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SkyMapper's Role for FunnelWeb in the Pre and Post-GAIA ERA

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(plus Chris Tinney, Luca Casagrande, Mike Bessel, Sarah Martell, David Latham, Andrew Hopkins… etc)

Outline

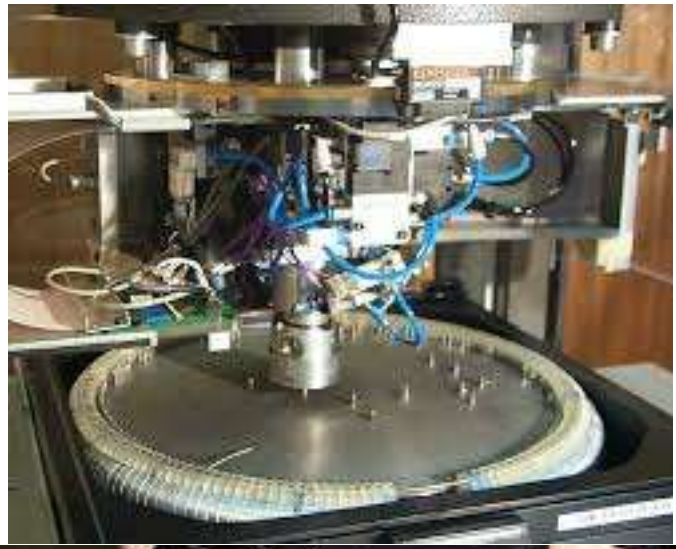
- Instrumentation background for TAIPAN and the FunnelWeb survey.
- The need for FunnelWeb.
- SkyMapper + FunnelWeb = photometrically calibrated spectra.
- A 5 arcsec seeing program for SkyMapper.

The UK Schmidt Telescope

- “Modern” wide-field telescopes began with the 48” Samuel Oschin Schmidt on Mt Palomar (1949)
- Still used for *very* competitive science (PTF: 2016 supernovae, M. Brown: Sedna, Haumea, Makemake).
- The UKST is based on this telescope, which has done some great science but could do

The UK Schmidt Telescope and 6dF

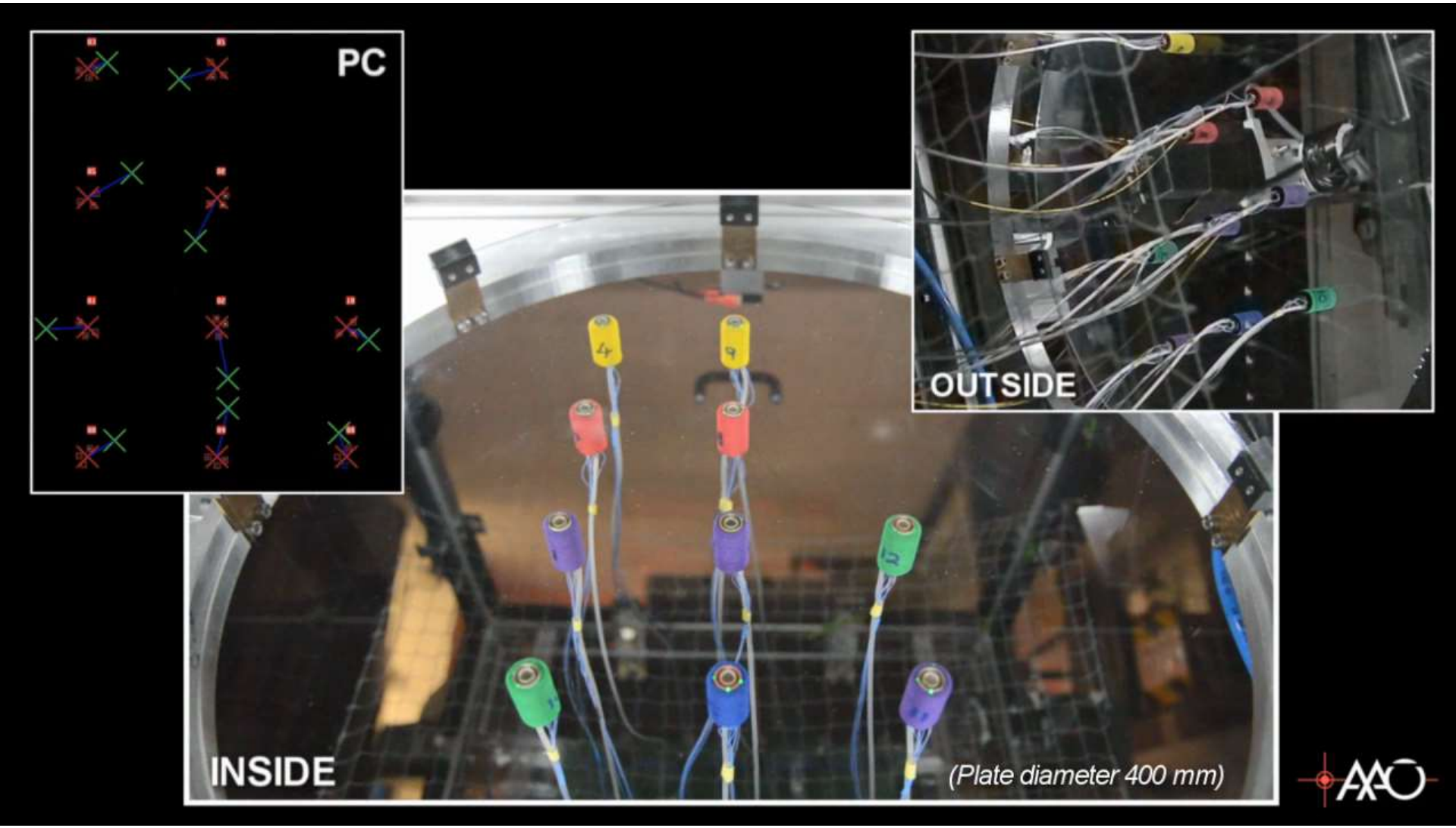
- An R-theta robot, positioning 150 fibers.



