The Quenching of the Ultra-Faint Dwarf Galaxies in the Reionization Era

(Brown et al. 2014)

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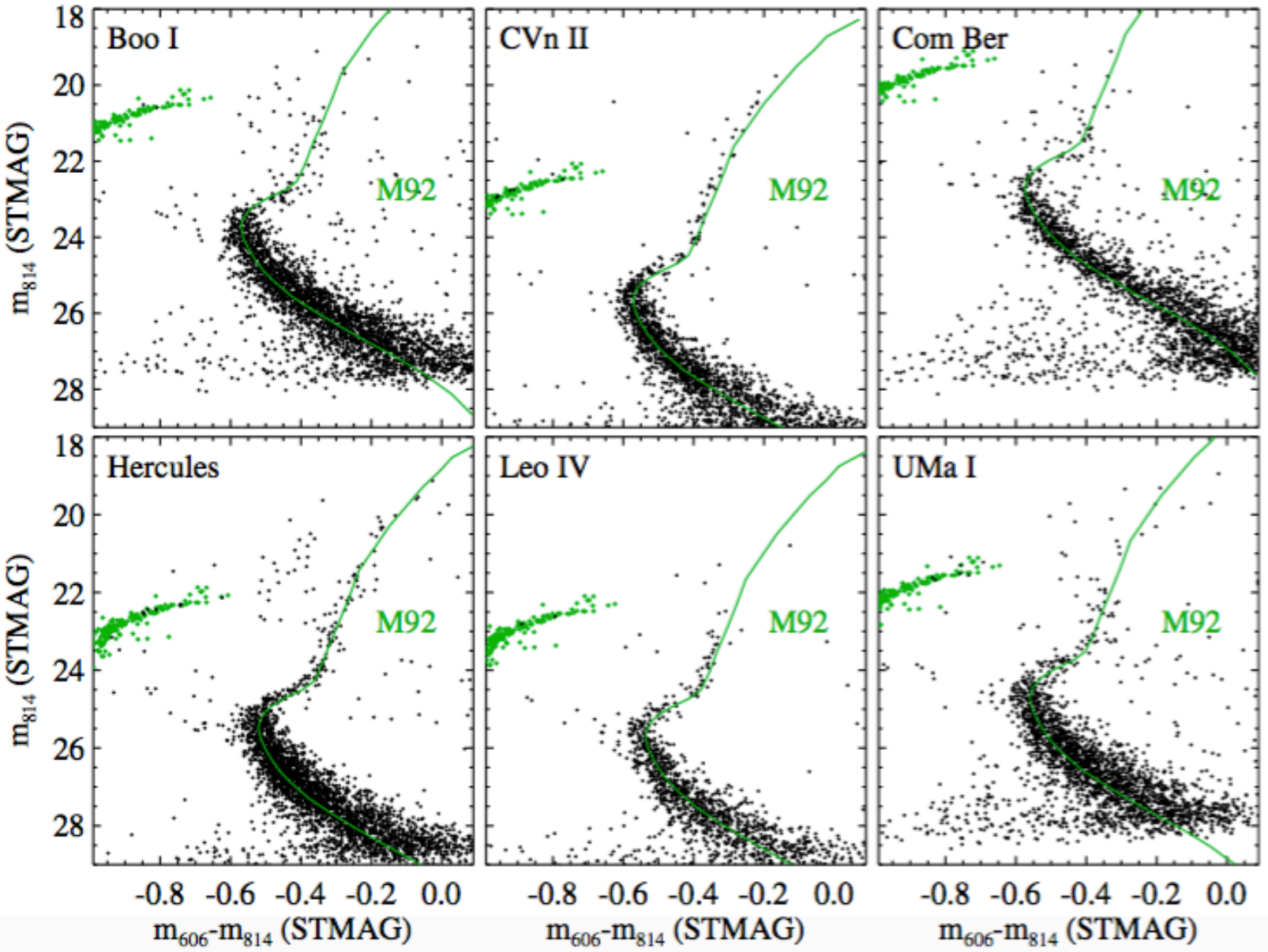
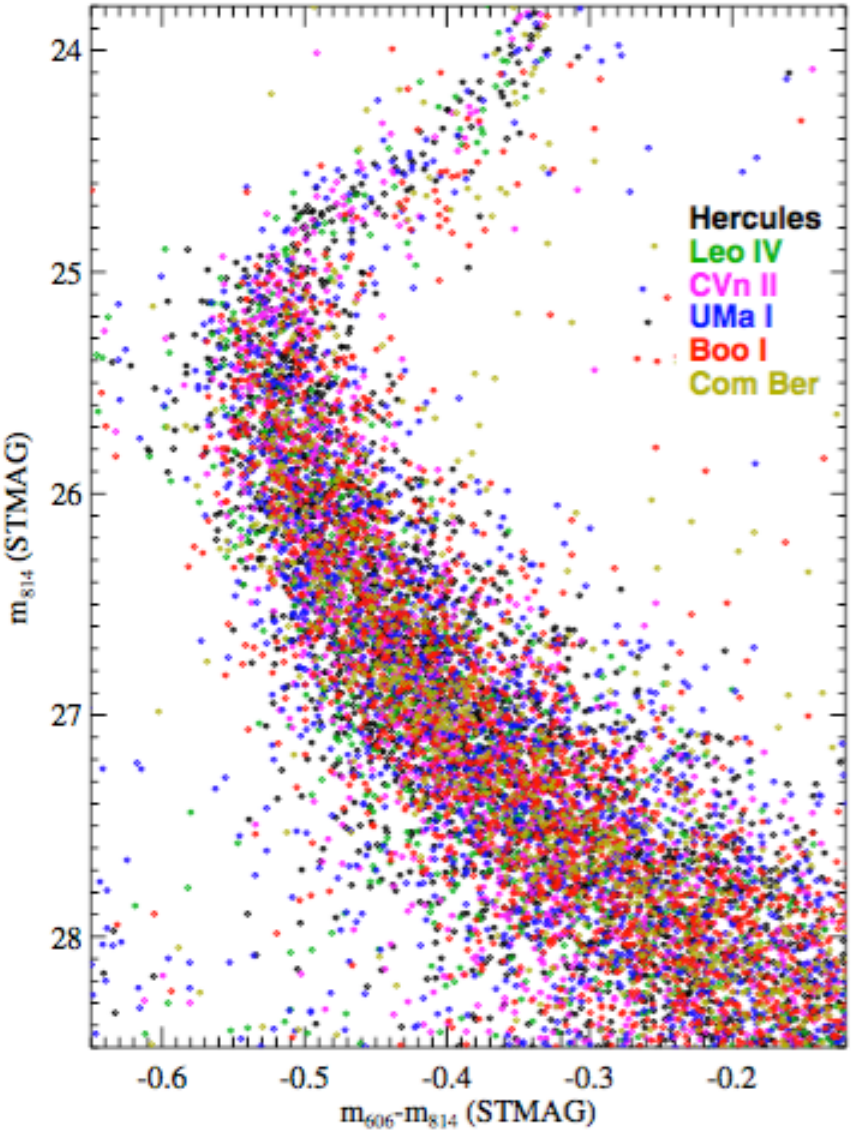
Why do we care about Ultra faint Dwarf galaxies?

