Development of Microwave Kinetic Inductance Detectors and a newly-developed Readout System for LiteBIRD

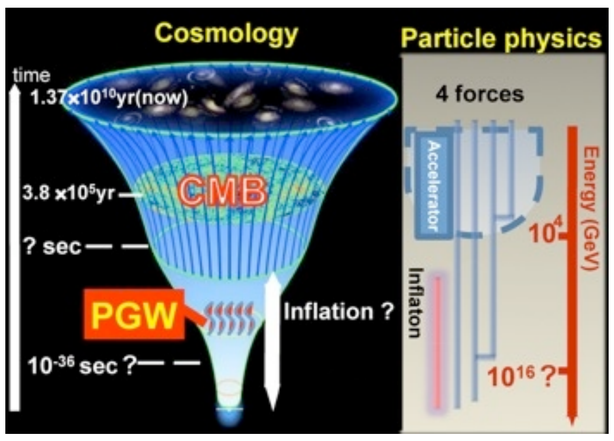
Y. Kibe, K.Hattori, M.Hazumi, H.Ishino, A.Kibayashi, S.Mima, T.Okamura,
N.Sato, T.Tomaru, Y.Yamada, M.Yoshida, T.Yuasa, and H.Watanabe

13th Vienna Conference on Instrumentation, Feb. 11 - 15, 2013

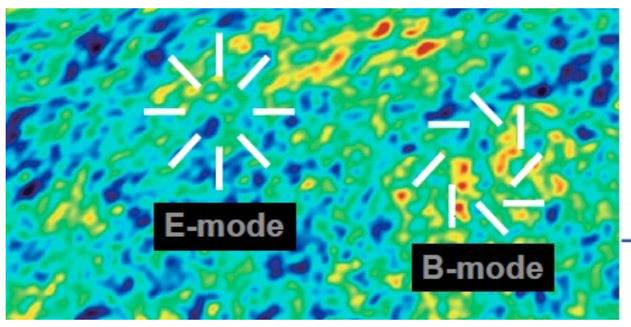
1. introdction

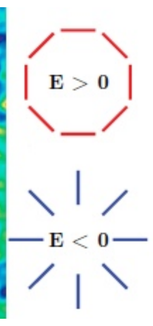
・Primordial gravitational waves (PGW) were supposed to be generated during inflation.
→ imprinted a **B-mode polarization pattern** on cosimic microwave background (CMB)
→ precise measurement of B-mode can identify an inflation model

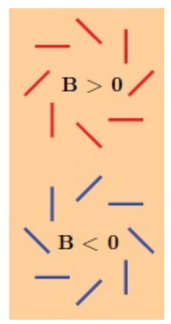
LiteBIRD: being designed to detect CMB B-mode polarization pattern
← need about 2,000 high sensitive detectos with wide frequency band (50 - 250 GHz) and high multiplexing factor due to limiting cooling power

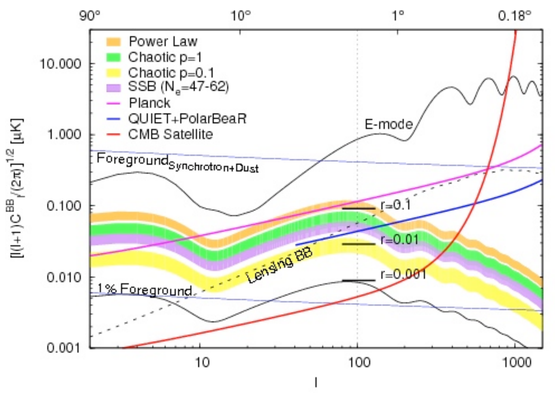


MKIDs are one of the candidates as suitable detectors!

