



Dark Energy Survey and WISPs

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Context

- WISPy new physics is highly motivated
- My previous work, GammeV, probed interesting regions of parameter space. Astrophysical hints and other open regions still to be explored.
- How can/will my current main project – an astronomical survey, the Dark Energy Survey, contribute to searching for WISPs?
- I'll tell you some things, but I welcome comments and new ideas throughout the workshop

History of DES

- Fermilab was looking for a next project after the Sloan Digital Sky Survey when an opportunity to build a $\sim 10\times$ better new camera for telescope time on a $\sim 10\times$ larger telescope
- Also, some of us were used to building silicon detectors for HEP collider experiments
- 2003-2013, Design, R&D, project approval, (international) agreements, construction, shipping, installation, data software, commissioning, and collecting first data.
- Ready for 1st season beginning Aug 2013

Cerro Tololo Inter-American Observatory (CTIO)

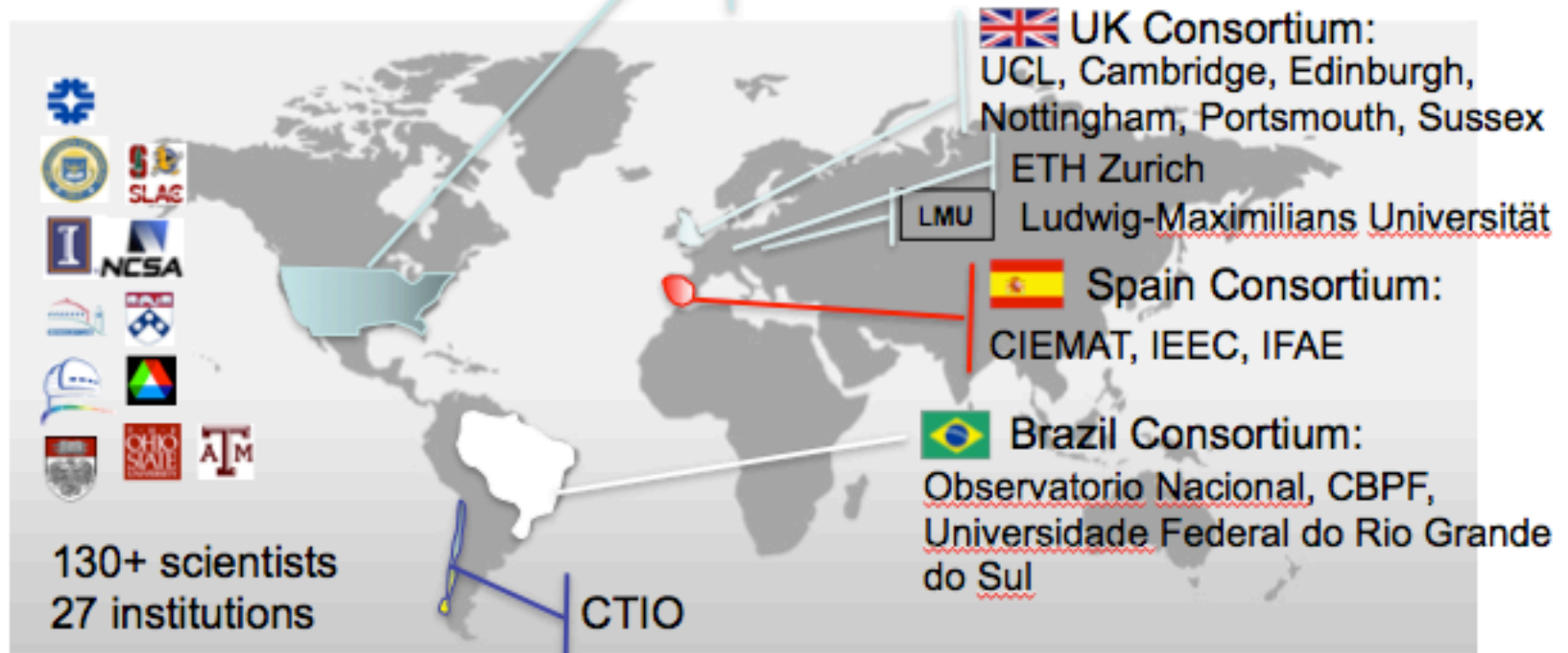
Located at 2200m near La Serena Chile
Excellent weather and seeing conditions
Home to the 4m Blanco telescope



