

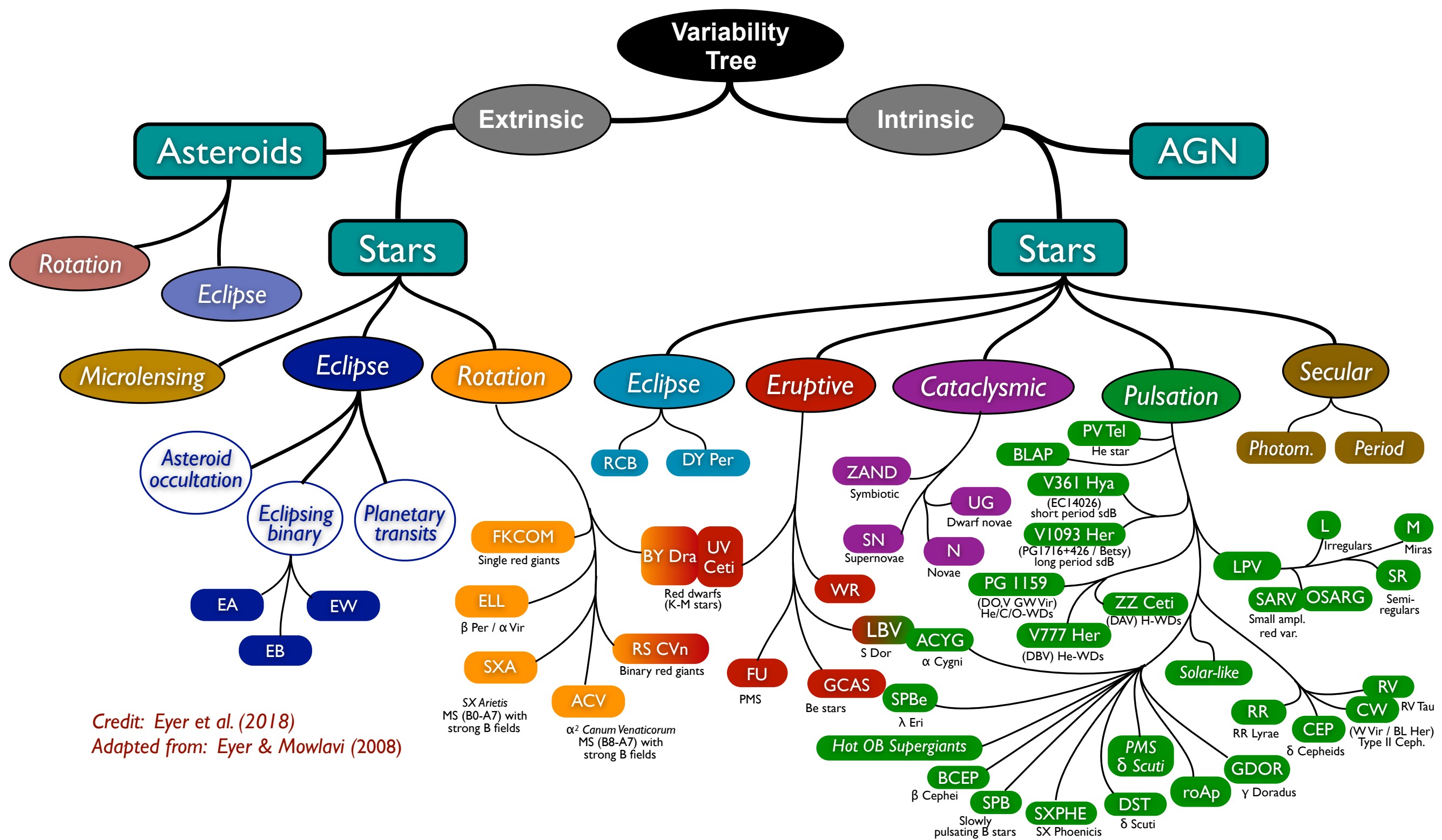


gaia

Classification of Gaia variable objects: DR2 vs DR3

Lorenzo Rimoldini
&
DPAC/CU7/DPCG

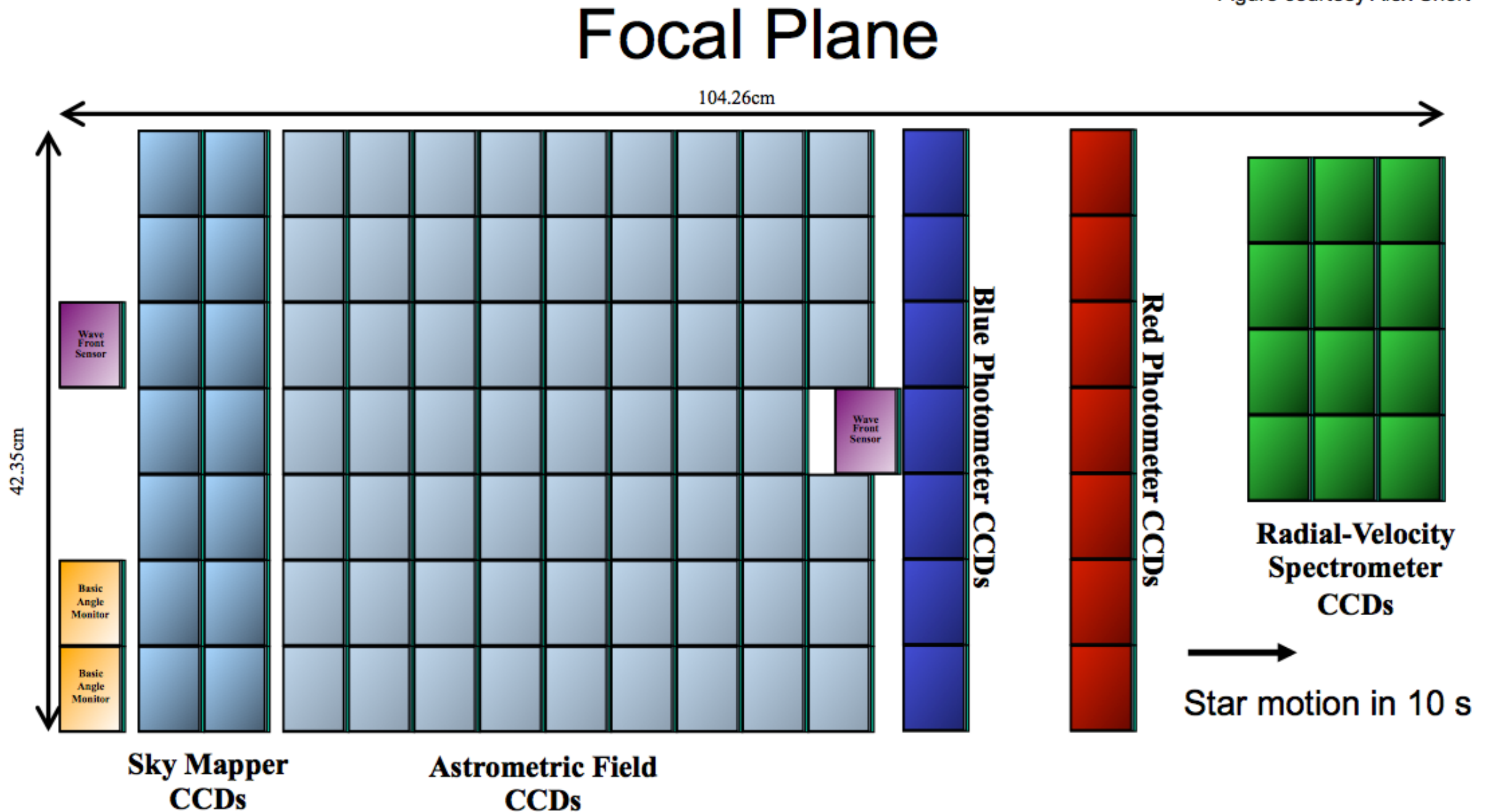
Gaia Science Alerts Workshop X
Catania, 18-20 December 2019



Credit: Eyer et al. (2018)
Adapted from: Eyer & Mowlavi (2008)

Gaia CCDs and Variability

Figure courtesy Alex Short



Total field:

- active area: 0.75 deg^2
- CCDs: $14 + 62 + 14 + 12 (+ 4)$
- 4500×1966 pixels (TDI)
- pixel size = $10 \mu\text{m} \times 30 \mu\text{m}$
= $59 \text{ mas} \times 177 \text{ mas}$

Sky mapper:

- detects all objects to $G=20 \text{ mag}$
- rejects cosmic-ray events
- field-of-view discrimination

Astrometry:

- total detection noise $\sim 4 e^-$

Photometry:

- spectro-photometer
- blue and red CCDs

Spectroscopy:

- high-resolution spectra
- red CCDs

gaia archive



- HOME
- SEARCH
- STATISTICS
- VISUALISATION
- DOCUMENTATION
- HELP

- Basic
- Advanced (ADQL)
- Query Results

gaia



- + Other
- + Gaia Data Release 1
- Gaia Data Release 2

- + Auxiliary
- + Cross match
- + Solar System

- Variability
 - +  gaiadr2.vari_cepheid
 - +  gaiadr2.vari_classifier_class_definition
 - +  gaiadr2.vari_classifier_definition
 - +  gaiadr2.vari_classifier_result
 - +  gaiadr2.vari_long_period_variable
 - +  gaiadr2.vari_rotation_modulation
 - +  gaiadr2.vari_rrlyrae
 - +  gaiadr2.vari_short_timescale
 - +  gaiadr2.vari_time_series_statistics

