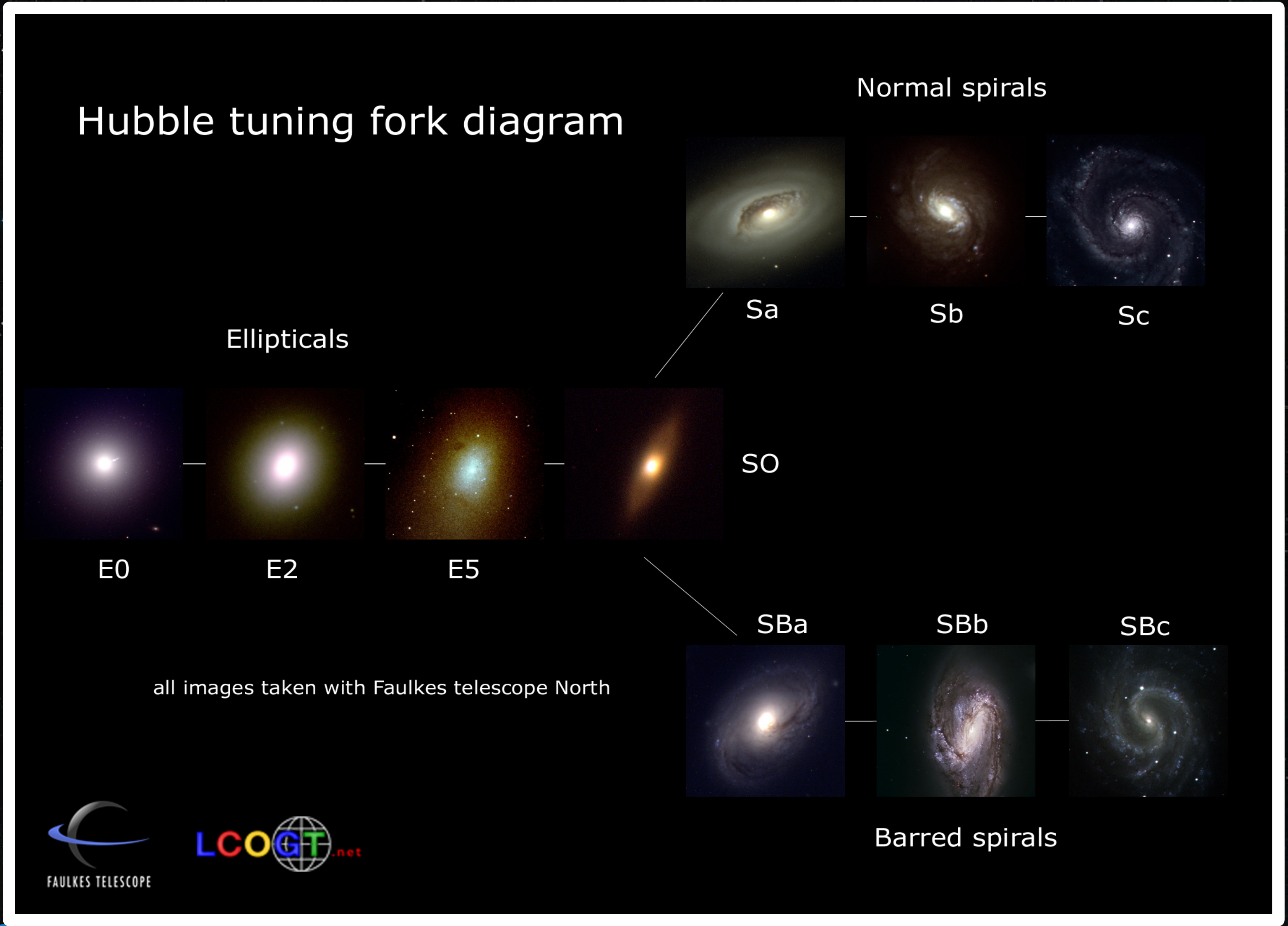
Clues to the Transformation of Spiral Galaxies into Lenticulars using Spectroscopic Bulge-Disc Decomposition

Evelyn Johnston
University of Nottingham

Alfonso Aragón-Salamanca, Michael Merrifield (University of Nottingham)

The 'Traditional' Hubble Sequence



Images taken by the Faulkes Telescope North, compiled by the Las Cumbres Observatory Global Telescope Network.

