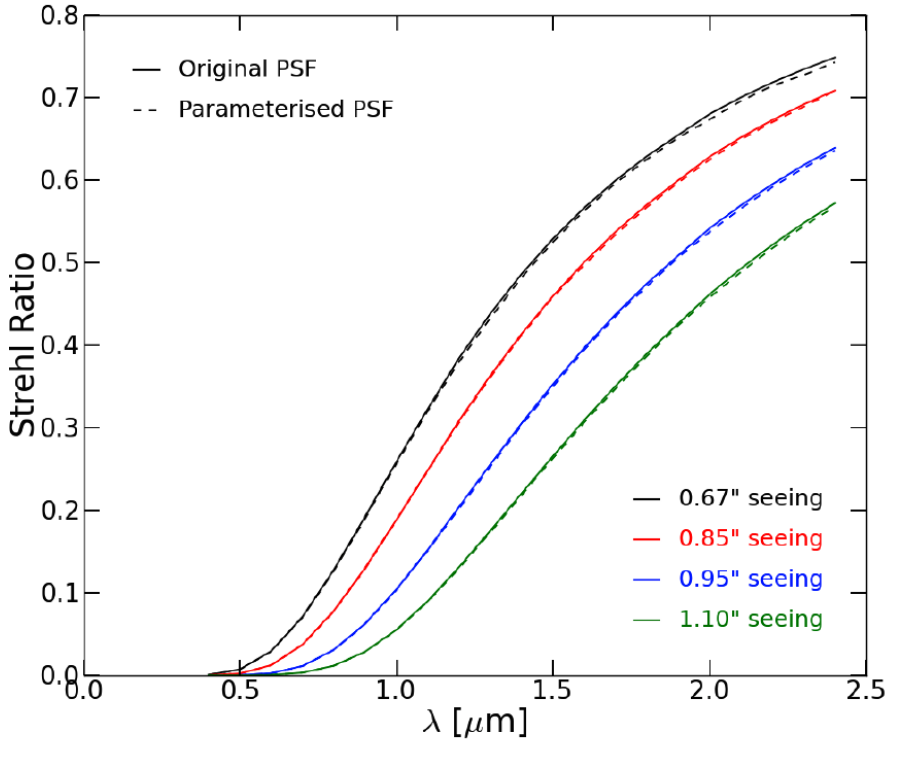




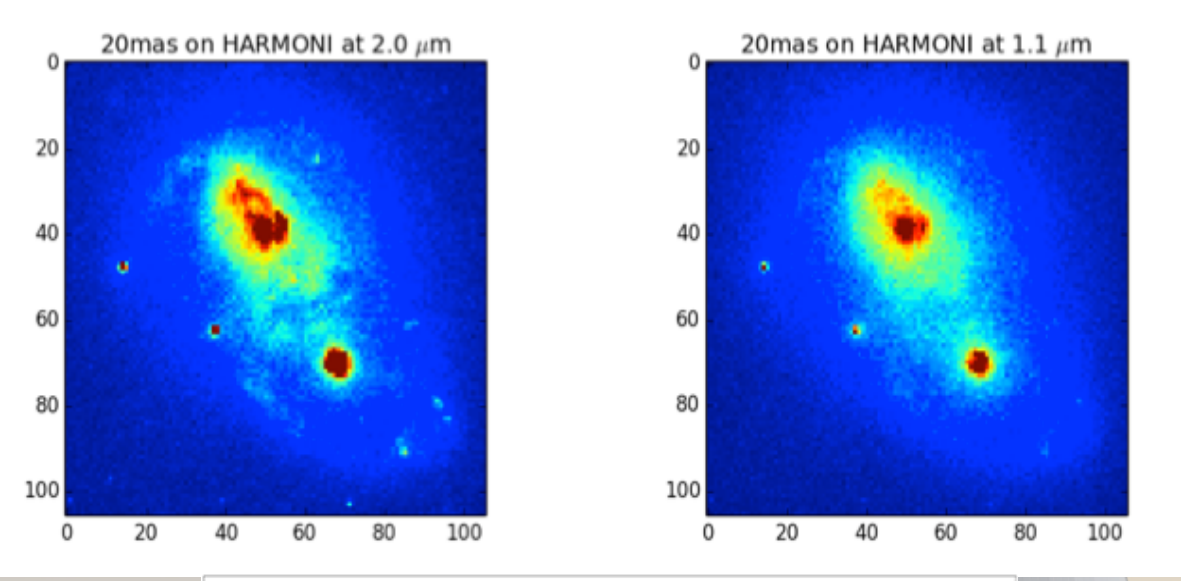
SCAO	GLAO	LTAO
1% sky coverage	100% sky coverage	~50% sky coverage
Diffraction limited (0.01")	Improved seeing (0.3")	Diffraction limited (0.01")

