

Spectroscopy of stellar populations with MOSAIC and the E-ELT

Chris Evans
UK Astronomy Technology Centre (STFC)



*“There’s a capacity for appetite that a whole
heaven and earth of cake can’t satisfy”*

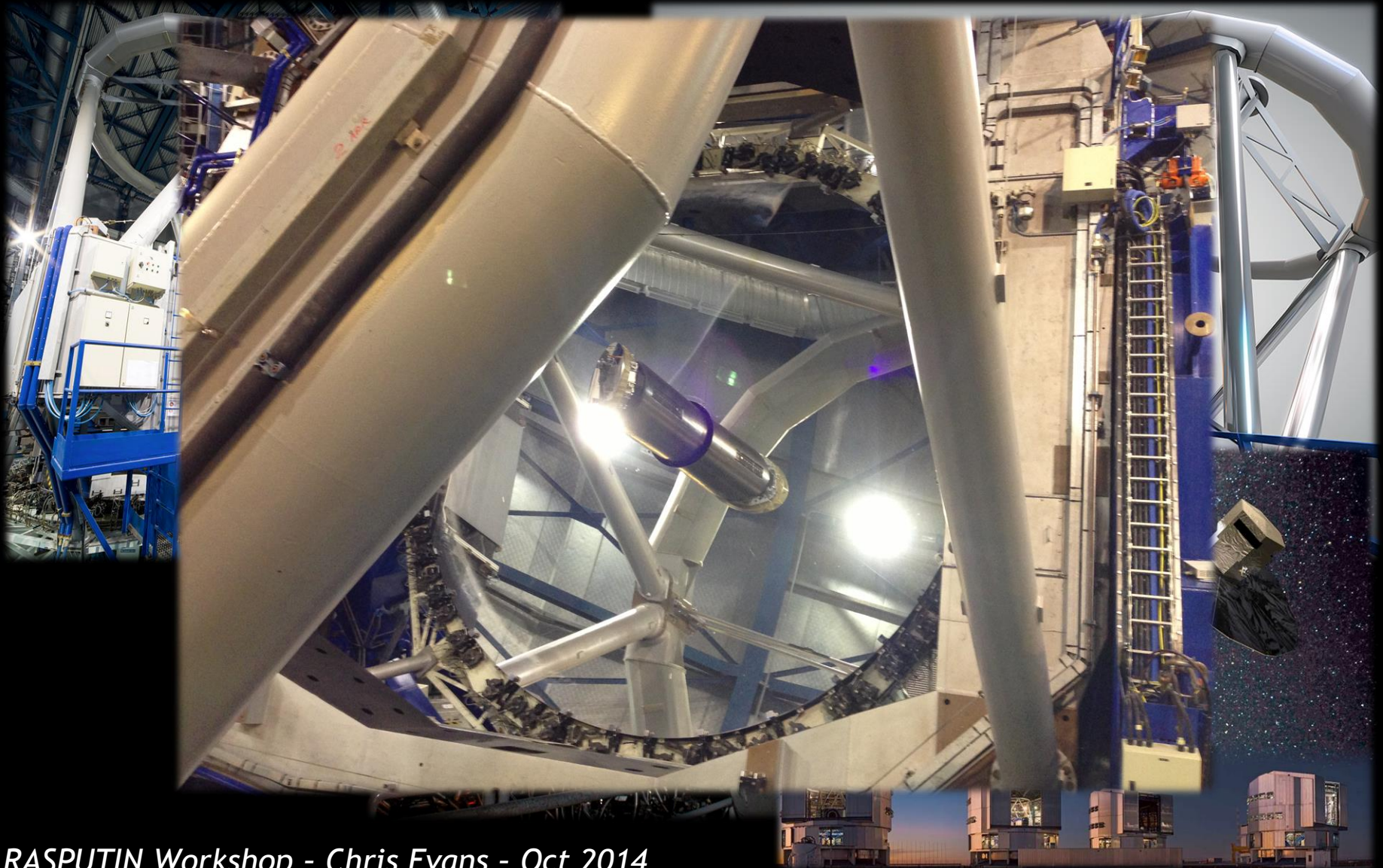
East of Eden, John Steinbeck



Getting the most from the VLT



Getting the most from the VLT

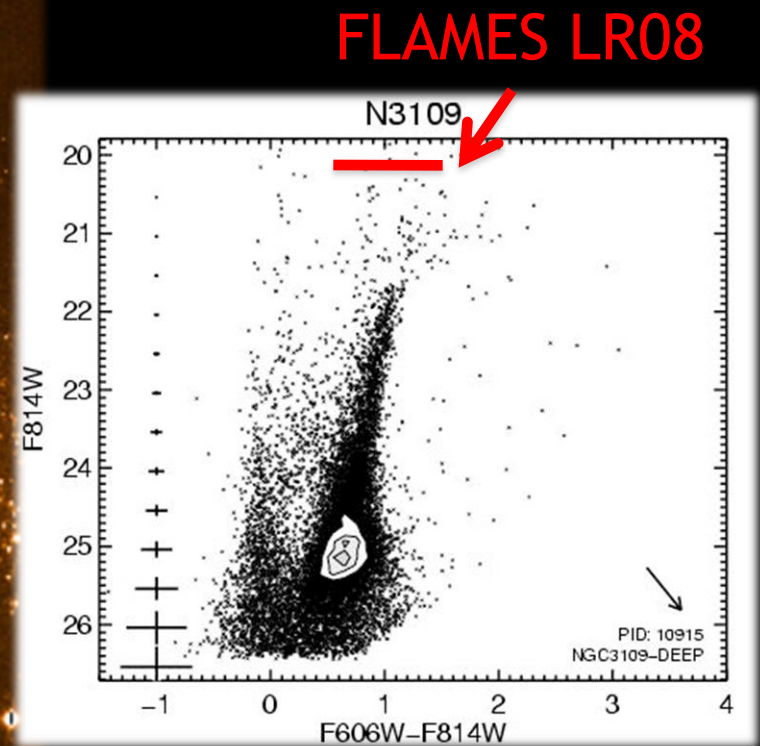


RASPUTIN Workshop - Chris Evans - Oct 2014

Current limits

NGC 3109

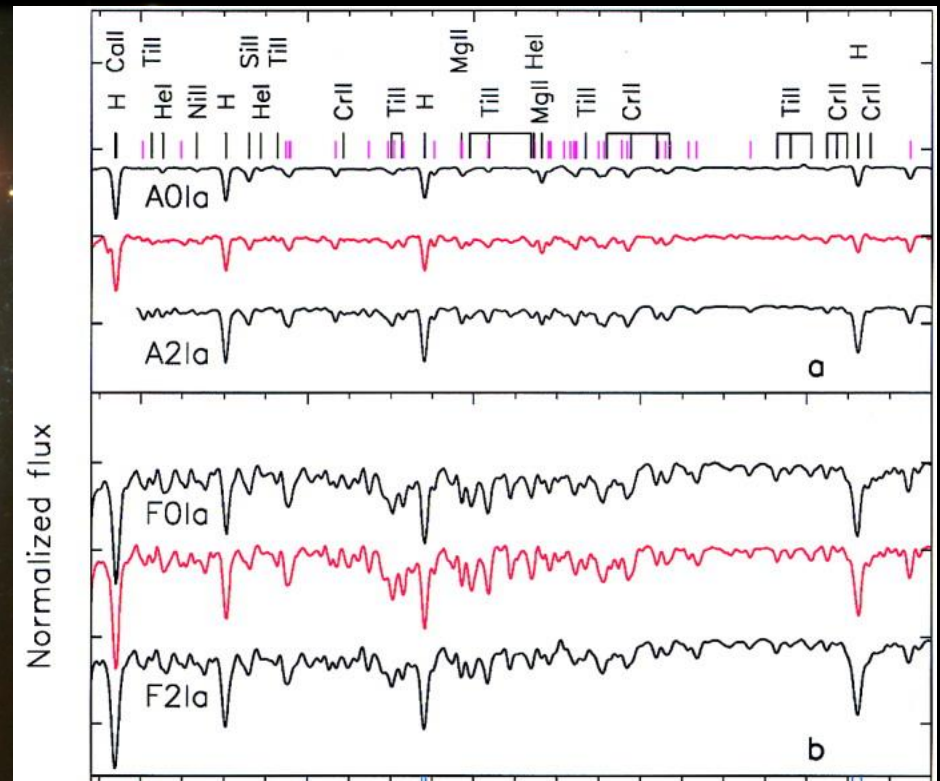
FORS V-band (Evans et al. 2007)



