THE HSC-VISTA FUSION DATASET & PROSPECTS FOR LSST-VISTA SCIENCE

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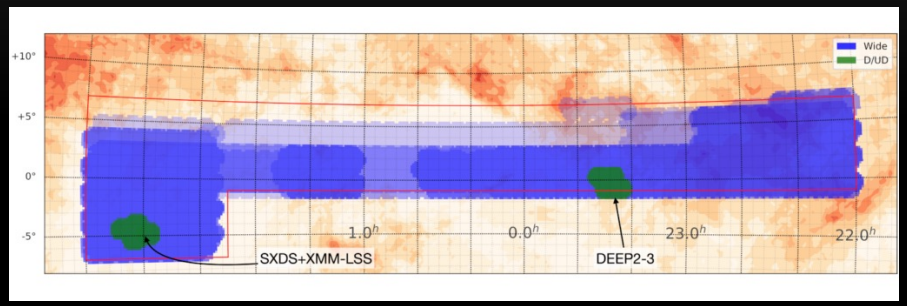
MOTIVATION

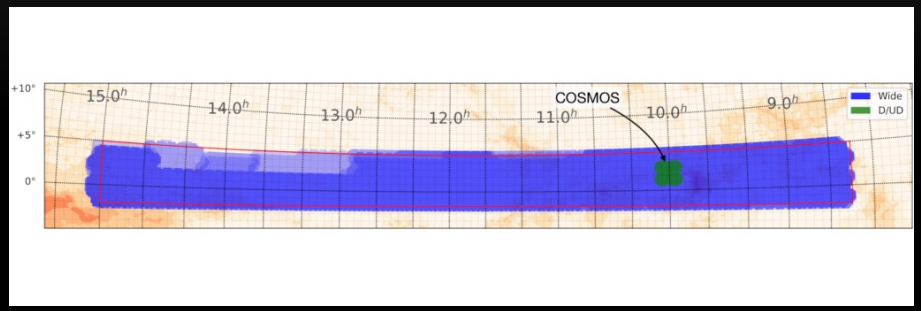
- Extend the coverage of Rubin-LSST to near infrared wavelengths
  - High-value science targets such as high-z galaxies and quasars which are ‘drop-outs’ in LSST passbands are naturally included in our dataset
  - Near infra-red fluxes when integrated with LSST measurements, enable more precise photometric redshifts and inferences on galaxy/AGN properties from SED-fitting
- Joint pixel analysis of LSST (currently HSC) and VISTA enables more science than just catalogue level matching.
- Developing the infrastructure to process large numbers of pixels from other cameras/instruments through Rubin Science Pipelines. Important for future datasets from e.g. Euclid and Roman where plans are already being developed for joint processing (Guy et al. 2022)
- Exploiting several decades of UK expertise in wide-field infrared survey astronomy e.g. using UKIRT and VISTA telescopes

PROJECT STATUS

- Project began in July 2020 as part of LSST Phase B:
  - Using latest version of Rubin Science Pipelines (sometimes weekly releases!) together with HSC pixels as a proxy for LSST
  - Deliverable D1 (March 2021): Prototype HSC-VISTA VIDEO catalogue in XMM-LSS Deep Field produced using first version of our pipeline
  - Deliverable D2 (March 2023): **HSC-VISTA catalogues from full areal overlap between surveys processed using latest version of LSST Science Pipeline**
- Funding for project extended into LSST Phase C (until 2027)
  - Plan to process jointly LSST Commissioning and DR1 data with overlapping VISTA surveys
- Within Rubin LSST, this project is one of the UK's accepted 'in-kind' contributions delivering both the software pipeline and LSST+VISTA dataset in return for UK data rights

