The UV Upturn: He-rich Stars in Cluster Early Type Galaxies

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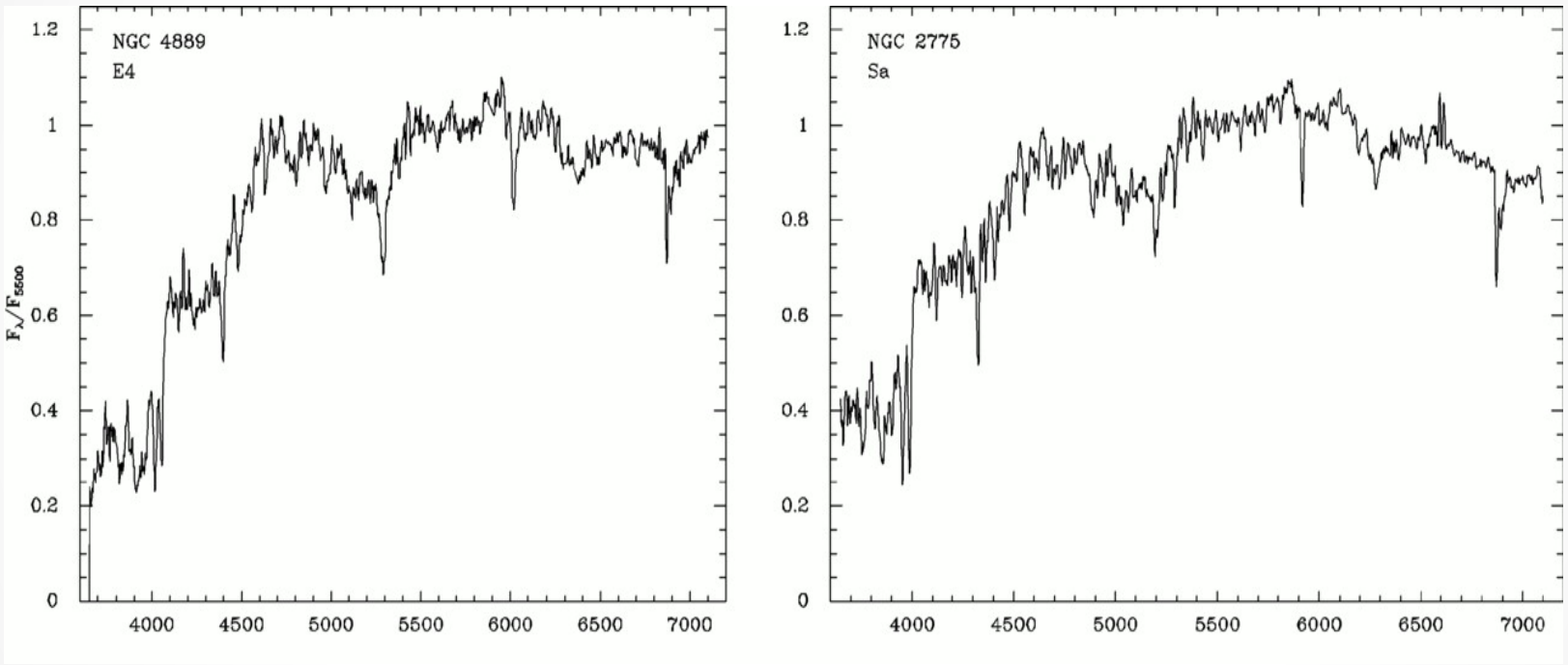
Stellar Populations in Early Type Galaxies

