The Star Formation History of M31

Knut Olsen

Collaborators: Bob Blum, Andrew Stephens, Tim Davidge, Phil Massey, Steve Strom, and François Rigaut

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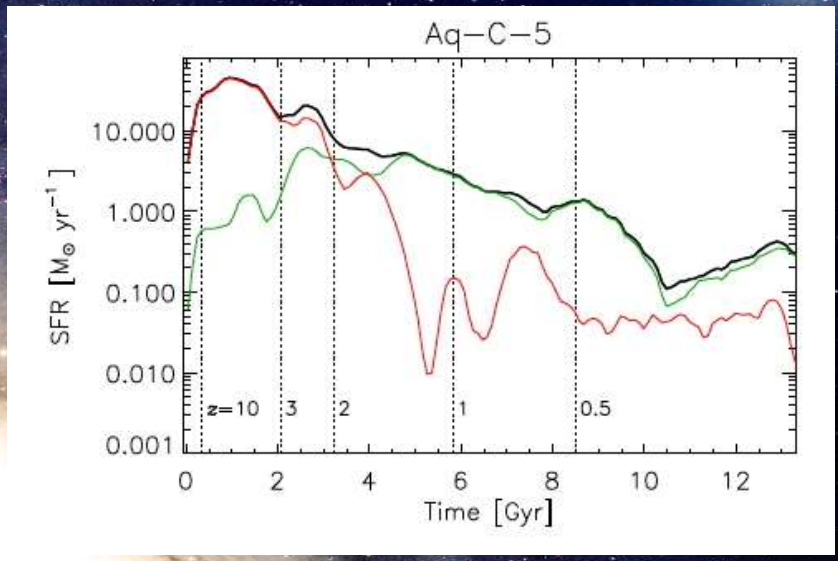
Motivation

– Hierarchical structure formation does an excellent job of describing large scale structure; history of build-up of dark matter, however, appears different than that of the observed stellar mass buildup

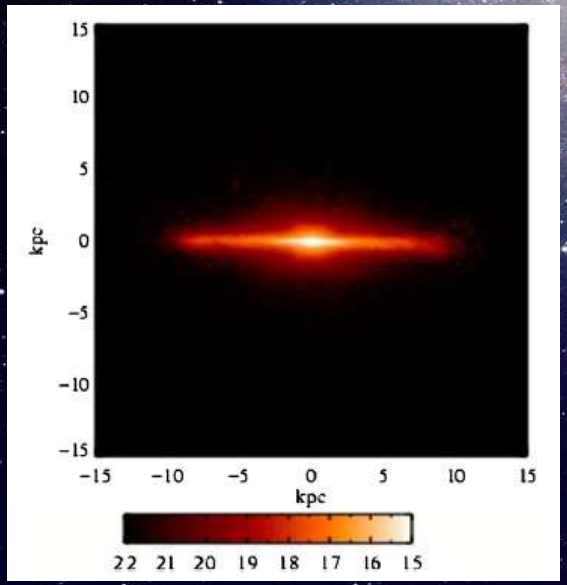
– Galaxy formation is complex and non-linear, depending on processes operating on a huge range of scales

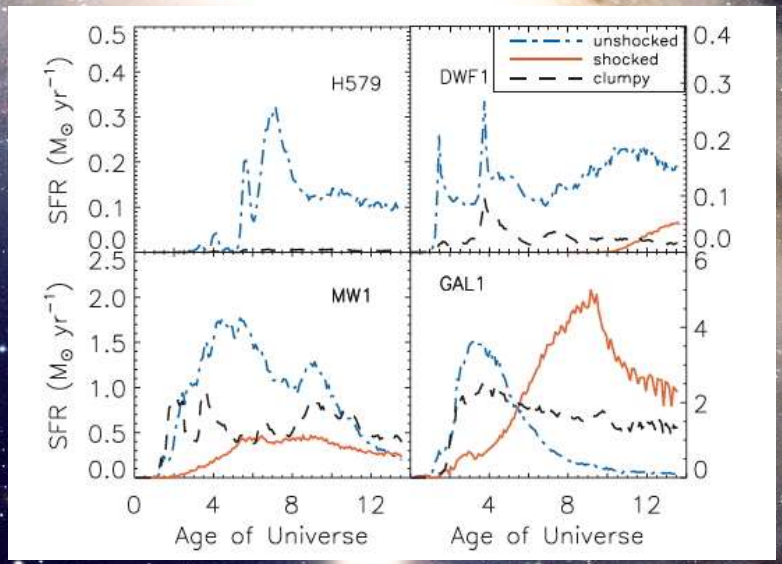
- Disk galaxies are especially difficult to make in simulations

