

SEGUE:

**JINA's Survey of Discovery
for Neutron-Capture
Enhanced Stars in the Milky
Way**

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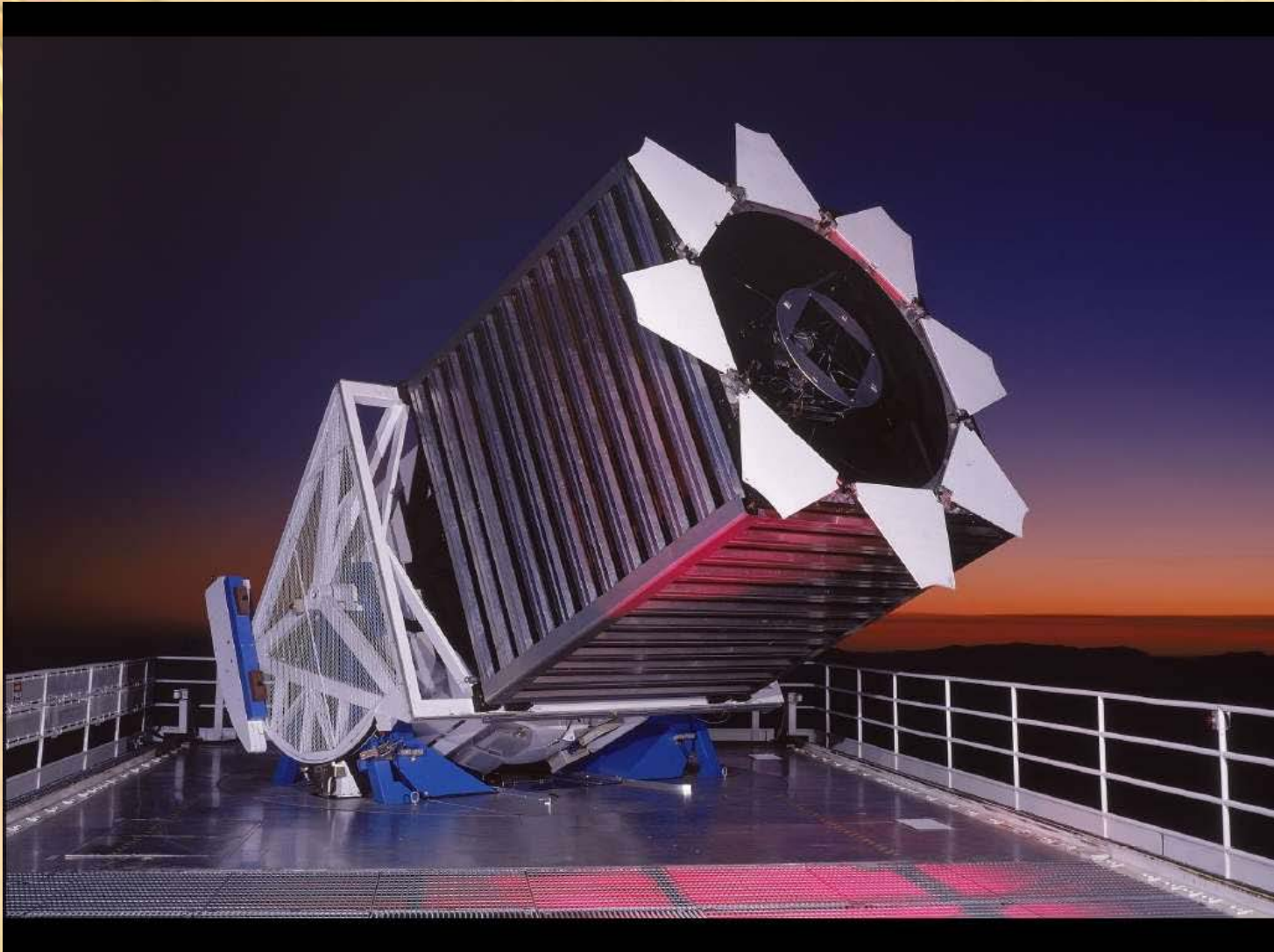
The Importance of Neutron-Capture Enhanced Stars to JINA

- Early generation (low metallicity) stars have recorded the direct astrophysical elemental patterns of, e.g., the **s-process** and the **r-process**
- Predictions and tests of nuclear physics (mass models, measurements of fundamental properties of nuclei, operation of n-capture processes) can be compared with observations of these **rare** stars that exhibit the variety of neutron-capture patterns produced in nature
- Determination of **absolute frequency** of various abundance patterns is required to construct astrophysically consistent models for formation of the elements

The Sloan Digital Sky Survey

- The most ambitious astronomy project ever undertaken
 - Obtain accurately calibrated imaging of **10,000** square degrees of (northern) sky, in five filters (*ugriz*)
 - Obtain medium-resolution spectroscopy for
 - **1,000,000 galaxies**
 - **100,000 quasars**
- Has been fully operational since ~ Jan 1999
- Completed its primary imaging mission in July 2005

