The Status of AO Worldwide

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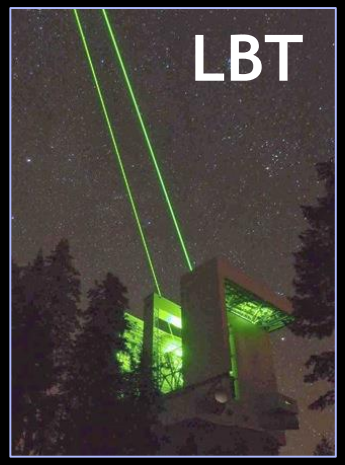
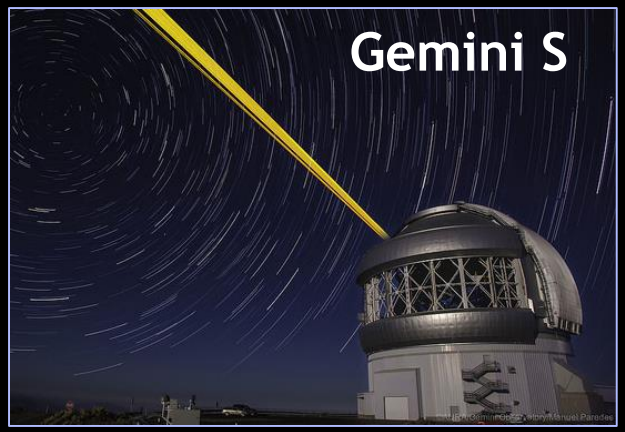
Topics

- AO on current 8-10m telescopes
- Plans for AO on ELTs
- Science output from today's AO systems on 8-10m telescopes
  - Publication statistics
  - A few juicy extragalactic science examples
- Conclusions – key points for this committee

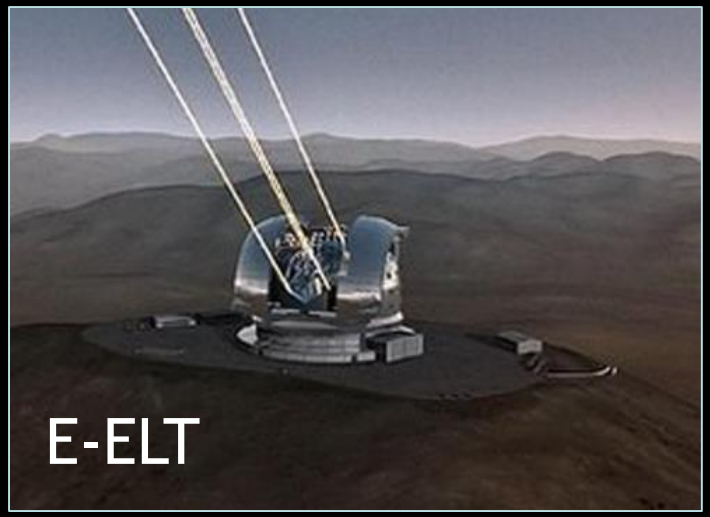
AO is now on all but one 8-10m class imaging telescopes

