Dust properties of galaxies at z~5-6

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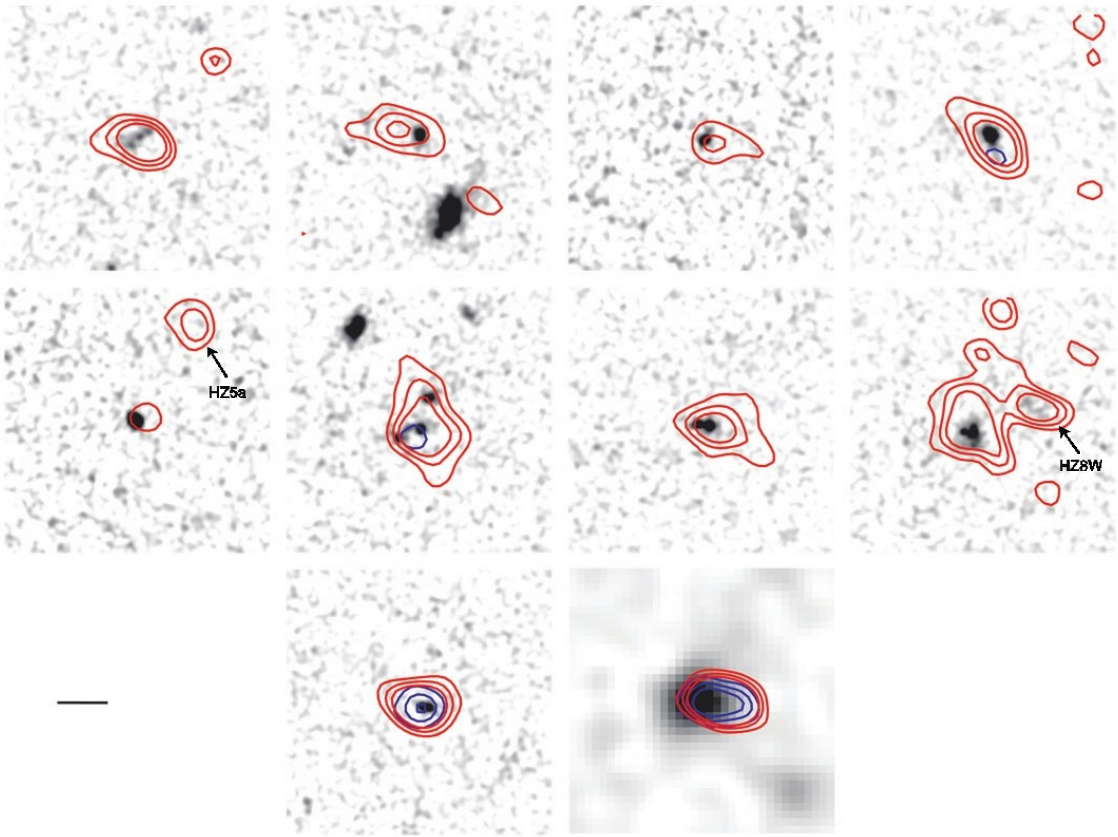
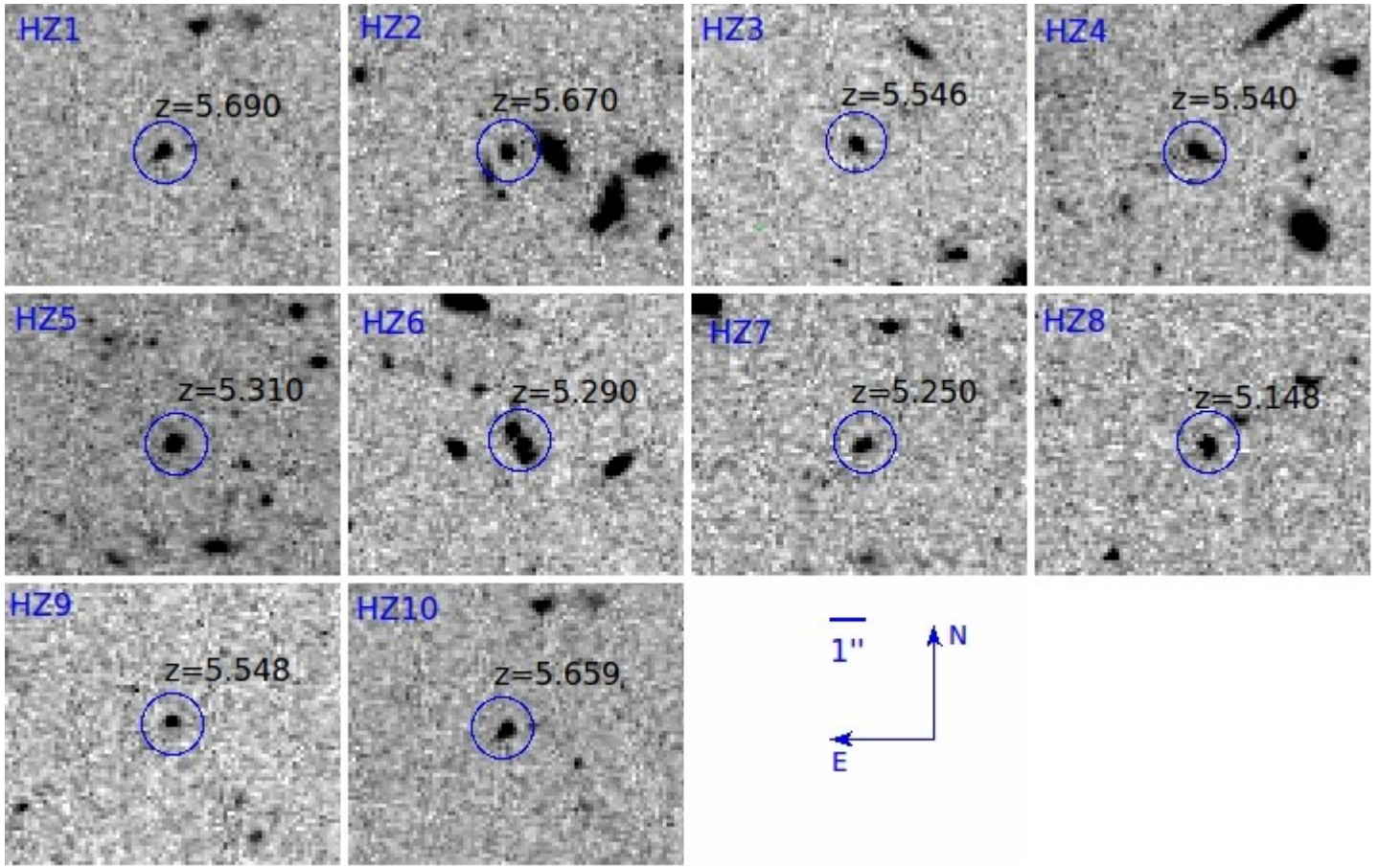
Background

- When did the first heavy elements form in the universe?
  - Dust forms from these
- When did they get into the interstellar medium and enrich it?
  - Dust is a signature of this
- How did this process change galaxy evolution?
  - Dust is very important for star formation in nearby galaxies
- Lets check with ALMA and HST!
- Selected 9 “Normal” objects and 1 quasar between 5.2<z<6
- Observed stars (UV) with HST
- Observed dust (IR) with ALMA
- Also go [CII] line (dynamics) with ALMA
  - Won’t talk about this here



Sample

- 9 galaxies and a quasar – COSMOS field
  - HST WFC-3 (3 bands, NIR)
- Redshift : z~5-6 – probing <u>rest-frame ultraviolet (UV)</u>



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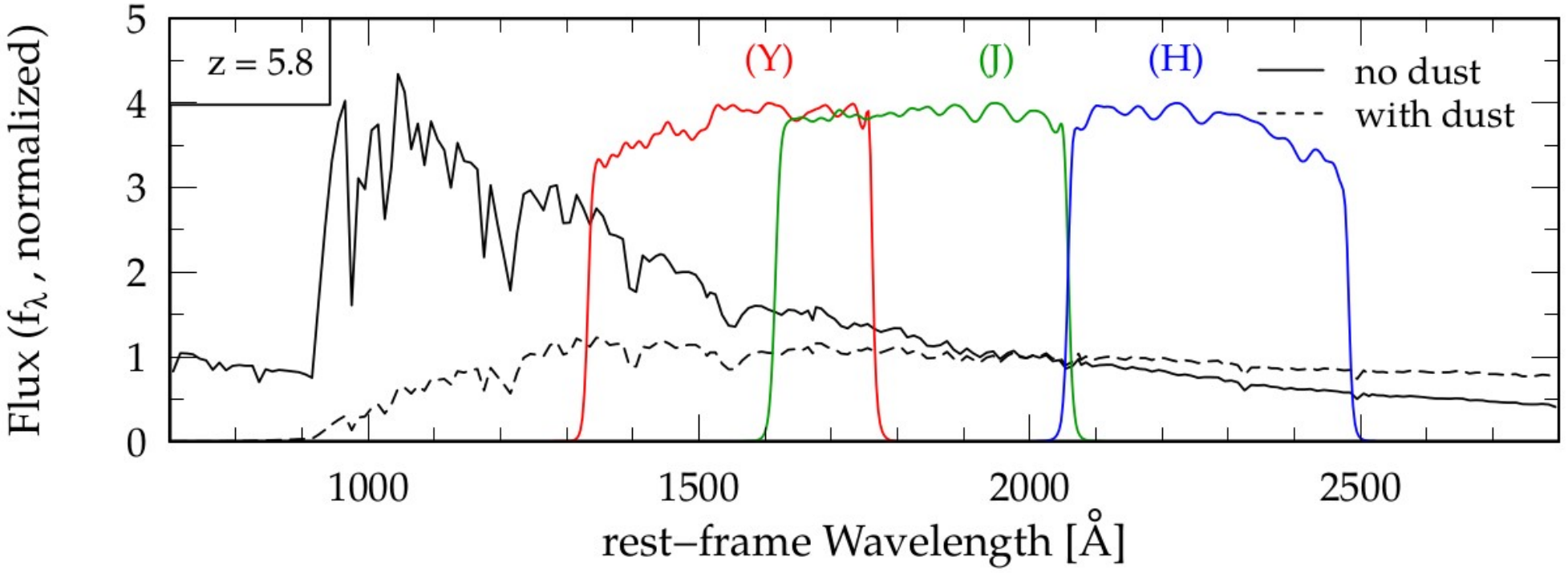

