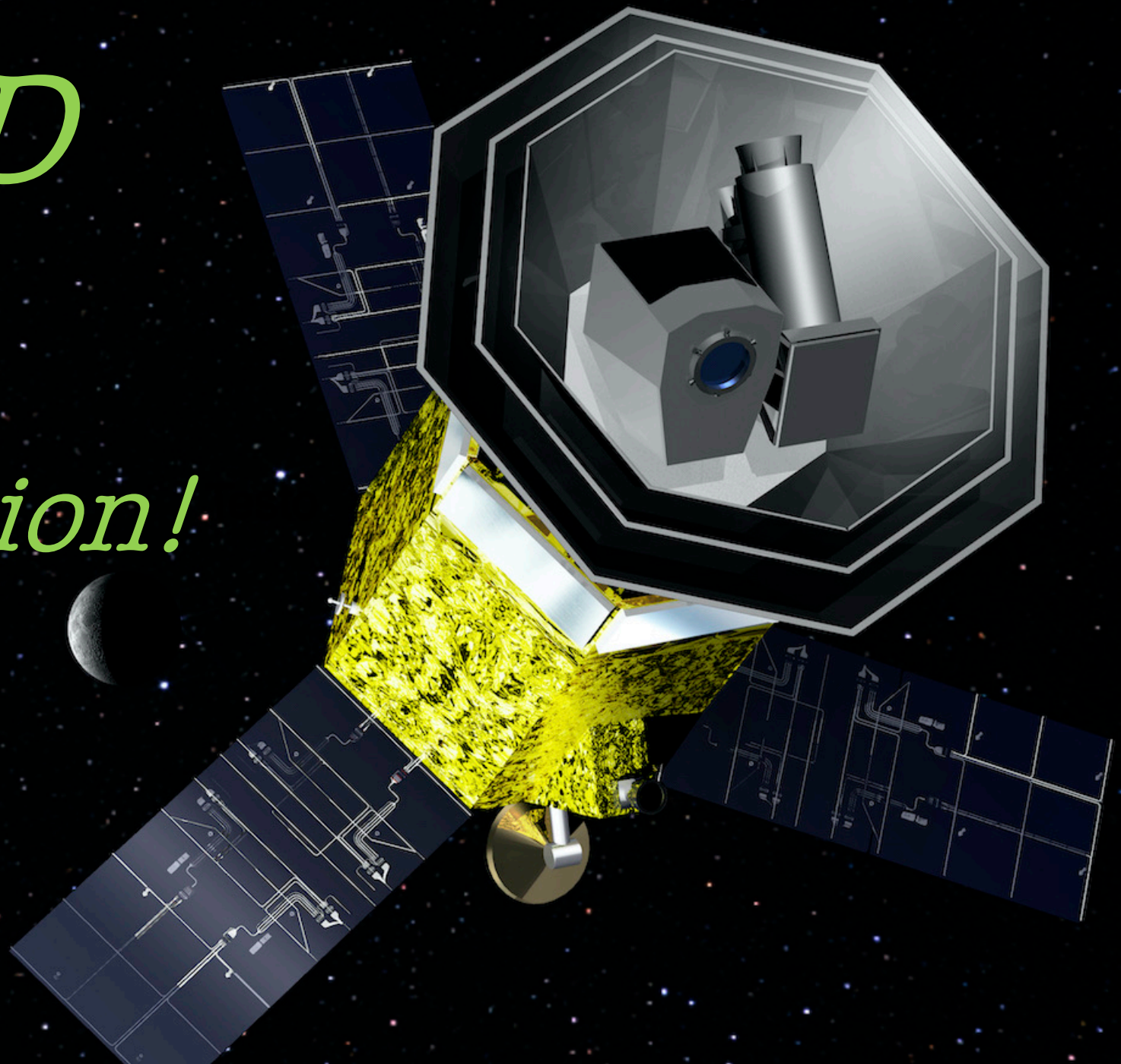
LiteBIRD

JAXA's strategic L-class mission!



LiteBIRD:
Lite (light) satellite for the studies of
B-mode polarization and
Inflation from cosmic background
Radiation
Detection

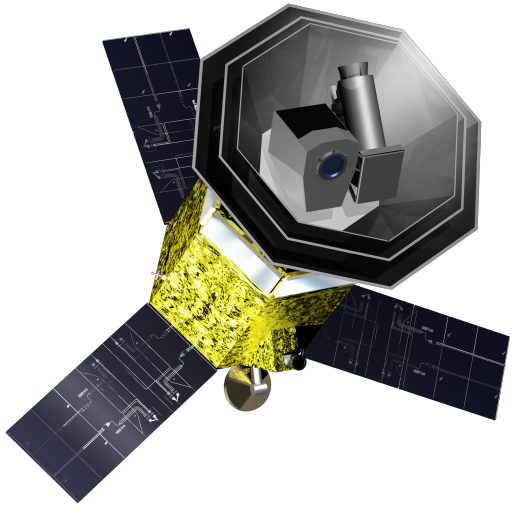
Why Measure from Space?

- Superb environment !
  - ✓ No statistical/systematic uncertainty due to atmosphere
  - ✓ No limitation on the choice of observing bands (except CO lines); important for foreground separation
  - ✓ No ground pickup

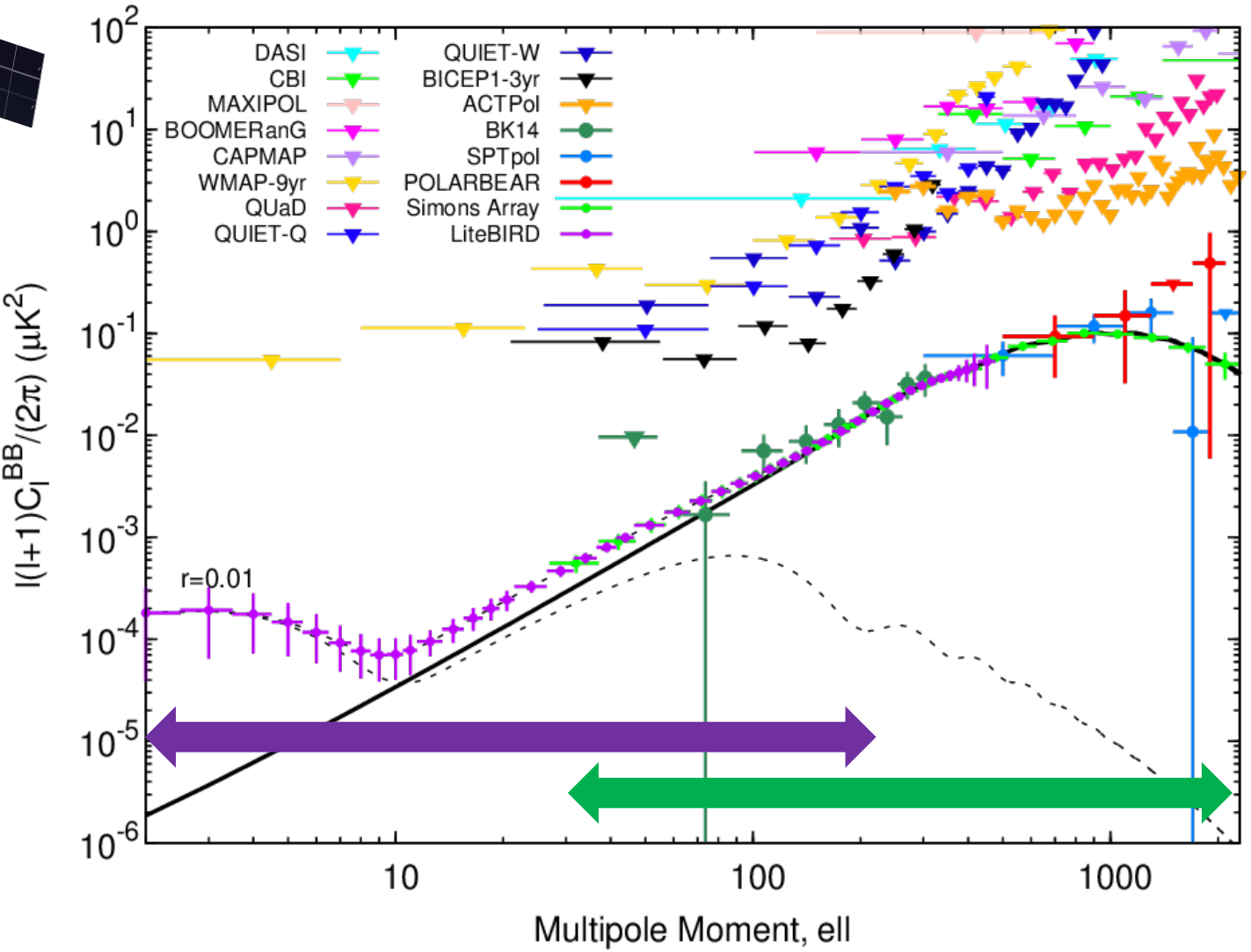
    - ✓ Rule of thumb: 1,000 detectors in space ~100,000 detectors on ground