Dominated by Old Stars

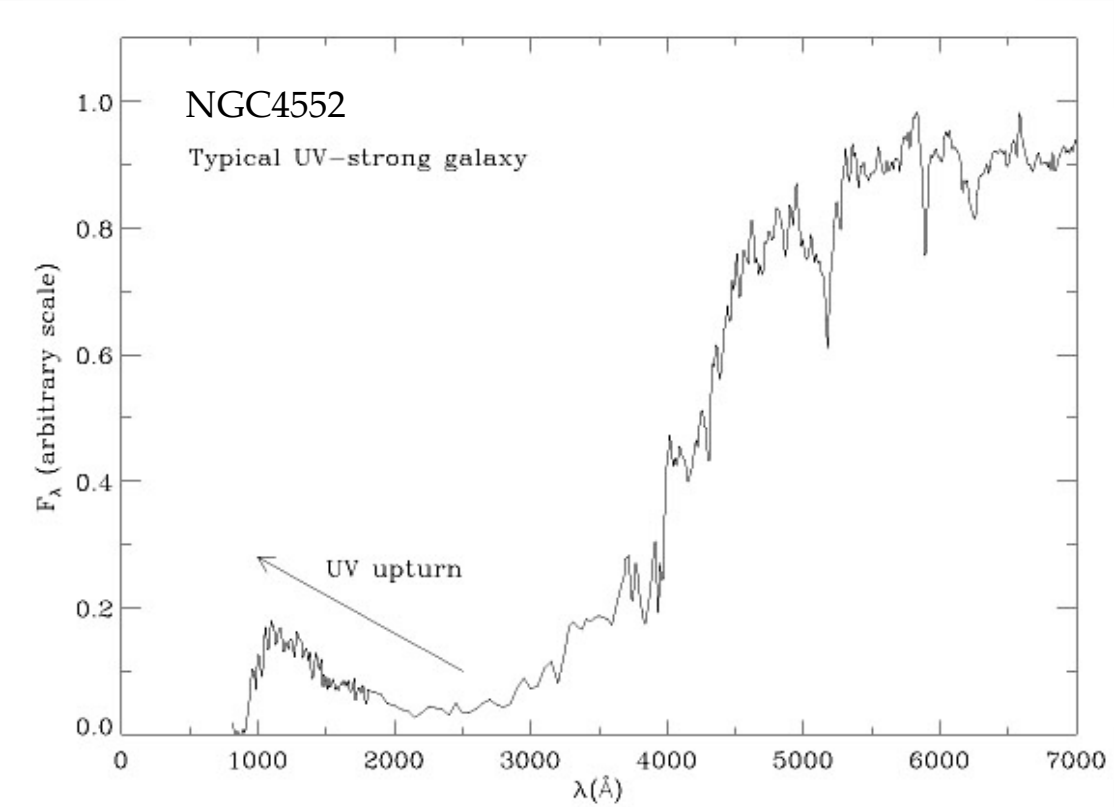


Kennicutt et al. (1992b)

- **MS and RGB stars that emit very strongly in the optical.**
  - **Very little to no signature of star formation.**

The UV Upturn

Hot HB stars in High Metallicity Systems



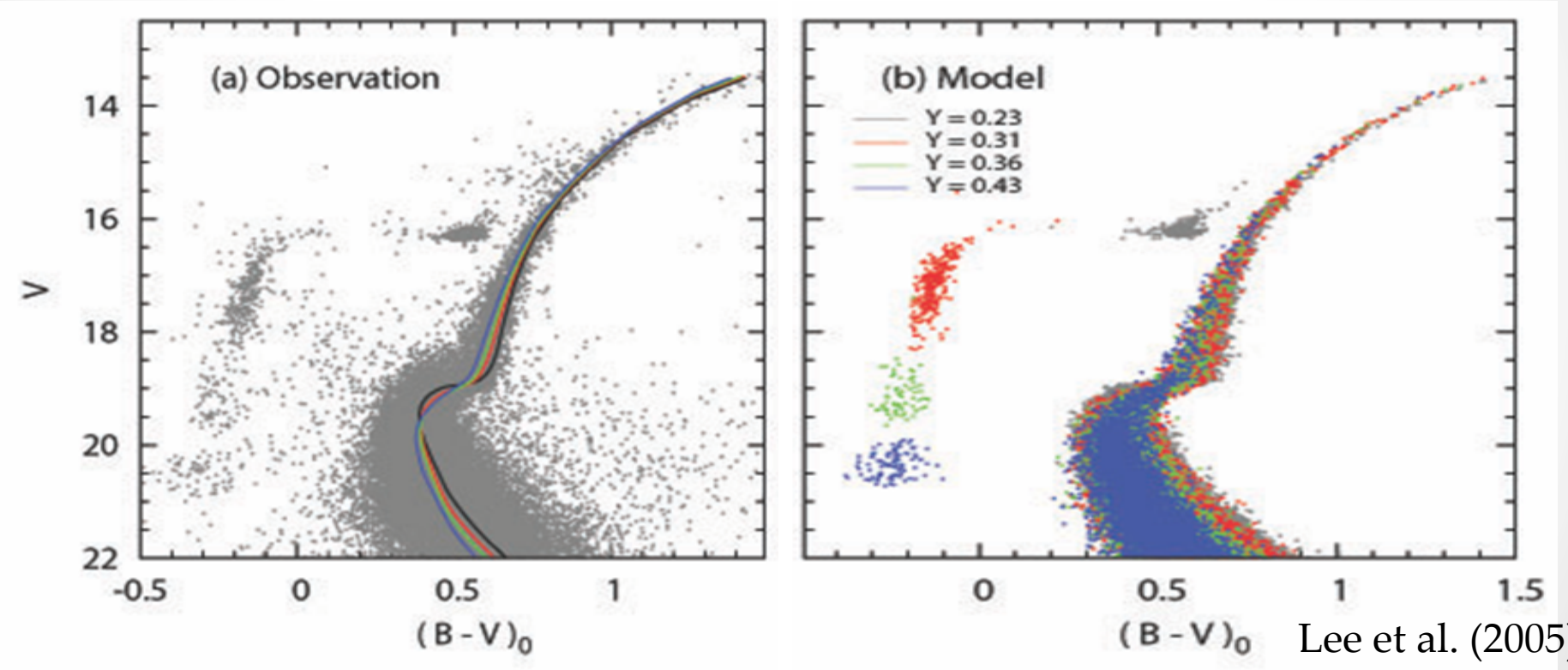
Yi et al. (1998)

