CF03: Cosmic Probes of Dark Matter Physics

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on behalf of CF3 Conveneres:
Chanda Prescod-Weinstein & Hai-Bo Yu

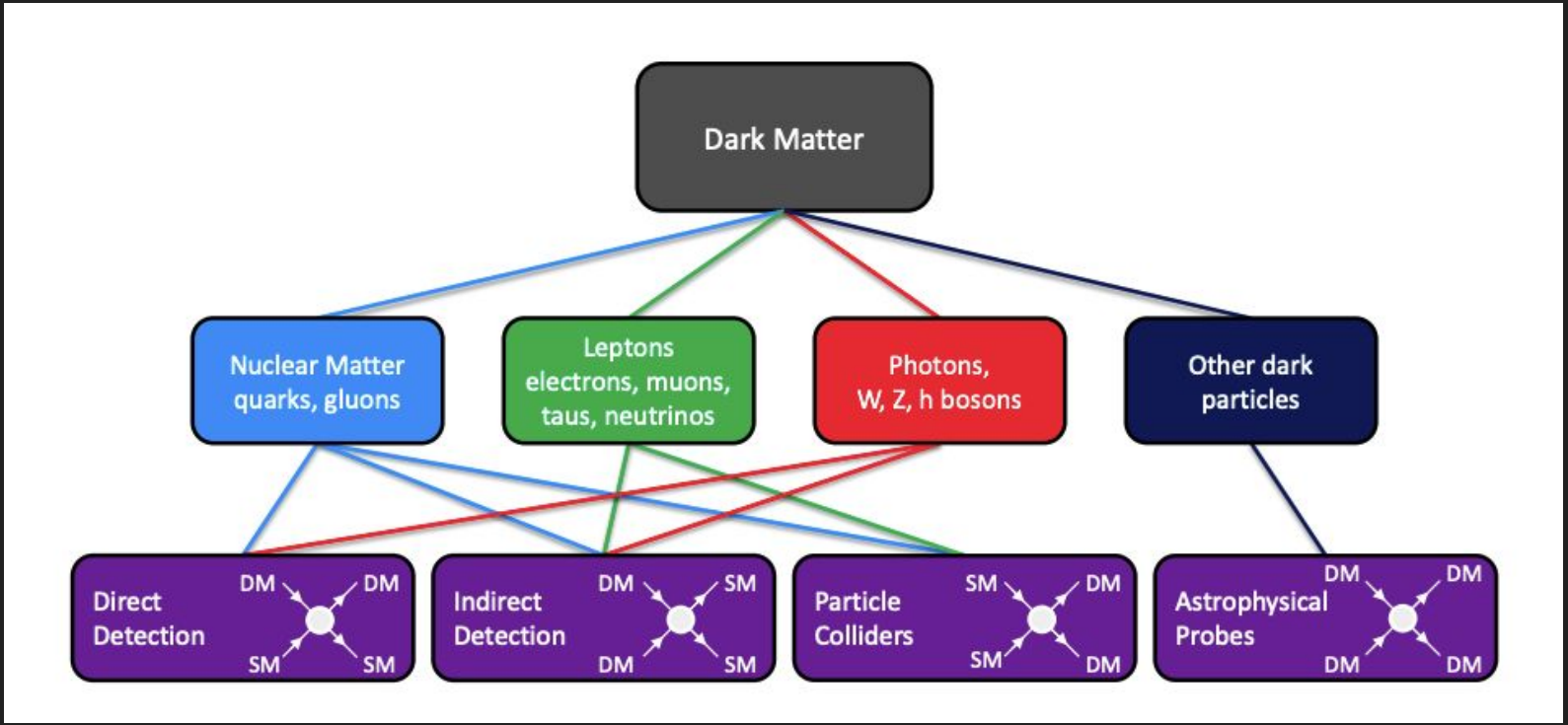
CMB-S4 Collaboration Meeting

August 12, 2021

Outline

- Dark Matter: Cosmic Probes
- Solicited White Papers
- Timelines
- How to get involved

Dark Matter in Snowmass 2013



2014 P5 without CF03...

The 2014 P5 report did not identify dark matter as a science driver for the large cosmic survey efforts (LSST, DESI, CMB-S4).

