



Cosmology from CMB polarization measurements

Radek Stompor (APC)



Project teams



- **Japan:**

IPNS/KEK:

- 2 permanent researchers: M. Hasegawa, M. Hazumi
- A postdoc: Y. Chinone

Kavli IPMU:

- Permanent researcher: N. Katayama
- Postodoc: H. Nishino

- **France:**

Laboratoire AstroParticule et Cosmologie:

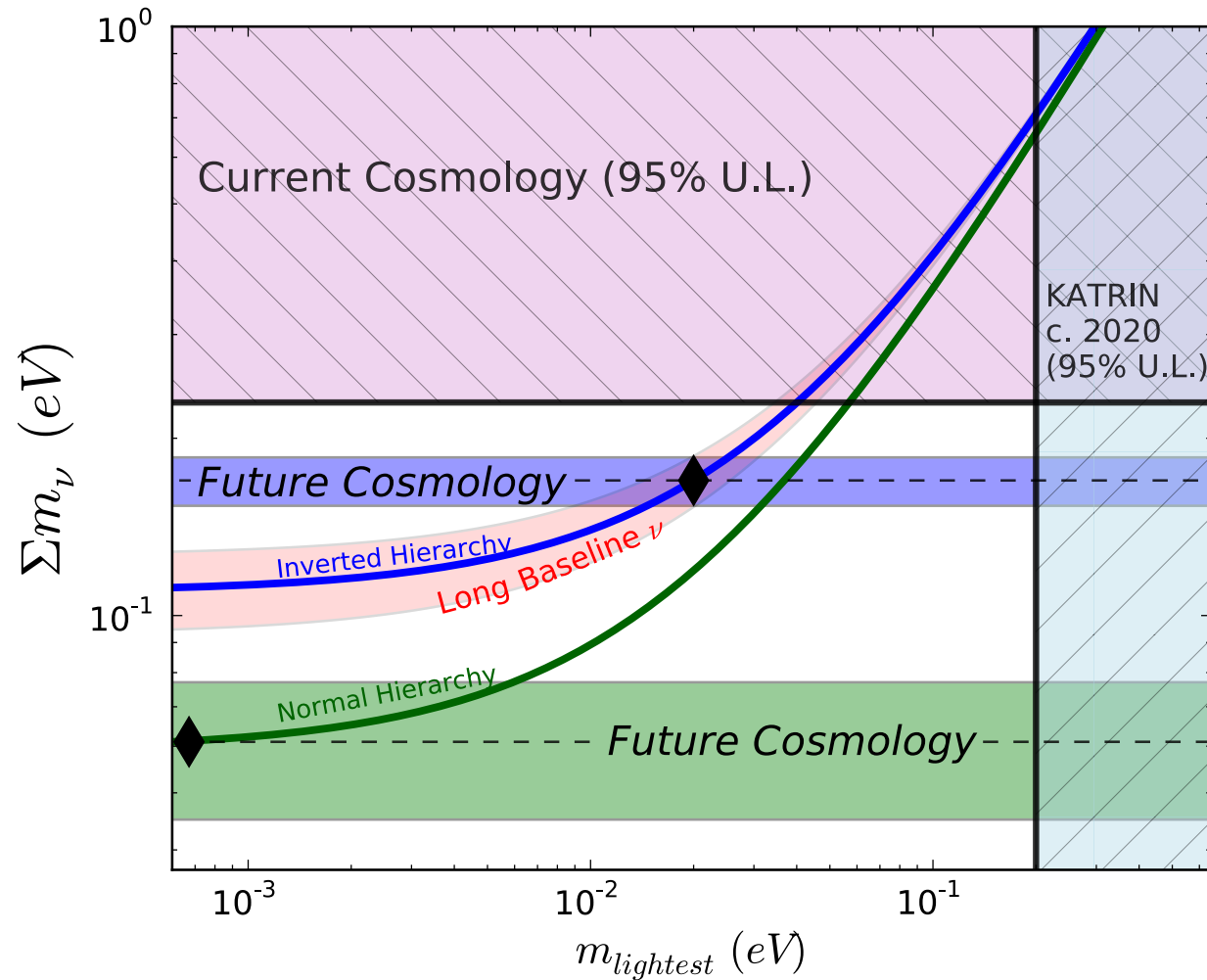
- 4 permanent researchers: M Bucher, J. Delabrouille, K. Ganga, R. Stompor
- 1 postdoc: A. Karakci
- 2 PhD students: J. Peloton, D. Poletti



