

Current Status and Future Plans of the Dark Energy Survey

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Notre Dame Astrophysics Seminar
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The Era of Observational Cosmology

Two (competing!) observations of supernovae showed that the cosmos is dominated by a mysterious “Dark Energy” that drives the accelerated expansion of the universe, and subsequent observations utilizing different probes (e.g. CMB) have confirmed this result.

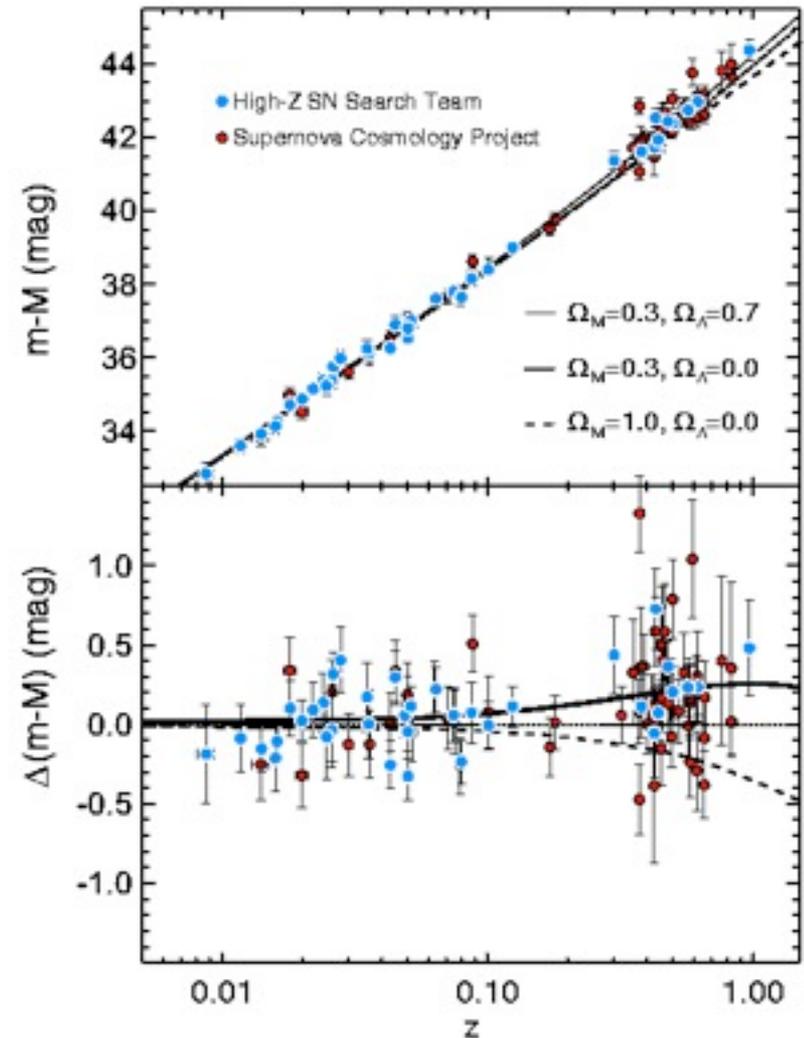
The properties of Dark Energy can be expressed in terms of its Equation of State at different redshifts:

$$w(z) = p/\rho$$

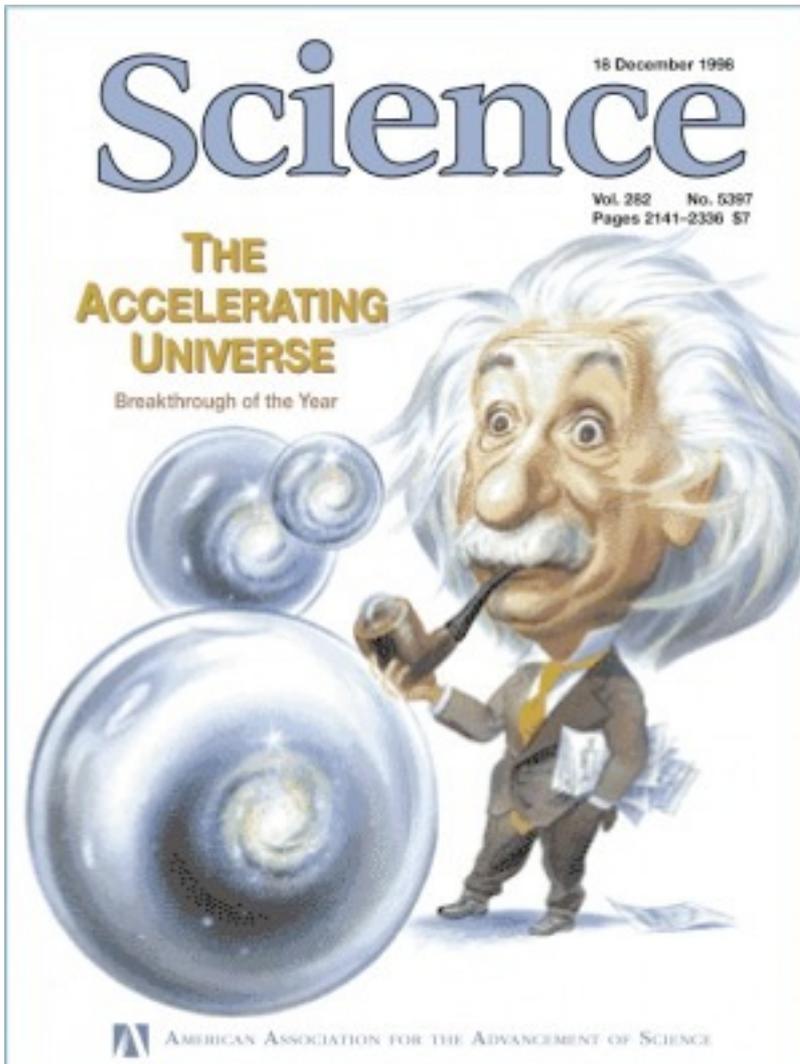
We parameterize $w(z)$ as follows:

$$w(z) = w_0 + w_a(1-a), \text{ where } a = (1+z)^{-1}$$

$w_0 = w_\Lambda$ (i.e. the cosmological constant) if $w_a = 0$.



The Discovery of Dark Energy is Big News...



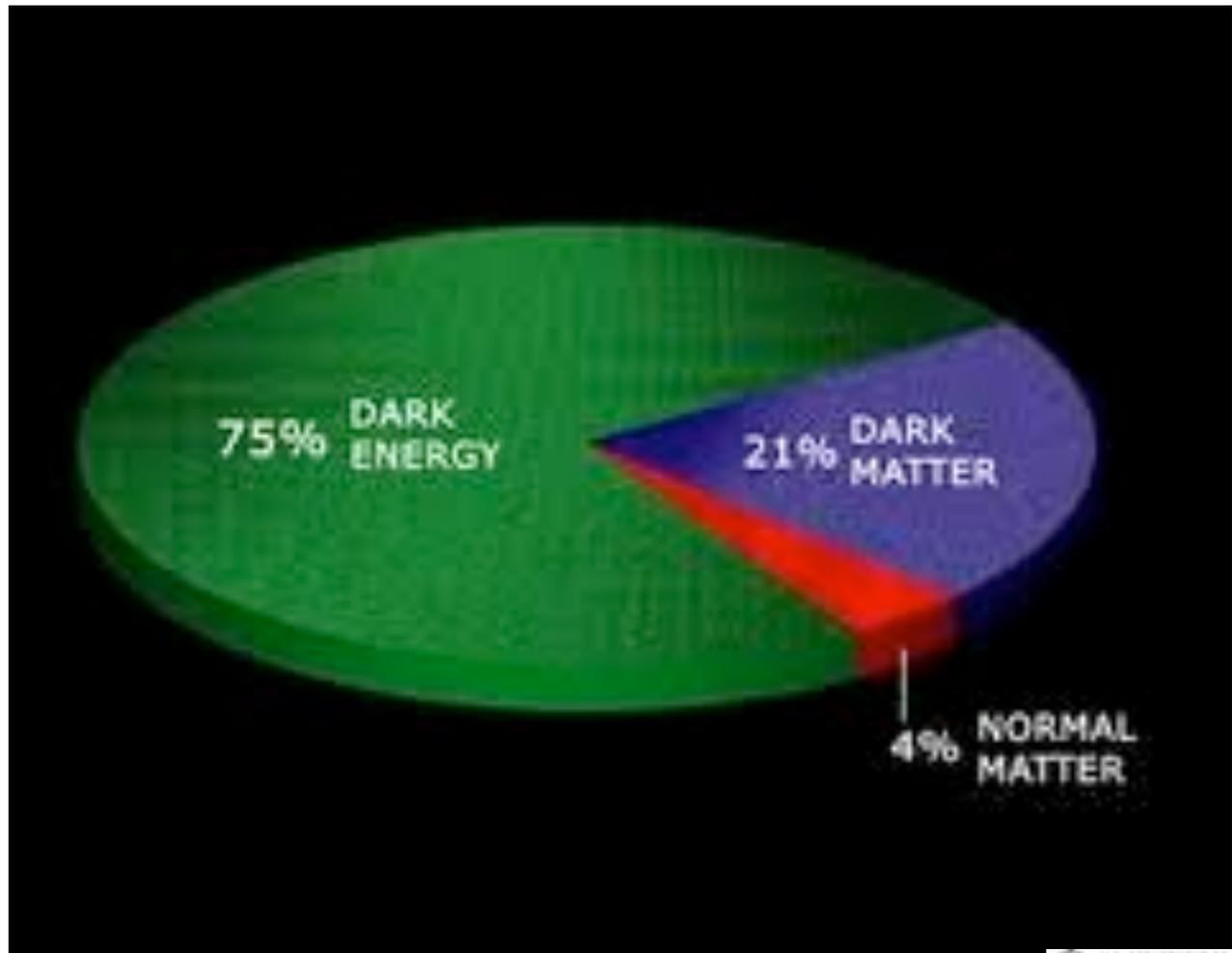
Science Magazine,
December 18, 1998



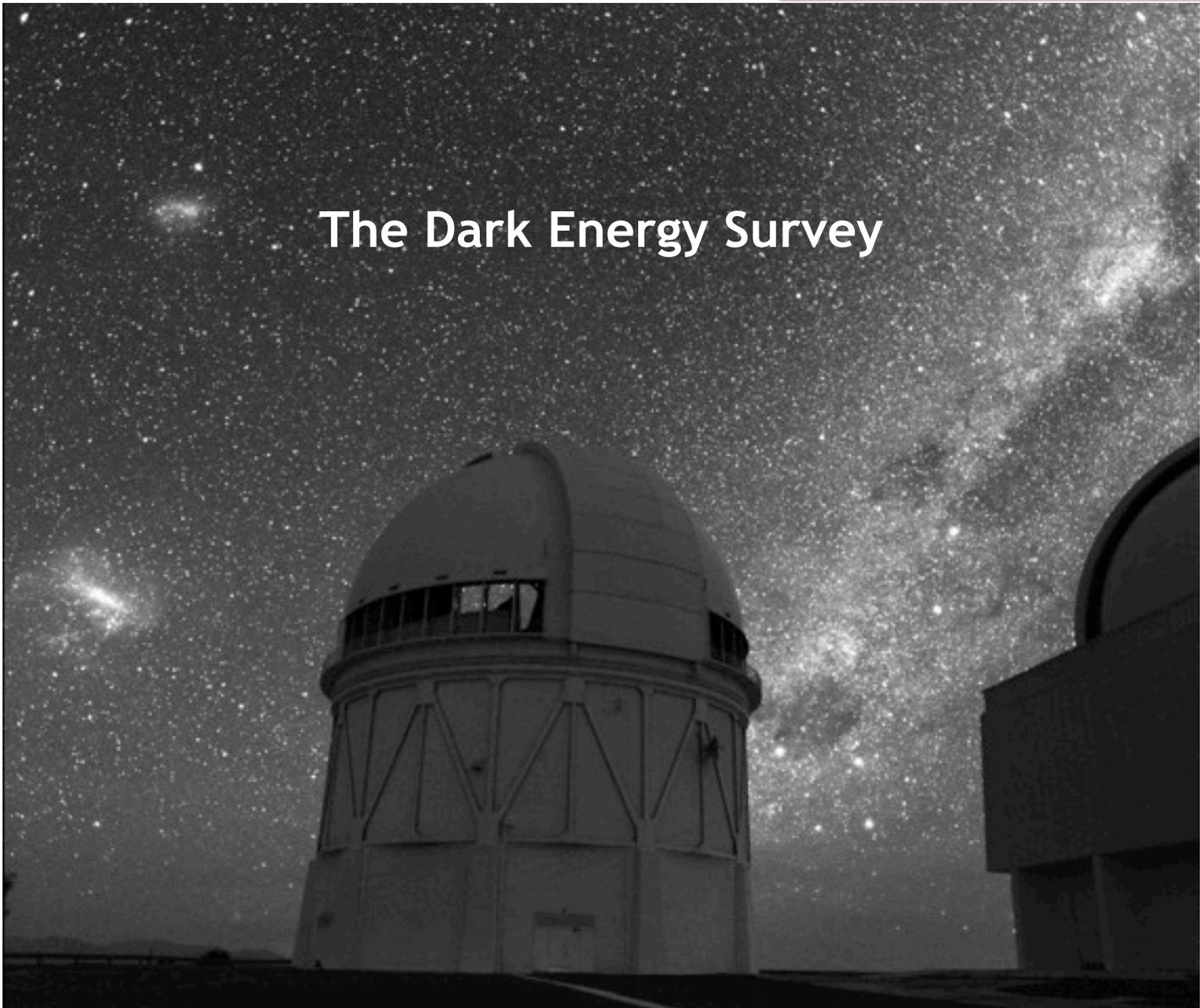
Nobel Prize in Physics, 2011

So, what is it...?

- Cosmological Constant?
- 10^{120} problem
- Dynamical Dark Energy?
- Modification of Gravity?
- Voids?
- Disfavored by HST Observations
- We don't know, yet...

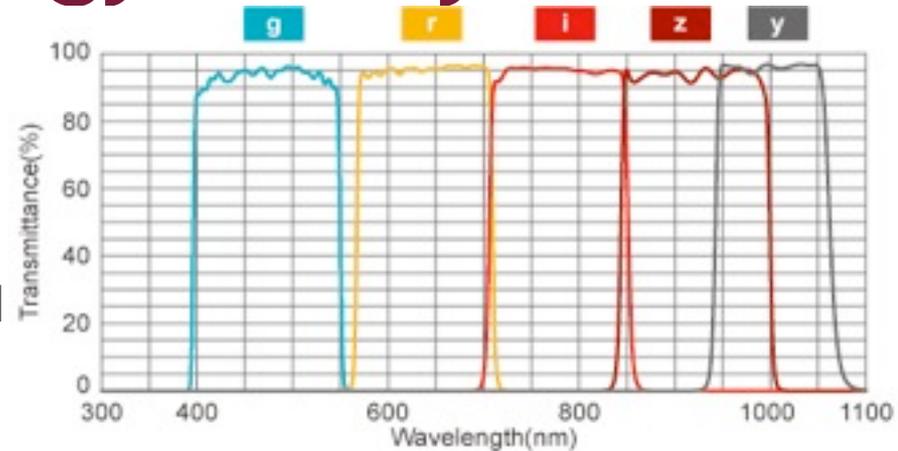


The Dark Energy Survey



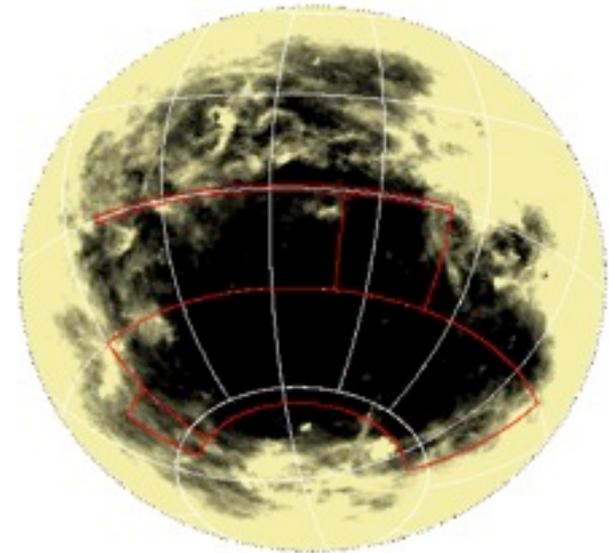
The Dark Energy Survey

Starting in November 2012, DES will observe 1/4 of the southern sky over 6 years with (SDSS-like) grizY filters. The DES “footprint” overlaps with VISTA Hemisphere Survey (DES Y-band data will be exchanged for VHS JHK data), as well as SDSS, SPT, and Skymapper.



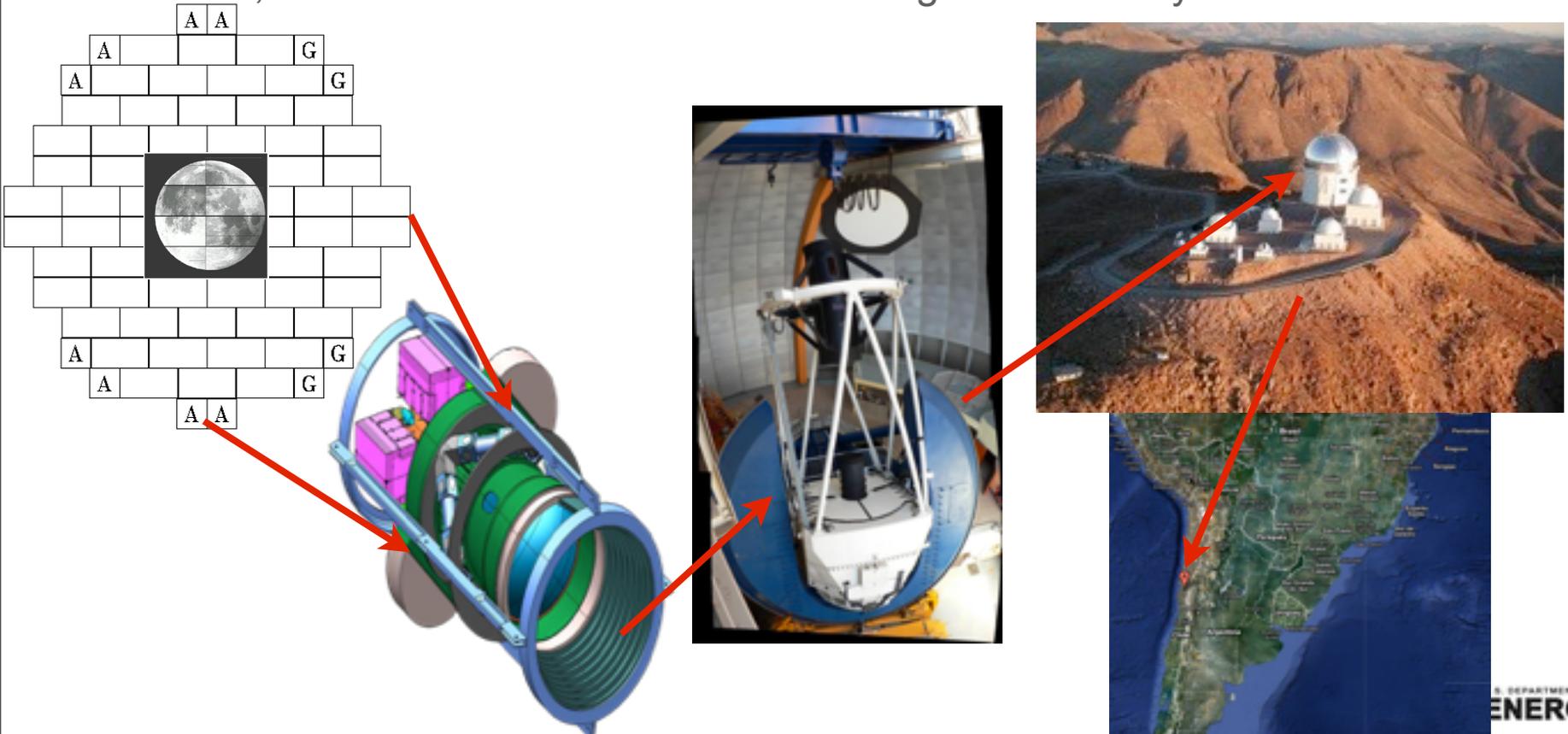
DES uses four complementary methods to constrain the Dark Energy Equation of State:

- Supernovae
- Galaxy Clusters
- Weak Lensing
- Large Scale Structure



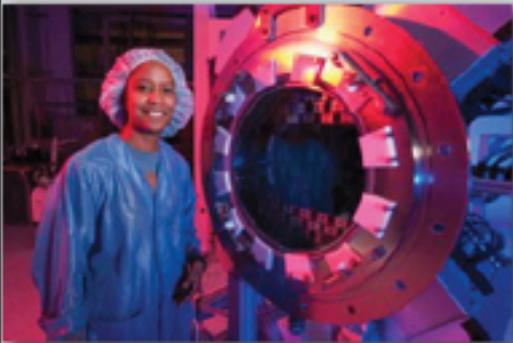
The DES Instrument: DECam

The newly-constructed Dark Energy Camera has been installed at the prime focus of the 4m. Blanco Telescope at Cerro Tololo Inter-American Observatory in Chile. DECam consist of 62 2k x 4k extremely red-sensitive CCDs, plus associated guide/focus CCDs, with a field of view suitable for a large-area survey.



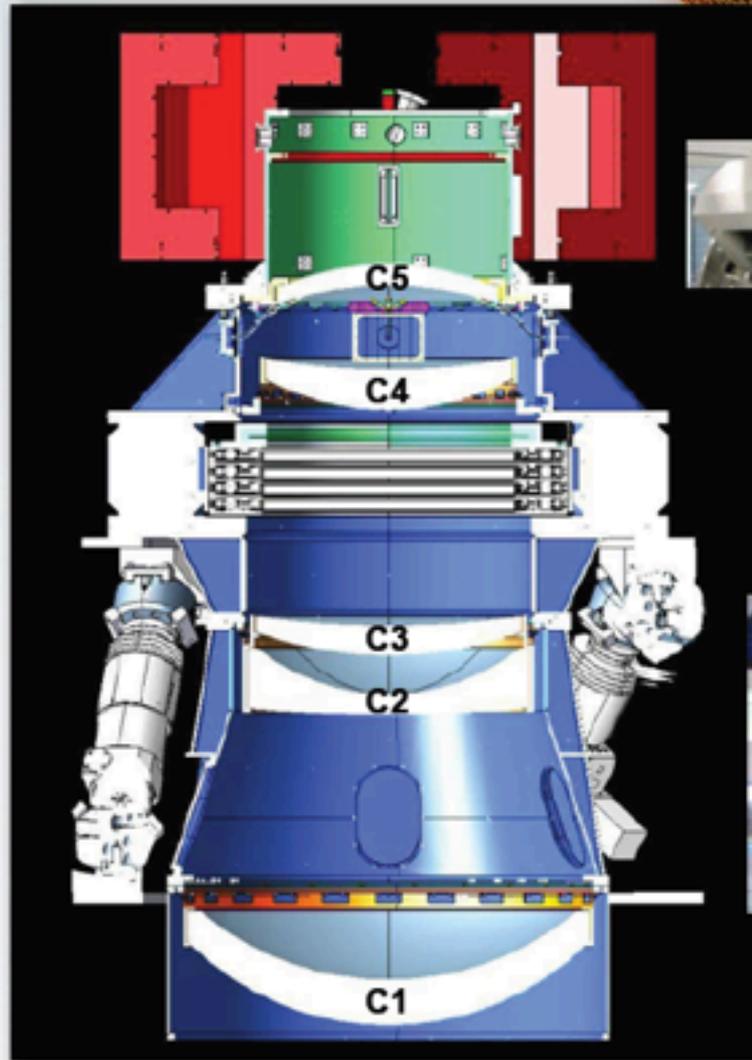
DECAM

CCD focal plane is housed in a vacuum vessel (**the imager**)



Hexapod provides focus and lateral alignment capability for the corrector-imager system

Barrel supports the **5 lenses** and imager



CCD readout electronic crates are actively cooled to eliminate thermal plumes



Filter changer with 8 filter capacity and **shutter** fit between lenses **C3** and **C4**

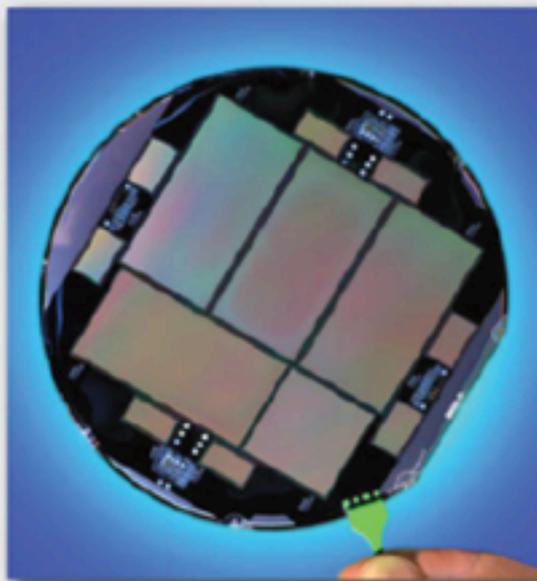
LN2 is pumped from the telescope floor to a heat exchanger in the imager: cools the CCDs to -100 C

DECAM CCDS

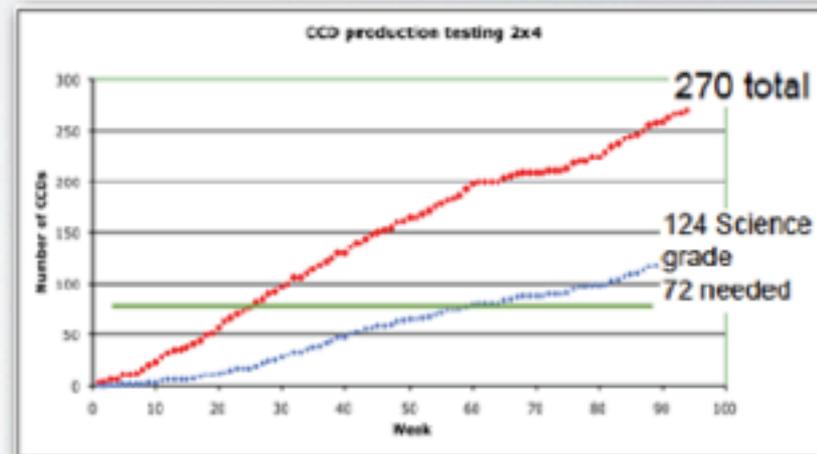
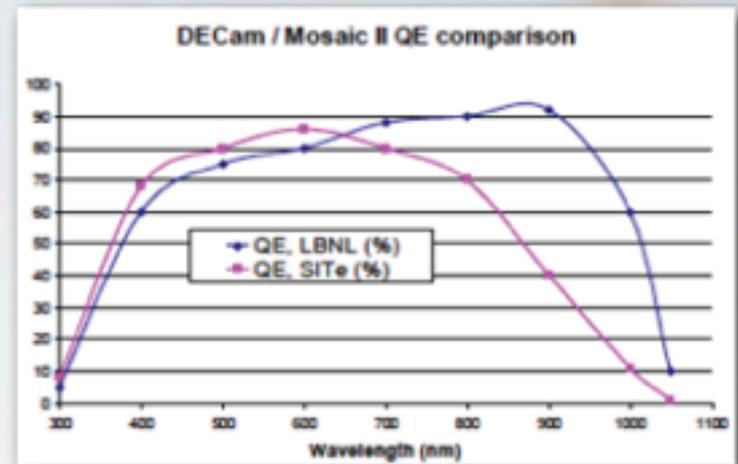


Red Sensitive CCD wafers, designed by LBNL, processed at DALSA and LBNL:

- QE > 50% at 1000 nm
- 250 microns thick
- readout 250 kpix/sec
- 2 RO channels/device
- readout time ~17sec



CCDs are packaged and tested at Fermilab.

