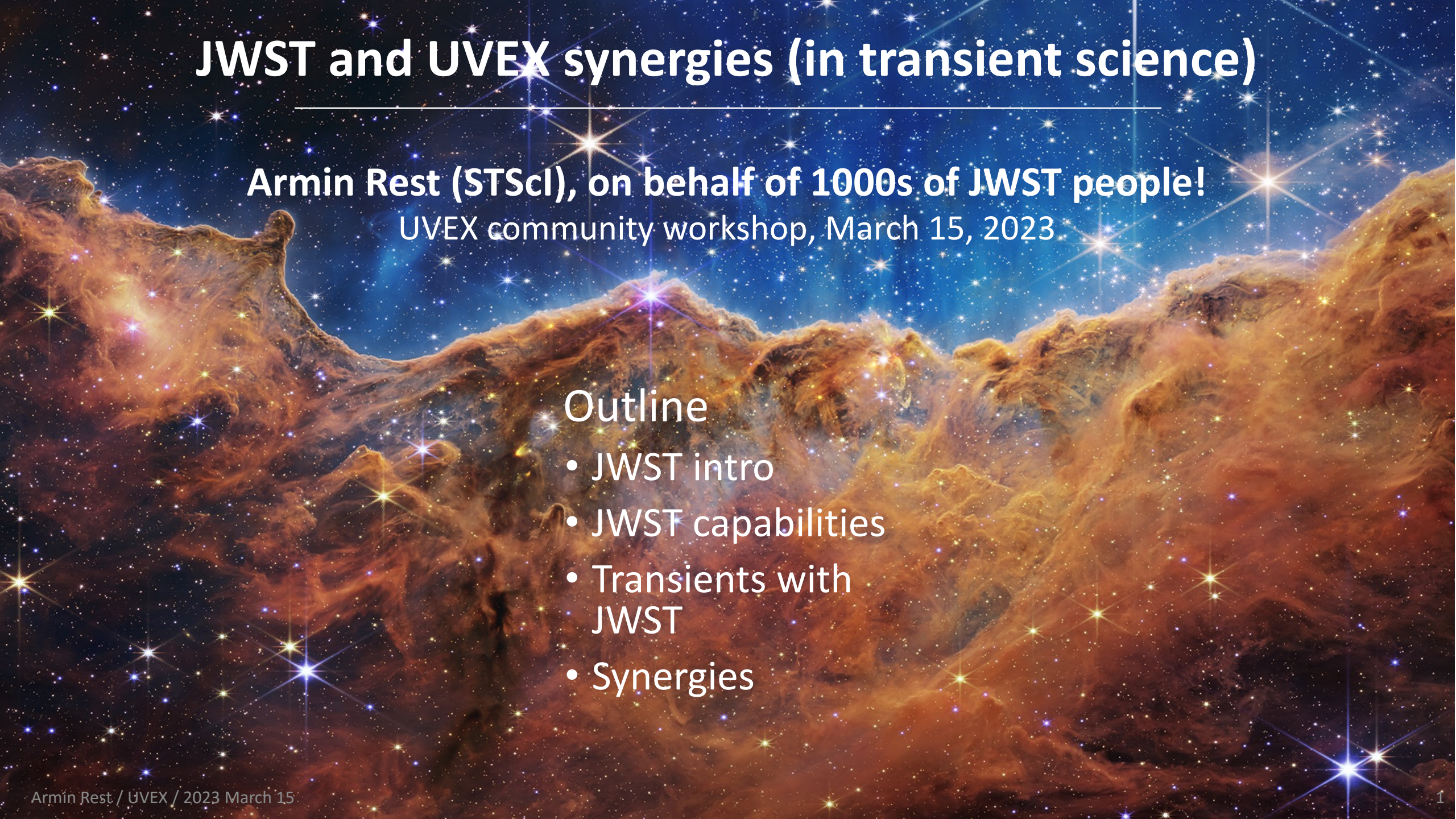
JWST and UVEX synergies (in transient science)

Armin Rest (STScI), on behalf of 1000s of JWST people!

