DASCH Variables in the Kepler Field

Sumin Tang

Harvard-Smithsonian Center for Astrophysics

And the *DASCH team:*

Jonathan Grindlay – PI

Edward Los - Software engineer

Alison Doane - Plate Curator

Jaimie Pepper – Plate Cleaning

Bob Simcoe - Hardware engineer

Sumin Tang – Photometry, variable search

Mathieu Servillat – Astrometry

Doug Mink – Astrometry & software

Numerous volunteers – Assist in Plate Cleaning/Scanning

DASCH (Digital Access to a Sky Century @ Harvard) to Digitize and Measure the Harvard Plates to
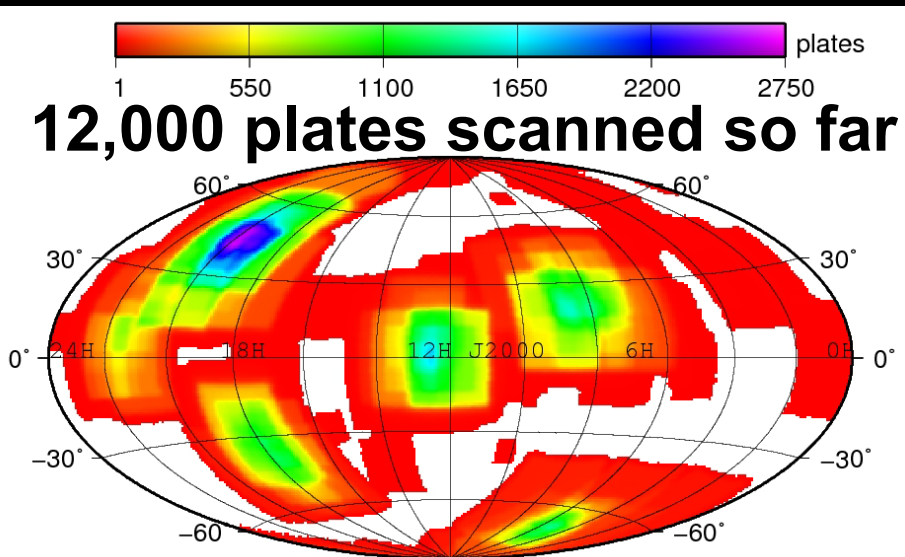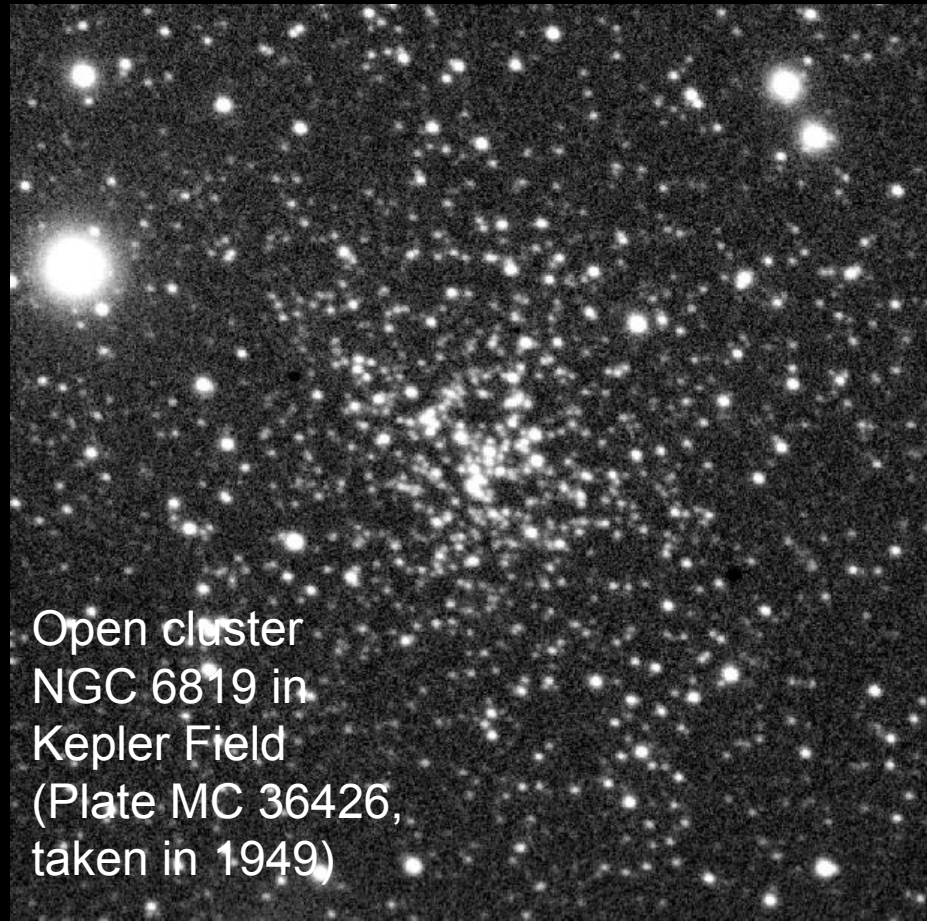
Open the ~100yr Time Domain Window

