



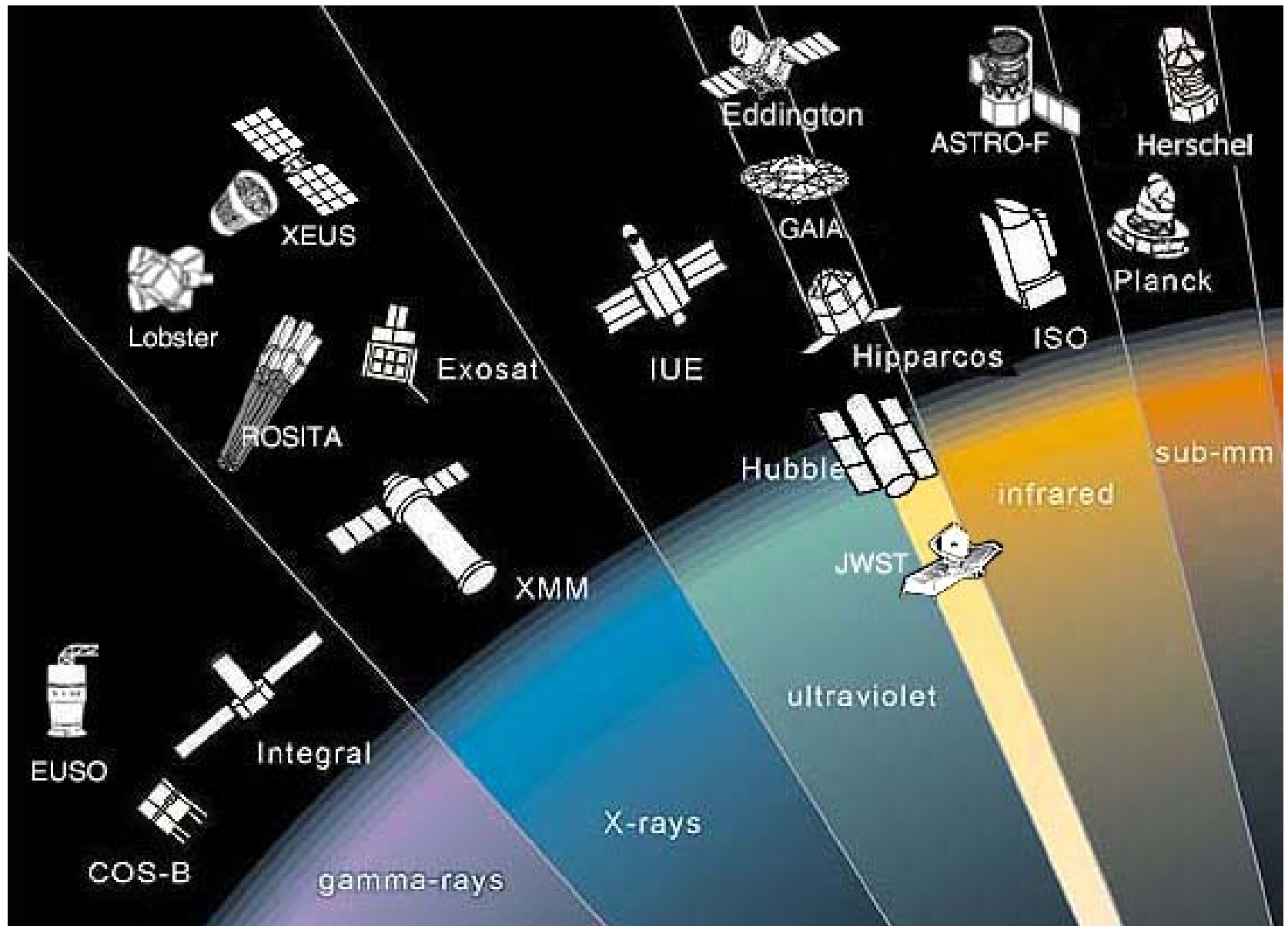
光赤外スペース計画 の世界情勢

1st Feb., 2007

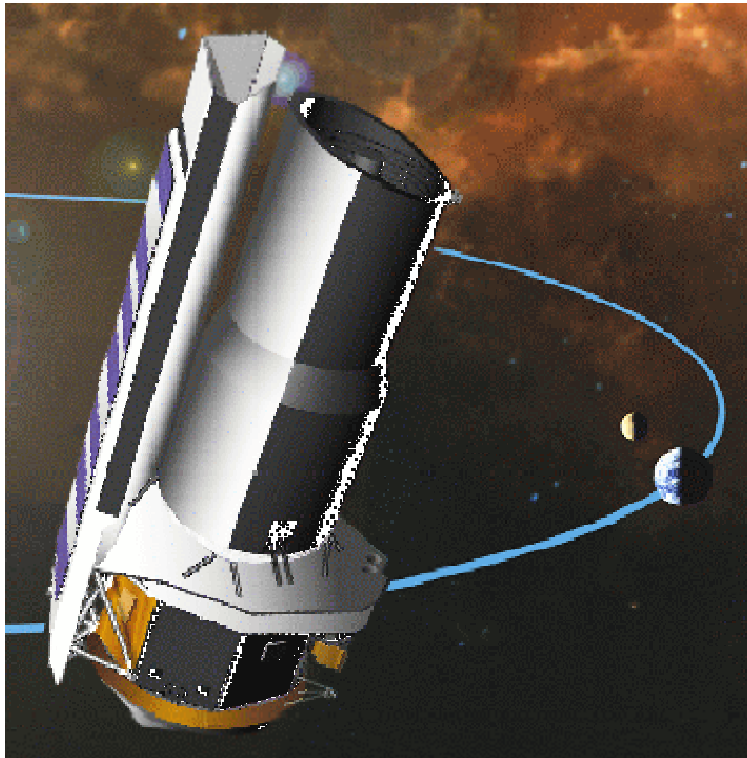
松原英雄

ISAS, JAXA

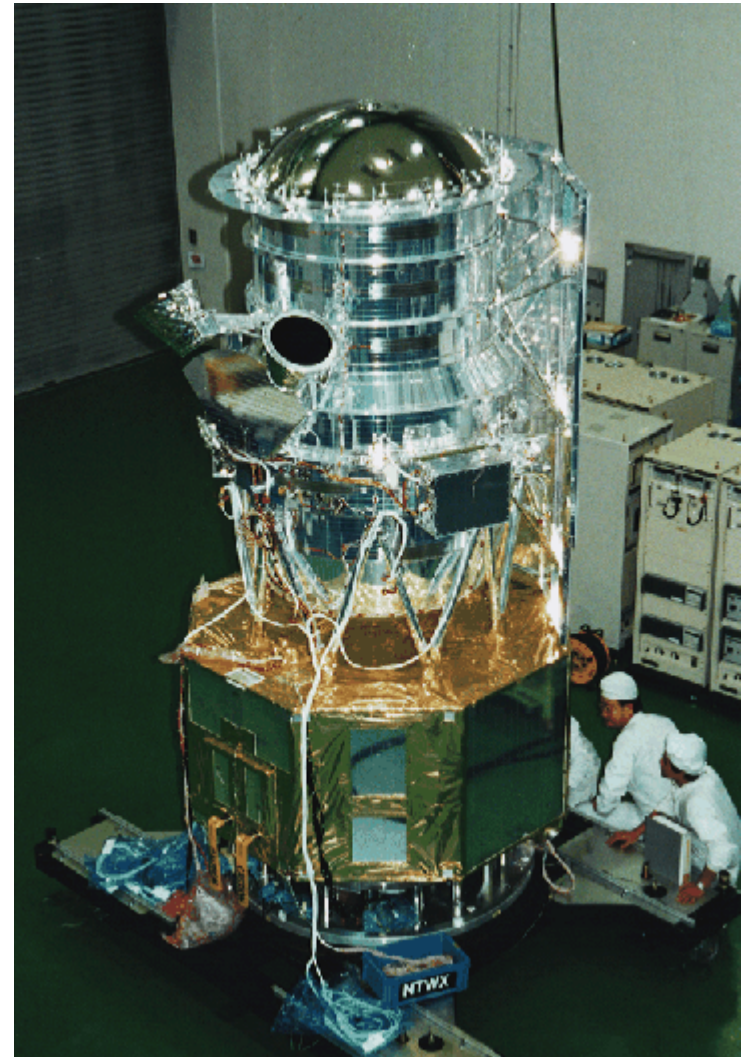
Astronomy Satellites (ESA related)