- +  gaiadr2.gaia_source
- +  gaiadr2.ruwe

Job name:

Query examples

1

Ctrl+Space for query autocompletion



Reset Form



Submit Query

No results found

Status	Job	Creation date	Num. rows	Size

1-1 of 0

Download format:

VOTable

Apply jobs filter

Filter this session

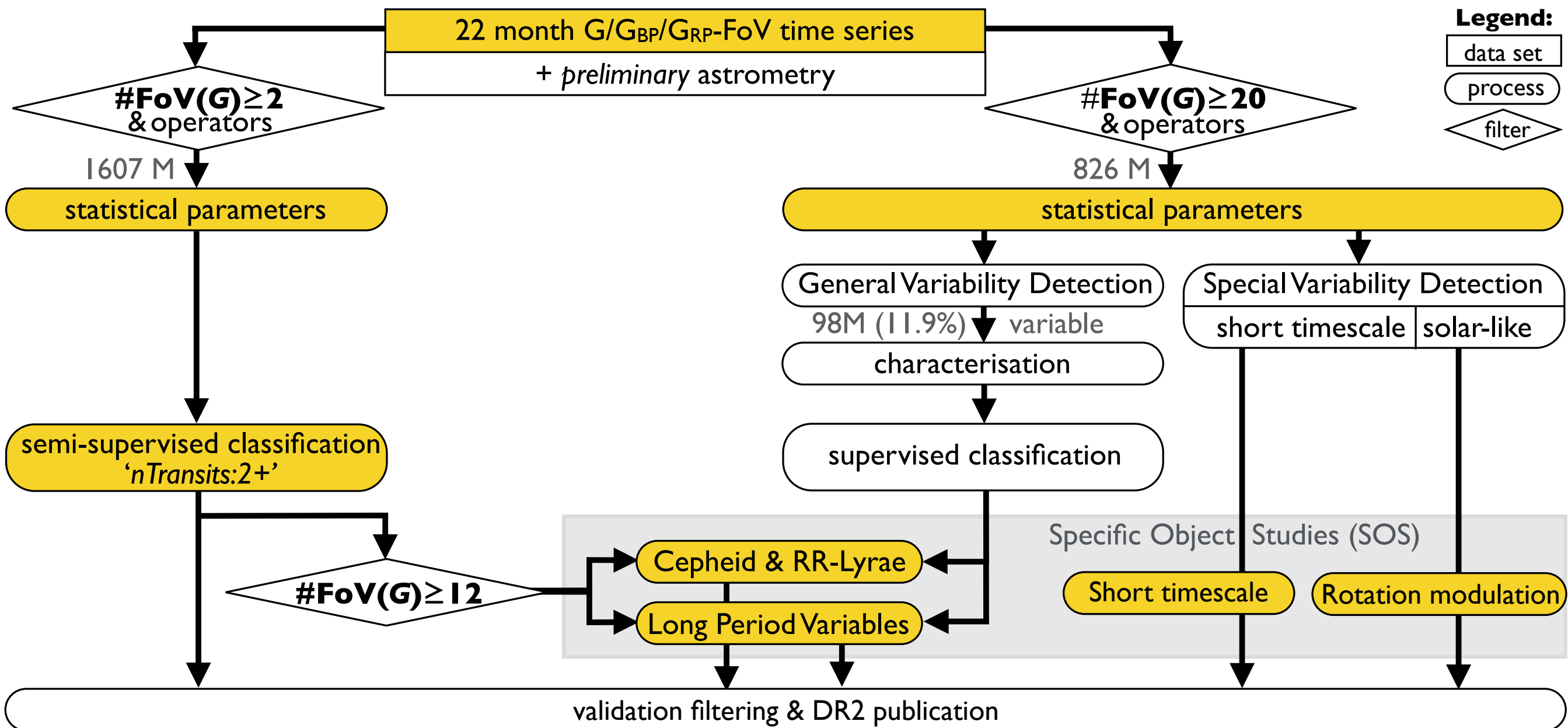


Select all jobs

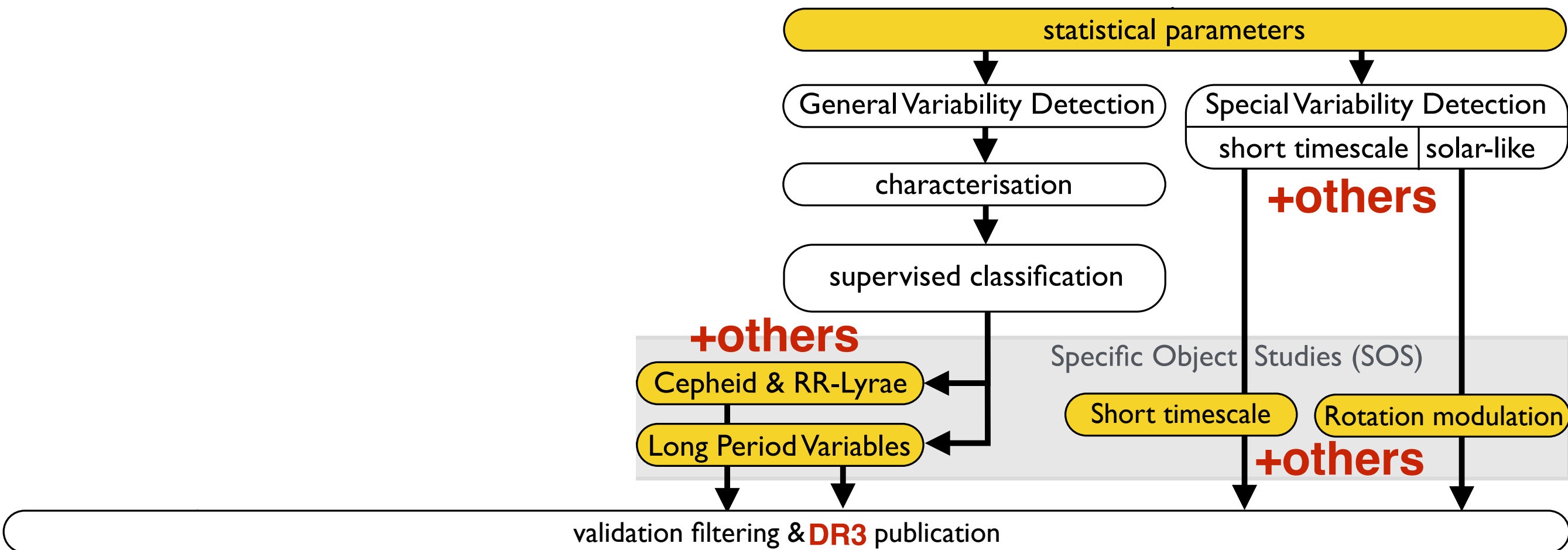


Delete selected jobs

Gaia DR2 (variables)



Gaia DR3 (variables)



Gaia DR2 Variability Results

		Classification (vari_classifier_result)		Specific Object Studies (SOS)		
		best_class_name	Total	Total Table name		
8 882	δ Scuti & SX Phoenicis	DSCT_SXPHE	8 882			
228 904	RR Lyrae stars	RRAB, RRC, RRD, ARRD	195 780	88 120	107 660	140 784 vari_rrlyrae
11 438	Cepheids	CEP, ACEP, T2CEP	8 550	1 863	6 687	9 575 vari_cepheid
151 761	Long period variables	MIRA_SR	150 757	62 144	88 613	89 617 vari_long_period_variable
3 018	Short timescale variables					3 018 vari_short_timescale
147 535	Rotation modul. (BY Dra) stars					147 535 vari_rotation_modulation
+ (550 737 unique source_id)						+
551 538			363 969 (all unique source_id)			390 529 (390 449 unique source_id)

~160K additional sources
rejected / not confirmed by SOS
with time series (G, BP, RP)

Gaia Classifications (DR2)

CLASSIFICATIONS IN SPECIFIC OBJECT STUDIES

Literature

	ACEP	AGN	ARRD	BCEP	BE	BLAP	BY	CEP	CST	CV	DSCT	DSCT_SXPHE	ECL	ELL	GALAXY	GCAS	HMXB	L	LPV	LSP	MICROLENSING
ACEP	56							114					1								
ARRD			6																		
CEP	21							5258					4			2		3		1	
DSCT_SXPHE																					
MIRA_SR								7					24	4				148	2172	262	2
RRAB	77	5	2				2	352			4		47		24						
RRC								17					298								
RRD			1					3					7								
T2CEP	1							517					11			2			15	1	

