



DES SCIENCE VERIFICATION

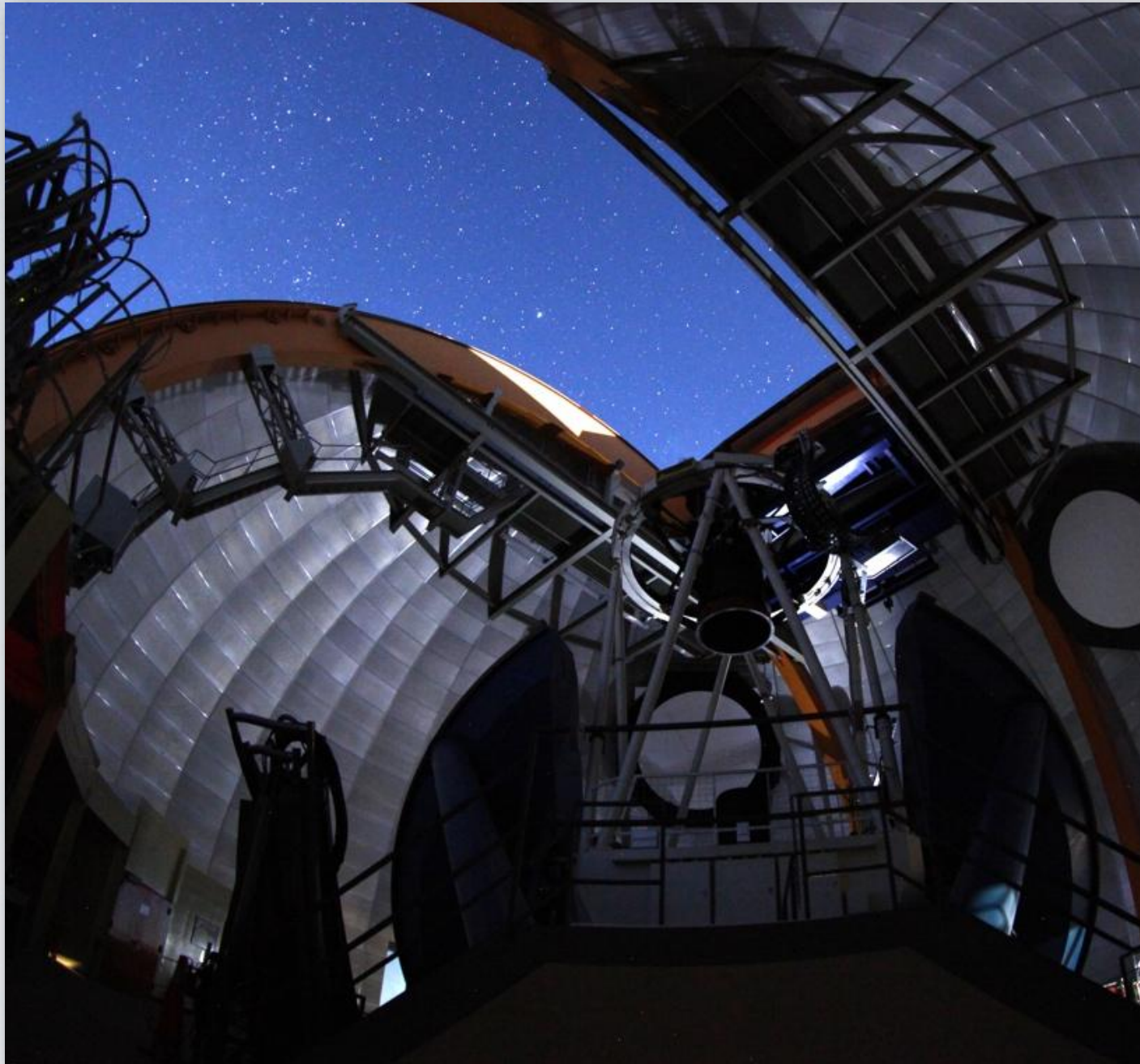
Marcelle Soares-Santos

 Fermilab

DPF 2013 ♦ Santa Cruz ♦ August 16, 2013



TIMELINE



Construction: 2008–2011

Installation: Feb–Aug 2012

Commissioning:
Sep–Oct 2012

**Science Verification:
Nov–Feb 2013**

DES: next 5 years



CHARGE

Required: Determine whether image data is being produced with sufficient quality and efficiency to meet the DES science goals.

Goals: Exercise downstream analyses (DESDM) and determine whether quantities derived from image data are meeting DES requirements.

Team: G. Bernstein (Penn), K. Honscheid (OSU)
Sevilla, Soares-Santos, Martini, Lin, Marriner, Flaugher, Armstrong, Tucker, Annis, Gruen, Patton, Suchyta, Kent, Melchior, Hao, Sako, Vikram, Rykoff, Jeltema, March, Reil, Roodman, Frieman, Petravick, Gruendl, Nord, Paech, Annis, Jarvis, Elliott, Neilsen, Regnault, Diehl, DePoy, Hofman, Gerdes, Szypniewski, Buckley-Geer, Ogando, Nichol, Old, Mccrann, Rooney, Helsby, Fausti, Serrano, Casas, Wester, Davis, Plazas Walker, Kunder, James, Abbott, Warner, Schumacher, Bonati, telescope support staff, and more



