Setting the Stage

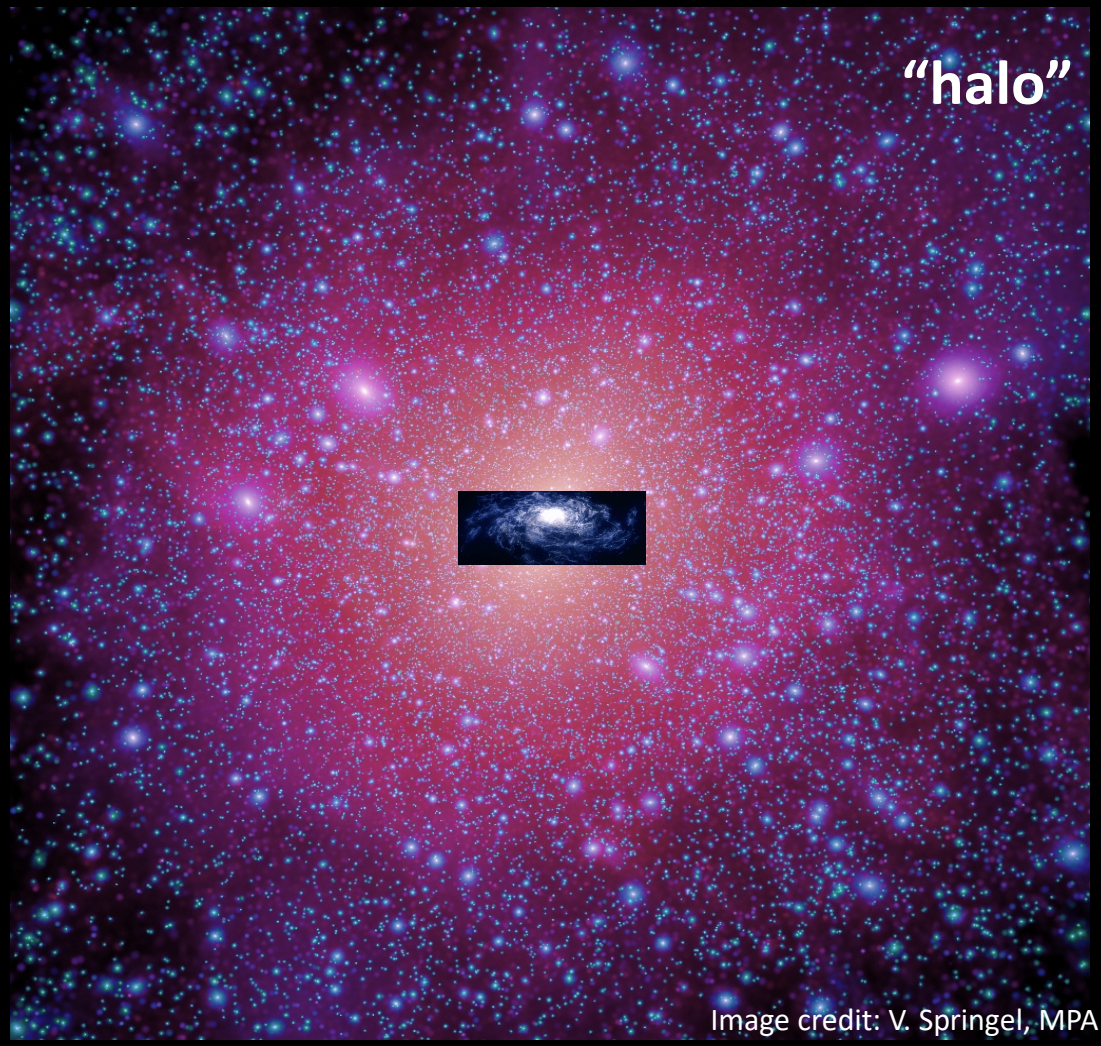


Image credit: V. Springel, MPA

Annika Peter

(+organizing committee)

Center for Cosmology and AstroParticle Physics

The Ohio State University

Ann E. Nelson (1958-2019)

Profile Name | Search

Help | 2019-08-05 13:52:00

Publications Datasets External

1. A Supersymmetric Theory of Baryogenesis and Sterile Sneutrino Dark Matter from B Mesons
2. Lattice-Friendly Gauge Completion of a Composite Higgs with Top Partners
3. Baryogenesis from B Meson Oscillations
4. Baryogenesis and Dark Matter from B Mesons
5. Composite Higgs Models with a Hidden Sector
6. Axion Cosmology with Early Matter Domination
7. Reducing the quadratic divergence in the Higgs boson mass squared without top partners
8. Dark halos around neutron stars and gravitational waves
9. Neutron stars exclude light dark baryons
10. Hidden-Sector Spectroscopy with Gravitational Waves from Binary Neutron Stars

Click here to see all

Welcome to Chicago!

What have we done so far?

https://lsstdarkmatter.github.io/

Workshops

The group has organized several workshops, which have been partially funded by a grant from the LSST Corporation Enabling Science Program. These workshops seek to organize the LSST dark matter community, and to coordinate efforts on the construction of a white paper on dark matter physics with LSST. Activity from previous workshop are summarized in a series of GitHub issues and tweets to #lsstdarkmatter.

- Probing the Nature of Dark Matter with LSST -- Kavli Institute of Cosmological Physics, August 5-7, 2019
- Probing the Nature of Dark Matter with LSST -- Lawrence Livermore National Laboratory, October 29-31, 2018
- Astrophysical Probes of Dark Matter with LSST -- LSST Project and Community Workshop, Tucson, AZ August 16, 2018
- Probing the Nature of Dark Matter with LSST -- University of Pittsburgh, March 5-7, 2018
- Dark Matter Science with LSST -- LSST Project and Community Workshop, Tucson, AZ August 16, 2017

What have we done so far?

https://lsstdarkmatter.github.io/

Products

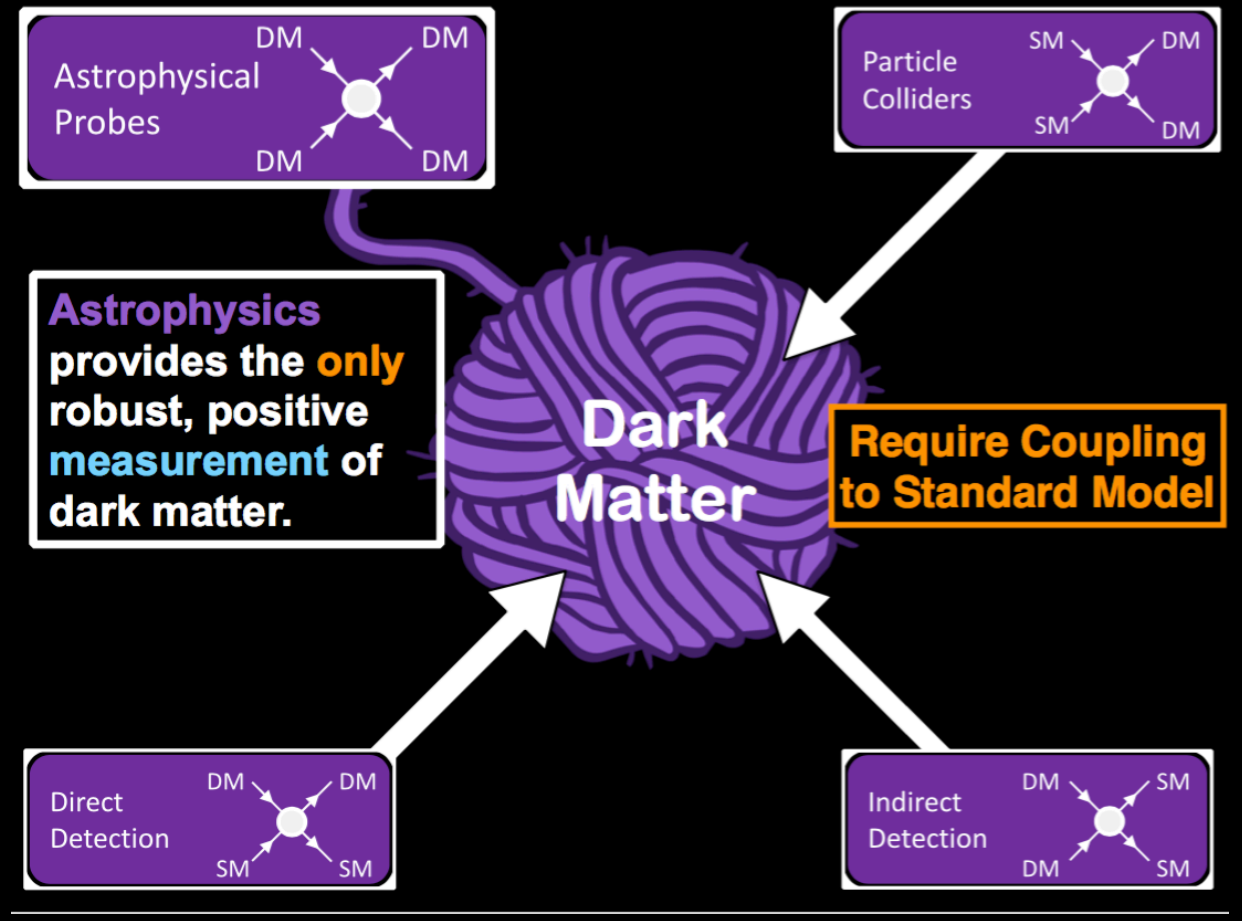
- **Dark Matter White Paper** -- One of the major efforts of the LSST dark matter group has been the preparation of a white paper detailing the fundamental probes of dark matter accessible to LSST. The latest version of the white paper can be found here.
- **Astro2020 White Paper** -- We plan to prepare a 5-page version of the white paper for submission to Astro2020. A draft of this paper can be accessed here.
- **Dark Matter Graphics** -- The landscape of astrophysical probes is complex and interconnected. We have assembled graphical representations of the LSST dark matter parameter space. This graphic is intended to help conceptually organize the LSST dark matter program and to serve as a road map for future scientific investigations. We encourage the addition of new components through this submission form.

Drlica-Wagner+ 1902.01055

Bechtol+ 1903.04425

Why do we keep meeting like this?

Dark matter astrophysics is compelling, and the future is bright.