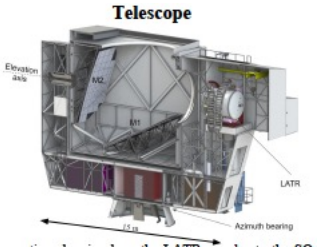
- Only way to access lowest multipoles w/ $\delta r \sim O(0.001)$
  - ✓ Both B-mode bumps need to be observed for the firm confirmation of Cosmic Inflation →We need measurements from space.
- Complementarity with ground-based CMB projects
  - ✓ Foreground information from space will help foreground cleaning for ground CMB data
  - ✓ High multipole information from ground will help "delense" space CMB data

Powerful Duo



LiteBIRD
JAXA-led
focused
mission
$\sigma(r)<0.001$
$2 \le \ell \le 200$

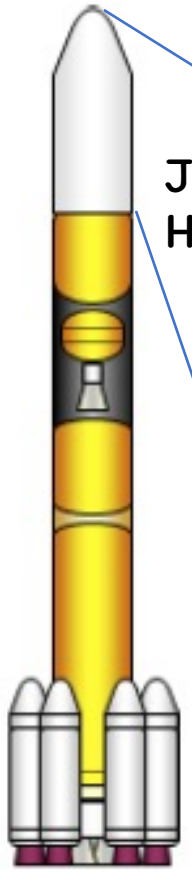




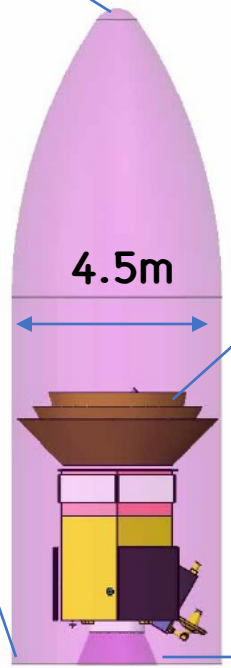
Ground
US-led telescopes
on ground
$30 \le \ell \le$ ~8000
e.g. Simons
Observatory and
CMB-S4

LiteBIRD Overview

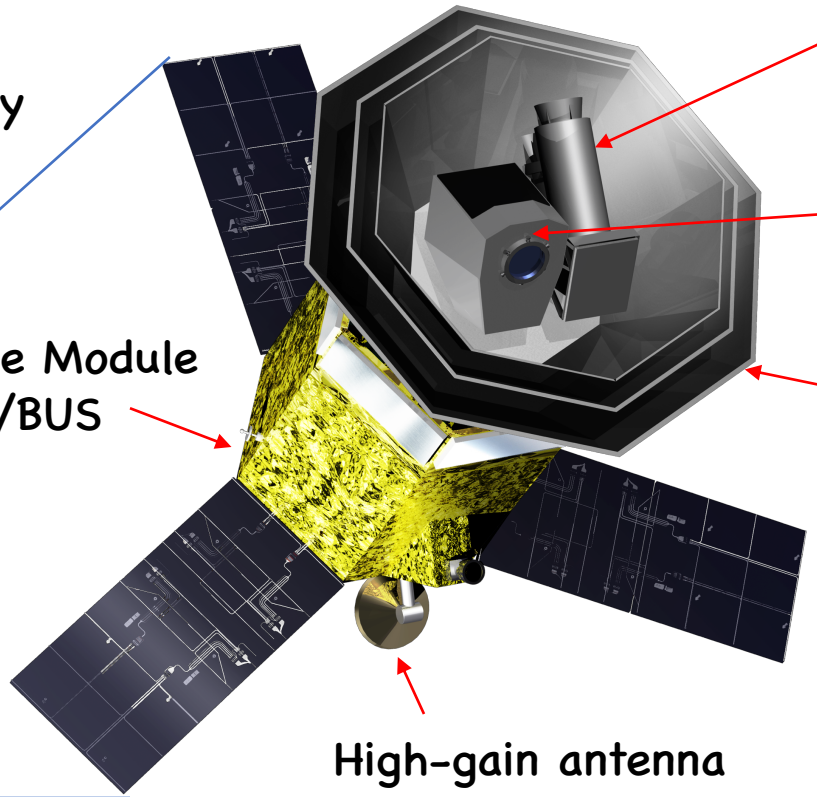
- JAXA's L-class mission selected in May 2019
- Expected launch in Japanese fiscal year 2027 with JAXA's H3 rocket.
- Observations for 3 years (baseline) around Sun-Earth Lagrangian point L2
- Millimeter-wave all sky surveys (34–448 GHz, 15 bands) at 70–20 arcmin.
- Mission: δr (total uncertainty) < 0.001 (for r=0) with CMB B-mode observation



JAXA
H3



Mass: 2.6t
Power: 3.0kW
Data: 10GB/day



Service Module
(SVM)/BUS

High-gain antenna

Middle/High-Frequency Telescope (MHFT) (5K) w/ Polarization Modulators

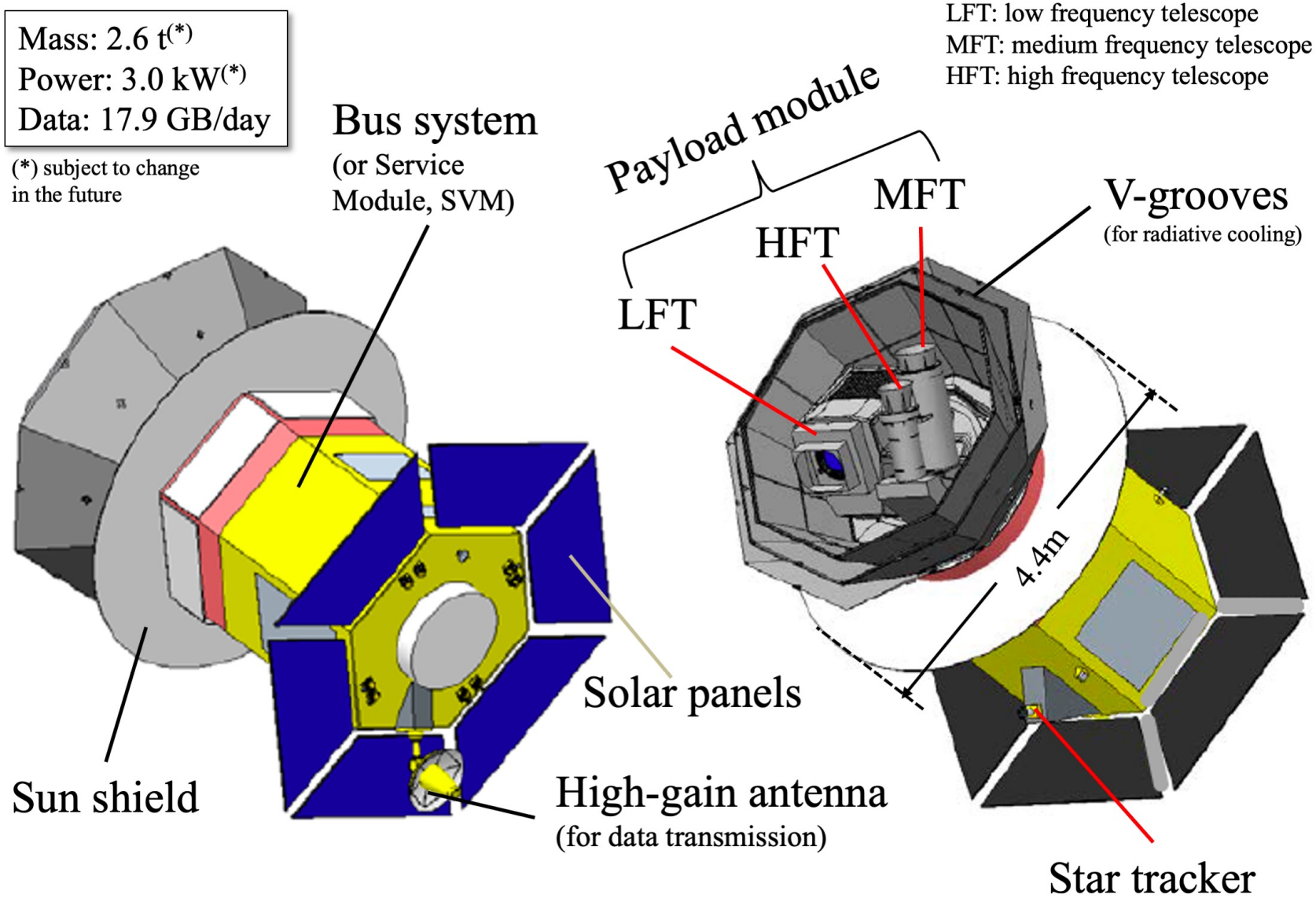
Low-Frequency Telescope (LFT) (5K) w/ Polarization Modulator

V-Grooves for radiative cooling (30K/100K/200K)

Active cooling with PT/ST/JT/ADR (not seen)

