

OVERVIEW OF THE DARK ENERGY CAMERA AND THE DARK ENERGY SURVEY

G. Bernstein (University of Pennsylvania) 6 January 2014

On behalf of the *Dark Energy Survey* Collaboration and the CTIO/DECam staff.

Outline

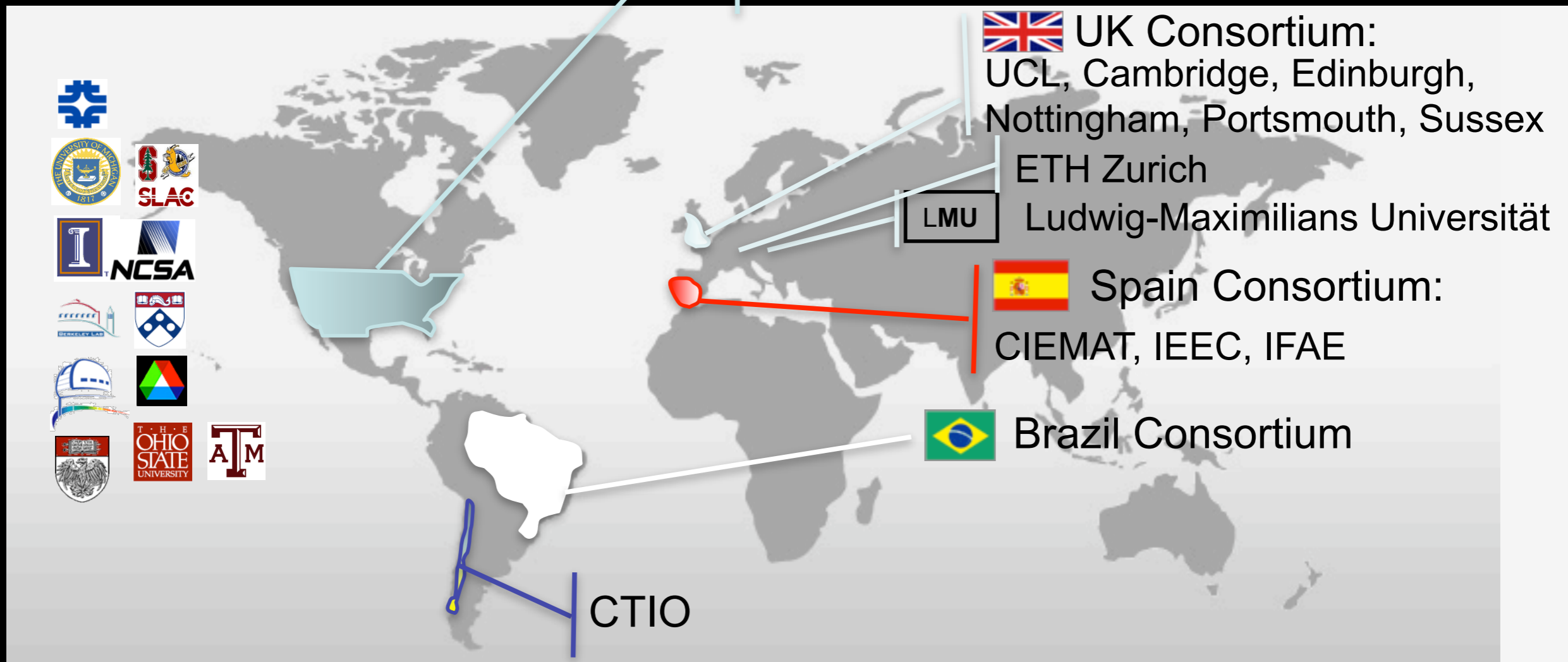
- * DECam overview and performance
- * Dark Energy Survey overview and status
- * DECam and DES for the general astronomical community



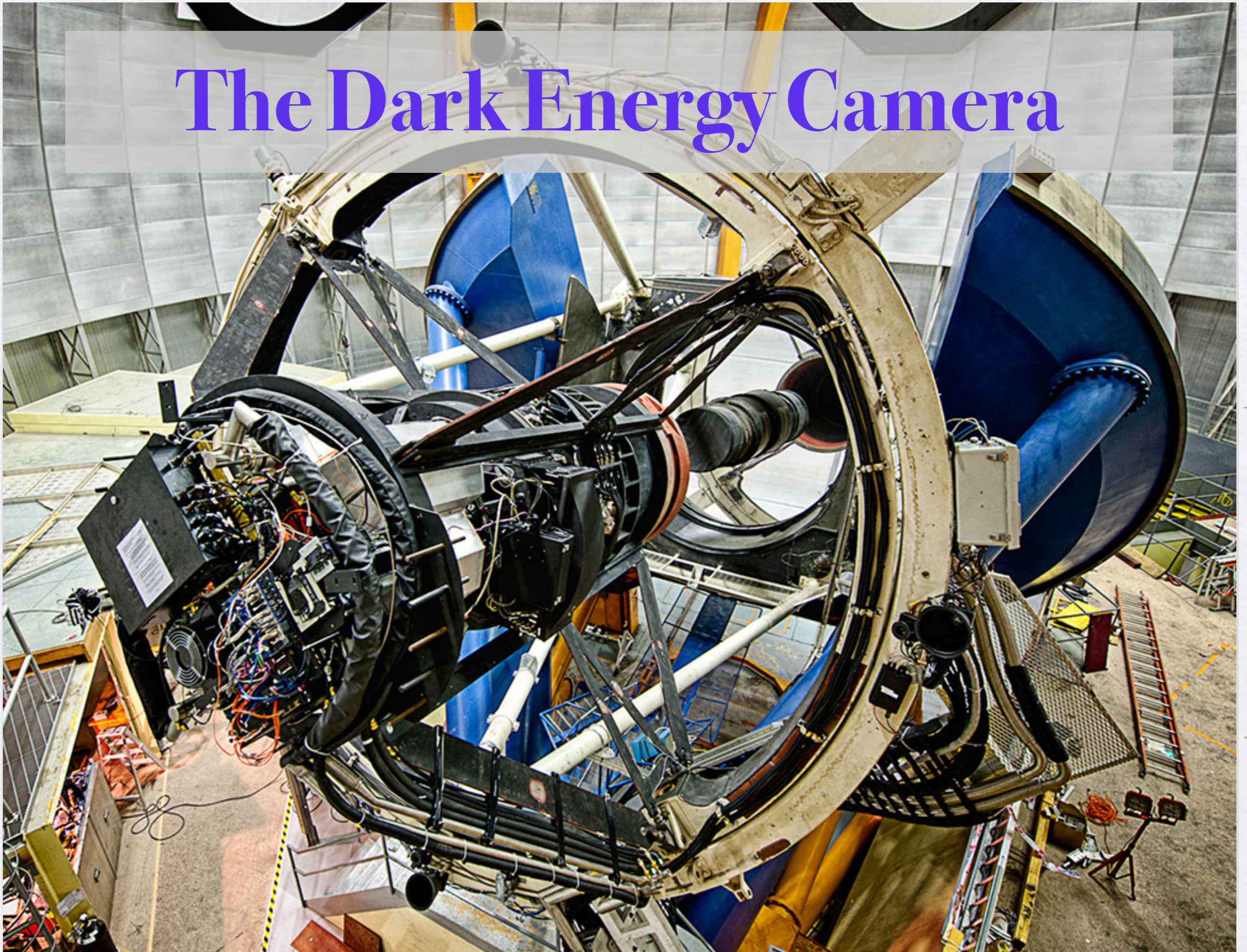
Dark Energy Survey Collaboration

~300 scientists from around
the world

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



The Dark Energy Camera

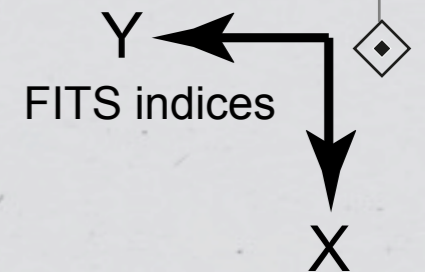


Scientist's view of DECcam

- 250 um LBL p-channel
- 15 um (0.264") pixels
- 2 amplifiers per CCD
- Science Array: 62 x 2k x 4k
- **2-degree diameter FOV**

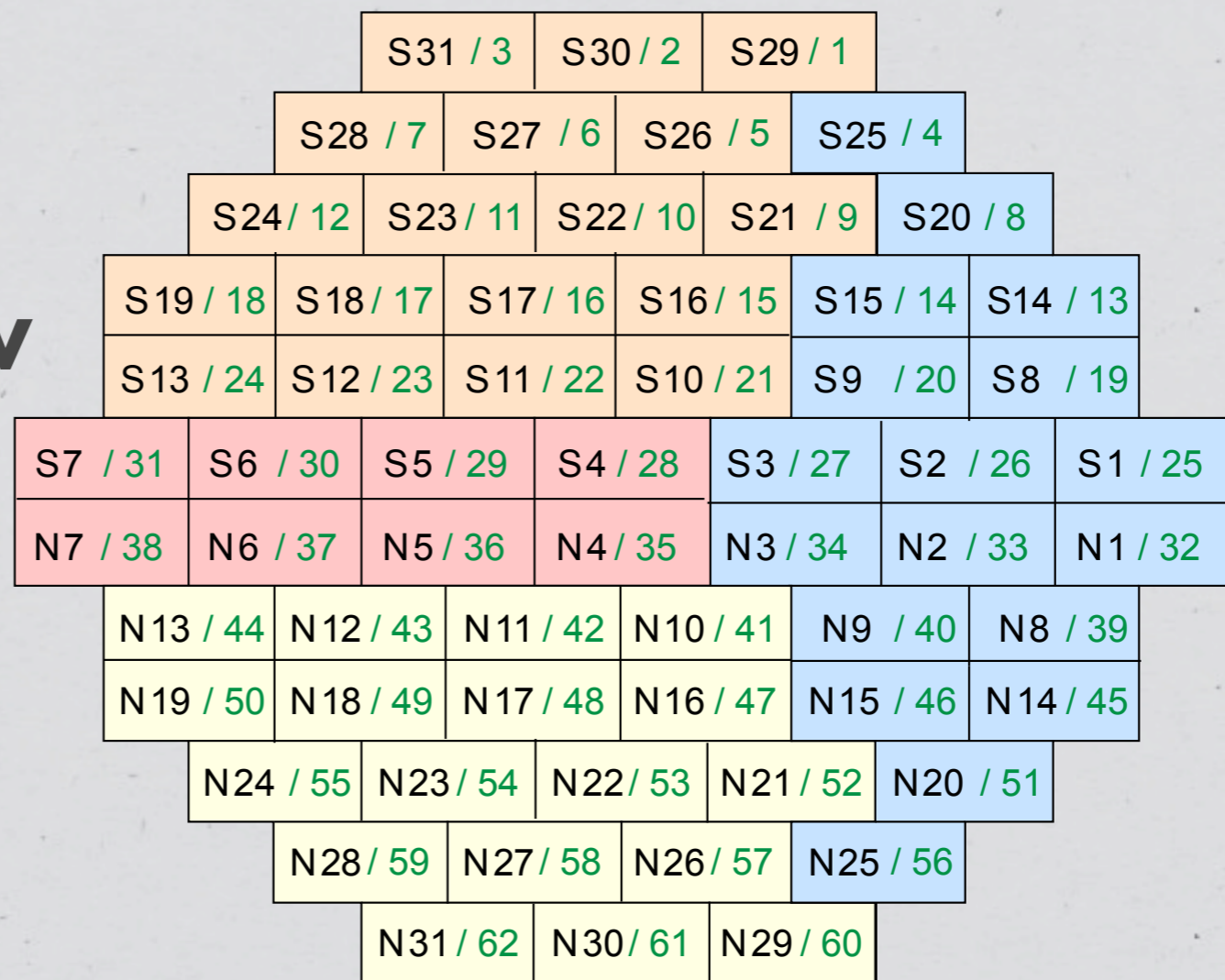
Sky Orientation of DECcam NORTH

DETPOS / CCDNUM



EAST

WEST



SOUTH

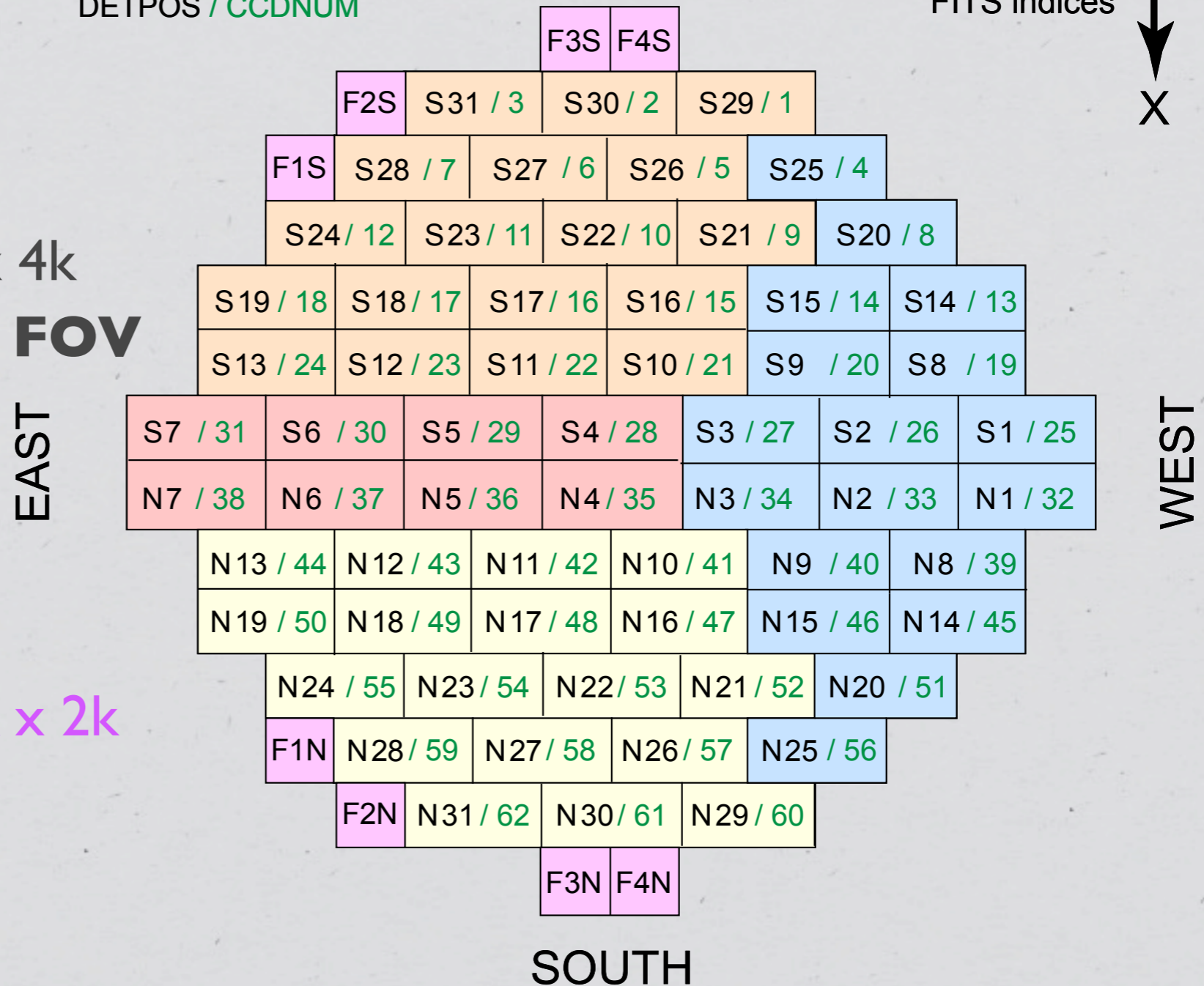
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Focus/Alignment: 8 x 2k x 2k

