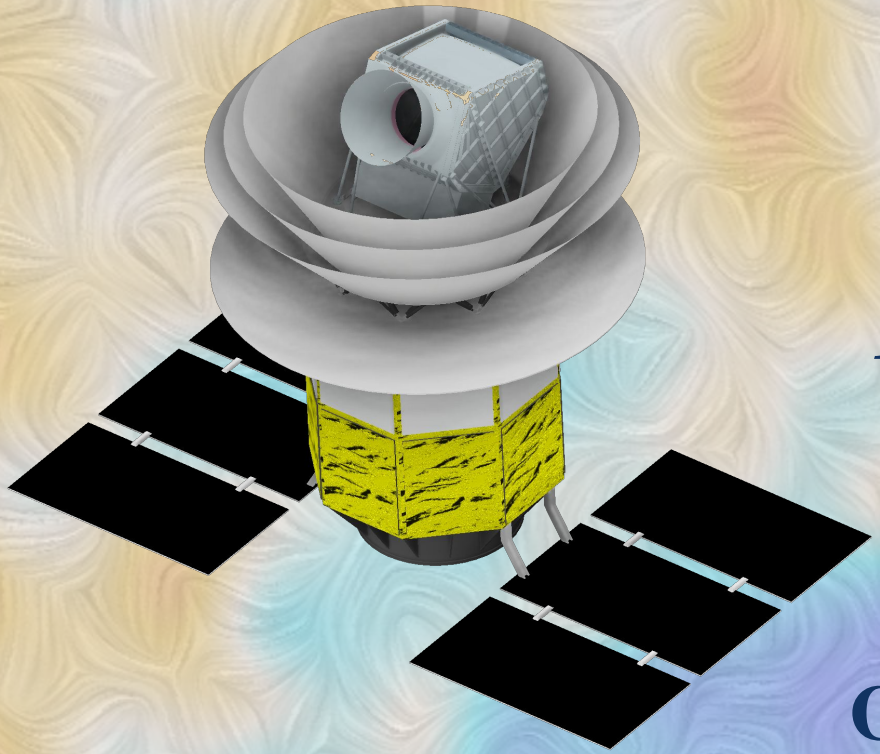
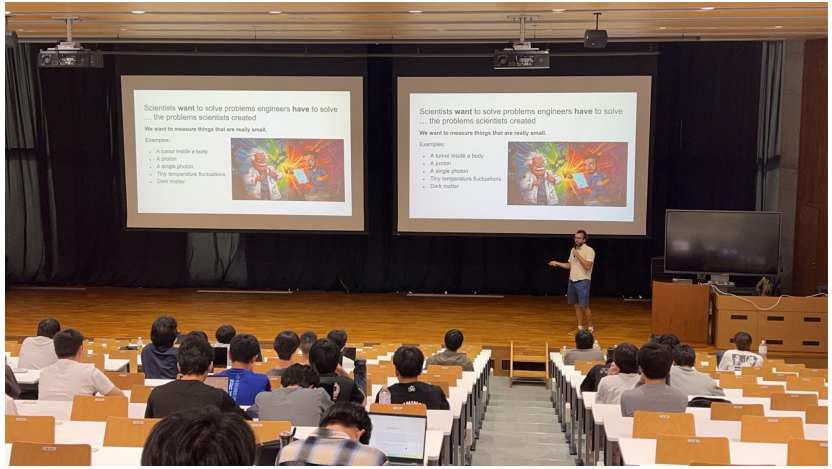
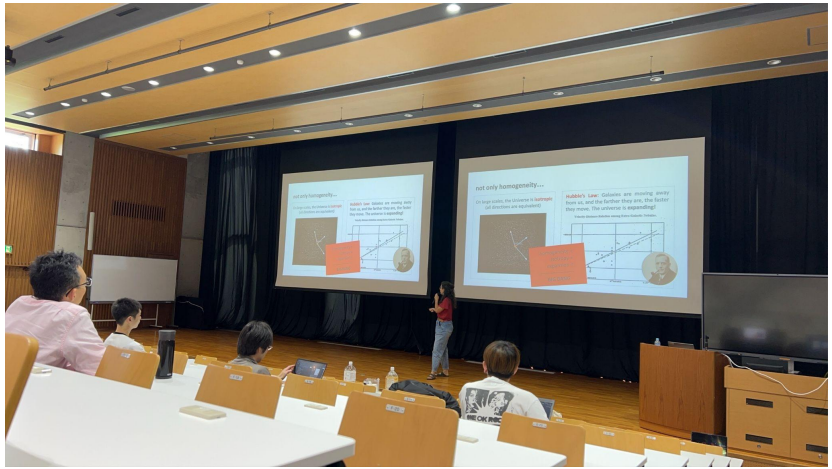


LiteBIRD

Ryota Takaku
Okayama University
On behalf of LiteBIRD collaboration

Outreaching event at Suwa University

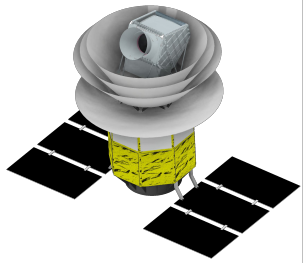




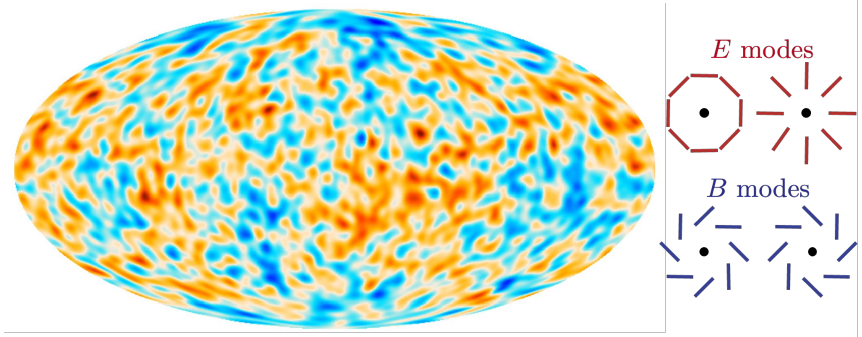
LiteBIRD overview

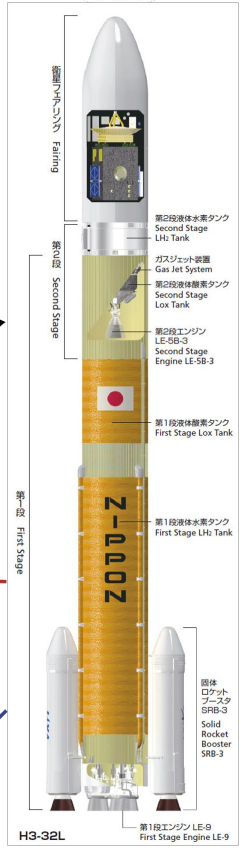
Lite (Light) spacecraft for the study of B-mode polarization and Inflation from cosmic background Radiation Detection

