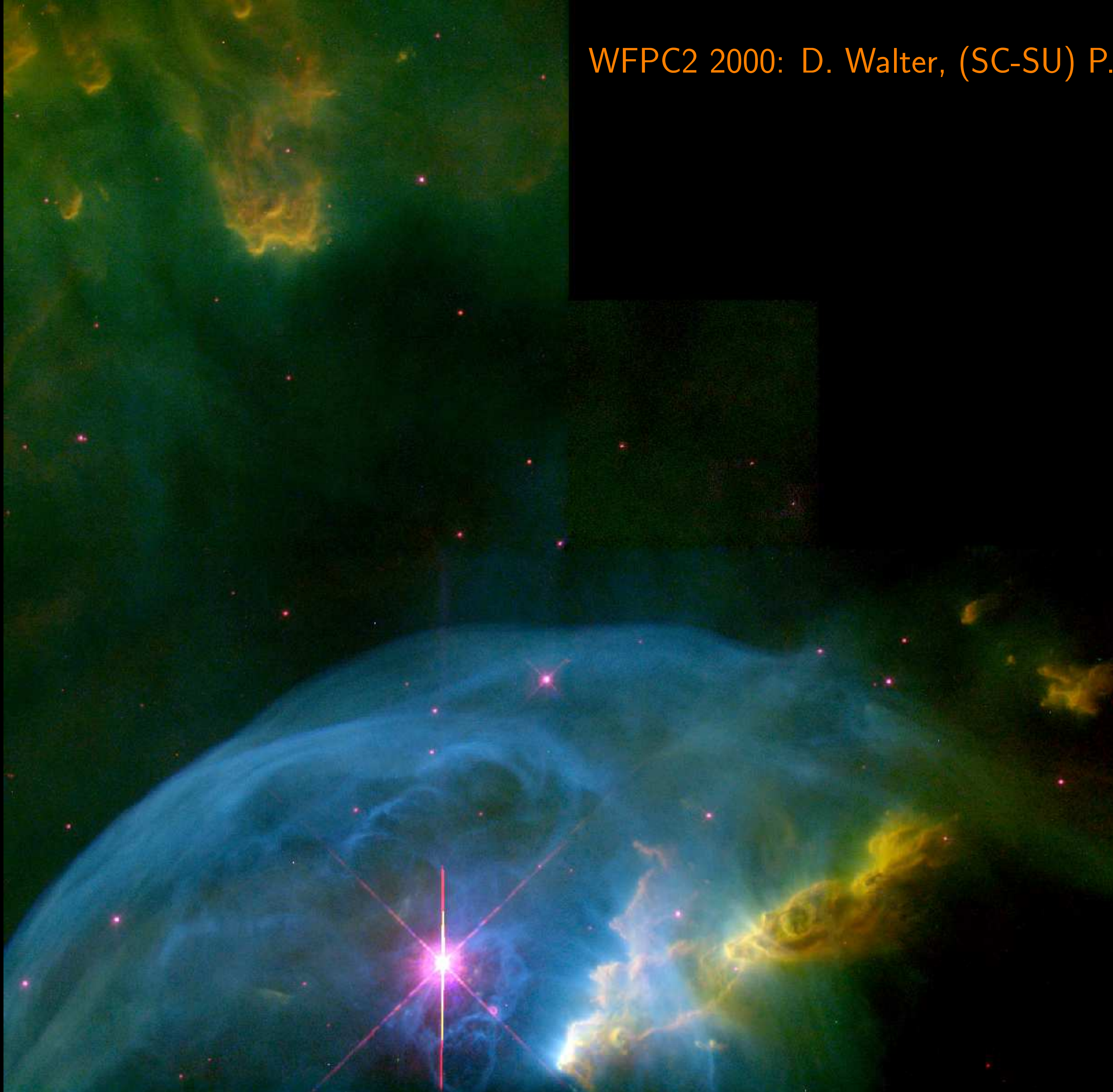
Thank you, Jeff Hoffman, for fixing Hubble for us so well in Dec. 1993!!

Hubble WFC3 & ACS reaching 26.5 mag ($\sim$100 fireflies from Moon) over 0.1$\times$full Moon area in 10 filters from 0.2–2μm (Windhorst's ASU group).

The Webb telescope has 3$\times$sharper imaging to 31.5 mag ($\sim$1 firefly from Moon) at 1–5μm wavelengths, tracing star-formation across cosmic time.

Eagle Nebula: hot stars (not shown) triggering star-birth in “Pillars of Creation”

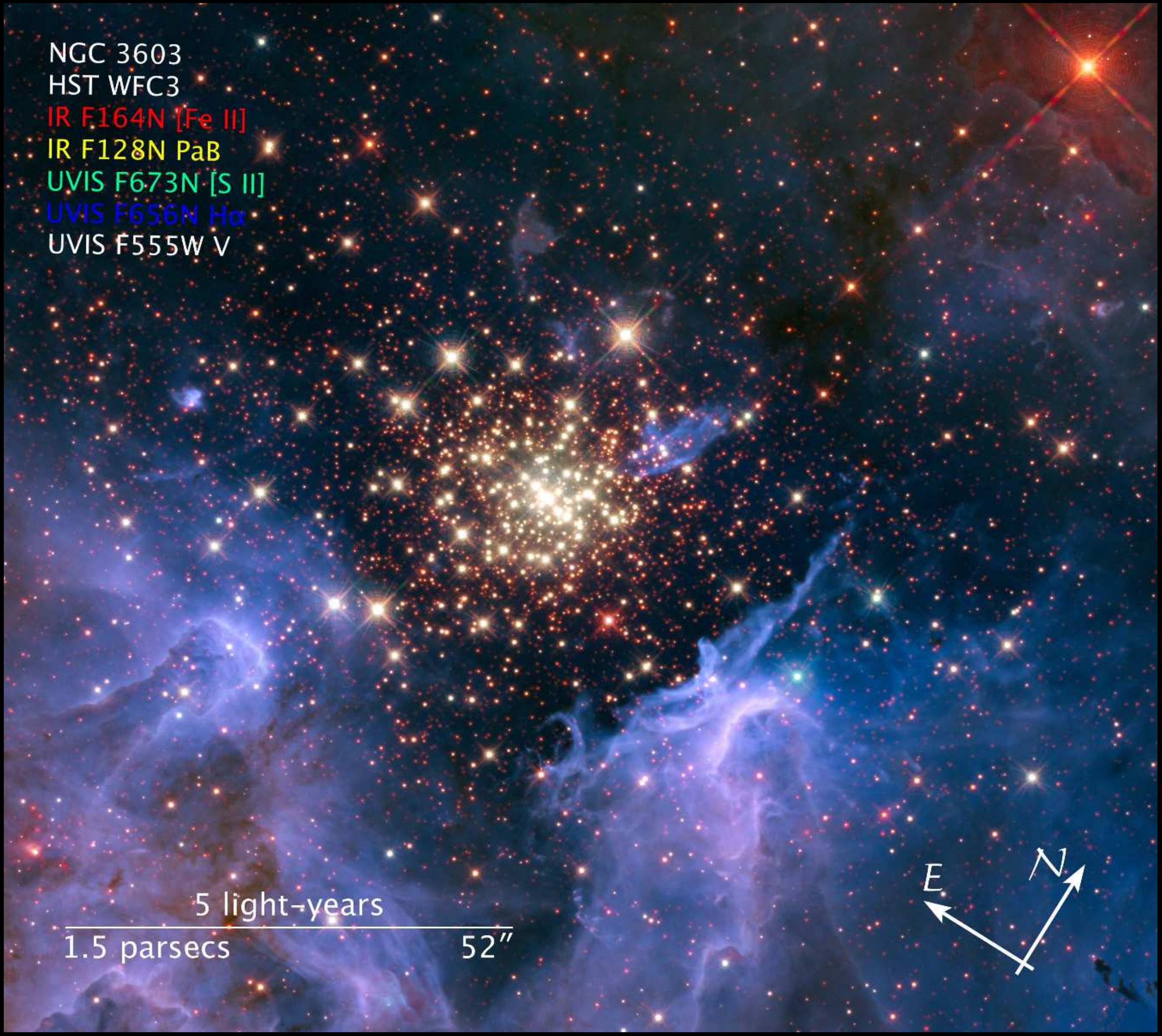
Eagle Nebula: hot stars (not shown) triggering star-birth in “Pillars of Creation”