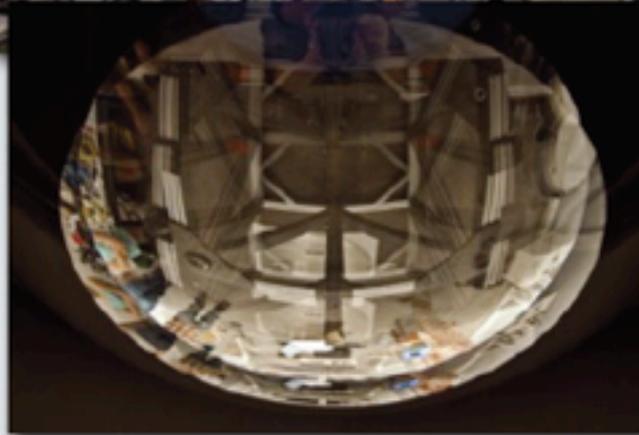
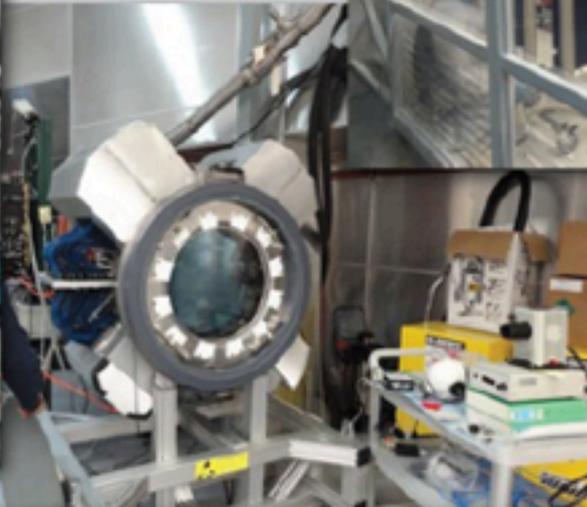
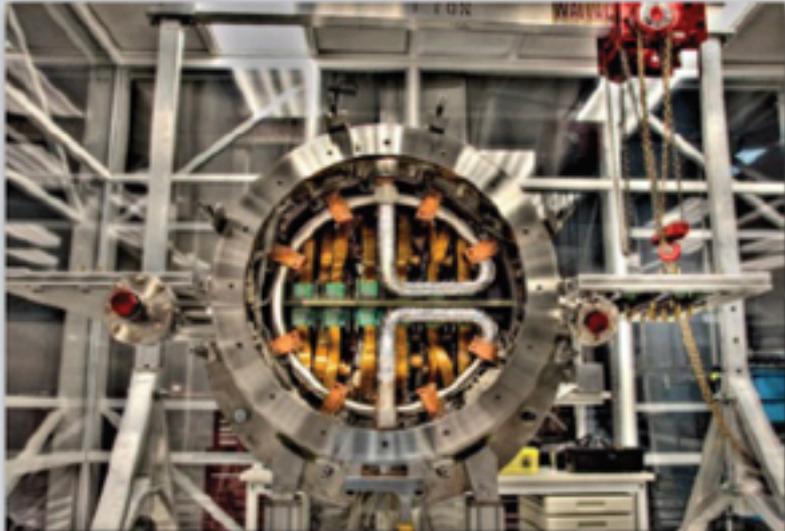


DECam Simulator at Fermilab

Extensive component and integration testing prior to installation

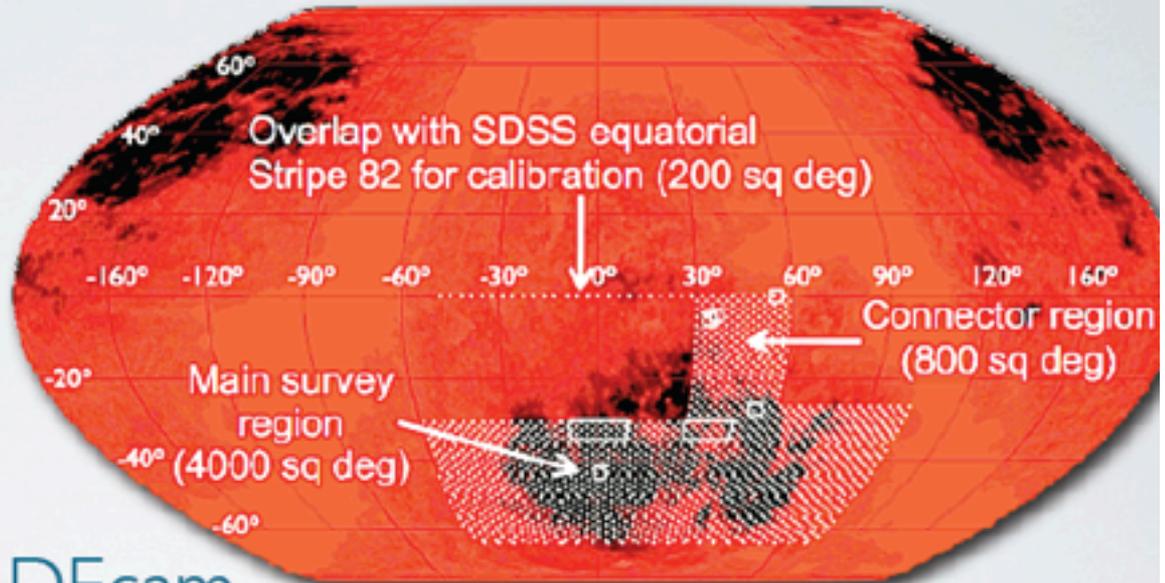
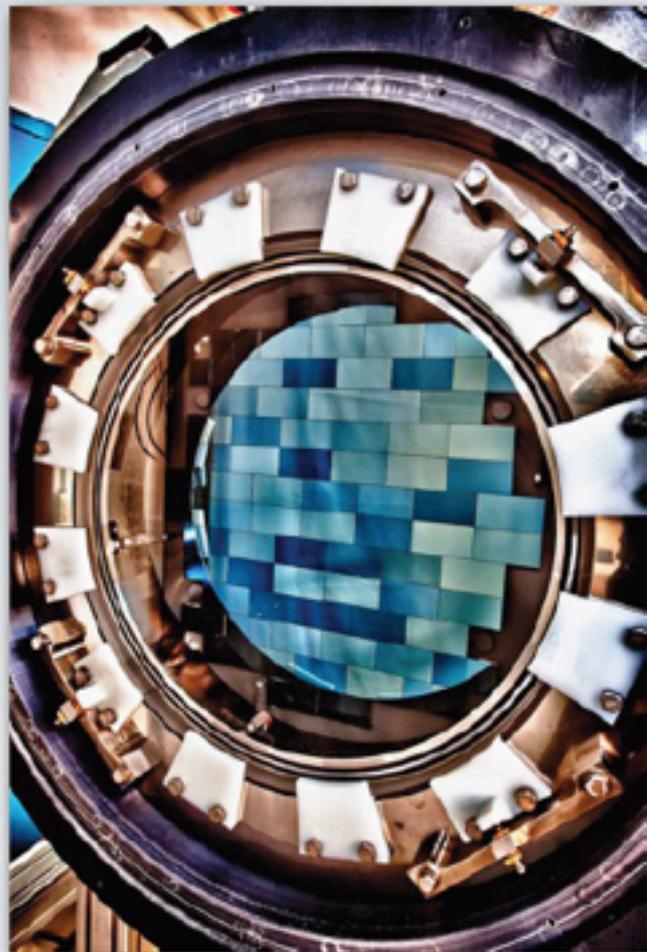


DECAM IN CHILE



From
Dec 2011
to
Jan 2012

We checked
out the imager
at CTIO!



DEcam

3 sq deg FOV, 570 Mpix
optical CCD camera

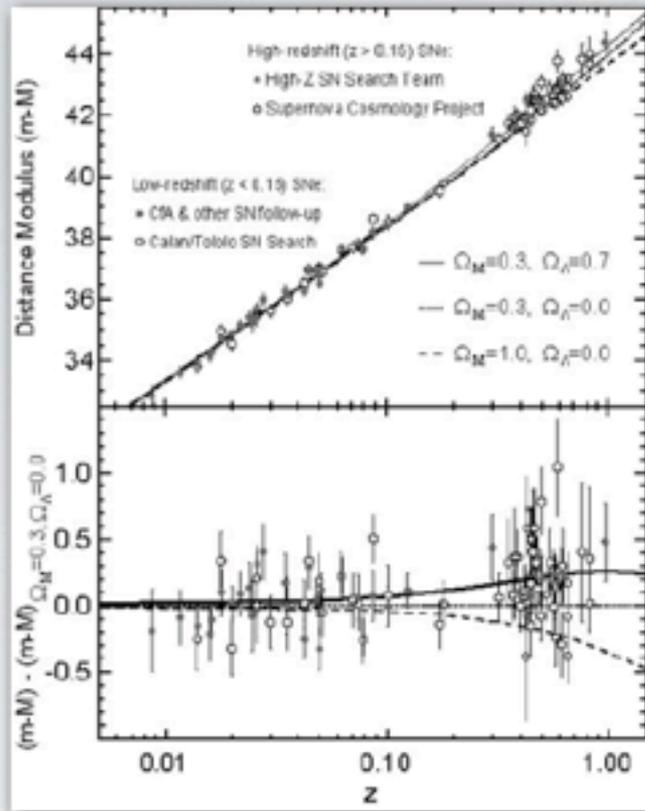
Facility instrument for
CTIO Blanco 4-m
telescope in Chile

First light: ~~Aug 2012~~
Sep 2012

Survey

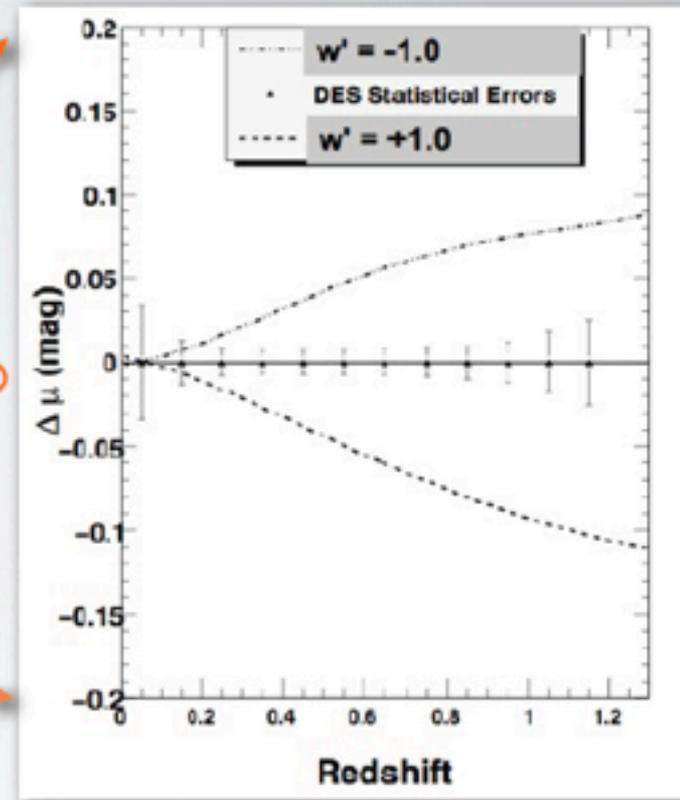
5000 sq deg grizY to 24th mag
overlapping with SPT and VISTA
30 sq deg repeat (SNe)
0.9 arcseconds seeing
525 nights: 2012-2017

DES SCIENCE: SN



4000
SNe up to
 $z \sim 1.2$

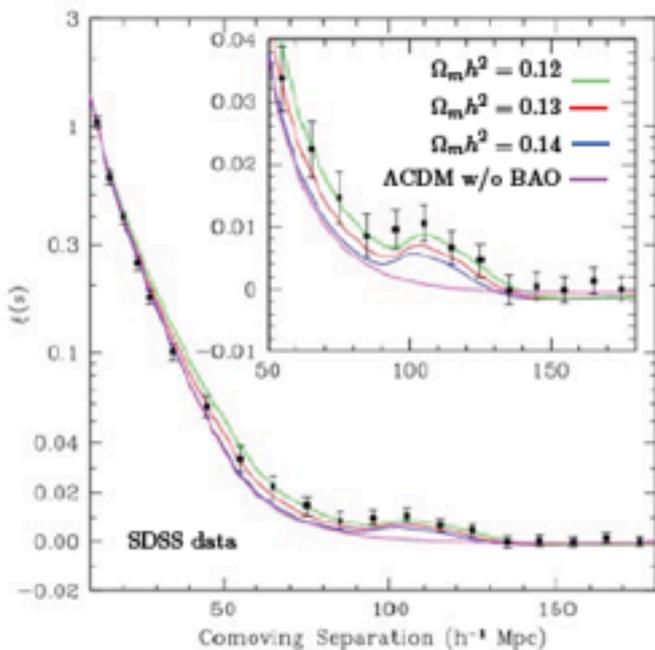
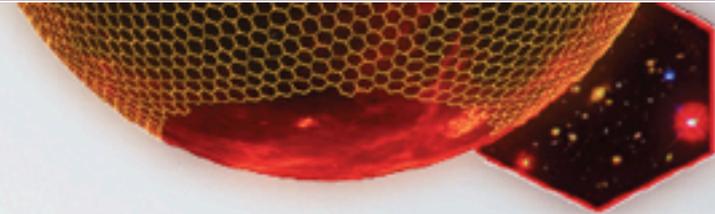
30 sq deg



First results: ~ 100 SNe. Measured w .
(Riess et al. 1998, Perlmutter et al. 1999).

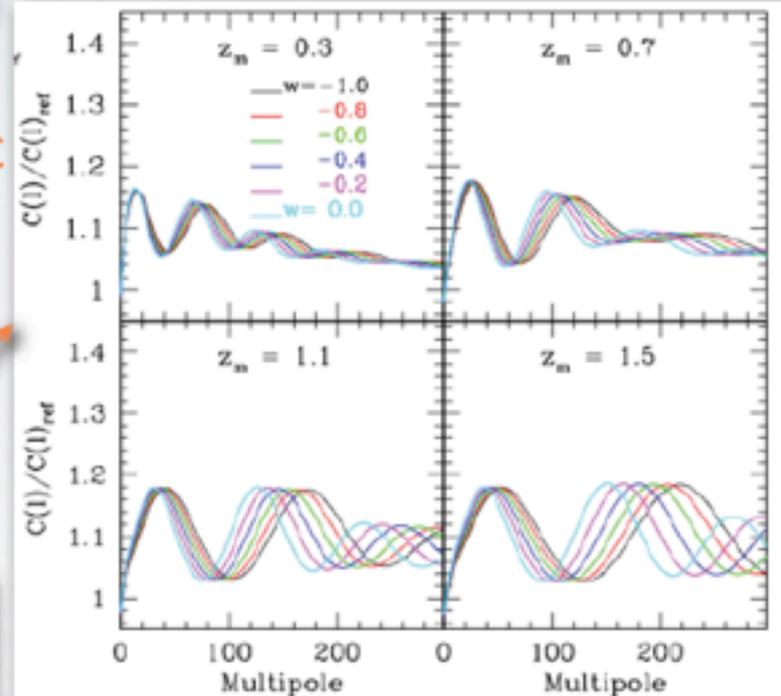
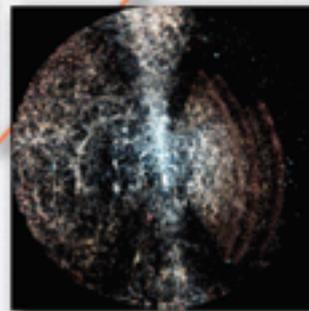
DES expected sensitivity. Large and deep
sample for measurement of $w(a)$.

DES SCIENCE: BAO



mean
photometric
redshift ~ 0.7

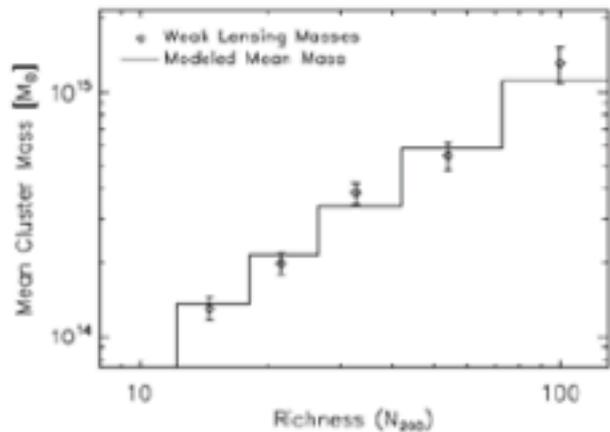
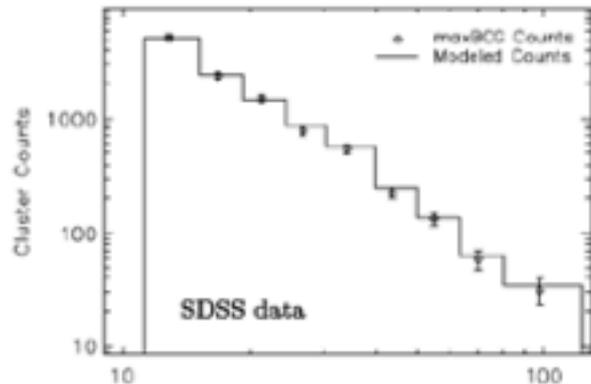
300M
glxs



First results: mean spectroscopic
redshift ~ 0.35 . Measured Ω_m
(Eisenstein et al. 2005)

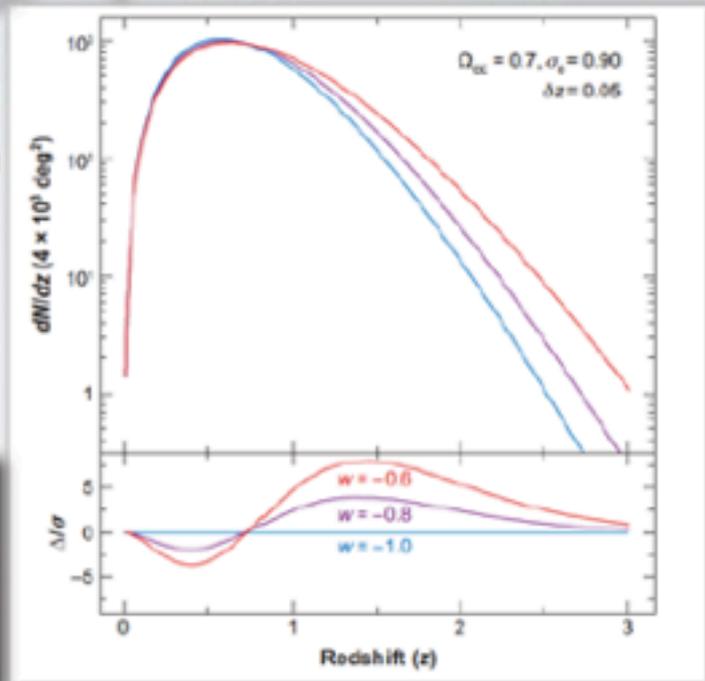
DES expected sensitivity. Can measure
 w by probing deeper.

DES SCIENCE: CLUSTERS



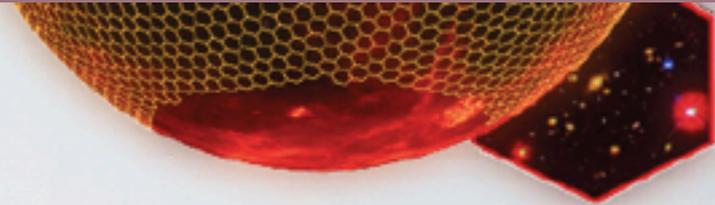
Current results: 6000 clusters, $z \sim 0.35$
Measured Ω_m (Rozo et al. 2010)

100,000
clusters
 $z \sim 1$

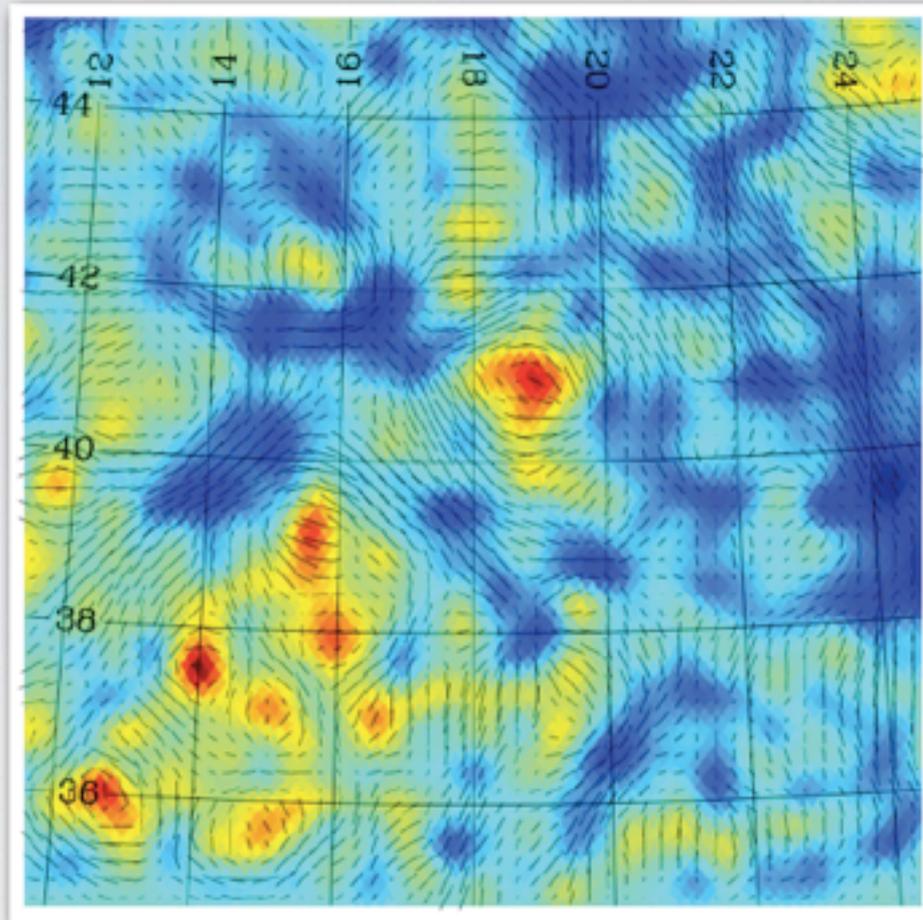


DES expected sensitivity. Measure w with deep & wide survey.