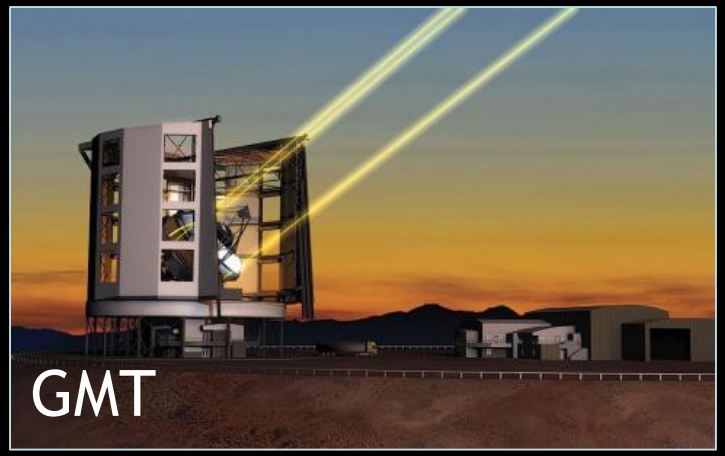


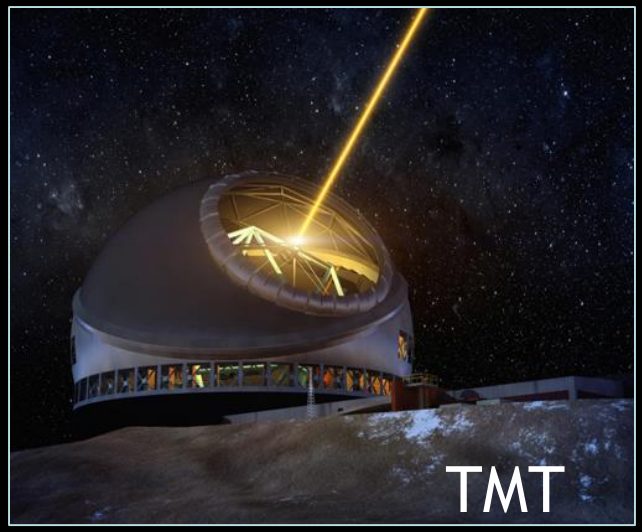


All three ELTs will rely on AO

Here are PR photos from all three ELTs





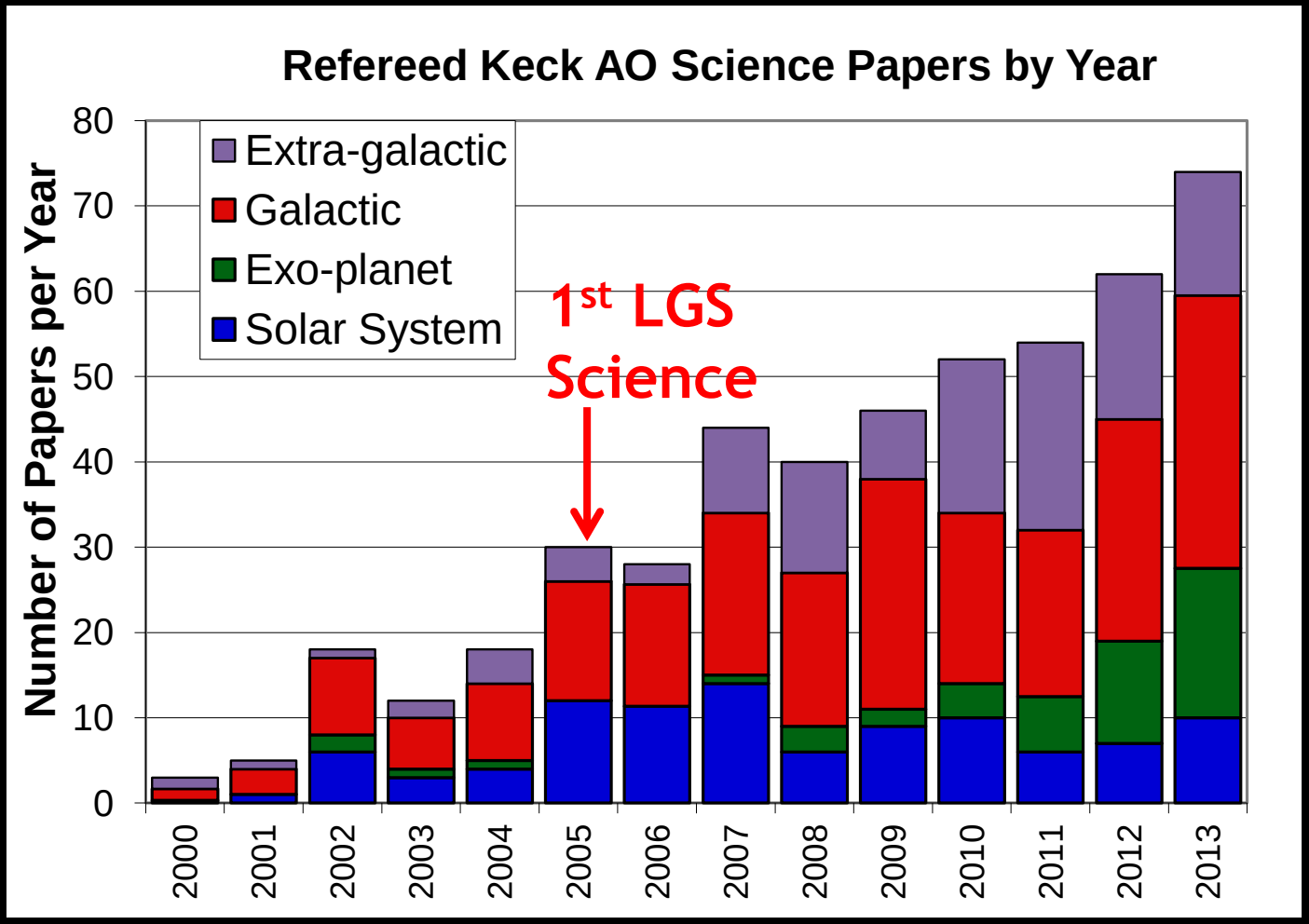


Laser Guide Star AO will be Central to ELT Science

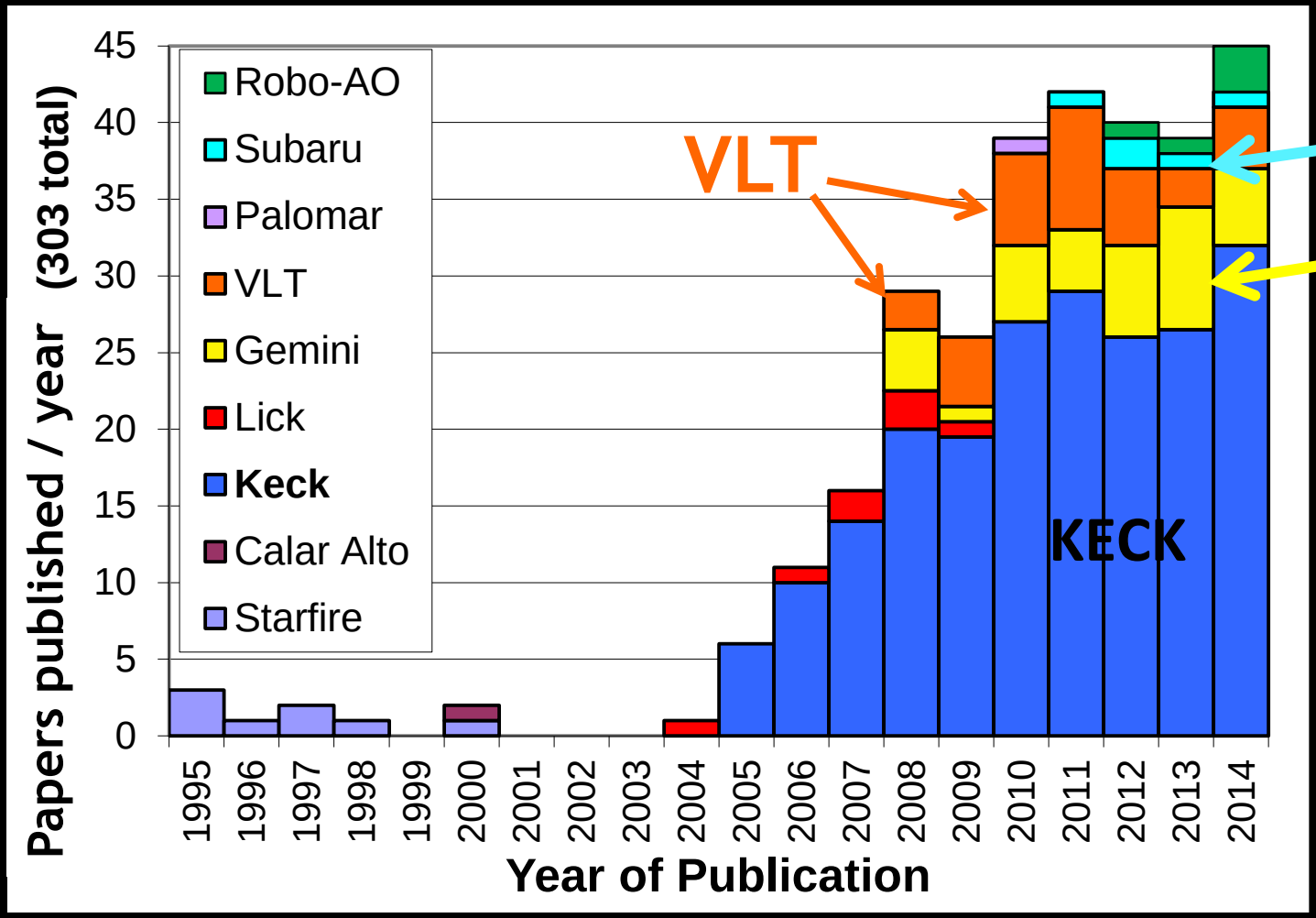
Telescope	Instrument	Type	λ (μm)
TMT	WFOS	Wide field optical spectrograph	0.3-1
	√ IRIS	Integral field spectro. (IFS) & imaging	0.8-2.5
	√ IRMS	Multi-object spectro.	0.8-2.5
GMT	√ G-CLEF	High resolution spectro.	0.35-0.95
	√ GMACS	Multi-object spectro.	0.36-1
	√ GMTIFS	IFS & imaging	0.9-2.5
E-ELT	√ HARMONI	Single field, wide band spectro.	0.8-2.4
	√ MICADO	Imager	0.8-2.4
	√ METIS	Imager & spectro.	3-13
	√ EAGLE	Multi-IFS	0.8-2.5
	√ CODEX	High resolution spectro.	0.37-0.69
	√ EPICS	Planet imager & spectro.	0.6-1.8