Spitzer and Akari are on orbit

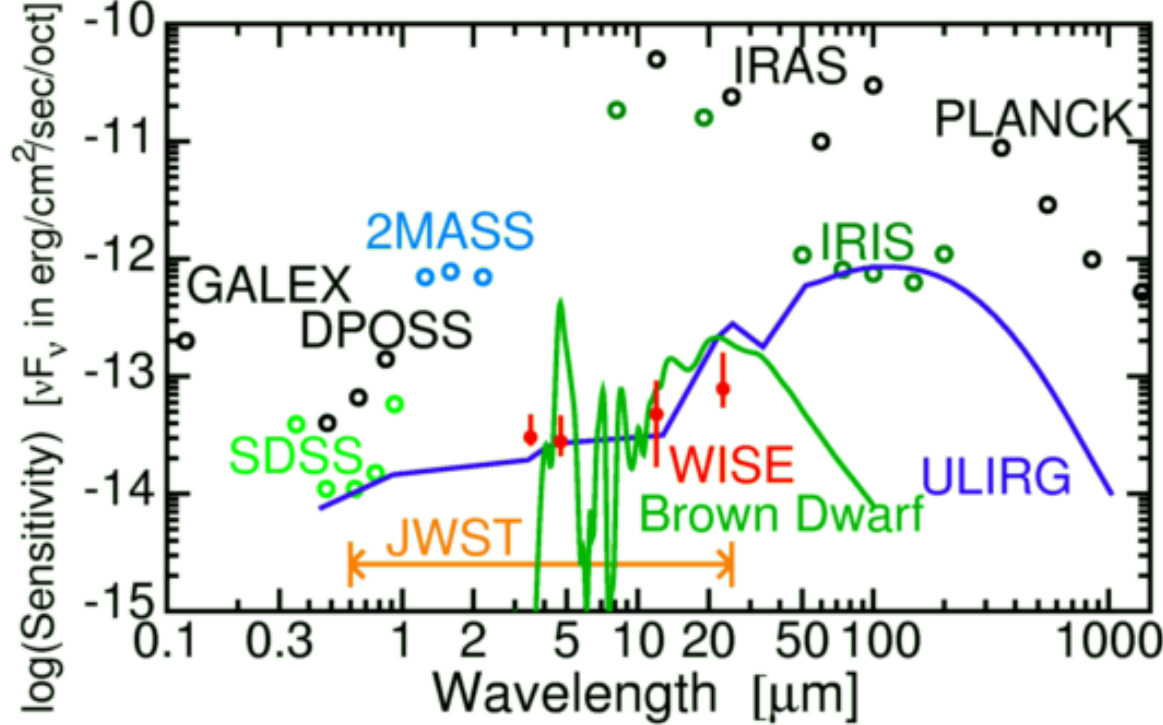


- Spitzer (2003)
 - 85cm, <5.5K
 - 3–160 μ m



- Akari (2006)
 - 70cm, <6K
 - 2–160 μ m

WISE (Wide-field Infrared Survey Explorer)

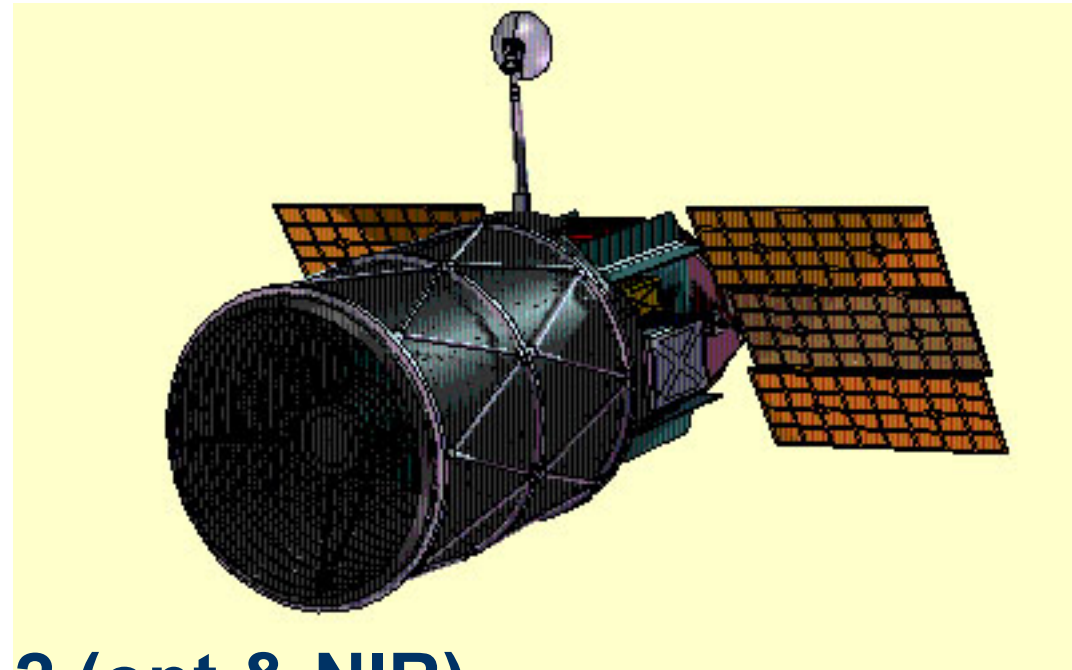


- **Dedicated for Survey**
 - Mid-IR version of 2MASS survey
- **Diameter: 0.5m**
- **Wavelength: 3.5 – 23 μm**
- **Spatial resolution: 5''**
- **Launch: 2009 Orbit: polar 600km**
 - NASA MIDEX selected (Aug. 2004)
 - Life: 6 months

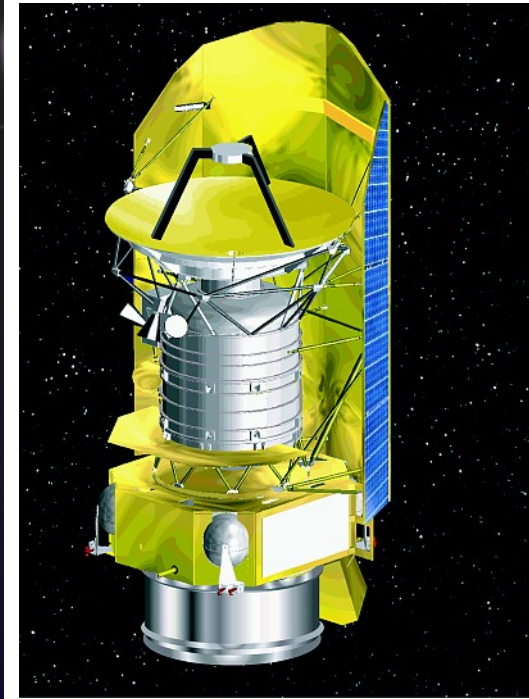
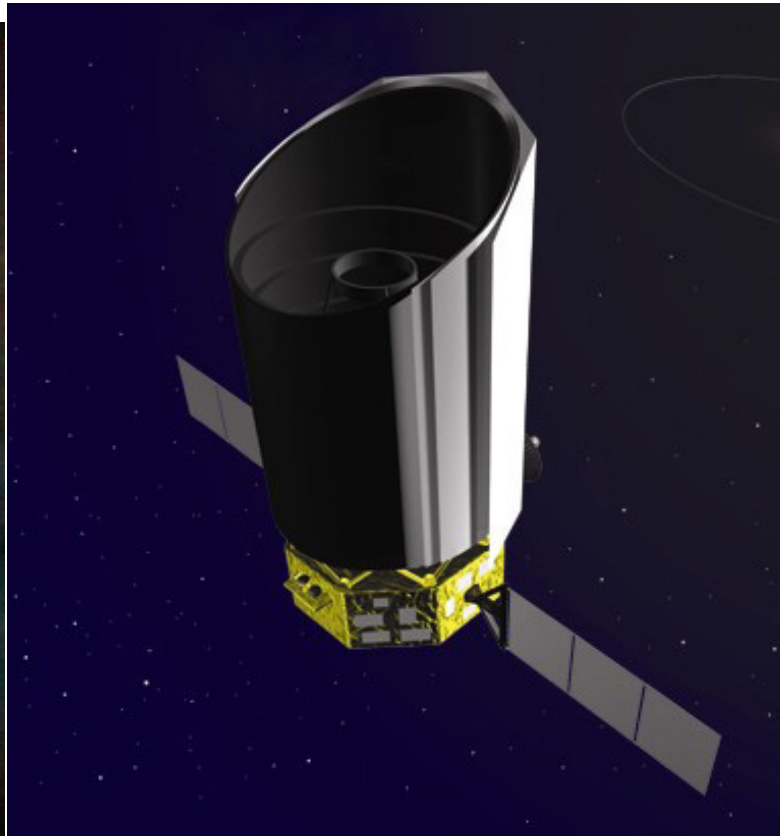
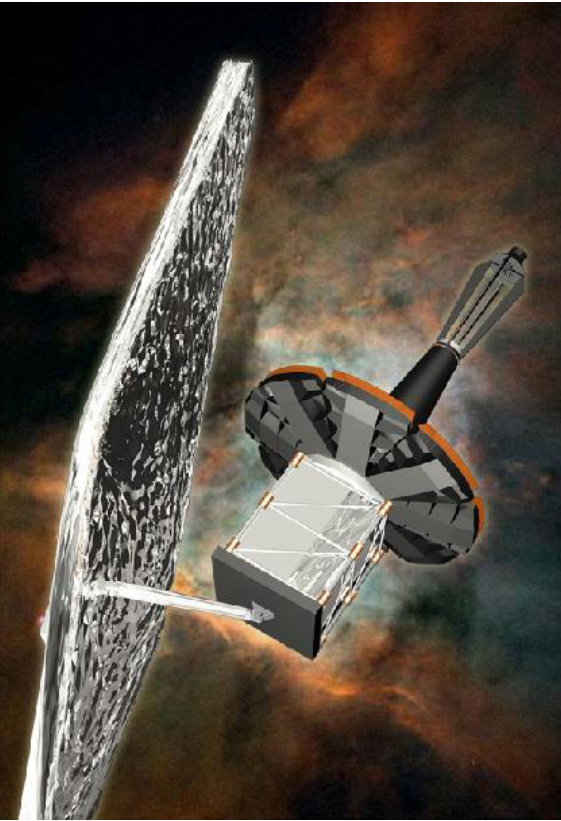
SNAP

