Status of Lynx Mission Concept Study

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on behalf of the Science & Technology Definition Team

Lynx Science & Technology Definition Team


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Key decisions and work topics for the Lynx science team

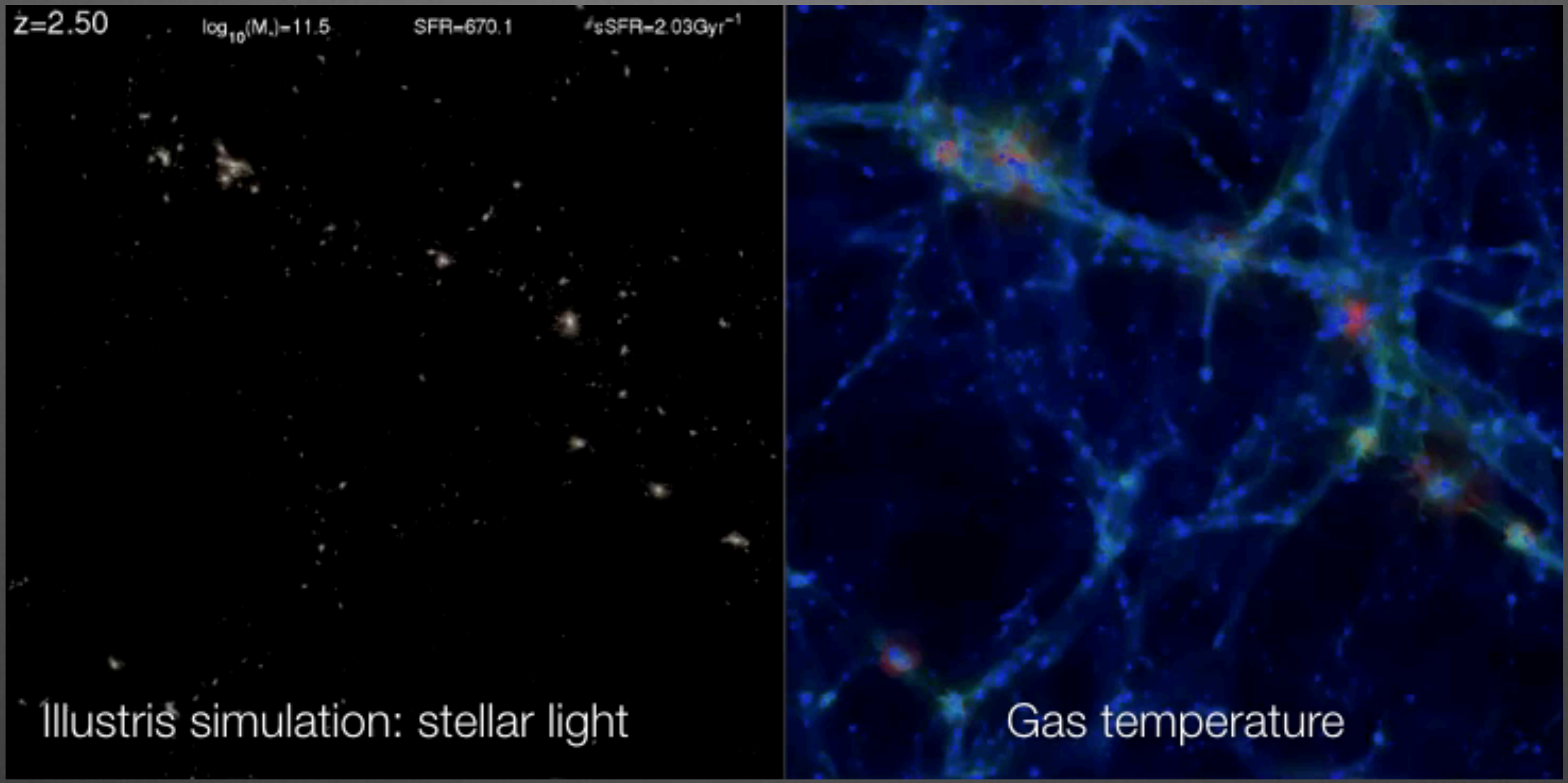
- ✓ What kind of observatory *Lynx* should be?
- ✓ How big?
- ✓ Detailed requirements for the optics
- ✓ Science instrument suite, and requirements
- Complete mission design
- Progress in technology, develop technology roadmap
- Write up the science case