√ MCAO | √ LTAO | √ MOAO | √ XAO | √ GLAO

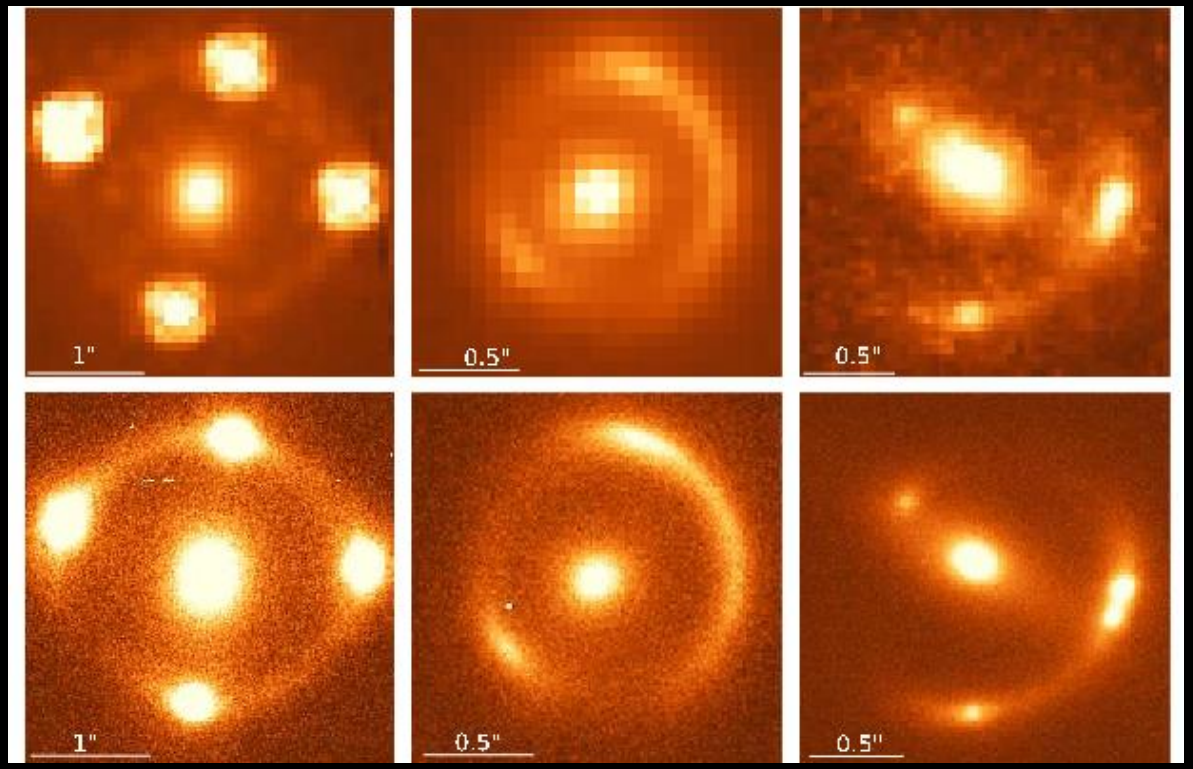
AO is now serving broad range of astronomy fields