(SuperNovae / Acceleration Probe)

- **Specific purpose**
 - **Cosmological constant / dark energy**
- **Diameter : 2.0m**
- **Wavelength: 0.35 – 1.7 μ m**
- **FOV: 35arcmin² x 2 (opt & NIR)**
- **Orbit: “Prometheus” orbit**
- **Launch: 20??**
 - **NASA, DOE funds have been approved by Council**
 - **Life : more than 2.5 years**



Next Generation IR Space Observatories

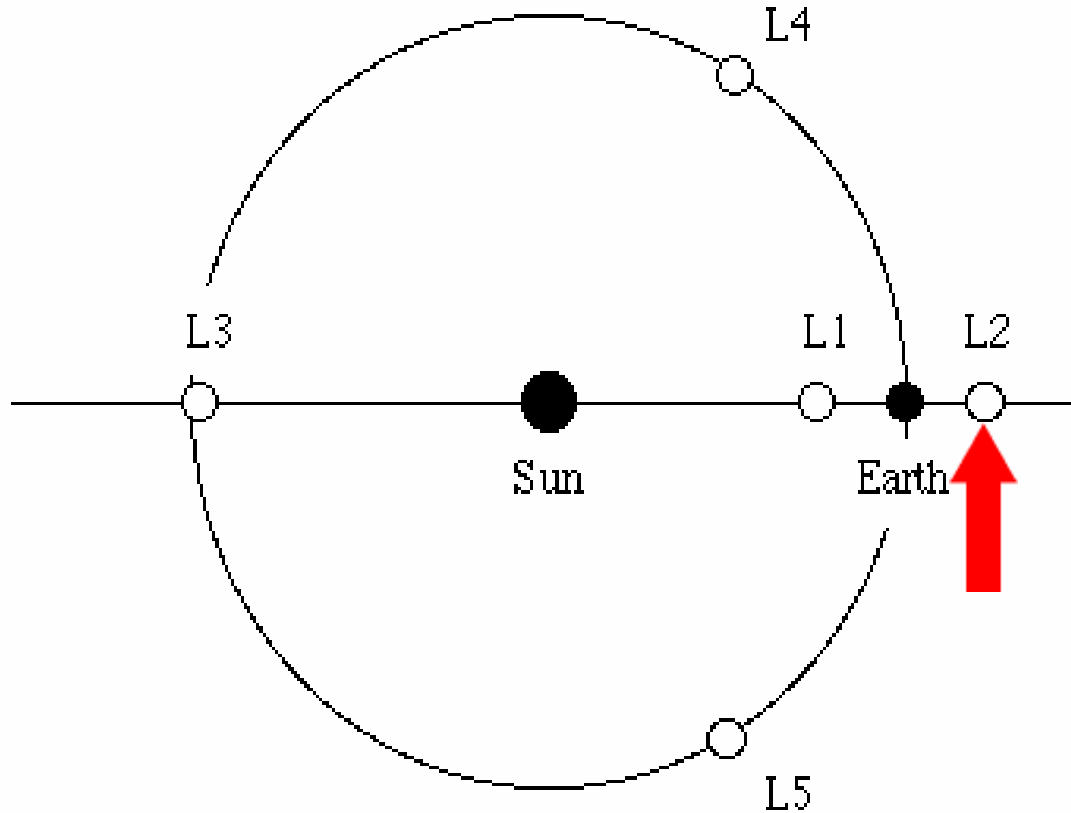


- JWST (2013?)
 - 6.5m, 30K
 - 0.6~27 μ m

- SPICA (2015?)
 - 3.5m, <5K
 - 5~200 μ m main

- Herschel (2008?)
 - 3.5m, 70K
 - 60~670 μ m

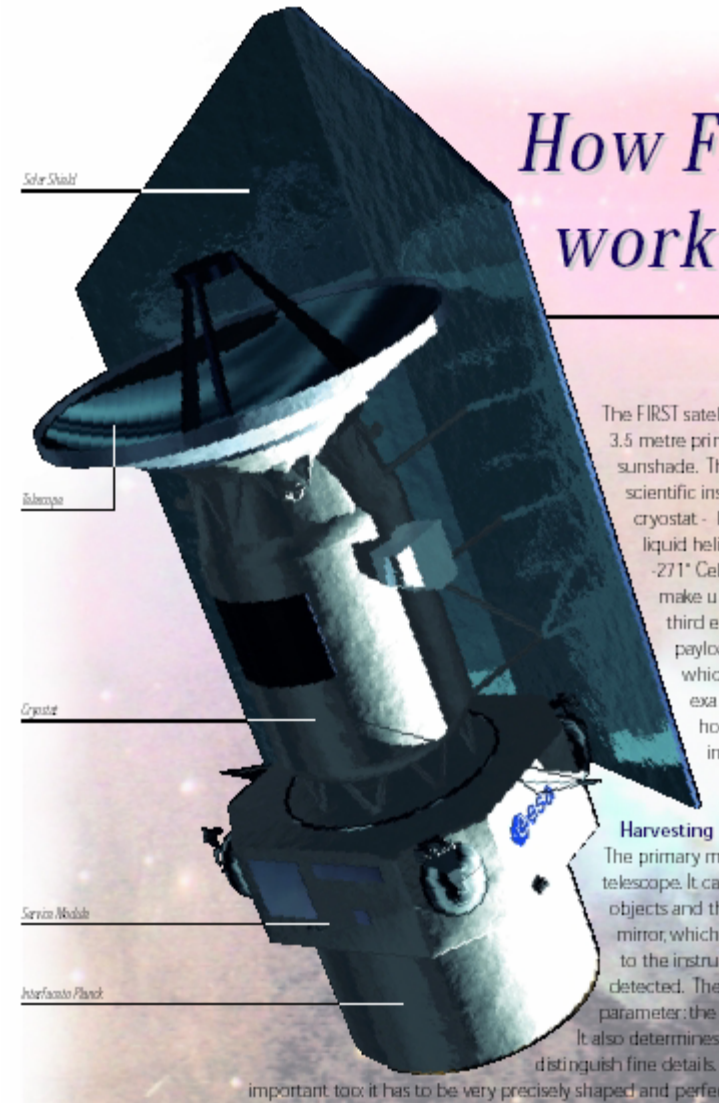
S-E L2



JWST Herschel/Planck SPICA GAIA ...

