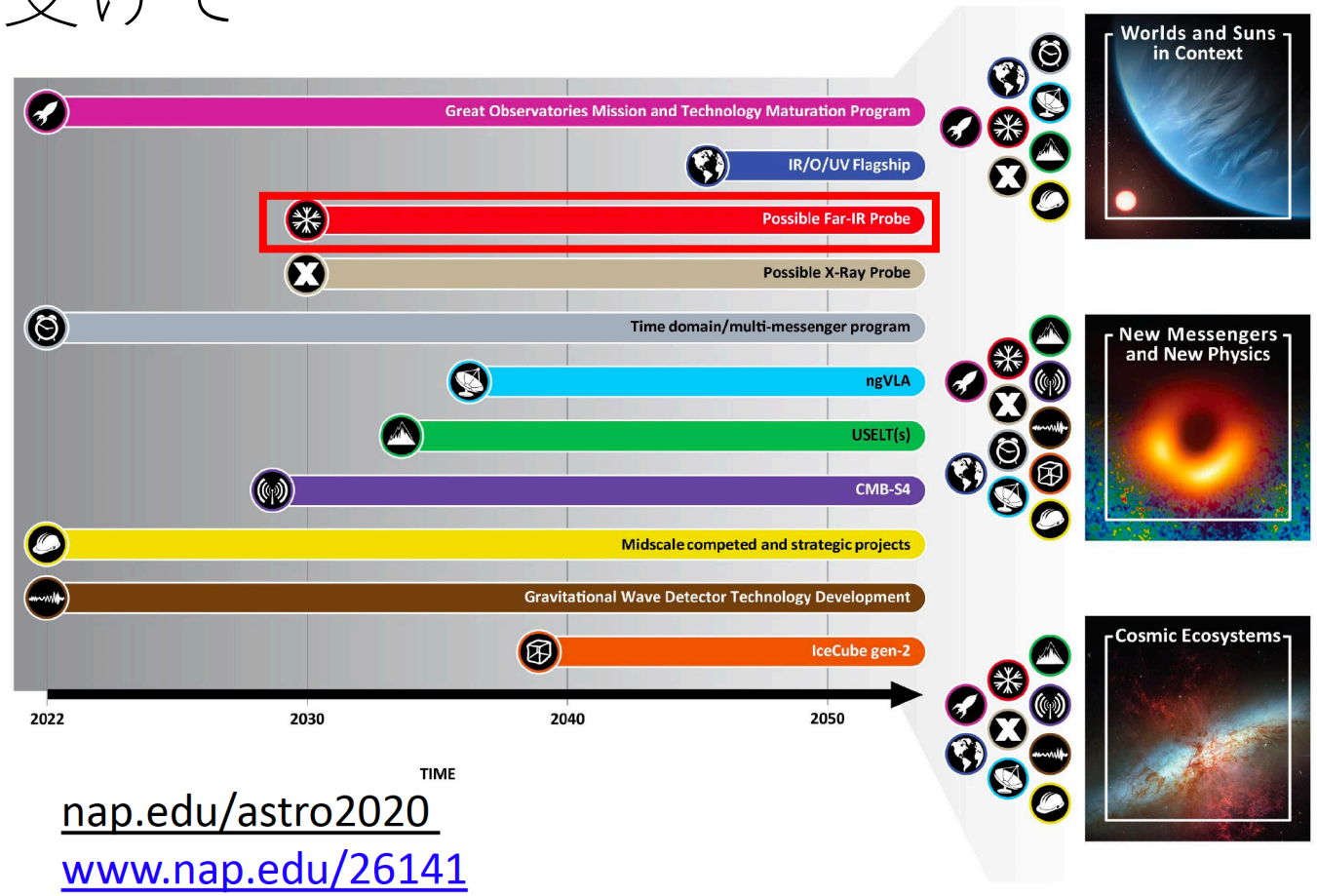
FIR Probeへの参加

左近　樹 (東京大学)

2021年度光赤天連シンポジウム「2030年代の戦略的中型をどうするのか」

Decadal Survey on Astronomy and Astrophysics 2020 (Astro2020) の結果を受けて



nap.edu/astro2020

www.nap.edu/26141

Decadal reportに FIR probe が SPICA recoveryとして明記

Astrophysics Probe Announcement of Opportunity Community Announcement

released by NASA Science Mission Directorate (SMD)on January 11, 2022 (notice ID NNH22ZDA008L)

The National Academies' 2020 Decadal Survey in Astronomy and Astrophysics, *Pathways to Discovery in Astronomy and Astrophysics for the 2020s*, recommends probe missions to be competed in broad areas identified as important to accomplish the survey's scientific goals.
For the coming decade, the Decadal Survey recommends

- **a far-infrared imaging and spectroscopy mission**
- **an X-ray mission designed to complement the European Space Agency (ESA's) Athena mission.**

Cost Cap: The PI-Managed Mission Cost (PIMMC) for an Astrophysics Probe mission is expected to be capped at **$1 billion** *in fiscal year (FY) 2023 dollars*, not including any contributions, the cost of an AO-provided access to space, or any General Observer (GO)/Guest Investigator (GI) program costs. *NASA will provide standard launch services on a single launch vehicle outside the cost capped PIMMC*. PI-provided alternative access to space may not be proposed.

