



Snowmass21

Aaron Chou, B.S. Sathyaprakash, and **Deirdre Shoemaker**

Goal of Snowmass: Produce a well-articulated report telling a compelling science story



- Snowmass is a particle physics community planning exercise organized by the APS Division of Particles and Fields
- Provides for the community to identify and document, via community white papers, a scientific vision for the future
- Defines the most important questions for the field and opportunities to address them
- P5 (Particle Physics Project Prioritization Panel) will take the scientific input from Snowmass and develop a 10 year strategic plan
- Letters of Intent have been gathered and consolidated into solicited community white papers
- Independent, contributed white papers also encouraged.
 - Please make topical conveners aware of your plans.
 - Engage early and provide executive summaries. Conveners will not necessarily have time to study all white papers in detail.
- These white papers will serve as **references** for the Snowmass report. The key ideas contained within will feed into the topical group and frontier summary reports.

Snowmass Organization

- Snowmass consists of several Frontiers
 - Energy Frontier, Neutrino Physics Frontier, Rare Processes and Precision, **Cosmic Frontier**, Theory Frontier, Accelerator Frontier, Instrumentation Frontier, Computational Frontier, Underground Facilities, Community Engagement, Snowmass Liaisons
 - CF Conveners: Aaron Chou (FNL), Marcelle Soares-Santos (U Mich), Tim M.P. Tait (UC Irvine)
- Frontiers consists of topical groups
 - Cosmic Frontier consists of 7 topical groups
 - CF1. Dark Matter: Particle-like, CF2. Dark Matter: Wave-like, **CF3**. Dark Matter: Cosmic Probes, CF4. Dark Energy and Cosmic Acceleration: The Modern Universe, **CF5**. Dark Energy and Cosmic Acceleration, **CF6**: Complementarity of Probes and New Facilities, **CF7**. Cosmic Probes of Fundamental Physics

Cosmic Frontier topical groups and conveners

- **CF1. Dark Matter: Particle-like** ([#cf01-dark_matter_particle](#))

Jodi Cooley (SMU), Hugh Lippincott (UCSB), Tracy Slatyer (MIT), Tien-Tien Yu (U.Oregon)

- **CF2. Dark Matter: Wave-like** ([#cf02-dark_matter_wave](#))

Joerg Jaeckel (Heidelberg), Gray Rybka (UW), Lindley Winslow (MIT)

- **CF3. Dark Matter: Cosmic Probes** ([#cf03-dark_matter_cosmic](#))

Alex Drlica-Wagner (Fermilab), Chanda Prescod-Weinstein (UNH), Haibo Yu (UCR)

- **CF4. Dark Energy and Cosmic Acceleration: The Modern Universe** ([#cf04-dark_energy_modern](#))

Jim Annis (Fermilab), Jeffrey Newman (Pittsburgh), Anže Slosar(BNL)

- **CF5: Dark Energy and Cosmic Acceleration: Cosmic Dawn and Before** ([#cf05-dark_energy_dawn](#))

Clarence Chang (LANL), Laura Newburgh (Yale), Deirdre Shoemaker (UT Austin)

- **CF6. Dark Energy and Cosmic Acceleration: Complementarity of Probes and New Facilities** ([#cf06-dark_energy_comp](#))

Chihway Chang (Chicago), Brenna Flaugher (Fermilab), David Schlegel (LBNL)

- **CF7. Cosmic Probes of Fundamental Physics** ([#cf07-cosmic_probes](#))

Rana Adhikari (Caltech), Luis Anchordoqui (CUNY), Ke Fang (UW-Madison), B.S. Sathyaprakash (Penn State), Kirsten Tollefson (MSU)



