Captions here, please.

Cosmic Frontier: Science Highlights

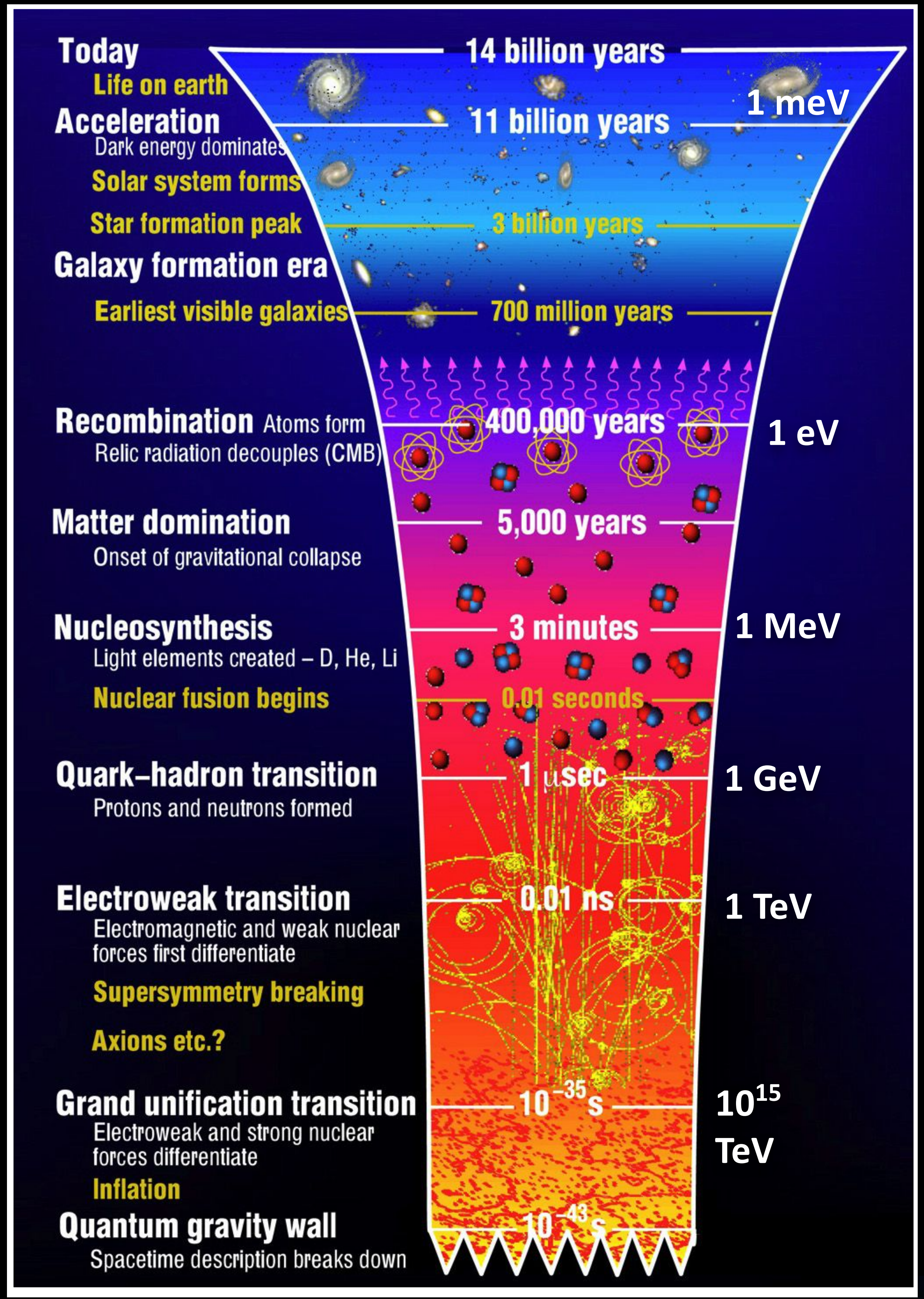
Tim M.P. Tait

University of California, Irvine

Snowmass 2021
July 25, 2022

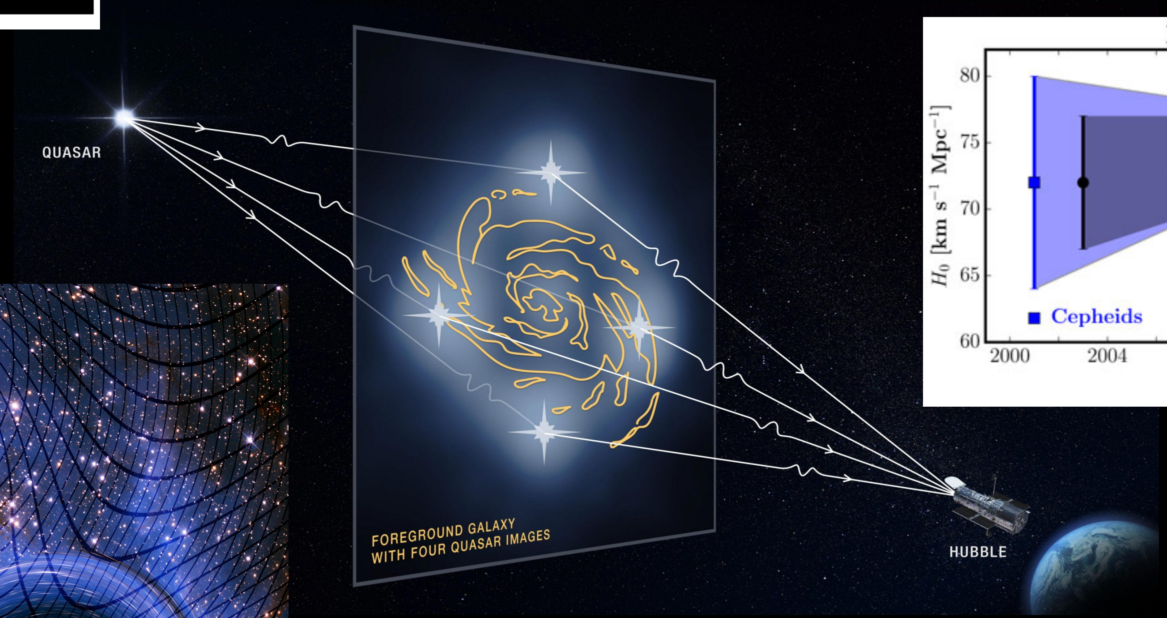
Captions here, please

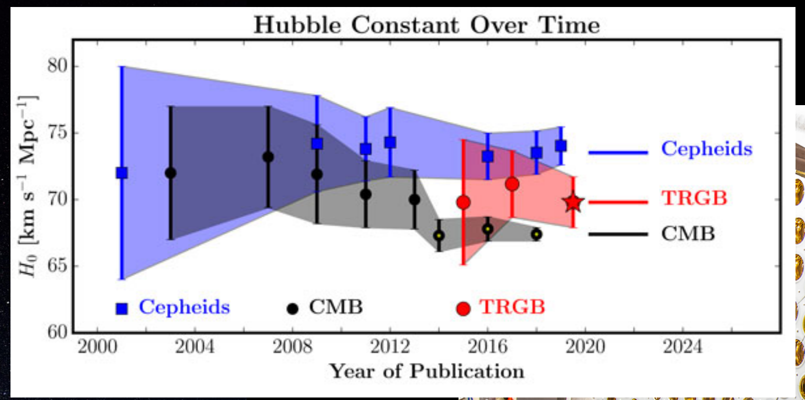
Science Highlights

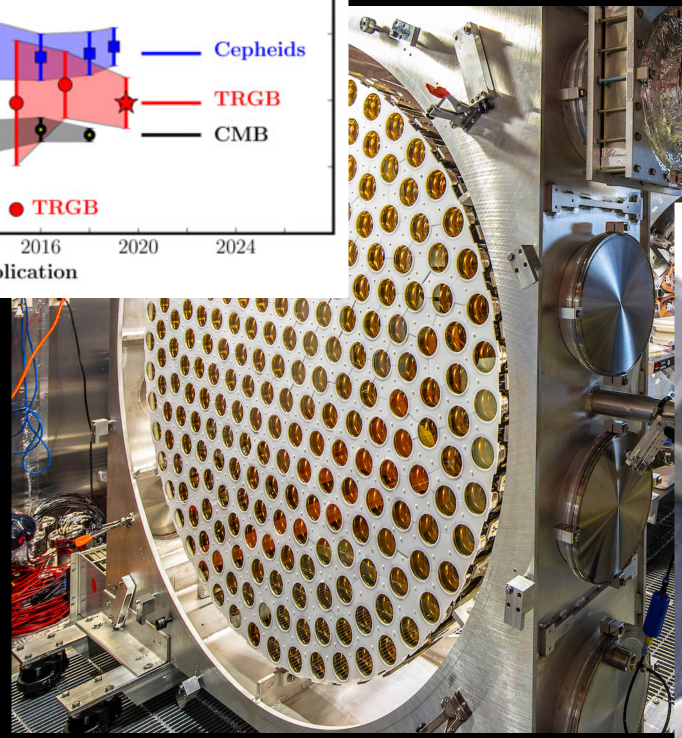


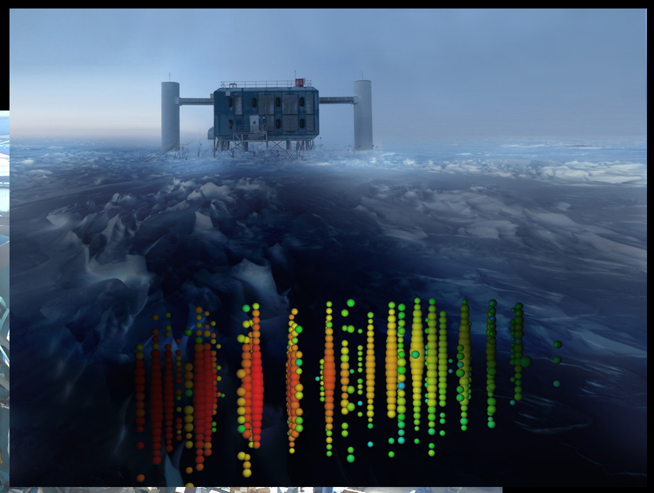
Captions here, please

The Cosmic Frontier seeks to understand the fundamental physics that governs the behavior of the Universe and its constituents.



