SKYSURF: Where Does Optical Background Come From?

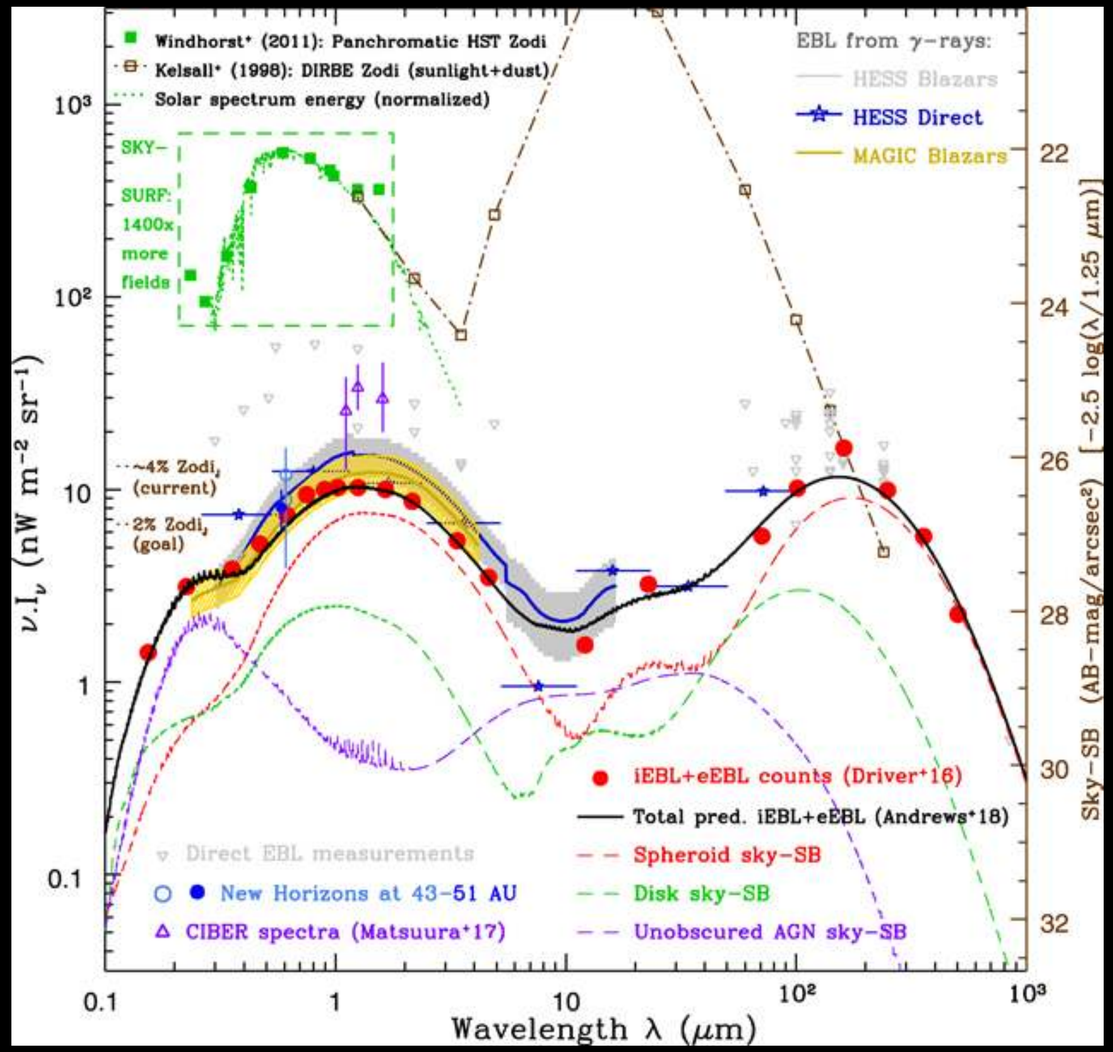
SKYSURF Team; Tim Carleton, **Delondrae Carter**, Seth Cohen, Rogier Windhorst, **Scott Tompkins**, **Zak Goisman**, Rosalia O'Brien, etc…






Where does Optical Background Come From?

- Normal (high-SB) Galaxies?
- Faint (low-SB) Galaxies? (Jones+2018, Zaritsky+21)
- Halos around bright galaxies? (Conselice+2016, Ashcraft+2018, Cheng+2021)
- Intergroup/intercluster light? (Bernstein+1995, Mihos+2005)
- Other cosmological signal? (Cooray+2004, Kashlinsky+2004)
- Foregrounds? (O'Brien+in prep, Matsuura+2017, Sano+2020)



Windhorst+22
Carleton+22

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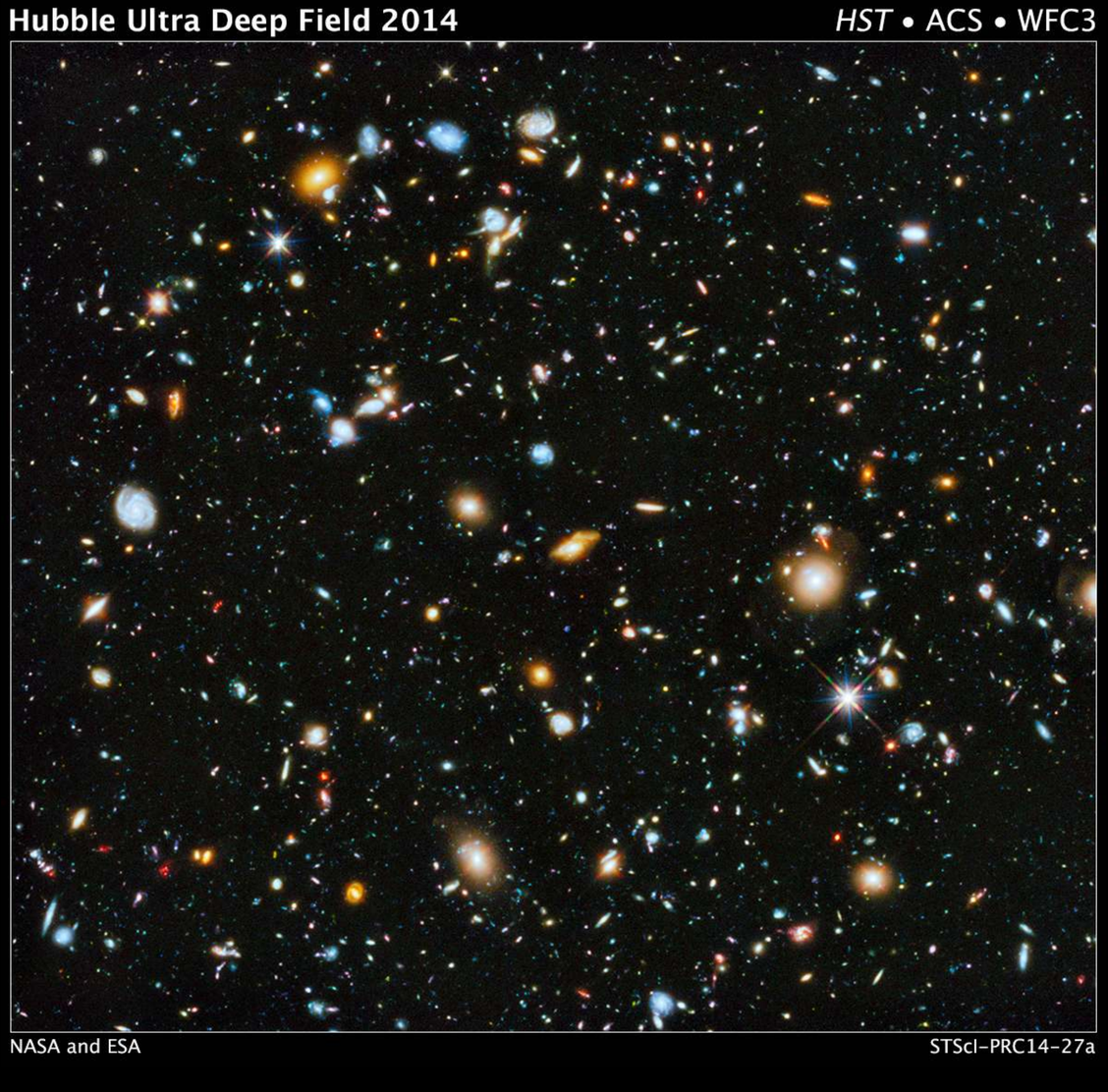

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van Dokkum+18

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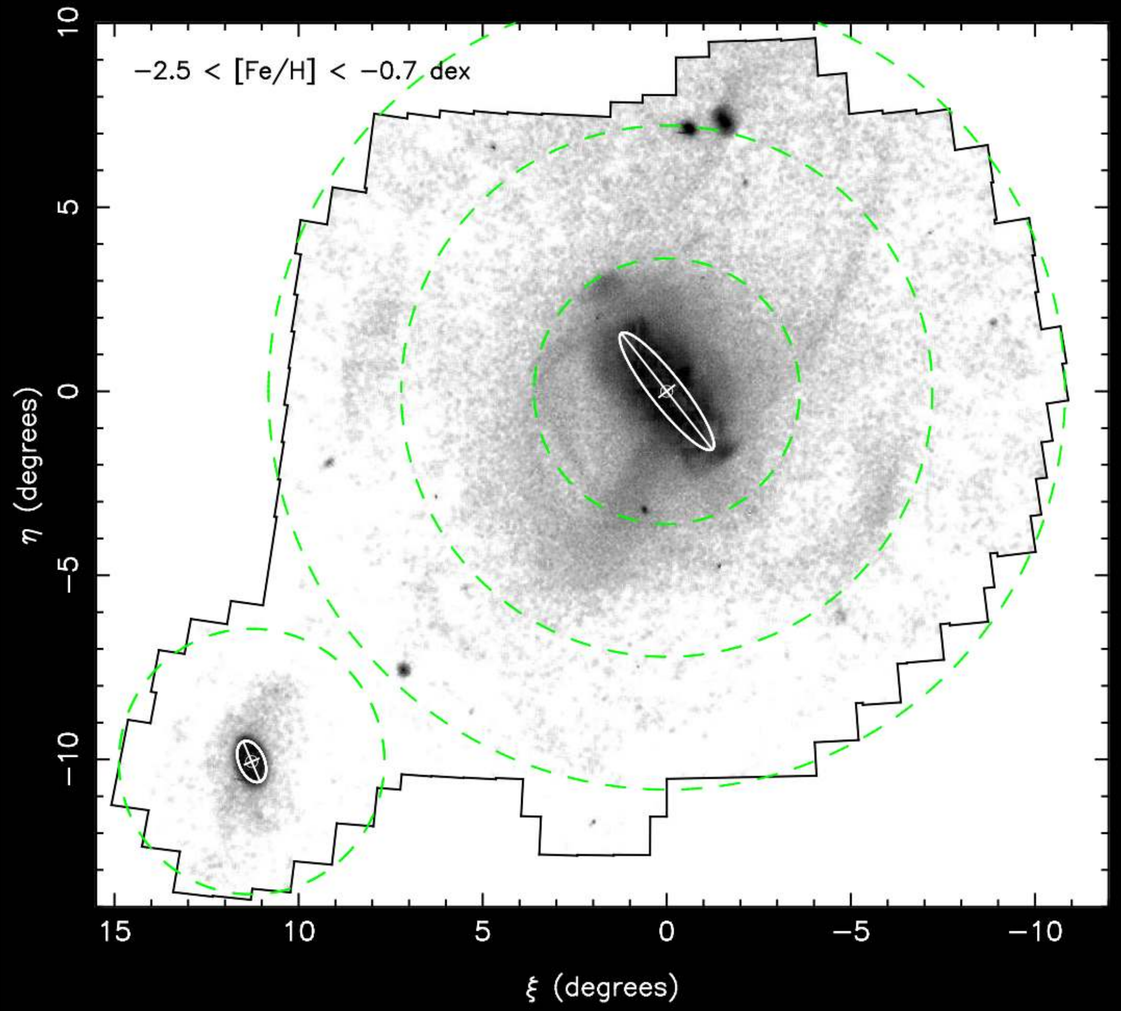