- JAXA's L-class mission selected in 2019 to be launched by JAXA's H3 rocket on JFY2036
- Scientific goals: test inflationary models through the measurements of primordial gravitational waves, and provide new insights into cosmology, particle physics and astrophysics



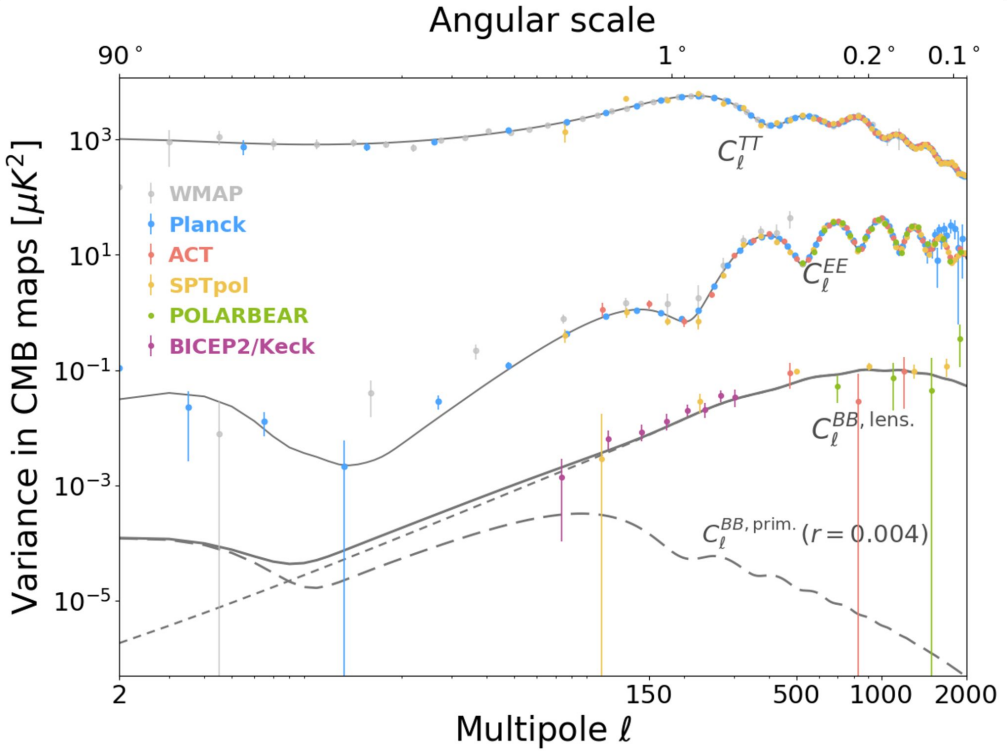
- All-sky 3-year survey from L2
- Frequency coverage: 40-402 GHz
- Angular resolution: 70-18 arcmin
- Final sensitivity: O(1) uK arcmin





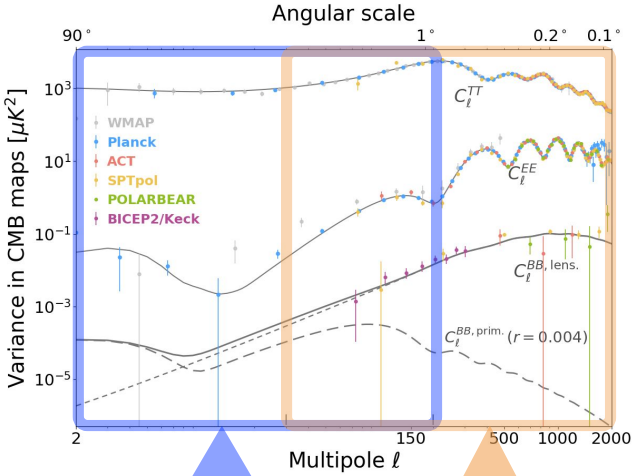
LiteBIRD main scientific objectives

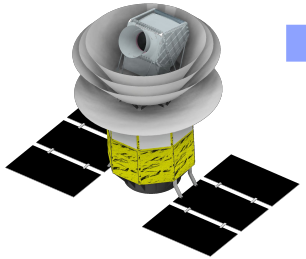
- *B*-mode signal from cosmic inflation
- The inflationary B-mode power is proportional to the tensor-to-scalar ratio, r
- Current best constraint: $r < 0.032$
  (Tristram et al. 2022, combining BK18 and Planck PR14)
- LiteBIRD will significantly improve the current sensitivity on r
- The final goal: to achieve a statistical uncertainty of $\sigma(r) \lesssim 0.001$ for $r = 0$



Satellite and ground

Satellite	Ground
Observe full sky No atmosphere effect No limitation of the bands	Rapid development speed Possible to fix No limitation of size
Stringent requirement No chance to fix Limitation of size	Limited sky fraction Atmosphere effect Limited observation bands





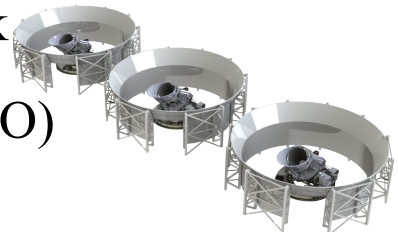
LiteBIRD

$2 \leq \ell \leq 200$

Yoshi's talk

Simons Observatory (SO)