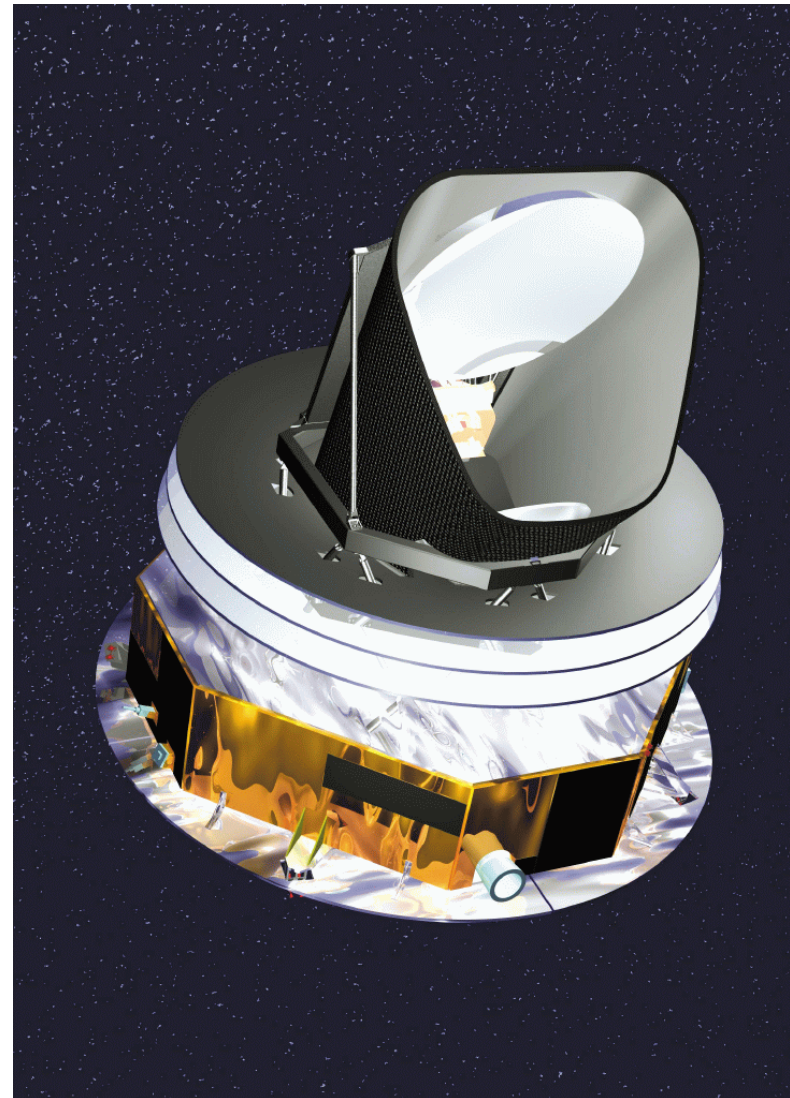
Herschel Space Observatory

- ESA
- Launch: 2008?, 3 years life
- Telescope: 3.5m, 80K
- Wavelength: 60-670 μm
- PACS ($\lambda=60\text{-}210\mu\text{m}$)
 - Imaging: 1'.75x3'.5
 - Spectroscopy: R=2000
- SPIRE ($\lambda=200\text{-}600\mu\text{m}$)
 - Imaging: 4'x8'
 - Spectroscopy: R=100-1000
- HIFI



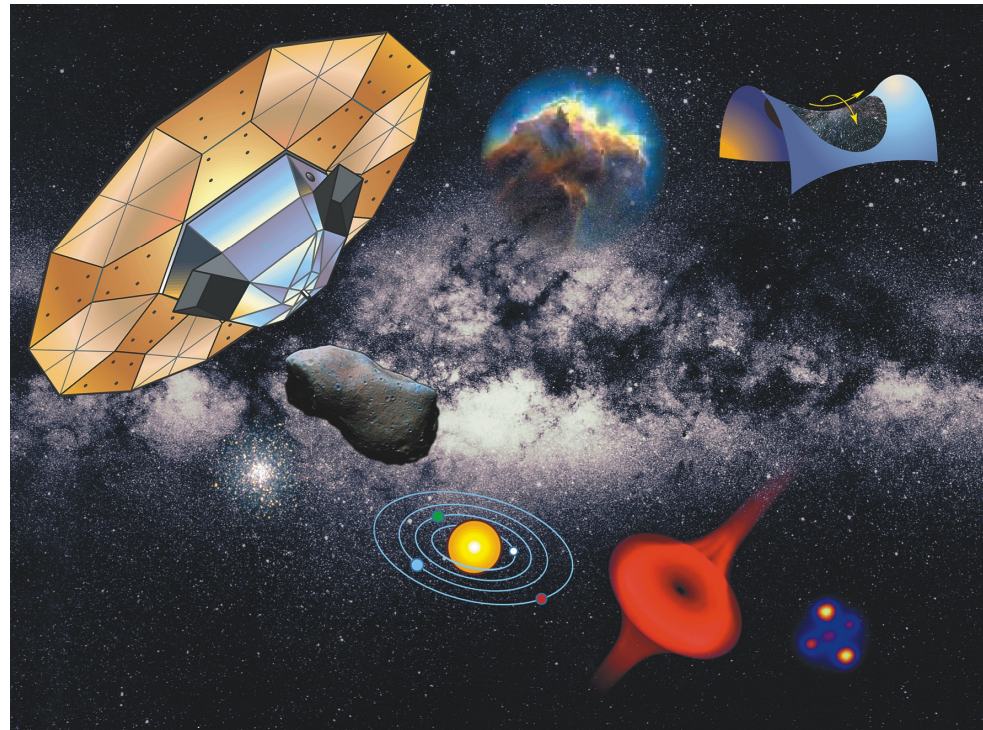
PLANCK

- ESA
- Launch: 2008? (together with Herschel)
- 1.5 m telescope
- CMB anisotropy over the whole sky (in 15 months)
 - Similar (better?) angular resolution with WMAP (~0.2deg)
 - wider wavelength coverage than WMAP, 0.3 – 10mm



GAIA

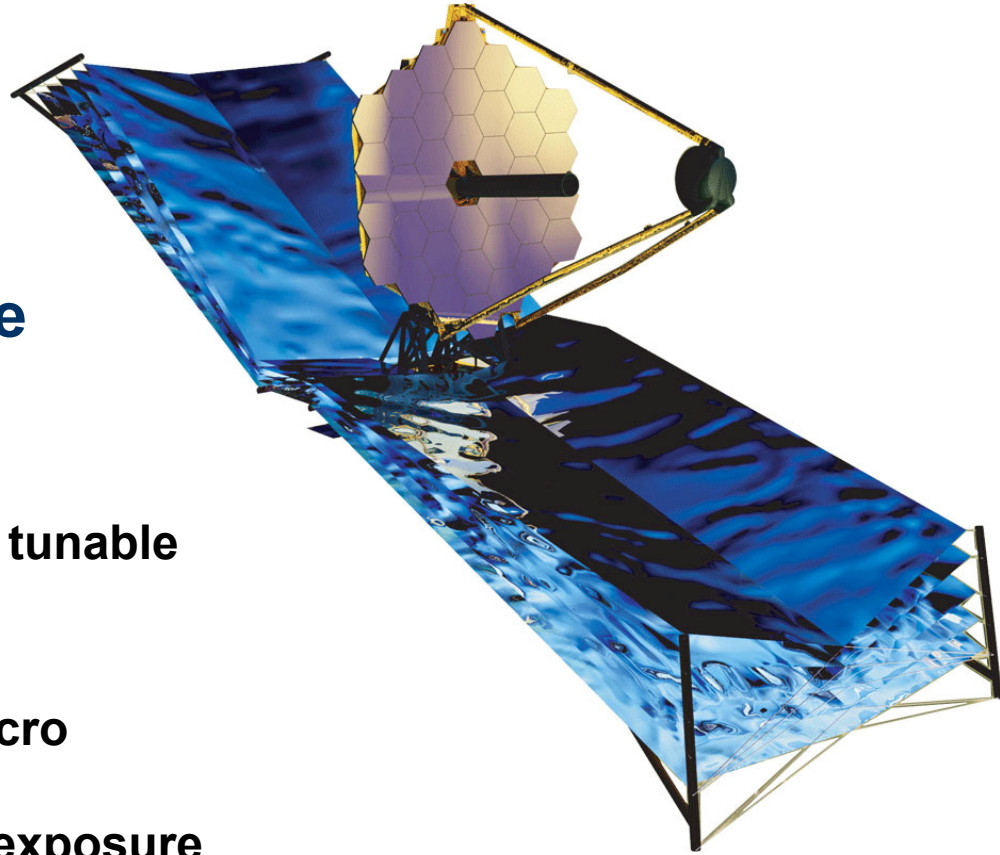
- **ESA's space astrometry mission at optical**
- **All-sky, $10\mu\text{as}$**
- **Launch:**
 - **December 2011**
(Soyuz rocket from French Guiana).
- **Status:**
 - **Under development,**
with EADS Astrium
SAS as prime contractor.
- **Orbit : S-E L2**



JWST

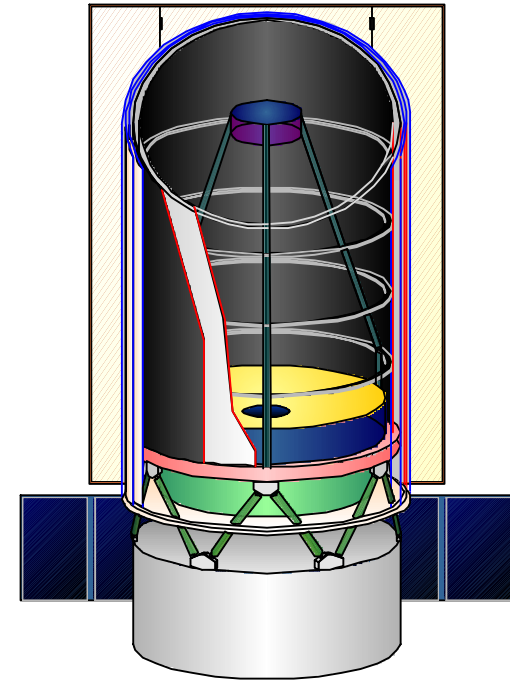
(James Webb Space Telescope)

