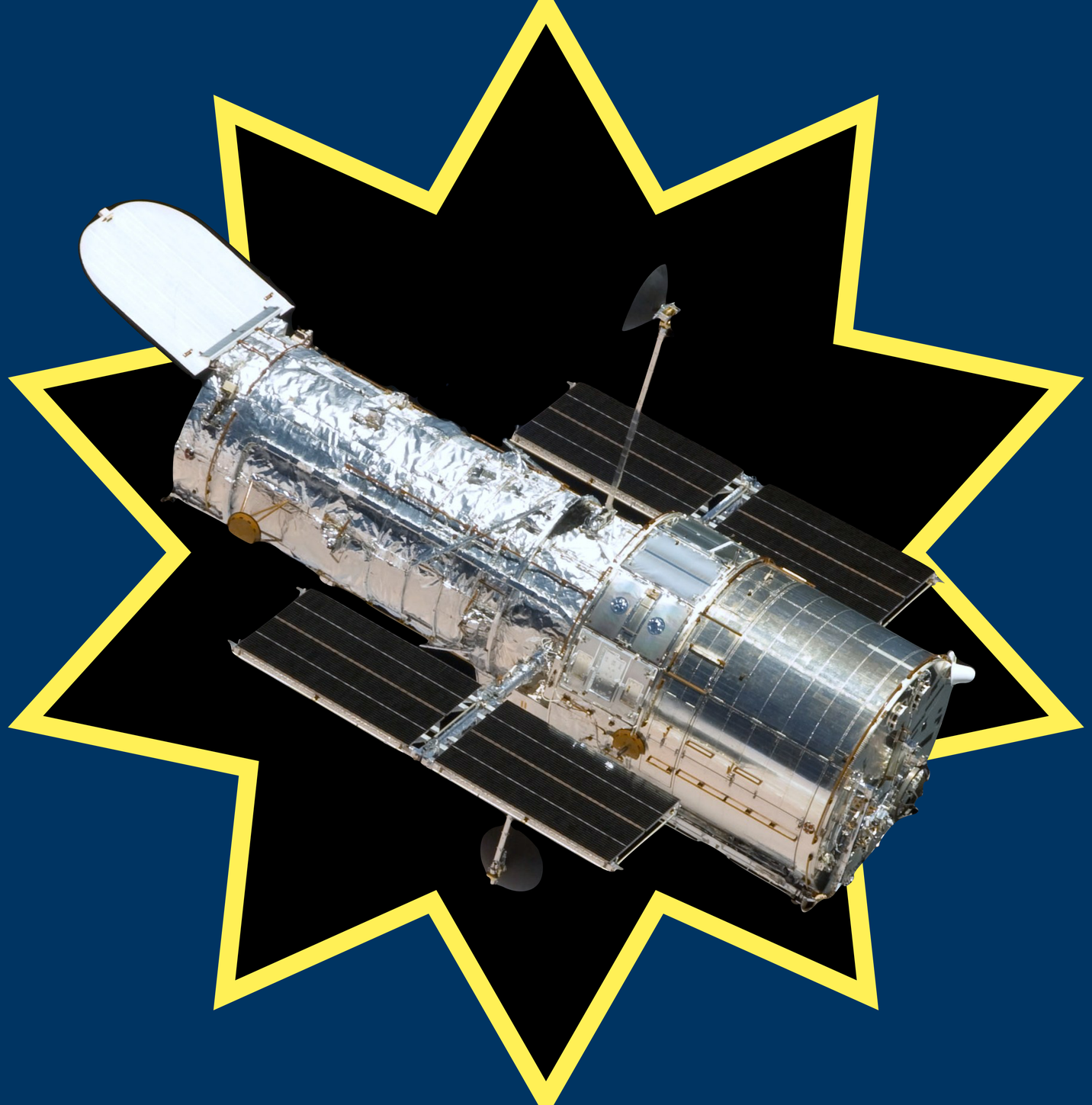
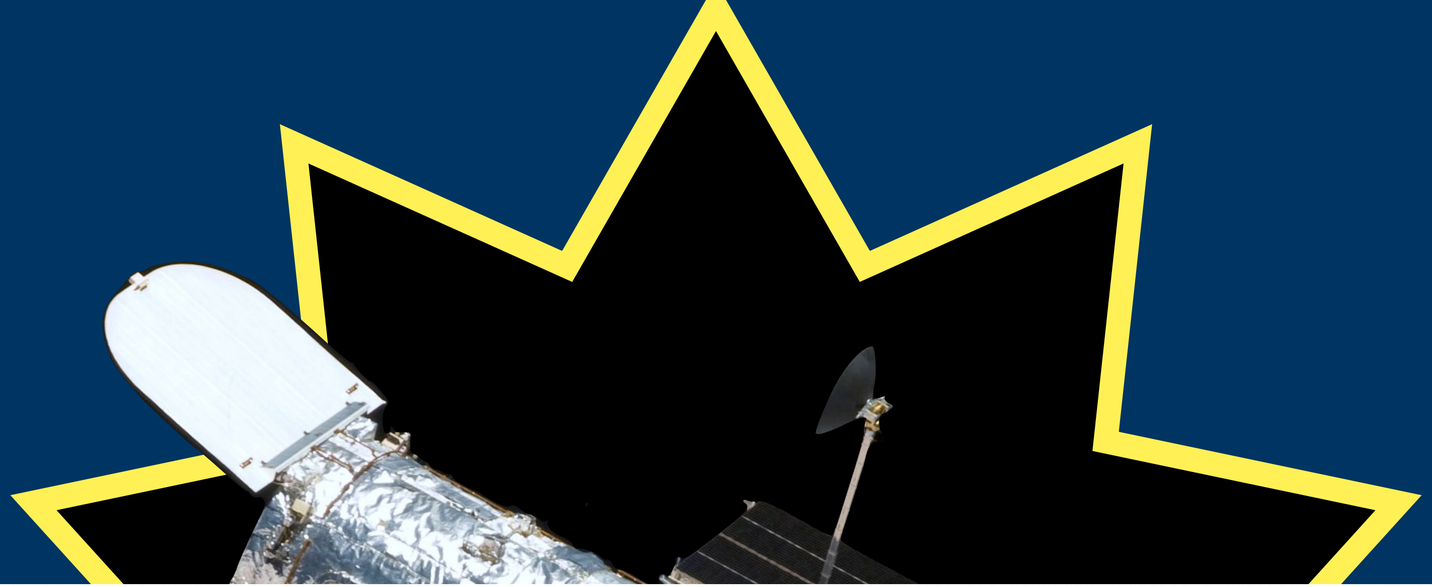
Galaxy Structural Properties and Star-Formation Histories with 3D-DASH

Sam Cutler, Lamiya Mowla, Kate Whitaker, Gabe Brammer, Iva Momcheva, Pieter van Dokkum, and the 3D-DASH Team

