Hyper Suprime-Cam, the HSC Survey, and the HSC Pipeline

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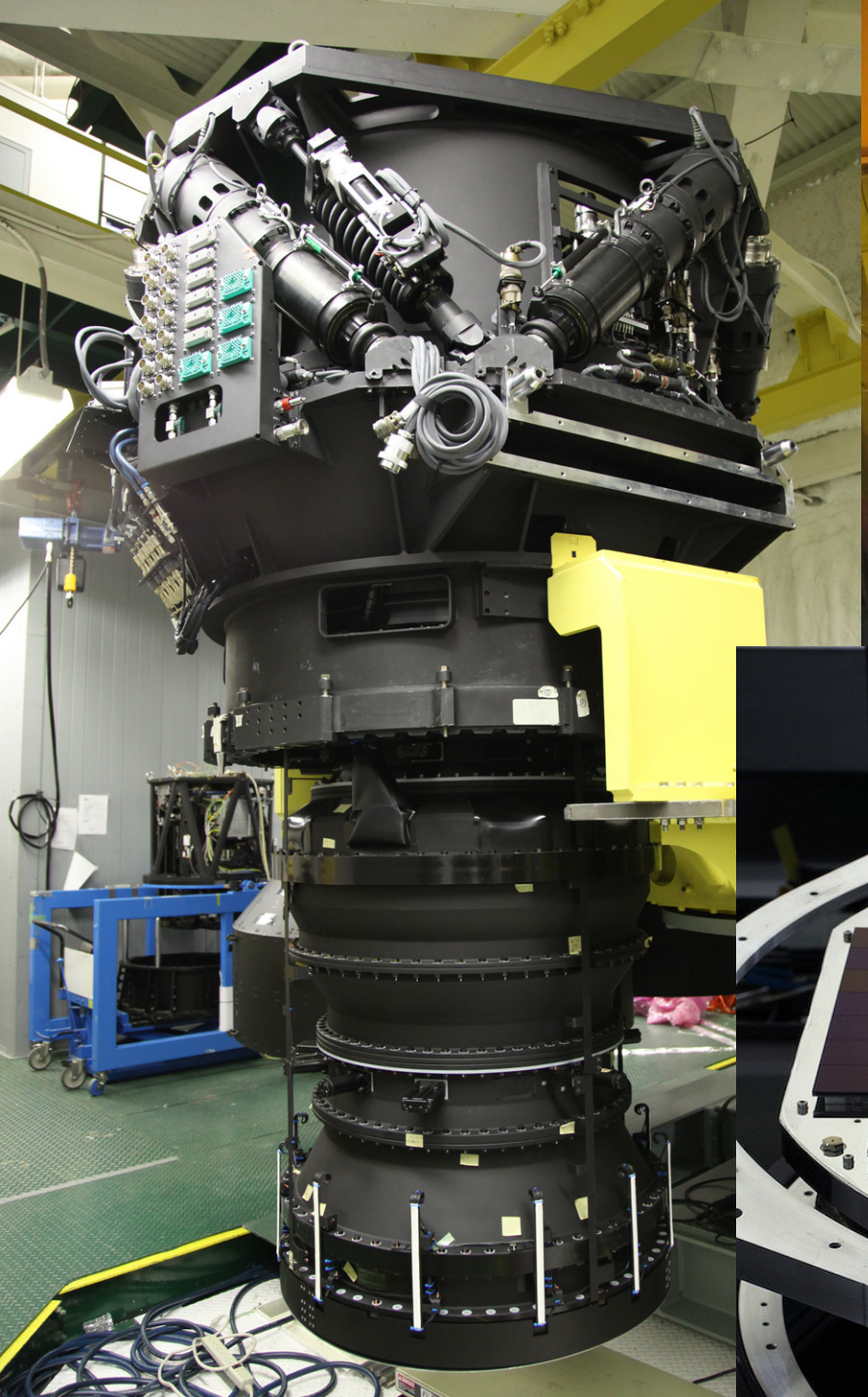
