

Planck's Dusty GEMS

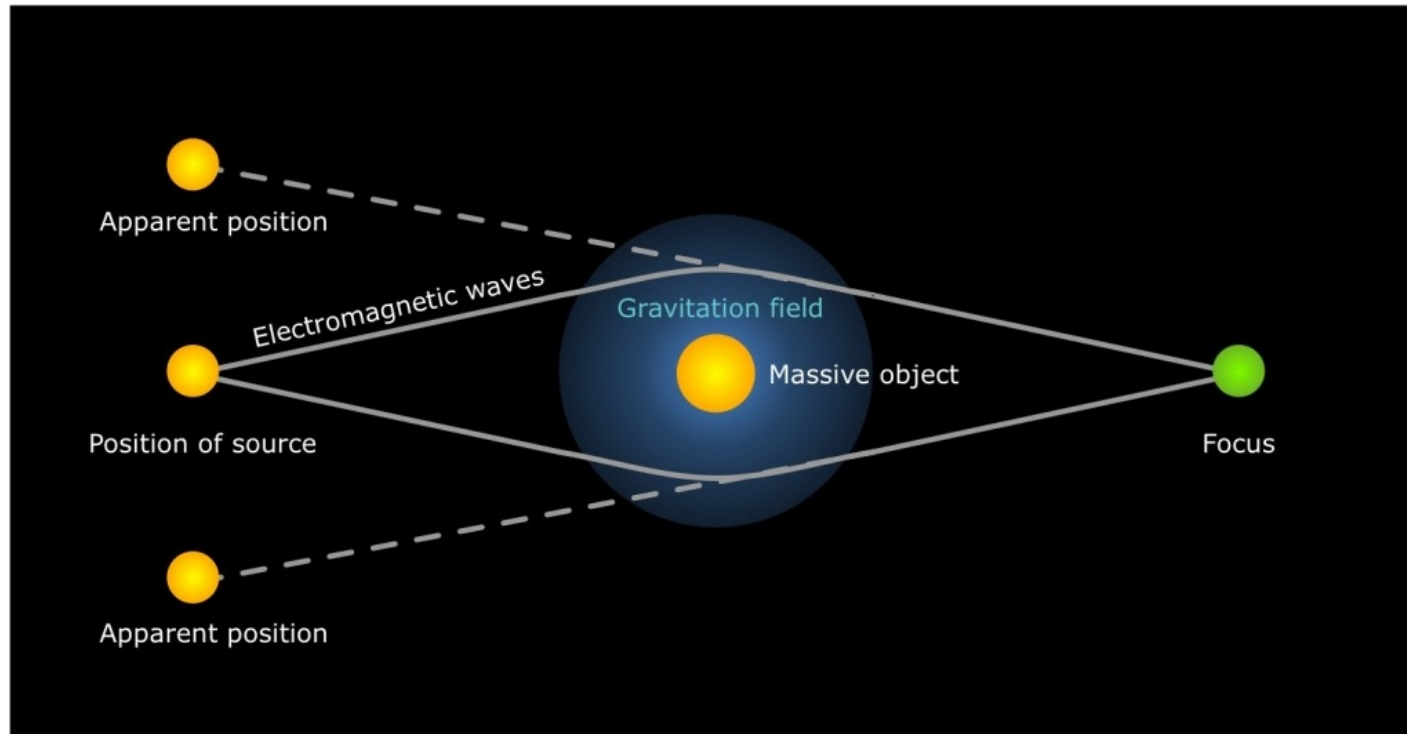
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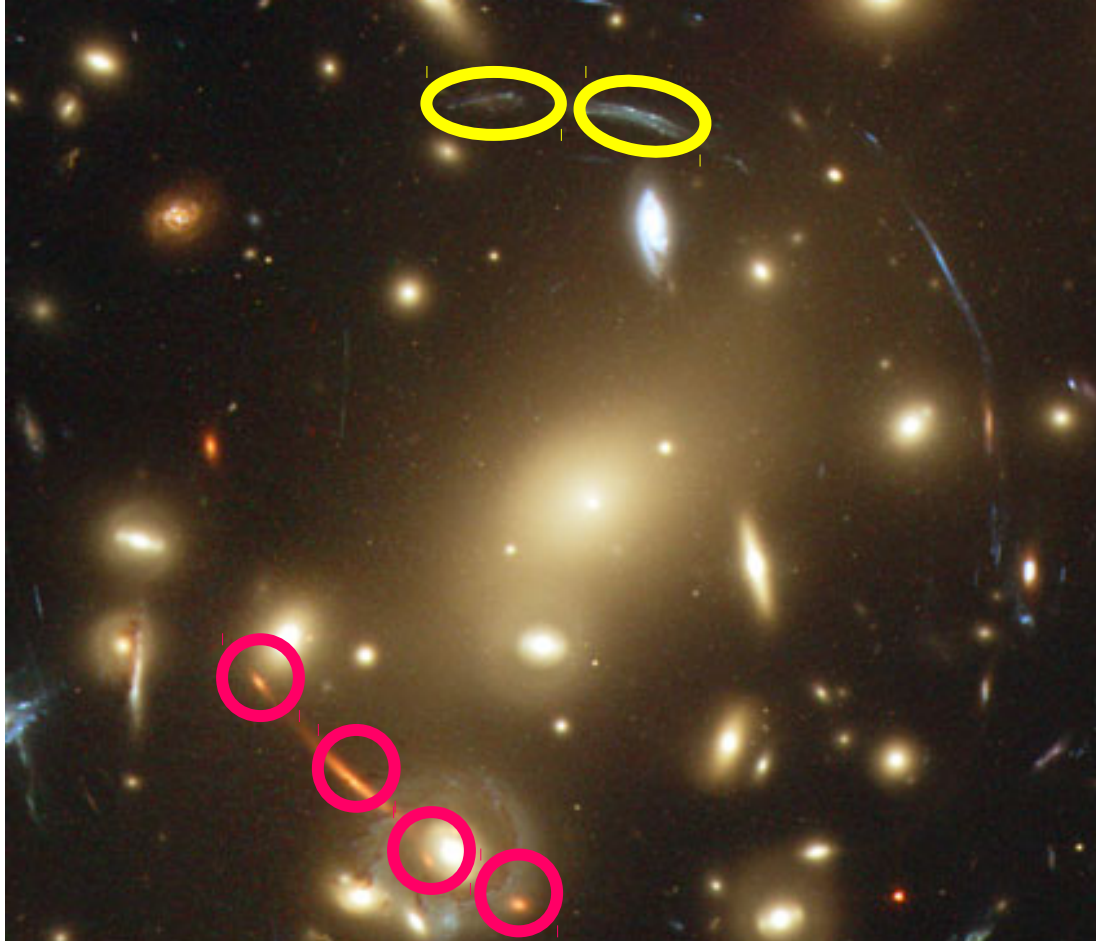