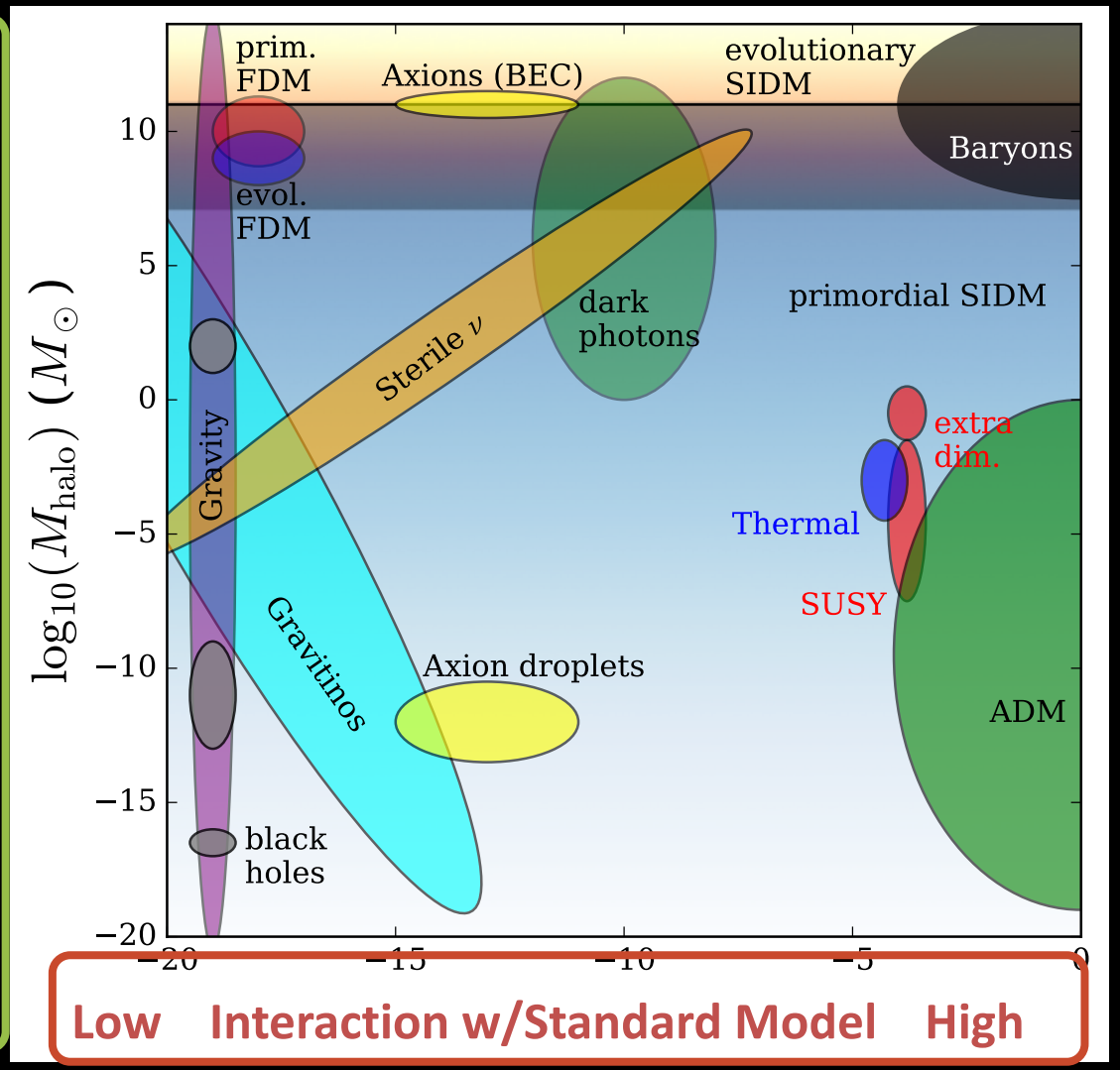


From Alex's talk at DPF last week

Why do we keep meeting like this?

Early-time effects (warmness, large de Broglie wavelength)—Halo abundance

Late-time effects (decays, self-interactions)—Halo shape

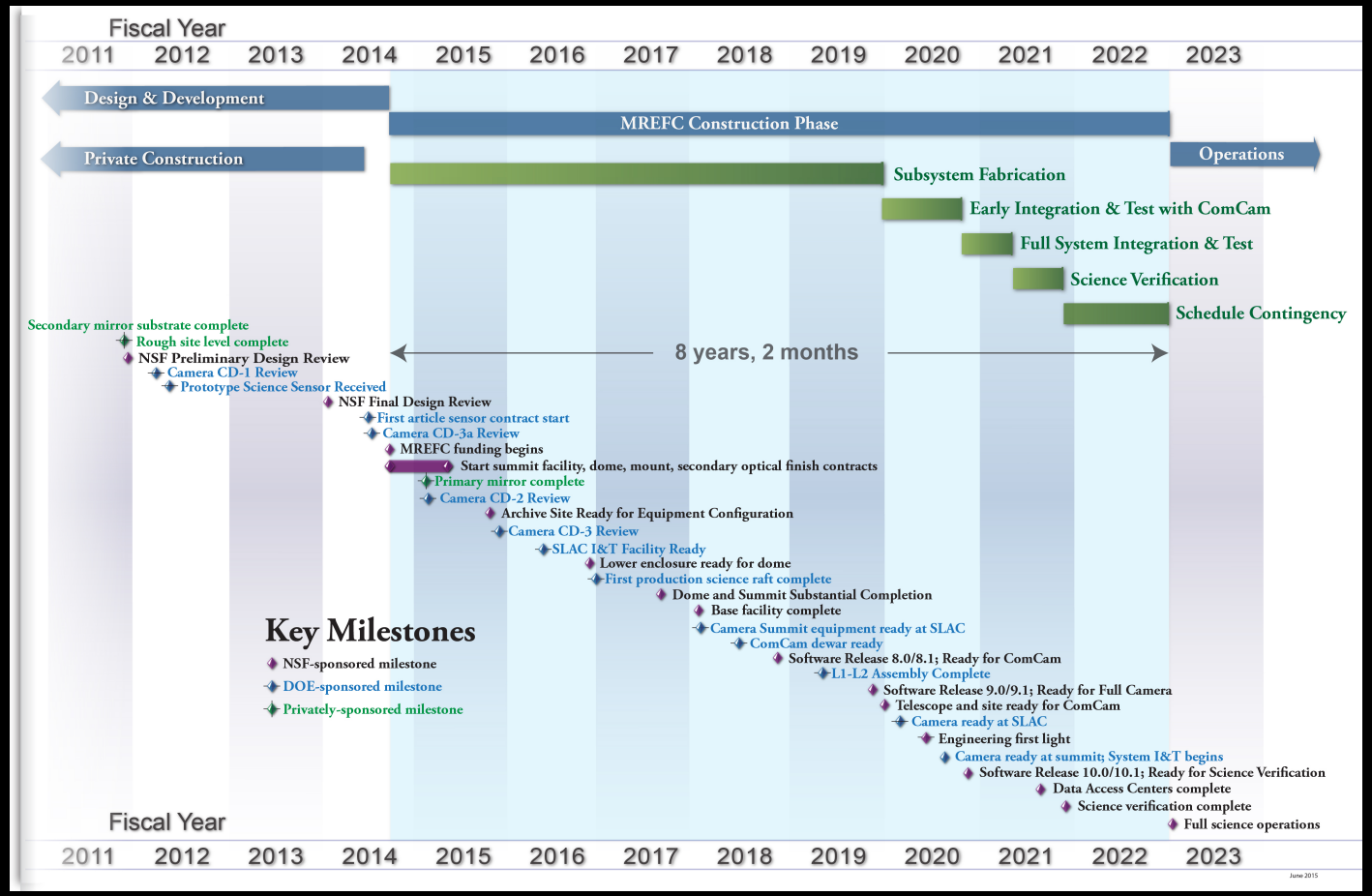


Buckley & AP, 1712.06615

Lab + astrophysics

LSST + theory + synergy w/facilities = power

…and coming soon!



LSST + theory + synergy w/facilities = power

LSST Key Numbers

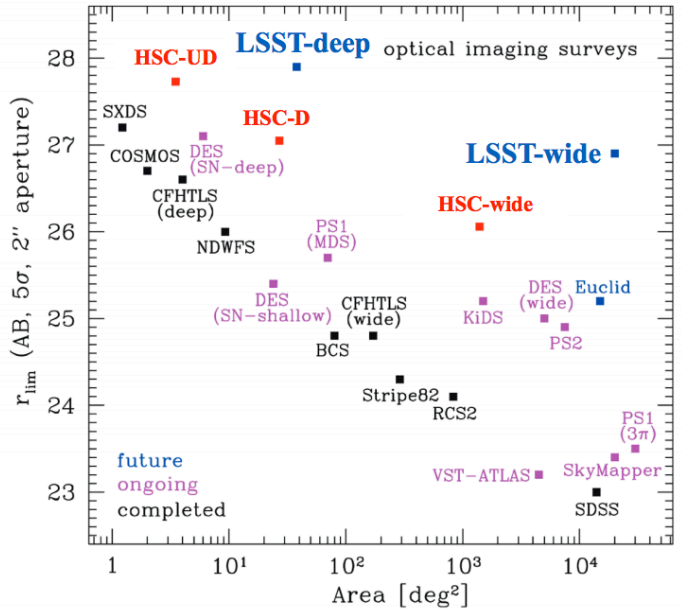
Survey:
- Telescope field of view = 9.6 deg²
- **Main survey area = 18,000 deg²**
- Filters = *ugrizy* (6)
- Visits per night = 1000
- Survey Duration = 10 yr
- Total visits per pointing = 825

Imaging depth:
- Single visit (*r*, S/N=5) = 24.7 mag
- **Stack depth (*r*, S/N=5) = 27.5 mag**

Expected number of objects:
- Galaxies = 20 billion
- Stars = 17 billion
- Sources (single-epoch) = 7 trillion
- Forced sources = 30 trillion

Alert production:
- Real-time alert latency = 60 sec
- Throughput = 10 million per night

Data (Data Release 11):
- Data collected per 24 hr = 20 TB
- Total image collection = 0.5 EB
- Database size = 15 PB