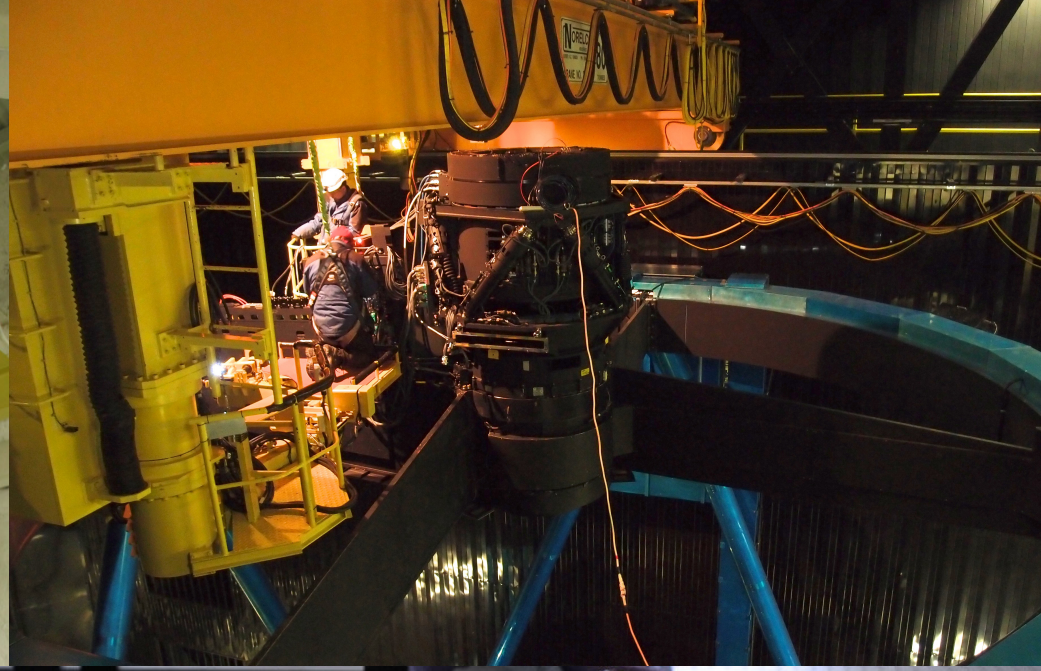
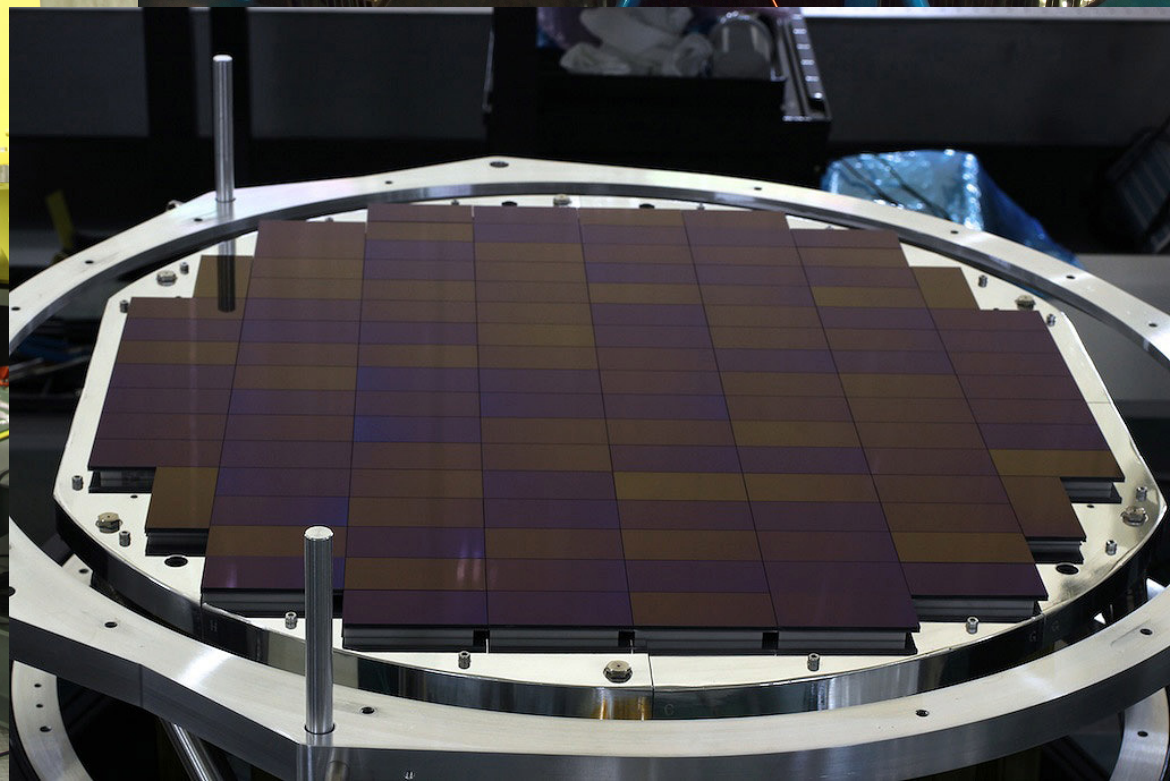
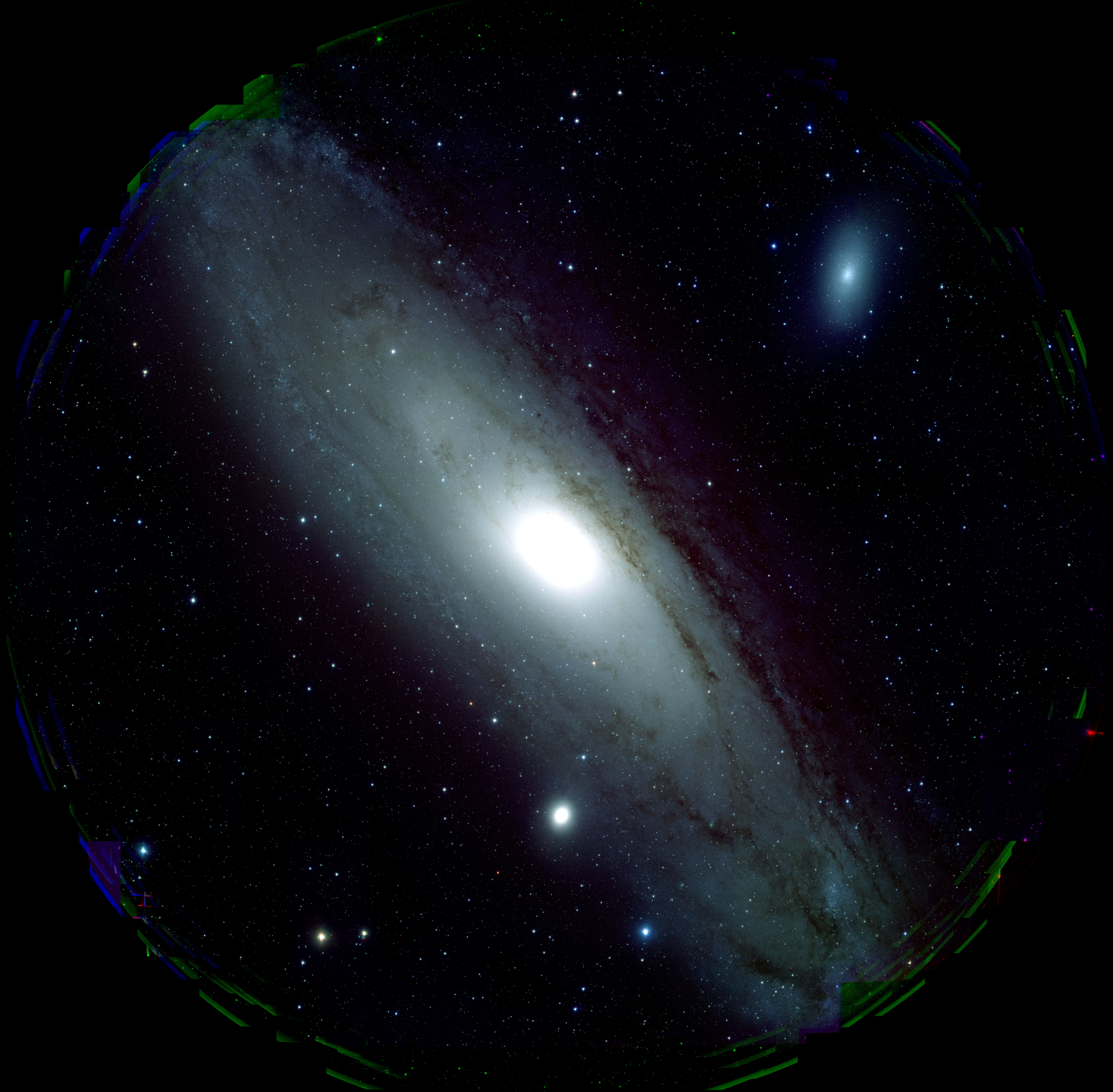
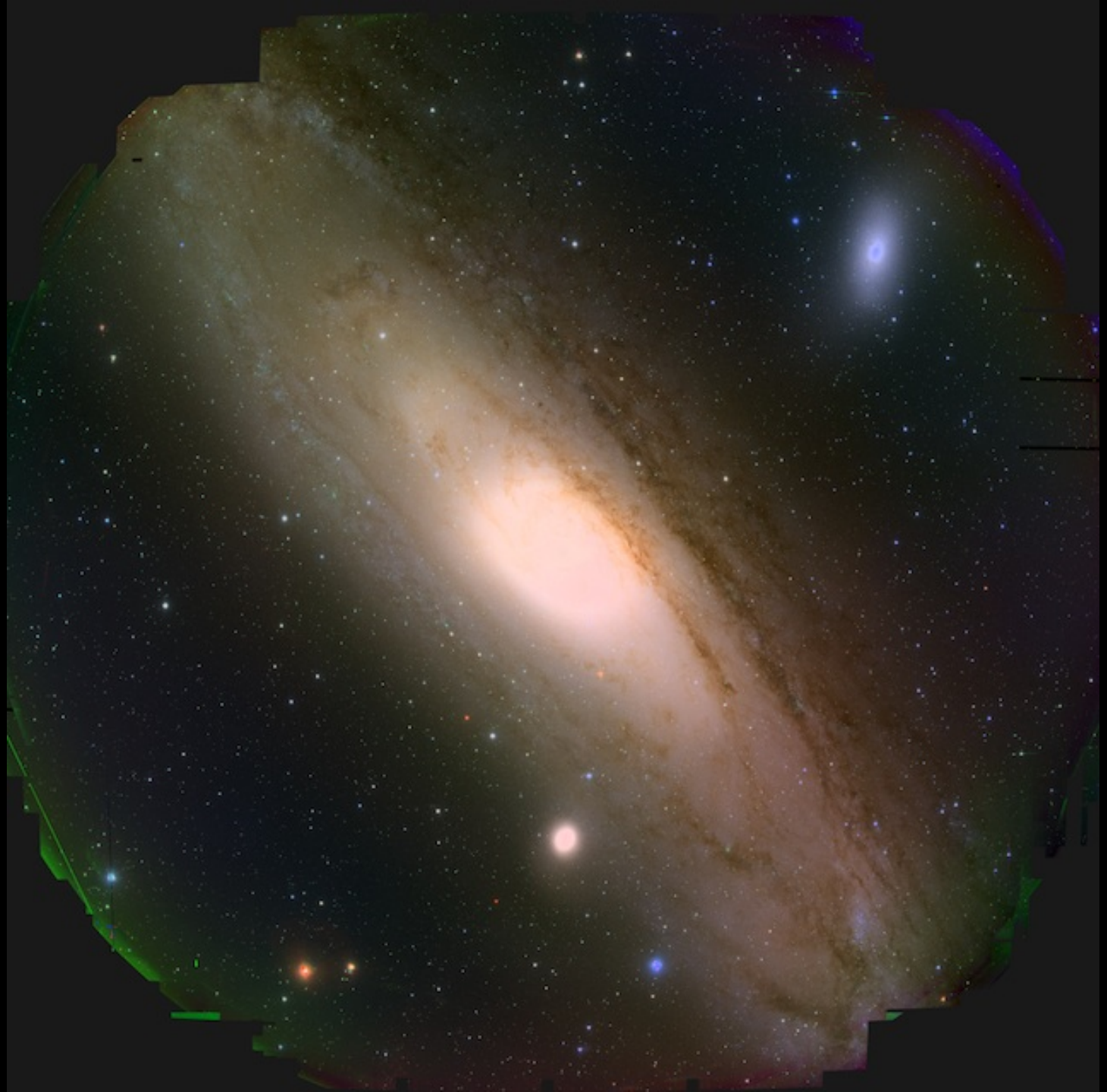






