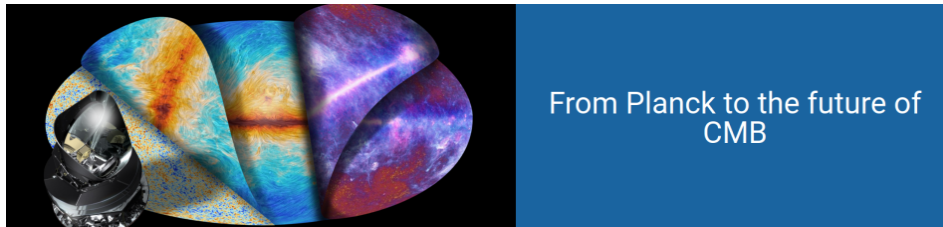


From Planck to the future of CMB



Report of Contributions

Contribution ID: **102**

Type: **not specified**

**Welcome and foreword from Laura Ramaciotti
(Rector of the University of Ferrara), Vincenzo Guidi
(Director of Department of Physics and Earth
Sciences - UniFe), Roberto Calabrese (Director of
INFN Ferrara)**

Monday, 23 May 2022 10:00 (20 minutes)

Session Classification: Science Challenges

Contribution ID: **103**

Type: **not specified**

Invited talk by Jo Dunkley (Princeton University) on "Key future science goals from the CMB"

Monday, 23 May 2022 10:45 (40 minutes)

There is still a great deal to be learnt from CMB measurements. I will give an overview of science that the community hope to do with new data, from testing initial conditions of the universe to probing the dark sector and better understanding cosmic reionization and galaxy evolution. I will also describe some of the rich millimeter-wave science that can be done with these datasets, including time-domain astrophysics.

Session Classification: Science Challenges

Contribution ID: 104

Type: **not specified**

Invited talk by Tomotake Matsumura (Kavli IPMU Tokyo) on "Scientific challenges expected from future space experiments"

Monday, 23 May 2022 11:25 (30 minutes)

The measurement of cosmic microwave background (CMB) from space is ideal for the entire sky access and broad observational frequency coverage. The past CMB satellite missions, COBE, WMAP, and Planck, play crucial roles in establishing modern cosmology. Now next-generation satellite missions will aim for even more demanding scientific goals, and the various corresponding requirements on the mission become stringent. In this talk, we will review the achievements and lessons learned from the past CMB space missions. With these heritages in the community, I will try projecting the upcoming challenges and make a bridge to the rest of the talks in this workshop.

Session Classification: Science Challenges

Contribution ID: **105**

Type: **not specified**

Invited talk by Suzanne Staggs (Princeton University) on "Scientific challenges expected from future ground experiments"

Monday, 23 May 2022 11:55 (30 minutes)

Session Classification: Science Challenges

Contribution ID: **106**

Type: **not specified**

Invited talk by Paolo de Bernardis (Rome Sapienza University) on "Scientific challenges expected from future balloon experiments"

Monday, 23 May 2022 12:25 (35 minutes)

Session Classification: Science Challenges

Contribution ID: 107

Type: **not specified**

Invited talk by Anthony Challinor (Cambridge University) on "CMB probes of cosmological inflation: current status and future prospects"

Monday, 23 May 2022 14:00 (40 minutes)

The temperature and polarisation anisotropies of the CMB offer our most direct view of the early universe and their observation has, and continues to be, critical in constraining early-universe models. In this talk, I will review the key ways that the CMB constrains the properties of the primordial fluctuations, which were likely produced during an early period of cosmological inflation, and the implications of current constraints for models of inflation. I will also discuss some of the challenges faced in these measurements and review the prospects of forthcoming CMB experiments to advance our understanding of inflation.

Session Classification: CMB, Cross-Correlation and Galactic Science

Contribution ID: **108**Type: **not specified**

Invited talk by Jon Gudmundsson (Stockholm University) on "Knowing your beams"

Monday, 23 May 2022 14:40 (40 minutes)

The cosmic microwave background (CMB) has played a foundational role in the establishment of the standard model of cosmology. Driven by significant technological advances, future CMB experiments aim to make dramatic strides in our understanding of the universe. Some of our most ambitious efforts, however, run the risk of being hamstrung by poorly-understood instrument effects, systematics. A commonly-discussed class of systematic effects relate to our optical systems in one way or another. In this talk, I will review some of the challenges that past CMB missions have faced and highlight lessons learned. I will present algorithms that have been developed to help us understand the impact of optical non-idealities and summarize key results from the applications of those. I will conclude by reviewing some of the challenging calibration requirements for upcoming missions and discuss how the community can work towards meeting those.

