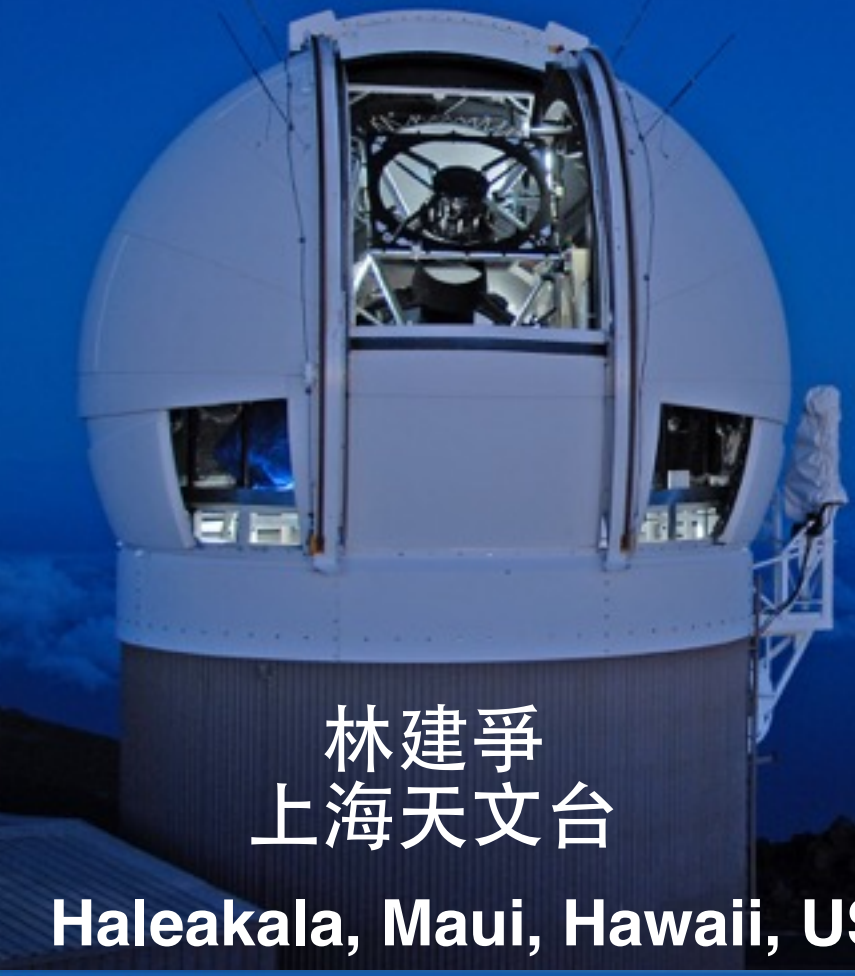
Pan-STARRS (PS1) 泛星計劃

Panoramic Survey Telescope And Rapid Response System

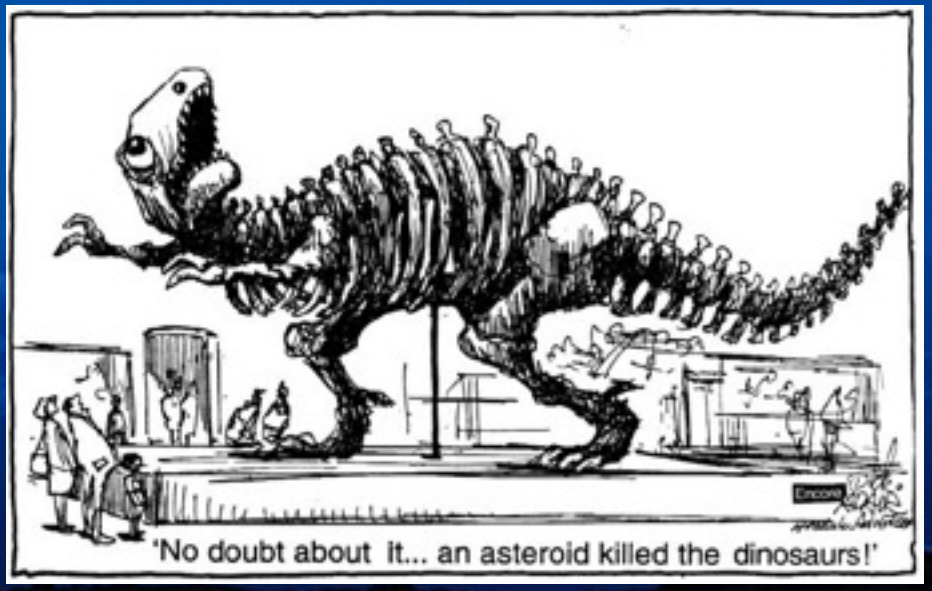
全面性的巡天望遠鏡與快速反應系統



林建爭
上海天文台

Haleakala, Maui, Hawaii, USA

To detect hazardous asteroids…



PS1 consortium members

Operated for NASA by AURA

Survey Power

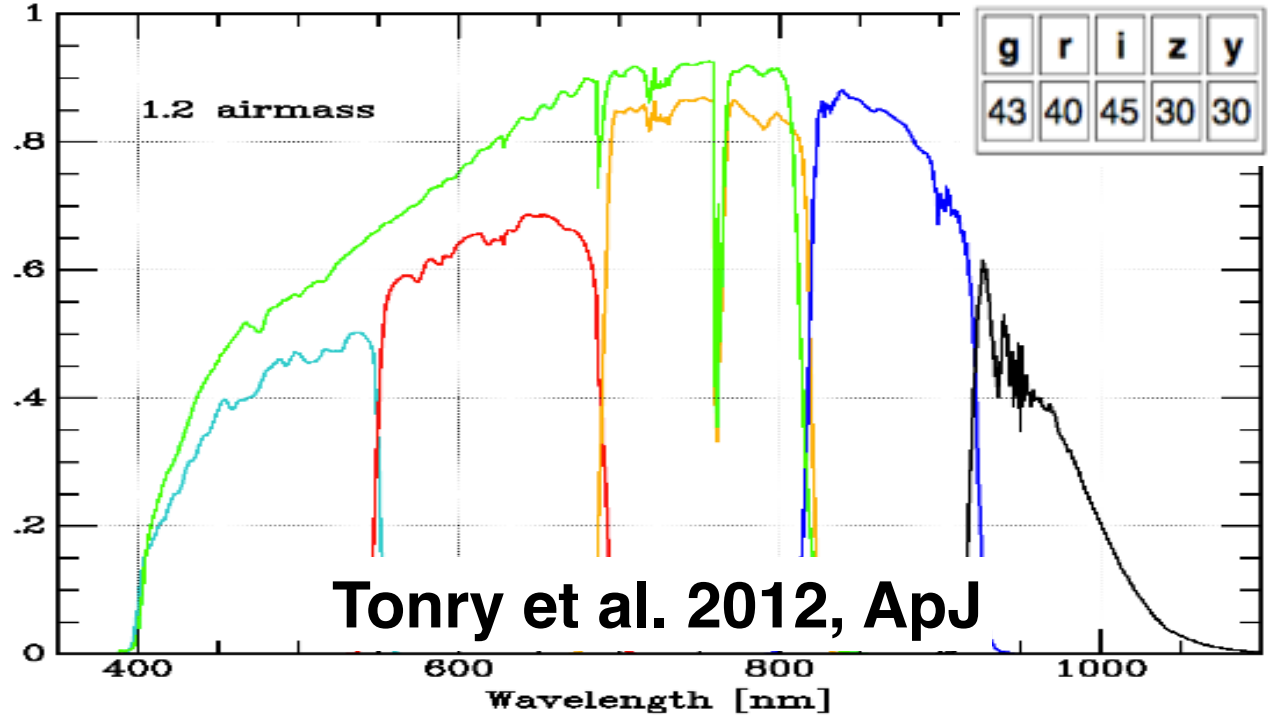
Telescope	D (m)[1]	A (m^2)[2]	Ω (deg^2)[3]	θ (arcsec)[4]	SP[5]	Status	
LINEAR[6]	1.0	0.8	2	2.5	0.2	Active	
Spacewatch	0.9	0.6	3	1.5	0.8	Active	
UH 2.2-m/PFCam	2.2	3.5	0.25	0.7	1.8	2004+	Active
Palomar/QUEST	1.2	1.1	16.6	2	4.6	2003+	Active
CFHT/Megacam	3.6	10	1.00	0.6	28	Active	
Subaru/Suprimecam HSC	8.0	45	0.25 1.8	0.6	35 225	Active	
Pan-STARRS PS1	3.6 1.8	10 2.5	7	0.5	280 70	2007+	Active
DMT/LSST	8.3	54	7	0.6	1050	2012+	2016+

[1] Telescope diameter.
[2] Effective collecting area.
[3] Solid angle subtended by field of view.
[4] Nominal image quality.
[5] The survey power, in units (m^2 deg^2 $arcsec^{-2}$), defined by Equation (1).
[6] LINEAR has recently been using two similar telescopes, raising the survey power to 0.4 m^2 deg^2 $arcsec^{-2}$.

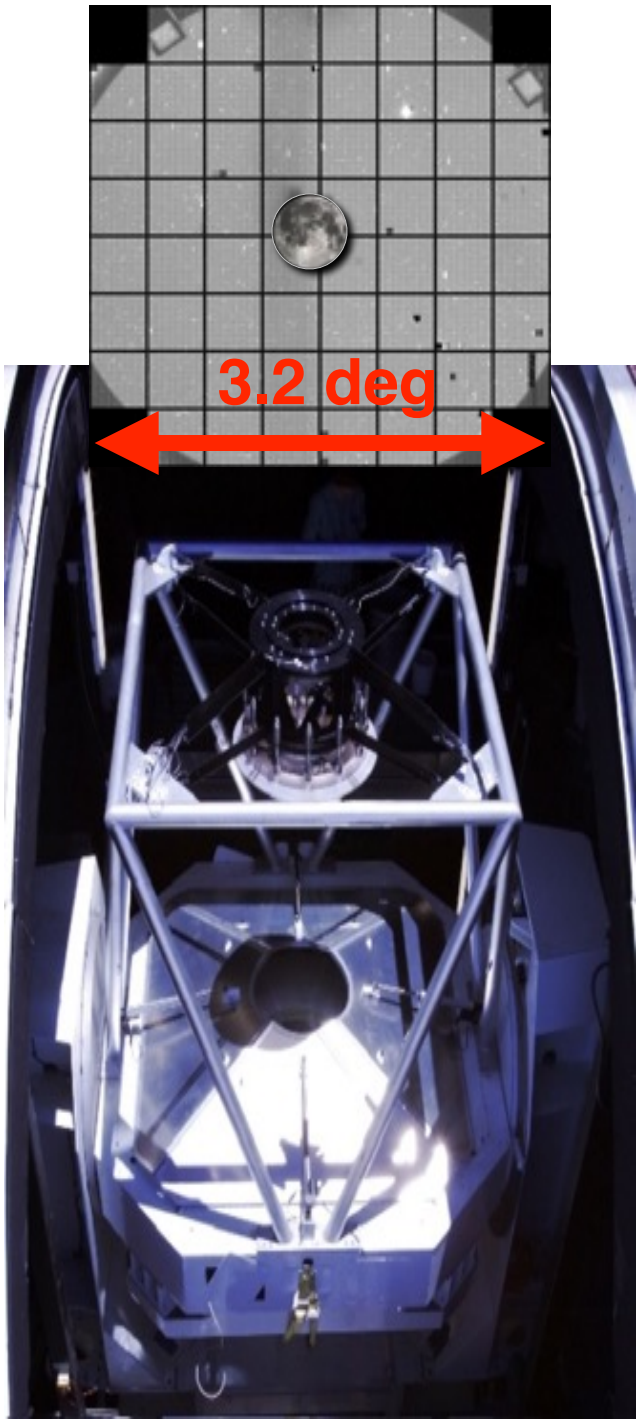
Jewitt 2003

PS1 Features

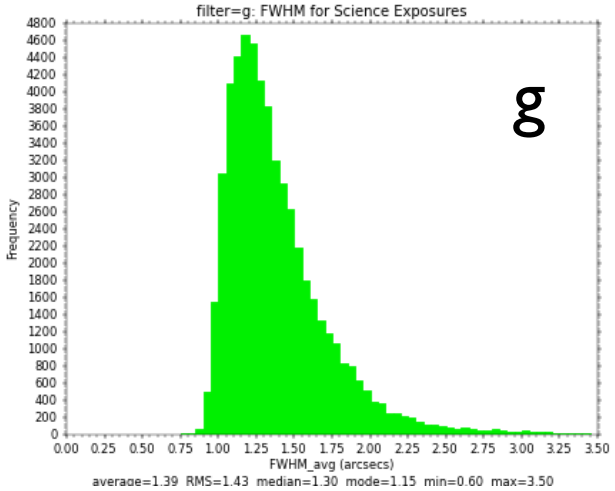
1. patrolling 3/4 sky several times a month
2. 1.8 m telescope at f/4.4 with 3.2 deg FOV
3. 1.4 Gigapixel camera, 10μm, 0.245”/pixel
4. reaching w, g,r,i ~24-27, z,y ~21-24 mag

