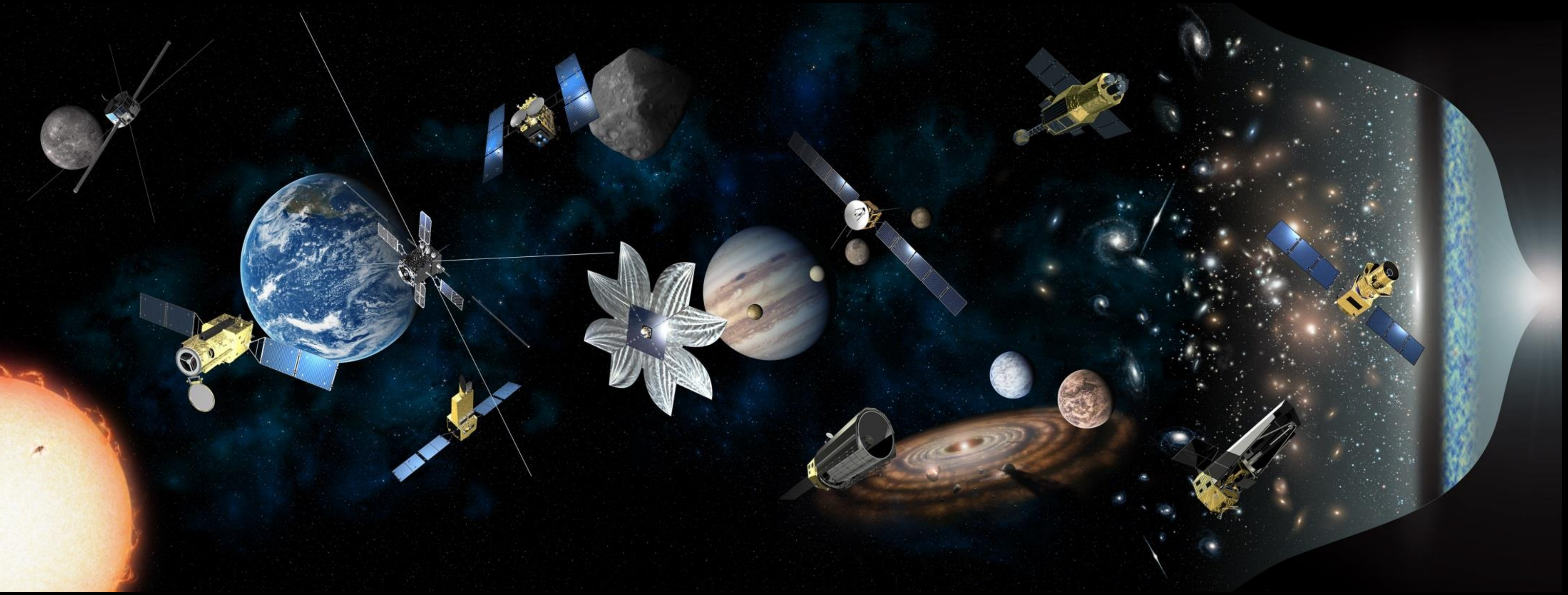
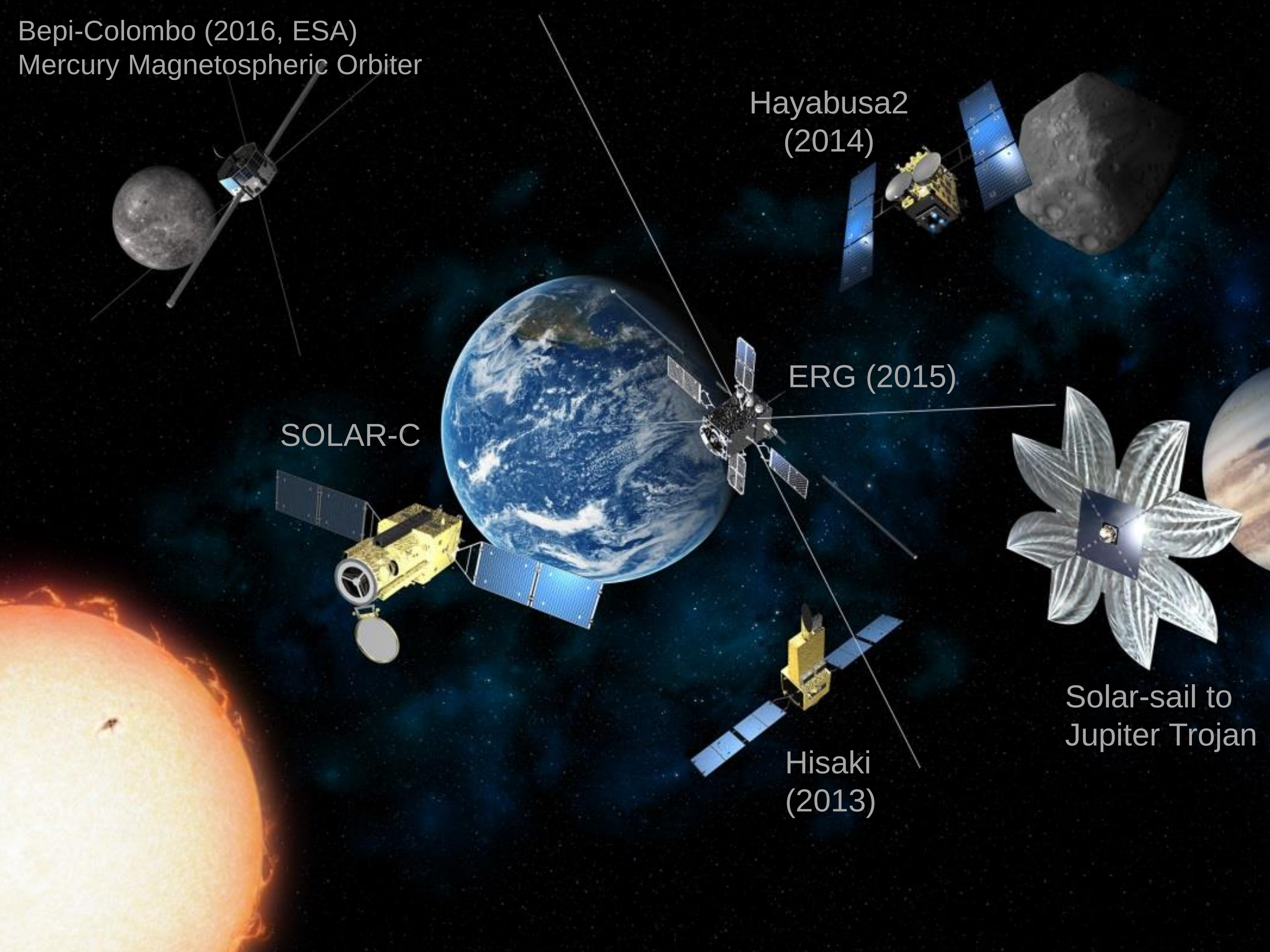
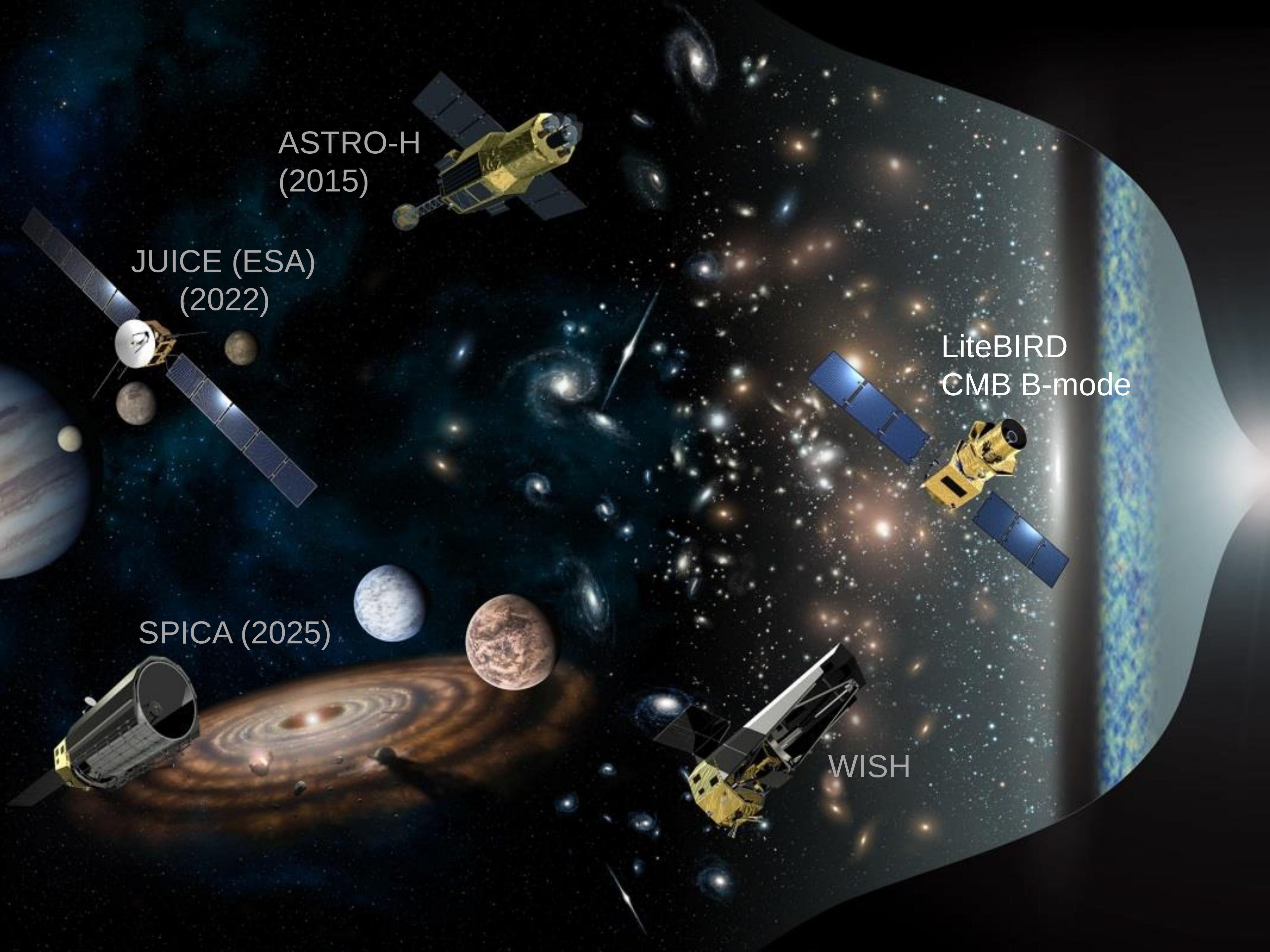
Program and planning at JAXA-Space Science

Saku Tsuneta
Institute of Space and Astronautical Science
Japan Aerospace Exploration Agency



National Research Council Space Science Week
Spring 2014 meeting of the standing committees of the Space Study Board
National Academy of Science Building, Washington, D.C.
March 3-5, 2014


Bepi-Colombo (2016, ESA)
Mercury Magnetospheric Orbiter
Hayabusa2
(2014)
ERG (2015)
SOLAR-C
Solar-sail to
Jupiter Trojan
Hisaki
(2013)


ASTRO-H
(2015)
JUICE (ESA)
(2022)
LiteBIRD
CMB B-mode
SPICA (2025)
WISH

Introduction of ISAS/JAXA

- As a national center of space ***science & engineering*** research, ISAS carries out ***development*** (including vehicle development)***, launch and in-orbit operation*** of space science missions (scientific satellites, probes, sounding rockets, balloons and instruments on ISS).
- As an inter-university research institute, these activities are intimately carried out with domestic universities.
- ISAS always seeks for ***international collaborations.***
- ***Bottom-up process for mission selection***: Space science missions proposed by researchers are reviewed by the steering committees for space science and space engineering.
- ISAS is in a process of transition of successes in the past 30 years into a future of ***sustainable excellence as a part of new JAXA.***

JAXA recent science missions

HAYABUSA(MUSES-C)2003-2010
Asteroid Explorer

AKARI(ASTRO-F)2006-2011
Infrared Astronomy

KAGUYA（SELENE)2007-2009
Lunar Exploration

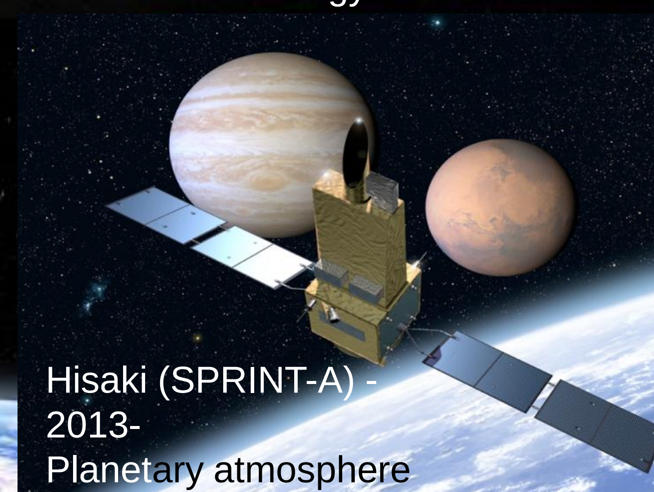
SUZAKU(ASTRO-E2)2005-
X-Ray Astronomy

IKAROS 2010-photon propulsion
thin-film solarpowergeneration

AKATSUKI(PLANET-C)2010-
Venus Meteorogy

REIMEI(INDEX)2005-
In-house small satellite

HINODE(SOLAR-B)2006-
Solar Observation



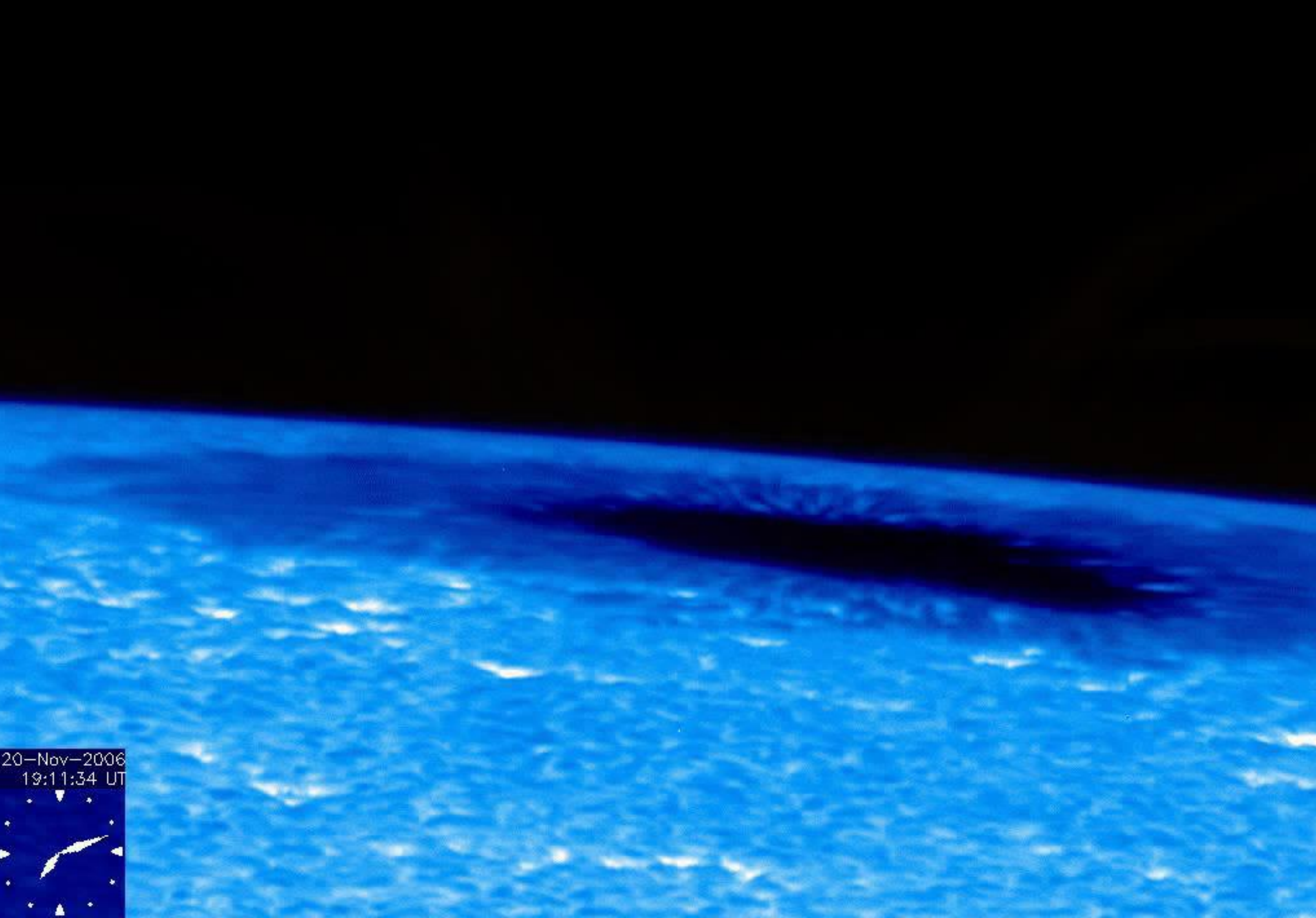
Hisaki (SPRINT-A) -
2013-
Planetary atmosphere

