

LiteBIRD(-LNF):

the measurement of the B-mode polarization of the CMB

**Contributed by the INFN-LNF Group:
L. Porcelli, S. Dabagov, G. Delle Monache,
D. Hampai, G. Modestino, S. Savaglio.**



LiteBIRD Joint Study Group



Over 400 researchers from **Japan**,
North America and **Europe**

Team experience in CMB experiments,
X-ray satellites and other large projects
(ALMA, HEP experiments, ...)



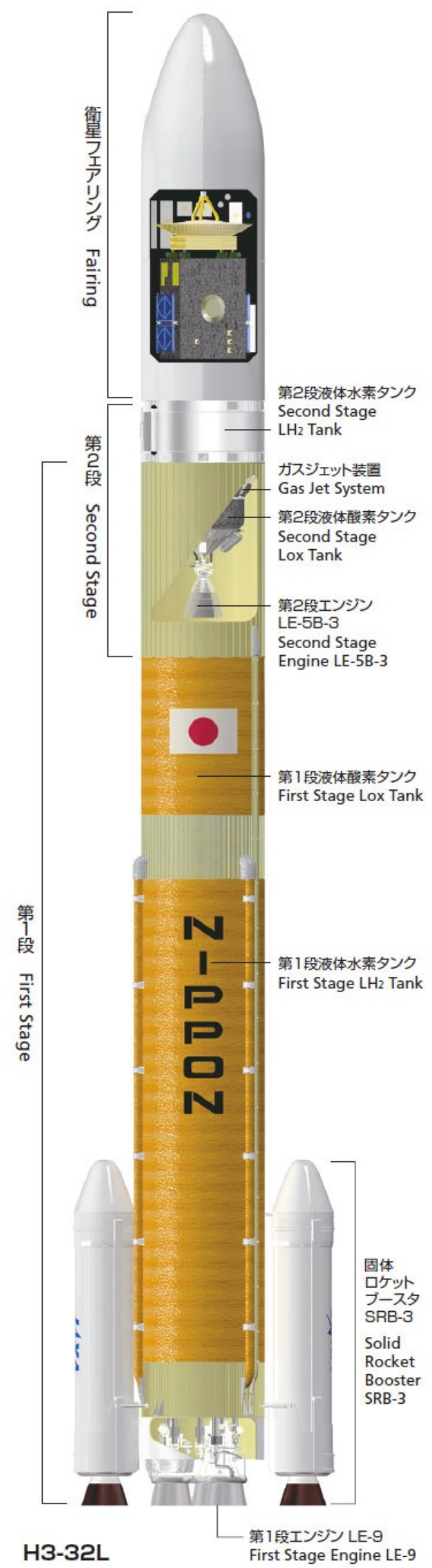
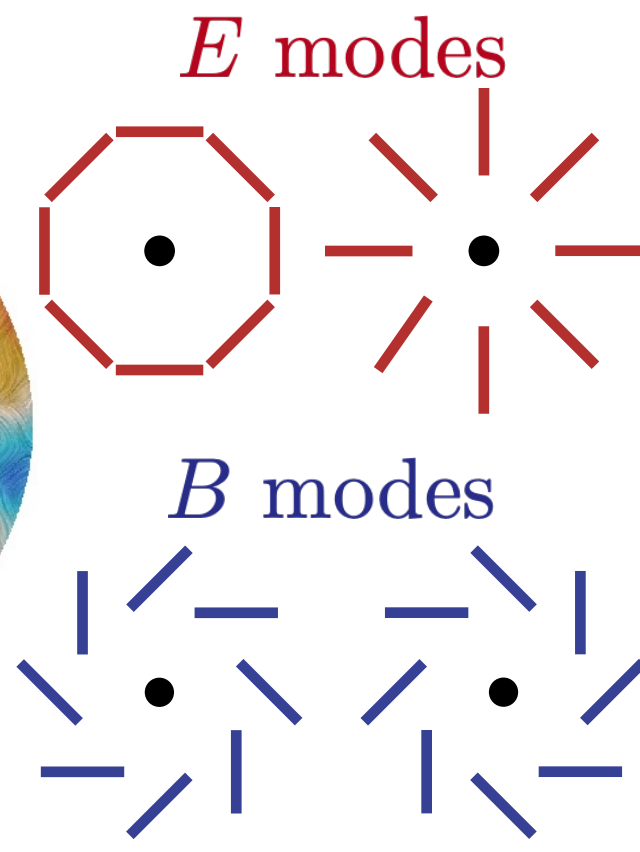
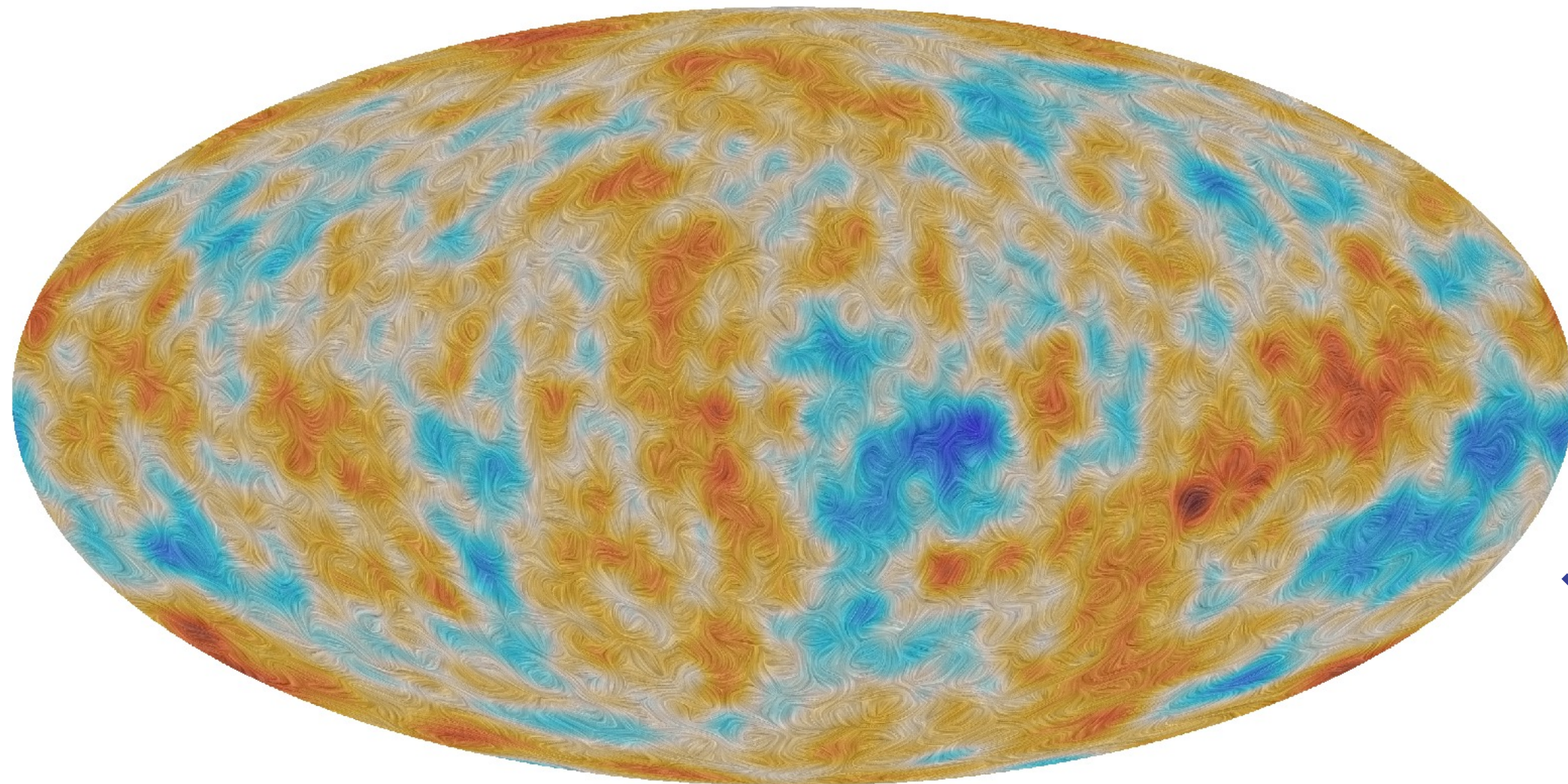
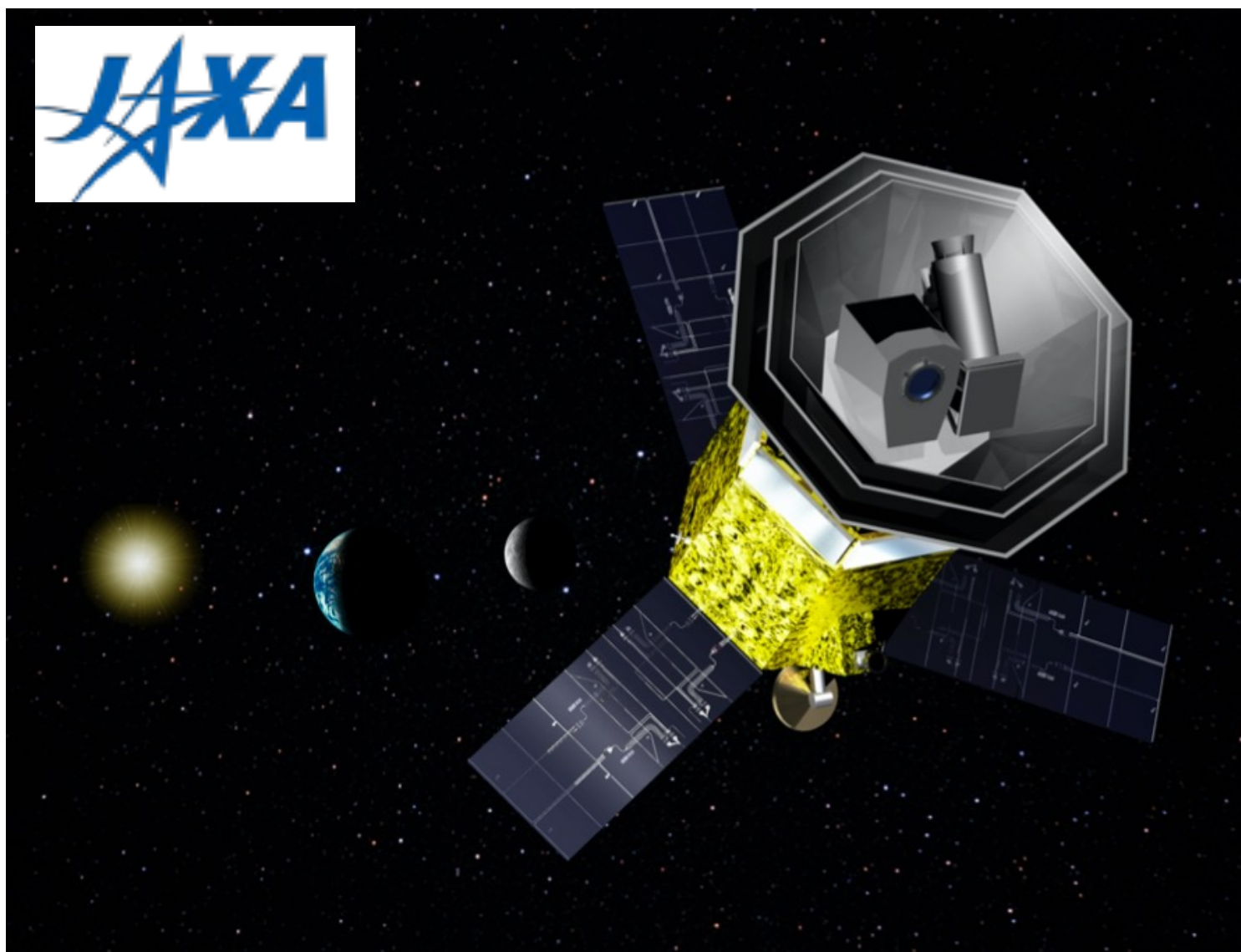
LiteBIRD Global F2F meeting
Sep 28 - Oct 1, 2023 at Elba

