

# Japan's Future Space Science Missions in Astronomy and Astrophysics

For Committee on Reviewing the Progress Toward the Decadal Survey Vision in New Worlds, New Horizons in Astronomy and Astrophysics

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# outline

- JAXA space science missions overview
  - Basic plan 2015 for space policy
- Strategic planning by the Science Council of Japan
- Mission status ( $\geq$  phase A1)
  - Strategic L-size missions
    - SPICA, LiteBIRD
  - Strategic contributions to foreign large missions
    - Athena
- Mission candidates (pre-phase A)
  - X-ray astronomy
  - Optical and IR astronomy

# Three lines of Space Science Missions

Basic Plan 2015 for Space policy

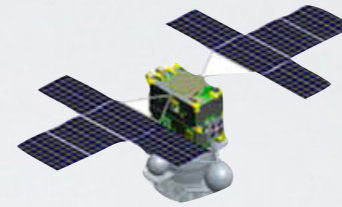
**Strategic Large missions (L)**  
(300M\$ class) for JAXA-led  
flagship science missions with  
H2A/H3 vehicle (3 in 10 years)

**Competitively-chosen medium-  
size focused missions (M)**  
(<150M\$ class) with Epsilon  
launch vehicle (every 2 years)

**Small size missions (S)**  
Mission of opportunity for foreign  
agency-led missions (~10M\$/year), and  
sub-orbitals and ISS.



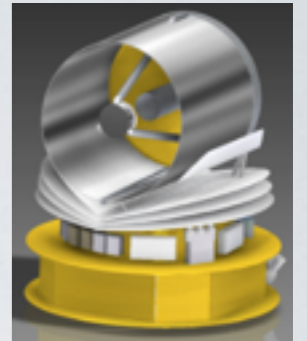
Approved/candidate missions



Phobos/Deimos



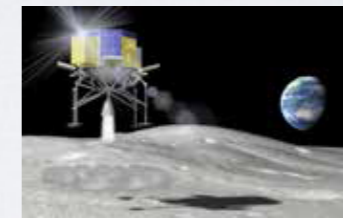
LiteBIRD



SPICA



ERG (#2)



SLIM(#3)

AO for #4  
& #5 issued  
soon



JUICE



Athena

# Provisional Timeline

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

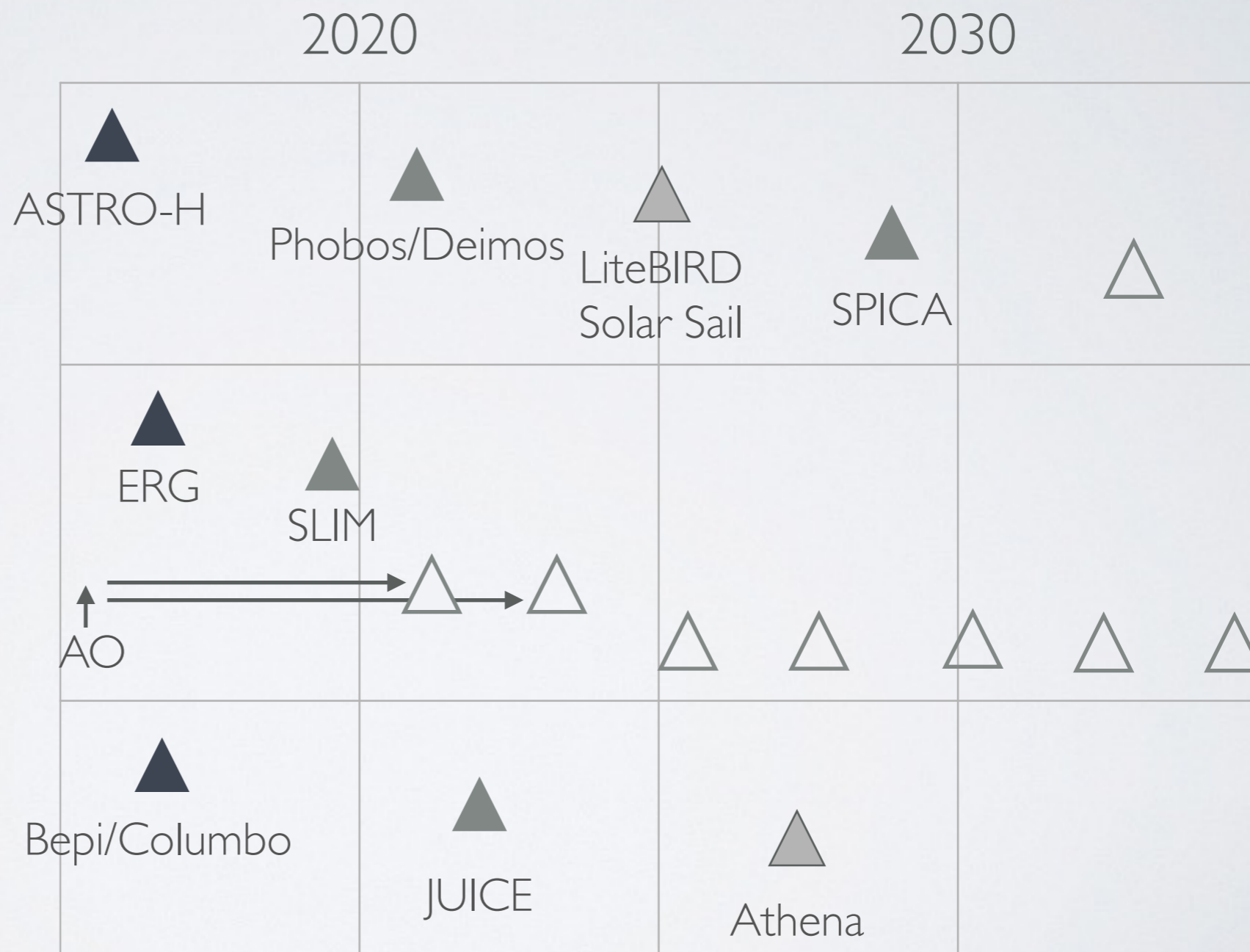


This does not mean the mission time lines below are guaranteed. However, they are foreseeable.

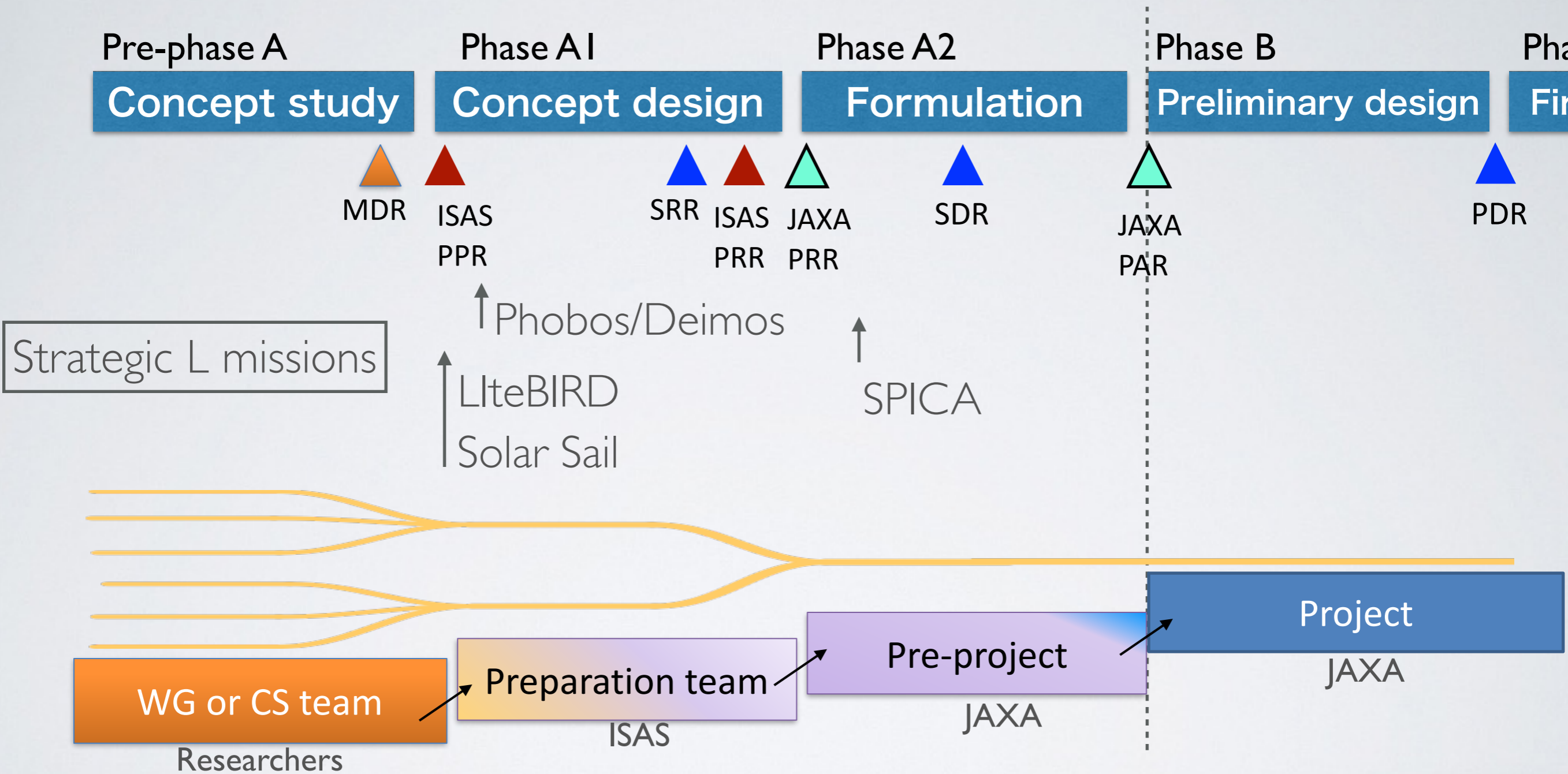
**Strategic Large missions (L)**  
~3 in 10 years

