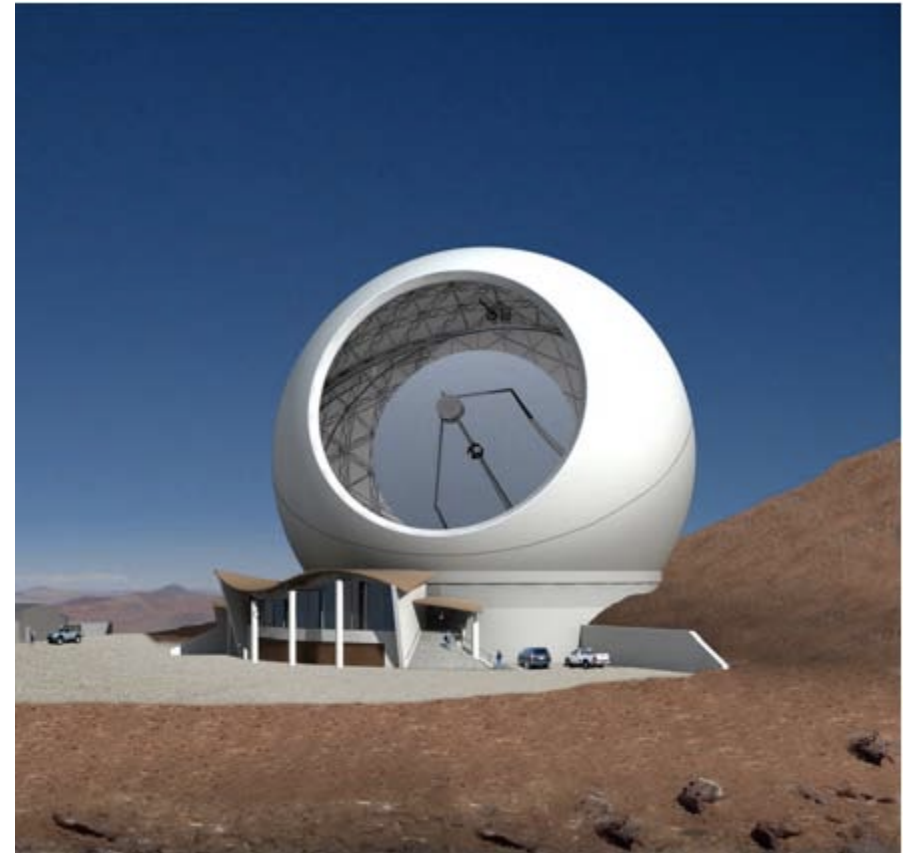


CCAT & LSST: Galactic (& Extragalactic!) Synergies



Kevin R. Covey (co-chair; Stellar Populations Science Collaboration)
Rachel Bean (co-chair; Cosmology Working Group)

CCAT & LSST: Galactic (& Extragalactic!) Synergies



-- LSST: Survey Design and Science Strengths

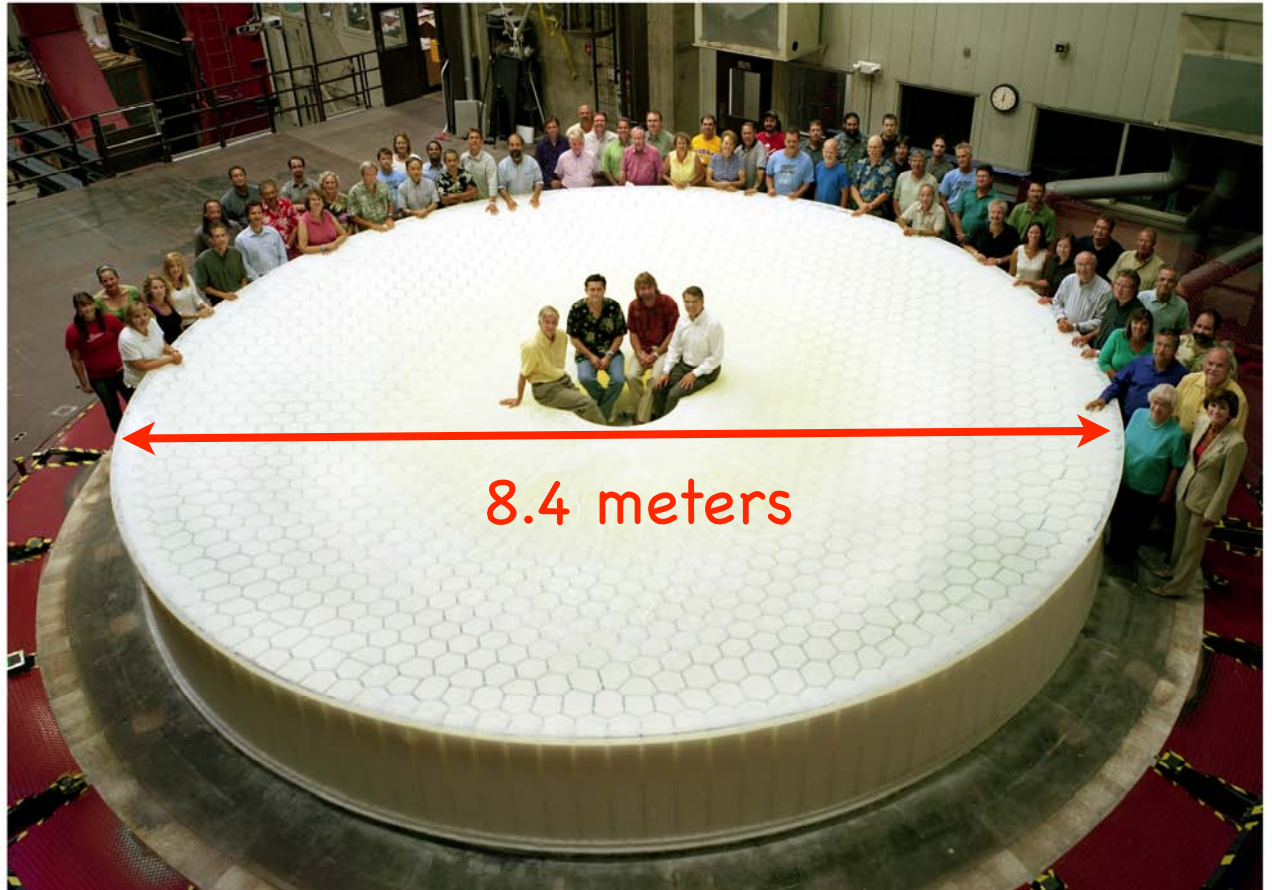
- A wide field time domain survey: Transients & astrometry
- A wide field static survey: An all-sky GOODS survey
- Deep Drilling Fields: Going deeper and faster

-- CCAT + LSST: Specific Science Synergies

- Debris disks in clusters and the field
- Evolution of circumstellar material during young stellar outbursts
- Extragalactic SFRs with SN & sub-mm: calibrating the cosmic SFH and the high mass IMF

