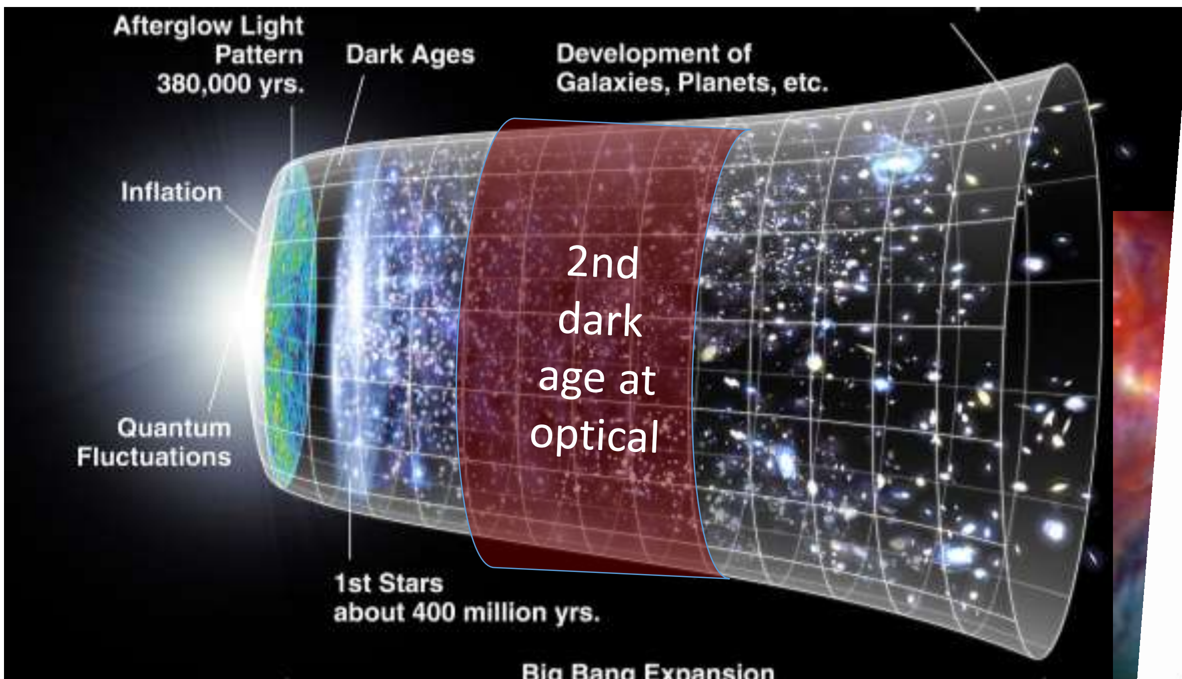
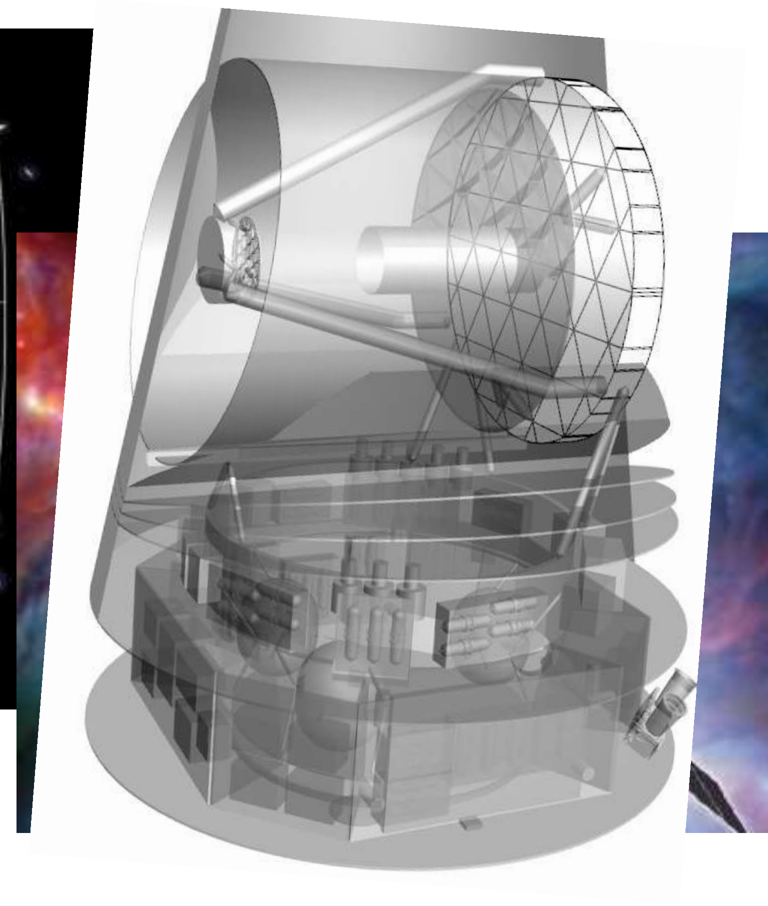
日本天文学会秋季年会　V252a　　　　2015-09-11

