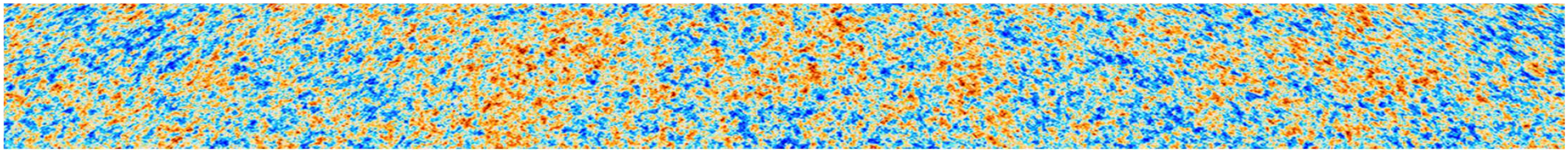


Florence, Villa Finaly – 8-10 September 2016
Towards a European Coordination of the CMB programme

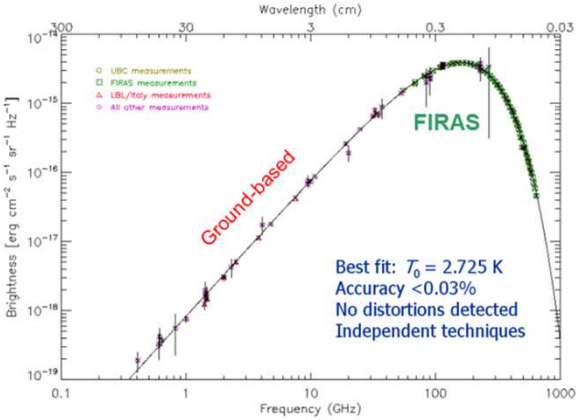
Reports from European roadmaps:
Italy

Marco Bersanelli
Università degli Studi di Milano
on behalf of the Italian CMB community

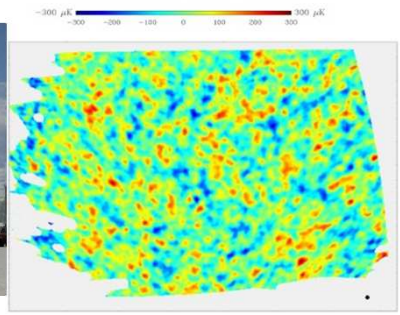
The Italian community has a long history in CMB experiments…

GROUND

Spectrum
WM+SP+TRIS
(1980-2000)