LSST = Large Synoptic Survey Telescope

Optical Survey
9.6 sq degree camera
Online 2017,
Cerro Pachon



LSST
Large Synoptic Survey Telescope

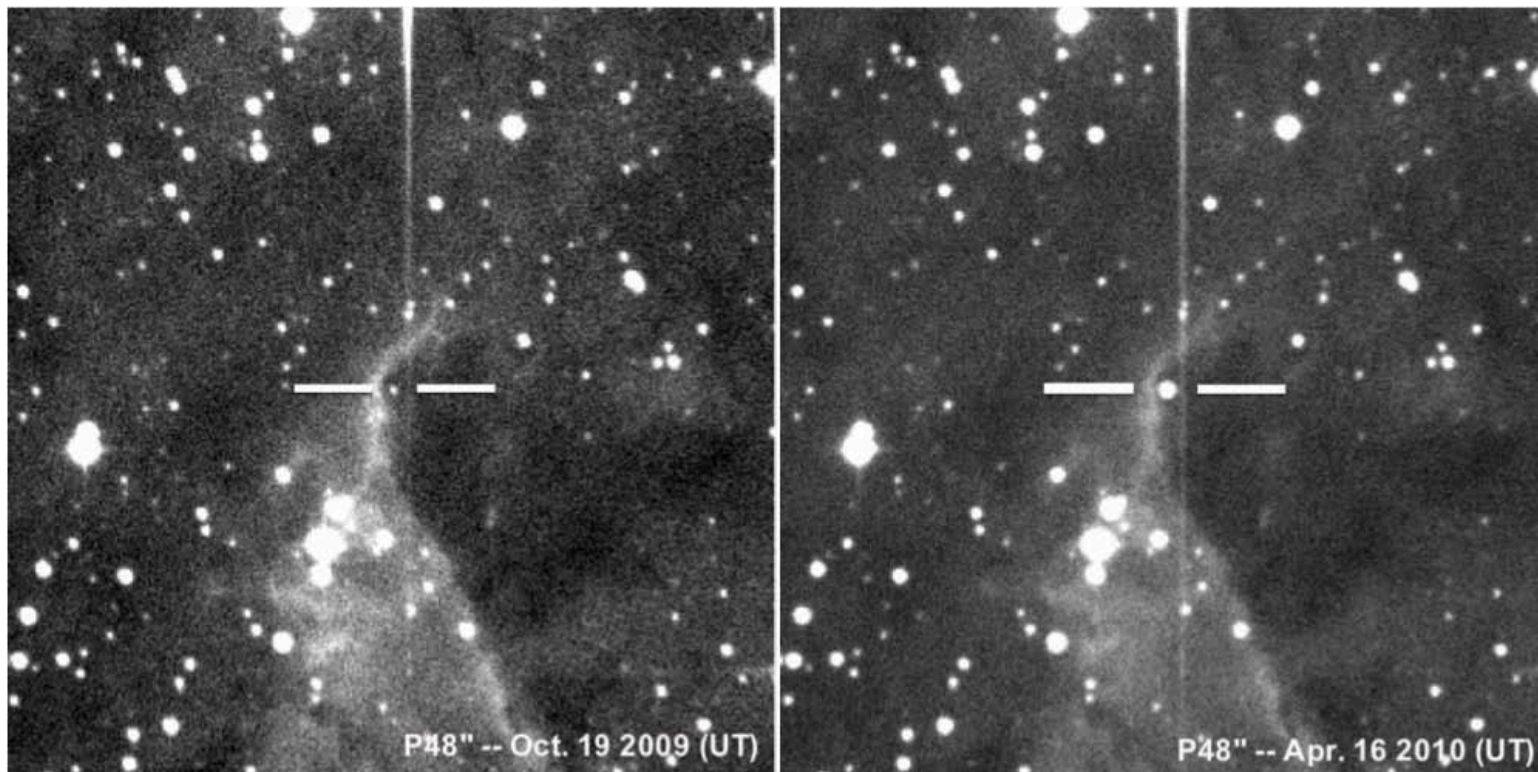
August 2008
LSST Primary/Tertiary Mirror Blank
University of Arizona Steward Observatory Mirror Lab