Dalcanton et al. (2009)

Current limits

NGC 3621



Bresolin et al. (2001); Kudritzki et al. (2014)

MOS requirements

Multi-Object Spectroscopy with the European ELT: Scientific synergies between EAGLE & EVE

C. J. Evans¹, B. Barbuy², P. Bonifacio³, F. Chemla³, J.-G. Cuby⁴, G. B. Dalton^{5,6}, B. Davies⁷,
K. Disseau³, K. Dohlen⁴, H. Flores³, E. Gendron⁸, I. Guinouard³, F. Hammer³, P. Hastings¹,
D. Horville³, P. Jagourel³, L. Kaper⁹, P. Laporte³, D. Lee¹, S. L. Morris¹⁰, T. Morris¹⁰,
R. Myers¹⁰, R. Navarro¹¹, P. Parr-Burman¹, P. Petitjean¹², M. Puech³, E. Rollinde¹², G. Rousset⁸,
H. Schnetler¹, N. Welikala¹³, M. Wells¹, Y. Yang^{3,14}

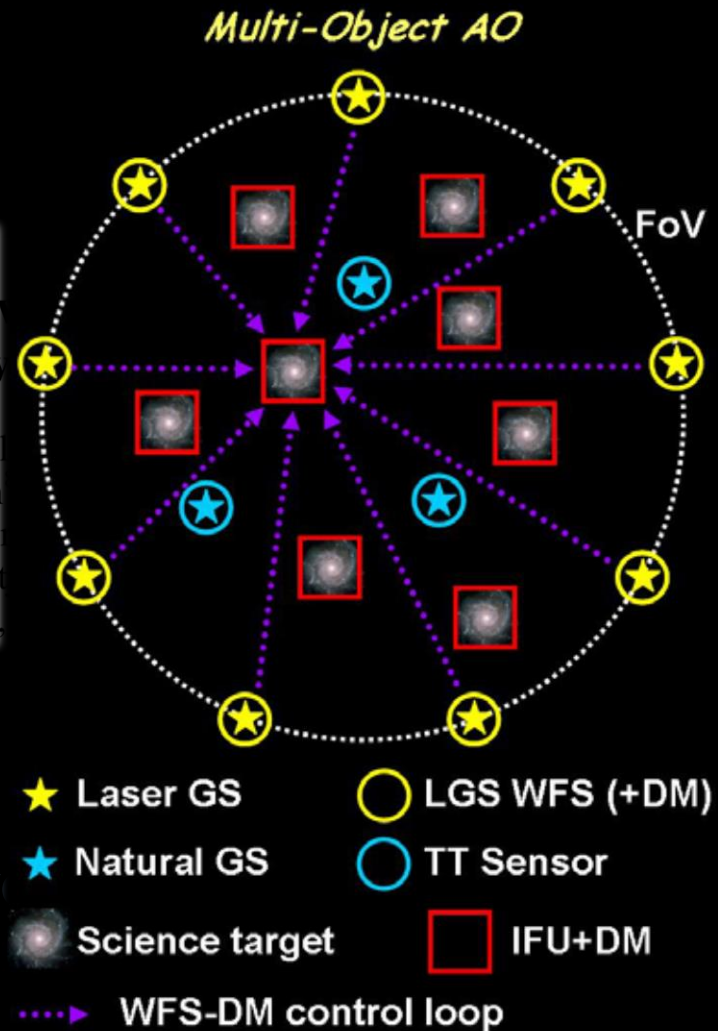
Evans et al. (2012)

- *High multiplex:*
Integrated-light (GLAO) spectroscopy of >100 objects
- *High definition:*
Tens of channels using high-performance (multi-object) AO

MOS requirements

Multi-Object Spectroscopy Scientific synergies between

C. J. Evans¹, B. Barbuy², P. Bonifacio³, F. Chem
K. Disseau³, K. Dohlen⁴, H. Flores³, E. Gendron
D. Horville³, P. Jagourel³, L. Kaper⁹, P. Lapo
R. Myers¹⁰, R. Navarro¹¹, P. Parr-Burman¹, P. Petit
H. Schnetler¹, N. Welikala¹³



© E. Marchetti / ESO / 2005

- *High multiplex:*
Integrated-light (GLAO) spectr
- *High definition:*
Tens of channels using high-performance (multi-object) AO

MOSAIC requirements



MOSAIC

MOS workshop in A'dam (Oct'12)

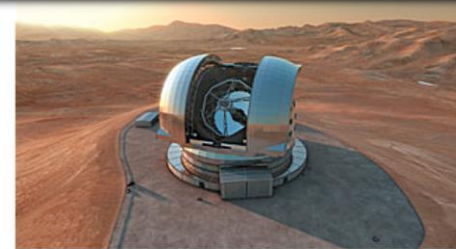
Meetings in UK, Ita, Fra, Bra, NL

New Science Simulations

'ELT-MOS White Paper'

Updates to White Paper

Phase A call; White Paper v2



Document Title	ELT-MOS White Paper: Science Overview & Requirements
Issue	1.0
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Editors	Chris Evans (UK ATC) & Mathieu Puech (GEPI)

Contributors:

Beatriz Barbay, Nate Bastian, Piercarlo Bonifacio, Elisabetta Caffau, Jean-Gabriel Cuby, Gavin Dalton, Ben Davies, Jim Dunlop, Chris Evans, Hector Flores, Francois Hammer, Lex Kaper, Bertrand Lemasle, Simon Morris, Laura Pentericci, Patrick Petitjean, Mathieu Puech, Daniel Schaerer, Eduardo Telles, Niraj Welikala, Bodo Ziegler

arXiv:1303.0029

arXiv:1406.6369

Science Case and Requirements for the MOSAIC Concept for a Multi-Object Spectrograph for the European Extremely Large Telescope

C. J. Evans¹, M. Puech², B. Barbay³, P. Bonifacio², J.-G. Cuby⁴, E. Guenther⁵, F. Hammer², P. Jagourel², L. Kaper⁶, S. L. Morris⁷, J. Afonso⁸, P. Amram⁴, H. Aussel⁹, A. Basden⁷, N. Bastian¹⁰, G. Battaglia¹¹, B. Biller¹², N. Bouché¹³, E. Caffau², S. Charlot¹⁴, Y. Clenet¹⁵, F. Combes¹⁶, C. Conselice¹⁷, T. Contini¹³, G. Dalton^{18,19}, B. Davies¹⁰, K. Disseau², J. Dunlop¹², F. Fiore²⁰, H. Flores², T. Fusco²¹, D. Gadotti²², A. Gallazzi²³, E. Giallongo²⁰, T. Gonçalves²⁴, D. Gratadour¹⁵, V. Hill²⁵, M. Huertas-Company², R. Ibata²⁶, S. Larsen²⁷, O. Le Fèvre⁴, B. Lemasle⁶, C. Maraston²⁸, S. Mei², Y. Mellier¹⁴, G. Östlin²⁹, T. Paumard¹⁵, R. Pello¹³, L. Pentericci²⁰, P. Petitjean¹⁴, M. Roth³⁰, D. Rouan¹⁵, D. Schaerer³¹, E. Telles³², S. Trager³³, N. Welikala¹⁸, S. Zibetti²³, B. Ziegler³⁴

MOSAIC: The MOS for the E-ELT



Table 3: Summary of top-level requirements for the MOS. 'Desirable' requirements are shown in italics.

