Cosmic Frontier: Work Plan

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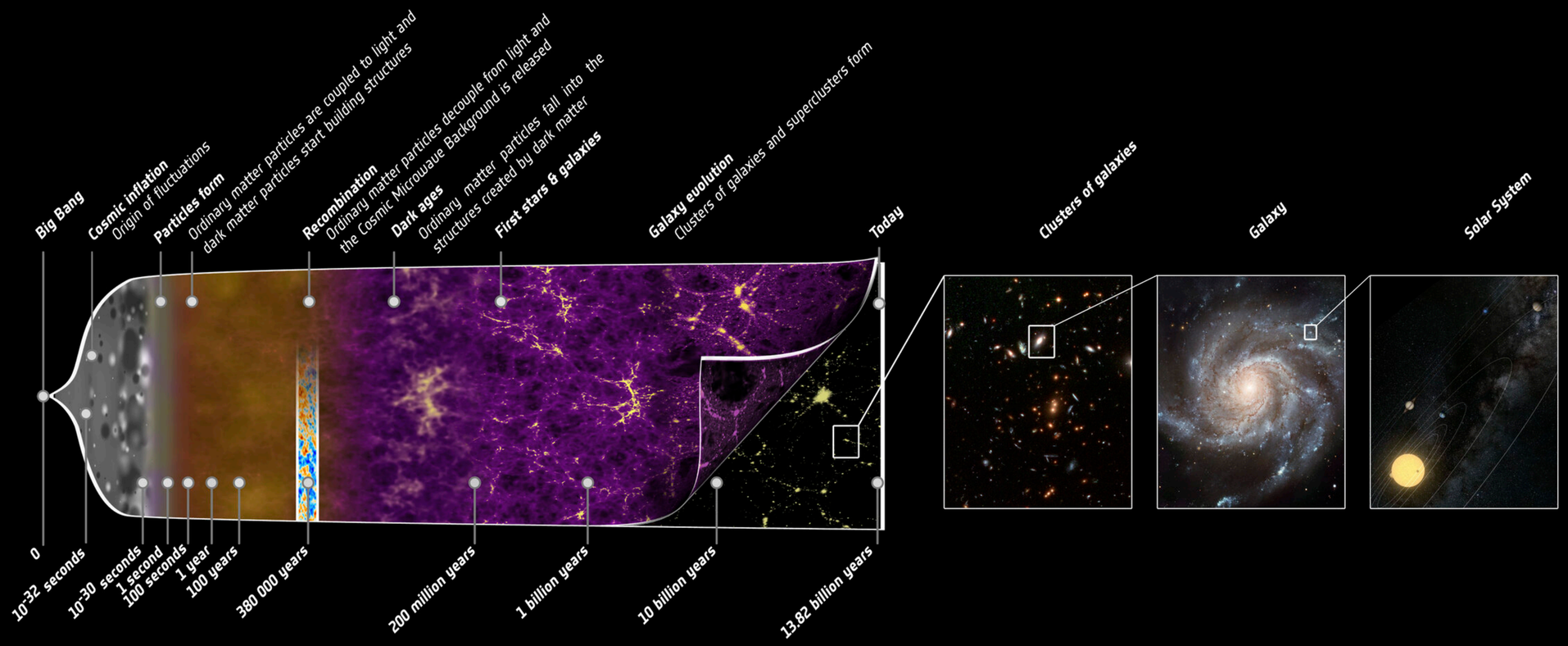
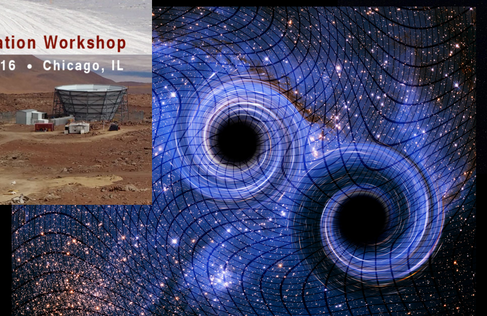
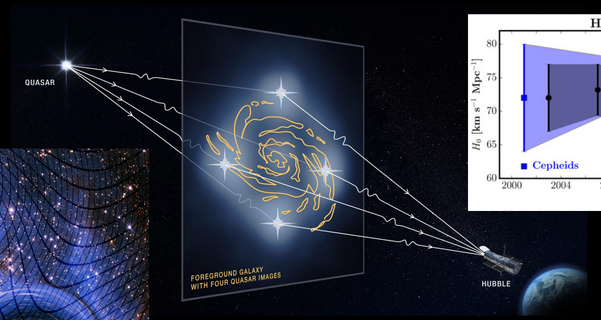
University of California, Irvine