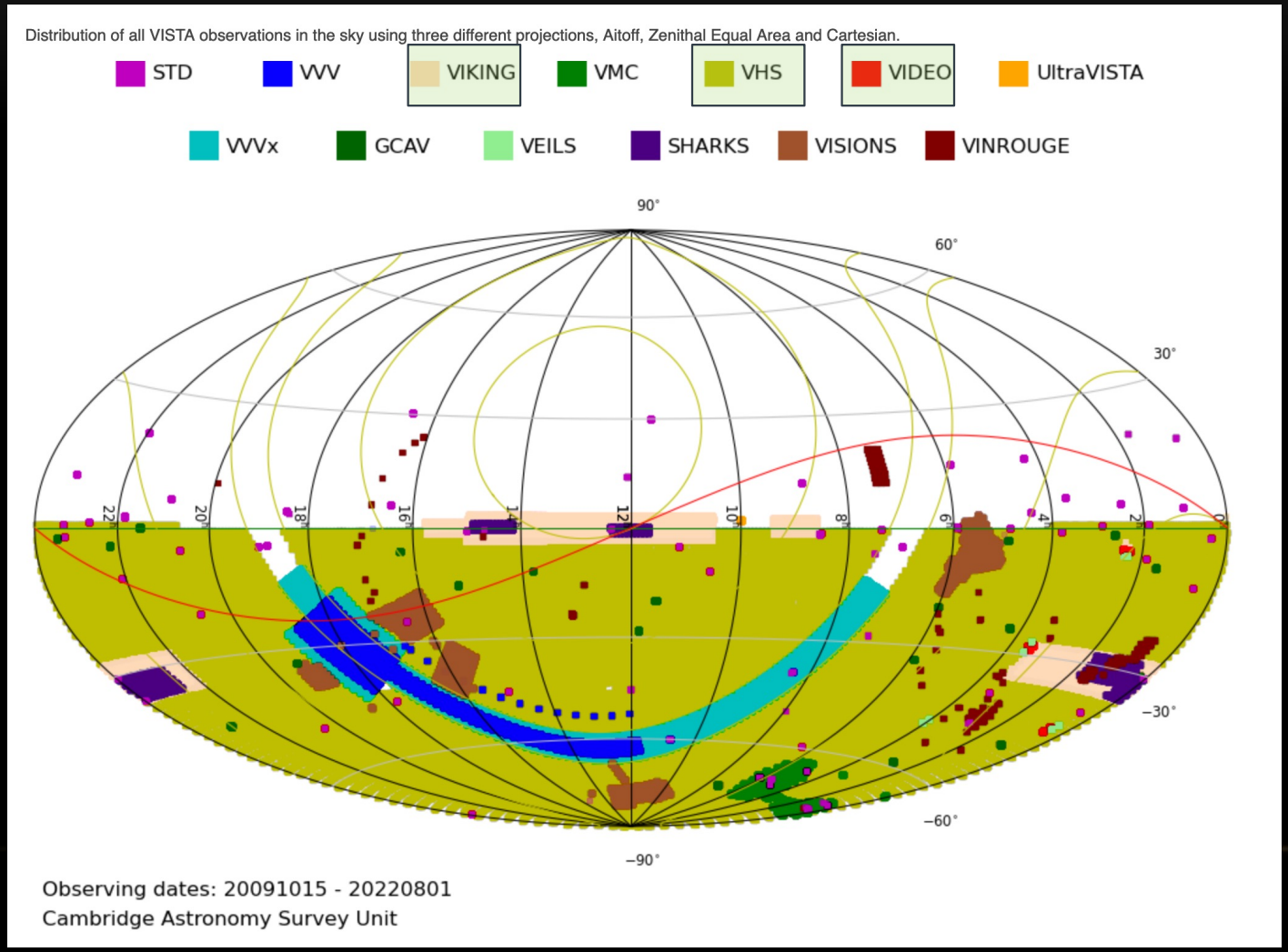
HSC PDR3





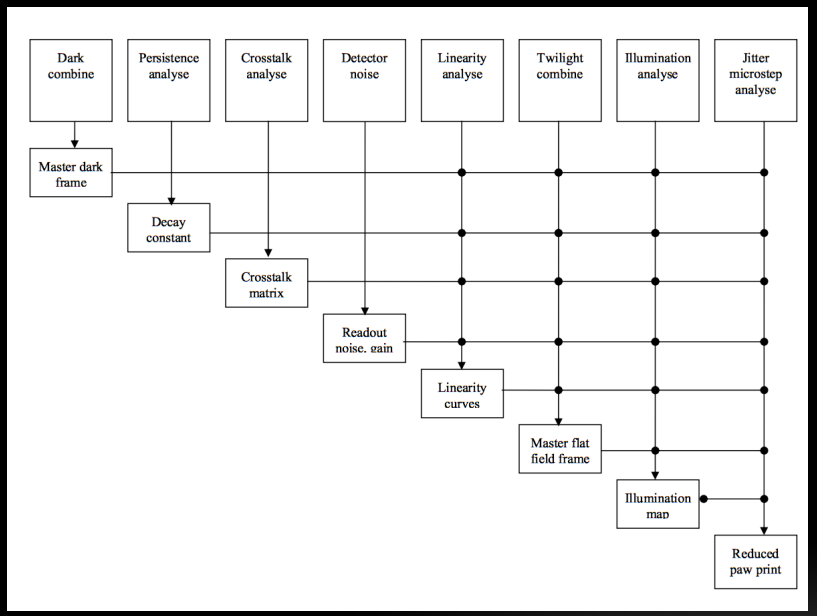
Wide	g	r	i	z	y				
exposure (min)	10^{+2}_{-2}	10^{+2}_{-2}	20^{+3}_{-6}	20^{+3}_{-10}	20^{+3}_{-10}				
seeing (arcsec)	$0.79^{+0.09}_{-0.08}$	$0.75^{+0.13}_{-0.09}$	$0.61^{+0.05}_{-0.05}$	$0.68^{+0.08}_{-0.06}$	$0.68^{+0.10}_{-0.08}$				
depth (mag)	$26.5^{+0.2}_{-0.2}$	$26.5^{+0.2}_{-0.2}$	$26.2^{+0.2}_{-0.3}$	$25.2^{+0.2}_{-0.3}$	$24.4^{+0.2}_{-0.3}$				
saturation (mag)	$17.4^{+0.6}_{-0.4}$	$18.1^{+0.5}_{-0.5}$	$18.3^{+0.5}_{-0.3}$	$17.5^{+0.5}_{-0.4}$	$17.0^{+0.5}_{-0.7}$				
area (deg^2)	1332	1298	1264	1299	1209				
Deep+UltraDeep	g	r	i	z	y	$NB387$	$NB816$	$NB921$	$NB1010$
exposure (min)	70^{+21}_{-21}	66^{+17}_{-17}	98^{+46}_{-32}	177^{+130}_{-46}	93^{+23}_{-23}	68^{+13}_{-13}	120^{+30}_{-15}	168^{+14}_{-28}	705^{+45}_{-345}