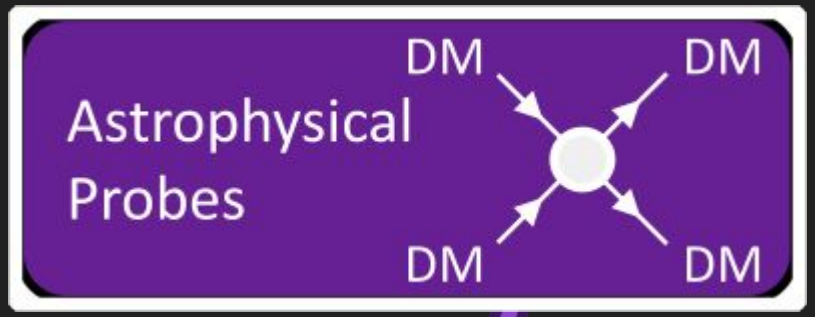
DOE resists expanding the scientific scope of these experiments to support dark matter research *even though* dark matter is a DOE mission priority.

We would like to avoid having this happen again...

https://www.usparticlephysics.org/wp-content/uploads/2018/03/FINAL_P5_Report_053014.pdf

Table 1
Summary of Scenarios

	Scenarios			Science Drivers					
Project/Activity	Scenario A	Scenario B	Scenario C	Higgs	Neutrinos	Dark Matter	Cosm. Accel.	The Unknown	Technique (Frontier)
Large Projects									
Muon program: Mu2e, Muon g-2	Y, Mu2e small reprofile needed	Y	Y					✓	I
HL-LHC	Y	Y	Y	✓		✓		✓	E
LBNF + PIP-II	Y, LBNF components delayed relative to Scenario B.	Y	Y, enhanced		✓			✓	I,C
ILC	R&D only	R&D, possibly small hardware contributions. See text.	Y	✓		✓		✓	E
NuSTORM	N	N	N		✓				I
RADAR	N	N	N		✓				I
Medium Projects									
LSST	Y	Y	Y		✓	X	✓		C
DM G2	Y	Y	Y			✓			C
Small Projects Portfolio	Y	Y	Y		✓	✓	✓	✓	All
Accelerator R&D and Test Facilities	Y, reduced	Y, some reductions with redirection to PIP-II development	Y, enhanced	✓	✓	✓		✓	E,I
CMB-S4	Y	Y	Y		✓	X	✓		C
DM G3	Y, reduced	Y	Y			✓			C
PINGU	Further development of concept encouraged				✓	✓			C
ORKA	N	N	N					✓	I
MAP	N	N	N	✓	✓	✓		✓	E,I
CHIPS	N	N	N		✓				I
LAr1	N	N	N		✓				I
Additional Small Projects (beyond the Small Projects Portfolio above)									
DESI	N	Y	Y		✓	X	✓		C
Short Baseline Neutrino Portfolio	Y	Y	Y		✓				I



Astrophysics provides the **only robust, positive empirical measurement** of **dark matter**