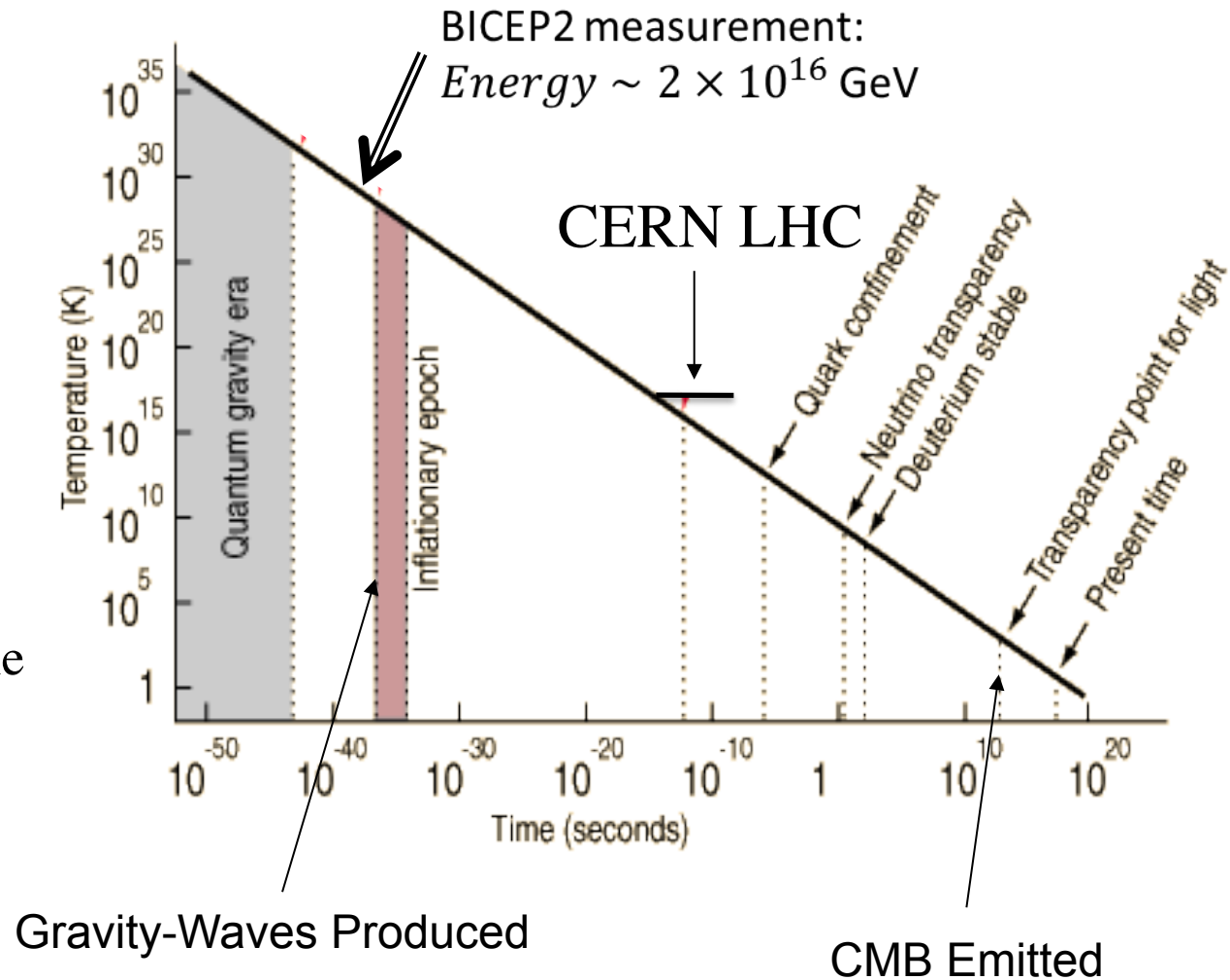
Cosmology meets fundamental physics



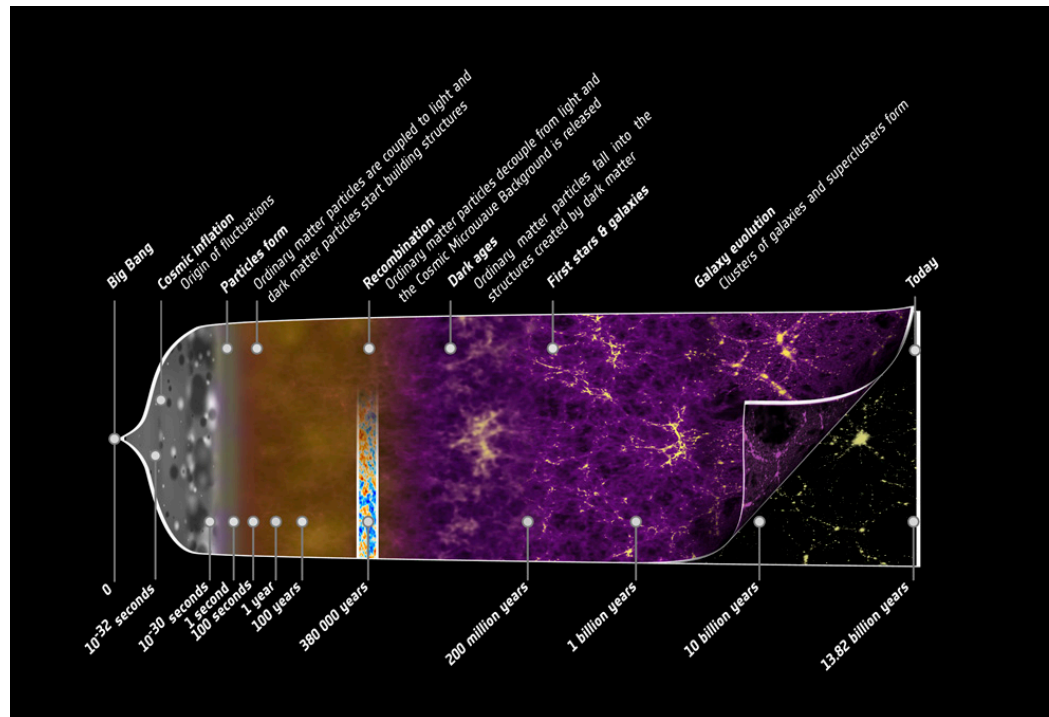
- Long tradition (roughly 30-40 years).
- Even greater future with exciting new probes coming on-line:
 - Weak lensing;
 - Baryonic Acoustic Oscillations
 - CMB polarization.
- Cross-correlations will be the name of the game for years to come ...



