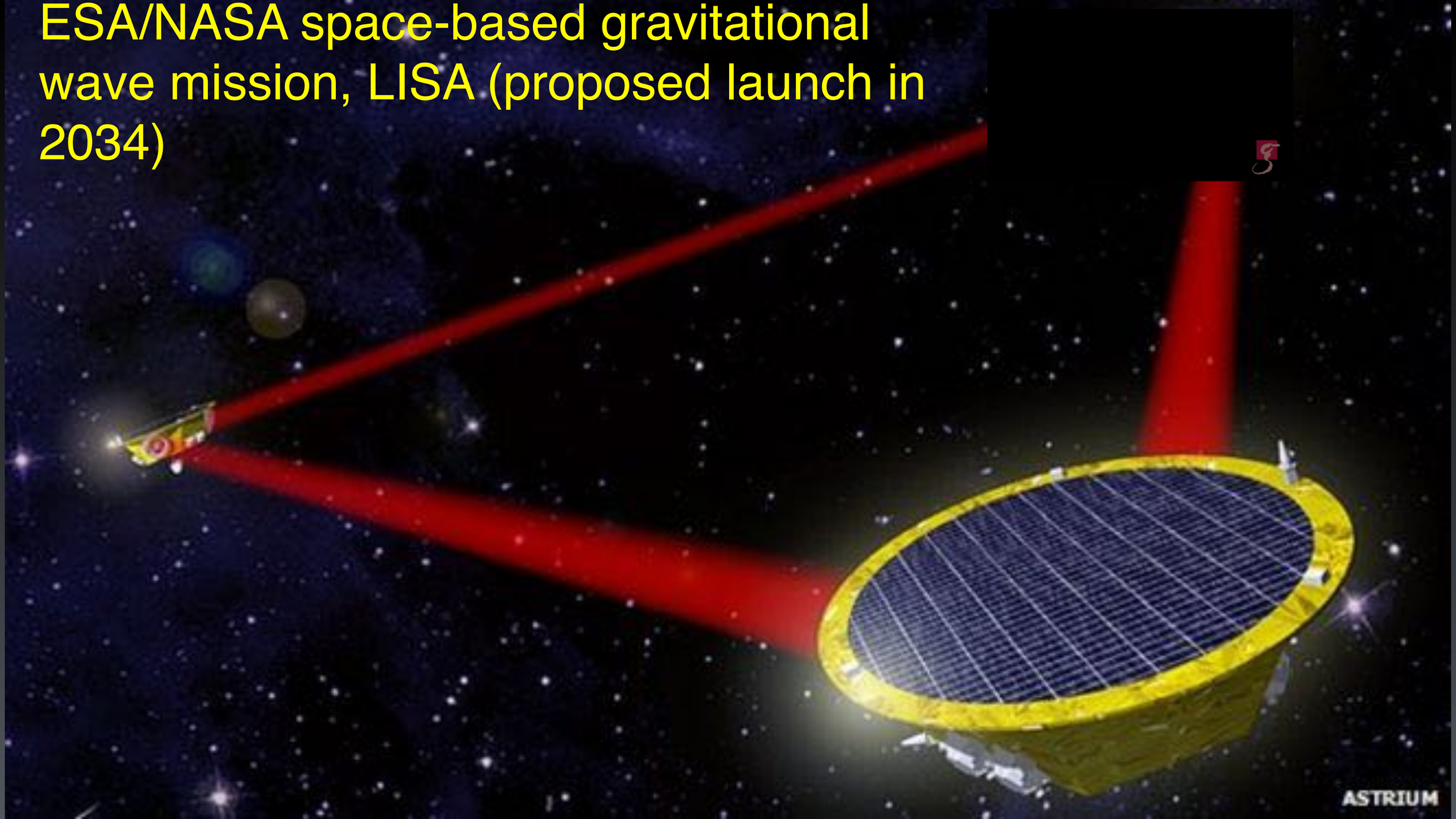
NASA LISA Study Team – talk with us about all things gravitational wave!

ESA/NASA space-based gravitational wave mission, LISA (proposed launch in 2034)



For objects with orbital periods of seconds — hours…
Imagine what you could do with:

Masses — 0.01 - 1%

Distances — 1-10%

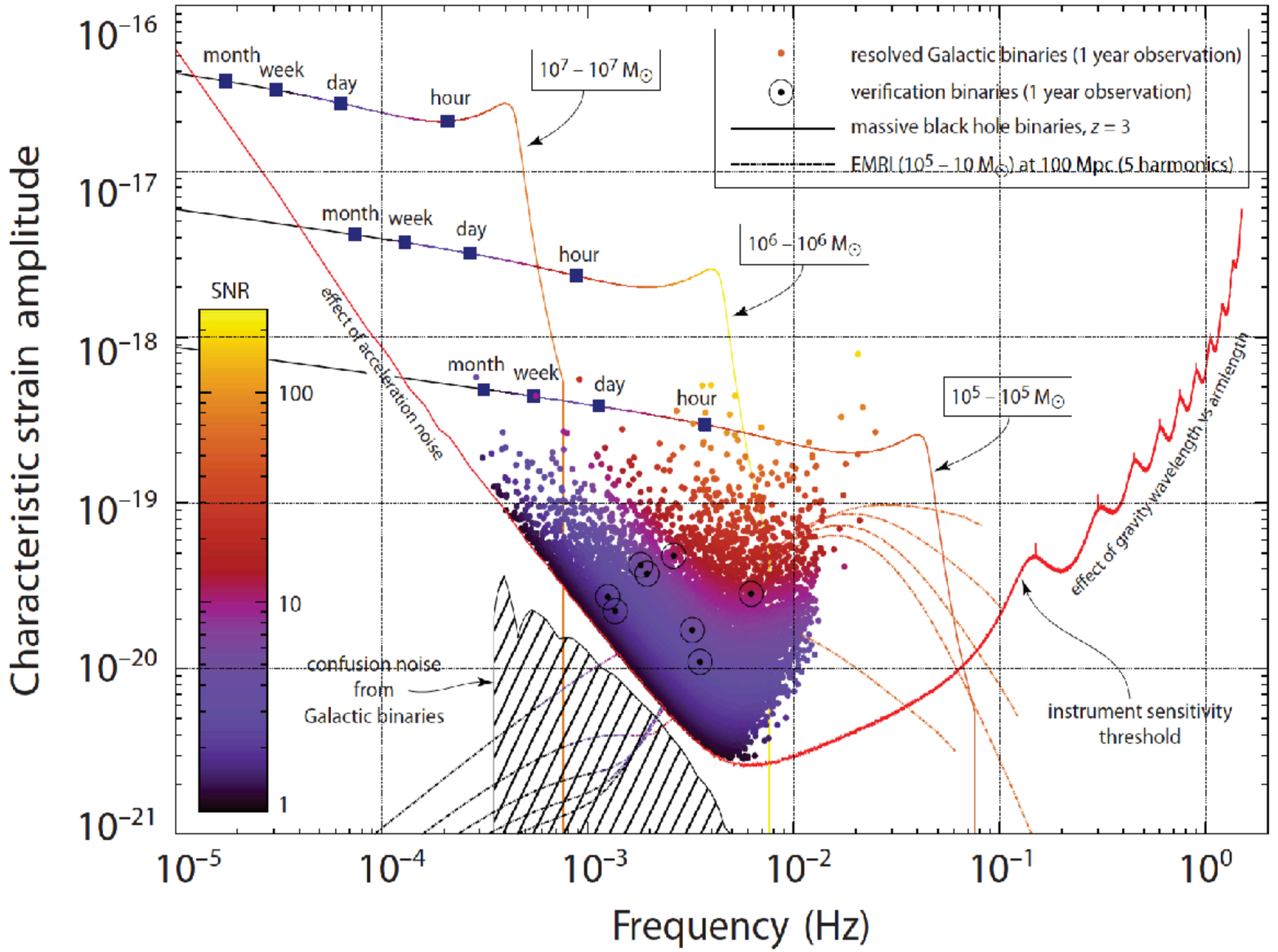
Spins — 1-10%

Spin directions — 10 degrees

Sky localization — 1 arcmin^2 — 10 deg^2

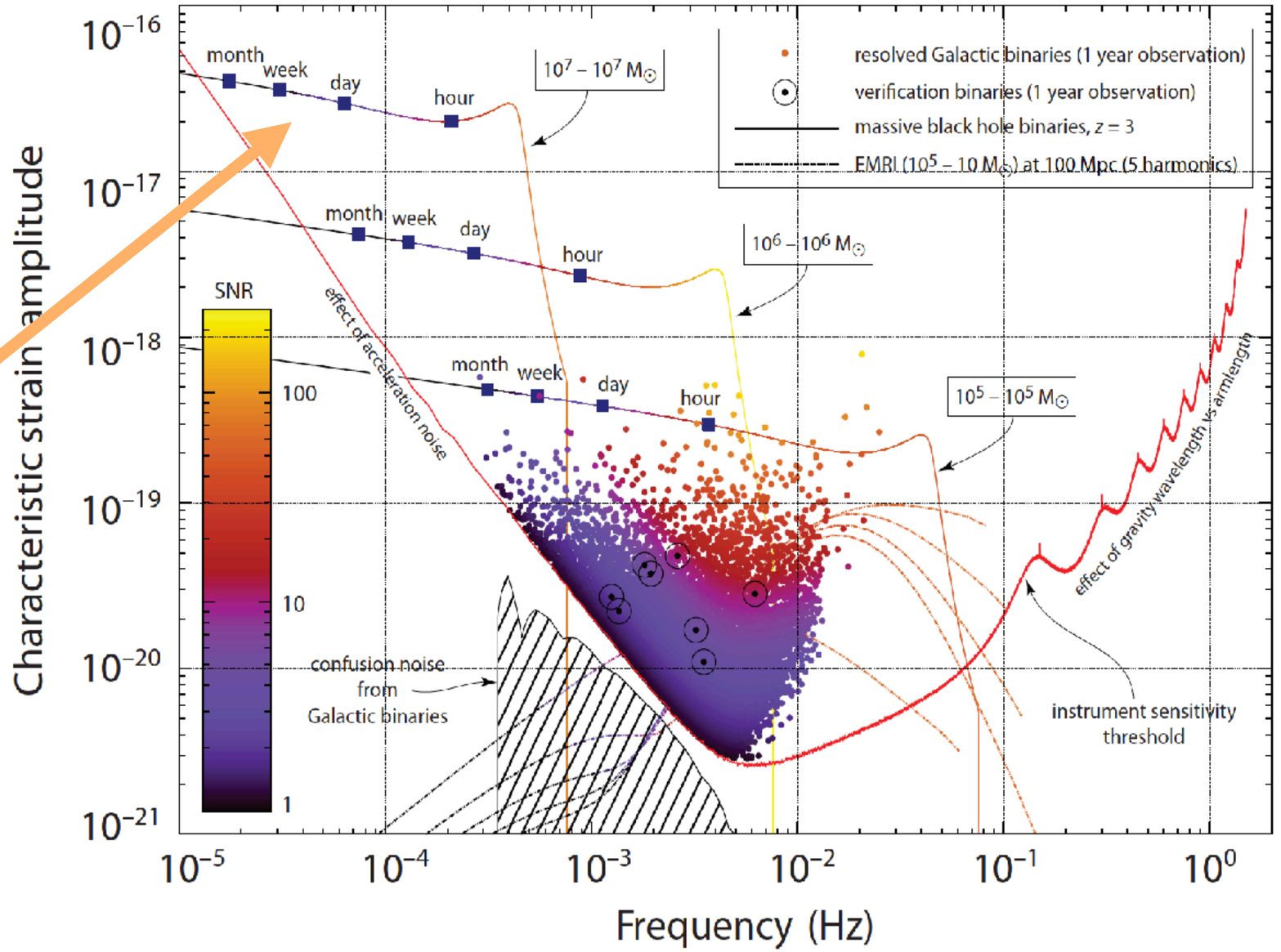
Eccentricity — 1%

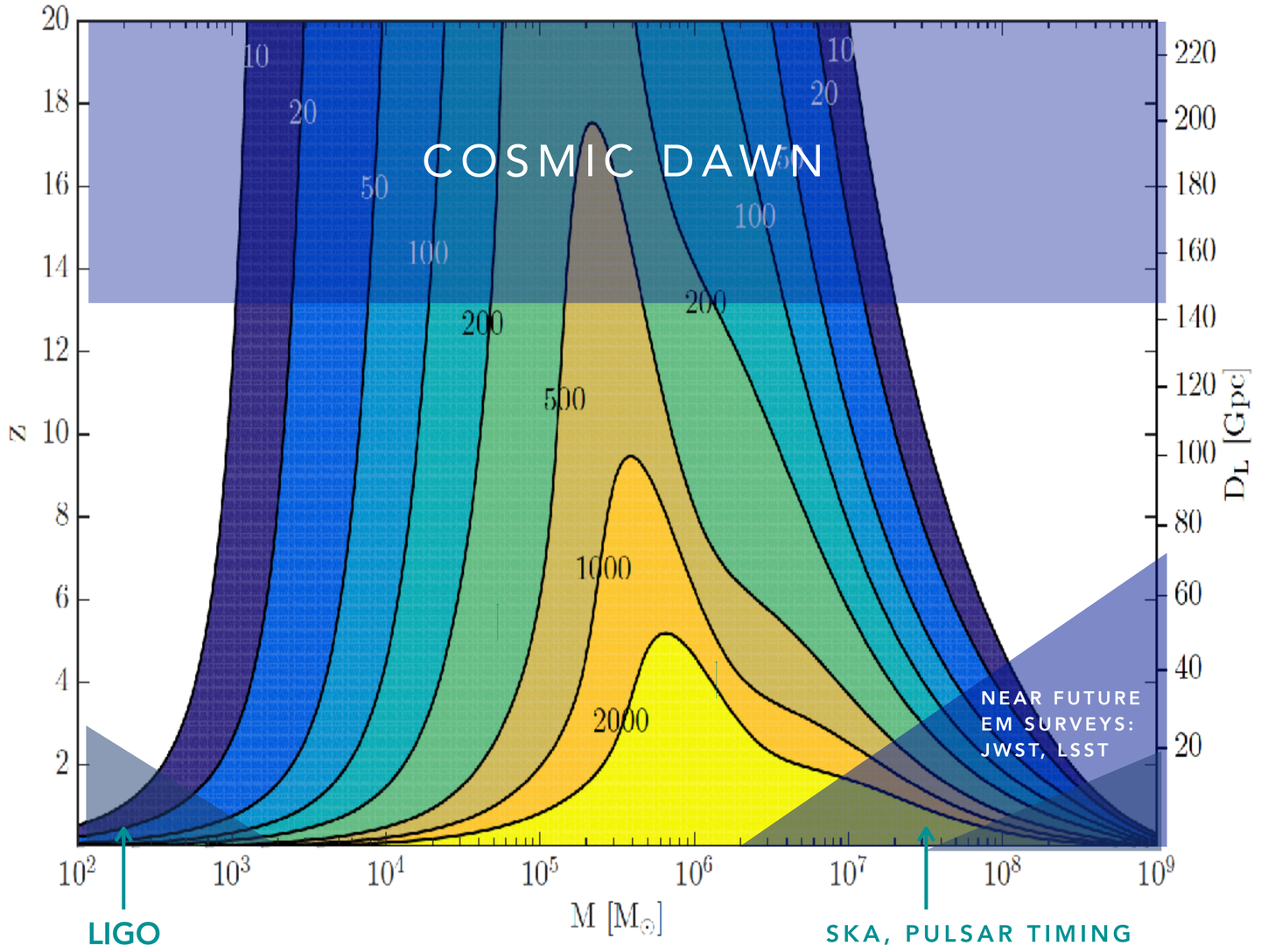
LISA Discovery Space



lisa

Mergers of Milky-Way Class Supermassive Black Holes



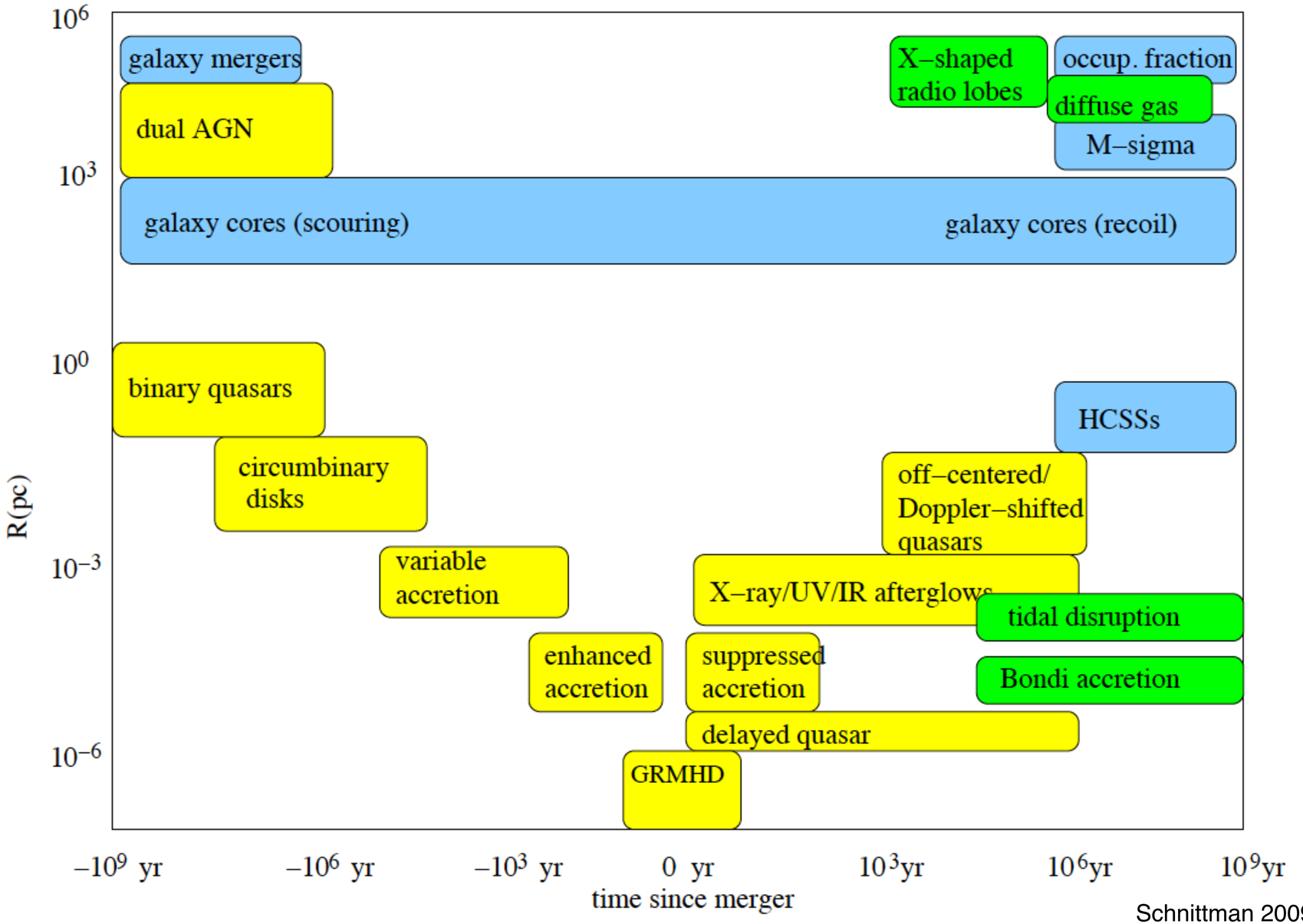


LISA detects the inspiral and merger of intermediate and massive Milky Way-class black holes with huge SNR throughout the observable universe and into the Cosmic Dawn.

What Do We Hope to Measure With LISA and What Do We Hope to Learn?

- Mergers of binary BHs with M ~ 10^4 – 10^8 $M_\odot$
- Trace BH (and galaxy) merger history to z~20 and constrain the origin of BH seeds.
- Complement deep X-ray surveys that trace BH demographics and growth to z~10.