次世代赤外線天文衛星SPICA：プロジェクト再定義

芝井 広（大阪大）、小川博之、中川貴雄、松原英雄（宇宙研）、
尾中 敬、河野孝太郎（東京大）、金田英宏（名古屋大）、他SPICAチーム

V253a　中川　次世代赤外線天文衛星SPICA：システム技術検討
V254a　金田　SPICA搭載 中間赤外線観測装置SMI：プロジェクト再定義への対応
V255a　土井　Grating-SAFARI -- A SPICA far-IR spectrometer with improved capabilities
V256a　鈴木　Development of ultra-low noise TESs onboard SPICA/SAFARI
V257c　片坐　次世代赤外線天文衛星SPICA：望遠鏡と焦点面観測装置





SPICA – Space Infrared Telescope for Cosmology and Astrophysics

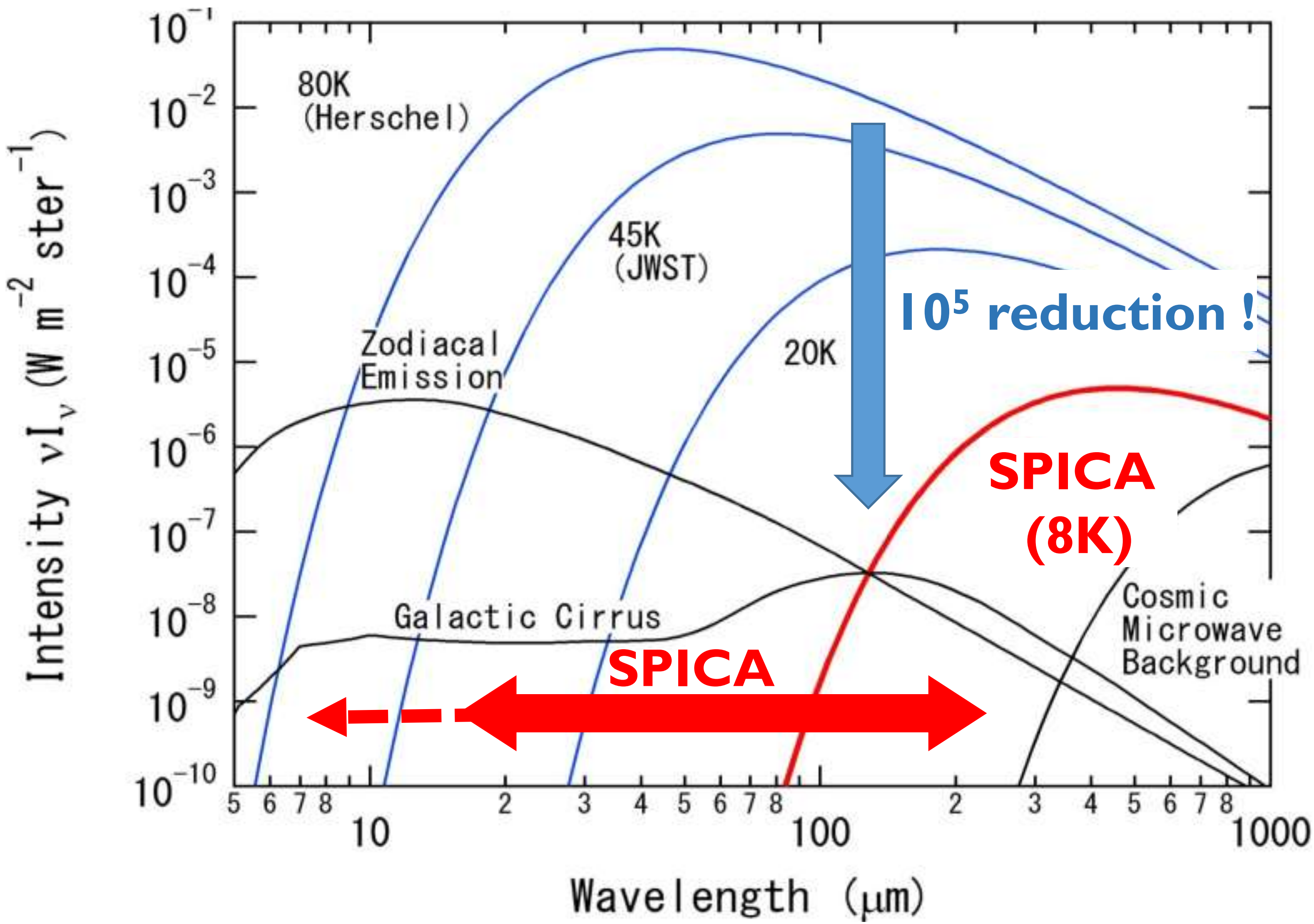
- 中間赤外線、遠赤外線に最適化されたスペース天文学ミッション
- The “dusty era” in the Universe (evolution of galaxies)
  A route to habitable planets (formation of planetary systems).
- 常温で打ち上げて、スペースで冷却（IRTSとAKARIからの技術継承発展)
- 中間赤外線分光装置 SMI（日本）: 17–36 μm
- 遠赤外線分光装置 SAFARI（欧州）: 34–230 μm
- 日欧宇宙機関の共同ミッションプロジェクト（米国その他からも参加予定）
- 現在、JAXA内で「再定義フェーズ」。まもなく(Δ)ミッション定義審査を受けるとともに、ESAの M5 ミッションに応募。

