

A major merger as the origin of the Giant Stream and inner halo substructures in the Andromeda Galaxy



Isaac Roberts (29th December 1888)

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Synopsis

- ★ Milky Way (MW) and Andromeda (M31)
- ★ Principal observed properties of M31
- ★ Our major (1:4) merger model



Setting the stage

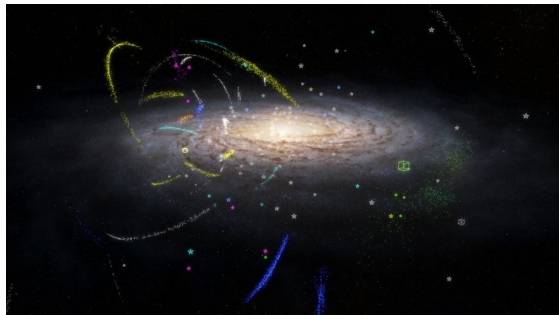
- ★ Assign the initial metallicity of the progenitors
- ★ 7D chemodynamical comparison with observations
- ★ Main conclusions/future prospects



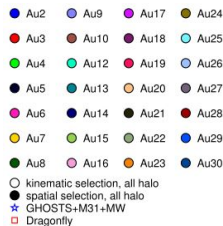
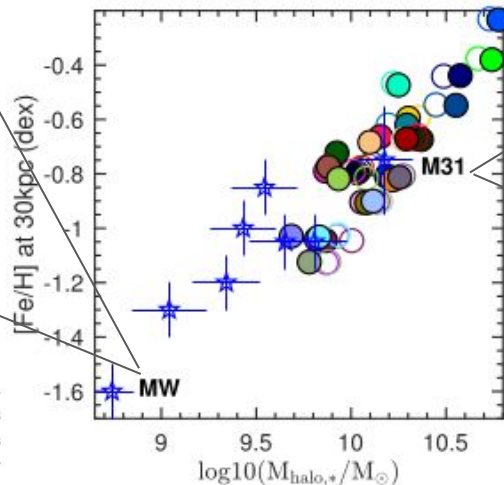
Our study

Andromeda VS Milky Way

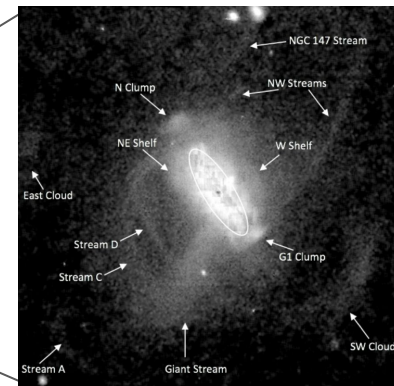
- ★ M31 is the ideal testbed for galactic archaeology studies; external view, inclination, distance.
- ★ M31 has a **more active accretion history** than the MW.
- ★ Last significant merger event of M31 $\sim 2\text{-}3$ Gyr ago whereas for the MW $\sim 8\text{-}10$ Gyr ago.