- Complement UV-O-IR surveys that probe star-formation history and evolution of galaxies to z~8–10 and beyond.
- Identification of individual events for detailed case studies.

While the theoretical and technological dust settles, let's think beyond electromagnetic counterparts



Schnittman 2009

— accurate black hole mass measurements up to z~8 for 10^5<10^7 $M_\odot$

— connecting SMBH birth/growth in the reionization era

— the type of galaxy for SMBH hosts

— BH occupation fraction up to z~8 and for Mgal=small

— find evidence of binary black holes (enlist time-domain?)

— look for recoiling AGN (can get 3-d space velocity) — maps to SMBH spin and mass ratio before SMBH merger

— measure galaxy merger rate to constrain SMBH merger dynamics (esp. @ low mass end)

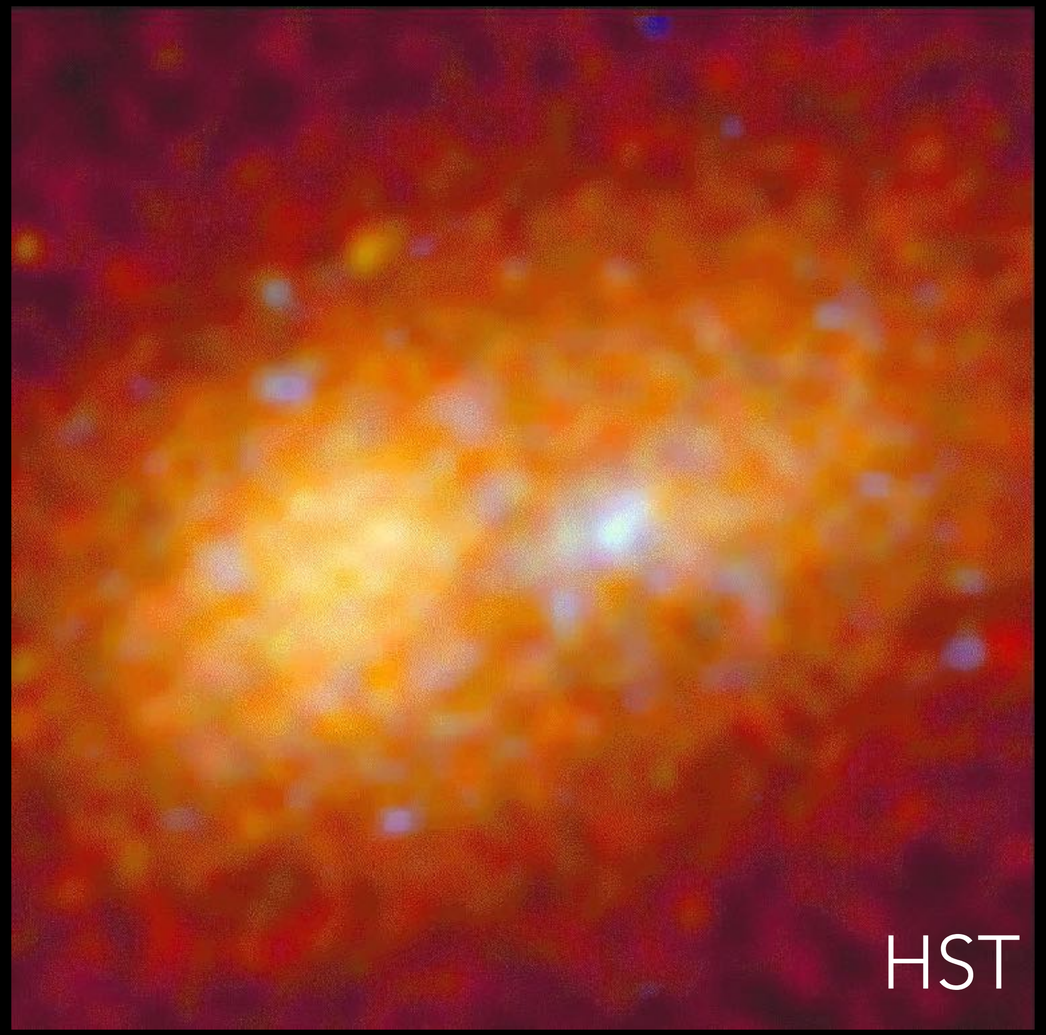
— hypervelocity stars from 3-body scattering out to Coma?

