

Science with Mega Surveys



- The survey advantage
- Recent hits
 - UKIDSS
 - VISTA
 - PanSTARRS
- Future promise
 - Gaia
 - Euclid
 - LSST



The Survey Advantage

Two modes of science

- Targeted
 - specific scientific question
 - conduct experiment to answer that question
 - make only the necessary measurements
- Survey
 - pre-collect data : summarise sky
 - the archive becomes the sky
 - science done with the archive (VO etc)

Survey advantages

- **cost effective**
 - many experiments from same data
- **supports other experiments**
 - create samples to observe elsewhere (follow-up)
 - match with observations made elsewhere (follow-down ?)
- **produces surprises**
 - first looks in new corners of parameter space
 - new populations

Large area advantages

- statistics : large samples
 - accurate function estimation : eg galaxy power spectrum
 - weak signal recovery : e.g. grav lensing
 - wider always faster than deeper
- large structures
 - eg Clusters, Milky Way, Dipole
- rare objects
 - eg Y dwarfs, $z=7$ quasars

Rich Heritage

- Radio : 3C, 4C ...
- IR : IRAS, 2MASS, UKIDSS
- Optical : APM, SuperCOSMOS, SDSS
- X-ray : Ariel-V, XMM
- Z-surveys PSC-z, 2dFGRS, SDSS-z
- Time domain Ogle, WASP, CRTS, PanSTARRS

the core of modern astronomy

Productivity

UKIDSS :
 10^6 queries run
 10^{10} rows extracted



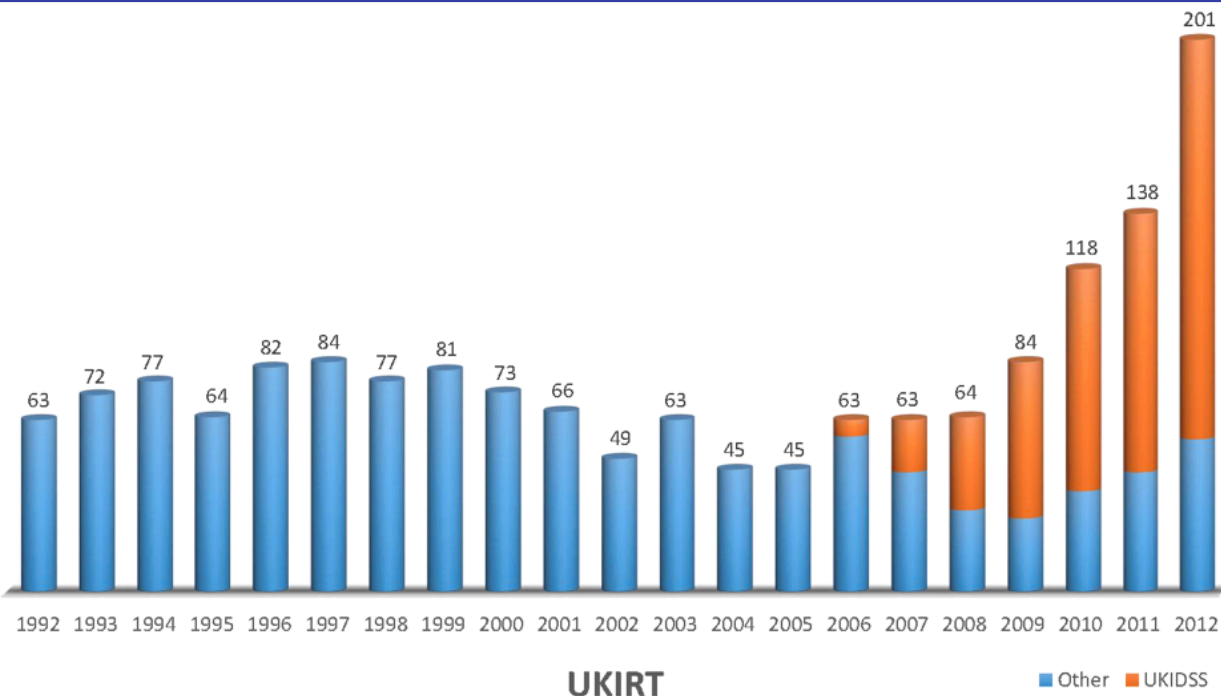
- WSA Home
- Start Here
- Data Overview
- Known Issues
- the Surveys
- Schema browser
- Data access
- Login
- Archive Listing
- GetImage
- MultiGetImage
- Region
- Menu query
- Freeform SQL
- CrossID
- Analysis

WSA - SQL Query menu form

This forms allows you to submit an SQL query to the WSA database ([notes and tips](#)).

```
SQL statement: select
sourceID,ra,dec,yAperMag3,j_1AperMag3,hAperMag3,kAperMag3,YAPERMAG3
- J_1APERMAG3
from ukidssdrplus..lasSource
where ra > 355.0 and
ra < 355.8 and
dec > 0.00 and
dec < 0.06 and
yAperMag3 < 17 and
YAPERMAG3 - J_1APERMAG3 < -0.2
```

the results of long running queries will be sent by email.





Recent Hits : UKIDSS

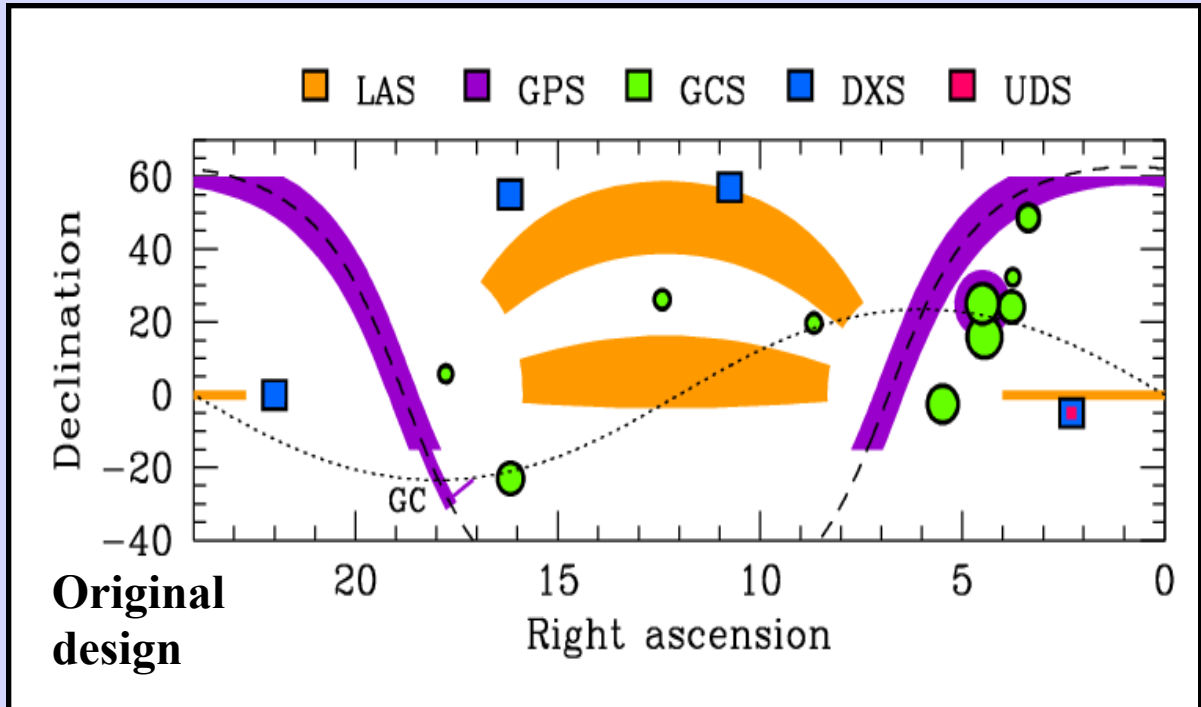
The UKIRT Infrared Deep Sky Survey

CPI A.Lawrence
CSS Steve Warren
plus 130 others

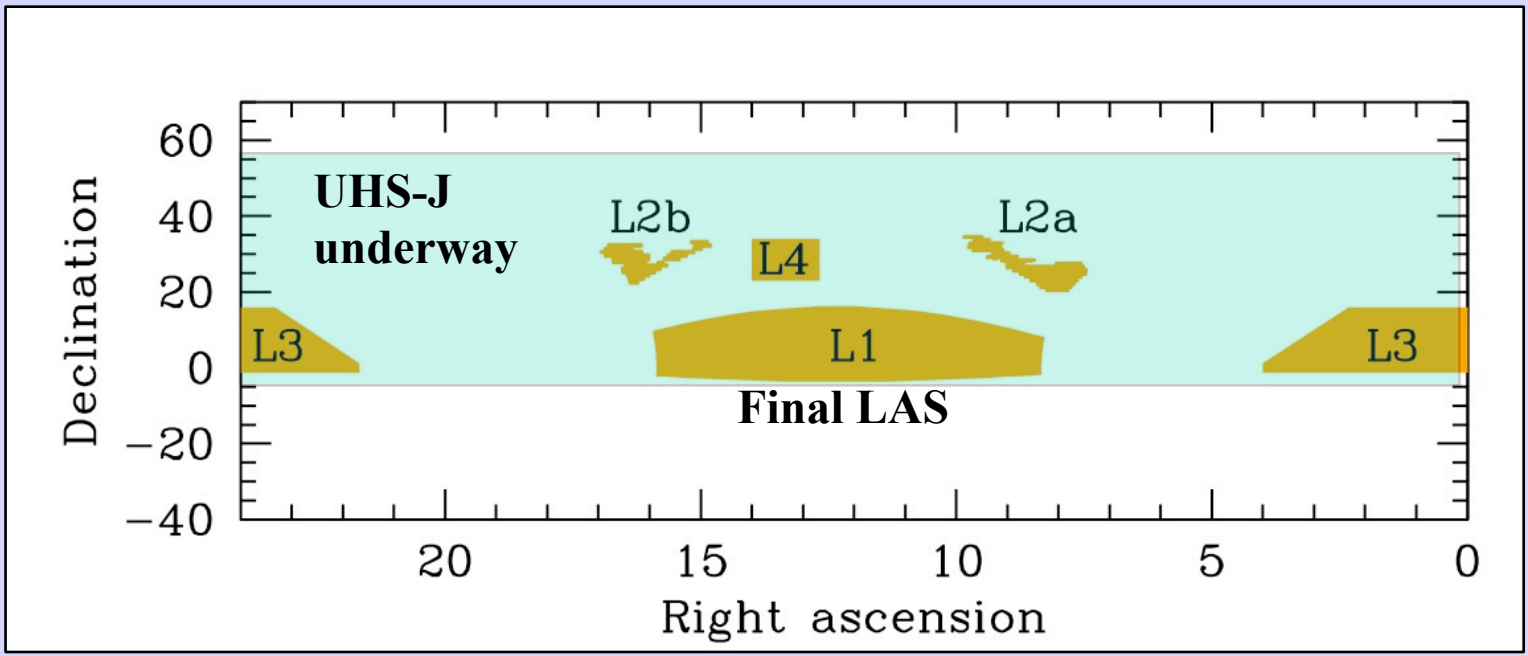
Core Reference
Lawrence et al 2007

- ✚ ESO public survey on UKIRT
- ✚ UKIDSS = 50 X 2MASS
- ✚ Near-IR SDSS
- ✚ Observations 2005 - 2012
- ✚ Data available at
<http://surveys.roe.ac.uk/wsa>





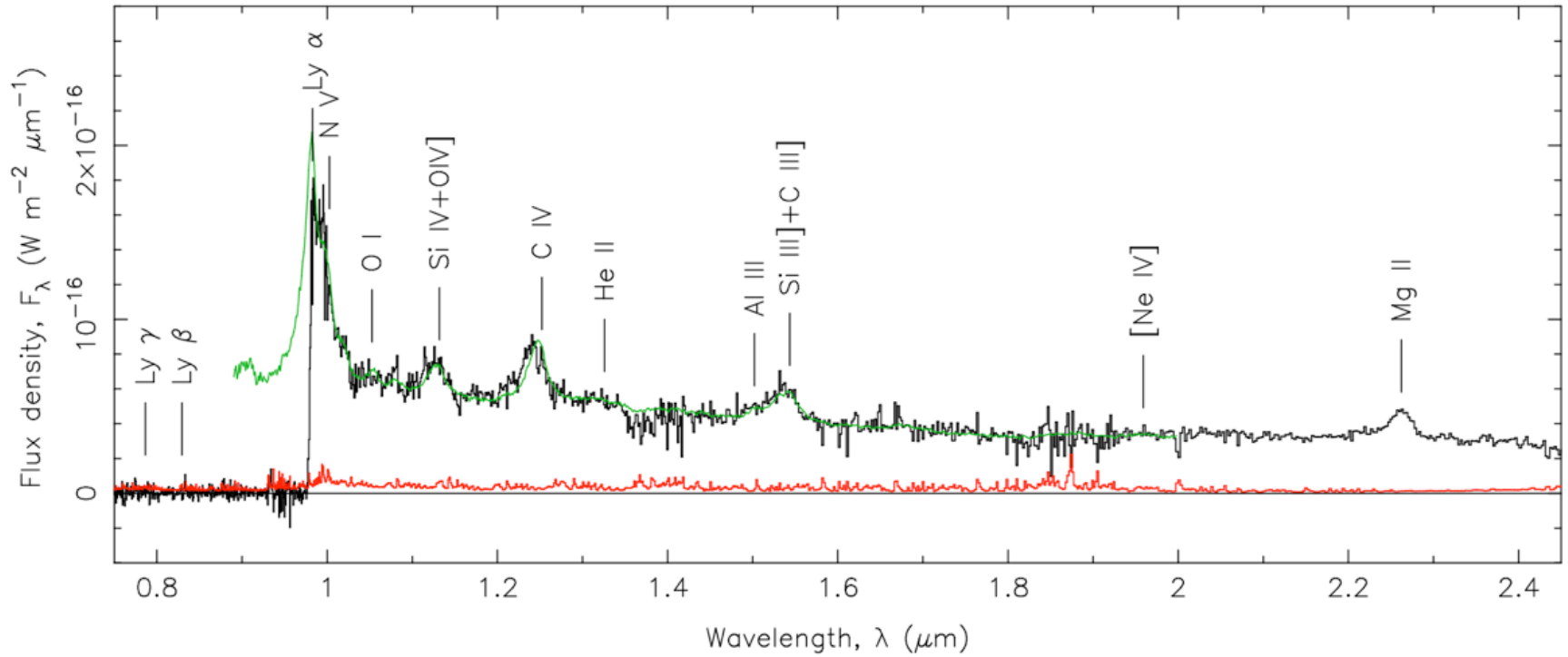
LAS/GPS/GCS $K_V \sim 18.5$
 DXS $K_V \sim 20.5$
 UDS $K_V \sim 22.5$