  口径と温度。遠赤外：フーリエ－＞グレイティング。サイエンス目的先鋭化。

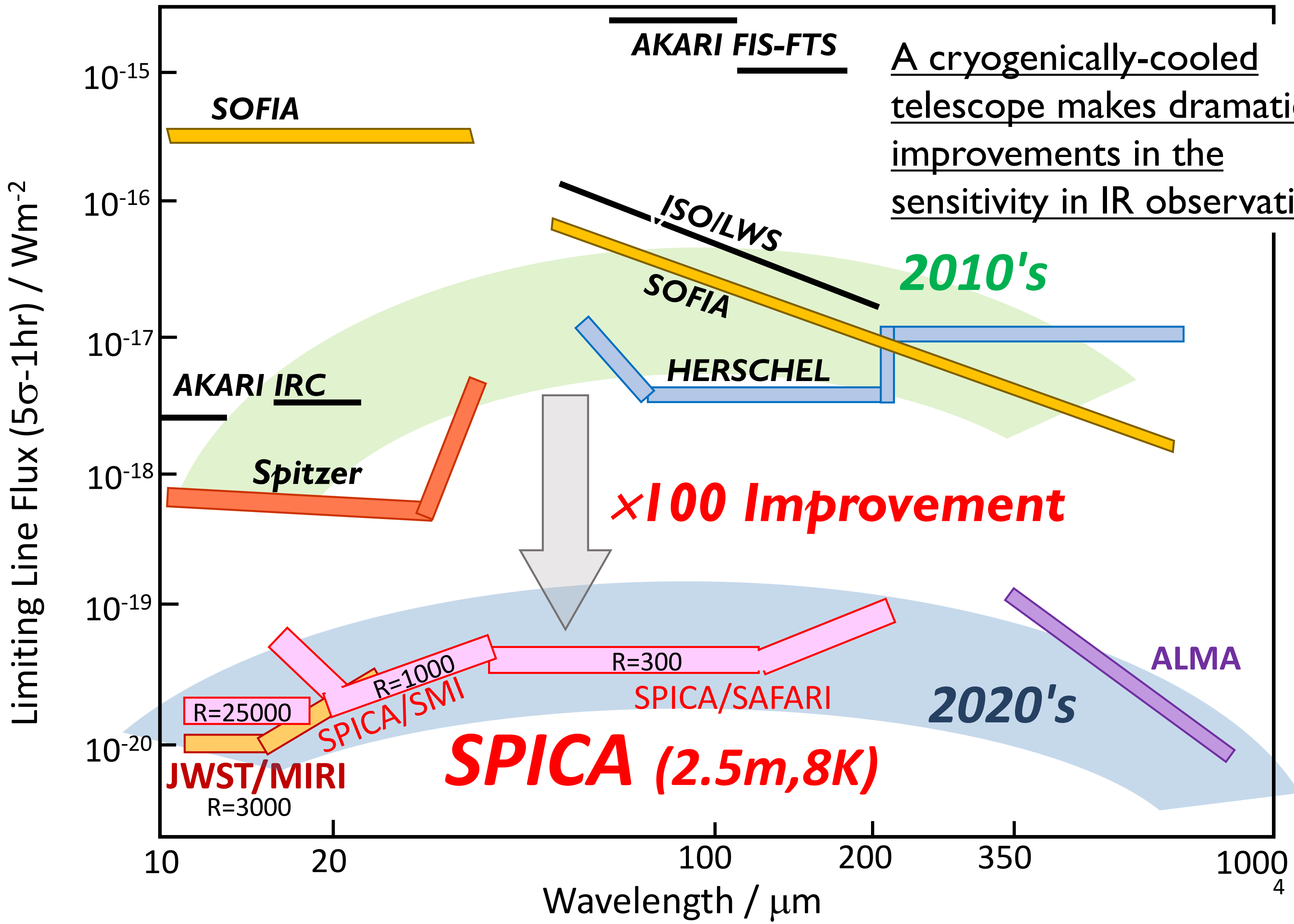
  宇宙科学の「戦略的中型」程度の規模。国内の総力を結集。日欧役割変更。

- Baseline specifications
  - Telescope : 2.5 m aperture, cooled below 8 K
  - Core wavelength : 17–230 μm
    (+ High-resolution spectrometer at 12–18 μm, Exoplanet instrument at 5–20 μm)
  - Orbit : S-E L2 Halo Orbit
  - Launcher : JAXA H3 Vehicle
  - Launch Year : 2027–2028

A cryogenically-cooled telescope significantly reduces the thermal emission from the telescope.



Dramatic Improvement in Sensitivity



A cryogenically-cooled telescope makes dramatic improvements in the sensitivity in IR observations.