DES Collaboration

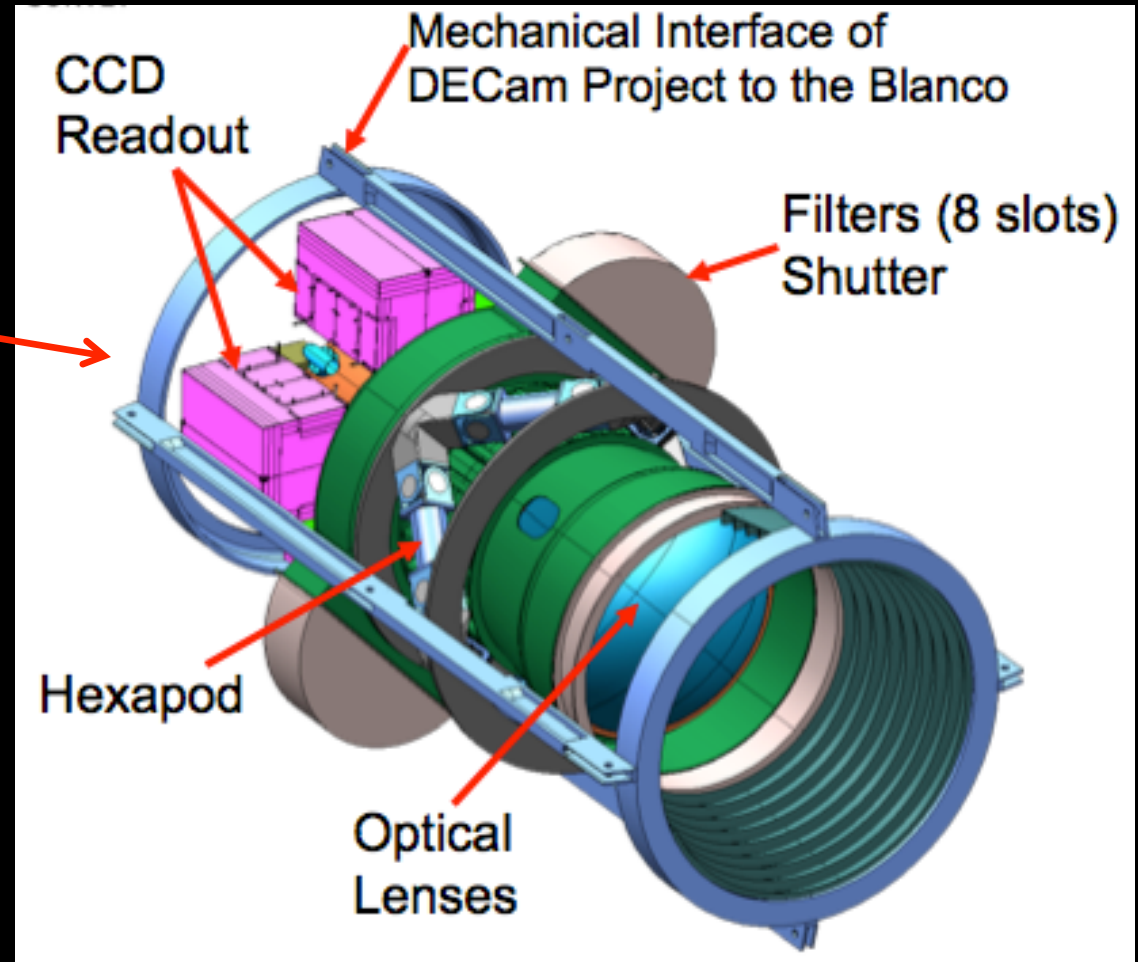
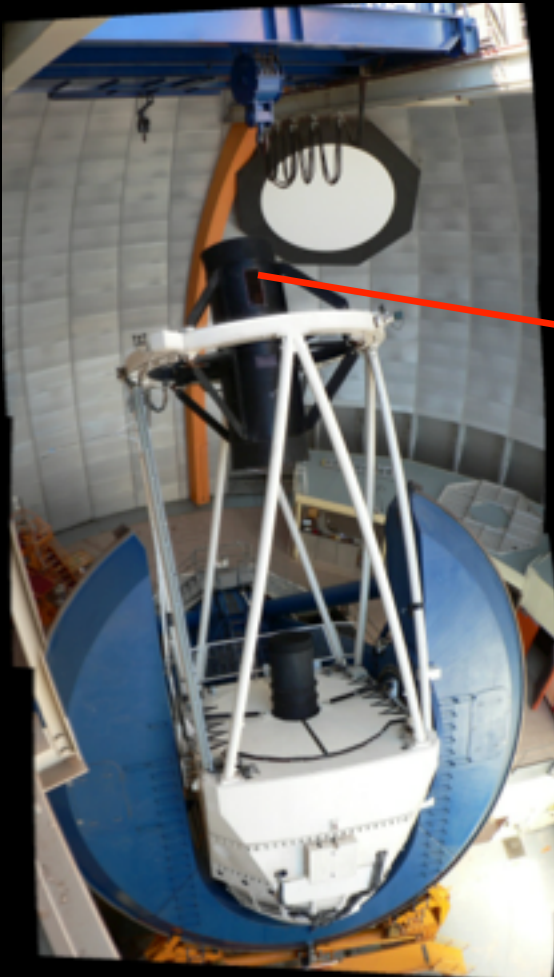
Funding from DOE, NSF, foreign funding agencies, and DES institutions

Fermilab, UIUC/NCSA, University of Chicago, LBNL, NOAO, University of Michigan, University of Pennsylvania, Argonne National Laboratory, Ohio State University, Santa-Cruz/SLAC/Stanford Consortium, Texas A&M



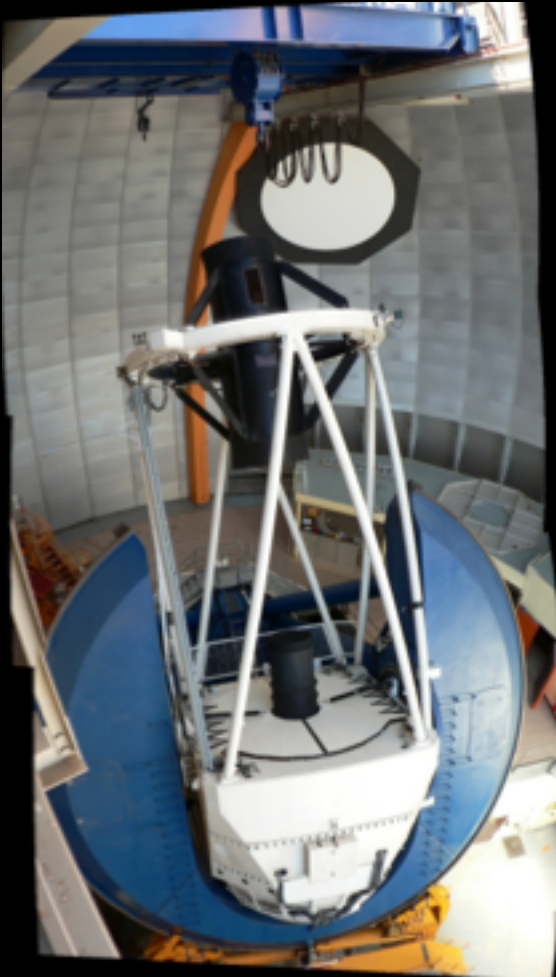
DECam

- The deliverable was a new prime focus cage consisting of a large focal plane, filters, optics, and mechanical support