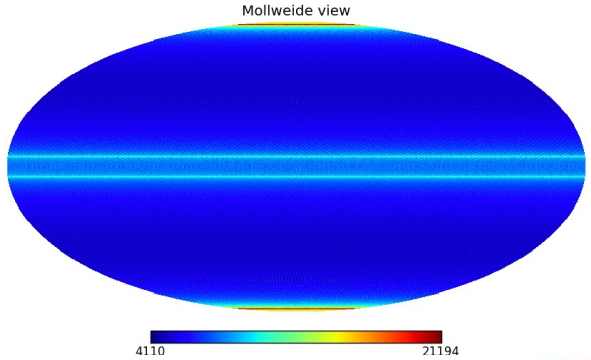
TES focal planes (not seen) with 100mK base temperature

LiteBIRD Overview

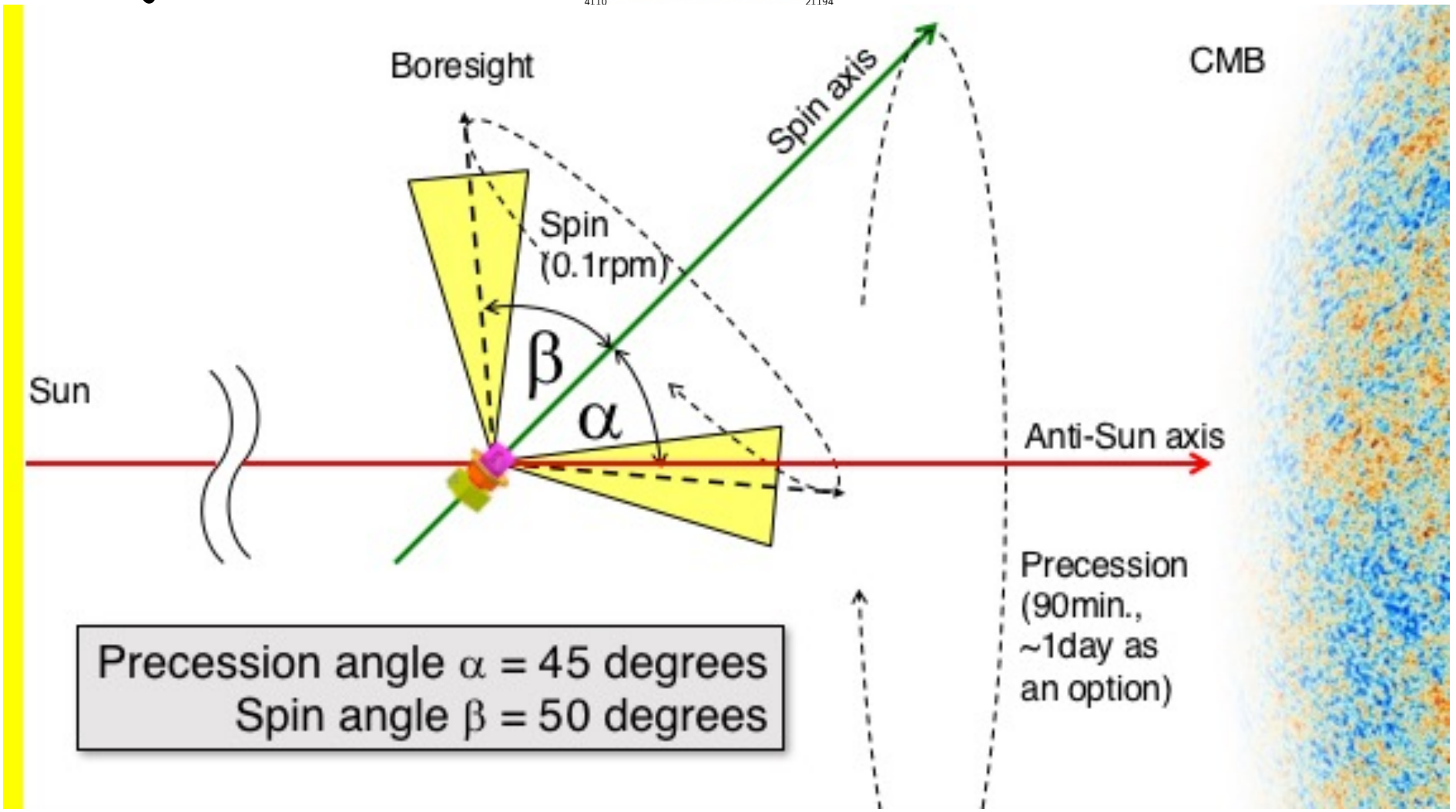


Operation

Orbit:
Sun-Earth L2 Lissajous



Hit map after 1 year

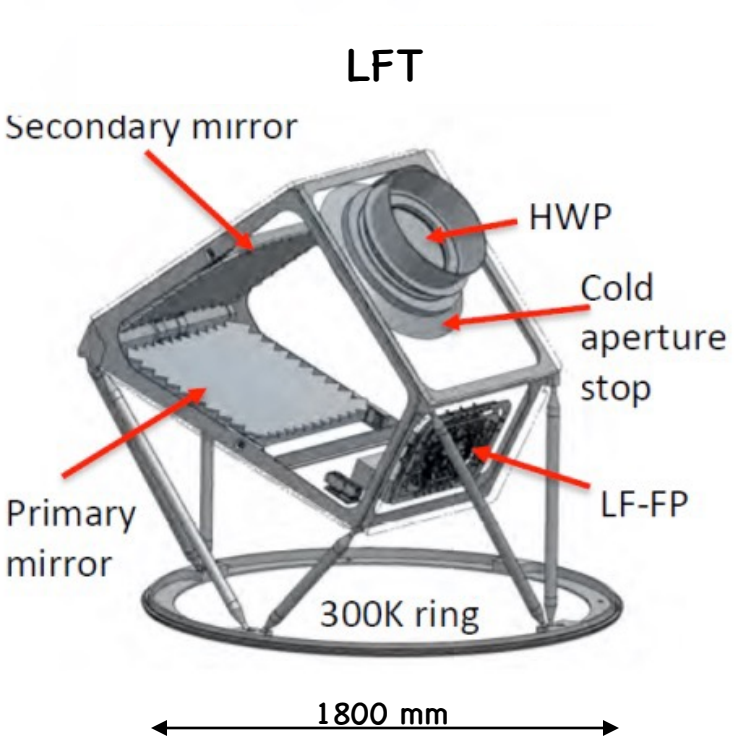


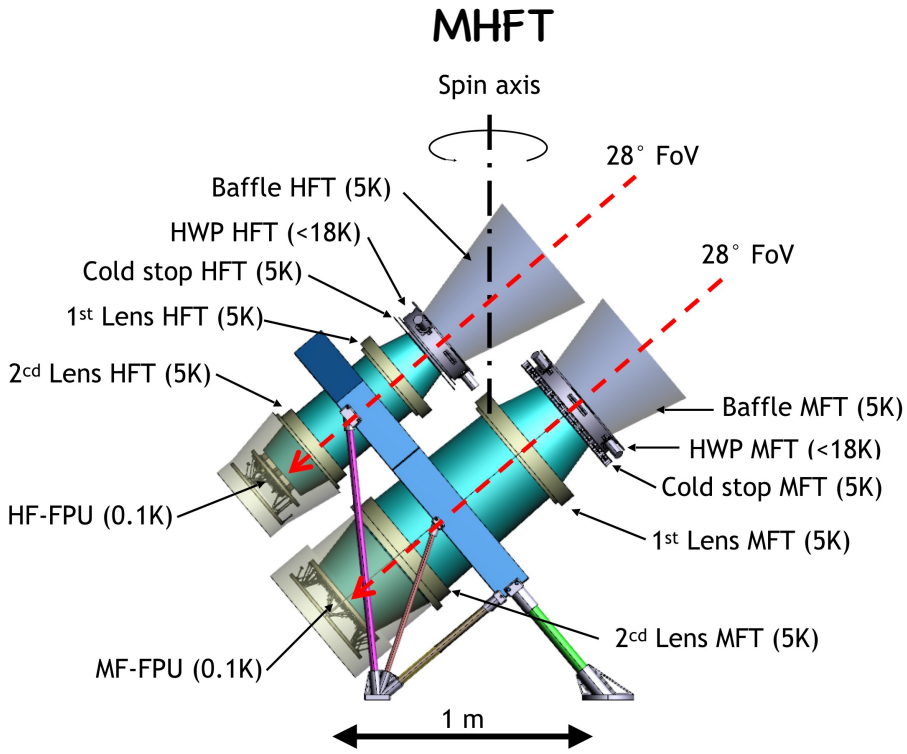
LiteBIRD Mission Instrument

Three features

1. Two sets of telescopes w/ TES arrays
2. Polarization modulator w/ rotating half-wave plate (HWP) for 1/f noise & systematics reduction
3. Cryogenic system for 0.1K base temperature