Session Classification: Beams

Contribution ID: **109**

Type: **not specified**

**Clara Vergès (Harvard CfA) "Beam calibration
campaign requirements to control
temperature-to-polarisation leakage for CMB-Stage
4"**

Monday, 23 May 2022 15:20 (20 minutes)

Session Classification: Beams

Contribution ID: **110**

Type: **not specified**

Clément Leloup (APC Paris) "Study of beam side-lobes systematics and calibration for the LiteBIRD mission"

Monday, 23 May 2022 15:40 (20 minutes)

Session Classification: Beams

Contribution ID: 111

Type: **not specified**

Emilie Storer (Princeton University) "Map-making and Beams for the Atacama Cosmology Telescope"

Monday, 23 May 2022 16:00 (20 minutes)

Session Classification: Beams

Contribution ID: 112

Type: **not specified**

Invited talk by Hannes Hubmayr (NIST Boulder) on "The shape of CMB focal planes to come"

Monday, 23 May 2022 16:40 (40 minutes)

The tantalizing science reach of CMB observations has driven remarkable innovation in superconducting detectors. Roughly two decades ago, CMB focal planes consisted of a few individually assembled detection channels. By use of modern micro-fabrication equipment and improved microwave design tools, today's imaging focal planes consist of multiple-tiled, large-format wafers. A wafer may contain hundreds of spatial pixels, each an integrated superconducting circuit capable of polarization diplexing and power sensing in multiple frequency channels. In this talk I will present the current CMB focal plane landscape, including the various optical coupling, sensing, and multiplexing techniques in use. Attention will be given to the formidable scaling challenge of near-term ground-based observations. Lastly, I will offer my opinion on what future focal plane developments would be most impactful for future ground and space-based CMB instruments.

Session Classification: Detectors and Beams

Contribution ID: 113

Type: **not specified**

Guillermo Pascual Cisneros (IFCA Santander)
**"Optimization of a microwave polarimeter for
astronomy with optical correlation and detection"**

Monday, 23 May 2022 17:20 (20 minutes)

Session Classification: Detectors and Beams

Contribution ID: 114

Type: **not specified**

Nadia Dachlythra (Oskar Klein Stockholm) "Optical calibration simulations for the Simons Observatory"

Monday, 23 May 2022 17:40 (20 minutes)

Session Classification: Detectors and Beams

Contribution ID: 115

Type: **not specified**

Discussion (Jon Gudmundsson, Hannes Hubmayr)

Monday, 23 May 2022 18:00 (30 minutes)

Session Classification: Detectors and Beams

Contribution ID: 116

Type: **not specified**

Invited talk by Charles R. Lawrence (NASA/JPL) on "Lessons from Planck Calibration for Future CMB Experiments"

Tuesday, 24 May 2022 09:00 (40 minutes)

Planck set new standards for calibration of CMB experiments. That was hard. Calibration of future experiments, which will require map noise levels of nanokelvin or better, will be much harder. I will discuss lessons learned in calibrating Planck for future experiments.

Session Classification: Data Calibration and Characterization

Contribution ID: 117

Type: **not specified**

Nicholas Galitzki (UCSD) "The Characterization and Calibration of the Simons Observatory Small Aperture Telescope: Status and future plans"

Tuesday, 24 May 2022 09:40 (20 minutes)

Session Classification: Data Calibration and Characterization

Contribution ID: 118

Type: **not specified**

Kirit Karkare (Chicago University) "Calibration and Systematics for the CMB-S4 Inflation Survey Small Aperture Telescopes"

Tuesday, 24 May 2022 10:00 (20 minutes)

Session Classification: Data Calibration and Characterization

Contribution ID: 119

Type: **not specified**

**Enrique Martínez-González (IFCA Santander)
"Polarization angle requirements for CMB B-mode
experiments. Application to the LiteBIRD satellite"**

Tuesday, 24 May 2022 10:20 (20 minutes)

Session Classification: Data Calibration and Characterization

Contribution ID: 120

Type: **not specified**

Gabriele Coppi (INFN Milan) "PROTOCOLC: Design and Simulation of a Calibration Source for mm Telescopes"