- General purpose space telescope
- Diameter: 6.5m, T<50K
- Launch: 2013?, ~5 year life
- Wavelength: 0.6-10 μ m
 - **NIRCAM**
 - 0.6-5 μ m, 2'.3x4'.6x2, R=100 tunable filter
 - **NIRSPEC**
 - 0.6-5 μ m, 3'x3' MOS with micro shutter (or IFU)
 - Spectra of 100 objects per exposure
 - **MIRI**
 - 5-27 μ m, 1'.5x1'.5
 - R=100, 1500-3000 spectroscopy

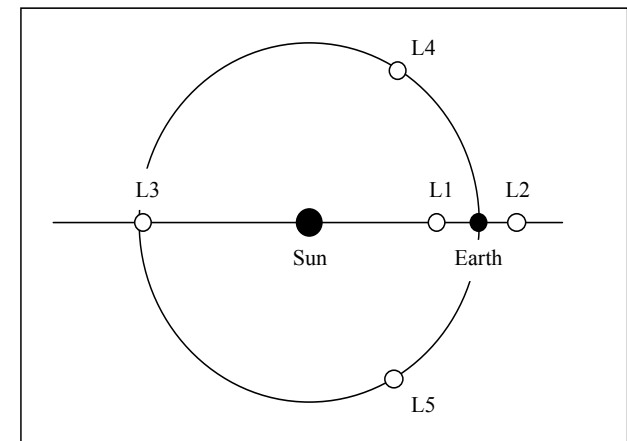


SPICA

Space Infrared telescope
for Cosmology and Astrophysics



- **Telescope: 3.5m, 4.5 K**
 - JWST(20-40K), HSO(80K)
- **Core λ : 5-200 μ m**
 - Complementary to JWST (Opt-NIR), HSO (Sub-mm)
- **Orbit: Sun-Earth L2 Halo**
- **Warm Launch, Cooling on Orbit**
- **Total Weight: 2.6 t**
- **Launch: 2015? by HIIA**
- **~5 year life**



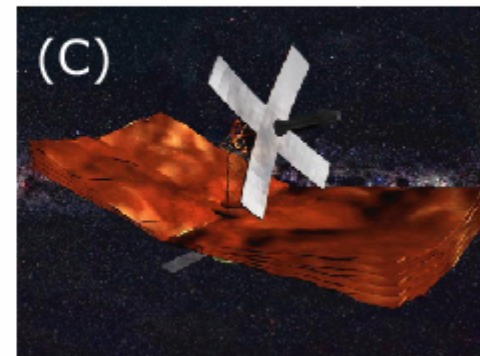
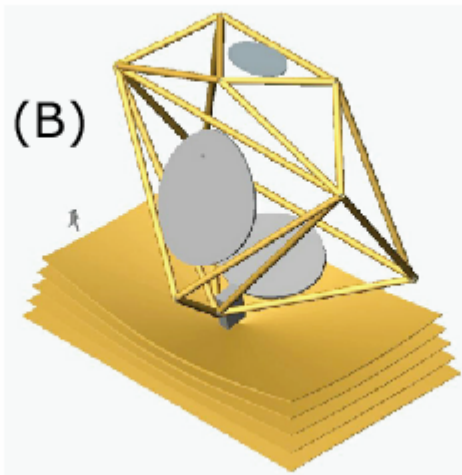
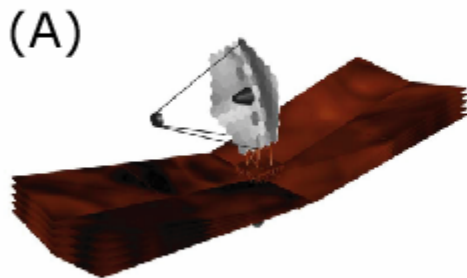


米国の状況

SAFIR

- (was) included in NASA space science road map
- 10 m telescope cooled to 4K
- Wavelength: 15-600 μm
 - Natural-background-limited sensitivity
- Diffraction-limited angular resolution at $\sim 40\mu\text{m}$

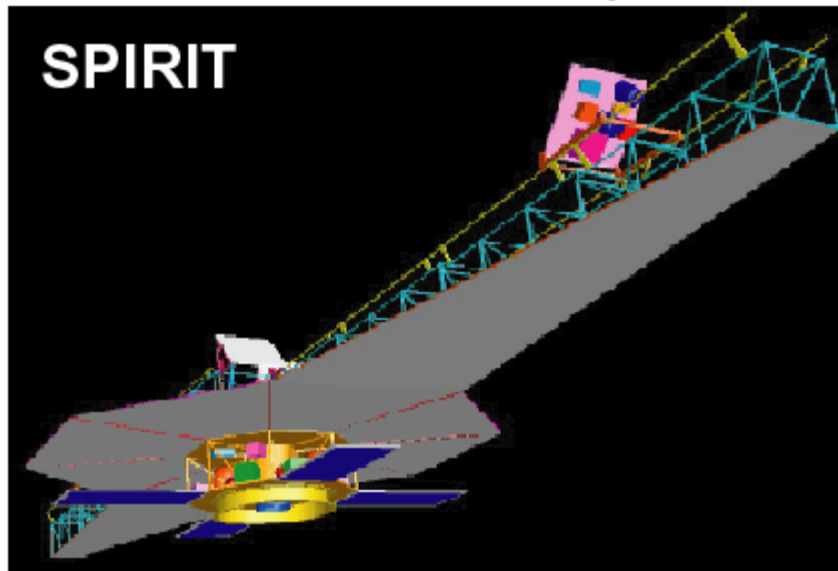
Single-Aperture Far-IR (SAFIR) Telescope



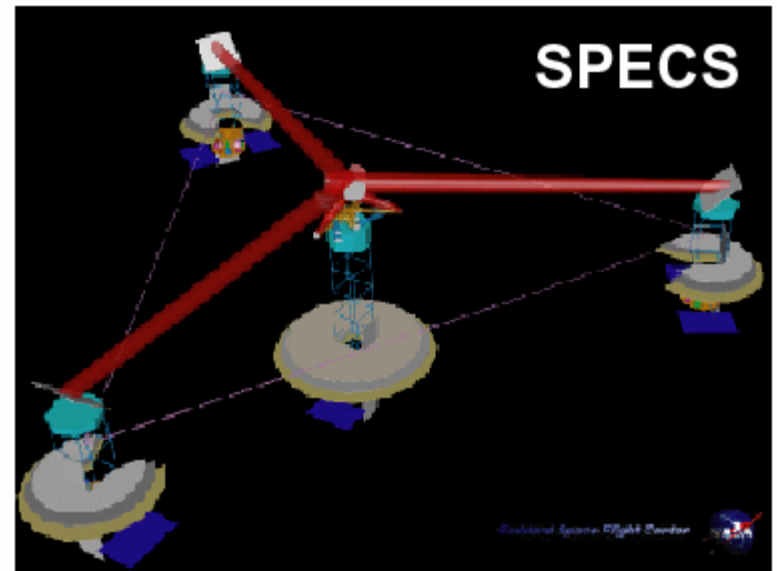
SPIRIT & SPECS

- **FIR & Submm space interferometer**
 - **1km maximum baseline**
- **Sensitivity comparable to that of SAFIR**
- **Far better angular resolution than SAFIR**