	MIRA	OSARG	PPN	R	RCB	ROT	RRAB	RRC	RRD	RRLYR	RS	RV	SARG	SDOR	SOLAR_LIKE	SR	SRD	SXPHE	SYSt	T2CEP	WD	YSO	ZAND
ACEP							14													26			
ARRD							8	24	1														
CEP						1	13	1				7				4			2	47			
DSCT_SXPHE																							
MIRA_SR	3687	2269			3	2	3	1	1		4	1	102		4	4155	1		32	2		58	
RRAB						2	41023	355	330	1161	2							1		75	34	2	
RRC							394	9655	600	116	11									2	9	1	
RRD							46	169	110	17	1										2		
T2CEP					1	25					4	45				12	7			215		11	

CLASSIFICATIONS NOT IN SPECIFIC OBJECT STUDIES

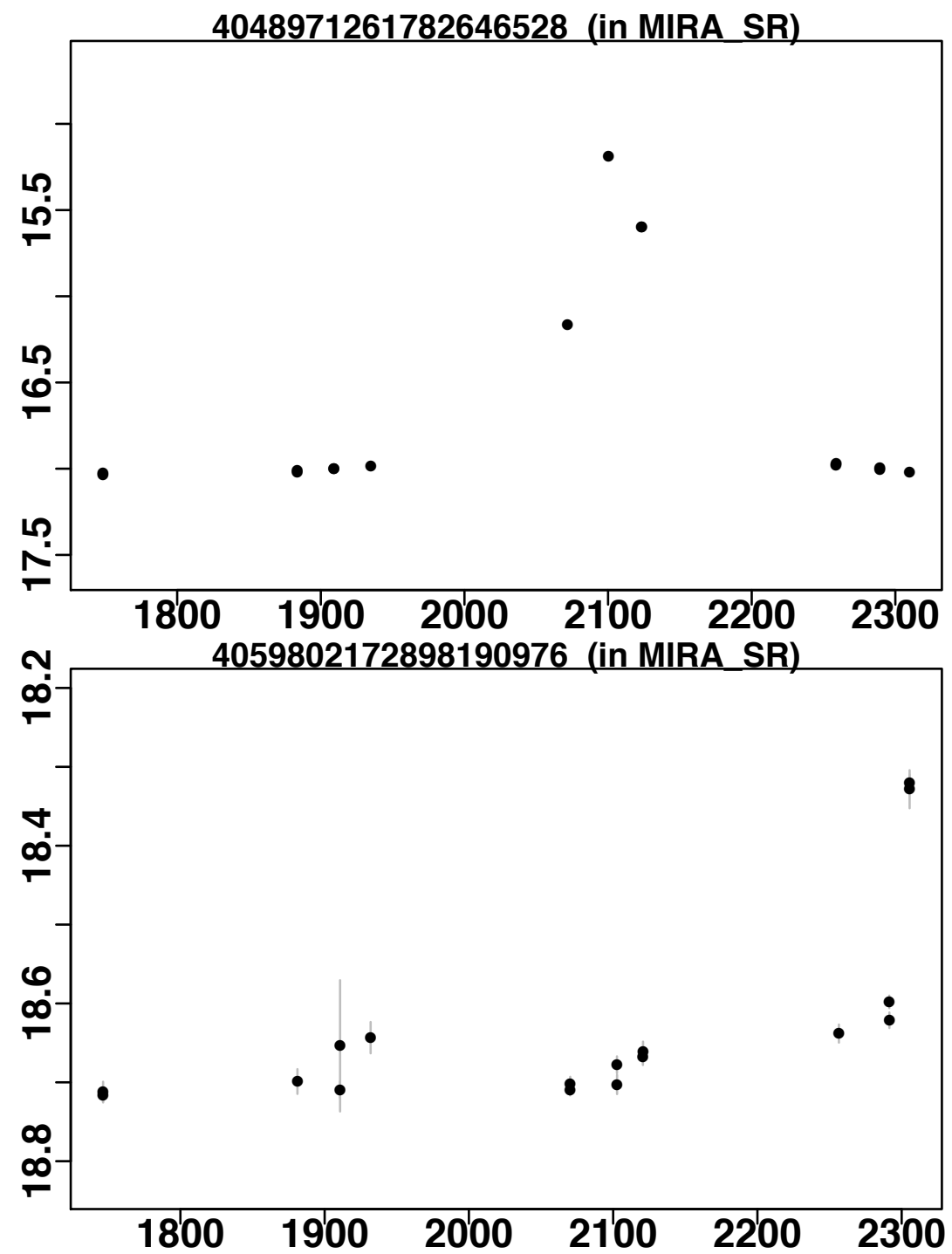
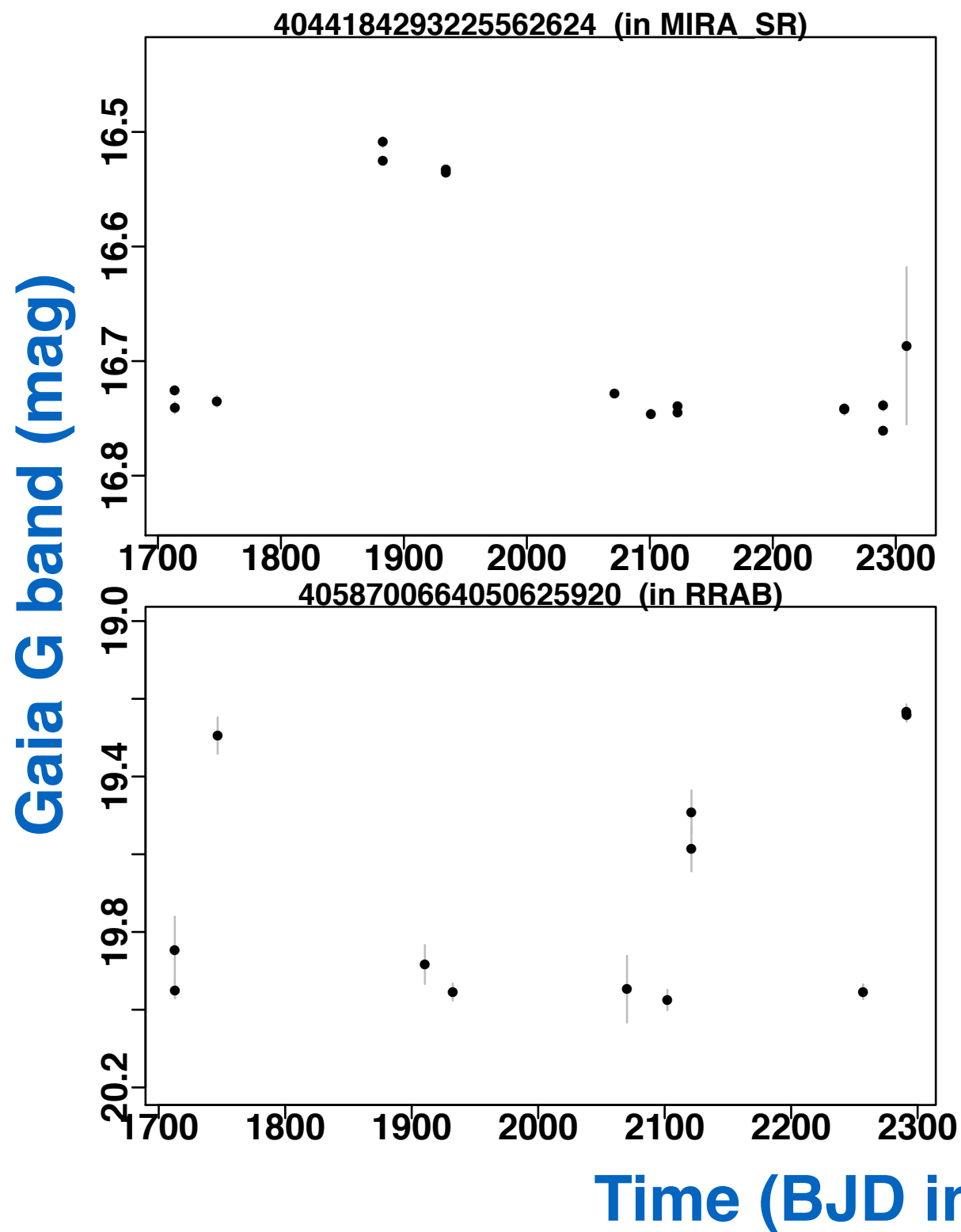
Literature

Gaia Classifications (DR2)

	ACEP	AGN	ARRD	BCEP	BE	BLAP	BY	CEP	CST	CV	DSCT	DSCT_SXPHE	ECL	ELL	GALAXY	GCAS	HMXB	L	LPV	LSP	MICROLENSING
ACEP	41							15					1								
ARRD		9	11										1								
CEP	5							789					12			3		20		2	
DSCT_SXPHE		453				10			3	1	501	1803	86	1							
MIRA_SR				1	1			53					45	3				54	910	197	1
RRAB	52	36	1					148		2	31		476	5	250						2
RRC	1	3						11			24		333	1							
RRD		2	1					2			2		6								
T2CEP								90					25			7	1	14	15		

	MIRA	OSARG	PPN	R	RCB	ROT	RRAB	RRC	RRD	RRLYR	RS	RV	SARG	SDOR	SOLAR_LIKE	SR	SRD	SXPHE	SYSt	T2CEP	WD	YSO	ZAND
ACEP							1													2			
ARRD							3	1	3														
CEP					2	2	1					2	1	1		9	3		3	7		1	1
DSCT_SXPHE							1	23			1							5			30		
MIRA_SR	189	2077			1	7	3				5	1	148			3422	1		18	30		103	
RRAB				1		3	18003	160	218	1	1									38	20		
RRC							103	713	122											2	9		
RRD							19	42	108												1		
T2CEP		1	1			10						13			1	73	10		1	145		25	