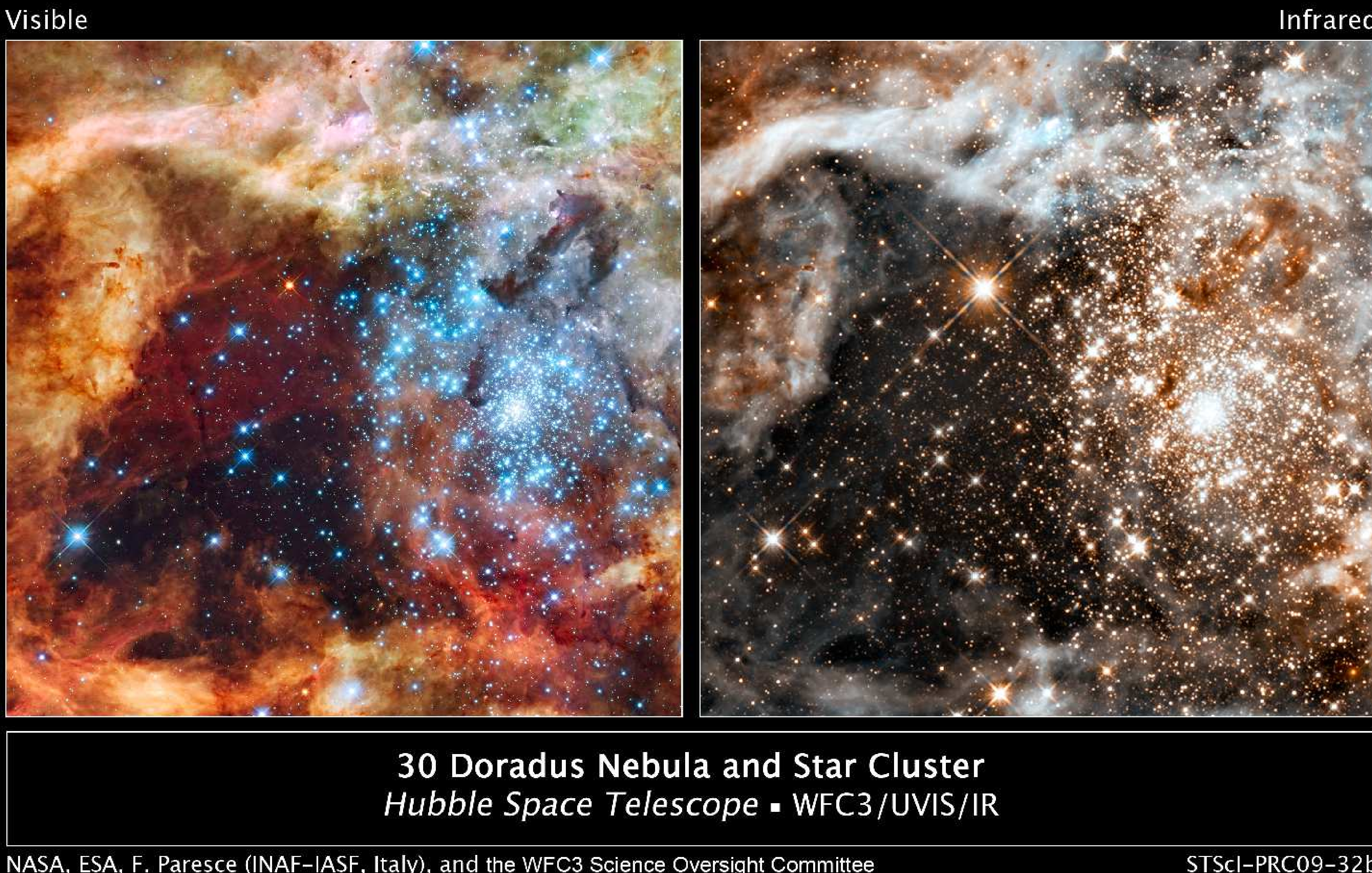
WFPC2 2000: D. Walter, (SC-SU) P. Scowen & B. Moore, (ASU).

Bubble Nebula NGC 7635 in Cassiopeia: A massive star blowing a giant bubble of material into space, shaping surrounding, much denser material.