GOAL CATEGORIES

Categories: **Signal & Noise**

Signals and noise close to DES design

Flux Calibration

Relative stellar photometry to 2%

Astrometry

Stable solution with <100 mas accuracy

Image Quality

No major degradation by any element

(automatic) focus < 50 μm

Pointing & Guiding

Sufficient to hit DES tilings

Anomalies

Bad pixels, cosmic ray rate as expected

Operations

Demonstrate operational readiness

Supernovae

Templates, Functional image subtraction pipeline



OBSERVING PLAN

Calibration

Bias

Dome Flats

Photometric Standards

Engineering

Hexapod LUT

Focus & Alignment

SN Fields

8 shallow

2 deep

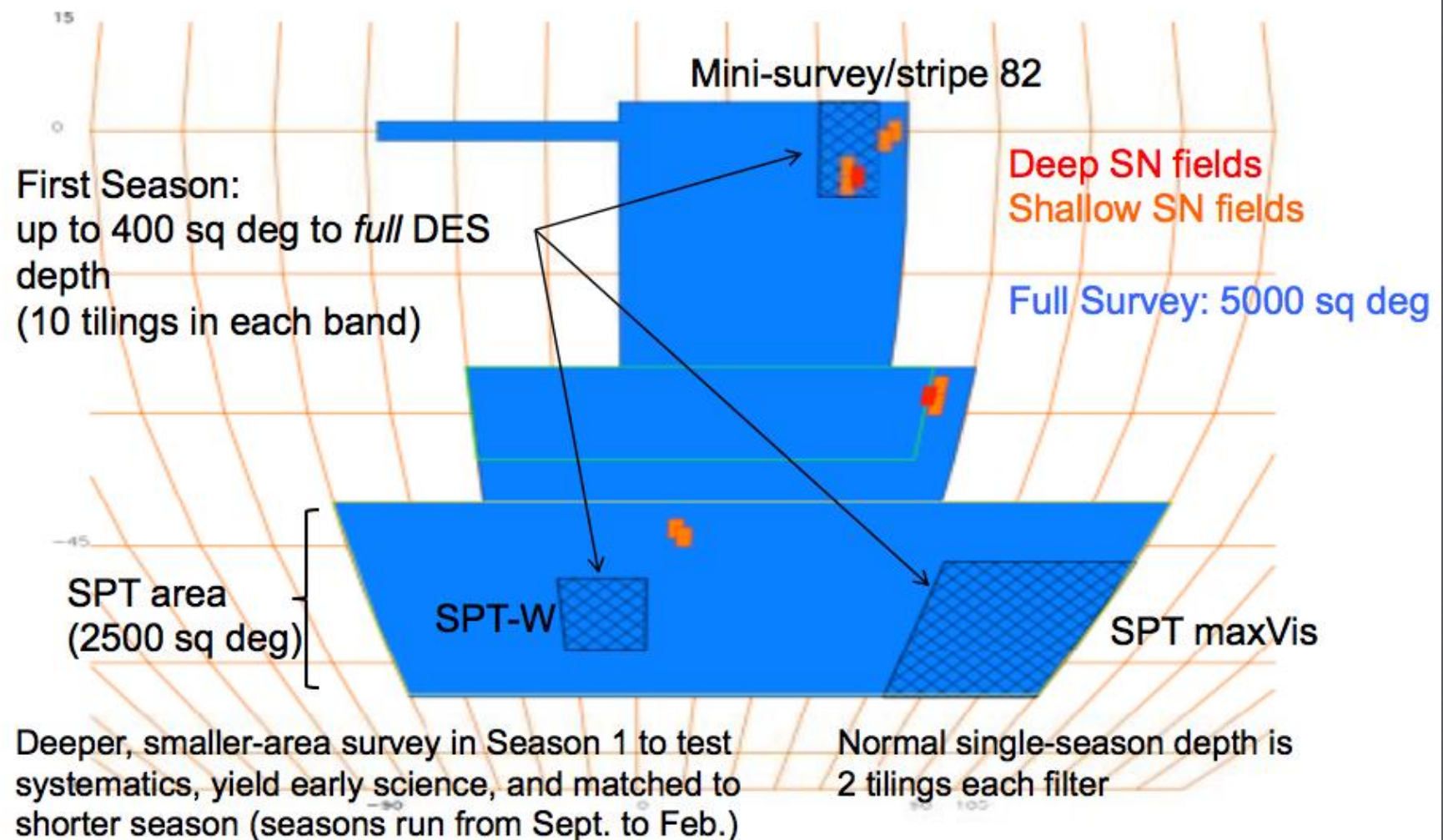
u, Y for photo-z (VVDS)

Mini Surveys (100 deg²)

Stripe 82

SPT-W

SPT-E/maxVis



OBSERVATIONS

Science Verification

November 1 – 24, 2012

Shared with Community SV

10, 366 Exposures

Very good weather

Issues with guiding

Issues with pointing

Issues with tracking (especially north)

3 rich galaxy clusters to survey depth

Extended SV

December 2 – February 23, 2013

Shared with Community Program

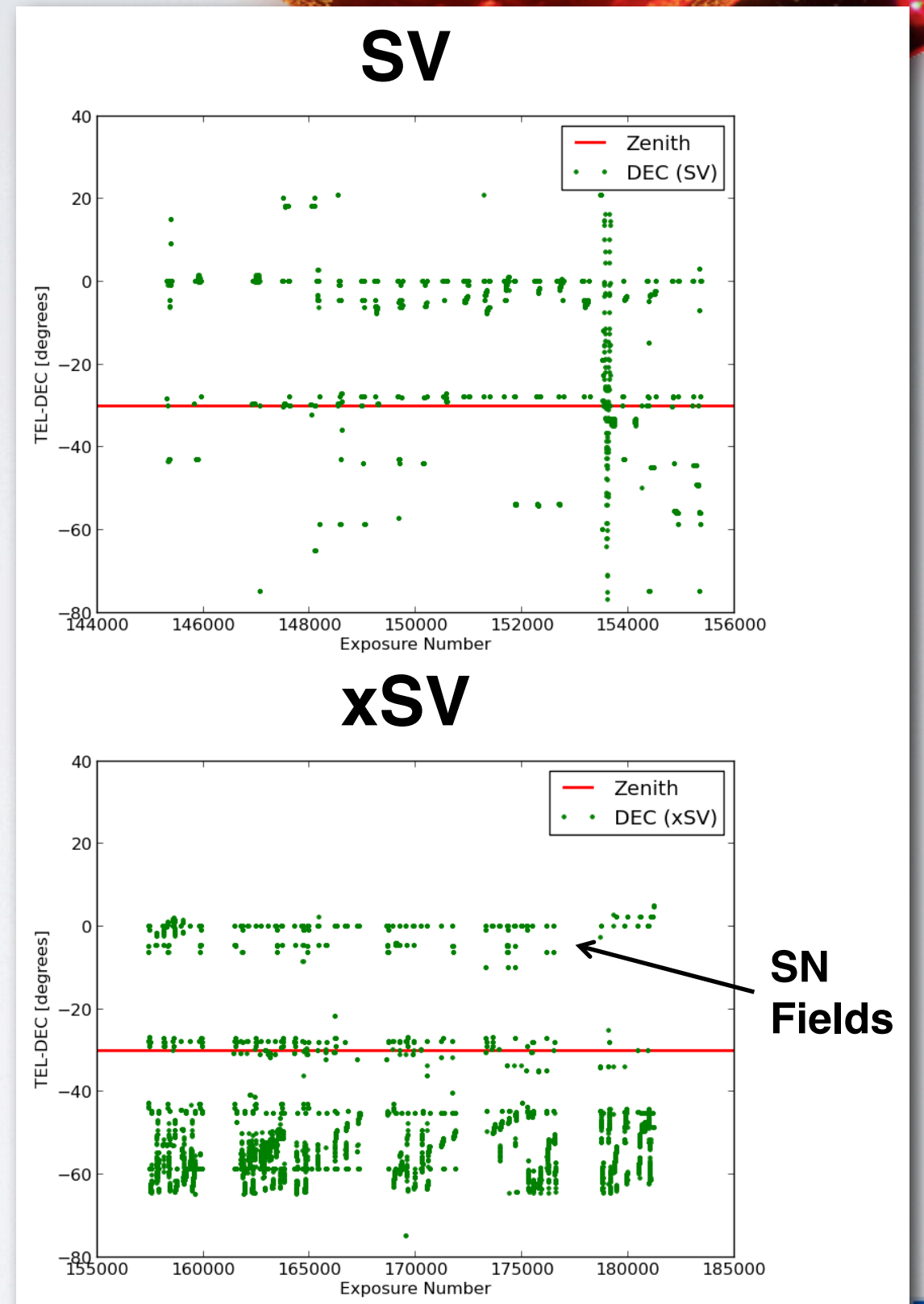
23,900 Exposures

Decent weather

Abandoned Mini Survey in North

SPT-W, SPT-E (~150 sqdeg, survey depth)

