



NGC 4676 – Mice Galaxies, *Hubble/ESA* 2002

QUANTIFYING THE LATE GALACTIC FORMATION PERIOD

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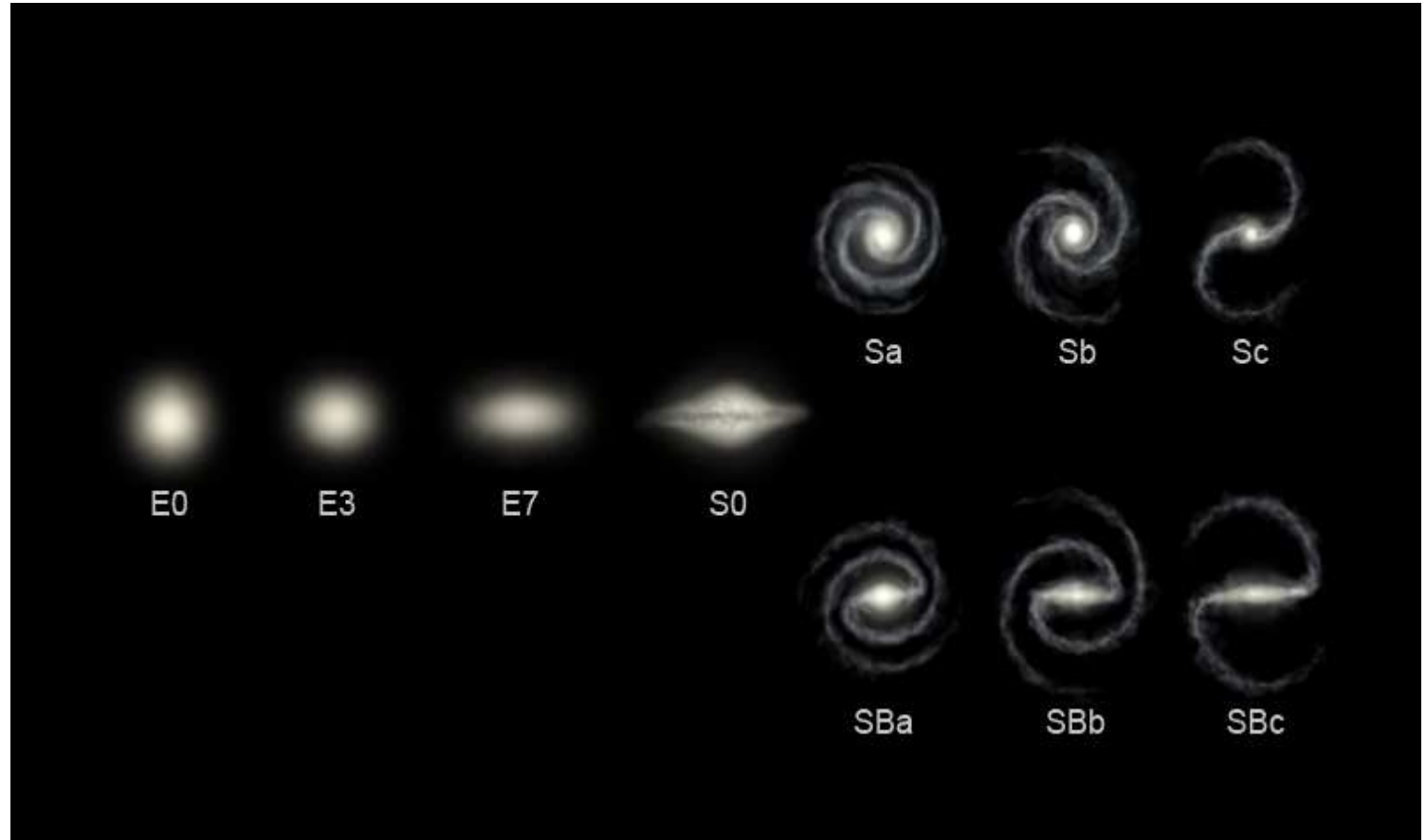
OVERVIEW

Galactic Morphology

- Gas rich – Spiral, barred, irregular
- Evolved – S0, **Elliptical**

Free gas in galaxies? Clusters?