- **The origin of this UV flux is thought to be hot Horizontal Branch stars.**

He Enhancement in HB Stars

"Second Parameter" in Globular Clusters

NGC2808

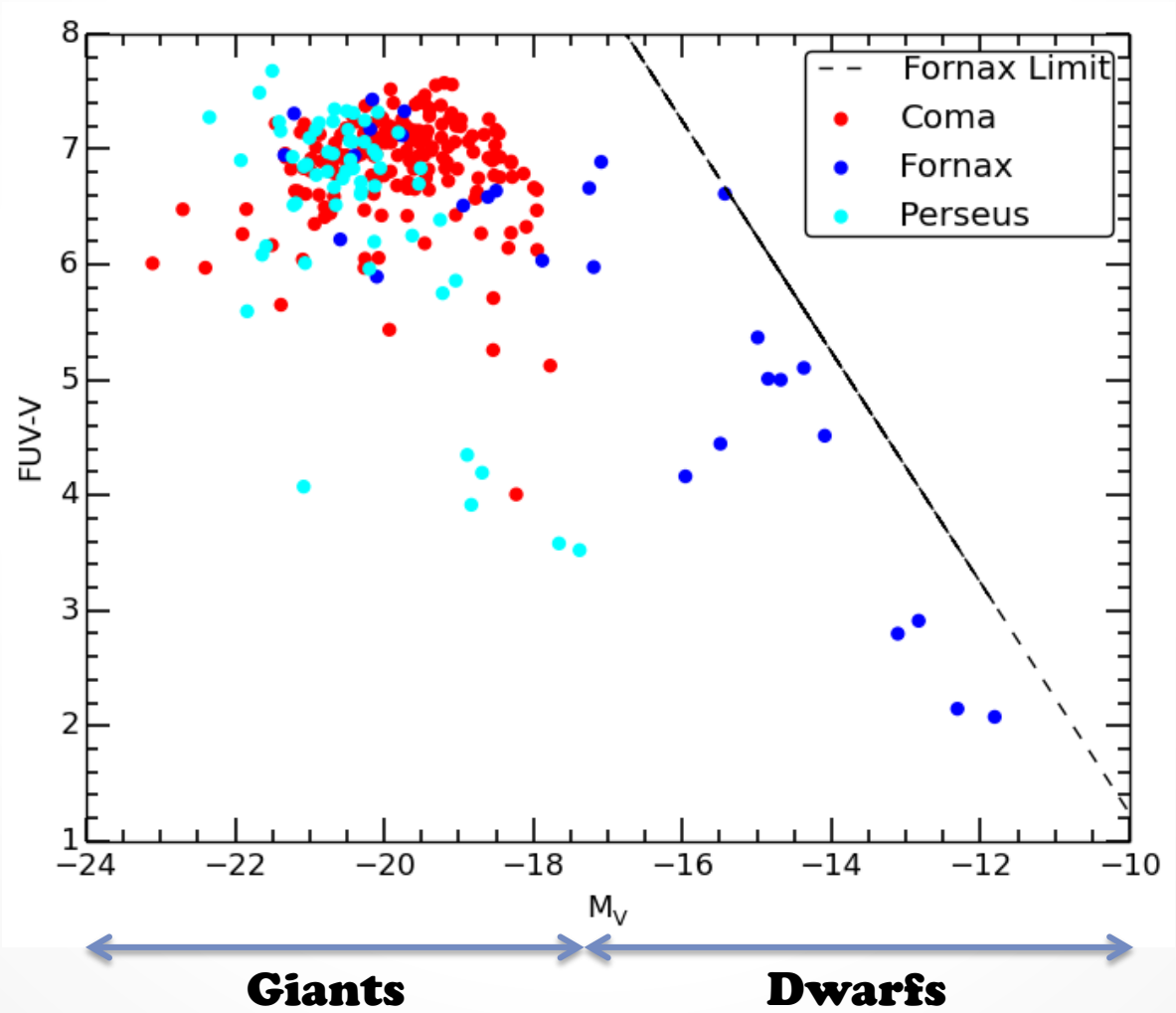


Lee et al. (2005)

- **HB stars can become UV-bright through the enhancement of Helium (Y>0.3 at high Z).**