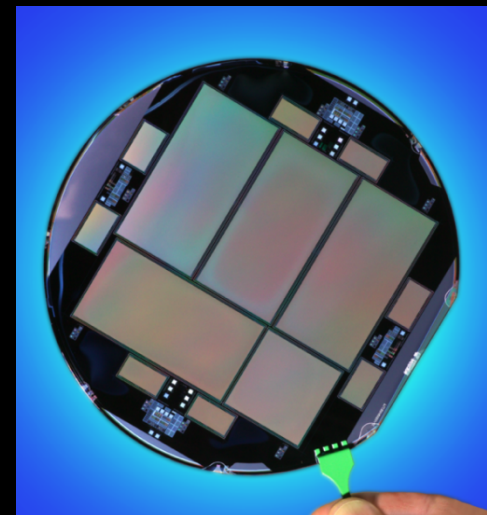
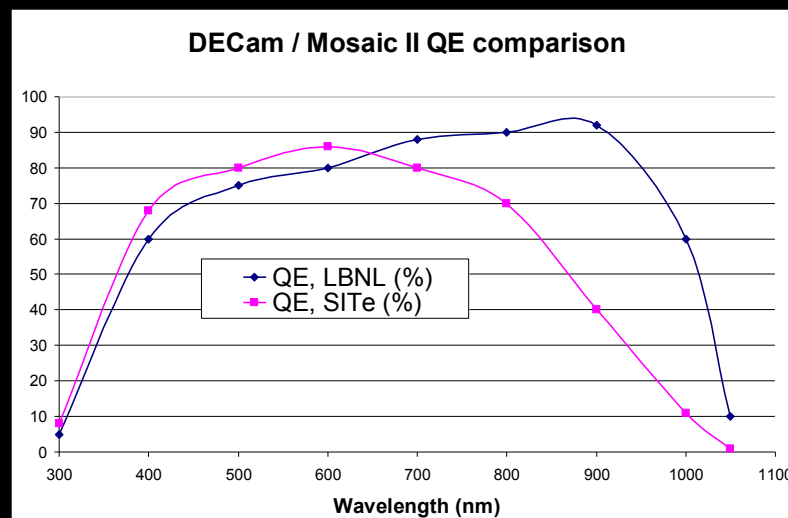
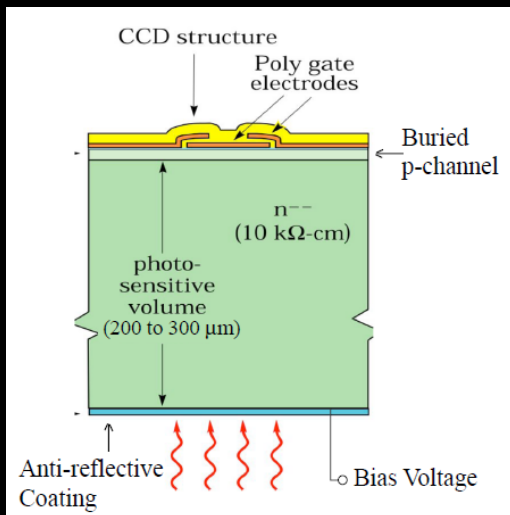
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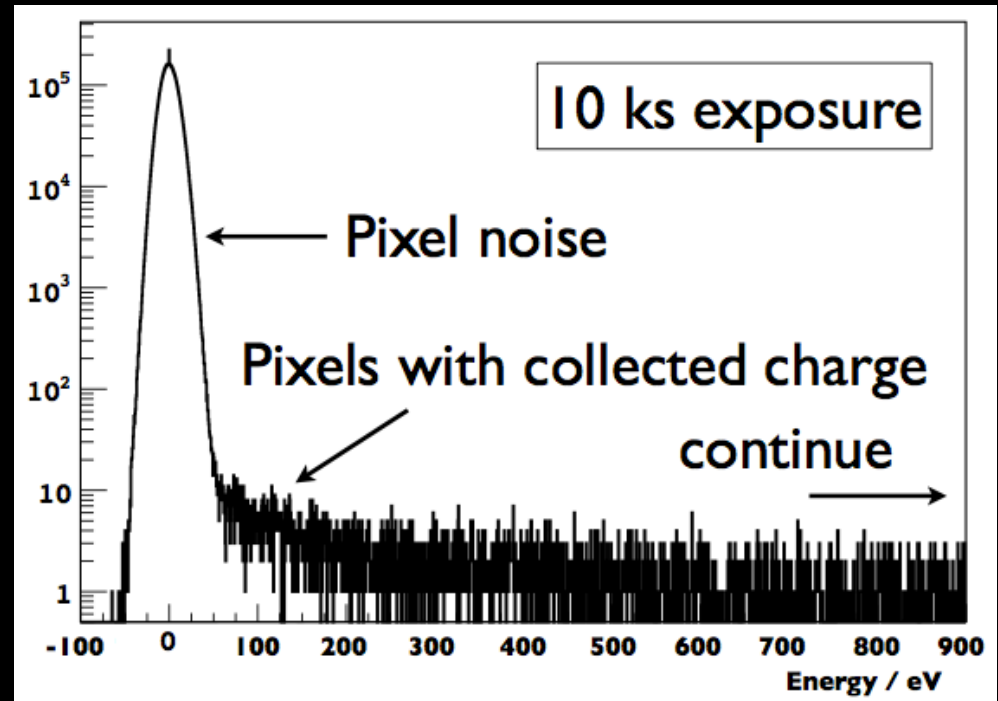
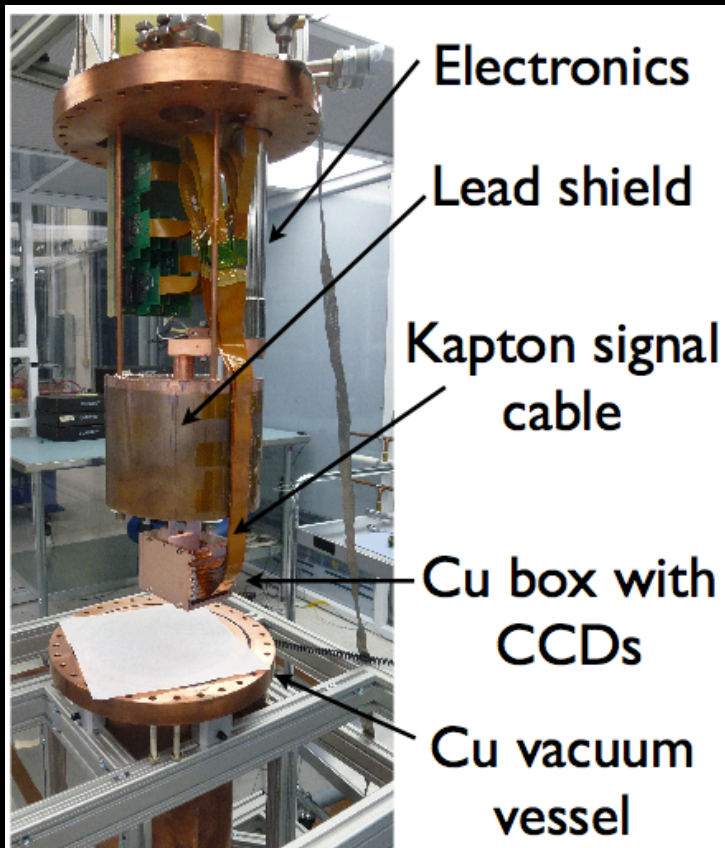
CCDs

- The CCD sensors are custom fabricated for enhanced sensitivity in the near infrared.
- Technology was originally developed for HEP (SSC detector CCD pixel tracking system)
- In-house final processing steps and full CCD testing and characterization facility



