The Relationship between Star Formation and the ISM in M31

Alexia R. Lewis (UW), A. K. Leroy (NRAO), D. R. Weisz (UW), J. J. Dalcanton (UW), PHAT Collaboration

Introduction

We use resolved star imaging taken as part of the Panchromatic Hubble Andromeda Treasury (PHAT, [1]) to derive spatially-resolved star formation histories (SFHs) in 900 contiguous 100 x 100 pc (26") regions that span the 10-kpc star-forming ring in M31. The deep, optical CMDs give us excellent insight into the SFHs over the past 500 Myr, allowing us to probe the history of the star-forming ring and the relationship between star formation and various tracers of the interstellar medium (ISM). We explore the correlations between the SFHs and various ISM tracers and find that the total ISM budget may be more important than either HI or CO individually. Using the PHAT catalog of more than 100 million stars, we will explore the recent SFH of over 1/3 of M31's star-forming disk, enabling an extremely detailed study of the relationship between star formation and the ISM in an L_* galaxy.

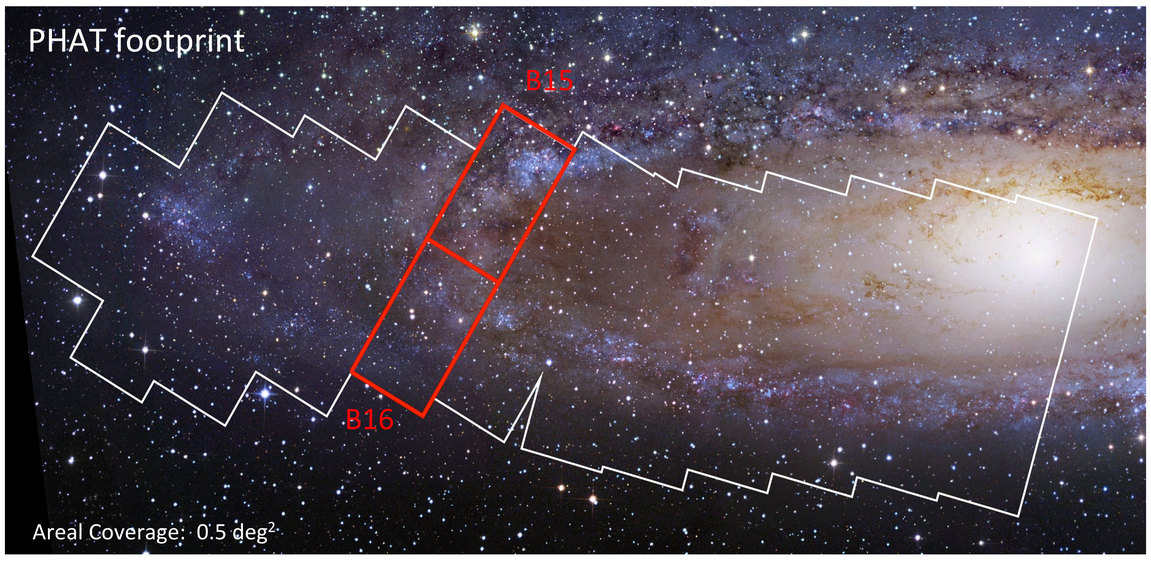
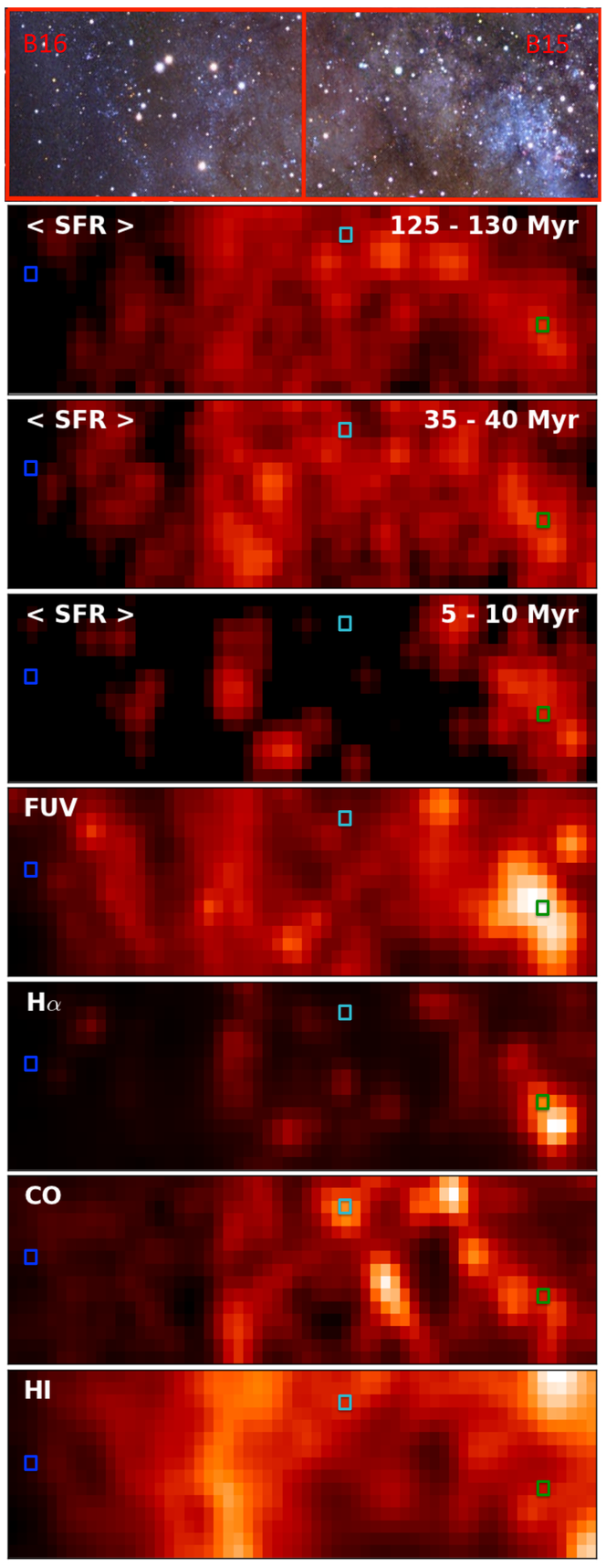
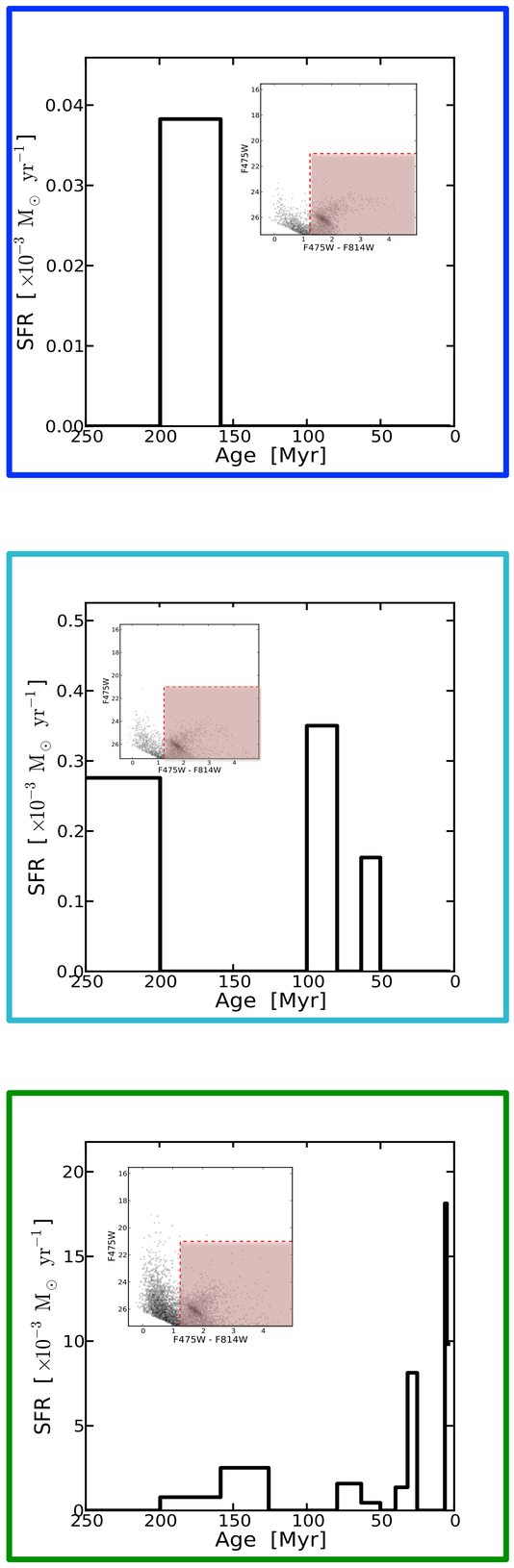


