SDSS-III Scientific Goals

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Legacy of SDSS & SDSSII

- Detection of the baryon acoustic peak in large-sacle structure
- Mapping of streams of stars left from galaxy mergers in the Milky Way
- Discovery of many new and unexpected phenomena

Open to public through web interfaces in the DAS and CAS

SDSS III

- Massive Spectroscopic Surveys of the Distant Universe, the Milky Way Galaxy and Extra-Solar Planetary System

Goals and Themes

to generate high-quality scientific data and to make important new discoveries.

- Dark energy and cosmological parameters
- The structure, dynamics, and chemical evolution of the Milky Way
- The architecture of planetary systems

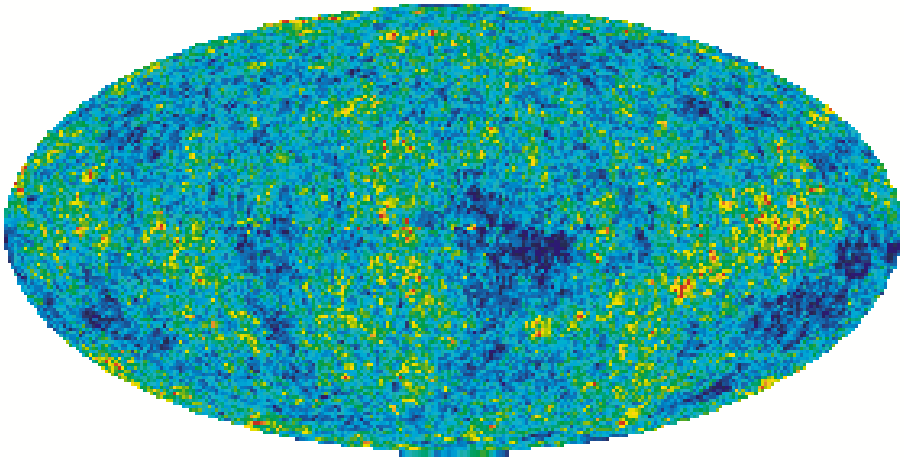
Surveys

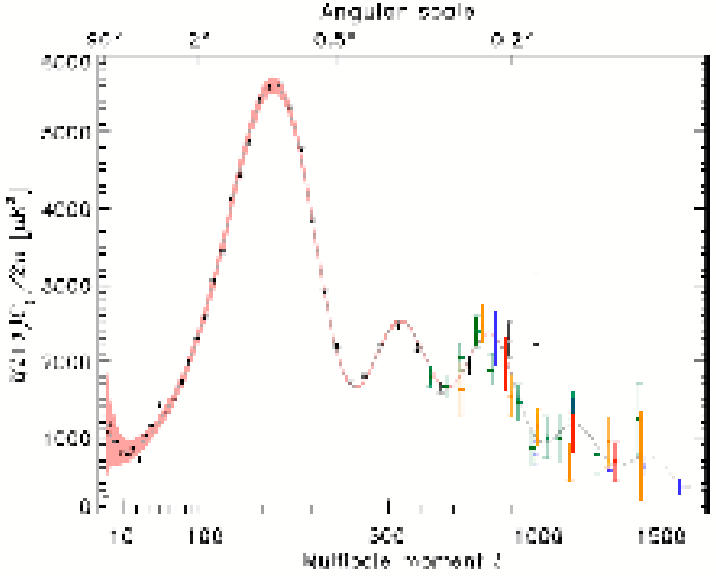
- **BOSS** will measure the cosmic distance scale via clustering in the large-scale galaxy distribution and the Lyman-α forest.
- **SEGUE-2** will map the structure, kinematics, and chemical evolution of the outer Milky Way disk and halo
- **APOGEE** will use high-resolution infrared spectroscopy to see through the dust to the inner Galaxy
- **MARVELS** will probe the population of giant planets via radial velocity monitoring of 11,000 stars

BOSS: Dark Energy and the Geometry of Space

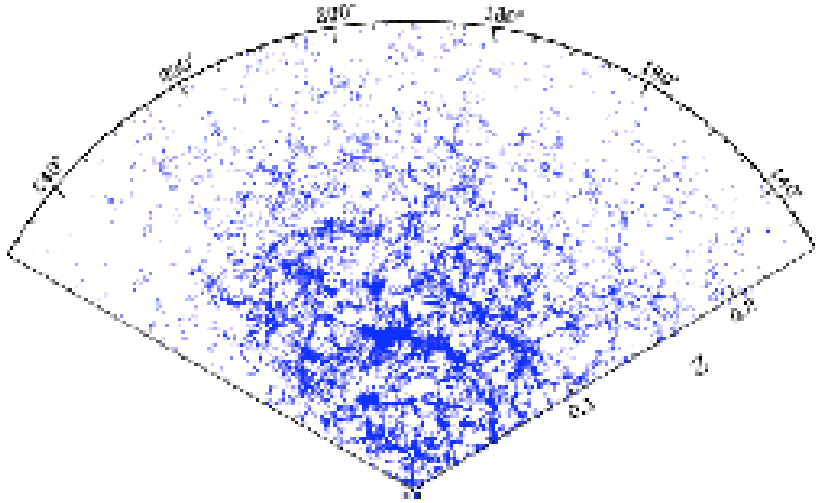
- The SDSS-III's **Baryon Oscillation Spectroscopic Survey (BOSS)** will map the spatial distribution of luminous galaxies and quasars to detect the characteristic scale imprinted by baryon acoustic oscillations in the early universe. Sound waves that propagate in the early universe, like spreading ripples in a pond, imprint a characteristic scale on cosmic microwave background fluctuations. These fluctuations have evolved into today's walls and voids of galaxies, meaning this baryon acoustic oscillation scale is visible among galaxies today.