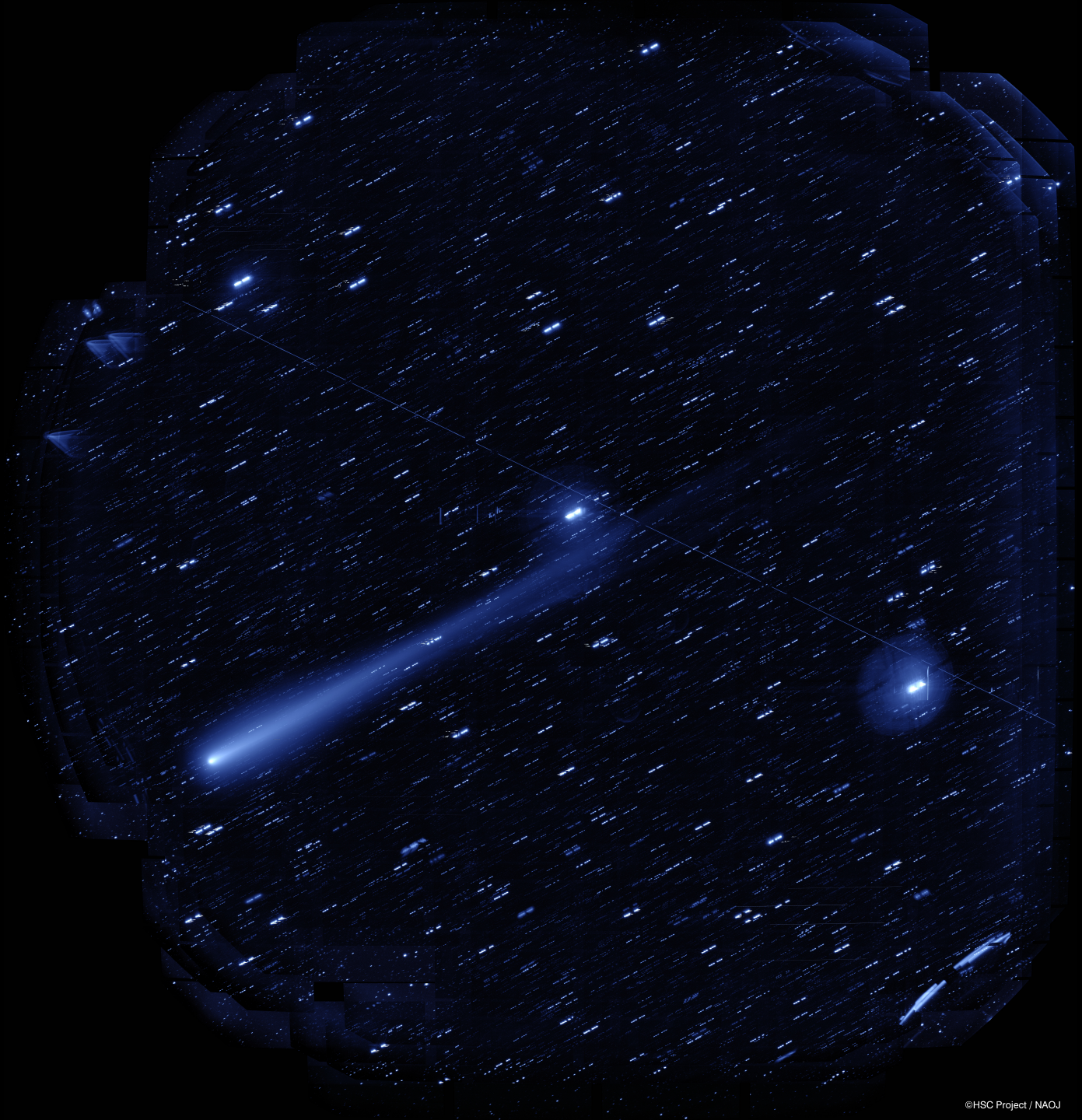




2x

8x

32x



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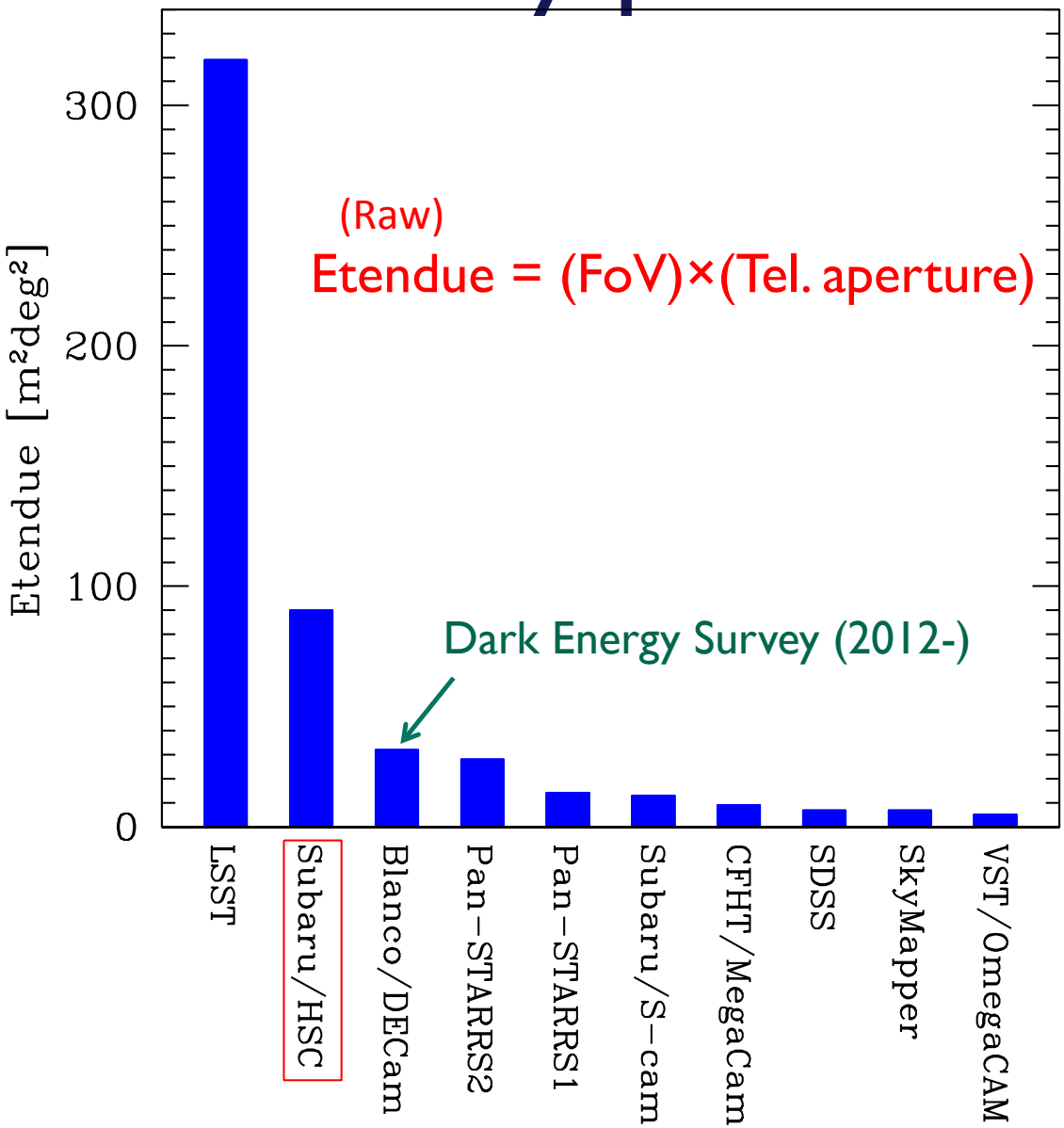
Survey power of HSC

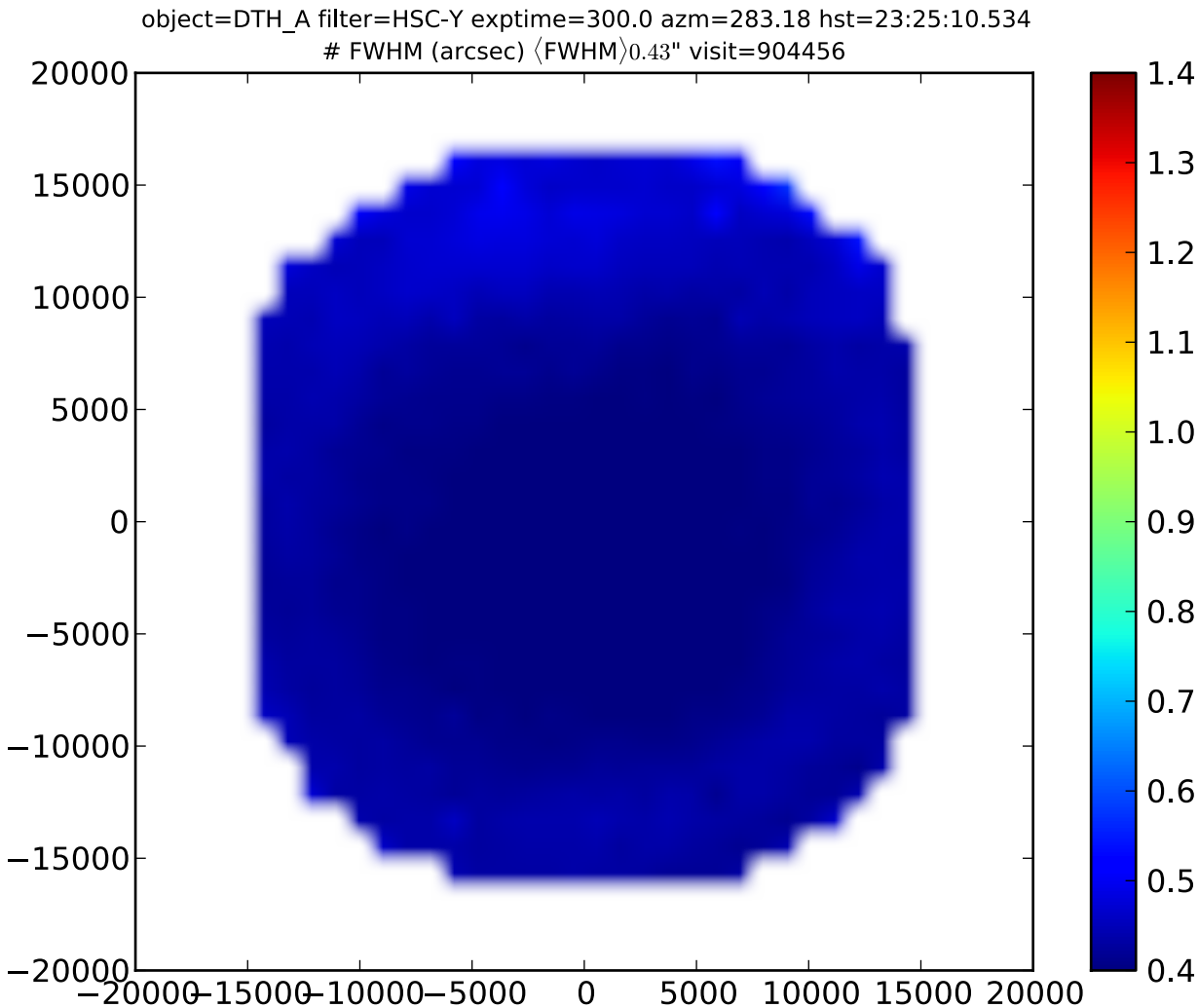


- Photon collecting power of 8.2m Subaru Tel.
- FoV
- Excellent image quality

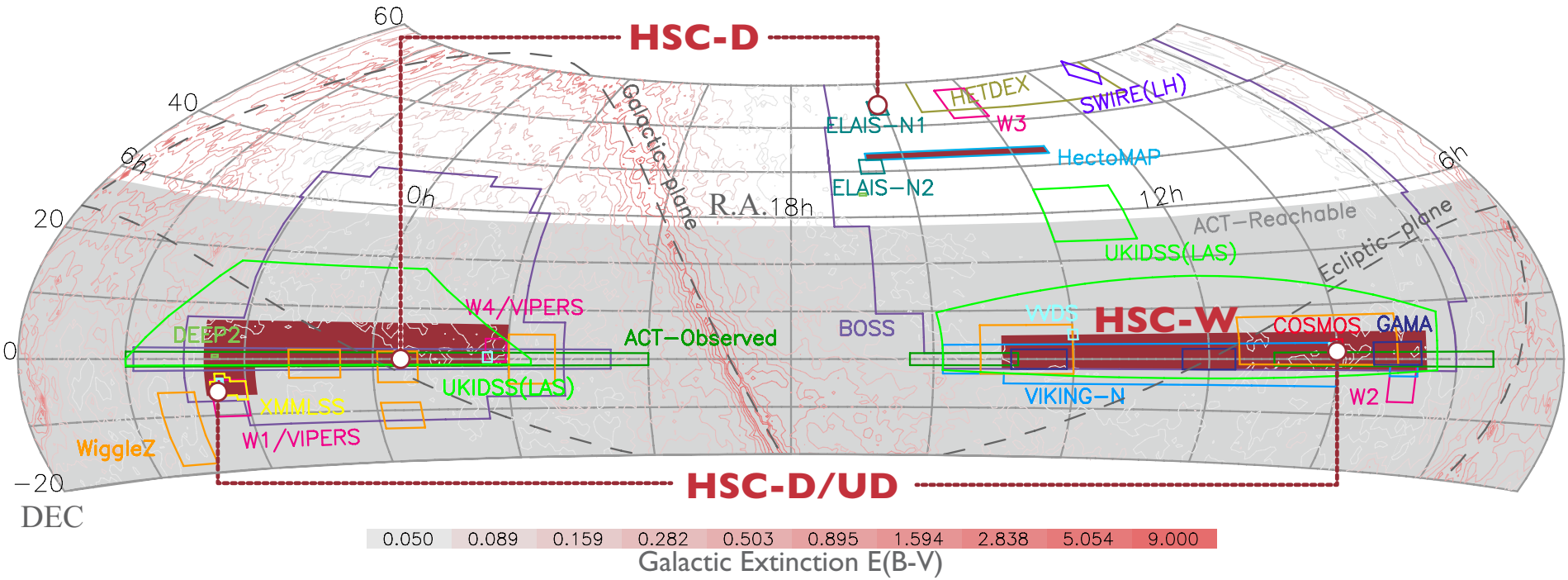
→ *These make HSC the most powerful survey camera/ telescope before LSST*