Tuesday, 24 May 2022 11:00 (20 minutes)

Session Classification: Data Calibration and Characterization

Contribution ID: 121

Type: **not specified**

Invited talk by Stephan Ilic (IJC Lab Paris) on "The history of reionisation : peering through the dark ages with the CMB"

Tuesday, 24 May 2022 11:50 (40 minutes)

Observations of the cosmic microwave background provide us with a unique window on the early Universe, and great new insights are expected from the next generation of dedicated ground and space telescopes. While probing the elusive inflationary epoch may be the most sought-after objective of those missions, they will also shed some light on another poorly-known era of the early Universe: the reionisation era. In this talk, after recalling the essentials of the reionisation epoch, I will review the methodologies used and state-of-the-art constraints derived from current data. I will then focus on the future of reionisation studies, detailing forecasts and new probes remaining to be exploited.

Session Classification: CMB, Cross-Correlation and Galactic Science

Contribution ID: **122**

Type: **not specified**

Discussion (Daniele Mennella, Tomotake Matsumura)

Tuesday, 24 May 2022 11:20 (30 minutes)

Session Classification: Data Calibration and Characterization

Contribution ID: 123

Type: **not specified**

Invited talk by Massimiliano Lattanzi (INFN Ferrara) on "Particle and energy composition of the Universe: Neutrinos, Light relics and Dark Matter"

Tuesday, 24 May 2022 14:00 (40 minutes)

The interaction between cosmology and particle physics has always been very fruitful. Cosmological observations provide a powerful mean to test particle physics theories, and to measure the properties of existing particles like neutrinos. At the same time, the solution to two long-standing mysteries in cosmology - the origin of dark matter and dark energy - might lie in physics beyond the standard model of particles. In my talk I will review what we have learned from cosmological observations of the recent past, especially Planck's, on light relics (including neutrinos) and dark matter, and discuss prospects for future experiments.

Session Classification: CMB, Cross-Correlation and Galactic Science

Contribution ID: 124

Type: **not specified**

**Invited talk by Loris Colombo (Milan University) on
"Lessons learned from Planck for cosmology from
large angle polarization"**

Tuesday, 24 May 2022 14:40 (40 minutes)

Session Classification: Systematics impact on large angular scale science

Contribution ID: 125

Type: **not specified**

Roger de Belsunce (Cambridge University)
**"Cosmological inference from large-angular scale
CMB data"**

Tuesday, 24 May 2022 15:20 (20 minutes)

Session Classification: Systematics impact on large angular scale science

Contribution ID: 126

Type: **not specified**

Dominic Beck (Stanford University) "Cosmological constraints and instrumental systematics studies using line-of-sight distortion fields with BICEP/Keck and beyond"

Tuesday, 24 May 2022 15:40 (20 minutes)

Session Classification: Systematics impact on large angular scale science

Contribution ID: 127

Type: **not specified**

Sofia Fatigoni (UBC) "High Resolution analysis of the South Pole Atmosphere for CMB observations"

Tuesday, 24 May 2022 16:00 (20 minutes)

Session Classification: Systematics impact on large angular scale science

Contribution ID: 128

Type: **not specified**

Giulio Fabbian (CCA Flatiron Institute) "Challenges for high precision lensing reconstruction"

Tuesday, 24 May 2022 16:40 (20 minutes)

Session Classification: Systematics impact on large angular scale science

Contribution ID: 129

Type: **not specified**

Baptiste Jost (APC Paris) "Novel method for joint systematic correction and foreground cleaning and its application to the estimation of cosmic birefringence in Simons Observatory"

Tuesday, 24 May 2022 17:00 (20 minutes)

Session Classification: Systematics impact on large angular scale science

Contribution ID: 130

Type: **not specified**

Patricia Diego-Palazuelos (IFCA Santander)
**"Simultaneous determination of miscalibrated
polarization angles and cosmic birefringence from
Planck PR4"**

Tuesday, 24 May 2022 17:20 (20 minutes)

Session Classification: Systematics impact on large angular scale science

Contribution ID: **131**

Type: **not specified**

Discussion (Matthieu Tristram, Loris Colombo)

Tuesday, 24 May 2022 17:40 (30 minutes)

Session Classification: Systematics impact on large angular scale science

Contribution ID: 132

Type: **not specified**

Invited talk by Nicoletta Krachmalnicoff (SISSA) on "Characterization of Foreground emission for CMB experiments: current status and future prospective"