**Medium-size focused missions (M)**  
every ~2 years,

**Small-size missions (S)**  
MoO and suborbital  
~10M\$/year



# Early phases of space science missions



# Strategic planning in Japan outside JAXA

- **ISAS/JAXA** evaluates and makes decision for space-science. missions. However, there are future-research evaluation processes outside ISAS.
- Among these, the most important is done by Science Council of Japan.
- **Science Council of Japan (SCJ)**
  - Science Council of Japan is the representative, highest-level organization of Japanese scientist community ranging over all fields of sciences subsuming humanities, social sciences, life sciences, natural sciences, and engineering.
    - The SCJ is evaluating large research plans every ~ 3 to 4 years.
    - Latest one is Master Plan 2014 and its follow-up Road Map 2014.
    - The strategic planning by SCJ does not directly affect the decisions of agencies and government. However, it indirectly and implicitly influences the decisions.

About 60% of plans which were highly recommended in the previous master plan, were funded.

# Strategic planning by SCJ in all fields of sciences

- Strategic planning of large future research plans by Science Council of Japan (SCJ).
    - **Master plan 2014 (Science Council of Japan)**
      - Large future research plans in all science fields
      - Plan period= 5-10 years, cost > a few 10 M\$
      - 209 plans recommended from communities
      - 192 were listed in the master plan
      - 27 were highly recommended
    - **Roadmap 2014 (Science Council of Japan)**
      - 27 in master plan 2014 were further evaluated
      - 10 plans were specially recommended.
      - 5 got highest (AA) rank
- Space science
- A & Ap: 8**  
Planetary sci: 2  
Space Eng: 4
- **SKA**
  - **LiteBIRD**
  - **SPICA**
  - Space Technology Demonstration Program for exploration
- **LiteBIRD**
  - **SPICA**

Mission status ( $\geq$  phase A I)

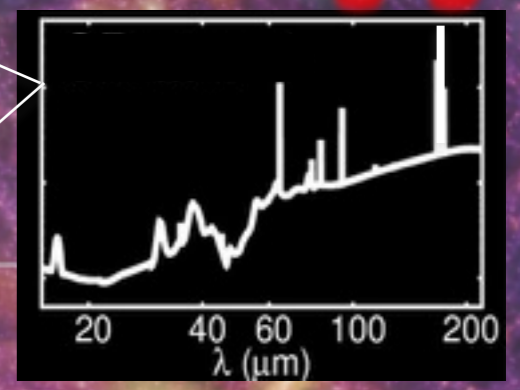
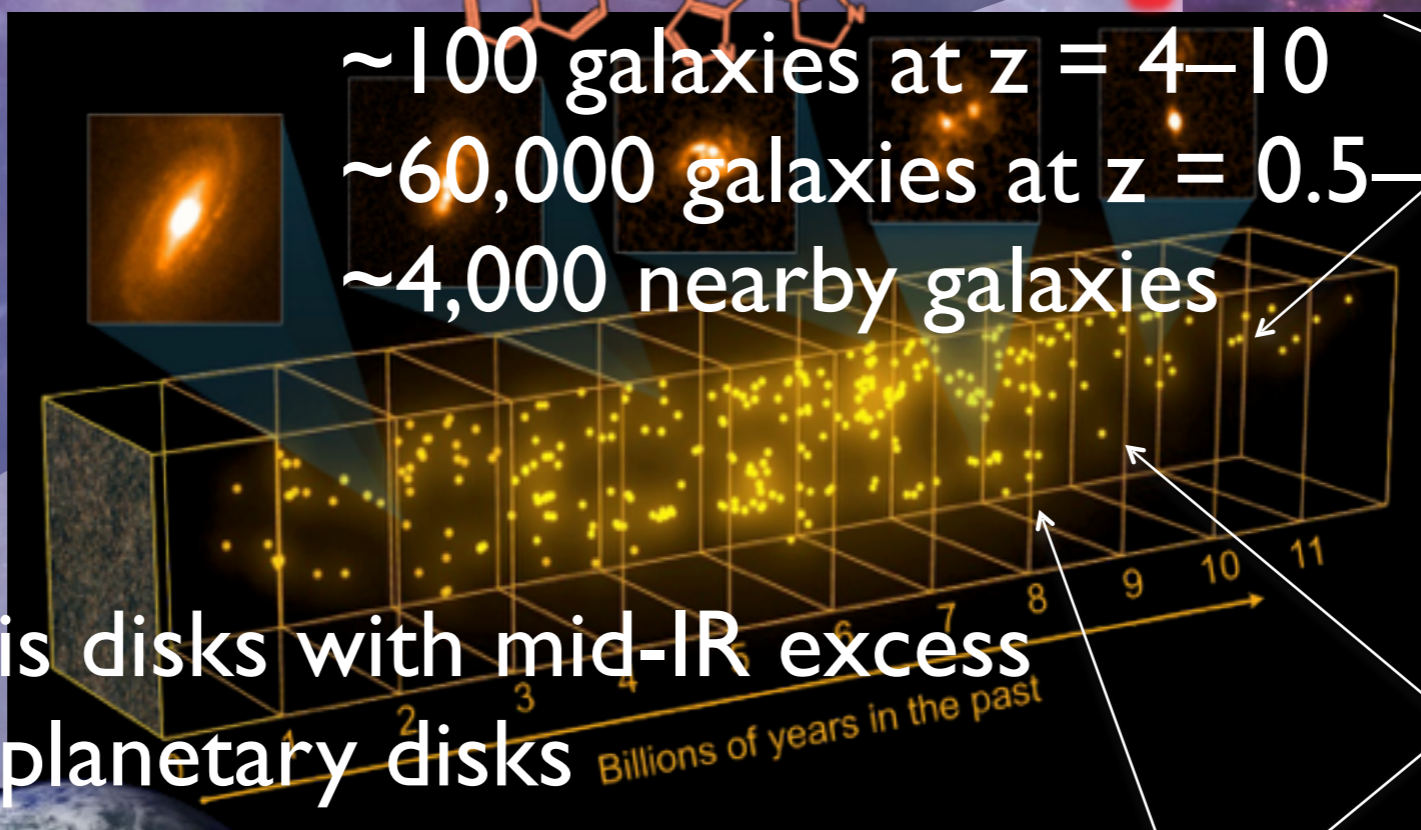
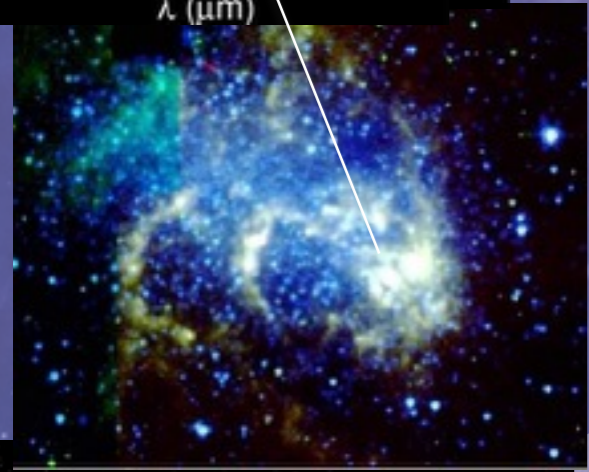
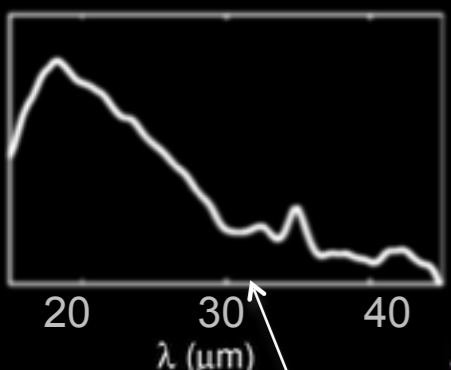
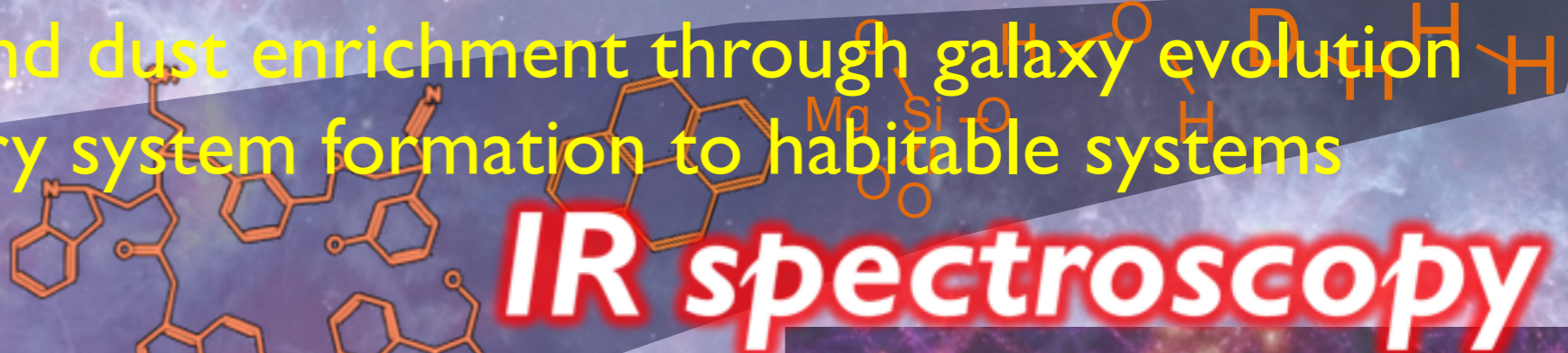