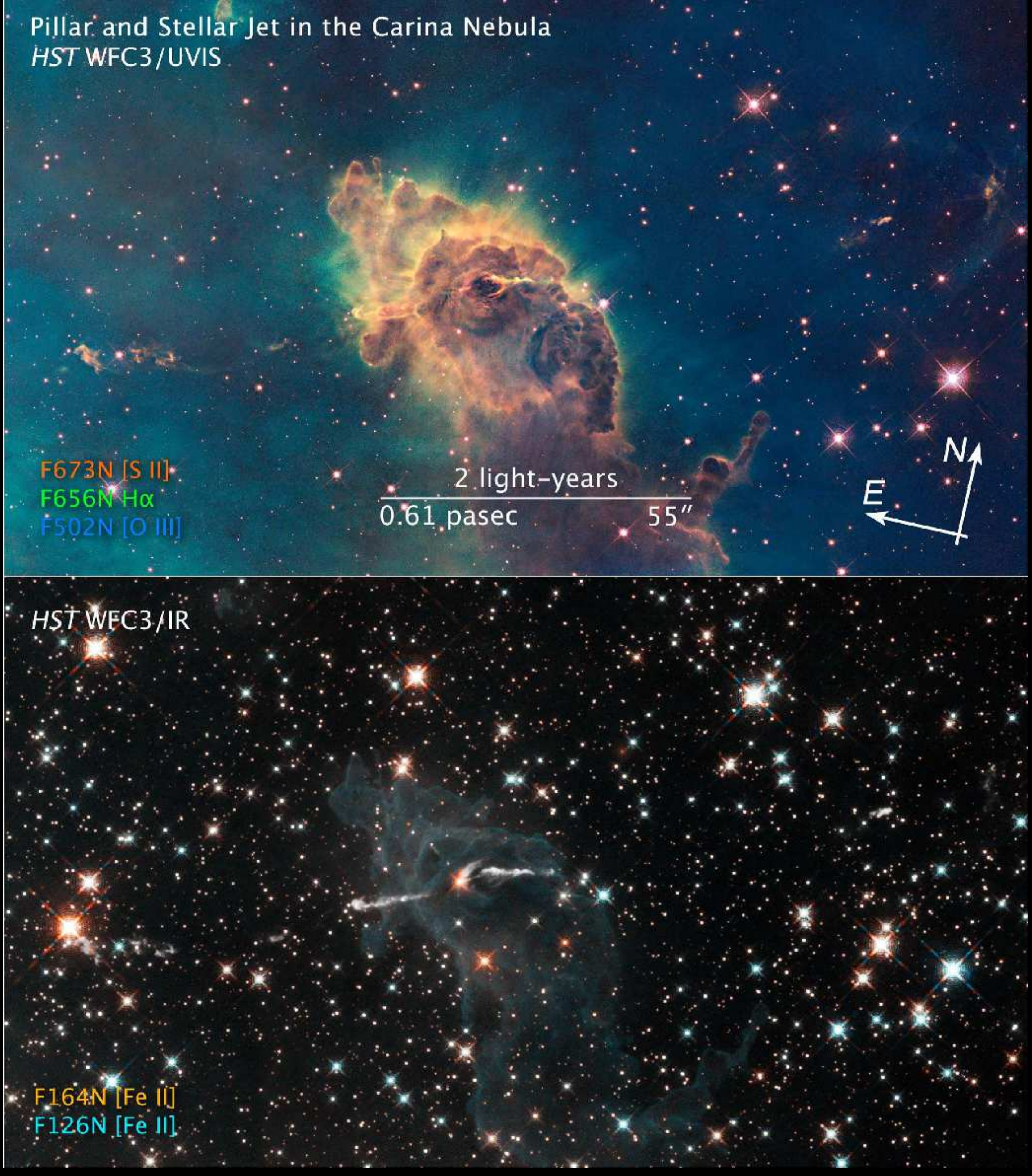
Measuring Star-birth with Hubble WFC3

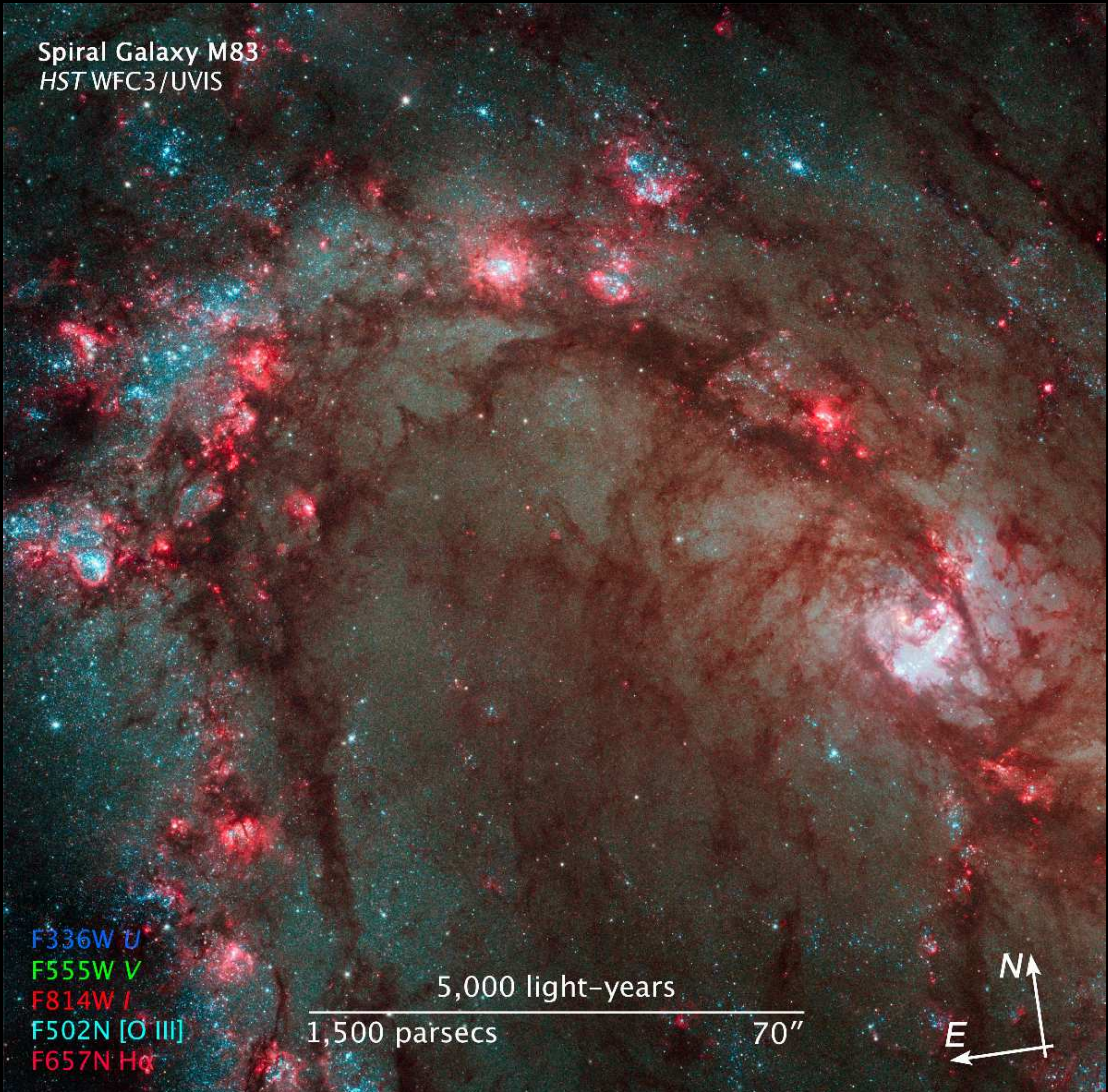


NGC 3603: Young star-cluster triggering star-birth in "Pillars of Creation"

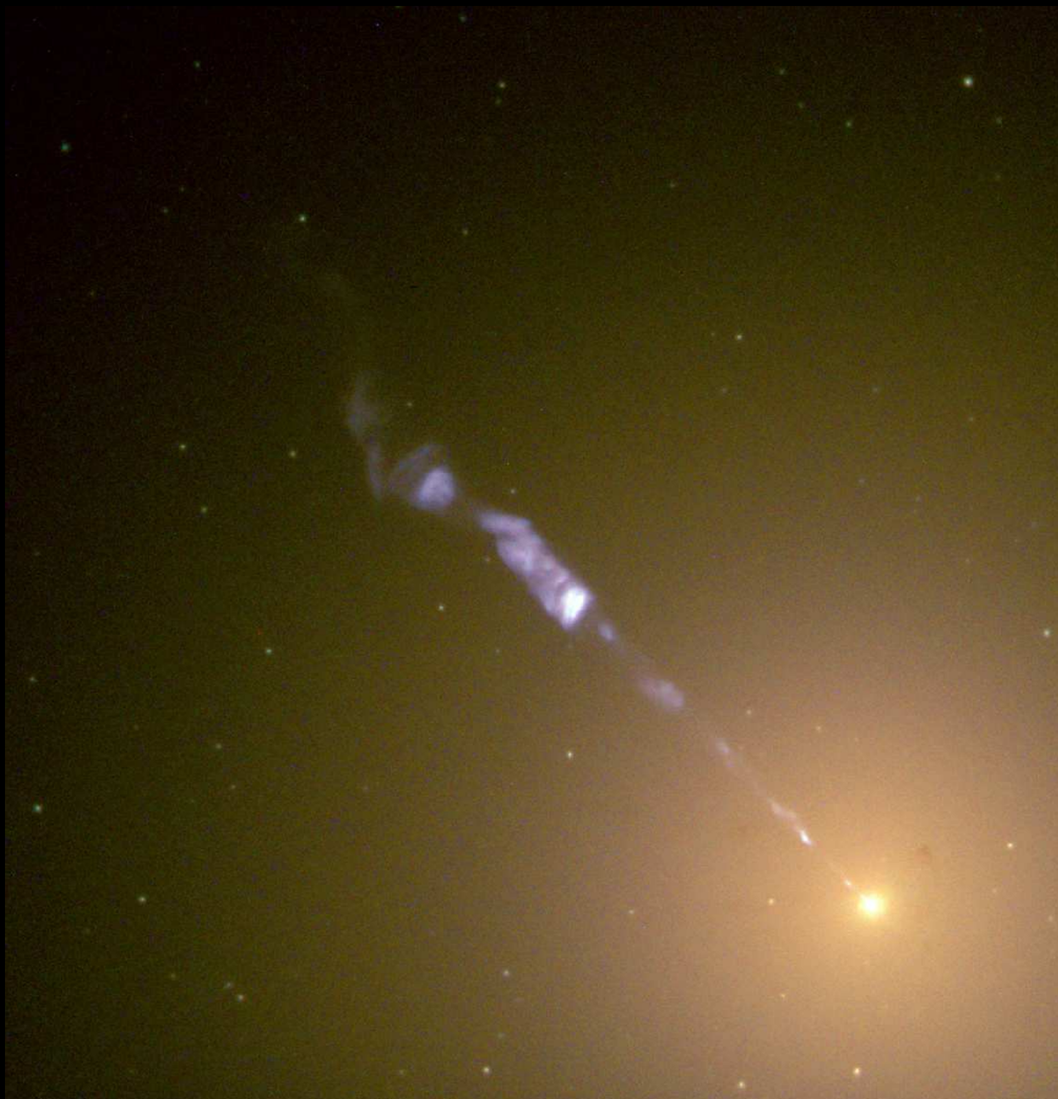


30 Doradus: Giant young star-cluster in Large Magellanic Cloud (150,000 ly away), triggering birth of Sun-like stars (and surrounding debris disks).