seeing (arcsec)	$0.83^{+0.05}_{-0.12}$	$0.77^{+0.04}_{-0.04}$	$0.66^{+0.07}_{-0.06}$	$0.78^{+0.02}_{-0.03}$	$0.70^{+0.04}_{-0.05}$	$0.82^{+0.07}_{-0.08}$	$0.70^{+0.07}_{-0.08}$	$0.67^{+0.04}_{-0.04}$	$0.77^{+0.02}_{-0.02}$
depth (mag)	$27.4^{+0.2}_{-0.2}$	$27.1^{+0.1}_{-0.2}$	$26.9^{+0.2}_{-0.3}$	$26.3^{+0.1}_{-0.3}$	$25.3^{+0.2}_{-0.2}$	$25.0^{+0.2}_{-0.2}$	$26.0^{+0.2}_{-0.2}$	$25.9^{+0.2}_{-0.2}$	$24.2^{+0.2}_{-0.5}$
saturation (mag)	$18.0^{+0.4}_{-0.5}$	$18.2^{+0.4}_{-0.4}$	$18.6^{+0.3}_{-0.4}$	$17.7^{+0.3}_{-0.3}$	$17.4^{+0.3}_{-0.3}$	$14.8^{+0.4}_{-0.3}$	$16.8^{+0.4}_{-0.4}$	$16.9^{+0.4}_{-0.3}$	$14.8^{+0.2}_{-0.2}$
area (deg^2)	36	36	36	37	36	30	33	33	5

VISTA PUBLIC SURVEYS

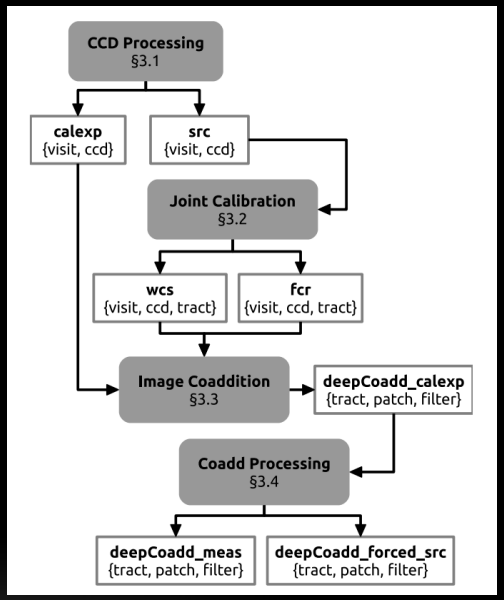


EXTENDING LSST COVERAGE TO INFRA-RED

- HSC and VISTA pixels being processed together through the LSST Stack.
- Currently we start with CASU reduced pawprints for VISTA



