

PRIMA: science and technology of a new NASA far-infrared observatory concept

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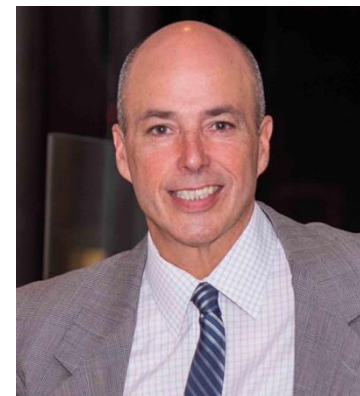
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Science Lead



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Collaboration

- 3 NASA centers and international partners
- 27 Co-Is
- Strong, experienced engineering and management team

Tiffany Kataria
Dep. Science Lead



Jenn Rocca
Dep. Project Manager

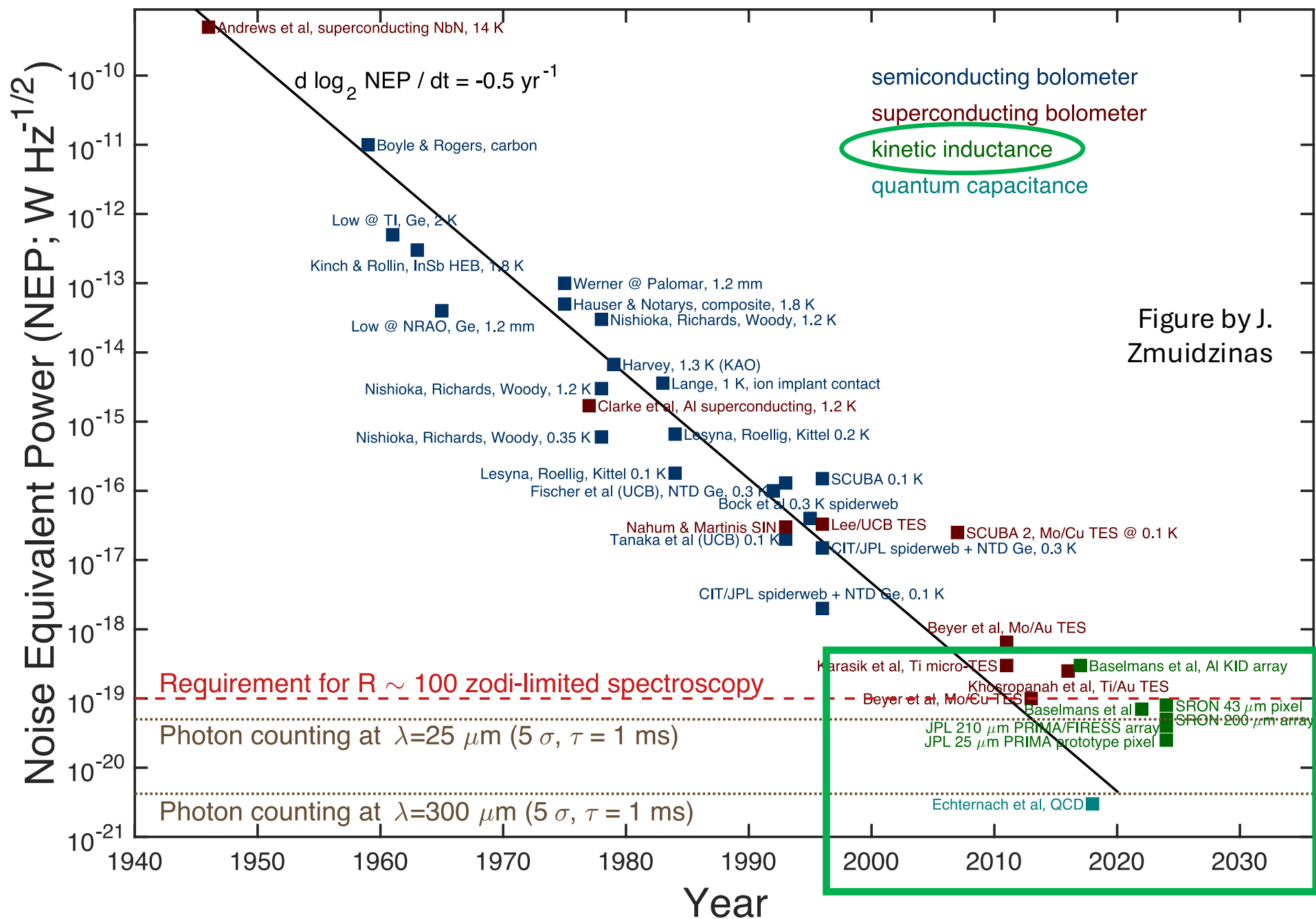


Why Now?

