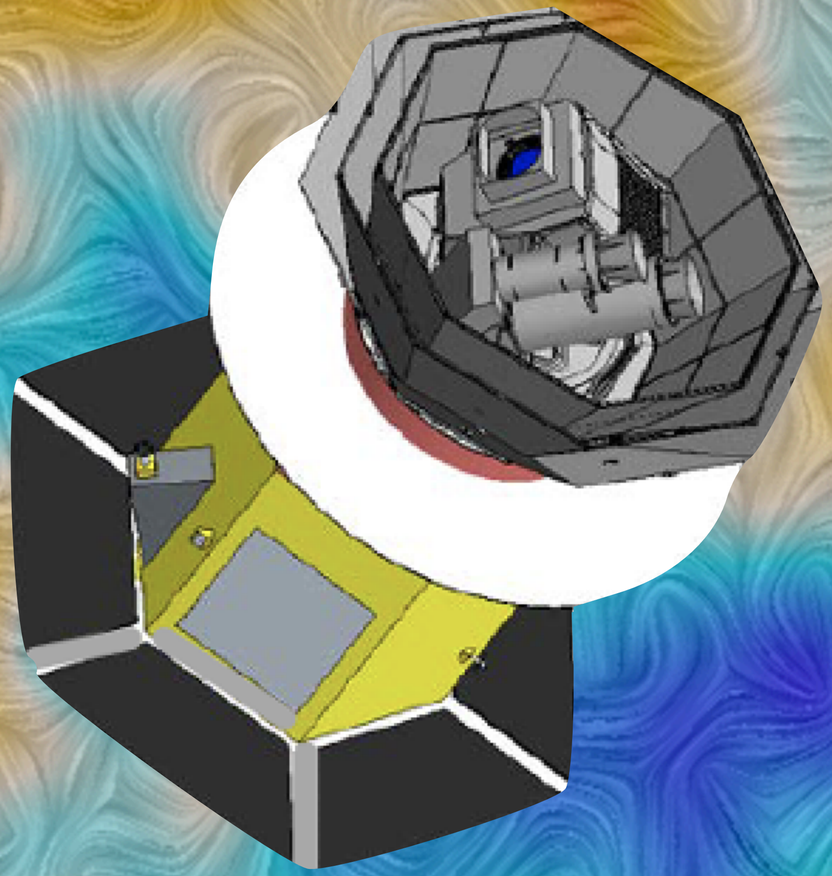
LiteBIRD Status



L. Montier

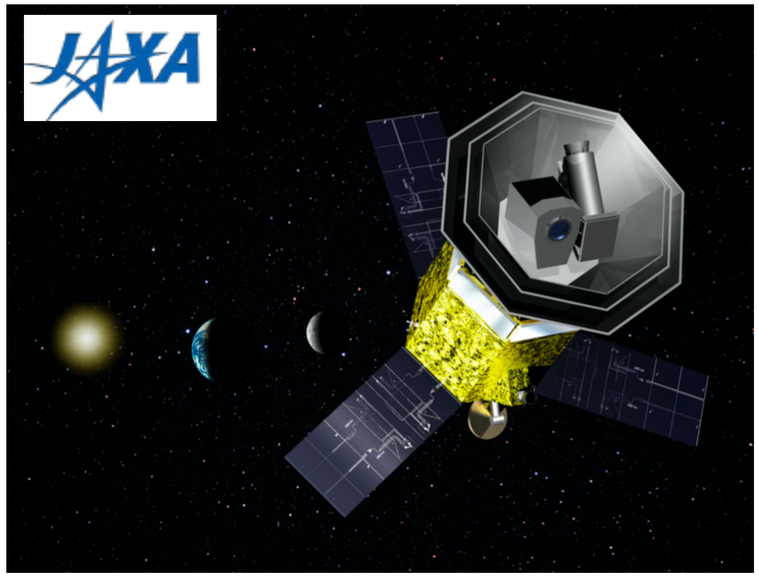
on behalf of LiteBIRD Collaboration

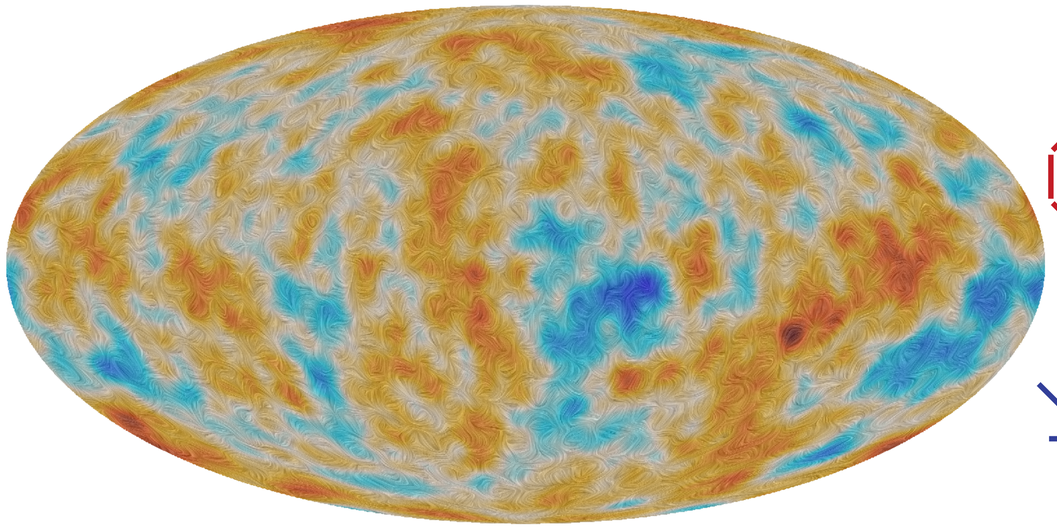
CMB-France #7

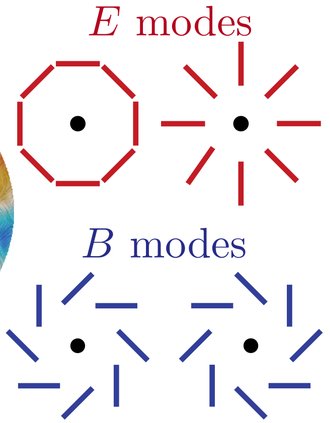
LiteBIRD Mission

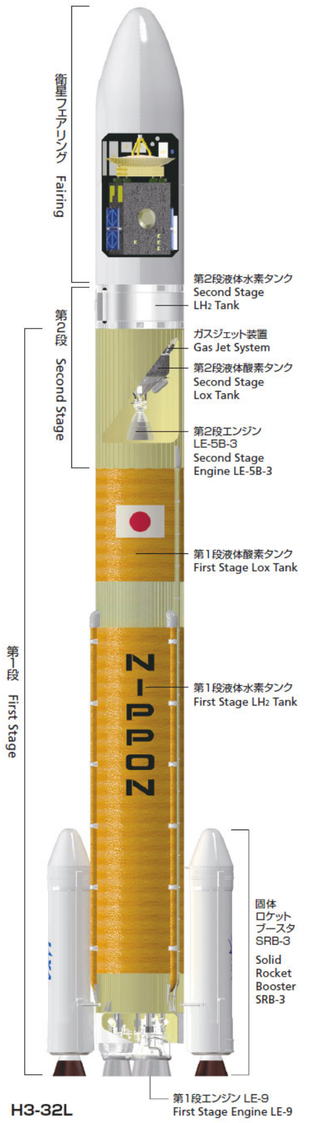
- Lite (Light) spacecraft for the study of *B*-mode polarization and Inflation from cosmic background Radiation Detection
- JAXA's L-class mission was selected in May 2019 to be launched by JAXA's H3 rocket.
- **All-sky 3-year survey**, from Sun-Earth Lagrangian point L2
- Large frequency coverage (**40–402 GHz**) at **53–6 arcmin** angular resolution for precision measurements of the **CMB *B*-modes**