SOUL THE UNIVERSITY OF
ARIZONA
TUCSON, ARIZONA

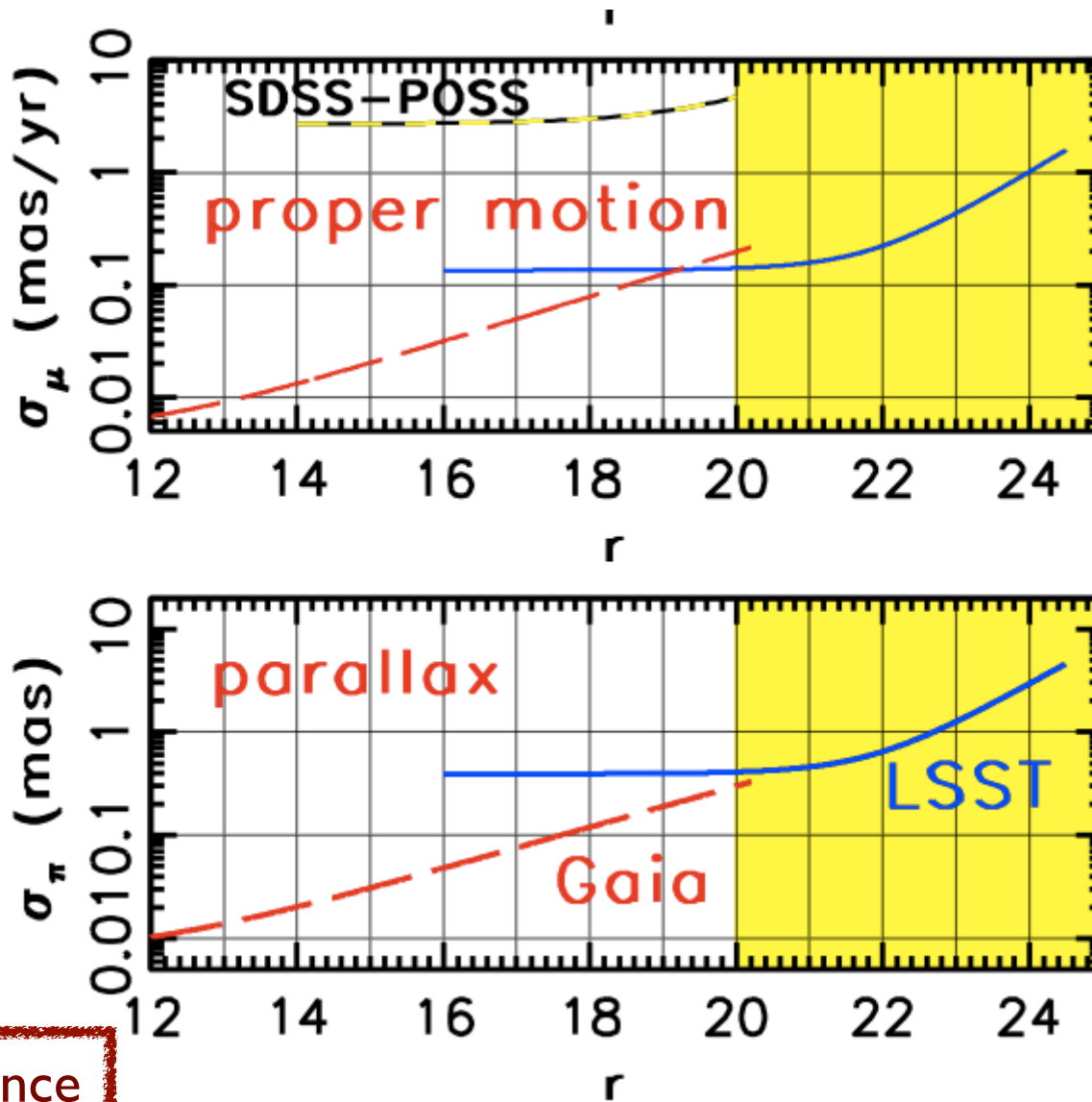
LSST: Exploring the Transient Universe

15s x 2 = 1 visit
2 visits / night
~3 night interval
100 visits / year

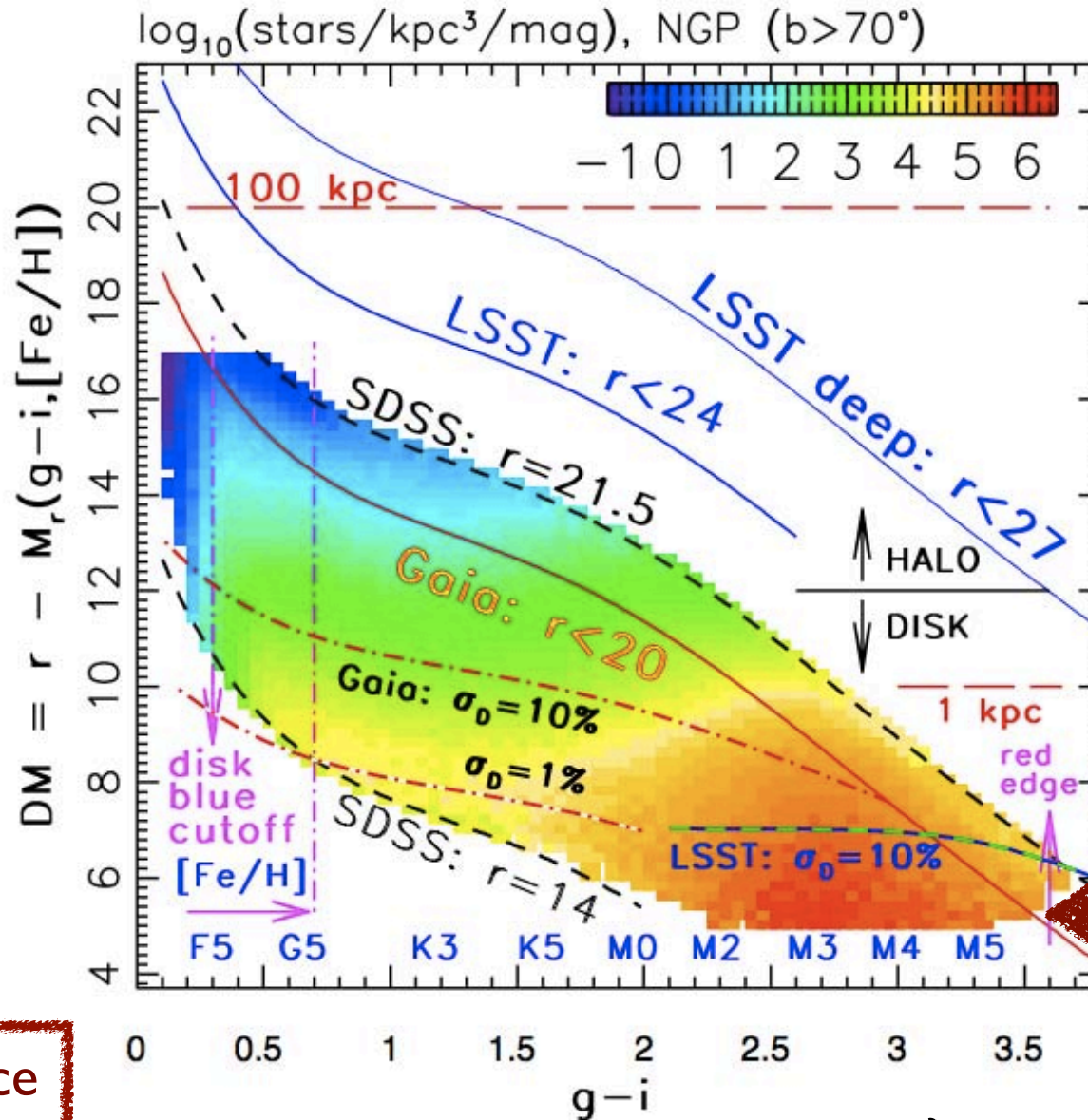
Process 3.2 Gigapixels (x200+/night),
release alerts in 60s