McConnachie+18

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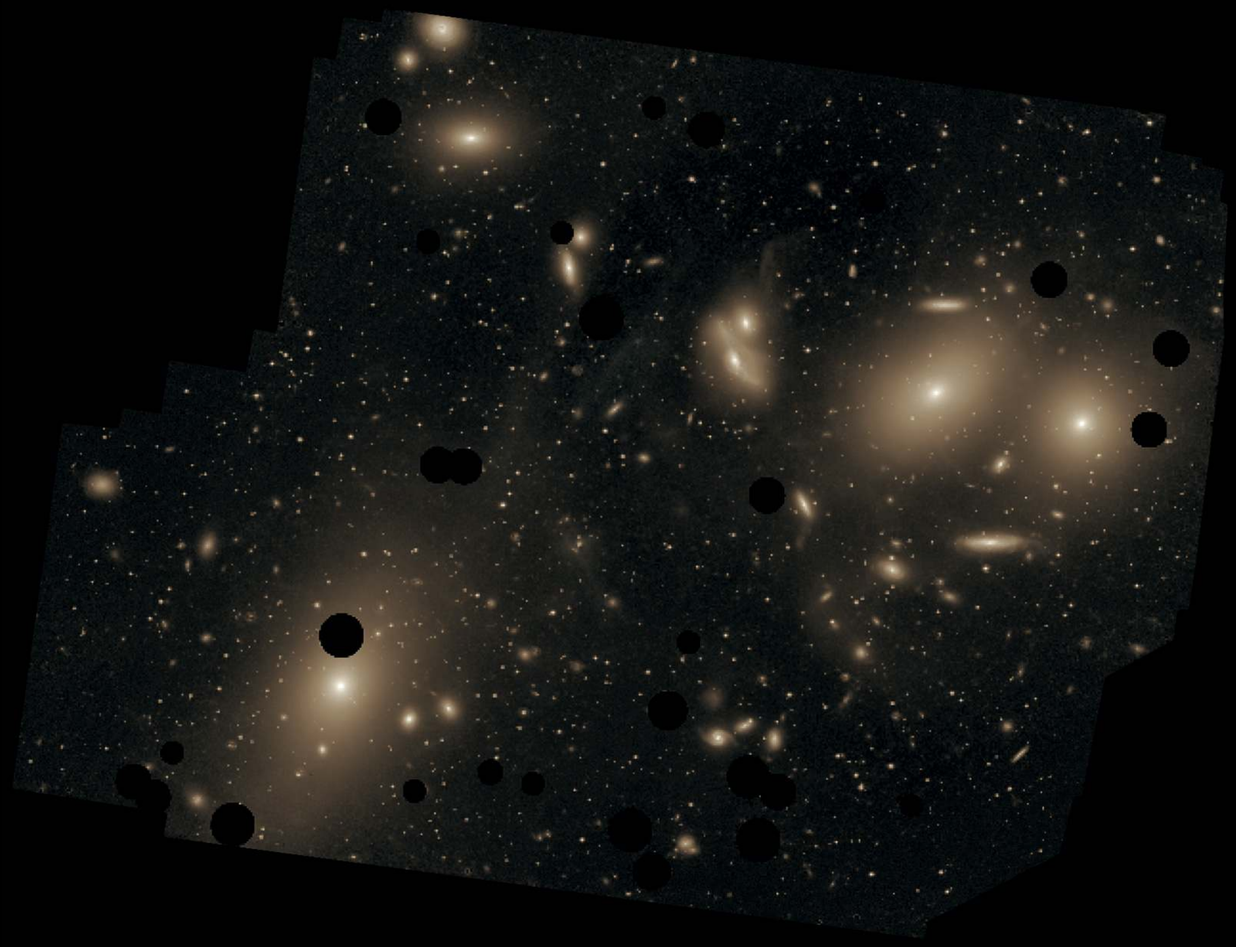

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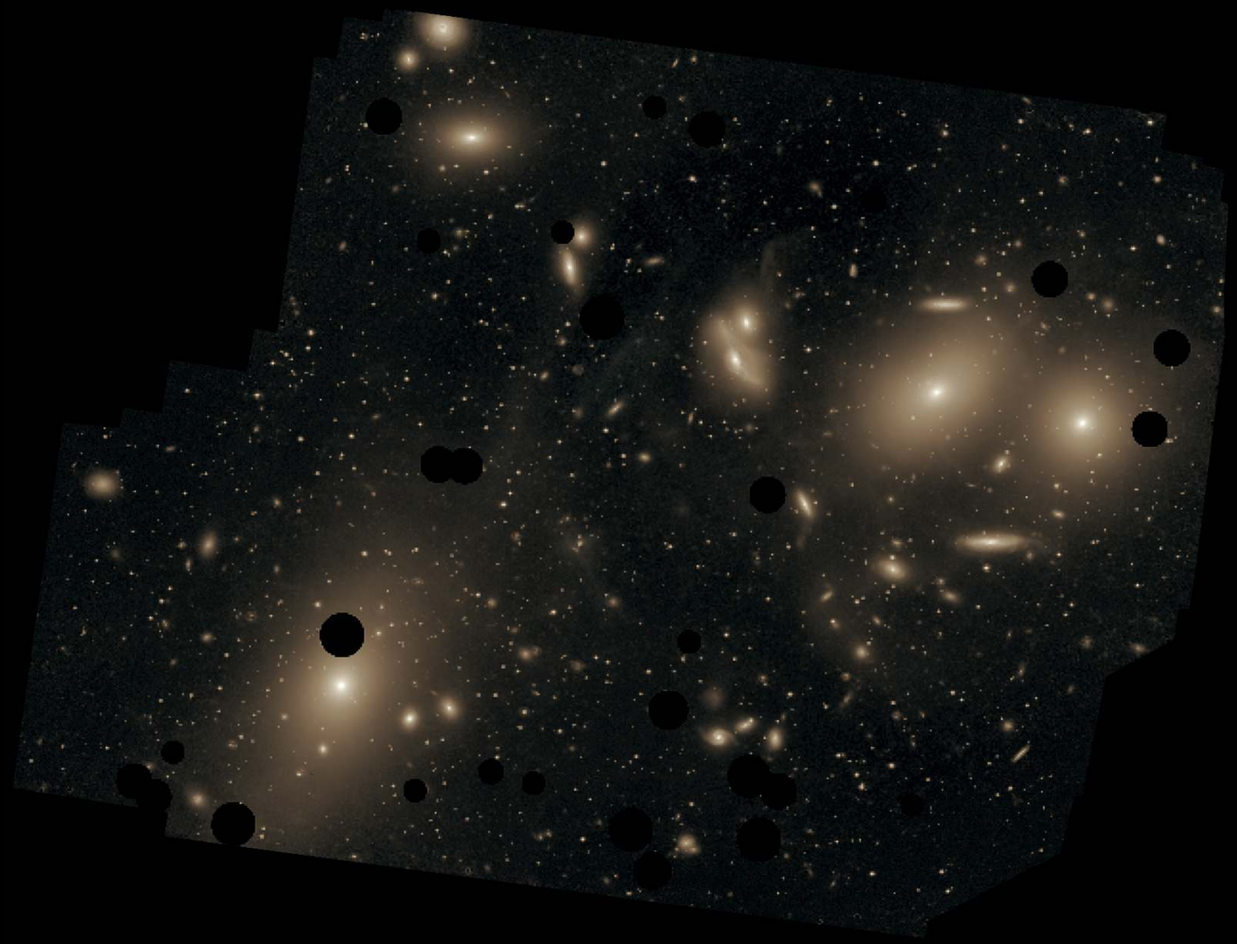
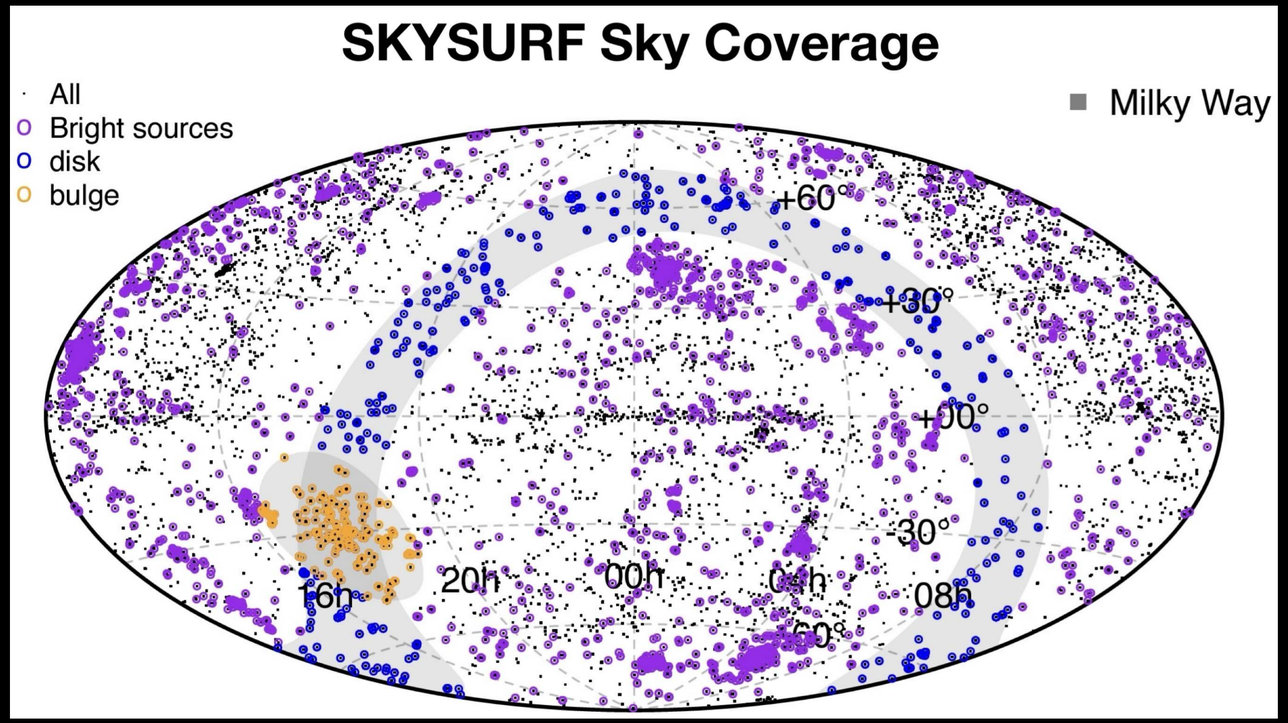


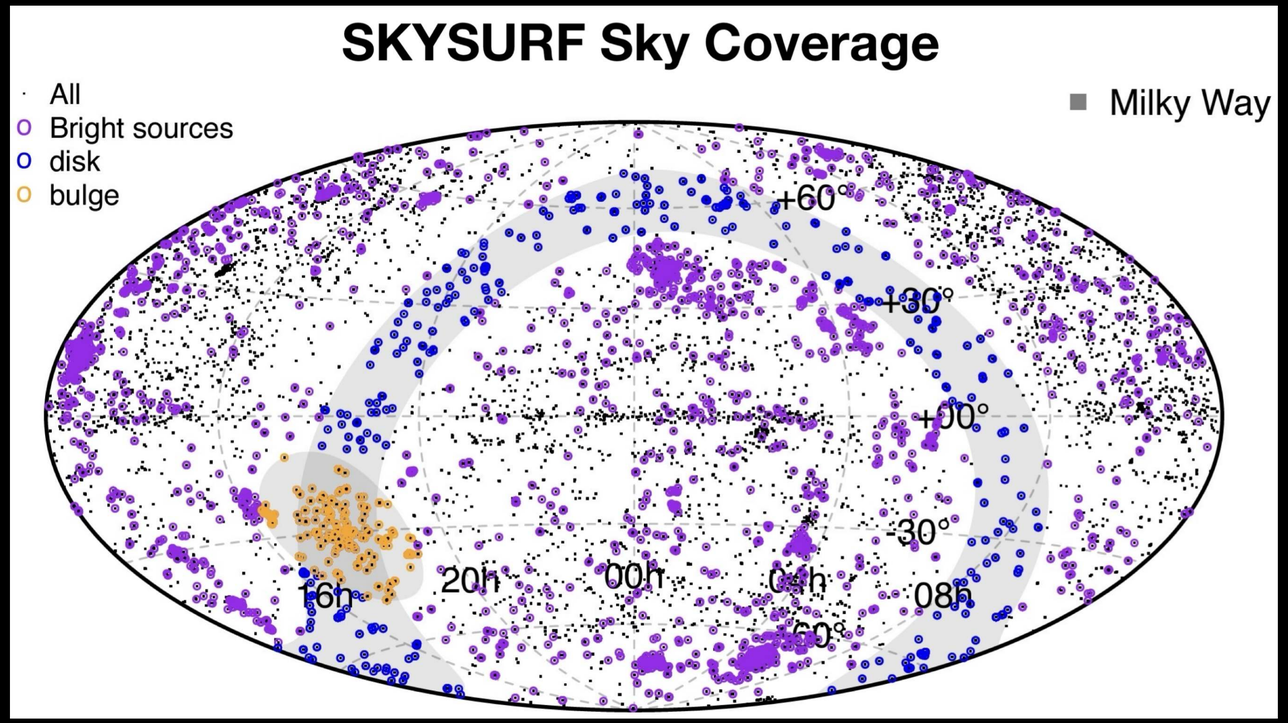
Use HST!