Final LAS
 and UHS
 underway

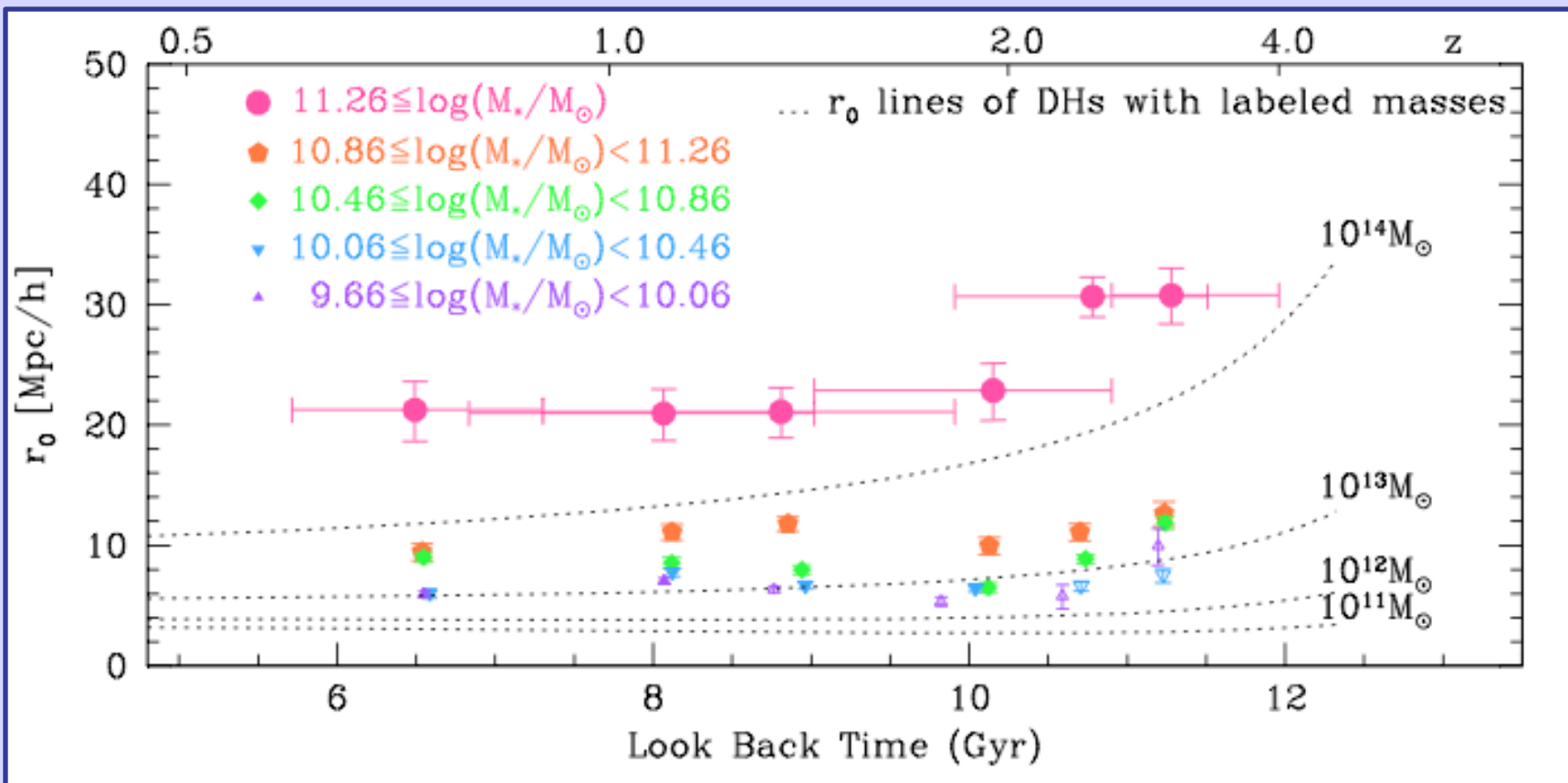
$z=7.085$ furthest quasar

Mortlock et al 2012



Two billion solar mass
black hole by $t=0.77$ Gyr

$z=0-4$ growth of clustering

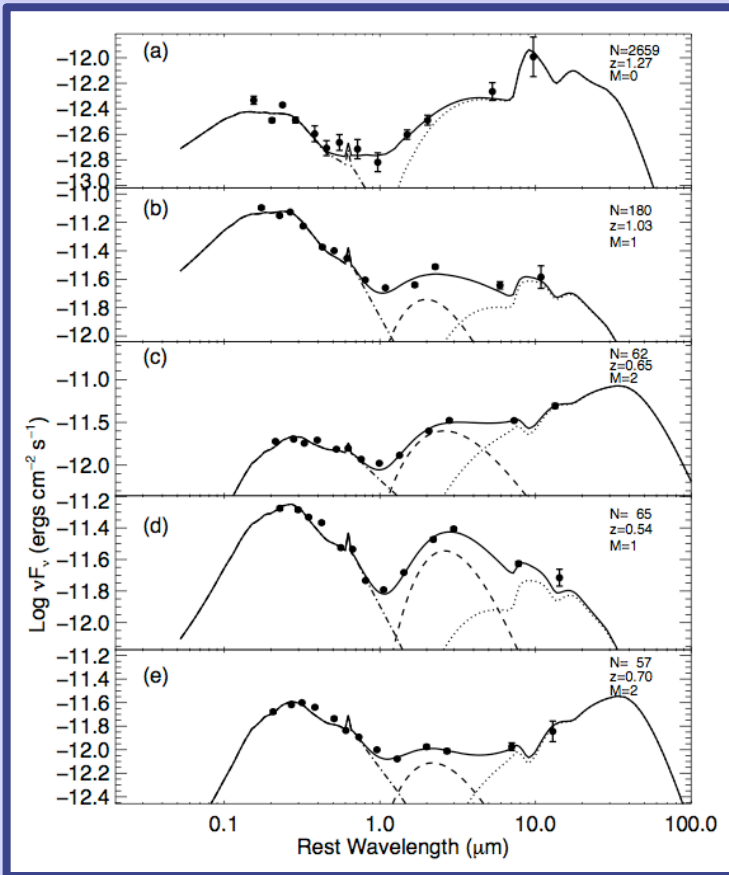


clustering scale and evolution
strongly mass dependent

Furusawa et al 2011
UKIDSS UDS+Subaru

AGN torus covering factor

Roseboom et al 2013

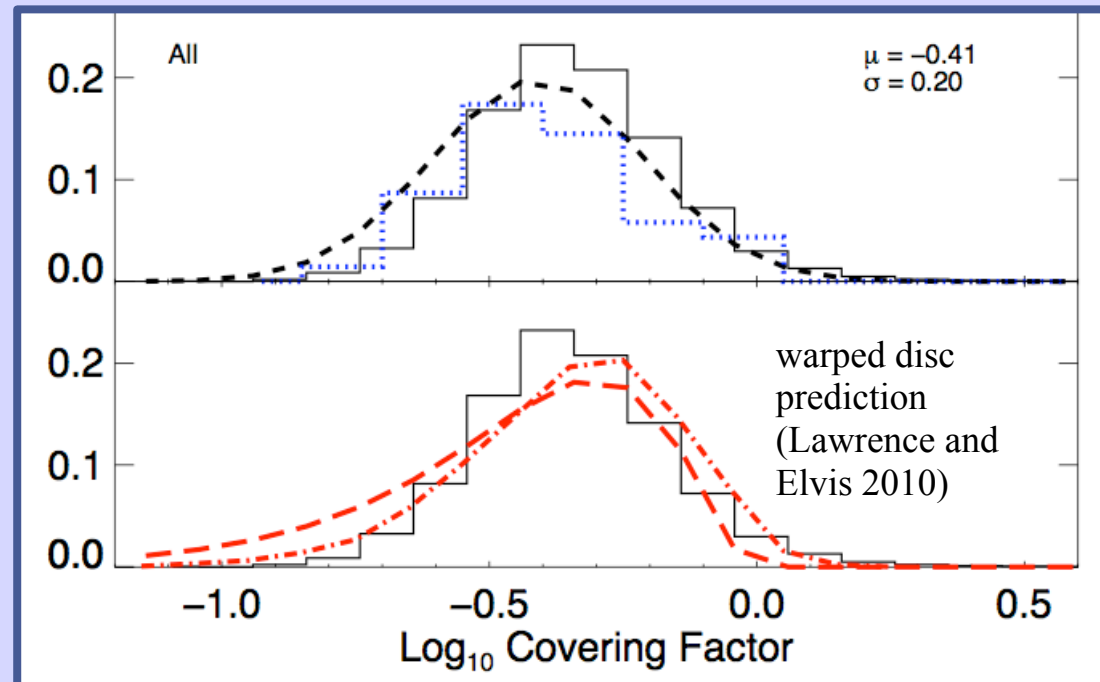


Even luminous quasars are 50% covered

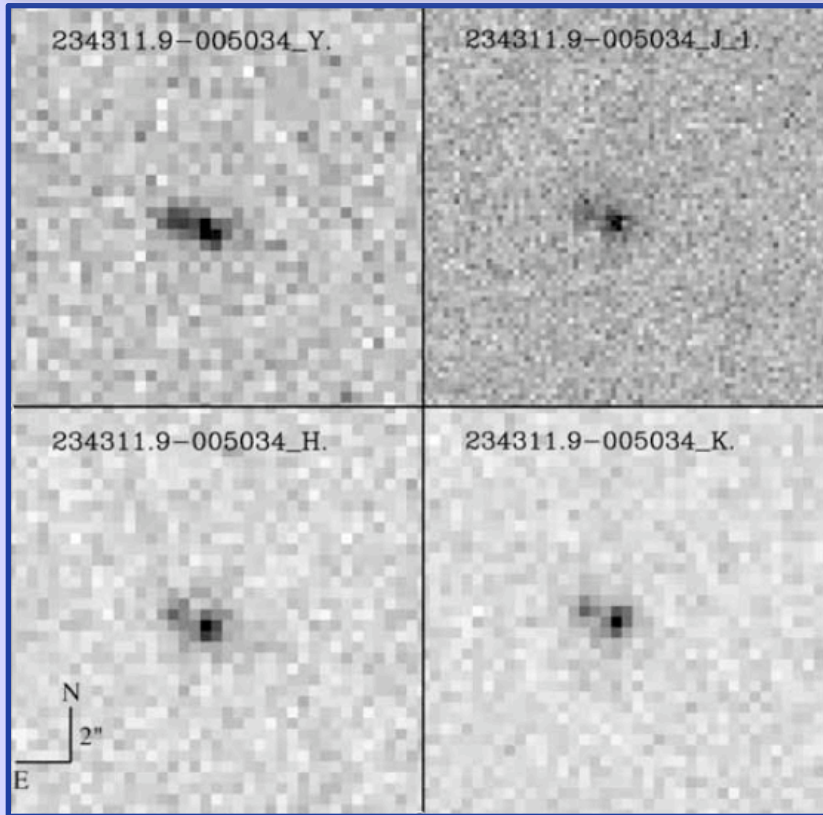
9000 WISE-UKIDSS-SDSS quasars

IR/UV ranges over factor of several

Distribution of covering factors



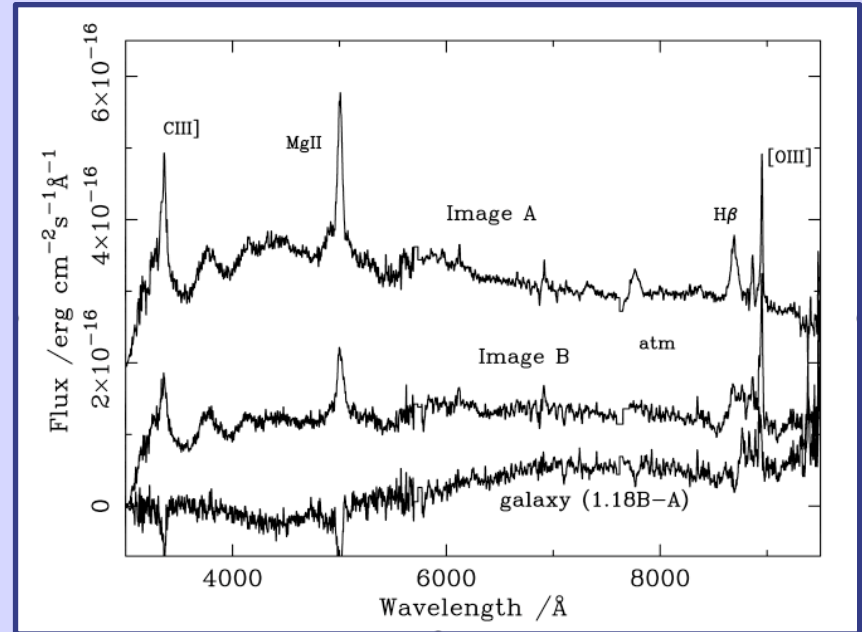
MUSCLES lens survey



Jackson et al 2008, 2009, 2012

SDSS median seeing 1.4"

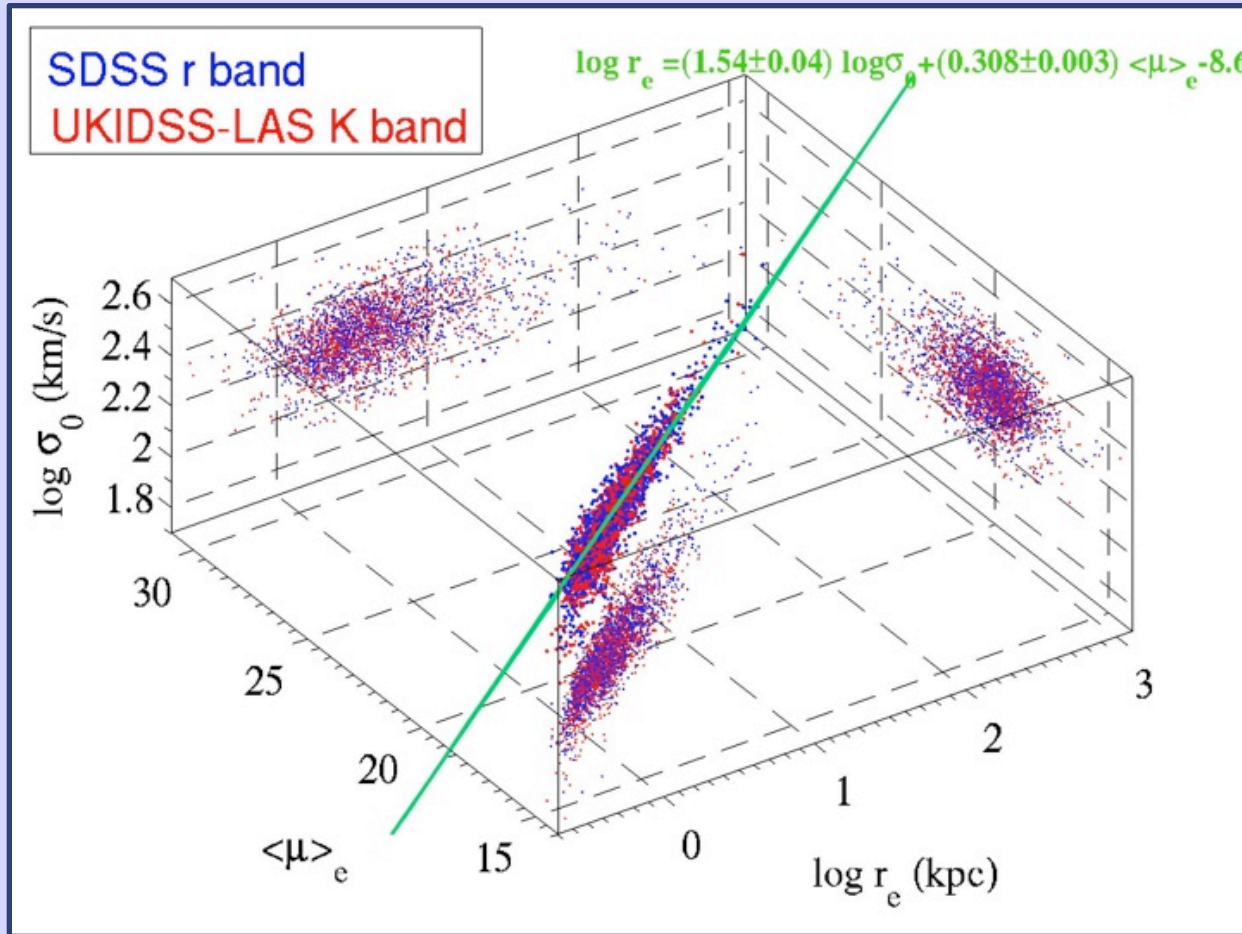
UKIDSS median seeing 0.9"