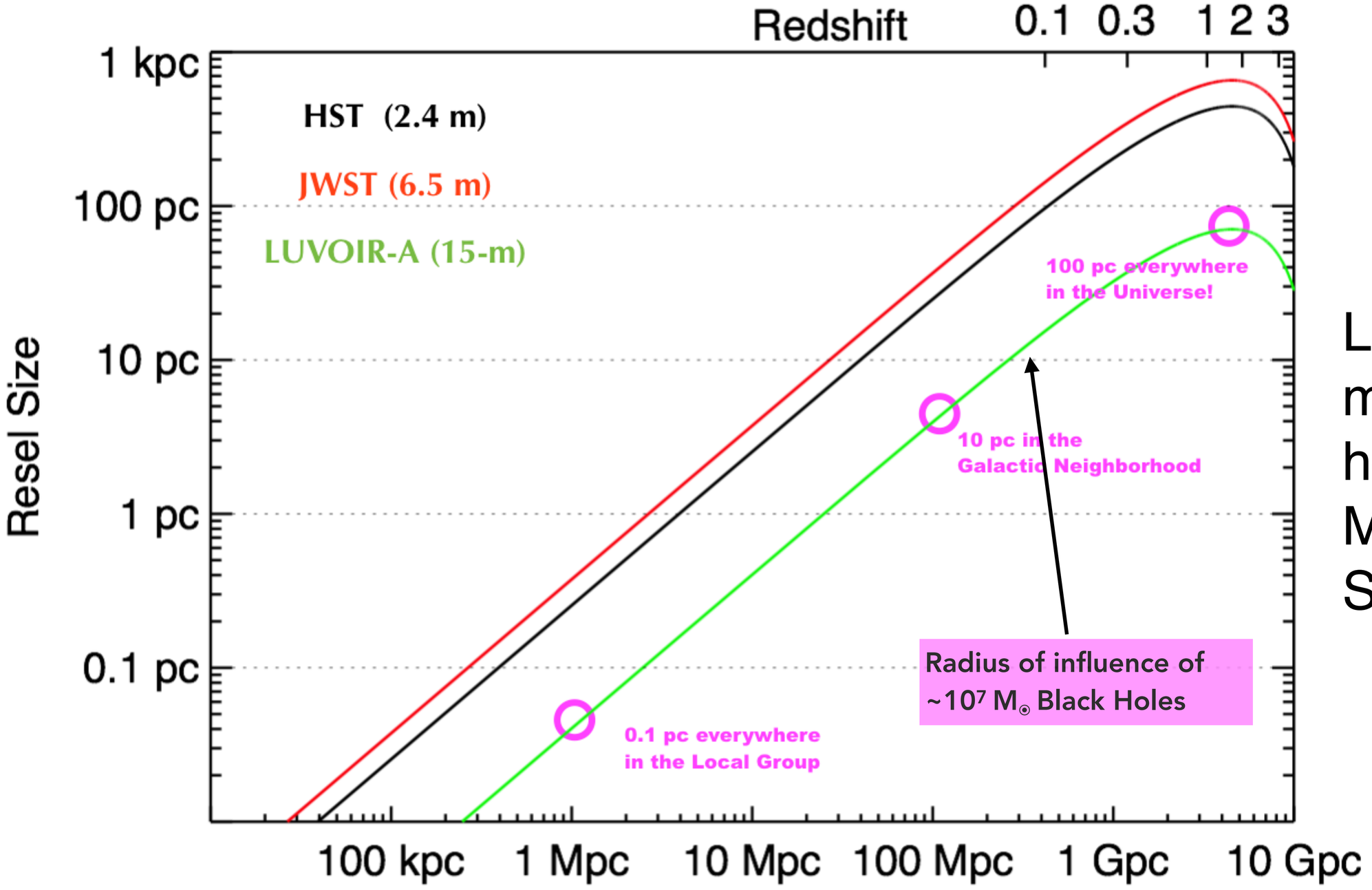
— maybe pulsar planets, nearby highly eccentric and/or hot Jupiter planets (regardless of inclination)

— nuclear structure to connect EMRIs to tidal disruption events, and to constrain core scouring

LUVOIR can help maximize LISA science, even without electromagnetic counterparts!

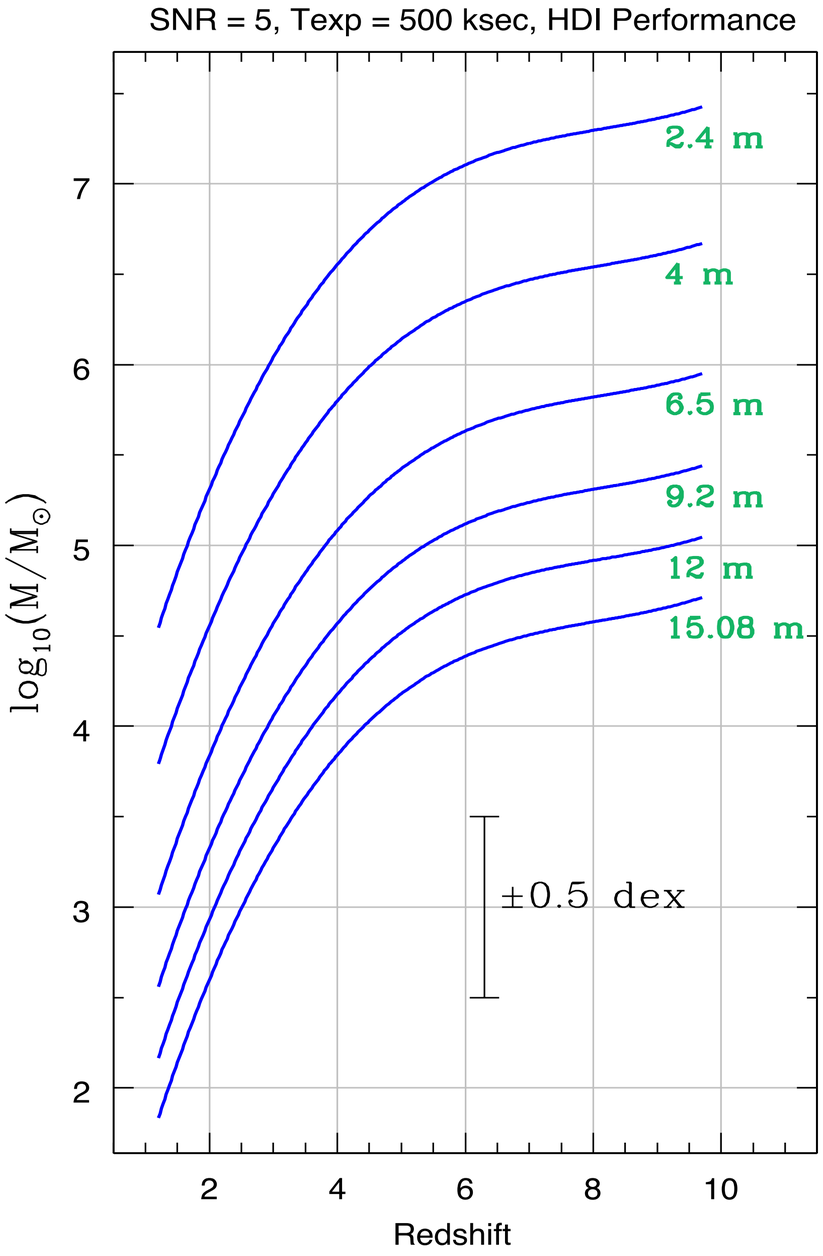
Combine the exquisite resolution of LUVOIR with LISA data