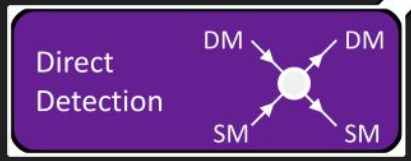
Dark Matter

CF Dark Matter Topical Groups

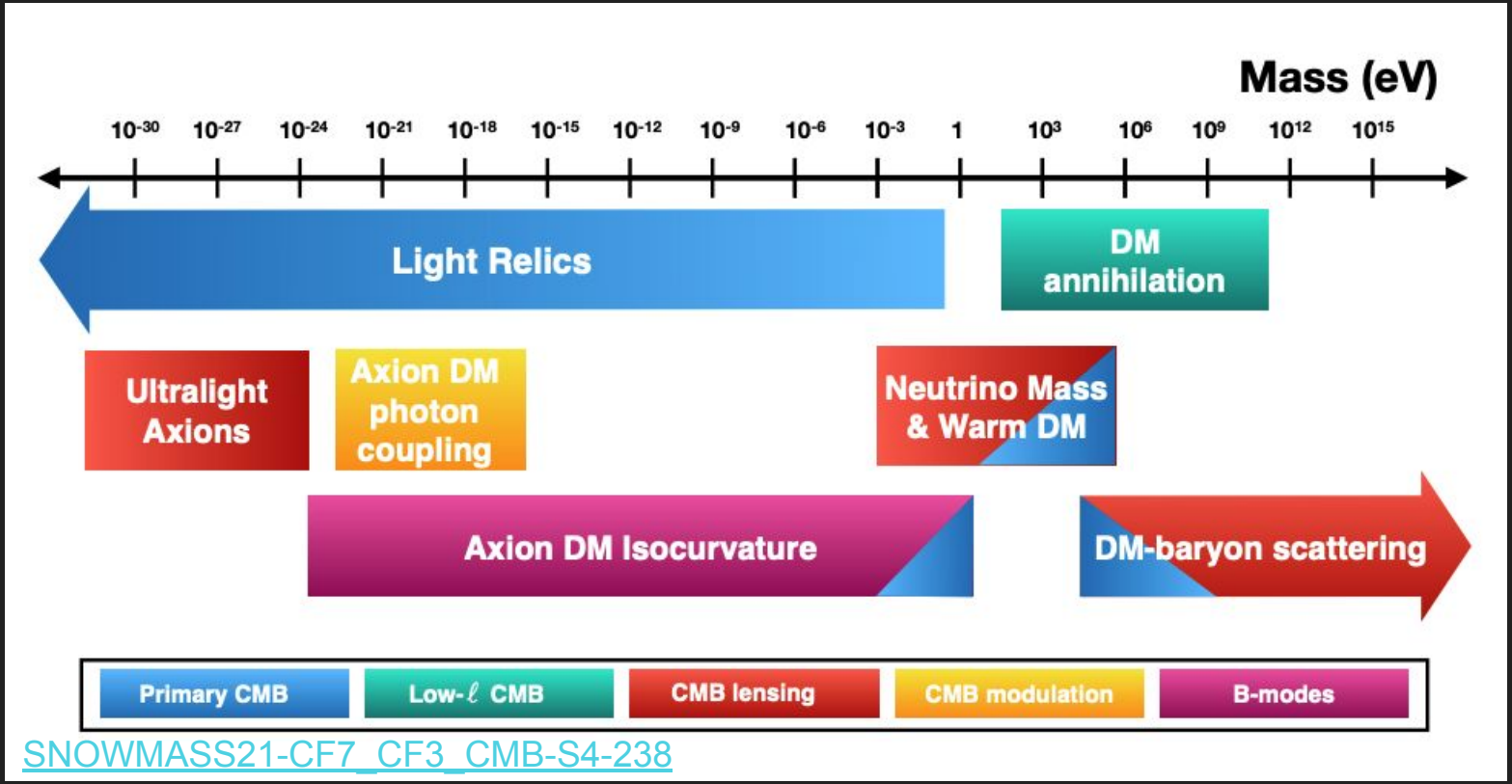
CF01: Dark Matter: Particle-like
CF02: Dark Matter: Wave-like
CF03: Dark Matter: Cosmic Probes

Related Topical Groups

CF07. Cosmic Probes of Fundamental Physics
EF10: BSM: Dark Matter at colliders
TF09: Astro-particle physics & cosmology