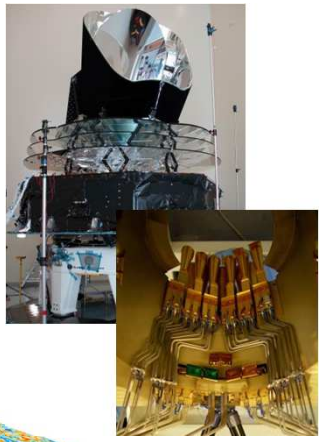


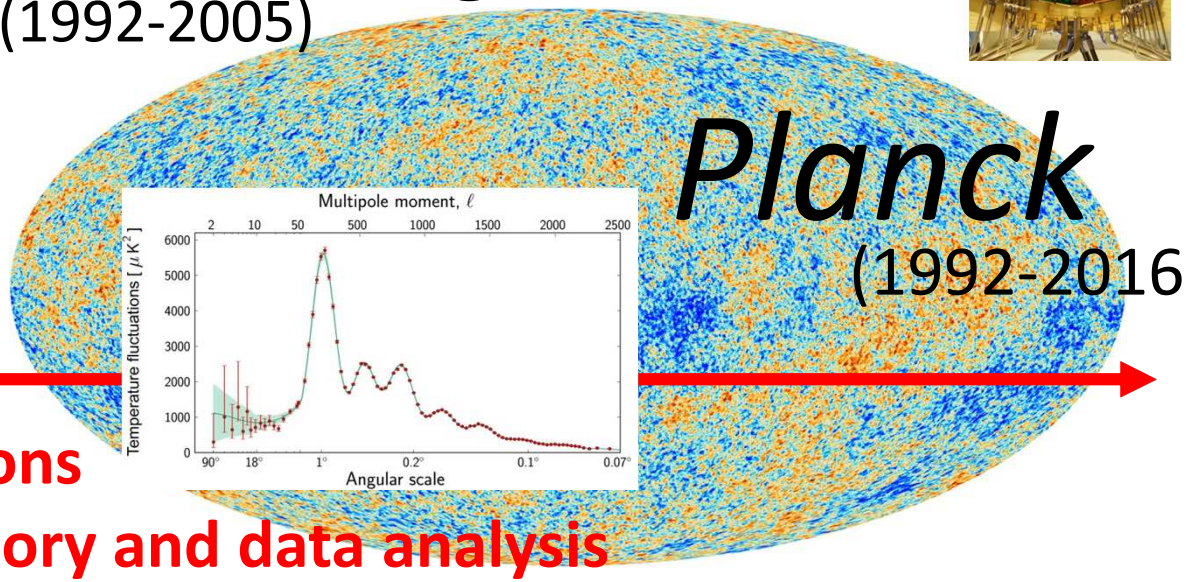
BALLOON



Boomerang
(1992-2005)

SPACE





Planck
(1992-2016)

…and in contributions to theory and data analysis

Università degli Studi di Milano

«Post-Planck»: Convergence of interest in Italy in support of CMB science
Unprecedented process of cohesion of the Italian CMB community

ASI, 30 March 2016, «CMB day»
New challenges in Cosmic Microwave Background studies in Italy

The Italian CMB community

BOLOGNA
- INAF/IASF, Bologna
- IRA/INAF, Bologna
- INFN Sezione di Bologna

CATANIA
- INAF – Osservatorio Astrofisico di Catania

FERRARA
- Dipartimento di Fisica, Università di Ferrara

FIRENZE
- Dip. Meccanica e Tecnologie Industriali, Univ. di Firenze
- IFAC-CNR, Sesto Fiorentino (FI)
- INAF, Osservatorio Astronomico di Arcetri

GENOVA
- INFN Sezione di Genova

MILANO
- Dipartimento di Fisica, Università degli Studi di Milano
- INAF/IASF Milano
- Dipartimento di Fisica, Università di Milano-Bicocca
- Istituto di Fisica del Plasma, CNR-ENEA-EURATOM, Milano

PADOVA
- Dip. di Fisica G. Galilei, Università degli Studi di Padova
- INAF, Osservatorio Astronomico di Padova
- INFN, Sezione di Padova

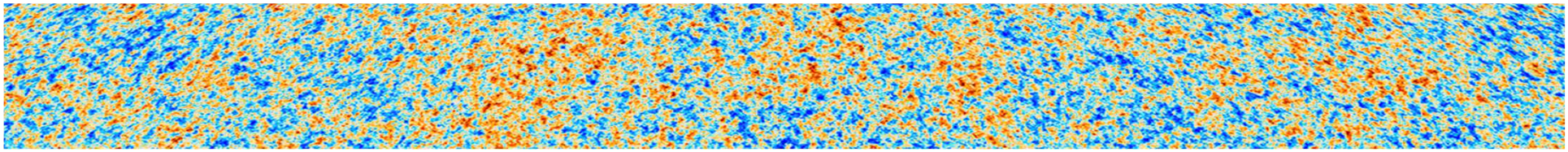
PISA
- INFN Sezione di Pisa
- CNR–ISTI, Area della Ricerca, Pisa

ROMA
- Dipartimento di Fisica, Università La Sapienza, Roma
- Dipartimento di Fisica, Università di Roma Tor Vergata
- INAF – Osservatorio Astronomico di Roma
- CNR, Istituto di Fotonica e Nanotecnologie, Roma
- Istituto Nazionale di Geofisica e Vulcanologia, Roma
- Agenzia Spaziale Italiana, Science Data Center, Roma

TORINO
- CNR-IEIIT/CNR, c/o Politecnico di Torino

TRIESTE
- SISSA, Astrophysics Sector, Trieste
- Dipartimento di Fisica, Università degli Studi di Trieste
- INAF, Osservatorio Astronomico di Trieste

