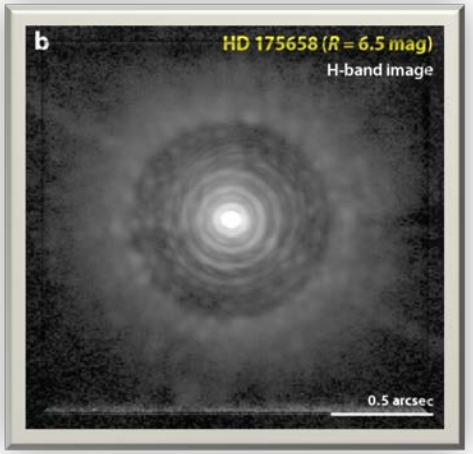
Scientific Potential of AO Systems

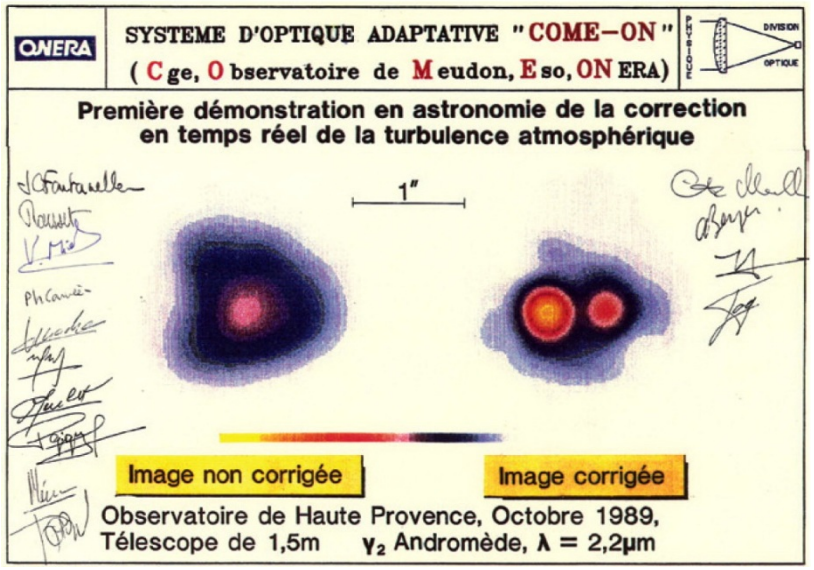
Richard Davies
Max Planck Institute for Extraterrestrial Physics, Germany

- Reality Check
- Science with AO
- Trade-Offs to think about

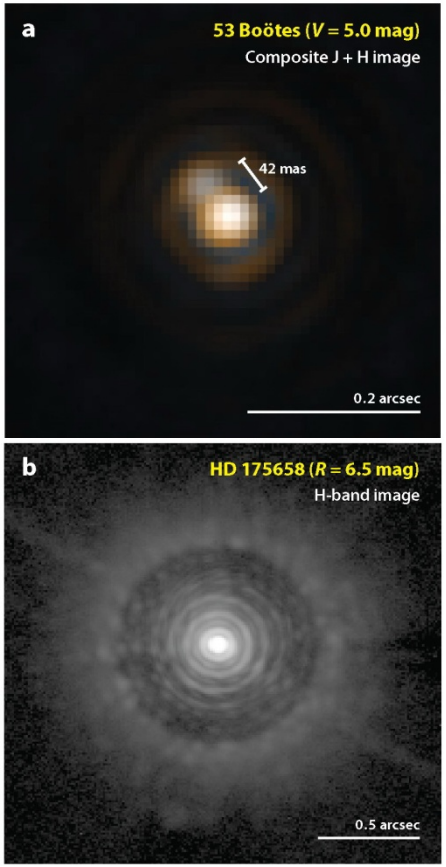


Adaptive Optics Developments

A history of astronomical adaptive optics in 1 slide



First (civilian/astronomical) AO correction



First telescope designed from start to have AO 'built in'; ASM + pyramid; first extreme AO performance

Science with AO

Davies & Kasper 2012

- Solar System
  - (The sun)
  - Asteroids
  - Planets & their Satellites
- Star & Planet Formation
  - Stellar multiplicity
  - Circumstellar disks
  - Extrasolar planets
- Resolved Stellar Populations
- The Galactic Center
- Galaxy Nuclei & Active Galaxies
  - Black hole masses
  - Gas inflow and outflow
  - Quasars & mergers
- The High Redshift Universe

Need to consider *science + instrument + AO* together

What does your science require?

