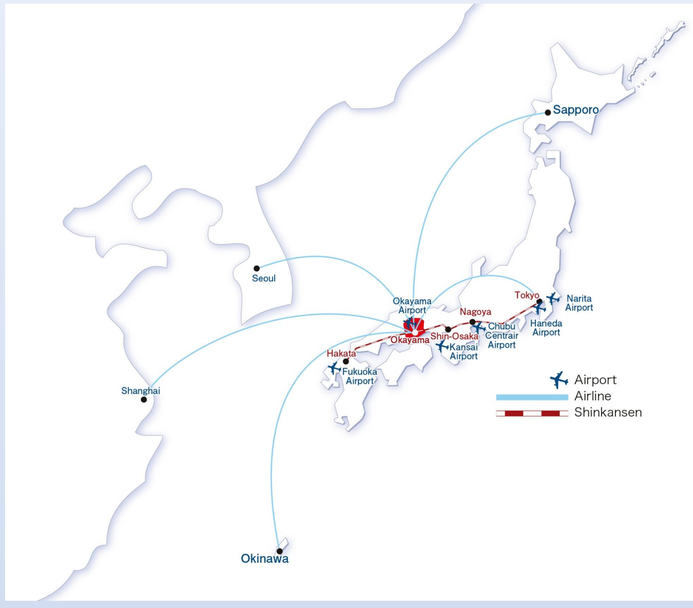
Activities at Okayama University for LiteBIRD

Hirokazu Ishino on behalf of the LiteBIRD team in Okayama University

The LiteBIRD team at Okayama University was formed in Apr. of 2008 and has been mainly working on the estimation of systematic uncertainties of tensor-to-scalar ratio r and the development of the low frequency telescope half wave plate (HWP). Hirokazu Ishino, PI in this laboratory, is one of the conveners of the LiteBIRD joint study group (JSG) for systematic error study and manages all the activities related to it by involving world wide LiteBIRD members. Students in our lab have been committed to the HWP hardware developments. Kunimoto Komatsu, a doctoral student and JSPS DC1 fellow, is one of the key players for the development, giving main contributions for the evaluation of HWP polarization efficiency with a construction of measurement systems for both room and cryogenic temperatures, and radiation tolerance tests using a 160 MeV proton beam at HIMAC.

Okayama University



Okayama Univ. is situated near downtown Okayama city, 2km from Okayama station, 3 hours from Tokyo and 1 hour from Kyoto by Shin-kan-sen.

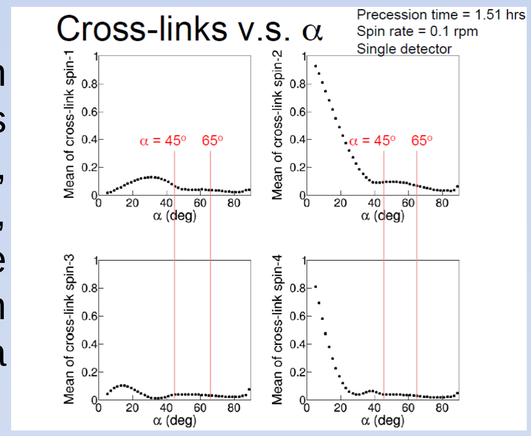
The Okayama team includes one faculty, one posdoc and eight students; most of them are involved in the LiteBIRD project.

Systematic Error Studies

We have been performing several studies on the systematic effects for LiteBIRD. Hirokazu Ishino, one of conveners of the systematic JSG (Guillaume Patanchon and Julian Borrill are co-conveners), manages the group for more than 4 years. We have identified about 70 systematic sources and summarized those effects on the tensor-to-scalar ratio in the document submitted to the pre-phase-A1 exit review. The systematic sources, identified as beam, gain, instrumental polarization, polarization efficiency, time-correlated noise, polarization angle, band pass, cosmic ray glitches, are studied in the world-wide JSG members. Some of them have been published or in preparation for journal papers. The studies are strongly related to the LiteBIRD basic specification, for example, the scan strategy, HWP module and the data sampling rate. Below we give a brief explanation of the scan strategy.