Continued SN Survey



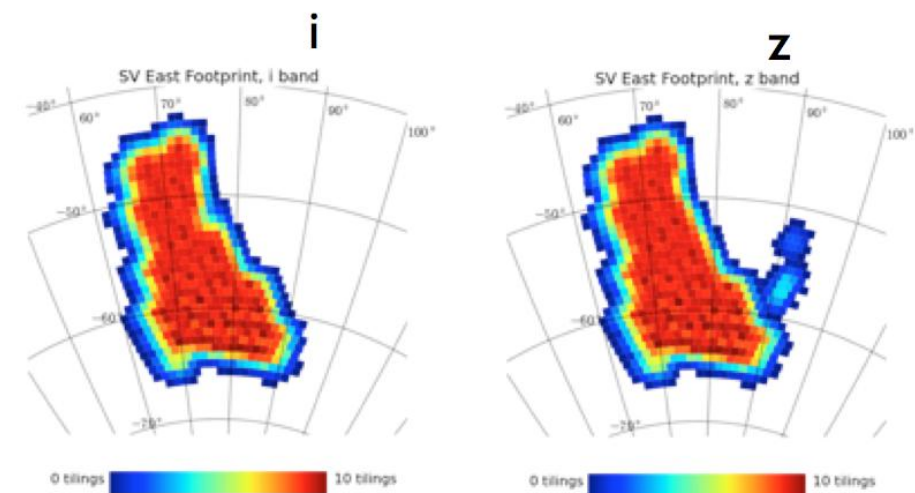
OVERVIEW

SV Accomplishments

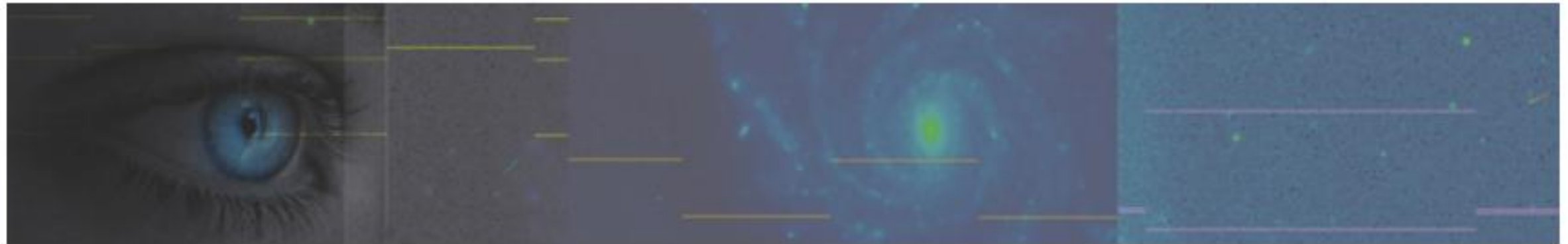
- Data flowing to NCSA
- First Cut Processing
- Verified proper signal and noise levels
- Astrometric solution with 20 mas RMS
- Fixed faulty primary mirror support
- OBSTAC runs properly
- SISPI (DAQ) works, improved
- AOS control of focus and collimation
- Look Up tables for pointing
- Cross talk measured, saturation detected
- Documentation
- Quick Reduce works, enhanced
- SN fields selected, templates
- SN pipeline works
- Photometric calibration regimen in place
- Repeatability to 0.02 mag verified
- Color terms as expected (except Y)
- Mirror cooling recommissioned
- RASICAM working
- Fringing measured, stable and small
- Detector non-linearities identified
- RA damper motor recommissioned
- Vastly improved tracking
- Ghost & scattering sources identified
- Photo-z calibration fields imaged
- BCAMS operating
- ... and more ...

SV Data Products

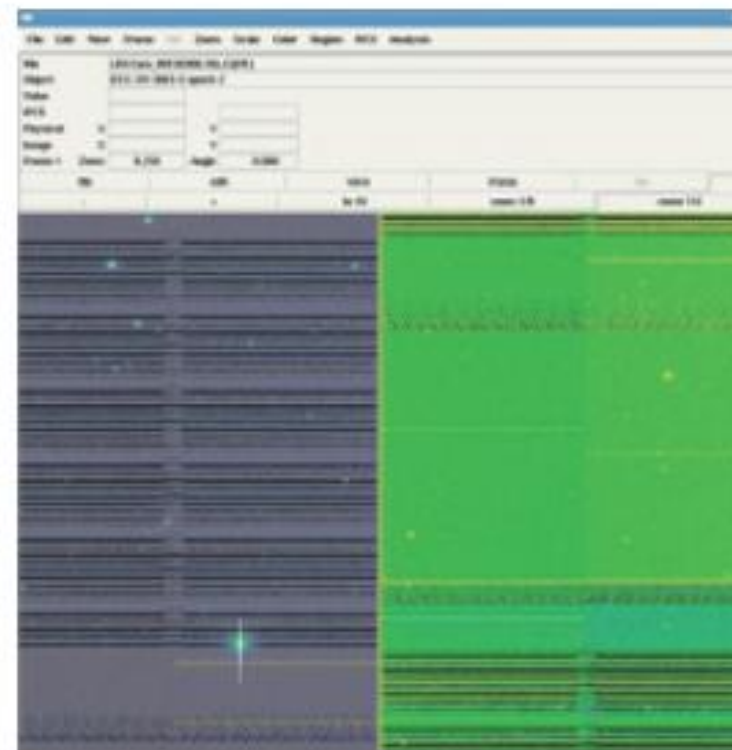
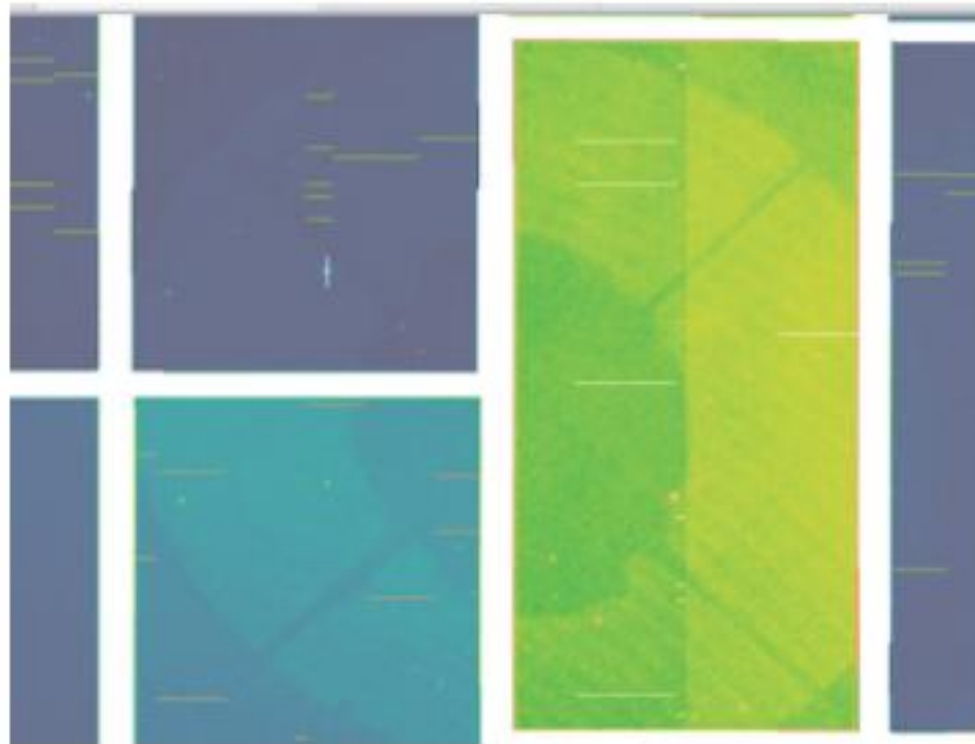
- **5 cluster fields** observed Nov/Dec
Good seeing
Bright moon
- **COSMOS field** (shared with community)
Depth well beyond DES needs
- >1000 exposures of **standard star fields**
- 8 shallow and 2 deep **SN fields**
- **SPT-W field** (~60 deg²)
- **SPE-E field** observed in Jan- Mar
Seeing <1.3", ~150 deg², 10 tilings
Homogeneous depth
Nominal moon for each filter



EYEBALL SQUAD



The EyeBall Squad visually inspected ~3000 frames from Science Verification - checking image quality and searching for evidence of electronic, optical or tracking issues.