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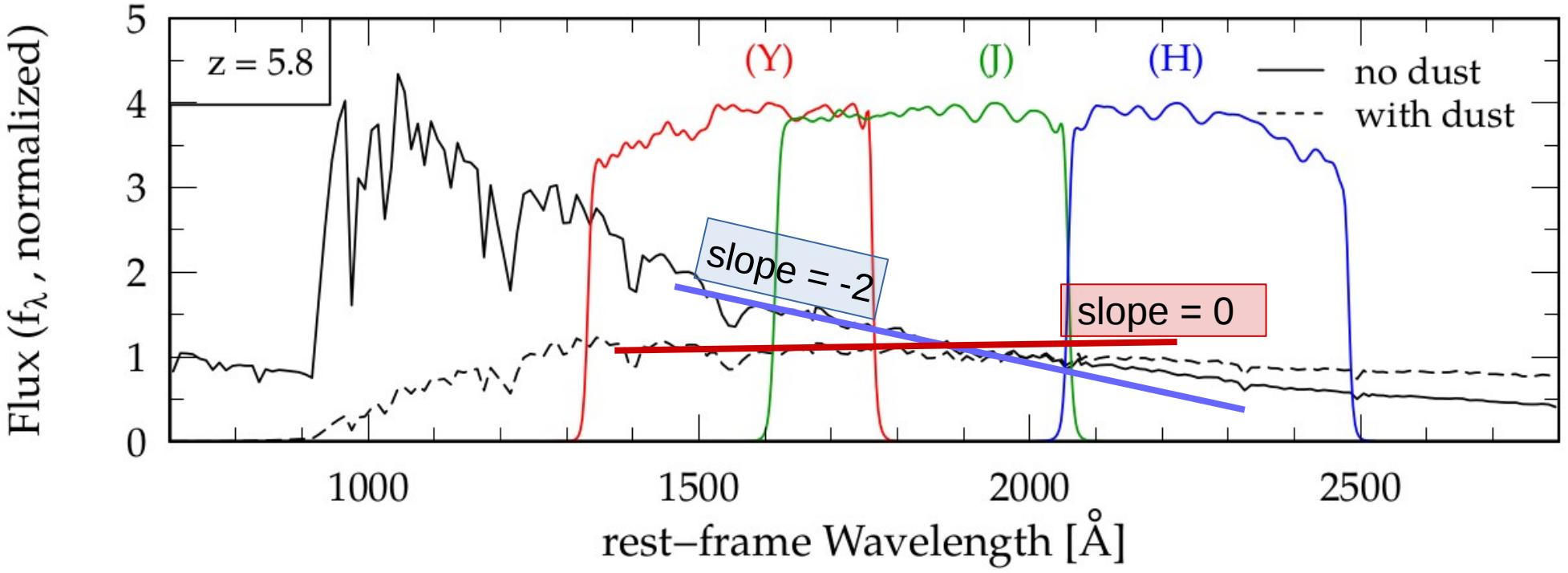
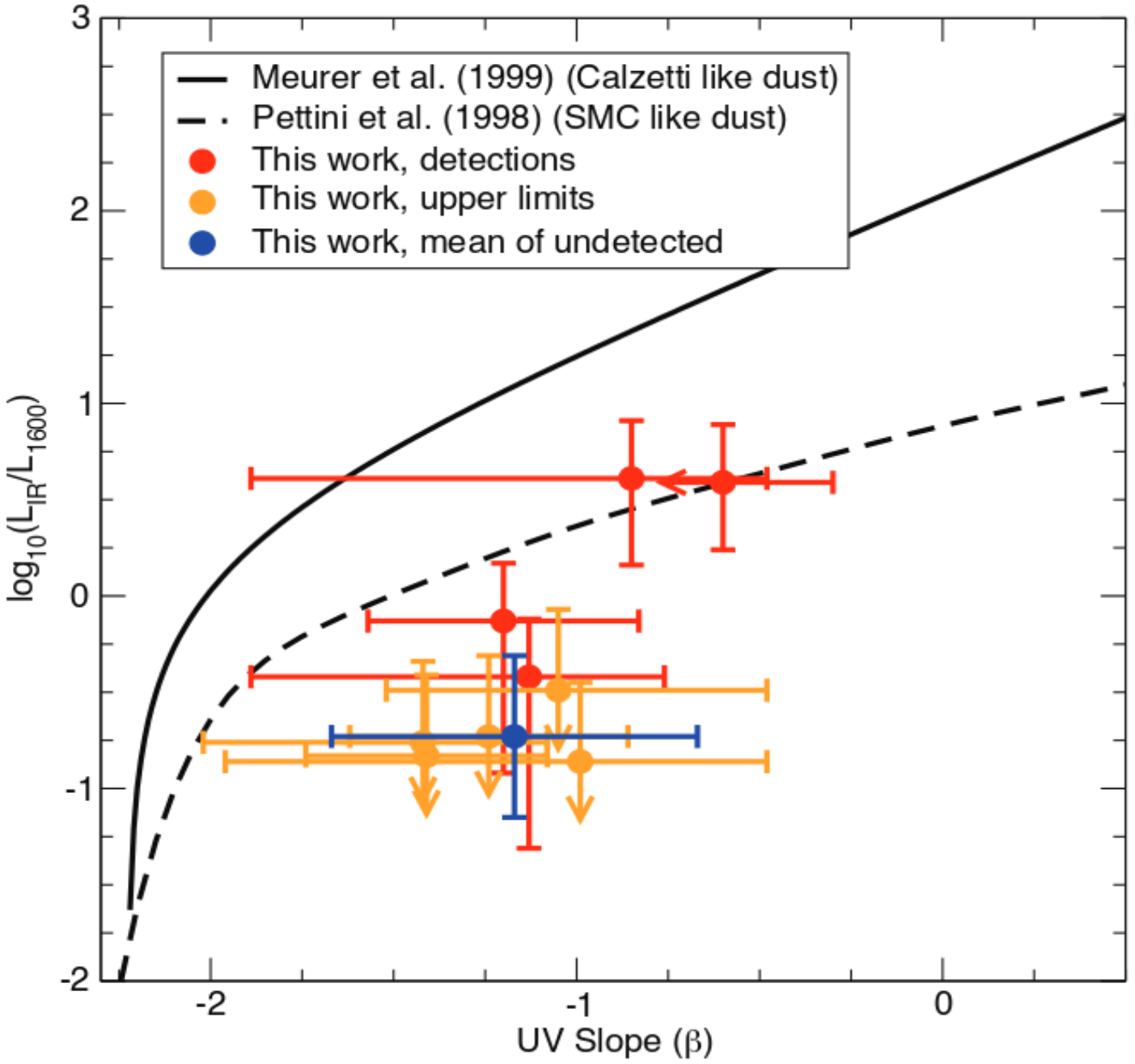
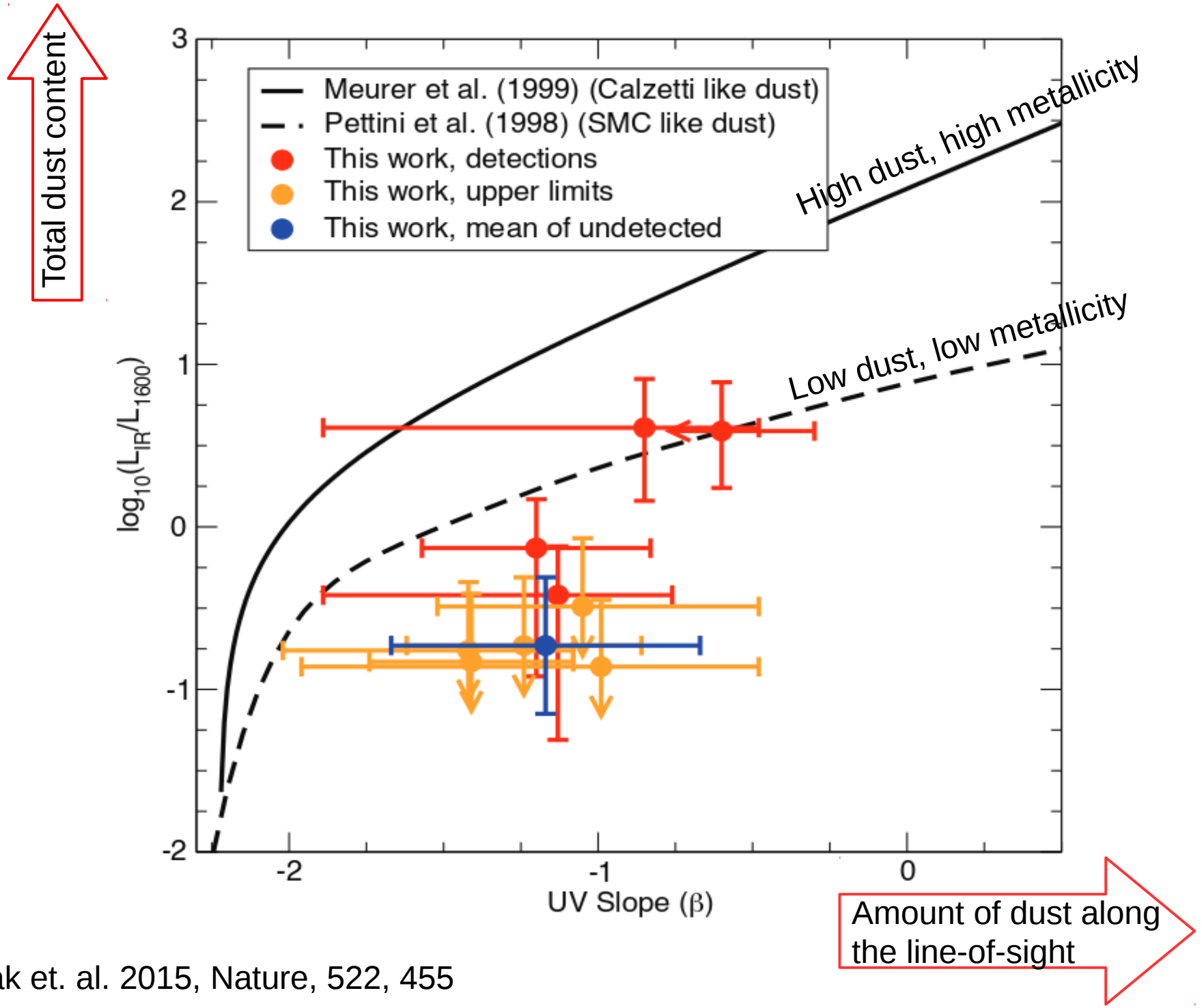




Capak et. al. 2015, Nature, 522, 455



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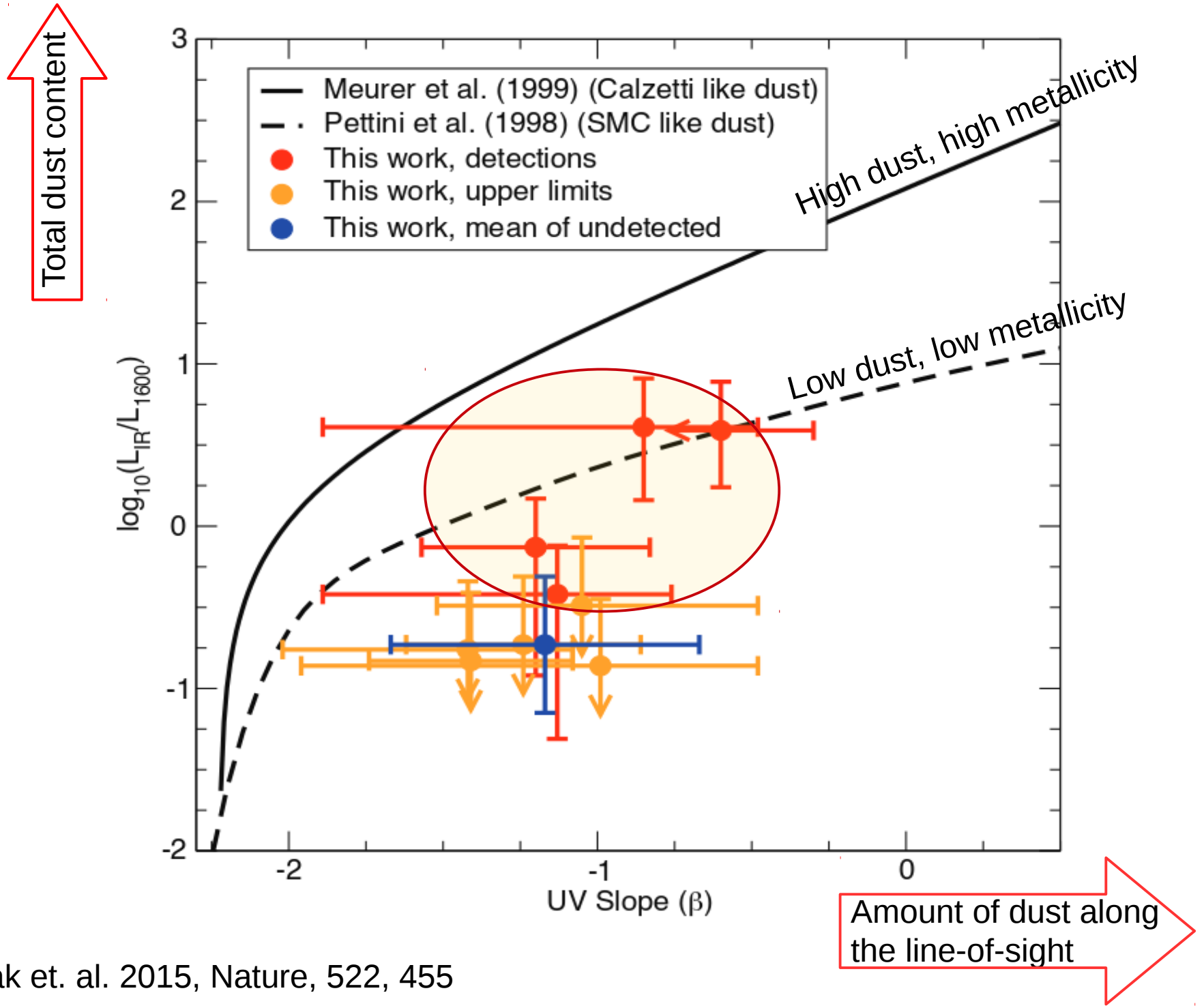