- FoV: Single source, multi-object, contiguous field
- Spectroscopy
- Wavelength range (mid-IR? Visible?)
- Sensitivity (e.g. faint objects vs crowded fields)
- Sample size
- Sky coverage (e.g. far off-axis or faint tip-tilt stars?)
- Performance: resolution, strehl, encircled energy
- PSF estimation

More technical issues:

LGS or not?

infrared vs optical WFS

Science with AO

Davies & Kasper 2012

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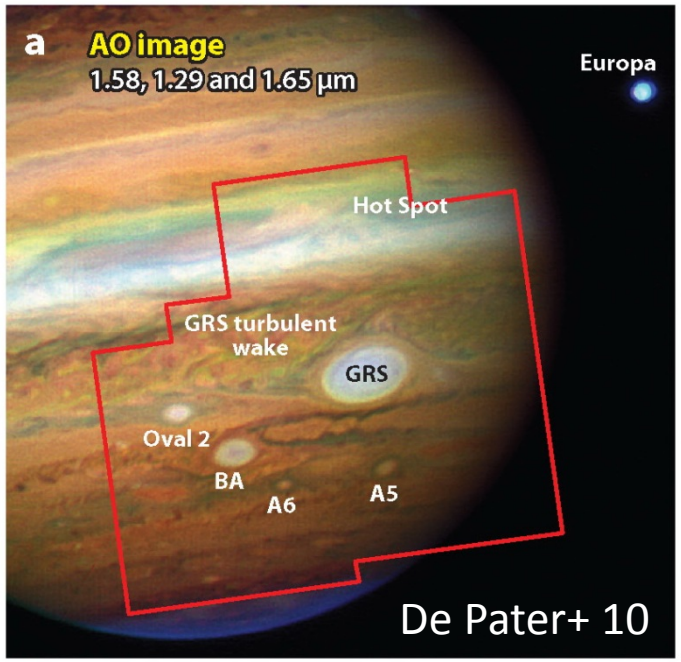

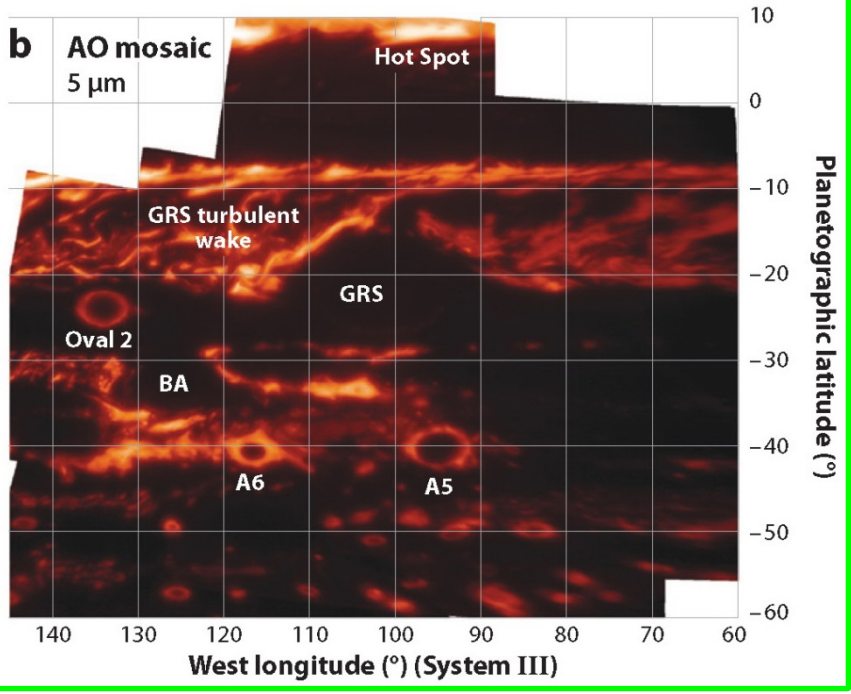

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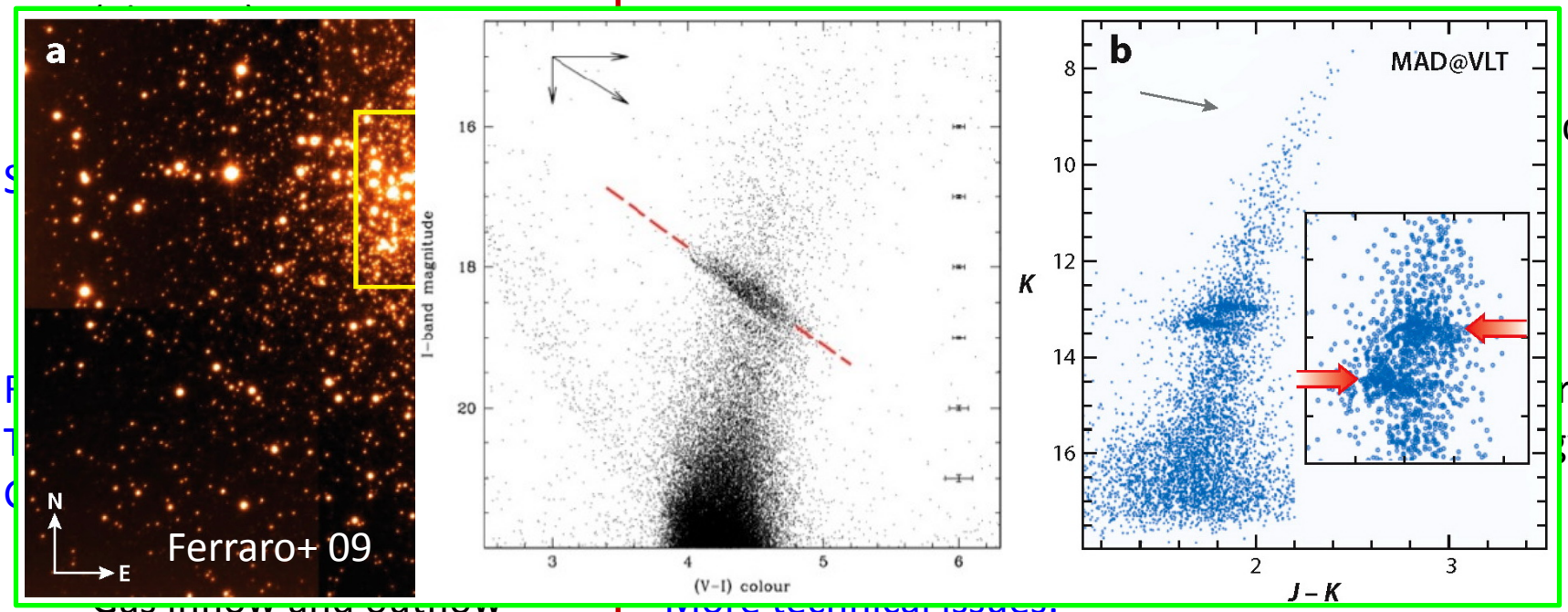