Major Science Pillars

- The Invisible Drivers of Galaxy Formation and Evolution

- The Dawn of Black Holes

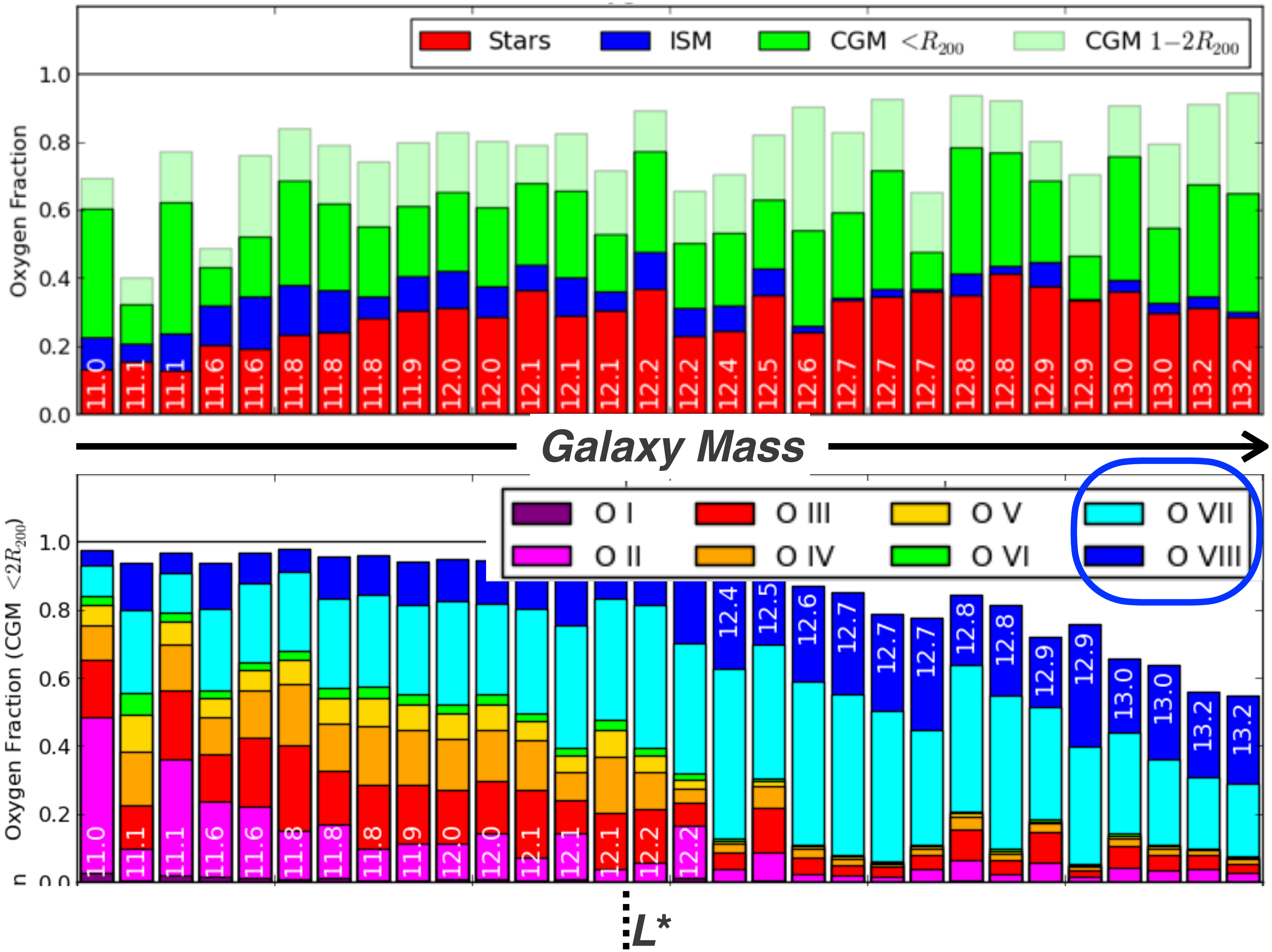
The Invisible Drivers of Galaxy Formation and Evolution



