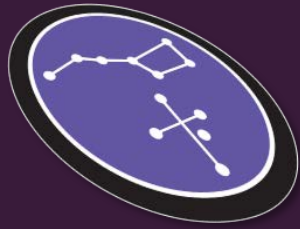


*Sloan Digital Sky Survey-IV:  
Passing the Torch to Phase V*



**SDSS**

Twitter: @SDSSurveys

# *Sloan Digital Sky Survey-IV: Passing the Torch to Phase V*



# SDSS

Twitter: @SDSSurveys

Rachael L. Beaton

Princeton & Carnegie Observatories

APOGEE-2 Science Working Group Chair

Committee On Inclusiveness in SDSS, Co-Chair

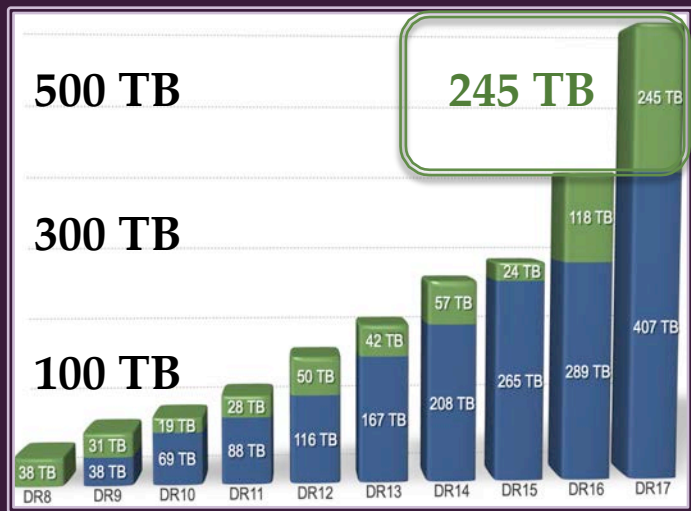
[rachael.l.beaton@gmail.com](mailto:rachael.l.beaton@gmail.com)

Twitter: @rareflwr41

Cell: +01 434 760 1404



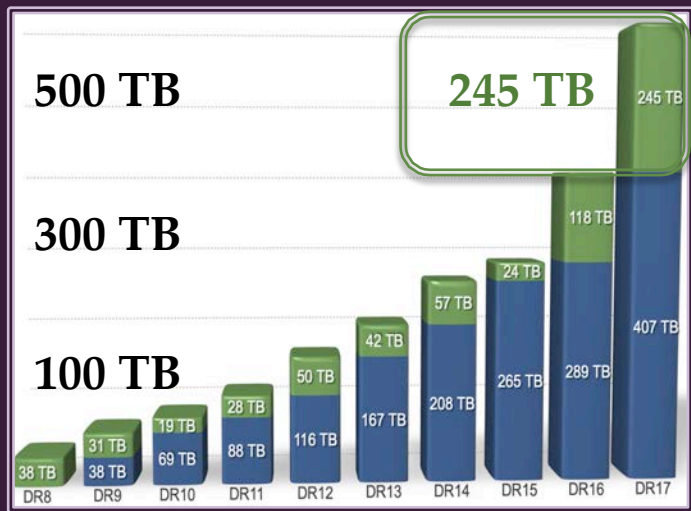
# Twenty-Two years of SDSS Data:



■ Previous Total   ■ Incremental

17 Public Data Releases  
DR17: December 2021

# Twenty-Two years of SDSS Data:



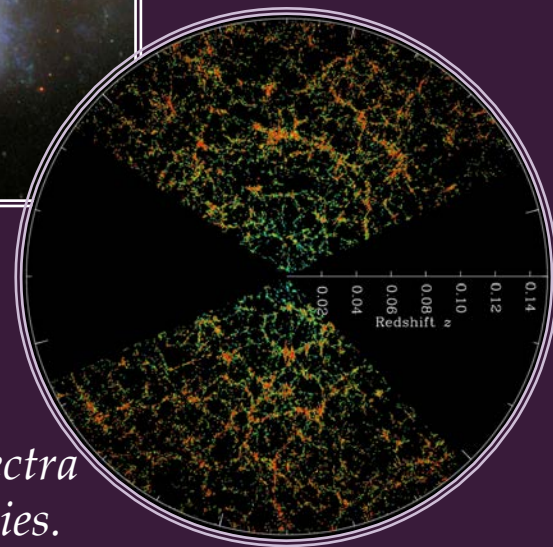
Abdurro'uf et al. (in press)

■ Previous Total   ■ Incremental

17 Public Data Releases  
DR17: December 2021



*Imaging covers  
35% of the sky*



*Over 5 million spectra  
of stars and galaxies.*

## APOGEE-2

Exploring the Milky Way from both  
hemispheres

Explore

@APOGEEsurvey

## eBOSS

Surveying galaxies and quasars to  
measure the Universe

Explore

@eBOSSsurvey

## MaNGA

Mapping the inner workings of  
thousands of nearby galaxies

Explore

@MaNGASurvey



## APOGEE-2

Exploring the Milky Way from both  
hemispheres

Explore

@APOGEEsurvey

## Previously Celebrated

★ Final Data Release  
in 2020  
Surveying galaxies and quasars to  
measure the Universe  
★ Big Science Results in  
2021

@eBOSSsurvey

## MaNGA

Mapping the inner workings of  
thousands of nearby galaxies

Explore

@MaNGASurvey

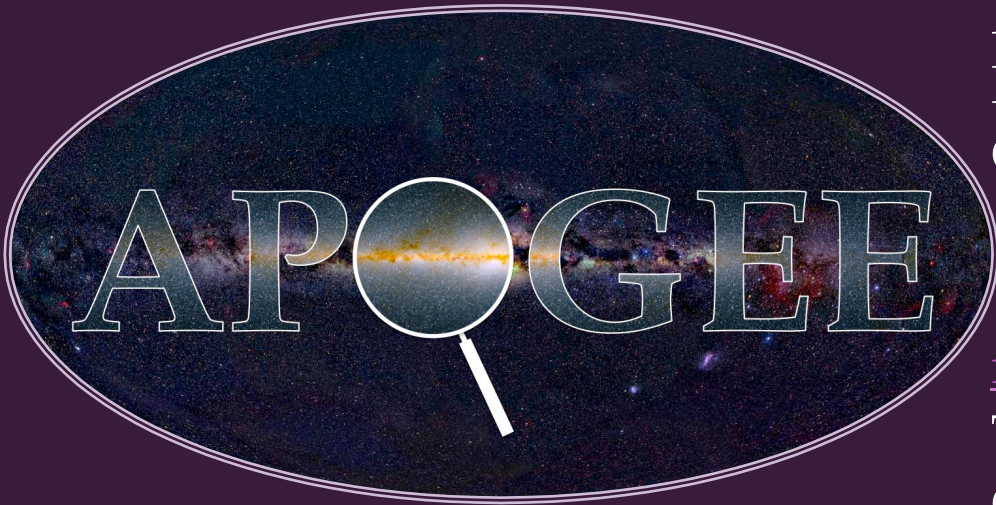


# SDSS *Passing the Torch to Phase V*

- *Almost a Million Stars and Counting: Mapping the History of the Milky Way with APOGEE and Beyond*
- *Galaxies Assemble: MaNGA Team Releases Largest-Ever Collection of 3D Maps of Nearby Galaxies*
- *SDSS-V Robots See First Light*

# *Almost a Million Stars and Counting:*

Mapping the History of the Milky Way with APOGEE and Beyond



Rachael L. Beaton  
Princeton &  
Carnegie Observatories



[rachael.l.beaton@gmail.com](mailto:rachael.l.beaton@gmail.com)

