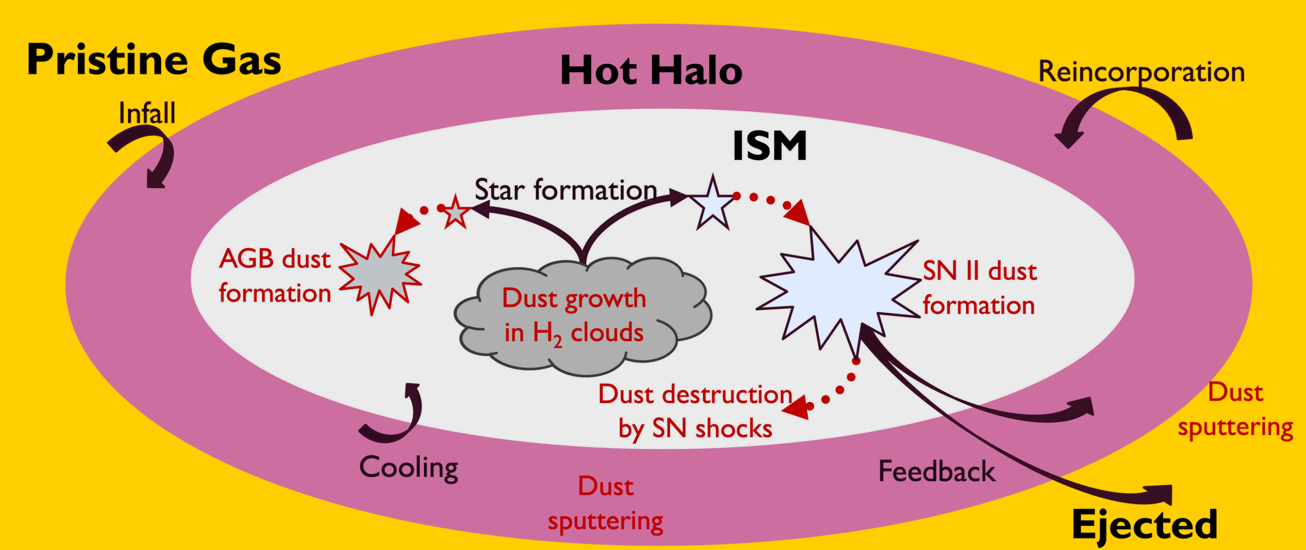
Tracing the Origins and Observables of Cosmic Dust with DUSTY SAGE

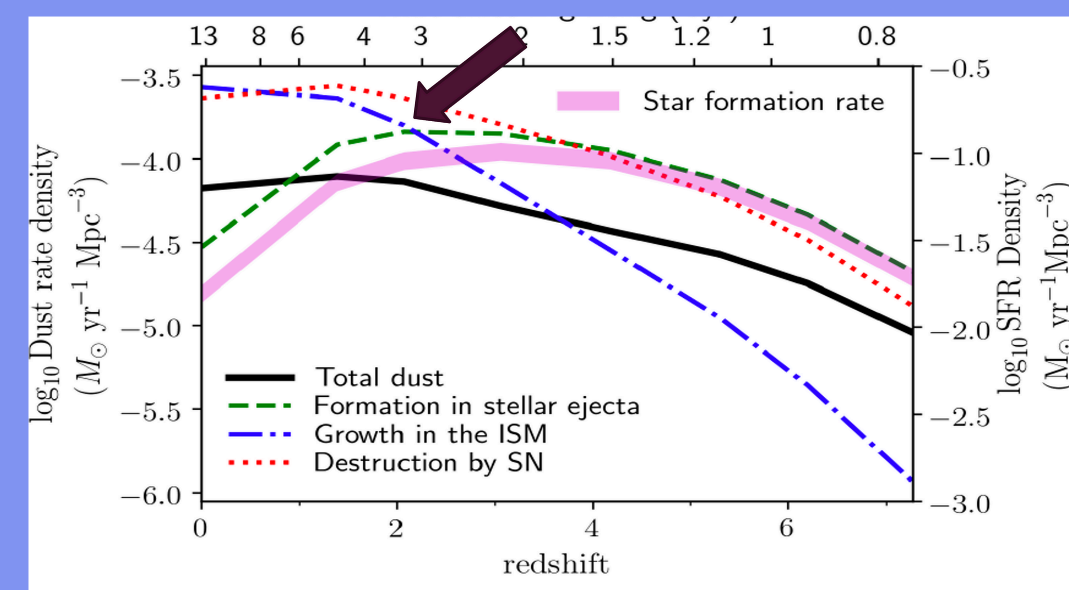
Dian P. Triani (Center for Astrophysics, Harvard | Smithsonian)