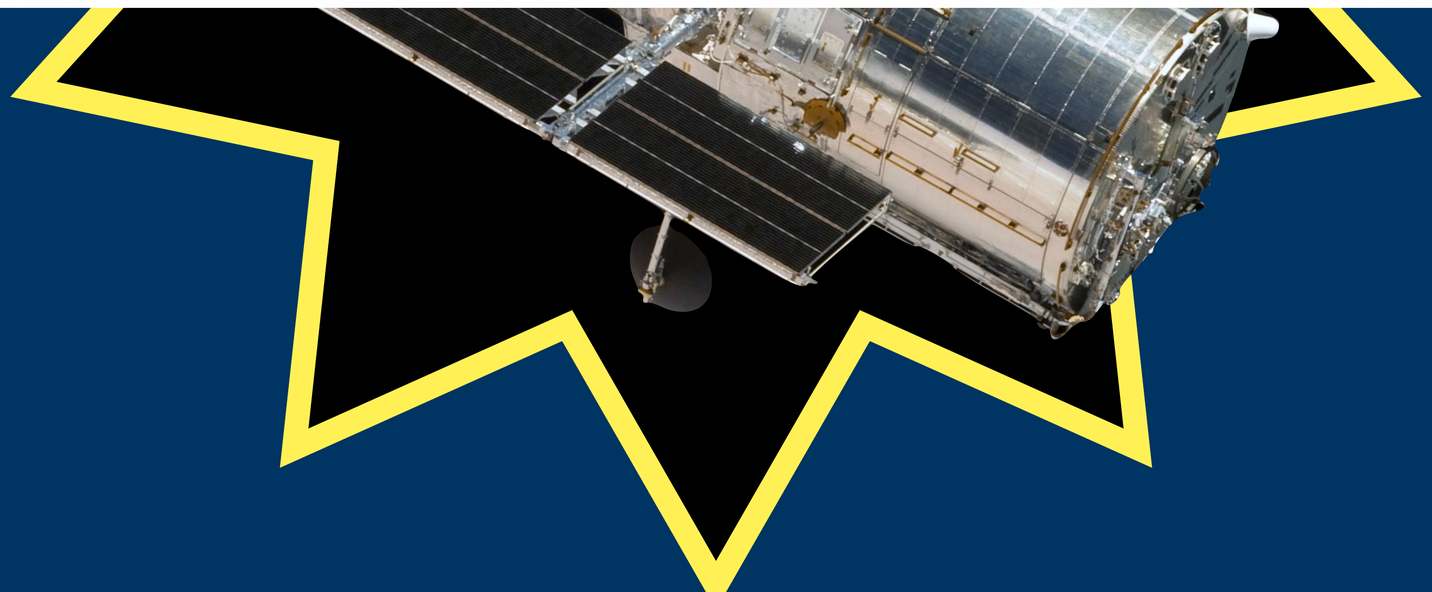
COSMOS2022 Meeting - July 12th 2022





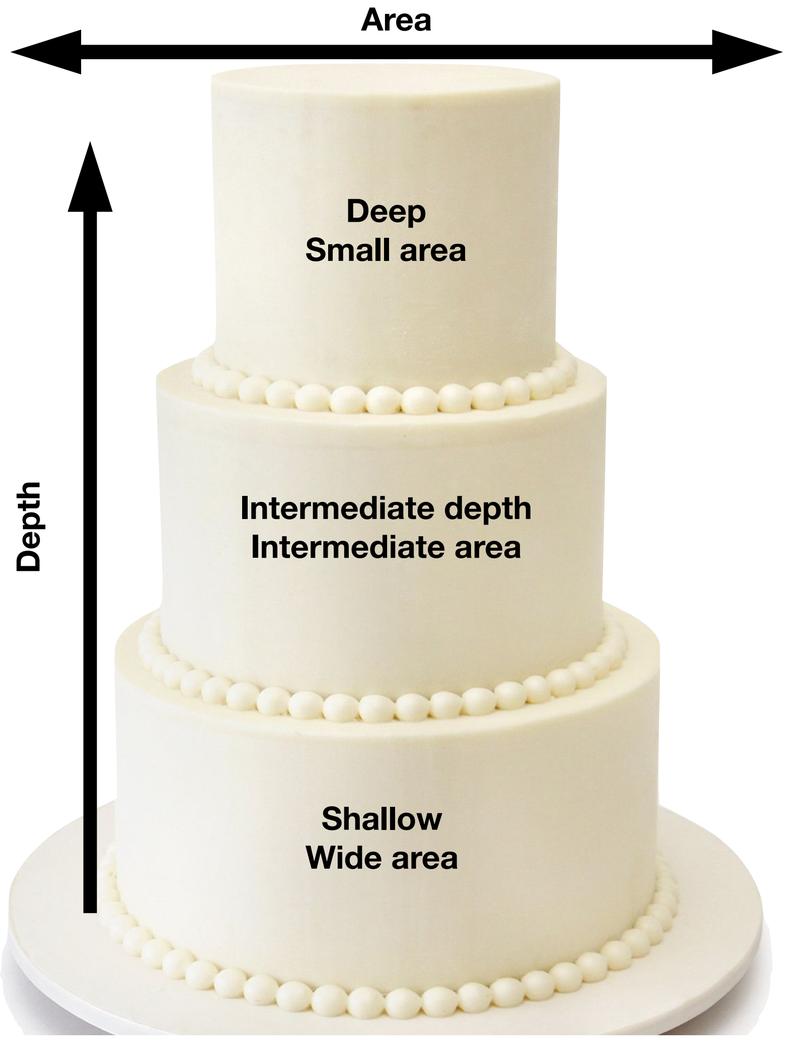
3D-DASH: The Widest Near-Infrared Hubble Space Telescope Survey

Lamiya A. Mowla,[1] Sam E. Cutler,[2] Gabriel B. Brammer,[3,4] Ivelina G. Momcheva,[5] Katherine E. Whitaker,[2,3] Pieter G. van Dokkum,[6] Rachel S. Bezanson,[7] Natascha M. Förster Schreiber,[8] Marijn Franx,[9] Kartheik G. Iyer,[1] Danilo Marchesini,[10] Adam Muzzin,[11] Erica J. Nelson,[12] Rosalind E. Skelton,[13] Gregory F. Snyder,[14] David A. Wake,[15] Stijn Wuyts,[16] and Arjen van der Wel[17]



Wide-Field Near-IR Imaging from 3D-DASH

Wide-field surveys are scientifically important



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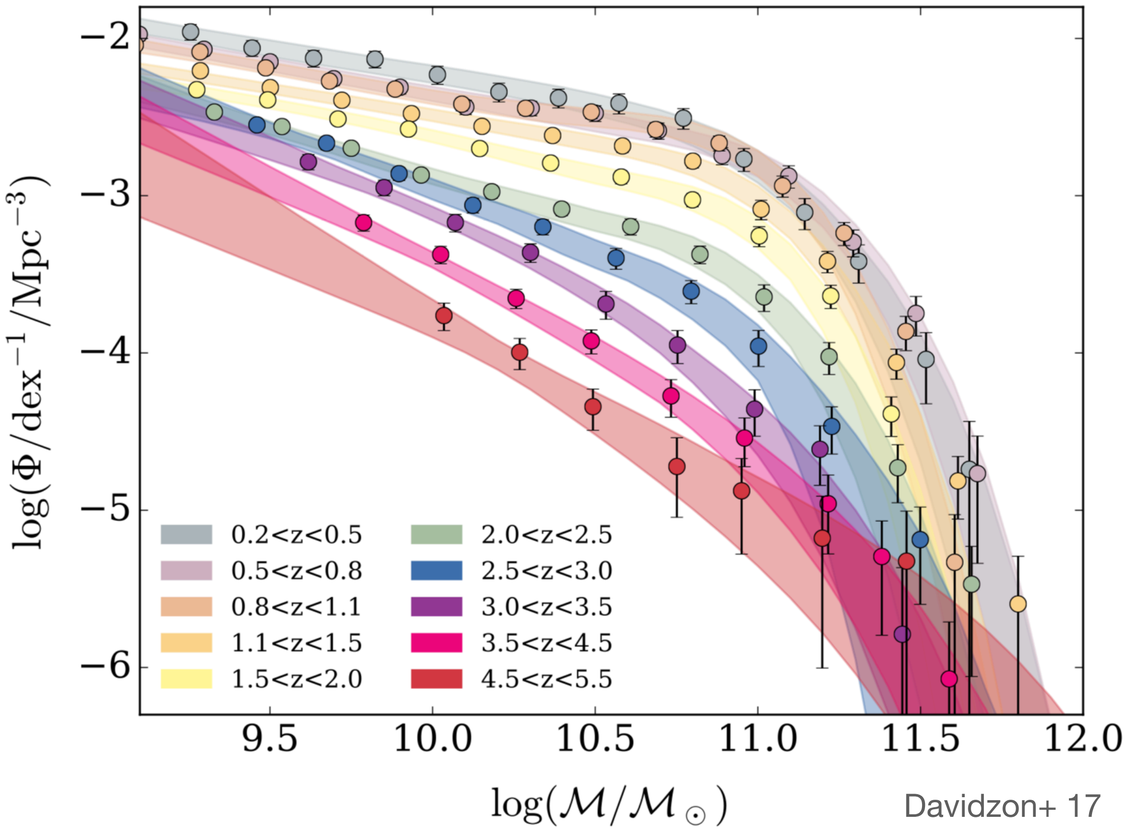
Wide-field surveys are scientifically important