Joint UKIDSS-SDSS
search finds 6 new lenses
so far

final version could double
known lens systems to ~90

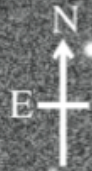
galaxy fundamental plane



Tilt of FP same in
IR and optical : not
due to stellar
population changes

La Barbera et al 2008

UKIDSS 2006 Nov 28

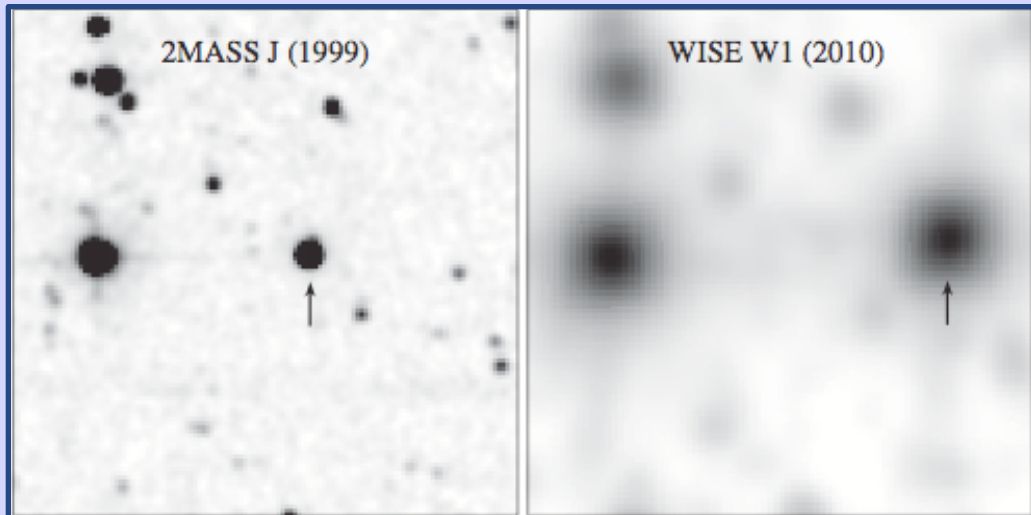


The nearest BDs

UGPS 0722-05

Lucas et al 2010 D=4.1pc
closest isolated brown dwarf

T=500K $L \sim 10^{-6} L_{\text{sun}}$



WISE 1049-5319

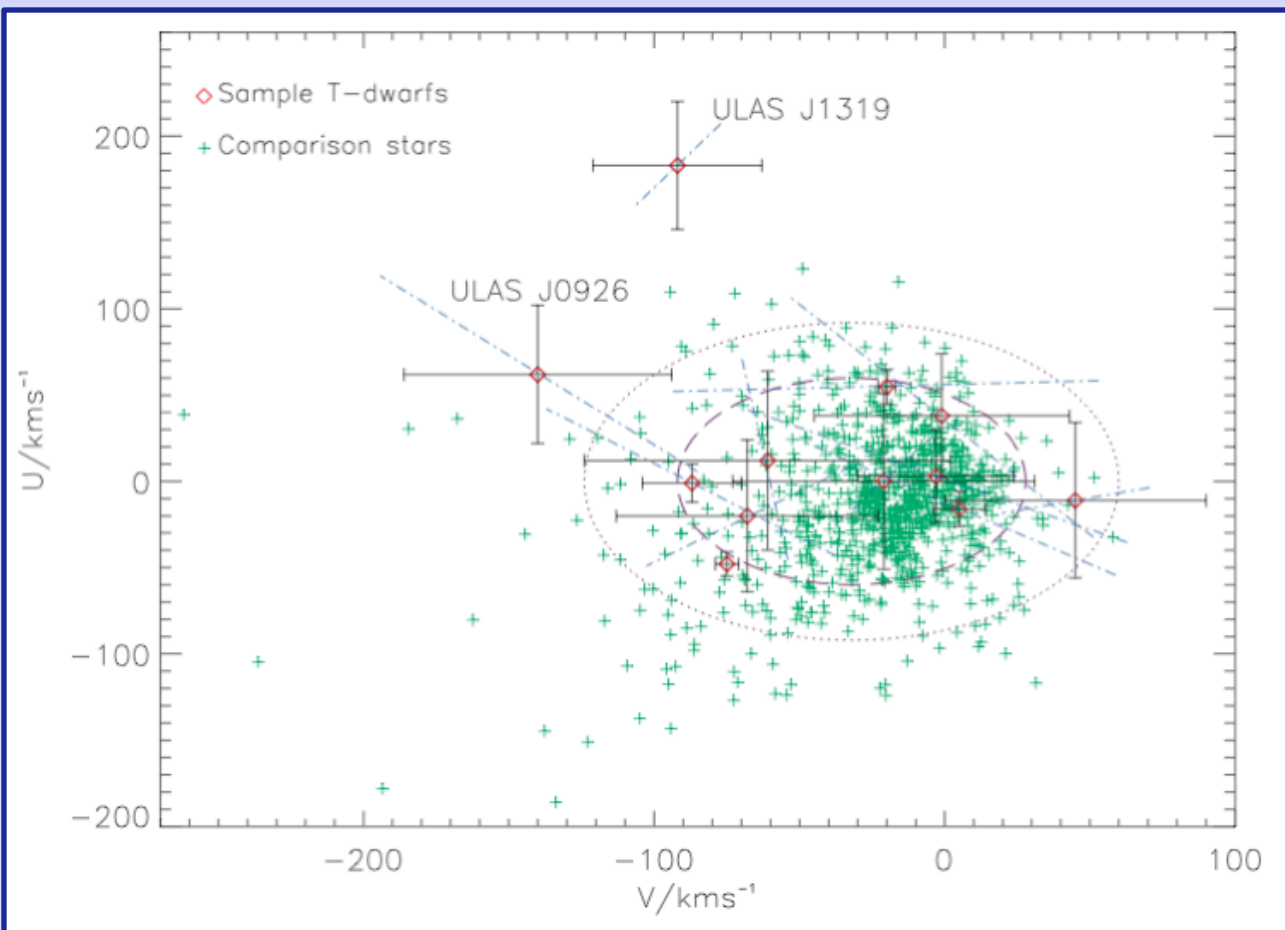
Luhman 2013 D=2pc

BD binary

third closest star

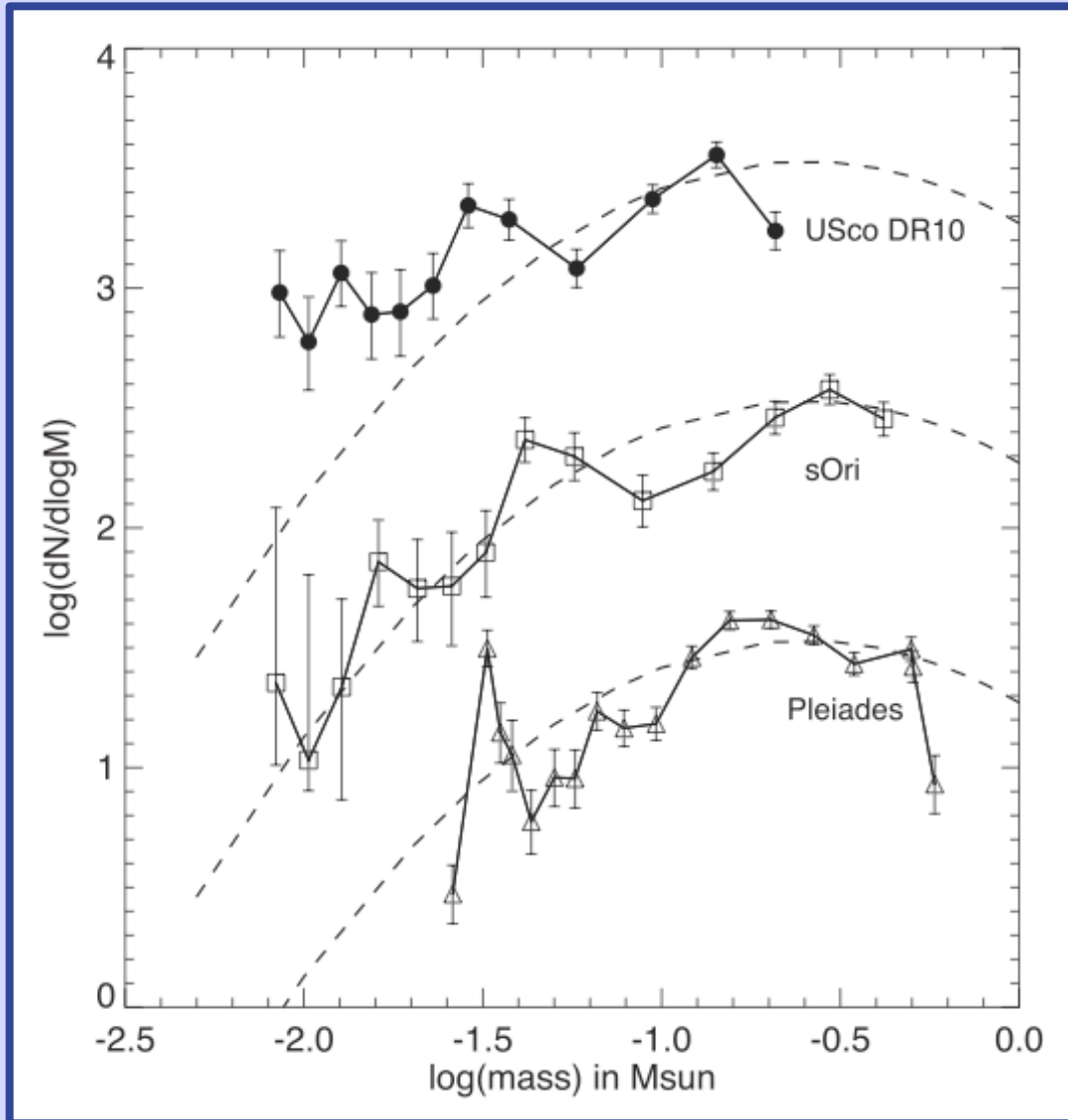
Halo brown dwarfs ?

Murray et al (2011)



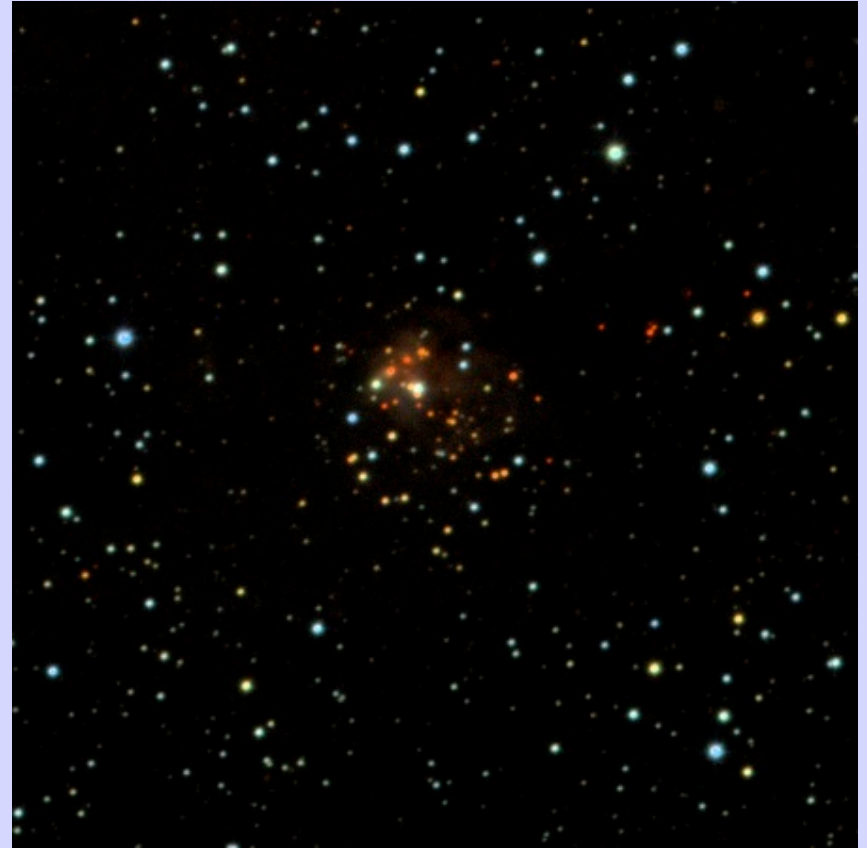
Selected as blue in H-K (so metal poor) with high proper motion

substellar mass function



excess of
brown
dwarfs in
Upper SCO?

New clusters in the Milky Way



Many tens of new clusters in GPS

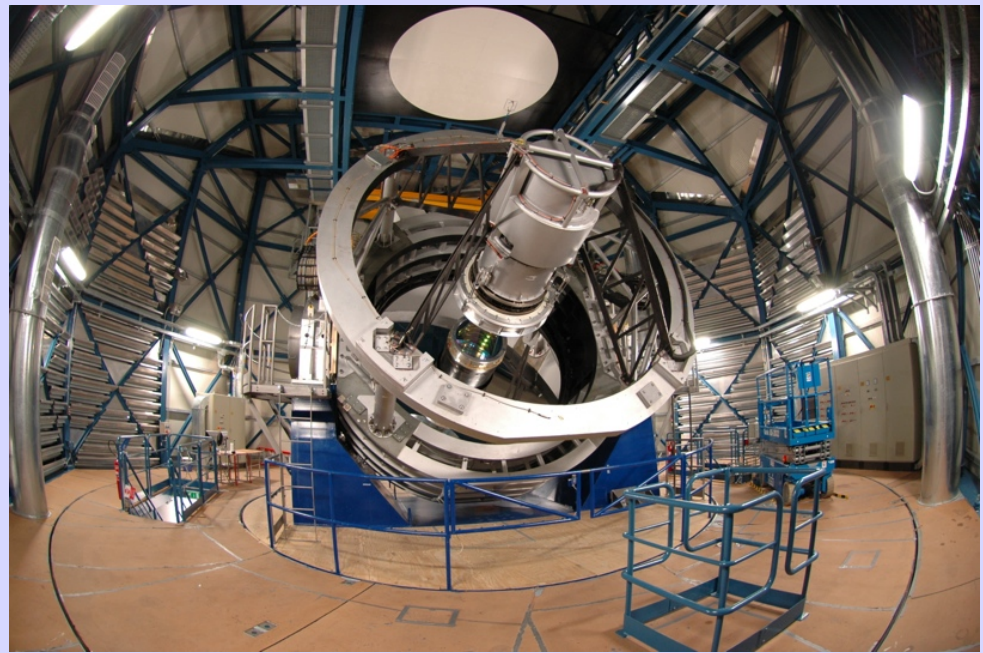
Solin et al 2013

Lucas et al in prepn



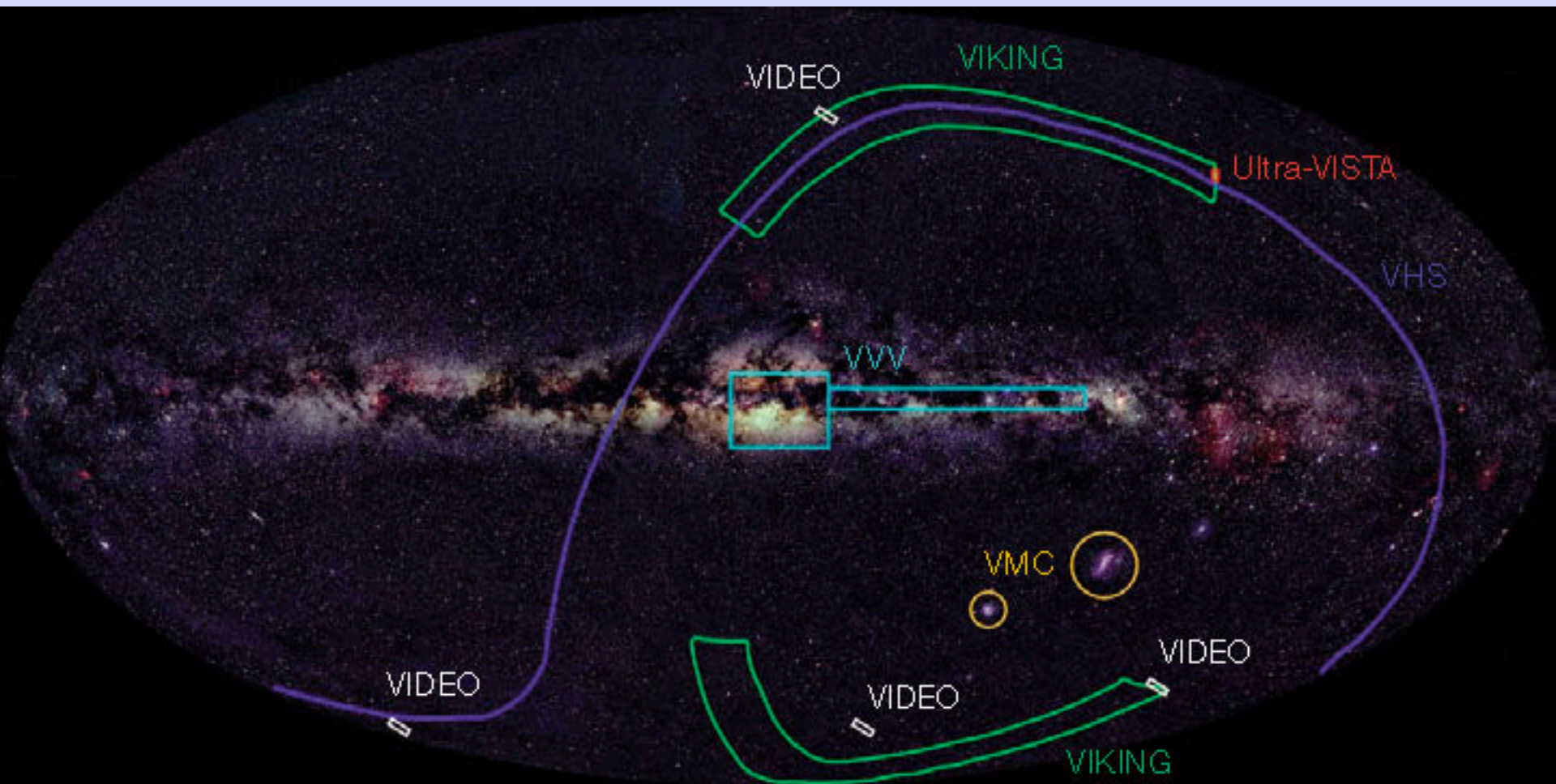
Recent Hits : VISTA

VISTA basics



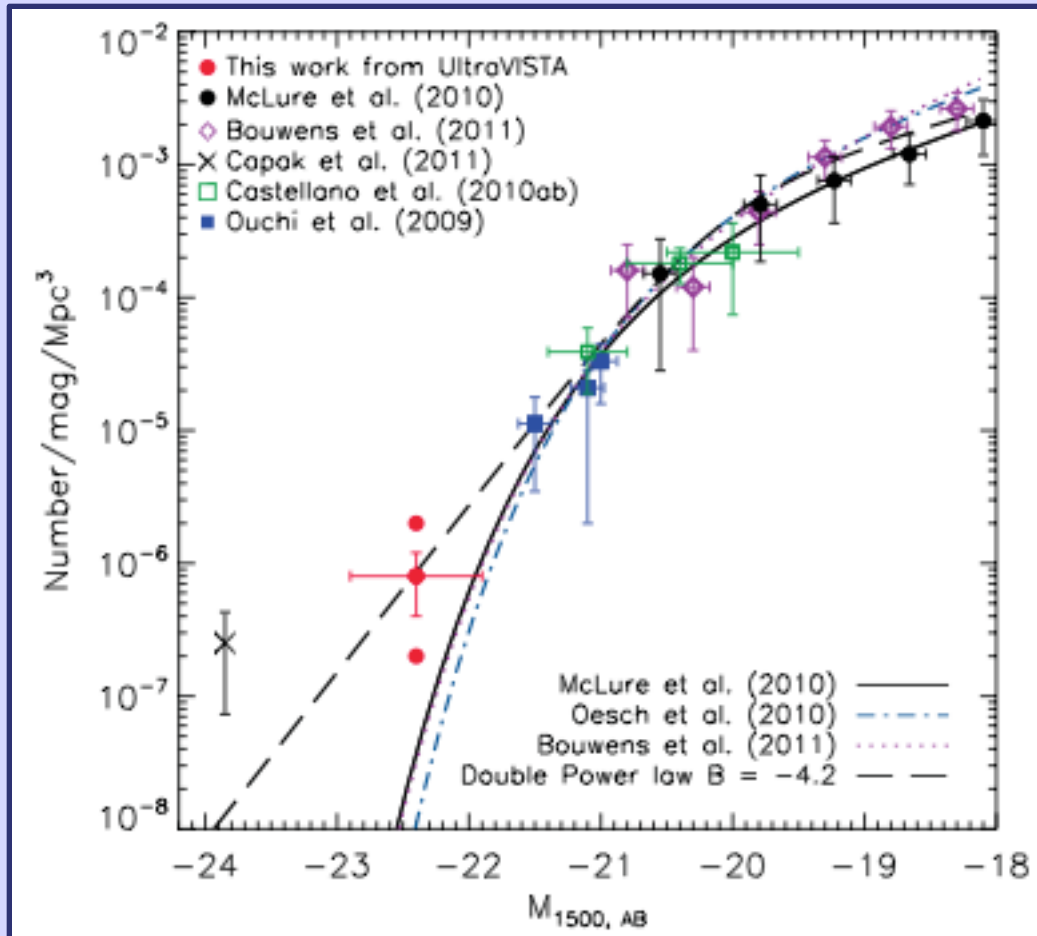
IR survey telescope $D=4.1\text{m}$
At ESO Paranal
Compact design
Field diameter 1.65 degrees
16 IR arrays