Background image credit: ESO/Digitized Sky Survey 2

S0s and the Hubble Sequence

- Most process proposed to explain the transformation of spirals to S0s focus on the truncation of star formation followed by passive evolution:
  - Ram pressure stripping (Gunn & Gott, 1972)
  - Starvation/strangulation (Larson, Tinsley & Caldwell, 1980)
  - Tidal stripping by galaxy harassment (Moore, Lake & Catz, 1998)
  - Starbursts triggered by unequal mass galaxy mergers (Mihos & Hernquist, 1994)
- It is thought that each of these mechanisms affects the bulge and disc differently.

Background image credit: ESO/Digitized Sky Survey 2

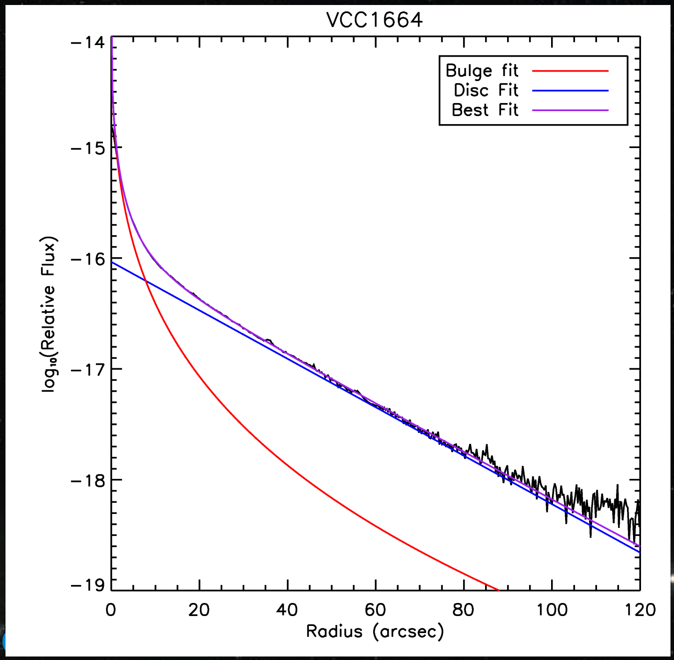
Sample Selection

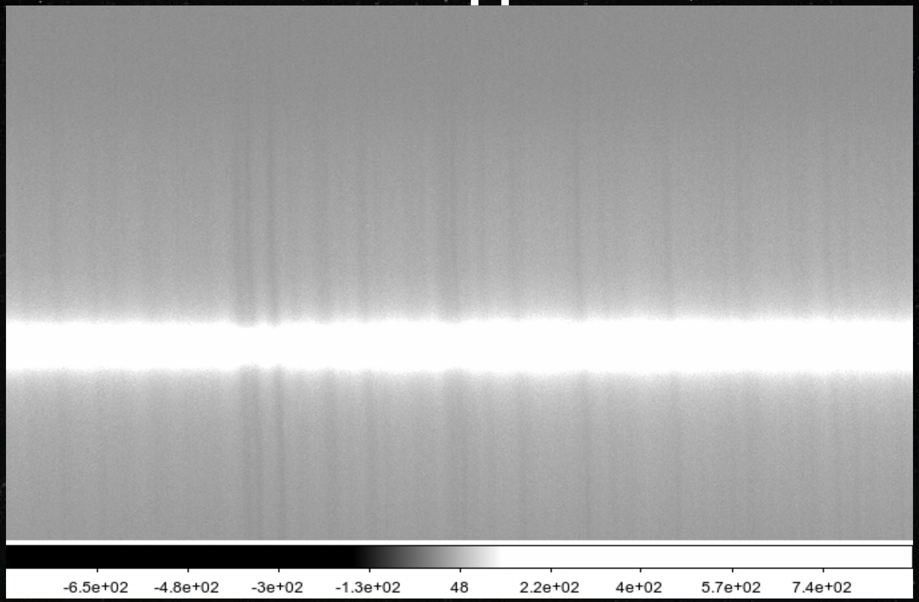
- 21 high inclination (i>40º) S0 galaxies from the Virgo Cluster
- Long-slit spectroscopy from Gemini/GMOS
- Wavelength range of $4300<\lambda<5500$ Å
- $-22.3 < M_B < -17.3$
- Exposure times ~ 20-200 minutes, S/N of peak of spectrum $\gtrsim$ 50.

