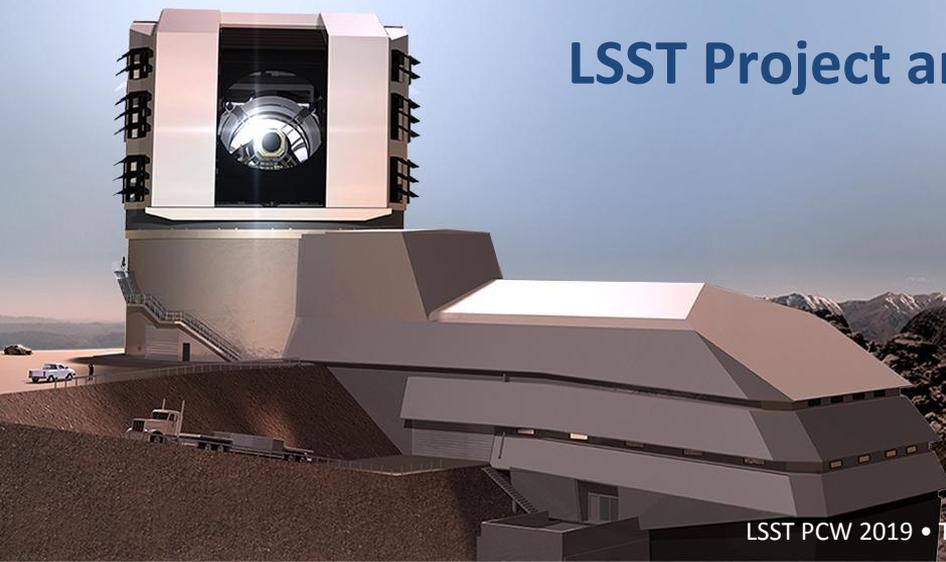




# Dark Matter Science w/ LSST: Collaboration and Next Steps

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on behalf of LSST Dark Matter Science Group

LSST Project and Community Workshop 2019  
August 13, 2019





## Who are we?



- LSST has a long history promoting fundamental dark matter research (i.e. “The Dark Matter Telescope” Tyson et al. 2000)
- The LSST Dark Matter Group is a grassroots community effort to revitalize dark matter science with LSST
- The dark matter problem requires input from astronomers, cosmologist, and physicists across various disciplines of theory, simulation, observation and experiment.
- We seek to bring these groups together in a concerted effort to tackle one of the pre-eminent problems in modern science.