NB: does not include time allocation, efficiency factors, PSFs…

Exquisite image quality

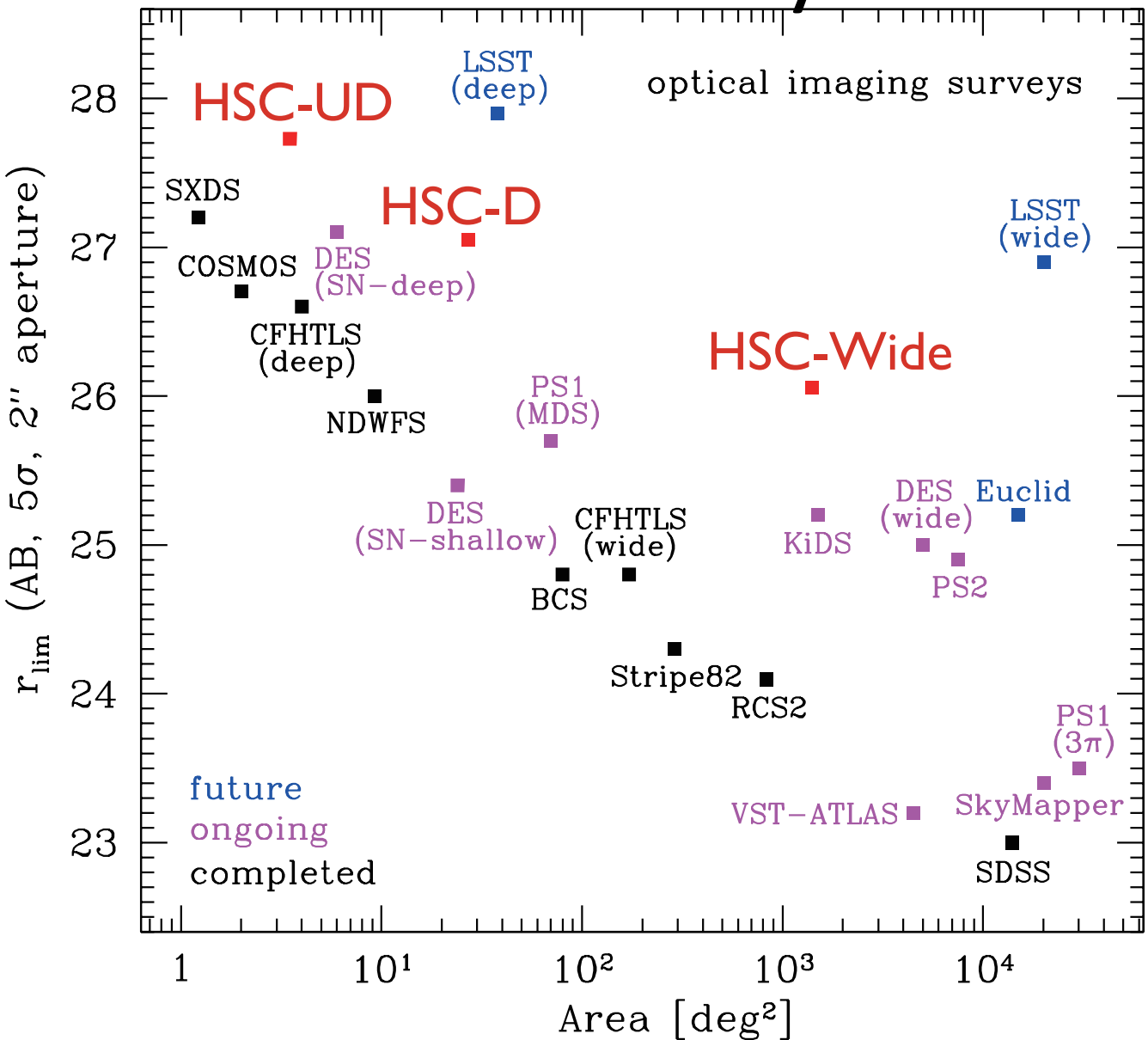


HSC Survey



To be completed over 300 nights through the next 5 years or so.

HSC Survey

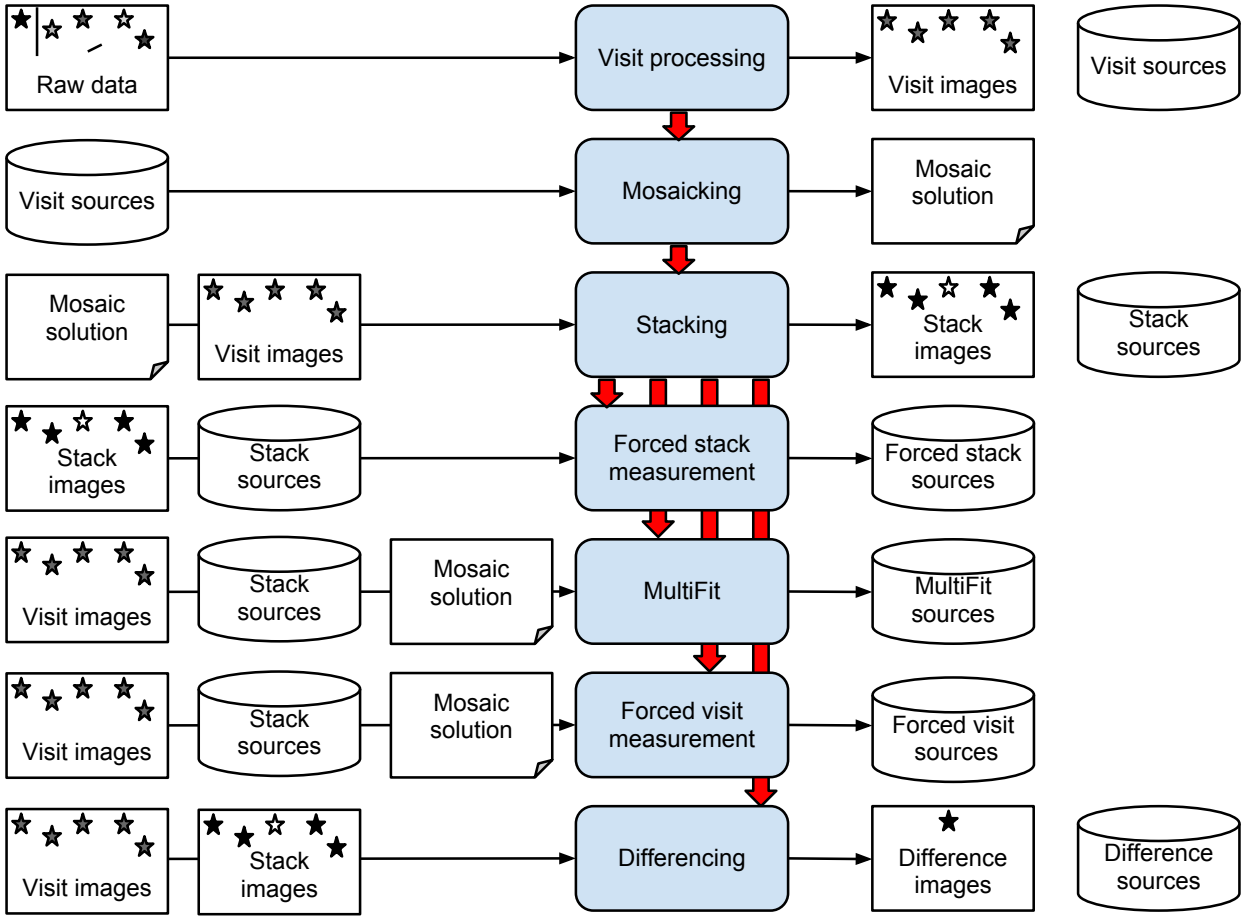

optical imaging surveys
HSC-UD
HSC-D
HSC-Wide
LSST (deep)
LSST (wide)
SXDS
COSMOS
CFHTLS (deep)
NDWFS
DES (SN−deep)
PS1 (MDS)
DES (SN−shallow)
CFHTLS (wide)
BCS
Stripe82
RCS2
KiDS
DES (wide)
Euclid
PS2
PS1 (3π)
SkyMapper
VST−ATLAS
SDSS
future
ongoing
completed
r_{lim} (AB, 5σ, 2″ aperture)
Area [deg²]
28
27
26
25
24
23
1
10¹
10²
10³
10⁴

HSC Survey has started!

Schedule for March 2014

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						Mar 01
						S14A-015 Iwata S-Cam
Mar 02	Mar 03	Mar 04	Mar 05	Mar 06	Mar 07	Mar 08 ◐
S14A-015 Iwata S-Cam		Keck Brodie S-Cam	S14A-006 Arnaboldi S-Cam	UH-38A Sanders FMOS		
Mar 09	Mar 10	Mar 11	Mar 12	Mar 13	Mar 14	Mar 15 ○
S14A-150 Ly FMOS		Service MOIRCS Service IRCS+AO188	S14A-089 Takahashi IRCS+AO188	S14A-093 Yano IRCS+AO188	S14A-104 Morii IRCS+AO188	S14A-131 Matsuoka MOIRCS
Mar 16	Mar 17	Mar 18	Mar 19	Mar 20	Mar 21	Mar 22 ◑
Obs IRCS+AO188	Obs IRCS+AO188 Eng IRCS+AO188	S14A-080 Tsumura IRCS+AO188 Eng OCS	Eng Eng IRCS+AO188	Obs IRCS+AO188 Eng IRCS+AO188	S14A-098 Nagao IRCS+AO188	S14A-159 Saitoh IRCS+AO188
Mar 23	Mar 24	Mar 25	Mar 26	Mar 27	Mar 28	Mar 29
S14A-159 Saitoh IRCS+AO188	StrObs HSC	UH-13B Hasinger HSC	UH-39A Hu HSC	StrObs HSC		S14A-184 Okamoto HSC
Mar 30 ●	Mar 31					
S14A-184 Okamoto HSC	StrObs HSC					

HSC Pipeline



Construction philosophy

- Based on LSST pipeline
  - Lots of ‘free’ effort
  - Additional testing and bug fixes
  - Win/win
  - C++, SWIG, Python
  - Extensible: cameras, measurements
  - Flexible and configurable
  - GPL version 3
- Not married to LSST
  - Can substitute
  - Can add and extend

Construction philosophy

- Use as much LSST code as we can
  - Principally algorithms, some middleware
- Supplement with additional functionality
  - Quality assessment
  - Mosaicking and stacking
  - Astrometric matching
  - Exposure-based astrometric solution
  - PostgreSQL-based registry, database
  - Detrend construction
- Run over PBS/Torque

