The LiteBIRD low-frequency telescope polarization modulation unit

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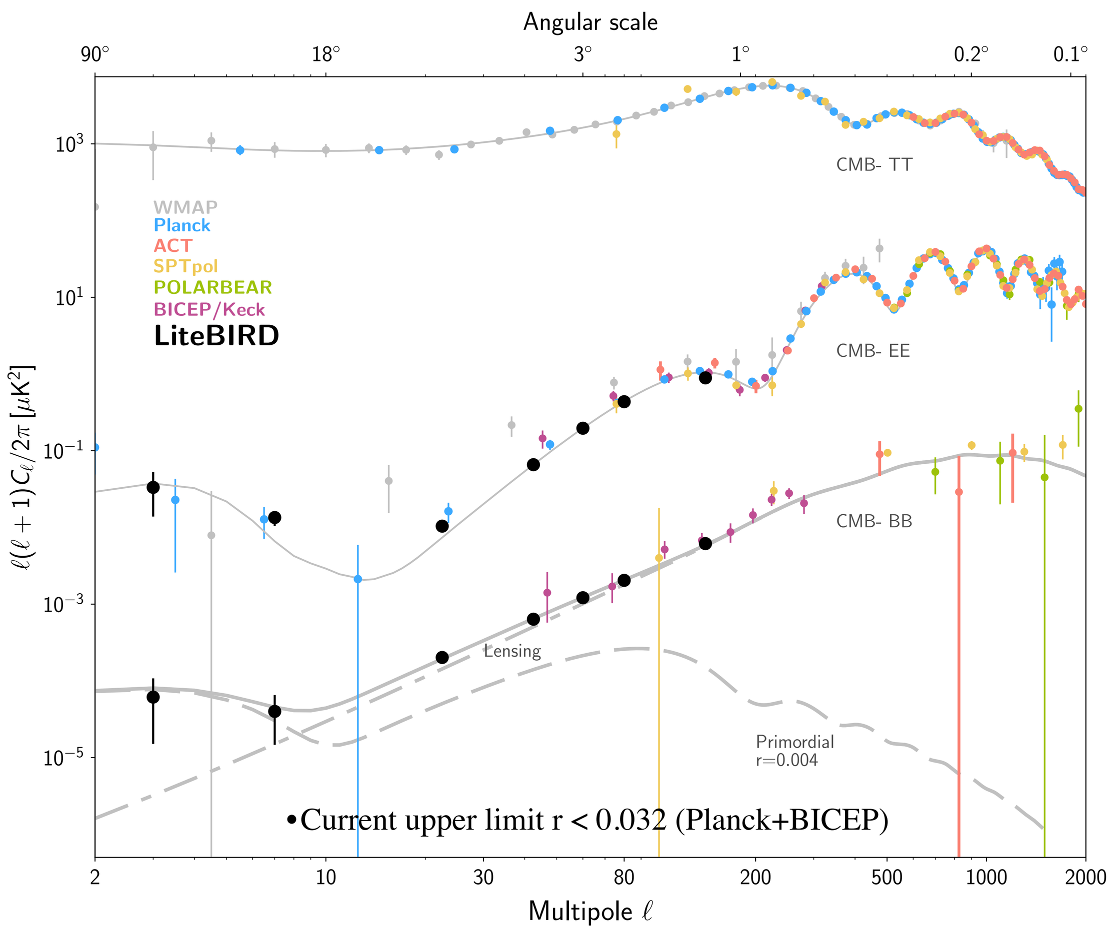
I. Introduction