Case	Multiplex	Field size	λ -coverage (μm)	R
SC1 <i>First light</i>	20-40	40-100 mas	1.0-1.8 <i>1.0-2.45</i>	5,000
SC2	$2'' \times 2''$	(GLAO – 0.6'' ϕ)	1.0-1.8 <i>1.0-2.45</i>	$>3,000$
SC3	—	(GLAO – IFU)	0.4-1.0 <i>0.37-1.0</i>	$>3,000$
SC4	—	(GLAO)	0.6-1.8 <i>0.6-2.45</i>	$>3,000$
SC5	≥ 10	$2'' \times 2''$	1.0-1.8 <i>1.0-2.45</i>	5,000
SC6	≥ 100	—	1.0-1.7 <i>0.8-2.45</i>	$\geq 5,000$ <i>$\sim 10,000$</i>
SC7	~ 10 per field	$2'' \times 2''$	≤ 100 mas	1.0-1.8 $>3,000$
SC8	10s per field	—	(GLAO)	0.5-0.6 $\geq 20,000$

Note: Minimum target size for SC1 is reduced to 1''x1'' if on/off sky subtraction is used.

Reader beware...
A wish list, not a set of instrument specs!

SC5: Resolved stellar pops beyond the Local Group

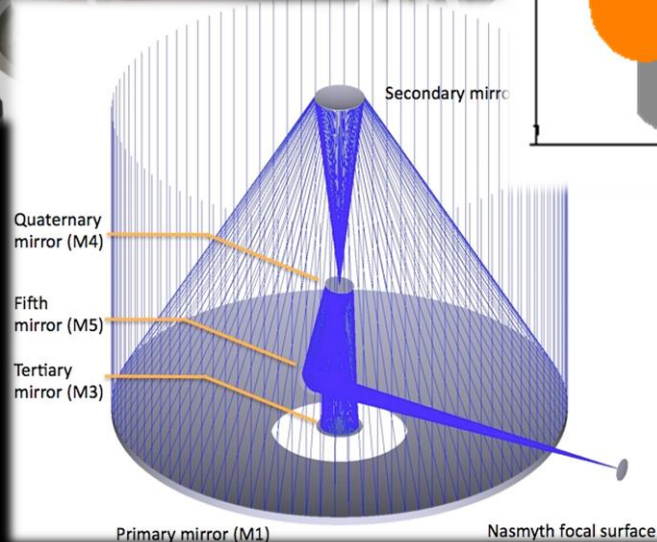
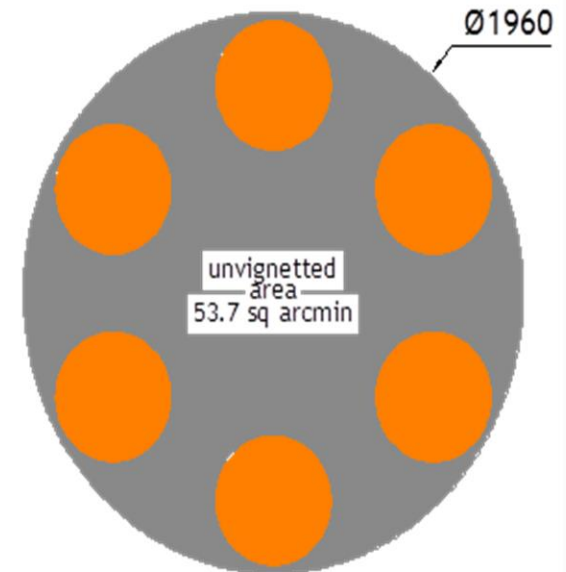
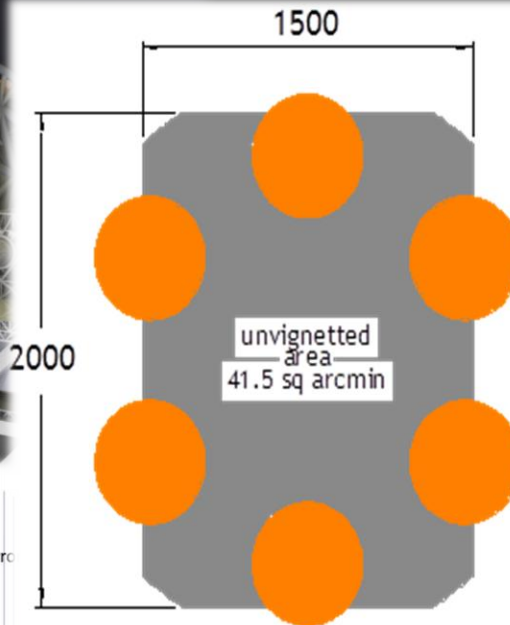
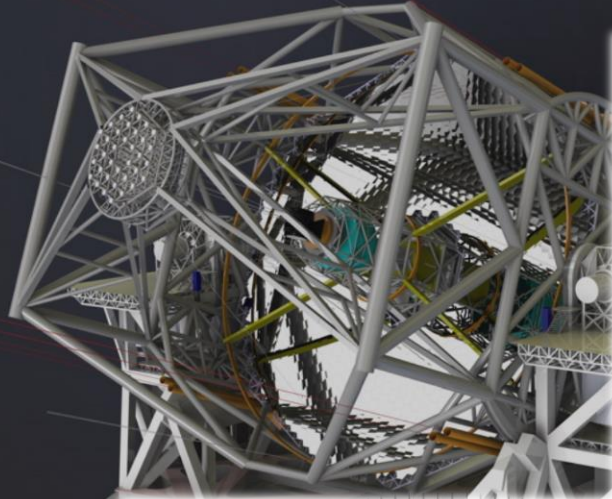
> 1 Mpc

SC6: Galaxy archaeology

< 1 Mpc

arXiv:1406.6369

E-ELT is designed for a 'wide' field

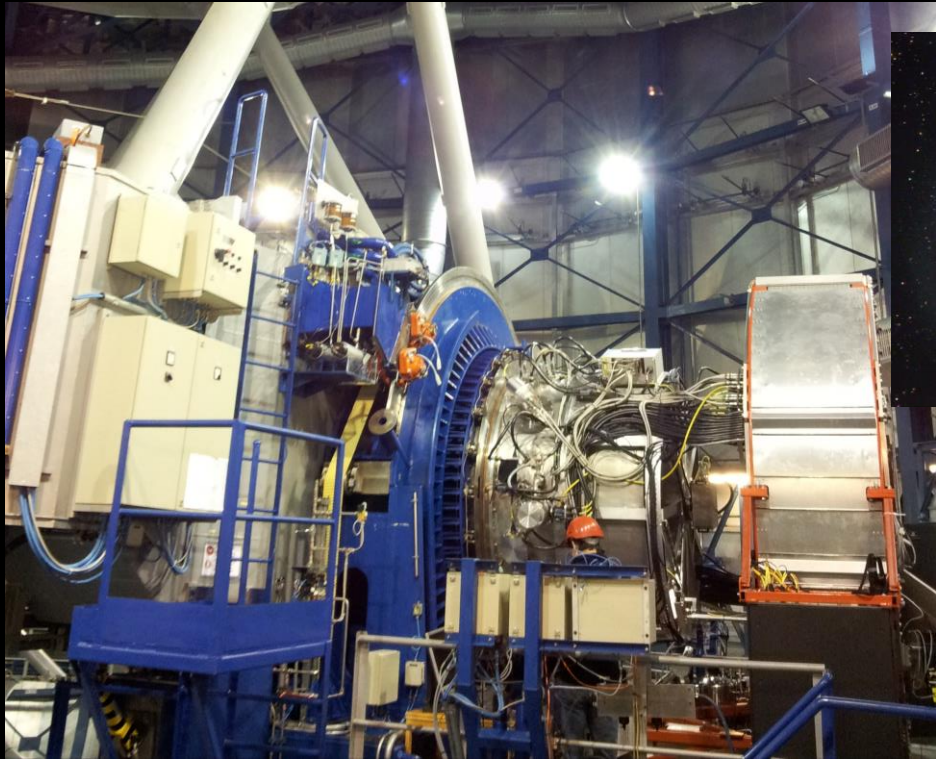


'...very nearly diffraction limited over entire 10-arcmin field of view'

