The discovery of a new class of periodic variable stars in NGC 3766

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- **Introduction**
- **Observations**
- **Properties of the new periodic variables**
- **Gaia**

Geneva Open Clusters survey

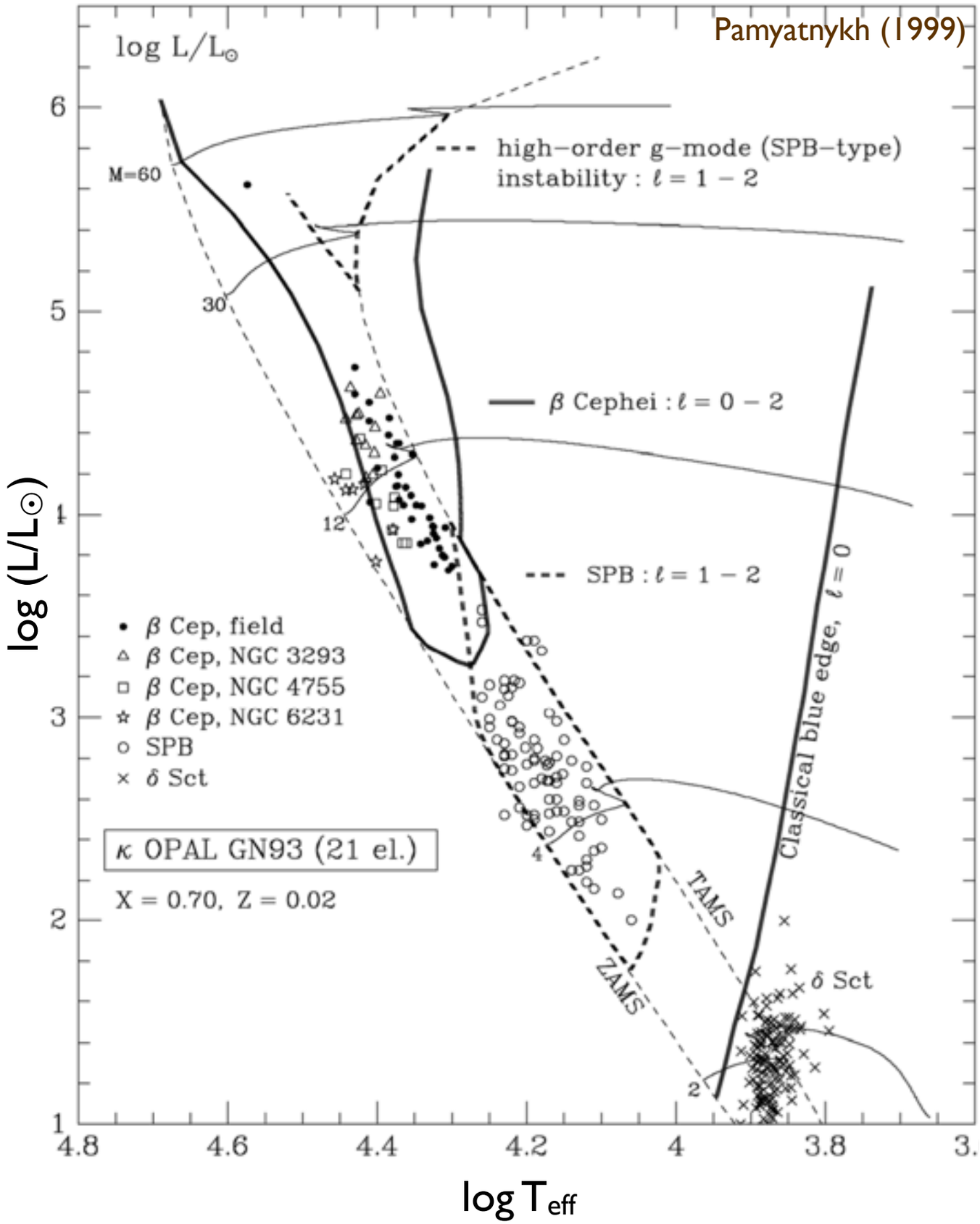
2002-2009

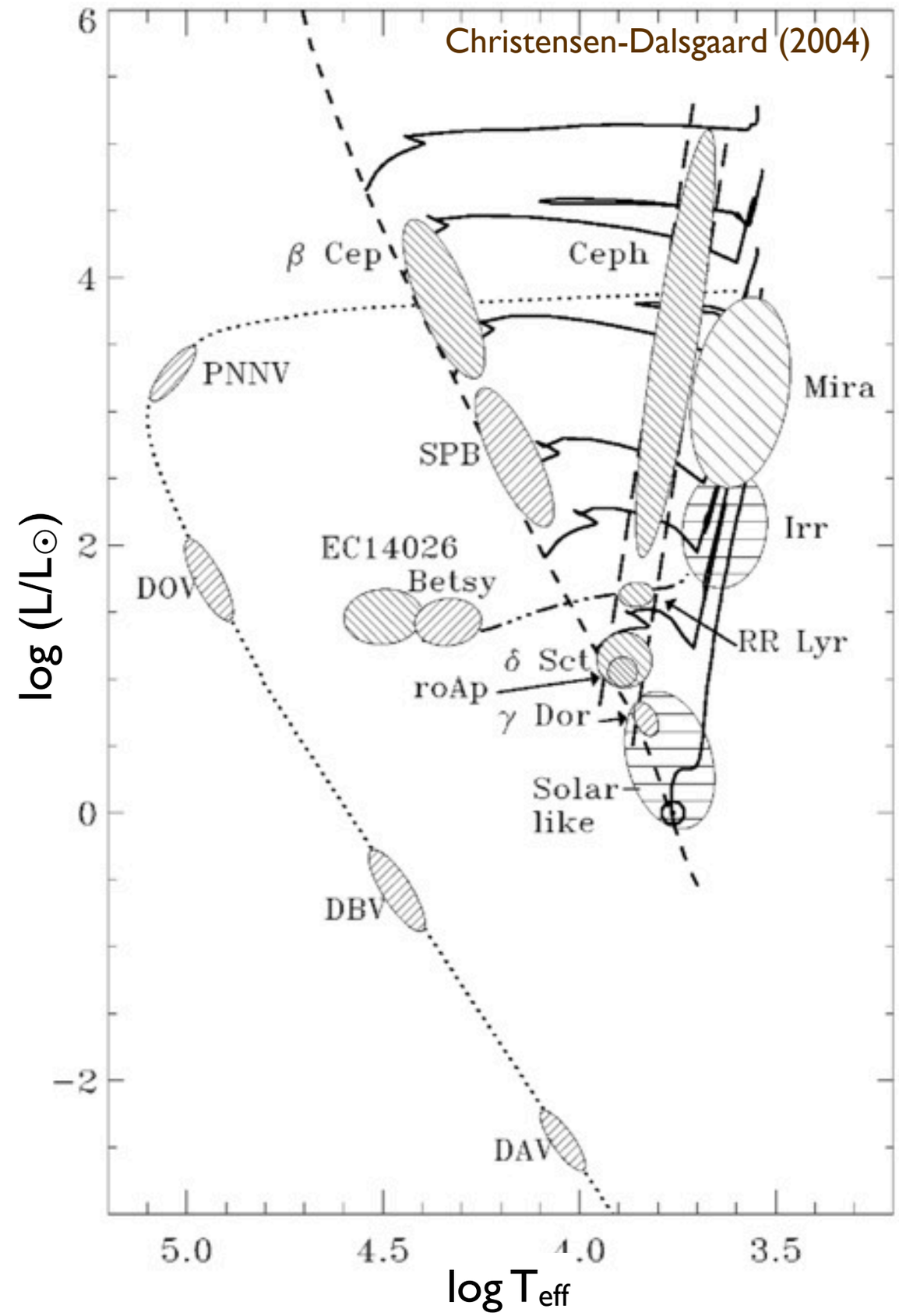
South (Euler)

North (Mercator)

Name	RA	DEC	log(age)	Telescope
IC 4651	17:24:49	-49:56:00	9.057	Euler
NGC 188	00:47:28	+85:15:18	9.632	Mercator
NGC 1245	03:14:42	+47:14:12	8.704	Mercator
NGC 1513	04:09:57	+49:30:54	8.110	Mercator
NGC 1901	05:18:15	-68:26:12	8.920	Euler
NGC 1907	05:28:05	+35:19:30	8.567	Mercator
NGC 2194	06:13:45	+12:48:24	8.515	Mercator
NGC 2323	07:02:42	-08:23:00	8.096	Euler
NGC 2324	07:04:07	+01:02:42	8.630	Mercator
NGC 2420	07:38:23	+21:34:24	9.048	Mercator
NGC 2437	07:41:46	-14:48:36	8.390	Euler
NGC 2447	07:44:30	-23:51:24	8.588	Euler
NGC 3247	10:25:51	-57:55:24	8.083	Euler
NGC 3532	11:05:39	-58:45:12	8.492	Euler
NGC 3766	**11:36:14**	**-61:36:30**	**7.160**	**Euler**
NGC 4103	12:06:40	-61:15:00	7.393	Euler
NGC 5617	14:29:44	-60:42:42	7.915	Euler
NGC 6067	16:13:11	-54.13:06	8.076	Euler
NGC 6134	16:27:46	-49:09:06	8.968	Euler
NGC 6705	18:51:05	-06:16:12	8.302	Mercator
NGC 6755	19:07:49	+04:16:00	7.719	Mercator
NGC 6811	19:37:17	+46:23:18	8.799	Mercator
NGC 6939	20:31:30	+60:39:42	9.346	Mercator
NGC 6996	20:56:30	+44:38:30	8.000	Mercator
NGC 7039	21:10:48	+45:37:00	7.820	Mercator
NGC 7654	23:24:48	+61:35:36	7.764	Mercator
NGC 7789	23:57:24	+56:42:30	9.235	Mercator

Stellar variability in the HR diagram





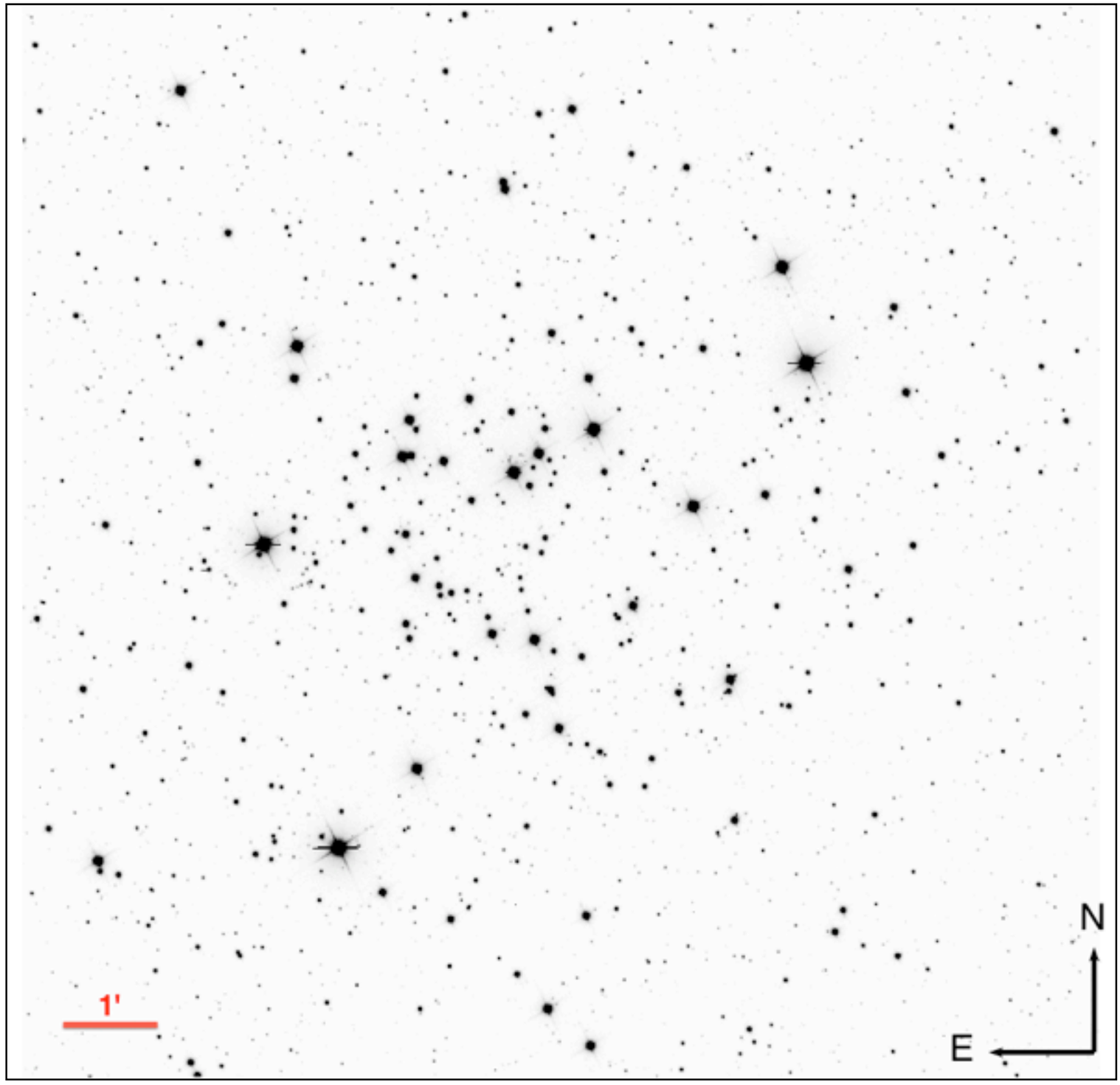
Open Cluster **NGC 3766**

(l,b) : (294°, -0.03°)
Dist. : 1.9 - 2.3 kpc from ⊙
Age : 14-30 My

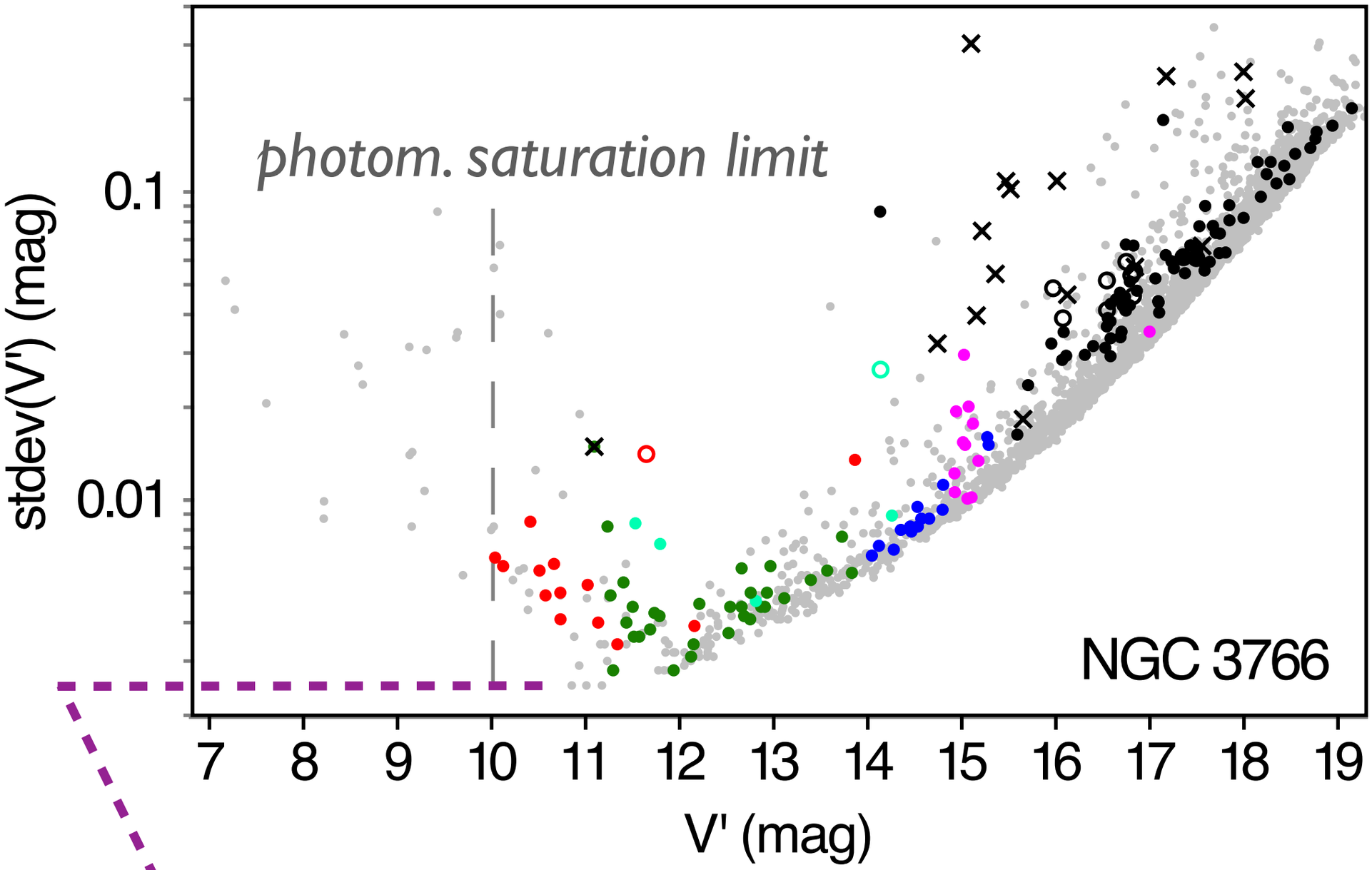
Rich in Be stars

Photom. survey: 2002-2009
(1.2m Euler telescope, La Silla)