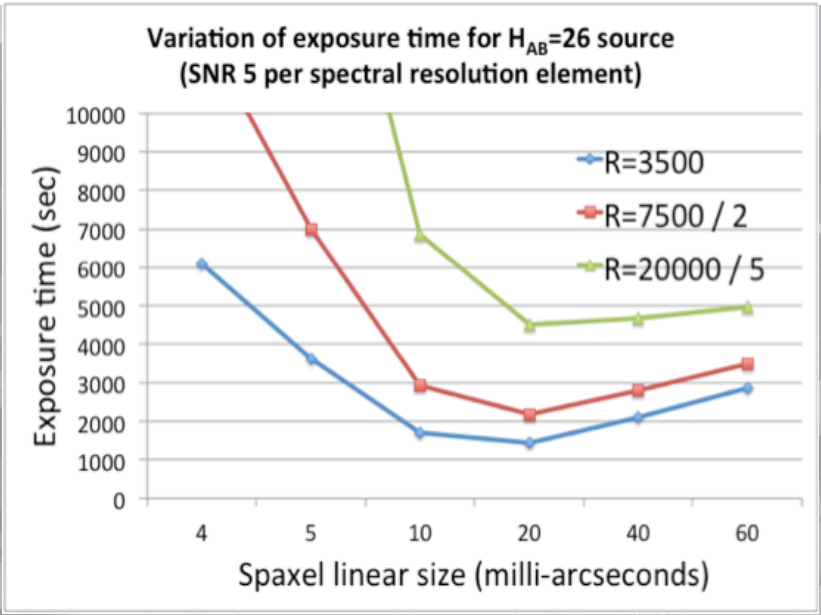
PSF Parameterisation





S. Zieleniewski et al. (in prep)





Also investigating (unique to HARMONI simulations) the effect of (strong) variations in PSF with wavelength (0.5% Strehl in V, to 50% Strehl in K), and its effects on point source sensitivity, and the need for variable spaxel scales.