Flexibility of Python, speed of C++

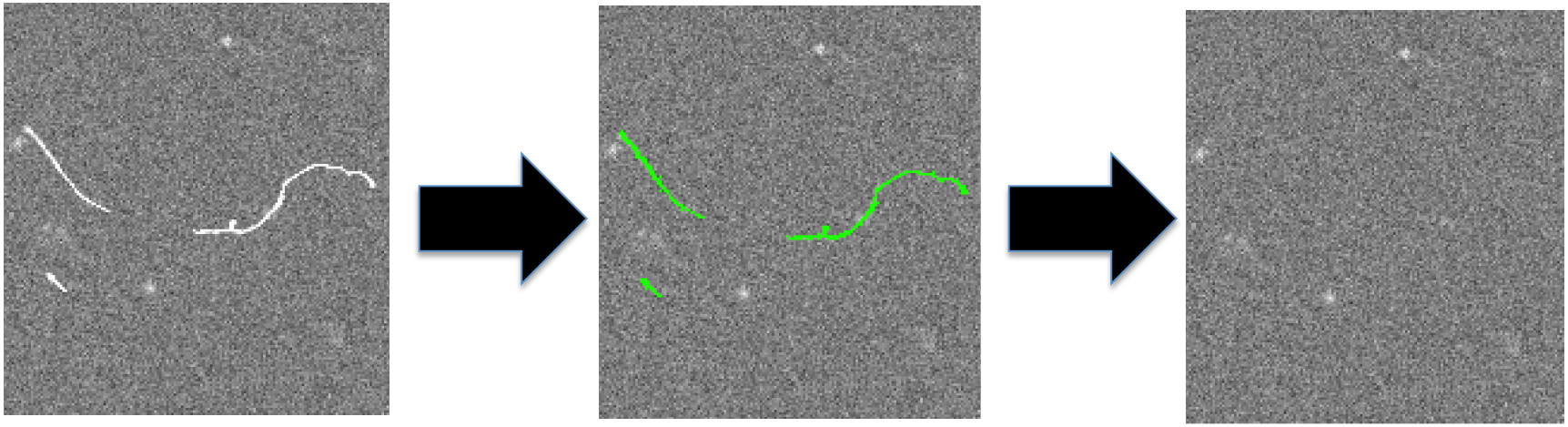
```
smoothingKernel = AnalyticKernel(ksize, ksize,
                                 GaussianFunction2D(alpha, alpha))

for f in filters:
    imgList = vectorMaskedImageF()

    for run, camCol, (field0, field1) in inputs:
        camColImgList = vectorMaskedImageF()

        fields = []
        for field in range(field0, field1 + 1):
            exposure = getExposure(run, camCol, field, f)

            if subtractBackground:
                bkgd = makeBackground(mim, BackgroundControl(nx, ny))

                im = exposure.getMaskedImage().getImage()
                im -= bkgd.getImageF()
                del im

            cmimg = maskedImageFactory(exposure.width(),exposure.height())
            convolve(cmimg, exposure.getMaskedImage(), smoothingKernel)
            exposure.setMaskedImage(cmimg)

            img = maskedImageFactory(exposure.getDimensions())
            warpedExposure = makeExposure(img, wcs0)
            warpExposure(warpedExposure, exposure, warpingKernel)
```

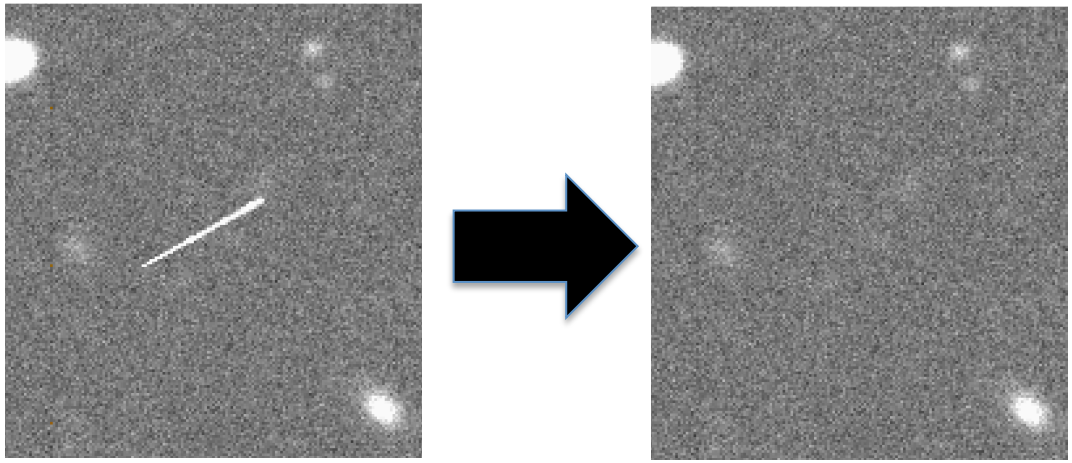
Every operation in red is written in C++.

LSST-DM camera agnosticism

- Algorithm code is camera agnostic, flexible
  - `root.algorithm.retarget(MyAlgorithmTask)`
- Interface packages written for
  - LSST ImSim
  - CFHT MegaCam
  - Suprime-Cam
  - HSC
  - SDSS
  - Space Surveillance Telescope
  - DECam
  - Generic