LSST: Supplementing Gaia astrometry at the faint end



LSST: Supplementing Gaia astrometry at the red end



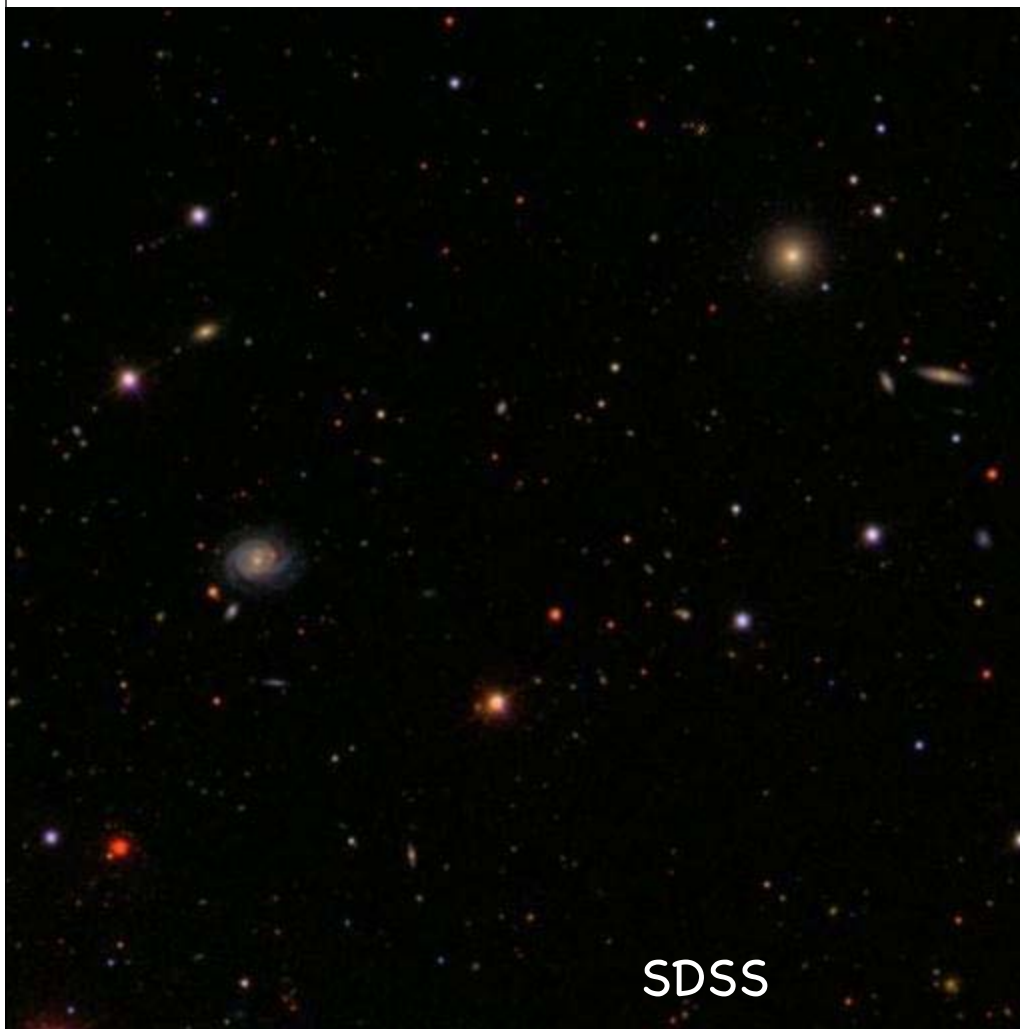
Distant stars

100 pc

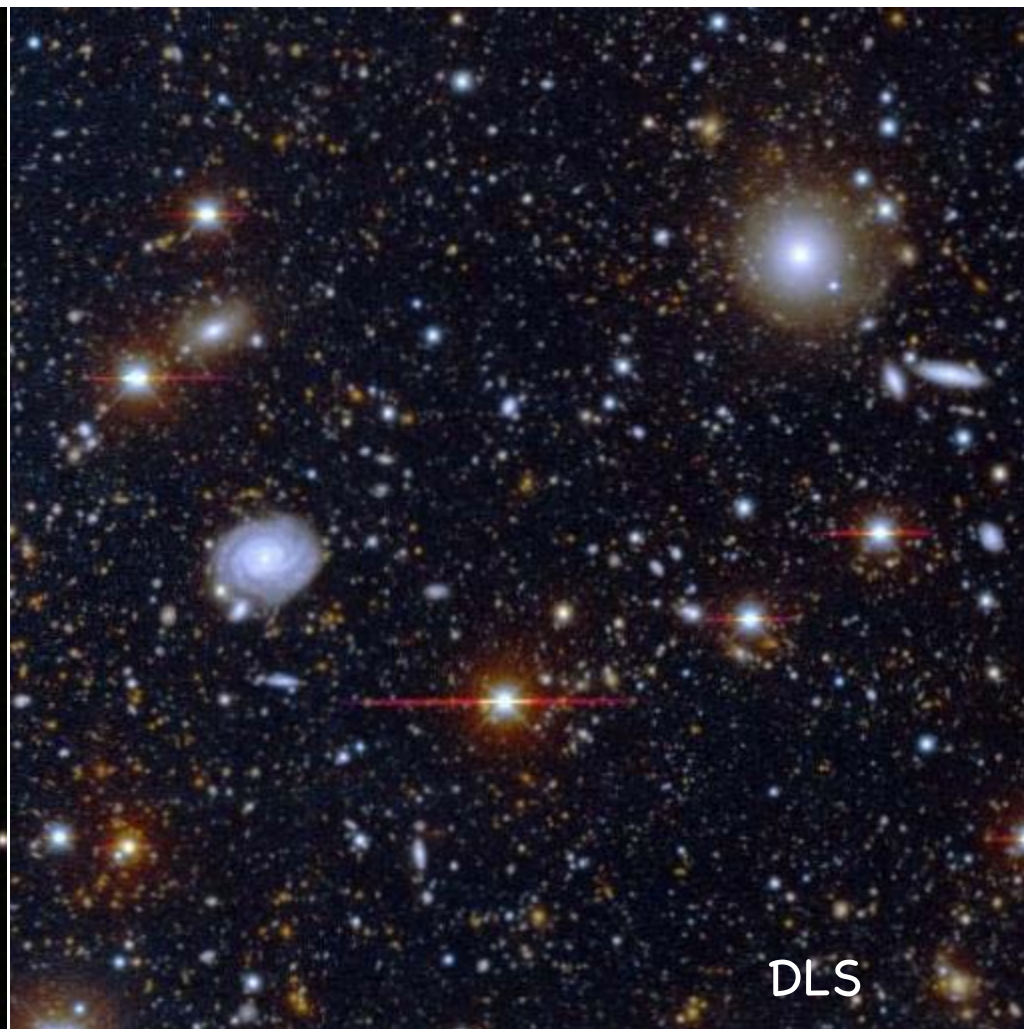
LSST Science
Book

Redder stars

LSST: image stacking to produce the deepest static optical sky survey



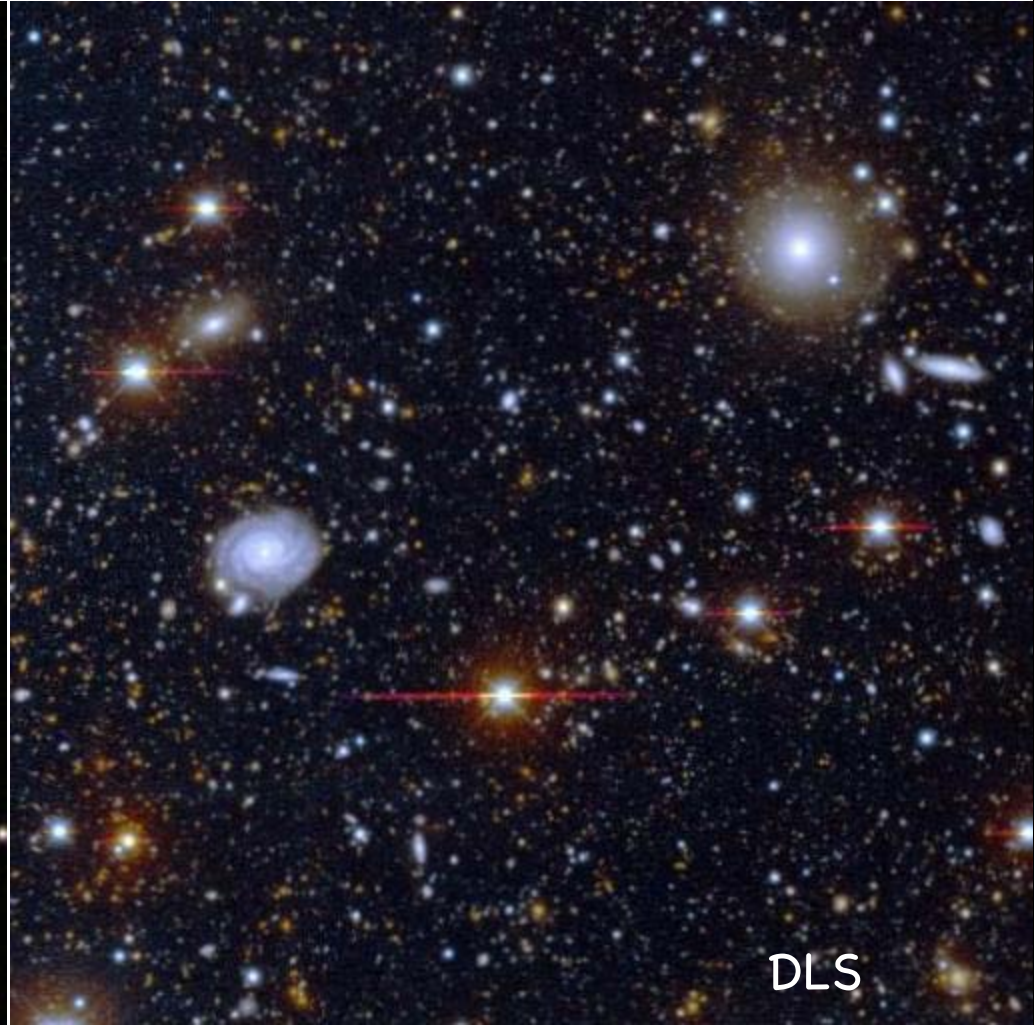
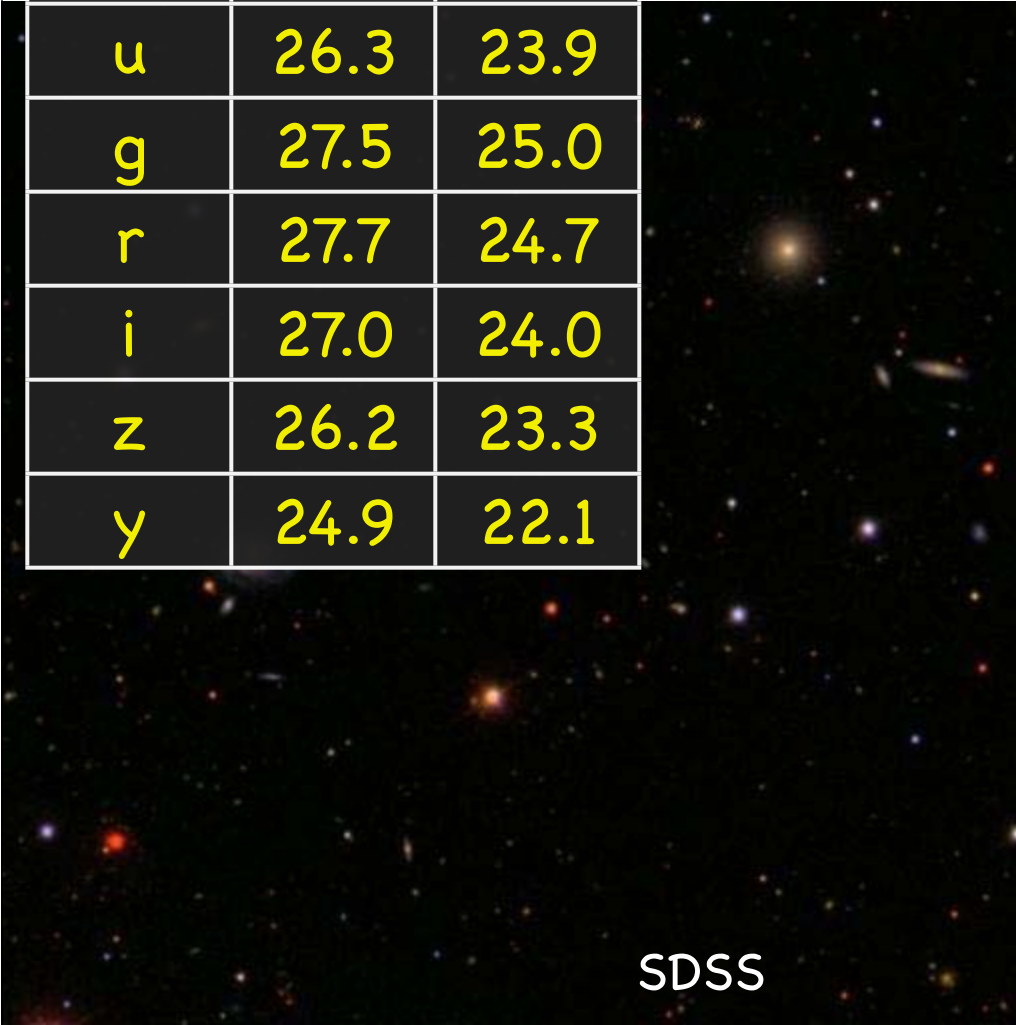
SDSS



DLS

LSST: image stacking to produce the deepest static optical sky survey

Filter	Coadd	Single
u	26.3	23.9
g	27.5	25.0
r	27.7	24.7
i	27.0	24.0
z	26.2	23.3
y	24.9	22.1