Planck's Dusty GEMS: Background



- Massive objects bend light from objects behind them.
- Lensed galaxies behind galaxy clusters appear to observers as if in front.

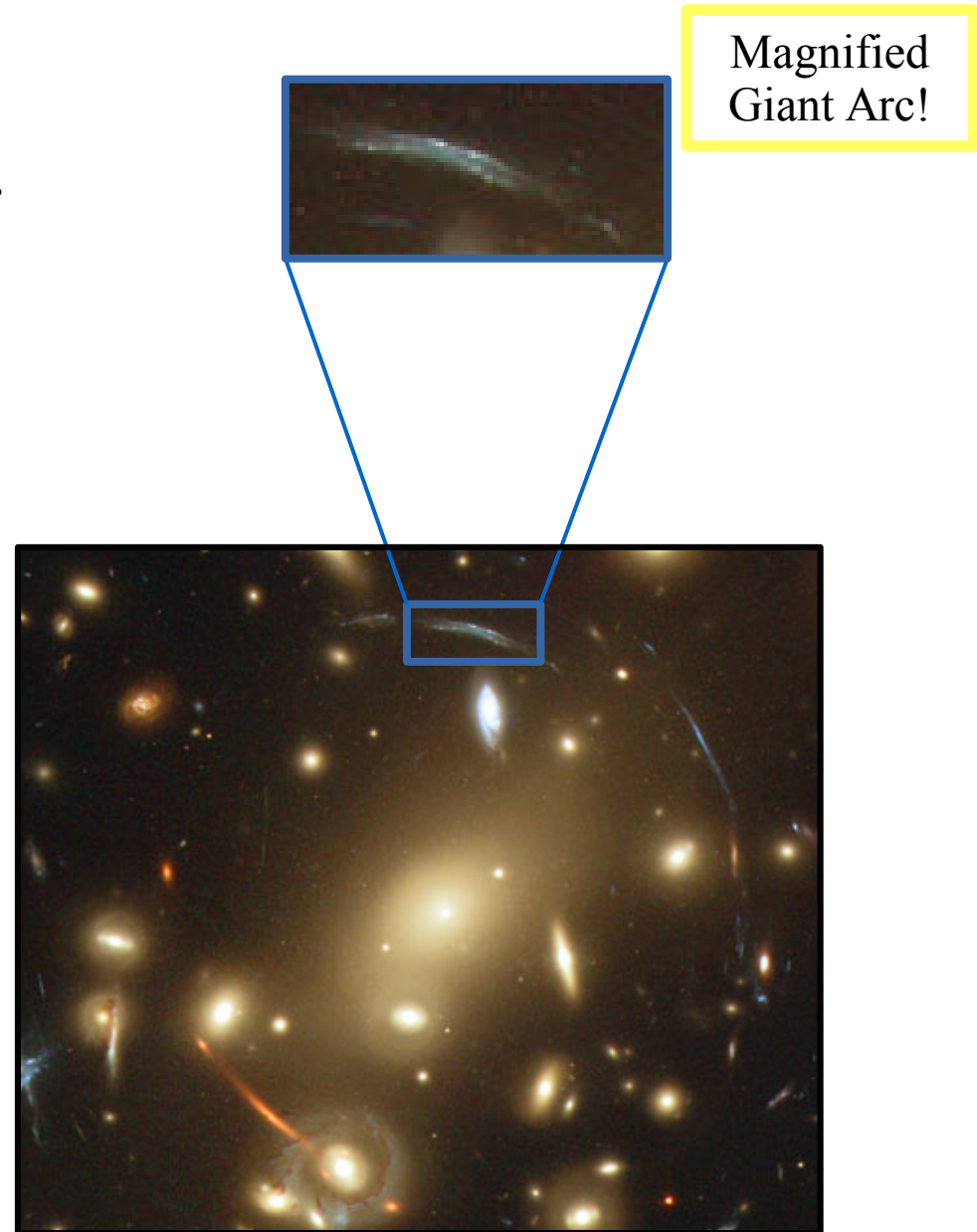
Planck's Dusty GEMS: Background



- Lensed galaxies appear as giant arcs in foreground
- Sometimes appear in multiple positions
- Important for analysis

Planck's Dusty GEMS: Background

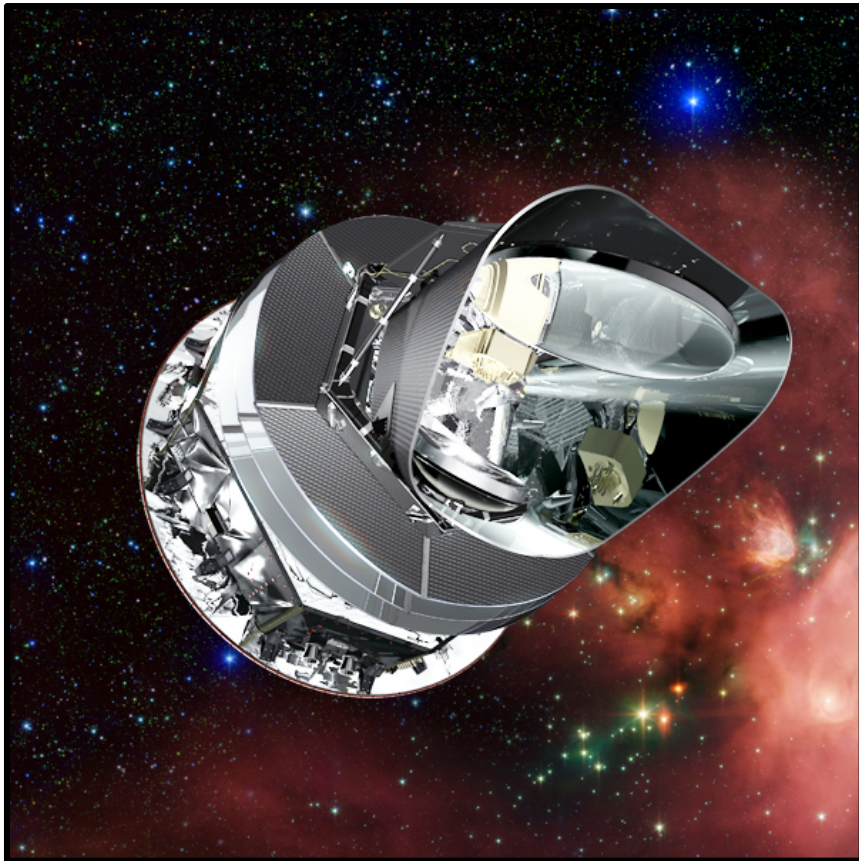
- We can model dark matter masses through lensing.
- Gives us more insight into dark matter.
- Lensing acts as a natural telescope.



