

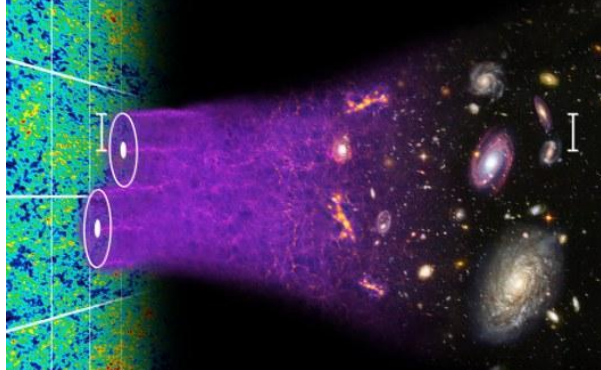
# Particle-Astrophysics Experiments at SLAC: *Fall 2018 Graduate Student Orientation*

Tom Shutt

SLAC National Accelerator Laboratory  
Kavli Institute for Particle Astrophysics & Cosmology  
Stanford University

# Standard cosmology: An inventory of the universe

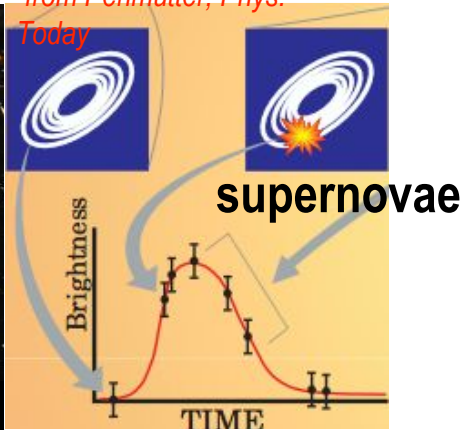
SDSS-III / BOSS



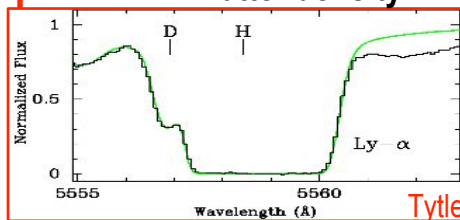
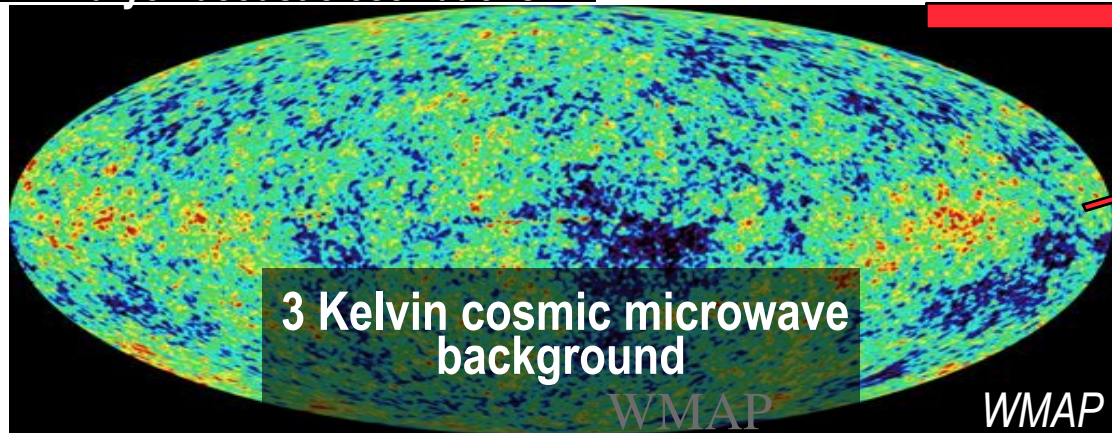
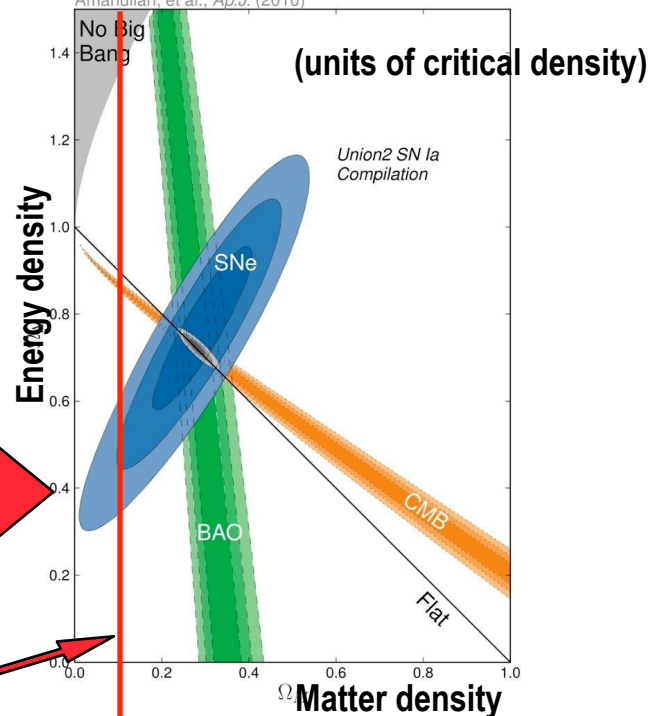
Baryon acoustic oscillations

from Perlmutter, Phys.

Today



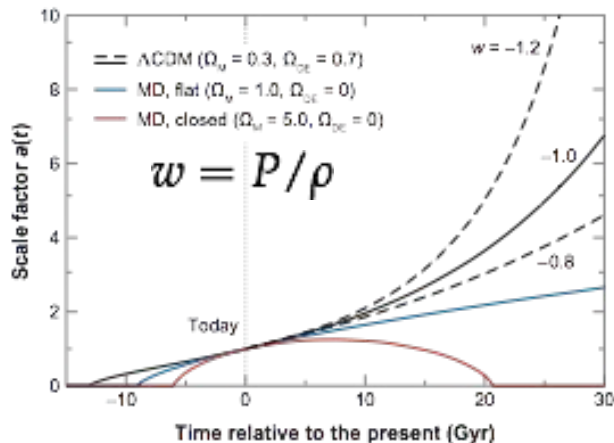
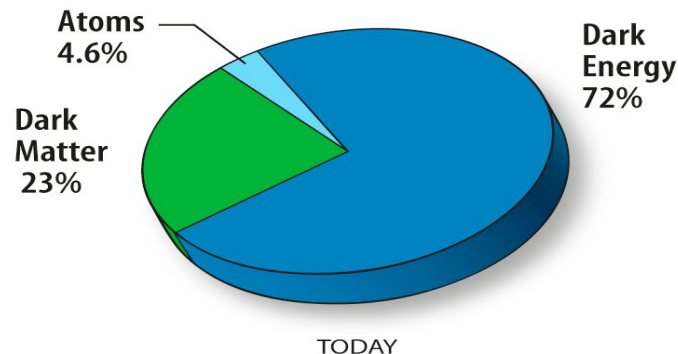
Supernova Cosmology Project  
Amanullah, et al., *Ap.J.* (2010)



Tytler & Burles

# Fate of the Universe?

- What is Dark Energy?
  - a Cosmological Constant?
  - a Quantum Field?
  - Or does General Relativity need to be modified?