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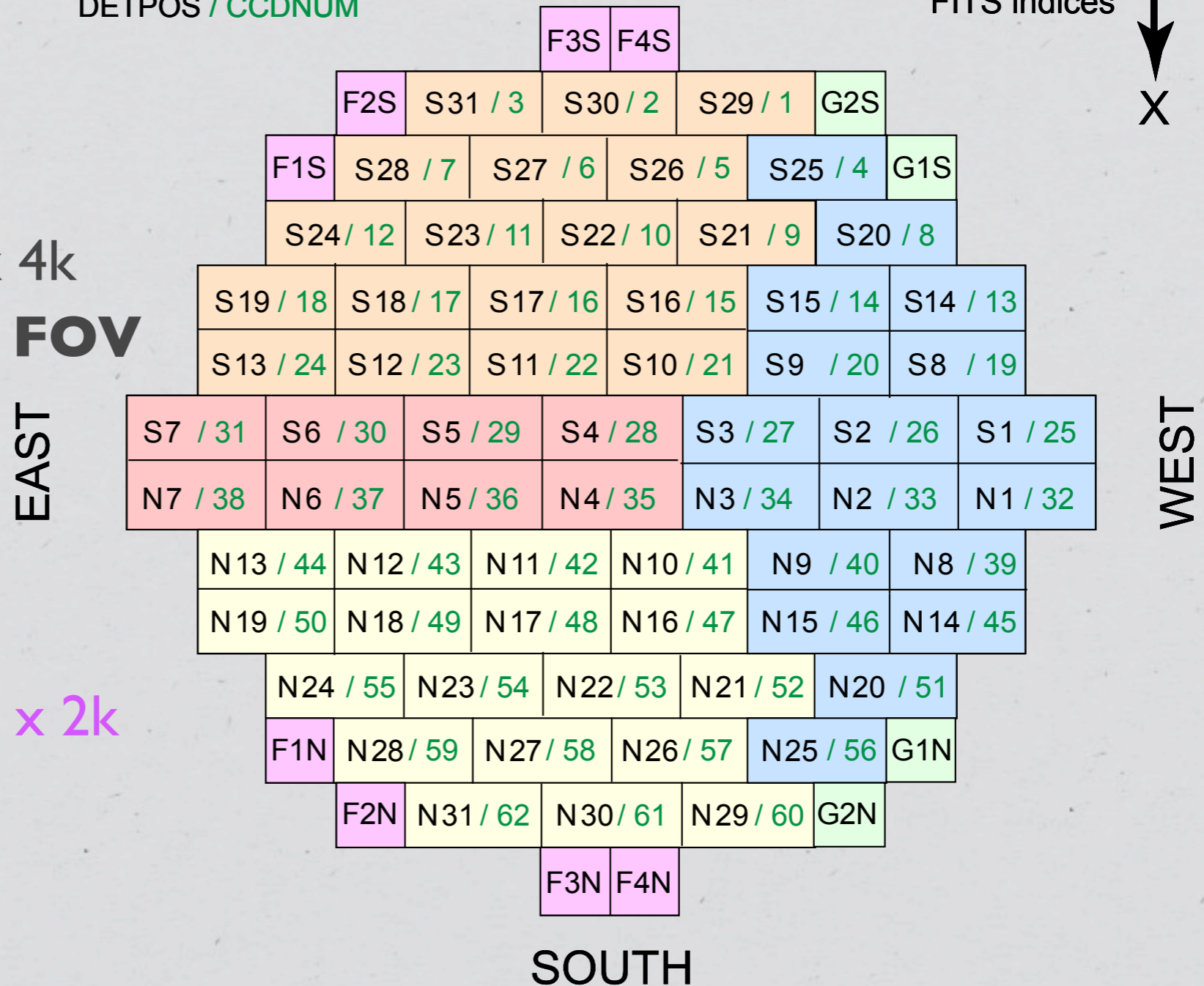
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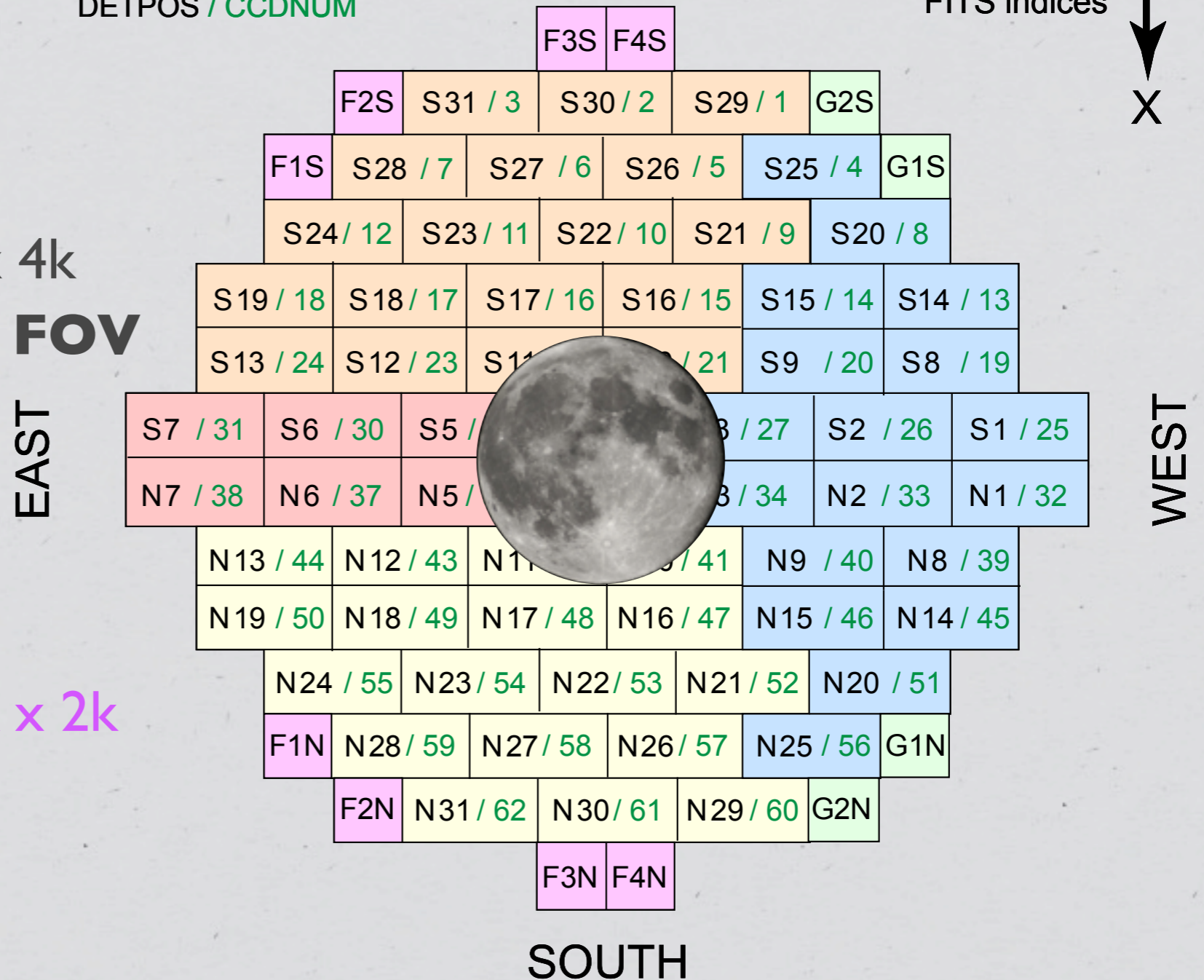
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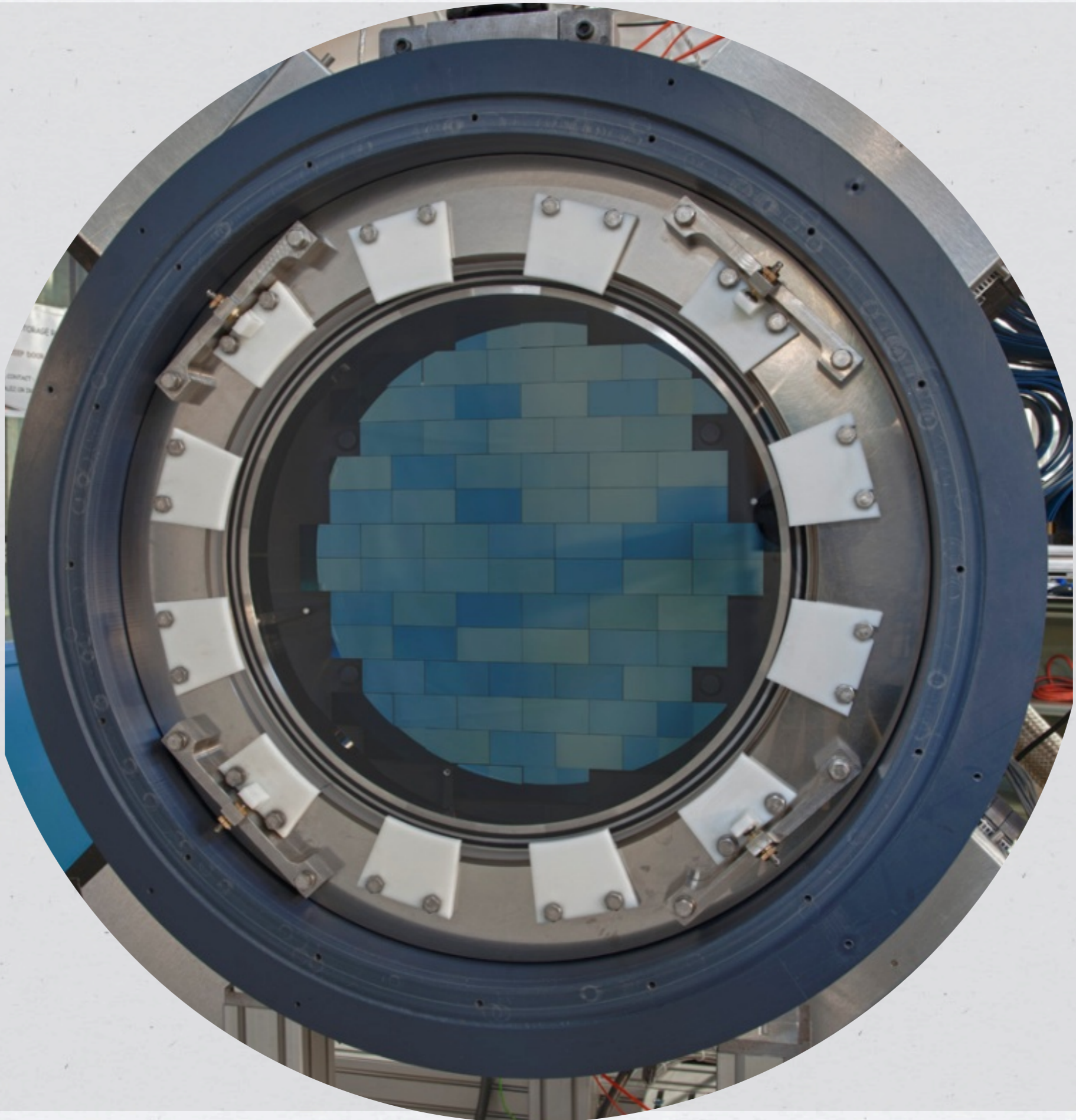
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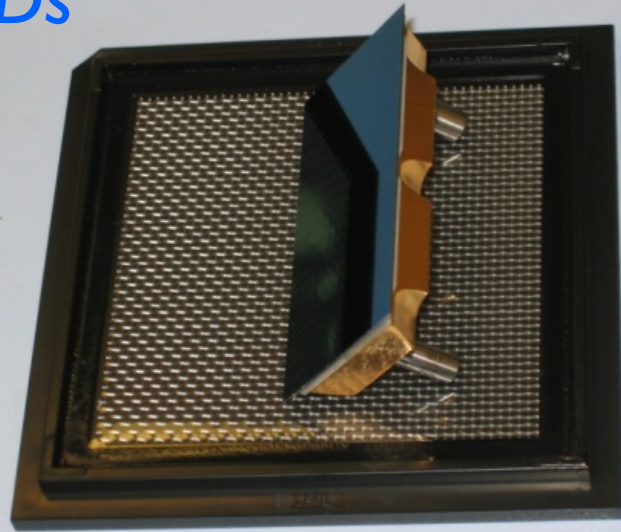
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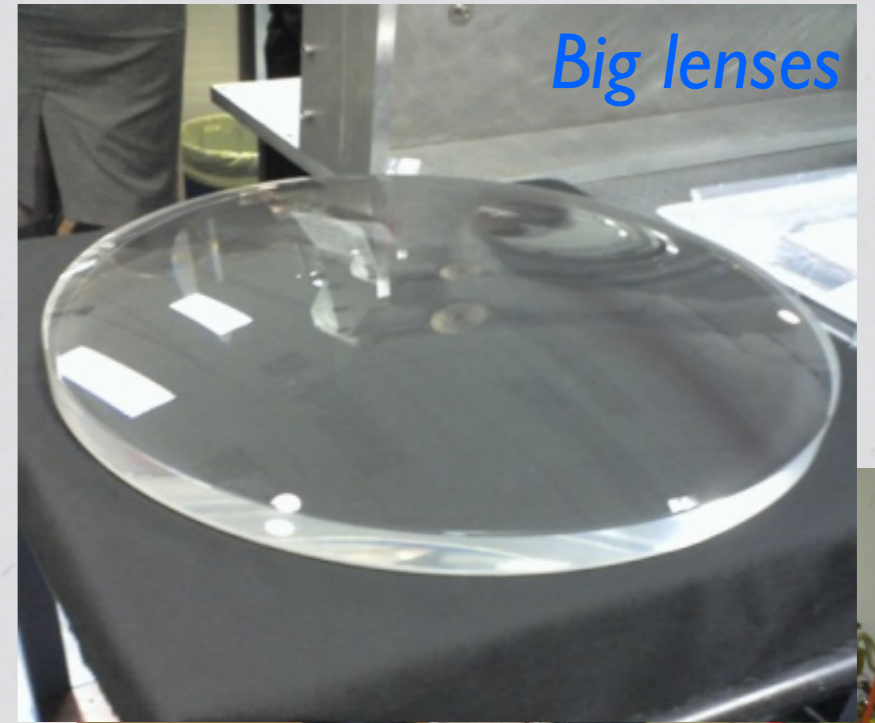
CCDs



