

Particle Physics and Particle Astrophysics Experiment

2019 Graduate Student Orientation

Tom Shutt

SLAC, KIPAC

Stanford University

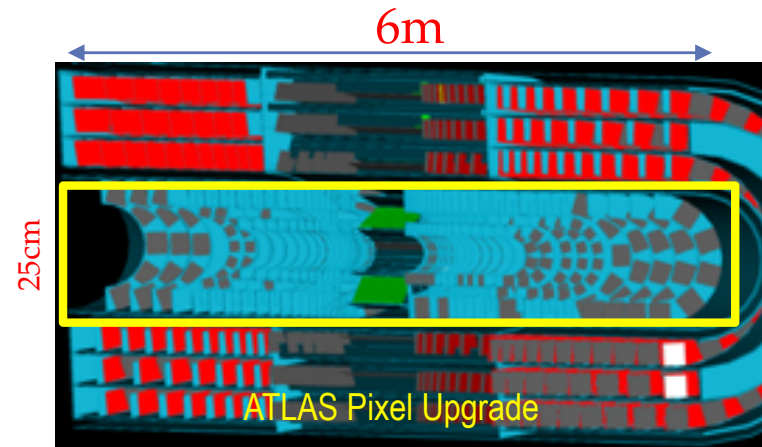
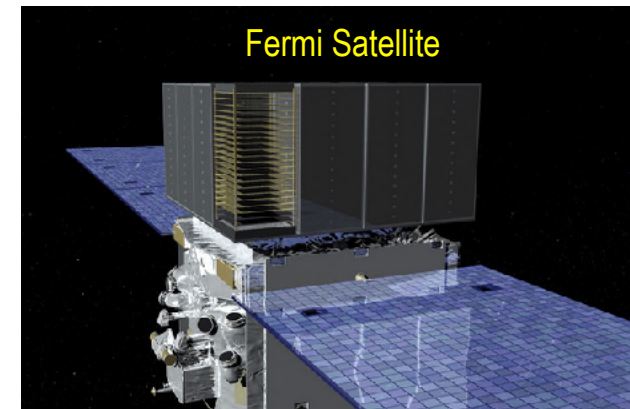


- **Cosmology and the subatomic world**
 - Dark matter
 - Dark energy
 - Inflation
 - Neutrinos mass, number
 - Origin of matter vs anti-matter

- **Other basic questions**
 - What lies beyond standard model?
 - Mass hierarchy in SM
 - Neutrino vs anti-neutrinos
 - others ...

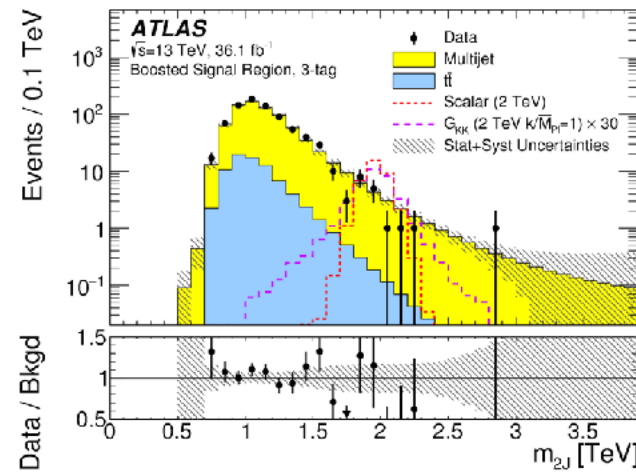
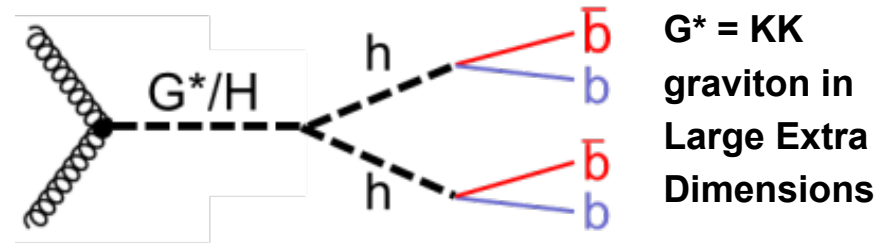
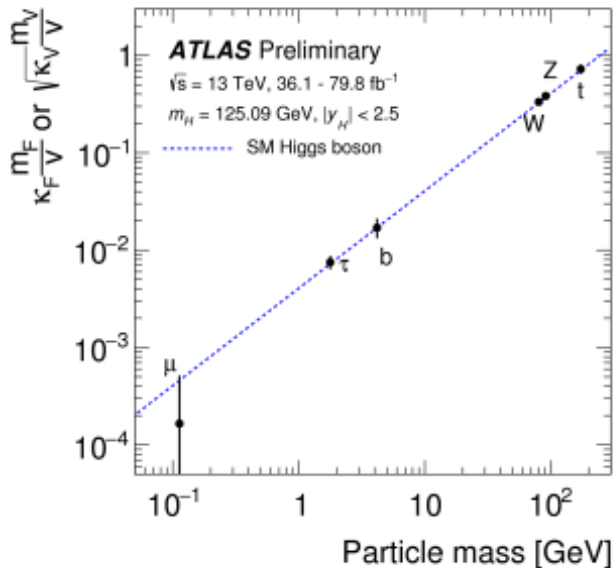
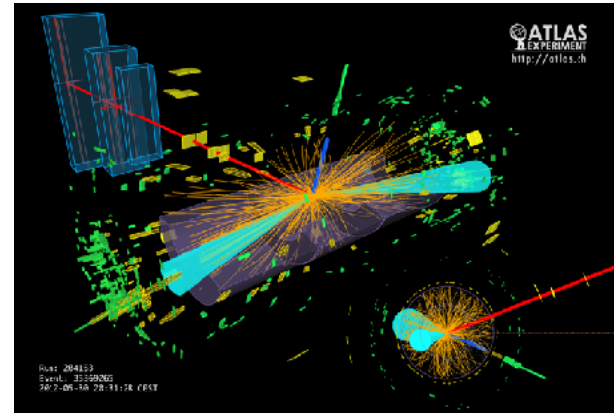
Experimental program at SLAC