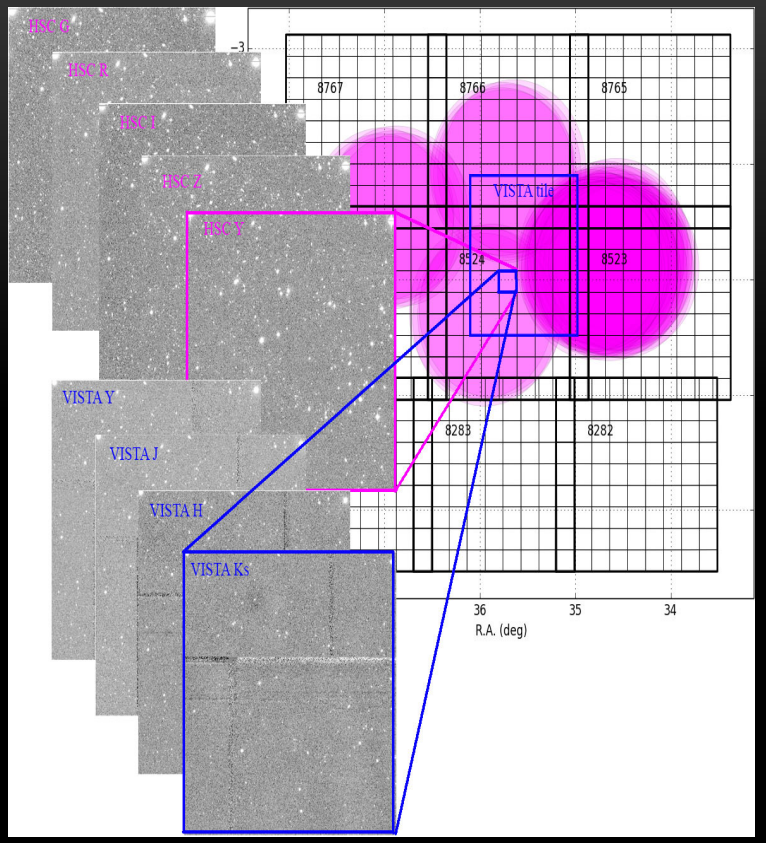
Irwin 1985 ++



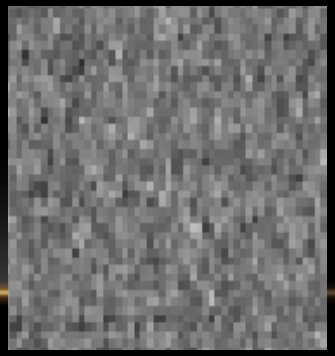
Bosch+18

WARPING AND COADDING

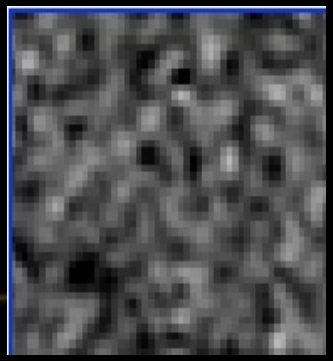
- One-one pixel matching between native Rubin/HSC and oversampled VISTA
- Source detection and measurement run simultaneously on both sets of images
- Error propagation accounted for in final catalogues
- Current HSC sky map:
  - Tracts approx. 1.7deg wide broken into 9×9 patches
  - Patches 4200 pixels on a side
  - HSC pixel = 0.168 arcsec



