Star Formation in Merging Clusters of Galaxies

Alison Mansheim
UC Davis
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Roadmap

- Inspiration — Why?
- Background — What?
  - Galaxies
  - Clusters of Galaxies
- Techniques — How?
  - Spectroscopy
  - Models
- Conclusion — So?

Inspiration

On September 3rd, 2003 The Hubble Space Telescope began pointing its camera at a particularly small and dark patch of sky. After 4 months...

Each dot of light in this image is a galaxy. Each galaxy contains up to 1 trillion stars. Each star may have a system of planets. There are 10 THOUSAND galaxies in this one image alone.

Inspiration

Infinite colors, shapes and sizes!

WHY?

Our Galaxy: The Milky Way

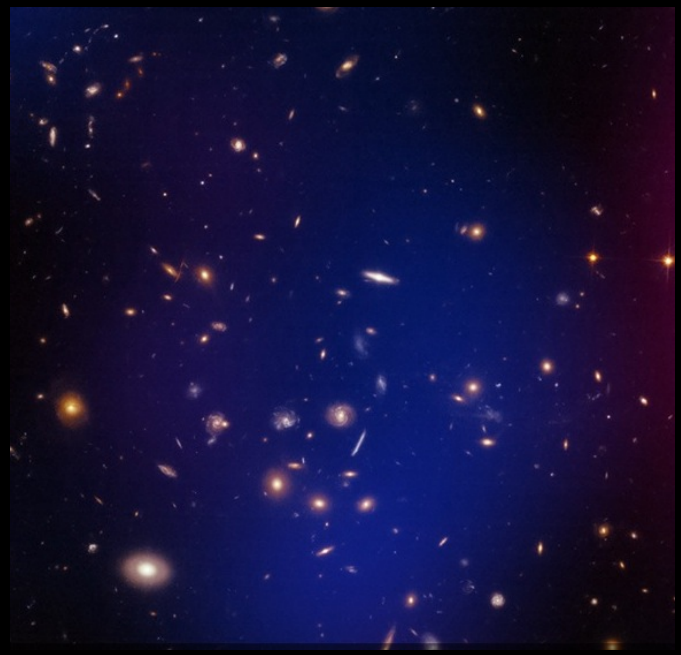
Beyond the Milky Way: The Local Group

- The local group is a group of 3 dozen nearby galaxies (3Mly)
- How do we find more?

Graphic from Chandra X-ray Telescope outreach

WAY Beyond the Milky Way: Clusters of Galaxies

- Clusters of galaxies are the largest gravitationally bound objects in the universe
- $M_{200} > 10^{14} M_{solar}$
- $r_{200} \sim 2\text{Mpc} \sim 10^{19}$ miles
- Diverse population
- 50-3000 galaxies
- Dynamic environment