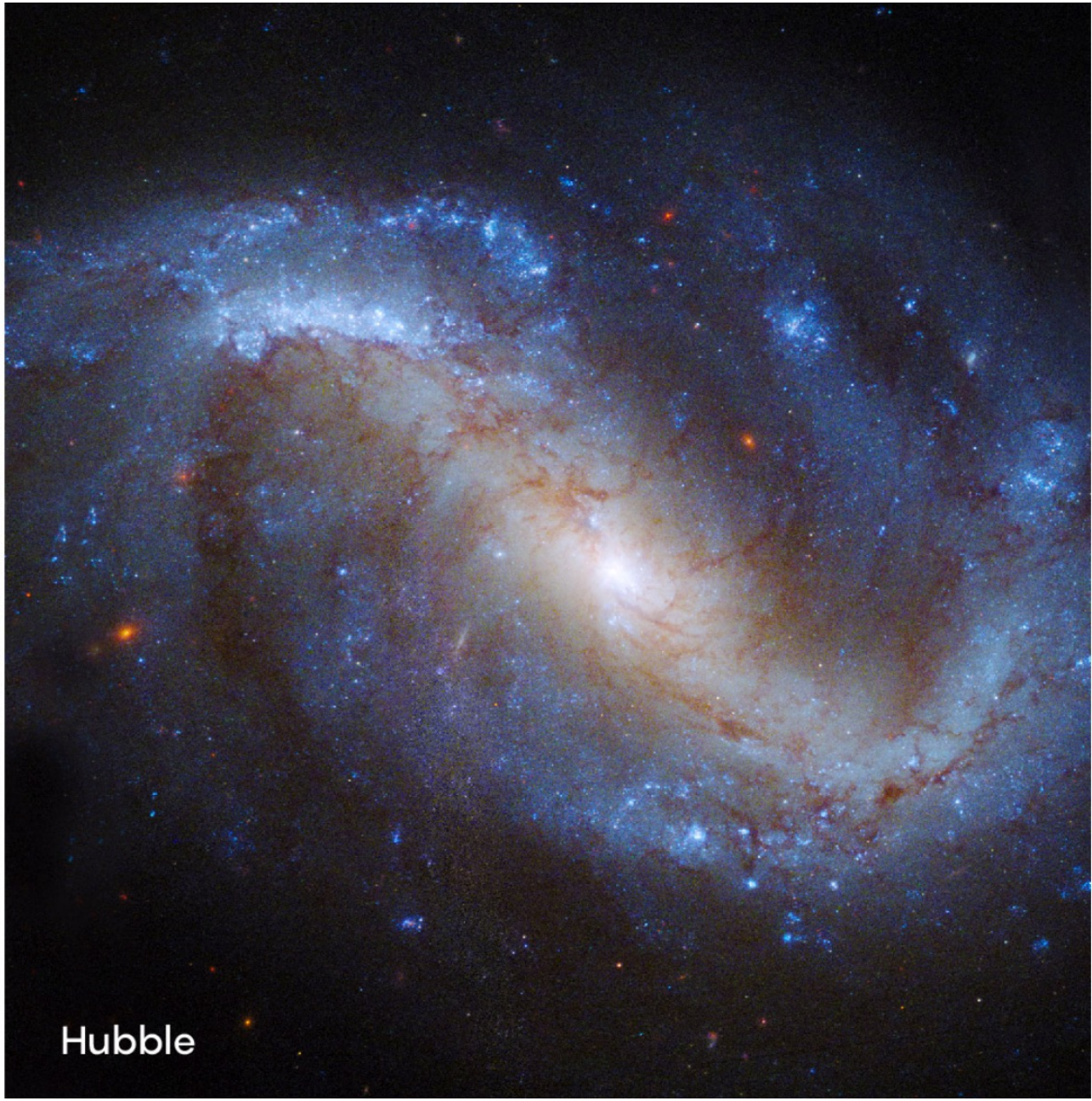
UVEX community workshop, March 15, 2023



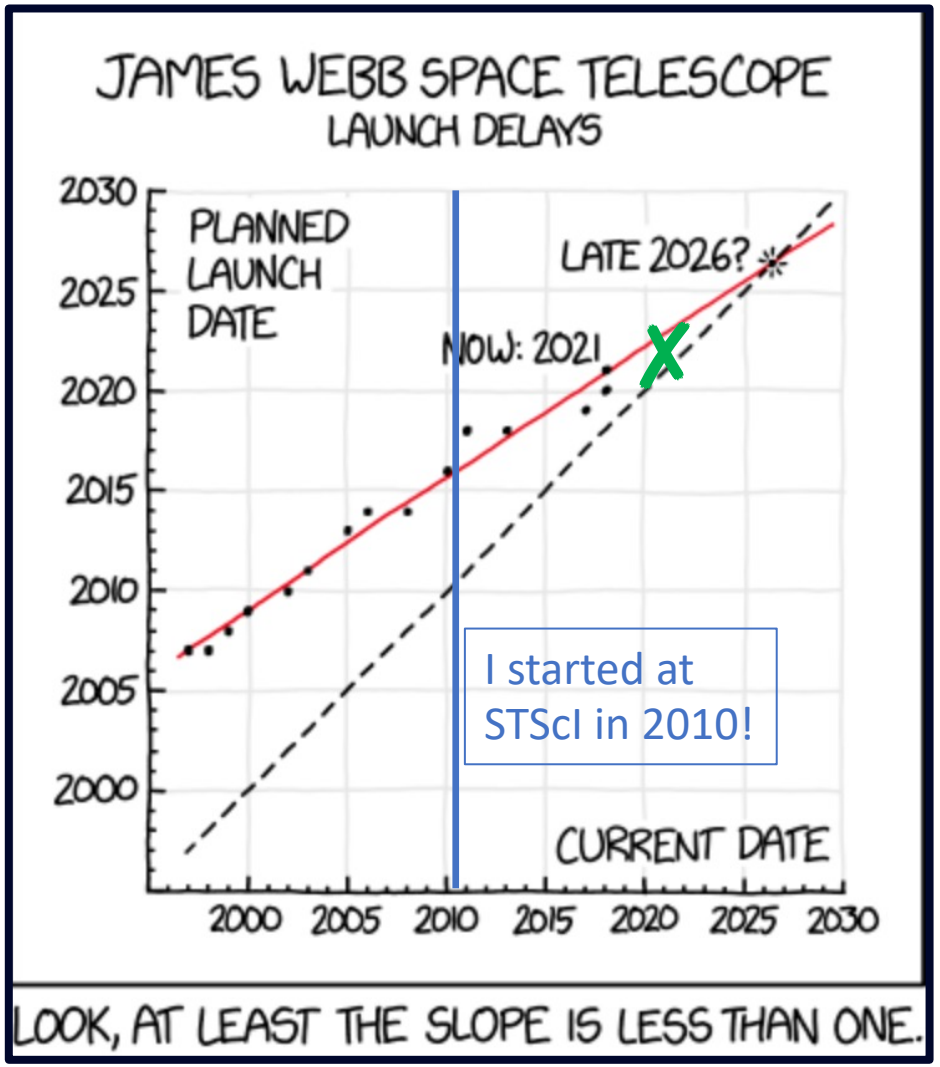
Outline

- JWST intro
- JWST capabilities
- Transients with JWST
- Synergies

JWST New Era: Depth, Resolution, and Wavelength range

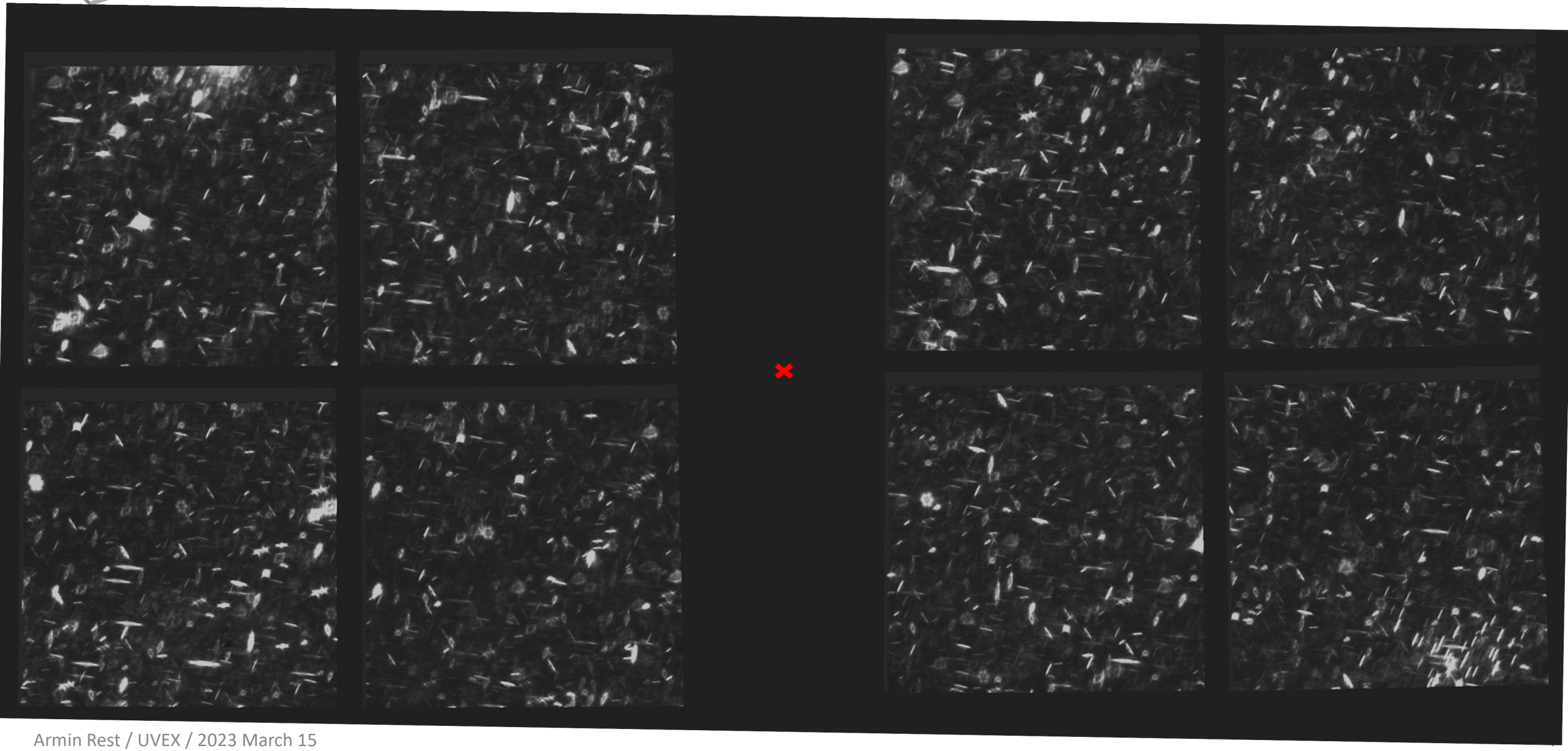


How did we get there?

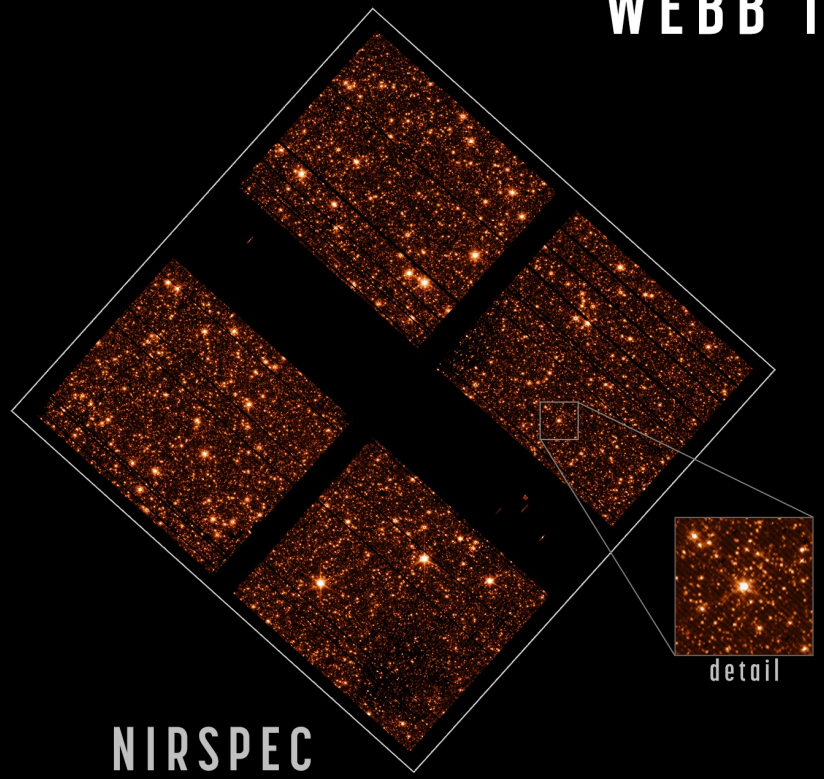


©randall munroe xkcd.com

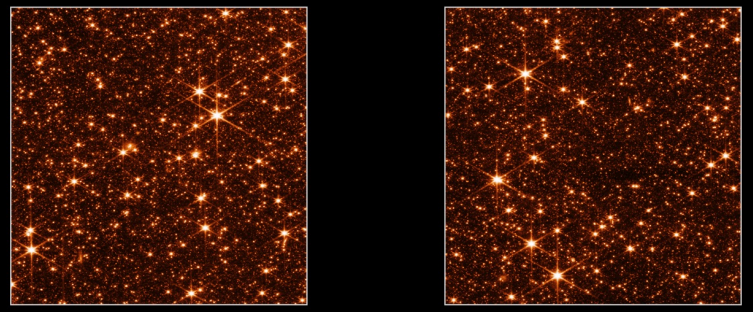
The First Light Image!!!