Slack signup instructions at bottom of <https://snowmass21.org>

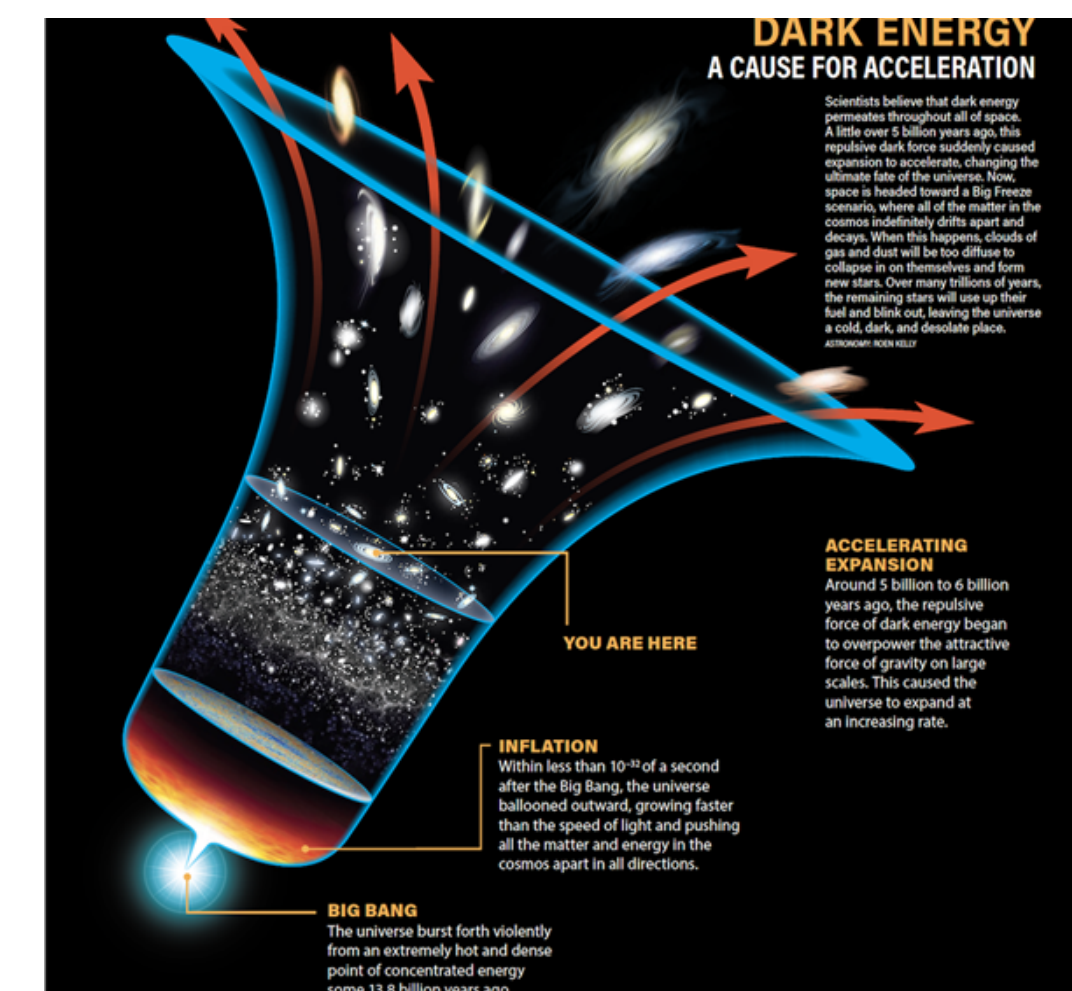
CF3:

- Science Goals: This group covers properties of dark matter that can be uniquely probed by cosmological and astrophysical observations. Techniques include measurements of the cosmological distribution of dark matter, as well as studies of astrophysical objects in extreme environments. Examples of dark matter models probed through these techniques are warm dark matter, self-interacting dark matter, ultra-light axions, and primordial black holes.
- Conveners: Alex Drlica-Wagner (Fermilab), Chanda Prescod-Weinstein (UNH), Haibo Yu (UCR)