Nearby cluster Early-type galaxies in the UV

FUV-V vs M_V for Coma, Fornax & Perseus



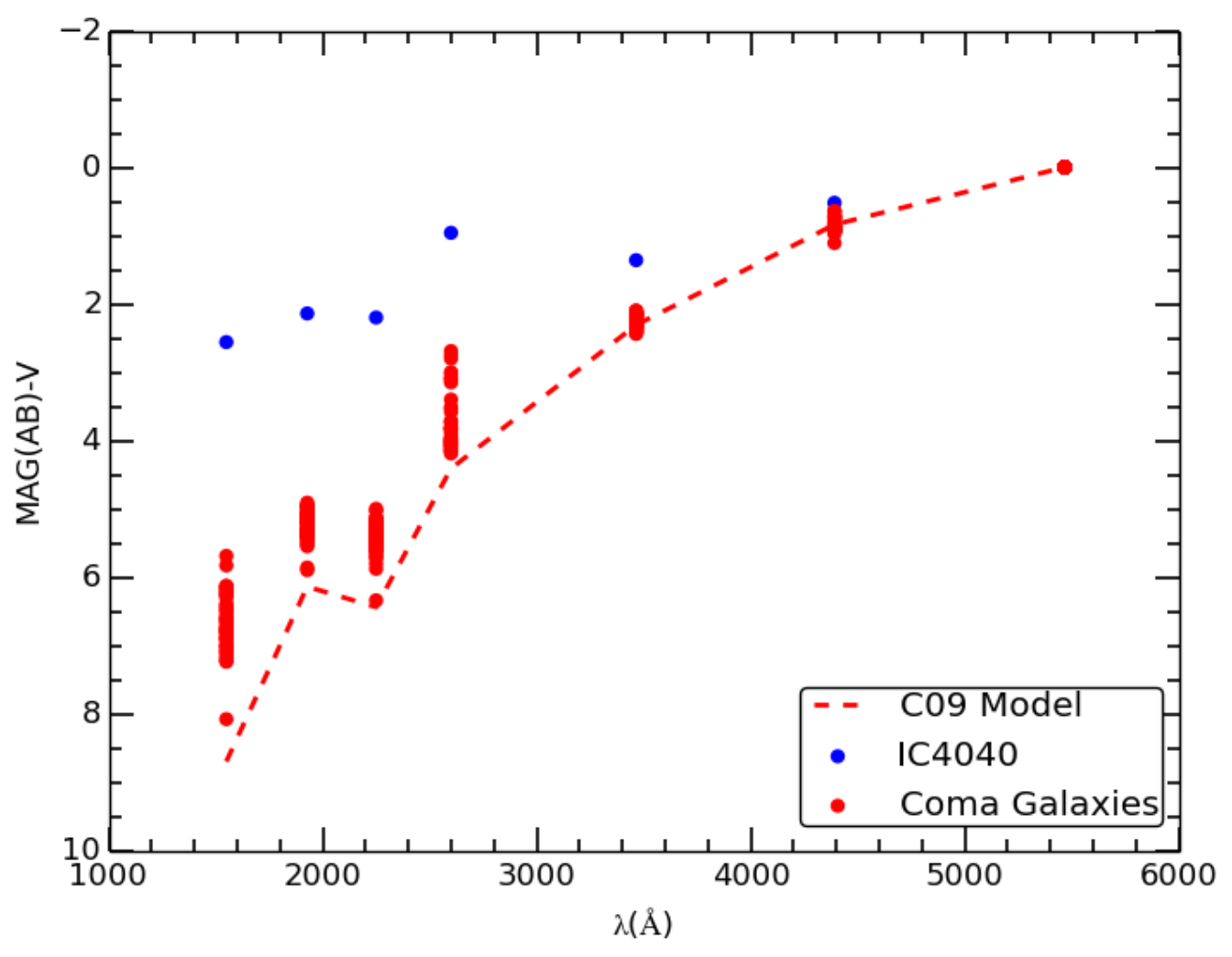
UV to optical SEDs of Coma Early-type Galaxies

1) Data

- Coma imaged in both GALEX & SWIFT UVOT.
- GALEX FUV & NUV: 1550A & 2250A.
- SWIFT UVOT UVW2 & UVW1: 1900A & 2600A.
- SWIFT UVOT UBV.
- Combining these data points allows us create *integrated SEDs from UV to Optical*.