LGS AO on 8-10m telescopes has matured in past 10 years



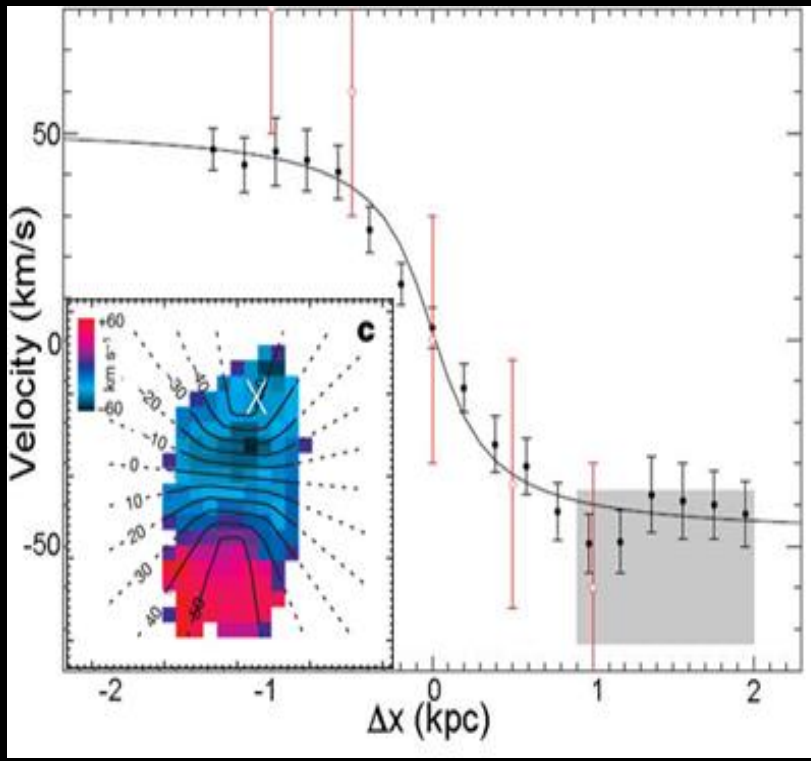
Gravitationally lensed distant galaxies seen by Keck LGS, HST



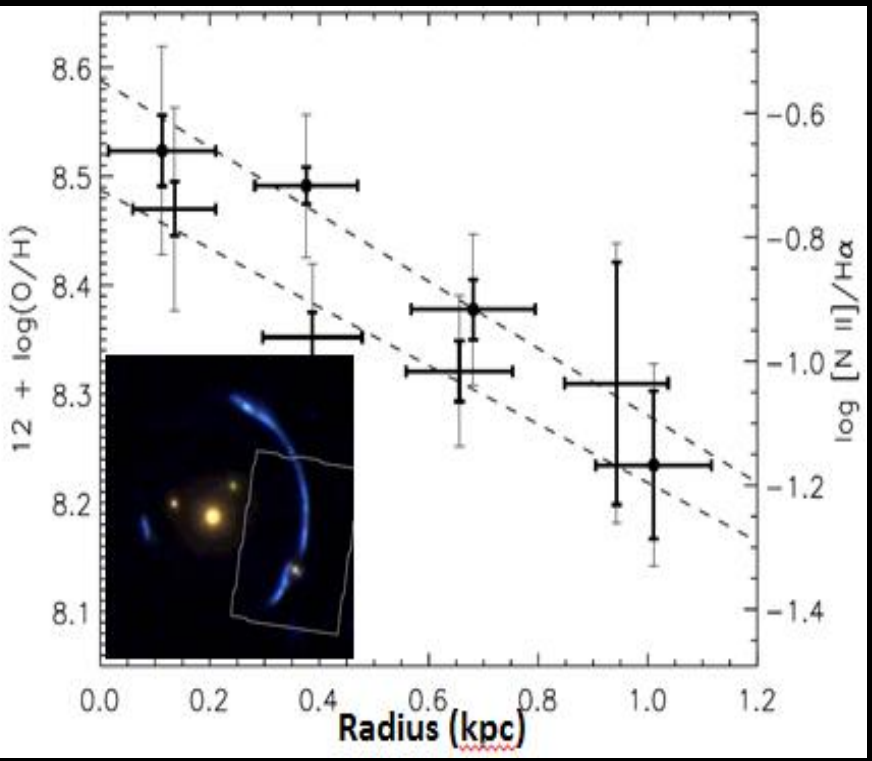
- Hubble Space Telescope
- Keck laser guide star AO

Credit: C. Fassnacht et al.