→ VG : 2545 images
BG : 430 images
UG : 376 images



2858 good time series in VG

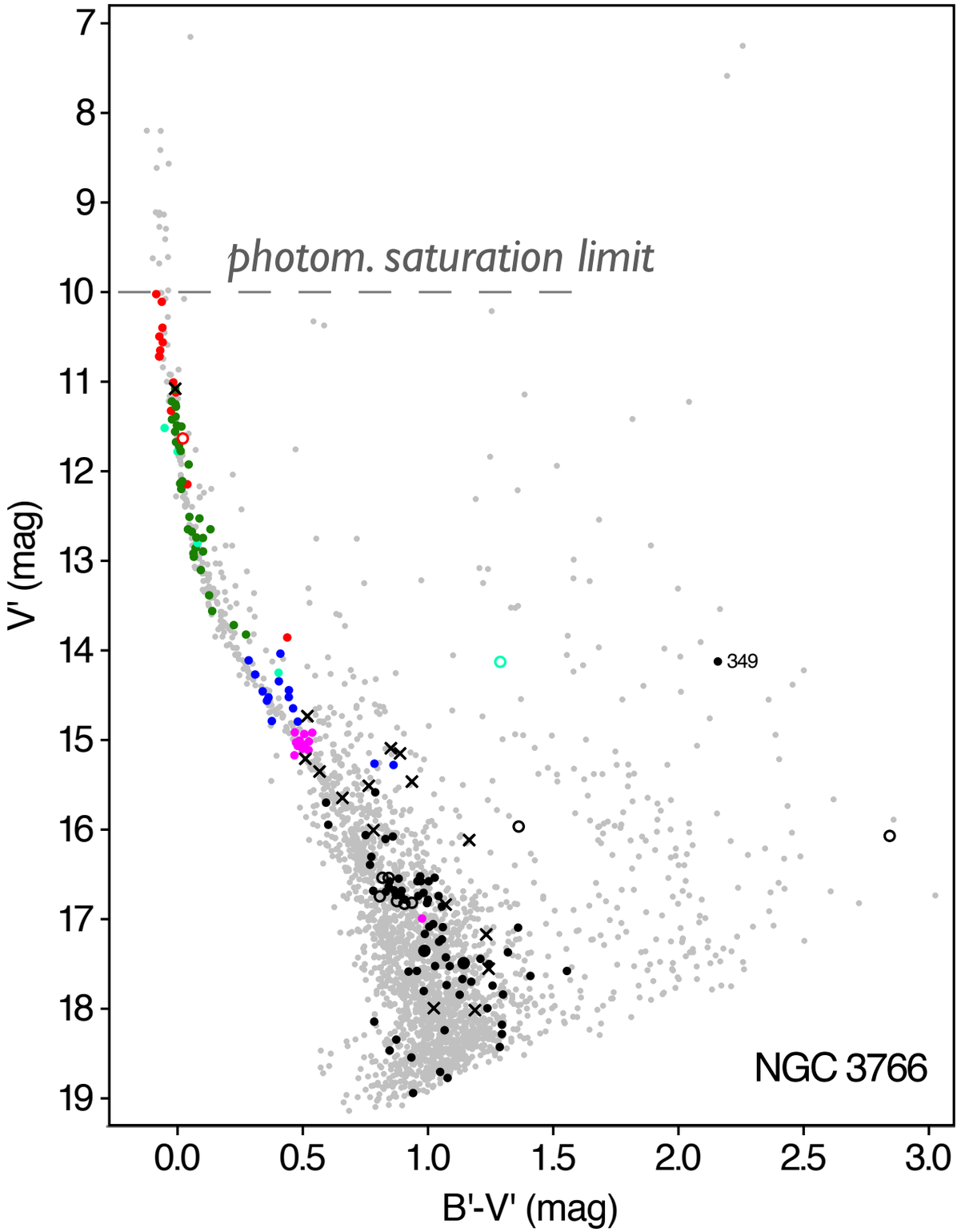


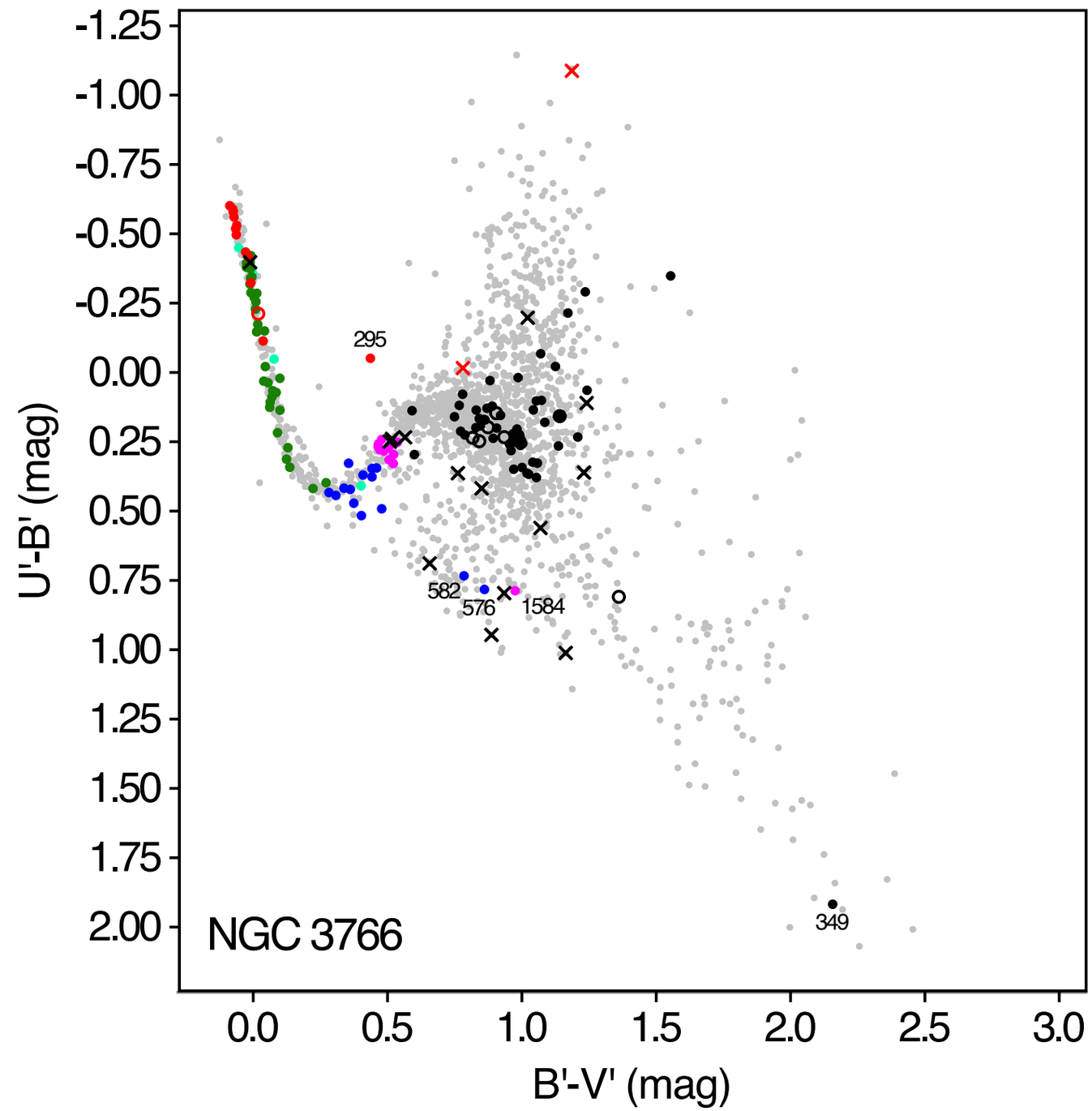
147 periodic variables : *colored* and *black points*

16 eclipsing binaries : *black crosses*

~2.5 mmag *precision at V'~11-12 mag*

NGC 3766



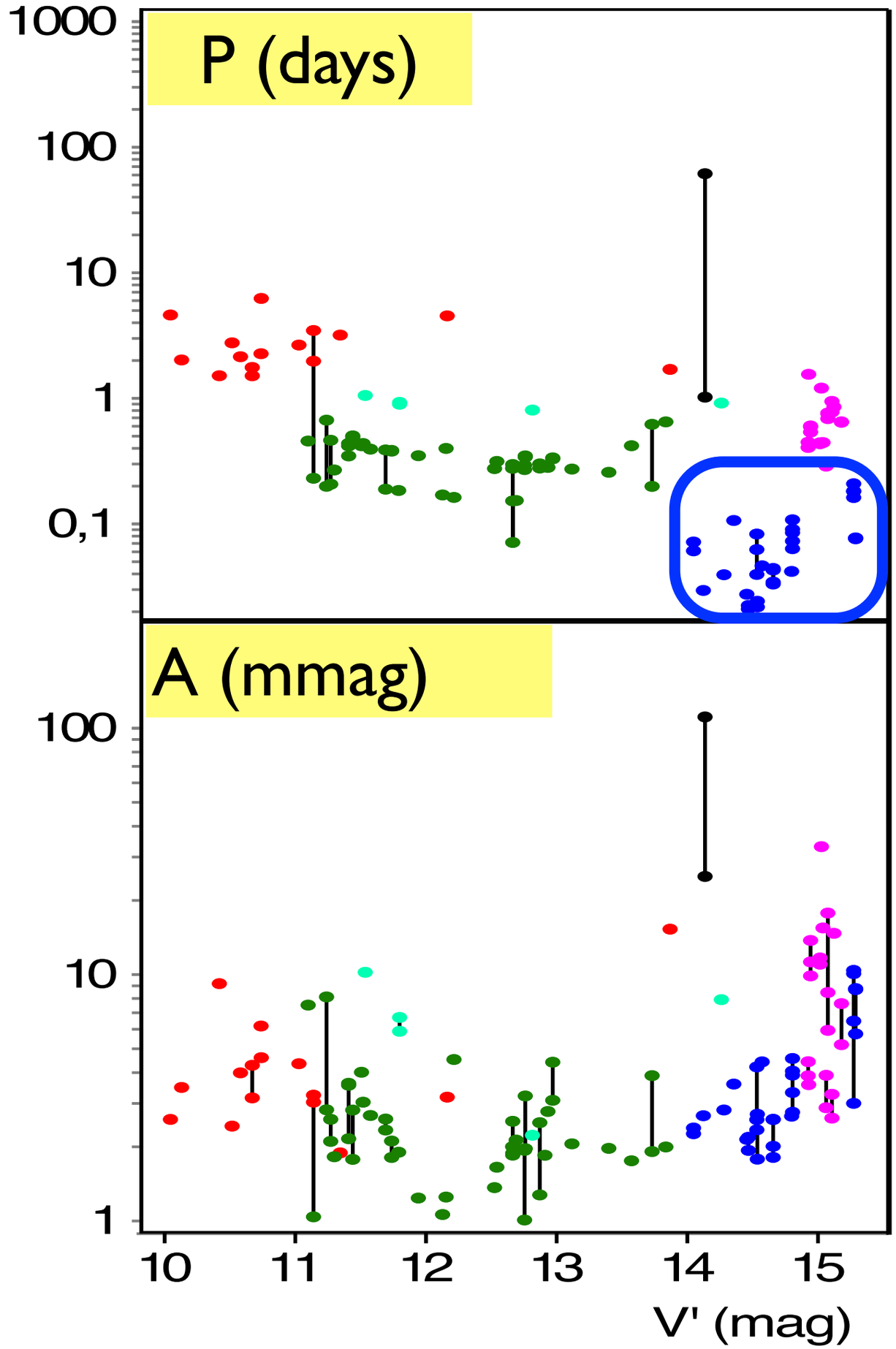


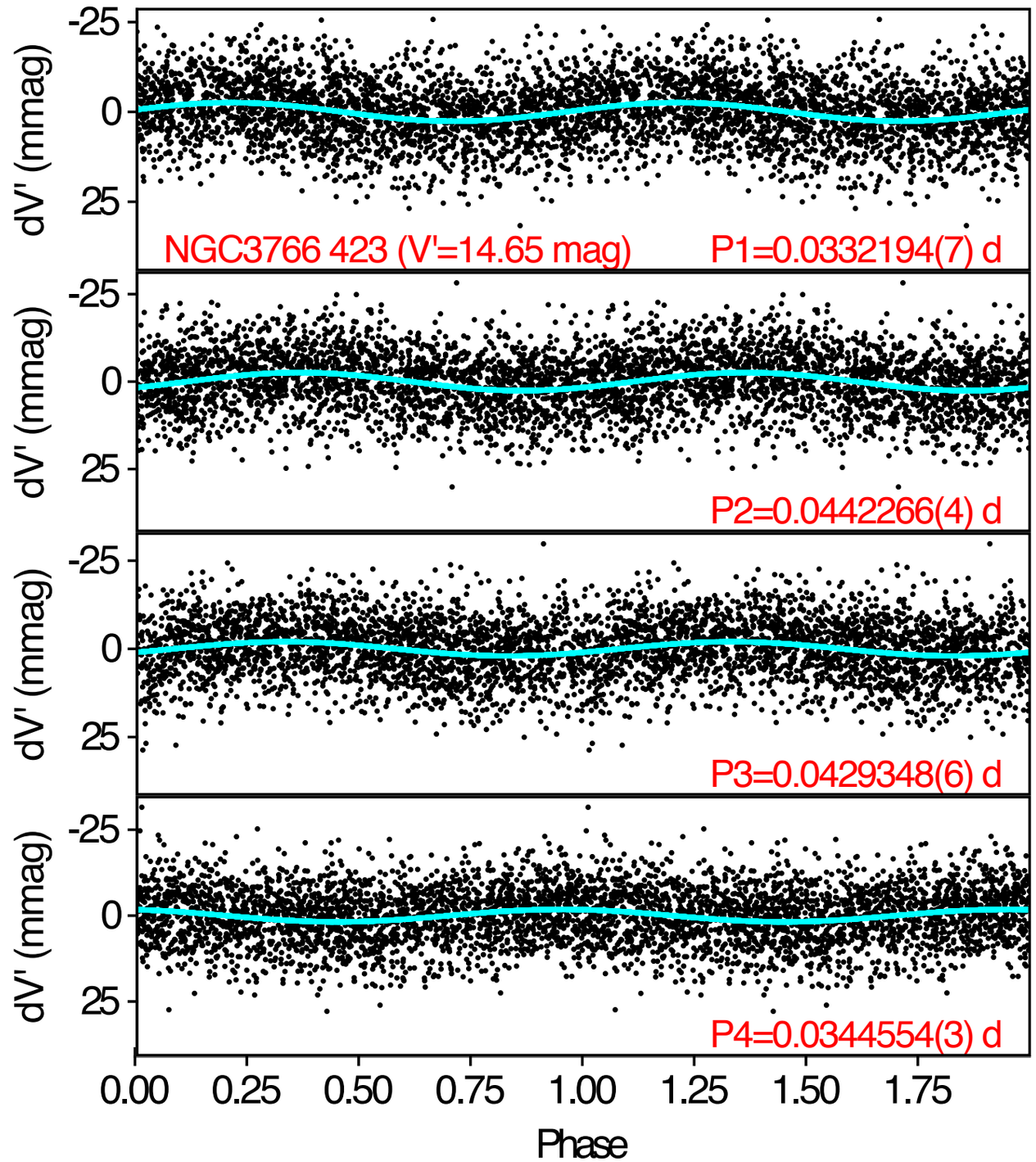
Periodic variables cover all magnitudes

δ Scuti candidates

P = 0.02-0.25 d

14 stars (6 / 3 / 2 / 2 / 1)