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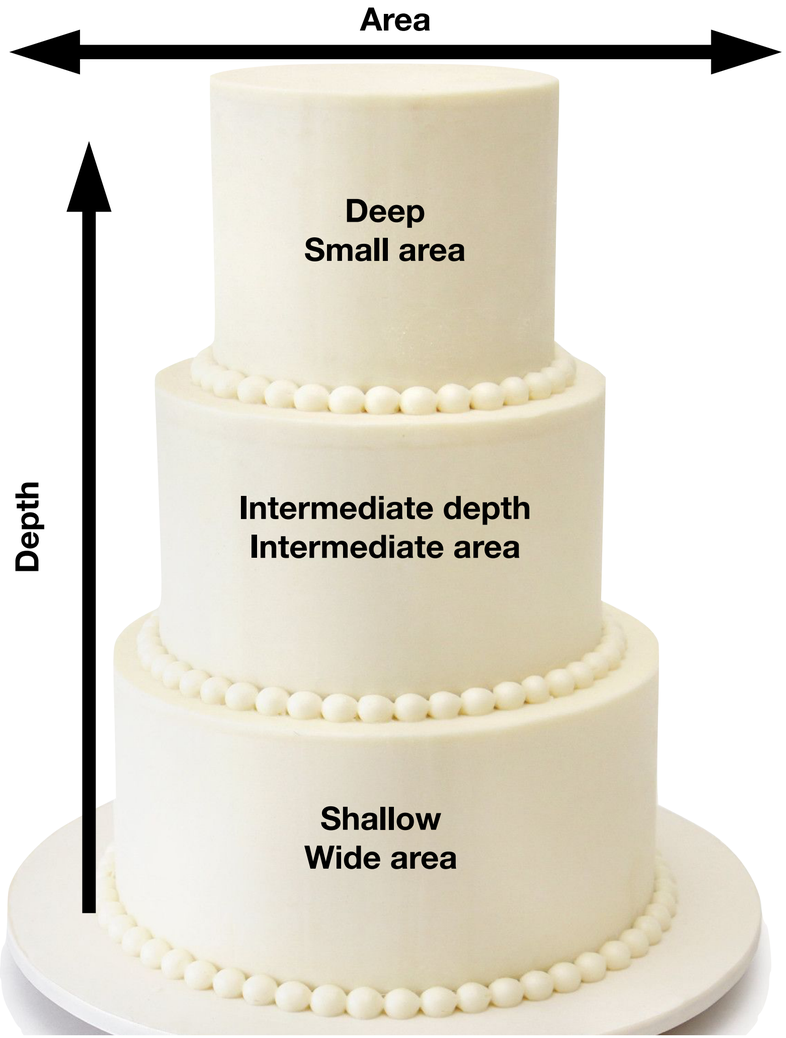
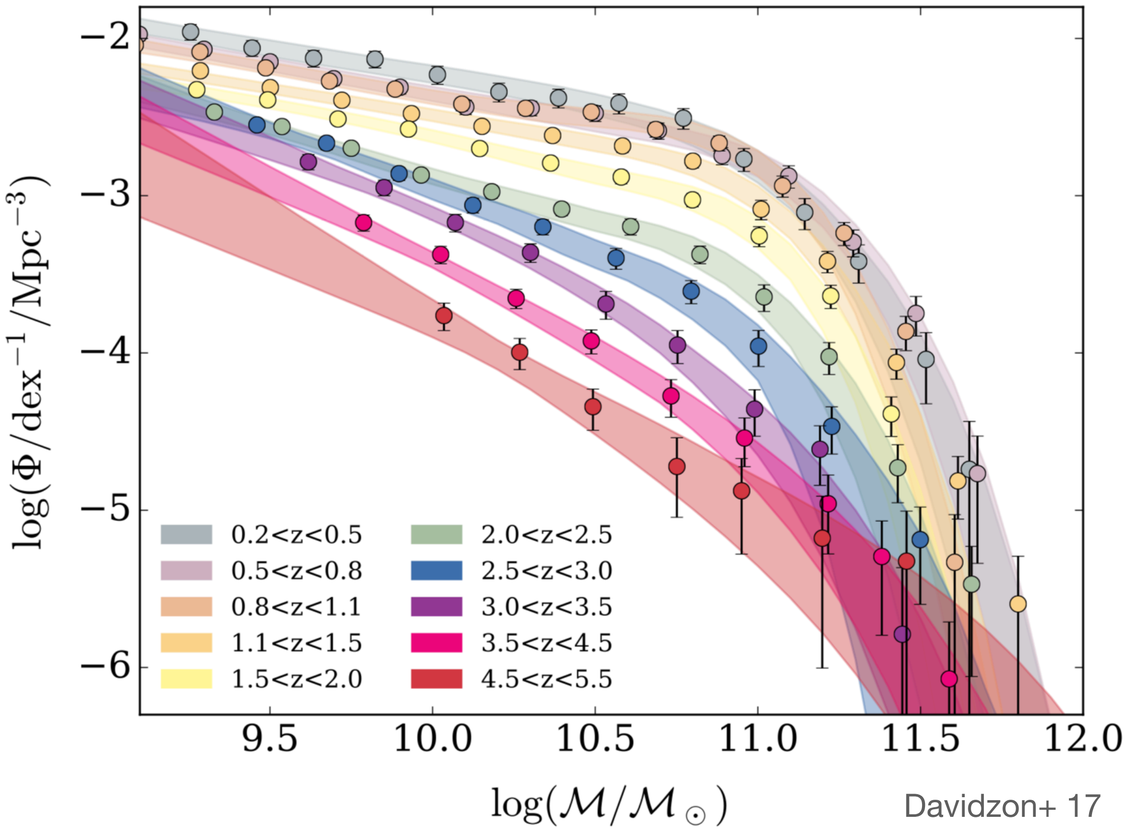
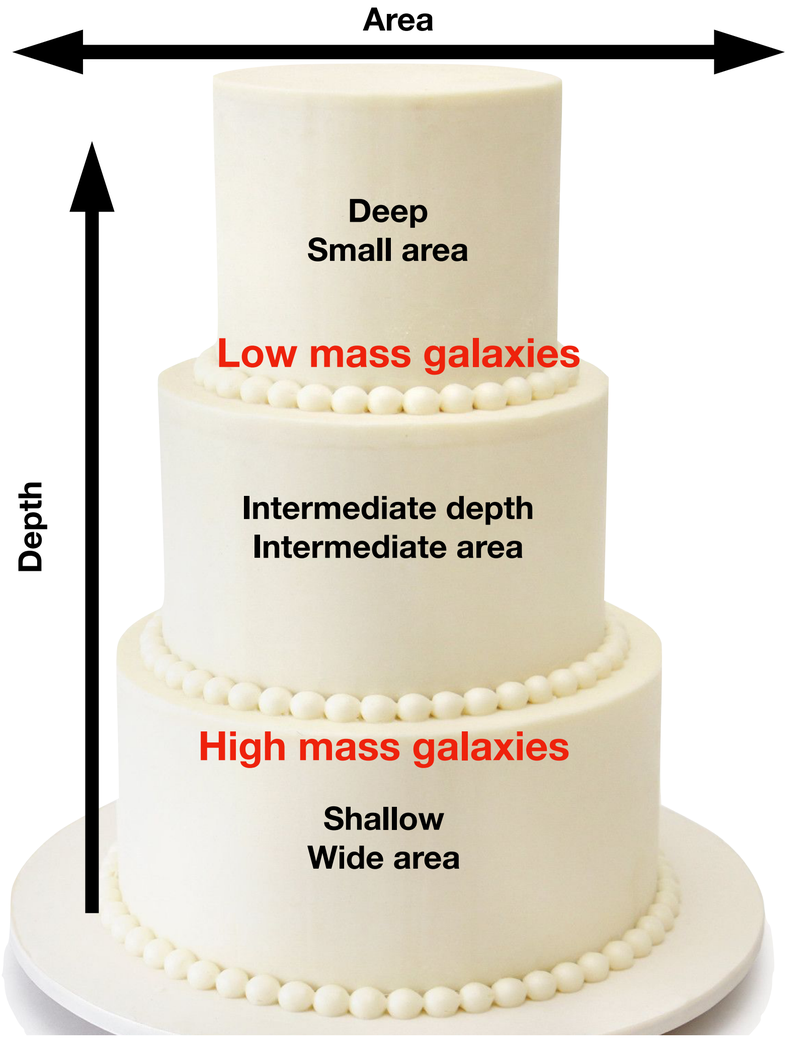