- Final combined sensitivity: **2.2 μK·arcmin**

📖 LiteBIRD collaboration PTEP 2023







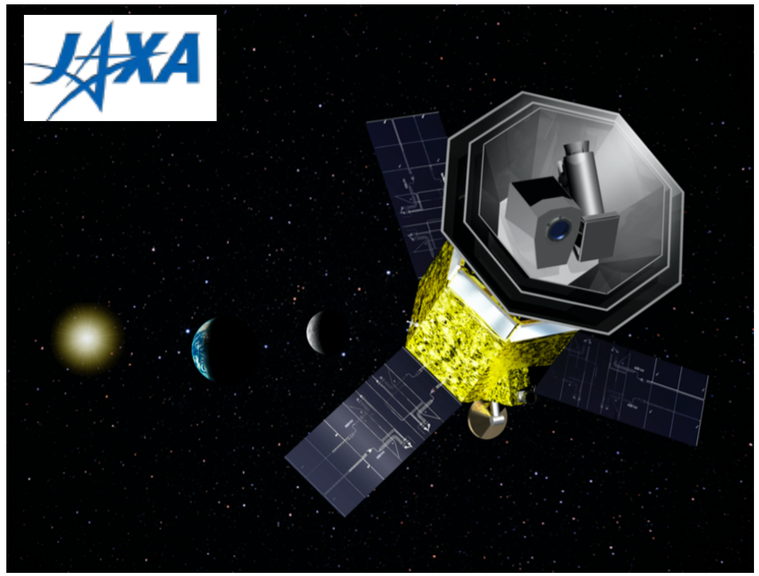


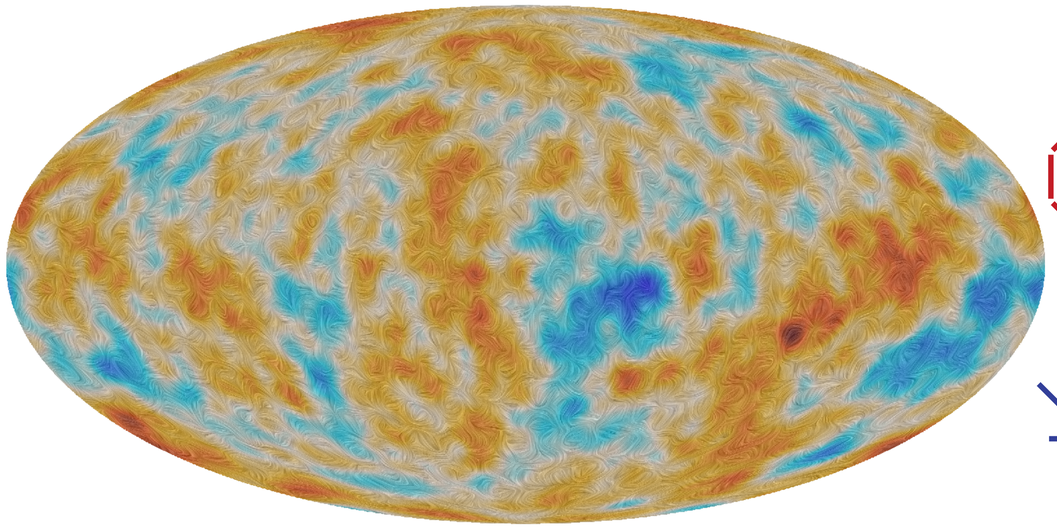
LiteBIRD Mission

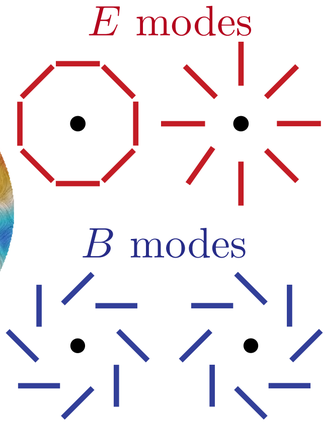
LiteBIRD reformation phase from Sep 2024

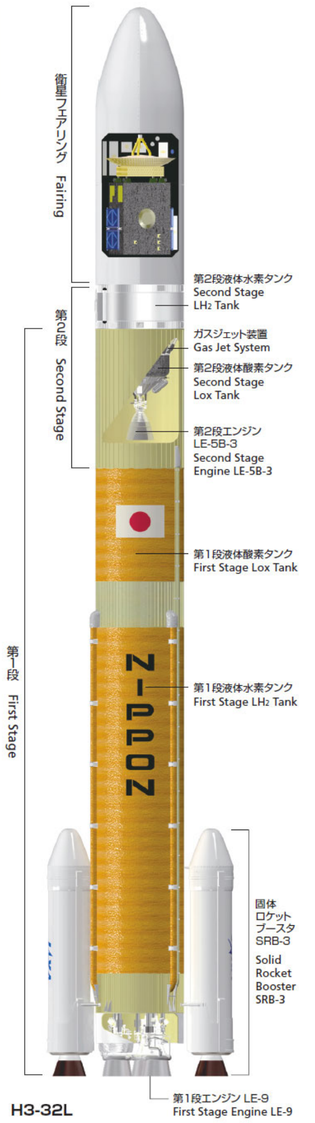
- After the ISAS/JAXA mission definition review, LiteBIRD is under rescope studies to consolidate the mission's feasibility with the same scientific objectives.
- The LiteBIRD collaboration spent one year (till Sep 2025) on the studies of the reformation plan.