Number of Referred Papers

Satellite	Objective	Start of Operation	End of Operation	Counting Period	Number
AKATSUKI	Venus Atmospheric Obs.	2010	operating	2011-2012	8
KAGUYA	Lunar Exploration	2007	2009	2008-2012	190
HINODE	Solar Obs.	2006	operating	2007-2012	844
AKARI	Infrared Astronomical Obs.	2006	2011	2007-2012	222
SUZAKU	X-ray Astronomical Obs.	2005	operating	2006-2012	681
HAYABUSA	Asteroid Sample Return	2003	2010	2004-2012	129
NOZOMI	Mars Scientific Obs.	1998	2003	1999-2012	26
HALCA	Space VLBI	1997	2005	1998-2012	44
ASCA	X-ray Astronomical Obs.	1993	2002	1994-2012	2287
GEOTAIL	Geo-Magnetospheric Obs.	1992	operating	1993-2012	1236
YOHKOH	Solar Obs.	1991	2000	1992-2012	1089
＜reference＞					
Subaru Telescope	The Ground based optical&infrared Observatory	1999	operating	2000-2012	1031

Red: JAXA-led mission with major NASA participation

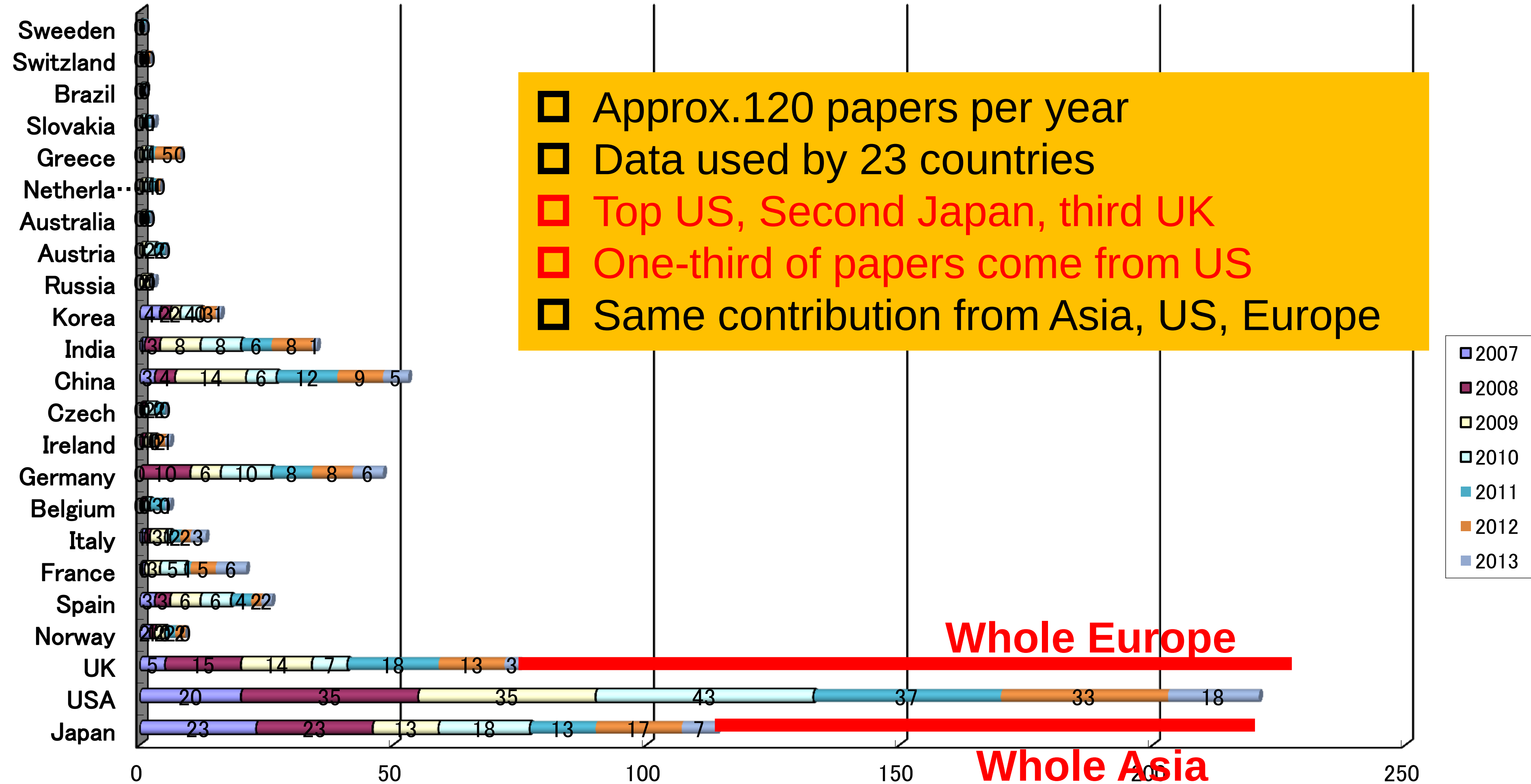
JAXA-NASA-UK-ESA Hinode



Hinode refereed papers: 844 papers for 7 years

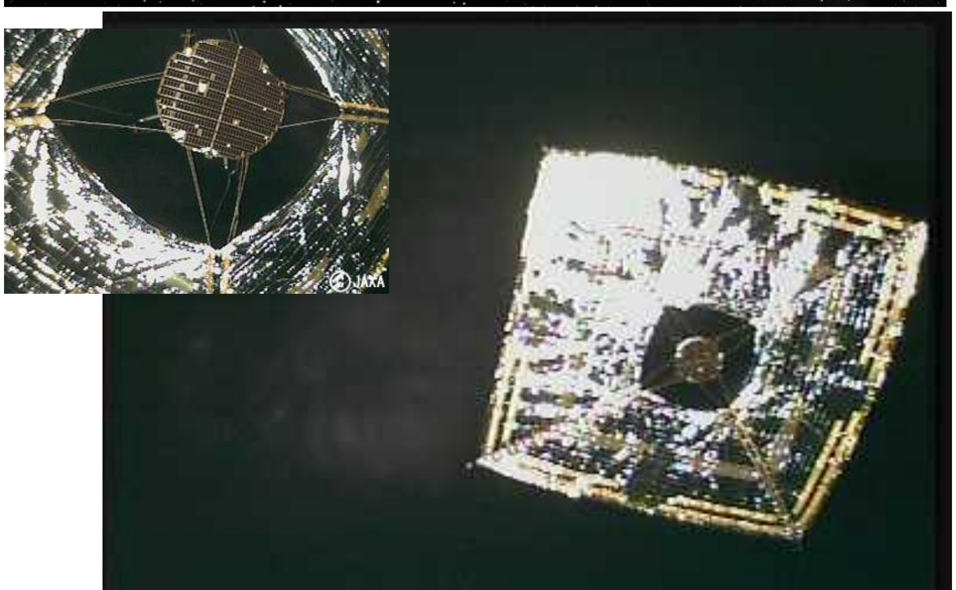
Immediate release of just-taken data
with analysis software & latest calibration info.

- Approx.120 papers per year
- Data used by 23 countries
- Top US, Second Japan, third UK
- One-third of papers come from US
- Same contribution from Asia, US, Europe



Curator: Dr. Shimojo (NAOJ)

Recent accomplishments
HAYABUSA & IKAROS

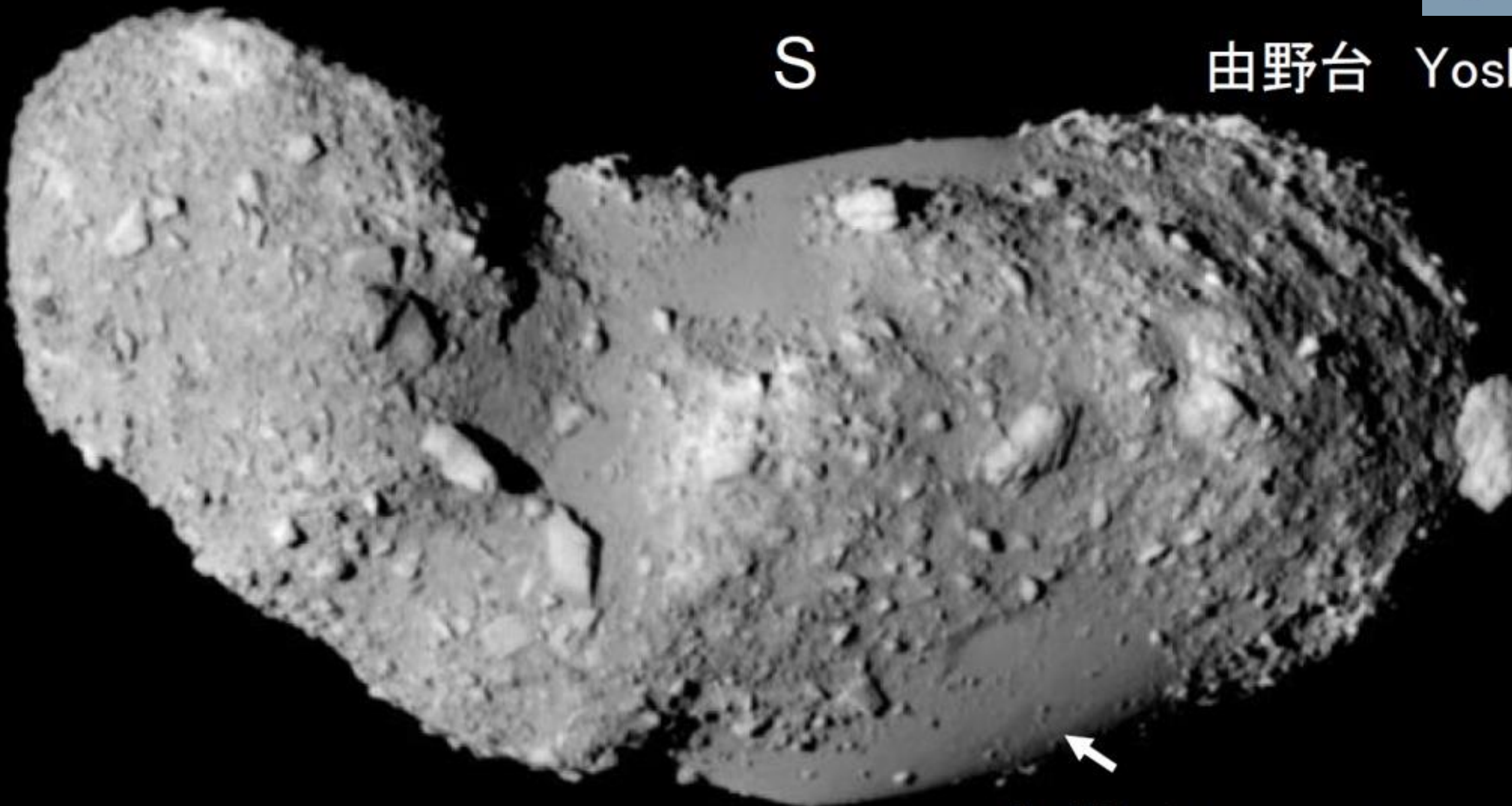


Led by JAXA Lunar & Planetary Exploration Program Group

IKAROS Technology Demonstration of Interplanetary Solar Power Sail

Led by JAXA Lunar & Planetary Exploration Program Group

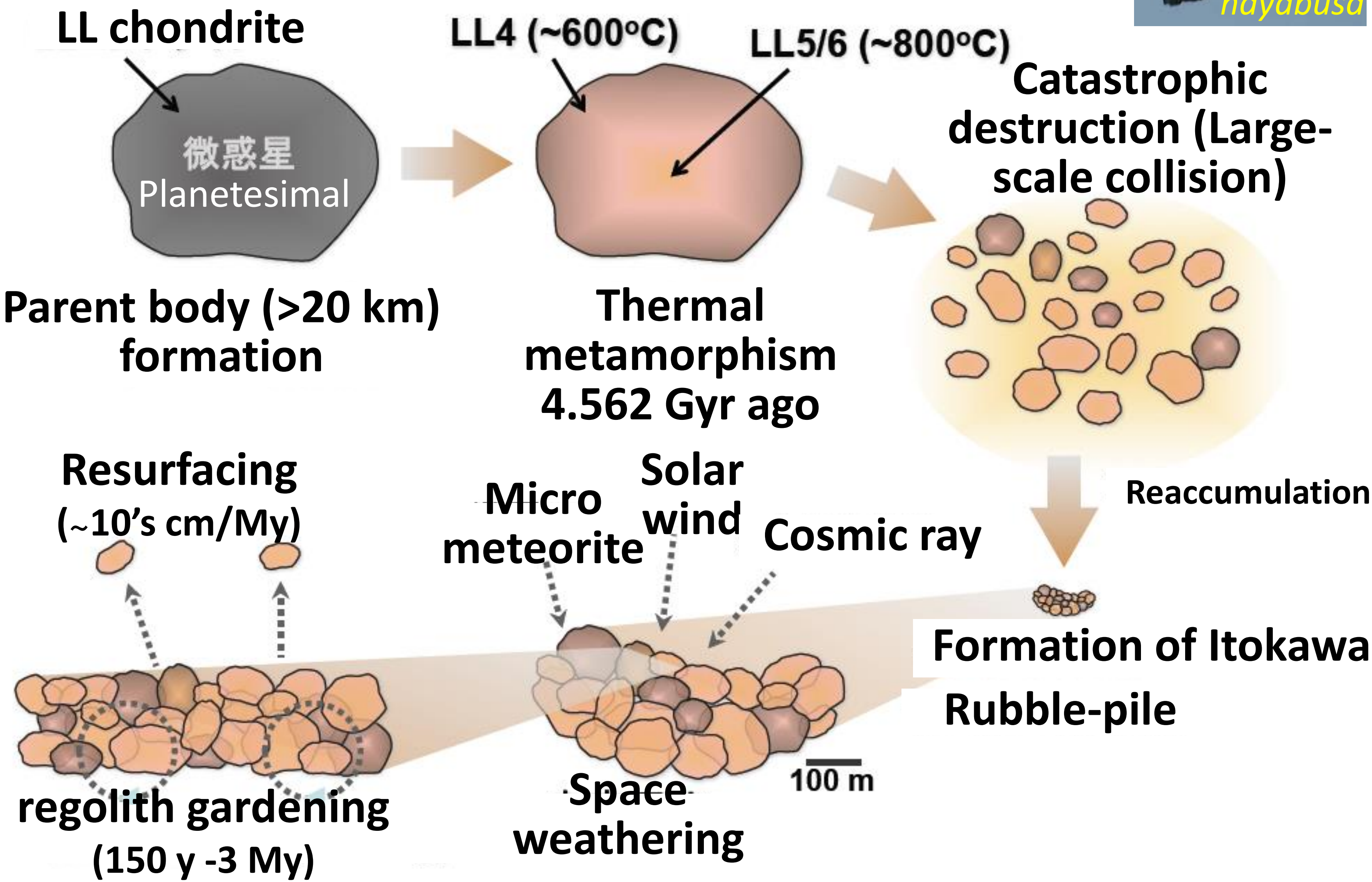
Itokawa



Led by JAXA Lunar & Planetary
Exploration Program Group

Hayabusa sample analysis

Astonishing pieces of information
Derived from 30-micron sample!