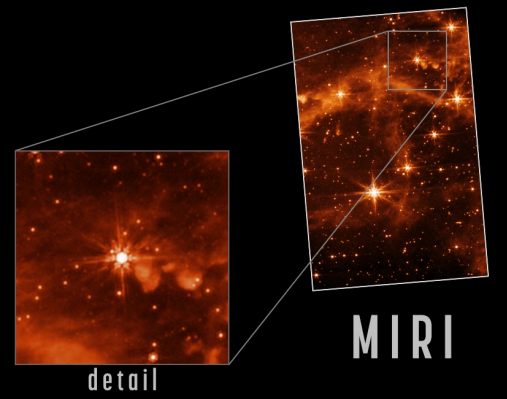


WEBB TELESCOPE IMAGE SHARPNESS CHECK

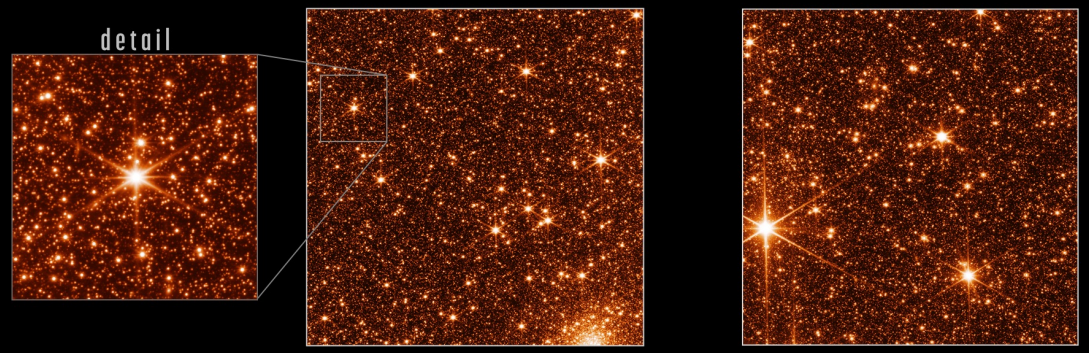


NIRCAM

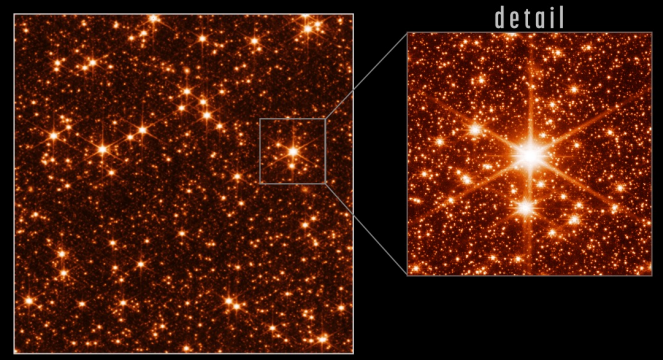




FINE GUIDANCE SENSOR

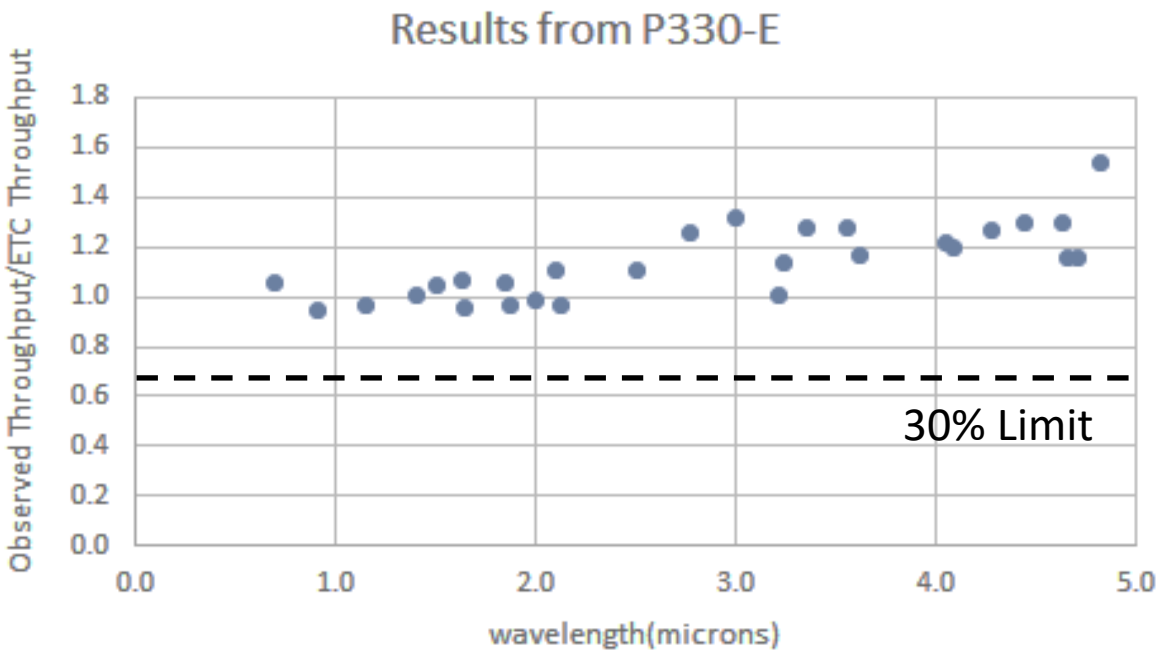


NIRISS

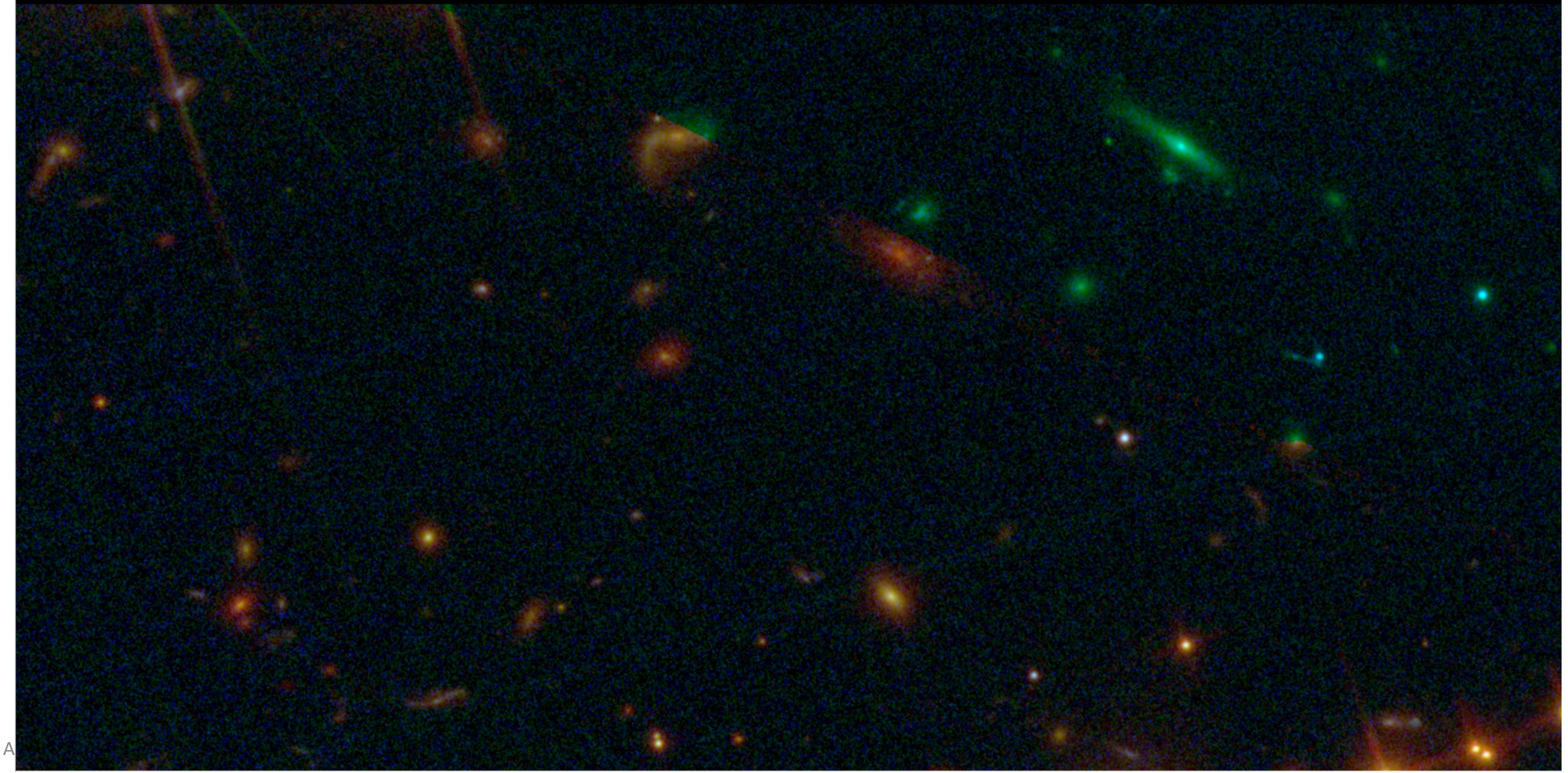


JWST instruments: NIRCam

- Short (0.6-2.3mm) and long (2.4-5mm) channels
  - Simultaneous!
- Nyquist sampling at 2 and 4 micron
- 2.2’ x 4.4’ total field of view