LiteBIRD overview



- Lite (Light) satellite for the study of *B*-mode polarization and Inflation from cosmic background Radiation Detection
- JAXA's L-class mission selected in May 2019
- Expected launch in **JFY 2032** with JAXA's H3 rocket
- **All-sky 3-year survey**, from Sun-Earth Lagrangian point L2
- Large frequency coverage (**40–402 GHz**, 15 bands) at **70–18 arcmin** angular resolution for precision measurements of the **CMB *B*-modes**
- Final combined sensitivity: **2.2 $\mu\text{K}\cdot\text{arcmin}$**

LiteBIRD collaboration
PTEP 2023



The challenge of B-modes detection



- The *B*-mode signal is expected to have an amplitude at least 3 orders of magnitude below the CMB temperature anisotropies
- LiteBIRD is targeting a sensitivity level in polarization ~ 30 times better than Planck
- This extremely good statistical uncertainty must go in parallel with exquisite control of:

1. **Instrument systematic** uncertainties
2. **Galactic foreground** contamination
3. **“Lensing B-mode signal”** induced by gravitational lensing
4. Observer biases

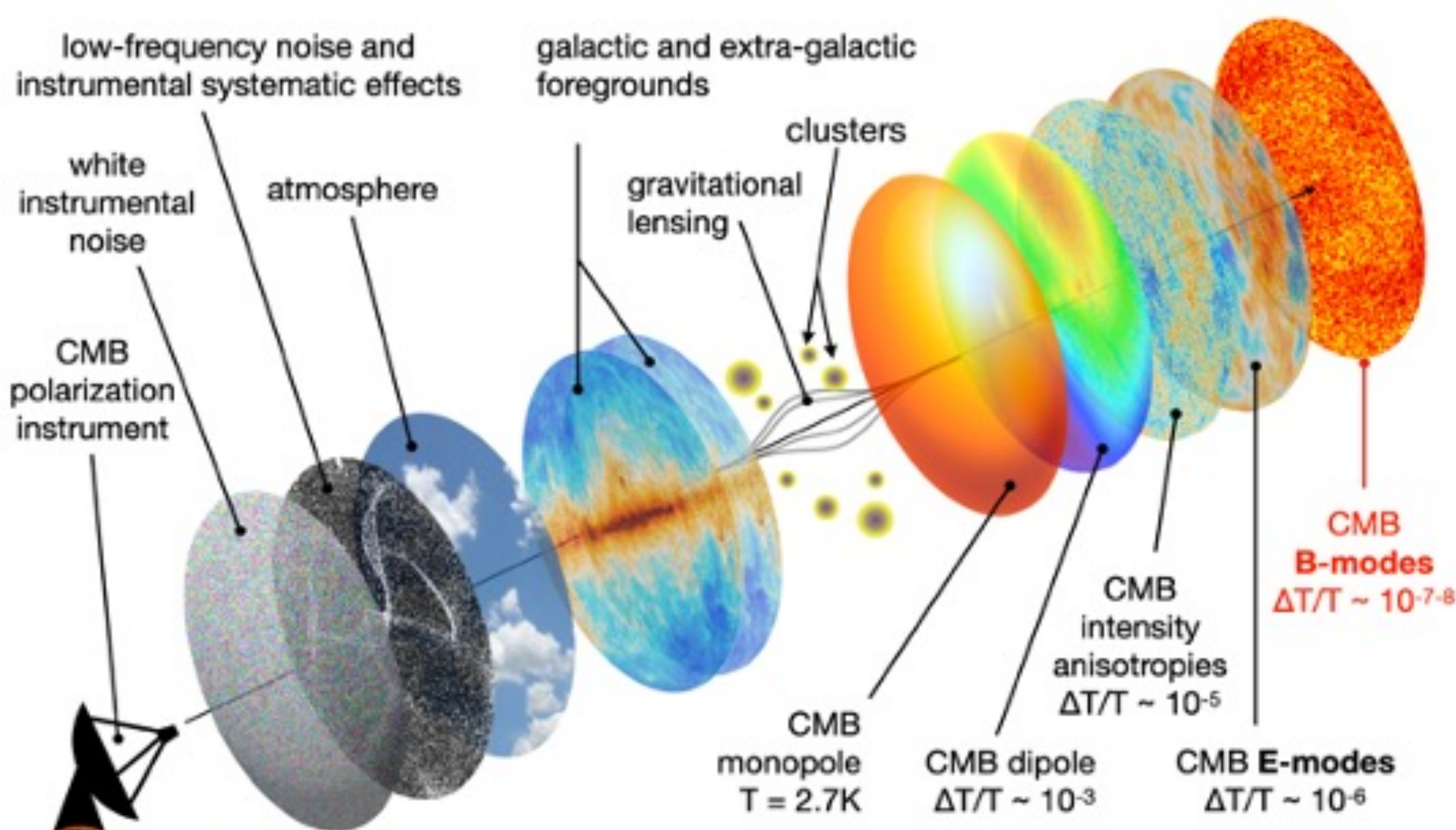
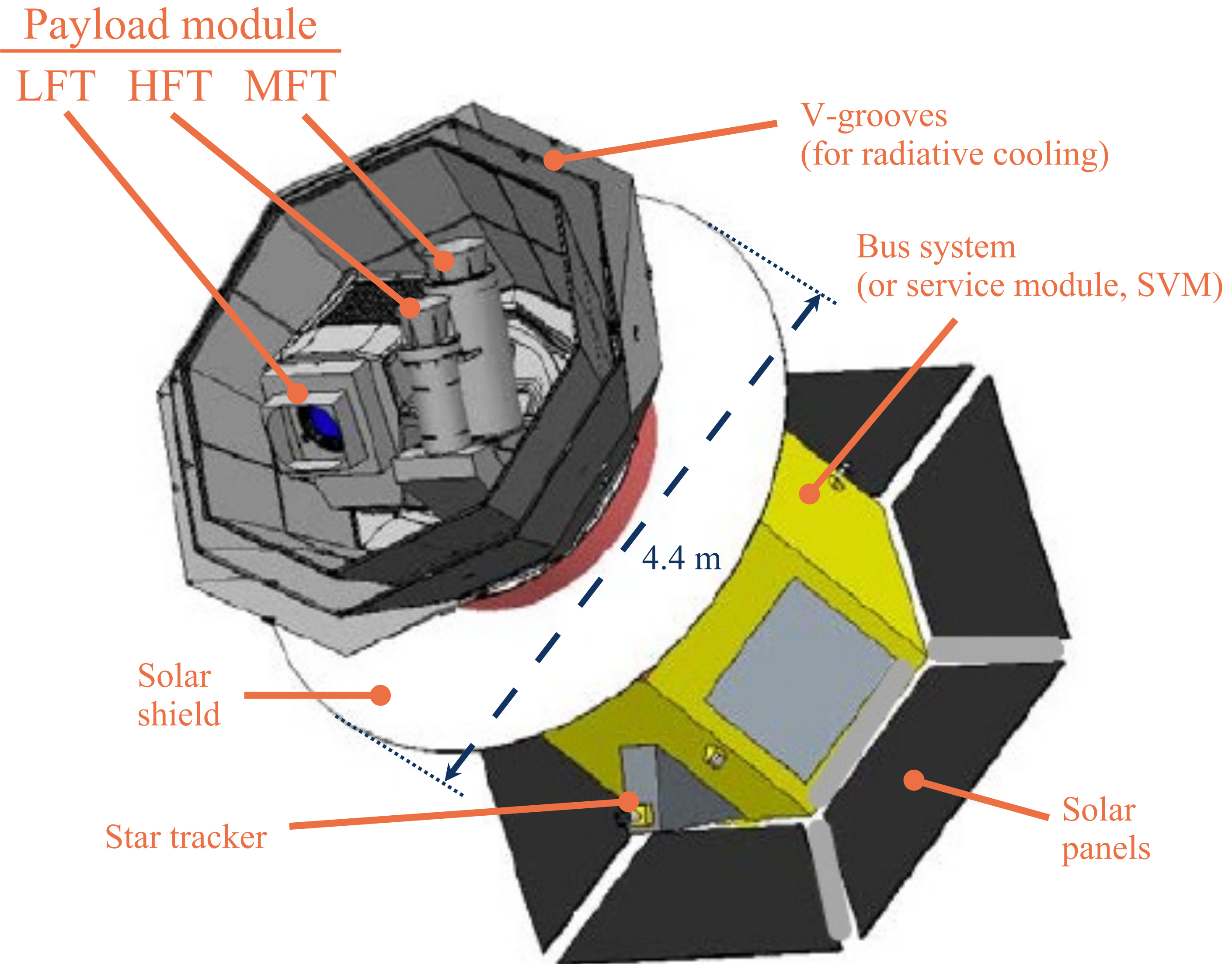


Image credit: Josquin Errard

LiteBIRD spacecraft overview

- **3 telescopes** are used to provide the **40-402 GHz** frequency coverage
 1. **LFT** (low frequency telescope)
 2. **MFT** (middle frequency telescope)
 3. **HFT** (high frequency telescope)
- Multi-chroic transition-edge sensor (TES) **bolometer arrays** cooled to **100 mK**
- Polarization modulation unit (PMU) in each telescope with **rotating half-wave plate** (HWP), for $1/f$ noise and systematics reduction
- Optics cooled to **5 K**

- Mass: 2.6 t
- Power: 3.0 kW
- Data: 17.9 Gb/day



LNF Thermo-Vacuum Facility Completion



LNF Thermo-Vacuum Facility Completion



Contributed by the INFN-LNF Group:
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D. Hampai, G. Modestino, S. Savaglio.

06/06/2024

LNF Thermo-Vacuum Facility Completion



LNF Thermo-Vacuum Facility Completion

Activity as of today:

- Thermal balance test (and correlation to models) thanks to the 'pocket' cryostat which is at our disposal, and that is being instrumented in a dedicated space.

