Combining MegaCam (u) and HSC images with hscPipe

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UNIVERSITÉ DE GENÈVE

Overview

- we obtained 375h at CFHT to follow-up HSC deep fields with u-band imaging (CLAUDS)
- developed code to do combined photometry with hscPipe on u+HSC images
- used a number of bypasses to produce science-ready catalogues rapidly
- made a SExtractor version to do validation and comparisons
- needs a number of adjustments but catalogue already complies with our science drivers requirements (dropouts, photo-z, etc.)

Why u-band? The CLAUDS project

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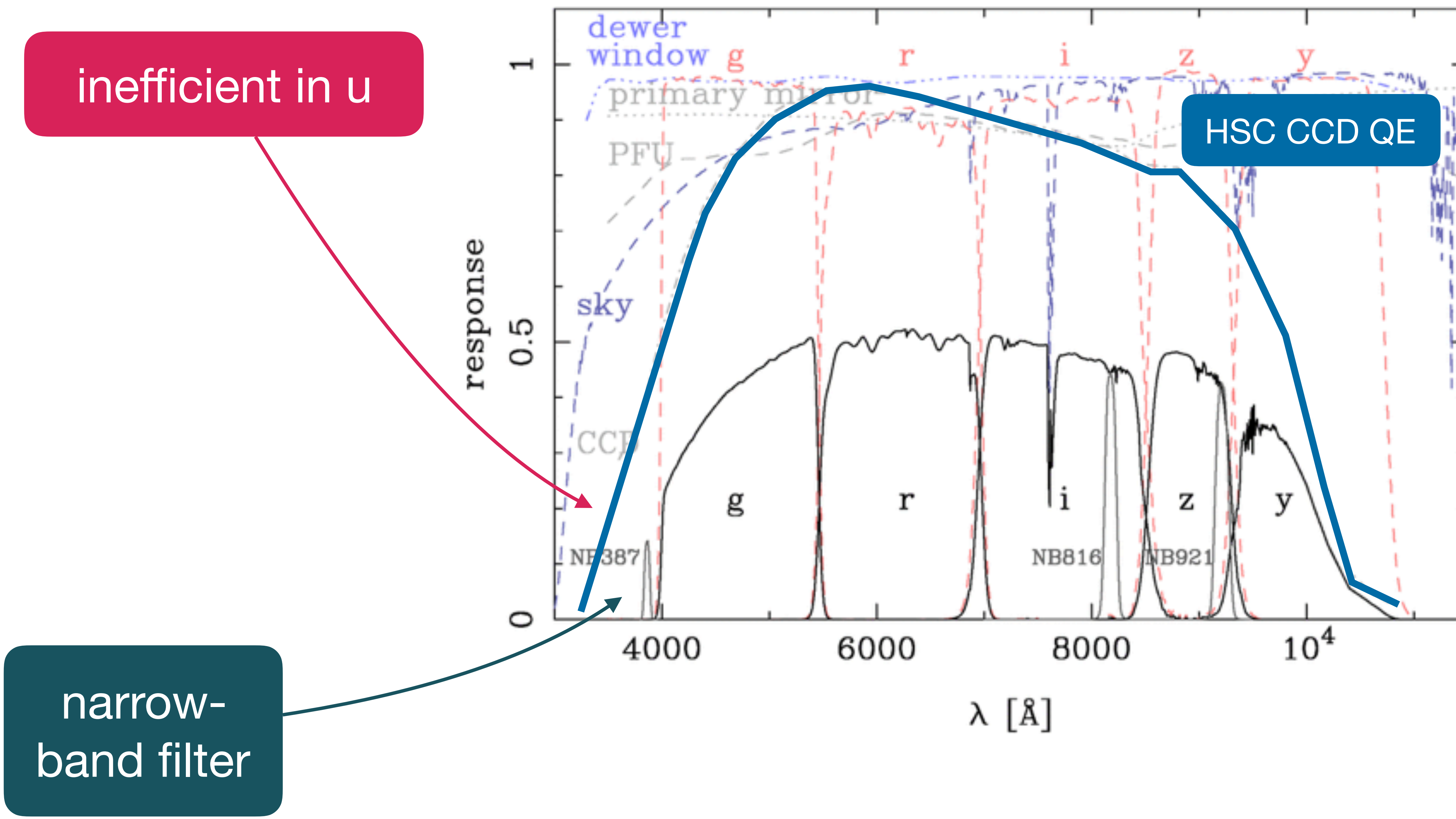
5. continuum for NB387 better than g-band
   LAEs, Ly-alpha blobs at z~2.2

HSC is a red sensitive camera



The CLAUDS project

- goal: benefit from u-band capability at CFHT to match HSC grizY imaging data in terms of seeing and depth
- instrument: MegaCam @ CFHT: smaller etendue but much better throughput in u (bluer camera)
- strategy: target HSC deep fields with Canada+France +China time over several semesters

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- awarded 375 hours = 68 dark-time nights over 5 semesters:
  - depth: u<27 (HSC: r<27), 5sigma 2”
  - area: ~20 deg^2 with Taiwan UD (85% of HSC fields)
  - 11h-14h integration per source
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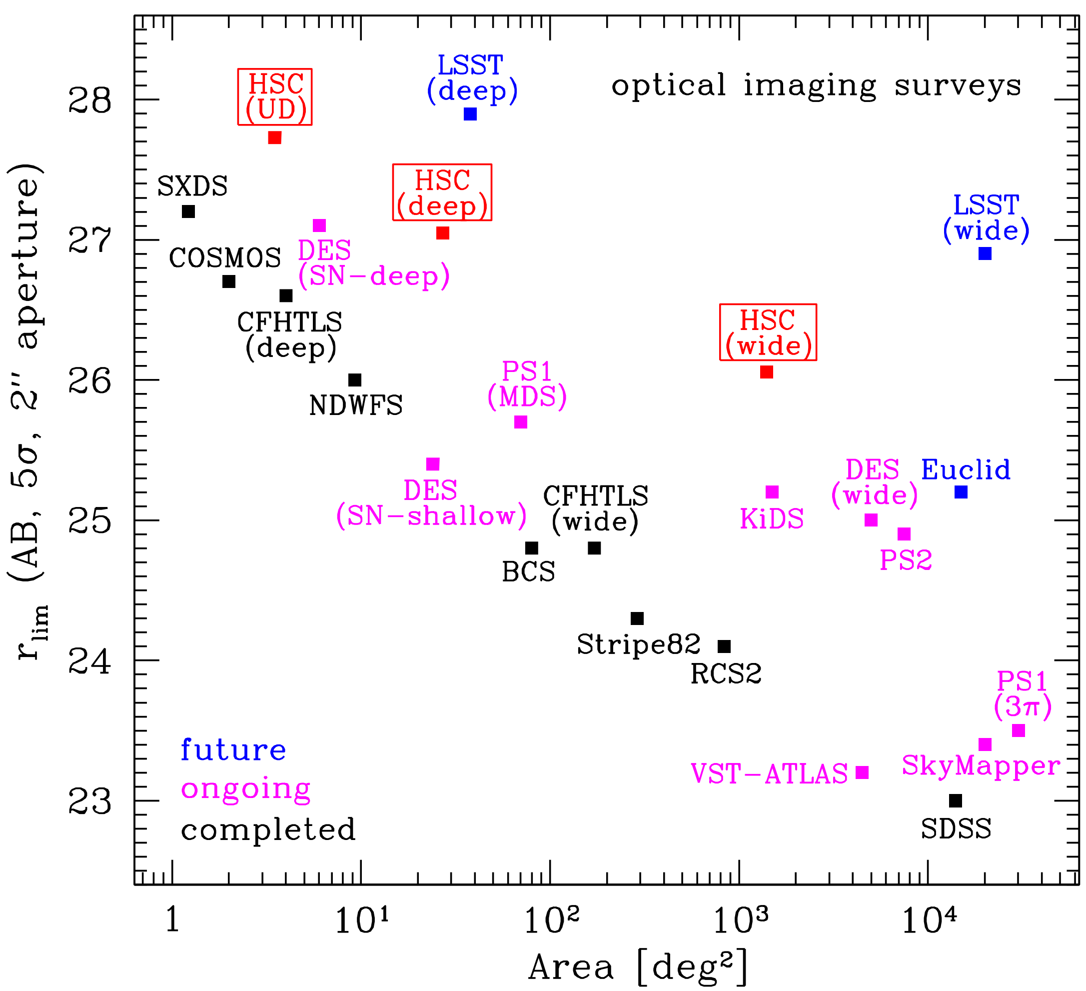
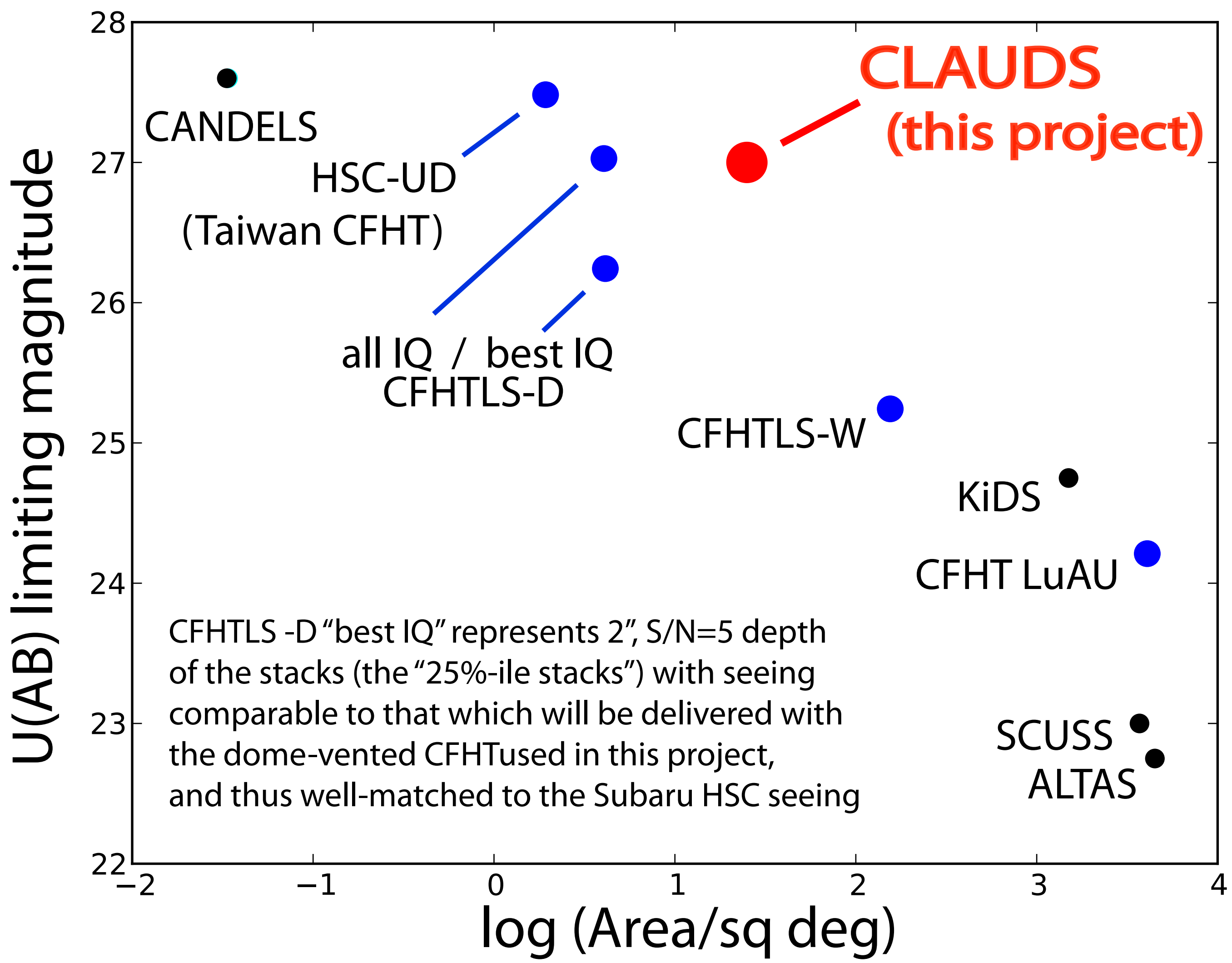
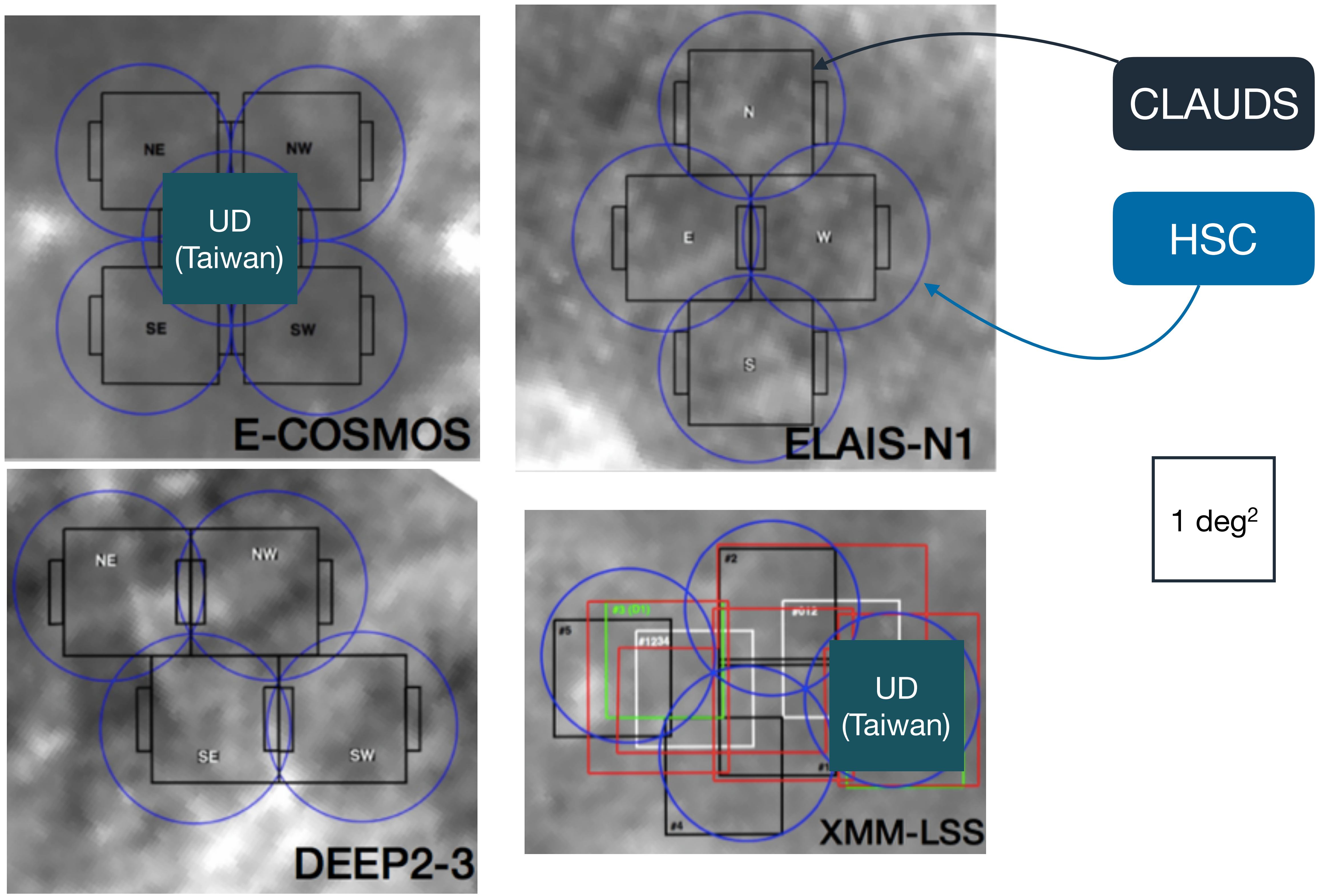
- survey completed in S16B