- Particle physics: rich history of detector development, data analysis
- Particle physicists: big impact on cosmology and astrophysics
- SLAC + Stanford: unique partnership

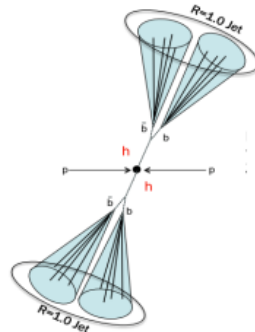


Beyond the Standard Model at the LHC

- Higgs as a window to new physics: properties, couplings, decays
- Dark matter searches
- Precision tests of standard model

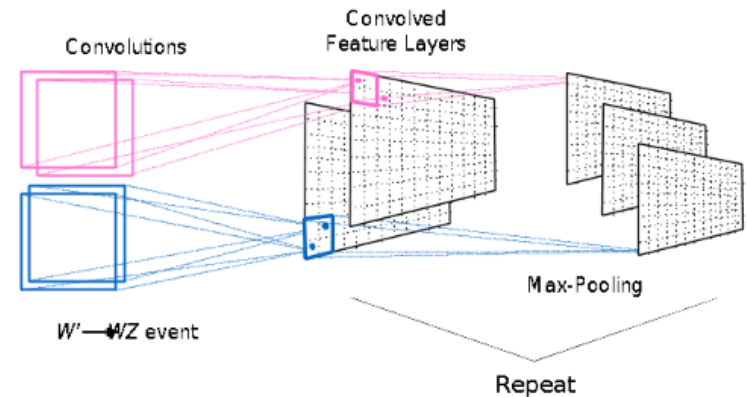
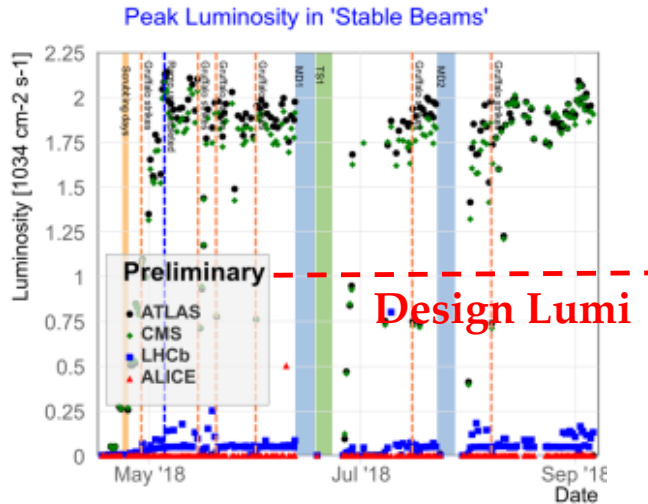
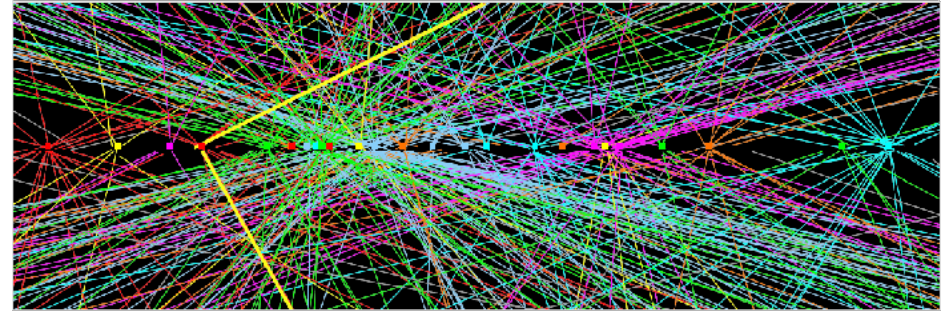