– Star formation histories of simulated disks are sensitive to the input physics, e.g. feedback from stars, accretion mode, and merging, as well the mass of the parent galaxy



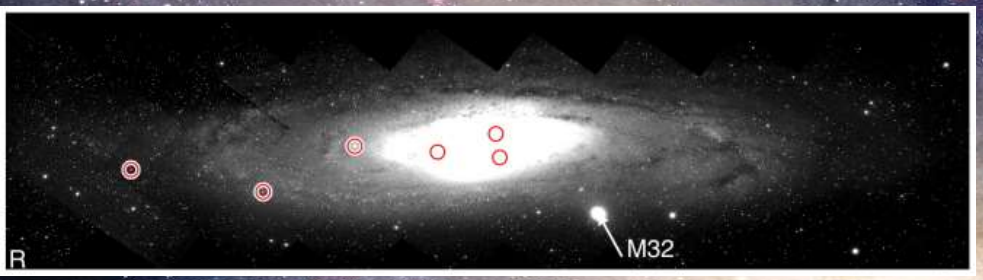
Scannapieco et al. (2009)





Brooks et al. (2009)

Observations



Gemini N+Altair/NIRI SV observations, 18-19 Nov 2003 (one night photometric)

Disk 2 field observed 14 Sep 2006: 0.´´2 - 0.´´3 seeing, photometric

Additional fields observed in Aug 2008, more to come

NIRI/Altair provided near diffraction-limited imaging in HK over 22.´´5 × 22.´´5 field

We also included published HST/NICMOS data from Stephens et al. (2003) in analysis

Disk 2: 540s H, 3420s K

0.”059 H (~30% Strehl), 0.”066 K (~40% Strehl)

Photometry

- PSF-fitting photometry with DAOPHOT/ALLSTAR

  Fits the core of the PSF (0.”44 diameter), neglecting the halo

- Corrections applied to account for:

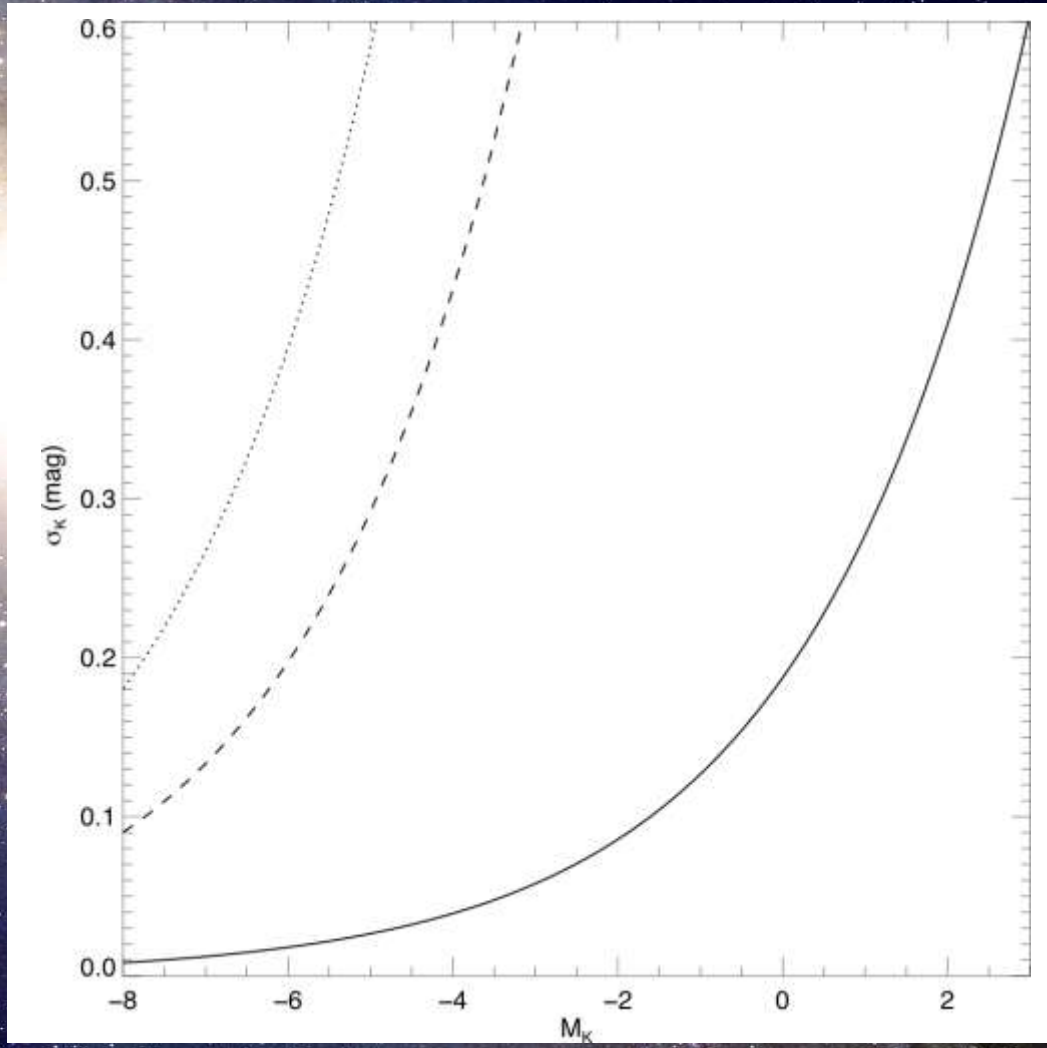
  -non-linearity of NIRI

  -difference between PSF and aperture magnitudes out to a diameter of 0.”66 (30 pixels): ~0.3 mags

  -difference between 0.”66 diameter aperture magnitudes and 4.”4 diameter aperture magnitudes: ~0.4 - 0.6 mags

  -spatial variability of the aperture correction

  -transformation of magnitudes to standard system



Deriving the population mix

- Build models from isochrones (Girardi et al. 2002):

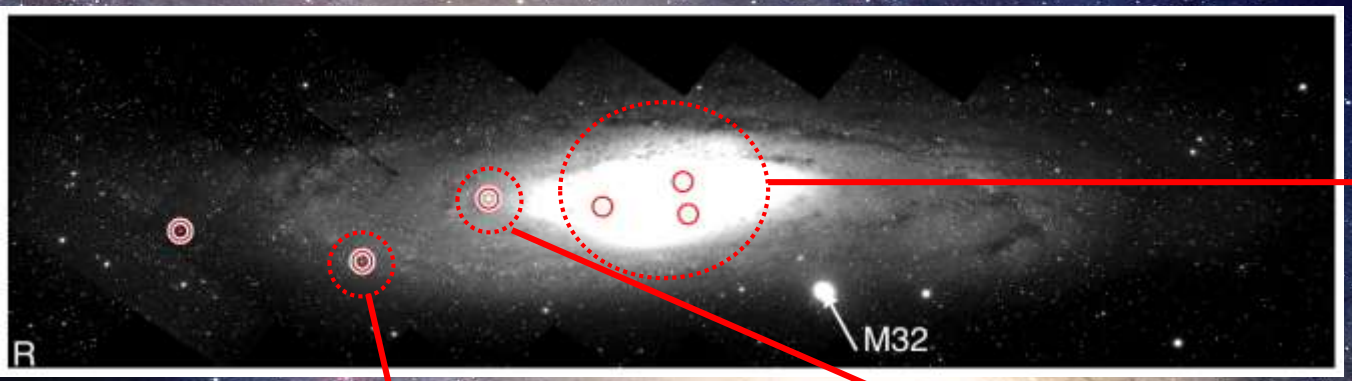
  Age = 1, 3, 5, 10 Gyr; Z=0.0001, 0.0004, 0.001, 0.008, 0.019, 0.03; Salpeter IMF for most crowded fields; finer age grid for less crowded fields

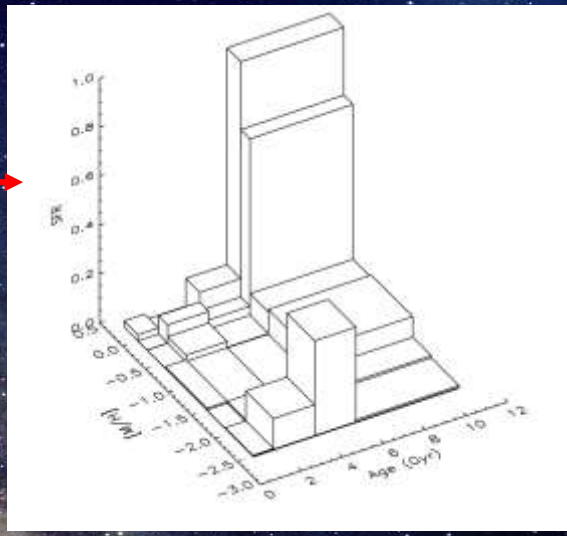
- Apply photometric errors and incompleteness to models