→ Far-IR Detector
Technological
Readiness

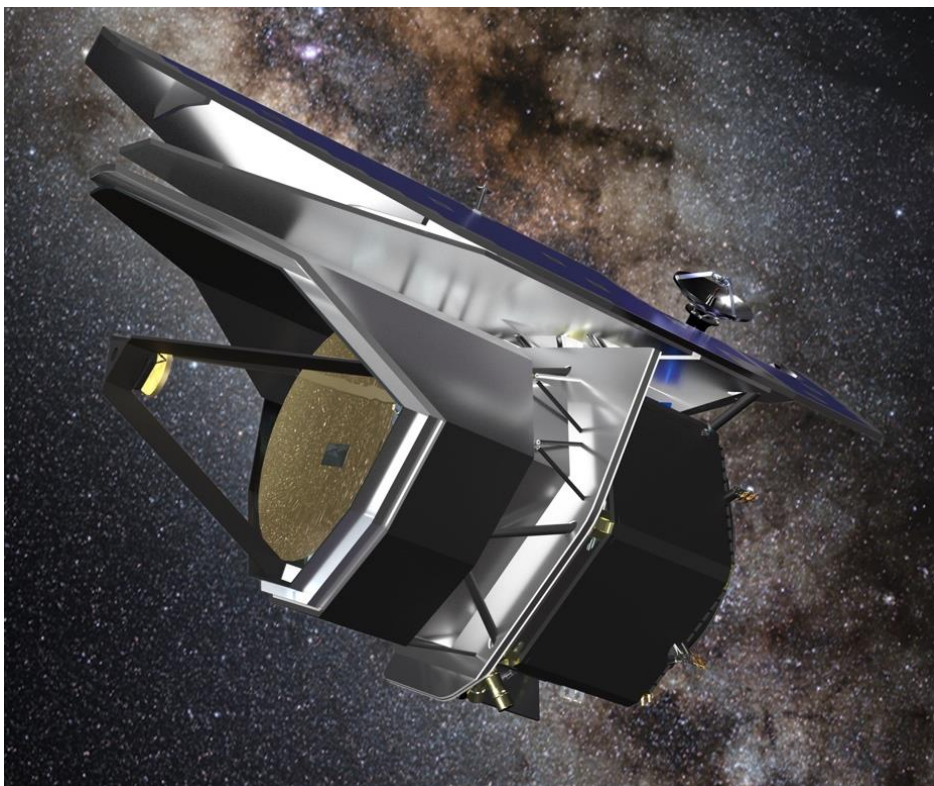
Sensitivities of far-IR
detectors have doubled
approx. every two years
for 75 years