HAYABUSA2 mission

- Launch: 2014, arrival:2018, departure: 2019, return: 2020
- Target: 1999 JU3, Only known C-type near-earth asteroid

  Less exposed to heating events and retain more information of the era when the solar system was formed.

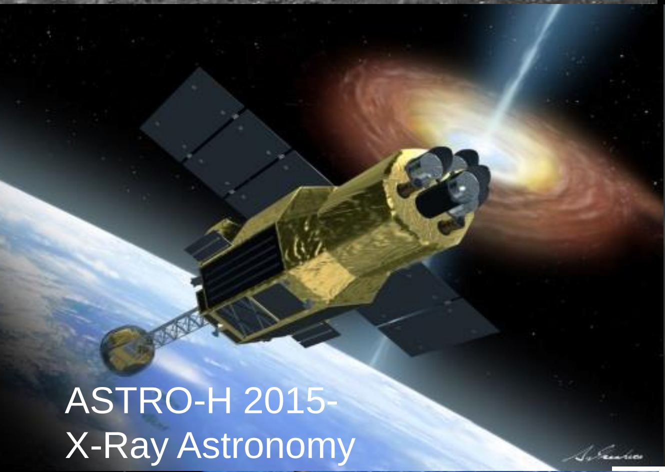
  Contain much more volatiles, such as organic matter and water.
- Key experiments: close-up observations, sample analyses, impact experiment in space
- Science goals

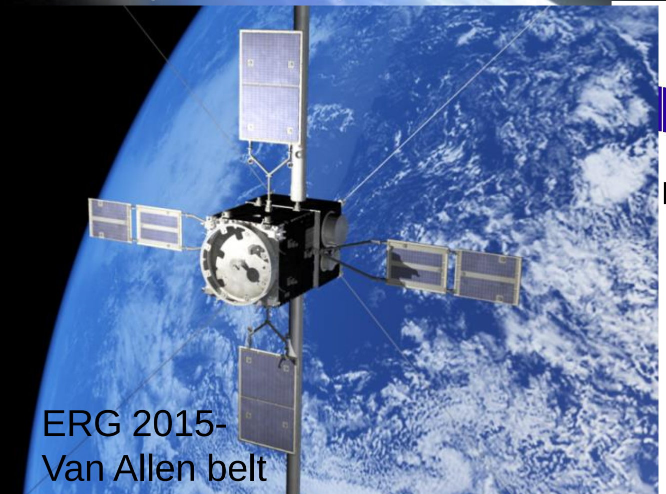
  Understand how materials evolve in the early phase of the solar system and are altered at later times on the asteroid.

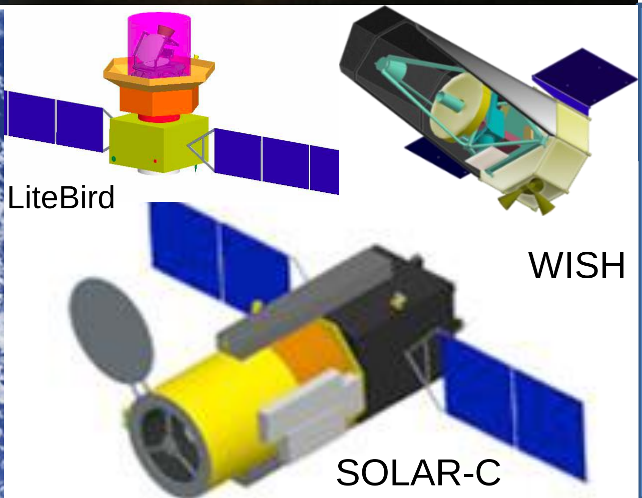
  Understand dynamical evolution and resultant structure of the asteroid, as a possible analogue for formatio of planetesimals.

Led by JAXA Lunar & Planetary Exploration Program Group

JAXA missions under development/being considered

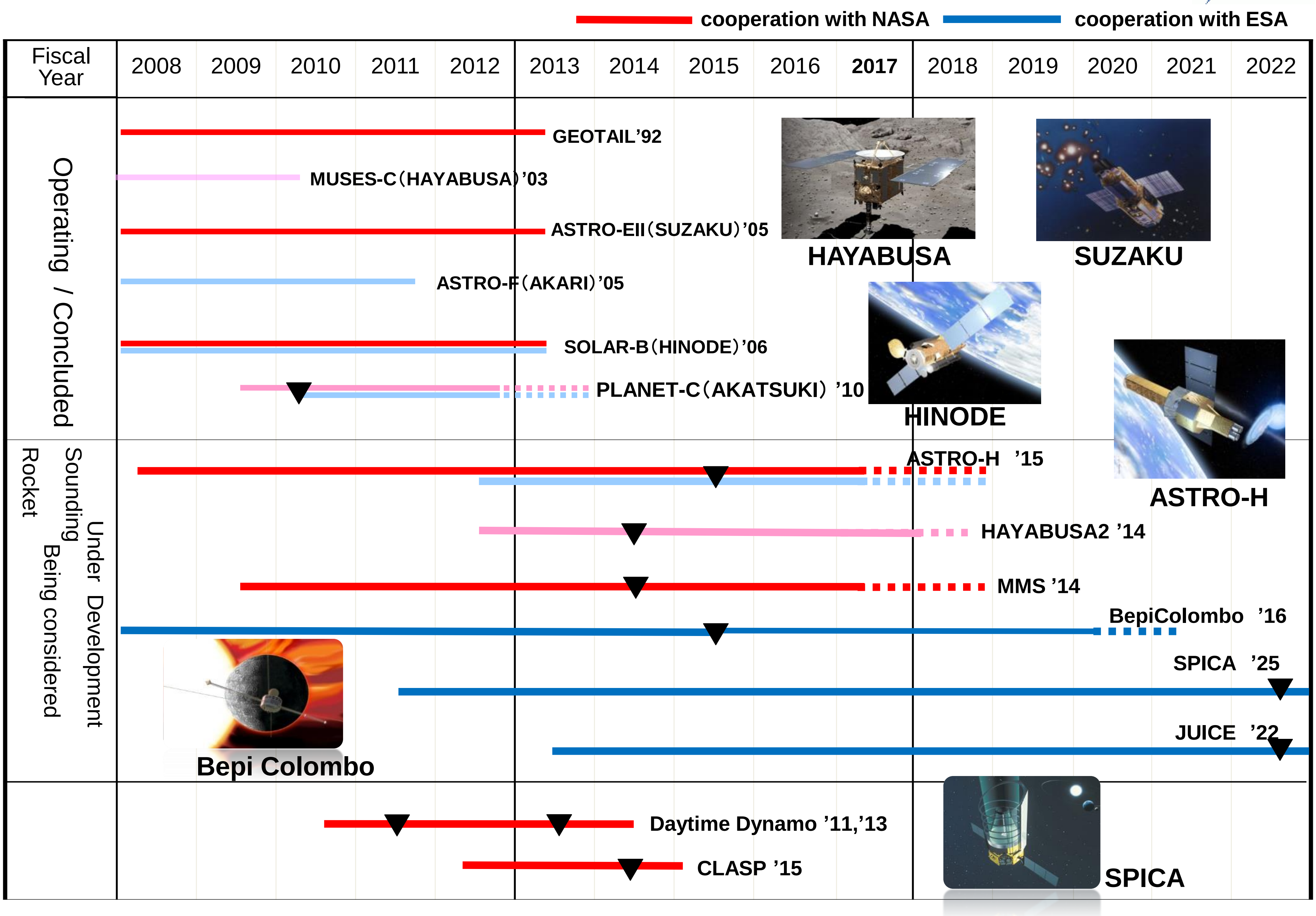




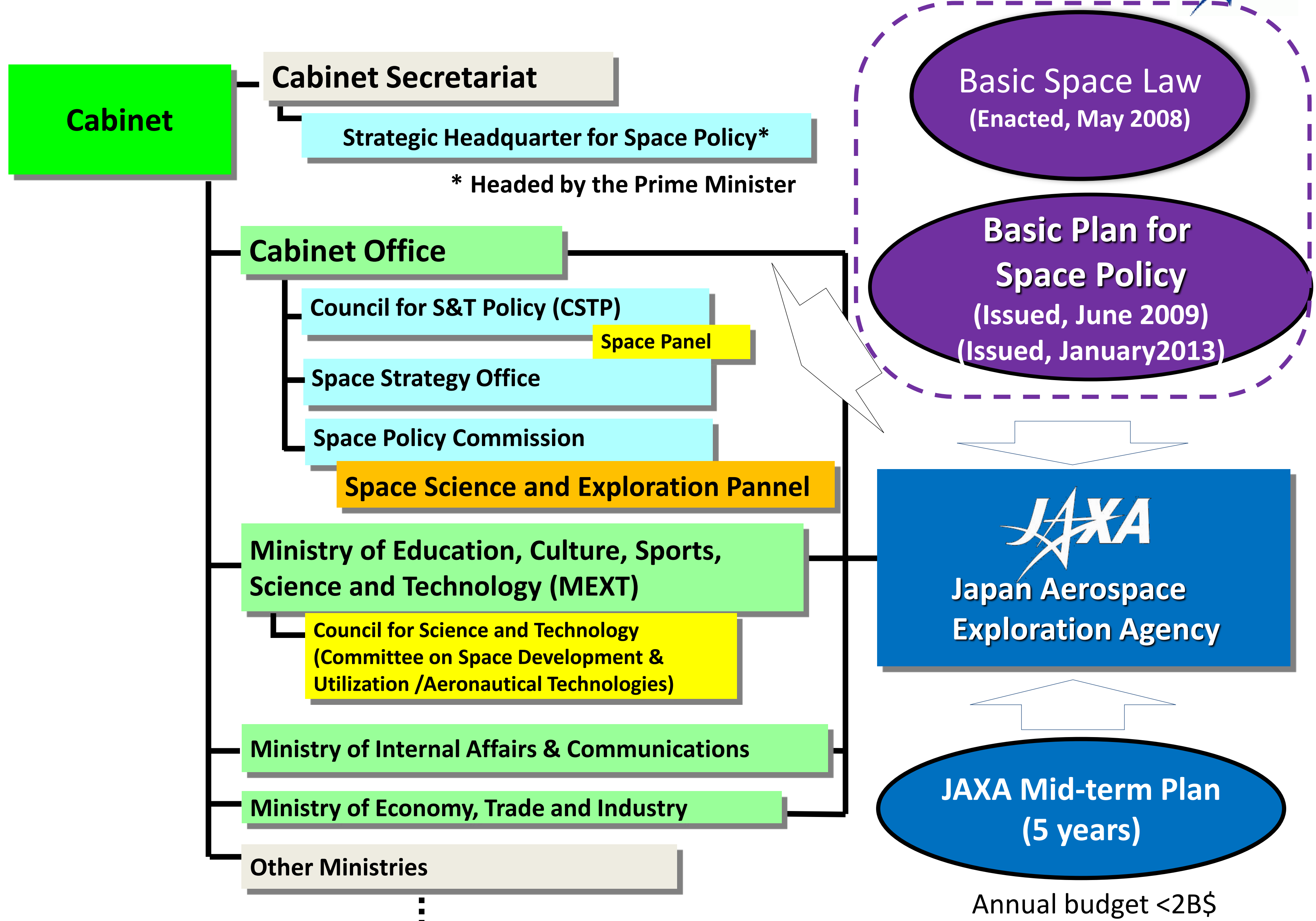


ISAS Meduim satellites
High cadence-low cost
focused missions
2017, 2019….

Space Science Cooperation with NASA and ESA



Japan's Space Related Organizations



JAXA Organization

As of April 1, 2013

Dr. Naoki OKUMURA
President

Kiyoshi HIGUCHI
Vice President

General Auditor
- General Auditor Office

Yuichi YAMAURA
Executive Director
- Chief Engineer Office
- Information Systems Department
- JAXA's Engineering Digital Innovation Center
- Industrial Collaboration and Coordination Center
- International Relations and Research Department
- Strategic Planning and Management Department
- New Business Promotion Office

Yoshikazu KATO
Executive Director
- Public Affairs Department
- Evaluation and Audit Office
- General Affairs Department
- Human Resources Department
- Finance Department
- Contract Department
- Security Administration Office
- Tsukuba Space Center Administration Department
- Ground Facilities Department
- Space Education Center

Safety and Mission Assurance Department

Mamoru ENDO
Executive Director
- Space Transportation Mission Directorate
  - Development of Space Transportation Systems

Shizuo YAMAMOTO
Executive Director
- Satellite Applications Mission Directorate I
  - Earth Observation Programs
  - Disaster Monitoring and Communications Programs
  - Satellite Positioning Programs
- Satellite Applications Mission Directorate II
- Consolidated Space Tracking and Data Acquisition Department
- Environmental Test Technology Center
- Spectrum Management Office