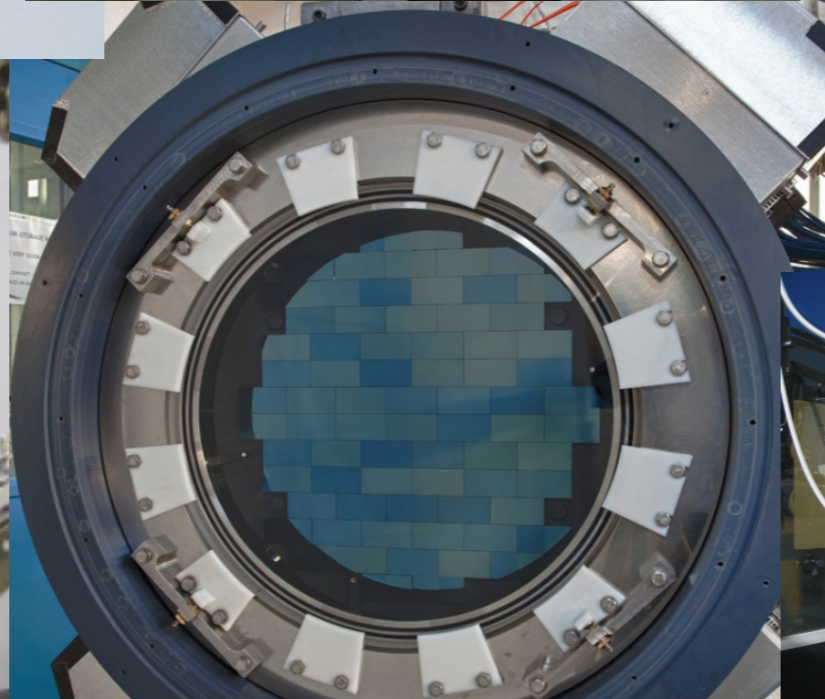
Filters



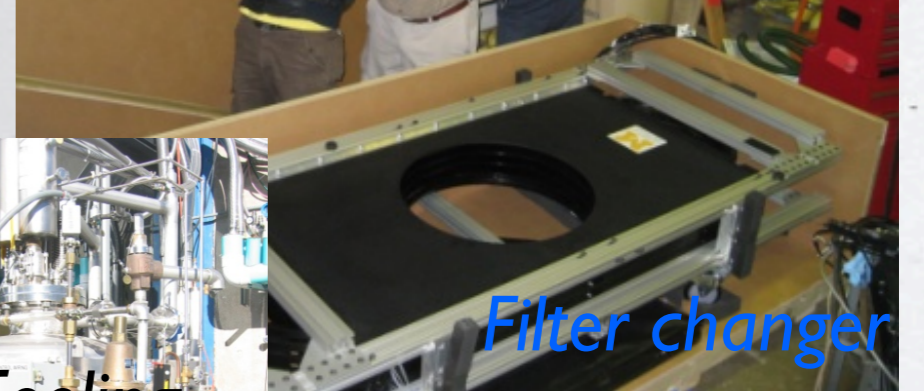
Big lenses



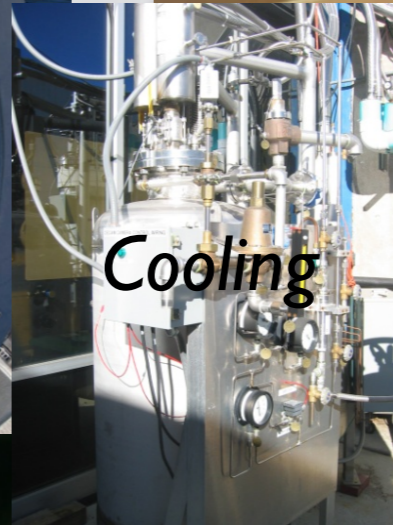
Readout system



Filter changer



Cooling



Shutter



Bigger lenses



Hexapod



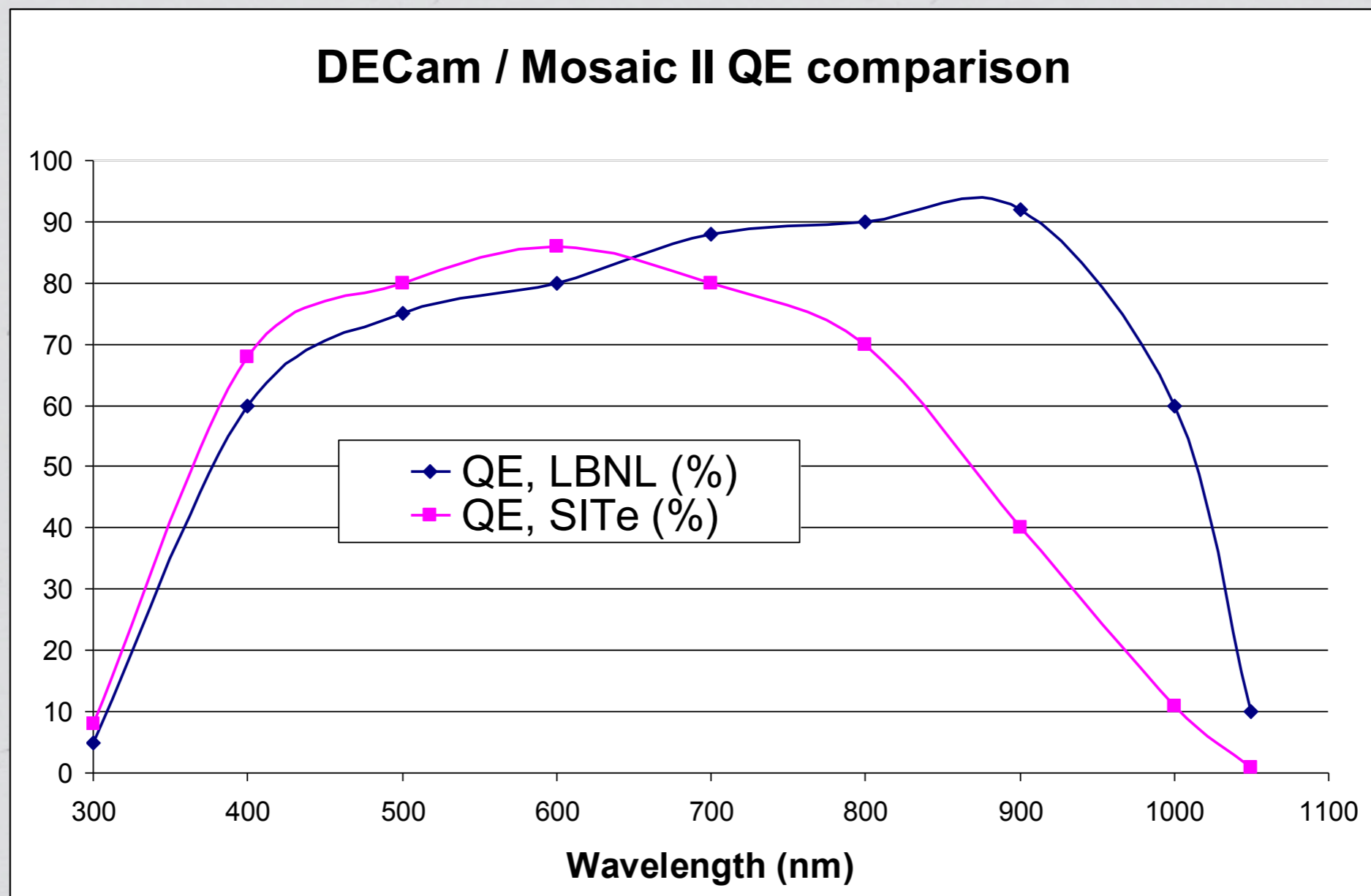
SISPI GUI Interfaces

Controls



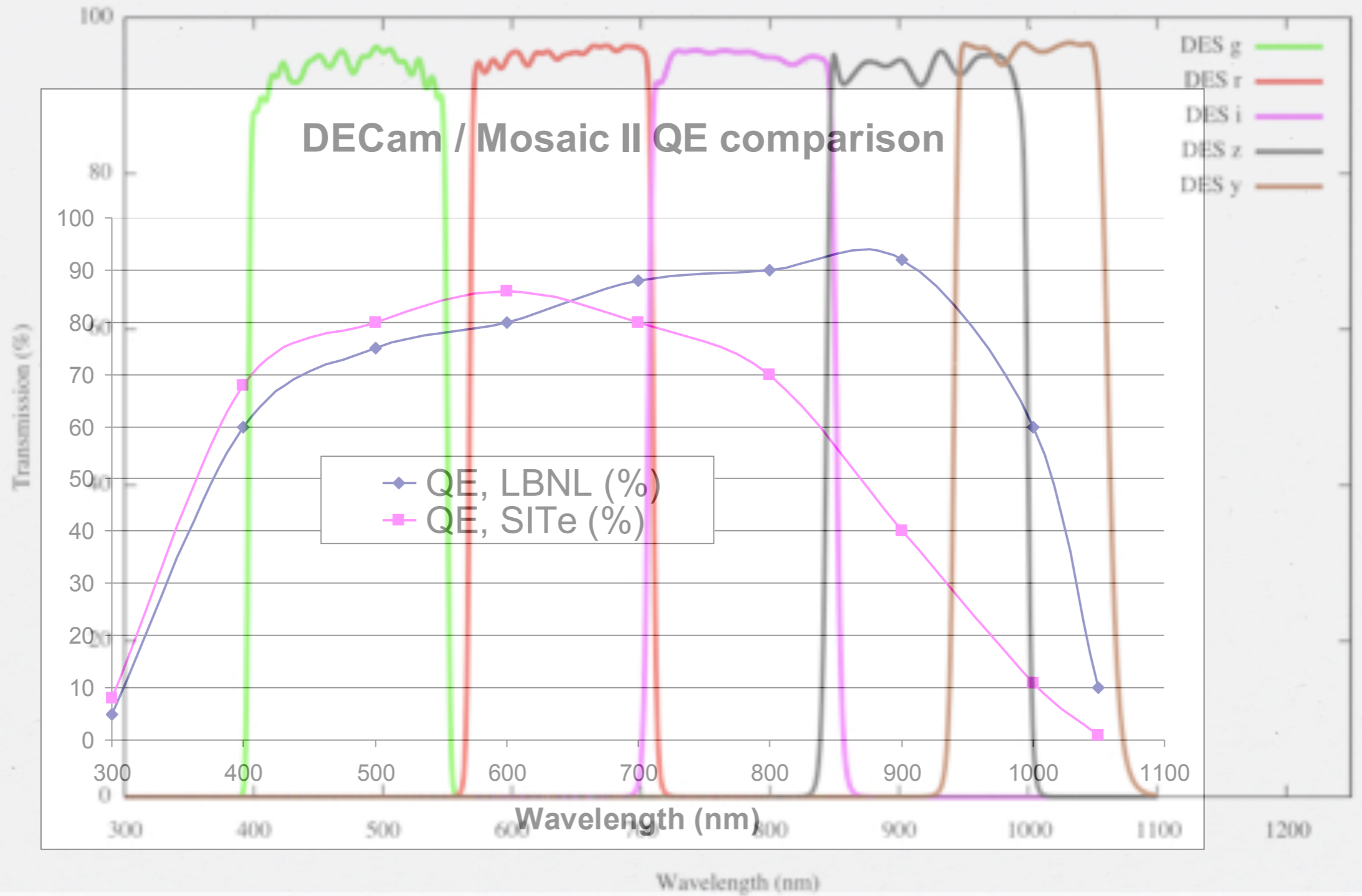
[image coming soon](#)