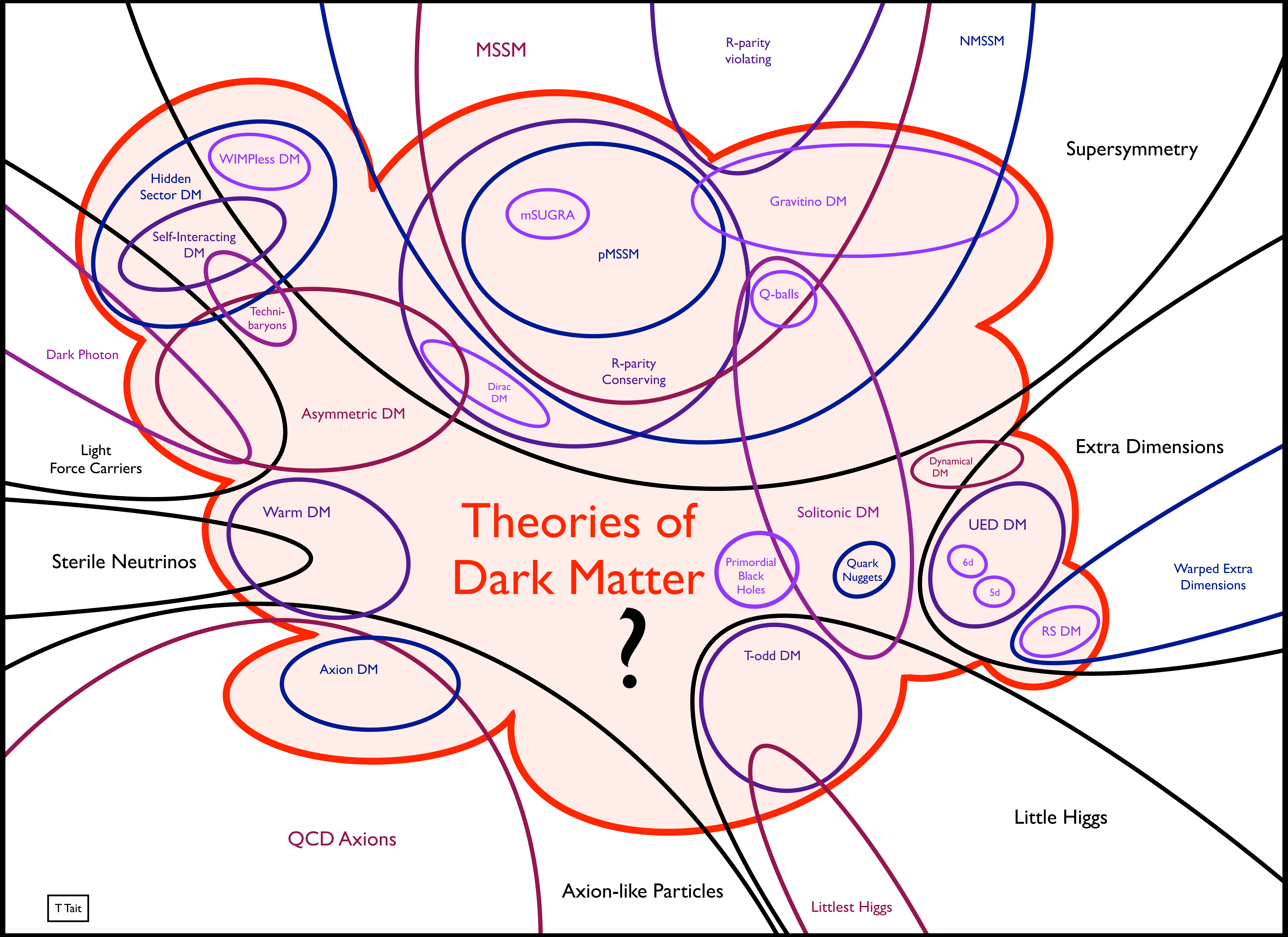




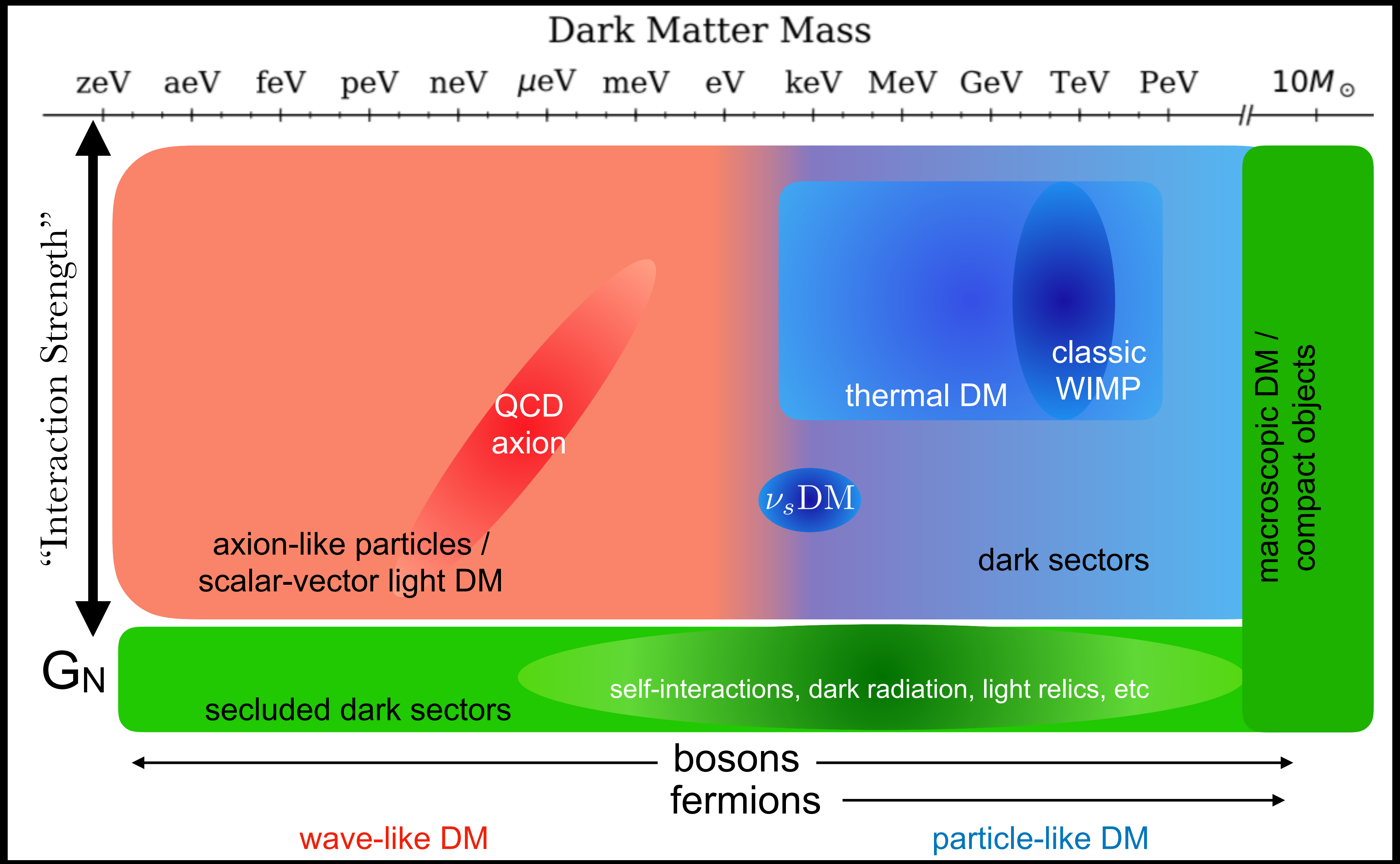


Dark Matter

Captions here, please



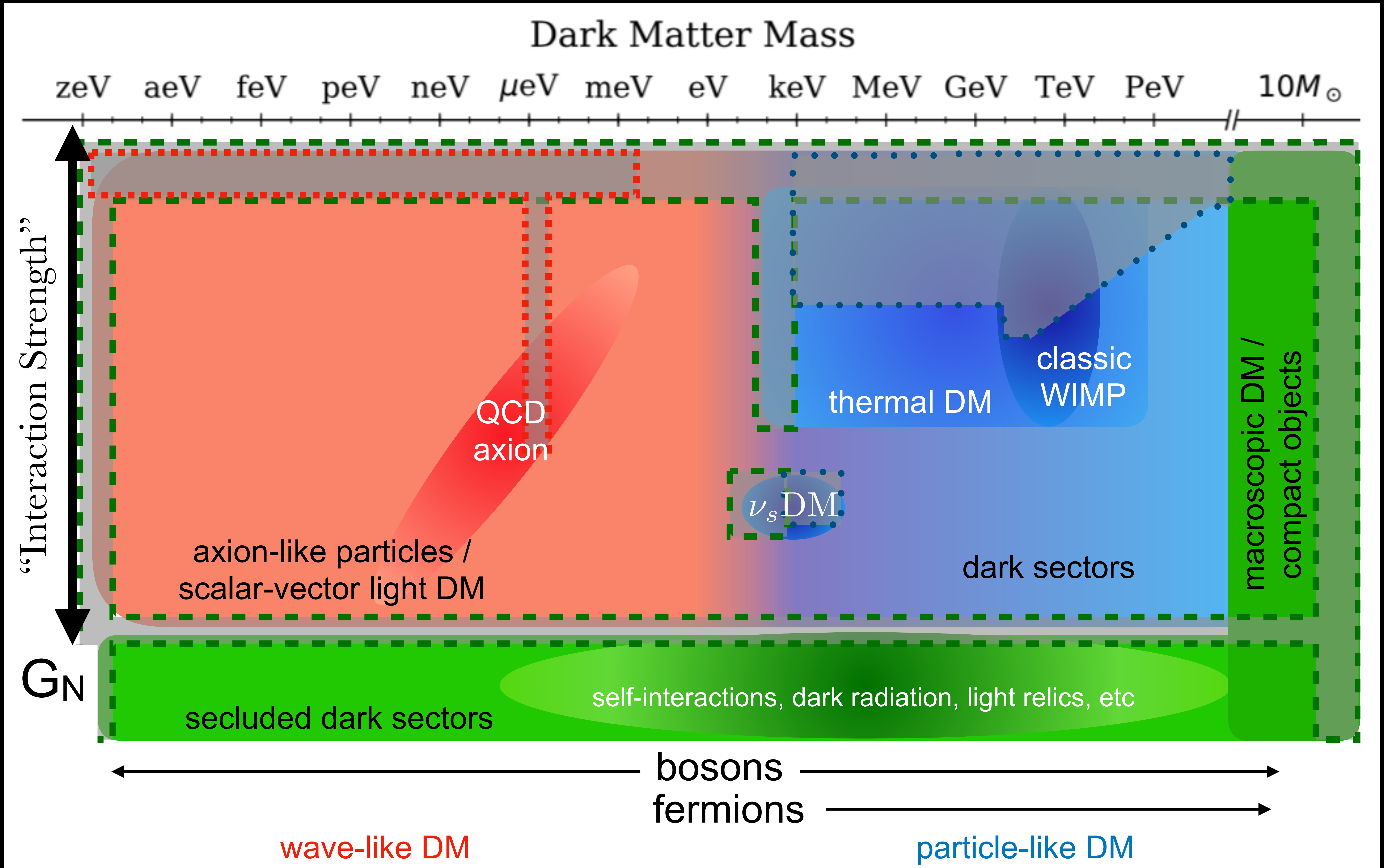
The space of dark matter models encompasses a dizzying array of possibilities, representing many orders of mass and couplings.



Aaron Chou, Thursday

Dark Matter

Captions here, please



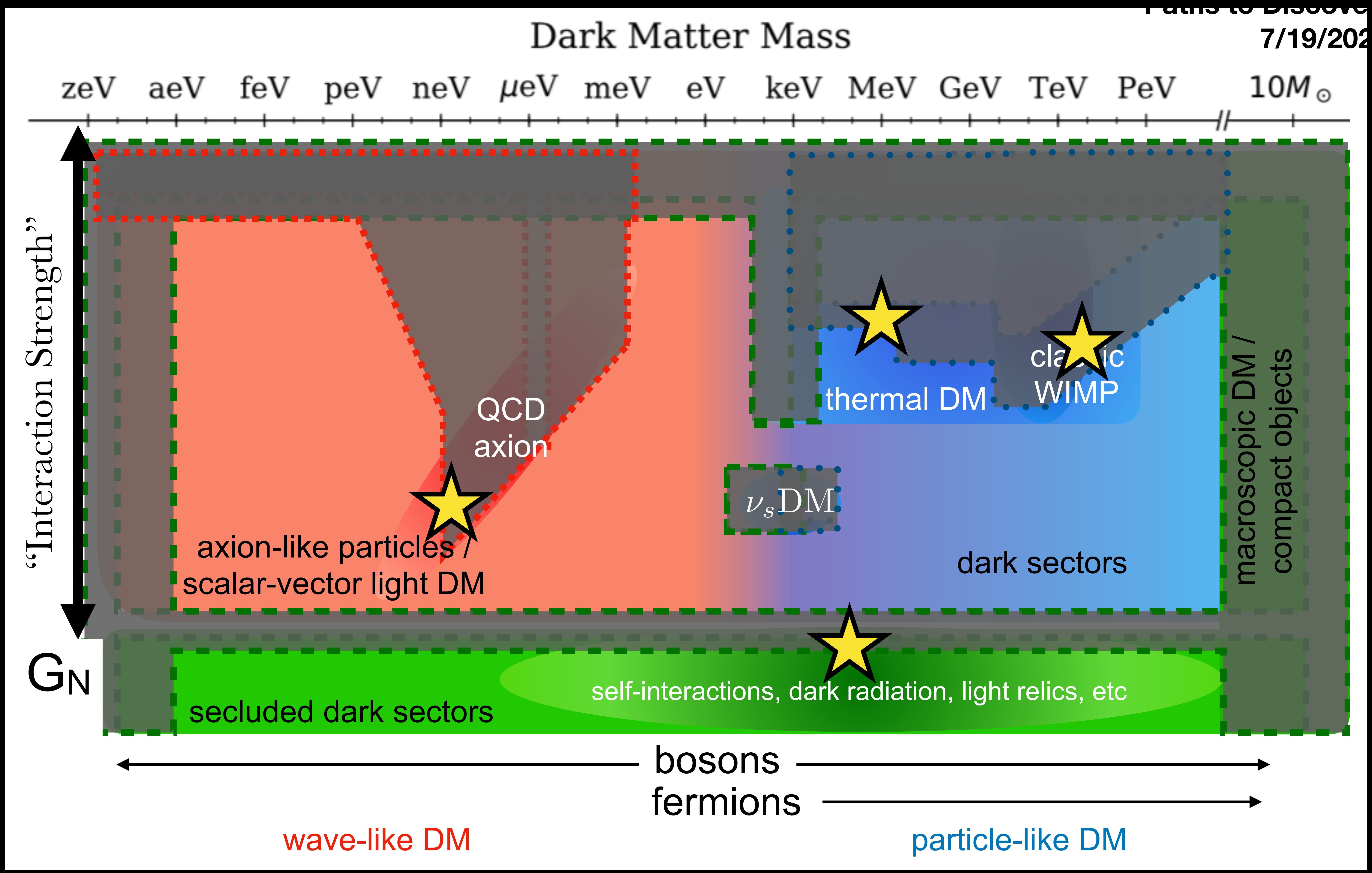
But we have a plan!

'Delve Deep, Search Wide' employs a range of direct searches for WIMPs interacting with targets on Earth, indirect searches for annihilation products, and cosmic probes based on structure, to scrutinize priority targets such as WIMPs and QCD axions, while broadly scanning parameter space, leaving no stone unturned.

Aaron Chou, Thursday

Dark Matter

Captions here, please



The next 10 years, including future Generation 3 direct searches for WIMPs and axions, combined with future indirect observatories, a program of smaller scale searches, and key inputs from cosmic probes, results in broad coverage.

...or transformational discoveries!

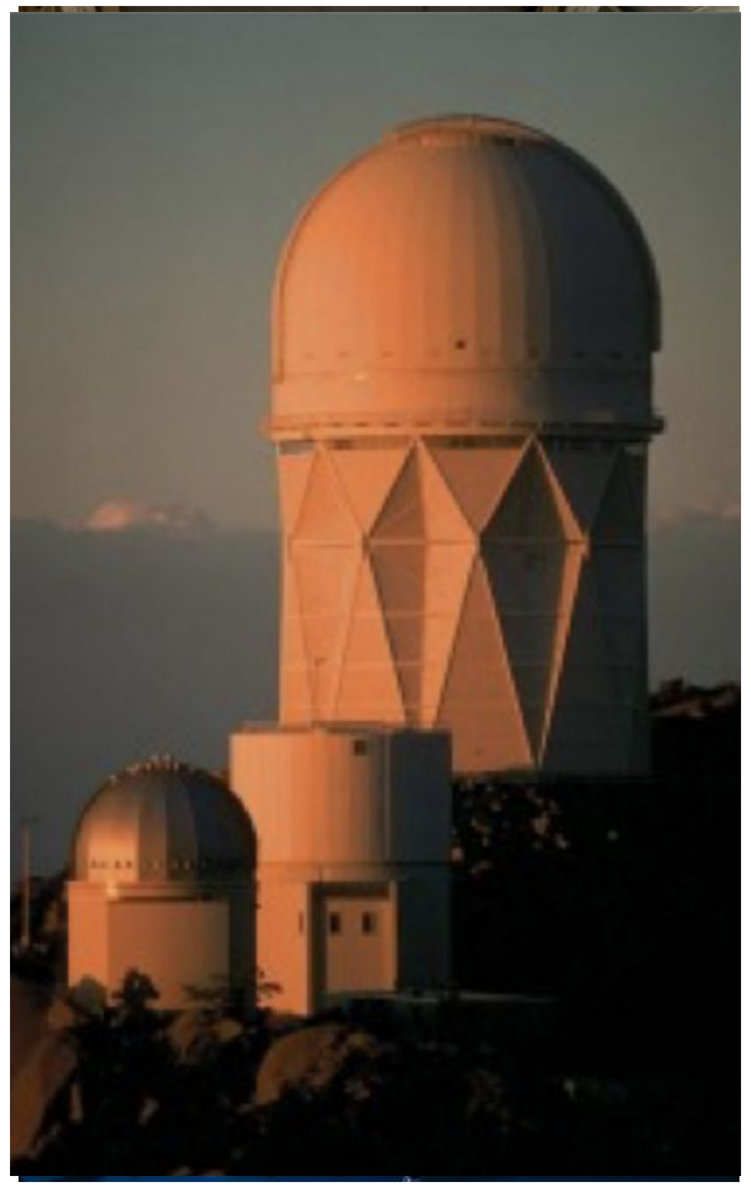
Aaron Chou, Thursday
Tracy Slatyer, Risa Wechsler, Tuesday