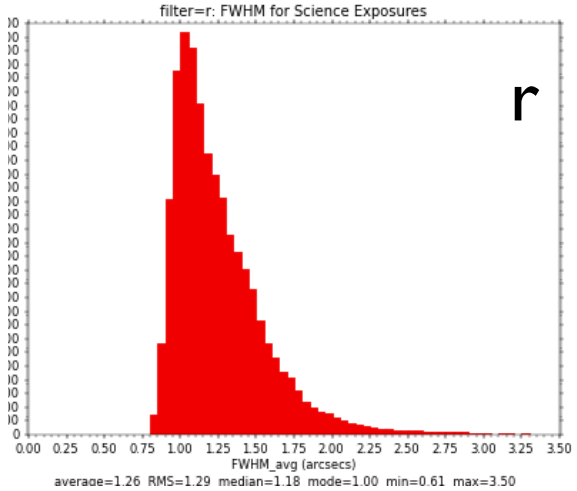


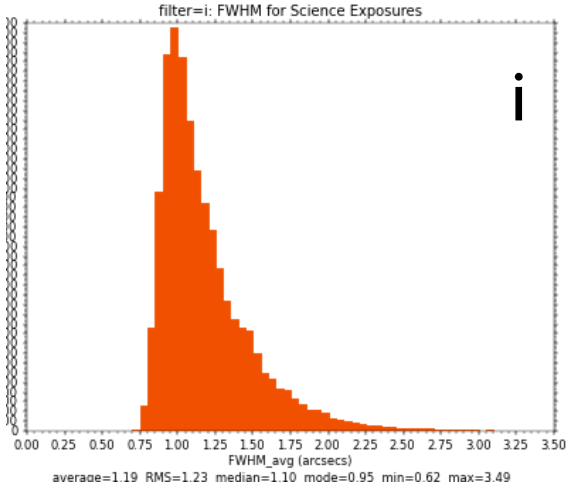
Tonry et al. 2012, ApJ

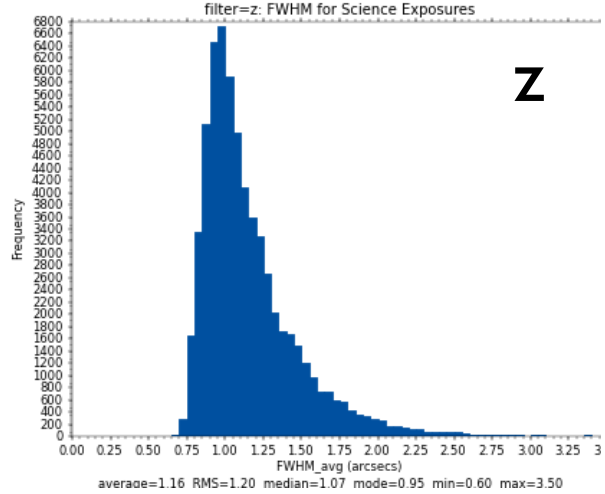


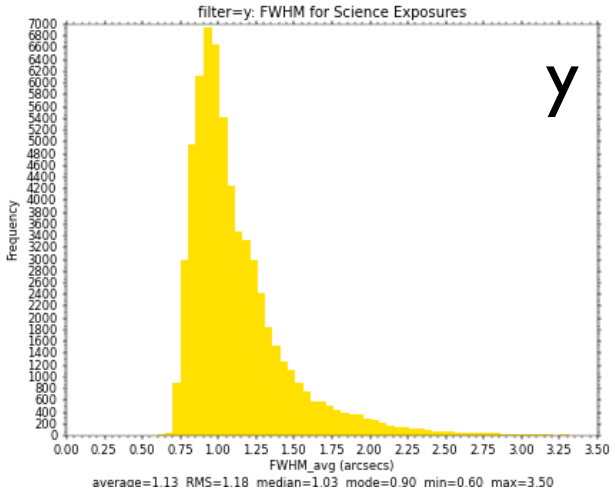
Histograms of FWHM Distribution / Filter

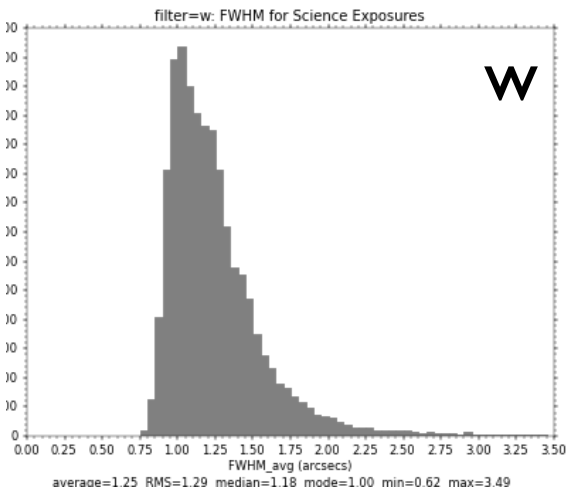












	g	r	i	z	y	w
FWHM Average	1.39	1.26	1.19	1.16	1.13	1.25
FWHM Median	1.30	1.18	1.10	1.07	1.03	1.18
FWHM Mode	1.18	1.02	0.96	0.96	0.92	1.02

Observing Time Statistics

Total night time	12704 hrs	100% of night time
Weather loss	4642 hrs	36.5% of night time
Downtime	1348 hrs	10.6% of night time
Overhead	2296 hrs	18.1% of night time
Open shutter on science	4416 hrs	34.8% of night time
Observing efficiency		54.8%

3.0-GB per image

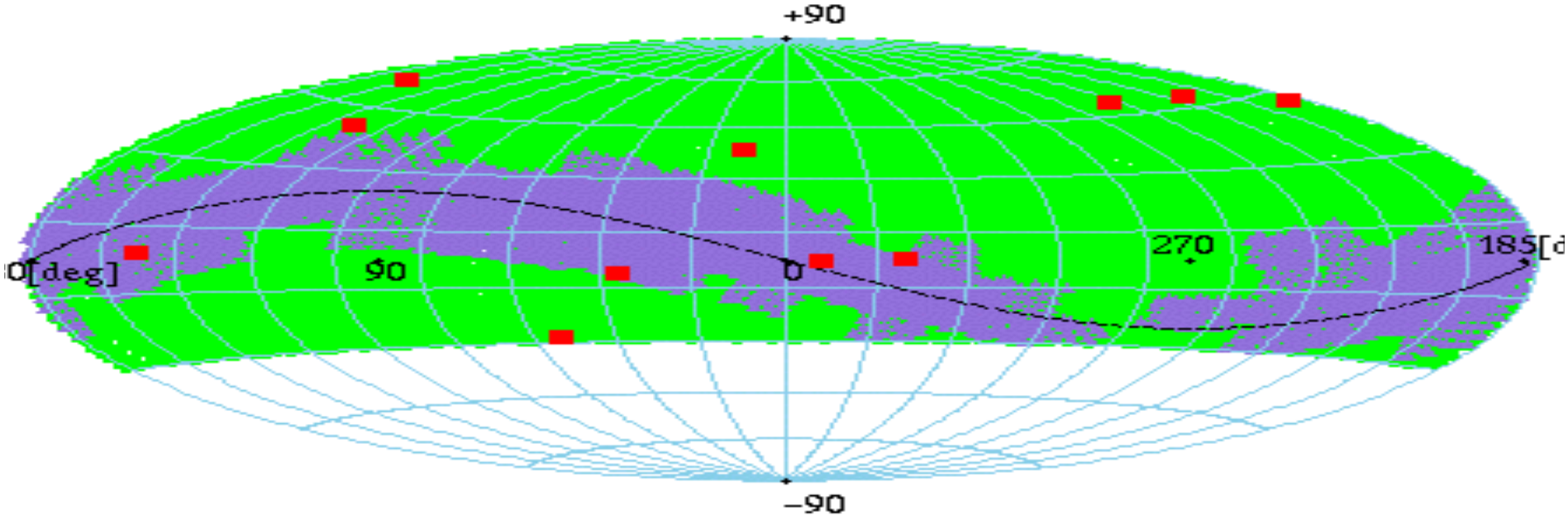
1.5-TB per night

1.8-PB survey

28-TB catalog

PS1 Surveys

1. 3π survey: 56% (low-mass stars, brown dwarfs, star clusters, structure of the Milky Way)
2. medium deep: 25 % (extragalactic, cosmology, large scale structure, etc.)
3. solar system: 11% (KBOs, asteroids, comets, etc.)
4. others: 8% (M31, exoplanet)