Spectroscopic Bulge-Disc Decomposition

- Obtain a good quality long-slit spectrum of a galaxy
- Fit light profile of galaxy over full wavelength range

Image credit: ESO



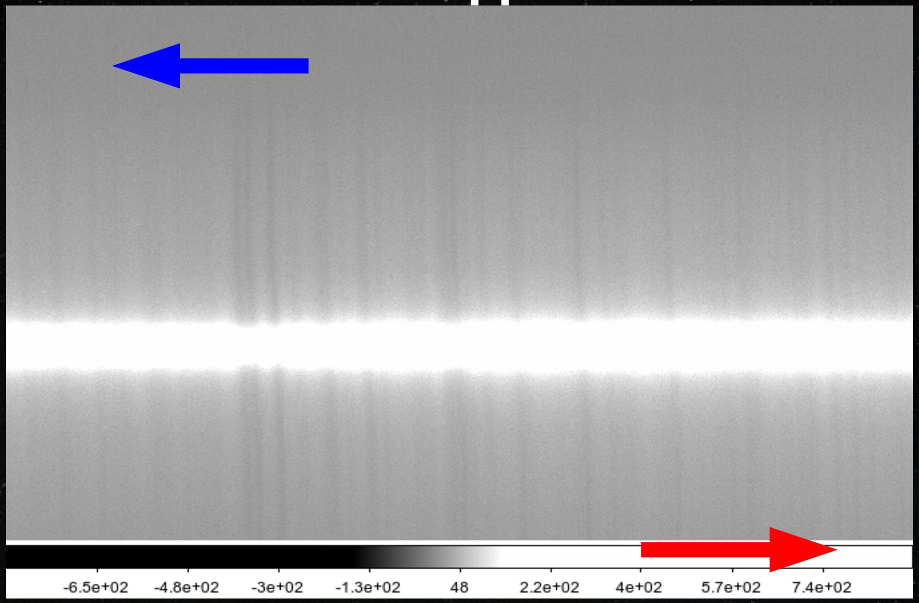


Background image credit: ESO/Digitized Sky Survey 2

Spectroscopic Bulge-Disc Decomposition

- Kinematic Corrections
  - Correct for redshift of spectral features
  - Correct for velocity dispersion
- Decompose light profile at each wavelength bin using estimates of bulge R_e and disc R_0 from previous step