- This topic concentrates on a critical and well-defined aspect of the broader subject of galaxy formation. It is related to numerical cosmology, extragalactic astronomy, AGNs, ISM physics, star formation, etc.
- **Breakthrough progress:** *Lynx* will be uniquely capable of observing the state of baryons in galactic haloes with M>Milky Way; measure the energetics and statistics of all relevant feedback modes; new unique insights on the physics of feedback to inform numerical models.
- **Unique *Lynx* contribution:** In galaxies with M>~Milky Way, the relevant baryonic component is heated and ionized to X-ray energies. Needed observations rely on high-resolution spectroscopy and the ability to detect low surface brightness continuum emission (both unique to *Lynx*), and on a capability to map large areas in the sky in OVII, OVIII etc.

Incisive Diagnostics of CGM/IGM

Oppenheimer et al '16: EAGLE simulation: Oxygen census and Ionization Fractions

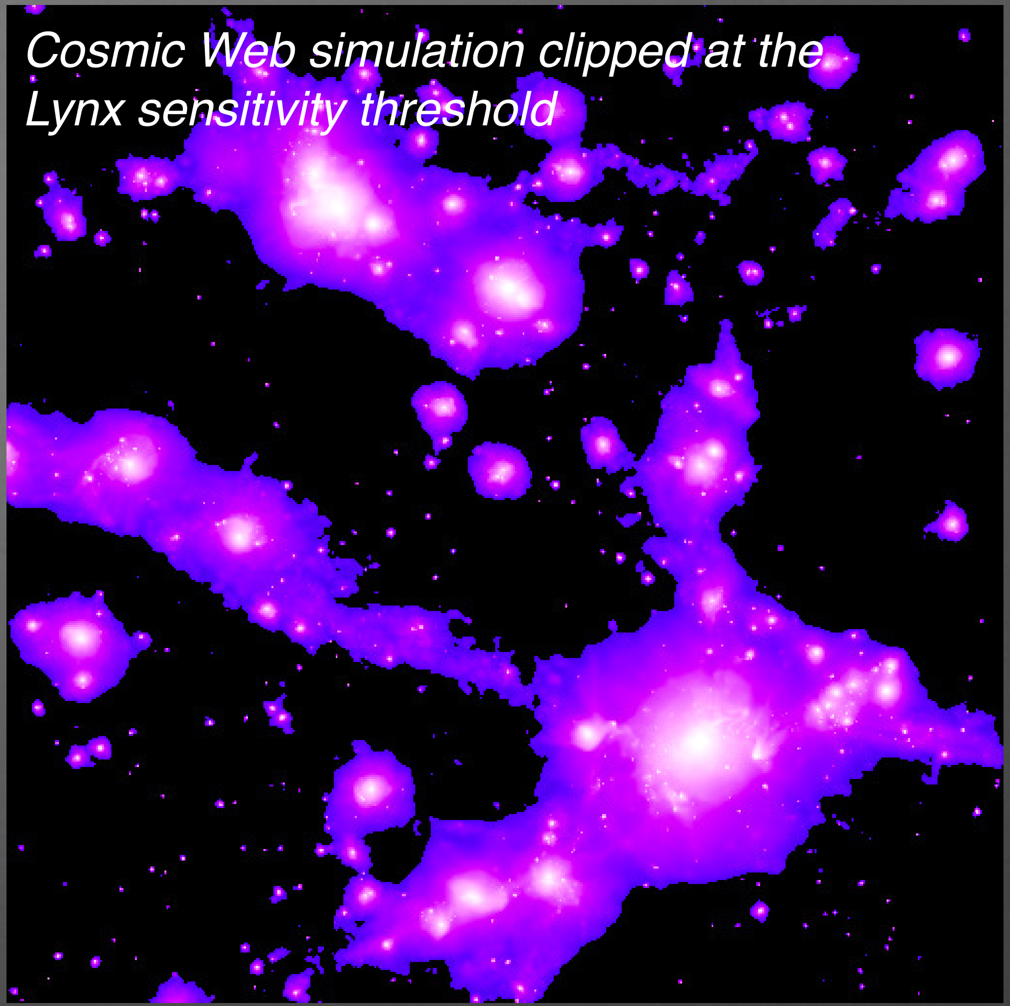


*L** galaxies: >50% of O is in CGM

~80% of that is observed in X-ray transitions (OVII at 0.57 keV, OVIII at 0.65 keV)

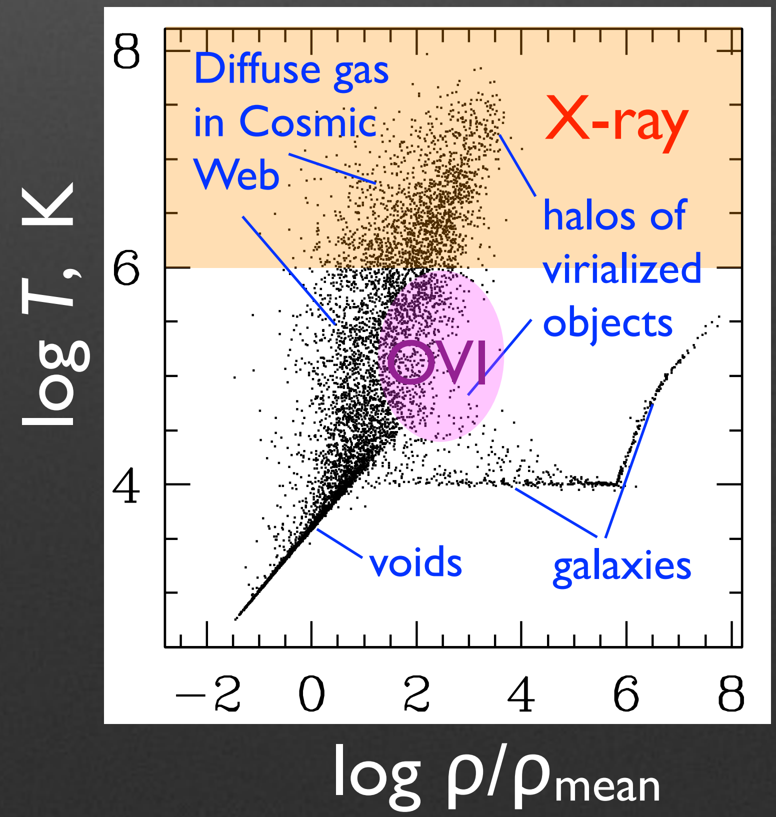
Incisive Diagnostics of CGM/IGM

Mock Lynx observation of gas halo in a galaxy from Illustris Simulation. Credit: R. Kraft, A. Bogdan, S. Nulsen, J. ZuHone



