Preparing for the Deluge

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Program: Strategic

Project Objective:

The 2020s will see the start of three cutting edge cosmological surveys: NASA's Wide Field Infrared Survey Telescope (WFIRST), ESA's Euclid mission, and the Large Synoptic Survey Telescope (LSST). The incoming deluge of cosmological data requires:

1. New paradigms for inter-agency/inter-project cooperation and coordination
2. Development of new analysis and simulation tools to mitigate systematics and optimize cosmological measurements from heterogeneous surveys, and
3. Vetting these new tools on simulations and datasets.

Through our efforts in these three areas, **we aimed to make JPL & IPAC leaders in understanding the mysterious "dark sector"** of the universe over the coming decade.

Significance of Results and Benefits to NASA/JPL

- Developing and validating analysis tools for the surveys of the 2020s has also enabled cutting-edge precursor science.
- Established a framework for coordination among the major cosmological surveys of the 2020s, and positioned JPL as a leader in analysis.
- NASA awarded $1.75M in FY20-21 (PI Kiessling) for joint coordination of cosmological simulations, 2 FTE/year (FY18 onward) to IPAC for joint pixel level processing development, and $825K in NASA-ADAP funding (science PI McCleary).

Highlighted Results from RTD FY19
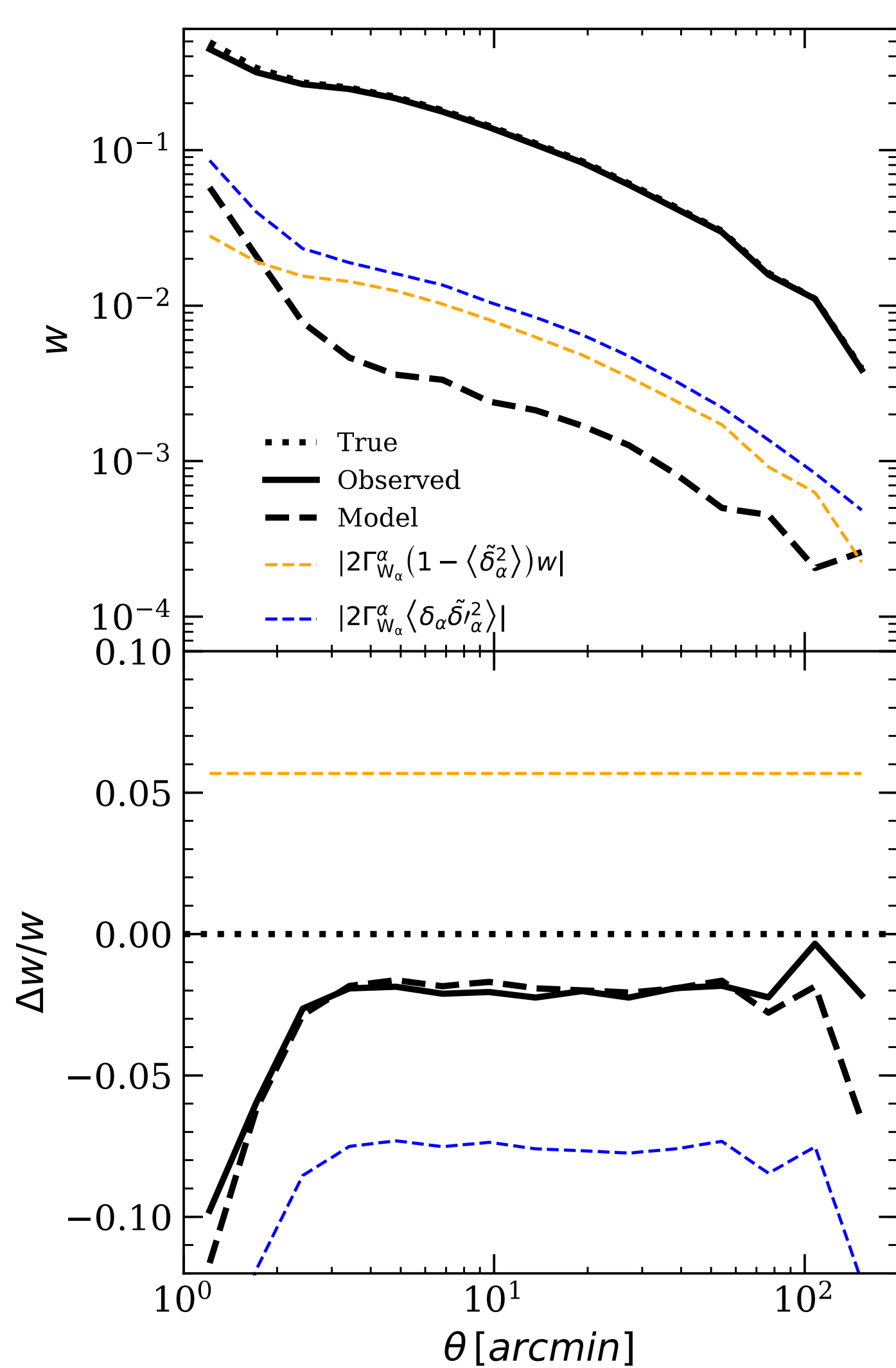