CCDs for WISPs

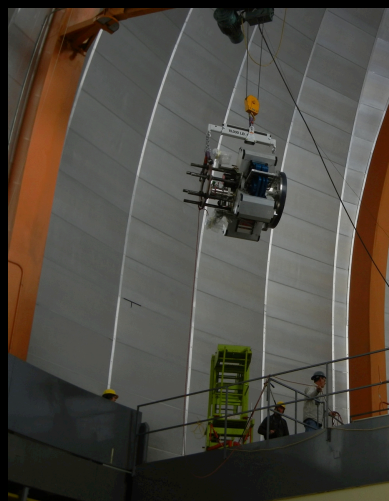
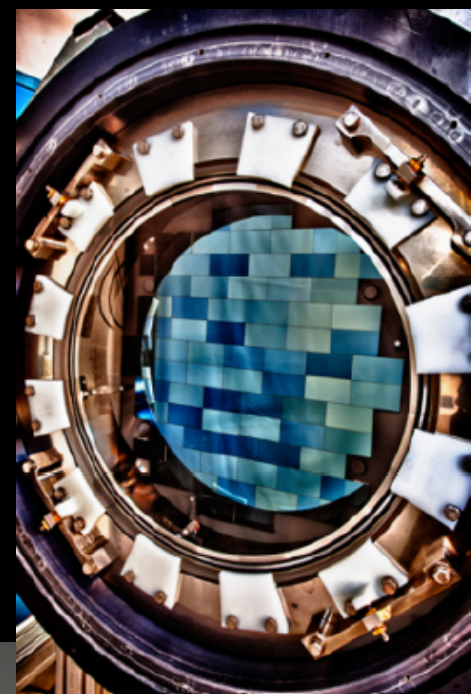
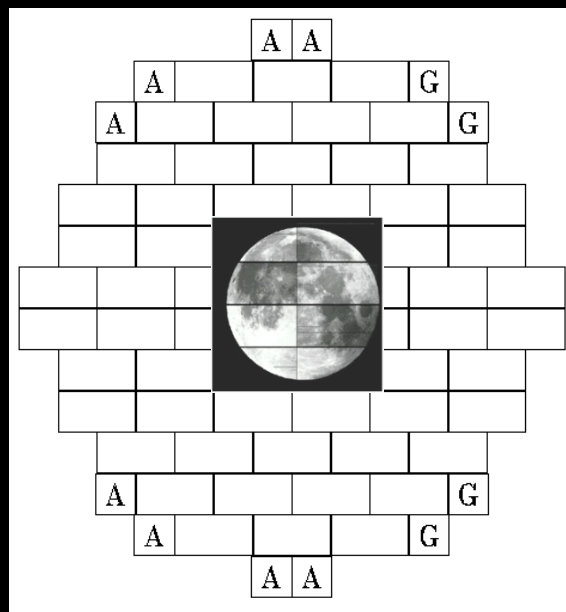
- DES CCDs are currently deployed to search for dark matter in the DAMIC experiment -- with sensitivity to low threshold recoils
- R&D on low noise and low-E x-rays make DES CCDs a possible choice to search for chameleon at helioscopes etc.



Nominal threshold 40 eVee
Sensitive to low mass dark matter

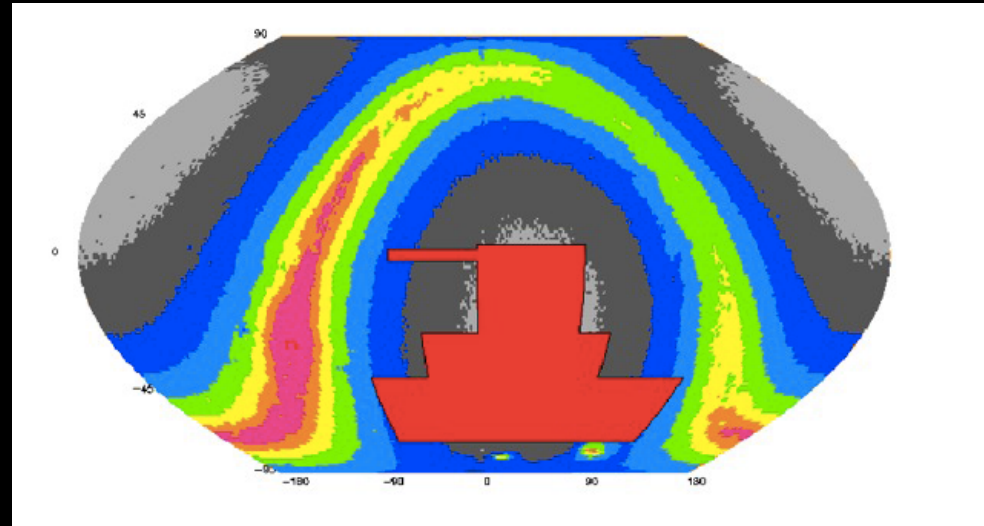
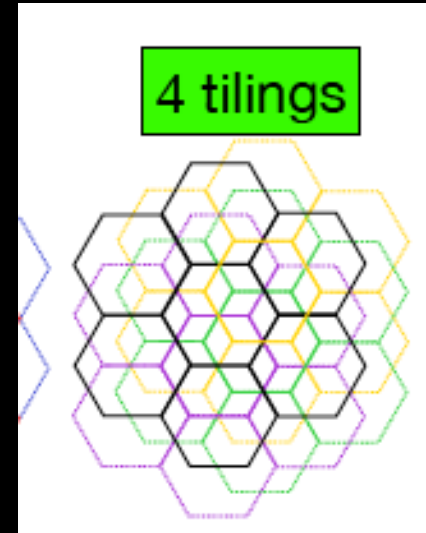
Focal Plane

- CCDs 570 Mpixels
15x15 μm , 0.27"/pixel
62 2Kx4K imaging, four
2Kx2K guiders, and eight
2Kx2K focus chips
- Cryogenic vessel 120K
- <15 e⁻ noise @ 250kpix/s
- 3 sq deg, 0.5m diameter
- (u),g,r,i,z,Y broad filters
- Typical exposure 100s,
readout during ~25s slew
- Each exposure ~300MB
- 2 weeks from hanging in
the dome to first image



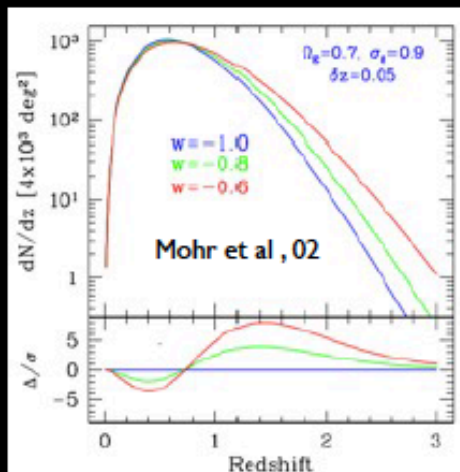
DES Survey

- 5000 sq deg nominally covered by 2 tilings per year
 - Overlap with South Pole Telescope
 - Minimal dust looking out of the Milky Way
 - Overlap with other surveys for calibration or areas with galaxy spectra
- Ten supernova fields
 - Visit ~weekly or if seeing not ideal
- Depth to $\sim 24^{\text{th}}$ magnitude
- Redshifts to ~ 1.5
- Expect 300M galaxies and 100K galaxy clusters
- Expect 4000 Type IA SN