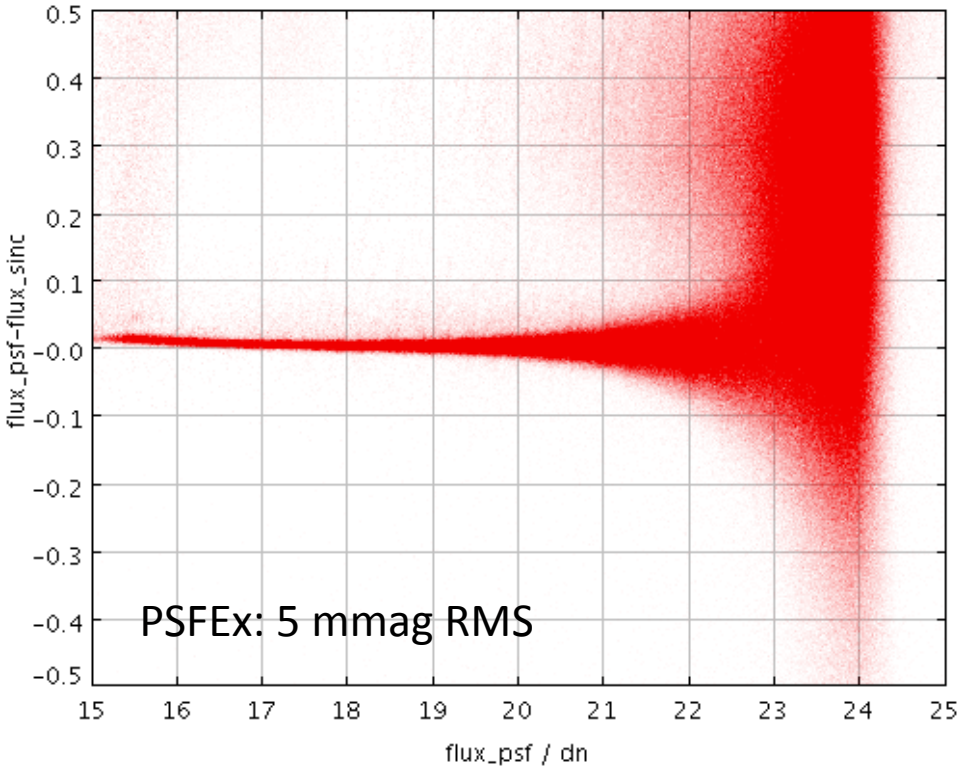
Cosmic rays



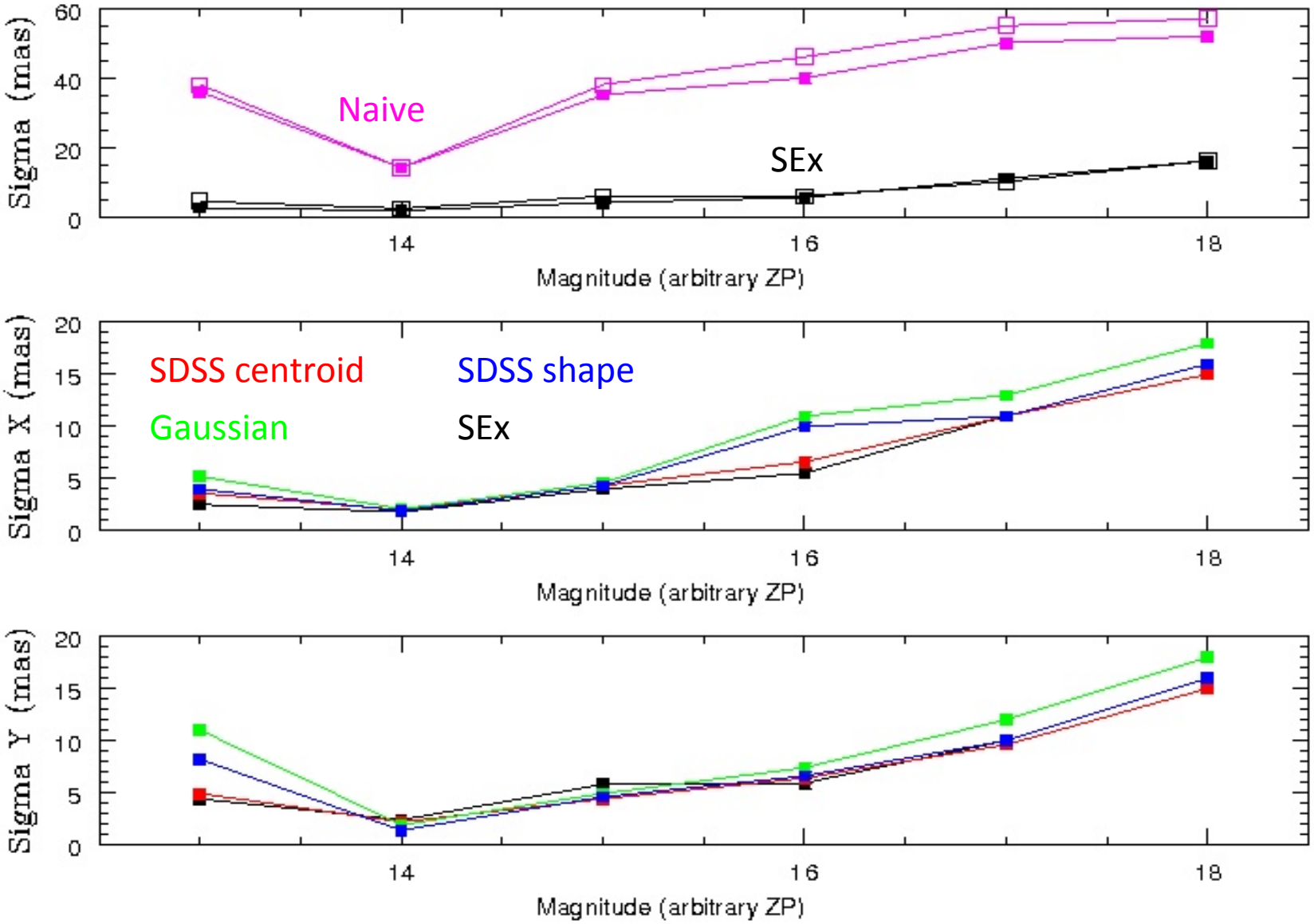


PSFs

- PcaPsf
- PSFEx (Bertin/Astromatix)
- KmsPsf
- CoaddPsf
- …

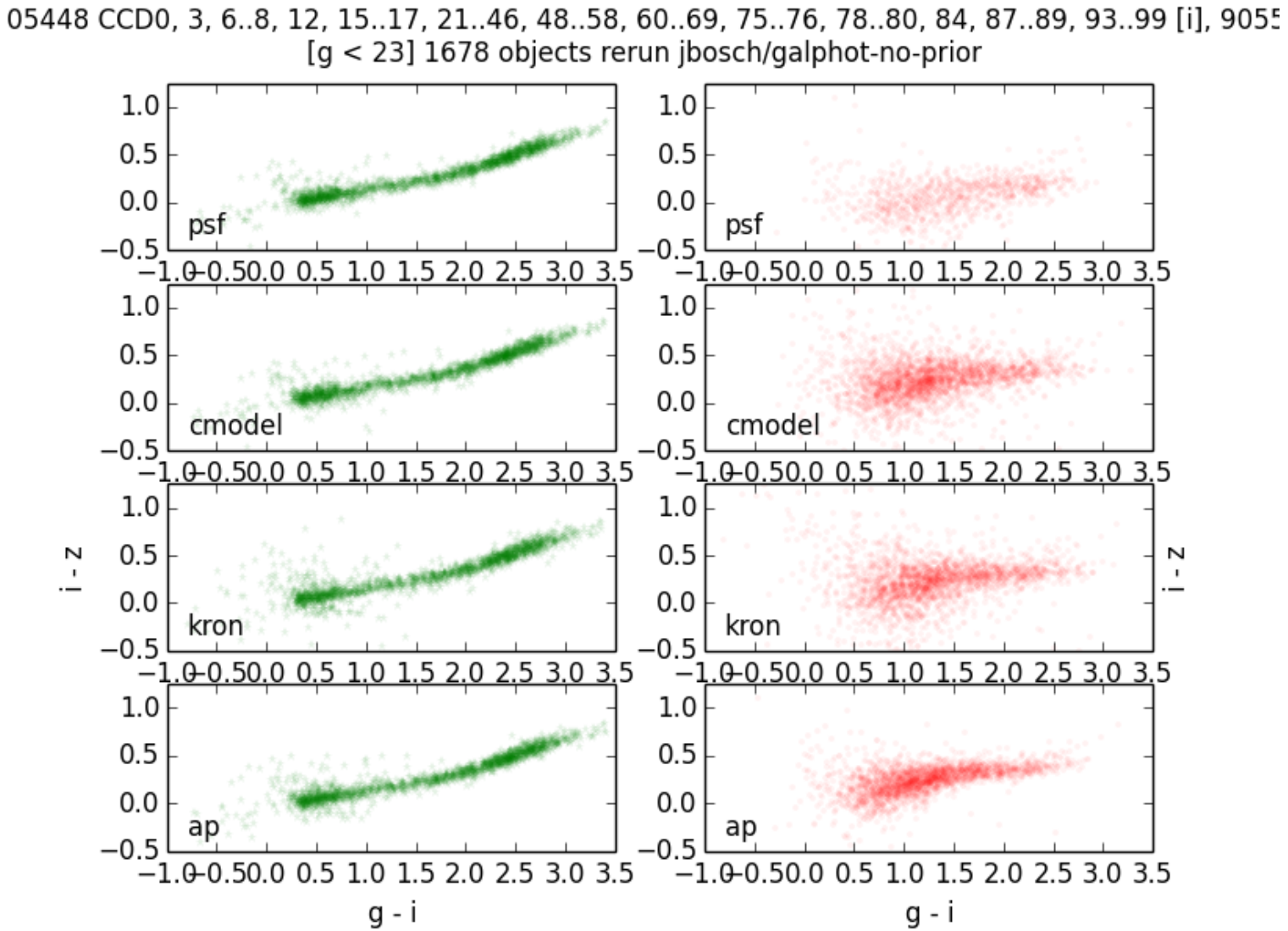


Various astrometry measurements

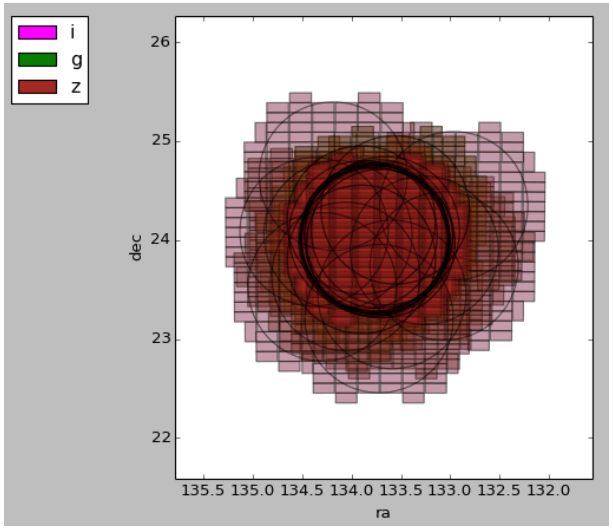


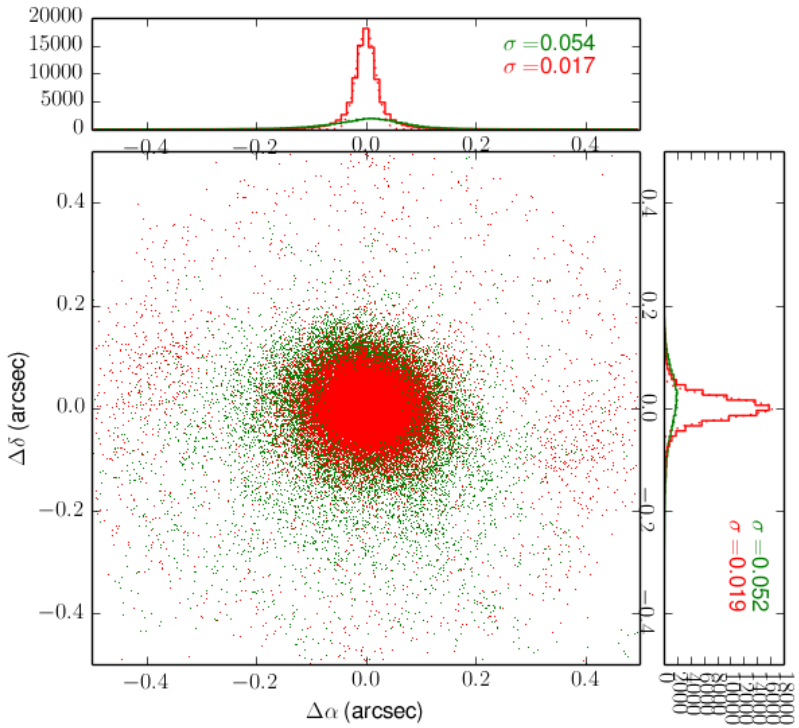
Dave Monet

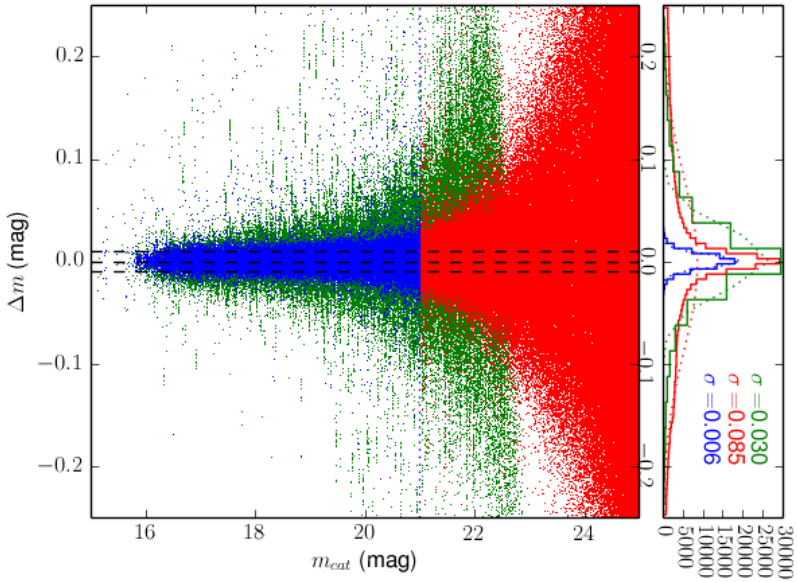
Colour-Colour Diagram stars and galaxies; g < 23 30s