DES SCIENCE:WL



Map of DES
“DC6B” 200 deg²
simulated
convergence and
shear fields



*Colors indicates
convergence \propto
surface mass density*

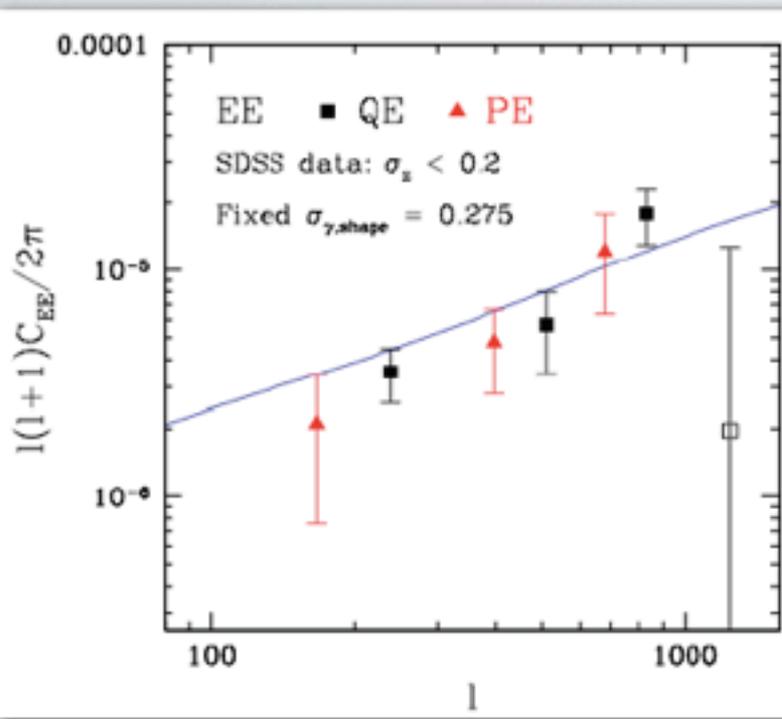
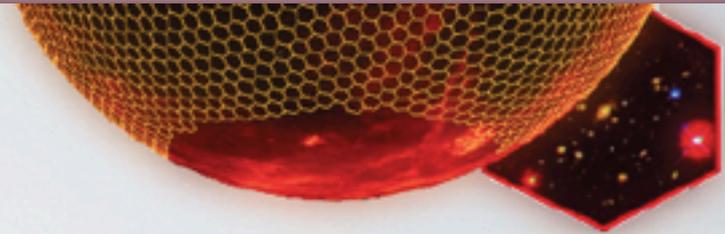
*red \implies high density
blue \implies low density*

*Black “whiskers”
show lensing
shear field*

*Whiskers indicate
magnitude and
direction of lensing
distortions acting
on galaxy shapes*

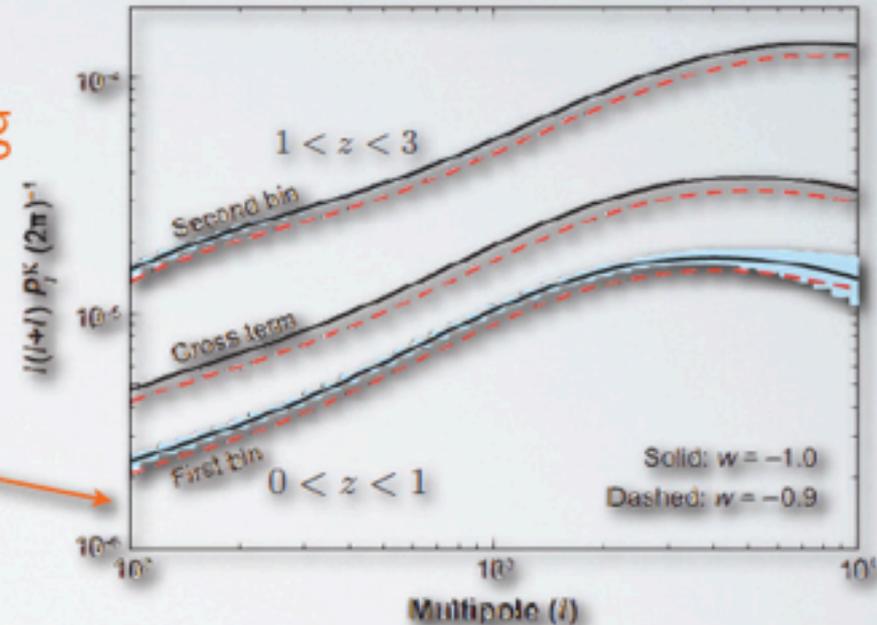
*Figure from
M. Becker*

DES SCIENCE: WL



5000
sq deg

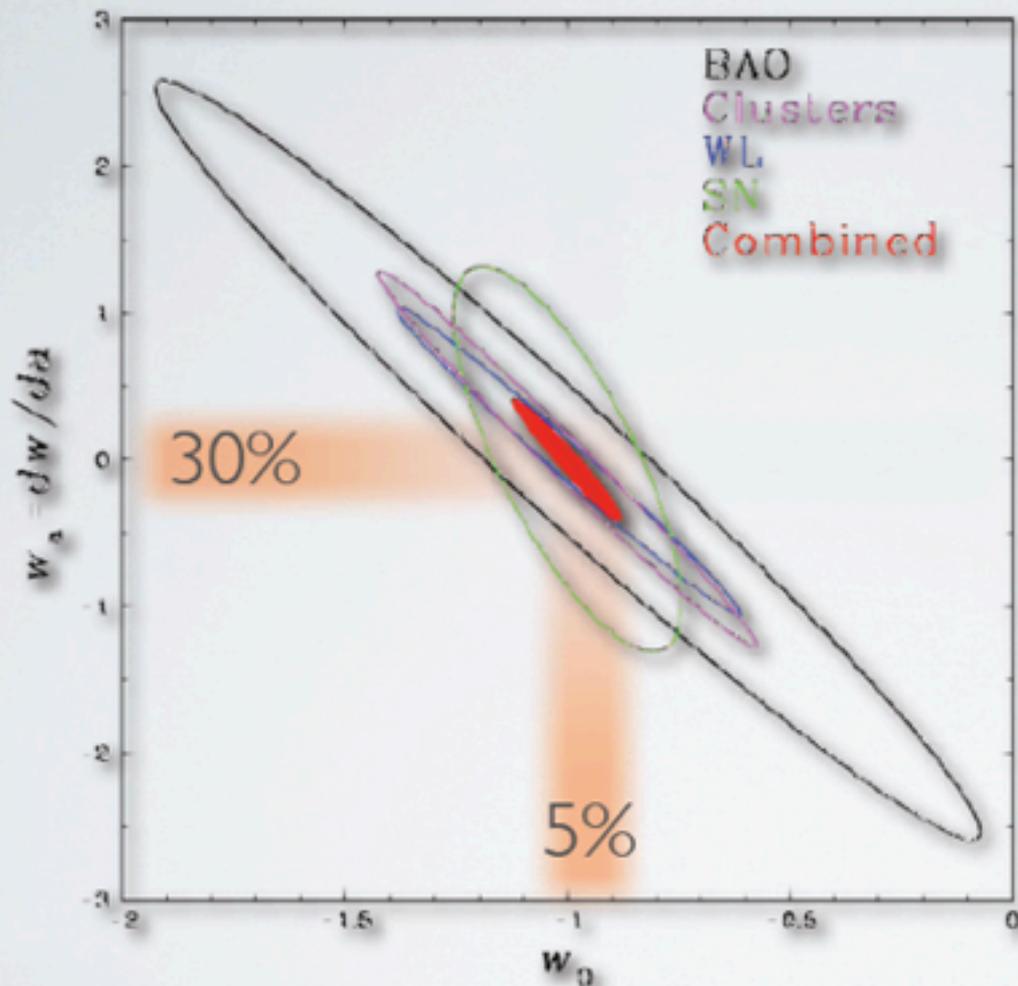
300M
glxs



Current results: 275 sq deg, 24th magnitude.
Measured Ω_m .

DES expected sensitivity. Source galaxies in first bin only. Can measure w by going wider.

DES PROJECTED LIMITS



5000 deg², 0.9" seeing,
24th mag (redshift ~ 1.4)

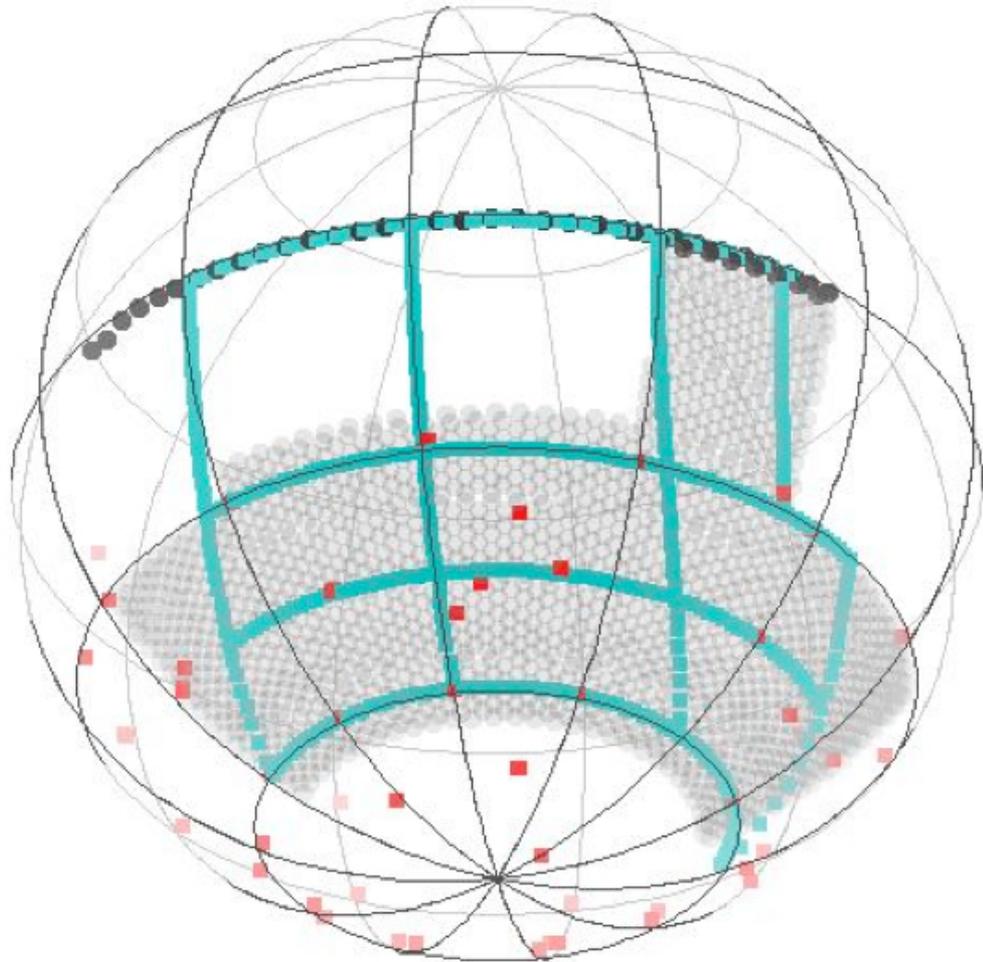
300M galaxies, shapes,
100K clusters, 4K SNe

4 combined probes

3-5x improved Dark
Energy measurement

Calibrating the DES: PreCam Grid & DES Footprint

Rib & Keel Strategy:
Every ~20 min during
the DES, a field
containing hundreds
of calibrated stars
will be observed.
These will be tied to
SDSS, USNO, and
Southern u'g'r'i'z'
Standard Stars.



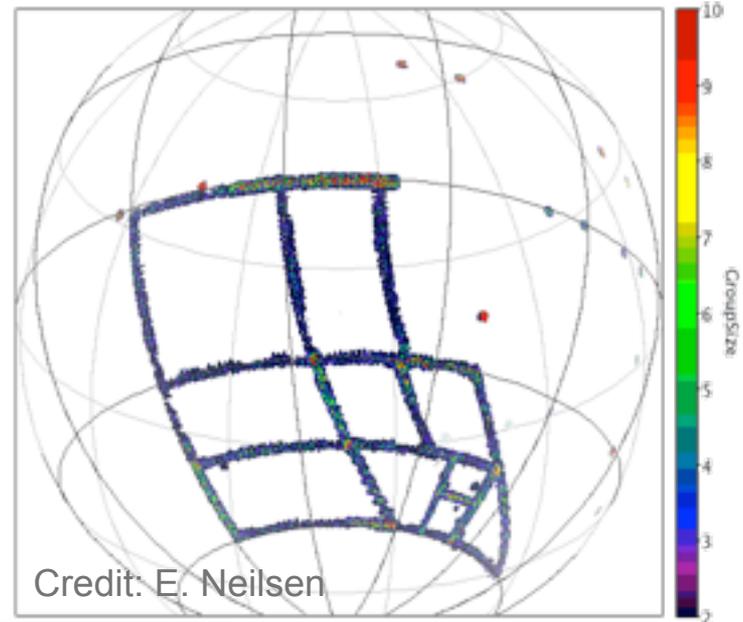
PreCam Goals and Timeline

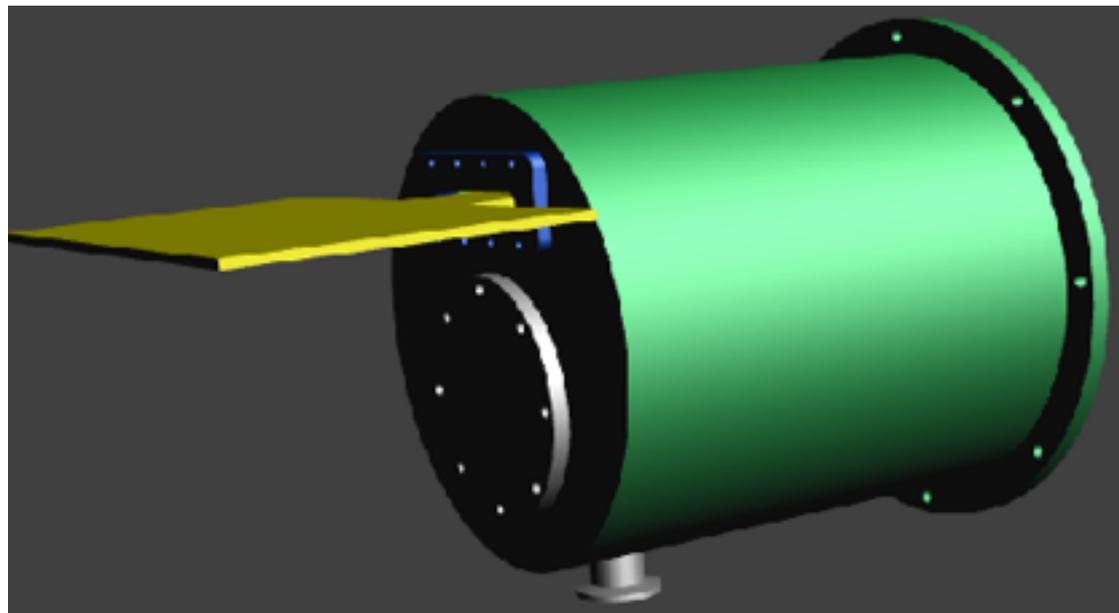
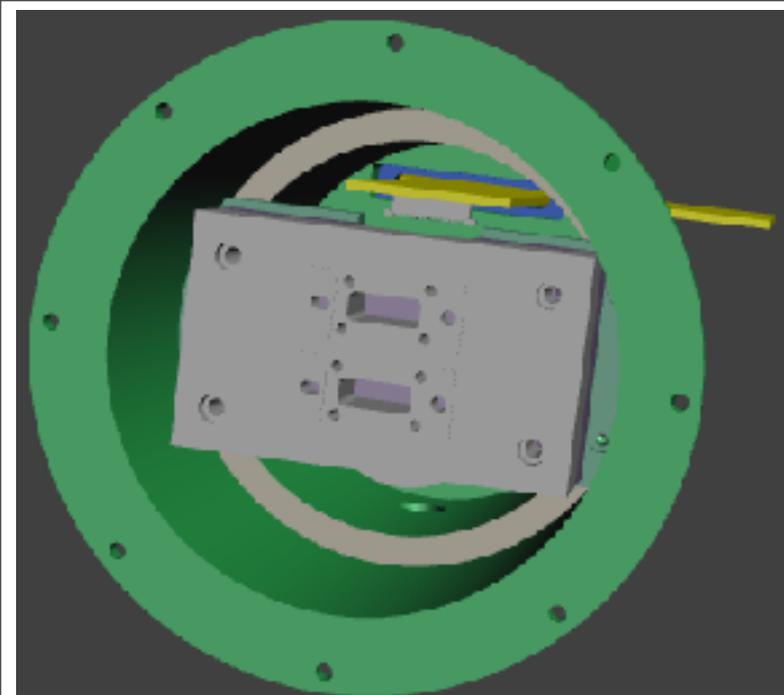
PreCam is a scaled down (2 CCD) version of the DECam that was used (in part) for development and testing of DECam hardware and software.

PreCam's primary goal was to observe a sparse grid of southern hemisphere standard stars ahead of the DES (especially in Y).

It was designed and constructed in less than one year. First orders for parts were placed in January 2010 and it achieved first light that August.

Precursor observations will allow DES to begin with photometric standards and save up to 10% of the DES observing time that would otherwise be devoted to calibration efforts.





PreCam Vessel

Focal Plane Support Plate

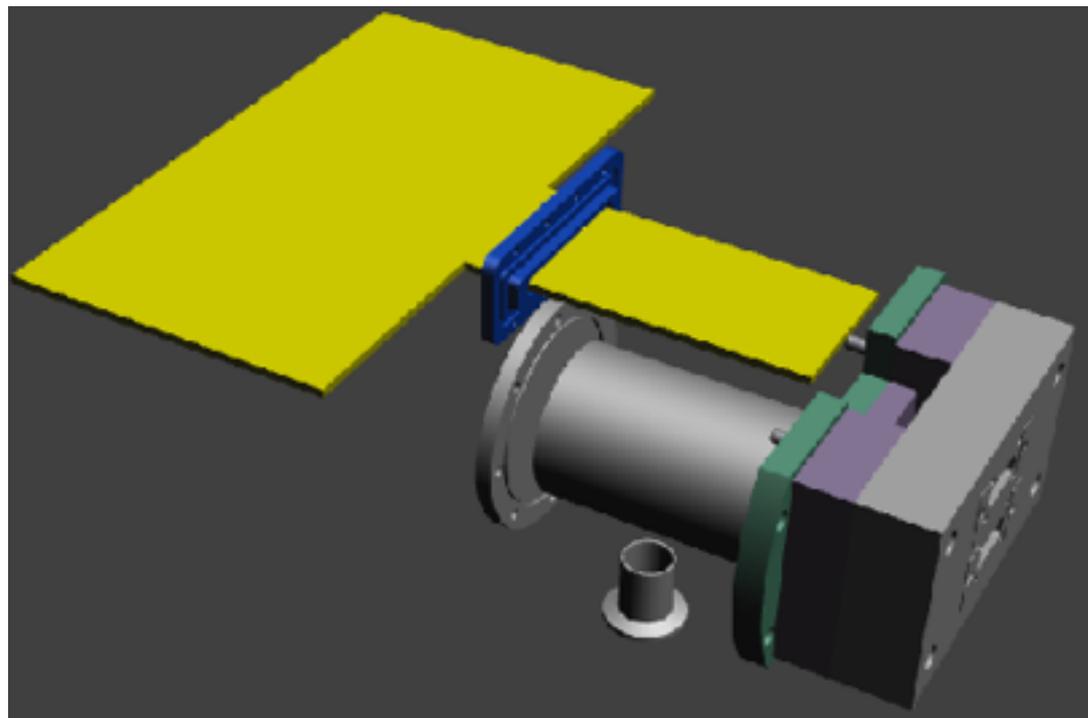
Thermal Transfer (Cu) Block

G-10 Mounting Block

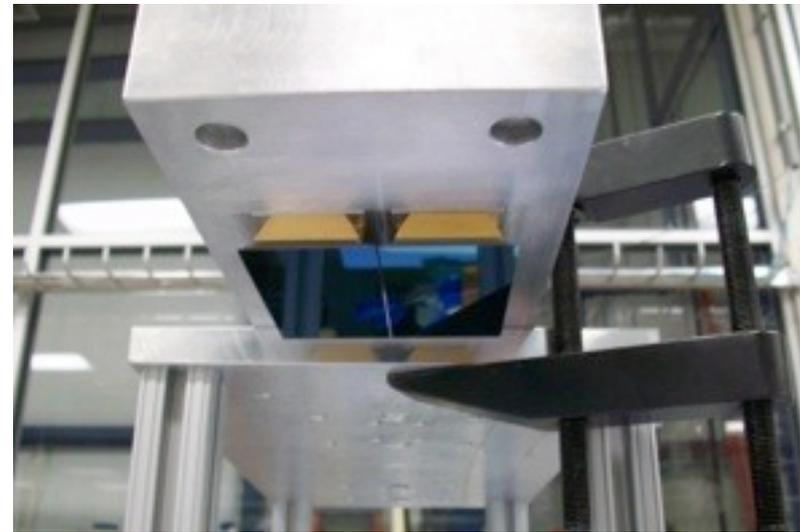
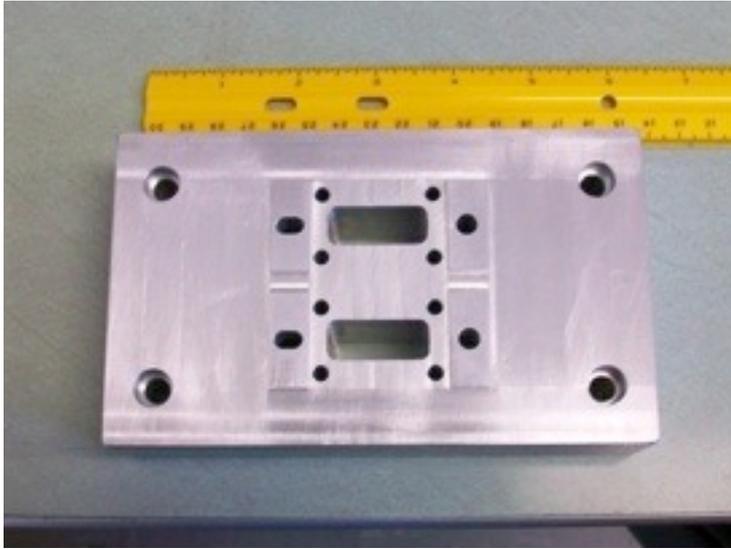
CryoTiger

Vacuum Interface Board

Dewar



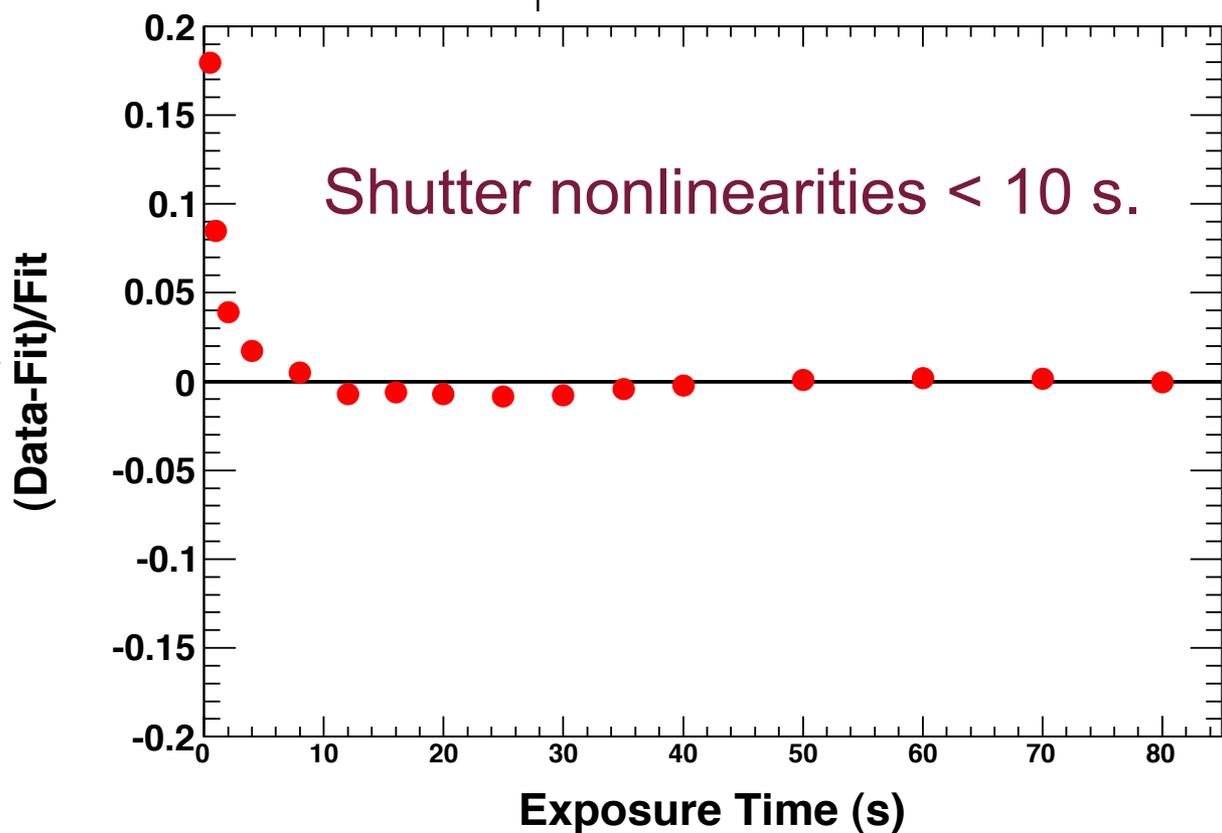
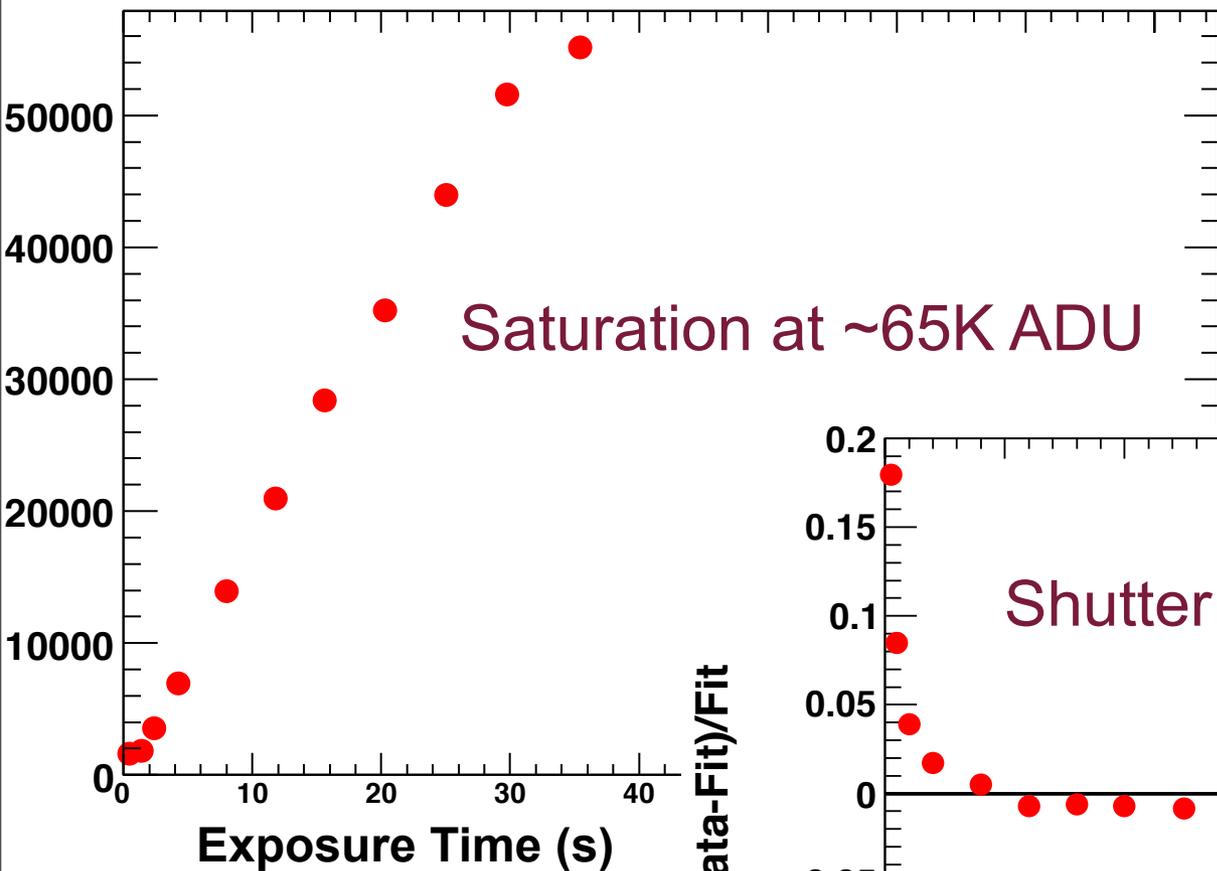
Focal Plane Support Plate & CCD Installation