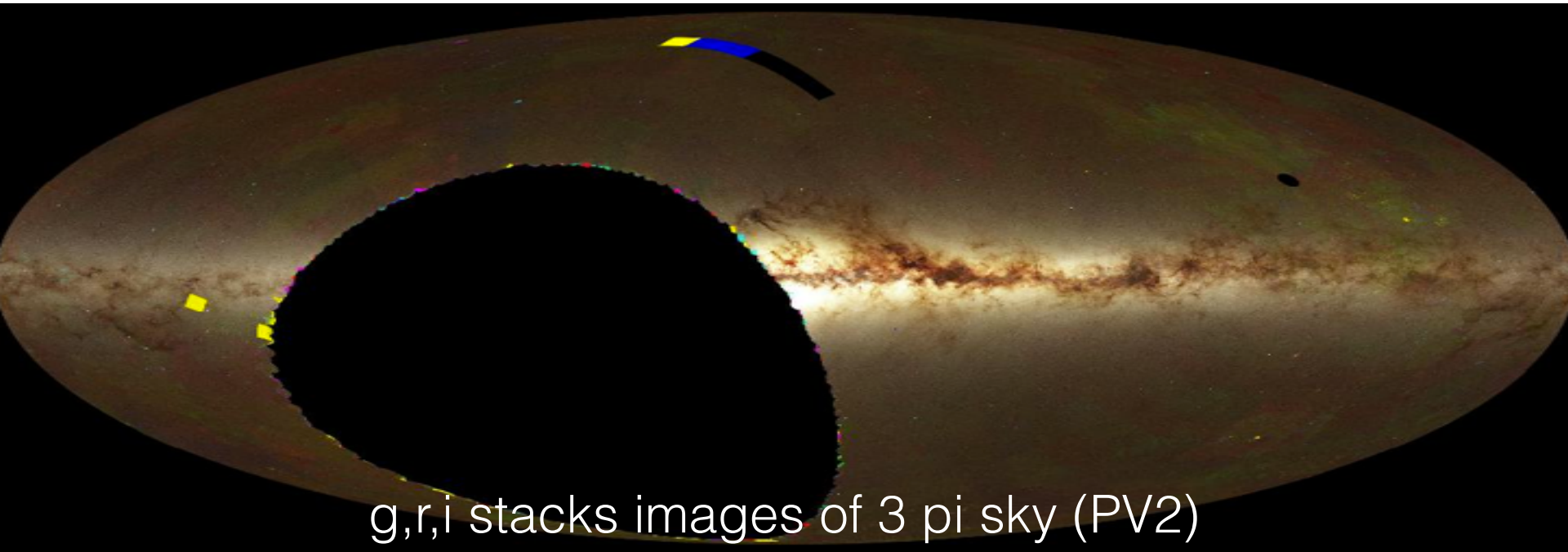


PS1 Key Projects

Key Project	Original KP Leads	KP leads as of Oct 2010
1. Populations of objects in the Inner Solar System	R. Jedicke	R. Jedicke, R. Wainscoat
2. Populations of objects in the Outer Solar System - (Beyond Jupiter)	M. Holman	M. Holman
3. Low-Mass Stars, Brown Dwarfs, and Young Stellar Objects	E. Magnier, W. Brandner	E. Magnier, W. Brandner
4. Search for Exo-Planets by dedicated Stellar Transit Surveys	C. Afonso, T. Henning	T. Henning, Johannes Koppenhoefer
5. Structure of the Milky Way and the Local Group	H.-W. Rix, E. Bell	H.-W. Rix, N. Martin, E. Bell
6. A Dedicated Deep Survey of M31	S. Seitz, R. Bender	S. Seitz, R. Bender
7. Massive stars and supernova progenitors	S. Smartt, F. Bresolin	S. Smartt, F. Bresolin
8. Cosmology Investigations with Variables and Explosive Transients	J. Tonry, C. Stubbs, A. Riess	J. Tonry, C. Stubbs, A. Riess
9. Galaxy Properties	T. Heckman	T. Heckman
10. Active Galactic Nuclei and High Redshift Quasars	F. Walter, K. Chambers	F. Walter, K. Chambers
11. Cosmological Lensing	A. Heavens, A. Taylor, N. Kaiser	A. Heavens, A. Taylor, N. Kaiser
12. Large Scale Structure	S. Cole, S. Phleps, R. Bender	S. Cole, S. Phleps, R. Bender

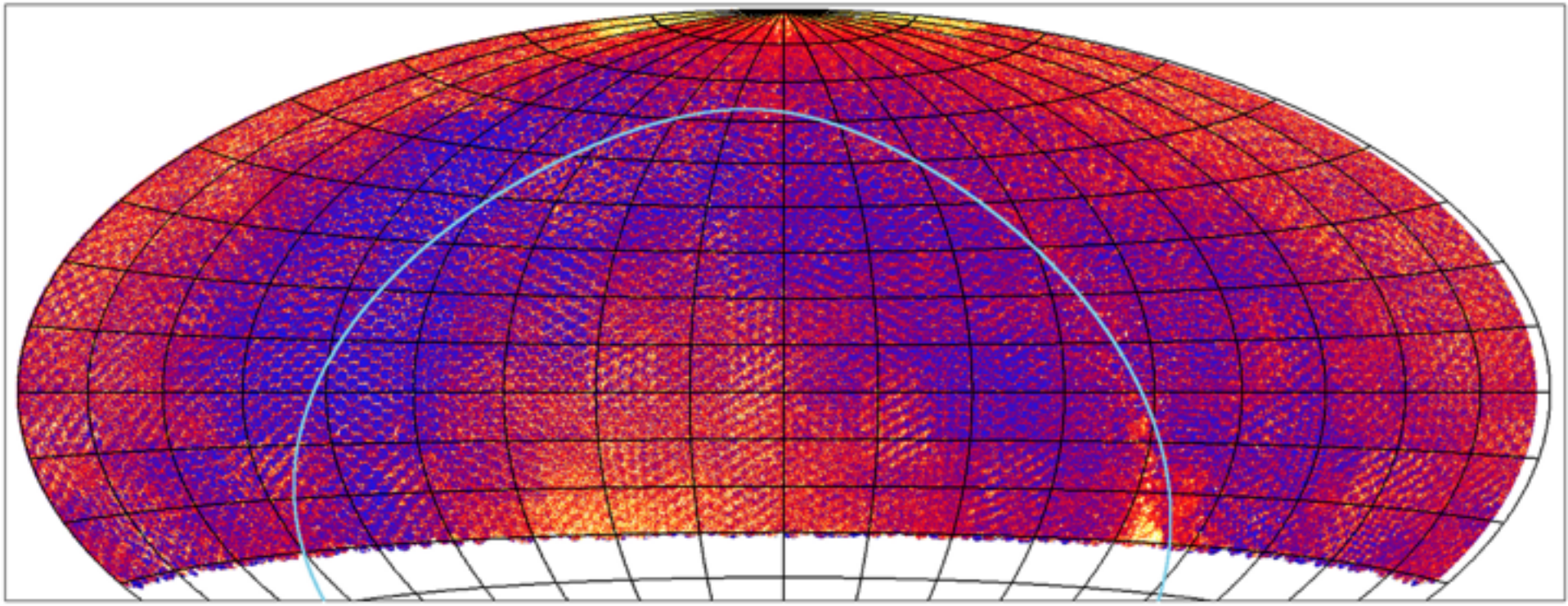
PS1 Status

1. Full survey stared in May 2010, for duration of ~4 yr
2. Included ~5 billion objects and ~120 billion detections
3. 90% of detections / objects at |b| < 10 degrees
4. Out GP 50 MB/deg^2; In GP 1.5 GB/deg^2
5. Finished in Mar 2014; released Jun(?) 2015



g,r,i stacks images of 3 pi sky (PV2)

PS1 PV2 Astrometry

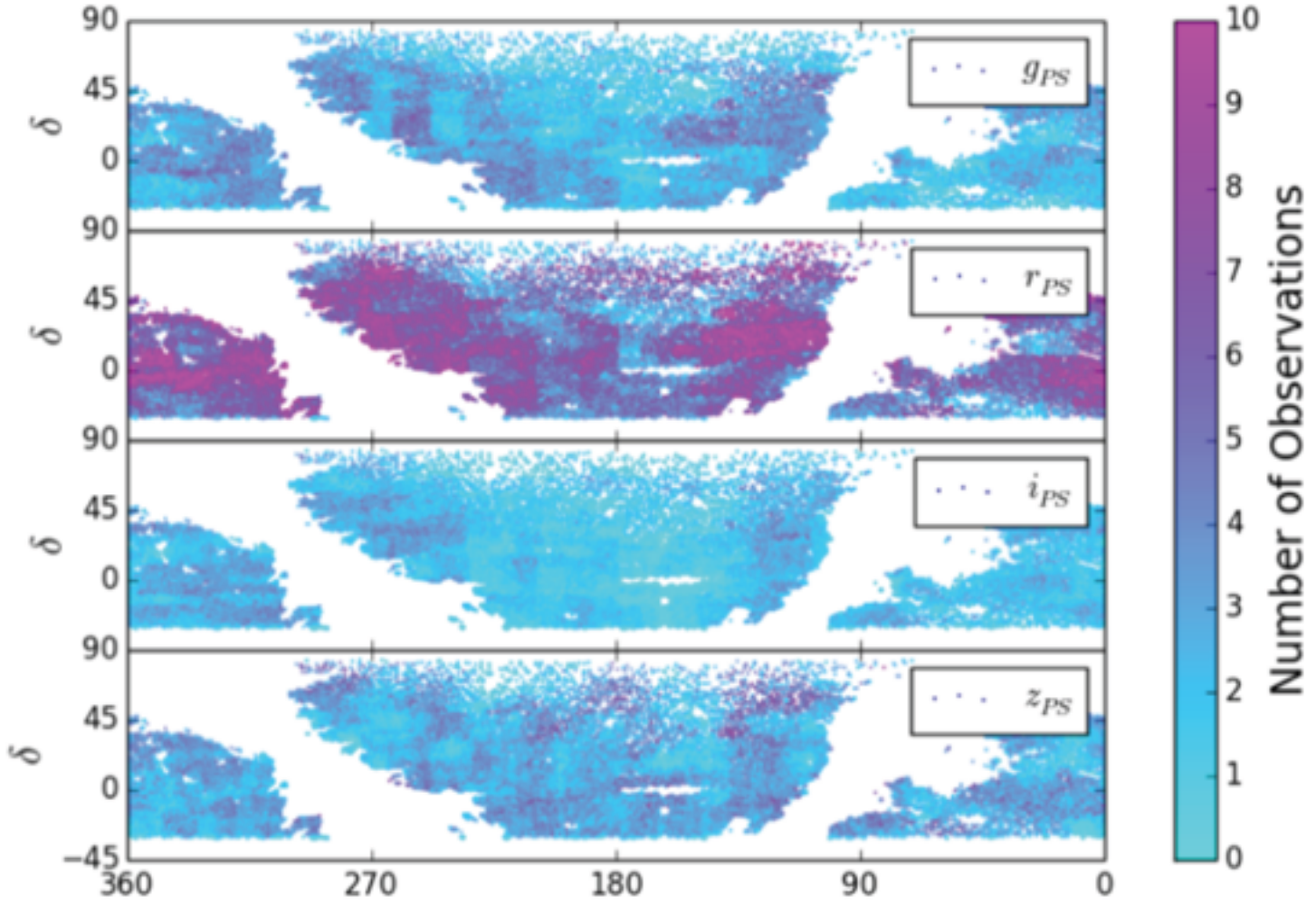


2015.02.09 Eugene Magnier

The values range from dark blue ~10 mas to yellow ~30 mas.