📖 LiteBIRD collaboration PTEP 2023









LiteBIRD Mission

LiteBIRD reformation phase since Sep 2024 (in a nutshell)

Why

- Jul 2024: New financial constraints
- Sep 2024: Key Decision Point #1 by JAXA
  - one year Reformation Study

What

- Rescope with same scientific goals
- Broaden the scientific case → Reformulation of top-level requirements
- Simplification & consolidation of the design → 1 single telescope (w/ or w/o HWP)
- Increase feasibility, lower risk
- Within original budget at JAXA
- Need a new procurement for Detection Chain → Consolidation detectors procurement

When

- Sep 2025: Key Decision Point #2 by JAXA
- Mid 2026: Mission Definition Review #2 by JAXA

LiteBIRD Mission

A tight action plan during reformation phase

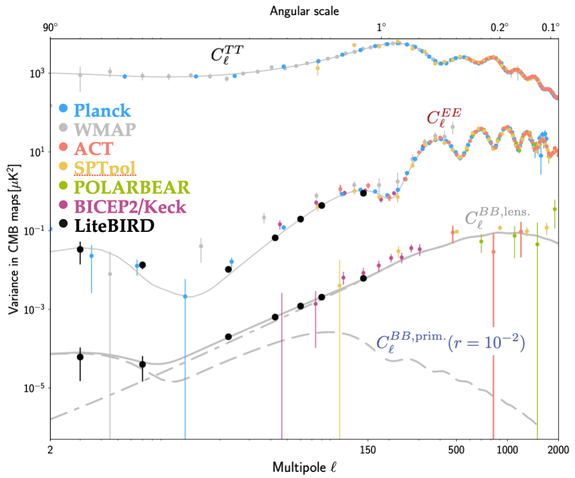
LMHFT Project Office (cnes)	• Optimisation of new design with a single telescope ✓ • New procurement tree assessment ✓ • Calibration PBS re-discussion ✓ • Consolidation between agencies ✓
TF Sensitivity Forecasts	• Comparative analyses of various designs (w/ & w/o HWP) ✓ • Optimisation of FP layout ✓ • Optimisation of number of bands ✓
TF Requirements	• New recipe for top-level requirements (map-depth based) ✓ • New consolidated Requirements Flow-down ✓
JSG Systematics	• Revisit the systematics budget allocation ✓ • Simulation effort on key systematics ✓
TF Detectors Procurement	• Detectors Technical trade-off ✓ • Detectors Procurement trade-off ✓ • Costing estimates ✓

LiteBIRD Mission

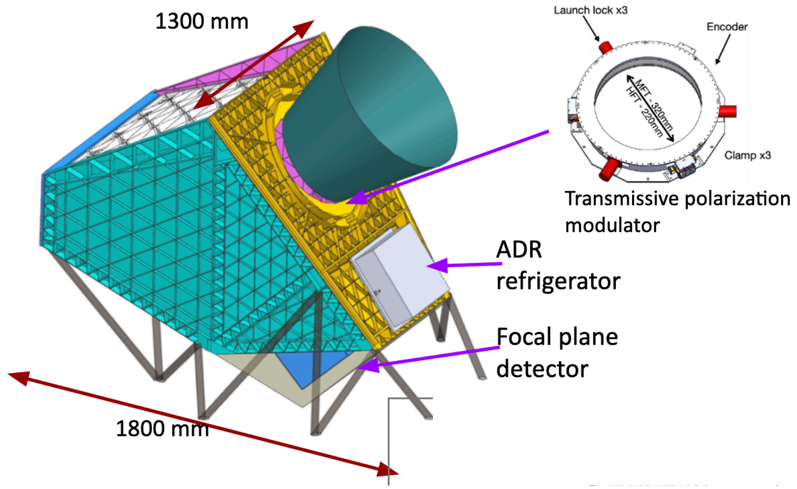
Outcomes of Reformation Phase:

Reformulation of scientific objectives

- For $r = 0$, **stat uncertainty of $\sigma r < 0.001$ (no systematics)**
- For $r = 0.01$, 3-σ detection of the reionization ($2 < \ell < 10$) and recombination ($11 < \ell < 200$) peaks independently



1 single telescope (w/ or w/o HWP)



Sep 2025: Key Decision Point #2 by JAXA

Successful !

Consolidation detectors procurement

Baseline = European procurement

Detectors R&D development plan up to TRL5 submitted to ESA D/TEC

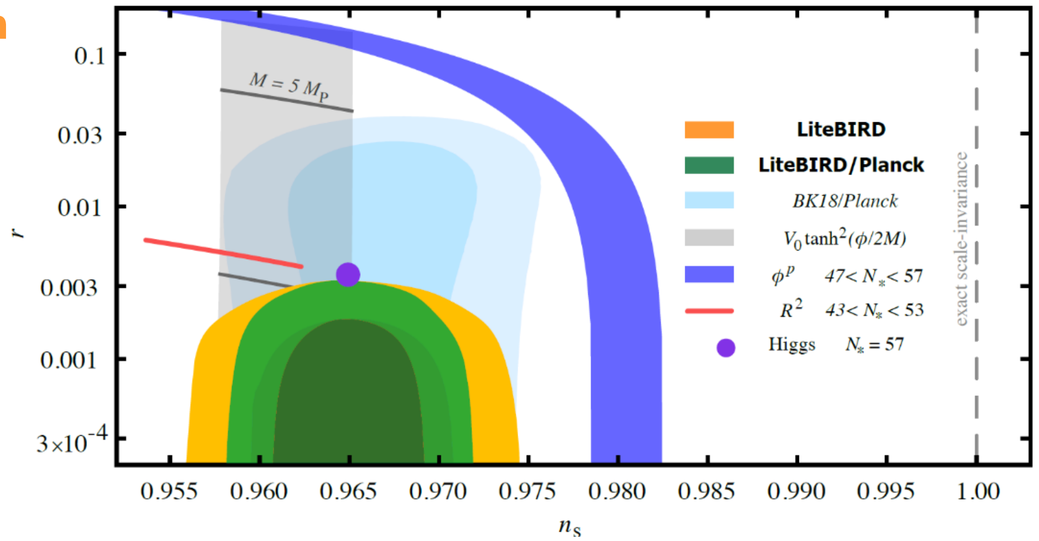
Led by Italy (INFN & ASI), NL (SRON), and Cardiff (UKSA), in cooperation with France, Switzerland, Finland, Spain, and Canada