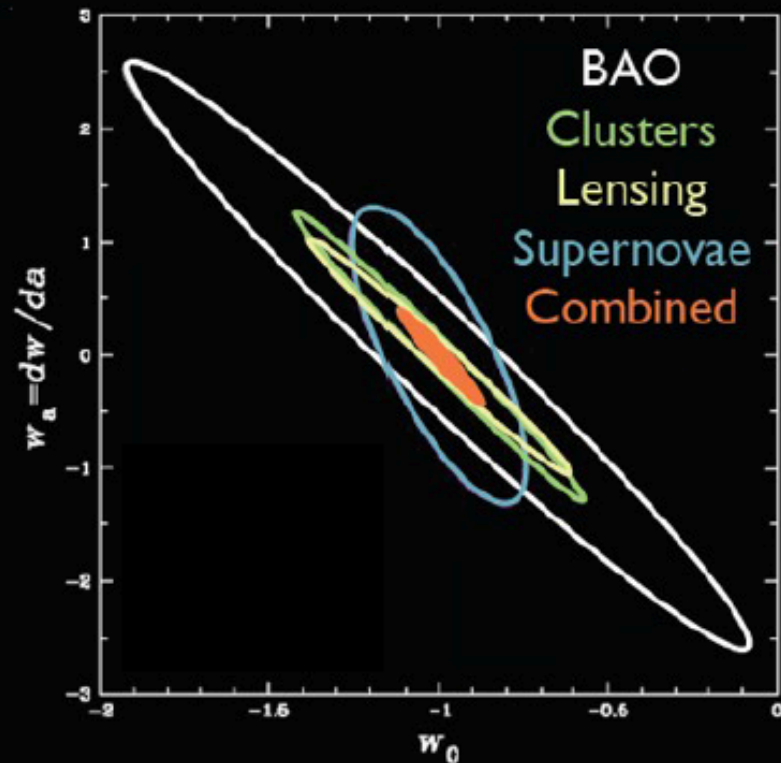
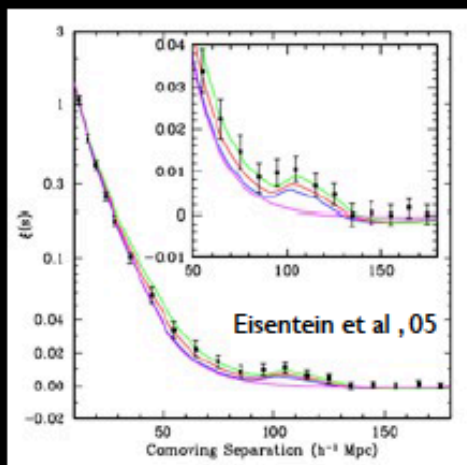


Dark Energy: Four Probes

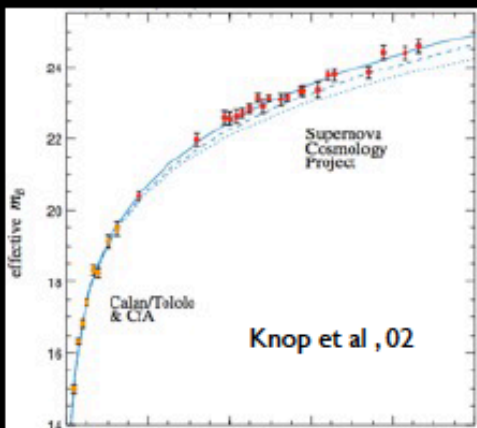
Galaxy Cluster Counts



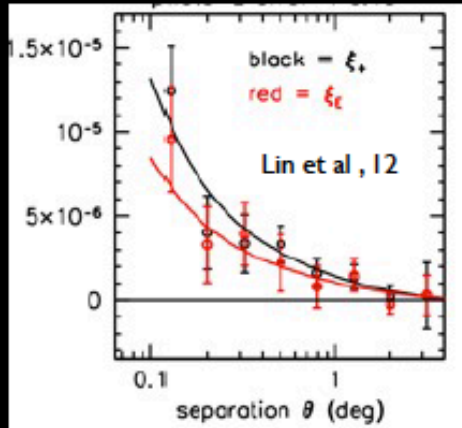
Baryon Acoustic Oscillation



Type Ia Supernovae



Weak Lensing



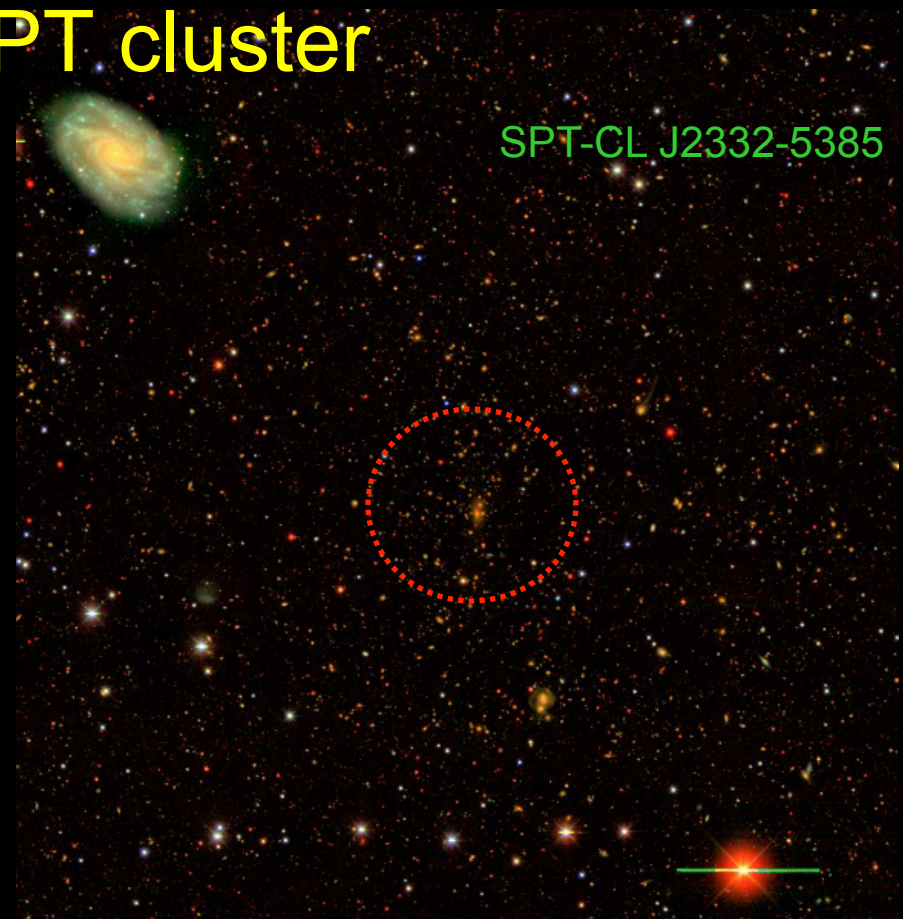
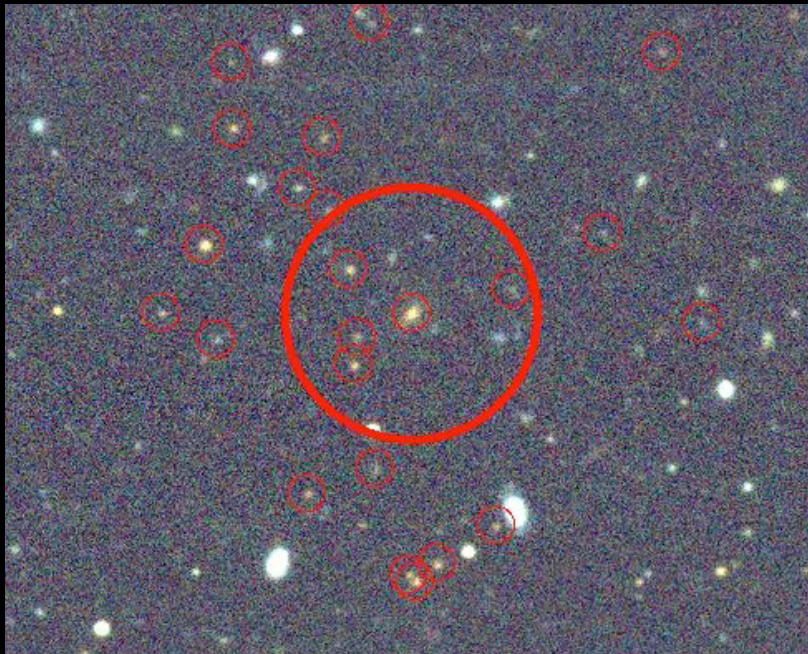
DES will improve the constraints on equation of state by a factor of $\sim 3 - 5$
 What if DE is due to chameleons?
 See A. Weltman talk