Far-IR Probe
region of
interest





PRIMA Basics

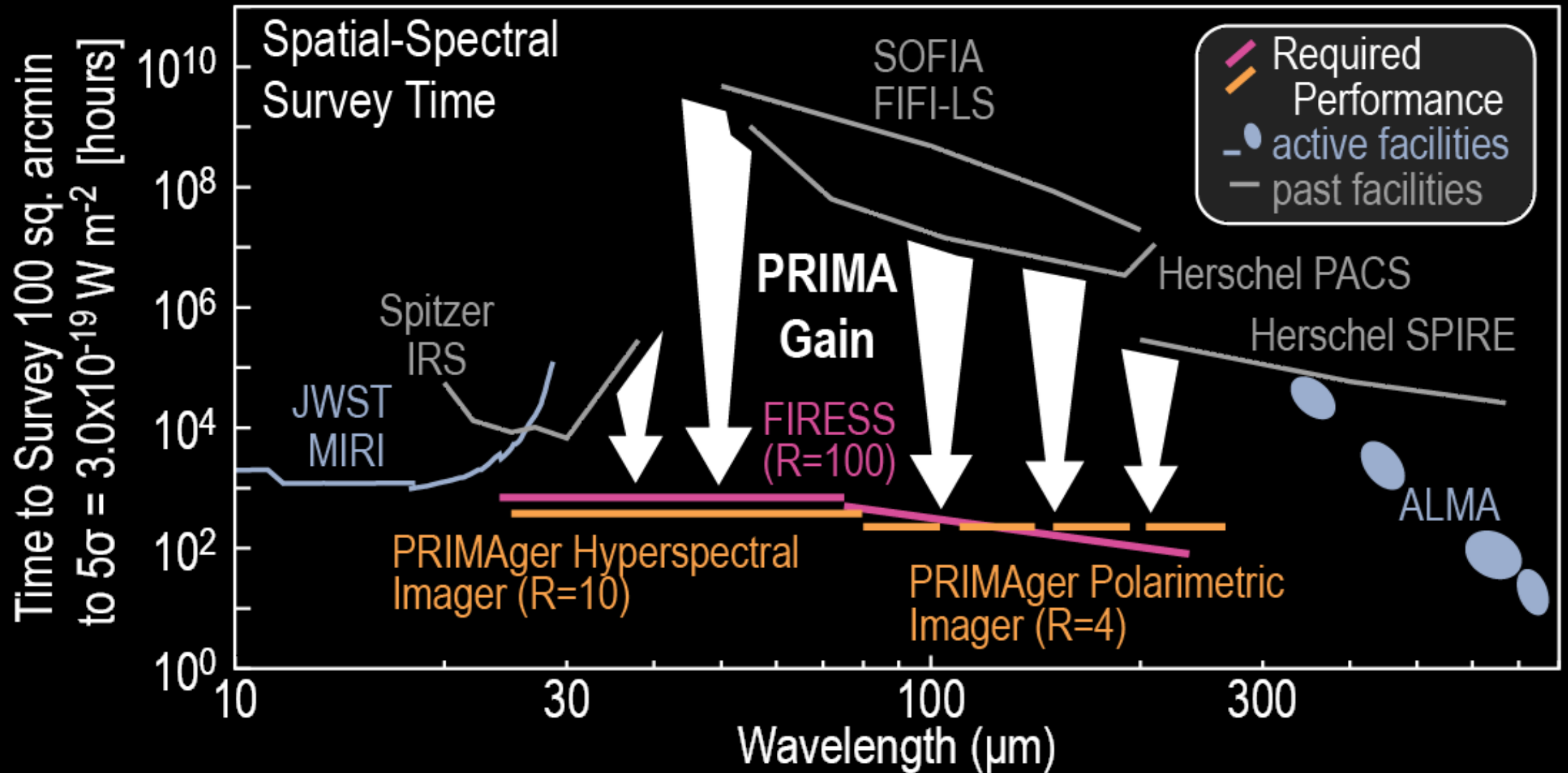


Observing Time

- 25% or Principal Investigator science
- 75% for NASA-managed General Observers
- 100% data available for Guest Investigators

Telescope	1.8-m, aluminum, 4.5 Kelvin
PRIMAger Imager & polarimeter	R = 8 hyperspectral imaging 25-80 μm R = 4 imaging & polarimetry 91-235 μm
FIRESS Spectrometer	R > 85 spectroscopy 24-235 μm High-resolution mode: R = 4,400 $\times$ ($112\mu\text{m}/\lambda$)
Detectors	100 mK KID arrays (11k total)
Orbit	Earth-Sun L2
Launch	2032
Lifetime	5 years