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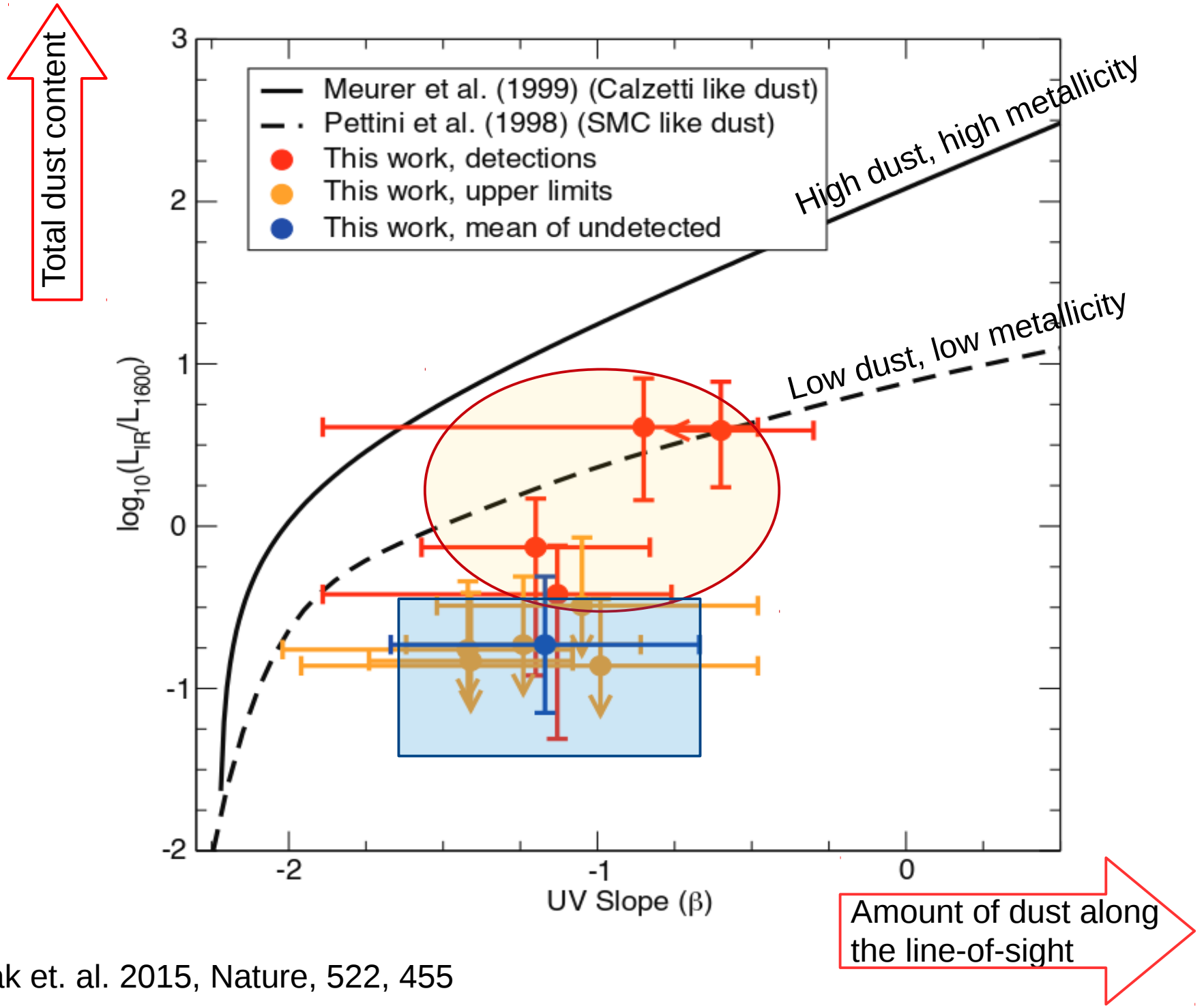

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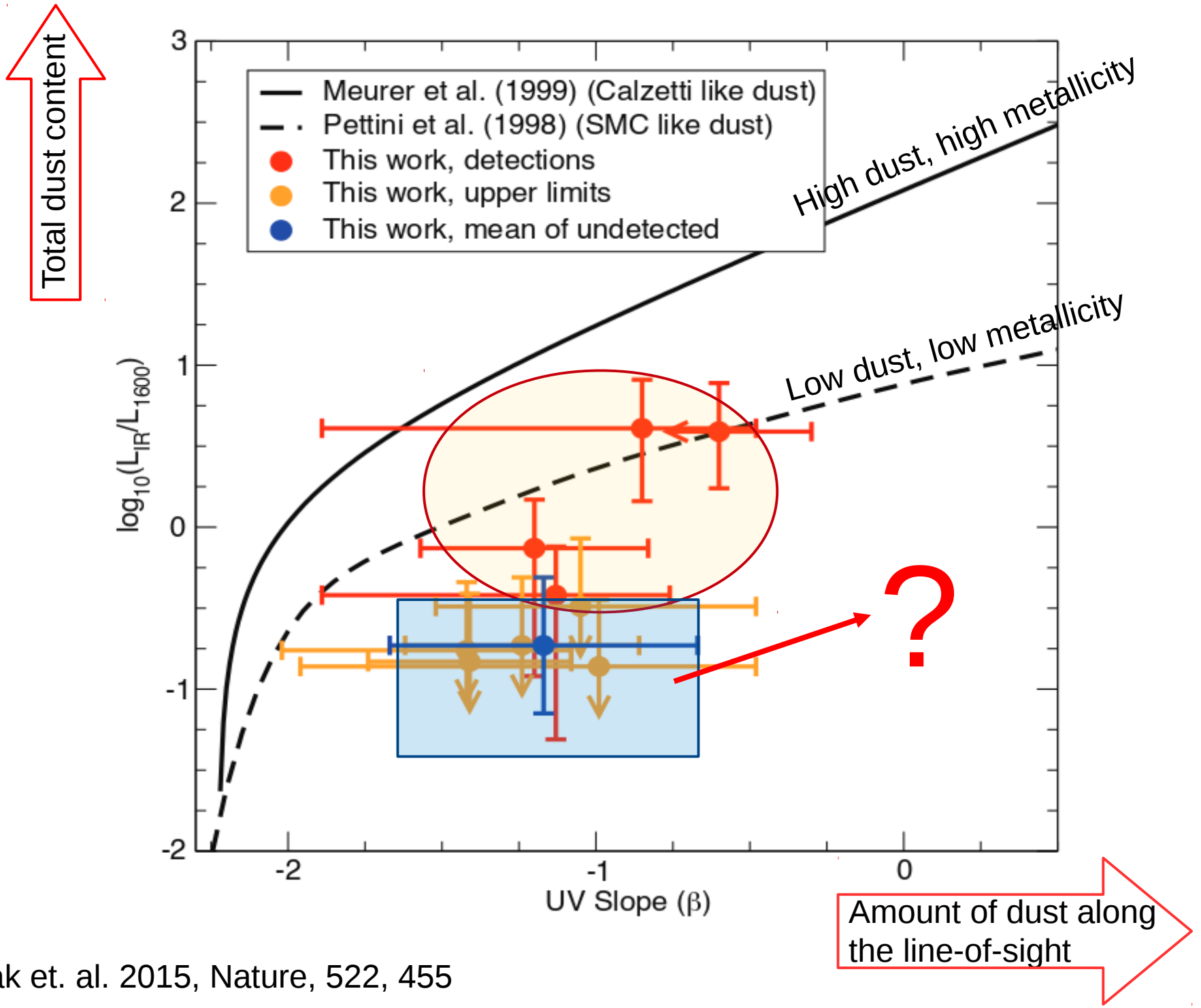

Capak et. al. 2015, Nature, 522, 455

Data

- ALMA(rest-frame FIR)
  - Infrared (IR) luminosity

Image by ESO/NAOJ/NRAO, ALMA

Data

- HST WFC-3
  - UV slope, UV luminosity
  - High accuracy
  - Deeper observations
  - High resolution

Image by NASA,
Hubble Space Telescope

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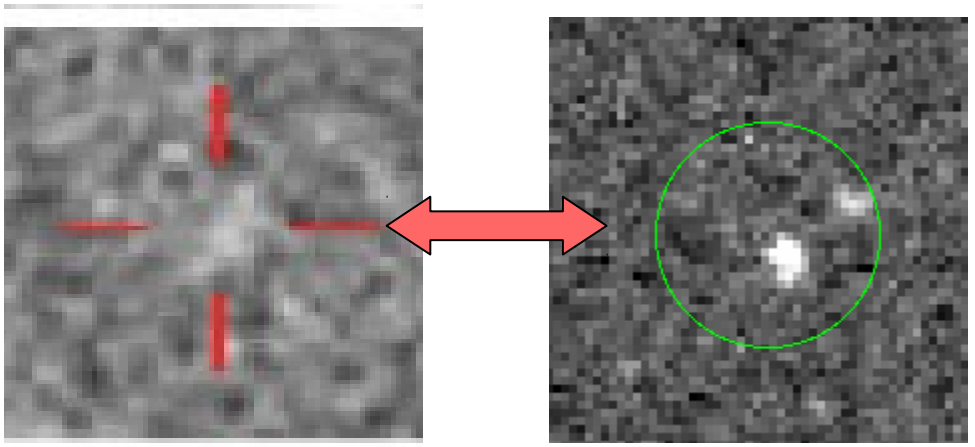
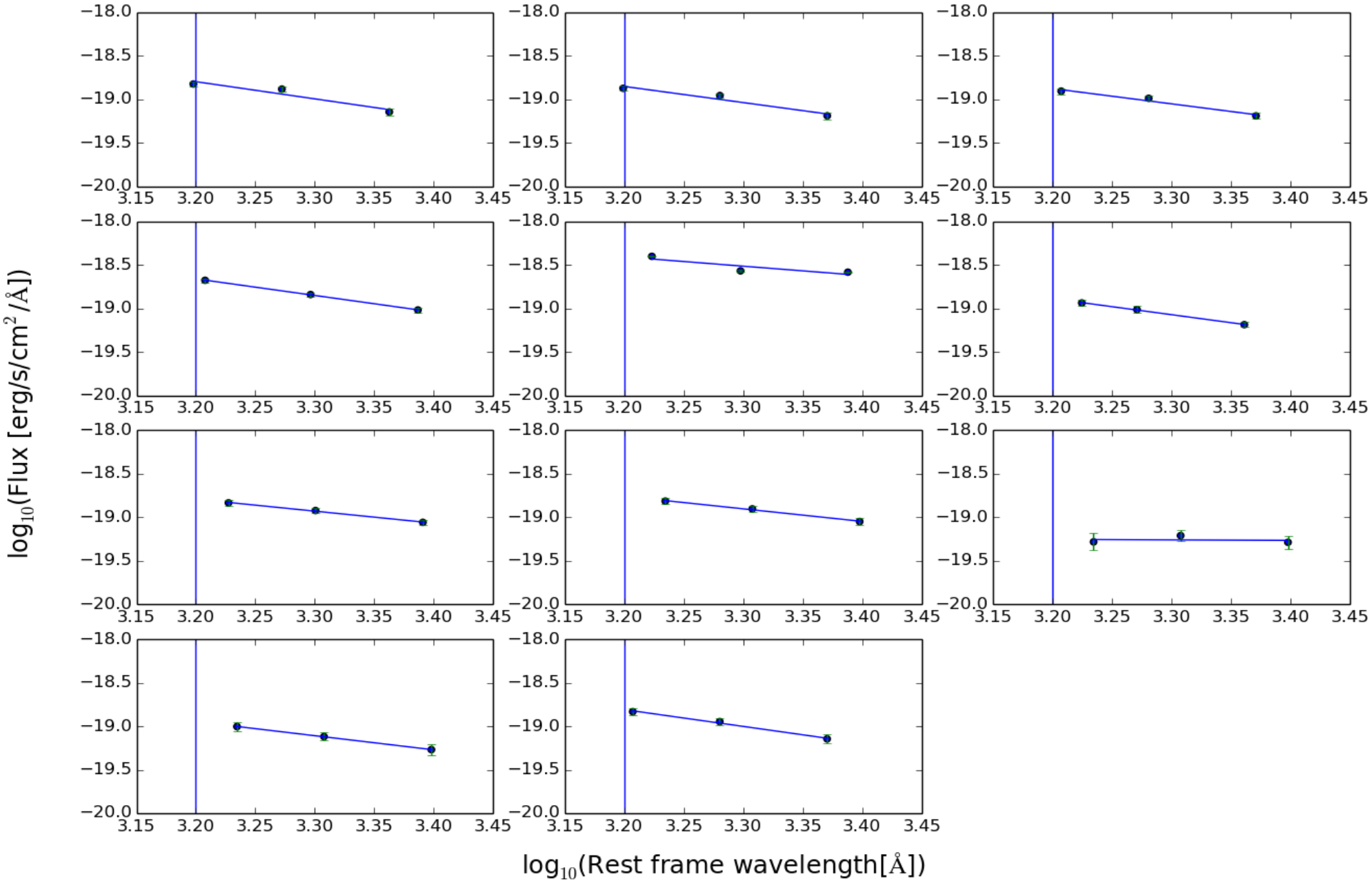