Twitter: @rareflwr41

Cell: +01 434 760 1404

AAS 239

@SDSSurveys

@APOGEEsurvey



## Milky Way in Visual Light



# Milky Way in Visual Light

disk

bulge

halo



Image Credit: ESO/S. Brunier

AAS 239

Use Infrared for access to all Galactic Components

Milky Way in Visual Light

Image Credit: ESO/S. Brunier



Image Credit: SDSS/G. Zasowski

AAS 239

Use Infrared for access to all Galactic Components



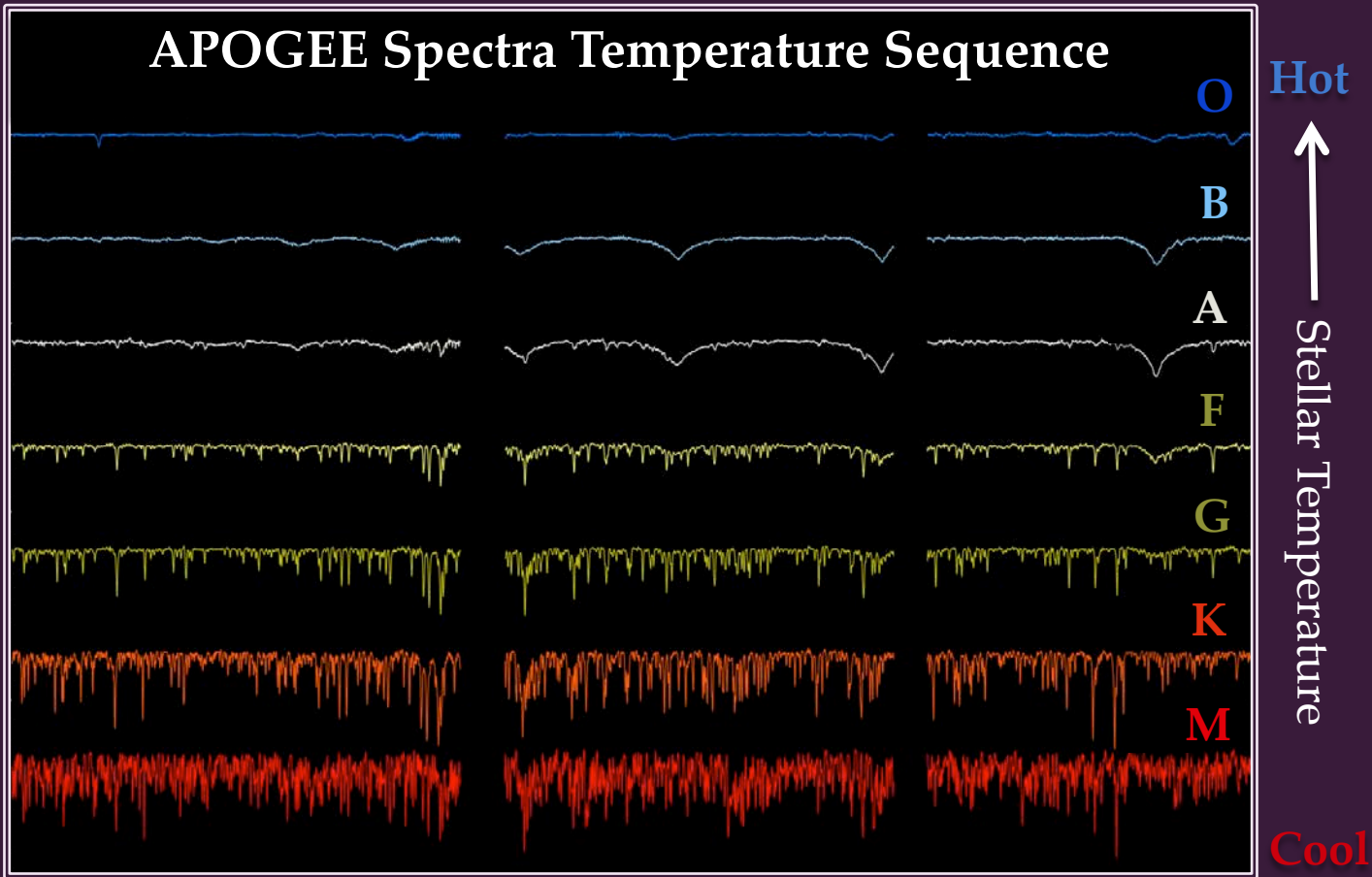
## Milky Way in Visual Light

### Big Data for Addressing Big Questions:

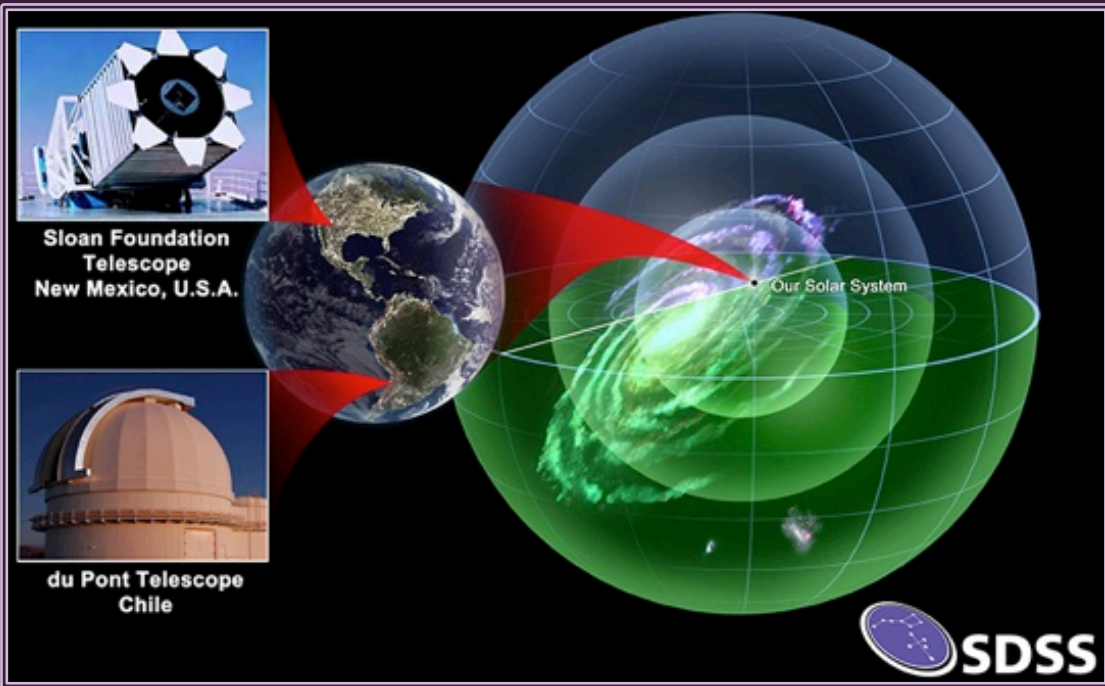
- ✧ What are the dynamics of the Milky Way?
- ✧ What is chemical enrichment in Milky Way?
- ✧ What are the ages of stars in the Milky Way?
- ✧ Are planet-hosting stars different from planet-less stars?