Image Credit: Robert Gendler

The Spatially Resolved SFH of the 10-kpc Ring

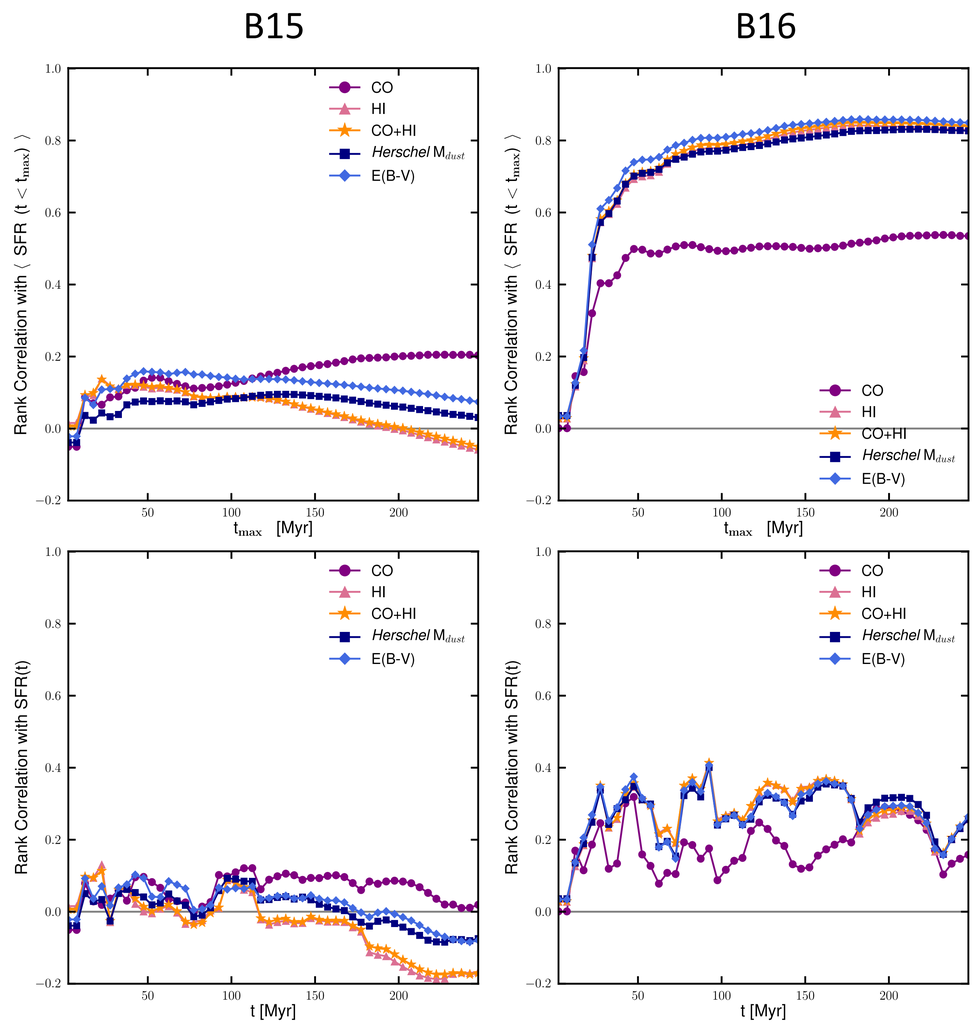




Star Formation History Maps on 100 pc Scales

- We model the resolved star color-magnitude diagrams (CMDs) using the SFH code of Dolphin 2002 [2]. The resolved upper MS and core helium burning populations provide excellent leverage on the SFH of M31 over the past 500 Myr.
- We find a clear correspondence between the spatially-resolved SFH maps and the GALEX FUV images (e.g. OB53 in the top right of the images and OB54 in much of the bottom right corner), reinforcing the power of resolved star analysis in reproducing commonly-used integrated star formation measures.
- As examined on the right, the relationship between the SFHs and the ISM is much more complex.
- Our SFH maps demonstrate the remarkable stability of the ring. The ring structure appears to persist over the entire 250 Myr SFH shown here (which is most of the roughly 300 Myr dynamical timescale [3] of M31), indicating dynamic stability of both the gas and stars.

Resolved SFHs and the ISM



Spearman Rank Correlation Between SFR and Gas

- The Spearman rank correlation is a non-parametric measure of how well two data sets can be described with a monotonic function, i.e. one variable either increases or decreases with the other. It is defined as: $\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}$.
- We compute the rank correlation with time-averaged integrated SFR (upper plots) and star formation rate within 5 Myr time bins (lower plots)
- The difference between the two bricks is primarily driven by the overall ISM content. Because B15 falls completely on the star-forming ring, gas and dust are found in all regions of the brick. B16 only partly covers the star-forming ring, resulting in a much larger dynamic range of dust and gas. The stability of the ring accentuates the correlation in B16.
- We might expect to see a strong correlation of SFR with CO because stars form in dense clouds of molecular gas. This is not the case in B16 and it is clear from the maps at left that star formation occurs in regions that lack significant CO detection. B15 seems to follow the expected behavior slightly better though the correlation is weak.
- Because the final molecular cloud phase of star formation is very short [4], it is possible that it is the total ISM content, rather than HI or CO individually, that drives star formation. If the ISM is strongly evolving with time, the correlation will look poor. The small dynamic range and poor correlation seen in B15 may support this possibility.
- The relative importance of HI and CO to star formation could be further probed by separately computing correlations for on- and off-ring regions within each brick.

References

[1] Dalcanton, J. J. et al. 2012, ApJS, 200, 18
[2] Dolphin, A. E. 2002, MNRAS, 332, 91
[3] Kennicutt Jr., R. C. 1998, ApJ, 498, 541
[4] Tamburro et al. 2008, AJ, 136, 2872

Contact: arlewis@astro.washington.edu

Support for this project is provided by NASA through grant number HST GO-12055 from the Space Telescope Science Institute.