PRIMA Brings Vast Discovery Potential



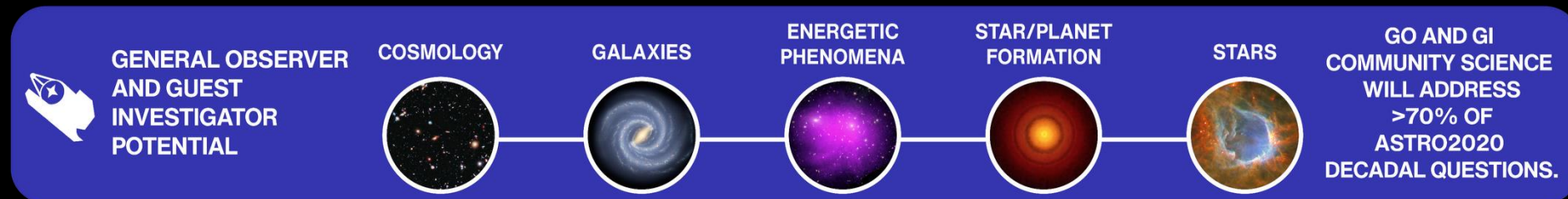
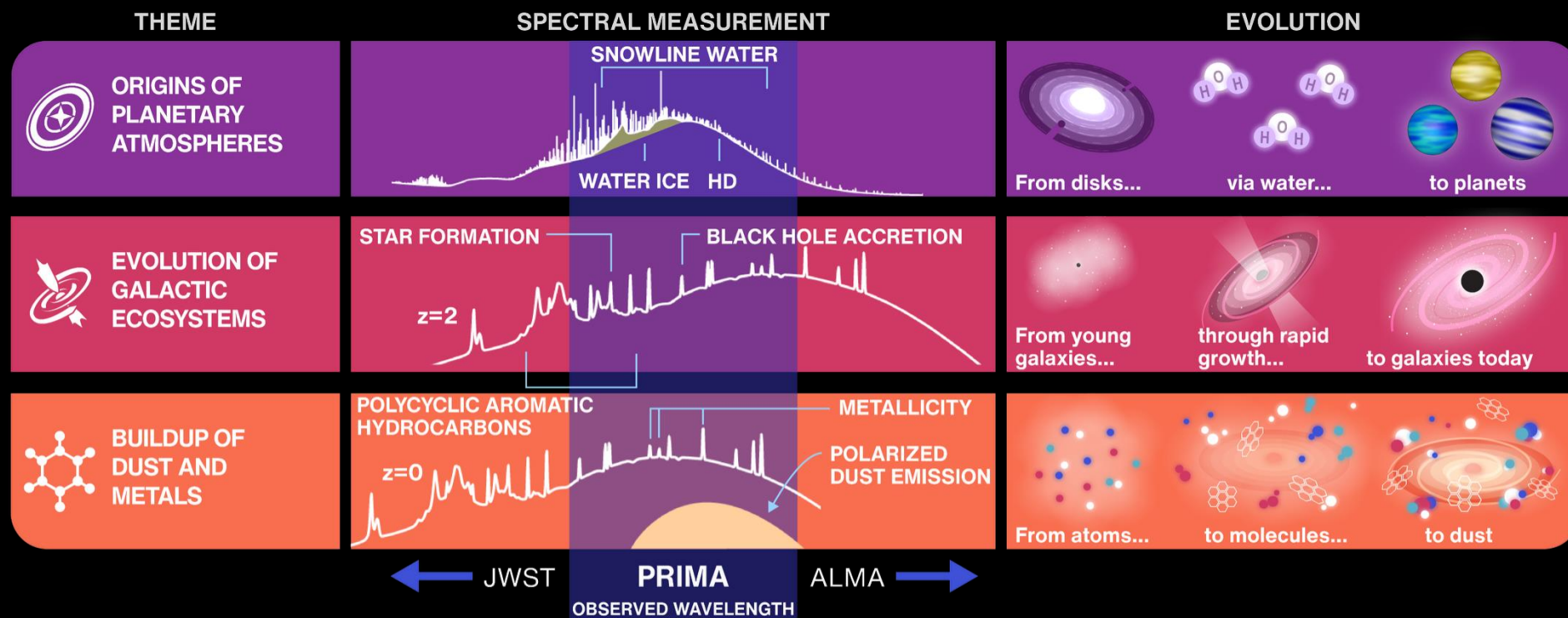
PRIMA's PI science addresses Astro2020's three science goals for a far-IR Probe

How do exoplanets and their atmospheres form?

How do supermassive black holes and galaxies coevolve over cosmic time?