Image Credit: SDSS/G. Zasowski

# APOGEE Spectra Temperature Sequence

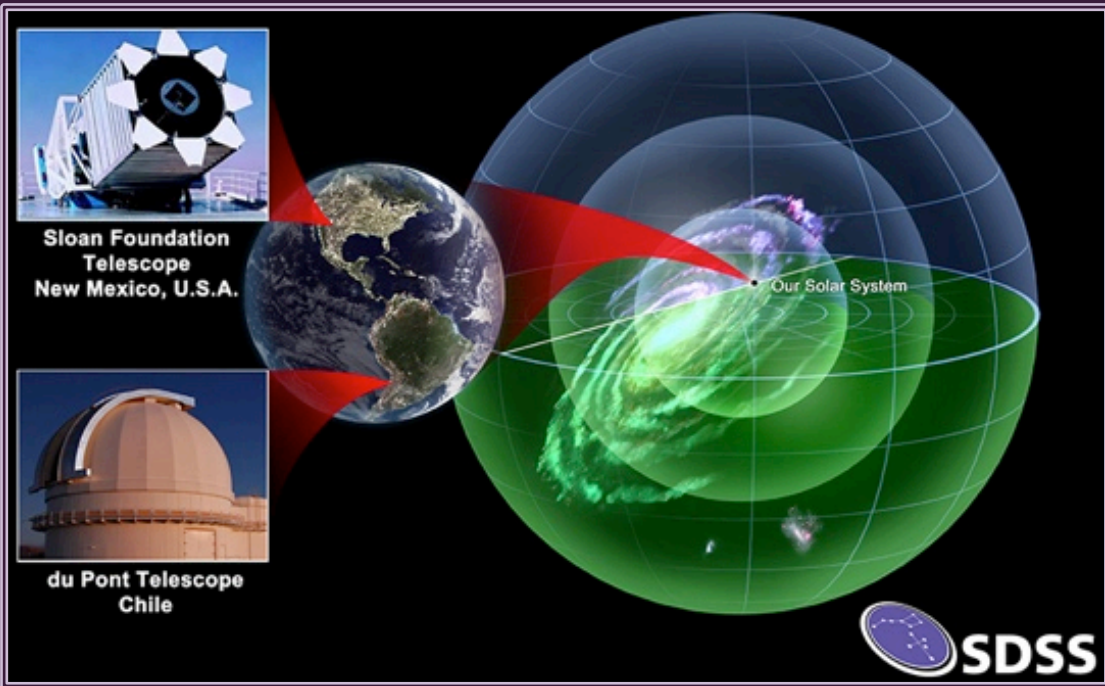




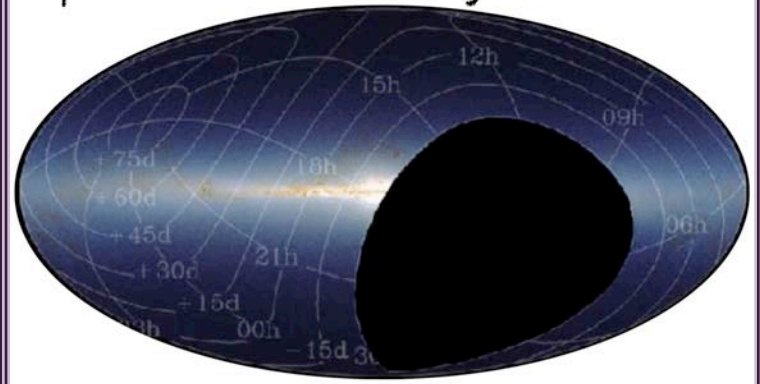


AAS 239

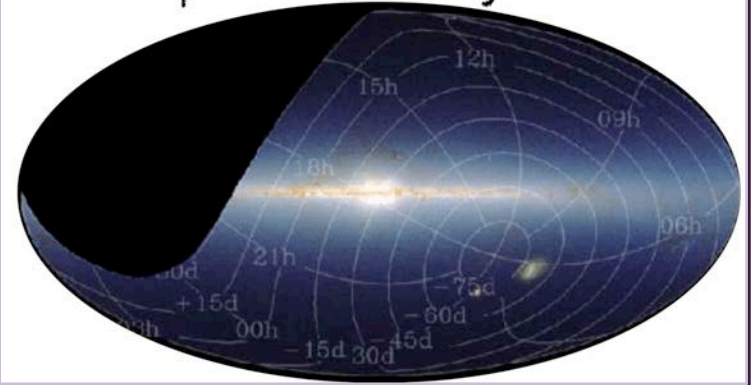
APOGEE-2 sees the full Milky Way



Northern Hemisphere  
Apache Point Observatory



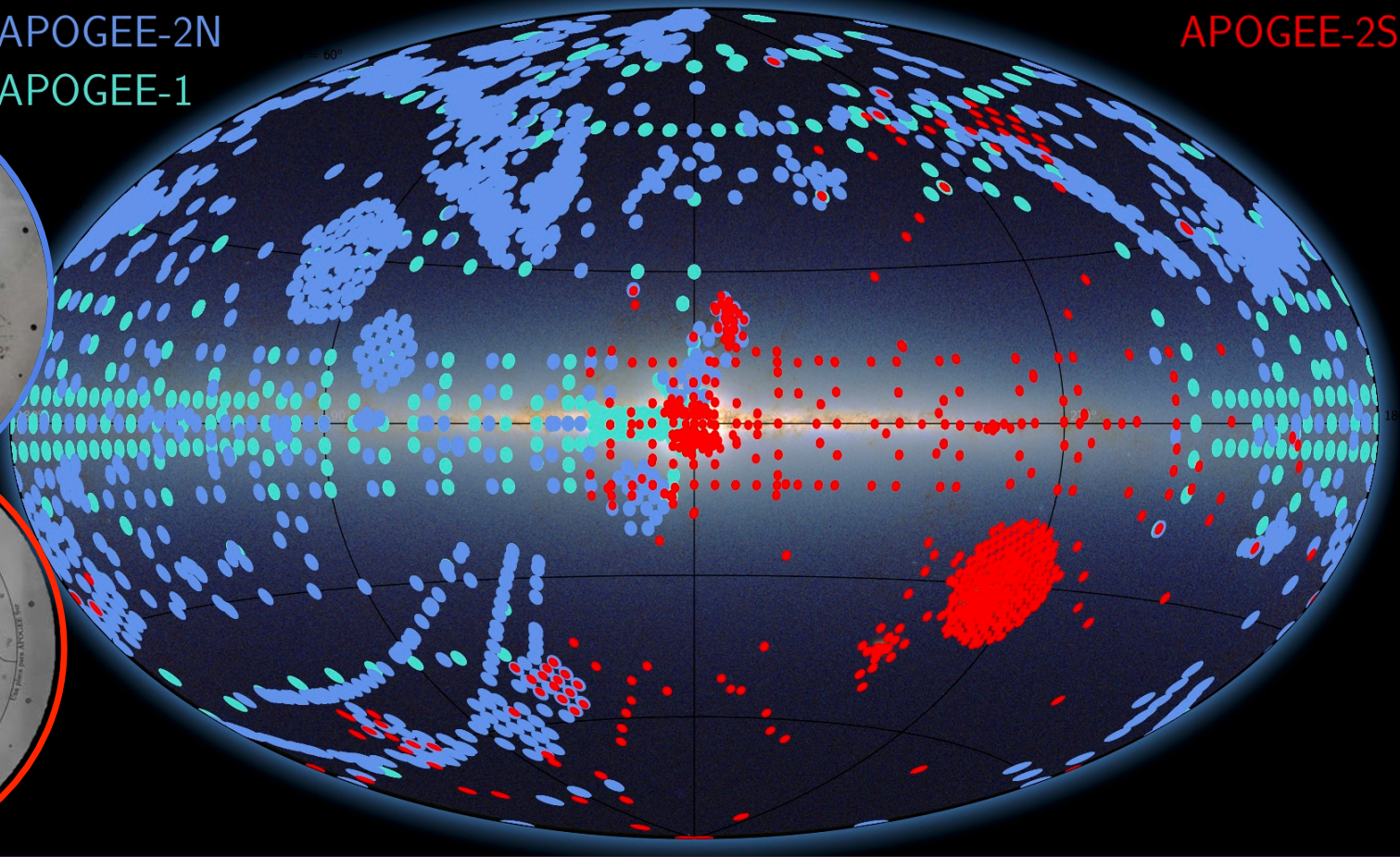
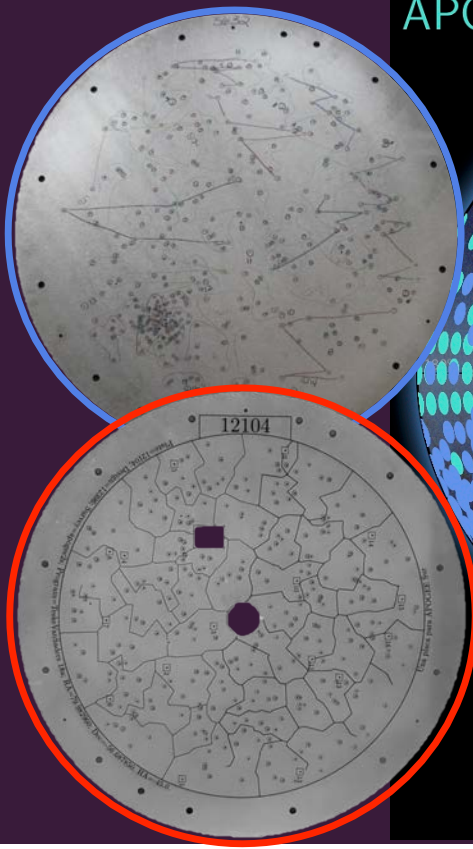
Southern Hemisphere  
Las Campanas Observatory





APOGEE-2N  
APOGEE-1

APOGEE-2S



AAS 239

Over 2000 individual fields targeted by plates.