UV to optical SEDs of Coma Early-type Galaxies

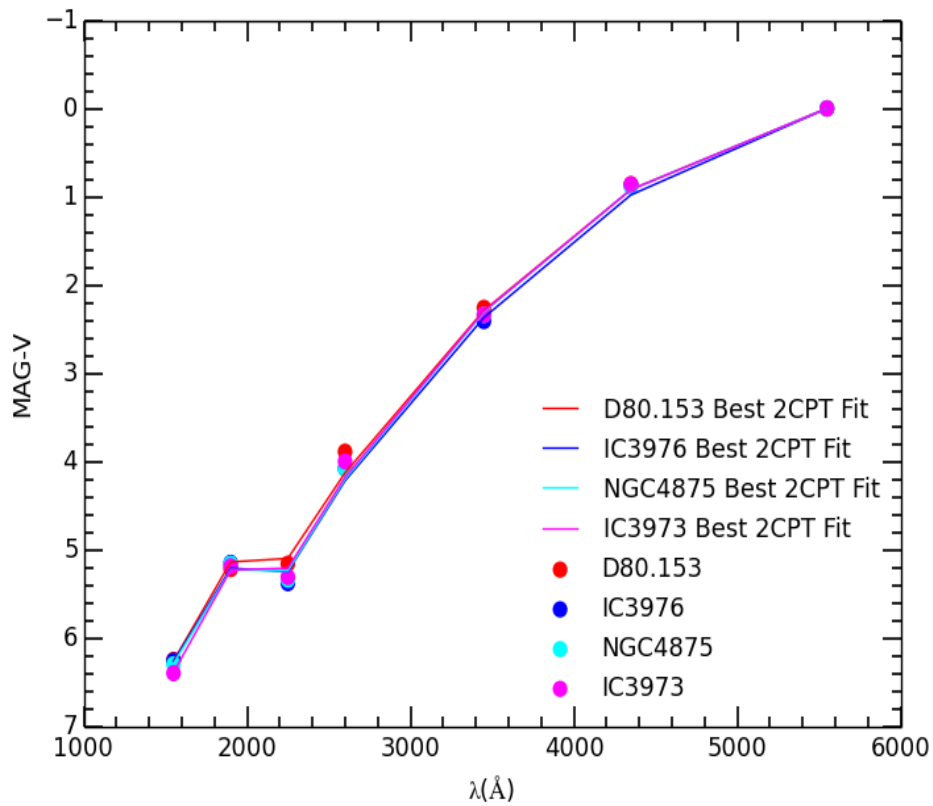
2) Results

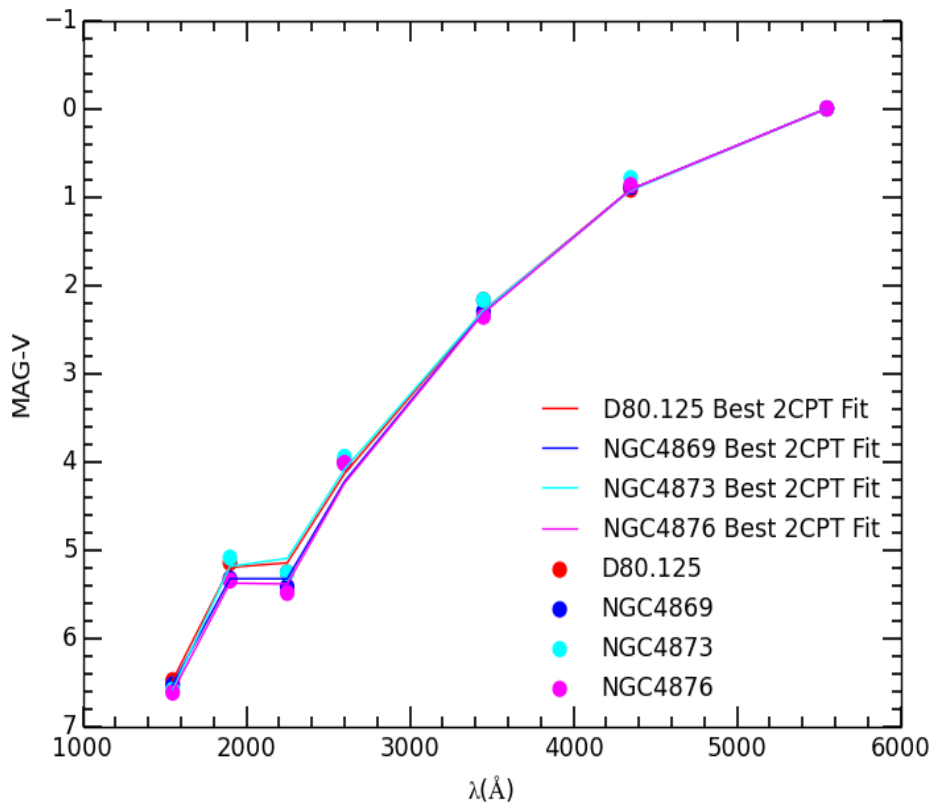


Fitting UV SEDs of Early-type Galaxies

Old SSP + Hot HB