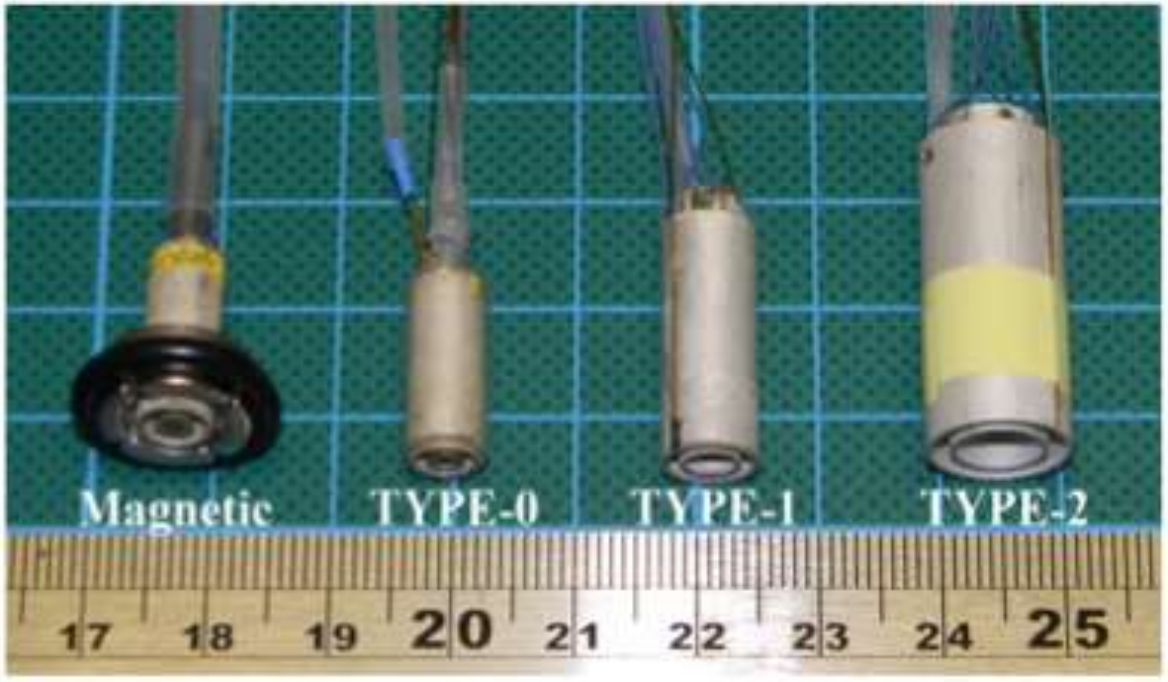
The UK Schmidt Telescope and 6dF

- 6dF was created as a prototype for OzPoz, which is part of GIRAFFE/FLAMES at the VLT.
- Most cited FLAMES paper is probably Giampaolo et al (2005, on Omega Cen, 287 cites).
- The most cited 6dF paper is the first data release (191 cites – 6dFGS total 26 papers, 749 cites).
- Once the galaxy people got bored, along came RAVE : DR1=190 cites since 2006, and many other high-impact papers (total 35 papers, 1326 cites).
- RAVE > 6dFGS and possibly RAVE >> FLAMES with telescope area taken into account. What could we do if stellar astrophysics *wasn't* and afterthought?

