LSPE

Large-Scale Polarization Explorer

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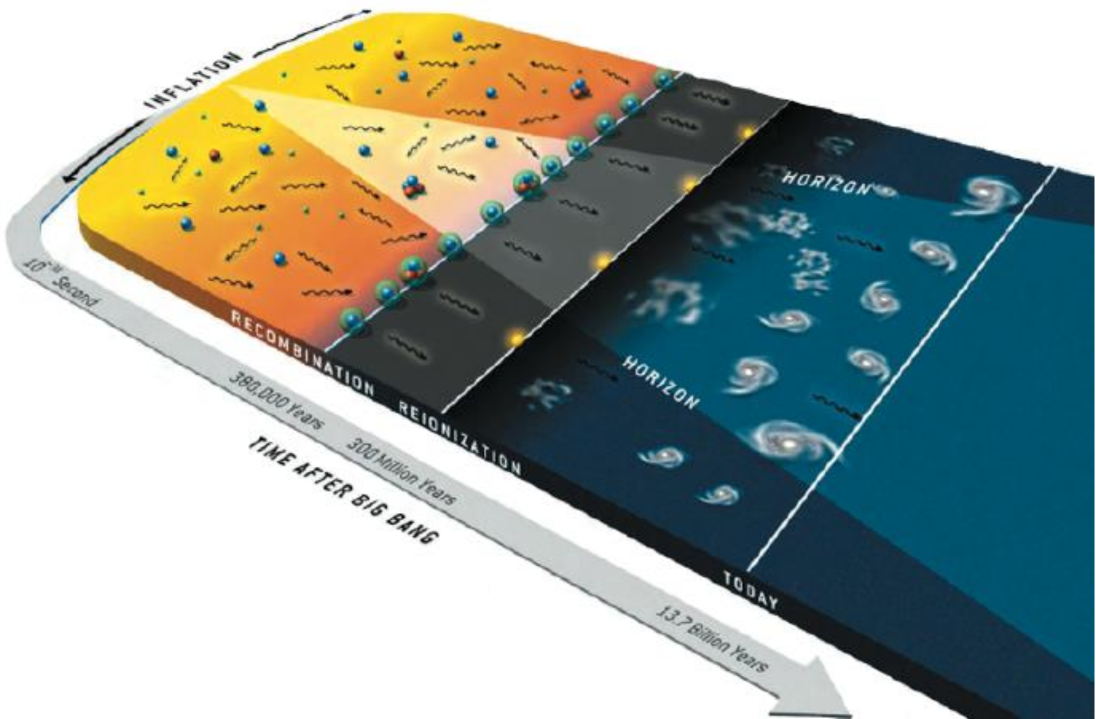
Tor Vergata, 13.07.2015

Outline

- CMB Physics: B-modes detection
- LSPE experiment
- Current status of the project
- Tor Vergata involvement

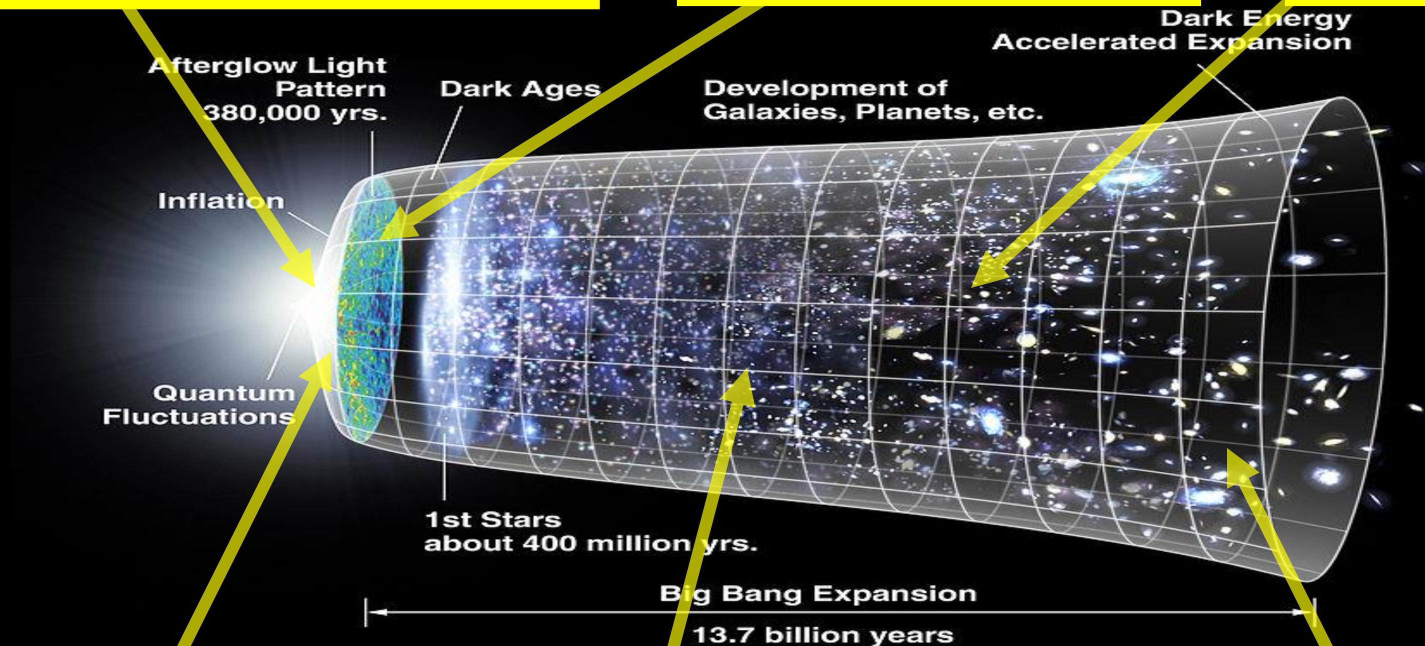


CMB measurements can probe all phases of the evolution of the Universe

measurement of CMB polarization, Gaussianity, Search for the gravitational waves produced during inflation. Also spectral distortions to probe inflation.