Credit: Payne-Wardenaar/Malhan, MPIA

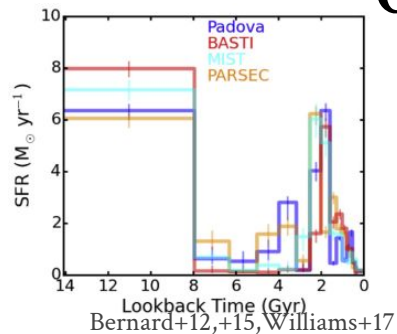


Monachesi+19

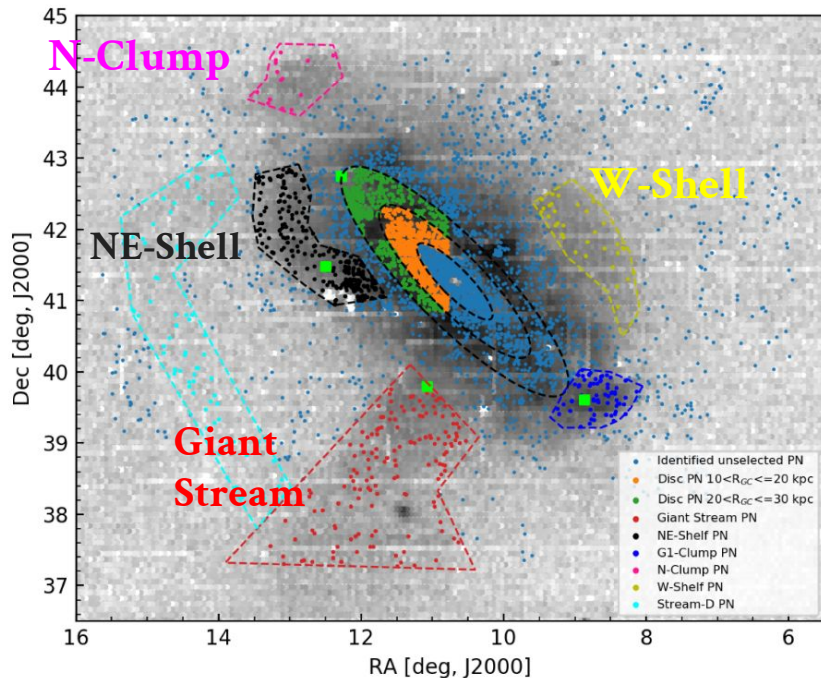


adapted from McConnachie+18

Observational evidence of a major merger

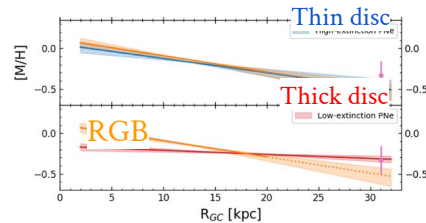


Burst of star formation
~2-3Gyr ago

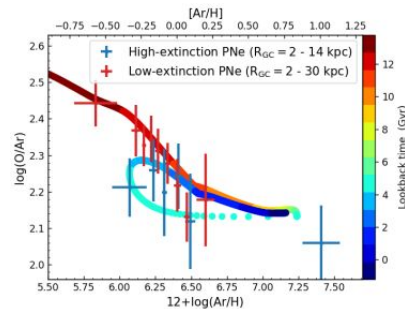
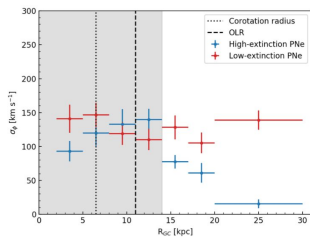
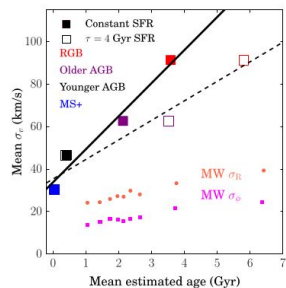