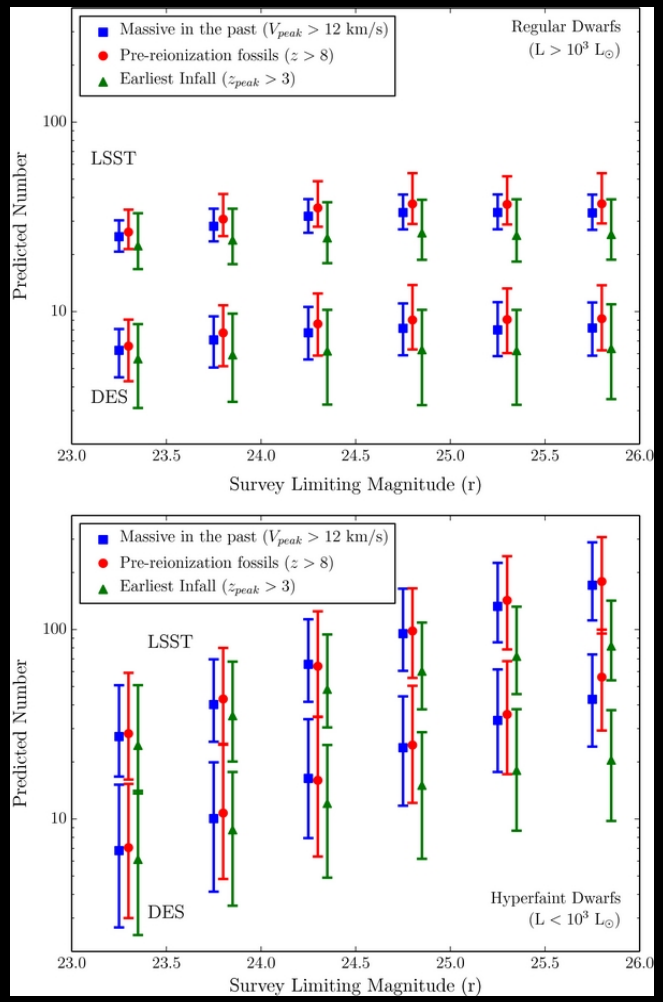


http://hsc.mtk.nao.ac.jp/ssp/wp-content/uploads/2016/05/hsc_ssp_rv_jan13.pdf 9

Keith's talk @NOAO Decadal Survey meeting

LSST + theory + synergy w/facilities = power

E.g., Milky Way satellite galaxies



Hargis, Willman, AP 2014

TABLE I. Completeness corrected satellite counts

	Predictions		
distribution	all sky	DES	LSST Year 1
NFW	124	11	56
SIS	157	13	69
ELVIS, stripped	139	13	65
D17	235	18	102
DMO + gal	250-503	20-28	109-198
DMO + gal + GK17	830-1740	49-69	335-614

Predictions for DES, when complete after year 5, and sensitive down to apparent magnitudes $V = 24.7$; and for LSST after year 1, down to $V = 26$.

Kim, AP, Hargis 2018

Short intro to science cases

Pathways to detection

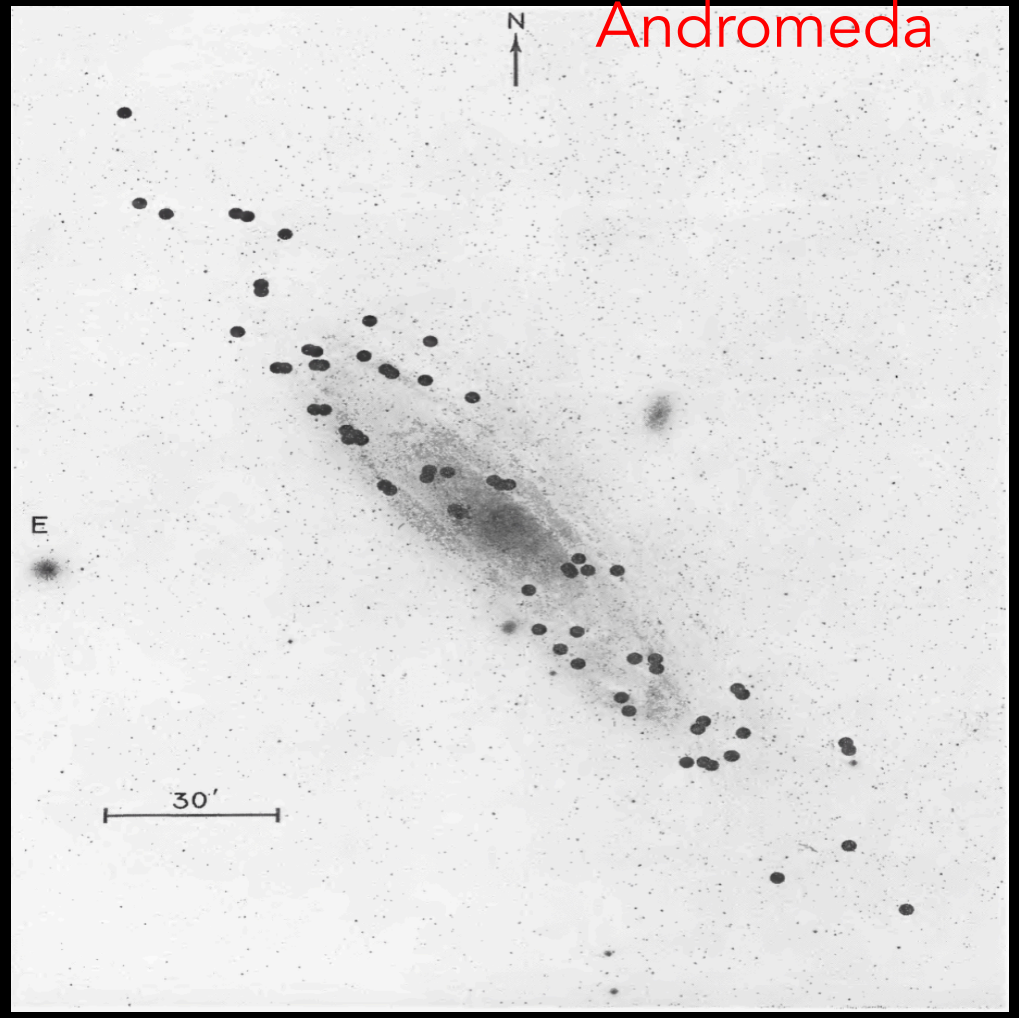
By measuring ***WHERE*** dark matter is, we measure ***WHAT*** it is.

Making stars act weird (i.e., anomalous cooling and/or destruction).

Discover individual macroscopic DM objects (e.g., primordial black holes)

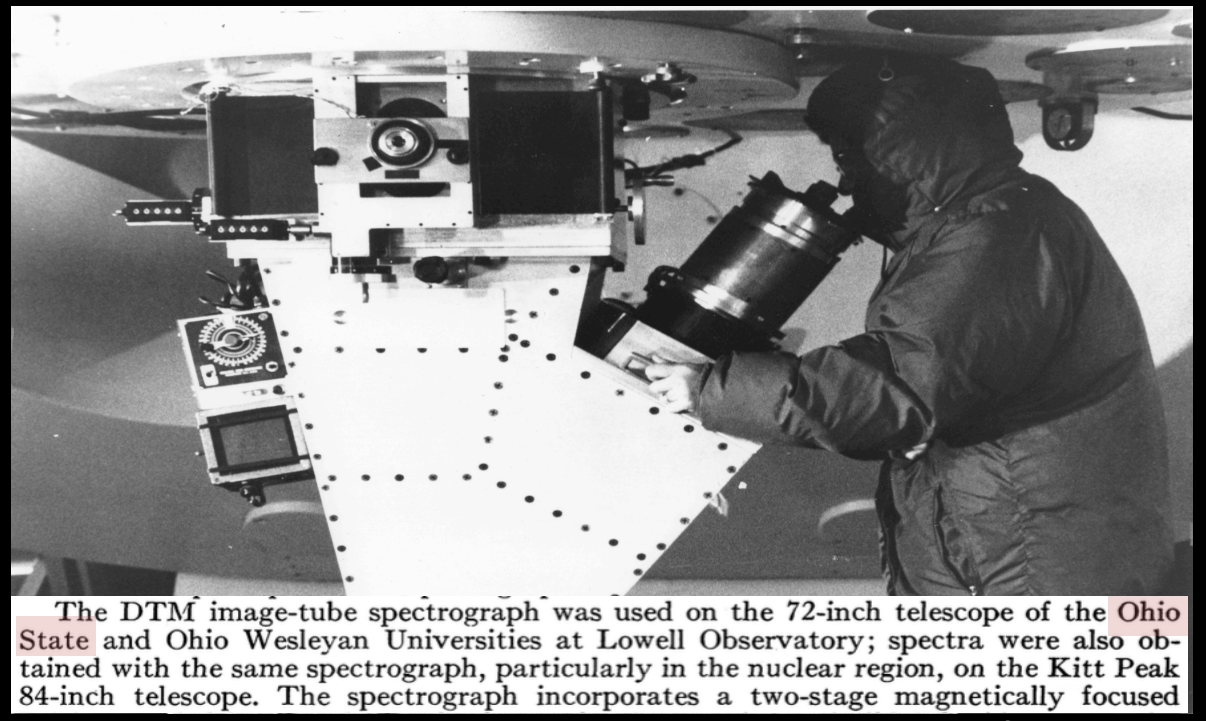
By measuring **where** it is, we find out **what** it is

Rubin & Ford 1970



Andromeda

Rubin w/Kent Ford's imaging spectrograph, Kitt Peak, 1970



The DTM image-tube spectrograph was used on the 72-inch telescope of the Ohio State and Ohio Wesleyan Universities at Lowell Observatory; spectra were also obtained with the same spectrograph, particularly in the nuclear region, on the Kitt Peak 84-inch telescope. The spectrograph incorporates a two-stage magnetically focused

Courtesy, American Institute of Physics

By measuring **where** it is, we find out **what** it is

SEC. 3. DESIGNATION.

The Large Synoptic Survey Telescope shall be known and designated as the "Vera C. Rubin Observatory".