Pillar and Stellar Jet in the Carina Nebula
HST WFC3/UVIS
F673N [S II]
F656N Hα
F502N [O III]
2 light-years
0.61 pasec
55″
N
E
HST WFC3/IR
F164N [Fe II]
F126N [Fe II]


Spiral Galaxy M83
HST WFC3/UVIS
F336W U
F555W V
F814W I
F502N [O III]
F657N Hα
5,000 light-years
1,500 parsecs
70″
N
E

Elliptical galaxy M87 with Active Galactic Nucleus (AGN) and relativistic jet:

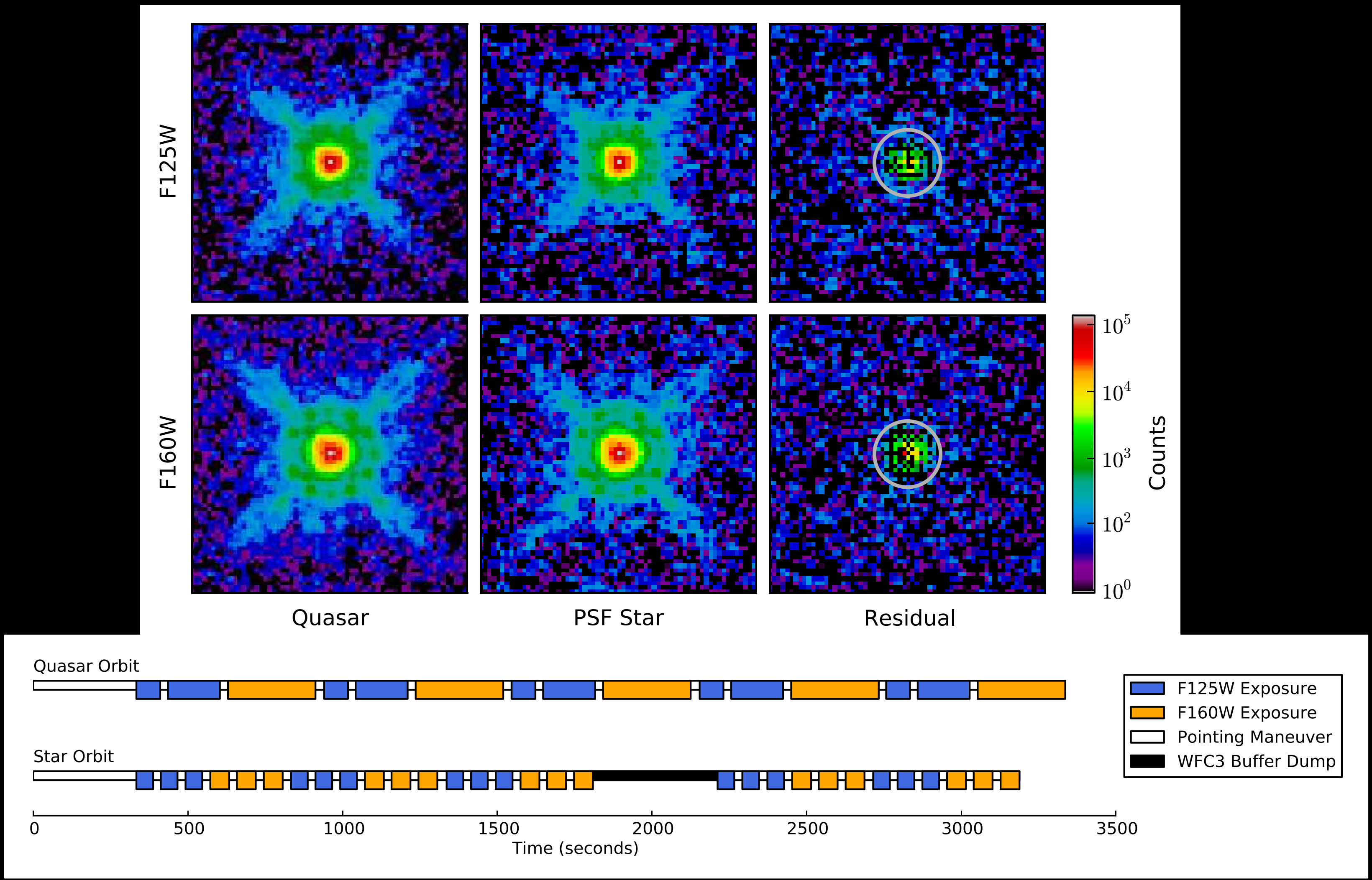


"For God's sake, Edwards. Put the laser pointer away."

The danger of having Quasar-like devices too close to home ...


Centaurus A
NGC 5128
HST WFC3/UVIS
F225W+F336W+F438W
F487N Hβ
F502N [O III]
F547M y
F657N Hα+[N II]
F673N [S II]
F814W *I*
3000 light-years
1400 parsecs
56″
E
N

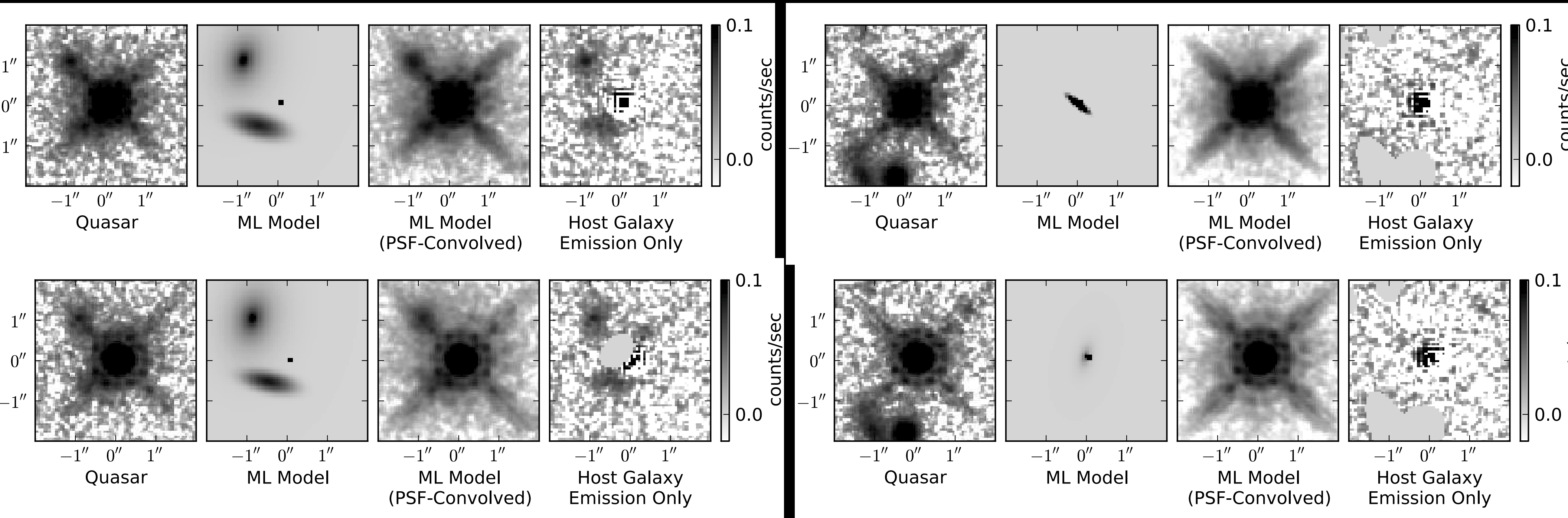
(3) HST WFC3 observations of QSO host galaxies at z≃6 (age≲1 Gyr)