SDSS -- The Telescope and Data

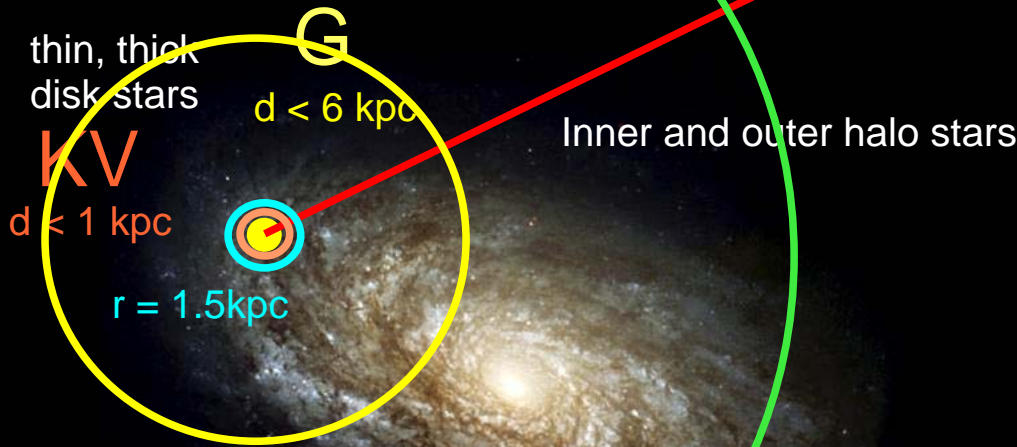


ARC 2.5m SDSS Telescope (3 deg FOV)

SEGUE: The Sloan Extension for Galactic Understanding and Exploration

- Fully funded (\$15 Million: Sloan Foundation / NSF / Partners (JINA) for operation through July 2008
- Use existing SDSS hardware and software to obtain:
 - 3500 square degrees of additional *ugriz* imaging at lower latitudes
 - Medium-resolution spectroscopy of 250,000 “optimally selected” stars in the thick disk and halo of the Galaxy
 - 200 “spectroscopic plate” pairs of 45 / 135 min exposures
 - Objects selected to populate distances from 1 to 100 kpc

SEGUE uses stellar probes of increasing absolute brightness to probe increasing distances in the disk, thick disk and Milky Way halo.

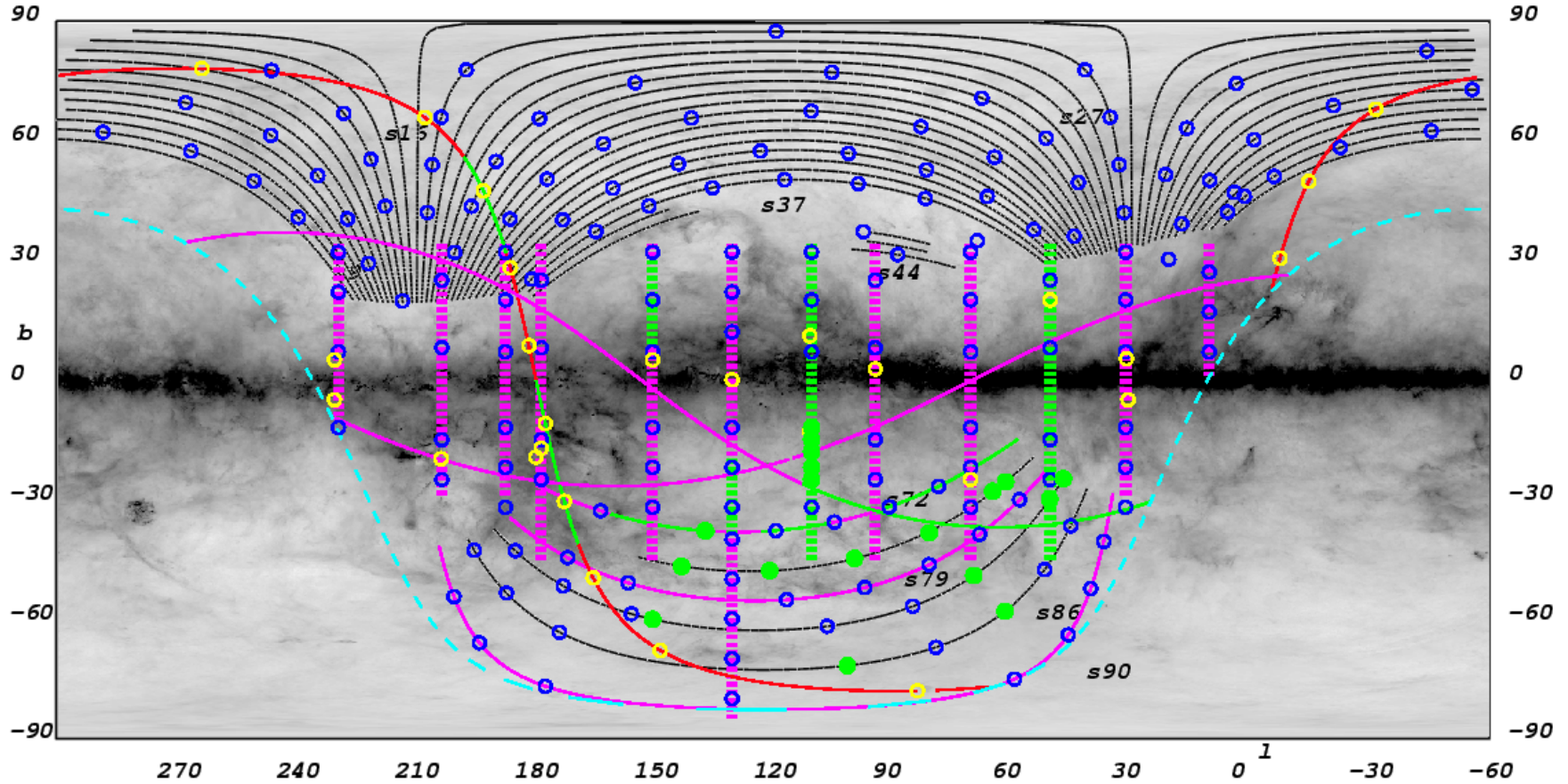


K III
 $d < 100 \text{ kpc}$

Streams and outer halo stars

Other spectroscopic surveys will not probe as deep, for instance, Blue Horizontal Branch Stars (BHBs) from a survey with $V < 12$ are from a volume within 1.5 kpc of the sun.