Capitolo	Note Richiesta	Rich.	Rich. Sij	Assegn. Sij	Settembre Sbloccato (O Reso)	Richiesta Prossima Riun.	Disponibile Dettaglio Per Rich.
1	ELETTRONICA: Considerare il costo per affittamento Laboratorio LNF e per test di blocco termico e connessione ai modelli. Si allega file LNF_20230701_v1.pdf a file Commenti_Laboratorio_LNF2023-07-01.pdf nel sito Webgate - EDCP	2.0		1.0		Acquisitato da PI, in arrivo. Al momento, spare preso in prestito.	
2	ELETTRONICA: Considerare il costo per affittamento Laboratorio LNF e per test di blocco termico e connessione ai modelli. Si allega file LNF_20230701_v1.pdf a file Commenti_Laboratorio_LNF2023-07-01.pdf nel sito Webgate - EDCP	2.0		1.0		Necessario. Al momento, spare preso in prestito.	
3	MECANICA/MECCANOTRONICA: Impiegare il costo per affittamento Laboratorio LNF e per test di blocco termico e connessione ai modelli. Si allega file LNF_20230701_v1.pdf a file Commenti_Laboratorio_LNF2023-07-01.pdf nel sito Webgate - EDCP	10.0		8.0		Necessario. Al momento, spare scroll preso in prestito.	
4	ELETTRONICA/ELETTRONICA: Considerare il costo per affittamento Laboratorio LNF e per test di blocco termico e connessione ai modelli. Si allega file LNF_20230701_v1.pdf a file Commenti_Laboratorio_LNF2023-07-01.pdf nel sito Webgate - EDCP	3.0		1.5		Necessario. Al momento, spare per controllo scroll prestato.	
5	ELETTRONICA/MECCANICA/PROGNOVA: Regolare il Pannello per LNF per affittamento Laboratorio LNF e per test di blocco termico e connessione ai modelli. Si allega file LNF_20230701_v1.pdf a file Commenti_Laboratorio_LNF2023-07-01.pdf nel sito Webgate - EDCP	2.0		1.0		Necessario. Al momento, catena del freddo assente.	
6	ELETTRONICA: Rimuovere per affittamento Laboratorio LNF e per test di blocco termico e connessione ai modelli. Si allega file LNF_20230701_v1.pdf a file Commenti_Laboratorio_LNF2023-07-01.pdf nel sito Webgate - EDCP	3.0		1.5		Necessari. Assenti; stiamo allestendo controllo dimostrativo.	1.5
7	ELETTRONICA: Considerare per affittamento Laboratorio LNF e per test di blocco termico e connessione ai modelli. Si allega file LNF_20230701_v1.pdf a file Commenti_Laboratorio_LNF2023-07-01.pdf nel sito Webgate - EDCP	3.0		1.5		Necessari. Assenti; stiamo allestendo controllo dimostrativo.	1.5
8	ELETTRONICA: Terminare per affittamento Laboratorio LNF e per test di blocco termico e connessione ai modelli. Si allega file LNF_20230701_v1.pdf a file Commenti_Laboratorio_LNF2023-07-01.pdf nel sito Webgate - EDCP	3.0		1.5		Necessari. Assenti; stiamo allestendo controllo dimostrativo.	1.5
TOT				17.0			17.0

06/06/2024

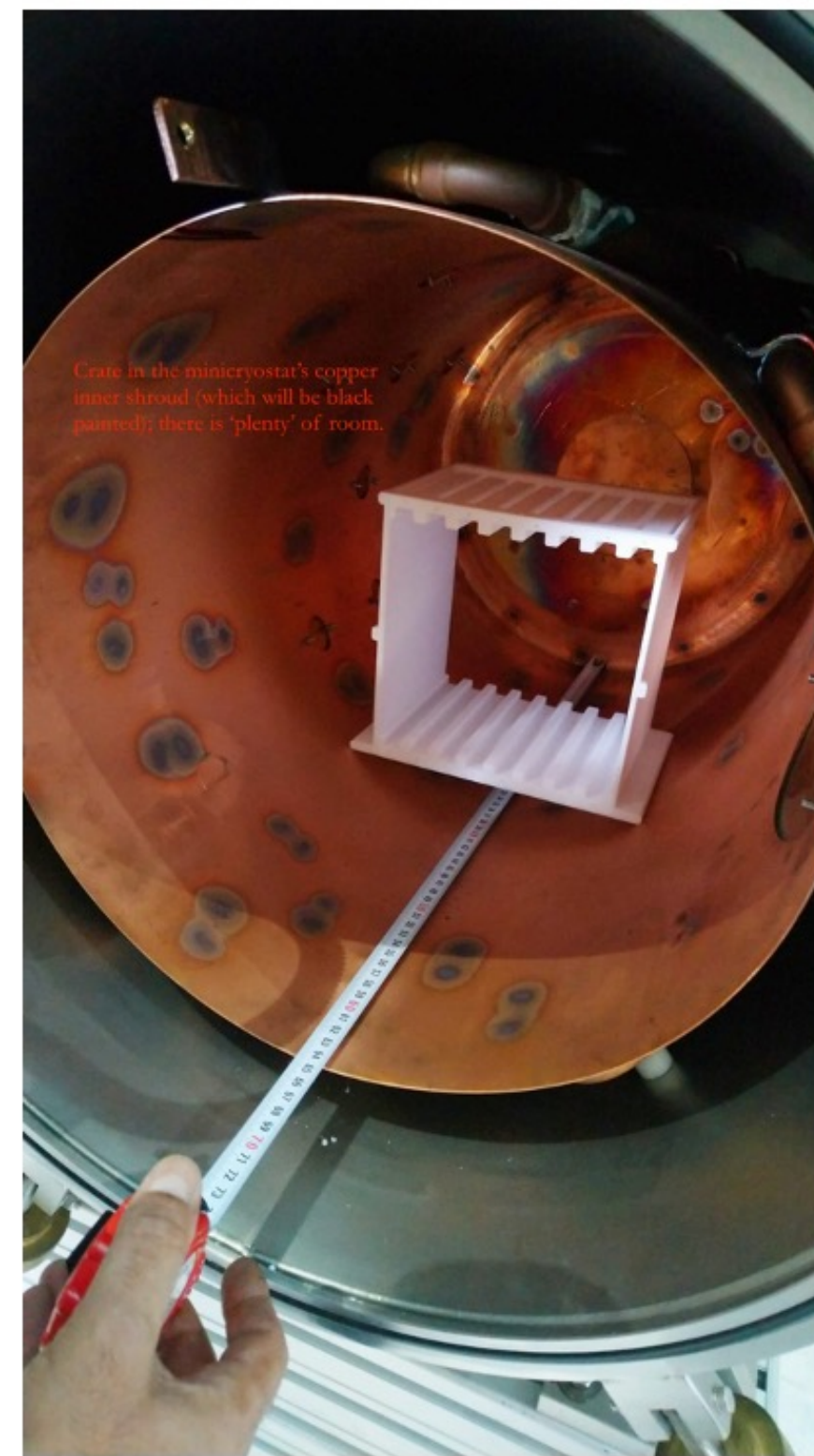
2025 Budget Telecon



LNF Thermo-Vacuum Facility Completion

Activity as of today:

- Thermal balance test (and correlation to models) thanks to the 'pocket' cryostat which is at our disposal, and that is being instrumented in a dedicated space.



06/06/2024

2025 Budget Telecon



LNf Thermo-Vacuum Facility Completion

Foreseen activity up to 31/12/2024:

- Finalise instrumentation of the 'pocket' cryostat, and perform several 'dry runs'.