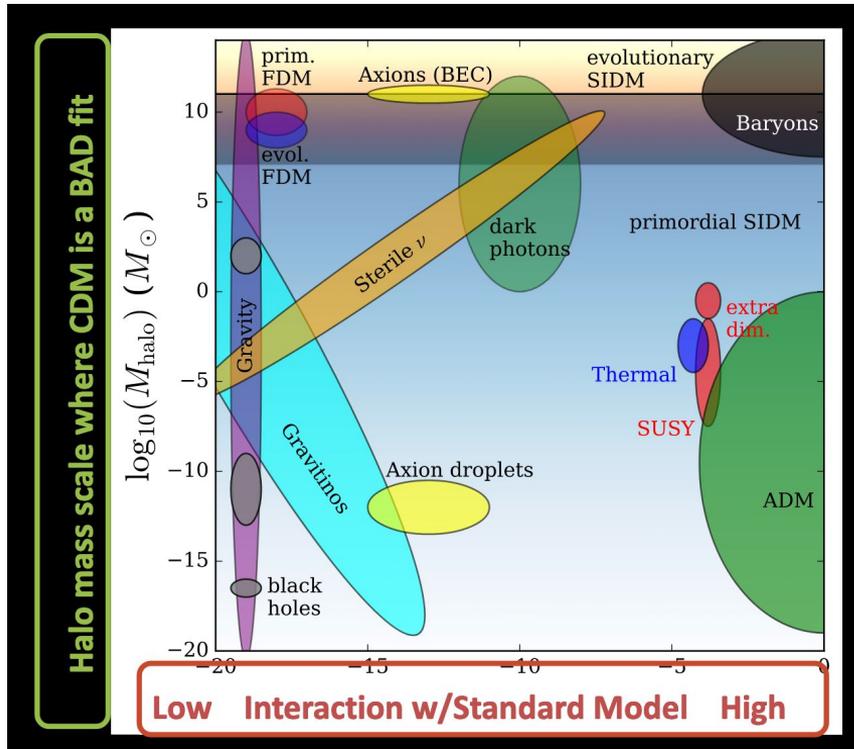
<https://lsstdarkmatter.github.io/>



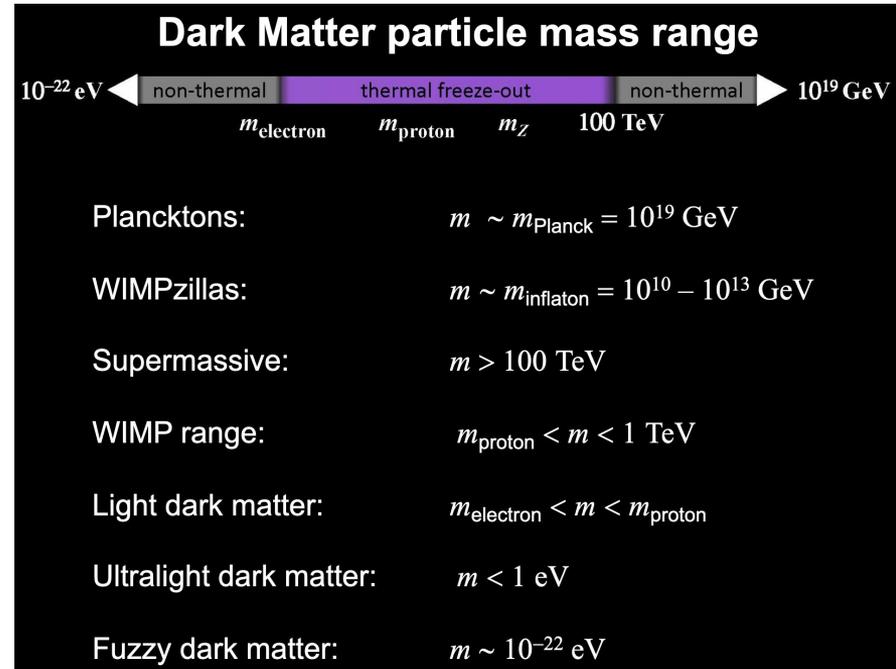
LSST data will enable and enhance multiple astrophysical probes of the **fundamental nature** of dark matter by

- (1) measuring the abundance, clustering, and density profiles/shapes of dark matter halos over an enormous range of physical scales,
- (2) searching for anomalous behavior of stars,
- (3) searching for compact objects, and
- (4) improving our knowledge of the local distribution of dark matter to inform indirect and direct dark matter searches.

*The associated observational/analytical/theoretical techniques span several of the eight currently existing LSST Science Collaborations recognized by LSSTC. We organized this session (and other related efforts) because we believe there is value in combining/coordinating efforts across the LSST scientific community to maximize the dark matter science coming out of LSST*



Slide from Annika Peter



Slide from Rocky Kolb

Evolving “landscape” of dark matter research  
 -> Considerable theoretical interest beyond WIMPs