Boosted Higgs



Enormous Data Playground

- Computer vision, image processing, and deep learning:

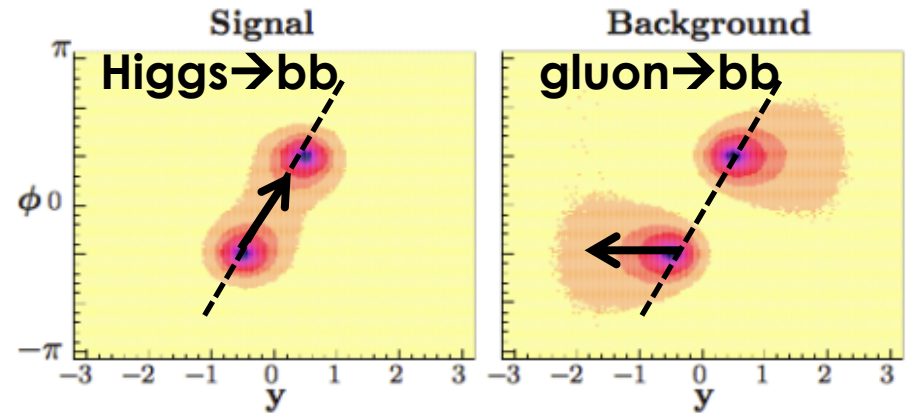


Physics tools vs LHC challenges:

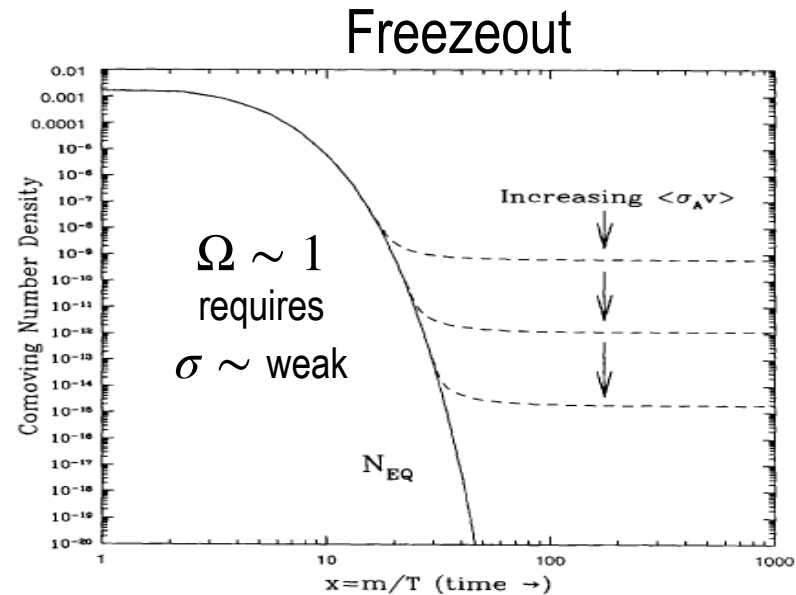
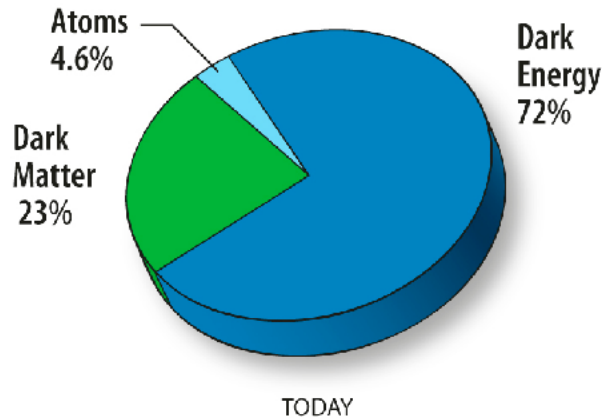
- Advanced b,c quark jet tagging
- Novel boosted object reconstruction
- Refined jet property extraction
- State-of-the-art pileup mitigation
- Exploring the use of fast timing