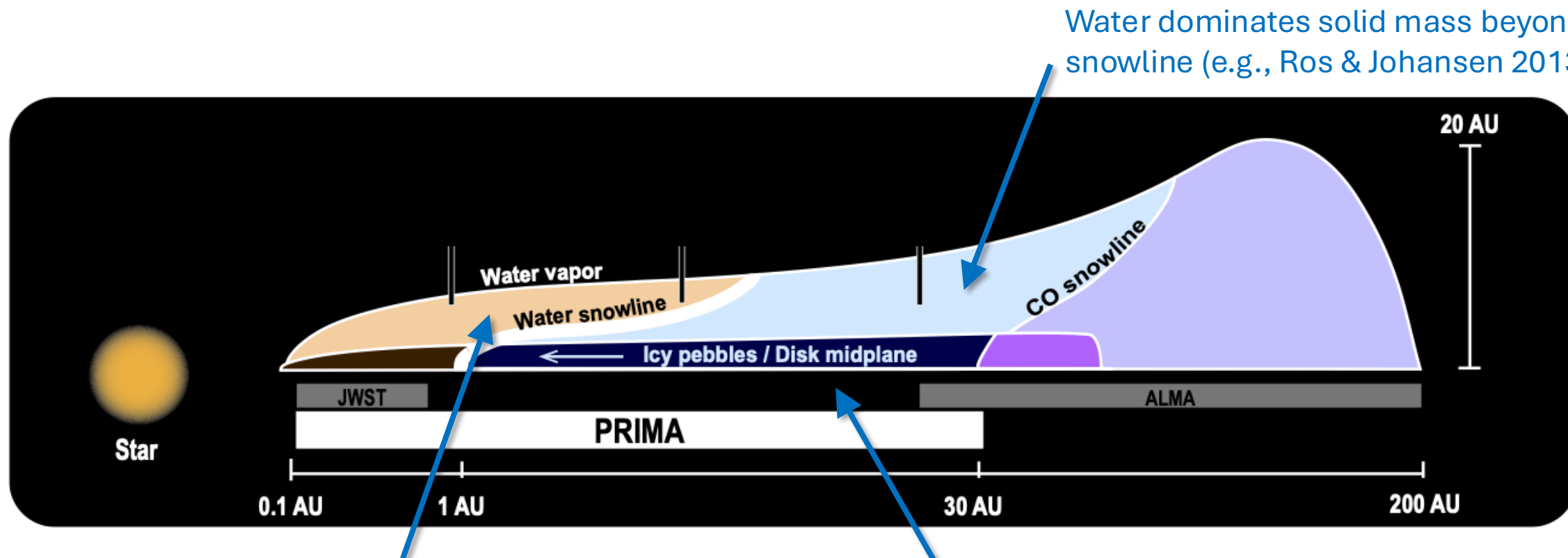
How do dust and metals build up in galaxies over cosmic time and how does dust form?

GO observations start early in the science phase.



Protoplanetary Disks

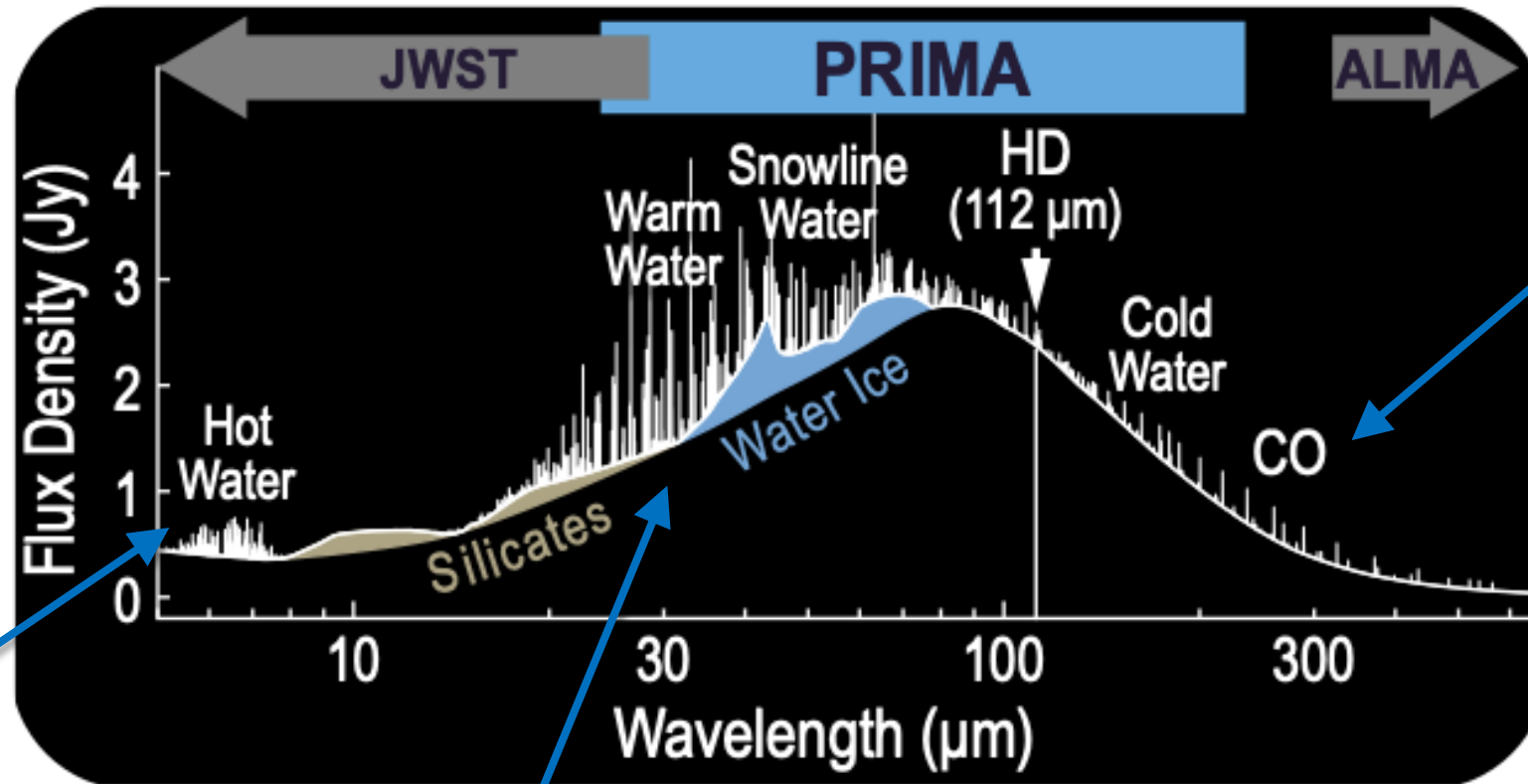
Is there sufficient water mass to drive the formation of planetesimals and giant planet cores near the water snow line?