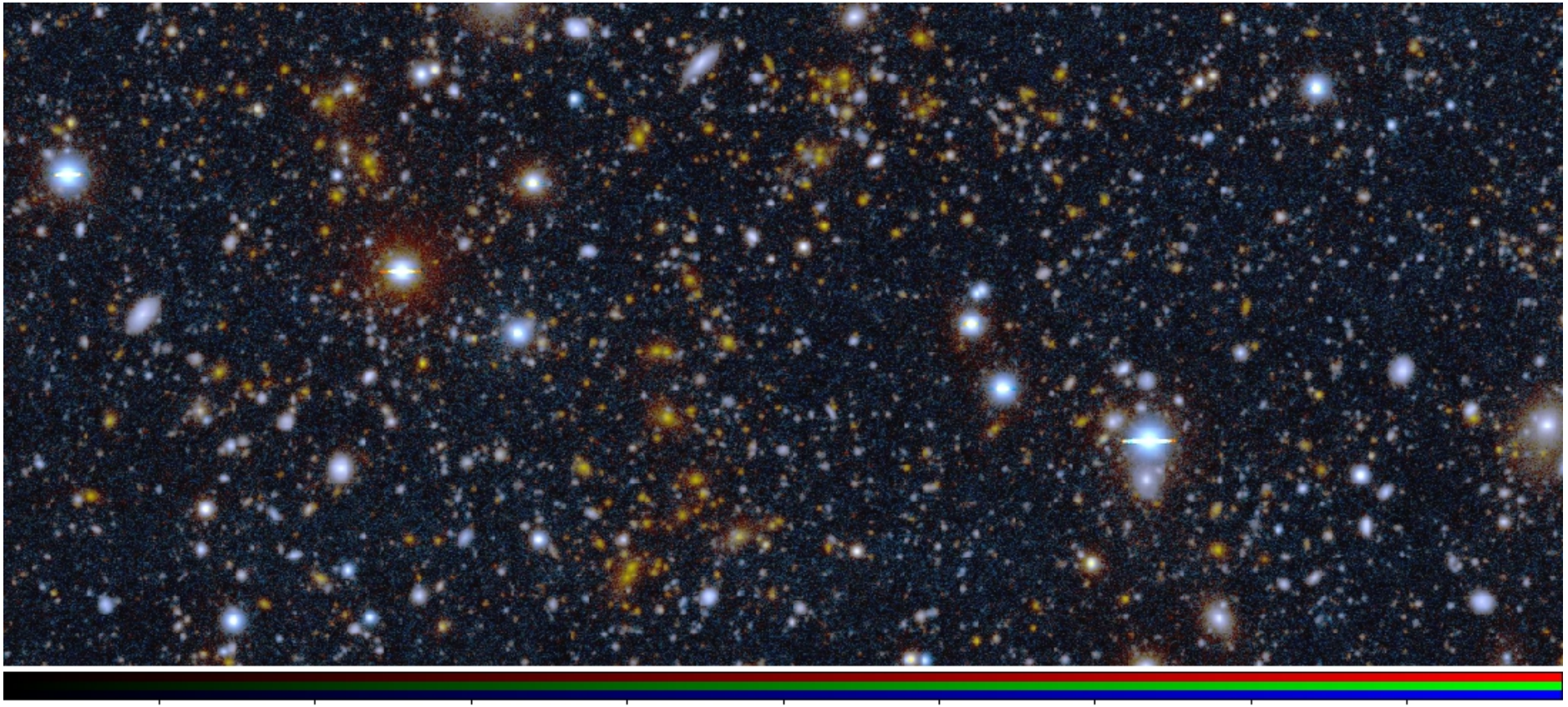


Merging Clusters of Galaxies

- More: Sample size, Diversity, Challenge
- Extreme conditions speeds up evolutionary processes
- Created to relaxed clusters we see today

Musket Ball Merger (DLSCL J0916.2+2953)

- 1.9x1.9Mpc^2~6x6 million-trillion miles^2)
- z~0.53 (universe 2Gyr old)



