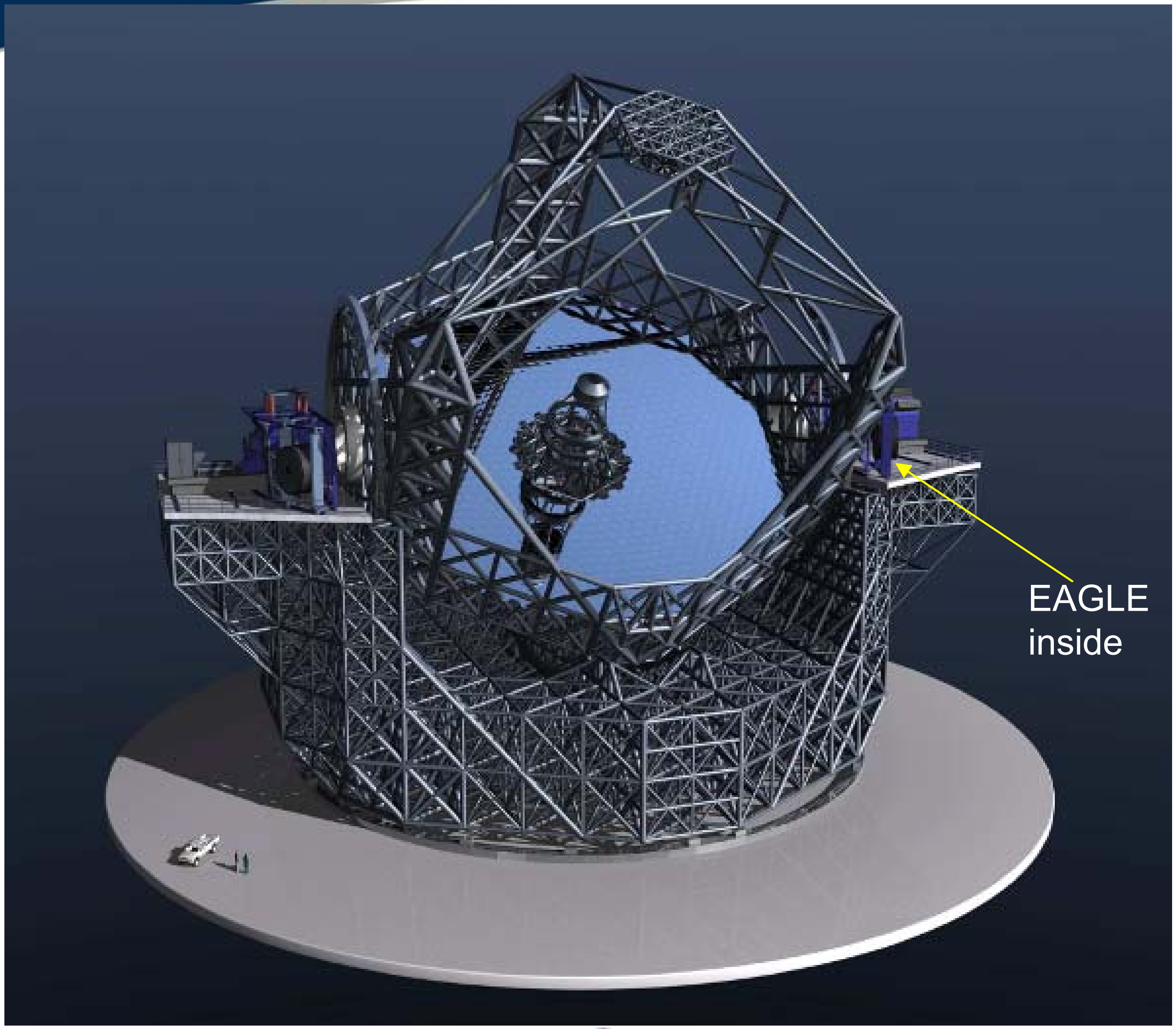
EAGLE: an MOAO fed dIFU working in the NIR on the E-ELT

Simon Morris (CfAI, Durham University)
For the EAGLE Consortium
Jean Gabriel Cuby PI

Outline

- The European Extremely Large Telescope
- The EAGLE Science Case (including why observe in the Near Infra-Red)
- The Challenge of Multi-Object Adaptive Optics
- CANARY on the William Herschel 4.2m Telescope
- The Target Acquisition System
- The deployable Integral Field Units and the Spectrographs
- Mechanical Support and Packaging
- Management
- Summary

The European Extremely Large Telescope



E-ELT baseline design
November 2006

M1 42m segmented
M2 6m monolithic, active
M4, M5 adaptive

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The EAGLE Science Case (including why observe in the Near Infra-Red)

E-ELT 'Prominent' Science Cases

- Planets and Stars:
  - Extrasolar Planets (S3)
  - Circumstellar disks (S9)
  - IMF in Stellar Clusters (S5)
- Stars and Galaxies:
  - Resolved Stellar Populations (G4)
  - Black Holes/AGN (G9)
- Galaxies and Cosmology
  - First light-the highest redshift galaxies (C4)
  - Studies of Absorption lines: Dynamical measurement of universal expansion,
  - IGM studies (C2, C7)
  - Physics of high redshift galaxies (C10)

Red Cases have common instrument requirements well served by EAGLE

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EAGLE Science Topics

Science areas that drive the EAGLE requirements:

- The evolution of distant galaxies
- Detection and characterisation of "first-light" galaxies
- The physics of galaxy evolution from stellar archaeology
- Star-formation, stellar clusters and the initial mass function
- Co-ordinated growth of black holes and galaxies

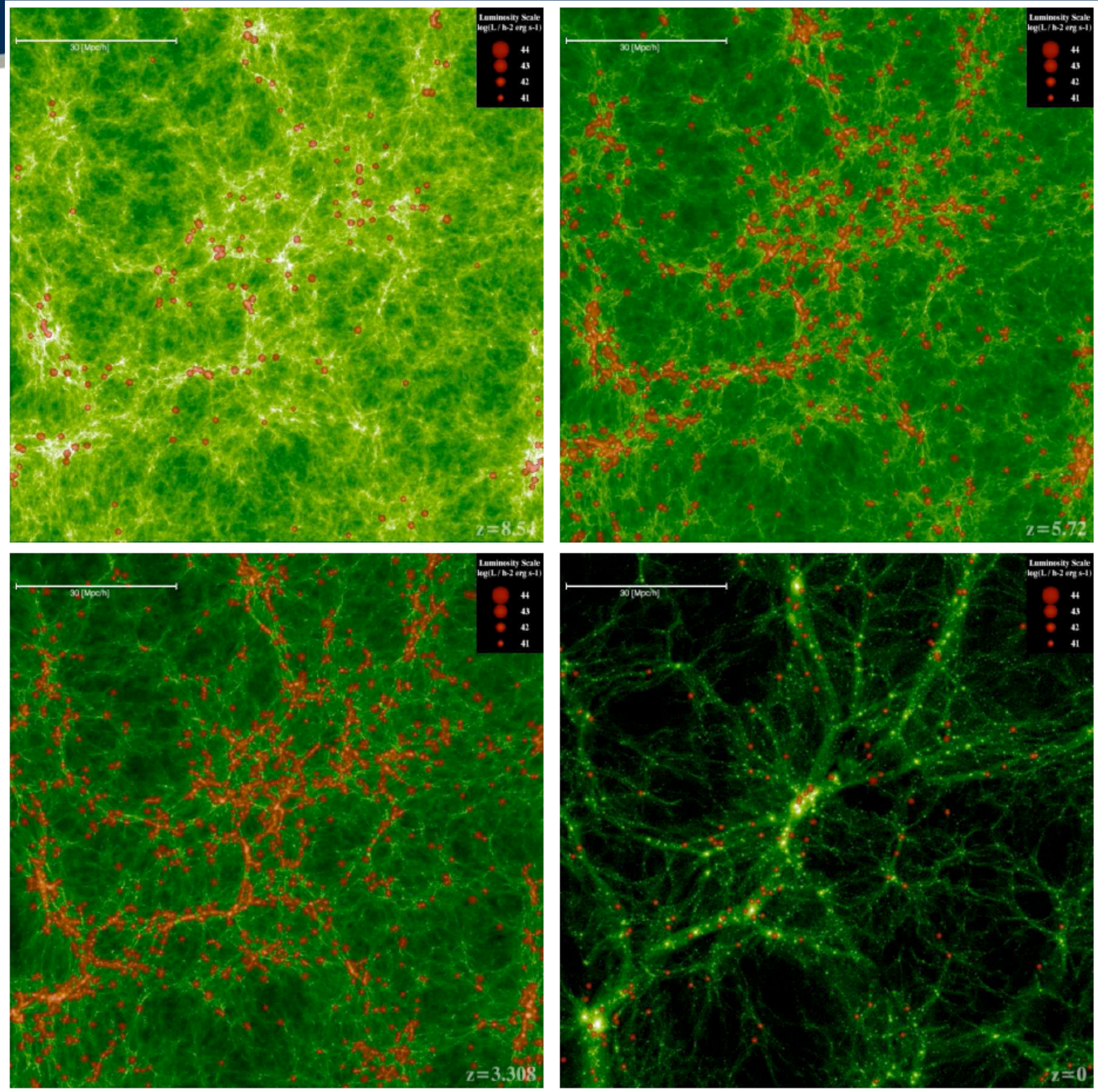
Full science case now under development…

The EAGLE Science Case (including why observe in the Near Infra-Red)

Z=8.5
(5 arcmin ~
9 Mpc
comoving)

Predicted
High-z
Lyman-α
Emitters
(red)
Lacey et al.