Cosmological Probes

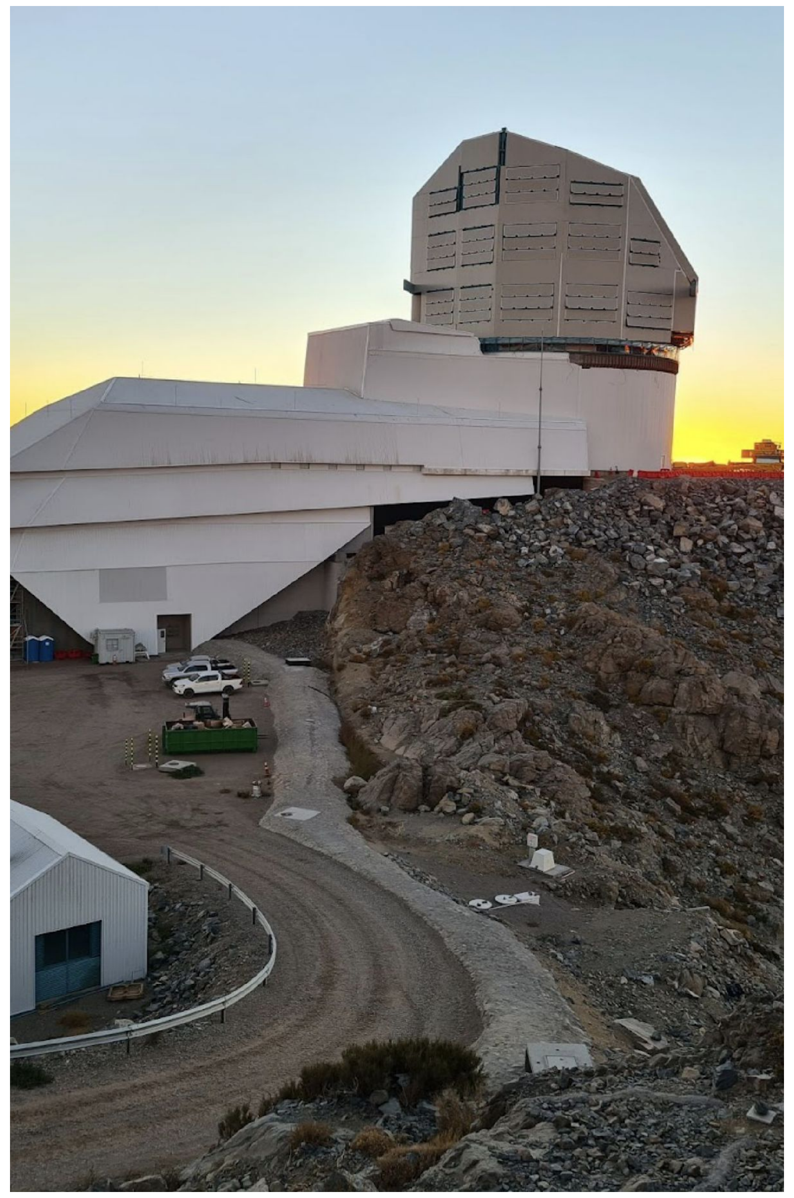
Captions here, please

Thanks to investments recommended by the previous P5, the next decade will be a golden age for cosmological data, able to inform the deepest mysteries of fundamental physics.

Cosmic expansion history
Cosmic Microwave Background
Growth of Structure
Gravitational Waves



DESI



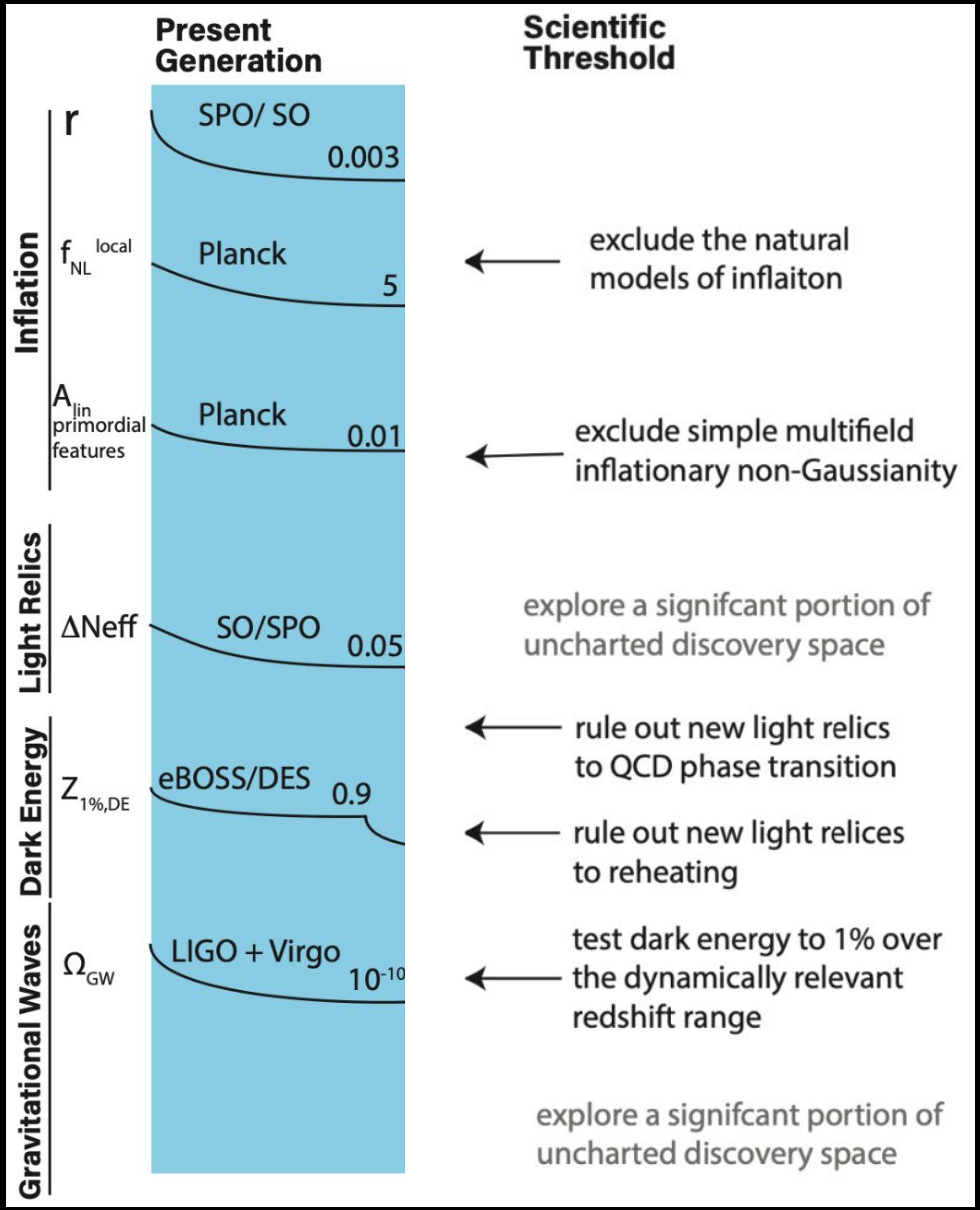
LSST

CMB-S4

GWO

Cosmological Probes

Captions here, please

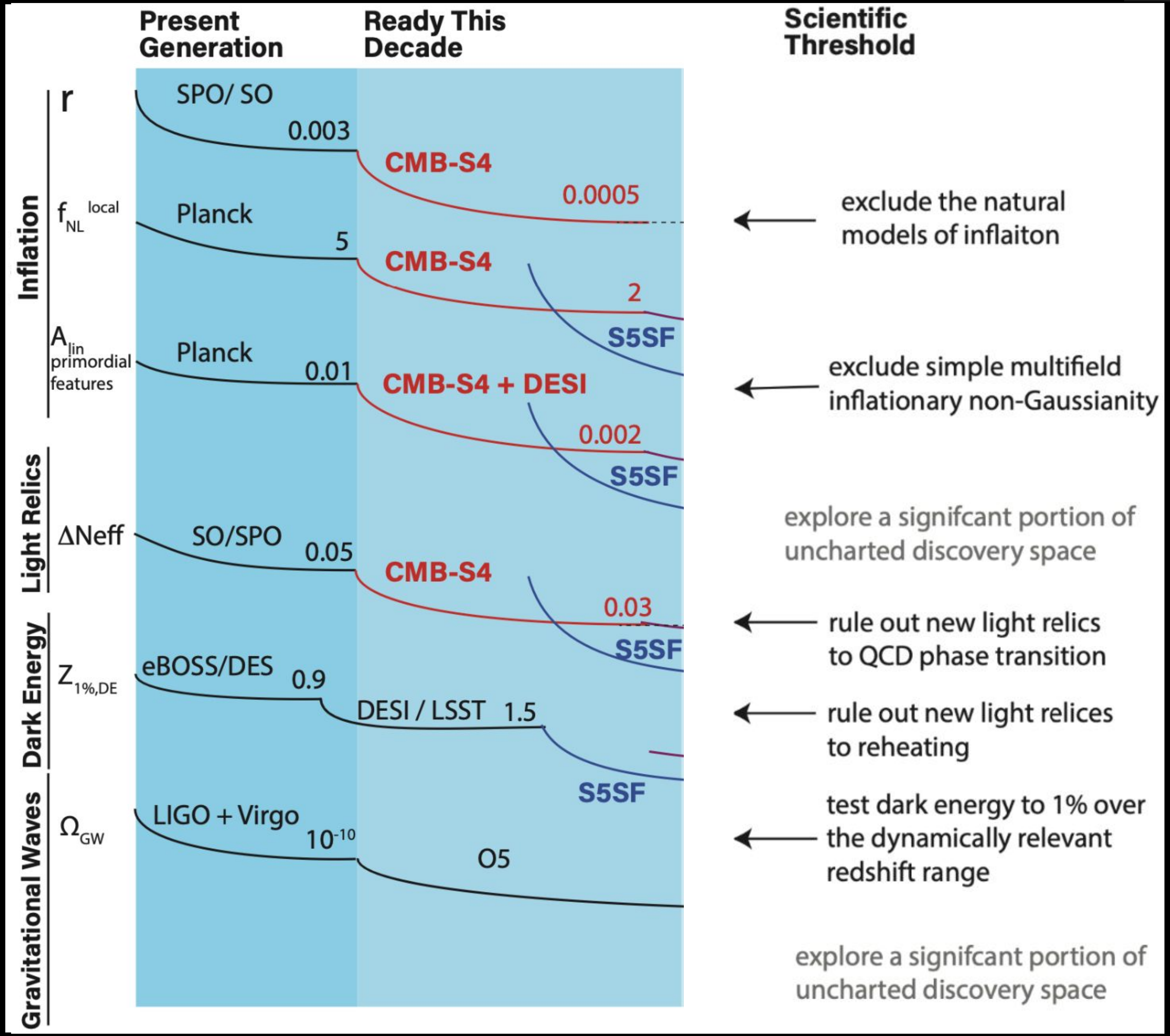


Current observations have revealed key properties of the Universe and its fundamental constituents. But there is still much left to learn.

Marcelle Soares-Santos
Thursday

Cosmological Probes

Captions here, please

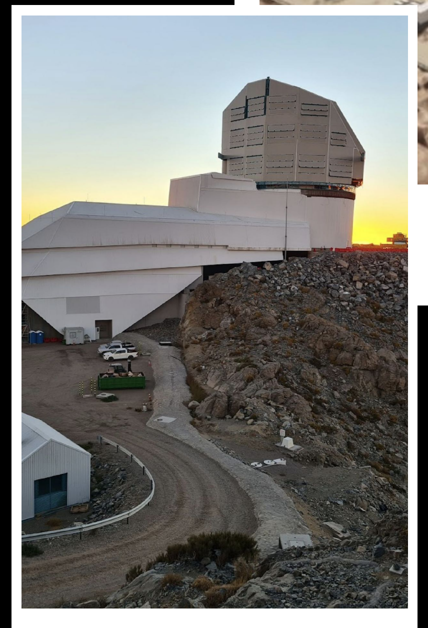


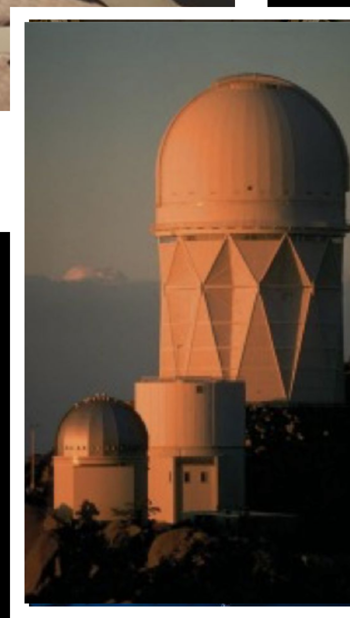
‘Search Wide, Aim High’

The near term future will be collecting the data from DESI, completing and executing Rubin/LSST, and constructing CMB-S4, currently on track with CD0.

This program will make unparalleled progress toward understanding the dynamics of cosmic inflation and search for new physics.