Starbugs – A (funded) Prototype for the GMT



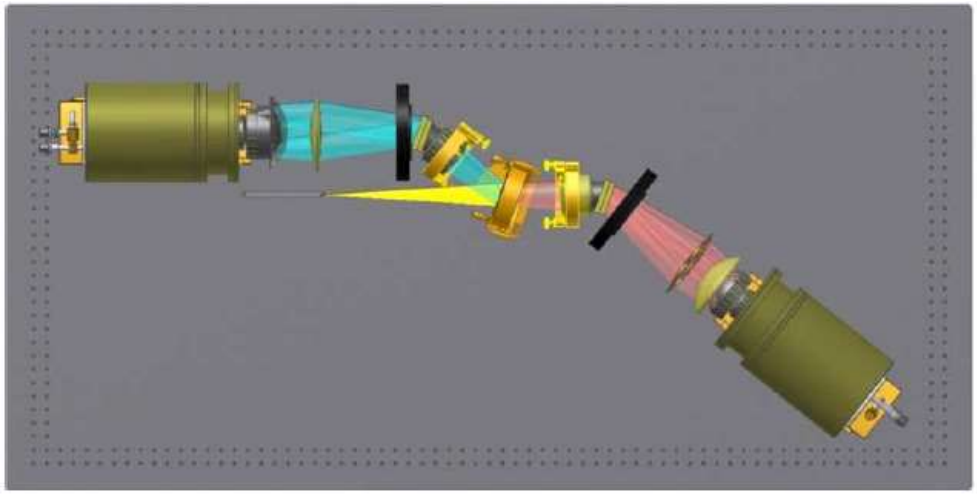
Performance



Starbug patrol radius	Duration of coarse positioning (to ±250 μm)	Duration of fine positioning (to ±10 μm)	Reconfiguration Time (type-1 Starbug)
Measured values (100 Hz coarse and fine positioning)			
25 mm	22 s	20 s	42 s
Estimated values (200 Hz coarse positioning; 100 Hz fine positioning)			
50 mm	22 s	20 s	42 s
100 mm	44 s	20 s	64 s (1.1 mins)
200 mm	88 s	20 s	108 s (1.8 mins)
400 mm	176 s	20 s	196 s (3.3 mins)

TAIPAN Spectrograph

- Key parameters are 370-870nm, red and blue channel, 4096 pixels total with some overlap -> ~4050 useable pixels.
- R~2100 is the current requirement for the TAIPAN spectrograph.



Sampling (Pix per res elt)	Resolution (mean in each arm)
2.0	2370
2.4	1970
2.8	1690

Funnel-Web…

1. Uses the UKST, one of the widest-field >1m telescopes in the world.
2. Uses the Starbugs fiber positioners, reposition multiple objects faster than other technologies.
3. Uses the TAIPAN spectrograph, funded through LIEF.
4. Is a Stellar Survey that shares these resources with the TAIPAN galaxy survey

Why? What Science?

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The Henry Draper Catalog

- The HD catalog was completed in 1924, with spectral types of 225,300 stars, to V~9.
- It does *not* include luminosity class, but the Michigan Spectral Survey (Houk) includes the Southern hemisphere 2D spectral types (Northern hemisphere still incomplete).
- Of course, with good photometry, spectral types (at least for FGK stars) *should* be 3D (plus RVs), with the addition of metalicity.
- *But*, this is old science, and it takes way too many resources to extend this, right?

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The Harvard Computers

Stellar Astrophysics History

- Stellar spectroscopic surveys ceased to be sexy in 1930 (pre-computer era…).
- 1950 to 1980 resulted in a good understanding of stellar evolution from a HR diagram and nuclear physics perspective (e.g. B^2FH… but where do r-process elements come from?)
- Given that remaining problems were too hard ("Galactic archaeology", "asteroseismology"…) many stellar astrophysicists respectfully moved on to new fields.

(past success does not predict future success of a field)

Currently massive changes, with:

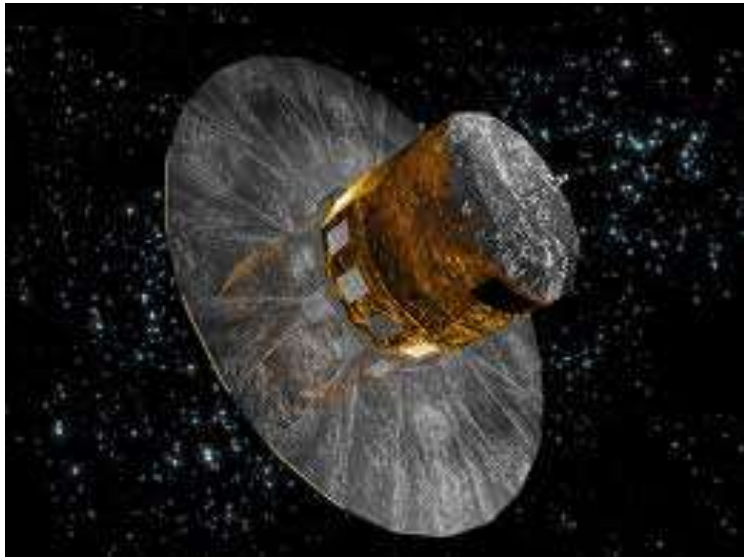
- Exoplanet research needing accurate stellar parameters.
- Asteroseismology resolving degeneracies (Bedding > 1200 cites/yr)
- High-dimensional spectral spaces makes Galactic archaeology possible.
- Space-based parallaxes, IR missions etc…