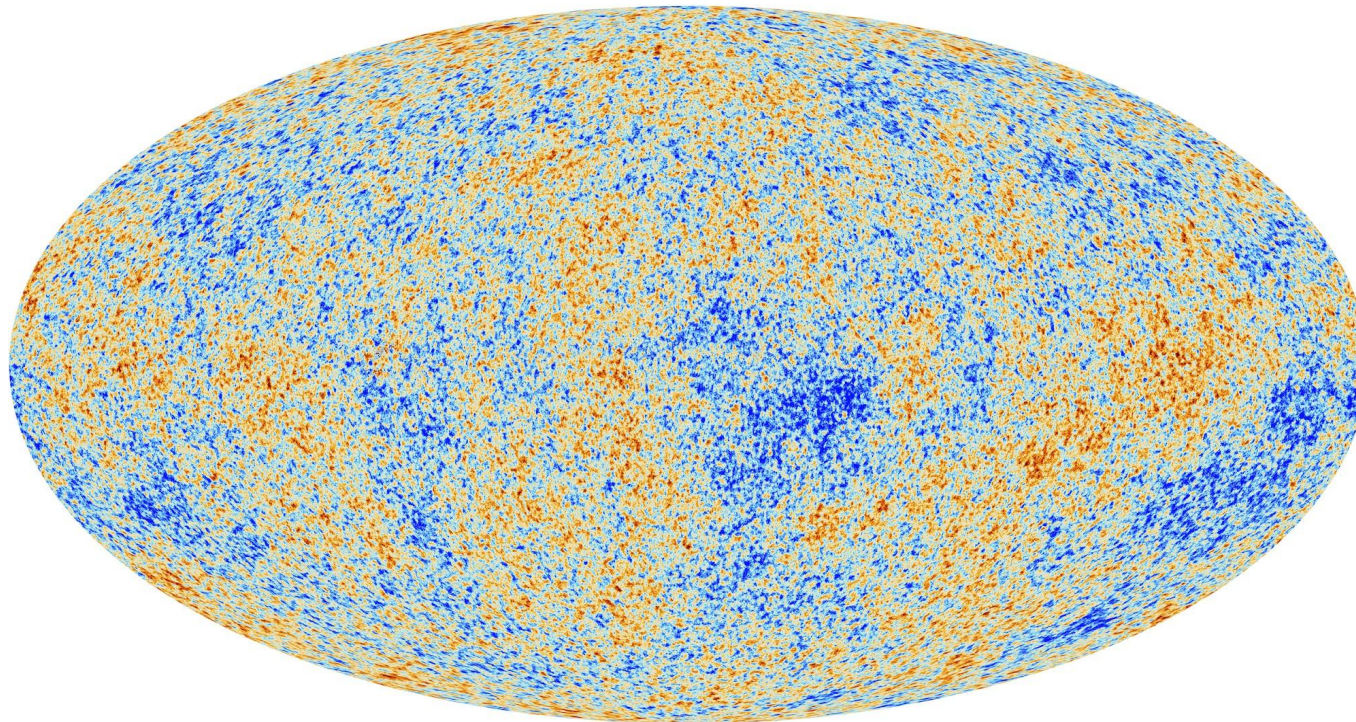
$r \propto \text{Energy}^4$
 ↑
 Amplitude of
 gravitational
 wave signal
 ↑
 Energy scale
 of inflation
 field



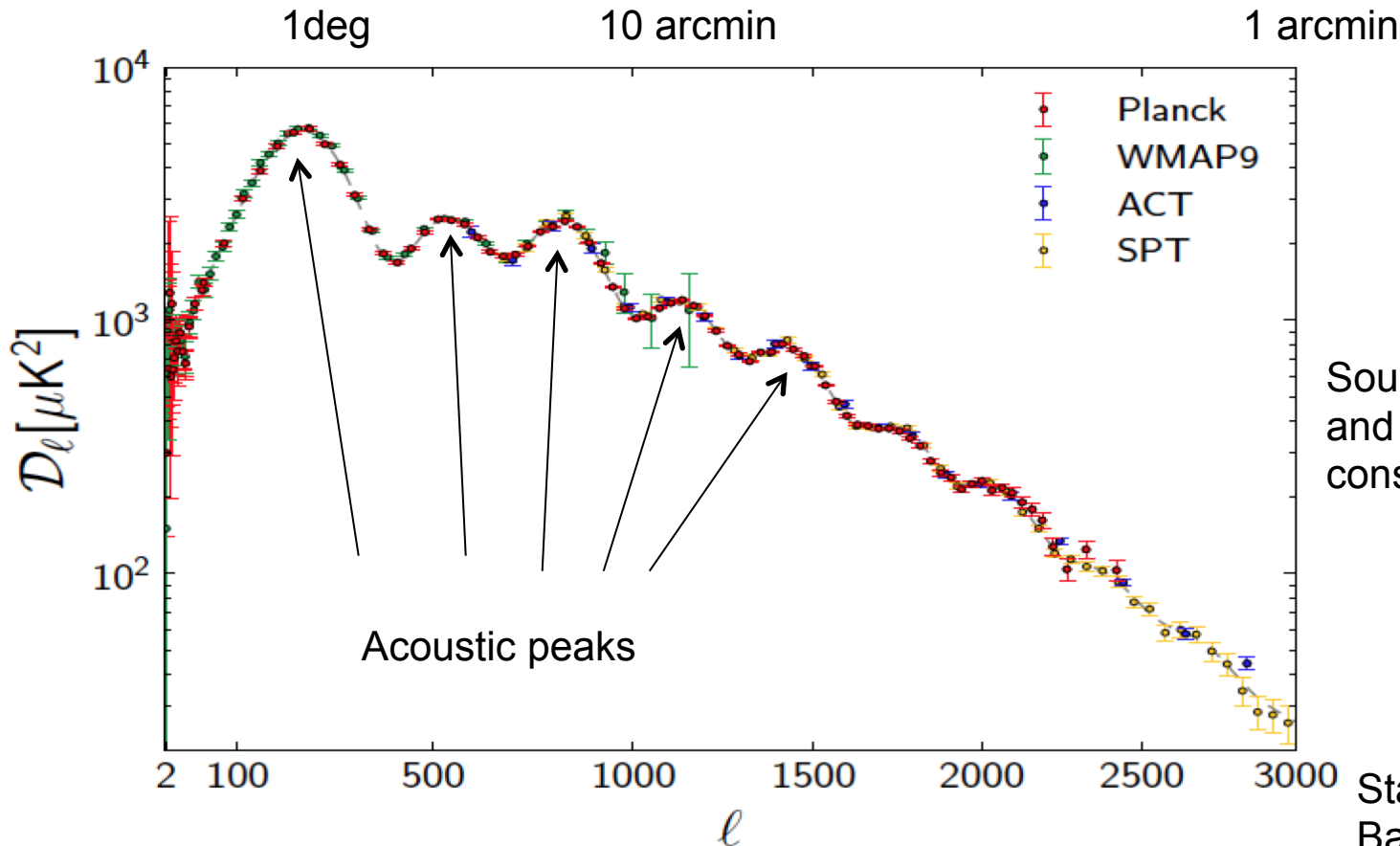
- Background of photons left over the hot and dense initial phase of the Universe;
- Travel freely once the Universe has become neutral (cosmological recombination);
- Carry an image of the Universe of roughly 0.3% of its current age.