Pixel detector development for HL-LHC upgrade

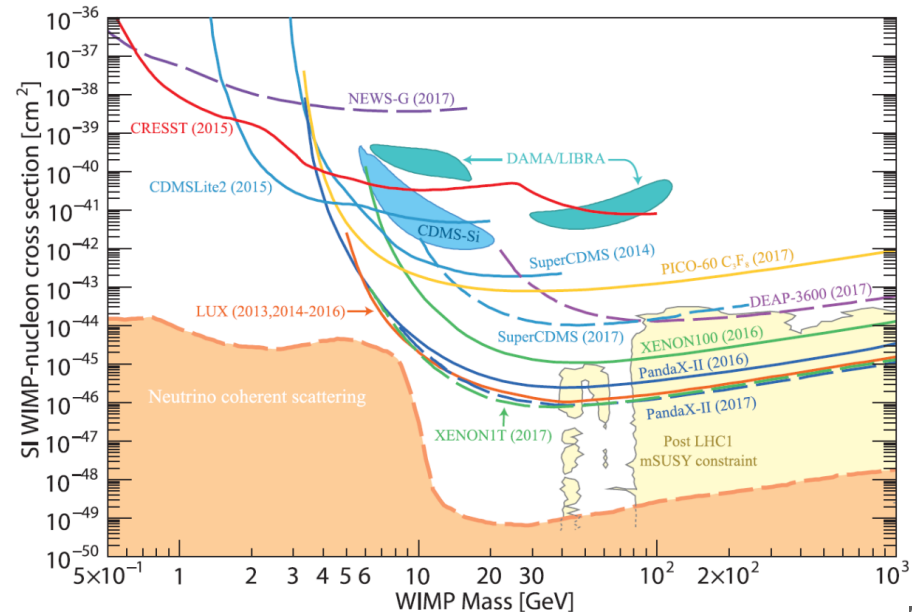
Boosted W, Z, H, and top quarks
Quantum properties of jets



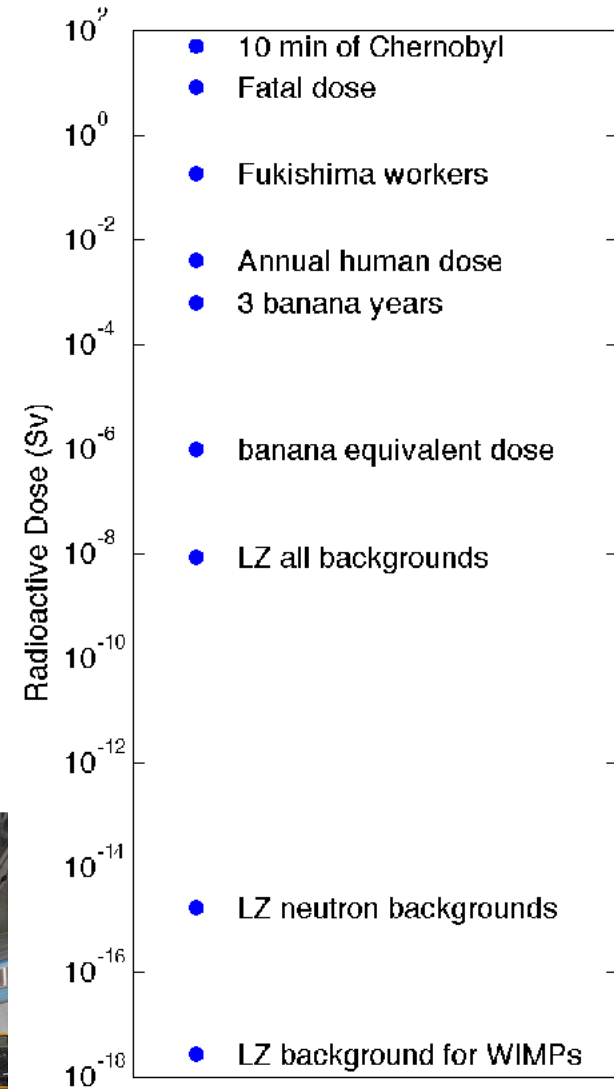
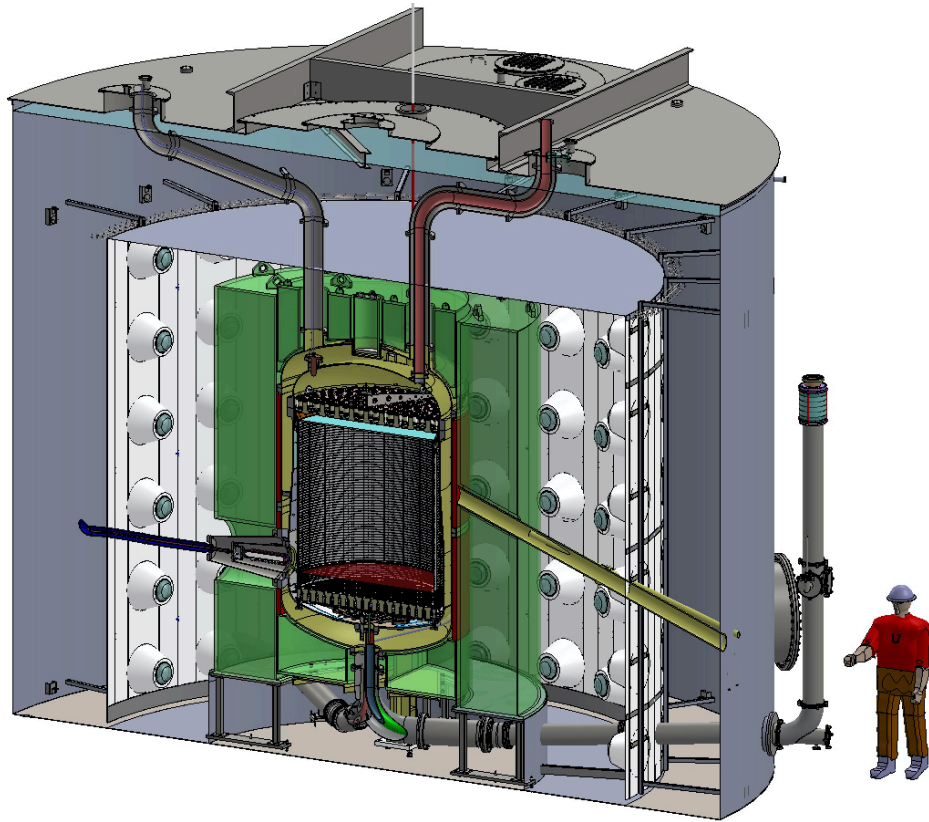
Dark Matter