Z=3.3



Z=5.7

White bar
30 Mpc
comoving

Z=0

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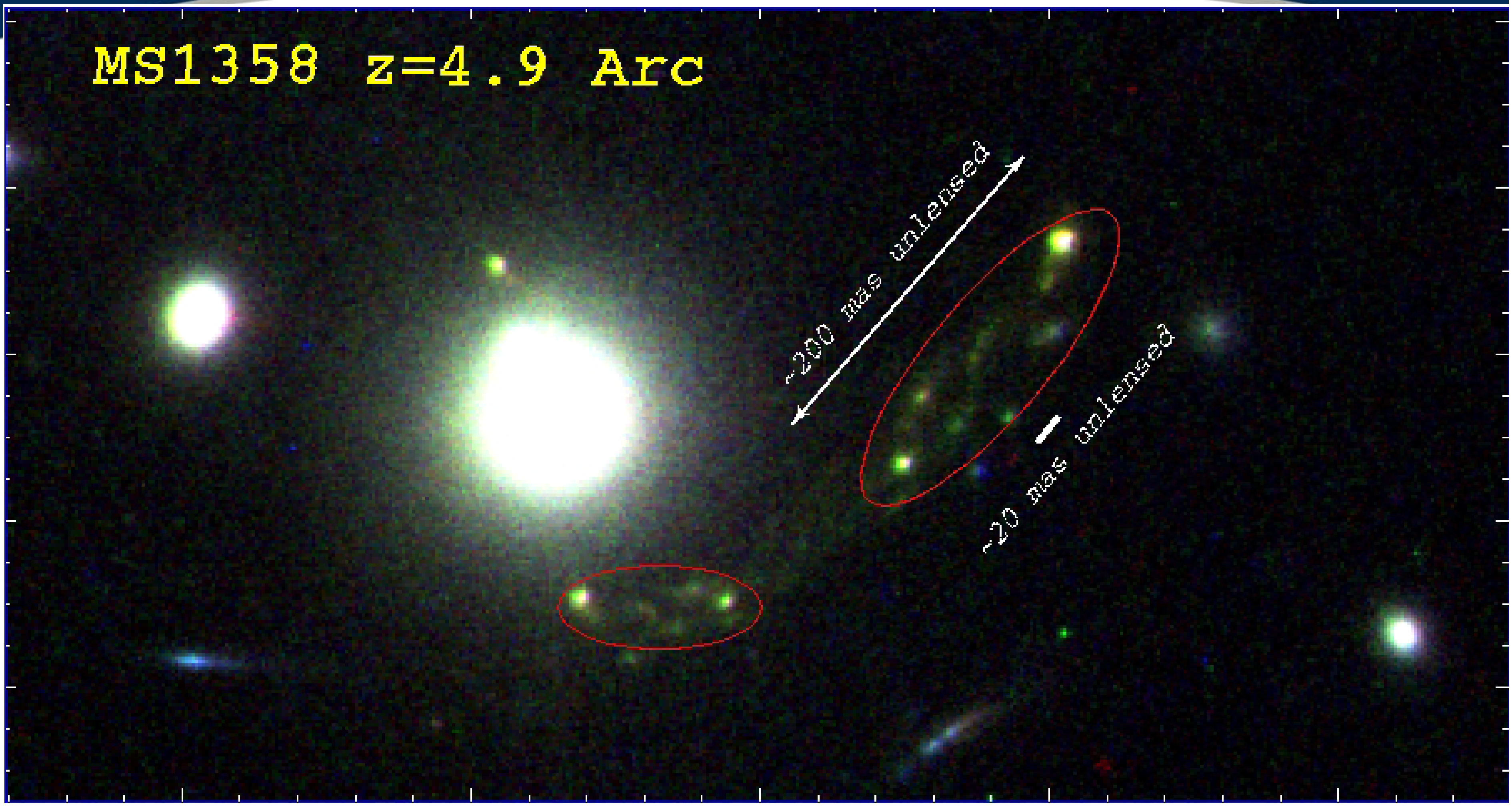
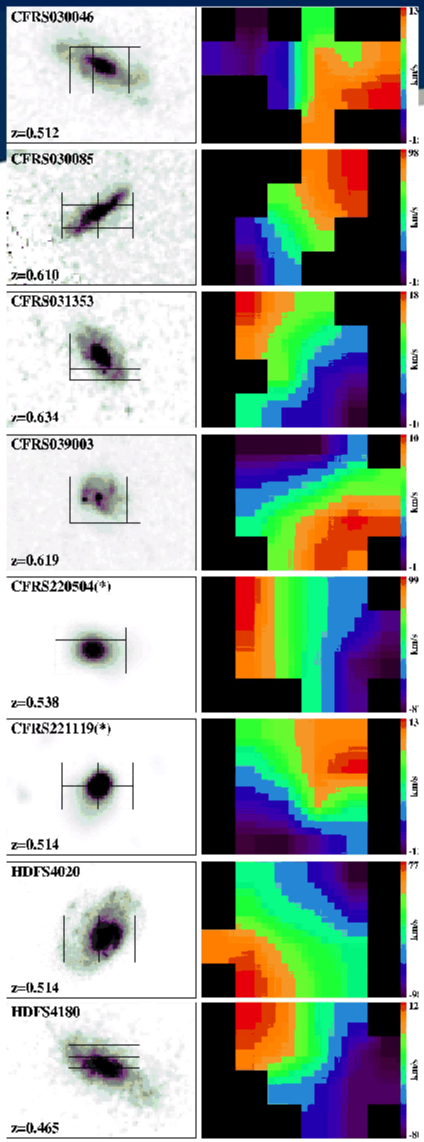


Evolution of Distant Galaxies



VLT-FLAMES, z~0.6
Flores et al. (2006)

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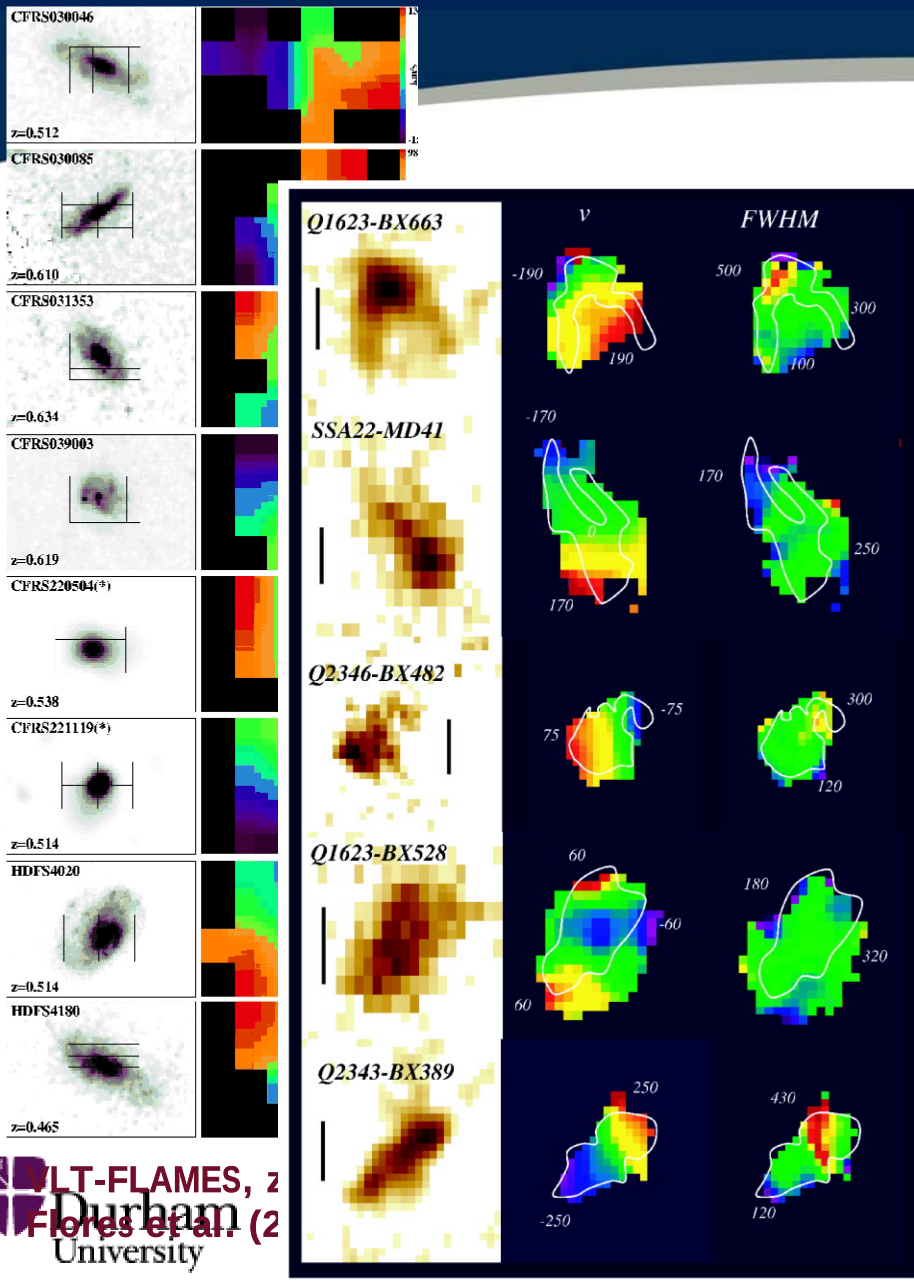
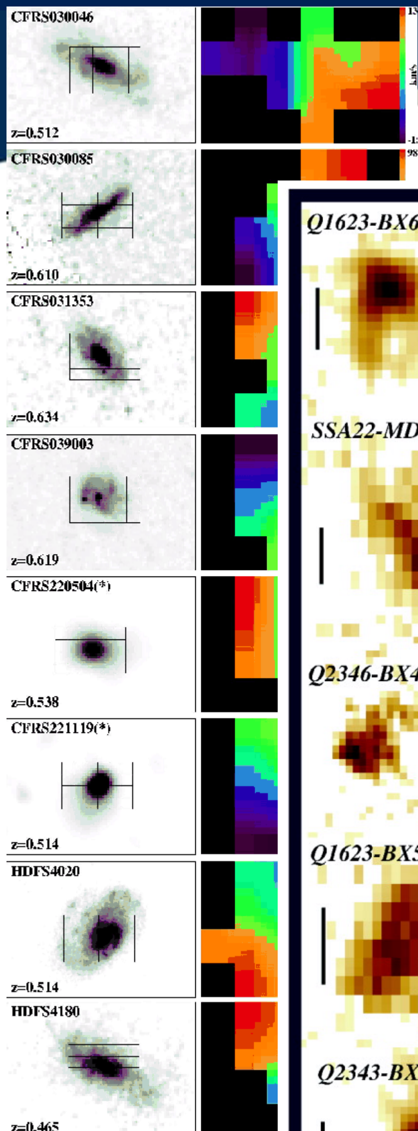
Evolution of Distant Galaxies