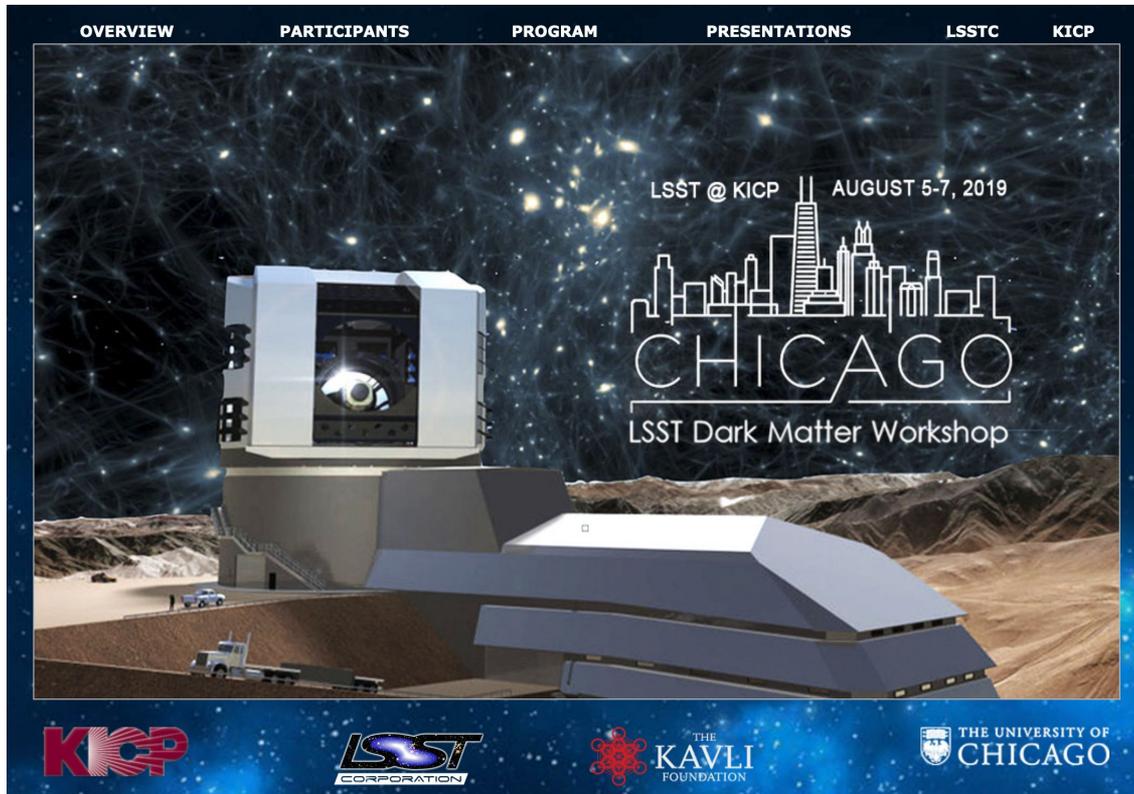
## What has happened since last year?



- [LSST Dark Matter Workshop at Livermore](#)
- [LSST Dark Matter White Paper](#) (“the big one”)
- [Astro2020 LSST Dark Matter White Paper](#) (“the killer app”)
- [LSST Dark Matter Workshop at KICP/UChicago](#)
- Dark Matter Working Group within DESC (to be confirmed...)
- [Vera Rubin Observatory](#) (to be confirmed...)



# LSST Dark Matter Workshop at KICP



- LSST Dark Matter Workshop held last week hosted by KICP @ UChicago
- Roughly 60 attendees from across the physics, cosmology, and astronomy communities
- Good mix of theorists, simulators, observers, and experimentalists
- Several hours of discussion, which can be summarized [here](#)

Talk slides posted: <https://kicp-workshops.uchicago.edu/lssdarkmatter-2019/>



# A Few Recent Science Highlights



Strong lensing

Microlensing

Stellar streams

Dwarf galaxies

Large-scale Structure

...

too many to list



Why establish a “home” for dark matter research within the LSST Science Collaborations?

- Nucleation point for larger dark matter community
- Scientific benefits of “joint-probes” analyses
- Coordinating follow-up observation and analysis efforts
- Opportunity to engage theorists and better integrate with observational efforts
- Advocacy
- (Opportunity to reduce administrative burden if within an existing science collaboration)



# Finding a Home of Dark Matter Research



## Why DESC?

- Scientific and technical synergies w/ dark energy research
- DESC's stated goal in the 2012 white paper is "the study of dark energy and related topics in fundamental physics with data from the LSST". A DKM WG with a focus on the fundamental nature of dark matter, though not the core mission of DESC, fits within the existing "fundamental physics" scope of the DESC.