# SPICA (IR astronomy mission) status

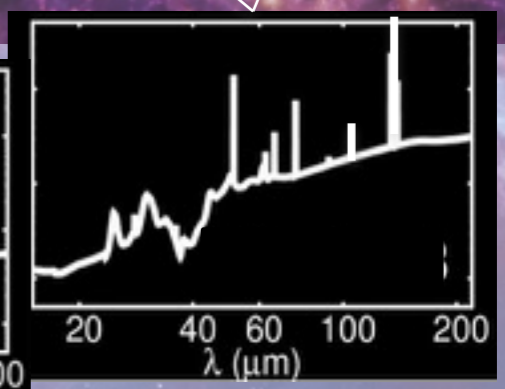
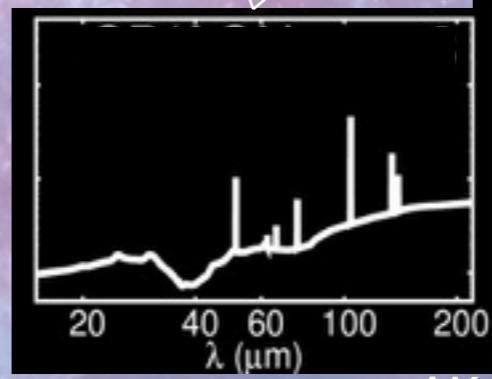
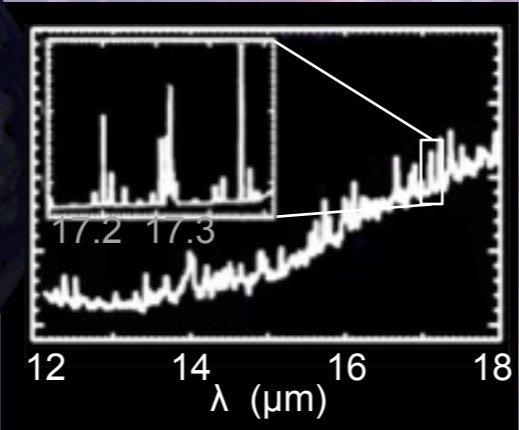
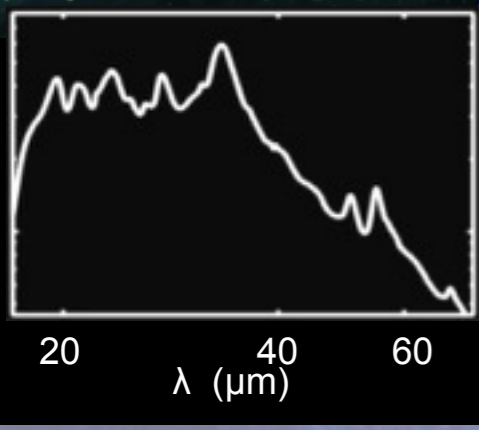
- Restructure process (2013-2015)
  - Extensive concept study lead by JAXA and ESA.
    - Key sciences, system requirements, J-E responsibilities.
    - A slot in late 2020's
- Review process
  - International science review in July 2015.
  - JAXA Mission Definition Review for new SPICA concept completed in September 2015.
  - European SPICA team will propose the New SPICA concept in response to the ESA CV M5 call.

# SPICA: Enrichment of the Universe with metal and dust, leading to the formation of habitable worlds

- ★ metal and dust enrichment through galaxy evolution
- ★ planetary system formation to habitable systems