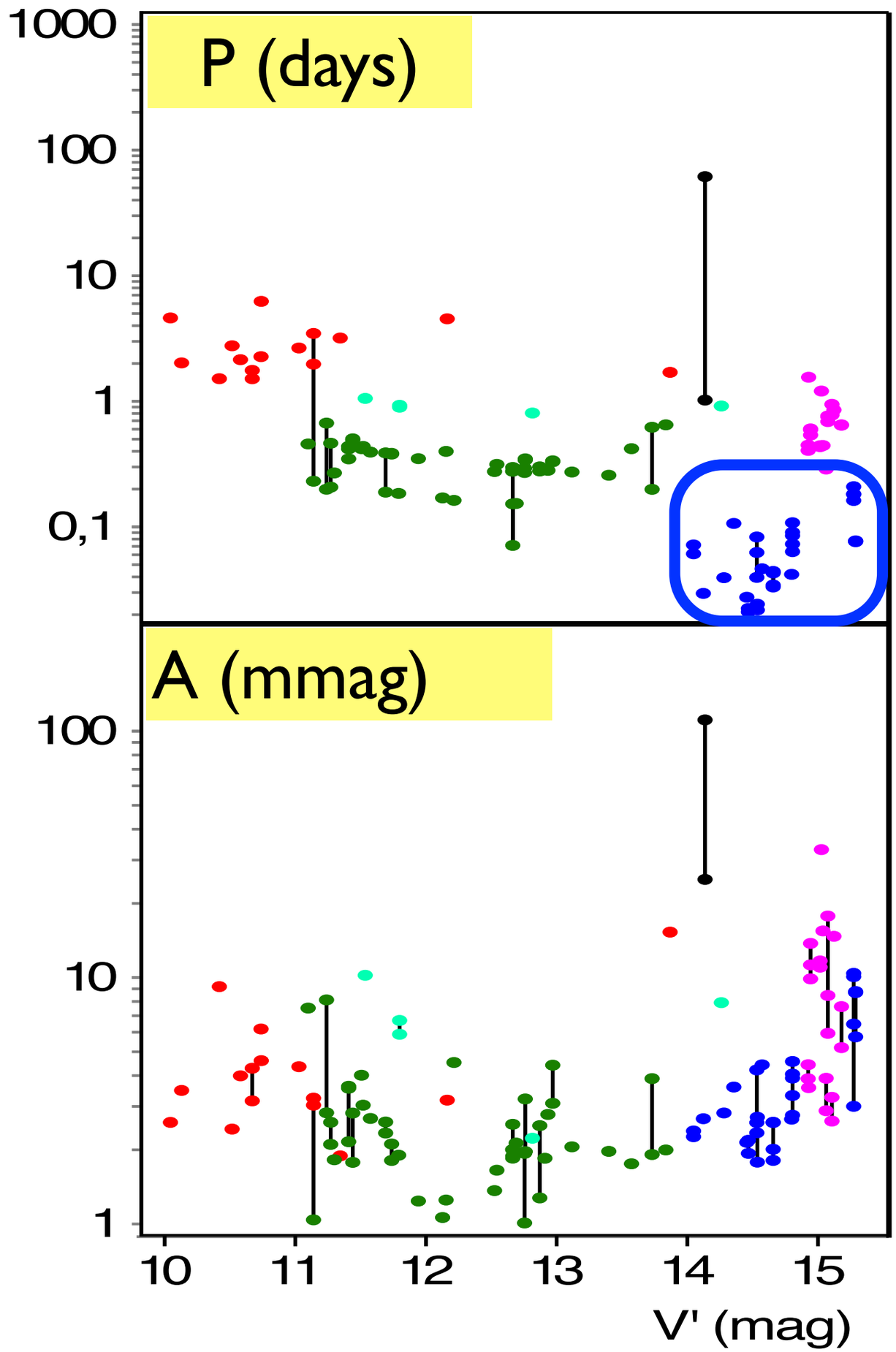


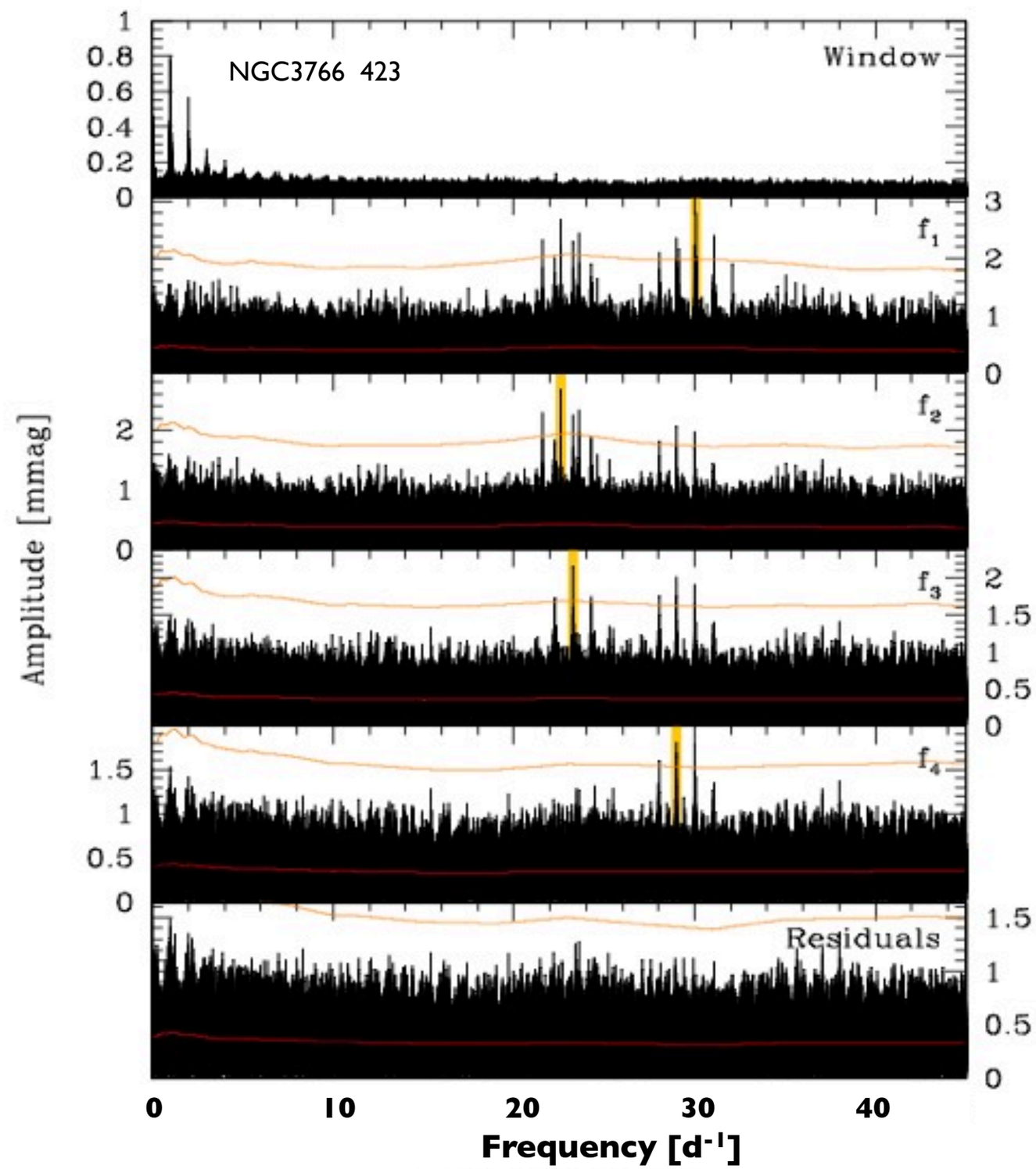


δ Scuti candidates

P = 0.02-0.25 d

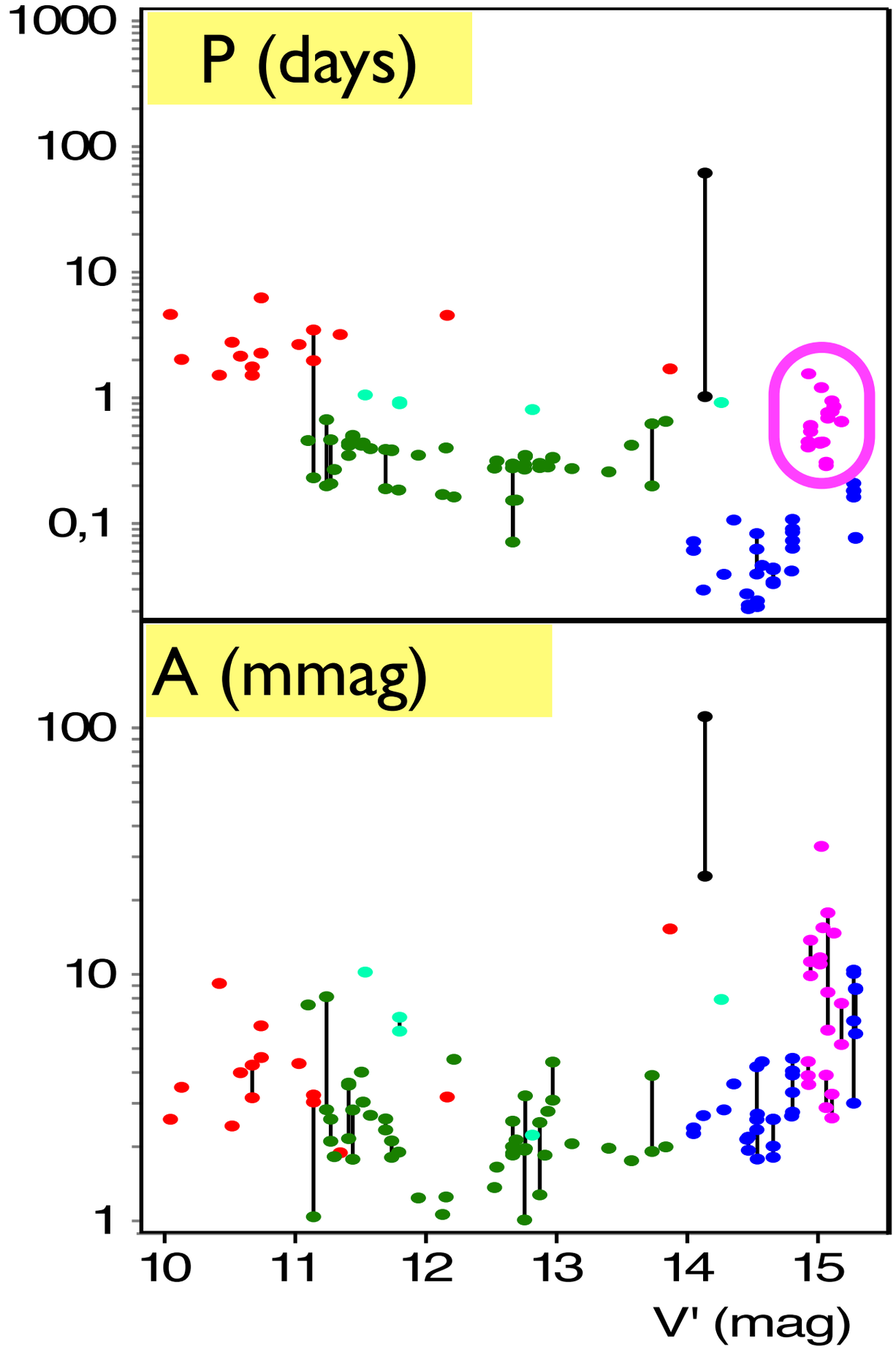
14 stars (6 / 3 / 2 / 2 / 1)

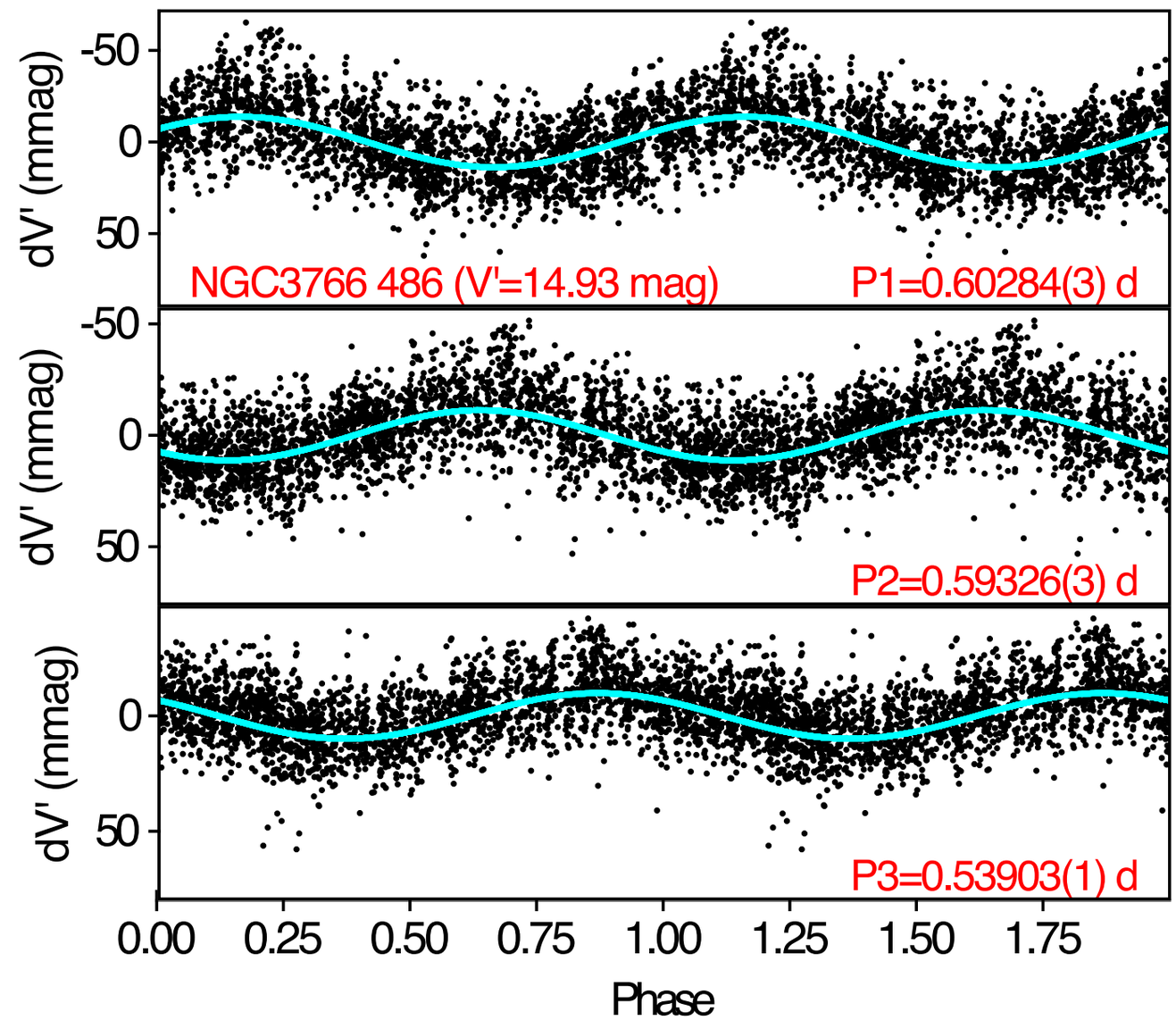




ϒ Dor candidates
P = 0.3-1.7 d

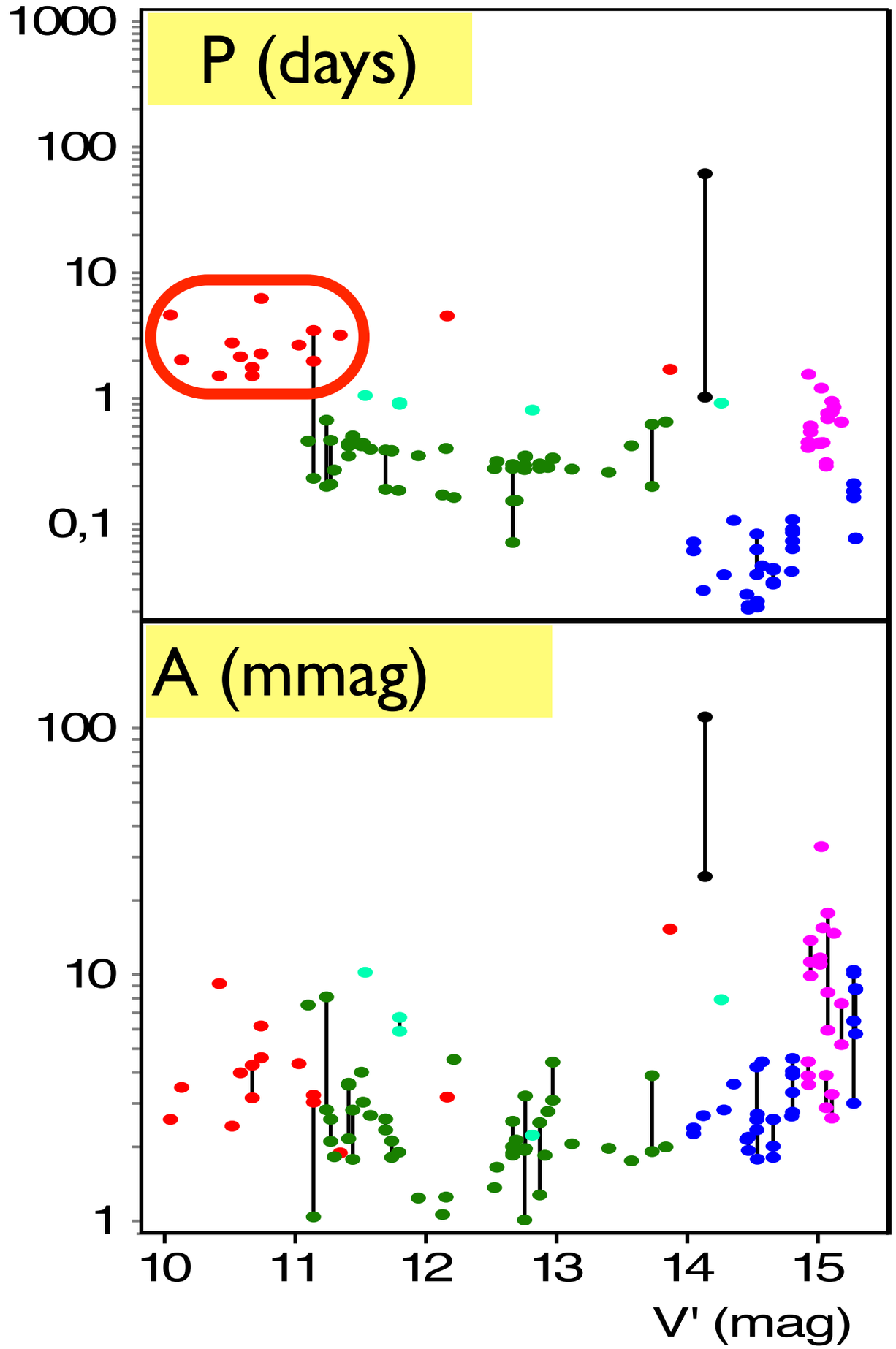
12 stars (5 / 5 / 2)