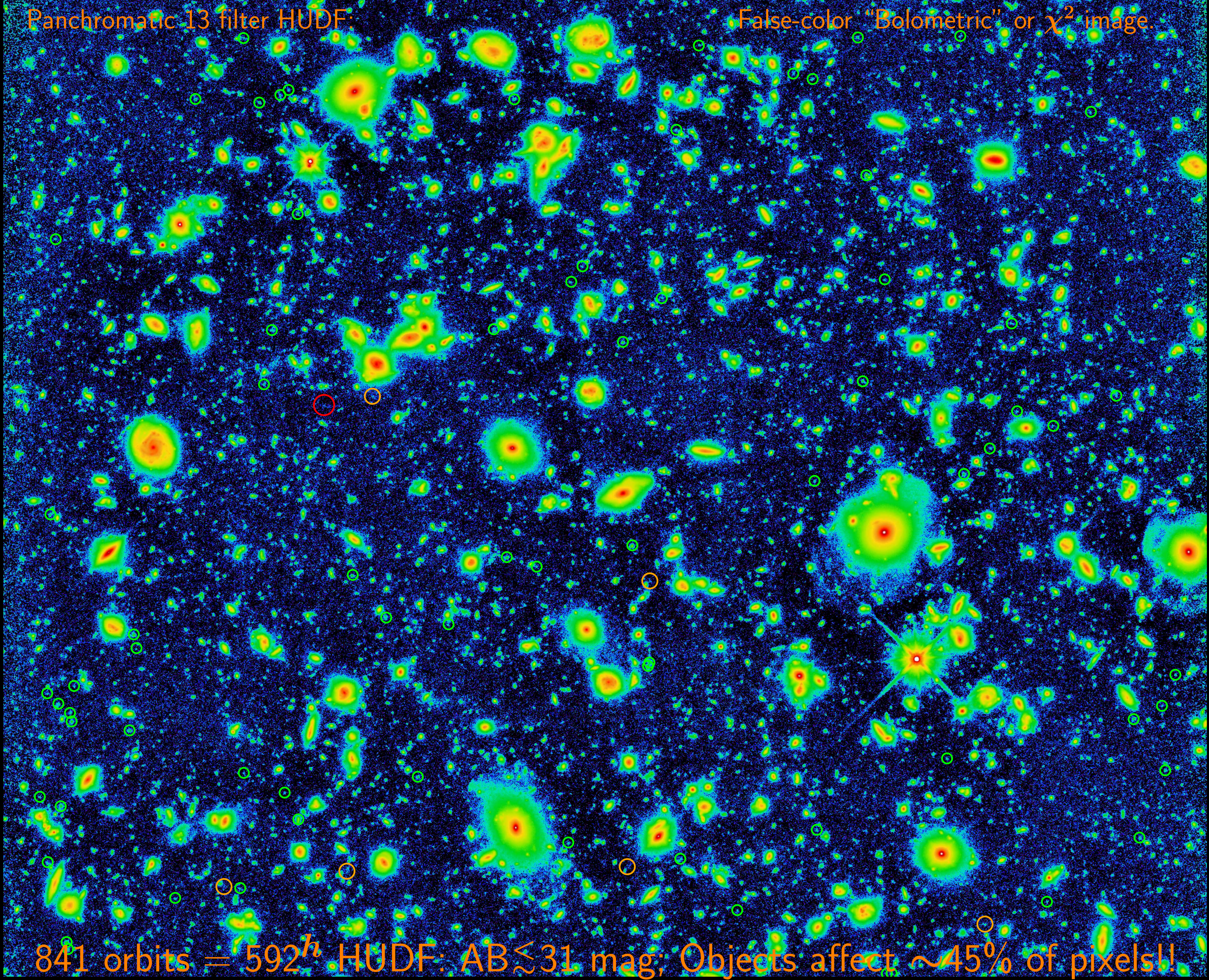
- Careful contemporaneous orbital PSF-star subtraction: Removes most of "OTA spacecraft breathing" effects (Mechtley ea 2012, ApJL, 756, L38).

- PSF-star (AB≃15 mag) subtracts z=6.42 QSO (AB≃18.5) nearly to the noise limit: NO host galaxy detected 100× fainter (AB≳23.5 at r≳0.″3).

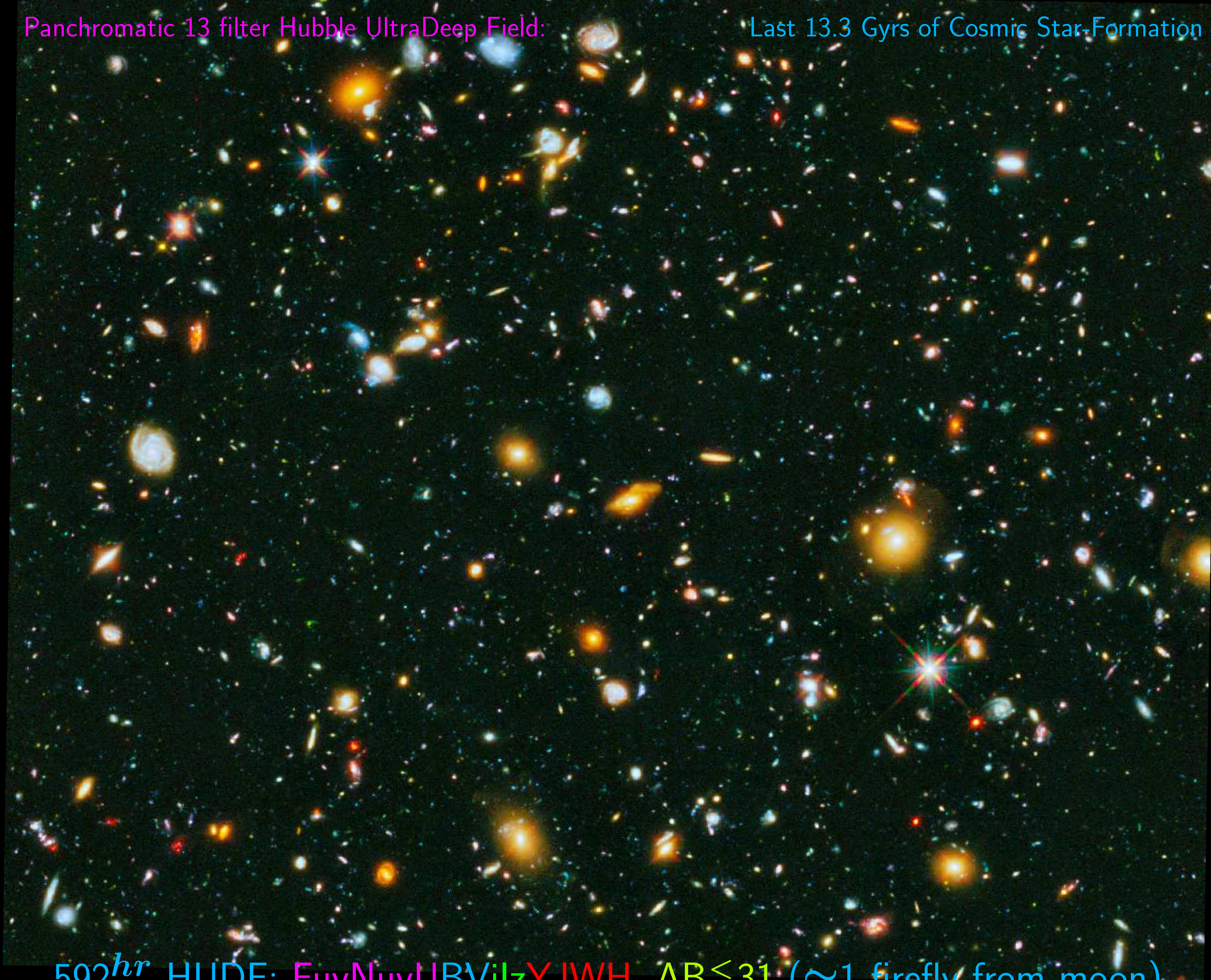
(3) WFC3: First detection of one QSO Host Galaxy at z≃6 (Giant merger?)



