

Dark Energy Research at SLAC

Steven M. Kahn, SLAC / KIPAC
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Constraining the Properties of Dark Energy

- The discovery of “dark energy” in the late 90’s has profound implications for fundamental physics. Unraveling this mystery is clearly one of the most pressing problems in all of physics.
- Further constraints can only come from higher precision measurements of the kinematic and dynamic history of the cosmic expansion. There are four main classes of techniques that have been suggested:
 - Measurements of the Hubble diagram for Type 1a Sne
 - Measurements of cosmic shear via weak gravitational lensing
 - Measurements of baryon acoustic oscillations in the spatial distributions of galaxies
 - Measurement of the number density and spatial distribution of clusters of galaxies as a function of redshift

DE Research at SLAC

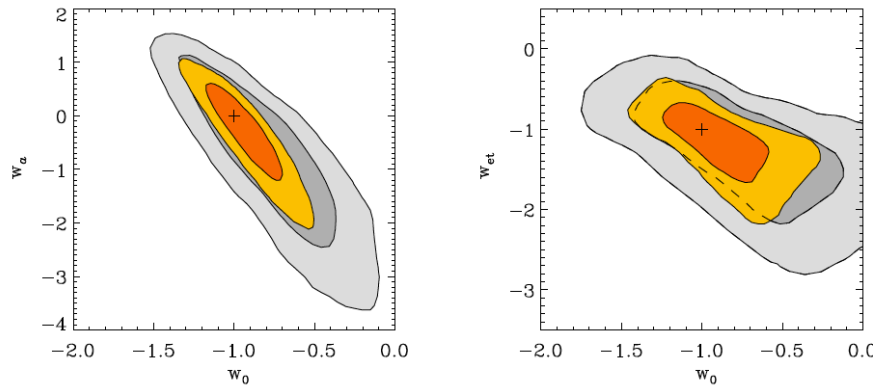
- With the formation of KIPAC in 2003, we embarked on a program to position SLAC in a leadership position in this field. Specifically, we initiated R&D programs in connection with two leading “stage IV” projects for the future: LSST and JDEM.
- For LSST, we led the effort within the DOE complex, by building a collaboration and spearheading the development of the 3.2 Gigapixel camera.
- For JDEM, we joined with LBNL in a supporting role, especially in the areas of electronics and guide sensing.
- However, both are long-term projects, and it will still be several years before either produces data. Therefore, we have embarked on nearer term projects to gain experience in this field both within SLAC and in our user community:
 - We are performing cutting edge DE research with existing data.
 - We joined the nearer term Dark Energy Survey project led by FNAL.



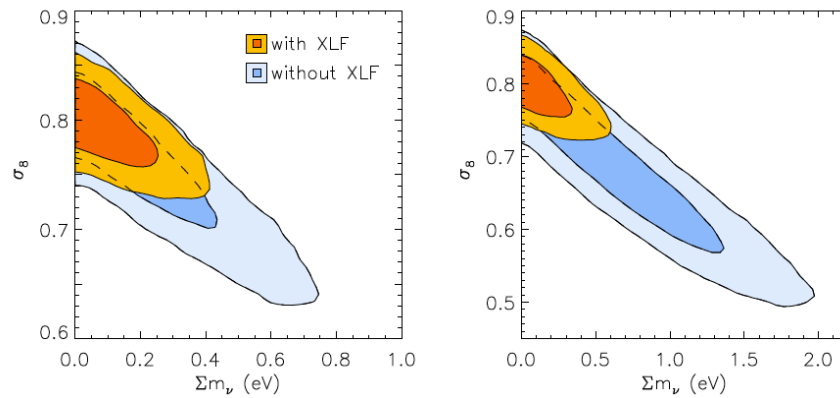
Observational Research with Existing Data

- A group led by Steve Allen has engaged in a comprehensive study of clusters of galaxies using X-ray, SZ, weak lensing, strong lensing, gamma-ray observations.
- They have conducted a wide-area cluster survey, and set up a statistical framework for self-consistently modeling all of the data to simultaneously constrain all cosmological parameters and all necessary scaling relations. This analysis has yielded some of the tightest and most robust constraints on w to date.
- They have also pioneered the f_{gas} technique for the derivation of completely independent constraints on dark energy.