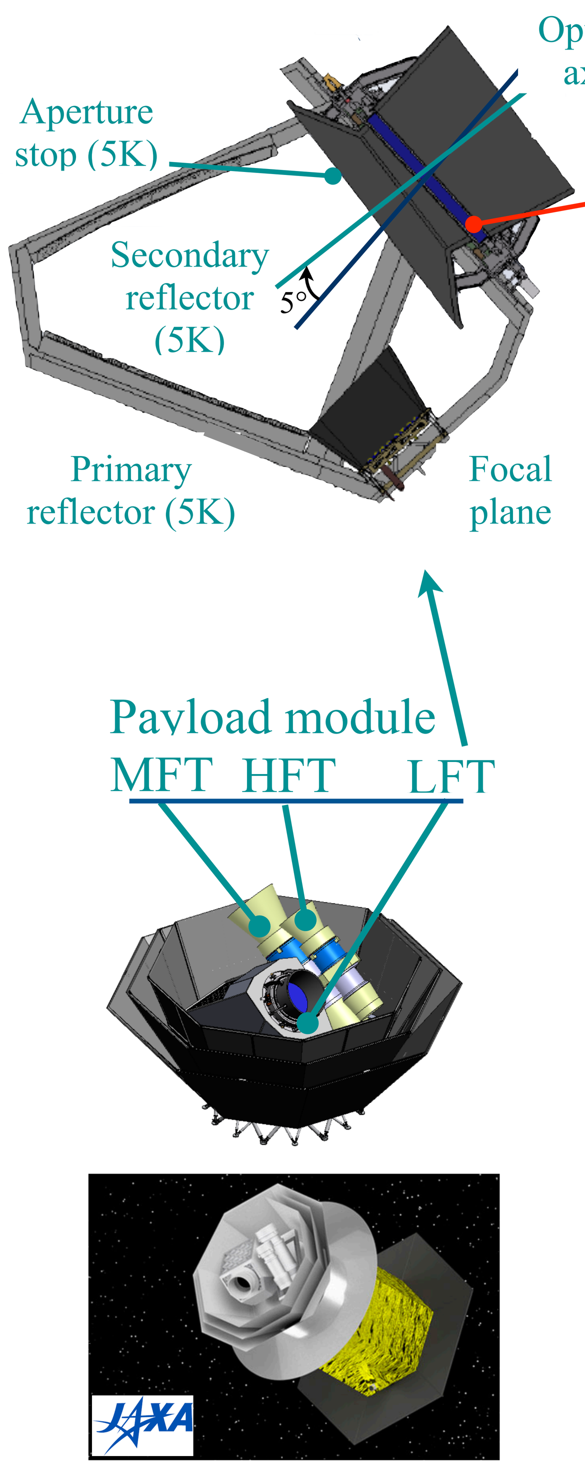
LiteBIRD is the future Cosmic Microwave Background (CMB) radiation polarization satellite searching for primordial gravitational waves generated during the inflationary epoch prior to the Big Bang. One of the main scientific goals is to **achieve an upper limit on, or measure, the amplitude of the primordial gravity waves (B mode polarization), which is parameterized by the tensor-to-scalar ratio $r < 0.001$ (for $2 \le \ell \le 200$)**. LiteBIRD payload module will deploy a low-frequency telescope (LFT), a medium-frequency telescope (MFT), and a high-frequency telescope (HFT). All telescopes employ polarization modulator units (PMU) using continuously rotating half-wave plates (HWP). The PMU is a crucial component to mitigate/avoid several systematic effects including 1/f noise, to reach unprecedented sensitivity.

We have developed a second breadboard model (BBMv2) PMU for the LFT. In this poster, we present the design and testbed of the **LiteBIRD LFT PMU BBMv2**.