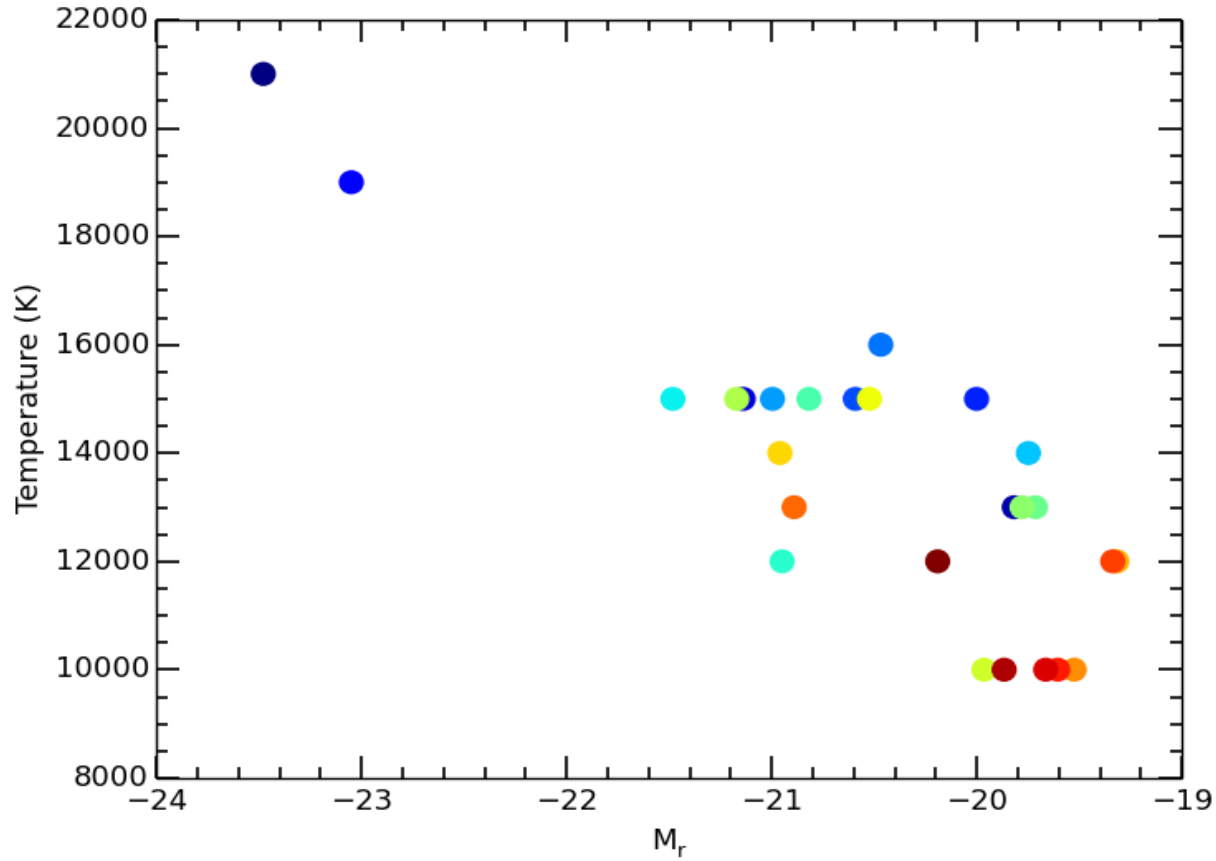
- **A conventional "red and dead" SSP from Conroy & Gunn (2009) with $Z=Z_{Solar}$ and $z_f=4$.**
- **Blackbody of a given temperature and normalisation.**





