POLARBEAR-2

– a new CMB polarization receiver for exploring the physics of inflation and neutrino mass –

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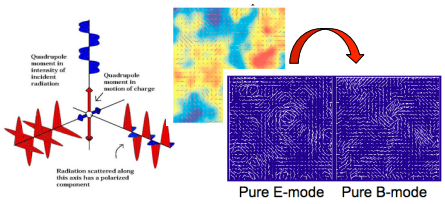
1. CMB Polarization

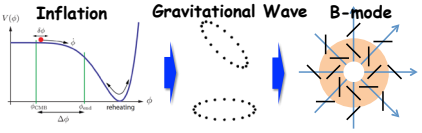


CMB is linearly polarized by Thomson scattering of radiation with quadrupole anisotropy.

The polarization signal can be separated into two orthogonal components: "E-mode" (modes of zero curl) and "B-mode" (modes of zero divergence)

2. Science target with CMB B-mode

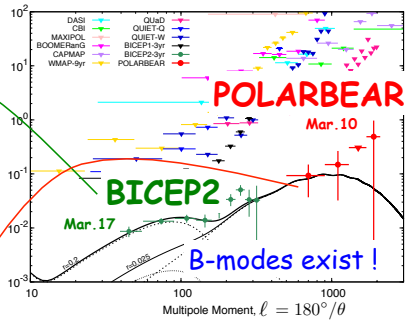
Inflationary B-mode



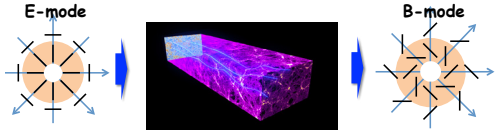
- B-mode is a smoking-gun signature of inflationary universe.
- Inflationary energy can be reconstructed with its amplitude.

$$V^{1/4} = 1.06 \times 10^{16} \times \left(\frac{r}{0.01}\right)^{1/4} \text{GeV}$$

→ Unique probe of gravity – quantum mechanics connection



(Gravitational) Lensing B-mode

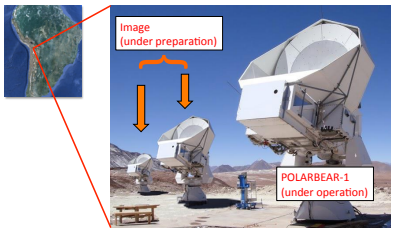


- Small scale (sub degree) B-modes originate from gravitational lensing effect of large scale structure. Its amplitude is sensitive to "sum of neutrino masses".

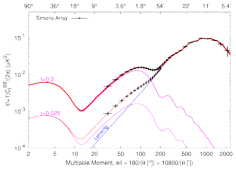
Recent results (BICEP2 and POLARBEAR) opened a door to a new era of B-mode cosmology !
→ New receiver is indispensable to fully exploit CMB B-mode physics.

3. POLARBEAR-2

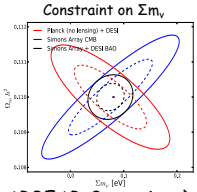
Simons Array Project



B-mode spectrum



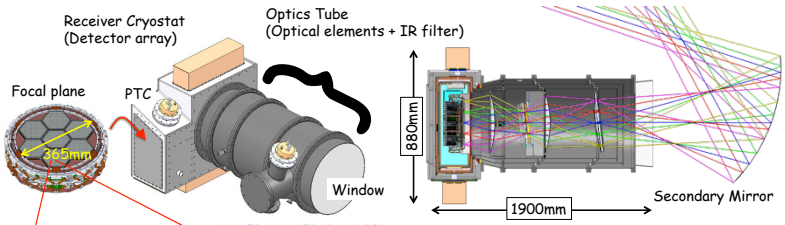
Constraint on Σm_ν

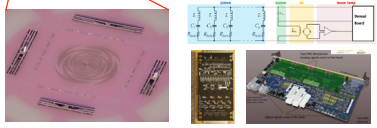


Simons Array is an expansion of POLARBEAR-1
- 3 identical 3.5m telescopes
- New multichroic bolometer receivers (POLARBEAR-2 receiver)