SEGUE observing plan and status as of July 2005



☪ SDSS Imaging scan

☪ Planned SEGUE scan (3500 sq deg)

☪ Sgr stream planned scan

☪ Completed SEGUE imaging

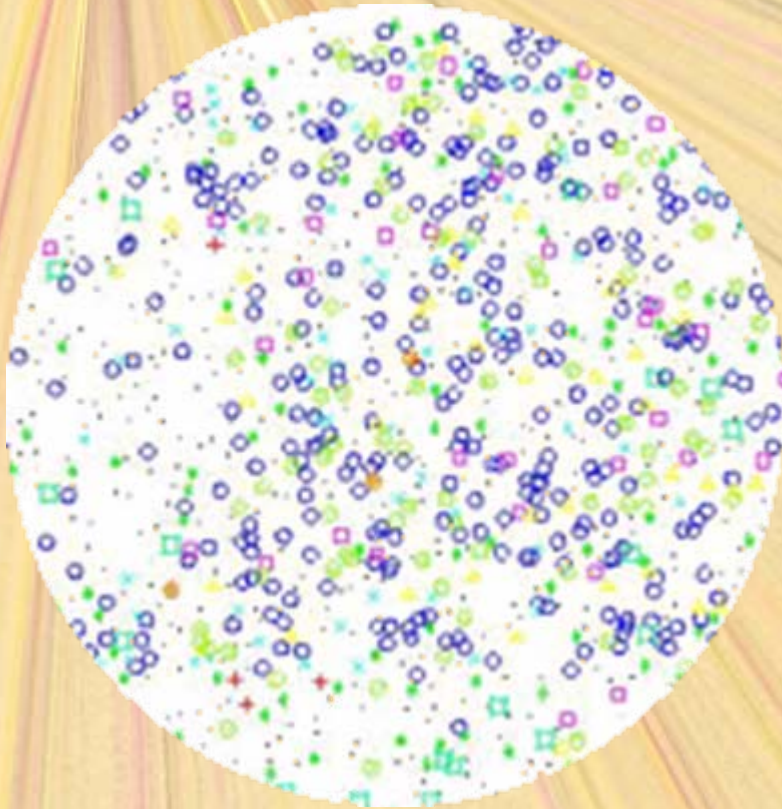
☪ Declination = -20 degrees

● Planned SEGUE grid pointings (200)

● Planned targeted SEGUE pointings (60)