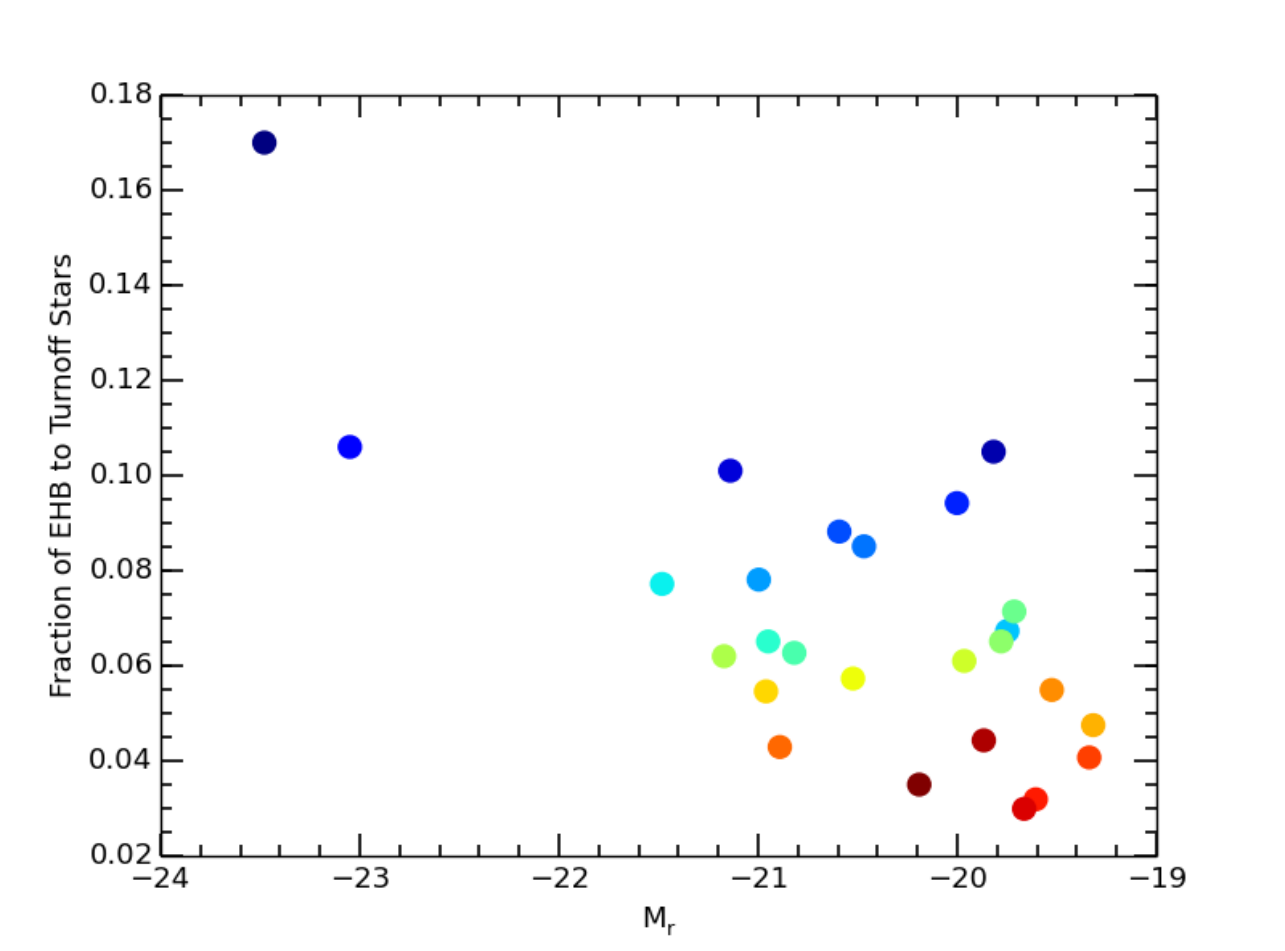
Temperature vs M_r

Range: ~10,000-21,000K



Fraction of EHB/turnoff vs M_r

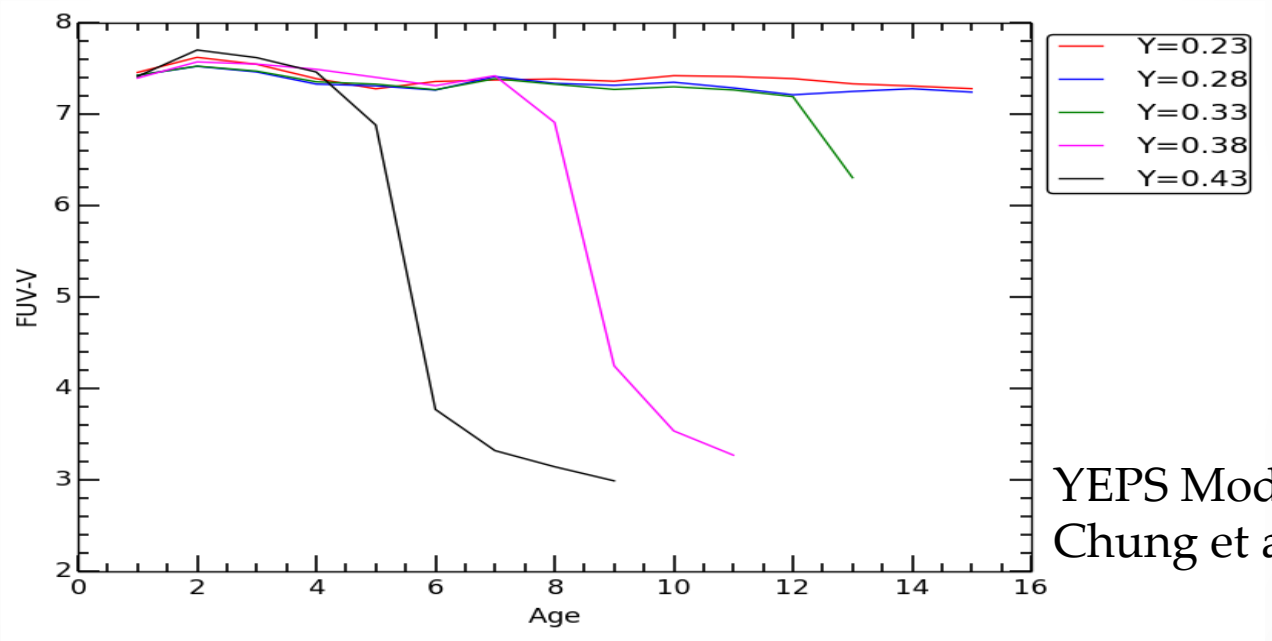
Range: ~4-20%



Estimating Age of hot HB stars in ETGs

A He-enriched population formed at high z

- **NGC6791 – Y=0.34 (Buzzoni et al. 2012).**



YEPS Models, Z=Z$_\odot$
Chung et al. (2017)

- **For Coma and Z=Solar, Y=0.34 stars would need ~12Gyrs (formed at z~4) to show up at present.**
- **Higher He-enrichment with increasing metallicity.**

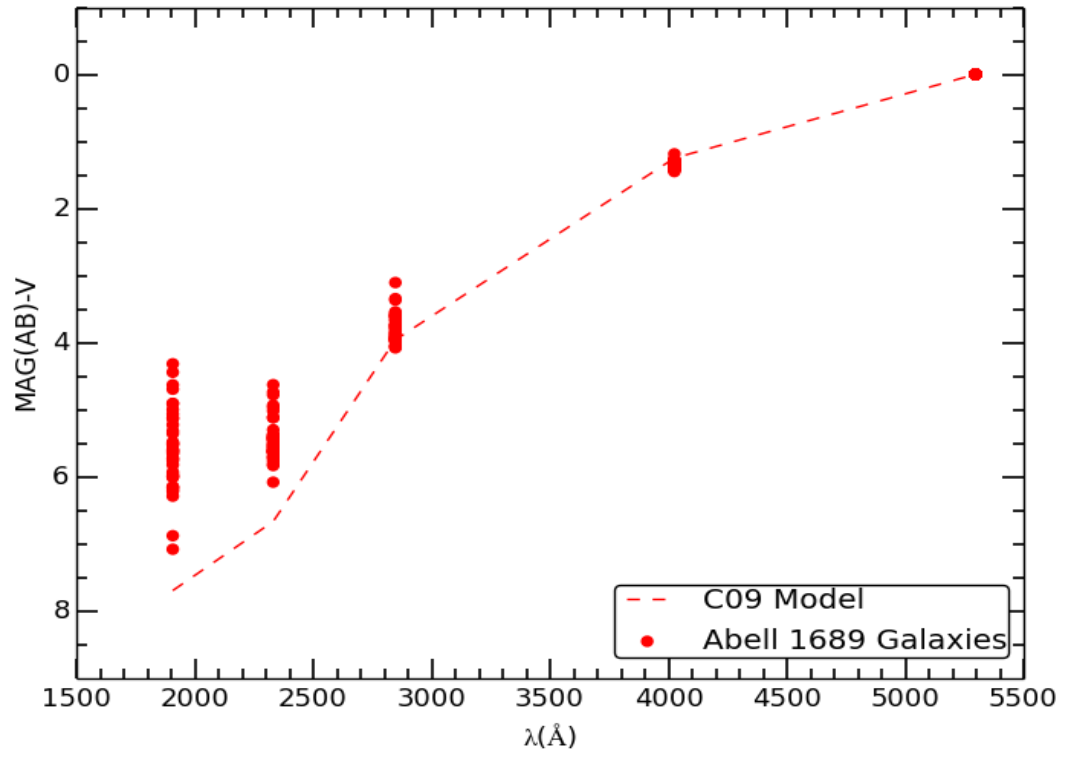
Conclusions

- We fit Coma SEDs with 2 component models.
- Temperatures of the HB increases with luminosity.
- Temperature range ~10,000-21,000.
- Galaxies with higher luminosities also tend to have higher fractions of He-enriched stars.
- Fraction of EHB to turnoff star is ~4-20%.
- For Y=0.34 and solar metallicity, these stars would need to form at z~4 to become UV-bright at present, or would need to be even more He-enriched.

SEDs of Abell 1689 Early-type Galaxies

Probing to L* at z~0.2

- HST F225W, F275W, F336W: ~1900A, 2300A, 2800A.
- HST F475W & F625W: ~B & V.
- ~50 galaxies detected in UV down to ~L*.



Conclusions

- **UV upturn persists to z~0.2 (2.5 Gyrs in lookback time).**
  - **Comparable to Coma galaxies.**
  - **The He-enriched populations in these galaxies would need to form even earlier (z~6?) than Coma.**
  - **And/or have even higher Y(>0.34) than Coma to show the range in UV outputs that we observe.**