- **High resolution**
  - Star/galaxy separation
  - Almost no instrumental confusion
- **High Sensitivity**
  - Reach galaxies “beyond the peak” of galaxy counts
- **Stable optics**
  - Few artifacts
  - Precise zero-points
  - Faint and stable background
  - Limited PSF leakage (bright stars are rare)
- **>30 year archive!**



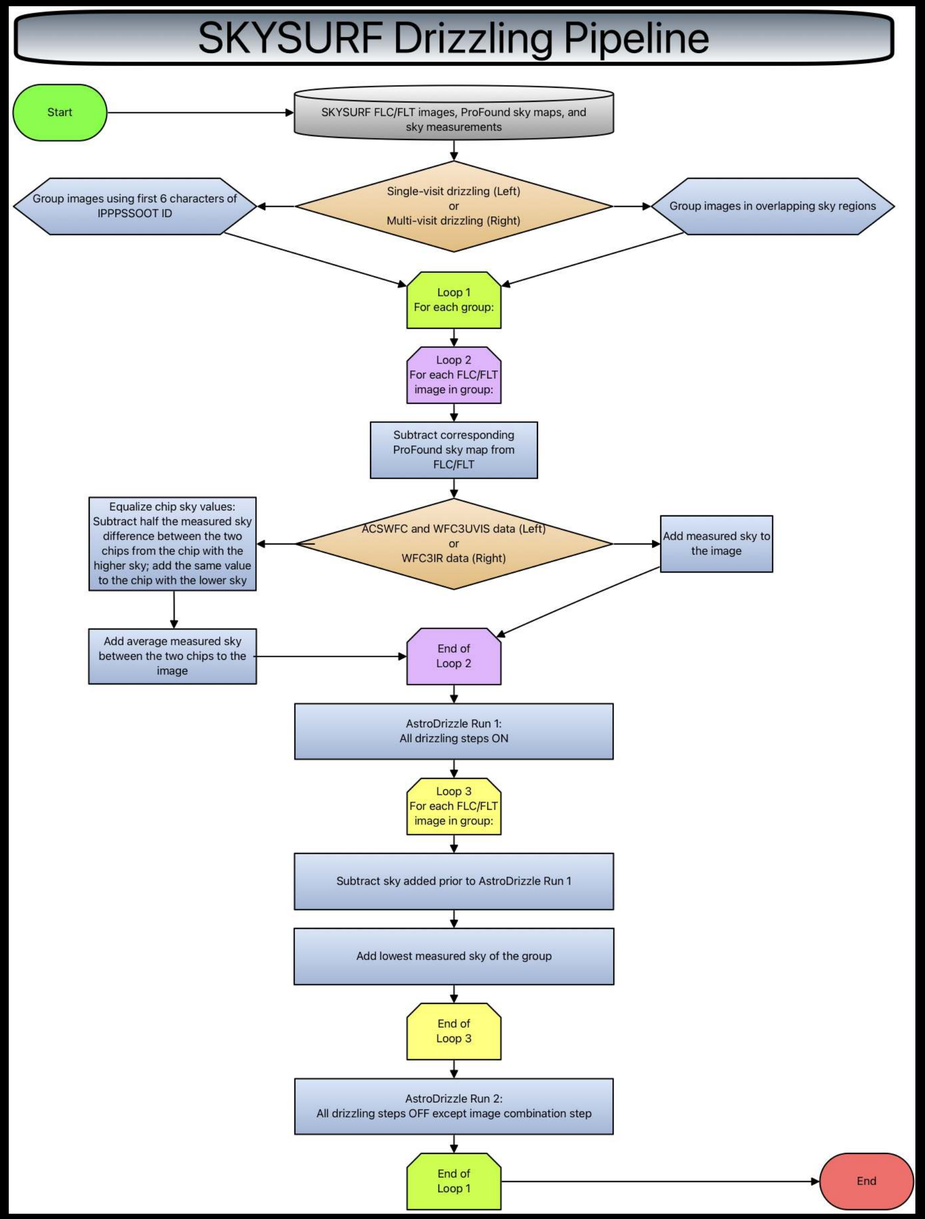
Use HST!

- **Challenges**
  - Resolves out some low surface brightness structure
    - Combine with ground-based surveys
  - Very non-random coverage
    - Calibrate effects of target selection
  - Small field of view
    - 30 year archive:
      - >1100 independent fields
      - >20 sq deg
      - ~1 sq deg per filter for 22 filters

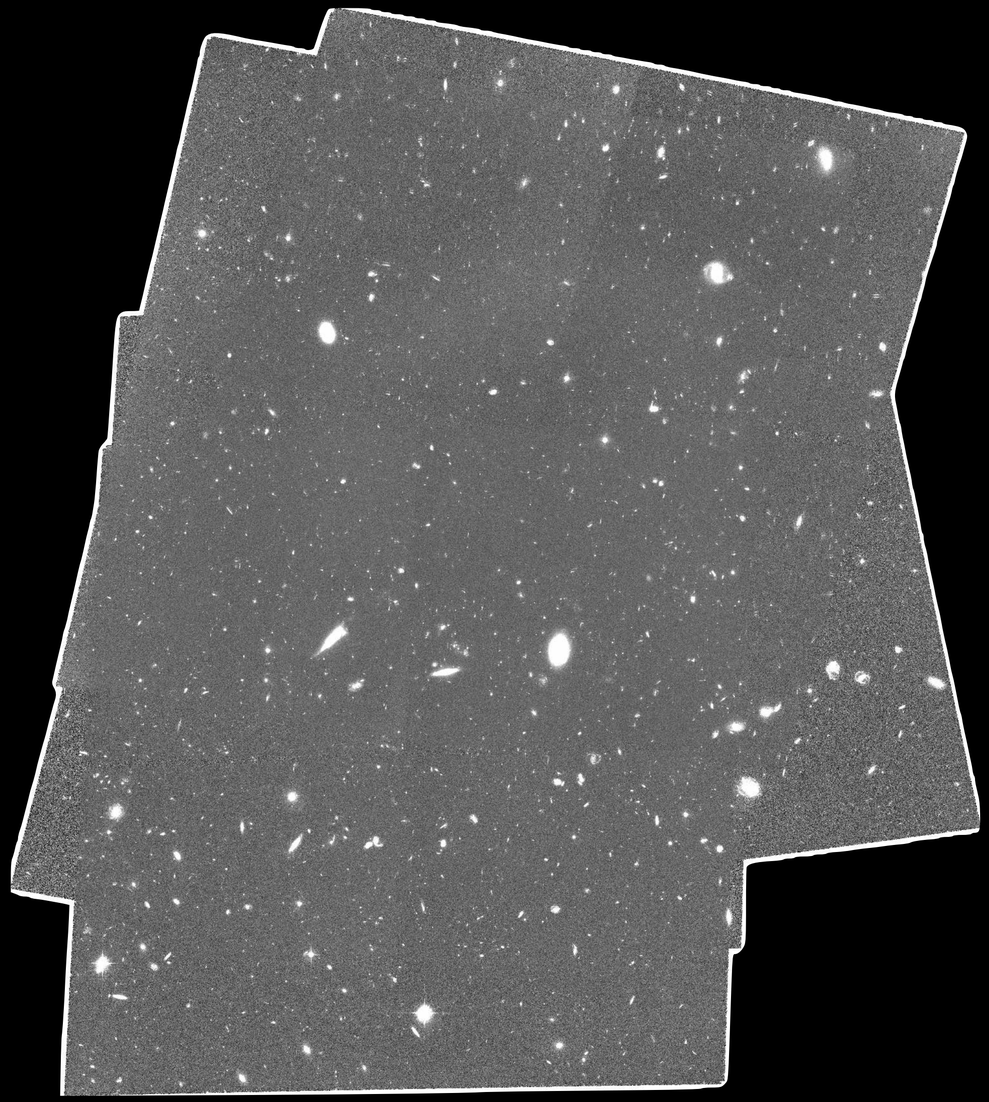


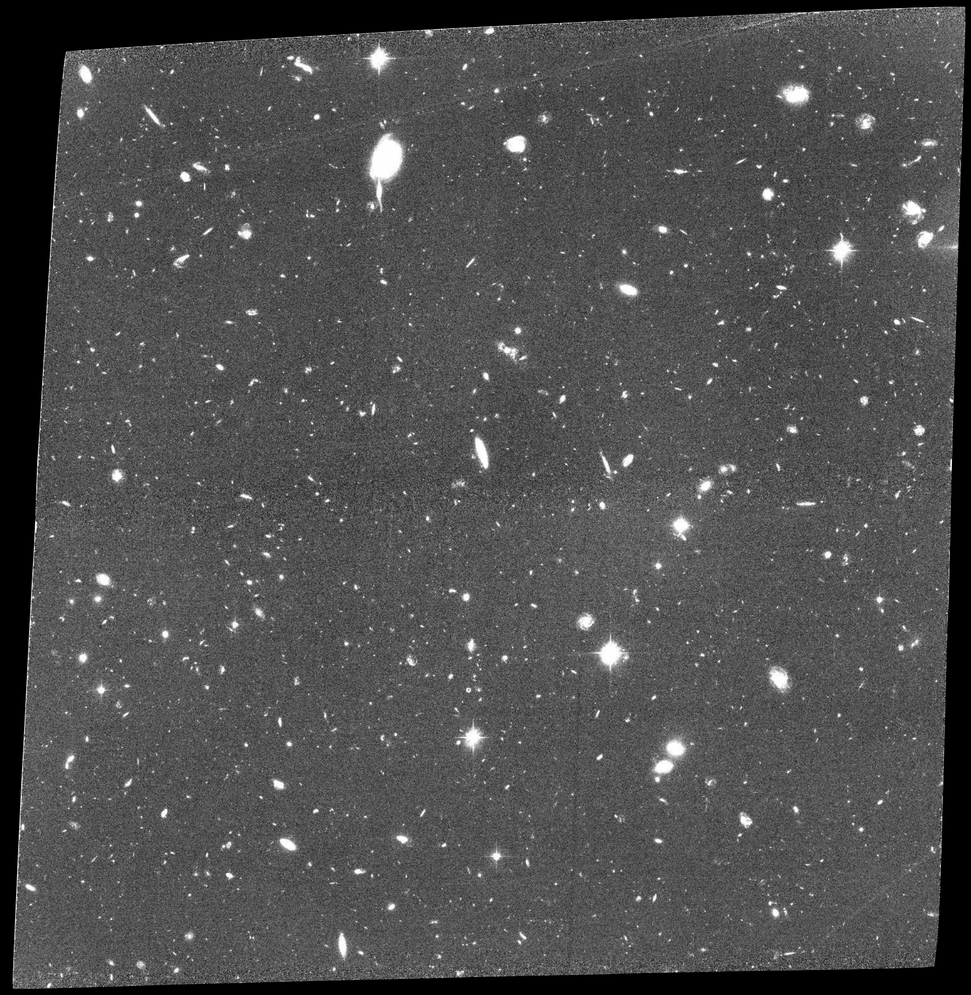
SKYSURF Drizzling

- ProFound generates background maps in individual frames
- Subtract this background for relevant frames
- Drizzle together relevant background-subtracted frames