Extragalactic science example: gravitationally lensed galaxies, LGS AO, <200pc resolution

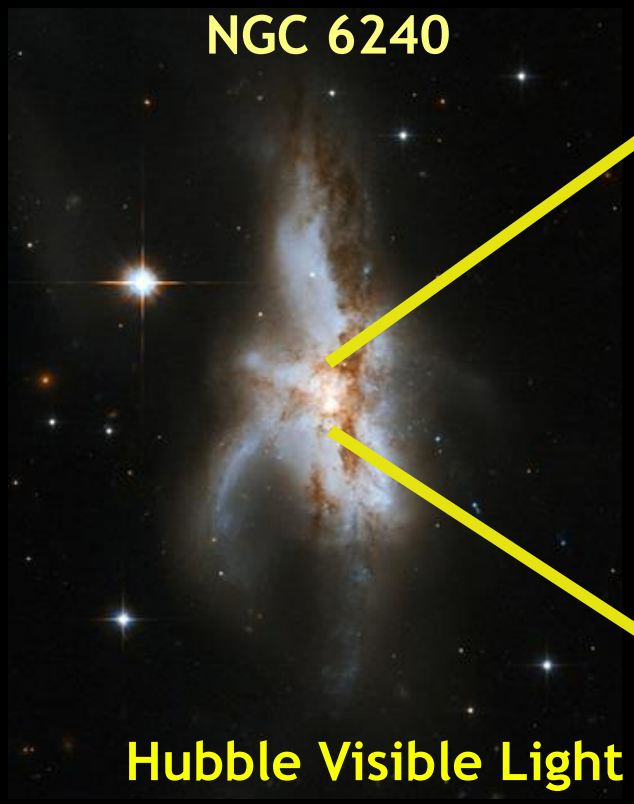


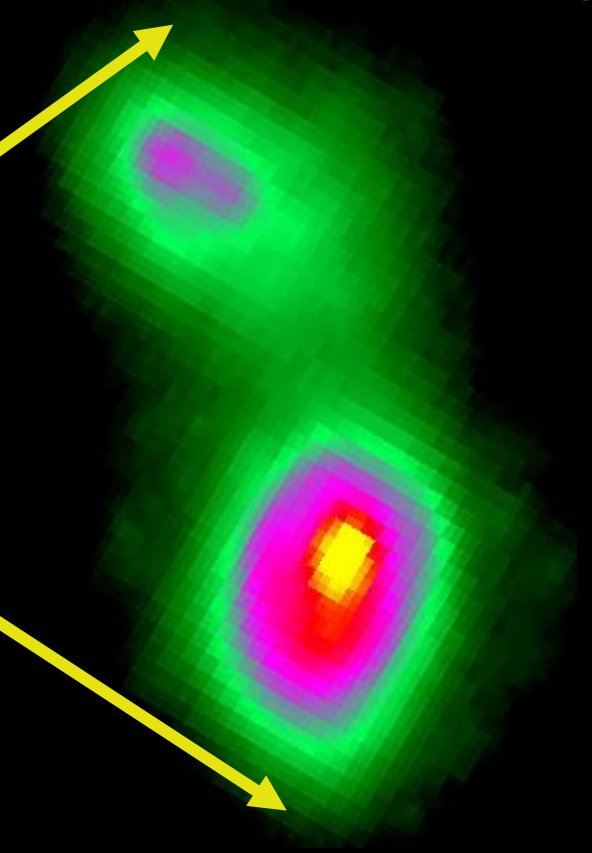
Rotation curve and velocity field (inset) for gravitationally lensed z=3.07 galaxy, spatial resolution of ~100pc (Stark et al., 2008).