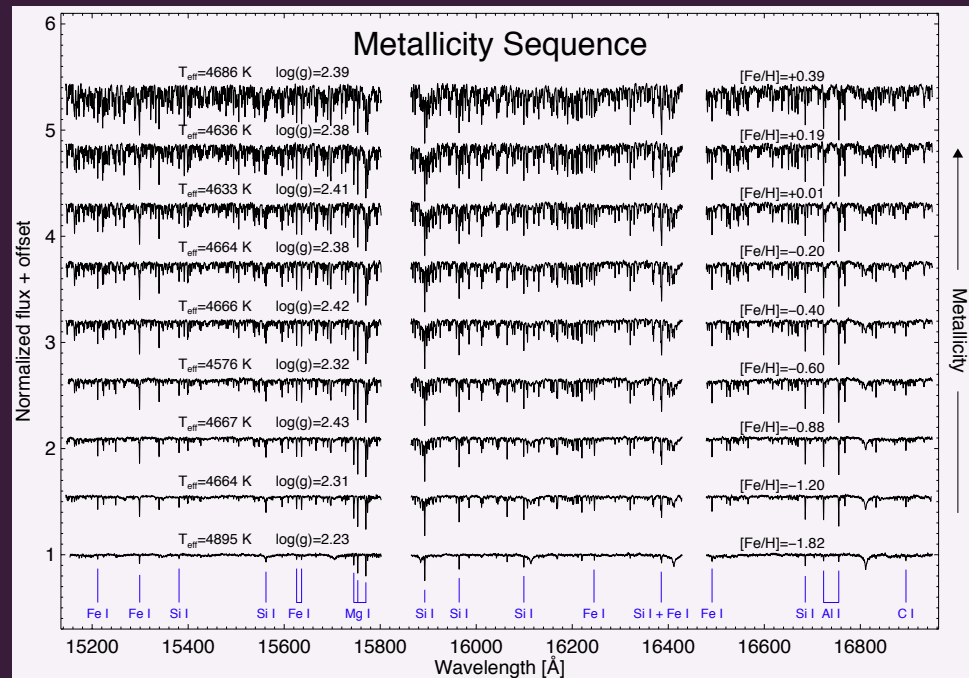
## Data Release 17:

- ★ Nearly 1 million targets
- ★ 2.6 million spectra
- ★ Multi-Epoch Radial Velocities
- ★ Stellar Types
- ★ 20 Elemental Abundances

Data Release 17:  
[sdss.org/dr17/irspec/](https://sdss.org/dr17/irspec/)

## Data Release 17:

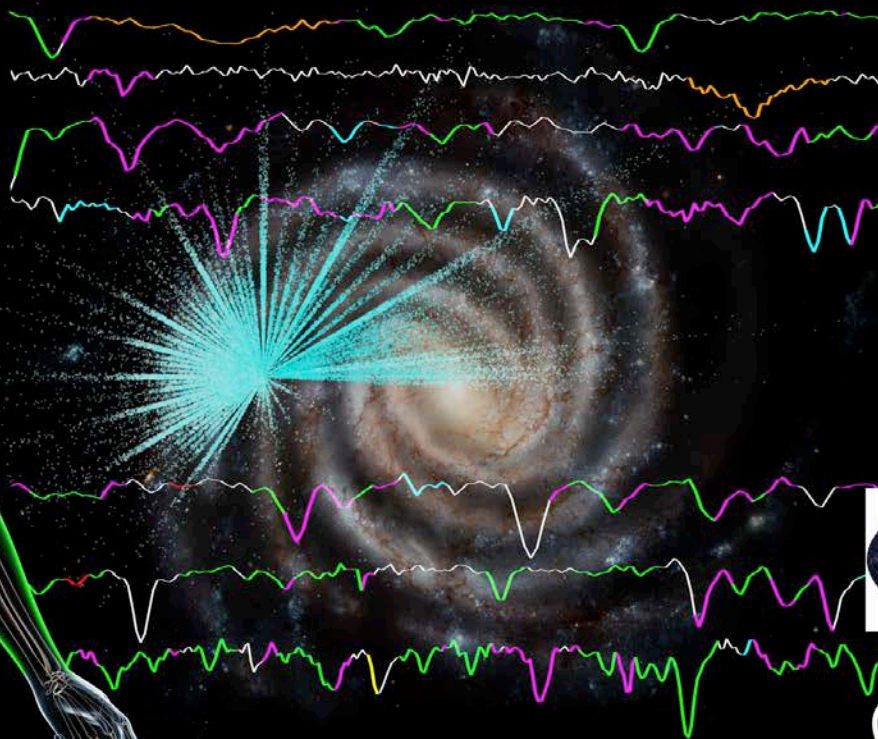
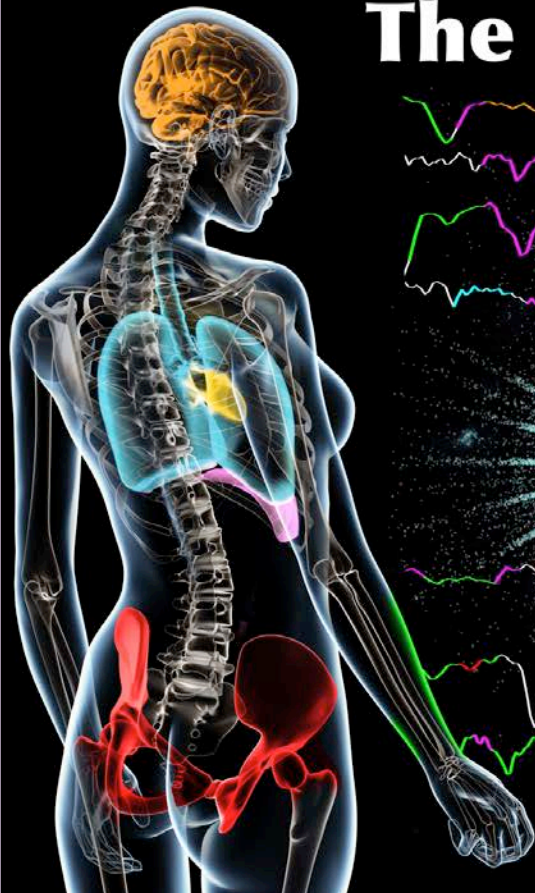
- ★ Nearly 1 million targets
- ★ 2.6 million spectra
- ★ Multi-Epoch Radial Velocities
- ★ Stellar Types
- ★ 20 Elemental Abundances



Data Release 17:  
[sdss.org/dr17/irspec/](https://sdss.org/dr17/irspec/)



# The Elements of Life



Hydrogen  
Carbon  
Nitrogen  
Oxygen  
Sulfur  
Phosphorus



AAS 239

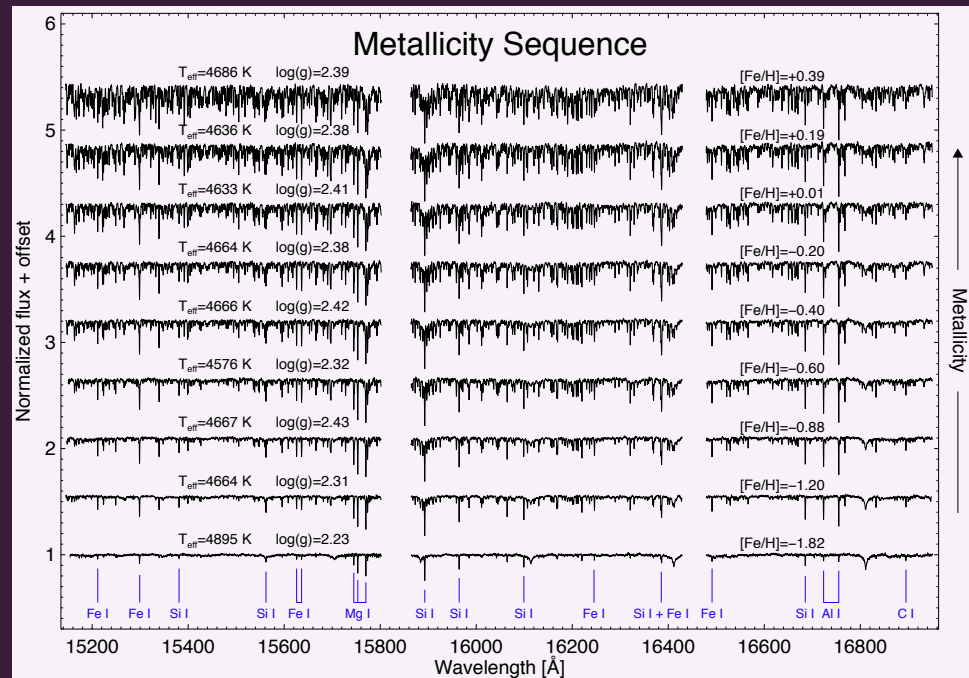
APOGEE measures abundances for 20 elements including the 6 most common in the human body.