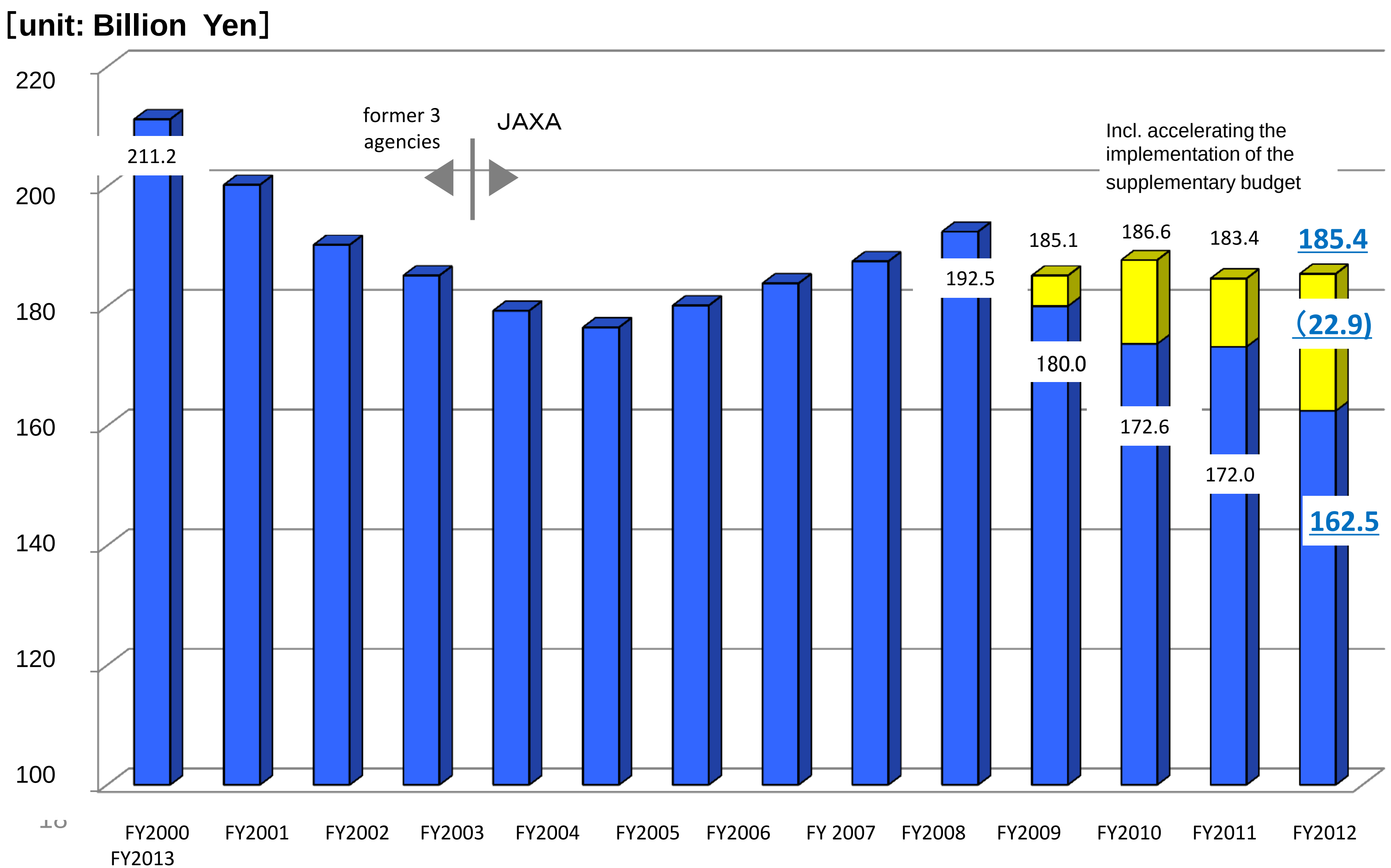
Yoshiyuki HASEGAWA
Executive Director
- Human Spaceflight Mission Directorate
  - Operations/Utilizations of ISS and KIBO JEM, R&D on Human Space Technologies
- Lunar and Planetary Exploration Program Group
  - Lunar and Planetary Explorations

Kazuhiro NAKAHASHI
Executive Director
- Institute of Aeronautical Technology
  - Aero Technology Programs
  - R&D on Aeronautical Science Technologies
- Aerospace Research and Development Directorate
  - Technical Development Support for Projects
  - Maintenance of base technologies for space utilization / R&D on advanced technologies

Saku TSUNETA
Executive Director
- Institute of Space and Astronautical Science (ISAS)
  - Space Science Research and postgraduate education
  - Space Science Programs
  - Technology Development support for Projects
- Promotion Office for Collaboration with Universities and Research Institutes

Transition of JAXA Budget

- **FY2013 Government Budget: 185.4 Billion Yen**
  (Principal Budget:162.5 billion yen, FY2012 Supplementary Budget: 22.9 billion yen)
- **Compared to the previous fiscal year: +1.0%**
  (Incl. accelerating the implementation of the supplementary budget)

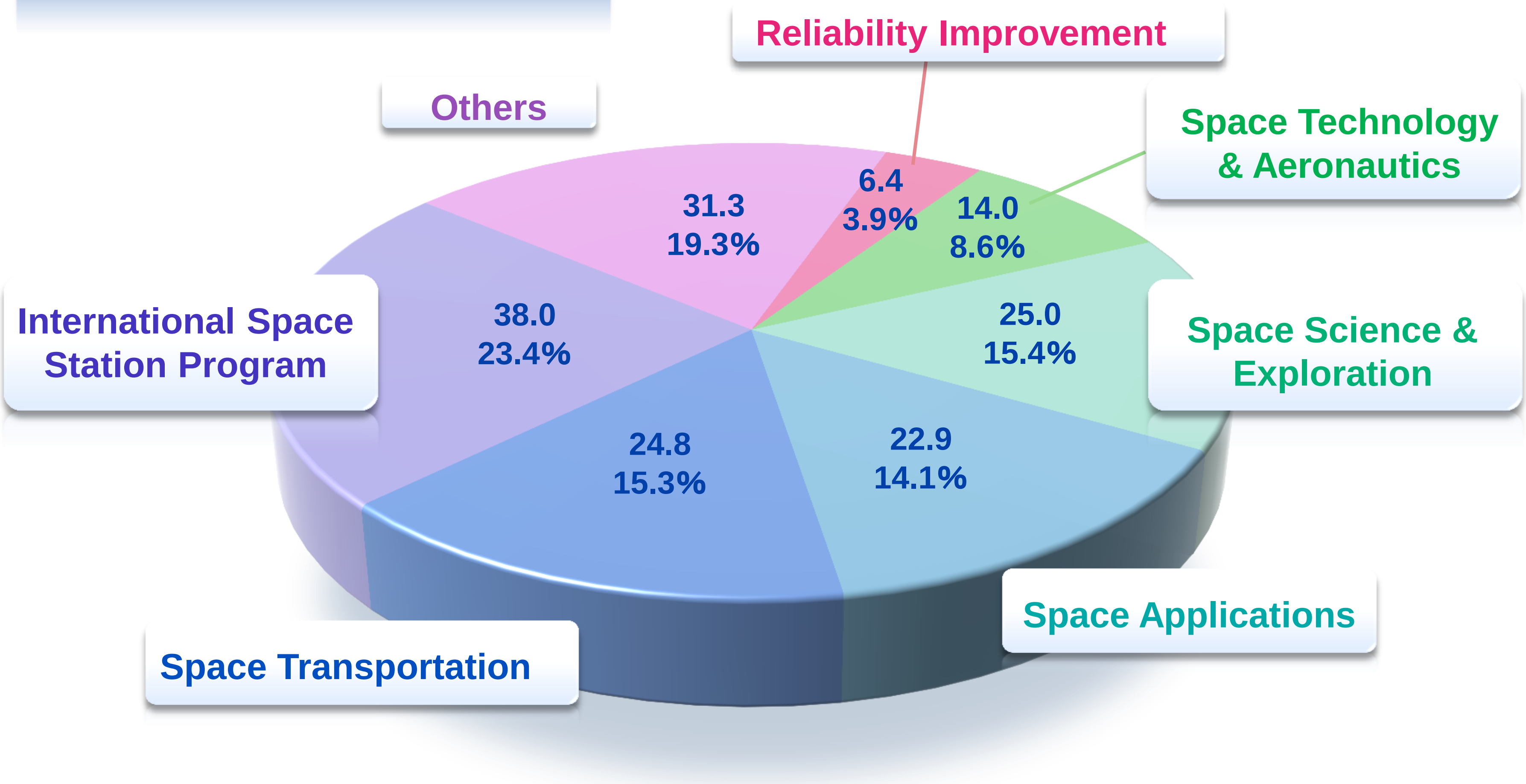


FY2013 Annual Budget

As of April, 2013

FY2013 : 162.5 Bil. Yen
FY2012: 172.0 Bil. Yen
FY2011: 172.6 Bil. Yen

Breakdown of Principal Budget
(not including stimulus money)



Launch Vehicles

To be replaced with H-III in 2020

Launch capability being improved

H-II A

- First Flight in 2001
- **23** successful launches/24
- Latest one: GPM
- GTO 4-6 ton class capability

H-II B

- First Flight in 2009
- **4** successful flights/4 of 16.5 ton HTV to ISS
- GTO 8 ton class capability

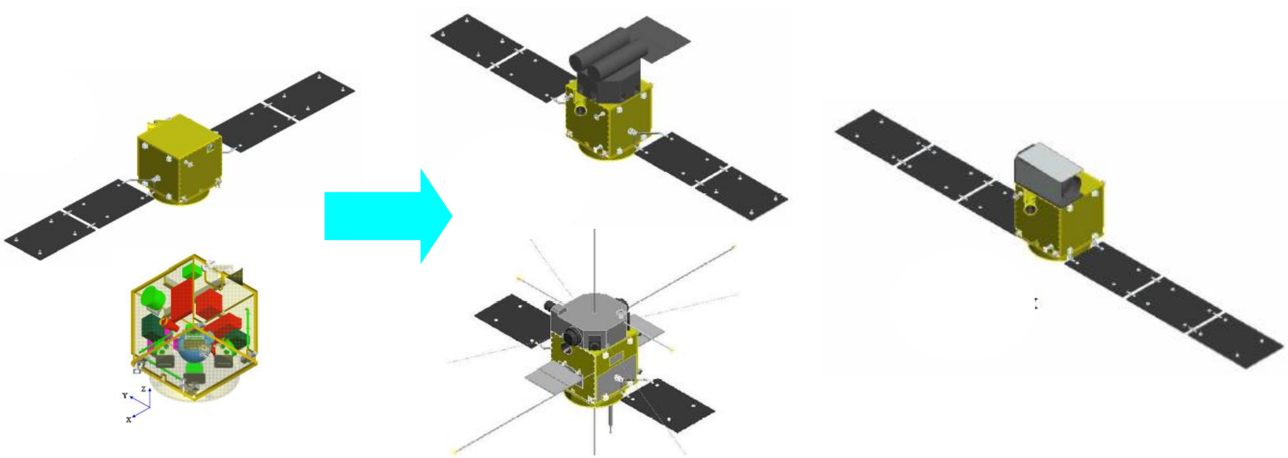
Epsilon

- **1** successful launch/1
- 3 stages Solid Rocket
- LEO 1.2 ton
  SSO 0.45 ton

GPM: Global Precipitation Measurement mission

New Medium-sized Satellite Program

- ***Epsilon Launch Vehicle*** is a solid propellant rocket capable of launching a satellite weighing 1.2 tonnes into LEO.
- The launch capability is being enhanced per plan.
- With standardized s/c bus, ISAS intend to implement ***low-cost, high-cadence focused missions.***



Hisaki Successfully launched on 14 Sep. 2013

by the 1st ***Epsilon*** launch vehicle

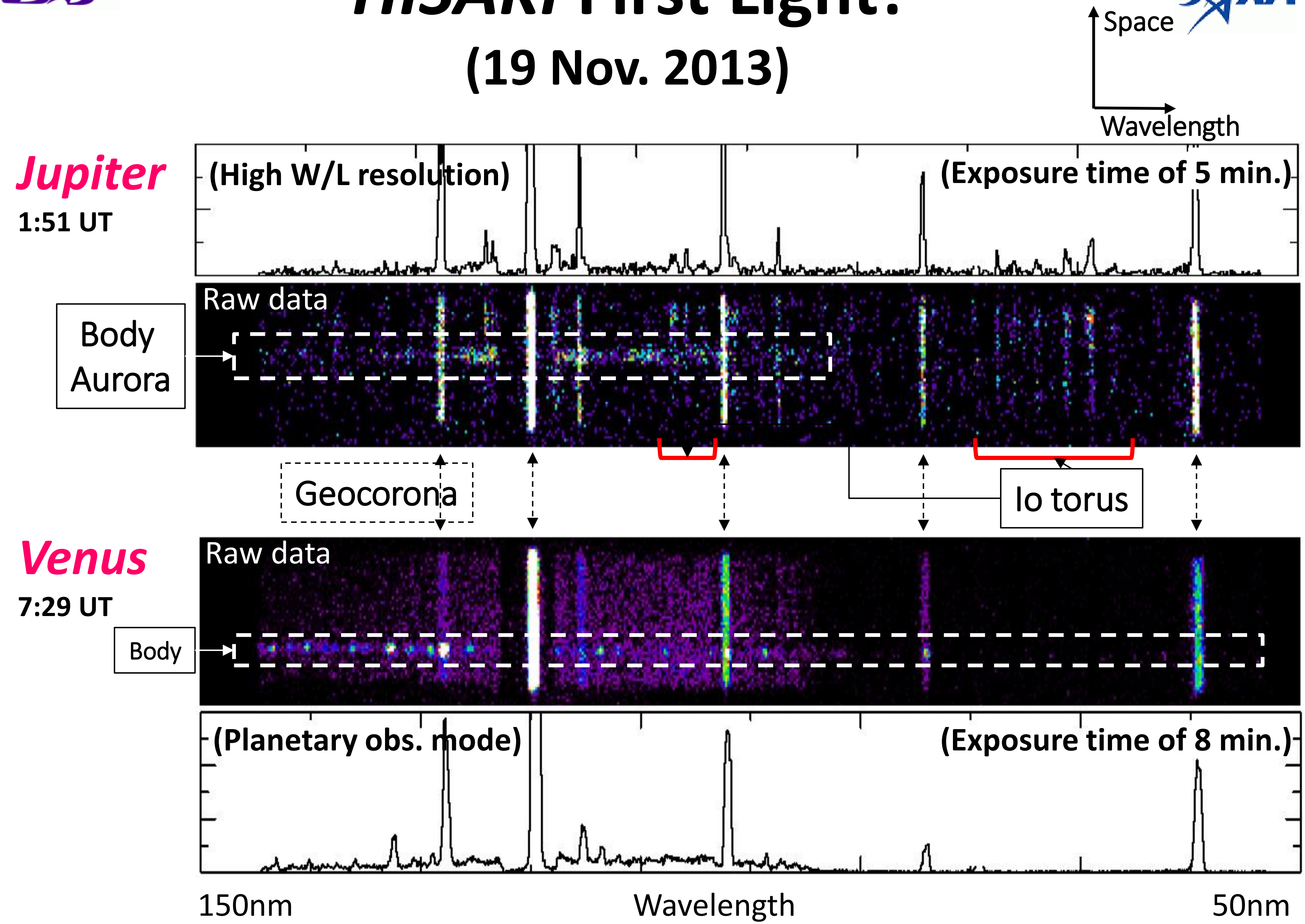
EUV spectrograph for dedicated planetary observations

(Venus, Mars, Jupiter, Mercury, Saturn)

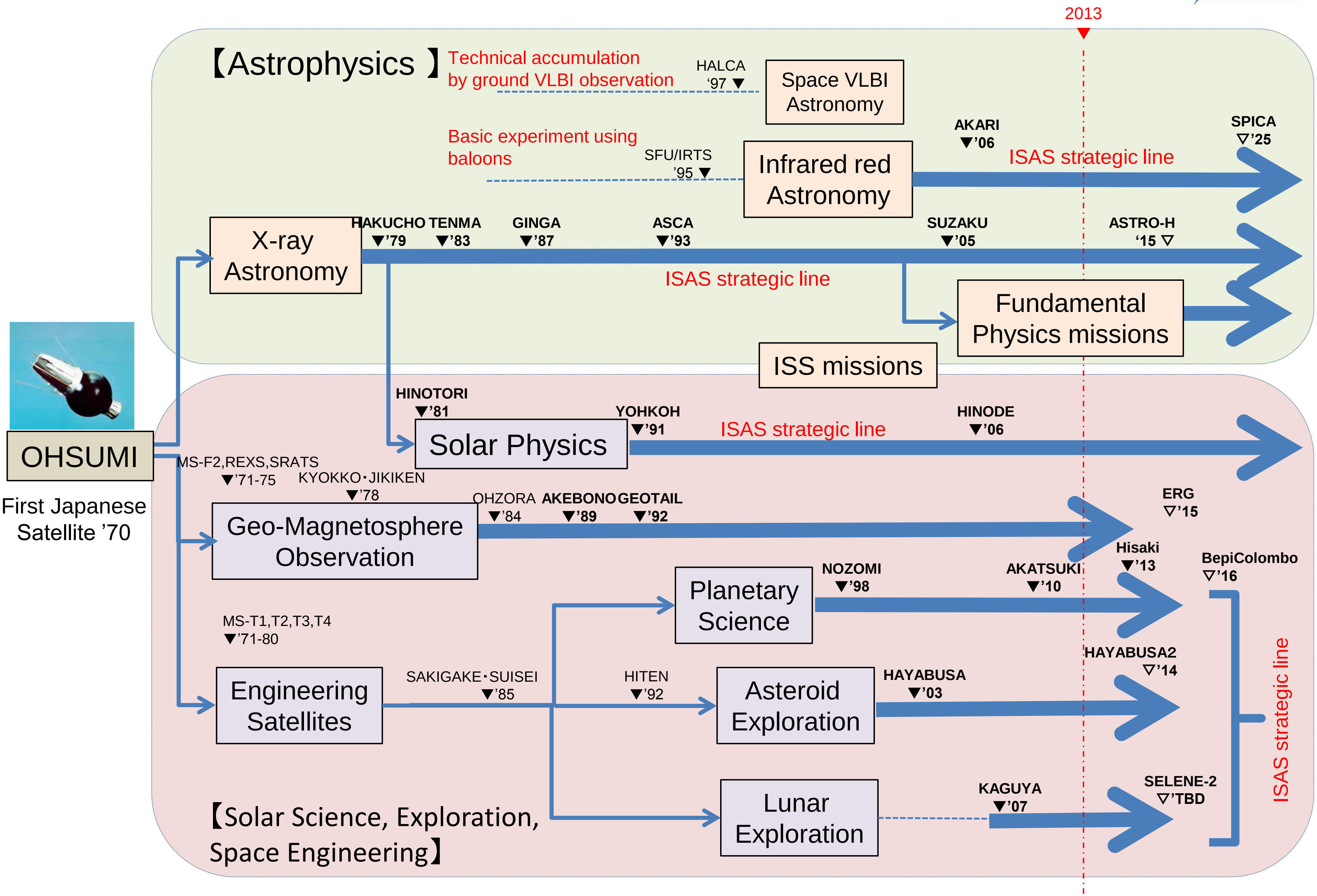
S/C weight：340kg
S/C power：900W
S/C size: 7m x 4m x 1m
Orbit：950～1150km
λ：50-150nm (EUV)

Erosion?