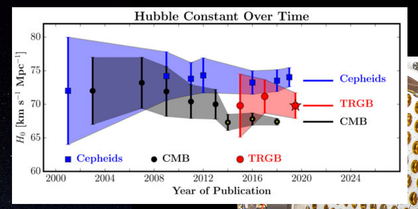
Snowmass 2021
July 17, 2022

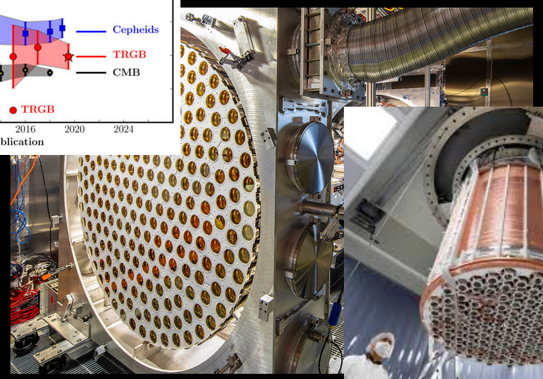


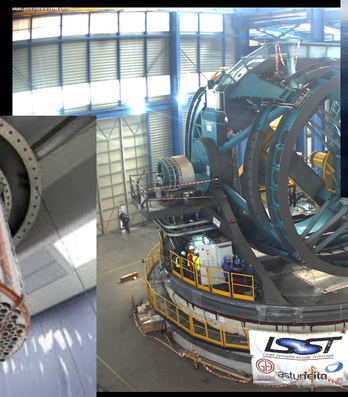
The Cosmic Frontier seeks to understand the fundamental physics that governs the behavior of the Universe and its constituents.