Image credit: ESO

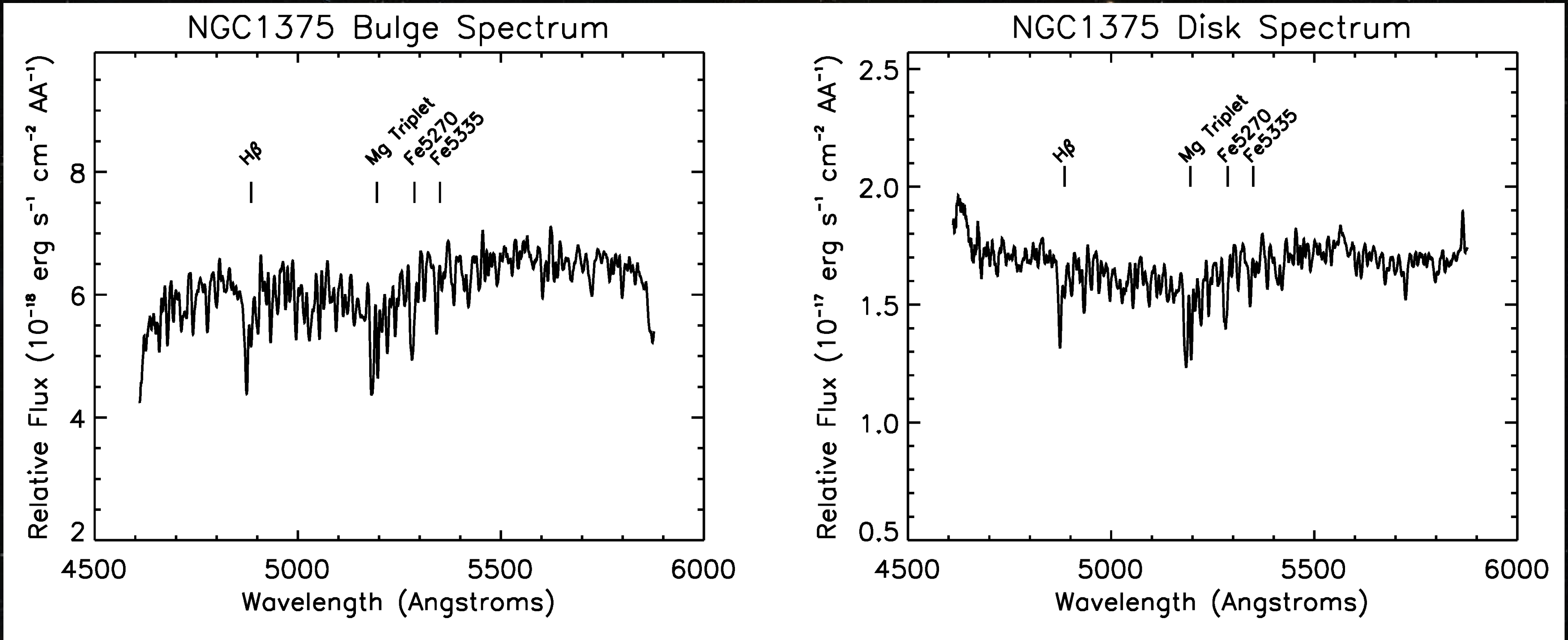


Wavelength

Background image credit: ESO/Digitized Sky Survey 2

Spectroscopic Bulge-Disc Decomposition

- Integrate to get total light of bulge and disc for that wavelength bin
- Plot against wavelength to obtain bulge and disc spectra

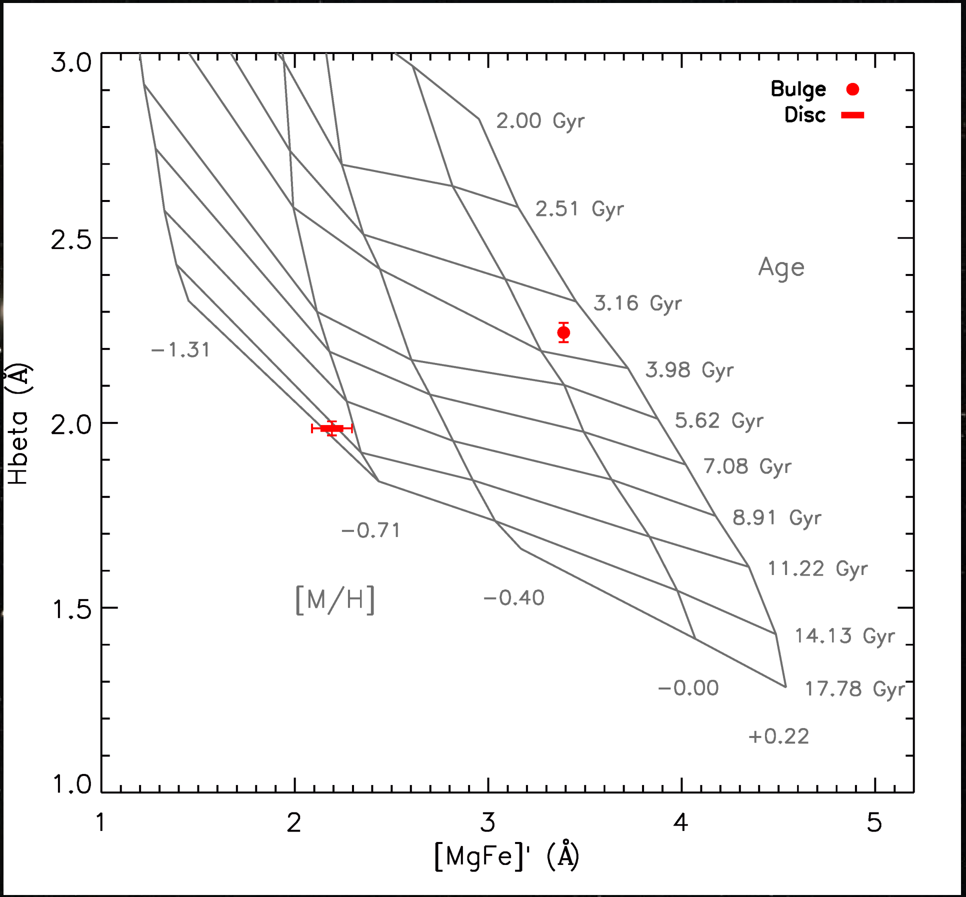


Johnston et al, 2012

Background image credit: ESO/Digitized Sky Survey 2

Star Formation Histories of the Bulge and Disc

- Hβ, Mg and Fe line strength indices measured, and plotted on SSP models of Vazdekis et al (2010)
- Estimates of relative global, light weighted ages and metallicities for the bulge and disc were made from these models