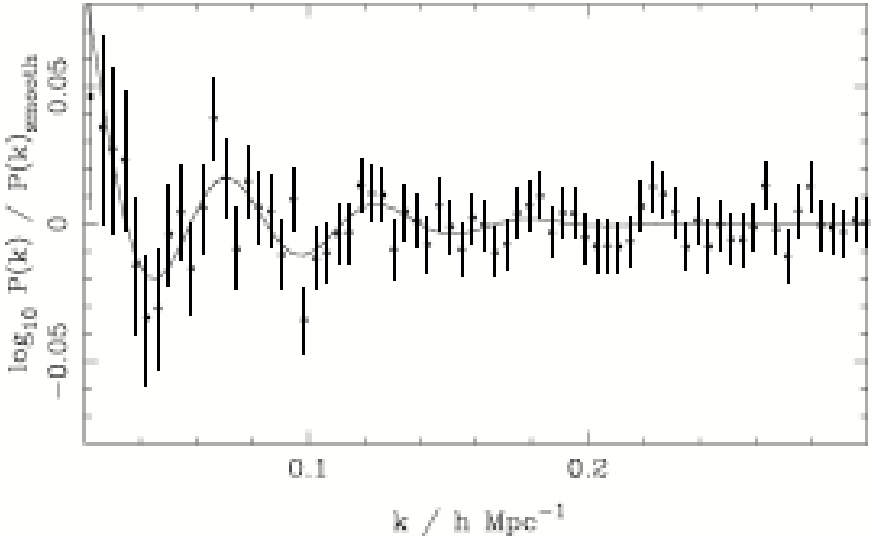
Cosmic microwave background



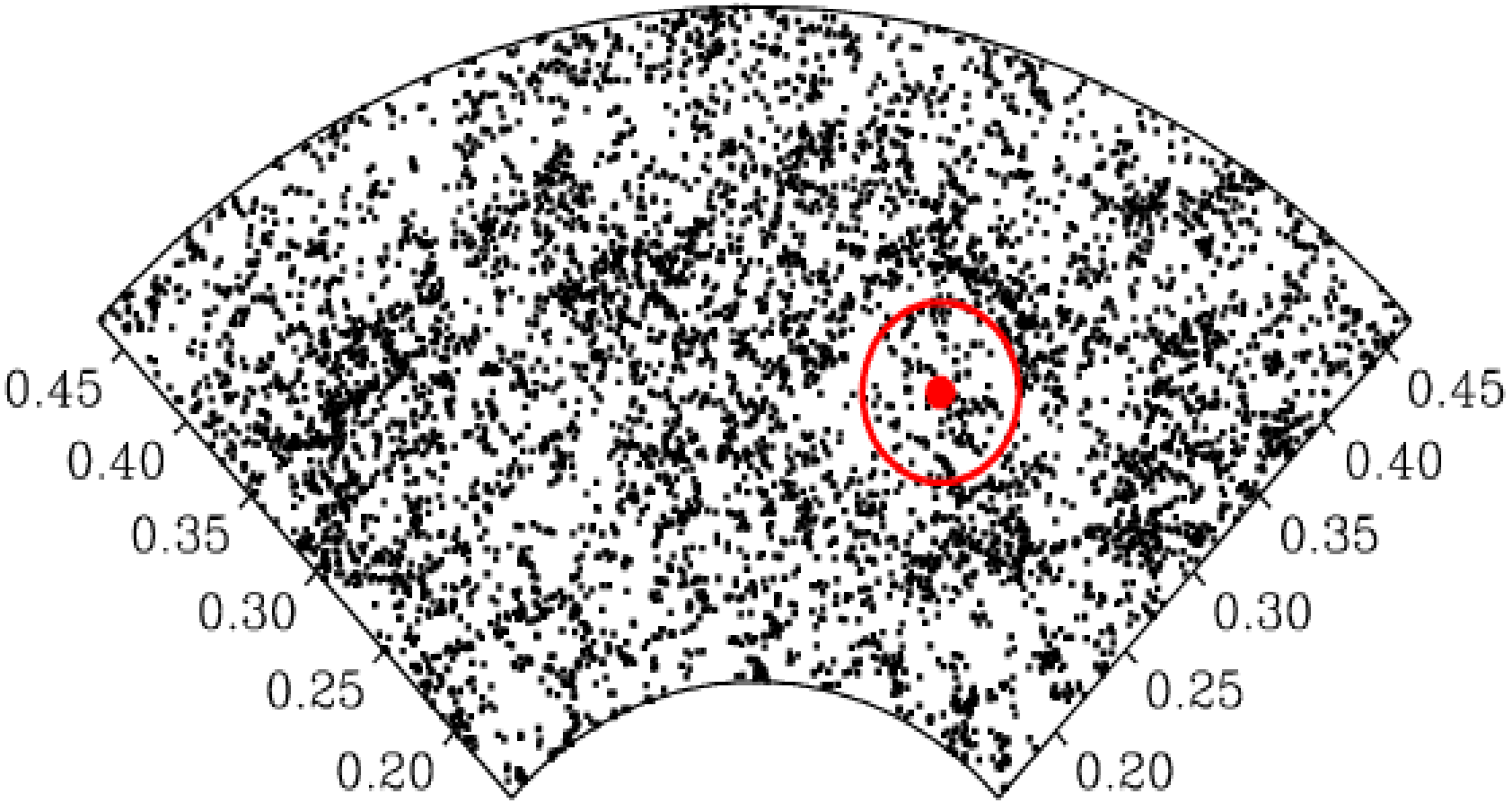


Galaxies





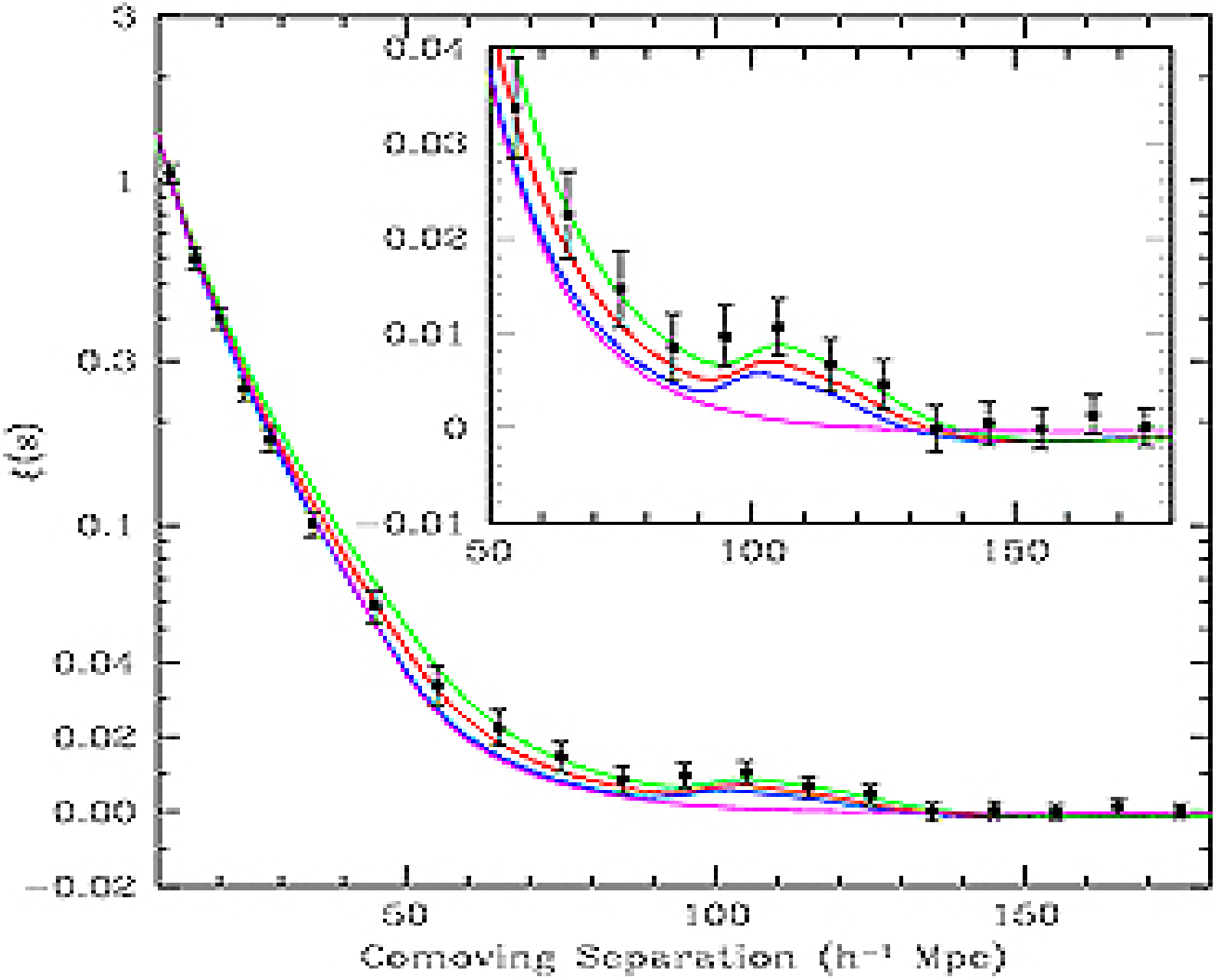
Luminous Red Galaxies



Red circle: characteristic scale of baryon acoustic oscillations

Angular diameter distance

- BOSS will determine the angular diameter distance with a precision of 1% at redshifts z = 0.3 and z = 0.6 and 1.5% at z = 2.5, and it will measure the cosmic expansion rate H(z) with 1–2% precision at the same redshifts. These measurements will provide demanding tests for theories of dark energy and the origin of cosmic acceleration.