*SC5: Resolved stellar populations beyond
the Local Group*

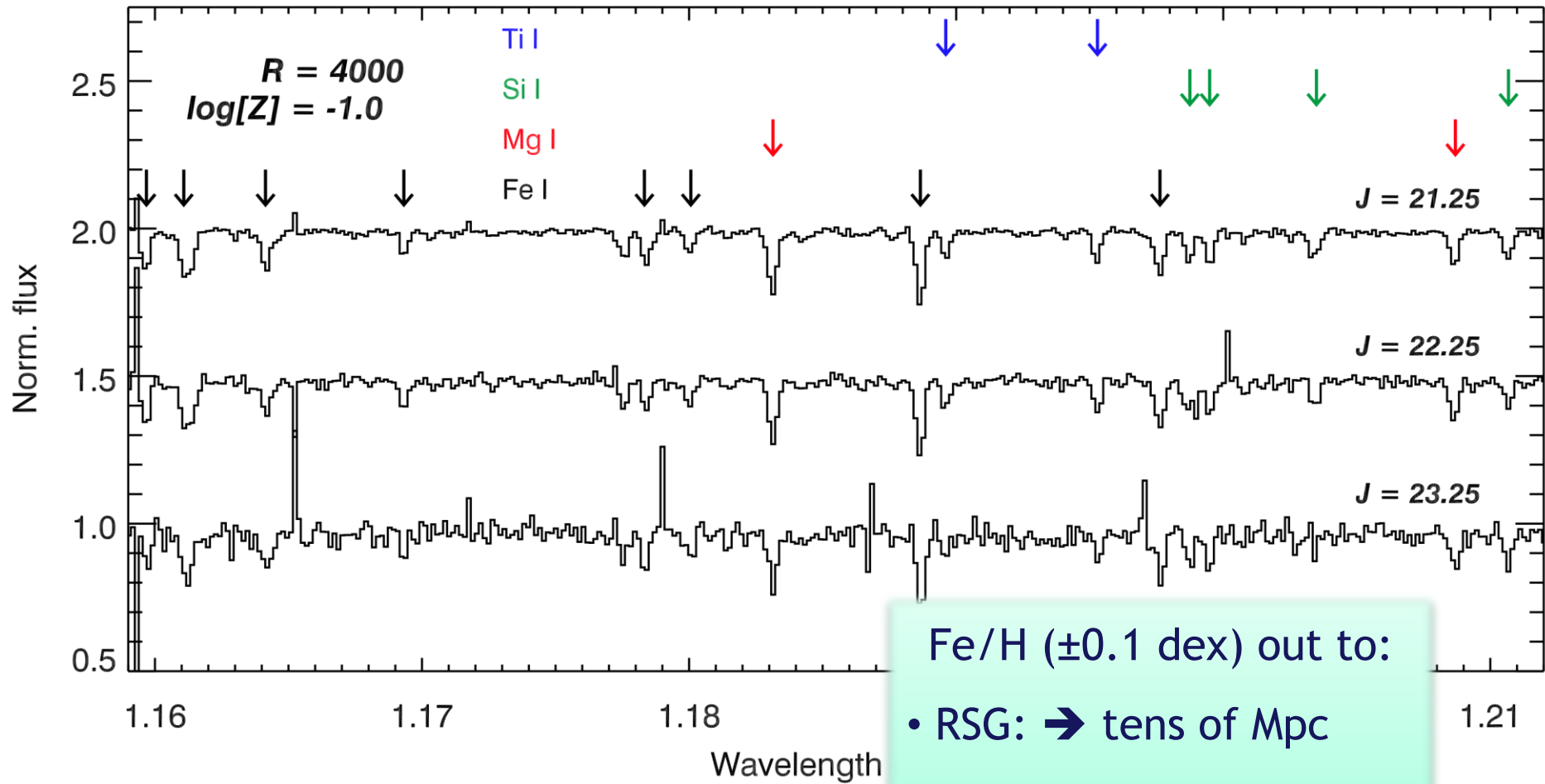
Near-IR spectroscopy of RSGs

KMOS GT
Joint UK/DE programme
(Evans/Kudritzki)



E-ELT spectroscopy beyond 1Mpc

Evans et al. (2011)



Fe/H (± 0.1 dex) out to:

- RSG: $\rightarrow$ tens of Mpc
- RGB: ≈ 2.5 Mpc
- TRGB: ≈ 4 Mpc

E-ELT spectroscopy beyond 1Mpc

RSGs

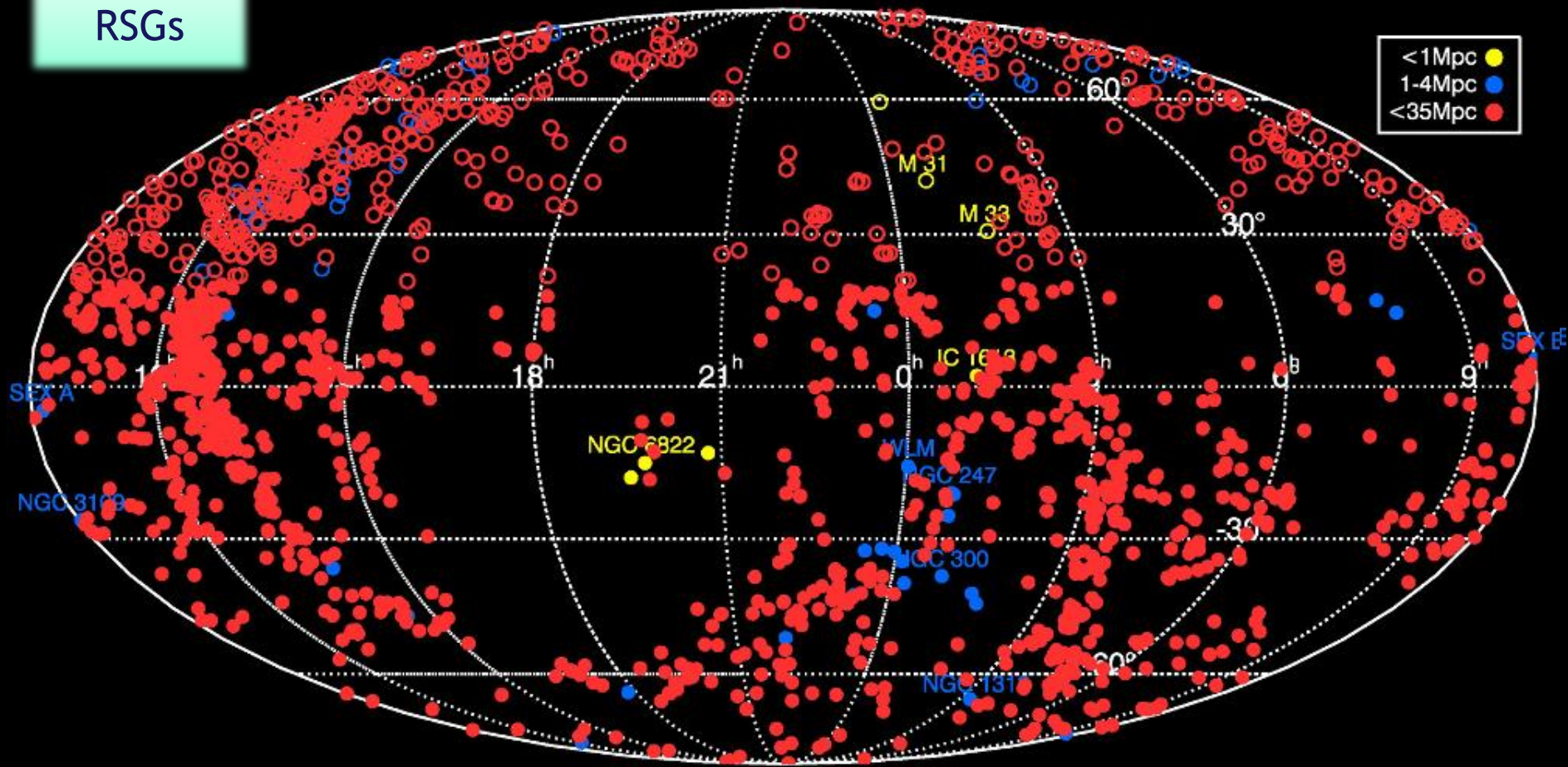


Image credit: Ben Davies

E-ELT spectroscopy beyond 1Mpc

RGB/AGB

NGC0247

NGC0055

disk

wide3
wide2
wide1

NGC0253

NGC0300

NGC7793

halo6
halo7

halo12
halo11
halo8
wide1
wide2
wide3
wide4
wide5
halo18

wide1
wide2
wide3

E-ELT spectroscopy beyond 1Mpc

RGB/AGB