- WIMPs
- Beyond WIMPs
 - Sub GeV DM: Assymmetric, other light
 - Dark Photon, dark sector
 - Axions + strong CP problem
 - A new sociology



Dark Matter search with LUX-ZEPLIN

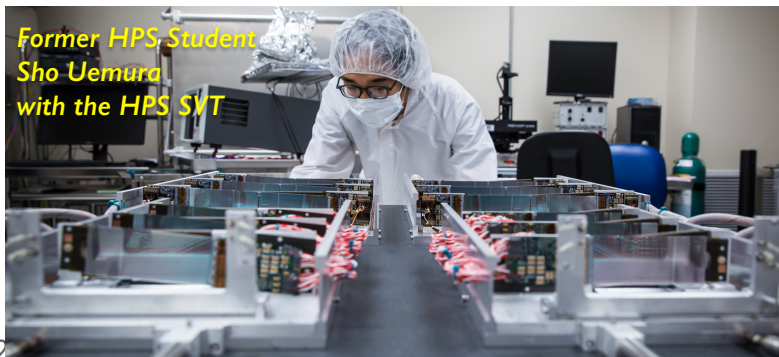
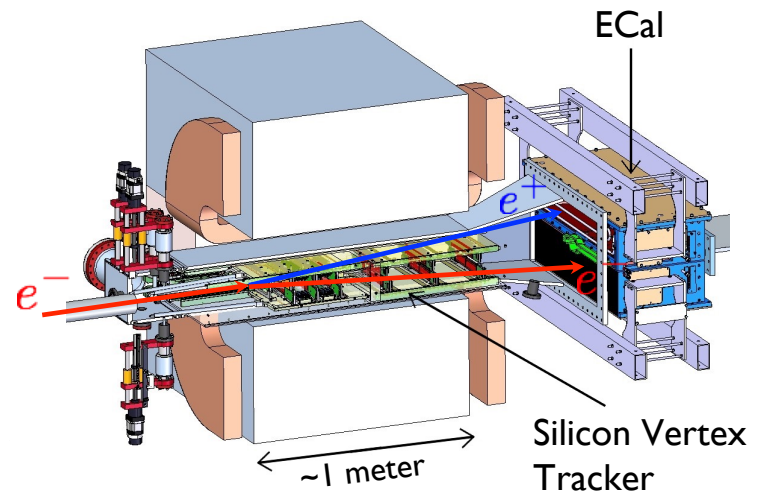
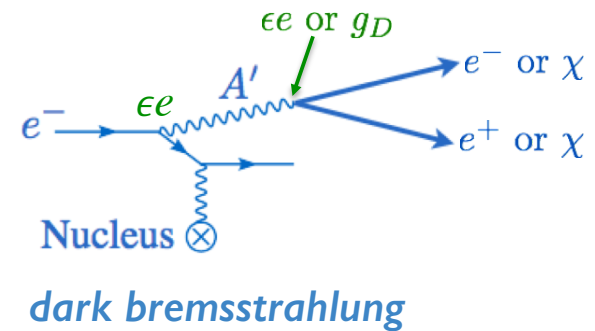
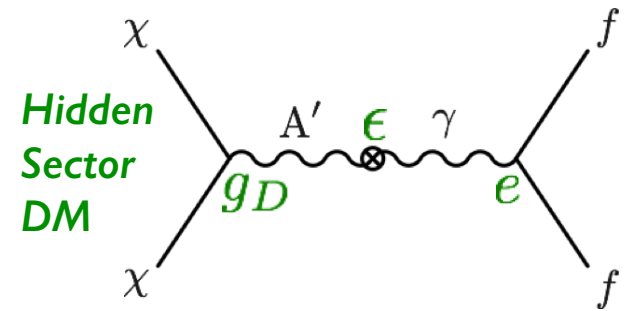