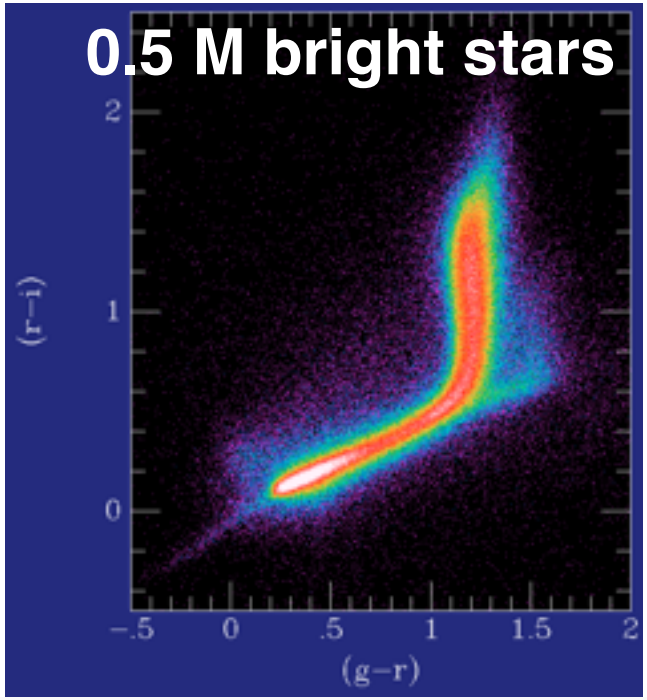
Measurements

Inhomogeneous, time-resolved survey

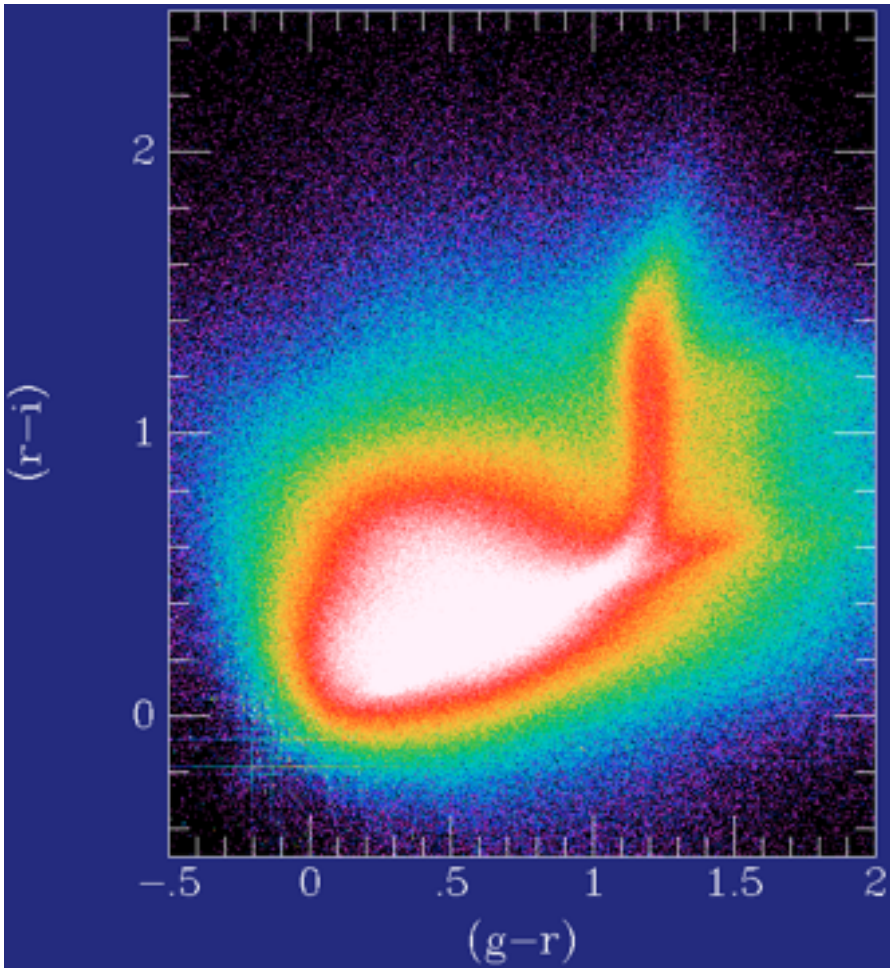


Vickers Thesis

Medium Deep Fields



MD	g	r	i	z	y
01	25.9	25.8	26.0	25.6	24.3
02	25.6	25.4	25.8	25.3	24.1
03	25.8	25.8	26.0	25.6	24.3
04	25.8	25.7	25.8	25.4	24.0
05	25.8	25.7	25.9	25.4	23.9
06	25.8	25.6	25.9	25.3	23.9
07	25.8	25.7	25.9	25.4	24.1
08	25.9	25.8	26.0	25.4	24.2
09	26.0	25.9	26.1	25.6	24.1
10	25.9	25.8	26.1	25.6	24.1

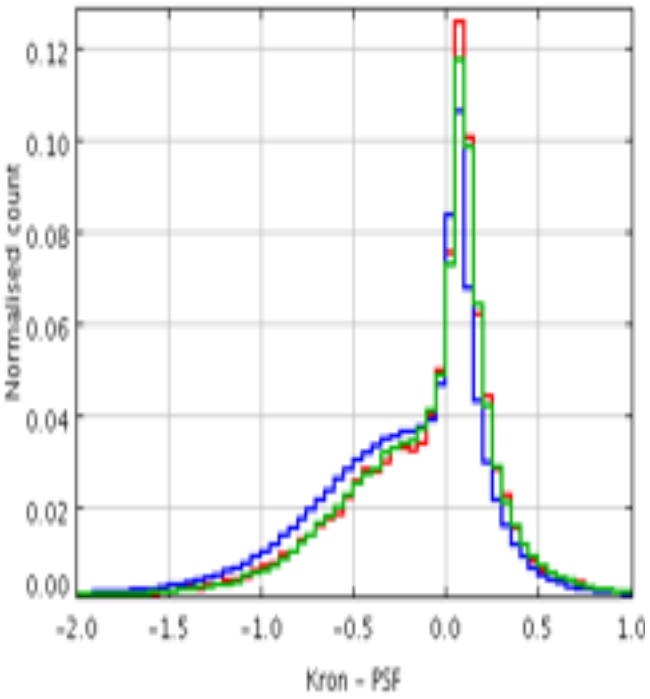


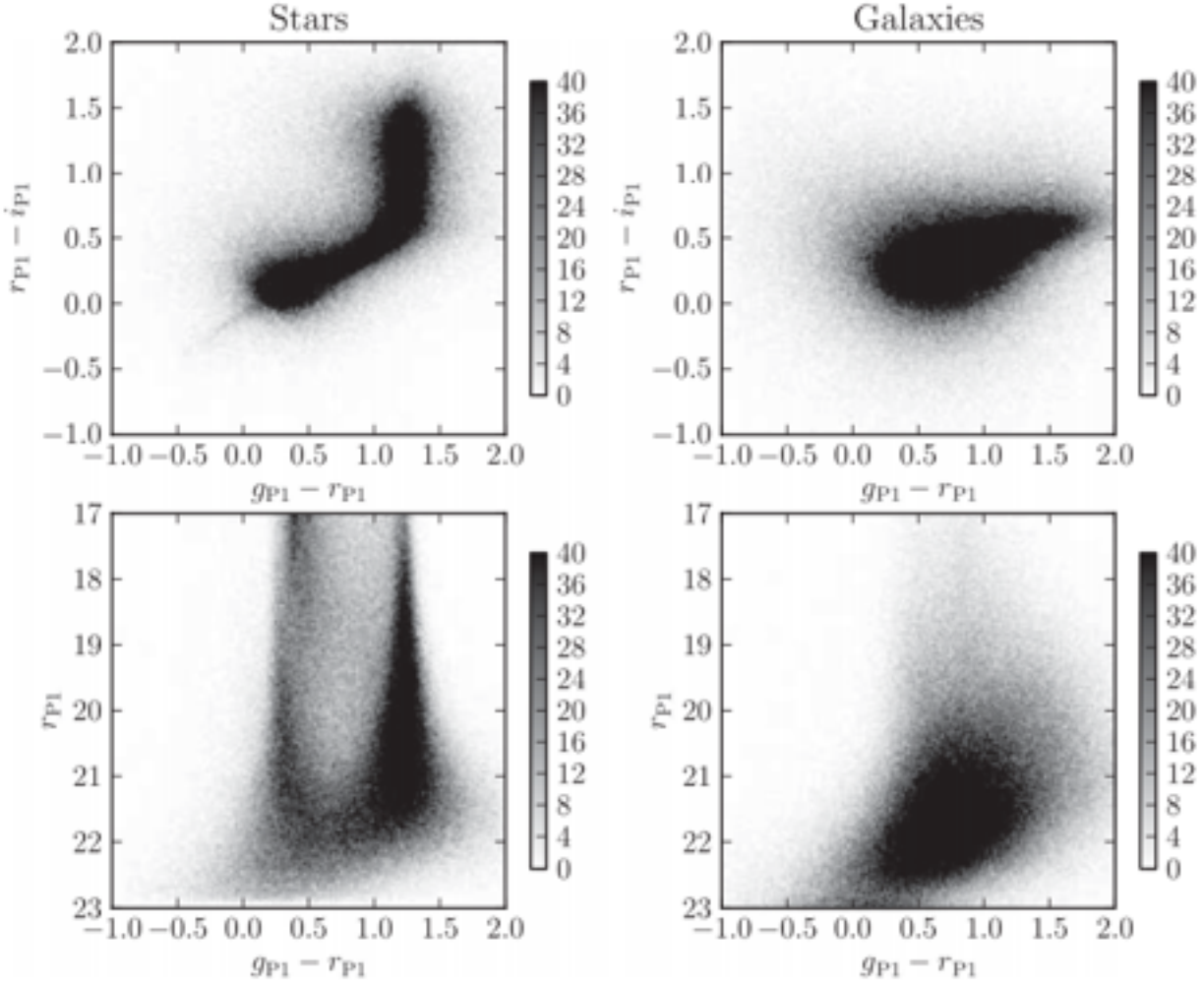
10 M all objects

Tonry's Slides

Star/Galaxy Separation

kron - psf = 0.018*(kron-21.0)*(kron - 21.0) + 0.120*(kron - 21.0) - 0.192

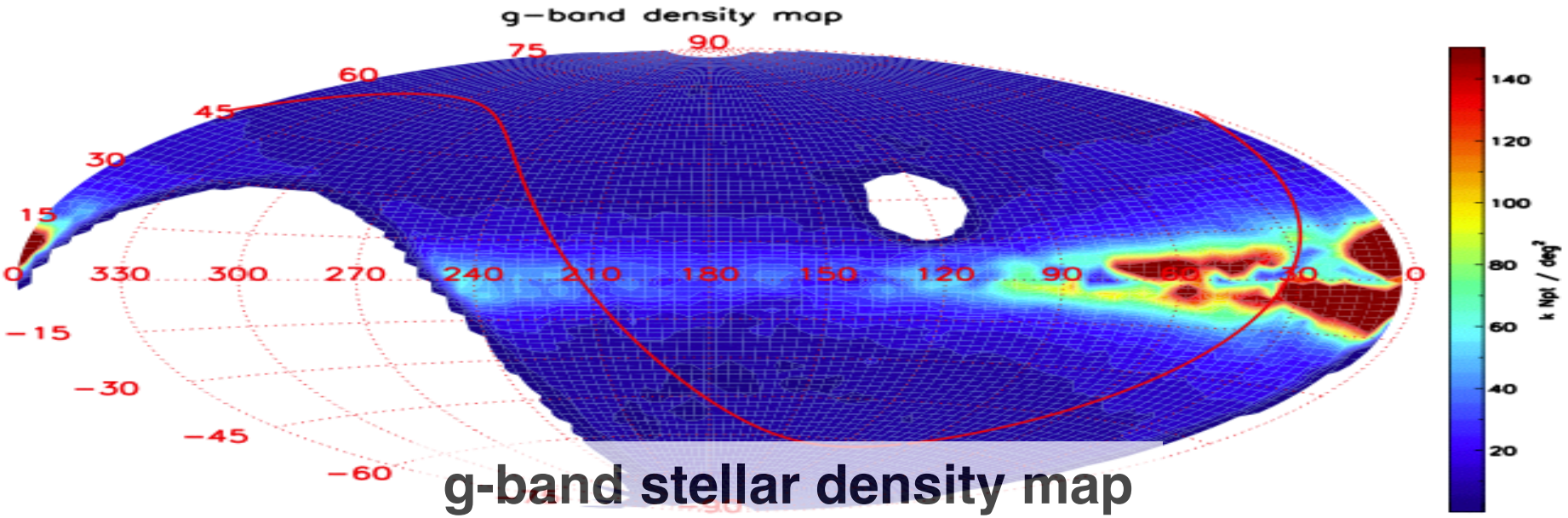




Daniel et al. 2014

PS1 3π Data

- Stellar objects are selected with PS1 object flags
  - exclude S/N < 5, psf quality < 0.85, and extend objects
  - measurements > 4
- Total of 1.3 billion stellar objects are in 3π sky (c.f. 1 billion, USNO)
- The 5σ limit. mag. are at 22.30, 22.22, 21.99, 21.29, 20.22 mag