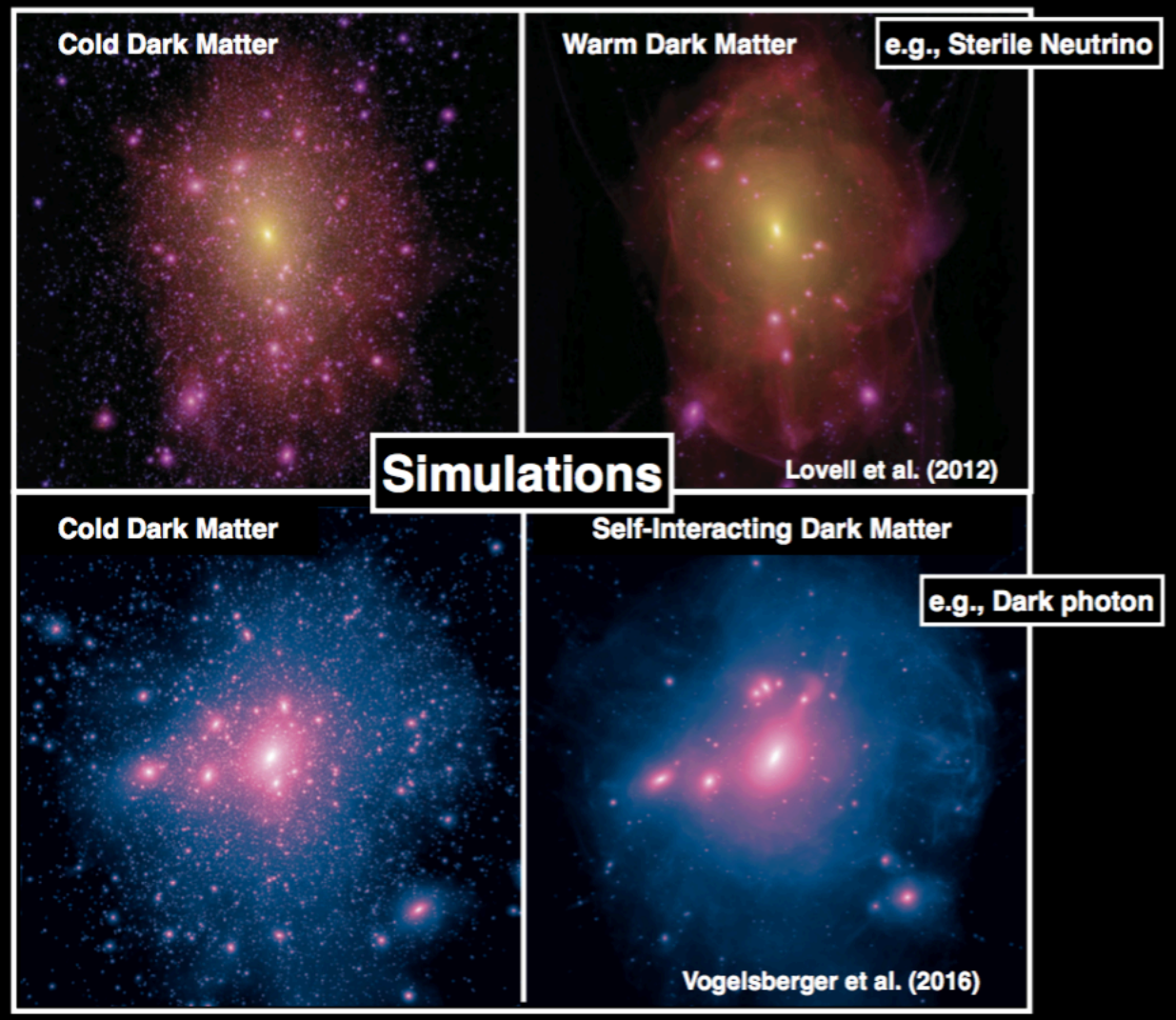
SEC. 4. REFERENCES.

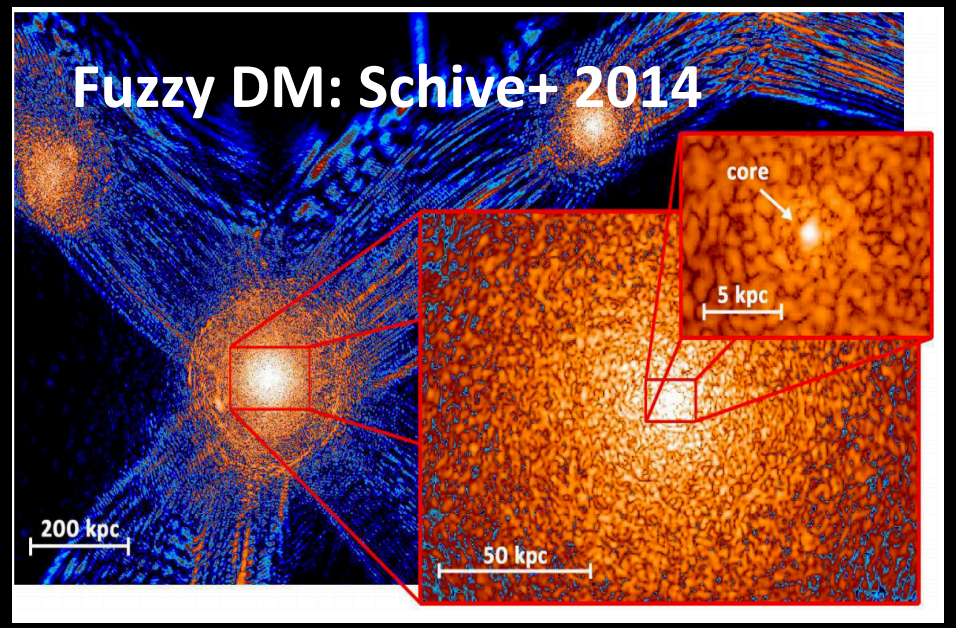
Any reference in a law, map, regulation, document, paper, or other record of the United States to the facility described in section 3 shall be deemed to be a reference to the "Vera C. Rubin Observatory".

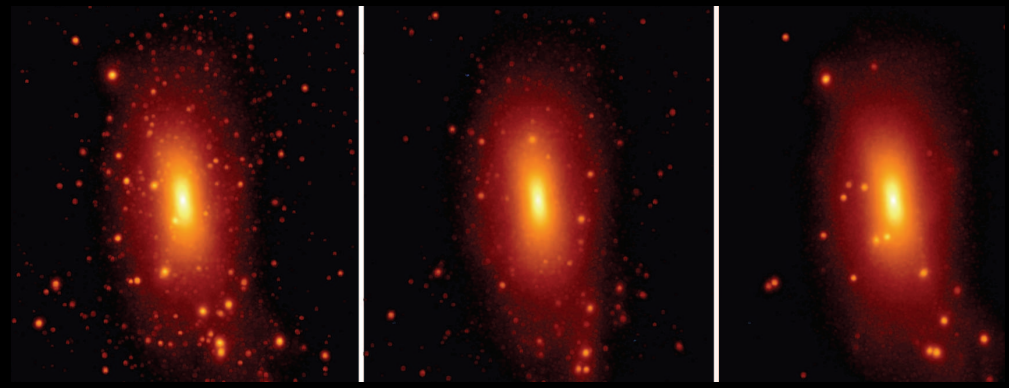
Amend the title so as to read: "A bill to designate the Large Synoptic Survey Telescope as the 'Vera C. Rubin Observatory'.".