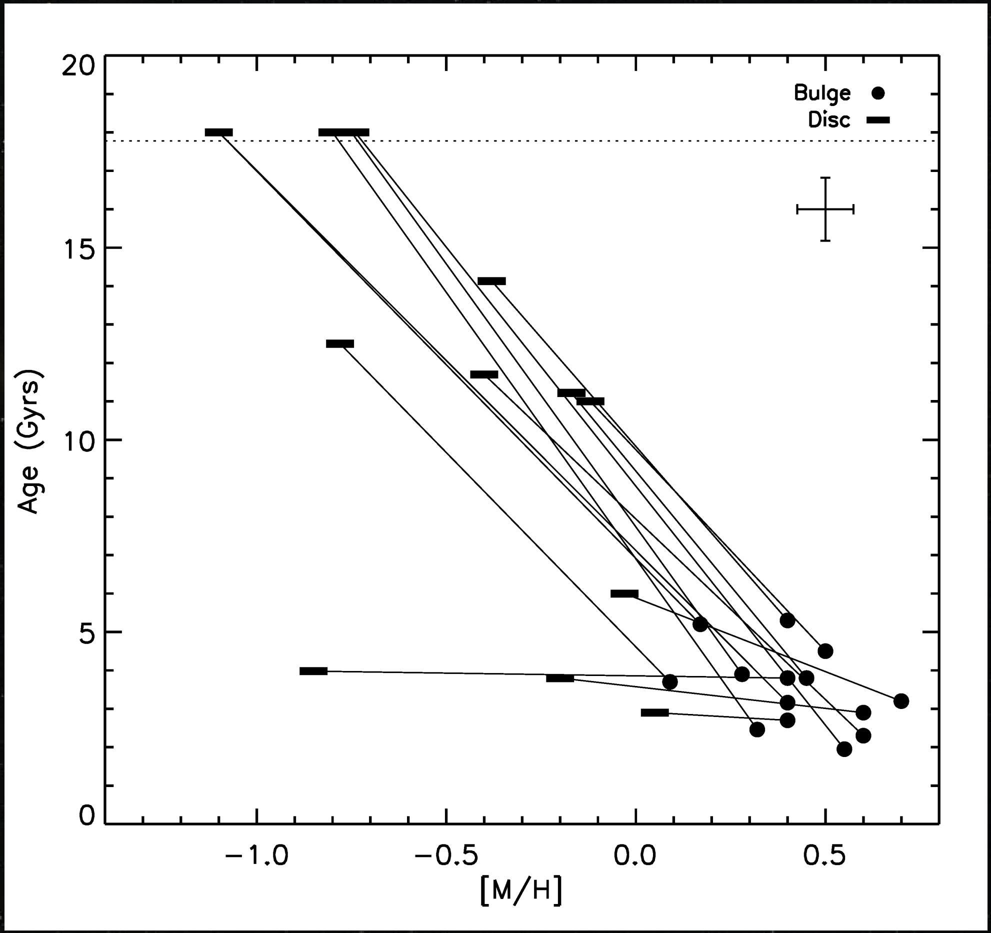


Johnston et al, in prep

Background image credit: ESO/Digitized Sky Survey 2

Relative Ages and Metallicities

- Younger stellar populations appear to correlate with higher metallicities
- Bulges appear to contain younger and more metal rich stellar populations than the discs within the same galaxy.
    - Star formation continued in the bulge after it had finished in the disc.