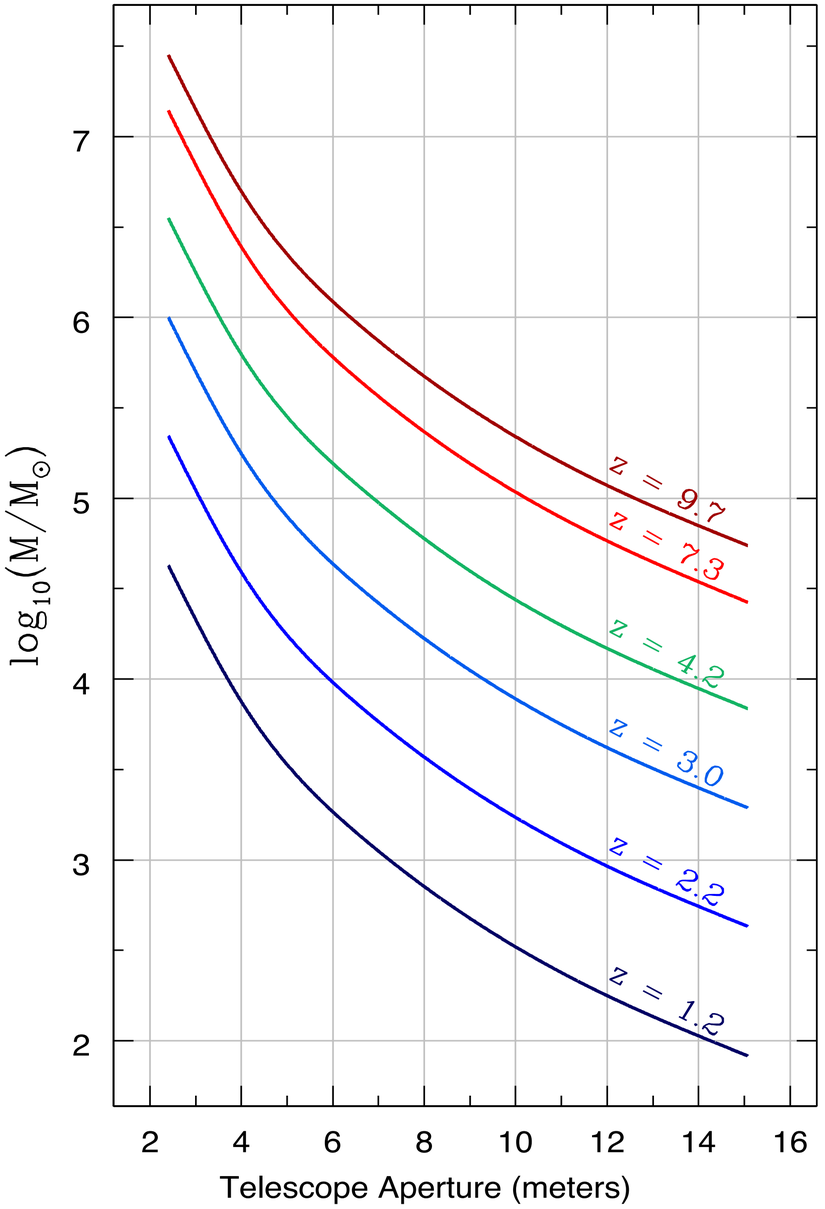




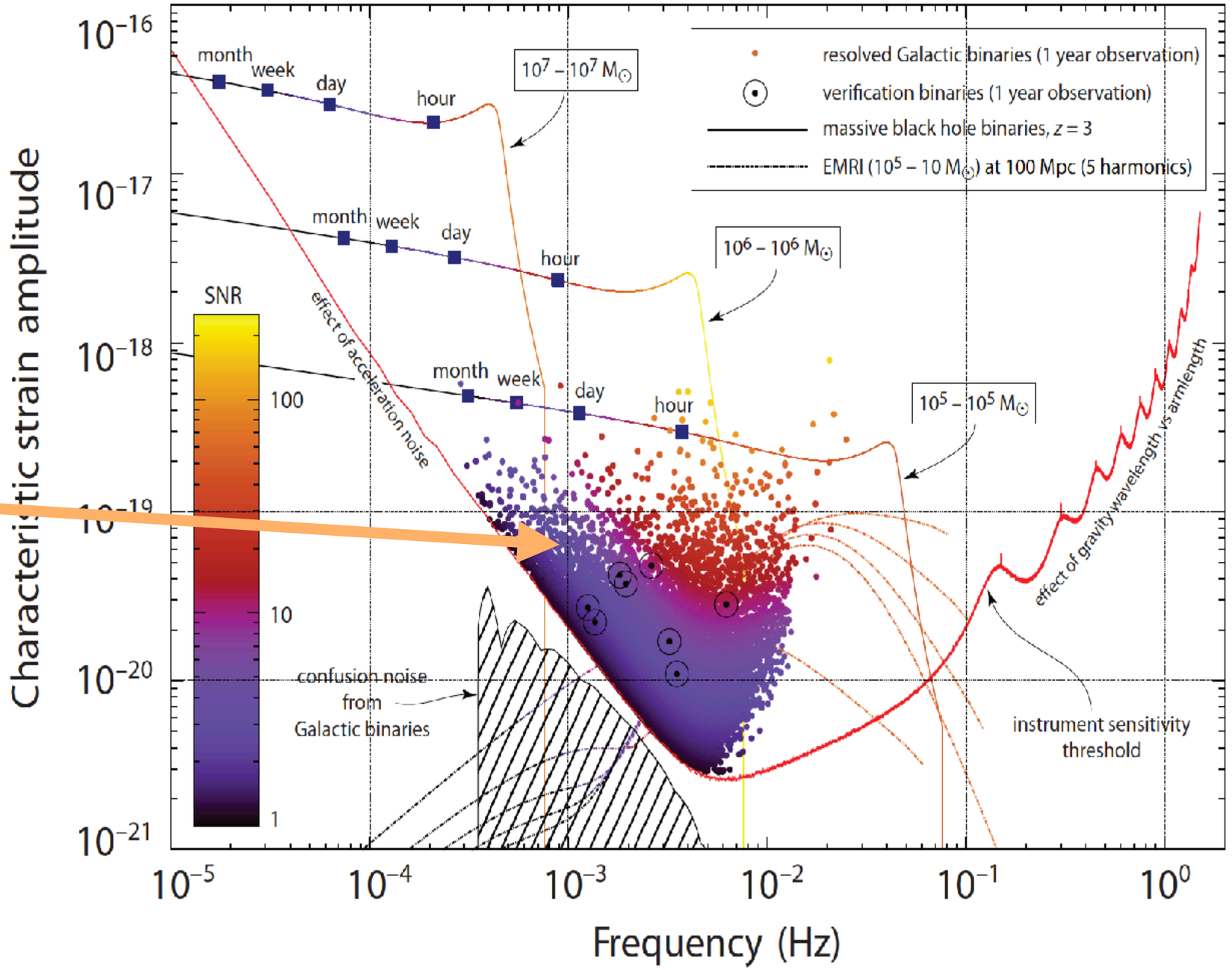
LUVOIR can measure black hole masses for Milky Way SMBHs