MICROLENSING EVENTS



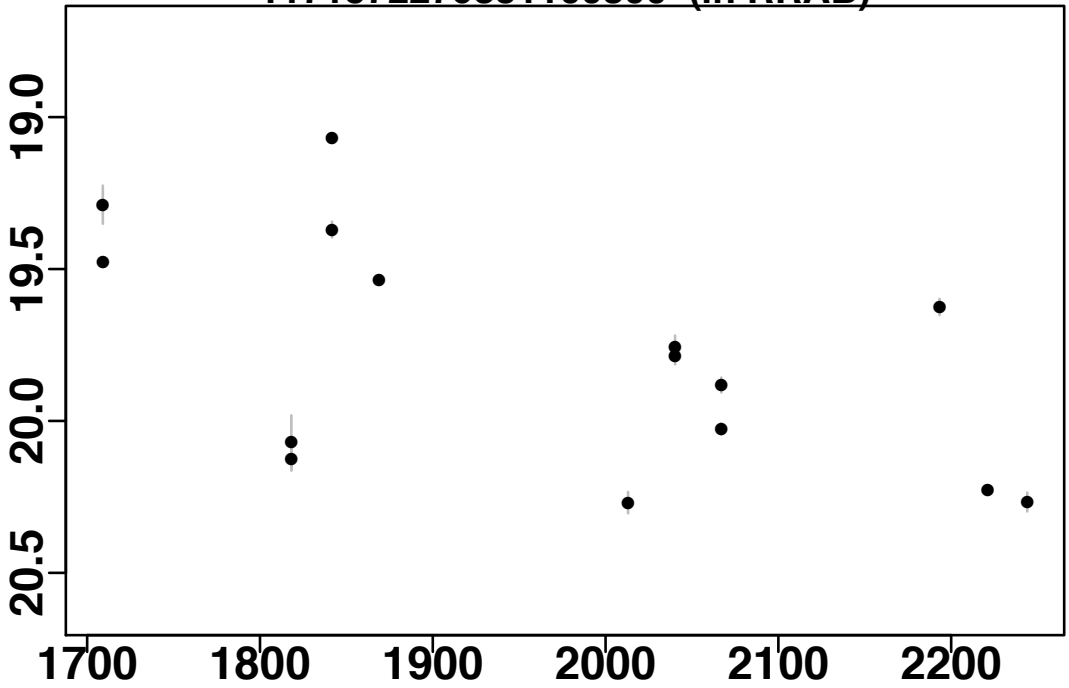
ACTIVE GALACTIC NUCLEI

Blazar

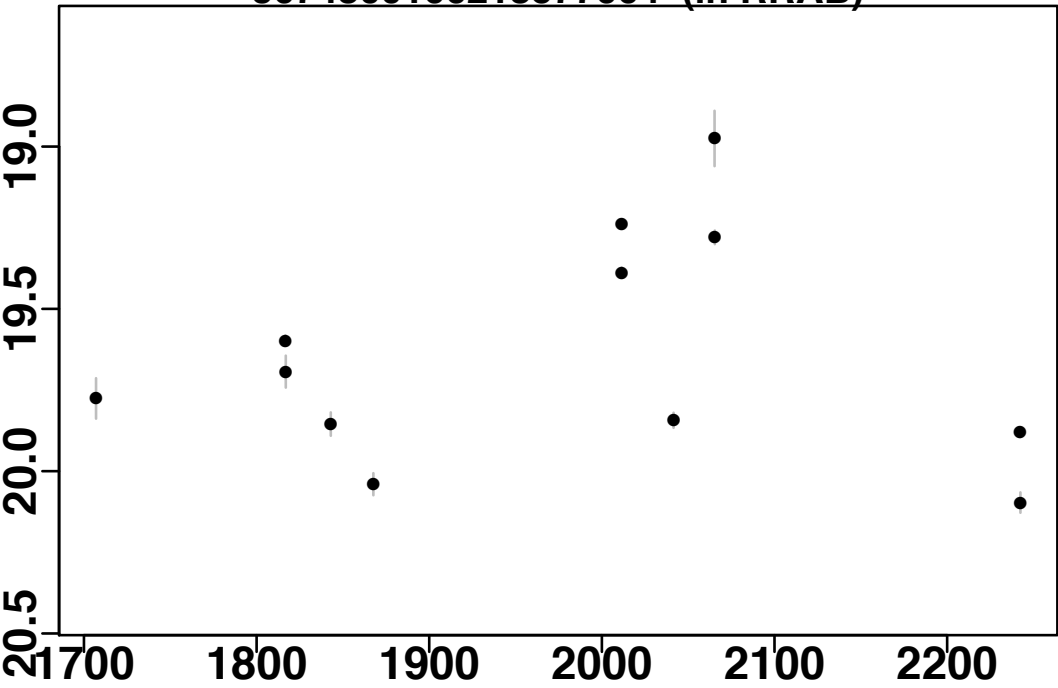


Gaia G band (mag)

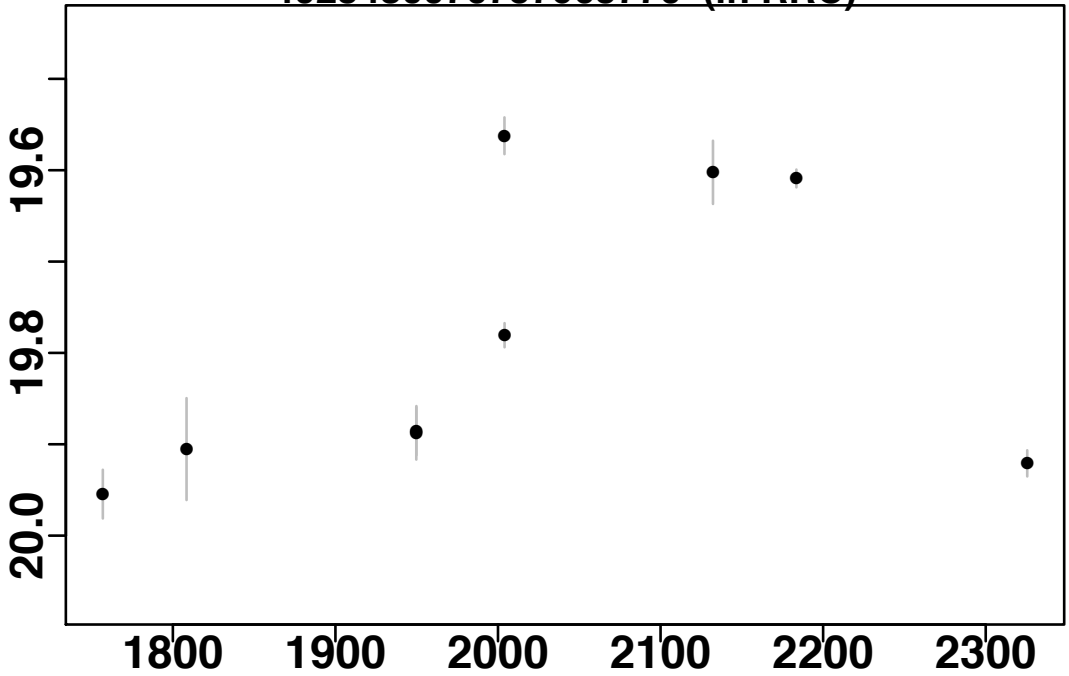
1171572279831100800 (in RRAB)



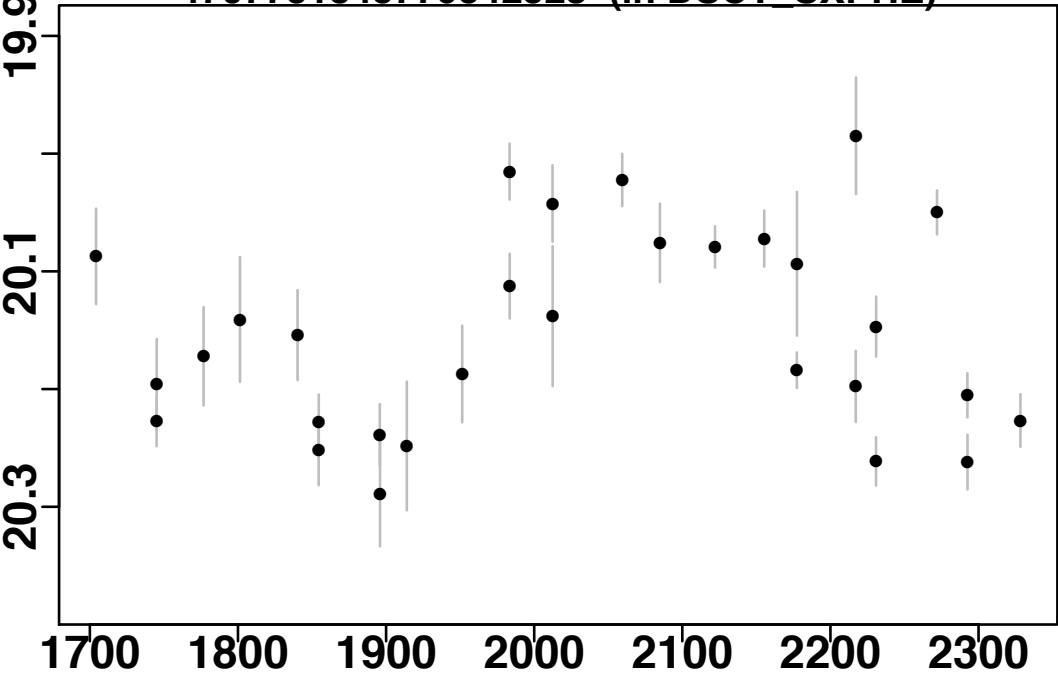
3674800166218577664 (in RRAB)