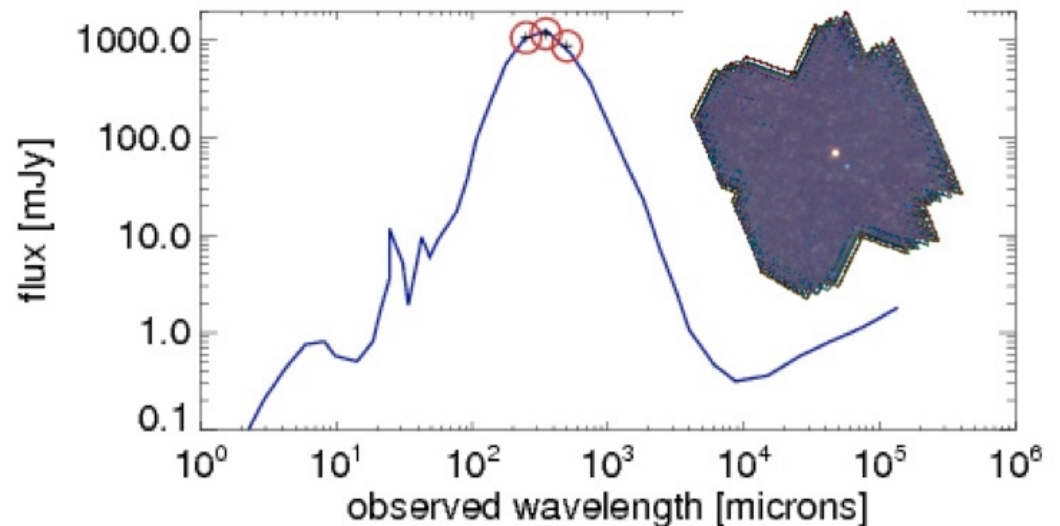
Planck's Dusty GEMS: Background

- Powerful lenses are difficult to find.
 - Referred to as having strong lensing features.
- Some current methods include:
 - Searching optical data
 - Sunyaev-Zeldovich Effect
- We present a new method:
 - Uses existing data
 - Can find lenses current methods cannot