Bench Tests I: Laboratory Setup



Bench Tests II: Linearity, Full Well



Installation on the Curtis-Schmidt Telescope at CTIO

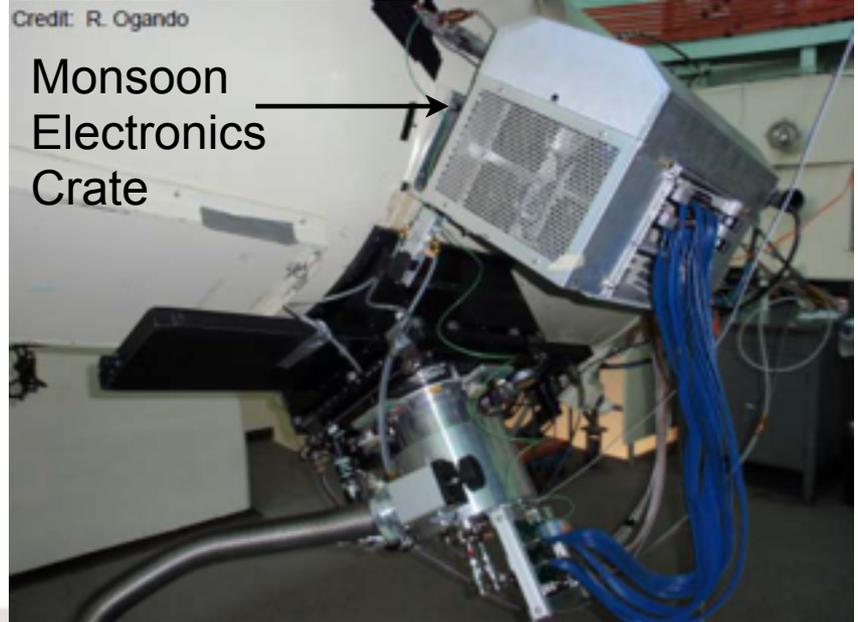


Credit: UofM Astronomy



Credit: R. Ogando

Monsoon
Electronics
Crate



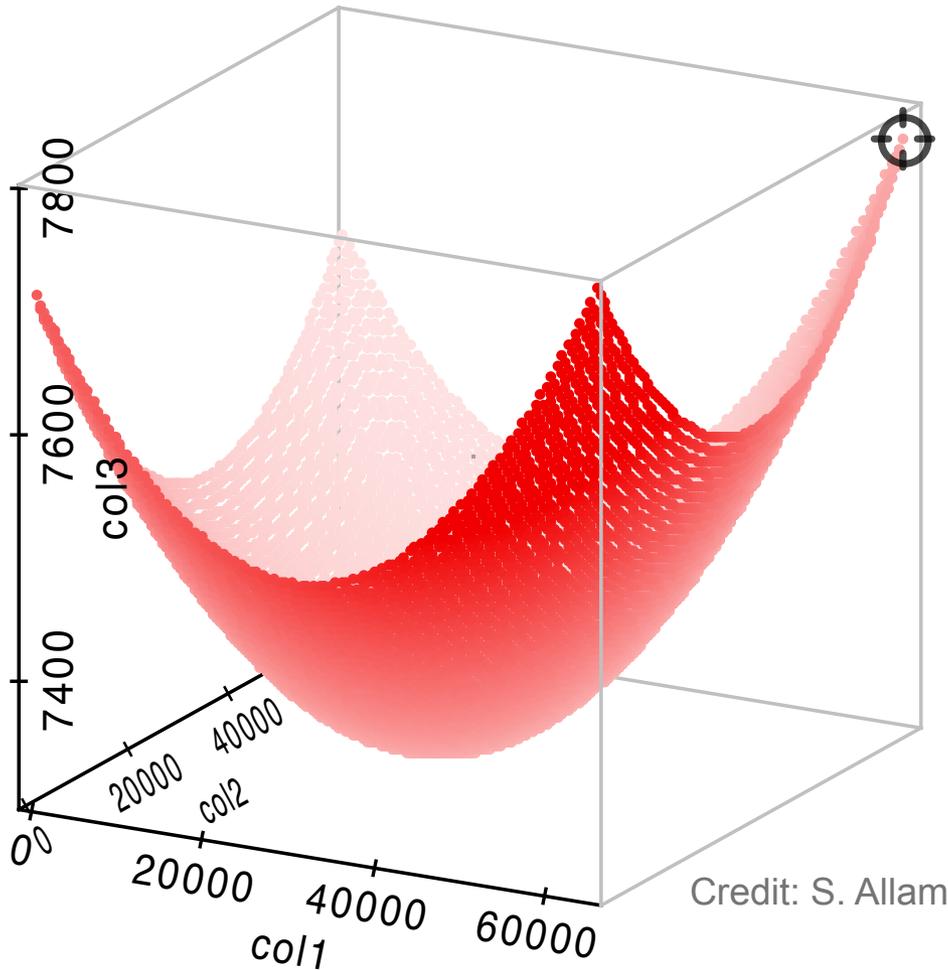


Tuesday, September 18, 2012

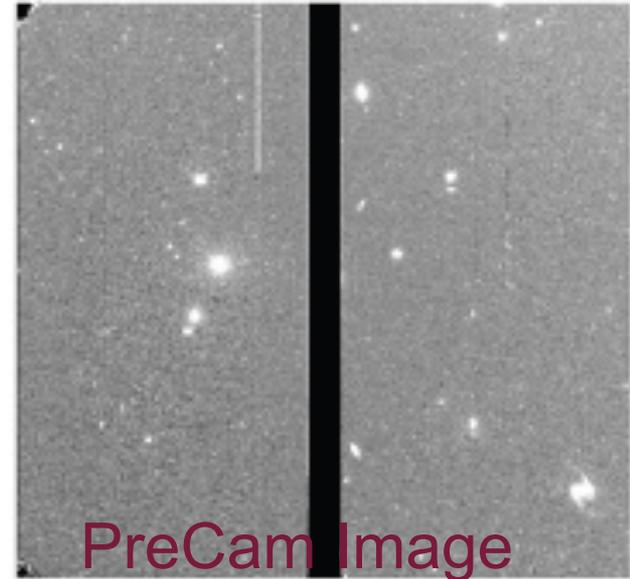


Tuesday, September 18, 2012

Commissioning I: Best Focus Surface, Early Images



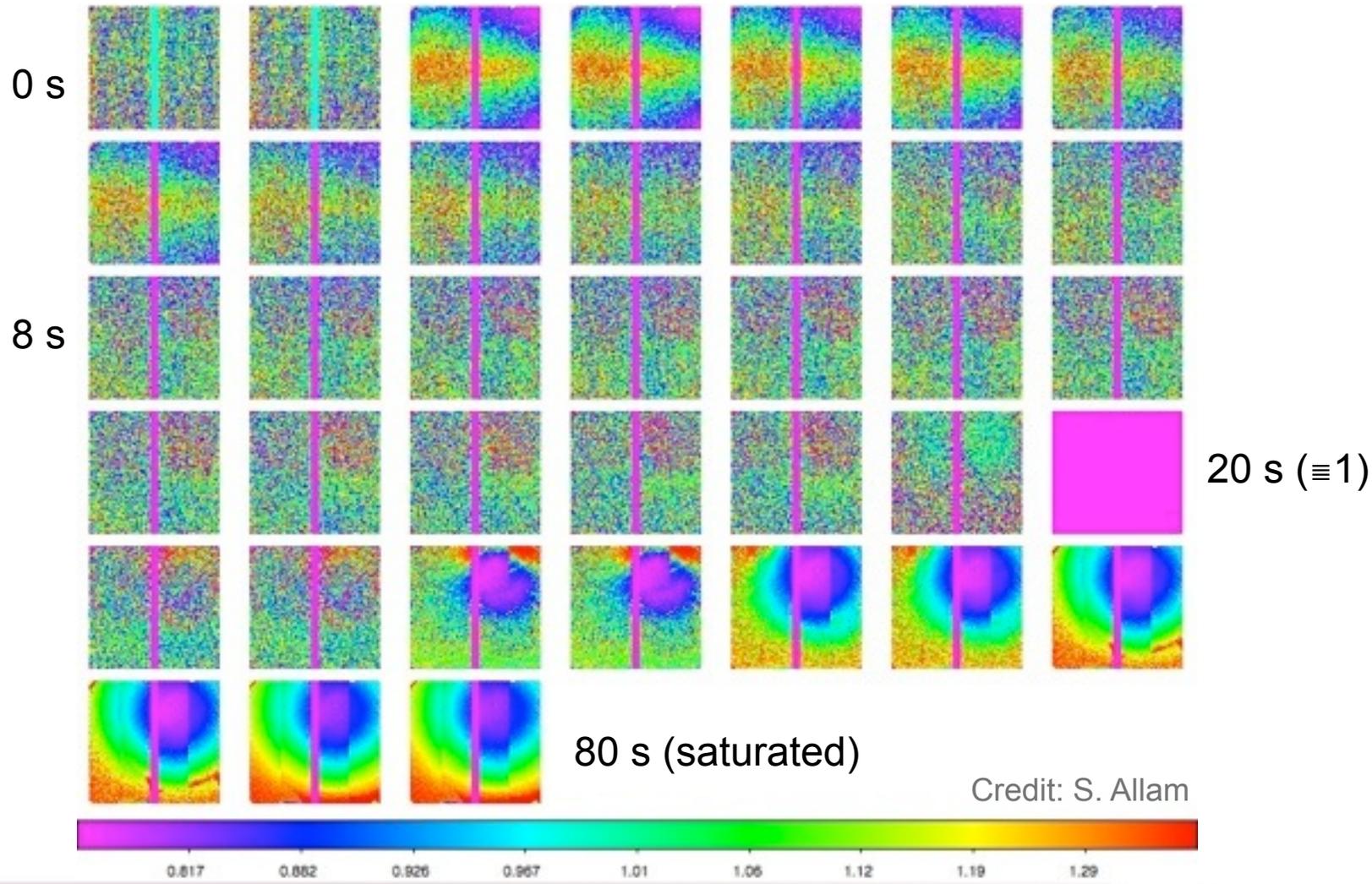
Note curved focus surface
due to lack of field flattener



Prior Sky Survey Image

Commissioning II: Shutter Timing from On-Sky Data

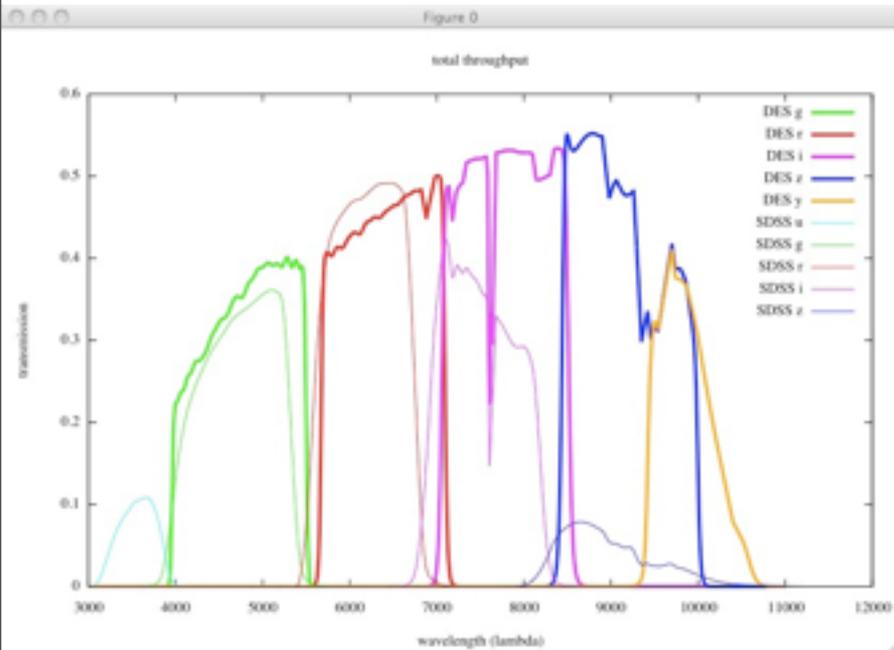
nonzero shutter actuation time effects are negligible beyond ~8s, confirming results of bench tests



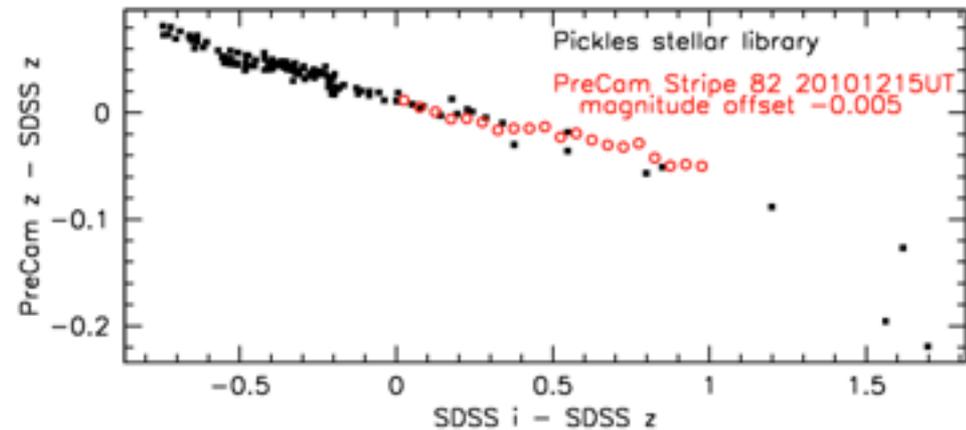
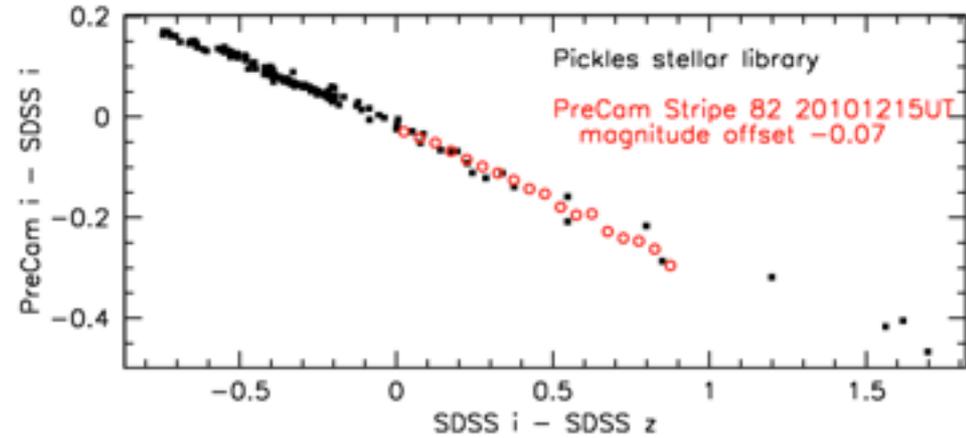
Credit: S. Allam

Commissioning III: Filter Performance

Transmission vs. Wavelength: DES Filters vs. Sloan Filters



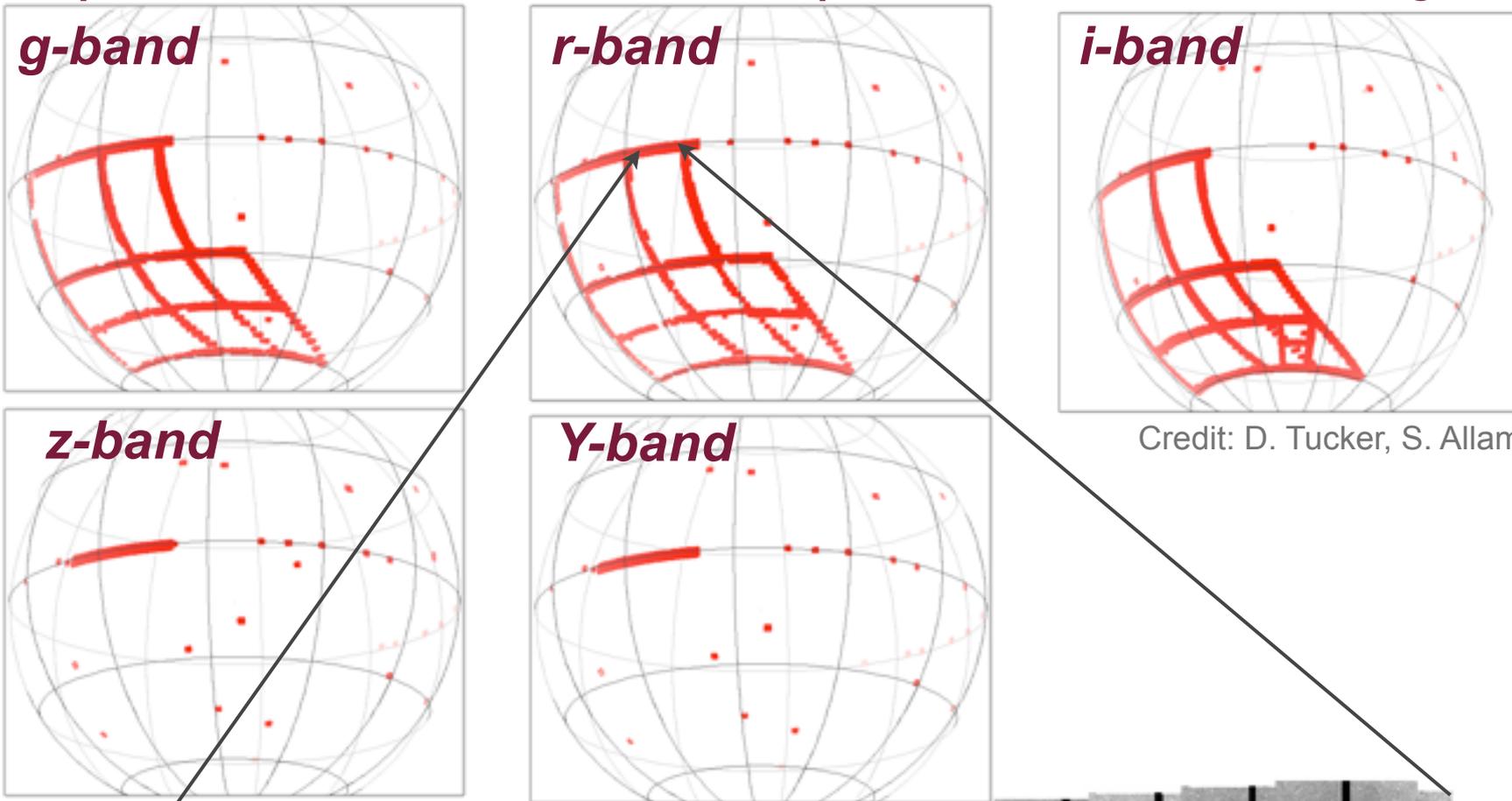
DES/PreCam Color Response



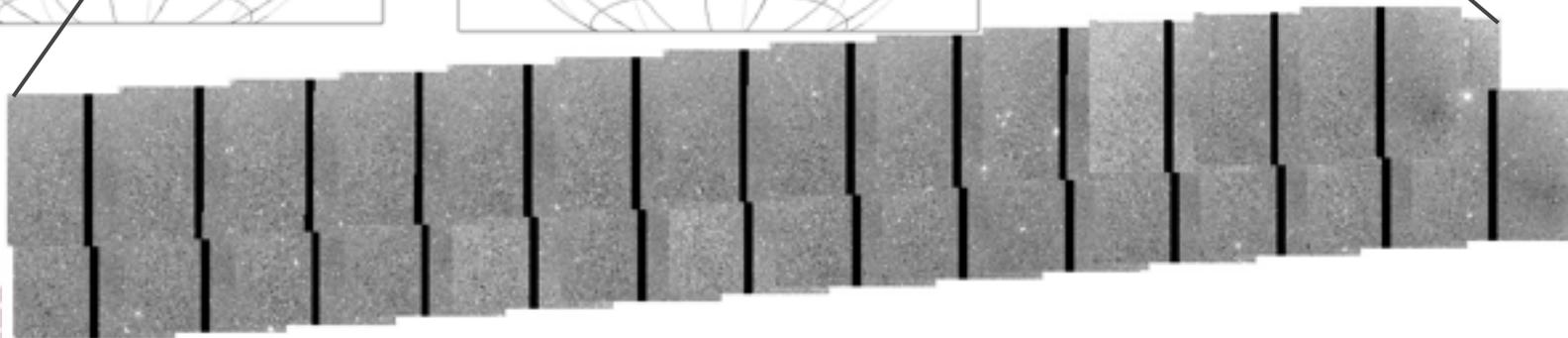
Credit: D. Tucker

PreCam Observations by Filter

Steps to the PreCam Southern Hemisphere Standard Star Catalog



Credit: D. Tucker, S. Allam

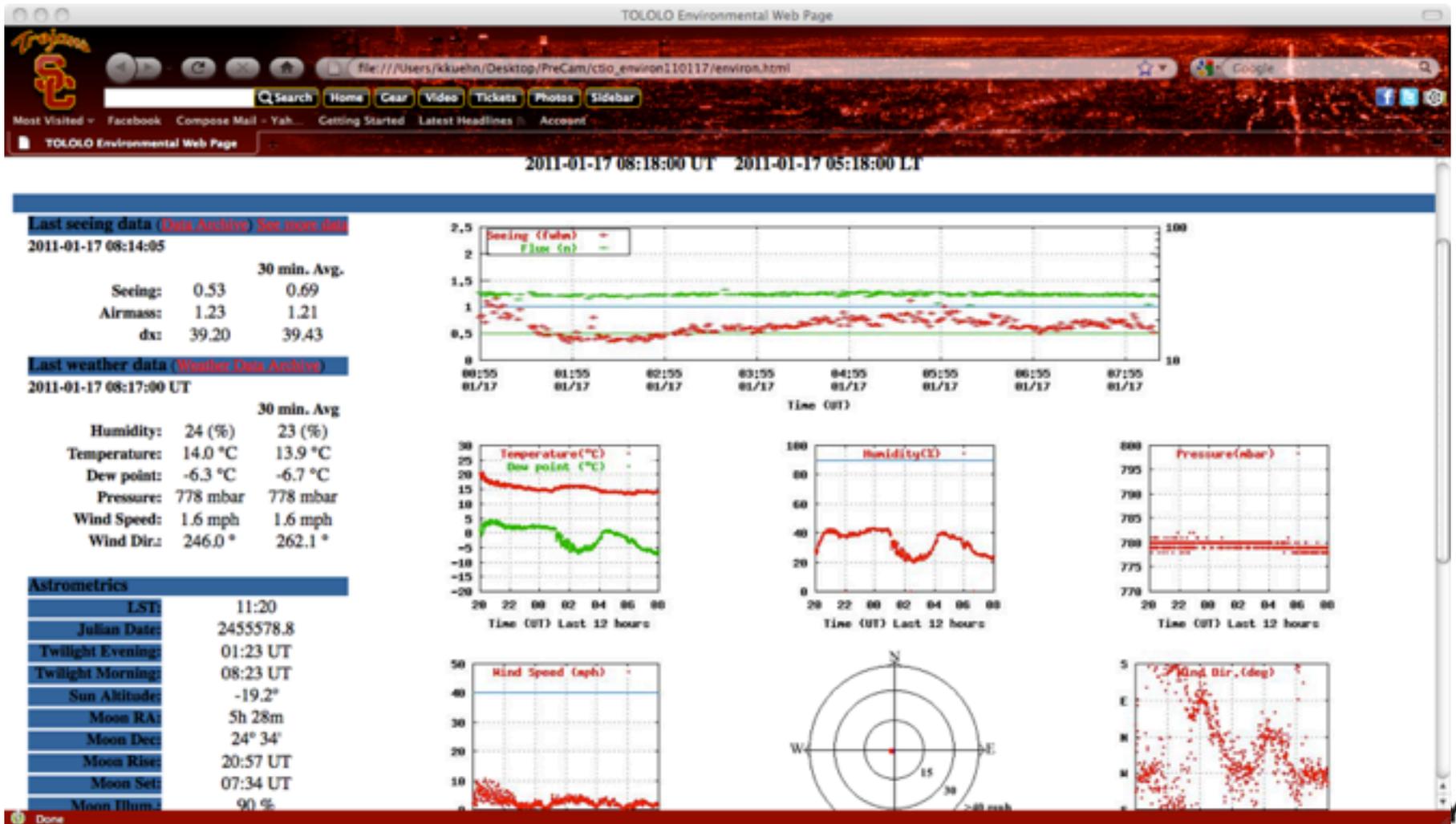


How is the weather?