LSST: image stacking to produce the deepest static optical sky survey

Giavalisco+ 2005

Filter	Coadd	Single
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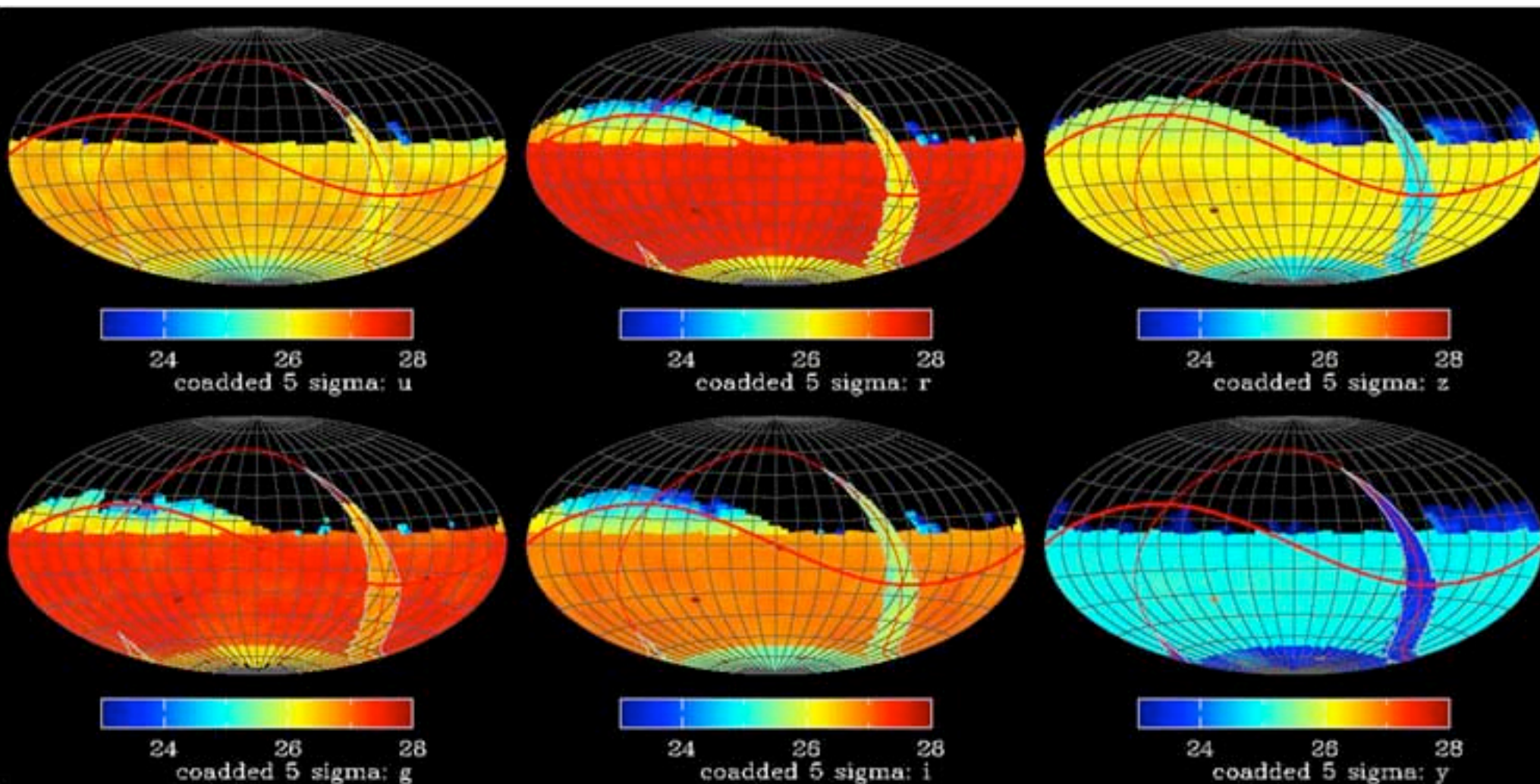
Facility	U'	U	B	V	R	I	z	J	H	K_s
<i>HST</i> +ACS	27.8	27.8	...	27.1	26.6
4 m MOSAIC	25.9	28.4	28.4	...	27.7	27.3
2.2 m WFI	25.0 ^a	29.0
	28.1 ^a	24.7 ^a	26.2	25.8	25.8	23.5
		27.9 ^a	29.3	28.9	28.9	26.6

SDSS

DLS

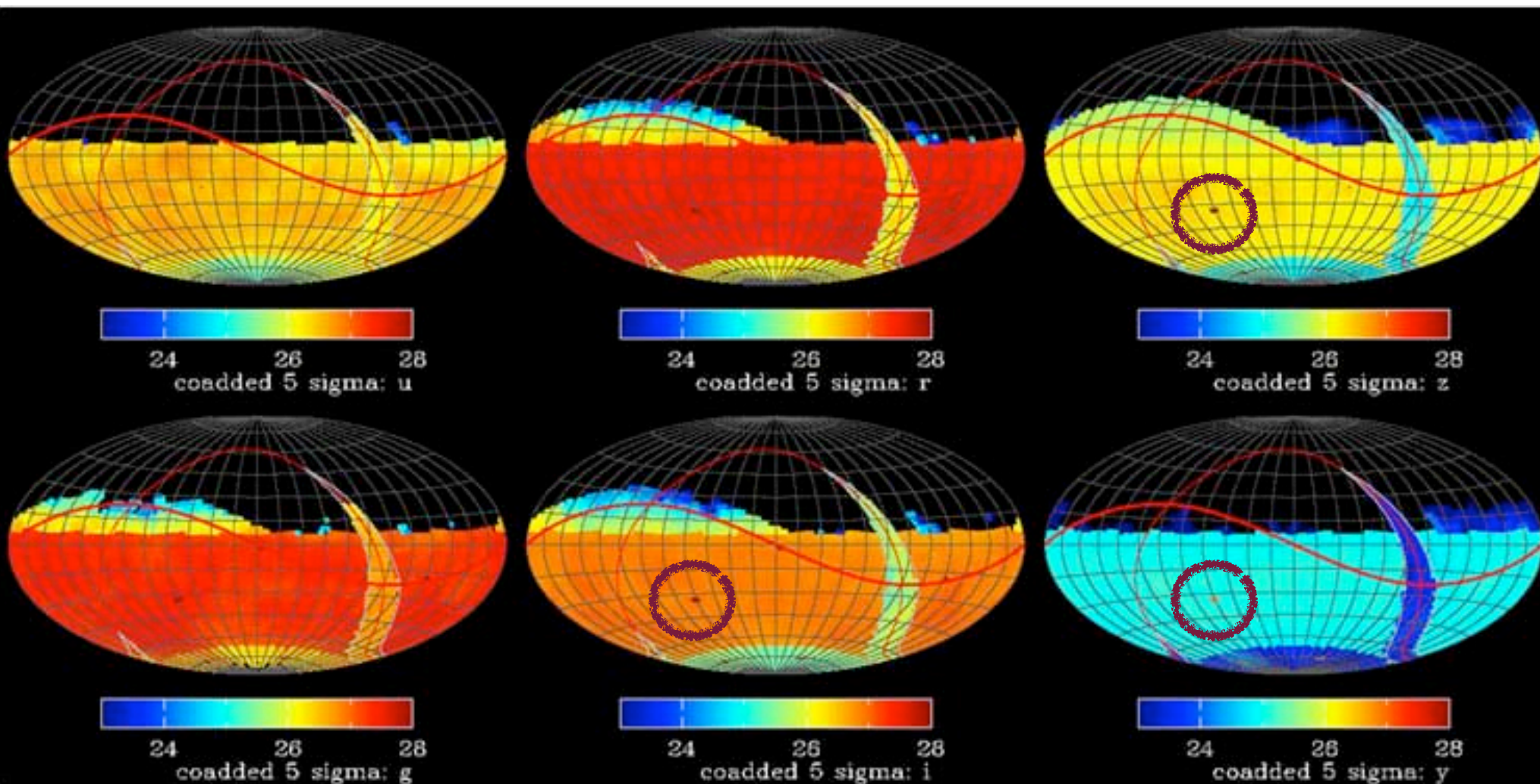
LSST: Deep Drilling Fields provide greater depth & higher cadence

-- Significant (~10%?) time reserved for selected fields (5? x 9 sq. deg.)