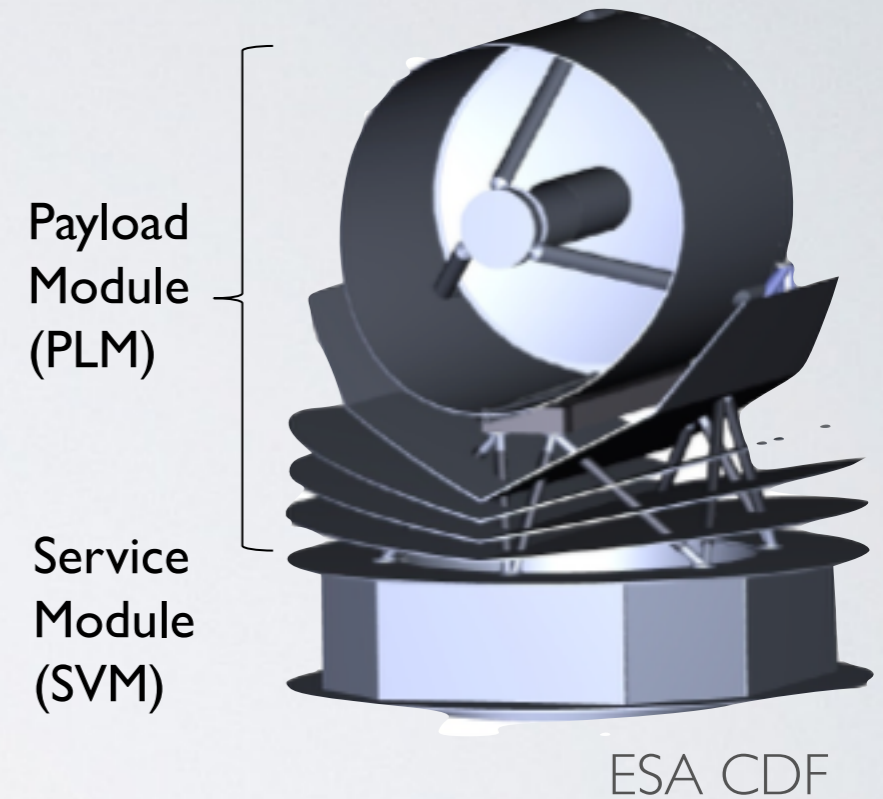
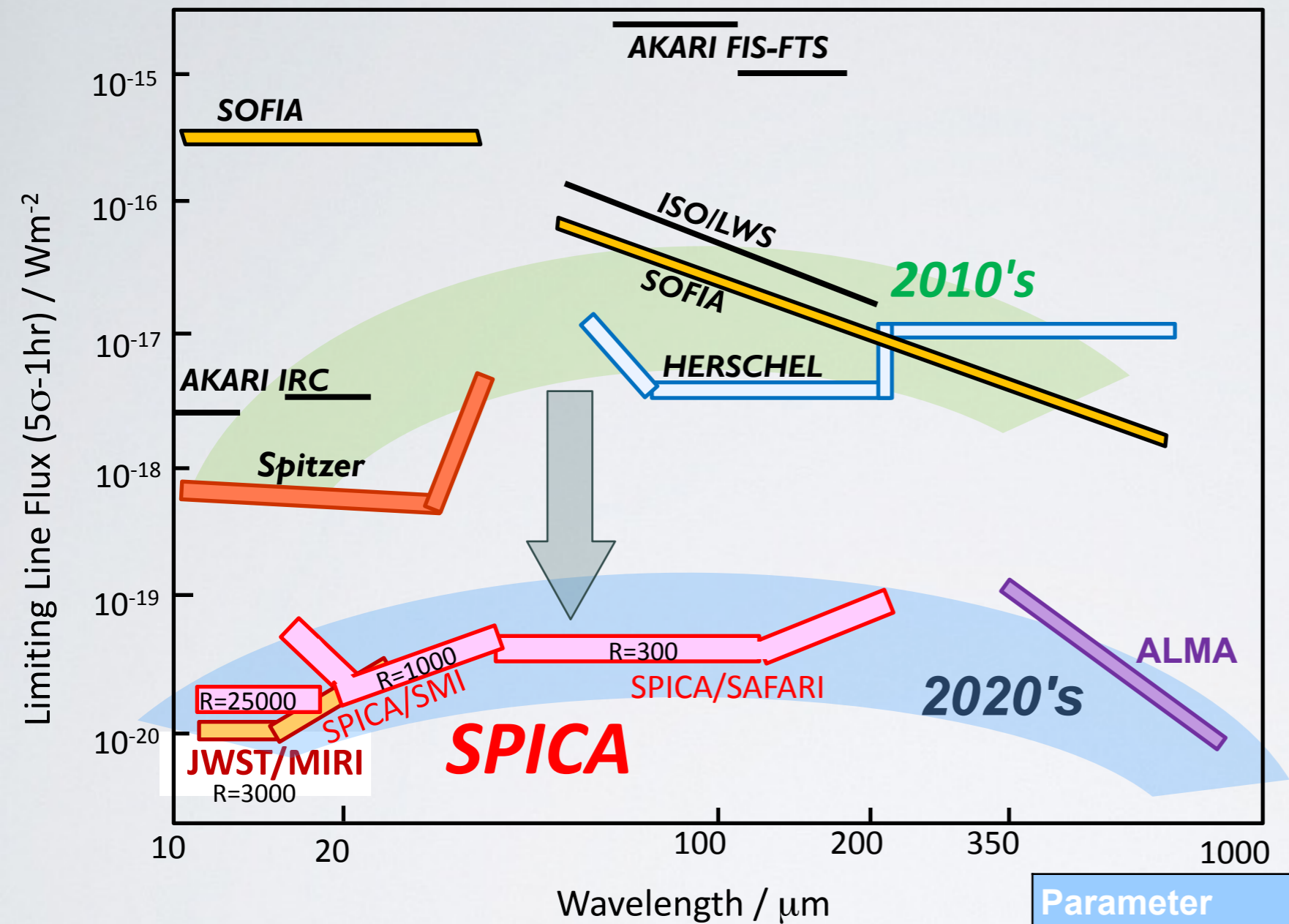


> 1,000 debris disks with mid-IR excess  
> 200 proto-planetary disks



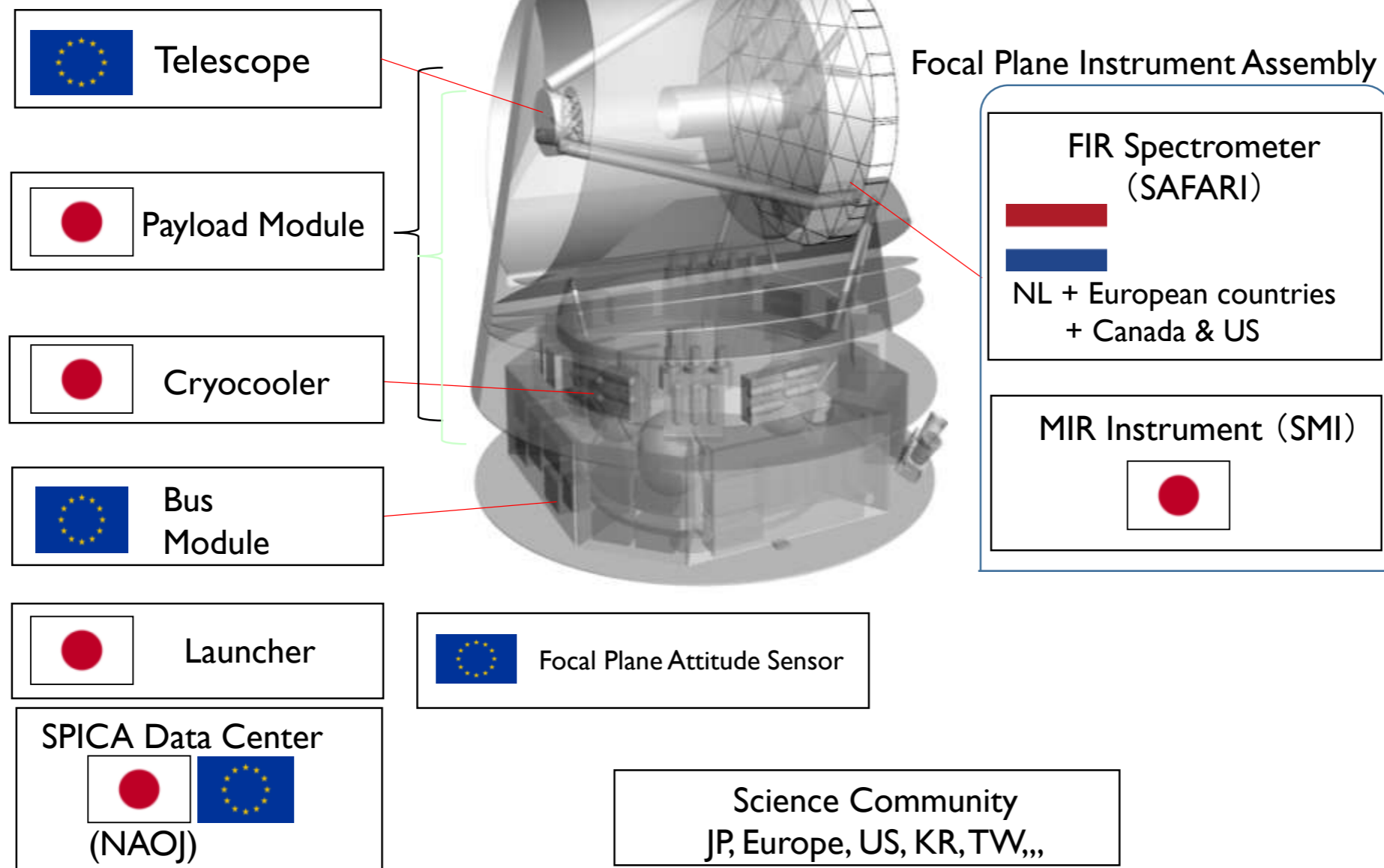
AKARI Mid-IR all-sky map

# SPICA



Parameter	Description
Telescope	2.5 m aperture, cooled below 8 K
Core Wavelength	17 – 230 $\mu m$
Orbit	Halo around S-E L2
Launcher	JAXA H3
Launch Year	2027-2028

## Work-sharing plan



## Possible US contributions

- Science Advisory Board members
  - Natural extension of international science evaluation committee
- and SAFARI (?)