About 150 people
from 28 different institutions
(ASI, INFN, INAF, CNR, Universities)



«Post-Planck»: Convergence of interest in Italy in support of CMB science
Unprecedented process of cohesion of the Italian CMB community

ASI, 30 March 2016, «CMB day»
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CONCLUSIONS (2/2)

We wish to propose a roadmap, to be discussed with ASI:

1. Completion of the ongoing ASI-funded missions LSPE and OLIMPO in the short term (2016-2020);

2. Strong support to a leading role of Italy in the forthcoming CMB satellite mission of ESA/M5;

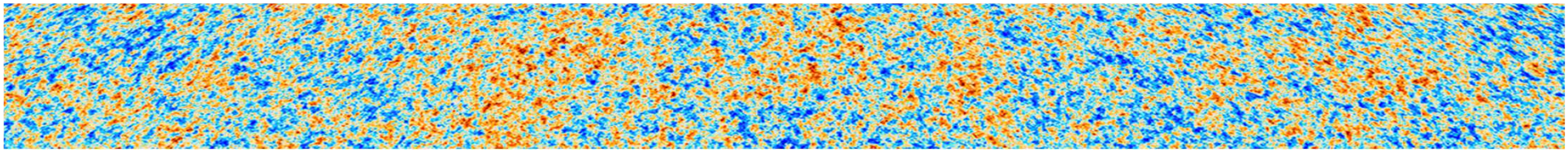
3. Strong support, in coordination with INAF and INFN, to
- Italian participation to next generation of Ground-based CMB experiments, preparatory and complementary to space;
- Definition of a pre-phase A study for a polarimetric stratospheric balloon in the medium timescale (2020-2025), to complement ground based Stage-IV .

Other key issues:
- *Data archiving and maintenance of CMB data (Planck, and more)*
- *Technological development, industry involvement, commercial applications*
- *High-level education: PhD, post docs, young researchers*

Mandate from ASI:

Develop strategic plan for the next decade in Italy

Consider Space, Balloon and Gronud experiments



1. Short term: Support to on-going projects

- ***LSPE*** (SWIPE and STRIP) (ASI, CNR, INAF, INFN, Univ.)
- ***Olimpo*** (ASI, CNR, Univ.)
- ***QUBIC*** (INAF, INFN, Italian Antarctic Program, Univ.)
- Technology development (ASI, INFN, INAF, CNR, Univ.)

2. Three-year study supported by ASI

- Proposal approved by ASI on July 25
- Develop **Italian roadmap** for the next decade, within international context (S4, …)
- 11 Italian «nodes» identified (7 Universities, 2 INFN, 2 INAF)
- First key deliverable (6-12 months after KO meeting): Definition of experimental strategy for the next decade