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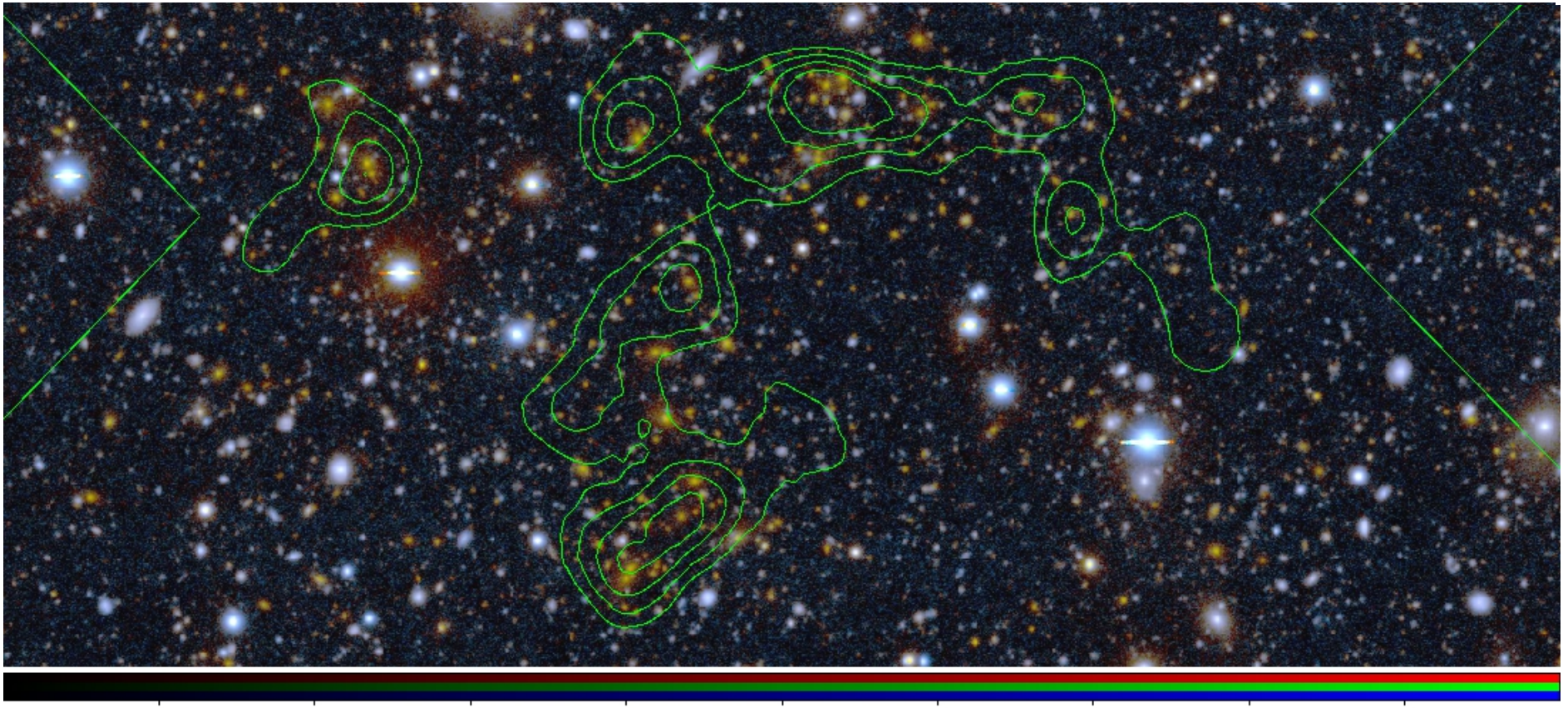