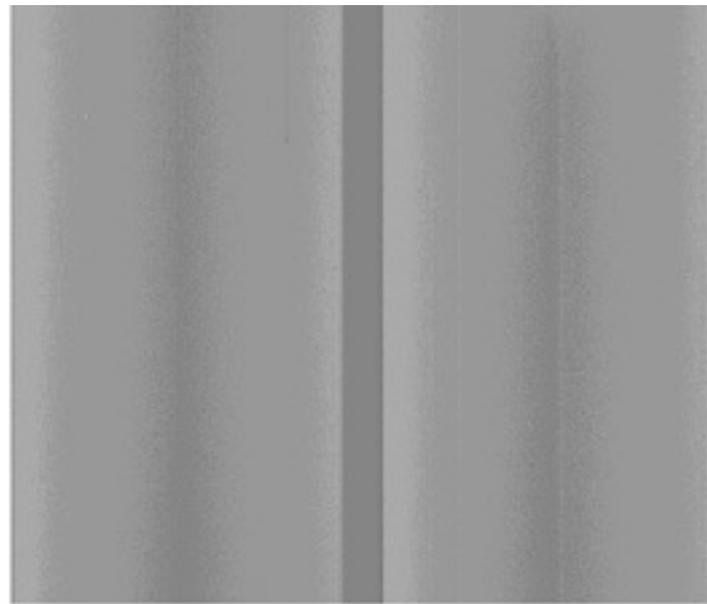


Recording the Environment at Cerro Tololo



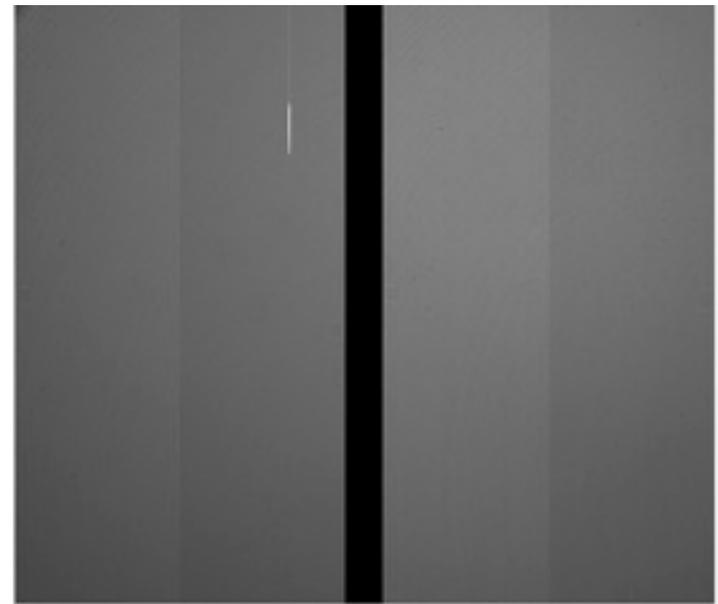
Data Processing at FNAL & ANL

- Fermilab developed processing pipeline consisting primarily of shell/py scripts for bias subtraction, flat-field corrections, etc.
- Each iteration added functionality--crucial improvements include banding/streaking removal, astrometry
- Further processing/analysis scripts developed in parallel at ANL



-4.5 -3.2 -1.9 -0.6 0.6 1.9 3.2 4.5 5.7

Bias



0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7

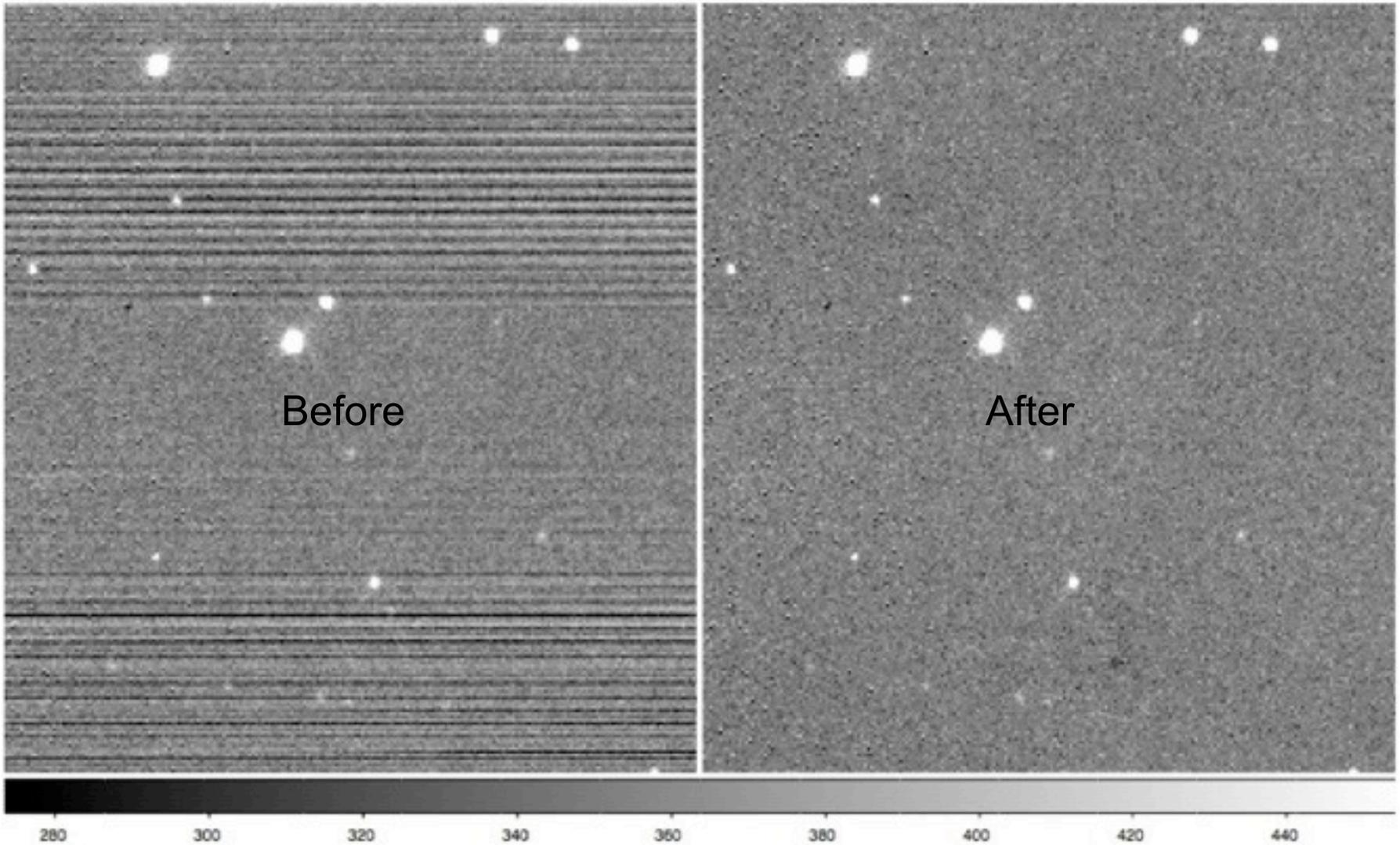
Flat



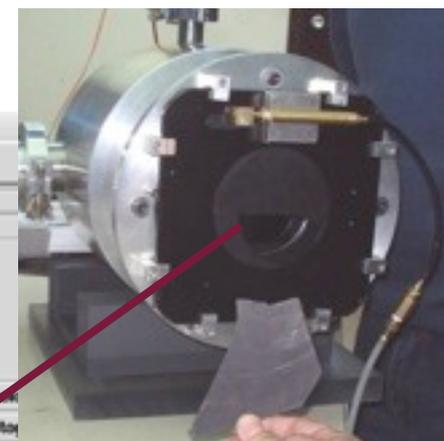
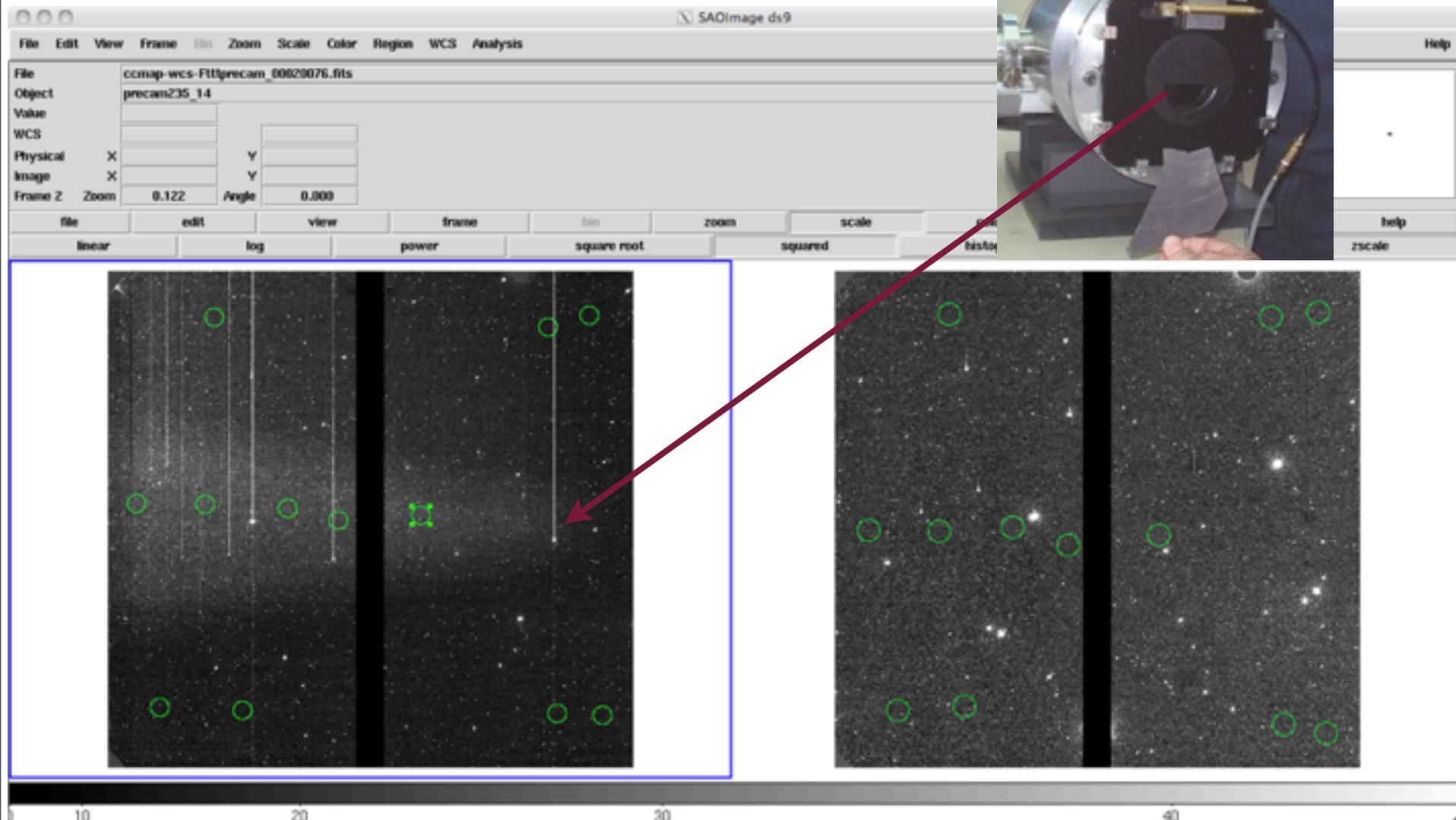
Cosmic Rays in the PreCam CCDs



Data Processing II: Streaking/Banding & Software Corrections



Data Processing III: Identifying Problematic Shutter Images corrected with local background subtraction



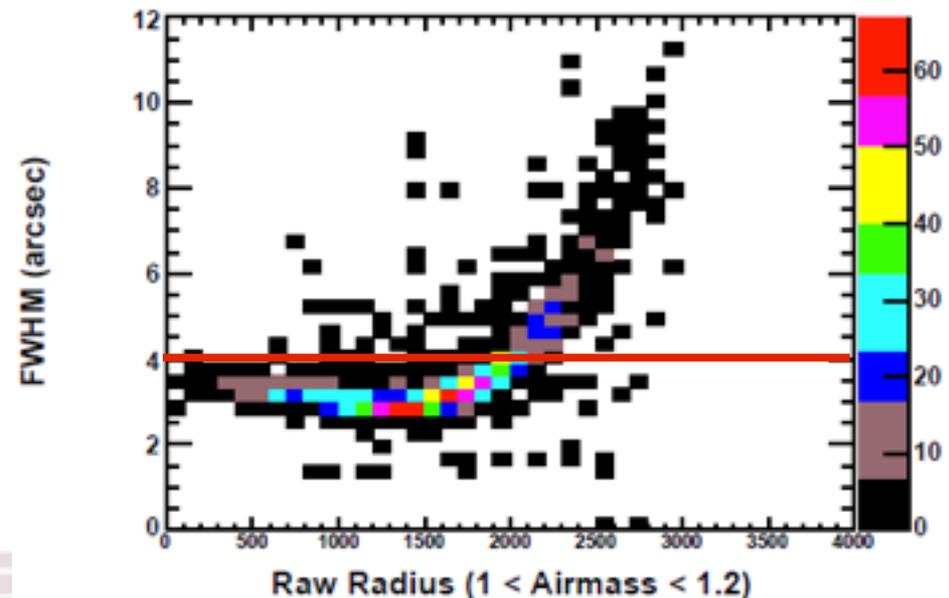
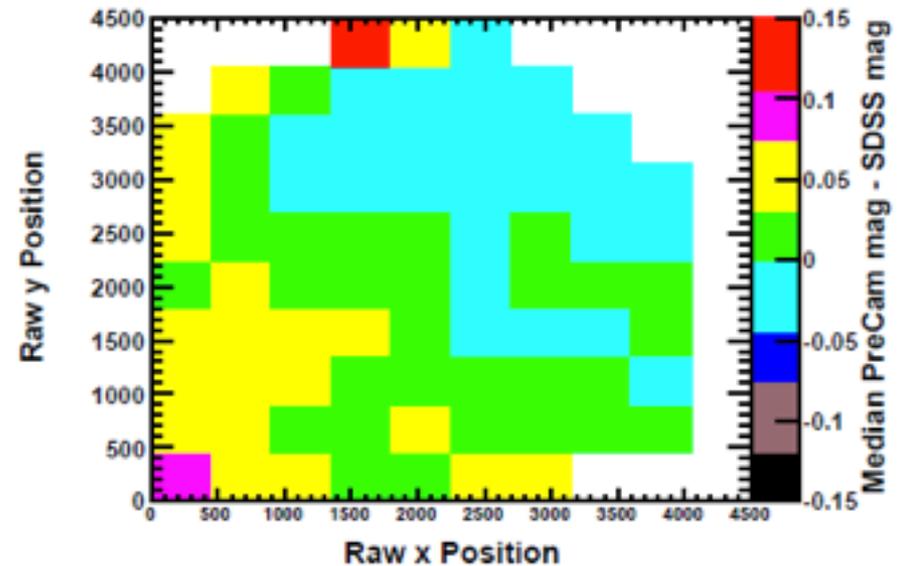
Date	Zero-Point Offset (USNO)	Standard Deviation (USNO)	Zero-Point Offset (Southern Standards)	Standard Deviation (Southern Standards)	Zero-Point Offset (SDSS)- RA40to50	Standard Deviation (SDSS)- mag<15	Standard Deviation (SDSS)-NoMagCut
20101215			g: 2.3372 r: 2.1269 i: 2.2864 z: 2.5072	g: .05323 r: .05176 i: .05021 z: .06227	g: 2.17425 r: 1.95941 i: 2.12993 z: 2.32859	g: .05258 r: .04194 i: .0581 z: .05982	g: .08925 r: .09445 i: .1065 z: .08172
20110107	g: 2.08978 r: 1.899857 i: 2.05227 z: 2.247	g: .02374 r: .03213 i: .03222 z: .02319	g: 2.0802 r: 1.91872 i: 2.05298 z: 2.263	g: .02843 r: .04228 i: .02944 z: .04915	g: 2.0645 r: 1.9346 i: 2.07891 z: 2.2993	g: .04711 r: .04305 i: .05134 z: .05304	g: .09277 r: .09258 i: .09468 z: .08514
20110108	g: 2.1784 r: 1.98041 i: 2.1281 z: 2.3587	g: .07305 r: .06301 i: .05031 z: .05476	g: 2.12746 r: 1.93154 i: 2.24 z: 2.3044	g: .03003 r: .04221 i: .04874 z: .03008	g: 2.1617 r: 1.94502 i: 2.10669 z: 2.3456	g: .05267 r: .03744 i: .05214 z: .05843	g: .1057 r: .09614 i: .1025 z: .07865
20110112	g: 2.1035 r: 1.932 i: 2.0765 z: 2.248	g: .03165 r: .05489 i: .04316 z: .04514	g: 2.07424 r: 1.905615 i: 2.06179 z: 2.21012	g: .02947 r: .03518 i: .03624 z: .03695	g: 2.11098 r: 1.92643 i: 2.07017 z: 2.25469	g: .04387 r: .03939 i: .04554 z: .05621	g: .08868 r: .08243 i: .102 z: .08538
20110113	g: 2.08618 r: 1.90392 i: 2.05038 z: 2.21058	g: .02186 r: .02544 i: .02691 z: .02033	g: 2.07 r: 1.89748 i: 2.06527 z: 2.20684	g: .03127 r: .03662 i: .04353 z: .03638	g: 2.143606 r: 1.9298 i: z: 2.26745	g: .02575 r: .04268 i: z: .06571	g: .09088 r: .08401 i: z: .0936

Final Data Analysis Steps: Star Flats + Data Quality Cuts

added “flat field” to remove final CCD response gradient prior to analysis

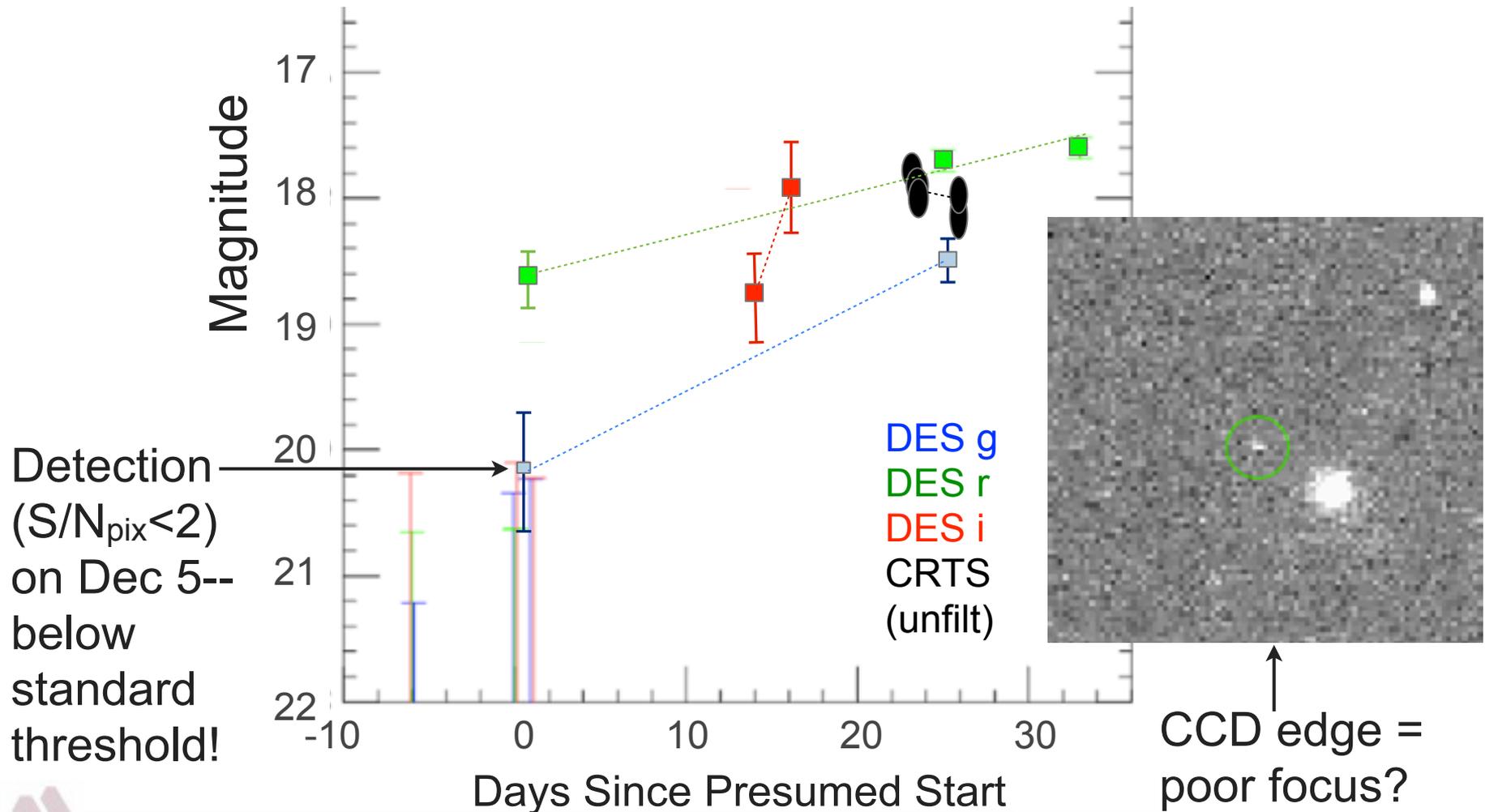
- USNO, Southern u’g’r’i’z’, and SDSS standards
- SDSS airmass correction and Star Flat correction applied
- Selection Criteria:
- magerr, FWHM, Stellerity

v3aper12	.06871
v3aper12, stellarity > .95	.04901
v3aper10, stellarity > .95	.048496
v3aper10, stellarity > .95, fwhm < 4.	.048434
v3aper10, stellarity > .95, fwhm < 4. , pixels cut	.048447
v3aper10, stellarity > .95, fwhm < 4. , pixels cut, starflats	.040106
v3aper10, stellarity > .95, fwhm < 4. , pixels cut, starflats, mag < 17.	.03838

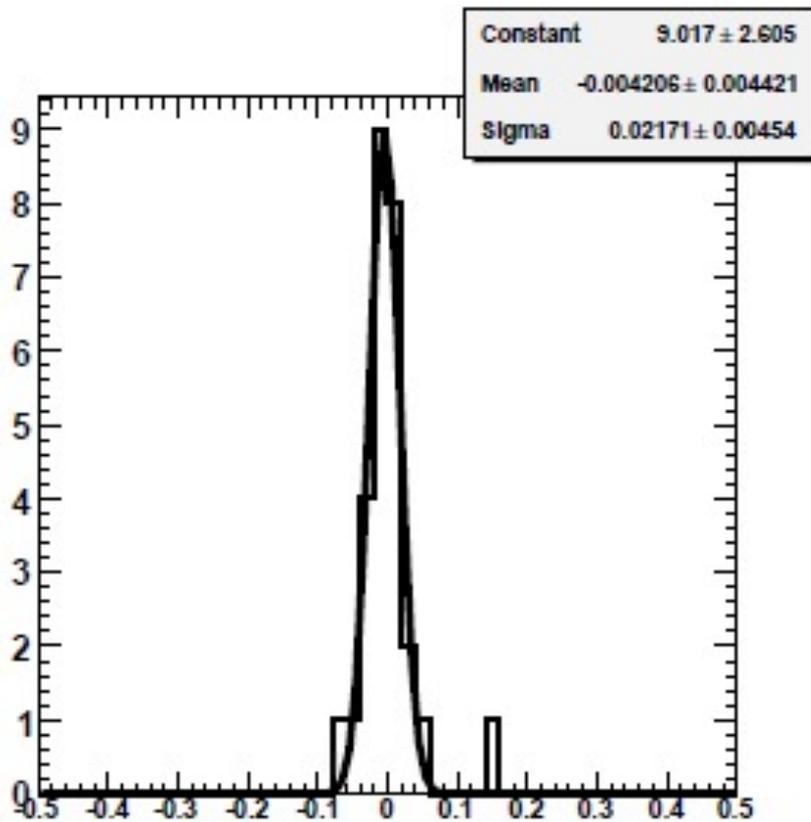


Data Quality Checks/DES Proof-of-Concept

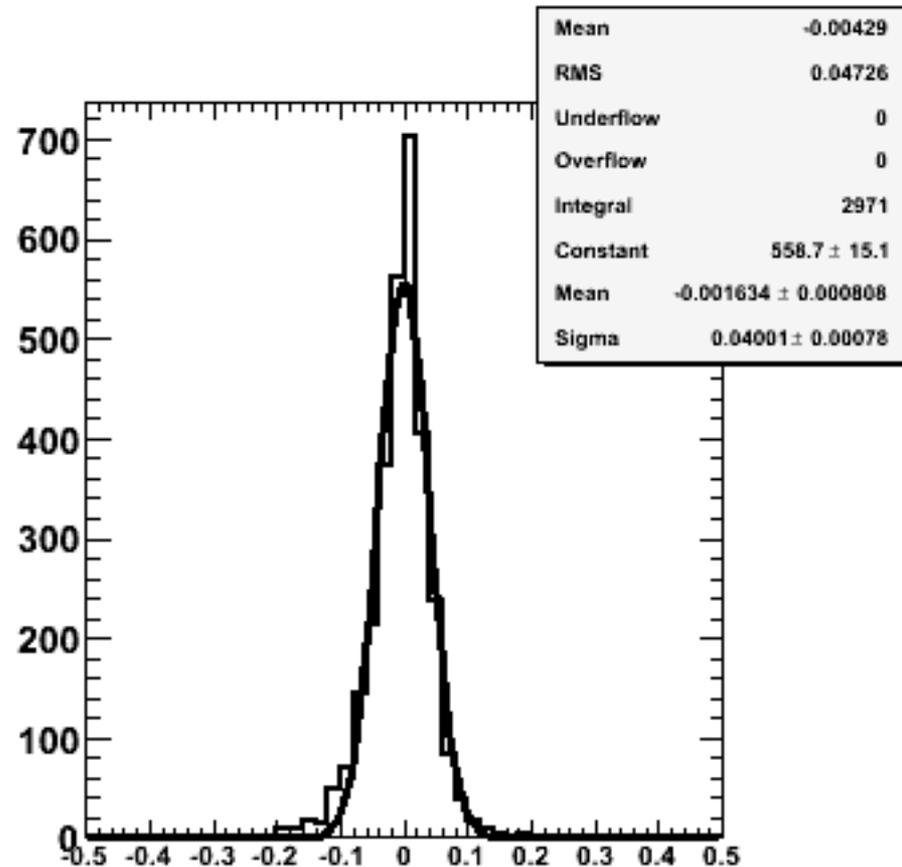
PreCam gri observations from 11/29/2010 to 01/01/11 of SN2010lr, a spectroscopically confirmed SNIa associated with host galaxy 2MASX J00023401-3044061 at $z \sim 0.062$ (Drake et al., Prieto et al.)