Total intensity anisotropies



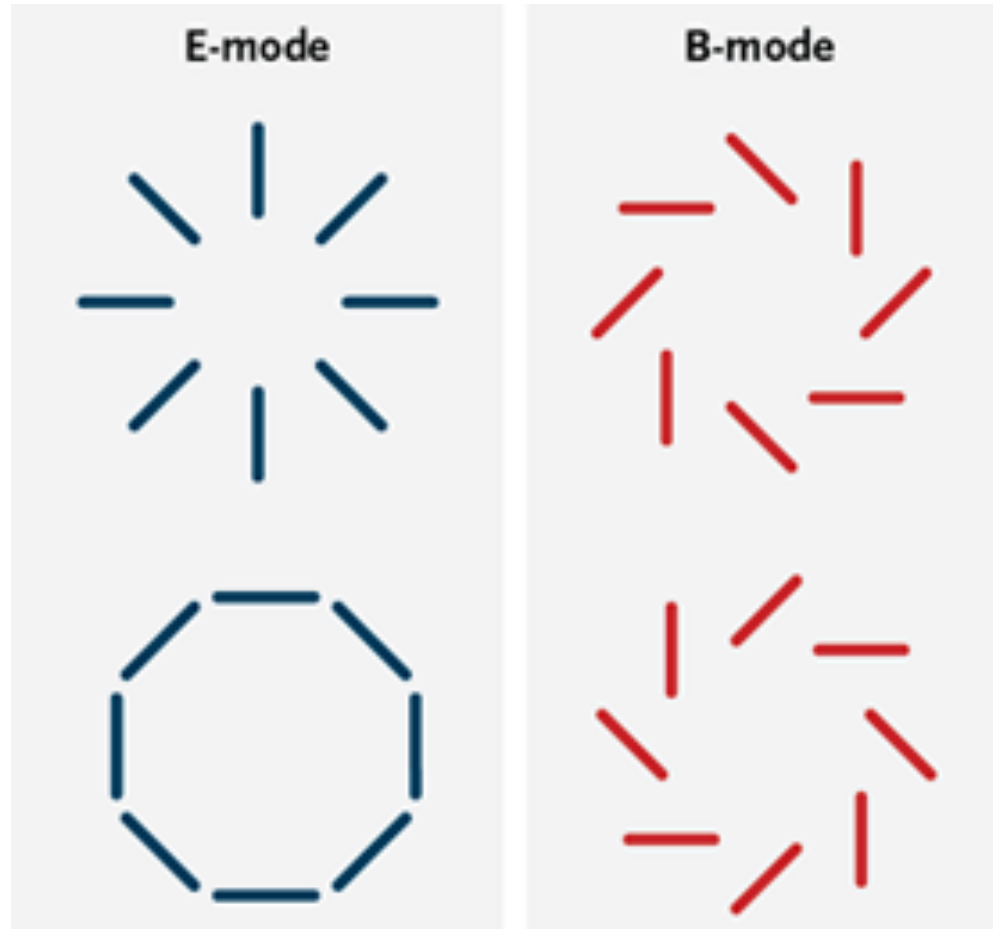
Planck collaboration 2013



Source of the qualitative and quantitative constraints on cosmology

Standard Lambda Big Bang cosmology combined with inflation does well !