- ~530,000 photographic plates between 1880s-1980s (*Grindlay et al. 2009*).

- 500-1500 measurements for each object with B~10-14 (up to 18 mag in some regions)

- study temporal variations of a wide variety of objects (stars to AGNs)

- Astrometry: 0.8-3 arcsec (but up to 6" near edge of low-res plates) Photometry: 0.1-0.15 mag (*Laycock et al. 2010*).
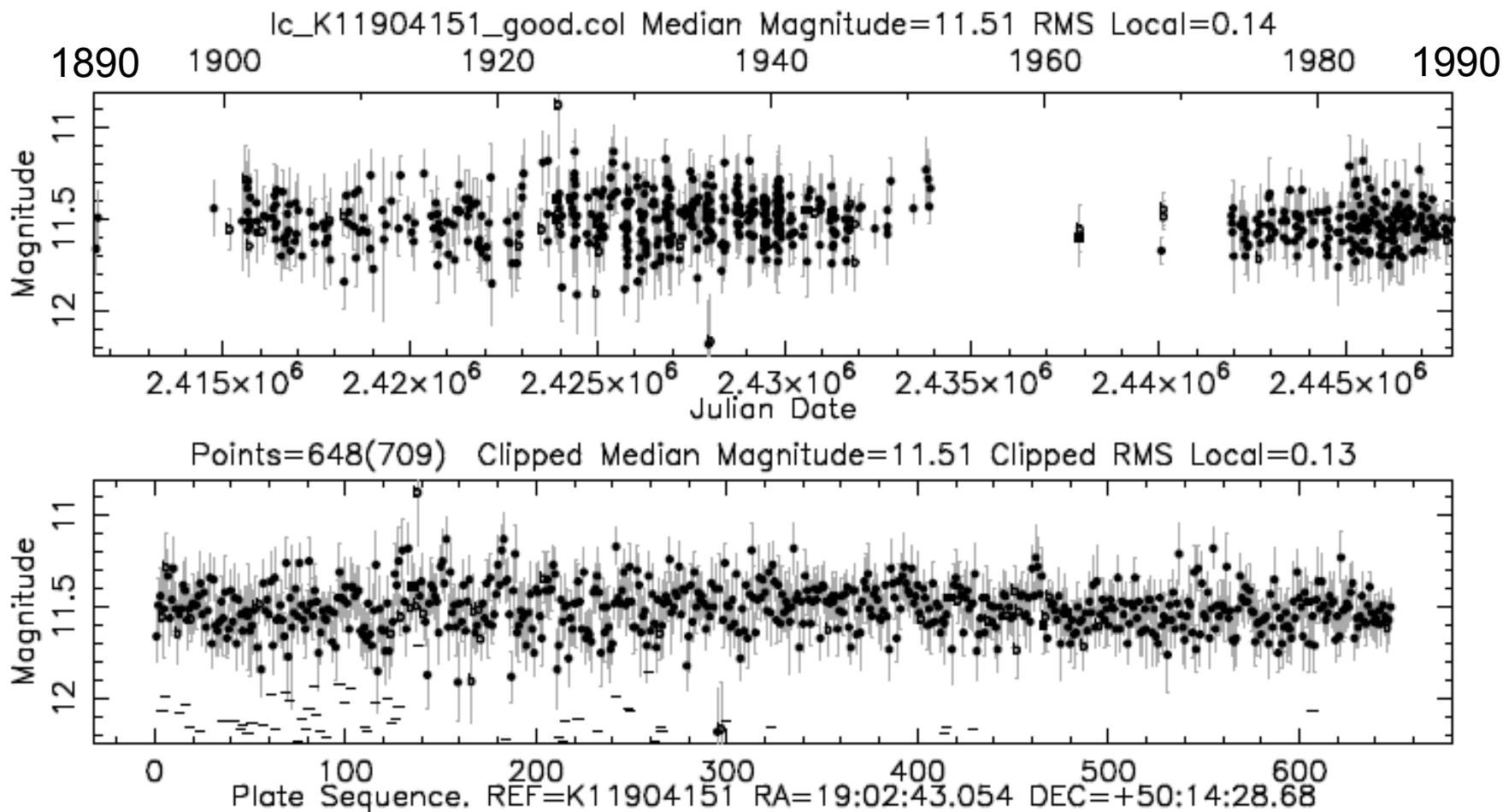
DASCH
scanner