- Excellent throughput
- Excellent PSF
- Wisps, Claws, Snowballs, “Stripe pattern”: some warts!
- Depth ~28th AB mag for 1h exposures



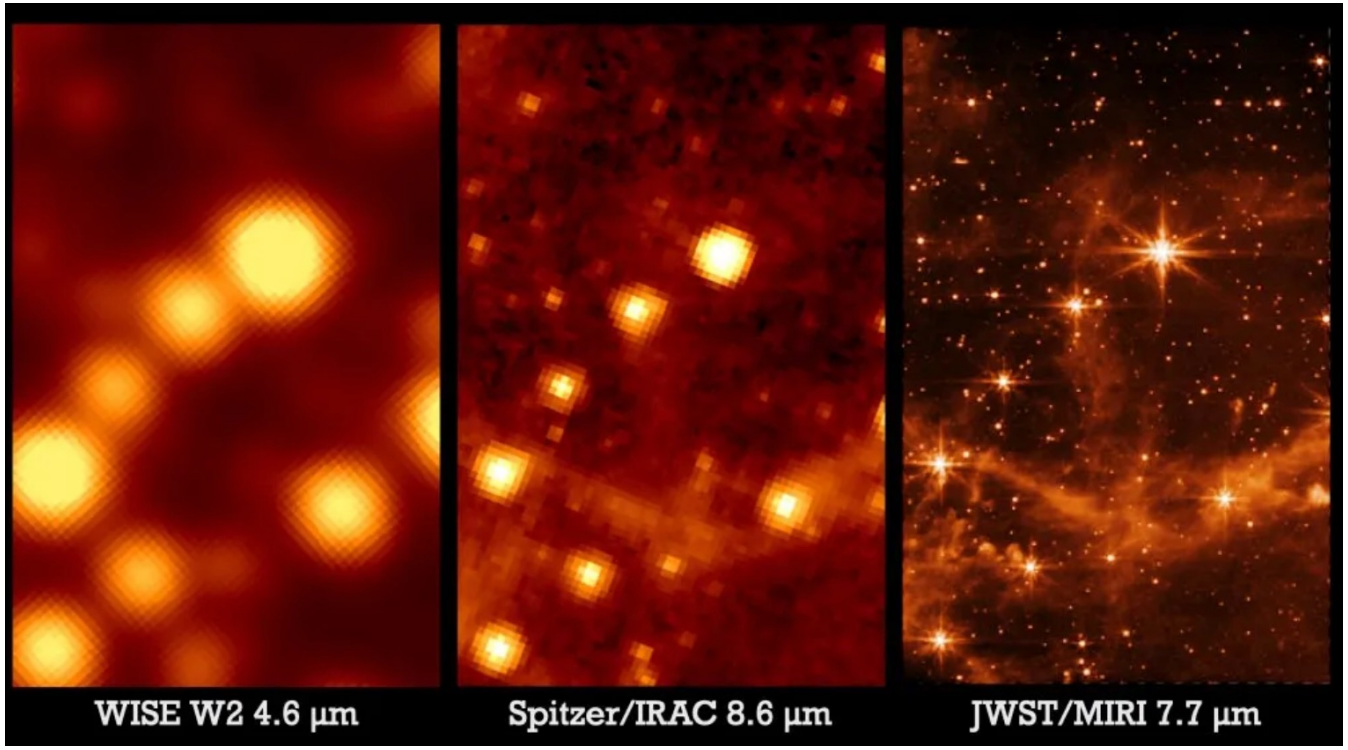
HST



JWST

JWST instruments: MIRI

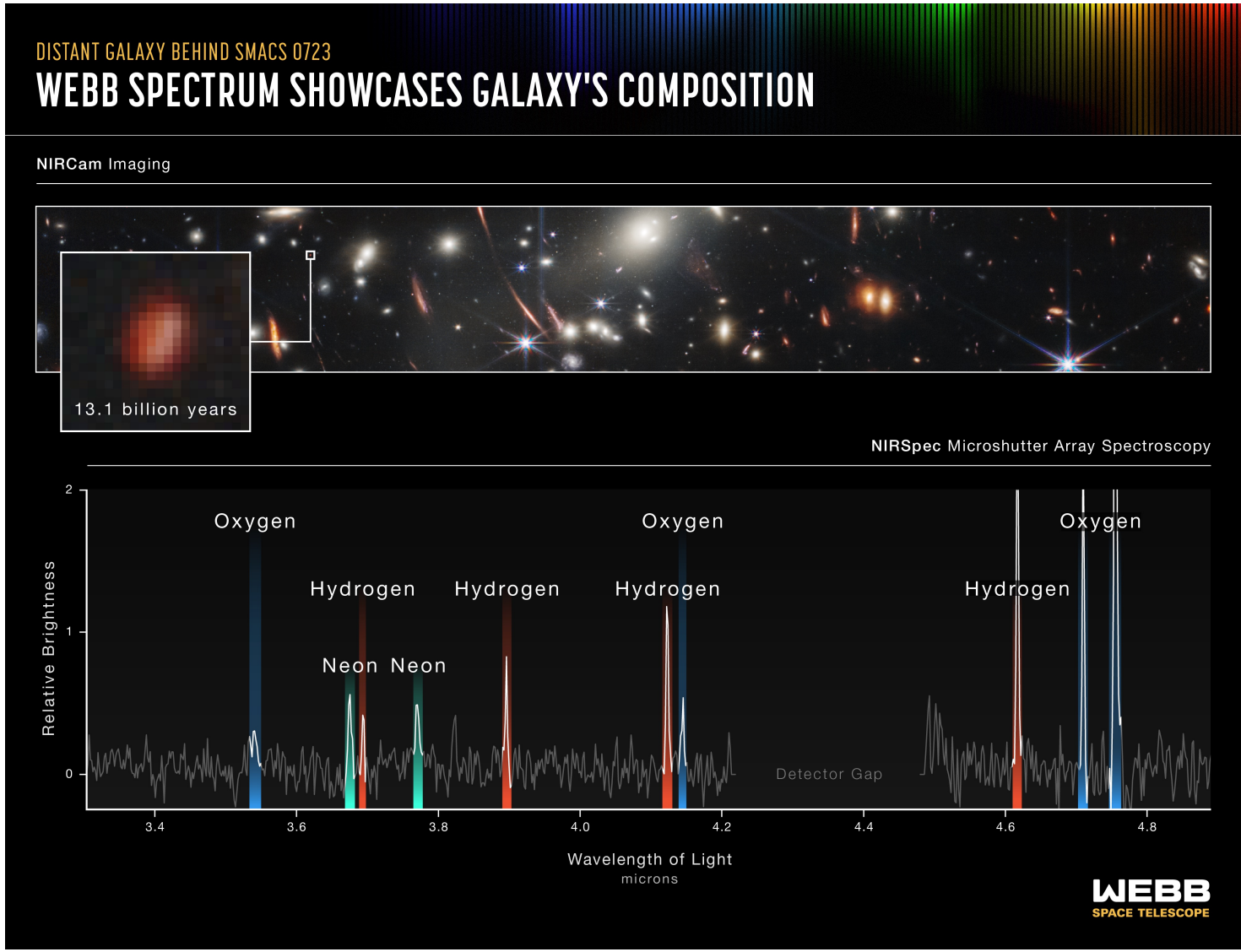
- Imaging:
  - 9 Filters covering 5 - 28um
- Low Resolution Slit Spectroscopy
  - 5 – 12um
- Sensitivity excellent
- PSF excellent
- ~26 mag in 1h at 7 microns
- ~22 mag in 1h at 20 microns