Work-sharing plan

Telescope

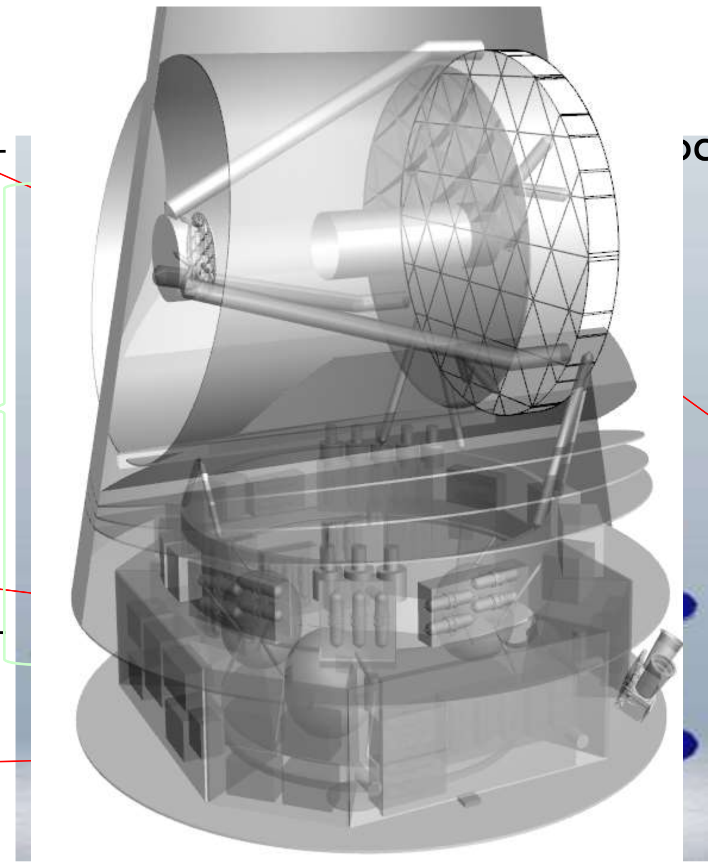
Payload Module

Cryocooler

Bus Module

Launcher

SPICA Data Center (NAOJ)



Focal Plane Attitude Sensor

ocal Plane Instrument Assembly

FIR Spectrometer (SAFARI)
NL + European countries + Canada & US

MIR Instrument (SMI)

Exoplanet Spectroscopy (SPEChO)
European countries

Science Community
JP, Europe, US, KR, TW,,,

SPICAチームの活動

3/25-27 SPICA（SAFARI?）コンソーシアム会議（Utrecht）

- M5提案に向けて最終決断。
- SAFARIチームが欧州＋カナダ＋米国（一部研究者）に拡大
- 高分散中間赤外線分光機能、および系外惑星大気分光機能を搭載する方向で検討を進める。

5/18　学術会議天文宇宙分科会にて状況報告

6/3-5　米国遠赤外コミュニティーワークショップ

6/10　宇宙研内に「SPICA CV M5 対応チーム」設置

6/19　SPICA 科学レビュー（宇宙研）

7/15　SPICA Science Case International Preview (Paris、宇宙研主催)

9/19　宇宙研（Δ）ミッション定義審査

9/30-10/1　SPICAコンソーシアム会議（Bordeaux、SAFARI主催）

周辺状況、関連事項

- 政府関連
  - 大型研究計画予算の大幅削減
- 日本学術会議
  - 天文宇宙分科会（5/18）にてSPICA現状報告。重点大型計画として再確認。
- 光赤天連
  - SPICAタスクフォースの報告書が完成
- 宇宙研
  - SPICA CV M5対応チーム設置
  - SPICA国際科学評価実施、勧告受領
  - ΔMDR再開、JAXA内プロジェクト化準備審査予定。
- 欧州
  - PLATO、CHOPSが進行中
  - ARIEL（系外惑星大気分光ミッション）がM4第一段階審査で残る。
- 米国
  - TESS、JWSTが着実に進展。WFIRSTがまもなくスタートの見込み
  - CALISTO計画（6x4m冷却望遠鏡）が提起