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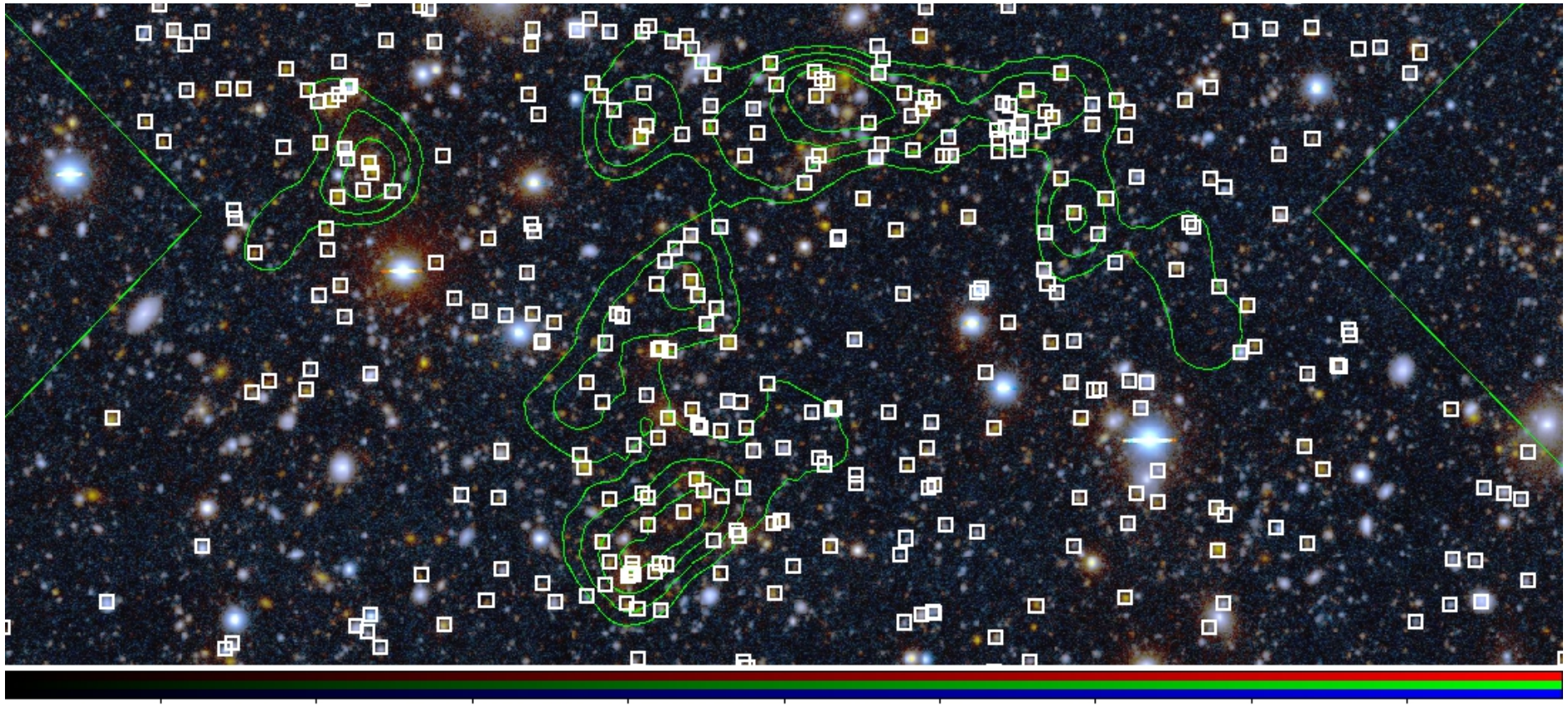
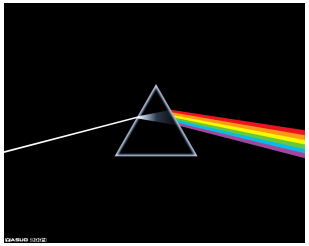
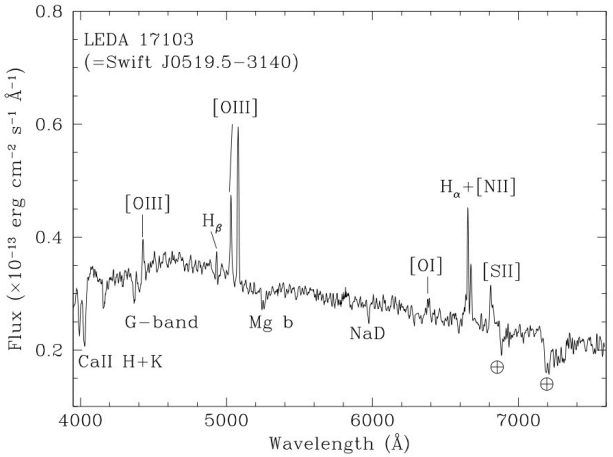
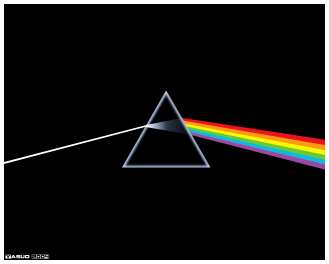