4023480076757963776 (in RRC)

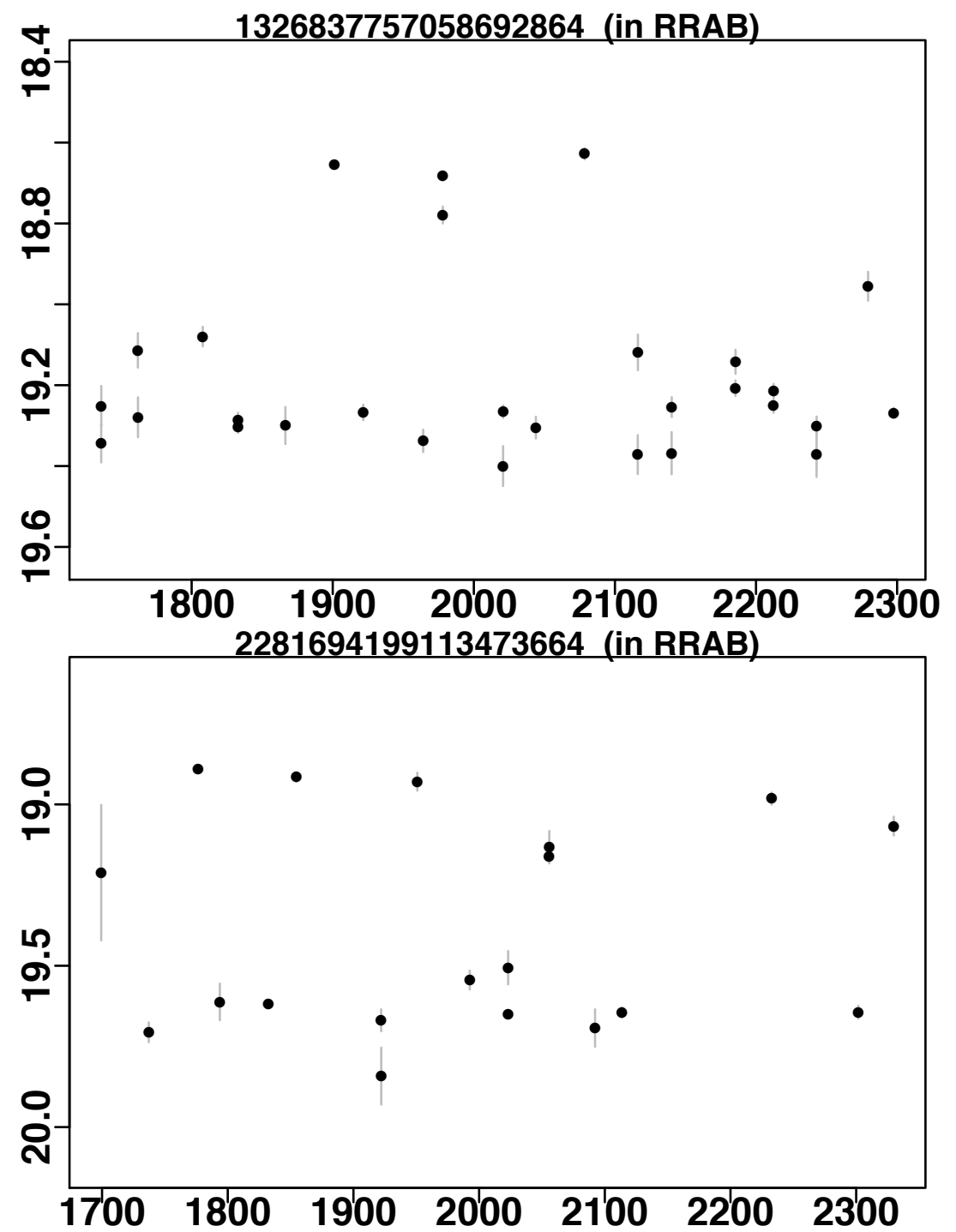
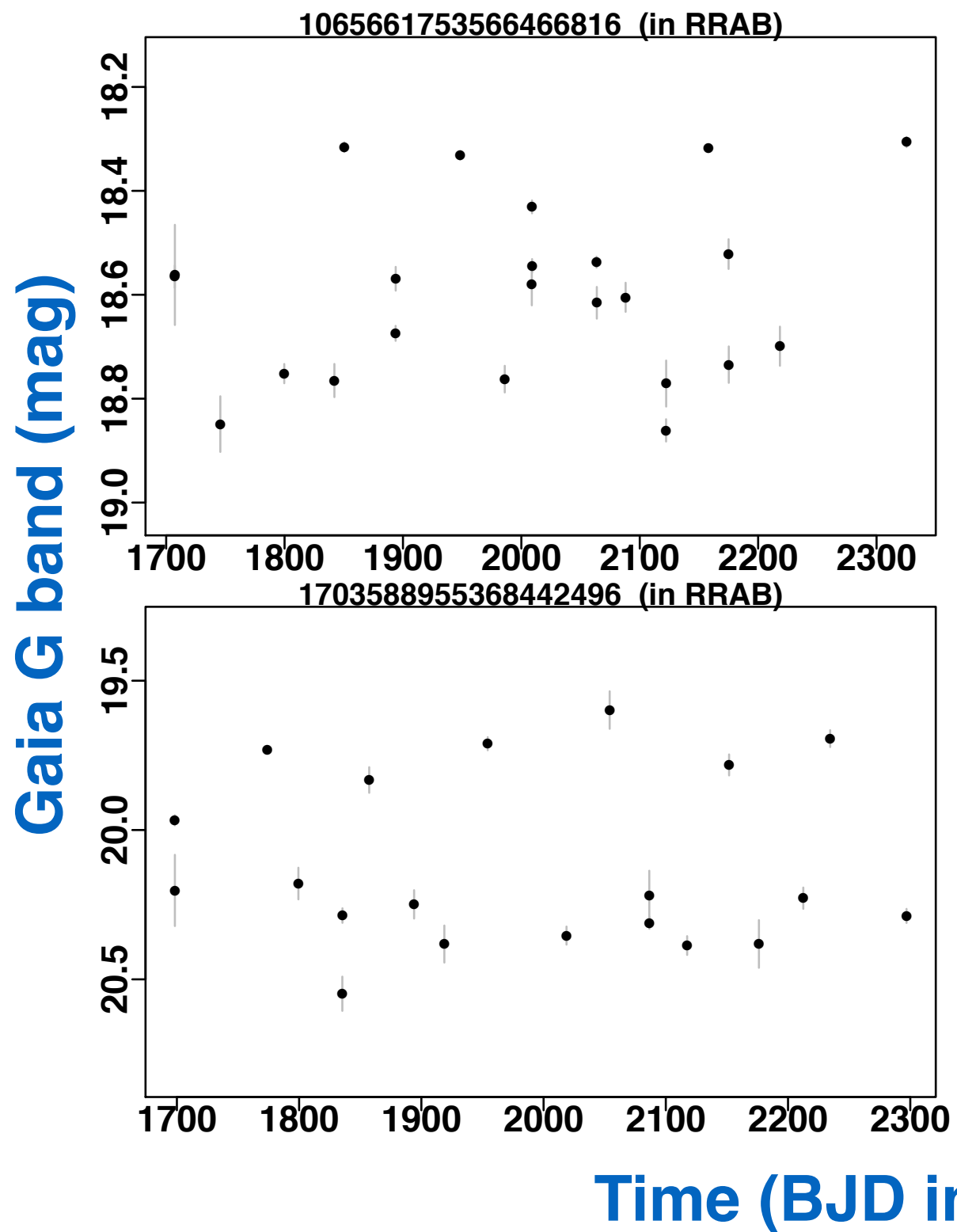


4707751345779542528 (in DSCT_SXPHE)



Time (BJD in TCB-2455197.5)