CF5: Dark Energy and Cosmic Acceleration

Cosmic Dawn and Before

- Science Goals: covers cosmic probes of cosmology in the early Universe from Inflation Era through the Cosmic Dawn. Subtopics include: growth of structure probes (e.g. 21 cm power spectrum in the dark ages), probes of expansion history (e.g. BAO with black hole mergers, CMB), primordial non-gaussianity and inflation. High- z gravitational wave observatories, 21cm and CMB projects are examples of experiments expected to be primarily discussed here. Overlaps with the previous section are expected.
- Conveners: Clarence Chang, Laura Newburgh, Deirdre Shoemaker
- Working Group: Adrian Liu, Emanuele Castorina, Neimack, Kevin Huffenberger, Dan Green, Reness Hlozek, Robert Caldwell Plan



Courtesy: Astronomy Magazine

CF6

Dark Energy and Cosmic Acceleration: Complementarity of Probes and New Facilities

- Science Goals: This group covers the connections between probes across multiple axes including combined probes across the early/late time regimes, and plans for future observatories/facilities to maximize the science outputs for Dark Energy and Cosmic Acceleration physics. Discussions about multimessenger projects (including GW, and Neutrinos) and new physics opportunities not included in the early/late universe topics are also welcome here.
- Conveners: Chihway Chang (Chicago), Brenna Flaugher (Fermilab), David Schlegel (LBNL)

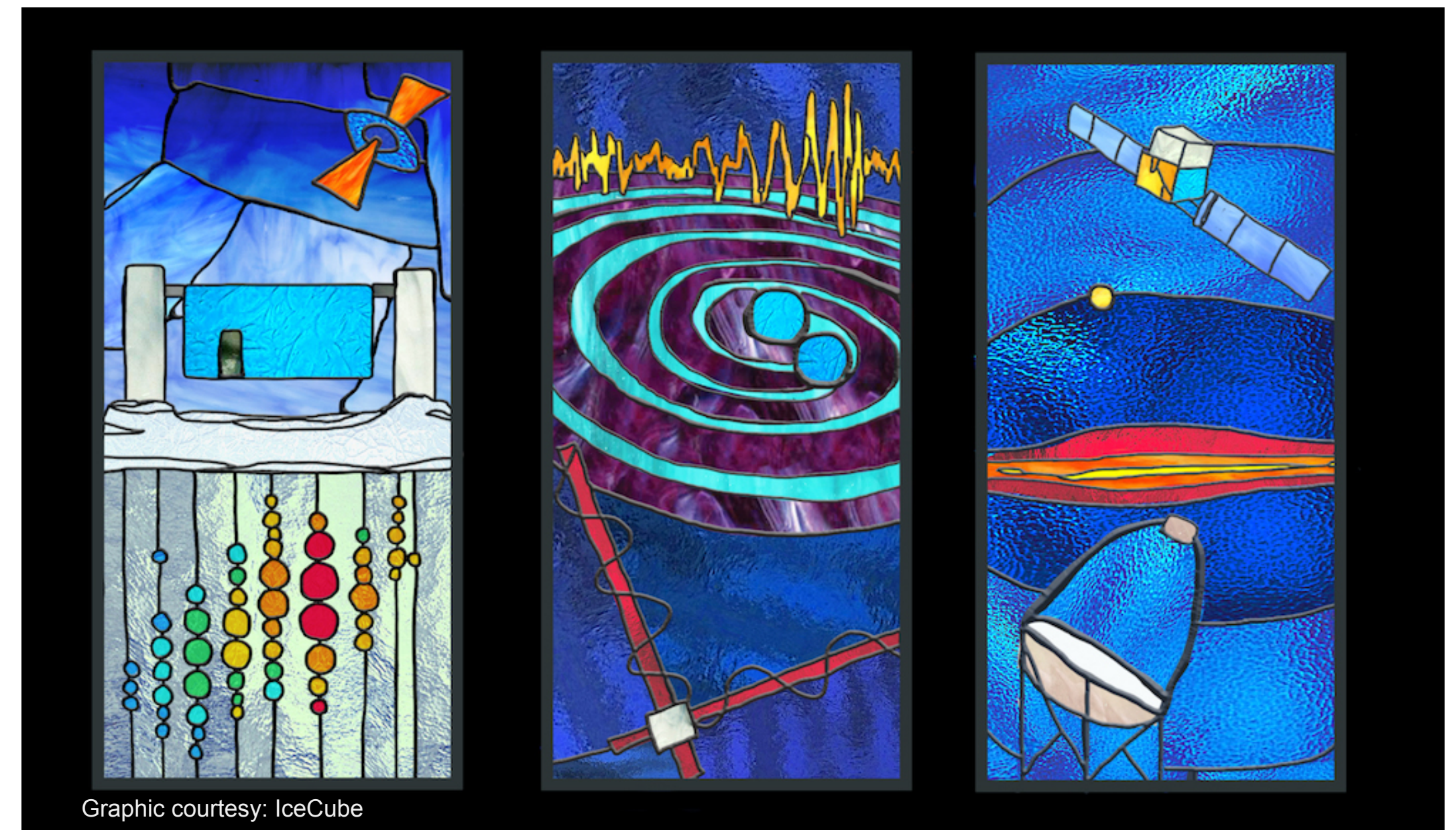
CF7: Cosmic Probes of Fundamental Physics