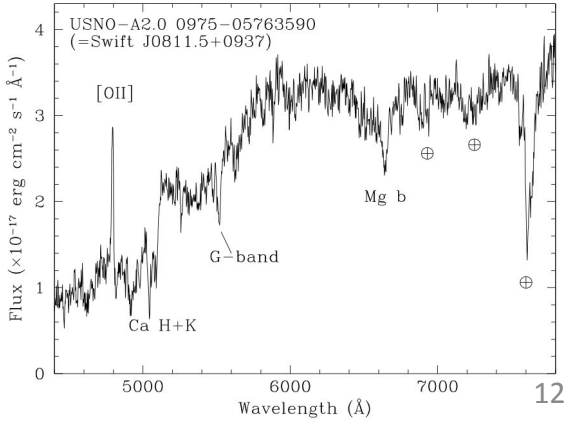
How do we study galaxies?

- Dissect light using spectroscopy.

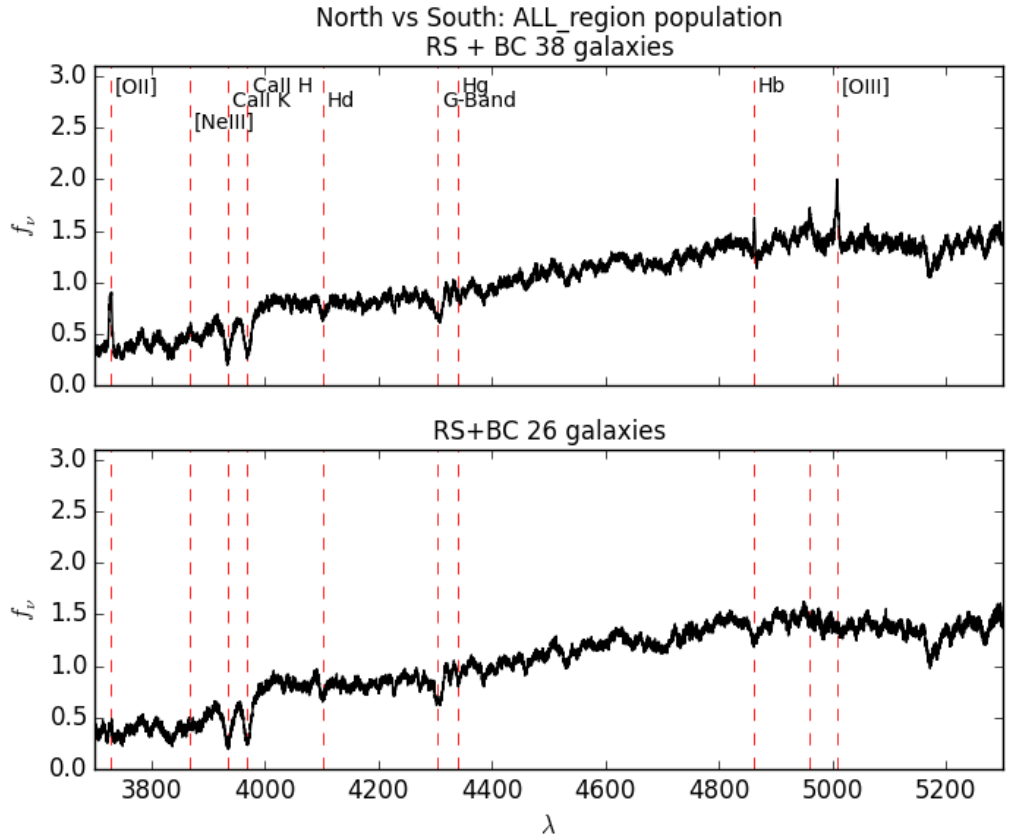








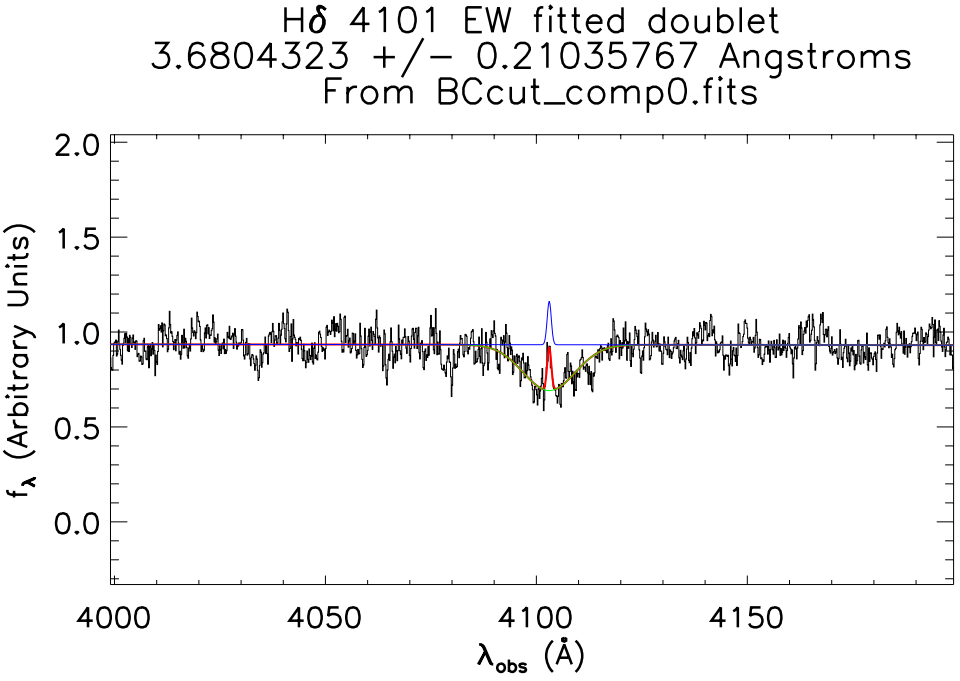
Composite Spectra: Star Formation in the North and South Clusters

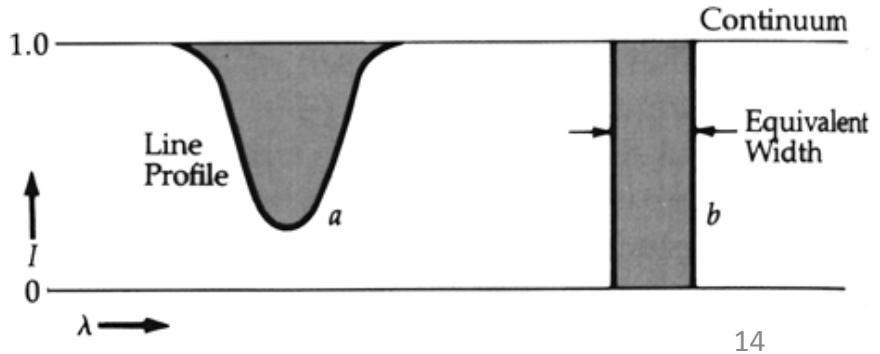


✧Composites reveal key features of average galaxy in region

How do we measure a spectrum?

- Equivalent Width (EW) is a quantitative measure of line strength
- Allows us to compare strengths among different populations