Sombrero Galaxy • M104

halo12

NGC0253

NGC0055

disk

& into semi-resolved regime

wide1

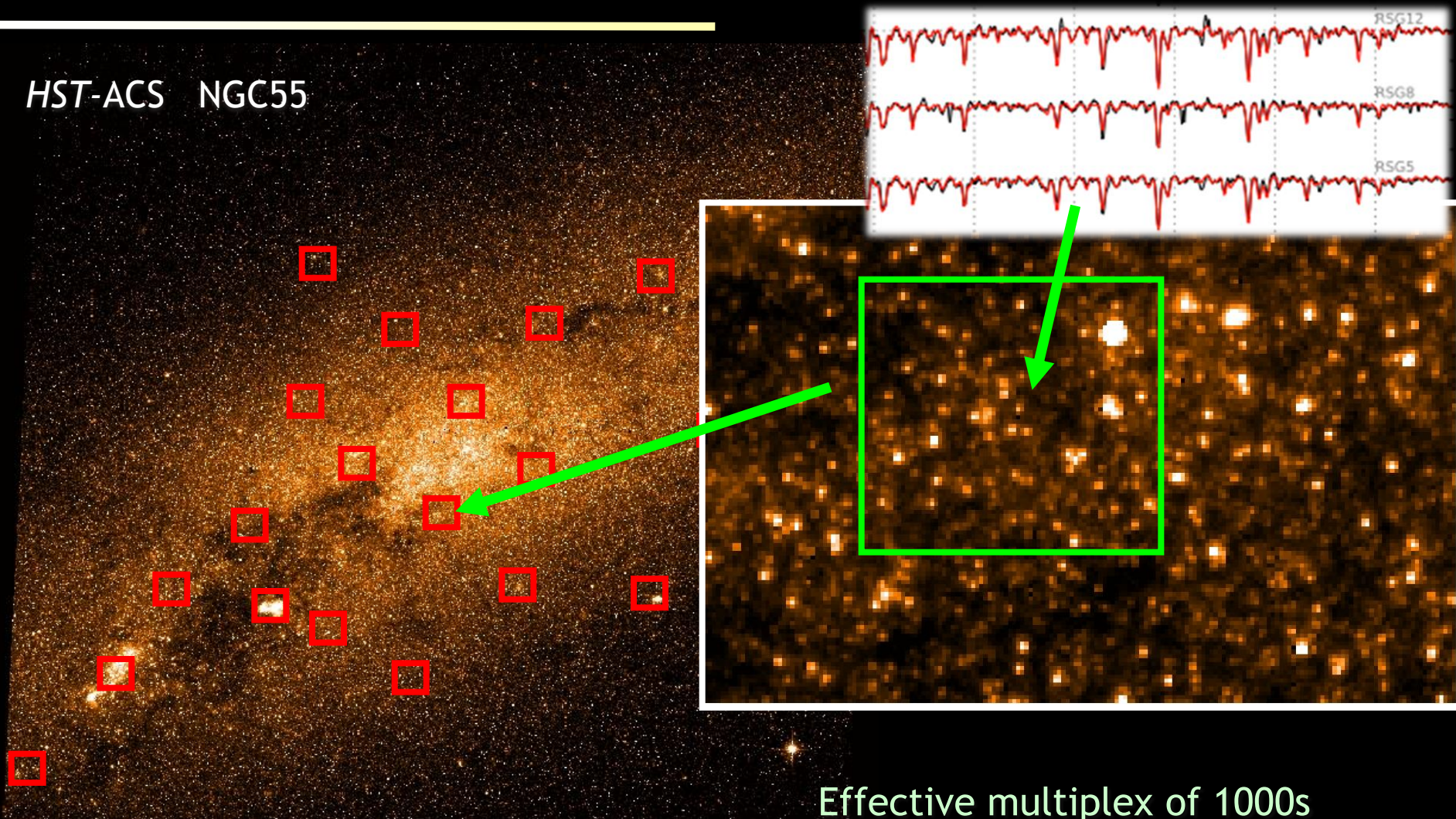
wide2

wide3

Hubble
Heritage

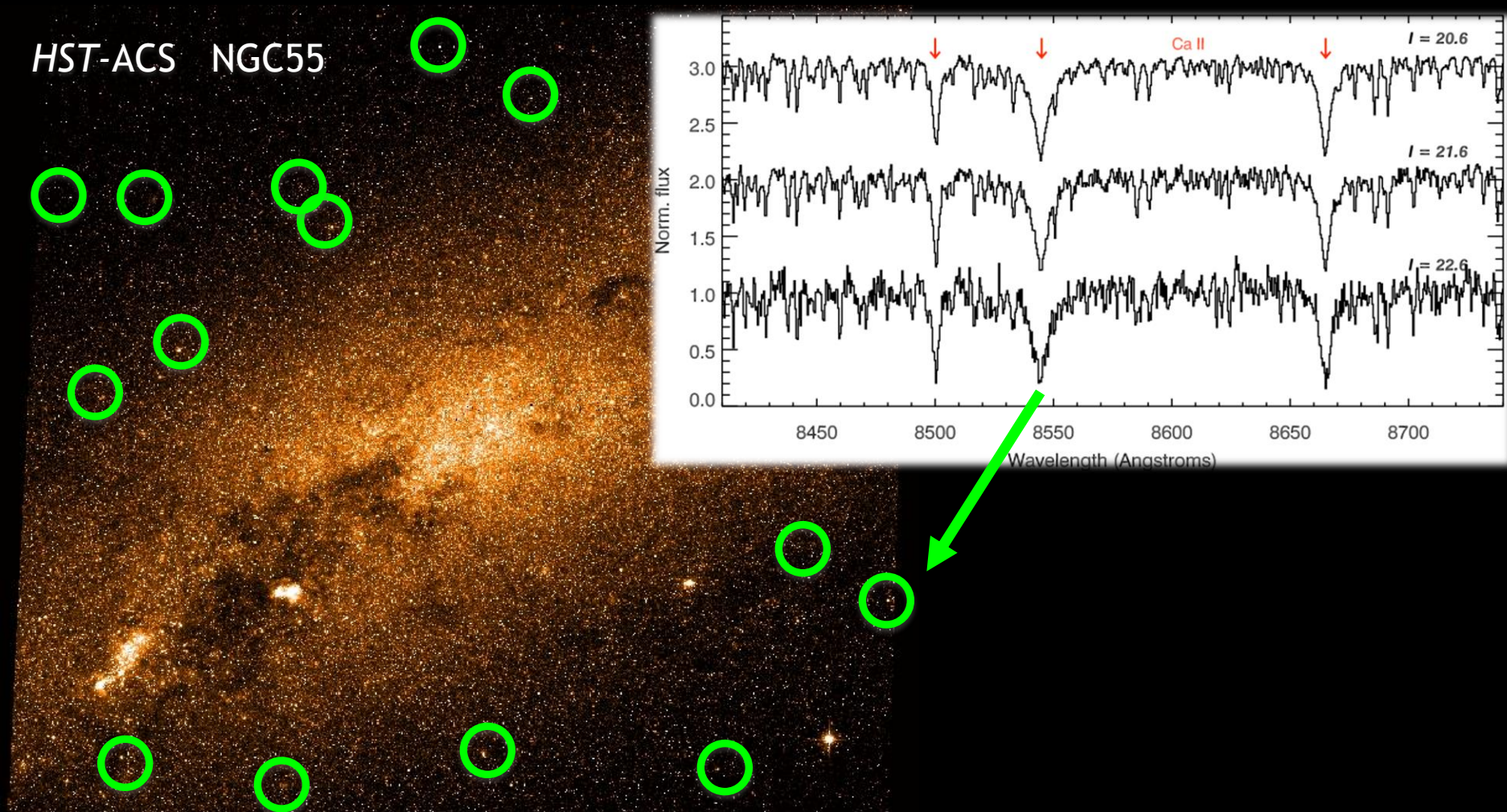
MOAO spectroscopy beyond 1Mpc

HST-ACS NGC55

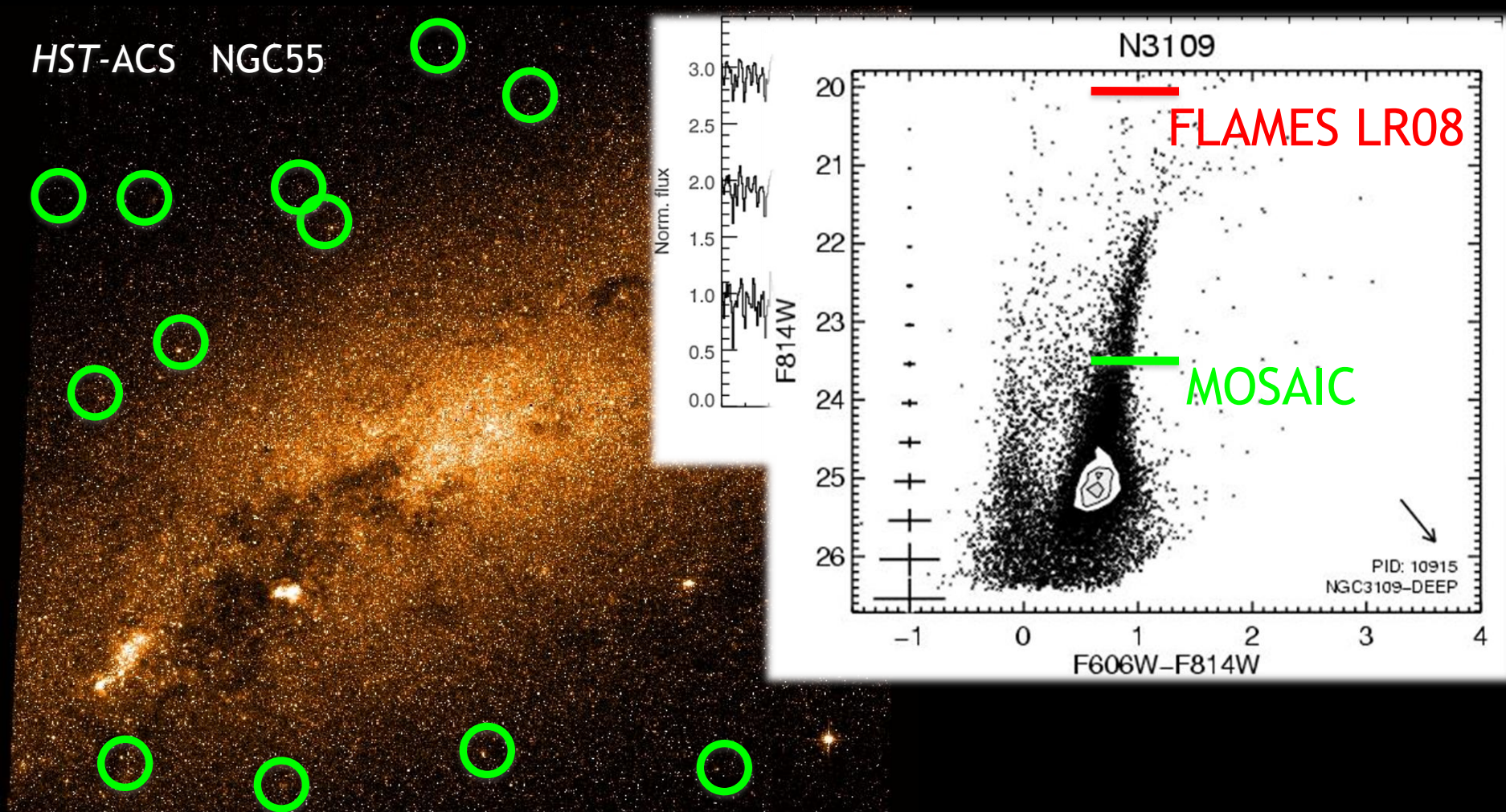


Effective multiplex of 1000s

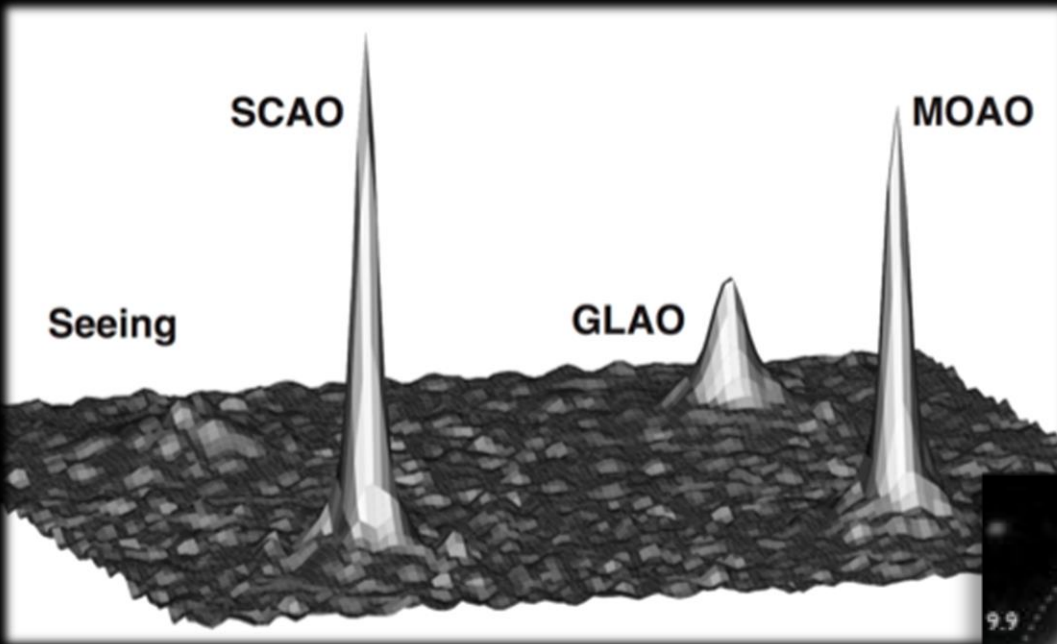
GLAO spectroscopy beyond 1Mpc