Left: Huff and Izard have identified a **new category of systematic error in cosmological surveys** arising from correlations between cosmological lensing/clustering signals and any source of measurement bias.
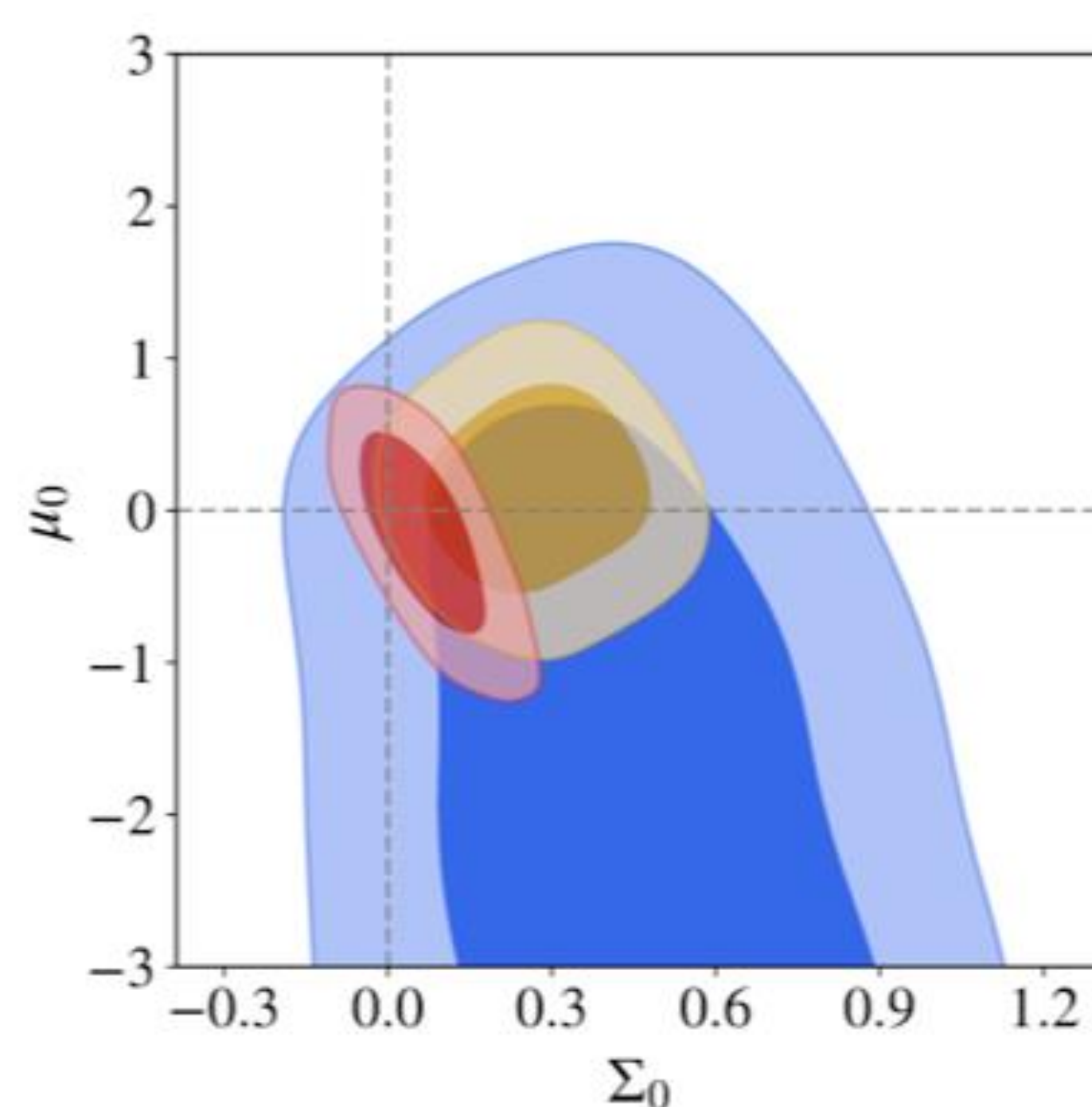
The figure shows a spurious correlation w between clustering and intrinsic alignments of galaxy shapes (top) and the residuals of Izard's model in predicting this systematic (bottom). Both are given as a function of impact parameter.
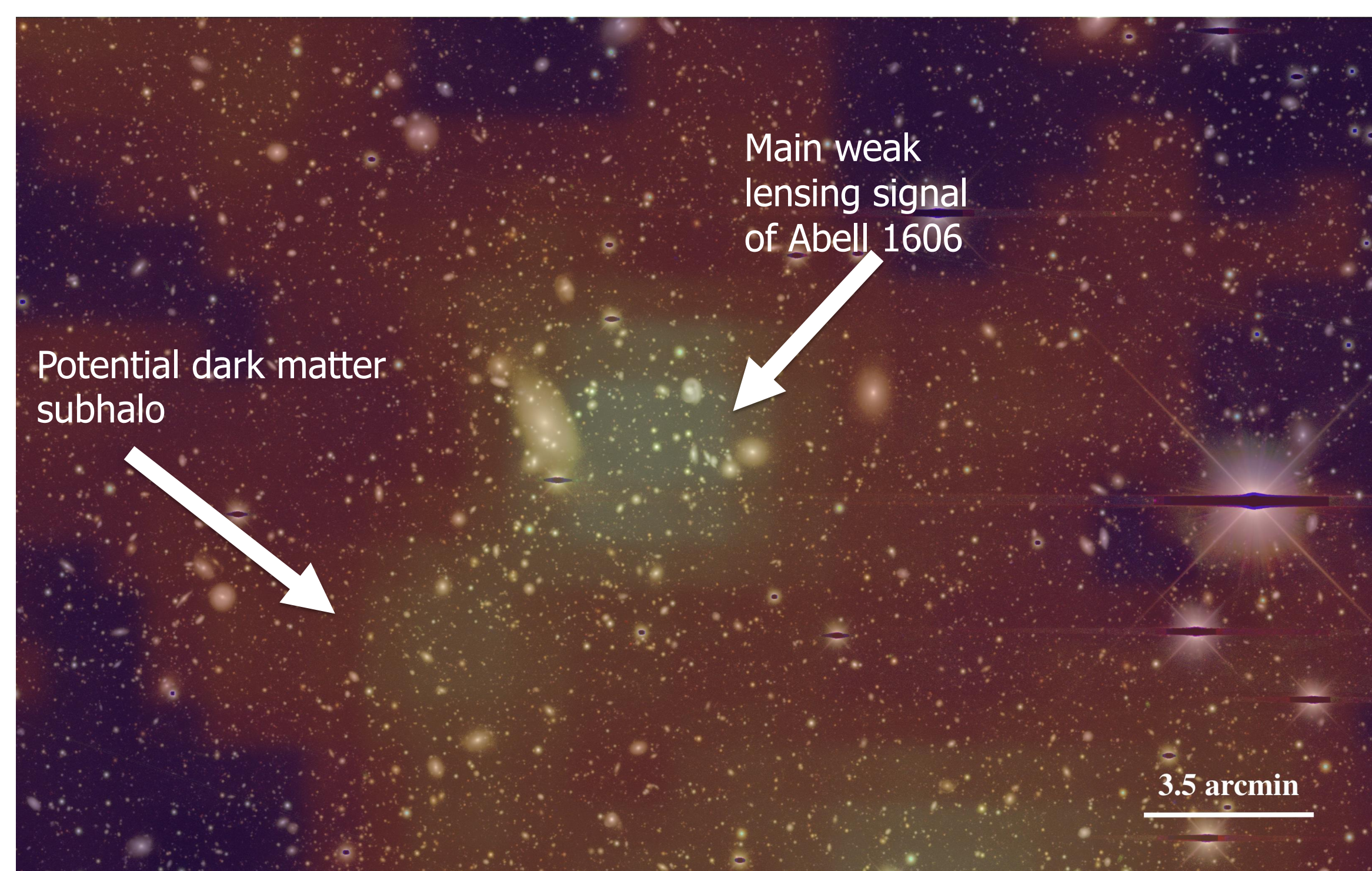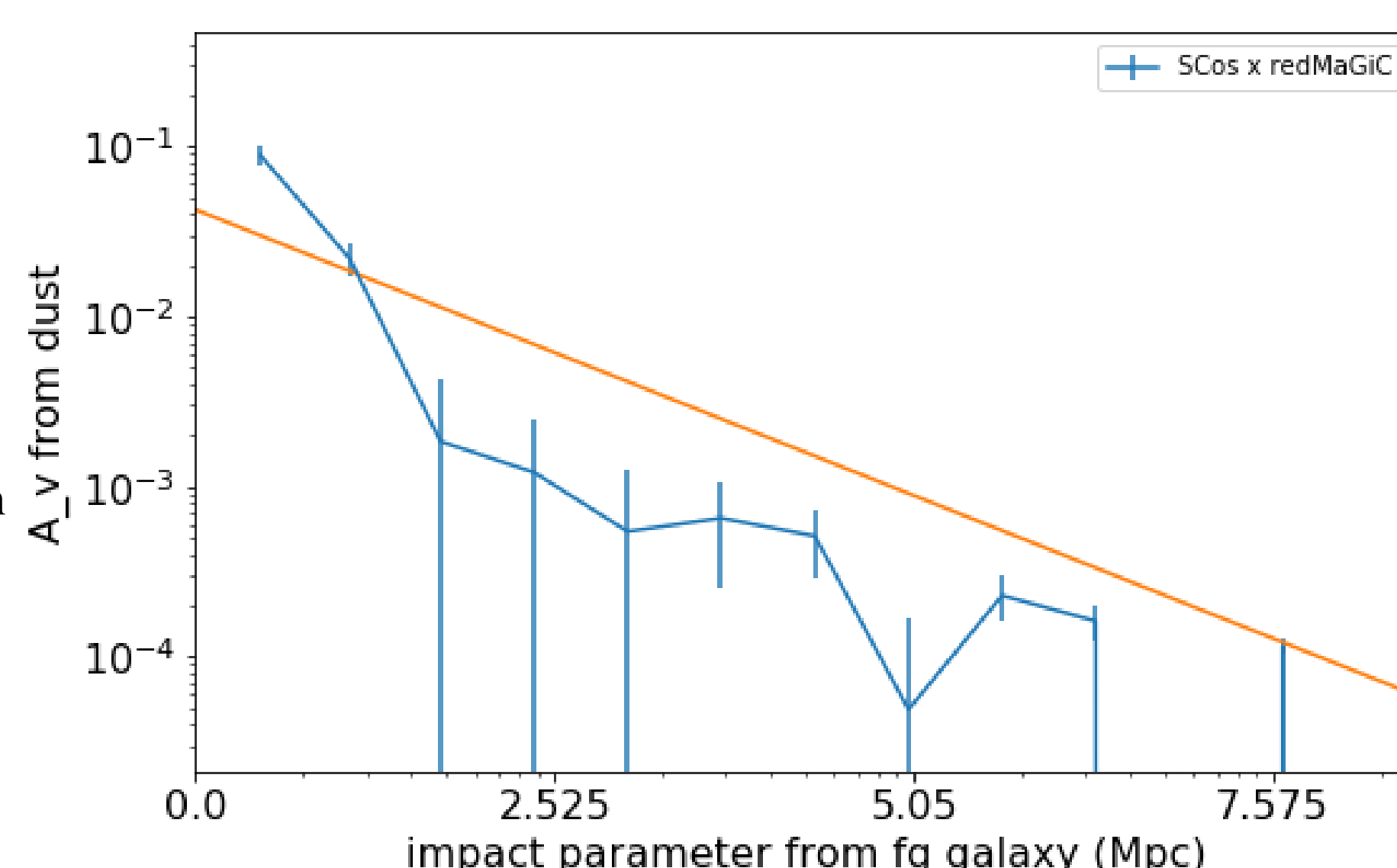