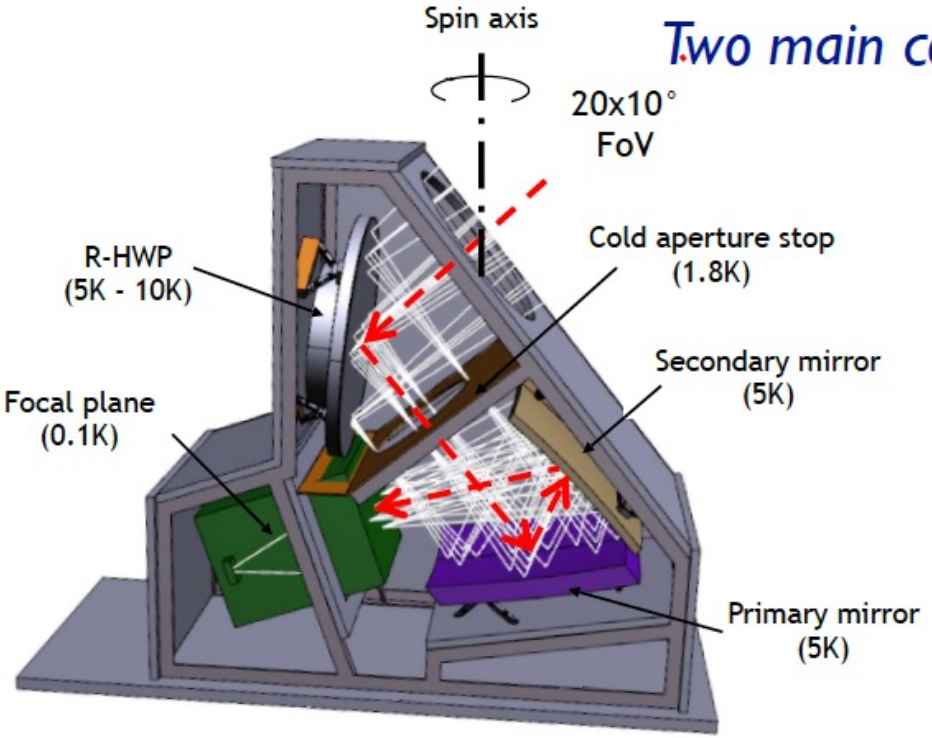
1. Two sets of telescopes w/ TES arrays

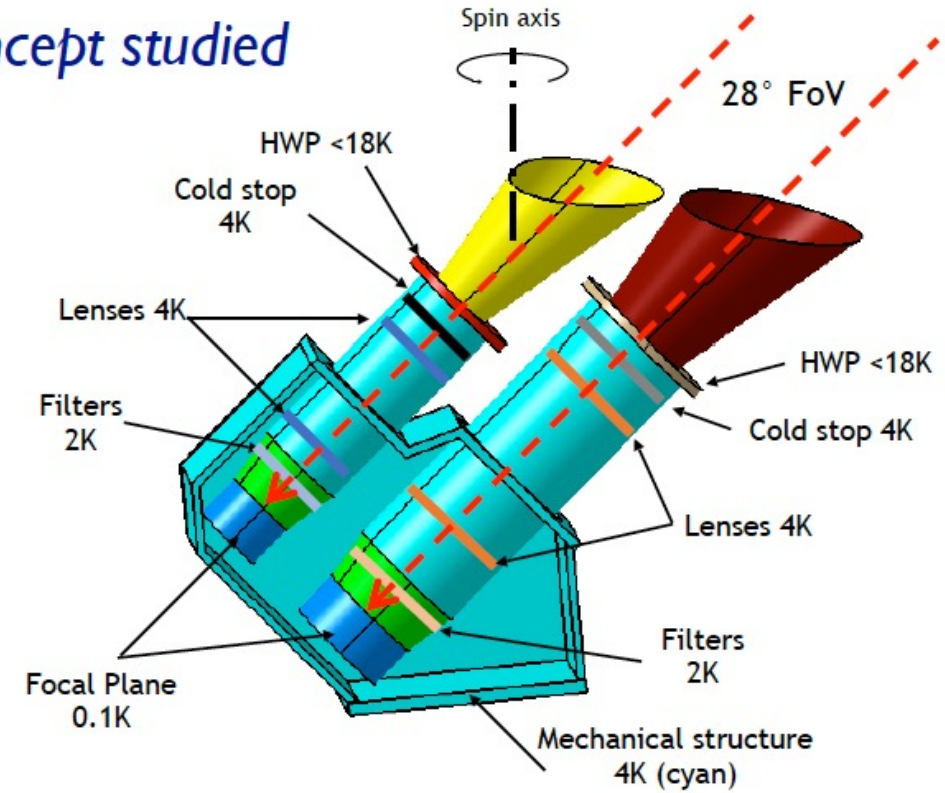




LiteBIRD Mission Instrument

Two main concept studied





Fully reflective

- Crossed Dragone telescope - F/3.5
- Frequency coverage: 89 - 448 GHz
- Continuous rotating HWP mechanism
  - Reflective Embedded Metal-mesh HWP tilted at 45°
- **Alternative design since end 2018**

Fully transmissive

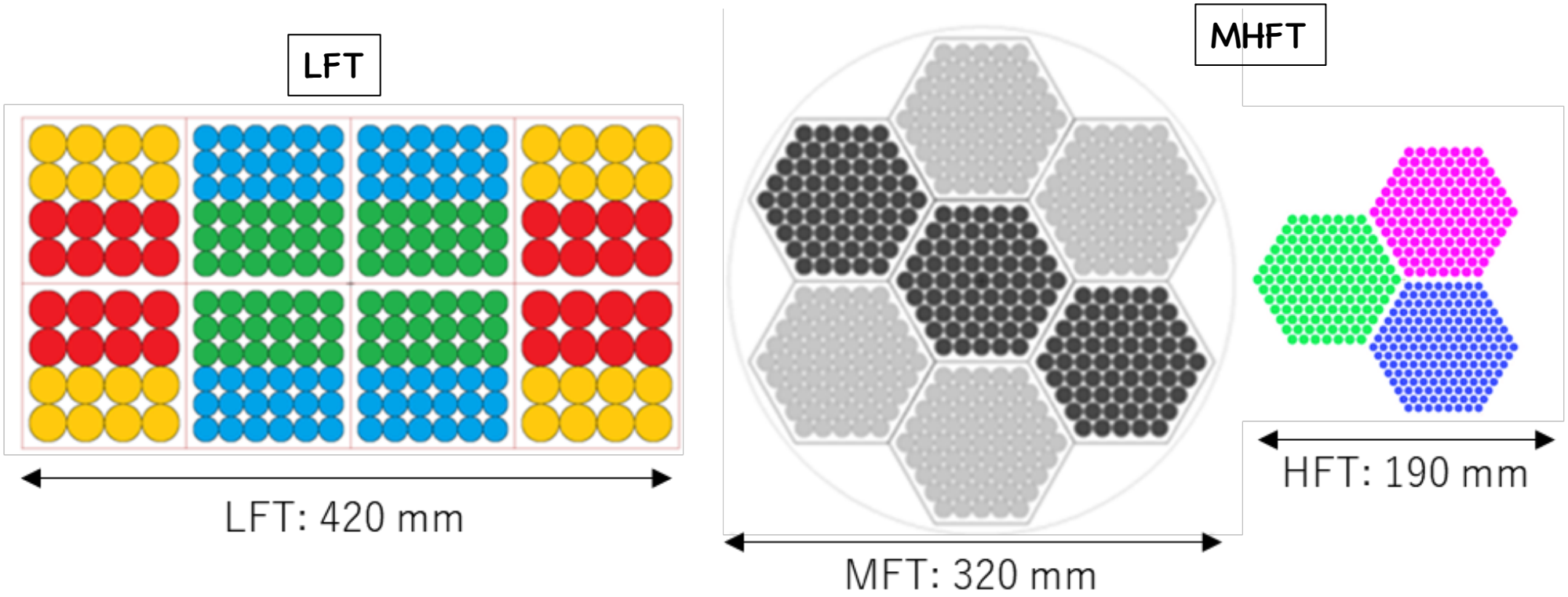
- Two telescopes - F/2.2
  - MFT: 89 - 224 GHz
  - HFT: 166 - 448 GHz
- HDPE lenses
- Continuous rotating HWP mechanism
  - Transmissive Metal-mesh HWP
- **Baseline since end 2018**

LiteBIRD Mission Instrument

Three features

1. Two sets of telescopes w/ TES arrays
2. Polarization modulator w/ rotating half-wave plate (HWP) for 1/f noise & systematics reduction
3. Cryogenic system for 0.1K base temperature

1. Two sets of telescopes w/ TES arrays



LiteBIRD Mission Instrument

Three features

1. Two sets of telescopes w/ TES arrays
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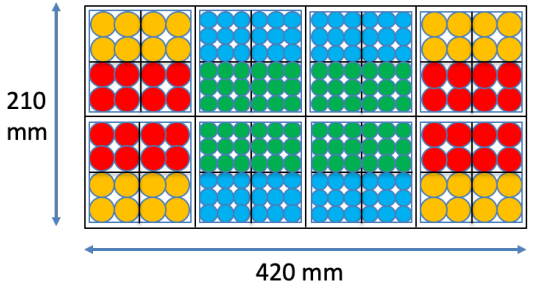
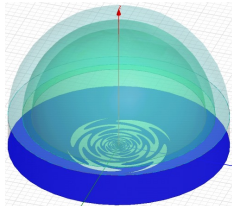
1. Two sets of telescopes w/ TES arrays: Radiation Coupling