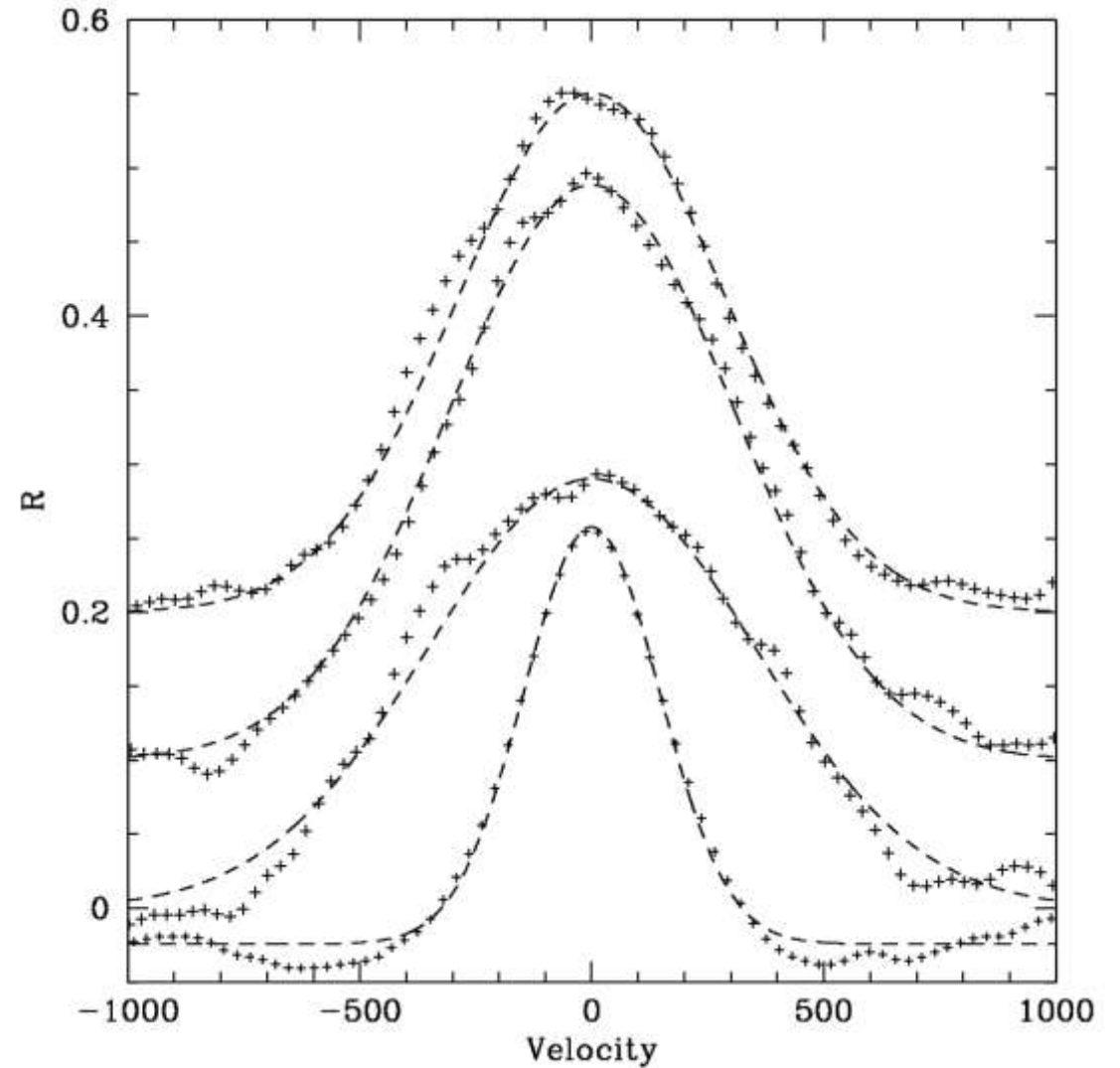
How do galaxies evolve?