Mosaic





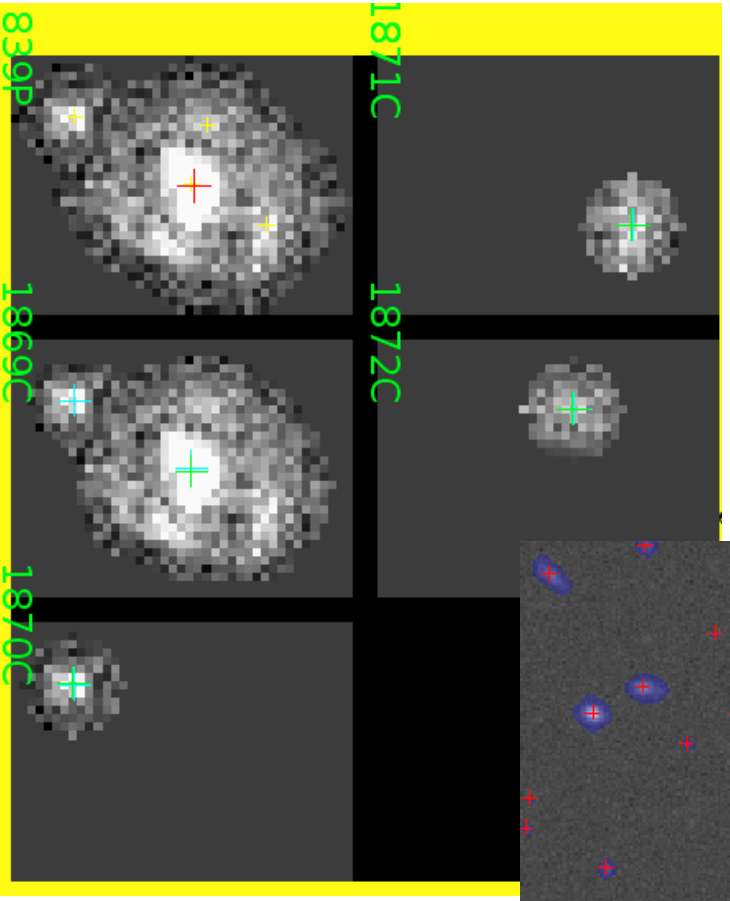


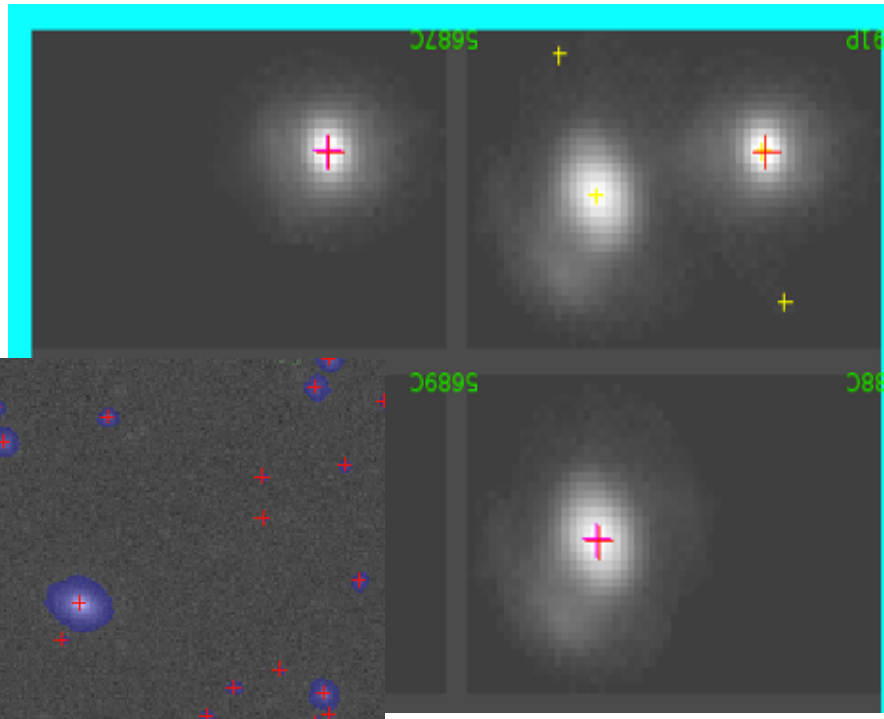
20 mas internal

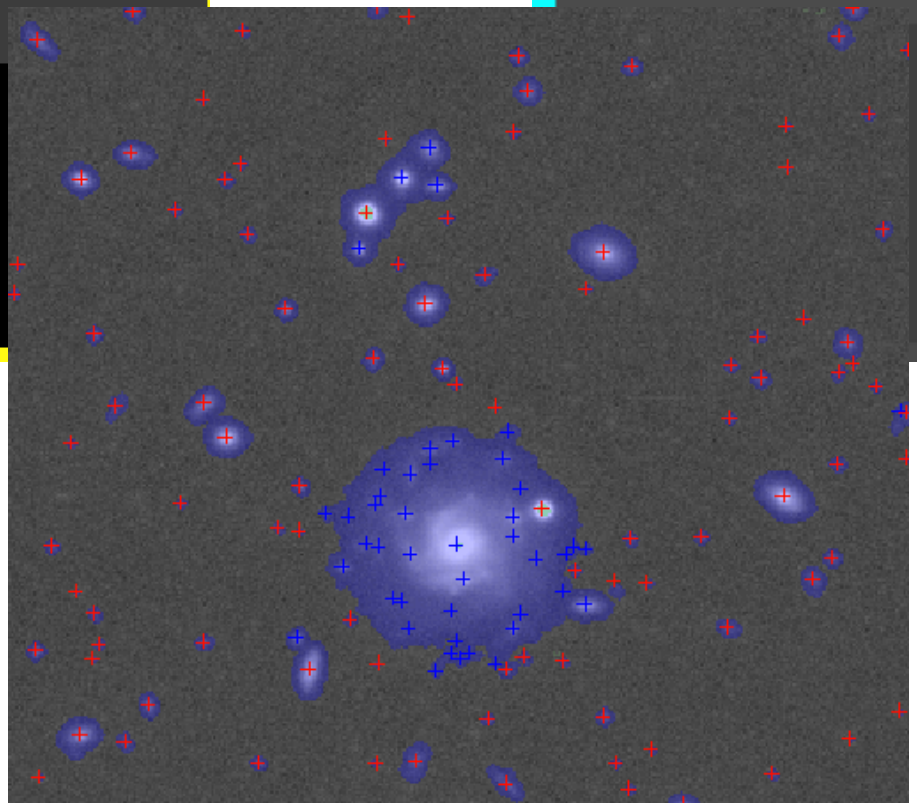
6 mmag internal

Caveat: these are from back-to-back 30 sec exposures
Should improve with longer exposures → more tie objects