Secondary infall of
metal poorer gas

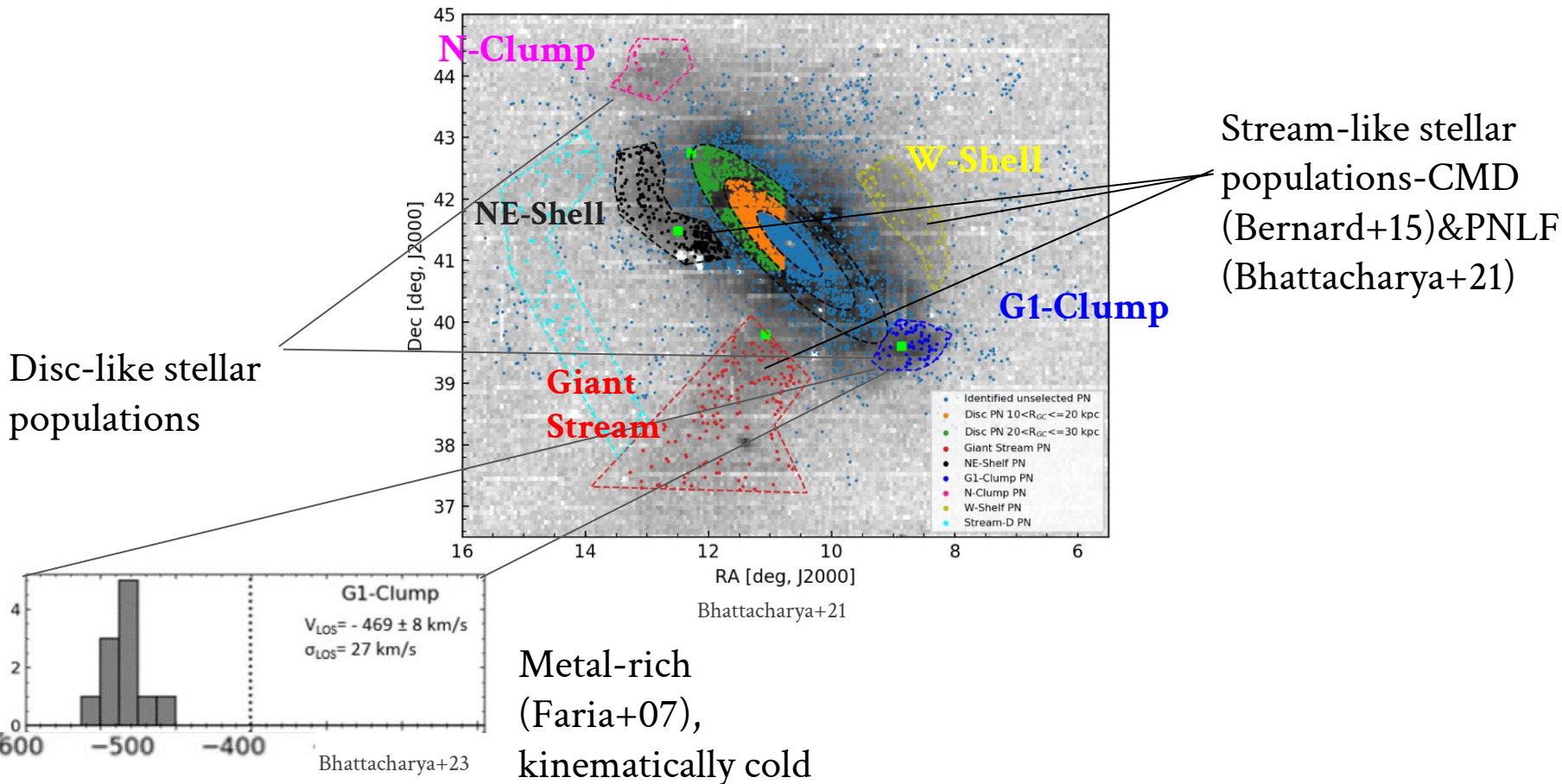
Arnaboldi+22



Kinematically and
chemically distinct
thin and thick discs

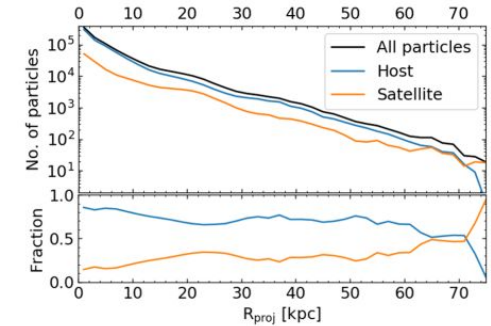


Observational evidence of a major merger



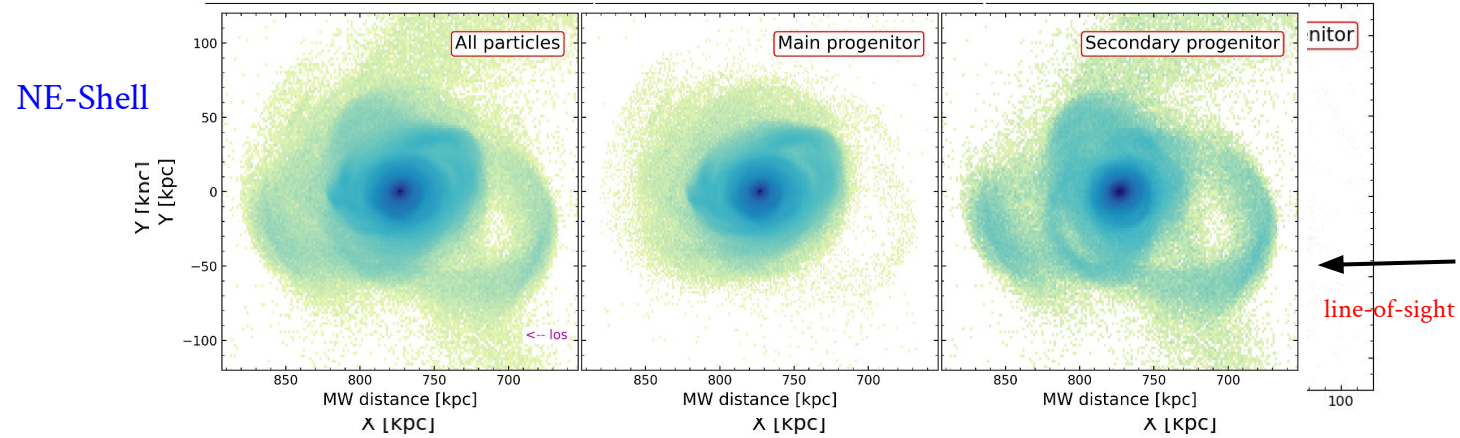
Modeling the last significant accretion event: A major (1:4) merger