Planck collaboration 2013



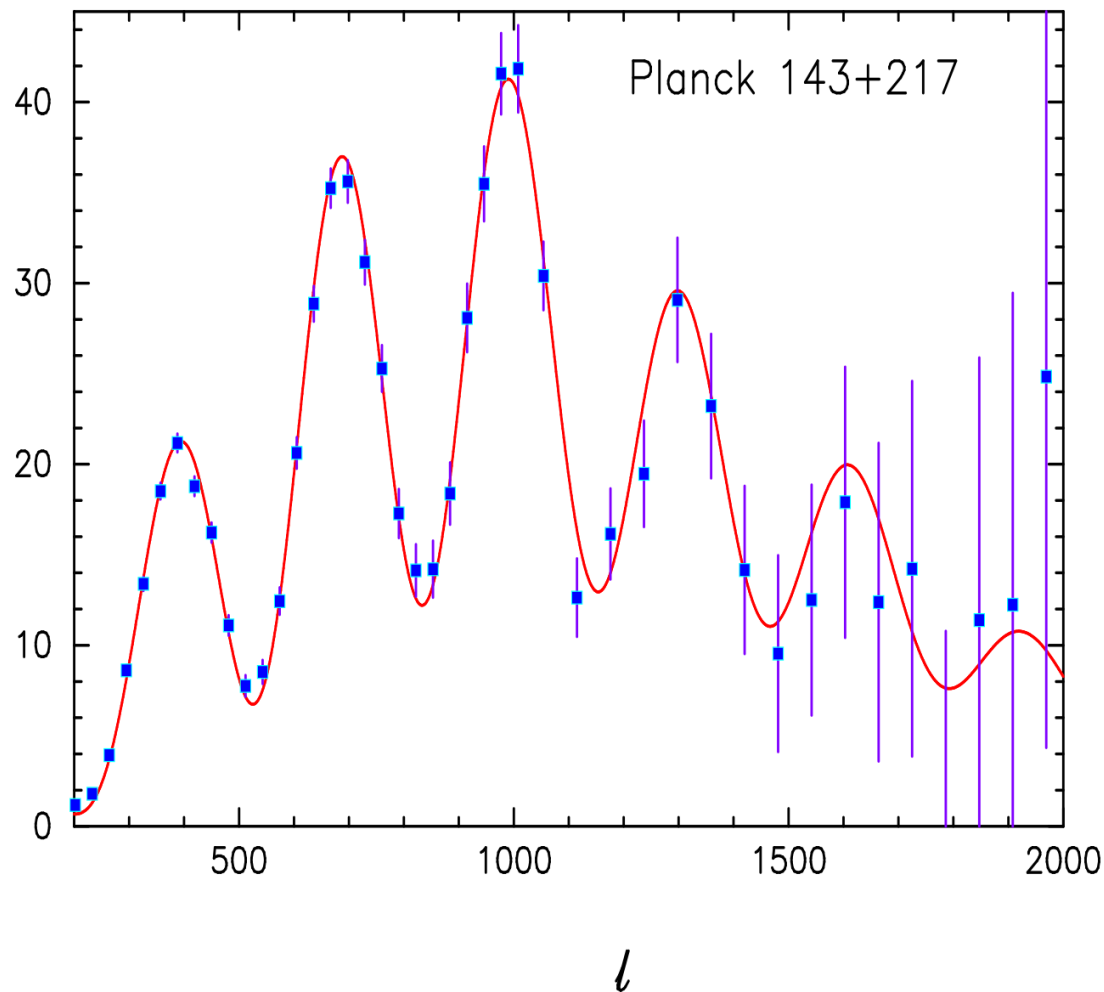
Can be generated by
scalar perturbations

Can be generated by:

gravity waves at the
recombination;
gravitational lensing acting
on E-polarization

Bad news -> small

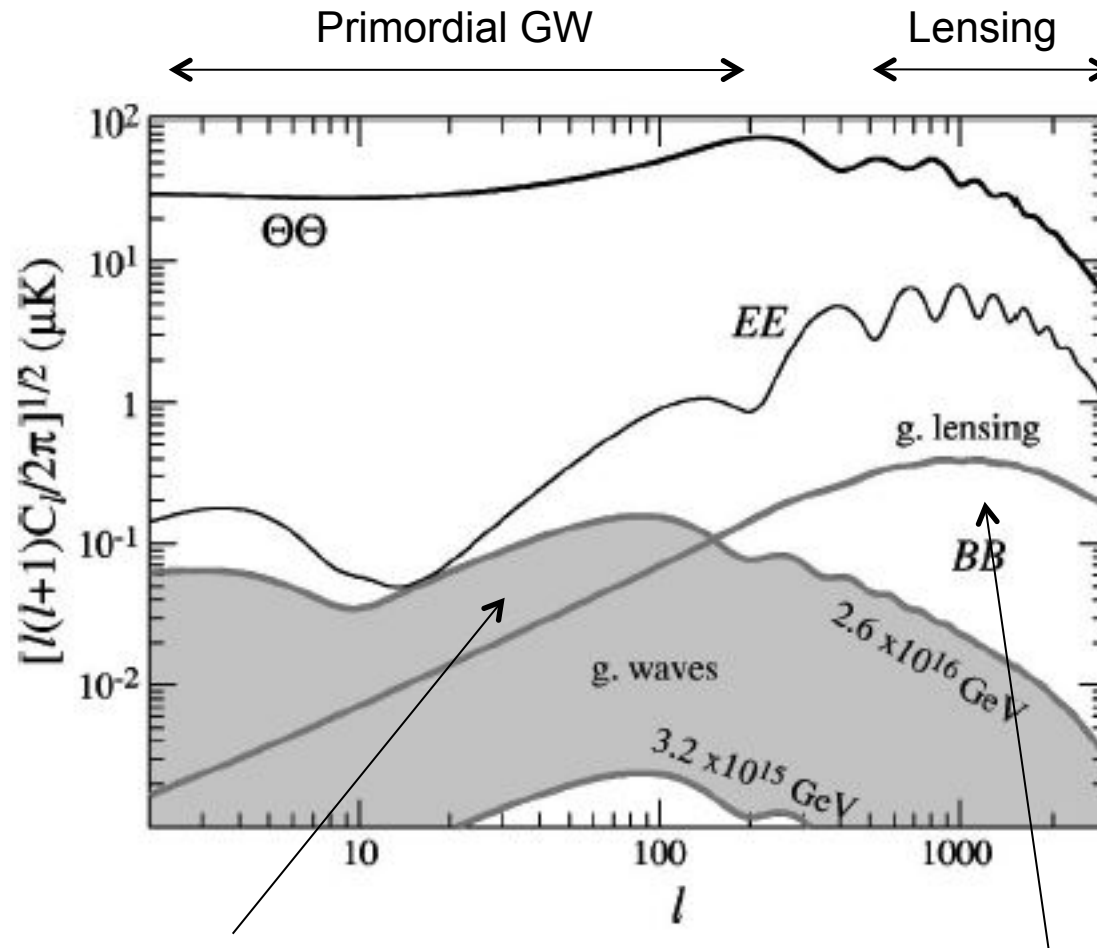
Good news -> source
of unique information