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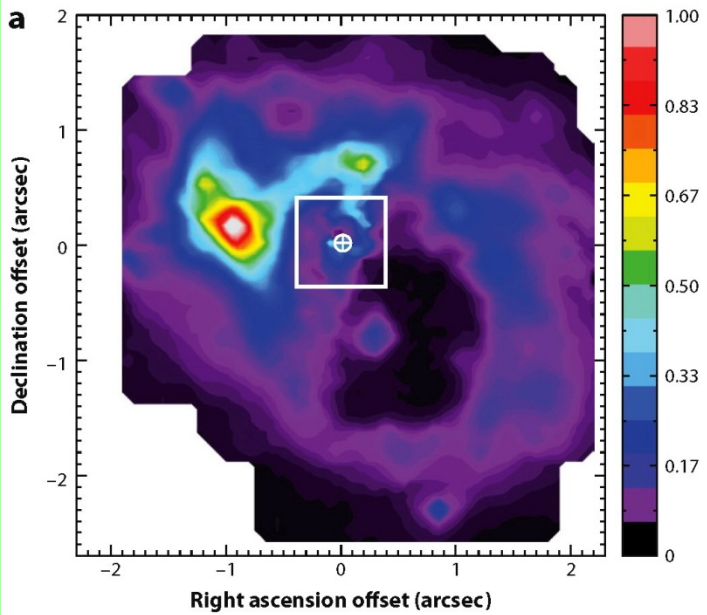