Letter of support from ESA-DG received in Sep 2025

LiteBIRD Mission

Main Scientific Objectives

- Definitive search for the ***B*-mode signal** from **cosmic inflation** in the CMB polarization
  - Making a discovery or ruling out well-motivated inflationary models
  - Insight into the quantum nature of gravity
- The inflationary (i.e. primordial) *B*-mode power is proportional to the **tensor-to-scalar ratio, *r***
- Current best constraint: $r < 0.032$ (95% C.L.)
  (📖 Tristram et al. 2021, combining BK18 + Planck PR4 data)



Outputs objectives: Creation of all-sky multi-frequency microwave polarisation maps

Outcome objectives:

1. Verifying representative inflationary universe theories by measuring the intensity of primordial waves

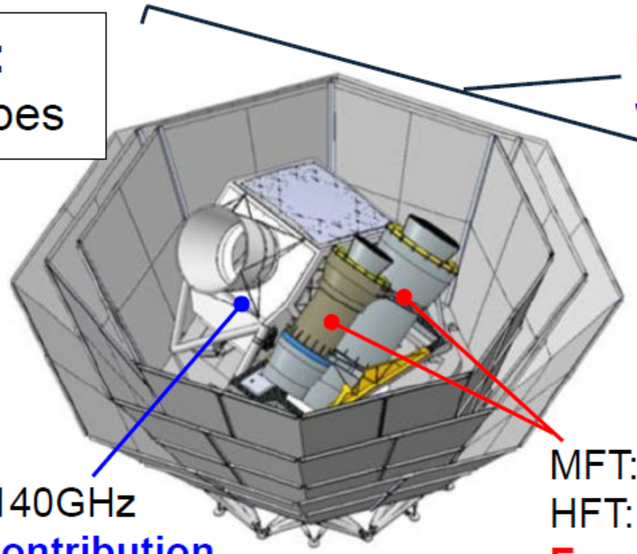
2. Creation of scientific knowledge in cosmology, particle physics, and astrophysics

1. Power spectrum features in polarization
   - Large-scale ***E*-modes**
   - **Reionization** (improve $\sigma(\tau)$ by a factor of 3)
   - **Neutrino mass** ($\sigma(\sum m_\nu)$ = 12 meV)
2. Constraints on **cosmic birefringence**
3. **Gravitational lensing**
4. **SZ effect** (thermal, diffuse, relativistic corrections)
5. **Anisotropic distortions** of the CMB spectrum
6. Constraints on **primordial magnetic fields**
7. Elucidating **anomalies**
8. Physics of **Galactic emission** mechanisms
9. Catalogues of polarized **point sources**

Design Simplification

Optical design (TBC)

Original plan:
Three telescopes

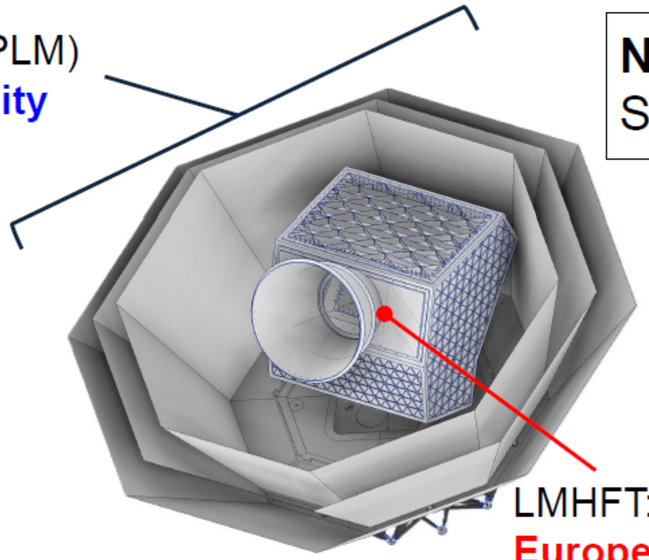


Payload Module (PLM)
JAXA responsibility

LFT:40-140GHz
Japan contribution
(JAXA lead)

MFT:100-195GHz
HFT: 195-402GHz
Europe contribution
(CNES lead)

New LiteBIRD:
Single telescope

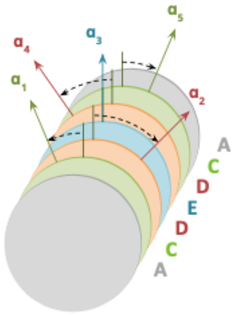


Cooling chain (300K to 0.1K) is also greatly simplified in the reformation study.

LMHFT:40-402GHz
Europe/Japan contribution
(CNES lead)

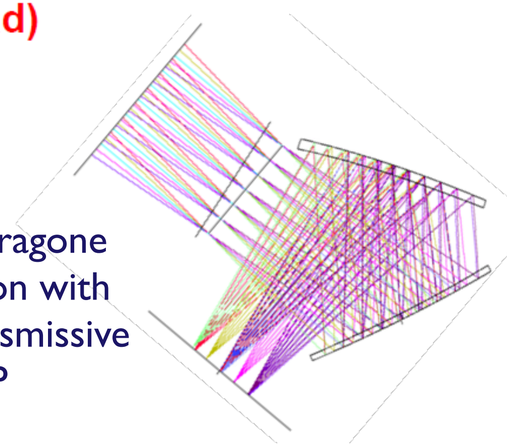
Thanks to a new HWP design with a very broad frequency range

5x6C



Example of stacking five 6-layer capacitive metal-mesh grids according to the Pancharatnam recipe

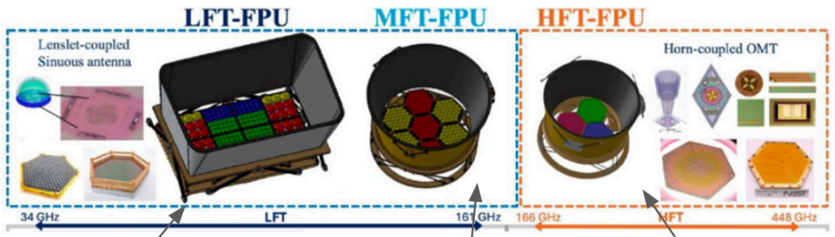
Crossed-Dragone configuration with rotating transmissive HWP