Preliminary Results I: Single-Epoch Photometry



PreCam z - USNO z Bright

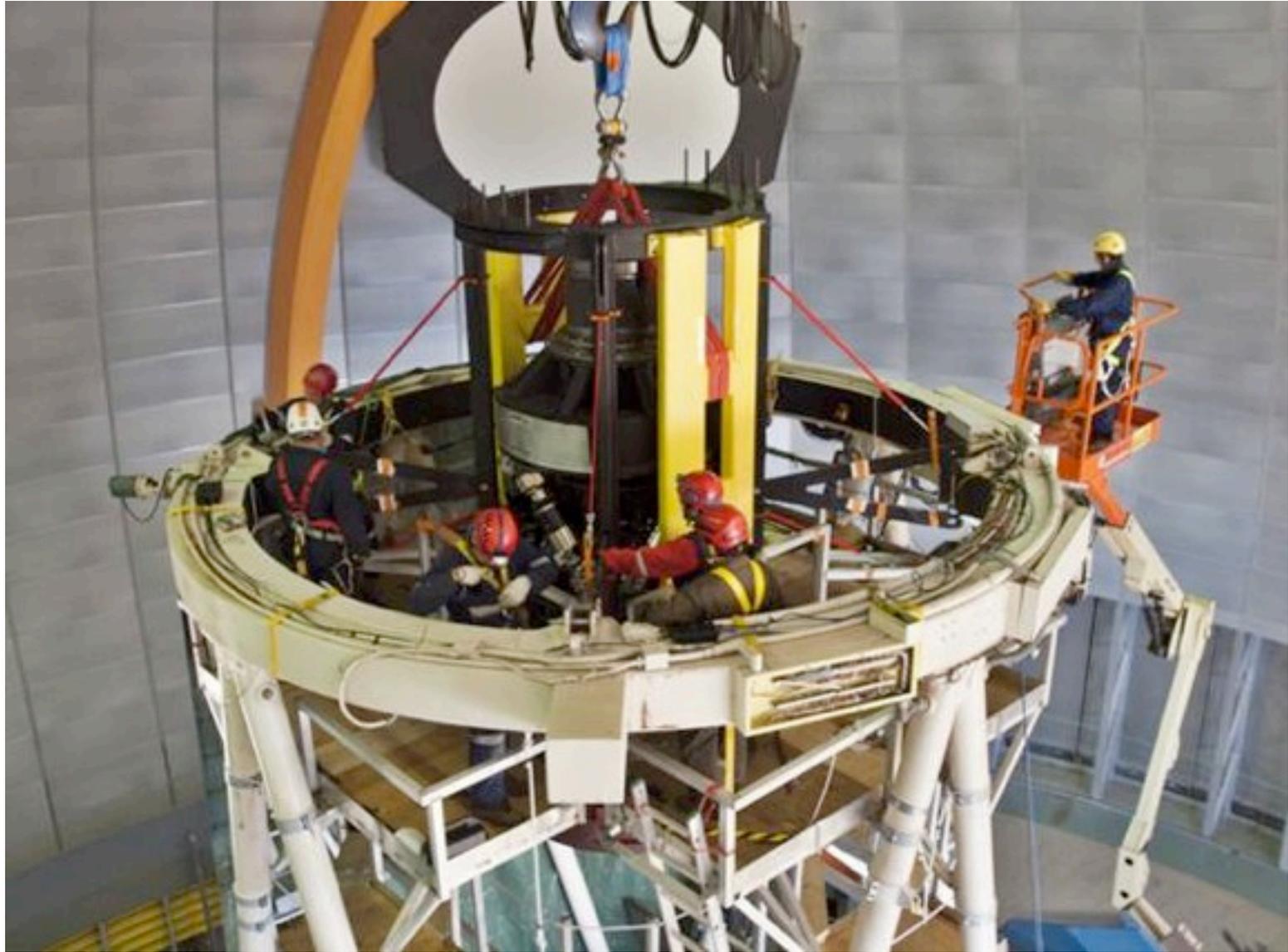


PreCam r - SDSS r

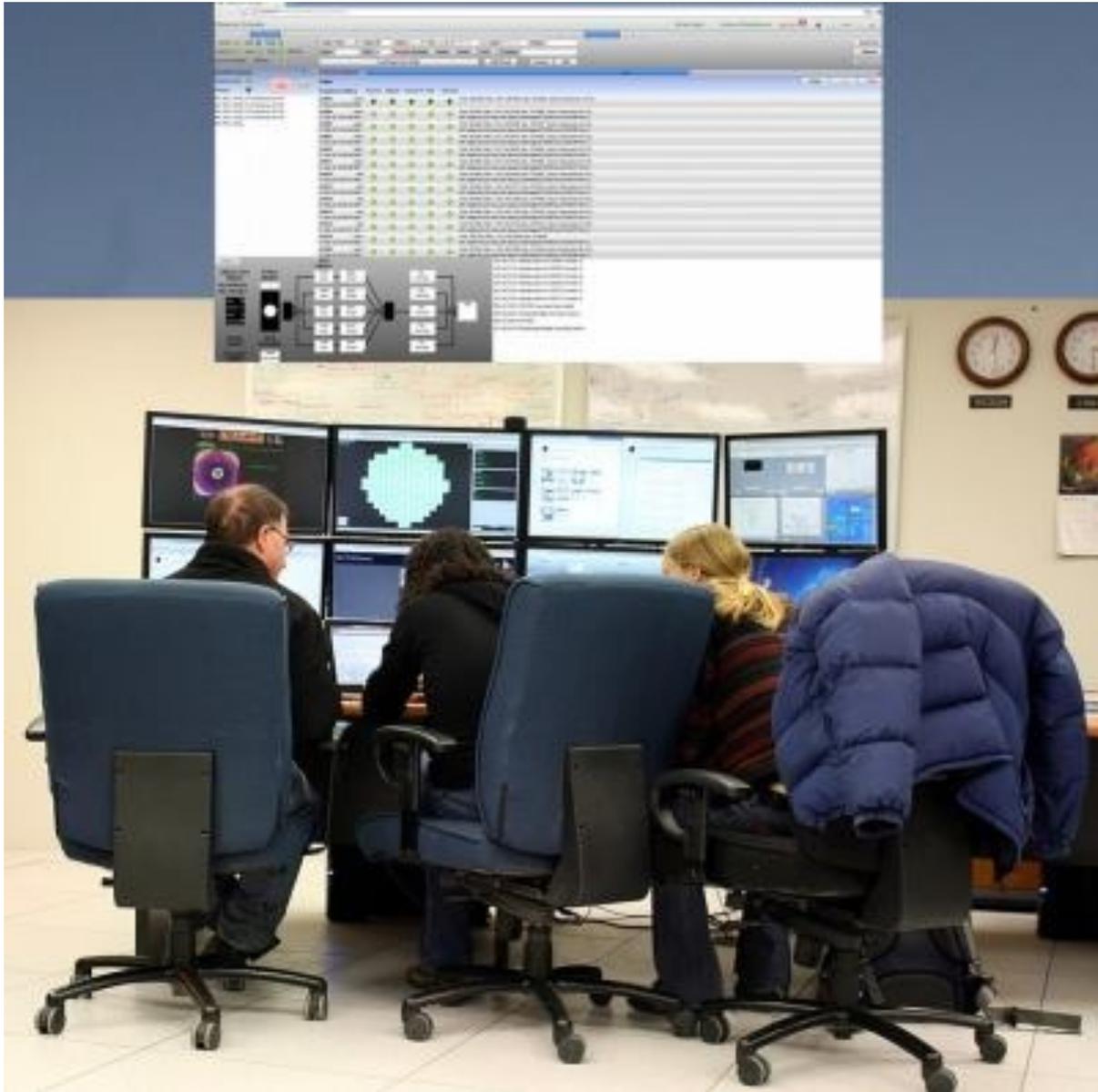
Preliminary Single-Image Photometric Accuracy:
4.0% (SDSS r,i); 3.2% (SDSS z); or 2.2% (USNO z, mag<14)



DECam on the Blanco Telescope!



Observing with DECam



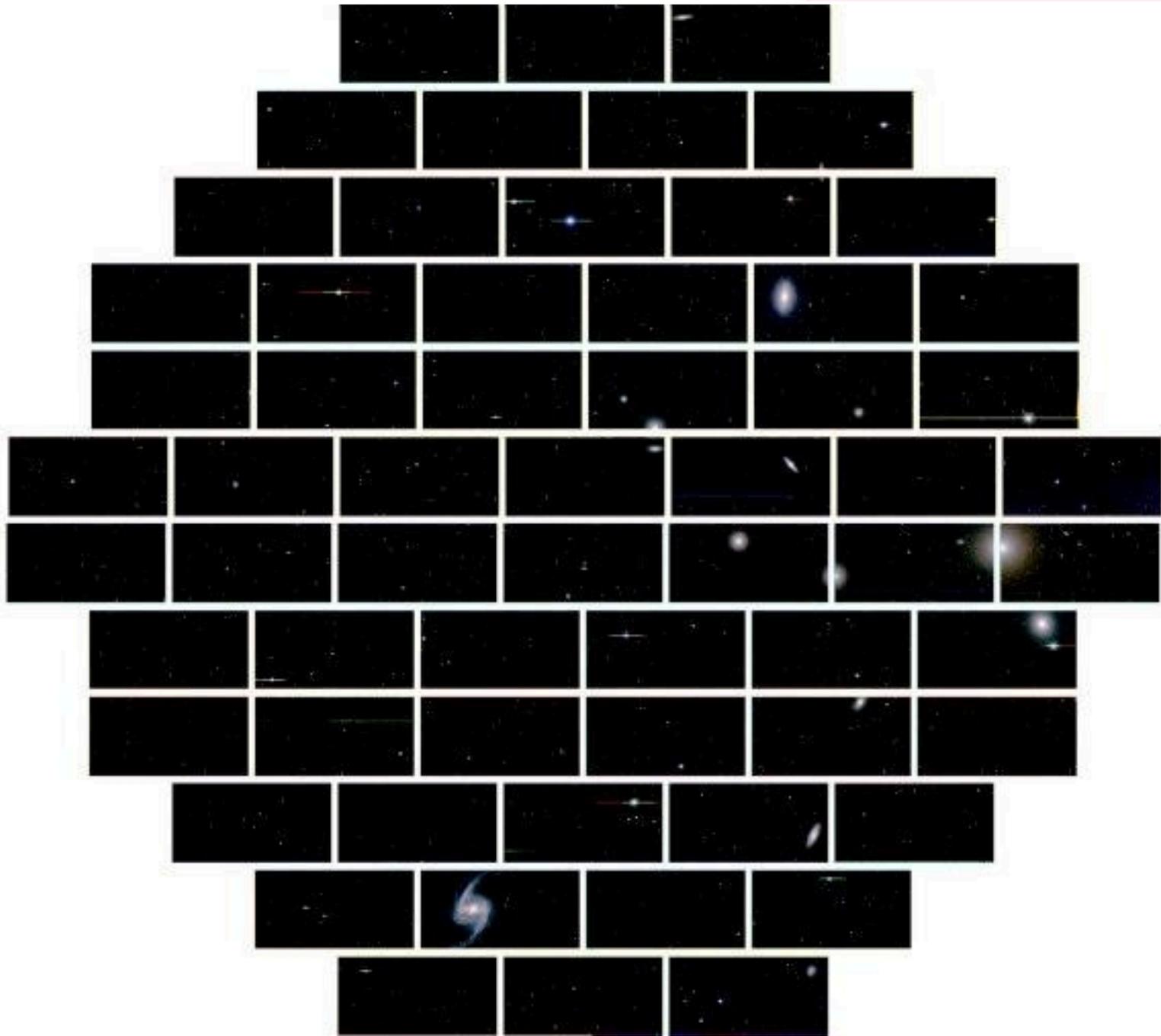
First Light Images!

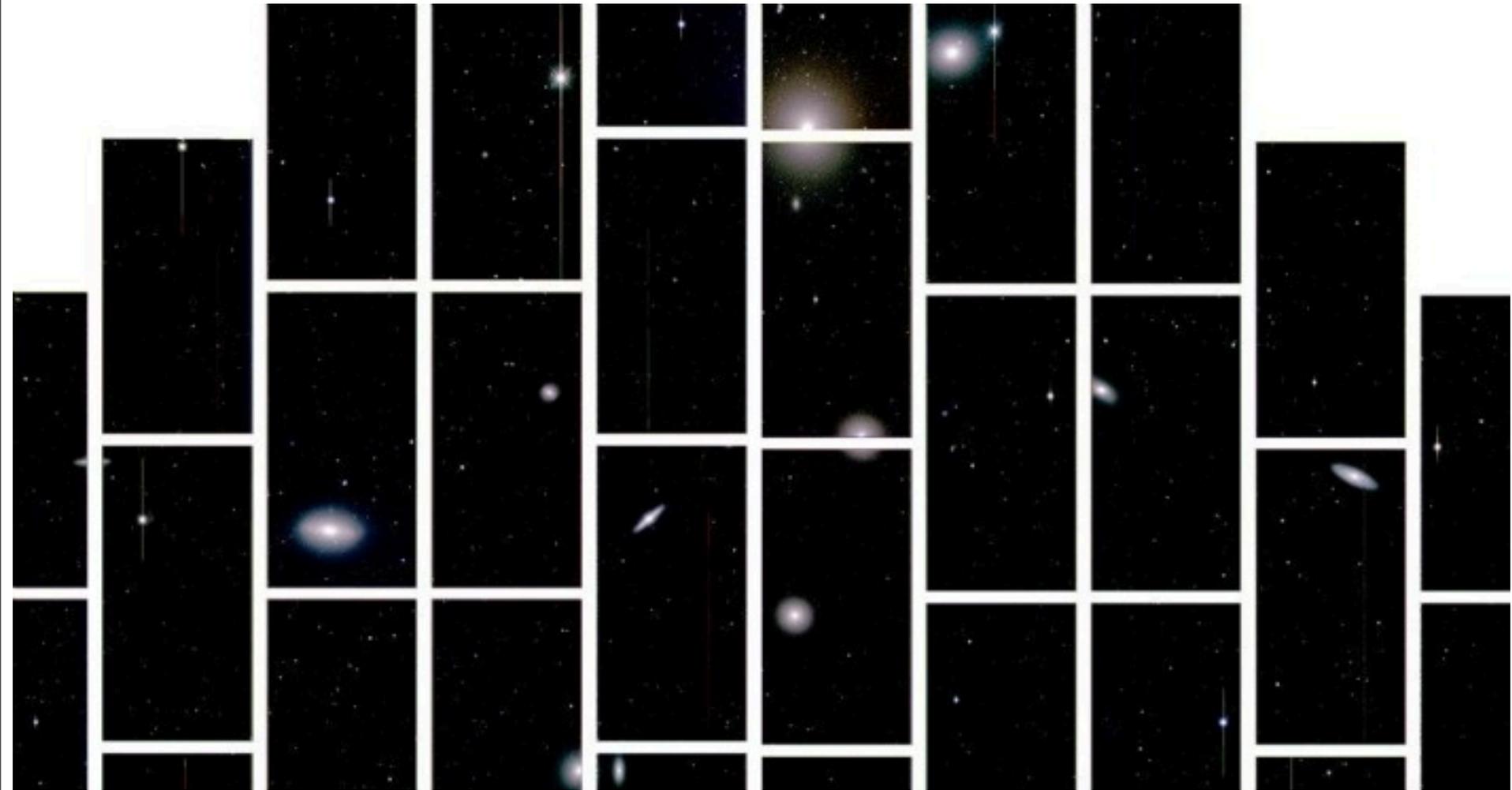
0".8 images with nearly uniform PSF across the focal plane, all *without* optimization of collimation, guider, hexapod, telescope control.

Images of the Fornax Cluster, NGC 1365, Small Magellanic Cluster, and 47 Tucanae...

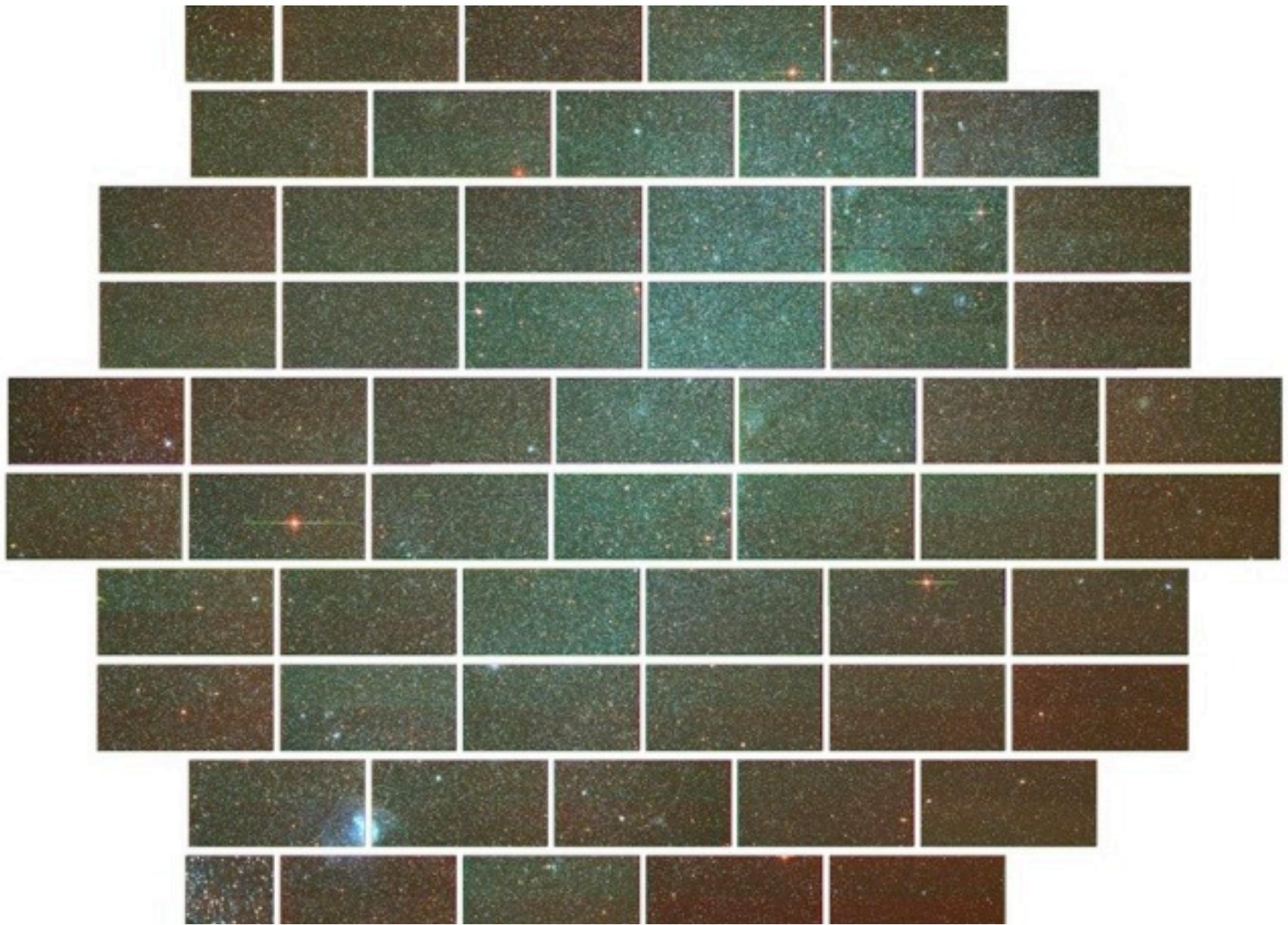
see <http://www.wired.com/wiredscience/2012/09/dark-energy-survey/>
<http://www.nature.com/news/cameras-to-focus-on-dark-energy-1.11391>
and <http://www.symmetrymagazine.org/> for press release information

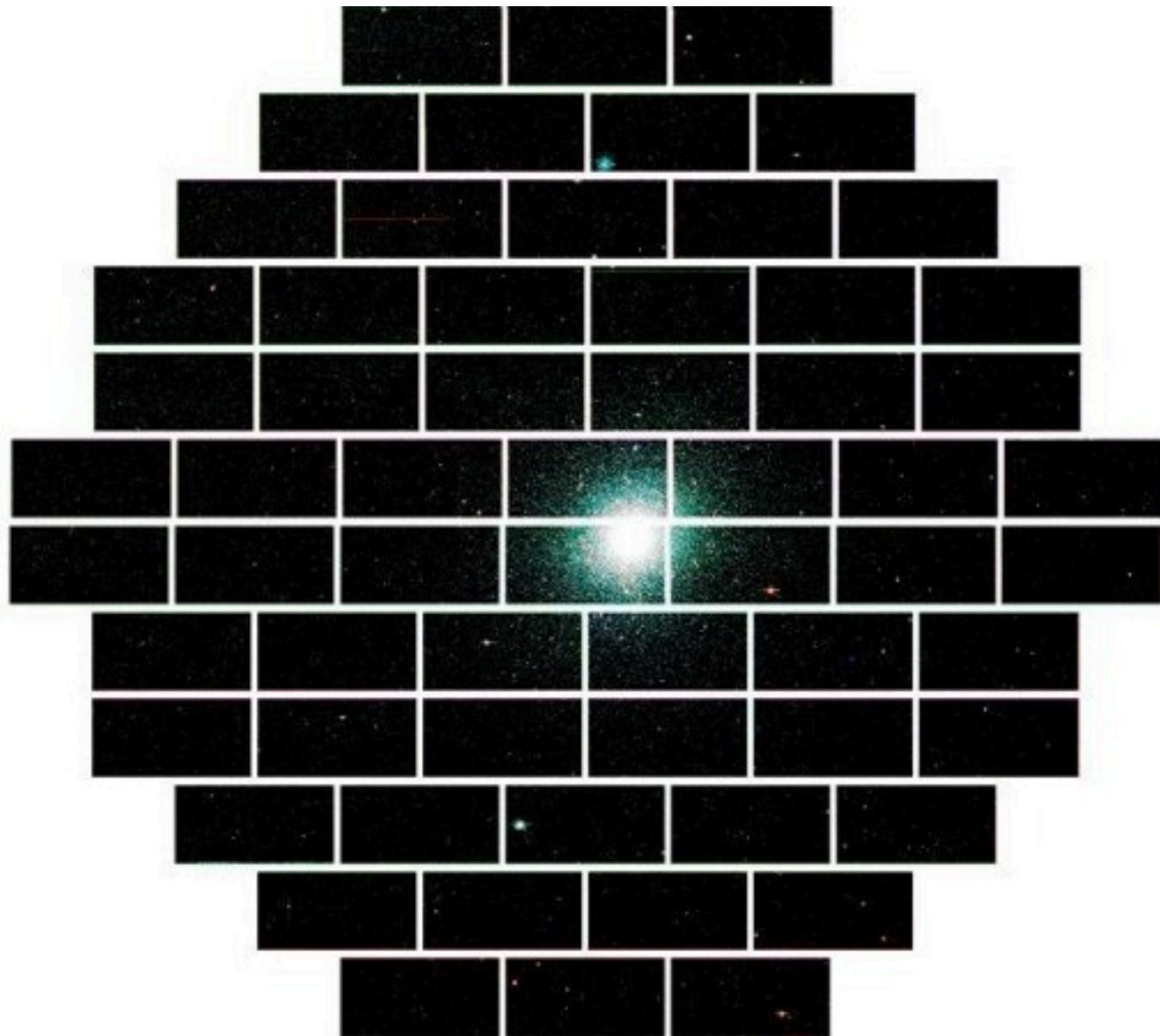


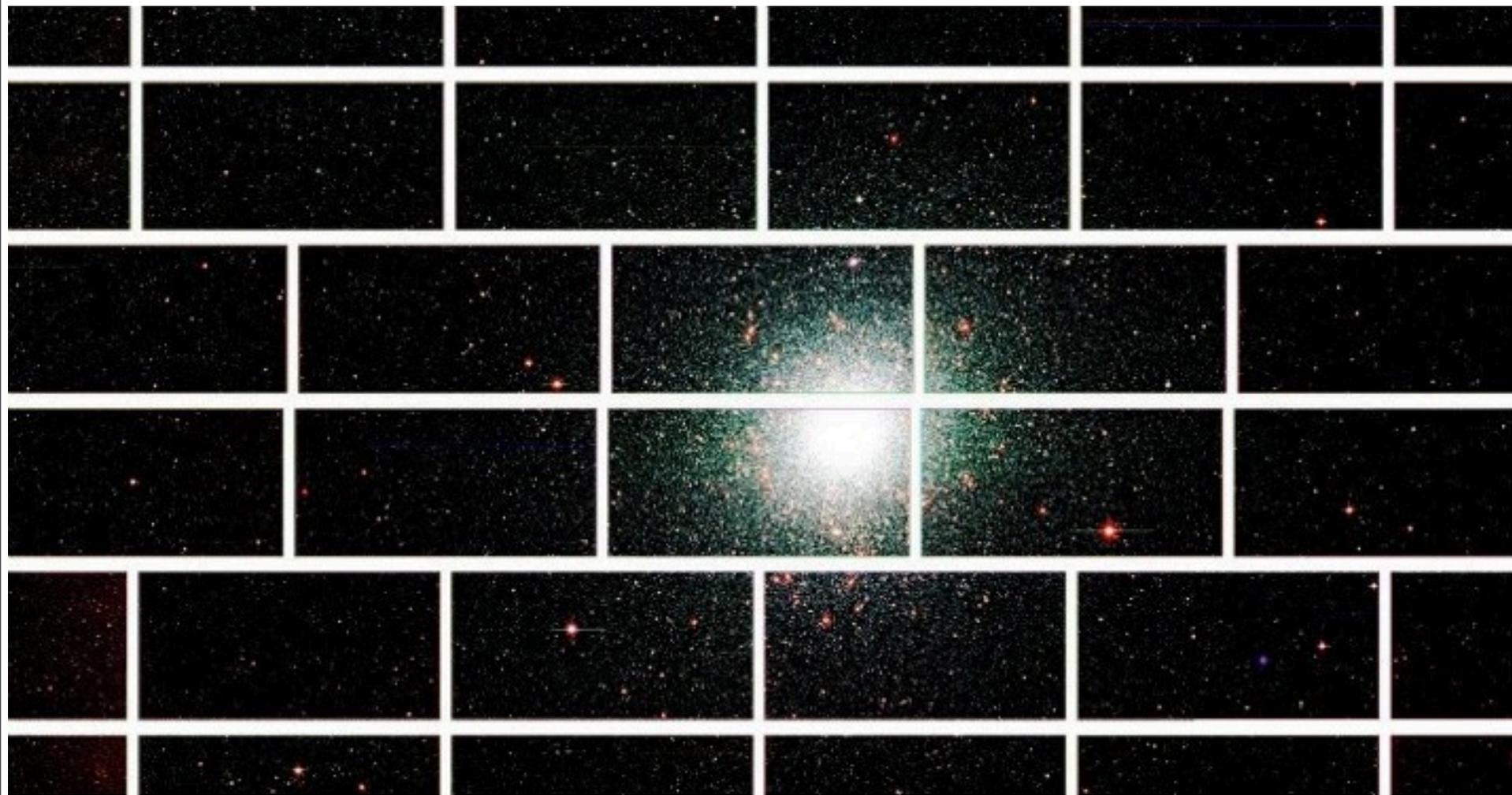






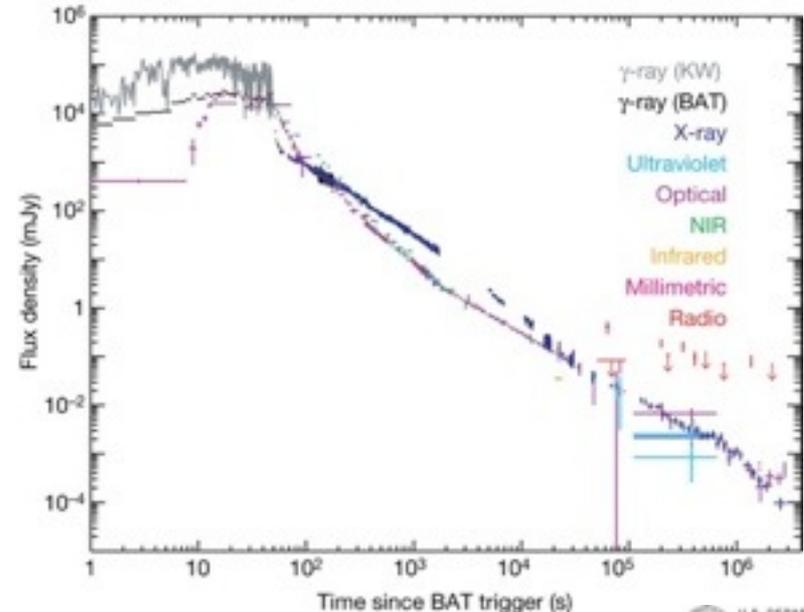
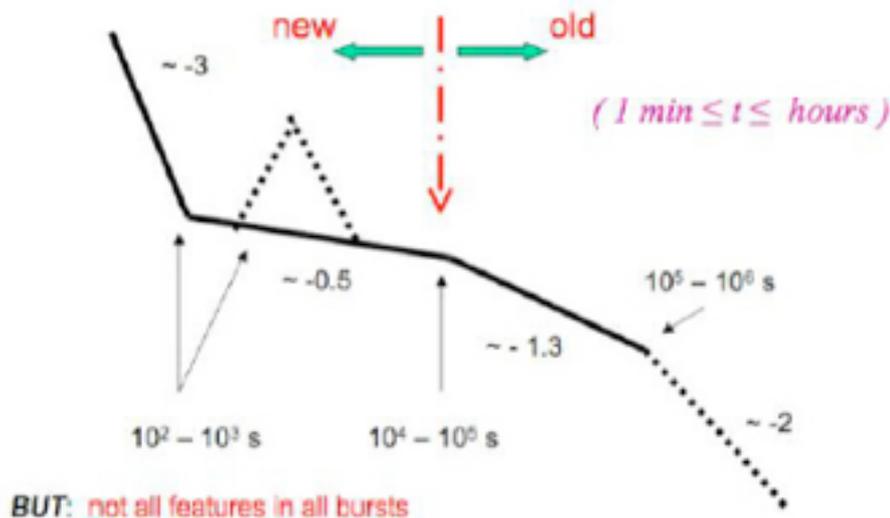