SKYSURF Detection





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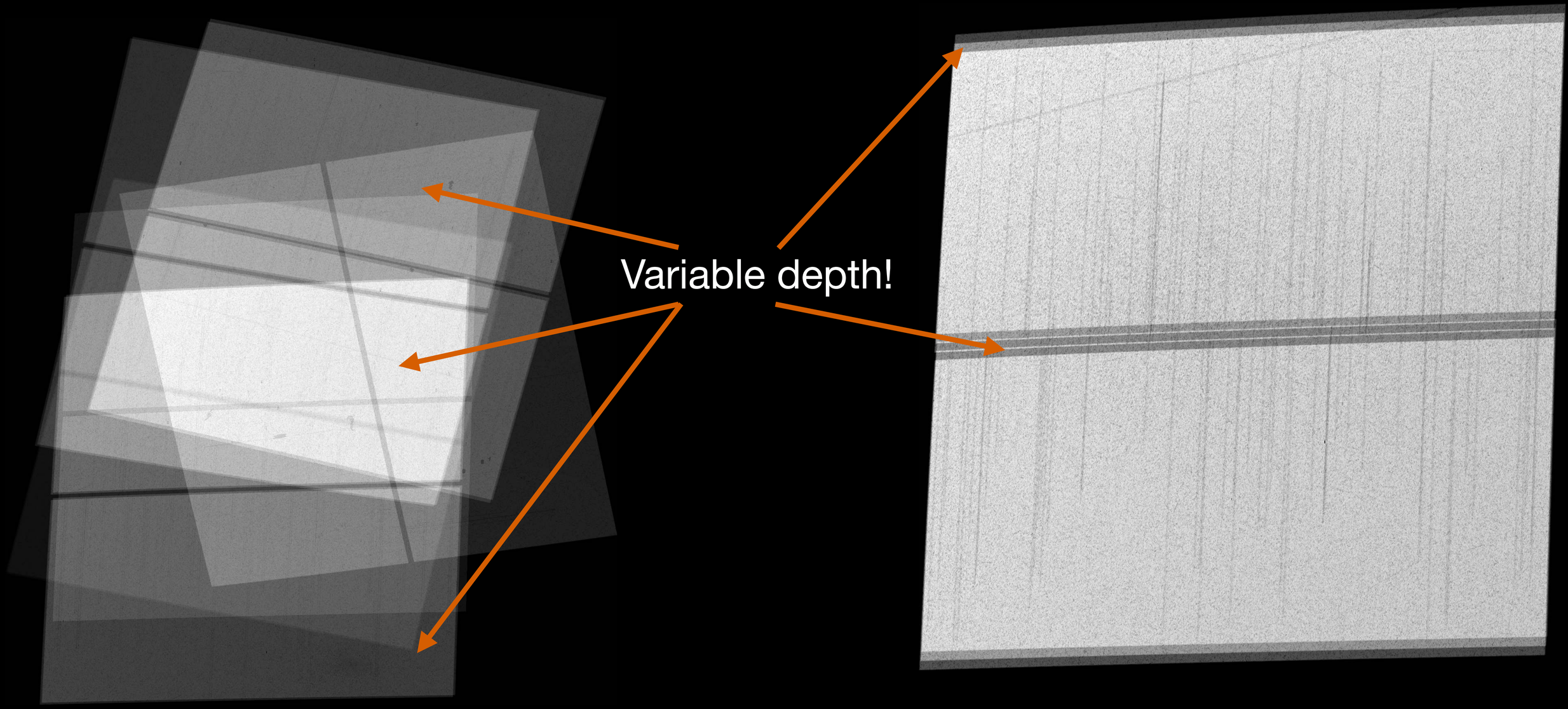
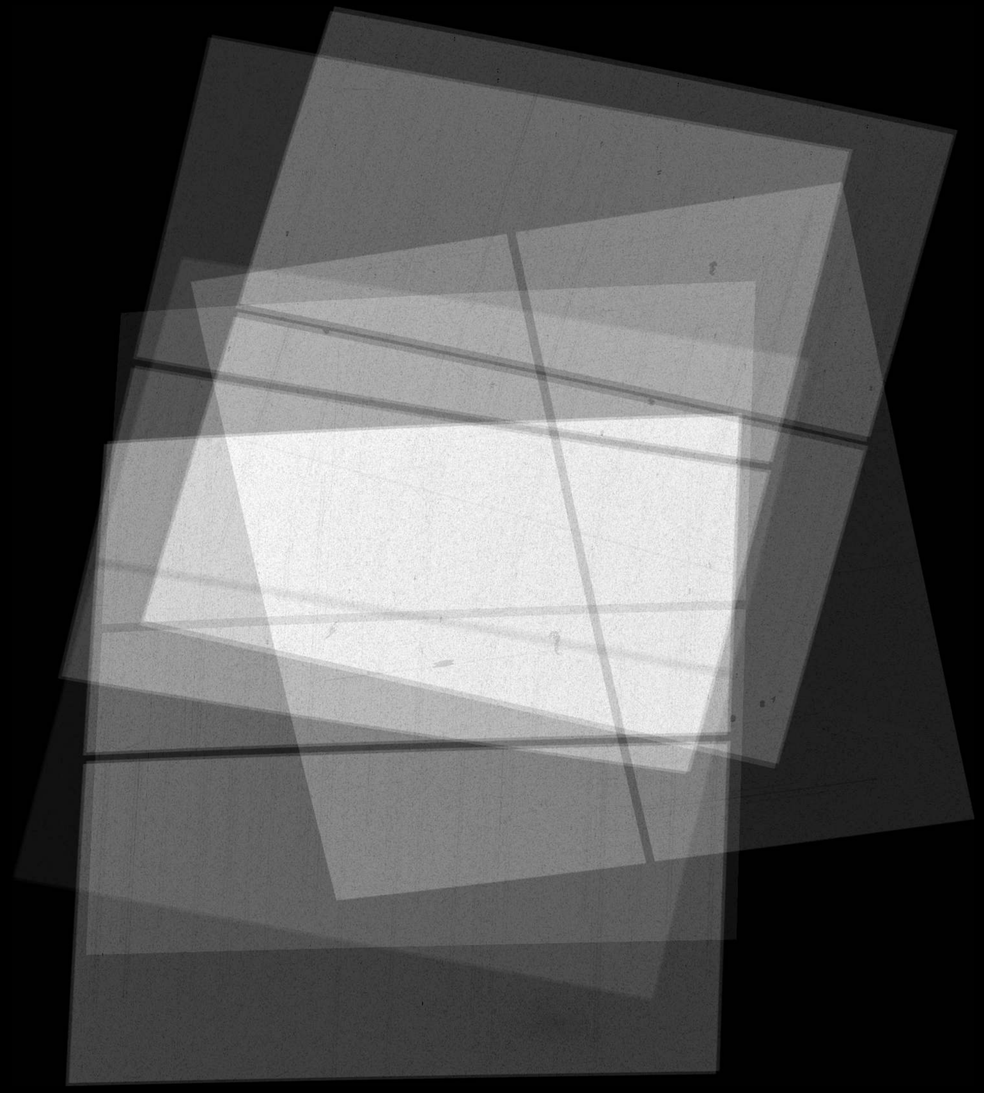


SKYSURF Detection

- Smooth weight map (128x128 boxcar)
- Threshold is 90% of max weight
- Include any 8x8 pixel region where at least 1 pixel is above threshold



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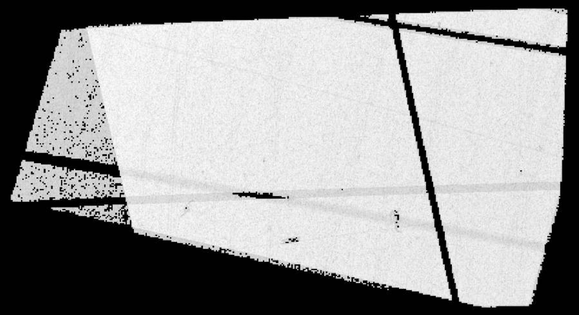

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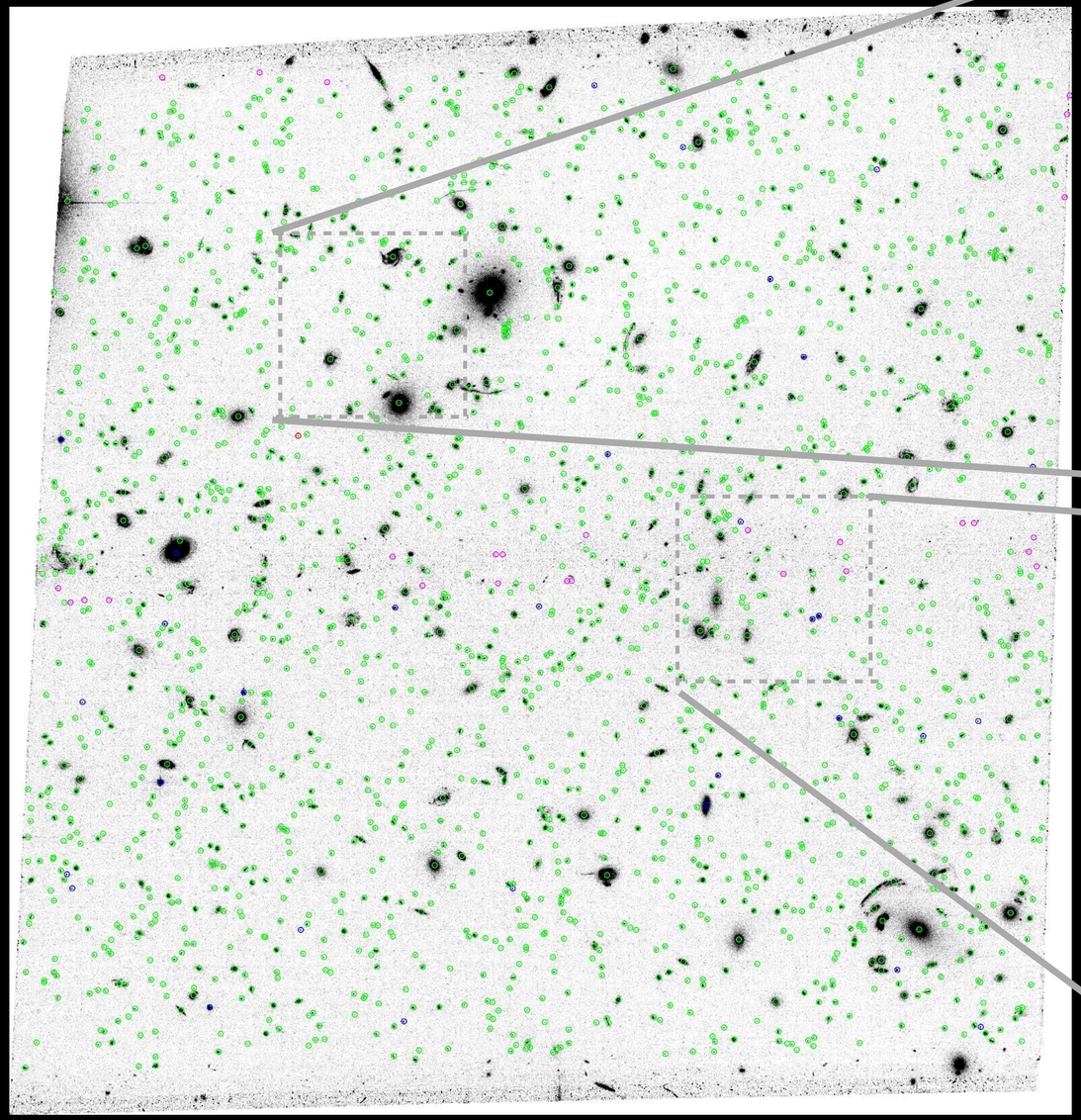
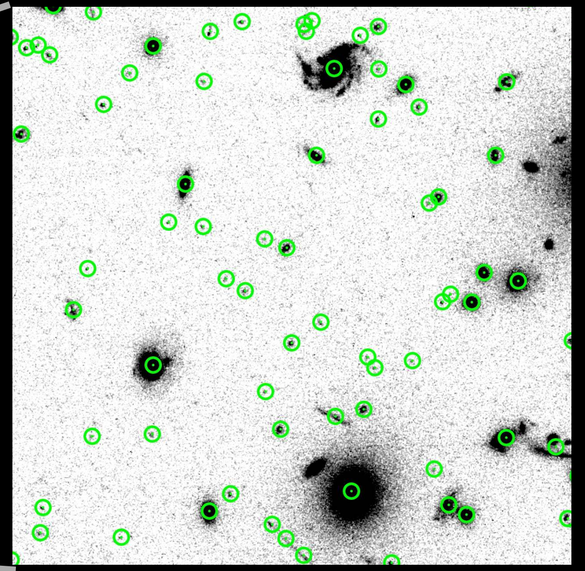
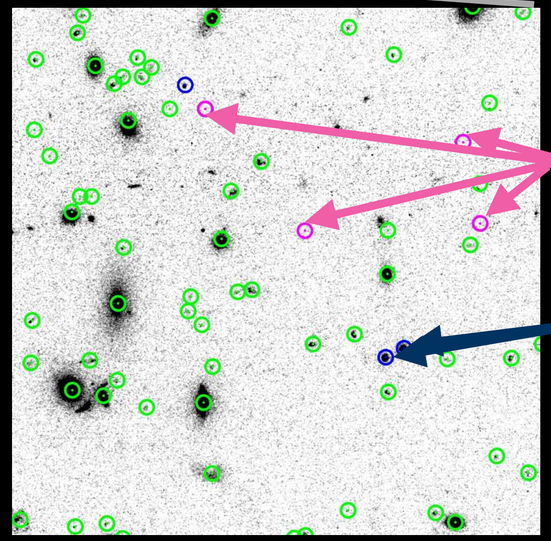