PRIMA measures relative water vapor column density in the disk surface around the snow line to establish if icy pebble drift can catalyze formation

Does icy pebble drift transfer enough mass in to 10-20 AU where most planets likely form?

Protoplanetary Disks: Model Spectrum



JWST probes hot water (>150 K)

PRIMA probes wide temperature range

ALMA measures disk radial structures and temperatures

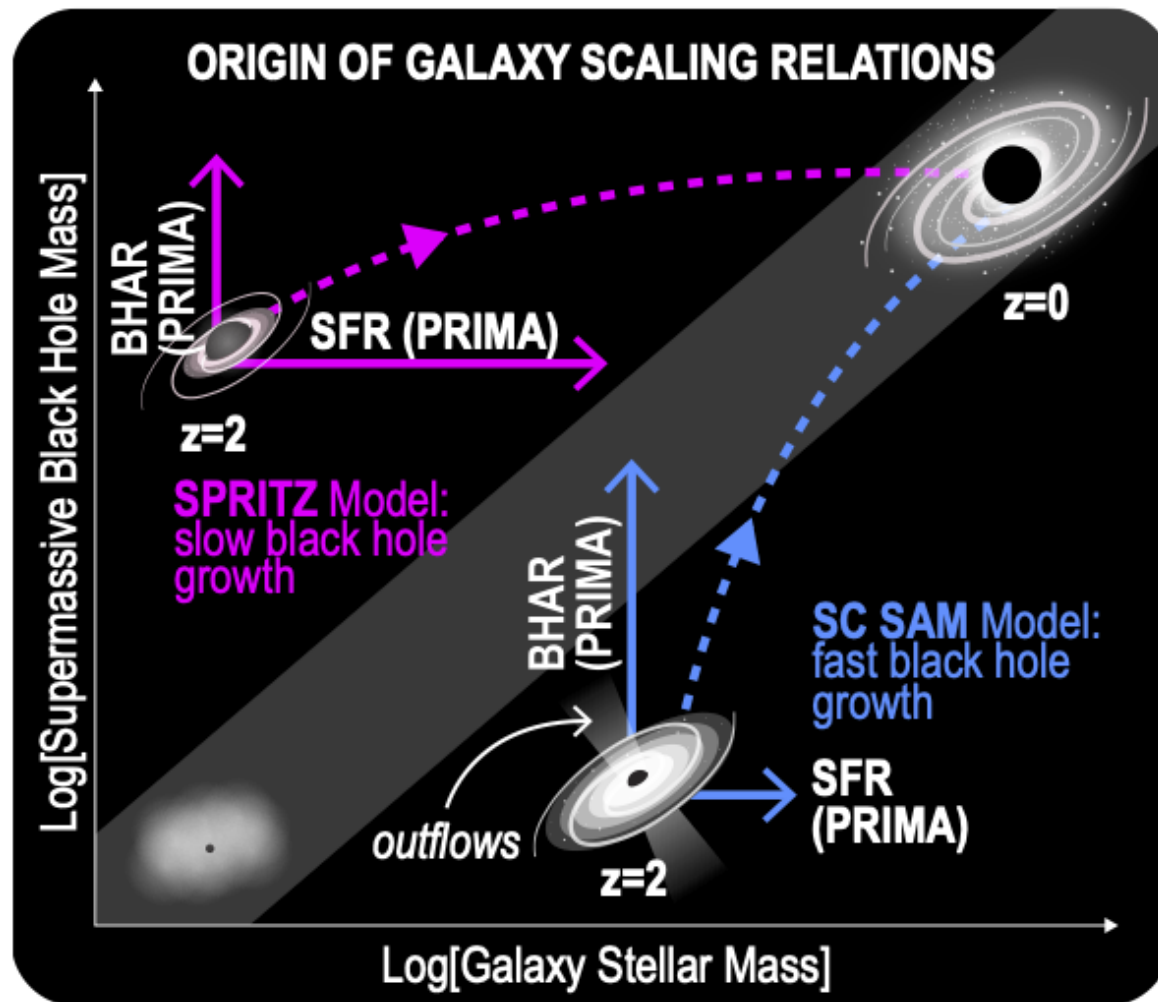
PRIMA FIRESS FTM will measure inner-disk water enhancement in 200 disks of various ages and masses.