g-band stellar density map

PS1 Data Product

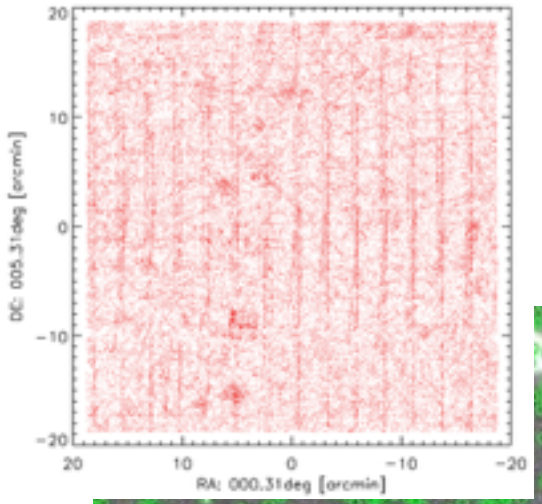
Fundamental IPP Data Products

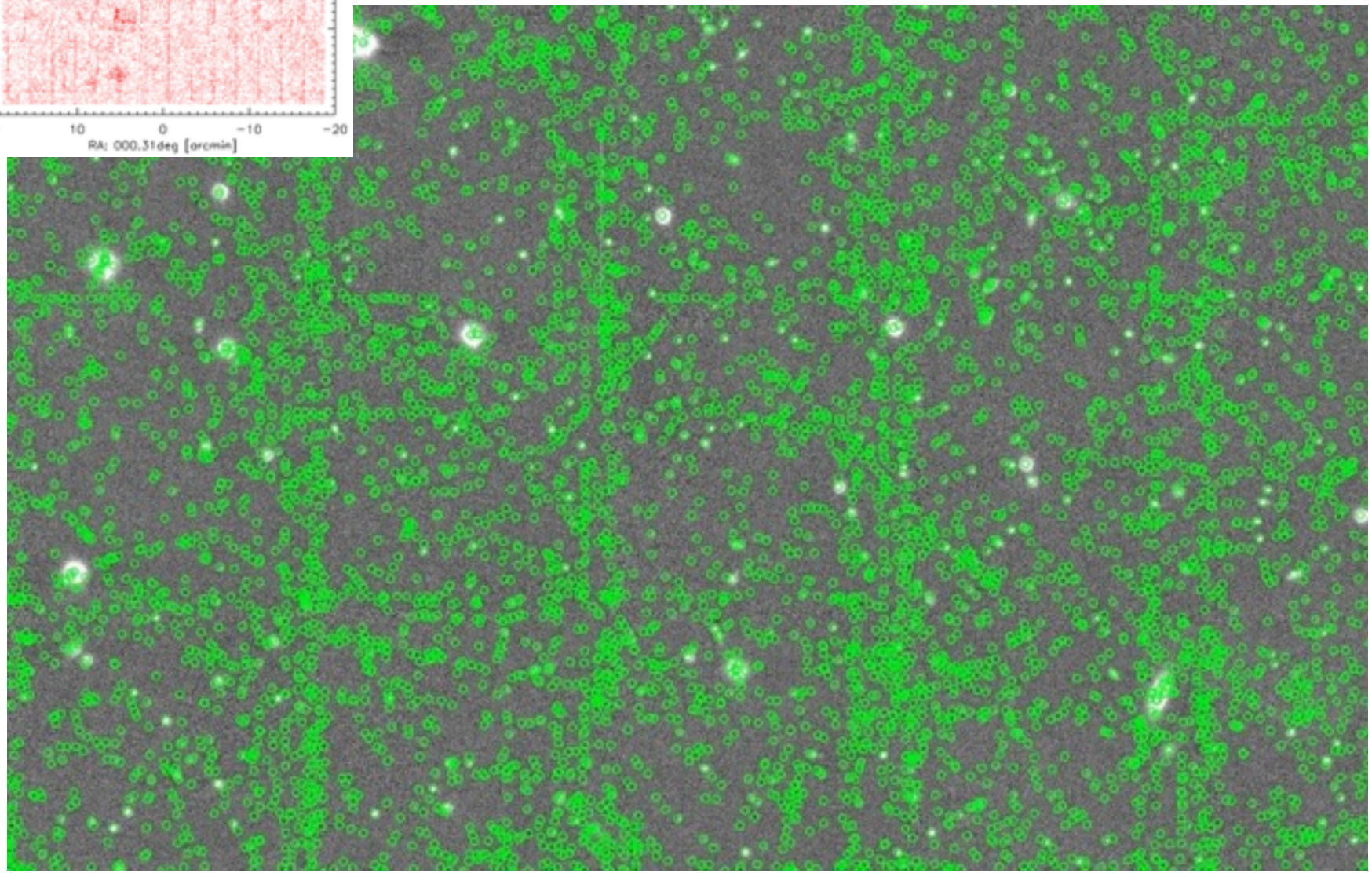
- Detection
- DiffDetObject
- DiffDetection
- DiffMeta
- DiffToImage
- ForcedMeanLensing
- ForcedMeanObject
- ForcedWarpMeasurement
- MeanObject
- ObjectThin
- StackApFlx
- StackApFlxEGCon6
- StackApFlxEGCon8
- StackApFlxEGUnc
- StackModelFitDeV
- StackModelFitExp
- StackModelFitExtra
- StackModelFitSer
- StackObjectAttributes
- StackObjectThin
- StackPetrosian

Name	Unit	Data Type	Size	Default Value	Description
objID	dimensionless	BIGINT	8	NA	ODM object identifier
uniquePspsP2id	dimensionless	BIGINT	8	NA	unique psps id
detectID	dimensionless	BIGINT	8	NA	ODM detection identifier
ippObjID	dimensionless	BIGINT	8	NA	object id generated by IPP
ippDetectID	dimensionless	BIGINT	8	NA	detection id generated by IPP
filterID	dimensionless	TINYINT	1	NA	filter ID: g=1, r=2, i=3, z=4, y=5, w=6, ...
surveyID	dimensionless	TINYINT	1	NA	survey flag identifier
imageID	dimensionless	BIGINT	8	NA	image id hash of frame identifier & OTA/CCD number
randomDetID	dimensionless	BIGINT	8	NA	random detection Id
dvoRegionID	dimensionless	REAL	4	-999	identifier to dvo spacial region
obsTime	MeanJulianDays	FLOAT	8	-999	Time of mid observation in Mean Julian Days
xPos	raw pixels	REAL	4	-999	measured x on CCD from PSF fit
yPos	raw pixels	REAL	4	-999	measured y on CCD from PSF fit
xPosErr	raw pixels	REAL	4	-999	estimated error in x
yPosErr	raw pixels	REAL	4	-999	estimated error in y
apFlux	adu/seconds	REAL	4	-999	Aperture flux
apFluxErr	adu/seconds	REAL	4	-999	Aperture flux error
kronFlux	adu/seconds	REAL	4	-999	Kron flux
kronFluxErr	adu/seconds	REAL	4	-999	Kron flux error
kronRad	raw pixels	REAL	4	-999	Kron radius
kronRadErr	raw pixels	REAL	4	-999	Kron radius error
psfQfPerfect	dimensionless	REAL	4	-999	PSF-weighted fraction of pixels totally unmasked
psfChiSq	dimensionless	REAL	4	-999	reduced-chisq of the psf model fit.
infoFlag	dimensionless	BIGINT	8	-999	flag indicating provenance information

(RA, Dec)=(0.31, 5.31)