Physics of the primeval fireball (acoustic oscillations of the primeval plasma)

LSS (galaxy clusters) via Sunyaev-Zeldovich effect (SZ):

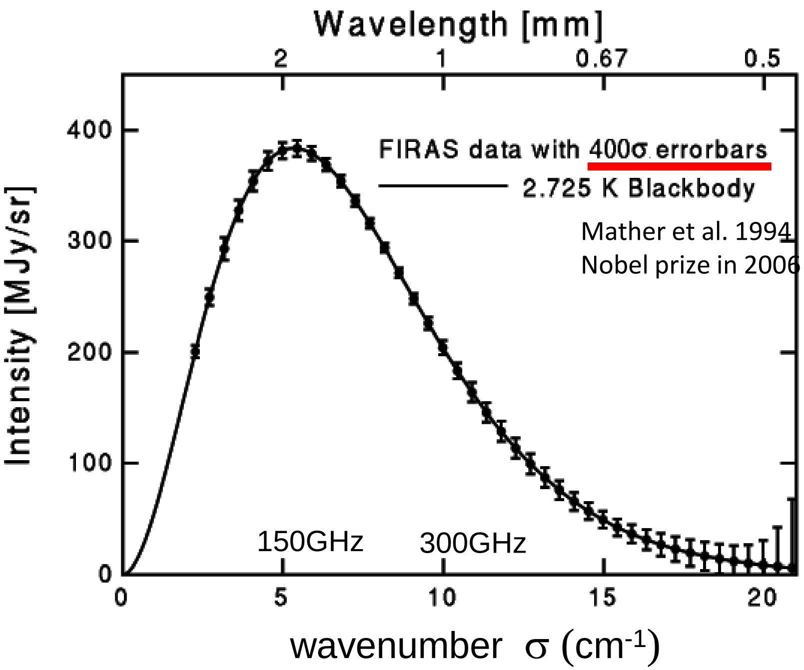


Probe epochs before recombination and new physics using CMB spectral distortion measurements

Map the gravitational potential all the way to z=1100 through CMB lensing

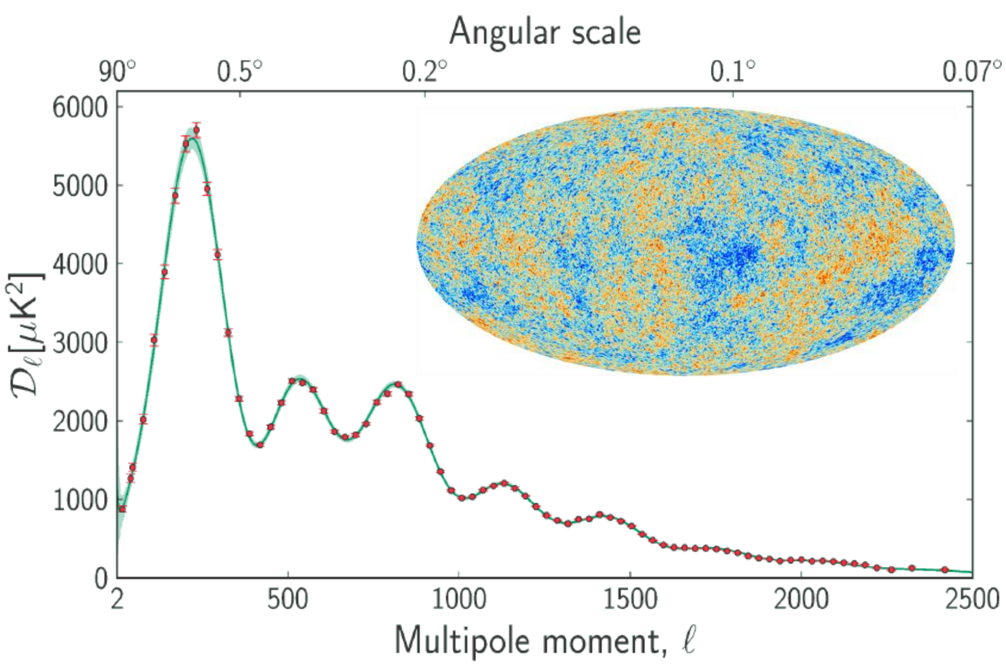
Dipole: our motion in the universe

What we already know



The spectrum of the CMB is a precise blackbody.