Deblender



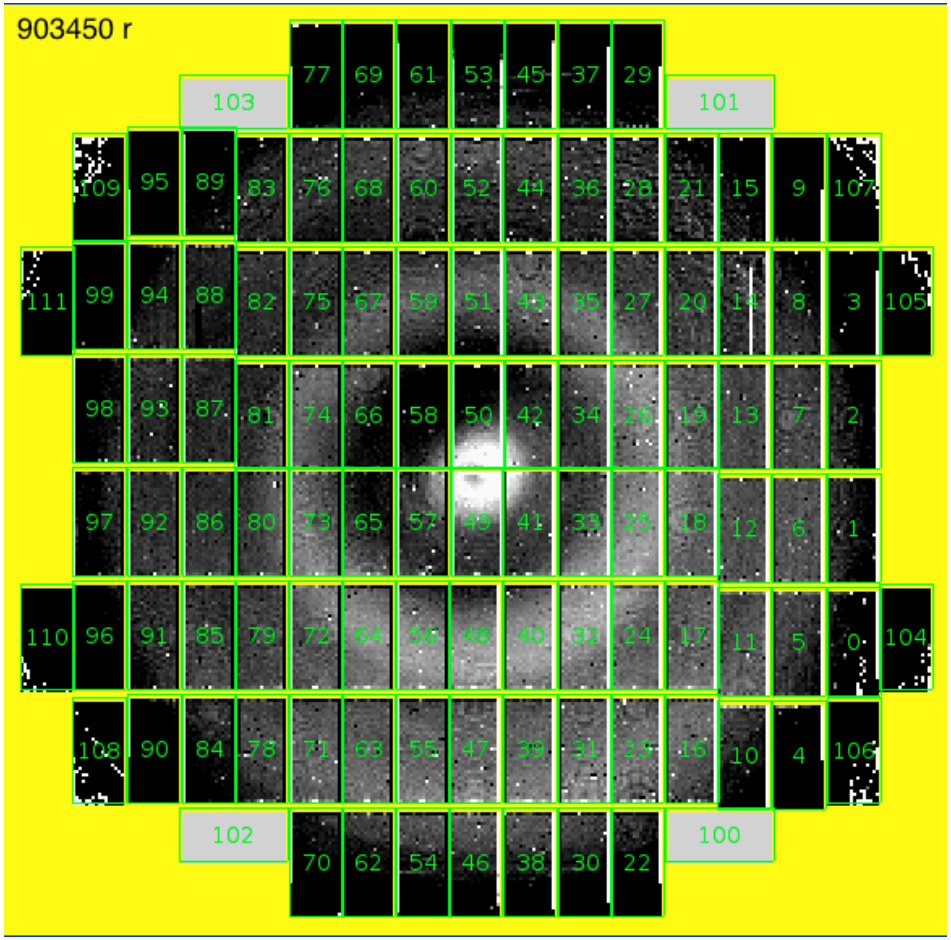


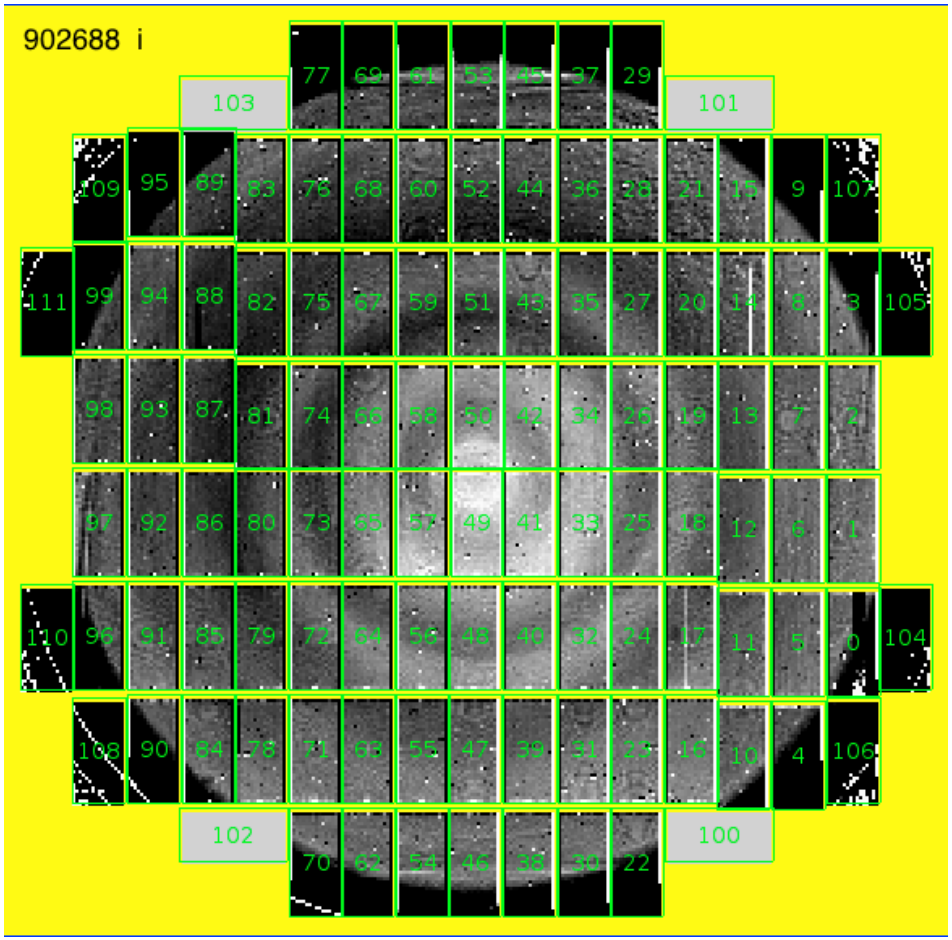


Conclusions

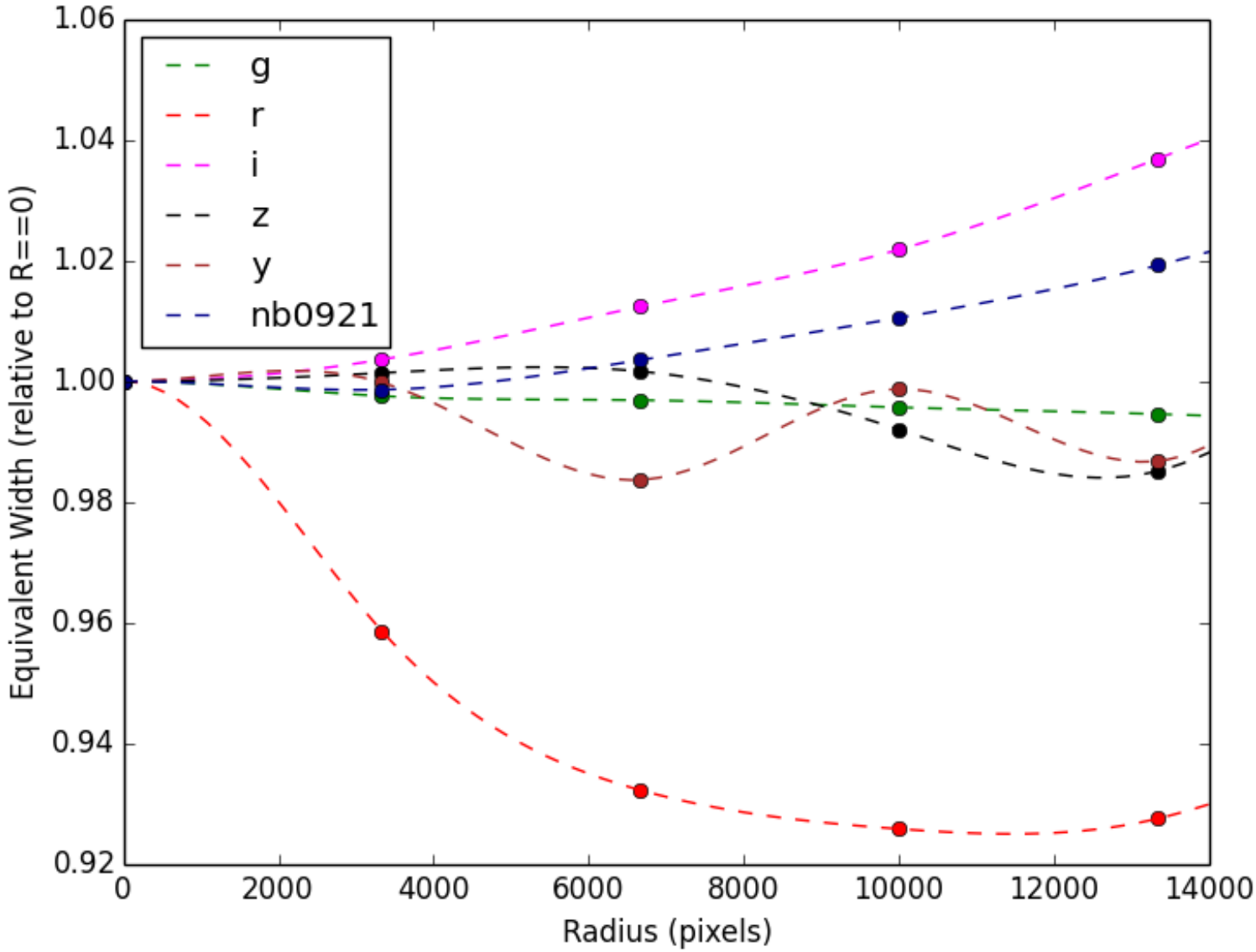
- HSC Survey started last night
- LSST DM is large, maturing public codebase
  - Documentation and support currently limited; should change soon!
- LSST pipeline is extensible and configurable
  - Camera agnostic; can easily substitute custom code
  - Components pluggable: PSF, measurements, astrometry, deblender, stacking, …
- LSST pipeline (customised) will reduce HSC data
  - Could also reduce DES data: systematics checks

Background structure

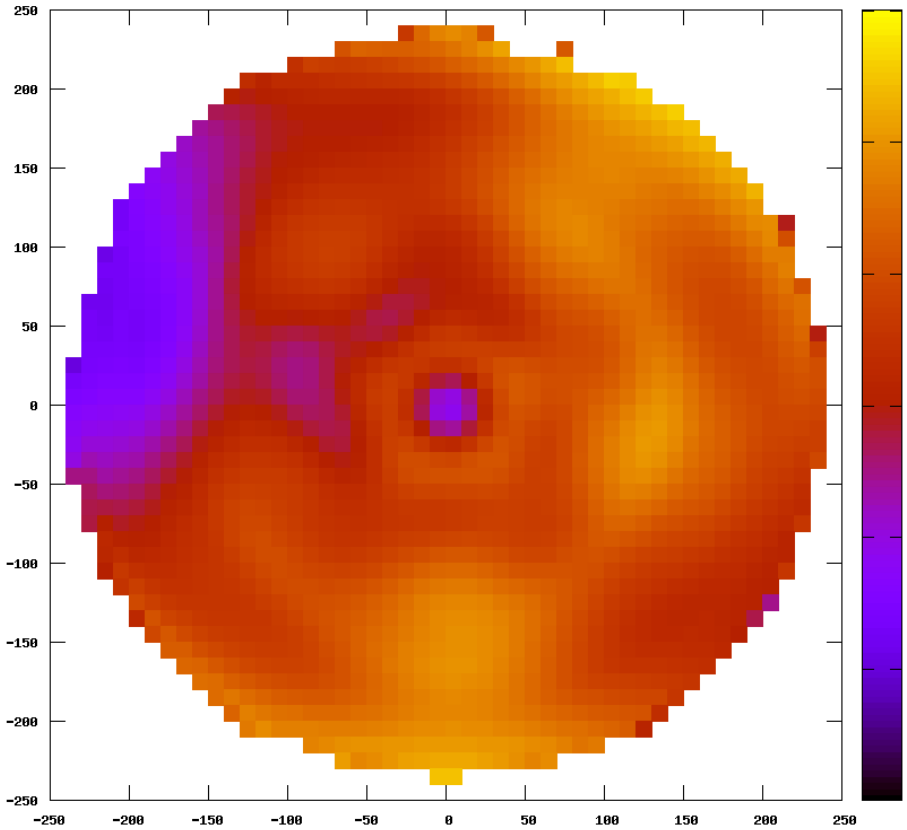




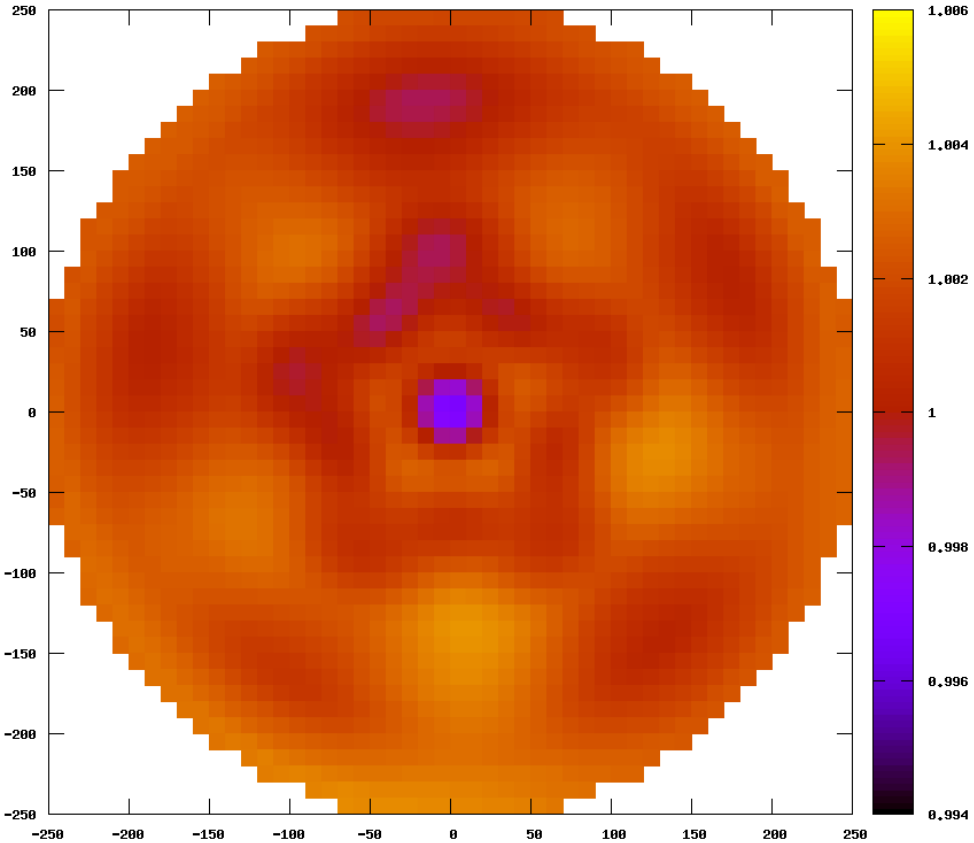
Background structure explained?



Background structure explained?



Observed



Model