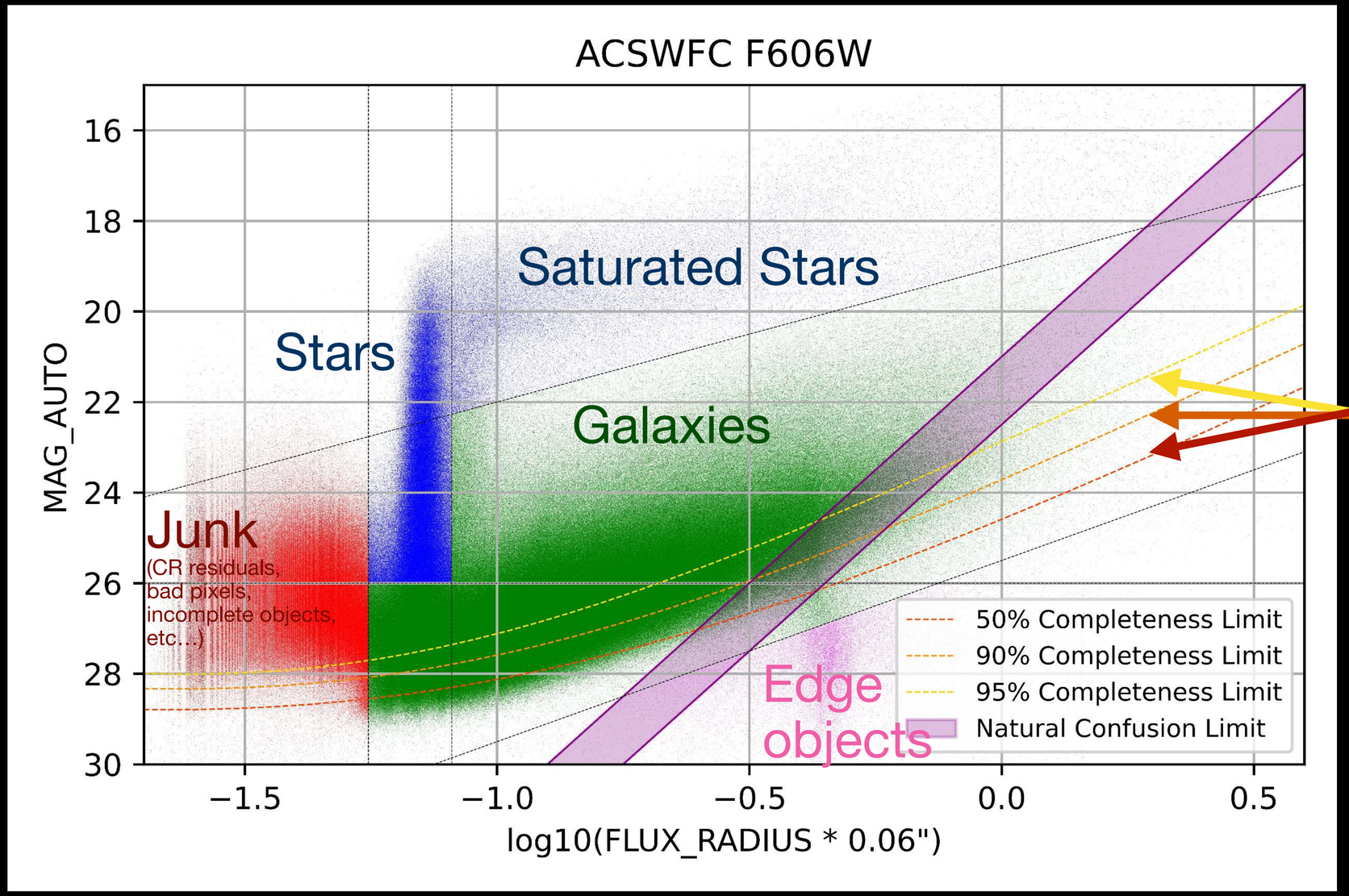
Lots of galaxies!



Also artifacts

And unresolved stars

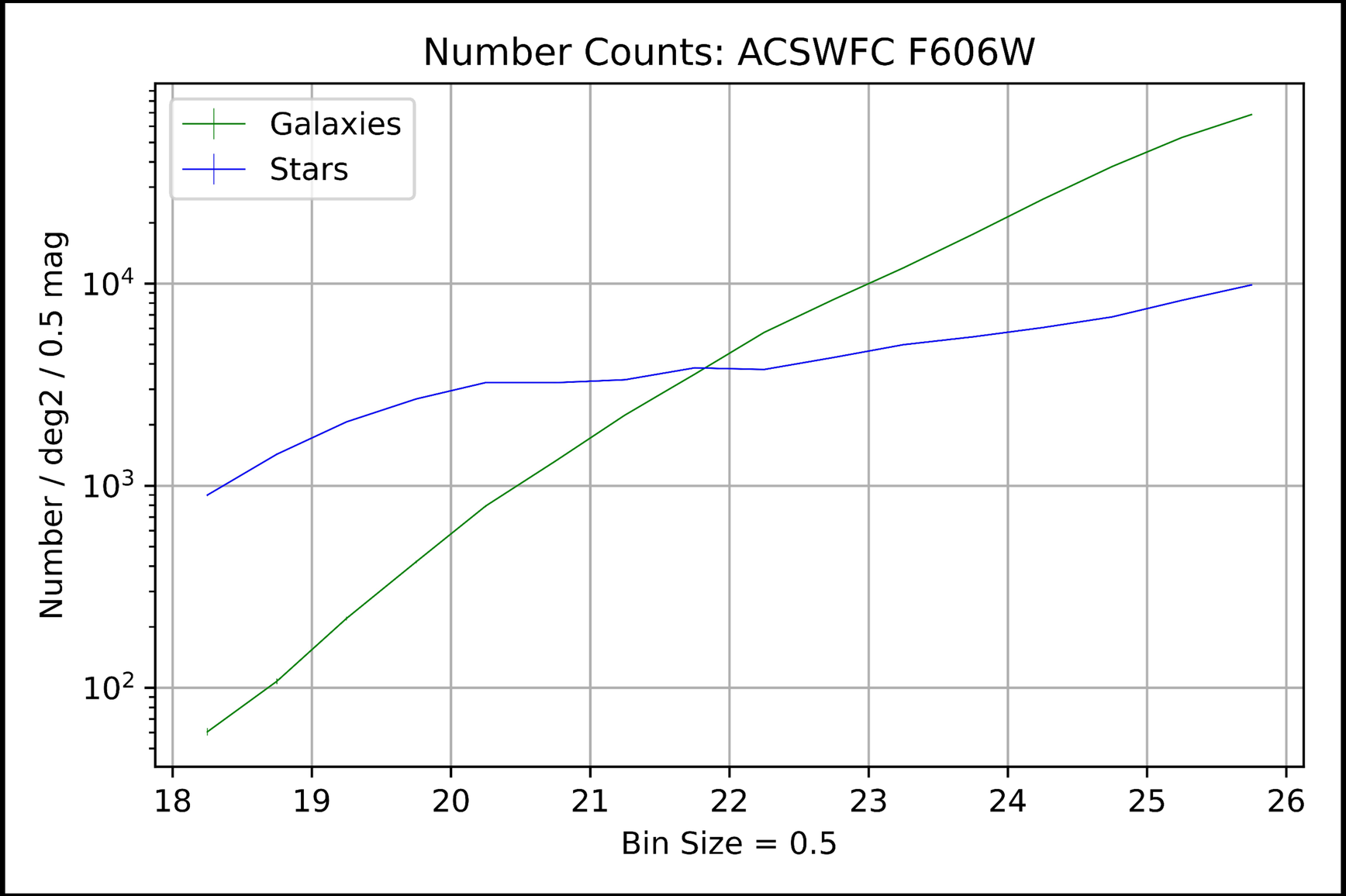
SKYSURF Detection



Natural confusion (due to overlapping galaxies; Kramer+22)

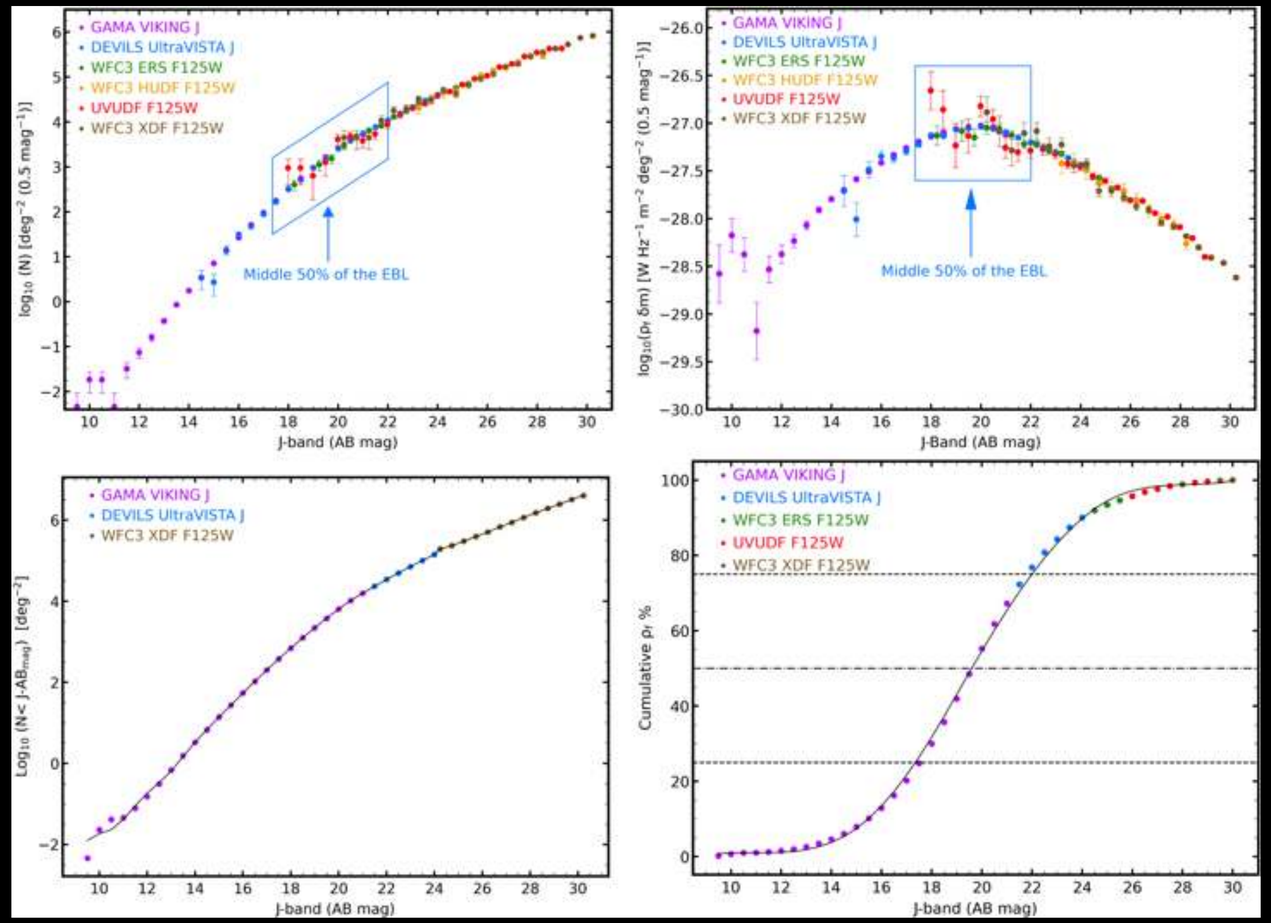
Empirically calculated SB limits at median t_{exp} (Goisman+ in prep)

SKYSURF Detection



How much optical background comes from “normal” galaxies?

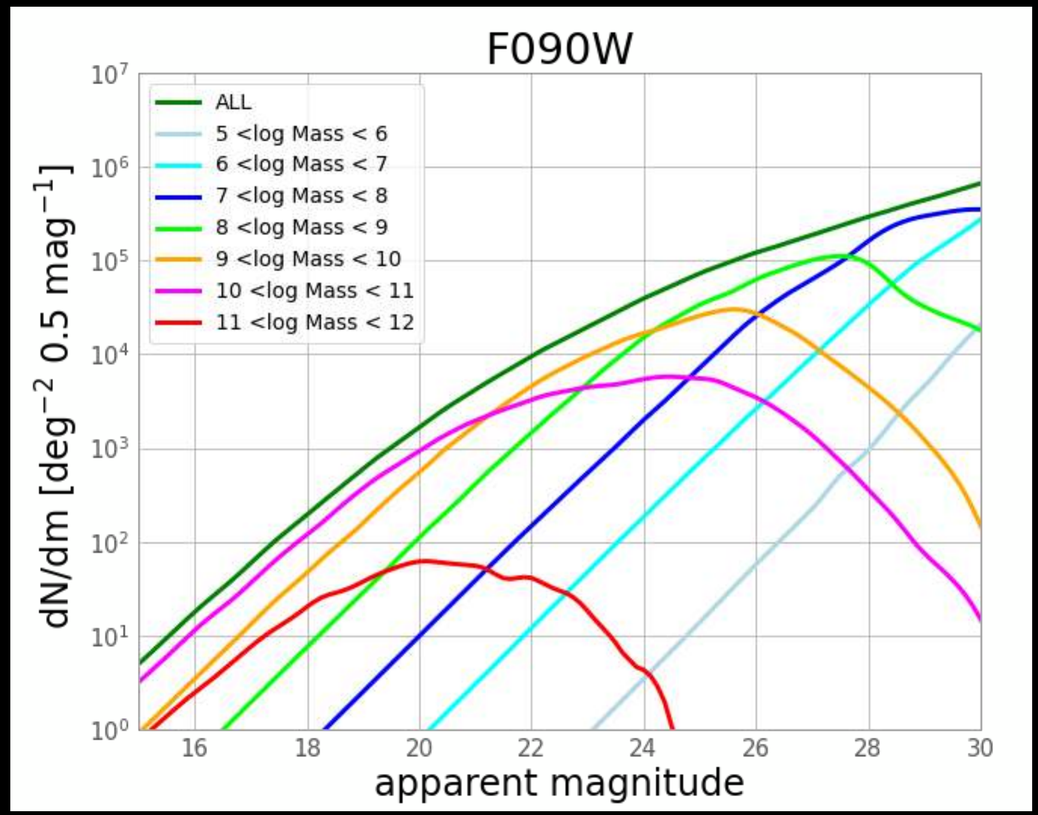
- Use ground-based surveys for bright end, deep HST fields for faint end
  - 11 nW/m2/sr out to mAB=30
  - <0.1 nW/m2/sr past mAB=30