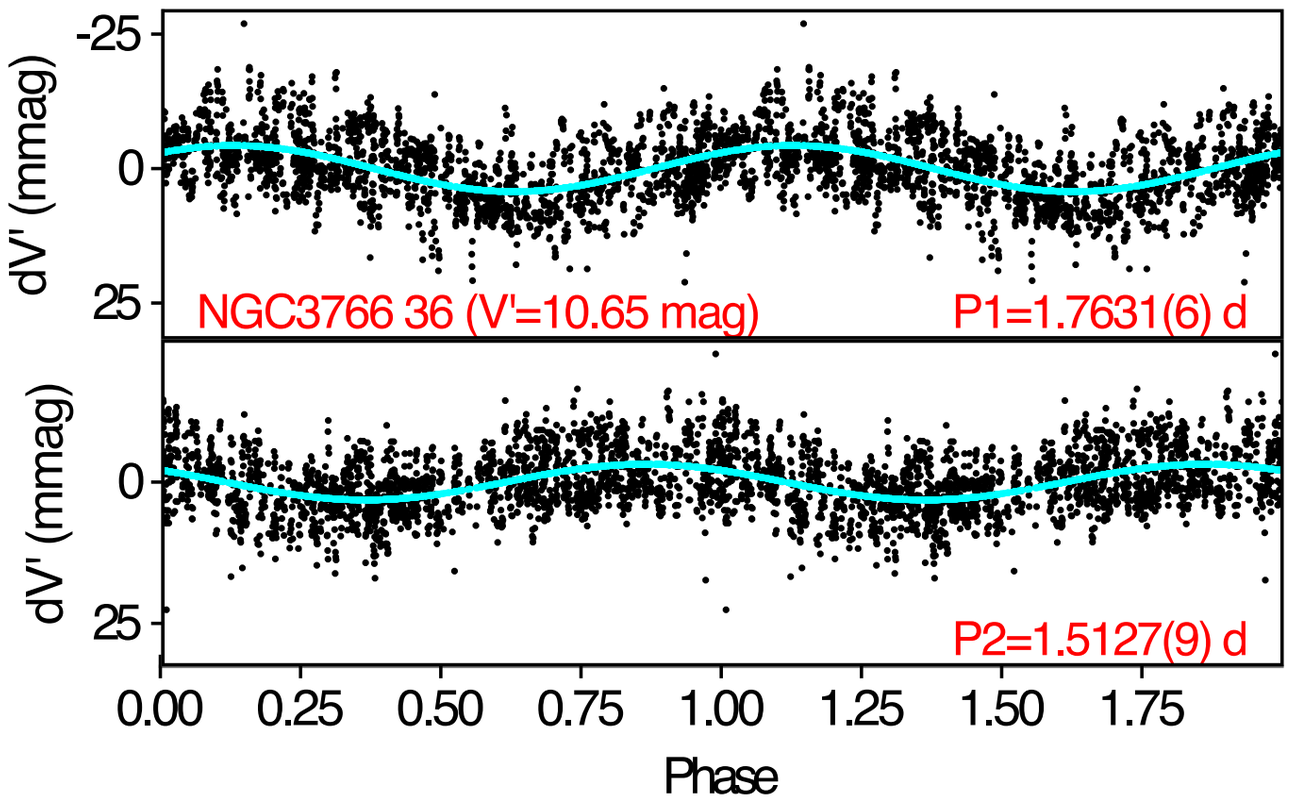




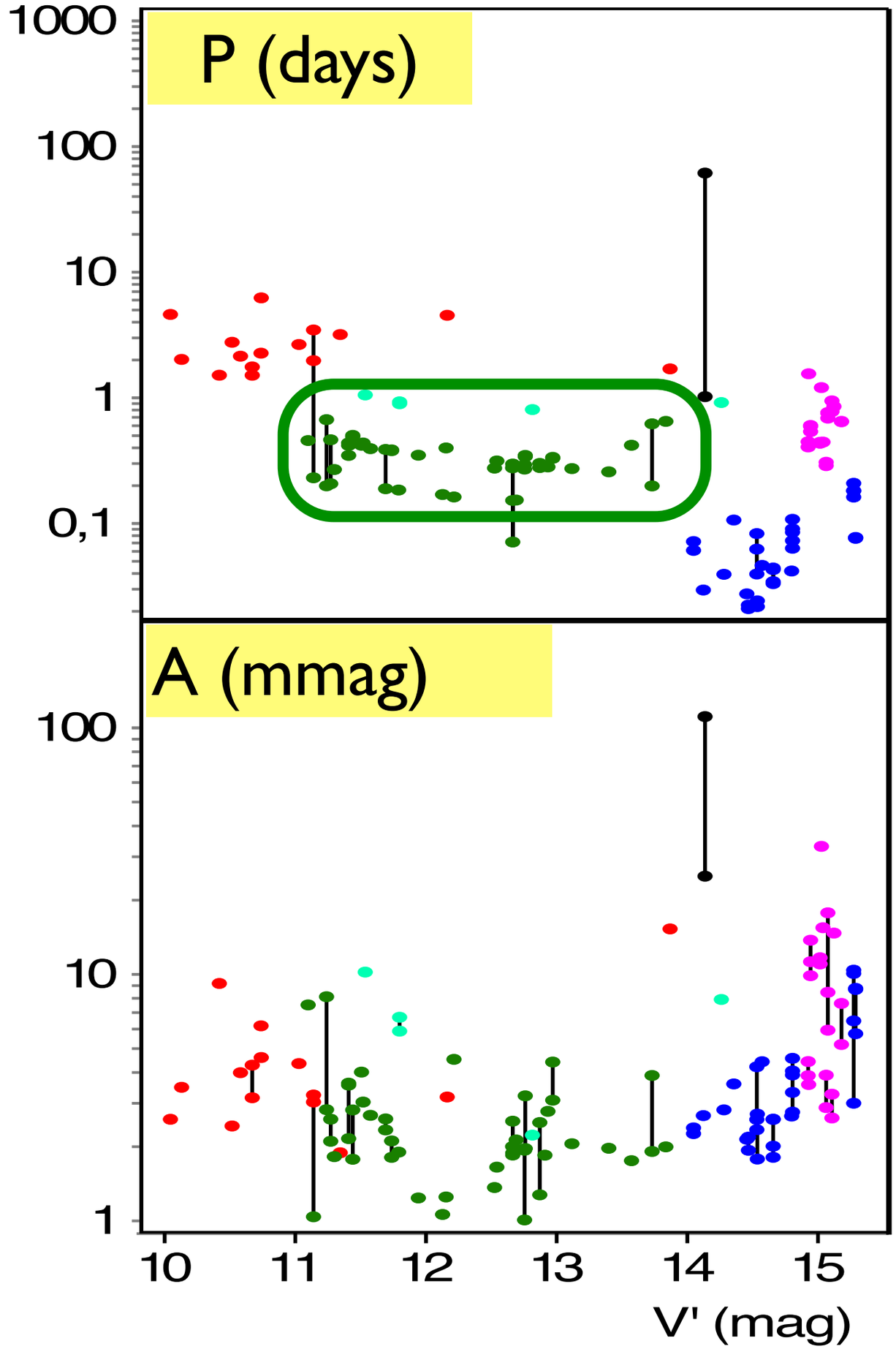
SPB candidates
P = 0.5-5 d

13 stars (11 / 2)





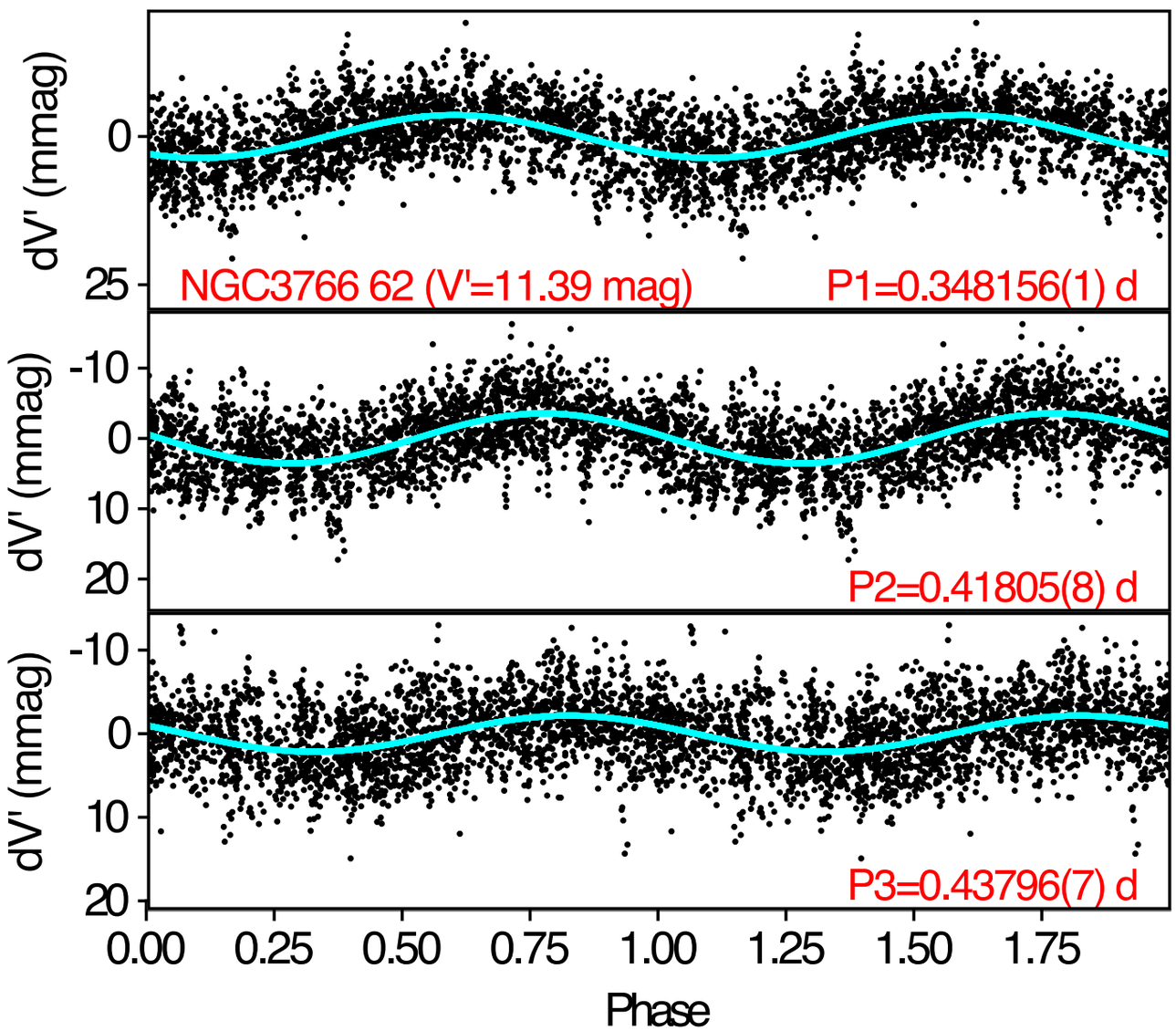
Periodic variables



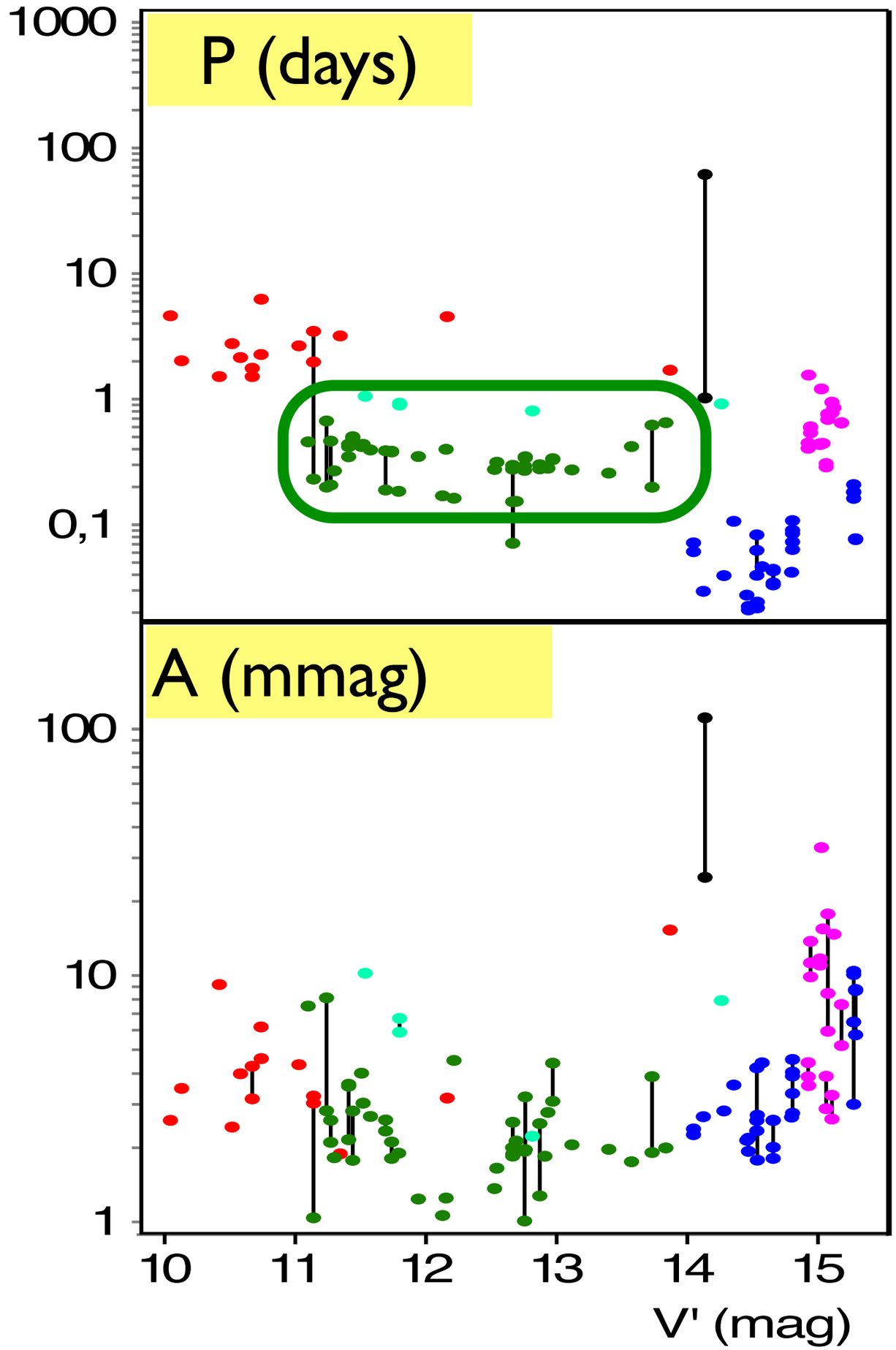
New group

P = 0.1-1.1 d

36 stars (23 / 11 / 2)