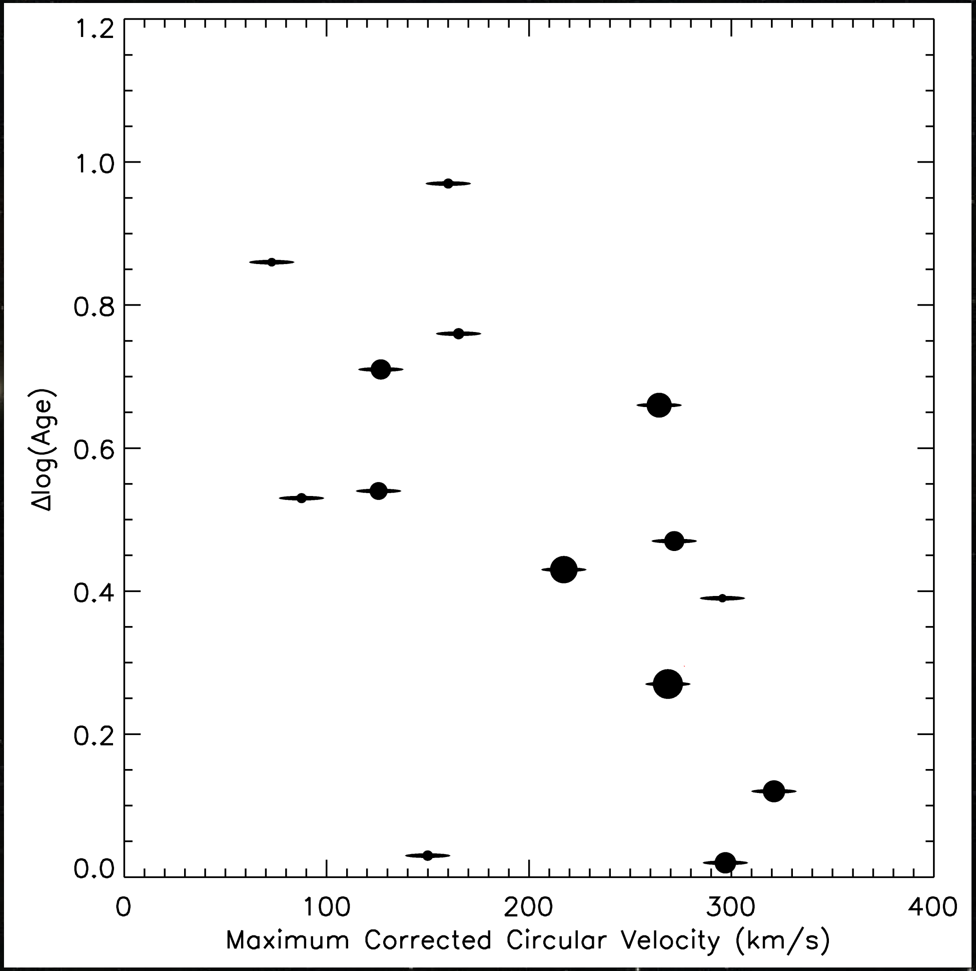


Johnston et al, in prep

A Look at the Galaxy Kinematics

- Corrected the circular velocity measurements for inclination and asymmetric drift (Neistein et al, 1999)
- Measured maximum circular velocity for each galaxy
- More massive galaxies were found to have younger stellar populations in their discs, and so smaller differences between bulge and disc ages

➔Downsizing?