Unmatched dataset until LSST



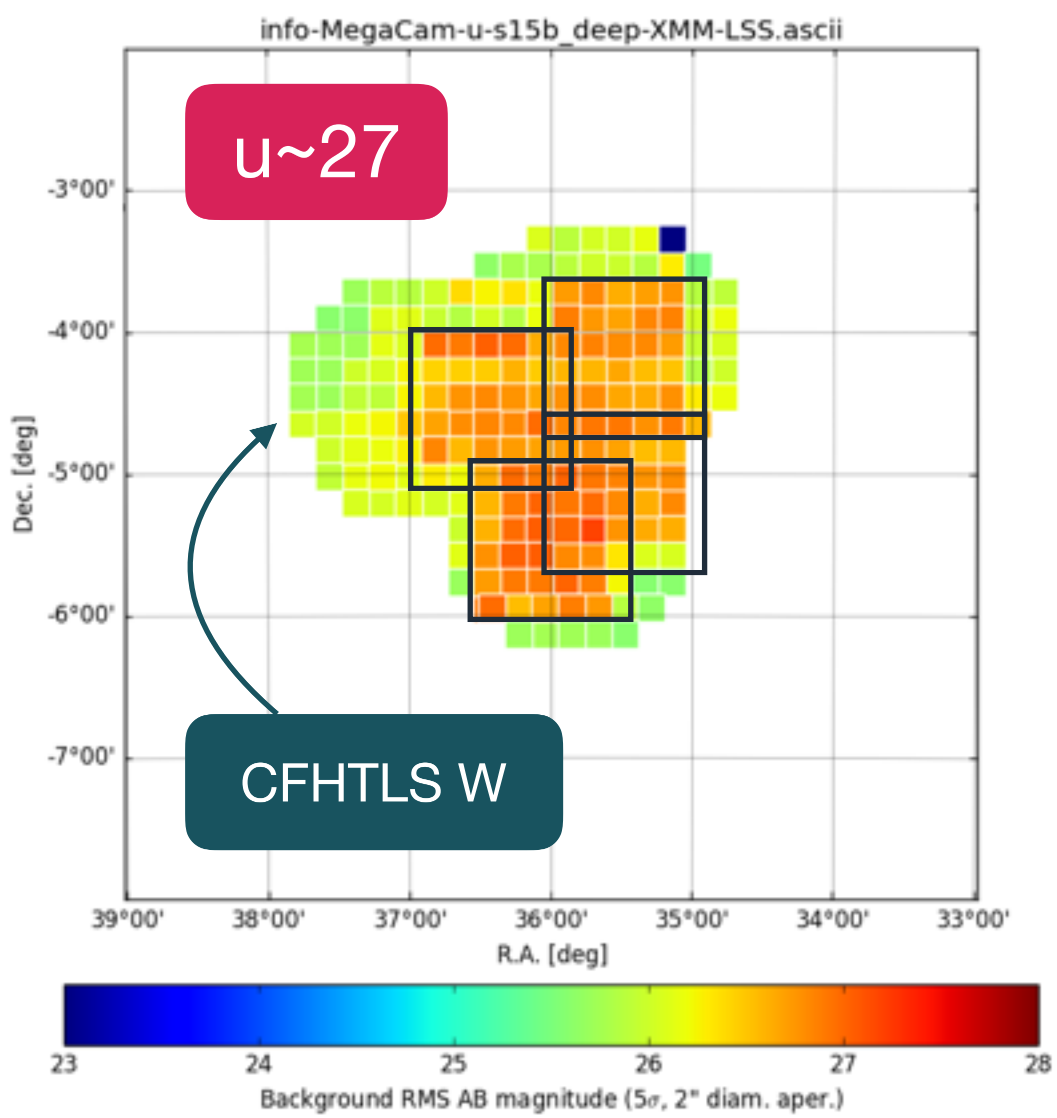


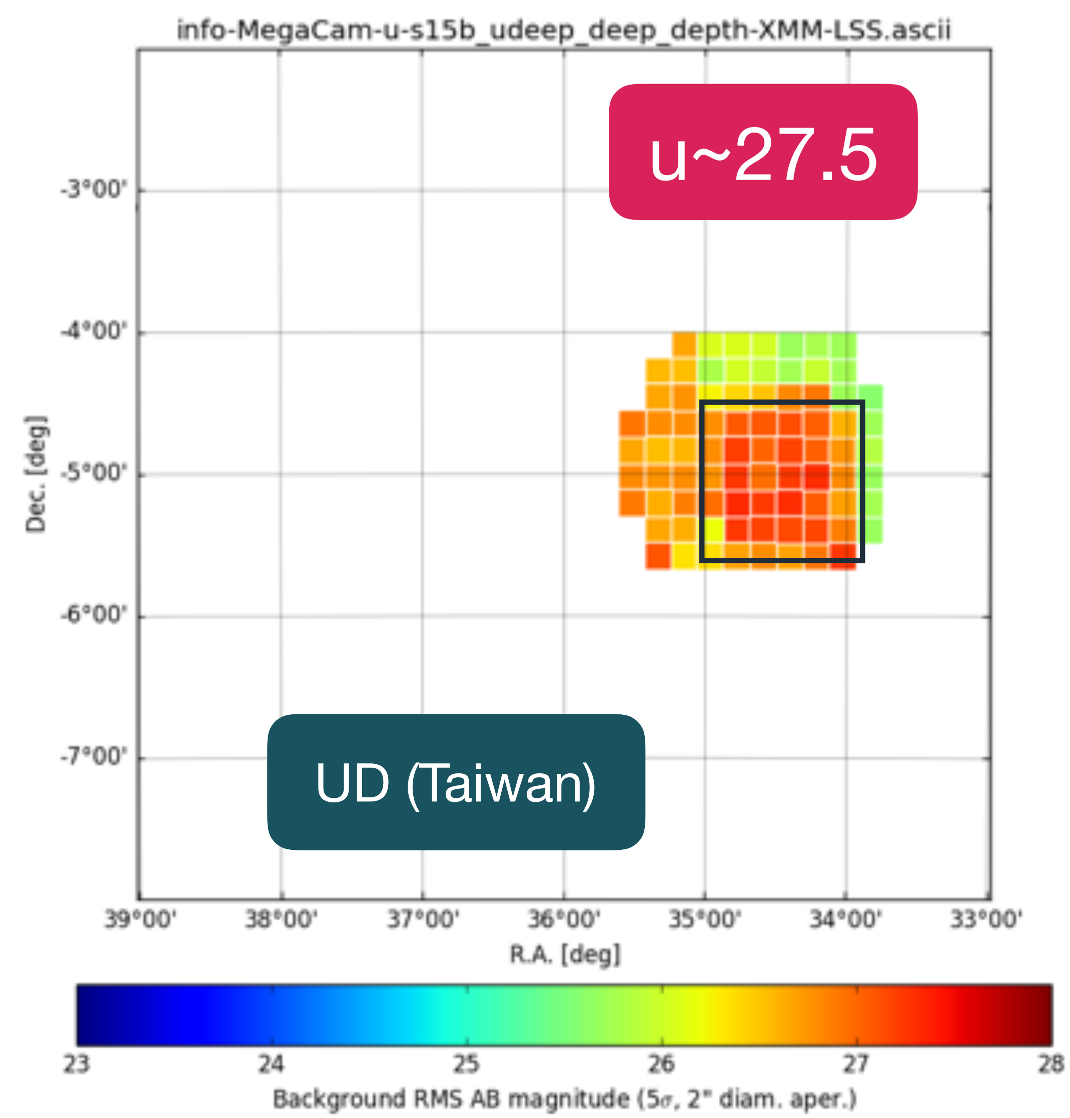
HSC/CLAUDS deep fields



Survey depths

- background dispersion from blank apertures (5σ, 2”)





Using the HSC pipeline

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4. data management:

   - HSC images and necessary files already in hscPipe format
   - access to HSC-SSP database and tools
   - matches pipeline products, facilitates data sharing with HSC team

But not so easy…

- pipeline still in development
  (science validation underway, multiple versions)

- megaCam model not in hscPipe
  no detrending, stacking (but see Dominique's talk)

- time consuming (compared to SExtractor)
  up to 400 cpu hours for one tract (1.5 deg^2)

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3. start from raw images, de-trend them, go to 2 (most difficult)

Adopted strategy (#1)

CLAUDS raw data

HSC images
+ grid, WCS and
astrometry

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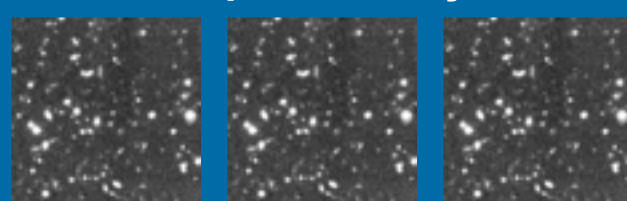
CLAUDS raw data