$30 \leq \ell$



LiteBIRD constraints on inflation

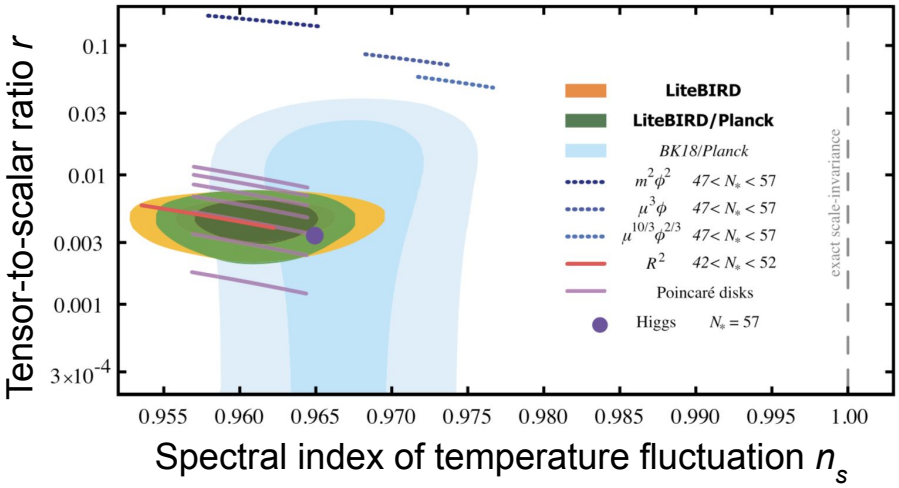
If *LiteBIRD*

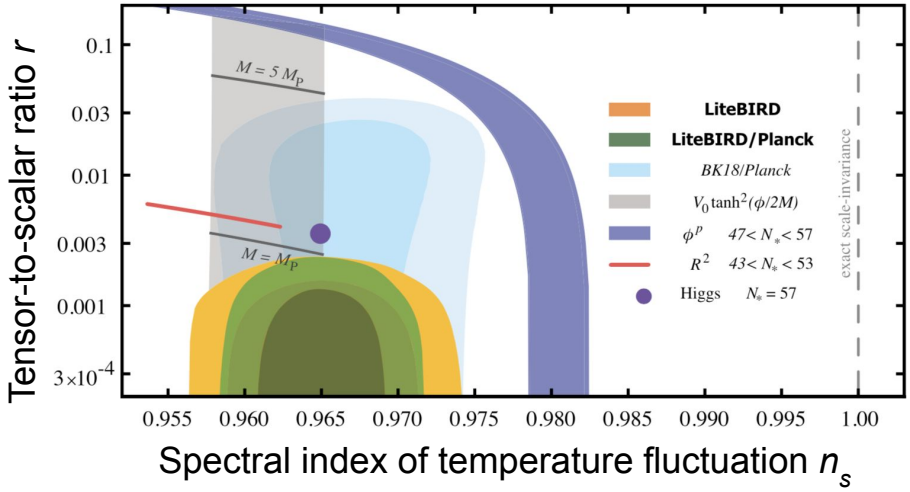
detects primordial B–mode

- Strong evidence for inflation
- Measures the energy scale of inflation
- r > 0.01 would imply the excursion of the inflation field exceeding M_{pl}

does not detect primordial B–mode

- A strong upper limit of r
- It would rule out simple inflation models

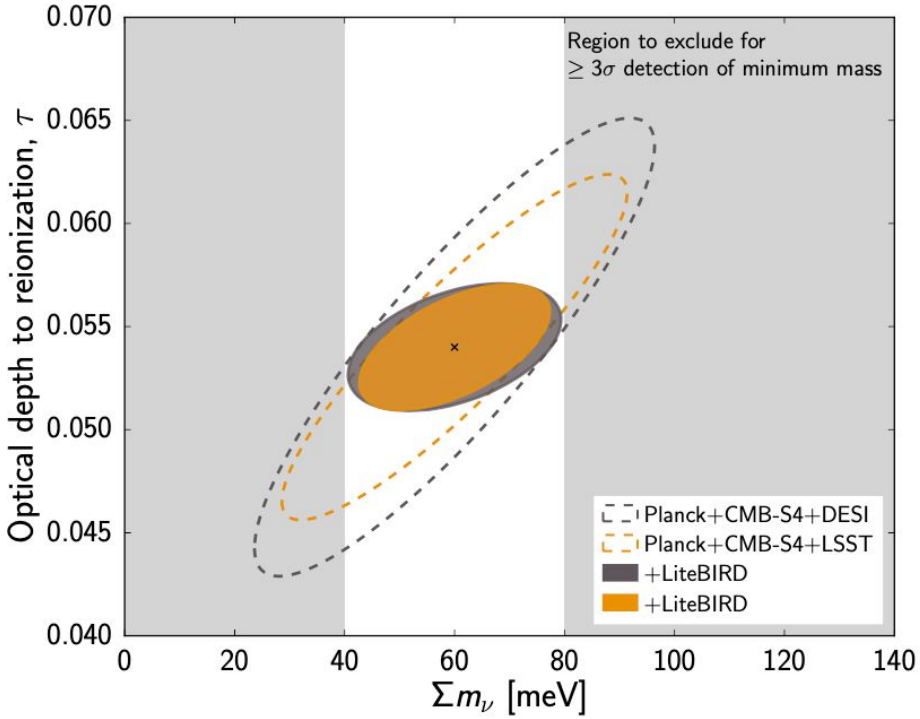




LiteBIRD other science outcomes

- Reionization and neutrino mass
- Precise measurement of large-scale E-modes
  → σ(τ) ~ 0.002

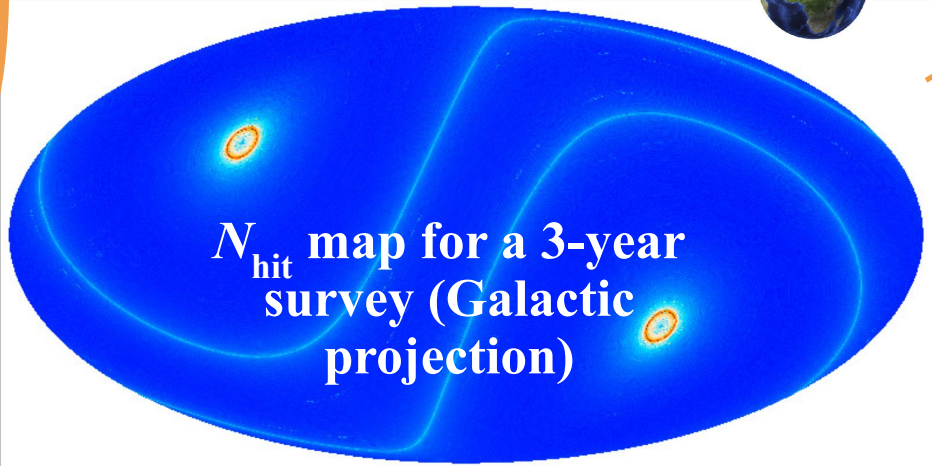
- τ limits cosmological constraints on Σmν
- LiteBIRD + external data improves neutrino-mass constraints