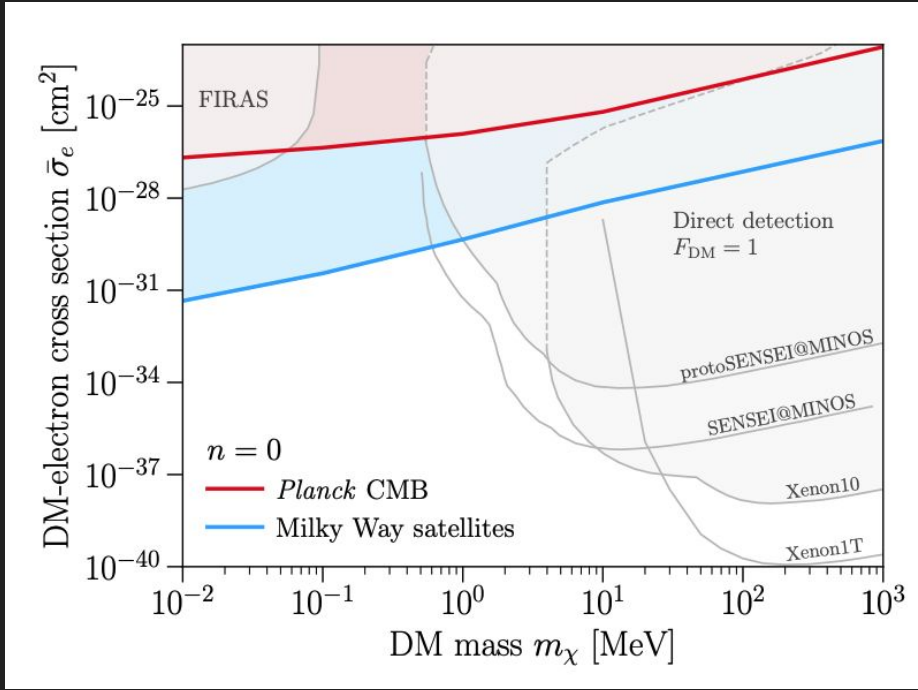


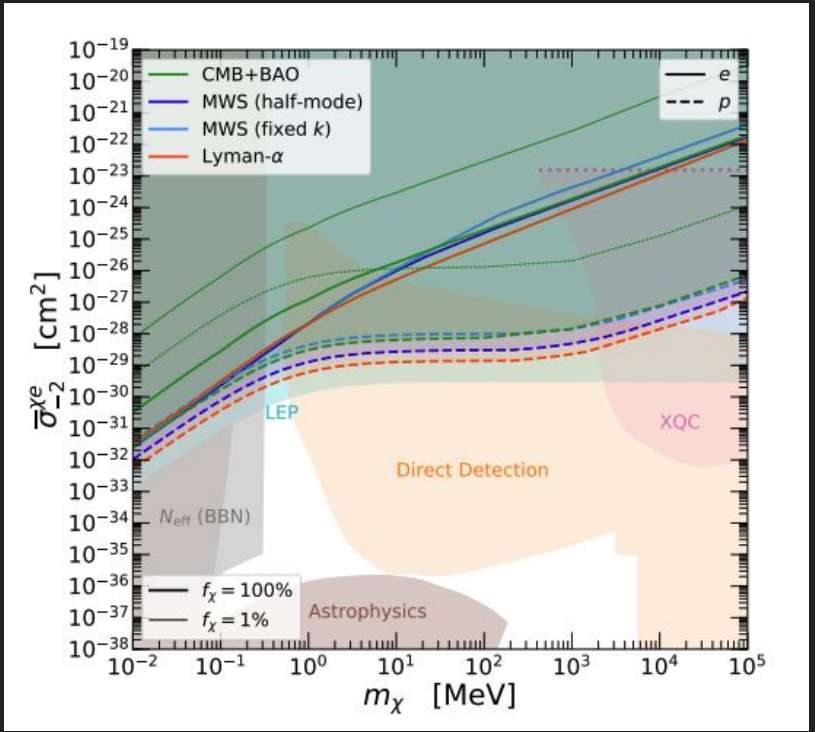
CMB-S4: Probes of the Dark Universe



SNOWMASS21-CF7_CF3_CMB-S4-238

Some recent examples...





Nguyen et al. (2107.12380)

Buen-Abad et al. (2107.12377)

Letters of Interest and Solicited White Papers

- CF03 received **75 Letters of Interest** from the community.
- Through a series of discussions (including the Community Planning Meeting), we have arrived at a list of **6 solicited white papers** with designated facilitators.
- CF03 is happy to accept additional contributed white papers, but we encourage people to join these efforts when possible.

CF03 “Solicited” White Paper Topics

- **Dark matter physics from halo measurements** [#wp-cf03-dark_matter_halos]
  Dark matter physics from dark matter halos ranging from large-scale structure to sub-galactic scales.
  Facilitators: **Keith Bechtol, Simon Birrer, Francis-Yan Cyr-Racine, Katelin Schutz**
- **Primordial Black Holes & Gravitational Waves** [#wp-cf03-dark_matter_pbh_gw]
  Primordial black holes as dark matter and probes of inflation (joint with CF7?)
  Facilitators: **Andrea Albert, Simeon Bird, Will Dawson**
- **Numerical simulations and systematics** [#wp-cf03-dark_matter_sims]
  Importance of numerical simulations for extracting dark matter physics (joint with CompF2?)
  Facilitators: **Arka Banerjee, Annika Peter, Ferah Munshi**
- **Connecting dark matter to early universe physics** [#wp-cf03-dark_matter_early_universe]
  Light relics, 21cm (EDGES), etc. (joint with CF5 & TF9?)
  Facilitators: **Kim Boddy, Cora Dvorkin, Vera Gluscevic, Julian Muñoz**
- **Dark matter physics in extreme astrophysical environments** [#wp-cf03-dark_matter_xtreme]
  Includes stellar interiors, neutron stars, non-primordial black holes (joint with TF9?)
  Facilitators: **Masha Baryakhtar, Regina Caputo, Djuna Croon, Kerstin Perez**
- **Facilities for cosmic probes of dark matter physics** [#wp-cf03-dark_matter_facilities]
  Proposed facilities for cosmic probes of dark matter including MSE, MegaMapper, CMB-HD, etc.
  Facilitators: **Ting Li, Josh Simon, Sukanya Chakrabarti, Neelima Sehgal**