Detrending and Coaddition
Stephen Gwyn



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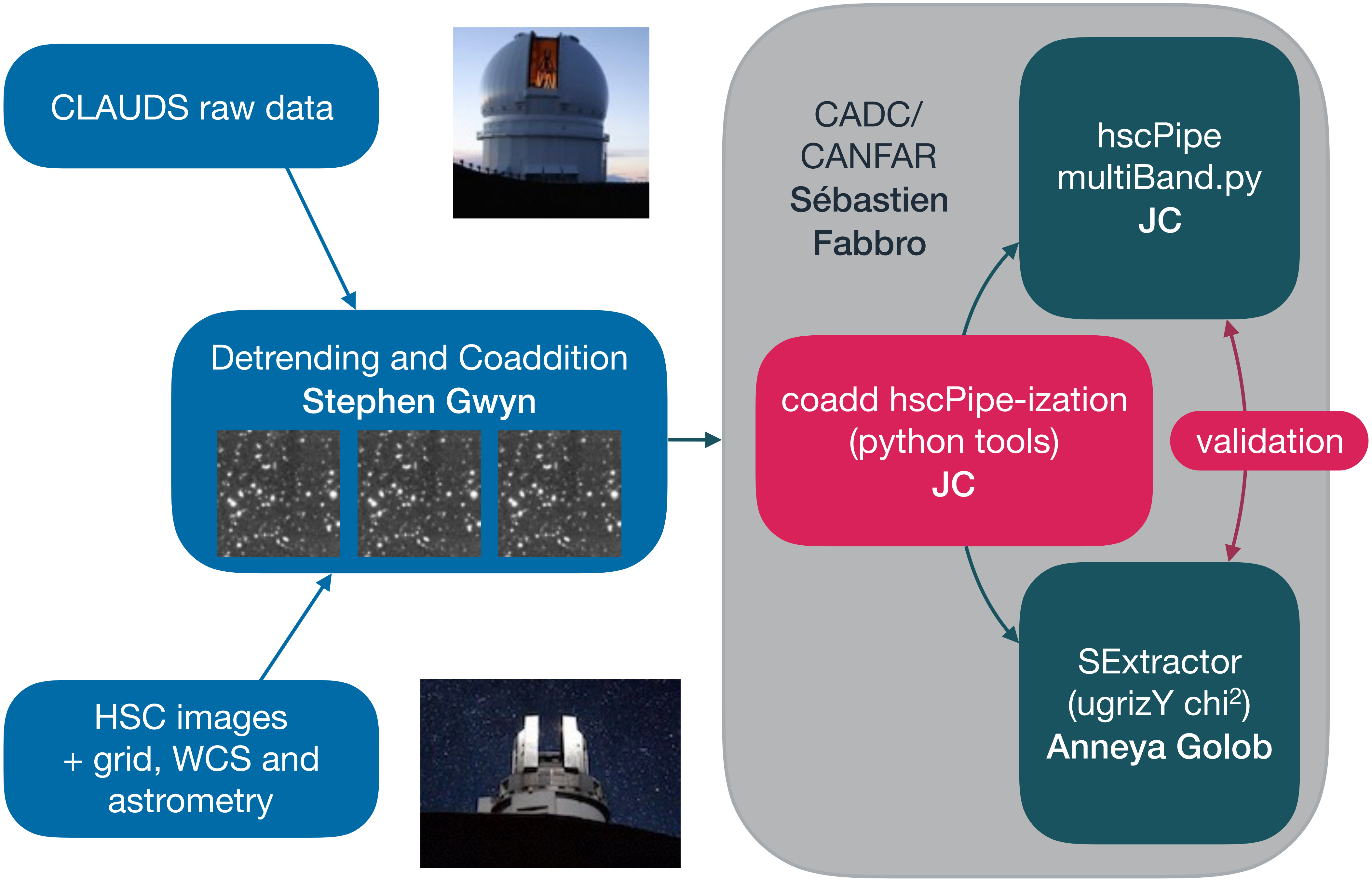

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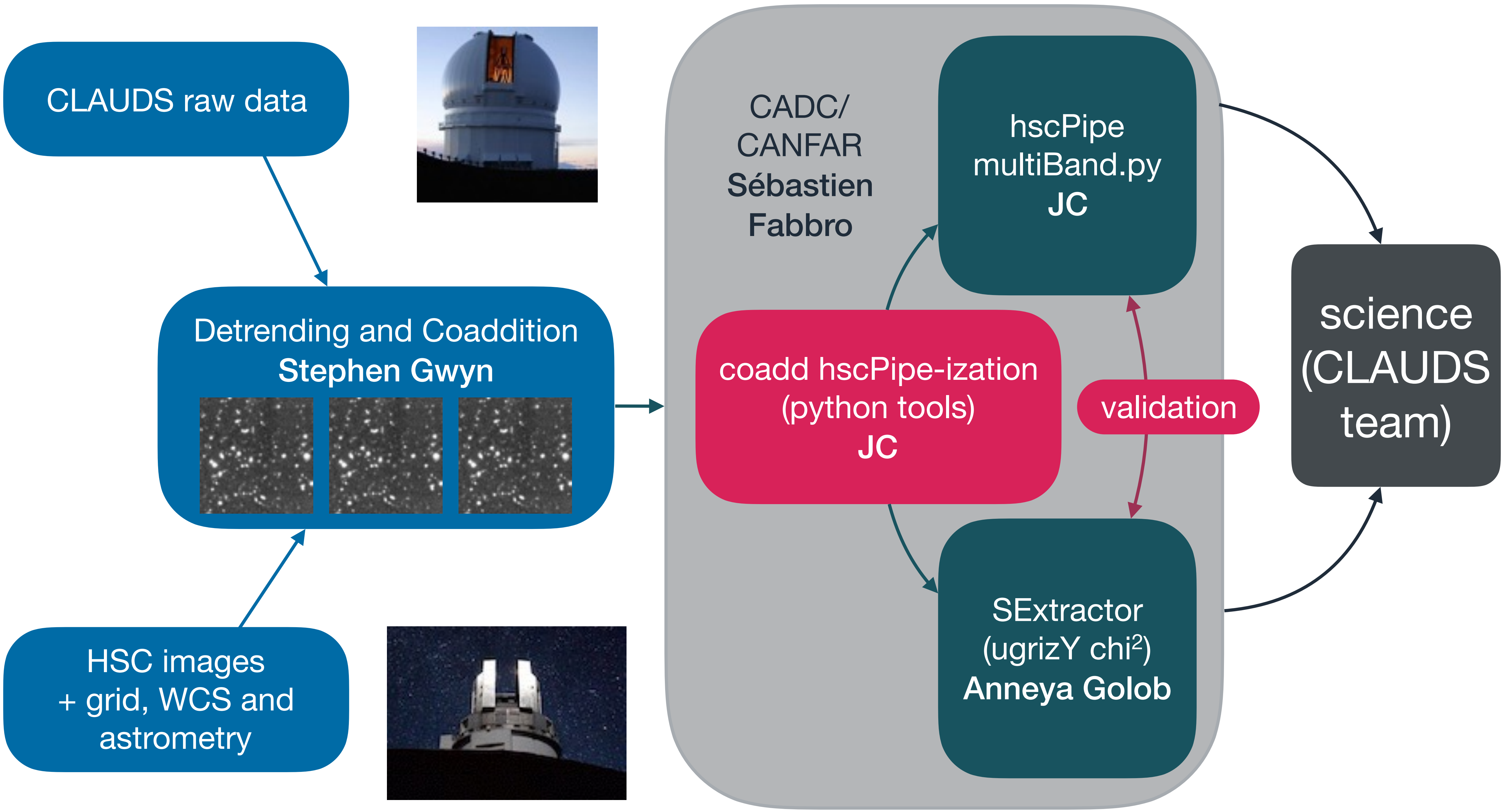
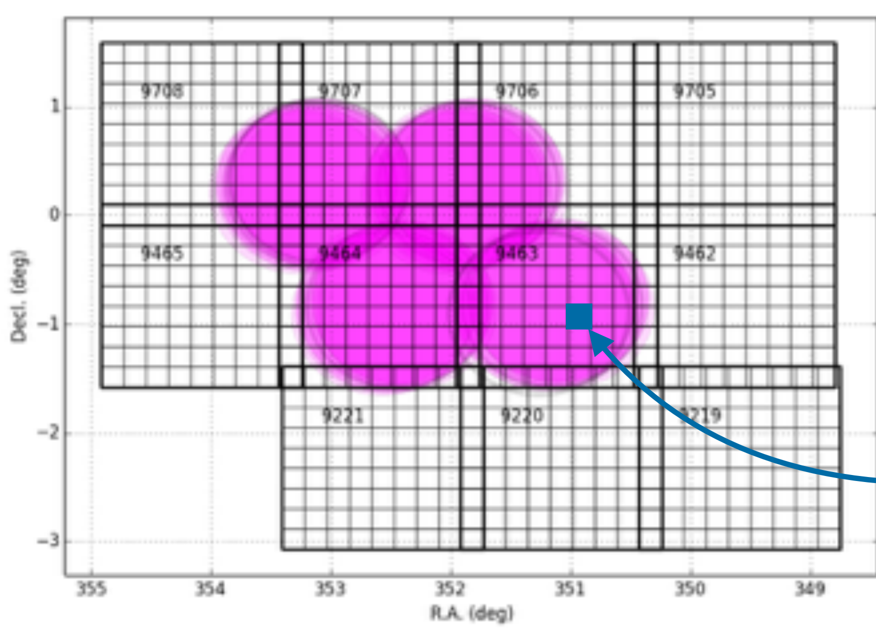


Ingesting the images into hscPipe (hscPipe-ization)

- Step 1: coadds and weight map built on HSC grid

detrending (modified megaPipe)

astrometry and co-addition



HSC WCS (patches)

astrometric reference (HSC-G point sources or PanSTARRS catalogue)

Ingesting the images into hscPipe (hscPipe-ization)

- **Step 2:** record filter name into mapper

overload the hscMapper class to add new filters
= (no code edit) robust against hscPipe updates

```
from lsst.obs.hsc import HscMapper
import lsst.afw.image as afwImage

class HscAndExtMapper(HscMapper):
    """Provides abstract-physical mapping for HSC + external data"""

    def __init__(self, **kwargs):

        HscMapper.__init__(self, **kwargs)

        # add filters
        afwImage.utils.defineFilter(name='MegaCam-uS', lambdaEff=375, alias=['u1', 'u',])
        afwImage.utils.defineFilter(name='MegaCam-u', lambdaEff=375, alias=['u2',])

        for f in ['MegaCam-uS', 'MegaCam-u']:
            self.filters[f] = afwImage.Filter(afwImage.Filter(f).getId()).getName()
```

Ingesting the images into hscPipe

- Step 3: build "exposure" using hscPipe tools

exposure
(.fits)

exposures are image containers in hscPipe

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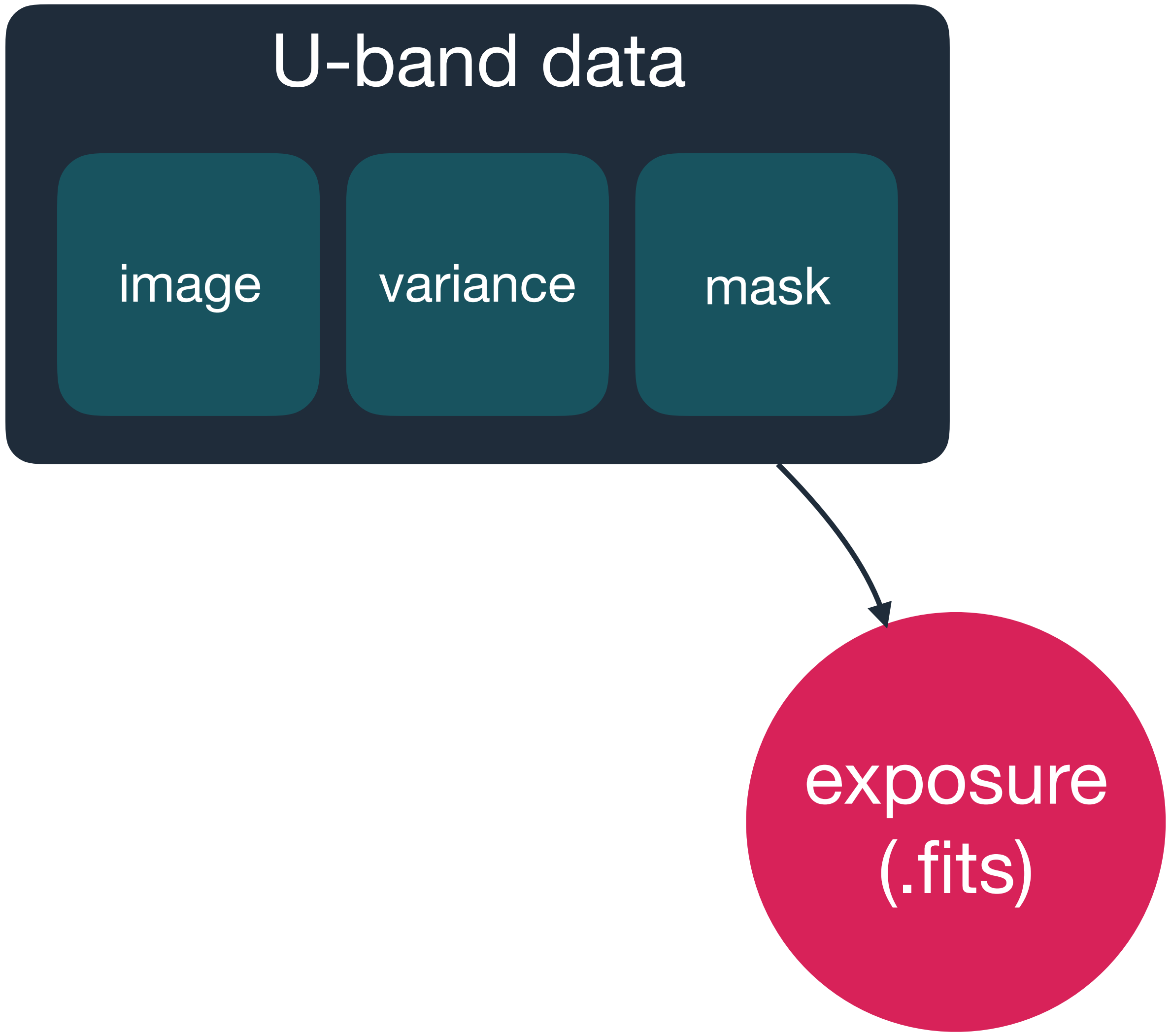