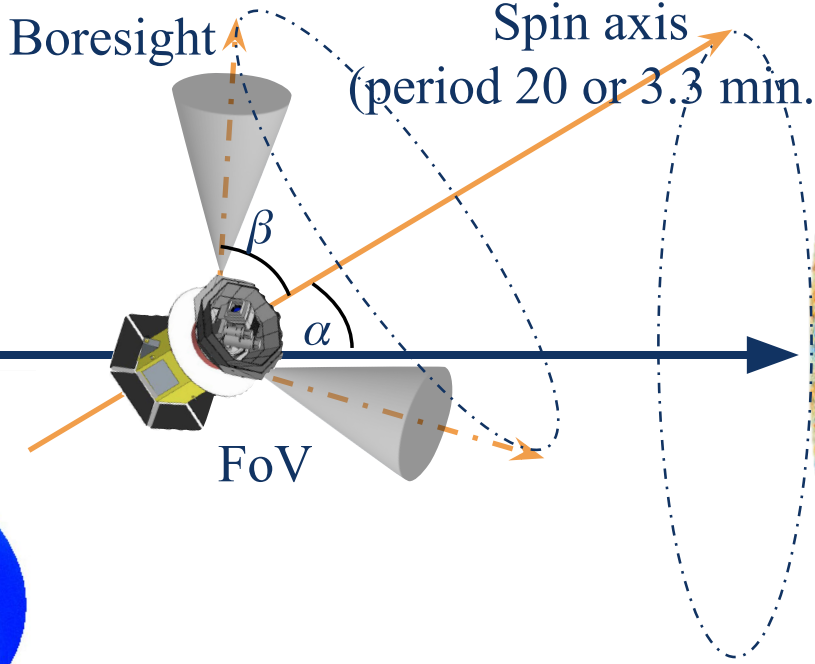


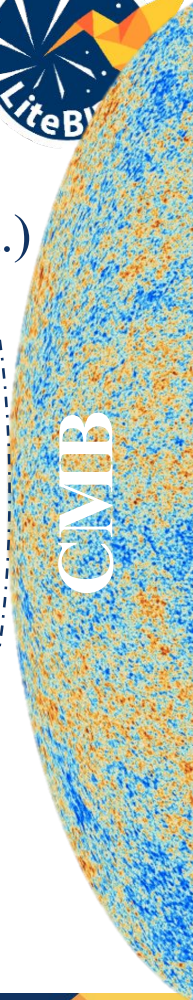
Examples from LiteBIRD Collaboration, PTEP 2023

LiteBIRD scanning strategy

- **3-year survey, Sun-Earth L2 Lissajous orbit**
- **Precision angle: α = 37.5°**
- **Spin angle: β = 57.5°**

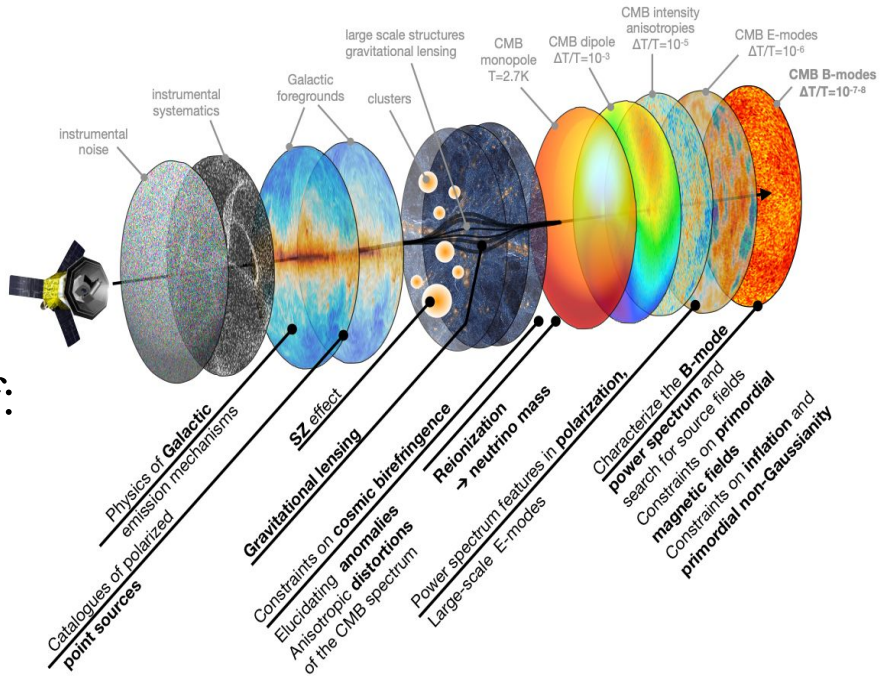






The challenge of B-mode detection

- The B-mode signal is expected to have an amplitude at least 3 orders of magnitude below the CMB temperature anisotropies
- LiteBIRD is targeting a sensitivity level in polarization ~30 times better than Planck
- This extremely good statistical uncertainty must go in parallel with exquisite control of:
  a. Instrument systematic uncertainties
  b. Galactic foreground contamination
  c. “Lensing B-mode signal” induced by gravitational lensing
  d. Observer biases