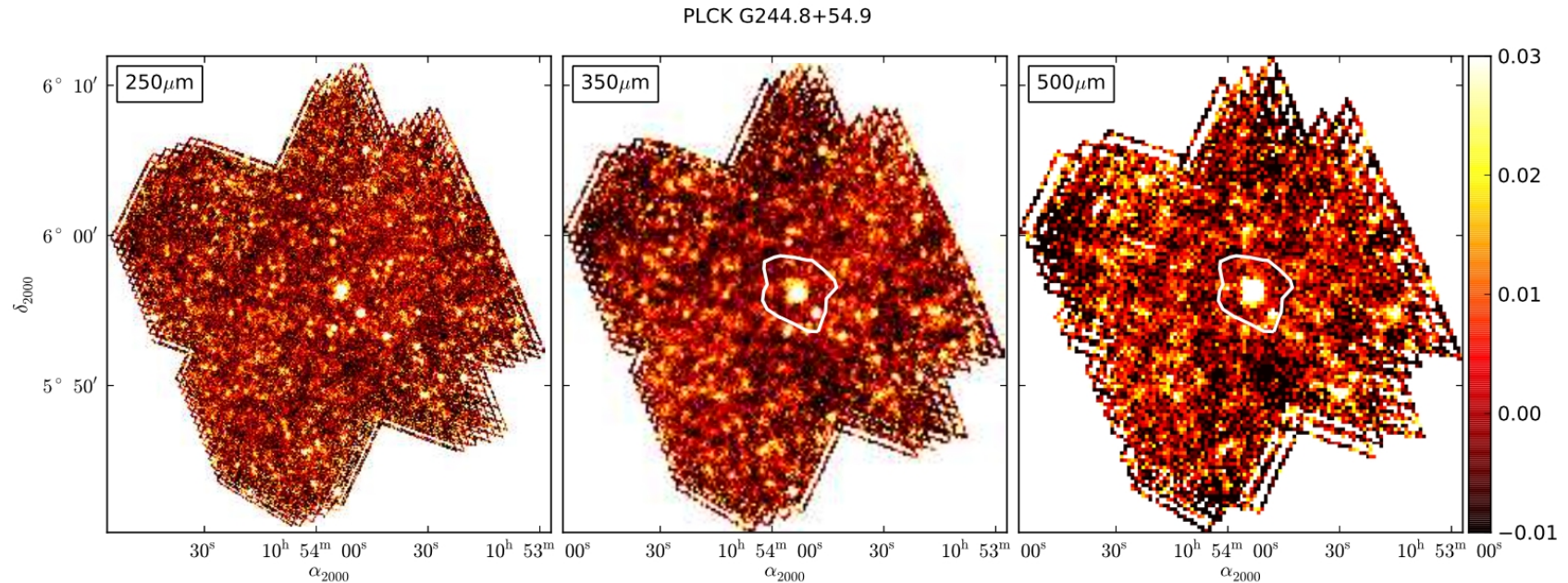
Planck's Dusty GEMS: Introduction



- Clean all-sky *Planck*/ HFI data.
- **Color Selection** of ~ 200 compact sources at $z = 2-4$ from FIR peak
 - Wavelength dependent
- Not Sunyaev-Zeldovich Effect
- Completely new



Planck's Dusty GEMS: Introduction

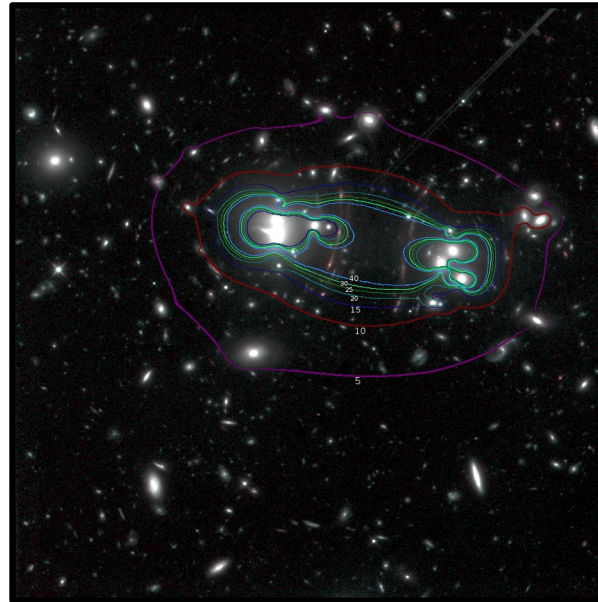


- 12 sources detected with 1 bright object within 50% contour
- These are **strongly-lensed**, **new**, and **bright**
- 6 selected for HST follow up