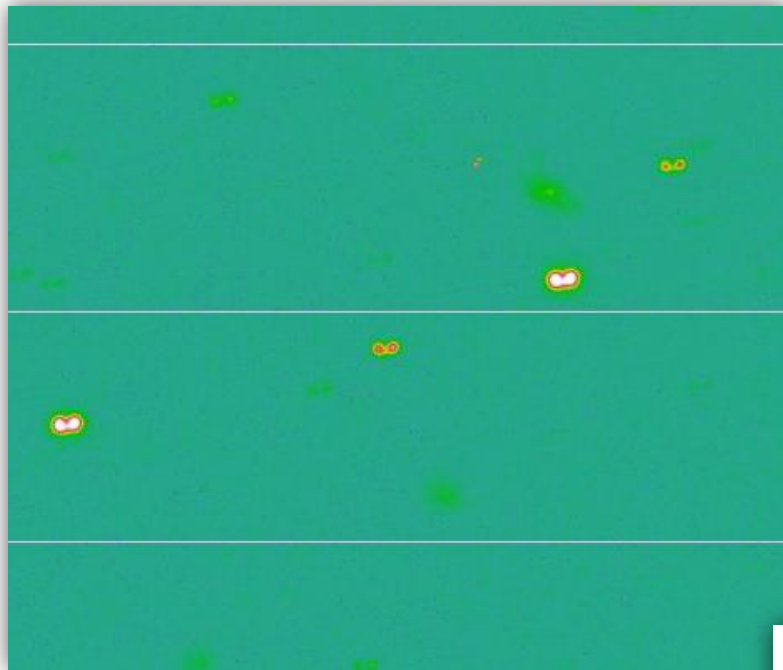
With thanks to:

Leon Baruah
Emma Beynon
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Mark Carter
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Chris D'Andrea
James Etherington
Daniel Gruen
John Katsaros
Rebecca Kennedy
Lyndsay Old
Andreas Papadopoulos
Andrés Plazas Malagón
Rhys Poulton
Tom Rigby
Kathy Romer
Philip Rooney
Harry Wilcox
Rob Williams

M. March (Sussex)

GUIDER JUMPS

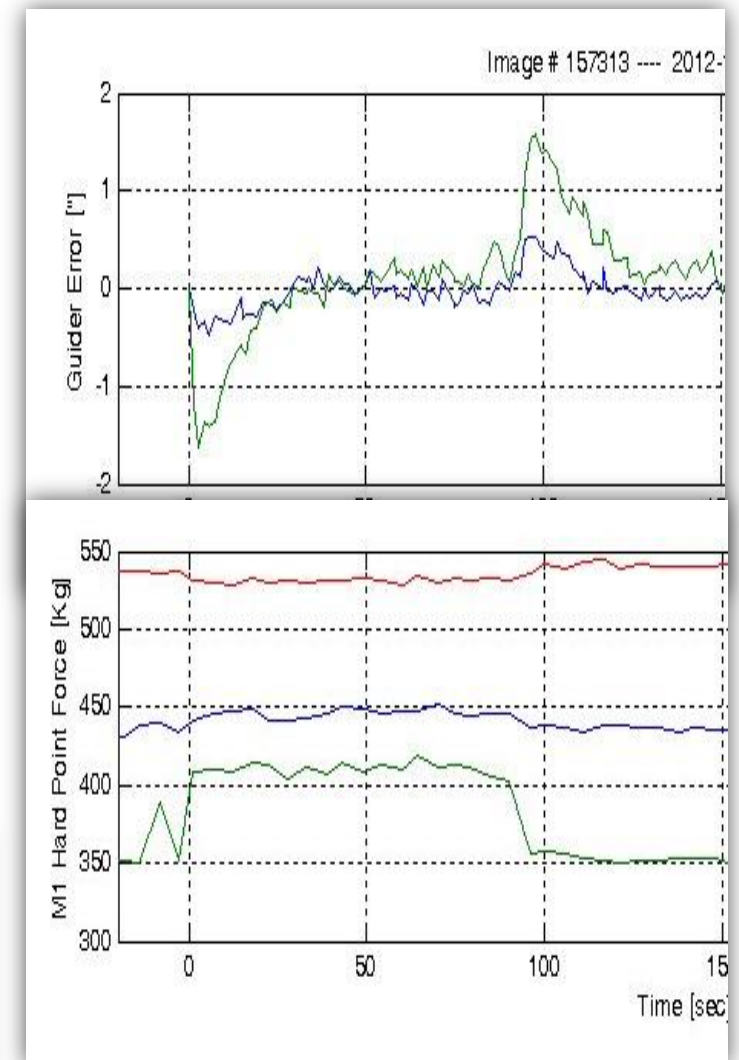
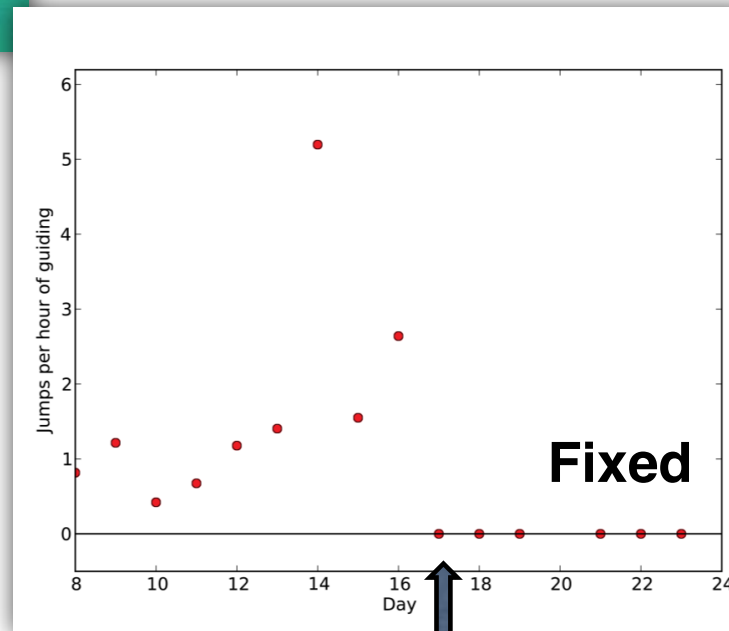
Nov - Dec 2012: Double Images



Observers, Eyeball Squad

Diagnosis:
**Unusual force on mirror
hardpoint when guider
corrections jump
(TCS Database)**