before

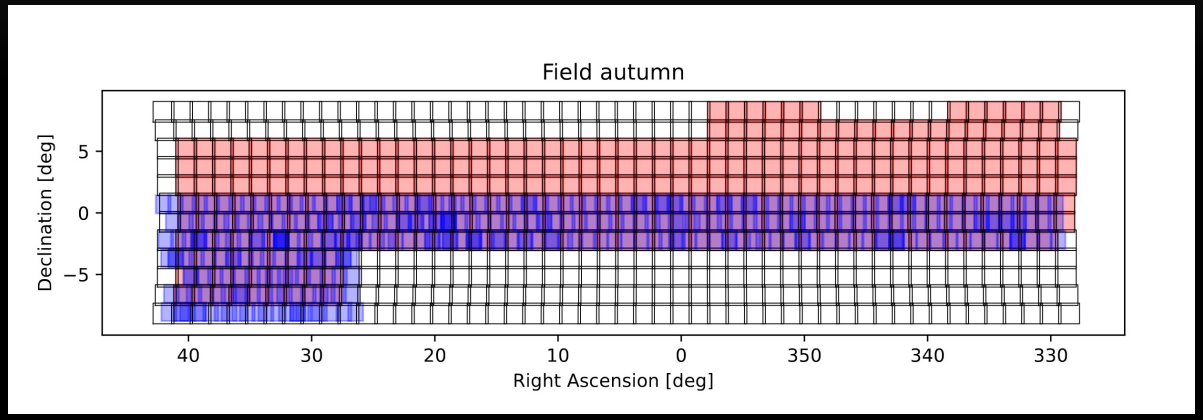


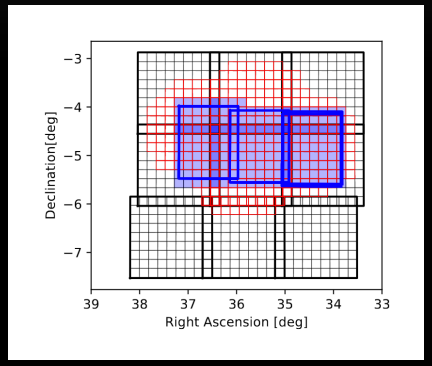
after

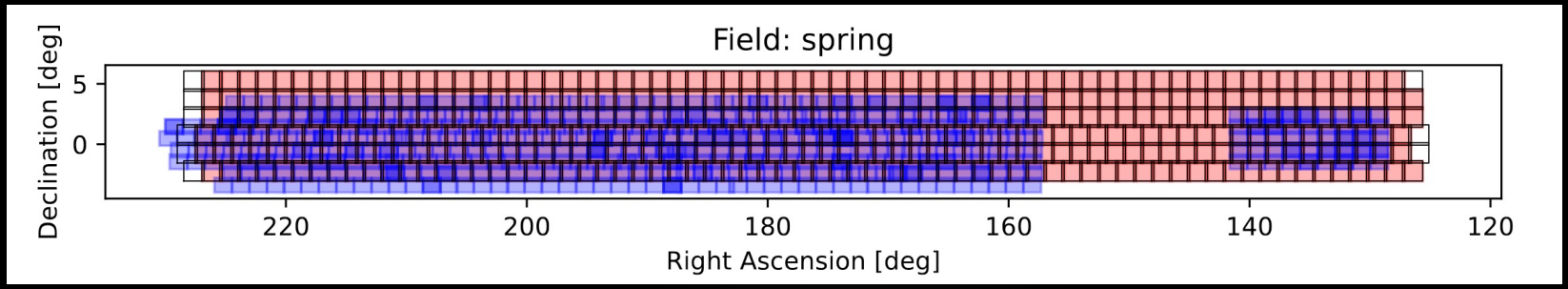


OVERLAP OF VISTA EXTRAGALACTIC SURVEYS (VHS, VIKING, VIDEO) WITH HSC PDR3

HSC tracts VISTA tile pointings



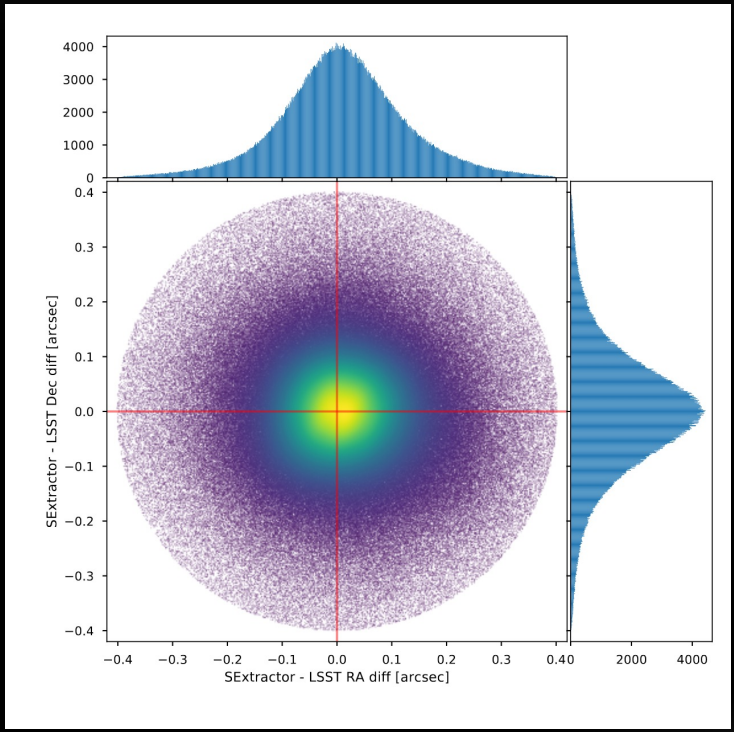




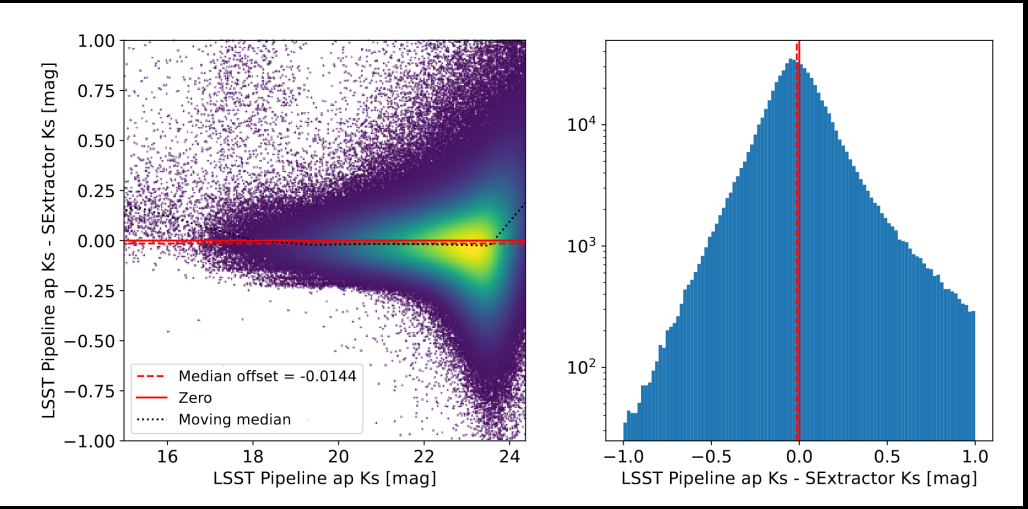
Both HSC Wide+VHS/VIKING (~800 sq-deg) and HSC DUD+VIDEO (~4.5 sq-deg) catalogues produced