Wide-Field Near-IR Imaging from 3D-DASH

Wide-field surveys are scientifically important

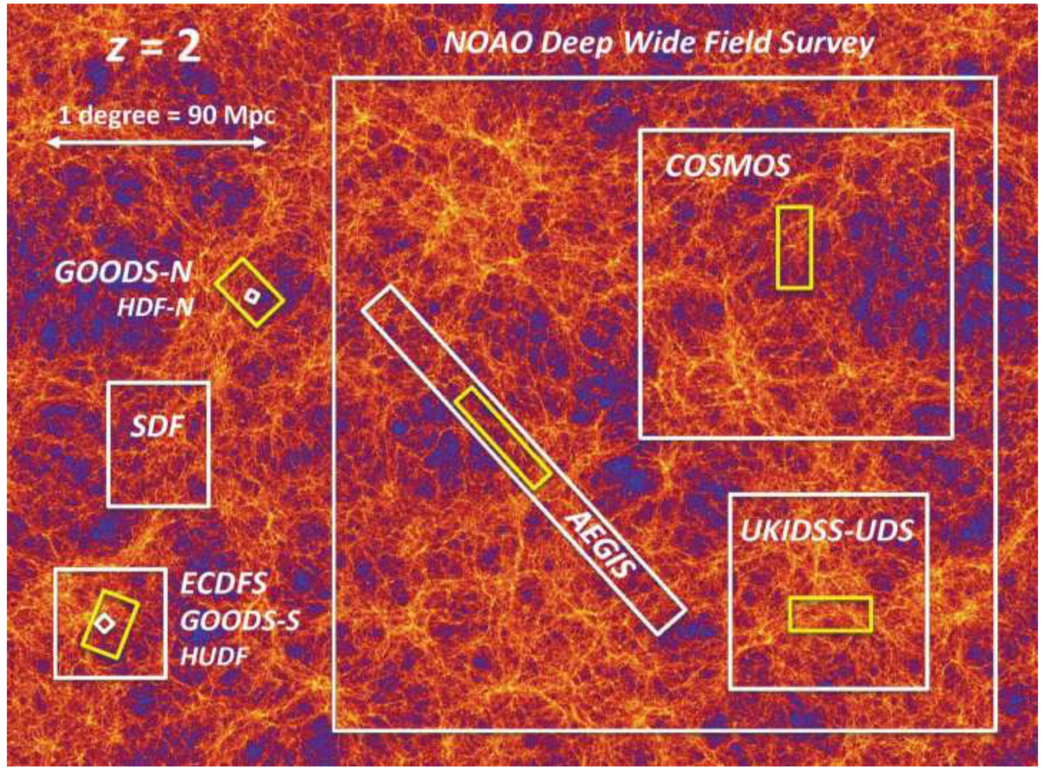


Davidzon+ 17

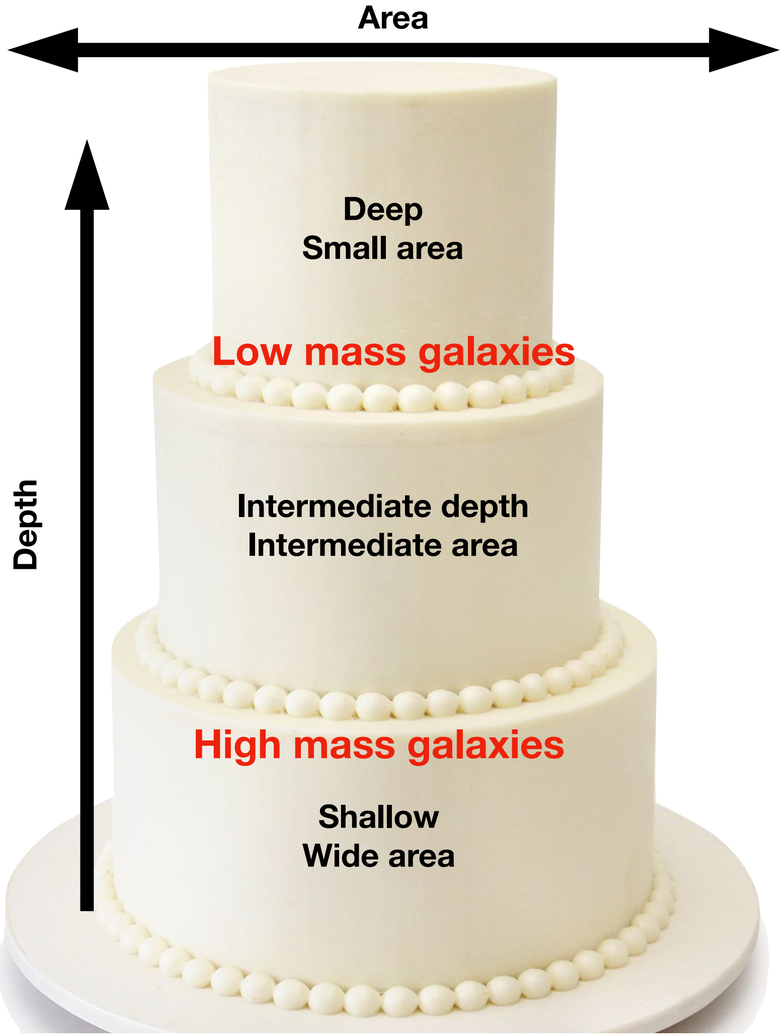


Wide-Field Near-IR Imaging from 3D-DASH

Wide-field surveys are scientifically important



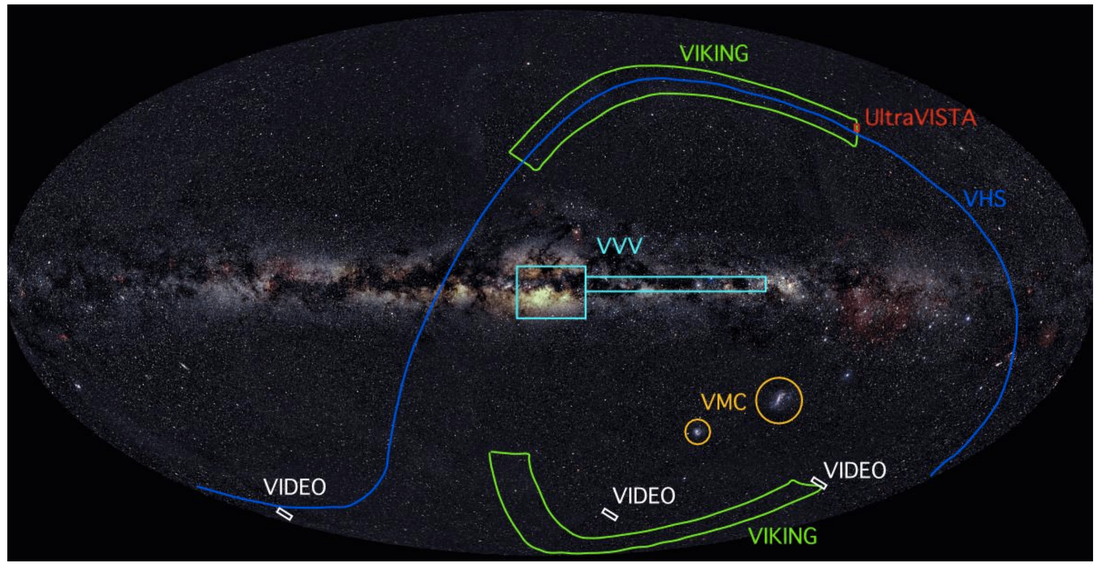
Madau & Dickinson 14



Wide-Field Near-IR Imaging from 3D-DASH

Difficult to achieve with HST (especially in NIR)

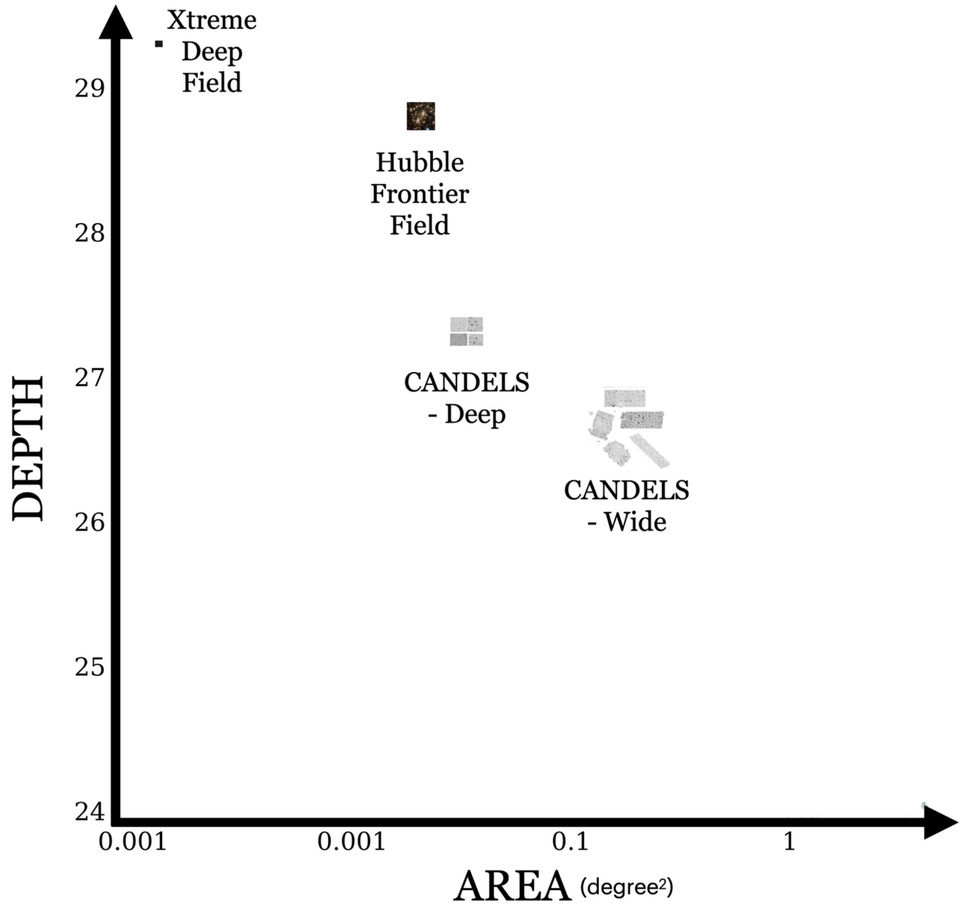
Already done from the ground!



VISTA survey observing strategies			
Survey	**Area (deg^2)**	**Filters and Depth Measure (mag (10σ, AB))**	**Depth (mag)**
Ultra-VISTA	0.73 (ultra-deep)	5σ, AB	Y=26.7 J=26.6 H=26.1 K_s=25.6 NB=26.0
VIKING	1500	5σ, AB	Z=23.1 Y=22.3 J=22.1 H=21.5 K_s=21.2
VMC	184	10σ, Vega	Y=21.9 J=21.4 Ks=20.3
VVV	520	5σ, Vega	Z=21.9 Y=21.2 J=20.2 H=18.2 K_s=18.1
VHS	20 000	5σ, AB	Y=21.2 J=21.2 H=20.6 Ks=20.0
VIDEO	12	5σ, AB	Z=25.7 Y=24.6 J=24.5 H=24.0 K_s=23.5