- ★ Thin discs with stars, **gas** and DM halo (Hammer+18).
- ★ Wet merger.
- ★ Distinct thin and thick discs, inner halo substructures.



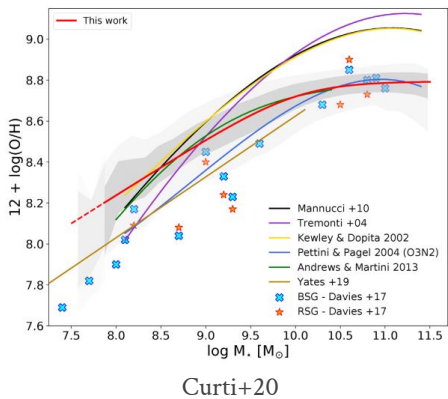
Bhattacharya+23

See next talk by Escala



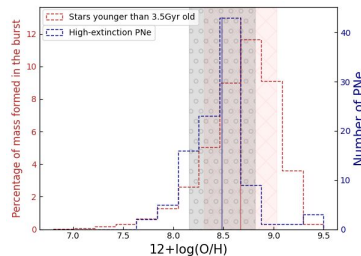
Tsakonas+24 (in prep.)

Set the initial metallicity distribution in host&secondary stars&gas



I. Stellar mass - metallicity relation at $z \sim 1$

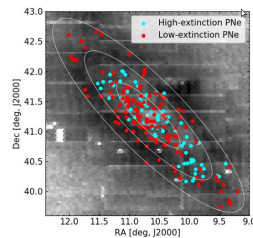
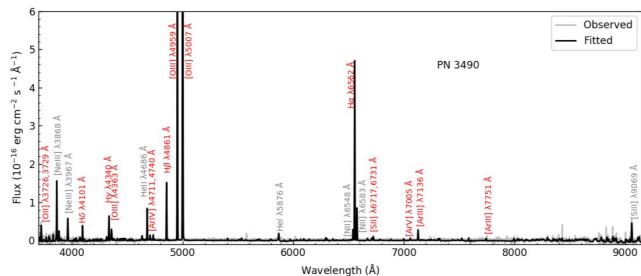
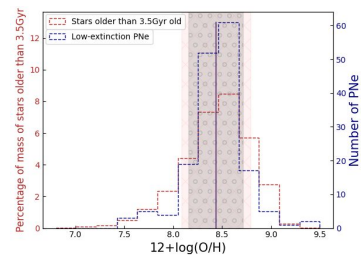
Tsakonas+24 (in prep.)



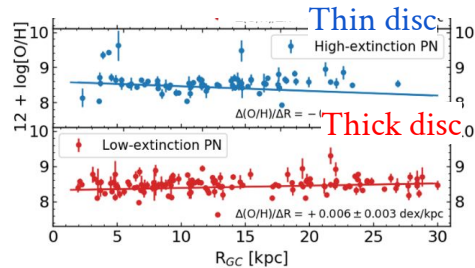
Leverage two constraints

Final [M/H]