Foreseen activity up to 31/12/2025:

- 'Pocket' cryostat up and running for actual tests.



LNf Thermo-Vacuum Facility Completion

2025 Budget Requests:

- Miss: ~ 10k (CC from 2024).
- Inv: ~ 10k (for fresh/new/spare pump).
- Acons: \leq 10k (LN₂ for thermal tests).

2025 HPC Requests:

- N/A.



LNF Thermo-Vacuum Facility Completion

Personnel in 2024:

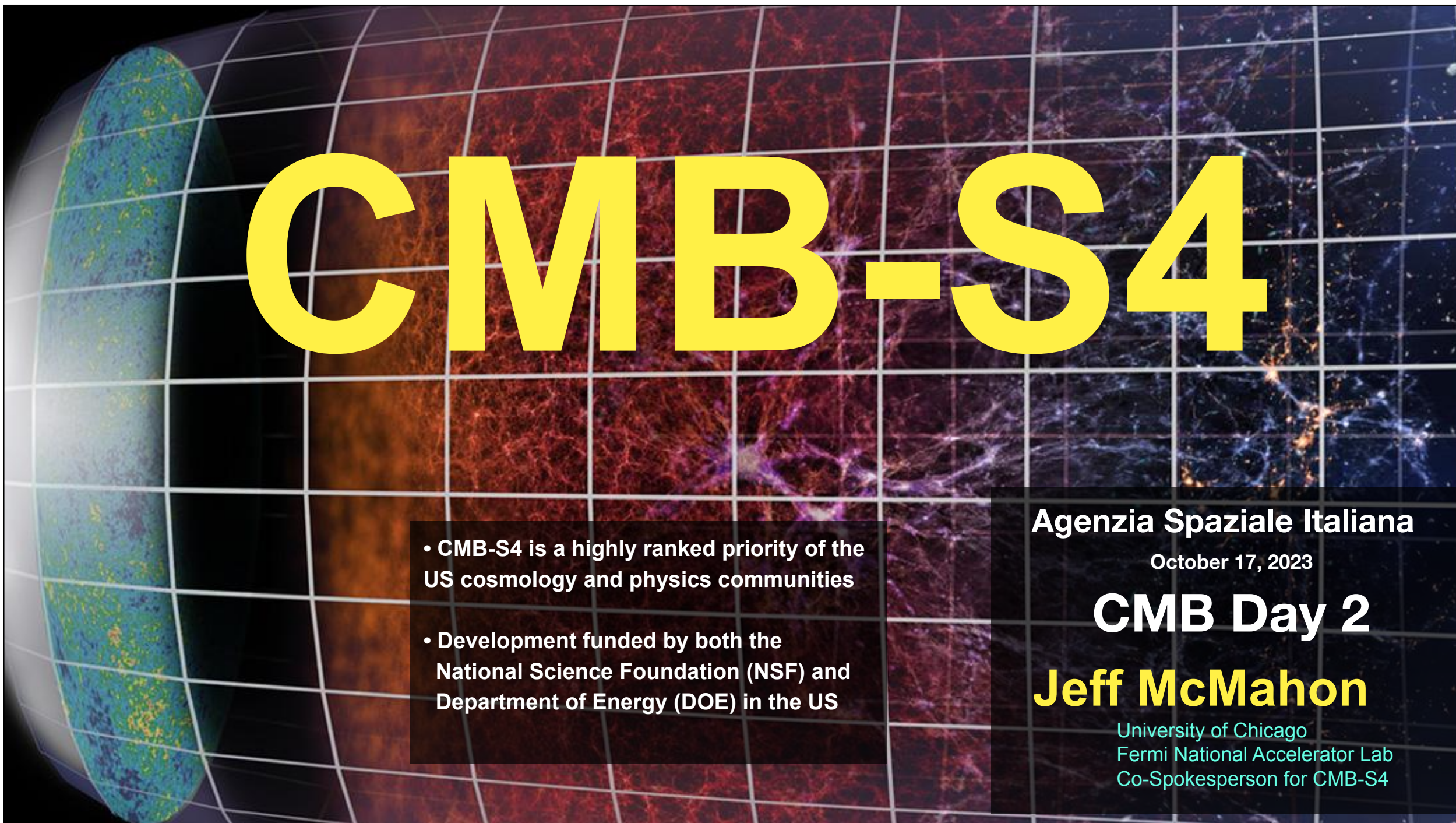
NOMINATIVO	TIPO	CONTRATTO	QUALIFICA	RICERCATORI	TECNOLOGI
Dabagov Sultan	DIP	Ricercatore	Dirigente di Ricerca	25	
Delle Monache Giovanni Ottavio	DIP	Tecnologo	Primo Tecnologo		50
Hampai Dariush	DIP	Tecnologo	Primo Tecnologo		25
Modestino Giuseppina	DIP	Ricercatore	Ricercatore	70	
Porcelli Luca	DIP	Ricercatore	Ricercatore	40	
Savaglio Sandra	ASSOC	Scientifica Ricercatori/Prof...	Prof. Ordinario	50	

Personnel in 2025:

- Same as 2024...
- - Modestino (70%; she is going to retire).
- + Tata (~ 50%).
- + Costanza (~ 50%).
- + Uniroma2 Engineering Students.
- Reshuffling with CMB-S4...