- Lambda CDM consistent with many observations but discrepancies exist at small scales.
  - Predicts more DM sub halos than dwarf galaxies we have observed.
- Reionization induced quenching.
  - Reionization could have suppressed star formation in smallest DM halos.

6 Ultra Faint Dwarf Galaxies

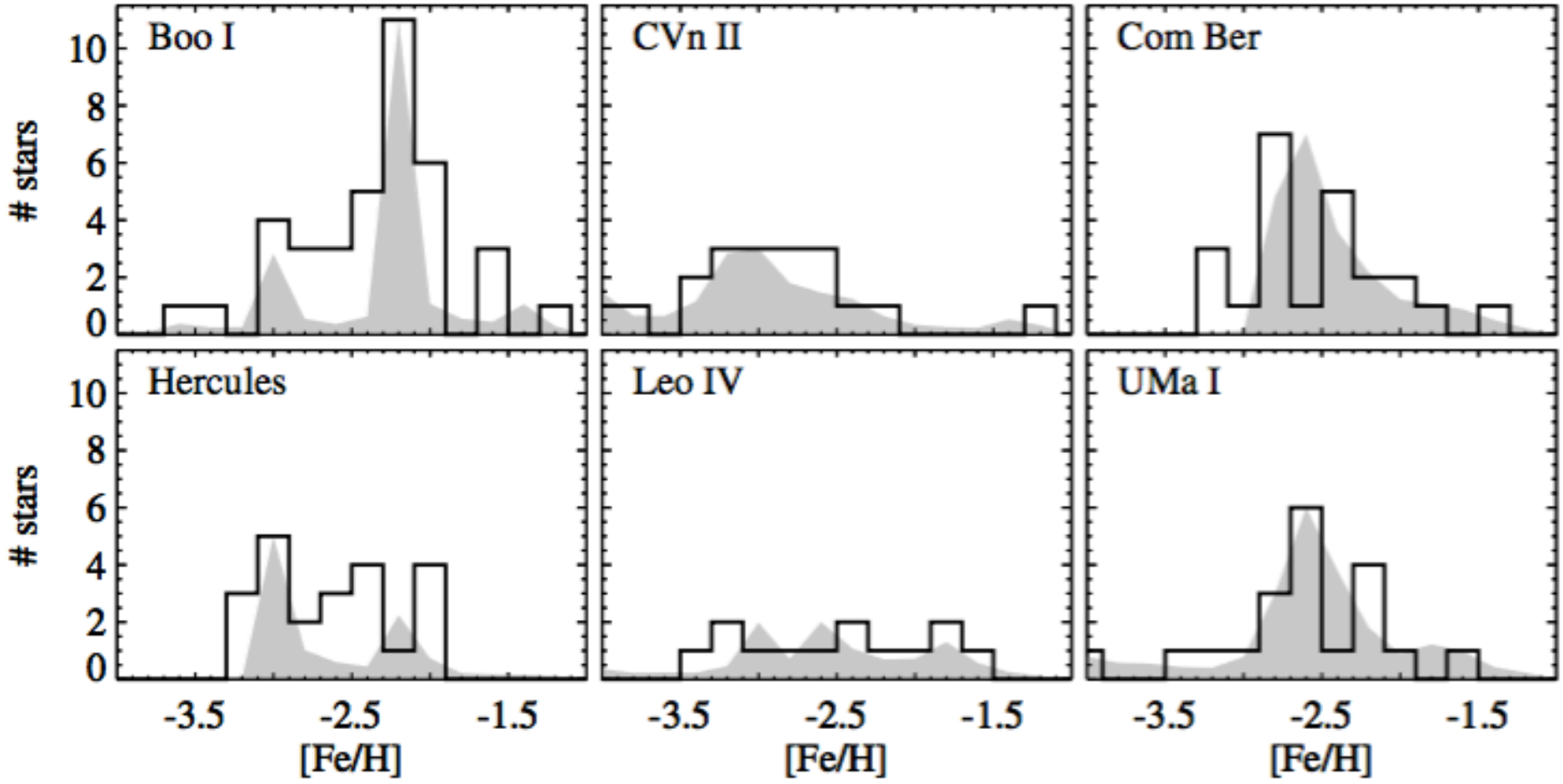


Composite CMD of Galaxy Sample

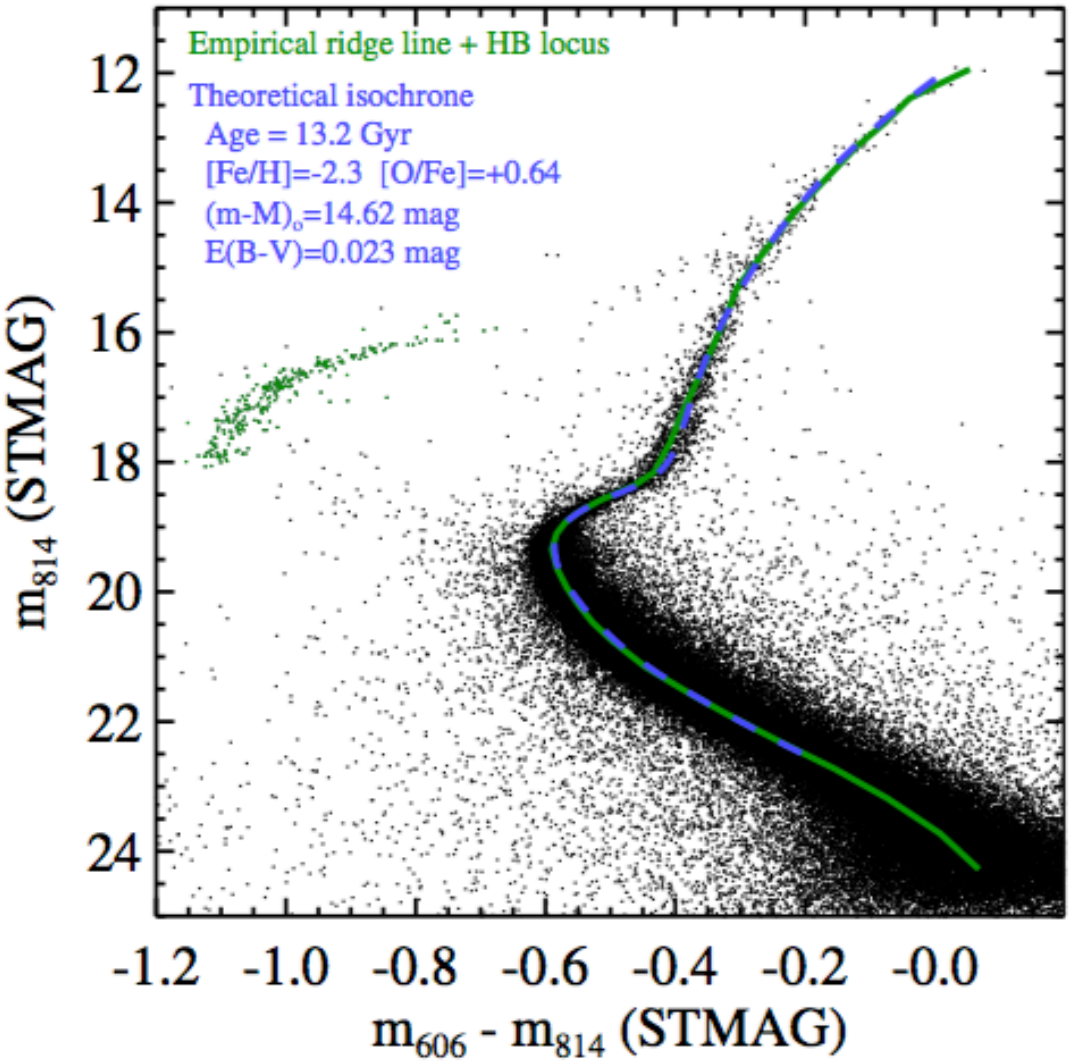


- Each shifted by distance and reddening to overlap
- Zoomed in on Main Sequence turn off
- High contamination for nearby galaxies