Recent Constraints on DE Parameters and Neutrino Mass from Cluster Survey



Constraints on equation of state parameters (Mantz et al. 2010a)

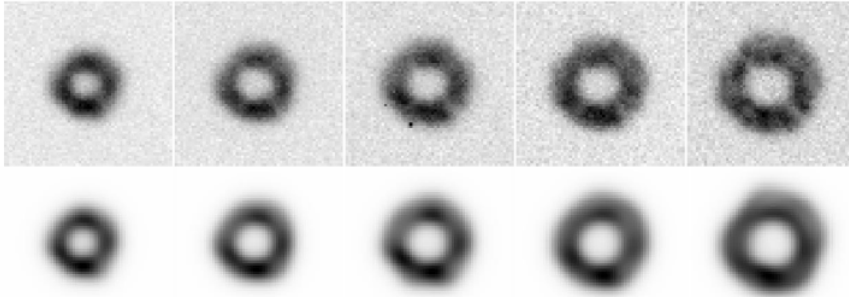


Constraints on the sum of the neutrino masses (Mantz et al. 2010b)

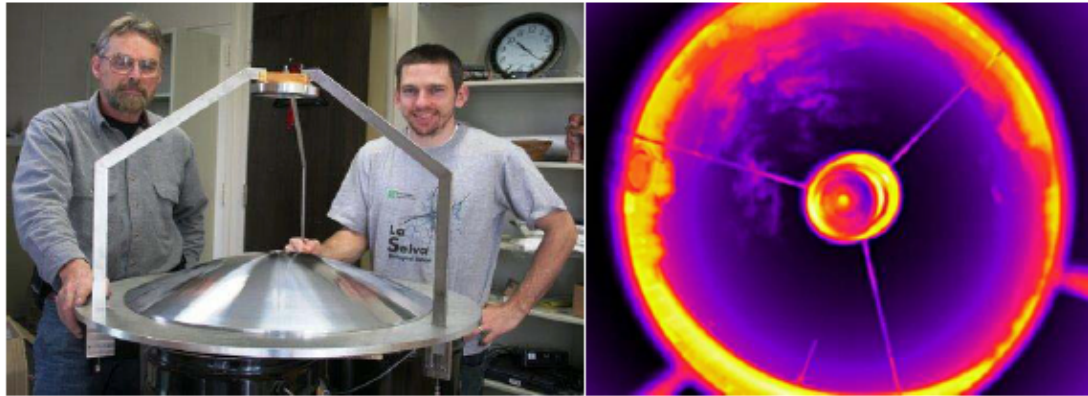
Dark Energy Survey

- A SLAC team including David Burke, Brian Gerke, Stuart Marshall, Aaron Roodman, Rafe Schindler, and Risa Wechsler joined DES in 2009.
- Key activities have included:
 - An investigation of new methods for deriving focus and alignment constraints using intrafocal and extrafocal images of stars (*Roodman*)
 - Design and construction of an all-sky monitoring camera (*Schindler*)
 - Development of a photometric calibration strategy (*Burke*)
 - Data acquisition software support (*Marshall*)
 - Development of simulation tools and science planning (*Wechsler, Gerke*)