Design Simplification

Focal Plane (TBC)

Developed based on US technology



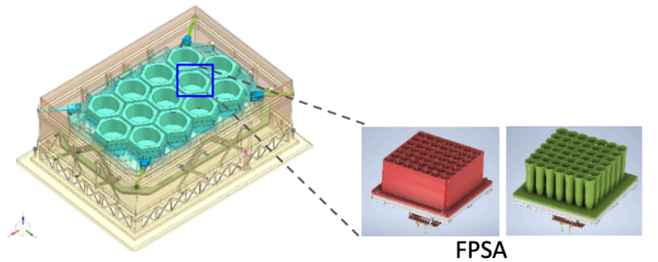
3 frequencies per pixel
Lenslet+Sinuous antenna
(Berkeley)

3 frequency bands per pixel
Lenslet+Sinuous antenna
(NIST)

2 frequencies per pixel
Horn+OMT
(NIST)

Focal plane detector configuration of the previous plan

Developed based on European technology



FPA

FPSA
(Left: high freq., Right: low freq.)

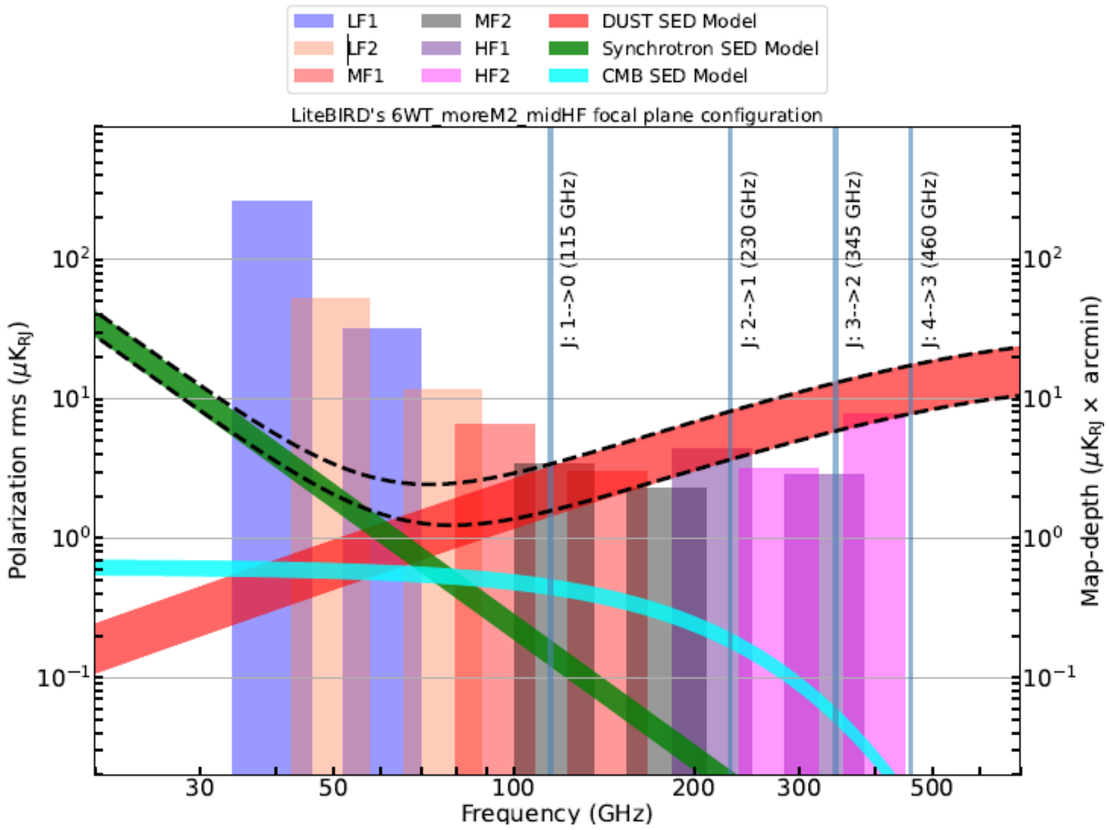
Unified to 2 frequency bands per pixel,
Horn + OMT

FPA/FPSA under consideration in Reformation

Led by ASI with SRON, UKSA

under support from ESA

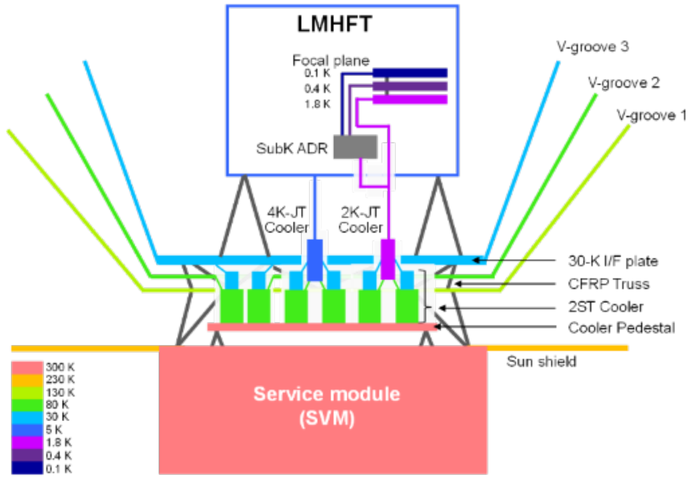
A single Focal Plane with 12 bands obtained with 6 dichroic wafer types spanning from 34GHz to 448GHz