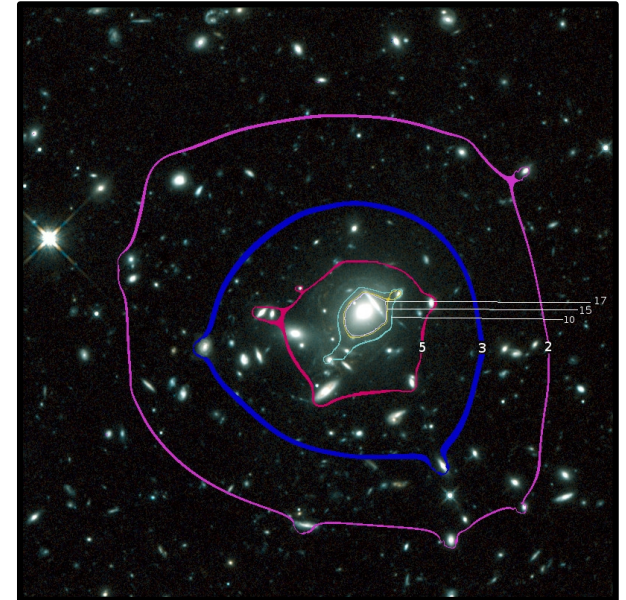
Planck's Dusty GEMS: Results

- 5 fields show evidence for strong lensing features and high magnifications
- Preliminary mass models made using Light-Traces-Mass method (Zitrin et al. 2009, 2013)
- Magnification Models for 4 fields shown