Science Investigations and Data: (1) A pointed observatory will have the bulk of its observing time made available to the community for General Observers (GO). *The NASA-managed GO program will be funded outside of the PIMMC*. The PI-led science team will conduct science investigation(s) with a limited amount of Guaranteed Time Observing (GTO); *the PI-led science investigations will be funded within the PIMMC*. (2) A survey observatory will have all of its survey data made available to the community for Guest Investigators (GI). The NASA-managed GI program will be funded outside of the PIMMC. The PI-led science team will conduct science investigation(s) with the survey data; the PI-led science investigations will be funded within the PIMMC. (3) All data will be made public as soon as practical through a NASA-managed astrophysics data archive. There is no limited data use period, even for pointed data.

The current Astrophysics Probe Program planning budget is sufficient to select and execute one Astrophysics Probe mission.

Astrophysics Probe Announcement of Opportunity Community Announcement

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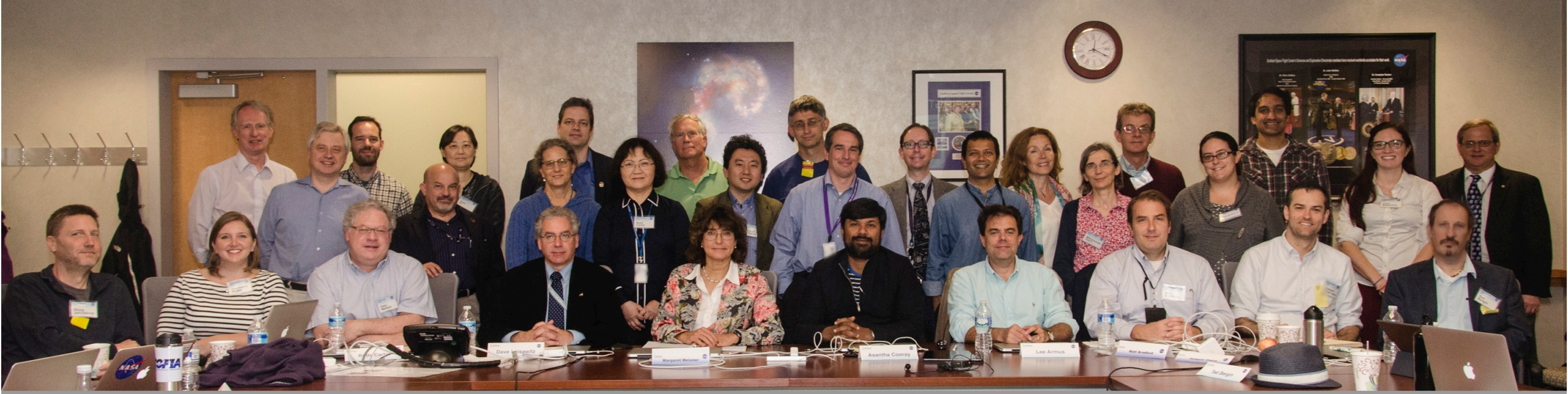
Proposals in response to the forthcoming Announcement of Opportunity (AO) will be due not less than 90 days after its final release. Participation will be open to all categories of U.S. and non-U.S. organizations, including educational institutions, industry, not-for-profit organizations, Federally Funded Research and Development Centers, NASA Centers, and other Government agencies. Participation by NASA Centers must be consistent with NASA's Center Roles policies.

The schedule for the solicitation is intended to be:

Release of this special notice	January 2022
Release of draft AO:	June 2022 (target)
Release of final AO:	January 2023 (target)
Preproposal conference:	~ 3 weeks after final AO release
Proposals due:	90 days after AO release
Selection for competitive Phase A studies:	Early 2024 (target)
Concept study reports due:	Late 2024 (target)
Down-selection:	Mid 2025 (target)



Far-IR Surveyor STDT Meeting

NASA's Goddard Space Flight Center

May 12 - 13, 2016

FIR probe candidates:

- **The Space Infrared Interferometric Telescope (SPIRIT)** [David Leisawitz (NASA Goddard)]