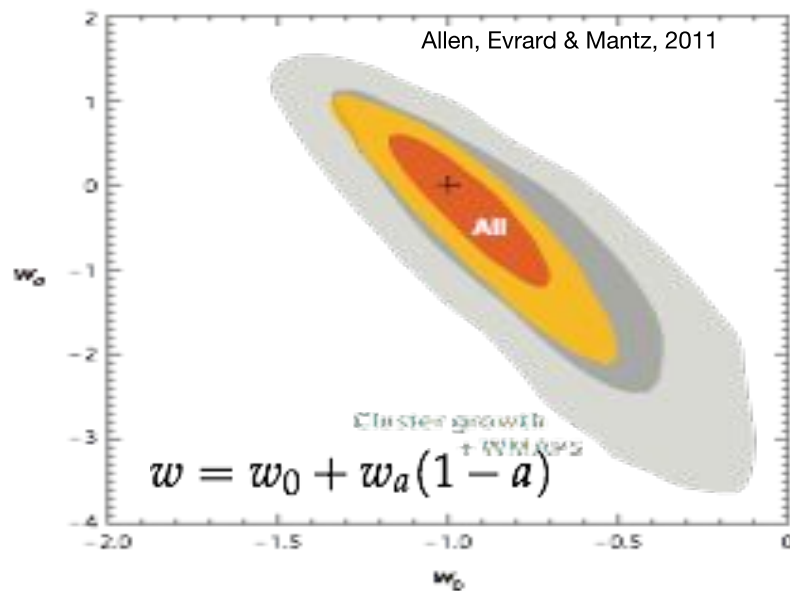
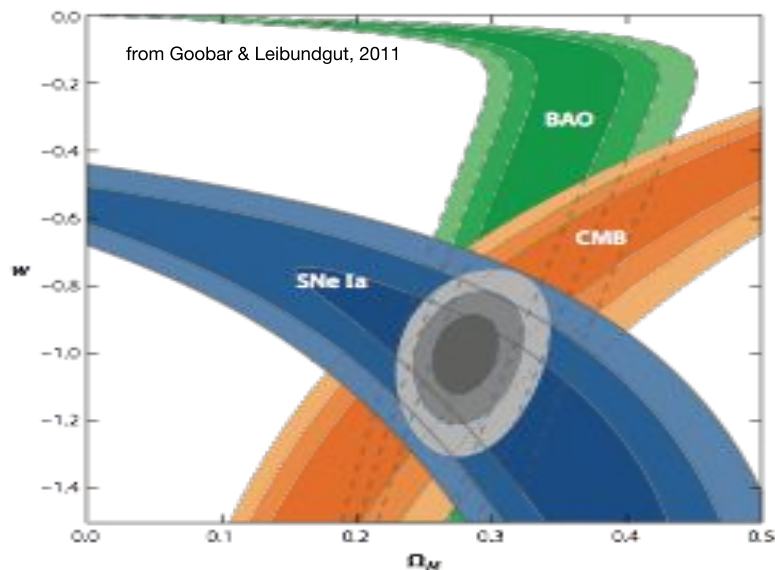


Rip Apart  
Space-Time  
Expand Forever

# Study Dark Energy with Multiple Methods

Complementary techniques, including:

- The mass function and clustering of **Galaxy Clusters**
- The power spectrum of **Weak Gravitational Lensing** shear
- The statistical distance scale in the galaxy distribution, the **Baryon Acoustic Oscillations**
- The distance-brightness relation of **Type Ia Supernovae**





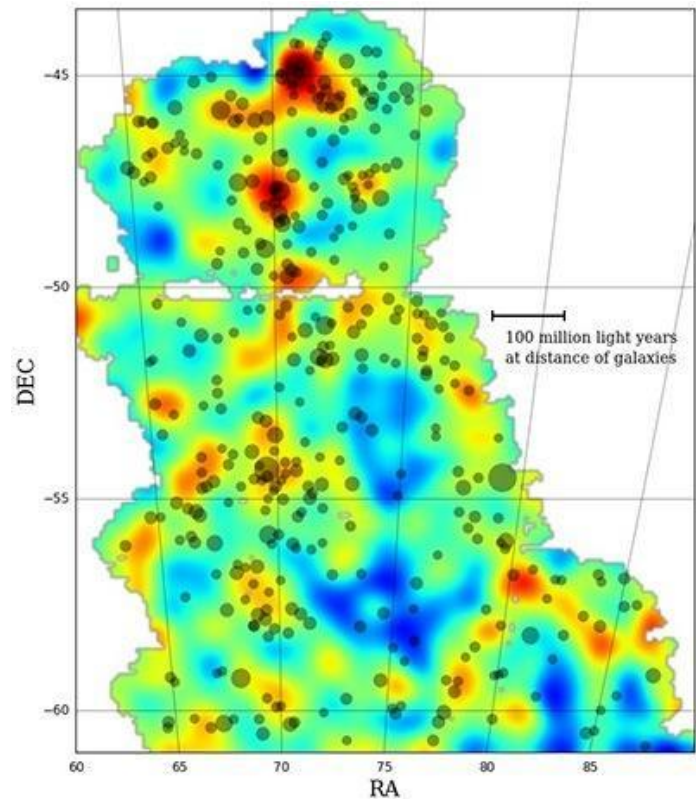
# Dark Energy Survey



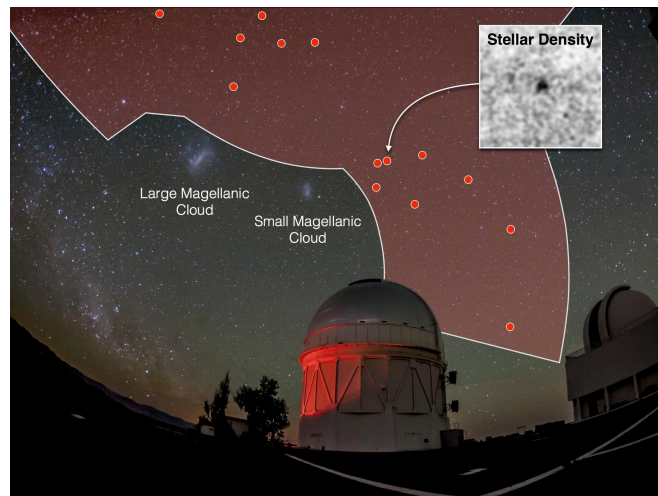
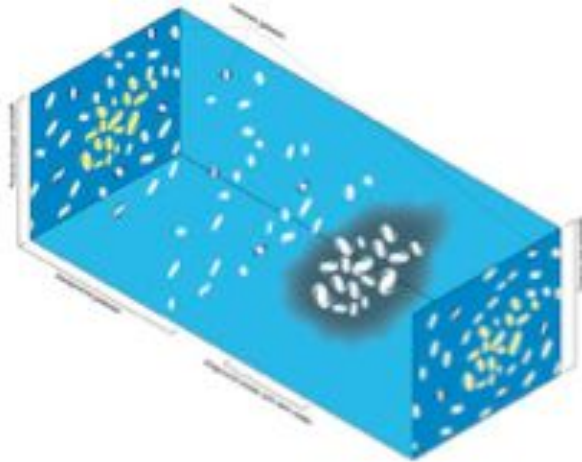
**570-megapixel imaging device**

Completing final year of 5 Yr Survey

# Dark Energy Survey



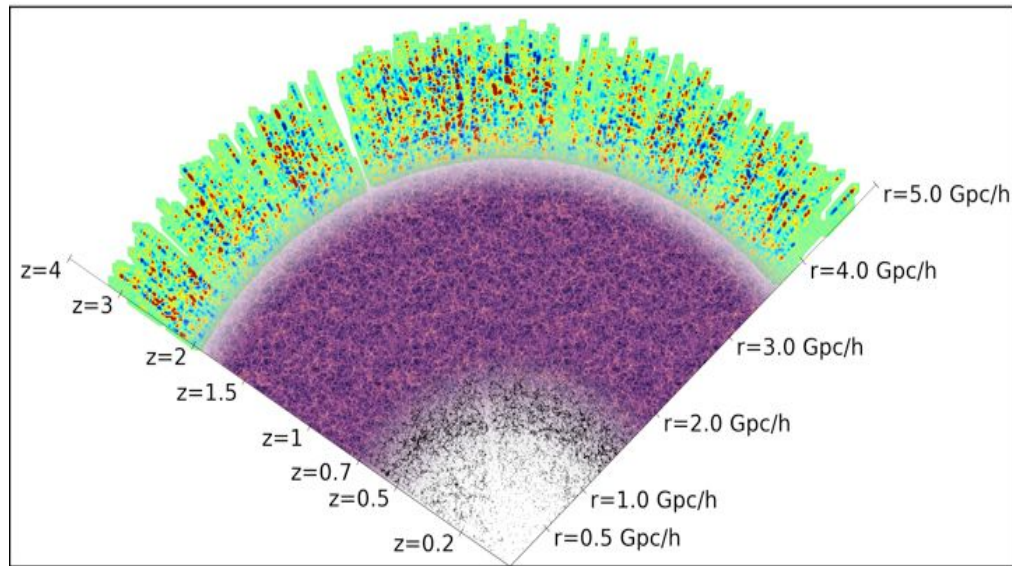
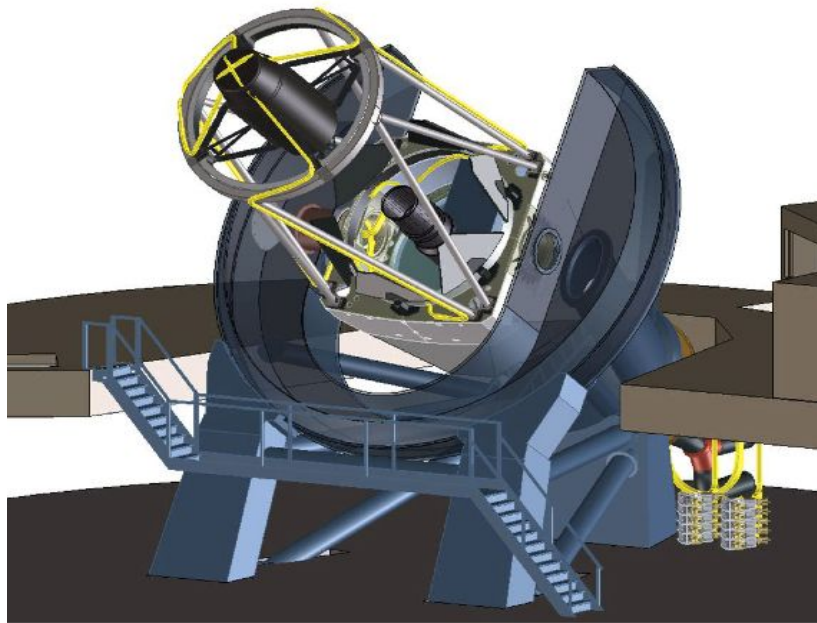
dark matter maps