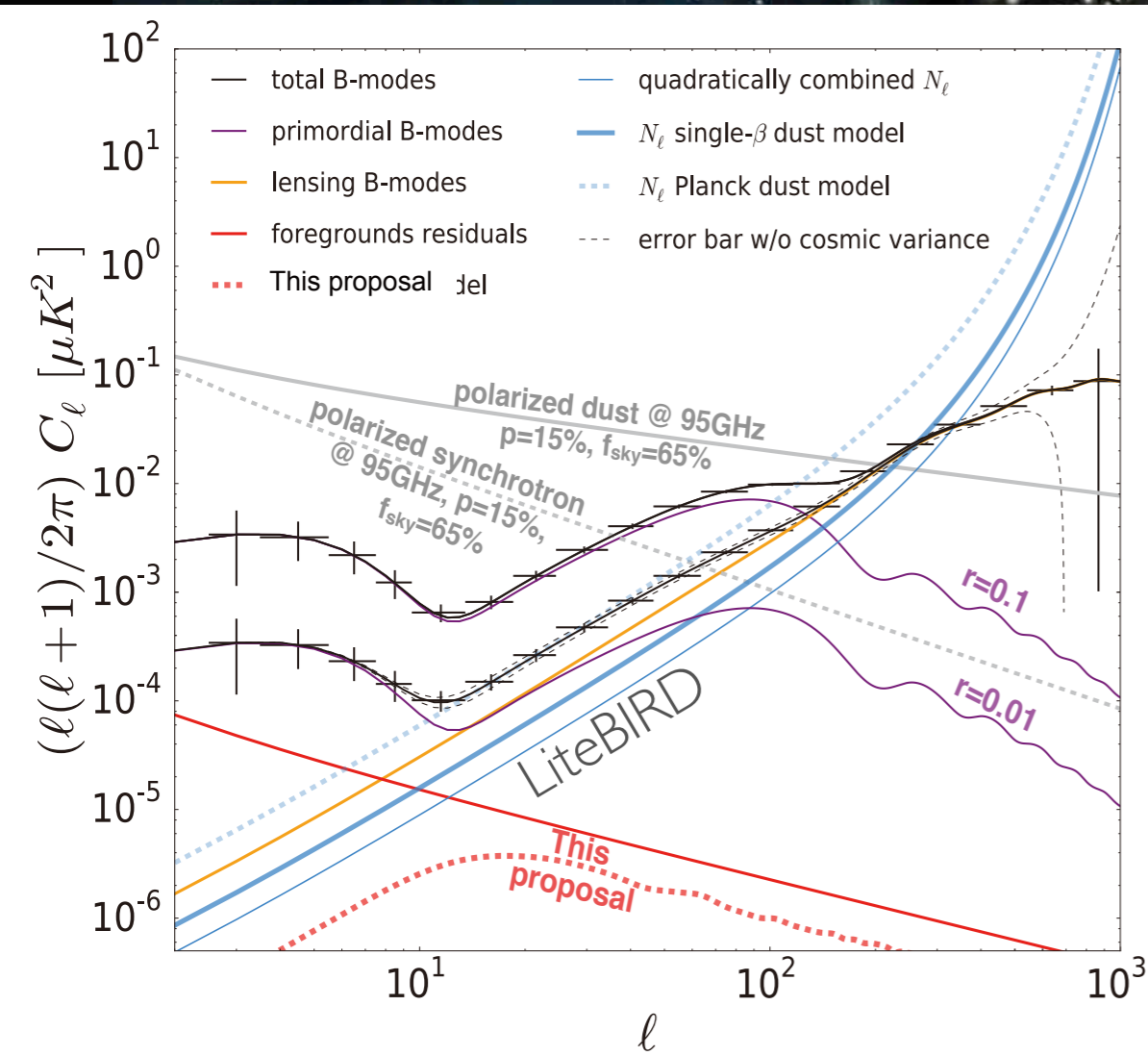
# LiteBIRD (CMB B-mode mission) status

- Detection of CMB B-mode polarization down to a sensitivity of  $r = 0.001$ .
- A strong candidate for the mid 2020's slot
  - Proposal submitted to ISAS in response to a call for a strategic large mission in Feb. 2015.
  - One of the two missions selected for phase-A1 study.
- US major contribution is expected.
  - Proposal submitted to NASA in response to a call for SMEX and MoO in Dec. 2014.
  - One of the two MoO missions selected for Phase A study
- J-US unified team is working hard in Phase-A(I) study.

# LiteBIRD Overview

Lite (Light) Satellite for the Studies of **B**-mode Polarization and Inflation from Cosmic Background **R**adiation **D**etection

- Total uncertainty on  $r$ :  $\sigma(r) < 0.001$
- Multipole coverage:  $2 \leq l \leq 200$ 
  - Each bump (reionization, recombination) with  $\sigma > 5$  if  $r > 0.01$