VISTA, European Southern Observatory

Not with HST (NIR)…



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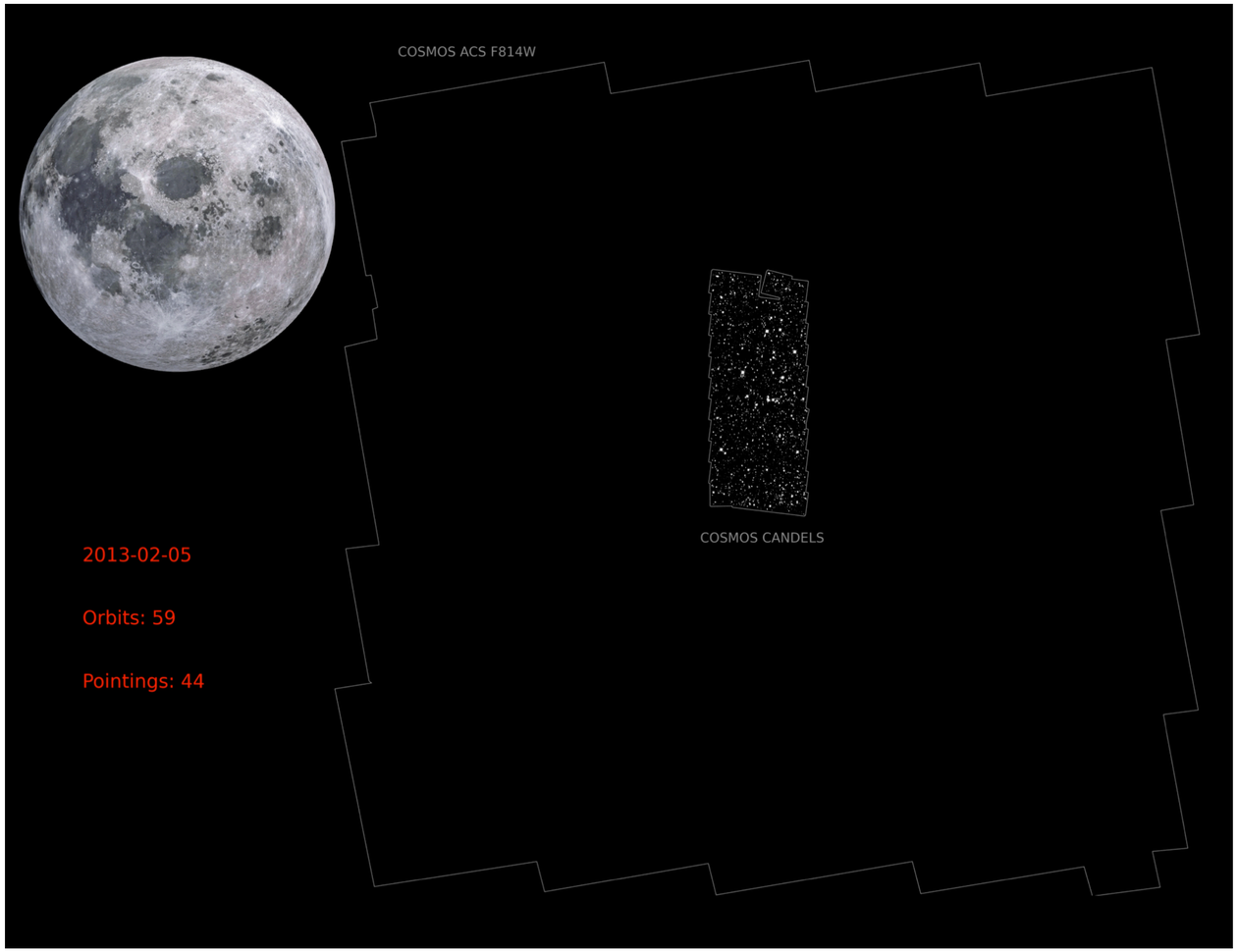
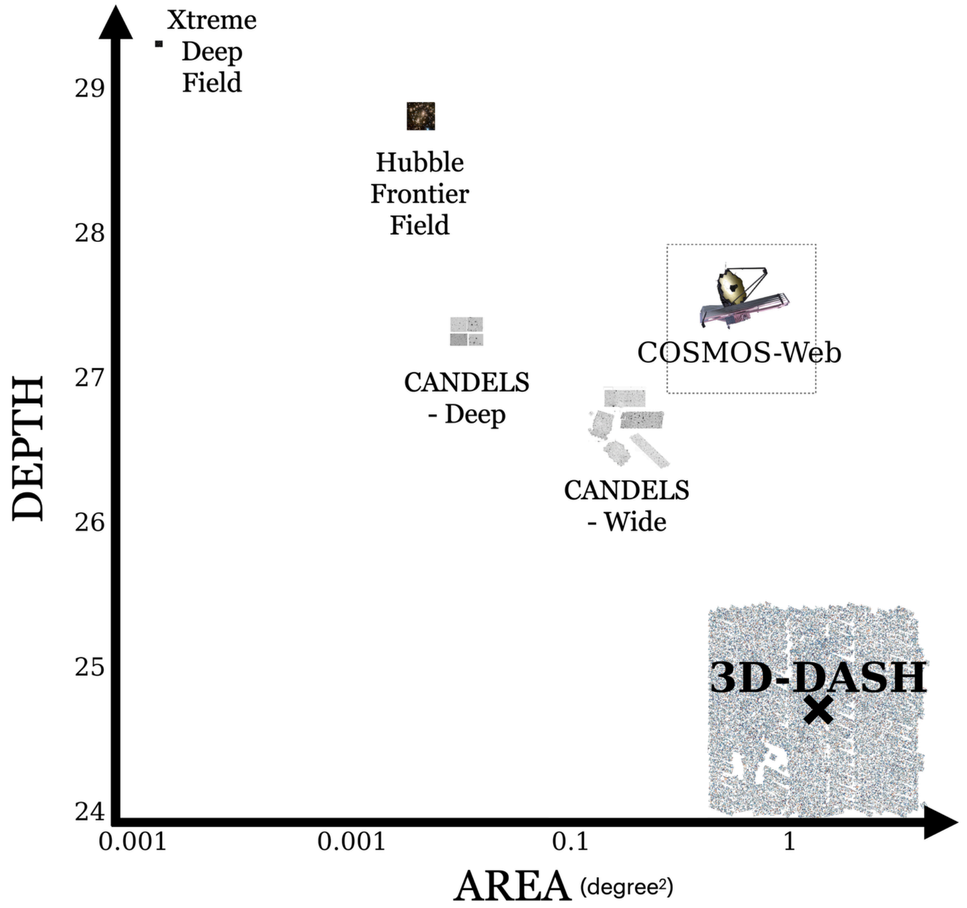
Wide-Field Near-IR Imaging from 3D-DASH

Drift and SHift solves this problem



Iva Momcheva, 3D-DASH Team



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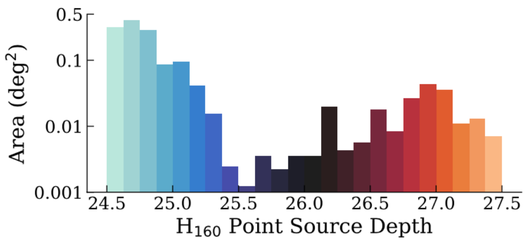
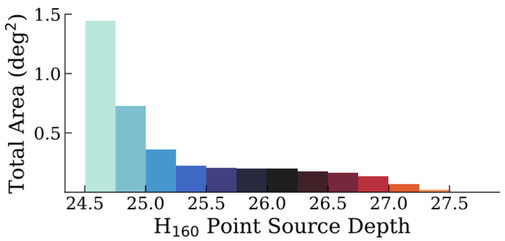
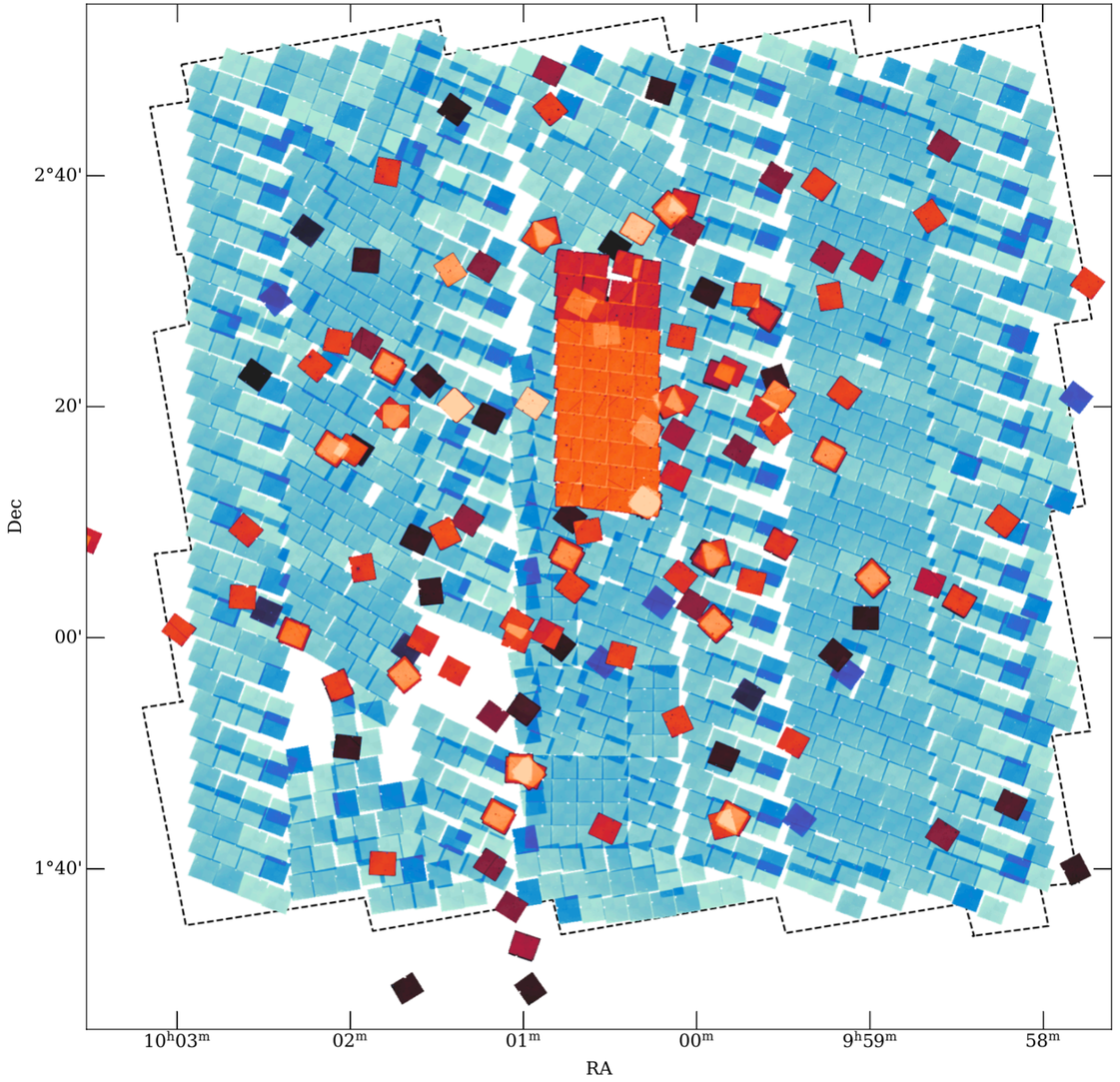
Wide-Field Near-IR Imaging from 3D-DASH