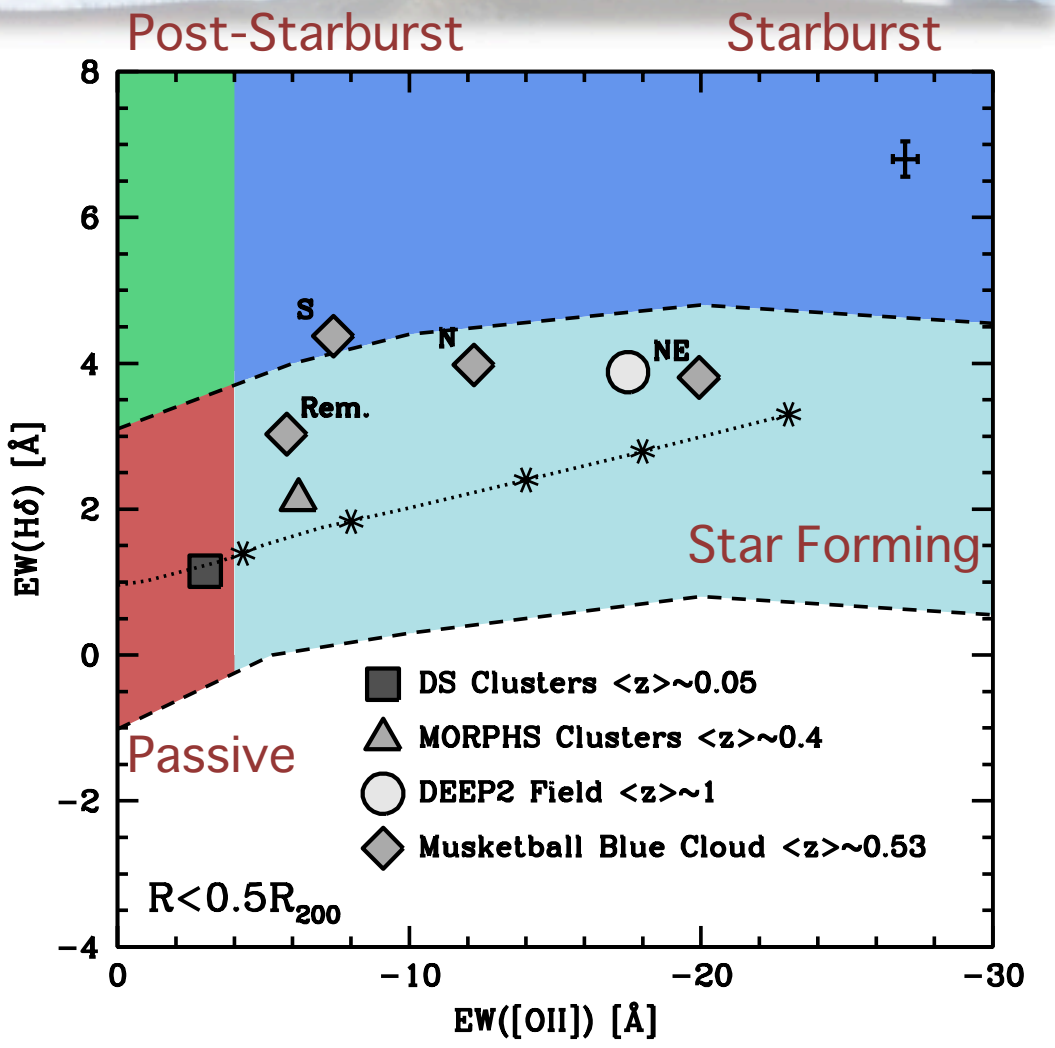




Results: EW(Hδ) vs EW([OII])

How much current star formation is happening on average in each region?

- ✧ N&S clusters well above passive/continuous line, indicating past burst
- ✧ S>N>Superfield