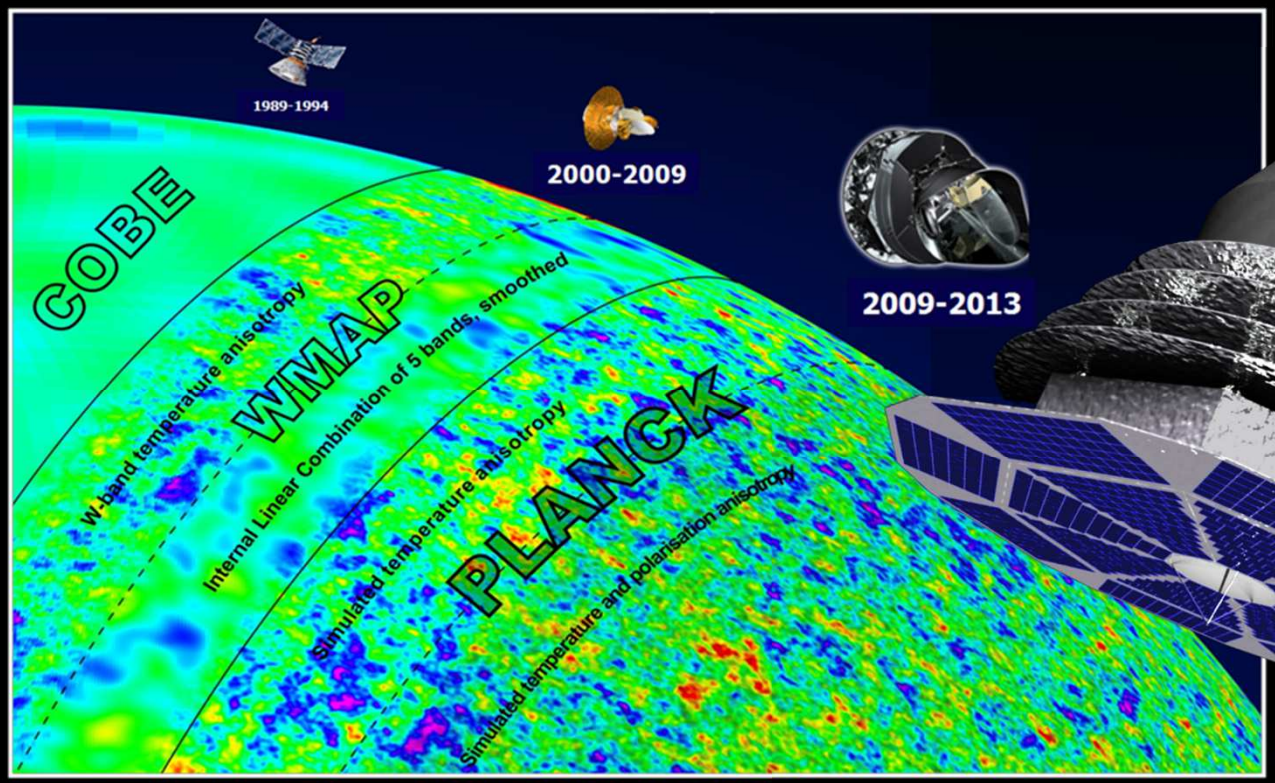
3. Ground, Balloon, Space

- Key opportunity is **CORE/M5**: full support by Italian CMB community (long term)
- Two parallel sub-orbital perspectives (short-medium term):
  - ***Ground based program*** («low» frequencies)
  - ***Balloon borne experiment*** («high» frequencies)
- Capability to respond to outcome of M5 selection process *(and Japan & US missions)*

  Low frequencies ground based measurements will be required (even more?) if CORE (or Litebird, or PIXIE…) will fly