Credit: Andras Gaspar

JWST instruments: NIRSpec

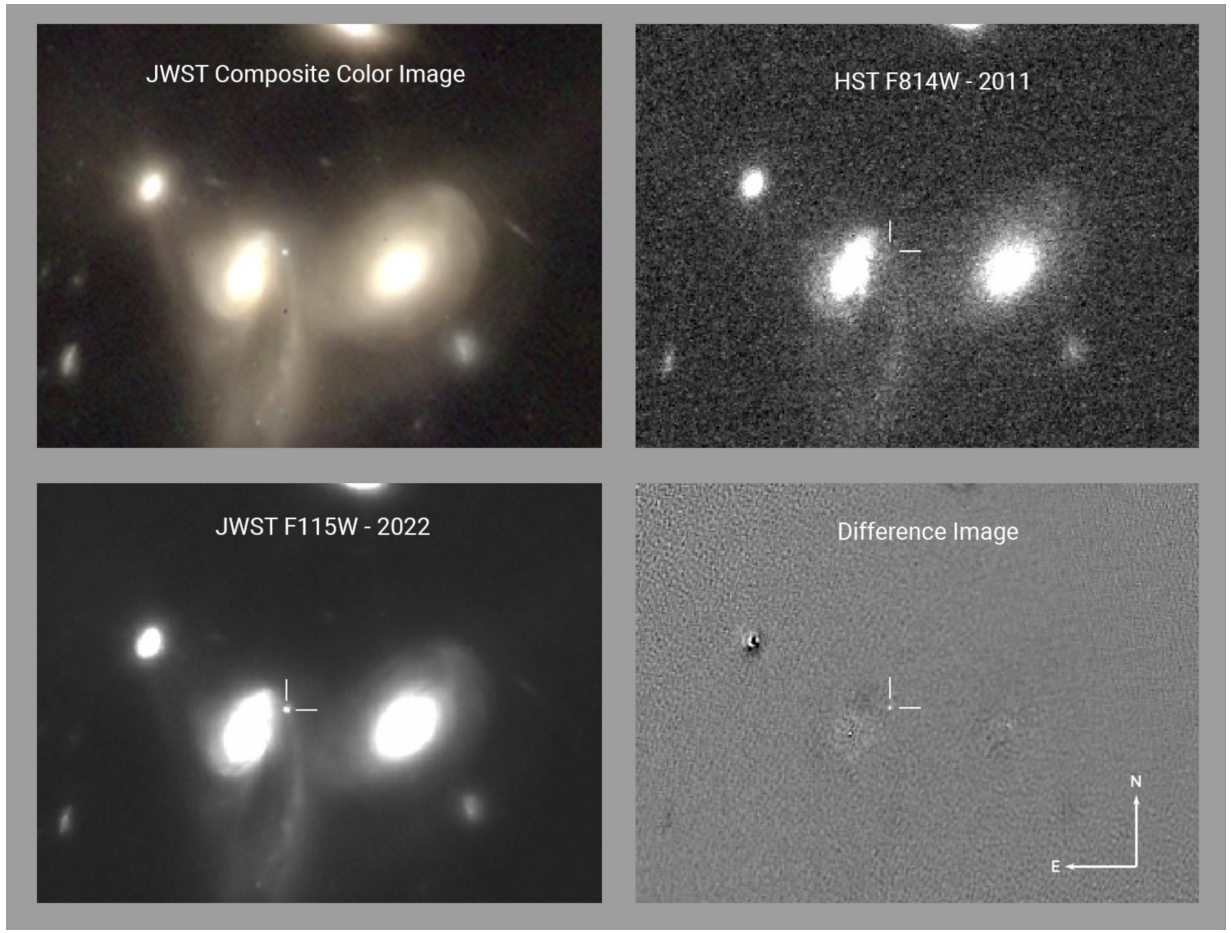
- Modes
  - Fixed slits (FS)
  - Multi-Object Spectroscopy (MOS)
  - Integral Field Spectroscopy (IFS)
- Wavelength range
  - 0.6 – 5.3 microns
- Resolutions
  - ~100, 1000, 2700
- R=100 possible down to 27-28 AB mag in a few hours!



Transients with JWST: We are just getting started!

- **Serendipitous discoveries (e.g., AT 2022owj, Engesser+22)**
- Photometric follow-up of old SNe (e.g., SN 2004et and SN 2017eaw, Shahbandeh+23): dust reservoirs
- Spectroscopic follow-up of SNe (e.g., SN 2021aefx, Kwok+23)
- High-z SNe (e.g., DeCoursey+23, JADES survey)

AT 2022owj, Engesser+22



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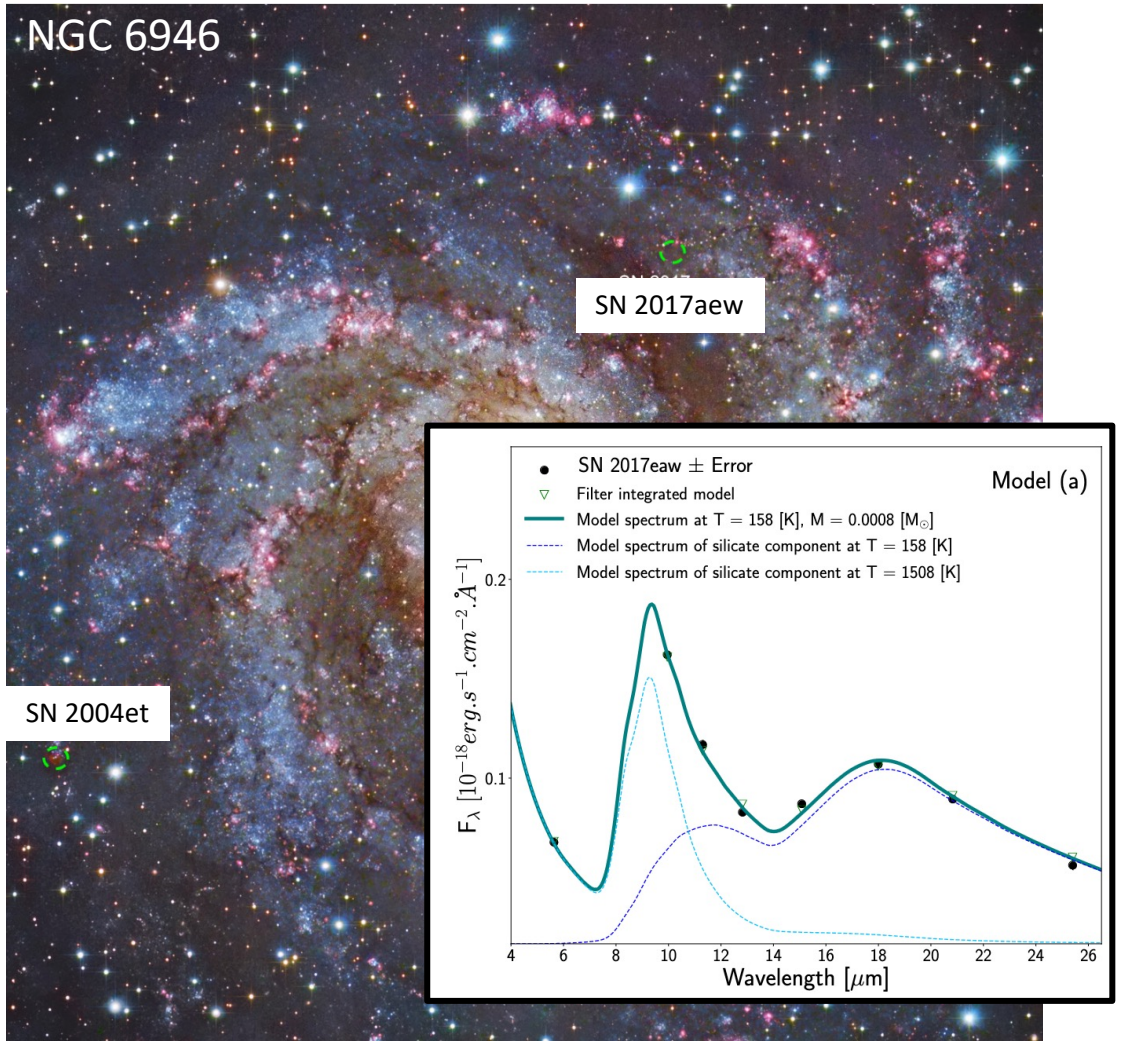
Shahbandeh+23