● Completed SEGUE plate pointing

The SDSS Spectrograph Plug Plate

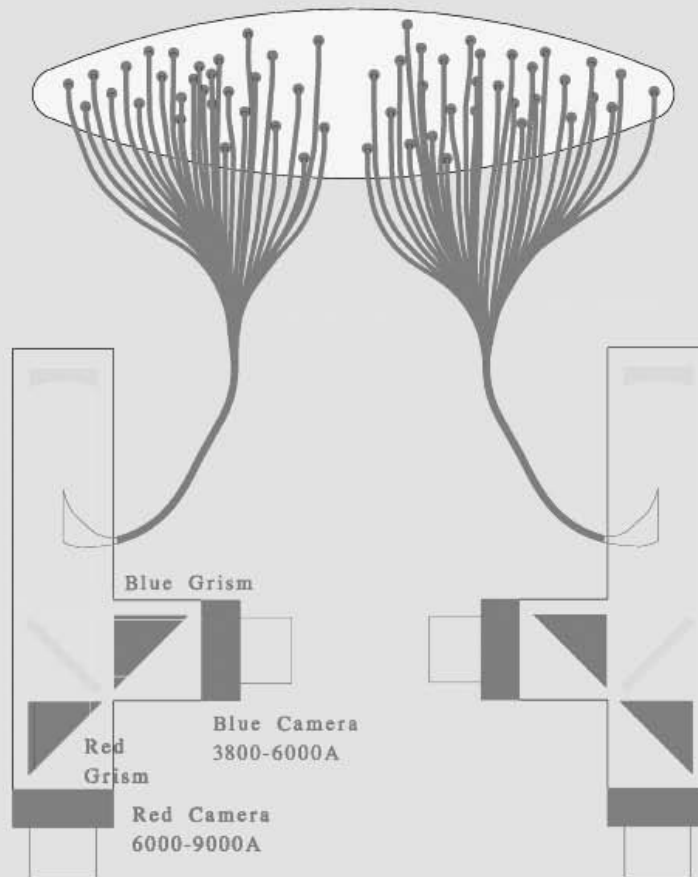


Identification of targets on the sky

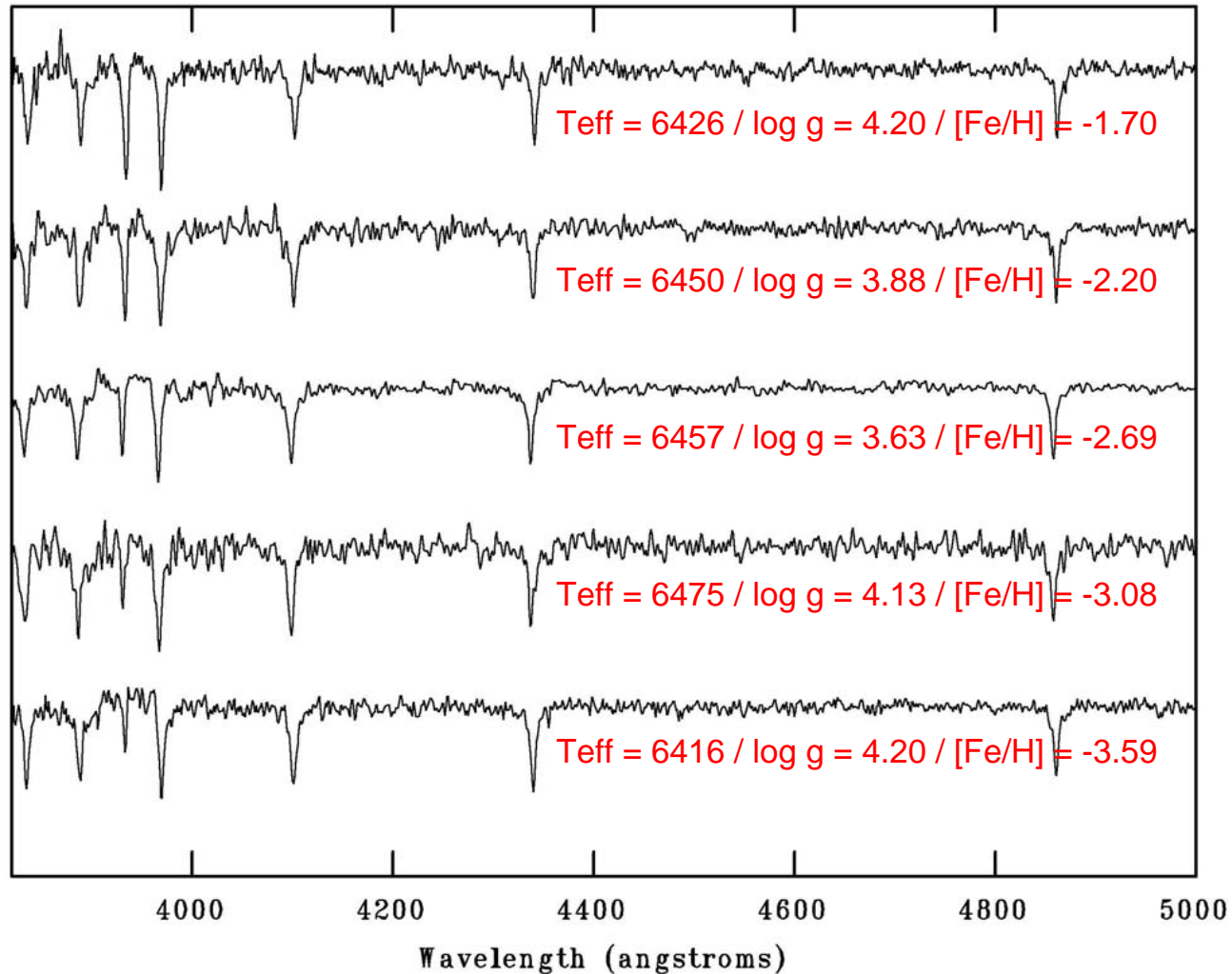
A prepped and drilled plate⁸

A Cartoon Version

SDSS Spectra



Example Main-Sequence Turnoff Stars of Low Metallicity

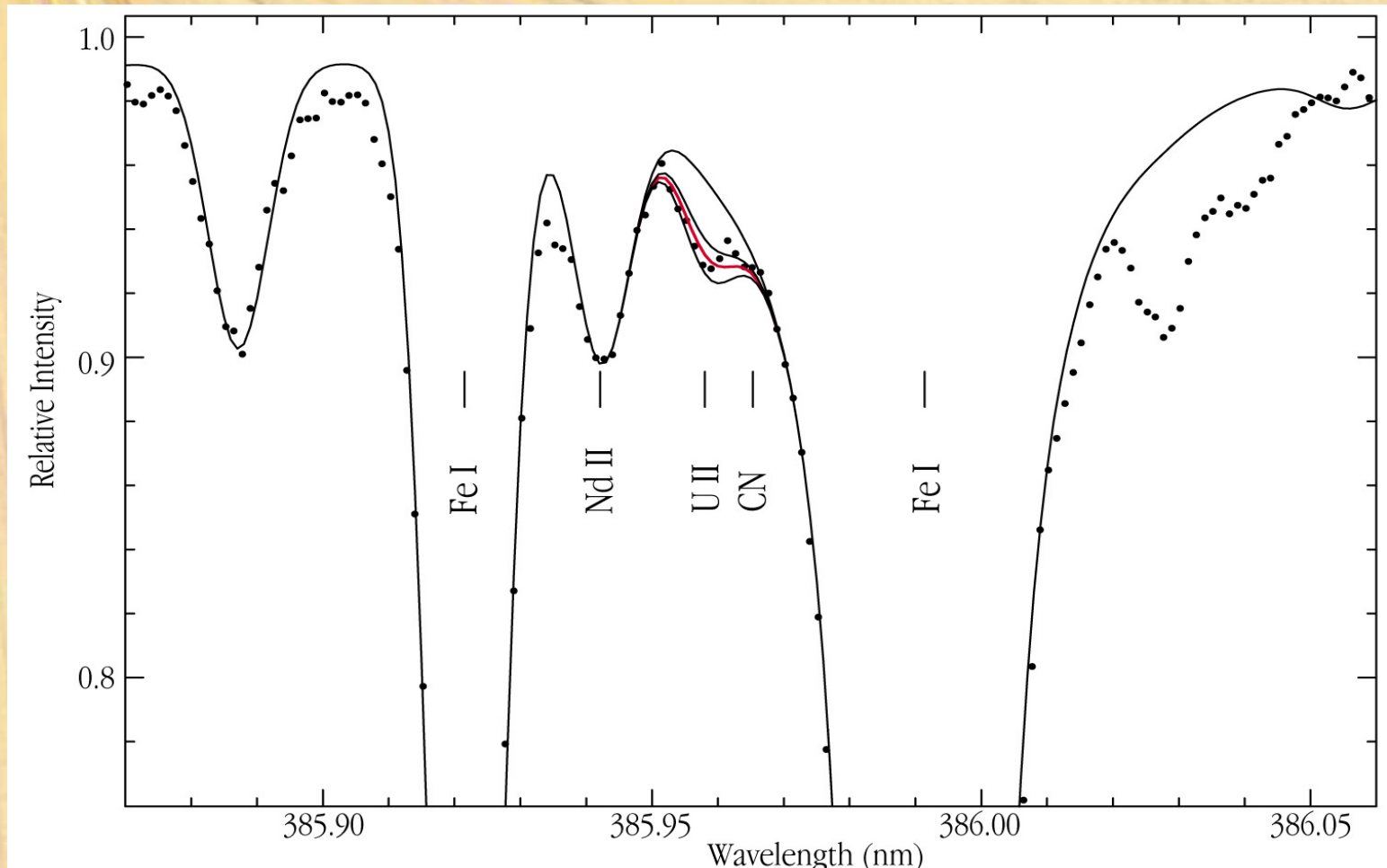


Likely Numbers of Detected MP Stars from **SEGUE**

- Actual numbers will depend on the shape of the halo Metallicity Distribution Function