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Ingesting the images into hscPipe

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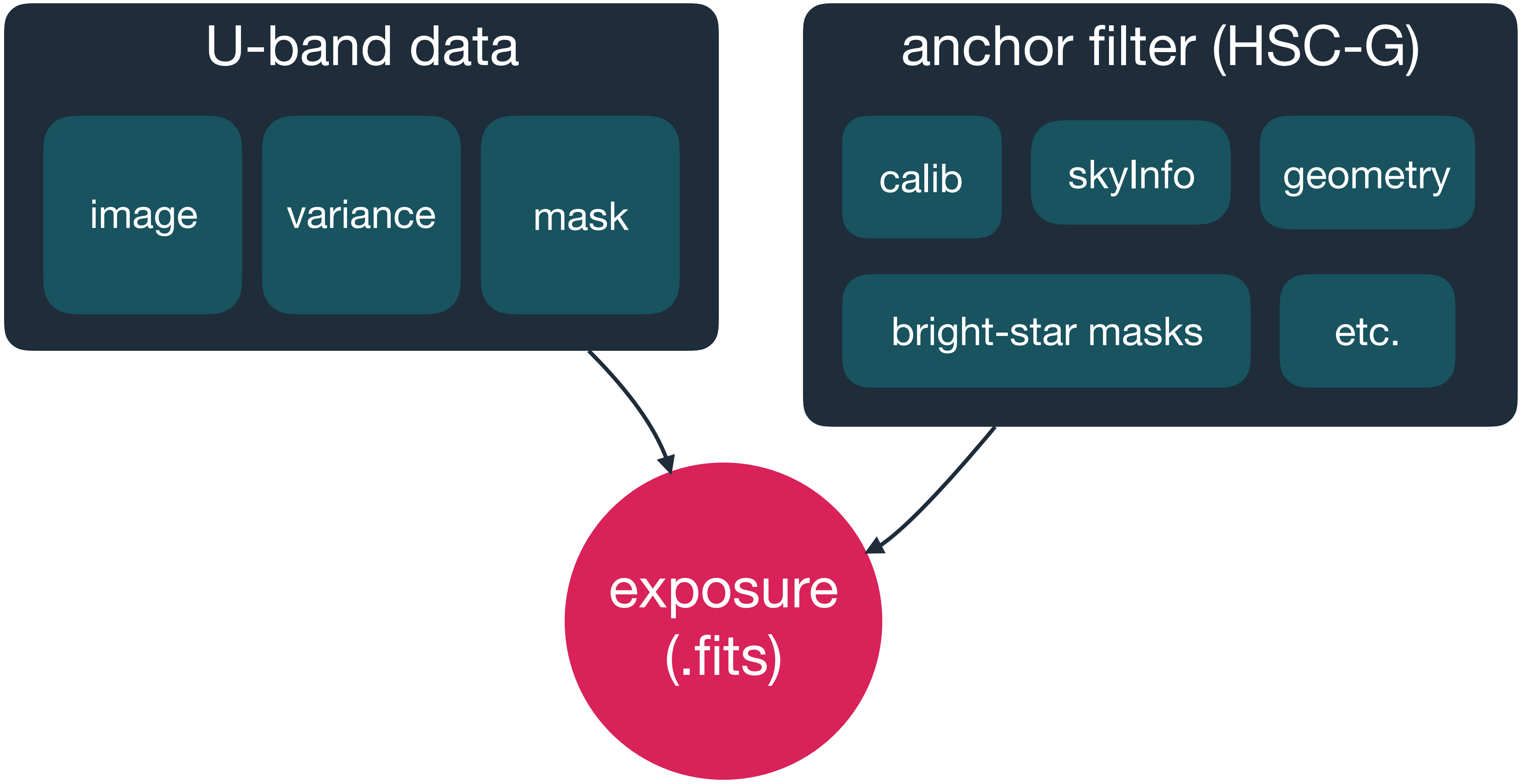

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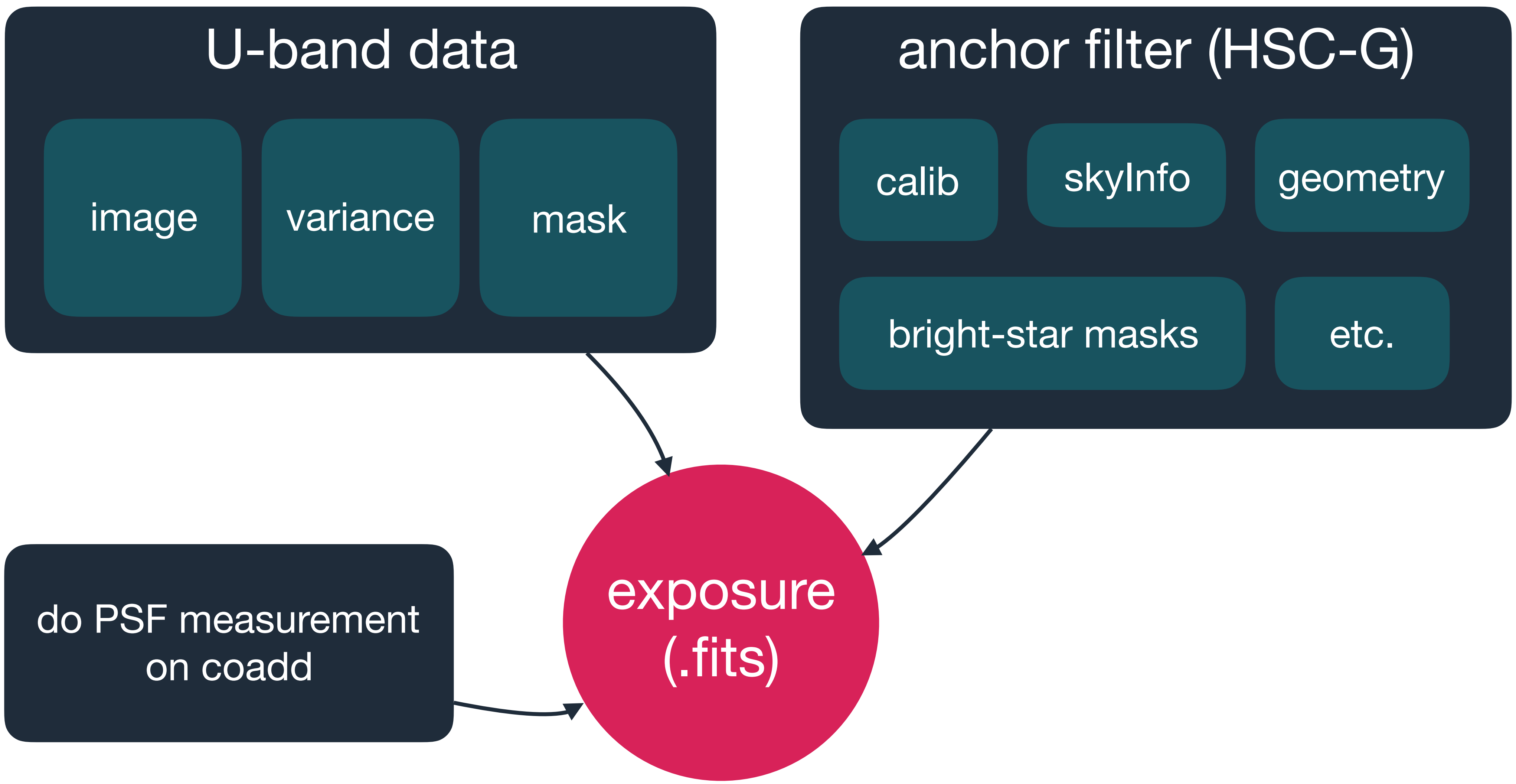

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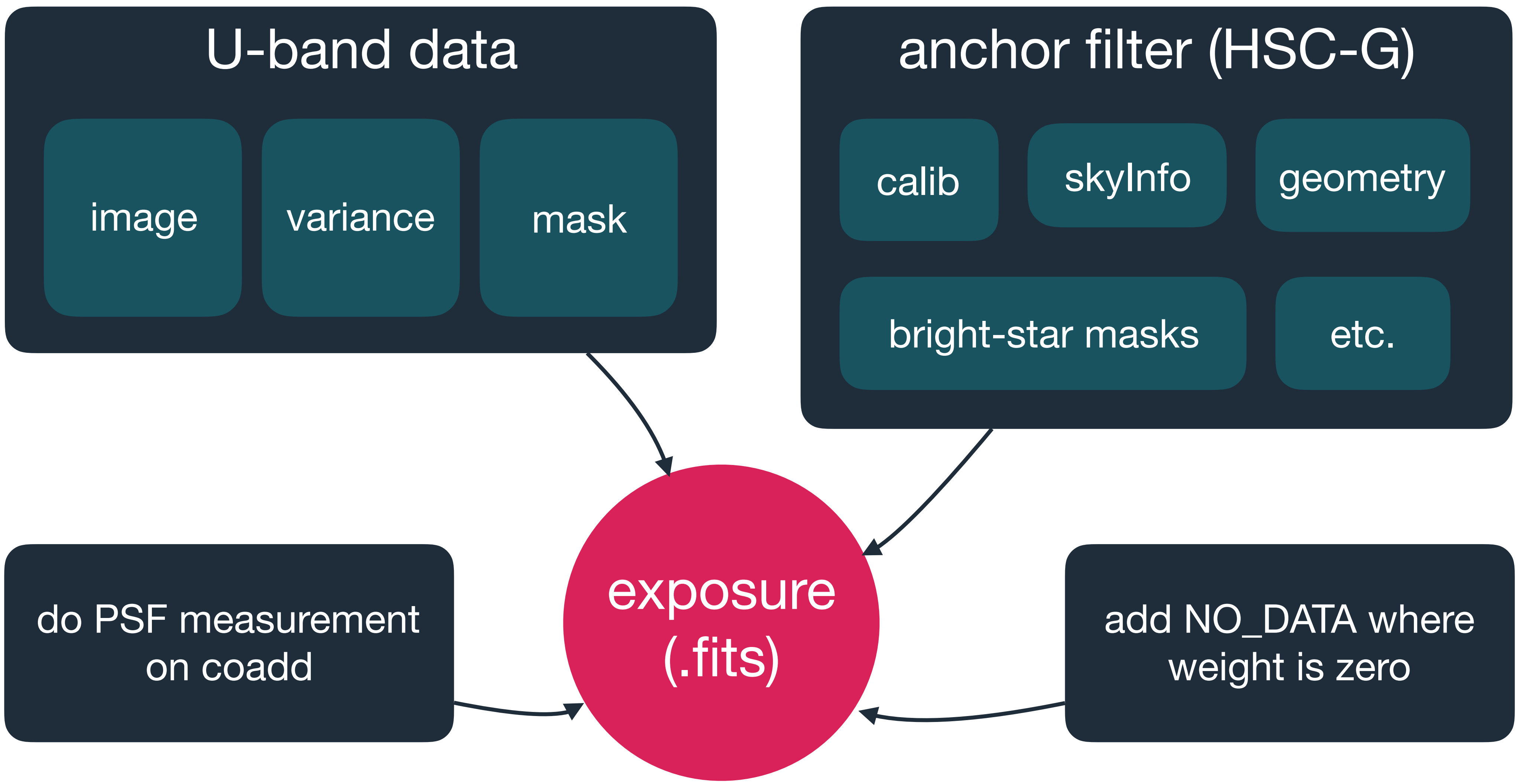


exposures are image containers in hscPipe

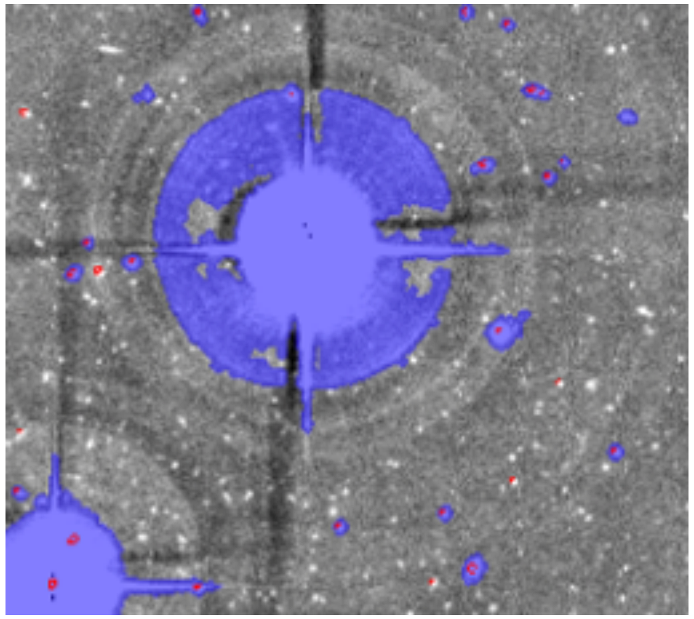
Ingesting the images into hscPipe

- Step 4: do source detection and multiBand processing

run detection (normally done during coaddition in hscPipe)

no de-blendling of large footprints
(MegaCam bright haloes)