LFT

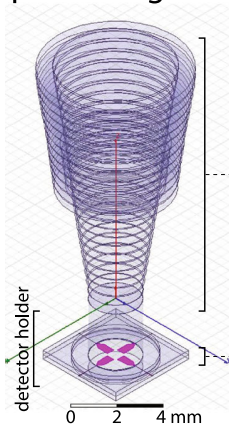


Silicon lenslet



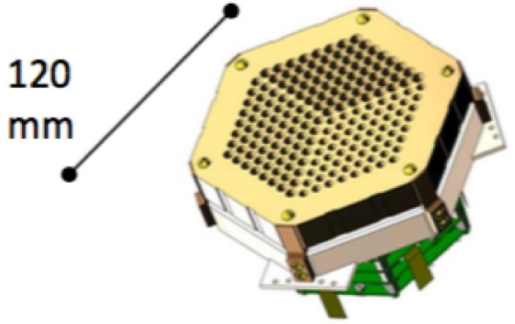
Sinuous Antenna for broadband trichroic pixels

pixel design



Silicon platelet Corrugated horn

MHFT



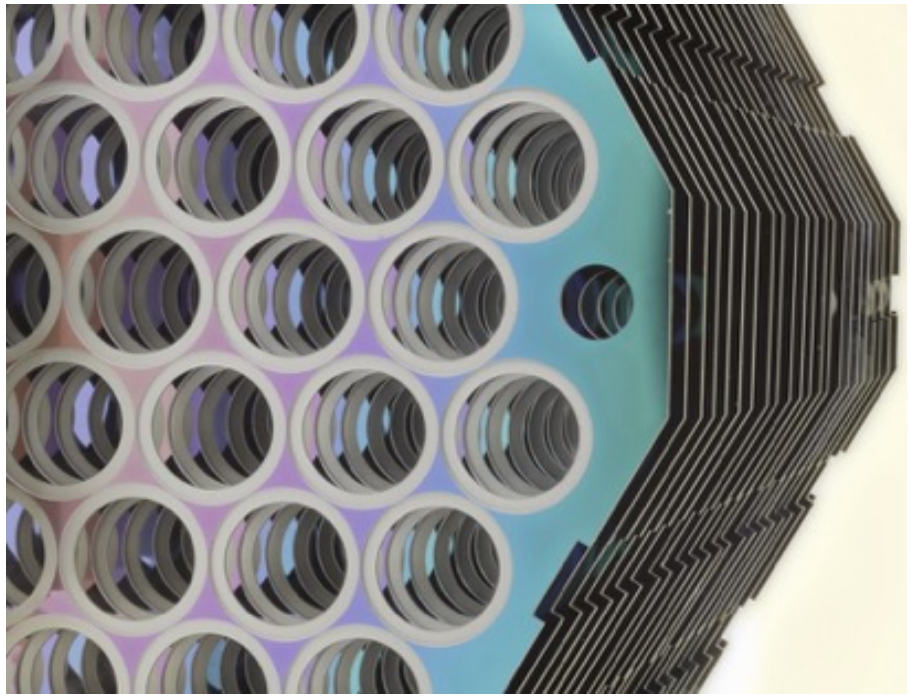
OMT

LiteBIRD Mission Instrument

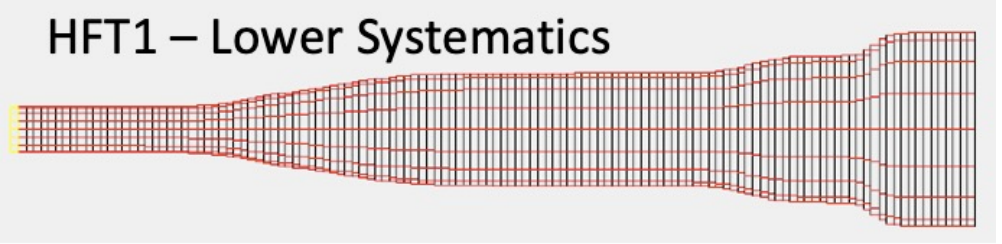
Three features

1. Two sets of telescopes w/ TES arrays
2. Polarization modulator w/ rotating half-wave plate (HWP) for 1/f noise & systematics reduction
3. Cryogenic system for 0.1K base temperature

1. Two sets of telescopes w/ TES arrays: Radiation Coupling

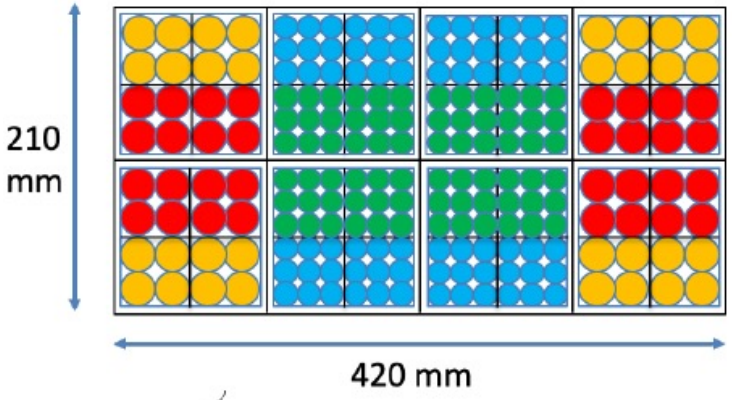


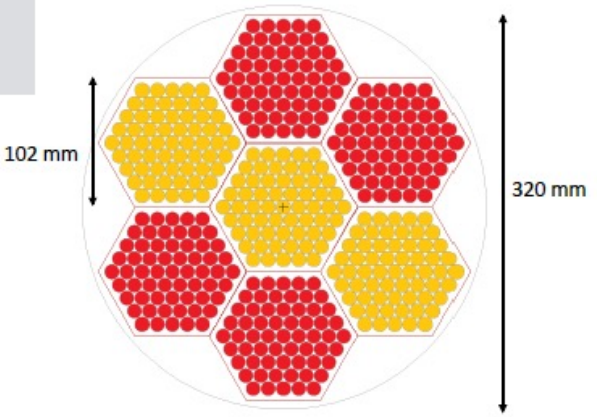
Horn array realized in Silicon
Platelet technology

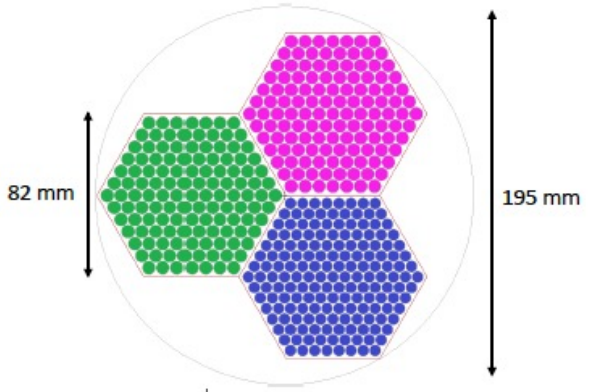


LiteBIRD Mission Instrument

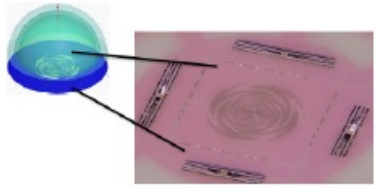
Number of detectors: 4676
Overlap between instruments



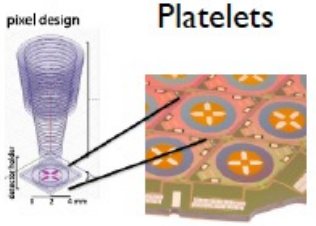




Lenslets



Platelets



MFT (2.5:1)

89GHz — 224 GHz

2074 detectors
366 Trichroic TES
488 Dichroic TES

100 | 119 | 140 | 166 | 195

LFT (4.7:1)

40 | 50 | 60 | 68 | 78 | 89 | 100 | 119 | 140

1248 detectors
2 x (64 + 144) Trichroic TES

34GHz — 161 GHz

HFT (2.7:1)