DECam CCDs have high red QE



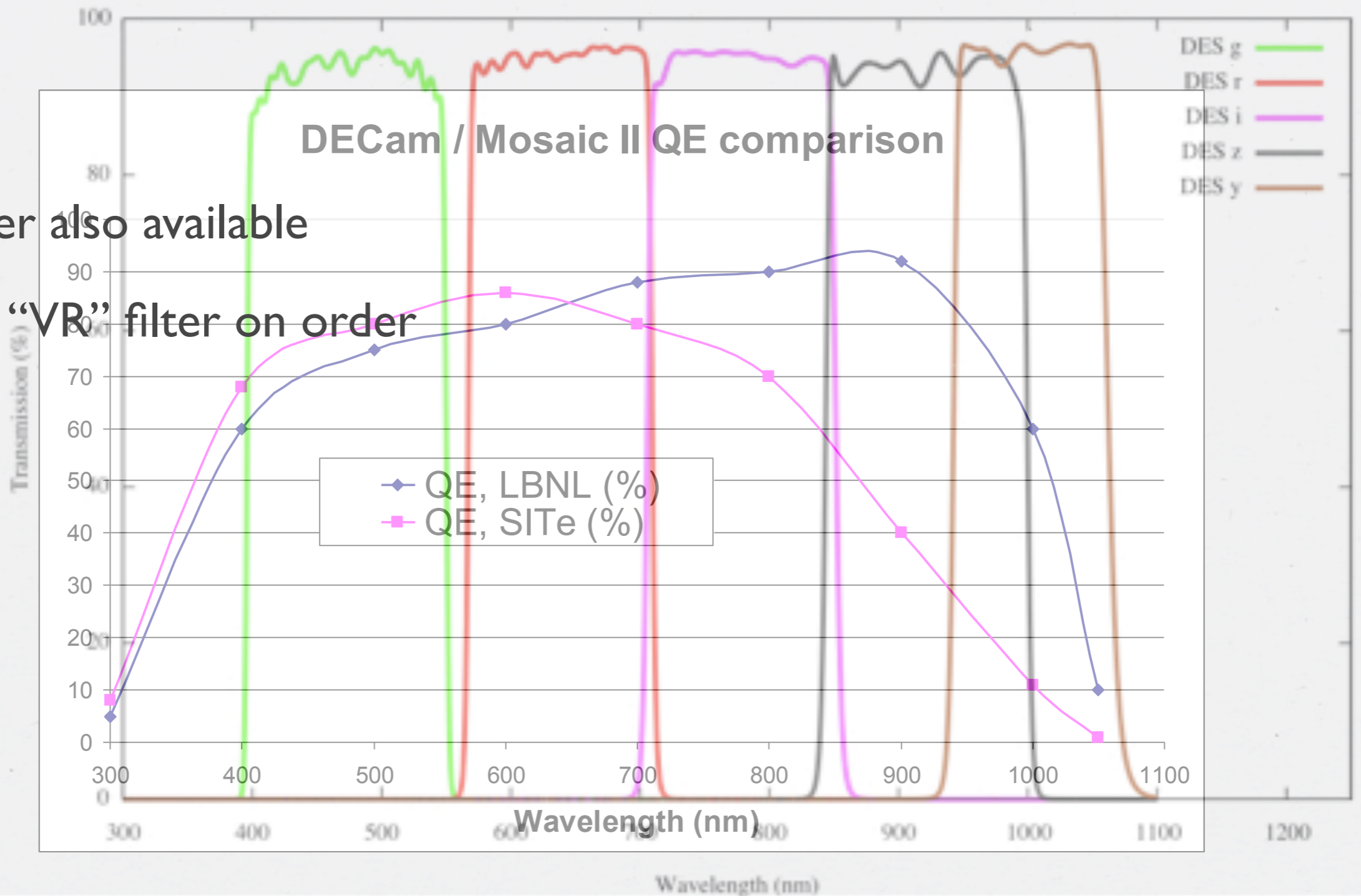
DECam CCDs have high red QE

Asahi-Measured Transmission Curves for Delivered 100mmx100mm DES grizy Filters



DECam CCDs have high red QE

Asahi-Measured Transmission Curves for Delivered 100mm x 100mm DES grizy Filters



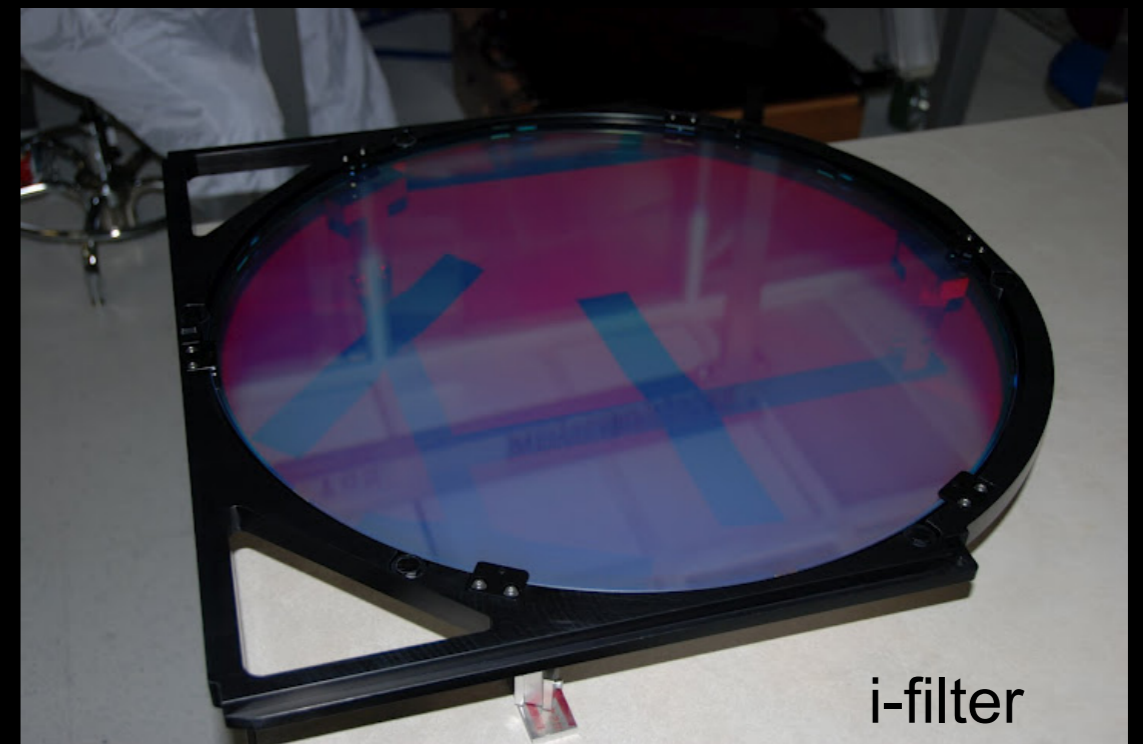
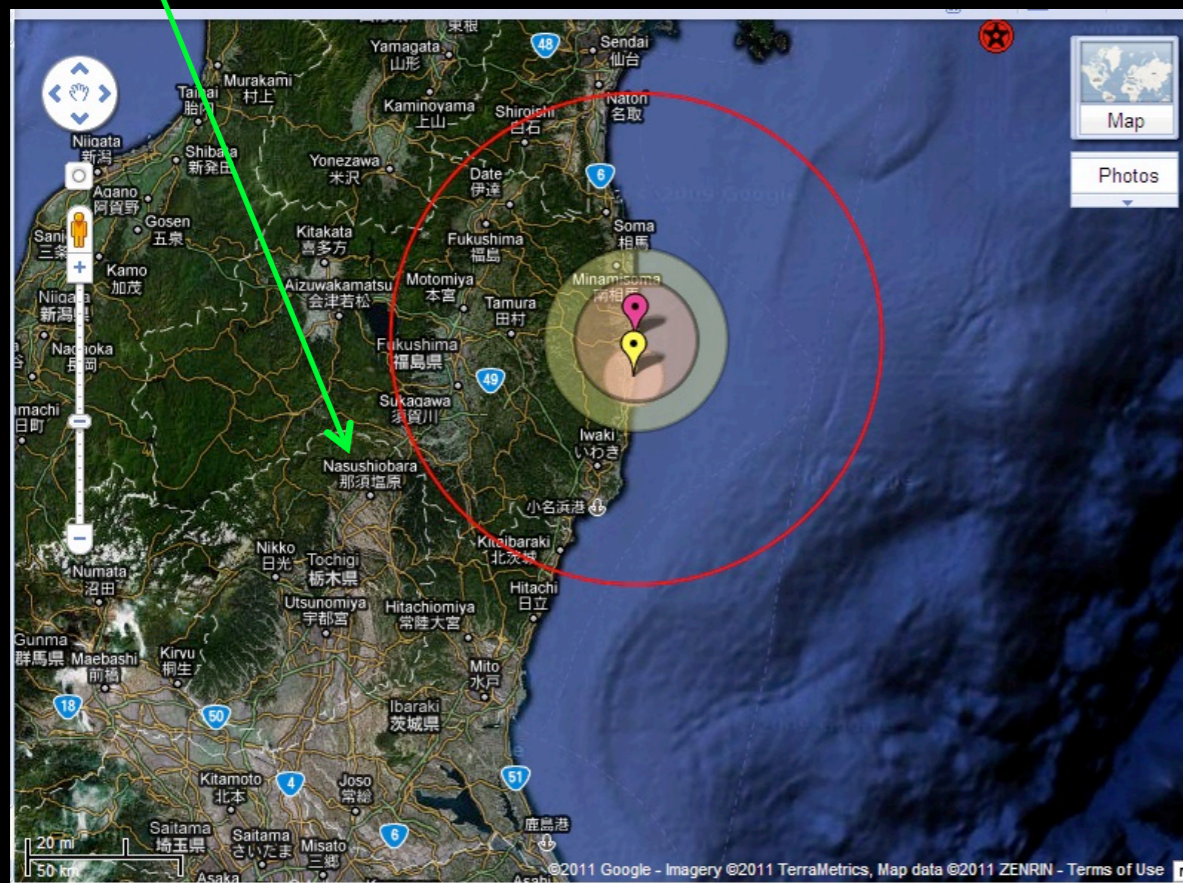
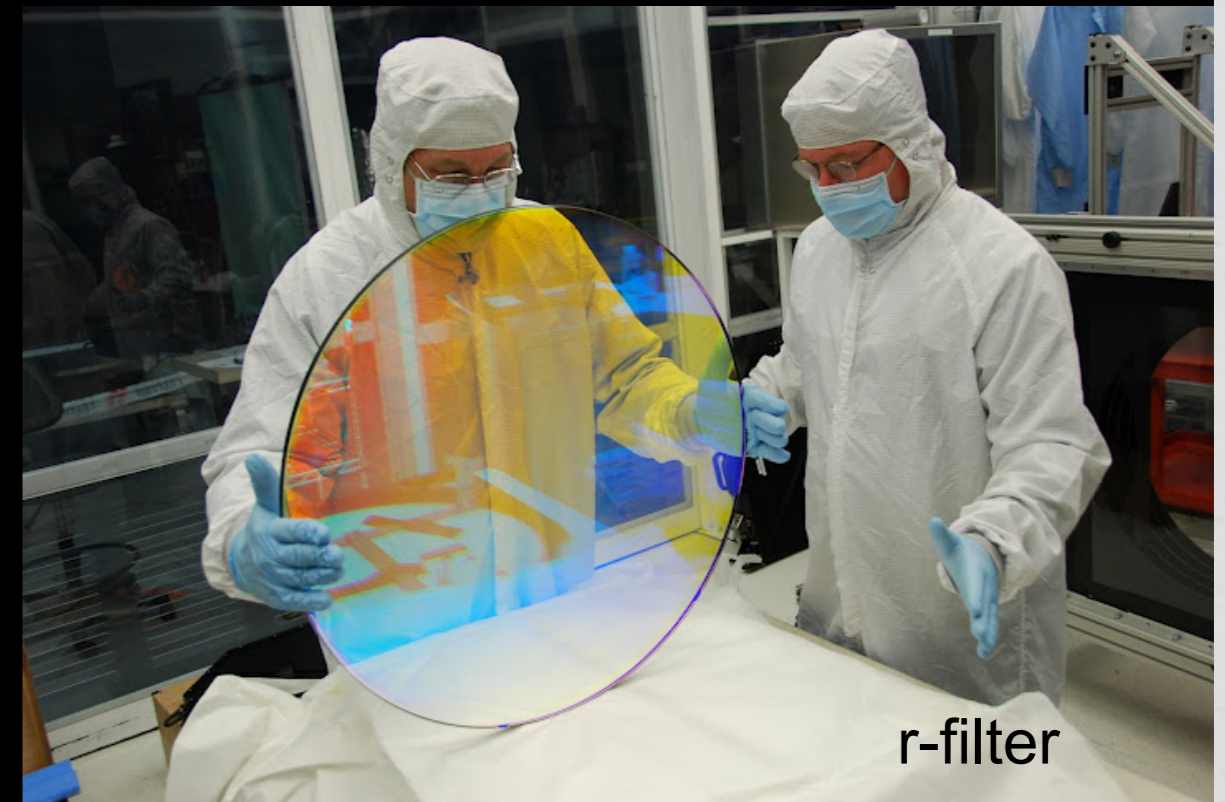
- *u* filter also available

- wide “VR” filter on order



Filters

- 600 mm clear aperture, tight uniformity constraints, excellent throughput.
- Fabrication completed by Asahi within months of the tsunami in Japan.