Via Keith

By measuring **where** it is, we find out **what** it is



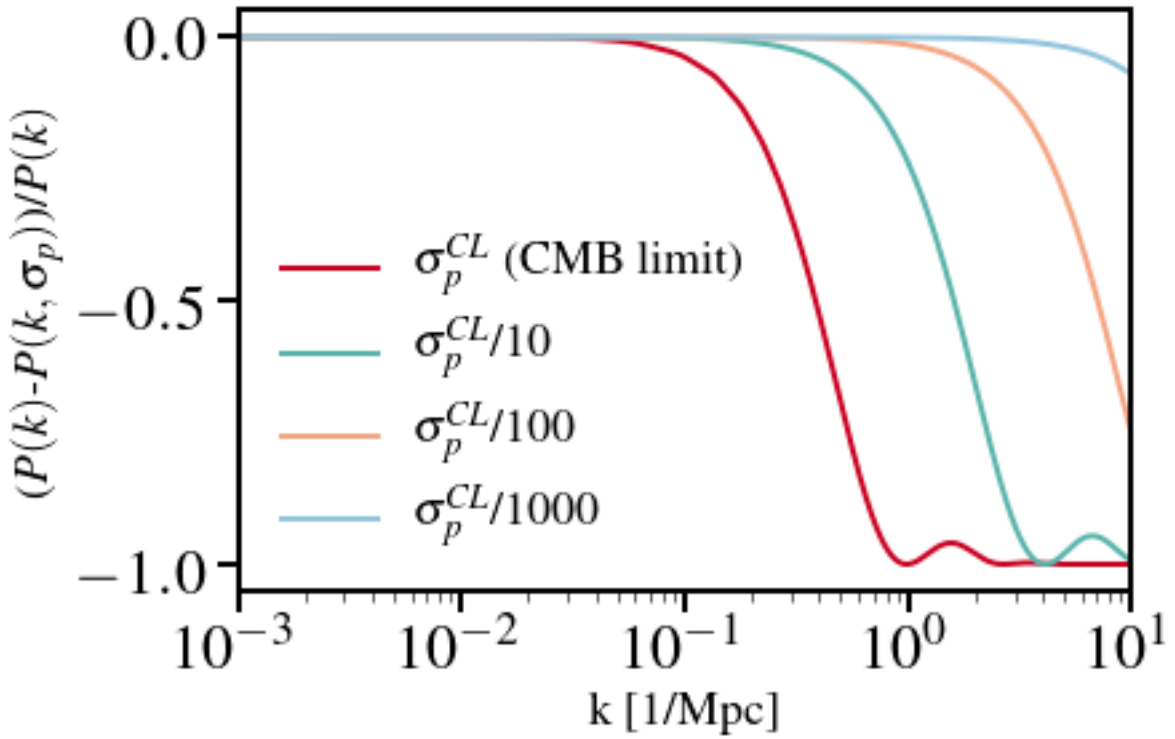


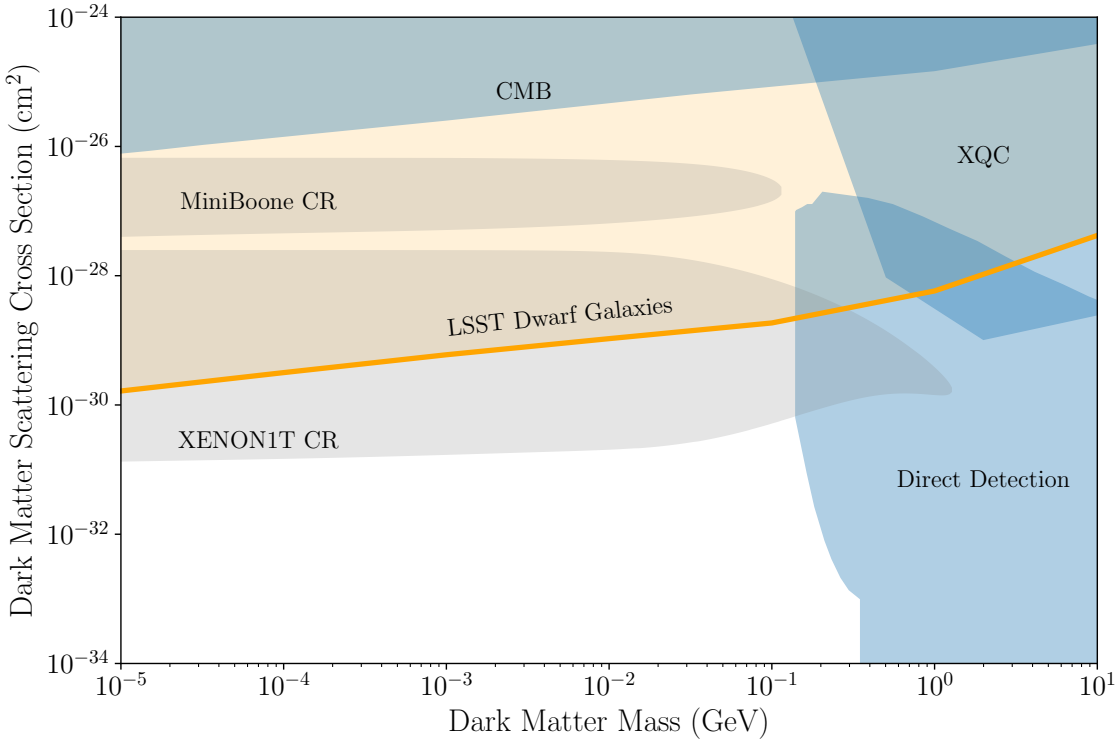


Decaying DM; Wang,Strigari, AP+ 2014

By measuring **where** it is, we find out **what** it is

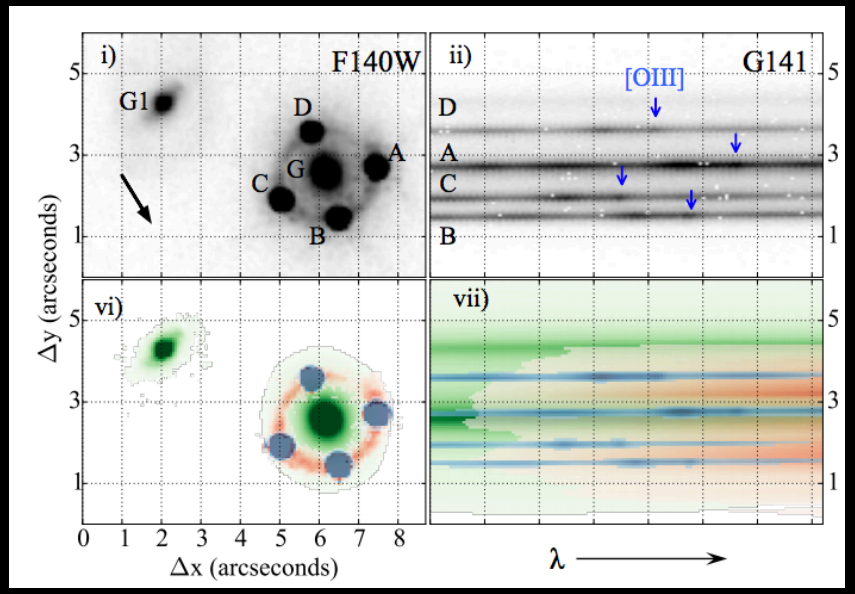
Structure also affected by DM interactions w/baryons!



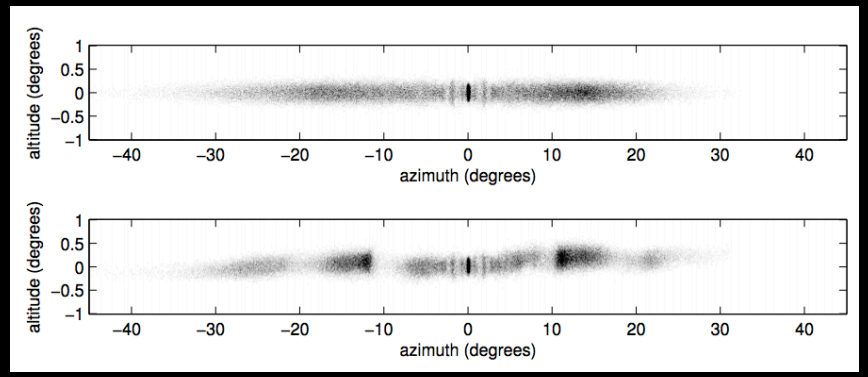


Nadler+ 1904.10000, LSST Dark Matter giant white paper

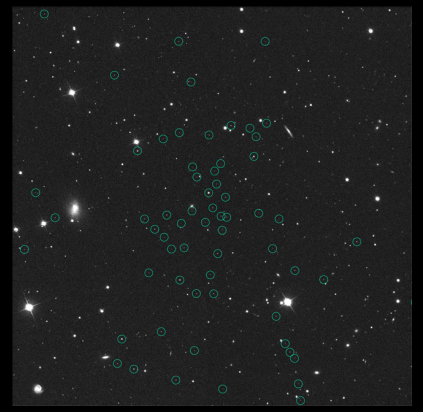
By measuring **where** it is, we find out **what** it is



Anna Nierenberg,..,AP,+ 1701.05188

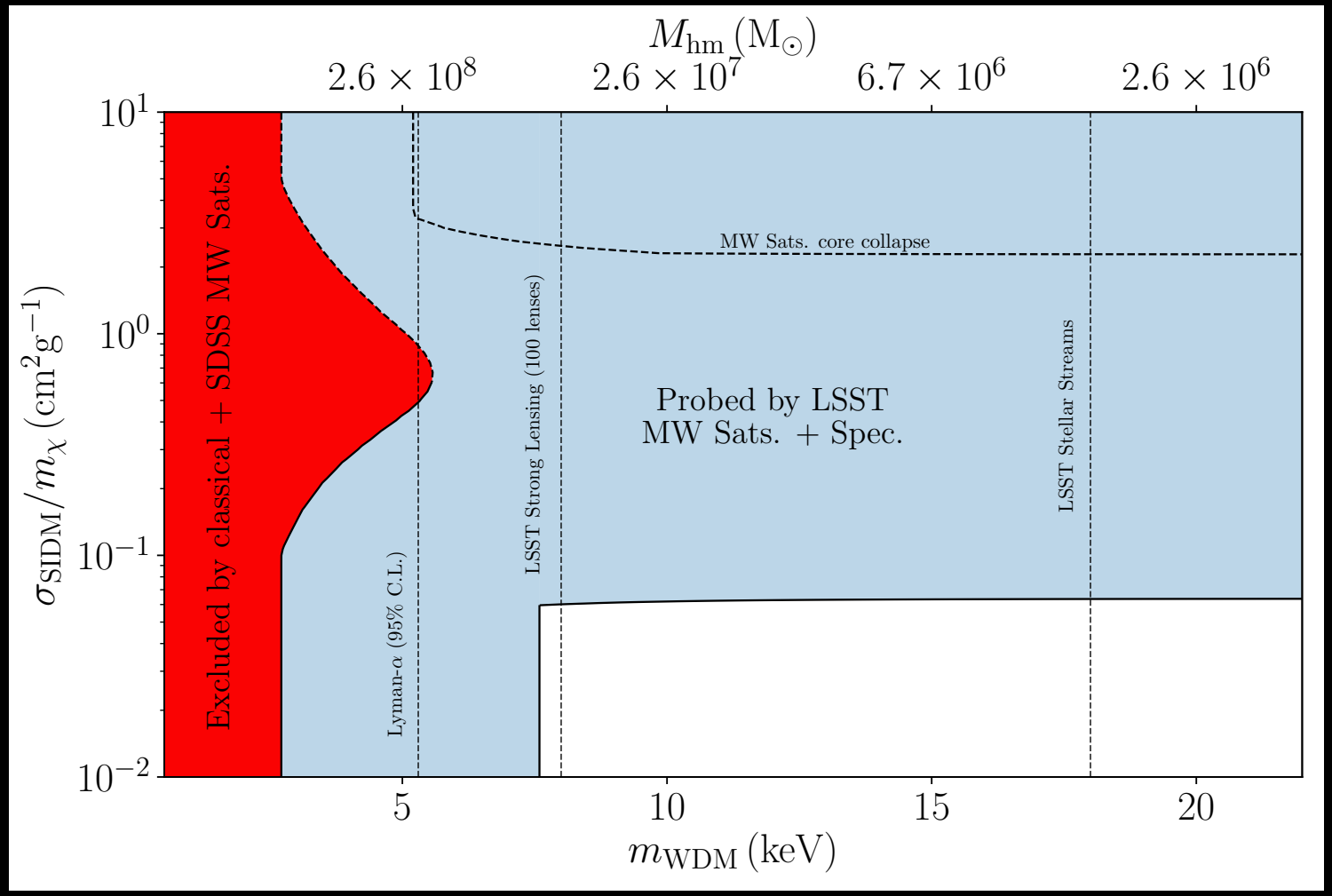


Carlberg & Johnston 2016



Segue I
(image credit: M. Geha)

By measuring **where** it is, we find out **what** it is



Giant LSST DM white paper

Pathways to detection

By measuring ***WHERE*** dark matter is, we measure ***WHAT*** it is.