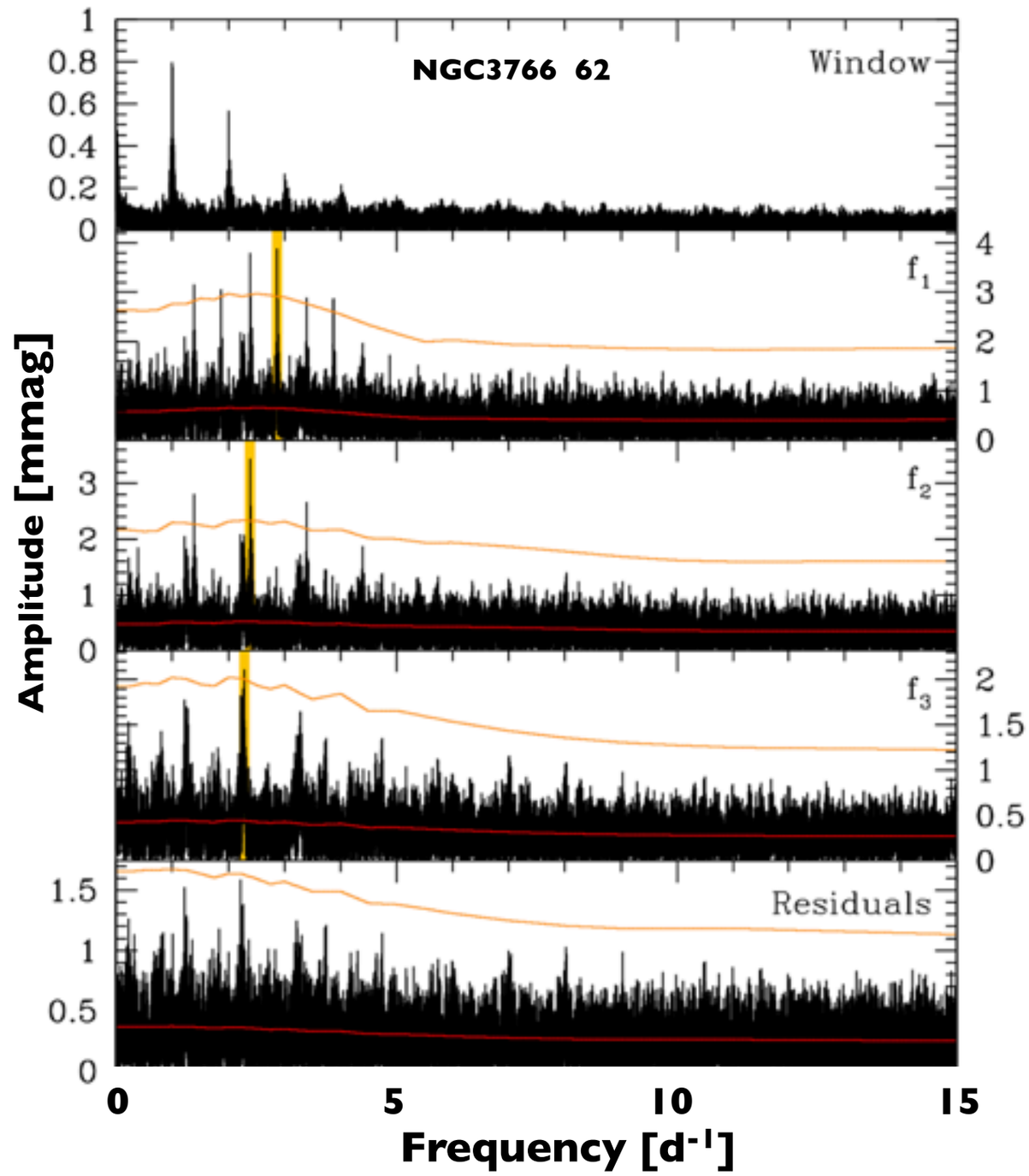
Periodic variables



New group

P = 0.1-1.1 d

36 stars (23 / 11 / 2)



New group

Mono-periodics

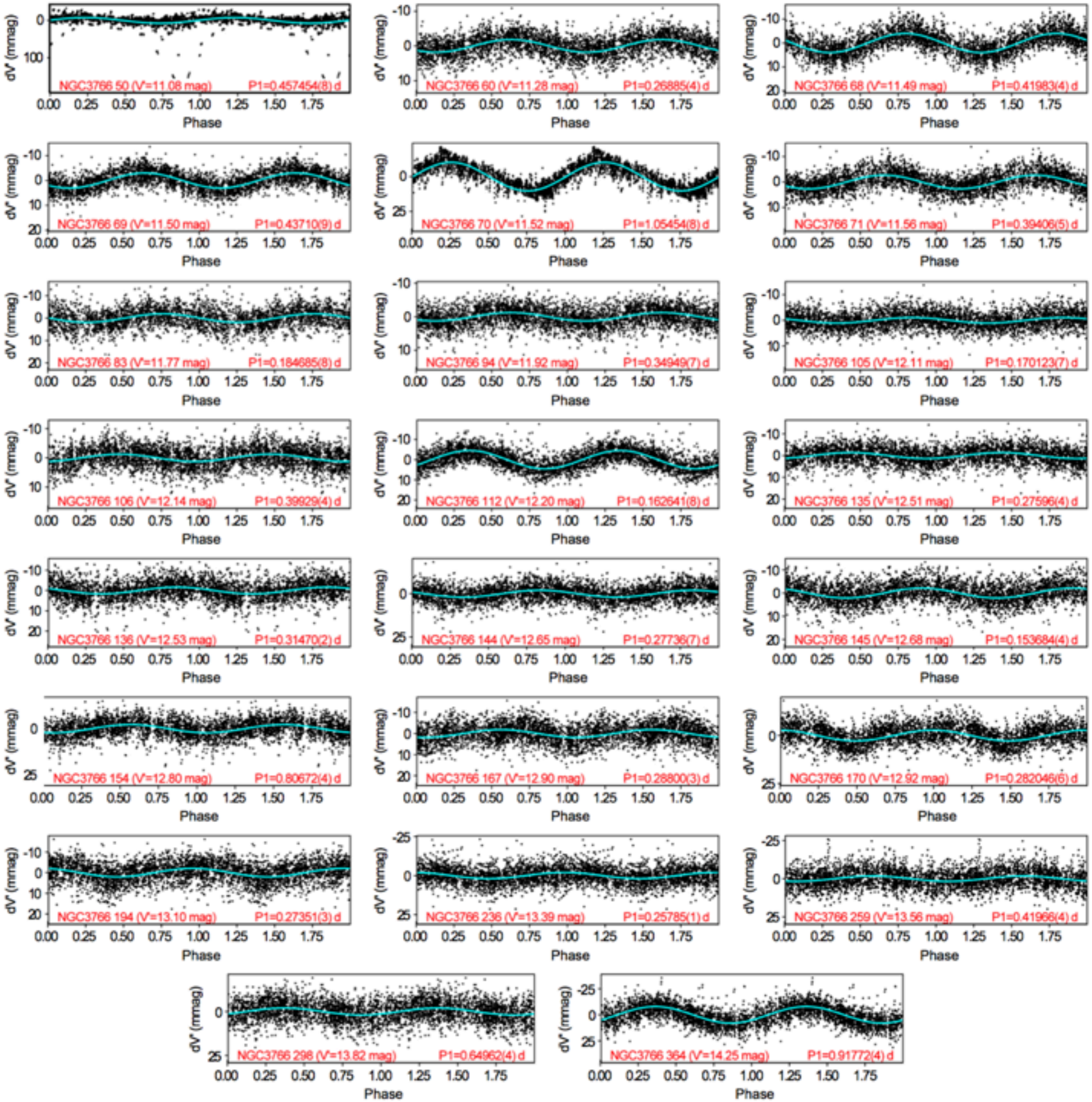


Fig. B.3. Same as Fig. B.1, but for the monoperiodic variables of group 2.

Bi-periodics

New group

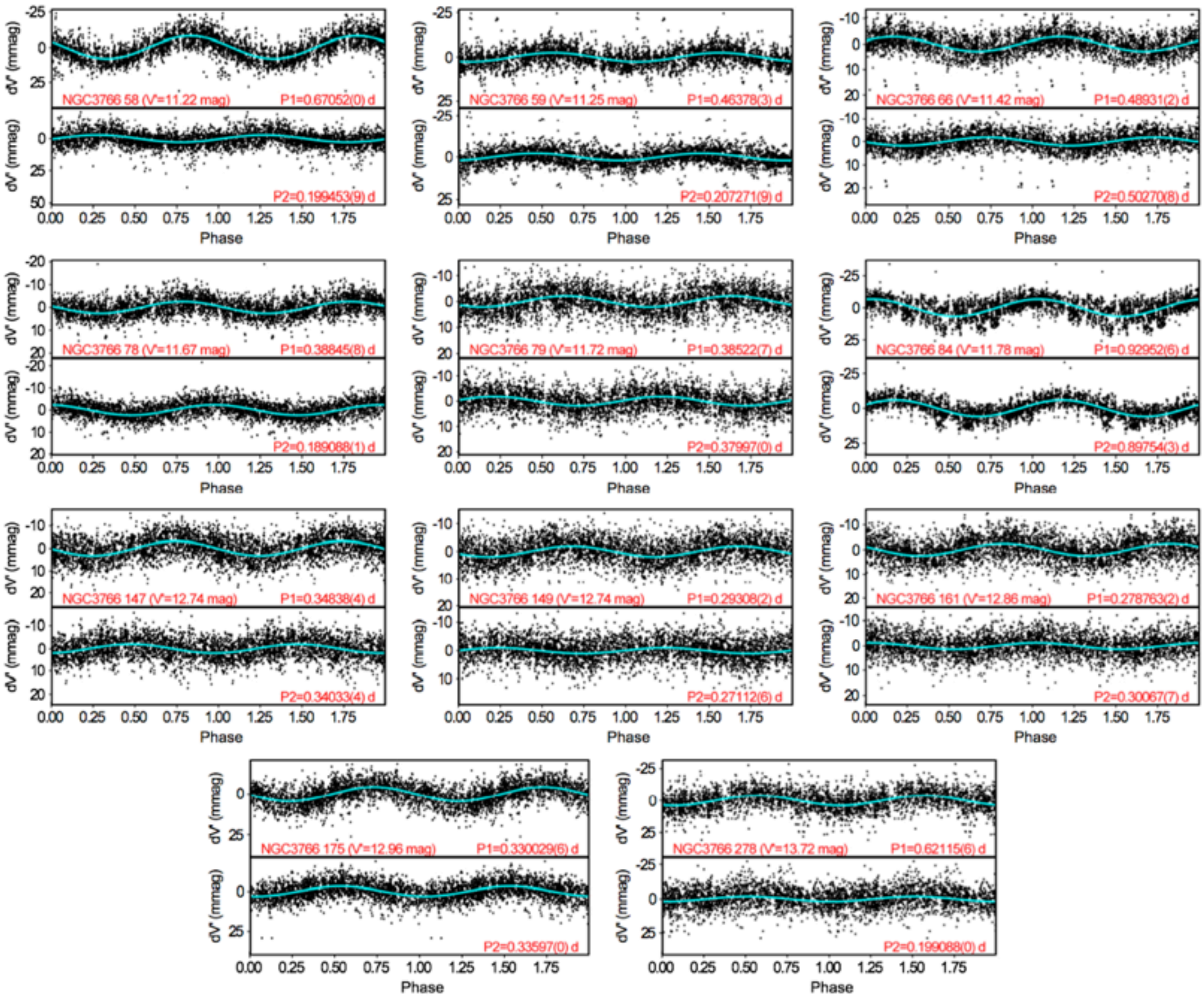
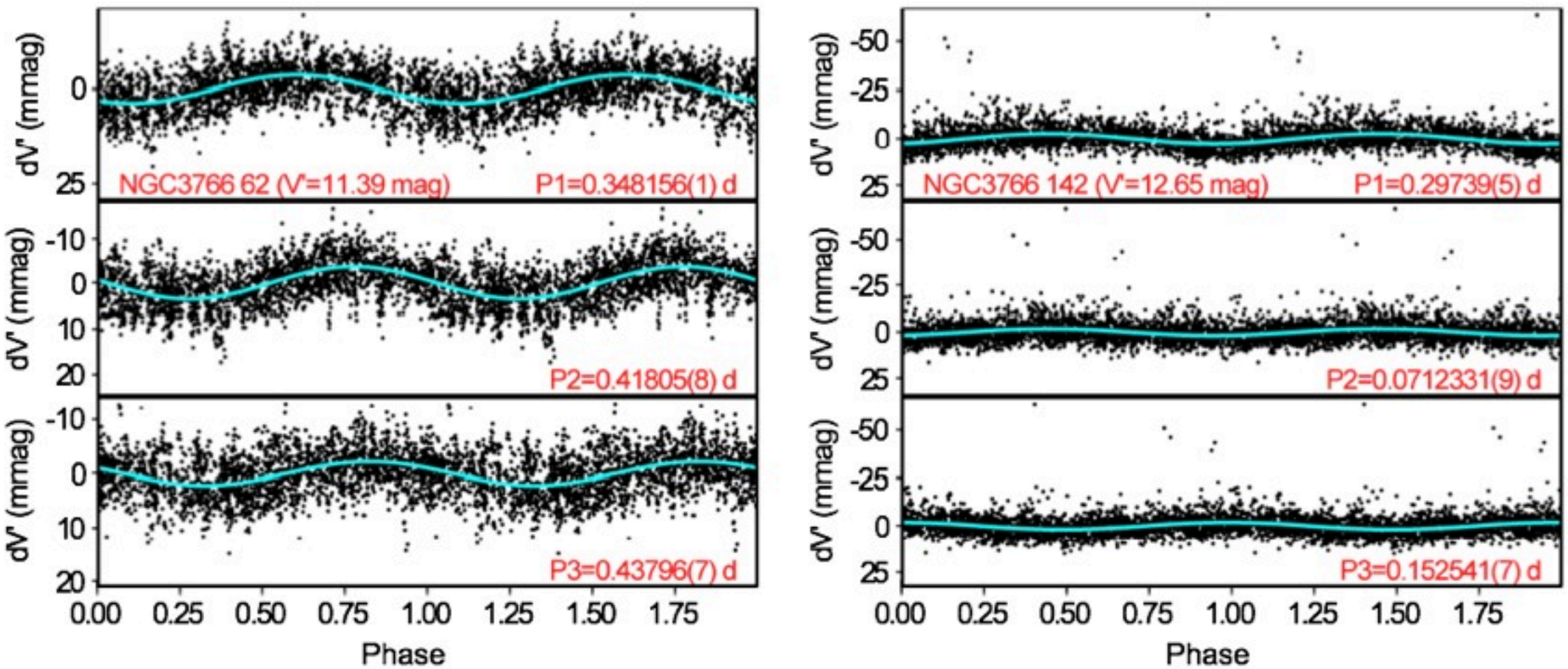
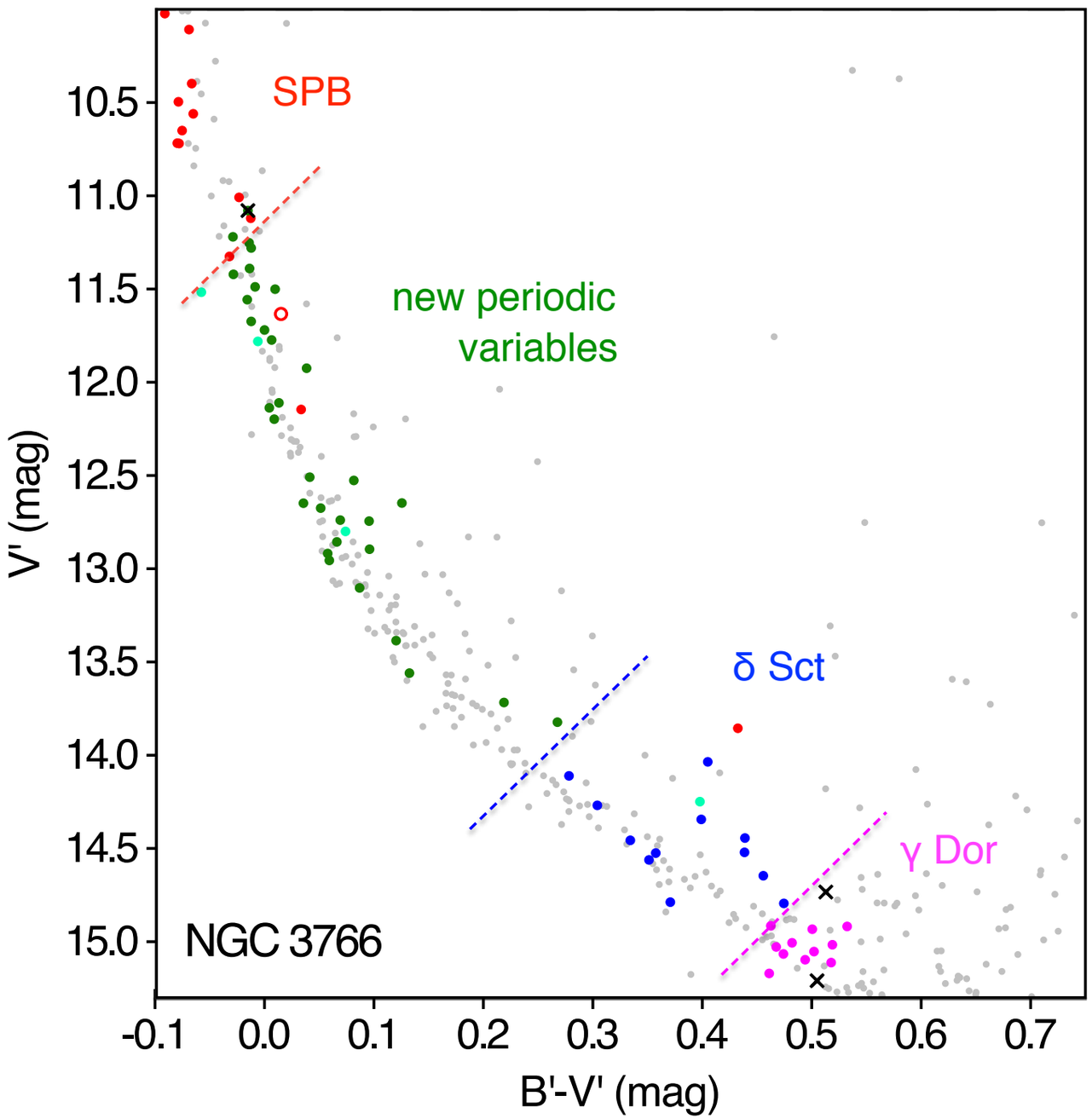