3
1
0.3
0.1
0.04
0.02
0.00
−0.02
ξ(s)
50
100
150
Comoving Separation (h⁻¹ Mpc)
0.04
0.03
0.02
0.01
0
−0.01
50
100
150

BOSS at a glance

- Dark time observations
- Fall 2009 – Spring 2014
- 1,000-fiber spectrograph, resolution R~2000
- wavelengths 360-1000 nm
- 10,000 square degrees
- Redshifts of 1.5 million luminous galaxies to $z = 0.7$
- Lyman-α forest spectra of 160,000 quasars at redshifts $2.2 < z < 3$

Mapping the Milky Way

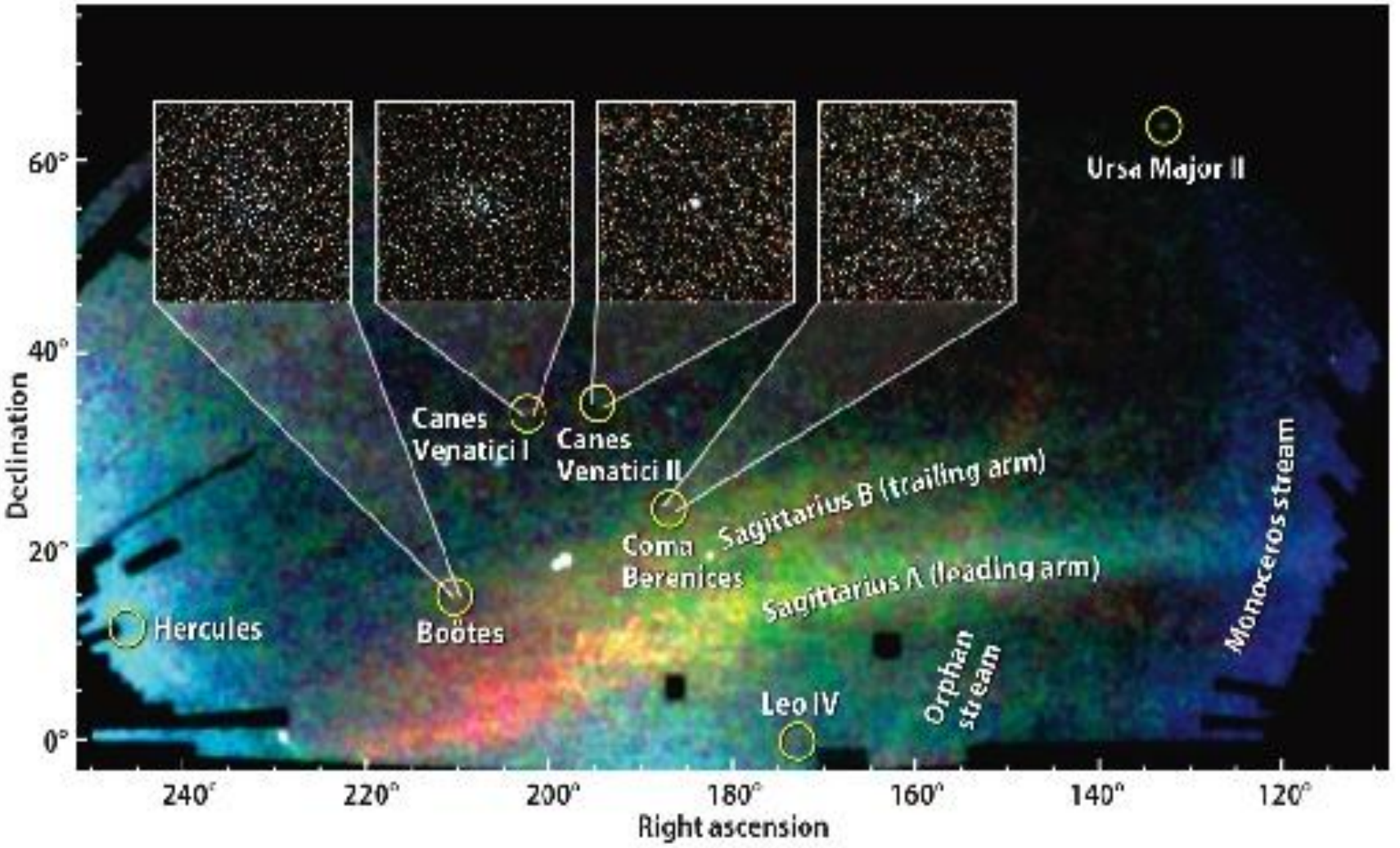
- The Sloan Extension for Galactic Understanding and Exploration-II (**SEGUE –II**)
- The APO Galactic Evolution Experiment (**APOGEE**)