Space Infrared
Interferometric Telescope

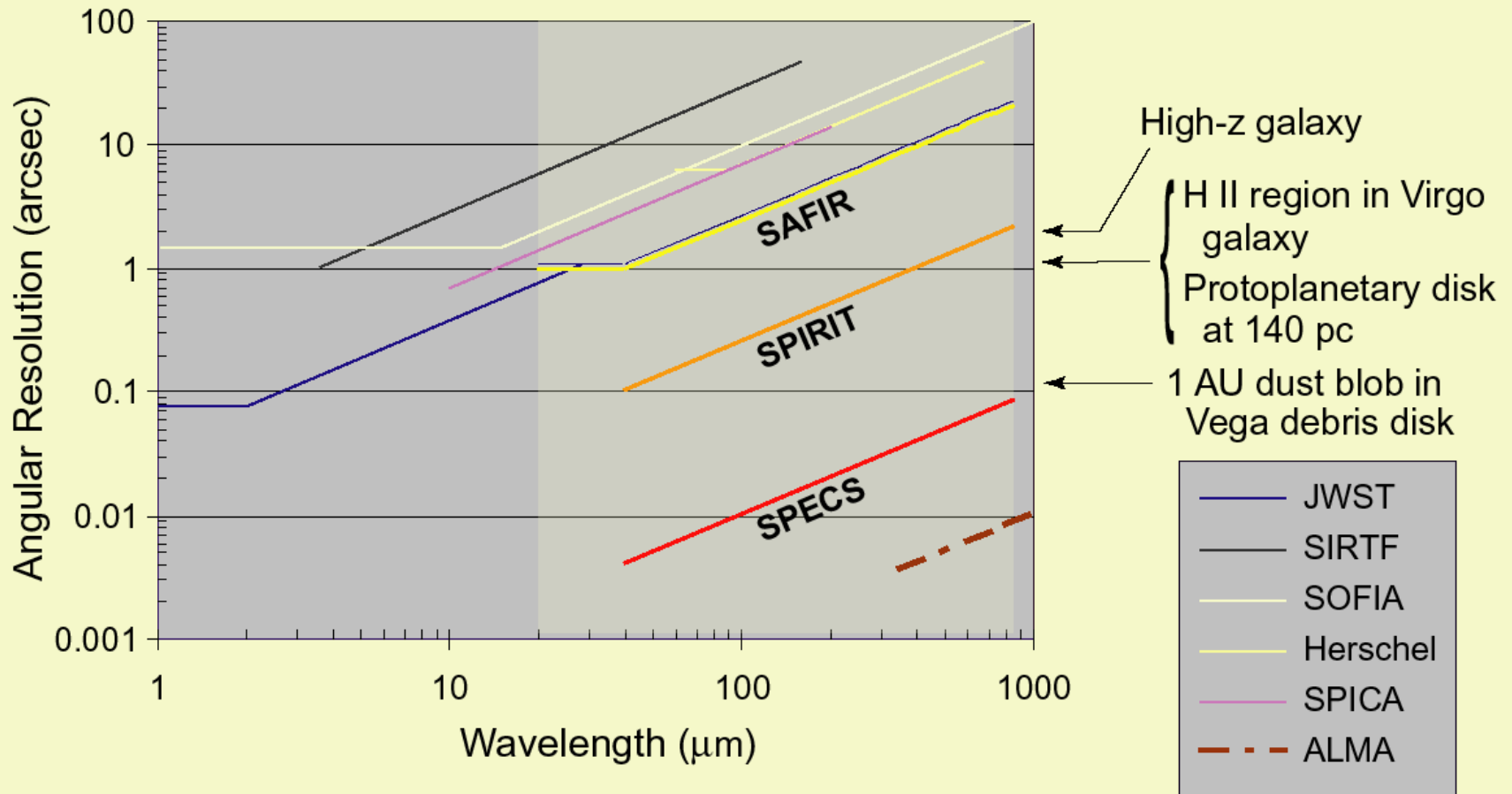


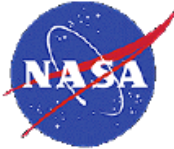
Submillimeter Probe of the
Evolution of Cosmic Structure



Angular resolution of SAFIR, SPIRIT, SPECS

Image Resolution





The Astrophysics: Content of FY07 Budget

	FY06	FY07	FY08	FY09	FY10	FY11
FY 07 President's Budget	1,507.9	1,509.2	1,500.9	1,307.9	1,276.1	1,309.7
Navigator	145.5	128.1	170.6	276.9	261.6	347.0
SIM	117.0	98.5	139.0	236.2	222.5	302.2
Keck Interferometer / Single Aperture	9.6	10.2	9.6	8.4	7.0	7.0
TPF	3.4					
Corporate / Other	15.5	19.4	22.0	32.3	32.1	37.8
James Webb Space Telescope	364.0	443.1	492.6	380.9	353.0	305.0
Hubble Space Telescope	268.6	336.7	302.2	161.4	120.3	138.5
Development	166.5	216.2	178.9	55.0	45.4	45.7
Operations and Data Analysis	87.0	102.0	106.0	97.0	68.0	85.0
Corporate	15.1	18.5	17.3	9.4	6.9	7.8
Stratospheric Observatory for Infrared Astronomy (SOFIA)	48.0					
Gamma-ray Large Space Telescope (GLAST)	125.9	85.4	25.2	28.8	29.3	30.4
Discovery (Kepler / Corporate)	137.5	100.8	69.9	13.8	13.4	13.0
Explorer (Universe)	85.4	67.6	86.1	56.7	19.0	4.6
WISE	69.7	53.9	71.7	44.8	8.8	4.3
Swift, Suzaku	10.9	10.0	9.5	8.6	9.1	
Corporate	4.8	3.7	4.9	3.3	1.1	0.3
Universe Research	305.8	306.6	309.2	297.4	288.9	259.6
Research and Analysis	65.1	54.4	54.0	56.0	53.9	55.9
Chandra	58.4	63.0	65.1	64.7	65.1	65.0
Spitzer	74.3	76.6	75.7	71.7	66.4	35.9
Other Missions / Data	68.1	71.2	70.8	59.2	58.4	59.2
Balloons	22.8	24.5	25.8	28.5	28.8	29.0
Corporate / Other	17.1	16.9	17.8	17.3	16.3	14.6
ISSC (Herschel / Planck)	13.0	19.6	23.6	38.9	38.5	36.3
Beyond Einstein	14.1	21.2	21.4	53.0	152.2	175.4

* Future Explorer Budget is in Heliophysics Division budget

米国のスペース天文学予算状況

- アメリカのスペース天文学の予算は年間1500M \$程度。
 - このうち、2/3がJWST とHST(サービスマッション)。他を大きく圧迫してる。
 - その結果、TPF、SIMの予算がほとんどゼロ。
- アメリカの単一鏡SAFIR (SPICAの拡大版)、スペース干渉計計画SPIRITは、実現のめどがまったくなし..
 - SPICAへの参加？ 2008年のMIDEXへの応募？

NASA Priority Table (1)

James Webb Space Telescope (JWST) [2013] Strategic mission	Top-ranked Space-based “Major Initiative” in the 2001 decadal survey; infrared successor to Hubble to image first light from the Big Bang
Hubble Space Telescope – Servicing Mission 4 (HST-SM4) [2008] Strategic mission	Continued operation endorsed by 2001 decadal survey; Report of the HST-JWST Transition Panel (2003). Shuttle mission to replace instruments and equipment to extend HST life.
Gamma-ray Large Area Space Telescope (GLAST) [2007] Strategic mission	Top-ranked space-based “Moderate Initiative” in the 2001 decadal survey; all sky survey of high-energy gamma ray sources
Herschel Space Observatory (Herschel) [2008] Planck Surveyor (Planck) [2008] Instruments on international missions	ESA mission with NASA as partner; US participation endorsed in the 2001 decadal survey; star formation and cosmic background radiation, respectively
Kepler [2008] Competed mission - Discovery	The 2002 solar system exploration decadal survey “endorses the fundamental importance of the Discovery line of missions.” Survey 100,000 stars to search for Earth-size planets.
Wide-field Infrared Survey Explorer (WISE) [2009] Competed mission - Explorer	2003 selection in MIDEX (Explorer) competition. The 2001 decadal survey “endorses the continuation of a vigorous Explorer Program”. All sky survey in infrared for a wide range of studies.
Stratospheric Observatory for Infrared Astronomy (SOFIA) [2010 Initial Operating Capability] Strategic Mission	Endorsed as a “Moderate” program in the 1991 decadal survey; reaffirmed in the 2001 decadal survey. Observations of stellar and planet-forming environments.
Explorer (MIDEX) [2013] Competed mission – Medium Explorer	2008 solicitation for launch in 2013. The 2001 decadal survey “endorses the continuation of a vigorous Explorer Program”
Explorer (SMEX) [2015] Competed mission - Small Explorer	2010 solicitation for launch in 2015; the 2001 decadal survey “endorses the continuation of a vigorous Explorer Program”

NASA Priority table (2)

Future strategic missions planned for launch after 2015 (unprioritized)

Space Interferometry Mission (SIM)
Strategic Mission

Beyond Einstein-1

Constellation-X (Con-X)

Joint Dark Energy Mission (JDEM)

Laser Interferometer Space Antenna (LISA)

Black Hole Finder Probe (BHFP)

Inflation Probe (IP)

Terrestrial Planet Finder (TPF)
Strategic mission

The priorities for those missions that launch after 2015 will be likely be re-established following the release of the next decadal report of the Astronomy and Astrophysics Decadal Survey (expected by 2010 or 2011).

Endorsed by the 1991 decadal survey as a new Moderate Program; re-endorsed in 2001 decadal survey. Characterize other planetary systems.