Upcoming Survey Data

- V=5.7 represents the GAIA bright limit. V=5.7 also represents the limit for solar-type stars with good 2MASS photometry (K~4.5).
- At V=12, APASS photometric errors are ~>3%.
- V=11 is the bright HERMES limit.
- I=12 is the faint TESS limit.

With the modern explosion in stellar astrophysics, it is *embarrassing* that there is no modern spectroscopic survey of V<12 stars.

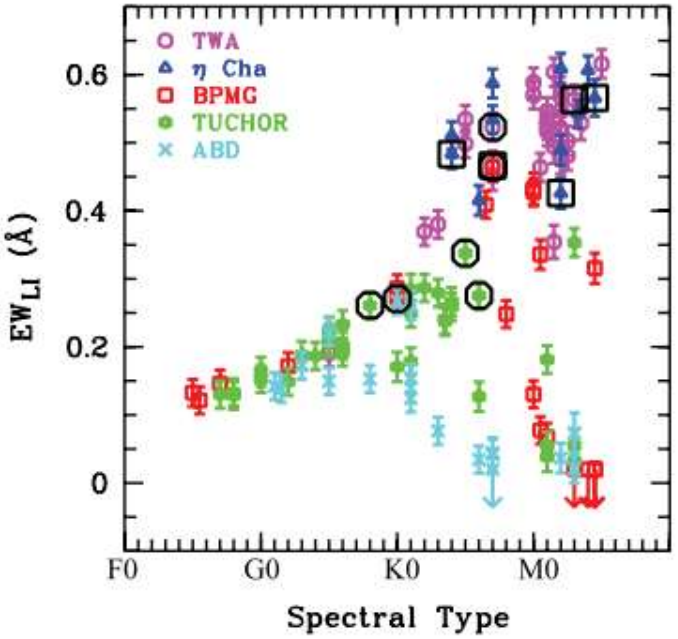
Surveying the *whole* sky at dec<+30 to I=12 is the FunnelWeb goal (I=10 within 10 degs of the plane, subsamples as faint as I=14)



GAIA

Calling all Young Stars

- Nearby young star lists are needed for planet searches e.g. GPI.
- The lists are incomplete, e.g. any object with low-ish proper motion is not studied (kinematic analysis hard).
- E.g. 50-100 < 50 Myr K0-K3V stars expected within 100pc… but only about 20 known (and many of these have unknown ages until Mike Bessel gets spectra one at a time with the 2.3m).
- What everyone really wants is good spectra including 0.05 Angstroms EW and good RVs for *every* star brighter than I=12…