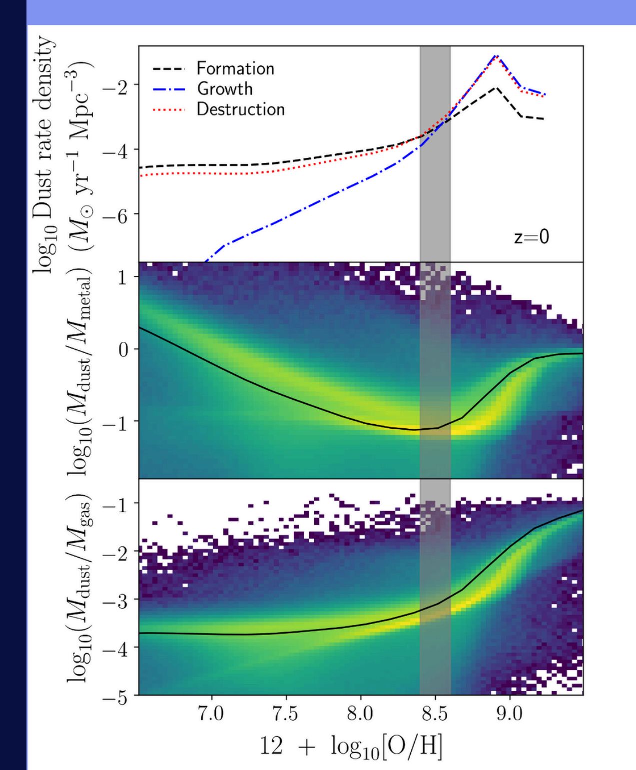
DUSTY SAGE Galaxy Formation Model



Dust shapes how we see galaxies, yet its origin and evolution remain unclear. Observations reveal dust properties through multi-wavelength emission and attenuation curves, which do not explain the underlying physics. DUSTY SAGE connects those observations to theory, modelling dust formation, growth, and destruction together with star formation, inflow, and outflow in a cosmological volume.