06/06/2024

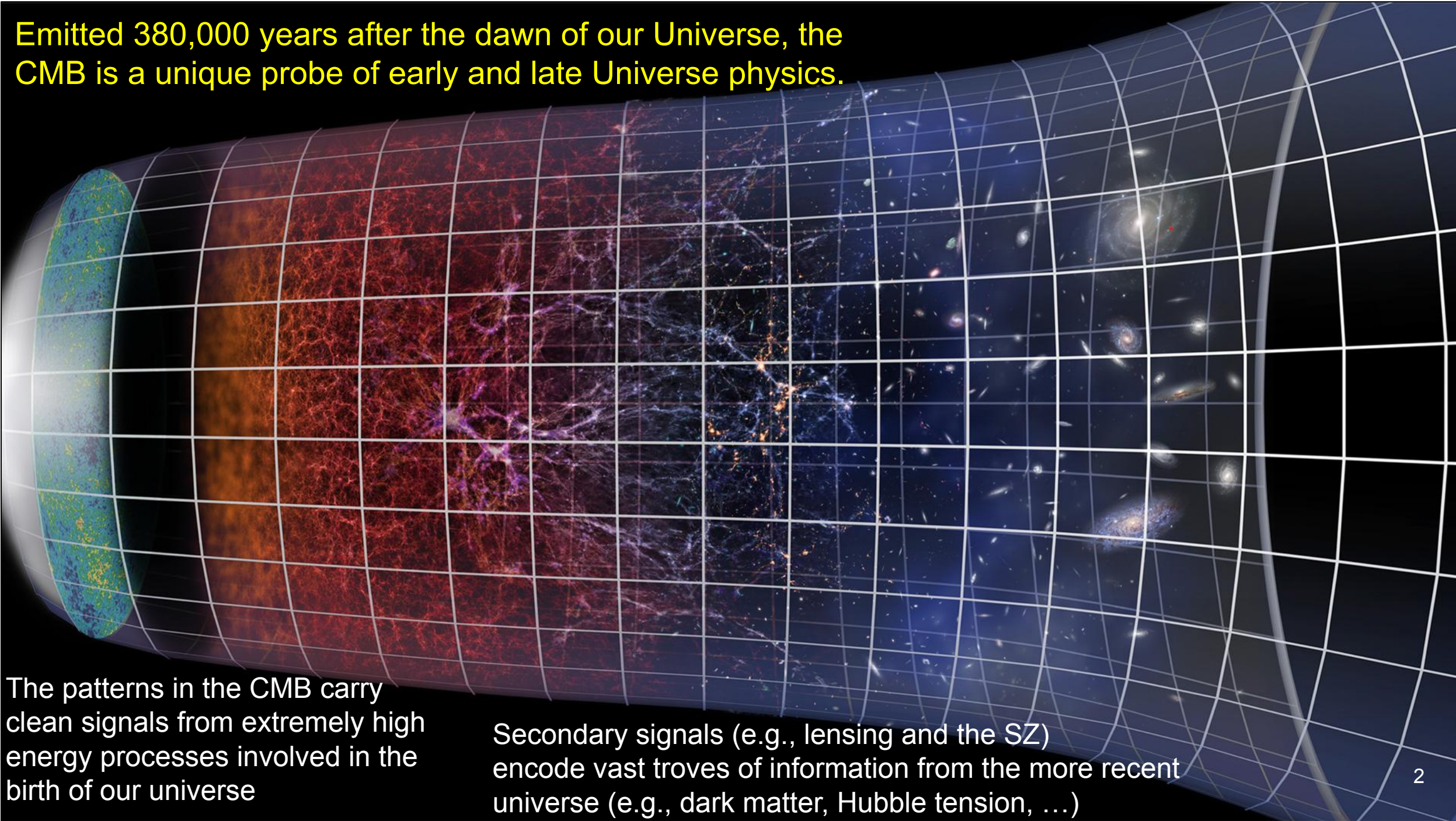
2025 Budget Telecon



CMB-S4

- CMB-S4 is a highly ranked priority of the US cosmology and physics communities
- Development funded by both the National Science Foundation (NSF) and Department of Energy (DOE) in the US

Agencia Spaziale Italiana
October 17, 2023
CMB Day 2
Jeff McMahon
University of Chicago
Fermi National Accelerator Lab
Co-Spokesperson for CMB-S4



Emitted 380,000 years after the dawn of our Universe, the CMB is a unique probe of early and late Universe physics.

The patterns in the CMB carry clean signals from extremely high energy processes involved in the birth of our universe

Secondary signals (e.g., lensing and the SZ) encode vast troves of information from the more recent universe (e.g., dark matter, Hubble tension, ...)

2

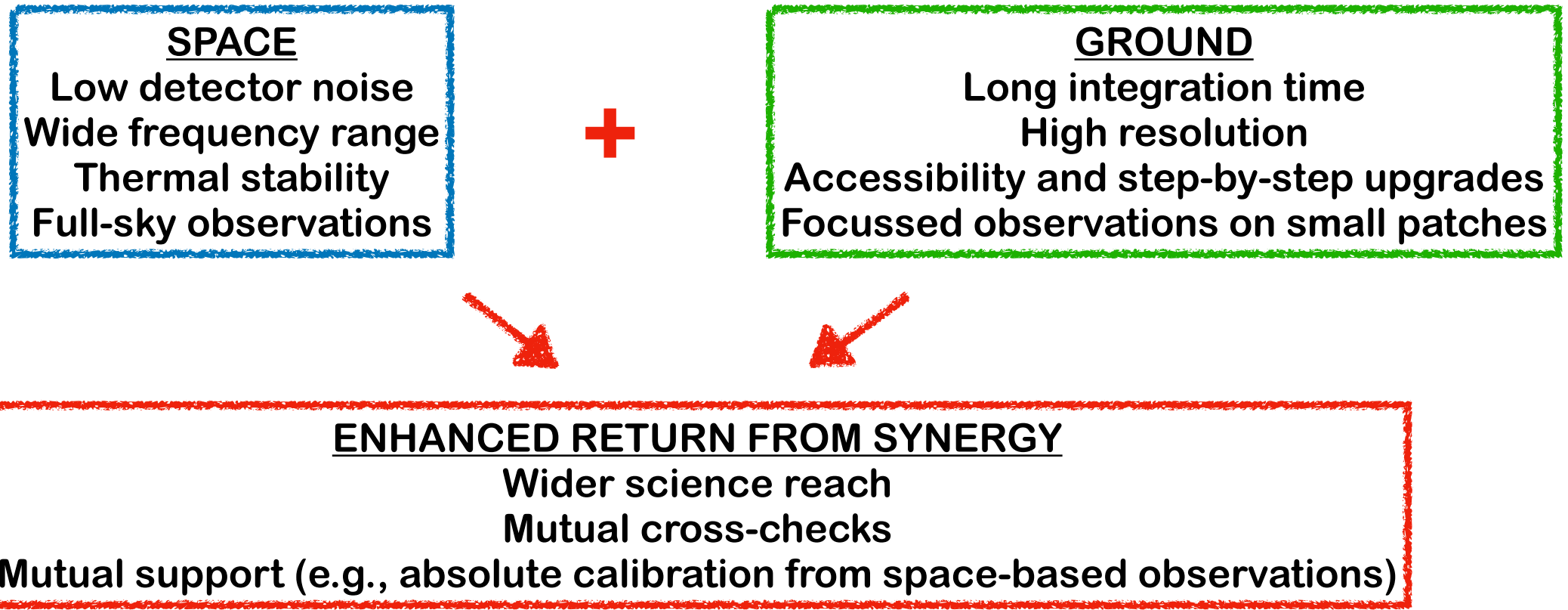
Synergies in CMB experiments

Pixar's The Moon



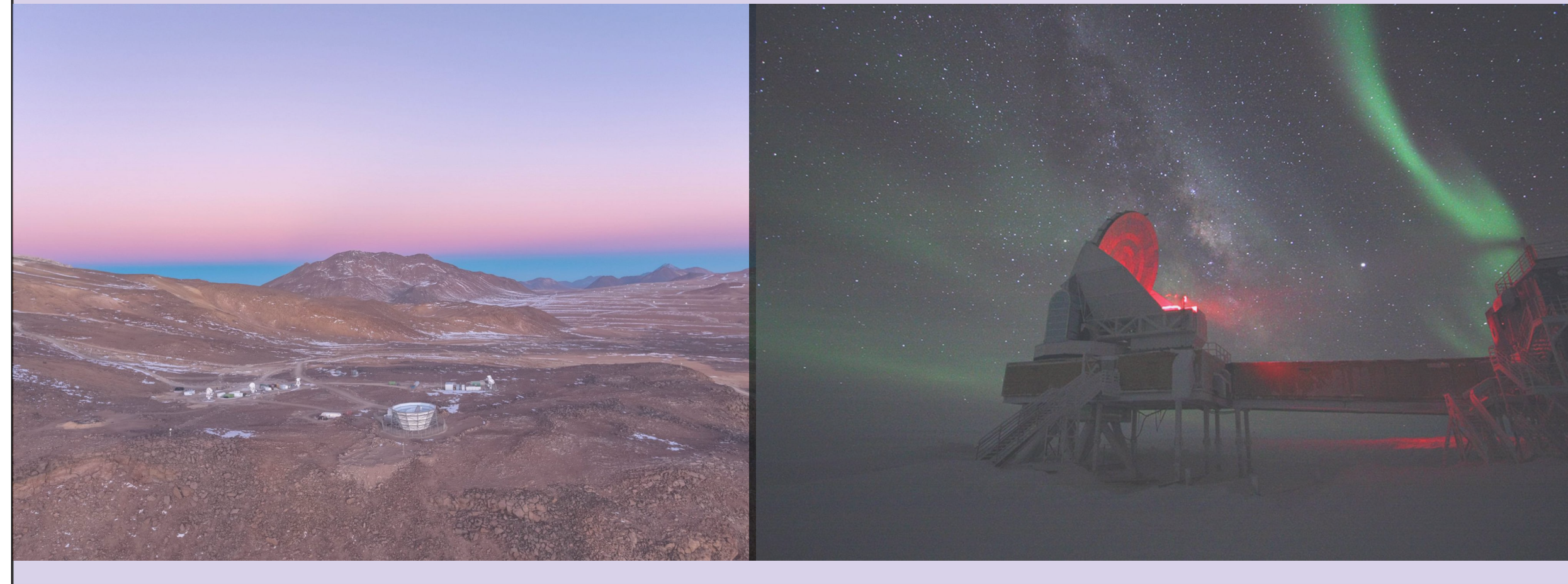
Martina Gerbino (INFN Ferrara) - CMB Day 2, ASI, 17 Ott 2023