## Data Release 17:

- ★ Nearly 1 million targets
- ★ 2.6 million spectra
- ★ Multi-Epoch Radial Velocities
- ★ Stellar Types
- ★ 20 Elemental Abundances

### + Value Added Catalogs:

- ★ Distances
- ★ Binary Identifications
- ★ Galactic Orbits
- ★ Star Cluster Membership



Data Release 17:  
[sdss.org/dr17/irspec/](https://sdss.org/dr17/irspec/)





Milky Way Artist's Impression

Image Credit:  
NASA/JPL-Caltech/R. Hurt (SSC/Caltech)

AAS 239

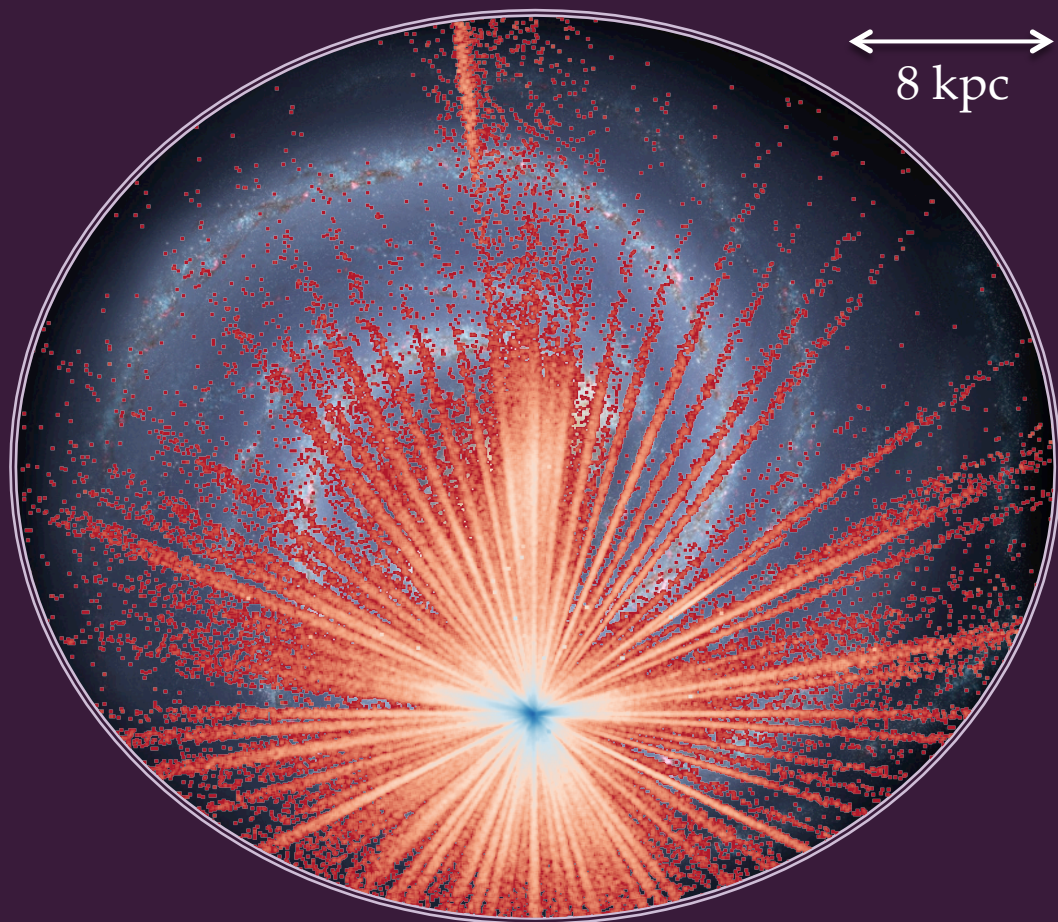
APOGEE's Final Map of the Milky Way





Milky Way Artist's Impression

Image Credit:  
NASA/JPL-Caltech/R. Hurt (SSC/Caltech)