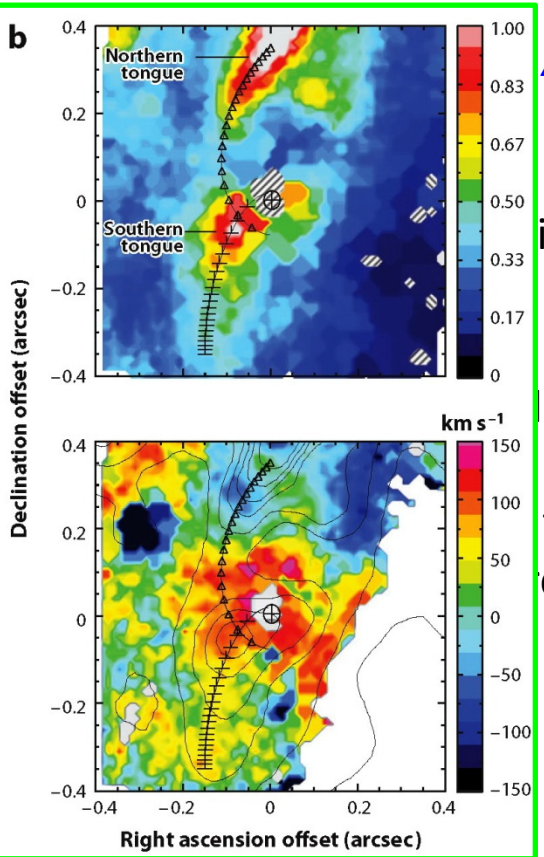

Mueller Sanchez+ 09

Infrared vs optical WFS

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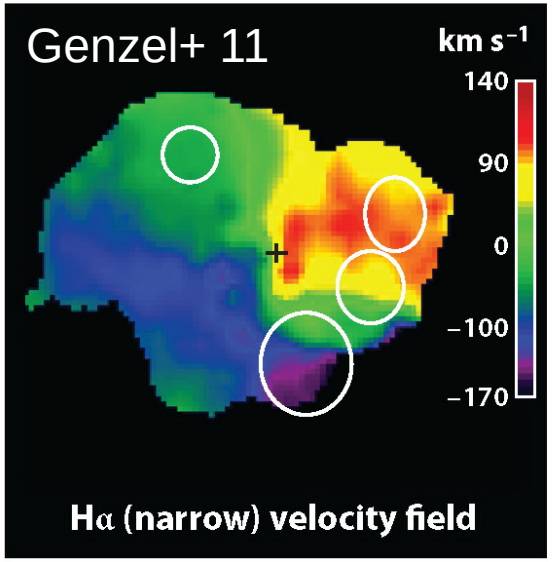
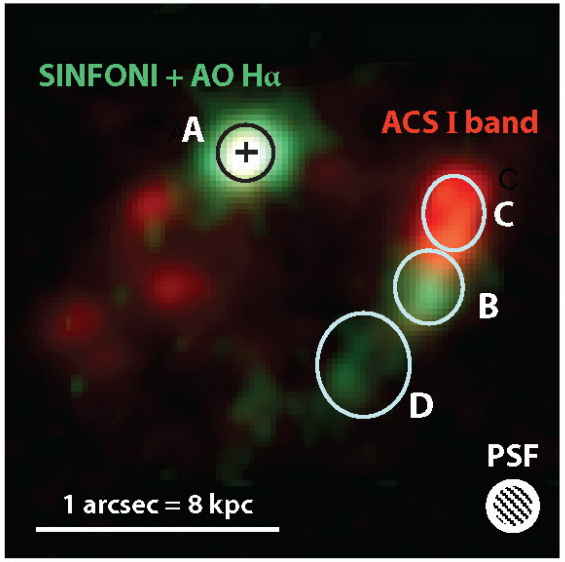
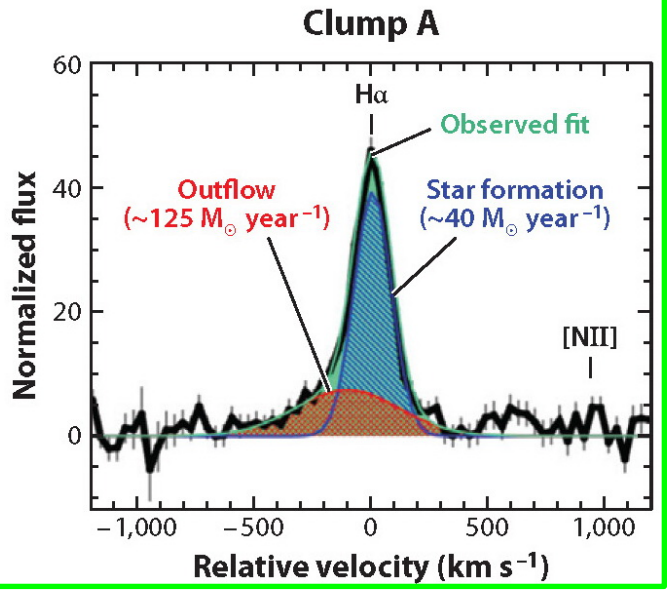






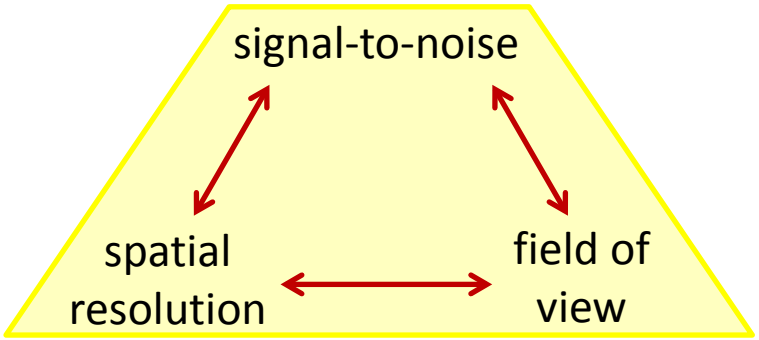
More technical issues:

LGS or not?