LUVOIR can peer into LISA host galaxies, even for IMBH/seed BH hosts

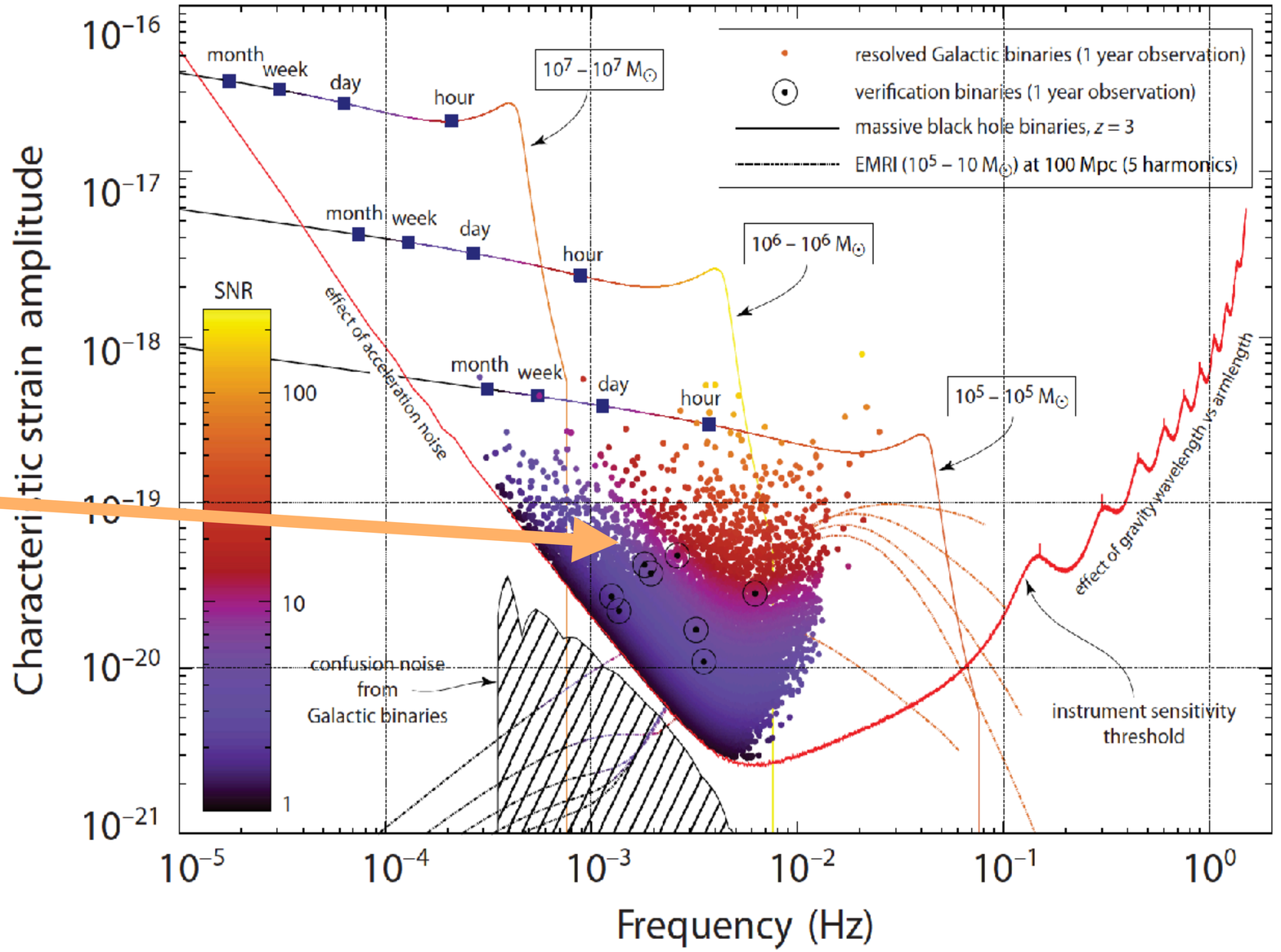




Millions of close compact object binaries



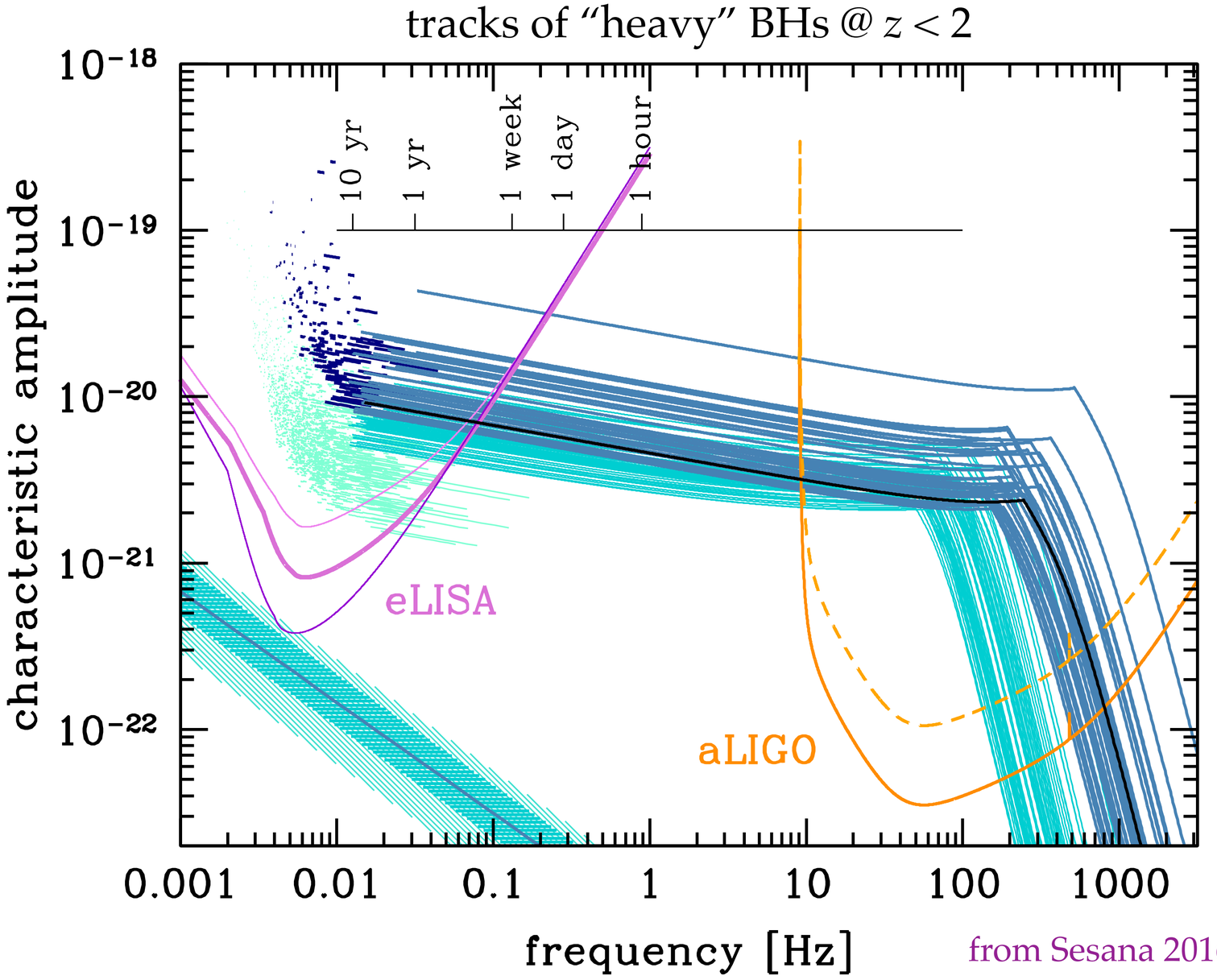
Gravitational waves are unaffected by dust!