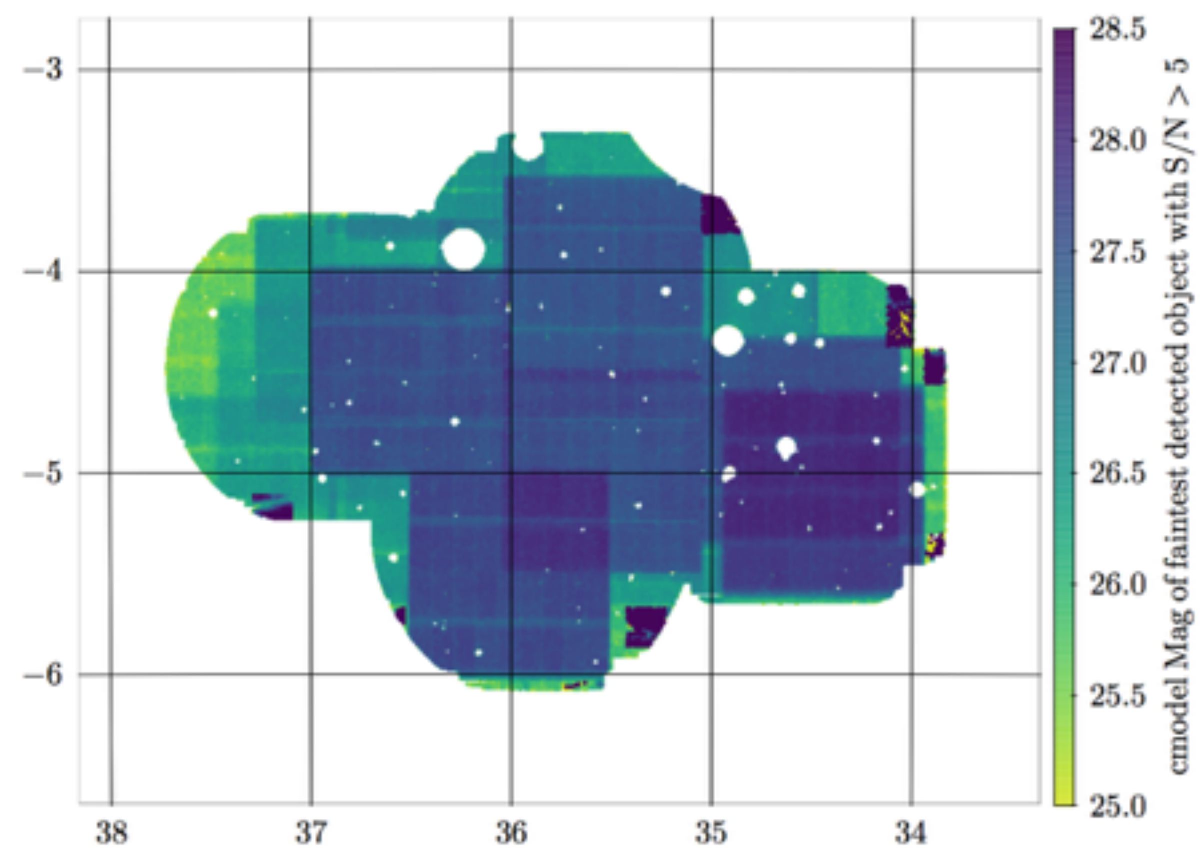
no background subtraction
(assume it's done in step 1)



multiBand.py (ugrizY)

MultiCat routines

- developed python scripts to combine the pipeline outputs
- compute E(B-V) correction
- combine some useful flags
- merge patches, tracts and fields
- working with NAOJ to add catalogues to HSC database

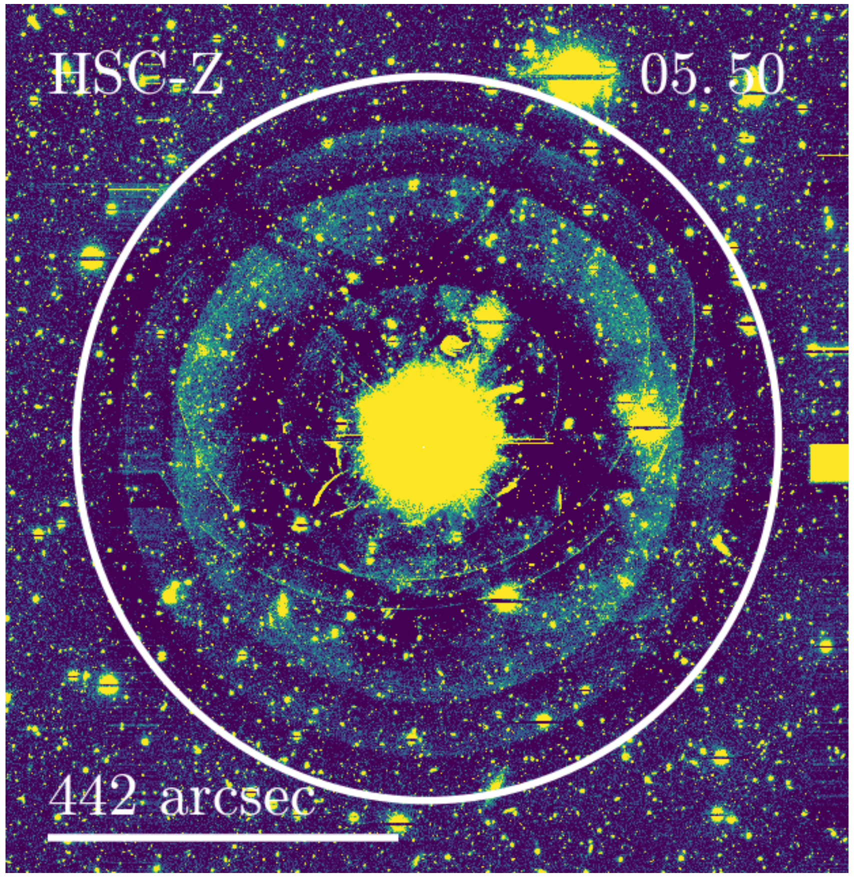


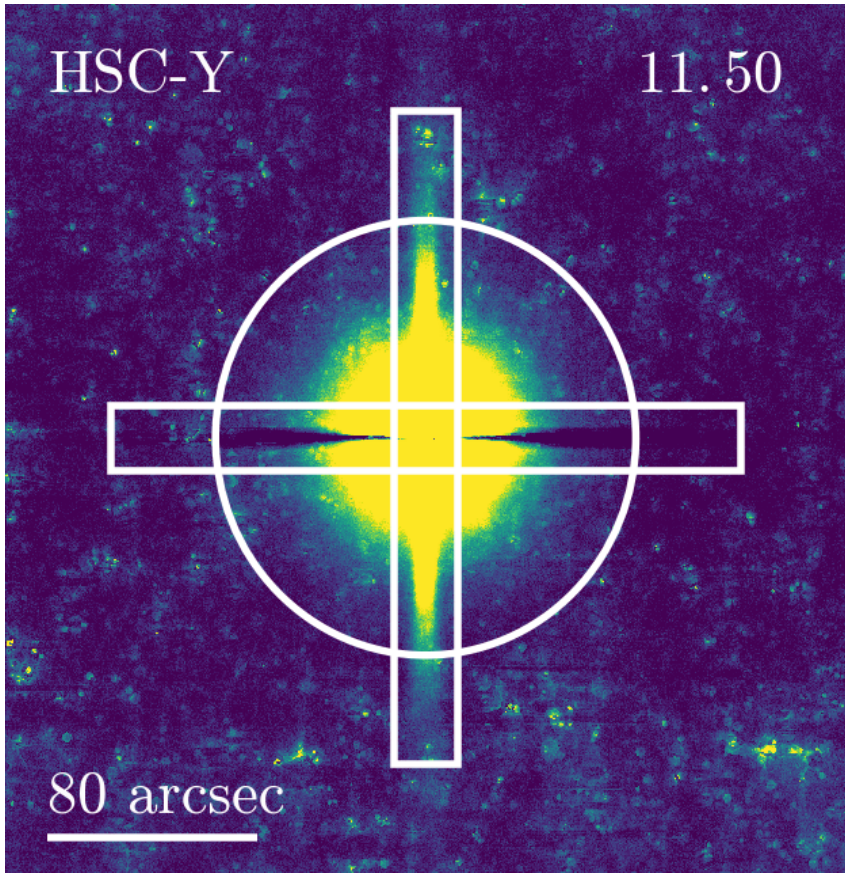
Random points routines

- developed python scripts to draw random points
- computes patch depth from 100 sky apertures
- records patch info (countinputs, PSF size, etc.)
- records survey area and geometry
- used for clustering and stellar mass functions

Bright star masks

- built new bright-star masks for HSC using Gaia, Tycho-2
- cleaned using SDSS to exclude extended sources wrongly identified as stars in Gaia catalog

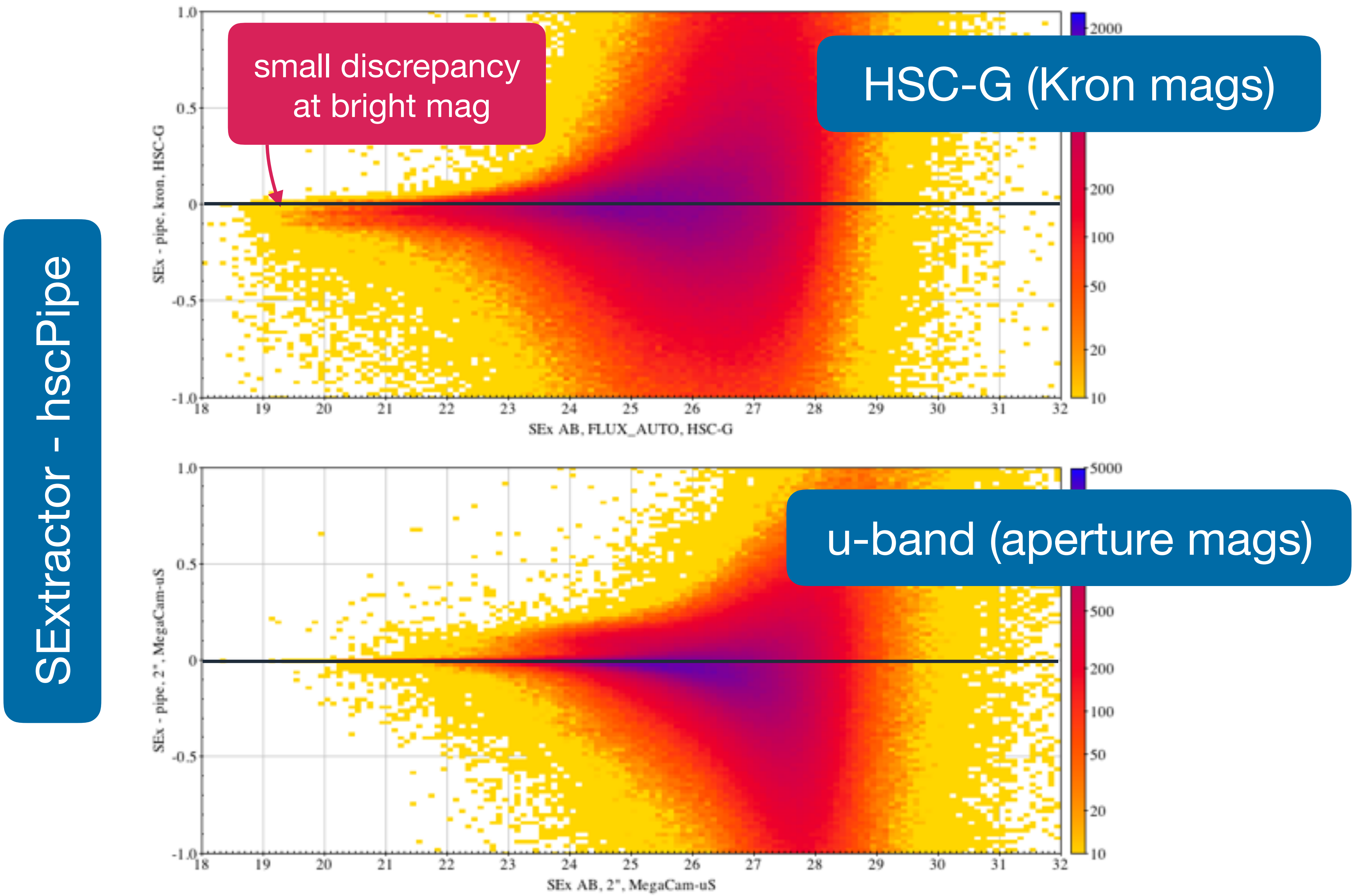




JC et al. (2017)