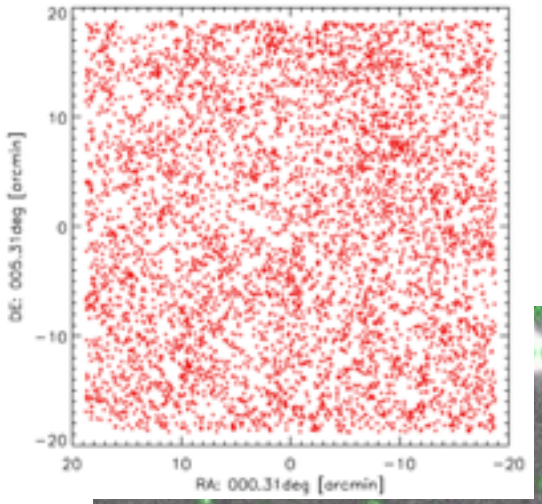
Distribution Before

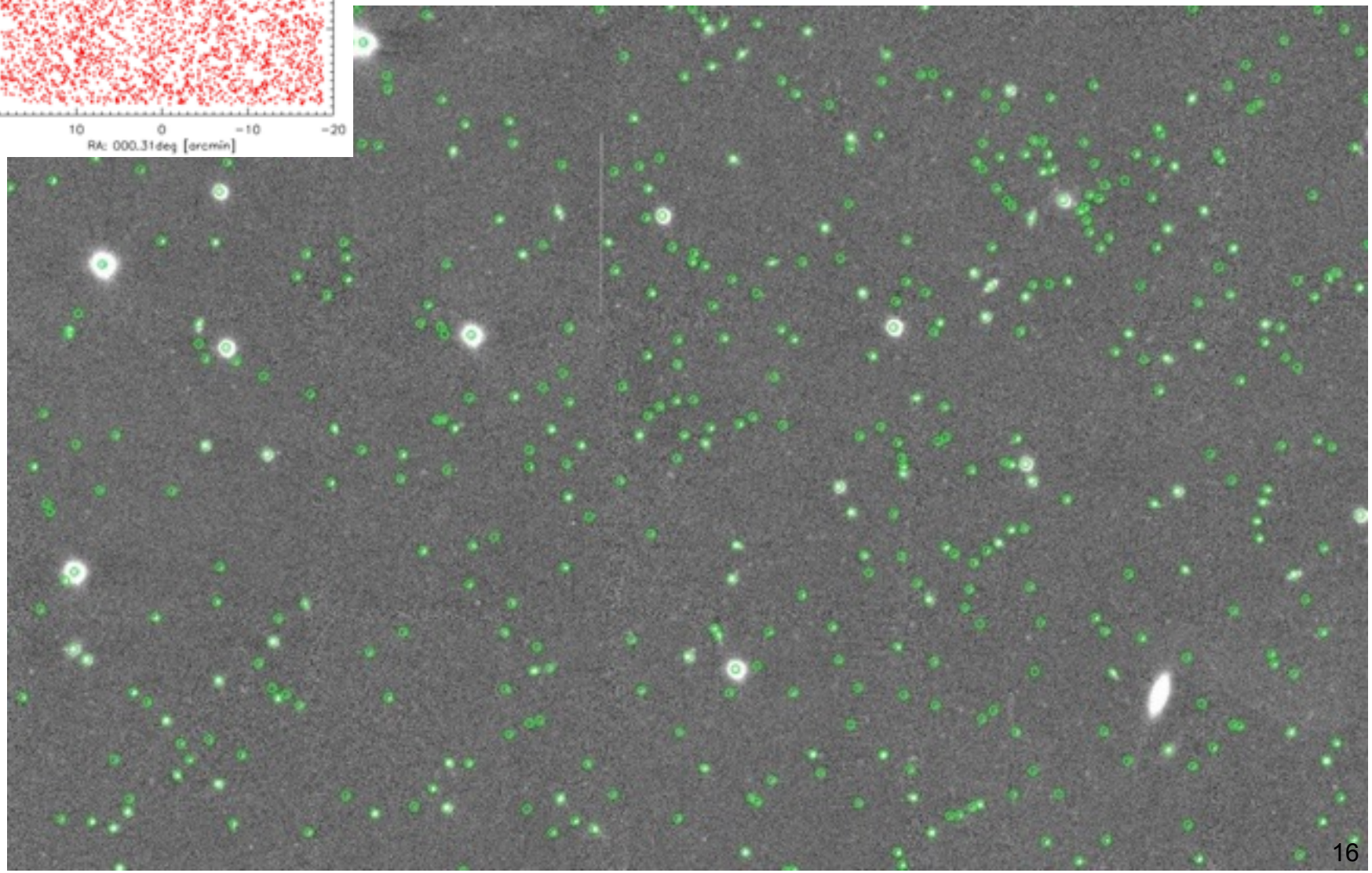


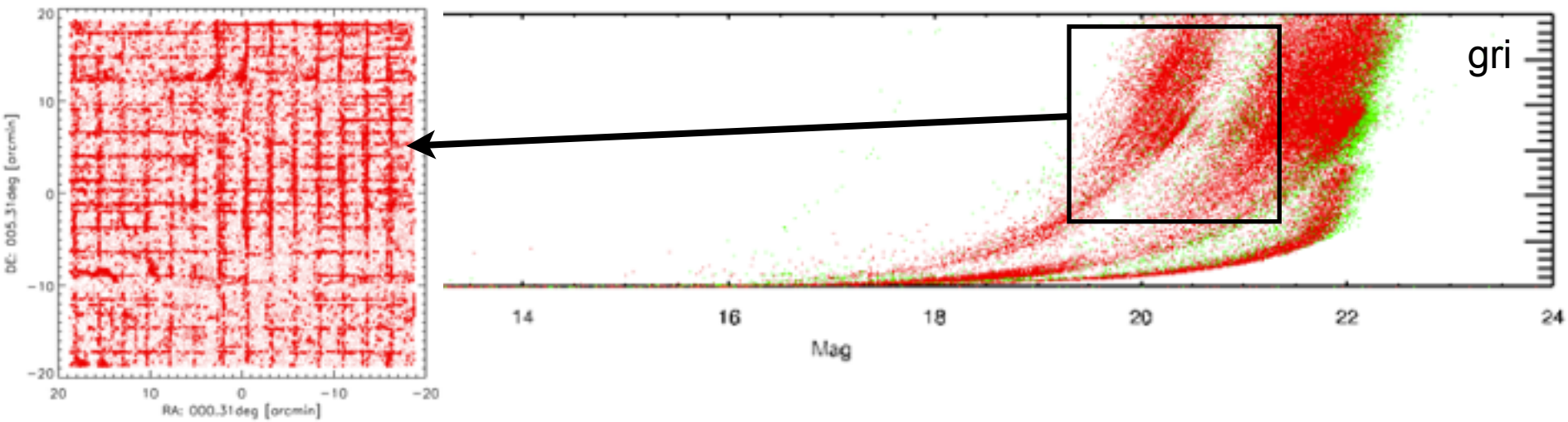


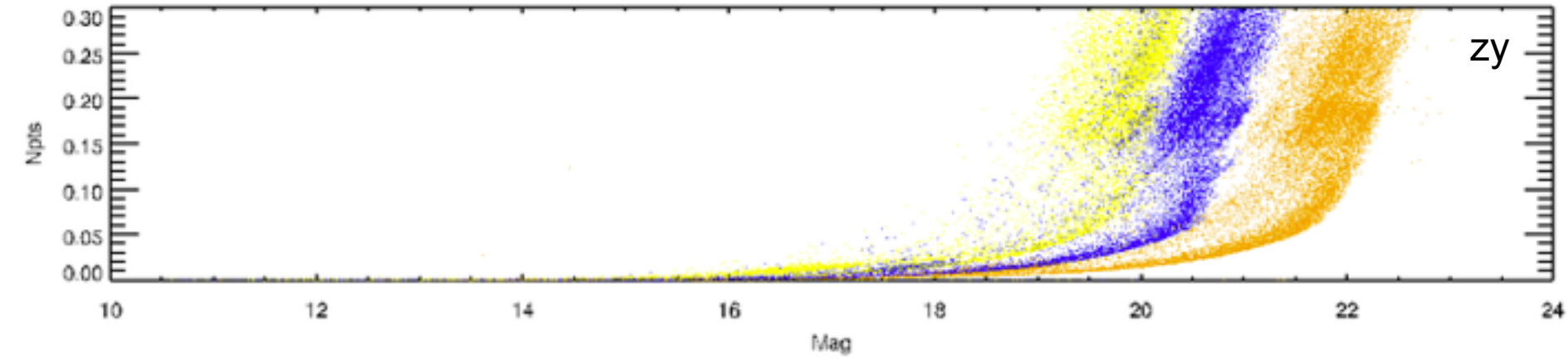
(RA, Dec)=(0.31, 5.31)