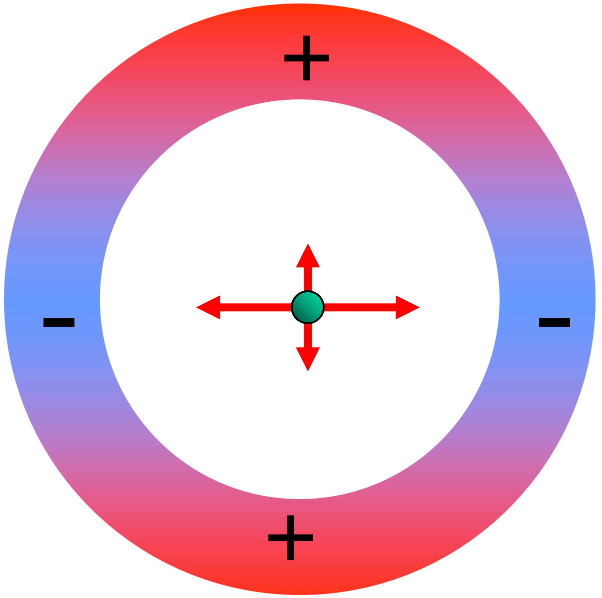
Planck 2013 CMB anisotropy map and power spectrum data (red dots with error bars)
Green line is the best fit to a 6-parameters cosmology model (inflationary Λ-CDM)



CMB Polarization – Why ?

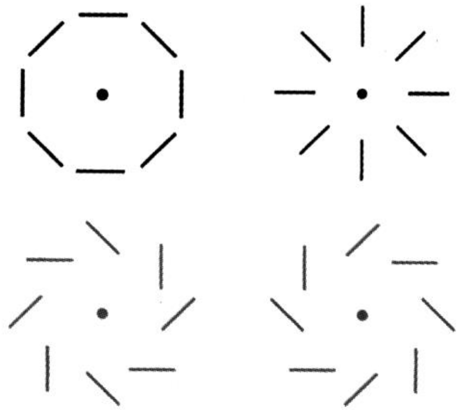
- An **inflation** phase at **$E=10^{16}$–10^{15} GeV** ($t=10^{-36}$-10^{-33} s) is currently the most popular scenario to explain
  - The origin of our universe
  - The geometry of our universe
  - The origin and morphology of structures in our universe
  - The lack of defects, and the smoothness of the CMB at super-horizon scales.
- Inflation is a **predictive** theory:
  1. Any initial curvature is flattened by the huge expansion: we expect an Euclidean universe.
  2. Adiabatic, Gaussian density perturbations are produced from quantum fluctuations. This is the physical origin for structures in the Universe.
  3. The power spectrum of scalar perturbations is approximately scale invariant, $P(k)=Ak^{n-1}$ with n slightly less than 1.
  4. Tensor perturbations produce a background of primordial gravitational waves (PGW)
- 1.,2.,3. have been confirmed already by measurements of CMB anisotropy
- **4. can be tested measuring CMB polarization**

CMB Polarization – Why ?



- Linear Polarization of CMB photons is induced via Thomson scattering by quadrupole anisotropy at recombination (z=1100, *t* =1.2x10^{13}s).
- In turn, quadrupole anisotropy is induced by
  - Density perturbations (*scalar* relics of inflation) producing a curl-free polarization vectors field (**E-modes**)
  - **Gravitational waves (*tensor* relics of inflation)** producing both curl-free and curl polarization fields (**B-modes**)
- No other sources for a curl polarization field of the CMB at large angular scales:
- **B-modes are a clear signature of inflation**.
- Extremely weak signal:
  - Monopole term: 2.7 K
  - Dipole anisotropy: 3.4 mK
  - Multipole anisotropy: 100 μK (RMS)
  - E-modes amplitude: 3 μK (RMS)
  - **B-modes amplitude: < 500 nK (RMS)**