- Data start: 2020
- R&D for low mass search: HydroX



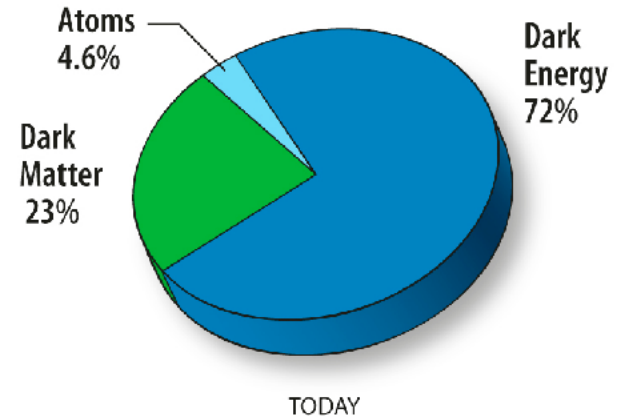
Hidden Sector Dark Matter

- Dark matter couples only through hidden sector to standard model particles. S
- Simplest case: dark photon, A'
- Search for A' at accelerator
 - A' decays to SM particles: HPS
 - A' decays to Dark Matter: LDMX
- Unique theory/experiment collaboration at SLAC



Dark Energy and Cosmology

- Dark Energy: a mystery wrapped in a riddle
 - Cosmological Constant?
 - Quantum Field?
 - General Relativity wrong?