Catalog validation

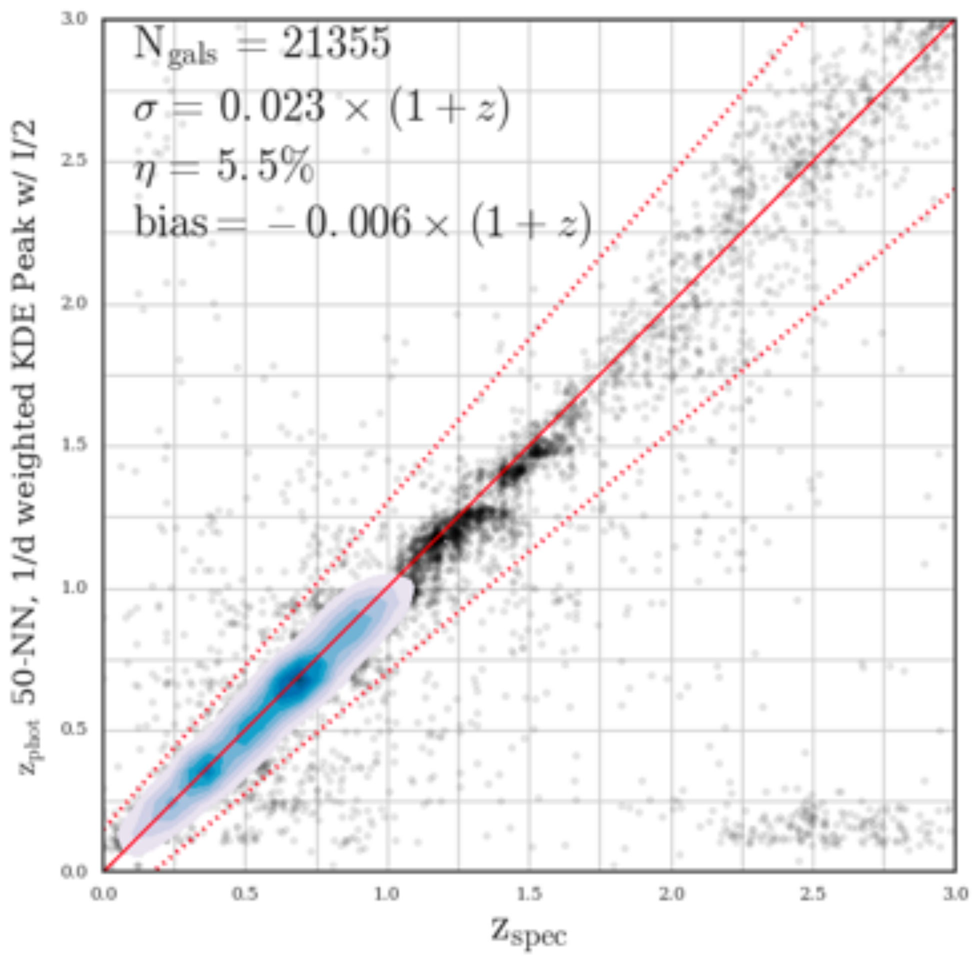
Flux measurement

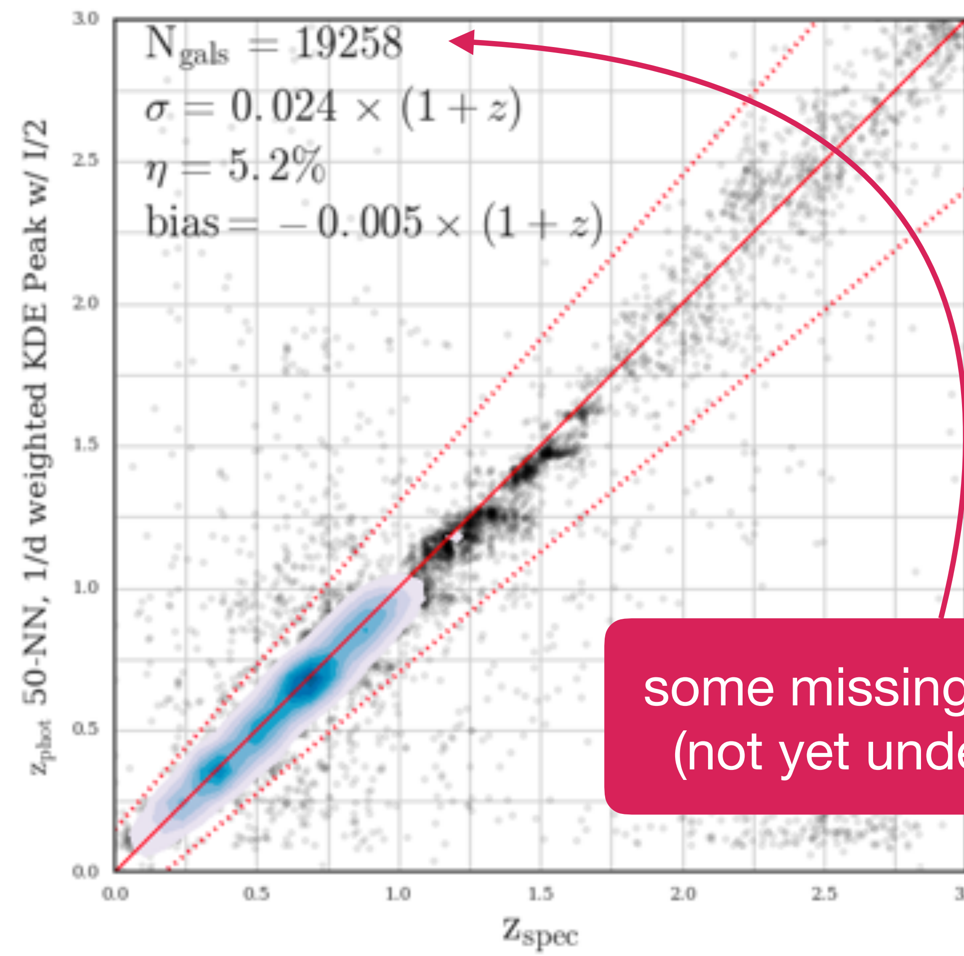


Photometric redshifts

SExtractor (MAG_ISO)

hscPipe (cmodel)





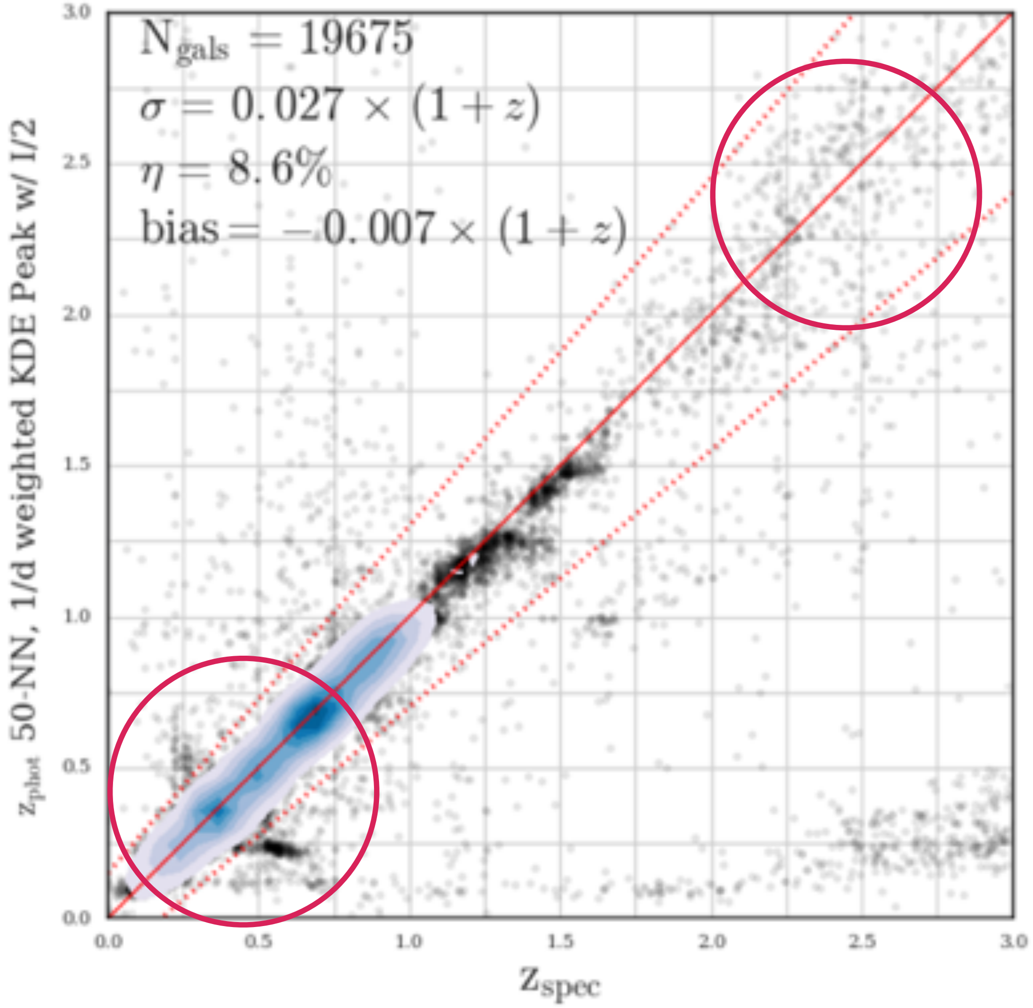
some missing galaxies (not yet understood)

