

## Background

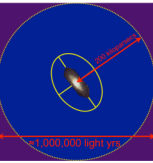
Big Picture Context

### Why Andromeda?

- External yet close-by vantage point—**global** but **detailed** view of galaxy
- Spiral galaxy similar to our own—**results applicable** to Milky Way



Traditional view of M31? Radius—20 kiloparsecs ≈ 65,000 light years



Area analyzed in this study Radius—200 kiloparsecs ≈ 600,000 light years

### Why dSphs?

- **Small**, less chemically enriched than larger galaxies, made up of mostly older stars, **intact**
- Small galaxies = **building blocks of galaxy formation**
- Outskirts of M31—**longer shredding time / longer memory preservation**

## Data Collection and Processing



Data collected over several years... then handled with software pipeline and individual analysis

## Methods

### Distinguishing between the dSph and Field Samples

#### Overall Criteria

- Sample is a mix of M31 stars, background galaxies, and foreground Milky Way (MW) stars
- 1. **Zquality 3 or 4**: Eliminates background galaxies, isolates stars with clean spectra from which **velocities** can be determined
- 2. **M31Class 1, 2, or 3**: eliminates foreground MW dwarf stars

#### dSph vs. Field Criteria

Two "flavors" of telescope pointing during data collection:

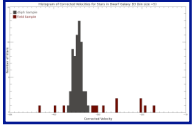
- **Towards** M31 dSph Satellites
- **Away** from M31 dSph Satellites ("non-dSph pointing")

When telescope is pointed towards dSph, collected sample is a mix of dSph AND field stars:

- 1. **Stringent Velocity Cuts**: histograms of corrected velocities (**Vcorr**) generated for each dSph

- Stars in **main histogram peak** selected as part of dSph Sample

- Stars from initial dSph Sample **not within stringent Vcorr range** selected as part of **Field Sample** (see figure)



Example Histogram of Corrected Velocities [km/s] for Stars in dSph Andromeda 3 (bin size = 5 [km/s])

For non-dSph pointing, **no velocity cuts necessary** (not shown)

(Methods Continued on Right Panel)

# A Spectral Analysis of the Chemical Enrichment History of Red Giants in the Andromeda Galaxy Field (M31) Versus its Dwarf Spheroidal (dSph) Satellites

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Research conducted at UC Santa Cruz

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## Introduction

Galaxies are interesting organisms: they move, change, grow, and, strangely enough, consume. In a process known as **galaxy cannibalism**, a dwarf satellite galaxy is drawn towards a larger, more massive galaxy and shredded by the forces of gravity.

What determines whether a dwarf satellite is shredded or remains intact? Is it possible to find dwarf galaxies that are in the midst of being shredded? What are the chemical differences between parent galaxies and their surviving satellites?

### About this study

- Analyzed **chemical trends** as a function of **photometric properties** of stars
- **1<sup>st</sup>** time that **cannibalism survivors** (Field) are compared to **cannibalism victims** (Dwarf Spheroidals)
- **1<sup>st</sup>** time that **coaddition** was used to group **LIKE** stars strictly and with great detail

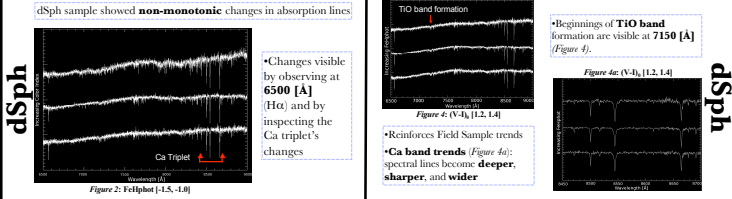
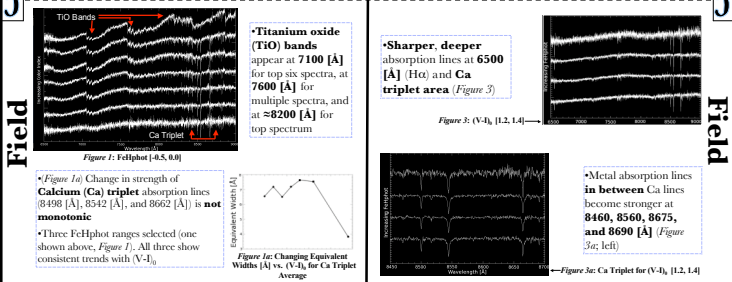
The Bulge and Inner Disk of the Andromeda Galaxy!