Galaxy Evolution

What is the relation between black-hole accretion rate and star-formation rate in luminous galaxies since the peak epoch ($z \sim 2$) and do winds quench star formation?

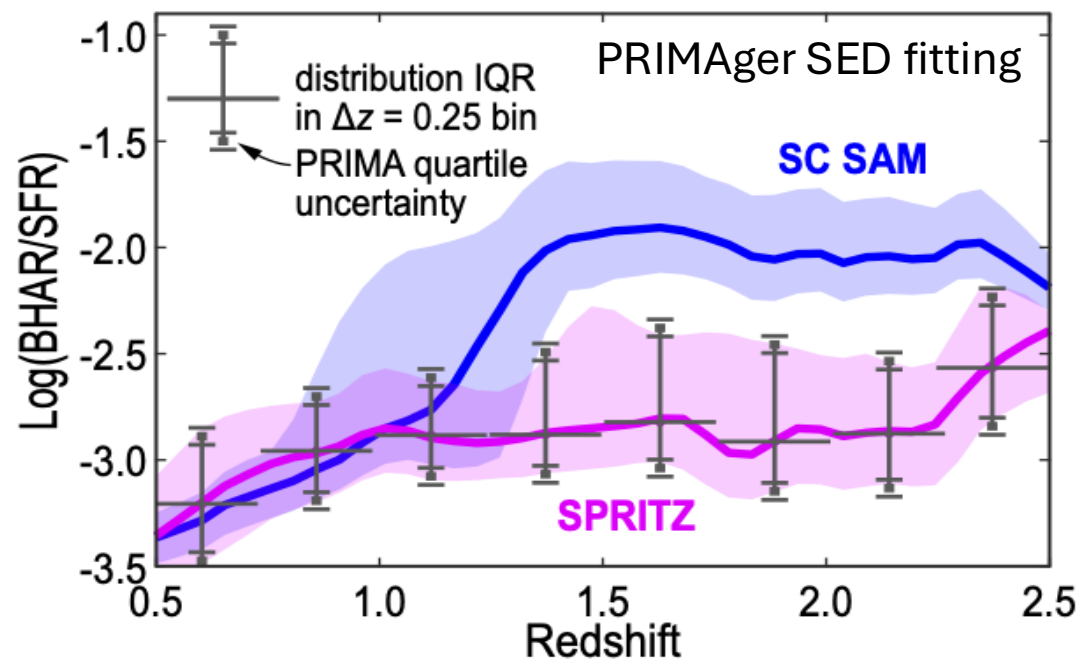
SPRITZ – star formation-based model linked to Spitzer & Herschel: slower black hole growth @ $z=2$, less quenching (Bisigello et al. 2021).

Observed relation between black hole mass and stellar mass (Reines & Volonteri 2015).