Windhorst+22

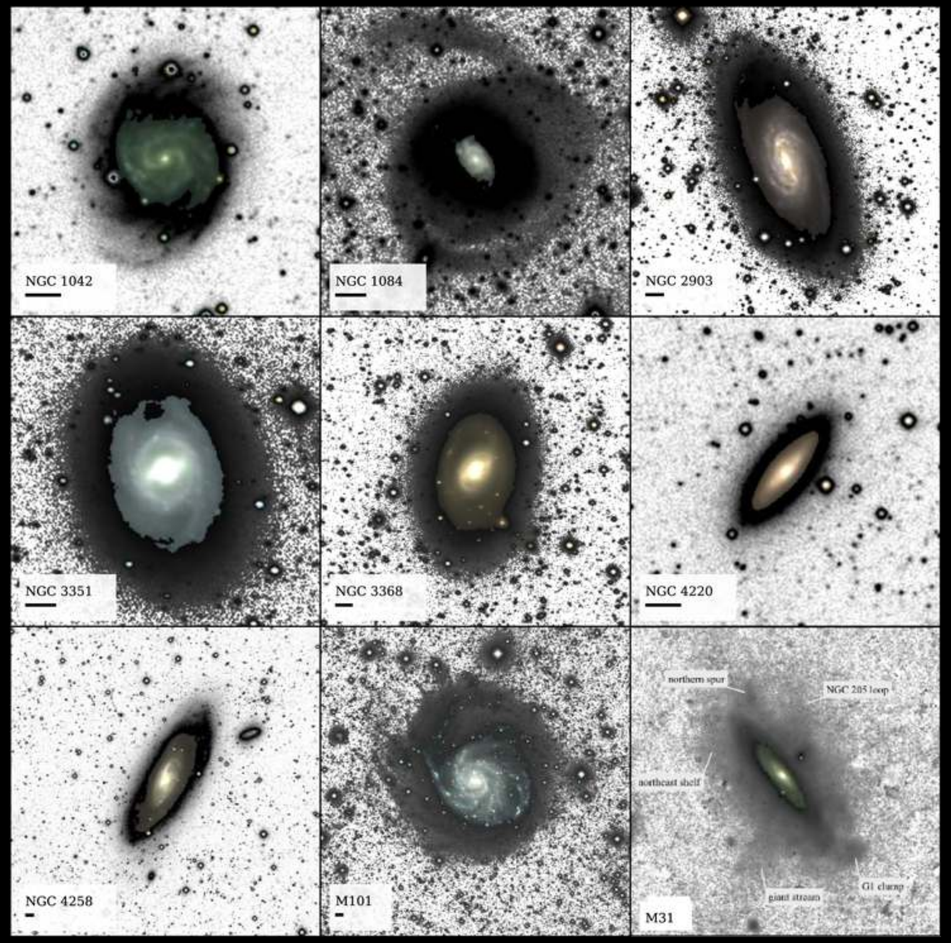
How much optical background comes from “normal” galaxies?

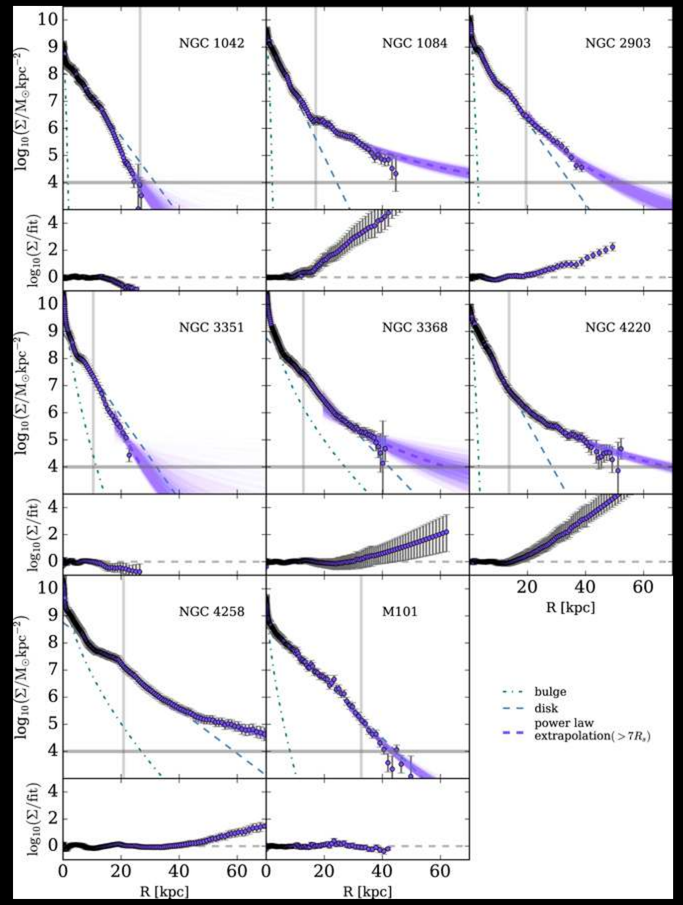
- Models suggest that most bright galaxies are L* galaxies at different redshifts, and most faint galaxies are dwarf galaxies are dwarf galaxies throughout redshift



Manzioni in prep

How much optical background comes from galaxy halos?

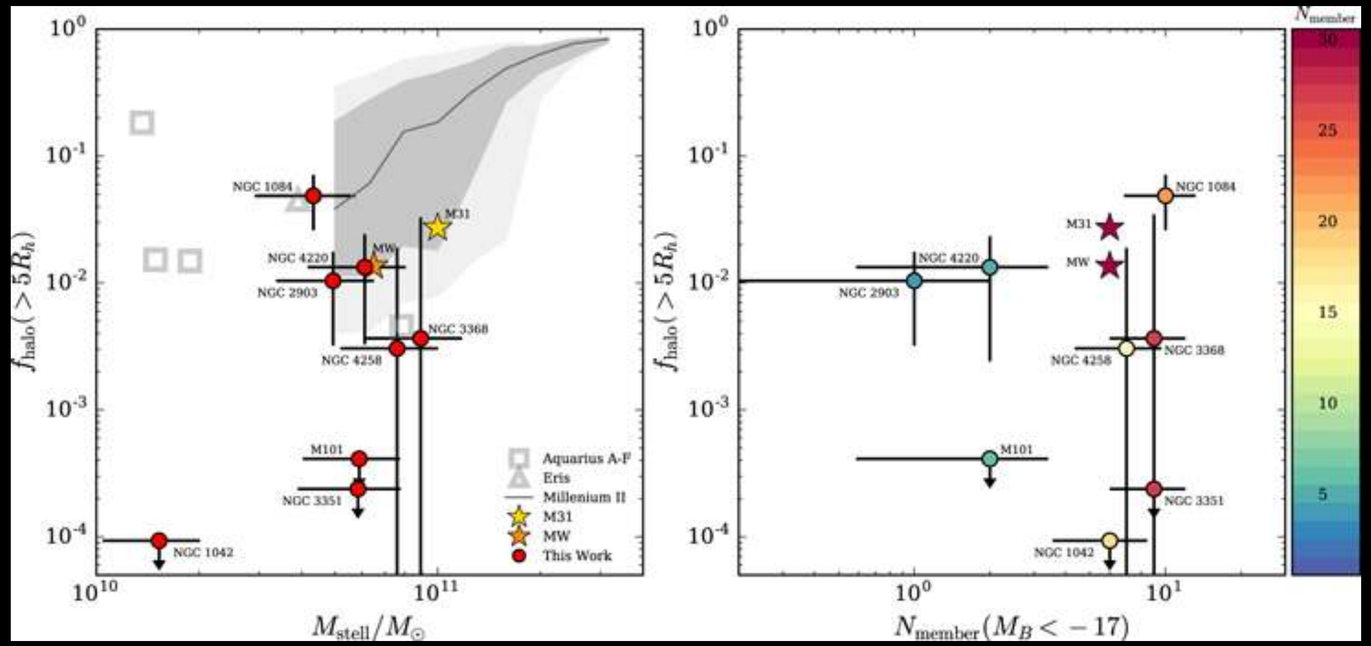




Merritt+16

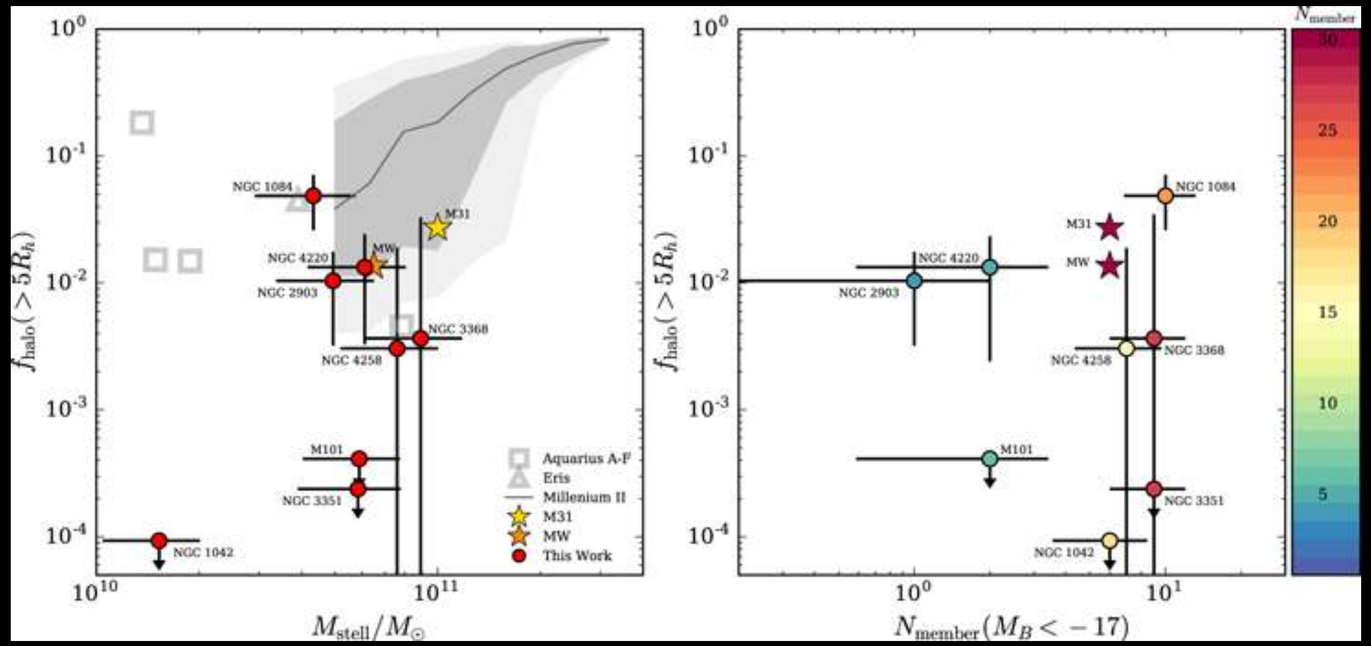
How much optical background comes from galaxy halos?

- From nearby galaxies: ~0-5% (Merritt+16)



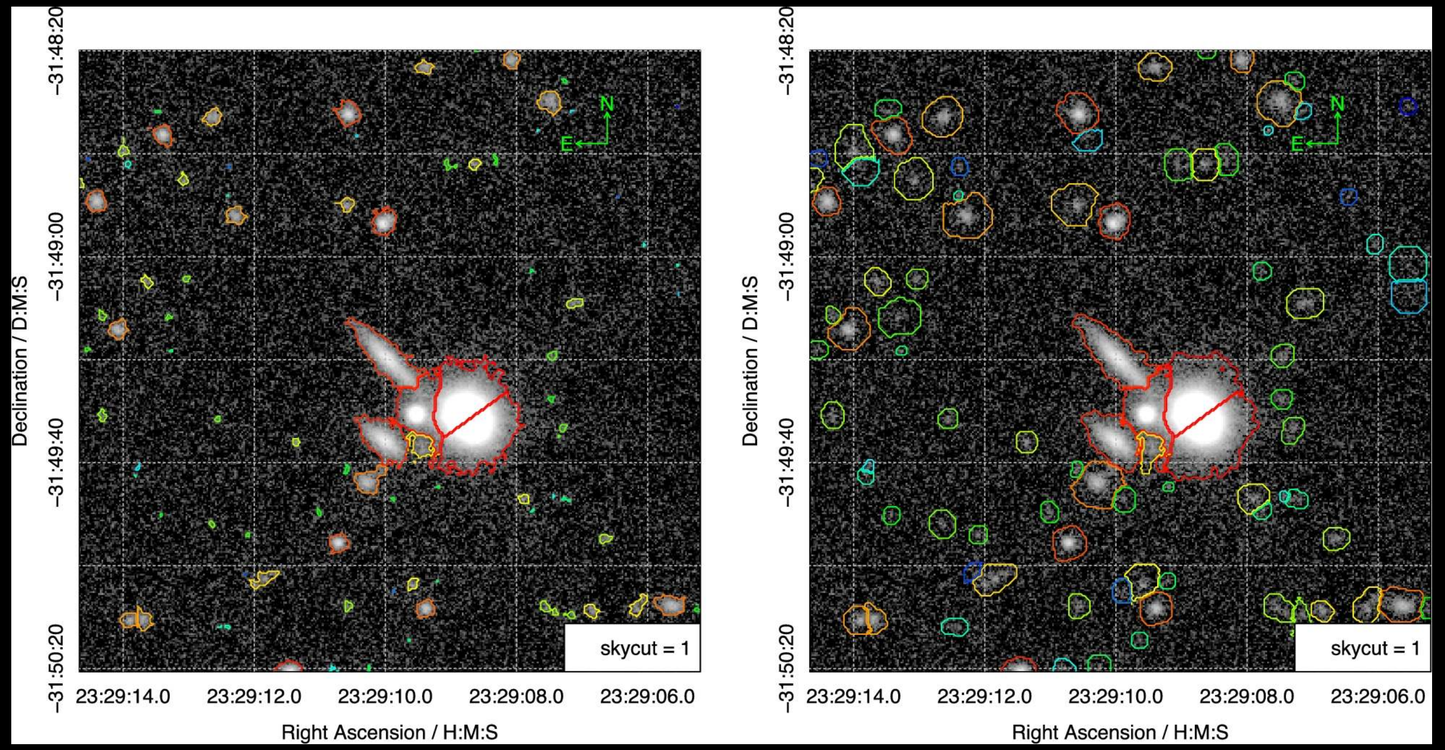
How much optical background comes from galaxy halos?