Jiangang Hao

Galaxy clusters

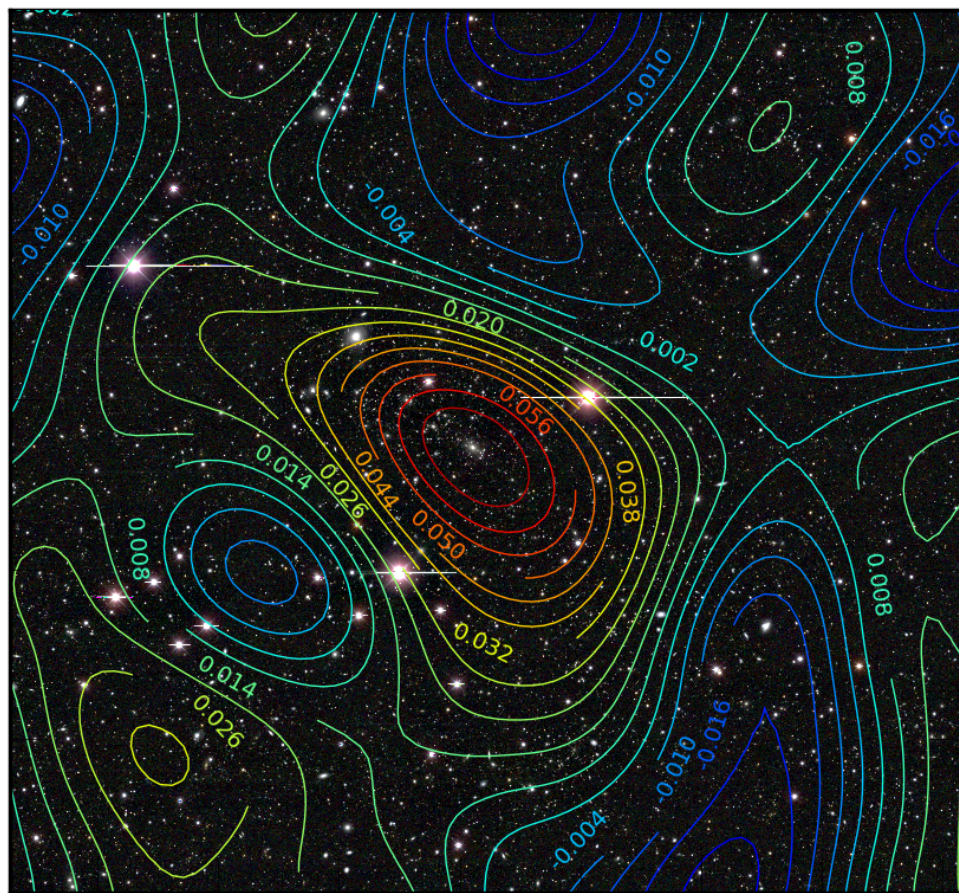
- Discovery of new clusters of galaxies identified by photometric redshift
- Optical follow-up of SPT cluster

Redshift $\sim 0.8-0.9$ discovery



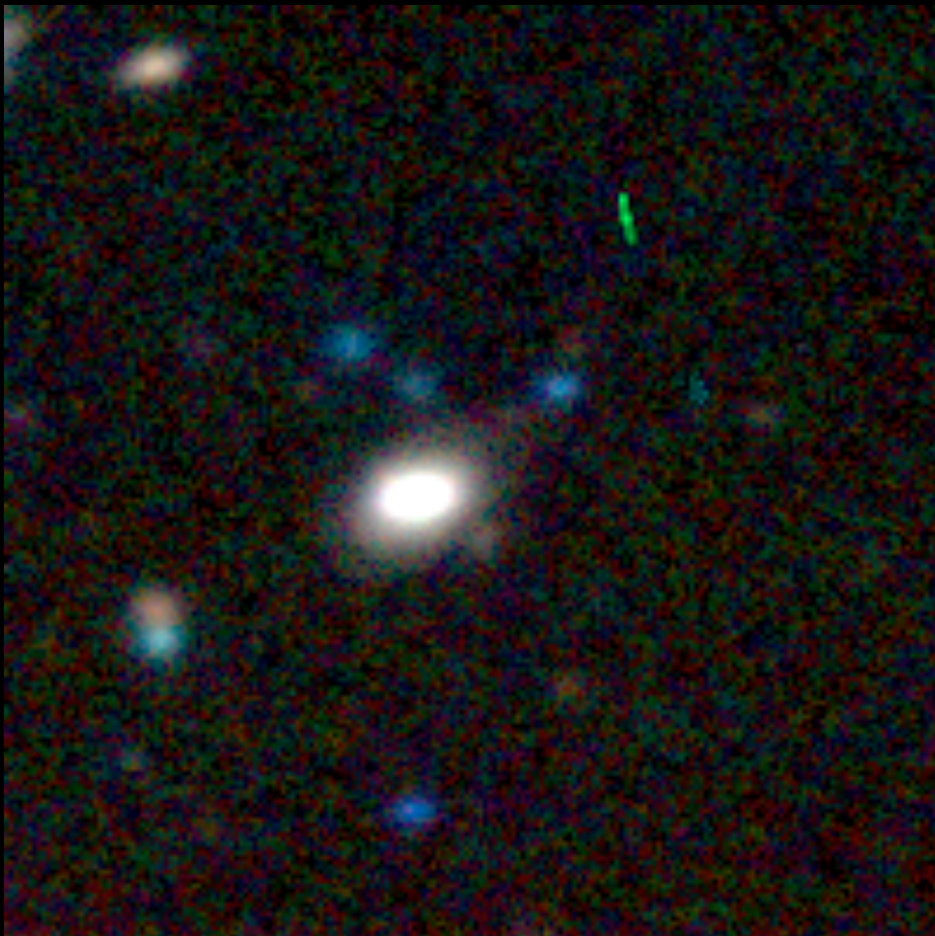
Weak lensing

- DES cluster with a map showing the dark matter mass distribution (preliminary) obtained by statistical analysis of the weak lensing distortion of galaxies



Type IA Supernova

- “Standardizable candles” that map the expansion history of the universe.