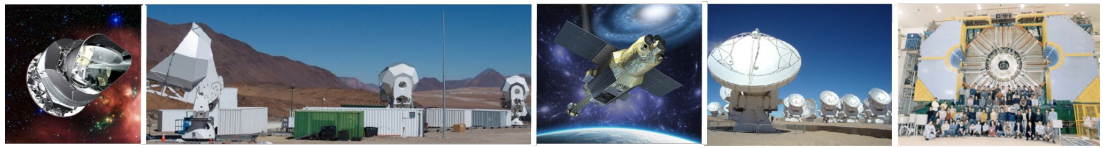



LiteBIRD

LiteBIRD Joint Study Group

Around 400 researchers from Japan, Europe and North America

Team experience in CMB experiments, X-ray satellites and other large projects (ALMA, HEP experiments, …)



LiteBIRD reformation phase

2024
- Mission Definition Review 1 (MDR1)
- KEK (QUP) decided to relinquish their responsibility for delivery of flight components (focal plane detectors)
- Key decision point (KDP1)
  - The LiteBIRD collaboration would conduct investigating reformation plans
  - ISAS/JAXA would judge the continuation of the project after KDP2

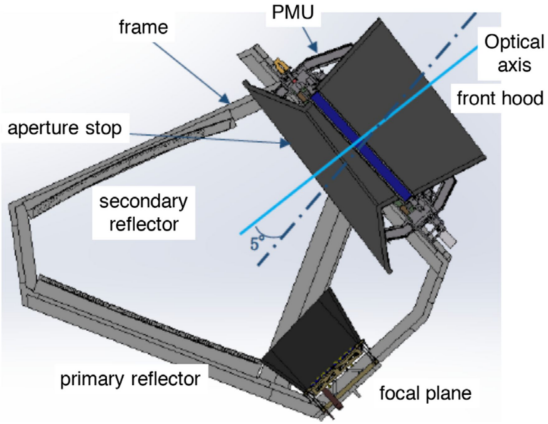
2025
- LiteBIRD PI has changed to Tomotake Matsumura
- CNES KP
- KDP2
  - Europe is in charge of procurement of focal plane detectors
  - ISAS/JAXA judged the continuation of the project. Moving forward to MDR2

2026

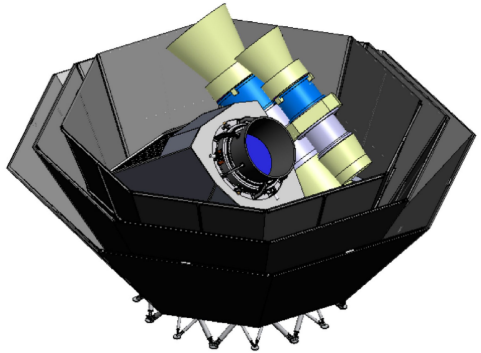
Now
- MDR2

LiteBIRD before reformation

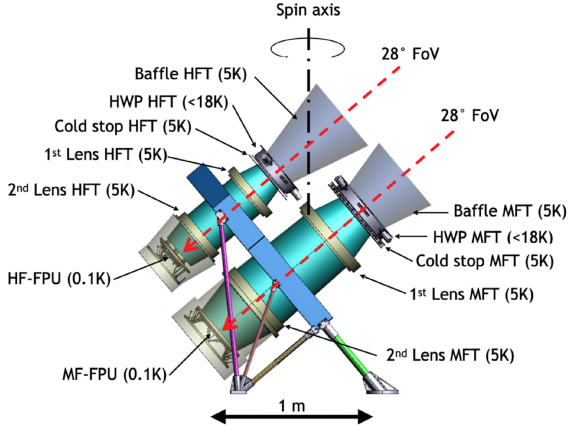
Low-frequency telescope (LFT)



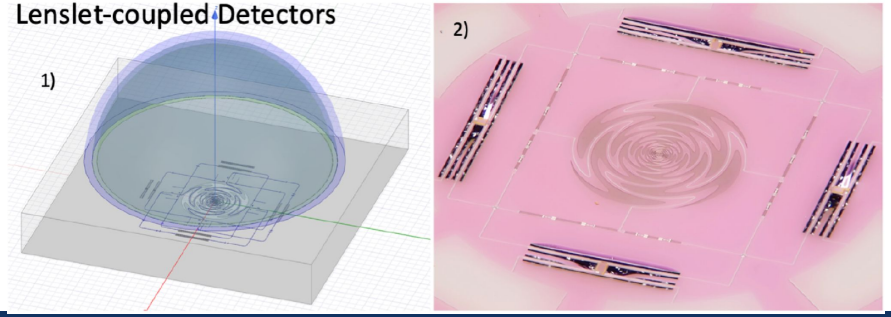
Mid- High frequency telescope (MHFT)



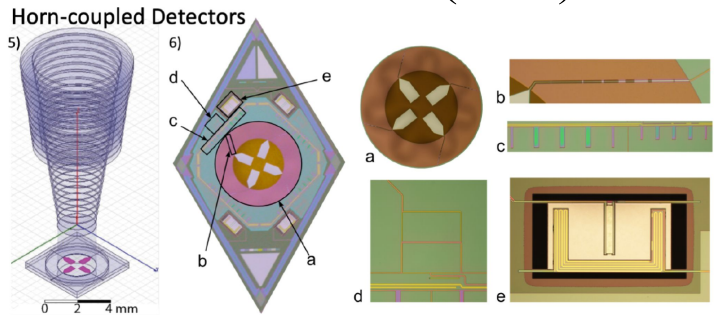
4500 detectors



Lenslet + sinuous antenna (L, MFT)

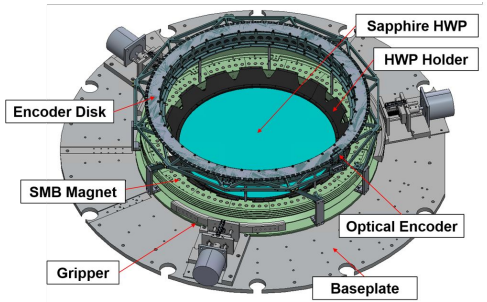


Horn + OMT (HFT)