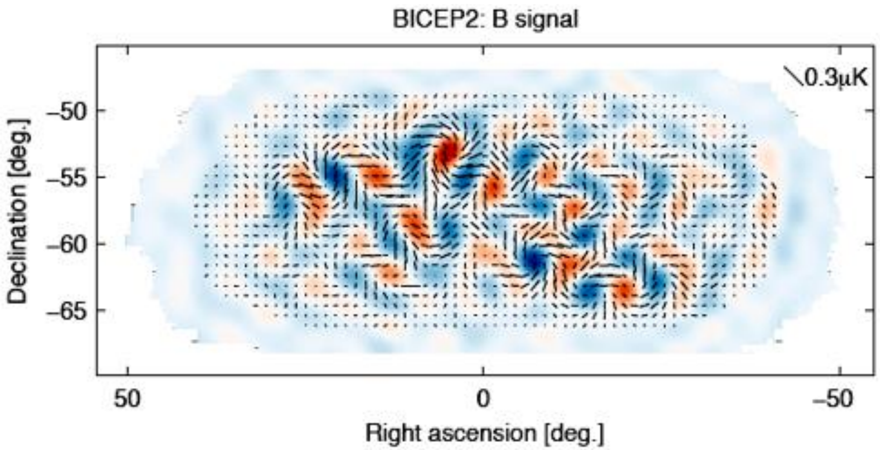
E-modes



B-modes

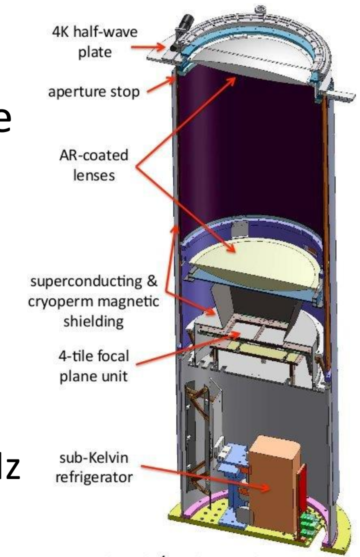
BICEP2 claim

South Pole

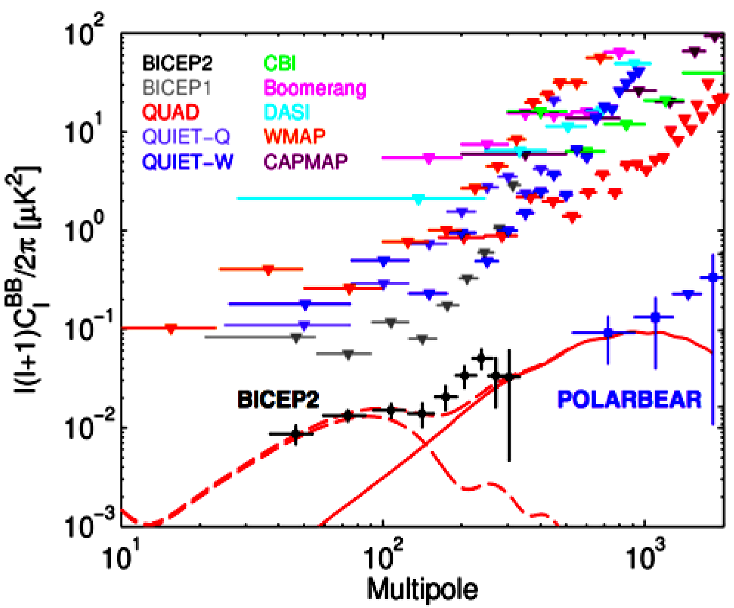


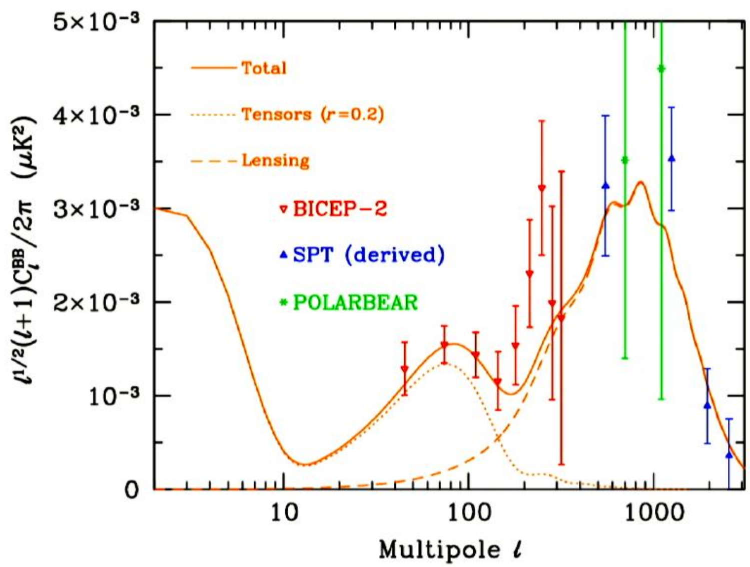
3 dark winters of integration
In the best sky spot
(<1000 sq. deg)