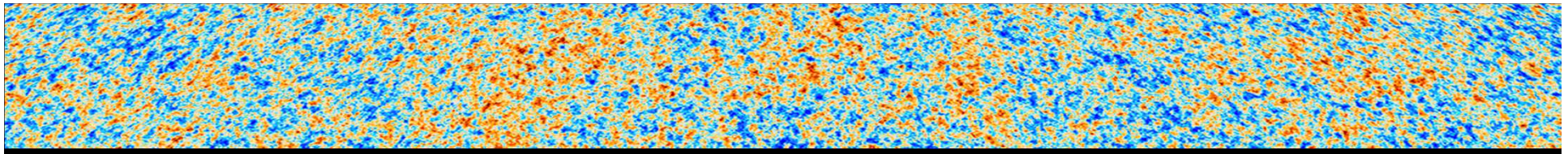
COrE

Fourth generation CMB space mission



M5

The Italian CMB community strongly supports the CORE/M5 proposal

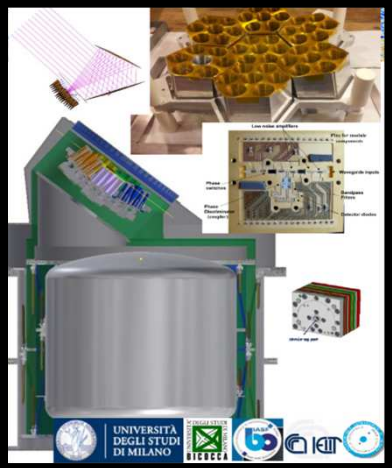


LSPE

CMB B-modes

STRIP

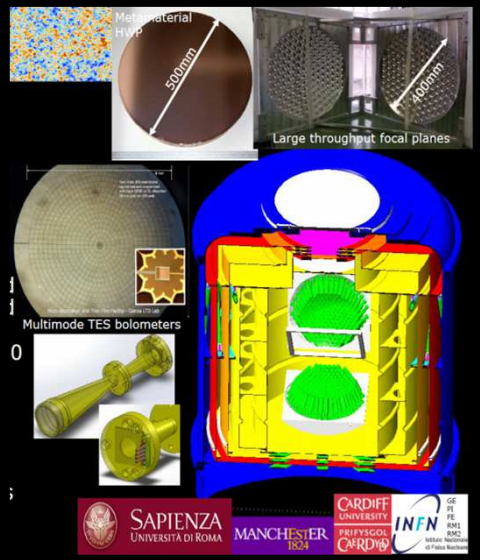
Polarimeter array
44, 90 GHz
Cooling to 20K



Ground-based

SWIPE

Bolometer array
140, 220, 240 GHz
Cooling to 0.3K



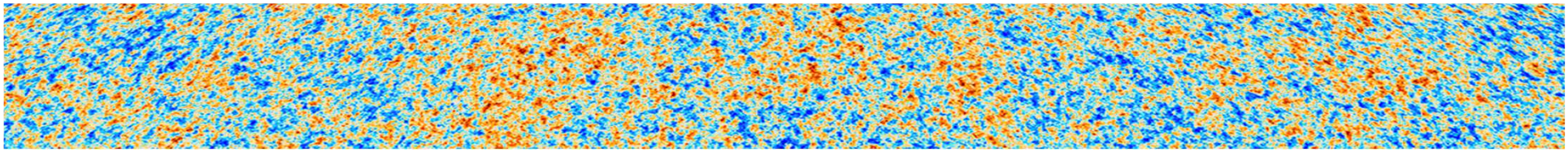
OLIMPO

SZ effect

2.6m telescope
140-480 GHz
Resolution 1.8GHz

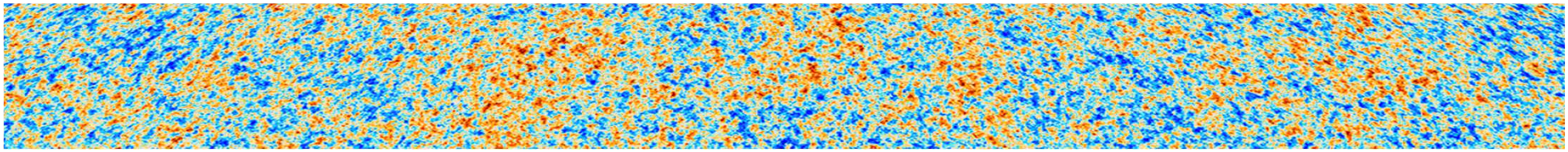
agenzia spaziale italiana

INFN Istituto Nazionale di Fisica Nucleare



ASI-funded, three-year project
Coordinator: Nicola Vittorio (Università di Roma Tor Vergata)
Structured in 11 nodes (7 Universities, 2 INAF Institutions, 2 INFN Sections).

Node	Site	Local coordinator	
1	INAF/OATS Trieste	Andrea Zacchei	INAF
2	SISSA	Carlo Baccigalupi	UNI
3	Università Milano	Marco Bersanelli	UNI
4	Università Milano Bicocca	Mario Zannoni	UNI
5	Università Padova	Sabino Matarrese	UNI
6	INAF/IAFS Bologna	Reno Mandolesi	INAF
7	Università Ferrara	Paolo Natoli	UNI
8	Sezione INFN/Uni. Genova	Flavio Gatti	INFN
9	Sezione INFN/Uni. Pisa	Giovanni Signorelli	INFN
10	Università Roma Sapienza	Paolo de Bernardis	UNI
11	Università Roma Tor Vergata	Nicola Vittorio	UNI