Wednesday, 25 May 2022 09:00 (30 minutes)

In the recent years it has become clear how the contamination coming from Galactic and extra-Galactic emissions represents one of the main limiting factor for any new science achievable with Cosmic Microwave Background observations. Having a thorough understanding of the foreground properties is therefore fundamental in order to achieve a reliable reconstruction of the clean CMB signal and to constrain its cosmological properties. In this talk I will review the current status of knowledge and characterization of foregrounds, focusing in particular Galactic polarized emission. I will summarize the main results from the latest analysis of available multi-frequency data, highlighting which are the main limitations in our current models and how we can overcome them in view of future CMB experiments.

Session Classification: Foregrounds

Contribution ID: 133

Type: **not specified**

Invited talk by Mathieu Remazeilles (IFCA Santander) on "Next steps in component separation for new CMB observables"

Wednesday, 25 May 2022 09:30 (30 minutes)

Beyond the significant legacy of the ESA's Planck mission, the cosmic microwave background (CMB) radiation carries much more information that remains to be exploited in the coming decades. Next-generation CMB experiments of unprecedented sensitivity are being planned to extract and interpret new cosmological observables out of future CMB data. Among these new, yet undetected, cosmological observables is the primary CMB B-mode polarization signal, but also secondary distortions to CMB anisotropies caused by the cosmic web, such as the relativistic SZ effect. A common aspect of these new cosmological signals is their very faint signature, furthermore obscured by intense astrophysical foreground emissions, which makes their recovery much more sensitive to foreground mismodeling, while the exact spectral properties of the foregrounds are also poorly known at the sensitivity levels required for these signals. I will discuss the problem of foregrounds and component separation for the search for such faint cosmological signals, and emphasize specific challenges in this context: foreground mismodeling, foreground spectral distortions, and spectral degeneracies versus frequency coverage. I will also present some recent developments in component separation which rely on statistical moment expansion of the foreground emission, and show how this offers an interesting avenue to overcome these new challenges.

Session Classification: Foregrounds

Contribution ID: 134

Type: **not specified**

Niall Jeffrey (UCL) "Single frequency CMB B-mode inference with realistic foregrounds from a single training image"

Wednesday, 25 May 2022 10:00 (20 minutes)

Session Classification: Foregrounds

Contribution ID: 135

Type: **not specified**

Elena de la Hoz (IFCA Santander) "Diffuse polarized foregrounds from component separation with QUIJOTE-MFI"

Wednesday, 25 May 2022 10:20 (20 minutes)

Session Classification: Foregrounds

Contribution ID: 137

Type: **not specified**

Alessia Ritacco (INAF OAC) "First low latitudes reconstruction of the dust polarization spectral energy distribution variation"

Wednesday, 25 May 2022 11:20 (20 minutes)

Session Classification: Foregrounds

Contribution ID: 138

Type: **not specified**

Giuseppe Puglisi (Tor Vergata University)
**"Foreground Removal for B-Modes Detection with
Clustering Methods"**

Wednesday, 25 May 2022 11:40 (20 minutes)

Session Classification: Foregrounds

Contribution ID: 139

Type: **not specified**

Discussion (Carlo Baccigalupi, Nicoletta Krachmalnicoff, Mathieu Remazeilles)

Wednesday, 25 May 2022 12:20 (30 minutes)

Session Classification: Foregrounds

Contribution ID: 140

Type: **not specified**

Invited talk by Reijo Keskitalo (LBNL) on "Integrated data analysis and end-to-end simulations"

Thursday, 26 May 2022 09:00 (40 minutes)

All data analysis for an experiment is, at least implicitly, integrated. It all aims to distill scientific knowledge from a common data set. Whether the architects of the data reduction pipelines make the integration explicit is influenced by external constraints (processing power, availability of accurate models) and design strategy (highly modular or tightly coupled). Regardless of the case, need for faithful simulations of the deliverable data set often lead to end-to-end simulations that end up integrating all of the analysis modules together. In my talk I will review the data reduction and end-to-end simulation strategies employed in the production of Planck public data releases, discuss the importance of integrating simulations into early development work and make connections with the next generation CMB experiments that are right now designing their data analysis pipelines.