Ground based telescope vs. HST WFC-3
(comparison of the same source from the sample)

Image by NASA,
Hubble Space Telescope

Measurements



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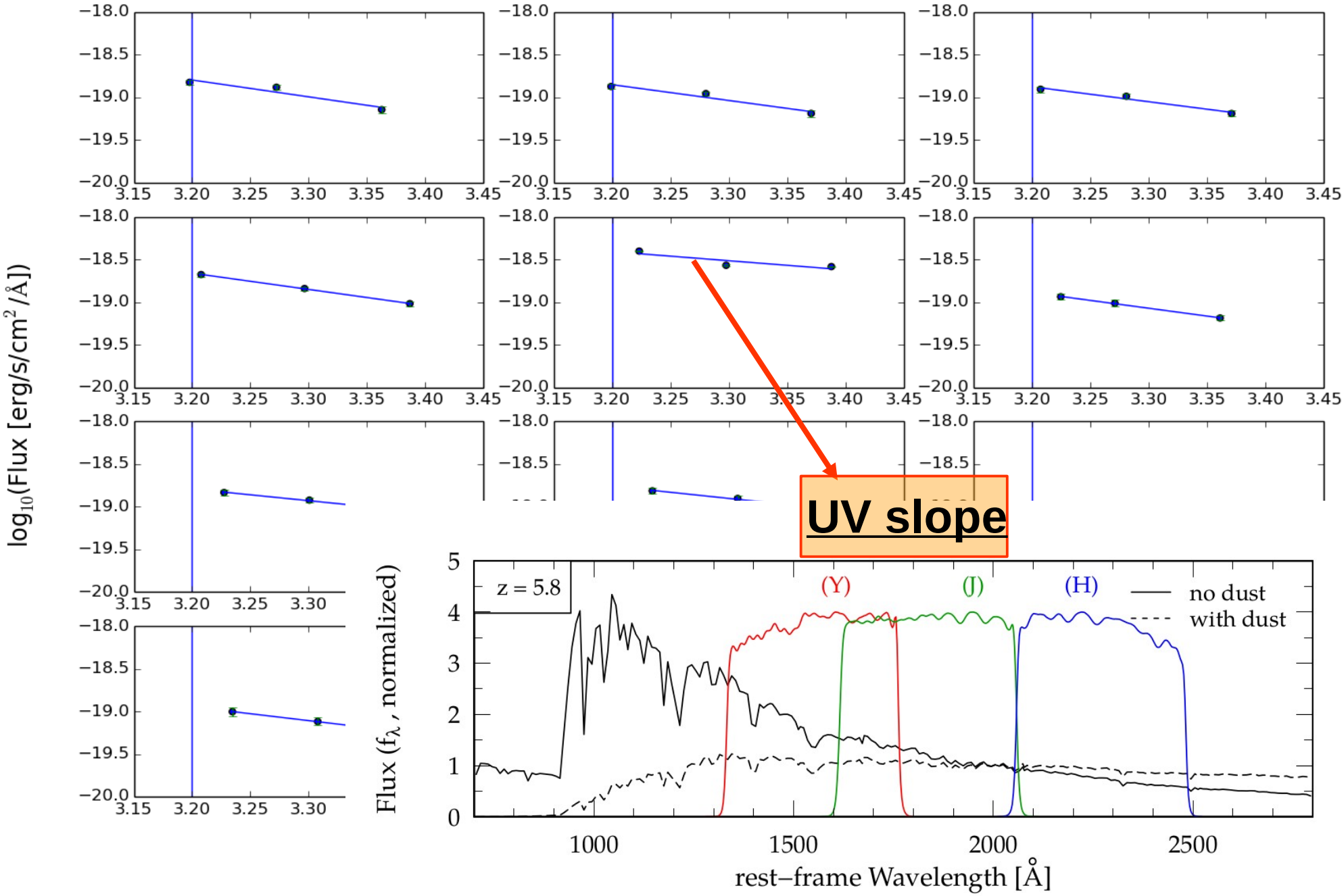
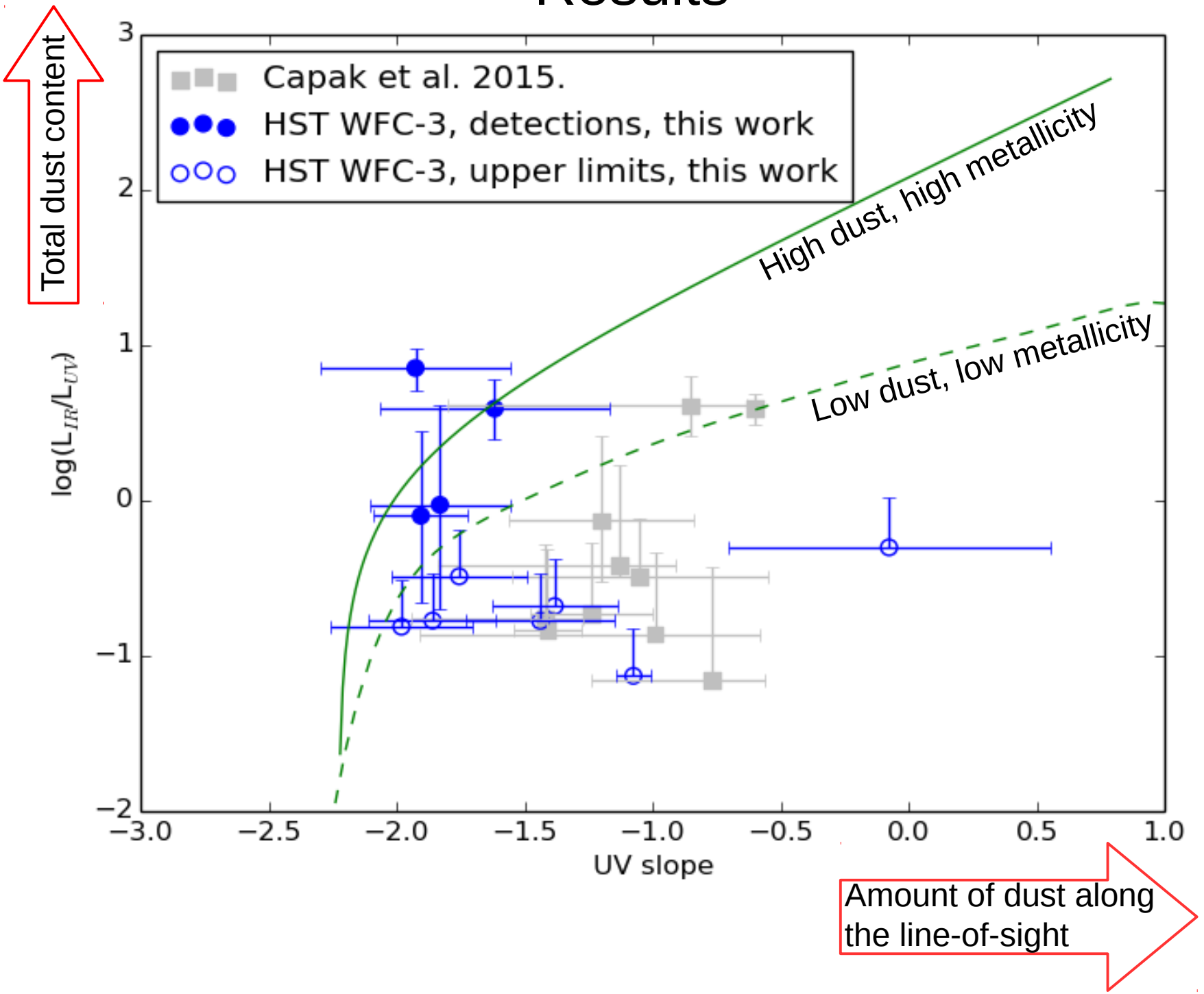
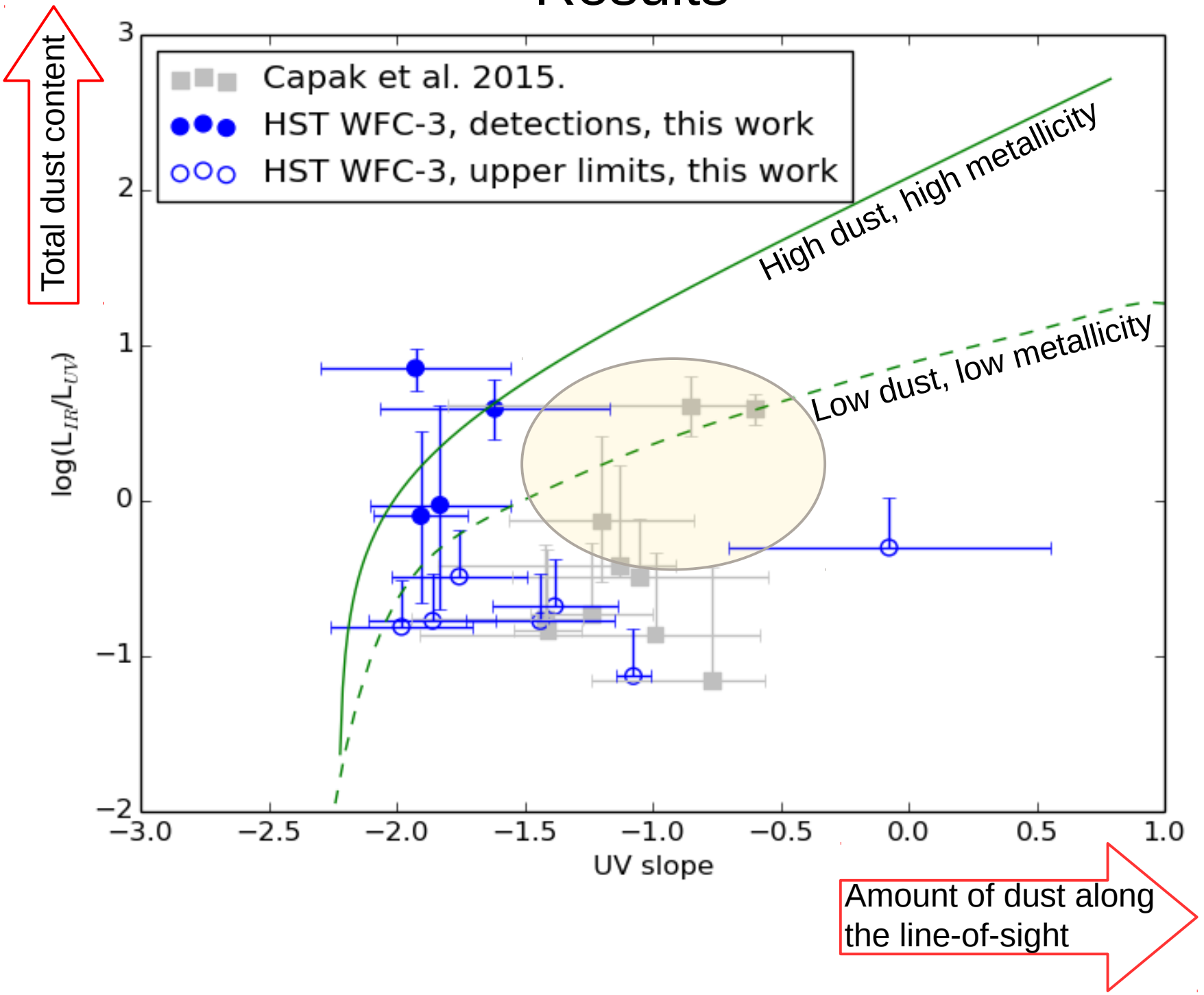


Results


Total dust content
Capak et al. 2015.
HST WFC-3, detections, this work
HST WFC-3, upper limits, this work
High dust, high metallicity
Low dust, low metallicity
log(L_IR/L_UV)
UV slope
3
2
1
0
−1
−2
−3.0
−2.5
−2.0
−1.5
−1.0
−0.5
0.0
0.5
1.0
Amount of dust along the line-of-sight