- L2 orbit
- >3 year mission life

# Why is LiteBIRD light?

Space mission

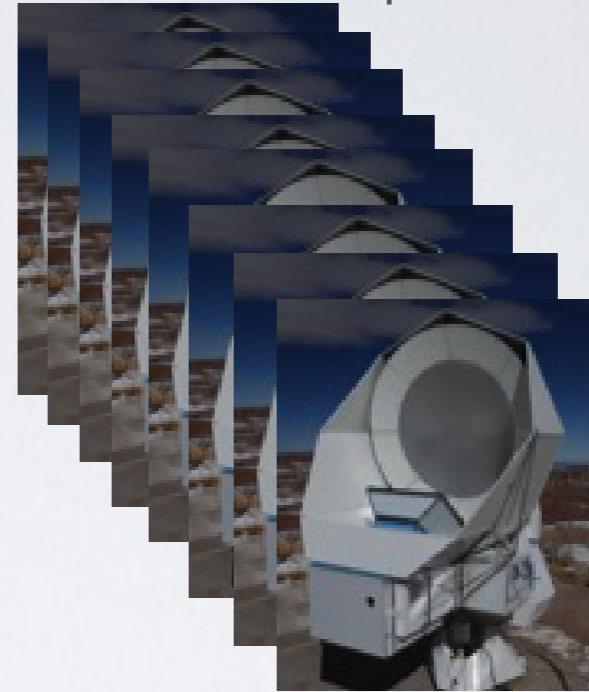


All sky coverage  
but limited spatial resolution

$$\sigma(r) < 0.001$$

$$2 \leq l \leq 200$$

Ground telescope array



high spatial resolution  
but limited sky coverage

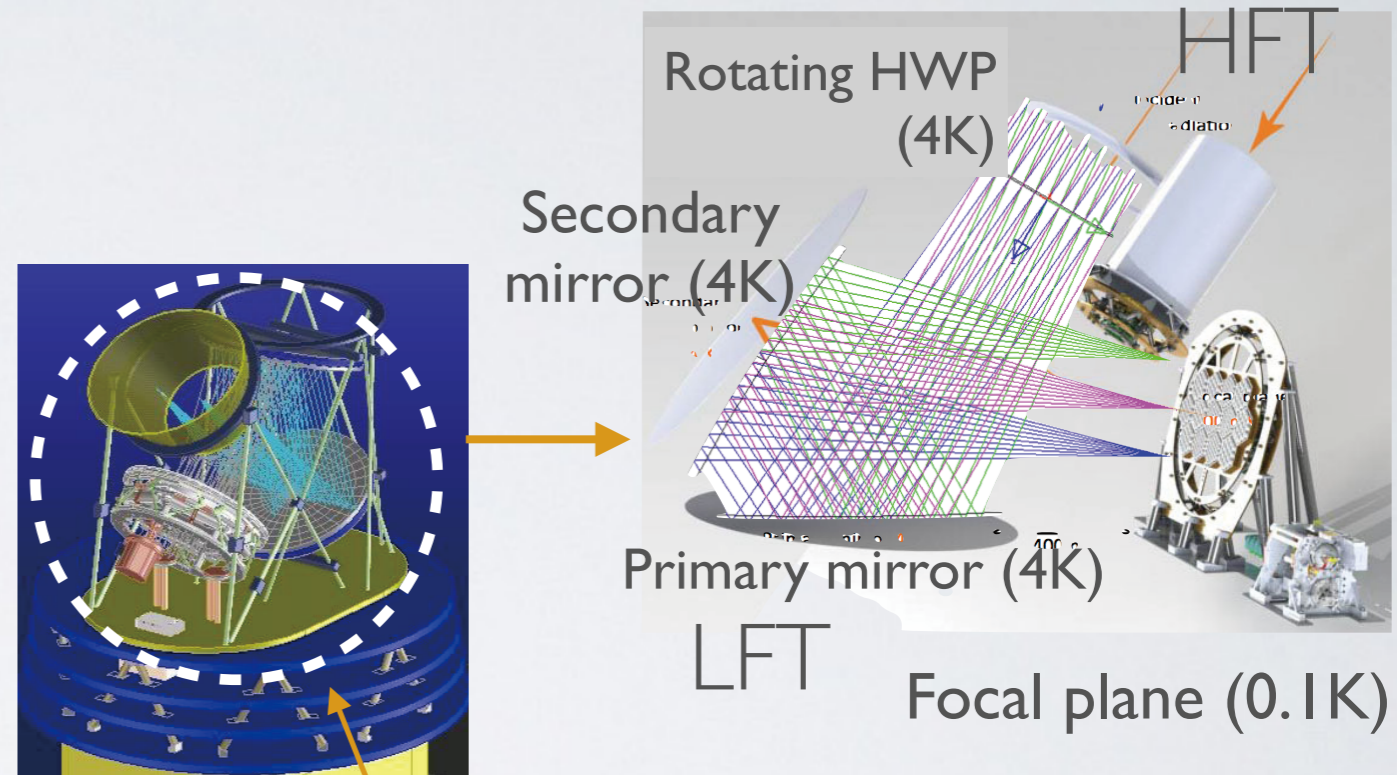
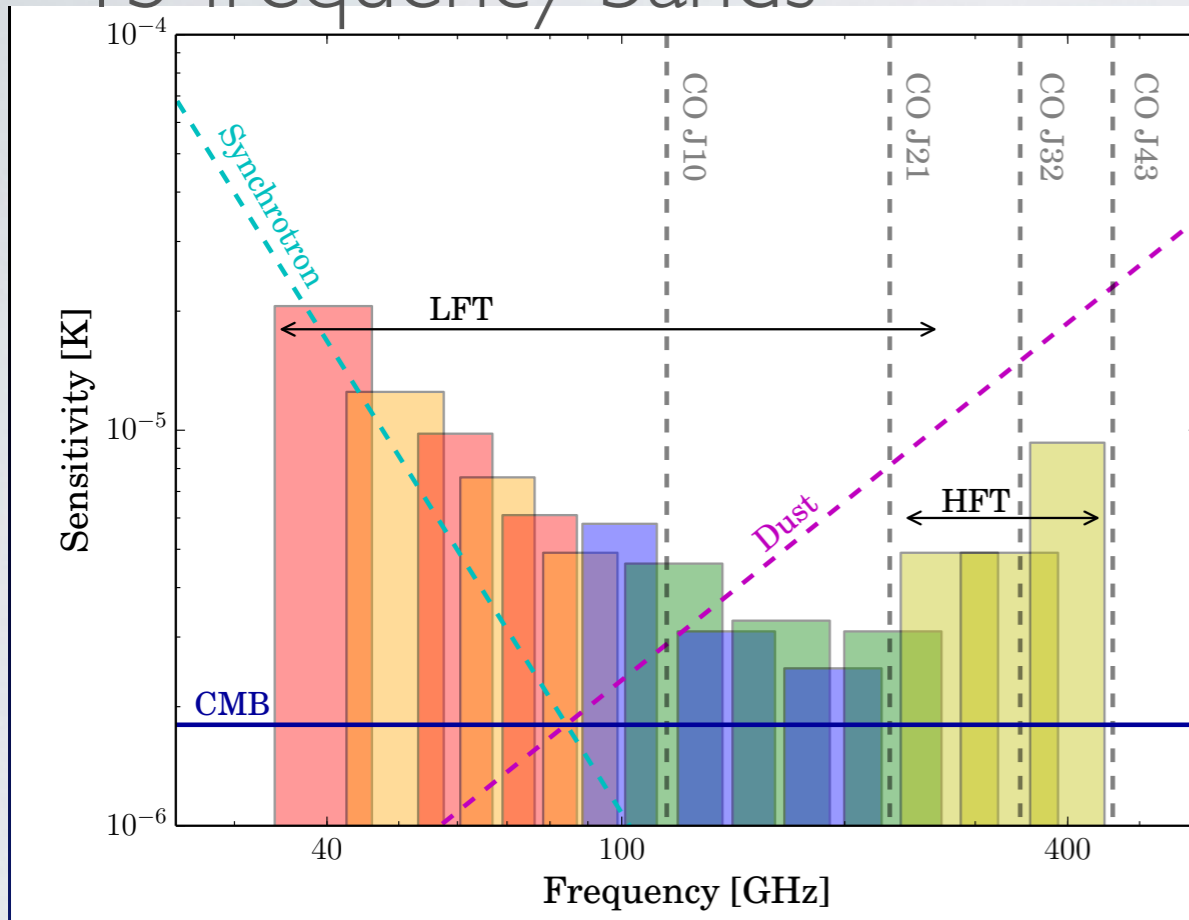
$$30 \leq l \leq 10000$$

Good synergy

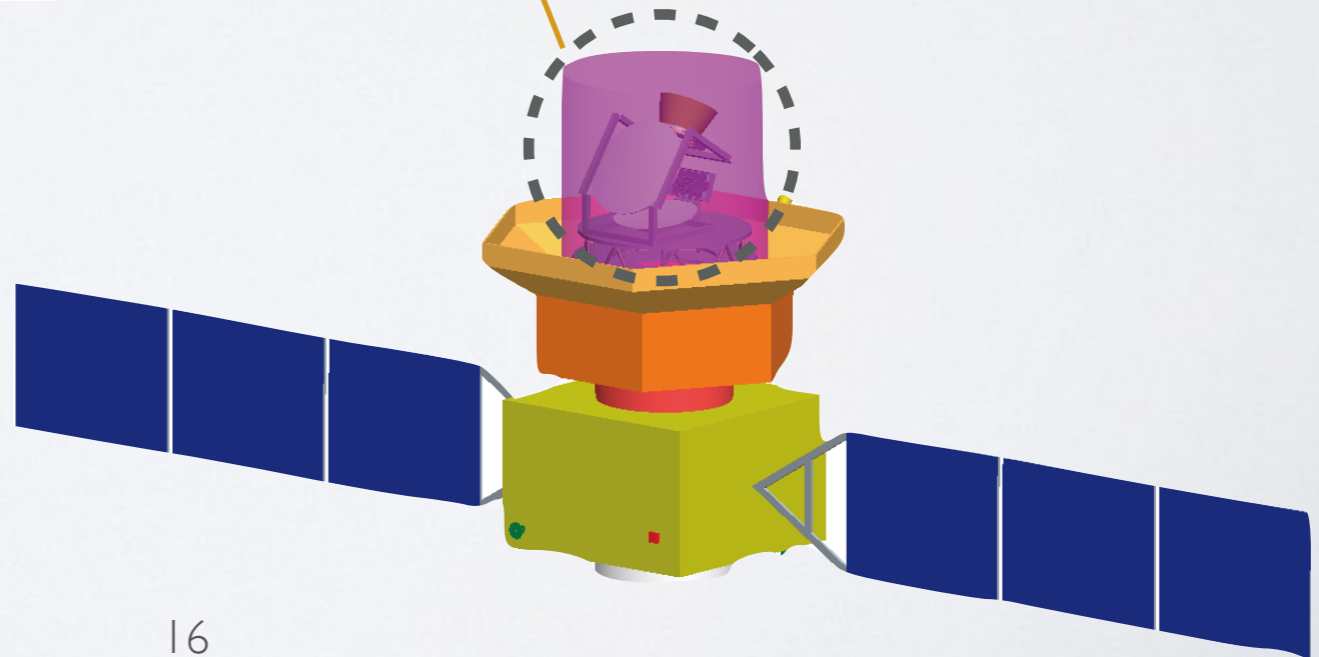
HeavyBIRD is not very feasible as a space mission