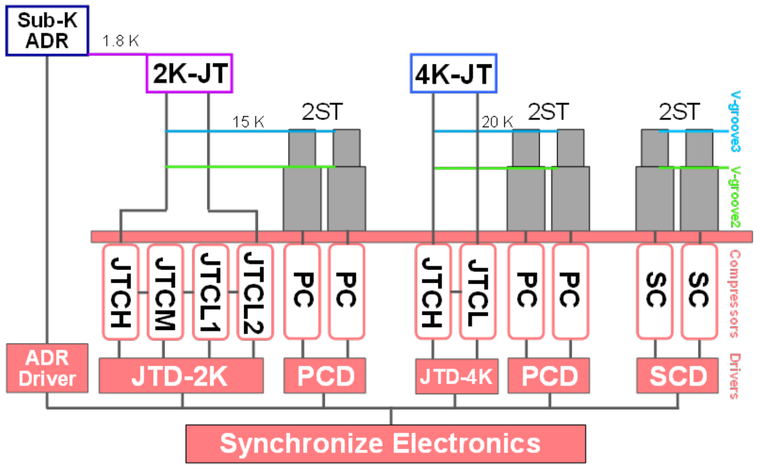


GHz	FWHM
40	53.4
61	37.8
50	42.5
77	29.9
94	22.6
145	15.6
118	18.5
182	13.1
217	10.3
334	7.6
280	8.0
402	6.3

Design Simplification

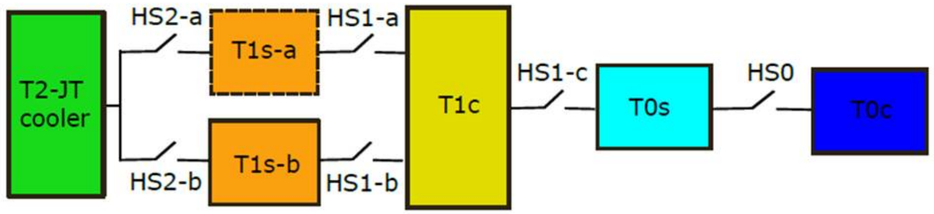
Cryo-chain & Sub-K Cooler (TBC)



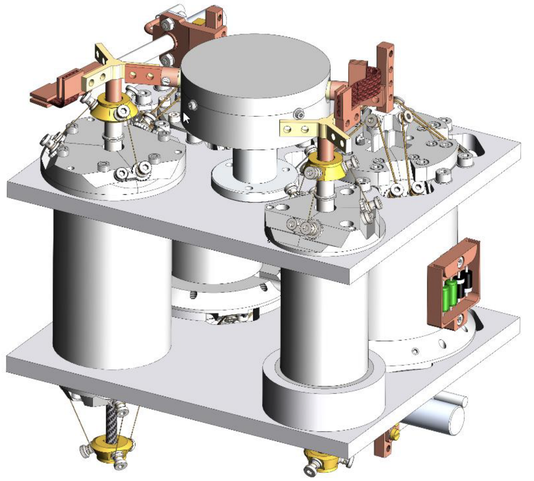


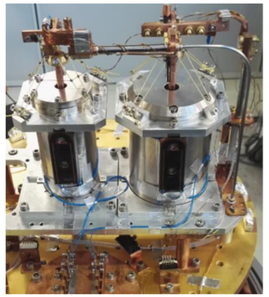
Sub-K Cooler

- Continuous cooling at 100mK
- 4 ADRs in series
- **Single chain for a single FP**