II. Oxygen abundance of disc PNe at $z=0$

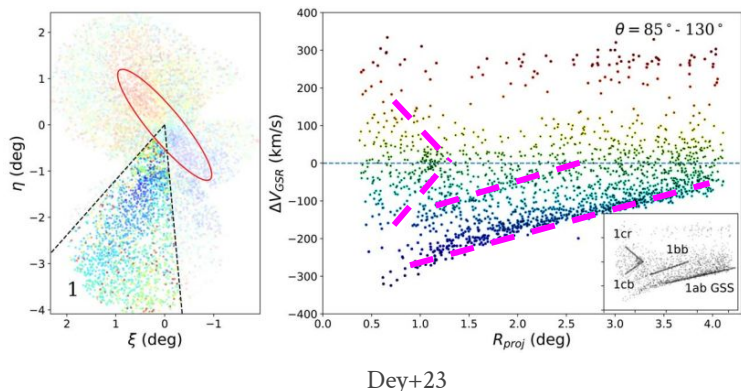


Bhattacharya+22

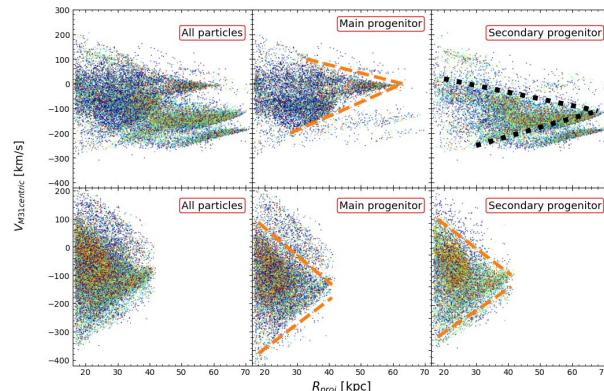


Phase space of stars in the Giant Stream

Observed (DESI)



Model prediction

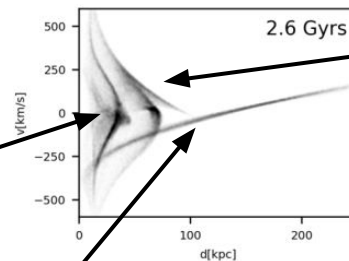


Tsakonas+24 (in prep.)

- ★ The presence of multiple coherent features (Kalirai+06, Gilbert+07,09, Dey+23) in position-velocity space.
- ★ Can be explained by major merger scenario.

W-Shell

NE-Shell



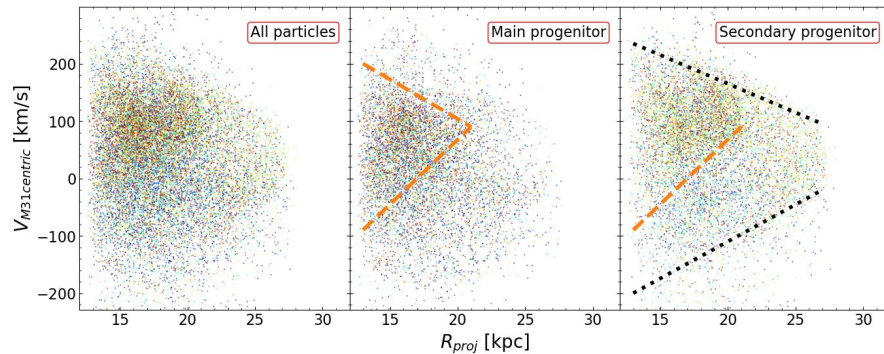
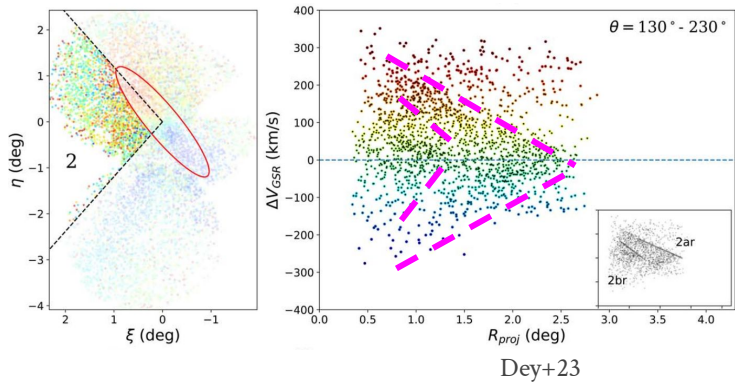
Milosevic+24