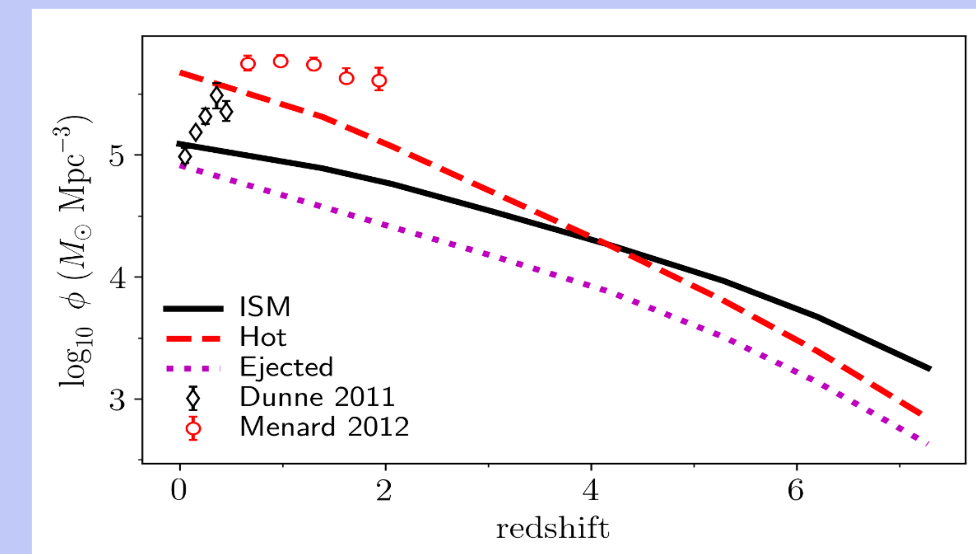
Evolution of Dust Origins



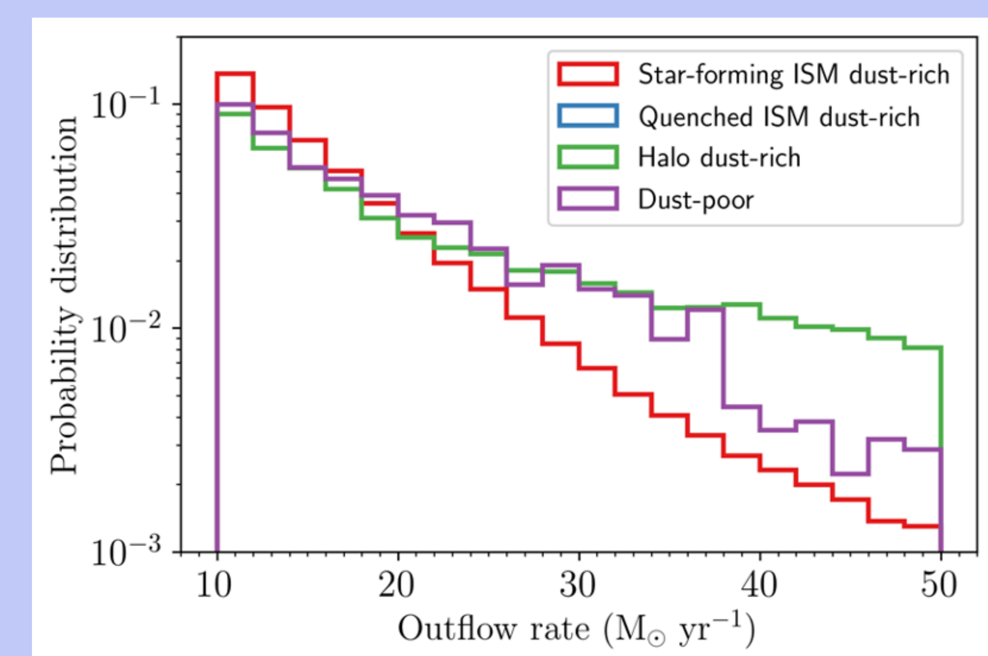


Dust production changes over cosmic time. At early epochs (z > 2), stellar ejecta dominate; as galaxies enrich, grain growth in the ISM becomes the main source. This transition imprints distinct slopes in dust-to-gas and dust-to-metal relations.

Dust Beyond Galaxies

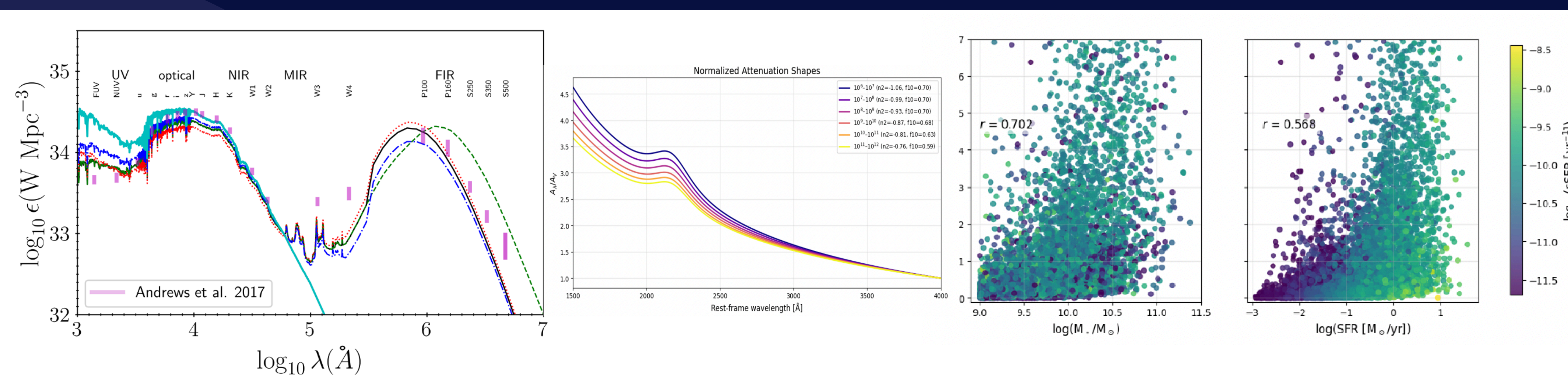


Feedback processes transport dust beyond galaxies. DUSTY SAGE predicts that dust expelled by outflows accumulates in the halo and ejected reservoirs, consistent with observations of extended dust around galaxies.



Galaxies with higher outflow rates retain more dust in their halo, revealing how feedback and gas cycling shape the circumgalactic dust

Connecting to Observables



DUSTY SAGE predicts galaxy emission from the UV to IR. The model improves fits in the UV, where dust attenuation dominates, and in the IR, where dust re-emits absorbed light. Attenuation curves vary with stellar mass, and AVcorrelates strongly with both stellar mass and star-formation rate.

Takeaway: DUSTY SAGE integrates dust physics into galaxy formation, accurately reproducing UV–IR observables in the nearby Universe — and is now ready to test against new high-z data from JWST and ALMA.

References: Triani et al. 2020, 2021, 2023