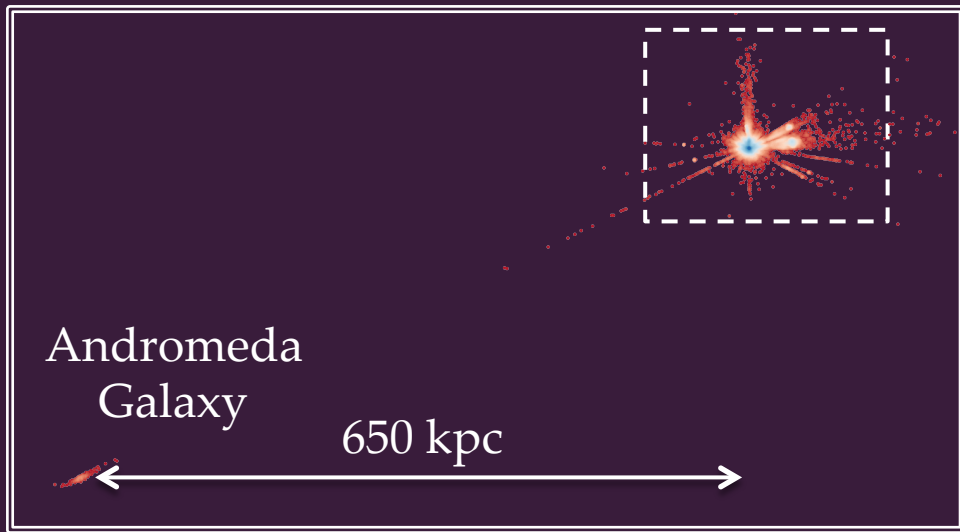


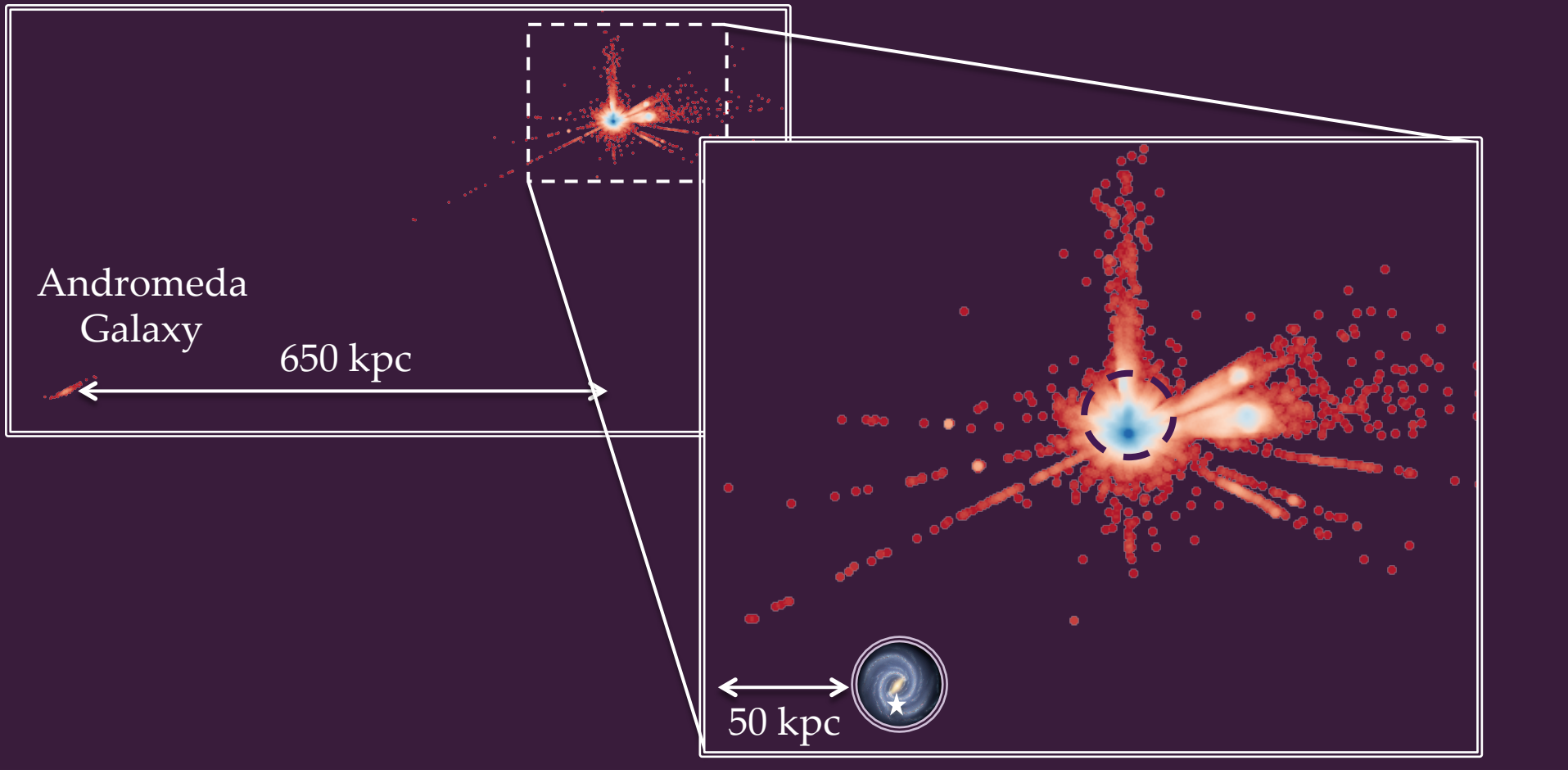
8 kpc

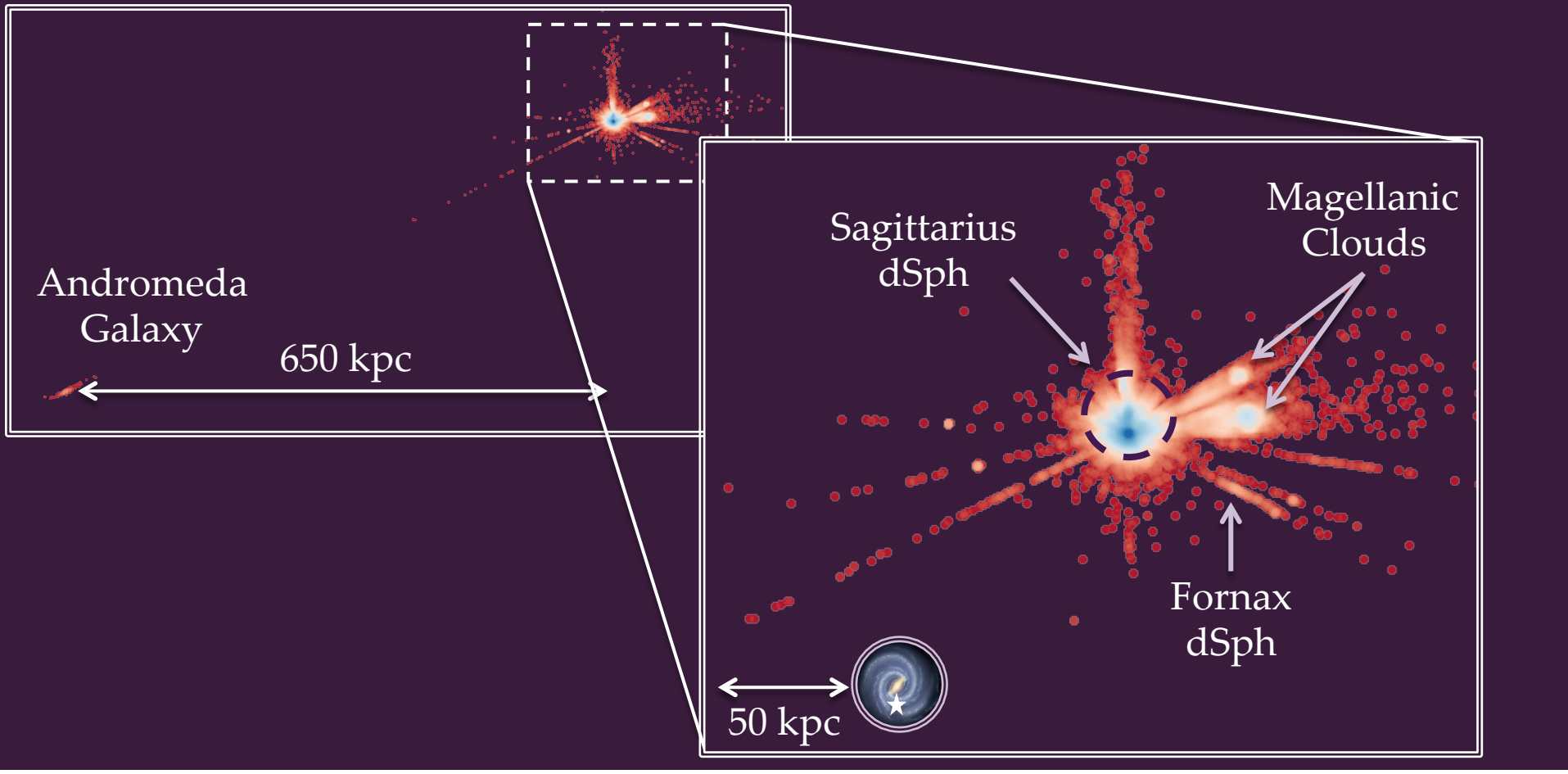
AAS 239

APOGEE's Final Map of the Milky Way









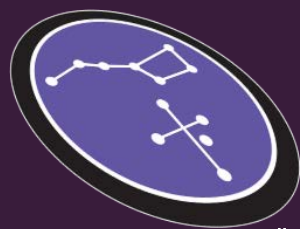


AAS 239

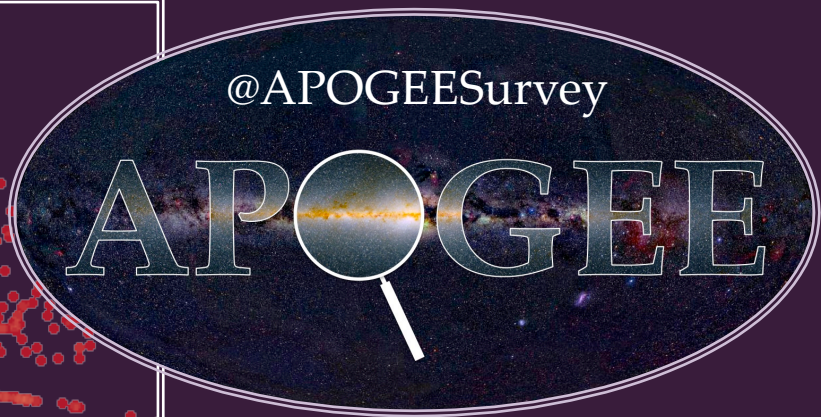
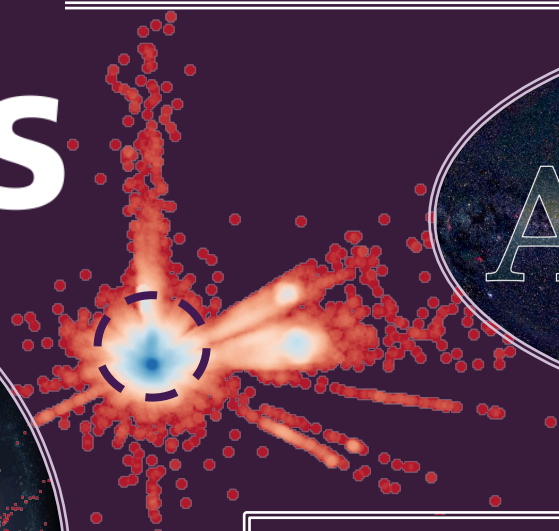
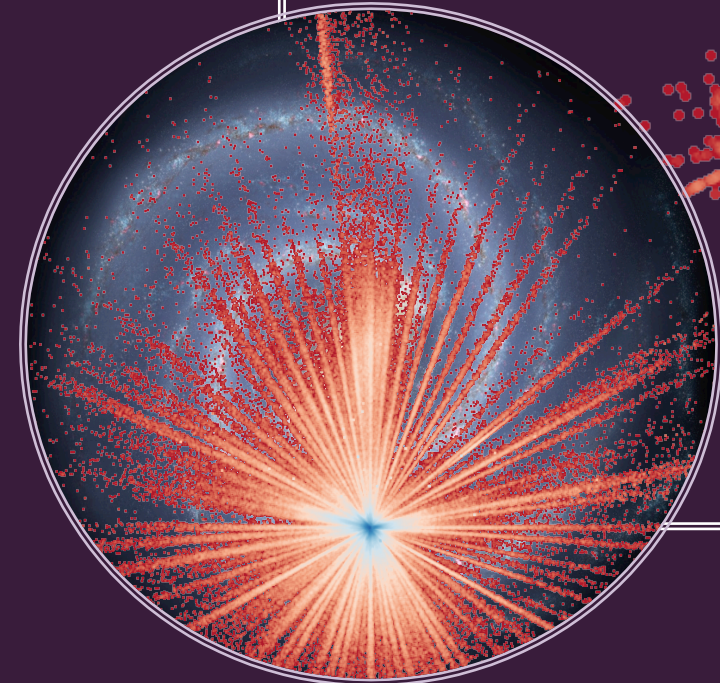
15 Years of APOGEE Teamwork  
Much more to look forward to in SDSS-V Milky Way Mapper!