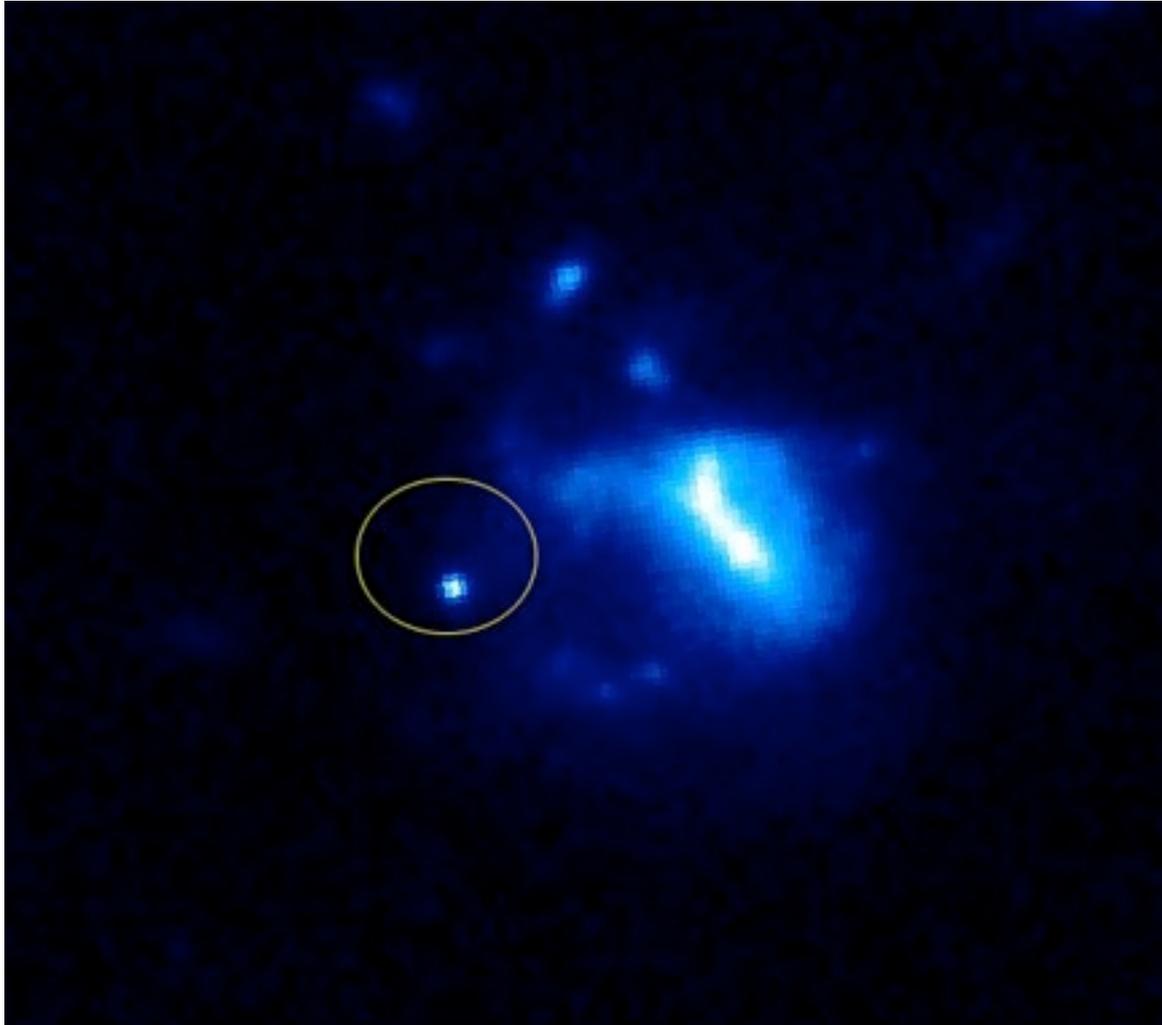
Non-SN Transient Science with the DES

Gamma Ray Bursts (GRBs) are bright transient sources at cosmological distances. In the time you can hold your breath, they output **more energy than the sun** does in its entire lifetime: $> 10^{51}$ ergs (isotropic) in 10^{-1} to 10^3 s. They are correlated with the collapse of massive stars (long GRBs) or neutron star mergers (short GRBs). The end result is expected to be a black hole; observations show prompt broadband emission (“**fireball**”) followed by long-timescale “**afterglow**”.



Lightcurves courtesy of Fox & Mészáros 2006, Racusin et al. 2008.

Multi-Wavelength/Multi-Messenger GRB Follow-Up



Host Galaxy for, e.g., GRB050709 observed with HST and many other instruments, both photometric and spectroscopic, to determine characteristics:

$z = 0.16$

$E_{\text{iso}} \sim 10^{50}$ erg

Relevant observations and/or flux limits for many hundreds of GRBs in:

Gamma Rays

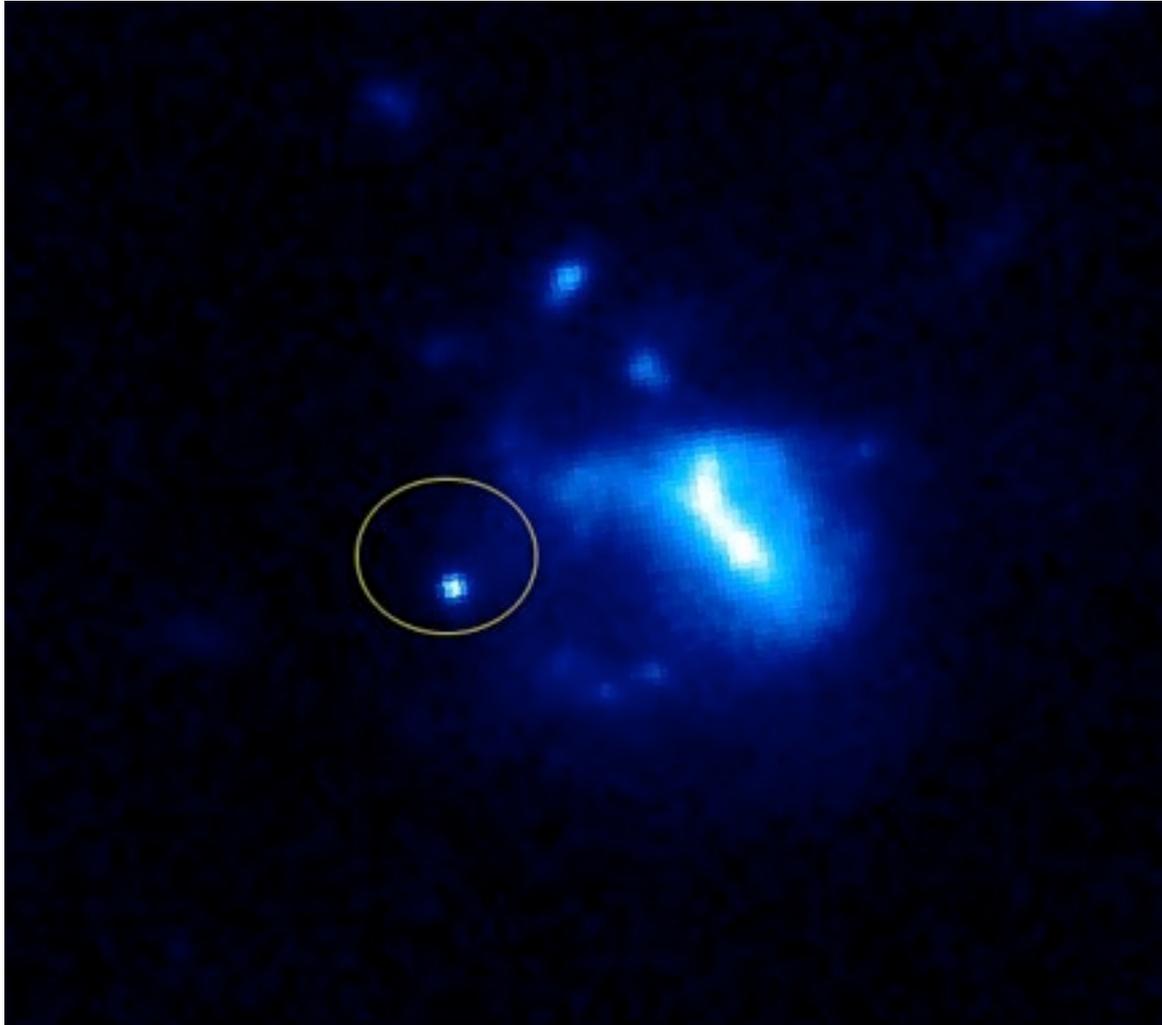
X Rays

UV/Optical/IR

Radio

Gravitational Radiation
and

Multi-Wavelength/Multi-Messenger GRB Follow-Up



Host Galaxy for, e.g., GRB050709 observed with HST and many other instruments, both photometric and spectroscopic, to determine characteristics:

$z = 0.16$

$E_{\text{iso}} \sim 10^{50}$ erg

Relevant observations and/or flux limits for many hundreds of GRBs in:

Gamma Rays

X Rays

UV/Optical/IR

Radio

Gravitational Radiation
and *Neutrinos*

1. Providing DES data to the Community in Real Time

- * Parse GCN Notices (RA, Dec, position uncertainty, time) for all bursts in footprint
- * Identify potential GRB hosts from pre-discovery images
- * Calculate relevant host characteristics (e.g photo-z) “on the fly”
- * Distribute data products and links to “finder images” via GCN Notices
- * Entire process must be automated for fastest response

GCN Circulares Archive

This page changes after each Circular submission, so hit the <reload> button NOW.

1. [The Latest Circulars](#)
2. [Older Circulars](#)
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This is the archive of the GCN Observation Report Circulars.

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(Listed in reverse serial number order -- newest first)

- [12100](#) GRB 110625A: Fermi GBM and LAT observations
- [12099](#) GRB 110625A: Swift/UVOT Upper Limits
- [12098](#) GRB 110625A: 1.23m CAHA I-band observations
- [12097](#) GRB 110625A: Fermi LAT detection
- [12096](#) GRB 110625A: GROND detection of a source inside the XRT error circle
- [12095](#) GRB 110625A: NIR Source
- [12094](#) GRB 110625A: Konkoly observations
- [12093](#) Konus-Wind observation of GRB 110625A
- [12092](#) GRB 110625A: Swift-XRT refined Analysis
- [12091](#) GRB 110625A: Swift-BAT refined analysis
- [12090](#) Swift J185003.2-005627: NIR Observation
- [12089](#) GRB 110625A: ROTSE-III Optical Limits
- [12088](#) GRB 110625A: Swift detection of a burst
- [12087](#) Swift J185003.2-005627: Swift-XRT/UVOT refined analysis
- [12086](#) Swift J185003.2-005627: Swift-BAT refined analysis
- [12085](#) Swift J185003.2-005627: TAROT La Silla observatory optical observations

```
TITLE: GCN CIRCULAR
NUMBER: 12088
SUBJECT: GRB 110625A: Swift detection of a burst
DATE: 11/06/25 21:25:19 GMT
FROM: Scott Barthelmy at NASA/GSFC <scott@milkyway.gsfc.nasa.gov>
```

K. L. Page (U Leicester), S. D. Barthelmy (GSFC), A. P. Beardmore (U Leicester), J. R. Cummings (NASA/UMBC), V. D'Elia (ASDC), S. T. Holland (CREST/USRA/GSFC), F. E. Marshall (NASA/GSFC), C. Paganì (U Leicester), D. M. Palmer (LASL), P. Romano (IMAF-IASFPA), C. J. Saxton (UCL-MSSL), M. E. Siegel (PSU), M. C. Stroh (PSU) and T. W. Ukwatta (MSU) report on behalf of the Swift Team:

At 21:08:28 UT, the Swift Burst Alert Telescope (BAT) triggered and located GRB 110625A (trigger=456073). Swift slewed immediately to the burst. The BAT on-board calculated location is RA, Dec 286.750, +6.753, which is RA(J2000) = 19h 07m 00s Dec(J2000) = +6d 45' 10" with an uncertainty of 3 arcmin (radius, 90% containment, including systematic uncertainty). The BAT light curve shows several bright peaks with a total duration of about 60 sec. The peak count rate was ~20,000 counts/sec (15-350 keV), at ~13 sec after the trigger.

The XRT began observing the field at 21:10:48.8 UT, 140.3 seconds after the BAT trigger. Using promptly downlinked data we find a bright, fading, uncatalogued X-ray source located at RA, Dec 286.73189, 6.75386 which is equivalent to: RA(J2000) = 19h 06m 55.65s Dec(J2000) = +6d 45' 13.9" with an uncertainty of 3.8 arcseconds (radius, 90% containment). This location is 64 arcseconds from the BAT onboard position, within the BAT error circle. This position may be improved as more data are received; the latest position is available at <http://www.swift.ac.uk/epcr>.

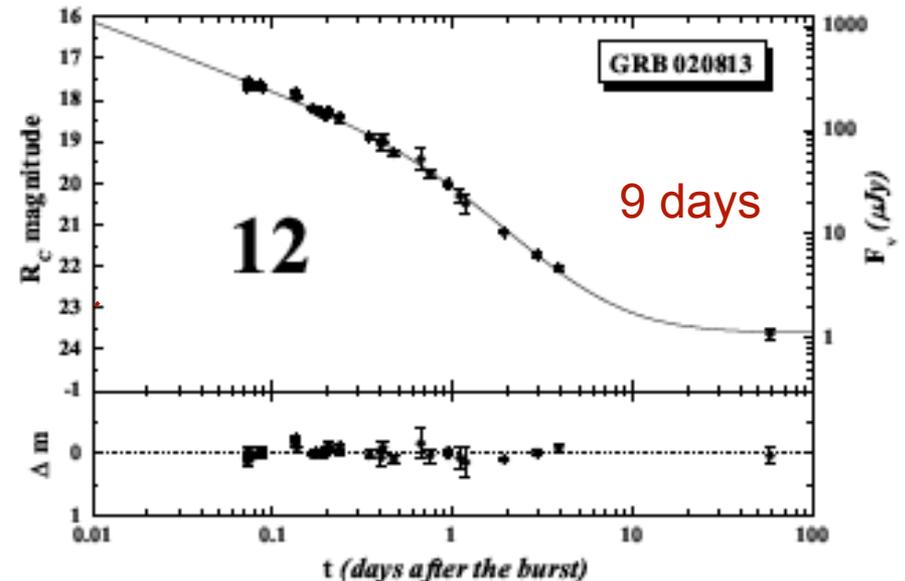
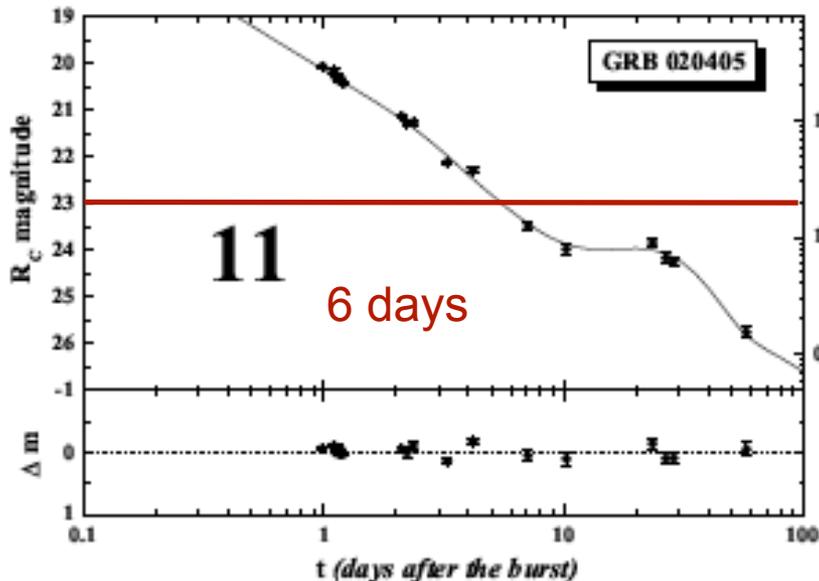
A power-law fit to a spectrum formed from promptly downlinked event data does not constrain the column density.

The initial flux in the 2.5 s image was 1.72e-09 erg cm⁻² s⁻¹ (0.2-10 keV).

UVOT took a finding chart exposure of 250 seconds with the U filter starting 205 seconds after the BAT trigger. No credible afterglow candidate has been found in the initial data products. The 2.7"x2.7" sub-image covers 100% of the VOT error circle. The nominal 3-sigma upper limit has been about 18.2 mag. The

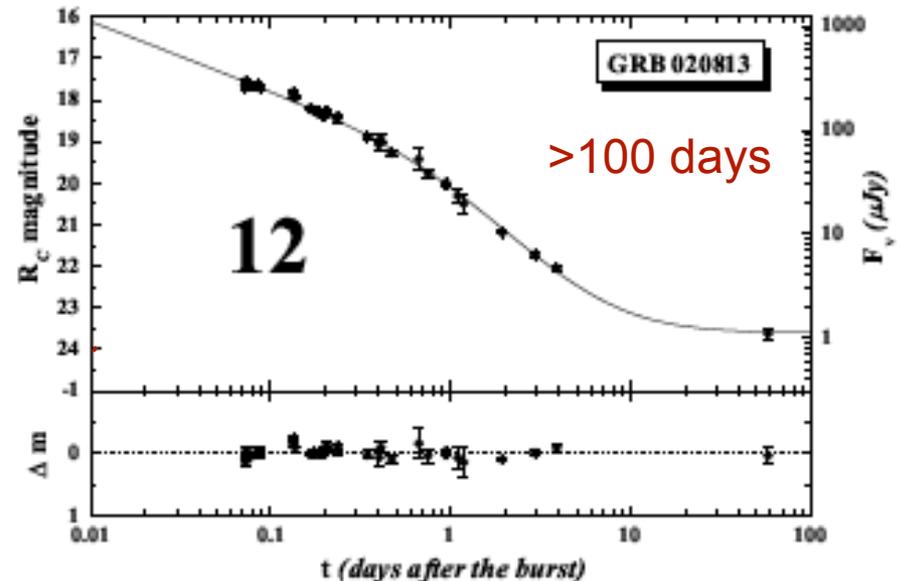
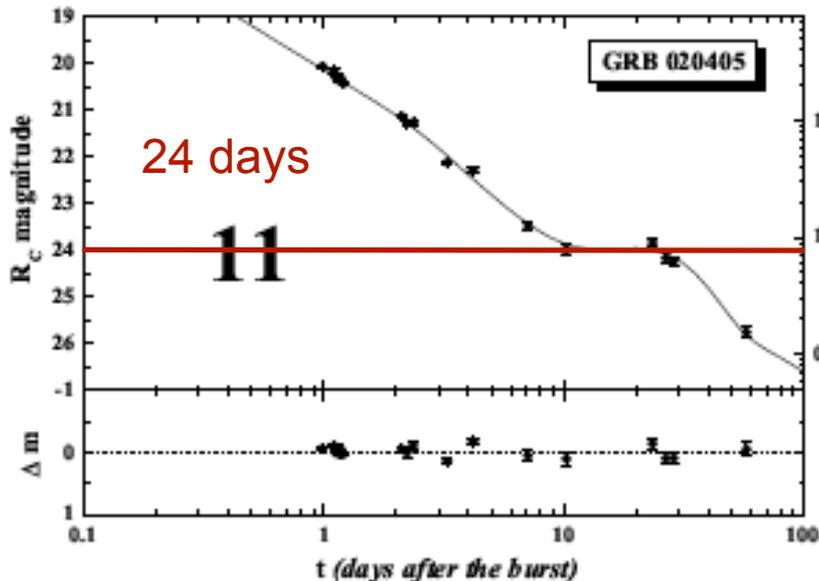
2. Afterglow follow-up within DES footprint

- * Most dedicated GRB telescopes are meter-class (or smaller); KPNO, Keck, etc. are used very rarely for follow-up of individual bursts.
- * Multi-filter observations with DECam can be obtained “for free” during Survey.
- * With 300 bursts/year, footprint covering 1/8 of sky, and (a few) afterglows brighter than 23rd magnitude for up to 1 month: 1–4 observable at any time.
- * For poorly-localized bursts, DECam has the field of view to find them!



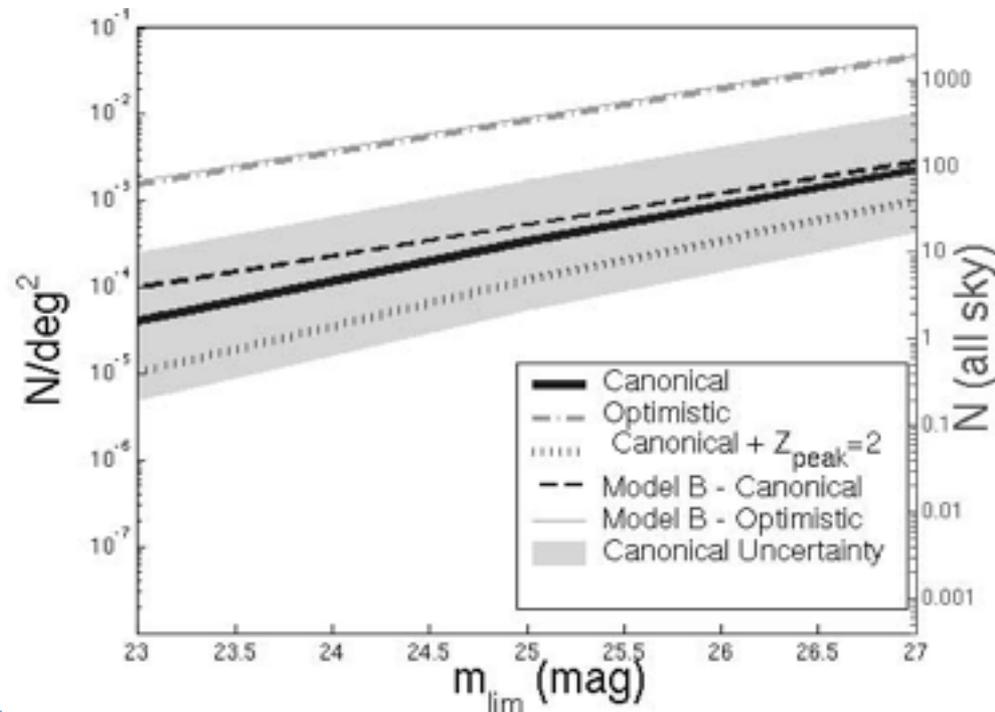
3. Afterglow Follow-Up within SN Fields

- * 30 deg^2 ($\sim 1/1000$ of full sky) means ~ 1 GRB every 3 years will be observed within the SN fields.
- * These will be observed with much greater frequency, leading to a detailed multi-epoch, multi-wavelength lightcurve that will be extremely informative.
- * Rebrightening of AG lightcurve from SN will be observable!



4. “Orphan” GRB Afterglow searches within SN fields

- * GRBs are “beamed”; the afterglow is has a wider opening angle than the burst
- * We can expect up to 10^{-3} “orphan” AGs per square degree per hour
- * These can be detected with as few as two observations 3 days apart above a limiting magnitude $m_{\text{lim}}=23$ (Nakar, Piran, Granot, ApJ 2002 579:669ff).
- * DES will have approximately this cadence in the 30 deg² SN fields, a total of 350 hours during DES would yield ~ 10 orphan AGs (in the optimistic case).
- * We’ll need to distinguish GRB AGs from all other transients... (Simulations?)