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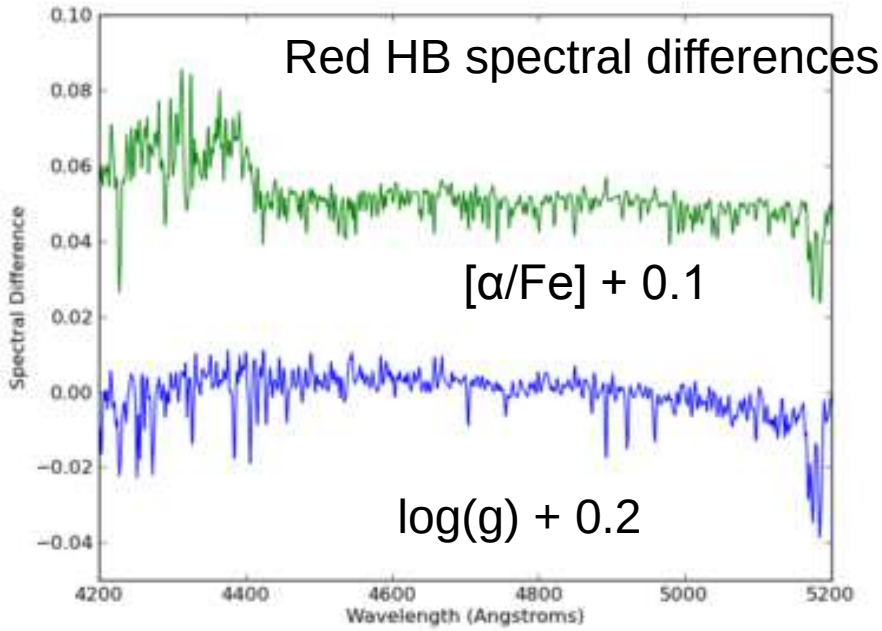
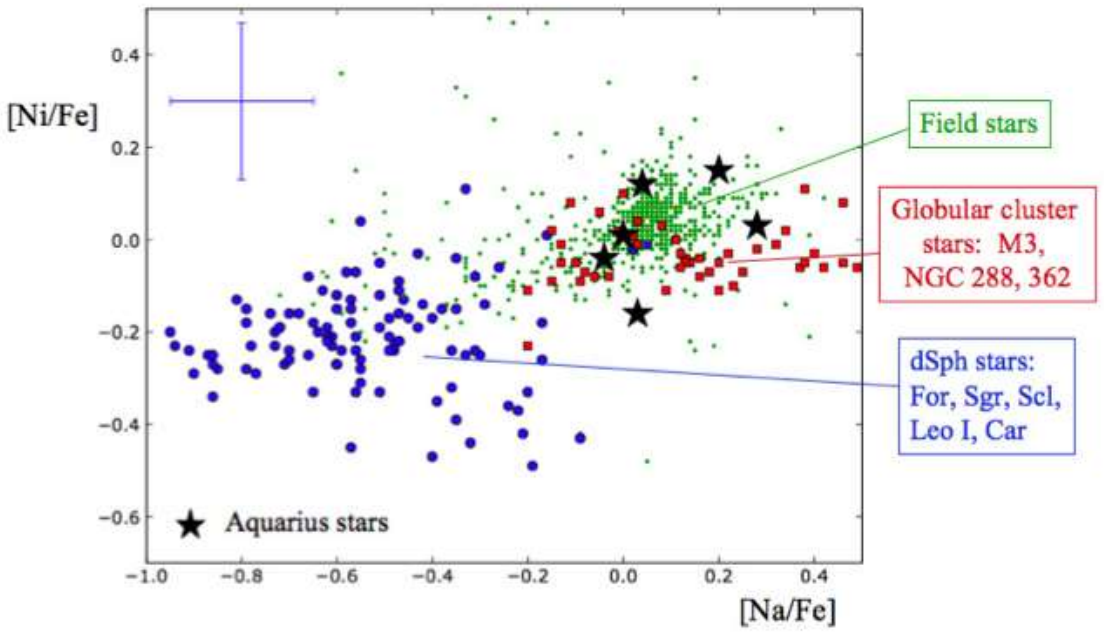
Galactic Archaeology