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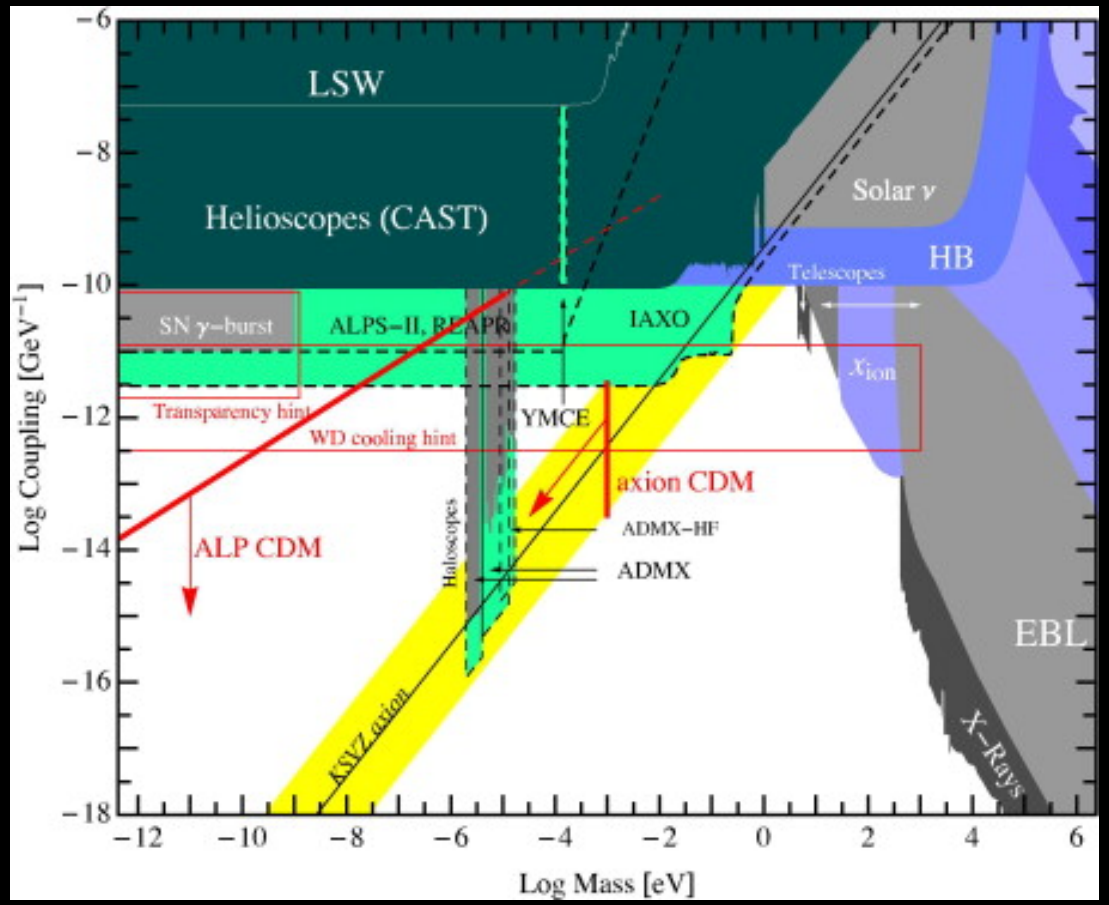
Discover individual macroscopic DM objects (e.g., primordial black holes)

Anomalous energy transport in/from stars

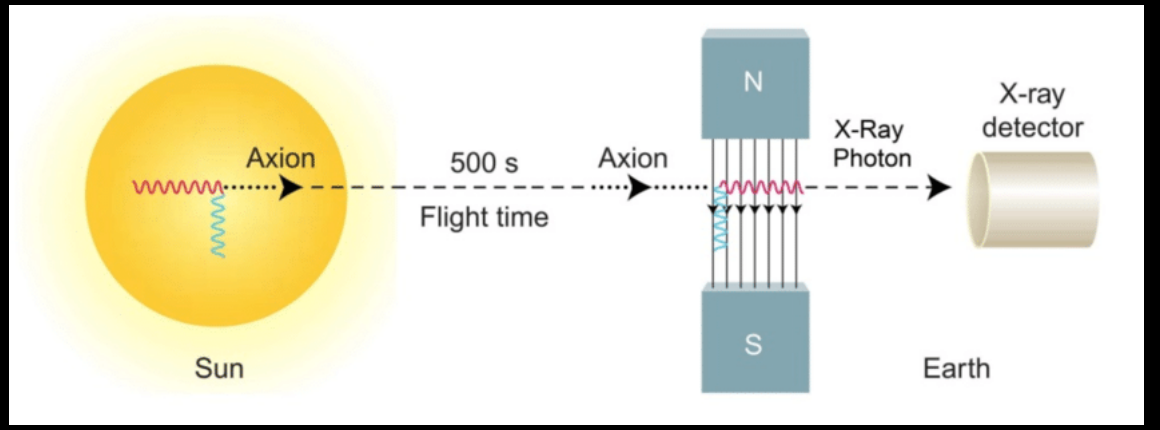
- This direction is only possible because of major advances by stellar astrophysicists, nuclear physicists, and observational facilities (e.g., Kepler)
- (We should keep this in mind---as astronomical objects are better understood, it shrinks or at least changes the morphology of new physics windows)

Axions and the Sun

Sikivie 1983



From Drlica-Wagner+ LSST DM paper 1902.01055

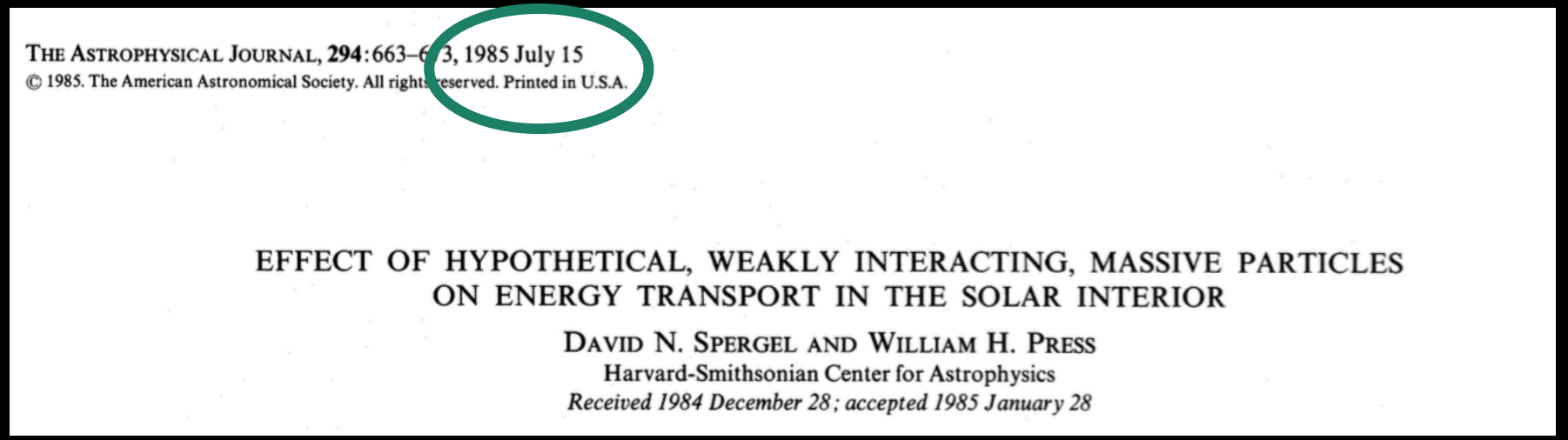


http://www.int.washington.edu/talks/WorkShops/int_12_50W/People/Ruz_J/Ruz.pdf

See also: white dwarf cooling curves (LSST DM giant paper)

Supernova rates also constrain anomalous energy loss.

Plain old WIMPs: main-sequence stars

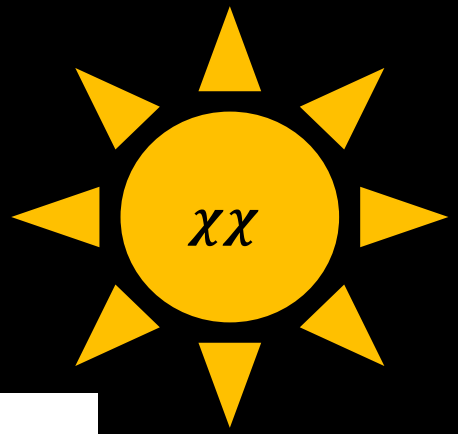


THE ASTROPHYSICAL JOURNAL, 294:663–6[illegible]3, 1985 July 15

EFFECT OF HYPOTHETICAL, WEAKLY INTERACTING, MASSIVE PARTICLES ON ENERGY TRANSPORT IN THE SOLAR INTERIOR

DAVID N. SPERGEL AND WILLIAM H. PRESS
Harvard-Smithsonian Center for Astrophysics
Received 1984 December 28; accepted 1985 January 28

Plain old WIMPs: main-sequence stars



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DAVID N. SPERGEL AND WILLIAM H. PRESS
Harvard-Smithsonian Center for Astrophysics
Received 1984 December 28; accepted 1985 January 28

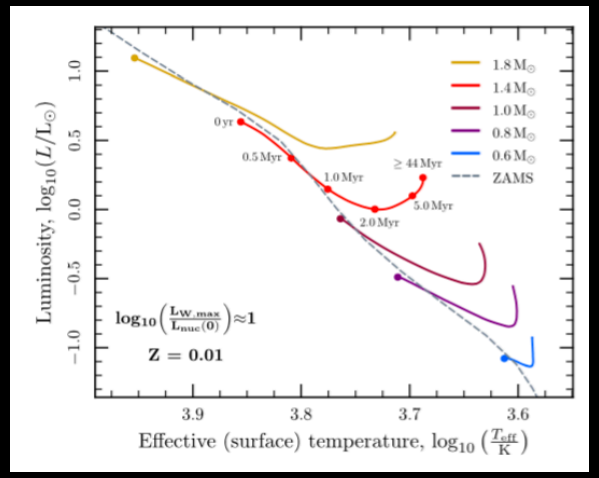
1. It's a trap!: capture by elastic scattering.
2. Energy injection (annihilation).
3. Extra source of heat conduction (can be non-local).

Plain old WIMPs: main-sequence stars

Everything old is new again.