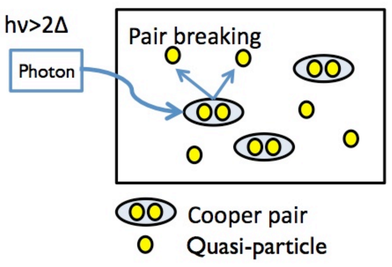




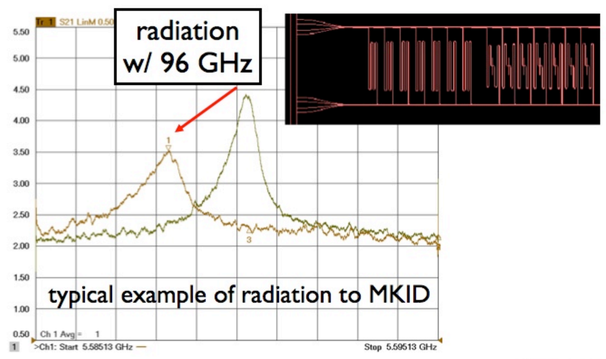




2. Microwave Kinetic Inductance Detectors (MKIDs)



Breaking Cooper Pair
→
Change Inductance



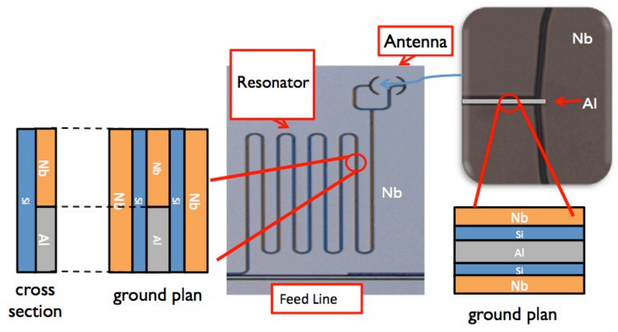
・MKIDs
- consist of a feed line and resonators
- Cooper pairs are broken and quasi-particles are generated when a resonator is irradiated by millimeter-wave radiation

→
Resonant frequency changes.
→ alters transmission **amplitude and phase** of the on-resonant microwave
→ enables us to detect the millimeter-wave radiation

・Making high sensitive MKIDs

a), Nb-Al hybrid CPW MKID

b), a niobium thin layer is used for feed line and resonators, and aluminum is used for resonators near the anntena

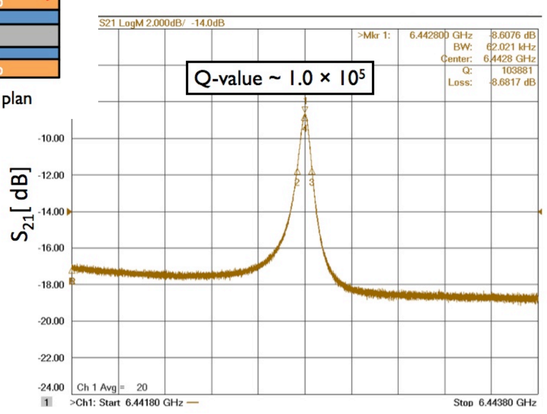


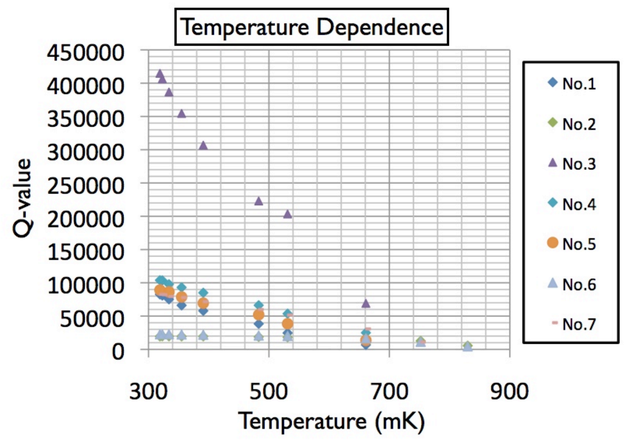
・Checking performance of Al-Nb hybrid MKIDs

