Technology Thoughts

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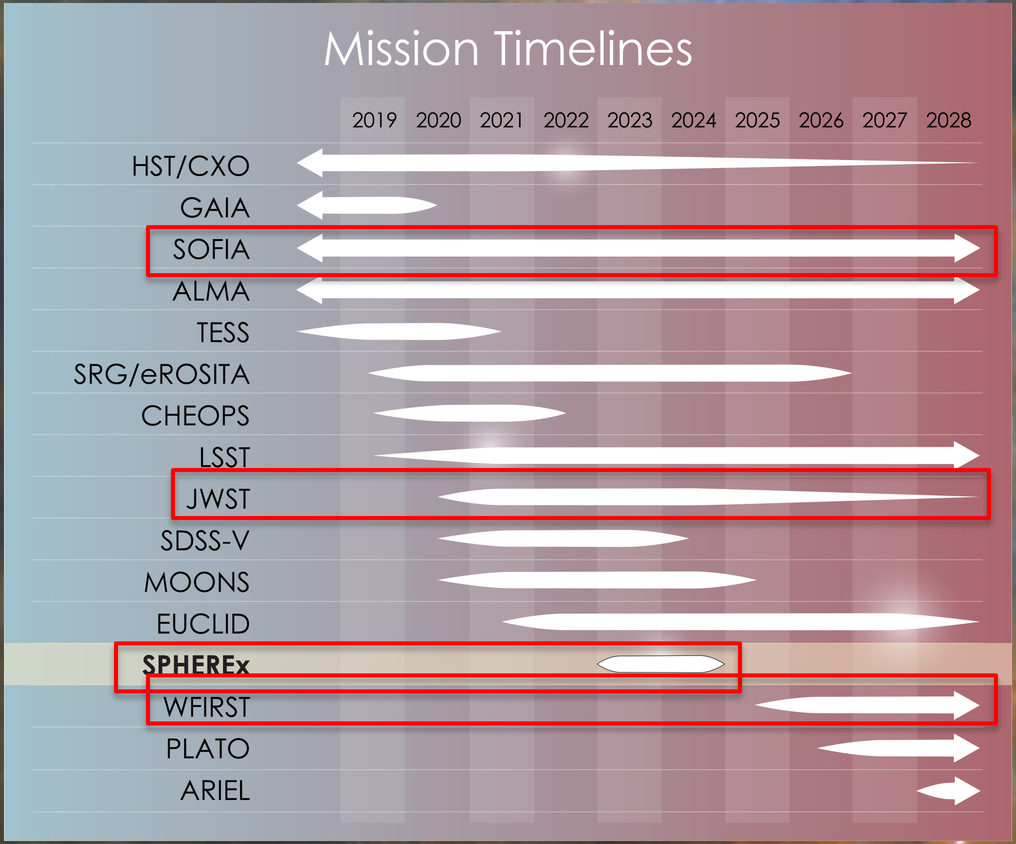


What enabling technologies do we need for the infrared science of the 2020s and 2030s?

GEP?

Origins?

Note: Several of these dates are approximate.

Additional Resources

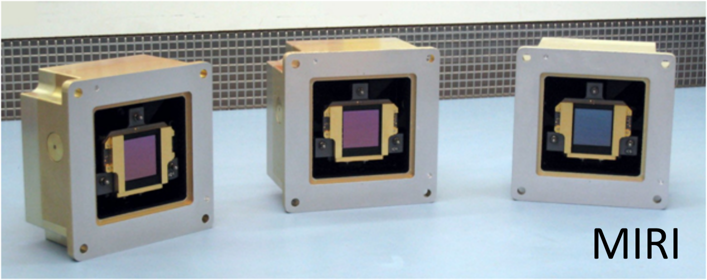
1. NASA Astrophysics Technology Gap Priorities (apd440.gsfc.nasa.gov/tech_gap_priorities.html)

2. ”Far-IR instrumentation and technology development for the next decade”, Farrah et al., *JATIS* (2019).