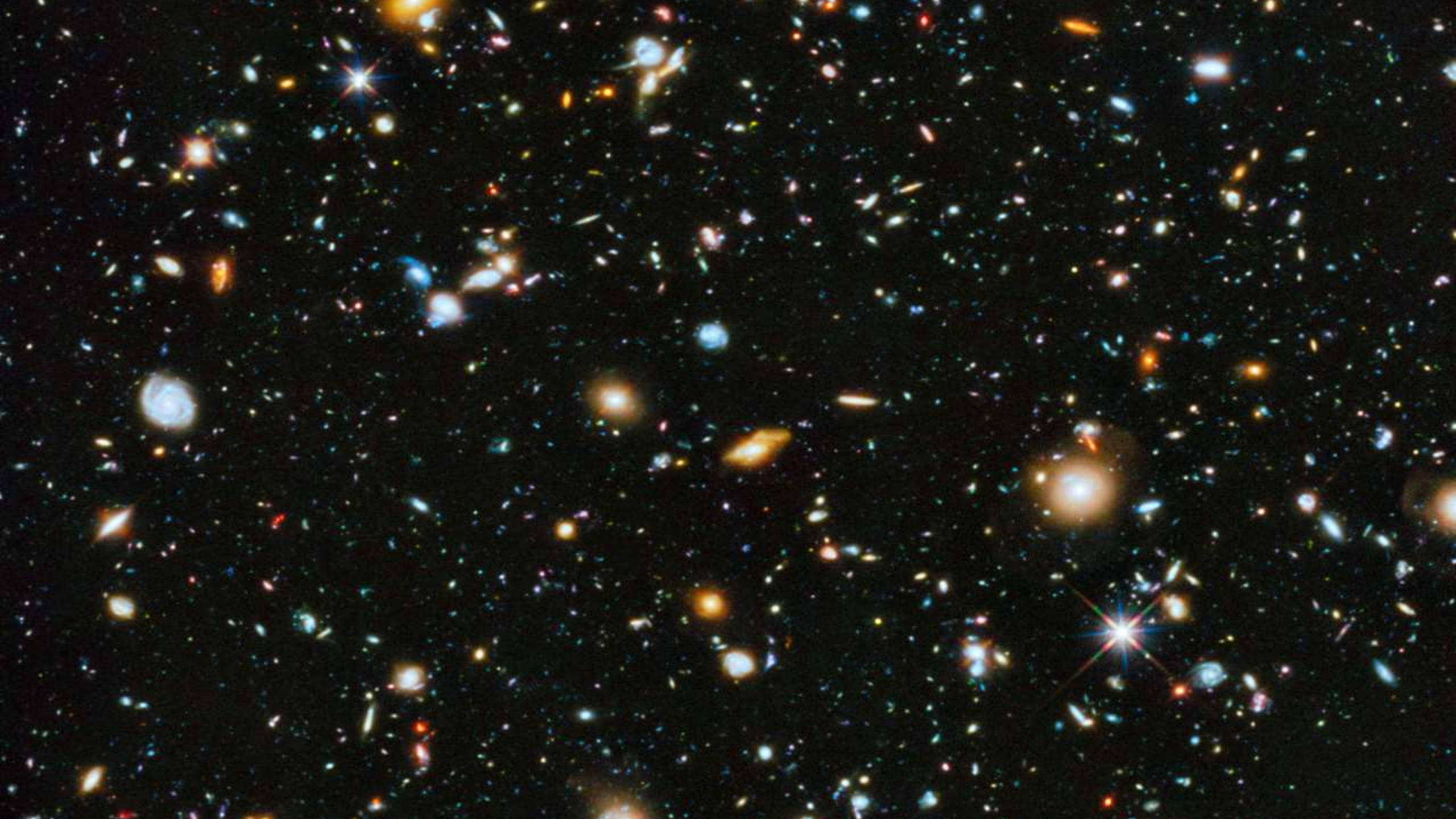
Hubble Tuning Fork, Harp 2015 PD

MOTIVATION

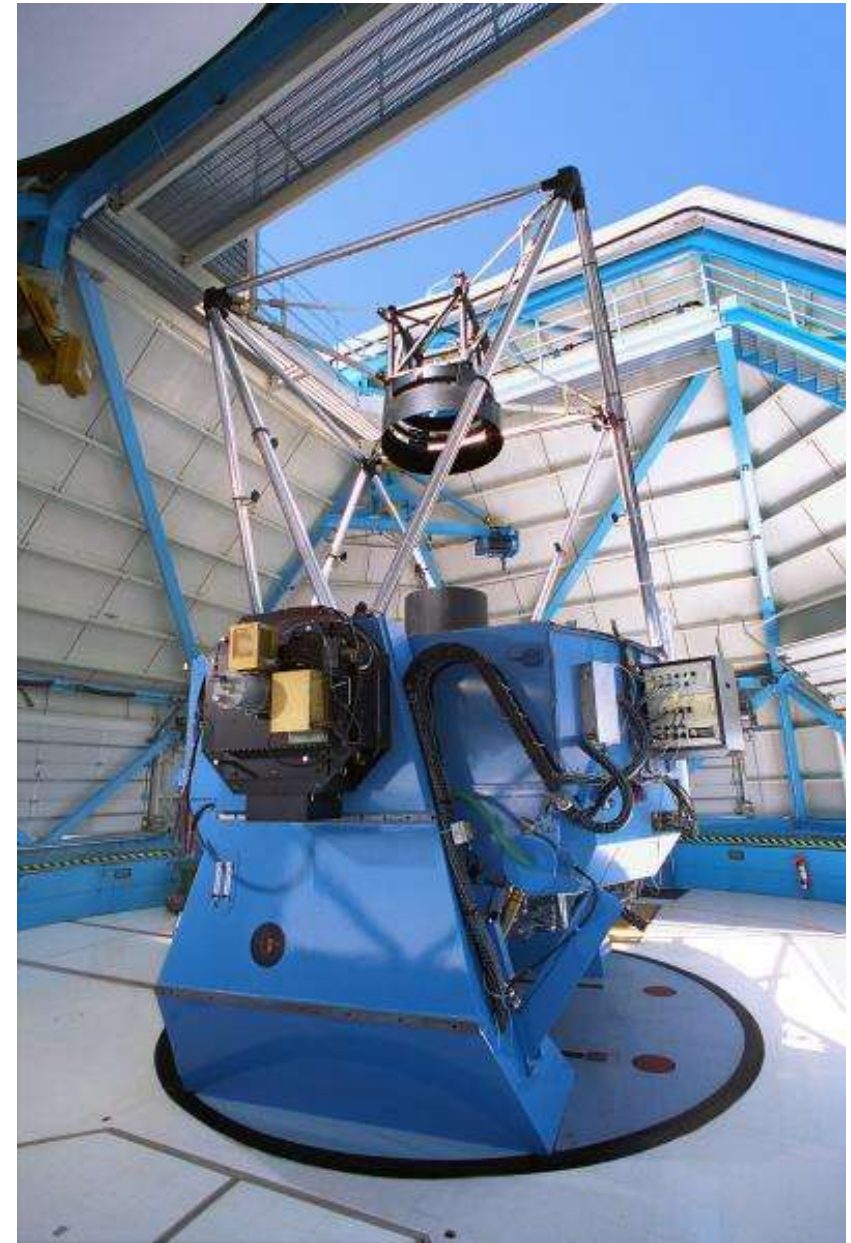
- Non-Gaussian shape present in Fourier Cross-Correlation function
- Need method to quantify
- We have a “fossil” record
- Approach:
 - Statistical analysis
 - Random sampled simulated galaxies