VLT-FLAMES, z
Flores et al. (2

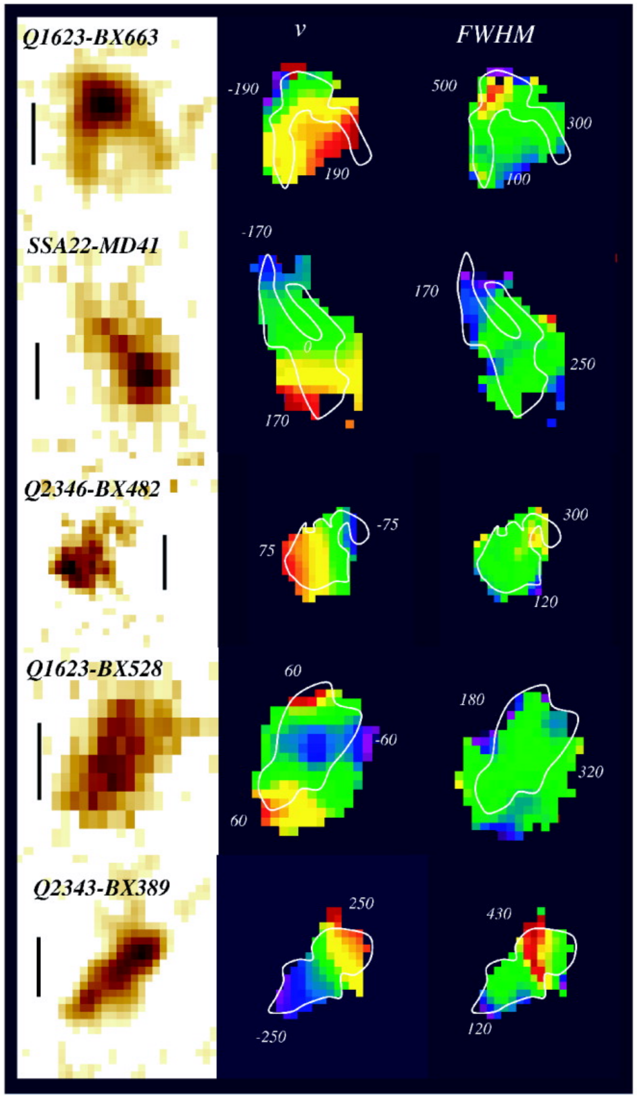
VLT-SINFONI, z~2
Forster-Schreiber et al. (2006)

Evolution of Distant Galaxies



VLT-FLAMES, z
Flores et al. (2

VLT-SINFONI, z~2
Forster-Schreiber et al. (2006)



How deep with 8-m class instruments?

- Flores et al. sample: I < 22.5
- KMOS sensitivities (5σ/8 hrs):
  - J = 22
  - H = 21
  - K = 20.5

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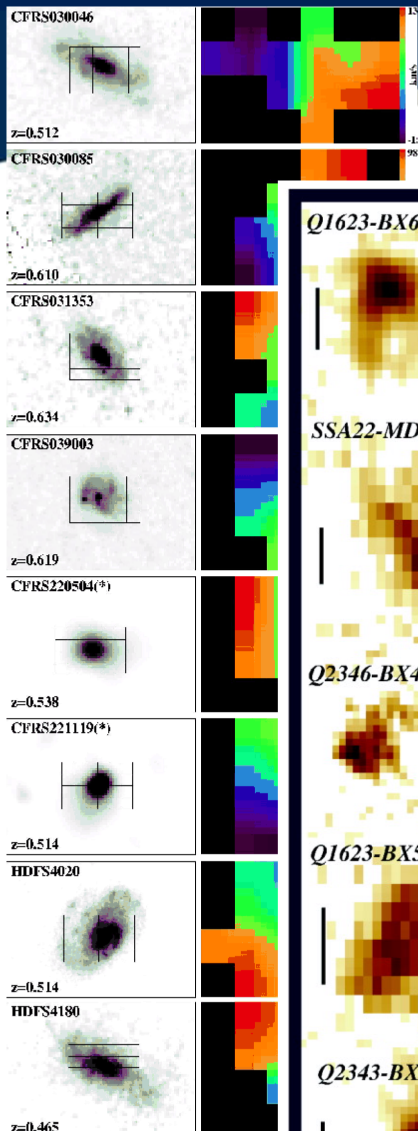
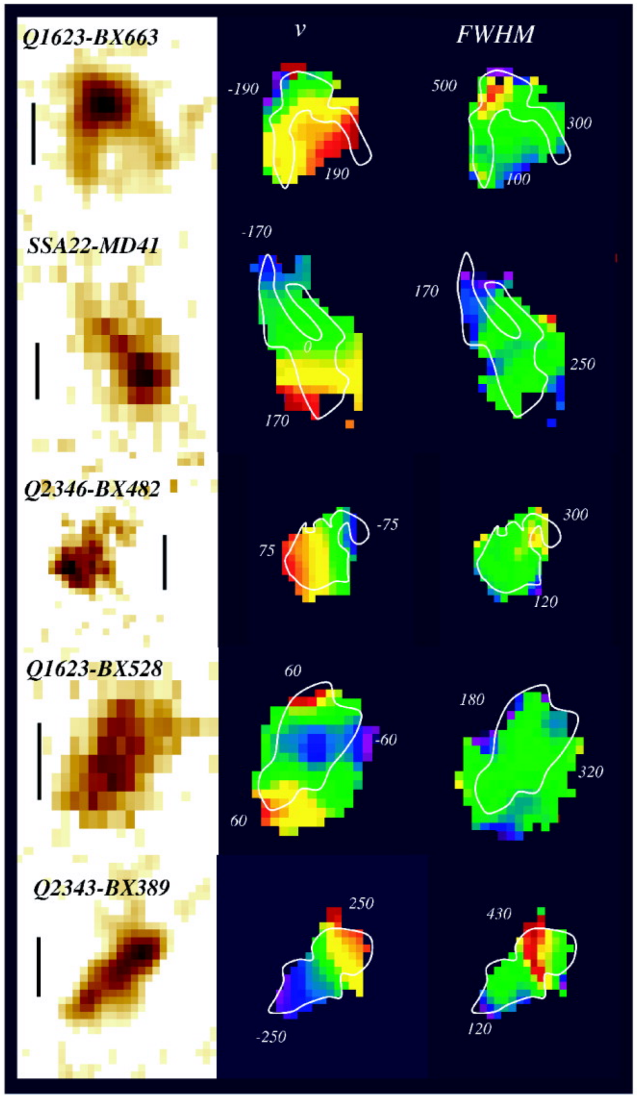
Evolution of Distant Galaxies



VLT-SINFONI, z~2
Forster-Schreiber et al. (2006)



VLT-FLAMES, z
Flores et al. (2

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How deep with 8-m class instruments?

- Flores et al. sample: I < 22.5
- KMOS sensitivities (5σ/8 hrs):
  - J = 22
  - H = 21
  - K = 20.5
- E-ELT sensitivities (5σ/8 hrs):
  - J = 26.5
  - H = 26
  - K = 25.5

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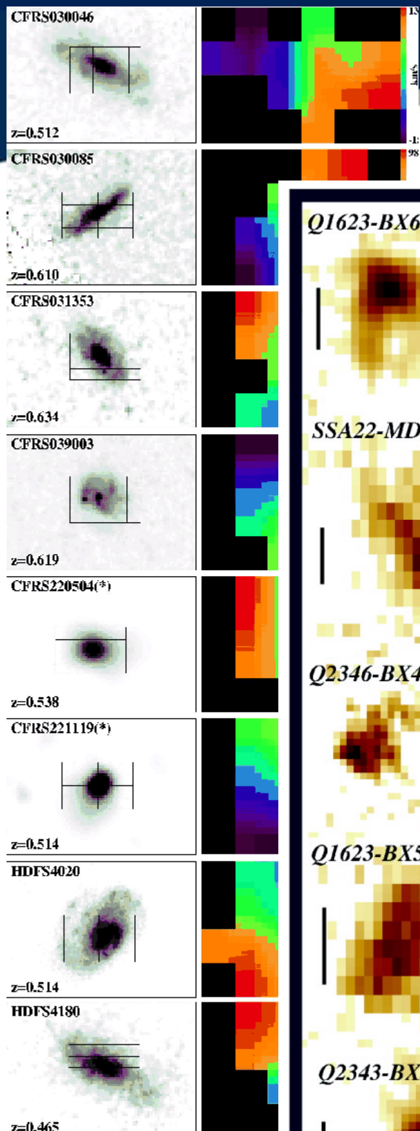
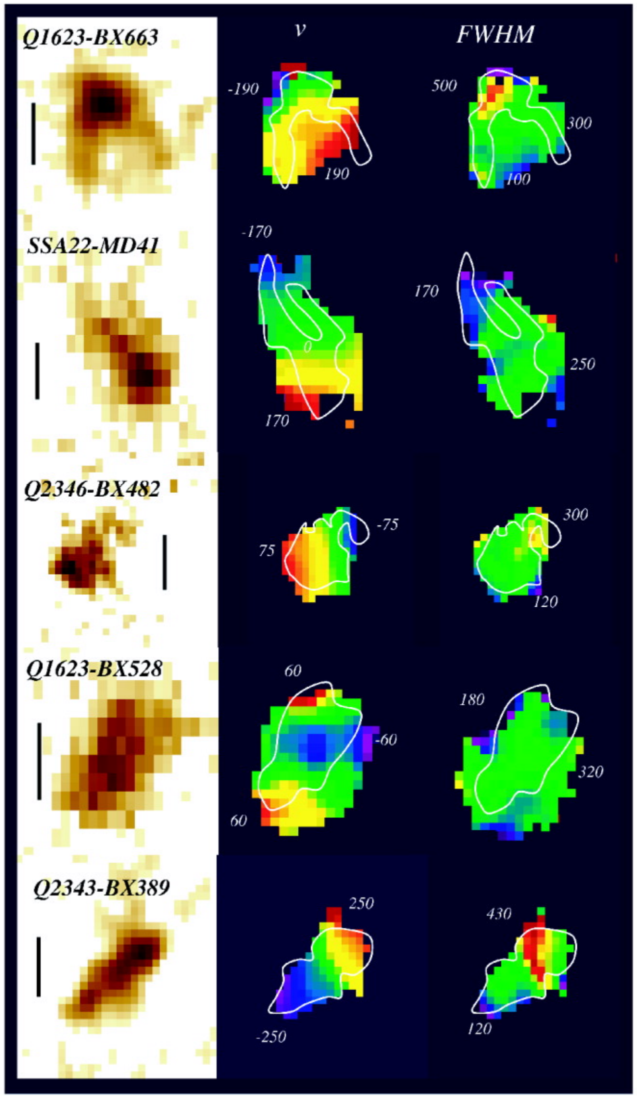
Evolution of Distant Galaxies