Sensitivity Table

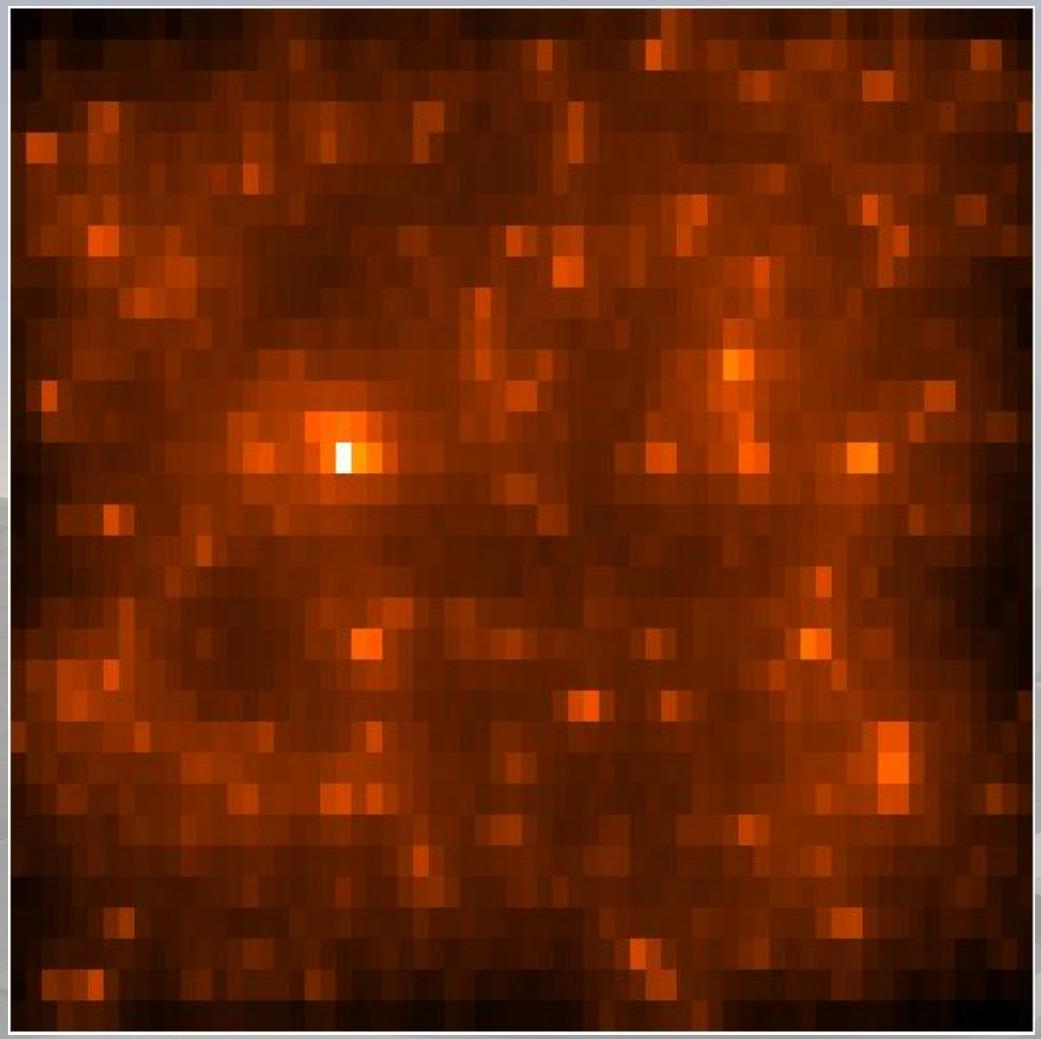
Limiting AB magnitude for which SNR of 5 per spectral pixel is achieved in 5 hours (20 x 900s), for a point source spectrum extracted from a 2 x 2 spaxel box, when using LTAO.

The computation assumes OH avoidance, and 0.67” seeing towards zenith at 500 nm, observations 30 degrees from zenith

Spectral	4 mas		10 mas		20 mas		30x60 mas	
Resolution	R_{AB}	H_{AB}	R_{AB}	H_{AB}	R_{AB}	H_{AB}	R_{AB}	H_{AB}
	Point source (AB mag)							
500		27.42		27.36		26.90		26.02
3500	22.93	26.64	23.89	27.44	24.69	27.53	25.64	26.98
7500		25.82		26.66		26.84		26.43
20000		24.76		25.63		25.87		25.63

Only 12% EE in R band in 120 mas, so don’t despair!!