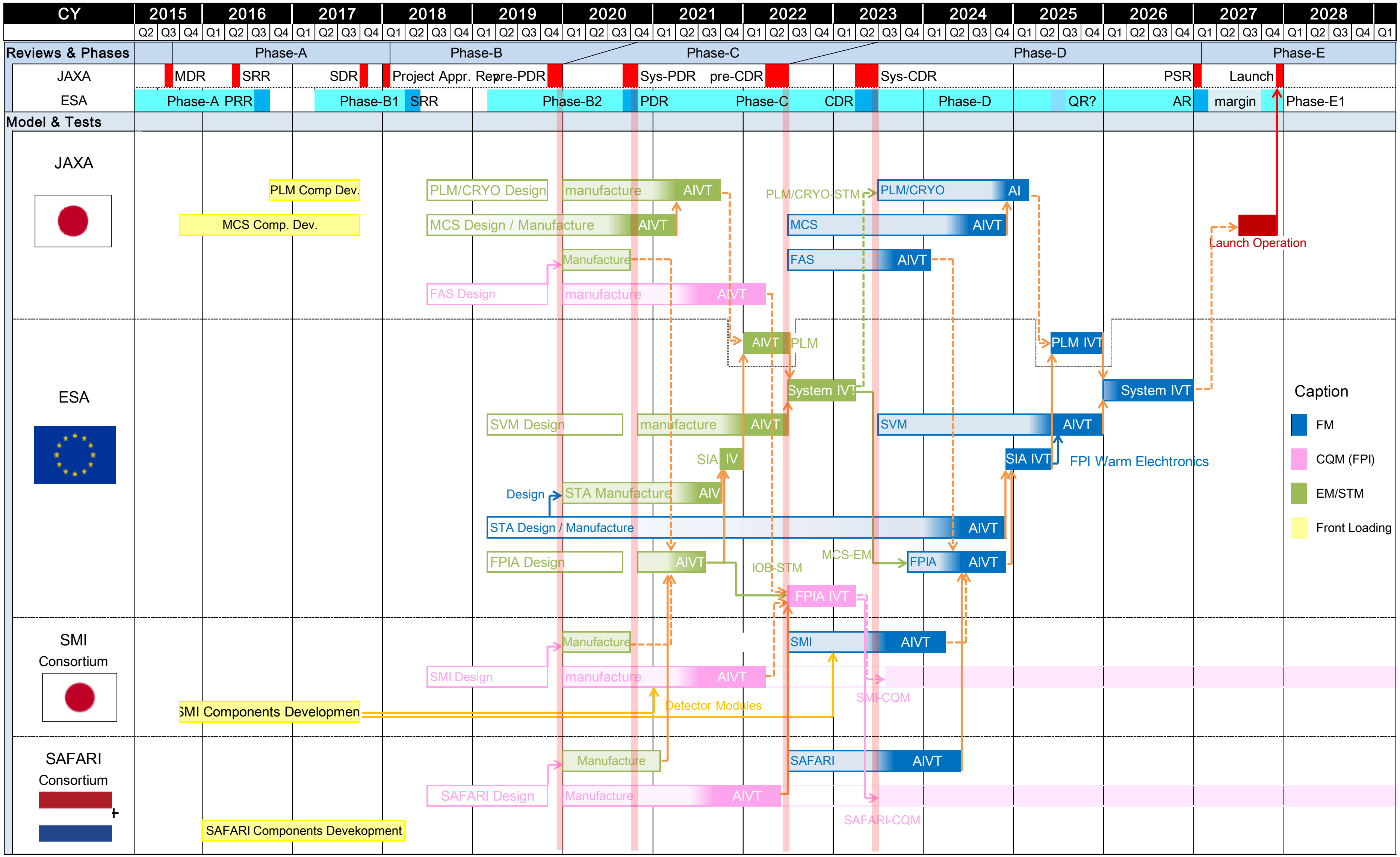
ESA Cosmic Vision M5 Call

SoI（提案意思表示）：9月25日まで

Event	Tentative date
M5 Call release	December 2015
Letters of Intent due	January 2016
Proposals due	April 2016
Evaluation process	May–June 2016
Selection of proposals for study phase	June 2016
Phase 0+A completion	June 2018
Down-selection to one mission	November 2018
Phase B1 completion	June 2020
Mission Adoption Reviews	September 2020
Mission adoption	November 2020
Launch (for an ESA-only mission)	Mid–2029 to mid–2030