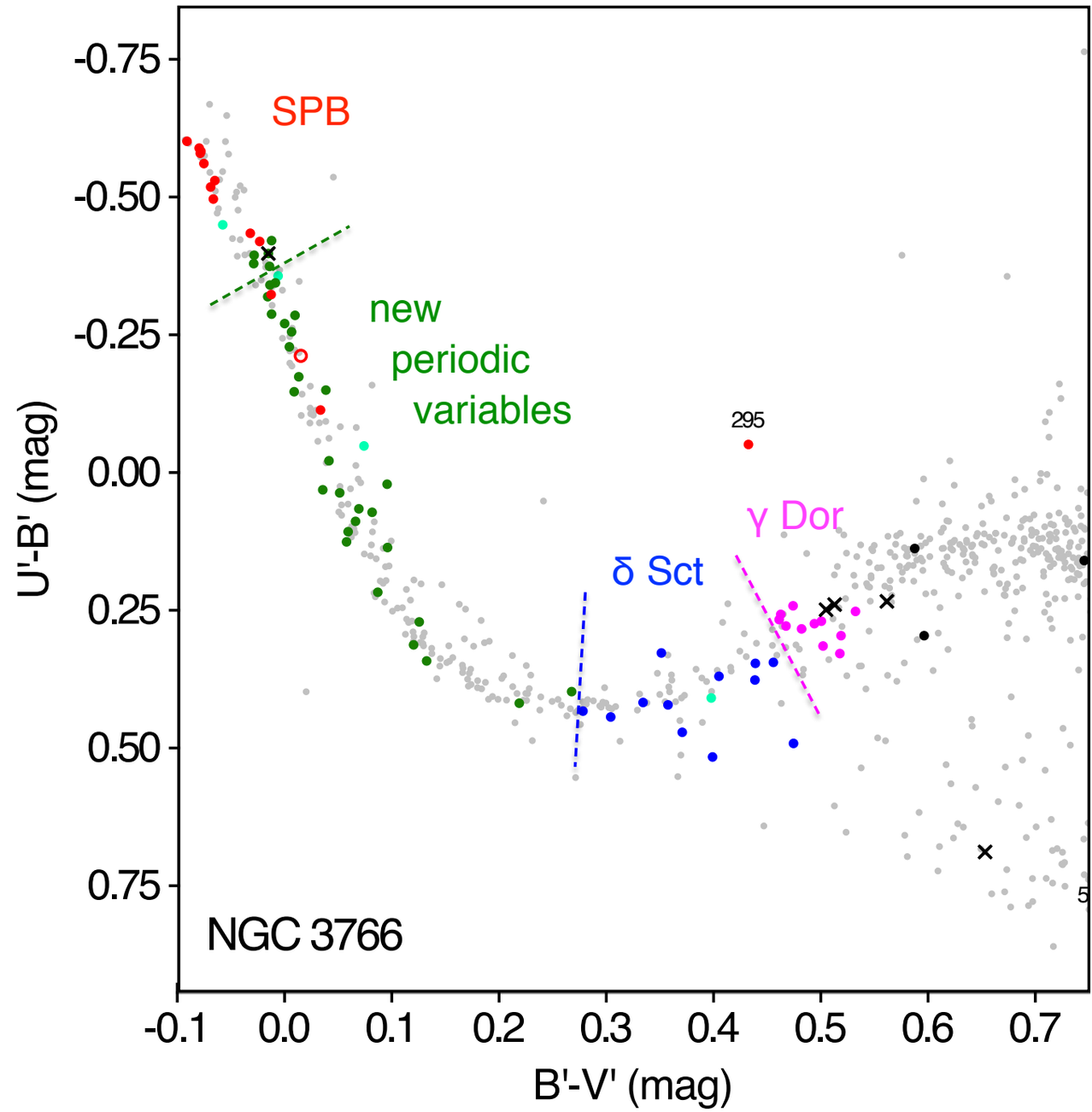
Fig. B.4. Same as Fig. B.2, but for the biperiodic variables of group 2.