Pierce 2014



WIYN+HYDRA

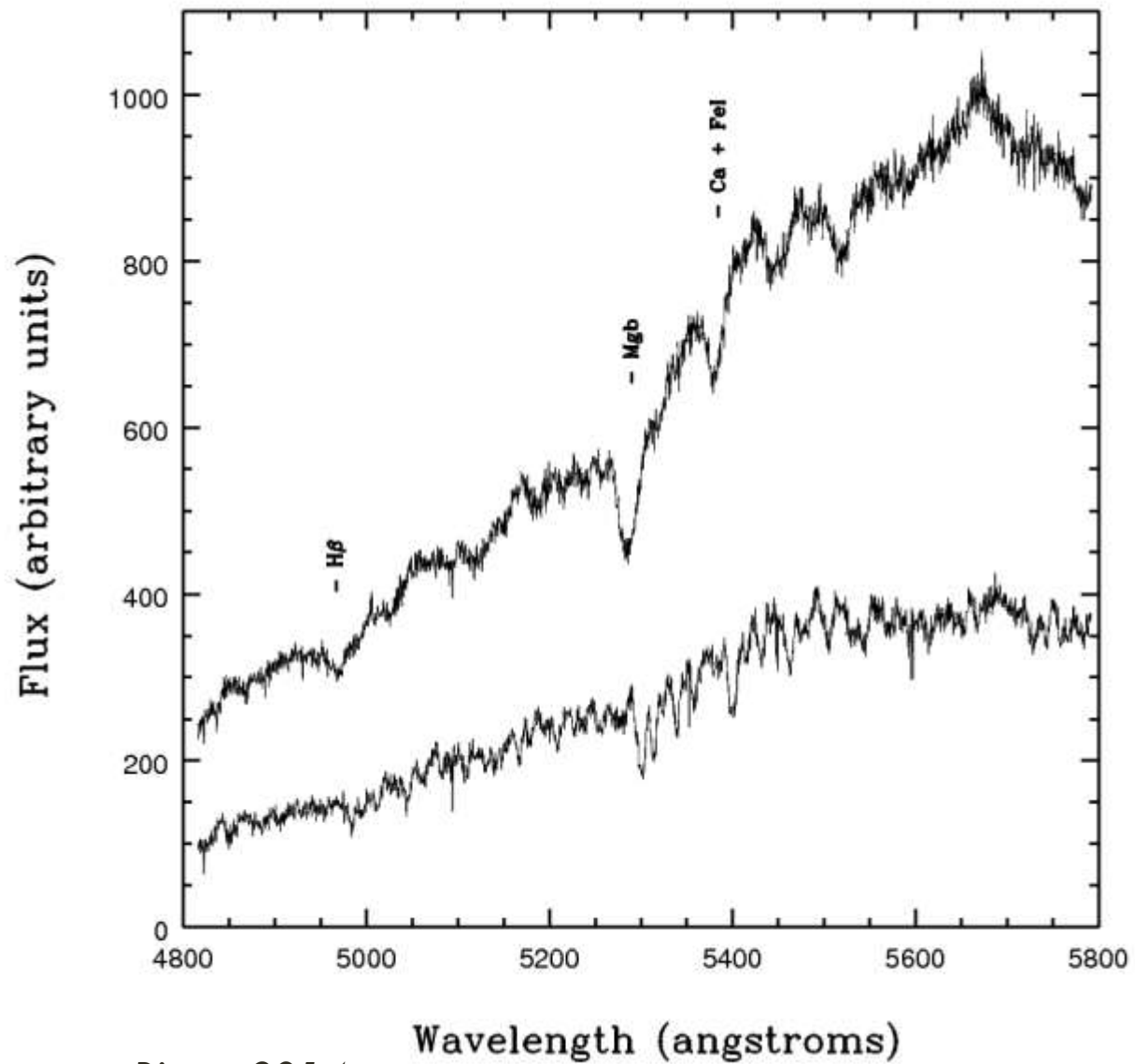


Left: Hydra focal plane. Right: WIYN 3.5m telescope
Phil Massey, Lowell Obs./NOAO/AURA/NSF