- From nearby galaxies: ~0-5% (Merritt+16)
- Just massive galaxies
- >1 dex scatter



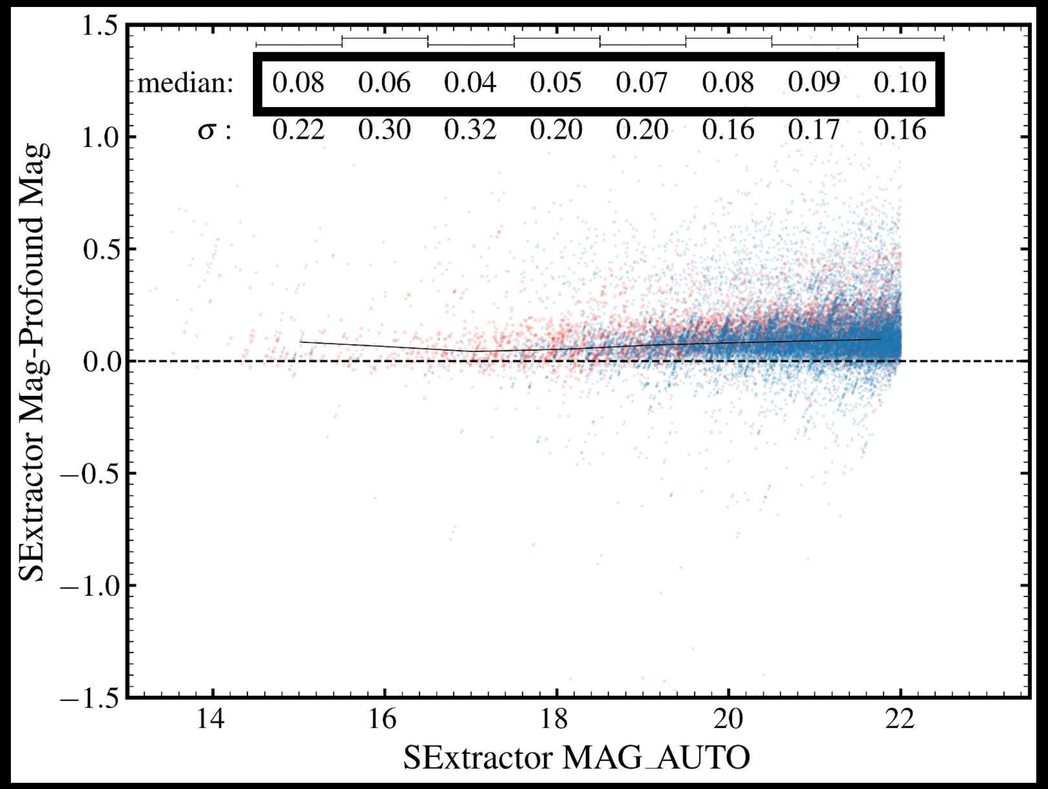
How much optical background comes from galaxy halos?

- Compare SExtractor (Kron magnitudes) to ProFound (apertures dilated until flux convergence)



How much optical background comes from galaxy halos?

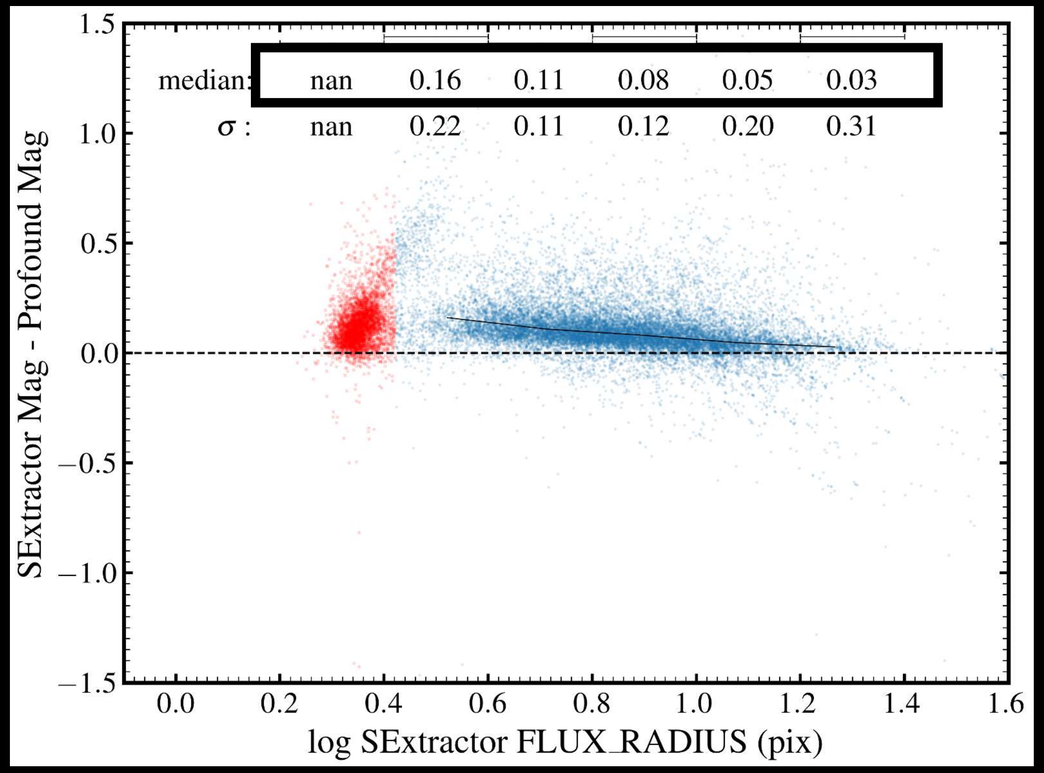
- ~5% for bright objects, ~10% for faint objects
- Agrees with Robotham+18, Miller+21



Carter+in prep

How much optical background comes from galaxy halos?

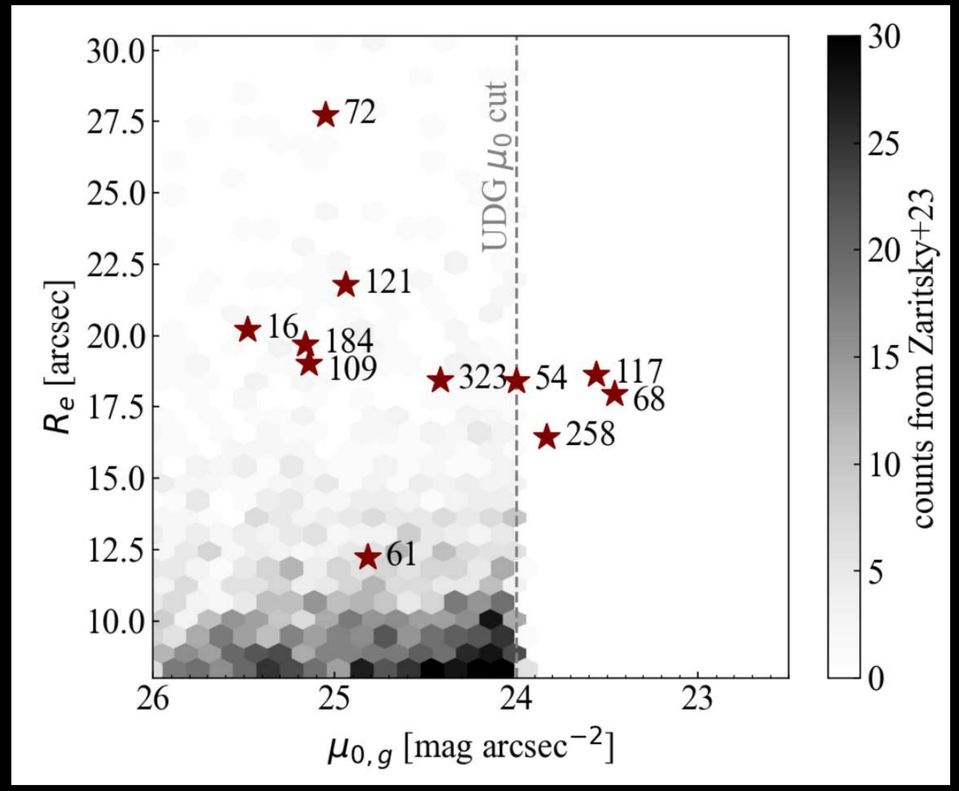
- ~10% for small objects, ~5% for large objects



Carter+in prep

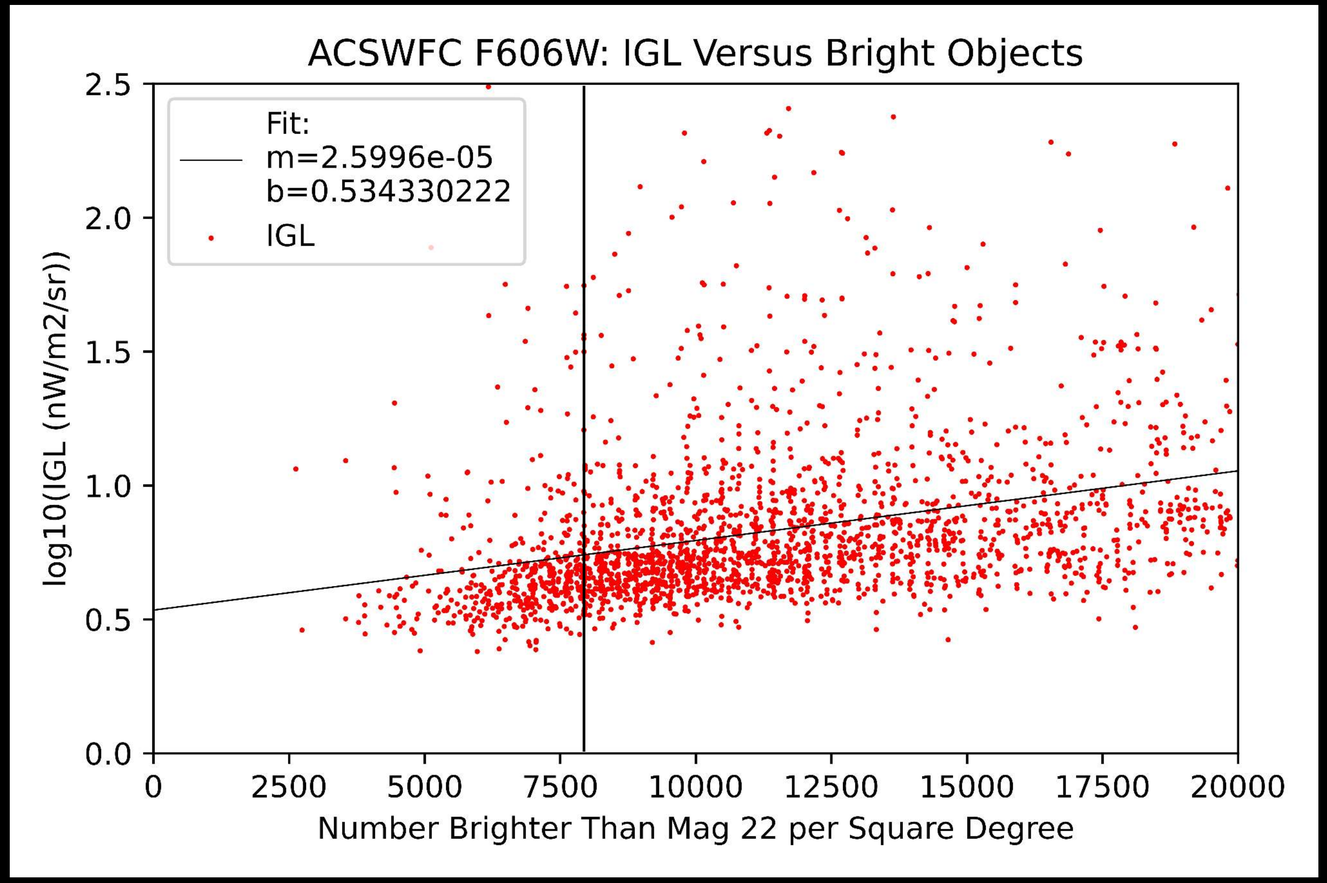
How much optical background comes from low surface brightness galaxies?