Spectroscopic Metallicity Distribution Function

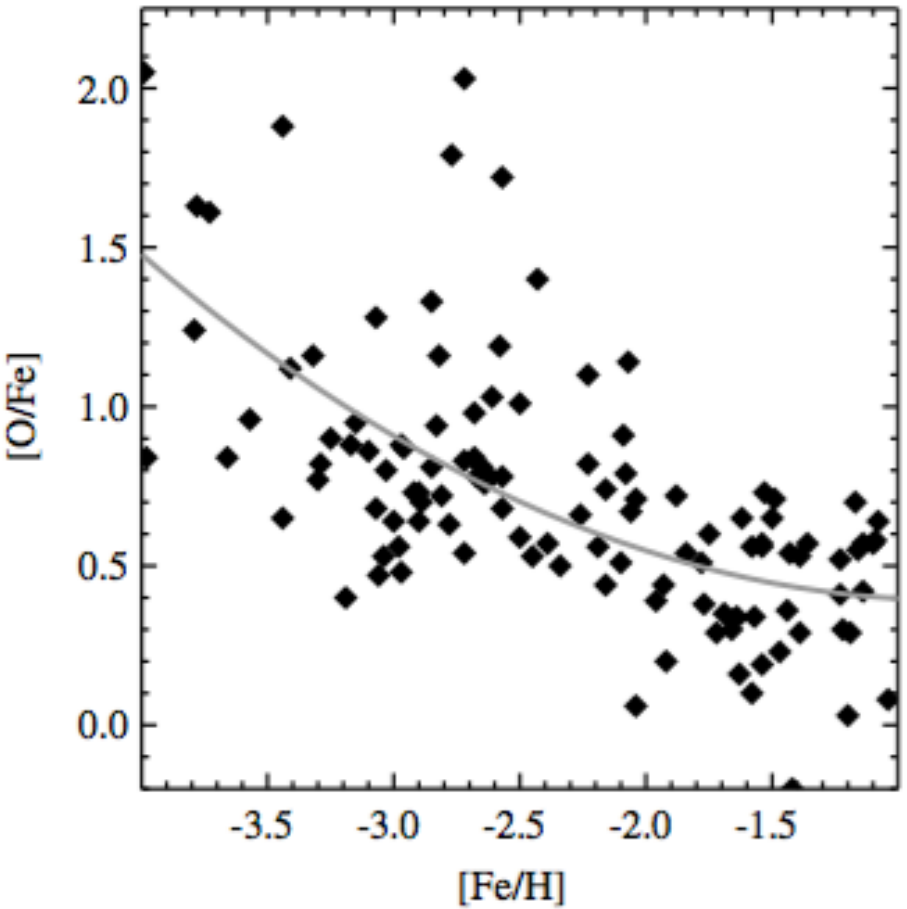


M92 Comparison



- UFDs in our sample are ancient and metal poor – compare to M92!
- Good agreement to first order, UFD stars extend bluer/brighter due to lower metallicity