a), performed the experiment with the sorption cryostat

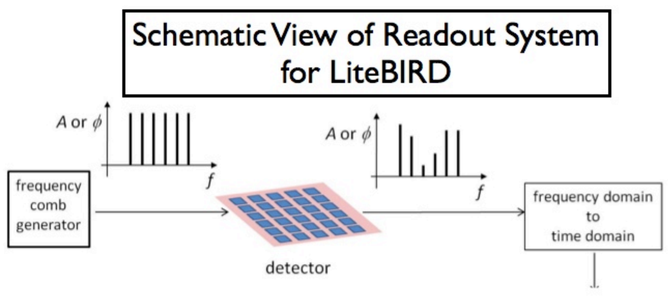
b), achieved the Q-value of ~ 4.0×10^5 @ 0.3 K

c), investigated the dependence of resonant peak on temperature, and confirmed that Q-value of a resonant peak decreases in inverse proportion to temperature





3. Readout System



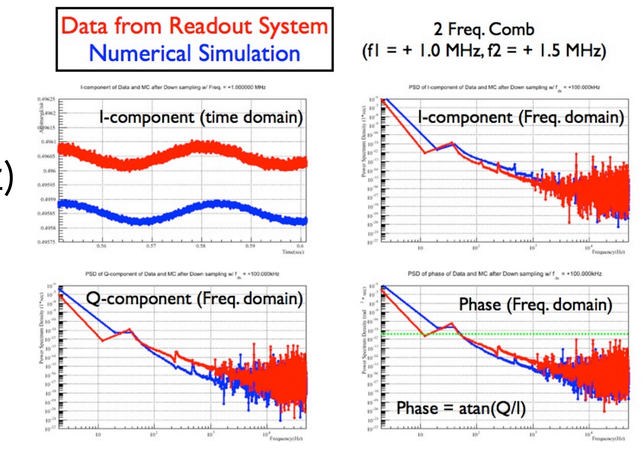
・Readout System for LiteBIRD

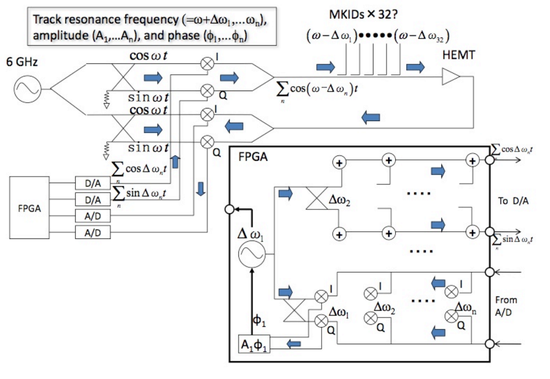
a), read out multi-channels with one cable
→ prevent heat inflow (favorable for low temperature)

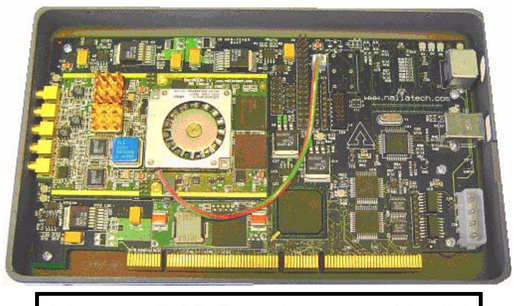
b), sampling rate is faster than detector response (>> 10 kHz)

c), observation without dead time

d), readout rate (data transfer to offline) > 10 kHz
→ perform common mode suppression to reduce noise







Xtream DSP Development Kit-IV
(Xilinx FPGA Vertex-4)

・R & D Status of Readout System

a), develop 2-channel FPGA-based readout system

b), debug the readout logic with comparing data and numerical simulation results. This simulation reproduces data well.
→ We can understand noise characterization sufficiently.
→ aim for low noise system to satisfy required noise level
(1.95×10^{-6} rad・√sec)