# LiteBIRD instruments

15 frequency bands



US contribution  
 LFT/HFT Focal plane sensor  
 +cold frond-end  
 +Last stage cooler  
 Data analysis

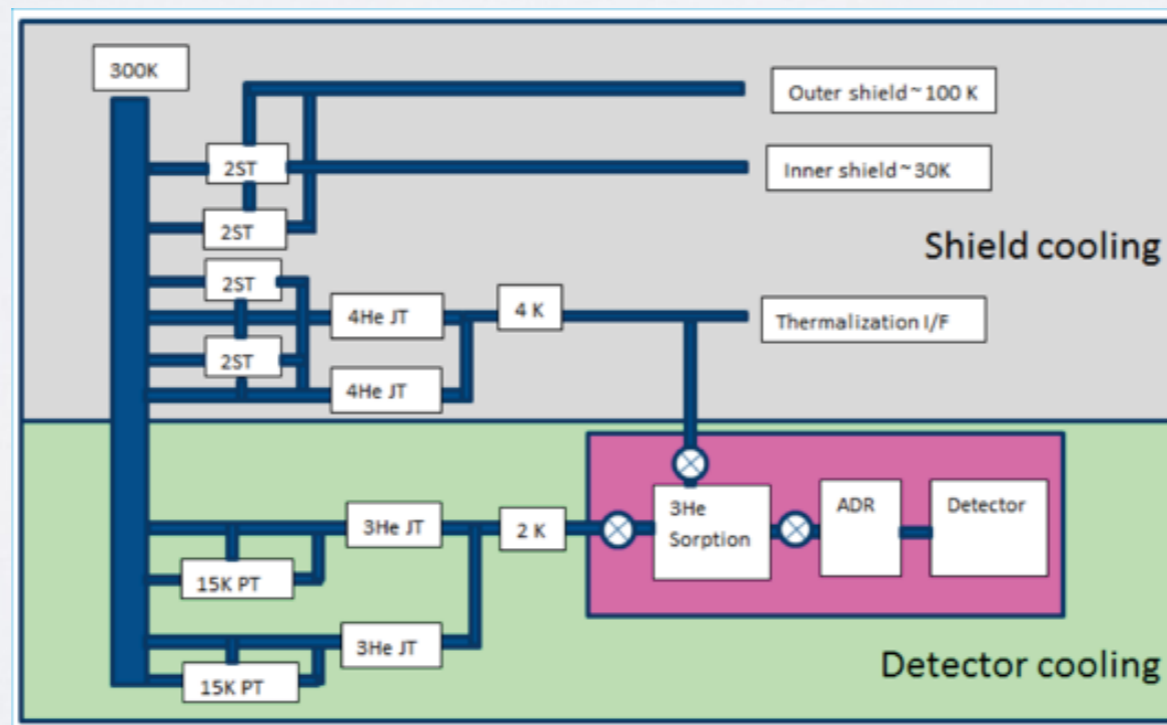




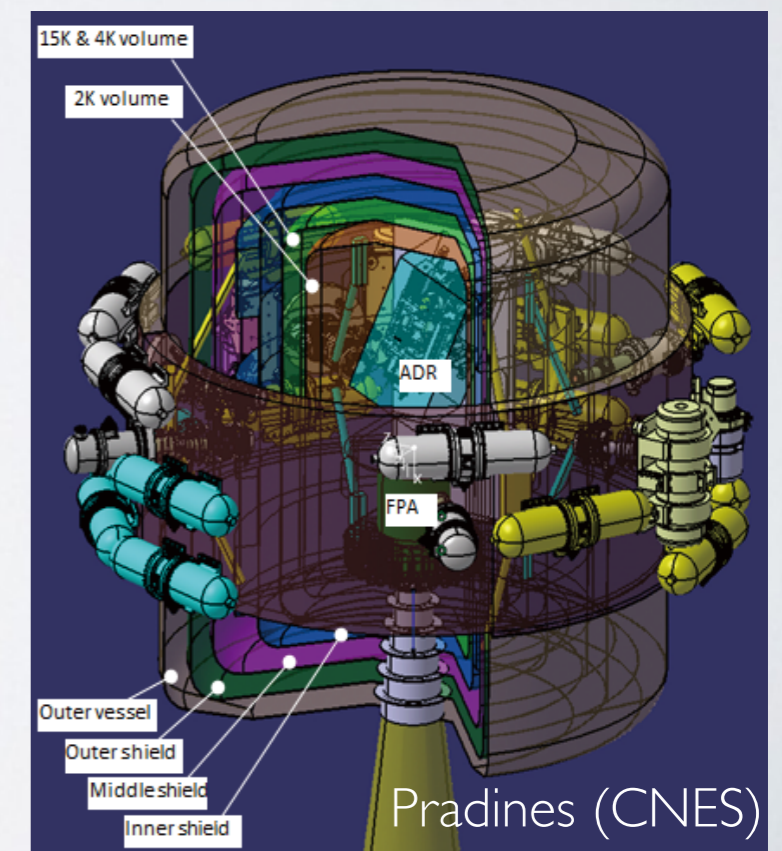
# Participation to Athena (ESA led X-ray astronomy mission)

- \$50M-100M participation. Mainly for cryogenic of the X-IFU.
- Importance of the participation is highly recognized by ISAS.
- Presently in the transition phase from pre-phase A to phase A1.
- The most important activity in phase A1, which is participation in the CC CTP (Cooling-Chain Core Technology Program) of ESA led by CNES, is recognized as technology development common to SPICA and LiteBIRD,

and starts soon,



ESA CDF



# A& Ap Mission concepts (Pre-phase A)

(studied by researcher communities, working groups,  
under support of ISAS)

# X-ray astronomy

ASTRO-H (L size)



(early 2016)

Structure formation,  
feedback and Black hole

High-resolution spectroscopy

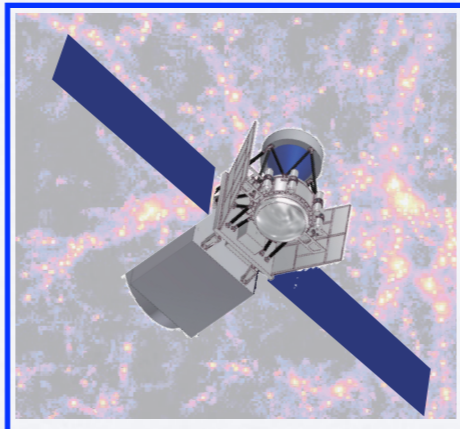
Hard X-ray Imaging spectroscopy

Wide-FOV  
high-resolution  
spectroscopy

~100 times more grasp than  
ASTRO-H SXS

Structure formation,  
Missing Baryon

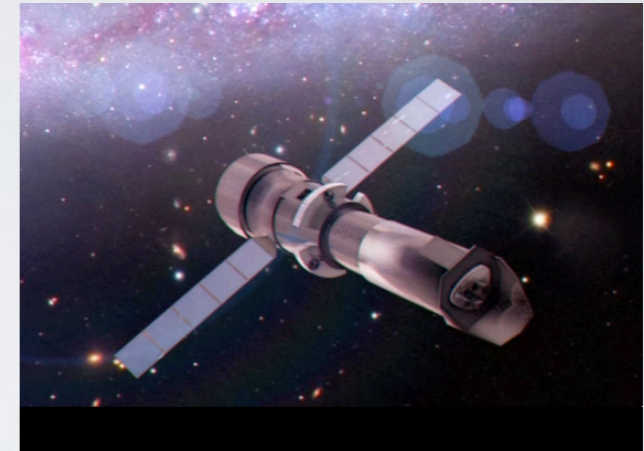
US participation: X-ray  
microcalorimeter