VISTA surveys



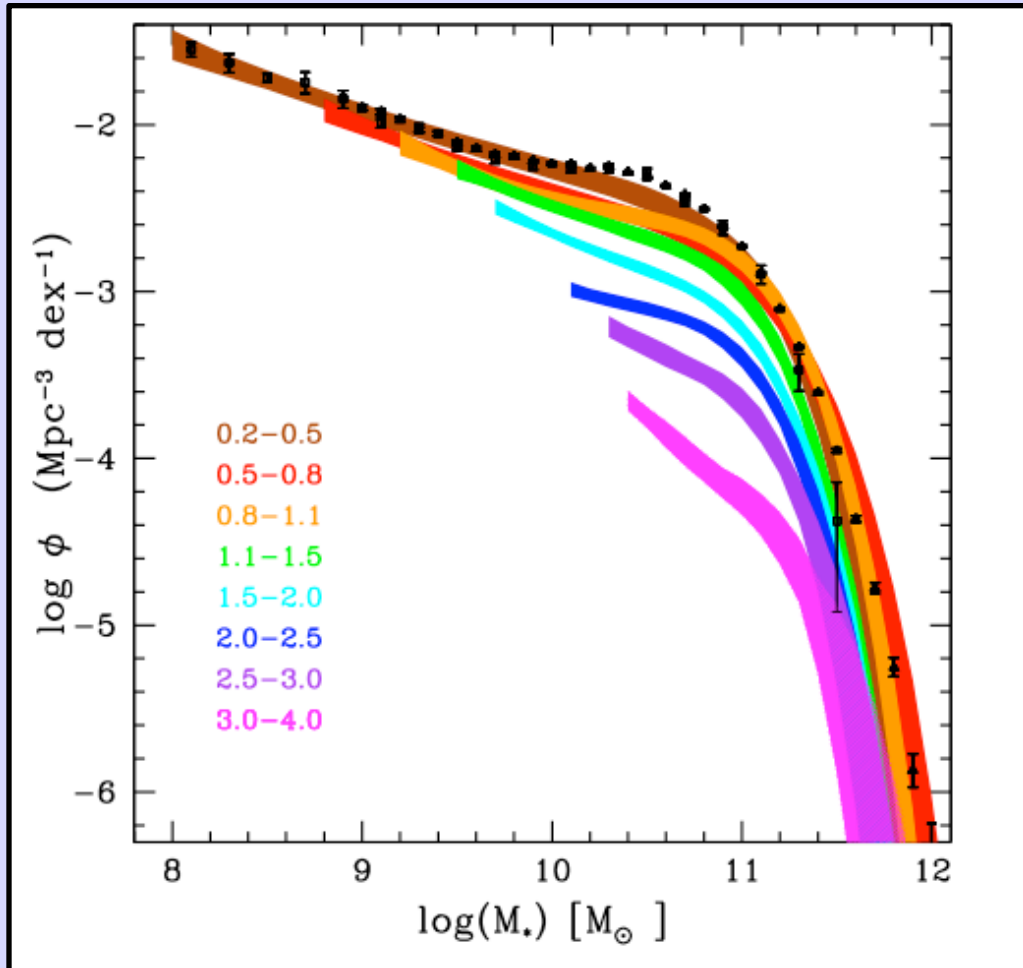
$z=7$ luminosity function

Bowler et al 2012



High-end luminosity function not consistent with Schechter function?

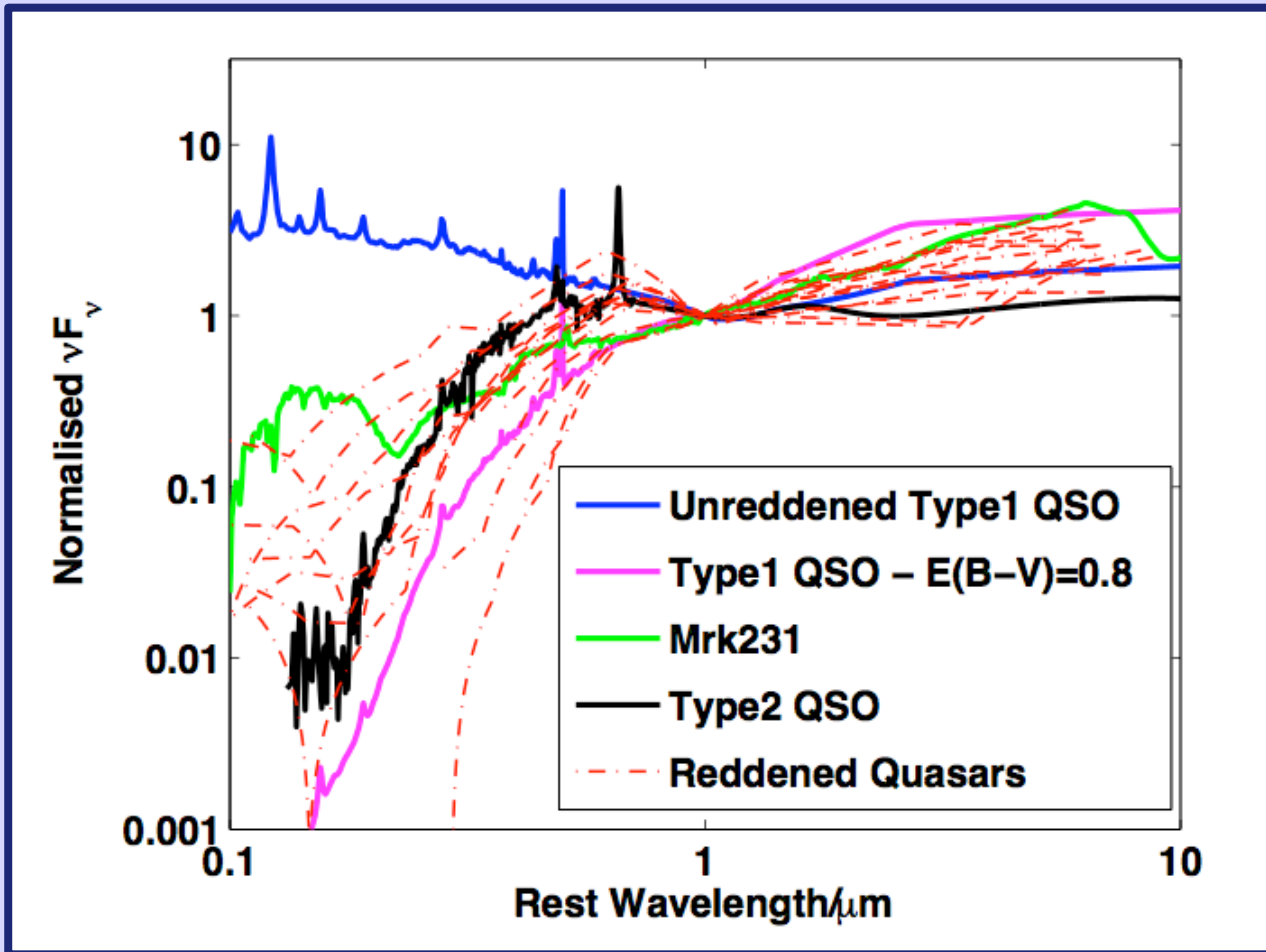
Evolution of galaxy mass function



Ilbert et al 2013

galaxy evolution
strongly mass
dependent

hyperluminous reddened quasars



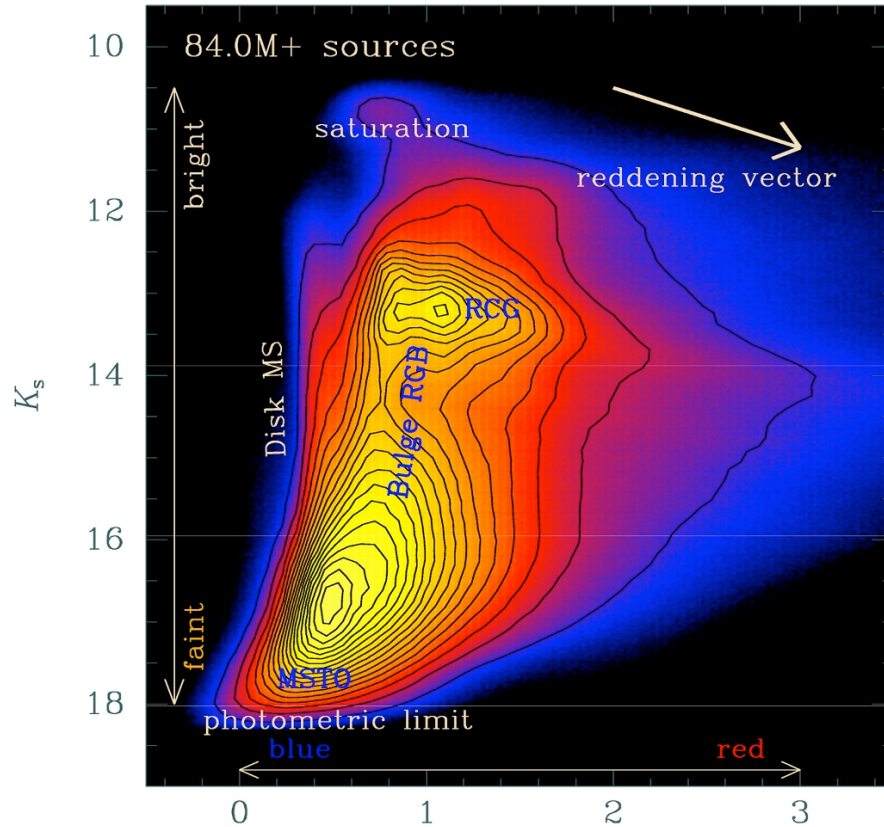
Banerji et al 2013

10^{47} erg/s at $z=2$
but invisible in
SDSS !

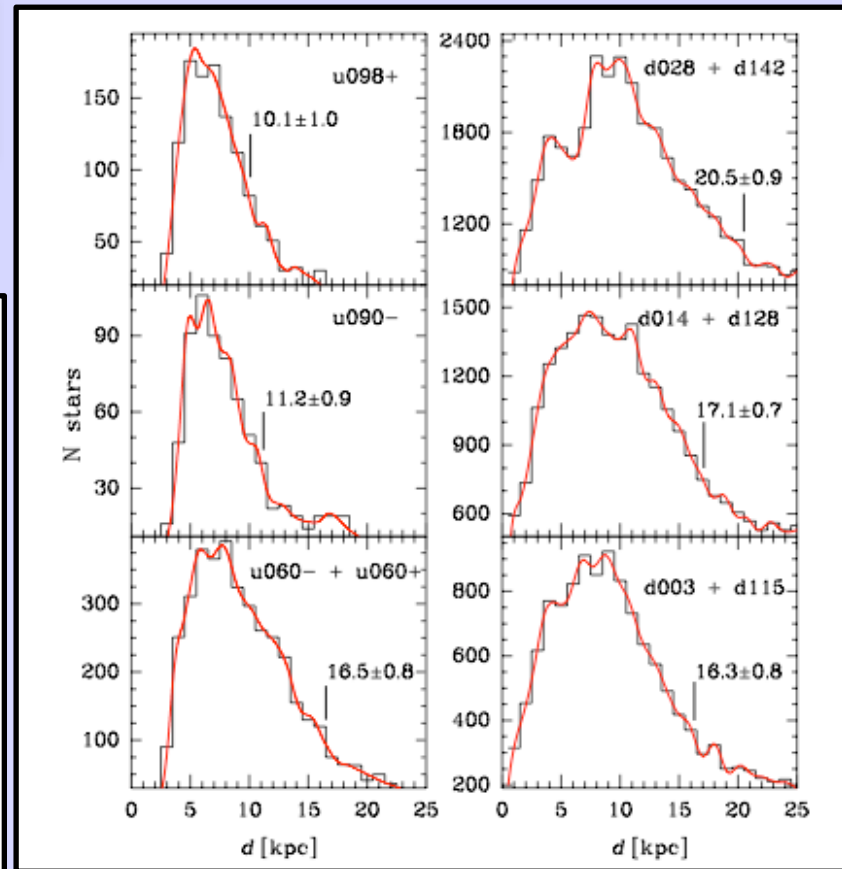
Galactic structure

Saito et al 2012

Stellar flag

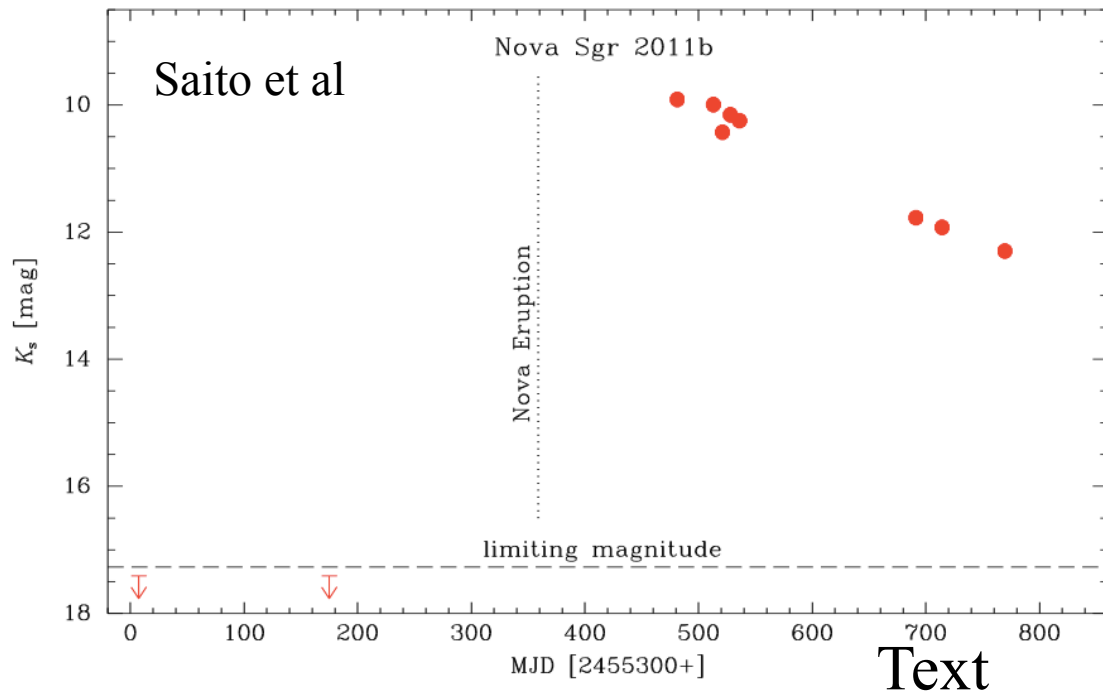


CMD for 84m stars^(J-K_s)

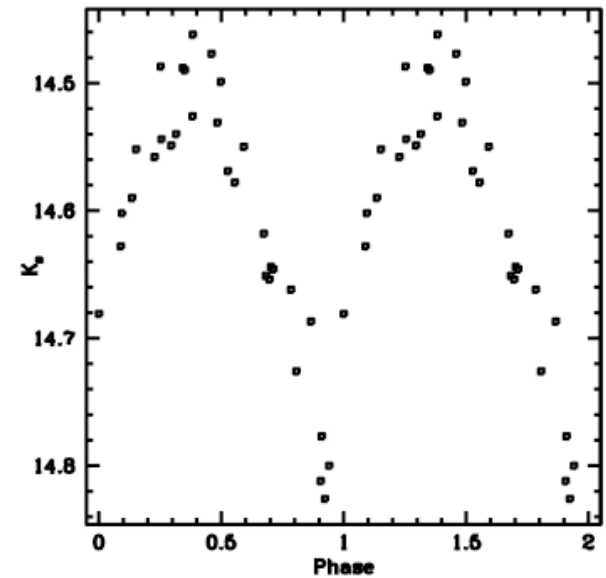
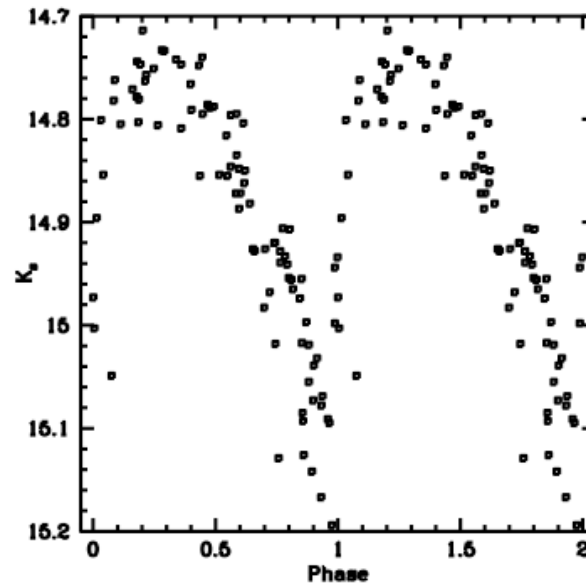


edge of disc
revealed using
clump giant stars as
distance indicator
(Minniti et al 2011)