Johnston et al, in prep

Background image credit: ESO/Digitized Sky Survey 2

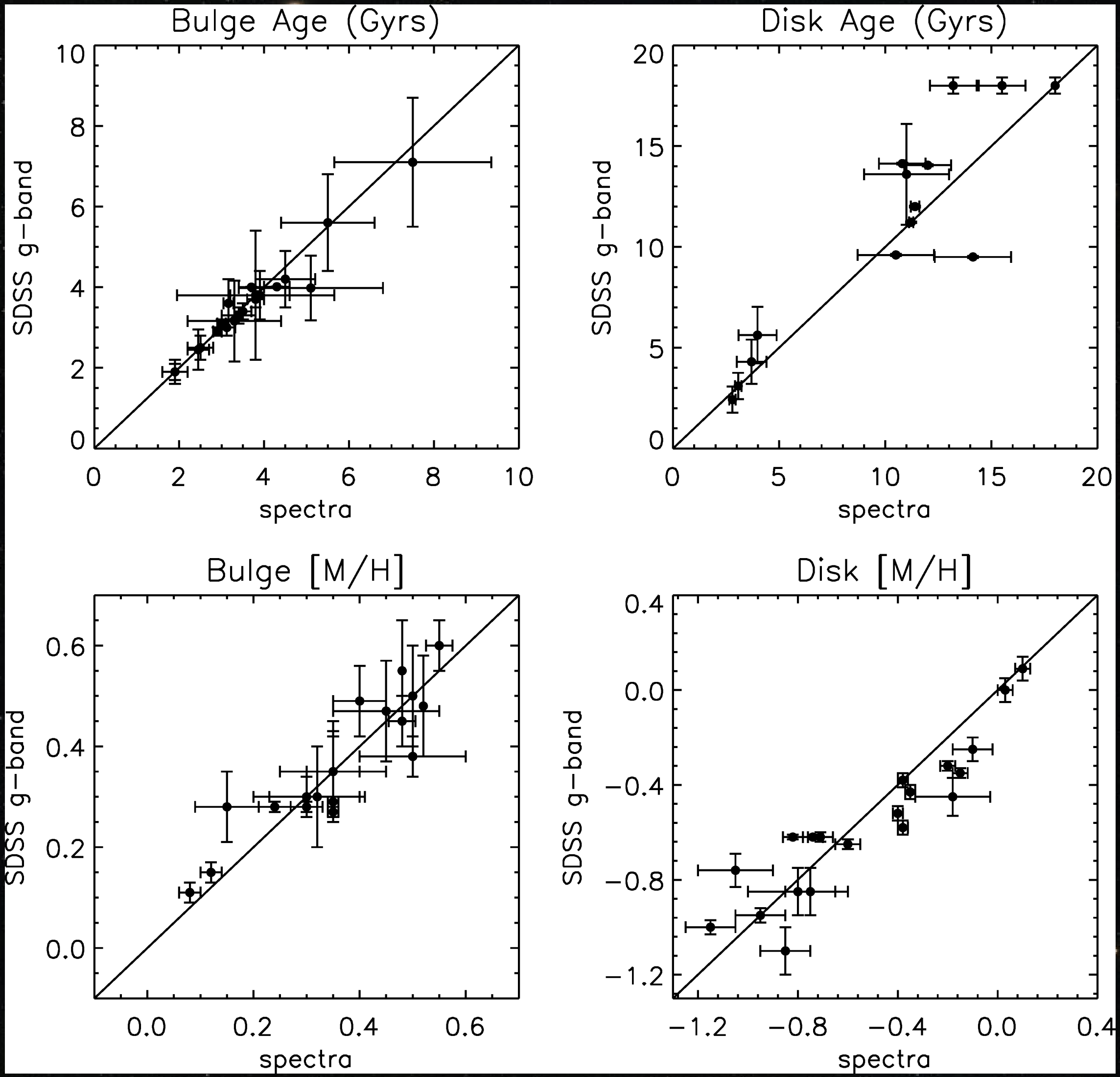
Conclusions

- It is now possible to decompose a long-slit spectrum into individual bulge and disc spectra in order to study their star formation histories.
- Bulges and Discs of S0s show different SF histories
  - SF in bulges continued after it ceased in the disc.
  - More massive galaxies show more rapid transformations, which could be explained by downsizing.
- Results from long-slit spectra are very limited
  - Next step would be to use IFU data.

Background image credit: ESO/Digitized Sky Survey 2

Comparison to SDSS Images

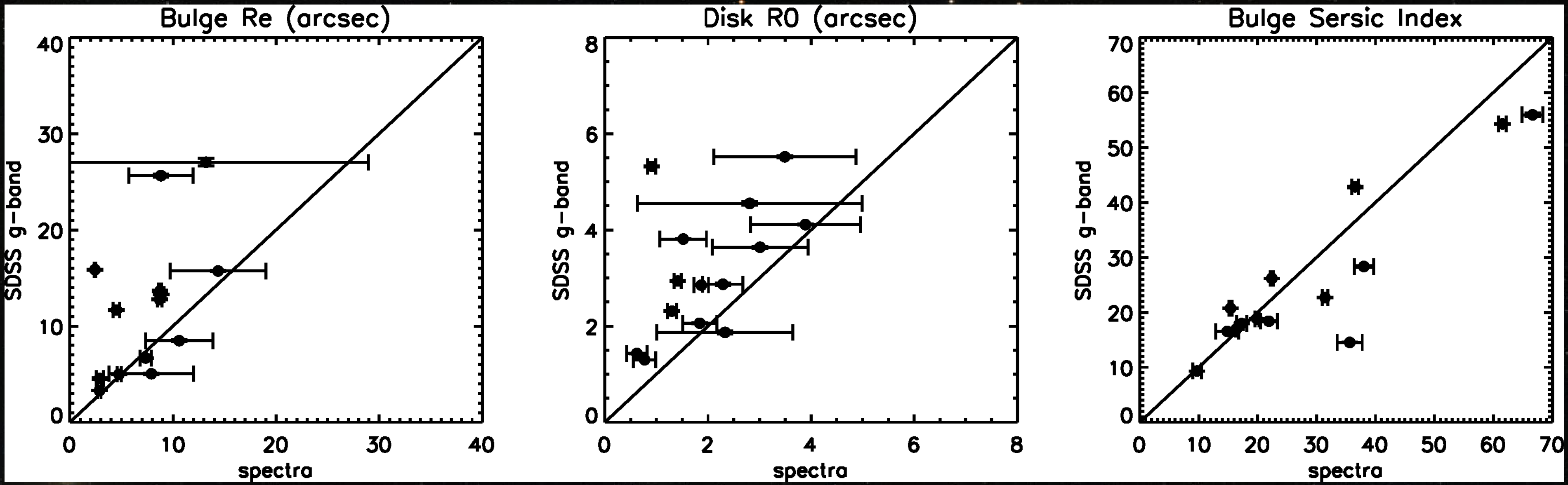
- Decomposed spectra again using SDSS parameters, and measured relative ages and metallicities in the same way