One of the five missions below, based on the recommendation of the NRC in a study now underway for this purpose

Second-ranked space-based “Major Initiative” in the 2001 decadal survey; x-ray observation to study black holes, dark matter & energy

Endorsed by the NRC *Connecting Quarks with the Cosmos* report (2003); measure cosmological parameters of the expanding universe joint mission with DOE

Second-ranked space-based “Moderate Initiative” in the 2001 decadal survey. Measure gravitational waves; joint mission with ESA

One potential implementation (the Energetic X-ray Imaging Survey Telescope) is the fourth-ranked Space-based Moderate Initiative in the 2001 decadal survey; census of black holes

One potential implementation (CMB Polarization) is endorsed by the NRC *Connecting Quarks with the Cosmos* report (2003); stringent test of inflationary cosmology and Big Bang physics

Third-ranked space-based “Major Initiative” in the 2001 decadal survey; characterize all components of other planetary systems, image Earth-like planets and search for signs of life



欧州の状況

Cosmic Vision 2015-2025

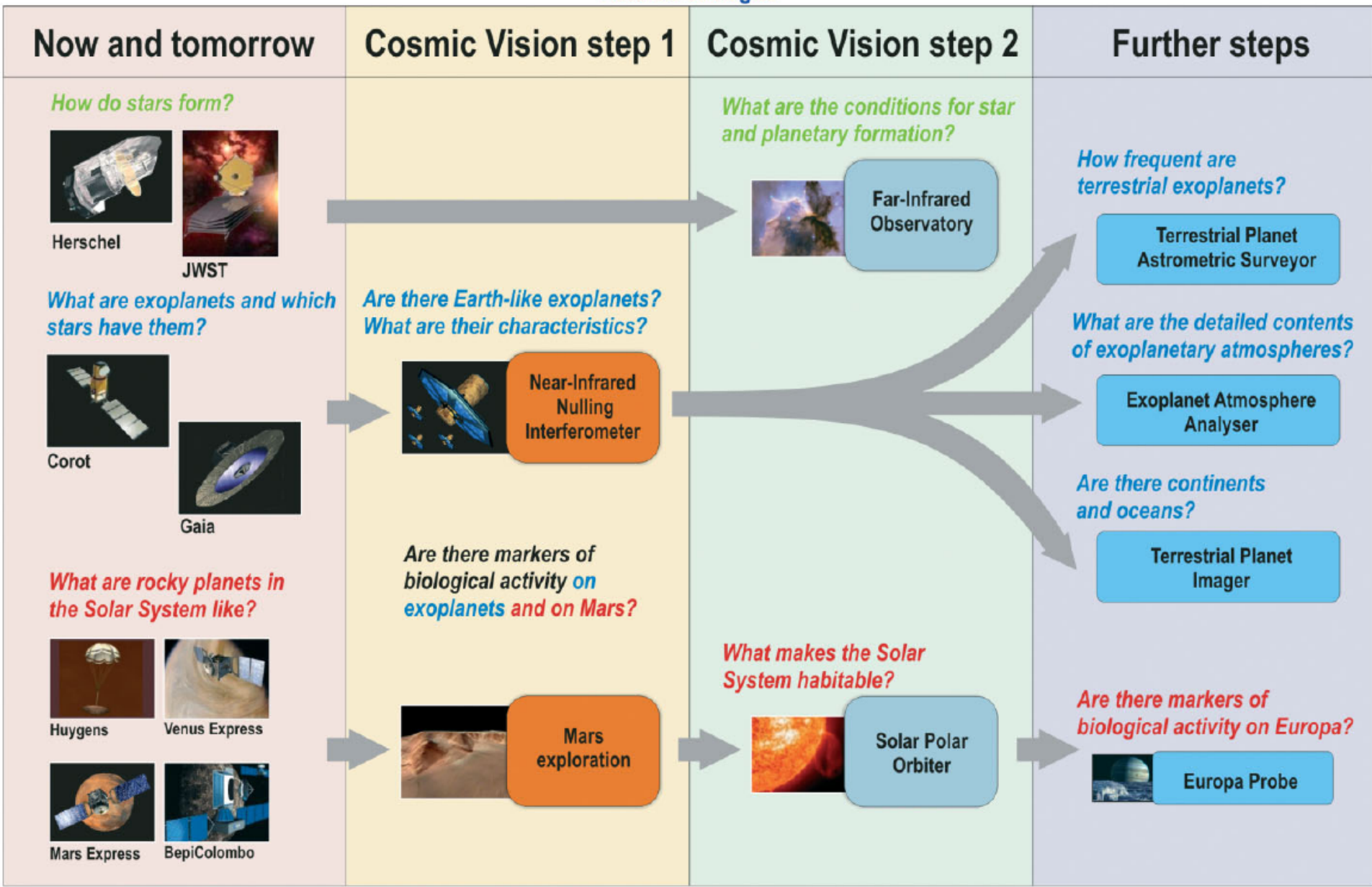
Cosmic Vision

- ESAのスペース科学
将来計画
- 2004年4月に色々な提案(全部で151)を募り、2004年9月のパリでのWSで選択。
- 4つの科学的課題を設定、それぞれについて将来ミッションを検討。