Solution:
**Replace broken controller
for mirror support
(Mamac)**



M. Warner, CTIO

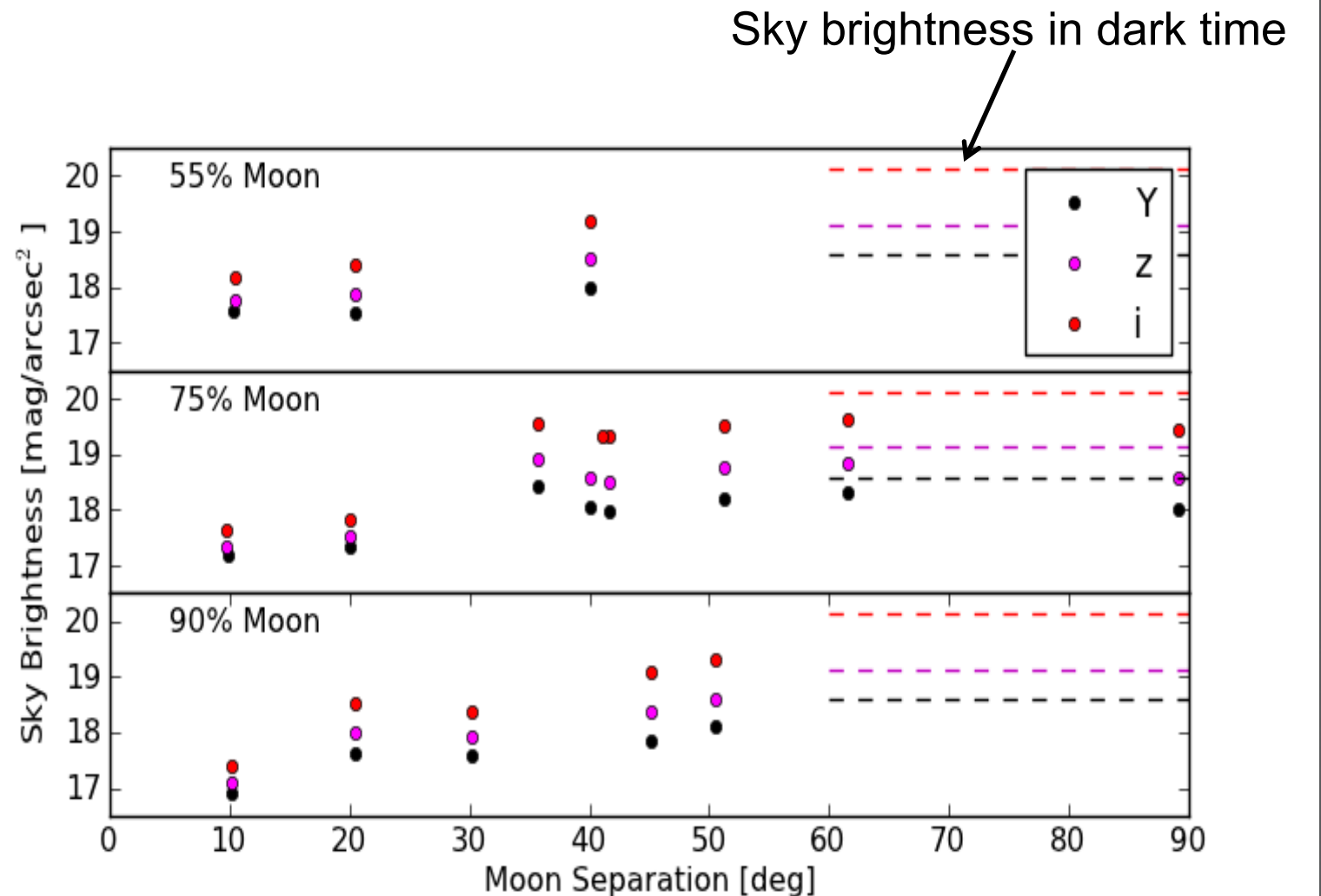
SIGNAL TO NOISE

Sig-R1 **Read noise <15 e-/pixel**

Sig-R2 **grizY zeropoints within 0.05 mag of expectation**

Sig-R3 **Sky brightness within 0.1 mag of expectations**

Sig-R4 **OBSTAC to use observed sky brightness**



P. Martini

Sky noticeably brighter within 45° of the moon (as expected)



ASTROMETRY

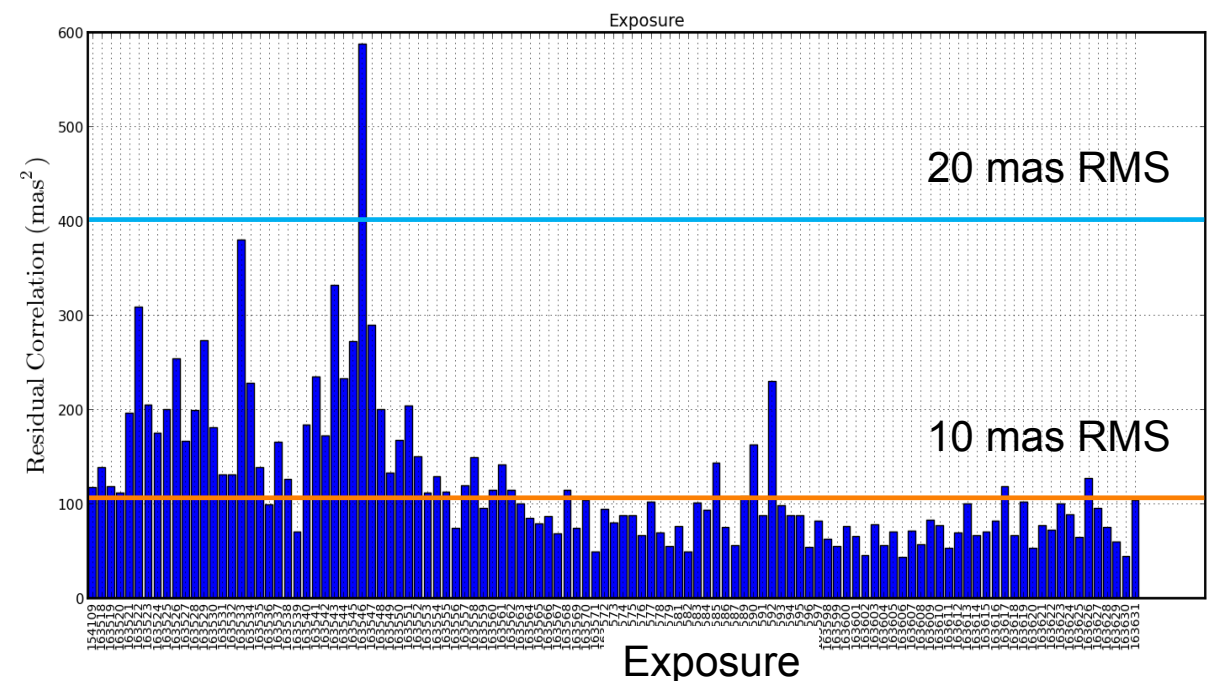
Ast-R1 WCS in raw image files
better than 1" for all CCDs
(Pointing accuracy, Calculations done)
Pointing Model
Survey procedures

Ast-R2 Large dither observations
repeatable to <100 mas median
absolute

Ast-R3, Cal-G2 No systematic
anomalies above ~~50~~ 20 mas (e.g. glowing
edges are the expected size, stable
CCD position etc)

Cal-G1 Bright star relative sky position
reproducible with < 25 mas median
absolute error

Procedure: ~20x50s dithered exposures
Generate instrumental astrometric solution in each filter
Add quadratic sky distortion
Evaluate errors using
distinct bright stars



~100 exposures, value of astrometric correlation
function at separation of 1 arcmin
(R. Armstrong)