Results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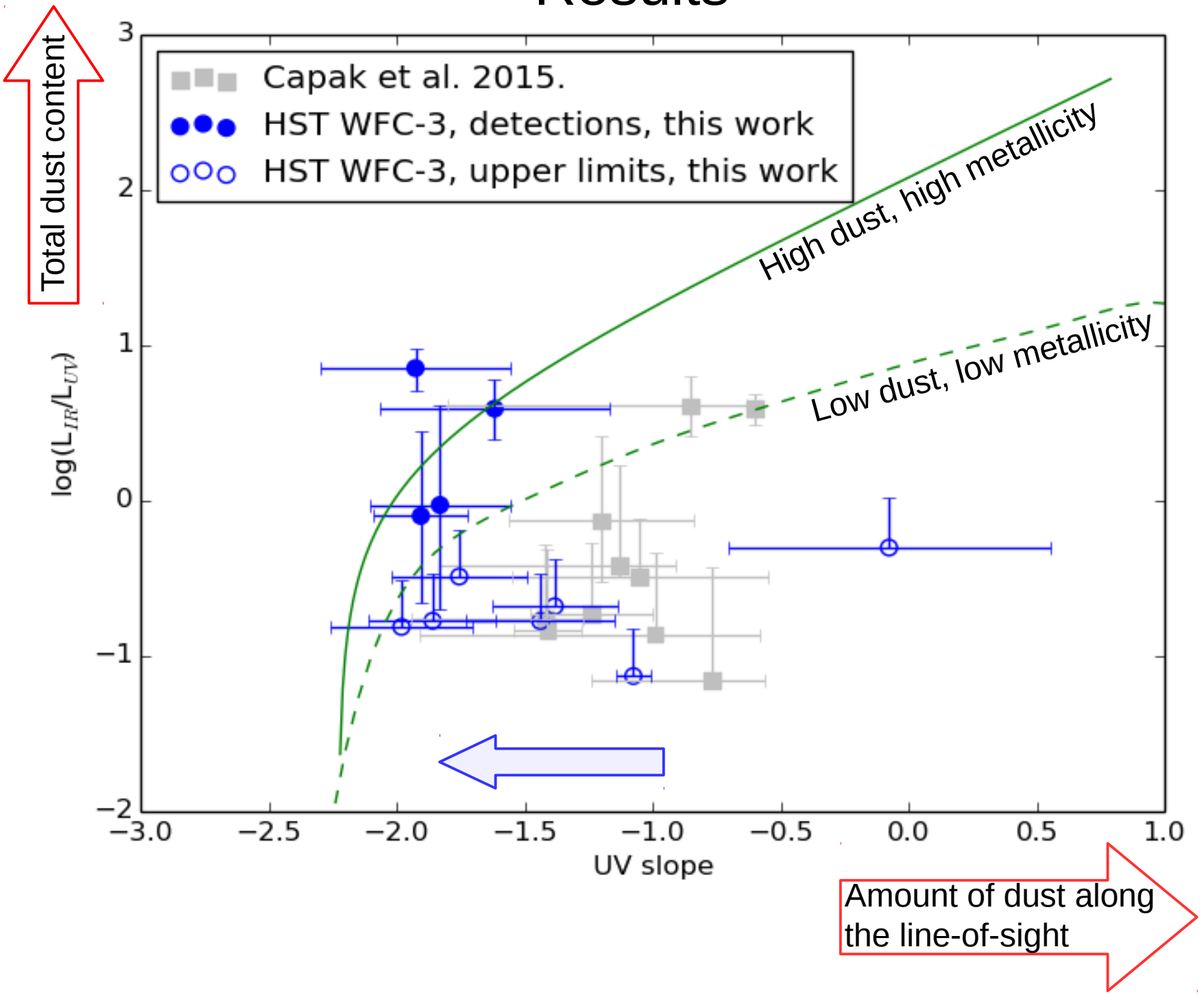
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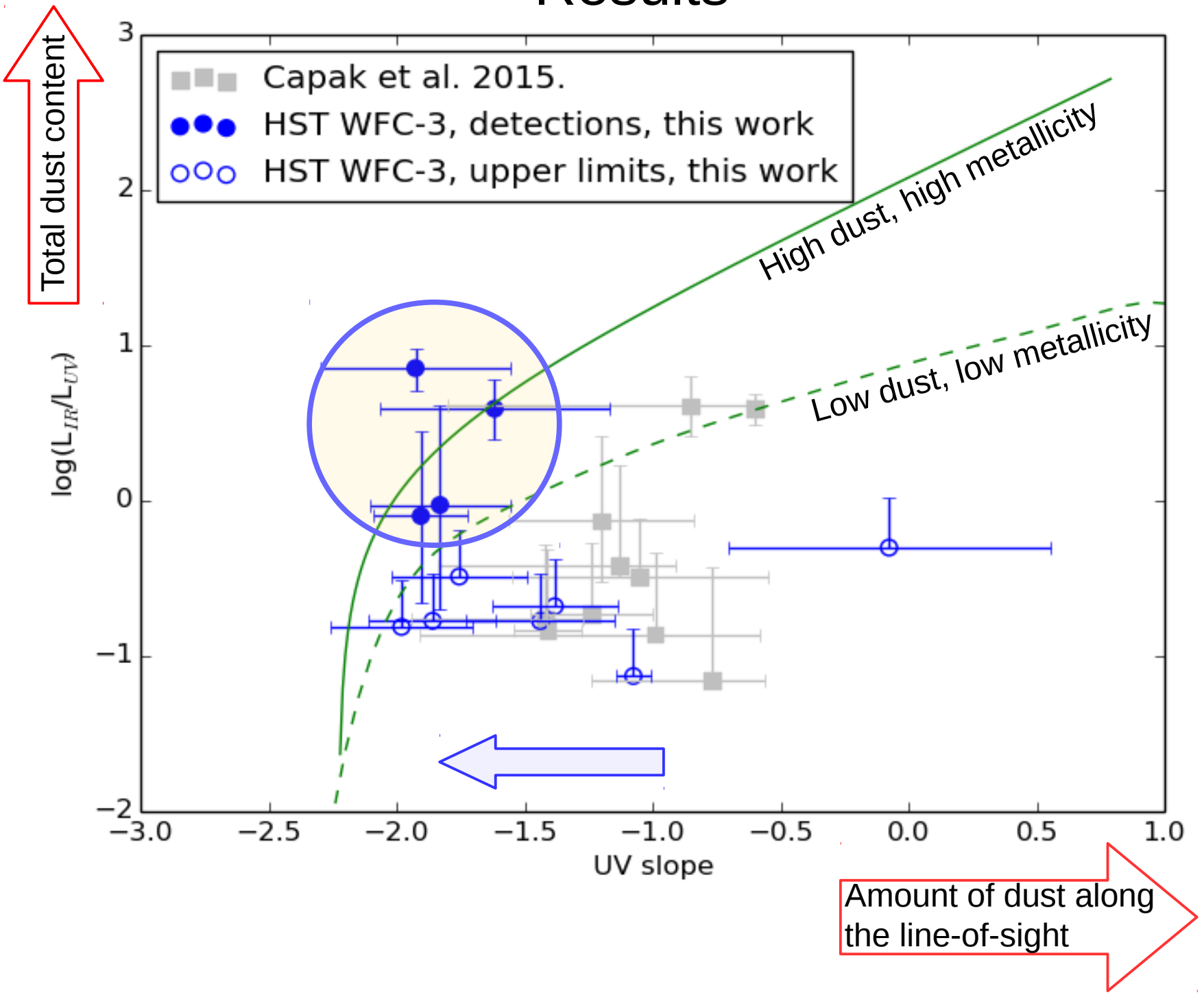
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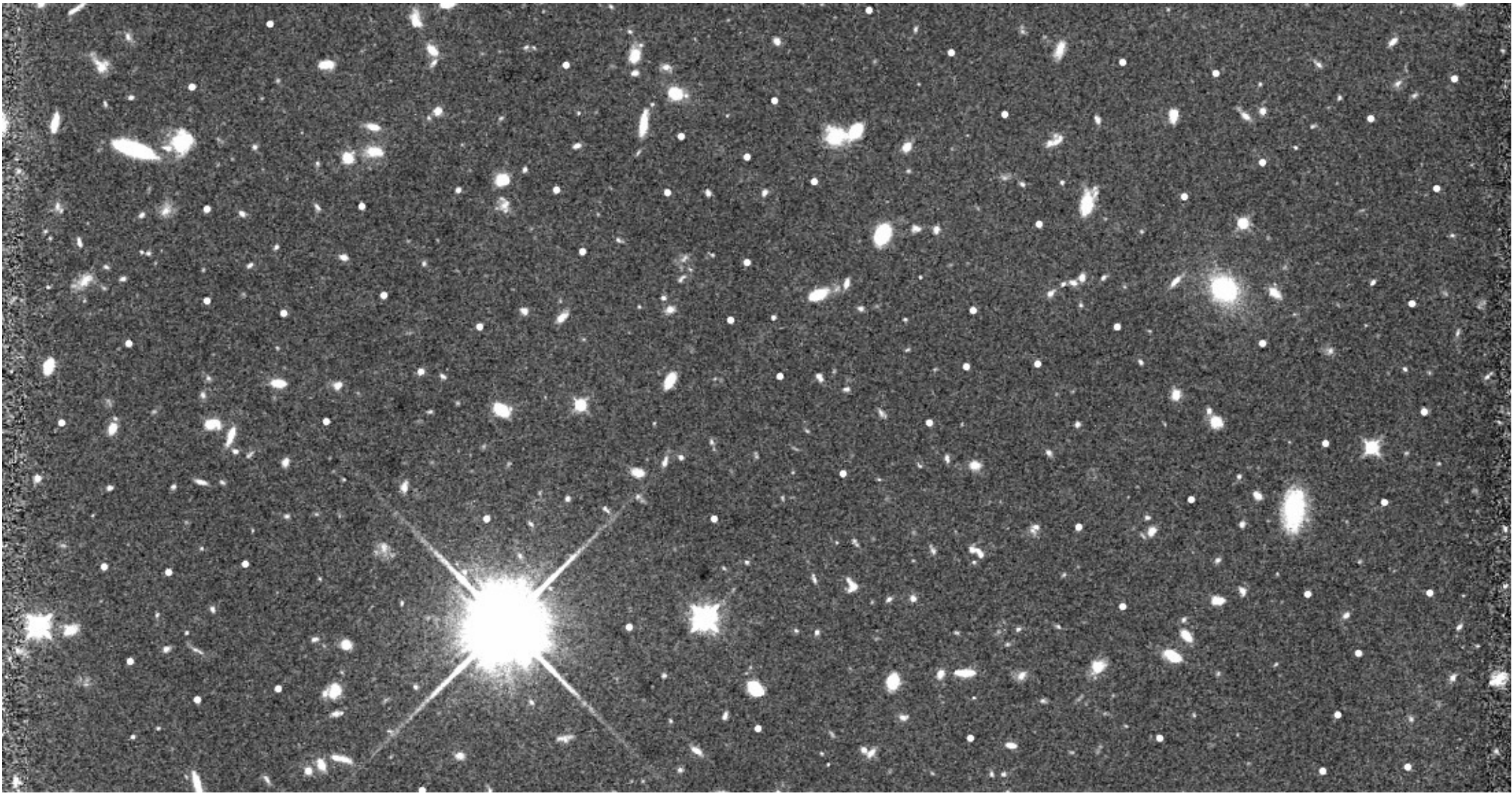
Simulations