Left: McCleary led a study of the dark matter distribution galaxy clusters. We are **validating the detection of subhalos** using state-of-the-art shear measurement tools developed by Huff. This work will eventually be a powerful test of cold dark matter.

The figure shows a weak lensing signal map (lighter color means more signal) super imposed on a 3-color composite.

Main weak lensing signal of Abell 1606

Potential dark matter subhalo

3.5 arcmin

WFIRST, Euclid and LSST/ DOE,NASA, NSF Tri-Agency Group (TAG)

Rhodes remains the Euclid Project and WFIRST Project representative for JPL on the TAG. Due to the efforts in the RTD, **the following TAG tasks forces are being led or co-led out of Pasadena**: (1) joint processing of heterogenous surveys, (2) coordination of cosmological model and systematics simulations, and (3) coordination of survey cadence and overlap for all three experiments.

Efforts by Kiessling led to **$1.75M of funding by NASA-HQ for her to lead a cosmological simulations task** force with Rhodes and Doré on the steering committee.

Top Right: Ferté has used existing ground based data to test models of modified gravity on large scales. The result is **one of the most robust constraints on beyond-ΛCDM models to date.** The figure shows shows the constraints on deviations from general relativity (parametrized as Σ_0, μ_0) on cosmological scales with Dark Energy Survey data in blue, CMB data in yellow and the joint constraint in red. For standard GR, $\Sigma_0 = \mu_0 = 0$.

Selected Publications:

- "Focal Ratio Degradation for Fiber Positioner Operation in Astronomical Spectrographs," Brent Belland et al., Journal of Astronomical Instrumentation, 8, 1950007 (2019)
- Image simulations for gravitational lensing with SKYLENS, Plazas, Meneghetti, and Rhodes, 2019, MNRAS 482. 2823
- Detecting Baryon Acoustic Oscillations in Dark Matter from Kinematic Weak Lensing Survey Ding, Z., Seo, H.-J., Huff, E., Saito, S., & Clowe, D. 2019, MNRAS, 2019, 487, 253
- Cosmic shear without shape noise (Huff, Krause, Eifler, Fang, Schlegel, George) APJ submitted
- Dark Energy Survey year 1 results: Constraints on extended cosmological models from galaxy clustering and weak lensing, Abbott et al, **incl. Ferté**, PhysRevD, 2019, 99, 123505

Bottom Right: By correlating excess reddening in galaxies behind a foreground galaxy catalog, McCleary and Huff **detected circumgalactic dust halos out to 10 Mpc**. This dust may be a powerful systematic error in cosmological measurement. The figure shows the excess extinction from dust A_V as a function of separation between foreground and background galaxies.

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