BASIC QUALITY CONTROL CHECKS

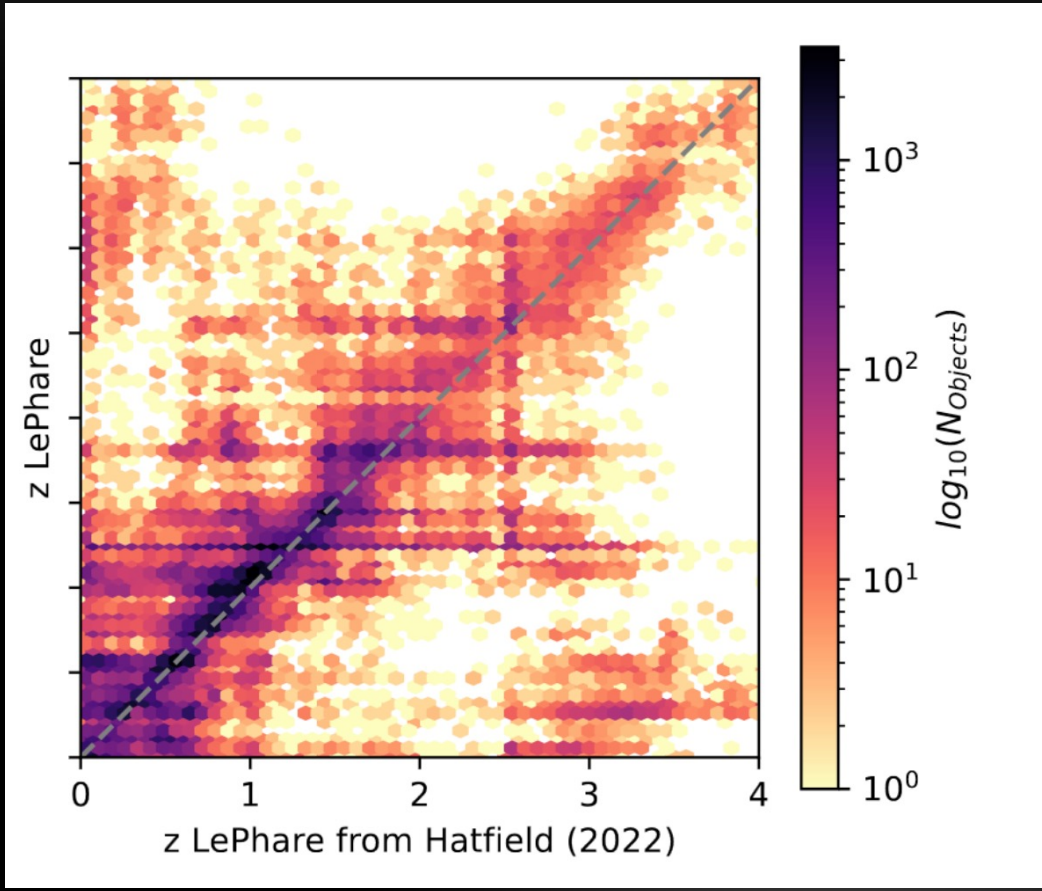
Astrometry



Photometry



PHOTOMETRIC REDSHIFTS

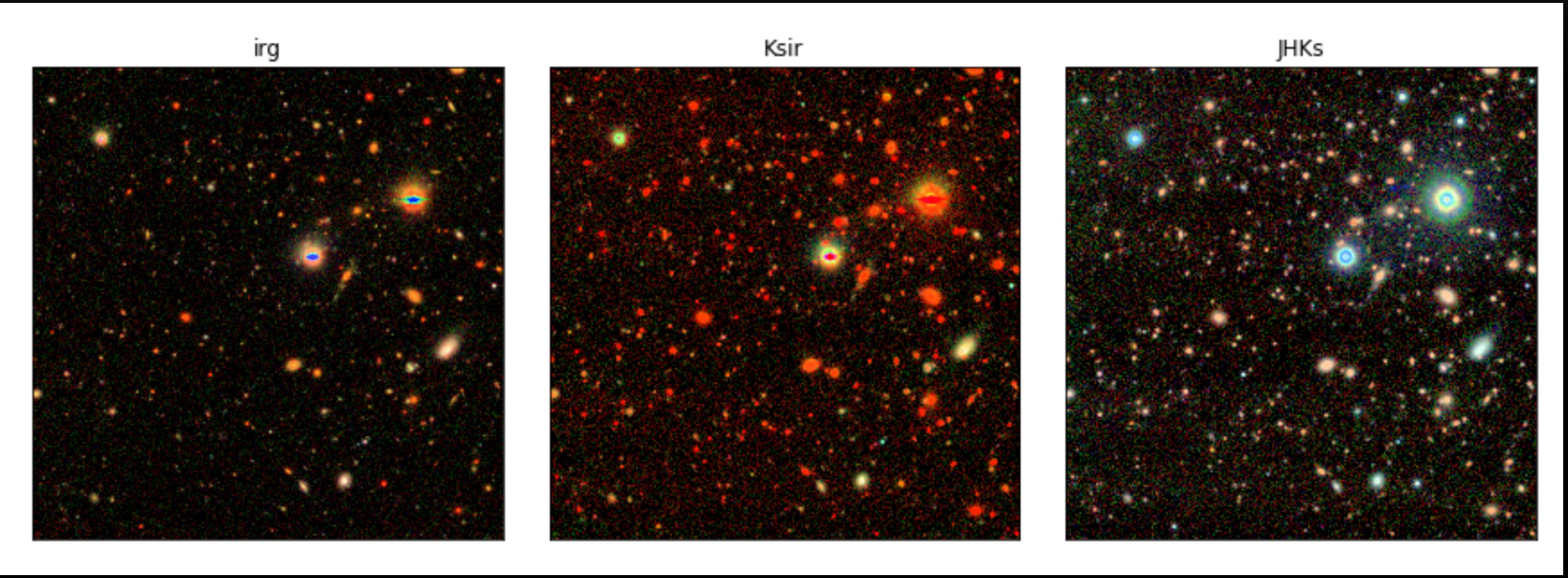


Current focus has been on parallelizing the photo-z estimation