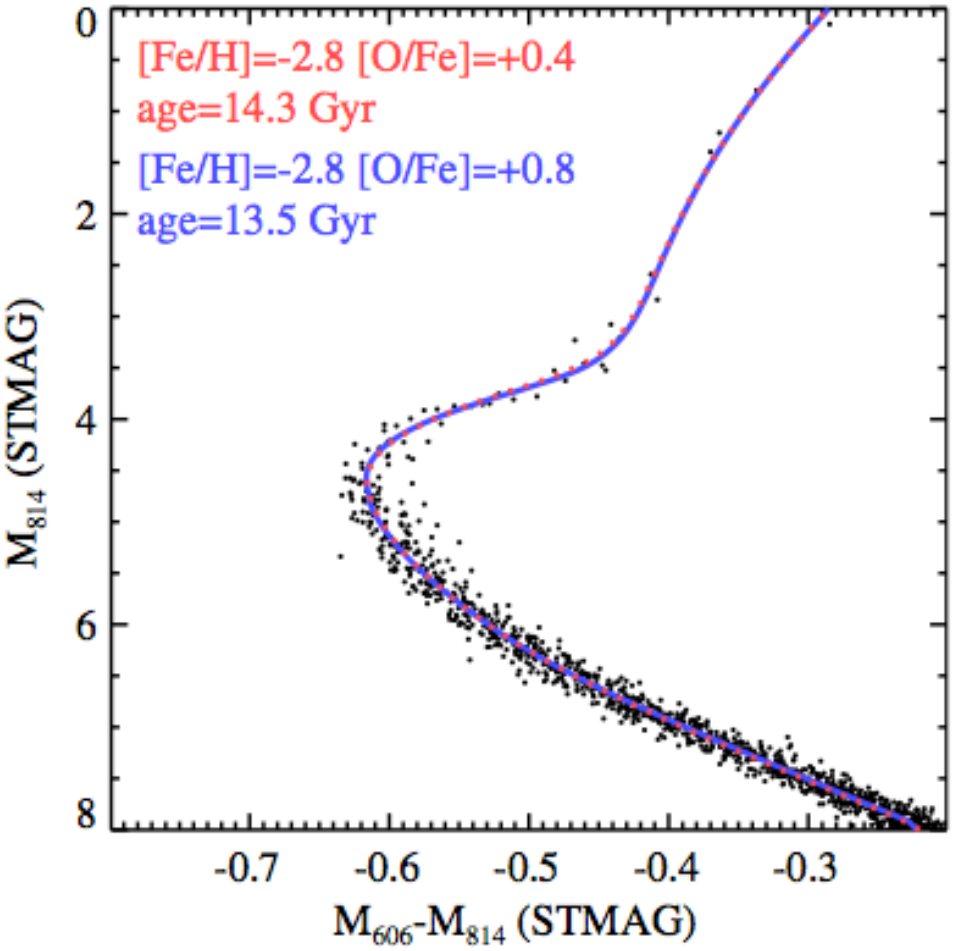
Sources of Uncertainty



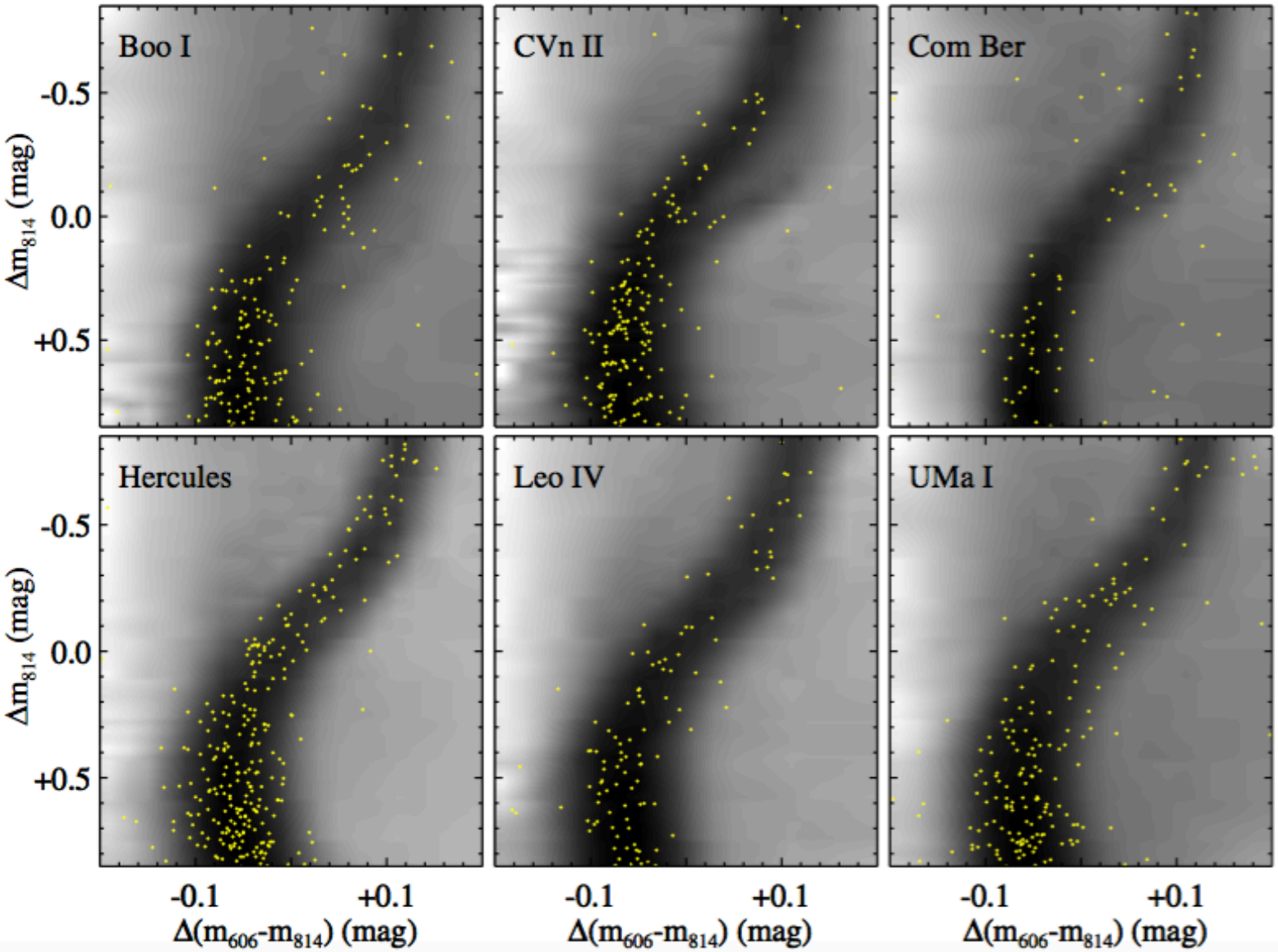
- Oxygen abundance affects CNO cycle and thus MS lifetime, making age measurement ~0.2-0.4 Gyr older.
- Age relative to M92, which has ~1 Gyr uncertainty (due to reddening, age, comp.)