DIOS (M size)

“Super ASTRO-H”

ATHENA (ESA: MoO, S size)

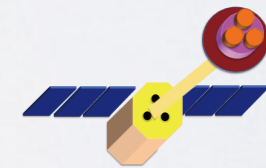


(2028)

contribution to  
cryogenic instrument

NGHXT (M size)

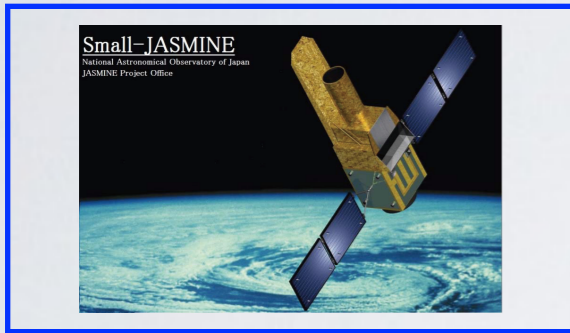
15” resolution (~4 times  
better than Nu-Star)



US participation: Hard  
X-ray optics

# Optical & IR astronomy

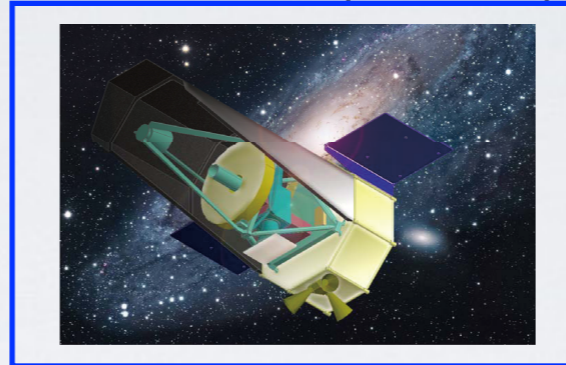
## S-JASMINE (M size)



Evolution of the Galactic bulge and the central BH

- IR astrometry of the Galactic Center region
- Europe and China collaborations for data analysis

## WISH (L size) The early universe:

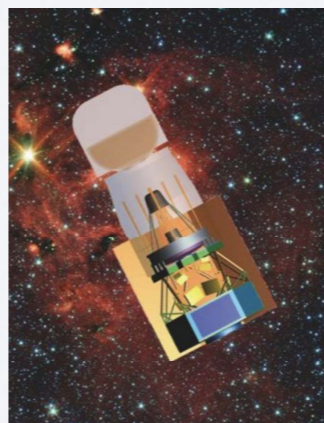


- The earliest galaxy formation at  $z=8-15$
- Cosmic Expansion History with type Ia Supernovae

## US participation:

- IR detector array and front-end electronics

Mission was not selected in down selection in 2015. Restructure of mission is being considered.



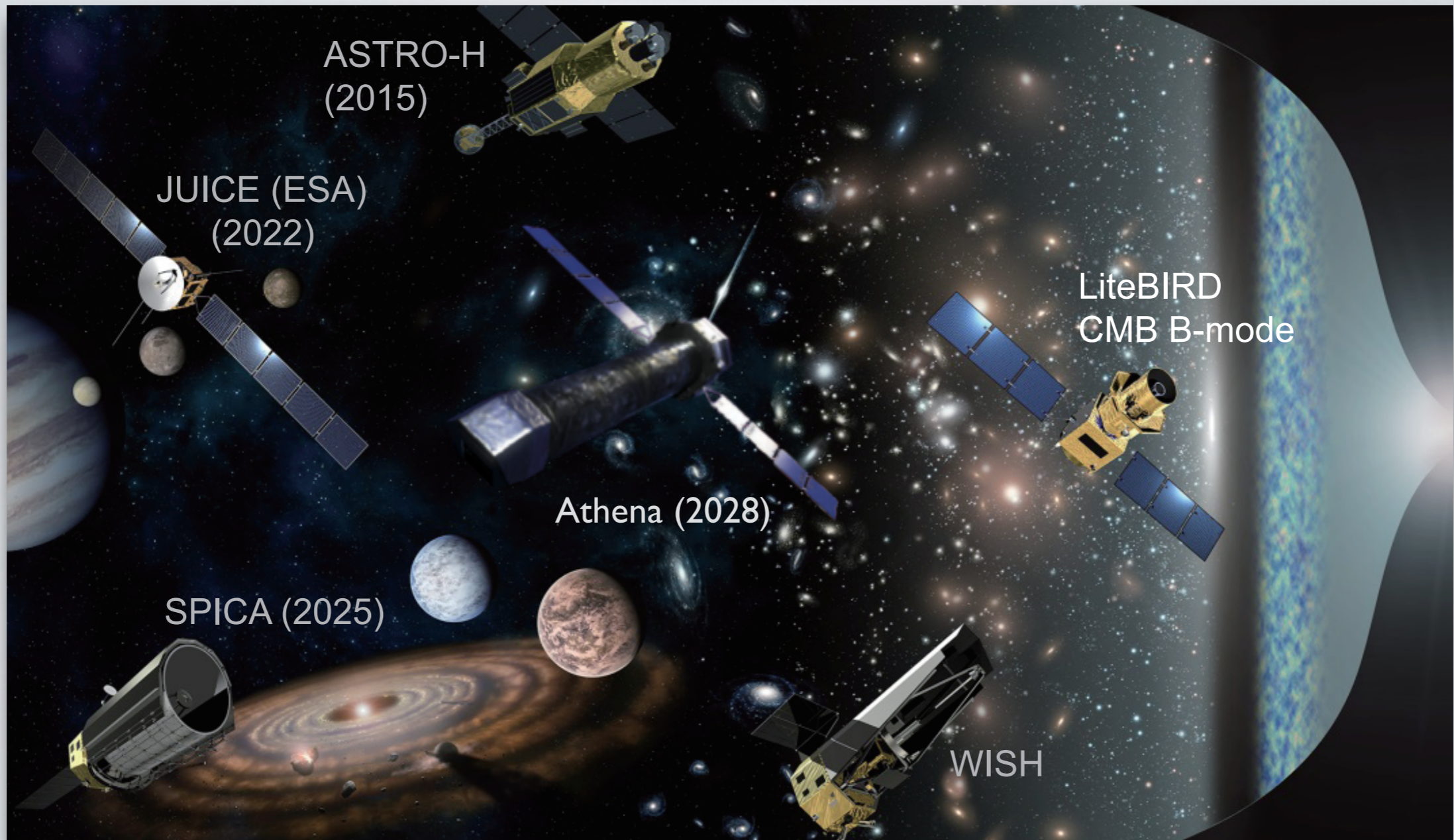
## Participation to WFIRST-AFTA/

(NASA, MoO, S size)

Participation in coronagraph is studied

# Summary

- In the basic plan of space policy revised in Jan. 2015, mission sizes and frequencies (or budget size) of three mission lines are pre-determined, which makes Japanese future space science missions foreseeable.
- JAXA is selecting strategic L-size missions for the three slots down to late 2020's.
  - Presently US contribution is not formalized for SPICA. However there are some possible areas of collaboration.
  - US contribution is essential for LiteBIRD.
- Several missions are under concept study by researcher communities. All of them involves International collaboration.



THANKS FOR YOUR ATTENTION

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