**The C1 corrector lens is the same size
as the Yerkes Refractor primary!**



Many Blanco upgrades beyond top ring

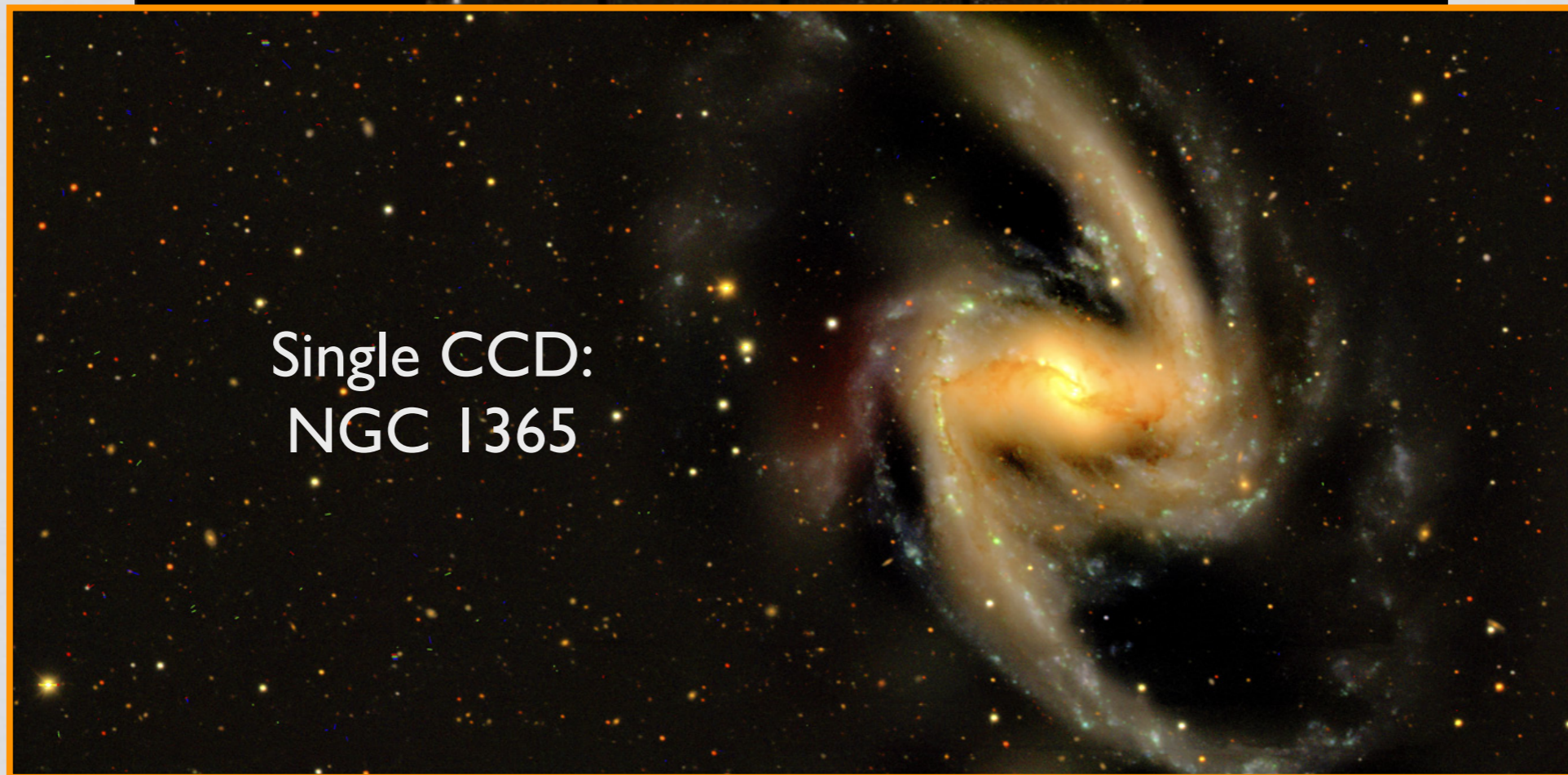
- * Primary mirror radial supports replaced
- * New telescope control software
- * **All-sky thermal-IR cloud monitor (*RASICAM* - on YouTube)**
- * ***DEC*al narrowband dome illumination system**
- * Database for Blanco engineering and environmental telemetry
- * Counterweights added to Cass cage (**8000 kg total mass gain!**)
- * Clean room in Blanco building
- * New dome encoder system (Dec. 2013)
- * New chillers (2012) and **daytime dome air cooling (2014)**
- * New primary mirror air support pressure sensors (2014)

First light 12 Sep 2012



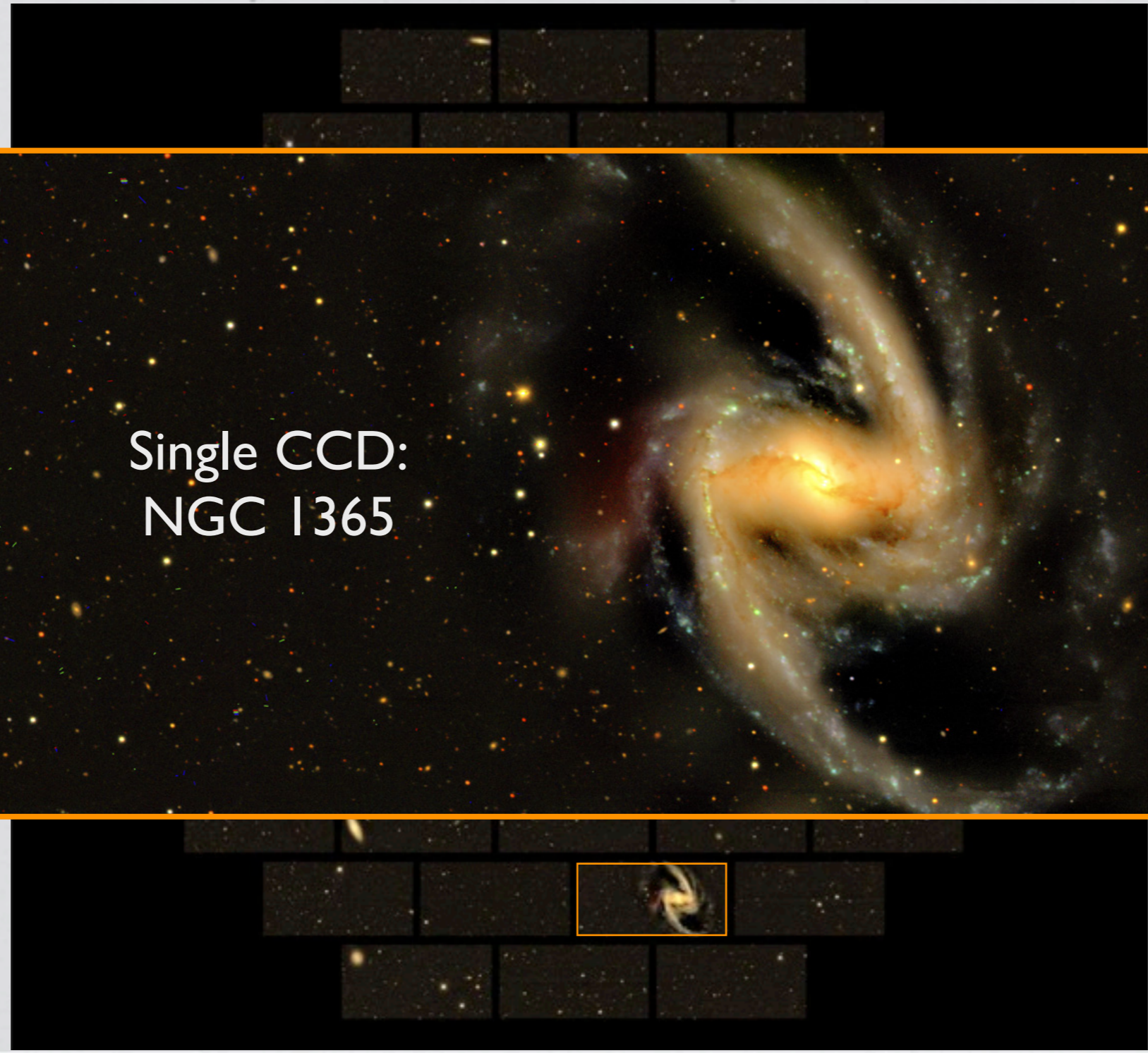
Fornax
cluster

First light 12 Sep 2012



Single CCD:
NGC 1365

Fornax
cluster



DECam by the end of 2013

- * Science Verification phase complete:
 - * Signal & noise levels within a few percent of forecasts
 - * Clean cosmetics, except one CCD lost in Nov 2012 and one in Nov 2013. Low fringing, very uniform QE as expected.
 - * Several performance issues resolved.
 - * Automatic focus and collimation loops in place (see Roodman talk)
- * 77,000 on-sky exposures taken since first light
- * Approx. 35 DECam 2013A/B observing programs from CTIO TACs
- * Downtime for rework of LN₂ system
- * 97% availability for DECam for Sep-Dec 2013.

DECam by the end of 2013

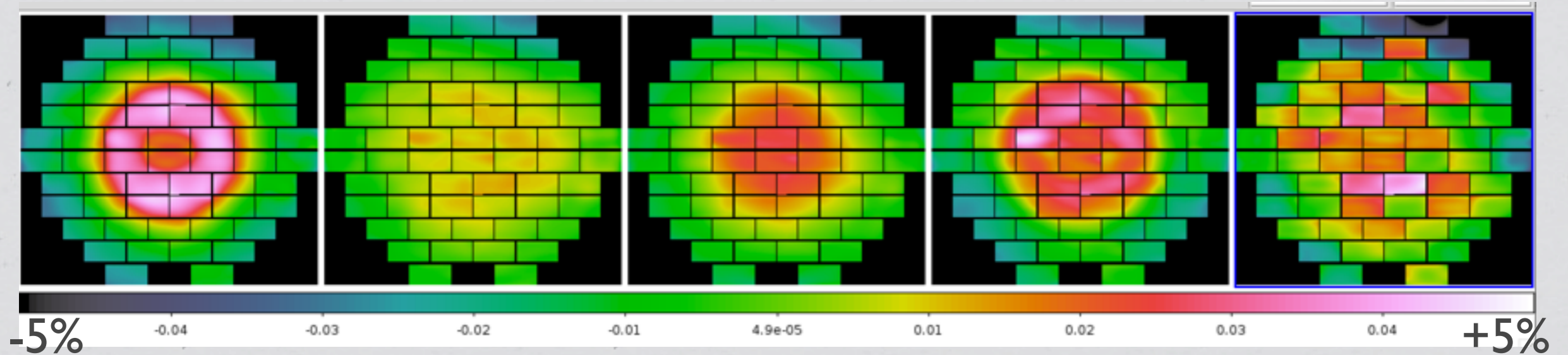
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DECam realizes the full light-collecting capability of the Blanco and is the most powerful imager available to US astronomers!

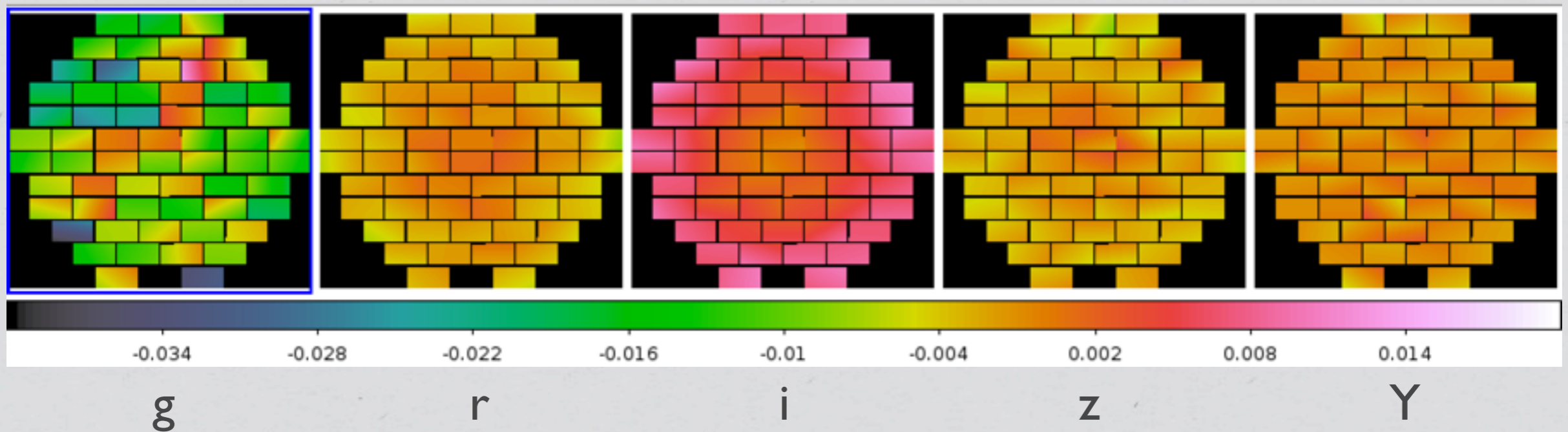
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Relative photometry across array achieved at < 2 mmag