dwarf galaxy candidates

# DESI: Dark Energy Spectroscopic Instrument

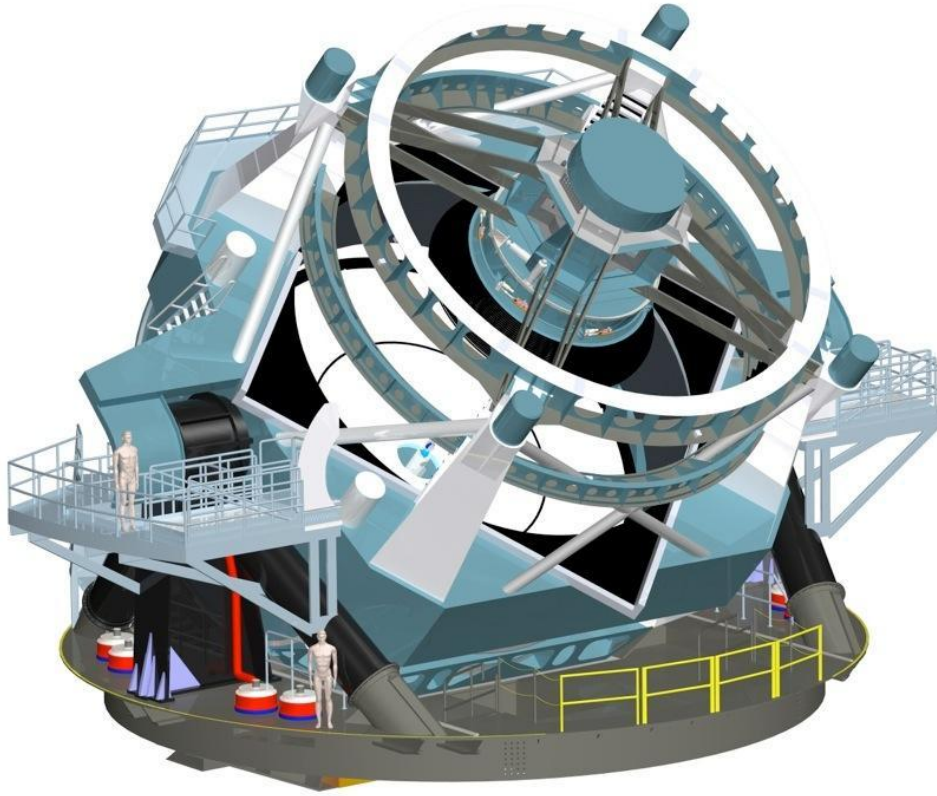
First light: 2019.



Complements LSST - fewer objects (20M) / better *redshift*

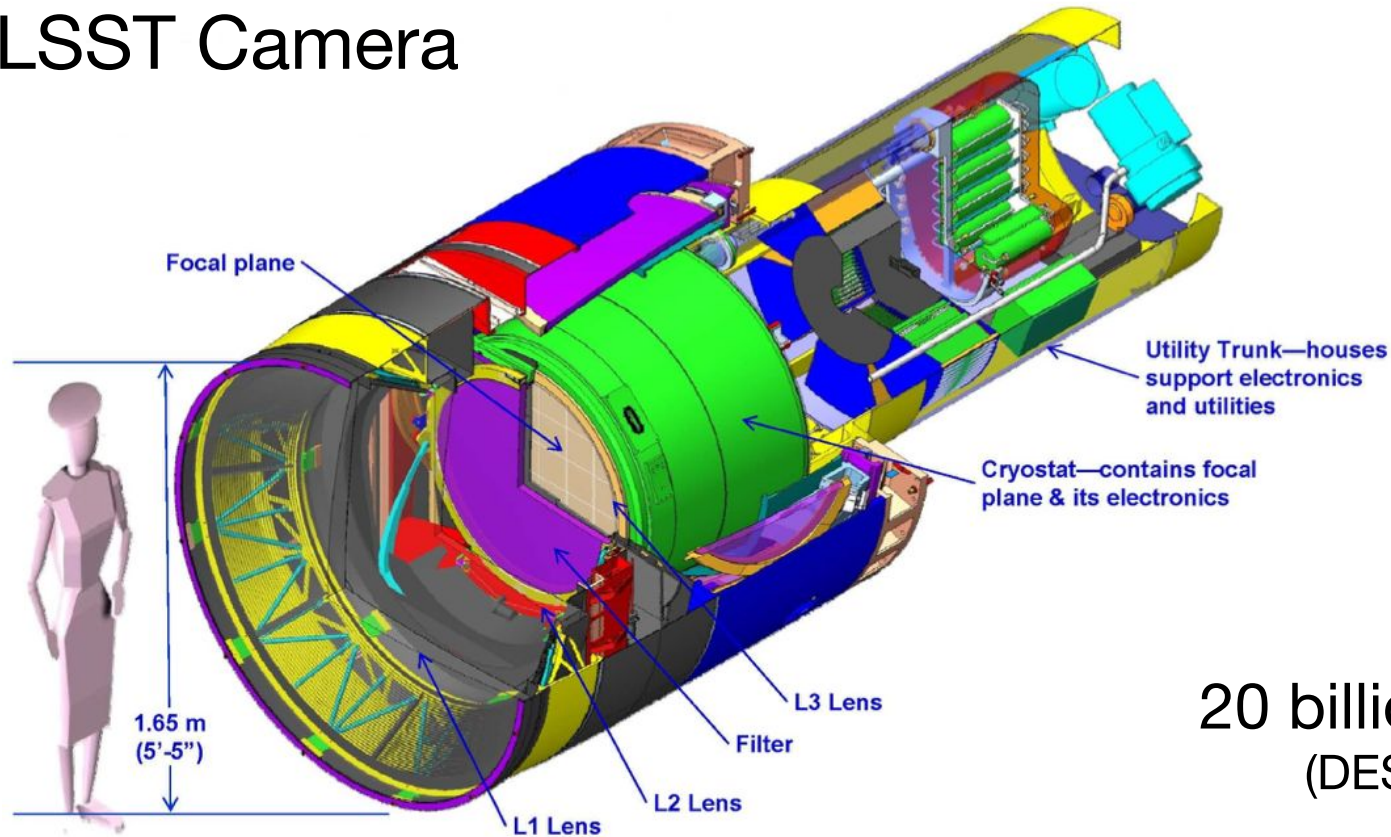


# Large Synoptic Survey Telescope



Construction now  
underway!