~3000 plates each covering
all or part of the Kepler field:

Long-term **DASCH** coverage
+ short-timescale **Kepler** data.

12,000 plates scanned so far

Open cluster
NGC 6819 in
Kepler Field
(Plate MC 36426,
taken in 1949)

100 yr DASCH lightcurve of Kepler-10

lc_K11904151_good.col Median Magnitude=11.51 RMS Local=0.14

Points=648(709) Clipped Median Magnitude=11.51 Clipped RMS Local=0.13

Plate Sequence. REF=K11904151 RA=19:02:43.054 DEC=+50:14:28.68

Variable Search:
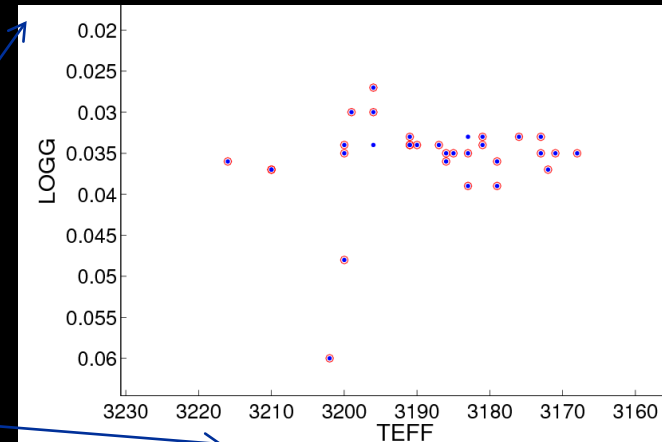
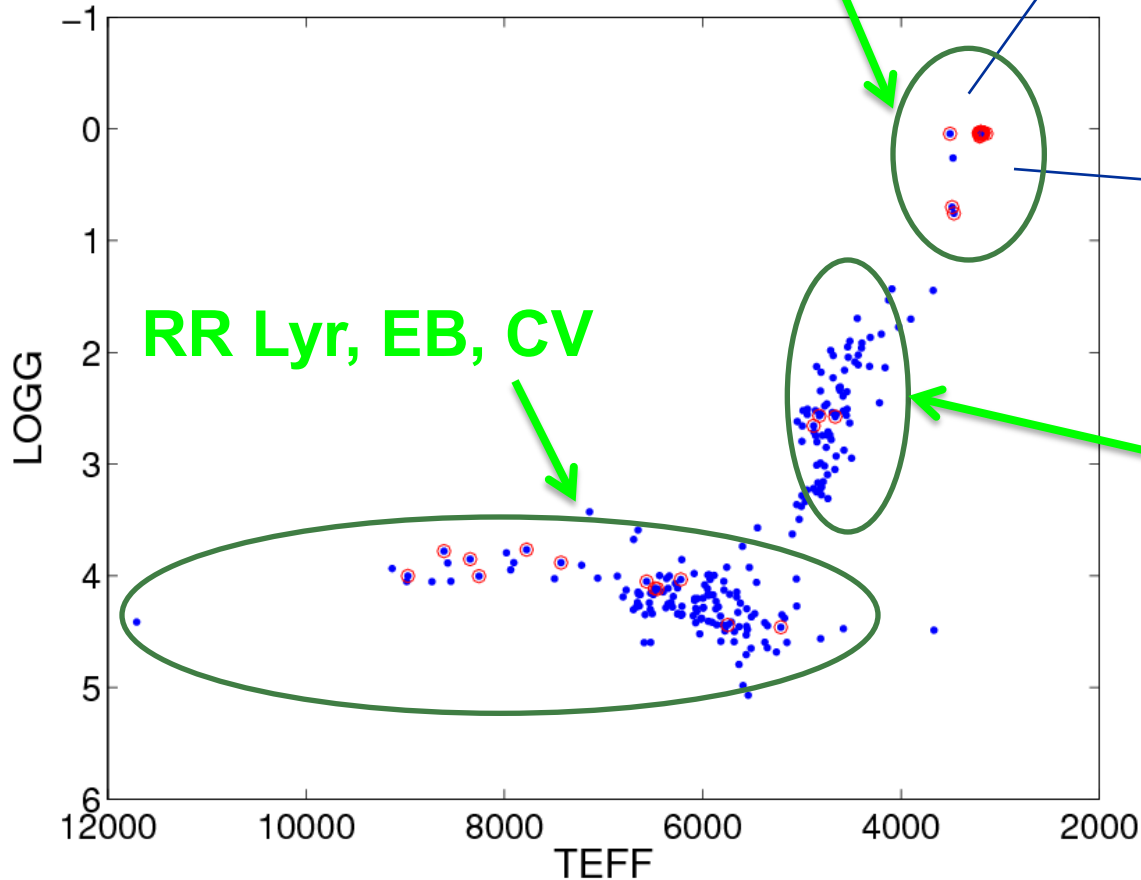1. divided into local 2º×2º bins