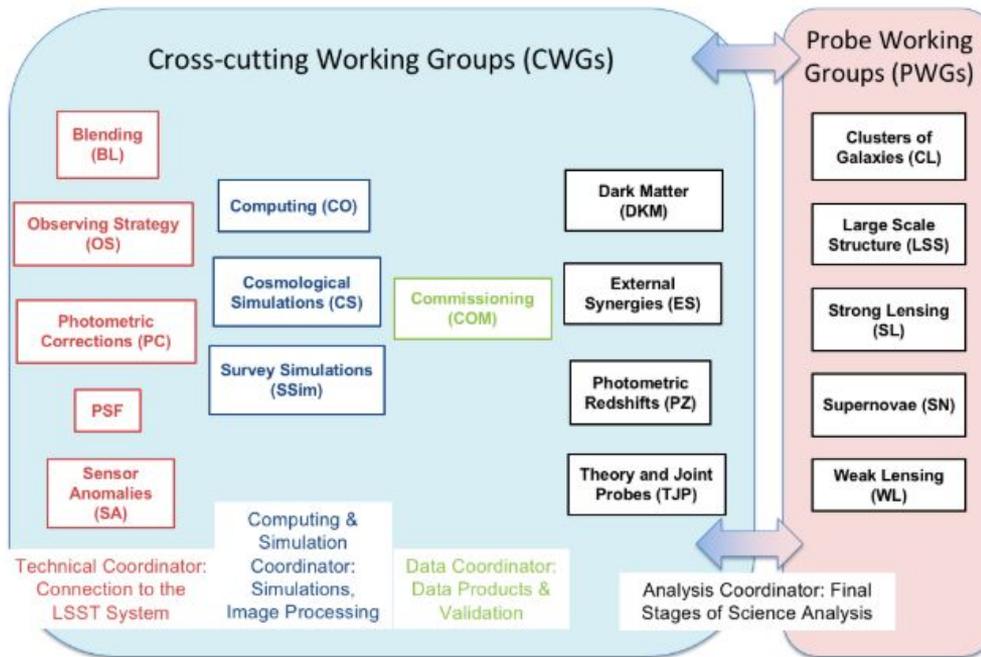
# Dark Matter Working Group in DESC



The 2019-2021 DESC Management Plan includes the addition of a new Dark Matter (DKM) Working Group (WG).

The DKM WG would coordinate efforts across DESC working groups and between DESC and other science collaborations

## Working group (WG) structure



Note: Management Plan with this structure is being discussed by the DESC Council

17



## Immediate Future



- Members of LSST dark matter group already in DESC will be able to continue their work in DESC
- Members of LSST dark matter group that are not already in DESC are invited to join DESC (<https://lsstdesc.org/pages/apply>); note this comes with associated resources and responsibilities.
- Our intention is **\*not\*** to force anyone to join DESC, but rather to provide an opportunity for mutually beneficial interactions.
- We will ensure that dark matter-related communications in DESC communication channels are mirrored, where appropriate, to our Google mailing list.
- We expect that the DESC Dark Matter Working Group will retain the culture and community that we have established over the last year with the dark matter group.



## Immediate Future



- Identifying conveners of the DESC Dark Matter (DKM) WG
- Expanding the public “brand” of DESC to more clearly encompass cosmology and fundamental physics with LSST, including dark matter research
- The DKM WG has zero (or negative) net operational cost to the core dark energy mission of DESC. It enhances the core mission of DESC due to scientific and technical overlap.



## Next Steps



- Inter-Collaboration Agreements
- Follow-up resources (e.g., spectroscopy, high-resolution imaging, time domain)
- Astro2020 / Snowmass
- Theory / simulations



# Snowmass/P5 Process



- Snowmass is a community-led process to set priorities in High Energy Physics (similar to Astro2020)
- Feeds into a P5 report, which DOE (and Congress) take very seriously
- Snowmass process is starting now!

## Table 1 Summary of Scenarios

Project/Activity	Scenarios			Science Drivers					Technique (Frontier)
	Scenario A	Scenario B	Scenario C	Higgs	Neutrinos	Dark Matter	Cosm. Accel.	The Unknown	
<b>Large Projects</b>									
Muon program: Mu2e, Muon g-2	Y, <small>Mu2e small reprofile needed</small>	Y	Y					✓	I
HL-LHC	Y	Y	Y	✓		✓		✓	E
LBNF + PIP-II	Y, <small>LBNF components delayed relative to Scenario B.</small>	Y	Y, enhanced		✓			✓	I,C
ILC	R&D only	R&D, <small>possibly small hardware contributions. See text.</small>	Y	✓		✓		✓	E
NuSTORM	N	N	N		✓				I
RADAR	N	N	N		✓				I
<b>Medium Projects</b>									
LSST	Y	Y	Y		✓			✓	C
DM G2	Y	Y	Y			✓			C
Small Projects Portfolio	Y	Y	Y		✓	✓	✓	✓	All