# LSST Camera



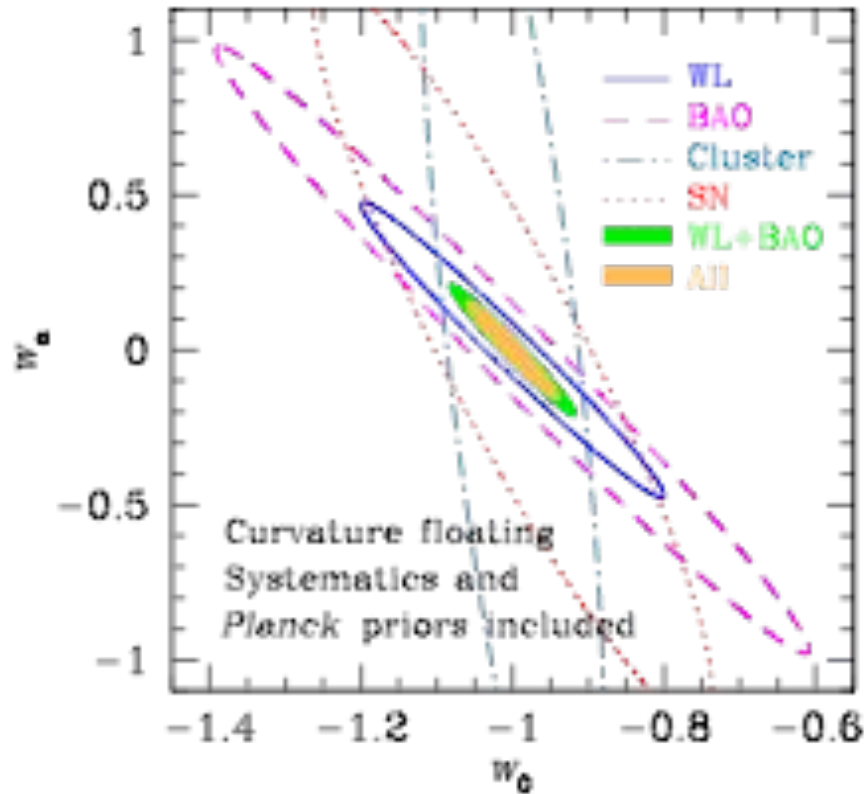
20 billion galaxies  
(DES ~ 200M)

Camera construction in new SLAC clean room

Lab tour 4-5 pm

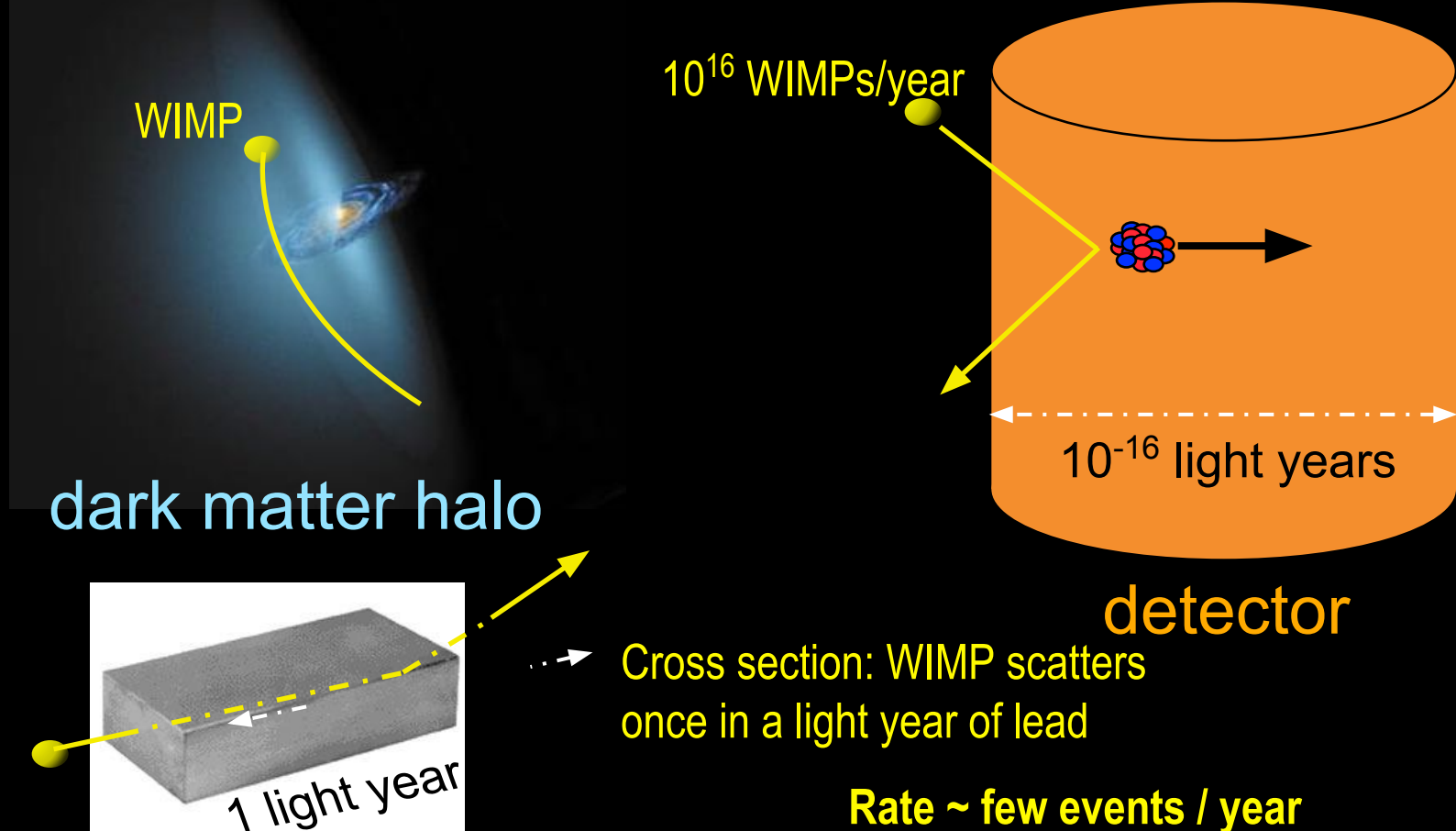
# Cosmology Measurements

LSST

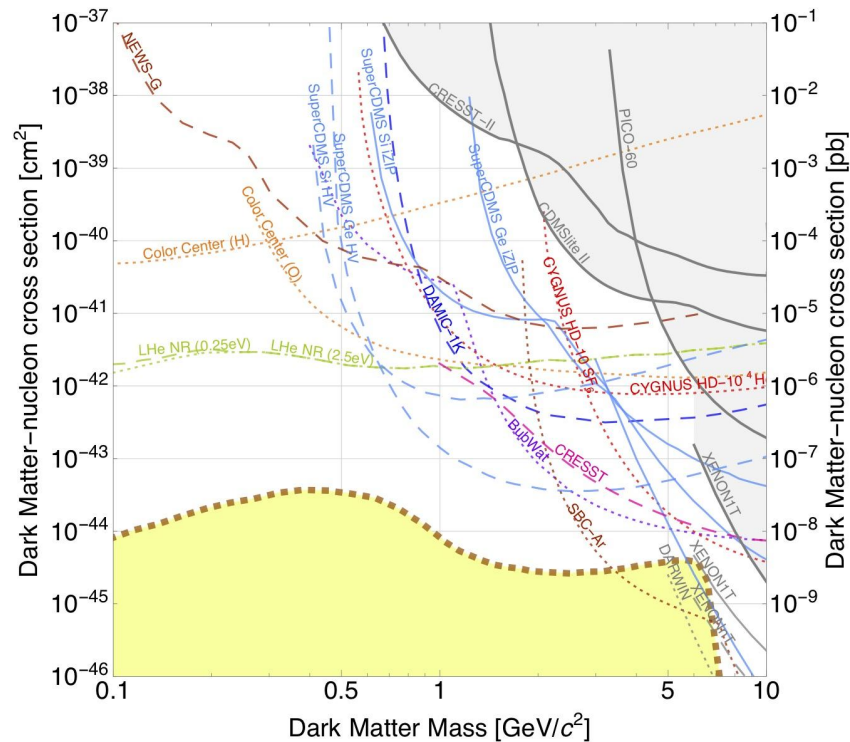
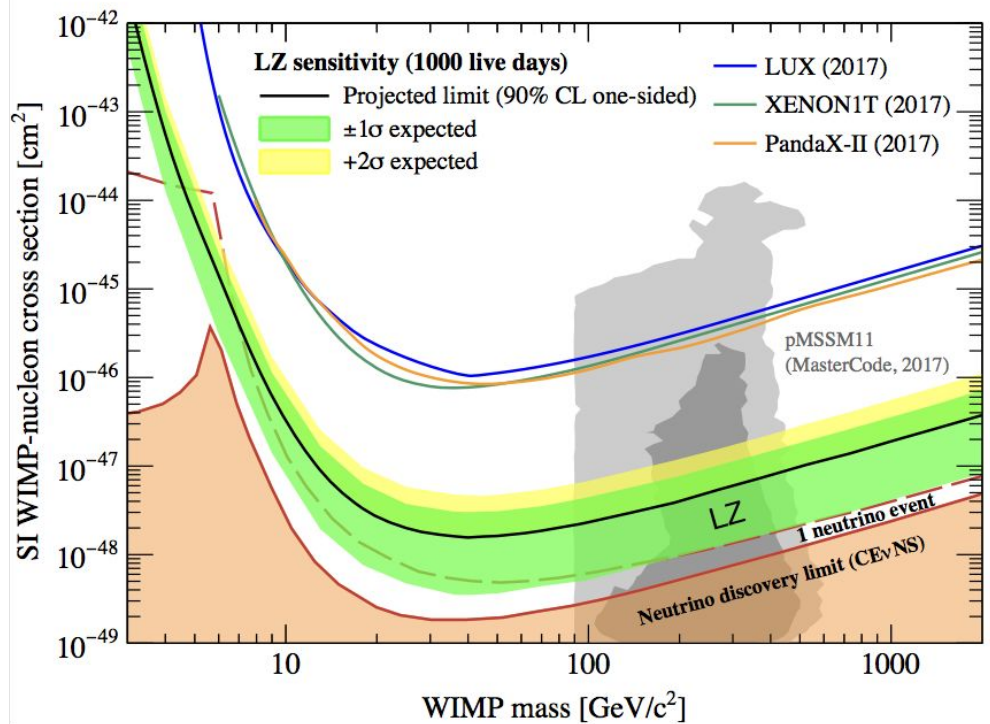