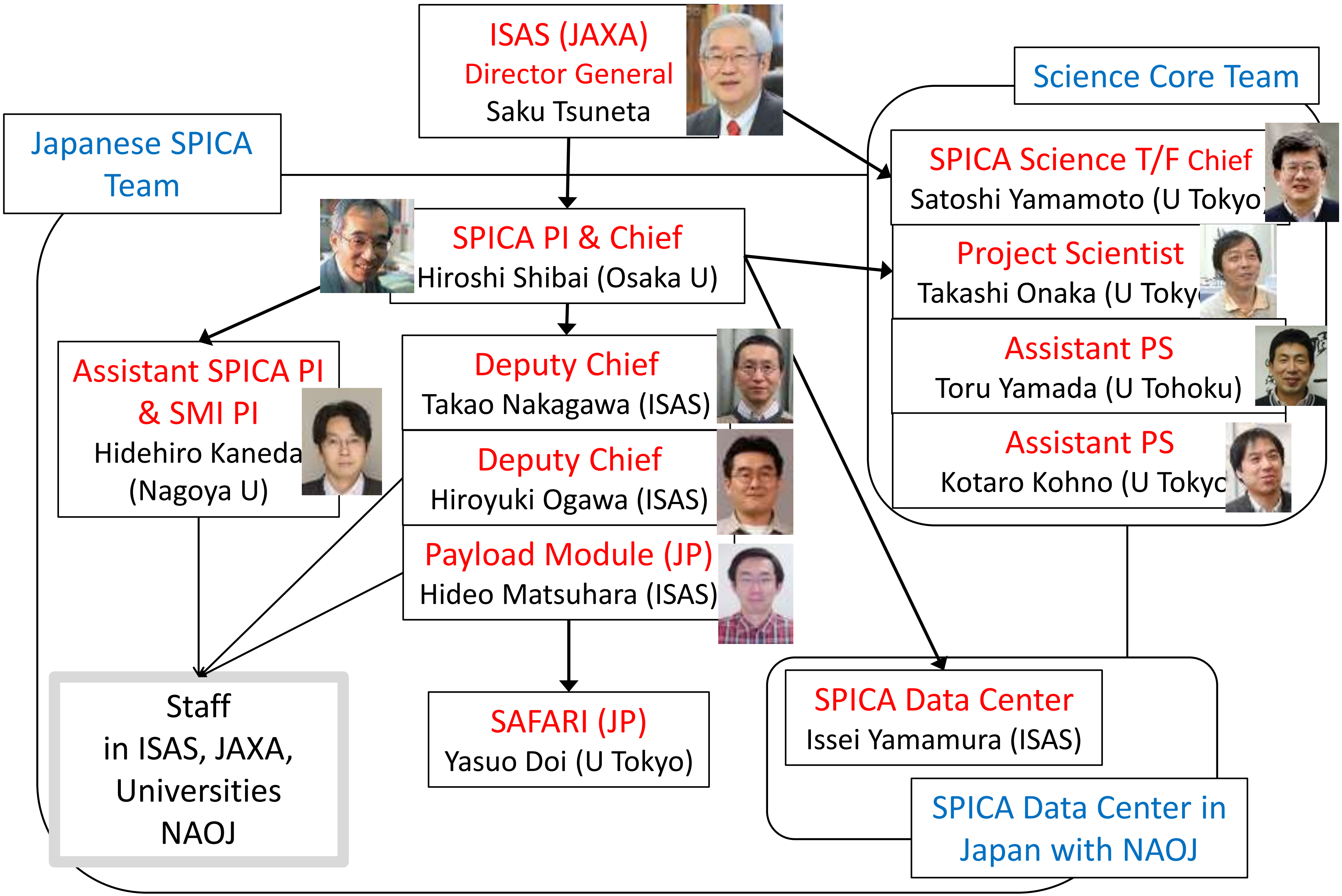
日本側は2027-2028年打ち上げ
ノミナル3年、ゴール5年の運用　で計画

Project schedule



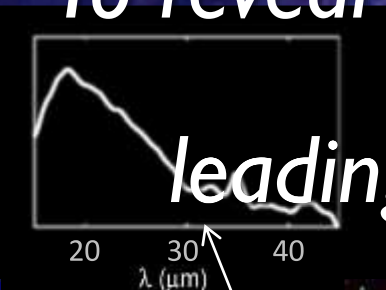
Operation: 3 Years (Nominal), 5 Years (Goal)

SPICA Management Structure (Japan)



Top-level science goal

To reveal the processes that enriched the Universe with metal and dust, leading to the formation of habitable worlds

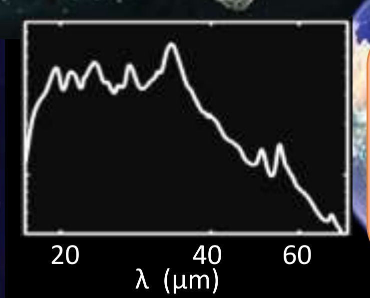


SPICA studies

★ metal and dust enrichment through galaxy evolution (Goal 1), and

★ planetary system formation to habitable systems (Goal 2)

IR spectroscopy



SPICA's unique probes

1. Dust bands (organic matter, mineral, ice)
2. Extinction-free metal lines
3. Molecular hydrogen lines

AKARI Mid-IR all-sky map

Science goals and objectives

Top-level goal
Enrichment of the Universe with metal and dust, leading to the formation of habitable worlds

SCIENCE GOALS

[SG1]
Metal and dust enrichment through galaxy evolution

Science objectives

- **[SO1]** Star formation of distant galaxies
- **[SO2]** Dust-obscured AGNs and AGN outflow
- **[SO3]** Star formation in nearby galaxies