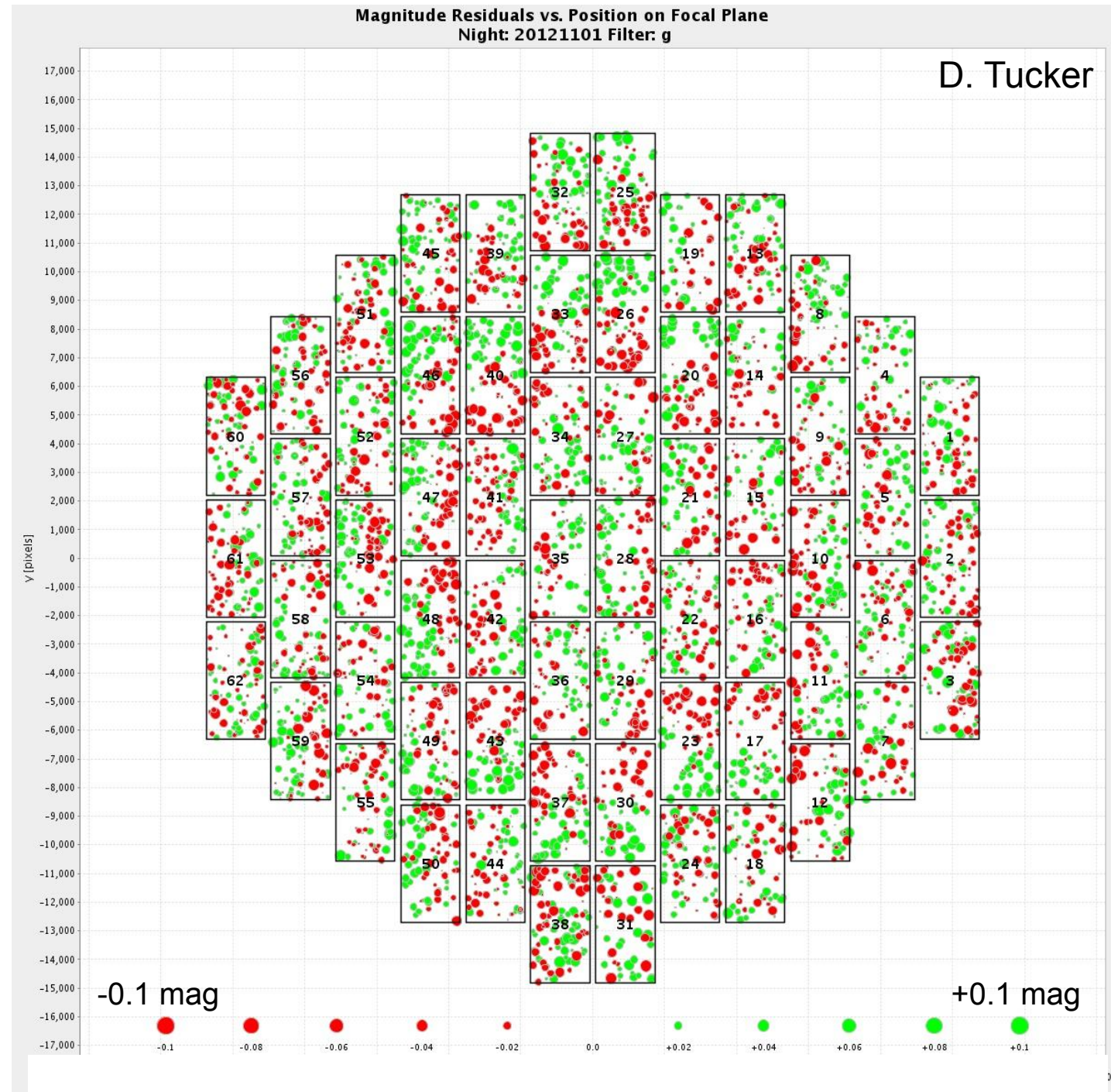
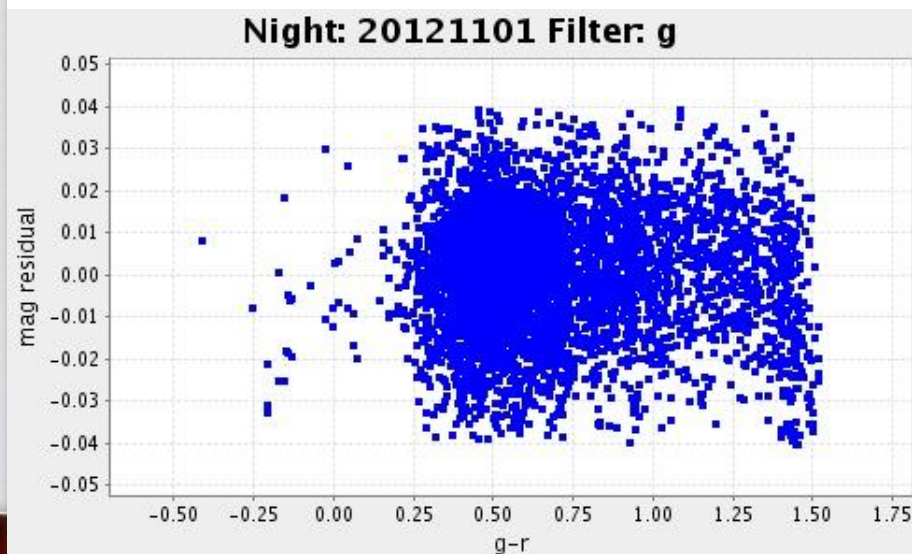
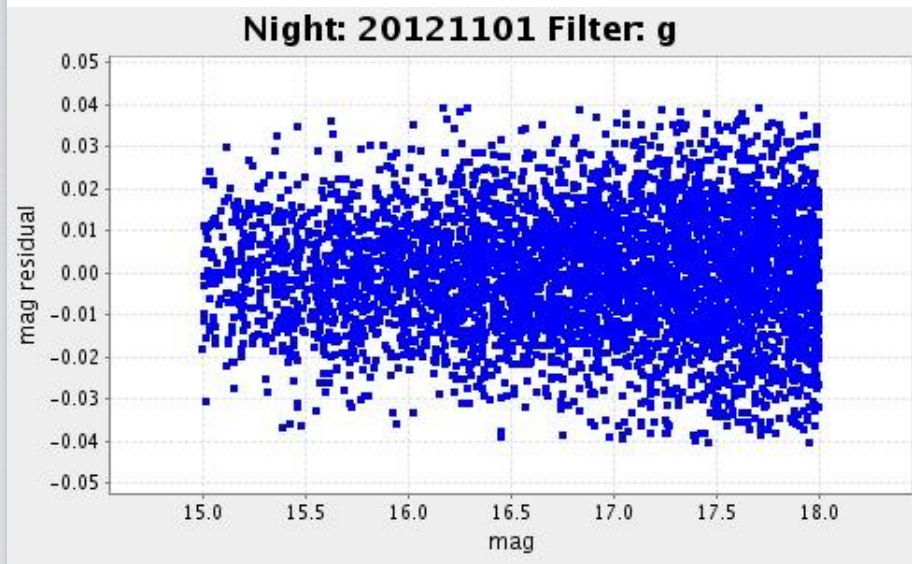


PHOTOMETRY

Nightly Standard Star Solution in g-band for the First Night of SV

RMS: 1.4%!

(combined internal and absolute calibration)



PHOTOMETRY

Cal-R1 **Relative magnitudes of bright stars reducible to <0.02 mag**

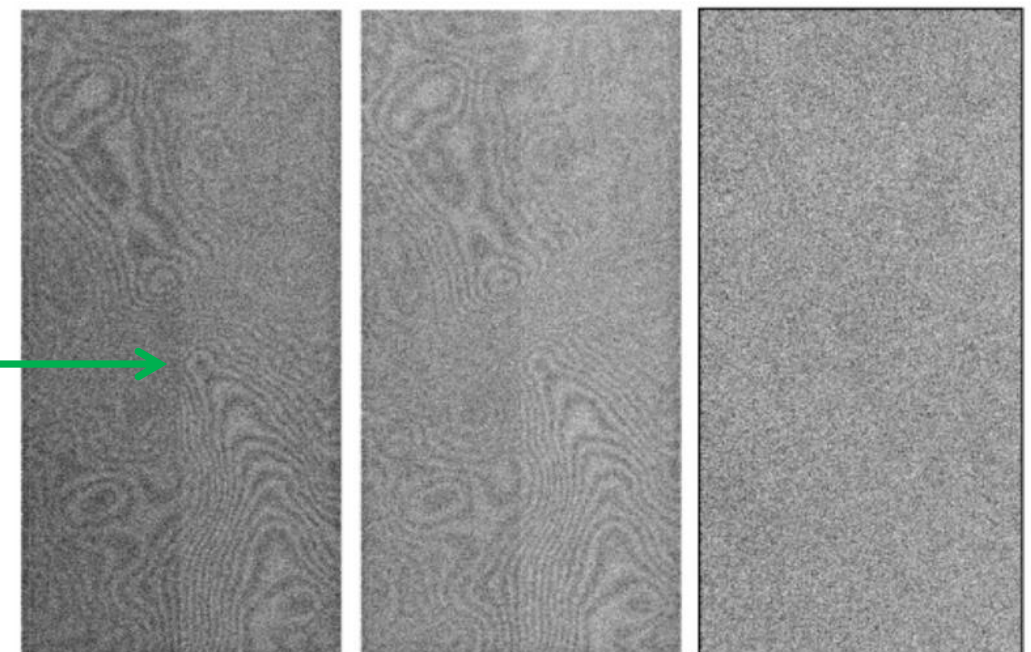
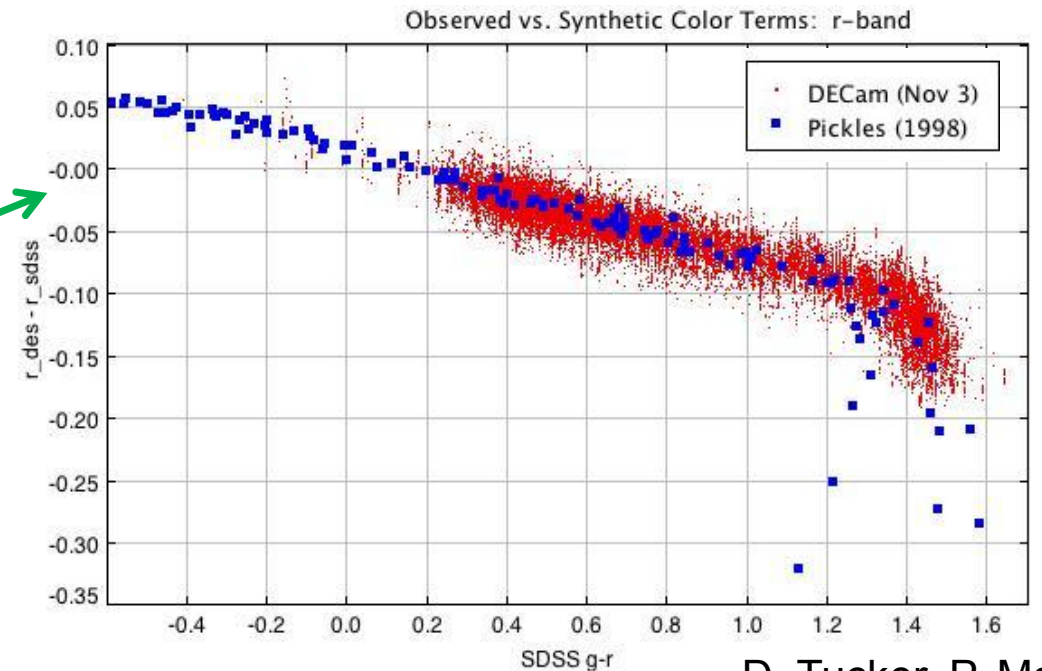
Cal-R2 **Color terms of DES vs SDSS photometry are within 2% of prediction**