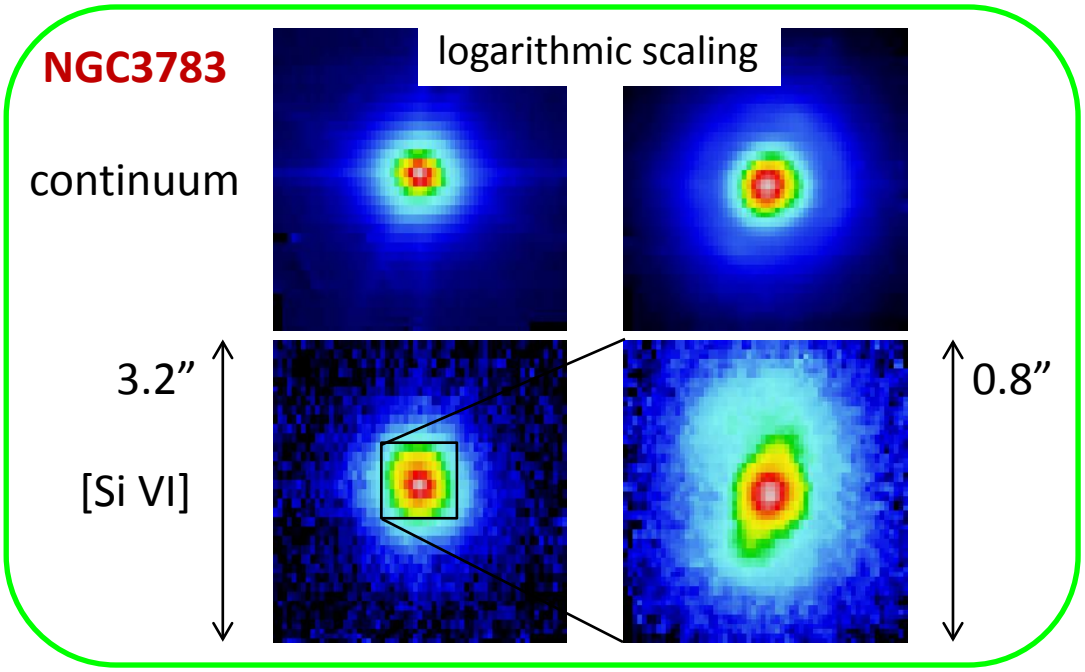
infrared vs optical WFS

Instrumental Trade-offs

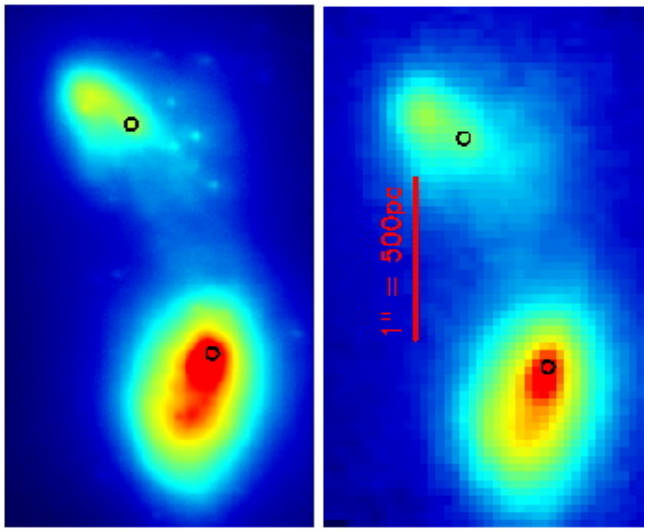
- AO does not always need to provide highest Strehl & diffraction limited resolution
- IFUs: 3-way trade-off related to choice of pixel scale
- Can lead to relaxed constraints on tip-tilt star