# Dark matter searches



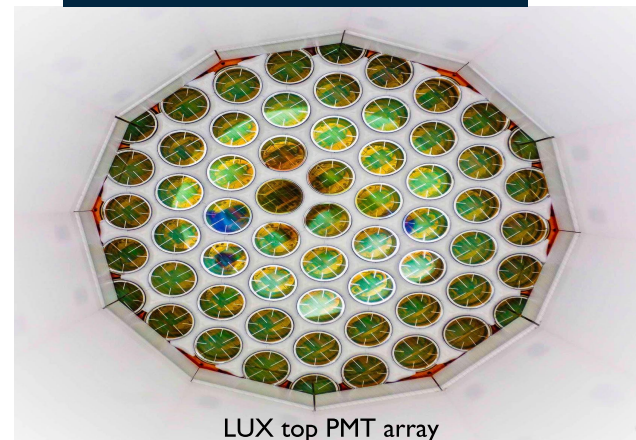
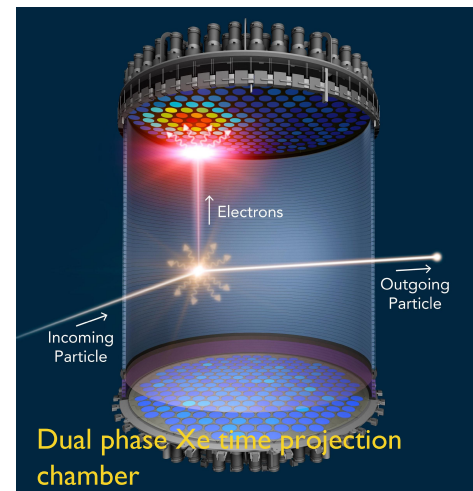
# SuperCDMS and LZ



# Akerib/Shutt (SLAC): Dark Matter with LUX and LZ



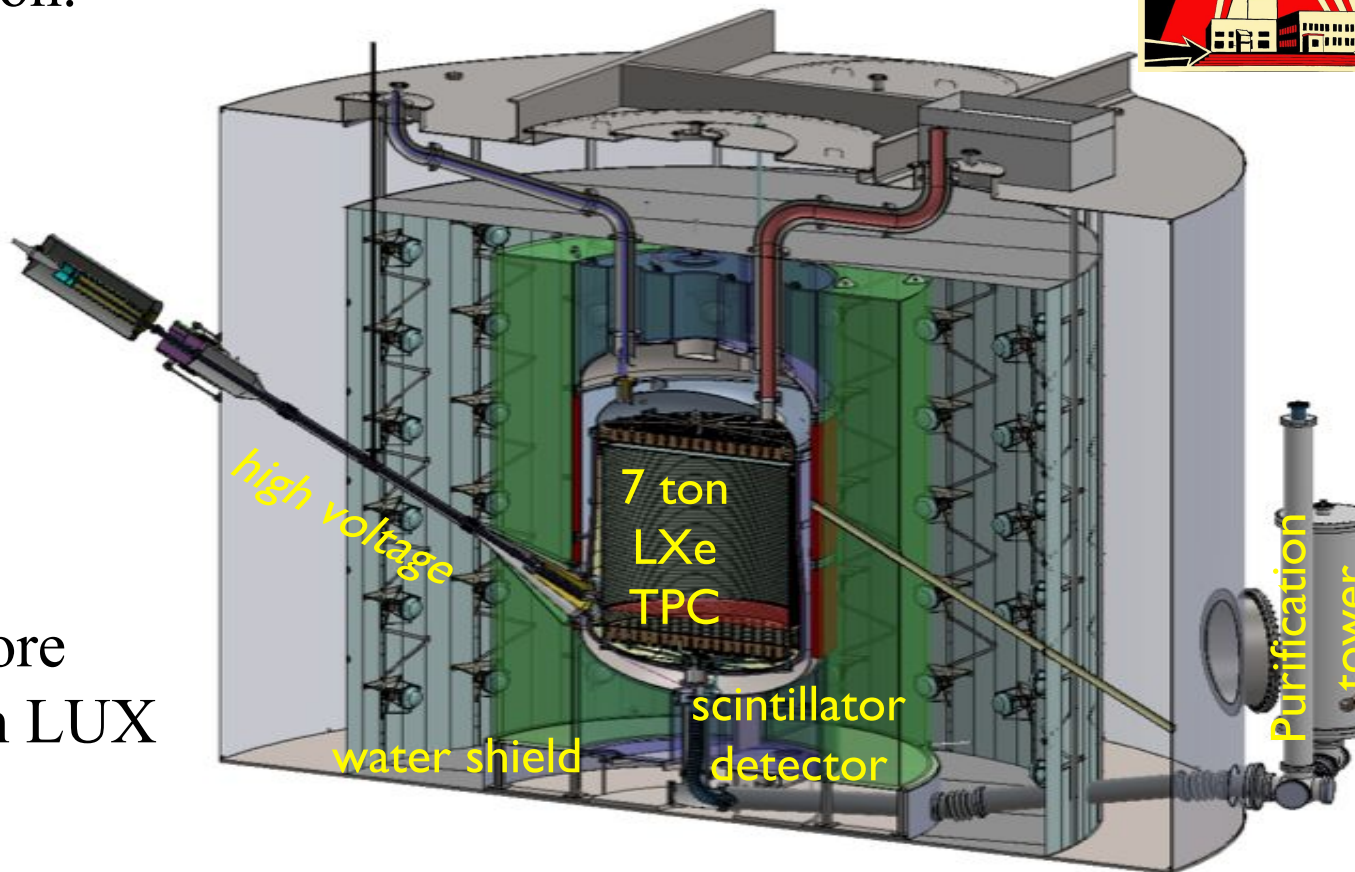
LUX: world-leading search experiment,  
4850 ft underground at SURF, South Dakota