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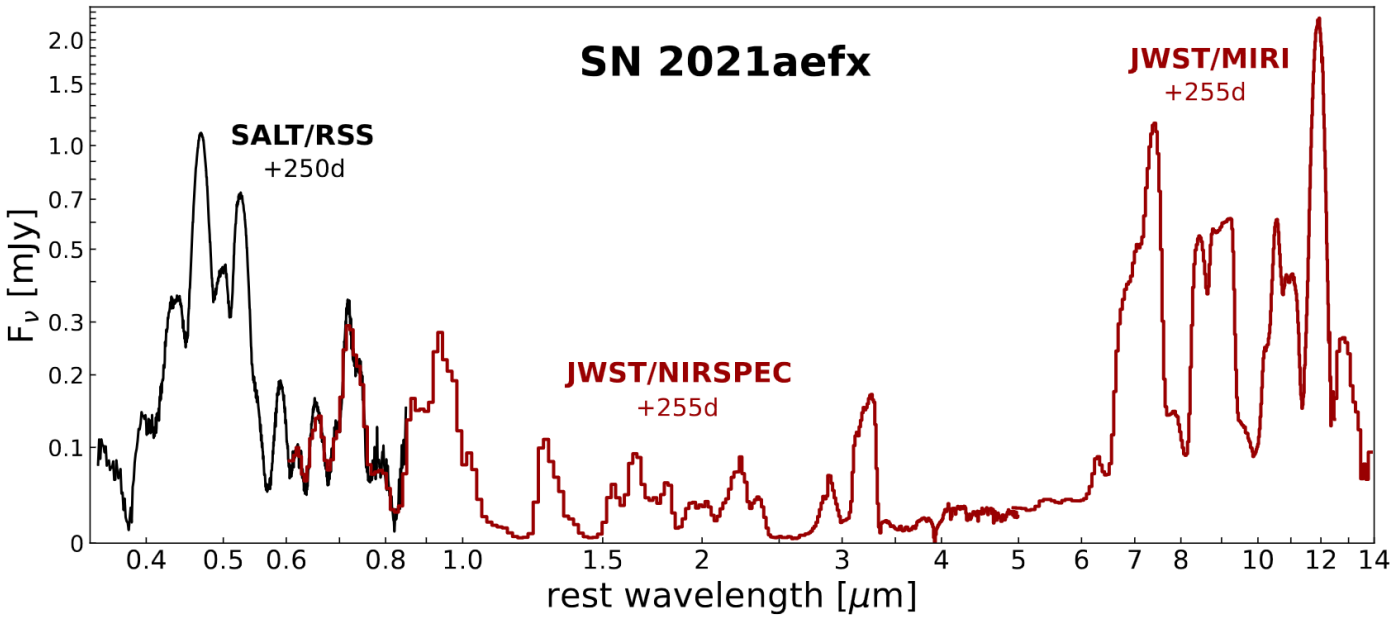
Kowk+23



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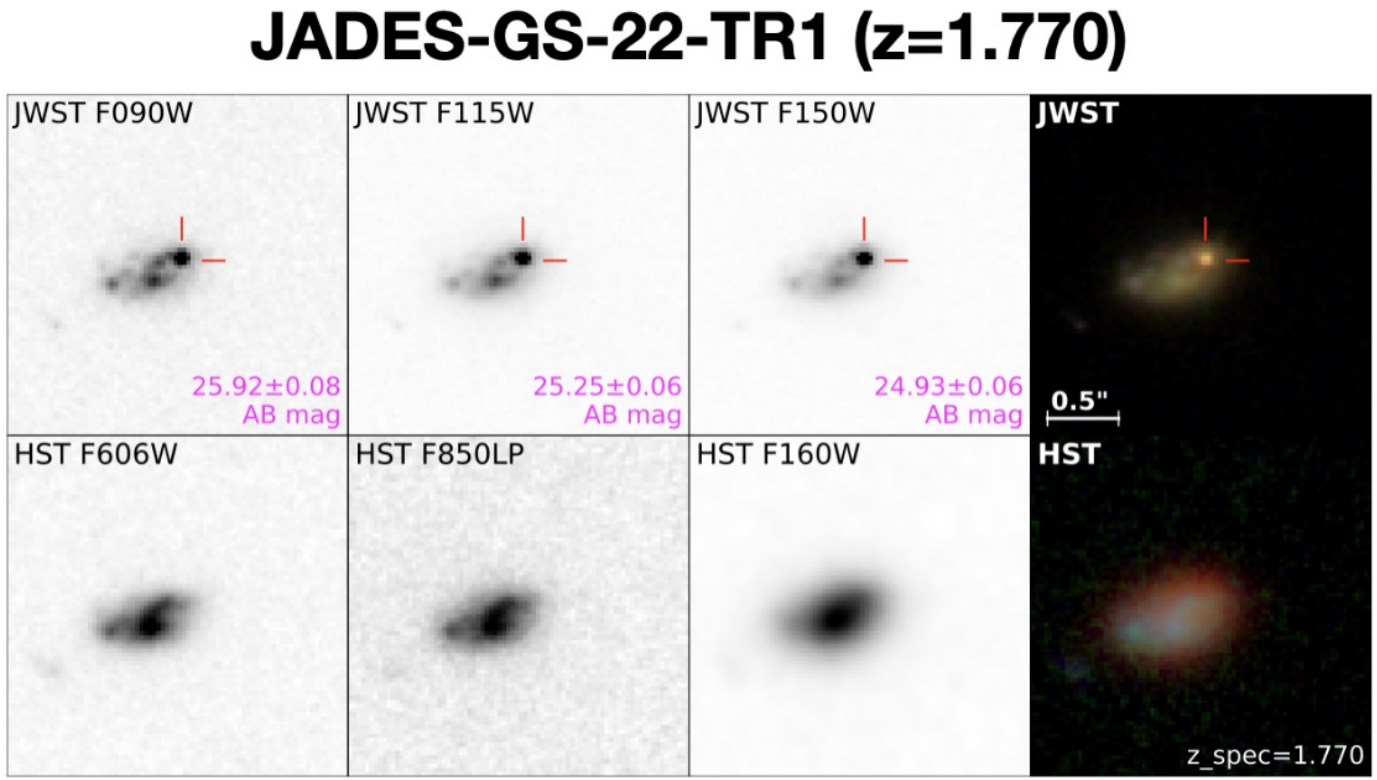


DeCoursey+23

Comparison UVEX and JWST

	UVEX	JWST
Imaging FOV	12 square degree	10 square arcmin
Imaging survey area	full sky	<1 square degree
Image Quality	2.5 arcsec	0.06-0.3 arcsec
Imaging Bandpass	1400-2700 Å	0.6-25 microns
Single Epoch Depth	24 AB mag	28 AB mag in NIR
Spectrograp Resolution	1000	100-3000
Average ToO Response	<3h	>2 days+
# of ToOs	many	very few
flexibility	nimble	"not so nimble"