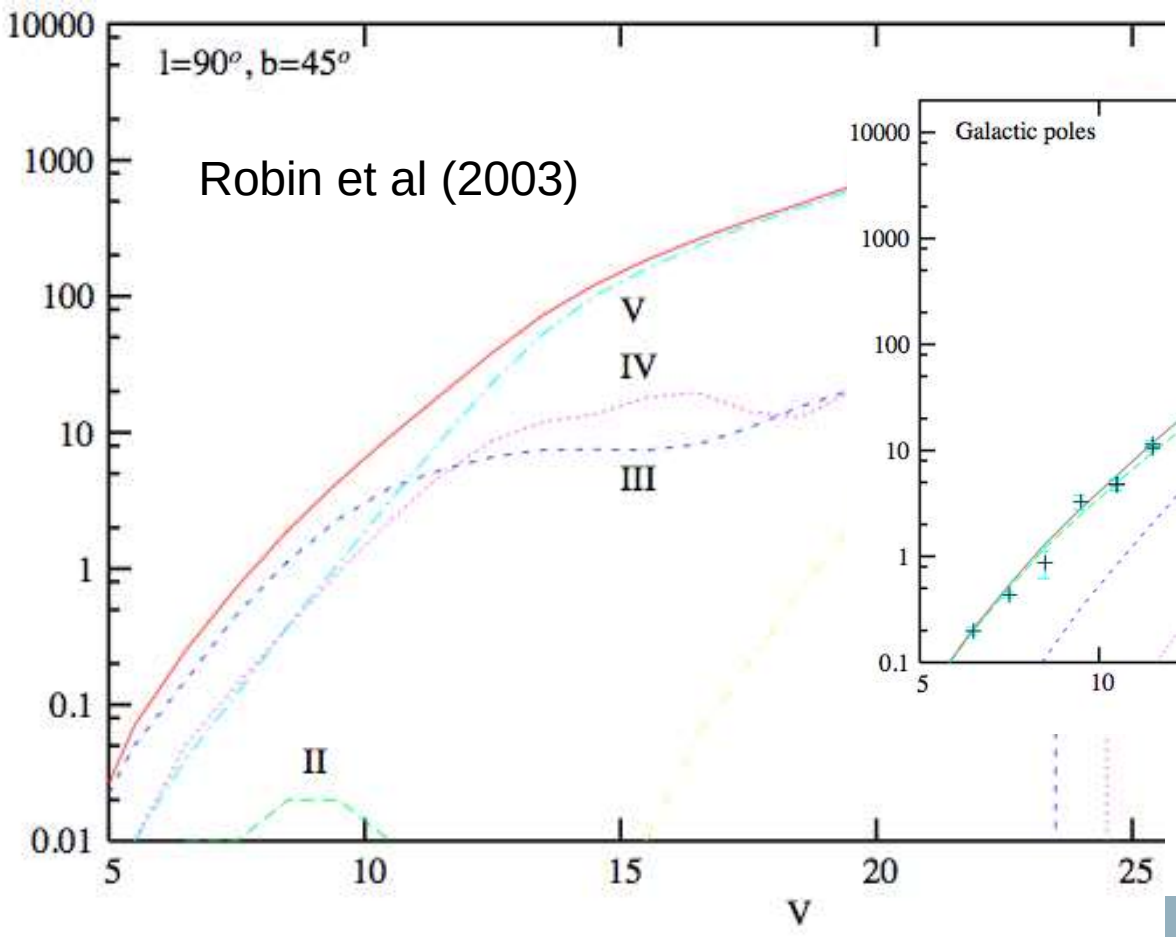


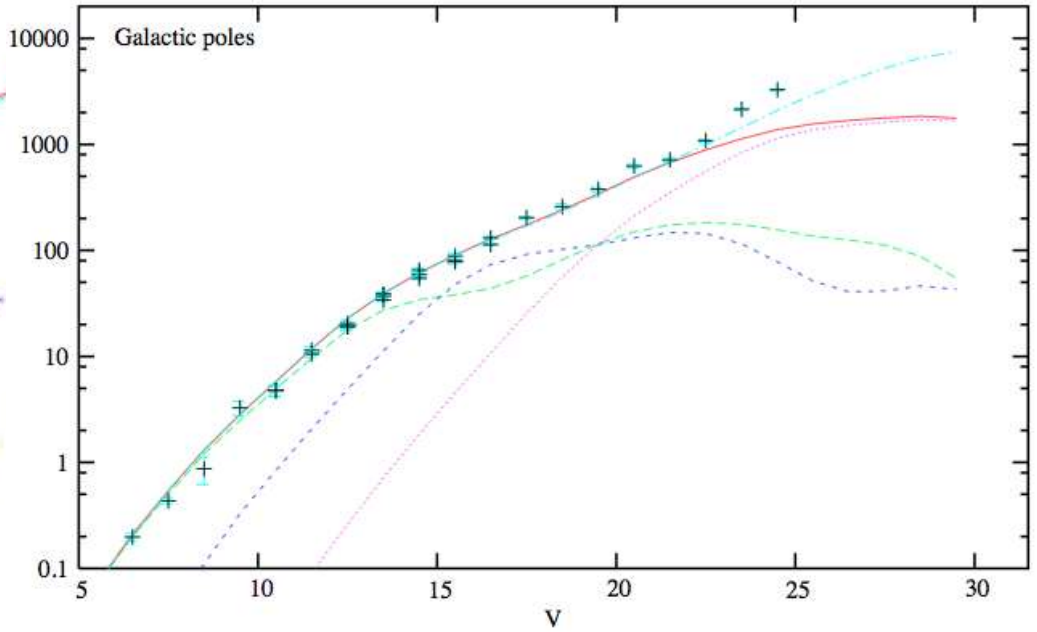
- High-res spectra are needed for detailed chemical abundances, e.g. HERMES.
- R~2000 spectra are enough for distinguishing [Fe/H], [alpha/Fe], Teff, log(g)