- High maturity
- Concept Demonstration @ 350mK with 2.7K interface



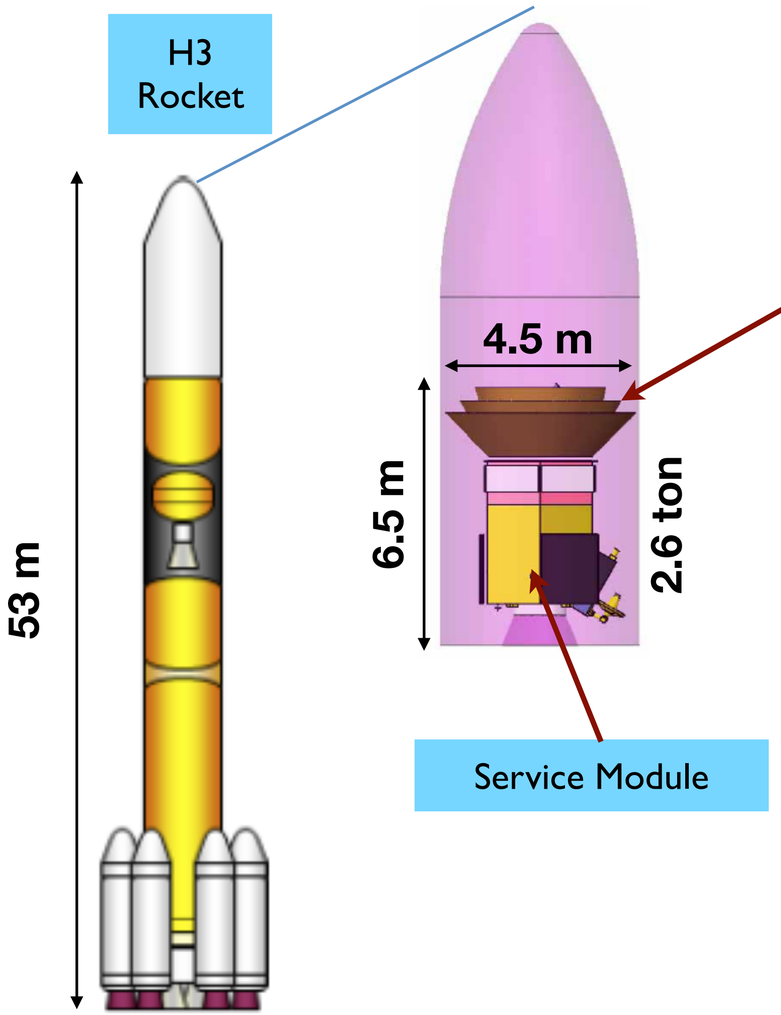


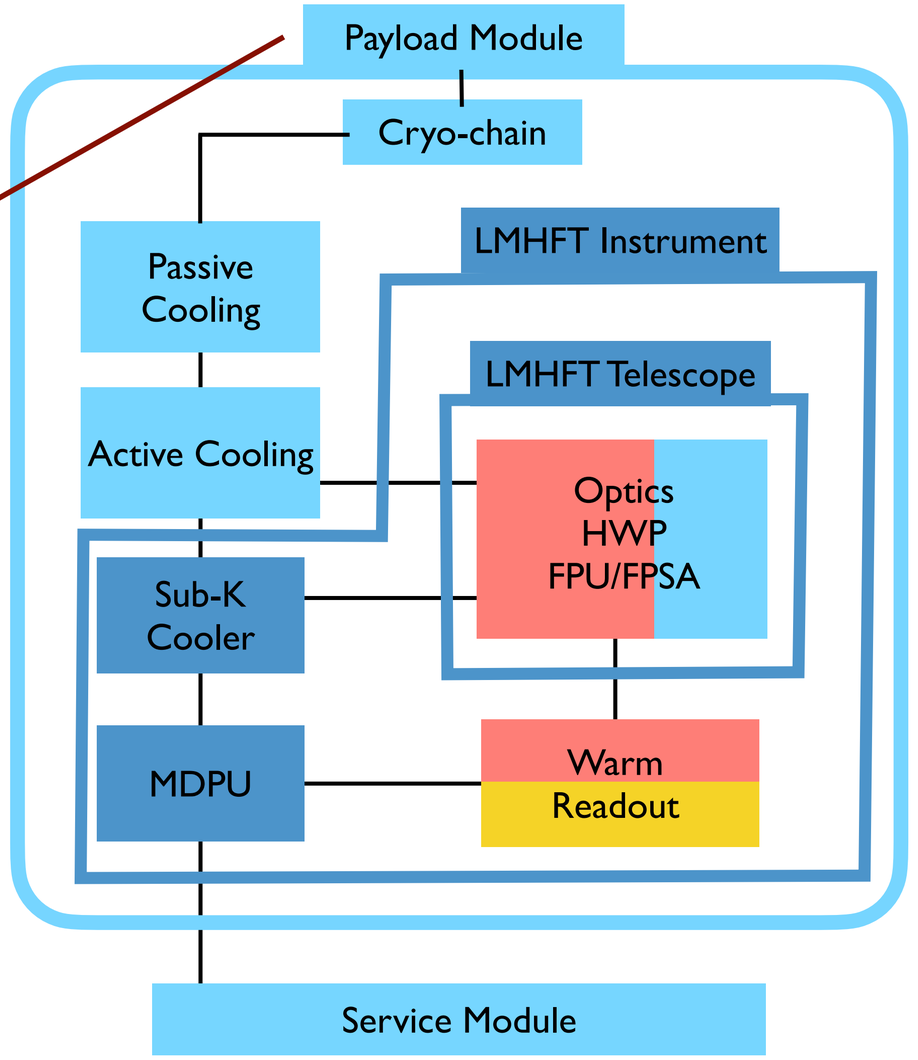
4 hours cycles
2.7 K interface

Procurement Update: (under discussion)

Oct 2025

International Task Sharing





JAXA

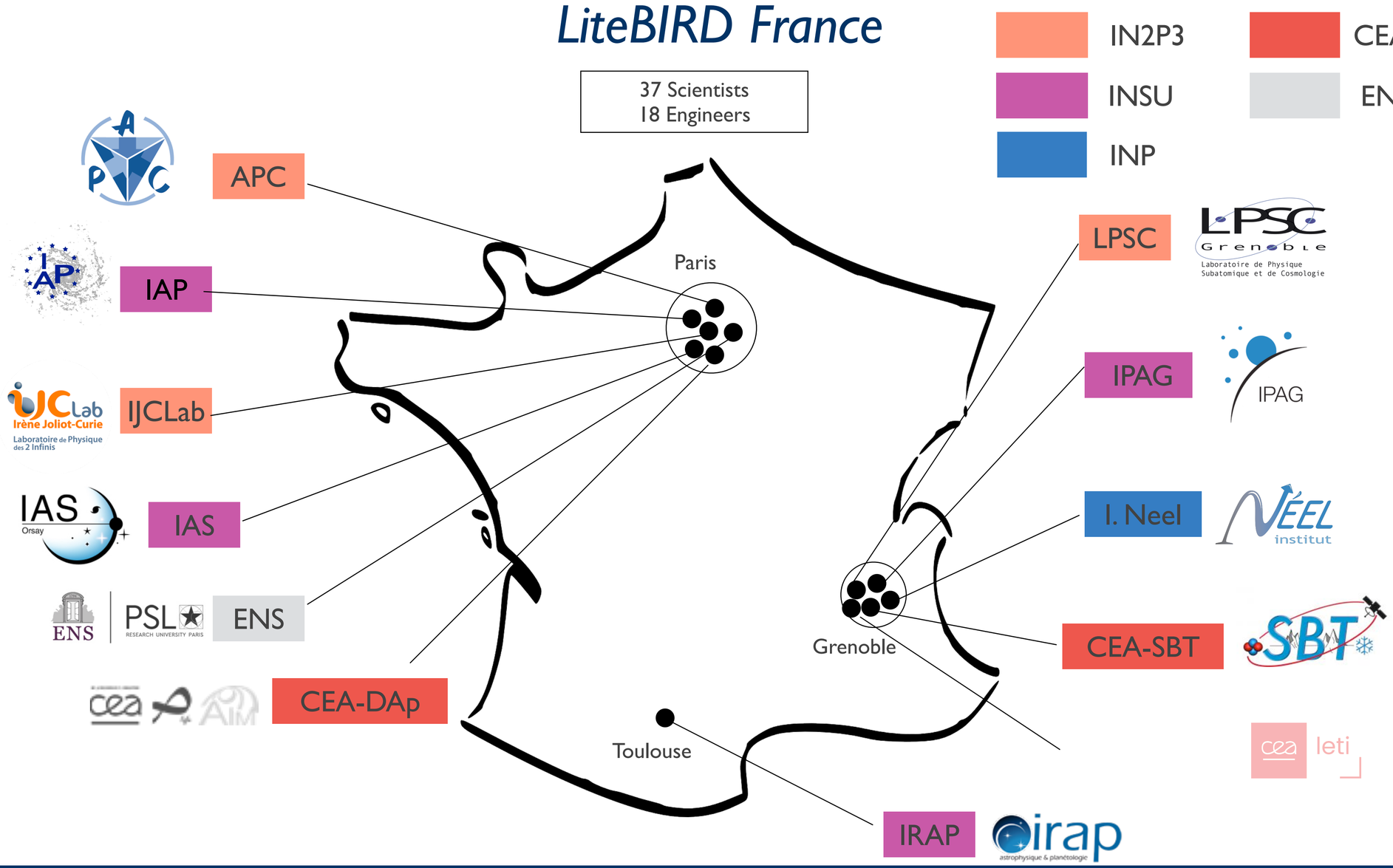
CNES

EU

CA

leading the single instrument

The LiteBIRD Collaboration



The LiteBIRD Collaboration

LiteBIRD France

37 Scientists
18 Engineers

IN2P3 | CEA | INSU | ENS | INP

Oct 2025

Organisation

LiteBIRD Collaboration

Oct 2025

PI: Tomotake Matsumura (JPN)
deputy-PI: Hirokazu Ishino (JPN)
EU-SP: Ludovic Montier (IRAP)