Johnston et al, in prep

Comparison to SDSS Images

- Decomposed SDSS g-band images of the data set using Galfit
- Compared results for bulge and disc parameters with spectral results

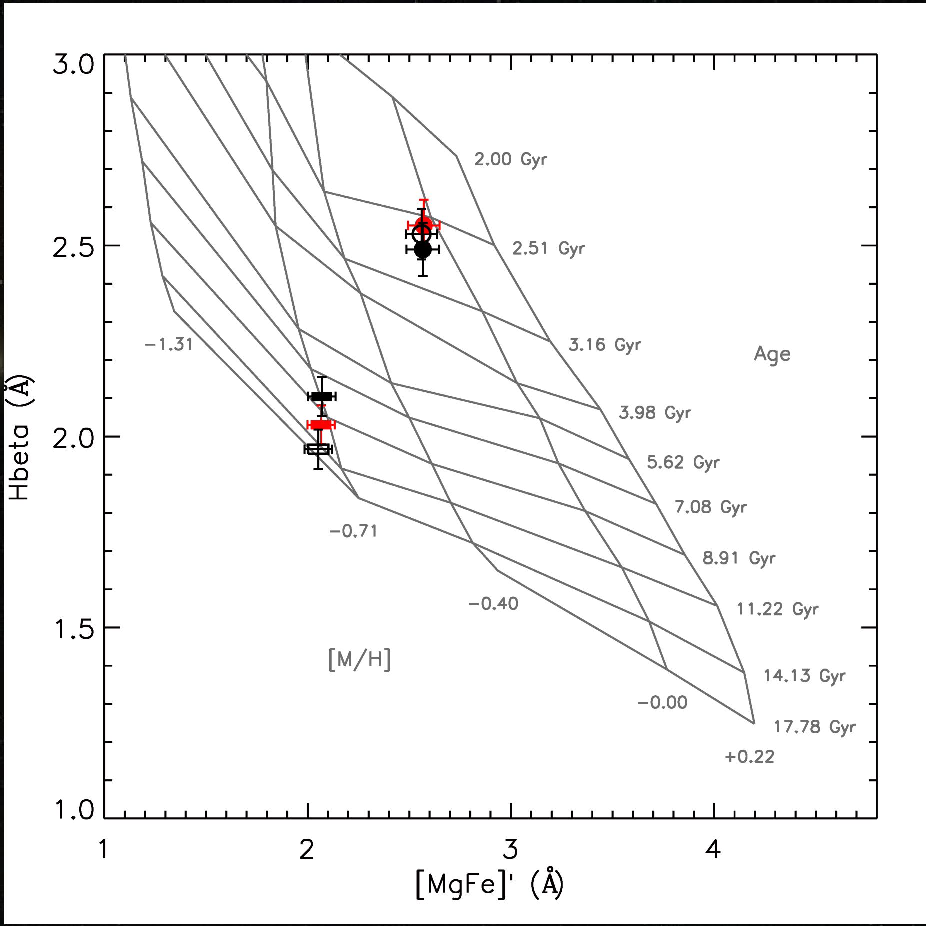


Johnston et al, in prep

Background image credit: ESO/Digitized Sky Survey 2

Kinematics Tests

- Fake spectrum created using spectra of known stellar populations to represent the bulge and disc, each given different kinematics before combining into 2D spectrum and adding noise.
- Spectrum was decomposed in same way as before, and stellar populations compared with input parameters



Johnston et al, in prep

Background image credit: ESO/Digitized Sky Survey 2