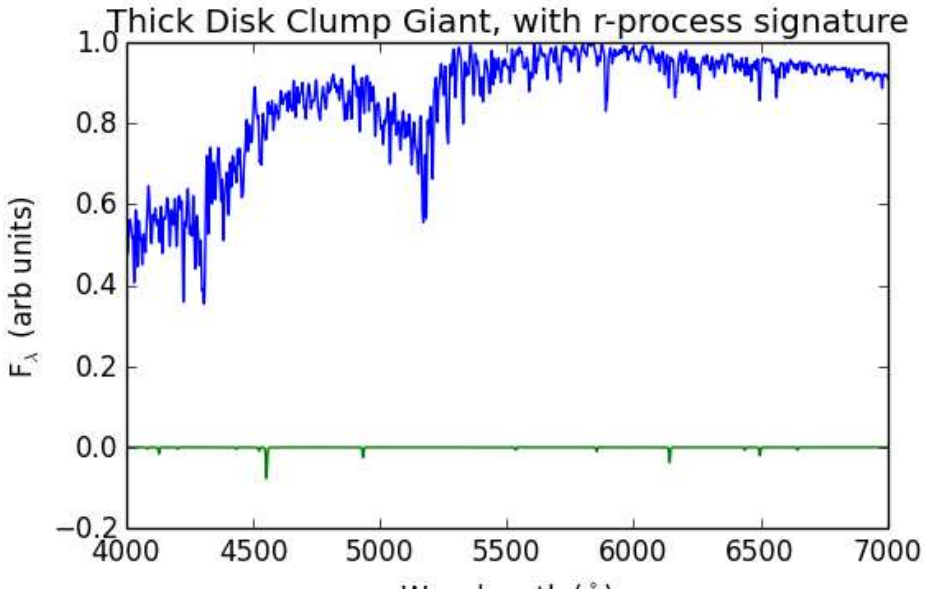
Galactic Archaeology

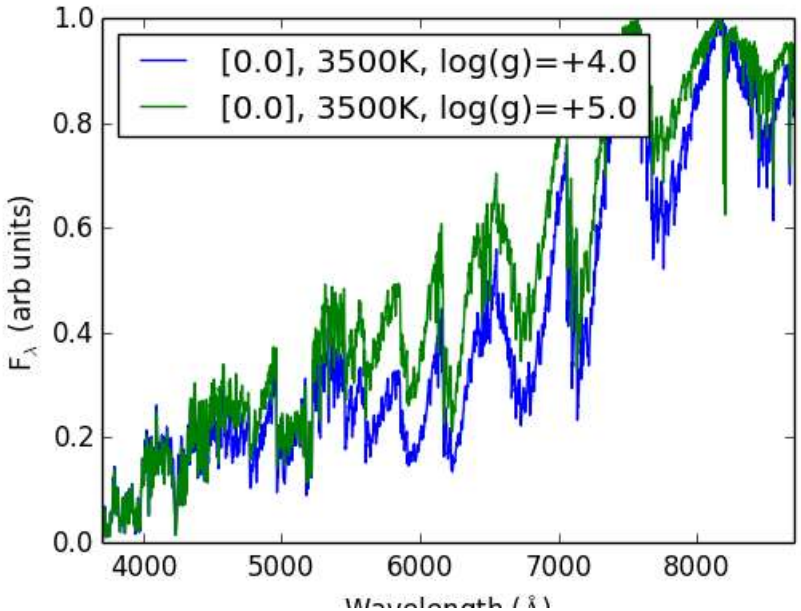
At I<12, FunnelWeb finds the thick disk giants that HERMES misses.





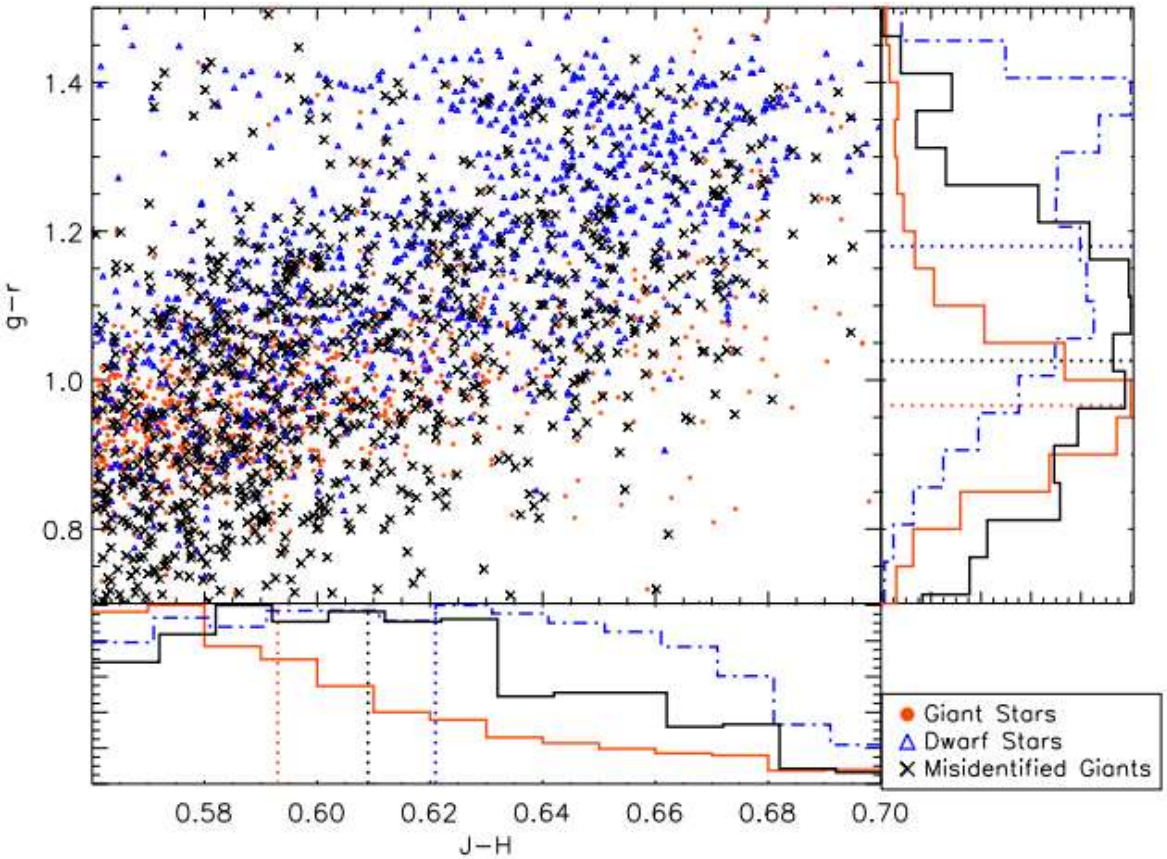
Stellar Parameters: Spectra always give higher dimensionality than photometry.