will play a central role in near-field cosmology tests of galaxy formation and the small-scale distribution of dark matter.

SEGUE-2

- will map the outer Milky Way with spectra of 250,000 stars, doubling the sample of the SEGUE component of SDSS-II. These measurements reveal the complex kinematic and chemical substructure of the Galactic halo and disks, providing essential clues to the assembly and enrichment history of the Galaxy. They uncover rare, chemically primitive stars that are fossils of the earliest generations of cosmic star formation.

SDSS stellar map of the northern sky



SEGUE-2 Science

- Halo Substructure
- Tracing Streams
- The Dark Matter Halo
- The Thick Disk
- The Metallicity Distribution Function
- Chemically Primitive Stars
- AGB Nucleosynthesis
- Rare Objects: eg. Chemically pecular WD

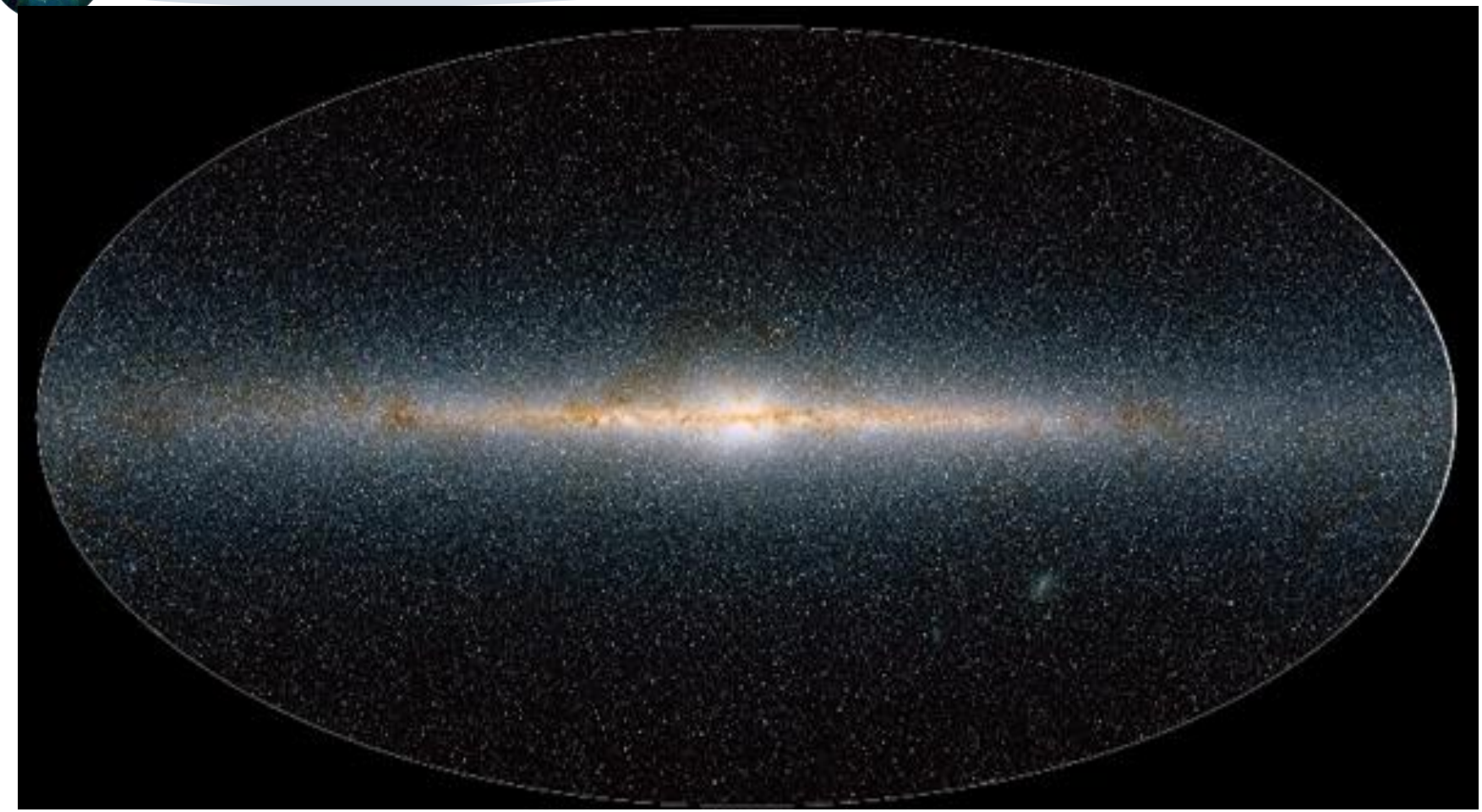
SEGUE-2 at a glance

- Dark time observations, Fall 2008 – Spring 2009
- 250,000 stars in multiple categories, to magnitude g=19
- Resolution R~2000, typical S/N=25
- wavelengths 385-920 nm
- Velocity error 4 km/s, [Fe/H] error 0.3 dex
- Bright time parallel program, 2010-2014: additional 100,000 stars to g=17