Essential: Detectors and Readouts

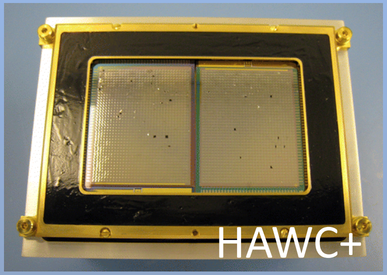
*Future observatories (OST, GEP, MIRECLE, SOFIA, balloons) will be limited by detector **sensitivities** and **array sizes** and power demands of **readouts**.*

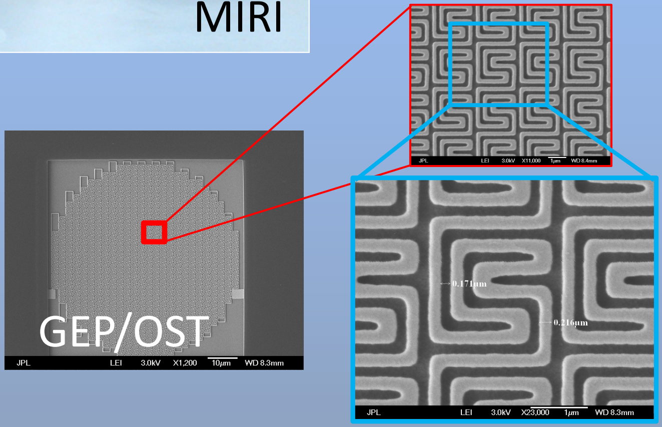
$\lambda \leq 25\ \mu m$: Si:As BIBs and IBCs will become <u>unavailable</u> if a new mission does not require them soon.



$10\ \mu m\ \leq \lambda \leq 3\ mm$: TESs, KIDs, and potentially others show the necessary potential but require <u>sustained funding</u>.

- NEPs: 10x – 100x improvement*
- Array sizes: 10x larger
- Architectures: $10\ \mu$m – $50\ \mu$m





Readouts: Large arrays require low power per channel → <u>space-qualified</u> small transistor node technology.

Readouts: Development is driven by industry, but implementation for astronomy has benefitted enormously from partnerships with universities (i.e., CASPER and ASU).

*See attached C.M. Bradford NEP slide.

Other Crucial Technologies

Optics and Filters:

Research into **materials** and **micromachining** to minimize transmission and reflection losses, especially at mid-IR wavelengths.

Cryocoolers:

Compact, economical solar-powered **cryocoolers** (4 K) and **refrigerators** (<1 K) to enable MIDEX and larger mission and smaller observatories and balloons.

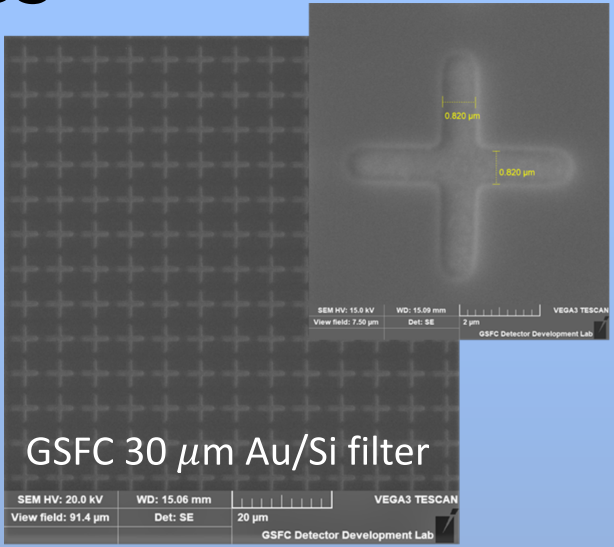
Untapped Potential:

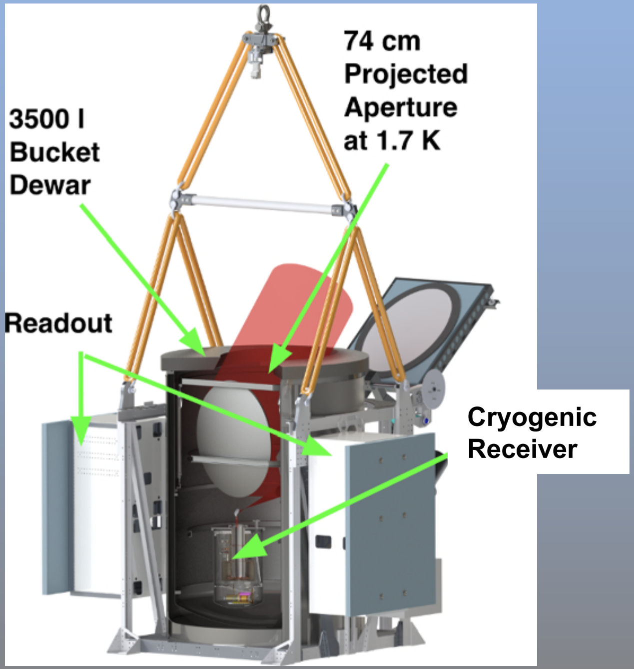
Getting to ~1 K telescope optics on balloons.