- Fit model mix to *K* LFs using maximum likelihood analysis (Dolphin 1997, Olsen 1999, Dolphin 2002); assume E(H-K) from IRAS/ISO; solve age and Z; $(m-M)_0 = 24.45$

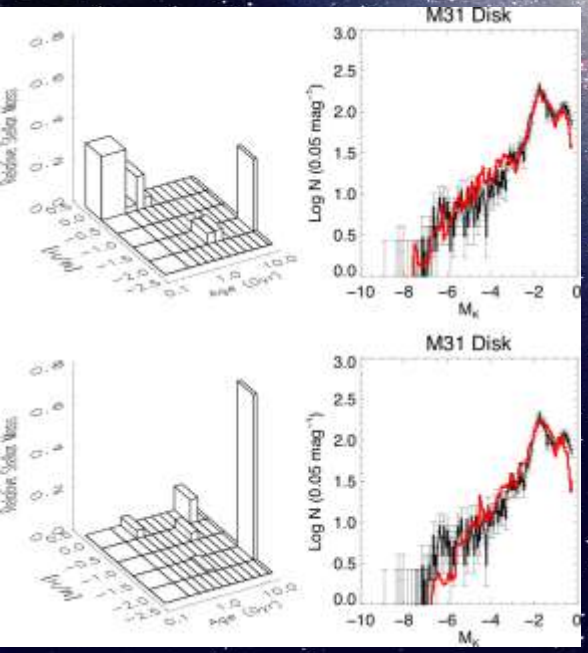
Results

Bulge and inner disk

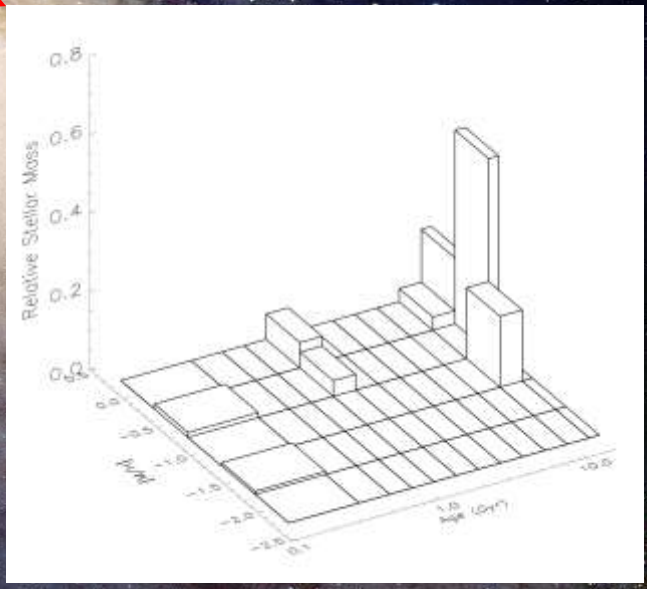




10 kpc ring field



30% of stellar mass formed within last ~100-300 Myr: prominent signature from the 10 kpc ring!



5 kpc disk field

Conclusions

- The age and metallicity distributions of stars in disks are sensitive indicators of galaxy formation physics.
- Resolved stellar populations can be used to measure the entire star formation and chemical enrichment histories of galaxies.
- Spatial resolution is the most critical capability needed to measure the star formation histories of massive galaxies.
- Photometry with ground-based adaptive optics on current (and future!) large telescopes are excellent tools to allow us to measure the star formation histories in the bright components of massive galaxies.
- Our Gemini North NIRI+Altair observations demonstrate that the M31 bulge and inner disk are dominated by old, metal-rich populations.
- The old component appears to remain dominant out to 10 kpc in the disk, with metallicity decreasing with radius
- The 10 kpc ring represents a substantial burst of star formation (~30% by mass in one field), and may be traceable to older ages at 5 kpc radius