Using the windows on the universe to learn about fundamental particles and high energy physics

- **Science goals:** CF7 covers cosmic probes of fundamental physics topics beyond Dark Matter and Dark Energy using gravitational waves, cosmic rays, gamma rays, and neutrinos, as well as their combined studies to facilitate the multi-messenger science. It also covers various tests of Λ CDM using high and low redshift observations and the potential of standard candle/siren cosmology to address existing tensions in the data.

- **Conveners:**

- Rana X Adhikari (Caltech)
- Luis Anchordoqui (CUNY)
- Ke Fang (UW-Madison)
- B.S. Sathyaprakash (Penn State)
- Kirsten Tollefson (MSU)



A deci-Hz Gravitational-Wave Lunar Observatory for Cosmology

LOI Submitted by Jani et al

Thematic Areas: (check all that apply ☐/☒)

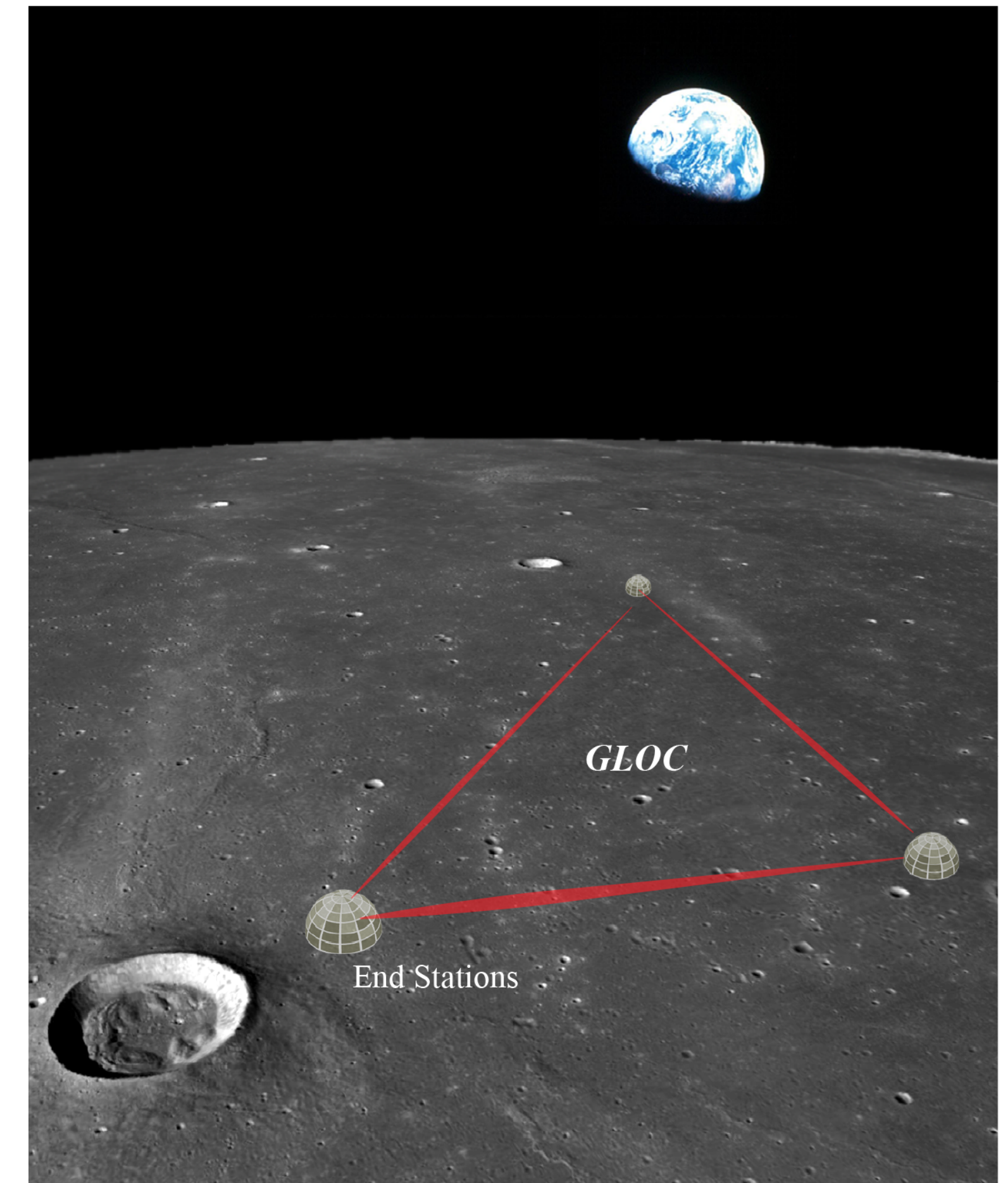
- ☐ (CF1) Dark Matter: Particle Like
- ☐ (CF2) Dark Matter: Wavelike
- ☒ (CF3) Dark Matter: Cosmic Probes
- ☐ (CF4) Dark Energy and Cosmic Acceleration: The Modern Universe
- ☒ (CF5) Dark Energy and Cosmic Acceleration: Cosmic Dawn and Before
- ☒ (CF6) Dark Energy and Cosmic Acceleration: Complementarity of Probes and New Facilities
- ☒ (CF7) Cosmic Probes of Fundamental Physics
- ☐ (Other) *[Please specify frontier/topical group]*