# LUX ZEPLIN

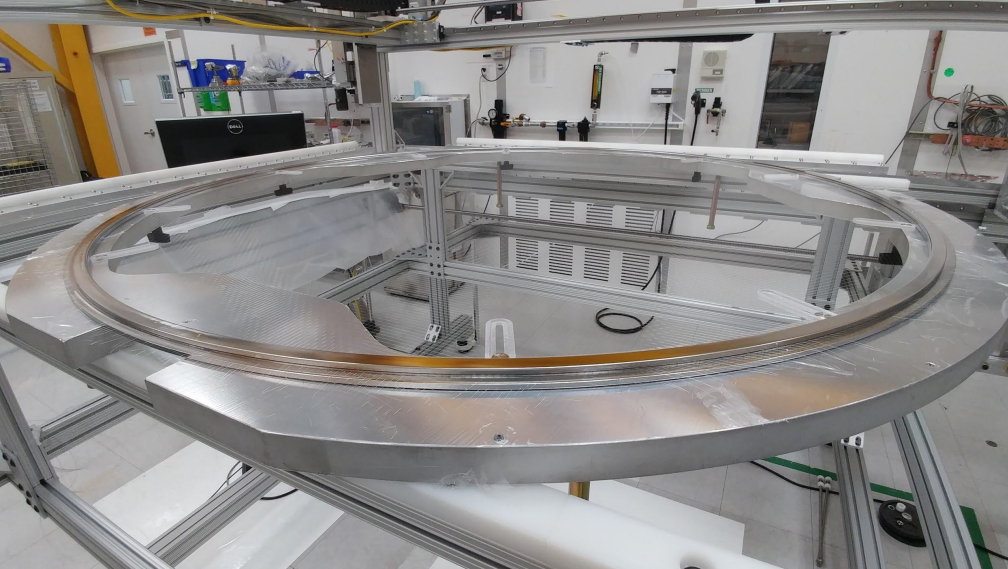
In construction.

Data: 2020



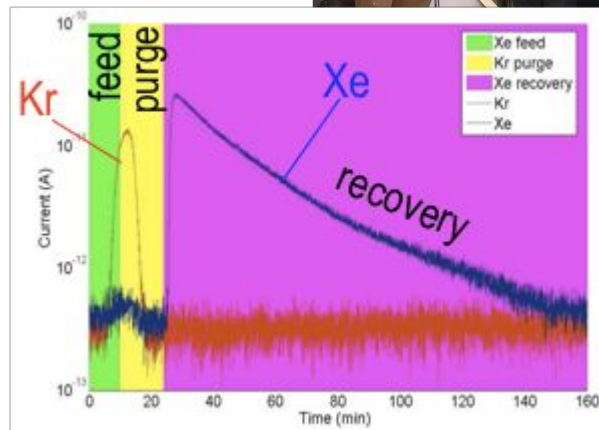
300 times more  
sensitive than LUX



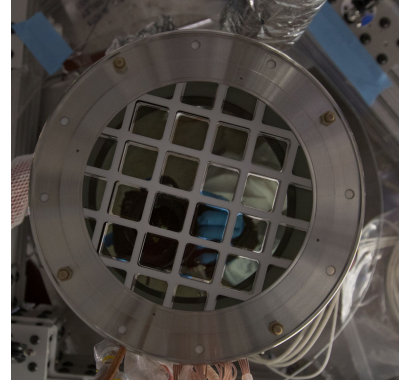
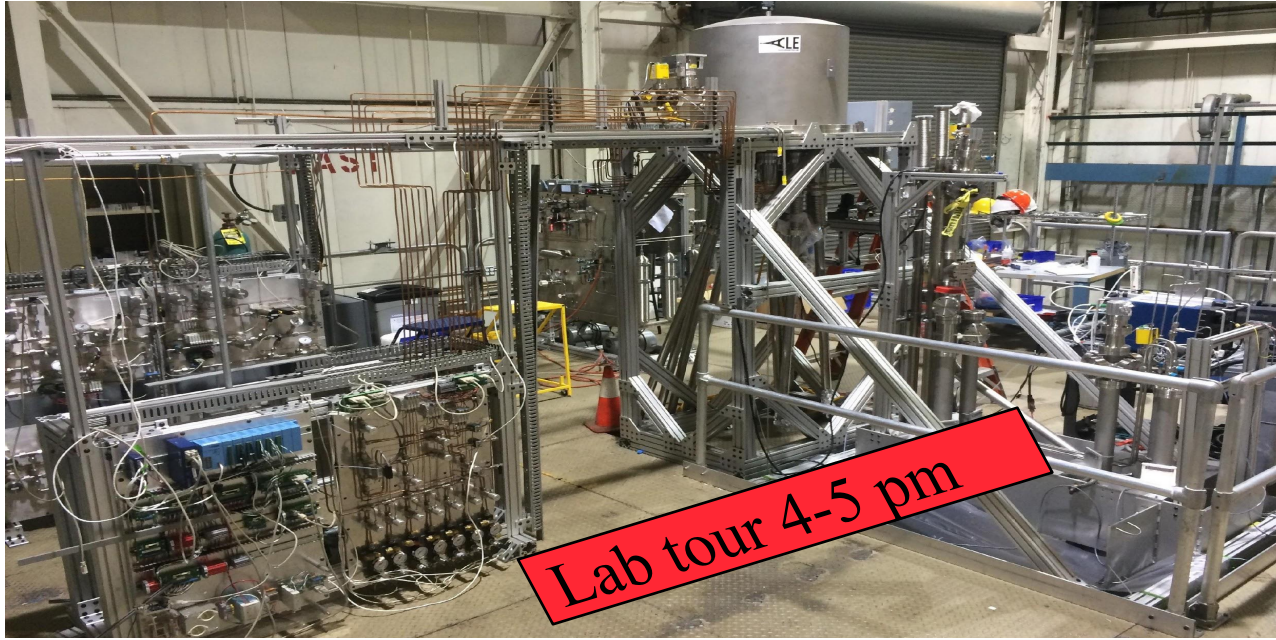


# Production and testing of LZ high voltage grids

Krypton removal  
from 10 tons of Xe  
to  $\sim 10^{-14}$



# Liquid Nobel Test Platform



Unique development  
platform with significant  
student involvement



# LZ at SLAC

- LZ dark matter data starting in 2020
  - Pipeline development
  - Dark matter analysis
- Broad range of instrumentation
  - HV grids - LZ, other applications
  - Purification / Cryogenics
  - Removal of Kr from Xe to  $10^{-14}$  g/g
- Liquid noble test platform
  - Calibrations, R&D, advanced DAQ
  - Other applications - gamma ray telescope?
  - Liquid Ar / DUNE
- Graduate opportunities in all these areas



# Conceptual Design for SuperCDMS SNOLAB



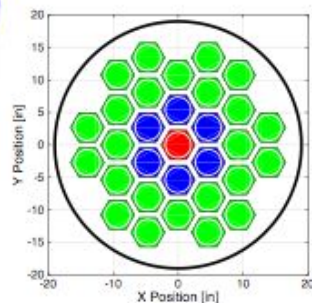
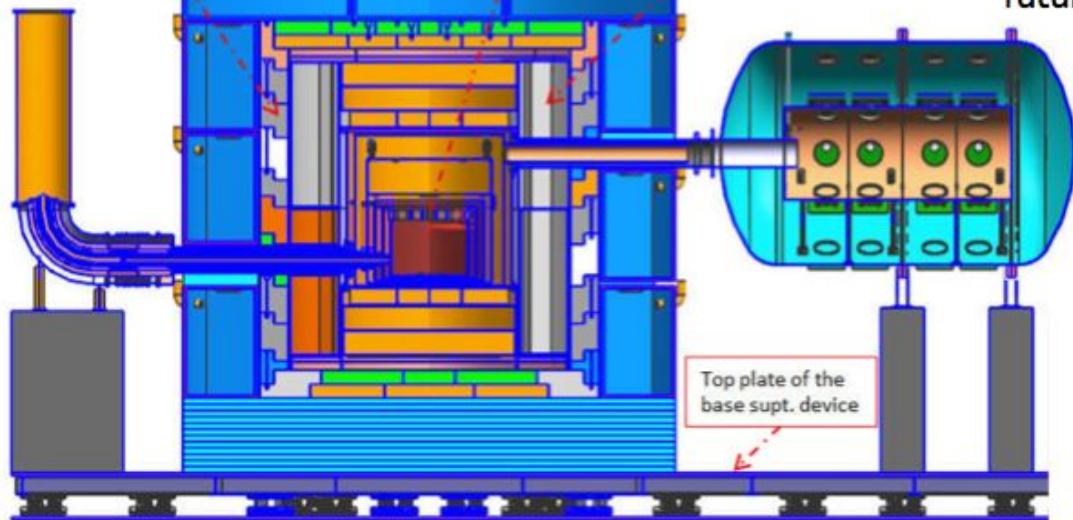
Poly/water tank Shield