METHODS



M87, Hubble 2009

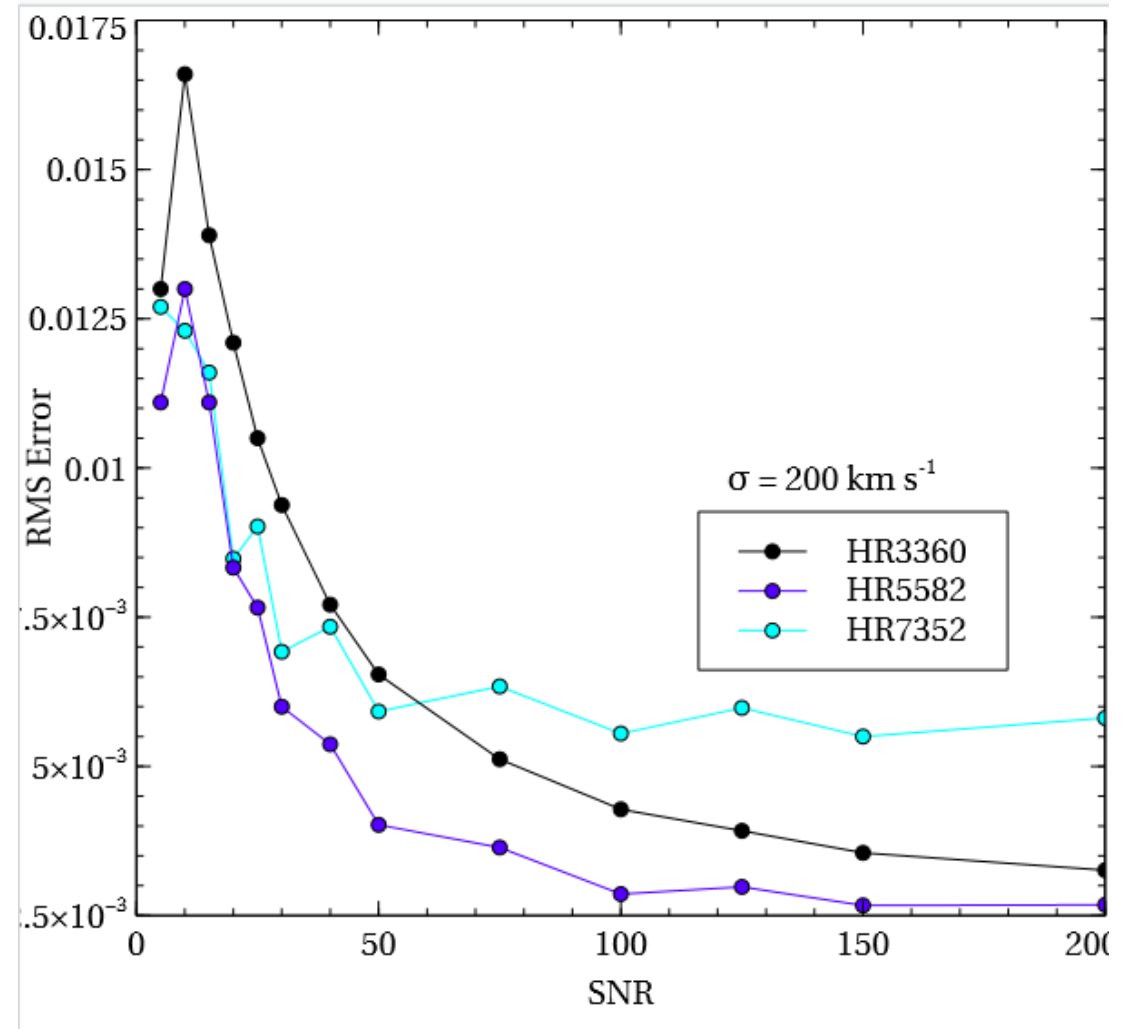


Pierce 2014