Interim Governance Board

40 members
(7 French)

Coordination Team

T. Matsumura (JPN)
H. Ishino (JPN)
L. Montier (IRAP)
F. Piacentini (IT)

G. Patanchon (APC)
S. Henrot-Versillé (IJCLab)
A. Banday (IRAP)
L. Pagano (IT)
Y. Chinone (JPN)

Joint Study Groups

Calib + Systematics	**G. Patanchon (APC)** H. Ishino (IPMU) **S. Henrot-Versille (IJClab)** M. Tsujimoto (ISAS)
Foregrounds	N. Katayama (Japan) R. Flauger (US) C. Baccigalupi (Europe)

Data Management Group

Paolo Natoli (Italy)
M. Tristram (IJClab)

Instrument Model Team	**S. Henrot-Versillé**
Simulation Team	M. Tomasi
Production Team	G. Pugliisi
Map-making, Power-Spectrum, Likelihood algorithms	Y. Chinone

Publication Board

A. Banday (IRAP)
T. Matsumura (Japan)

Liaison:
J. Aumont (IRAP)

Speaker Selection

B. Barreiro (Spain)

Membership Board

H. Ishino (JPN)
A. Lee (US)
F. Piacentini (IT)

Deep involvement of the French community in the LB collaboration and in the management levels

Programmatic in Europe

European Collaboration

Oct 2025

Committed in Phase-A2 leading the **Single Instrument since Mid-2024**

France

APC (Paris)
CEA-DAp (Saclay)
CEA-SBT (Grenoble)
ENS-LERMA (Paris)
IAP (Paris)
IAS (Orsay)
Institut Néel (Grenoble)
IPAG (Grenoble)
IRAP (Toulouse)
IJCLab (Orsay)
LPSC (Grenoble)

Italy

Università di Roma "Tor Vergata"
Università di Milano
Sapienza Università di Roma
INAF/IASF, Bologna
INAF/OATS, Trieste
Università di Milano-Bicocca
Università di Genova
INFN-Sezione di Pisa
Università di Ferrara
Università di Padova
SISSA – Trieste

UK

Cardiff University
University of Cambridge
Imperial College London
University of Manchester
University College London
University of Oxford
University of Portsmouth
University of Sussex

Germany

Max Planck Society (MPA, MPE, MPIfR)
Ludwig-Maximilians-Universität München
Universität Bonn
RWTH Aachen Universität

Phase-A commitment:

- France:
  - Phase A1 2018
  - Phase A2 (LMHFT leadership) 2020
- Italy: 2018
- Spain: 2021
- Germany: 2022
- Belgium: 2022
- UK 2023

Spain

IFCA, IDR/UPM, DICOM/UC
ICCUB, IAC
Universidad de Oviedo
Universidad de Salamanca
Universidad de Granada
CEFCA

Holland

SRON
RuG

Norway

University of Oslo

Belgium

CSL
University Louvain

All European Partners working with CNES inside the Reformation Plan

~240 scientists, including experts on instrument and data analysis

Programmatic

Toward the JAXA LiteBIRD Project Phase

Oct 2025

Sep 2024

JAXA Key Decision Point #1

Start of Reformation Phase

Mar 2025

CNES Key Point

Selection of design baseline

Sep 2025

JAXA Key Decision Point #2

Conclusion Reformation Phase

Mid 2026

JAXA Mission Definition Review #2

Starting JAXA **Project Phase**

for ~3 years

Beg 2026

Start of Detectors Development BBM

led by ASI under ESA support

for ~2 years

Launch Date to be revised :

around mid-2030's

Science Exploitation

The Science Study Groups

A new set of Science Study Groups dedicated to science forecast with LiteBIRD.
Short term goal (1-2 years)

9 Scientific Forecasts Groups

- LiteBIRD: Isotropy and Statistics — A. Banday
- LiteBIRD: Tests of Cosmic Inflation
- LiteBIRD: Optical Depth, Reionization of the Universe, and Neutrino Masses — M. Tristram
- LiteBIRD: Cosmic Birefringence — J. Errard
- LiteBIRD: Mapping the Hot Gas in the Universe
- LiteBIRD: Primordial Magnetic Fields
- LiteBIRD: Gravitational Lensing of the CMB
- LiteBIRD: Cross-correlation Science
- LiteBIRD: E-modes
- LiteBIRD: B-modes — C. Leloup

Galactic Science Project Study (GSPS) — J. Aumont

- 3D Galaxy
- Dust Properties / AME
- Foreground Separation techniques for Galactic Science

→ • 48 published papers
• 3 post-PTEP to be published
• 7 post-PTEP in prep.
• 36 other papers in prep.

→ MoU between
CMB-S4 and LiteBIRD

Science Forecast Activity is increasing
We have to put more resources on this

Opportunity to include new members on dedicated forecast activities

Science Exploitation

The Science Ground Segment

Oct 2025

Task-Force SGS #1 Done

- Prepare a document summarizing information and discussion at past LiteBIRD IGB meetings and global meetings on science ground segments (SGSs) and related collaboration governance.
- Identify differences between projects led by Europe, Japan, and the US.
- Study possible LiteBIRD SGS configurations(1). Evaluate, compare, and score them(2).

Task-Force SGS #2 Done

- Triggered by JAXA
- Members: representatives of partner agencies
- Tasks:
  - ✦ SGS role and scope
  - ✦ Estimate of computing / human ressources
  - ✦ Basic organisational structure
  - ✦ Data Management Plan

France:
- Laurence Chaoule (CNES SGS director)
- Matthieu Tristram

SGS Preparation Team (to be formed soon)

- Triggered by JAXA
- Members: representatives of partner agencies
- Led by Tokyo IPMU
- Tasks:
  - ✦ SGS structure conceptual study
  - ✦ Organizational plans
  - ✦ Role sharing

SGS to be included into global task-sharing for MDR#2

Take-away Message

Strong activity on the Reformation Plan

- Reformation Plan since Sep 2024 ended in Sep 2025 with a successful KDP#2
- Design Simplification with increased feasibility
  - Same scientific goals, with broader scientific outcomes
  - Strong commitment of CNES into single instrument lead
- Building a Detectors R&D development in Europe under ESA support
- Preparation of Science Exploitation still beeing reinforced: Science Study groups / papers / SGS / Simulations
- Next Steps:
  - Beg 2026: Start of Detectors R&D
  - Mid 2026: JAXA MDR#2

Launch date to be updated :
around mid-2030's


LiteBIRD