Session Classification: Data Analysis Interdependencies

Contribution ID: **141**

Type: **not specified**

Mathew Galloway (Oslo University) "BeyondPlanck – Bayesian end-to-end Analysis of Planck LFI"

Thursday, 26 May 2022 09:40 (20 minutes)

Session Classification: Data Analysis Interdependencies

Contribution ID: 142

Type: **not specified**

Ian Harrison (Cardiff University) "SO Likelihood Codes for CMB Combined Probes"

Thursday, 26 May 2022 10:00 (20 minutes)

Session Classification: Data Analysis Interdependencies

Contribution ID: 143

Type: **not specified**

Erik Rosenberg (Cambridge University) "CMB power spectra and cosmological parameters from Planck PR4 (NPIPE) with CamSpec"

Thursday, 26 May 2022 10:20 (20 minutes)

Session Classification: Data Analysis Interdependencies

Contribution ID: 144

Type: **not specified**

Gabriel Jung (Padova University) "The integrated angular bispectrum of the CMB"

Thursday, 26 May 2022 11:00 (20 minutes)

Session Classification: Data Analysis Interdependencies

Contribution ID: 145

Type: **not specified**

Adriaan Duivenvoorden (Princeton University) "The Atacama Cosmology Telescope: science and analysis pipeline"

Thursday, 26 May 2022 11:20 (20 minutes)

Session Classification: Data Analysis Interdependencies

Contribution ID: 146

Type: **not specified**

Etienne Camphuis (IAP Paris) "Building an accurate analytical power spectrum covariance matrix on a small survey area"

Thursday, 26 May 2022 11:40 (20 minutes)

Session Classification: Data Analysis Interdependencies

Contribution ID: **147**

Type: **not specified**

Discussion (Paolo Natoli, Reijo Keskitalo)

Thursday, 26 May 2022 12:00 (30 minutes)

Session Classification: Data Analysis Interdependencies

Contribution ID: 148

Type: **not specified**

Laura Salvati (IAS Orsay) "Galaxy clusters in the mm wavelengths: cosmological analysis and future perspectives"

Thursday, 26 May 2022 15:00 (20 minutes)

Session Classification: CMB, Cross-Correlation and Galactic Science

Contribution ID: 149

Type: **not specified**

Vincent Pelgrims (Crete University) "Pasiphae: Goal and overview of current status"

Thursday, 26 May 2022 15:40 (20 minutes)

Session Classification: CMB, Cross-Correlation and Galactic Science

Contribution ID: 150

Type: **not specified**

Invited talk by Jia Liu (Kavli IPMU Tokyo) on "Simulating correlated CMB and large-scale structure observables"

Thursday, 26 May 2022 14:00 (40 minutes)

We are expecting high-precision observations from upcoming CMB surveys, such as the Simons Observatory, CMB-S4, and LiteBIRD, as well as from future surveys of the large-scale structure, such as Euclid, Rubin LSST, SPHEREx, PSF, and Roman Space Telescope. Most of the observables from these independent surveys will be correlated due to their large overlaps in sky and redshift coverage. Joint analysis of CMB and LSS surveys will allow us to increase the overall signal, break degeneracies, mitigate systematics, and potentially probe new science. In this talk, I will discuss the possible paths to simulate correlated CMB and LSS observables to achieve these scientific goals.

Session Classification: CMB, Cross-Correlation and Galactic Science

Contribution ID: **151**

Type: **not specified**

Federica Guidi (IAP Paris) "Cosmology from SPT-3G"

Thursday, 26 May 2022 15:20 (20 minutes)

Session Classification: CMB, Cross-Correlation and Galactic Science

Contribution ID: 152

Type: **not specified**

Mathew Madhavacheril (USC) "Cosmology with CMB Lensing: ACT, SO and beyond"

Thursday, 26 May 2022 14:40 (20 minutes)

Session Classification: CMB, Cross-Correlation and Galactic Science

Contribution ID: 153

Type: **not specified**

**Invited talk by Aditya Rotti (Manchester University)
on "Spectral distortion science and measurement
challenges"**

Thursday, 26 May 2022 16:20 (40 minutes)

Session Classification: CMB, Cross-Correlation and Galactic Science

Contribution ID: 155

Type: **not specified**

Jose Alberto Rubino-Martin (IAC Tenerife) "The QUIJOTE MFI wide survey: A northern sky survey in intensity and polarization at 10–20GHz"

Thursday, 26 May 2022 17:40 (20 minutes)