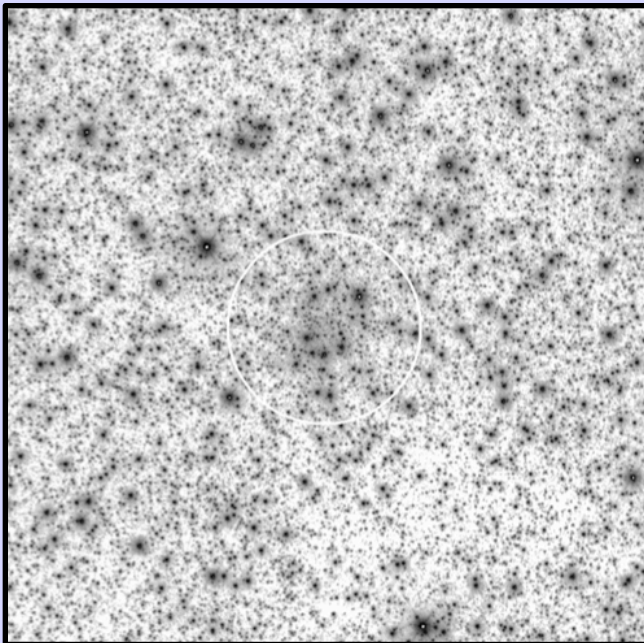
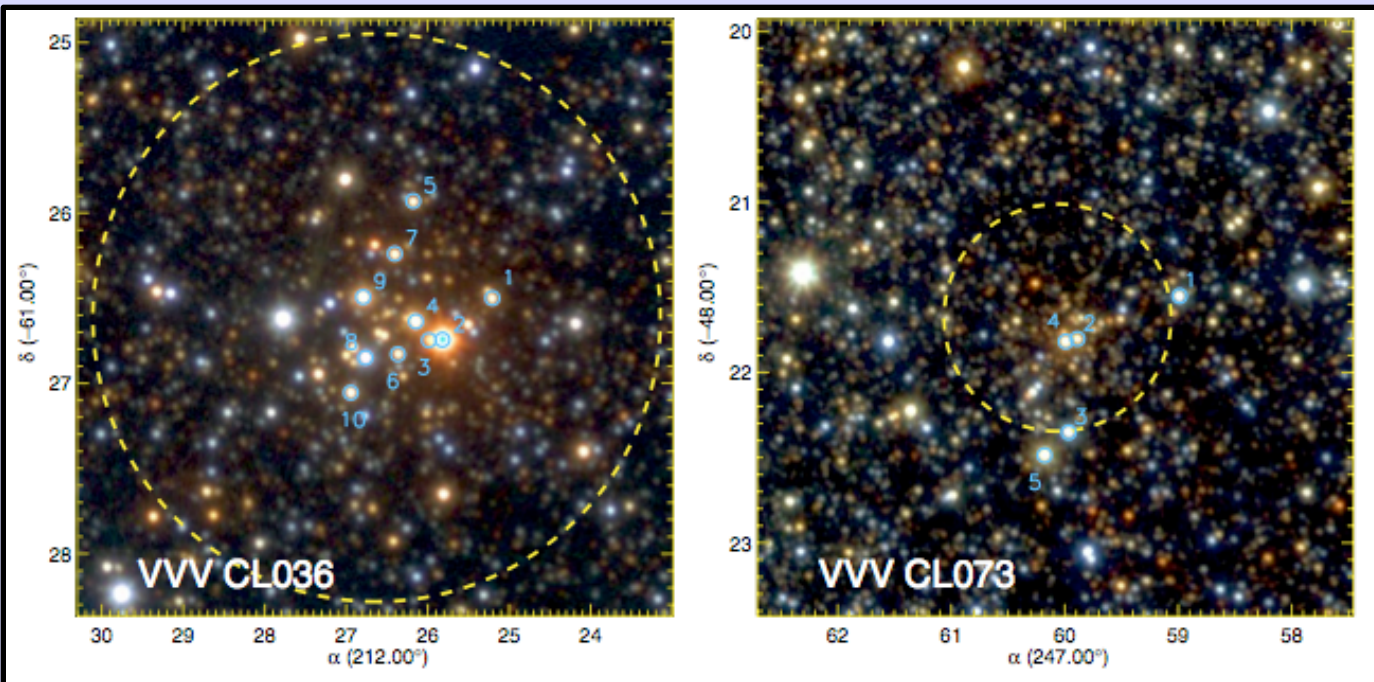
variable star search



New RR Lyraes
in globular
clusters
(Alonso-Garcia
et al 2013)



new clusters



96 new MW clusters
(Borrisova et al 2011)

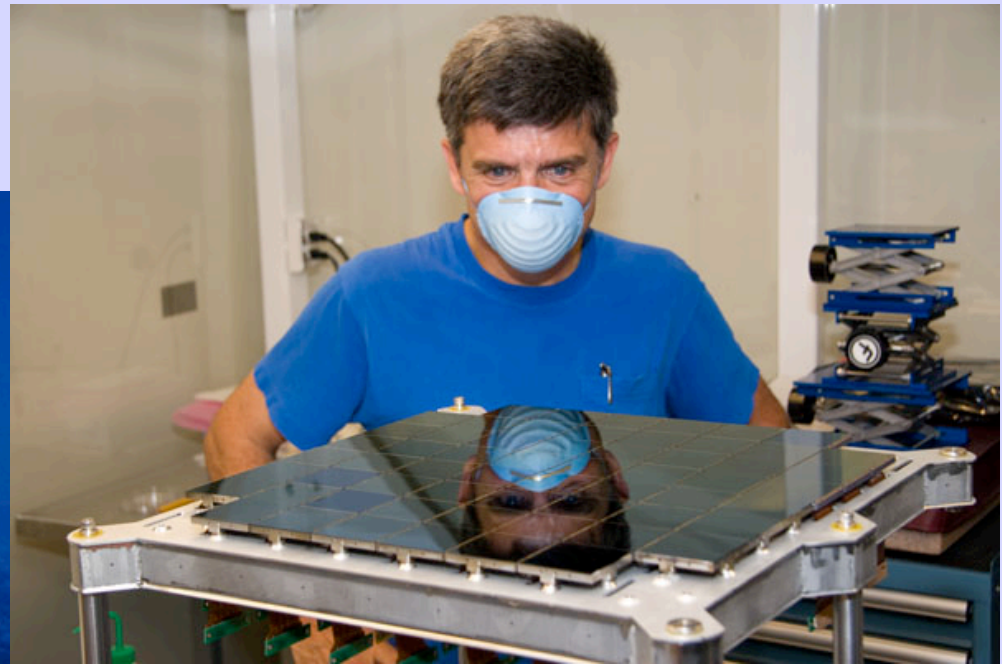
6 with new Wolf Rayet stars
(Chene et al 2012)

3 new globulars behind plane
(Moni Bidin et al 2013)



Recent Hits : PanSTARRS-1

PanSTARRS-1



- 1.8m telescope on Haleakala
- Gigapixel camera
- *grizy* filters
- 7 sq.deg. FOV
- Prototype for PS-4
- Built by Univ.Hawaii
- operated by PS1SC
- funded to Dec 2013

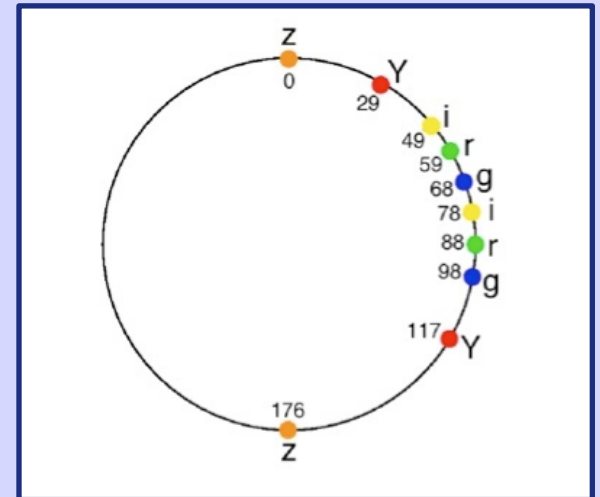
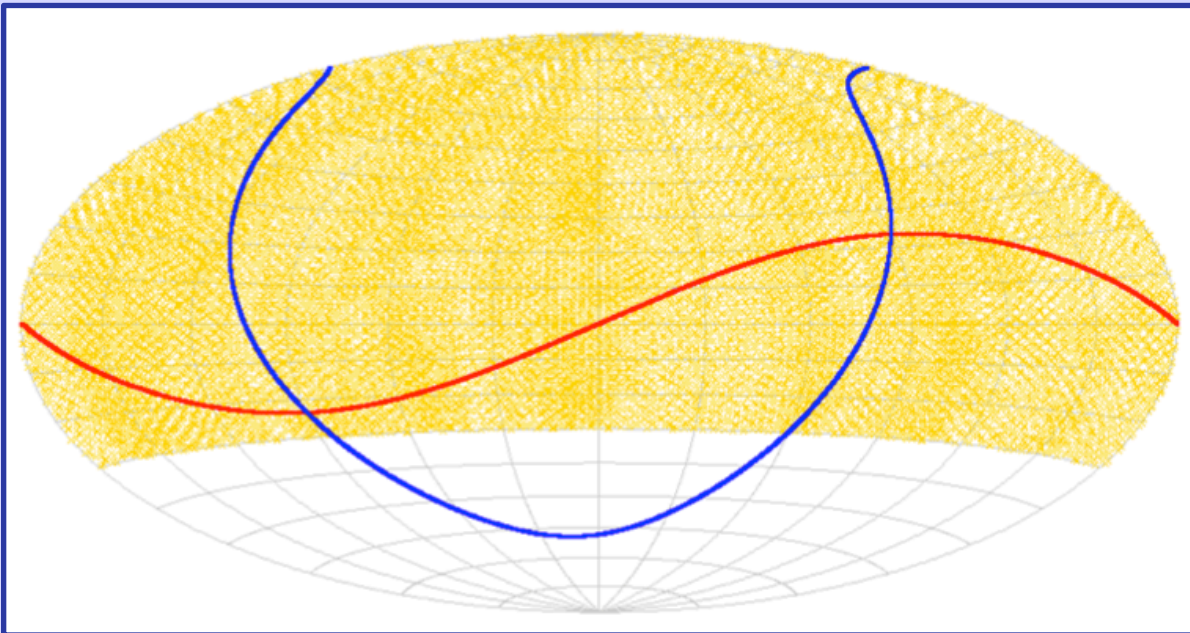
Pan-STARRS
PS1 Science Consortium

PS1 consortium members

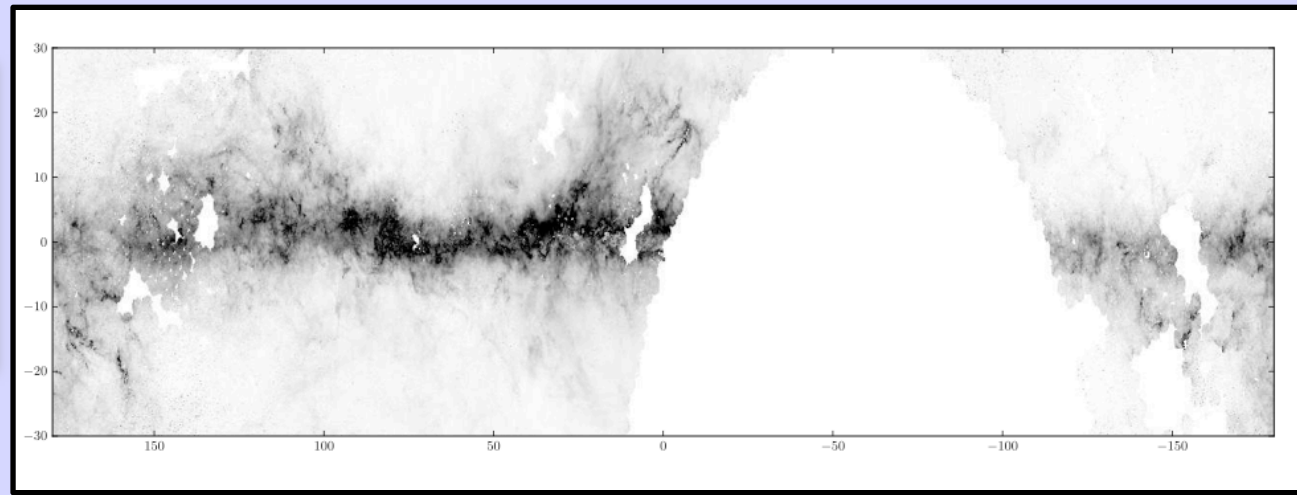
UNIVERSITY OF HAWAII
JOHNS HOPKINS UNIVERSITY
DURHAM UNIVERSITY

Survey

- 12 Medium Deep Survey fields : four day cadence
- $g \sim 25$ per epoch; eventual $g \sim 27$
- 3π survey *grizy* 4 times/yr; 20 visits/yr in some filter
- $g \sim 22$ per visit ; eventual $g \sim 24$
- seeing : mode 1.0" median 1.25"
- **public release 2014 through MAST/STScI**

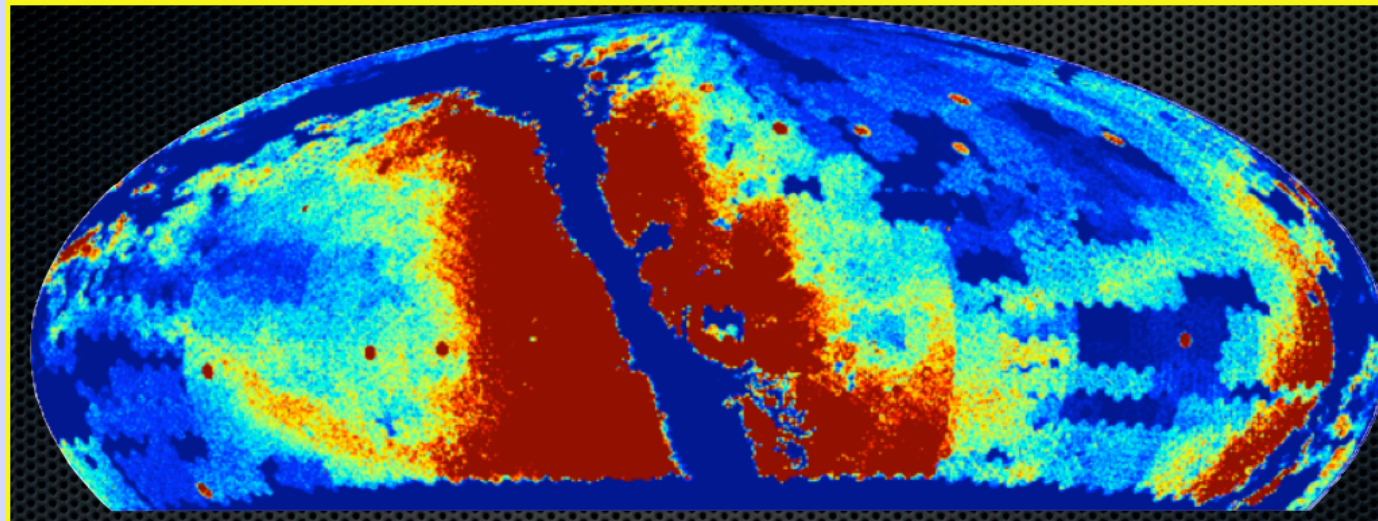


Galactic Science



3D dust map
(Schlafly et al)