to run on HPC using queuing system

No attempt yet to optimize photo-z – focus in Phase C

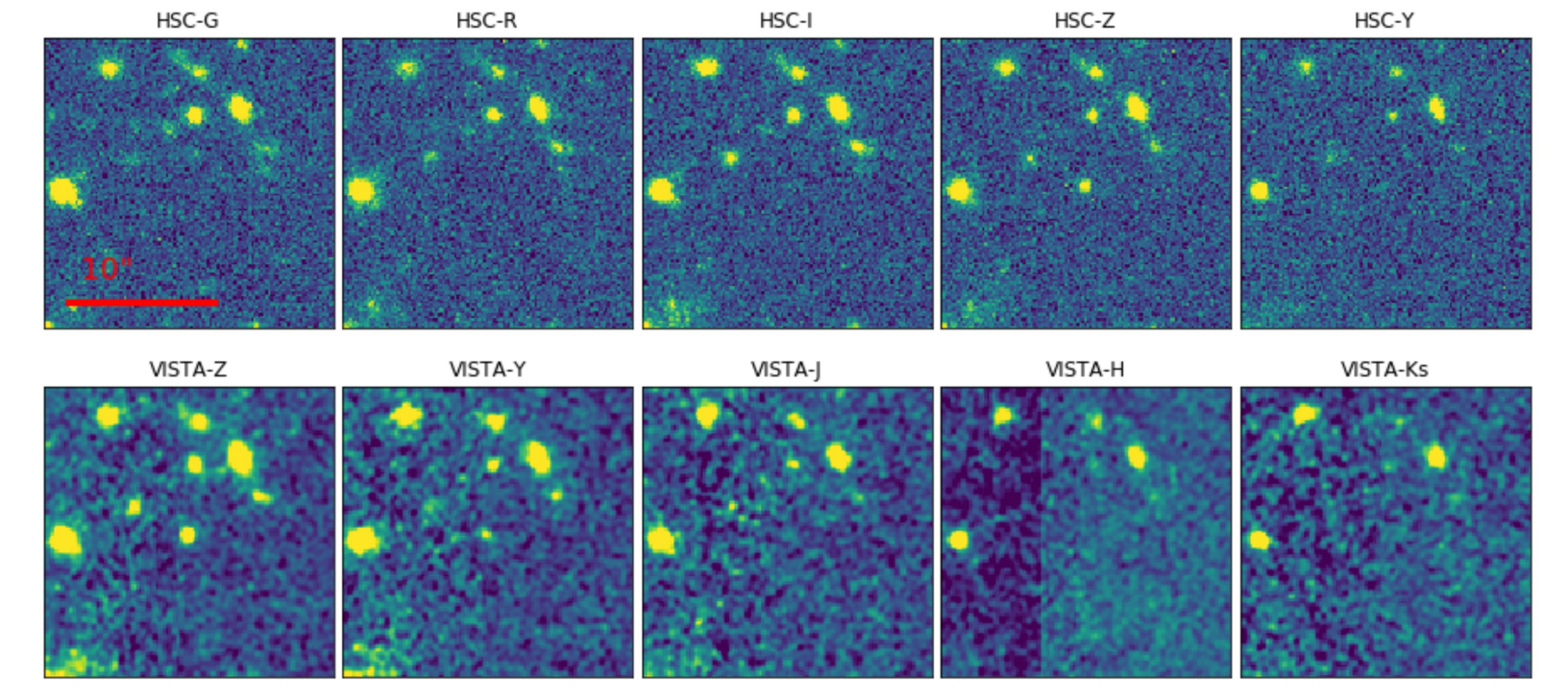
However photometry validated based on broad agreement with literature photo-z's (Hatfield+22)