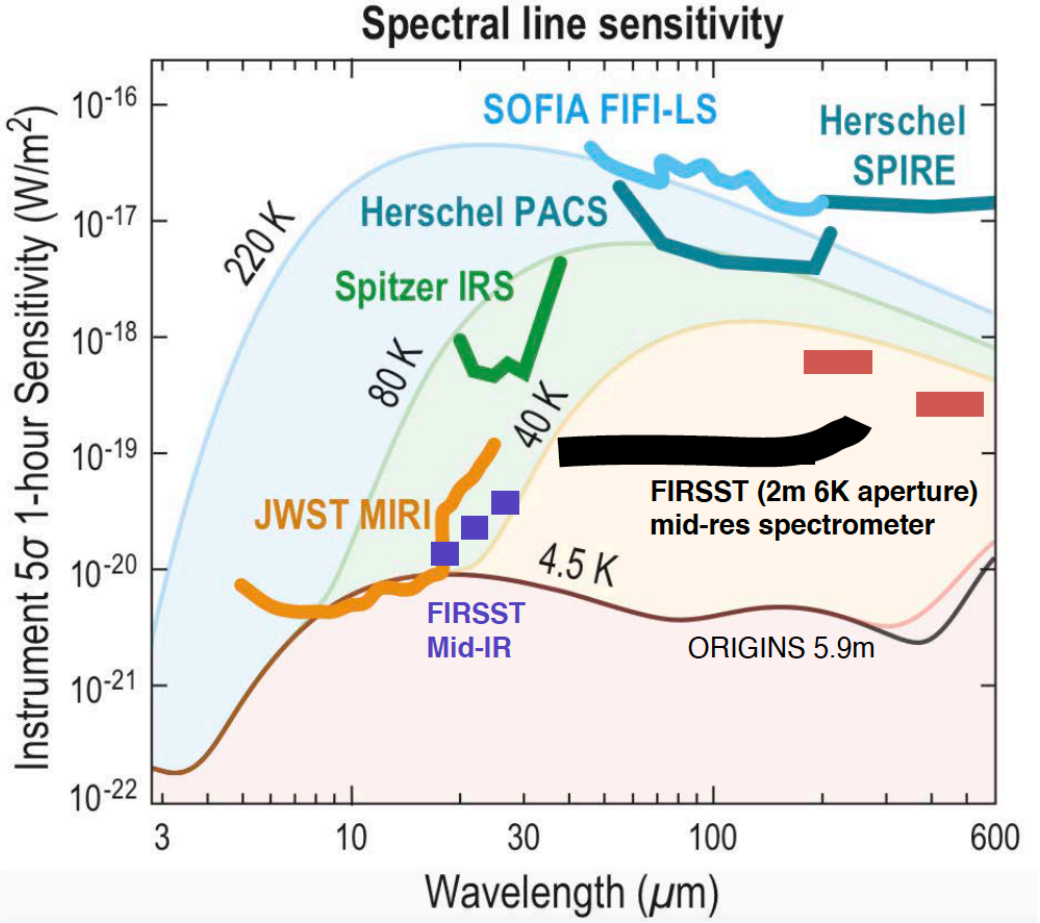
- **Galaxy Evolution Probe (GEP)** [Jason Glenn (NASA Goddard), Charles M. Bradford (JPL)]

- **The Far-IR Spectroscopy Space Telescope (FIRSST)** [Asantha Cooray (UC Irvine)]

The Far-IR Spectroscopy Space Telescope (FIRSST)

Asantha Cooray (UC Irvine)

"FIRSST is a natural evolution of Origins Study for the Astro2020 Decadal."



- ~x100 more sensitive than anything before
- Low-risk, Spitzer-like architecture
- 1.8m-2.2m aperture, 30 micron diff. limit, cooled to 6K
- 3 instruments for spectroscopy
  - ***30-320 microns R=200-300***
  - ***R>40,000 HD112μm and R>300,000 H2O 179, 243, 269, 538μm and HDO 234μm***
  - ***mid-IR extend MIRI (imaging + spectroscopy with a grism)***
- 1 of 3 instruments contributed by foreign partner
- 5 year science, Earth-trailing orbit
- >90% Community-led science + small GTO

A compelling 100% GO mission within $1B is feasible
Two instruments: can be total $150M-$175M