Tri-periodics

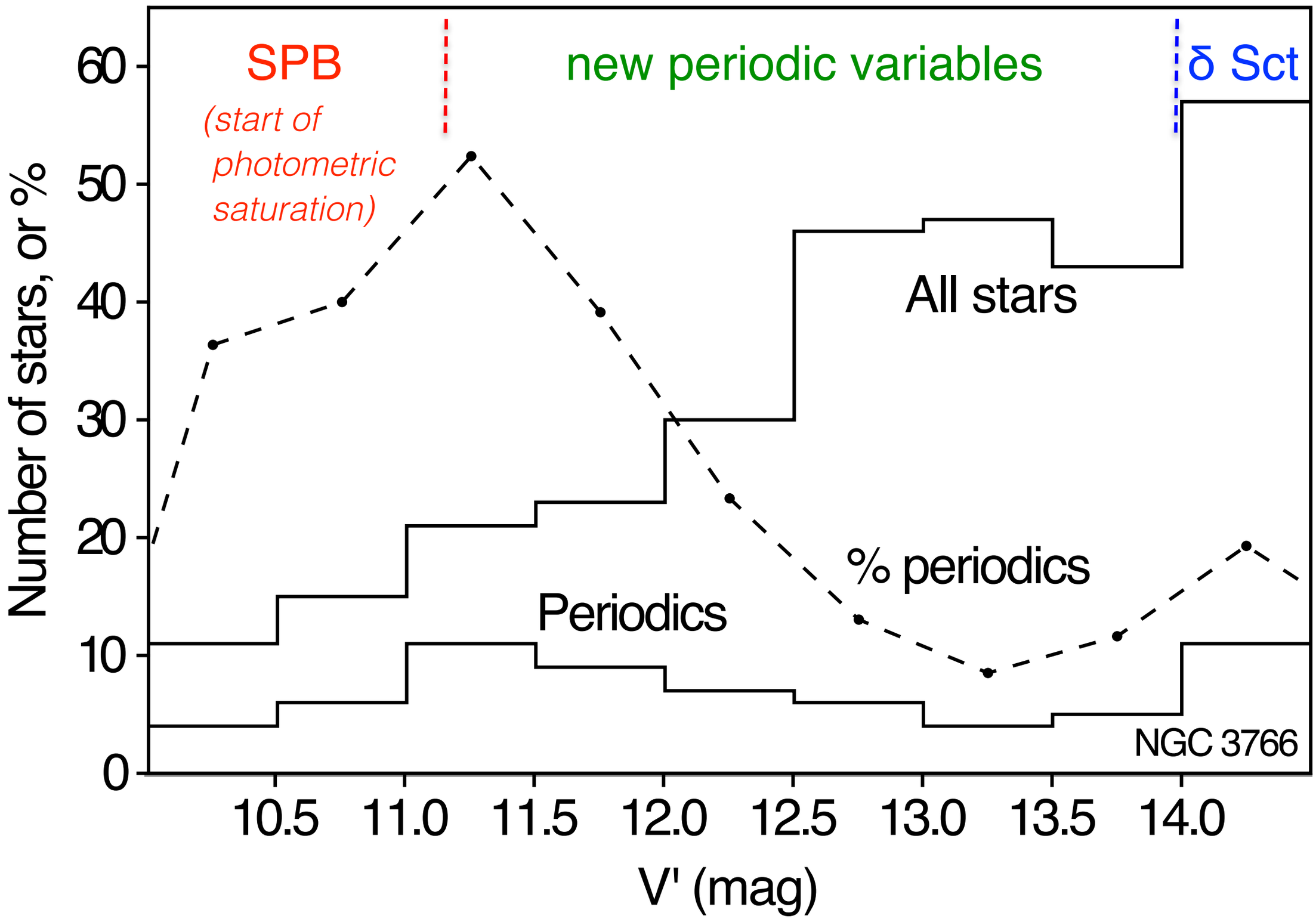


Properties of the new group

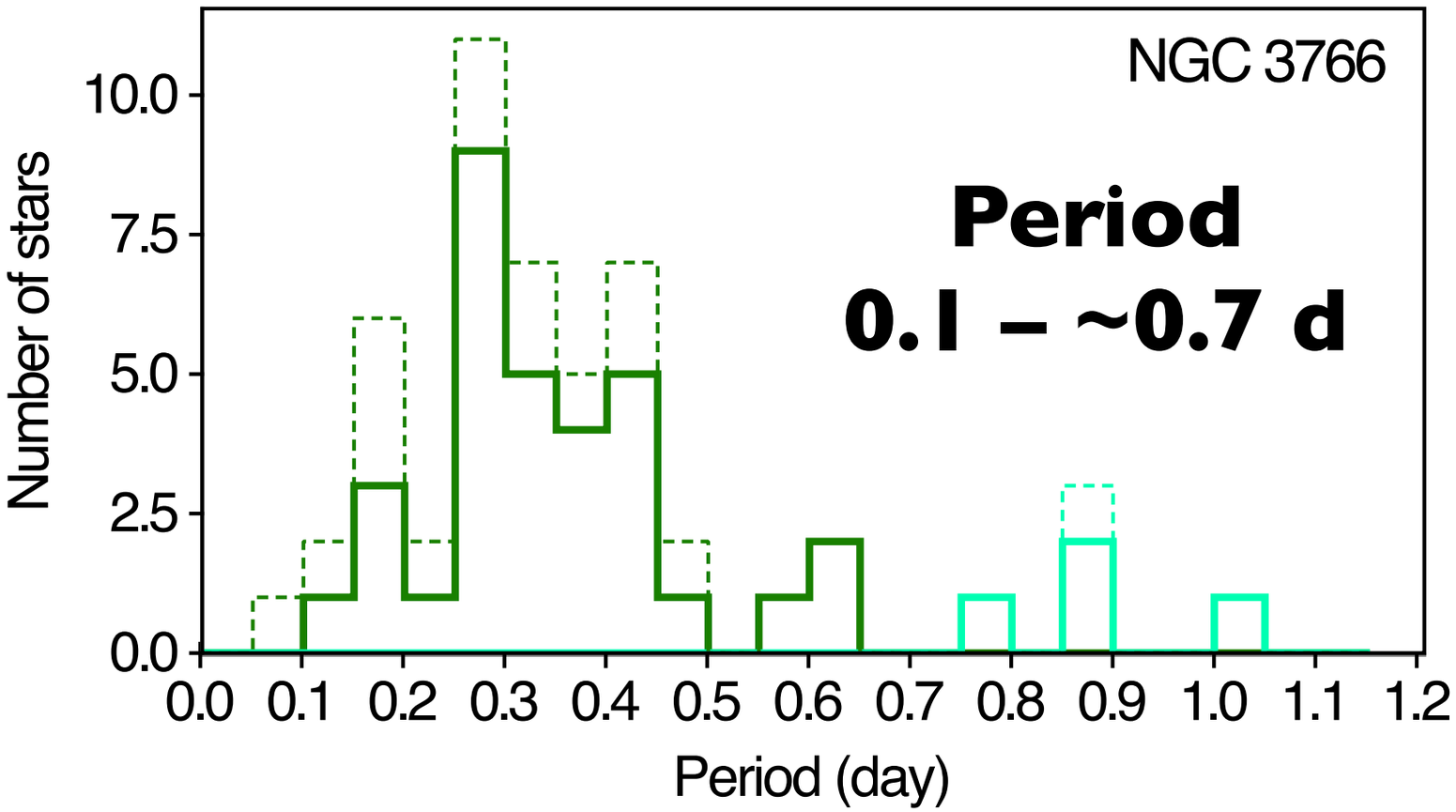


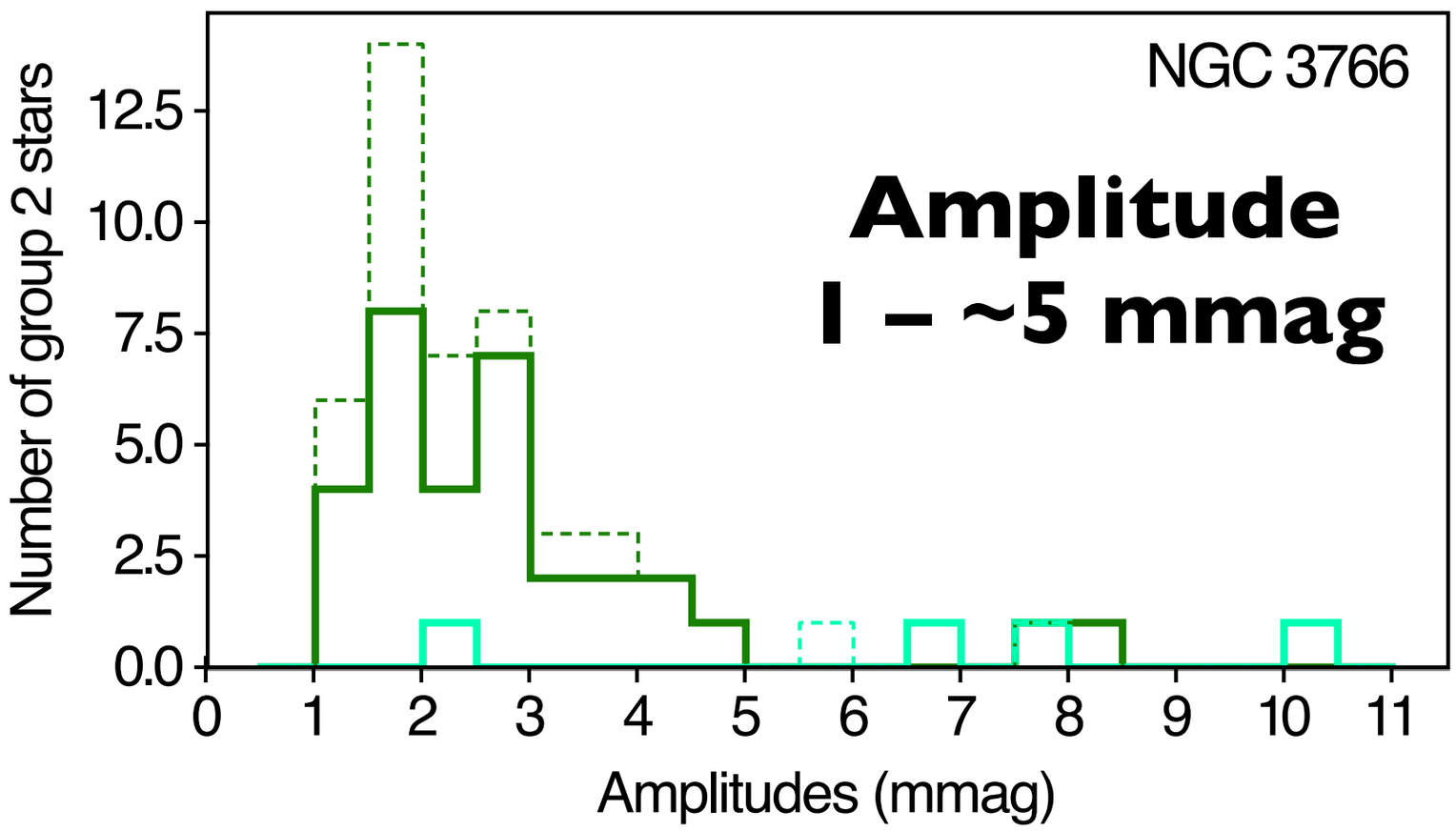


Properties of the new group



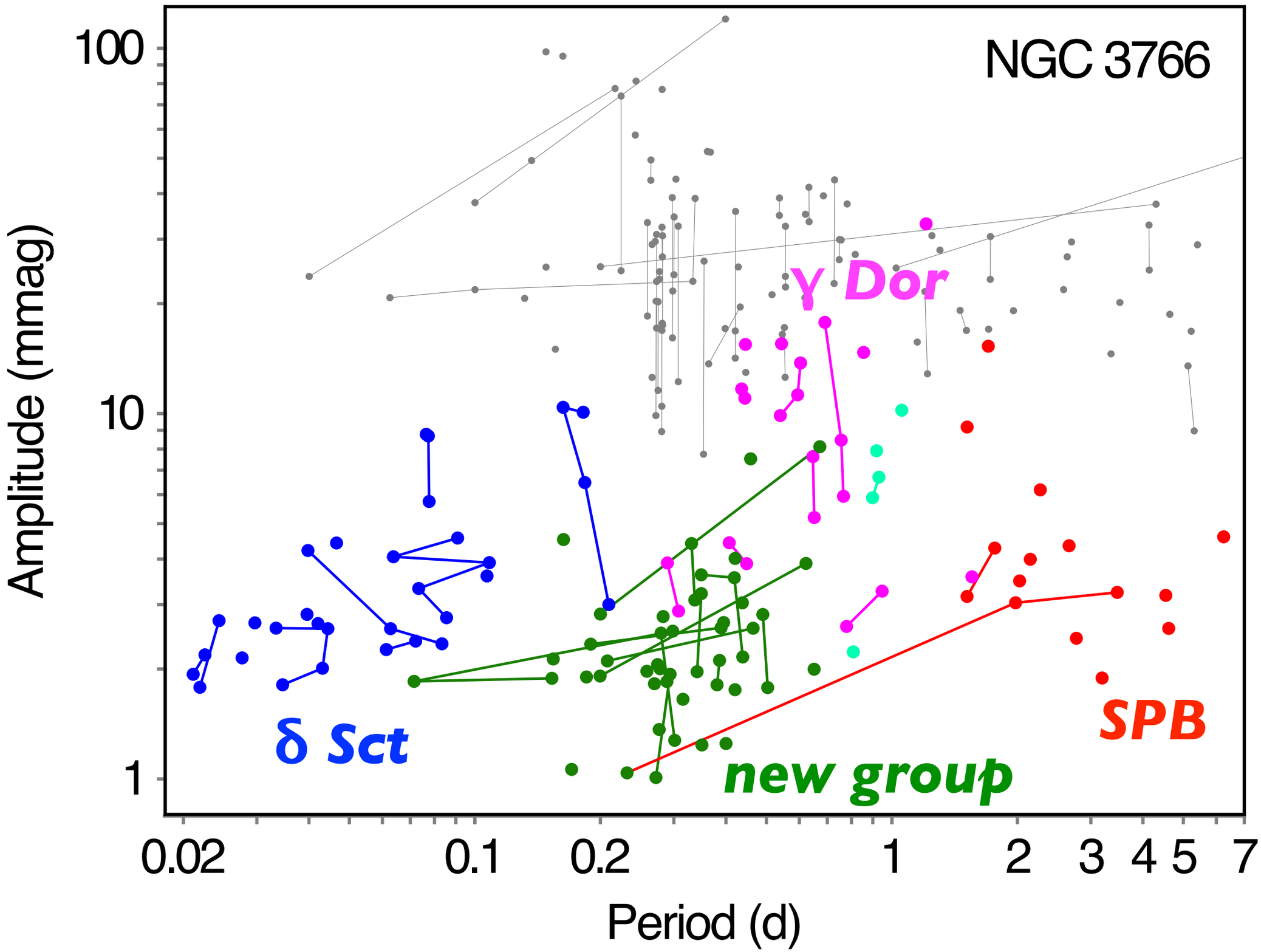
Properties of the new group



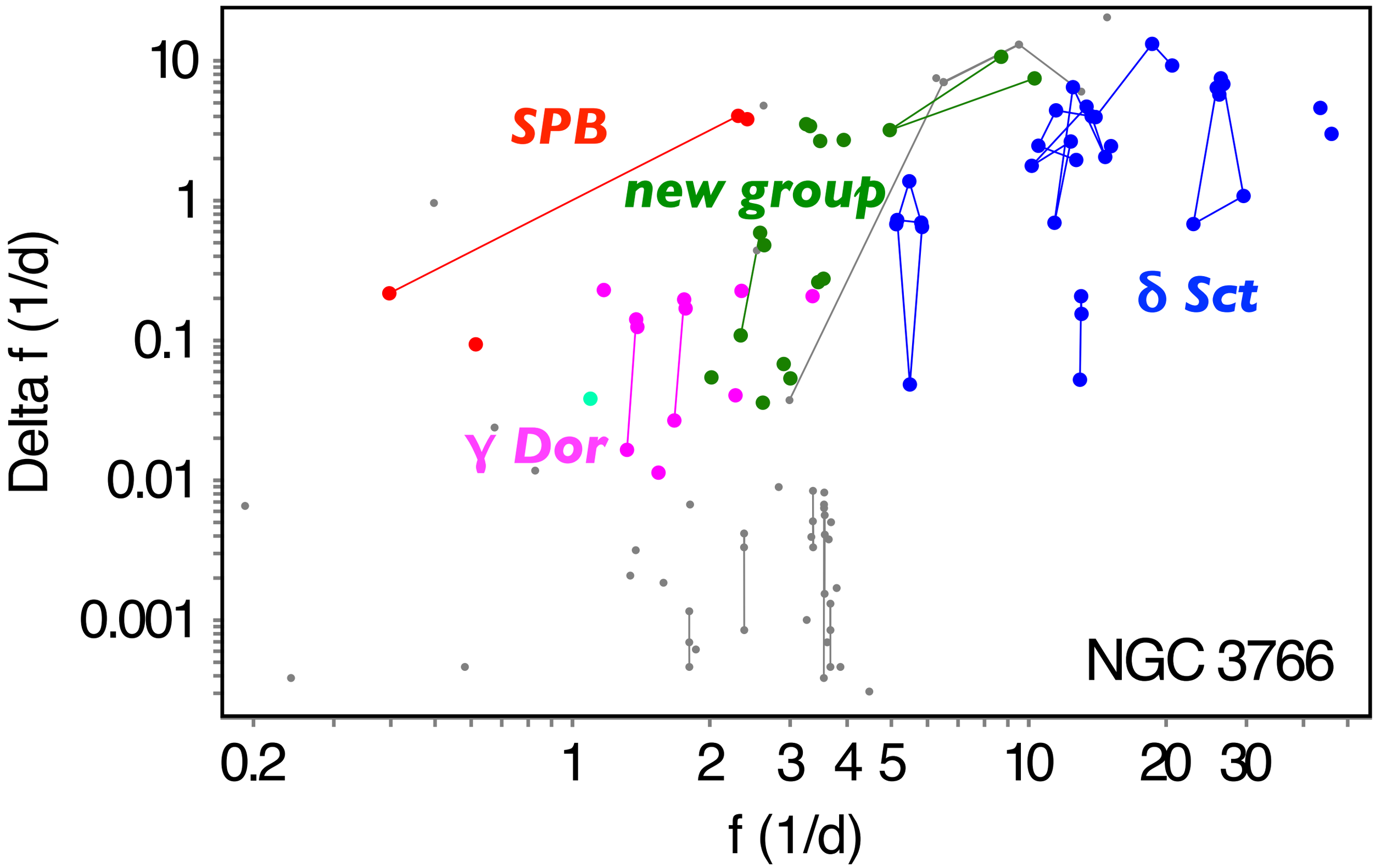


Limited by
photometric precision
→ ***extends below mmag***

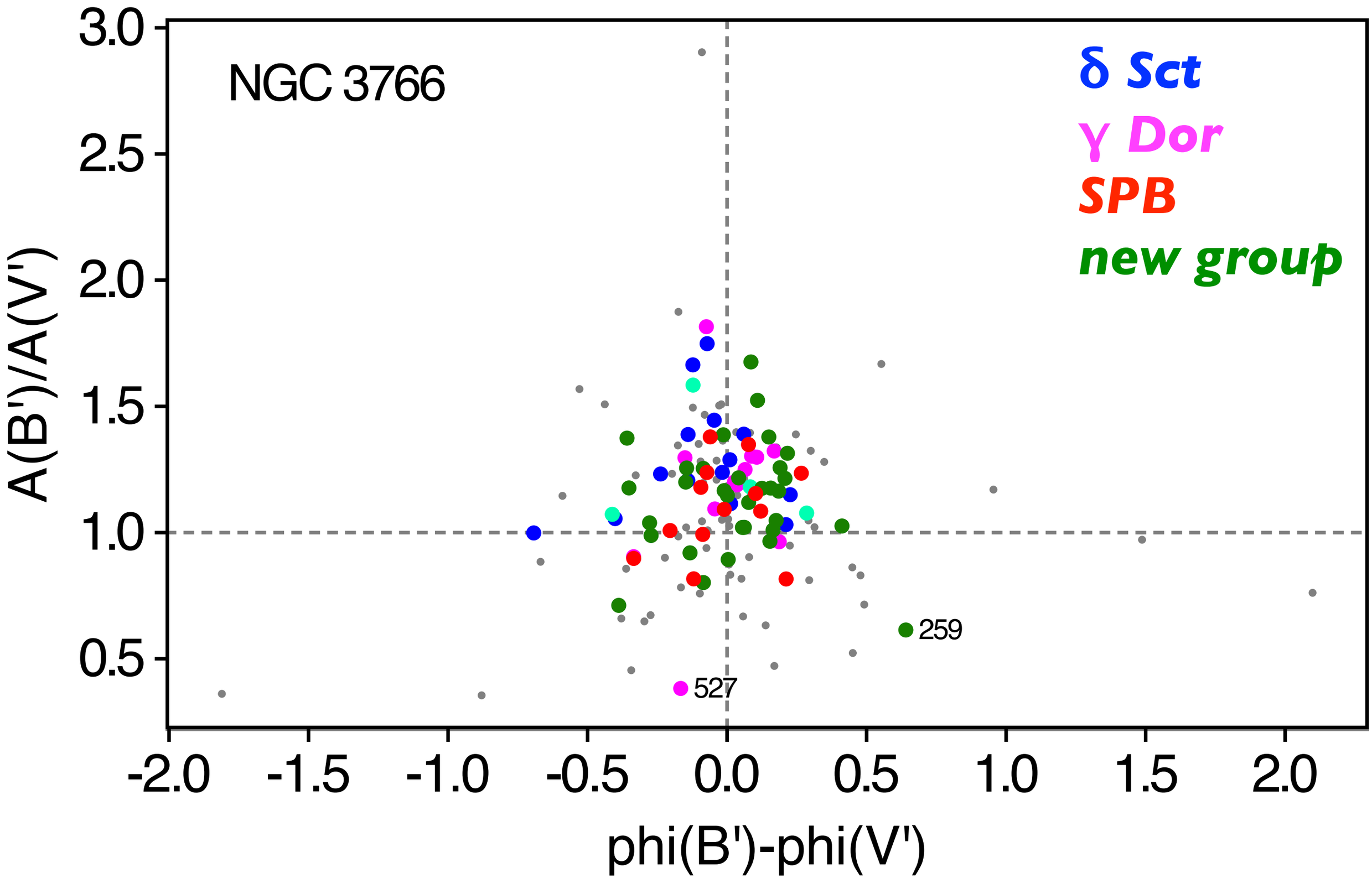
Period - amplitude diagram



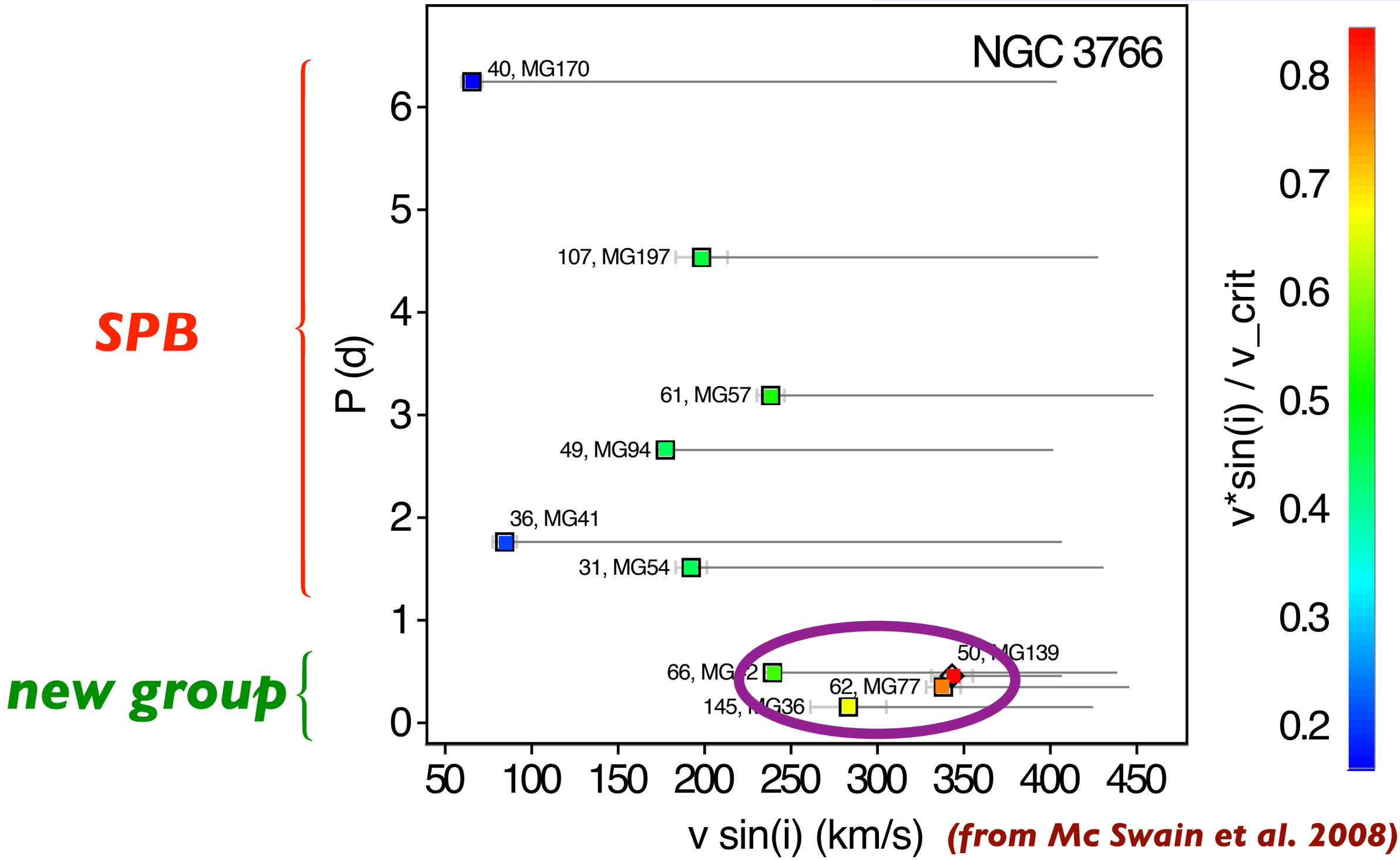
Multi-periodic stars



B and V band variability



Origin of variability ?



(from Mc Swain et al. 2008)

→ **High rotation rates** (>50% critical velocity)

In literature ?

* **Maia stars (?)**
  Struve (1955), ... , Scholz et al. (1998)

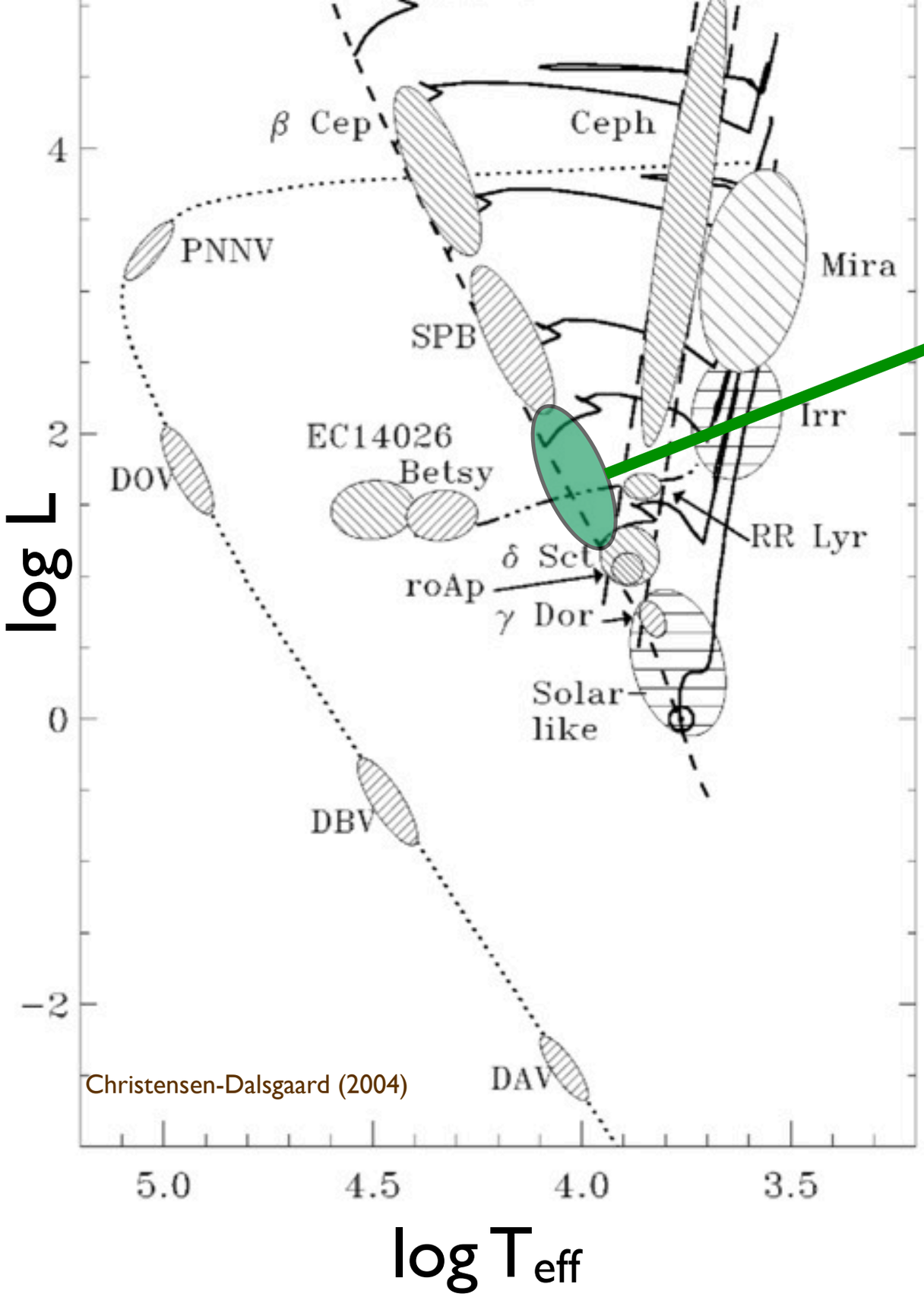
* **Individual stars**
  Ex: HD 121190 (Waelkens et al 1998, Aerts & Kolenberg 2005)

* **CoRoT** : yes, pulsation proposed (Degroote et al. 2009)
  But star characterization difficult

* **Kepler** : yes, spots proposed (Balona 2013)
  But star characterization difficult

Our work: *First detection in a cluster*

Summary



Low-amplitude periodic B A-type variable stars

Origin?