HIGH REDSHIFT GALAXY CLUSTERS



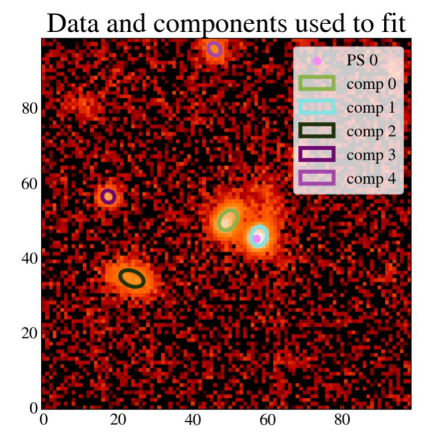
Coma cluster ‘progenitor’ at z=1.8 from Andreon et al. (2018)

HIGH REDSHIFT QUASARS (Z > 6)



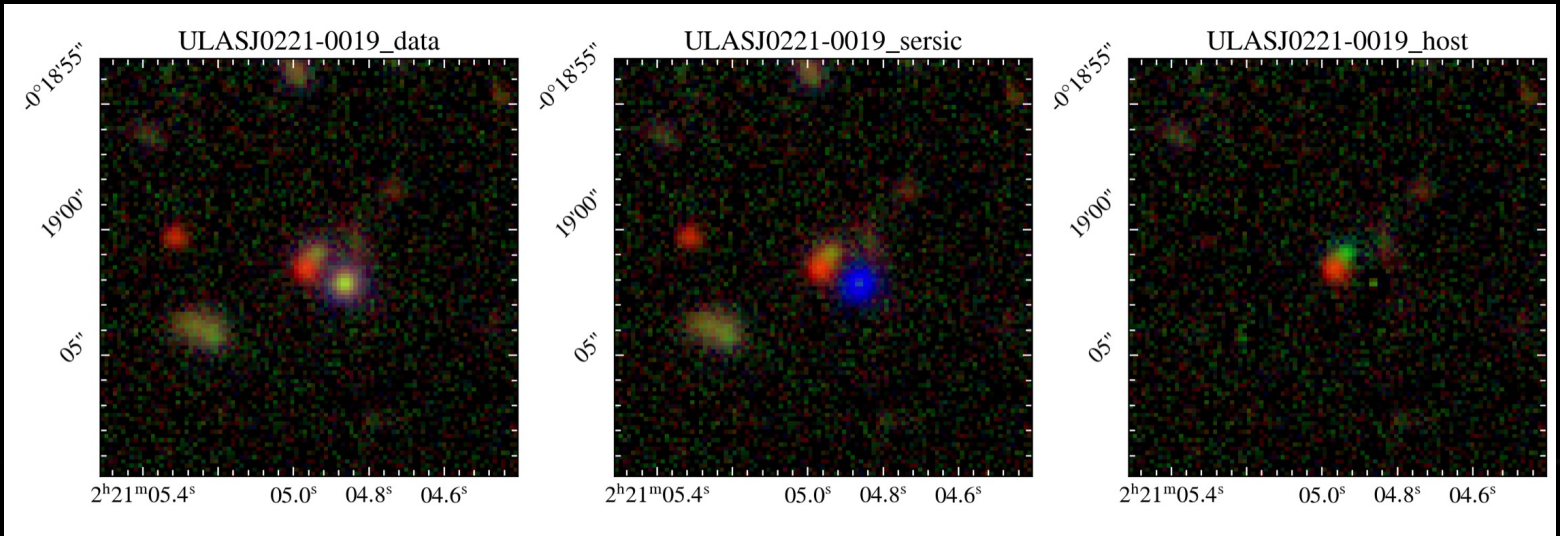
Quasar at z=6.10 from Willott et al. 2010

QUASARS & THEIR HOST GALAXIES



Luminous, red quasar at z=2.247 discovered using NIR surveys (Banerji+12)

Model-fits to HSC images suggest we are seeing emission from the quasar host galaxy due to dust obscuration of the quasar itself
Maybe even a companion galaxy – merger?



Project led by Shenli Tang (U. Tokyo -> Southampton) – images on same pixel scale crucial

DATA ACCESS

- We are working with the UK IDAC team at Edinburgh to ingest our HSC+VISTA catalogues and make them available through the Rubin Science Platform (RSP)

- Deliberate creation of VISTA data products – 'Butler' – in the same format as HSC/LSST to enable easy access

- Chance for UK community to engage with the data to:
  - Conduct your own scientific investigations / pilot studies before LSST is on-sky
  - Help us with scientific validation of our data products
  - Get used to the format in which LSST data will be made available to you

- Get in touch: M.Banerji-Wright@soton.ac.uk