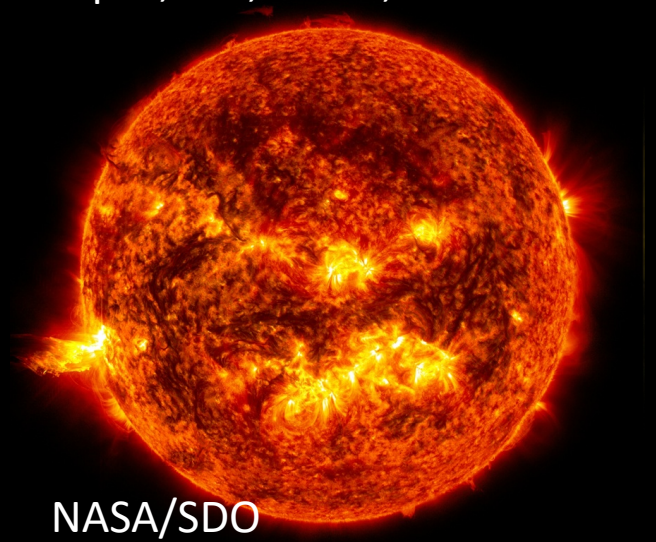
Galactic Center

Scott+ 0809.1871



Asymmetric DM+ Sun

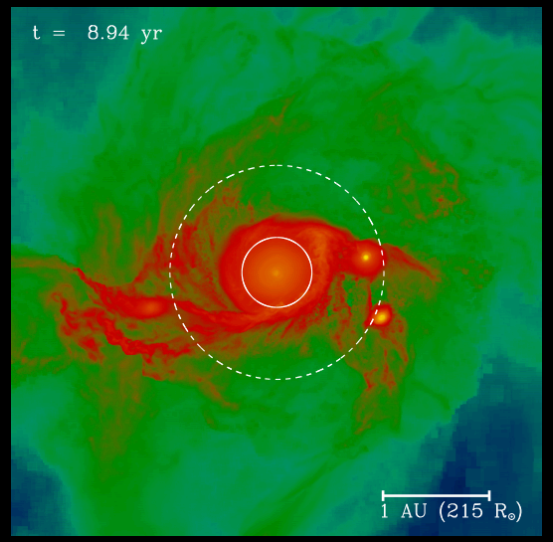
Lopes, Silk, Taoso, Zentner



NASA/SDO

First stars

Freese, Bromm, Gondolo…



Stacy+ 2013

Pathways to detection

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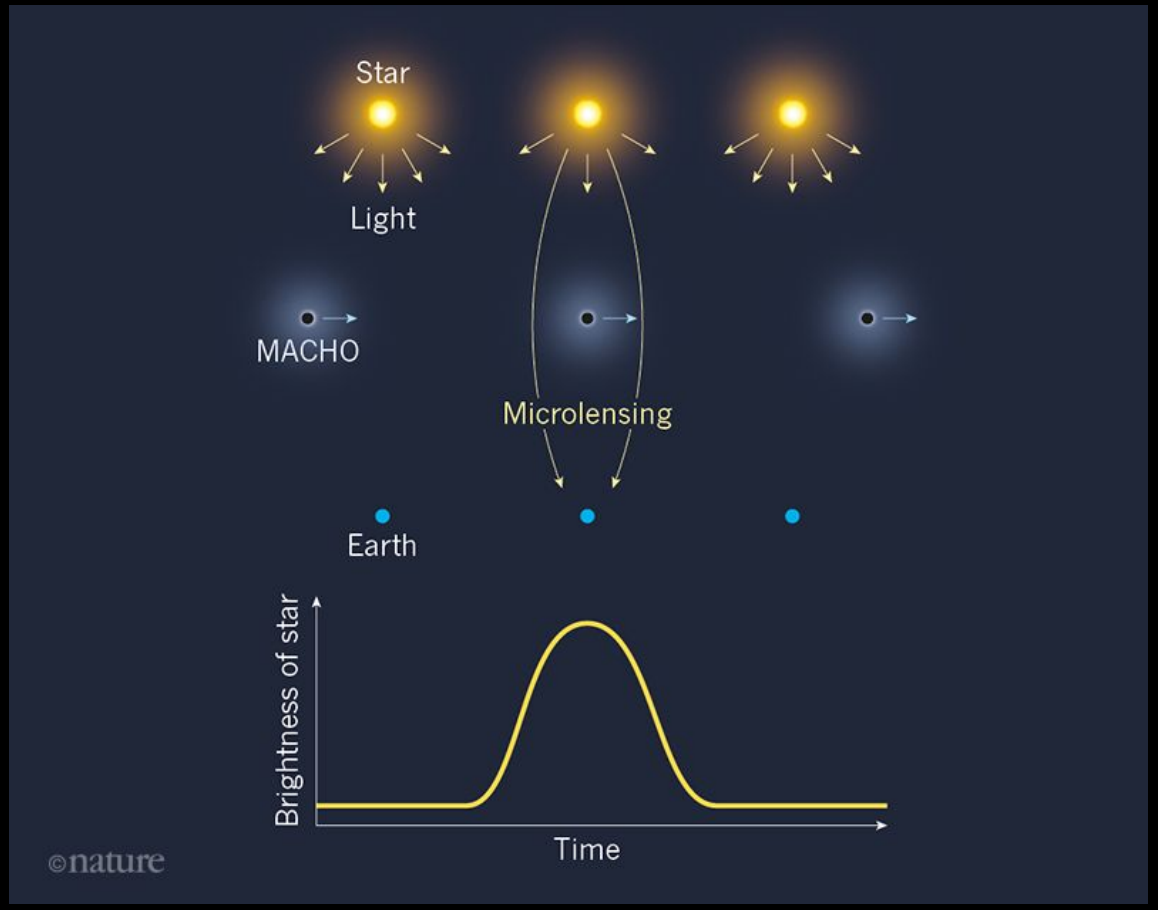
Macroscopic dark matter

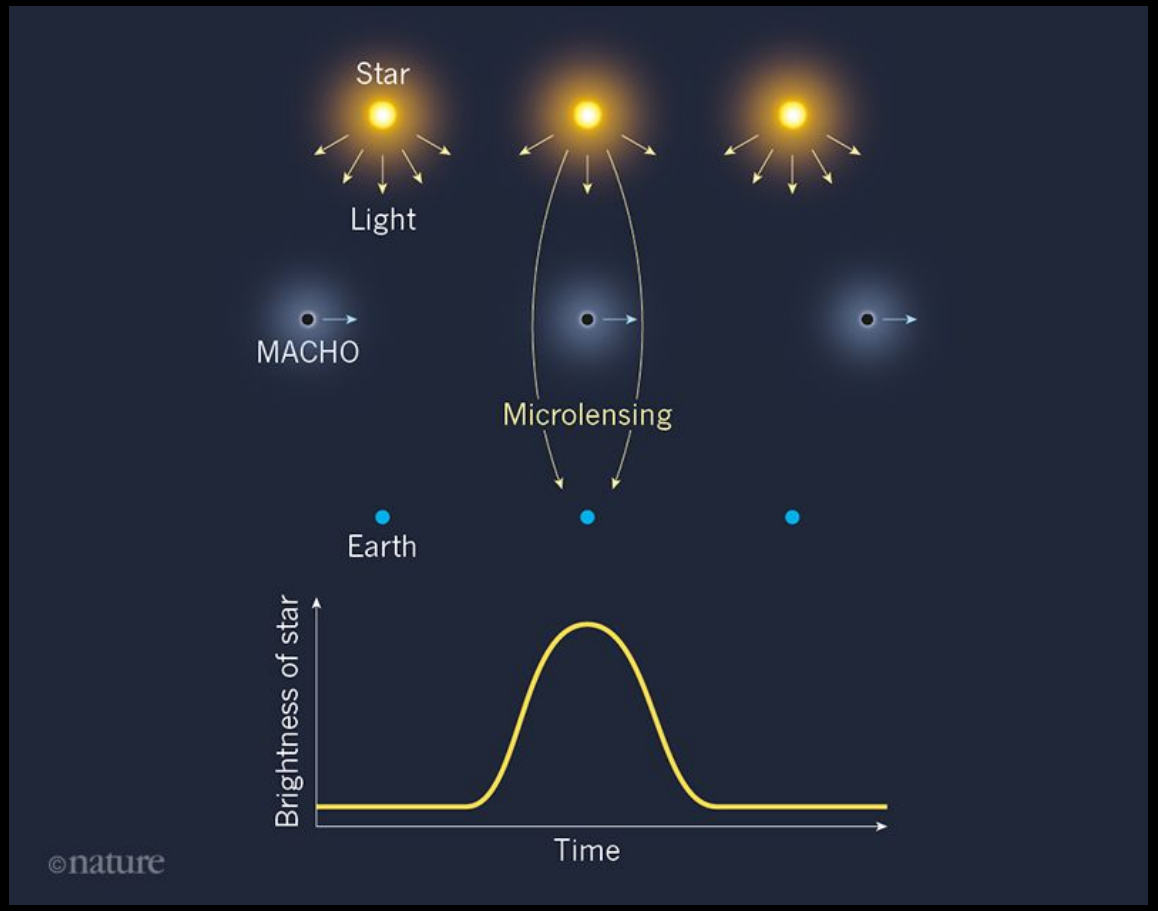
Alcock+ 1993, Augbourg+ 1993 MACHO, EROS, OGLE