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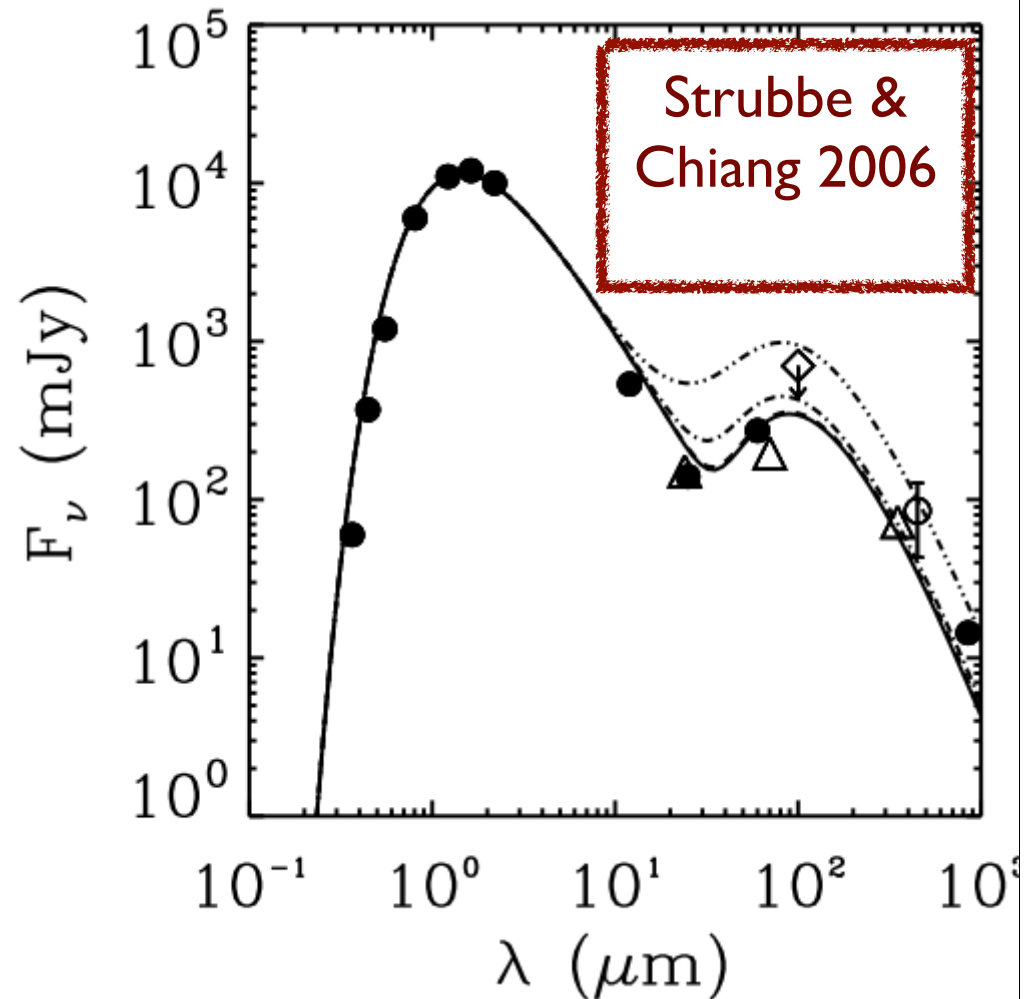
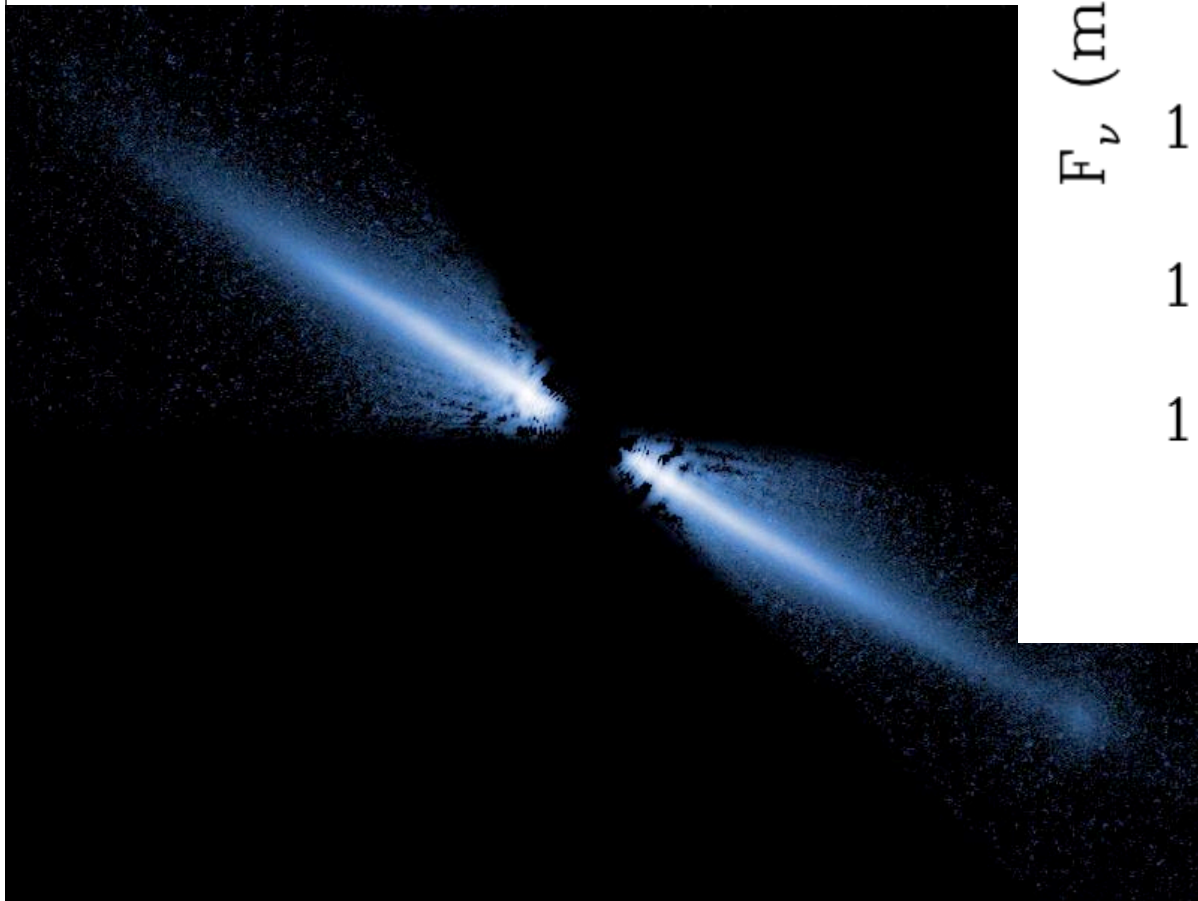


Prime Opportunities for CCAT/LSST Synergy

- LSST's value-added for CCAT:
 - Transient identification & sparse timescale variability (AGN)
 - All-sky deep photometry (entire sky is a GOODS field!)
 - Astrometry, particularly for faint red stars (low-masses, embedded stars).
 - Deep Drilling Fields -- even deeper & higher cadence!

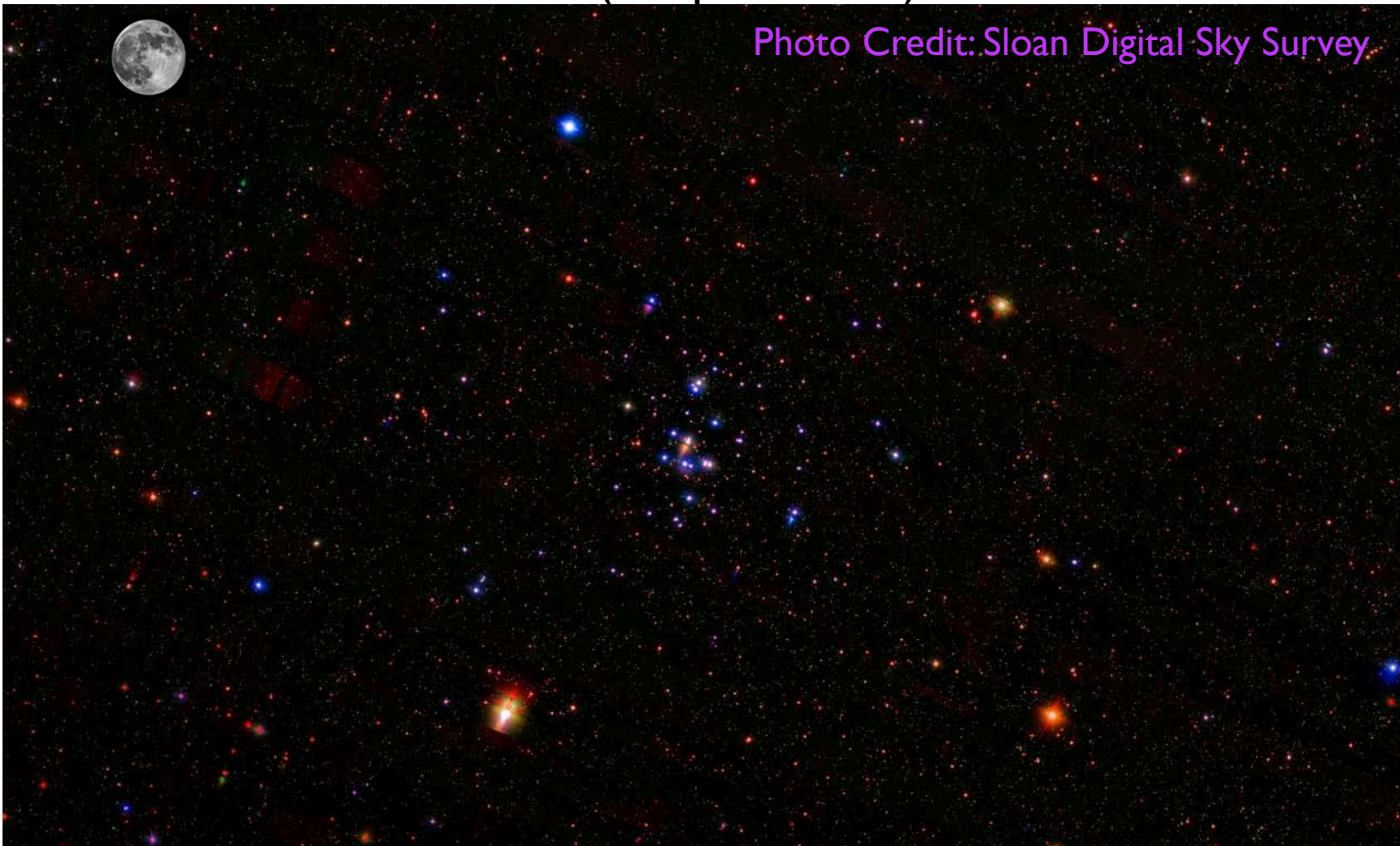
Synergy #I: CCAT Debris Disks around LSST stars