EXCLAIM

NASA-GSFC

ASU · NYU · UMD

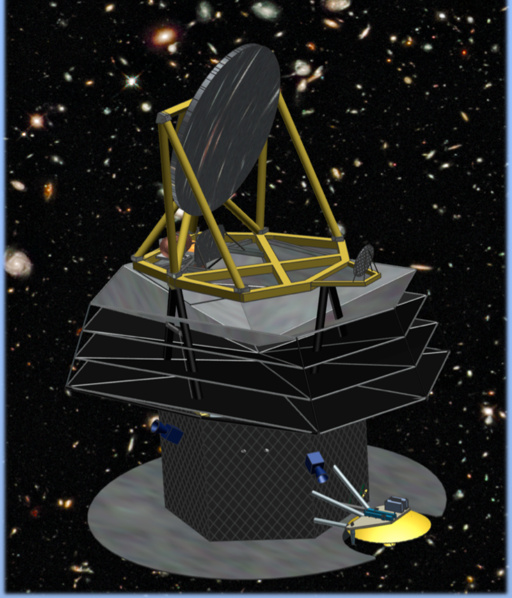

GSFC 30 μm Au/Si filter



Galaxy Evolution Probe

A mid-to-far-IR surveyor

- Extragalactic and Galactic science
- Hyperspectral $R \sim 10$ imaging: $10 - 400\ \mu m$
- $R = 200$ long-slit spectroscopy: $24 - 193\ \mu m$
- Deep and wide surveys
- **New technologies:**
    - 25k x2 KIDs
    - Continuously linear-variable filters

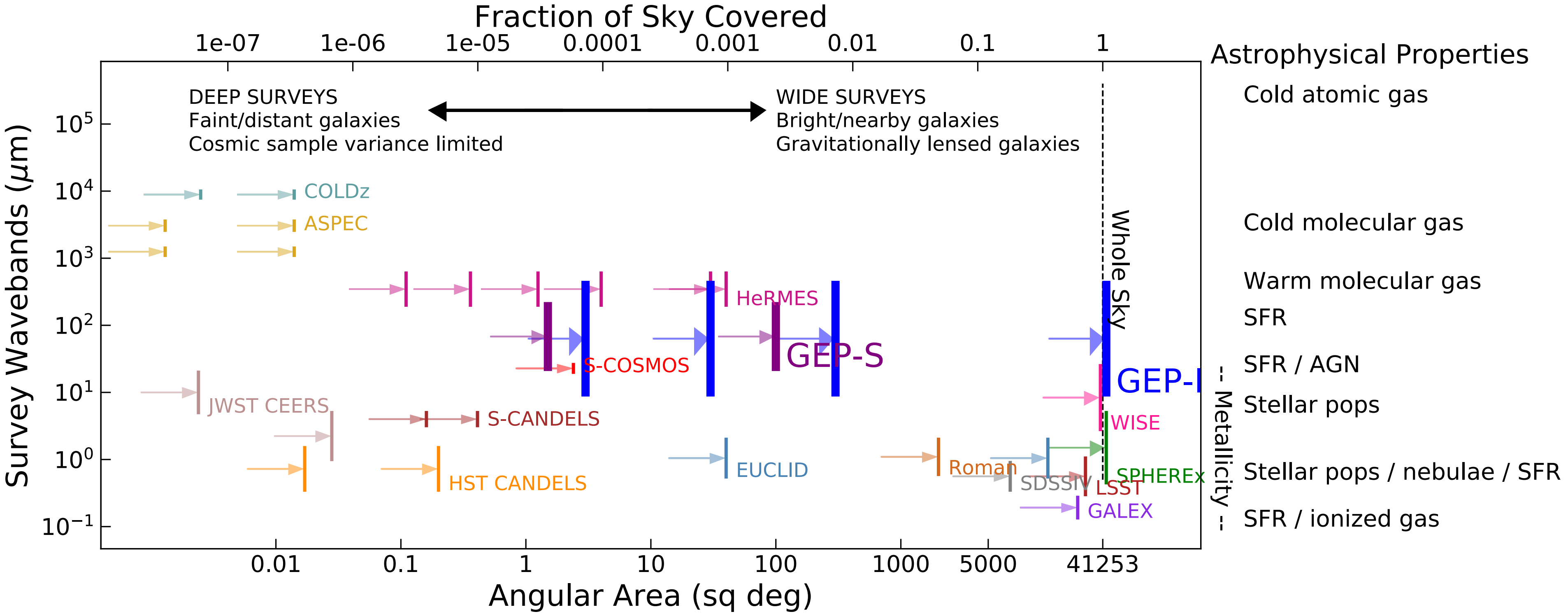


NASA

JPL

Ball Aerospace & Technologies Corp.