BICEP2: single frequency 150 GHz



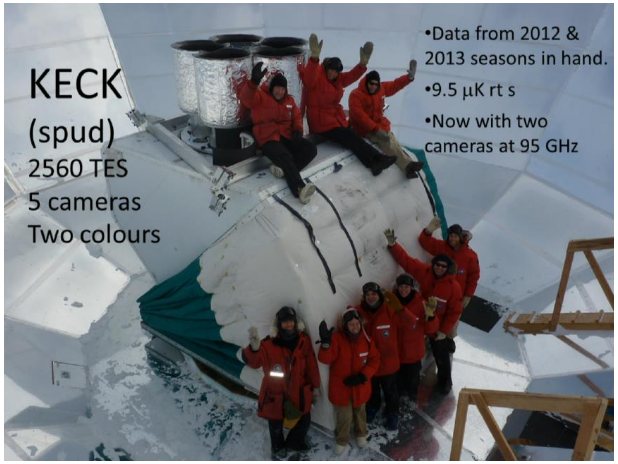
BICEP2/KECK INSERT



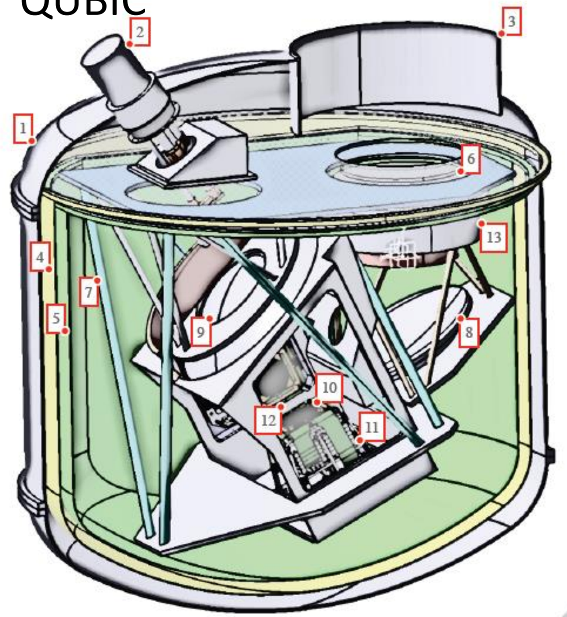


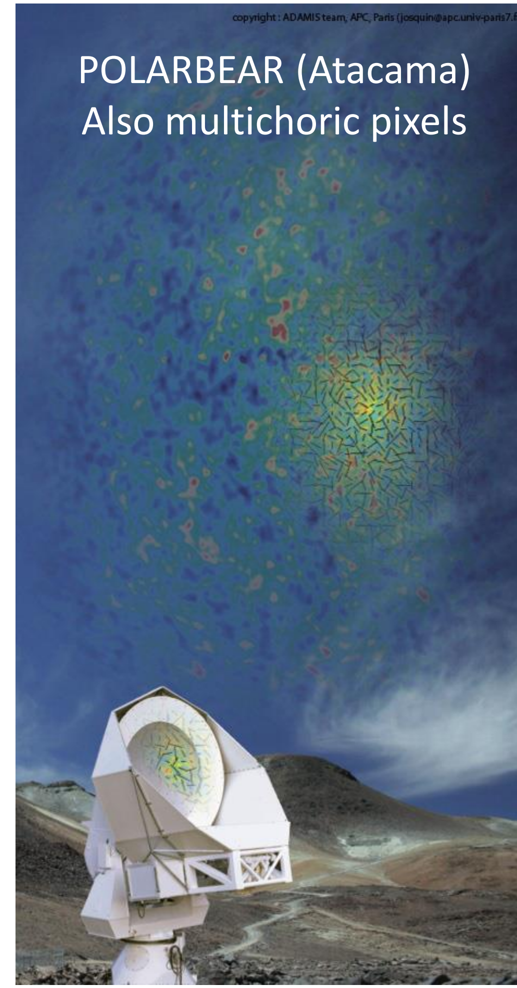
After correlation with Plank data, BICEP2 measurements consistent with contamination from insterstellar dust