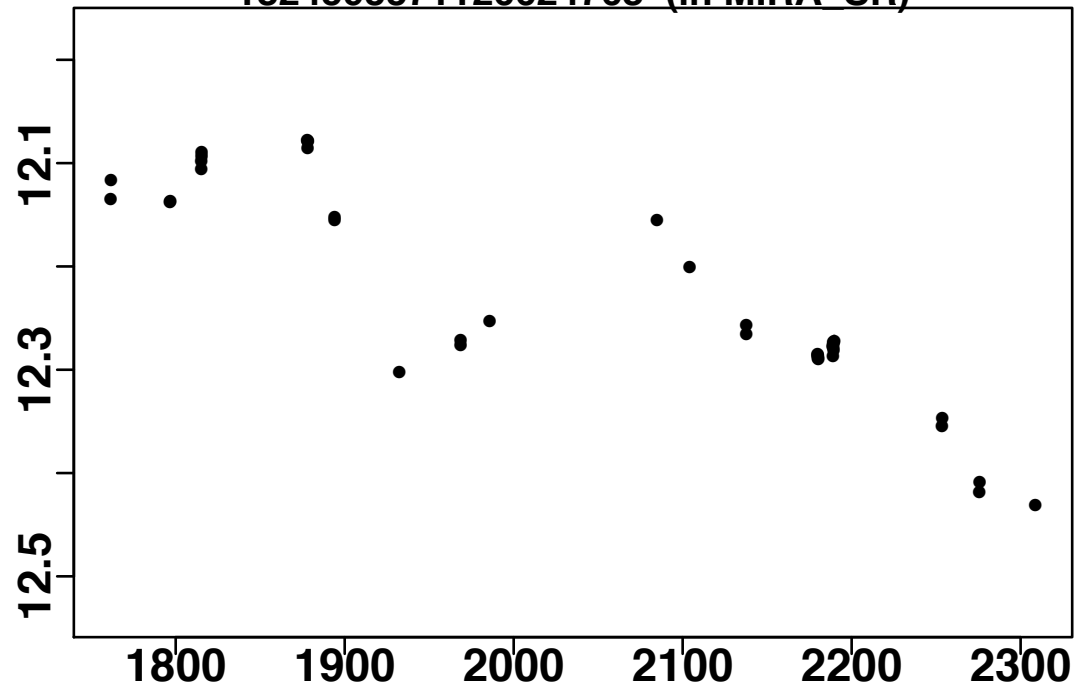
GALAXIES



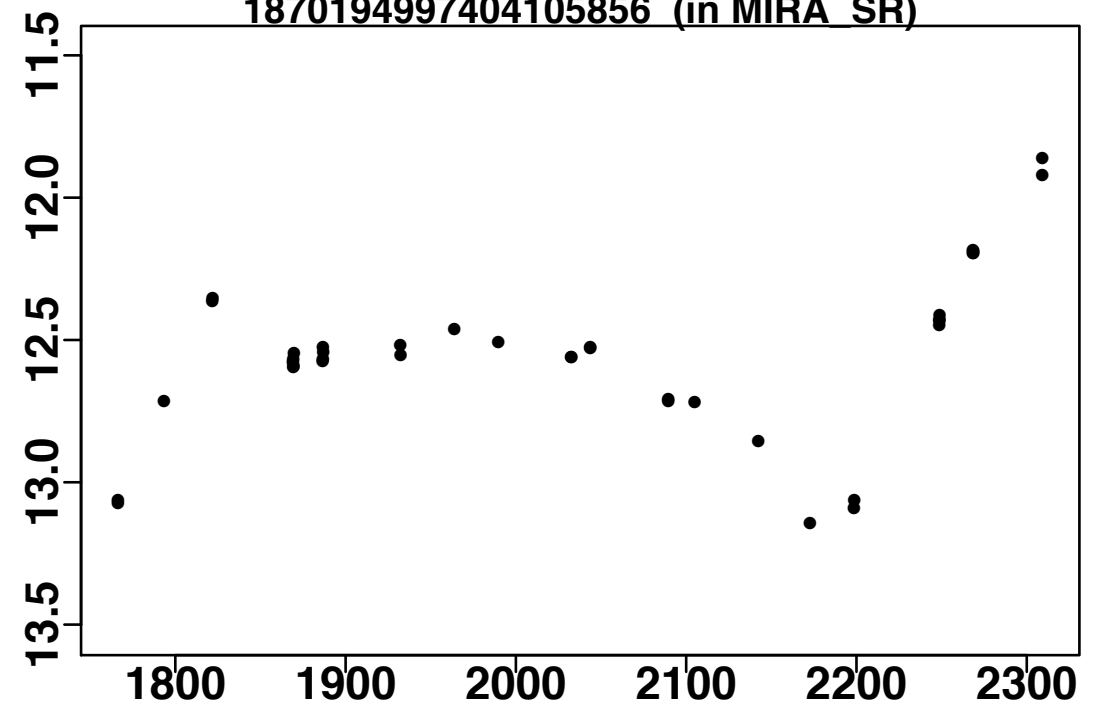
SYMBIOTIC BINARIES

Gaia G band (mag)

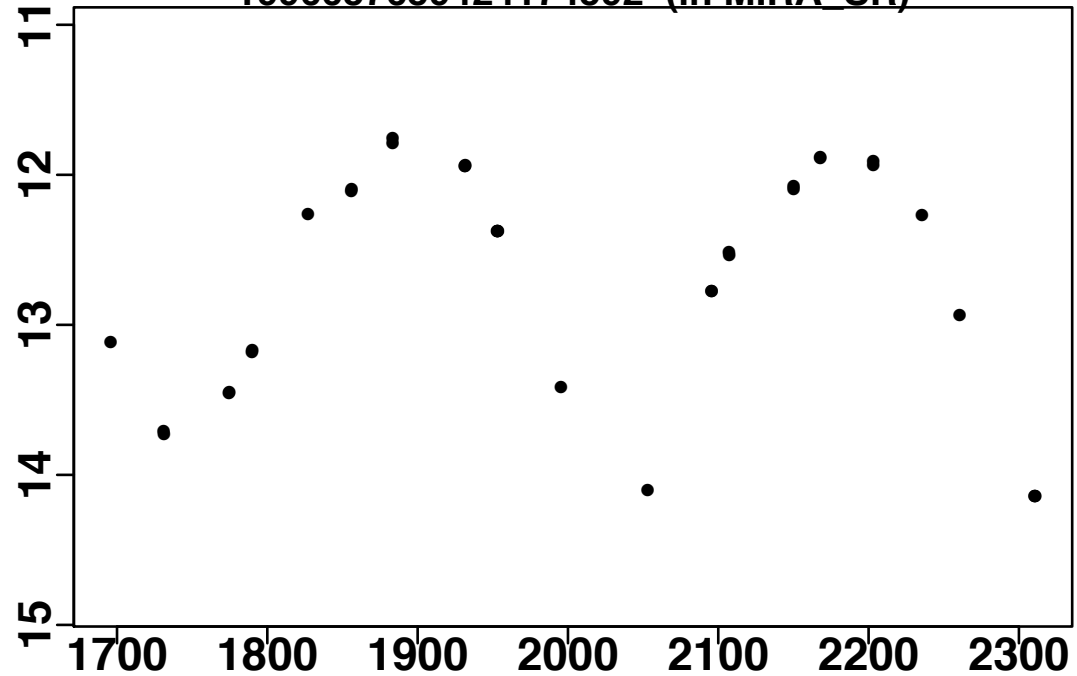
1824593371126624768 (in MIRA SR)



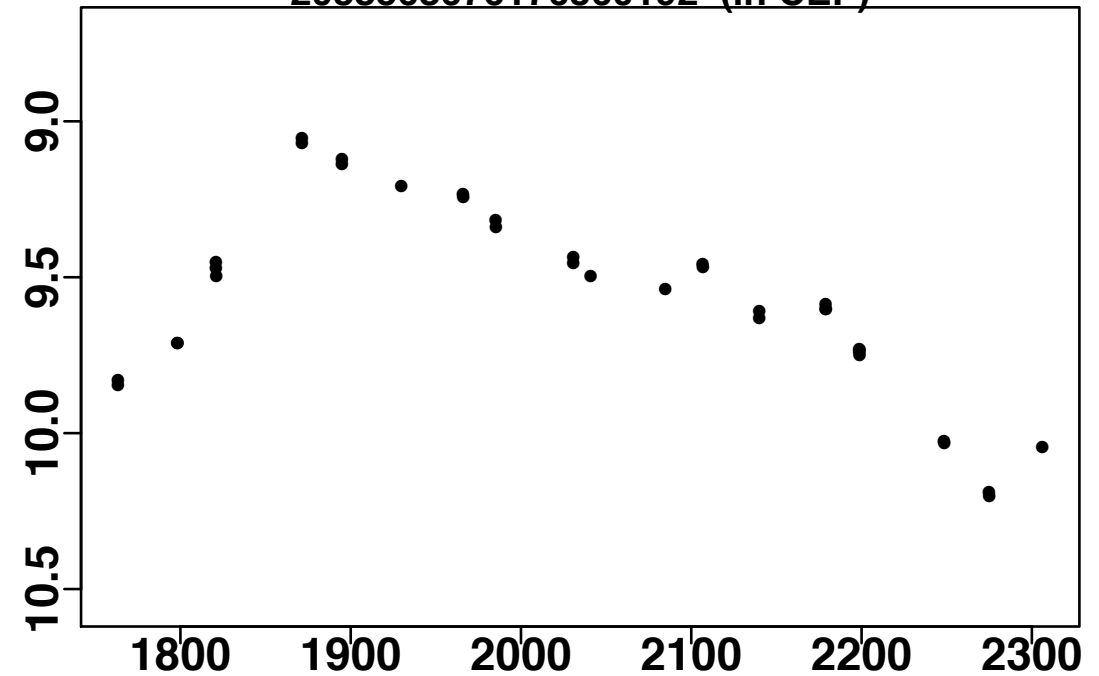
1870194997404105856 (in MIRA SR)