HISAKI First Light!
(19 Nov. 2013)

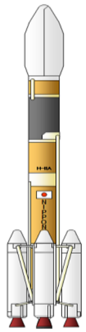


Genealogy of Space Science missions



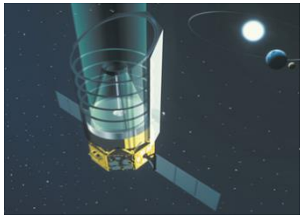
ISAS/JAXA mission categories

Space Policy Commission under cabinet office intends to guarantee predetermined ***steady annual budget*** for space science and exploration for ISAS/JAXA to maintain its excellent scientific activities



Strategic Large Missions (300M$ class) for JAXA-led flagship science mission with HIIA vehicle (3 in ten years)

ASTRO-H



SPICA

Competitively-chosen medium-sized focused missions (<150M$ class) with Epsilon rocket (every 2 year)

ERG

#3 Under selection

Missions of opportunity (10M$ per year) for foreign agency-led mission, sounding rocket, ISS

JUICE

Three lines for ISAS science missions

2010 2020 2030

Strategic *L-class*
(3 missions /10 yrs)
w/ HII-A

Hayabusa2 (2014)
Astro-H (2015)
SPICA (2025~)
New AO (international) for 2020～ (notional)

Competitive *M-class*
(1 mission/2 yrs)
w/ Epsilon

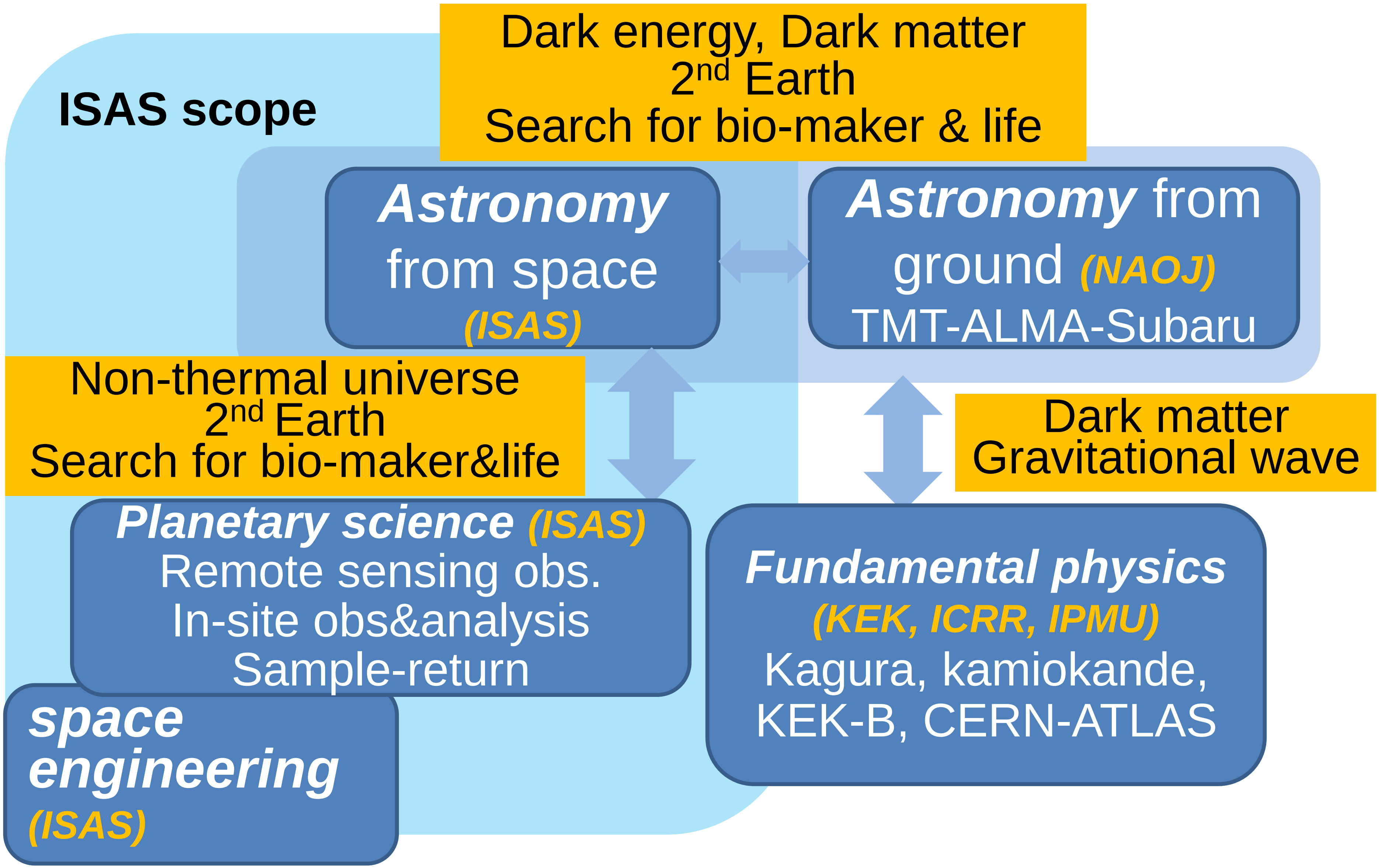
Hisaki(2013)
ERG (2015)
AO#3 for 2017 (domestic)
AO#4 (international) for 2019～ (notional)

S-class
mainly for foreign agency-led mission

CLASP(2015)(JAXA-NASA-CNES)
BepiColombo (ESA, 2016)
JUICE (ESA, 2022)
WFIRST(NASA, 2025)
ATHENA(ESA, 2028)

Space science in Japan: Big picture

~task-share, complementarity, synergy, balance~



Active Working Groups

Steering Committee for Space Science

- International X-ray Observatory (ATHENA) WG
- Wide-field Imaging Surveyor for High-redshift(WISH) WG
- General Anti-Particle Spectrometer（GAPS） WG
- Japanese Terrestrial Planet Finder(JTPF)WG
- JUpiter ICy moon explorer (JUICE) WG
- Luna-GLOB Penetrator WG
- Solar Observatory Satellite（Solar-C) WG
- Mars Atmospheric Escape Study WG
- Mars Exploration with a Lander and OrbiterS (MELOS)WG
- ISS JEM-EUSO WG
- Lite (light) satellite for the studies of B-mode polarization and Inflation from cosmic background Radiation Detection (LiteBIRD) WG

(Medium-sized Scientific Satellite program)

- High-z Gamma-ray bursts for Unraveling the Dark Ages Mission(Hiz-GUNDUM) WG
- Formation Flight All Sky Telescope（FFSAT) WG
- Precise Positioning Mission with a micro-Satellite（PPM-sat) WG
- Compton telescope for Astro and Solar Terrestrial (CAST) WG
- Gravitational DECIGO Pathfinder (DPF) WG
- Diffuse Intergalactic Oxygen Surveyor（DIOS) WG
- Polarimetry Satellite（POLARIS) WG
- Japan Astrometry Satellite Mission for INfrared Exploration (JASMINE) WG

Steering Committee for Space Engineering

- Solar Sail WG
- Studies on the Technology for Exploration of Planetary Surface(STEPS) WG
- Hybrid rocket WG
- Spaceplane Engineering Demonstrator (SEED) WG
- Formation flying technology WG
- Advanced Solid Rocket R&D WG
- Next generation small standard bus technology WG
- Mars Airplane Exploration (MELOS)WG

(Medium-sized Scientific Satellite program)

- Solar Power Plant Technology Demonstration WG
- Smart Lander for Investigating Moon WG
- Magnet plasma Sail WG
- Demonstration and Experiment of Space
- Technology for INterplanetary voYage (DESTINY)WG

- ISS WF-MAXI
- MARS2020/NASA
- WFIRST/NASA

ISAS: a unique combination of space science and space technology

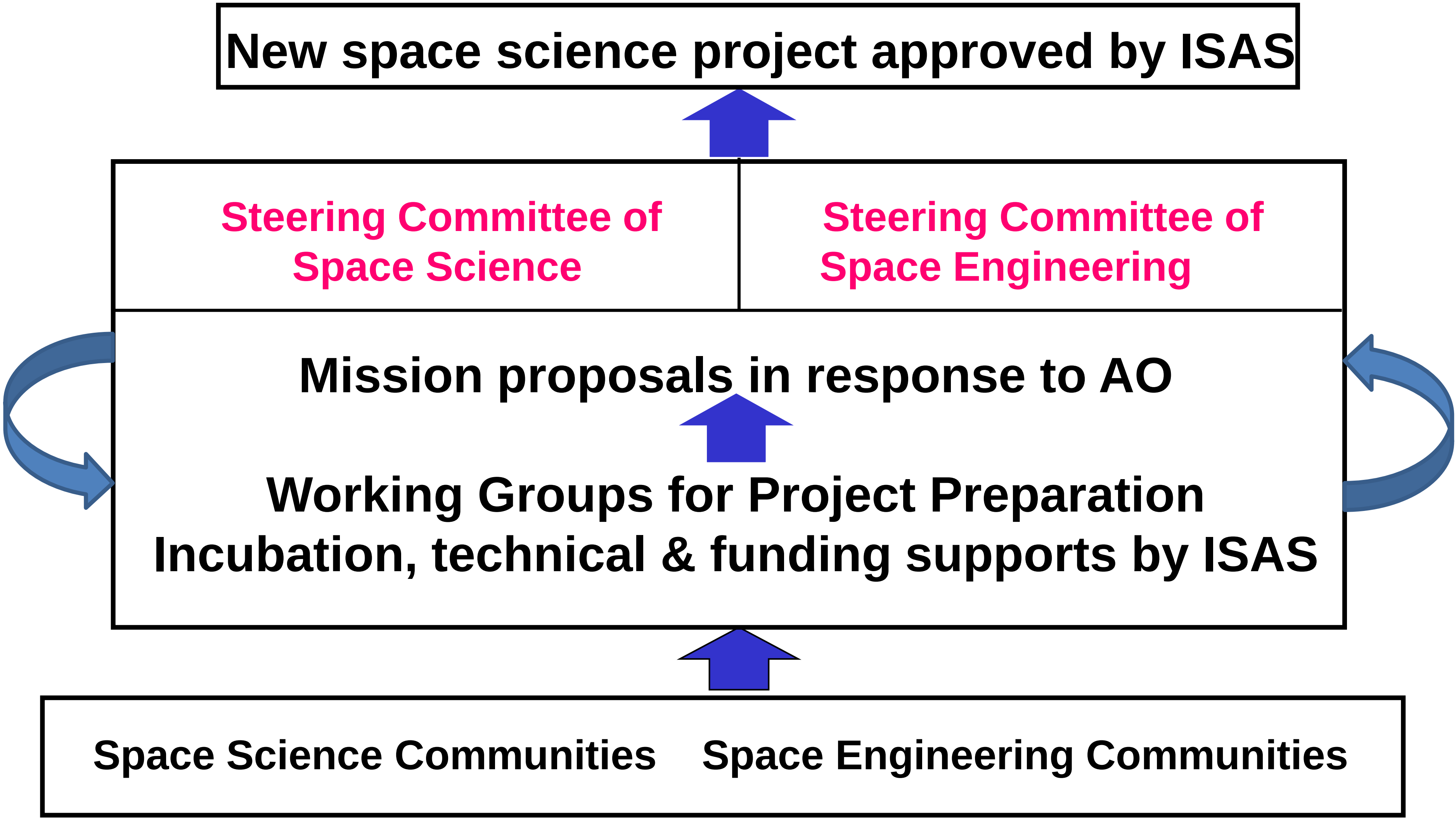
Space Technology Divisions
Space Flight Systems
Spacecraft Engineering

Technology driven
Leading and creating space science programs

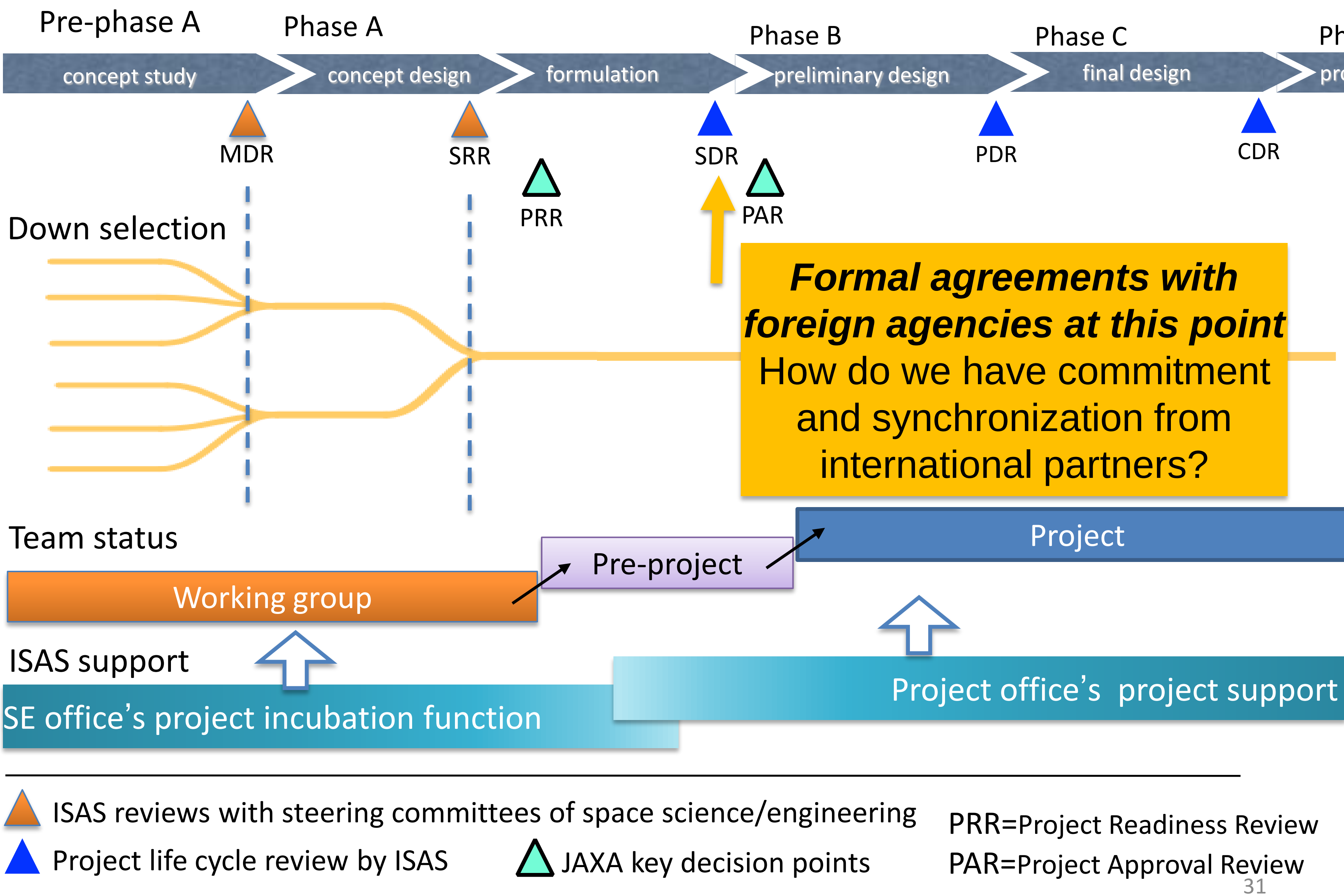
Science driven
Create, stimulate and encourage new technology research