Scan strategy

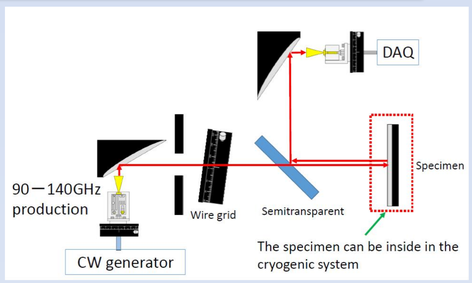
Our group proposes the scan strategy based on various studies including the cross-link, hit uniformity, revisit time, CMB dipole calibration, visible time of planets under the limiting conditions of the momentum inertia, HWP spinning rate and data transfer rate.

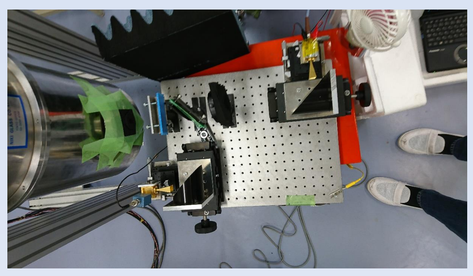


The scan parameters include the precession rate/angle and spin rate/angle. We present one plot to show the cross-link dependence on the precession angle below. We propose the precession rate/angle = 1.51 hours/45 deg., and spin rate/angle = 0.1 rpm/50 deg.

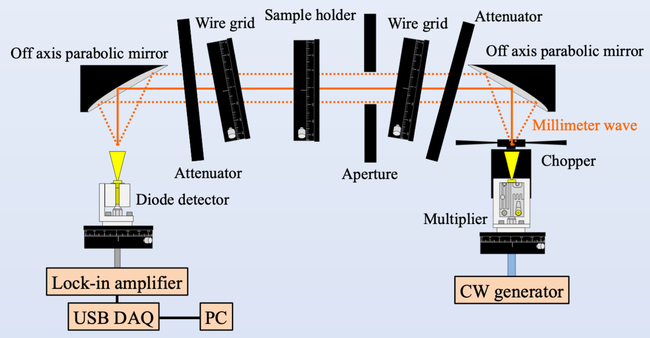
Millimeter wave measurement system at Okayama U.

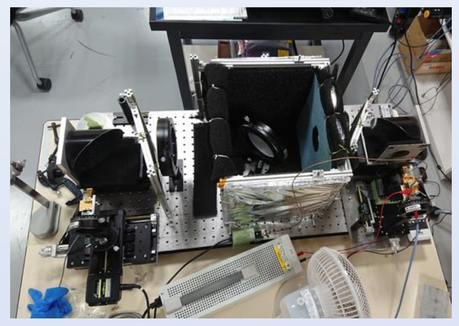
We have build a system that can measure the reflectance of a specimen using semitransparent wafer made of silicon at Okayama U. The system can be carried to other institution. For example, we measure a specimen placed inside of a 0.3 K cryogenic refrigerator at KEK as shown in the right picture. The measurement system will be used to characterize the optical properties of stacked HWPs.





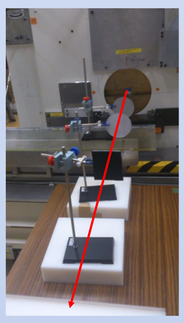
MM-wave optical measurement system at Kavli IPMU

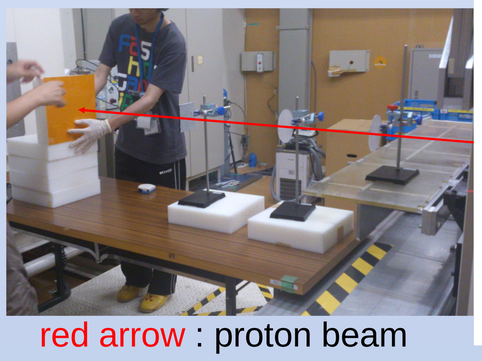




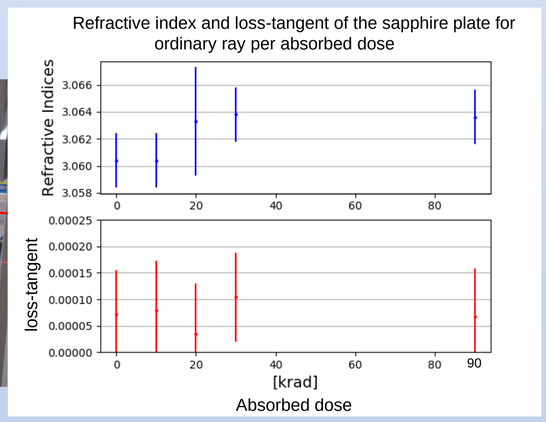
We, Kunimoto Komatsu and Tomo Matsumura (IPMU), have developed a mm-wave optical measurement system. The system enables us to measure the transparency, refractive index and loss-tangent of specimens as well as HWP modulation efficiency for mm-waves at 33-260 GHz. At present, we are building the measurement system functioning at the cryogenic temperature at Kavli IPMU.