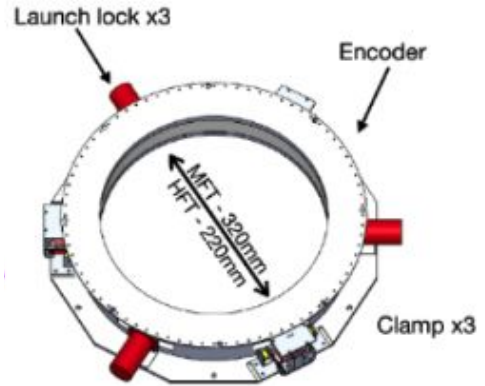


LiteBIRD before reformation

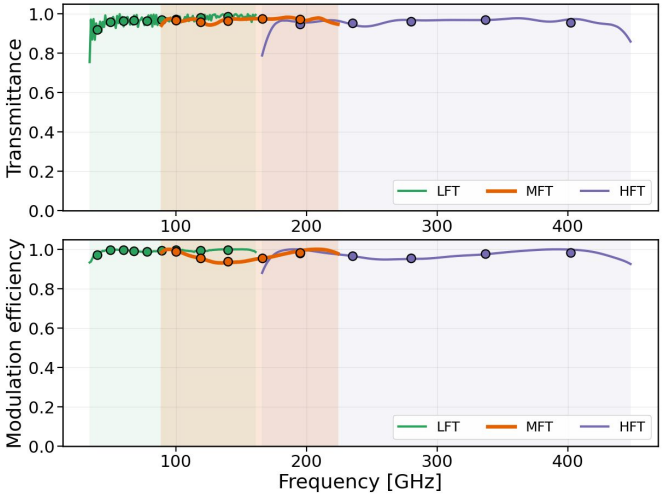
LFT: sapphire HWP

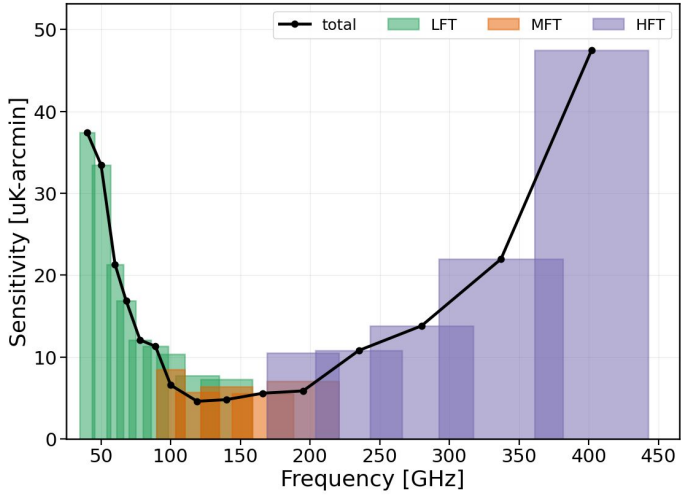


MHFT: mesh HWP



	ν_l	ν_h	# of bands	Fractional bandwidth
LFT	34	161	9	1.30
MFT	89	224	5	0.87
HFT	166	448	5	0.92



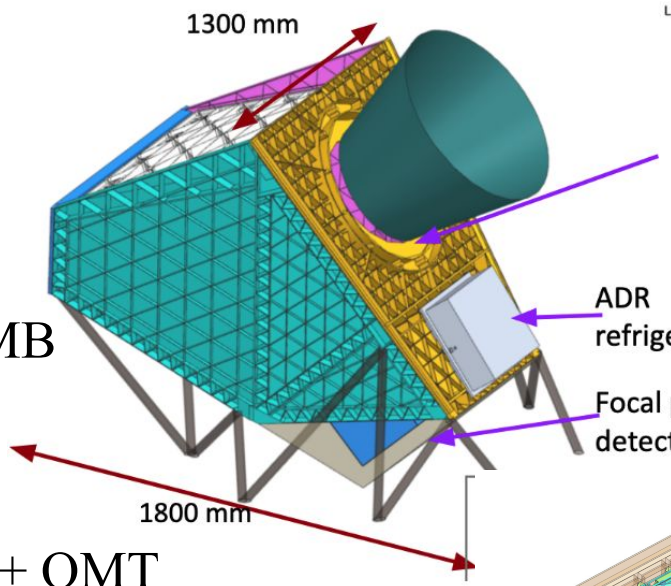


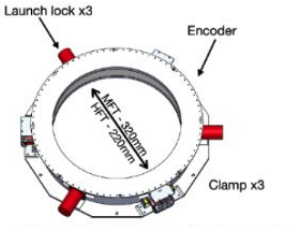
LiteBIRD after reformation

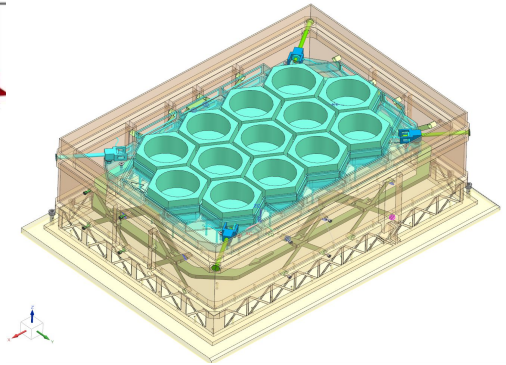
- Single telescope
- Crossed-Dragone telescope

- Frequency: 34-448 GHz (12 bands)
- Fractional bandwidth: 1.72
- Metal-mesh broadband HWP with SMB
- Focal plane array:
  - ~ 4000 detectors in total
  - TES bolometer coupled to Horn + OMT
  - Led by Europe

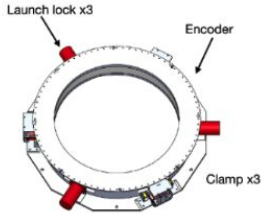
- Option 1 (No HWP): 0.3 RPM
- Option 2 (with HWP): 0.05 RPM (HWP: 46 RPM)