Projected sensitivity
- Detect r=0.01 with 5σ significance
- Sum of neutrino masses : 19meV at 1σ w/ Planck and DASI(BAO)

POLARBEAR-2 Receiver overview




Multichroic Detector

Multiplex Readout

Main features

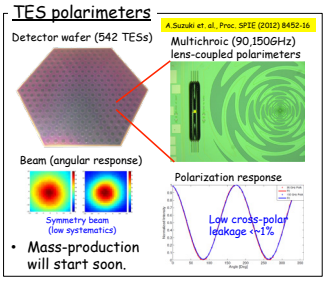
- World largest focal plane (for statistics)
- Optics system matching to the large mirror (for systematics)
- Multichroic detector (for foregrounds)

Specification of PB-1 and PB-2 receiver

	PB-1	PB-2
Frequency [GHz]	150	95, 150 (220)
# bolometers	1274	7588
Focal plane size (diameter)	190mm	365mm
NET array	23μK√s	4.1μK√s (95+150)
Field of view	2.4°	4.8° (150GHz)

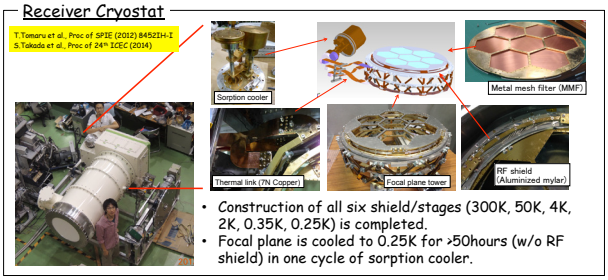
Core Technologies

TES polarimeters



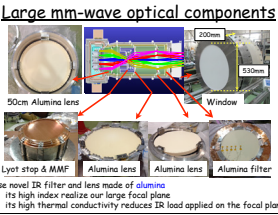
- Mass-production will start soon.

Receiver Cryostat

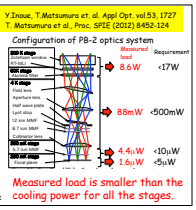


- Construction of all six shield/stages (300K, 50K, 4K, 2K, 0.35K, 0.25K) is completed.
- Focal plane is cooled to 0.25K for >50hours (w/o RF shield) in one cycle of sorption cooler.

Large mm-wave optical components



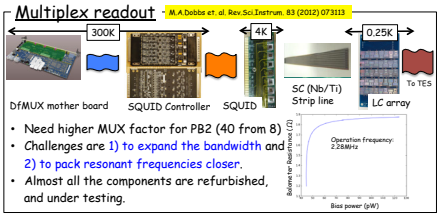
Use novel IR filter and lens made of alumina
- its high index realize our large focal plane
- its high thermal conductivity reduces IR load applied on the focal plane



Measured load is smaller than the cooling power for all the stages.

Multiplex readout

M.A.Dobbs et. al. Rev.Sci.Instrum. 83 (2012) 073113



- Need higher MUX factor for PB2 (40 from 8)
- Challenges are 1) to expand the bandwidth and 2) to pack resonant frequencies closer.
- Almost all the components are refurbished, and under testing.

4.Plan and Summary

- All the R&Ds are done by next summer.
- Deployment at the site is in autumn – winter of 2015.
- Start observation in early 2016.

2015

2016

- 2nd PB-2 receiver (95+150GHz)will be deployed.

2017

- 3rd one (150+220GHz) will be deployed.

- POLARBEAR-2 is a next generation CMB polarization receiver to explore the physics of inflation and neutrino mass with unprecedented precision.
- New technologies (multichroic detector, cold optics, high multiplex readout) are critical steps to S4 CMB experiment, and making impacts to CMB community.
- First receiver is being developed in the lab, and will be deployed at the site in late 2015. Observation with three receivers (95/150/220 GHz) will start in 2017.