Modeled CMD

- Use isochrone grid and artificial stars to make synthetic CMD that has properties of observed CMD.
- Each synthetic CMD represents stellar pop. at single age/ metallicity.



CMDs and Best Fit Models



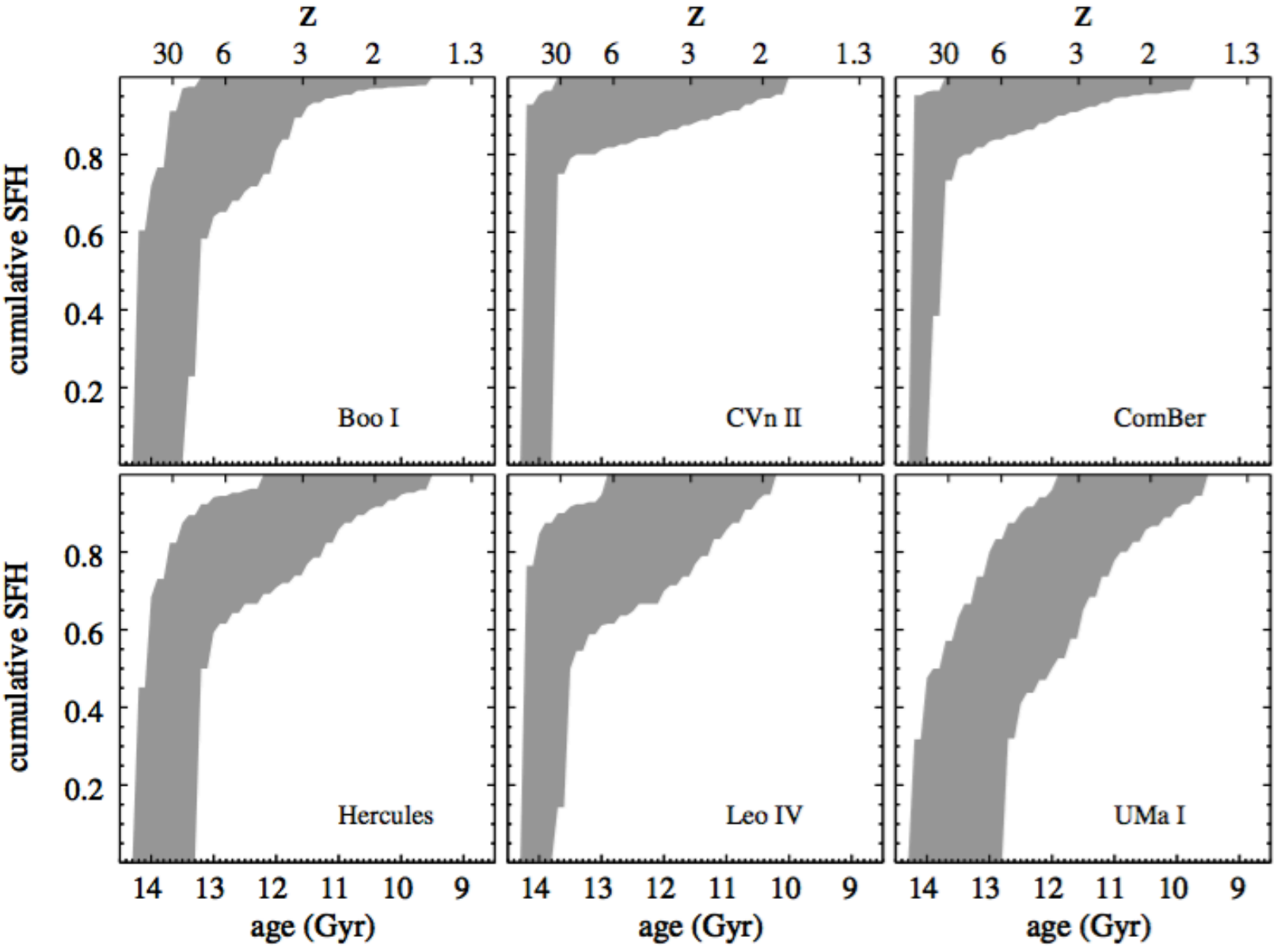
Star Formation History Fitting

SFH Fitting

Name	Age[a] Component 1 (Gyr)	Fraction Component 1 (%)	Age[a] Component 2 (Gyr)	Fraction Component 2 (%)	Mean Age[b] (Gyr)	χ_{eff}	Q (σ)
Bootes I	13.4	3	13.3	97	13.3 ± 0.3	1.05	+0.9
Canes Venatici II	13.8	95	10.6	5	13.6 ± 0.3	0.99	−0.2
Coma Berenices	14.0	96	11.1	4	13.9 ± 0.3	1.09	+1.8
Hercules	13.7	82	10.6	18	13.1 ± 0.3	0.98	−0.3
Leo IV	13.7	77	11.2	23	13.1 ± 0.4	1.01	+0.2
Ursa Major I	14.1	45	11.6	55	12.7 ± 0.3	1.02	+0.3

Notes:
Age components are relative to an M92 age of 13.2 Gyr (which itself is uncertain)
The mean age is of the two-component model

Cumulative Star Formation History



Conclusion

- This paper has characterized 6 ultra faint dwarf galaxies comprised of ancient, extremely metal poor stars.
- Two star-burst model is best fit to all 6 CMDs, although time between bursts and fractions differ.
- Still significant uncertainties due to oxygen abundance and distance moduli.
- Discovery of these galaxies reduce tension between Lambda CDM and observations.

Reionization

- Majority of stars (>75%) were formed prior to 13.3 Gyr (z~10), when reionization begins.
- 'The population of these galaxies are very similar to each other, as one might expect if they were all influenced by an event that synchronized the truncation of star formation in each.'
- Reionization heated the gas in small DM halos to ~10^4 K, thermal pressure boiled the gas out into IGM. Gravity too weak to retain/reacquire gas from reionized IGM.

~~The Future~~

- Currently, studying cosmologically interesting dwarfs only possible in LG.
- Most of the discovered dwarfs are too massive to experience quenching from reionization (must be fainter than Mv ~ -8 mag).
- Best hope for future progress is wide field surveys to reveal additional faint satellites.