Irradiation test at HIMAC



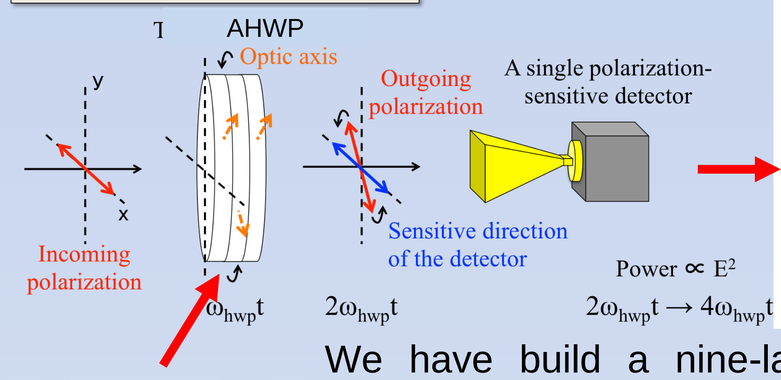


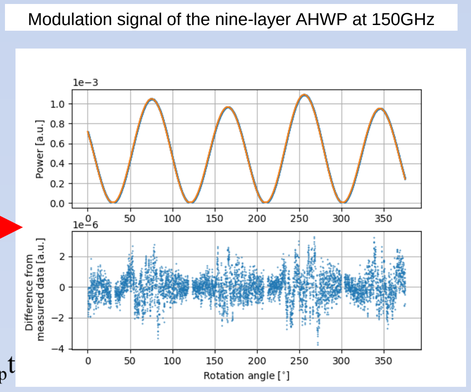
red arrow : proton beam

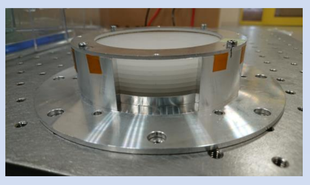


We have performed irradiation tests using a 160 MeV proton beam at HIMAC. We expect cosmic ray radiation does of 2 krad at maximum during the operation at L2. The radiation may change the properties of the optical components and electric devices. We measured the index of refraction and tan-loss for several optical components by measuring the fringe pattern in the transparency as a function of frequency. One example is that we confirm the sapphire plates used for the LFT HWP do not change the properties up to 90 krad.

HWP demonstration



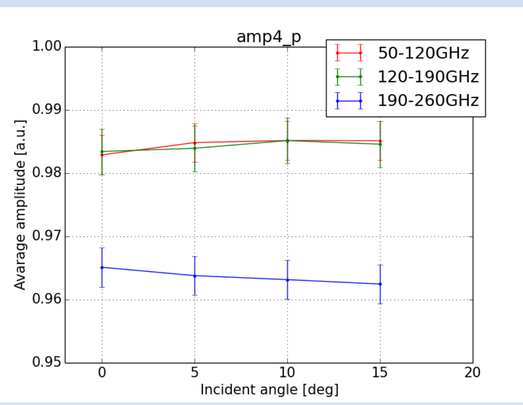




The nine-layer AHWP

We have build a nine-layer achromatic HWP to demonstrate a broadband high polarization efficiency. The AHWP was prepared using an alignment machine at KEK. We measure the polarization efficiency as a function of the frequency using the evaluation system at Kavli IPMU.

We have demonstrated that the AHWP has more than 96 % polarization efficiency in a frequency range of 90 - 280 GH. The AHWP used for this study was not yet tuned for the current LFT design. We will rebuild AHWP to cover 34-161 GHz.



Other activities in LiteBIRD

Students in our group are working on forming of AR structure using a laser system at Kavli IPMU, gluing of stacked HWP to have tolerance to vibration during launch and software development to perform data analysis and evaluation/mitigation of systematic effects. Geant-4 simulation is used to estimate of the irradiation dose to the S/C.