Drift and SHift solves this problem

- 1.43 deg^2 in F160W (incl. archival data)
  - 159 orbits, 1256 pointings
- Median 5σ depth of 24.74 ABmag







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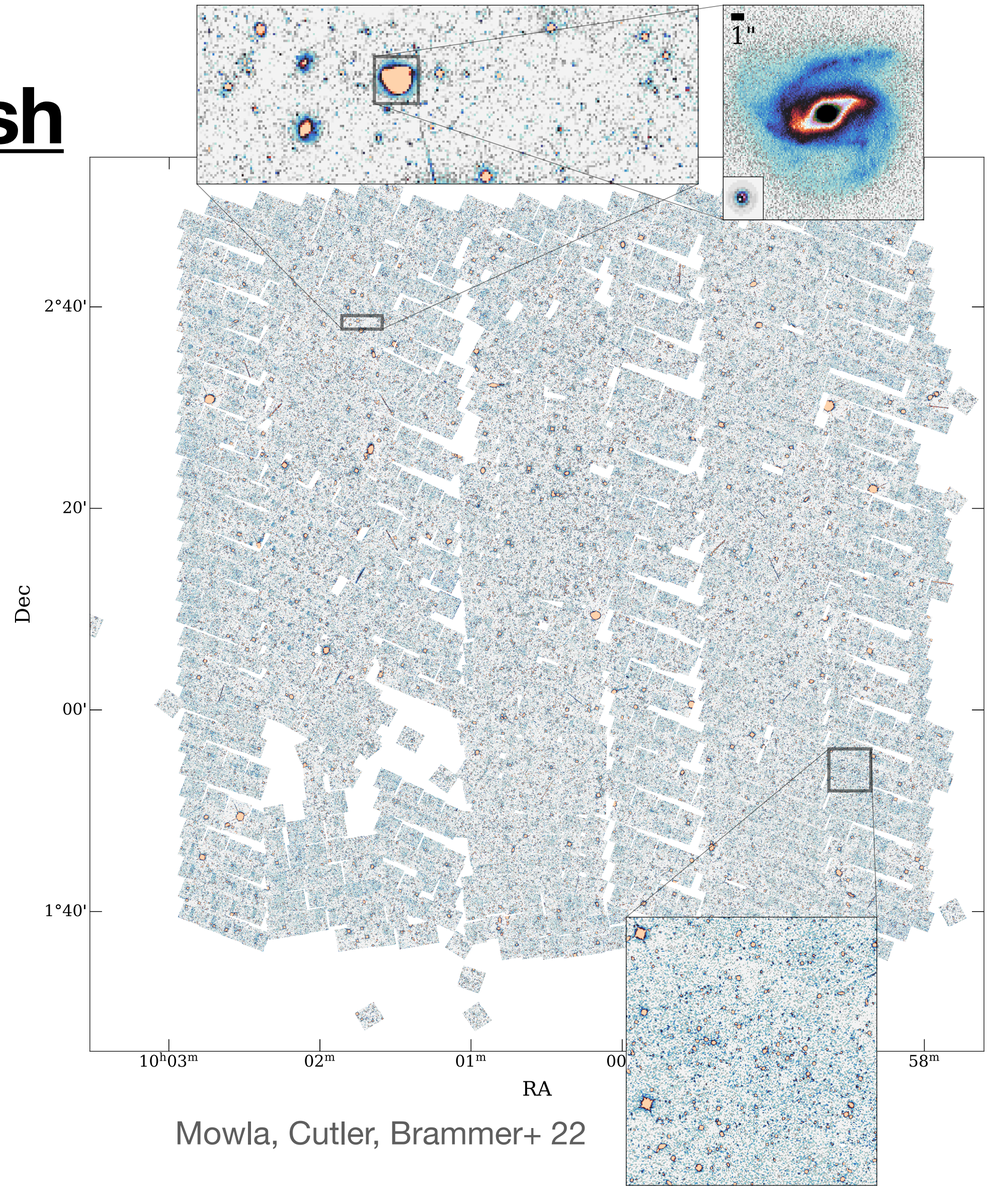
Wide-Field Near-IR Imaging from 3D-DASH

Now public!
https://archive.stsci.edu/hlsp/3d-dash

- Mosaics and individual tiles available on MAST



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Wide-Field Near-IR Imaging from 3D-DASH

Now public!

https://www.lamiyamowla.com/3d-dash

- Mosaics and individual tiles available on MAST
- Image cutout tool and PSF generator available via Lamiya Mowla

Please make a duplicate of the notebook in order to make edits

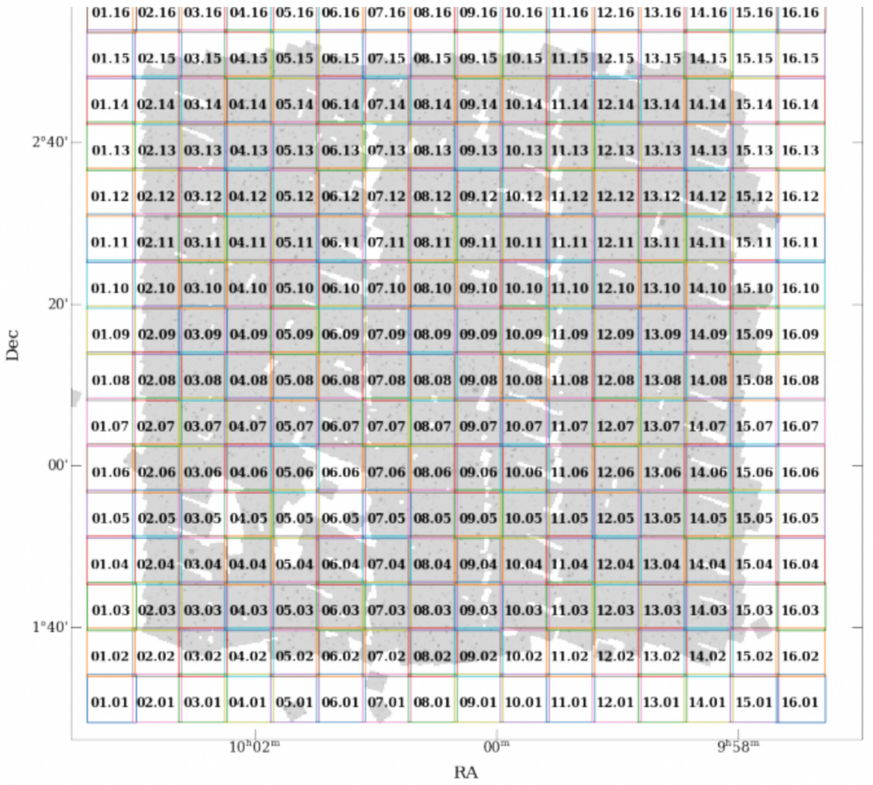
PSF generator for 3D-DASH data

```
from psf_generator_heroku import *
```

- ra - Target ra, degrees
- dec - Target dec, degrees
- nearest - nearest sources
- filter - Bandpass filter (`f606w` , `f814w` , `f105w` , `f125w` , `f140w` , `f160w`)
- extra_where - Additional query criteria, e.g., `&extra_where= AND f160w_exptime>1000` (with leading space and no quote marks)
- window - Window function to taper edges
- require_source - Require that a source was identified in the image cutout
- use_weights - Use thumbnail weights when making average PSF.
- max_centroid_offset - Maximum centroid offset of identified source to use for average PSF
- max_nsrc - Maximum number of identified sources to consider as valid (e.g., with neighbors)
- recenter - Recenter data cutouts based on source centroids
- subtract_median - Subtract a median from the cutouts
- output - Output type: `fits` , `png` . Will be in the `psf` folder
- display - Display the generated PSF

Cutout

```
from dash_cutout import *
```



Lamiya Mowla, Gabe Brammer, 3D-DASH Team

Wide-Field Near-IR Imaging from 3D-DASH

Now public!