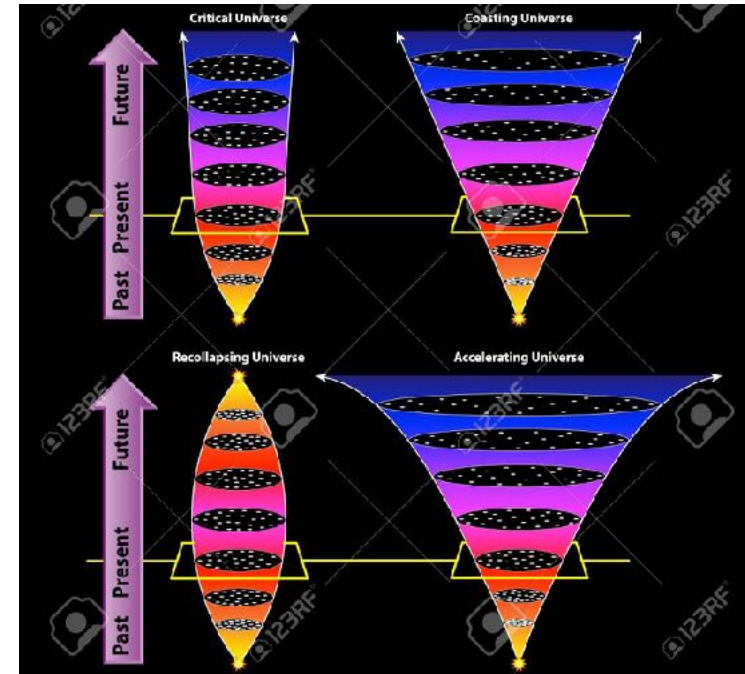
- Determines ultimate fate of universe

- Galaxy surveys

- Imaging
- Spectroscopic

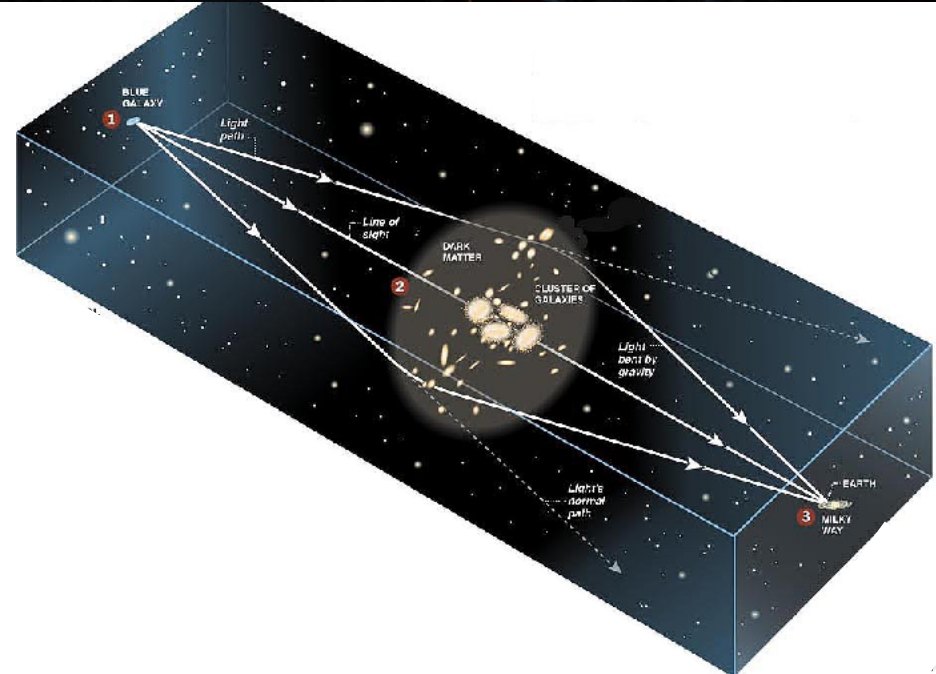
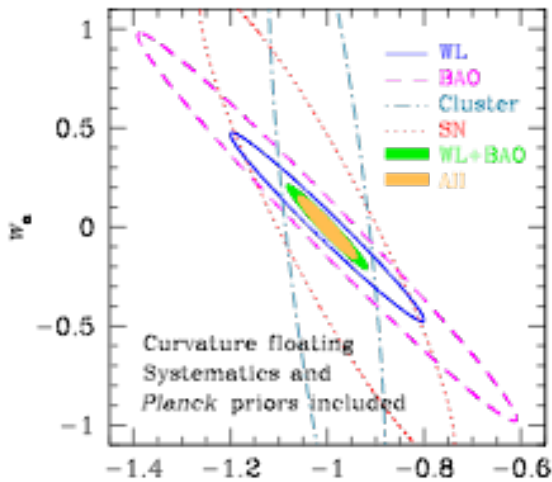
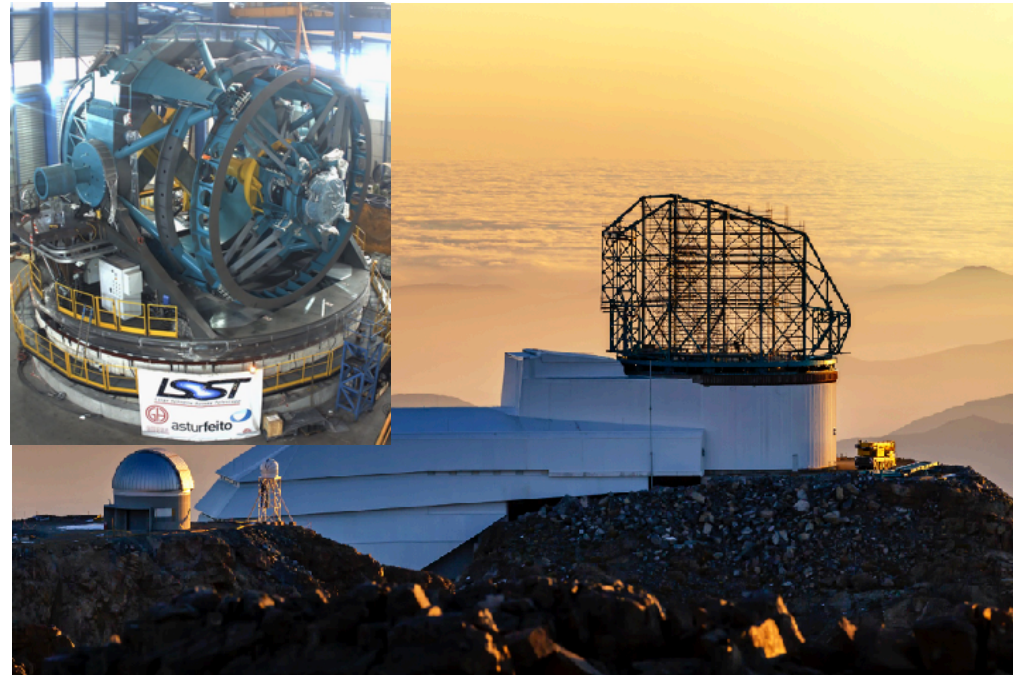
- Supernova

- CMB



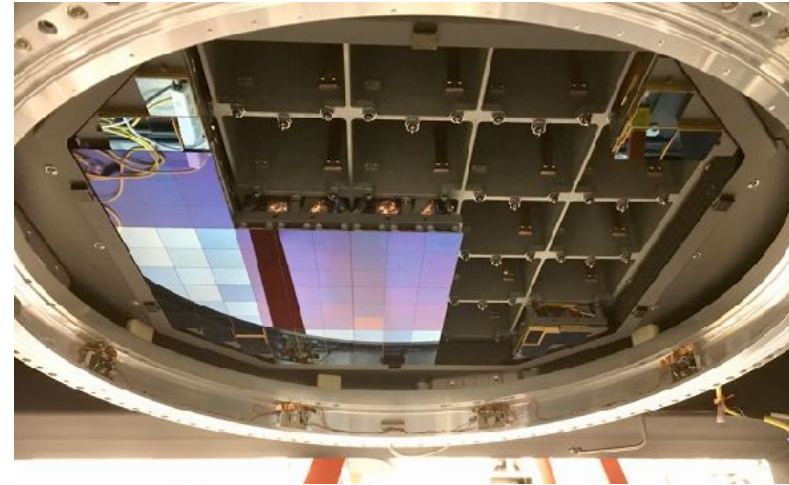
LSST

- Wide field survey with massive camera
- Dark energy
 - Independent measures of structure evolution
 - 1 million supernovae
- First light in 2021