For clarity, not all surveys are shown.

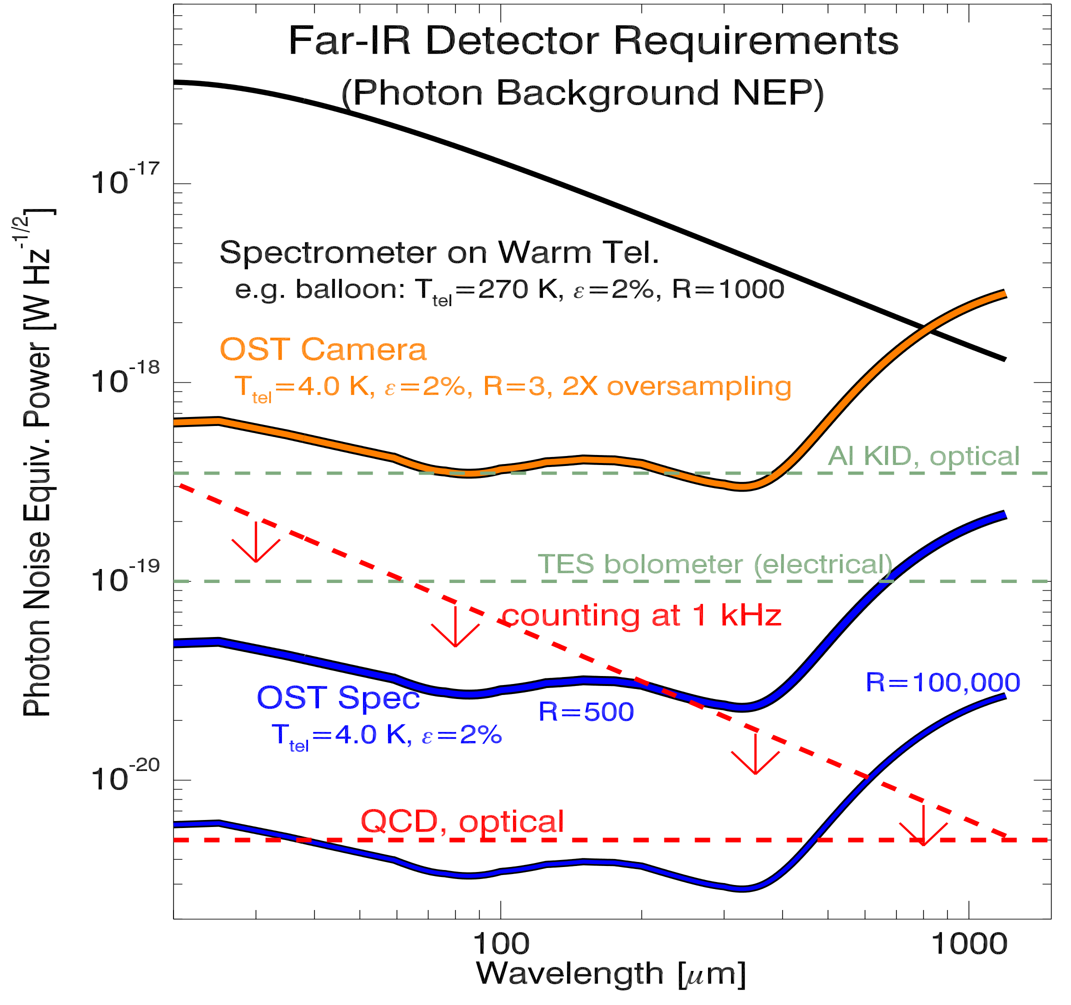


Recommendations for Community Advocacy

Addressing the major challenges

1. **Sustained** detector technology development funding
2. Enhanced support for **balloon** science and technology
3. **Drive innovation** with faster SOFIA new instrument cycles
4. Invitation: **GEP** science case development pending Decadal Origins and Probes outcome
5. **Encourage** young people and members of historically under-represented groups to pursue careers in infrared instrumentation: *they are our future*.

Detectors Sensitivities



Detector **sensitivities** generally need to improve **10x – 100x** and **array sizes** need to increase **10x**.

10 – 50 μm detectors with good optical coupling need to be demonstrated.

Figure: C.M. Bradford

Image Credits

https://spherex.caltech.edu/Science.html
https://jwst-docs.stsci.edu/mid-infrared-instrument/miri-instrumentation/miri-detector-overview
The Experiment for Cryogenic Large-Aperture Intensity Mapping (EXCLAIM), P.A.R. Ade, et al., PI Eric Switzer, *JLTP*, 199, 1027 – 1037 (2020).