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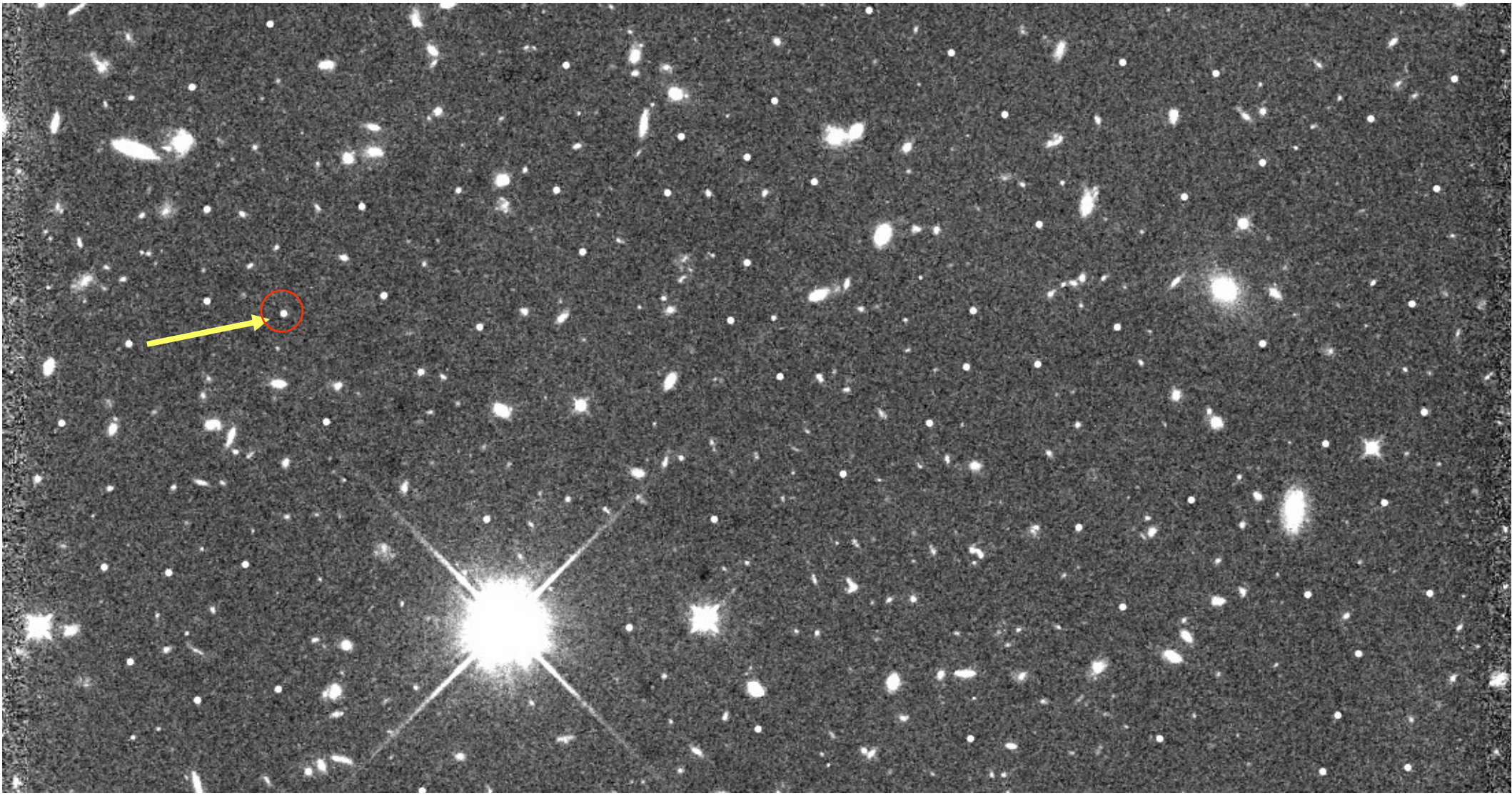

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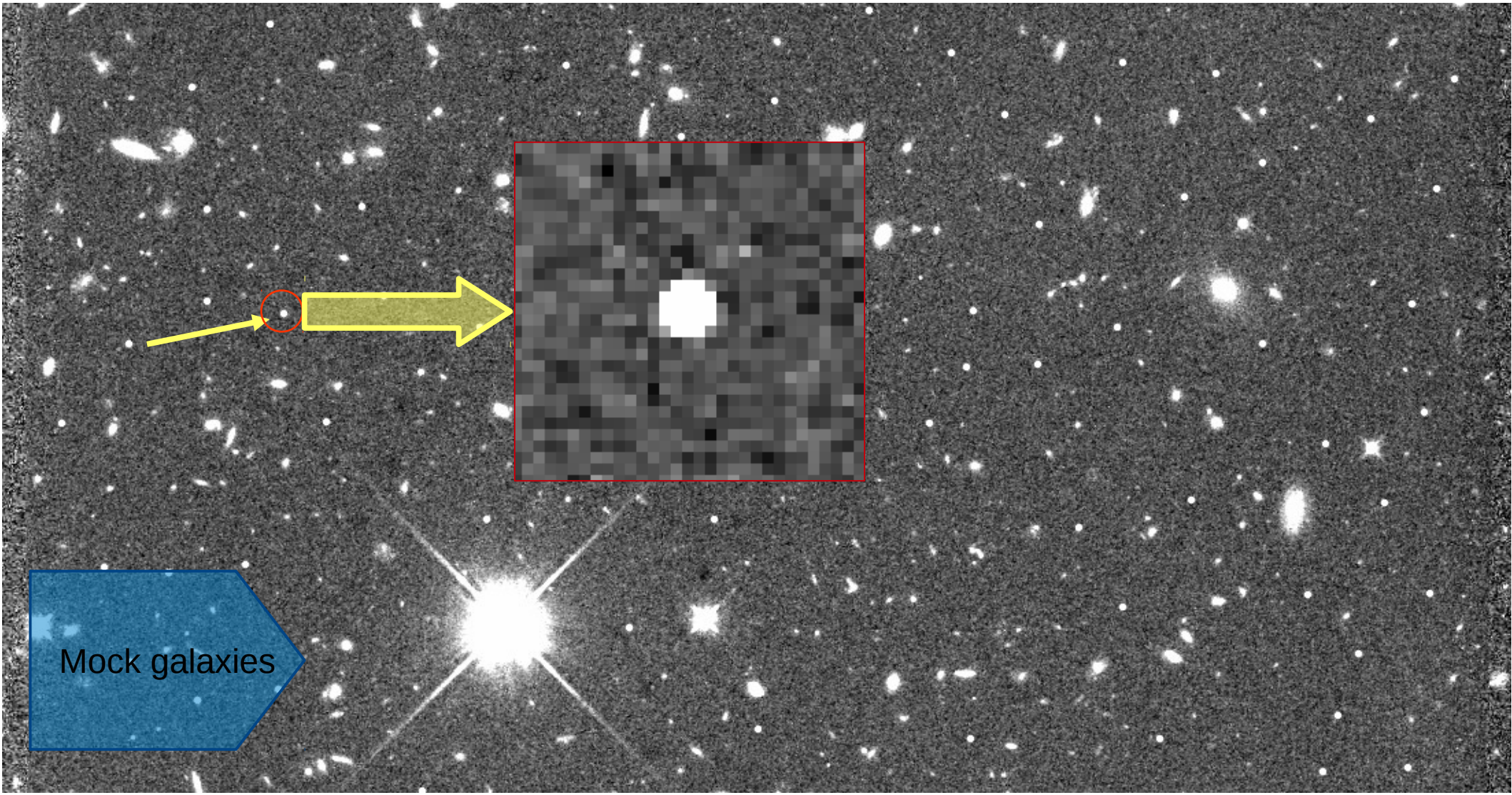

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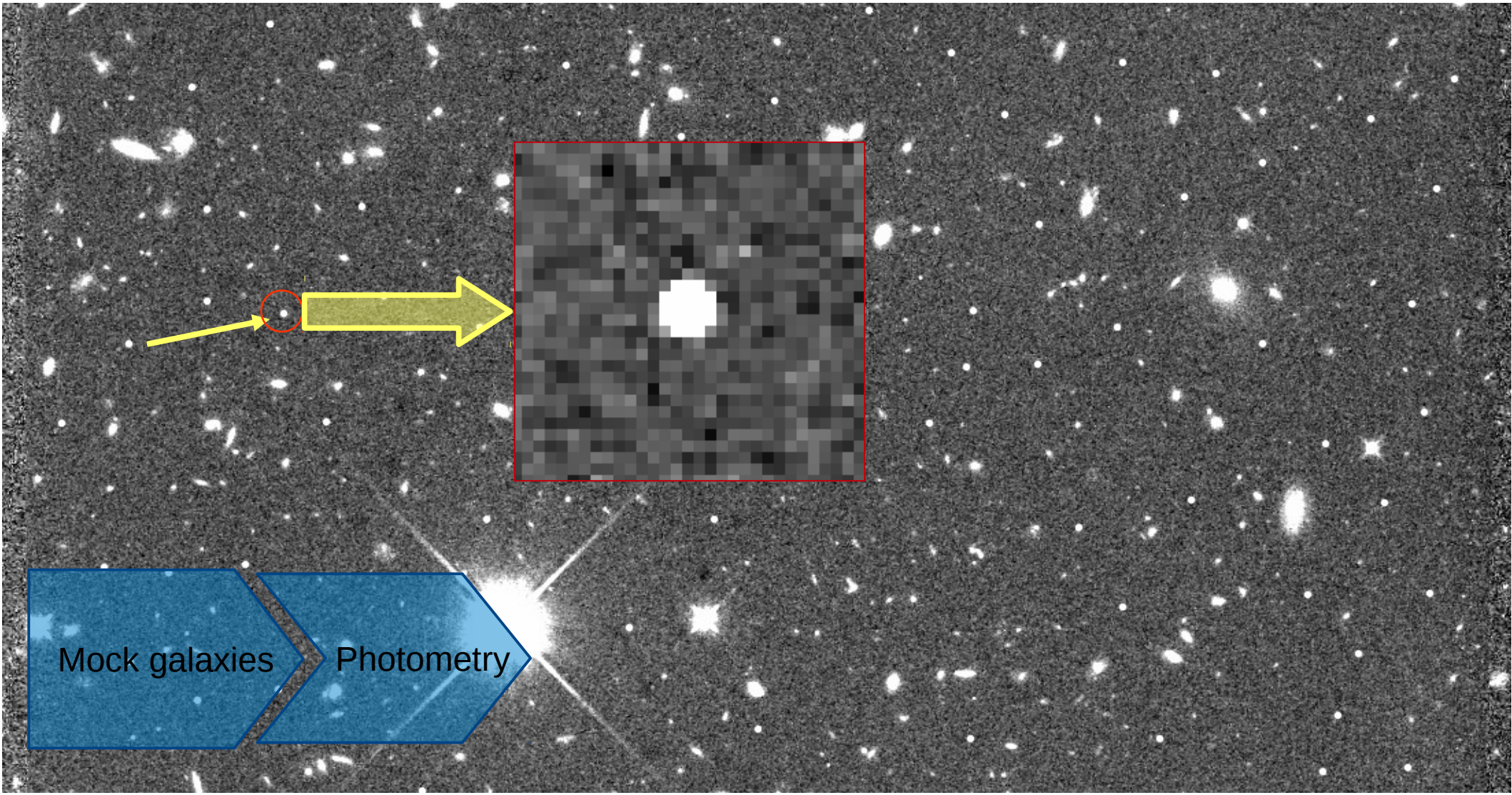

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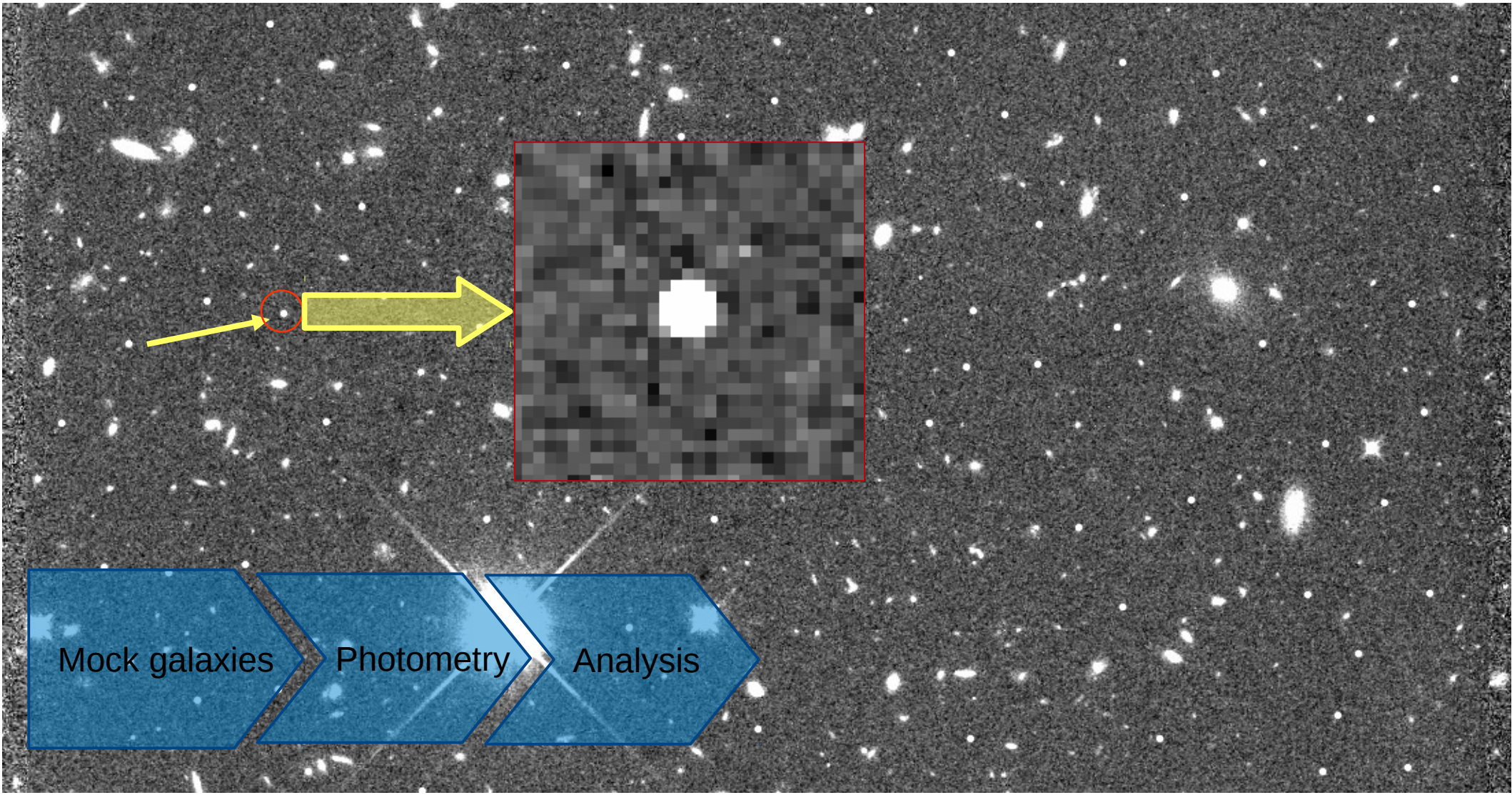