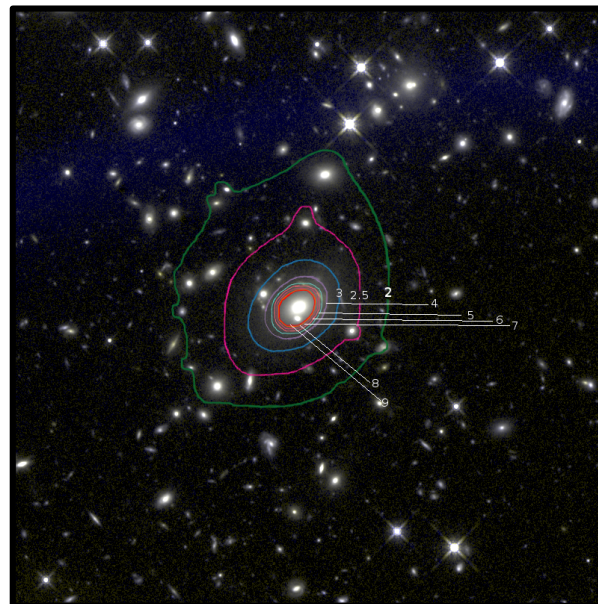
G165



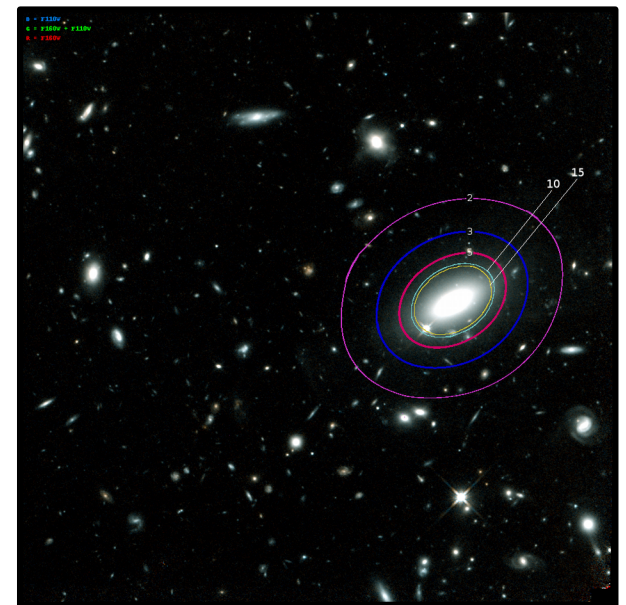
G045



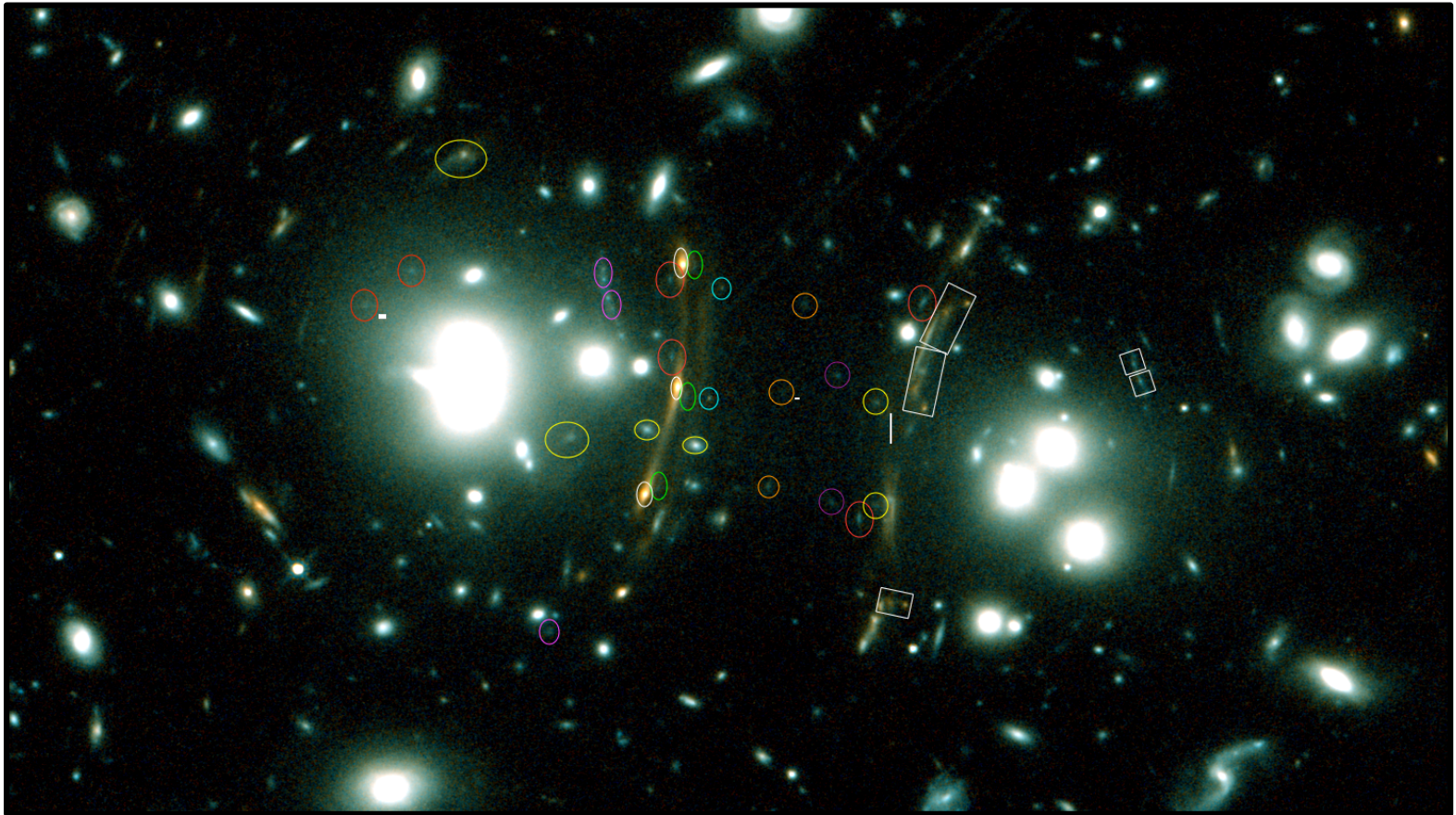
G092



G244



Planck's Dusty GEMS: Results



- G165 shows many strong lensing features
- 10 sets of multiple images
- 2.5×10^{14} solar masses at ~ 250 kpc radius
- Comparable to Hubble Frontier Fields Abell 2744

Planck's Dusty GEMS: Conclusion

- G165 shows promise for *Planck* selection method
- Large Binocular Telescope + Spitzer data coming
- Improve accuracy and find more arcs
- Thanks To:
 - Dr. Brenda Frye
 - University of Arizona
 - UA/NASA Space Grant

Planck's Dusty GEMS: References

- Canameras, et al. “Planck’s Dusty GEMS: Gravitationally Lensed High-Redshift Galaxies Discovered with the Planck Survey”. *Astronomy and Astrophysics*, Vol. 581, 2015.
- Planck Collaboration, et al. “Planck 2015 Results XXVII. The Second Planck Catalog of Sunyaev-Zeldovich Sources”. *Astronomy and Astrophysics*, Vol. 594, 2015.
- Qin, Frye, Pascale et al. 2017, APJ, *in Preparation*.
- Zitrin, et al. “New Multiple-Lensed Galaxies Identified in ACS/NIC3 Observations of C10024+1654 Using an Improved Mass Model”. *MNRAS*, Vol. 396, 2009