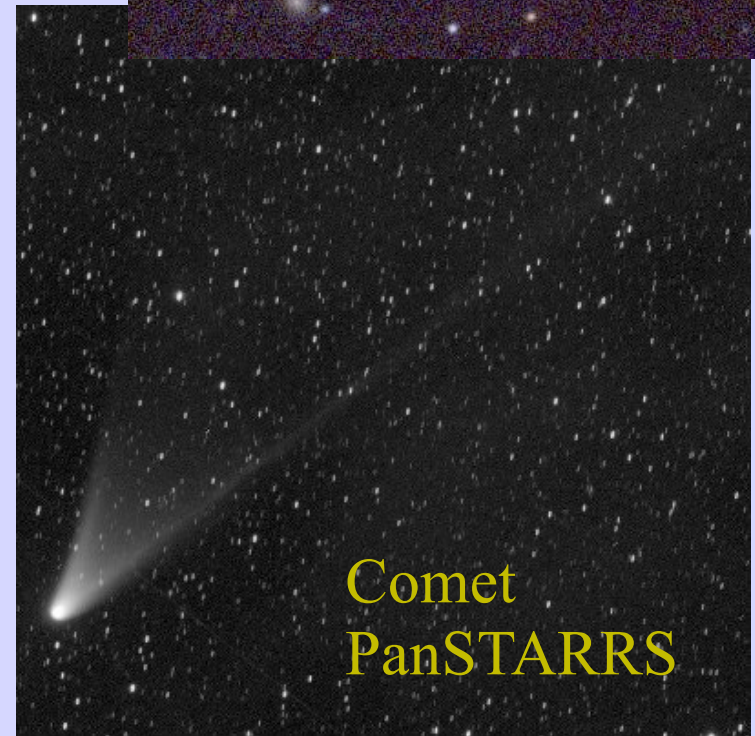
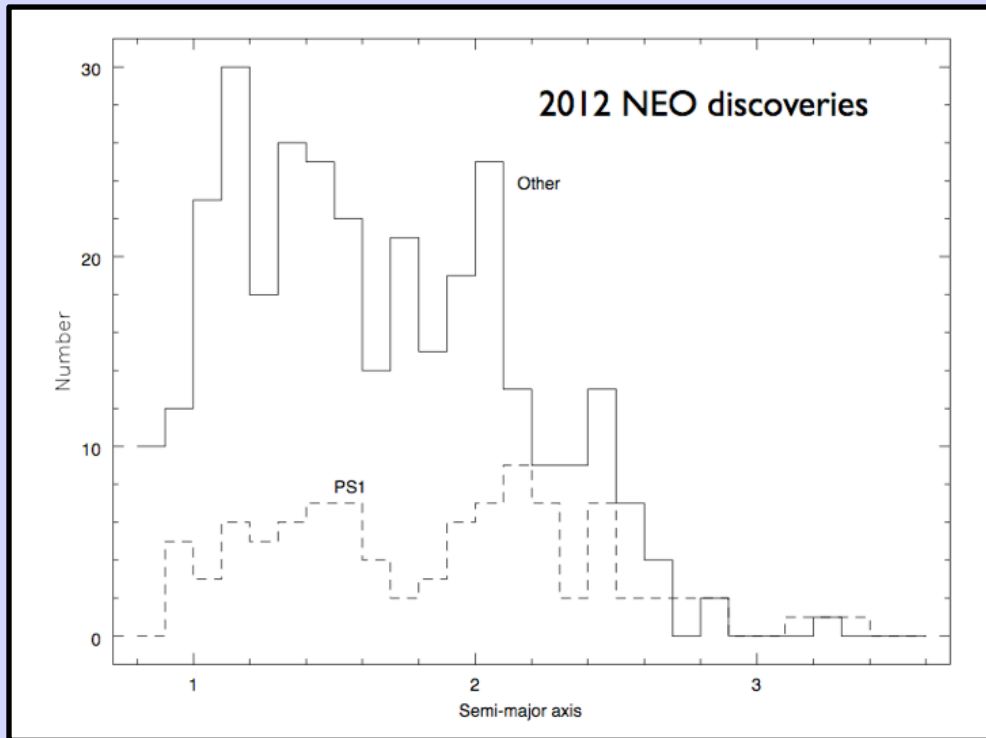
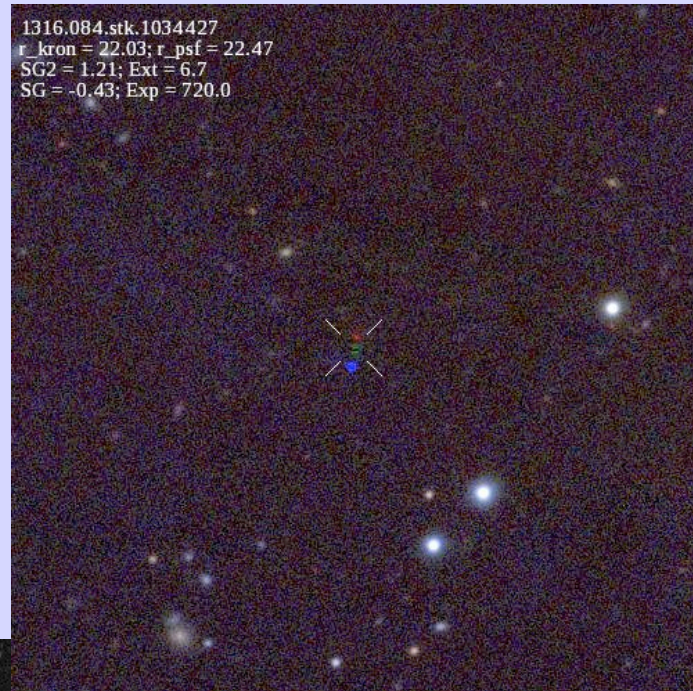
Sag. star stream
(Slater et al)



Solar System Science

asteroids
detected from
back to back
exposures

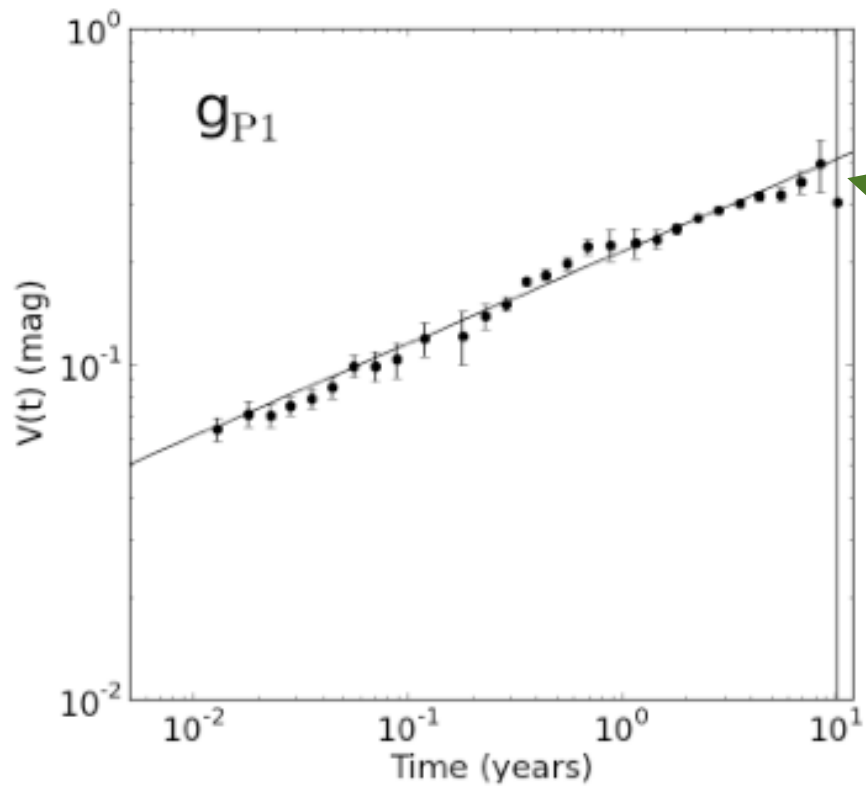
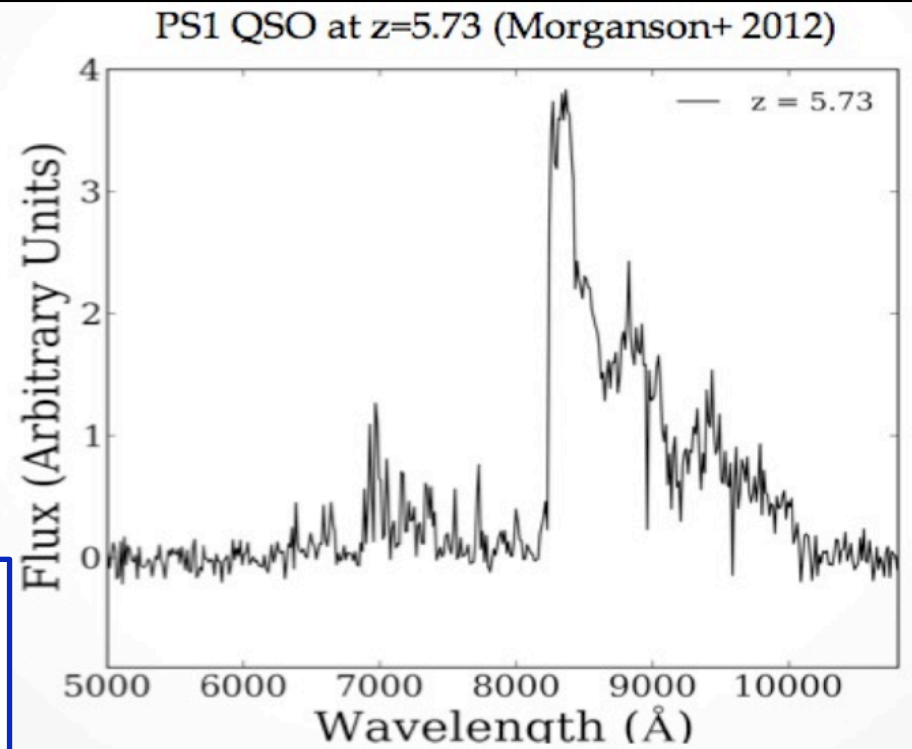
1316.084.stk.1034427
r_kron = 22.03; r_psf = 22.47
SG2 = 1.21; Ext = 6.7
SG = -0.43; Exp = 720.0



dominating large NEO
discovery

Comet
PanSTARRS

Quasars

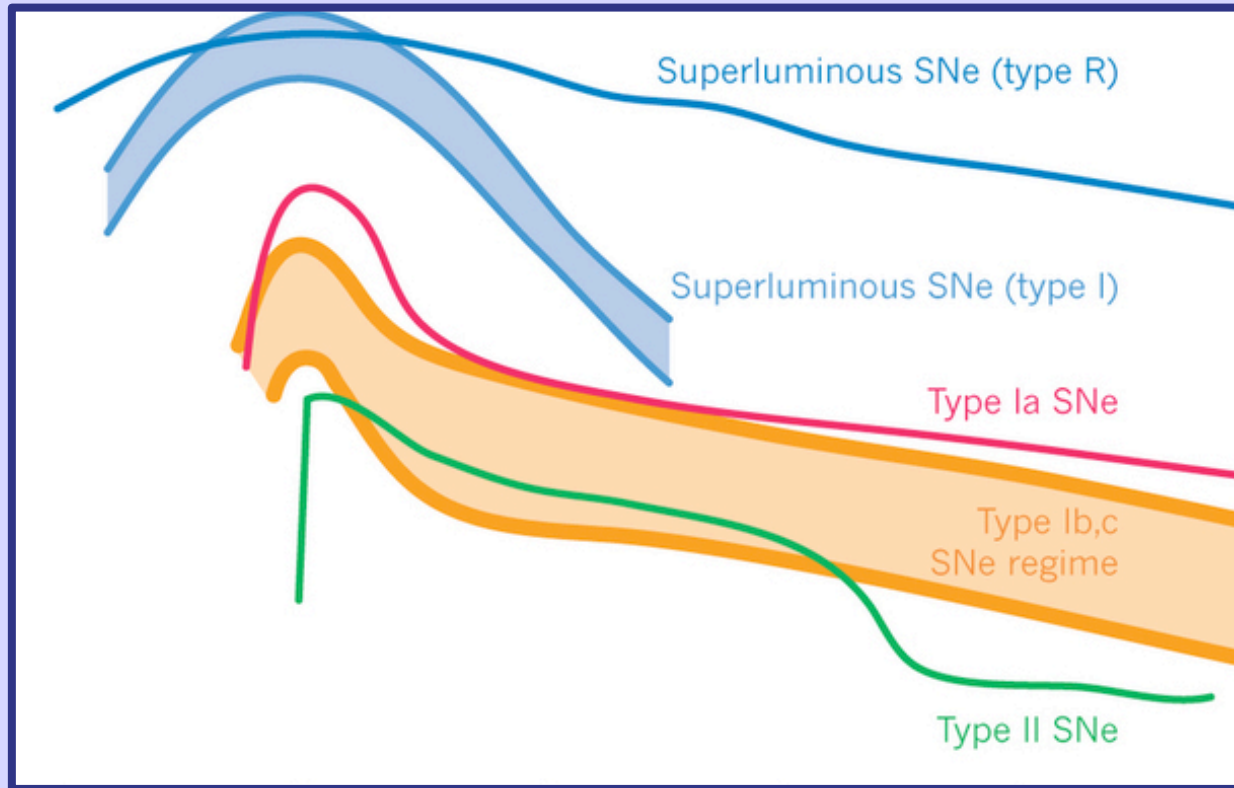


need longer to test flattening

Structure function for several thousand quasars (Morganson in prepn)

Ultraluminous Supernovae

Pastorello et al. 2010,
Chomiuk et al. 2011,
Beger et al. 2012, Nicholl
et al. (2013 subm)



First discovered in
Texas Supernova
search

Many more examples
in PS1 as far as $z=1.5$

Explosions in dwarf galaxies
100 times more luminous than core-collapse SNe.
Luminosity source unknown

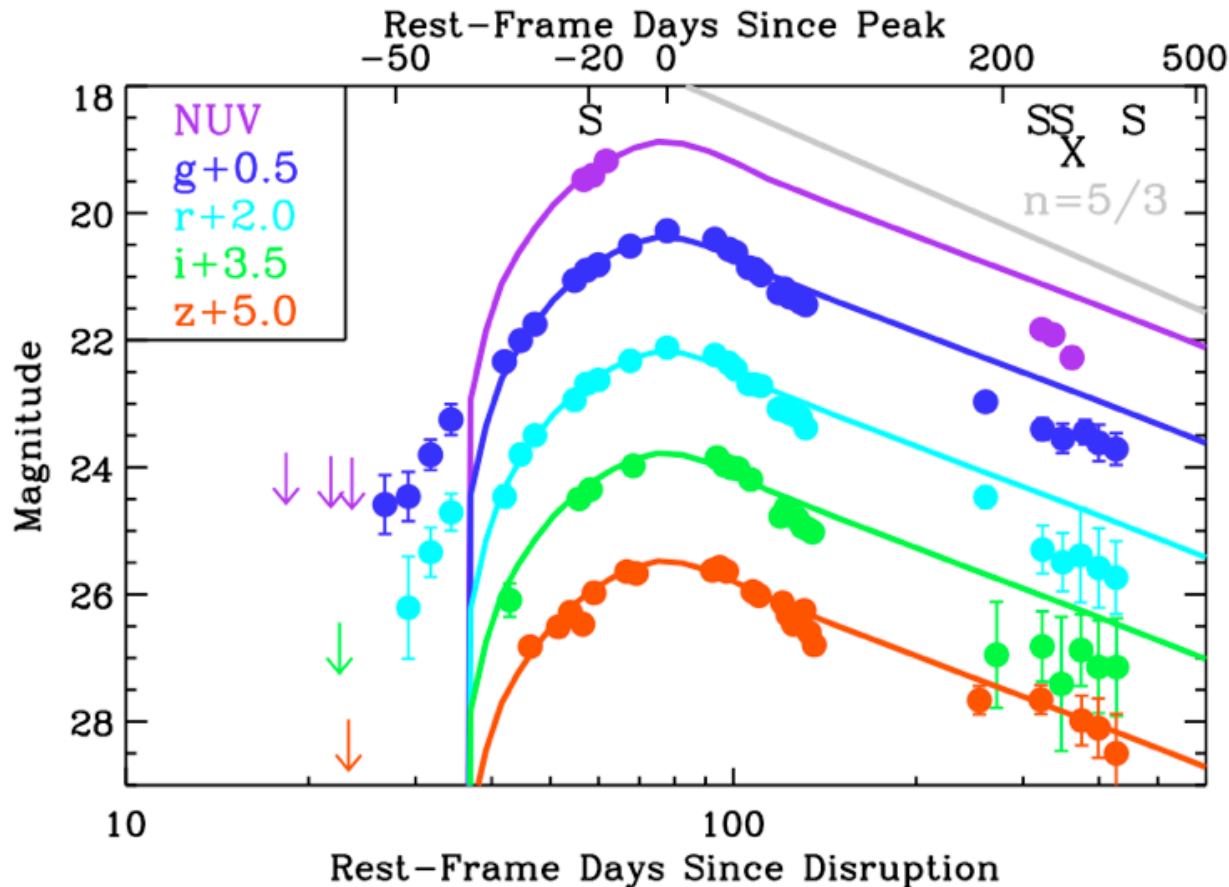
Tidal Disruption Events

PS1-10jh
best Tidal
Disruption
Candidate so far

**First clearly
detected rise**

Spectrum with
only He emission

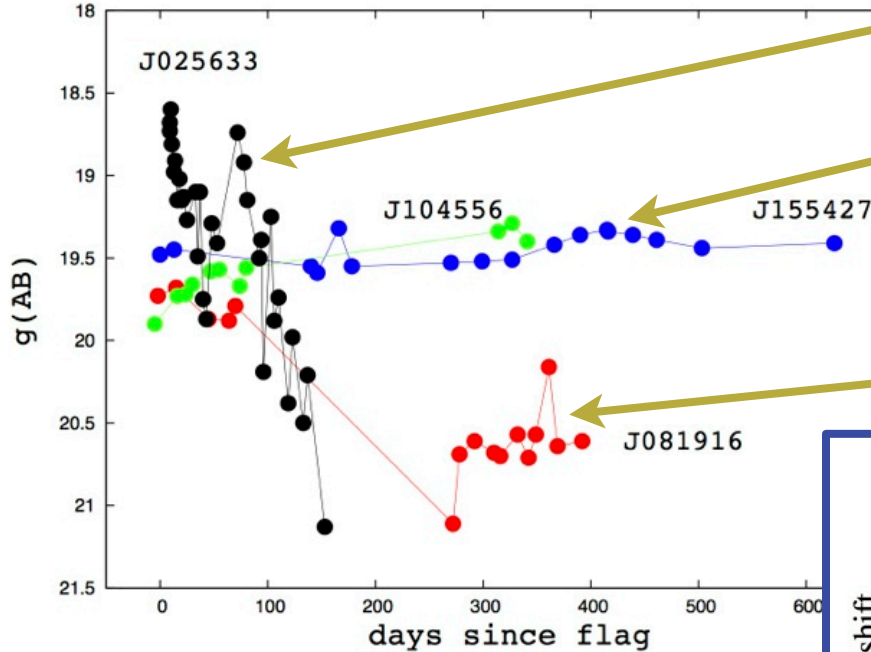
Disruption of a
single Helium
rich star?