Simulations with HARMONI

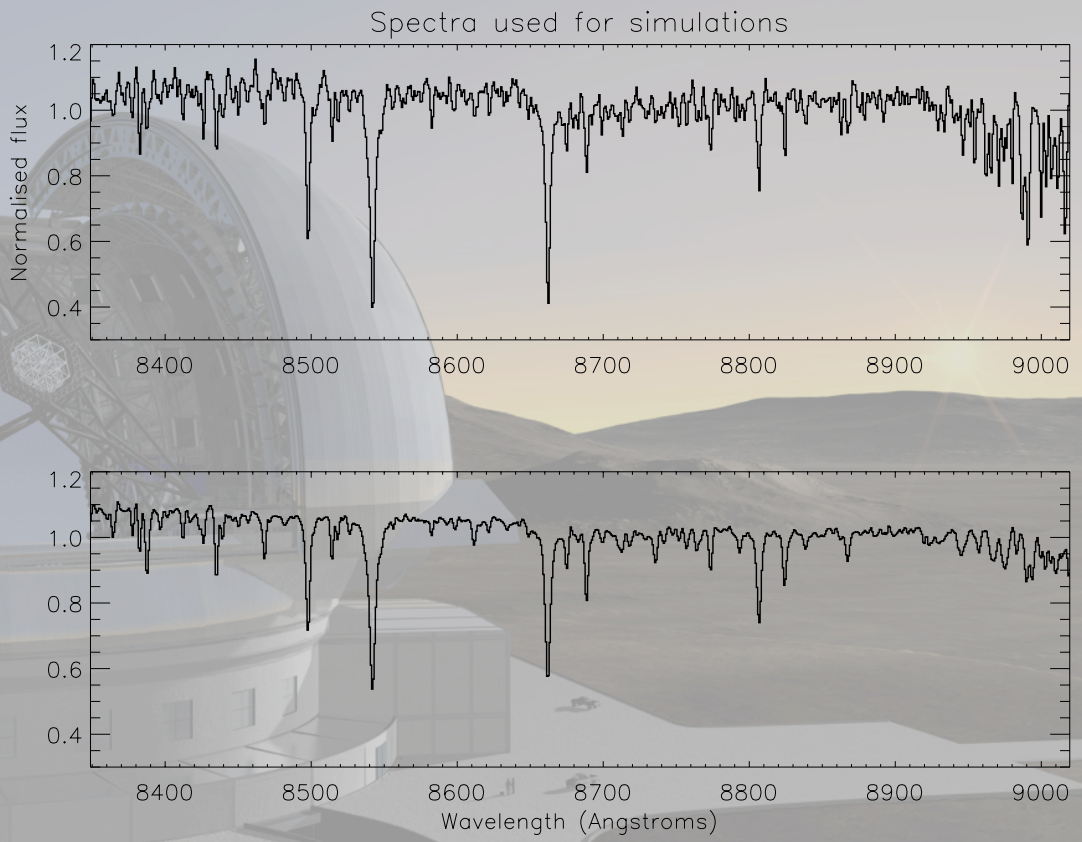


HARMONI simulations of M31 field, using real star positions and magnitudes.

HARMONI spaxel scale: 30 × 60 mas
HARMONI FoV: 20×20 arcsec
Distance: 5 Mpc
Exposure time: 30 mins

HARMONI Simulations

- Simulator developed by S. Zieleniewski and S. Kendrew
- Full data cube simulation, including parametrised wavelength dependent PSF
- Add realistic noise, sky background, thermal background etc.
- Post-process observed cube for scientific analysis



Next Steps

- Realistic spectra for every star in FoV (age, metallicity?)
- Random V_los for each star to mimic real galaxy
- Test J band (also H/K band) against CaTriplet to find sweet spot in sensitivity
- Constrained deconvolution using image (from MICADO)
- Different densities, optimum spaxel scale
- M31, Cen A, Virgo distances