Cal-R3 **Color terms of DES vs UKIDS photometry are within 4% of prediction**
R3 \rightarrow not yet in Y. need DECam

Cal-R4 **Ratio of dome flat to twilight flat is constant to 1%**

Cal-R5, Cal-G6 **Time variability of Y band fringes has been studied.**
Fringes removable without traces

Cal-R7 **Unsaturated exposures of BD+17 in all filters. Shutter-timing error $<1\%$**



SN SURVEY

SN-R1 All SN field observed multiple times. 95% complete star catalog

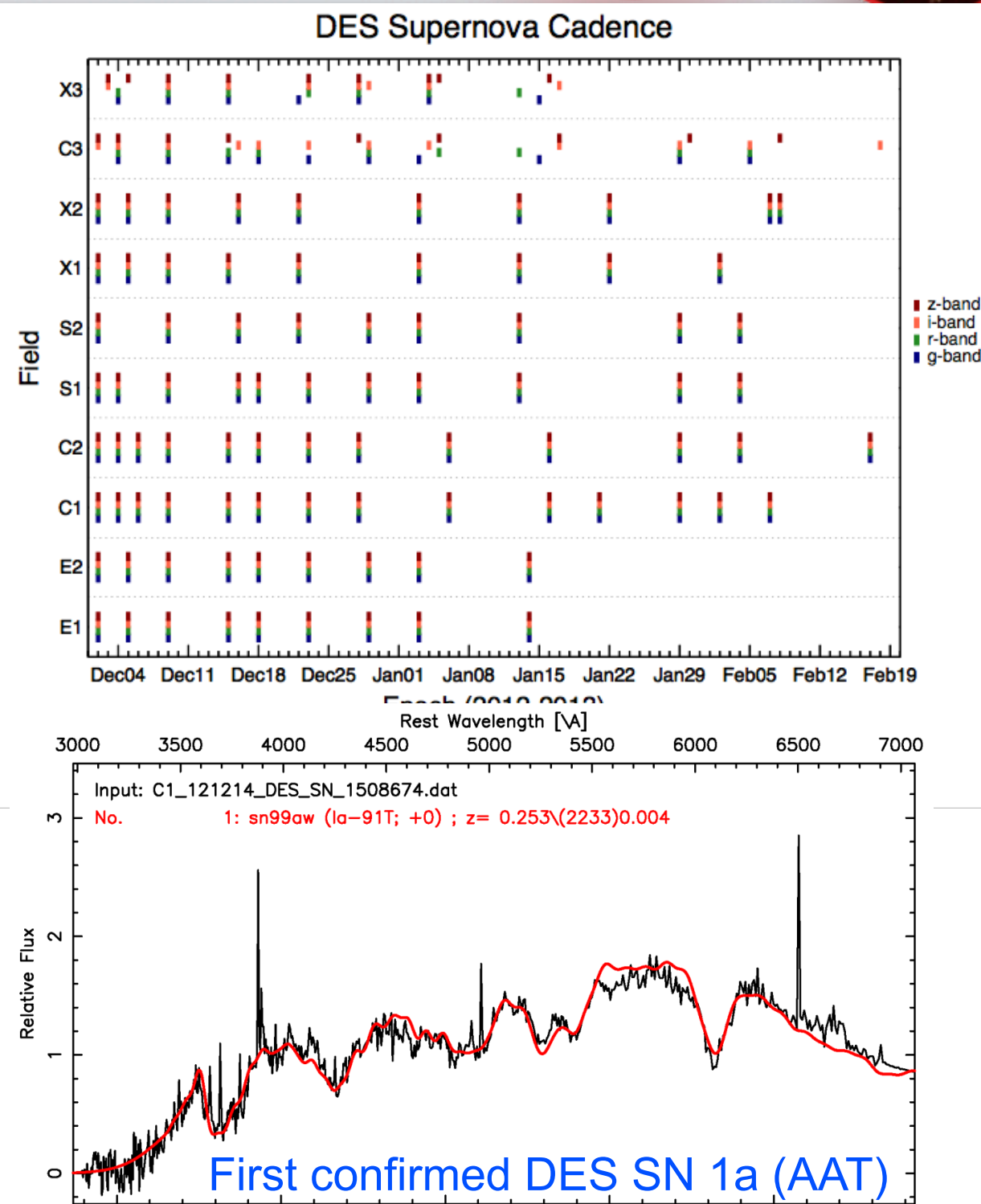
SN-R2 Stacked templates for all fields. Stacked stellar signal studies.

SN-R5 Difference imaging at DES-DM

SN-R6 Select SN candidates for Spectroscopic follow up

SN-R7 Reduce SN observations in < 24 hours

SN-G3 u and Y-band exposures



OPERATIONS

Ops-R1 **OBSTAC** works
Switch between main and SN survey
Feedback into Survey Table