1996657659424174592 (in MIRA SR)



2038568676176360192 (in CEP)

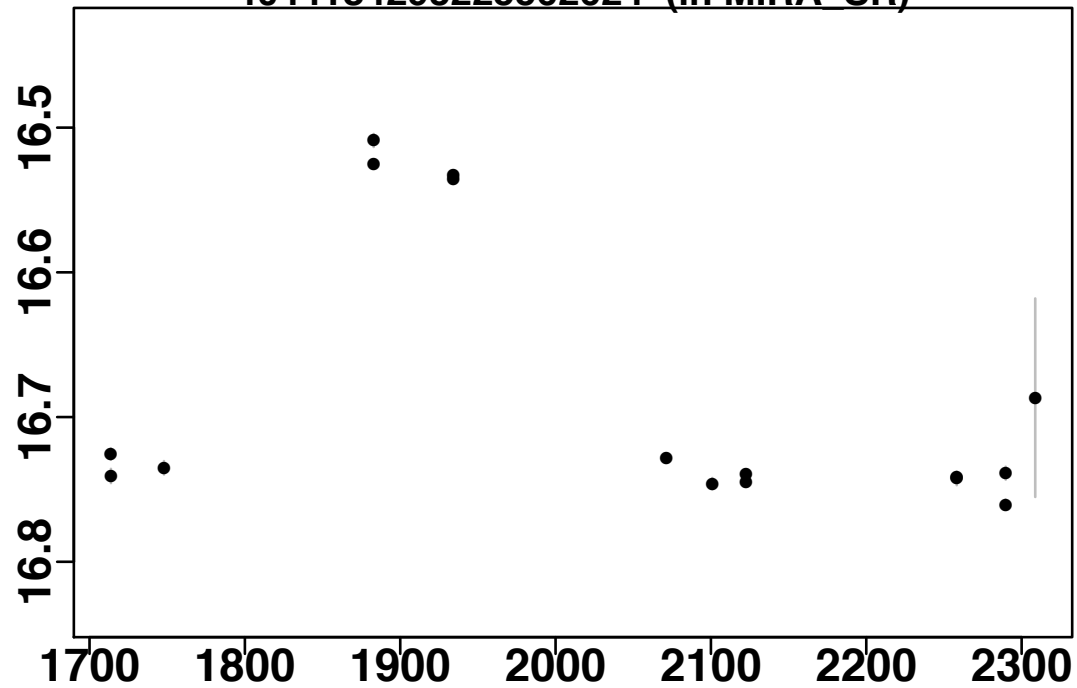


Time (BJD in TCB-2455197.5)

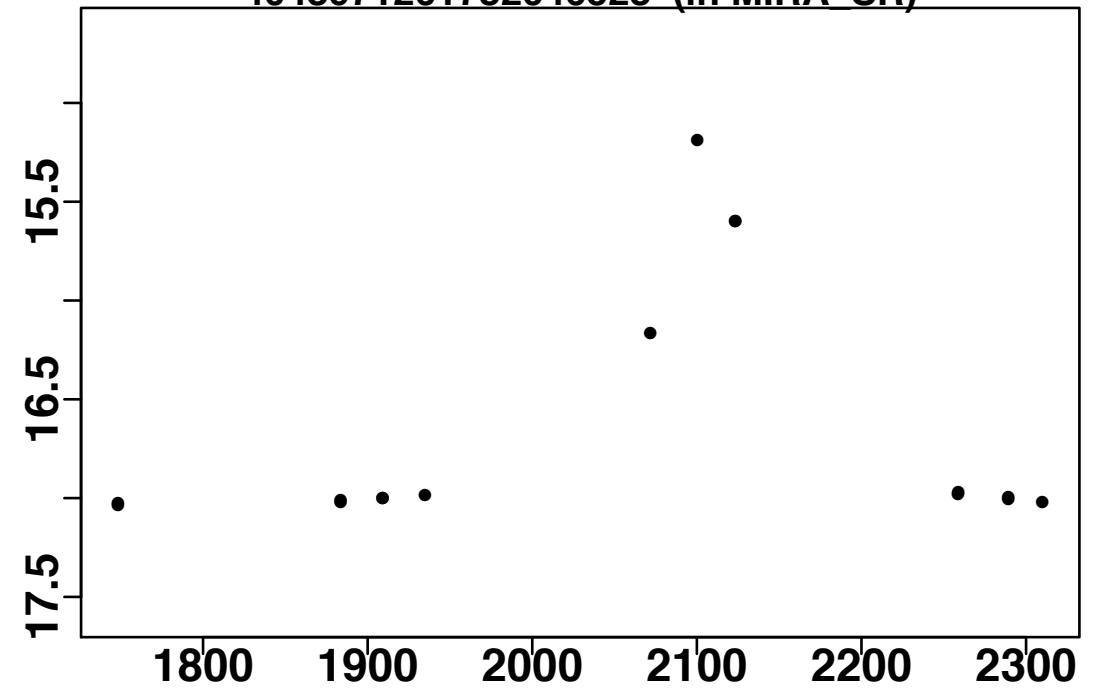
GAMMA CASSIOPEIAE STARS

Gaia G band (mag)

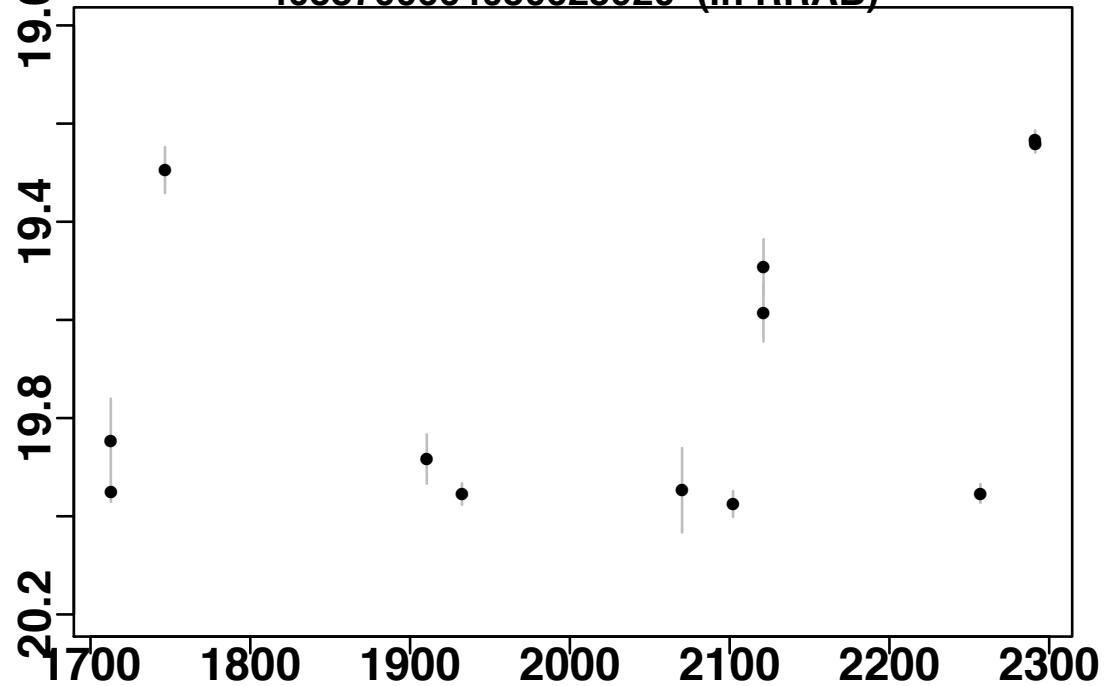
4044184293225562624 (in MIRA SR)