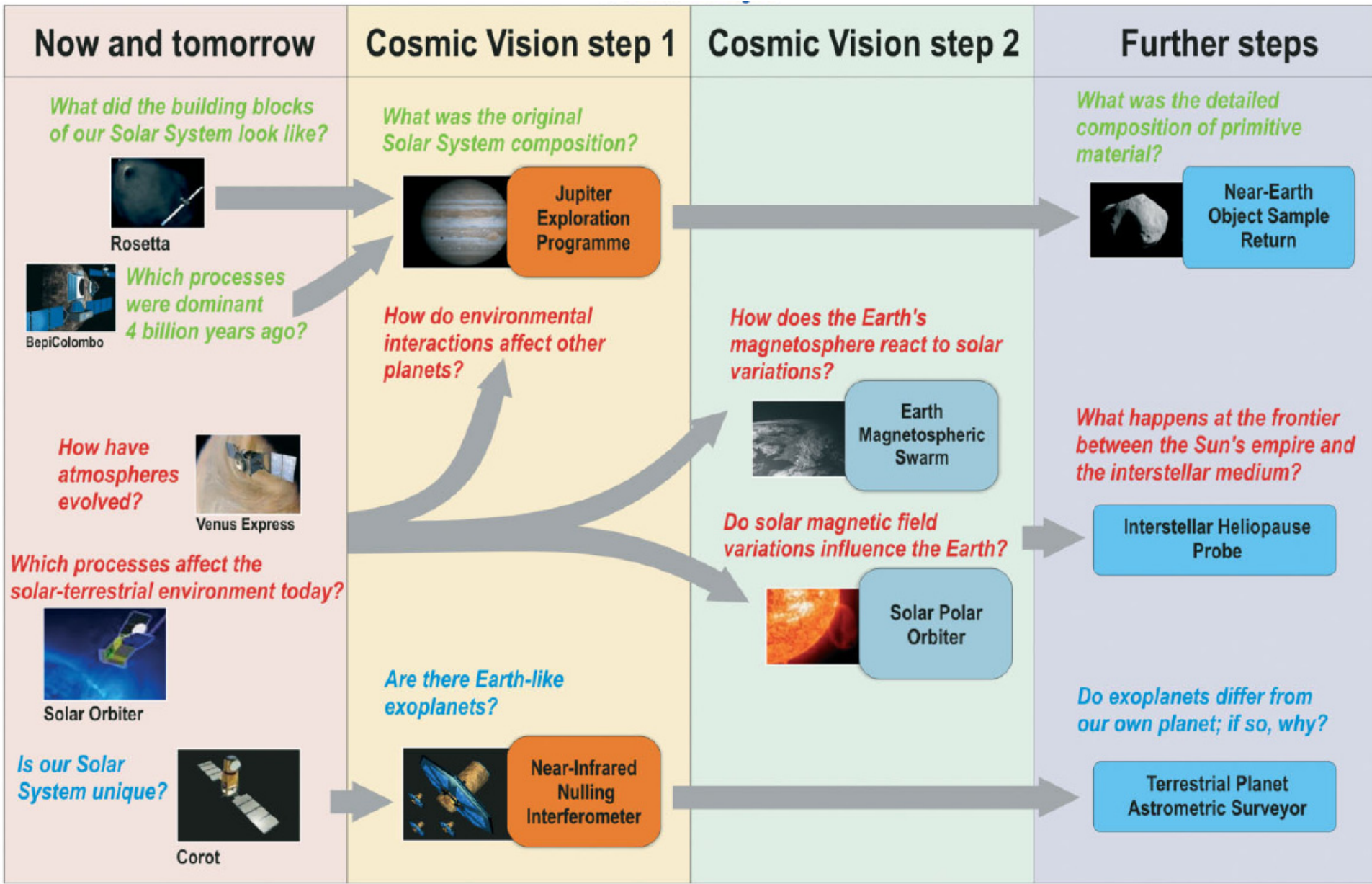
Space Science for Europe 2015-2025



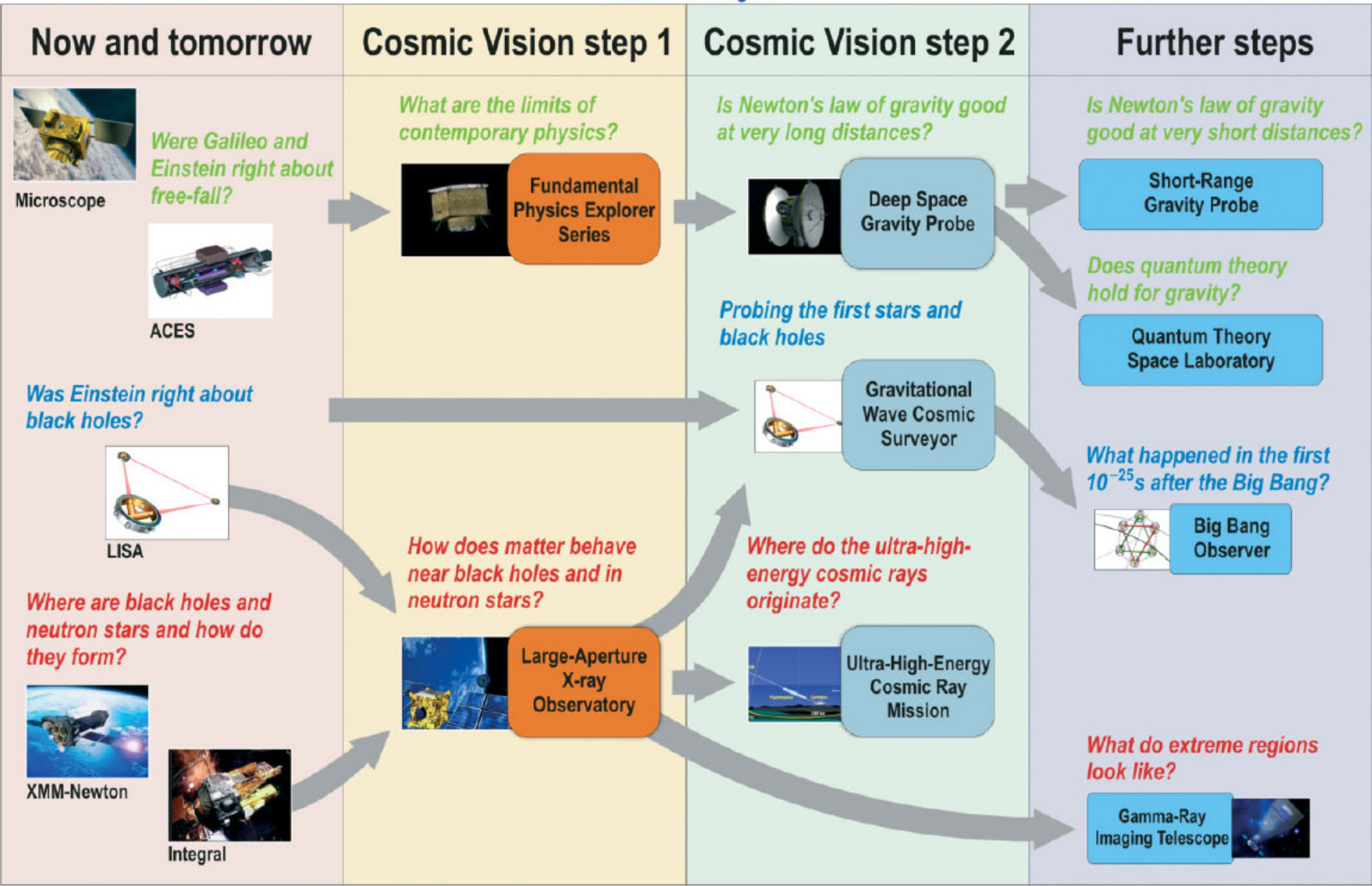
What are the conditions for planetary formation and the emergence of life?



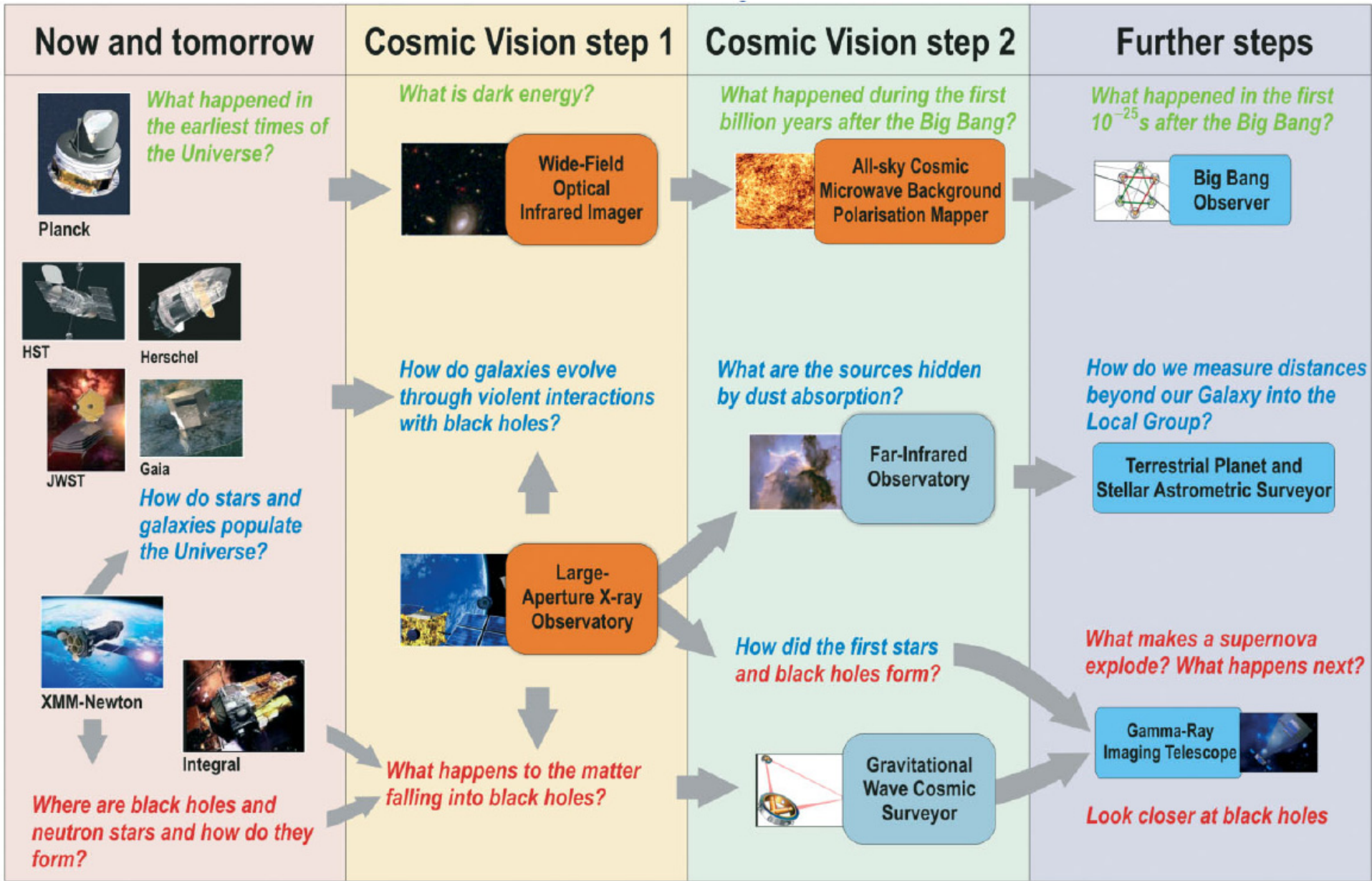
How does the solar system work?



What are the fundamental physical laws of the Universe?



How did the Universe originate and what is it made of?



ESA Cosmic Visionのスケジュール

- 2007年 2月頃 L(6億ユーロ)、M(3億ユーロ)の公募開始
- 2007年 6月頃 公募締め切り
- 2007年10月頃 L 3件、M 3件程度に絞る
- (2008年 Herschel打上げ)
- 2009年 Mを2件に絞る
- 2011年 Mを1件に絞ってスタート
- Lを2件に絞る
- 2015年 Lを1件に絞ってスタート
- 2017年 Mの打ち上げ
- 2020年以降 Lの打ち上げ
- 平行して、2010年頃には次回の公募があるかもしれない
- ESAの予算が大変厳しい。2020年すぎまでに、MとLを1件ずつしか実現できない
 - この枠をX線や惑星、Darwin、LISA(重力波)と赤外で争う。
 - ESI on SPICAをMの枠で応募
 - FIRIをLの枠で応募