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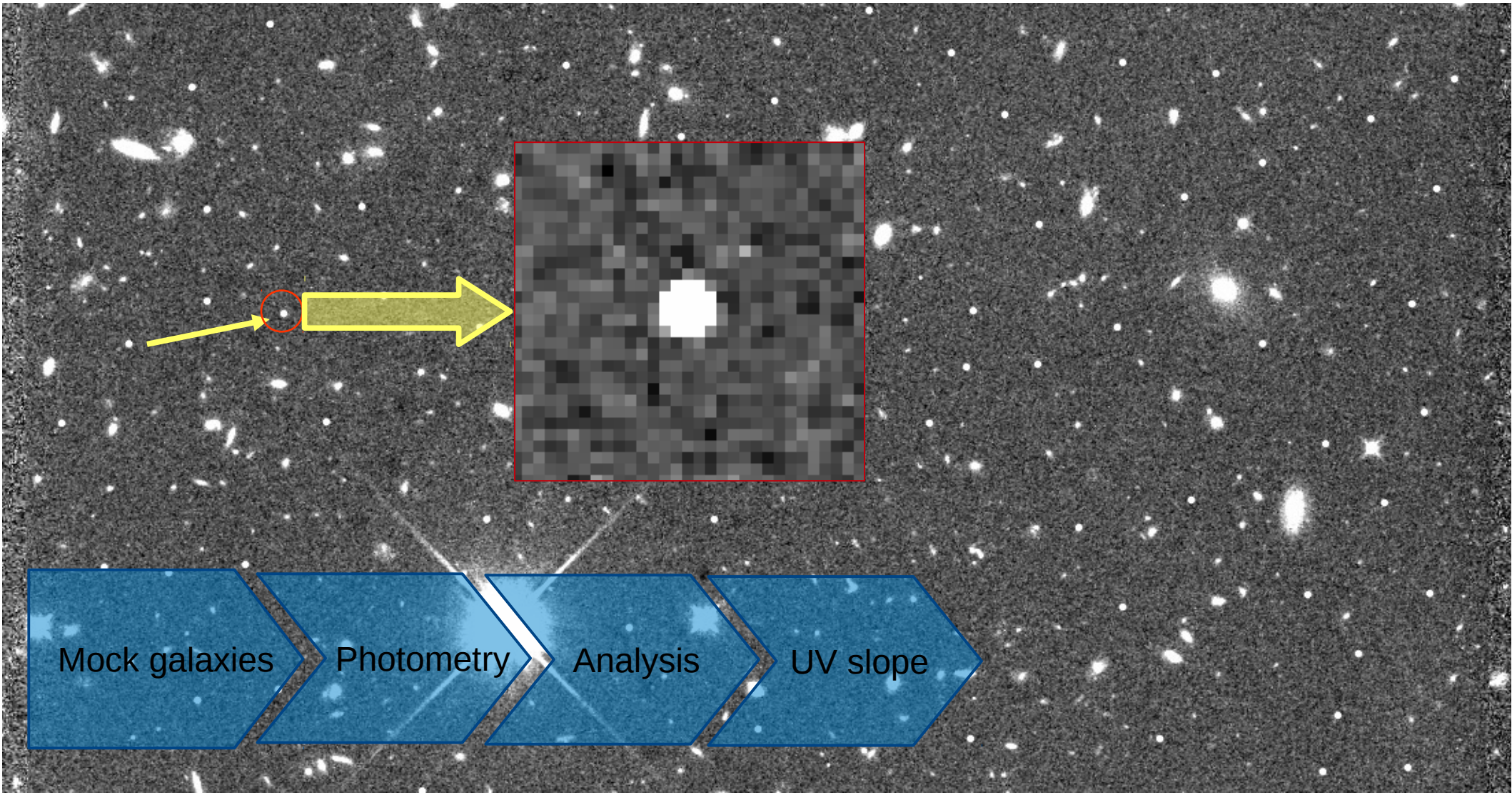

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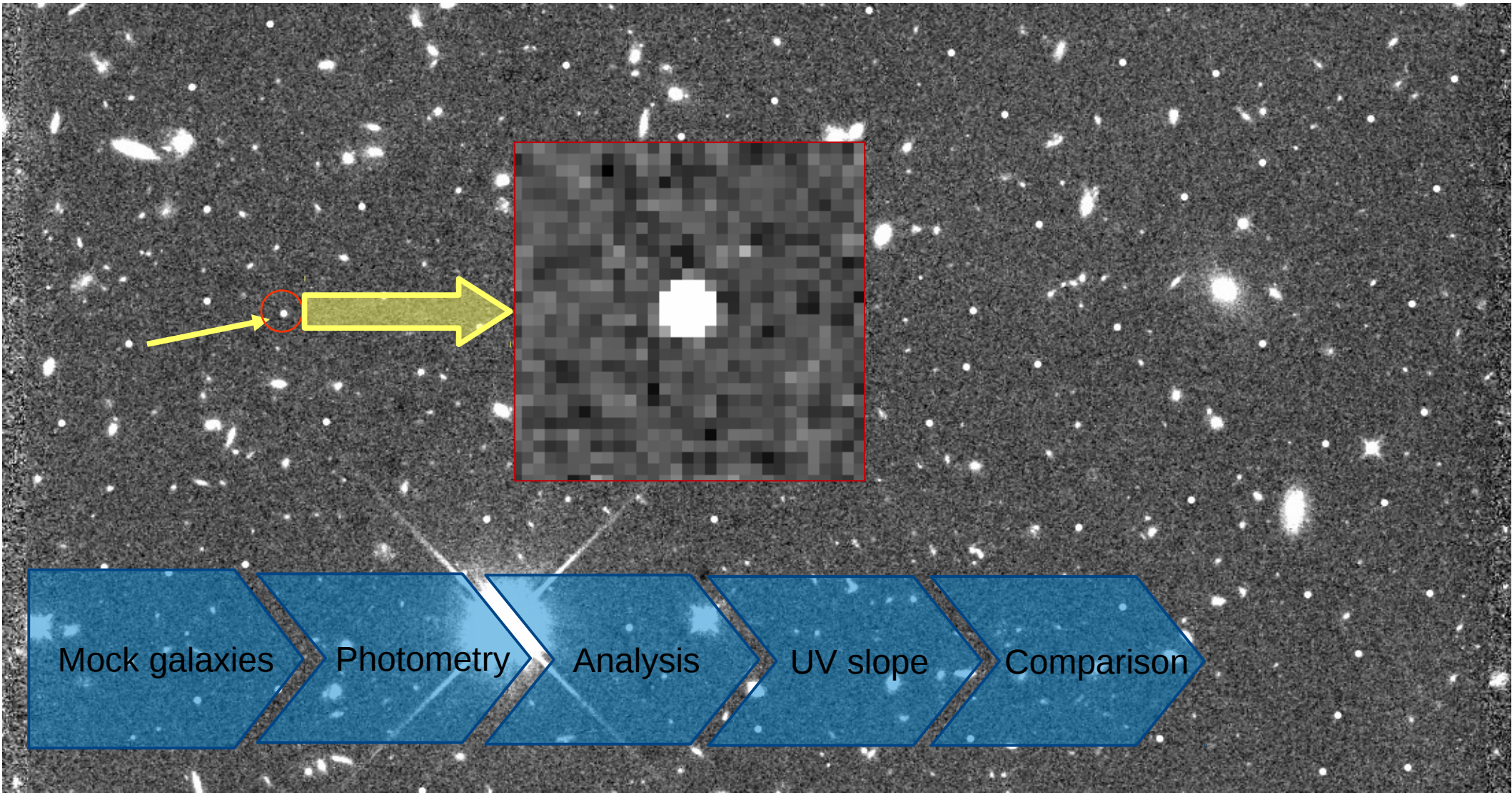