# Discussion Questions



## How should the dark matter community collaborate on LSST?

- What is the unique power of LSST as an instrument and community?
- How do we organize in the context of LSST?
- Do we need an organizational structure?
- How can we encourage/improve communication between theorists, simulators, observers, and experimentalists?
- Each sub-community (i.e., strong lensing, dwarfs, etc.) will have its own difficulties connected to LSST. How do we keep the larger picture in mind?
- How do we interact with existing science collaboration (e.g., DESC Dark Matter Working Group, the Strong Lensing Science Collaboration, the Stars, Milky Way, and Local Volume Science Collaboration)?
- How can we most effectively provide feedback to LSST (and get it listened to)?
- Are there opportunities to fund groups of PIs or teams of scientists?



# Discussion Questions



## What follow-up facilities/resources do we need to do our science?

- What facilities are necessary to accomplish our science?
- If we consider the dark sector more generally, what are the resources needed to respond to LSST discovery?
- Which of these are likely to get funded/built? Can we help make this happen?
- How can we best handle large programs (e.g., dozens of nights of 30m telescope time)? Key project?
- Does having an organized structure help with this goal?



# Discussion Questions



## How can our community make an impact in the Snowmass/Astro2020 process?

- What is our “ask”? Is it big or little? Is it focused on LSST, or other facilities?
- What is Snowmass? How does it differ from Astro2020? How does Snowmass relate to HEPAP and P5?
- What is the timeline of Snowmass (and Astro2020)?
- What can we as a community do to make a strong showing?
- How can we involve the DOE?
- Where do we belong in NSF (Phys, Astr, etc.)?
- Does having an organized LSST Dark Matter community help with these goals?
- What is our “ask”? Is it big or little?
- Need funding for scientists now, and during LSST operations. This is beyond Project and Operations funding.



# Discussion Questions



## What advances in simulation and/or theory are necessary for dark matter science?

- What is necessary to correctly interpret the data in the coming decade?
- What kind of computing time requirements are necessary?
- How do we distinguish baryonic effects from non-CDM model effects?
- What alternative dark matter models should be simulated: WDM, SIDM, ultralight bosonic dark matter, (what else)?
- How can we emulate/approximate simulations?
- Can we define a common language among the various dark matter probes? (e.g. consistent definition of a halo?)
- How can we encourage/improve communication between theorists, simulators, observers, and experimentalists?
- Simulators often select systems that are interesting/extreme; are flashy simulations what we really want?
- Can we “combine probes” for improved sensitivity?
- Does having an organized structure help with this goal?



# Discussion Questions



## What does dark matter discovery look like in the context of LSST?

- We already discovered dark matter -- how do we uncover the properties of dark matter?
- How would LSST contribute if there were a discovery from another experimental search (colliders, fixed target, direct detection, etc.)?
- Would the community believe a cutoff in the power spectrum?
- Will anyone believe halo profile suppression?
- How do we distinguish baryonic effects from non-CDM model effects?
- Would primordial black holes be separable from astrophysical black holes?
- Dark matter-dark energy cross correlations?
- We like to split dark energy and dark matter, but maybe we should ask what LSST can discover in the dark sector?



# LSST -> Vera Rubin Observatory (?)



Currently a bill going to the US Senate that would rename LSST...



14 **SEC. 3. DESIGNATION.**

15       The Large Synoptic Survey Telescope shall be known  
16 and designated as the “Vera C. Rubin Observatory”.

17 **SEC. 4. REFERENCES.**

18       Any reference in a law, map, regulation, document,  
19 paper, or other record of the United States to the facility  
1 described in section 3 shall be deemed to be a reference  
2 to the “Vera C. Rubin Observatory”.

<https://www.congress.gov/bill/116th-congress/house-bill/3196/text>



## Get Involved!



Basic Info: <https://lsstdarkmatter.github.io/>

Mailing List: [fill out this form](#)

LSSTC Slack: [#desc-dark-matter](#)

DESC: <https://lsstdesc.org/>

Continued in-person meetings (TBD)