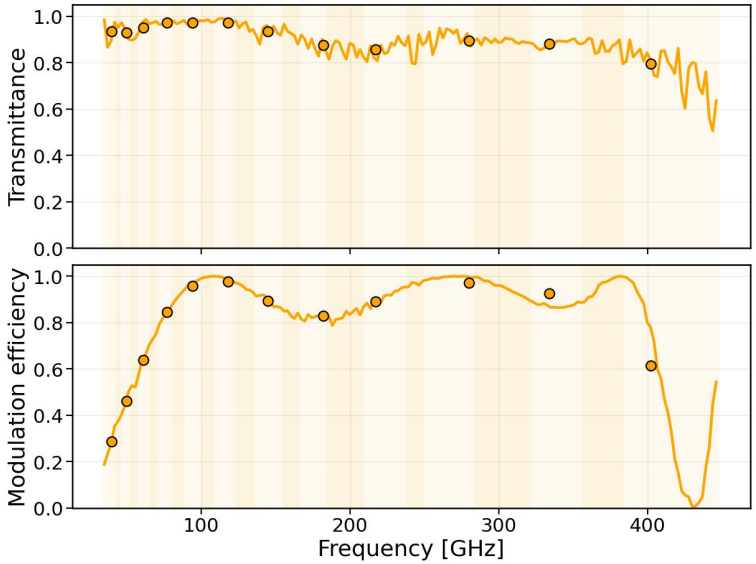




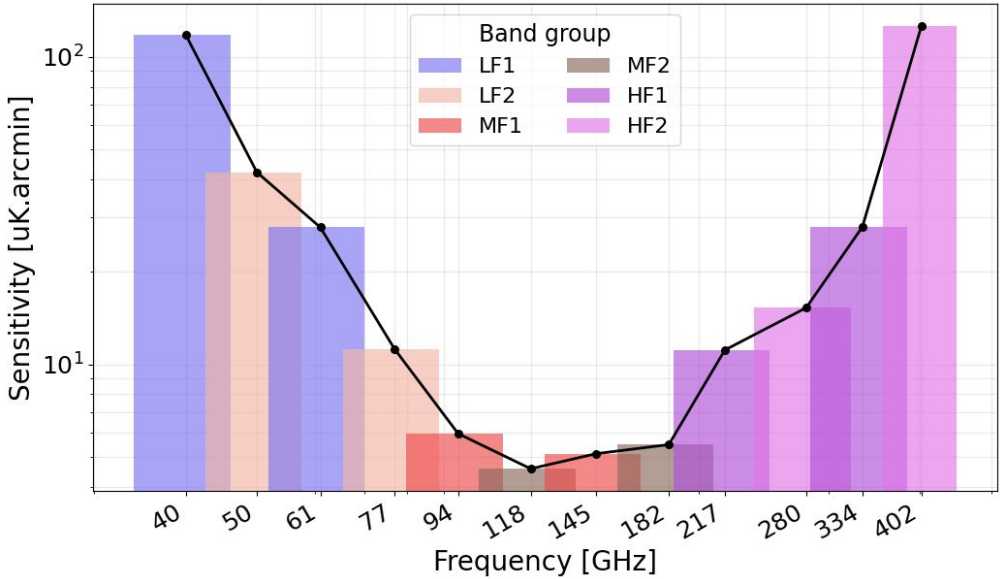
LiteBIRD after reformation



- HWP: Metal-mesh HWP
- Frequency: 34-448 GHz (12 bands)
- Fractional bandwidth: 1.72
- Designed by G. Pisano



Expected Sensitivity

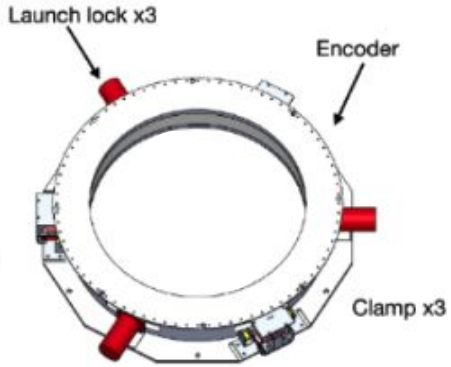


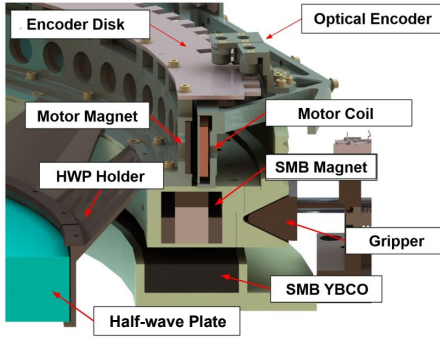
Total sensitivity = 2.5 μK arcmin (preliminary)

“Challenges” at *LiteBIRD* feasibility

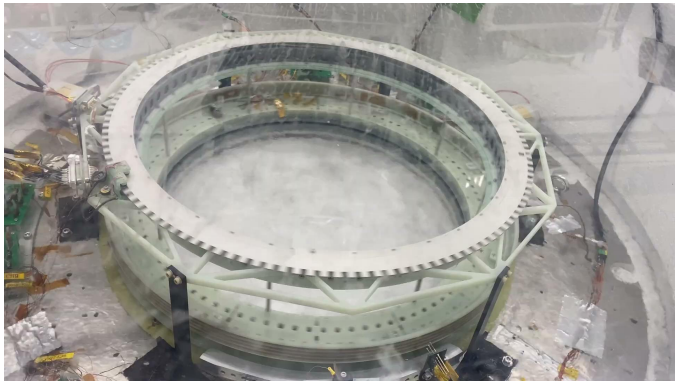
Polarization modulator unit (PMU)

Many items to be achieved
Only focusing on the “main challenges”…





- Thermal requirement
  - HWP/PMU temperature < 20 K / 4-6 K
  - Total heat of PMU: < 7 mW
    - Uniform SMB magnetic field
    - Optimization of drive mechanism and operation
- Optical requirement
  - Fractional bandwidth: 1.72
  - Realization and Characterization of HWP
    - Joint studies of systematic effects