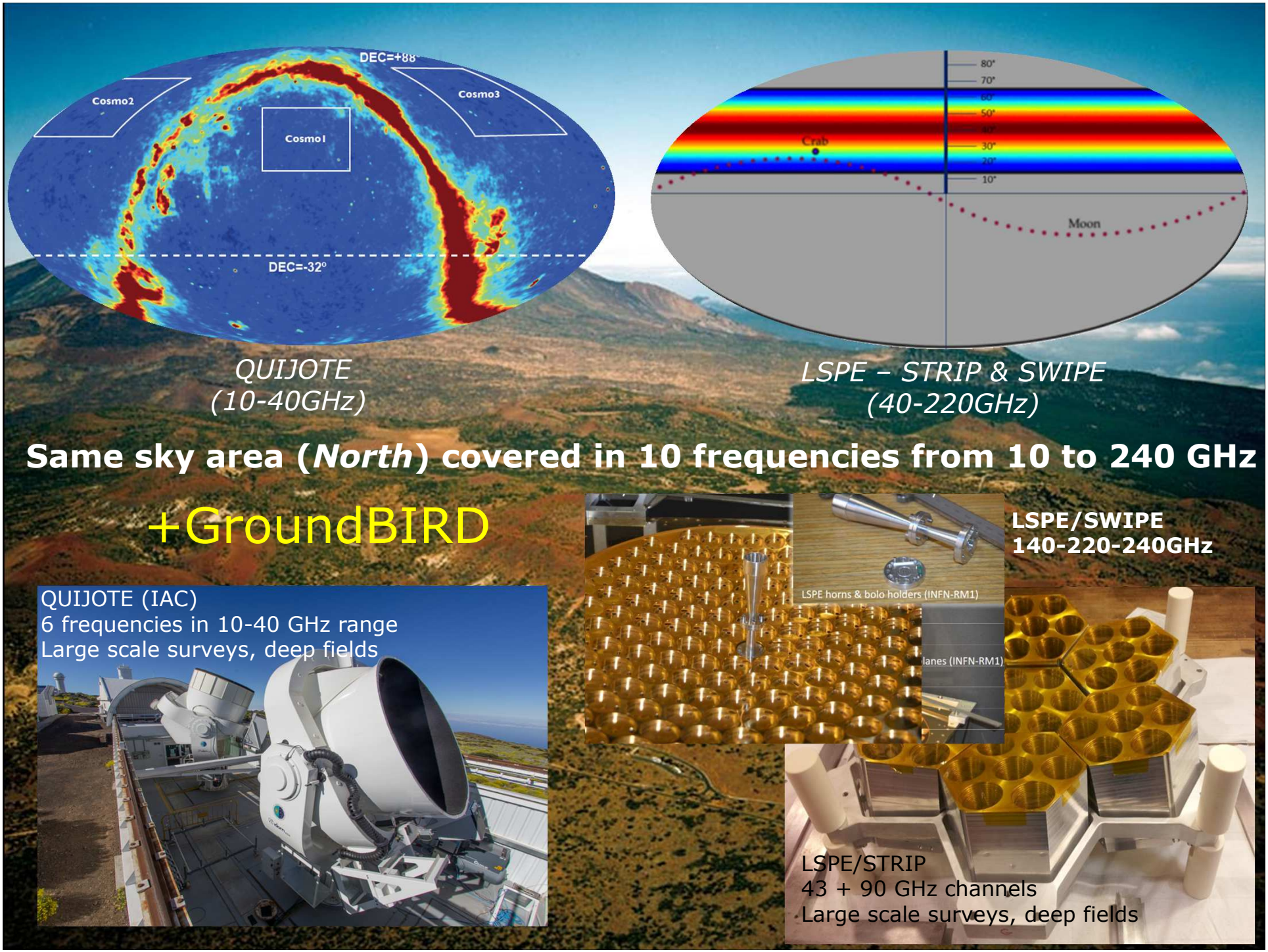
Feasibility study for next generation sub-orbital and space CMB missions

Ground based & Balloon borne programme

- Identify optimal approach
  with and without a CORE/M5 or LiteBird mission; S4 context
- Options for detector arrays, optics, cryogenics, readout electronics, polarization modulation, testing and calibration
- Define key experimental parameters (sensitivity, angular resolution, spectral coverage, sky area, calibration, systematics control) for maximum cosmological outcome
- Detailed simulations, combining instrument characteristics, sky model (foregrounds and CMB) to quantitatively assess different options.