 - $[\text{Fe}/\text{H}] < -2.0$ ~ 20,000 (VMP)
 - $[\text{Fe}/\text{H}] < -3.0$ ~ 2,000 (EMP)
 - $[\text{Fe}/\text{H}] < -4.0$ ~ 200 ? (UMP)
 - $[\text{Fe}/\text{H}] < -5.0$ ~ 20 ? (HMP)
 - $[\text{Fe}/\text{H}] < -6.0$ ~ 2 ? (MMP)

A Star with Measurable Uranium

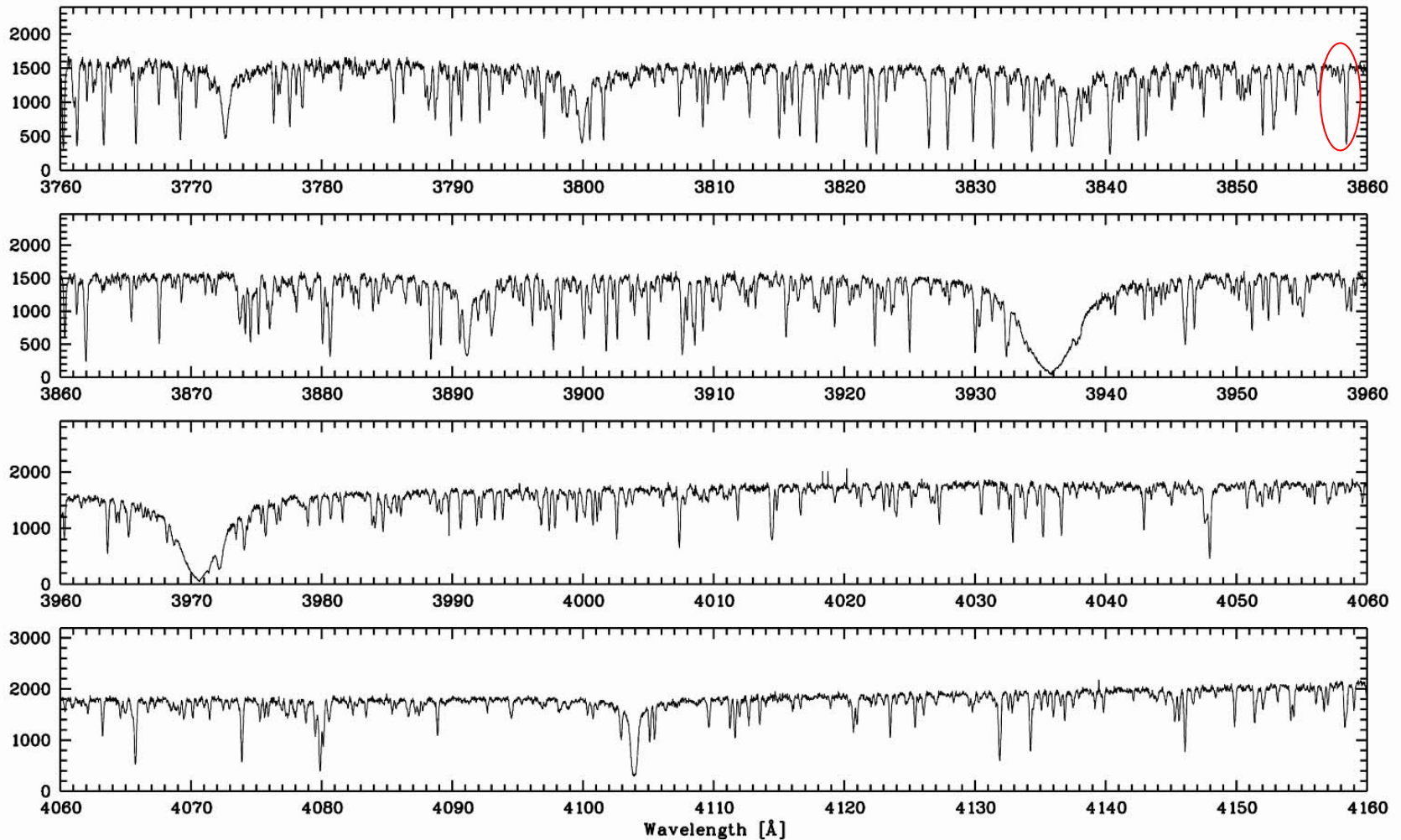
CS 31082-001 ($[Fe/H] = -2.9$); The First Meaningful Measurement of Uranium Outside the Solar System (Cayrel et al. Nature 2001)