## Procedures

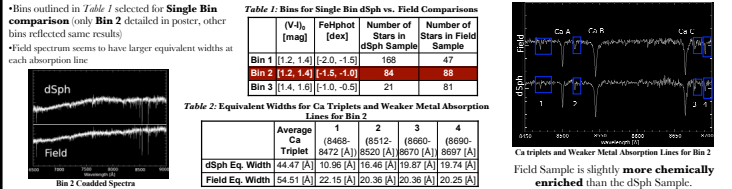


## Results

Analysis of Spectral Changes for Each Sample As a function of (V-I)<sub>0</sub> at a given FeHphot range: As a function of FeHphot at a given (V-I)<sub>0</sub> range:



### dSph vs. Field Single Bin Spectral Comparison



## Conclusions/Future Plans

**Benefits of the Coaddition Process**

- Individual stellar spectra have **low signal-to-noise**—coaddition suppresses noise while preserving actual absorption features
- Trends as a function of FeHphot or (V-I)<sub>0</sub> were **seen**

**Spectral Analysis**

- Changes in Metallicity and Temperature have effect on star's spectrum and result in **systematic trends**
- Field and dSph populations show similar trends, but Field Sample is **chemically richer** on average
- Chemical properties of M31's stellar halo are consistent with the halo's formation by merger and dissolution of dSph satellites
- Interesting to see whether cannibalism victims are similar to cannibalism survivors in terms of their distinct chemical properties

**Future Plans**

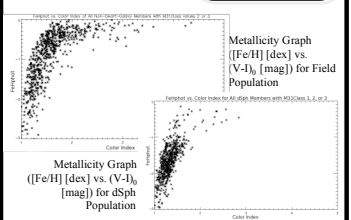
- Compare detailed absorption line strengths in spectra to comprehensive **computer models** of stars with range of known chemical properties
- Based on comparison, determine [Fe/H] and [X/Fe] for various elements (X=Ca, Mg, Ti, etc)
- Compare individual dSphs with each other, Field to tidal streams, dSphs to tidal streams, etc
- Take Metallicity Distribution Function (MDF) of dSphs into account to study star formation and chemical enrichment history of galaxy

## Methods, continued

**Metallicity Distributions**

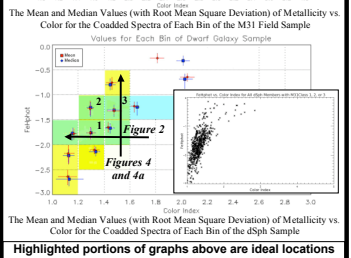
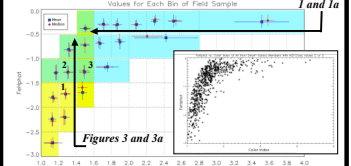
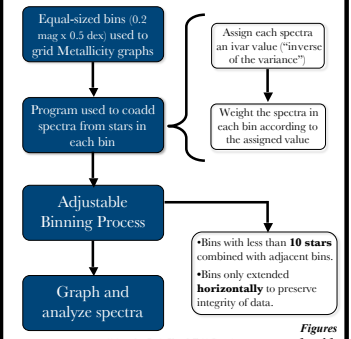
Metallicity graphs (FeHphot vs. (V-I)<sub>0</sub>) generated

FeHphot ([Fe/H]): photometric metallicity estimate; iron to hydrogen ratio in a star; log unit [dex] relative to Sun (V-I)<sub>0</sub> [mag] measure representing a star's temperature



Step shows that dSph sample is more anemic than Field sample (consistent with findings of other researchers)

### Binning and Coadding Spectra



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