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Present Time: 4 Apr 2013; 02:31 UT

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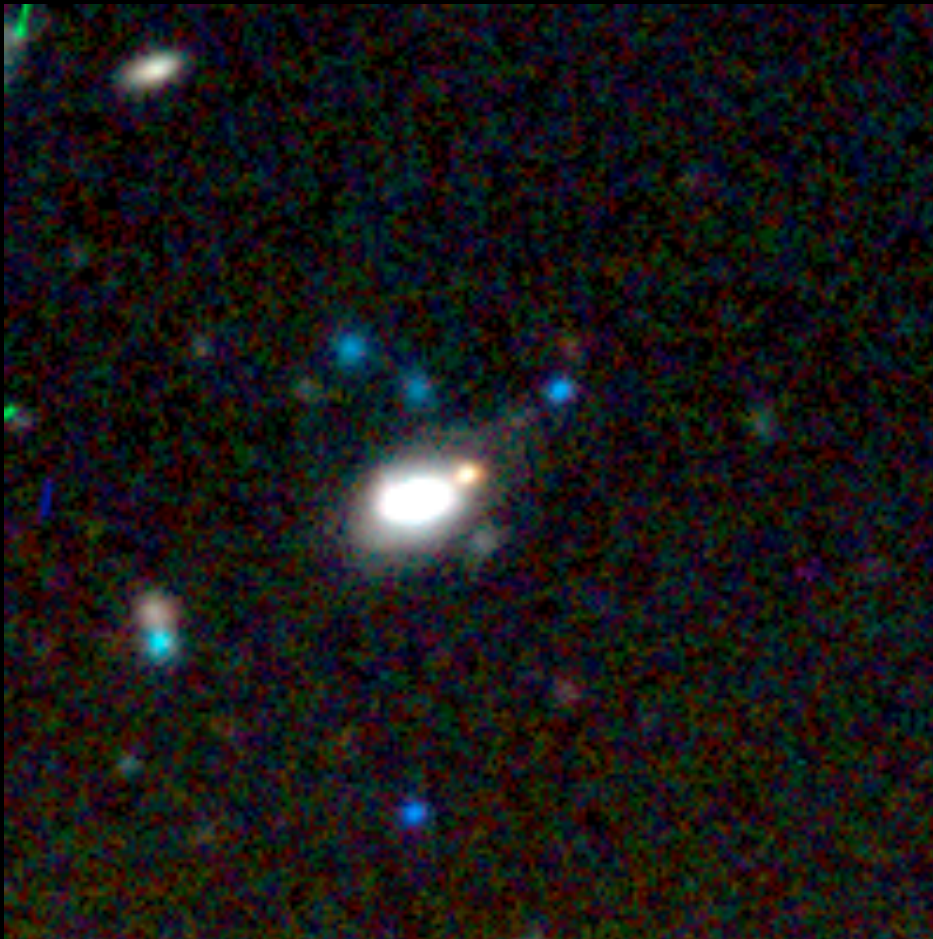
Telegrams Containing **All** of the Keywords:
dark, energy, survey

5 Selected of 4949 Telegrams

4826	Spectroscopic confirmation of DES12S2b	S. B. Cenko, K. I. Clubb (University of California, Berkeley), G. Aldering, J. S. Bloom, A. Kim, P. Nugent,..... -- 20 Feb 2013; 01:10 UT
4800	Spectroscopic confirmation of DES12S2a	P. J. Brown, K. Krisciunas, J. Marshall, N. Suntzeff (Texas A&M University), E. Ahn, D. Finley, J. -- 8 Feb 2013; 19:02 UT
4741	Spectroscopic confirmation of DES12S1a	P. J. Brown, K. Krisciunas, J. Marshall, N. Suntzeff (Texas A&M University), K. Barbary, J. P. Bernstein,..... -- 17 Jan 2013; 21:21 UT
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4668	First SN Discoveries from the Dark Energy Survey	T. Abbott (1), F. Abdalla (2), I. Achitouv (3), E. Ahn (4), G. Aldering (6), S. Allam (4), D. Alonso..... -- 22 Dec 2012; 14:34 UT

Type IA Supernova

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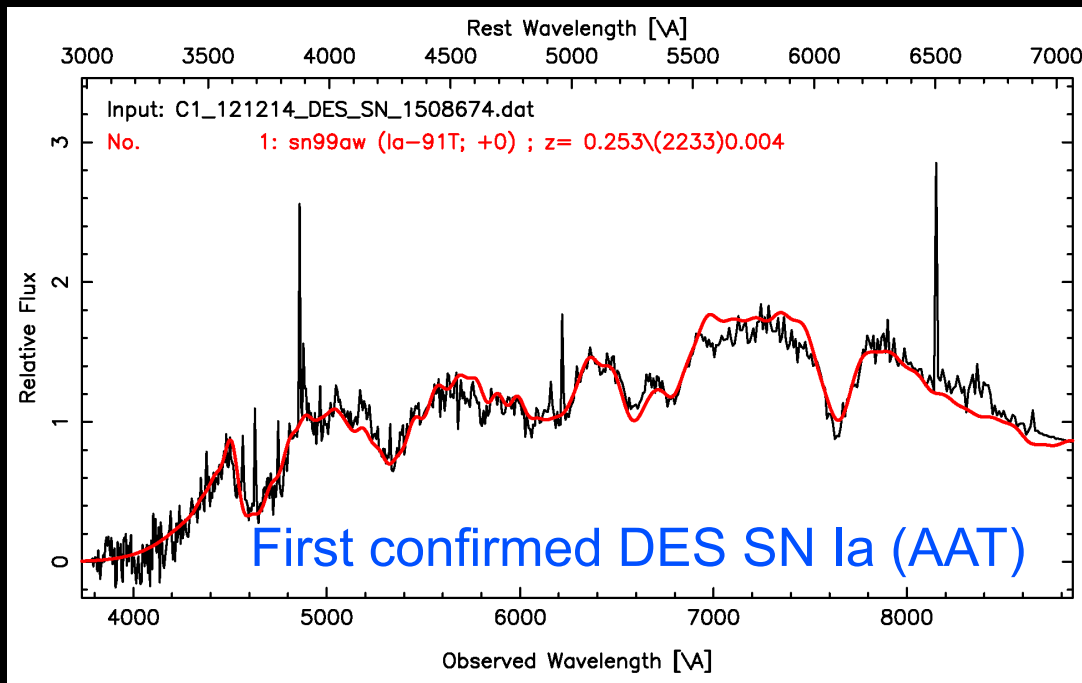
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Type Ia Supernova

- “Standardizable candles” that map the expansion history of the universe.
- Follow up spectroscopy for typing and redshift.