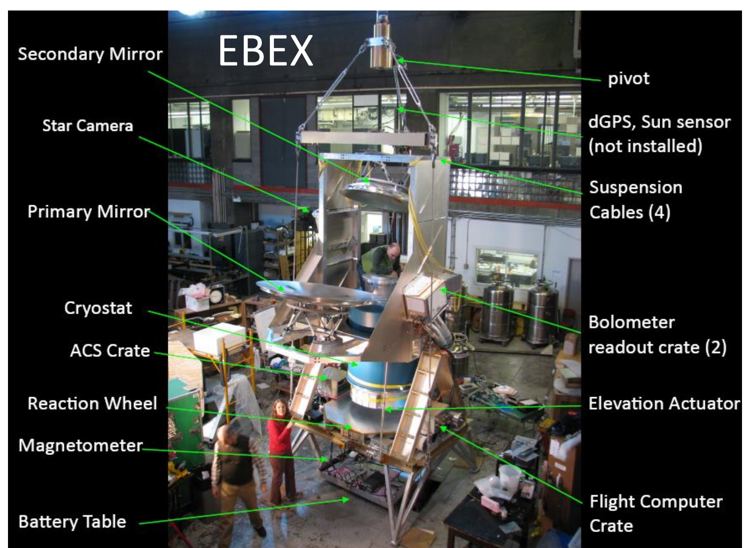
Wide international effort

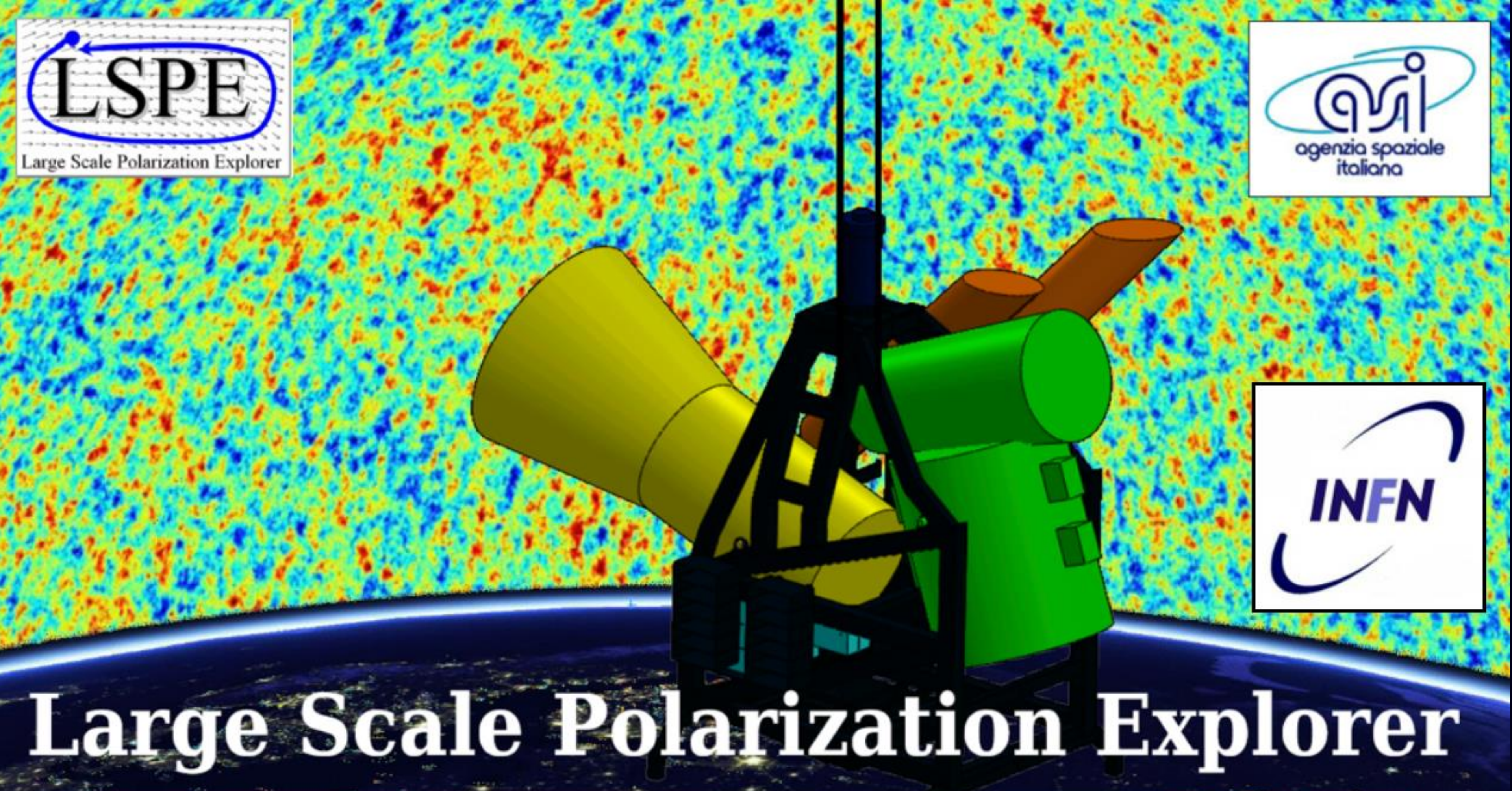


QUBIC









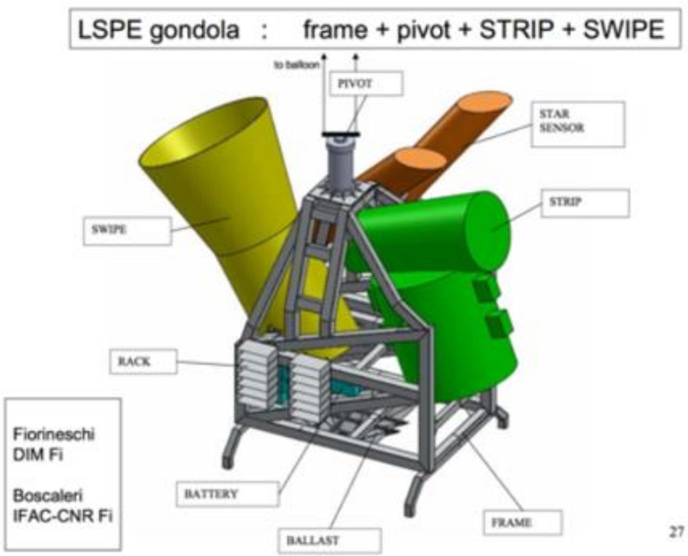
Large Scale Polarization Explorer

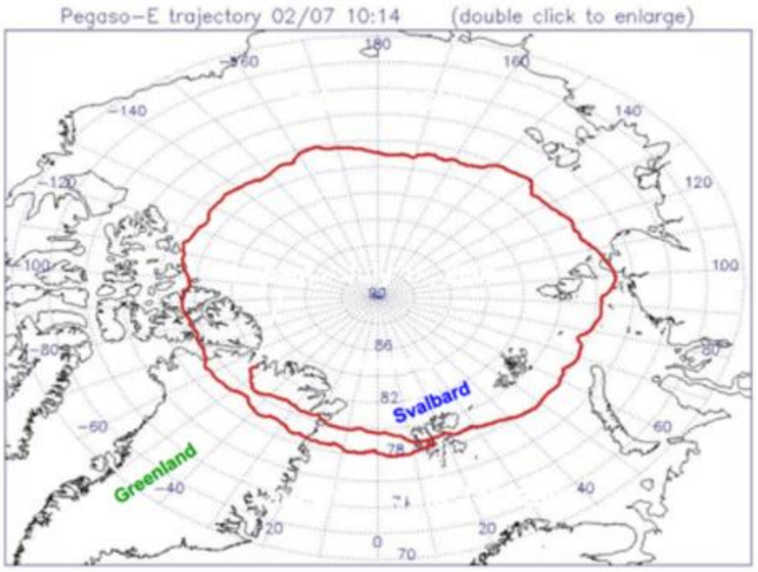
PI: Paolo de Bernardis

INFN Genova, Pisa, Roma1, Roma2

LSPE in a nutshell

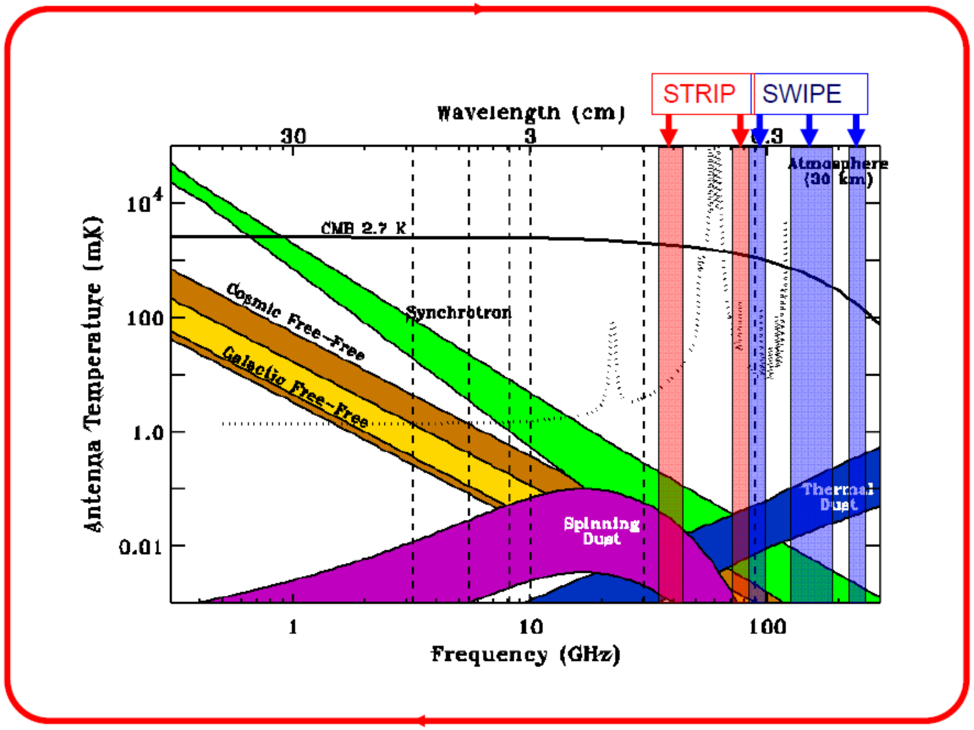
- The Large-Scale Polarization Explorer is
  - a spinning stratospheric balloon payload
  - flying long-duration (21 days), in the polar night
  - aiming at CMB polarization at large angular scales
  - using polarization modulators to achieve high stability
- Frequency coverage: 40 – 240 GHz (5 channels) – two instruments STRIP (LF) & **SWIPE (HF, INFN contribution)**
- Angular resolution: 1.5 – 2.3 deg FWHM
- Sky coverage: 20 – 25% of the sky per flight – target both reionization bump and horizon bump.
- Combined sensitivity: 10 μK *arcmin* per flight