Nuclear transients

PS1+LT

Lawrence et al in prep



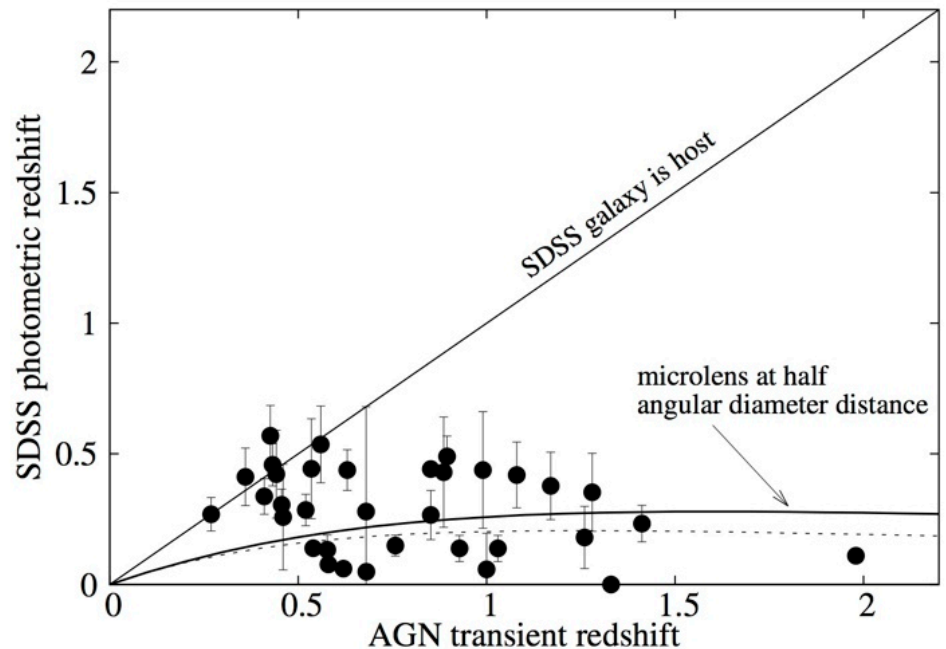
probable blazar

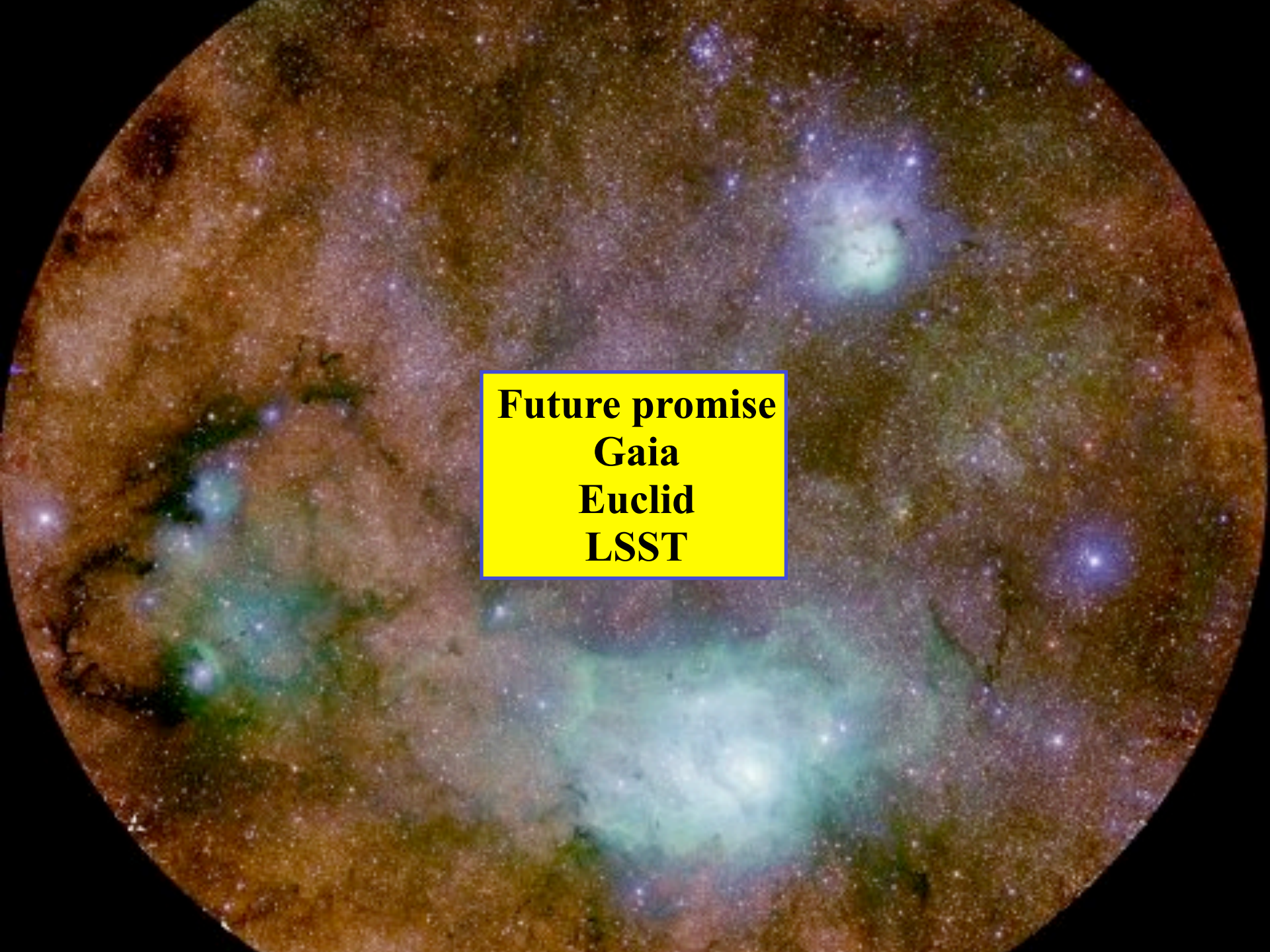
New class of slow blue transient : amplitude x 10-30

Nuclear Supernova

Transients are quasars at $z \sim 1$
Existing galaxies photo- $z \sim 0.3$

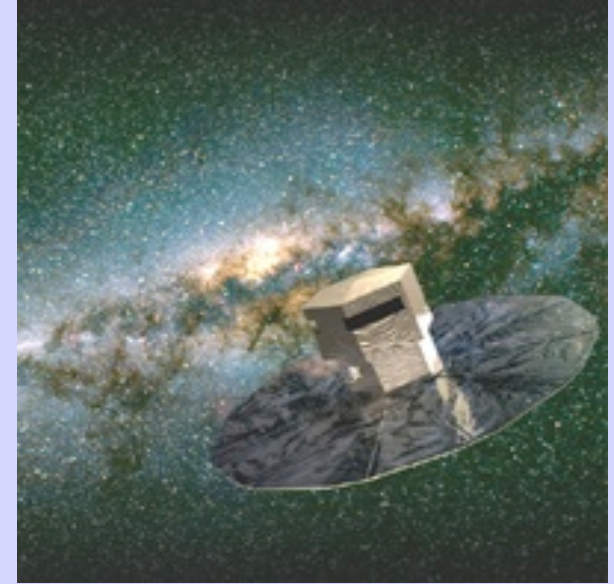
probably rare extreme
microlensing events



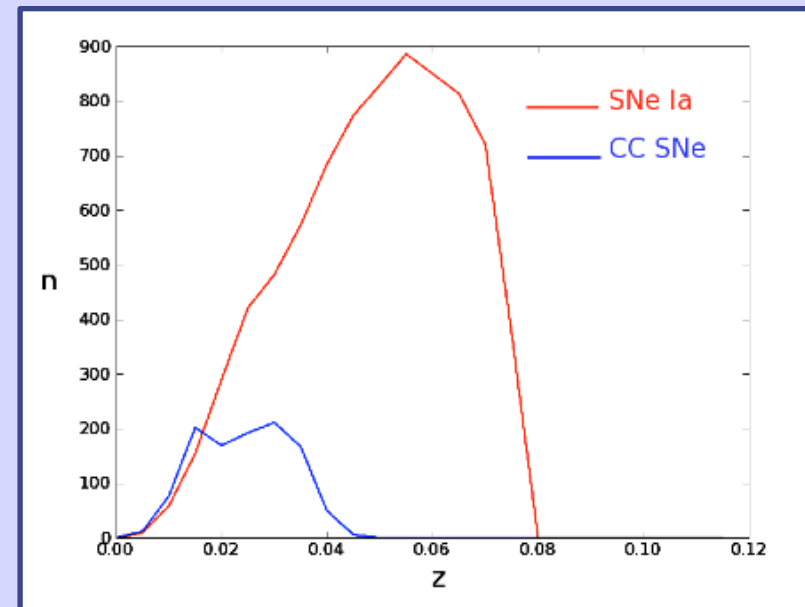


Future promise
Gaia
Euclid
LSST

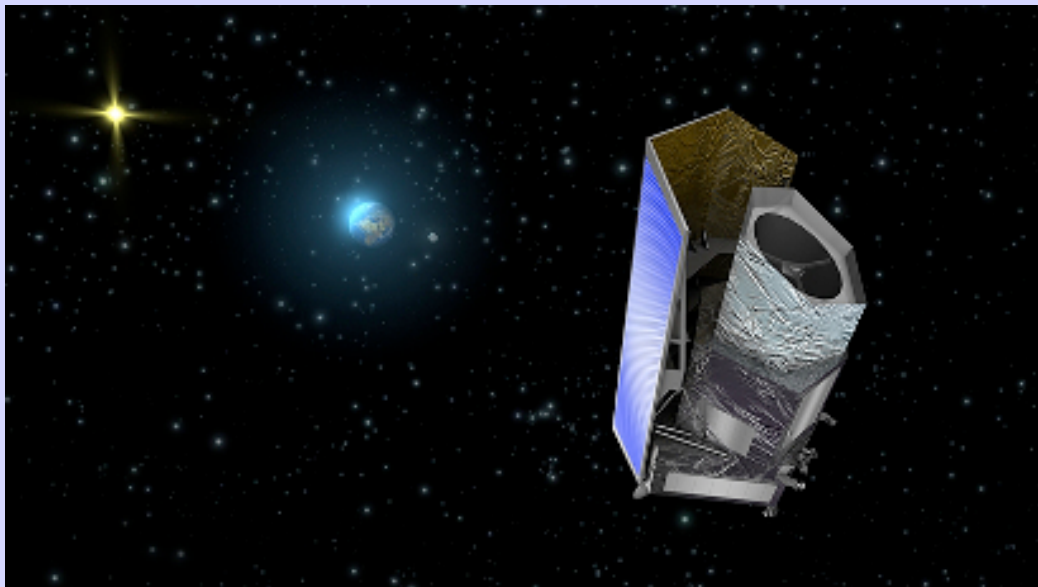
Gaia : launch October!



- centroiding to $10\mu\text{as}$
- everything moves
==> the Galaxy in 3D
==> watch external galaxies rotating
- Also a transient machine
expect several SNe/day



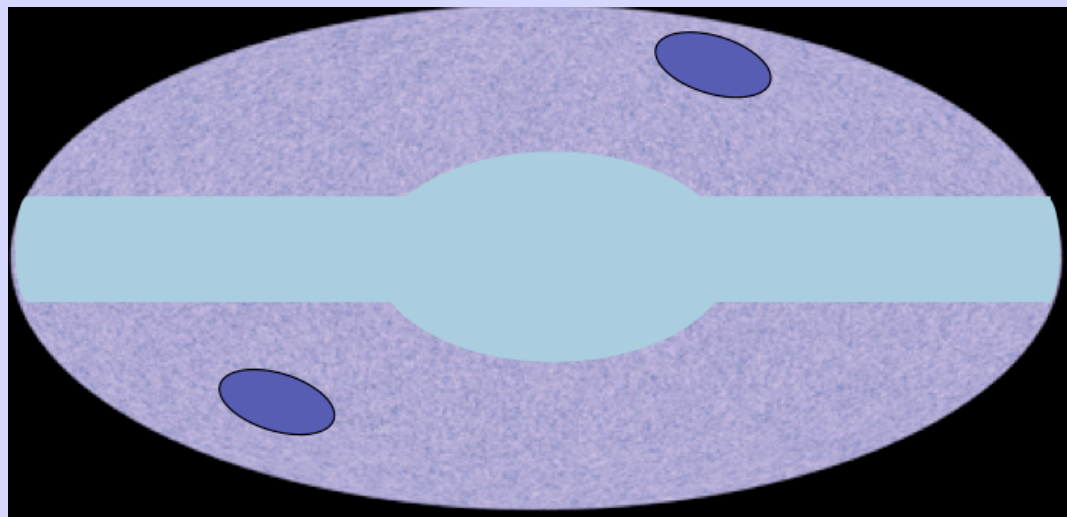
Euclid : 2020



1.3m space telescope
L2 orbit; 6 year mission
0.18 arcsec PSF
0.5 sq.deg FOV
VIS and NIR channels
NIR low-res spec

Wide Survey : 15,000 sq.deg
AB~24.5

Deep Survey : 40 sq.deg
AB ~29



Euclid science

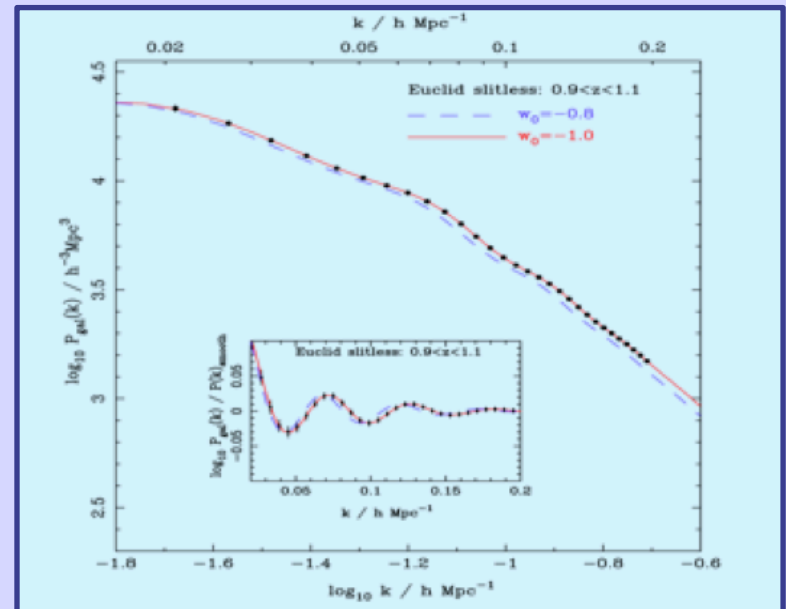
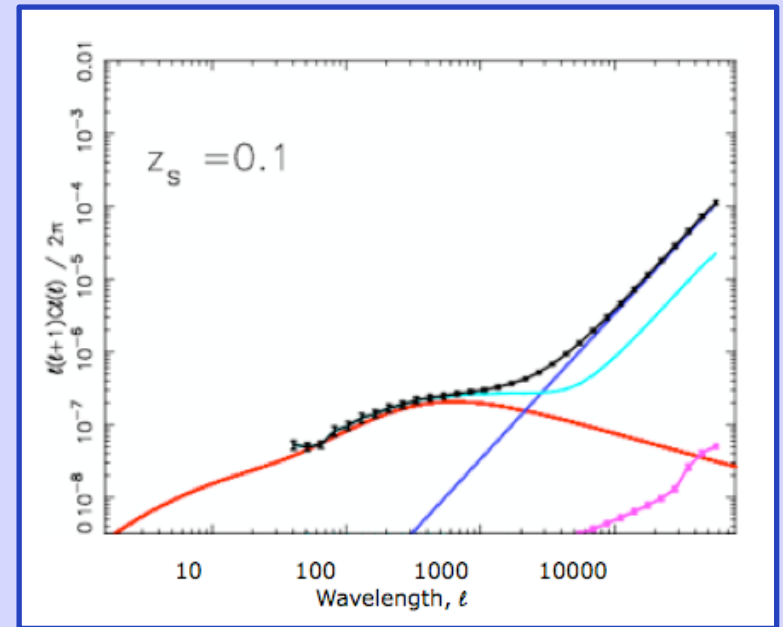
Primary science :

weak lensing 3D dark matter map
galaxy clustering power spectrum

Legacy science :

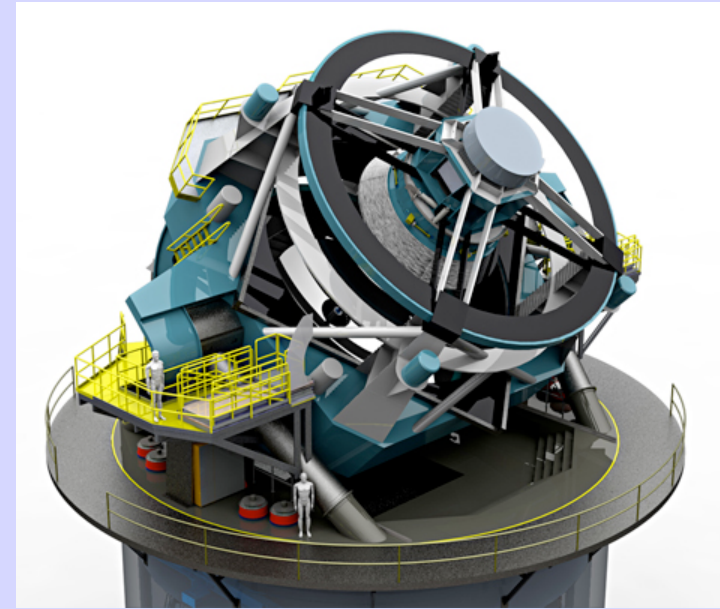
$z > 7$ quasars and galaxies
Near-field cosmology
Strong lensing

... transient science ?