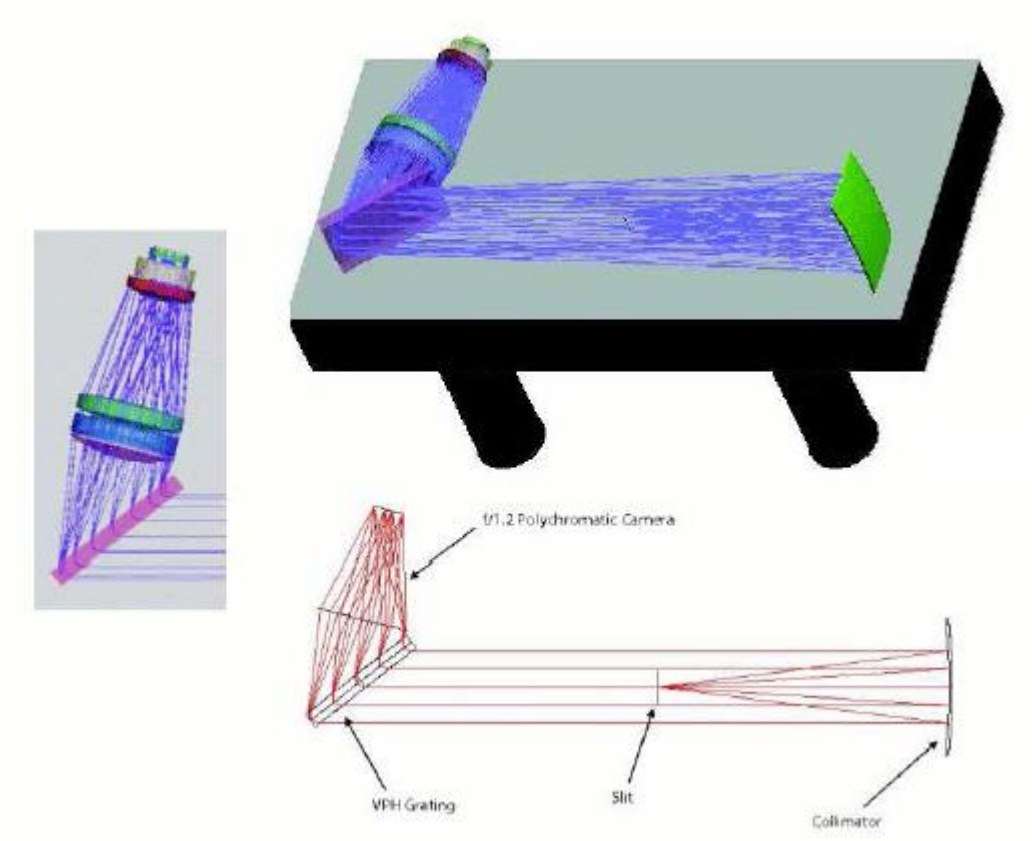
APOGEE

- will use high-resolution, high signal-to-noise *infrared spectroscopy* to penetrate the dust that obscures the inner Galaxy. APOGEE will survey 100,000 red giant stars across the full range of the Galactic bulge, bar, disk, and halo. Precise radial velocities and detailed chemical abundance "fingerprinting" will provide unprecedented insights into the dynamical structure and chemical history of the Galaxy.

2MASS map of the Milky Way



APOGEE optical design



APOGEE Science

- Galactic Stellar Populations
- Hierarchical Formation of the Inner Galaxy
- Population III stars
- Halo Substructure
- Galactic Dynamics
- The Galactic Bulge
- The Galactic Bar
- Legacy Survey of Low-Latitude Star Clusters
- Star Formation