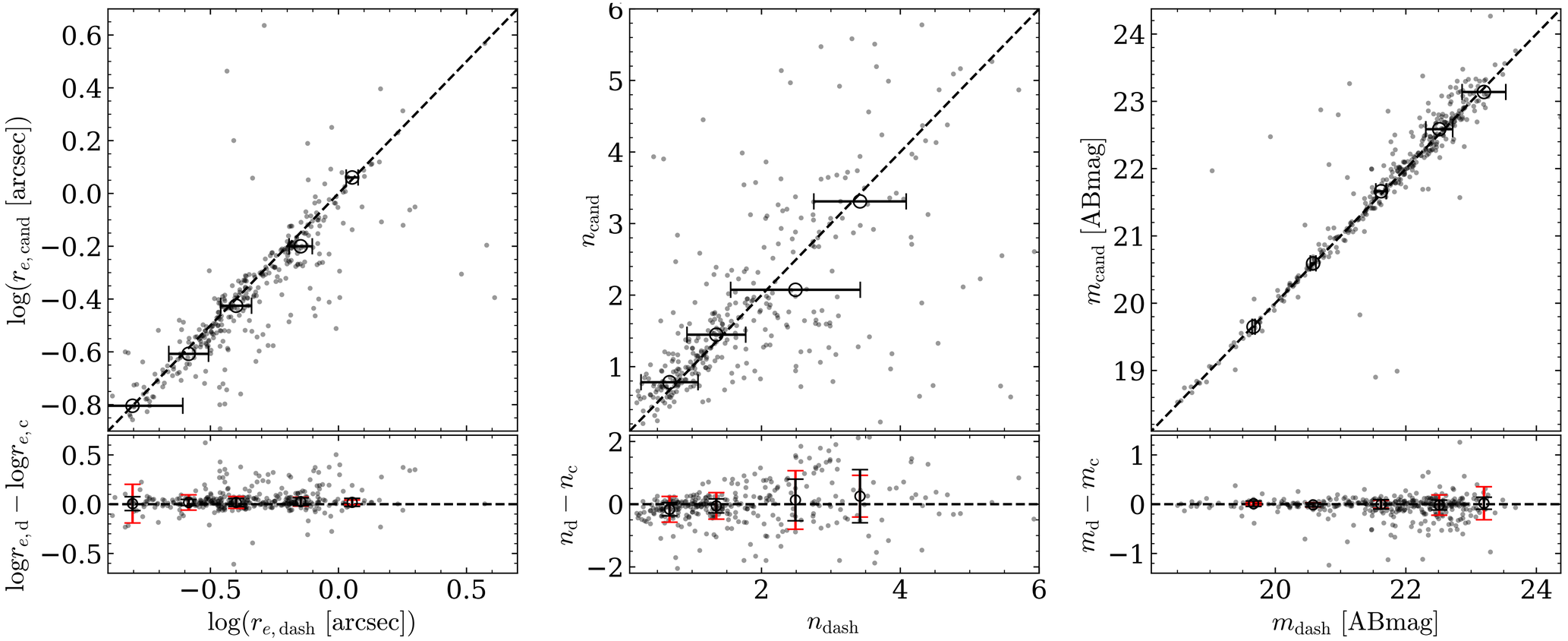
https://www.lamiyamowla.com/3d-dash

- Mosaics and individual tiles available on MAST
- Image cutout tool and PSF generator available via Lamiya Mowla
- Interactive image explorer via Gabe Brammer

Lamiya Mowla, Gabe Brammer, 3D-DASH Team

Wide-Field Near-IR Imaging from 3D-DASH

DASH morphologies agree with deeper CANDELS/3D-HST measurements



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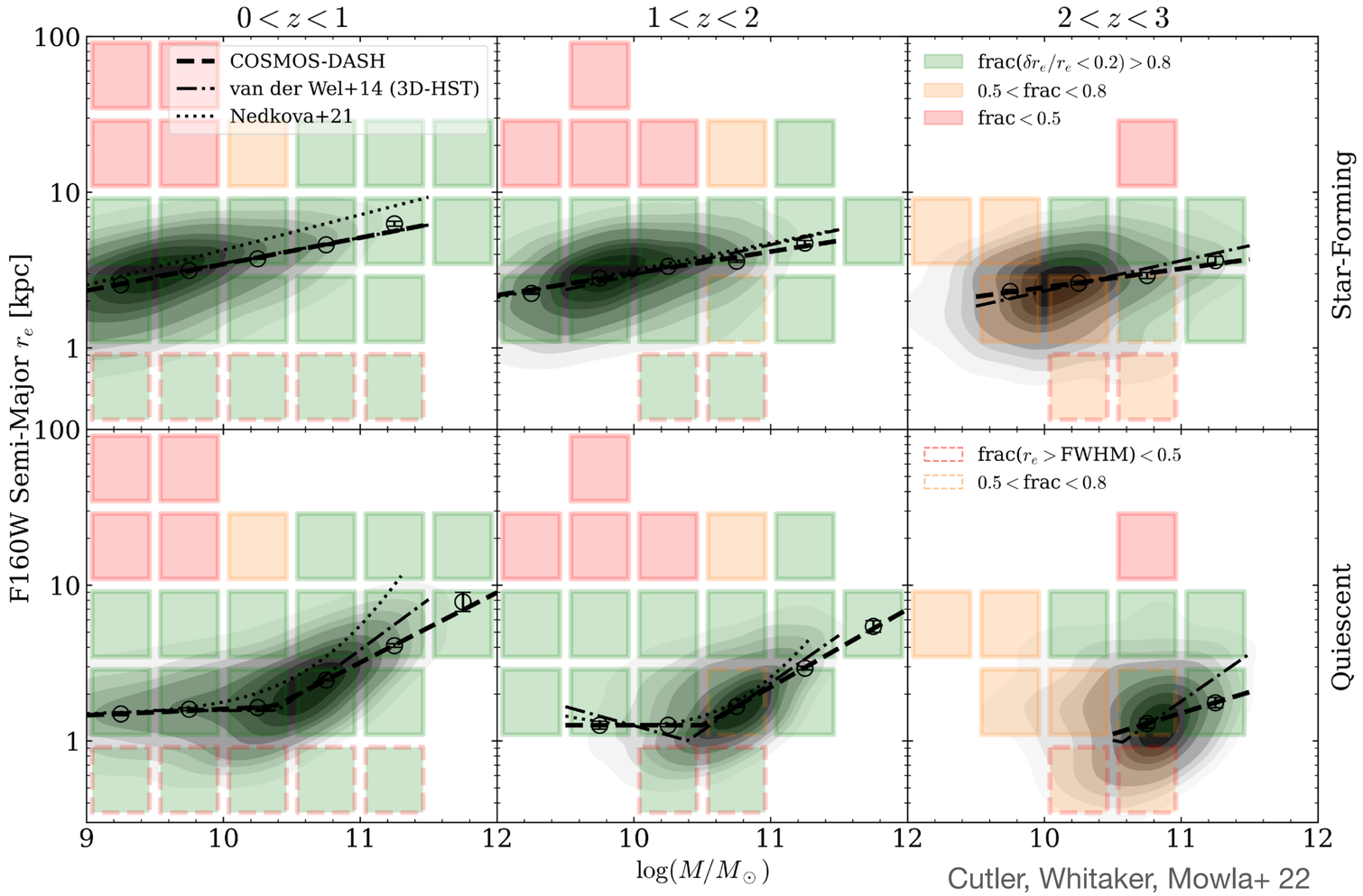
Wide-Field Near-IR Imaging from 3D-DASH

DASH preserves morphologies out to z~2 and log(M)~9



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Wide-Field Near-IR Imaging from 3D-DASH

COSMOS-DASH (3D-DASH pilot) Morphological catalog is public

https://archive.stsci.edu/hlsp/cosmos-dash

```
MAST webpage: https://archive.stsci.edu/hlsp/cosmos-dash
Refer to this HLSP with DOI: https://doi.org/10.17909/T96Q5M

2021-Nov-1

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The catalog (hlsp_cosmos-dash_hst_wfc3_cosmos_f160w_v1.3_morph-cat.txt) contains the following
columns:

COLUMN,   NAME,          DTYPE, UNIT,   DESCRIPTION
-------------------------------------------------------
# COL 1,  ID,            int,   none,   Object identifier from UVISTA catalog of Muzzin et al. (2013)
# COL 2,  RA,            float, deg,    Right ascension (J2000; decimal degrees)
# COL 3,  DEC,           float, deg,    Declination (J2000; decimal degrees)
# COL 4,  flag,          int,   none,   GALFIT flag; 0=good, 1=suspicious, 2=bad, 3=failed, 4=no
coverage (see Cutler et al. 2021)
# COL 5,  use,           int,   none,   General use flag; 1=GALFIT flag<2,re>FWHM,Deblending flag<2
(see Cutler et al. 2021)
# COL 6,  mag,           float, ABmag,  GALFIT best-fit magnitude
# COL 7,  dmag,          float, ABmag,  Uncertainty in GALFIT magnitude
# COL 8,  re,            float, arcsec, GALFIT best-fit effective (half-light) radius in arcsec
# COL 9,  dre,           float, arcsec, Uncertainty in GALFIT effective radius in arcsec
# COL 10, n,             float, none,   GALFIT best-fit Sersic index
# COL 11, dn,            float, none,   Uncertainty in GALFIT Sersic index
# COL 12, q,             float, none,   GALFIT best-fit axis ratio
# COL 13, dq,            float, none,   Uncertainty in GALFIT axis ratio
# COL 14, pa,            float, deg,    GALFIT best-fit position angle (0: North; 90: East)
# COL 15, dpa,           float, deg,    Uncertainty in GALFIT position angle
```