NGC3783



NGC6240

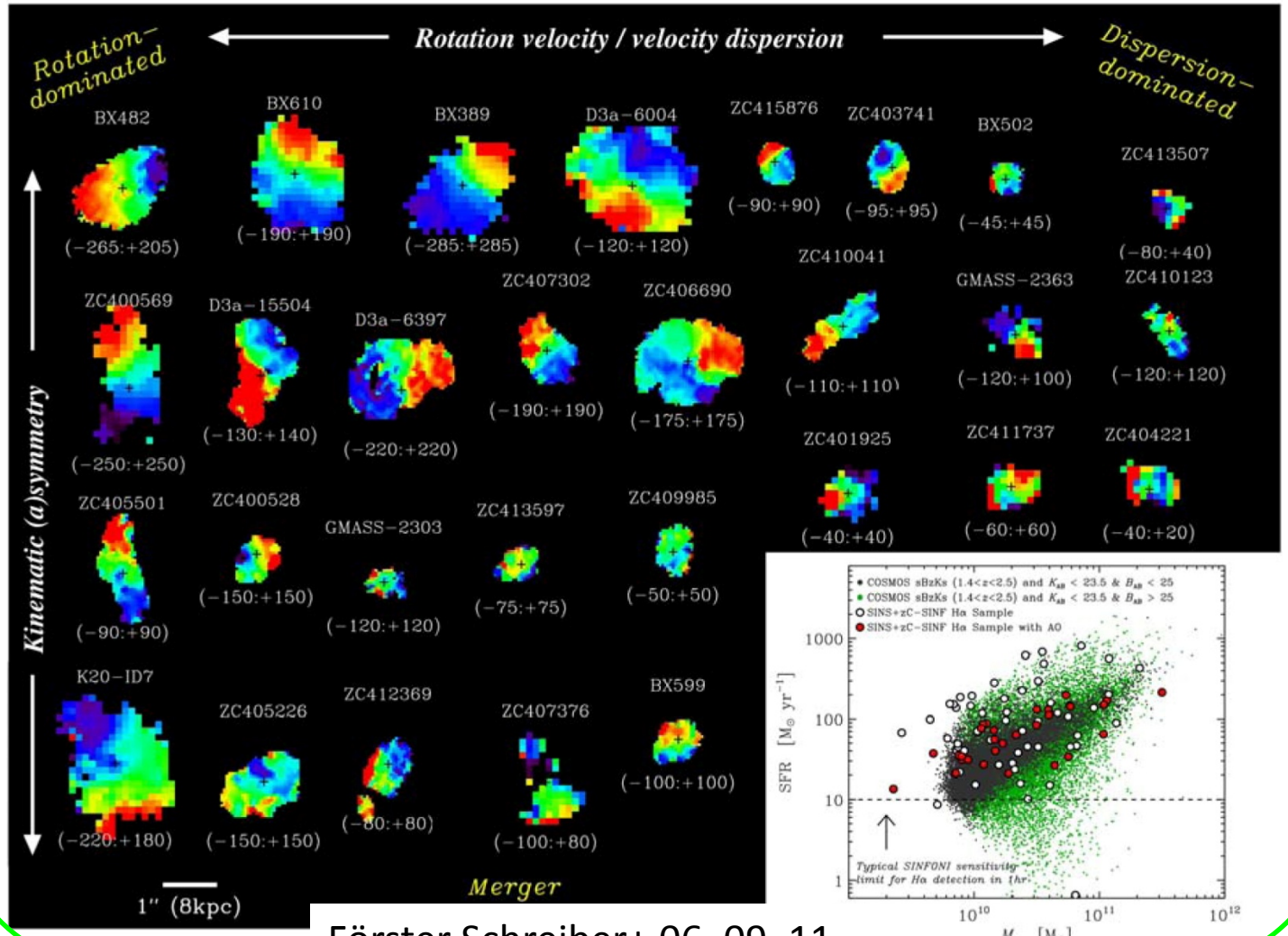


Max+ 07 (NIRC2/Keck)
Engel+ 10 (SINFONI/VLT)
Medling+ 11 (OSIRIS/Keck)

Instrumental Trade-offs

- AO does n… …lution
- IFUs:
- Lead…

Kinematics of z~2 galaxies



Förster Schreiber+ 06, 09, 11

NGC3…

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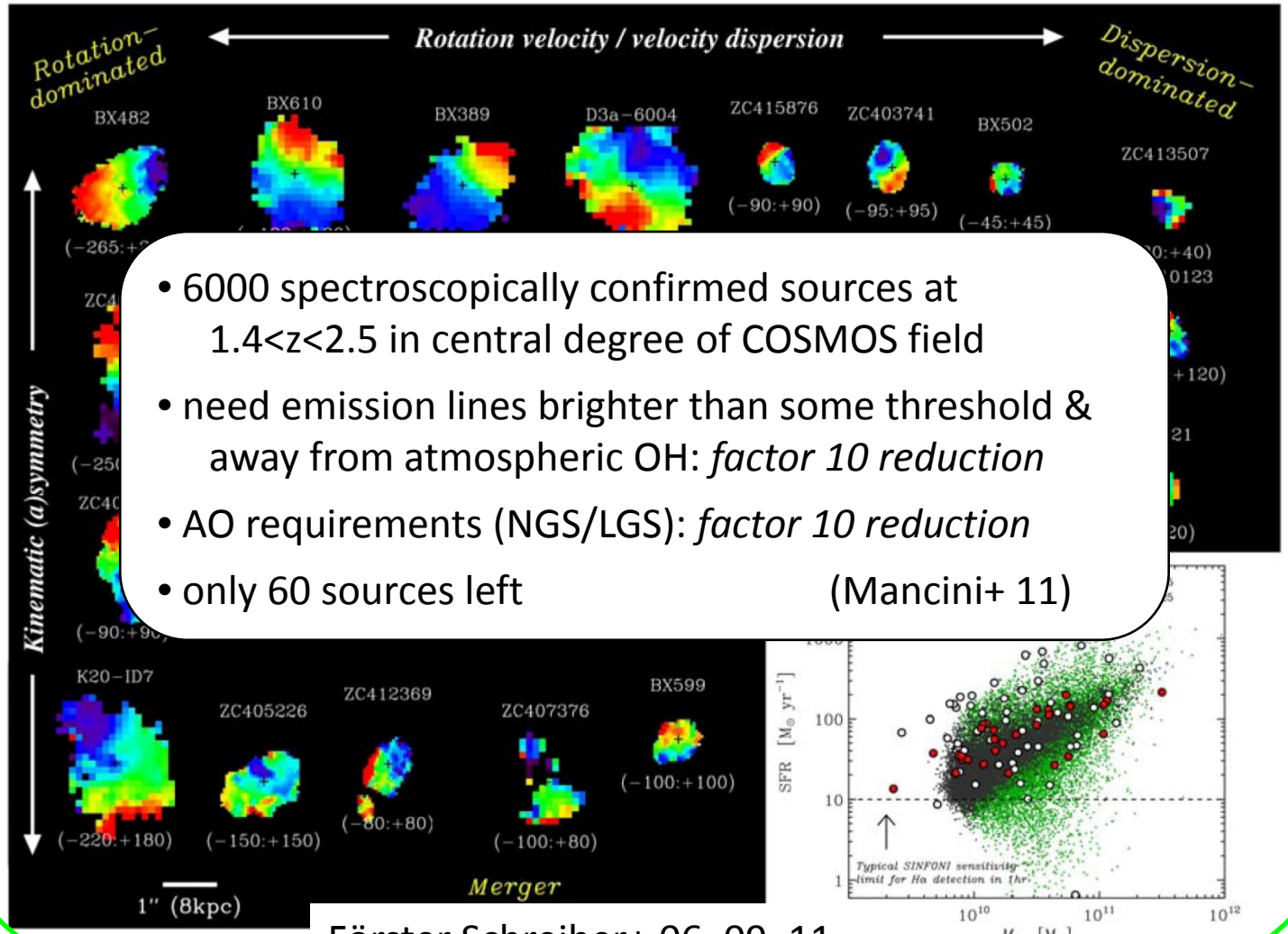
Kinematics of z~2 galaxies