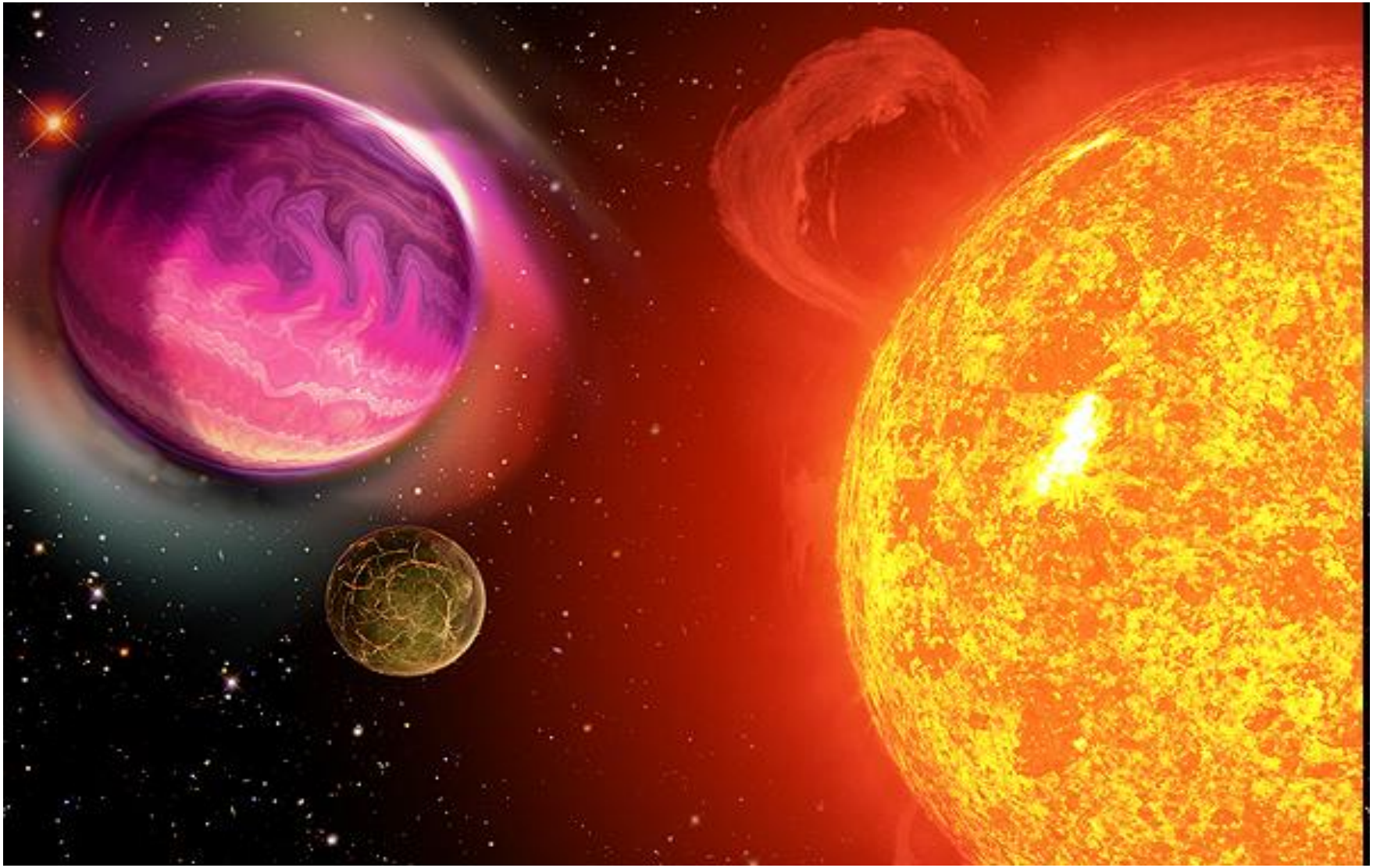
APOGEE at a glance

- Bright time observations, Spring 2011 – Spring 2014
- 300-fiber cryogenic spectrograph, resolution R~20,000, S/N=100
- wavelengths 1.52-1.69 μm
- Velocity error 0.5 km/s
- Abundances of more than 15 elements
- 100,000 2MASS-selected giant stars to H=13.5, probing all Galactic populations

MARVELS

- The Multi-object APO Radial Velocity Exoplanet Large-area Survey (MARVELS) will monitor the radial velocities of 11,000 bright stars, with the precision and cadence needed to detect gas giant planets that have orbital periods ranging from several hours to two years.