[SG2]
Planetary formation to habitable systems

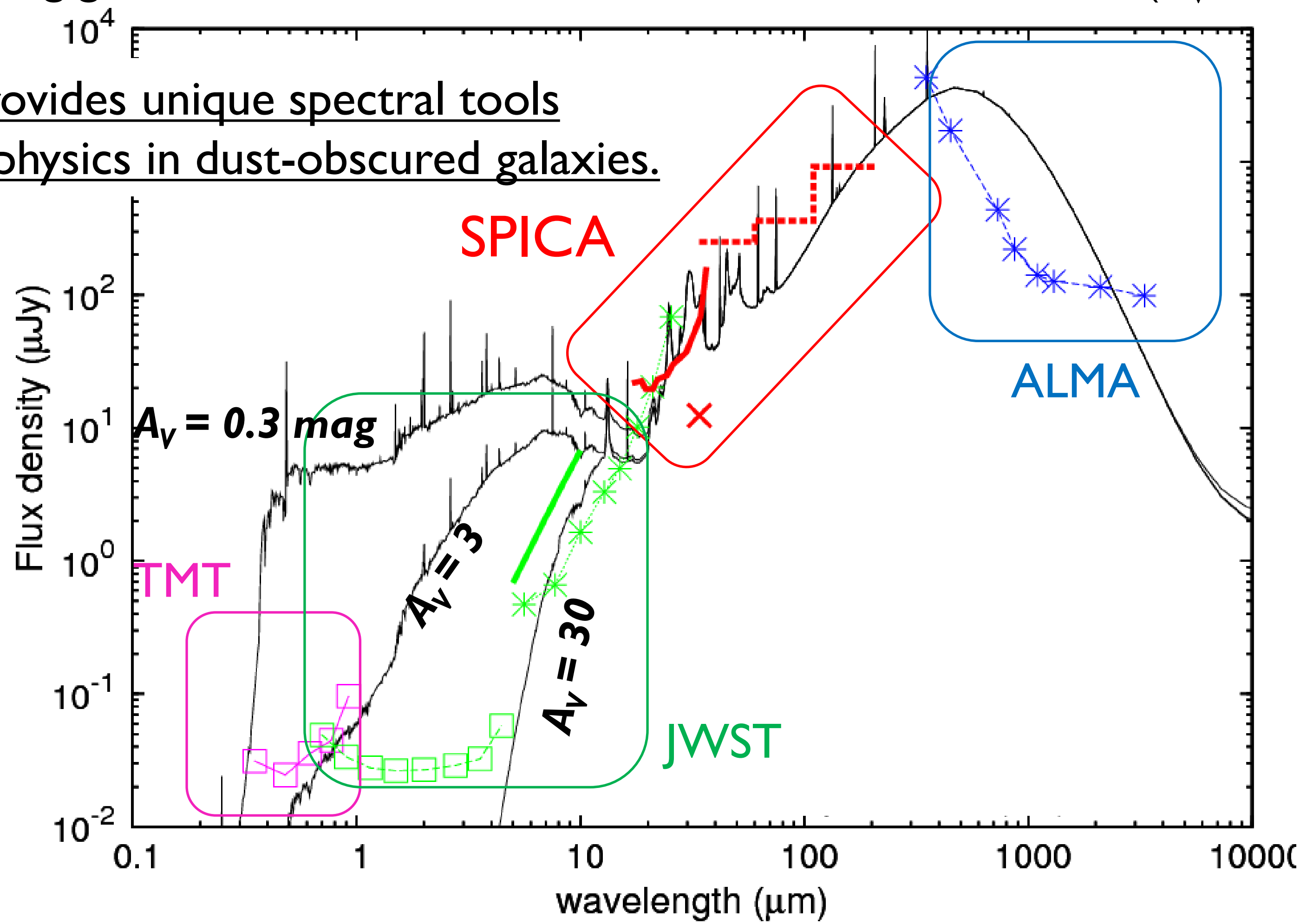
Science objectives

- **[SO4]** Gas dissipation in planet-forming disks
- **[SO5]** Dust evolution in planet-forming disks to solar system analogues
- **[SO6] Optional** Exoplanet atmosphere

SPICA's uniqueness in extra-galactic astronomy

Sensitivity (5σ, 1 hour) of ALMA, SPICA, JWST and TMT, plotted on spectra of typical star-forming galaxies at z = 3 with different dust extinction values (A_V = 0.3, 3, 30 mag).

SPICA provides unique spectral tools to study physics in dust-obscured galaxies.



SPICA fills the spectral gap between ALMA and JWST.

国際科学評価委員会

目的

SPICA計画について、科学的観点からの評価を得る。

日時・場所

2015年7月15日 Paris

評価委員

Michael Rowan-Robinson (UK), Martin Bureau (UK),
David Elbaz (FR), Anthony Peter Jones (FR)
Peter Barthel (NL),
Martin Harwit (US), George Helou (US)
Kazuhisa Mitsuda (JP),

ISAS Saku Tsuneta, Masaki Fujimoto, Munetaka Ueno, Ikko Funaki

SPICA Hiroshi Shibai (PI), Takashi Onaka (PS),
Hidehiro Kaneda (PI補佐), Kotaro Kohno (PS補佐)
Daisuke Ishihara, Takehiko Wada, Naoki Isobe,
Peter Roelfsema (NL), Bruce Sibthorpe (NL)

Executive Summary

The SPace Infrared telescope for Cosmology and Astrophysics (SPICA) is a mid- and far-infrared spectroscopic mission to reveal the processes that enriched the Universe with complicated materials and led to the formation of our world today. This scientific goal and derived scientific objectives have been set by the SPICA team, and were evaluated by an international review committee. This Short Report summarizes the key findings of the committee, and will be followed by a more detailed report. The Committee is most appreciative of the team's work in preparing the material for the Preview, and of the quality of the presentations.

Executive Summary

1. The committee strongly supports the mission concept of a 2.5m telescope cooled to 8K with powerful spectrometers in the focal plane; it represents two orders of magnitude improvement in sensitivity over Herschel, and offers major discovery potential. The Committee feels however that this is a minimum configuration, i.e. there is no margin for reducing sensitivity or resolution requirements. (NB: Based on discussions during the Preview, the Committee assumes that the SAFARI instrument is photometry-capable, even though the specifics of that capability were not presented)

2. The science case as stated is compelling, both today and in the anticipated environment of the 2020's.

3. The science case can be strengthened by (a) integrating more closely in the statement of each Science Objective scientific synergies with other facilities of the 2020's (e.g. TMT/ELT; ALMA; JWST; Euclid & WFIRST; ATHENA; SKA, etc); and (b) identifying more science topics to engage and serve the science community beyond traditional users of IR missions (e.g. stellar astrophysics, baryon circulation between galaxies and inter-galactic medium, exoplanet science, etc). Item (b) might be accomplished by identifying "key questions" in major community reports to which SPICA could contribute.

4. The summary science justification (slide entitled "Science goals and objectives") can be strengthened as follows: (a) Keep the vision of heavy element enrichment and push it both to earlier epochs and to the low-redshift Universe by emphasizing the potential for great advances in our estimation of the abundances of chemical elements; (b) modify SO2 to emphasize heavily obscured and Compton-thick systems [strong synergy with ATHENA]; (3) bring in as SO the detection of SiO and Aromatics at redshifts of 3 to 6; (4) bring in as SO something related to the top-level goal, such as metallicity evolution using Fine-Structure Line observations. More significantly, (5) move SO6 to an appendix (along with SPEChO); the reason is that if SPEChO is essential to mission success, then it brings to SPICA a

significant risk of very limited science return as it flies a decade after JWST, at a high cost in observing time.

5. Even after removing SO6, the mission has too large a fraction of time committed to pre-determined observing programs; the committee feels this would lessen community interest, and would weaken the science case in the context of the ESA competitive processes. As a guideline, pre-determined “key science” programs should fit within a year of wall-clock time.