- 6000 spectroscopically confirmed sources at 1.4<z<2.5 in central degree of COSMOS field
- need emission lines brighter than some threshold & away from atmospheric OH: *factor 10 reduction*
- AO requirements (NGS/LGS): *factor 10 reduction*
- only 60 sources left (Mancini+ 11)

Förster Schreiber+ 06, 09, 11

NGC3

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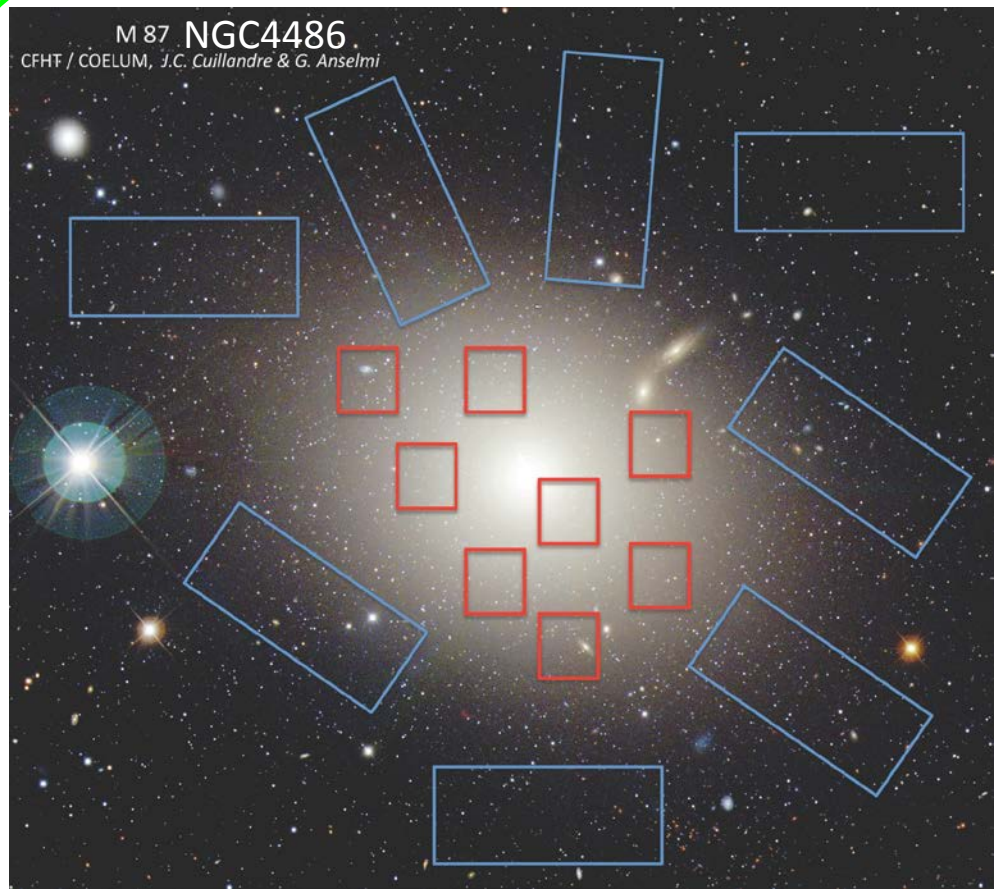
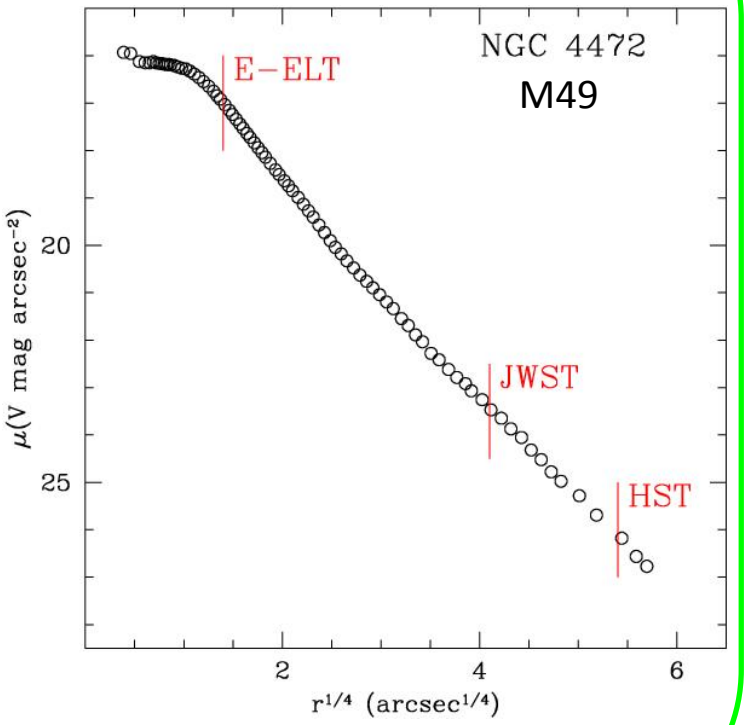
[Si V