Cosmic Web simulation clipped at the Lynx sensitivity threshold

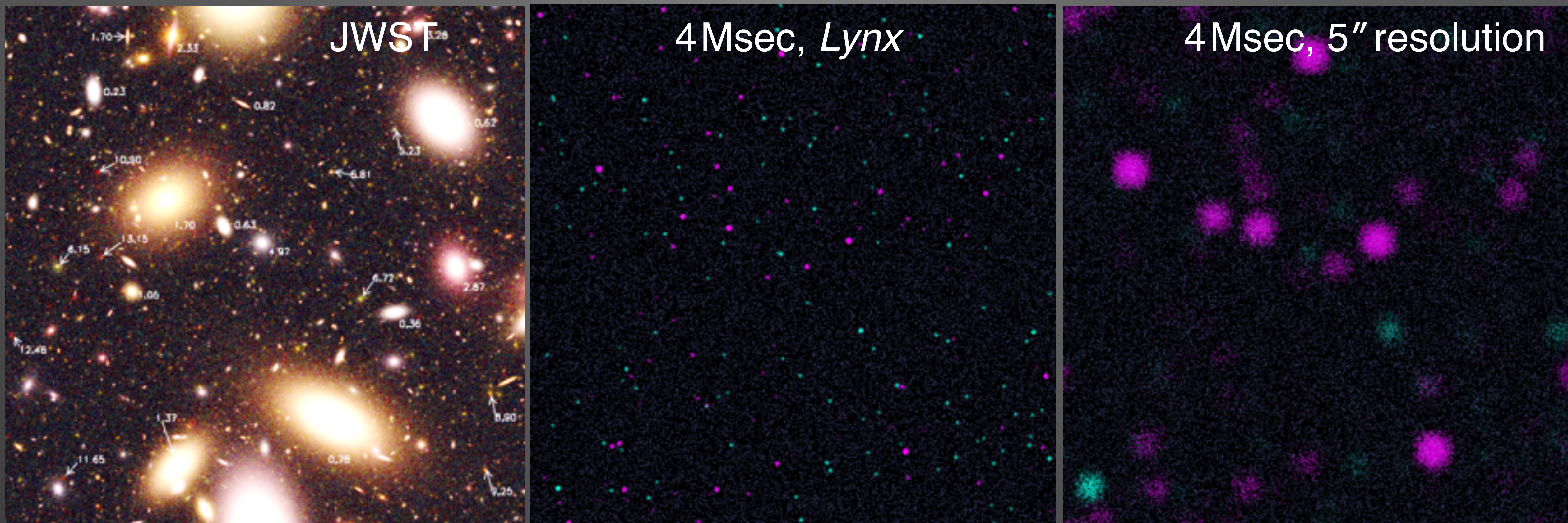
Hot gas in galactic halos and Cosmic Web filaments will be observable in emission with direct imaging both in continuum and brightest emission lines, and in absorption in X-ray gratings spectra of background AGNs.



Phase diagram for the baryons in the Local Universe (theoretical prediction from Davé et al. 2010). Heated gas ($T>10^5$ K) in virialized halos and Cosmic Web accounts for >40% of all baryons by mass.