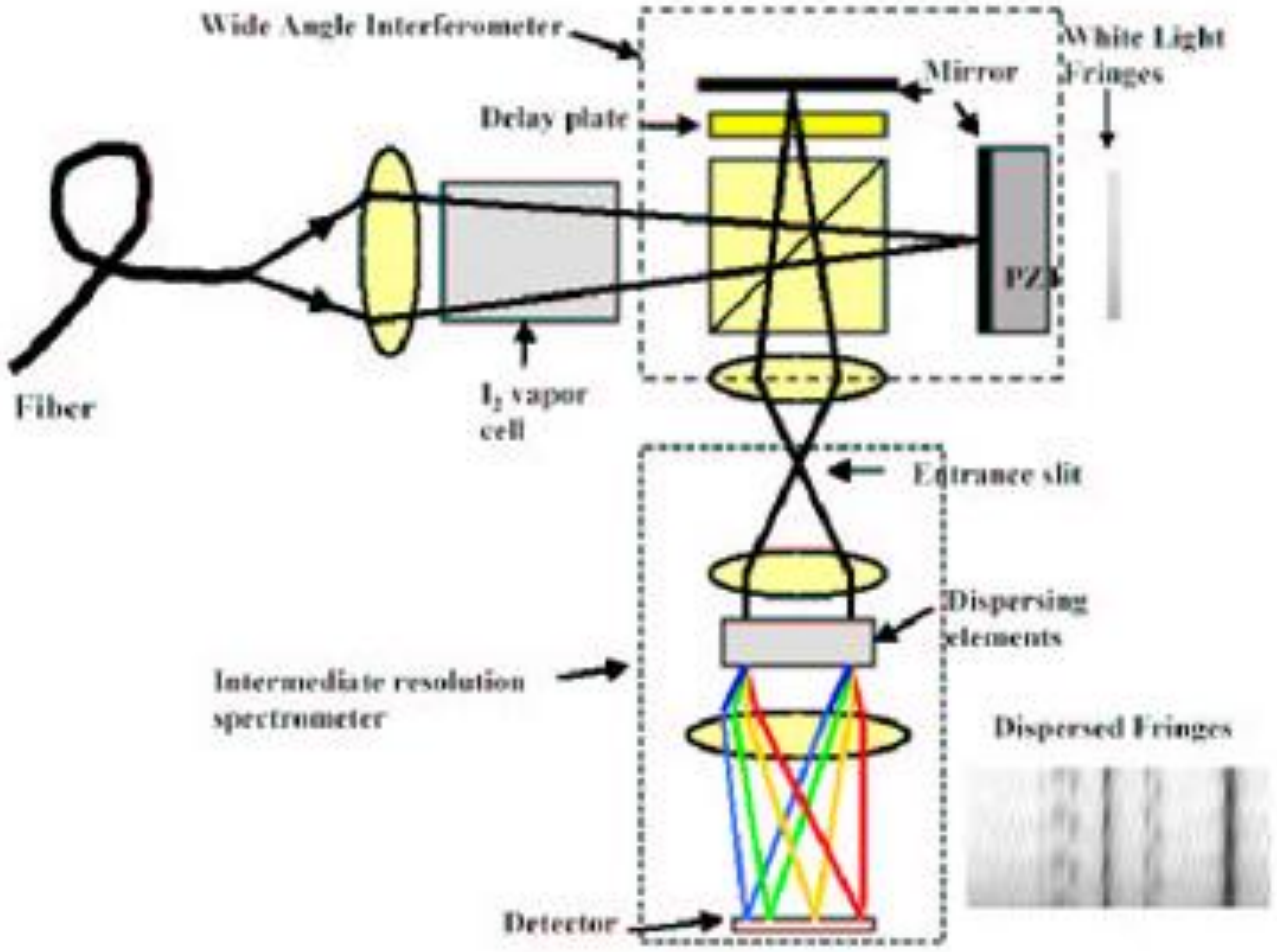
extrasolar planetary system



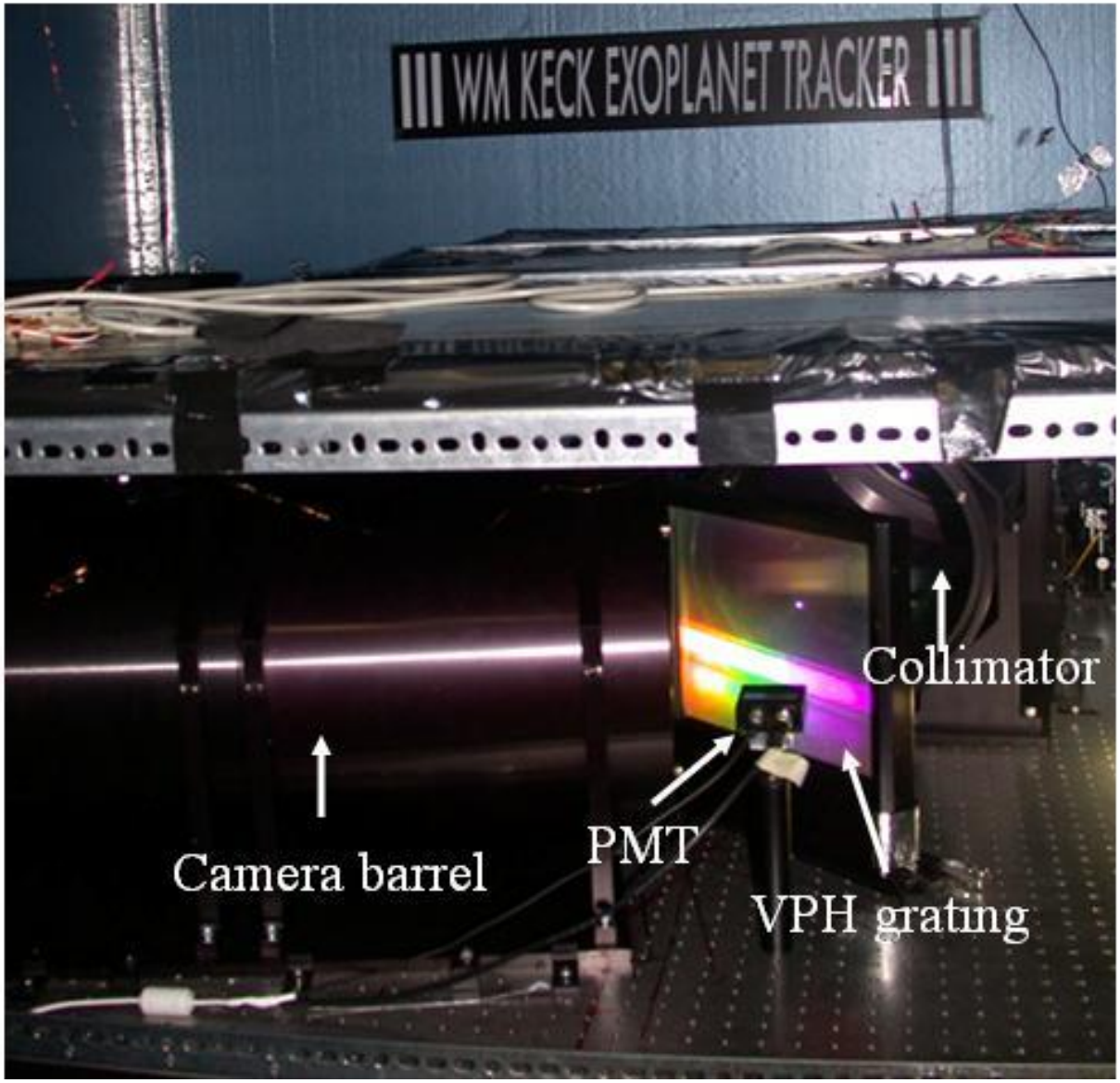
Characterizing Extrasolar Planets

- With well-characterized sensitivity and a broad range of target star properties, MARVELS will provide a critical dataset for testing theoretical models of the formation, migration, and dynamical evolution of giant planet systems. It will have unique sensitivity to rare systems such as extreme eccentricity planets or objects in the "brown dwarf desert."

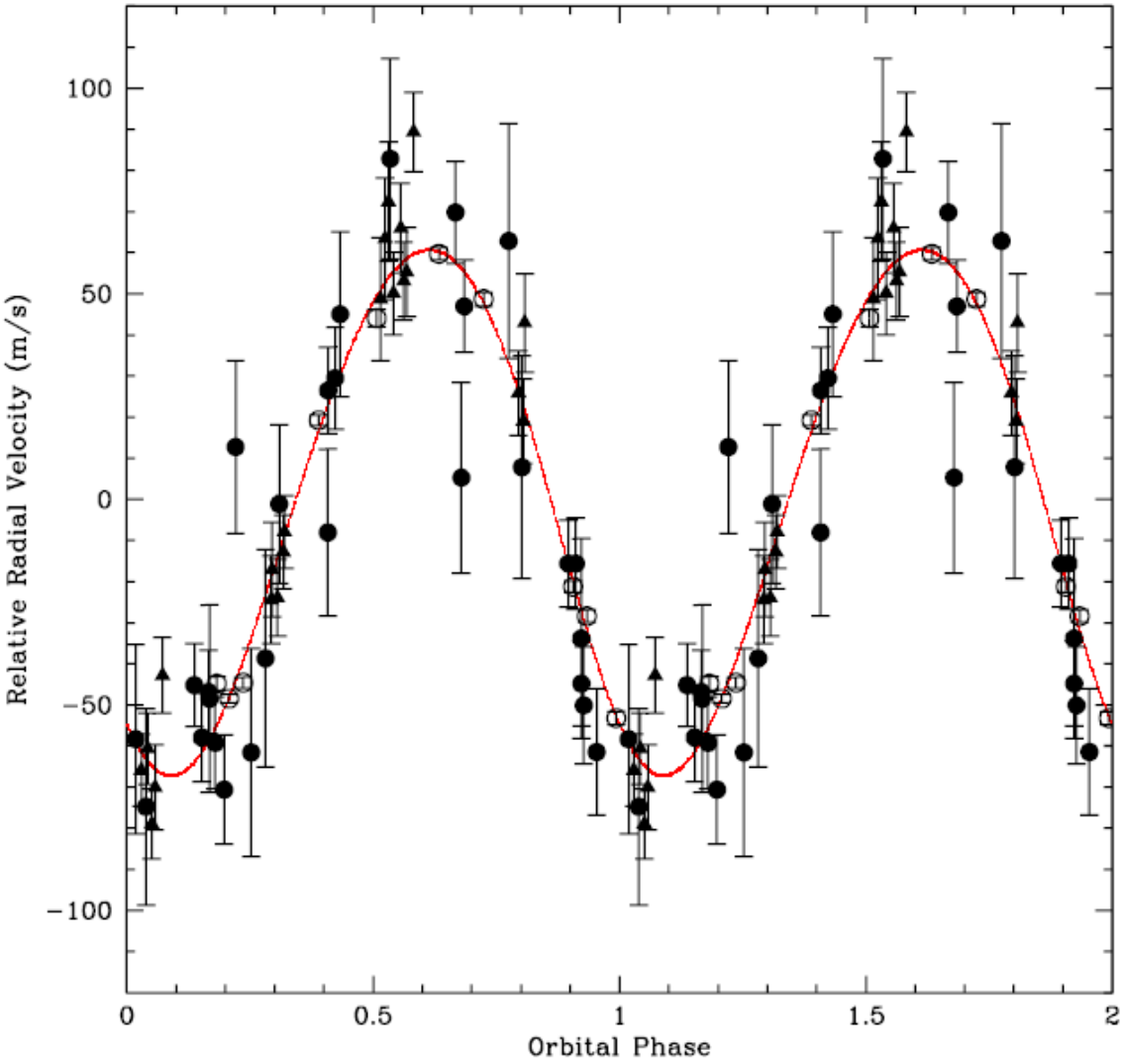
Dispersed fixed-delay Interferometer (DFDI)