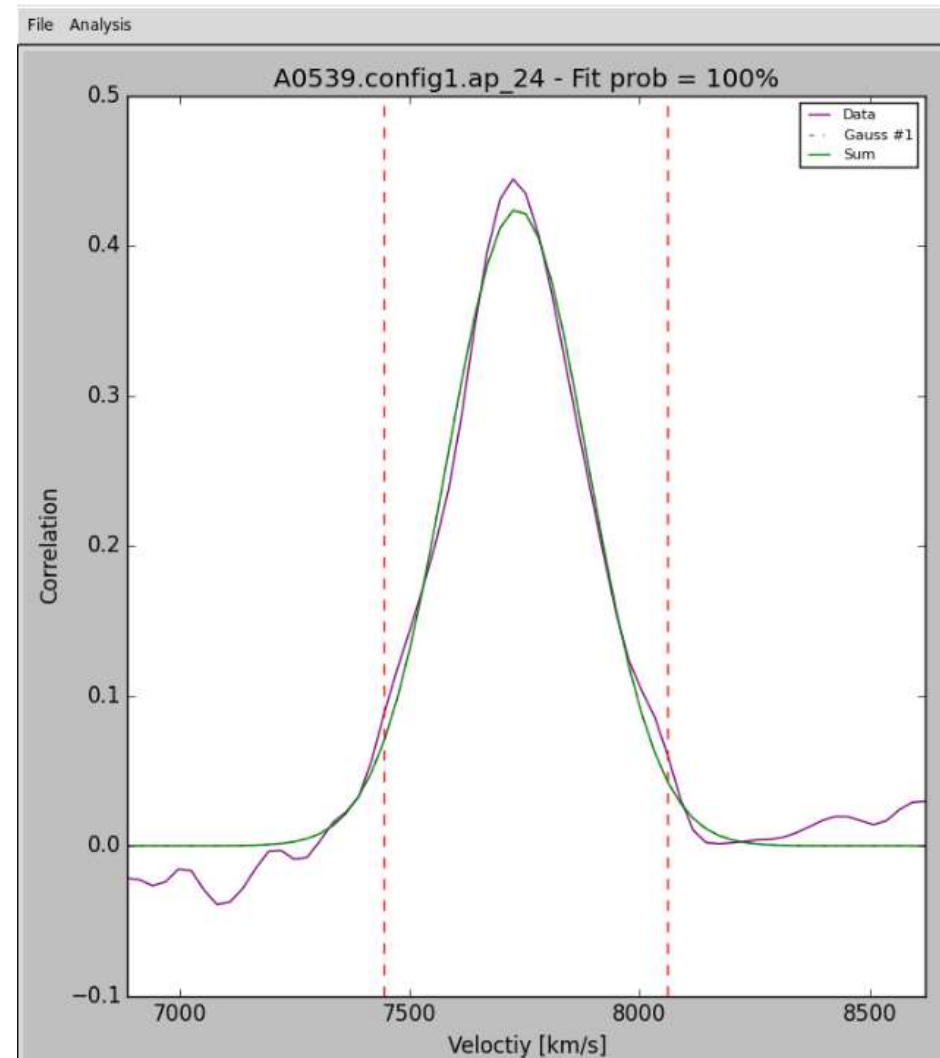
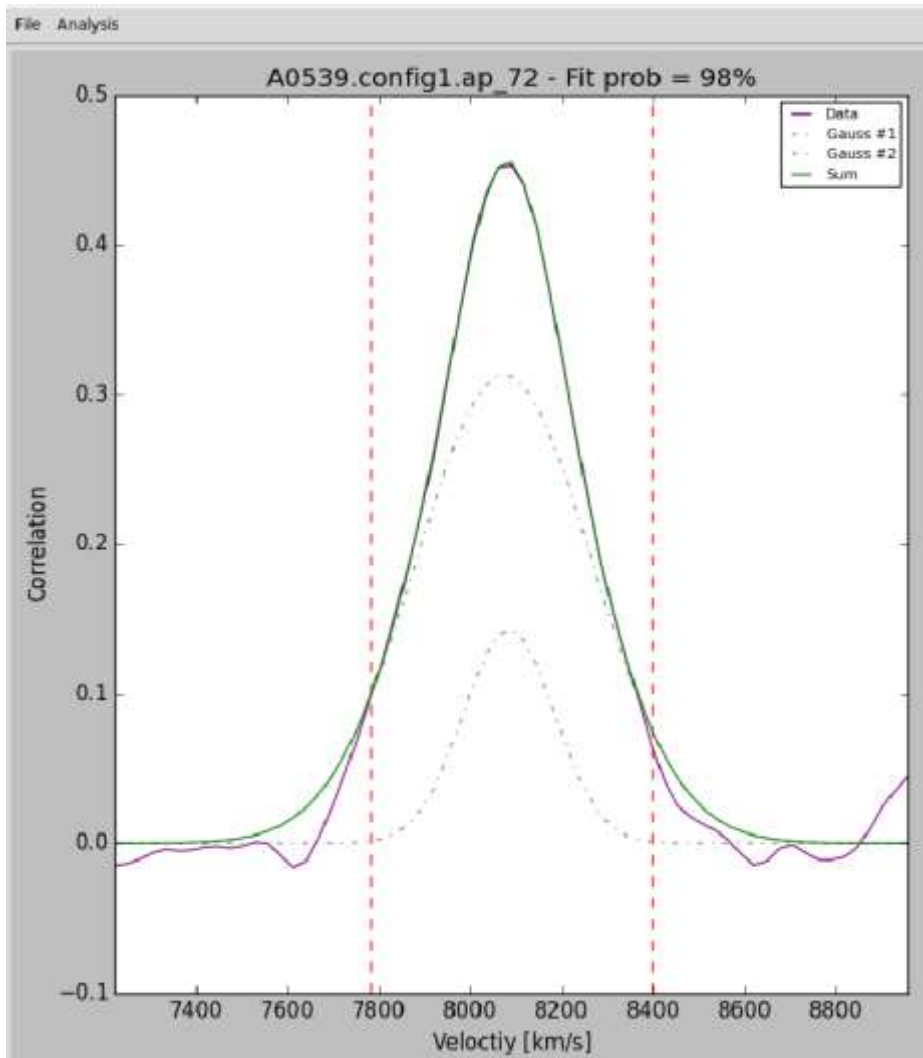
CHALLENGES— ERROR ANALYSIS IN CCF