2. calculate lightcurve statistics for each star
3. pick up outliers (variable candidates)
4. Visual examination of plate images
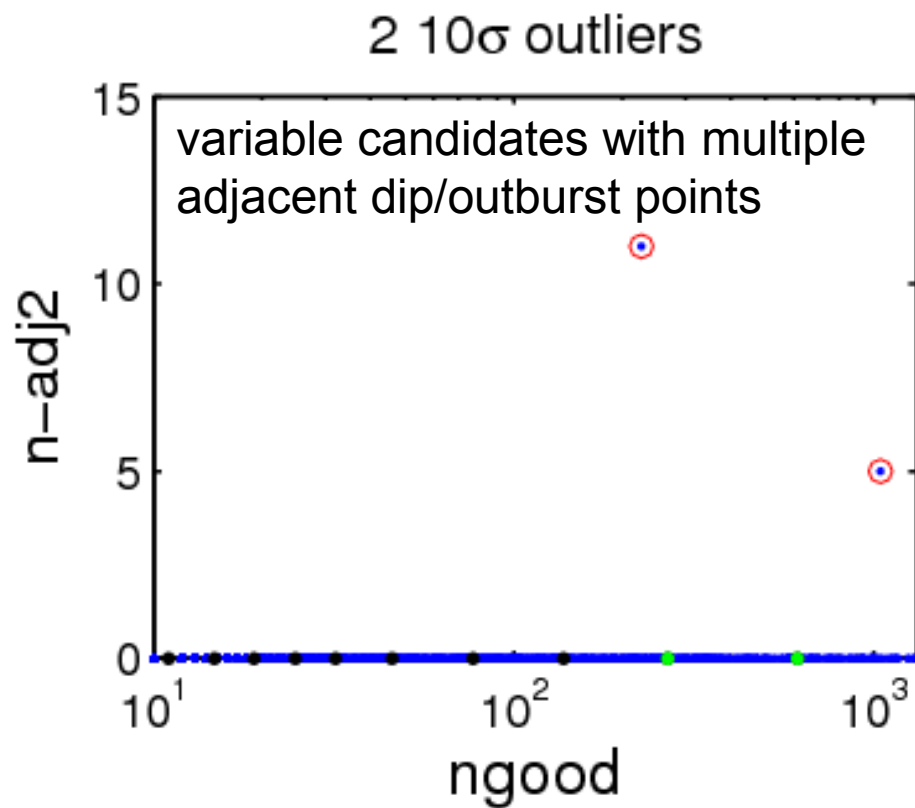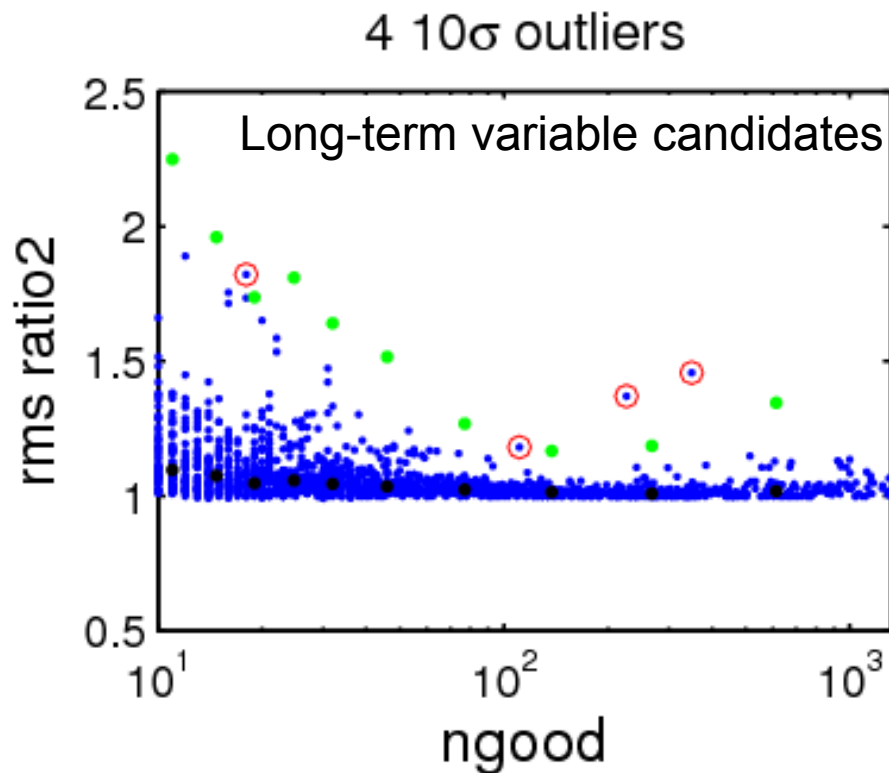
Different types of Variable Candidates
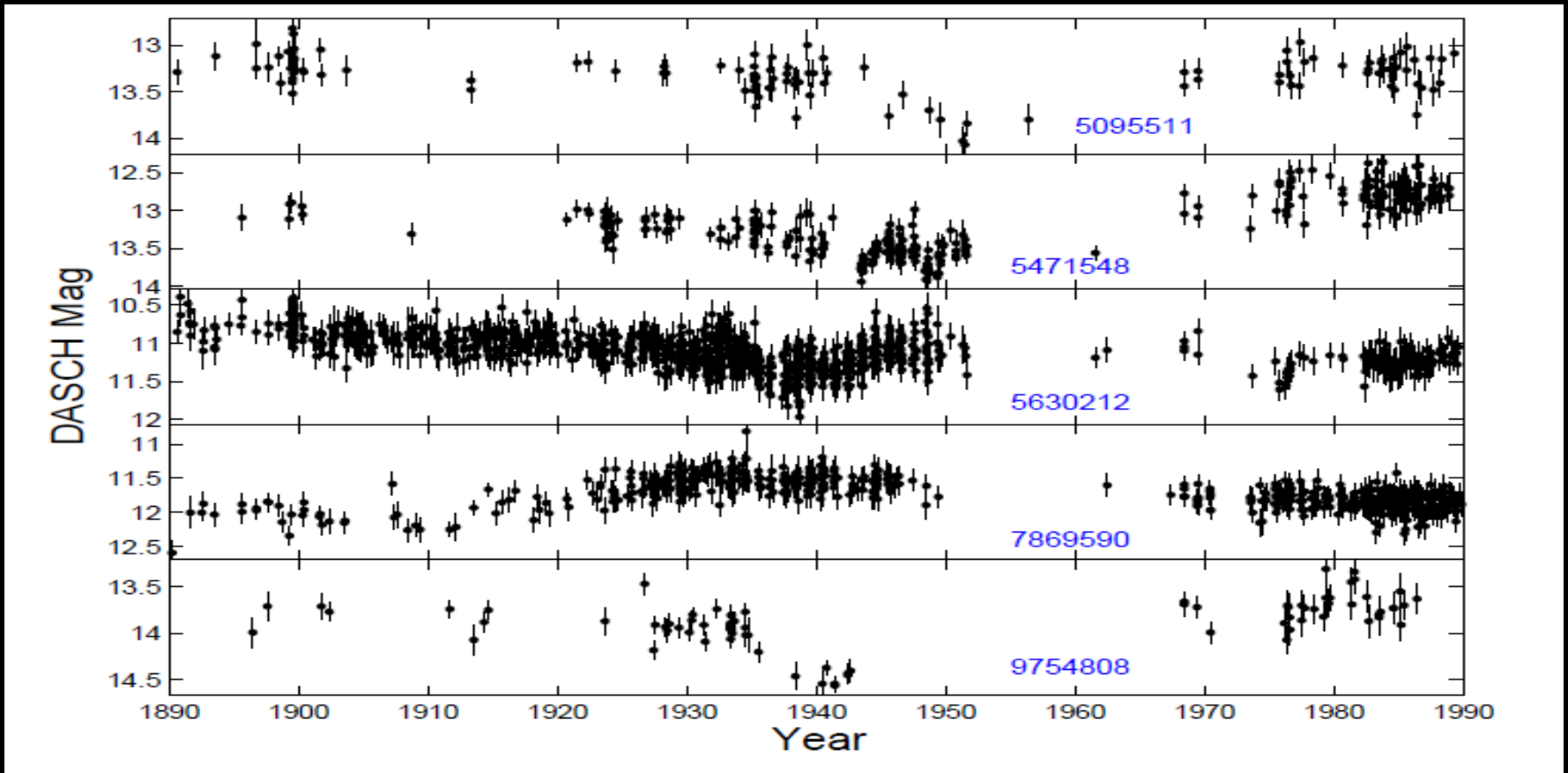
Red giant variables: Mira, LPV