The Dawn of Black Holes

Simulated 2×2 arcmin deep fields observed with JWST, Lynx, and ATHENA

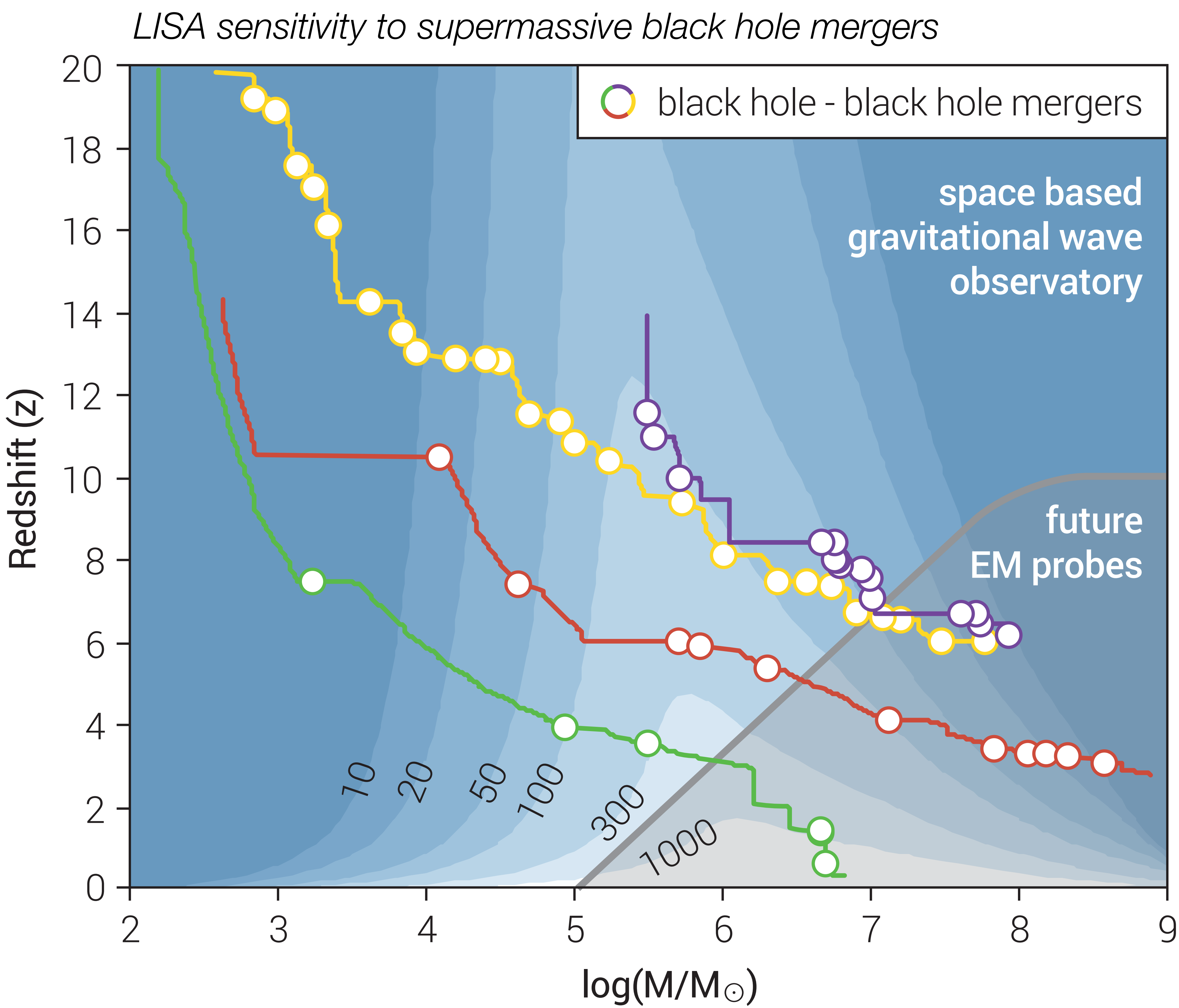


- This topic is an essential component of the broad subject of the Early Universe as it goes through the reionization epoch and the first generations of galaxies emerge. Of interest to all astronomers working on the early universe, galaxy formation, black holes.