GLAO spectroscopy beyond 1Mpc



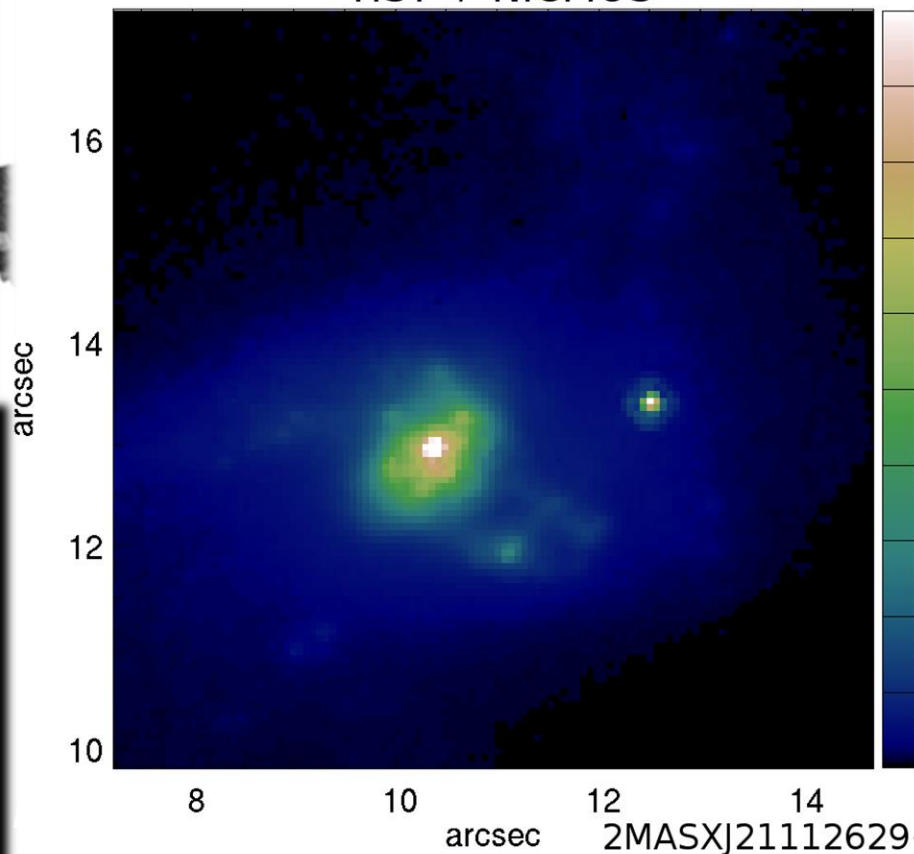
Technical challenges: AO



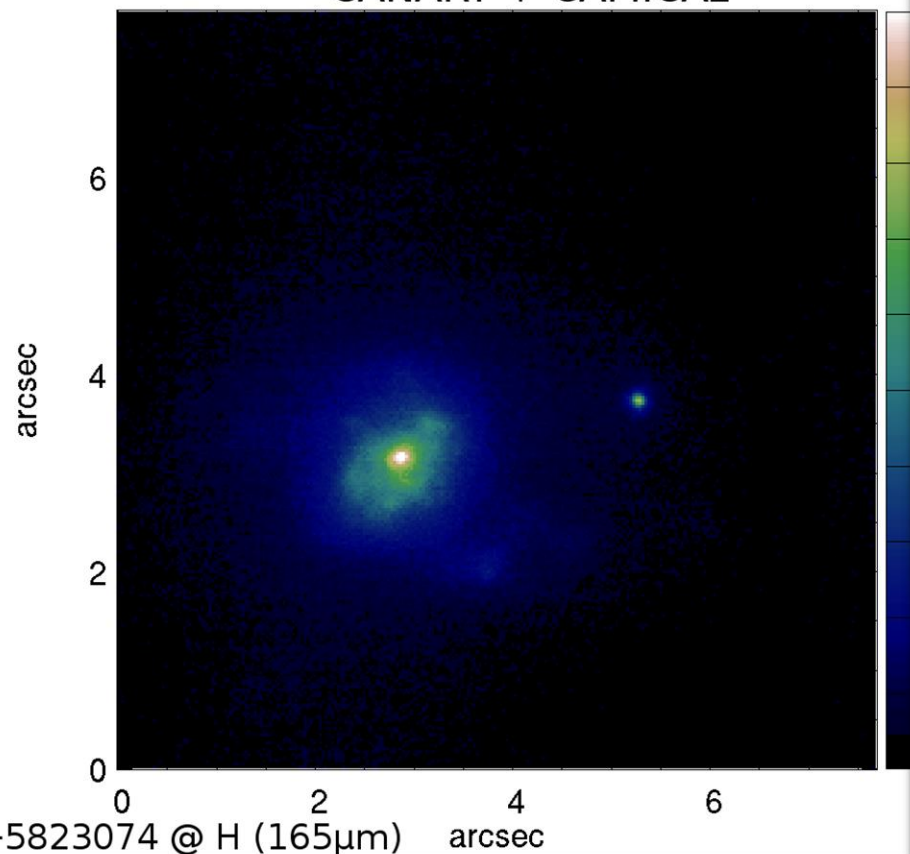
Gendron et al. (2011)



Technical challenges: AO



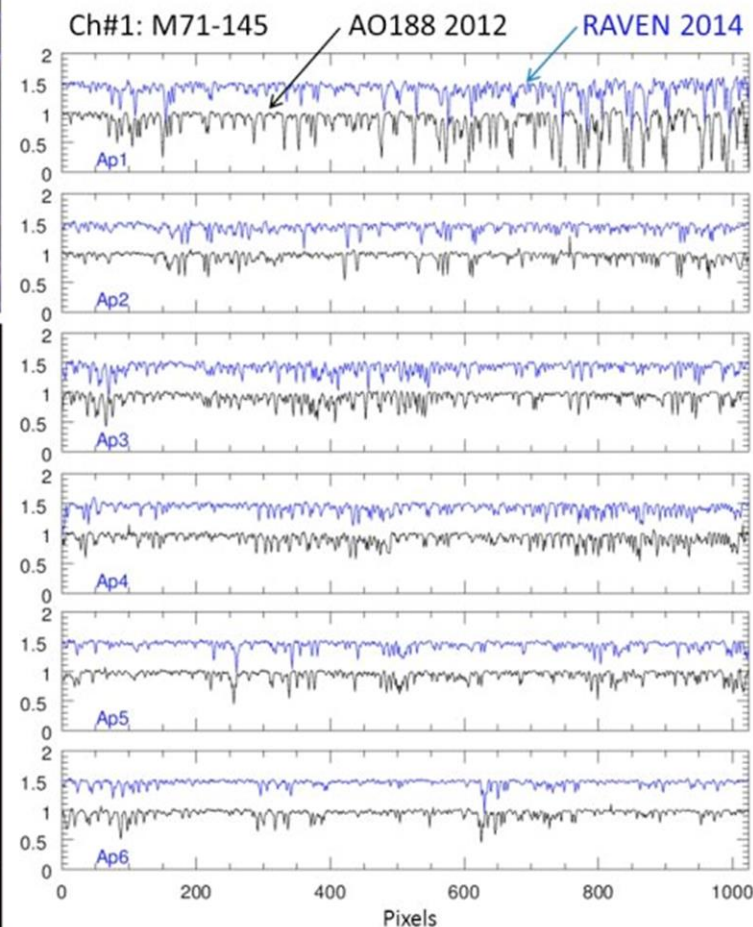
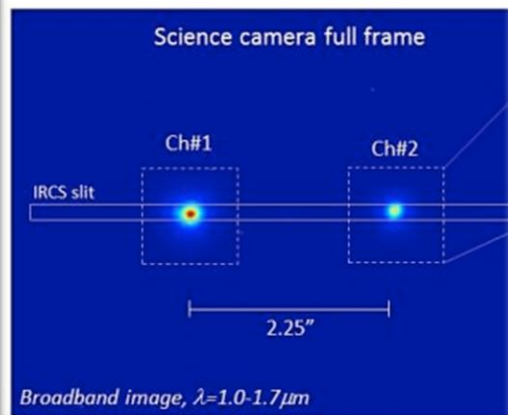
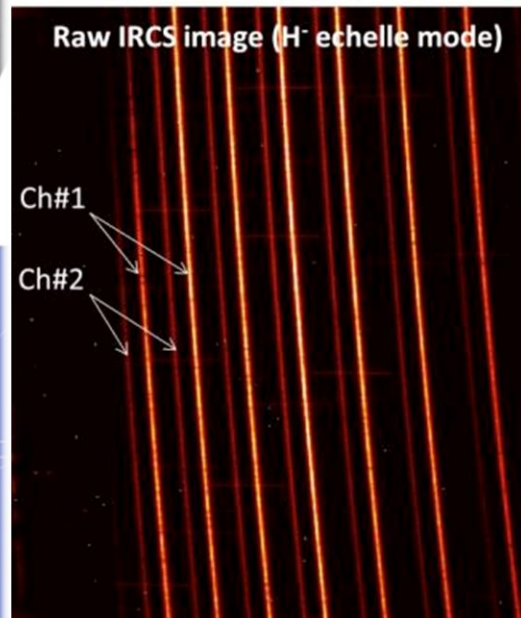
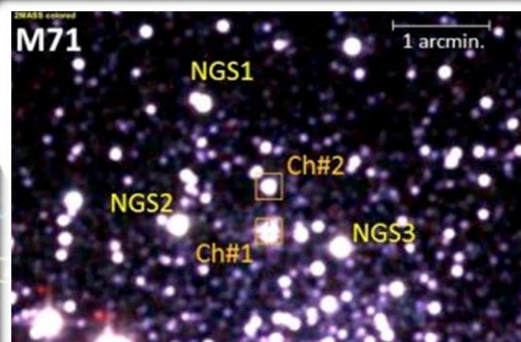
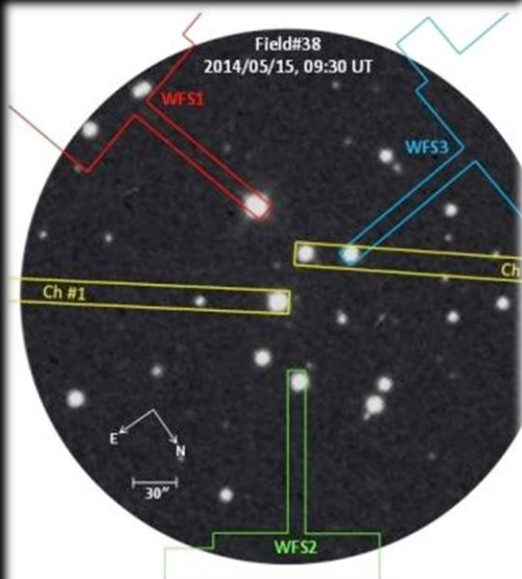
CANARY + CAMICaz