These corrections to dome flats

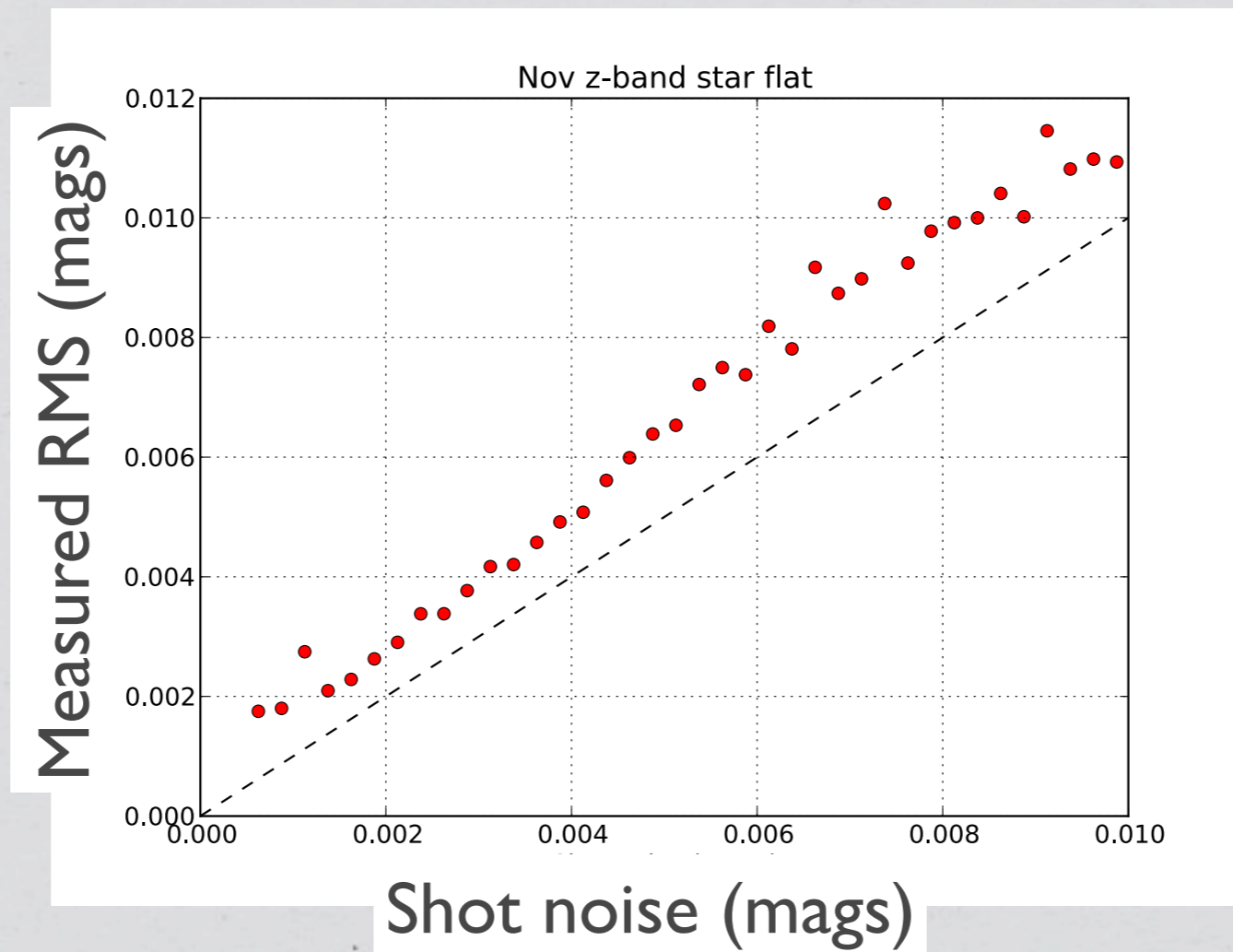


and these color terms



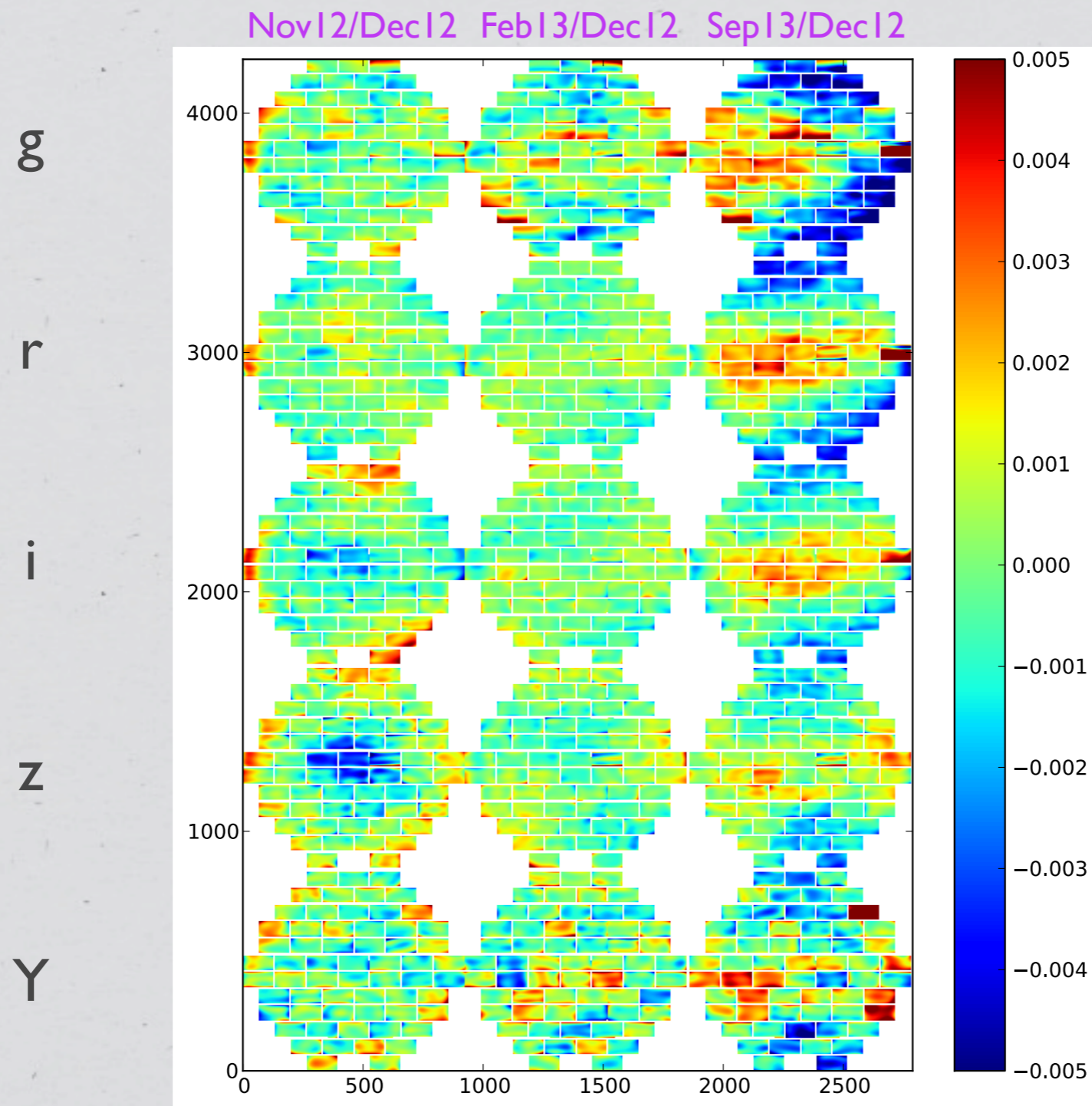
Relative photometry across array achieved at < 2 mmag

...Yield relative photometric variation within 2 mmag of shot noise



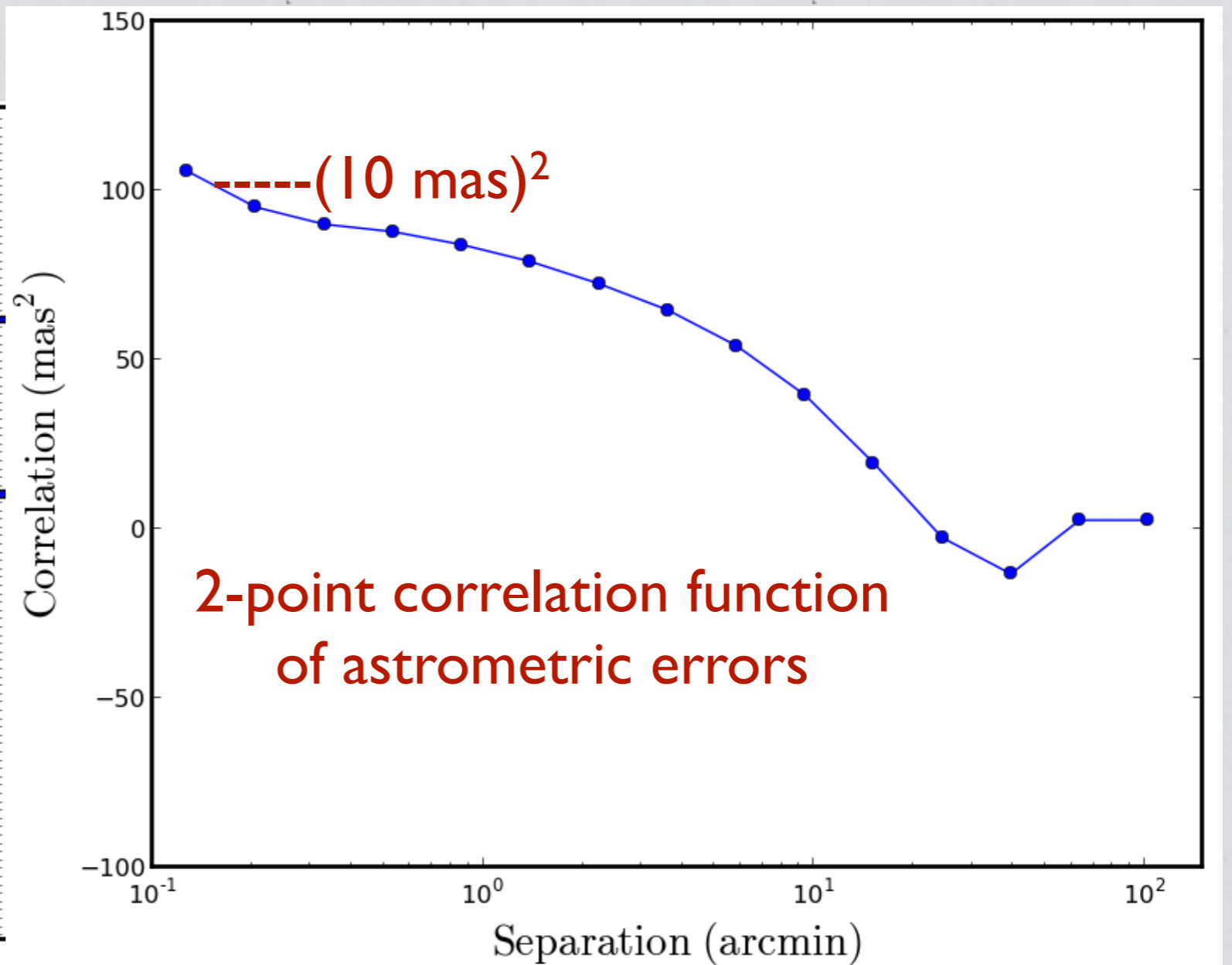
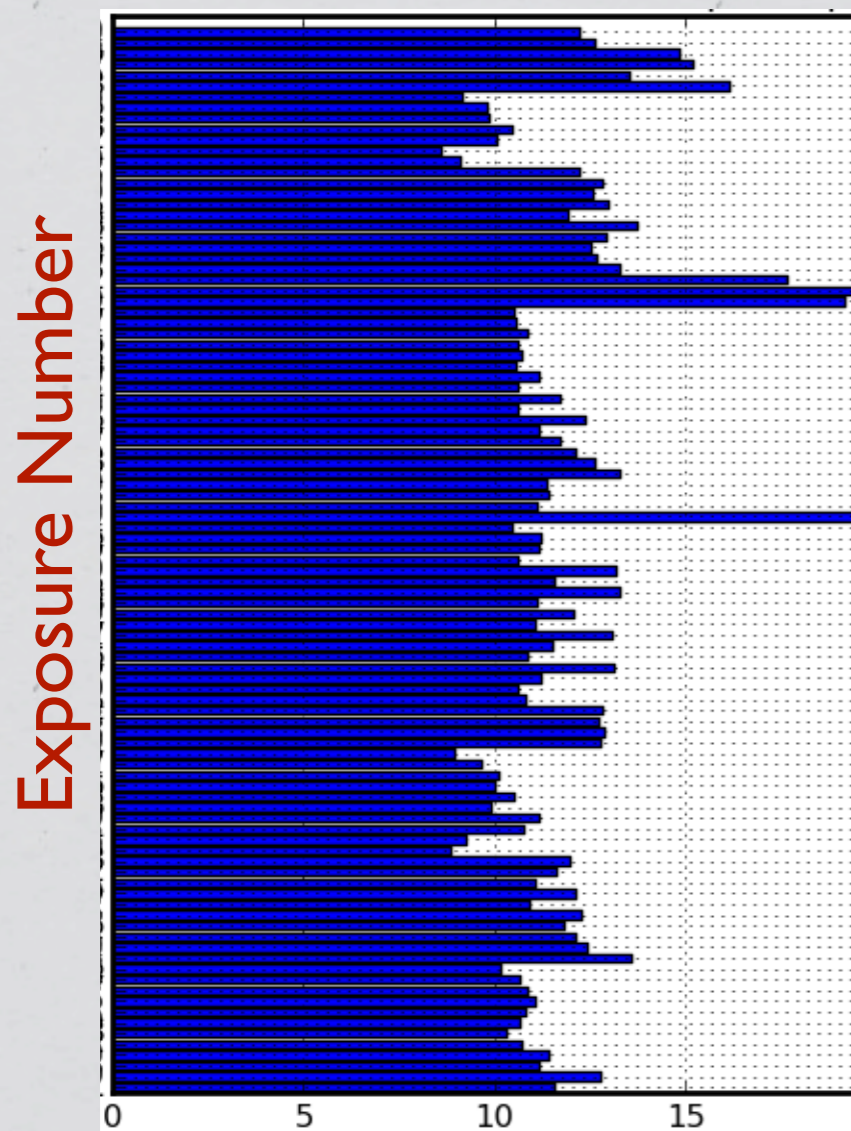
(5x better than DES photometry goal)