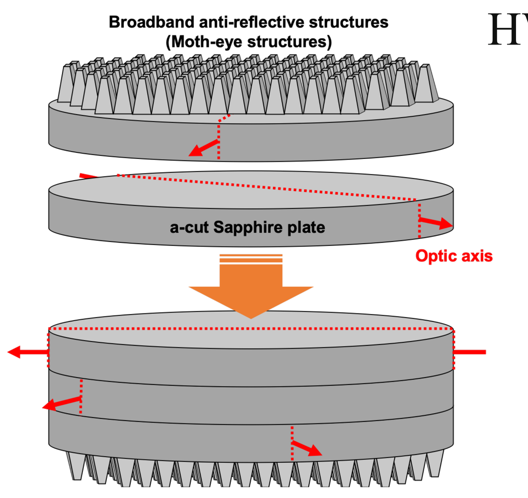


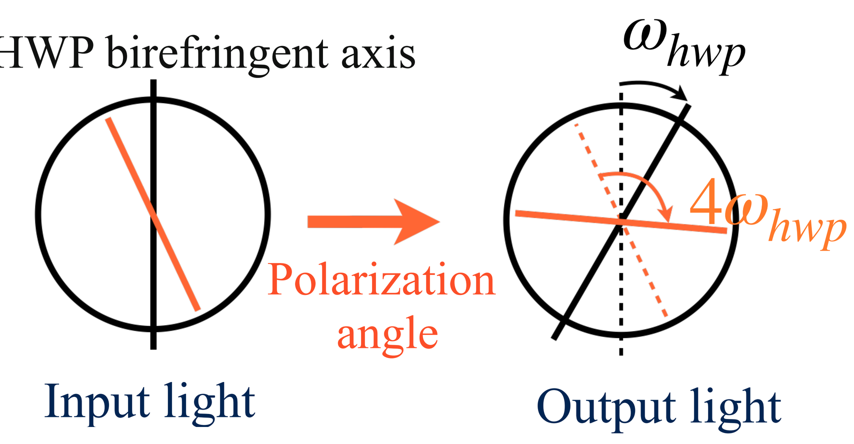
•LiteBIRD will improve current sensitivity on r at large angular scale.

II. LFT Polarization Modulation Unit

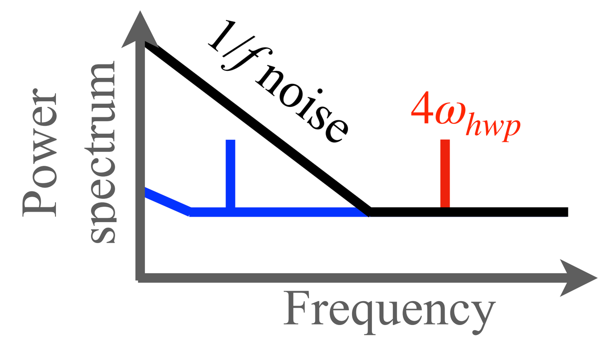


A 5-layer sapphire Achromatic Half-Wave Plate (AHWP): Rotating birefringent plates to modulate CMB polarization signal.