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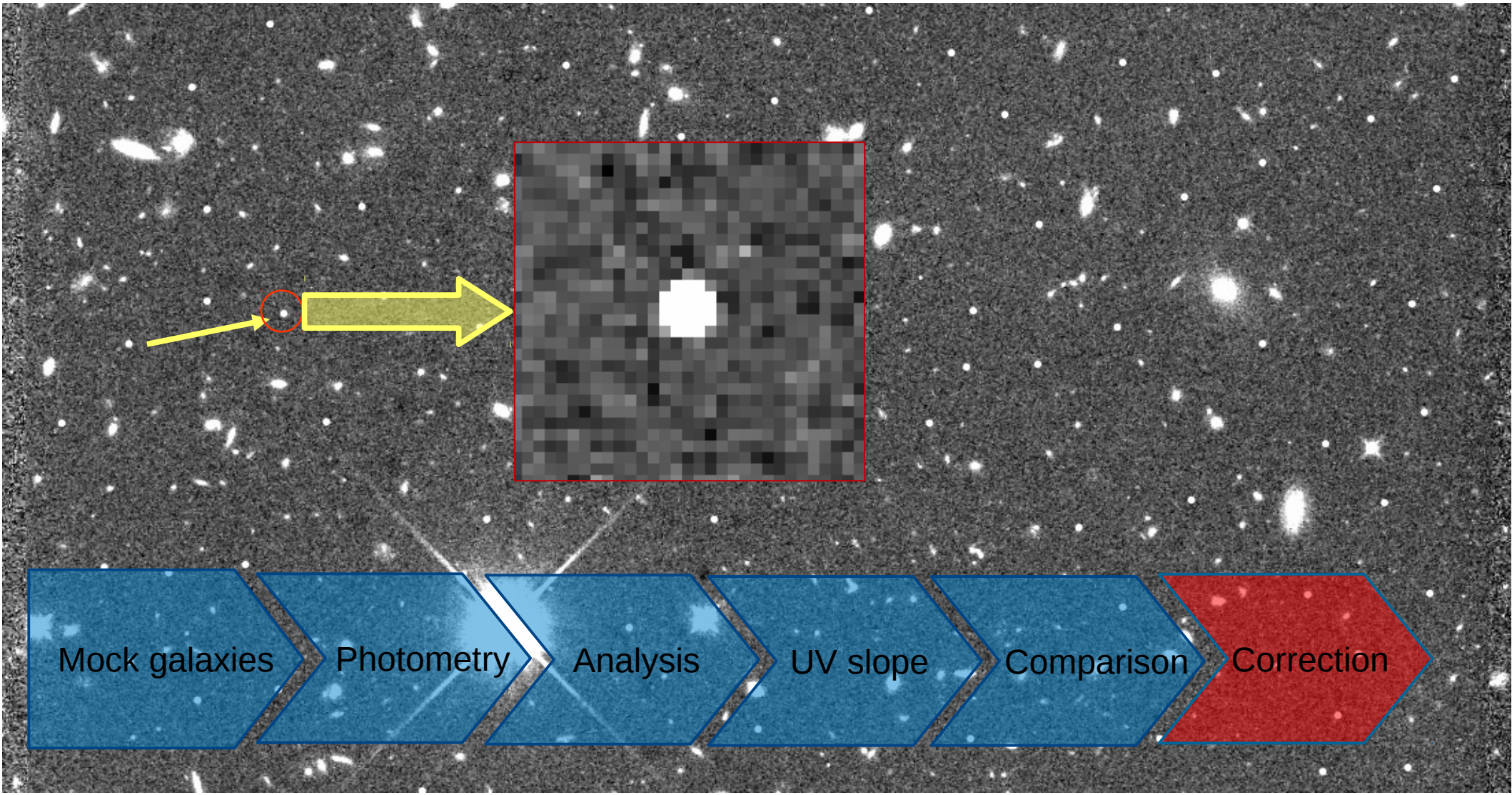
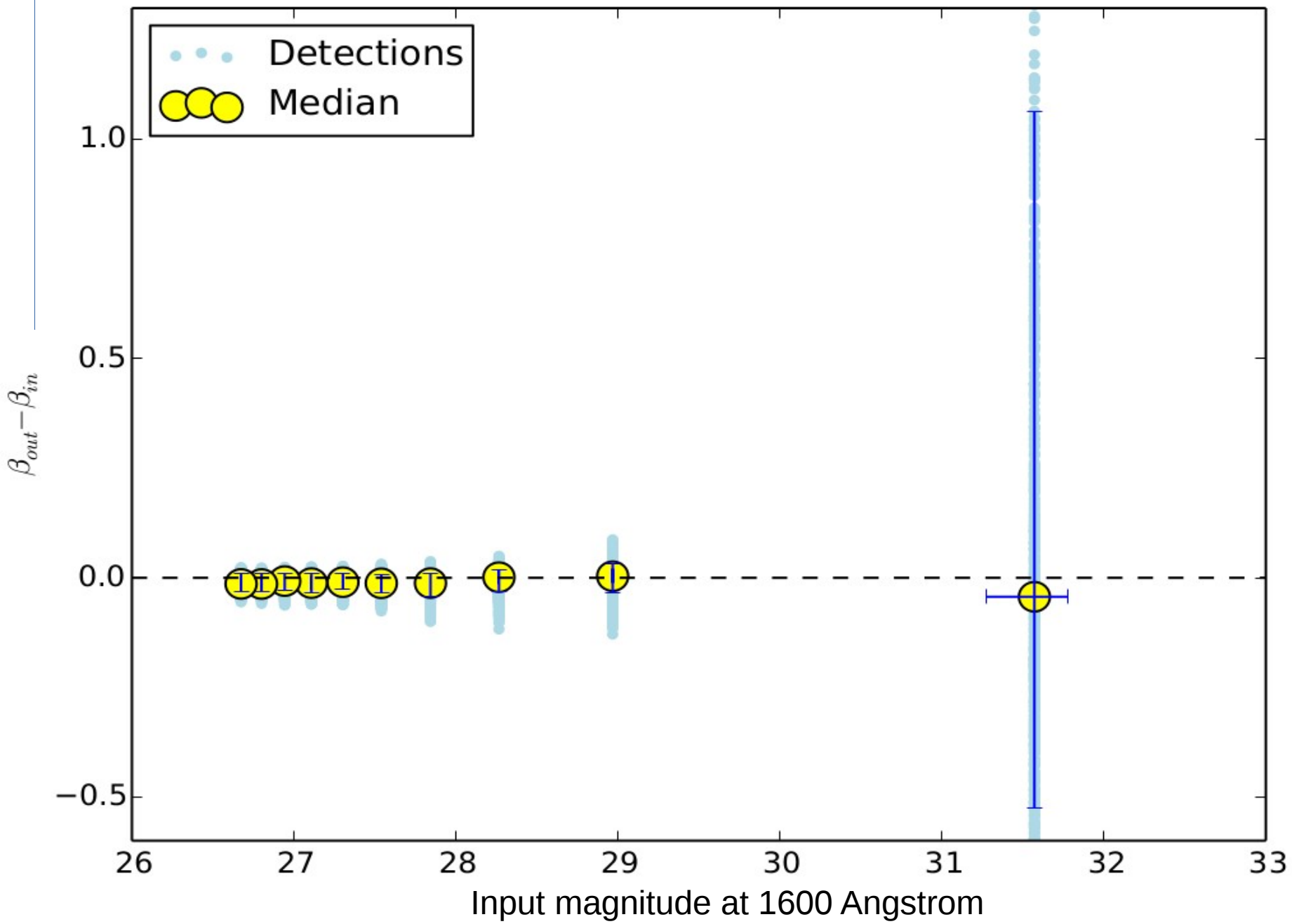
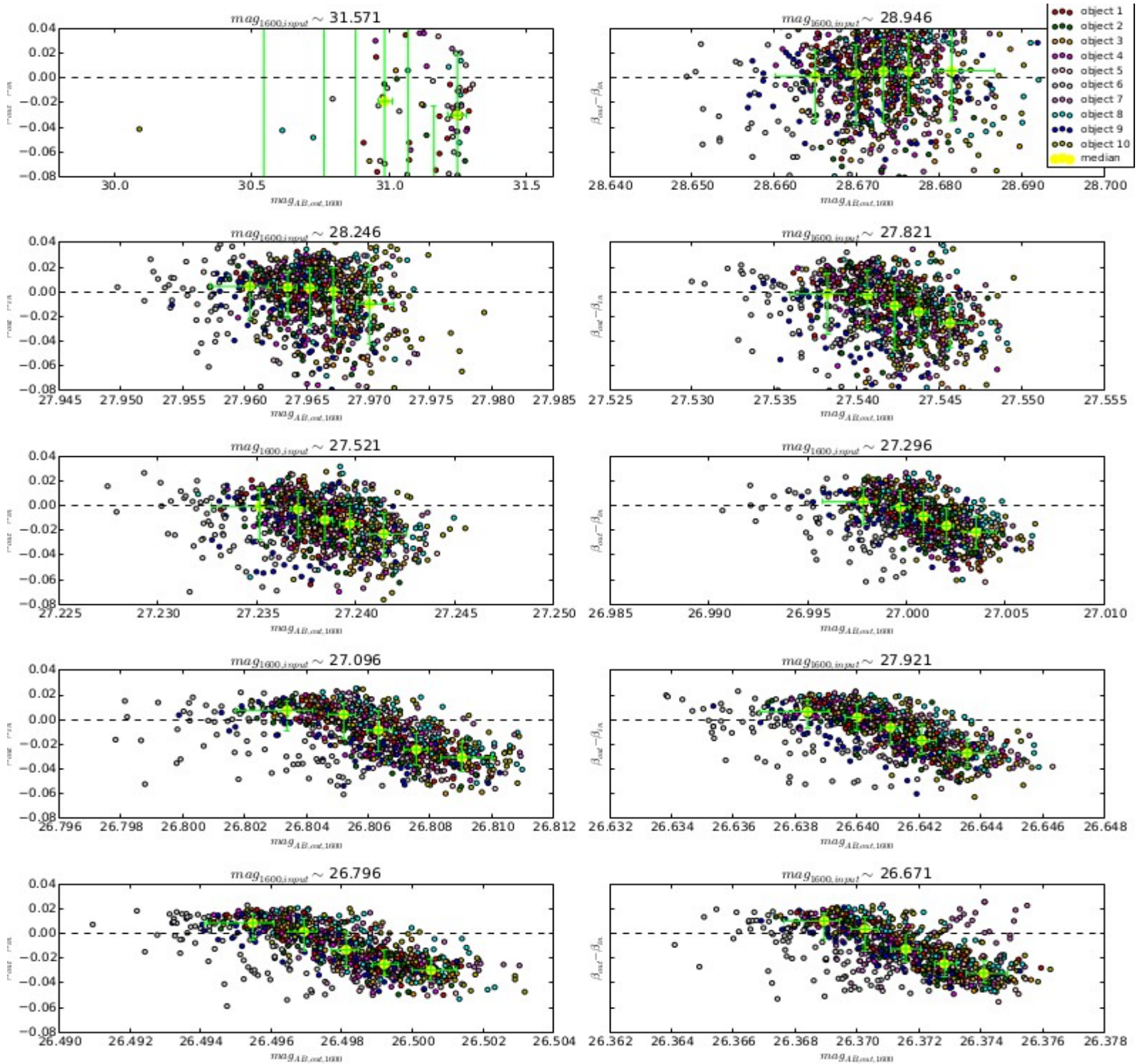


Preliminary results

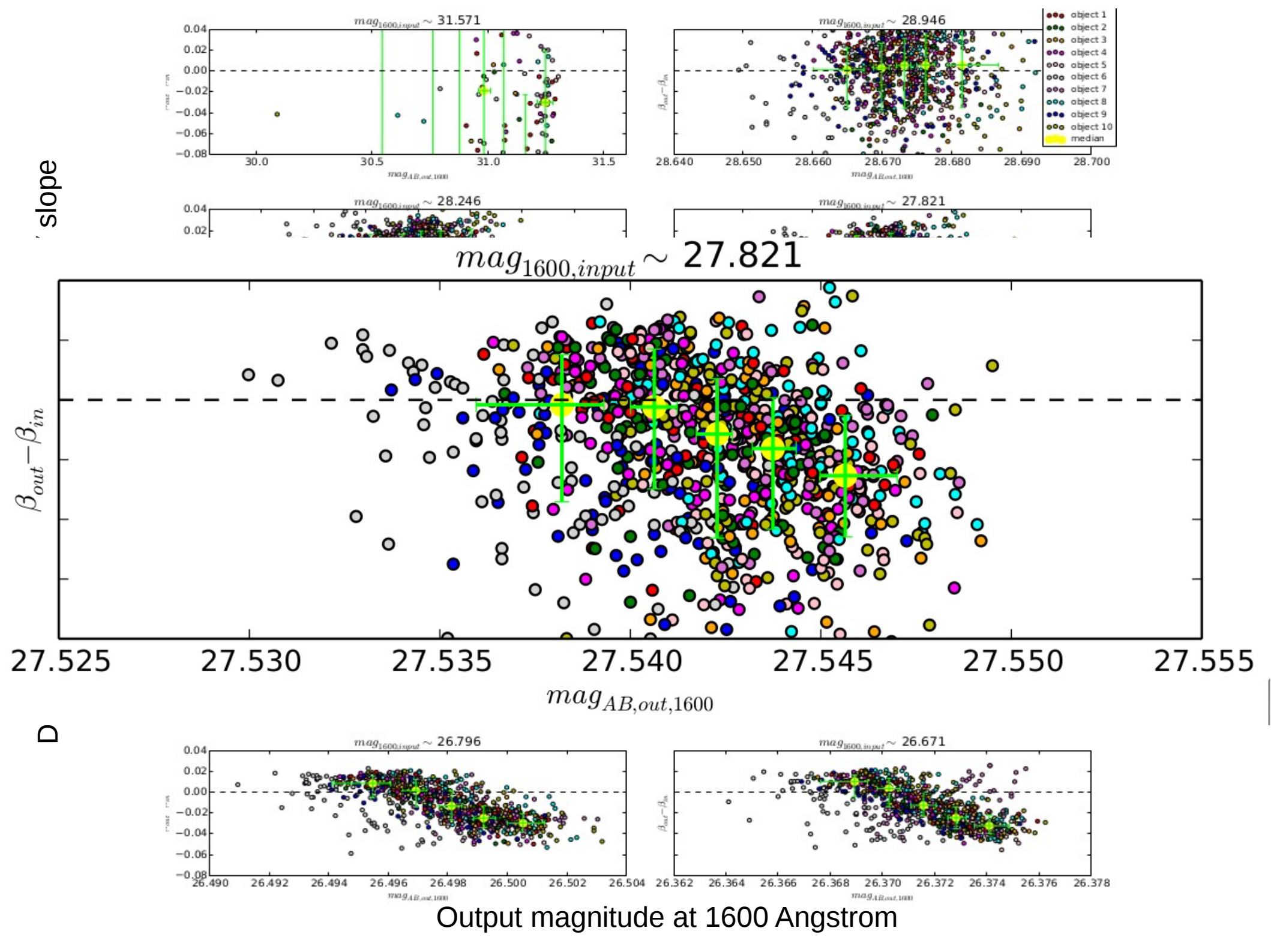
Difference between output and input UV slope





Difference between output and input UV slope

Output magnitude at 1600 Angstrom


slope
$mag_{1600,input} \sim 31.571$
$mag_{1600,input} \sim 28.946$
object 1
object 2
object 3
object 4
object 5
object 6
object 7
object 8
object 9
object 10
median
$mag_{1600,input} \sim 28.246$
$mag_{1600,input} \sim 27.821$
$mag_{1600,input} \sim 27.821$
$\beta_{out} - \beta_{in}$
27.525
27.530
27.535
27.540
27.545
27.550
27.555
$mag_{AB,out,1600}$
D
$mag_{1600,input} \sim 26.796$
$mag_{1600,input} \sim 26.671$
Output magnitude at 1600 Angstrom

Summary

Dust properties of high redshift galaxies?

- High resolution HST WFC-3 data
- **Bluer** UV slope values
- This sample (z~6) – 2 distinct populations

    1) **IR detections** – similar to local **star-burst** galaxies

    2) **Upper limits** – similar to **SMC**

Acknowledgements

I would like to thank my supervisors Dr. Peter Capak and Dr. Andreas Faisst for guiding me throughout the project as well as to Assoc. Prof. Vernesa Smolcic and Micaela Bagley for valuable discussions.