Complementary information to that from the total intensity measurements,

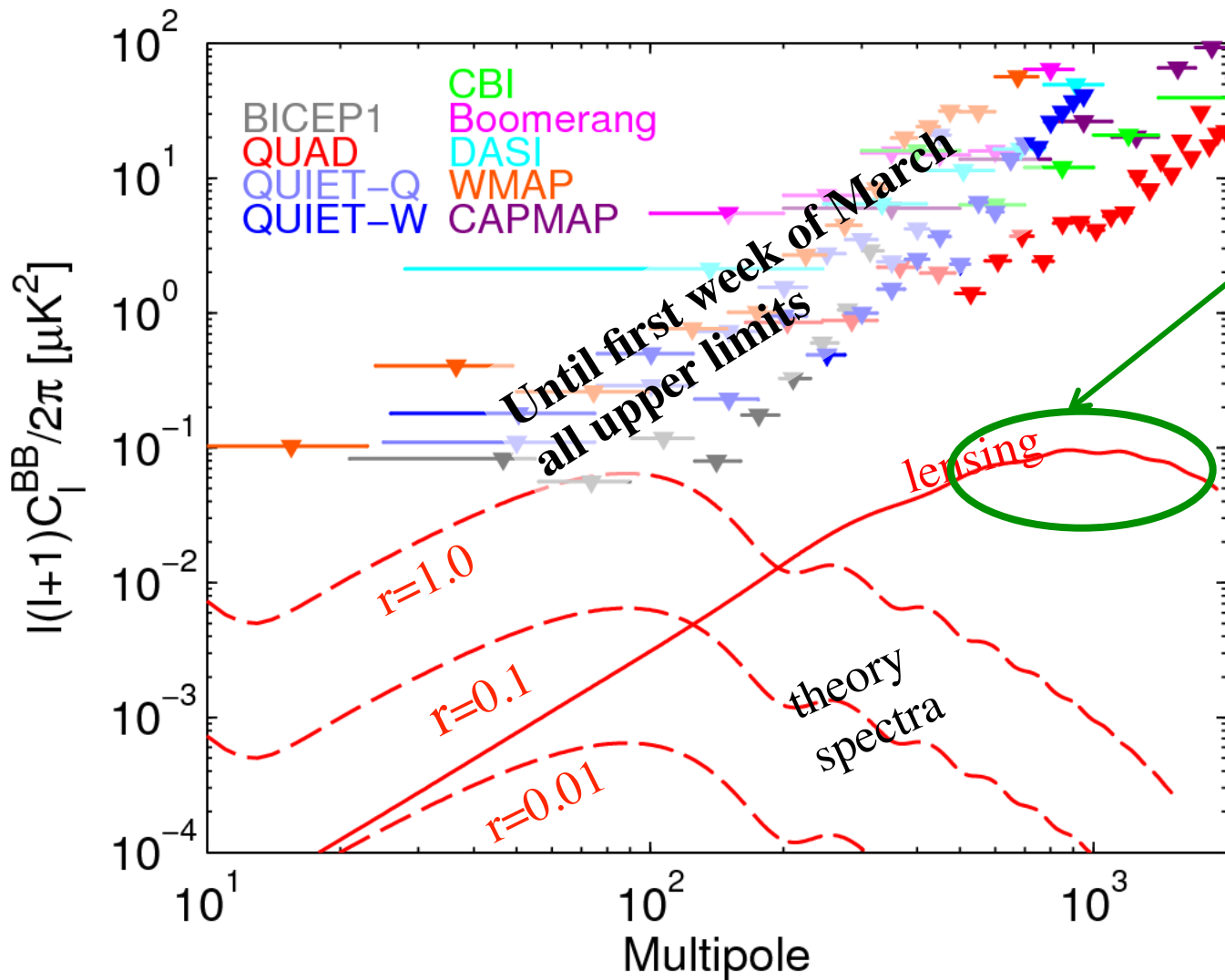
Great source of constraints on some cosmological parameters (no gravity effects)

Planck collaboration 2013



Primordial GW: « smoking gun » of inflation;

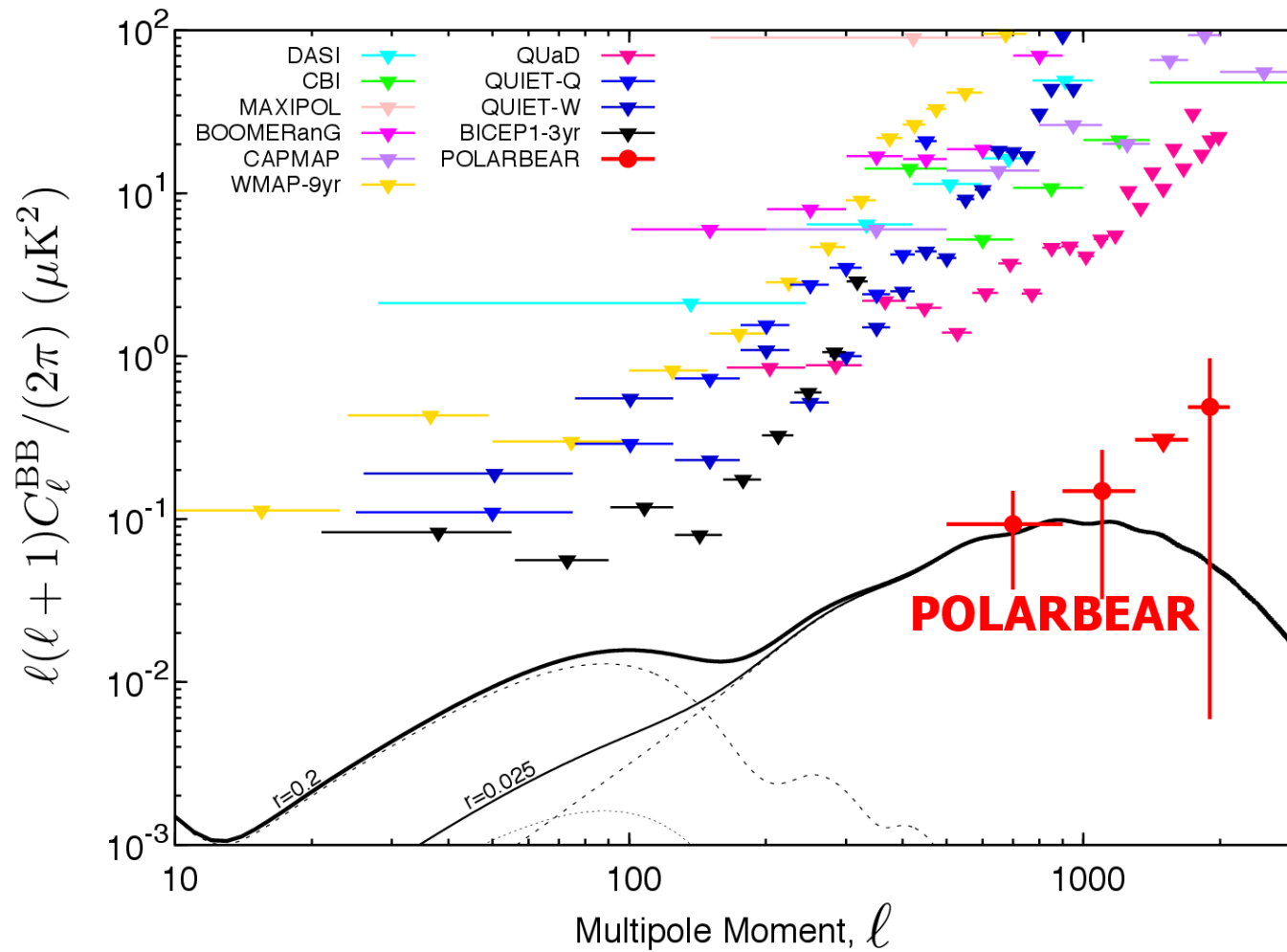
Powerful (self)consistency test of structure formation