6. The placement of “PAH survey” on the sky is critically important: the SPICA Team is advised to exploit existing fields which already have deep coverage at a variety of wavelengths to leverage extant data for enhanced science, and more readily engage with other communities and additional science themes.

7. In stating the case for Evolution of Galaxies, model shortfalls were over-emphasized; the science case could mention those shortfalls as motivation, but then emphasize the need for essential or unique data that address the underlying physics, both in processes and in dust properties. Where appropriate, the science case could include testing specific hypotheses (e.g. Initial Mass Function variations). The same point applies to the discussion of proto-planetary disk science.

8. Before ESA's M5 competition gets under way, the SPICA team should address the question of the programmatic organization of time allocation and science responsibility, and in particular express their views on how to stimulate a vigorous, competitive open time program.

9. Before ESA's M5 competition gets under way, the SPICA team should address the means and plans to enable rapid data reduction and calibration.

10. The committee couldn't help but notice the all-male cast on the SPICA team and on the review committee itself. It is in the best interests of the future of Japanese (infrared space) astronomy to address this gender imbalance. Apart from that, the imbalance may become an issue in the context of the ESA competitive process.

この勧告を受け入れて対応し、
来週のミッション定義審査に臨む

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次世代赤外線天文衛星SPICA：プロジェクト再定義

芝井 広（大阪大）、小
松原英雄（宇宙研）、
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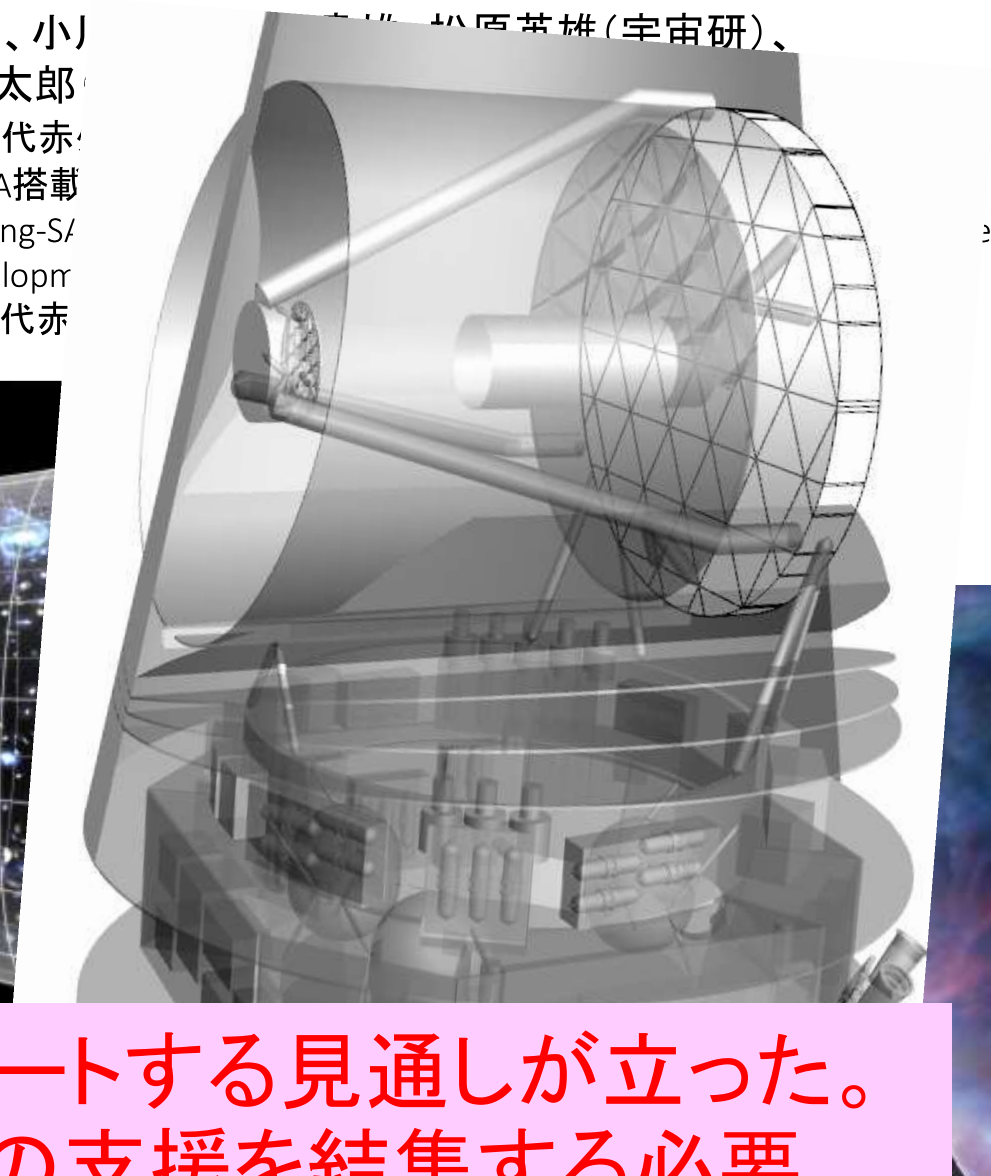
V253a　中川　次世代赤
V254a　金田　SPICA搭載
V255a　土井　Grating-S
V256a　鈴木　Developm
V257c　片坐　次世代赤
es



戦略的中型としてスタートする見通しが立った。
日欧（米亜）の研究者の支援を結集する必要。