Commissioning of the W.M. Keck Exoplanet Tracker with 60 object capability at APO by Dr. Jian Ge's team in March 2006



Radial velocity curve of an extrasolar planet



MARVELS Science

- Planet formation, migration, and dynamical evolution
- Eccentricity distribution of giant planets
- Detecting multiple planet systems
- Correlation of planetary systems with stellar properties.
- Better statistics of transiting planets
- Exploring the brown dwarf desert

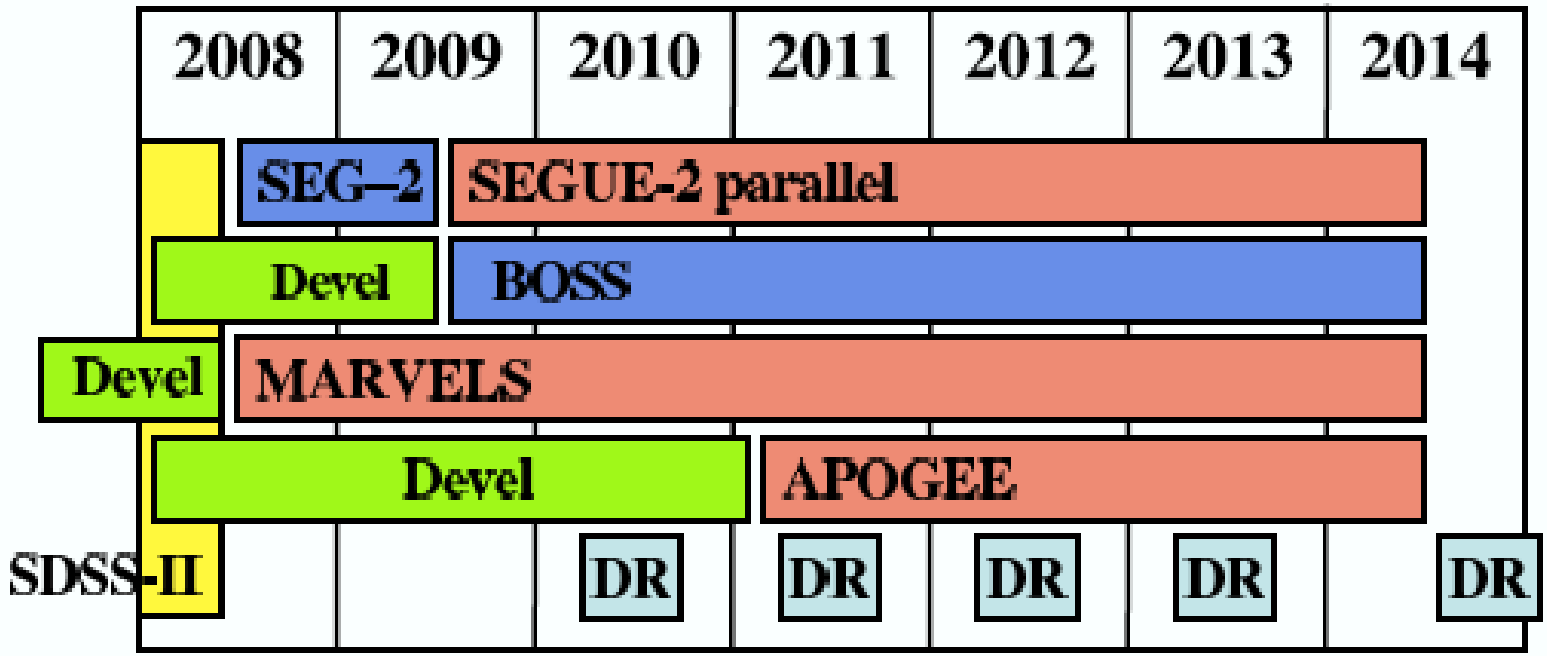
MARVELS at a glance

- Bright time observations
- Fall 2008 – Spring 2014
- Two 60-fiber interferometric spectrographs (one initially)
- 10,000 main sequence targets, 1,000 giant targets, V=8-12
- 25-35 observations per star over 18 months
- Velocity error 12 m/s at V=10
- Mass sensitivity at P=100 days: 0.35 MJup (V=9.5), 0.7 MJup (V=11.5)

Policy & Schedule

- SDSS-III will continue the SDSS tradition of public data releases, with the first release scheduled for 2010. The survey will also continue its commitment to making its data available and useful to students, amateur astronomers, and the public.

High-level SDSS-III schedule



Auxiillary project

Disk Galaxy Rotation and Satellite Kinematics

C. Park, H. B. Ann, Y.-Y. Choi, & G. Rossi

Thank you