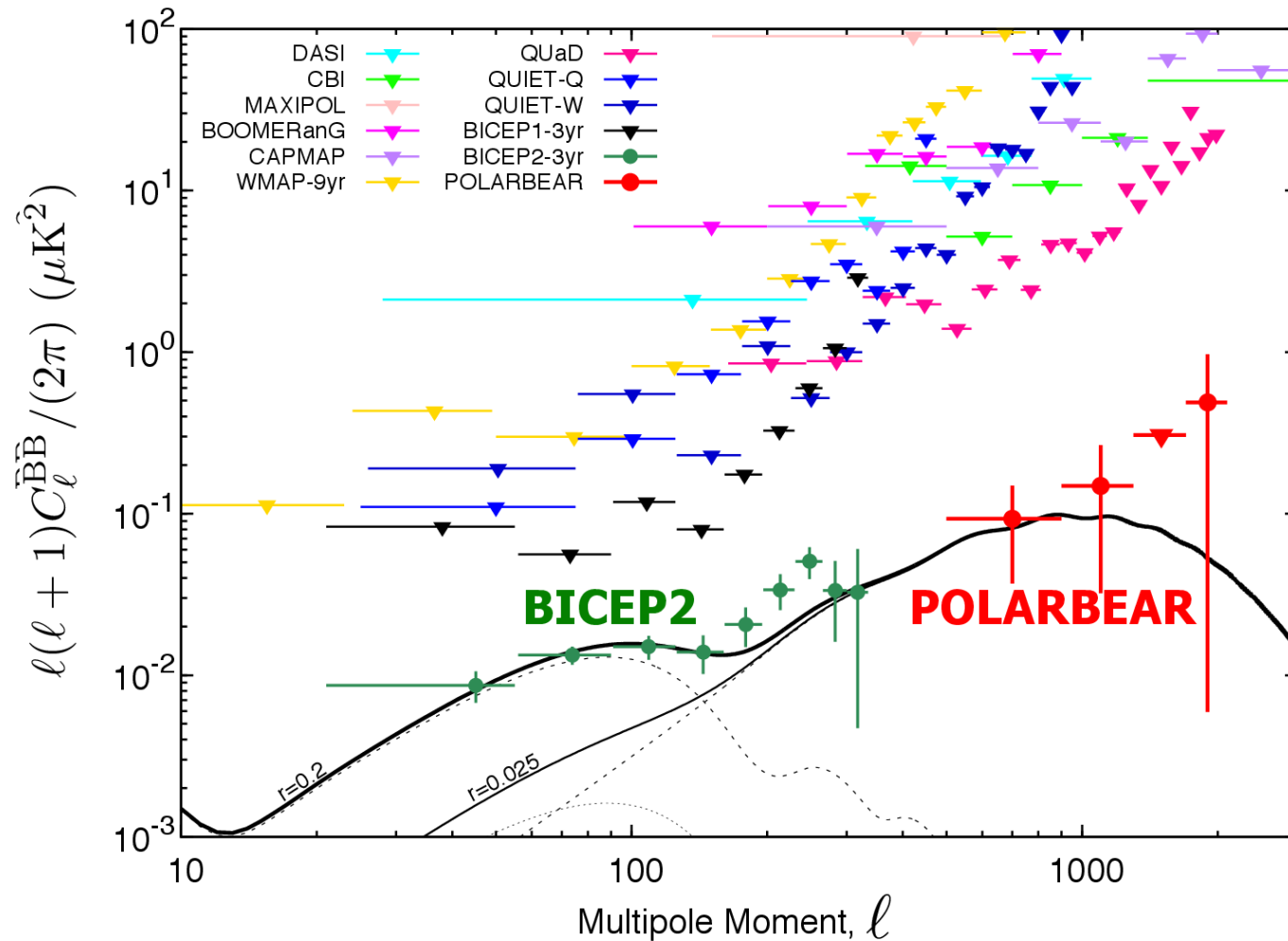
Some indirect constraints:
SPTpol: Aug 2013
POLARBEAR: Dec 2013

Best previous limit on r
 from B-modes:
 $r < 0.7$ (95% CL)

Best previous limit on r
 from total intensity
 (Planck+co):
 $r < 0.11$ (95% CL)



arXiv:1403.2369



5.2 σ excess in the B-mode spectrum at low multipoles!