340 10−σ DASCH variables in the Kepler field

RR Lyr, EB, CV

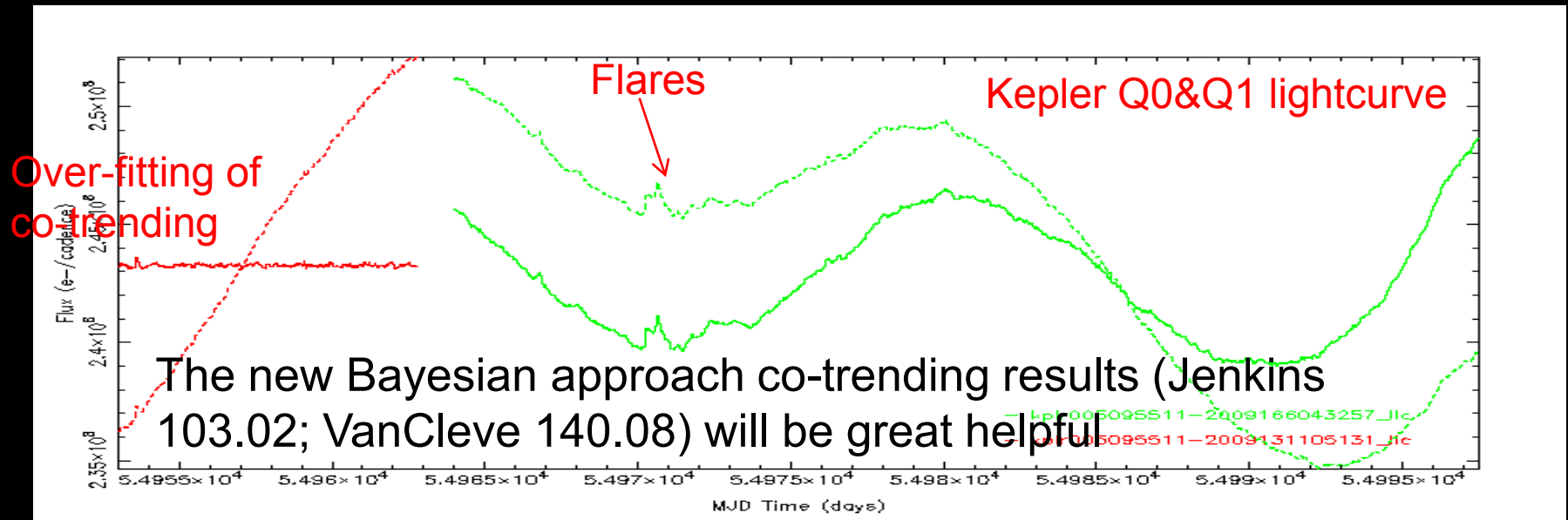**MISC, including some unusal long-term variables**

Visual validation still in progress… Only ~30 most interesting candidates have been done so far