Lead Shield

Copper Cans (6)

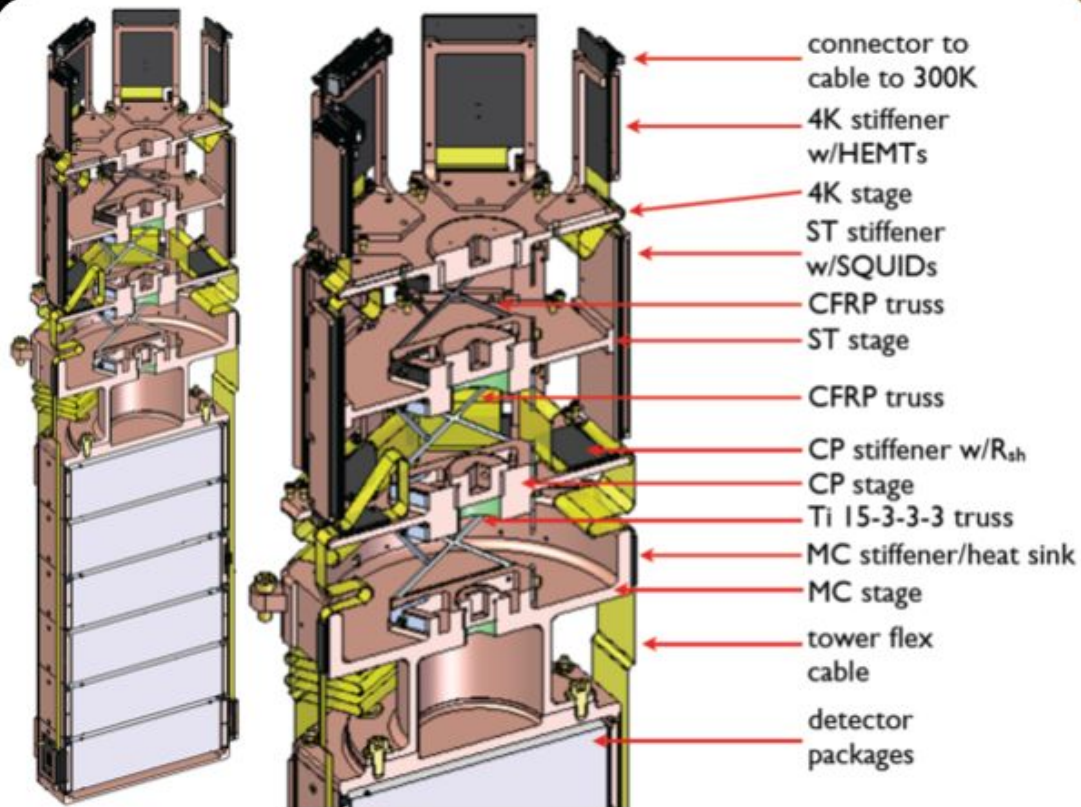
Inner Poly

CDR baseline design contains 31 tower positions, fulfilling mission need with capability of reaching neutrino floor in future upgrade