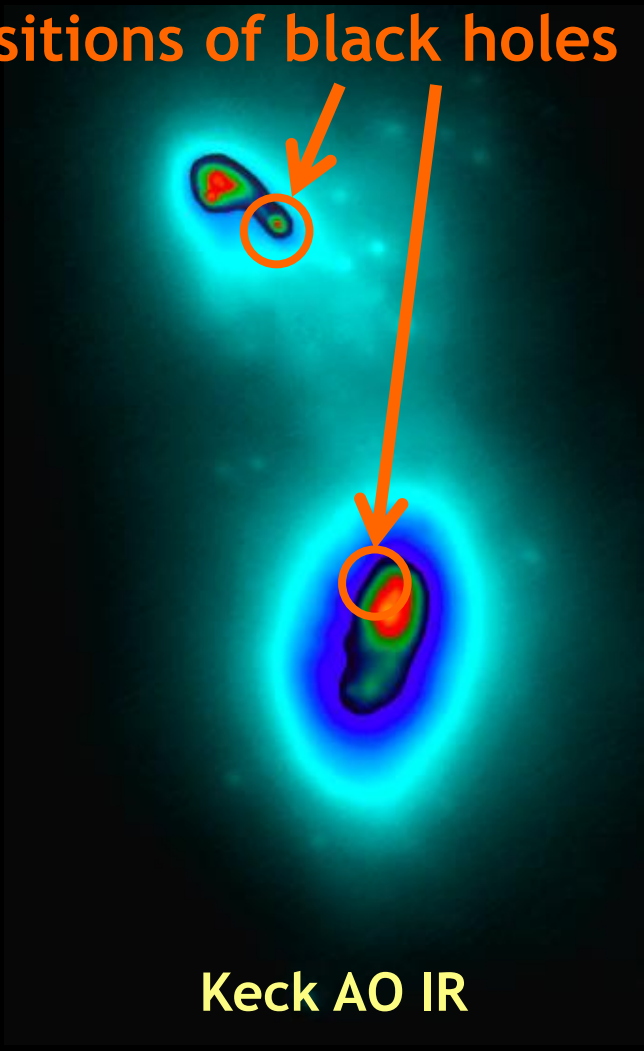


Metallicity gradient inferred from gaseous emission lines for two images of the same lensed z=2.00 source (inset) (Jones et al., 2010).

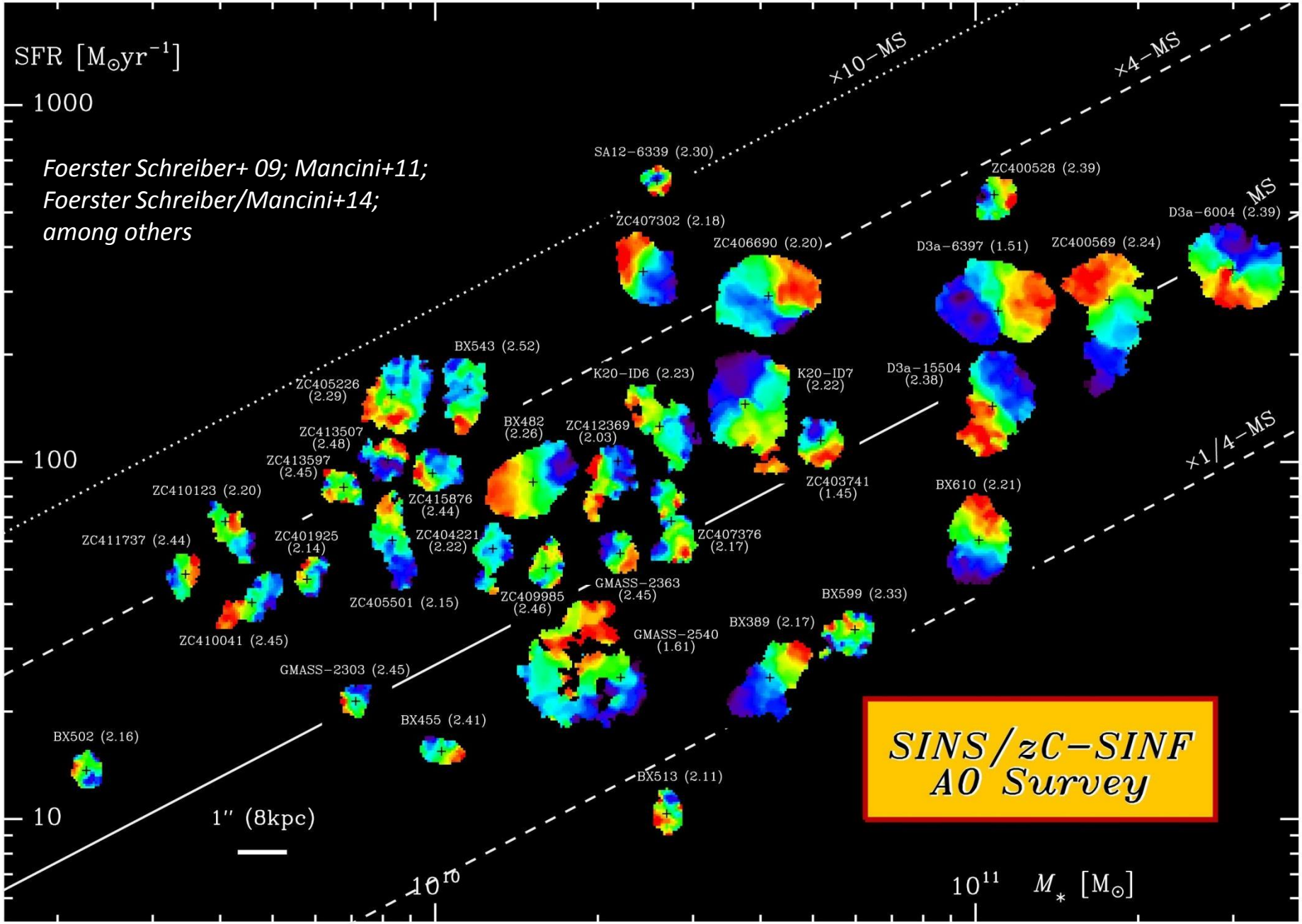
Nuclei of merging galaxies: Identifying the 2 supermassive black holes with AO