VLT-SINFONI, z~2
Forster-Schreiber et al. (2006)



VLT-FLAMES, z
Flores et al. (2

Science objectives with the E-ELT:

- Star-formation histories
- Extinction
- Metallicities
- Clusters
- Dynamics

- Need **large, unbiased** samples

  …over large volumes to avoid cosmic variance.

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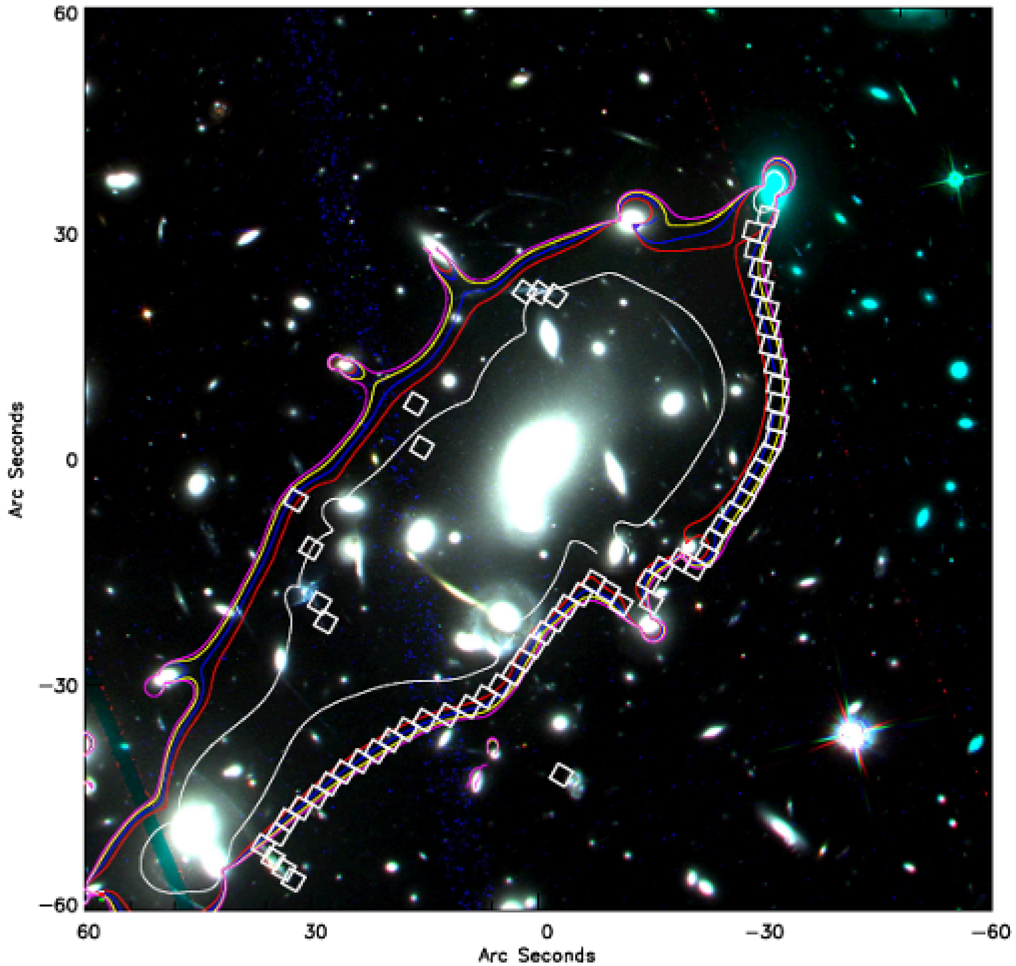
The EAGLE Science Case (including why observe in the Near Infra-Red)



A2218
Z=2, 5, 10 & 20
critical lines shown

Boxes show possible
EAGLE IFU
Mapping of high z
Critical lines

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The EAGLE Science Case (including why observe in the Near Infra-Red)

- **High spatial resolution (~ 75 milli-arcsec)**
  - **Adaptive Optics needed**
- **Extended sources (~ 2 x 2 arcsec)**
  - **For galaxies, clustered stellar objects etc**
  - **Integral Field Units needed**
- **Source count for statistics etc**
  - **Multi-object instrument (20+)**
- **Efficiency**
  - **Wide-field (5 arcmin) to ensure all IFUs are used for each observation**
- **R~4,000 main spectral resolution (OH + 1 band in 2000 pix), but also R~10,000 being considered for stellar physics**

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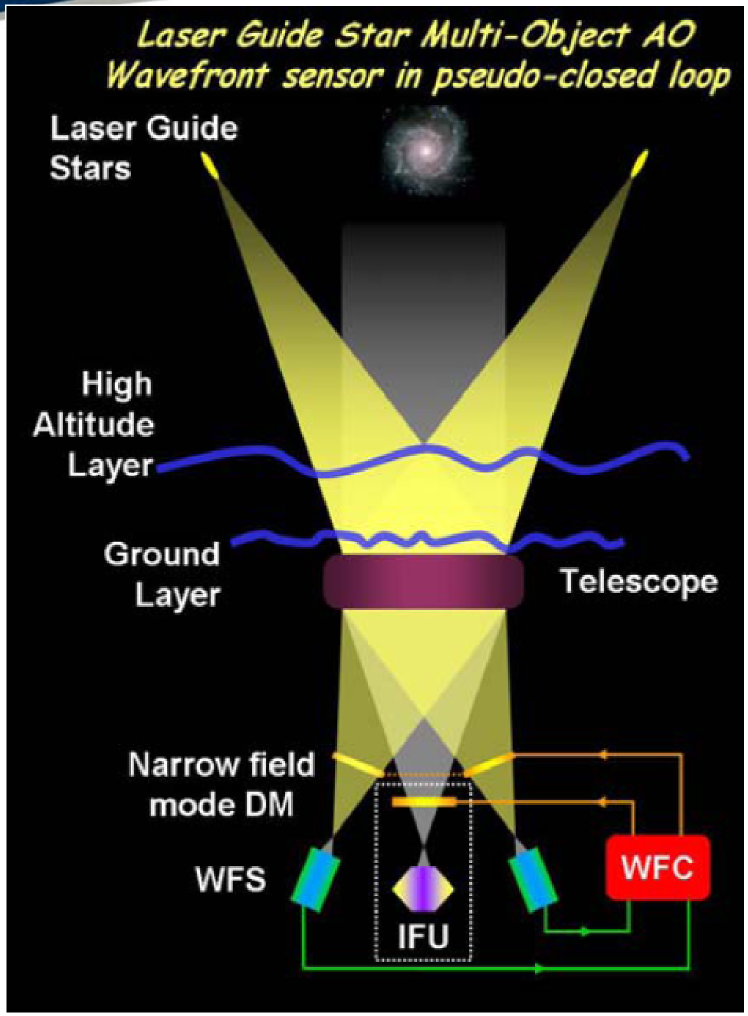
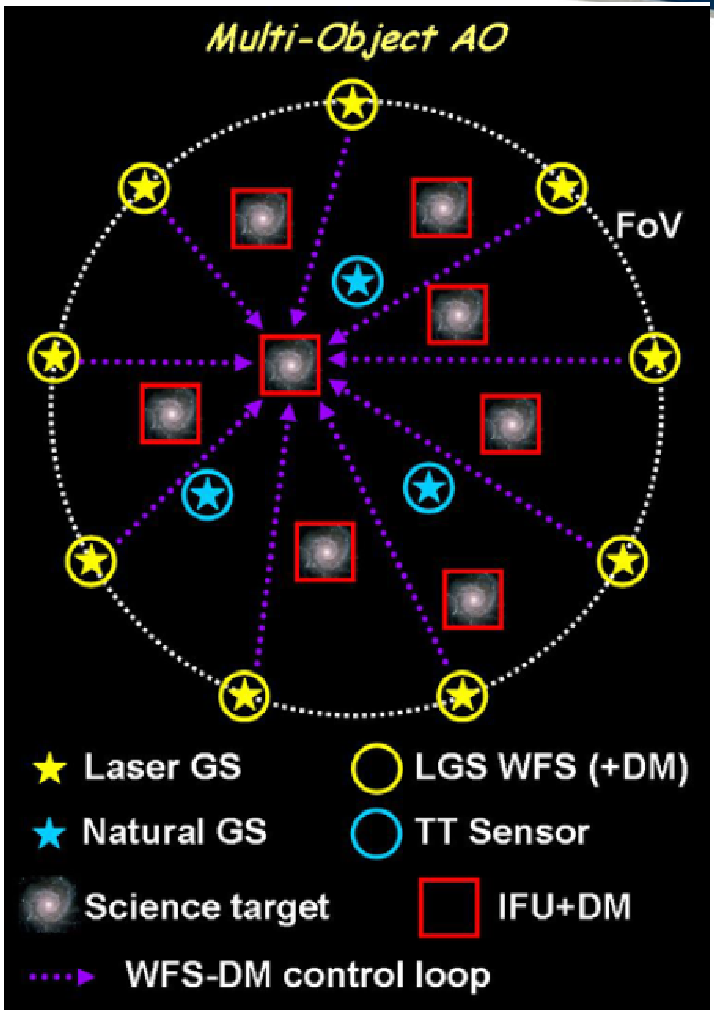
The Challenge of Multi-Object Adaptive Optics