What do we hope to measure with LISA and what do we hope to learn?

- Binary Star Evolution
  - Census of compact binaries, especially WD+WD
  - Determination of binary parameters
- Mapping of old stellar population in Milky Way
- Accretion Physics
  - Obtain system parameters, especially masses and mass transfer rates
  - Combine with known distances/luminosities to constrain accretion flow models
- Preview of LIGO sources (out to z~2)

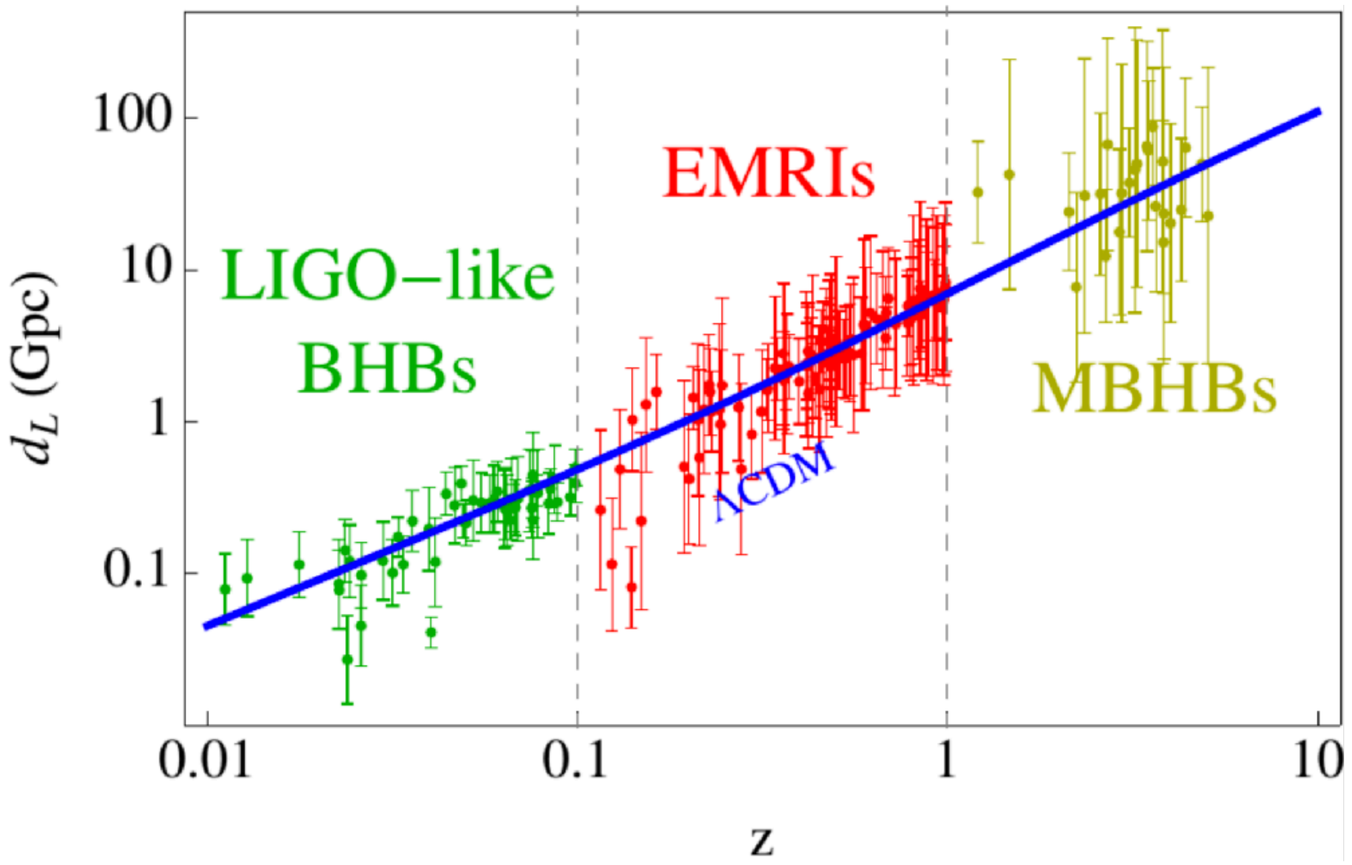
Extending and complementing LIGO science



from Sesana 2016, *Phys. Rev. Lett.*, **116**, 231102

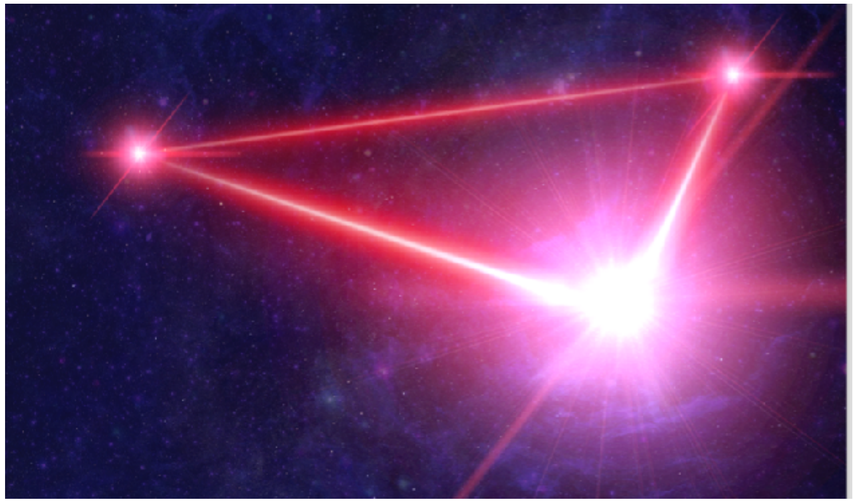
Black hole cosmology with standard sirens

- **BH mergers as standard sirens**
  - chirp rate gives mass
  - mass gives intrinsic amplitude
  - measured amplitude gives distance
- **combine with redshift to get H_0**
  - Need EM follow-up to identify (or constrain) hosts



Luminosity distances for simulated catalog of LISA BH binaries (N. Tamanini)