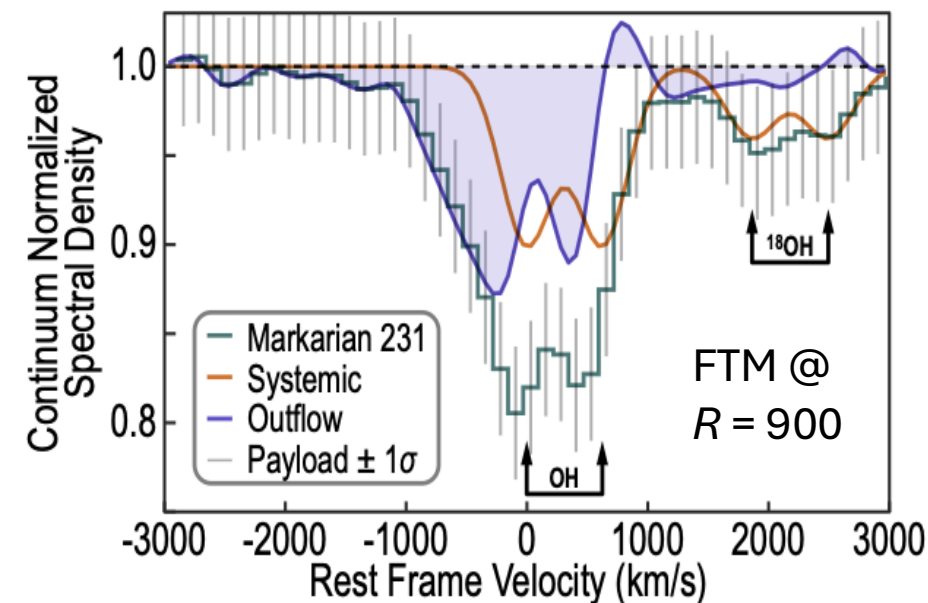


Santa Cruz Semi-analytic model: more black hole growth at cosmic noon, quenches star formation @ $z=2$ (Somerville et al. 2021).

Supermassive Black Hole and Galaxy Coevolution



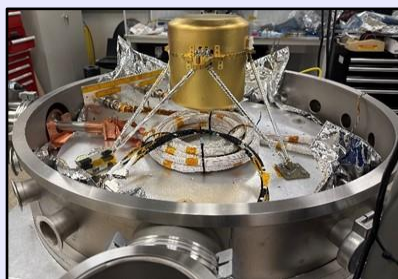
- **PRIMAger one square degree survey:** 42k galaxies (Donnellan+ 2024)
- **FIRESS spectroscopic validation:** Spectroscopic sub-samples of 160 $z = 1.0$ -2.5 galaxies using [O IV] and [Ne II] (rest frame 26 & $12.8 \mu\text{m}$)
- **FTM test of quenching models:** outflow mass and velocity measurements of 25 $z = 1$ -2 galaxies (Shown: $84 \mu\text{m}$ @ $z=1.5$ with $850 M_{\text{sun}} / \text{yr}$ outflow)



Recent technology maturation efforts

End-to-End Cryogenic Architecture

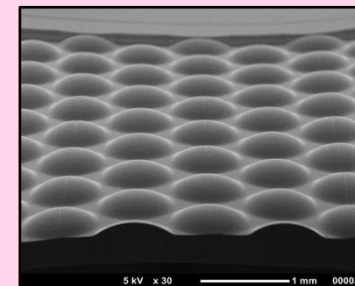
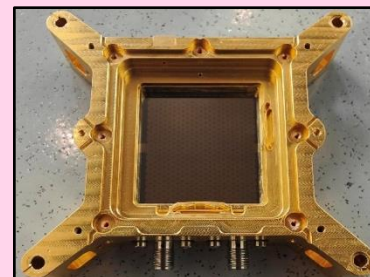
*NASA/JPL:
JWST-MIRI flight
spare cryocooler
demonstrated to
4.5 K with ^3He
working fluid*



*NASA/GSFC:
CADR
demonstrated
at 1 K*

Kinetic Inductance Detector Arrays & Signal Processing

*Flight-like
NASA/JPL FIRESS
and CNES/SRON
PRIMAger array
prototypes meet
PRIMA NEP and
pixel yield*



*NASA/GSFC & SRON:
Lenslet arrays
successfully hybridized
for FIRESS & PRIMAger*

*NASA/GSFC:
End-to-end signal
chain demonstrated
with readout
electronics*

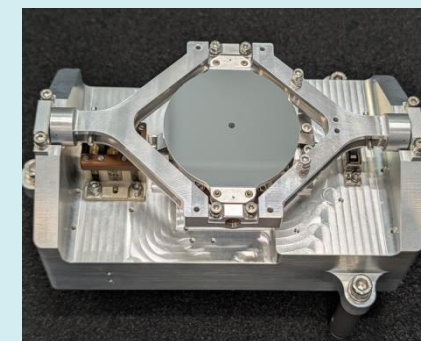


Cryogenic Optical Elements

*DLR/MPIA: BSM prototype demonstration
envelopes PRIMA requirements*



*CSA/ABB: FTM phase delay
mechanism prototype demonstration
meets PRIMA requirements*





*The PRobe far-Infrared
Mission for Astrophysics*

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more information, papers,
presentations, and news!