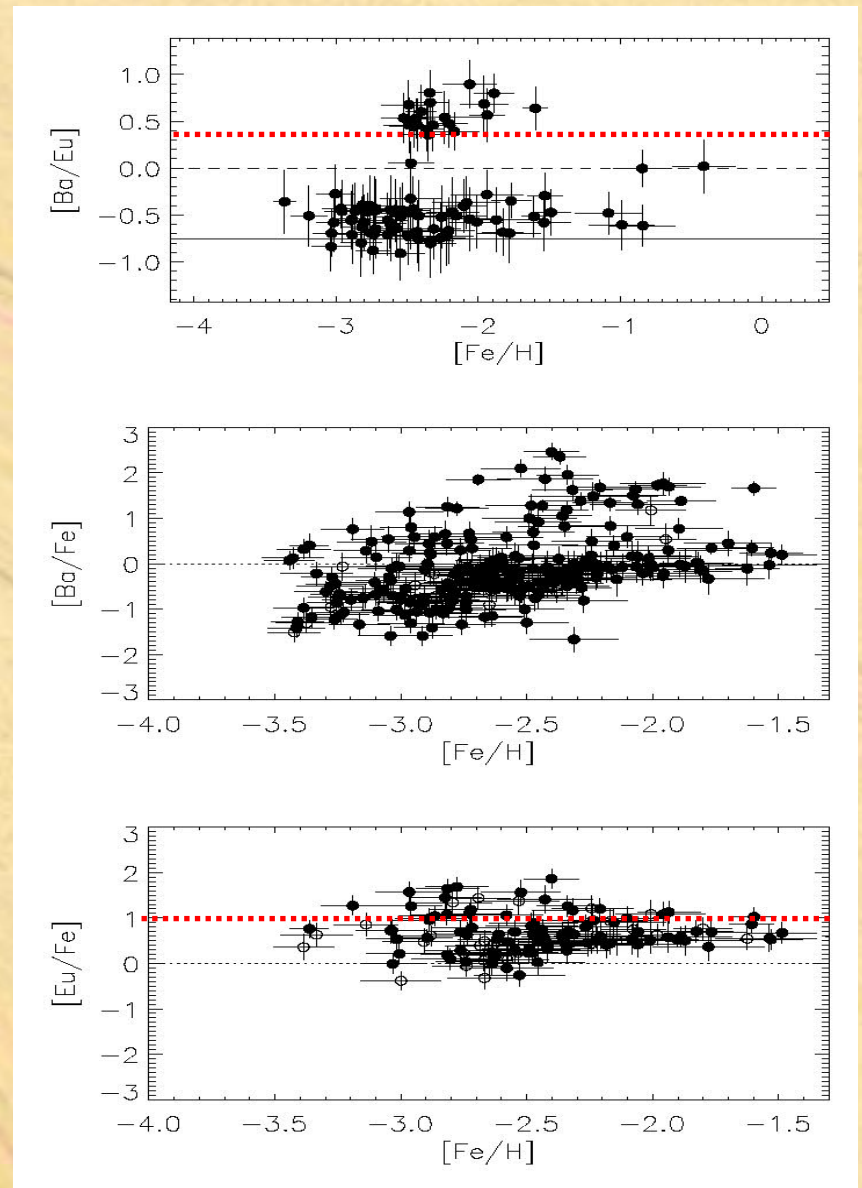
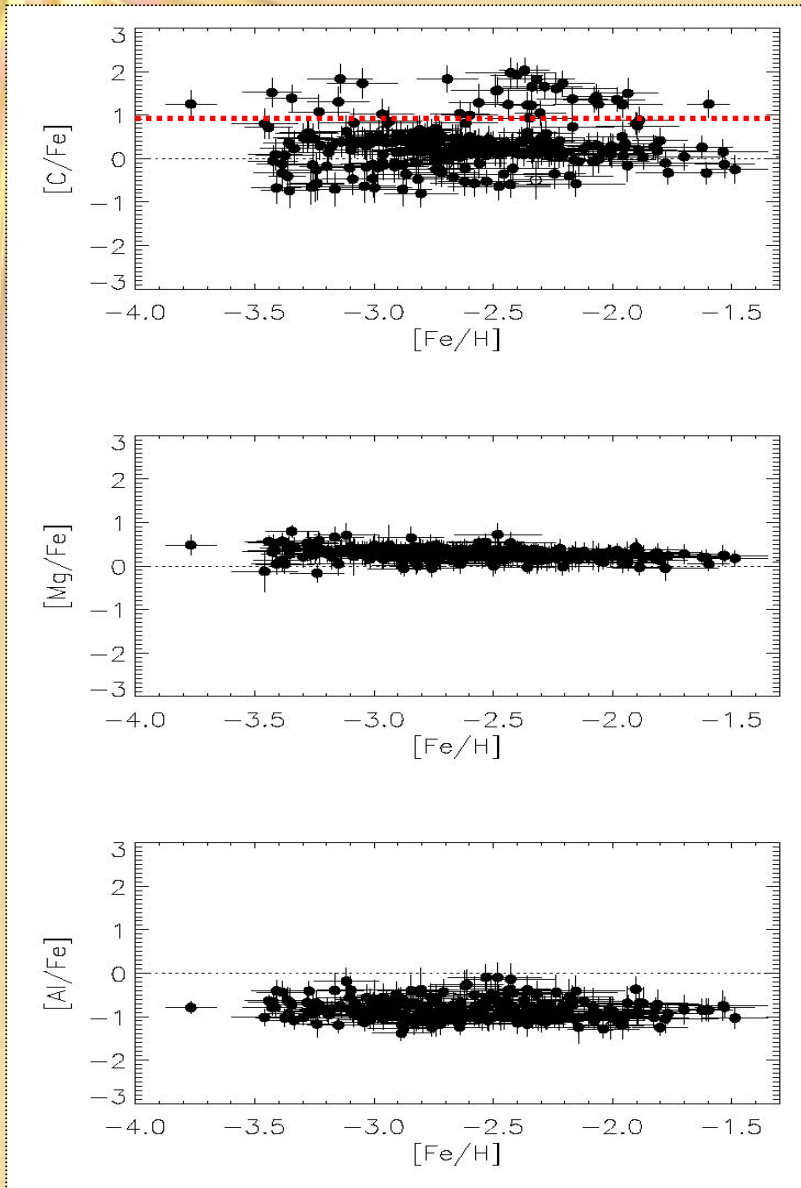
HERES Survey: Other Elements !