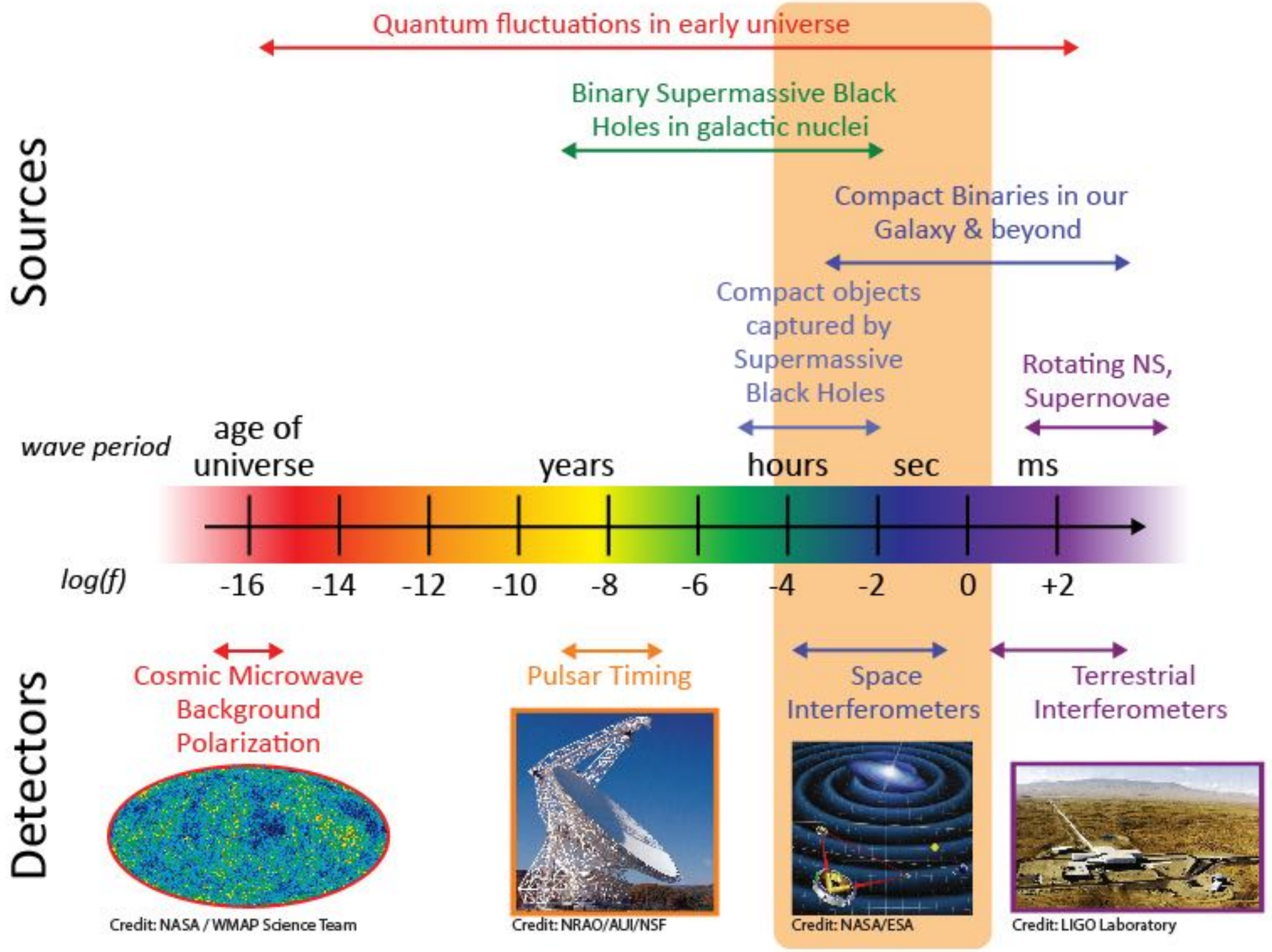
It’s a wonderful time to be an astronomer!



My Fellow Astronomers: **LISA is happening!** It’s time to think about how how to get the most science out of LISA data. We need to build capacity in the brand new field of gravitational wave astronomy and we need you!

Than
ks!

The Gravitational Wave Spectrum



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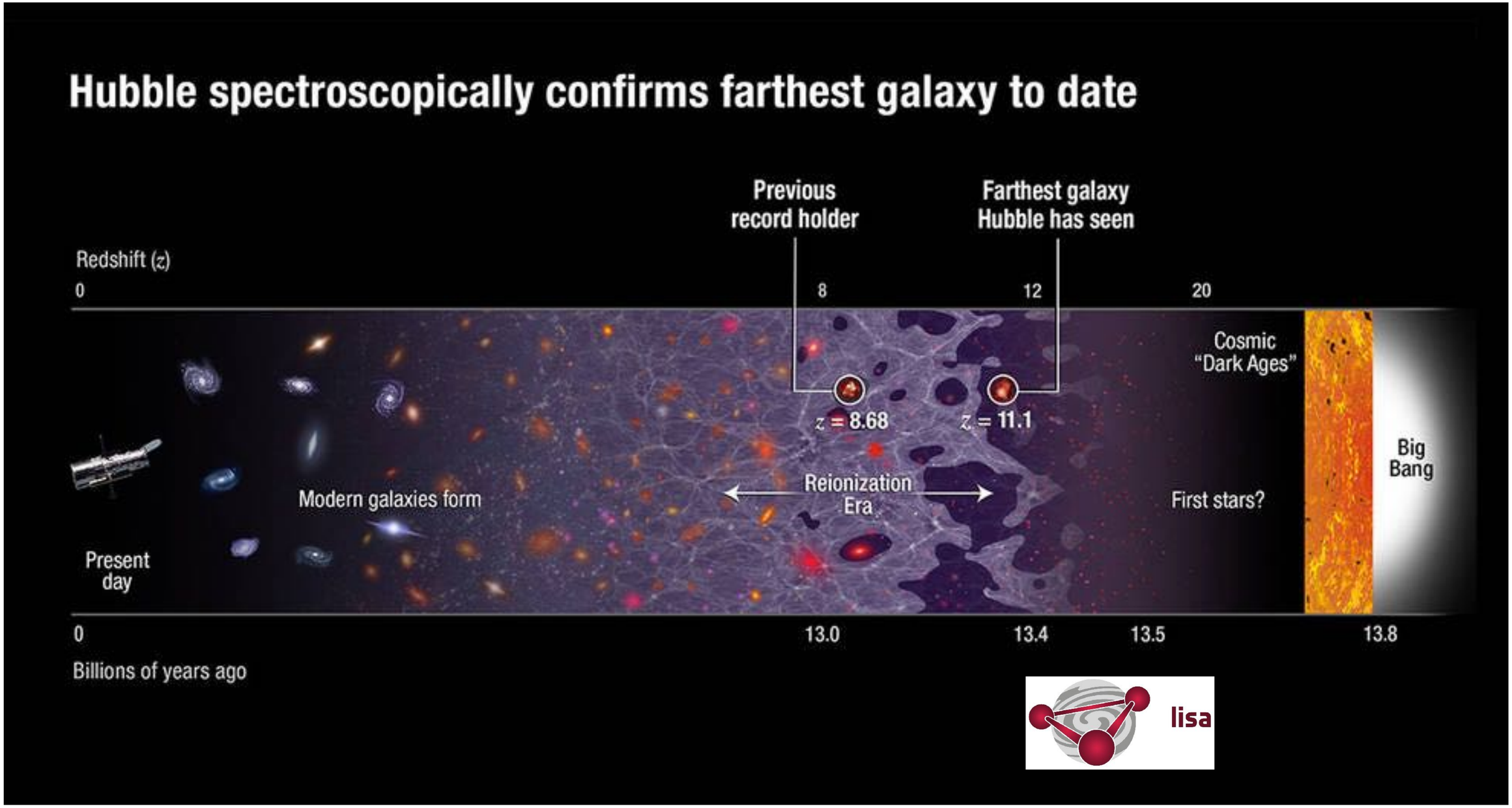
Hubble spectroscopically confirms farthest galaxy to date
Previous record holder
Farthest galaxy Hubble has seen
Redshift (z)
0
8
12
20
Cosmic "Dark Ages"
z = 8.68
z = 11.1
Big Bang
Reionization Era
Modern galaxies form
First stars?
Present day
0
13.0
13.4
13.5
13.8
Billions of years ago
lisa

STELLAR REMNANTS ORBITING SMBHS