HST

- Ultra-rapid ToO:
  - 1-2 days
  - 1 per cycle
- Disruptive ToO:
  - 2-5 days
  - 8 per cycle
- Non-disruptive ToO:
  - 2-3 weeks

JWST

- Disruptive ToO
  - 2-14 days
  - 8 per cycle
- Non-disruptive ToO:
  - 14+ days

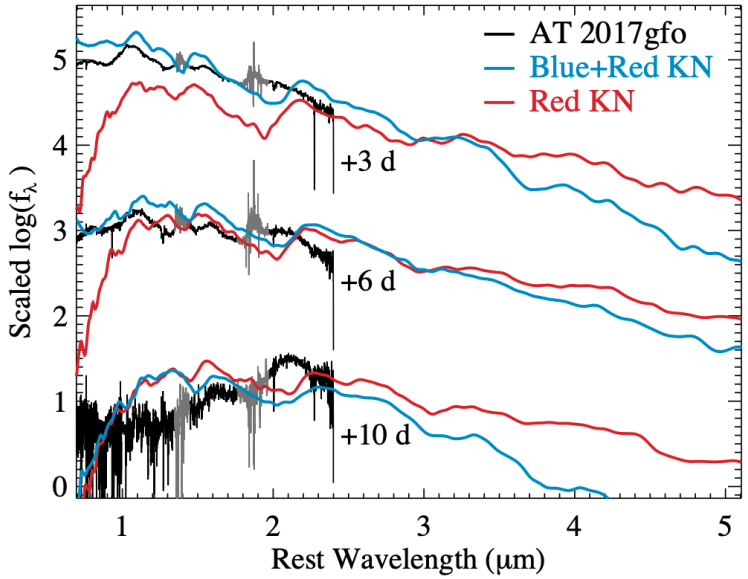
UVEX and JWST synergy (transients)

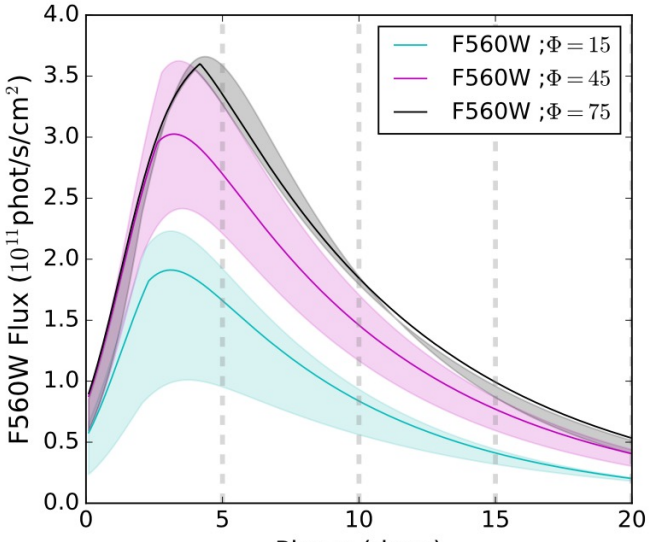
- UVEX: Discovery (and follow-up) of UV bright transients
  - UV emission is early and often fast-lived!
  - Depends on ejecta velocity, geometry, composition, nuclear physics…
  - Kilonova, Sne, TDEs
- JWST follow-up
  - Complete SED from UV to MIR after a few days of explosion
  - Nebular phase photometry and spectroscopy
  - Very late time observations (years!): dust production

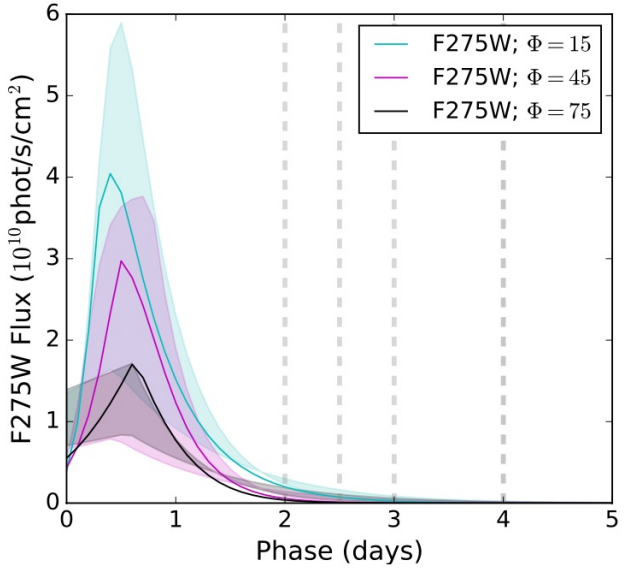
Chris Fryer, 1st day:
“They both depend on everything, just in different ways!”

Case I: Kilonova: Early Time JWST observations (JWST-GO-02061, PI R. Foley, JWST cycle 2 proposal, PI A. Rest)

- Kilonova can have multiple ejecta components (jet/sGRB, wind, disk, tidal tails, disk winds, …)
- Each component is expected to have different masses, velocities, and Y_e
- Need UV to IR to break degeneracies

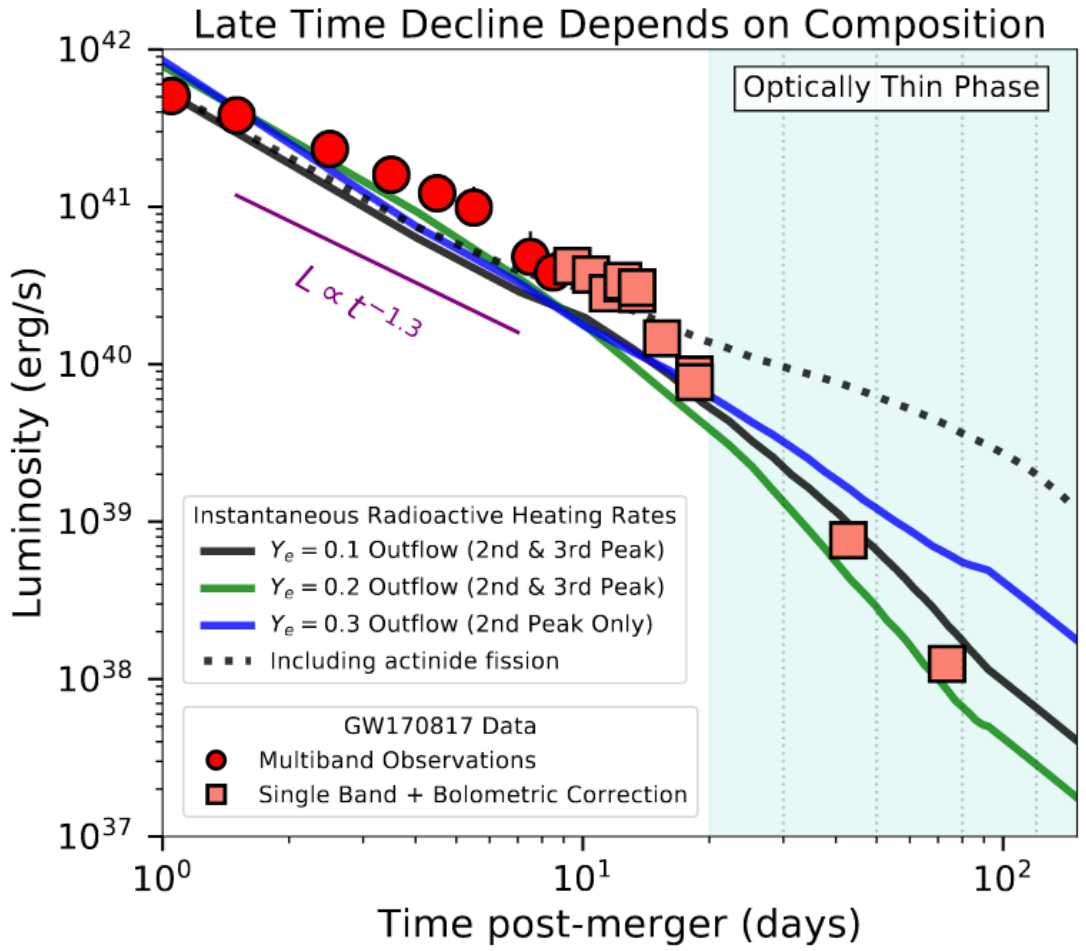






Case I: Kilonova: Late Time JWST photometry (JWST-GO-02091, PI M. Drout)