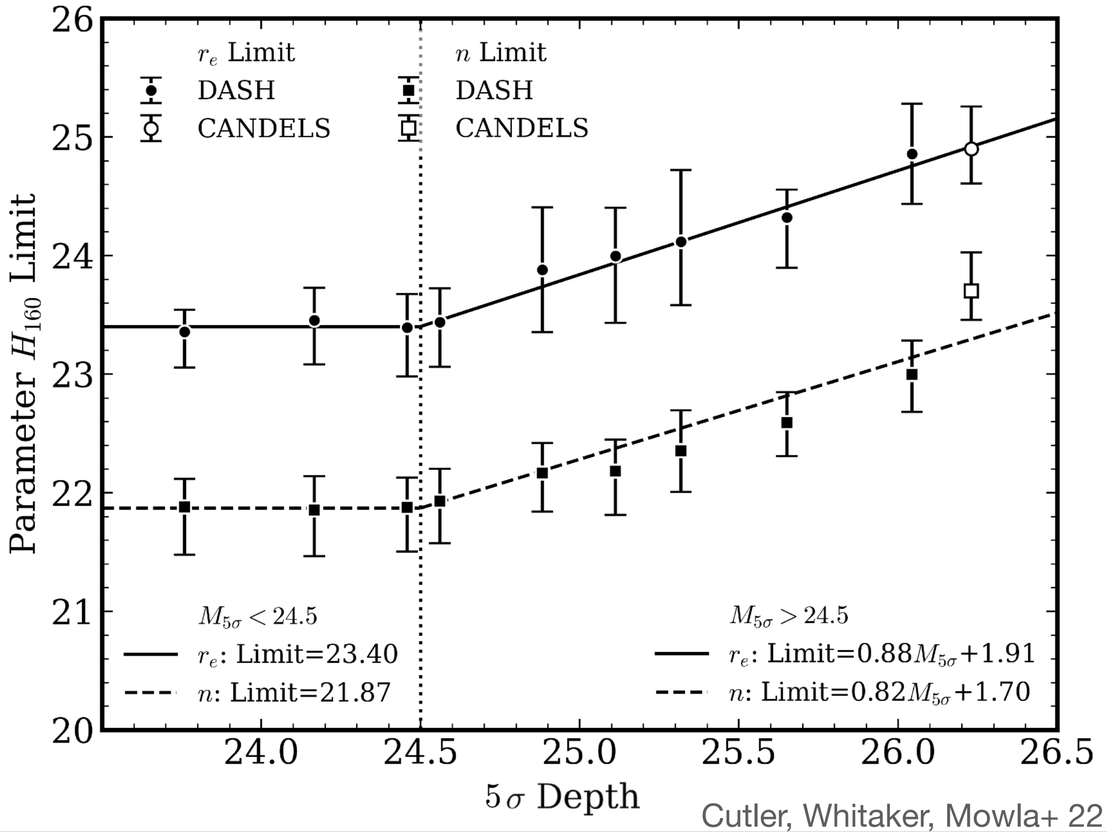

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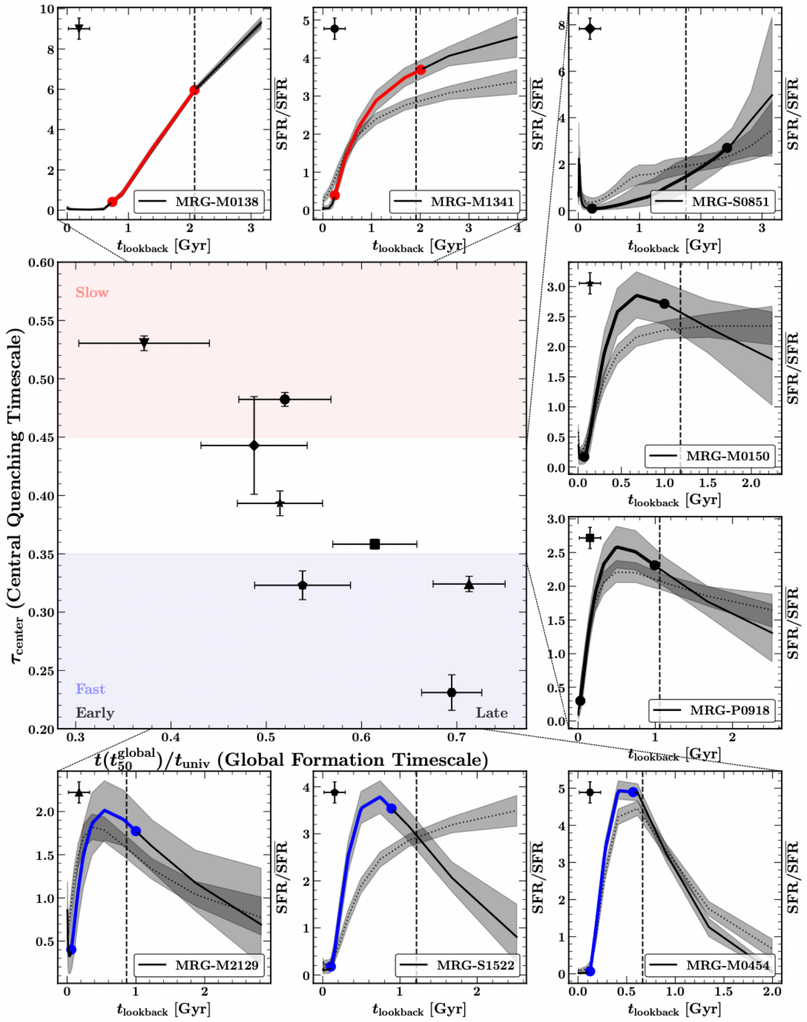
Wide-Field Near-IR Imaging from 3D-DASH

Resolved quenched star-formation histories with 3D-DASH and COSMOS ACS (F814W) color gradients

- The global formation time (t_{50}) describes whether a galaxy formed early or late
- The central quenching timescale (τ_{center}) describes whether a galaxy quenched quickly or slowly



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Wide-Field Near-IR Imaging from 3D-DASH

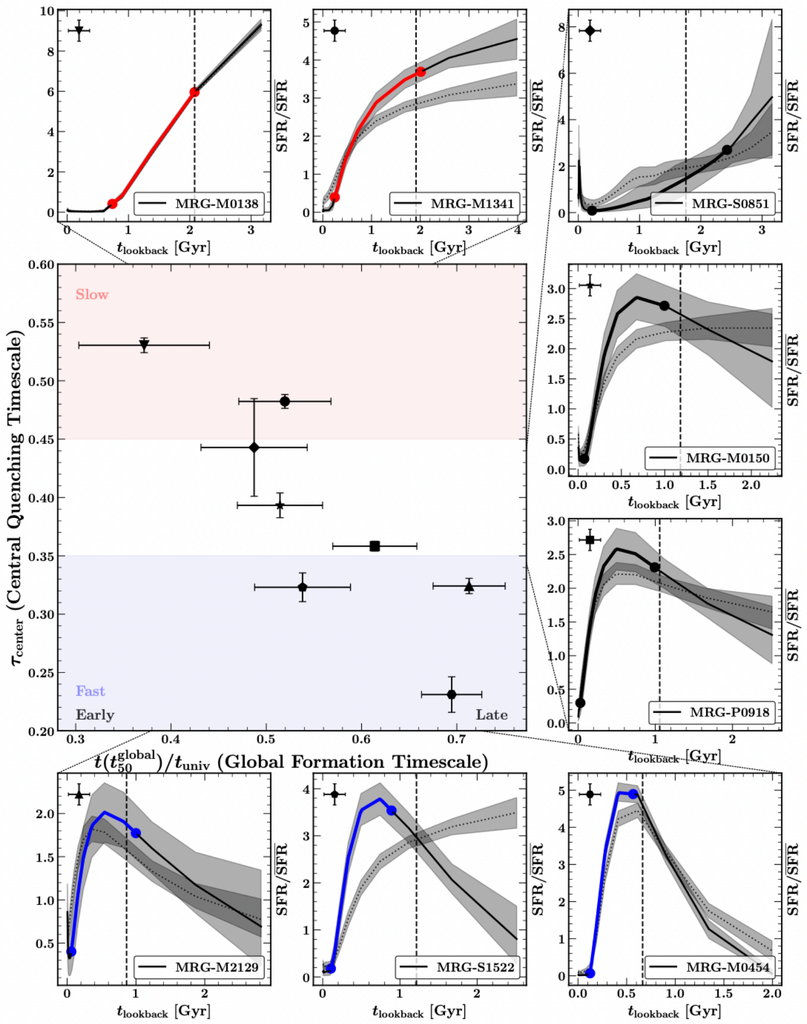
Resolved quenched star-formation histories with 3D-DASH and COSMOS ACS (F814W) color gradients

1. Get grid of t_{50} and τ_{center} from REQUIEM SFHs

2. Generate model spectra with Prospector using SFHs and stellar population parameters

3. Mock observed I_{F814W}-H_{F160W} color gradients from model spectra

4. Measure color gradients from 3D-DASH/ COSMOS ACS



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Wide-Field Near-IR Imaging from 3D-DASH

Summary

3D-DASH data is public:

- Mosaics and tiles at https://archive.stsci.edu/hlsp/3d-dash
- Image tools at https://www.lamiyamowla.com/3d-dash
- Morphologies at https://archive.stsci.edu/hlsp/cosmos-dash

Takeaways:

- The DASH technique allows HST to mosaic efficiently in the NIR
- DASH observations preserve galaxy morphologies
- Future studies into quiescent SFHs using color gradients

Contact me with any thoughts or suggestions!
secutler@umass.edu; @secutler on Twitter; samecutler.github.io