Photo-z's (NNPZ) from Anneya Golob

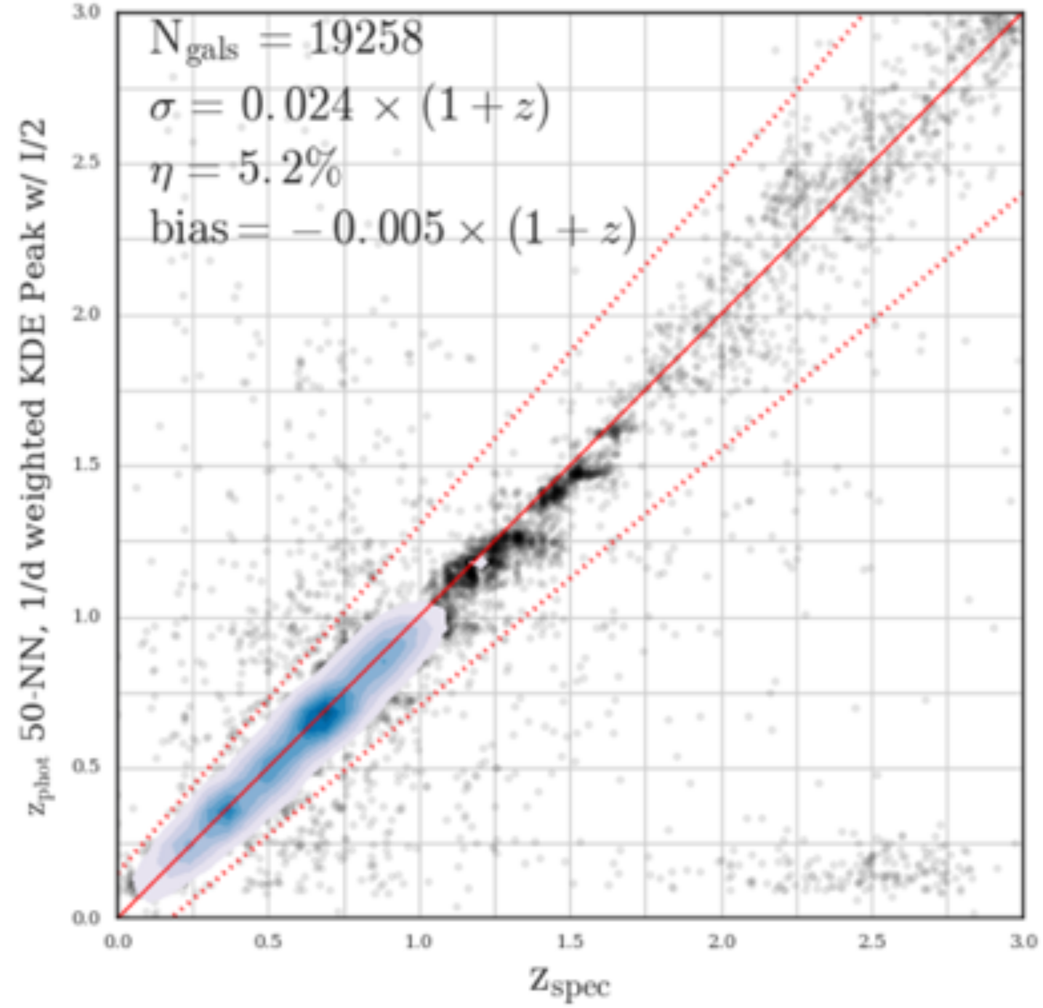
good overall agreement. No PSF matching in SExtractor (but no large PSF variation is expected in the DEEP)

u-band improvement

no u band



with u band



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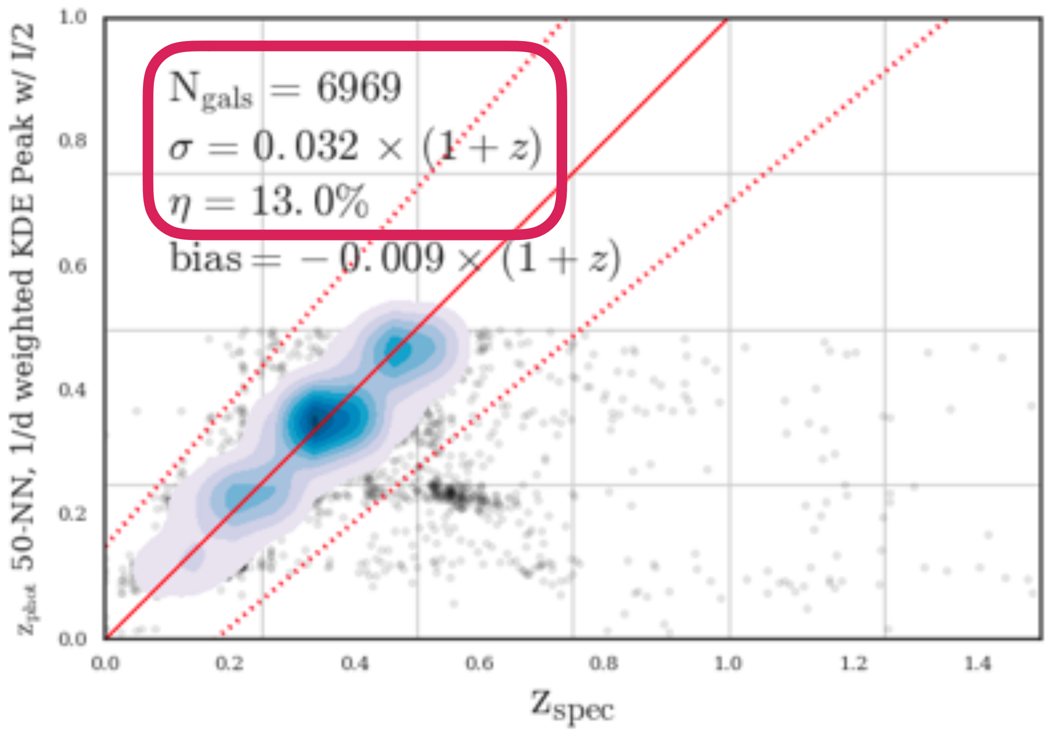

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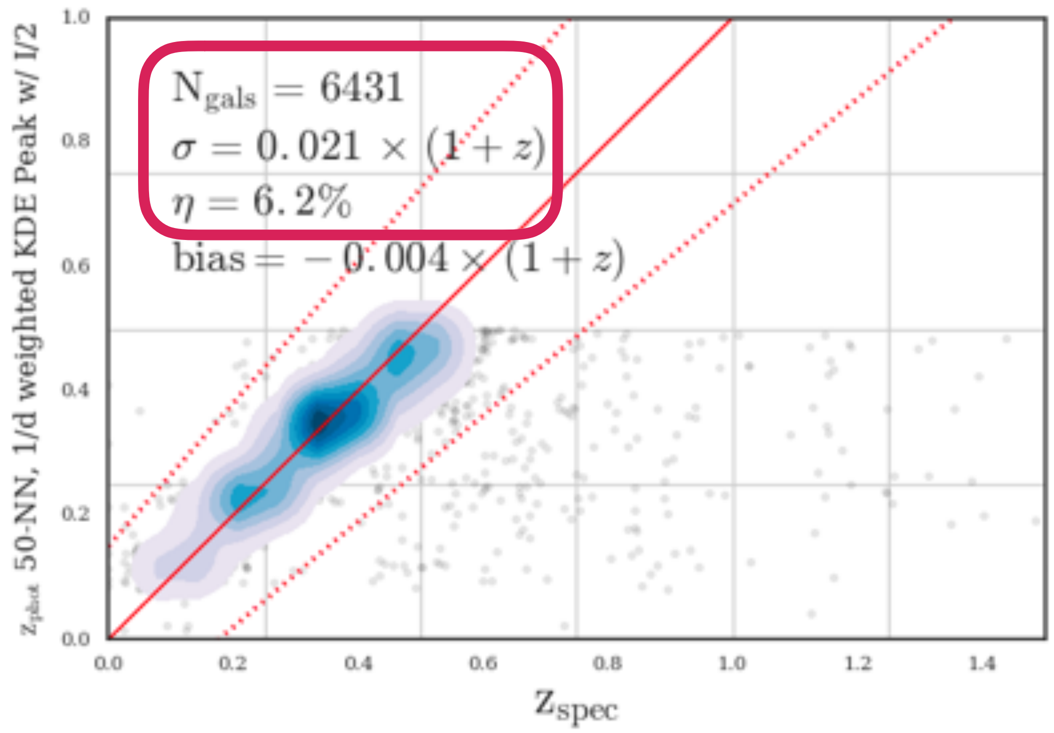
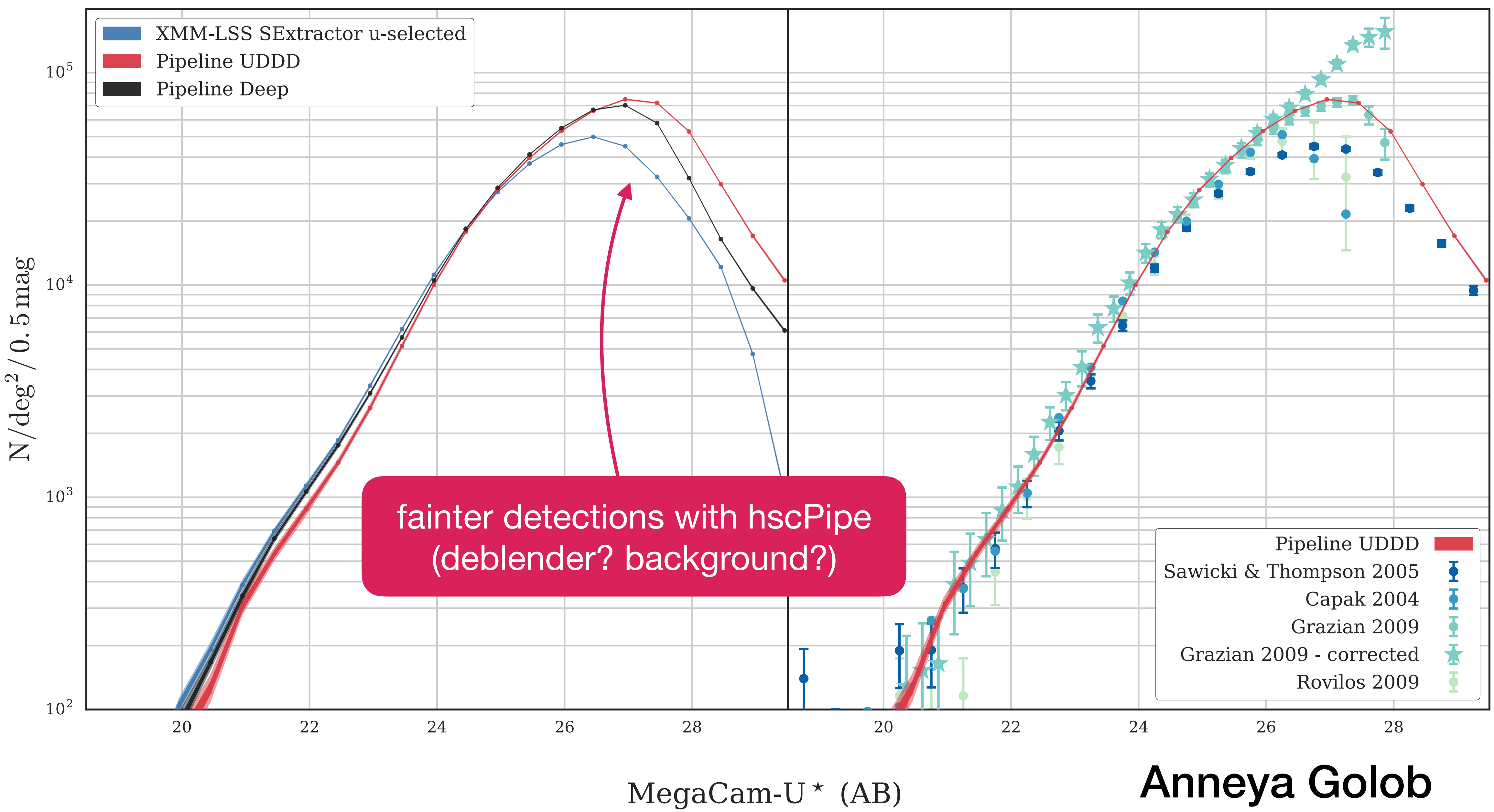