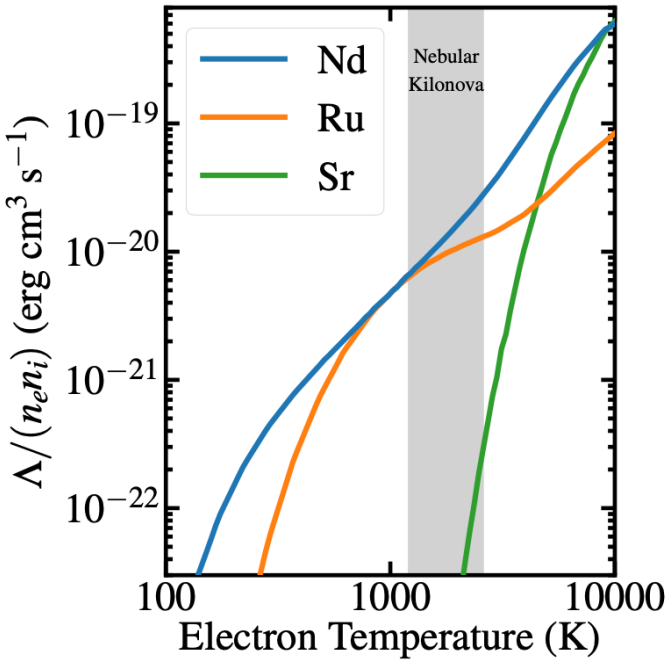
- Early phase bolometric photometry nearly independent of composition
- Nebular phase photometry depends on composition!
- Non-thermal emission (afterglow) might be observed very late



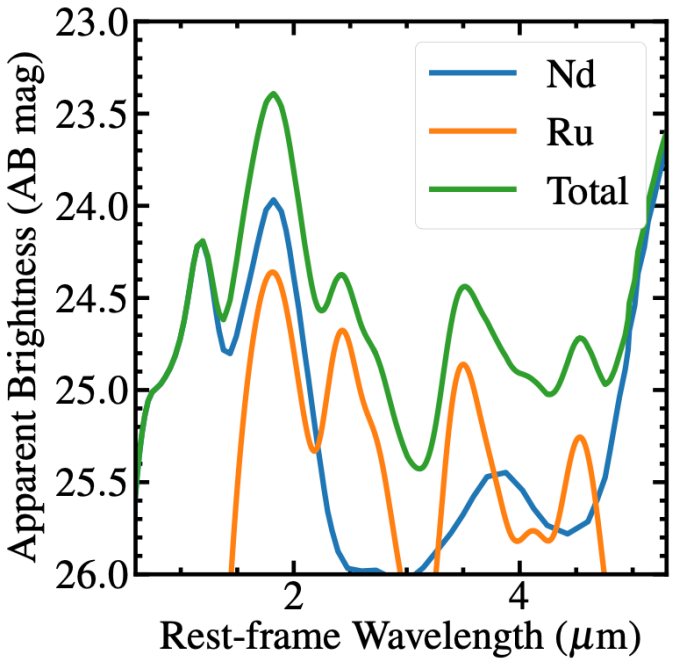
Case I: Kilonova: Late Time JWST spectroscopy (JWST-GO-01936, PI C. Kilpatrick)

- Radiative cooling rates of Neodymium (Nd), Ruthenium (Ru), and Strontium (Sr) (s- and r-process)
- Nd and Ru: most efficient cooling rates

Radiative cooling rates



Synthetic spectrum at T_e=1500K



Case II: TDEs: missing energy problem? (JWST cycle 2 proposal, PI: S. van Velzen)

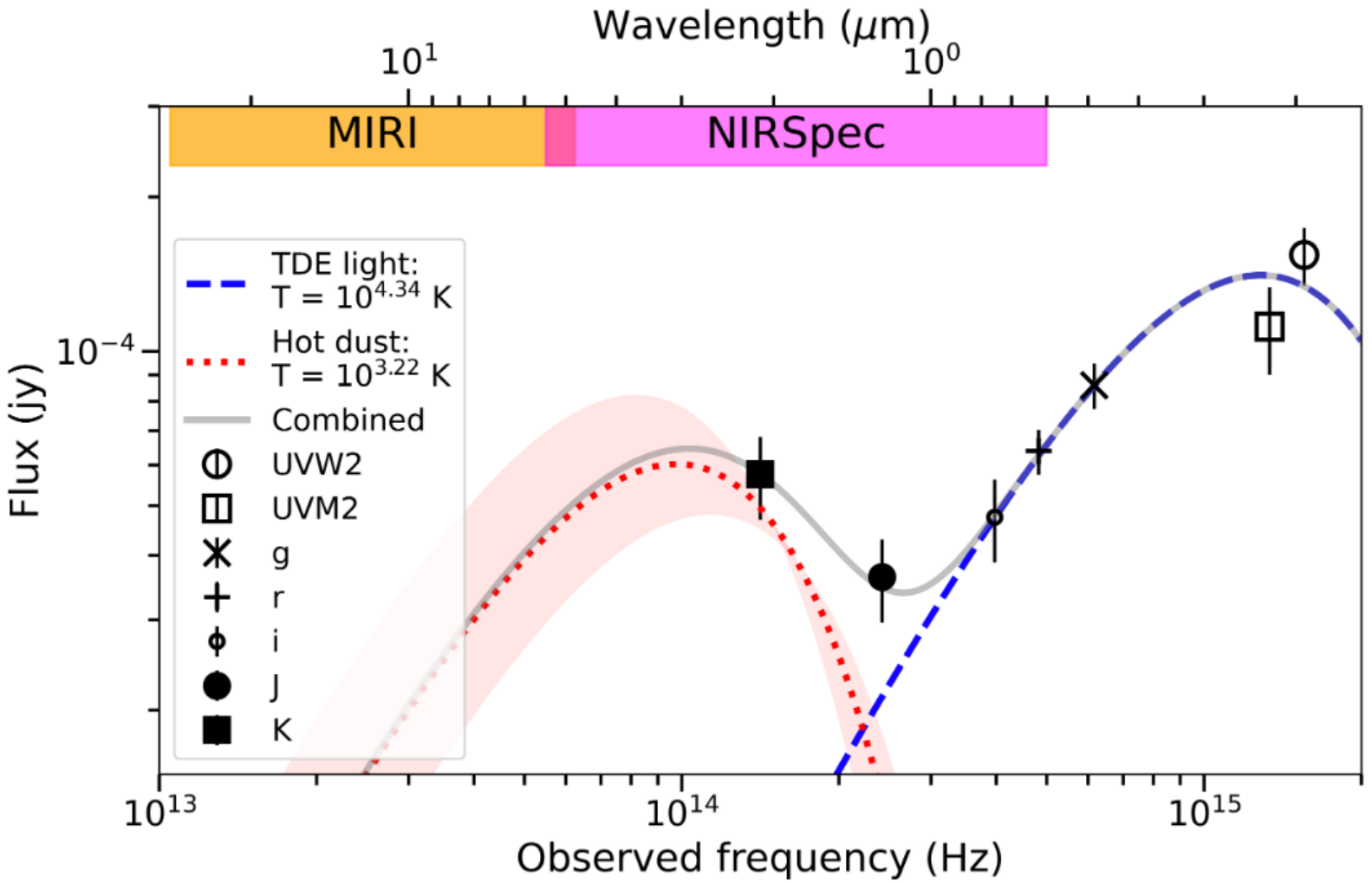


Figure 1: SED of the recent TDE AT2021sdu, including ground-based near-IR detections from our team. The near-IR transient flux exceeds the single blackbody fit that describes the blue TDE emission. Dust reverberation of the TDE can explain our IR data, but the temperature of the dust remains poorly constrained (red shaded region).

Conclusions

- JWST: new era in depth, wavelength range, and resolution!
- Telescope performs above expectations
  - Sensitivity up to 20% better than ground estimates
  - Excellent PSF
  - Some warts: glints, claws, snowballs, persistence, stripes
  - Calibration is still in progress! Please be patient!
- First transient science!
  - Follow-up of known SN (nebular phase, dust reservoirs)
  - Discoveries, in particular high-z
- Synergy with UVEX
  - Folow-up of UV-bright transients
  - Full SED
  - “They both [UVEX, JWST] depend on everything, just in different ways!”: Breaking degeneracies!