CS 31082-001: [Fe/H] = -2.9

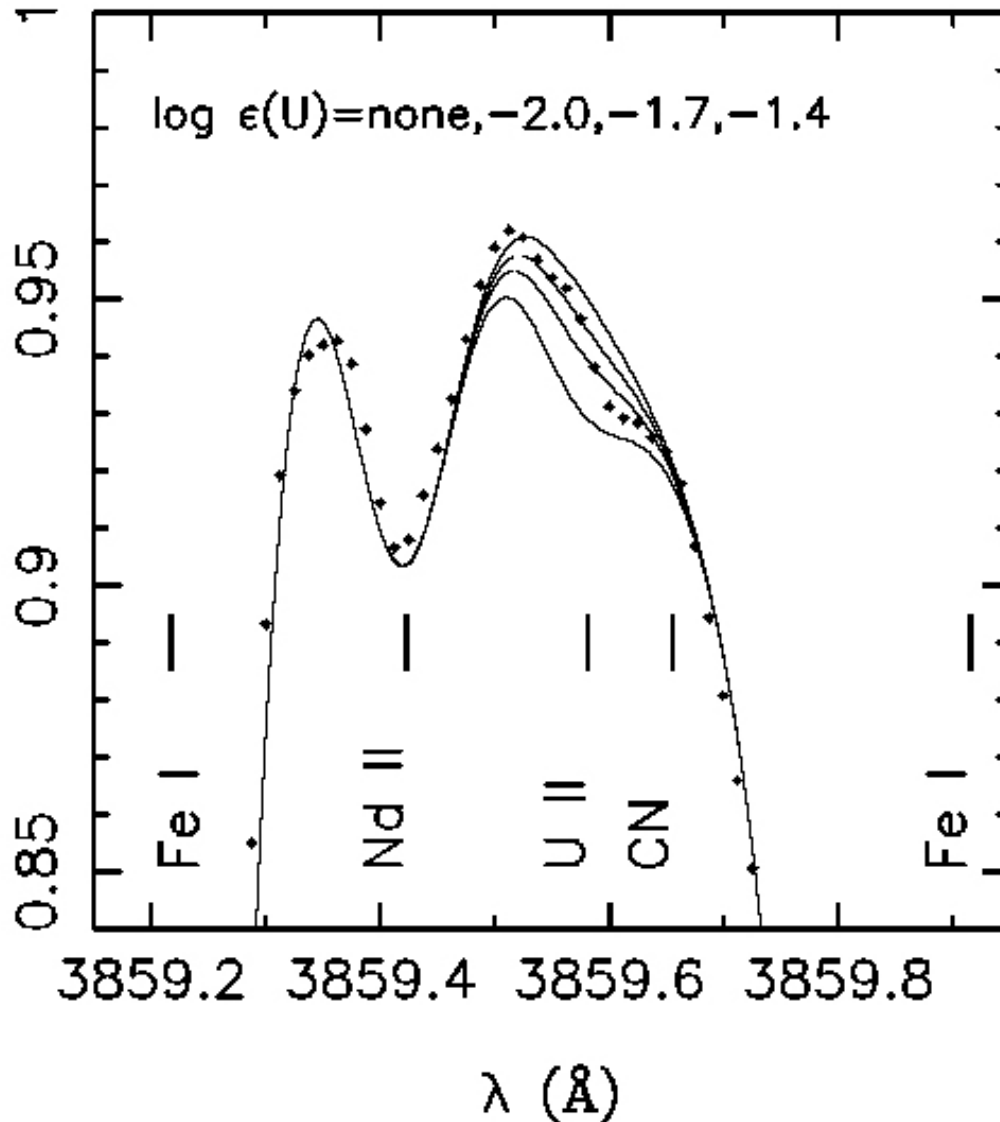
HERES Blue Spectrum



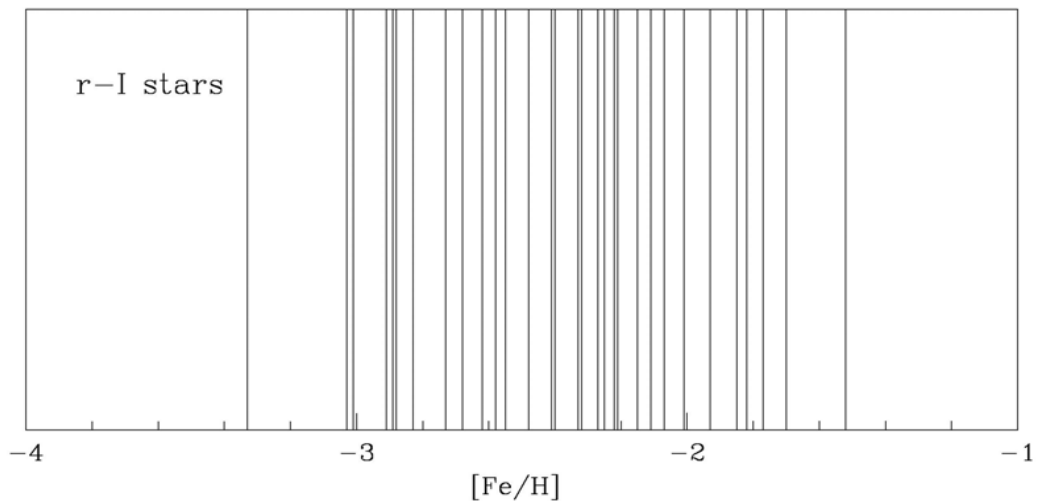
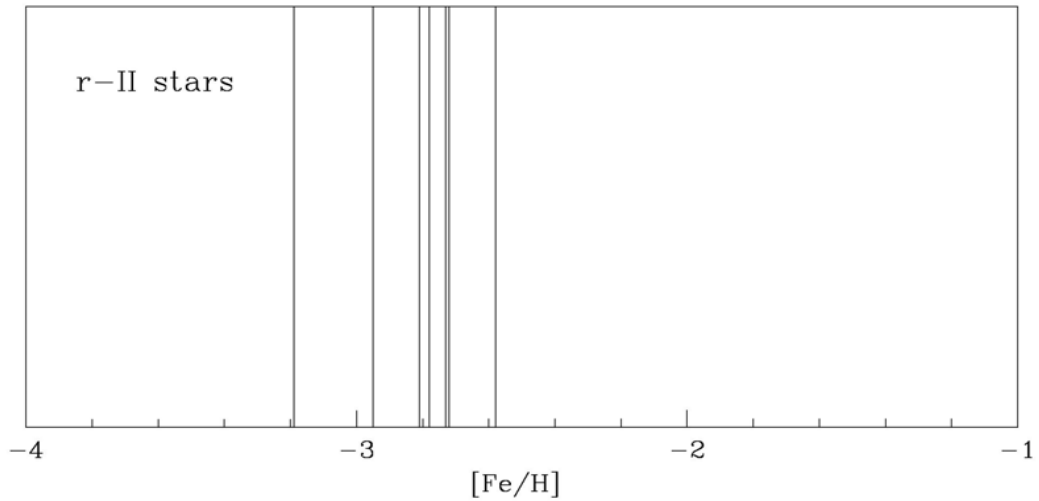
The Power Of Large N: 274 Stars from HERES



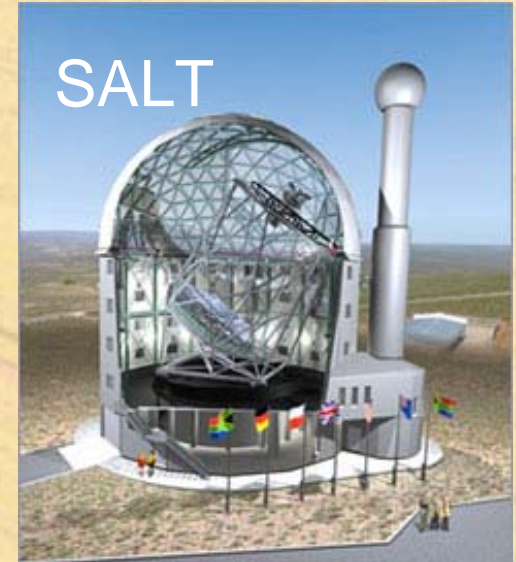
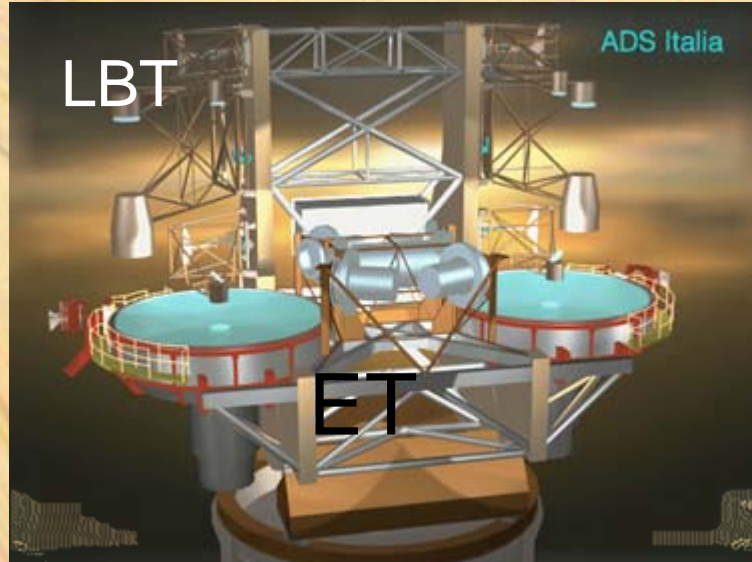
A New R-Process Enhanced Star with Uranium Detected: CS 29497-004 !



Hints About the Nature of the r-Process from HERES



HERES-Like Follow-Up of VMP Giants with $B < 17$



The Plan of Attack

- **SEGUE** identification of bright MP giants with $[\text{Fe}/\text{H}] < -2.0$
- Brightest **2000-3000** taken to HET, etc., for “snapshot” high-resolution spectroscopy
- Most interesting (e.g., r-process / s-process-enhanced) stars thus identified taken to, e.g., Subaru/Keck/LBT, etc. for **higher S/N** determinations of elemental abundance patterns
- Construction of **astrophysically-consistent** scenarios to account for patterns and frequency of n-capture (and other) abundance patterns
- Note: **Within 5-7 years**, expect to be able to accomplish high-resolution surveys directly, targeting **millions** of individual stars

Suggested Questions...

- “I hear you have some cool SDSS imaging you would like to share – can I see some of that ?”
- “Tell me more about the million-star samples, in particular:
 - LAMOST (China)
 - Keck-ET (SDSS)
 - WFMOS (Gemini/Subaru)”

The SDSS Scrolling Sky

<http://skyserver.sdss.org/dr1/en/tools/scroll/>