How are uncertainties in galaxy image carried into the CCF?

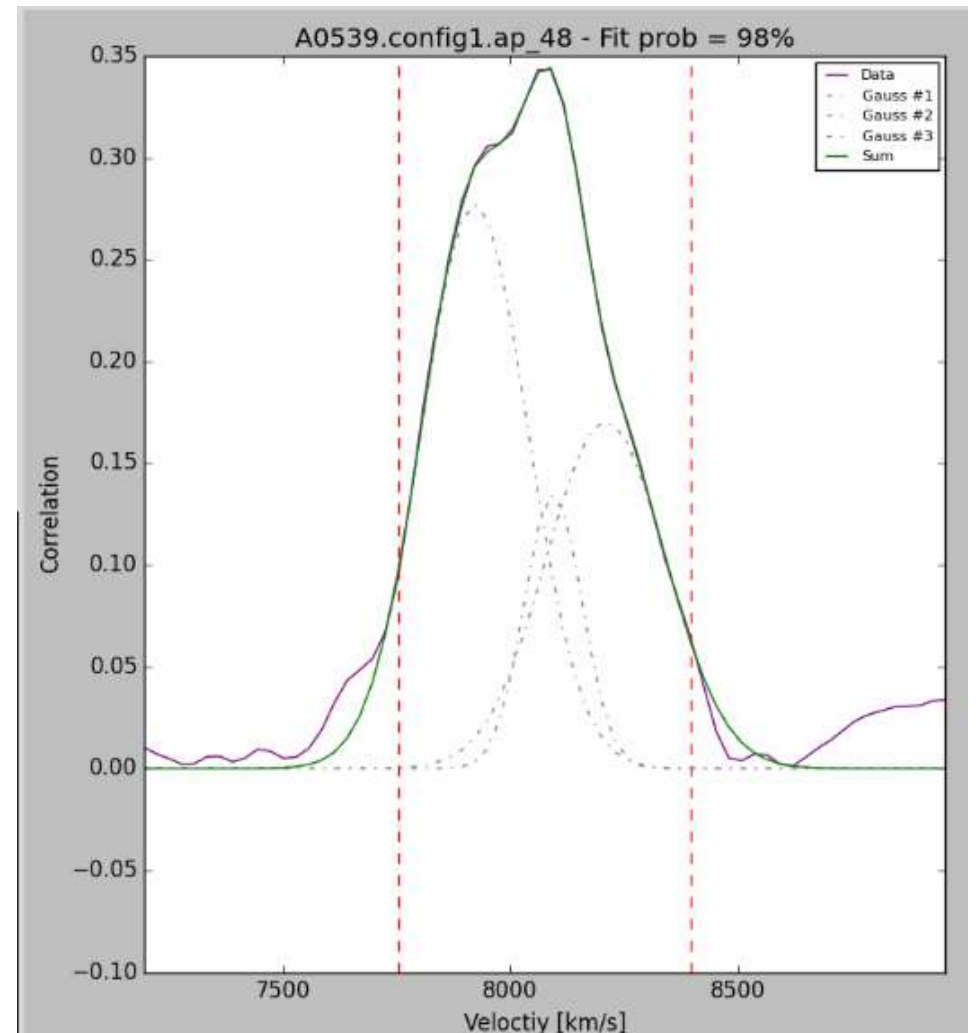
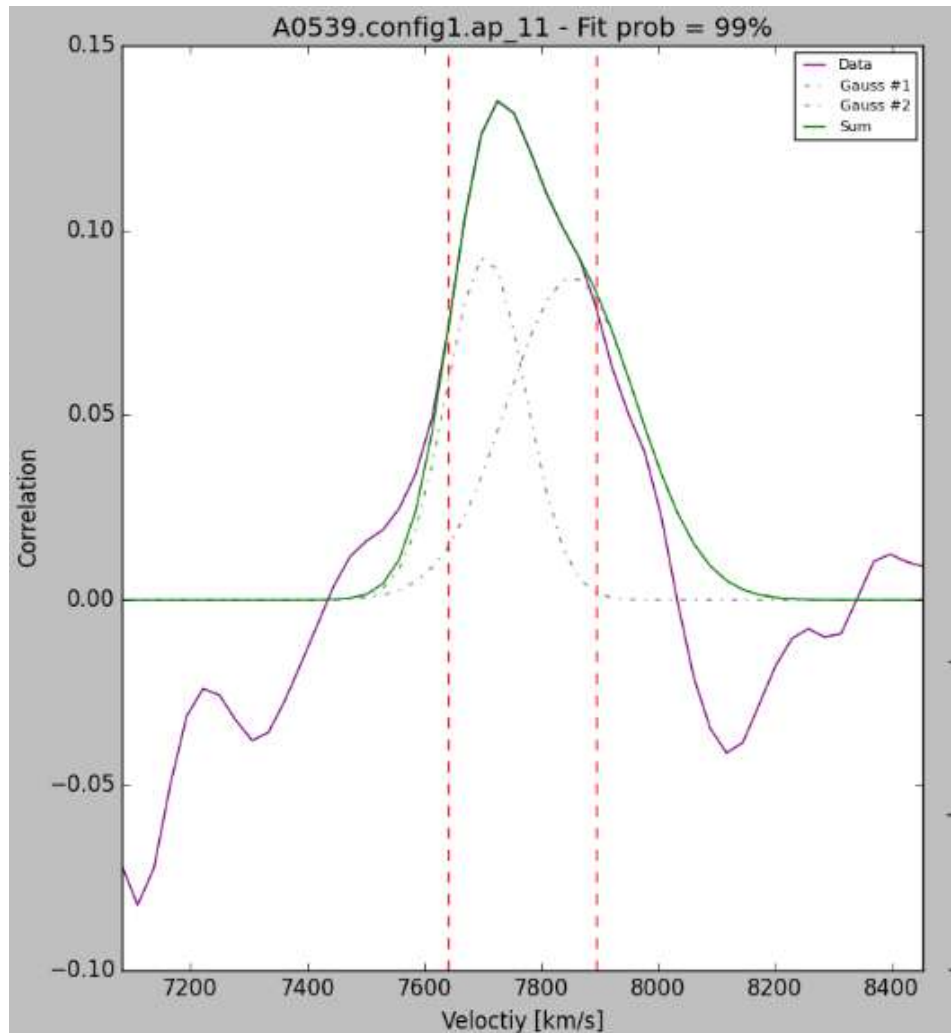
No analytical function exists! Must be approximated, but how?



RESULTS — NON-NORMALITIES IN CCF



RESULTS — MULTI-COMPONENT CCFS



FUTURE WORK

Complete analysis of 4,000 high quality spectra in forty clusters

Gather new data with Dark Energy Spectroscopic Instrument

Much later, Thirty Meter Telescopes, high z



Design of TMT, *TMT Organization 2015*

CONCLUSIONS

Non normality is present in CCFs for massive elliptical galaxies

Analysis of these functions yields complex galactic structure, prolate or multicomponent

Small selection of galaxies have been analyzed – thousands remain

Future telescopes will yield full evolutionary picture!



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GAS IN CLUSTERS — PERVASIVENESS OF MERGERS