CMB-S4

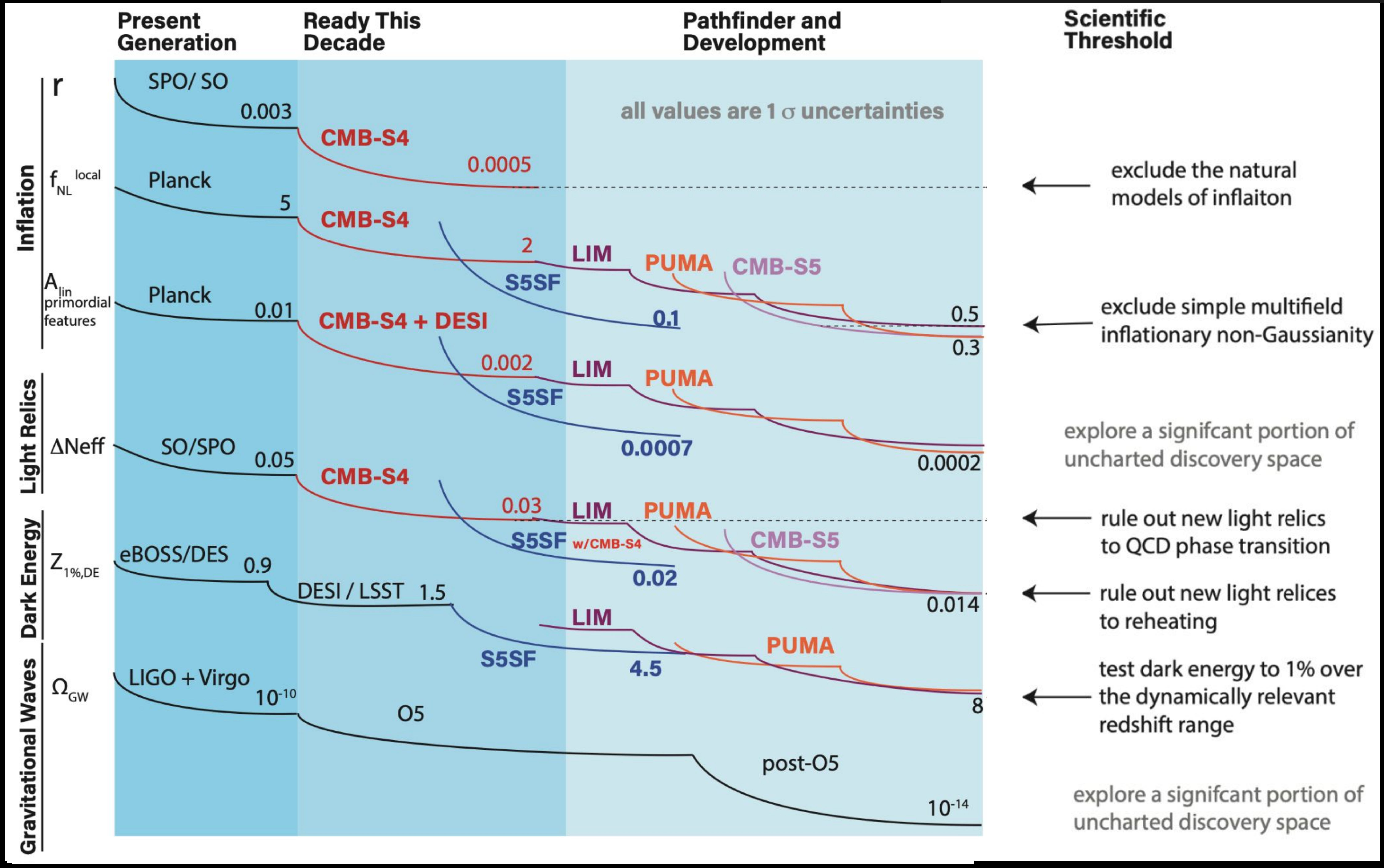

LSST


DESI

Marcelle Soares-Santos
Thursday

Cosmological Probes

Captions here, please



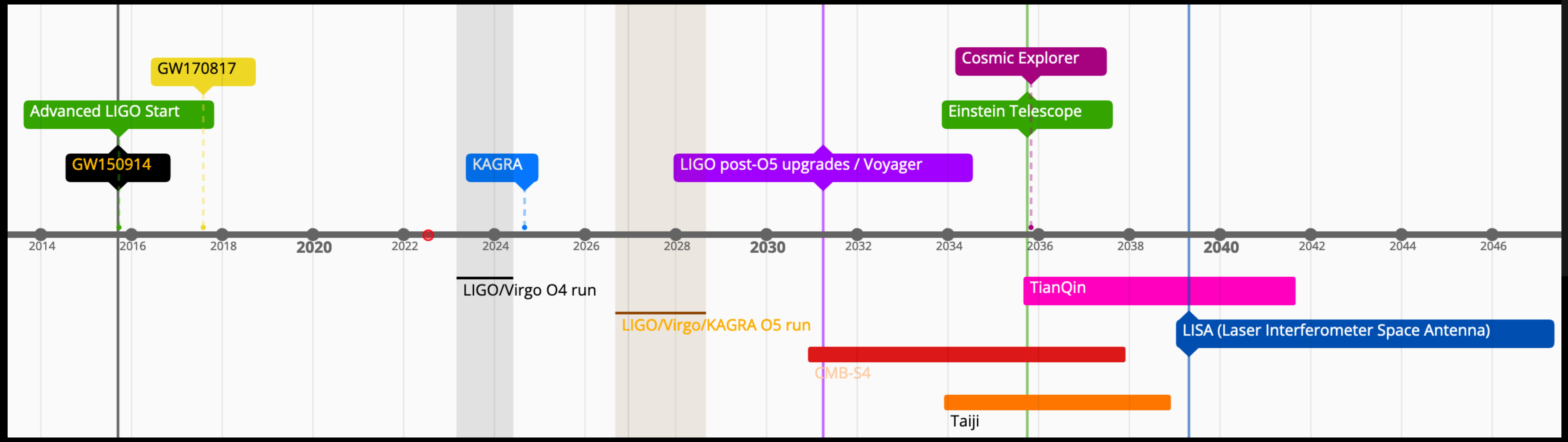
Longer term priorities are the roadmap to a future **Stage V Spectroscopic Facility,** and small projects and pathfinders toward new opportunities such as gravitational waves, 21cm, and Line-Intensity Mapping.

Marcelle Soares-Santos
Thursday

Captions here, please

Timelines

CF7 Report



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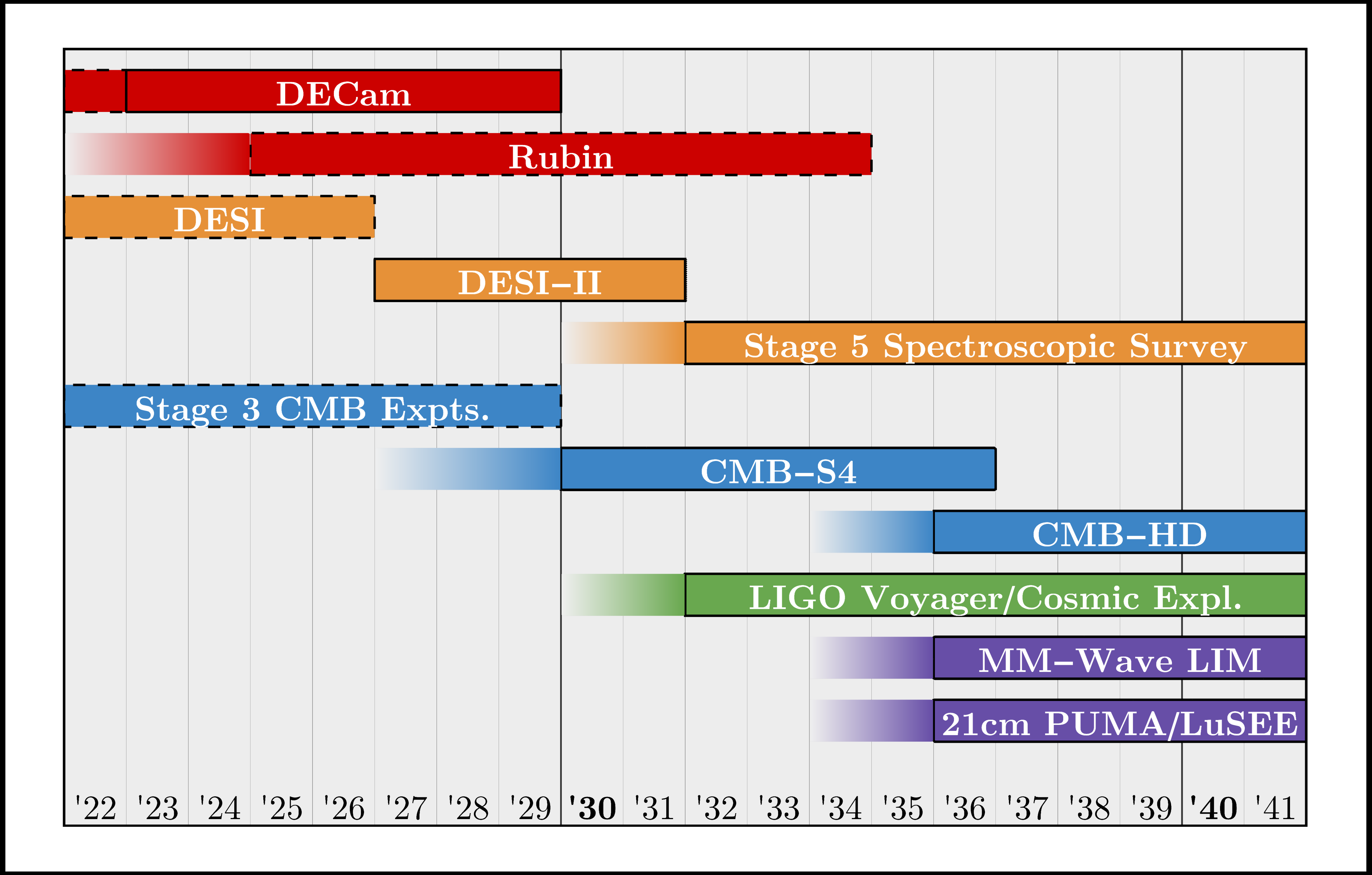
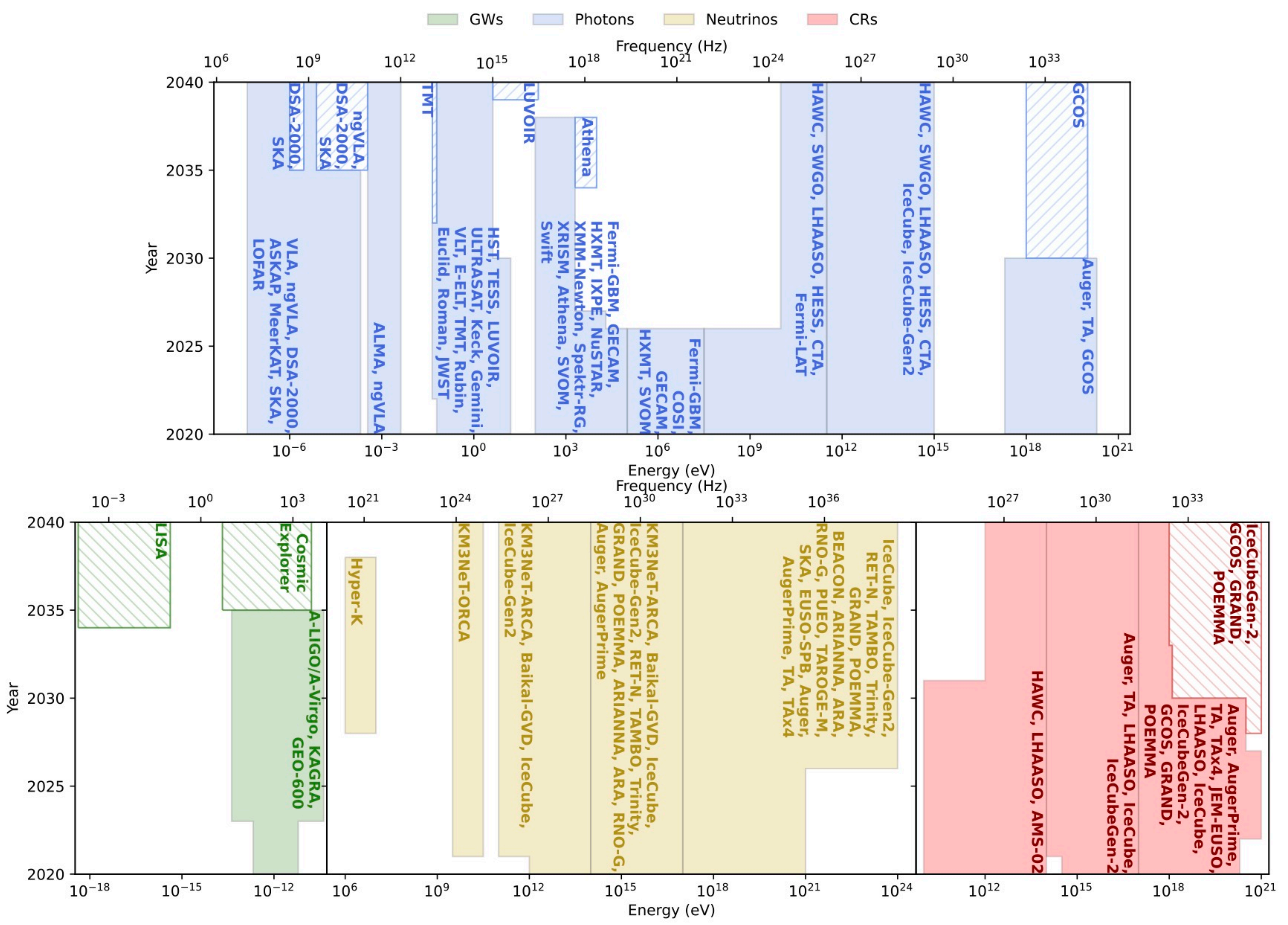
CF7 Report