Resolved Kinematics at z~2



Keck AO serves a large and diverse community

	Caltech	UC	UH	Other-US	International	Total
Lead Authors	10	13	10	24	5	62
Unique Lead Authors	9	13	8	21	5	56
All Authors	110	144	40	296	232	822
Unique All Authors	68	93	22	240	186	609

Conclusions about current and future status of AO systems

- AO with laser guide stars now on all but one of current 8-10m telescopes. Science Productivity is high and growing.
- LGS AO will be key to instrumentation on ELTs. Required AO technology is significant extension of today's state of the art. Technology investment and observing experience on 8-10m telescopes in next few years will lower risk for ELTs.
- Directions for Component Development:
  - High spatial resolution correctors including Adaptive Secondary Mirrors
  - Wide passband (Optical-IR), fast, low noise wavefront sensors
  - Advanced laser guide star beacons and tomography
- Directions for Systems Development:
  - GLAO with ASMs for highly multiplexed surveys
  - High Strehl high sky coverage narrow-field AO systems
- Programs that train instrumentalists key to new discoveries.

Issues in structure of NSF funding opportunities for AO R&D

- TSIP and AO Dev. Program were key funding paths for AO.
- Funded both ***research*** on advanced AO technologies, and ***implementation*** on broadly used telescopes.
- The ***implementation*** aspect turned out to be key
  - A long way to go between a lab or telescope prototype and a fully capable "facility instrument" that produces science every night.
- Cost of new AO technologies exceeds limits for ATI and MRI
  - Adaptive Secondary Mirror for VLT costs approx. $14M
  - Full Ground Layer AO System for VLT will cost closer to $20M
  - Proposed High-Strehl High-Sky-Coverage AO system will cost ~$30M

Challenge: Can we structure NSF funding mechanisms to better meet these needs

- Increase funding cap on ATI / MRI proposals?
- Can we make MSIP guidelines more appropriate for AO system implementation on 8-10m telescopes?
  - Cost of individual projects > upper limits for ATI, MRI
  - Most will cost > $9M max for FY15 MSIP projects
  - There wasn't a good ***category*** for advanced new AO systems installed on existing telescopes
  - Clarify "return to the community" expectations.
    - Not special-purpose such as HERA, ACT-Pol
    - Yet not public telescopes like Gemini
    - How many community-use nights are appropriate? State clearly ahead of time.