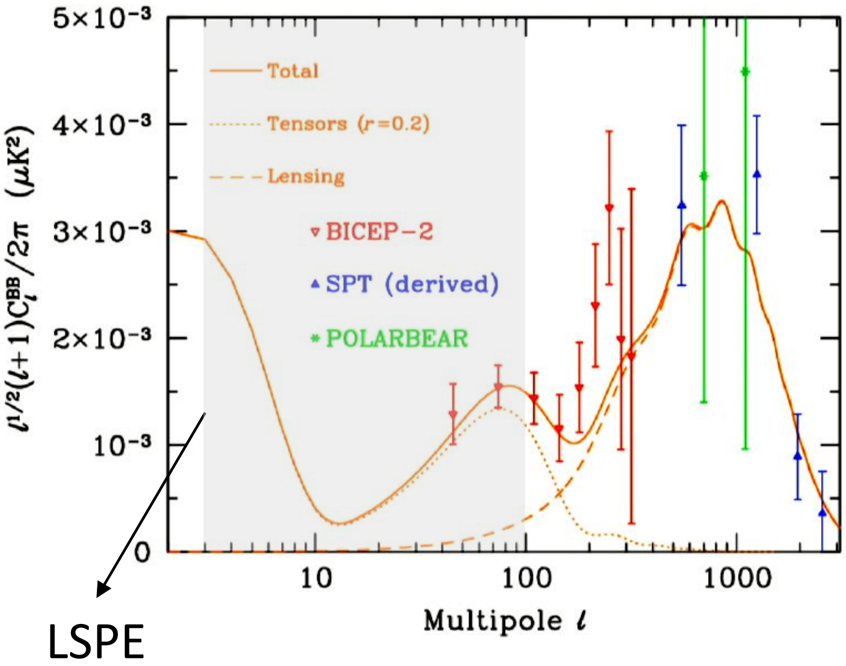




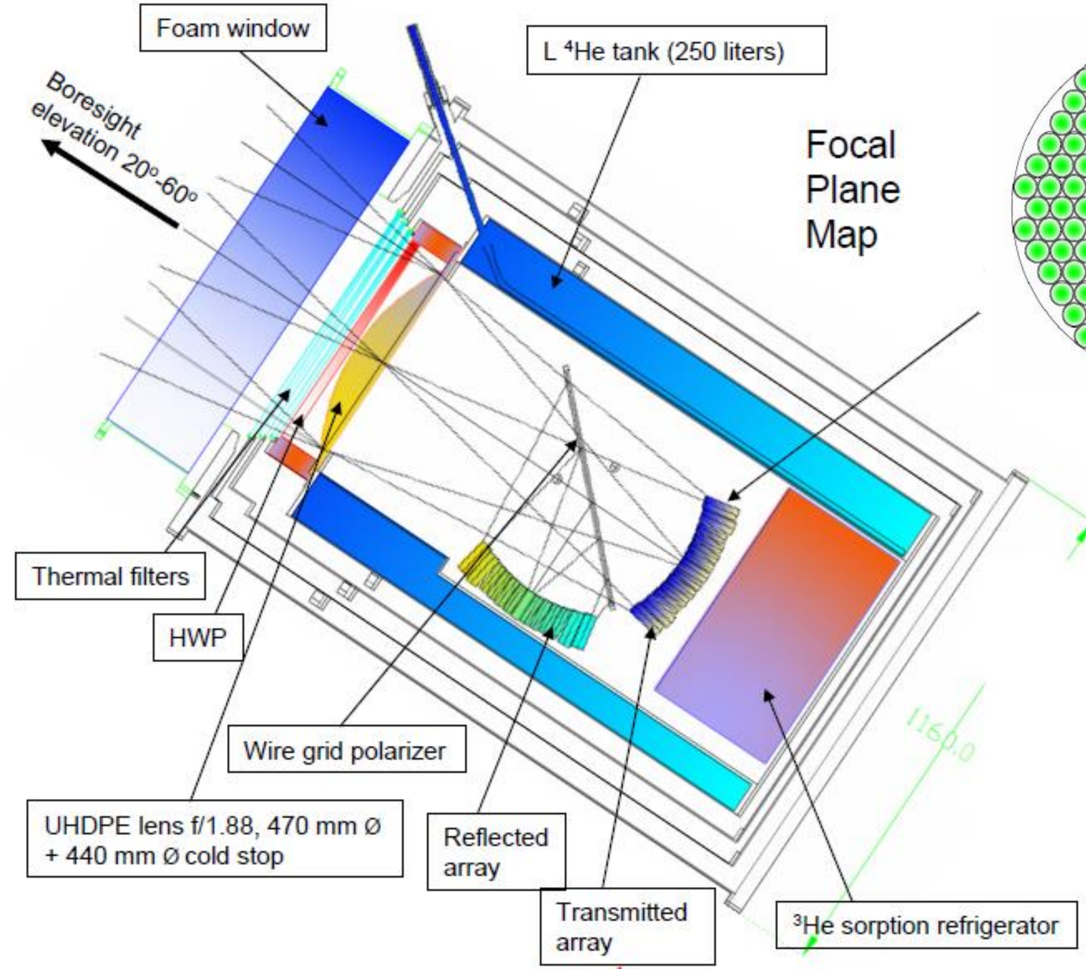
Advantages of LSPE

- … in terms of systematic effects:
  - Designed as a polarimeter from the very beginning - Polarization modulation obtained with a rotating HWP
  - Wide frequency coverage (all foregrounds monitored)
  - Wide sky coverage (winter flights, northern hemisphere)
  - Clean beam patterns (multimode horns)

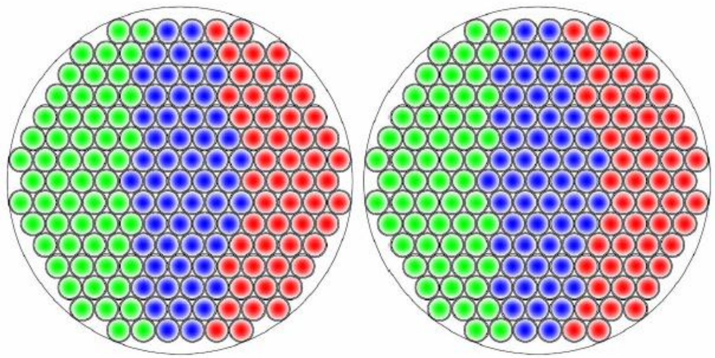


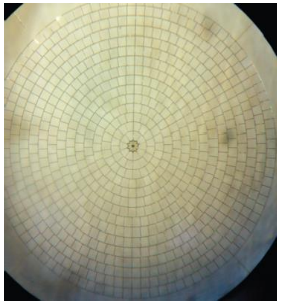


SWIPE details



140, 220 and 240 GHz





TES bolometers
Genova

LSPE/SWIPE

- Progetto parzialmente finanziato da ASI (lancio, criostato, sistema ottico, rivelatori coerenti, navicella…), coinvolte diverse università (Sapienza, Bologna, Firenze, Milano);
- Dal 2015, contributo INFN:
  - Genova (Gatti, resp. naz.) – progetto, costruzione e test elettrico dei sensori bolometrici
  - Pisa (Signorelli) – progetto, costruzione e collaudo elettronica lettura sensori bolometrici
  - **Roma Tor Vergata (Rocchi) – assembleggio e test del criostato di volo e test criogenici delle principali componenti (cryo-harness, filtri ottici, cavi criogenici…) presso il laboratorio PP1.**
  - Roma (de Bernardis) – accoppiamento ottico e test ottico dei sensori bolometrici, integrazione sull'esperimento da pallone, campagna di lancio.
- Tutti i gruppi parteciperanno inoltre all'analisi e interpretazione scientifica dei dati dell'esperimento.
- Lancio previsto durante l'inverno 2016/2017.

Richieste finanziarie e anagrafica 2016

Missioni	12 k€
Consumo	45 k€
Inventario	15 k€
Totale	72 k€

(ancora in fase di definizione)

Nominativo	Qualifica	FTE
Buzzelli Alessandro	Dottorando	0,80
Cabella Paolo	Ricercatore Univ.	0,30
Coccia Eugenio	PO	0,30
D'Antonio Sabrina	Tecnologo INFN	0,20
De Gasperis Giancarlo	Ricercatore Univ.	0,30
Fafone Viviana	PA	0,30
Alessio Rocchi	Tecnologo INFN (Resp. Loc)	0,40
Nicola Vittorio	PO	0,30
Totale FTE		2,9