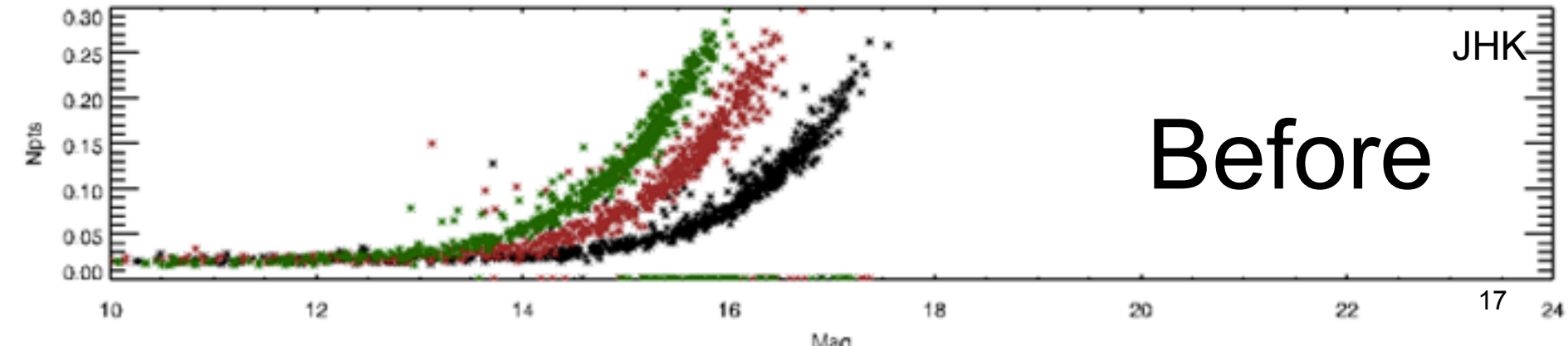
Distribution After

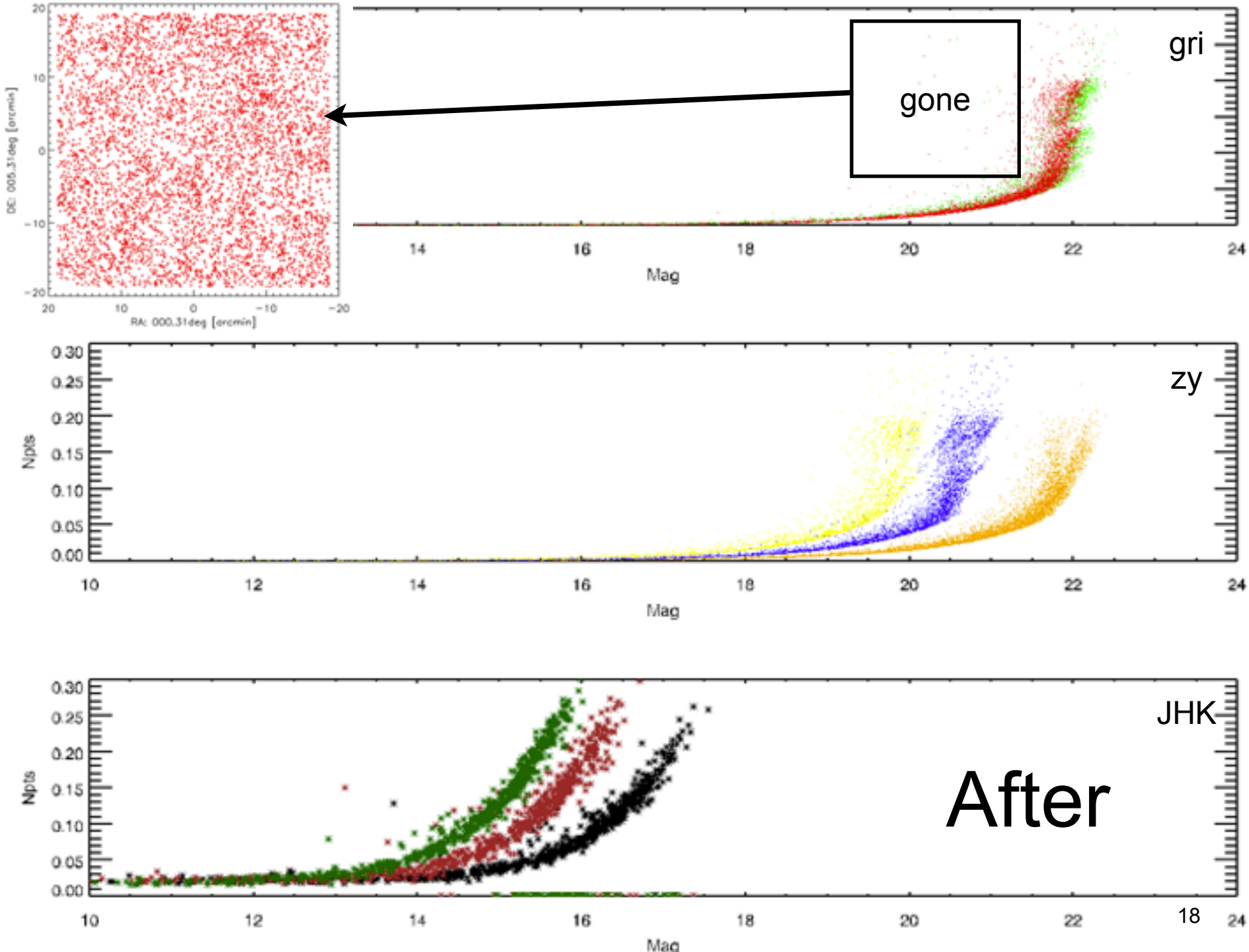




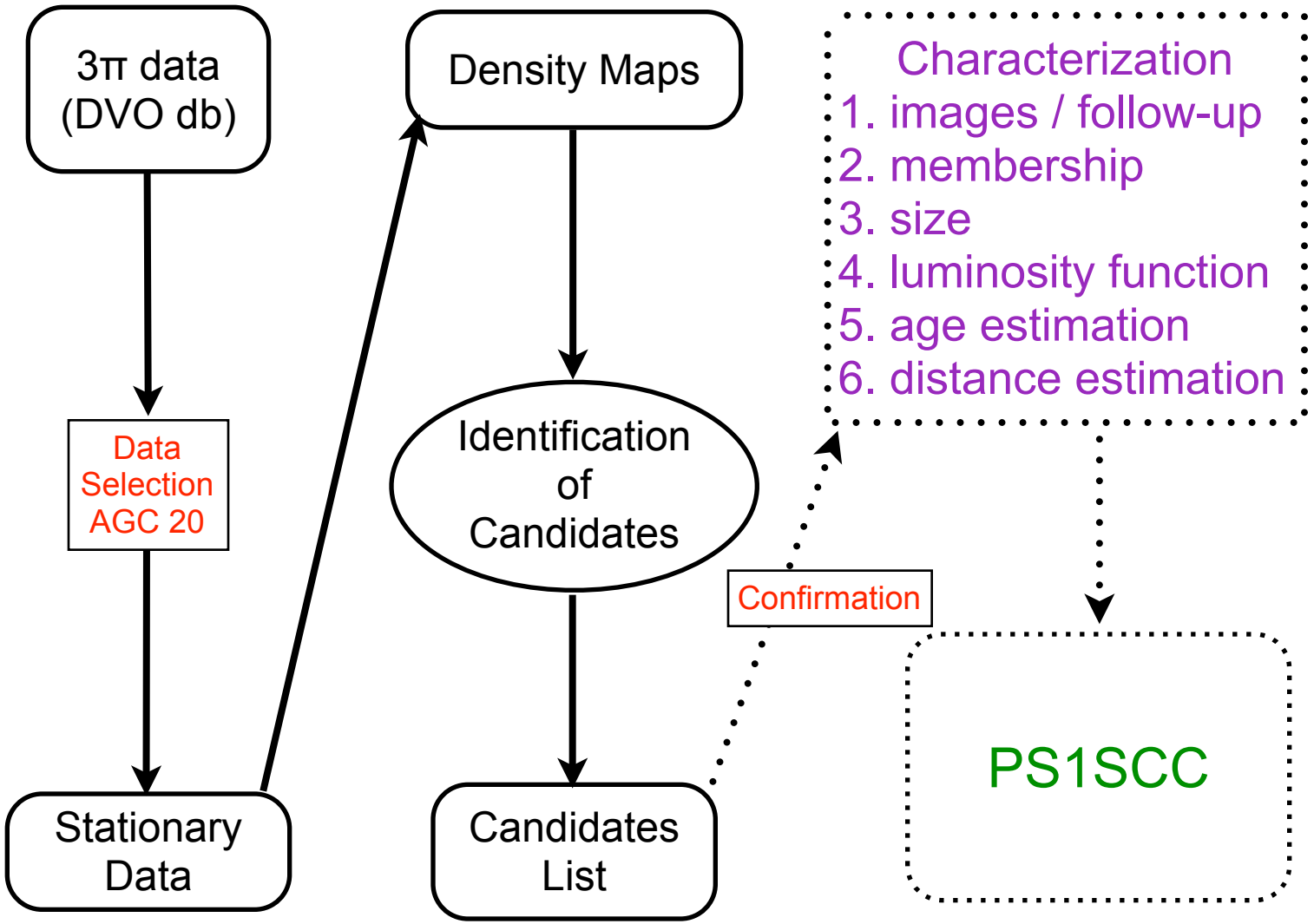

gri
Mag
RA: 000.31deg [arcmin]
DE: 005.31deg [arcmin]


zy
Npts
Mag

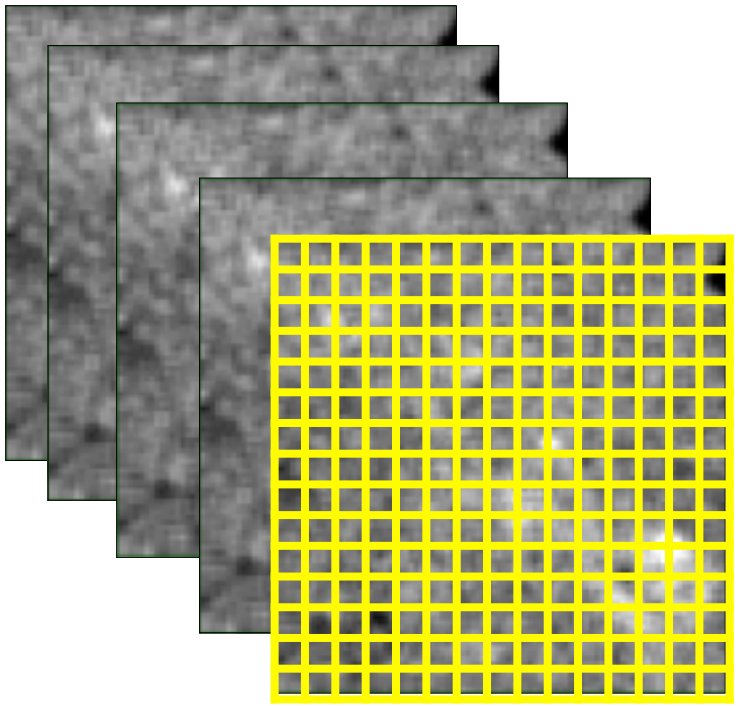

JHK
Before
Npts
Mag

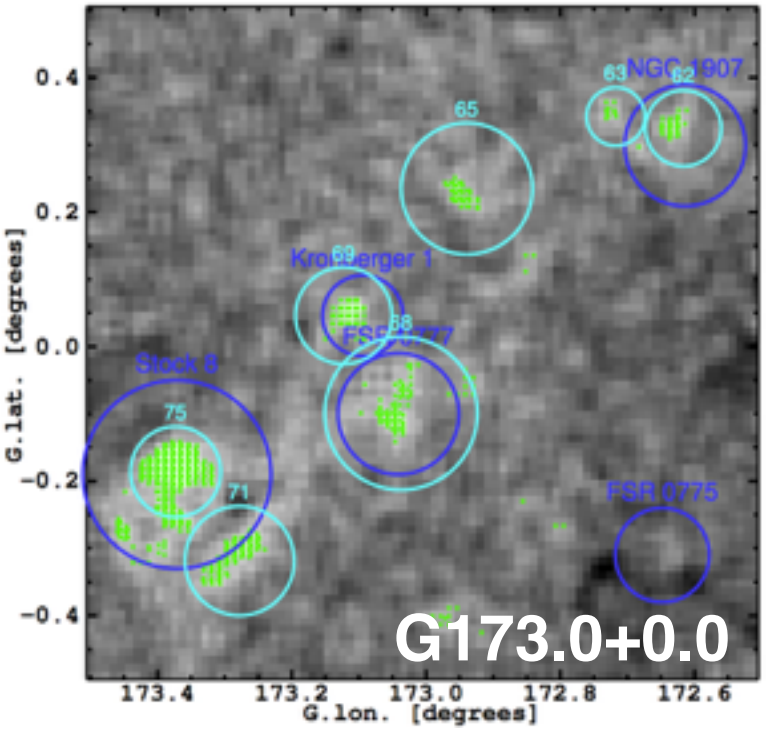

gone
gri
zy
JHK
After
Mag
Npts
18

PS1SCC Flow Chart



Star Counting to Search for Stellar Density Enhancement Regions

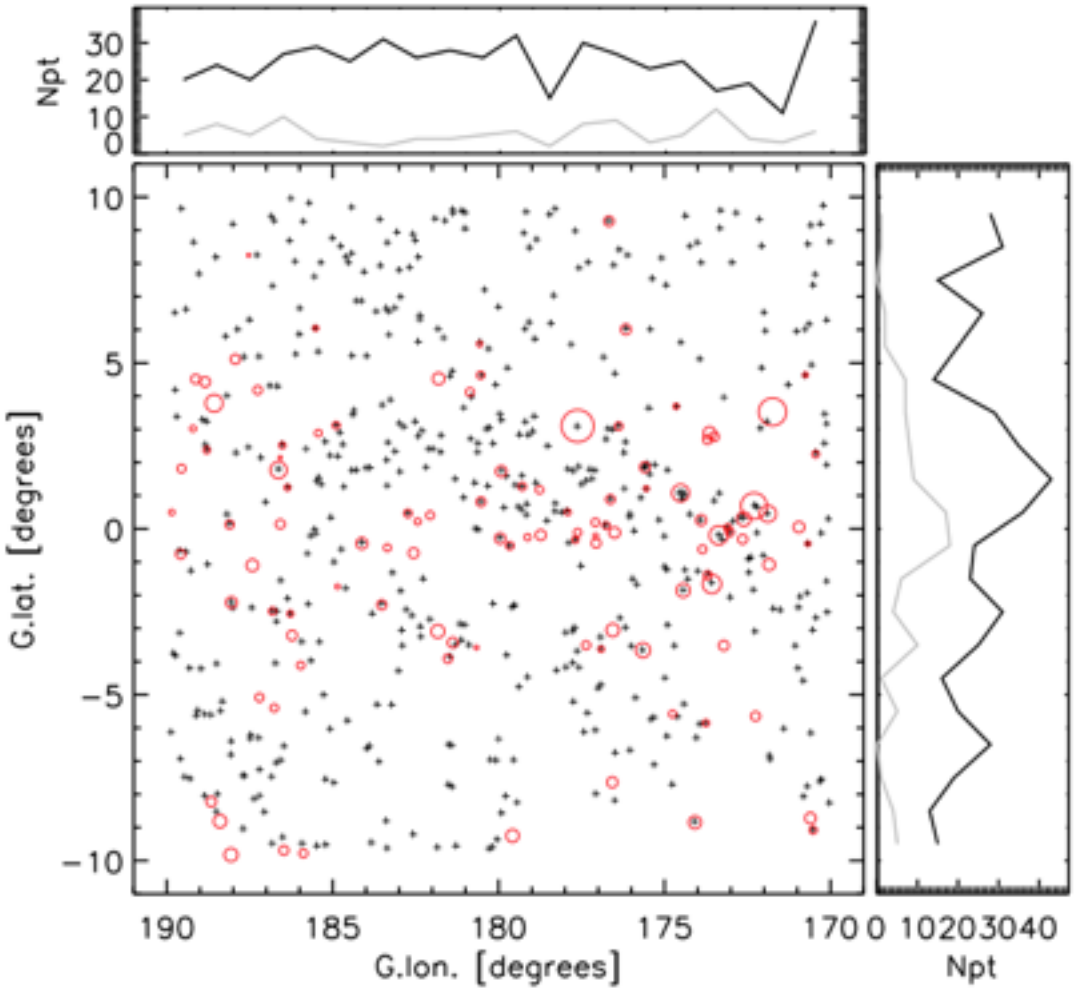




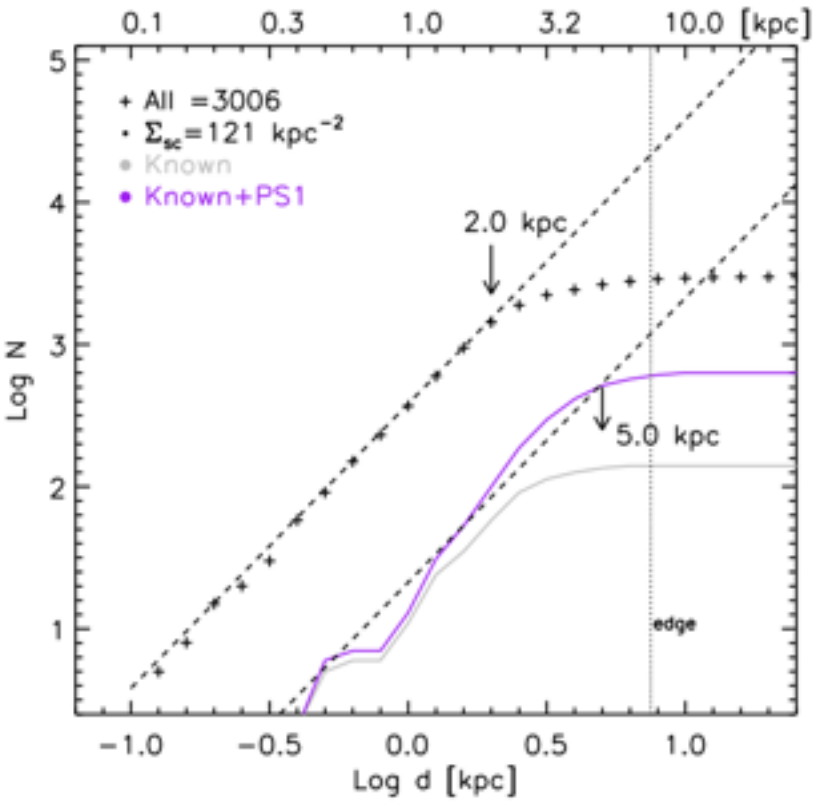
- Density Map: grid size contains ~10 stars, smoothing with 3x3 boxes, subtracting median value, dividing standard deviation
- Cluster candidate: contains at least 3 adjacent grids, with each gird $\geq 3\sigma$, and > 3 times detections in different fields