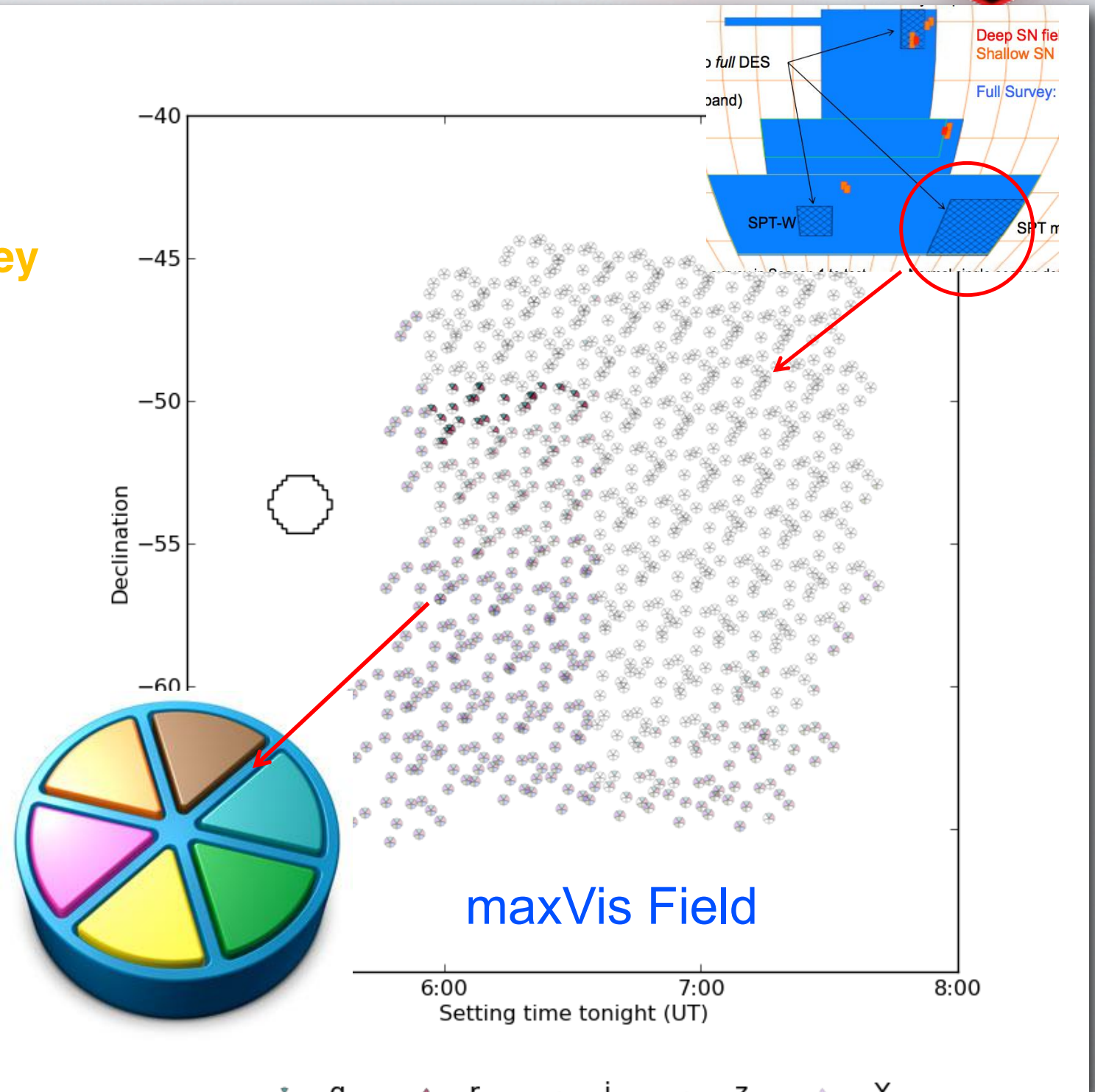
Ops-R2 **Run Manager**

Ops-R3 **Calibration Plan**

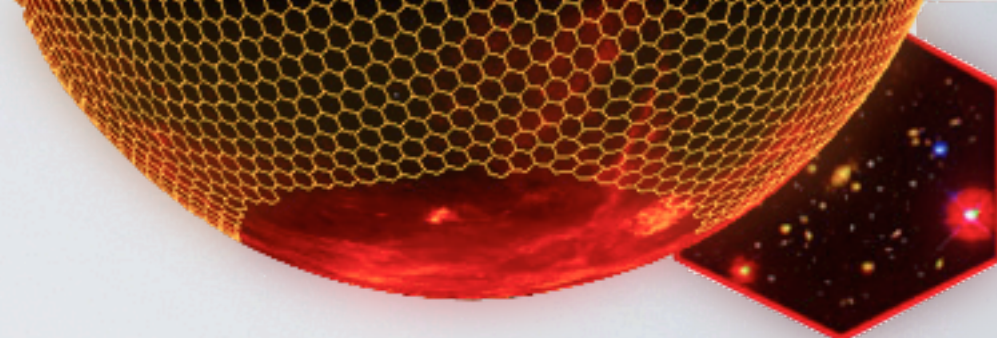
Ops-R9 **Routine operations**
DAQ, Procedures, Shifts

Data Transfer **no problems!!**

DES DM Processing
First Cut, SN Pipeline



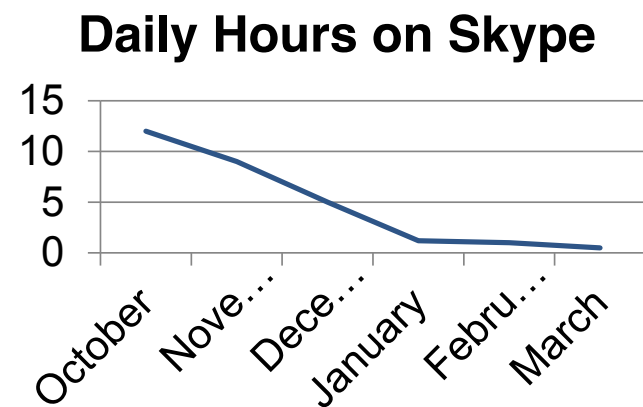
SUPPORT



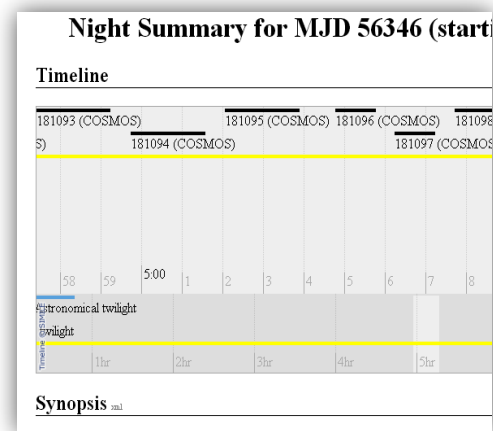
Documentation



Remote Support



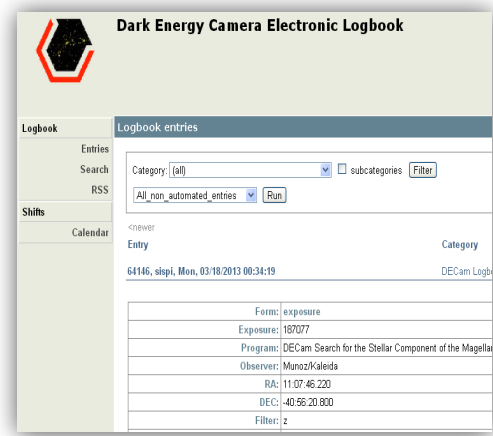
Night Summary



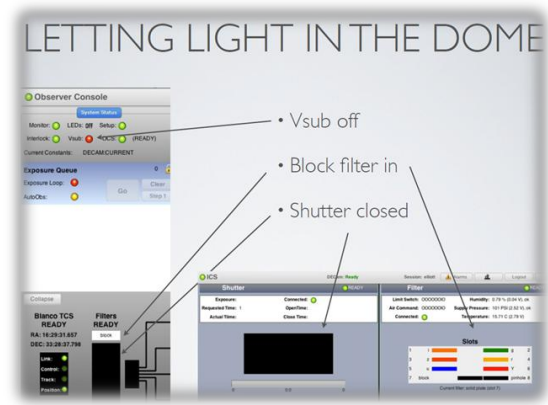
Software Maintenance

Code Management Releases

Log Book



Training



SUMMARY

DECam works very well

0.7" images,
No Surprises
Routine Operation

Science Verification:

Signal/Noise,
Photometry,
Astrometry,
Survey Tools,
Photo-z,
SN Program,
Operations/Procedures
at or near DES requirements



darkenergysurvey.org