- **Thanks to N. Hubin**
- **Each AO system has specific performance niches on E-ELT – for example**
  - **MCAO provides 'averaged' improvements to image quality over 2 arcmin diameter field of view**
  - **LTAO provides better IQ but FOV max is 45 arcsec**
- **MOAO applies optimised correction to small areas within a large Field of View (5 arcmin) by**
  - **Tomography of the whole field using combination of Laser and Natural Guide Stars**
  - **Individual Deformable mirrors for each science object gives optimal image quality improvement**

Multi-Object Adaptive Optics





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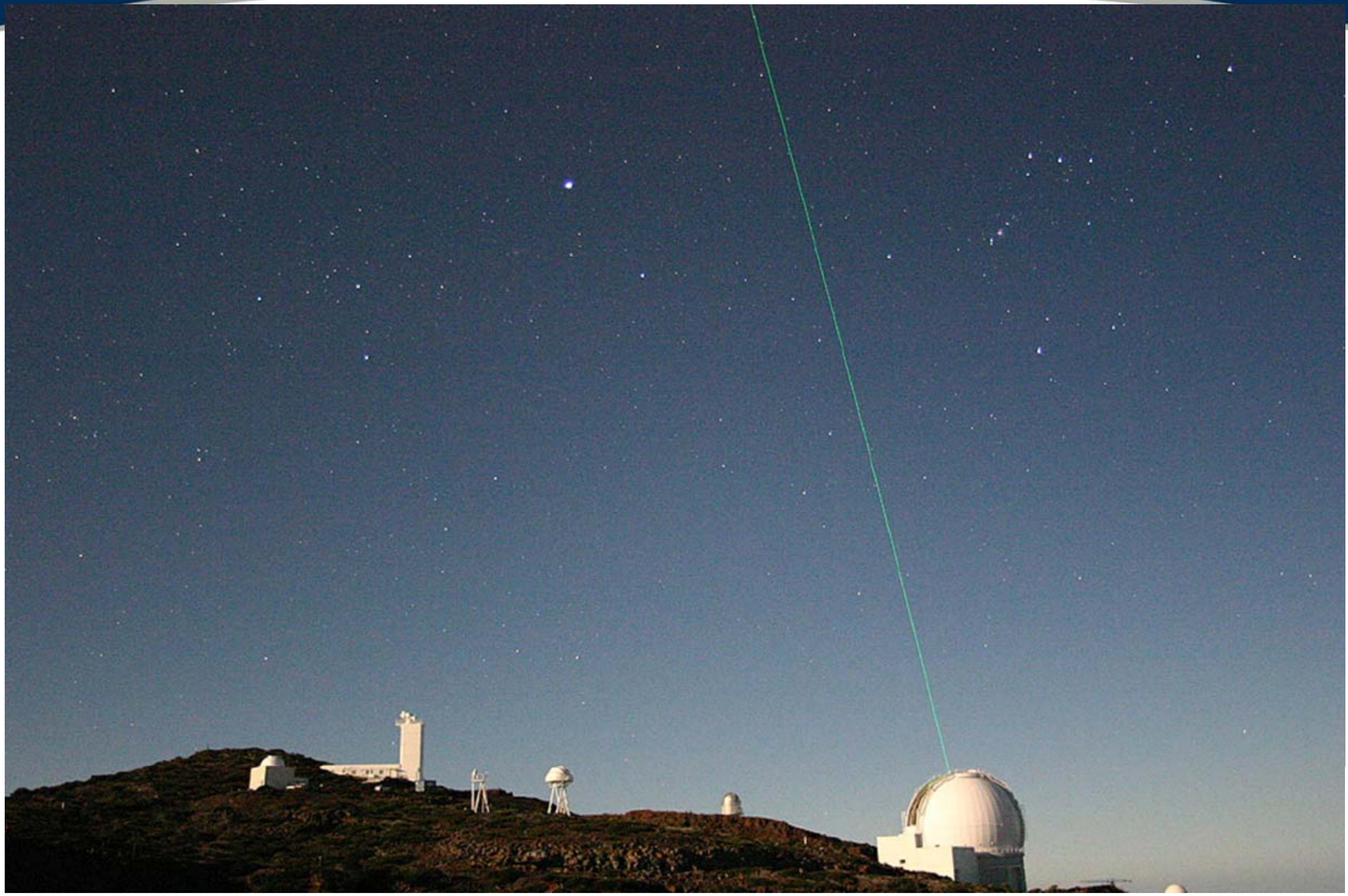
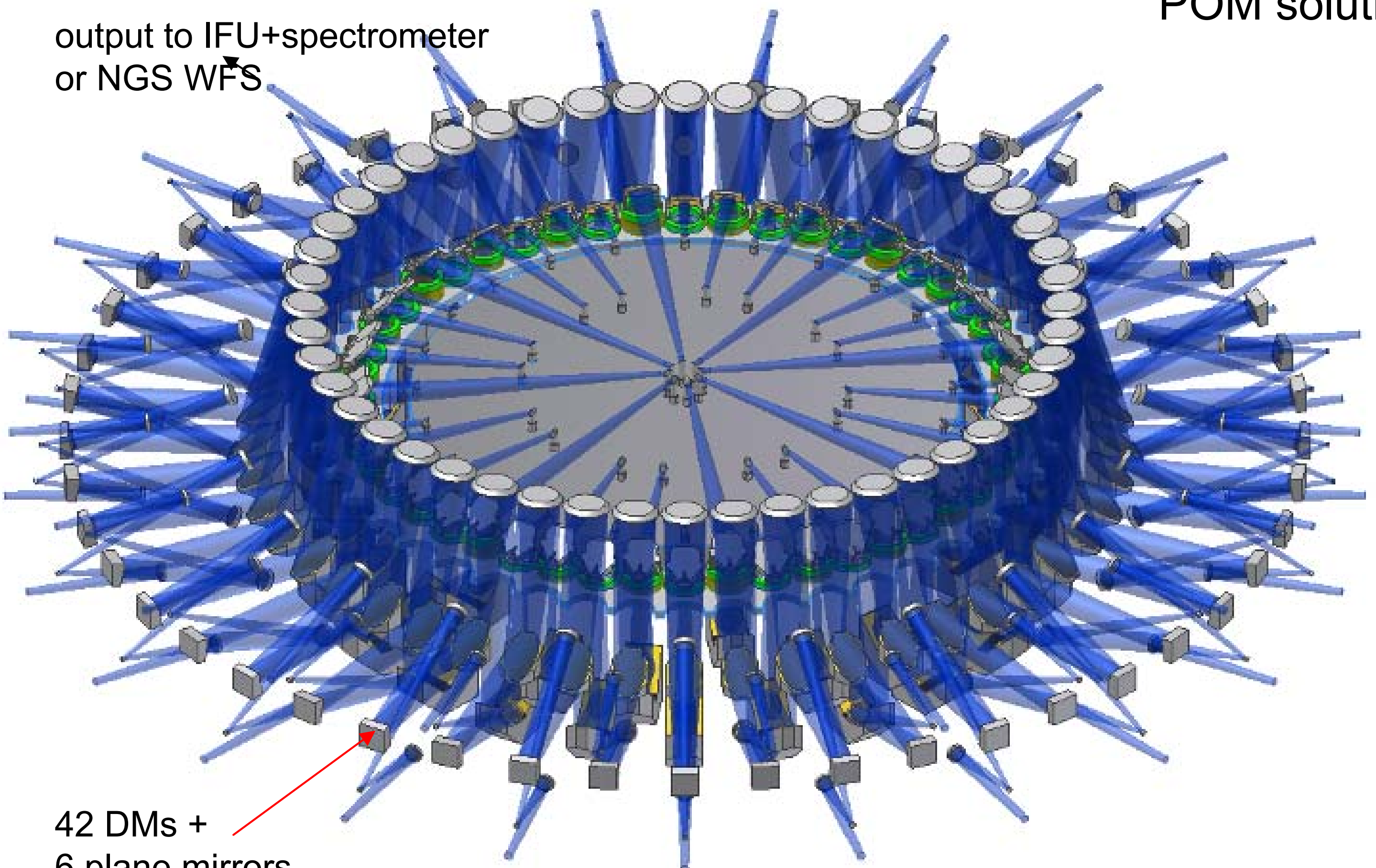
Proof of concept: CANARY on the WHT