Technical synergy



Misure di CMB

Riunione CSN2 - Foligno, 10 Aprile 2024
Martina Gerbino (INFN Ferrara)



LiteBIRD-LNF x 2025

Objective: perform the first tests on the (flight) electronics of interest.

- **2024 Results:**

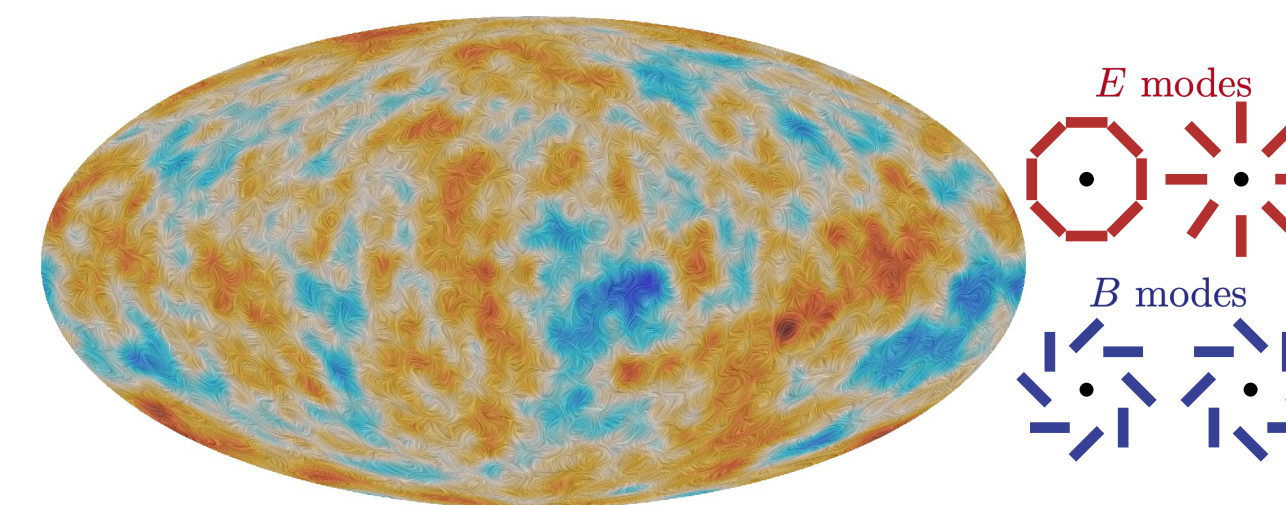
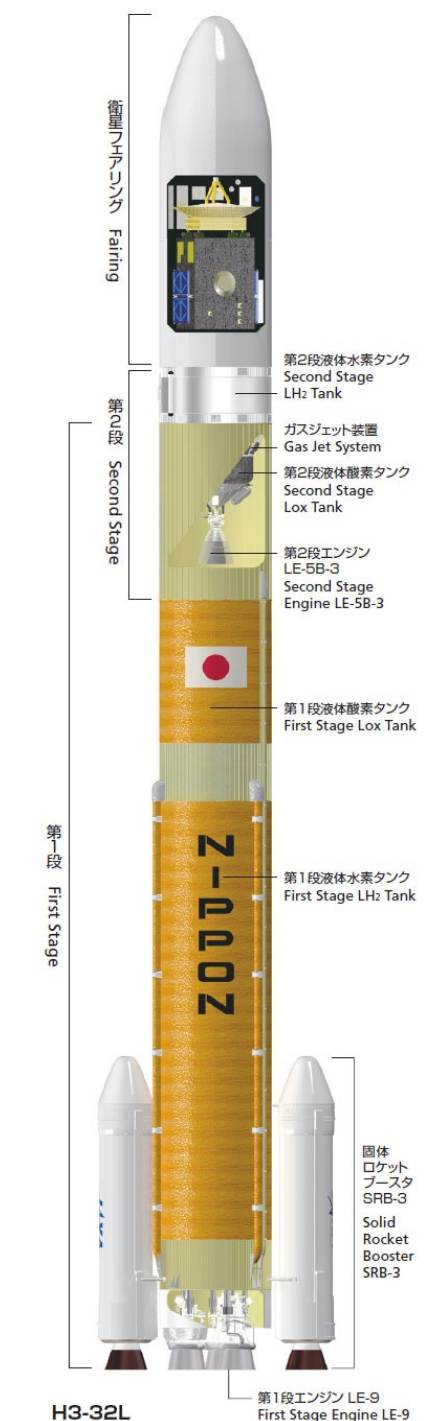
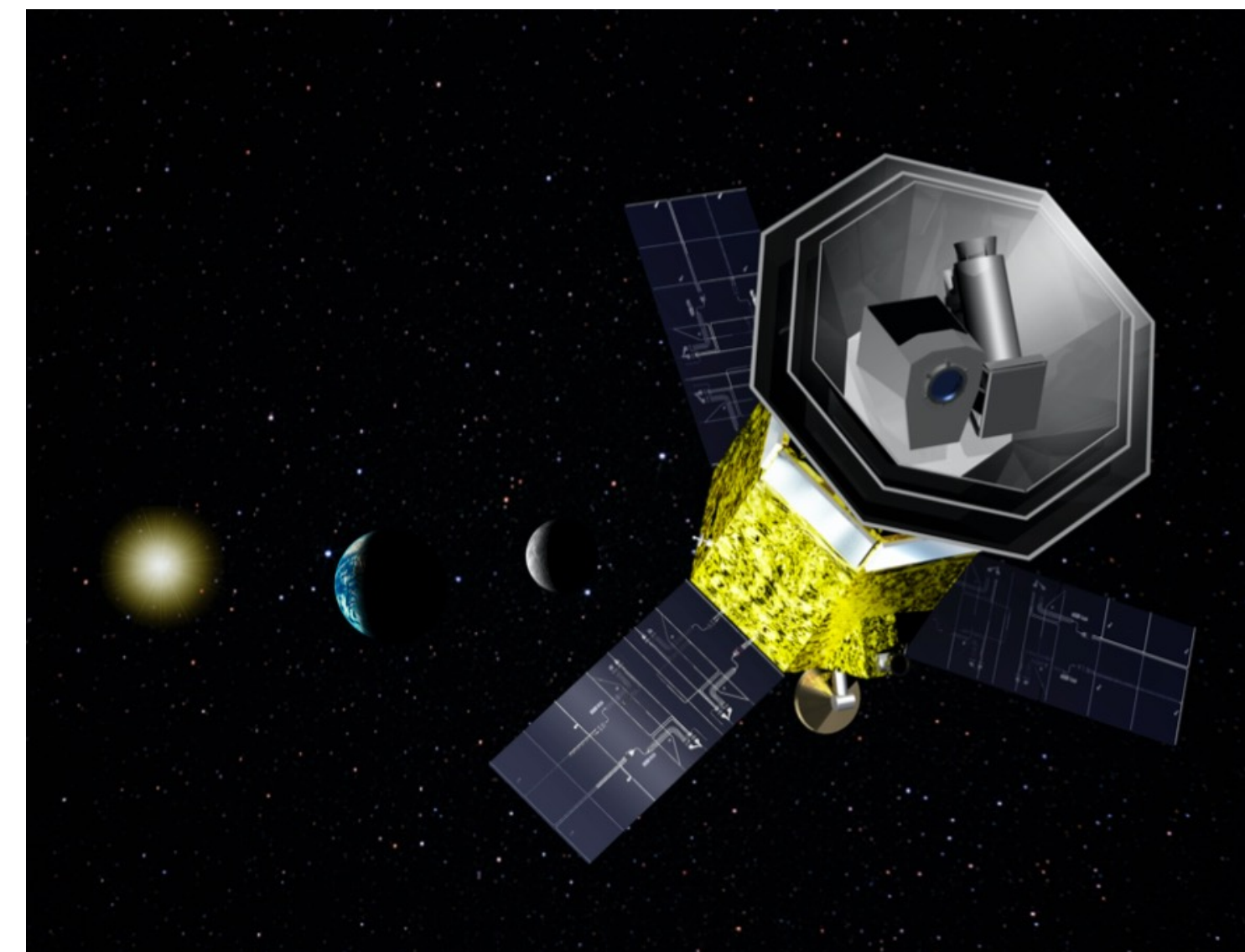
- Local activity alive and well:
 - Setting up and instrumenting the ‘pocket’ cryostat for tests on the electronics of interest.
 - Defining a strategy for (non)destructive irradiation testing and X-ray circuitry diagnostics.
 - Defining a strategy for teaming with the wider collaboration in order to get involved in data analysis, modelling and simulations for the physical processes of interest, at ‘cosmological’ level.