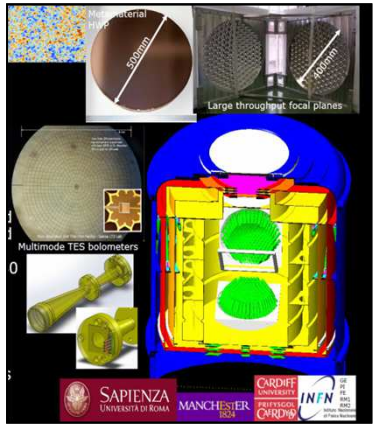
Scientific case

- Polarization of the Galactic foregrounds
- Gravitational Lensing
- The Sunyaev and Zel'dovich effect
- Extragalactic point sources
- Inflation physics
- Astroparticle and Fundamental Physics


DEC=+88°
Cosmo2
Cosmo3
Cosmo1
DEC=-32°
80°
70°
60°
50°
40°
30°
20°
10°
Crab
Moon
QUIJOTE
(10-40GHz)
LSPE – STRIP & SWIPE
(40-220GHz)
Same sky area (North) covered in 10 frequencies from 10 to 240 GHz
+GroundBIRD
LSPE horns & bolo holders (INFN-RM1)
lanes (INFN-RM1)
LSPE/SWIPE
140-220-240GHz
QUIJOTE (IAC)
6 frequencies in 10-40 GHz range
Large scale surveys, deep fields
LSPE/STRIP
43 + 90 GHz channels
Large scale surveys, deep fields

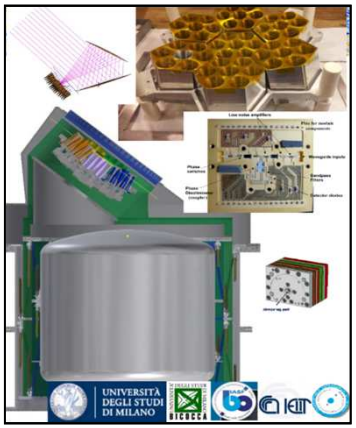
LSPE
Scanning strategy & sky coverage

SWIPE



Balloon borne

STRIP



Ground-based

North Pole

25% of sky

~1min

~1min

24h

~15d

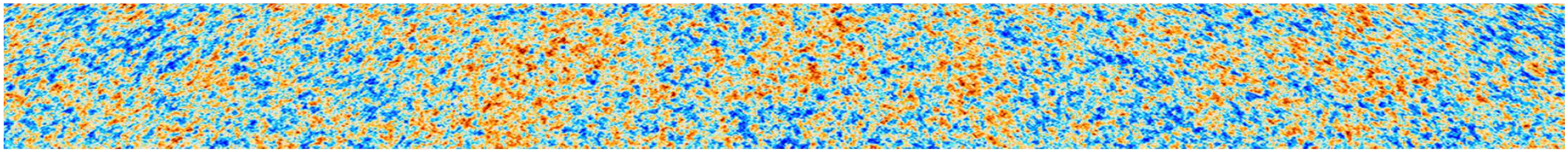
SWIPE

STRIP

Svalbard Is.