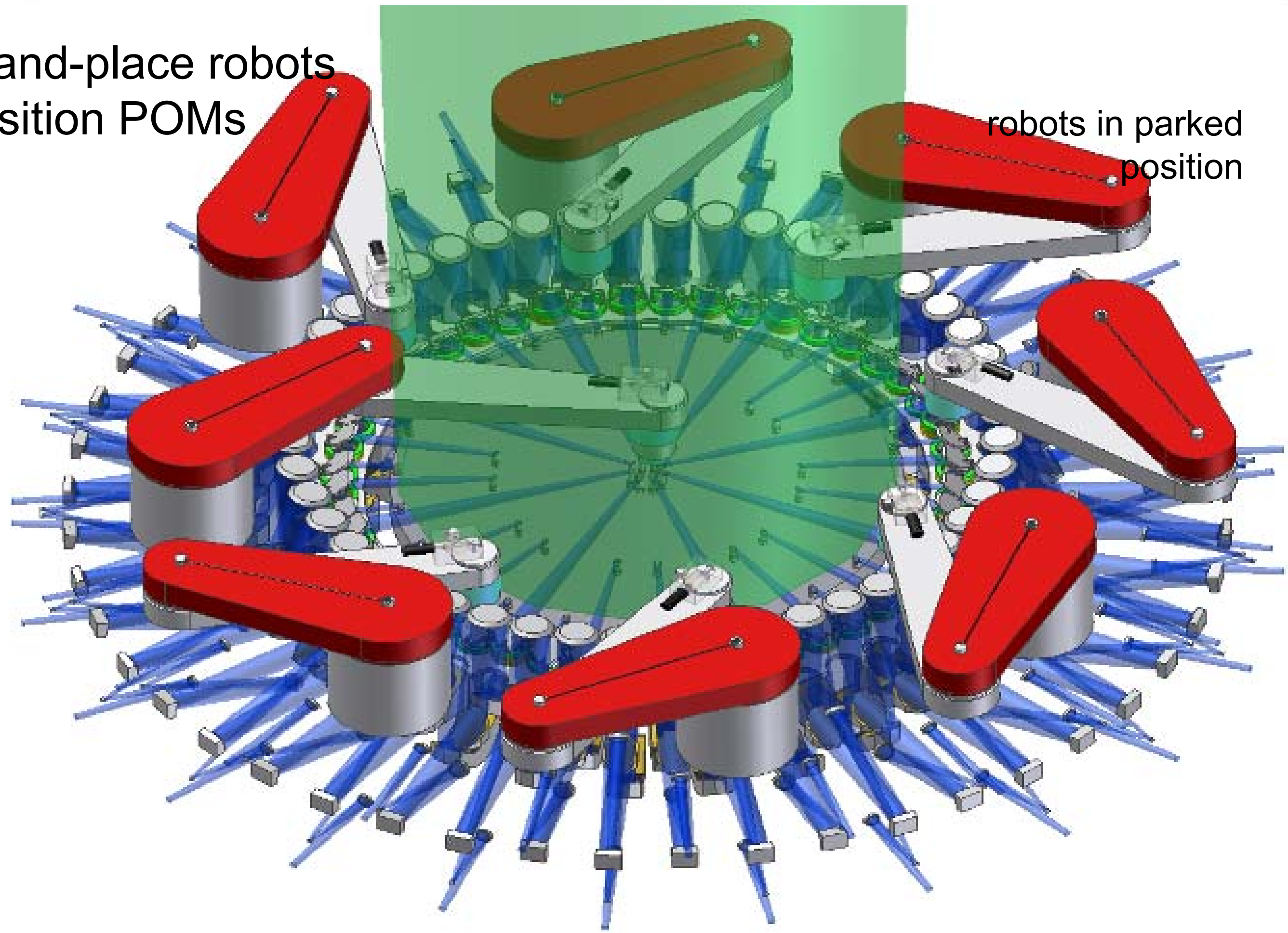
More in Rich Myers' talk

The Target Acquisition System

POM solution

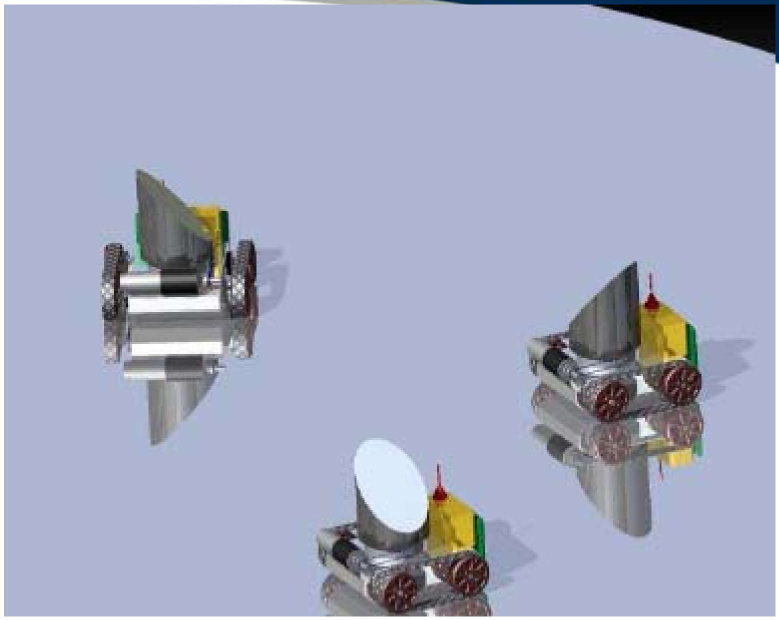


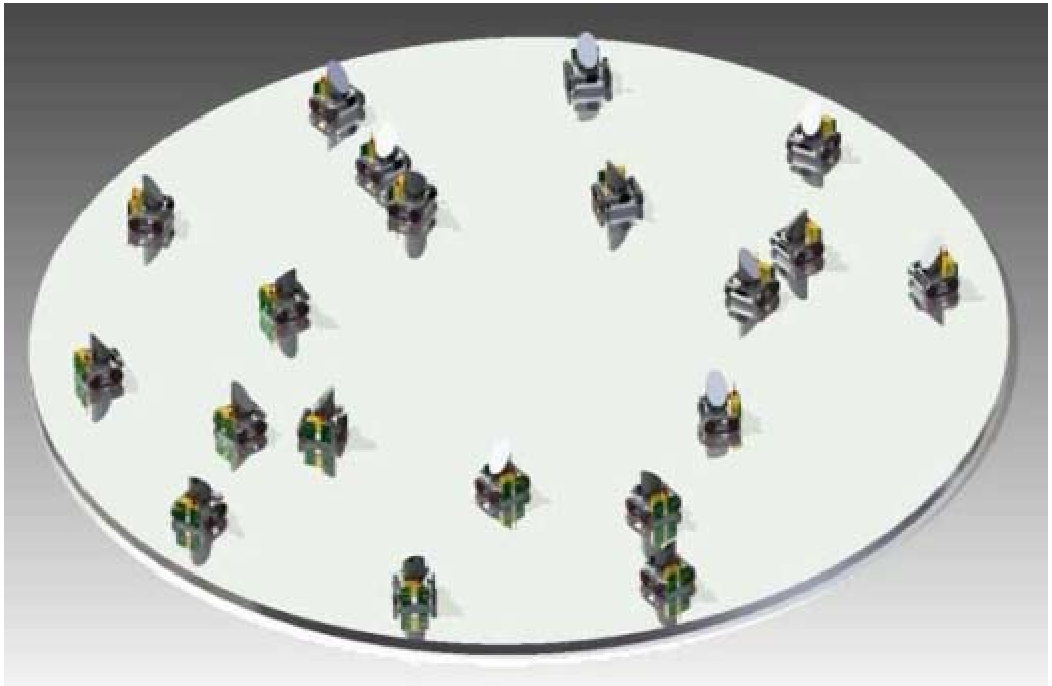
The Target Acquisition System



The Target Acquisition System

Micro Autonomous Robot System





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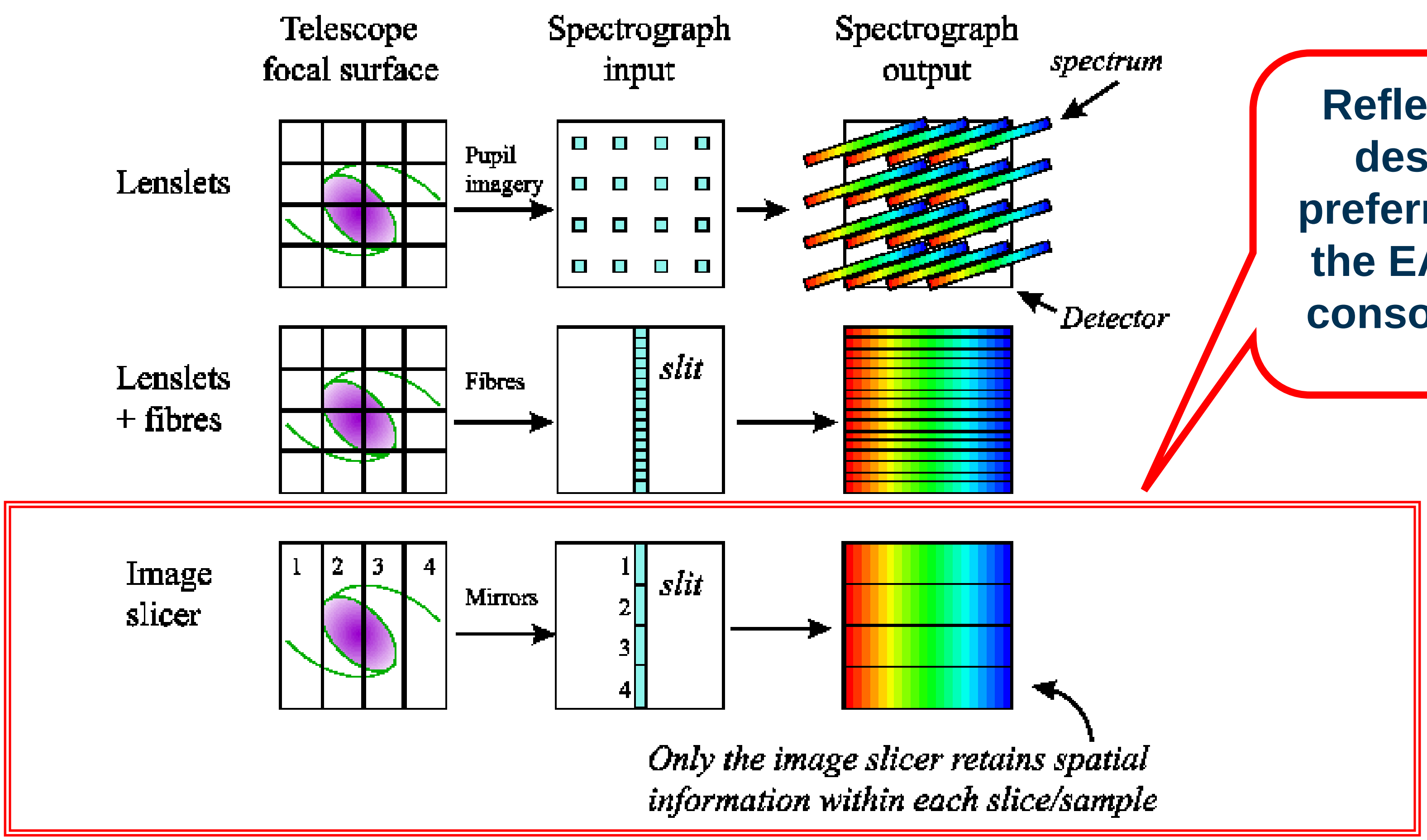
The deployable Integral Field Units and the Spectrographs