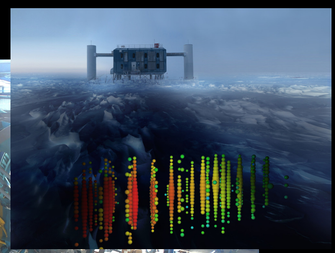






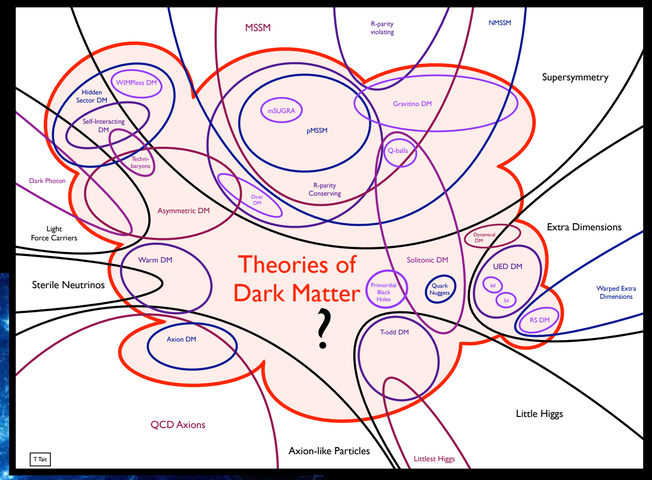


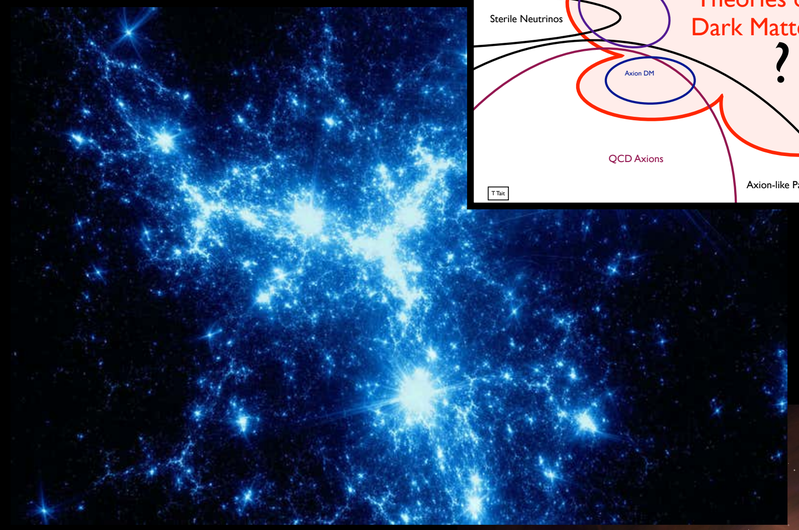


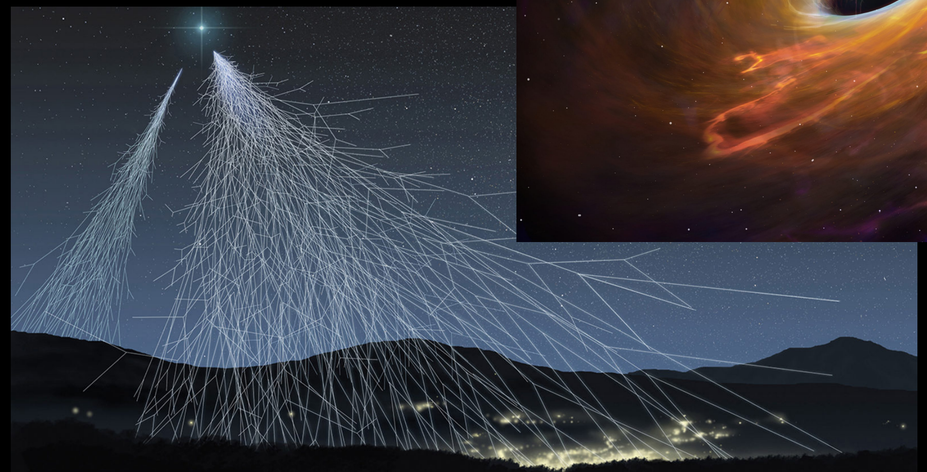


Cosmic Frontier

- The Cosmic Frontier hosts a wide range of research, spanning new cutting-edge detectors to novel analyses of data that touch on astroparticle physics and astronomy.
- It encompasses the interface between particle physics and cosmology and astrophysics.
- With the exception of neutrino masses, all of the current incontravertible evidence for physics beyond the Standard Model (dark matter, cosmic inflation, dark energy, and the baryon asymmetry of the Universe) are the direct result of Cosmic Frontier research.



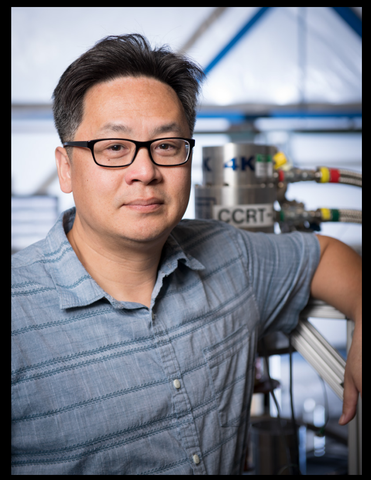




Big Questions

- What is the fundamental nature of the dark matter? How does it fit in with the Standard Model and what would we learn by detecting it ?
  - Does it manifest as individual quanta (CF1)…or as collective waves (CF2) ?
  - Can we further refine our understand of its properties based on cosmic observations (CF3) ?
- What is the nature of dark energy and cosmic acceleration (CF4 & CF5) ?
  - Is the dark energy dynamical? What is the physics of cosmic inflation? Are there other cosmological transitions whose existence we can infer ?
  - Can we constrain or discover ultra-weakly interacting or super-heavy components of the Universe ?
  - How can we use our existing and planned facilities to extract information that is more than the sum of the individual parts (CF6) ?
- How can we use cosmic probes to learn about fundamental physics (CF7) ?

Cosmic Frontier Conveners



Aaron Chou
Fermilab

Marcelle Soares-Santos
University of Michigan

Tim Tait
UC Irvine

Topical Subgroups & Conveners

Topical Group	Co-conveners				
CF1: Particle DM	Jodi Cooley SMU	Tracy Slatyer MIT	Hugh Lippincott UCSB	Tien-Tien Yu Oregon	
CF2: Wavelike DM	Joerg Jackel Heidelberg	Gray Rybka UW	Lindley Winslow MIT		
CF3: DM Astro Probes	Alex Drlica-Wagner Fermilab	Chanda Prescod-Weinstein UNH	Haibo Yu UC Riverside		
CF4: DE & CA The Modern Universe	James Annis Fermilab	Jeff Newman Pittsburgh	Anze Slosar BNL		
CF5: DE & CA Cosmic Dawn & Before	Clarence Chang ANL	Laura Newburgh Yale	Deirdre Shoemaker Georgia Tech		
CF6: Dark Energy Complimentarity	Vivian Miranda Stony Brook	Brenna Flaugher Fermilab	David Schlegel LBNL		
CF7: Cosmic Probes	Rana Adhikari Caltech	Luis Anchordoqui CUNY	Ke Fang UW Madison	B.S. Sathyaprakash Penn State	Kirsten Tollefson MSU