Contributions to DES



Modeling of out of focus images for focus and alignment



Construction of an infrared all sky monitoring camera for sky transparency

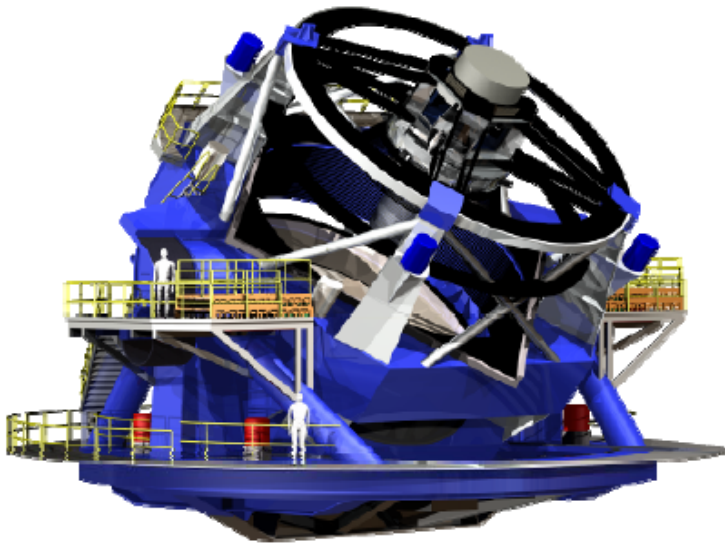
JDEM and BigBOSS

- Work at SLAC begin within the confines of the SNAP concept. Aaron Roodman and Kevin Reil took responsibility for the fine guidance system and its effects on image quality. Gunther Haller and his group led the electronics effort.
- Much of this work has been sufficiently generic that it translates well to other JDEM concepts, including a purely IR mission. However, with the selection of WFIRST by the Astro2010 committee, it remains to be seen whether and how this effort will be incorporated into a putative DOE role in that mission.
- If a suitable role in WFIRST does not materialize, the group has also joined the BigBOSS collaboration. Likely SLAC roles will also include focus & alignment, electronics support, and possibly software for slow controls.

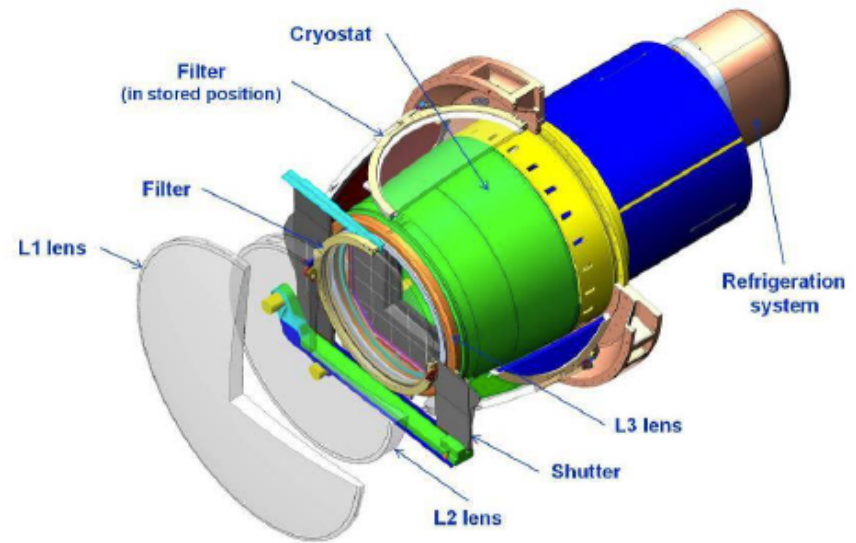
LSST

- With the strong endorsement of Astro2010, we are looking forward to onset of LSST fabrication as an MIE in the 2012/2013 timeframe.
- SLAC has several key leadership roles in the LSST program:
 - Steve Kahn is Deputy Project Director and Lead Scientist for the Camera.
 - Kirk Gilmore is the Camera Project Scientist, and Nadine Kurita is the Camera Project Manager.
 - David Burke is the LSST Calibration Scientist.
 - Gregory Dubois-Felsmann is the Data Management Systems Engineer.
 - Kian-Tat Lim leads the Data Management Architecture team.
- The key R&D activities have involved the design and development of the Camera. We also have a smaller but influential role in the Data Management, specifically in the area of the database and data access services.

LSST



Rendering of LSST Telescope Mount



Blow-up of LSST Camera

Issues for DE Research

- Funding profile for LSST: Will we have the resources to maintain the camera development on the schedule for the project established by NSF?
- Organization of the Dark Energy Science Collaboration for LSST: Do we need a separate DOE-funded DE Center? How do we interface to the NSF-funded user community?
- Evolution of DE Analysis Effort: How do we optimize the balance between work on auxiliary data sets and DES data analysis once LSST data-taking begins?