Reflective design preferred by the EAGLE consortium

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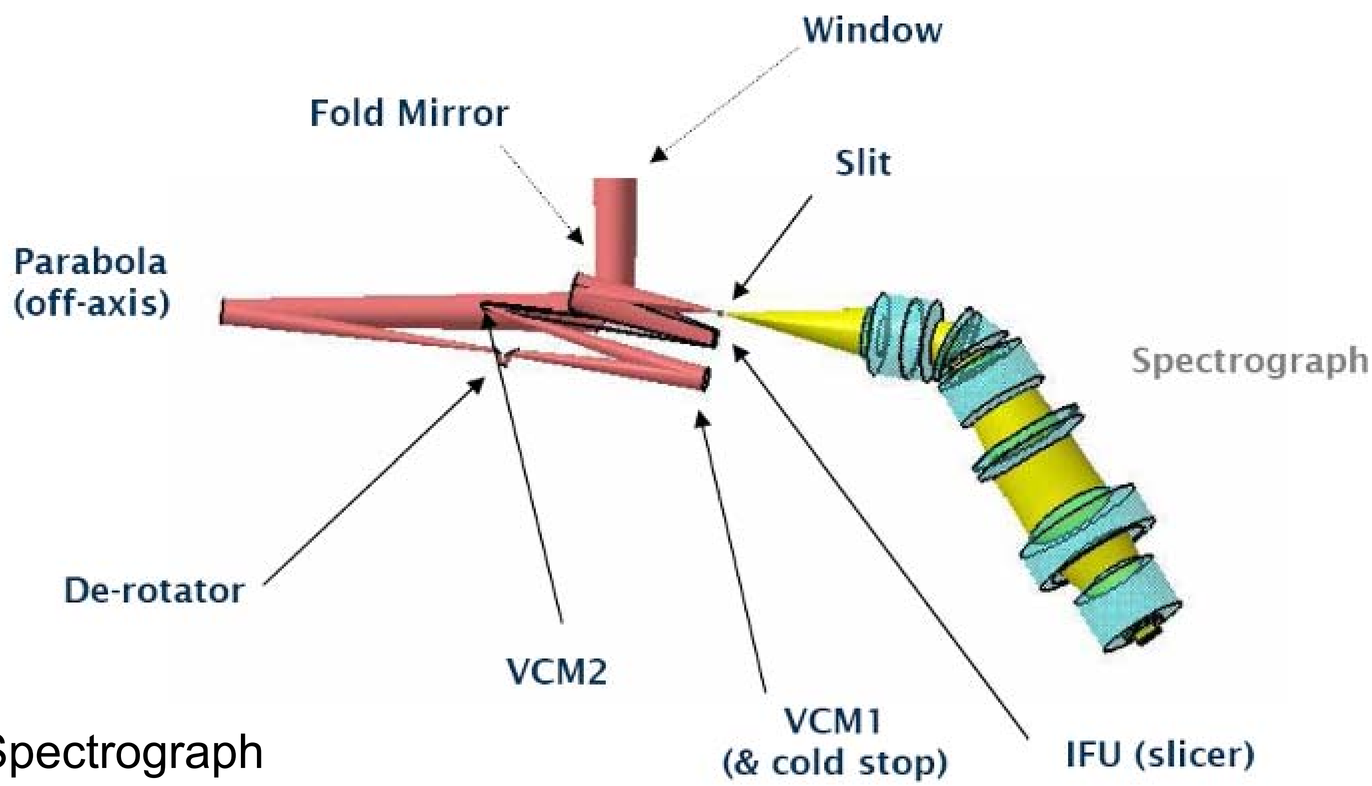

IFU and Spectrograph

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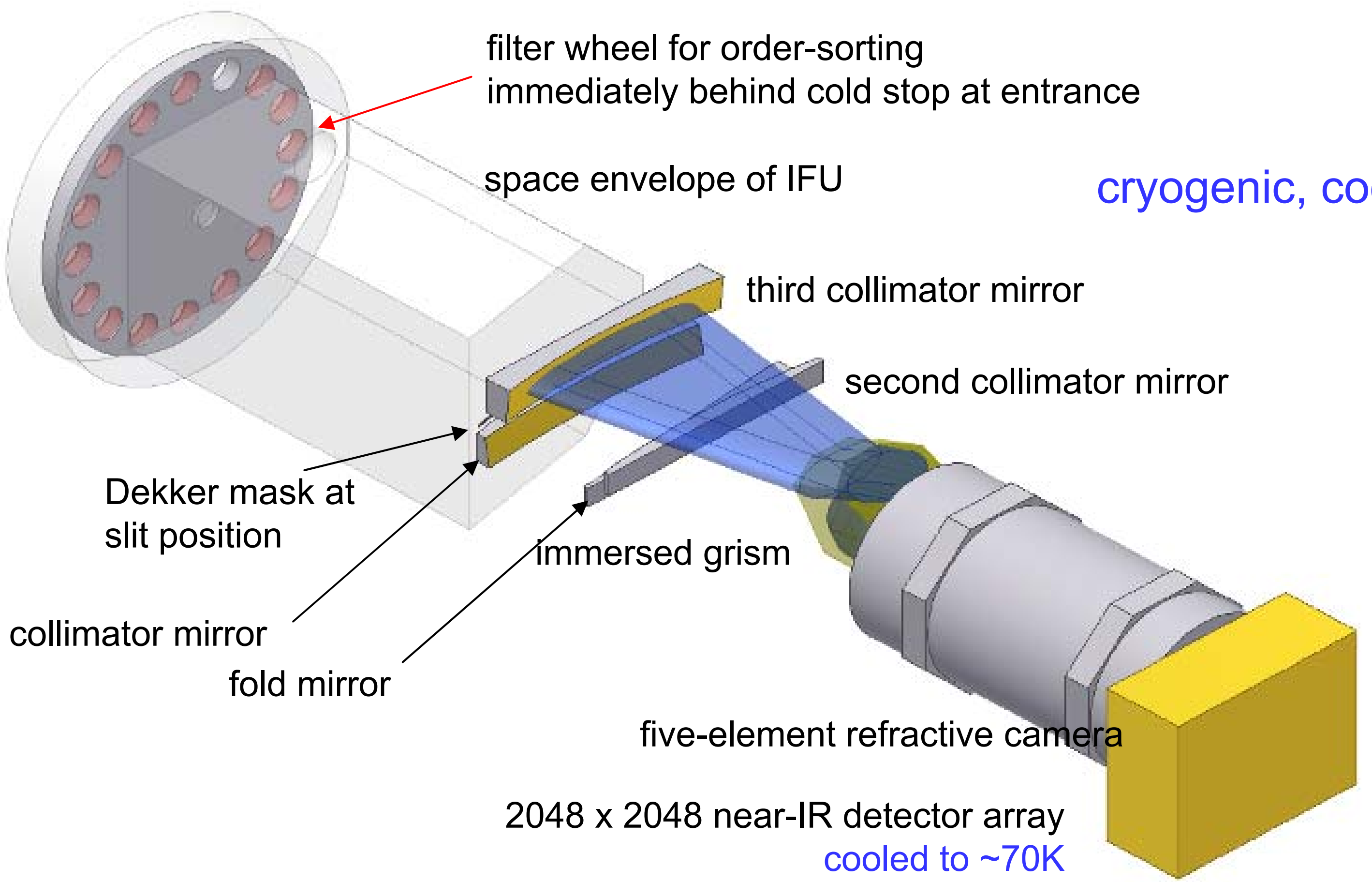

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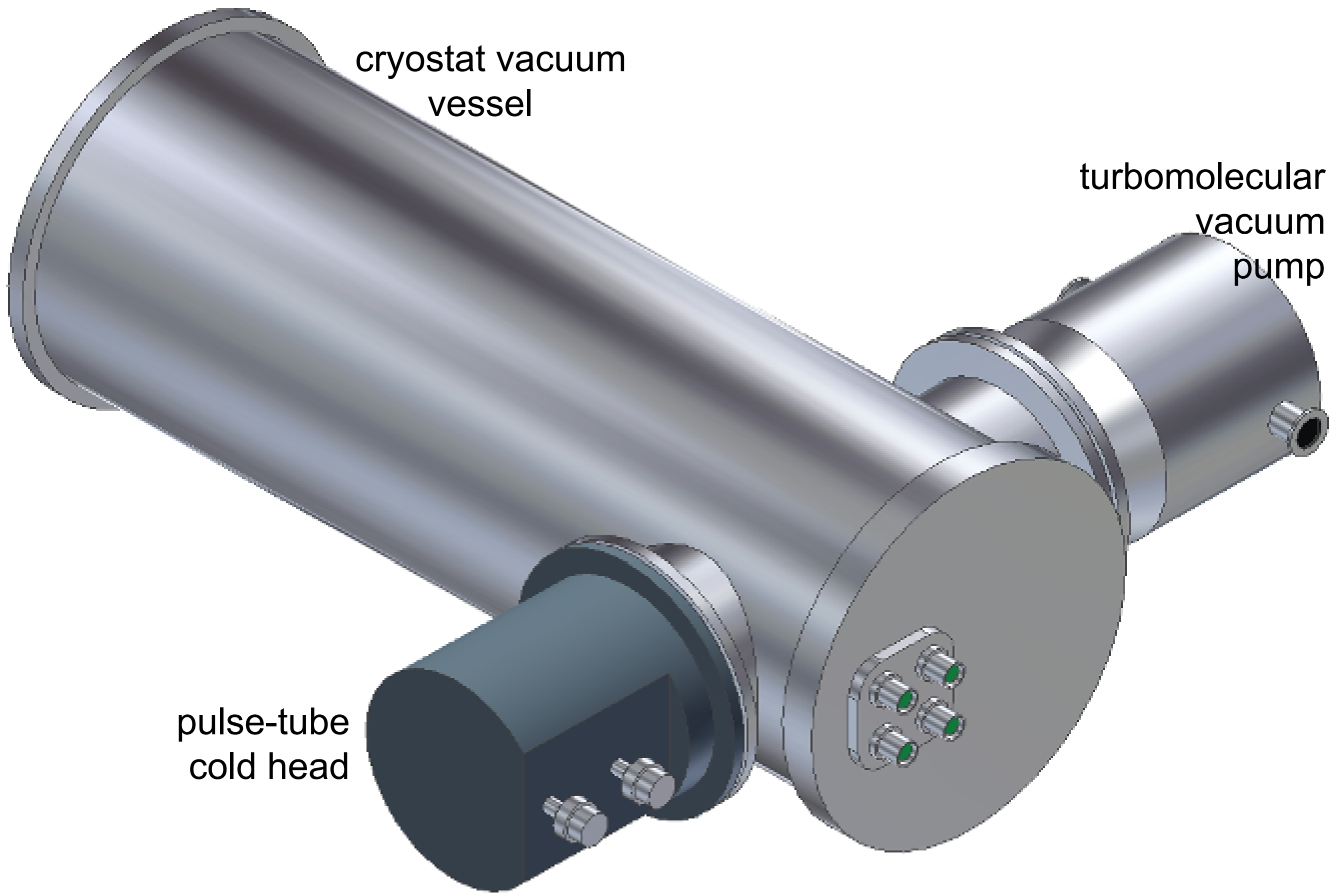