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White Dwarfs and Stars

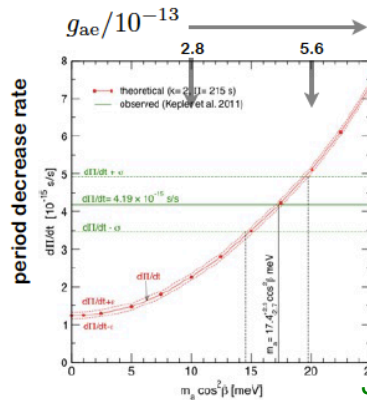
Hints from white dwarfs are suggestive of possible cooling through an axion-like particle

--- systematics ??

DES studies WDs as part of the calibration effort

Period decrease of G117-B15A

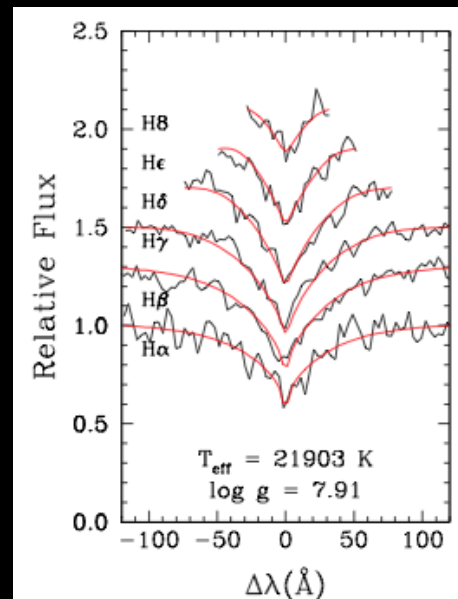
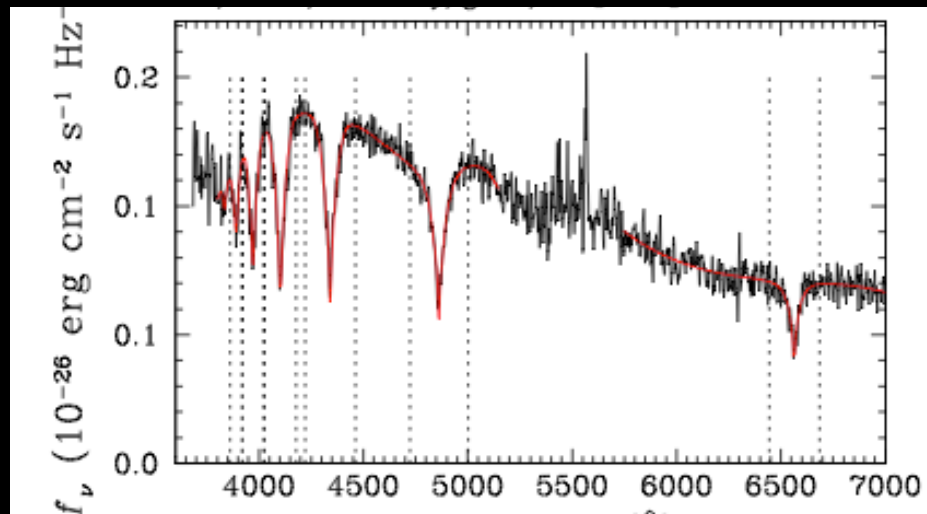
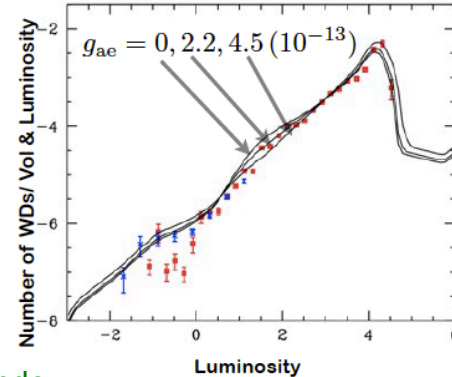
Corsico et al. arXiv:1205.6180



J. Redondo

WD luminosity function

Isern et al. arXiv:1204.3565



Model fit of the Balmer H lines to obtain WD properties and provide $\log g$ and T_{eff} needed for a synthetic spectrum

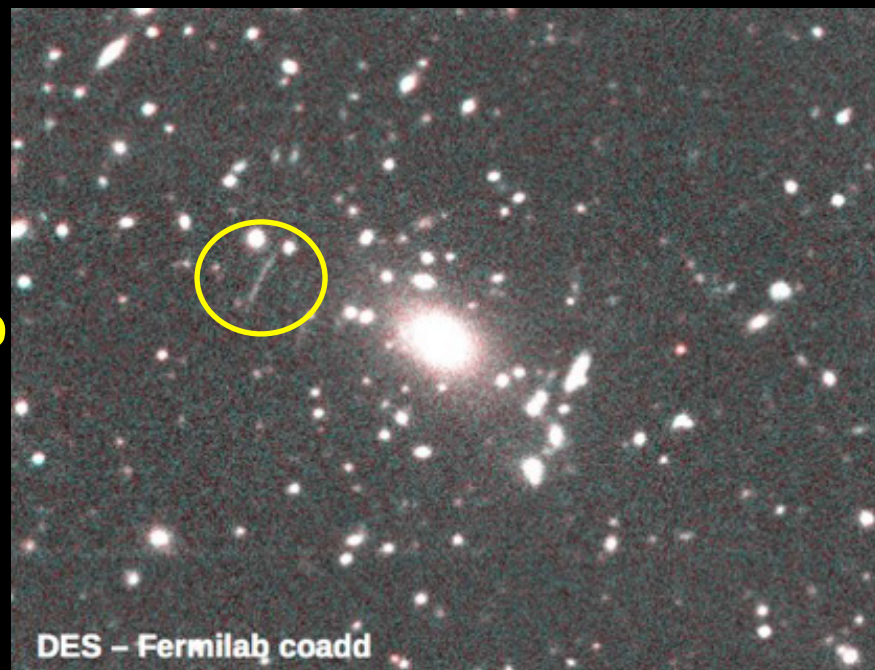
Pier-Emmanuel Tremblay

Also, M. Giannotti talk on Massive Stars

Playground of objects

- DES will be sensitive to large array of objects
 - Shown below is a strongly lensed distant galaxy
 - Large scale structure plus CMB gives n_{eff}
 - Milky way and satellite galaxy measurements
 - Also, high redshift quasars, AGNs, etc.
- With such a large survey, what might DES find that can lead to meaningful measurements?

See talk Thur, P. Sikivie (galaxies)
See talk Fri, A. Payez (quasars)



Conclusions

- The Dark Energy Survey has begun
 - Impressive results during science verification
 - First season of science data begins Aug 2013
- This survey should achieve its goals of improving upon knowledge of Dark Energy
- There are a handful of areas where DES might contribute to WISPy physics
- Suggestions on how to use this rich data set are welcome