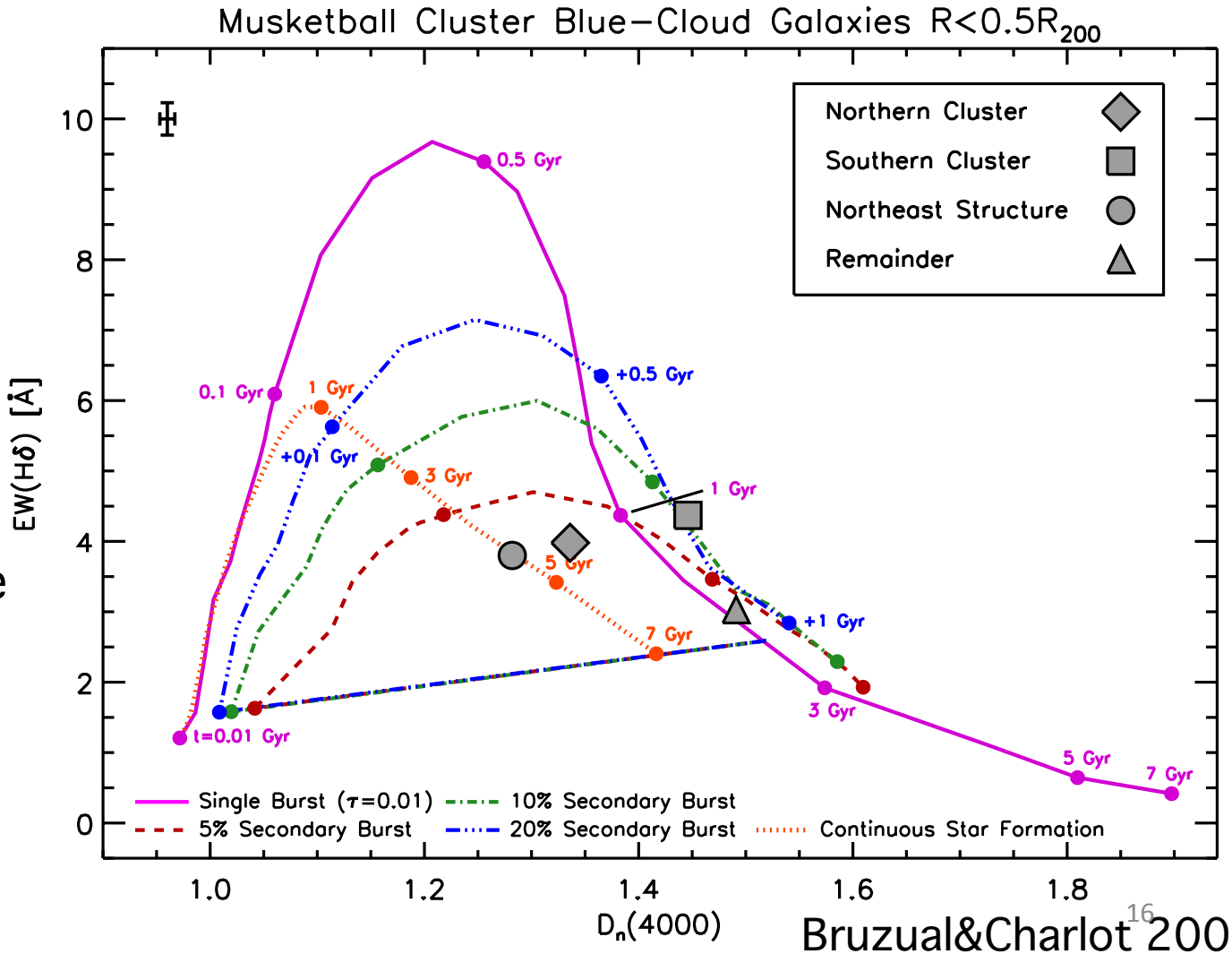


Dressler 2004

Results: EW(Hδ) vs $D_n(4000)$

How long ago was last starburst?

- ✧ Data consistent with Starburst in South approximately 0.7 Gyrs ago
- ✧ Recall time since merger ~0.7Gyr ago!



Bruzual&Charlot 2007

Summary

- Clusters of galaxies are important tools for studying galaxy evolution and star formation
- Spectroscopy allows us to connect the light we observe to the internal workings of a galaxy
- Data suggests a starburst in the Southern cluster approximately 0.7 Gyrs ago
- Starburst coincides with time of cluster merger indicating collision as possible cause

Thank you to the organizers for this opportunity!

Thank you to the audience for listening!

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