CF6 Report

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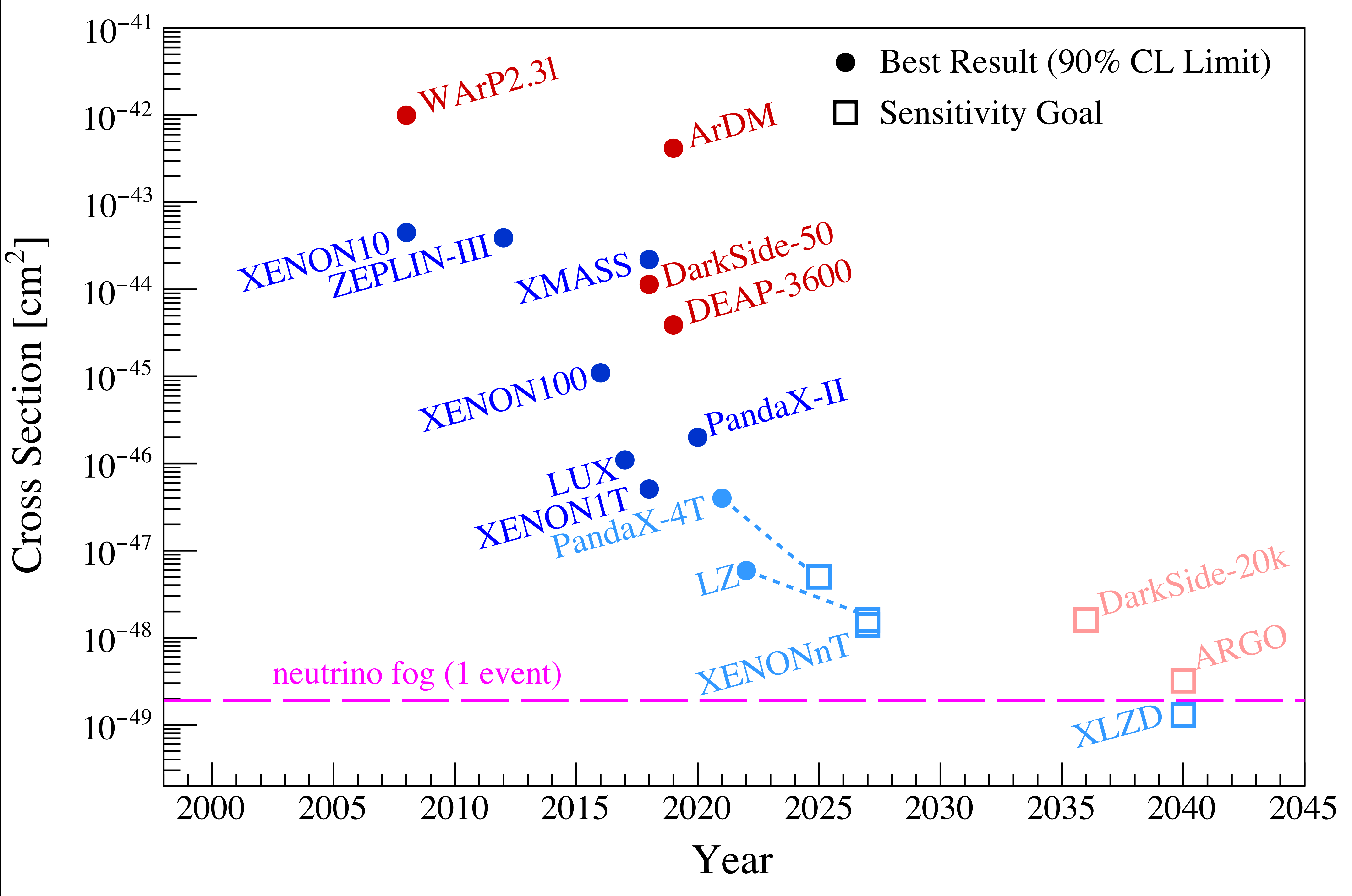
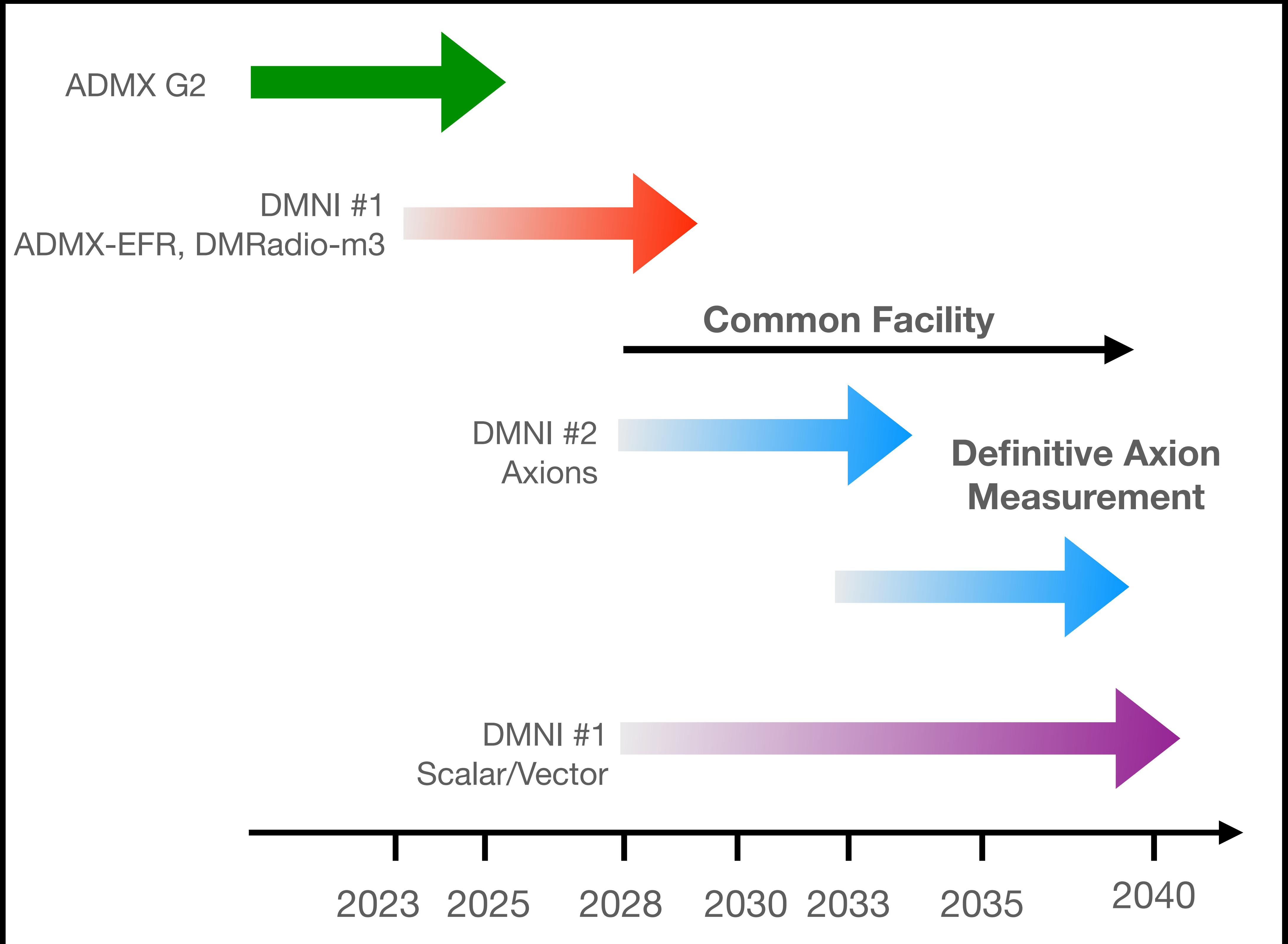
CF1 Report





CF2 Report

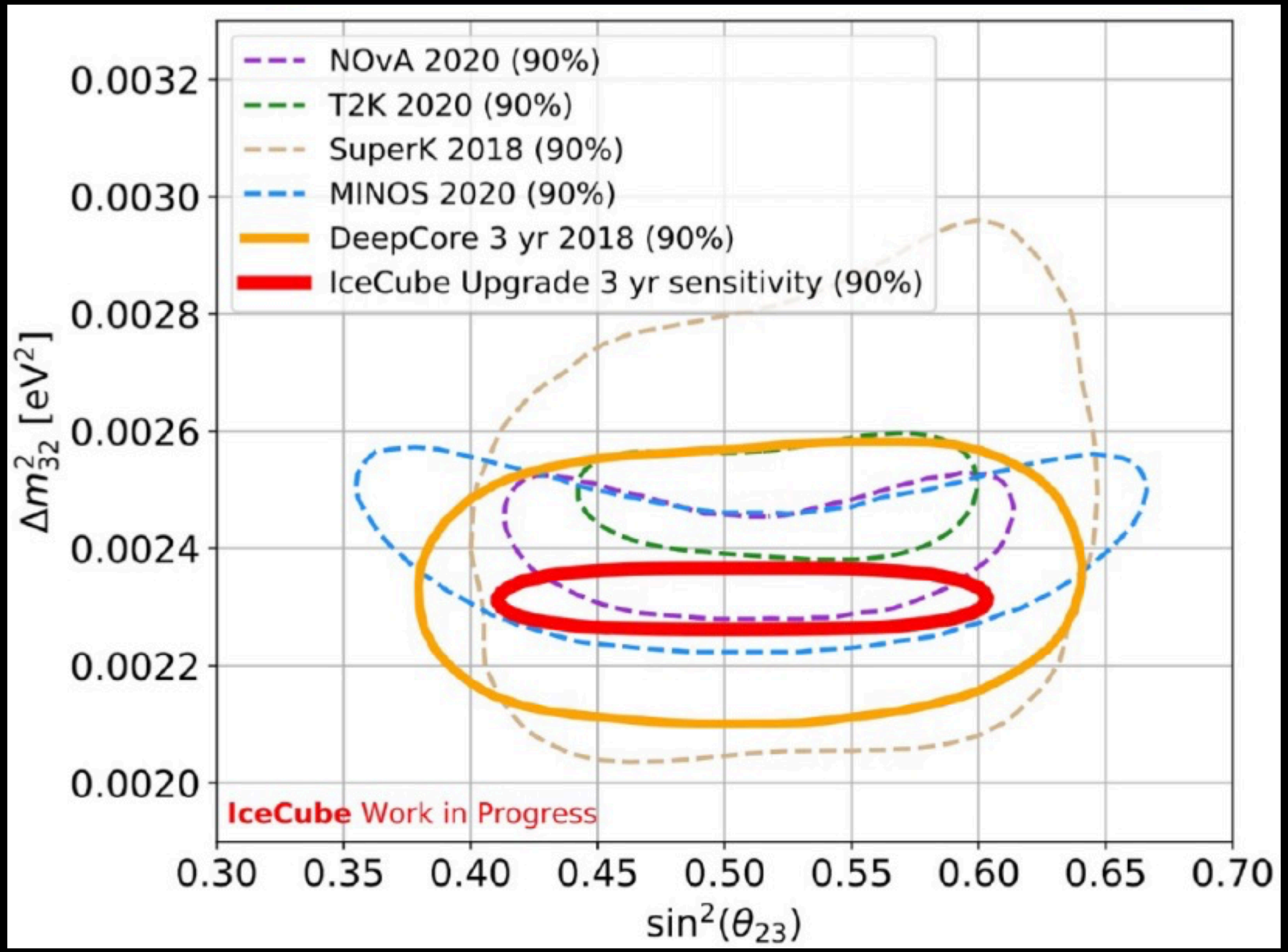
Captions here, please

Science Drivers

Pursue the physics associated with neutrino mass.

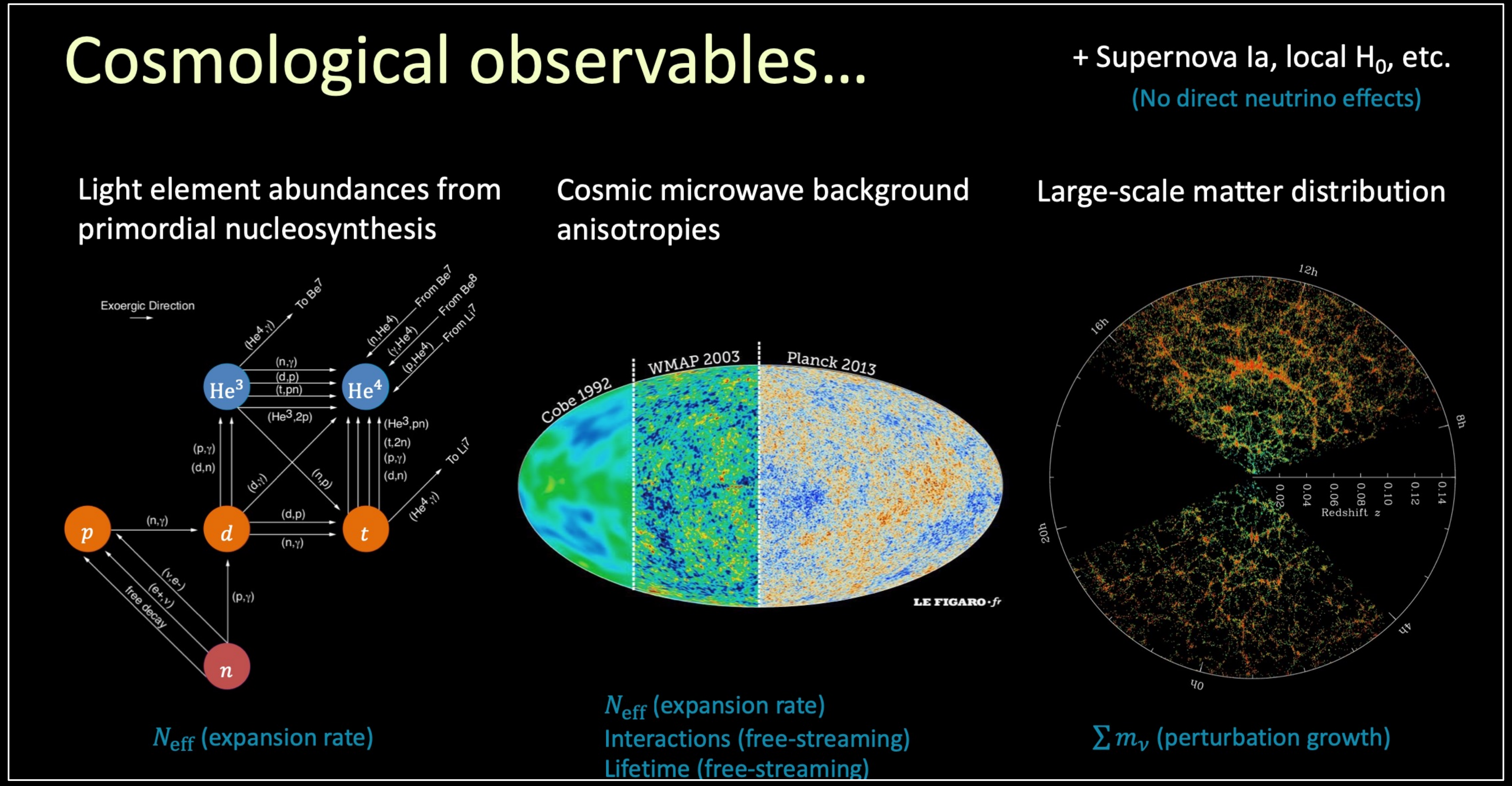
Captions here, please

(You thought I was going to start with dark matter, didn't you…?)



Indirect information about CNB from cosmology

Yvonne Wong, Snowmass Neutrino colloquium



Kate Scholberg, Friday

Planck TTTEEE+lowE +lensing+BAO; 7-parameters

$N_{\rm eff} = 2.99 \pm 0.34$ (95% CL)

Aghanim et al. [Planck] 2021

Remarkably consistent with Standard Model prediction $N_{\rm eff} \approx 3$

Planck TTTEEE+lowE+lensing+BAO; 7-parameters

$\sum m_\nu < 0.12$ eV (95% CL)

Aghanim et al. [Planck] 2021

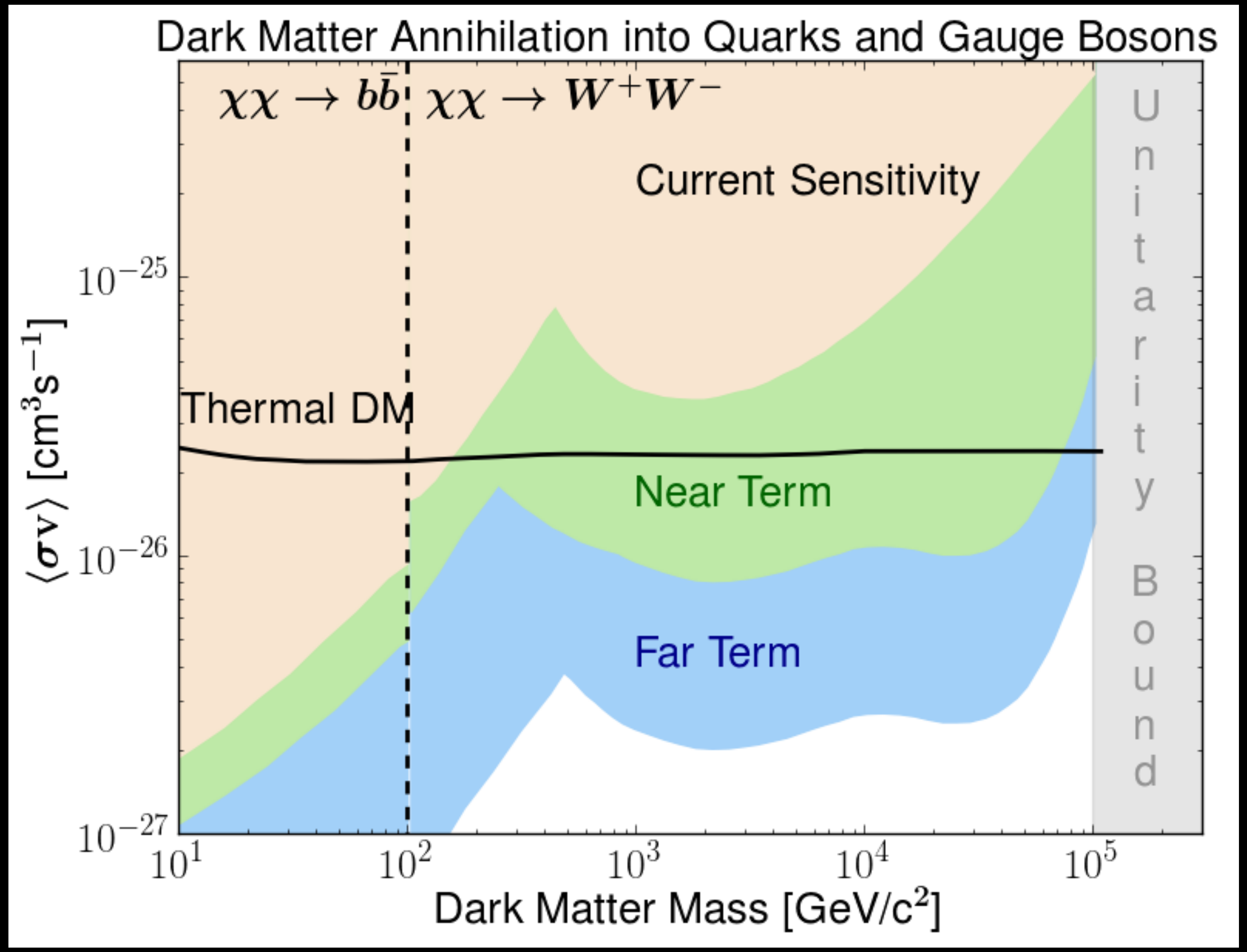
At face value a factor of 30 tighter than current lab bound from KATRIN, $\sum m$ <2.4 eV (90% C.L.)