195 | 235 | 280 | 337 | 402

1354 detectors
2 x 254 Dichroic TES
338 Monochromatic TES

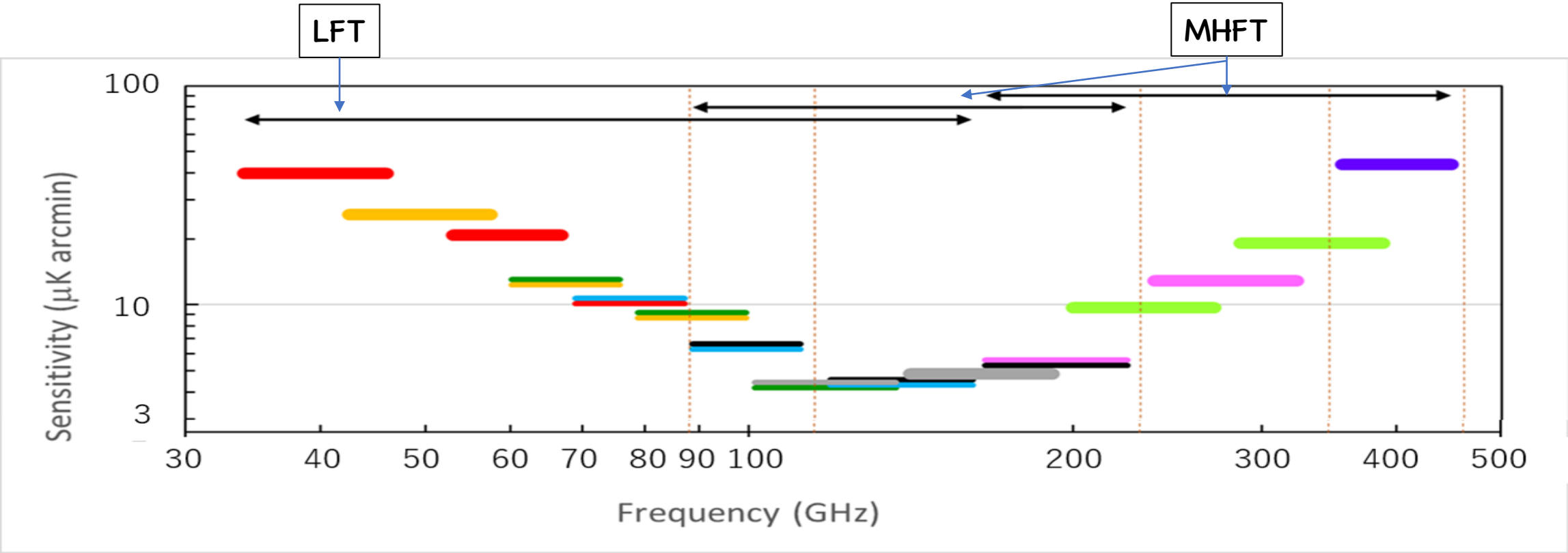
166 GHz — 448 GHz

LiteBIRD Mission Instrument

Three features

1. Two sets of telescopes w/ TES arrays
2. Polarization modulator w/ rotating half-wave plate (HWP) for 1/f noise & systematics reduction
3. Cryogenic system for 0.1K base temperature

1. Two sets of telescopes w/ TES arrays



LiteBIRD Mission Instrument

Three features

1. Two sets of telescopes w/ TES arrays
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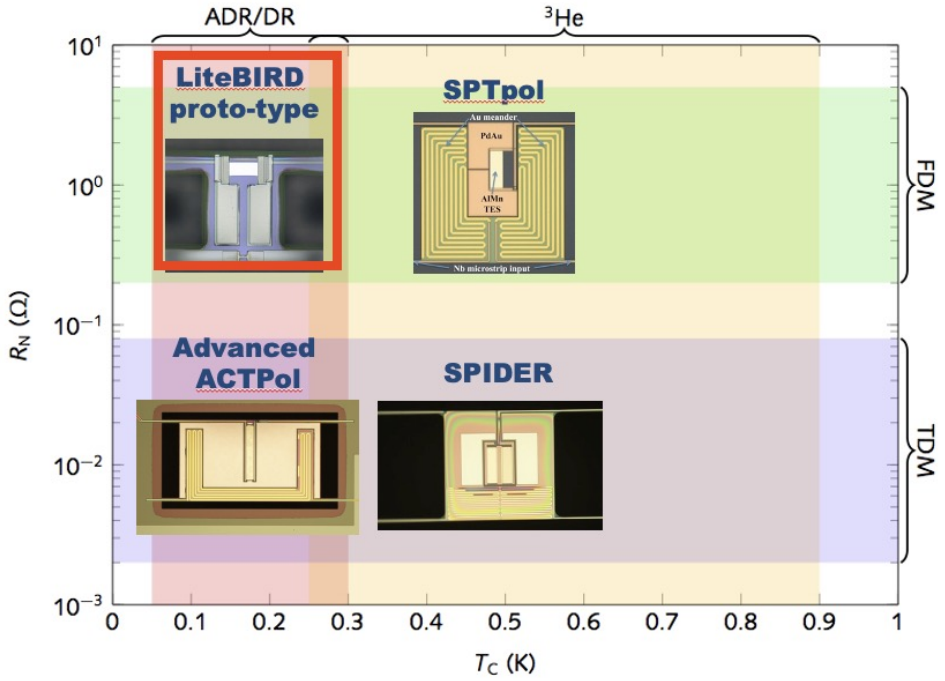
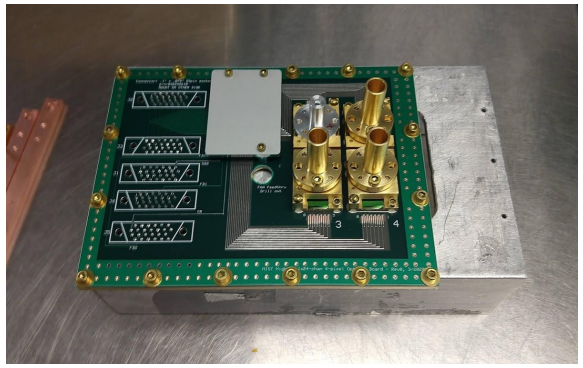
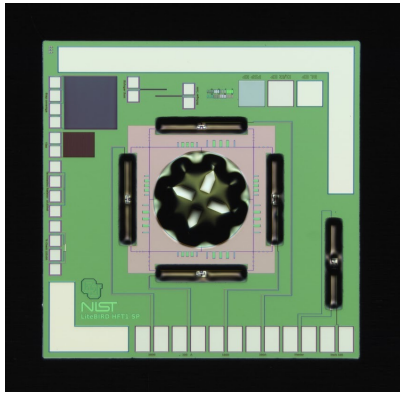
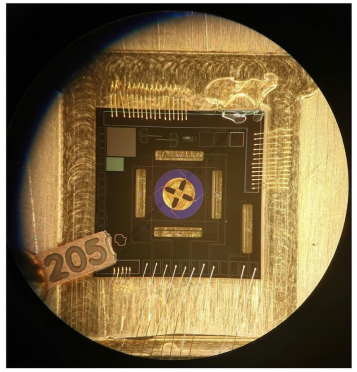
1. Two sets of telescopes w/ TES arrays: Test on MHFT TES/OMT prototype









LiteBIRD Mission Instrument

Three features

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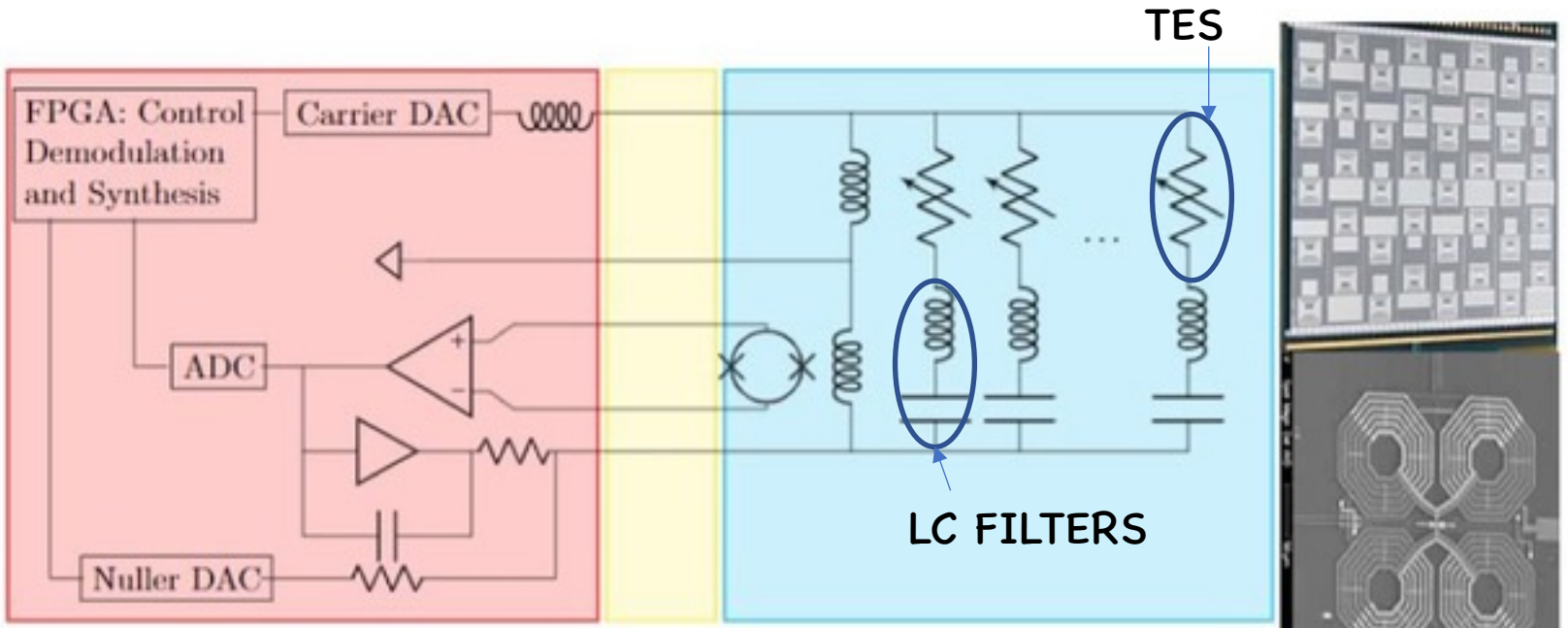
3. Cryogenic system for 0.1K base temperature