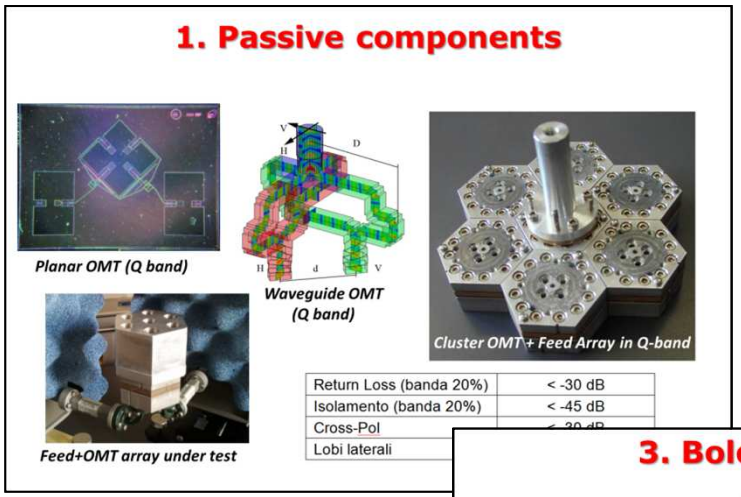
Tenerife

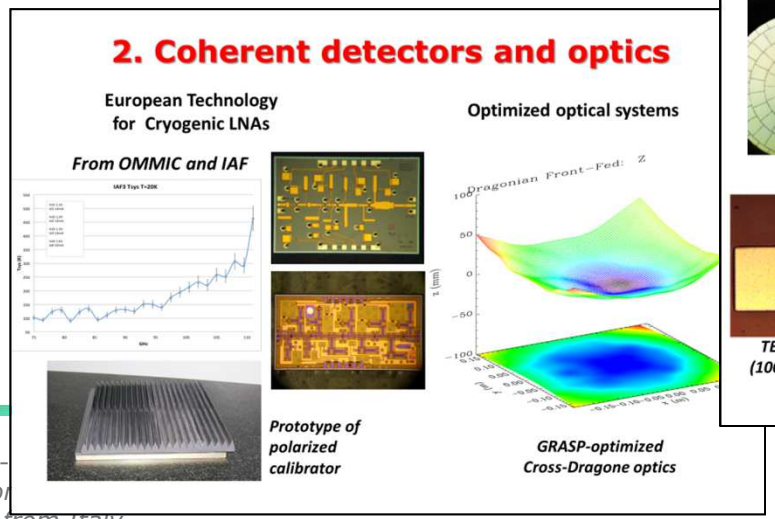
Avoid Sun in beam
~1 yr observations

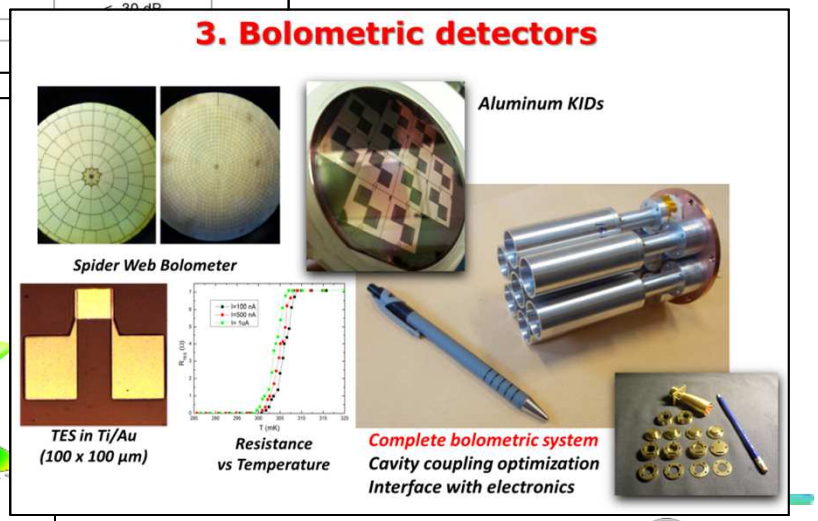


New (2016) ASI+INFN funded mm-wave technology project on Antennas, OMTs/ Polarimeters, KIDs, TES, Read-out electronics

CMB science has highly benefitted from *(and triggered new)* strategic technology in the microwaves and mm-waves







Industry involvement

- CMB H/W development
- Commercial applications

Università degli Studi di Milano

Conclusions

- Italy is developing a coherent plan for the next decade, involving ASI, INFN and INAF
- Major and increasing scientific interest of INFN in CMB science, with contribution to know-how and funding
- Maintain cohesion and effectiveness of the Italian CMB community inherited from the Planck experience

Coordination is crucial

Seeking sinergy with other partners in Europe & beyond