Aker et al. [KATRIN] 2022

Cosmic Frontier observations offer unique and important perspectives on the parameters describing neutrino masses which can inform terrestrial searches.

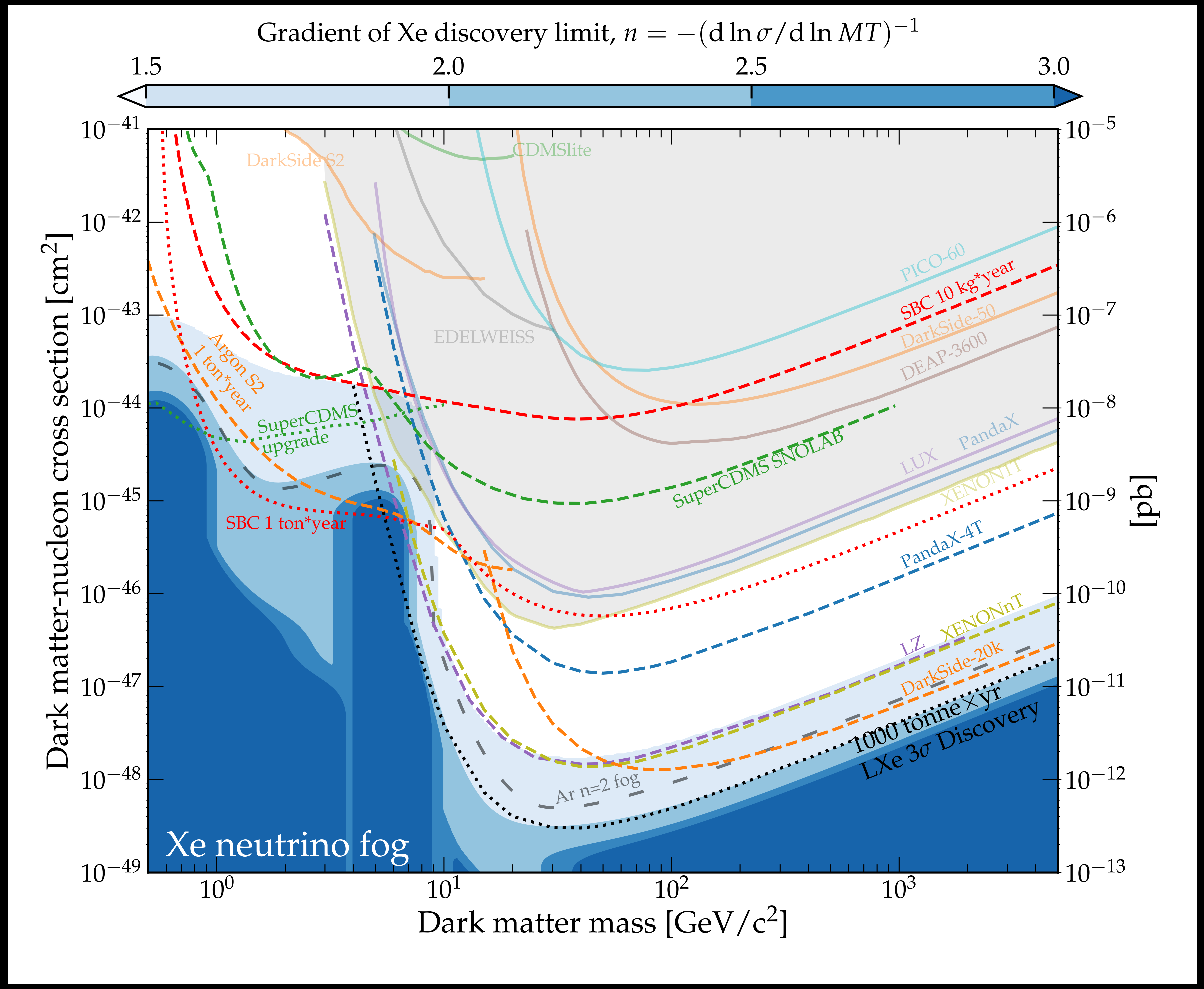
Identify the new physics of dark matter.

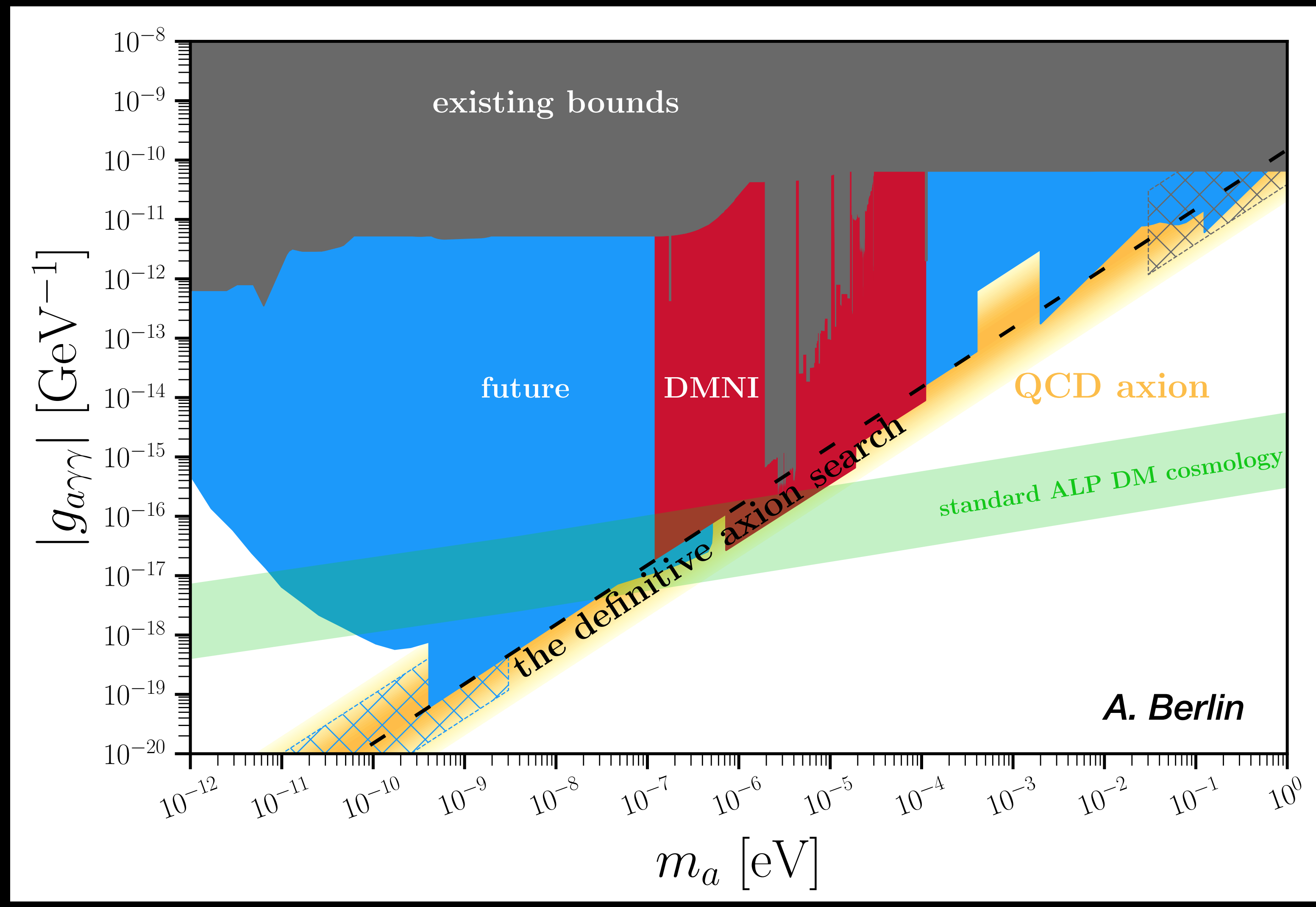
Captions here, please

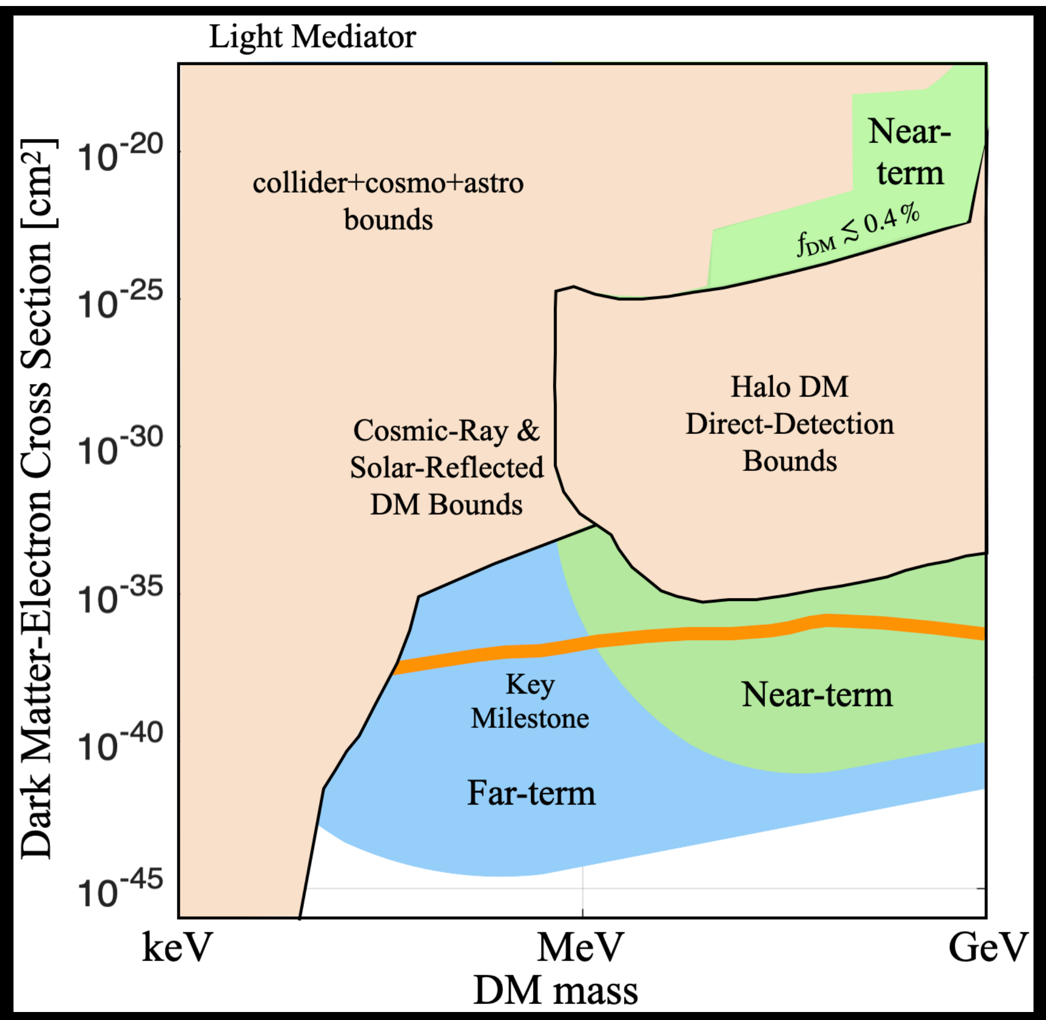


Delve deep, search wide!

The Cosmic Frontier is *required* to verify that any candidate new physics we discover is *actually* making up the dark matter we see.