- SMUDGES (Zaritsky+23) searched extensively for low surface brightness galaxies in DECALS imaging
  - ~7000 objects in 20,000 sq. deg.: Total IGL for objects with $24<\mu_0<26$ and $R_e>5$” in DECALS is **0.0005 nW/m²/sr**
- Dragonfly Ultrawide Survey (Shen+24): ~300 more objects in 3100 sq. Deg.
- For reference, DECALS has ~10^4 galaxies *per square degree* in this magnitude range (AB~18-22)



How much optical background comes from galaxy groups/clusters?

- Quantify environment based on number of bright galaxies
- SKYSURF IGL measurements vary by ~0.5 dex depending on # of bright objects
- Slope of this correlation dependent on contribution of satellites to IGL



Carter in prep

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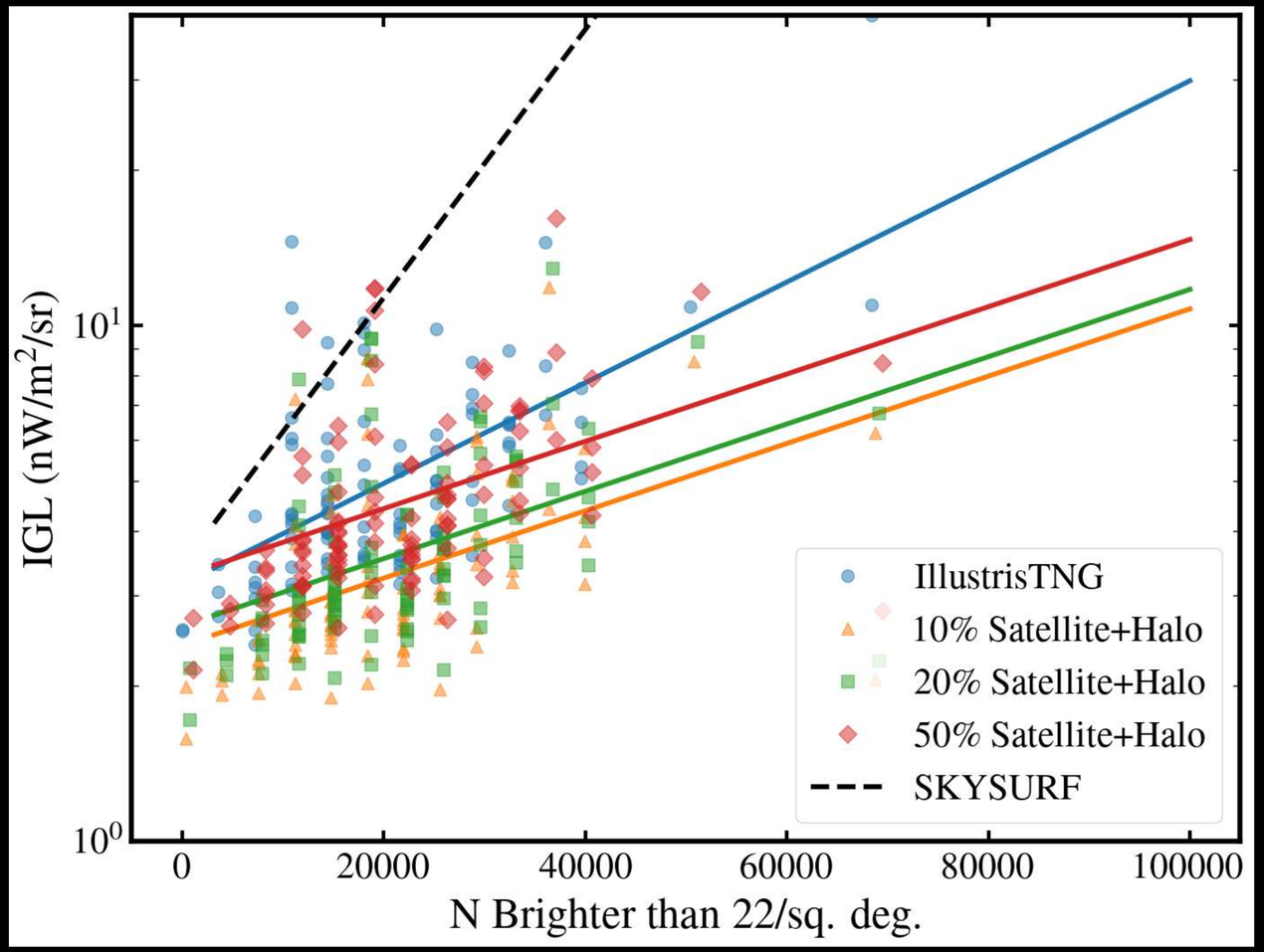

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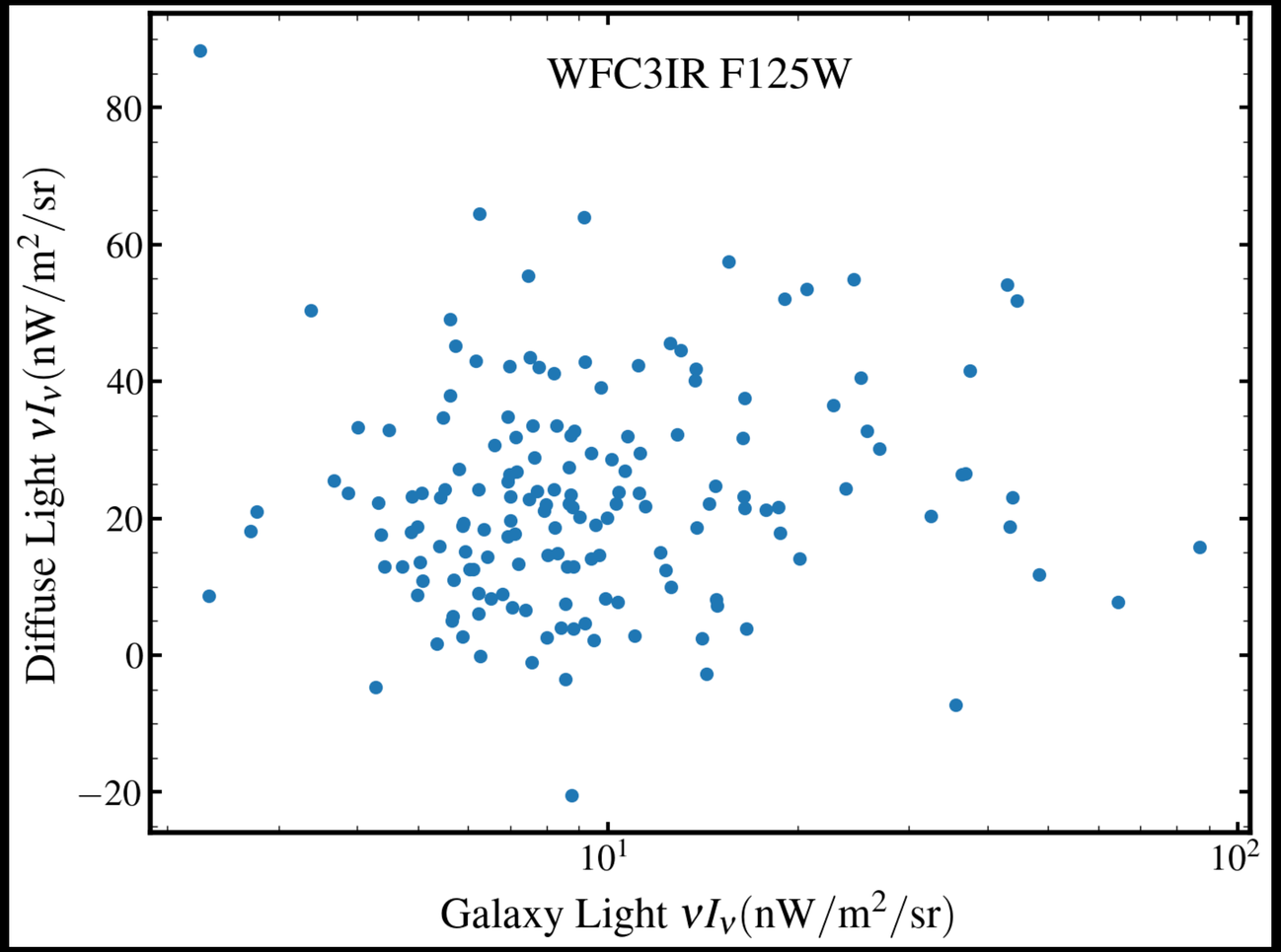
- No significant correlation between IGL and diffuse light levels -> no significant diffuse light *between* galaxies!



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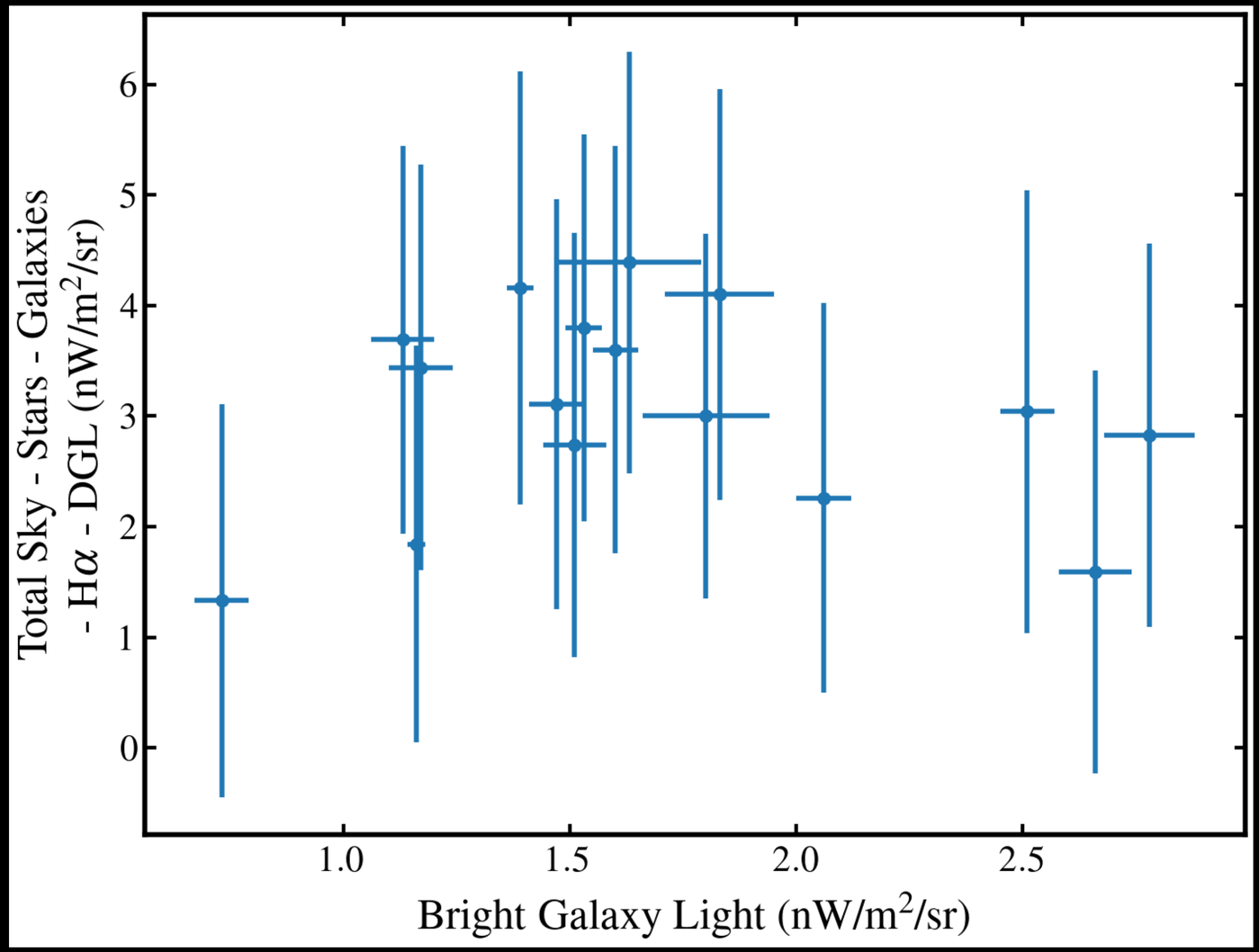

Conclusions

- SKYSURF robustly identifies galaxy light and converges on IGL value (see Simon’s talk)
- Galaxy outskirts contribute <~10% to galaxy light
- Low surface brightness galaxies don’t significantly contribute to IGL
- Cosmic variance of IGL is significant and physically interesting

Questions

SKYSURF Detection