Instrumental Trade-Offs

- It can be crucial for AO to provide highest Strehl & diffraction limited resolution
- Resolved stellar populations– IMF issues (i.e. stars in galactic clusters)
  – galaxy star formation histories (i.e. stars in other galaxies)
- Leads to requirements on performance at short wavelengths





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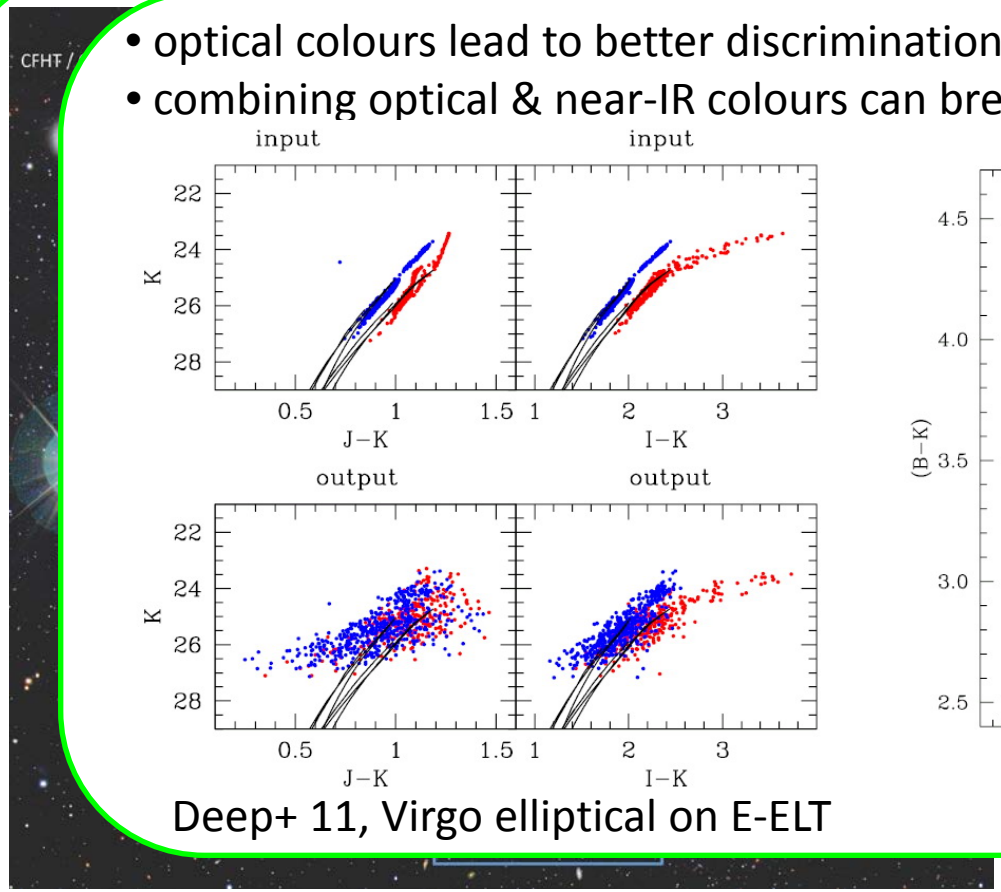
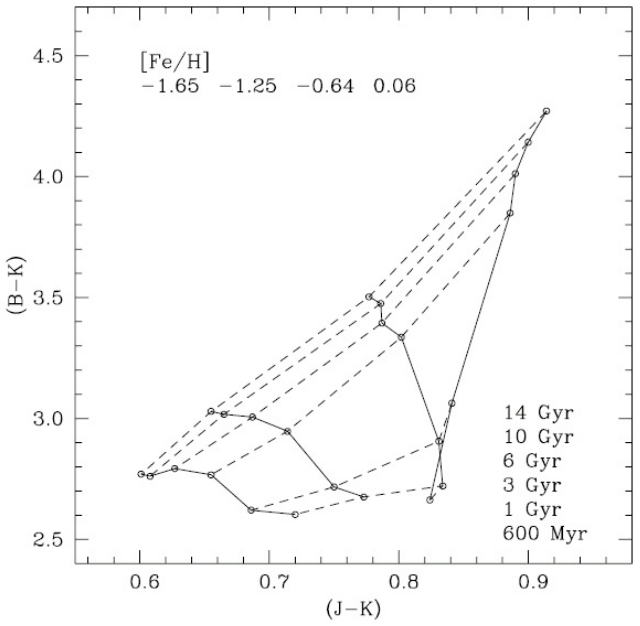
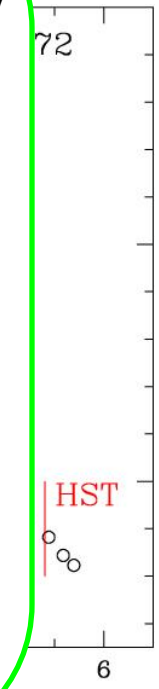


- optical colours lead to better discrimination of stellar populations
- combining optical & near-IR colours can break age-metallicity degeneracy

Deep+ 11, Virgo elliptical on E-ELT



James+ 06



Science with (future) AO…

- What science will have a major impact in 5-10yrs?
- What measurements are needed to achieve it?
- What AO+instrument requirements will enable this?