Space Science Divisions
Space Astronomy Astrophysics
Solar System Science
Interdisciplinary Space Science

Scheme for Project Creation/Selection



Project in time domain



Candidates for US participation to JAXA missions

1. ***SPICA*** is currently ISAS's top-priority strategic mission. ISAS strongly desires to proceed to implementation phase, pending ESA M4 result.
2. ***Medium-sized satellite series*** w/ Epsilon: ISAS desires to create a path for US and European participation.
3. ***Solar-C***: ISAS requests formation of SDT for SOLAR-C in US based on strong Japan-US-European activities. Its fate depends on the availability of collaboration with NASA.
4. ***LiteBIRD***: ISAS is paying attention to the fundamental physics mission among other candidates. There are apparent multiple areas for collaboration with NASA.

US decadal process and JAXA planned missions

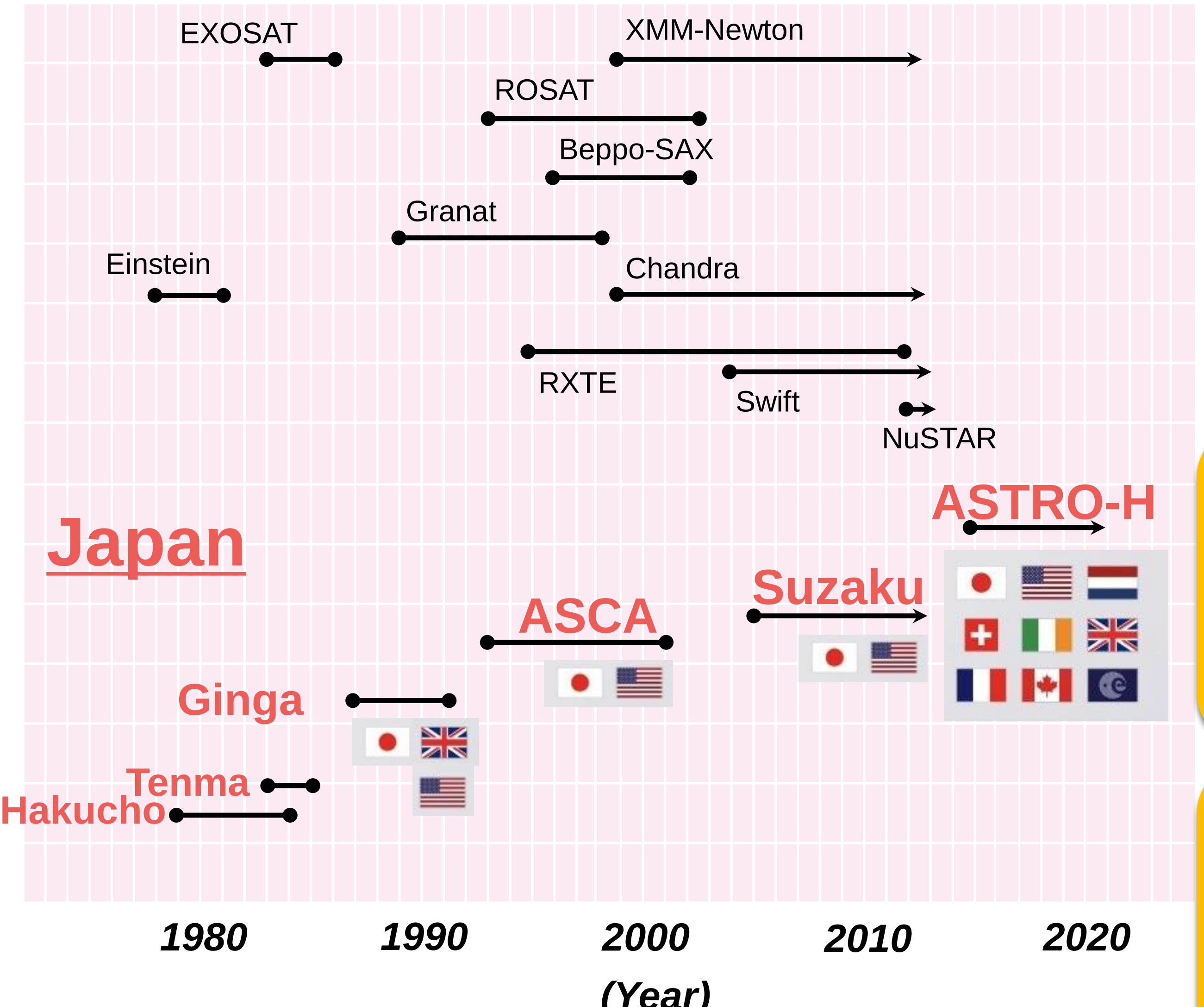
- Use of NASA MoO for many international programs significantly limits collaborative productivity because:
  - It is difficult for Japanese programs with application to NASA MoO line to get approval in JAXA review process due to its uncertainty of success.
  - Limited budgetary scope of 50M$
  - Very long and asynchronous cycle time
- US Decadal surveys become inadvertent barriers for very productive potential international collaborations, because these programs are not considered or recognized by the Steering Committee since they are not NASA led.
- NASA is not afforded the flexibility to take advantage of these international partnerships due to the strong adherence to the priorities listed in the Decadal Survey

Two problematic examples
A case study

- Case studies:
  - ASTRO-H
  - **US involvement in SPICA**
  - **Formation of Solar-C SDT (Science Definition Team) in NASA**
  - LiteBIRD (CMB B-mode polarization detection)
  - WISH (Wide-field Imaging Surveyor for High-redshift galaxies)
- These missions have been developed with significant and substantial contributions from JAXA and U.S.A science community, including bilateral findings of support from NASA and ISAS advisory panels.
- Relatively small investment on the side of US brings powerful scientific outcome as our history shows.

Collaboration in X-ray astronomy worked well in ad-hoc manner
More strategic approach is needed for mission beyond ASTRO-H

X-ray Astronomy Missions for 4 decades



(*) including Roger Blandford, Meg Urry, Richard Mushotzky

ASTRO-H

Weight: 2.7t
Launch (planned):2015

Most recent JAXA/NASA mission

- High-resolution spectroscopy
- Wide band from 0.3 to 600 keV

US contributions

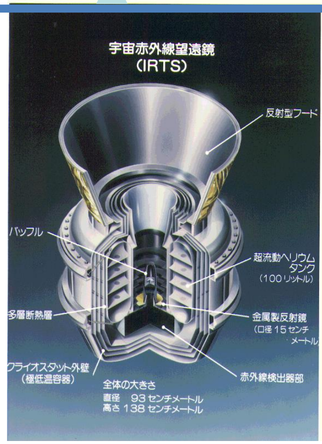
- Micro calorimeter/ADR
- Two soft X-ray telescopes
- Eight science advisors(*)
- Pipeline analysis

Infrared Space Astronomy in Japan leading to *SPICA mission*

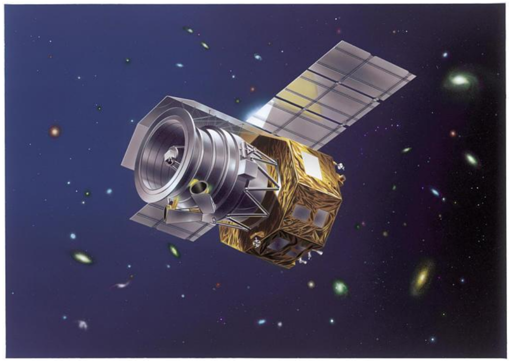
Balloon 1970's-80's

恒星用赤外線望遠鏡BAT-II

SFU/IRTS 1995



AKARI(ASTRO-F) 2006-2011



SPICA 2025

Collaboration with USA: IRTS to SPICA

International collaboration between USA and Japan in space infrared astronomy has a long history: far-infrared balloon experiments (80-90s, **U. Arizona**) and various sounding rocket experiments (80s-current**, U.C. Berkeley, Caltech**). US joined the first Japanese infrared space mission IRTS (1995, **NASA, Caltech**). US participation to SPICA, which is expected to enhance the longer-wavelength capability of SPICA significantly, was strongly recommended in the decadal survey ASTRO 2010.

Cosmic history *from big bang to life*

- Birth and evolution of galaxies
- Formation processes of stellar planetary systems
- Life cycle of complex material in our universe

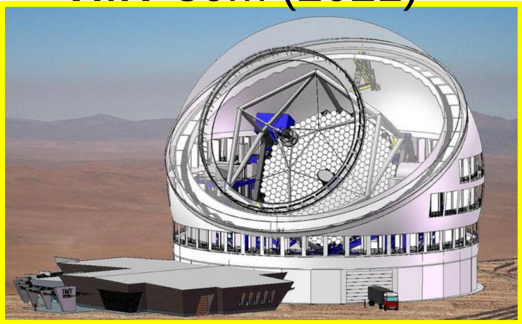
SPICA Key Specifications

- Telescope: 3.2m cooled to 6K
- Wavelength: 20-210 (350) microns
- Instrument: SAFARI, MCS, (NASA)
- Orbit: Sun-Earth L2 Halo

Golden age in astrophysics with participation of ***Japan-Europe SPICA***

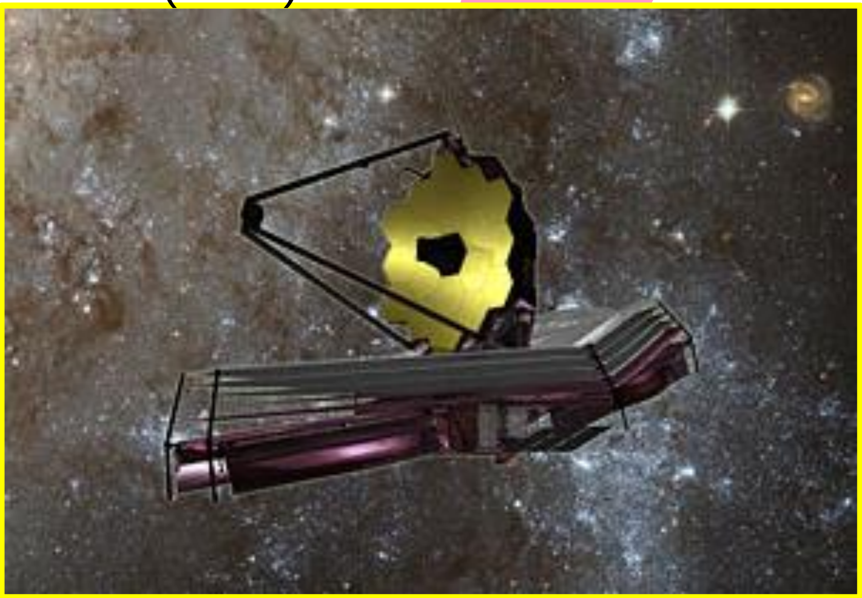
E-ELT 39m(2020's)

TMT 30m (2021)

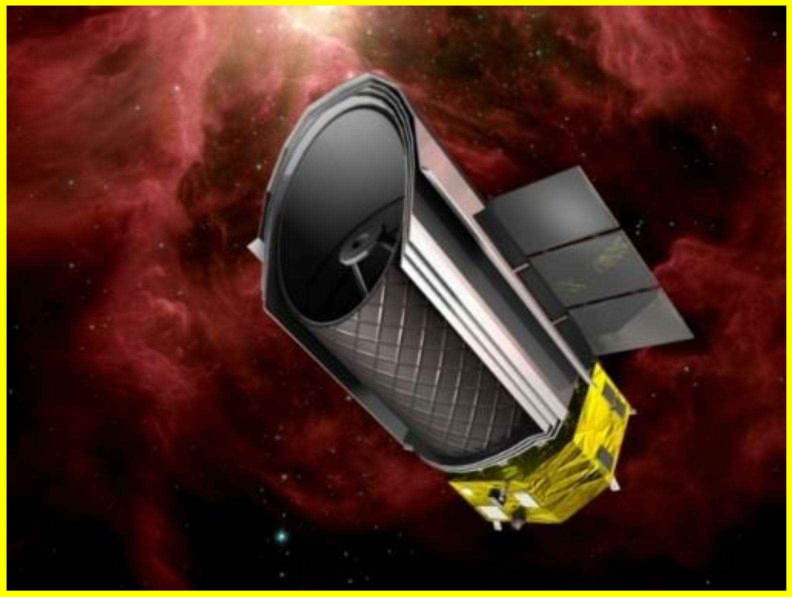


ALMA

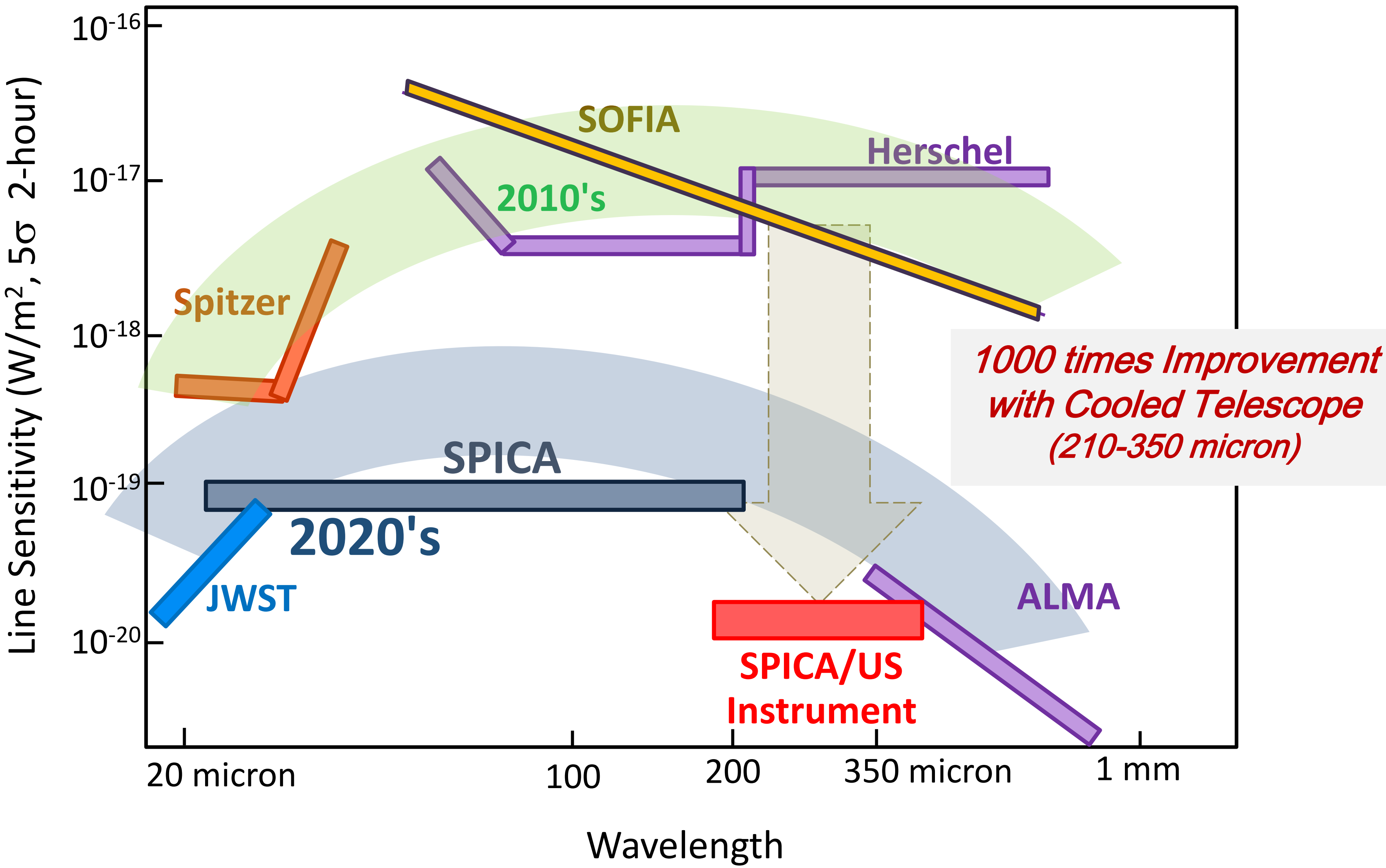
JWST (2018)