Constraint on tensor-to-scalar ratio r in simple inflationary gravitational wave model:

$$r = 0.20^{+0.07}_{-0.05}$$

arXiv:1403.3985

arXiv:1403.2369



CMB B-modes the next steps



- 2-3 years from now:
 - Confirm, or refute, the BICEP2 claim;
 - Turn the B-mode lensing observation into an effective tool;
- Longer term:
 - Turn the primordial B-mode detection into effective tool;
 - Exploit the B-mode lensing observation.

POLARBEAR project - now

- Campaign '13 - first data analyzed and science results published;

- Demonstrated

- sensitivity;
- control of systematic effects;
- team's ability to analyze huge and complex data set;
- efficiency of the French-Japanese collaboration

- Campaign '13 - not finished

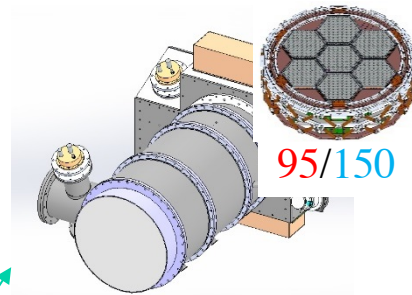
- Campaign '14 - to be prepared and executed



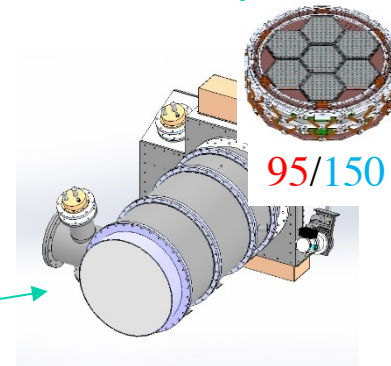
The future: PB/Simons Array

Leverage POLARBEAR experience to rapidly increase sensitivity

2014-2015: Construct two more telescopes

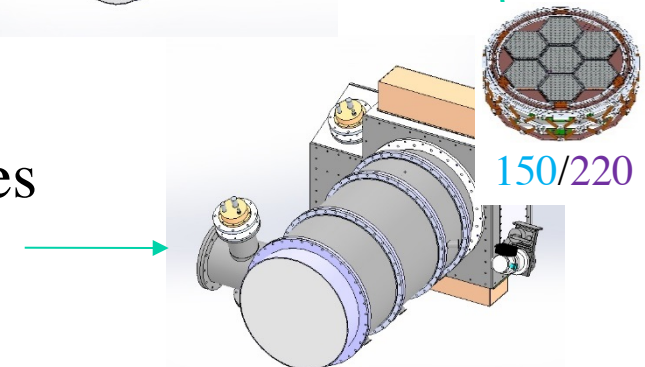


2015: POLARBEAR-2 (95 GHz / 150 GHz) first light on one new telescope



2015: A copy of POLARBEAR -2 deploys onto second new telescope

2016: A 150 GHz / 220 GHz receiver replaces POLARBEAR-1 on the original telescope

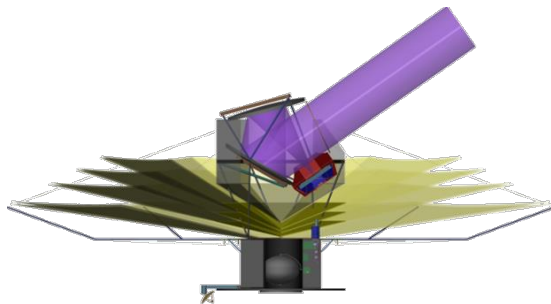


3 receivers (22,764 bolometers) observing at 95, 150, 220 GHz

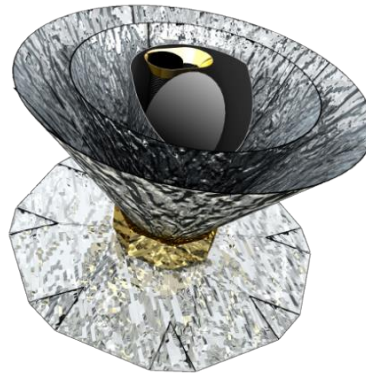
All hardware funded by the Simons Foundation



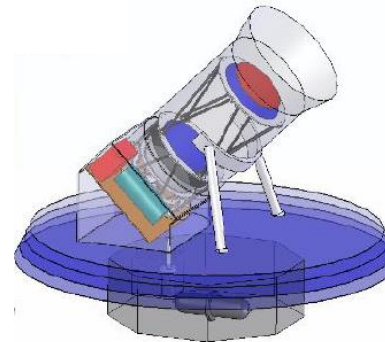
EPIC-IM



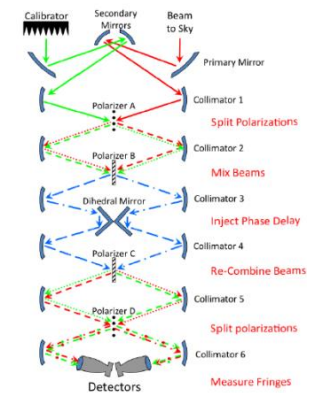
PRISM



LITEBIRD



PIXIE



- Use POLARBEAR experience to help in definition of the future CMB mission;
- Coordinate the efforts on-going in Japan (LiteBIRD) and France (CORe+) in that respect.



Goals of this project 2014/15



- To strengthen KEK/IPU-APC collaboration within one of the leading, ground-based, CMB B-mode experiments called POLARBEAR.
 - analysis of the extended POLARBEAR-1 data set (B-mode lensing);
 - optimize and execute the new observations aiming at the primordial B-mode signal.
- To strengthen common reflexion and work on definition of the future CMB B-mode polarization missions: (Japan - LiteBIRD, Europe - CORe+) building
 - on the POLARBEAR experiences;
 - Planck know-how (in particular in the foreground modeling and their removal).