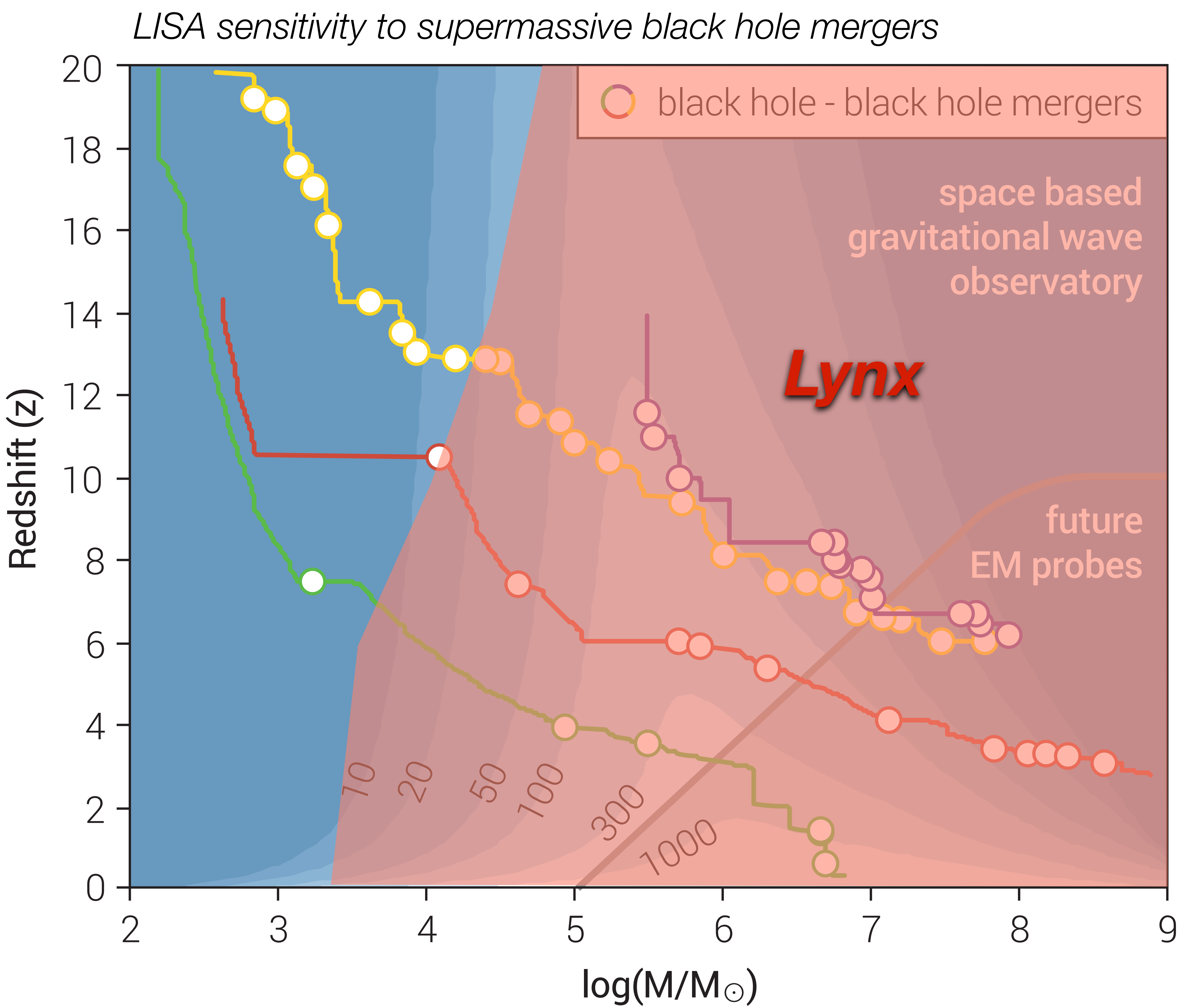
- **Breakthrough progress:** The origin of SMBHs is a mystery and will likely remain the mystery until 2030s. Lynx is uniquely positioned to detect the SMBH at their seed stage or soon after.

- **Unique *Lynx* contribution:** Low-mass black holes, generically, are best observed at X-rays. Reaching into the seed regime requires sensitivities ~ 1e-19 erg/s/cm^2, which only *Lynx* can achieve.