FIRSST Notional Instrument Specifications

Instrument	Wavelength Coverage	Spectral Resolving Power (λ/Δλ)	Number of spatial pixels or sky beams	Typical Required Sensitivity:	Other
FIRSST mid-resolution far-IR spectrometer	~30 to 330 µm	R > 200. (300 preferred)	5 gratings; long-slit spectroscopy; mapping mode by shifting slit.	Reqt: 10^{-19} W/m^2 (spectral line), 5 sigma; 1 hour	also pursue a R > 10,000 mode? FTS vs etalon. *likely subject to instrument cost.*
FIRSST high-resolution far-IR spectrometer	112 µm HD; H20/ D20 118 µm ; 243 µm; 234 µm; 538 µm crucial lines	R > 40,000 for HD 112 µm; R > 300,000 for water lines	Minimum 2 pixels.	Reqt: 10^{-18} W/m^2 (spectral line), 5sigma; 20 hrs at 112 µm R=40,000	water lines 179-269 & 538 µm. This looks to be a heterodyne.
FIRSST mid-IR imager	Dual or triple band (15, 20, 30 microns?)	broad-band imaging R=5; a R=100 dispersion element?	TBD; larger FoV than MIRI with bigger pixels.	TBD; should improve over MIRI in sensitivity at longest wavelengths.	MIRI pixels: 0.11”/pixel. FIRSST ~ 0.3-0.5”/pixel.

FIRSST mid-resolution far-IR spectrometer;
likely be led at GSFC with Karwan Rostem as the lead with internal GSFC-APL discussions

FIRSST high-resolution far-IR spectrometer;
A team at JPL has expressed an interest to take over that work

Asantha Cooray氏からの提案と質問 (2022年2月13日に打診)

- A general mid-IR capability, a wide field of view relative to MIRI and some mid-IR spectroscopy, is needed.
- up to a maximum of 30% of the cost of 1/3 of the instrument payload, is allowed for this first probe
- a direct involvement on the mid-IR instrument makes the most sense, given the participation in Origins MISC study and existing design work and effort for SPICA/SMI in Japan.
- The level of participation (i.e., full Mid-IR instrument or just components or parts) is of course open for discussion. At this stage I think what we are looking for is if there is interest or not on your end.
- If there is interest, we also welcome Japanese scientists to join **the science working groups**.

The science Working Groups

Galaxy formation and evolution:

ISM and Star Formation:

Planet formation, Exoplanets, and Solar System

Advisory board:

日本のスペース赤外天文学の科学的観点において FIR Probeはどのような役割を持つか？(議論)

・IRTSで、近赤外線から遠赤外線のスペース観測の開拓が始まった。

・あかり衛星において、より強固な近赤外線から遠赤外線の天文学への足がかりの構築へと繋がった。

・SPICAにおいても、サイエンスチームが編成され、日本が担当する装置がカバーする中間赤外線だけでなく遠赤外線を含む幅広い科学的興味に対応する策定活動が実施された。

・あるいは、少なくともSPICAまたはOriginsを通じて、Herschel宇宙望遠鏡以来の遠赤外ミッションに対して、ミッションの当事者として(あかりの経験を持つ現役の)国内研究者が科学データを手にし、将来に継承することに向けた努力を行ってきた。

→ Astro2020 のDecadal Reportでは、probe classという新しいカテゴリーが創設され、
そこで Originsの検討のヘリテージを最大限に生かして、FIR probe missionの検討が開始した。
Decadal Reportには SPICA recoveryとしての位置付けも明記。
SPICAで行われたサイエンス策定が直接のadvantageとして、FIR probeのサイエンスワーキンググループに当事者として参加できれば、日本の研究者による中間赤外・遠赤外のスペース赤外のサイエンス成果排出が促される。

日本のスペース赤外天文学の技術的観点において FIR Probeはどのような役割を持つか？(議論)

・SPICAの中止
→ 日本がスペースの中間赤外線および遠赤外線の天文学のミッションの国際的な技術開発の最前線を見通す戦略を、IRTS、あかりの実績、そしてSPICAおよびOriginsのヘリテージを生かして探る必要がある。
→ 仮に2050年代に予定されるかもしれないFIR Flagshipに対して、『競争力のある技術を武器に、費用対効果の高いハードウェア貢献を行うこと』に繋げる必要がある。

・SPICAの遠赤外線観測装置は欧州の担当、中間赤外線観測装置が日本の担当
・Originsでは、中間赤外線装置の概念検討を日本が実施
→ SPICAの中間赤外線観測装置SMIの一部(HR)はGREX-PLUSに活きる
→ 一方、SPICAが日本に技術的遺産をもたらすはずであった中間赤外線の長波長側の技術、そして欧州SPICAを通して共有できるはずであった遠赤外線の技術をどのようにrecoveryするか？

・**Asantha Cooray氏からの提案**に応じることができれば、SPICAのこれまでの技術的な遺産が継承され、同時にFIR Probeを通して、次世代につながる遠赤外の技術の習得が可能になる。
さらに、日本にとって重要な戦略技術である冷凍機技術による貢献を得る足がかりとなる。