AU Mic: Template (young!) debris disk
M1; $M=0.5 M_{\text{sun}}$; $d = 9.9 \text{ pc}$; $t=12 \text{ Myrs}$



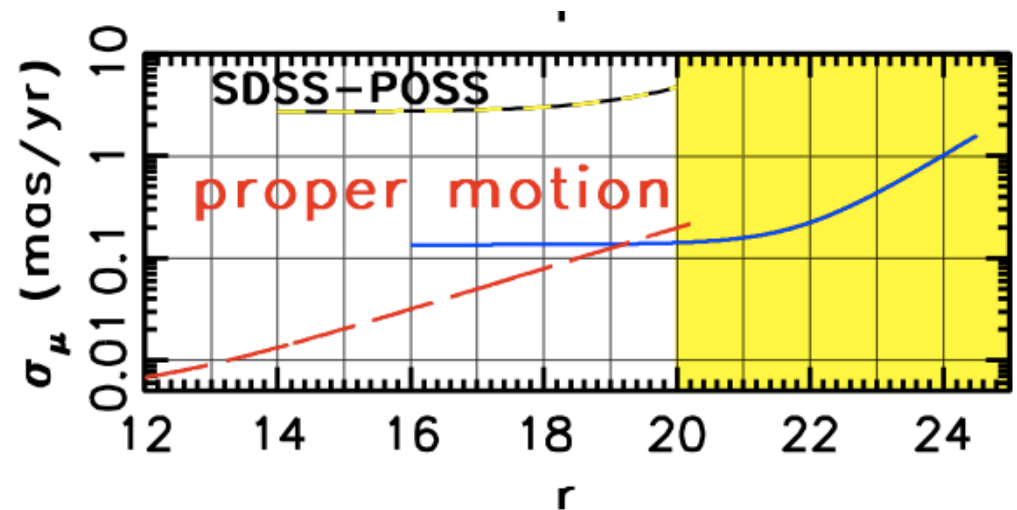
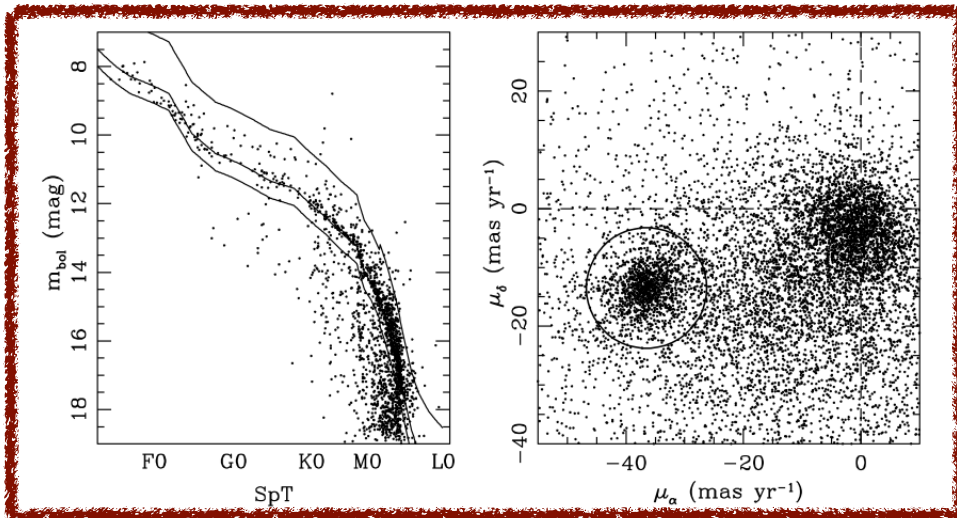
Synergy #1: CCAT Debris Disks around LSST stars

- Exemplar cluster target: Praesepe: 600 Myrs; rich (>1000 members); nearby (160pc, but northern!) cluster
- Spitzer survey of 193 members identified ~3 debris disks around solar type stars (Gaspar+ 2009)