Conference

Early E-ELT science: Spectroscopy with HARMONI

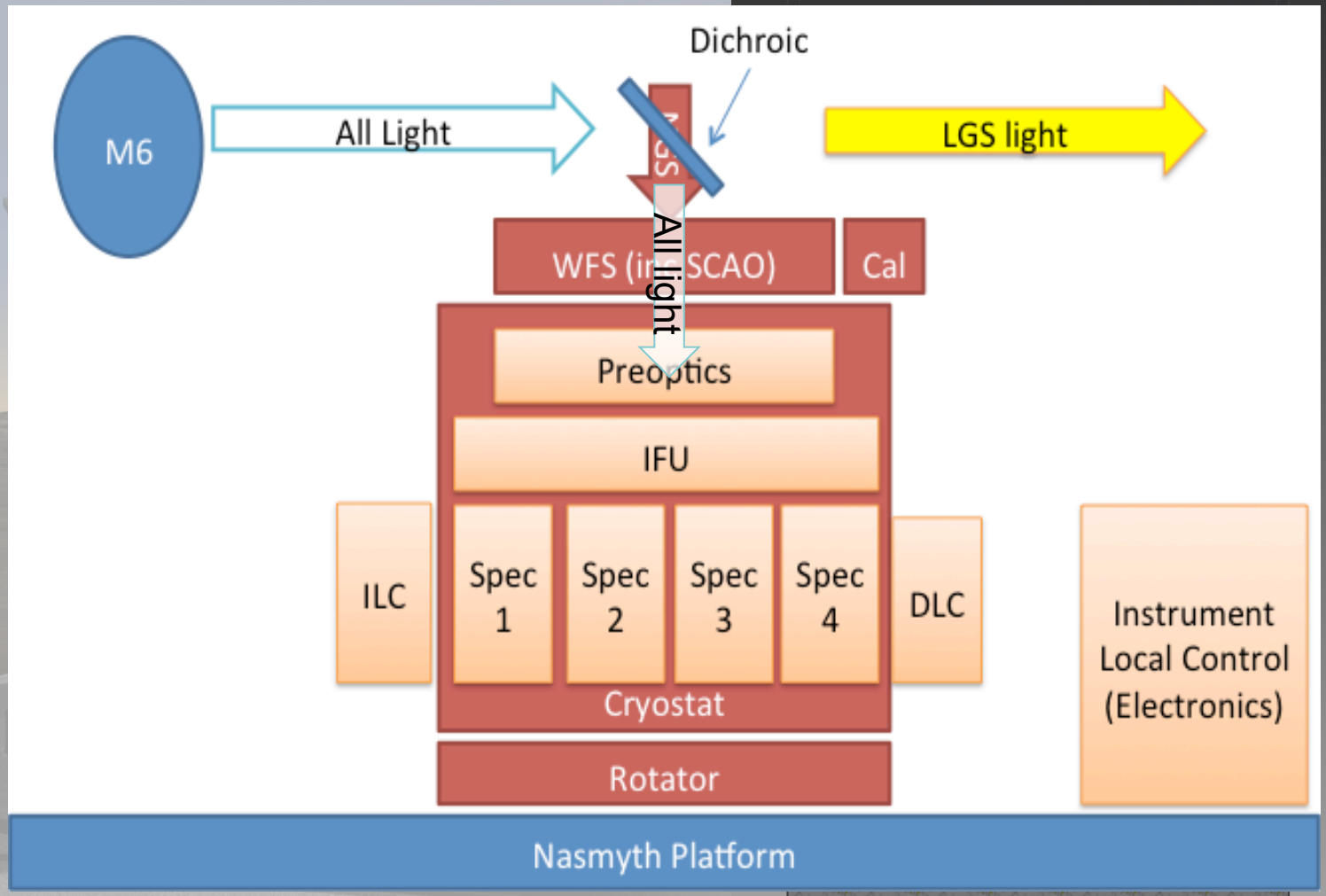
University of Oxford

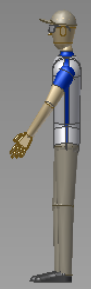
29 June 2015 – 3rd July 2015

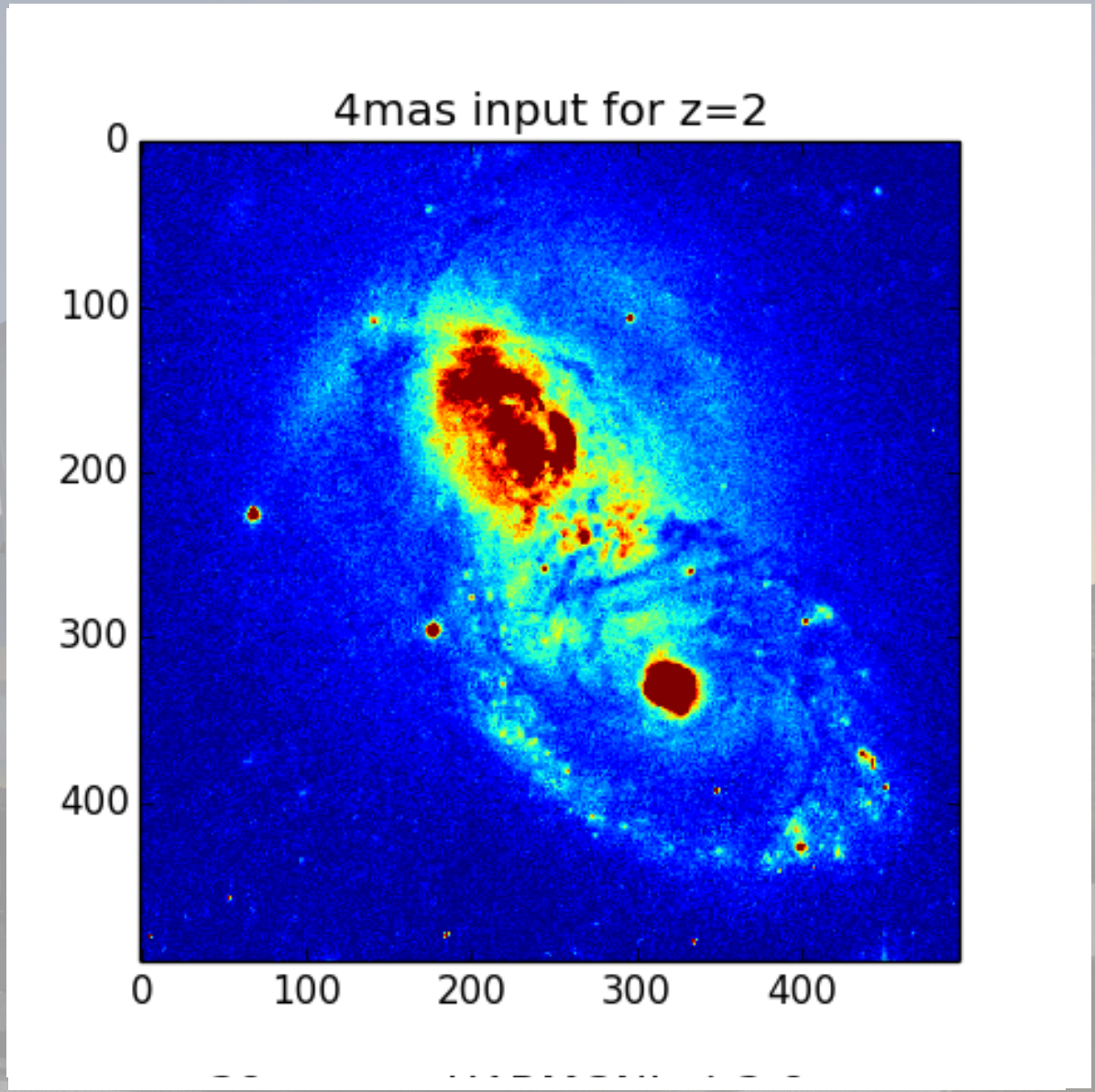
Venue: Oxford Museum of Natural History

Science & Technology Facilities Council
UK Astronomy Technology Centre

HARMONI Instrument Description






4mas input for z=2
0
100
200
300
400
0
100
200
300
400