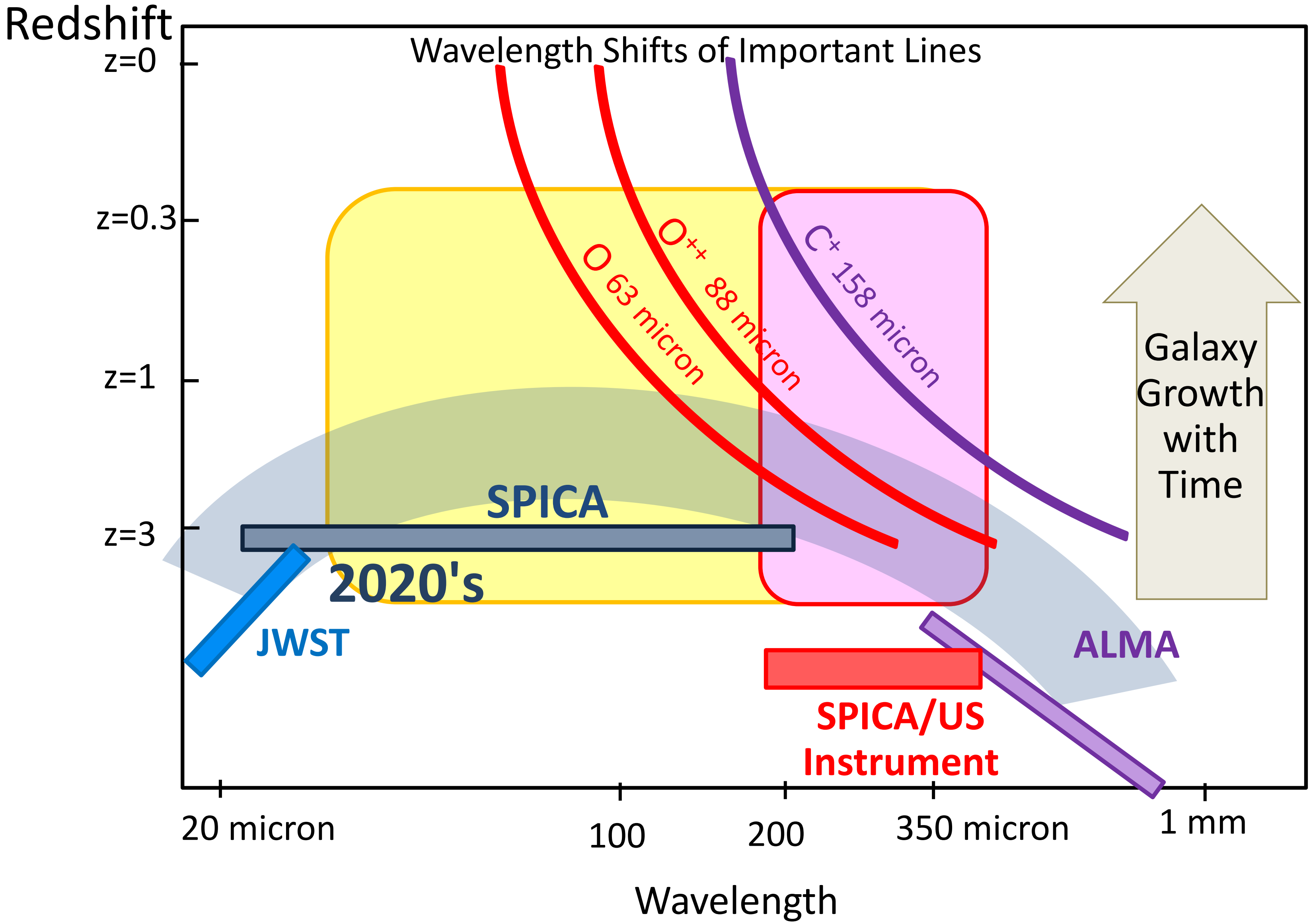
SPICA (2025)



US participation to SPICA is essential to fill spectral gap between JWST and ALMA

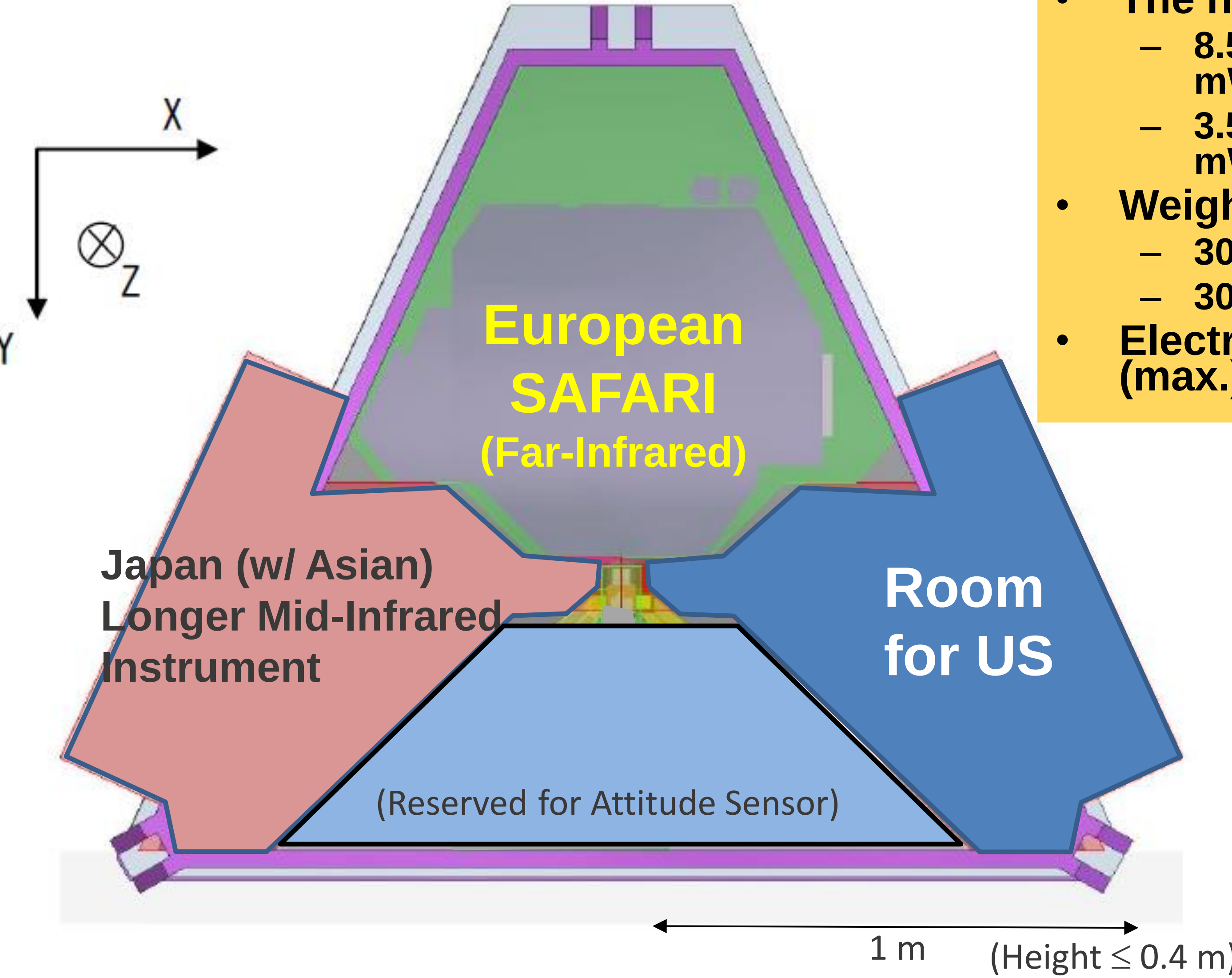


Most important diagnostic lines are lost without US participation to SPICA



Resources reserved for US participation to SPICA

SPICA **4.5K Focal Plane layout**



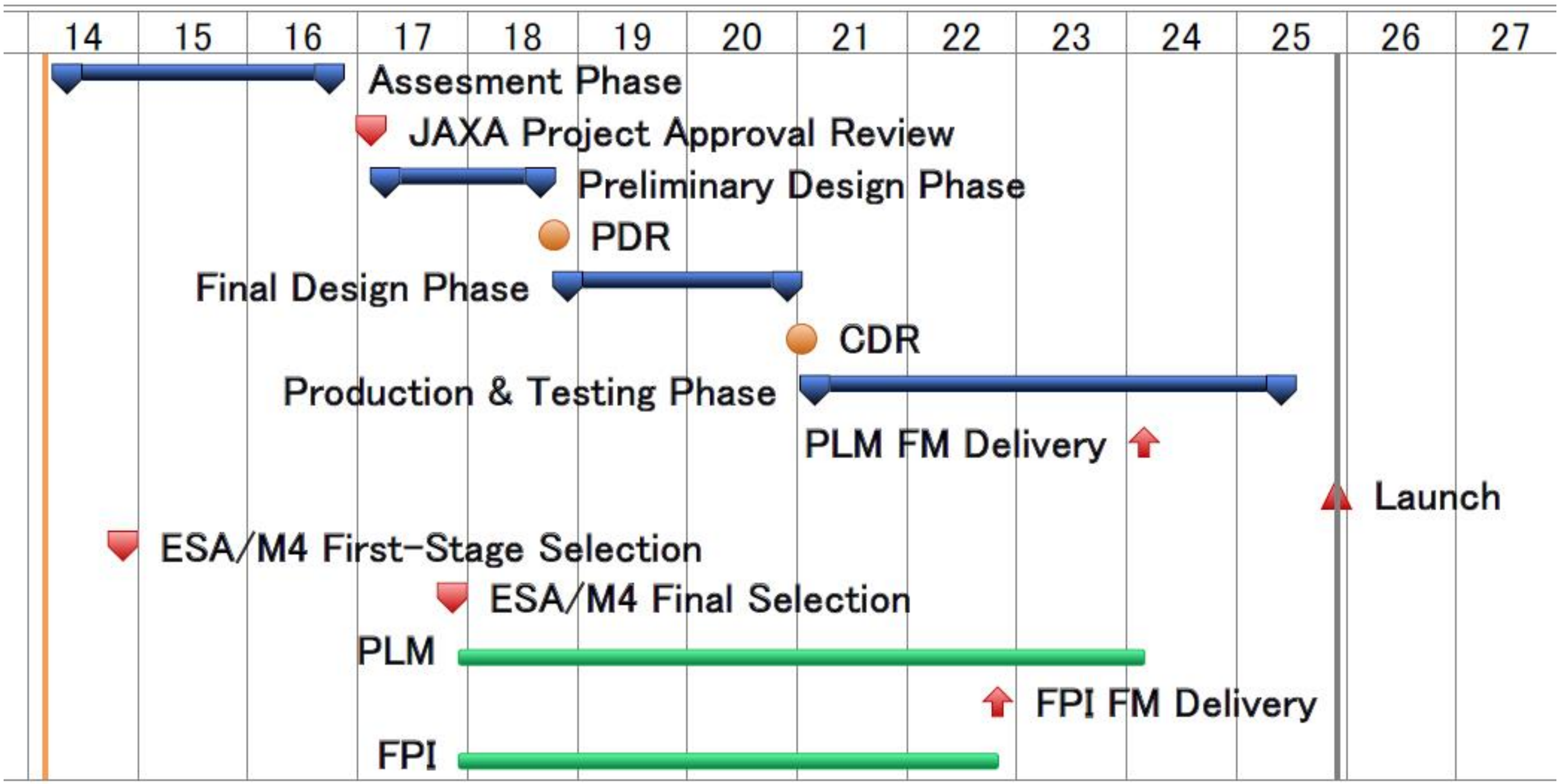
Available resources for US instrument on SPICA

- **The heat load**
  - **8.5 mW (in operation), 0.47 mW (stand-by) at 4.5 K**
  - **3.5 mW (in operation), 0.20 mW (stand-by) at 1.7 K**
- **Weight**
  - **30 kg (max.) focal plane**
  - **30 kg (max.) electronics**
- **Electrical Power: 100 watt (max.)**

Excerpts from "New Worlds, New Horizons in Astronomy and Astrophysics"

The committee recommends that ***the United States should join this project by contributing infrared instrumentation***, which would exploit unique U.S. expertise and detector experience. The committee received a proposal from a project called ***BLISS*** which provided one possible way to meet this opportunity and was ***rated highly by the survey's Program Prioritization Panel*** on Electromagnetic Observations from Space. NASA has recently issued a call for proposals for science investigation concept studies that will elicit more ideas. ***Such participation would provide cost-effective access to an advanced facility for the U.S. research community and full participation in the science teams***.

Critical milestone for US participation is coming soon

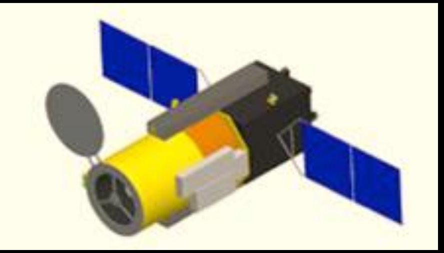


Schedule being developed (not authorized)

Exceptional success
Japan-US Collaboration in Solar Physics

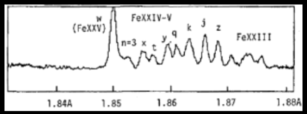
1980 1990 2000 2010



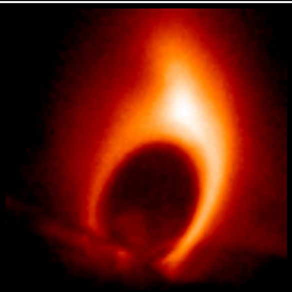



Spacecraft	Hinotori, SMM	Yohkoh	Hinode	Solar-C
Operation Period	1980-1982	1991-2001	2006 -	2020 -
Weight	195 kg, 2t	390 kg	900 kg	4t
Instrument	SOX, XRP	SXT/BCS (Yohkoh)	SOT/XRT/EIS (Hinode)	SUVIT/EUVST/ XIT(Solar-C)

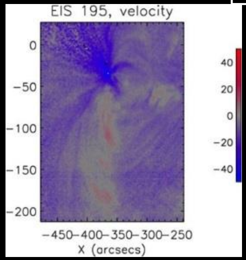
Initiation of high-energy solar physics

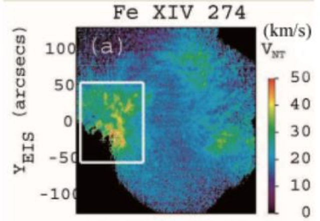



Magnetic reconnection as the origin of solar magnetic activity



Solar magnetic fields, dynamics of solar plasmas





- ✓3D structure of magnetic field
- ✓Fundamental physical
- ✓Chromospheric coronal heating
- ✓Solar activity prediction.