The completeness limit of revised sample ~ 5 kpc

Kharchenko+ 2013 ~ 2 kpc



Spatial Distribution

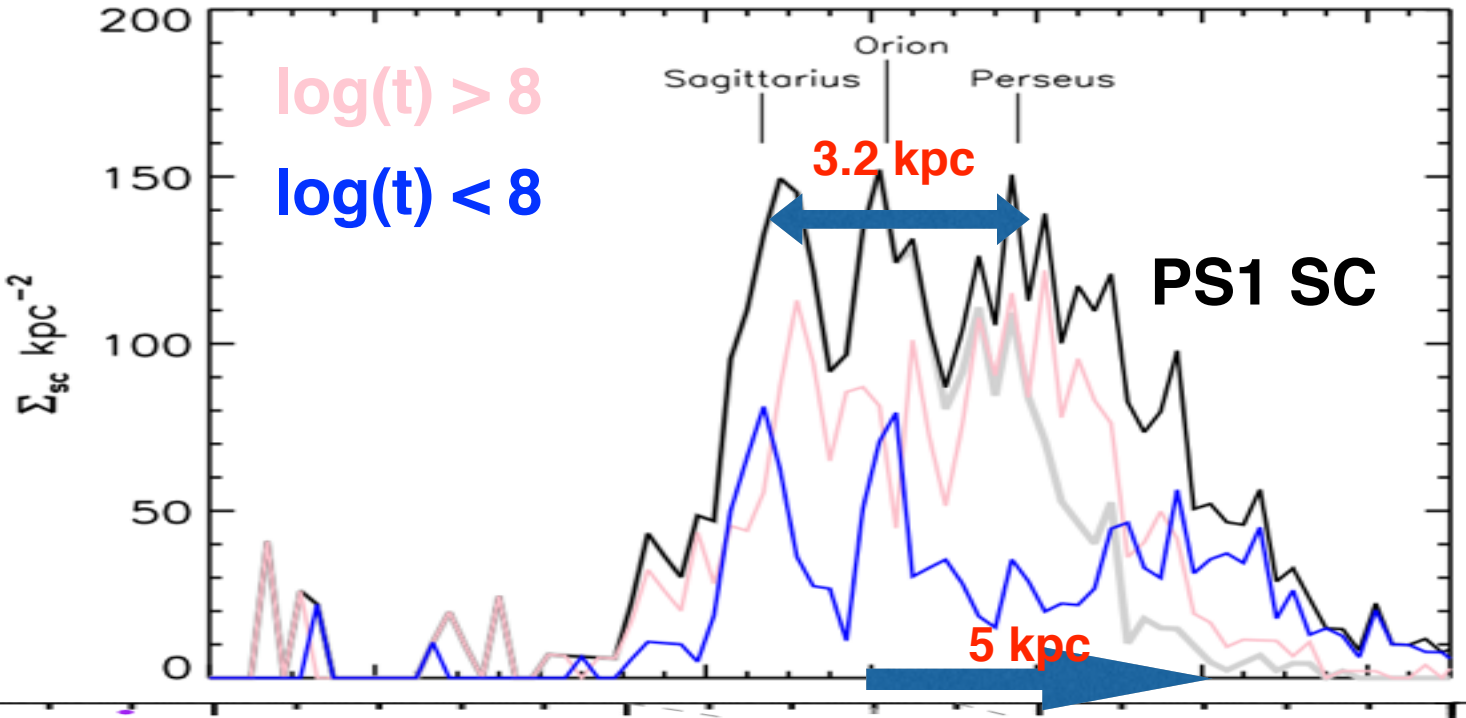


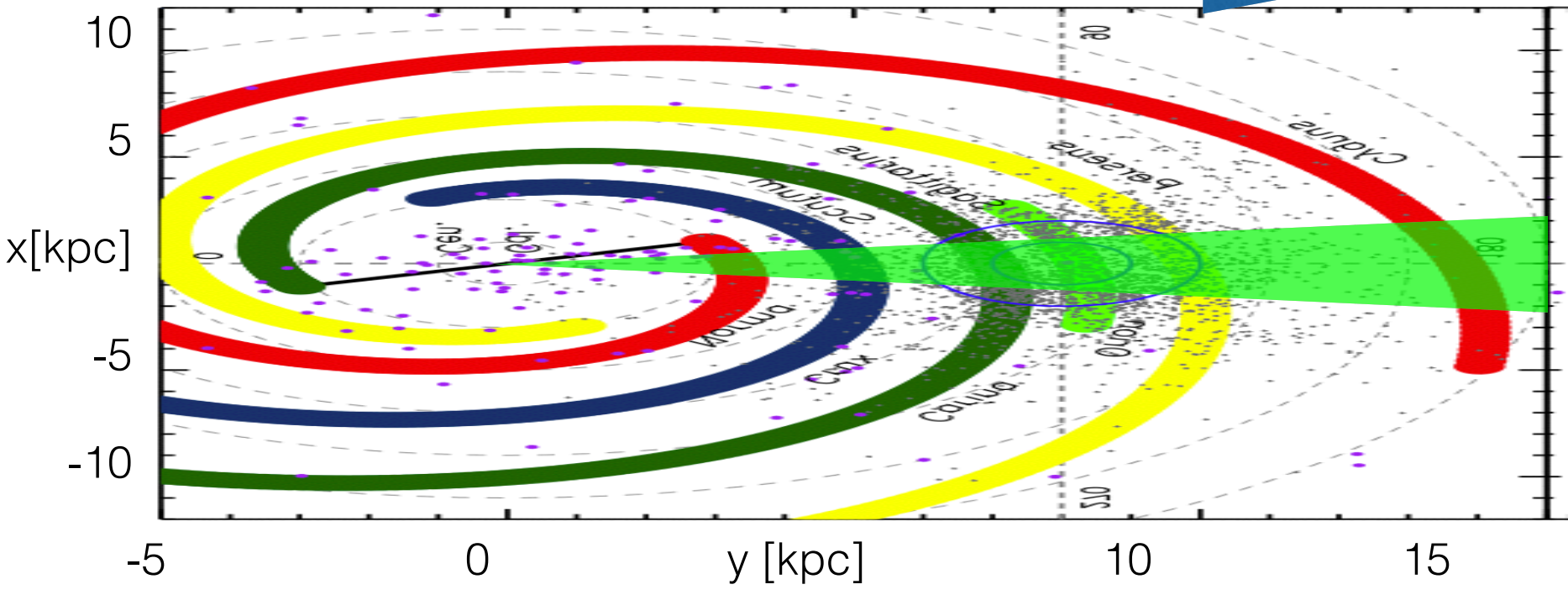
Cumulative distribution

Sagittarius:
450±50 pc

Orion:
400±50 pc

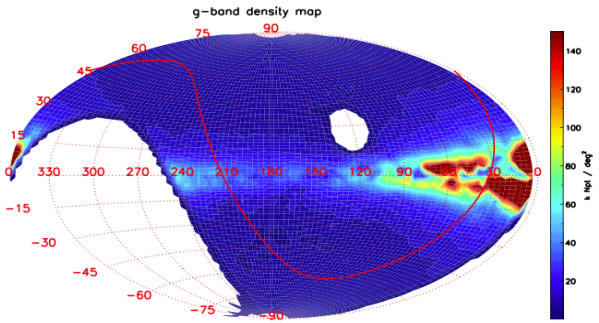
Perseus:
800±100 pc

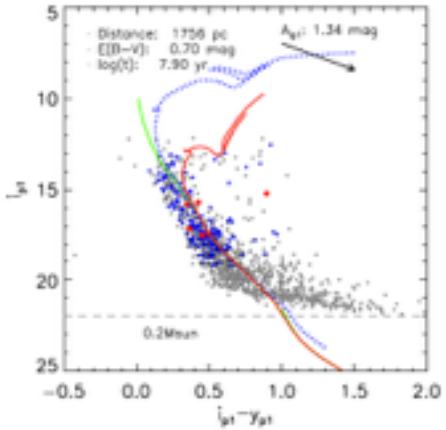


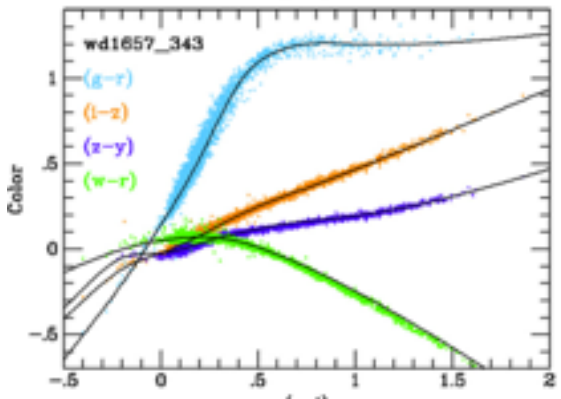

10
5
0
-5
-10
x[kpc]
-5
0
y [kpc]
10
15
Cetus
Eridanus
Phoenix
Tucana
Horologium
Hydrus
Carina
Columba
Pictor
Volans
Dorado
Reticulum
Hyades
Pleiades
Perseus
Cepheus
Cygnus
Cassiopeia
Camelopardalis
Auriga
Canis Major
Monoceros
Gem
Lyn
Leo
Crater
Hya
Vela
Pup
Cen
Lup
Ara
Ind
Pav
Aps
Mus
Cha
Men
Cir
Sco
Oph
Her
Lyr
Vul
Sge
Aql
Del
Equ
Peg
Cep
Cam
Per
Aur
Tau
Ori
Gem
CMa
CMi
Hya
Sex
Crt
Crv
Cen
Lup
Ara
Nor
Sco
Oph
Her
Lyr
Cyg
Cep
Cas
Per
Aur
Ori
Lep
Pup
Vel
Car
Cen
Mus
Cir

Discussion & Future Works

- Search for uncharted star clusters with all survey region (3PI)
- Characterize star clusters with PS1 photometry, proper motions + LAMOST radial velocity + SDSSIV (APOGEE) stellar rotation
- Create PS1 stellar locus with different metallicities (From LAMOST)







http://panstarrs.stsci.edu/PSI/