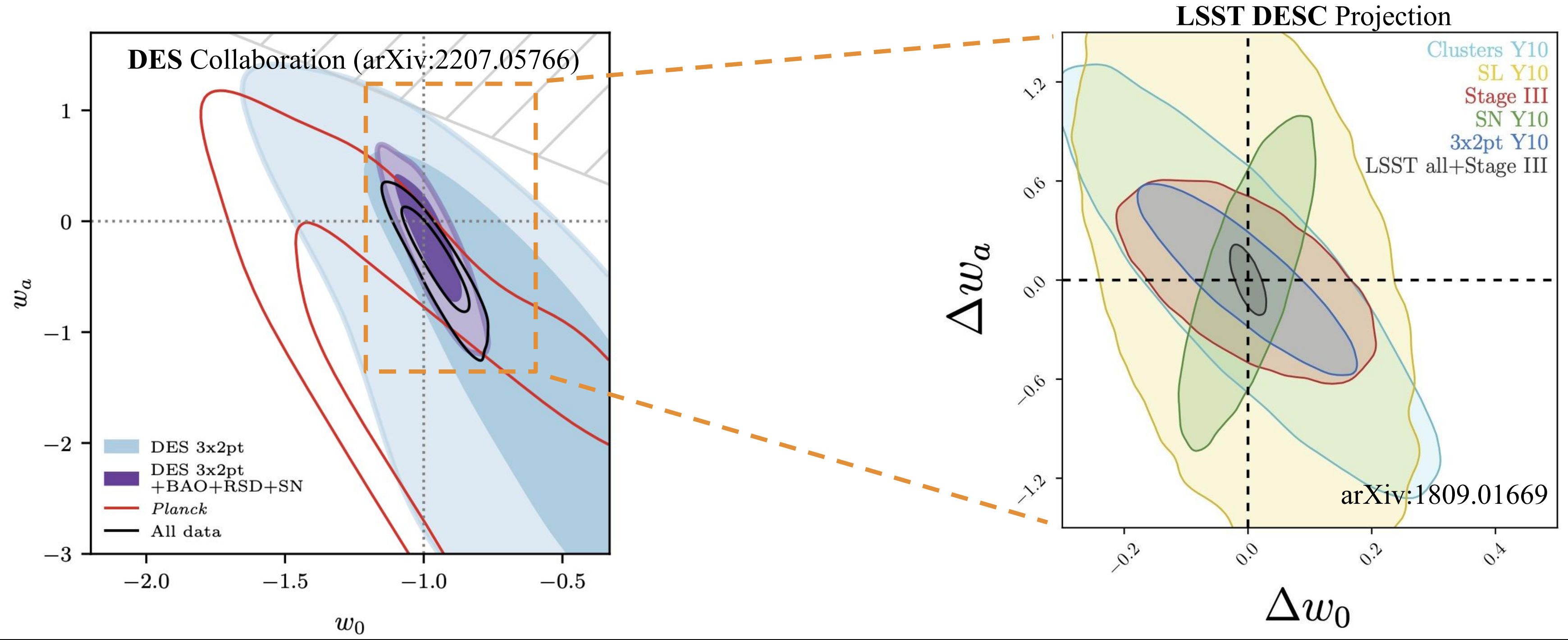


Understand cosmic acceleration: dark energy and inflation.

Captions here, please

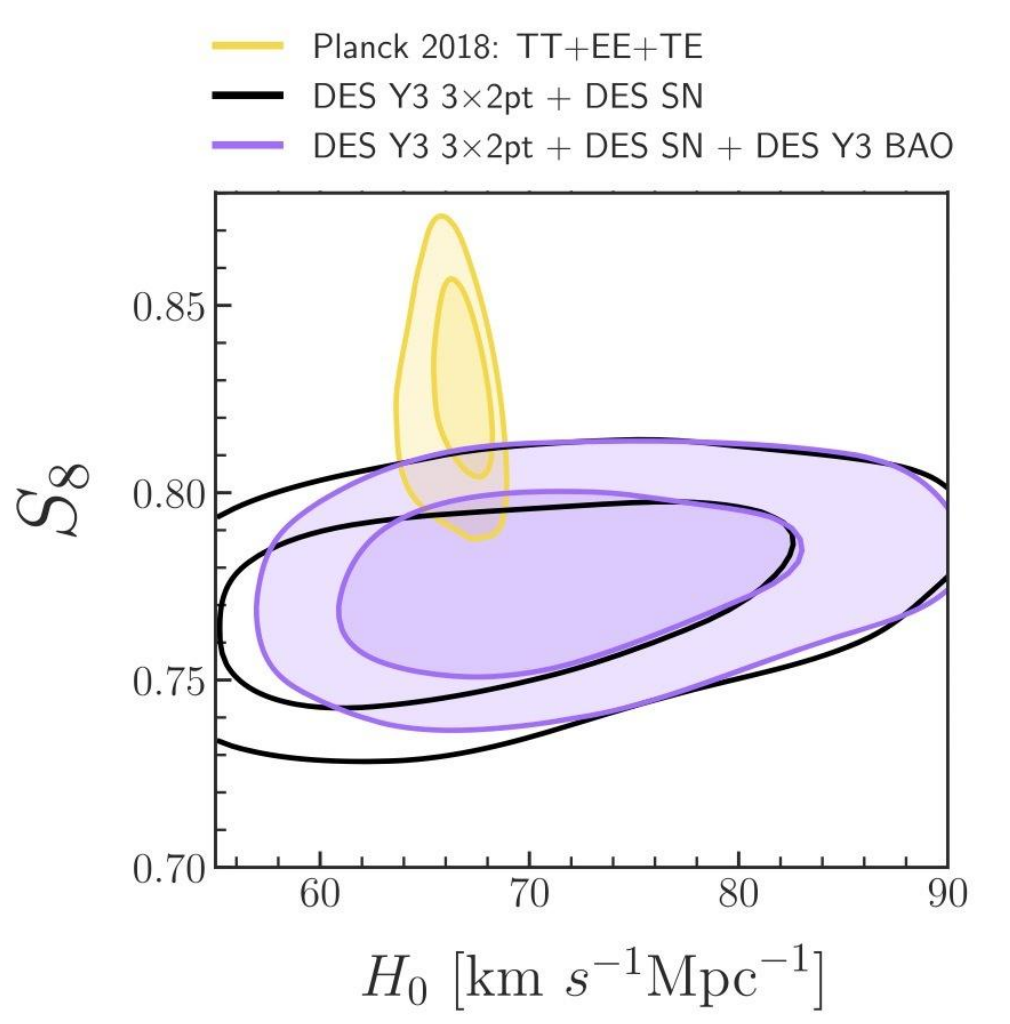
Precision cosmology

The discovery of **dark energy** led to a **precision measurement program** to understand its physics.

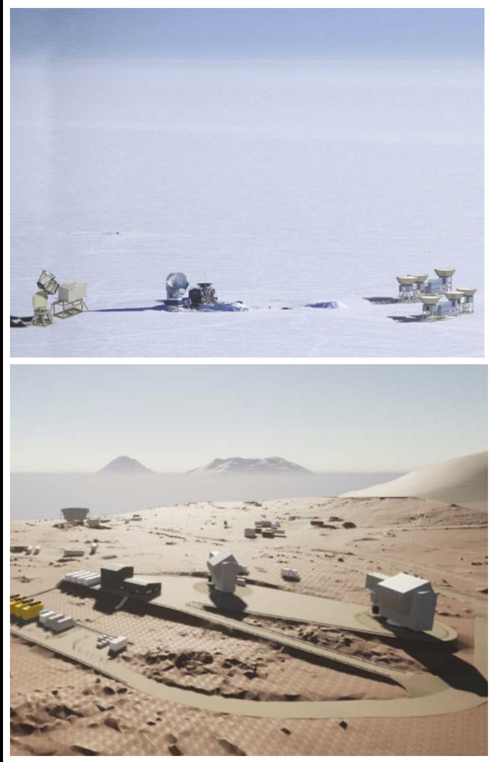


Search wide, aim high!

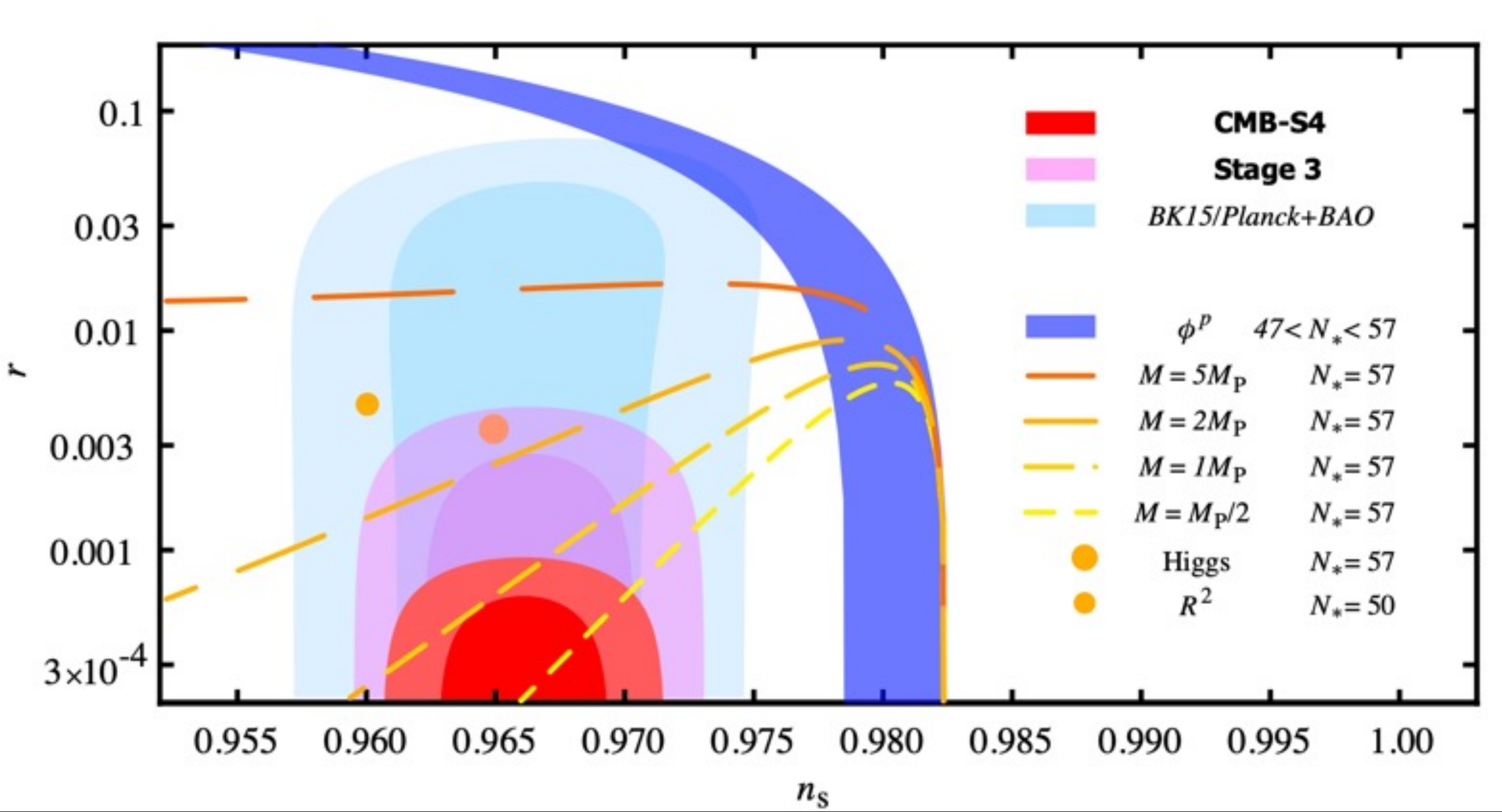
DES Collaboration, **PRD** 105, 043512 (2022)