Synergy #1: CCAT Debris Disks around LSST stars

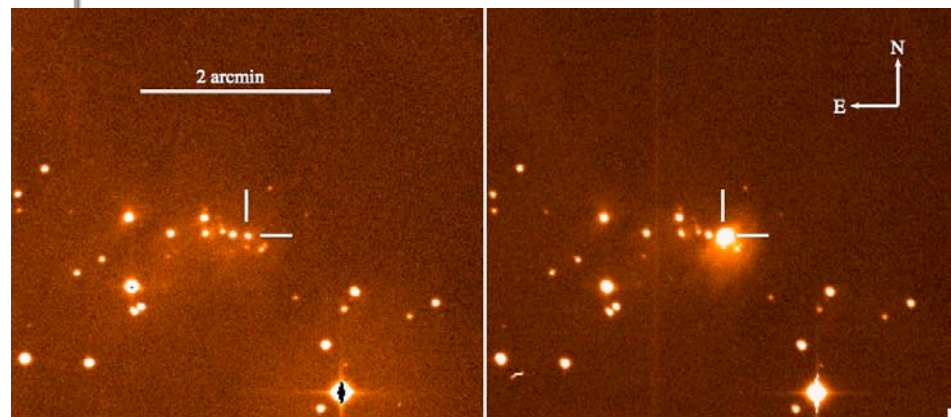
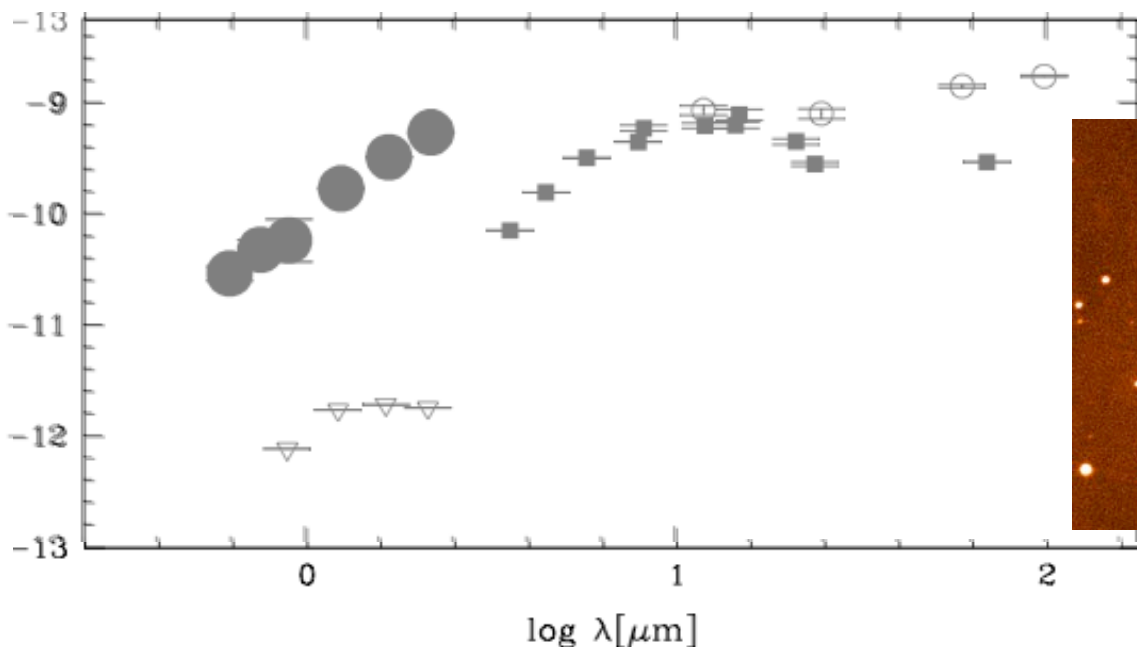
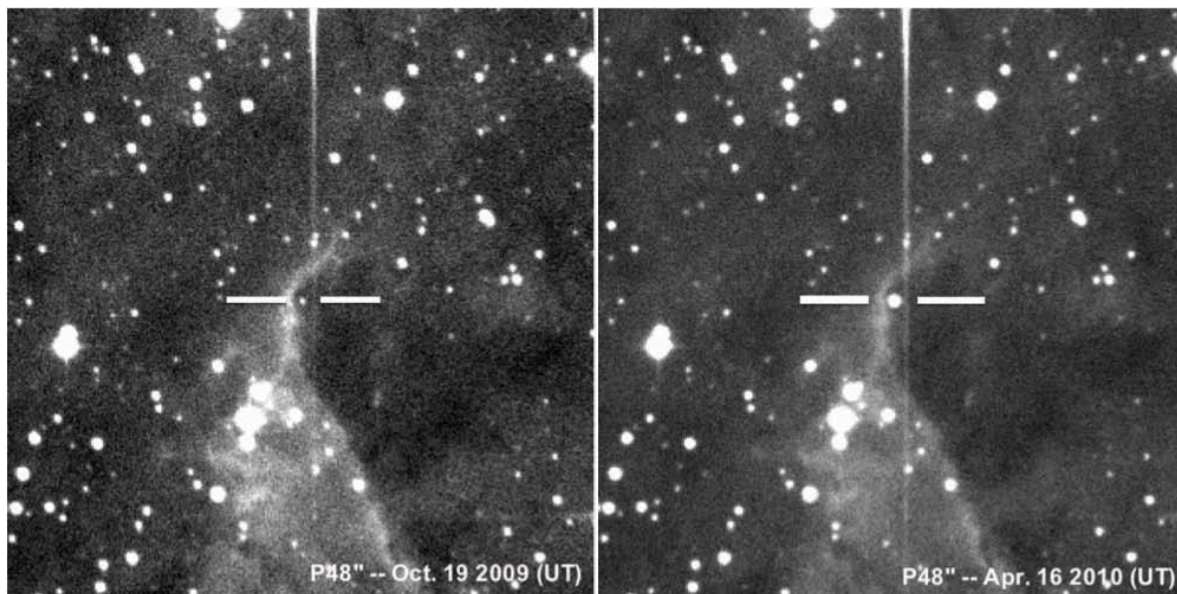
- Exemplar cluster target: Praesepe: 600 Myrs; rich (>1000 members); nearby (160pc, but northern!) cluster
- Spitzer survey of 193 members identified ~3 debris disks around solar type stars (Gaspar+ 2009)
- Gaia won't obtain astrometry for the low-mass stars or brown dwarfs!



Synergy #2: Pre-Outburst Characterization of Young Stellar Outbursts

-- LSST will detect FU Ori events in W40 (600 pc), Lagoon Nebula (1.3kpc) but we don't know which ones yet. Need large scale map to provide precursor SEDs.

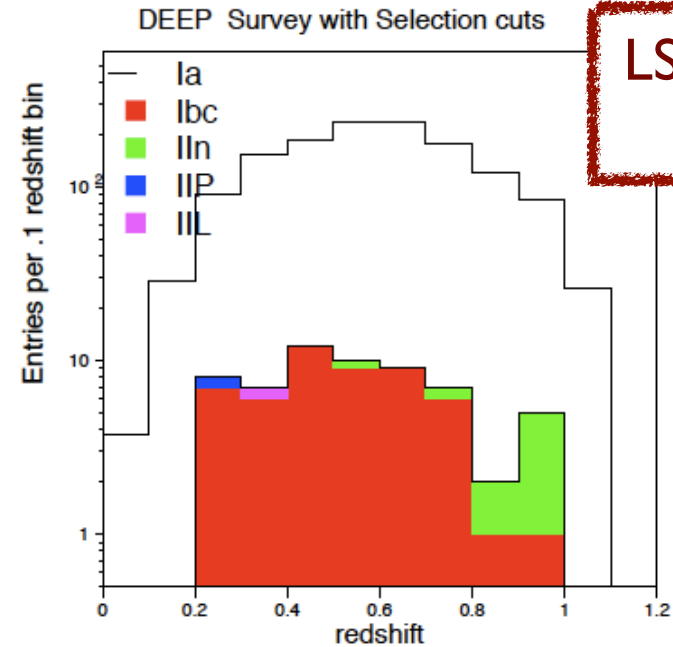
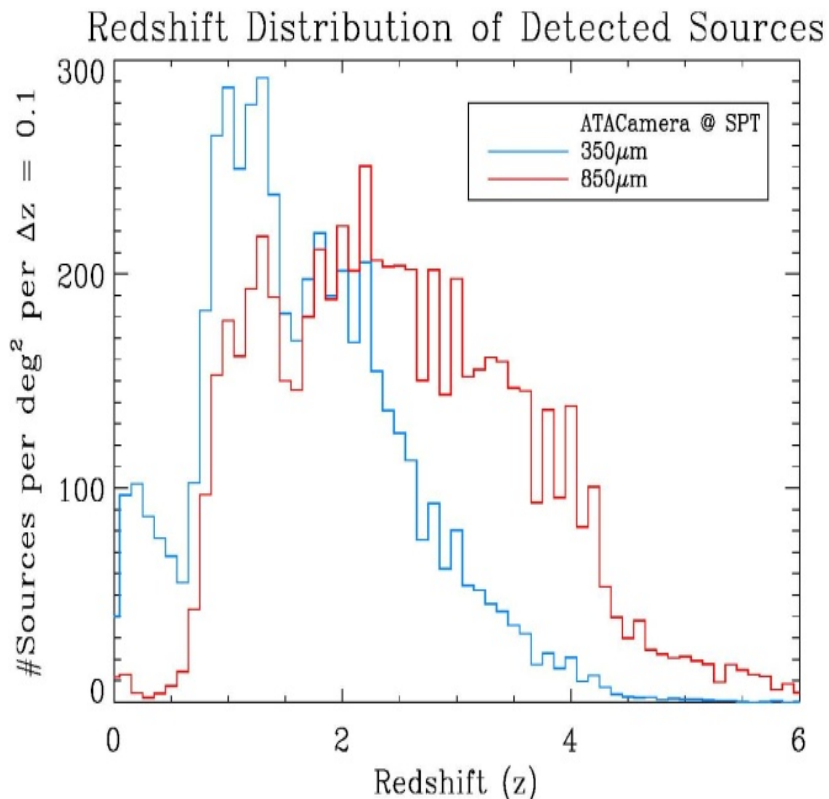
Covey et al.,
submitted



Miller et al., submitted

Synergy #3: Comparing SFRs from CCAT (FIR) and LSST (SN)

-- LSST's deep drilling fields will yield hundreds of SN (mainly Ia) per degree per year; prompt component diagnoses SFR (Scannapieco & Bildsten 2005)



LSST Science Book

-- Deep (~ 500 hr/sq. deg.) short wavelength CCAT surveys will detect tens of thousands of galaxies in deep drilling footprint.

Prime Opportunities for CCAT/LSST Synergy

-- LSST's value-added for CCAT:

- Transient identification & sparse timescale variability (AGN)
- All-sky deep photometry (entire sky is a GOODS field!)
- Astrometry, particularly for faint red stars (low-masses, embedded stars).
- Deep Drilling Fields -- even deeper & higher cadence!

-- Specific Science Synergies

- Debris Disks in Open Clusters & the Field (membership/distances via LSST PM's and parallaxes)
- Pre & Post-Outburst Sub-mm SED evolution for LSST identified outbursting young stars
- Calibrate SN rates as SFR indicators and/or SN vs. Sub-mm SFR as independent constraints on high mass IMF

-- Odds & Ends:

- Low Surface Brightness Galaxies
- Magellanic clouds
- Deep Drilling Fields