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CMB

- SNOWMASS21-CF5_CF3-NF2_NF0-TF9_TF11_Neelima_Sehgal-016.pdf (CMB-HD: An Ultra-Deep, High-Resolution Millimeter-Wave Survey Over Half the Sky)
- SNOWMASS21-CF7_CF3_CMB-S4-238.pdf (CMB-S4: Probes of the Dark Universe)
- SNOWMASS21-CF5_CF6_wu_and_young-036.pdf (Future of CMB)

Gravitational Waves

- SNOWMASS21-CF7_CF5-059.pdf (Probing Fundamental Physics using the Stochastic Gravitational Wave Background from the Early Universe)

Dark structures in the early universe

- SNOWMASS21-CF5_CF3-TF9_TF0-CompF2_CompF0_Julian_Munoz-211.pdf (Cosmic dawn: A probe of dark matter at small scales)
- SNOWMASS21-CF3_CF1-TF9_TF0-CompF2_CompF0_Vid_Irsic-128.pdf (Small-scale structure at high redshift: Lyman-alpha forest)
- SNOWMASS21-CF3_CF2-TF9_TF0_Rogers-266.pdf Cosmic probes of ultra-light axion dark matter

Light Relics/Early Universe

- Insights for Fundamental Physics and Cosmology with Light Relics
- Light but Massive Relics in Cosmology
- Illuminating the Dark Sector in Neutron Star Mergers
- Indirect Detection Aspects of Hidden Sector Dark Matter

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- SNOWMASS21-CF5_CF6_wu_and_young-036.pdf (Future of CMB)

21cm

- Packed Ultra-wideband Mapping Array (PUMA): Next generation facility for Sky Survey in Radio

Optical/NIR

- SNOWMASS21-CF3_CF7_Ting_Li-153.pdf (Probing Dark Matter Physics with Maunakea Spectroscopic Explorer)
- Cosmology with the MaunaKea Spectroscopic Explorer
- SNOWMASS21-CF6_CF4-IF2_IF0_Jennifer_Marshall-141.pdf (The Maunakea Spectroscopic Explorer

■ ■ ■

DPF Timeline from Tao Han (APS DPF Chair) in the January Snowmass newsletter

- **Mar 15, 2022**: White Paper submission to arXiv. Late submissions and updates are likely not to be incorporated in the working group reports, but will be included in the Snowmass online archive documents.
- **May 31, 2022**: Preliminary reports by the Topical Groups due.
- **Jun 30, 2022**: Preliminary reports by the Frontiers due.
- **Jul, 2022**: Snowmass Community Summer Study (CSS) at UW-Seattle.
- **Sep 30, 2022**: All final reports by TGs and Frontiers due.
- **Oct 31, 2022**: Snowmass Book and the online archive documents due.

CF03 Internal White Paper Timeline (updated)

Proposed timeline for CF03 paper writing:

- **Nov 2020**: identify “solicited” white papers and “facilitators”
- **Aug 30, 2021**: identify writers for each white paper
- **Oct 18, 2021**: White paper outlines/skeletons -- what will the paper cover, begin to articulate key questions and opportunities; identify key questions and opportunities for each white paper
- **Jan 17, 2022**: first draft of white paper to CF03 conveners, for feedback and discussion; share among sub working groups; reminder, topical group report is written in parallel to white papers (so need to know early)
- **Feb-Mar, 2022**: further polish the white papers and submit them

How to Get Involved

Join our meetings and engage on the Snowmass Slack!

Meetings: August 30th @ 12PM EDT/9AM PDT
Slides/Recordings: https://indico.fnal.gov/category/1195/
Slack: #cf03-dark_matter_cosmic
Email: snowmass-cf-03-dm-cosmic@listserv.fnal.gov
Snowmass Wiki: https://snowmass21.org/cosmic/dm_probes

Questions for the CF03 Conveners?
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Chanda Prescod-Weinstein Chanda.Prescod-Weinstein@unh.edu
Hai-Bo Yu haiboyu@ucr.edu