Giant Stream

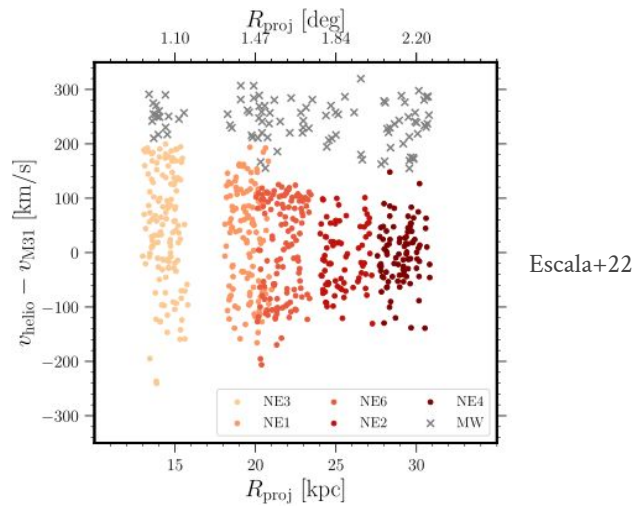
Phase space of stars in the Northeast Shell

Observed (DESI)

Model prediction



Tsakonas+24 (in prep.)

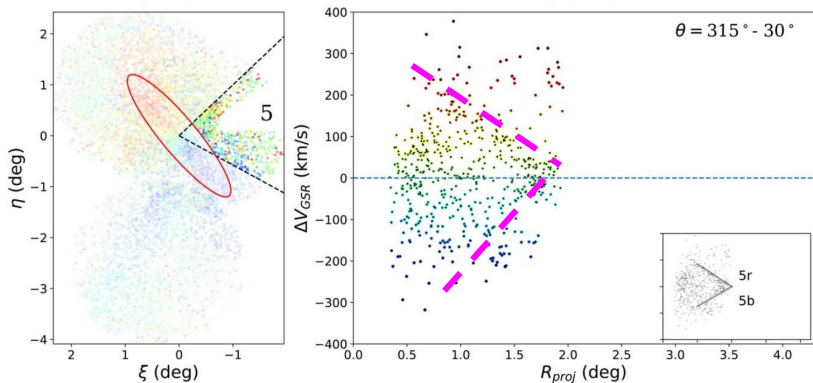


- ★ Two wedge-like patterns in the phase space diagram.
- ★ The inner wedge populated by main progenitor stars.

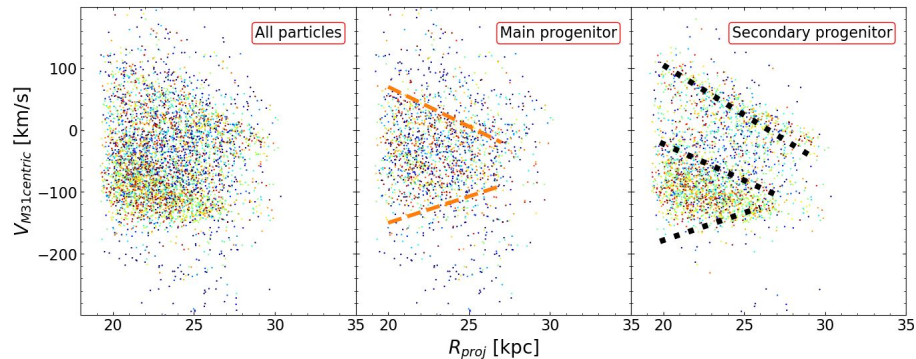
Phase space of stars in the Western Shell

Observed (DESI)