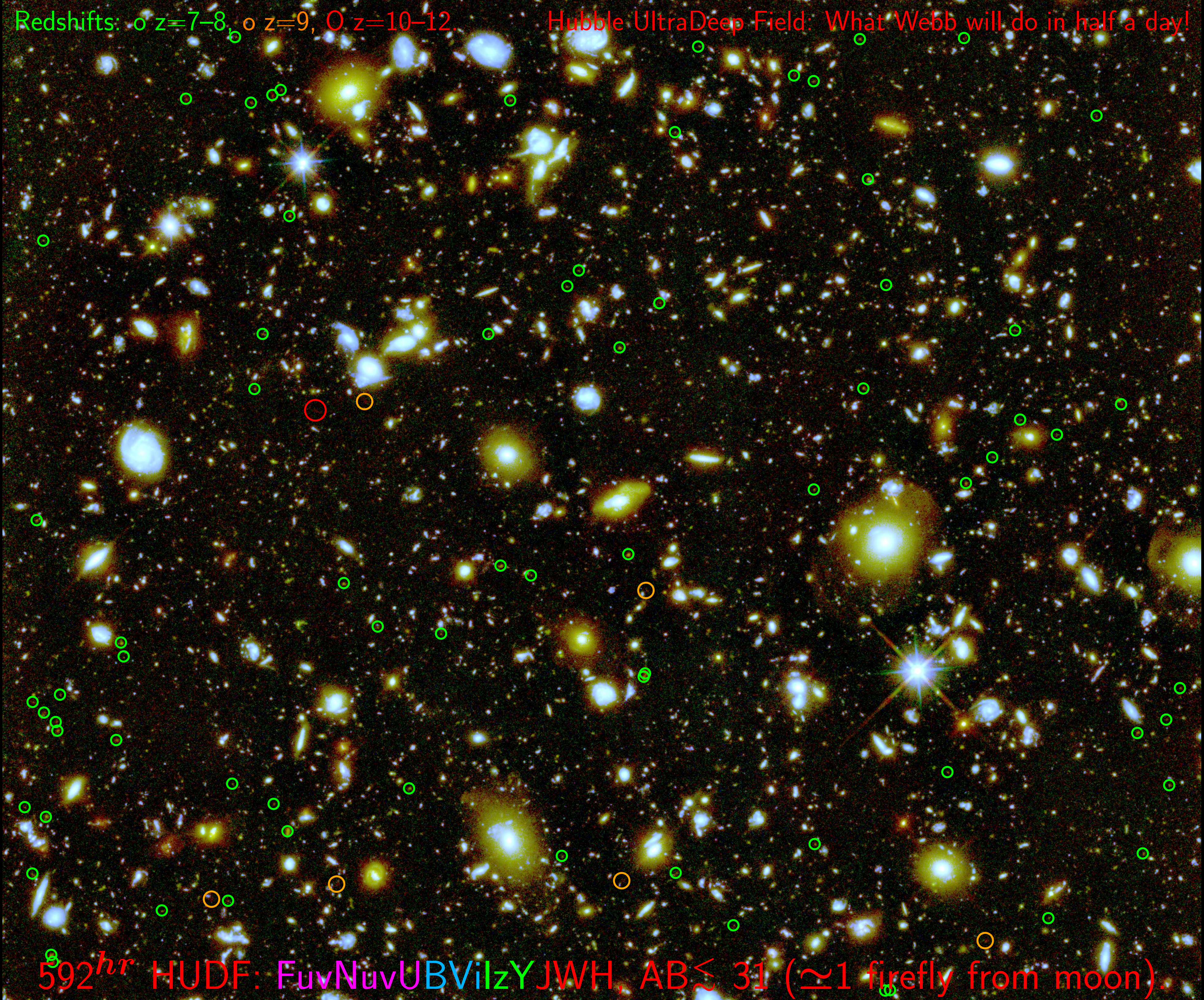
- Monte Carlo Markov-Chain modeling of PSF-star + galaxy light-profile: (Mechtley, MPI, Jiang, Windhorst et al. 2014; Mechtley 2013, PhD):
- FIRST solid detection out of four z≃6 QSOs [3 more to be observed].
- One z≃6 QSO host galaxy: Giant merger morphology + tidal structure??
- Same 1.2–1.6μm structure! Blue UV-spectrum: Modest dust.
- L (z≃6 host system) brighter than typical galaxy: Monster!
- JWST Coronagraphs can do this 10–100× fainter (& for z$\lesssim$20, $\boldsymbol{\lambda}\lesssim$28$\mu$m).

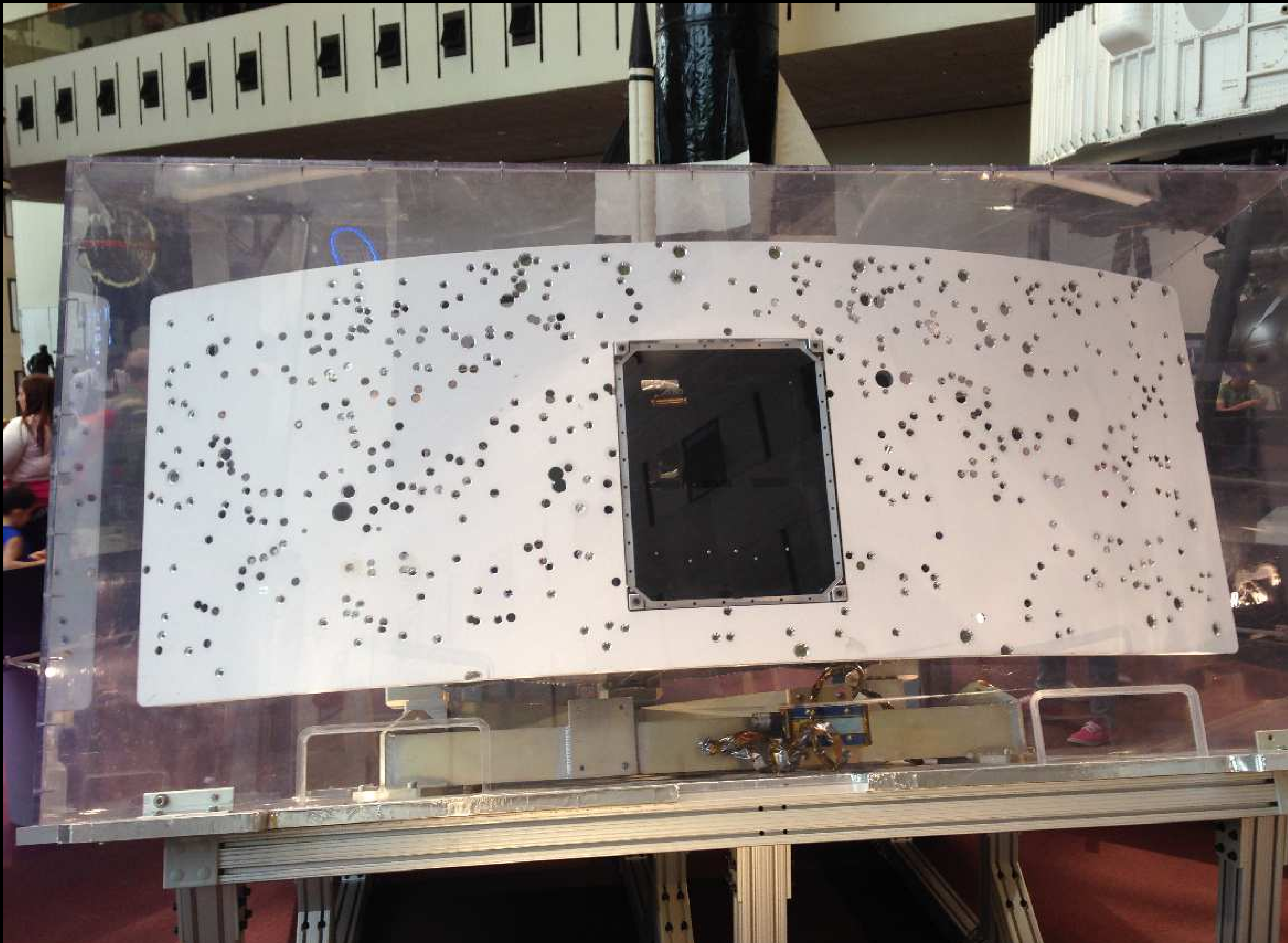

Panchromatic 13 filter HUDF:
False-color "Bolometric" or χ^2 image.
841 orbits = 592^h HUDF: AB$\lesssim$31 mag; Objects affect $\sim$45% of pixels!!