Stellar response changes few mmag over months



Dome x Star Flat
relative to Dec
2012

Astrometric solutions are stable and accurate to 10 mas RMS in 50s exposures

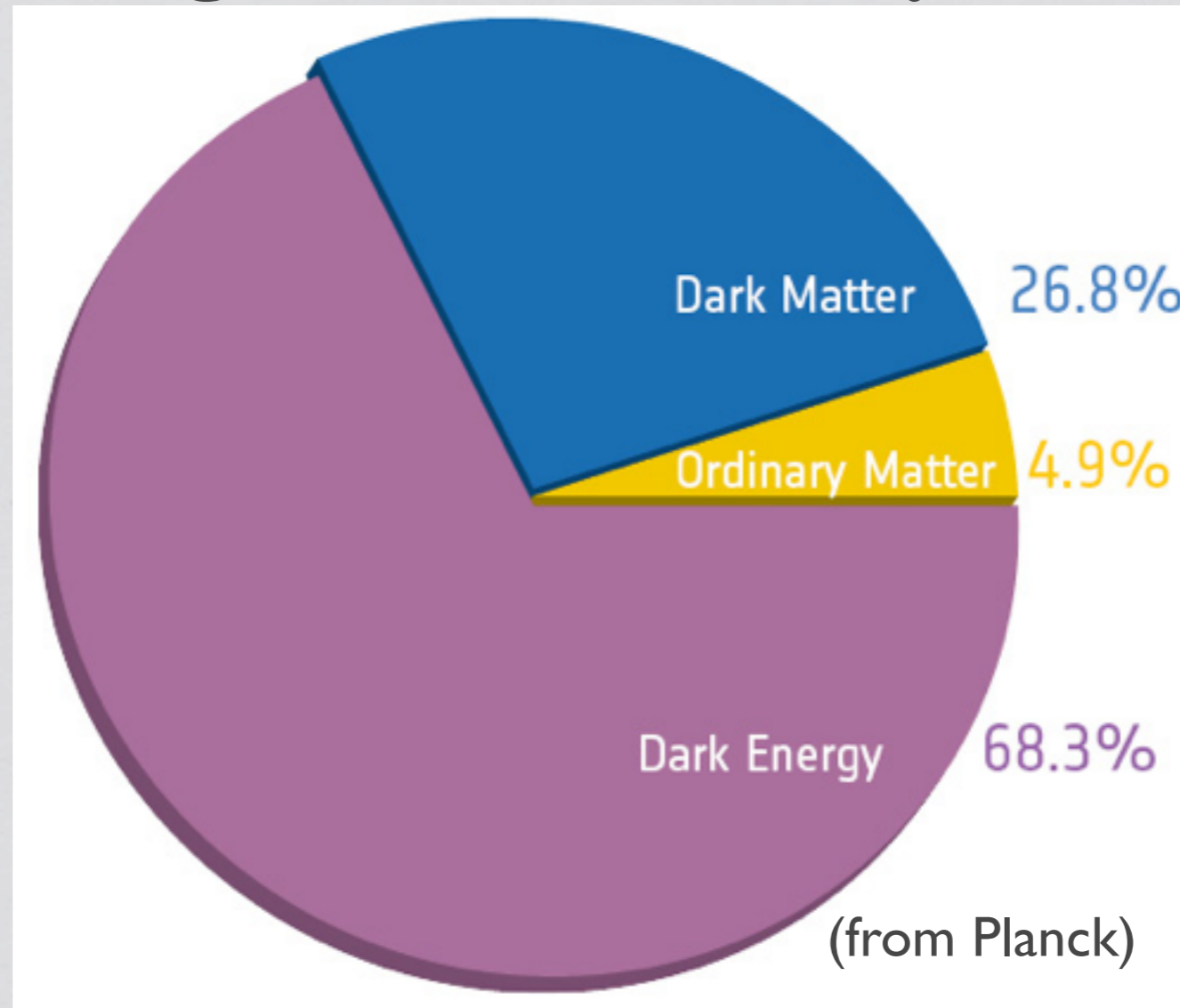


RMS astrometric disagreement (mas) (better than DES astrometry goal)

The Dark Energy Survey

- * Dark Energy Camera & Blanco facility upgrades
- * Observations: 525 nights spread over 5 Sep-Feb seasons beginning 31 Aug 2013
- * DES Data Management (NCSA):
 - * Image detrending, calibration, stacking
 - * Cataloging
 - * Image and object databases
 - * Differencing for SN survey

DES: Moving from Discovery to Physics



- * What is the physical cause of cosmic acceleration?
 - * “Dark energy” or modification to General Relativity?
 - * If it’s dark energy, is it the cosmological constant or something else?
 - * What is the dark energy equation of state w and how does it evolve?

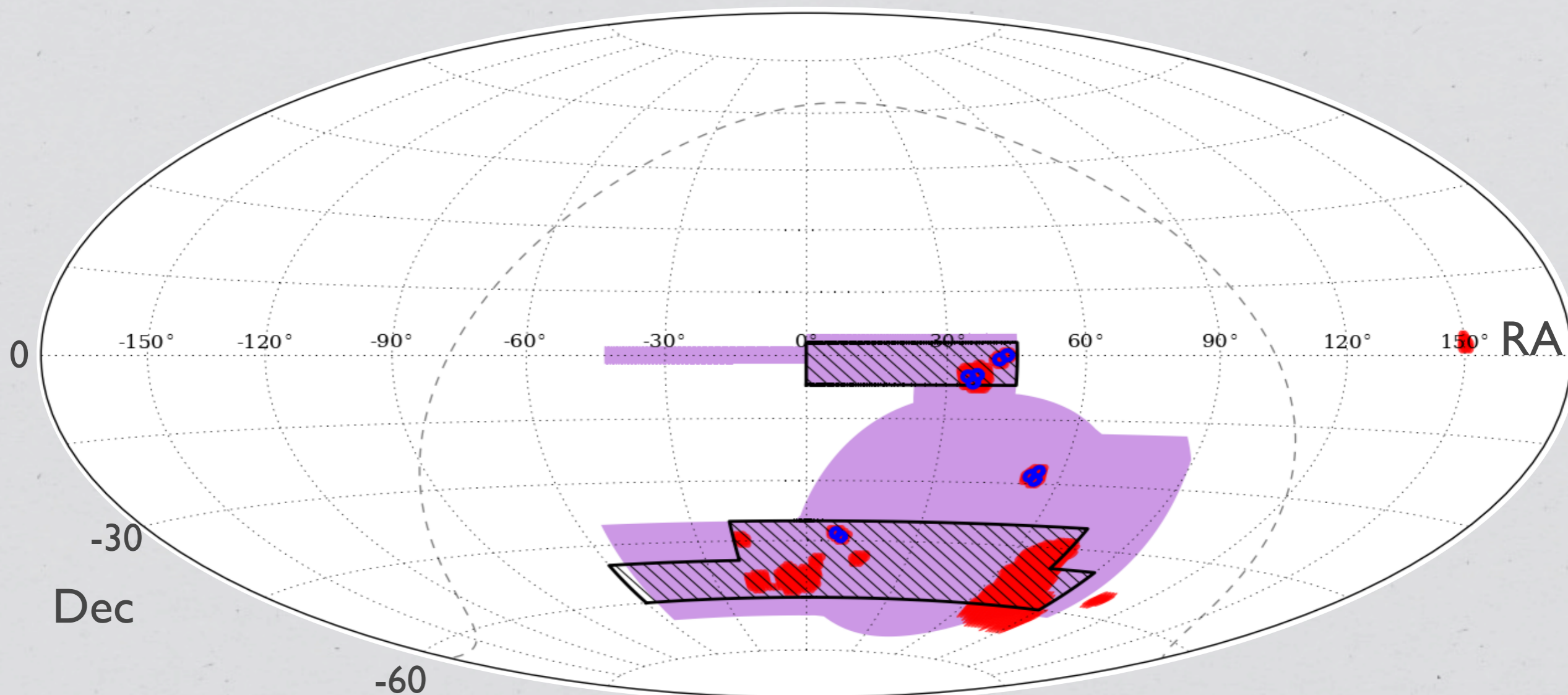
DES emphasizes 4 measurements of cosmic expansion and growth:

1. High-redshift Type Ia supernovae: ≈ 4000 well-sampled Ia light curves plus host galaxy redshifts for most from *OzDES* spectroscopy.
2. Weak gravitational lensing of background galaxies: $\approx 200\text{M}$ galaxies with measured shapes and photometric redshifts
3. Galaxy cluster counts $\approx 30,000$ optically detected clusters plus SZ data from overlap with *SPT* and future *ACTPol* surveys
4. Large-scale structure of galaxies

The DES surveys

	Area (deg ²)	Exposure time (s) (per visit for SNe) Specified median PSF FWHM (arcsec)					Dithering	Cadence
		g	r	i	z	Y		
Wide	5000	10x90 -	10x90 0.9"	10x90 0.9"	10x90 0.9"	10x45 -	10 fully interlaced tilings	10 tilings over 5 years
SN Shallow	24	1x175 -	1x150 -	1x200 -	2x200 -	-	Minimal dithers	Seeing >1.1" or 7 days since last observed
SN Deep	6	3x200 -	3x400 -	5x360 -	10x330 -			

DES footprint



5-yr footprint

SN fields

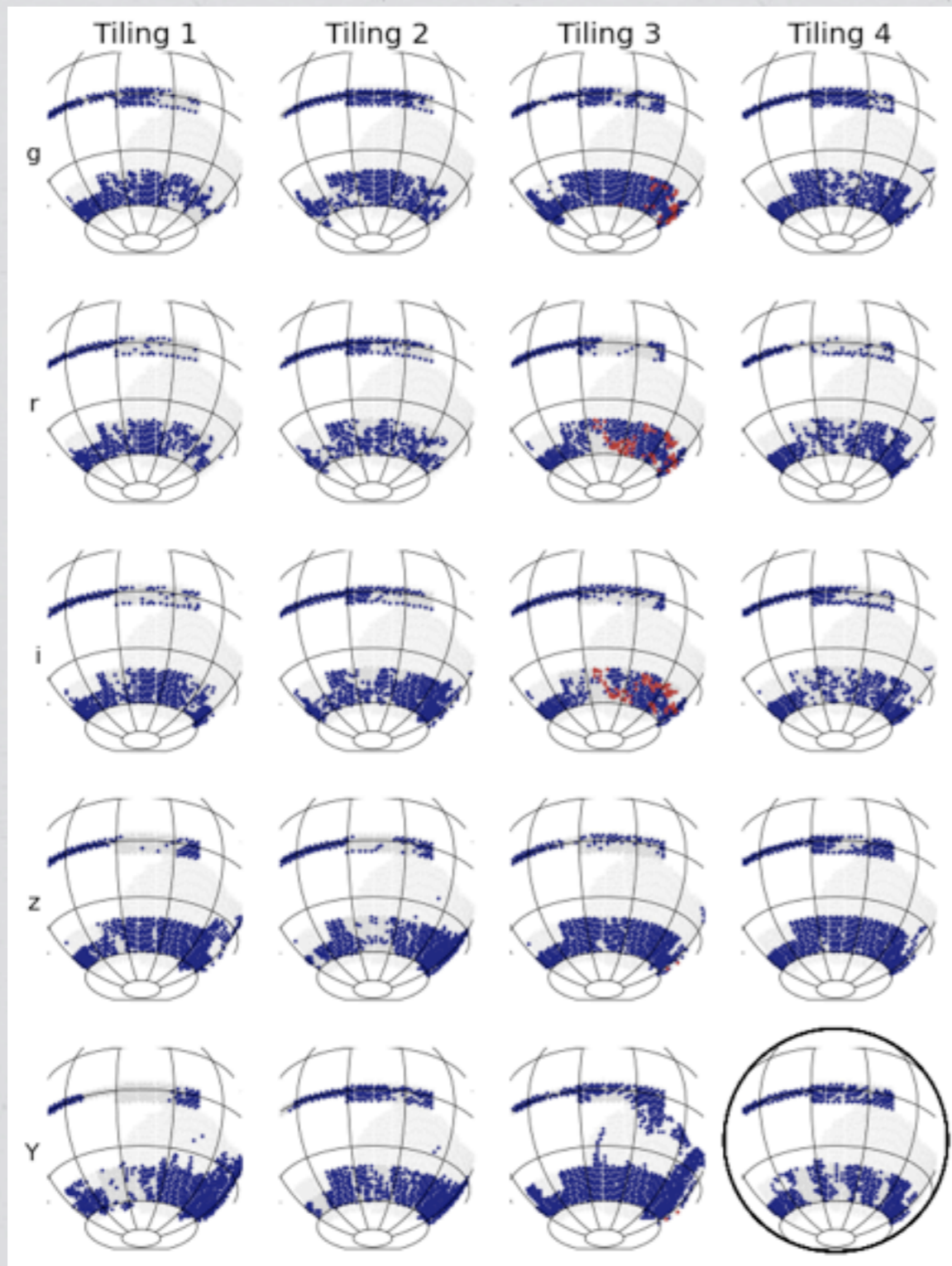
Science Verification

Year I

Affiliated Surveys

- * **OzDES** spectroscopic survey with AAT 2dF (see D'Andrea poster on Tuesday)
- * **South Pole Telescope** temperature & polarization surveys
- * **VISTA Hemisphere Survey** (near-IR)
- * **eBOSS** spectroscopic survey (MOU in preparation)
- * Overlap with or available observations of many canonical fields: COSMOS, CFHLS, VVDS, Stripe 82 / BOSS, ACT, ...