Session Classification: Experimental results

Contribution ID: 157

Type: **not specified**

Invited talk by François R. Bouchet (IAP Paris) on "Introduction to future experiments"

Friday, 27 May 2022 09:00 (30 minutes)

Session Classification: Future Plans

Contribution ID: **158**

Type: **not specified**

Invited talk by Masashi Hazumi (KEK Tsukuba) on "LiteBIRD"

Friday, 27 May 2022 09:30 (20 minutes)

Session Classification: Future Plans

Contribution ID: 159

Type: **not specified**

Invited talk by Jens Chluba (Manchester University) on "Ongoing and planned CMB spectrometers and what we still need to make this happen"

Friday, 27 May 2022 09:50 (20 minutes)

CMB spectral distortion measurements are going to be challenging and multiple groups are considering experimental approaches that might allow us to target these small signals in the near and distant future. In my talk I will give a brief overview of all the ongoing and planned CMB spectrometer concepts and initiatives trying in particular to highlight synergies and individual strengths. I will then address the question about what is still needed for us to take major steps forward and how we might start to get organized with this ambitious goal.

Session Classification: Future Plans

Contribution ID: **160**

Type: **not specified**

Invited talk by Julian Borrill (LBNL) on "From Stage 3 to Stage 4 - South Pole Observatory, Simons Observatory and CMB-S4"

Friday, 27 May 2022 10:10 (20 minutes)

Ground-based CMB experiments are evolving from fielding thousands of detectors on telescope(s) of a single size at a single observing site in the last decade (eg. the Atacama Cosmology Telescope, BICEP/Keck, Polarbear/Simons Array, and South Pole Telescope), through tens of thousands of detectors on telescopes of multiple sizes at a single observing site in this decade (the South Pole Observatory and Simons Observatory), culminating in hundreds of thousands of detectors on telescopes of multiple apertures at multiple observing sites in the next decade (CMB-S4). In this talk I will describe the scientific, technical, and organizational drivers and challenges in this evolution.

Session Classification: Future Plans

Contribution ID: 161

Type: **not specified**

Invited talk by Mark Devlin (UPenn) on "All the Way from Earth to Space. How Earth-based, sub-orbital, and space missions are complimenting each other with precision measurements of the millimeter sky"

Friday, 27 May 2022 10:50 (20 minutes)

Session Classification: Future Plans

Contribution ID: **164**

Type: **not specified**

Discussion EOM (Charles R. Lawrence, Francois R. Bouchet)

Friday, 27 May 2022 11:10 (1 hour)

Session Classification: Future Plans

Contribution ID: **165**

Type: **not specified**

Angela Taylor (Oxford University) "The C-Band All-Sky Survey: Northern sky-survey results"

Thursday, 26 May 2022 17:00 (20 minutes)

Session Classification: Experimental results

Contribution ID: 166

Type: **not specified**

Kirit Karkare (Chicago University) "The BICEP/Keck program: latest results and progress update on the upcoming BICEP Array receiver deployments"

Thursday, 26 May 2022 17:20 (20 minutes)

Session Classification: Experimental results

Contribution ID: **167**

Type: **not specified**

Elle Shaw (UIUC) "Limits on Cosmological B-mode Polarization in the CMB from Spider"

Thursday, 26 May 2022 18:00 (20 minutes)

Session Classification: Experimental results

Contribution ID: **168**

Type: **not specified**

Benjamin Beringue (Cardiff University) "Component separation for the Simons Observatory Large Aperture Telescope"

Wednesday, 25 May 2022 11:00 (20 minutes)

Session Classification: Foregrounds

Contribution ID: **169**

Type: **not specified**

Ludovic Montier and Jan Tauber: objectives of the workshop

Monday, 23 May 2022 10:20 (5 minutes)

Session Classification: Science Challenges

Contribution ID: 170

Type: **not specified**

Paolo Natoli: logistic information

Monday, 23 May 2022 10:25 (5 minutes)

Session Classification: Science Challenges

Contribution ID: 171

Type: **not specified**

Reno Mandolesi and Jean-Loup Puget: setting the context

Monday, 23 May 2022 10:30 (15 minutes)

Session Classification: Science Challenges

Contribution ID: 172

Type: **not specified**

Brandon Hensley (Princeton University) "Beyond Foregrounds: Galactic Science in the 2020s"

Wednesday, 25 May 2022 12:00 (20 minutes)

Session Classification: Foregrounds