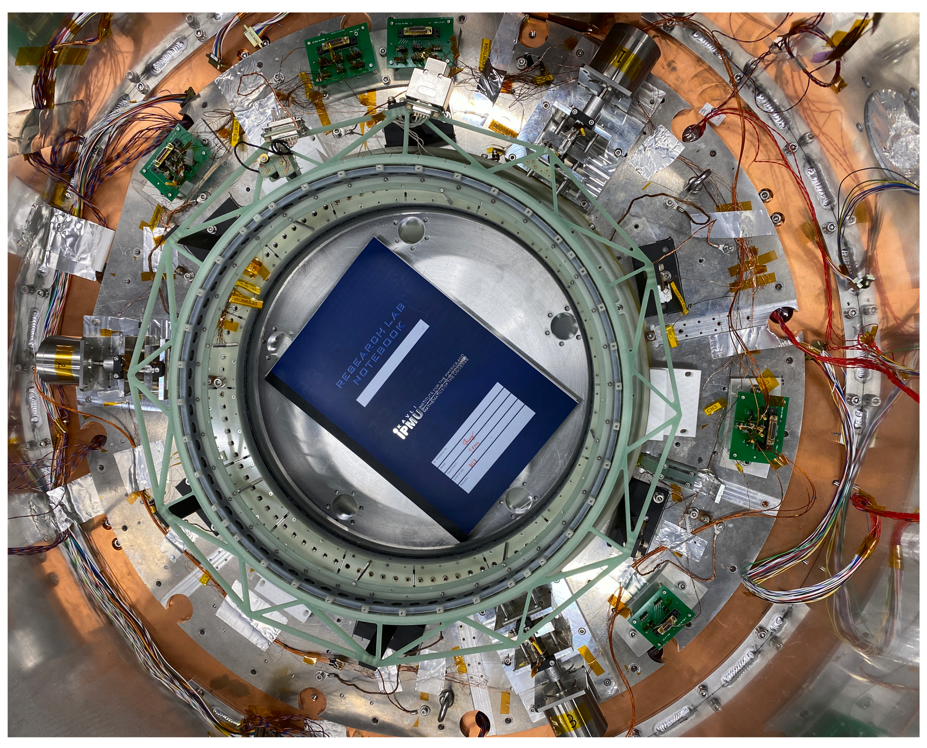


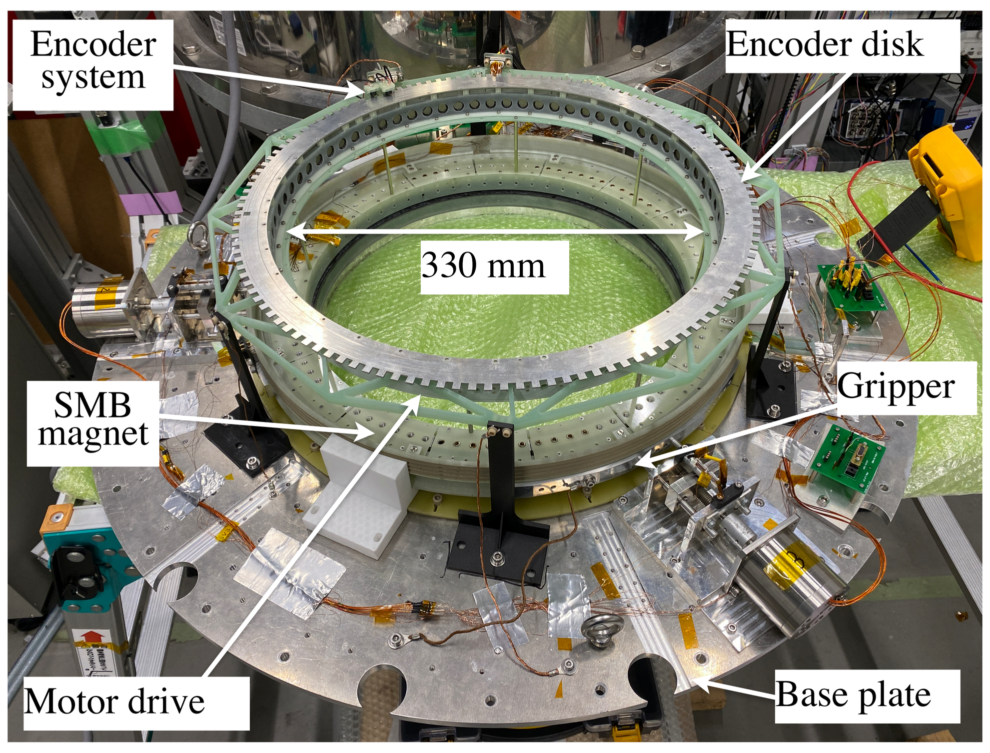


$$d_m(t) = I + Q\cos 4\omega_{hwp}t + U\sin 4\omega_{hwp}t$$

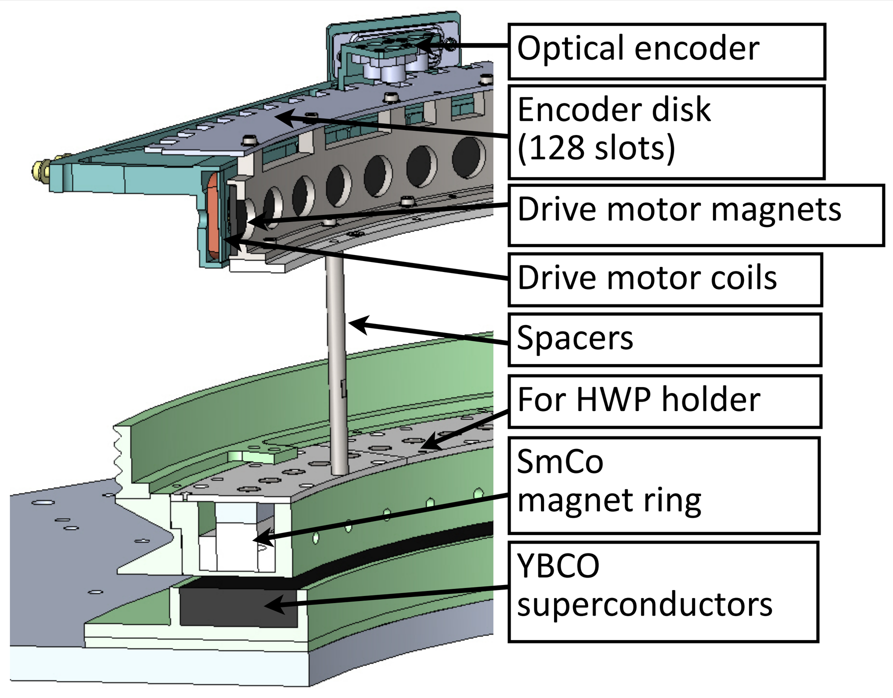


III. Breadboard model (BBM) of the PMU





• The second version of the breadboard model (BBMv2) of the PMU contains **a cryogenic rotational mechanism (a YBCO ring, and a rotor), a holder mechanism (grippers), and an optical encoder system.**