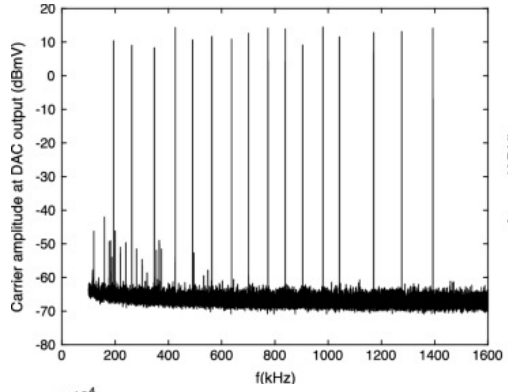
1. Two sets of telescopes w/ TES arrays: Readout by FDM via SQUID

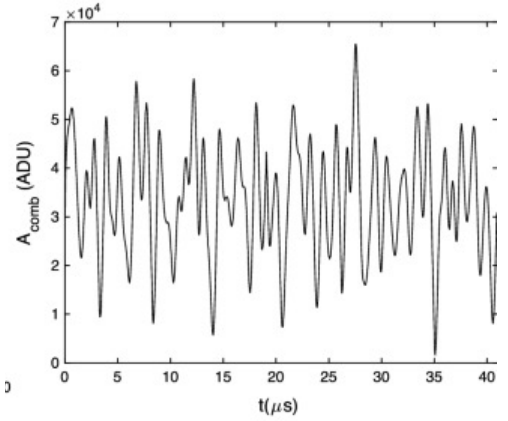


WARM READOUT

COLD READOUT

TES ARRAY





LiteBIRD Mission Instrument

Three features

1. Two sets of telescopes w/ TES arrays
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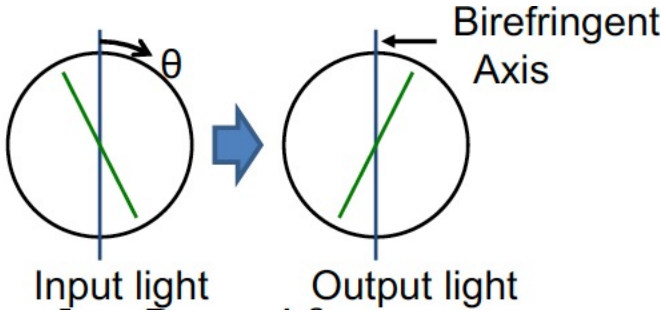
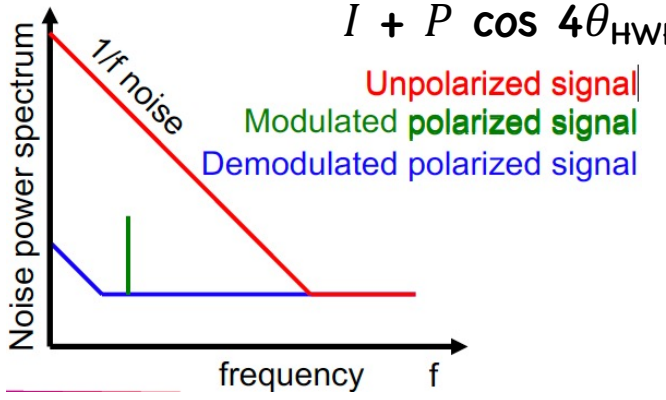
2. Polarization modulator with a rotating half-wave plate (HWP) for 1/f noise & systematics reduction

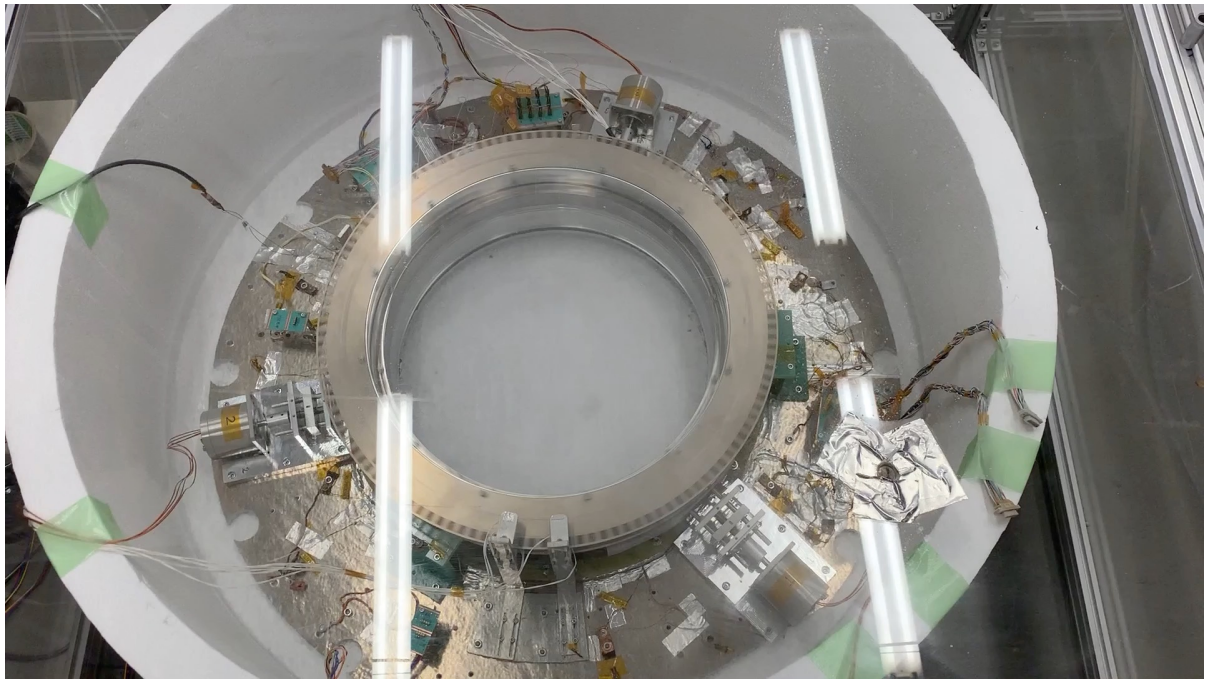
Rotating a birefringent plate at the most sky side



$$I + P \cos 4\theta_{\mathrm{HWP}}$$



LFT HWP prototype @4K



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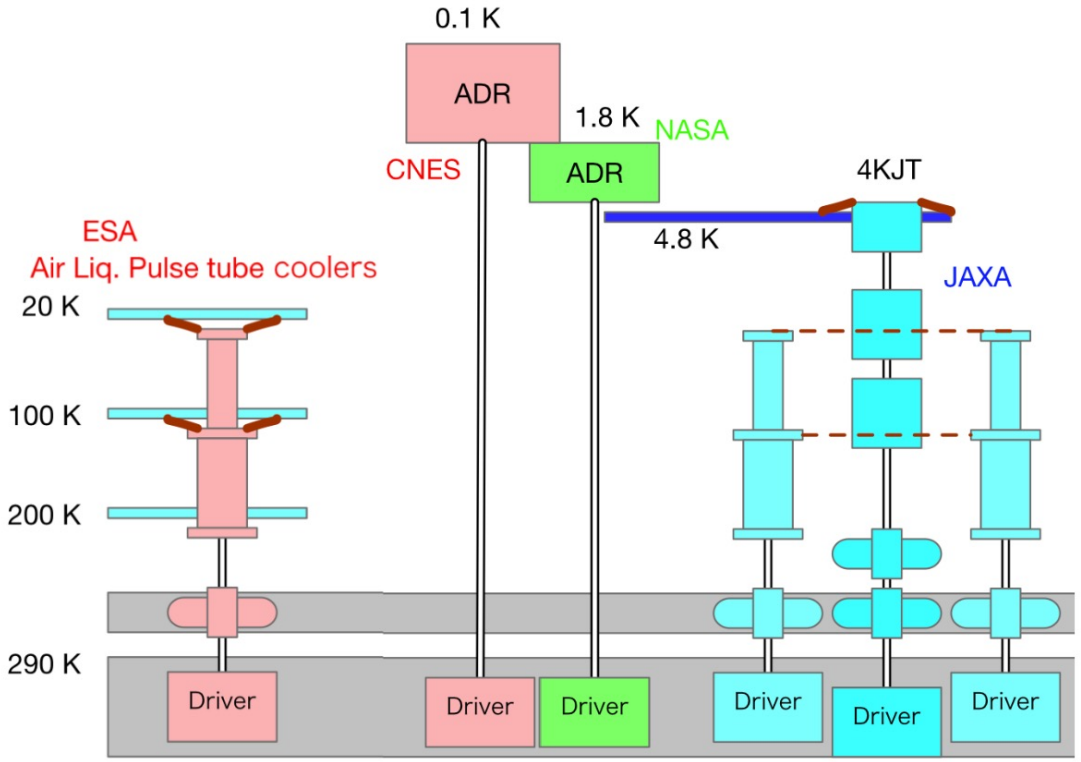