Panchromatic 13 filter Hubble UltraDeep Field: Last 13.3 Gyrs of Cosmic Star-Formation

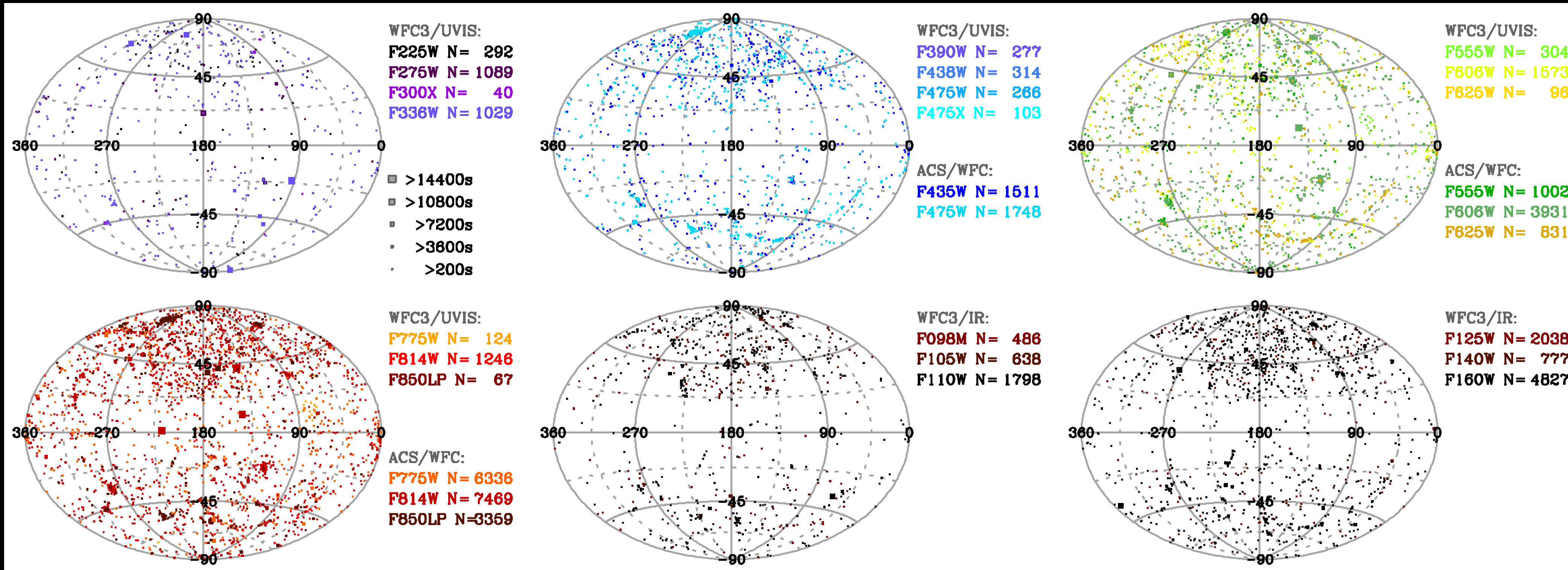


592^{hr} HUDF: FuvNuvUBViIzYJWH, AB$\lesssim$31 ($\simeq$1 firefly from moon).


Redshifts: o z=7–8, o z=9, O z=10–12.
Hubble UltraDeep Field: What Webb will do in half a day!
592^{hr} HUDF: FuvNuvUBViIzYJWH, AB$\lesssim$ 31 ($\simeq$1 firefly from moon).



Hubble's WFPC2 returned to Smithsonian in 2009: Results from 16 years of micro-meteorite hits ... (holes drilled in shield for sample analysis).

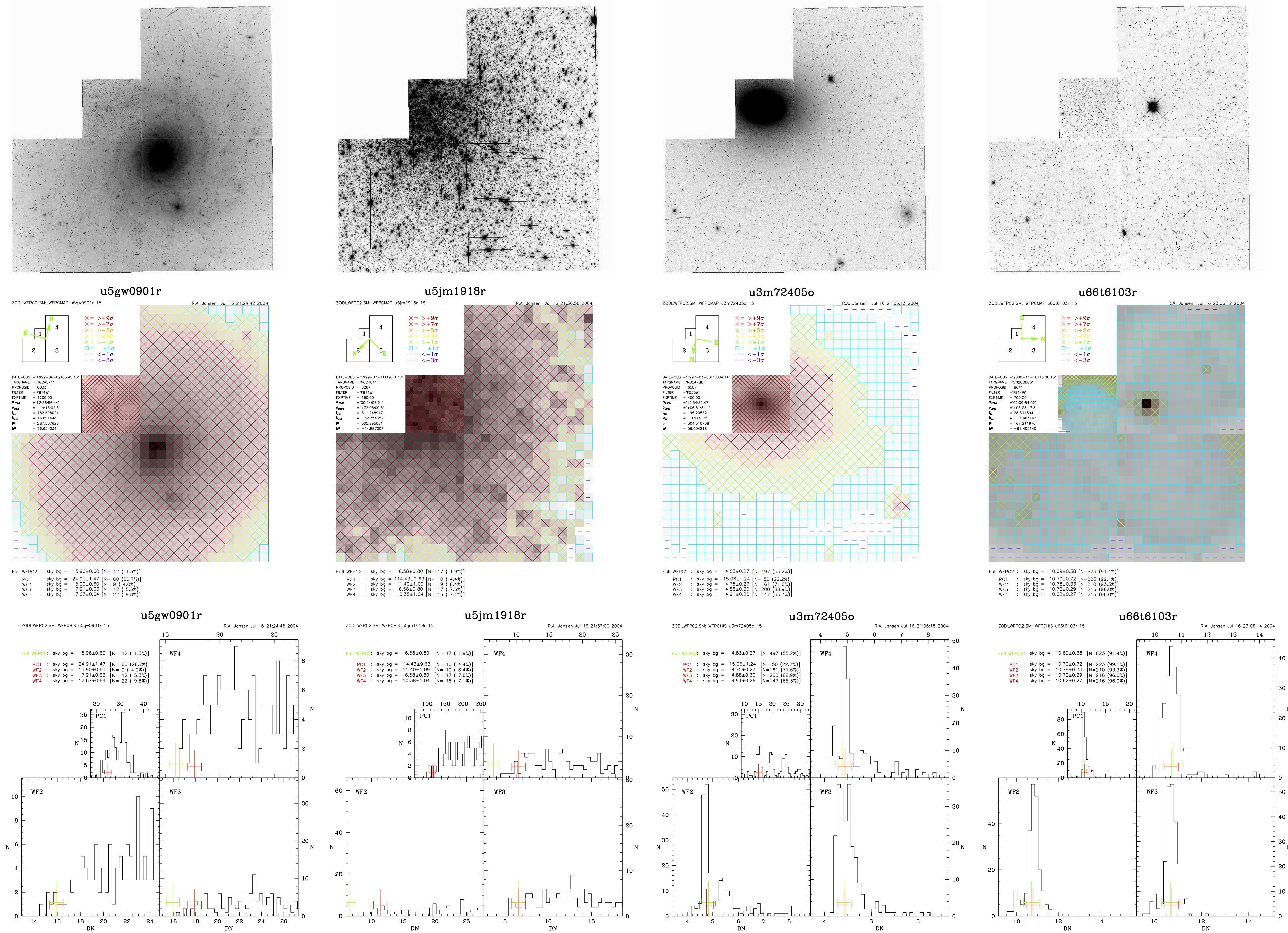


Using HST for its 4^{th} great advantage: Stable (long-term) photometry:

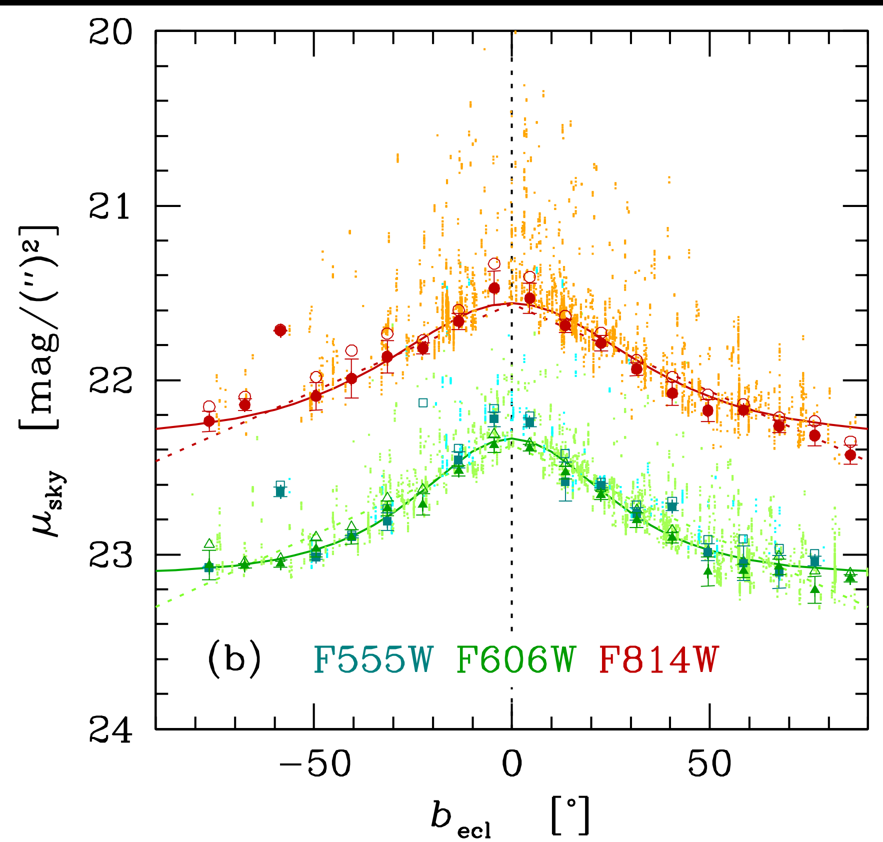
Summary of 21 years of HST WFPC2, ACS and WFC3 Zodi measurements:

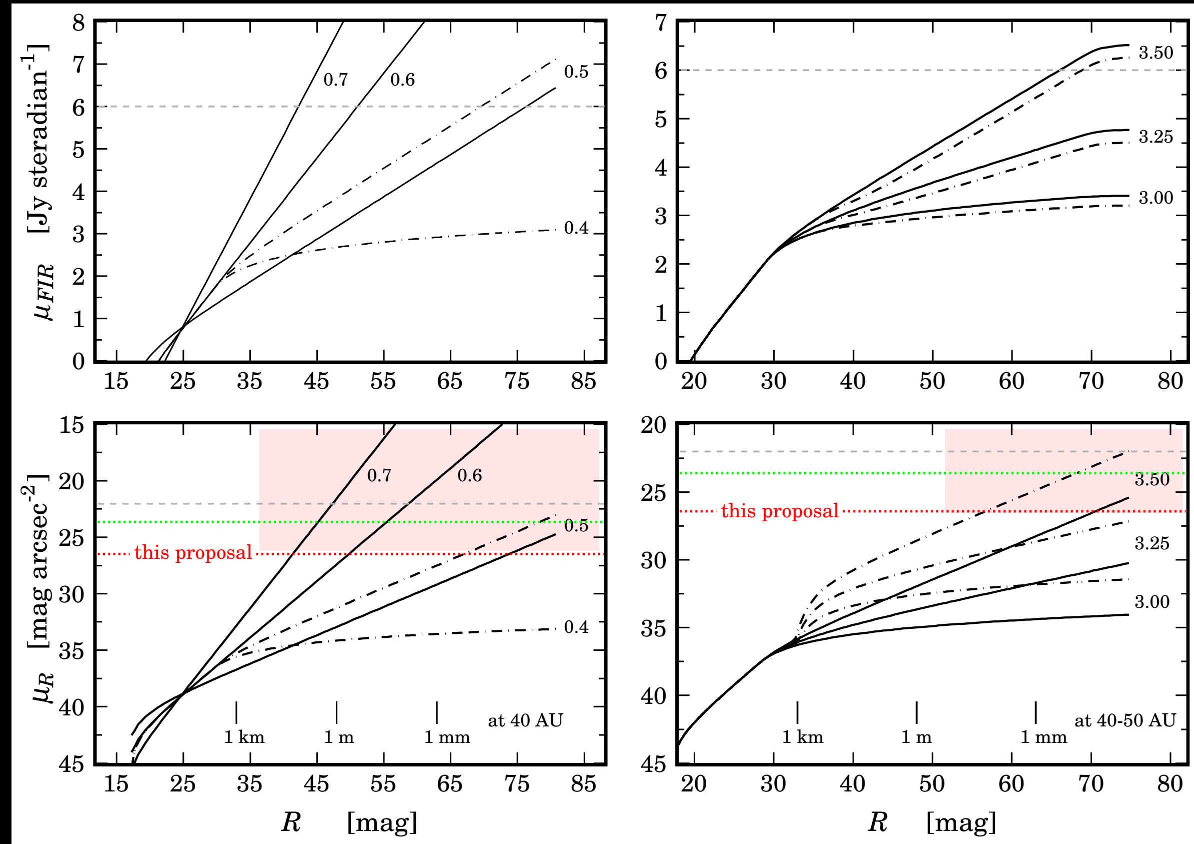
- Ecliptic distribution of 43,571 ACS/WFC and WFC3/UVIS+IR targets as of Spring 2014: Use to measure Zodi sky SB(l^{Ecl} , b^{Ecl}).
- WFPC2 Zodi measurements on next pages (Jansen et al. 2014).

This analysis will help address micro-meteorite hit-rate for JWST in L2, which could be substantial (see Gerry Gilmore's GAIA talk).



Measuring the Zodi modal sky-SB for *all* HST WFPC2 targets over 16.3 years in orbit, rejecting those where target overfills FOV.





[LEFT]: Measured Zodi sky-SB(b^{Ecl}) in HST V555/V606 and I814.

[RIGHT]: Constrains KBO sky-integral at $\gtrsim$40 AU (Kenyon & Windhorst, 2001, ApJL, 547, L69) beyond AB$\sim$29 (where it is measured):

To avoid Olbers paradox, KBO size distribution must have N(r) $\propto$ r$^{-\alpha}$, with $\alpha\lesssim$3.3 at AB$\gtrsim$29 mag (due to solar system collisional history).

If L2 meteoroid size *distribution* same as in Kuiper belt (also have $\alpha\lesssim$3.3 to avoid Olbers paradox!), then L2 meteoroid impact rate predictable.