# SDSS



Rachael L. Beaton  
(Princeton/Carnegie Observatories)

[Rachael.l.beaton@gmail.com](mailto:Rachael.l.beaton@gmail.com)

twitter: @rareflwr41

Cell: +01 434 760 1404





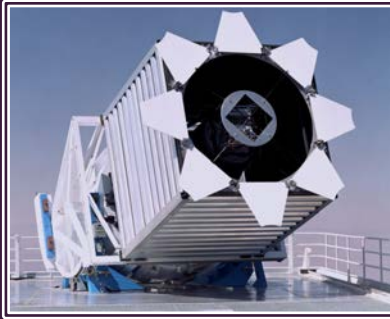
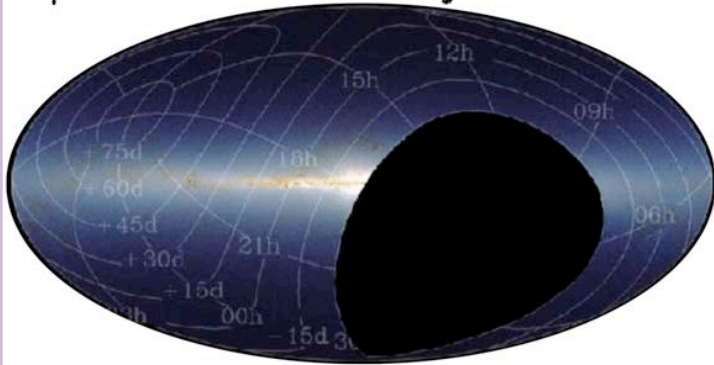
# APOGEE-2 Project Leadership

|                                      |  |
|--------------------------------------|--|
| <b>Principal Investigator:</b>       | Steve Majewski (University of Virginia)              |
| <b>Survey Scientist:</b>             | Jon Holtzman (New Mexico State University)           |
| <b>Project Manager:</b>              | Jennifer Sobeck (CFHT)                               |
| <b>Instrument Scientist:</b>         | John Wilson (University of Virginia)                 |
| <b>Pipeline Coordinator:</b>         | Matthew Shetrone (UCO/Lick)                          |
| <b>Target Selection Coordinators</b> |  |
| North:                               | Drew Chojnowski (Montana), Chris Hayes (U Victoria); |
| South:                               | Felipe Antonio Santana Rojas (Universidad de Chile); |
| Special Targets & External Programs: | Kevin Covey (WWU)                                    |
| <b>Survey Operations Scientists</b>  |  |
| North:                               | Nathan De Lee (Northern Kentucky University);        |
| South:                               | Penélope Longa-Peña (Universidad de Antofagasta)     |
| <b>LCO Operations Liaison</b>        | Christian Nitschelm (Universidad de Antofagasta)     |

Science Working  
Group Chairs

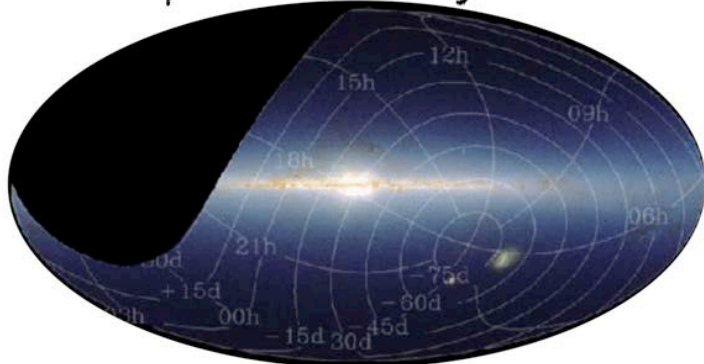
Jonathan Bird (Vanderbilt) ★ Melissa Ness (Columbia) ★ Diane Feuillet (Lund) ★  
Sten Hasselquist (STSci) ★ Rachael Beaton (Princeton/Carnegie)

Northern Hemisphere  
Apache Point Observatory



APOGEE-1 & APOGEE-2N  
Apache Point Observatory  
2011 - 2020

Southern Hemisphere  
Las Campanas Observatory



APOGEE-2S  
Las Campanas Observatory  
2017 - 2021



Visit & Visit Combined Spectra:

2.6 million visit spectra ★  
730,000 combined spectra

Radial Velocity Measurements:

400,000 targets with 3+ RV  
measurements ★ 35,000 targets  
with 10+ RV measurements

Atmospheric Stellar Parameters:

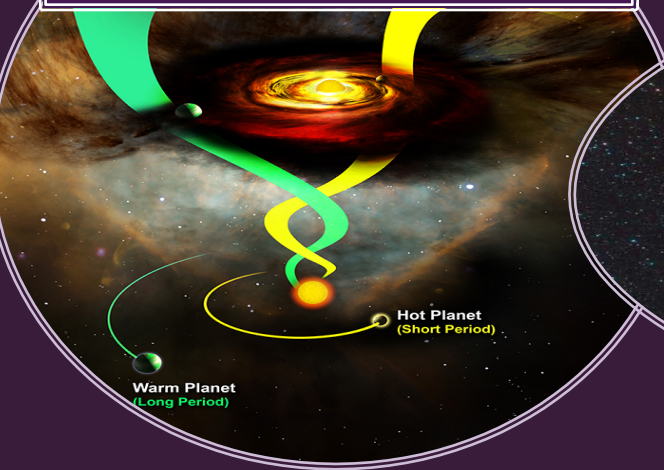
$\log(g)$  ★  $T_{\text{eff}}$  ★  $v_{\text{micro}}$  ★  $[M/H]$  ★  
 $[C/M]$  ★  $[N/M]$  ★  $[\alpha/M]$  ★  
 $v_{\text{macro}}$  (gi) or  $v_{\text{sini}}$  (dw)

Individual Element Abundances:

C, C I, N, O, Na, Mg, Al, Si, S, K,  
Ca, Ti, Ti II, V, Cr, Mn, Fe, Co, Ni,  
Ce



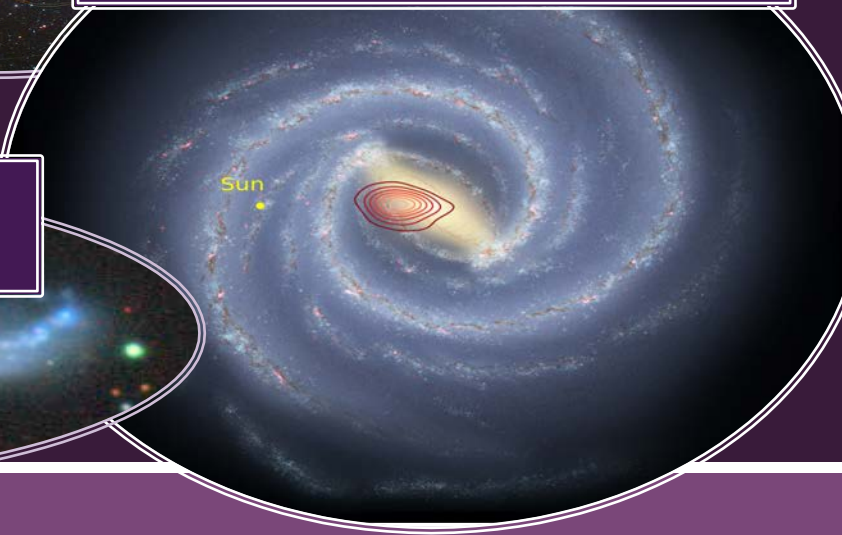
Insight into compositions  
of Exoplanets



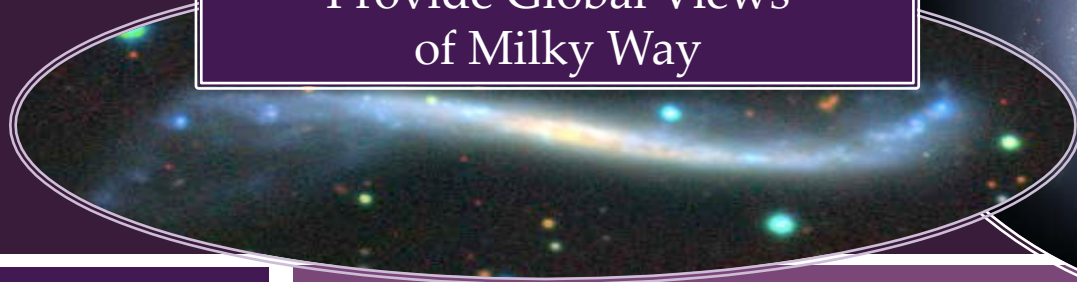
Interesting Binary Systems



Reveal coeval structures within  
the Milky Way

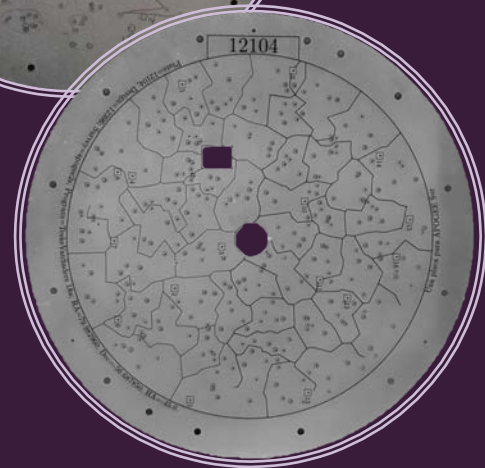
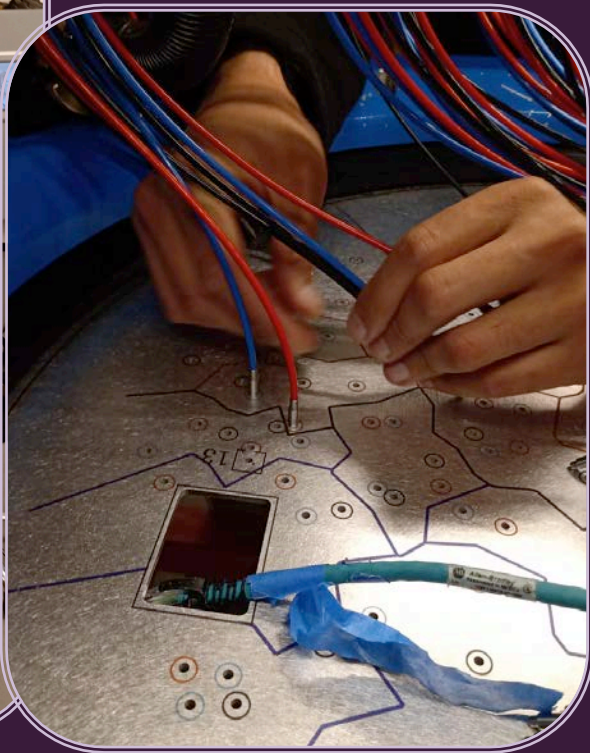
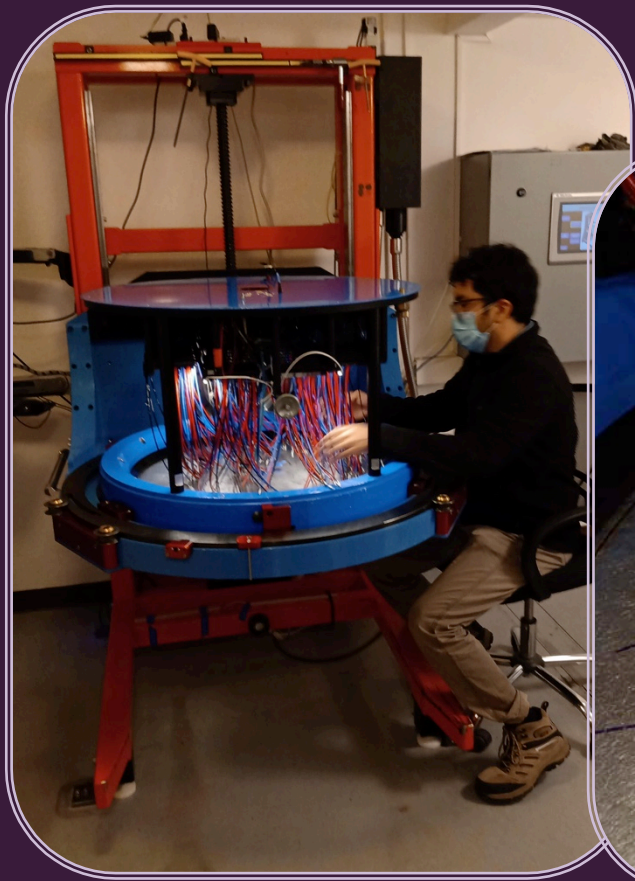


Provide Global Views  
of Milky Way



AAS 239

Science Snapshot

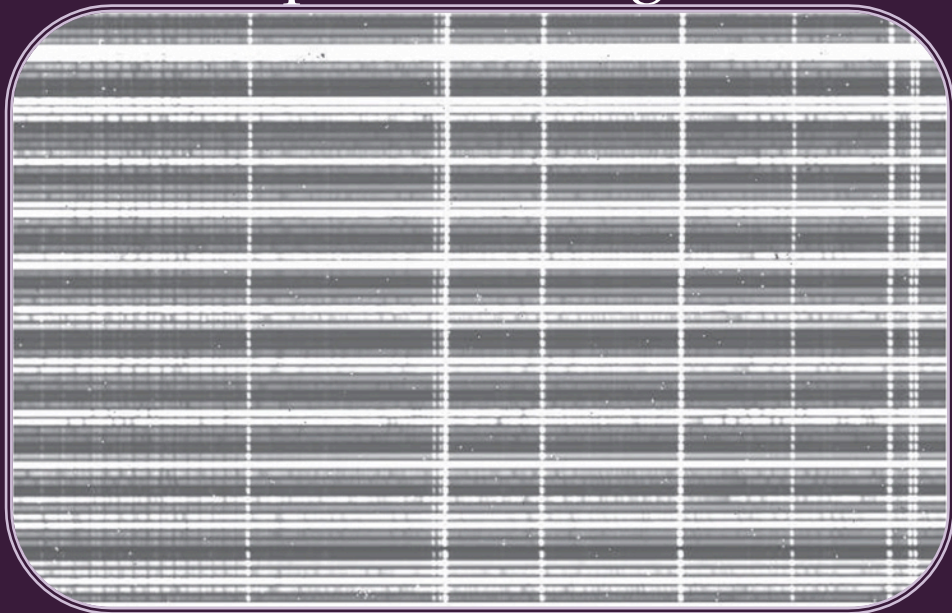


AAS 239

SDSS-IV APOGEE Plate



# Spectral Images



# 1-D Spectra