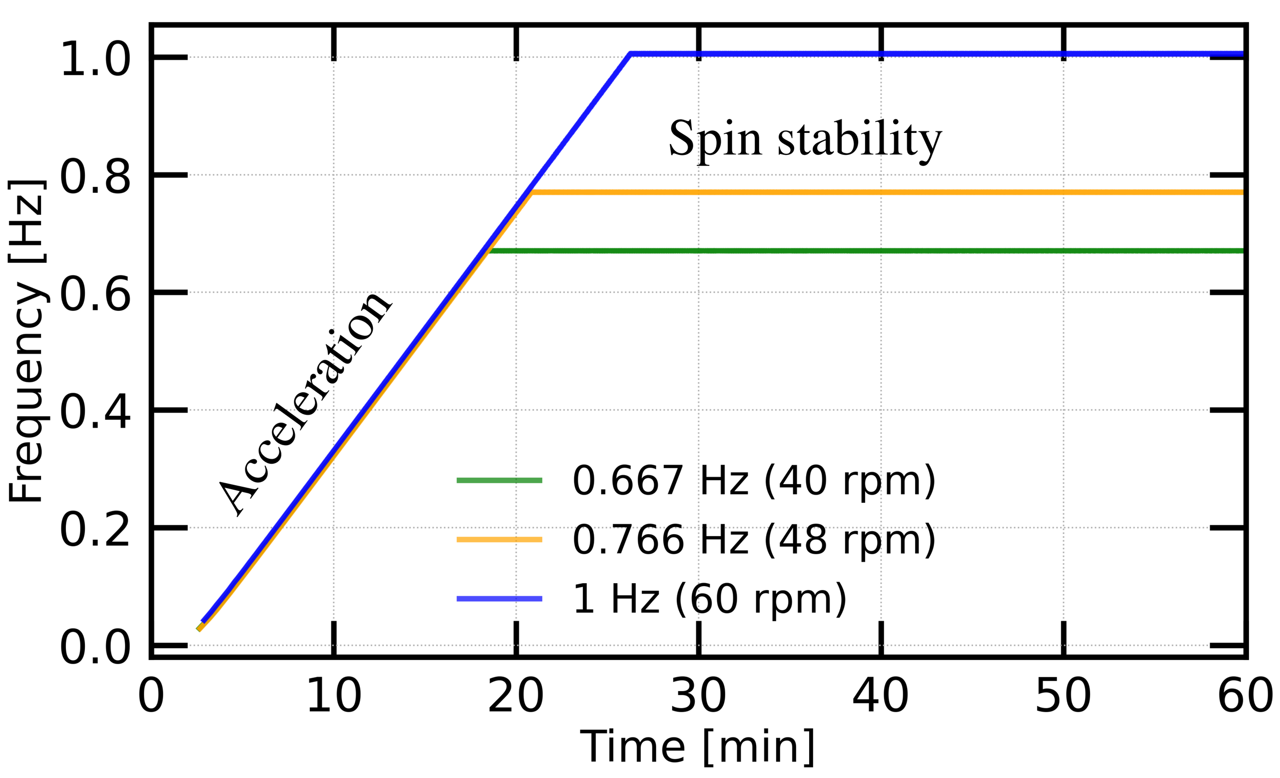


•We employ a custom AC driver motor which outputs a 3-phase signal to accelerate and maintain the rotor/HWP at a constant rotational frequency.

•The cryogenic rotational mechanism is **a superconducting magnetic bearing (SMB)** which consists of high-temperature superconductors (HTS) YBCO (46 pieces arranged in a ring shape) and a SmCo permanent magnet (32 pieces arranges in a ring shape).

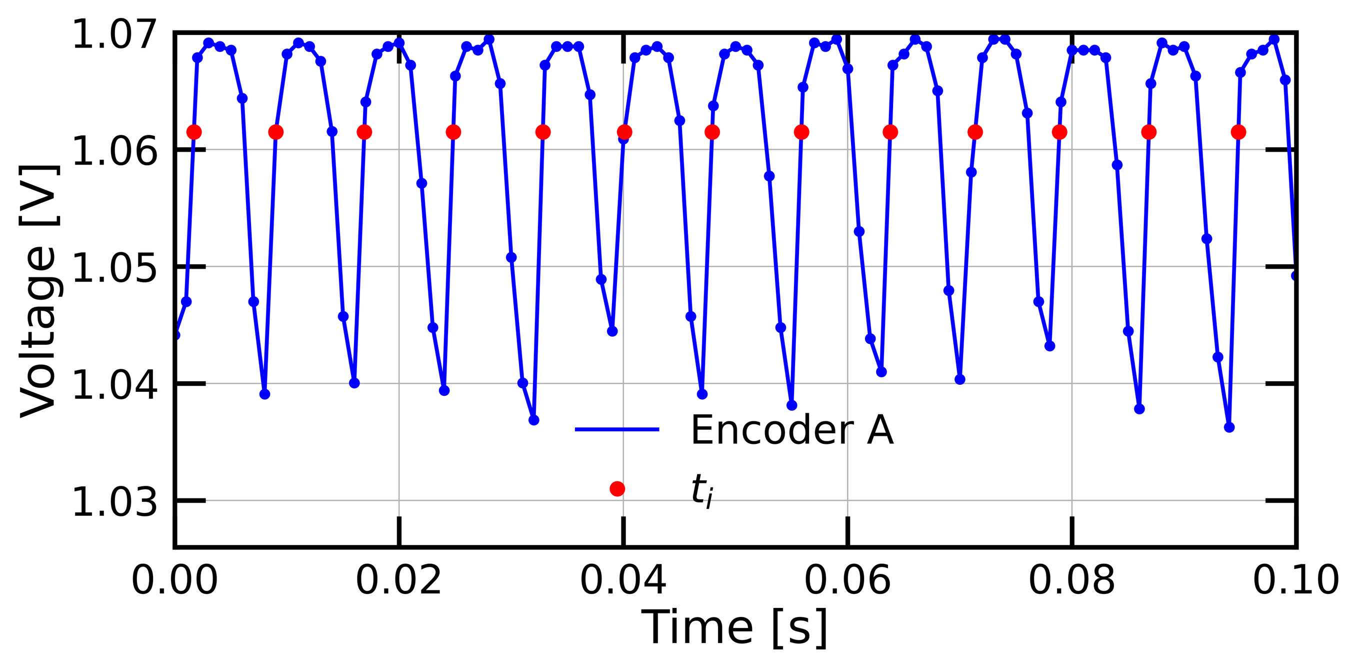
•At cryogenic temperature, the HTS will levitate the SmCo ring as the rotor. Therefore, the SMB with no mechanical contact can avoid the heat dissipation from the physical friction.