Marcelle Soares-Santos, Thursday



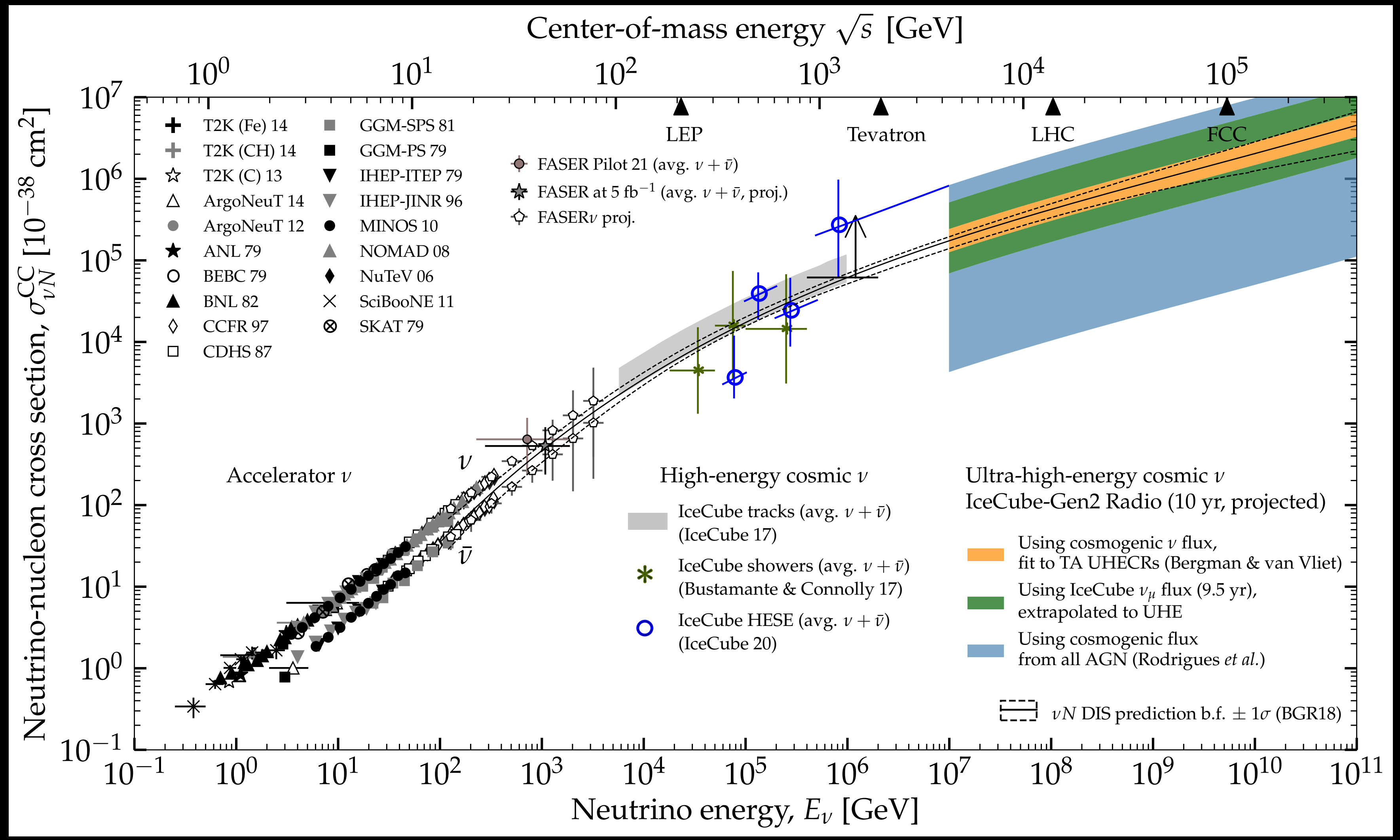
CMB-S4

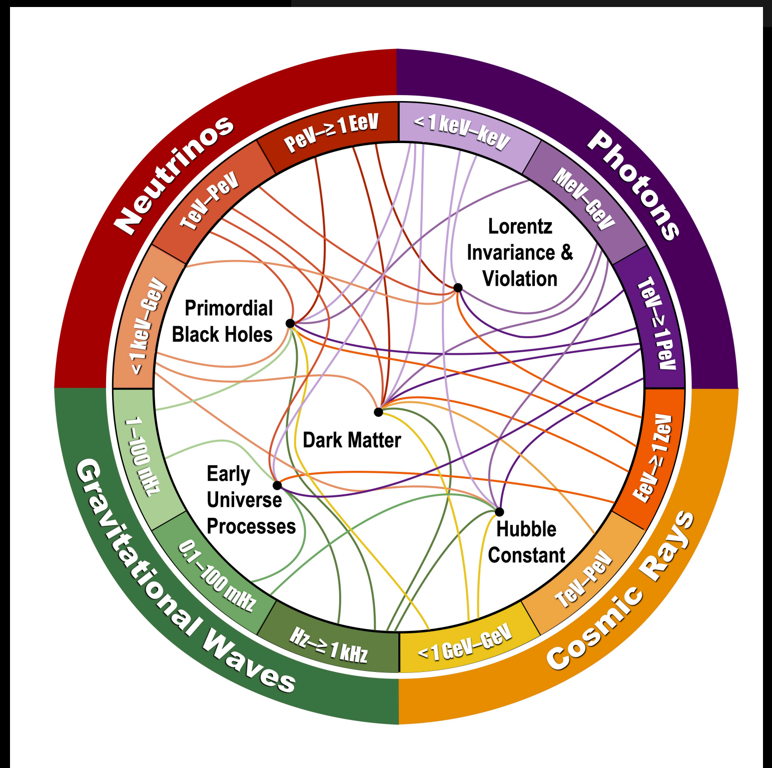


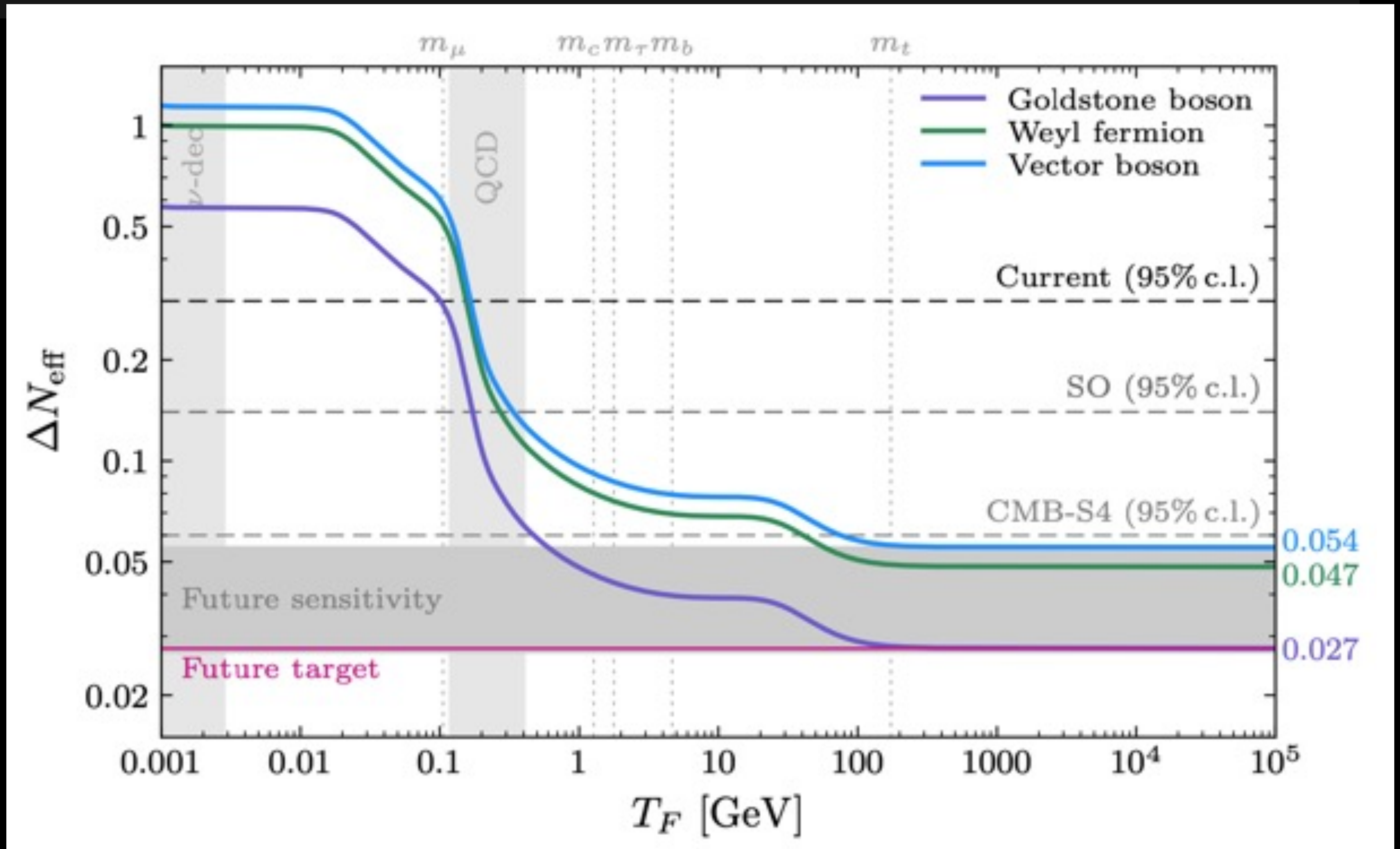
The Cosmic Frontier offers *unique* handles on the physics of inflation and to search for ultra-weakly interacting particles.

Explore the unknown: new particles, interactions, and physical principles.

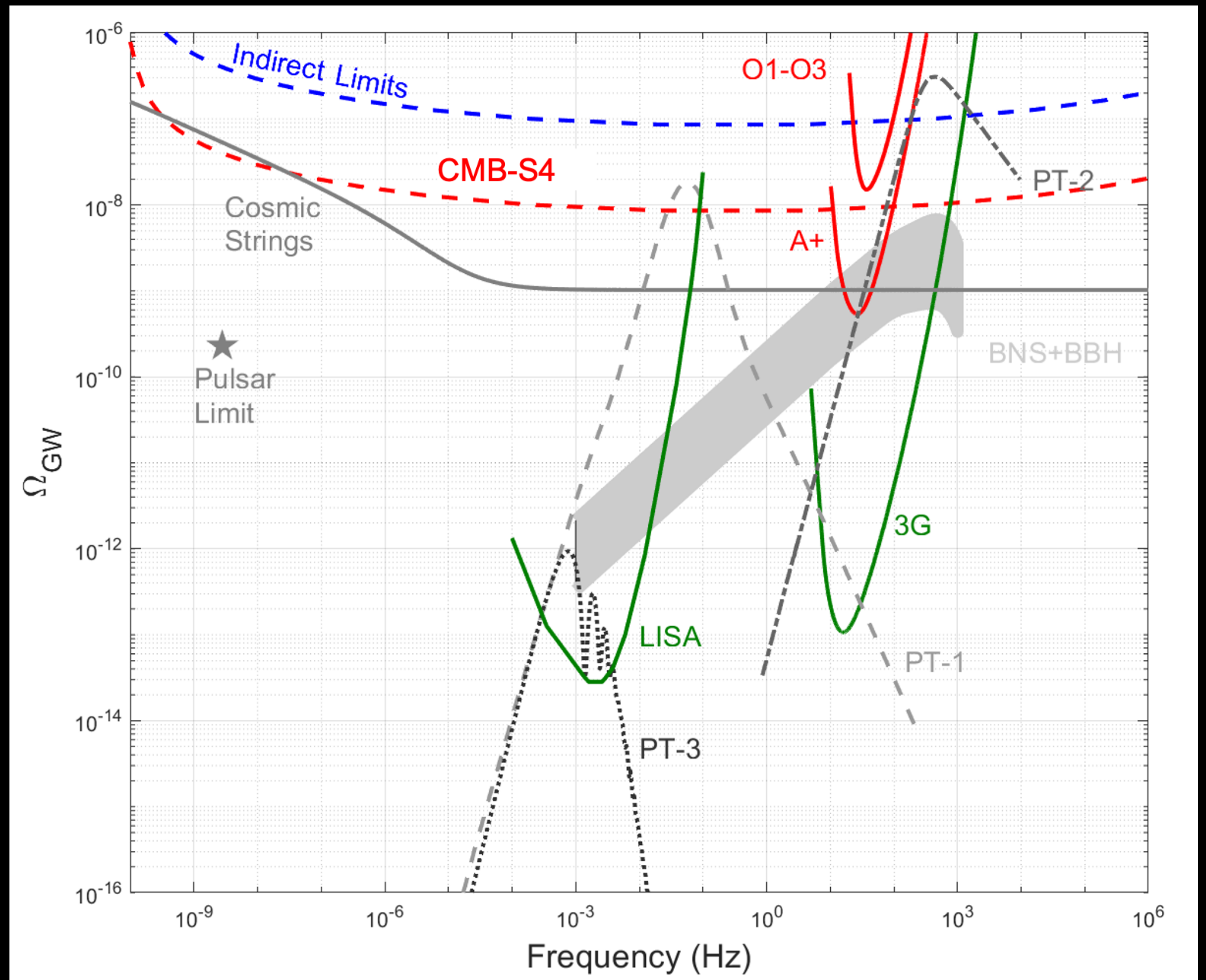
Captions here, please

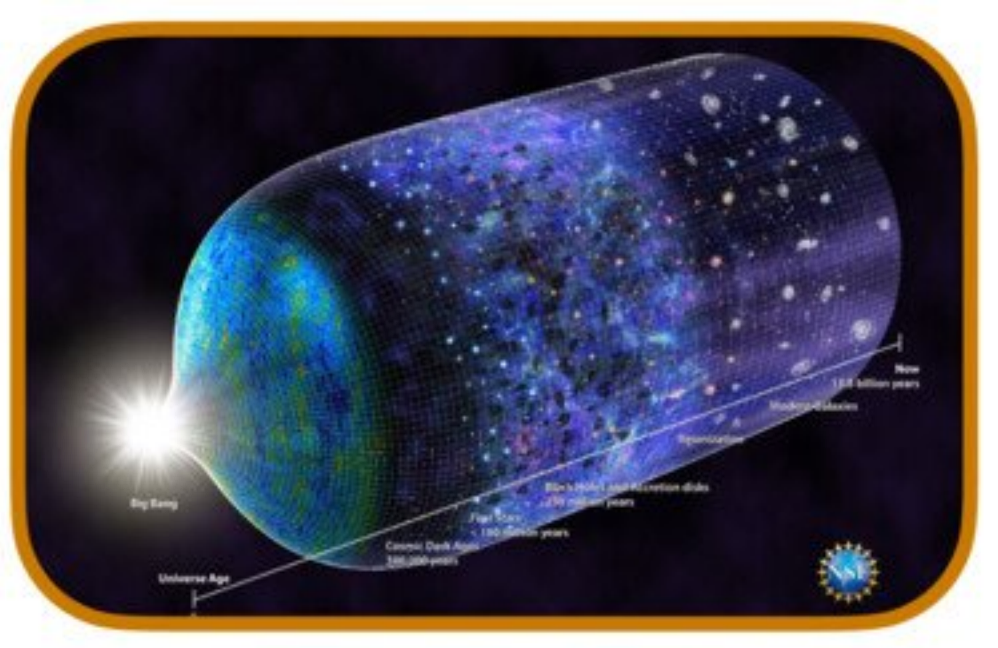


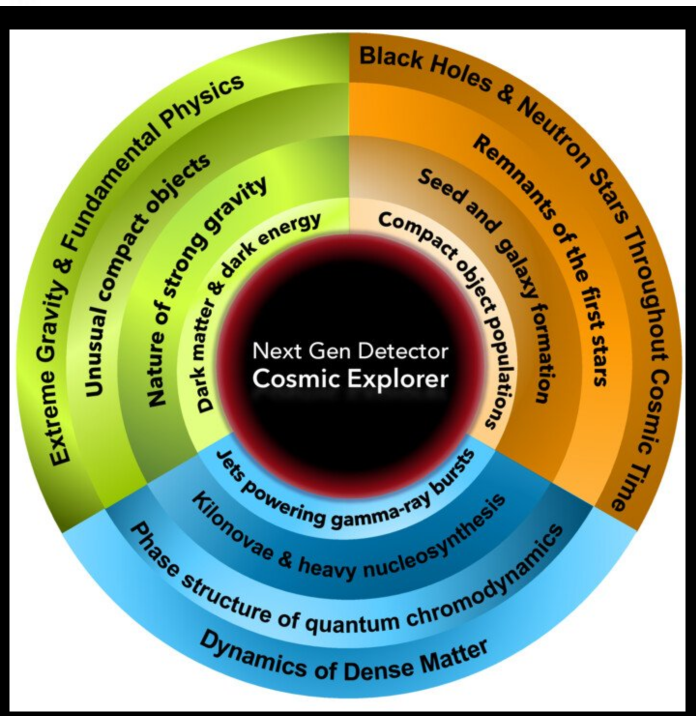




Where to even begin…!?







Use the Higgs boson as a new tool for discovery.

Captions here, please

Higgs in Space!

C. B. Jackson[a], Géraldine Servant[b], Gabe Shaughnessy[a,c], Tim M.P. Tait[a,c,d] and Marco Taoso[b,e]

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[hep-ph] 18 Mar 2010

Higgs inflation

Javier Rubio

Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany

Abstract

The properties of the recently discovered Higgs boson together with the absence of new physics at collider experiments allows us to speculate about consistently extending the Standard Model of particle physics all the way up to the Planck scale. In this context, the Standard Model Higgs non-minimally coupled to gravity could be responsible for the symmetry properties of the Universe at large scales and for the generation of the primordial spectrum of curvature perturbations seeding structure formation. We overview the minimalistic Higgs inflation scenario, its predictions, open issues and extensions and discuss its interplay with the possible metastability of the Standard Model vacuum.

The Higgs may not be the ‘go to’ tool for disovery in the Cosmic Frontier, but it has its important role to play!

Captions here, please

Delve Deep. Search Wide. Aim High.

The Cosmic Frontier contributes unique opportunities to the pursuit of the 2014 science drivers.

It has strong synergies with the Energy, Neutrino, and Rare Processes Frontiers, benefits from *essential* connections with the Theory, Computational, Instrumentation, and Underground Facilities Frontiers, and offers interesting opportunities for the Community Engagement Frontier.

CMB
21 CM + INTENSITY MAPPING
GRAVITATIONAL WAVES
SPECTROSCOPIC SURVEYS
IMAGING SURVEYS
GAMMA RAYS
LOCAL GROUP
WAVE-LIKE DETECTION
COSMIC RAYS
THEORY
DIRECT DETECTION
DARK MATTER
DARK ENERGY
INFLATION
NEUTRINOS
EXPLORING THE UNKNOWN

Captions here, please

THANK YOU

(In particular to my CF coconveners and topical working group leaders, liaisons and contributors. The success of CF at Snowmass 2021 would have been *impossible* without you!)