- Wider collaboration joint:

- <https://wiki.kek.jp/display/cmb/LiteBIRD+Joint+Study+Group+members+picture+book>

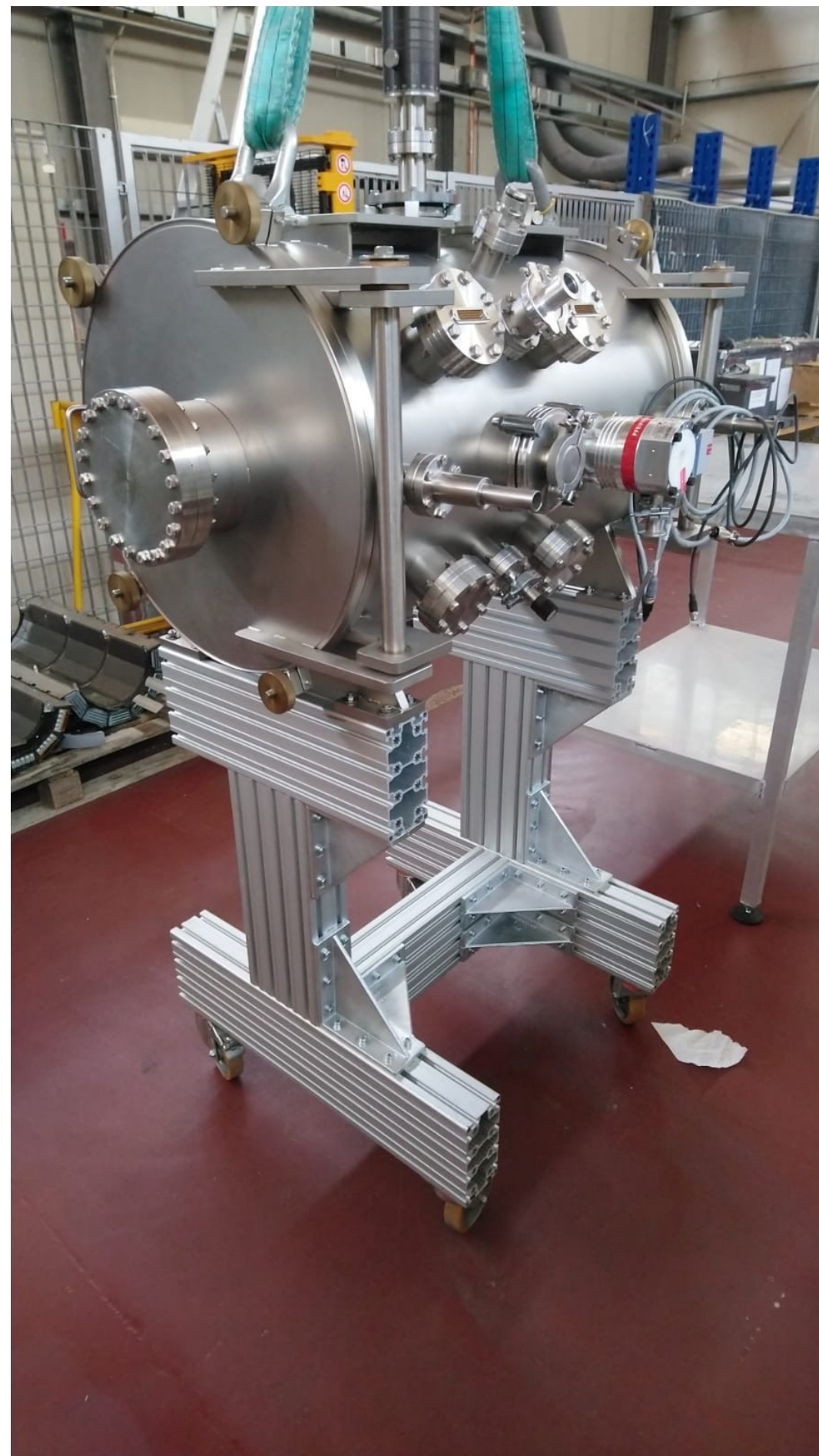
- **2025 Objectives:**

- Finalise setup and instrumentation of the ‘pocket’ cryostat for tests on the electronics of interest.
- Perform the first thermal balance test on the electronics of interest, and, eventually, on the very flight hardware.
- Proposing a strategy for (non)destructive irradiation testing and X-ray circuitry diagnostics.
- Teaming with the wider collaboration in order to get involved in data analysis, modelling and simulations for the physical processes of interest, at ‘cosmological’ level.



LiteBIRD-LNF x 2025

Objective: perform the first tests on the (flight) electronics of interest.



- **FTE (LNF):** L. Porcelli (RL, 40%), S. Dabagov (25%), G. Delle Monache (50%), D. Hampai (25%), G. Modestino (70%) + S. Savaglio (Unical, 50%) = 6 PP (2.60 FTE)
- **Richieste CSN2 2025 (overall, TBD):** missioni 10k, inventario 10k, altri cons 10k, license SW ...k, apparati ...k, servizi ...k
- **Richieste LNF 2025 (mesi-uomo):** Criogenia 1; Elettronica 1; Progettazione DR 1; ...
- **Fondi Esterni:** N/A