Solar-C Fundamental research for space weather

Mission Goals

Understand solar and heliospheric **magnetic activity**
Develop an understanding of the **magnetic coupling** of convection zone – photosphere – chromosphere – transition region and corona
Develop and observationally test **algorithms for solar activity prediction**

Expected Achievements

- **3D magnetic structure in the solar atmosphere**
- **Solar flare prediction** – contribution to **SW and SSA**
- Chromospheric and coronal heating - Origin of **solar wind**
- **Fundamental plasma processes** - **Magnetic reconnection**

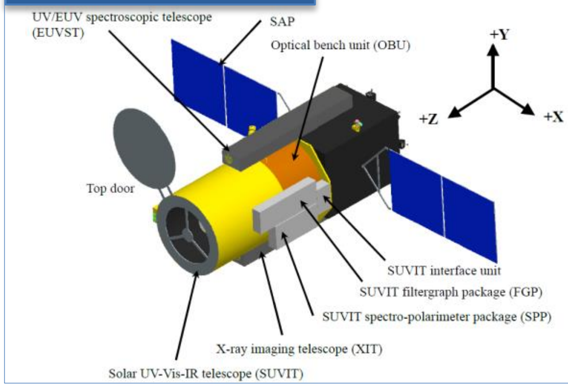
Distinct Features

■a **fundamentally new way of viewing** the entire solar atmosphere, essentially with the high spatial and temporal resolution, in addition to performing simultaneous high resolution spectropolarimetric measurements for the first time.
■a very **challenging mission** to design, develop, scientifically and technically, and to deliver **an order-of-magnitude improvement** over present measurement capabilities.

Project Status/Plan

■JAXA-based working group with more than 70 members & contributors from JAXA, NAOJ, Kyoto U., Nagoya U., Riken NIST, LMSAL/US, HAO/US, HSAC/US, MPS/DE, IAC/ES & MSSL/UK [Working group PI: Tetsuya Watanabe (NAOJ)]
■Selected as one of eight most important future projects by astronomy/astrophysics division of Science Council of Japan
■Recognized as one of key future JAXA missions in solar & heliospheric physics
■Expected to include substantial contributions from the United States and Europe
■To be ready for Mission Proposal by FY2013/E
■Target launch year 2021.

Model Payloads



SUVIT: UV Optical IR Telescope
Aperture: 1.5 m diameter
Focal Instruments:
wide & narrow band imager
spectropolarimeter (2D)

XIT: X-ray Imaging Telescope
Normal incidence EUV imager
angular res.: 0.2" arcsec
(optional) Grazing incidence soft X-ray imager
CMOS-based photon-counting with 1" ang. res.

EUVST: (UV/)EUV Imaging Spectrometer/LEMUR
Angular resolution: 0.3 arcsec
Wavelength: 17-130 nm
Temperature coverage: 0.01 - 20 MK

International Task Shares

Spacecraft		JAXA
Launch vehicle		JAXA
SUVIT	Large-aperture telescope	JAXA (with feed optics to focal plane)
	Primary/secondary mirror	ESA (with test flat)
	Focal plane instrument	
	Filtergraph	NASA
	Spectro-polarimeter	JAXA-led international consortium
EUVST		ESA/NASA
XIT	Normal incidence	NASA
	Grazing incidence (optional)	TBD

US-Japan Collaboration

■**NASA contribution**: It is a high priority of the SHP panel that NASA and its partners form a **Science and Technology Definition Team** for Solar-C as soon as possible. NASA contributions would involve the most technically challenging elements, such as the focal-plane packages (cameras, detectors, and so on), which would afford the U.S. science community an opportunity to make critical advances in remote-sensing capabilities.
■Solar-C presents a unique opportunity for solar and space physics to make **flagship-level science** advances for the cost of an Explorer.

Schedules

FY2015-16: Pre-project (phase-A)
FY2017-18: Basic design (phase-B), PDR
FY2018-19: Detailed design (phase-C), CDR
FY2019-21: Fabrication, testing (phase-D), PQR/PSR
FY2021 - : Launch, Operation (phase-E)

Solar and Space Physics: A Science for a Technological Society

Committee on a Decadal Strategy for Solar and Space Physics

- **10.5.2.3 Solar-C** Solar-C is a Japan-led mission expected to include substantial contributions from the United States and Europe. It builds on the highly successful Yohkoh and Hinode collaborations **with our most reliable partner**. As with Yohkoh and Hinode, Japan will provide the satellite and launch. Almost all NASA funding would go to the U.S. science community for state-of-the-art instrumentation and data analysis. Hence, Solar-C presents an important opportunity to leverage NASA science funding. The science objectives of Solar-C are to determine…….**Solar-C is central to our science strategy for the next decade; therefore, the panel strongly endorses U.S. participation in the mission.**
- **NASA contribution to Solar-C.** The strawman instruments above are only for the purposes of planning and costing the mission. Concrete plans for the instruments and for the roles of the international partners are urgently needed; consequently, it is a *high* priority of the SHP Panel that, as with Hinode, **NASA and its partners form a Science and Technology Definition Team for Solar-C as soon as possible**.

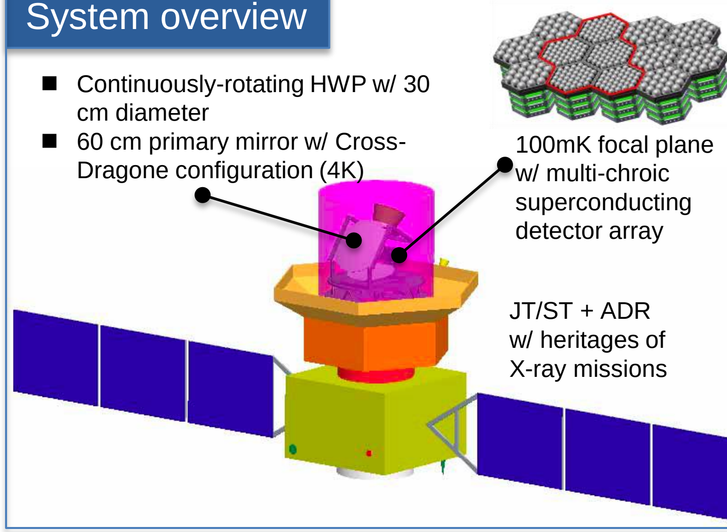
LiteBIRD

Lite (Light) Satellite for the Studies of B-mode Polarization and Inflation from Cosmic Background Radiation Detection

Scientific objectives

- Tests of cosmic inflation and quantum gravity theories with unprecedented precision
- Search for primordial gravitational waves to the lower bound of well-motivated inflationary models
  - -Full success: dr < 0.001 (dr is the total uncertainties on tensor-to-scalar ratio, which is a fundamental cosmology parameter related to the power of primordial gravitational waves)

System overview



Expected achievements

- Cosmology and Particle Physics
  - -Discovery of primordial gravitational waves
  - -Narrowing down cosmic inflation models
  - -Narrowing down quantum gravity theories
  - -Shed light on fundamental laws of physics
- Astronomy
  - -Cosmic reionization
  - -Galactic haze emission
  - -Galactic magnetic fields
  - -Polarized dust emission

Observations

- Full-sky CMB polarization survey at a degree scale (30arcmin @ 150 GHz)
- 6 bands b/w 50 and 320 GHz

Strategy

- Part of technology verification from ground-based projects
- Synergy with ground-based large telescopes
- Synergy w/ X-ray mission R&D

Major specifications

- Orbit: L2 (Twilight LEO ~600km as an option)
- Weight: ~1300kg
- Power: ~2000W
- Observing time: > 2 years
- Spin rate: ~0.1rpm

Project status/plan

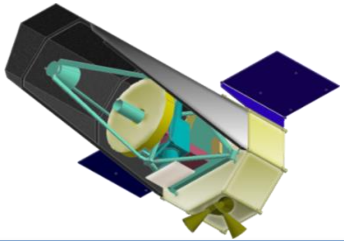
- JAXA-based working group w/ more than 60 members from JAXA, Kavli IPMU, KEK, NAOJ, UC Berkeley/LBNL, McGill, Riken, MPA and Japanese universities (Working group PI: Masashi Hazumi (KEK))
- Selected as one of eight most important future projects by astronomy/astrophysics division of Science Council of Japan
- Recognized as one of key future JAXA missions in fundamental physics
- To be ready for Mission Definition Review by August 2014
- Target launch year ~2020

International collaboration

- LiteBIRD working group is already international
  - -US PI of LiteBIRD: Adrian T. Lee (UC Berkeley/LBNL)
- Strong collaboration among some of LiteBIRD members also exists for ground-based projects
  - -POLARBEAR, POLARBEAR-2, Simons Array
- US contributions in various components are possible
  - -Superconducting detector array
  - -Cryogenics
  - -Optics

ISAS **WISH**

Wide-field Imaging Surveyor for High-redshift



JAXA

Science Goals

- Explore the universe beyond Cosmic Reionization :
  Studying the earliest galaxy formation at z=8-15
- Cosmic Expansion History with SNIa (type Ia Supernovae)
  NIR detection and light curves of SNIa at z=0-2
- Deep and Wide-field NIR Survey at 1-5μm
  Various fields in astronomy

Key Features

- Dedicated deep and wide-field imaging surveys at **1-5μm**
- Survey strategy: **$100deg^2$, 28AB (5σ)**, 6 broad bands (main survey)

Base Design Model

- **1.5m** light-weighted glass primary mirror
- CFRP structure @**90-100K**
- Diffraction limited image at **1-5μm** over the flat focal plane
- H2RG 32x2kx2k 128Mpix
- **0.155"**/pixel(18μm-pitch), **$850arcmin^2$**/FoV
- Light weight: **1.4t** (WET)

Current Status

- JAXA/ISAS WISH Working Group since 2008 (pre Phase A)
- JAXA/ISAS R&D budget (~1M$, without including man power cost)
- WISH Mission Proposal Draft distributed (2012, in Japanese)
- Potential international Partners: SAO (USA), LAM (France), Canada
- Proposed Schedule: 2014 Mission Definition Review,
  2016 System Definition Review, Launch by ~2020
- Expected Cost (w/o launch, operation, data facility) : 250-300M$

International Collaboration

- **Collaboration with France** optional narrow-field IFU spectrograph
  (lead by LAM, MoO proposal submitted to CNES)
- Collaboration with USA detector testing and procurement
  (lead by SAO, MoO proposal submitted to NASA)
- Collaboration with Canada, under discussion

Comparison

Comparison with Euclid

WISH is optimized for very high-redshift galaxies and cosmology (SNe), while Euclid is optimized for cosmology (WL, clustering). Euclid has optical imaging, NIR photometry and NIR wide-field spectroscopy.

- **uniqueness of WISH:**
  - **higher-resolution (Euclid IR photometer 0.3"/pix)**
  - **imaging at 1-5μm (Euclid IR photometer 0.9-2μm)**
  - different survey strategy
    [WISH UDS: 28AB, 100deg2 / Euclid 24AB (wide) 26AB (deep)]
- **similarity:**
  - primary mirror size (Euclid1.2m), field of view (Euclid 0.5deg),
    number of pixels (Euclid 96Mpix)

Comparison with WFIRST (AFTA 2.4m)

WISH is optimized for very high-redshift galaxies and cosmology (SNe), while WFIRST is optimized for cosmology (SNe, clustering), exolanets, and IR surveys. WFIRST has NIR imaging and wide-field spectroscopy.

- **uniqueness of WISH:**
  - **imaging at 1-5μm (0.9-2μm for WFIRST)**
  - **earlier launch schedule (proposed)**
- **similarity:**
  - AFTA 2.4m option may achieve comparable depth (27AB) over
    significantly larger area ($2500deg^2$)

Comparison with JWST

- **uniqueness of WISH:**
  - **wide-field (JWST NIRCam <20 $arcmin^2$)**
- **synergy:**
  - **WISH provides unique and feasible targets for JWST spectroscopy**

Synergy with SPICA

SPICA studies dust emission / dust-free fine structure lines of galaxies while WISH observes the stellar components of high-z galaxies

- WISH core wavelength: 1-5μm ←→ SPICA core wavelength 5-210μm

Synergy with Extremely Large Telescopes

- WISH survey depth (<28AB) is well matched with
  the AO-assisted NIR spectroscopic capability of ELTs.

Candidates for JAXA participation to NASA/ESA missions

1. ***Bepi-Colombo*** is an ESA mission to Mercury. JAXA provides *Mercury Magnetospheric Orbiter*. Ongoing.
2. ***CLASP*** is a NASA sounding rocket experiment for ***Solar-C*** pathfinder. JAXA/NAOJ provides major part of its optics and structure. Ongoing.
3. ***ATHENA*** is an ESA X-ray observatory. JAXA desires to be involved in this mission as a minor partner.
4. ***WFIRST***: JAXA is interested in its coronagraph instrument.
5. ***MARS2020***: JAXA scientists submitted two proposals for the mission.
6. ***JWST***: JAXA desires to have observing time with ***SPICA*** observing time allocated to US scientists in return.
7. ***ISS JEM-EUSO*** is a Russian mission for ultra-high energy cosmic ray science with possible minor participation of JAXA.

US decadal survey comments from an international partner

- There has been no explicit category nor definition in the US decadal survey process for missions with international partners.
- This has made the international missions with Japan less competitive or visible in the prioritization process simply due to not-enough advocacy for those missions.
- Options for improvement
  - To create a category for international collaboration that allows NASA for timely response to international partners.
  - To create a mechanism for interaction with foreign agencies to provide information on their plan, so that US decadal survey committees are better informed for their planning.
  - To have more agency level-dialog for planning, early-warning and expediting community bottom-up activities leading to implementation.

Summary

- ISAS/JAXA has been significantly contributing to space science. We have been having international collaboration with NASA and ESA/European countries in an ad-hoc manner for most of our successful missions.
- JAXA and Space Policy Commission under cabinet office recently established Large/Medium/Small mission categories.
- International collaboration for these JAXA-led L and M class missions is essential for continued success of space science in JAXA, and we invite foreign agencies to participate in our program.
- ISAS/JAXA also prepared to contribute more to NASA-led and ESA-led large missions that JAXA cannot afford.
- We do complex sometimes risky international collaboration for the sake of the maximum science. We should recognize that there are issues to be resolved. We need a mechanism for early planning and exchange of information.

Specific questions from NRC

- What basic principles guide the way you plan?
- What planning processes are underway or planned for your programs?
- What missions are planned for launch in the shorter term, within the next 5-7 years, that could be relevant for US planning and what are the core elements of your longer-term scientific strategy?
- Can you suggest how the US decadal process could be better synchronized with your planning?
- What are your thoughts about future planning, your own, as well as that of the US? What lessons have we learned?
- What other messages would you like to convey to the gathering?