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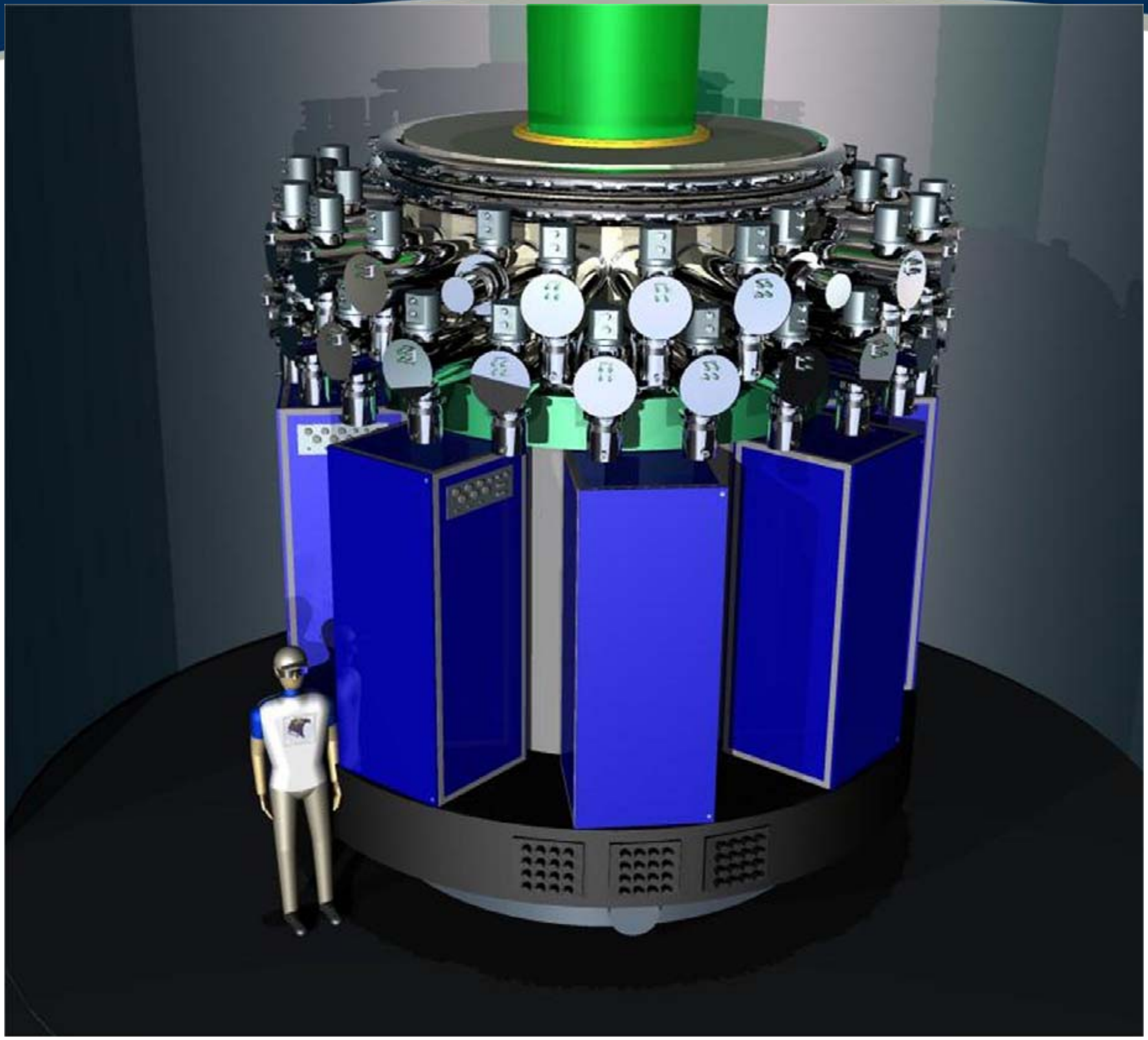
Mechanical Support and Packaging



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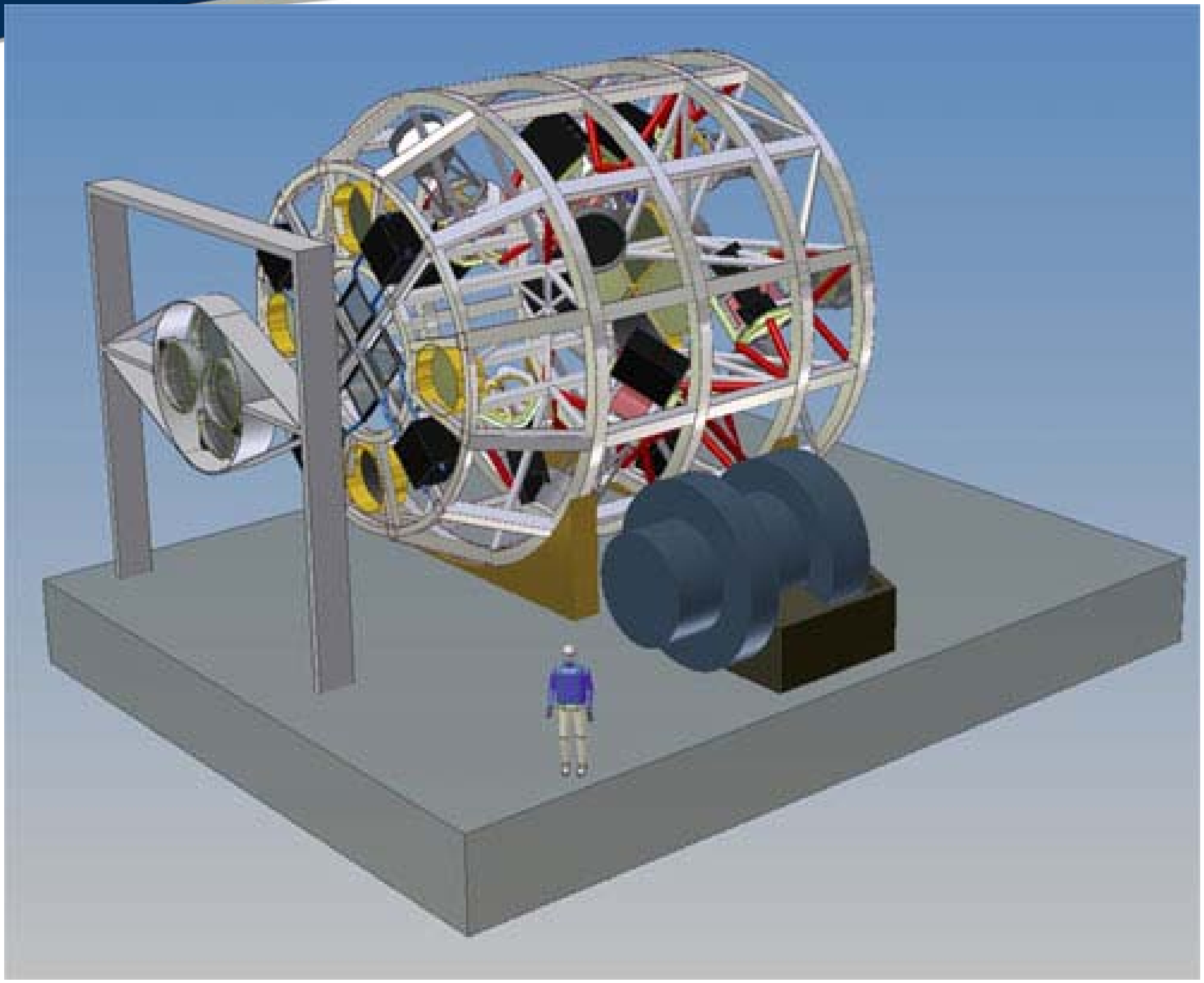

TMT WFOS (for scale comparison with EAGLE)

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Management, Funding and Politics

- French/UK instrument 50%/50% split
- French PI, Jean-Gabriel Cuby (Marseille)
- UK coPI, Simon Morris (Durham)
- Current French Institutions:
  - LAM (Marseille)
  - ONERA
  - Observatoire de Paris (GEPI and LESIA)
- Current UK Institutions
  - UK ATC
  - Durham (CfAI)

Summary

- EAGLE combined with the E-ELT will yield huge sensitivity and efficiency gains over existing facilities:
  - Unprecedented primary aperture
  - Large multiplex
  - Excellent AO correction

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The End