Technical challenges: AO

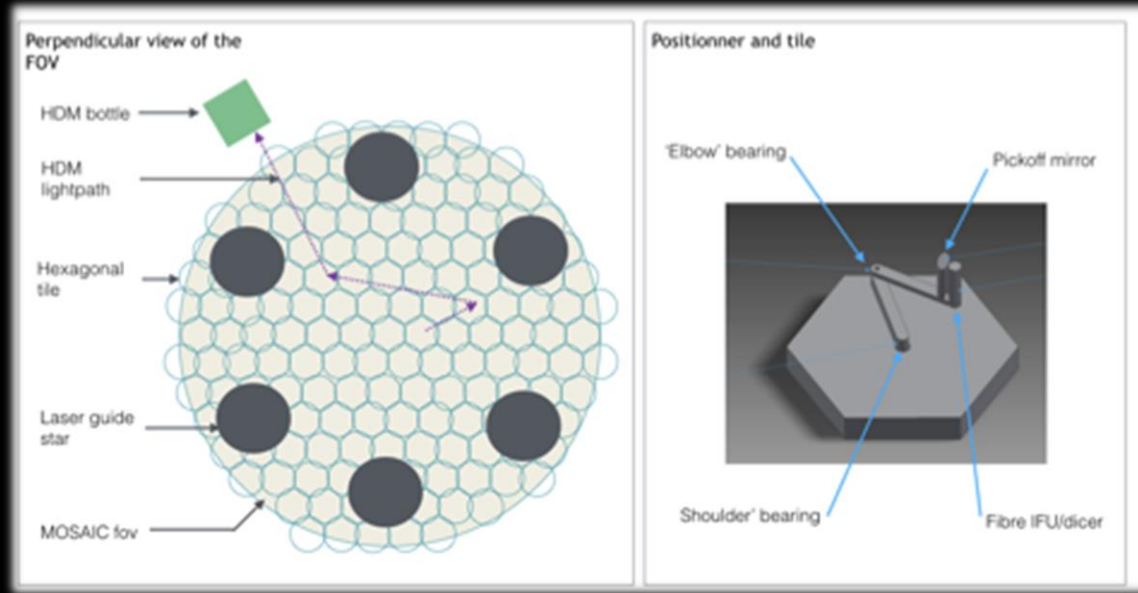


University of Victoria
AO Lab



Conceptual design

Design work ongoing - one possible focal-plane architecture:



Good alloc. efficiencies for high-z & stellar targets ✓

Avoids need for multiple plates/carousel ✓

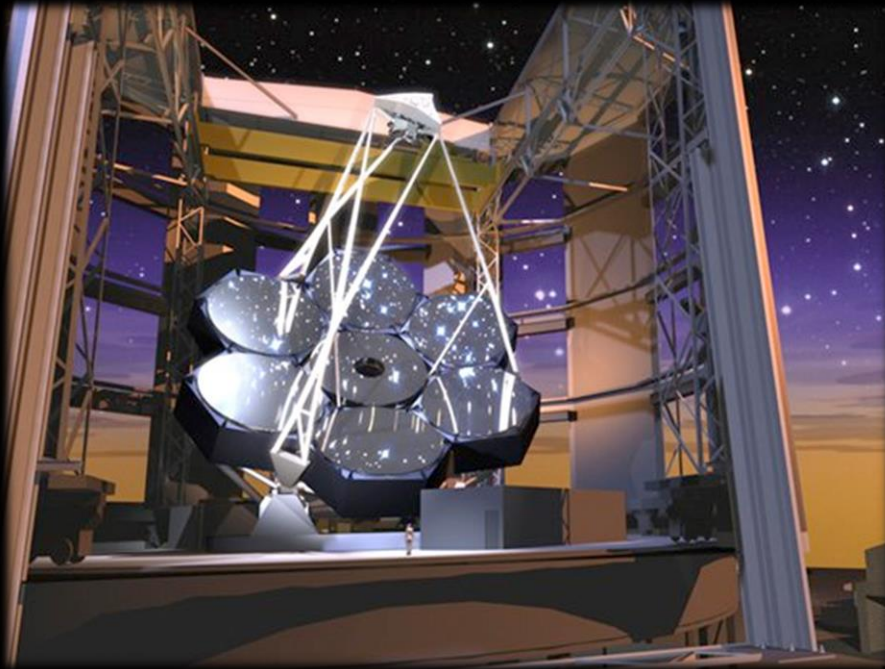
Potentially quicker target allocation ✓

The future...



‘ESO in the 2020s’

Competition/complementarity

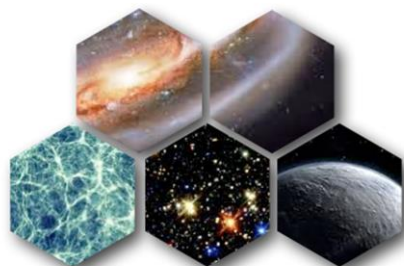


Synergies/opportunities



Summary

- MOS instruments are the workhorses of the 8-10m
- MOS instruments early-on in GMT and TMT plans
- Huge potential for stellar spectroscopy with E-ELT + MOSAIC
- White Paper presenting top-level cases
- Phase A study coming soon...



MOSAIC