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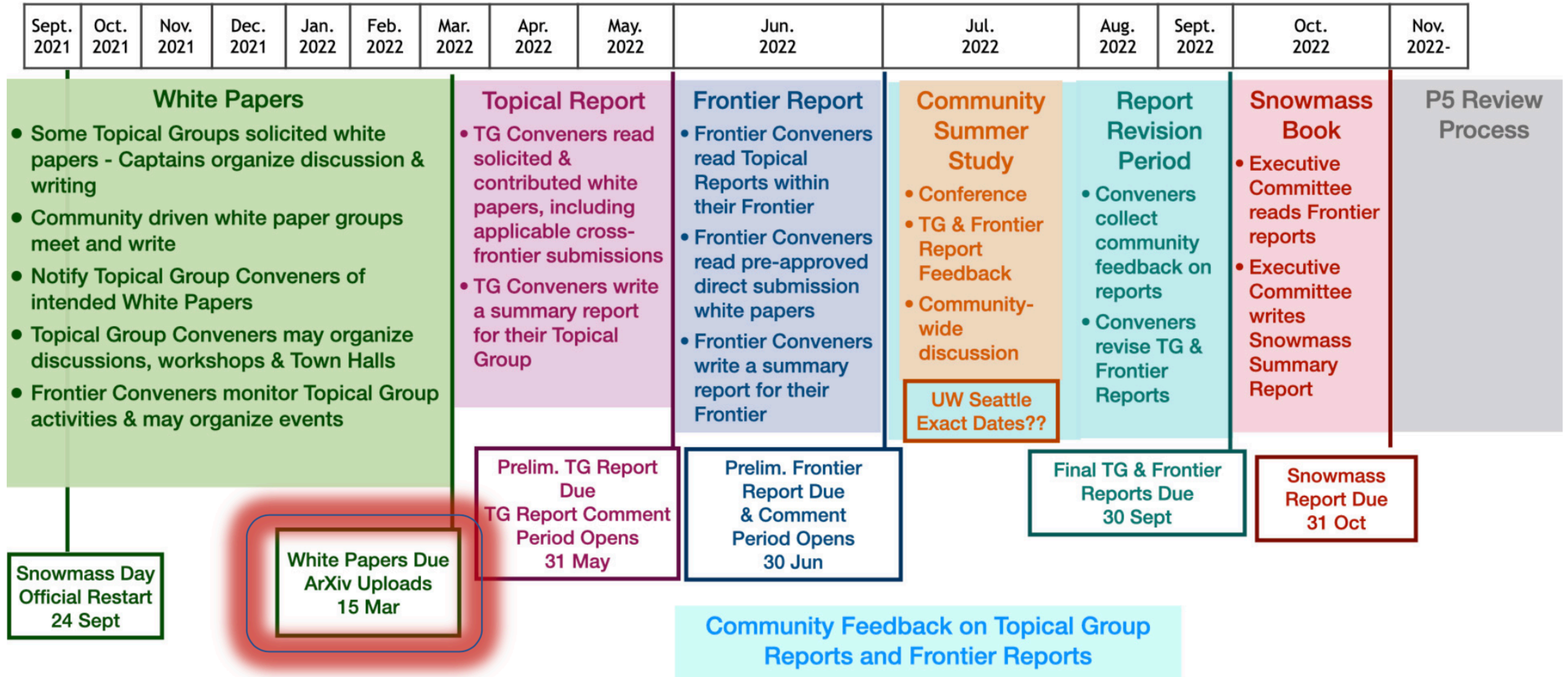


Community White Papers

of potential interest to this community

- CF03: *Primordial Black Holes & Gravitational Waves* with captains Will Dawson, Andrea Albert, Simeon Bird
- CF05: *Stochastic GW Background* with Robert Caldwell and Deirdre Shoemaker
- CF06: *High Precision in Astrophysics* (#wp-cf06-precision) with Jeff Newman, Peter Nugent, Alex Kim and Mark Dickinson
- CF06: *Importance/power of joint analysis for “transient” science* (#wp-cf06-transient-probes) with Maria Elidaiana, Alex Kim, Antonella Palmese
- CF07: *Multimessenger facilities and experiments* (#wp-cf07-multimessenger) Aleksi Kurkela, Emmanuel Fonseca, J. Read, Slavko Bogdanov, Kuver Sinha, Or Hen
- CF07: *GW Facilities* with Rana Adhikari
- CF07: *Probes of the Early Universe* with Vuk Madnic and Robert Caldwell
- CF07: *Modeling Gravitational Wave Sources* (joint with TF04) with unconfirmed captains

Post-Break Snowmass Timeline



Get Involved

- Snowmass Website: <https://snowmass21.org/cosmic/start>
- Slack channels
 - Slack signup instructions at bottom of <https://snowmass21.org>
 - List of slack on slide 4
- Wiki of planned white papers
 - https://docs.google.com/document/d/1hKnvyakgLFGfVO4PPQYoZF_MWvRvWOfW5zudUeDVIu4/edit
 - contact the white paper captains to participate and/or you can write your own