outlier fraction reduced by a factor 2 at z < 0.5

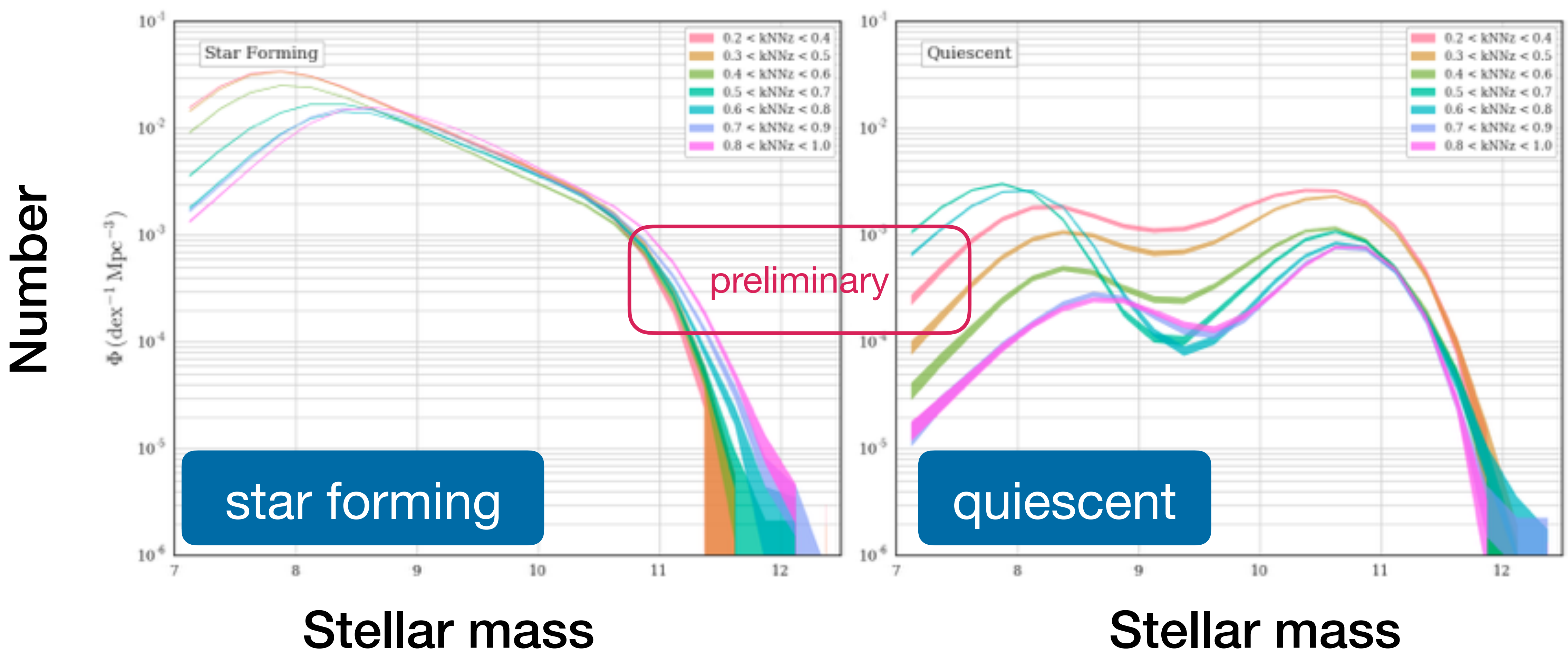
Number counts



Anneya Golob

z<1 stellar mass functions

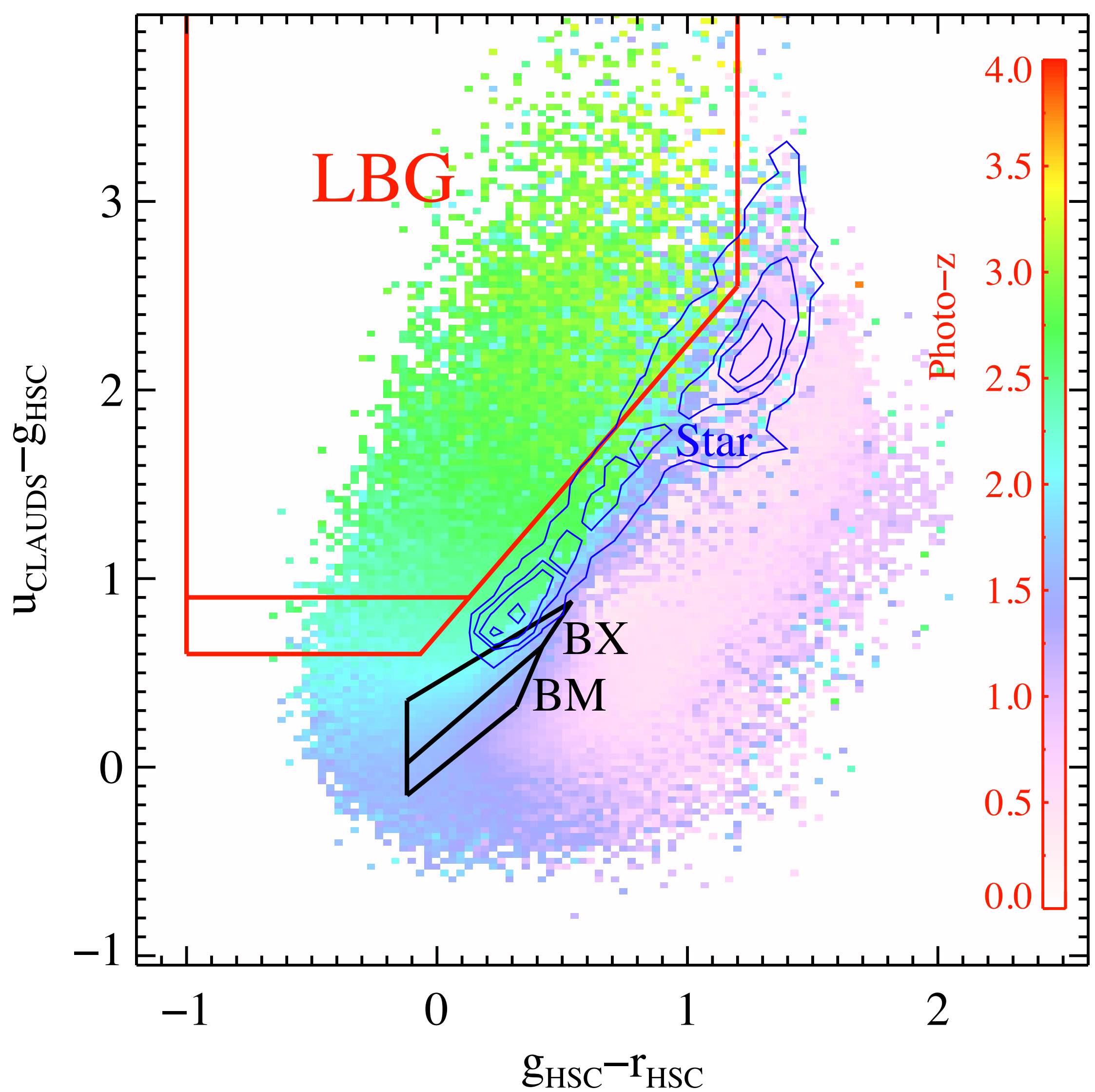
Unique combination of depth and volume

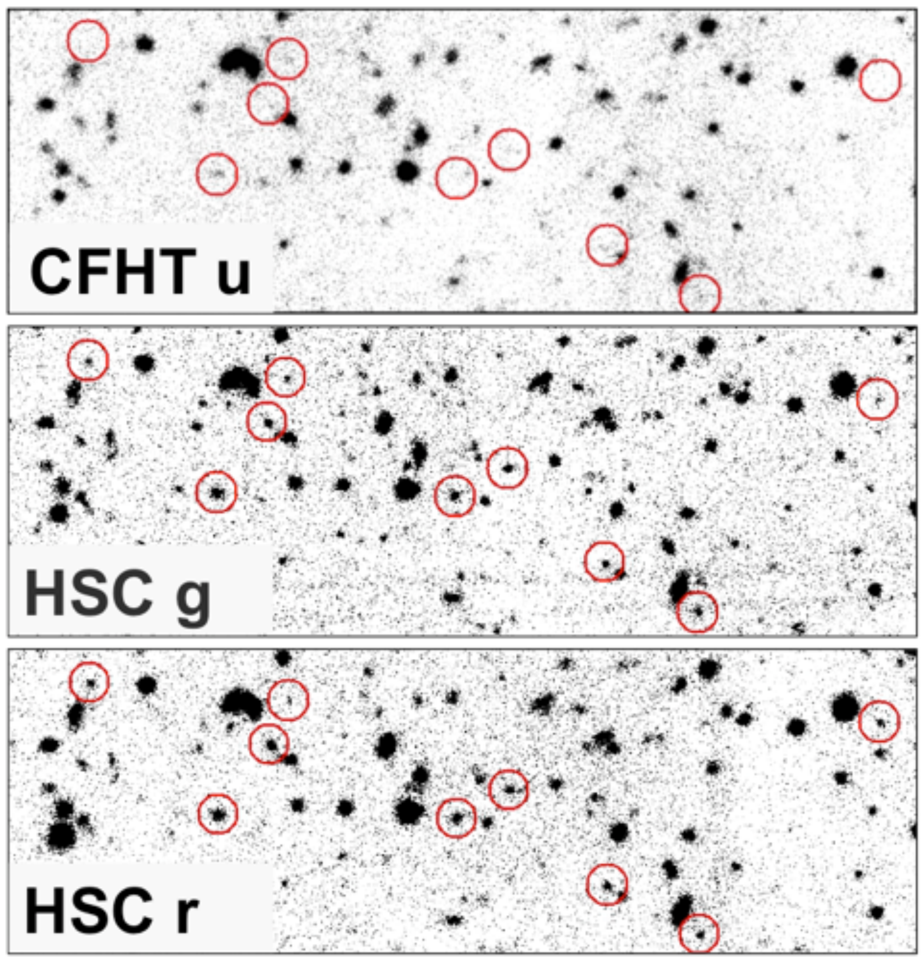


Anneya Golob

z~3 galaxy science: dropout selection

0.5M z~3 dropouts expected over full area (20 deg^2)

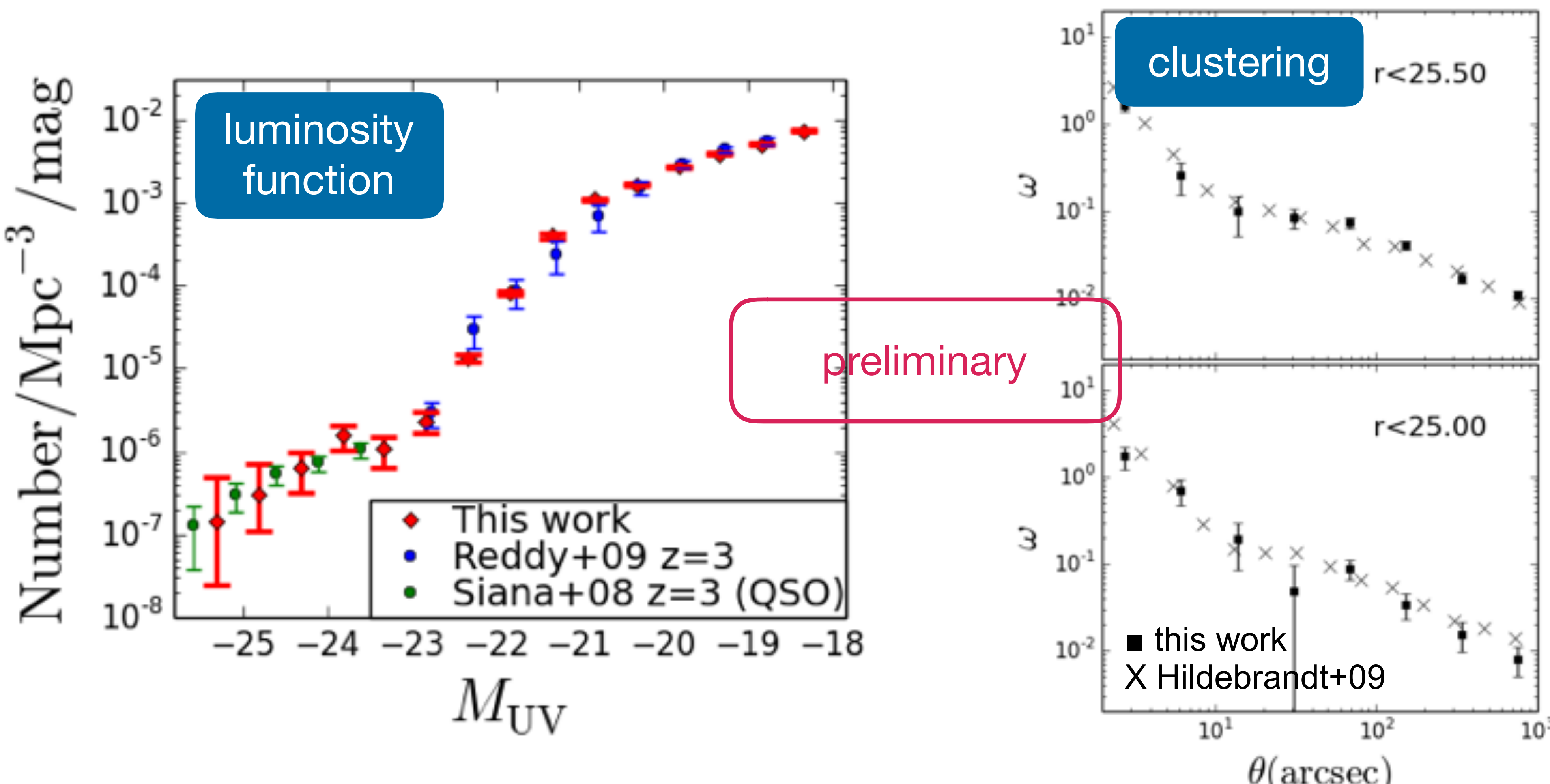




Chengze Liu

z~3 galaxy science: dropout selection

- Consistent with previous results at M_{uv}>-23
- Bright-end excess comparable to QSO LF



Yuichi Harikane
Yoshiaki Ono

Conclusions

- unique dataset, will remain unmatched until LSST
- developed code to combine u-band images with HSC
- adopted strategy based on coadds (can be easily applied to other data set)
- preliminary catalogues ready
- do we expect better performance? Obviously room for improvement…
- but good agreement with SExtractor, validation looks good
- ready to move forward with science