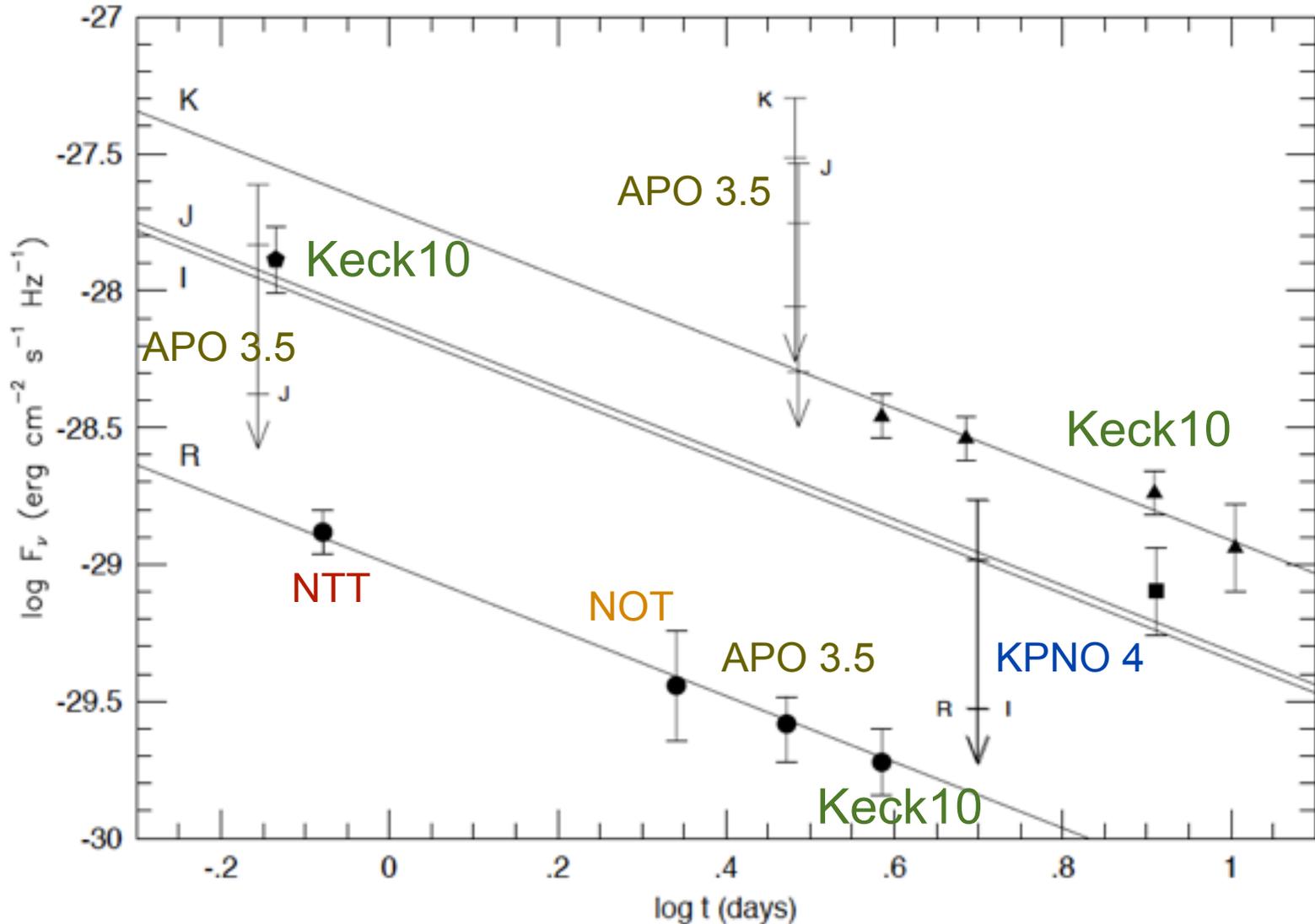
5. Expanding the Search with DECam Community Use

- * In addition to observations governed by (modified) ObsTac within DES, all of these searches would benefit from non-DES time with DECam on the Blanco.
- * GRB afterglows (including orphan AGs) can be observed over a wider area and followed up with deeper observations through a “Target of Opportunity” program.
- * This allows extending lightcurves/detection/confirmation beyond the constraints of DES observations.
- * Several external collaborators have been contacted to participate in the DES/Community Effort. Discussions with Blanco ToO Coordinator underway.



Multi-Wavelength Observations

Reichart et al. 1999



DES/DECam Community Use Contributions to GRB Science

- **Increased Statistics (esp. Jet Properties):**

Add to GRB statistics via multiwavelength/
multimessenger campaigns

- **Serendipity:**

Interesting/unique GRBs--e.g. brightest (GRB080319B @ 10^{54} erg iso) or closest (GRB030329 at $z=0.16$) or most distant (GRB090423 at $z=8.2$)

- **Host Galaxies:**

Metallicity--c.f. Modjaz et al. (2008)

Morphology--e.g. LGRBs in star-forming galaxies, SGRBs in (outskirts of) ellipticals

Absorption (ISM/IGM)

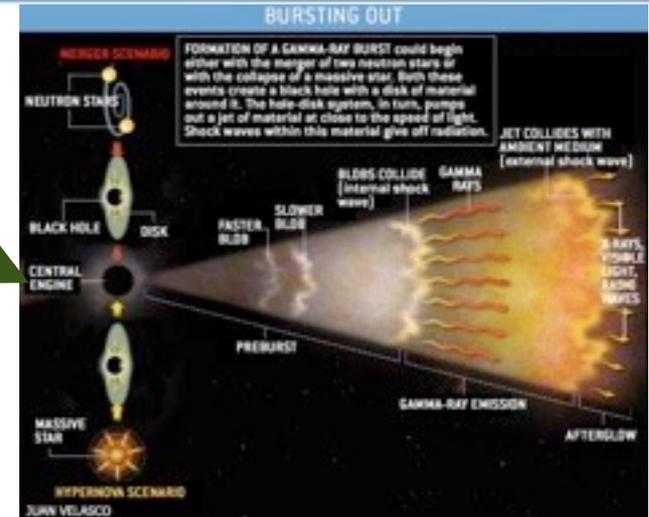
Redshift (photo- z , dropout of successive bands)

- **From Star Formation to Cosmology:**

Primordial (Pop. III) star formation, reionization,

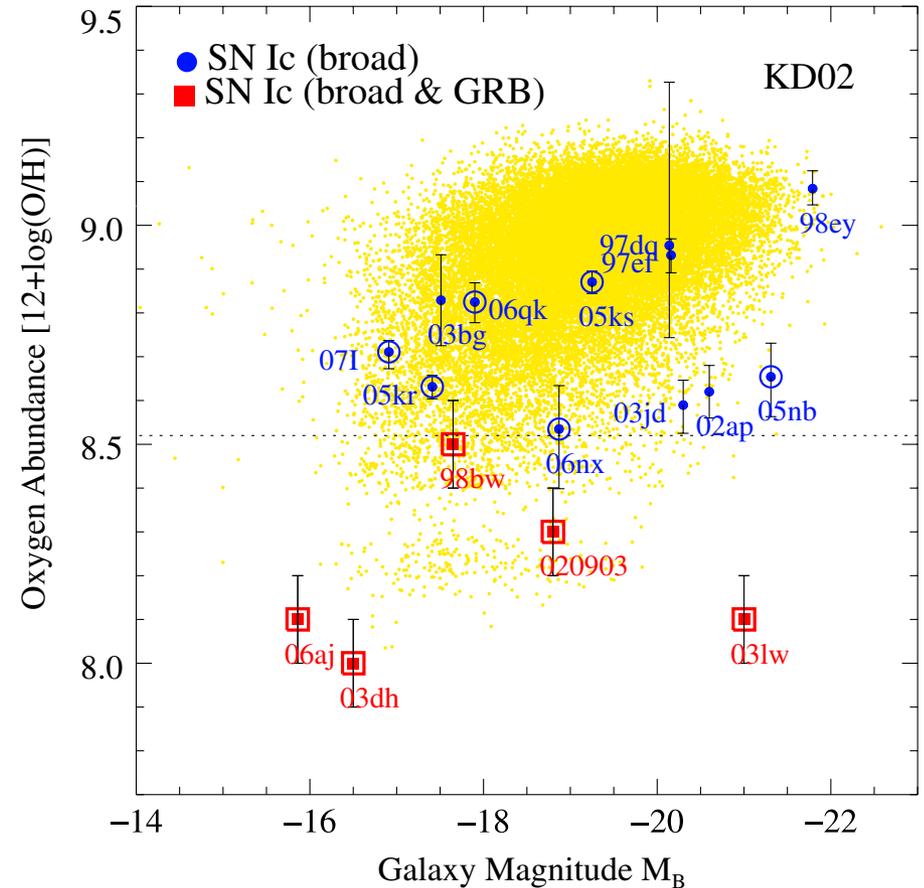
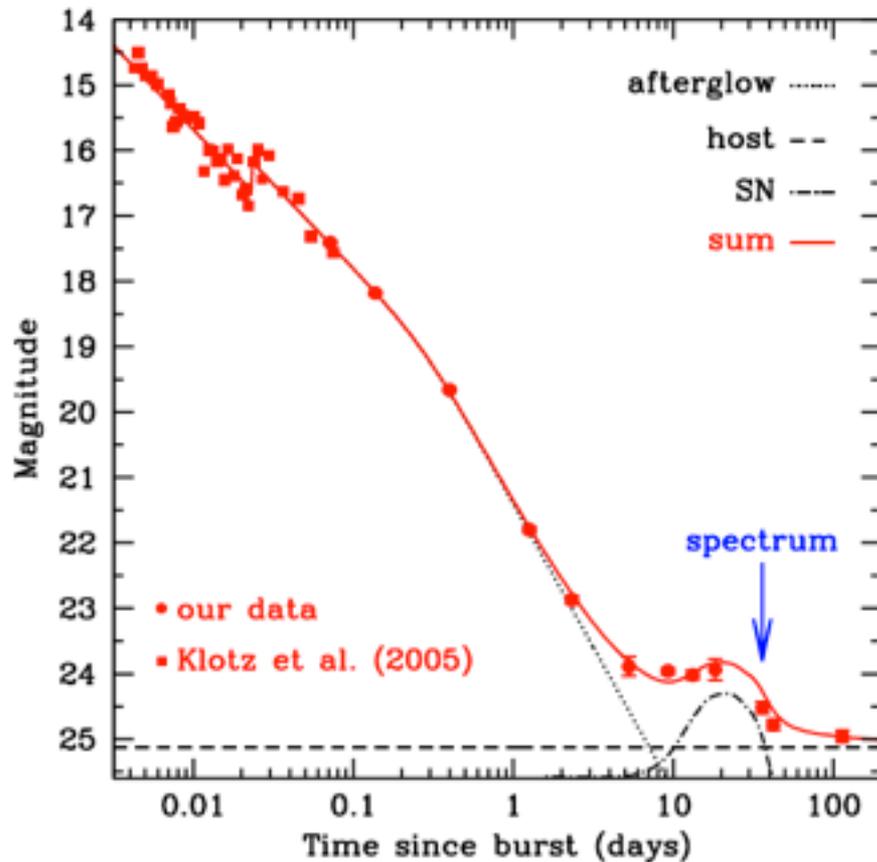
Standard(izable?) candles--Amati and Ghirlanda Relations (Amati et al. 2002, Ghirlanda et al. 2004), Liang-Zhang Relation (Liang et al. 2008).

However, see Friedman & Bloom (2005)...



The GRB-SN Connection

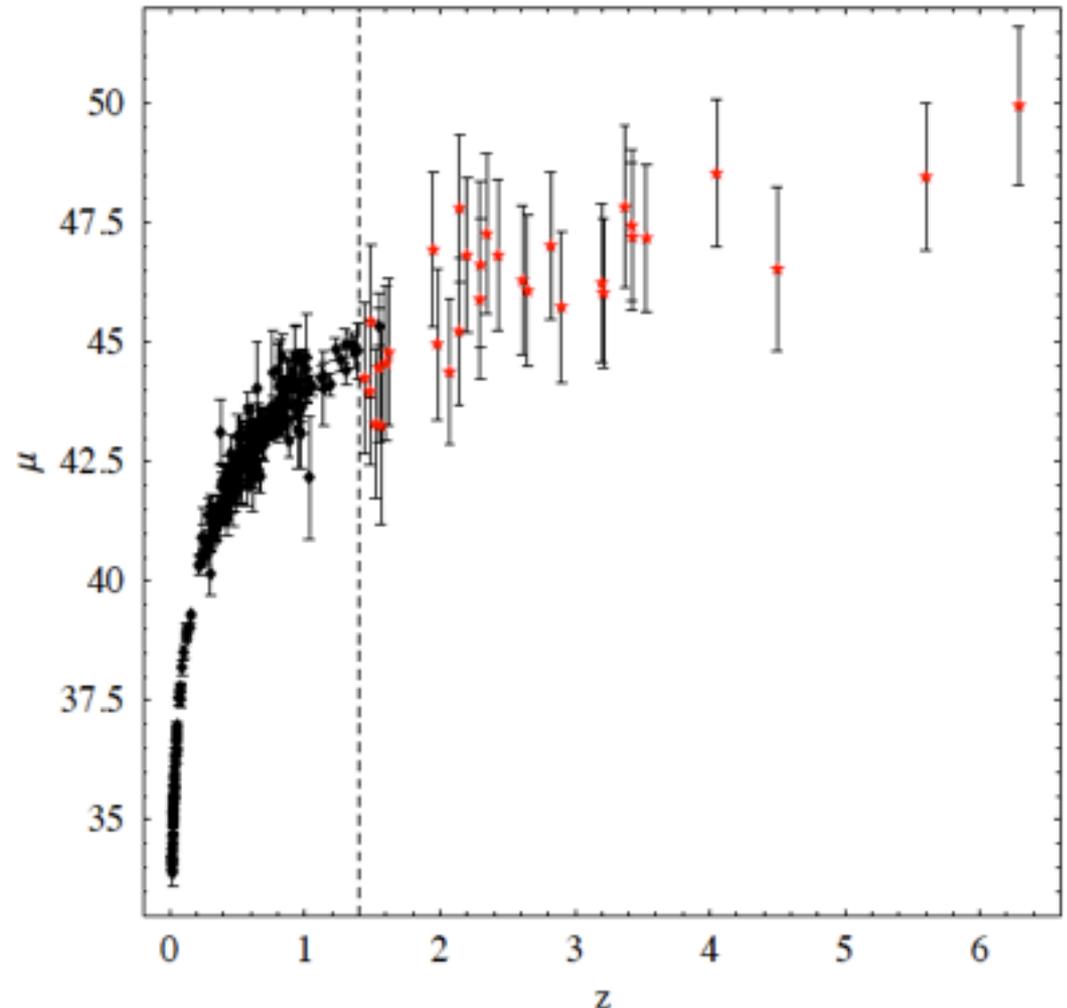
One of the Most Interesting GRB-Related Discoveries in the Last Decade...



Images Courtesy of Della Valle et al. (2006), Modjaz et al. (2008)

GRB Cosmology: Extrapolating Calibrated GRBs to High z

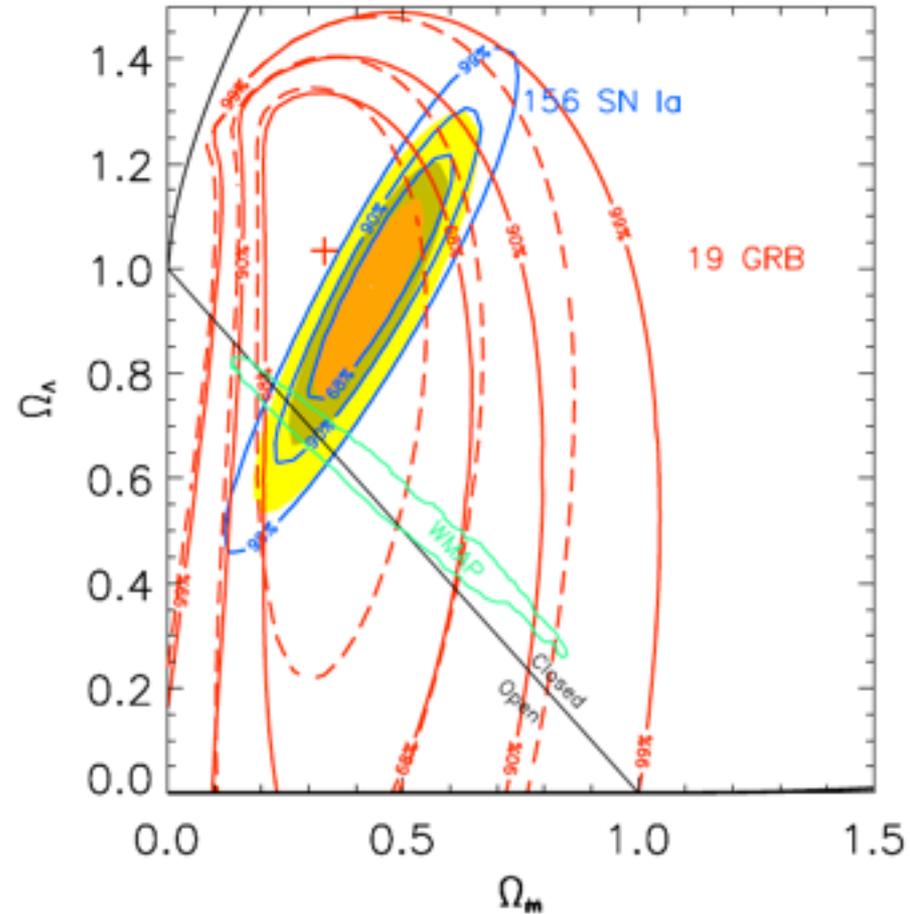
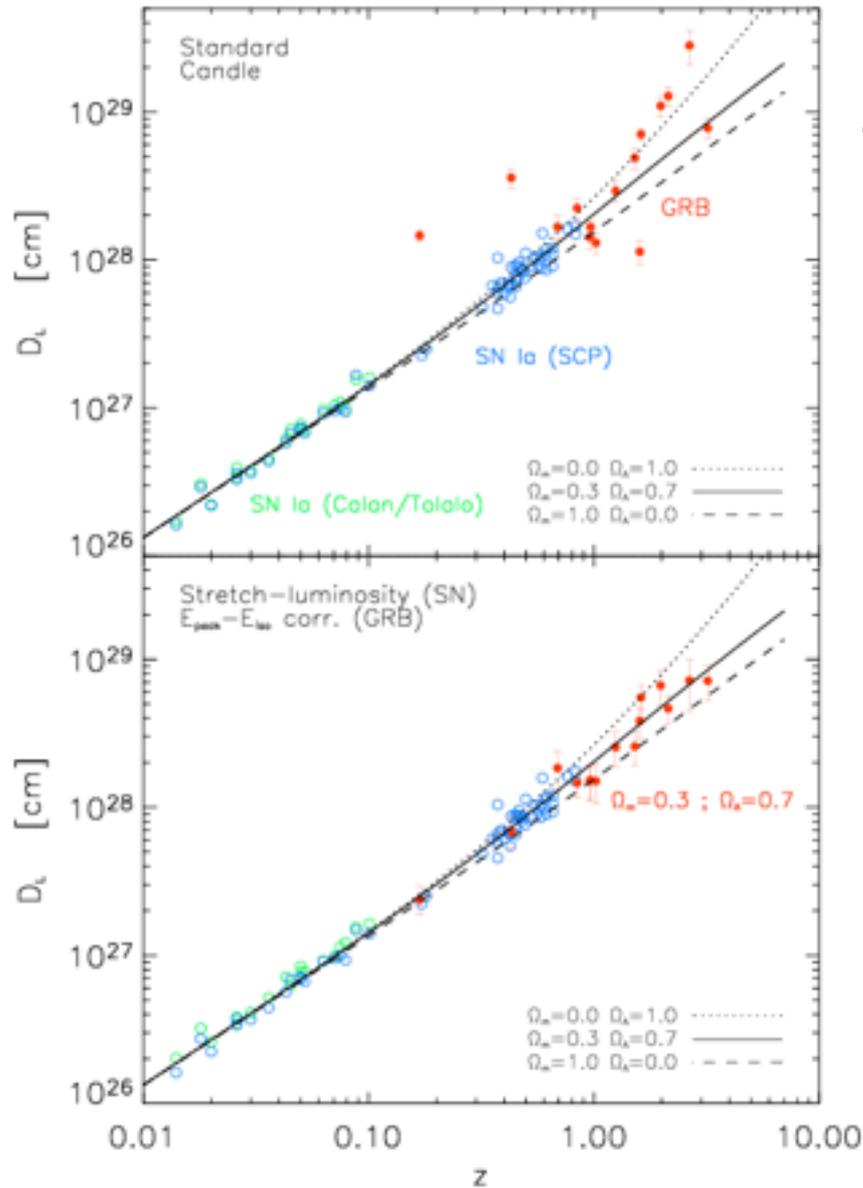
- * GRBs have been calibrated against SNe Ia up to $z \sim 1.4$
- * Assuming standard(izable) candle characteristics, GRBs can constrain cosmology in a similar fashion to SNe Ia.
- * Large error bars currently--every high z GRB can be of benefit!



Wei & Zhang (2006)

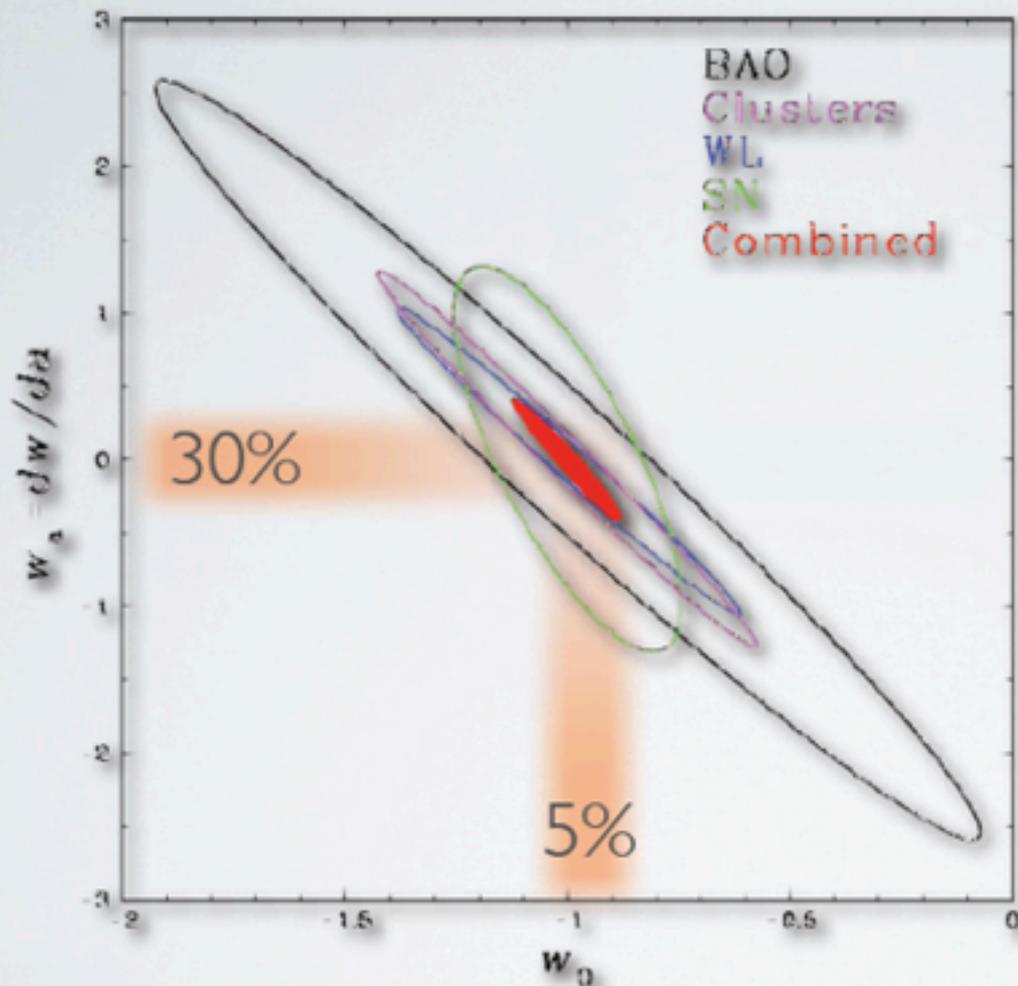


GRB Cosmology: Constraints on Parameters



Ghirlanda et al. (2004), Lazzati et al. (2006)

DES PROJECTED LIMITS



5000 deg², 0.9" seeing,
24th mag (redshift ~ 1.4)

300M galaxies, shapes,
100K clusters, 4K SNe

4 combined probes

3-5x improved Dark
Energy measurement

Conclusions

- Dark Energy is (probably) causing the accelerated expansion of the universe. The Dark Energy Camera has been successfully built and tested, and is ready to engage in the Dark Energy Survey.
- The Precursor to the Dark Energy Camera (PreCam) has been successfully built and deployed at Cerro Tololo Interamerican Observatory for the purpose of calibrating the DECam.
- Preliminary results show single-epoch photometric accuracy of 3–4%, with accuracy better than 2% expected for final PreCam Southern Hemisphere Standard Star Catalog.
- In addition to the Key Science goals with the four probes (operating independently and collectively), the DES will accomplish an enormous amount of auxiliary science (e.g. non-SN transients).
- The Dark Energy Survey has recently achieved first light, and will begin science operations later this fall, with the goal of providing unprecedented constraints on the time-(in)dependent component of the dark energy equation of state over the next five years.



The Dark Energy Survey Collaboration

More than 200 scientists and engineers from...

[Fermilab](#) — The Fermi National Accelerator Laboratory

[UIUC/NCSA](#) — The University of Illinois at Urbana-Champaign

[Chicago](#) — The University of Chicago

[LBNL](#) — The Lawrence Berkeley National Laboratory

[NOAO](#) — The National Optical Astronomy Observatory

United Kingdom DES Collaboration

- [UCL](#) - University College London
- [Cambridge](#) - University of Cambridge
- [Edinburgh](#) - University of Edinburgh
- [Portsmouth](#) - University of Portsmouth
- [Sussex](#) - University of Sussex
- [Nottingham](#) - University of Nottingham

Spain DES Collaboration

- [IEEC/CSIC](#) - Instituto de Ciencias del Espacio,
- [IFAE](#) - Institut de Fisica d'Altes Energies
- [CIEMAT](#) - Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas

[Michigan](#) — The University of Michigan
DES-Brazil Consortium

- [ON](#) - Observatorio Nacional
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Committee on the International Freedom of Scientists

<http://www.aps.org/about/governance/committees/cifs/index.cfm>

DARK ENERGY
SURVEY

- “To achieve its full potential and to benefit all mankind, science requires that governments respect basic human rights, allow open communication, and avoid interference with the rights of scientists as they carry out their professional work.”
-- from the APS Statements on Human Rights
- “This Committee shall be responsible for monitoring concerns regarding human rights for scientists throughout the world. It shall apprise the [Society] of problems encountered by scientists in the pursuit of their scientific interests or in effecting satisfactory communication with other scientists and may recommend appropriate courses of action designed to alleviate such problems.”
-- from the APS CIFS Statement of Purpose
- Cases currently being reviewed from China, Cuba, Gaza Strip/Israel, Iran, Iraq, Mexico, Saudi Arabia, Turkey, Russia, and the United States, involving allegations of everything from scientists being unfairly tried and incarcerated to students prevented from traveling internationally to participate in educational opportunities.
- CIFS also participates in the awarding of the APS Andrei Sakharov Prize, “to recognize outstanding leadership and/or achievements of scientists in upholding human rights.”



Thank You!