Year-1 observations through 30 Dec 2013

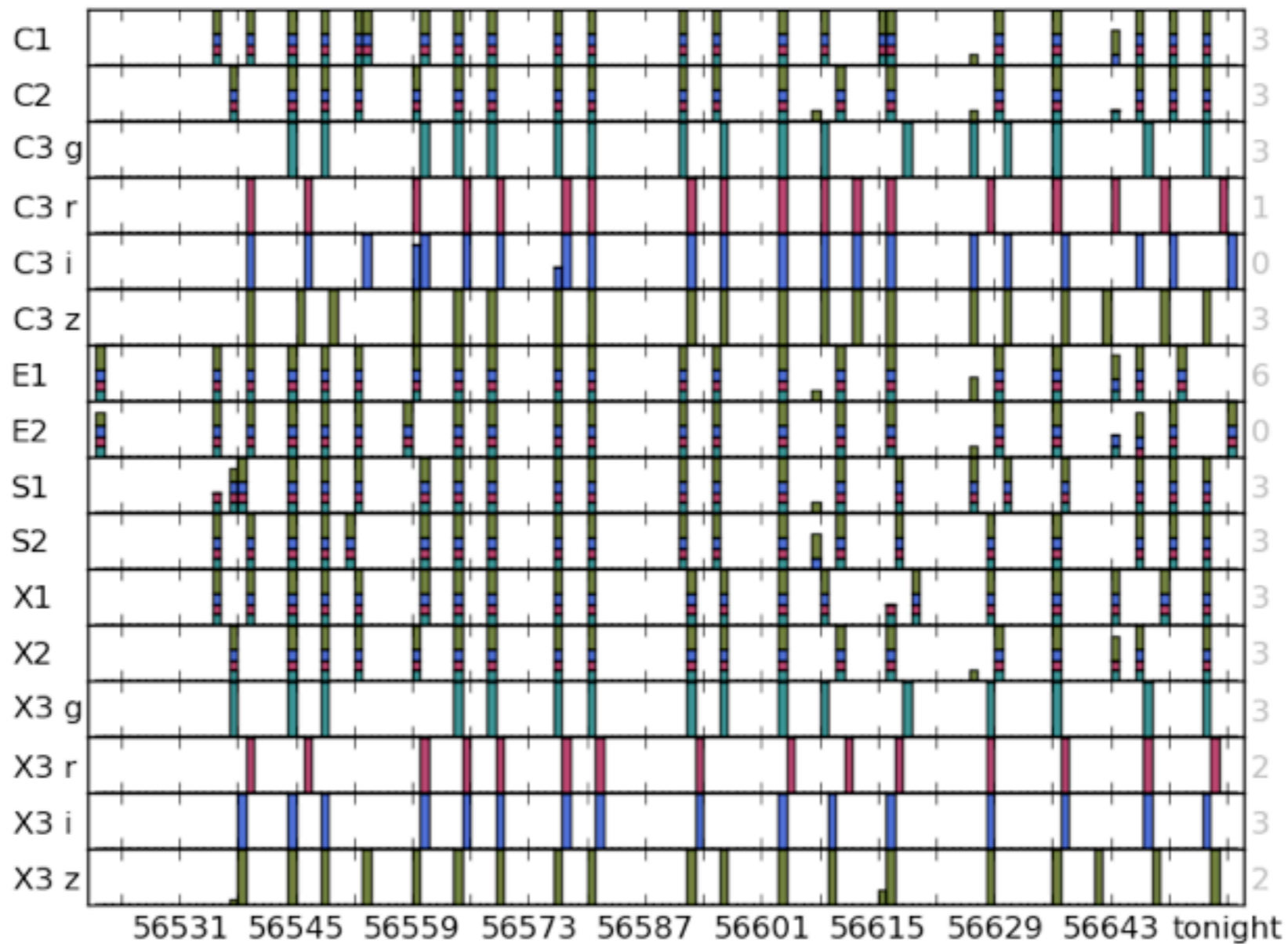


Year-1 Wide Survey targets two zones of full footprint:

- * Equatorial strip (Stripe82, BOSS)
- * SPT region

with goal of 4 full tilings per filter over 2000 deg²

Year-1 observations through 30 Dec 2013



Each tick represent one visit to a supernova field.
15-20 epochs in each filter in each field over 90 days.

DECam & DES for the community

- * Highest-end OIR instrument available to the US community.
- * Improved quality as well as quantity of data relative to predecessors: better red performance, auto-focus
- * Reliable, efficient, clean data with instrumental signatures very well calibrated and DECam Community Pipeline available.
- * DES data available to the community:
 - * all Science Verification images are already public
 - * all subsequent raw images available on NOAO archive 1 year after observation
 - * Expect reduced data releases through NCSA in two phases:
1st 2 years' data released in 2017, full survey release in 2020.

More DECam & DES Information

* Talks in this session:

* DECam Image Quality (Aaron Roodman)

* Science Verification results for supernova (Chris D'Andrea), weak lensing (Peter Melchior), galaxy clusters (Eli Rykoff), and large-scale structure (Nacho Sevilla)

* Posters Tuesday in sessions 248, 254

Extra slides

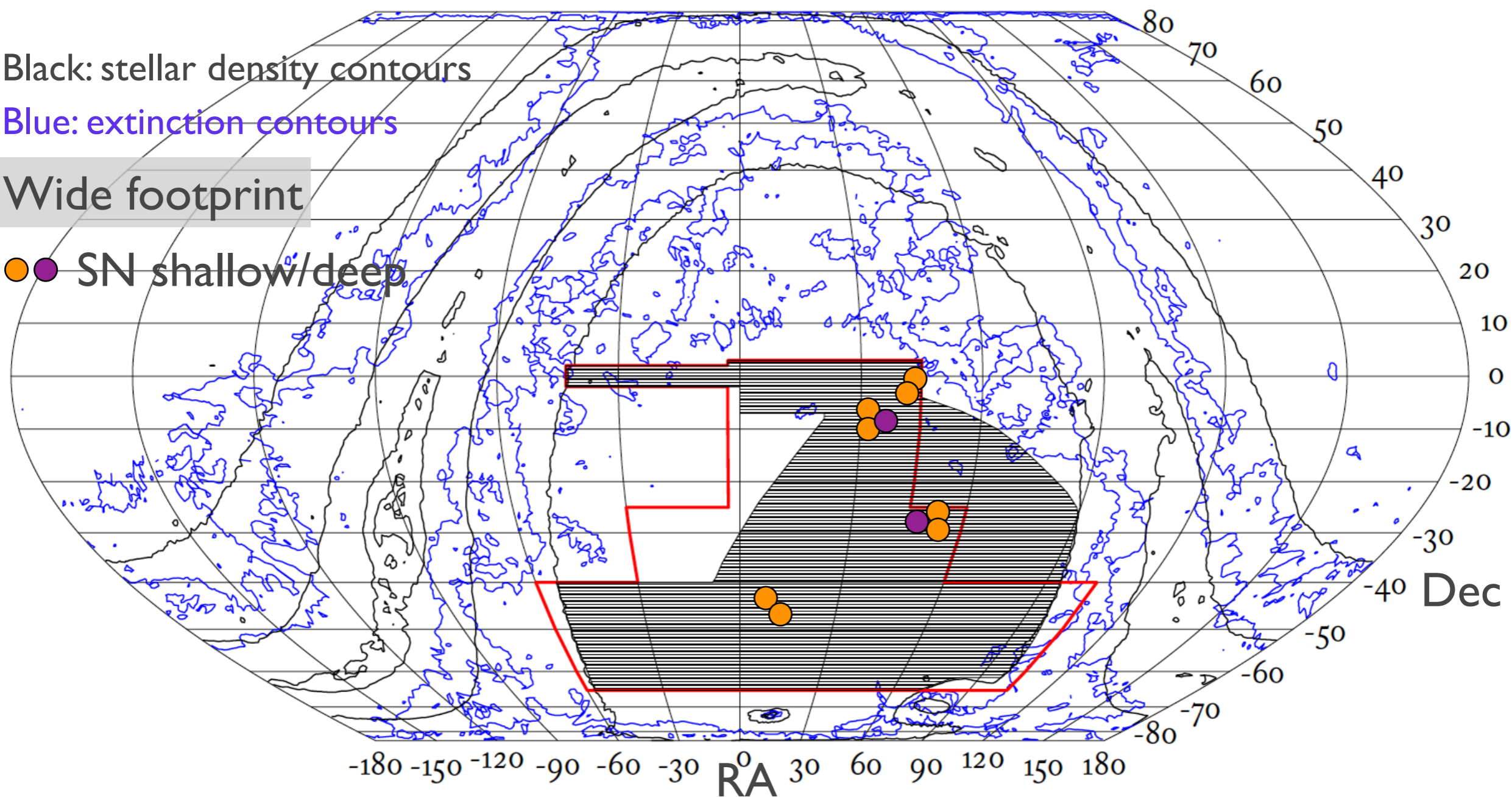
DES footprint

Black: stellar density contours

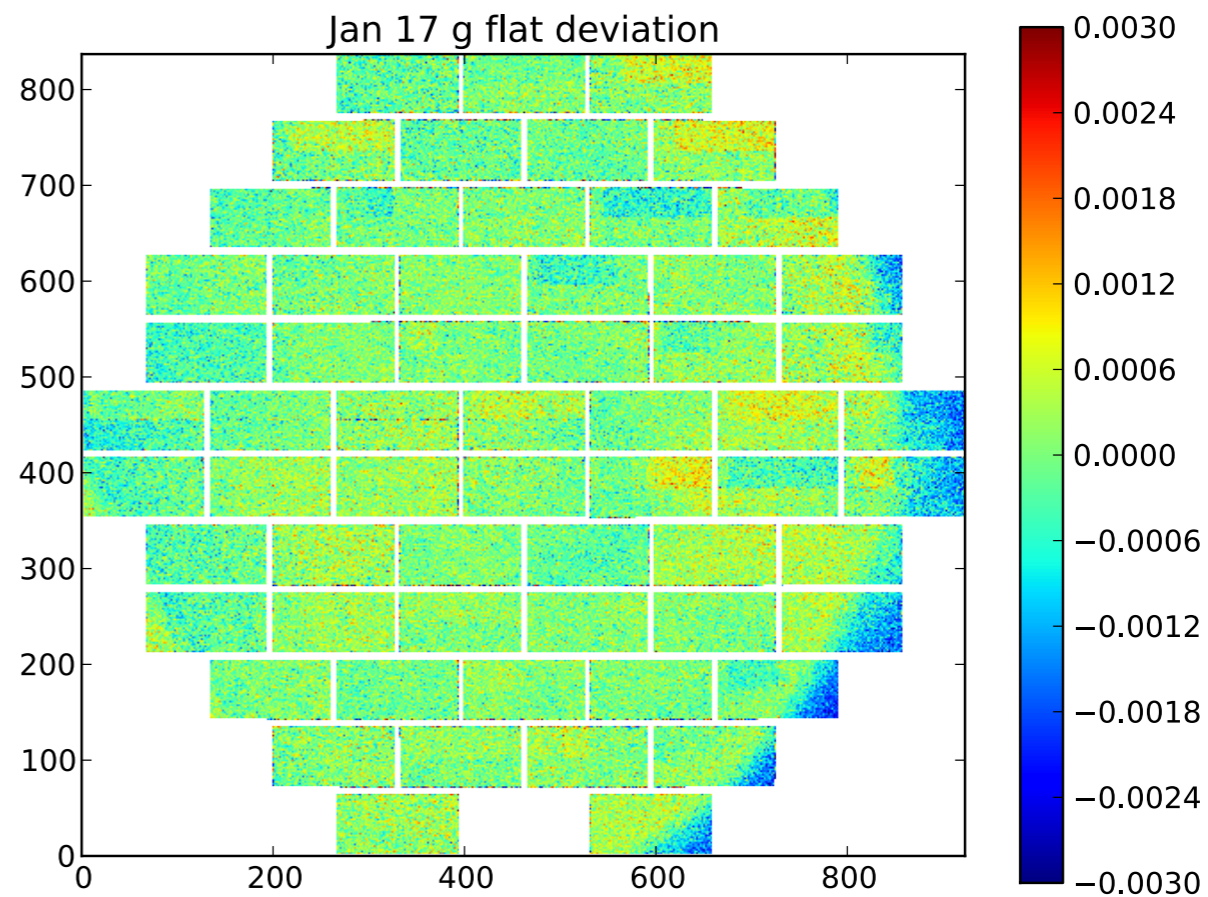
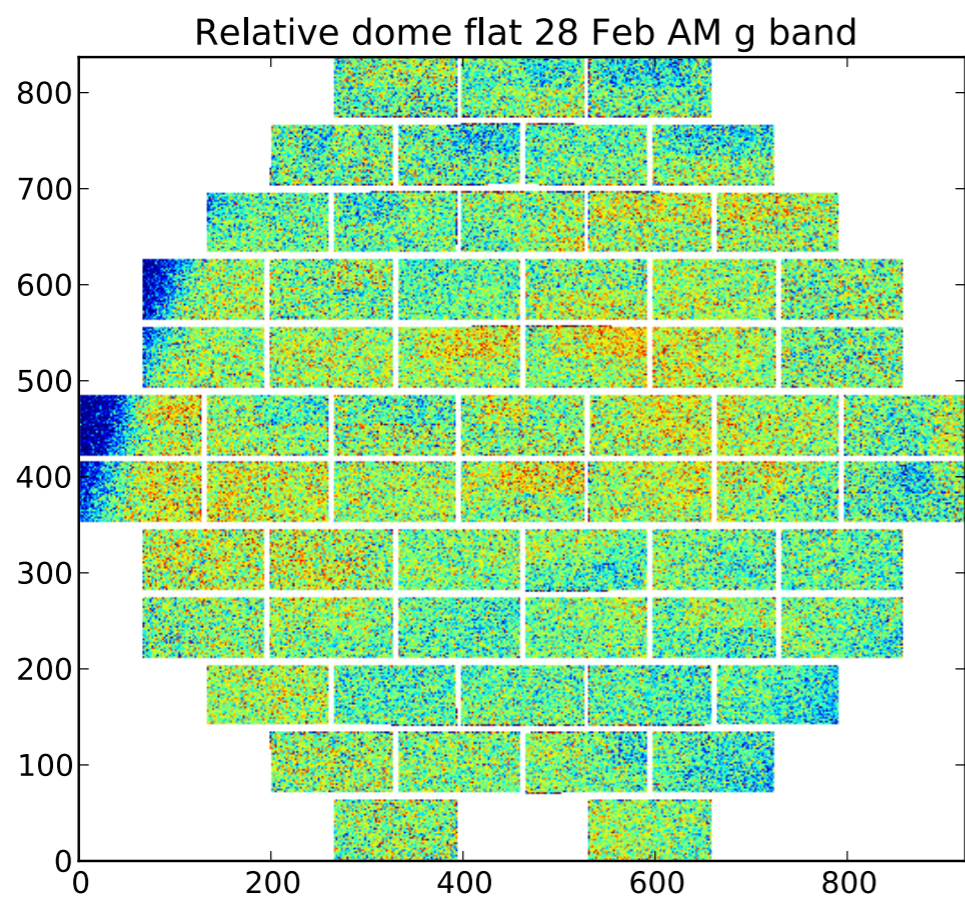
Blue: extinction contours

Wide footprint

● SN shallow/deep



Stability of dome flats



See few-mmag changes over days/weeks/months