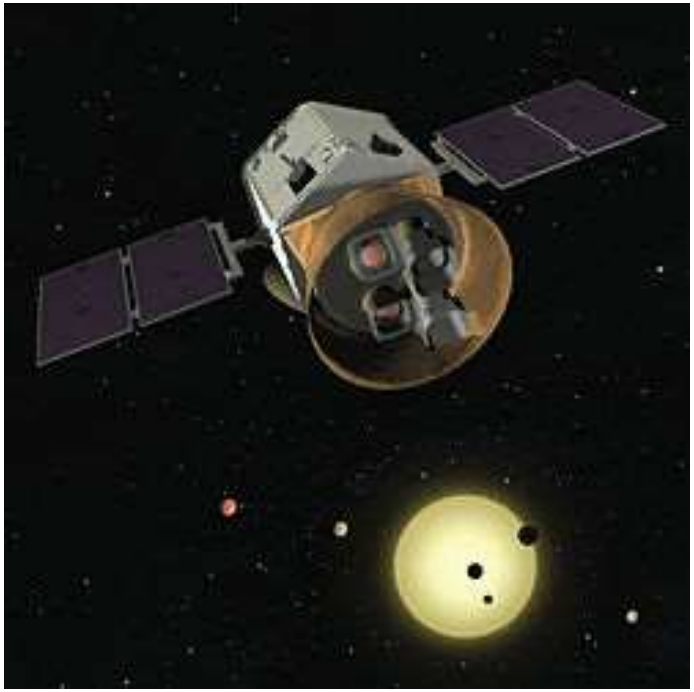




TESS Pre-Survey Spectra

- Transiting Exopanet Survey Satellite (TESS: launch 2017) will survey all stars brighter than I~12 for exoplanets.
- Like Kepler, it is essential to *at least* know which stars are dwarfs and which are giants. Photometry is inadequate (esp for K stars).
- Dependence of exoplanetary systems on stellar params e.g. [Fe/H] key research.





Mann (2012). ~10s of thousands of misidentified giants in KIC.

Calibration…

- Fundamental parameters from FunnelWeb assumes calibrated spectra.
- With positioning errors, dispersion, variable seeing, spectrophotometric calibration will *at best* require a 3-parameter “illumination correction” per field.
- Likely, a 3-parameter correction per fiber will be needed: SkyMapper’s *vgri* provides the ideal filter set for this.
- For early-F and hotter stars, Skymapper’s *u* filter is gravity sensitive and really helps stellar parameter estimation.

The Brighter FunnelWeb Stars…

- Using seeing 2.5 times worse than the best survey conditions (4” or worse), and exposure times ~5 times smaller, a “SkyMapper Bright” survey could be done with saturation limits <6th magnitude in all filters.
- Benefits:
  - Consistent FunnelWeb calibration across the full magnitude range.
  - Phase-dependent colors for variable stars (e.g. ASAS).
  - Multi-band photometry across the full unsaturated range of 2MASS

What about GAIA?

- In principle – GAIA's prism spectrographs (RP and BP) will supercede Skymapper.
- "Some spectrophotometry" is planned to be released mid-2017 (2 years after optimistic TAIPAN commissioning).
- Our goal is to to have the full FunnelWeb release significantly prior to the full GAIA reliease – it only makes sense to use Skymapper for calibration.
- All about timing…if Skymapper can be fed into FunnelWeb calibration from mid-2016, then *FunnelWeb will be the catalog that all GAIA papers on I<12 stars need, and not the other way around.*