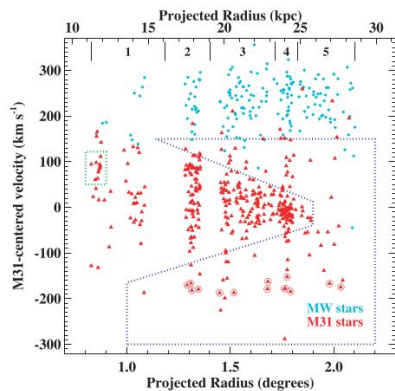
Model prediction



Dey+23



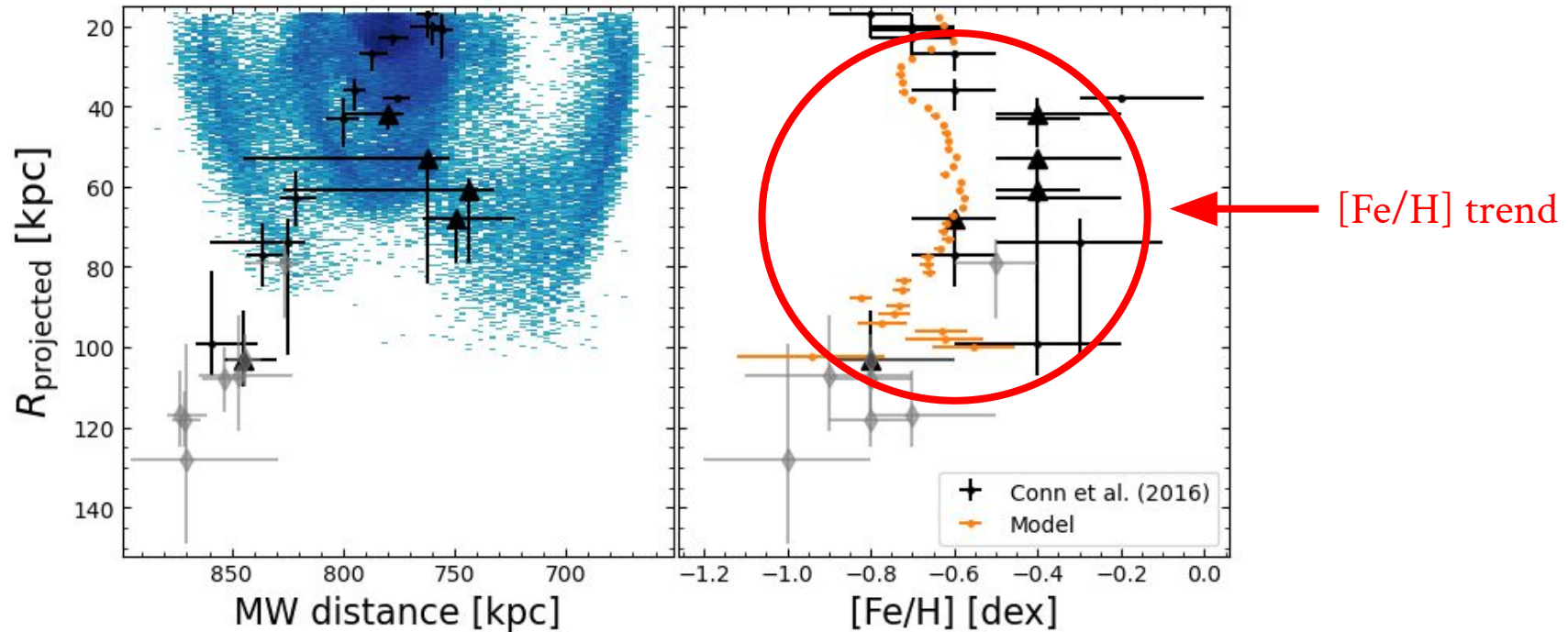
Tsakonas+24 (in prep.)



Fardal+12

- ★ A wedge-like pattern in the phase space diagram.
- ★ Reproduced in the major merger.

Distances and photometric metallicity comparisons for the Giant Stream



Conclusions



Lemoyne (1723)



Tiziano (1556)

- ★ Established the metallicity framework within the context of a major merger model.
- ★ Coherent kinematic features emerging in the phase space of stars observed by resolved stellar populations are echoed in modeled stars.
- ★ The reproduction of some of the observed kinematic features in the substructures further corroborate a major merger scenario event (GS, NE-Shell).
- ★ The simulated M31 analog predicts the observed metallicity gradients along the Giant Stream.
- ★ Prediction for a metal-rich inner halo.
- ★ The 7D (chemodynamical) comparison reproduced qualitatively the observed properties of M31.

Future prospects

- ★ Predictions that can be compared against observations (Subaru PFS).
- ★ New iterations of the model.
- ★ Improved metallicity estimates from future wide-field spectroscopy data.