LSST basics

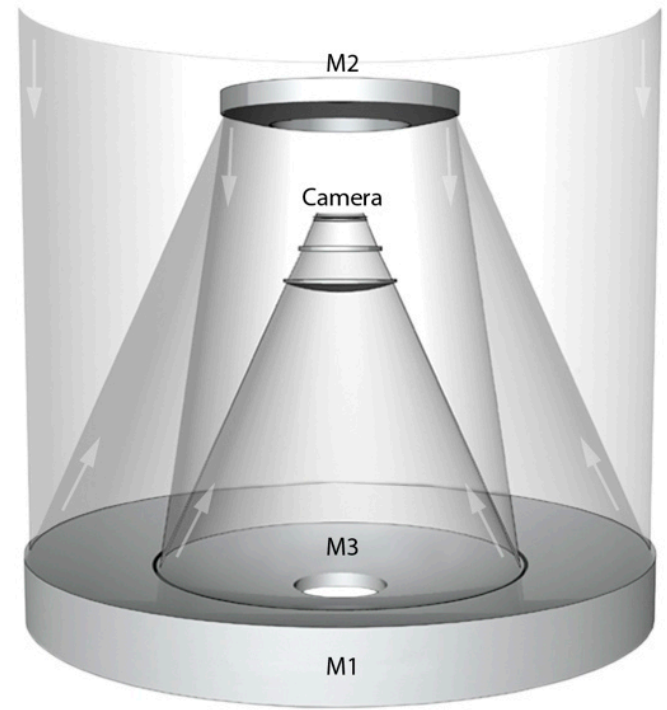
- US project
- $D=8.4\text{m} / 6.5\text{m}$ effective
- $\text{FOV} = 10 \text{ sq.deg.}$
- u g r i z y
- Cerro Pachon
- Ten year programme
- Capital cost \$665M
- Operations \$37M/yr



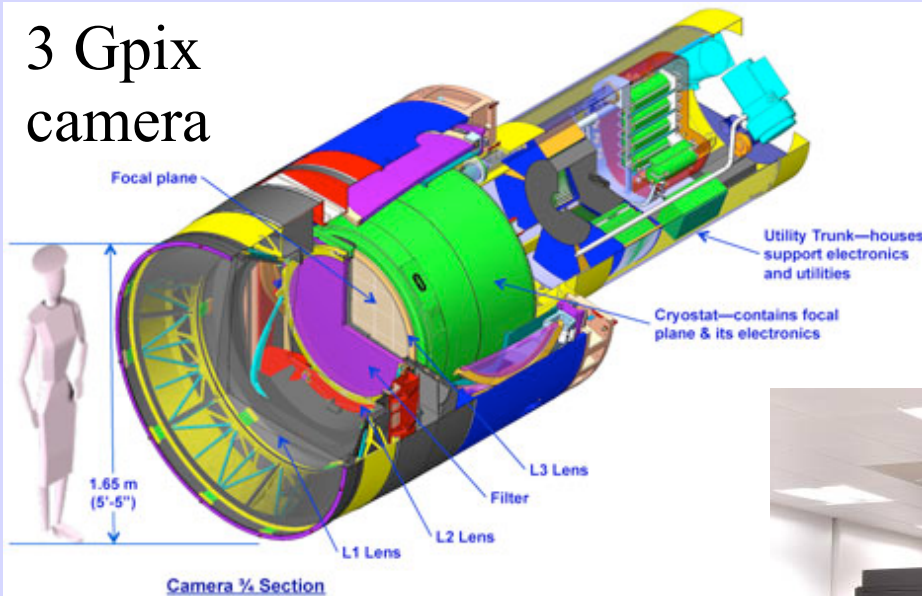
*a movie of the sky
with an 8m-class
telescope*

key features

3-mirror design for wide field



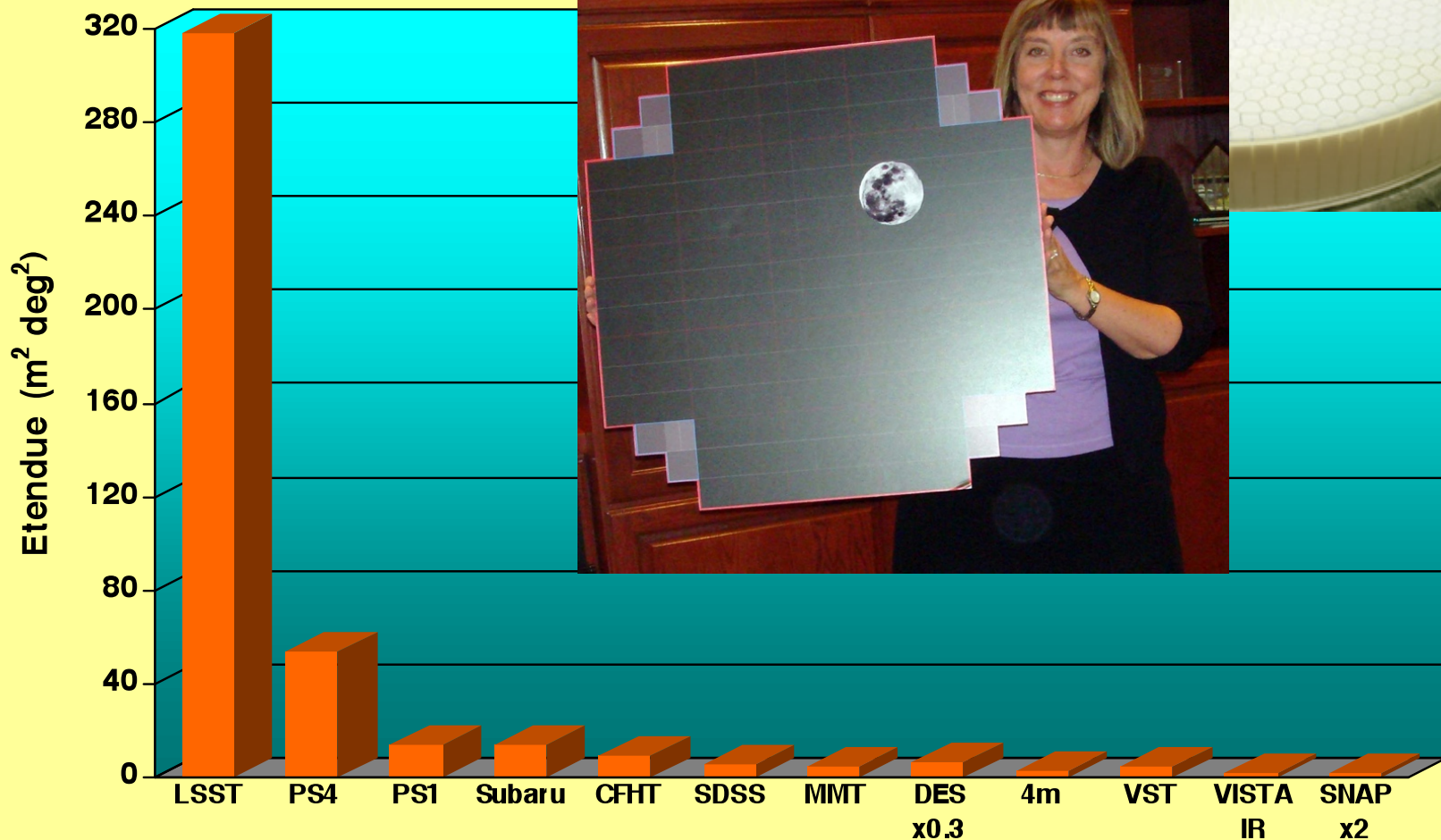
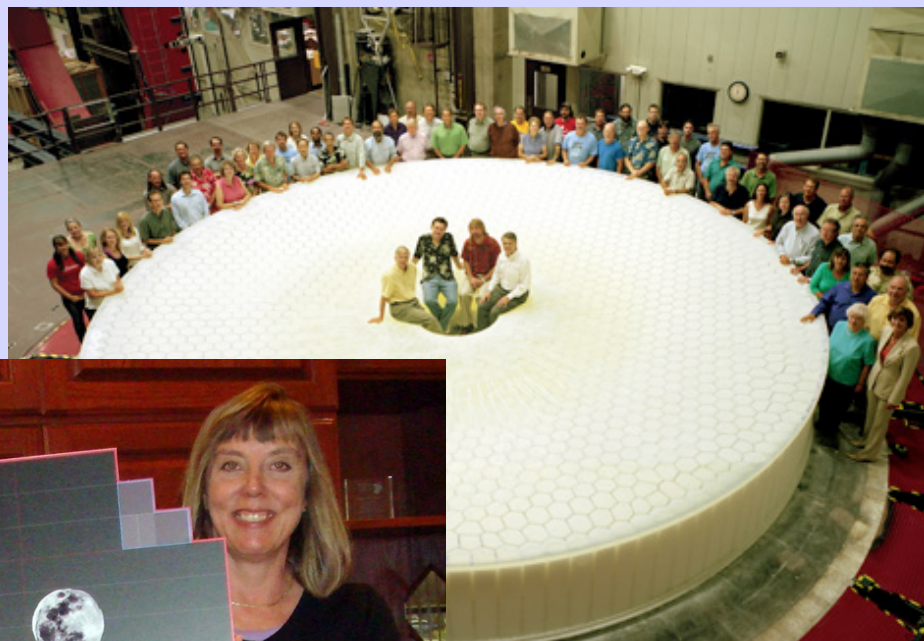
3 Gpix camera



serious approach to data processing and user tools



large mirror
+ large detector
means large grasp



Science impact

- 10^{10} stars, 10^{10} galaxies
- Photo zs for 3×10^9 galaxies
- 250,000 SNe/yr
- Orbits for 10^5 NEOs and 10^5 Trojans
- Gaia-quality PMs – 4 mags deeper
- Light curves for 2×10^6 low-z quasars
- 1000 quasars with $6.5 < z < 7.5$
- ...etc etc etc...
- plus The Transient Unknown

survey plan

Deep-Wide Survey : 18,000 sq. deg
pair of 15 sec exposures
repeat within hour
repeat within a few days
825 visits over ten years

g=24 night
g=27.5 final

a million alerts/night
released within 60sec

Special regions + deep drilling fields
10% of time

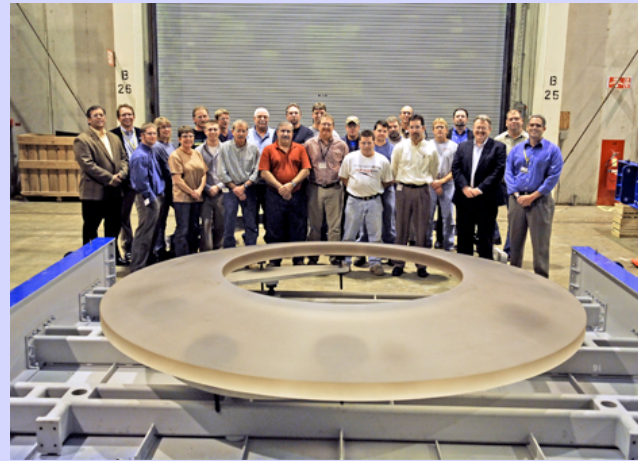
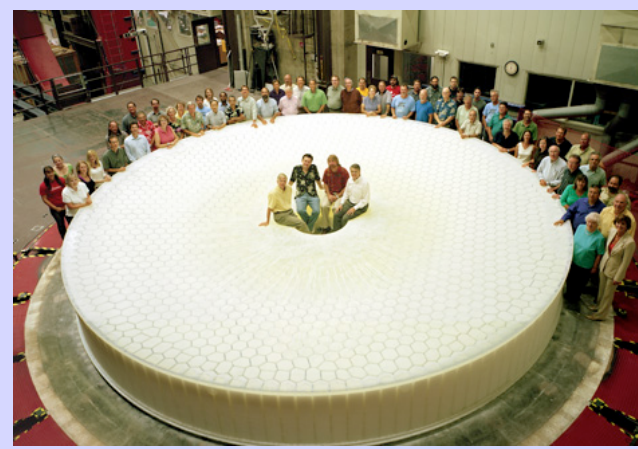
status

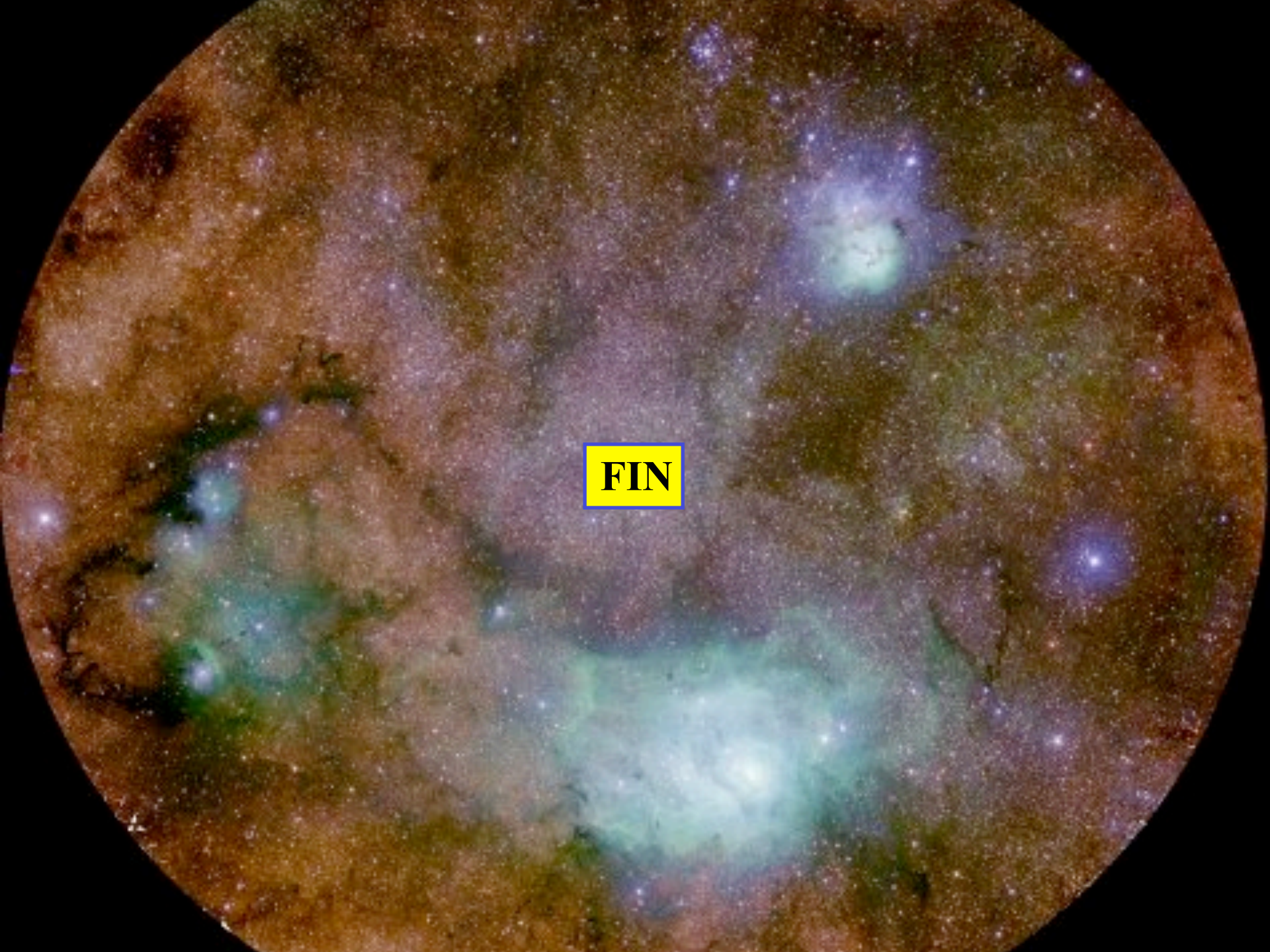
M1/M3 and M2 cast
Camera construction started
Site partly levelled

Capital budget in 2013 NSF request
2014-19 construction
2020-21 commissioning
2022-32 operations

Instructed to find 30% of ops costs
from partners

*UK involvement under discussion
in STFC prog. review*





FIN