Liaisons with other Frontiers

- Community Engagement Frontier: Sijbrand de Jong
- Computational Frontier: Brian Yanny
- Energy Frontier: Caterina Doglioni, Antonio Boveia
- Instrumentation Frontier: Kent Irwin, Hugh Lippincott
- Neutrino Frontier: Kim Palladino, Yvonne Wong
- Rare & Precision Frontier: Susan Gardner
- Theory Frontier: Flip Tanedo
- Underground Facilities Frontier: Jodi Cooley, Hugh Lippincott
- Snowmass Early Career: Tiffany Lewis, Kristi Engel, Bibhushan Shakya

CF Plenary Schedule

- Tuesday, 7/19 3:30 pm - 5 pm (half-plenary): Cosmic Paths to Discovery
  - Tracy Slatyer (MIT) : Paths to DM Discovery
  - Kyle Dawson (Utah): Paths to Dark Energy & Cosmic Acceleration
  - Risa Wechsler (Stanford/SLAC): Paths to Cosmic Probes

- Thursday, 7/21 5:30 pm - 7 pm (plenary):
  - Aaron Chou (Fermilab): Dark Matter
  - Marcelle Soares-Santos (Michigan): Dark Energy & Cosmic Acceleration
  - Panel Discussion: Cosmic Opportunities for Fundamental Physics

CF Parallel Schedule

- Monday, 7/18, 8 am - 12 pm: CF1 - 4 working group meetings.

- Tuesday 7/19, 8 am - 11 am : CF5 - 7 working group meetings.
- Tuesday 7/19, 11 am - 12 pm: Dark Energy Complementarity.
- Tuesday 7/19, 8 am - 12 pm: Dark Matter Complementarity (CF/EF/RF/TF).

- Wednesday 7/20, 8 am - 12 pm: CF Working group report presentations.
- Wednesday 7/20, 8 am - 12 pm: TF9 (Astroparticle Physics & Cosmology)

CF Parallel Schedule

- Thursday 7/21, 10 am - 12 pm: Large Volume data analysis, Simulation, and HPC usage.
- Thursday 7/21, 8 am - 10 am: Cosmic Frontier Report Discussion
- Thursday 7/21, 10:30 am - 12 pm: Panel: Astroparticle Synergies with Particle Physics.

- Saturday 7/23, 8 am - 12 pm : Theory / Cosmic Frontier Cross-cutting session.
- Saturday 7/23, 10 am - 12 pm : Neutrino / Instrumentation / Cosmic Frontier Discussion of DM Detectors.

CF Parallel Schedule

- Sunday 7/24, 10 am - 12 pm: Neutrino / Theory / Cosmic Frontier: High Energy and Ultrahigh energy astrophysical neutrinos.
- Sunday 7/24, 10 am - 12 pm: Neutrino / Cosmic Frontier: Neutrino mass scale from measurements of β decay, double β decay, and cosmology.

How to Participate

- All CF topical working group report drafts have been shared widely. Comments and questions are very welcome.
- If you don't have time to wade through the reports, the CF parallel session on Wednesday (7/20) morning will have brief over-view presentations of each one, with lots of space for feedback from the audience.

- The CF frontier report itself is still moving toward being ready for prime time.
  - There are good aspects to this: there is still time to meaningfully contribute to the discussion and message.

Public Lecture

The Surprising Expansion History of the Universe

Adam Riess (2011 Nobel Laureate in Physics), Johns Hopkins University and the Space Telescope Science Institute

Wednesday, July 20, 2022 - 7:30pm

Kane Hall 130

WATCH LIVESTREAM

In 1929 Edwin Hubble discovered that our Universe is expanding. Eighty years later, the Space Telescope that bears his name is being used to study an even more surprising phenomenon: that the expansion is speeding up. The origin of this effect is not known, but is broadly attributed to a type of “dark energy” first posited to exist by Albert Einstein and now dominating the mass-energy budget of the Universe. Professor Riess will describe how his team discovered the acceleration of the Universe and why understanding the nature of dark energy presents one of the greatest remaining challenges in astrophysics and cosmology. He will also discuss recent evidence that the Universe continues to defy our best efforts to predict its behavior.