K Giants with 10-50 yr variation:
An unknown phase of RGB/AGB evolution?
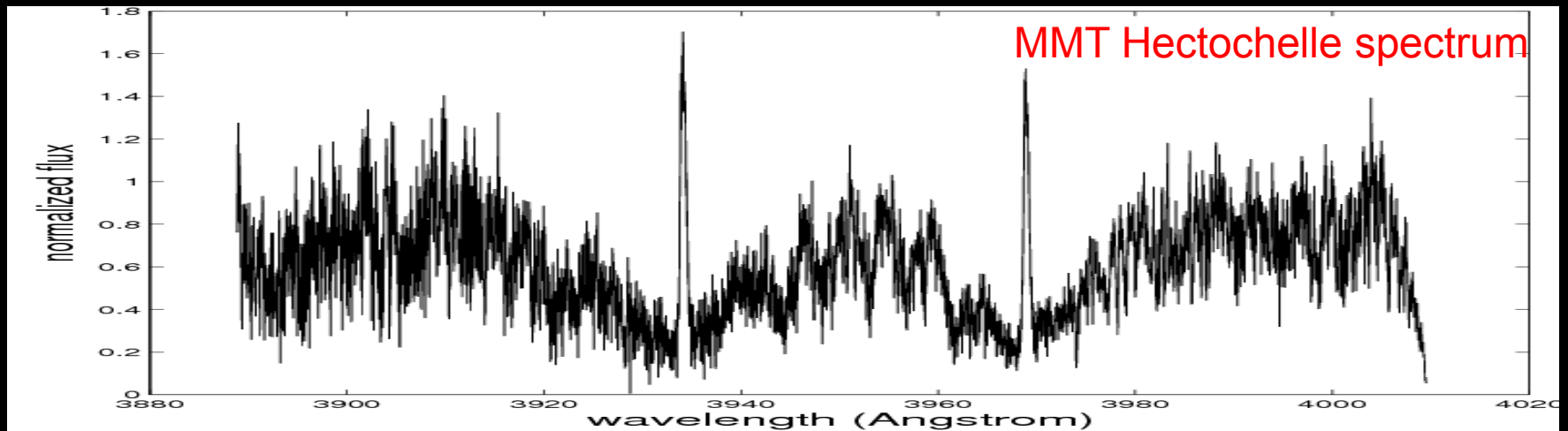similar to what we found in the M44 field (Tang et al. 2010)

Teff ~4400-4500 K, log g~2-3 cm/s2, R~6-15 R⊙ in the KIC
5630212: also a K giant according to its spectra

K5095511: a long term variable and active/spotted Giant?

Flares

Kepler Q0&Q1 lightcurve

Over-fitting of co-trending

The new Bayesian approach co-trending results (Jenkins 103.02; VanCleve 140.08) will be great helpful

Strong Ca K&H emission lines: indicate strong magnetic activity

MMT Hectochelle spectrum

A few more examples

9465763, g = 12.4, g−r = 3.87

lightcurve

2010.1102.0059.K9465763.ms.fits

FAST spectrum

Carbon star: dust obscuration?

Long-term A star variable: 1.5 mag rising

10711056

K dwarf (KIC), Chandra X-ray source, 2-3 mag flares: active binary?