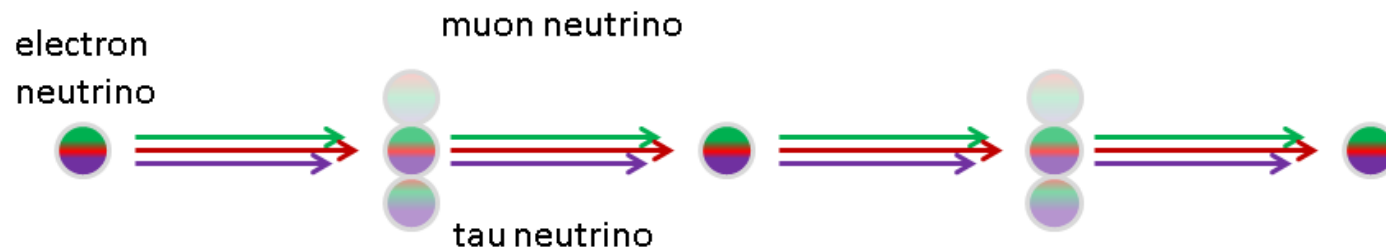
LSST - Camera

- Camera assembled and tested at SLAC
 - Large effort to characterize and minimize systematics
- Wealth of other astrophysics topics
 - Dark matter from weak lensing
 - Extensive map of Milky Way
 - Time domain: transients and variable objects
 - etc...



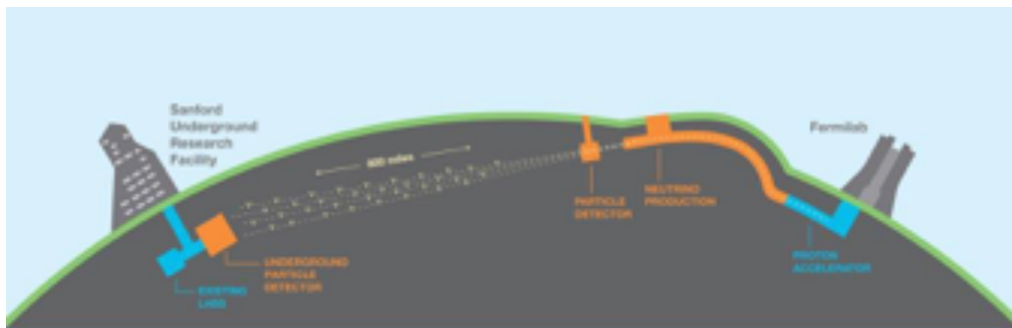
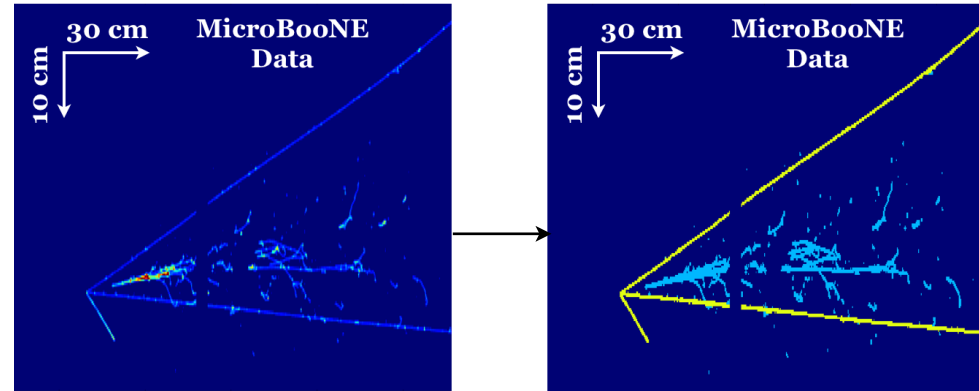
Neutrinos

- Neutrinos oscillate and have mass
 - First direct physics beyond the standard model
- But much not yet known
 - Neutrino masses
 - CP violation? Is this the origin of mass in the universe?
 - Dirac or Majorana?
 - Other physics? e.g., sterile neutrinos



Accelerator neutrino program

- Ongoing short baseline at Fermilab: MicroBooNE, ICARUS
- DUNE - near detector
- Event reconstruction: machine learning
- Electronics
- TPC design + testing



At SLAC

- ATLAS
- LZ
- SuperCDMS
- Fermi-LAT
- HPS + LDMX
- LSST
- DES
- LSST
- Short baseline: MicroBooNE, ICARUS
- DUNE, T2K
- nEXO
- CMB S4

Talk to poster presenters about office / lab visits this afternoon