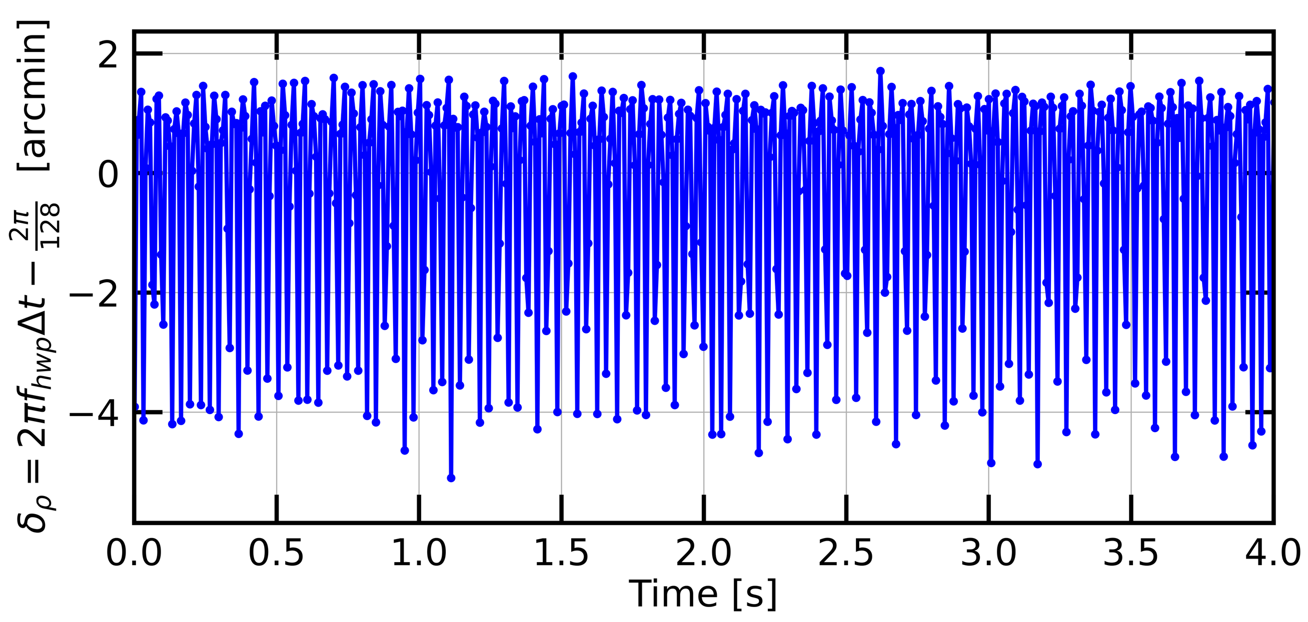
IV. Results: *We present some preliminary results of the BBMv2 cryogenic test.*



•We accelerated the rotor to a constant frequency. The minimum current for the constant rotation at 1 Hz is 150 mA.

•The resistance of the single motor drive coil $R_{coil,300K} = 5.5\Omega$, then the power of the heat dissipation from the 3-phase coil at 30K is estimated about 3 mW.





•HWP angle reconstruction is critical for data analysis. We evaluate the instability in the HWP angle using the period of the encoder.

$$\delta\rho_{A;i} = 2\pi f_{hwp}\Delta t_{A;i} - \frac{2\pi}{128}$$

Measurement *Design*

•Using the raw encoder data, we can estimate the HWP angle instability.

V. Summary and future works

- We have developed LiteBIRD LFT PMU a bread model. We have carried out cryogenic testbed for the system.
- We spun the rotor at different frequencies, measured the Hall sensor signal, and the encoder signal.
- The BBMv2 tested results help to develop the design of the PMU flight model.
- The thermal model of the PMU and cryostat system is necessary for the power consumption estimation. Heat dissipation of the rotational mechanism is an on going research and development.
- In the future we will integrate 5-layer HWP with/without Anti-Reflecting coating, an aperture to the system and measure the optical modulated signal.