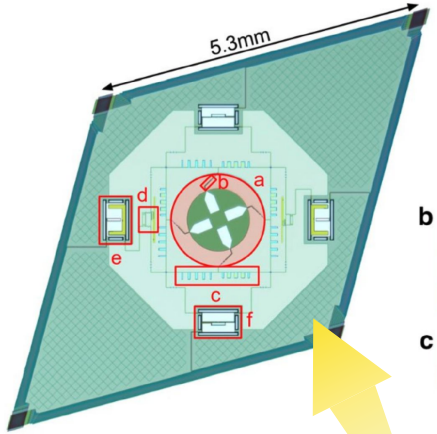


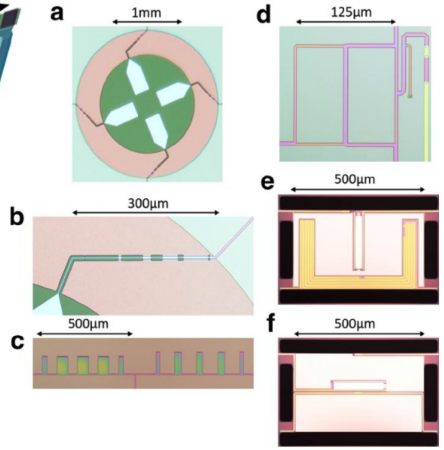
“Challenges” at *LiteBIRD* feasibility

Focal plane

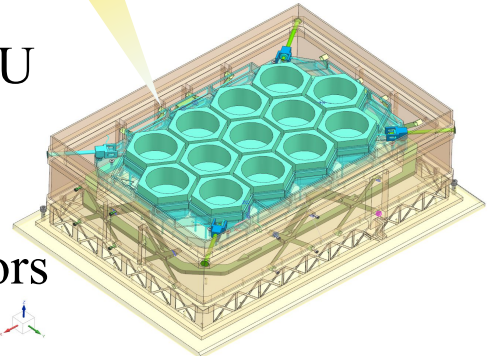
Many items to be achieved
Only focusing on the “main challenges”…

- High detector optical efficiency > 0.7
  Horn + OMT structure optimization
- NEP mitigation
  Internal and external NEP
  < photon noise NEP limited
- Fabrication/performance yield > 0.8





FPU



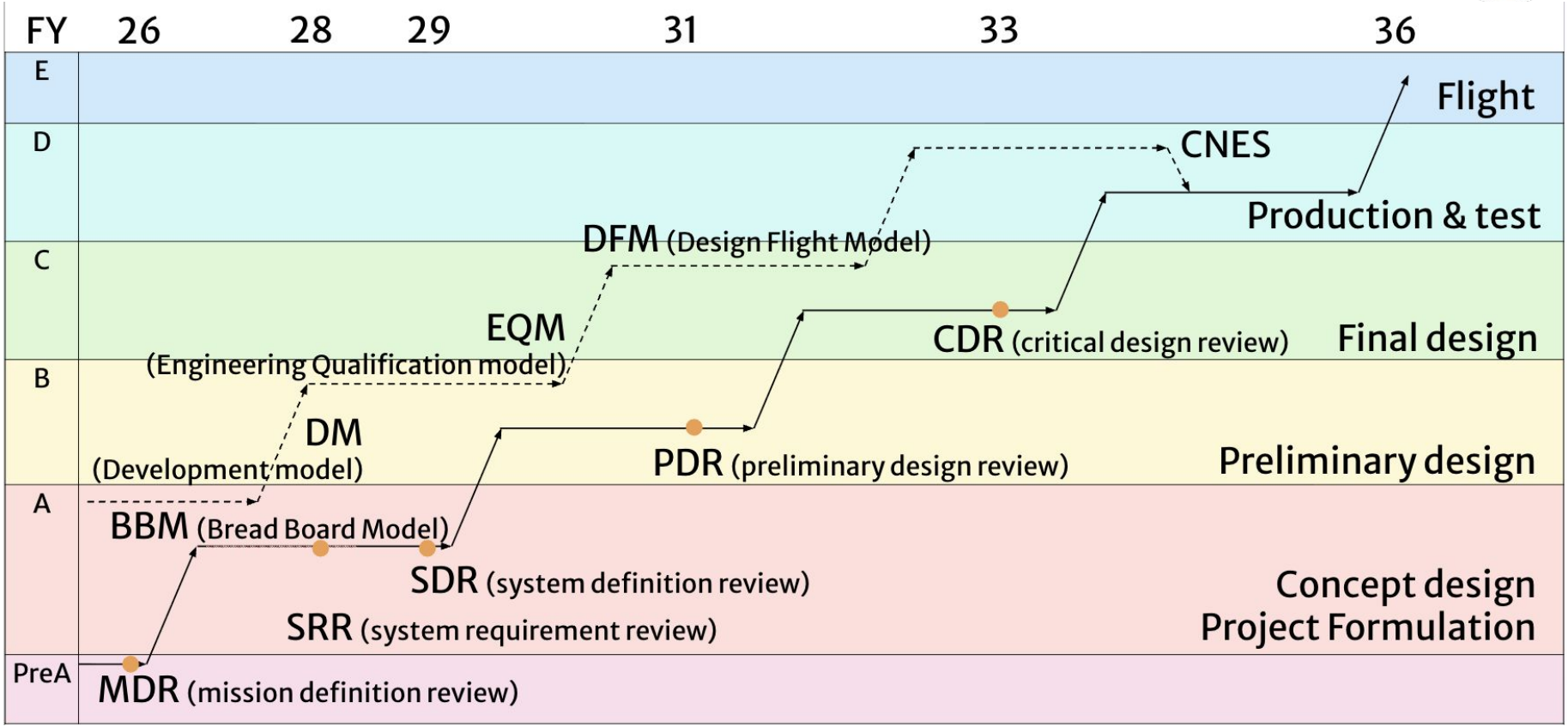
~ 4000 detectors

Mission Definition Review 2 (MDR2)

6/26, 2026
We passed the MDR2

LiteBIRD PI
Tomo Matsumura
, will talk for SPIE conference next week

After MDR2


FY
26
28
29
31
33
36
E
D
C
B
A
PreA
Flight
CNES
Production & test
DFM (Design Flight Model)
EQM
(Engineering Qualification model)
CDR (critical design review)
Final design
DM
(Development model)
PDR (preliminary design review)
Preliminary design
BBM (Bread Board Model)
SDR (system definition review)
SRR (system requirement review)
Concept design
Project Formulation
MDR (mission definition review)

Summary

LiteBIRD

- A satellite project, led by JAXA, aiming for the exploration of the B-mode polarization of the Cosmic Microwave Background (CMB), which is the trace of primordial gravitational waves caused by quantum fluctuations in space before the hot Big Bang, through precise millimeter-wave polarization observations across the entire sky on large angular scales.

- Driven by a research team consisting of more than 400 researchers from Japan, North America and Europe.