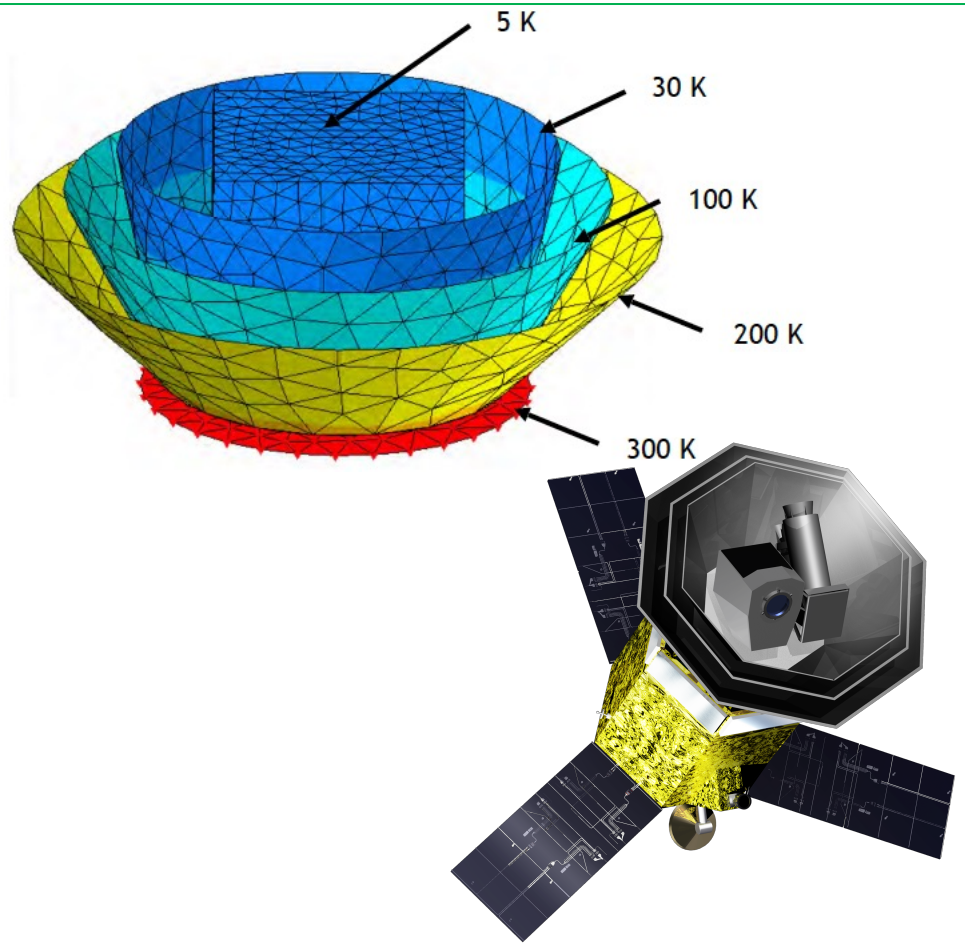

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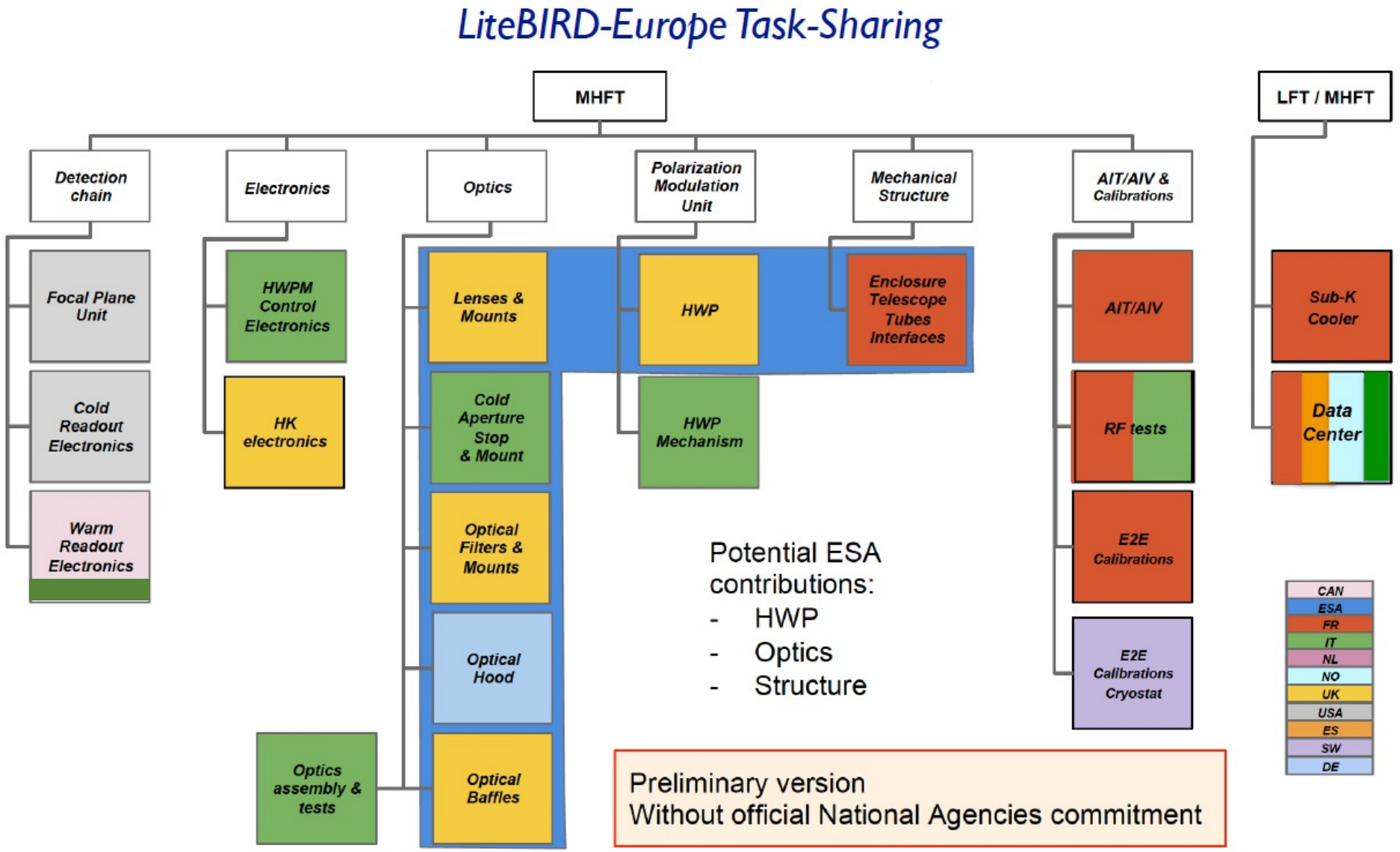
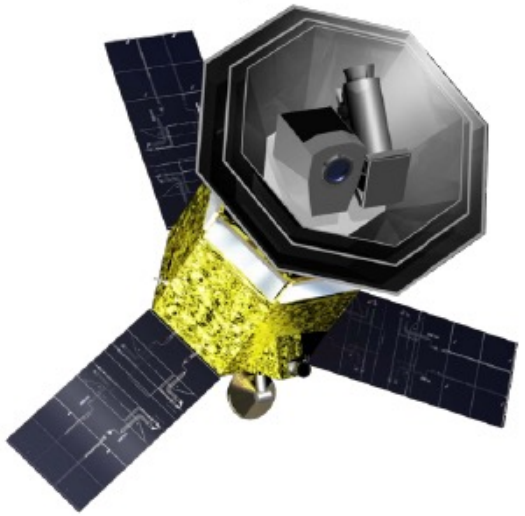


LiteBIRD Mission Summary

	Low Frequency Telescope (LFT)	Mid and High Frequency Telescope (MFT & HFT)
Frequency	34 ~ 161 GHz	89 ~ 448 GHz
field of view	> 20 deg ×10 deg	28 deg
aperture diameter	400 mm	200 mm & 300 mm
angular resolution	20 ~ 70 arcmin	10 ~ 40 arcmin
rotational HWP	88 rpm	~90 - 180 rpm
number of detectors	~1250	~3400
Uncertainty of r	$\delta r < 1 \times 10^{(-3)}$	
Observation period	3 years	
Scan	L2 Lissajous, precession angle 45 deg, spin angle 50 deg (0.05 rpm)	
Sensitivity	< 3 μK·arcmin	
pointing knowledge	< 3 arcmin	
focal plane array	bath temperature 100 mK	
	NET^{P}array = 1.7 μK√s@ 100 mK	
	f_{knee} < 20 mHz	
data transfer	7 GByte/day	
mass	2.6 ton	
electrical power	3.0 kW	



LiteBIRD Mission Summary