https://www.nature.com/articles/d41586-018-07006-8#ref-CR5

Macroscopic dark matter

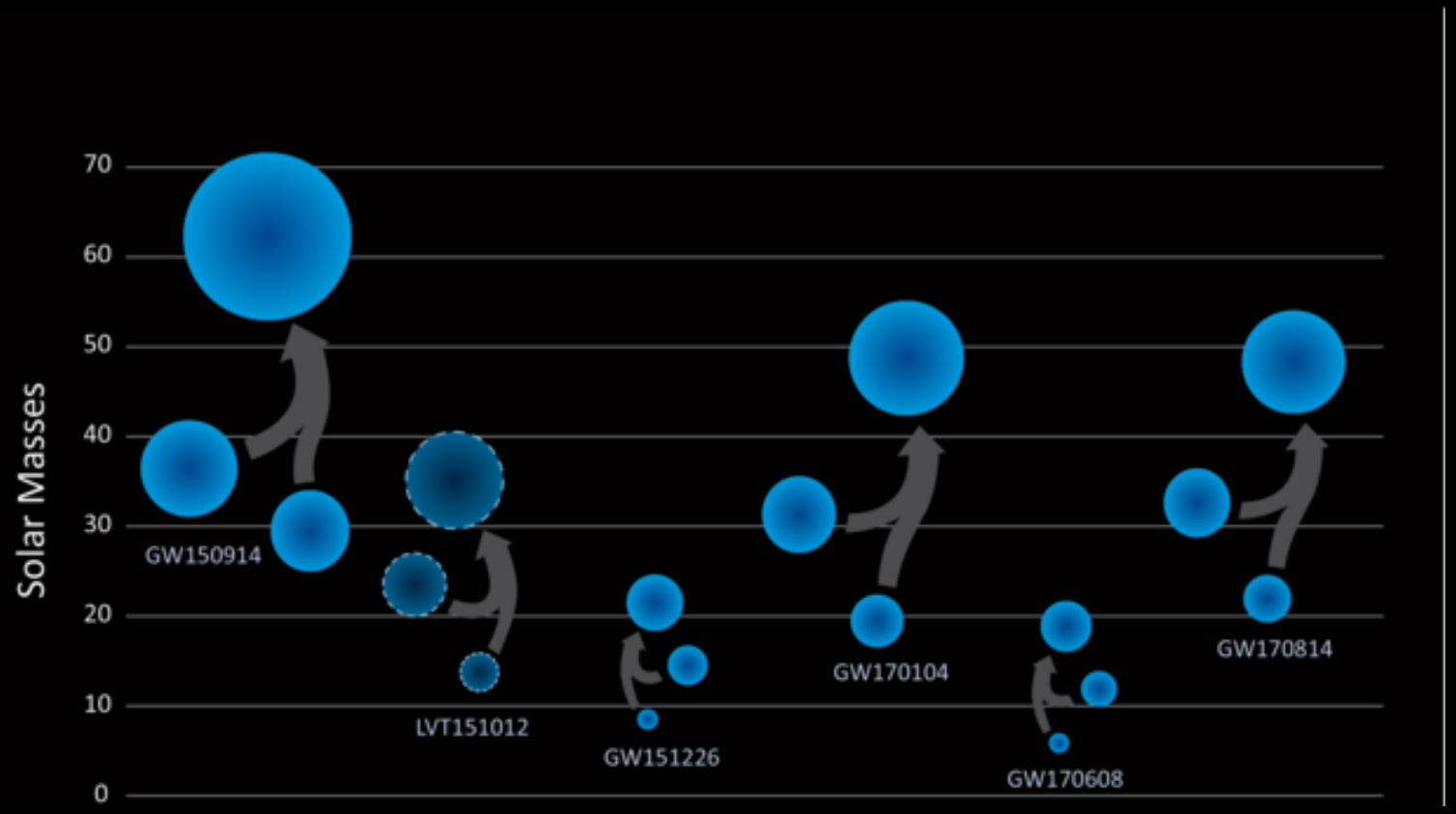
Alcock+ 1993, Augbourg+ 1993



MACHO, EROS, OGLE

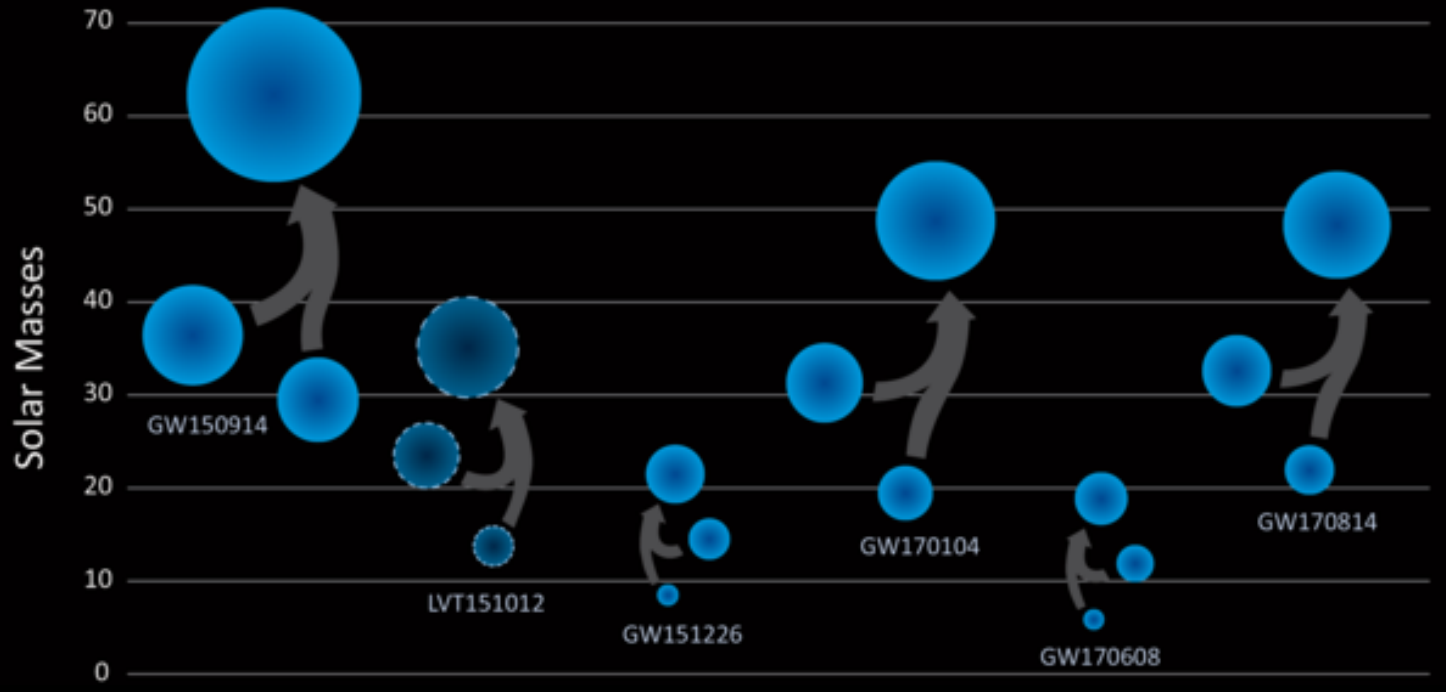
https://www.nature.com/articles/d41586-018-07006-8#ref-CR5

Macroscopic dark matter



LIGO collaboration 2017

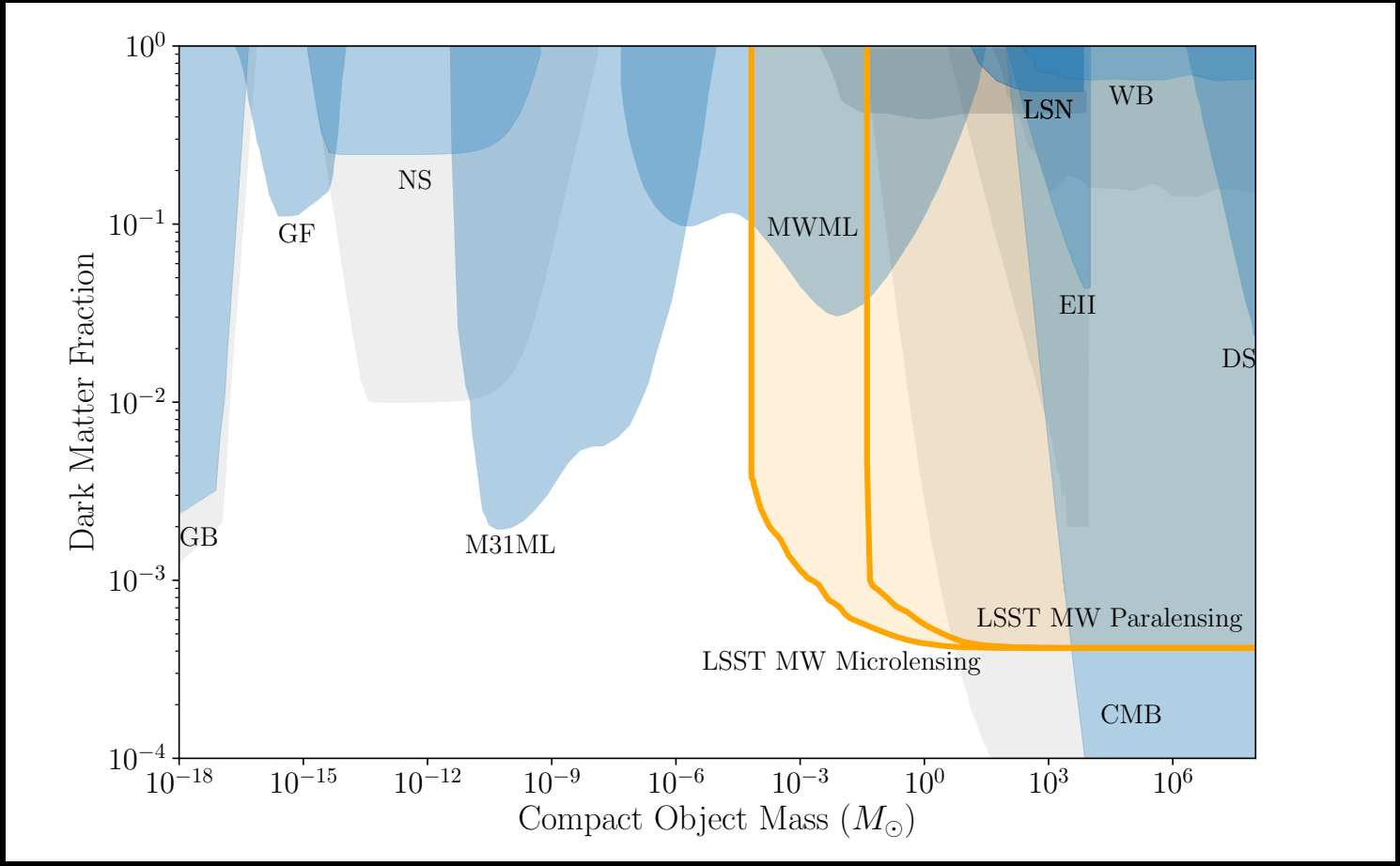
Macroscopic dark matter



LIGO collaboration 2017

Season 10/11 (after a LONG hiatus)

Limits/constraints



Giant LSST DM paper

What do we do and how do we do it?

- What kinds of science will be enabled by LSST?
- What planning work (theory, building synergies with other experiments, analysis tools) do we need to do to be ready?
- How do we fit within the LSST community?
- How do we get ourselves funded?
- How do we fit into the 2020 decadal survey and the next Snowmass?
- More broadly, how to raise visibility in the particle and astronomy communities? (like in the Basic Research Needs (BRN): Dark Matter Small Projects New Initiatives)

This week

- Hearing about the “whys” and the “hows” of doing dark-matter science w/LSST!
- Community organization!

Participation

The LSST dark matter group encourages broad participation from the dark matter community, including cosmologists, astrophysicists, and particle physicists. Experimentalists, observers, and theorists are all welcome. We encourage the participantion from early career scientists and scientists with diverse backgrounds.

If you are interested in joining the LSST Dark Matter effort, please fill out this form to join our mailing list. If you are already a member of the LSST Project or Science Collaborations, you can join our effort on the LSSTC Slack at #desc-dark-matter.

https://lsstdarkmatter.github.io/