10614158
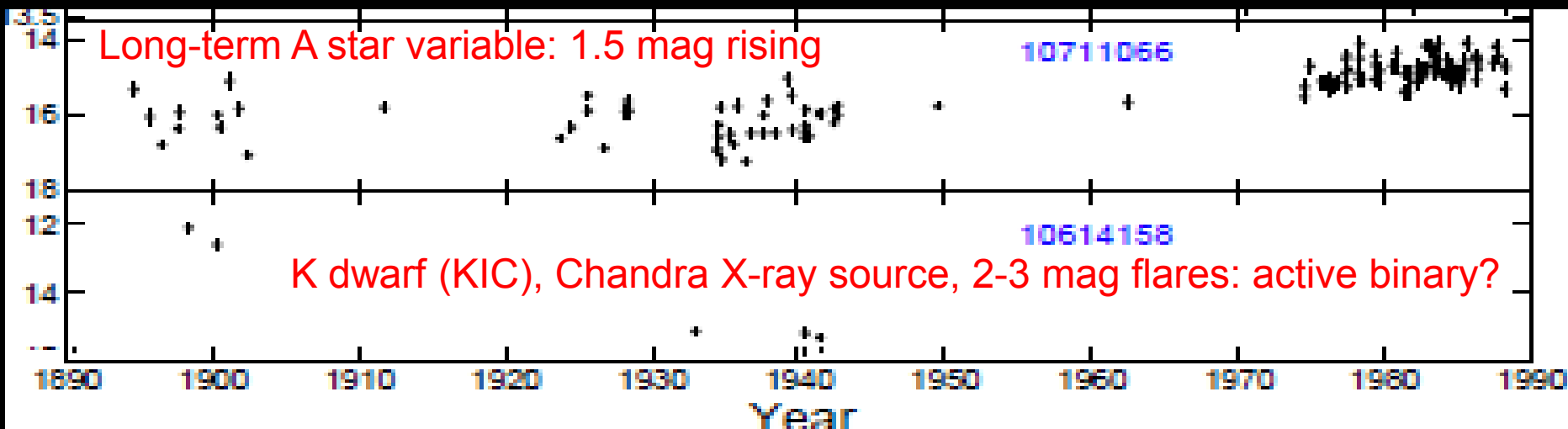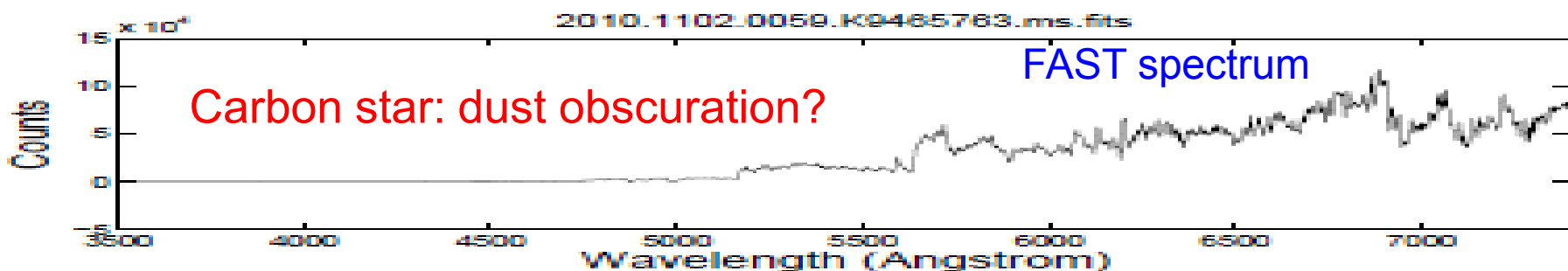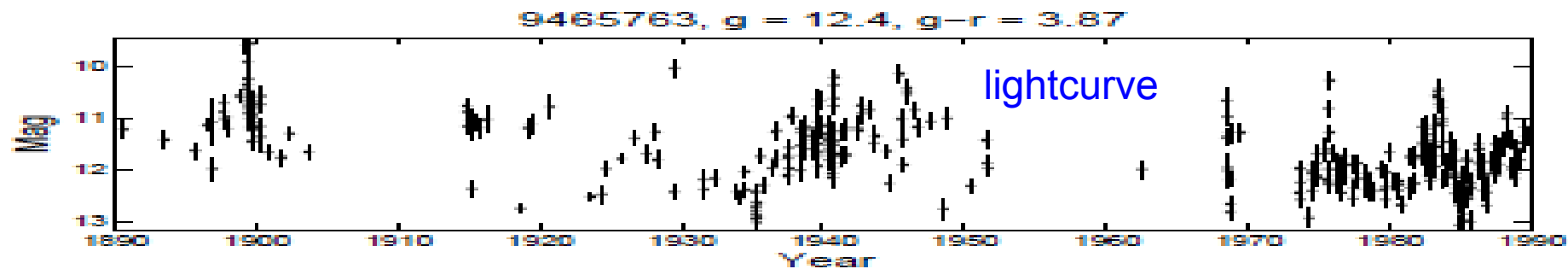
Combining DASCH

- 100yr lightcurves for B<15 mag objects in the whole sky
- Discovery of exciting new types of variables
- Explore long-term variability for known variables

with the high-cadence great accuracy Kepler data

- Short-term variability (flares, dimmings, oscillations)
- Magnetic activity, star spots and rotation
- Asteroseismology: derive stellar parameters, pin down their position in the evolutionary track. Compare the stellar parameters derived from atmosphere fitting (MMT Hectochelle/Magellan MIKE spectra).

Enables a unique study of stellar variability on the widest range of timescales. We have applied for the Kepler Cycle 3 GO program for ~20 of our most interesting DASCH variables.