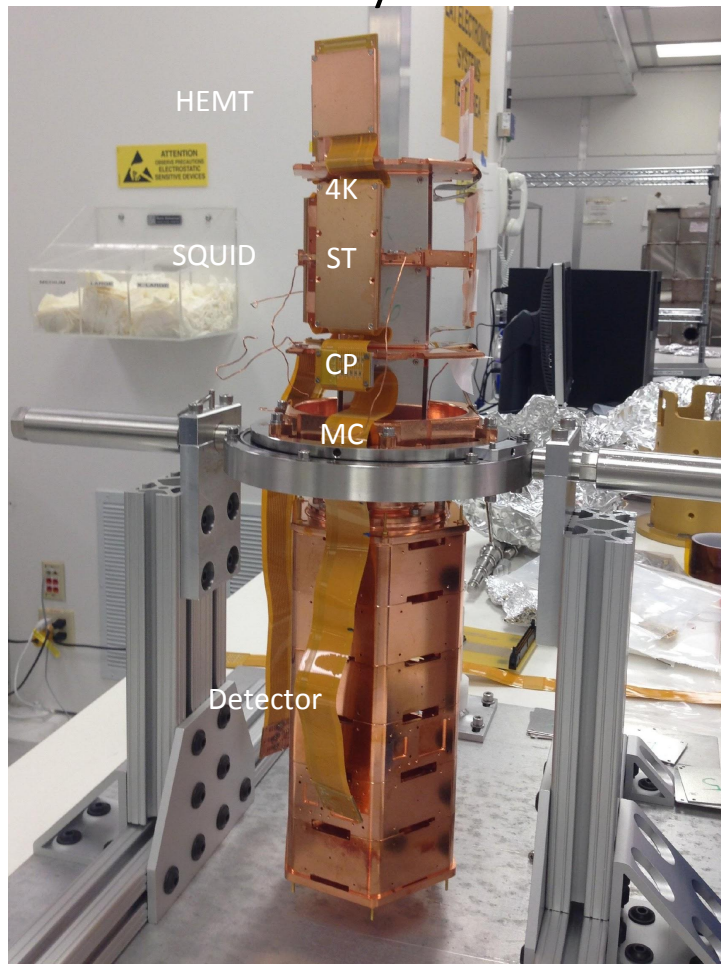




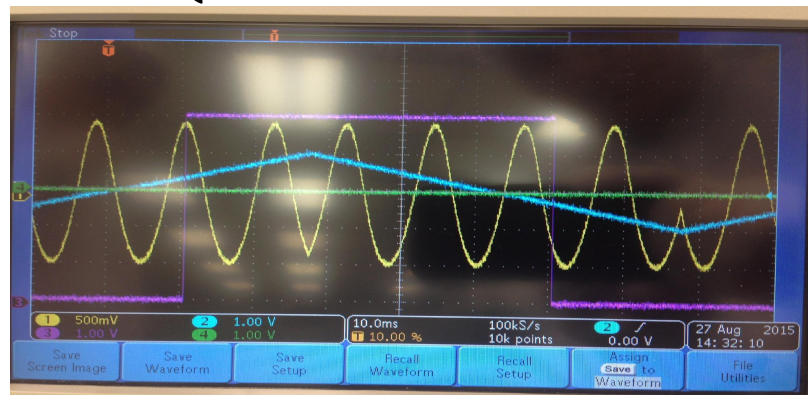
# Detector Tower payload



# Tower Assembly Stand

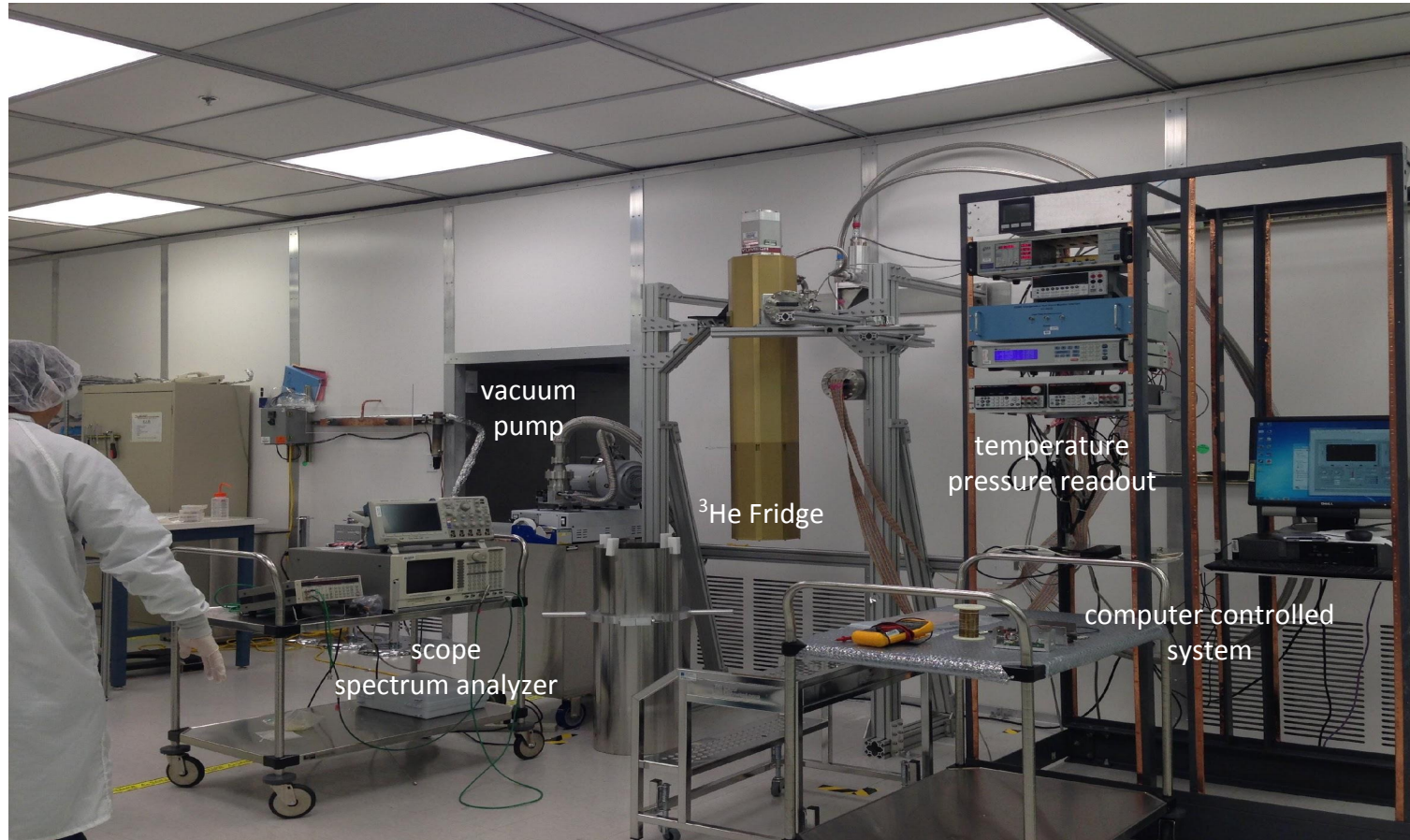


# SQUID Modulation Curve

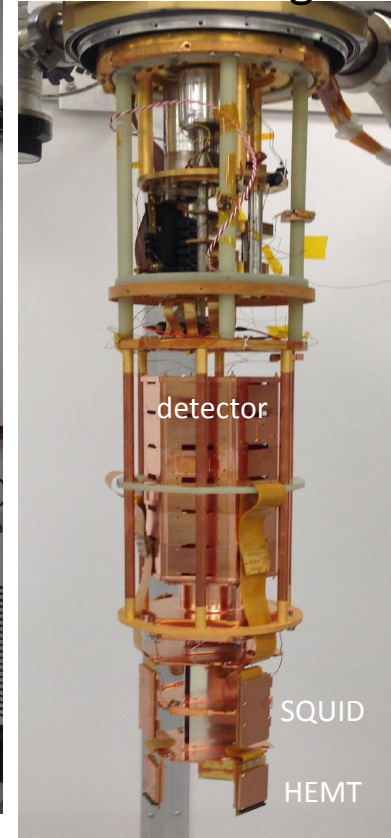




# CDMS Tower Test Stand in Cleanroom



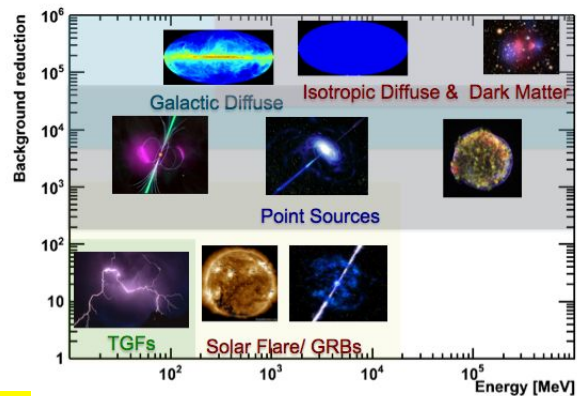
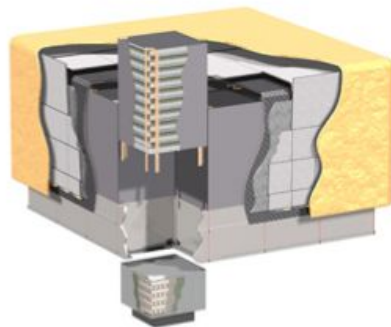
CDMS Tower  
in  $^3\text{He}$  Fridge



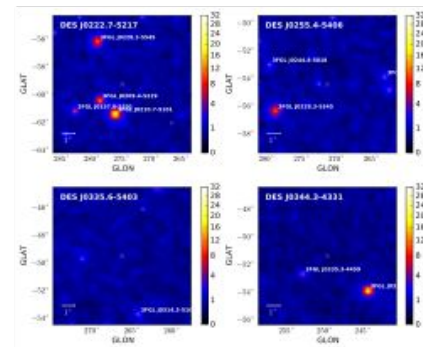
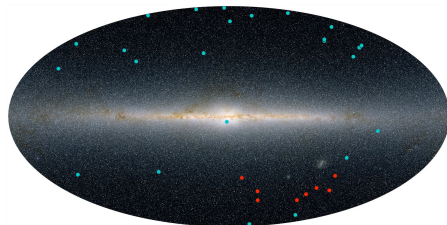
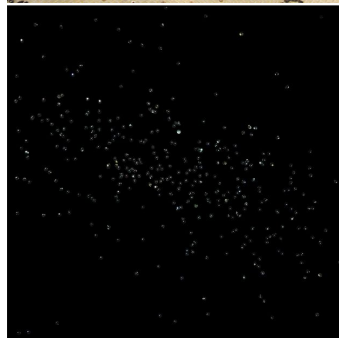
# Fermi Large Area Telescope (LAT)

Constructed and operated  
at SLAC

Monitors the sky  $>20$  MeV since 2008



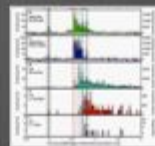
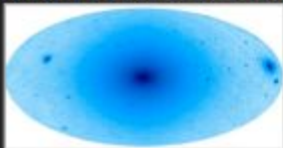
DES & Fermi: Dwarf  
Galaxies



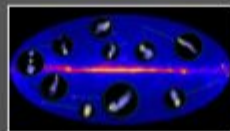


# Fermi Highlights and Discoveries

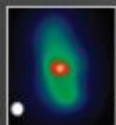
Dark Matter searches



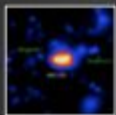
GRBs



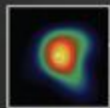
Blazars



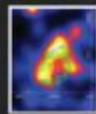
Radio Galaxies



Starburst Galaxies



Globular Clusters



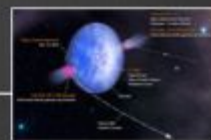
SNRs & PWN



Novae

Galactic

$\gamma$ -ray Binaries



Pulsars: isolated, binaries, & MSPs

Sun: flares & CR interactions



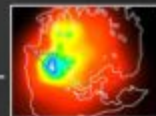
Terrestrial  $\gamma$ -ray Flashes



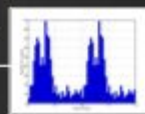
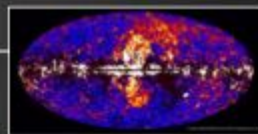
Unidentified Sources

Extragalactic

LMC & SMC



Fermi Bubbles



$e^+e^-$  spectrum

# Particle-Astro Experiments at SLAC

- SLAC history of particle physics experimentation & experiment development
- Large scale facilities & technical support
  - Complements campus
- Dark Energy Survey
  - Profs. Allen, Burke, Roodman, Weschler,
- Large Synoptic Survey Telescope
  - Profs. Kahn, Roodman, Burchat, Allen, Schindler, Weschler
- Dark Energy Spectroscopic Instrument
  - Profs. Weschler, Roodman
- SuperCDMS
  - Prof. Cabrera, Dr. Partridge (SLAC Sr. Scientist)
- Fermi-LAT
  - Dr. Madejski (SLAC Sr. Scientist)
- LUX / LZ
  - Profs. Akerib, Shutt