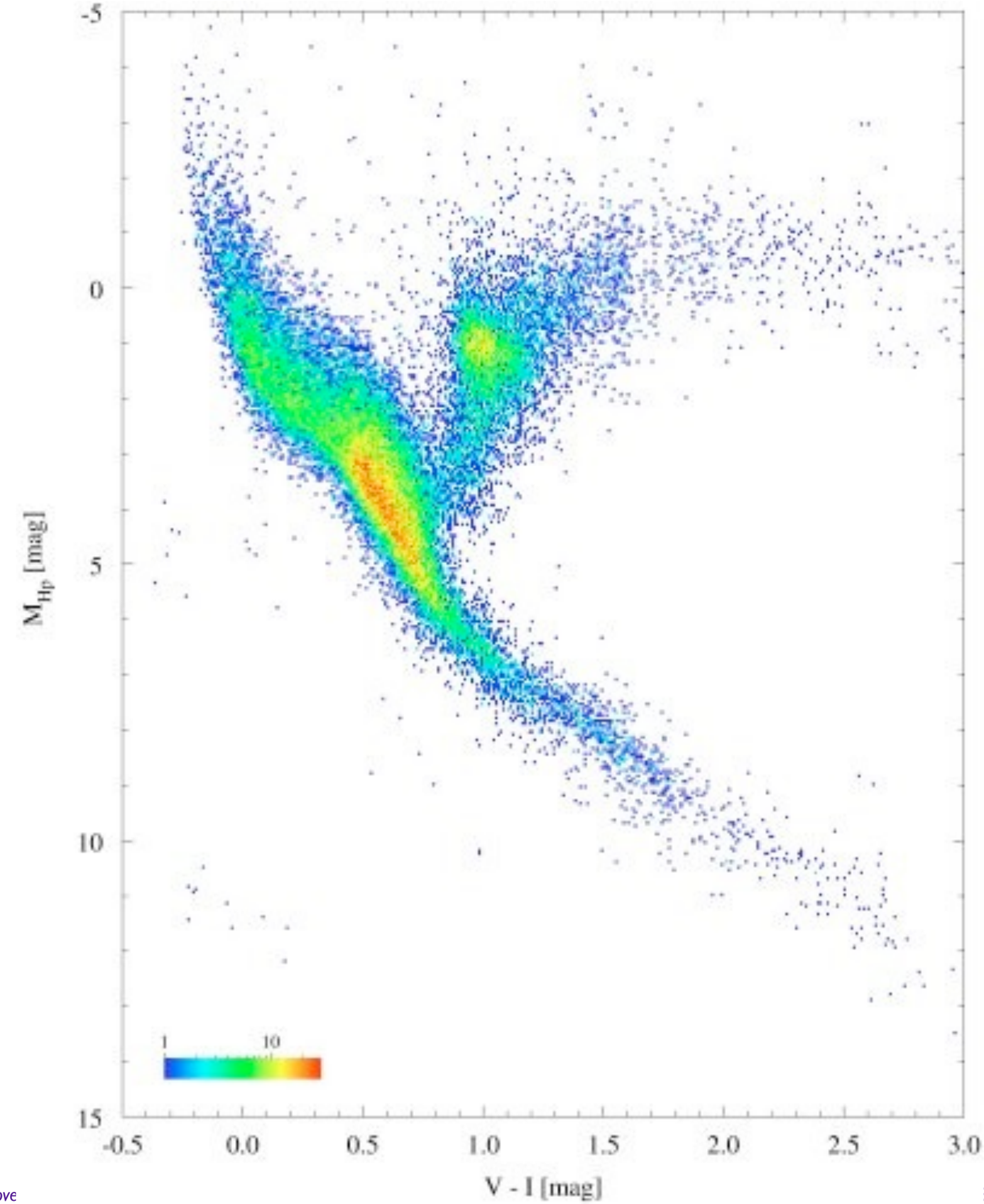
- **Pulsation (κ mechanism)?**
  But out of instability strips
  Sustained by fast rotation?
- **Spots?**
  But not expected in those stars
- **Binary (ellipsoidals)?**
  But multi-periodics

Clue:

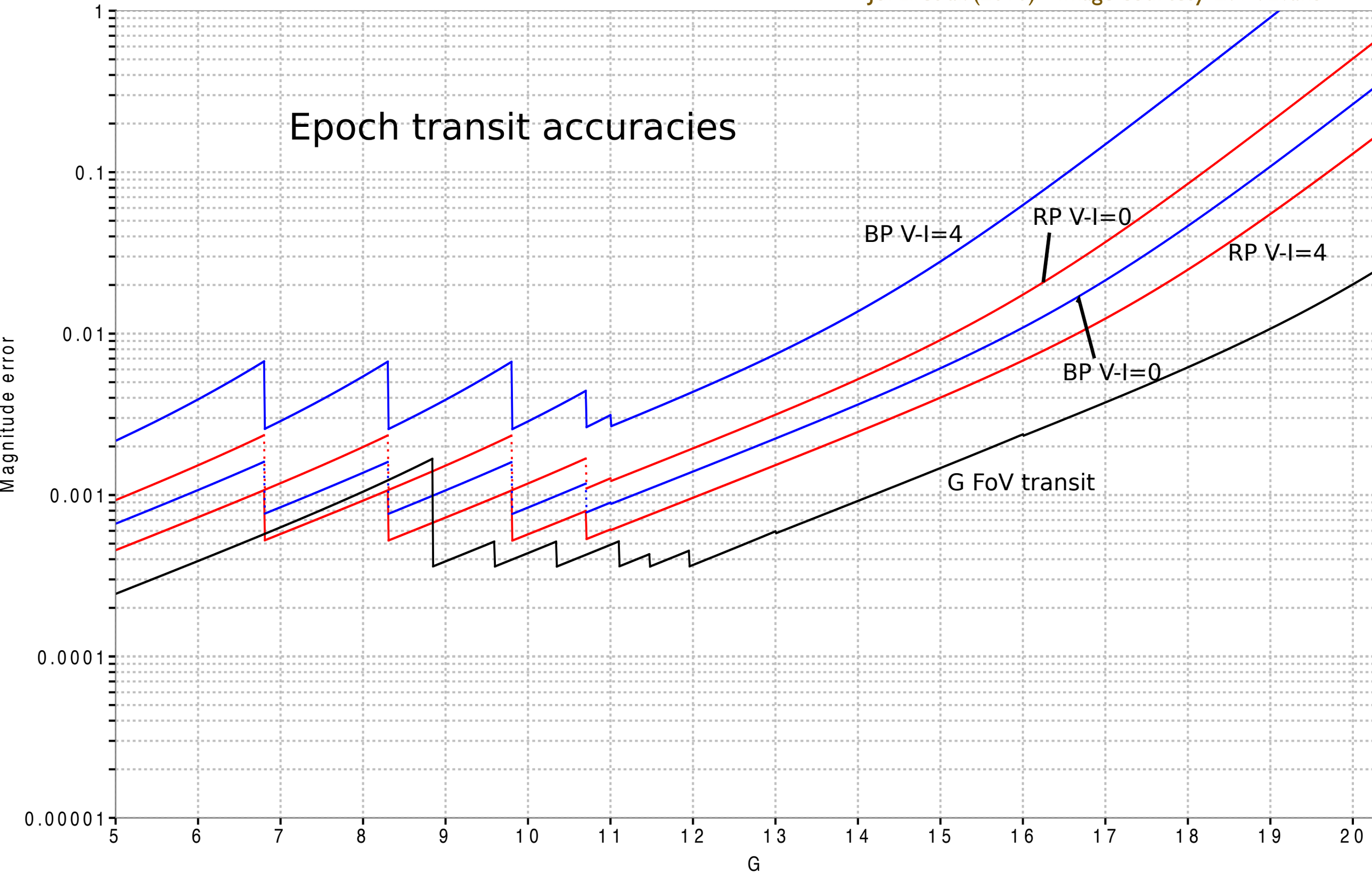
- Seem to be fast rotating

→ Importance of knowing stellar parameters

From
Hipparcos
to
Gaia

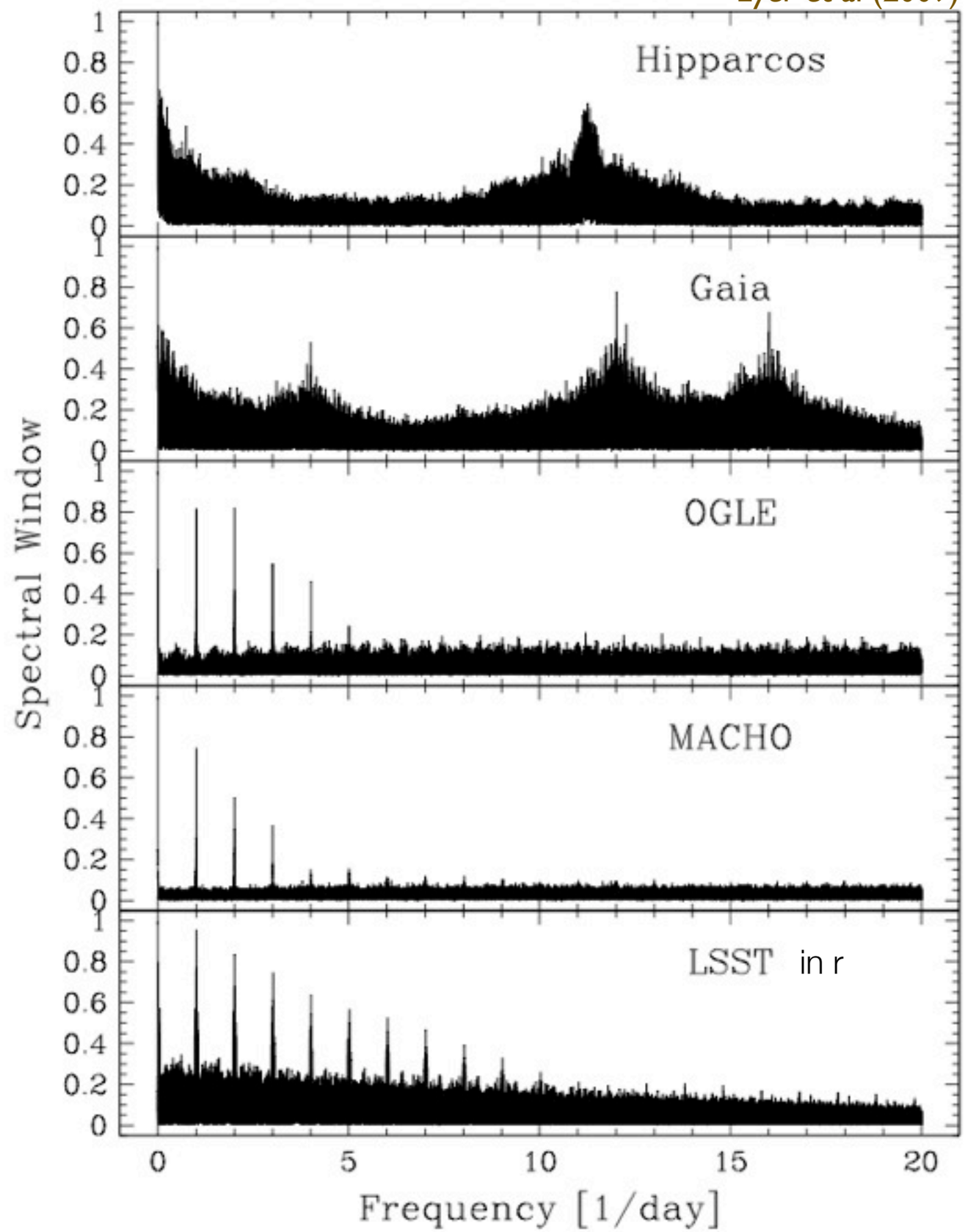


Jordi et al. (2010) - Image courtesy D.W. Evans



Spectral windows

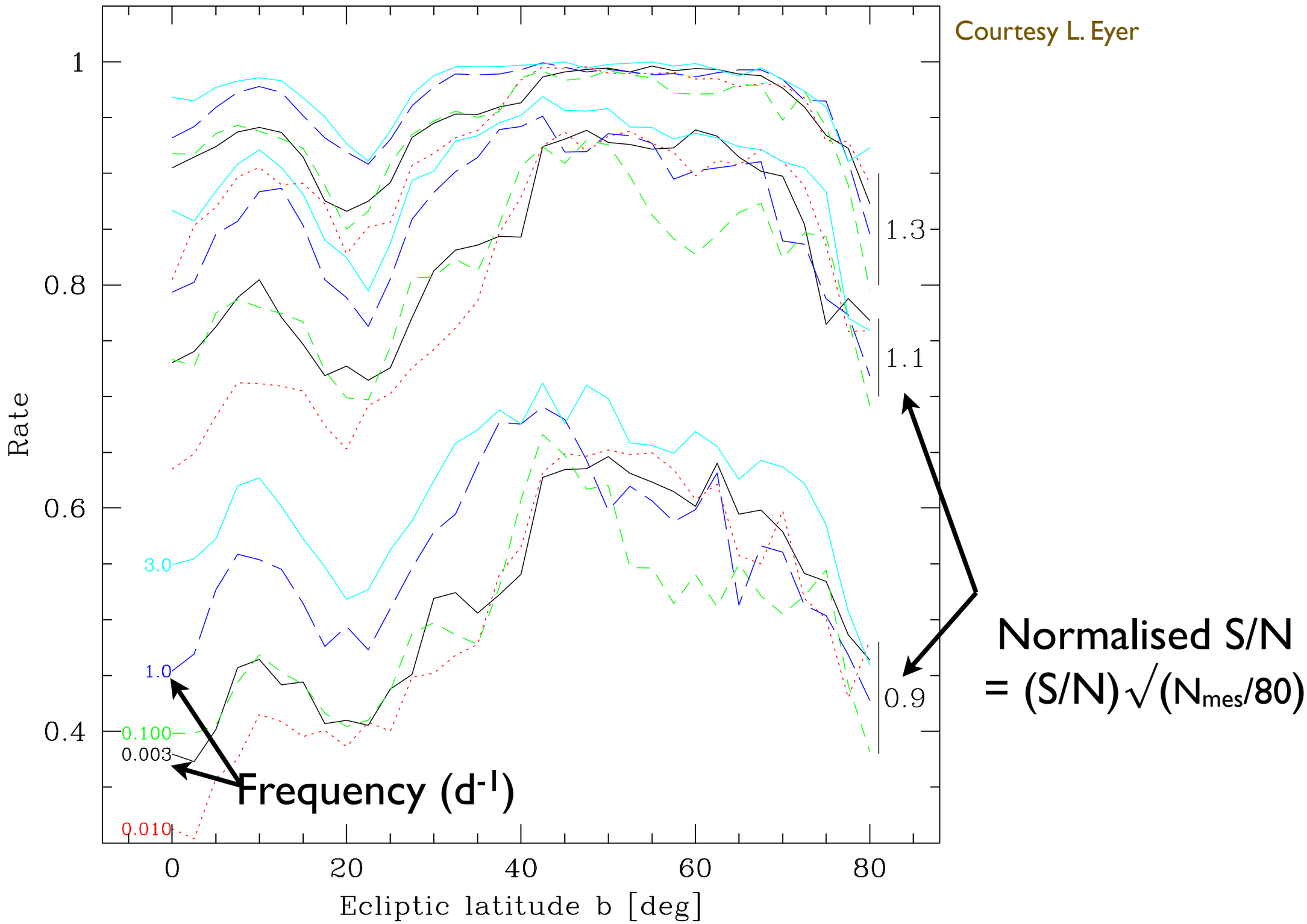
Eyer et al (2009)



Gaia aliases at high frequencies

→ frequencies below 10 c/d not expected to be much polluted

GAIA



1 mmag error →1.3 mmag signal recovered 97-100 %

GAIA

- **Multi-epoch** mission (mean ~75 measures/star over 5y)
- **~1 mmag** photometric uncertainty up to 14 mag in G
- Good **detection of periodic variables** with P<few days
- **Parallaxes** → accurate positioning in HR diagram
- Spectro-photometry → **two colors**
- Spectroscopy → **atmospheric parameters**, rotational velocities (for G_{RVS} > 12mag)
- **All-sky** survey