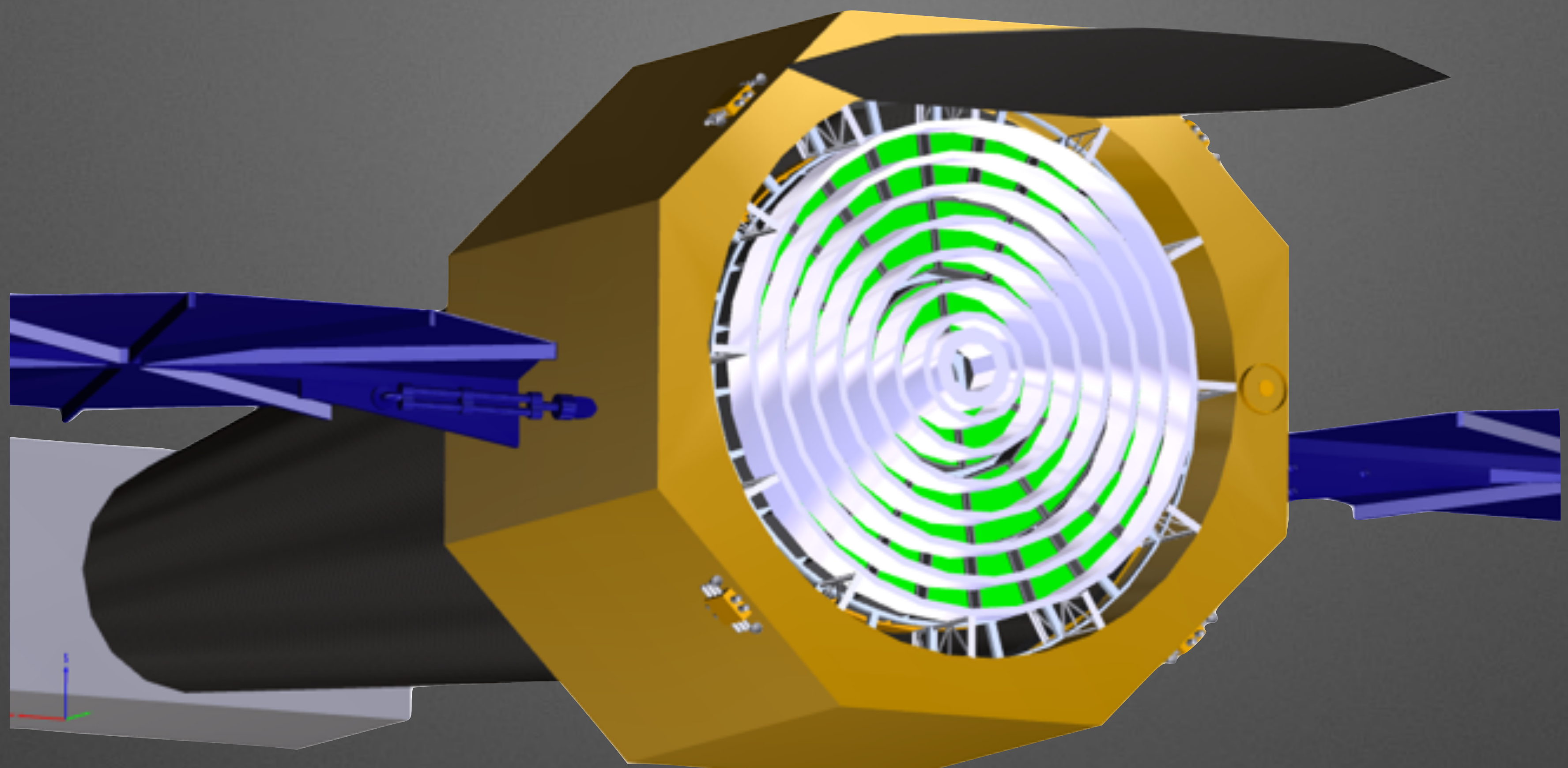
The Dawn of Black Holes



The Dawn of Black Holes



Lynx mission requirements



- **0.5″ angular resolution on-axis**
- **Effective area of 2 m^2 at ~1 keV.** Implies a 3m diameter for the mirror system — can be accommodated by current launch vehicle fairings. **Soft-band throughput is ~ 50× *Chandra,***
- Sub-arcsec imaging out to 10 arcmin radius. **Speed for sensitive surveys is 800× *Chandra***
- “Invisible Drivers” science requires high resolution spectroscopy with gratings (R~ 5,000-10,000) and microcalorimeter (0.5–1″ pixels, up to 1–2 eV energy resolution).

Recent assessment of technology gaps for Lynx by NASA PCOS office

ASTROPHYSICS

Lynx

	Total Gaps	TRL 2 Gaps	TRL 3 Gaps	TRL 4+ Gaps
Enabling+ enhancing	5	1	3	1
Enabling only	5	1	3	1

ID	Technology Gap	TRL	Note
1	High-resolution lightweight X-ray optics	2	Should the required system-level angular resolution be achievable with mirror-level resolution of 2 arcsec, and/or if the factor currently limiting mirror-level performance to 2 arcsec and a credible technological extension are identified, this TRL would be at 3.
2	Non-deforming X-ray reflecting coatings	3	Thin glass substrate coated with Pt showed identical thickness coatings on two sides resulted in minimal net distortion
3	Megapixel X-ray imaging detectors	3	
4	Large-format, high spectral resolution X-ray detectors	3	
5	X-ray grating arrays	4	