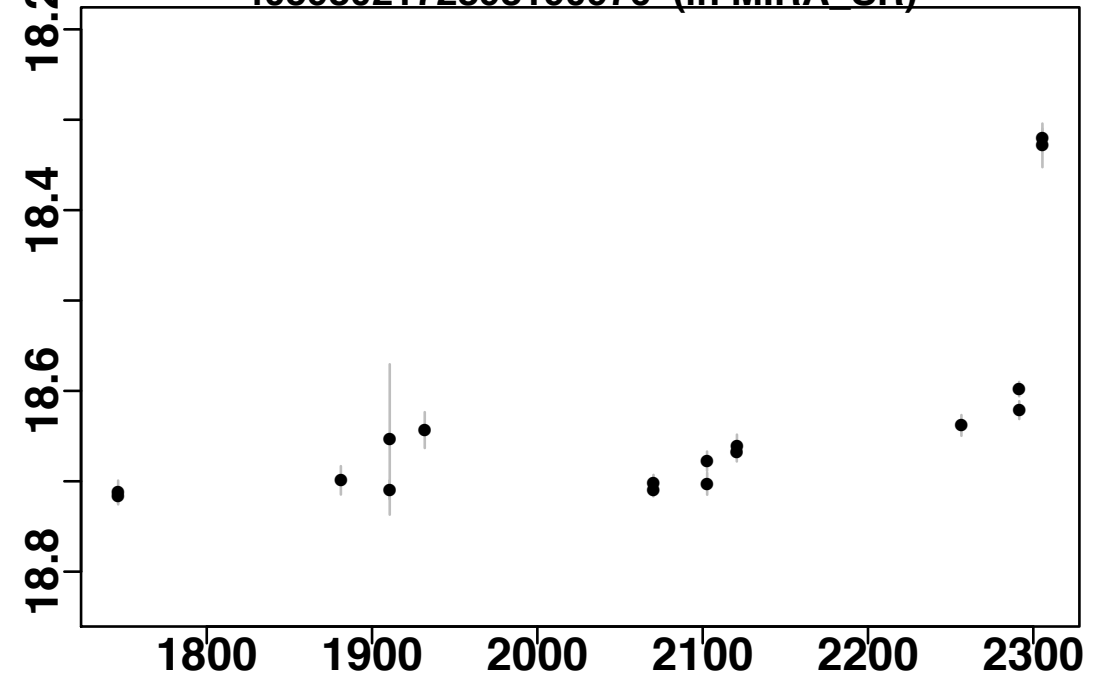
4048971261782646528 (in MIRA SR)



4058700664050625920 (in RRAB)

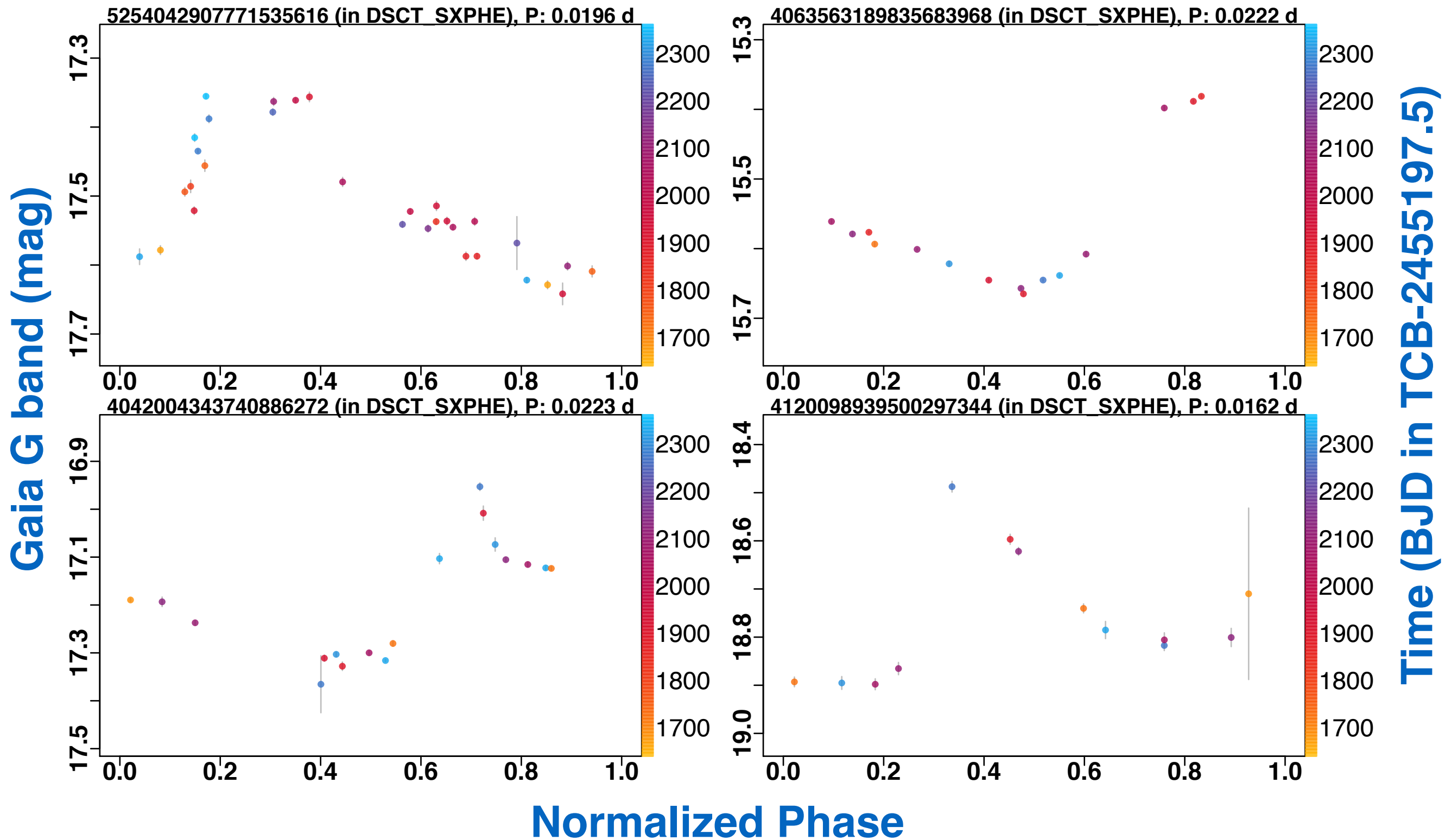


4059802172898190976 (in MIRA SR)

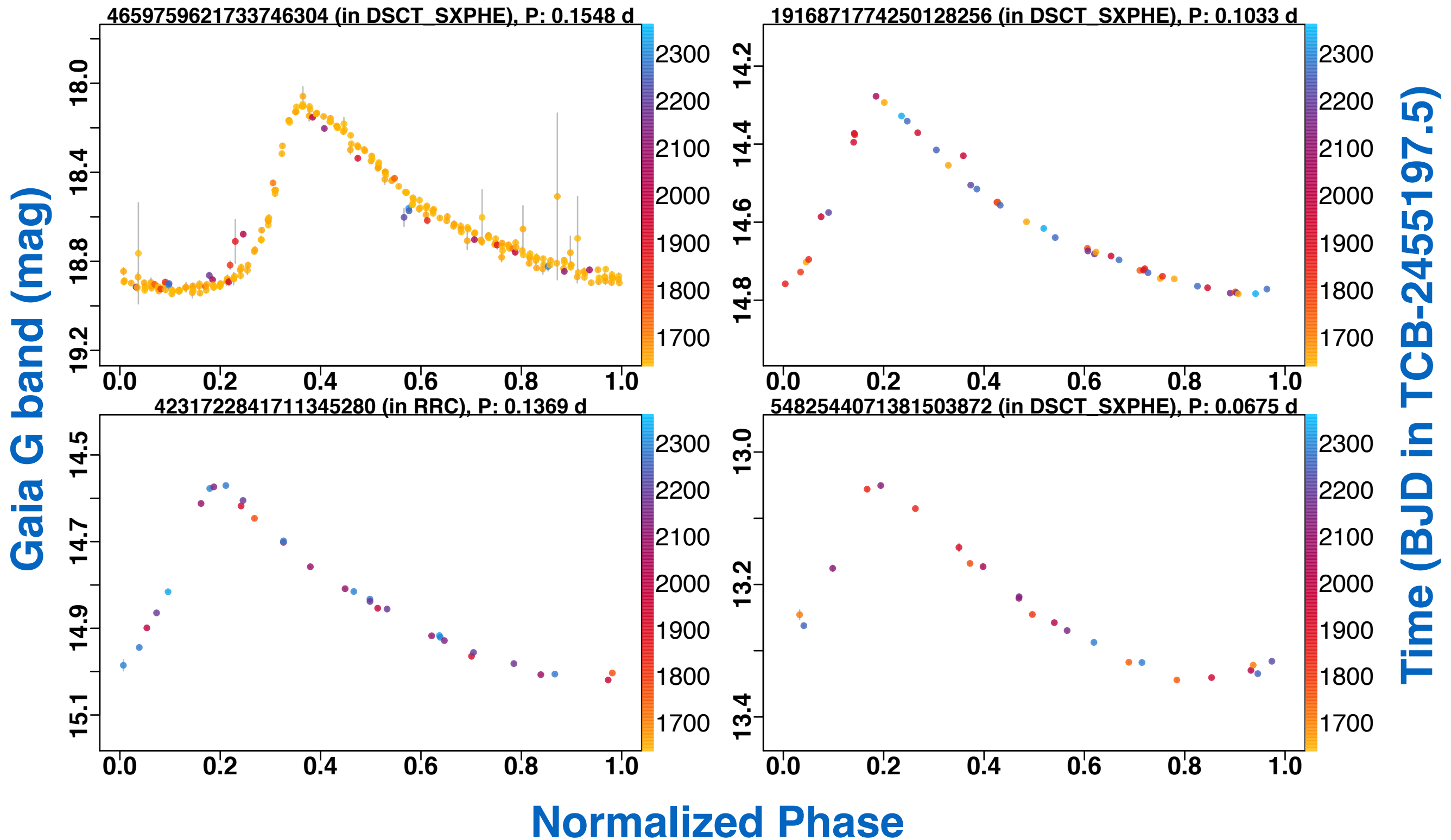


Time (BJD in TCB-2455197.5)

BLUE LARGE AMPLITUDE PULSATORS

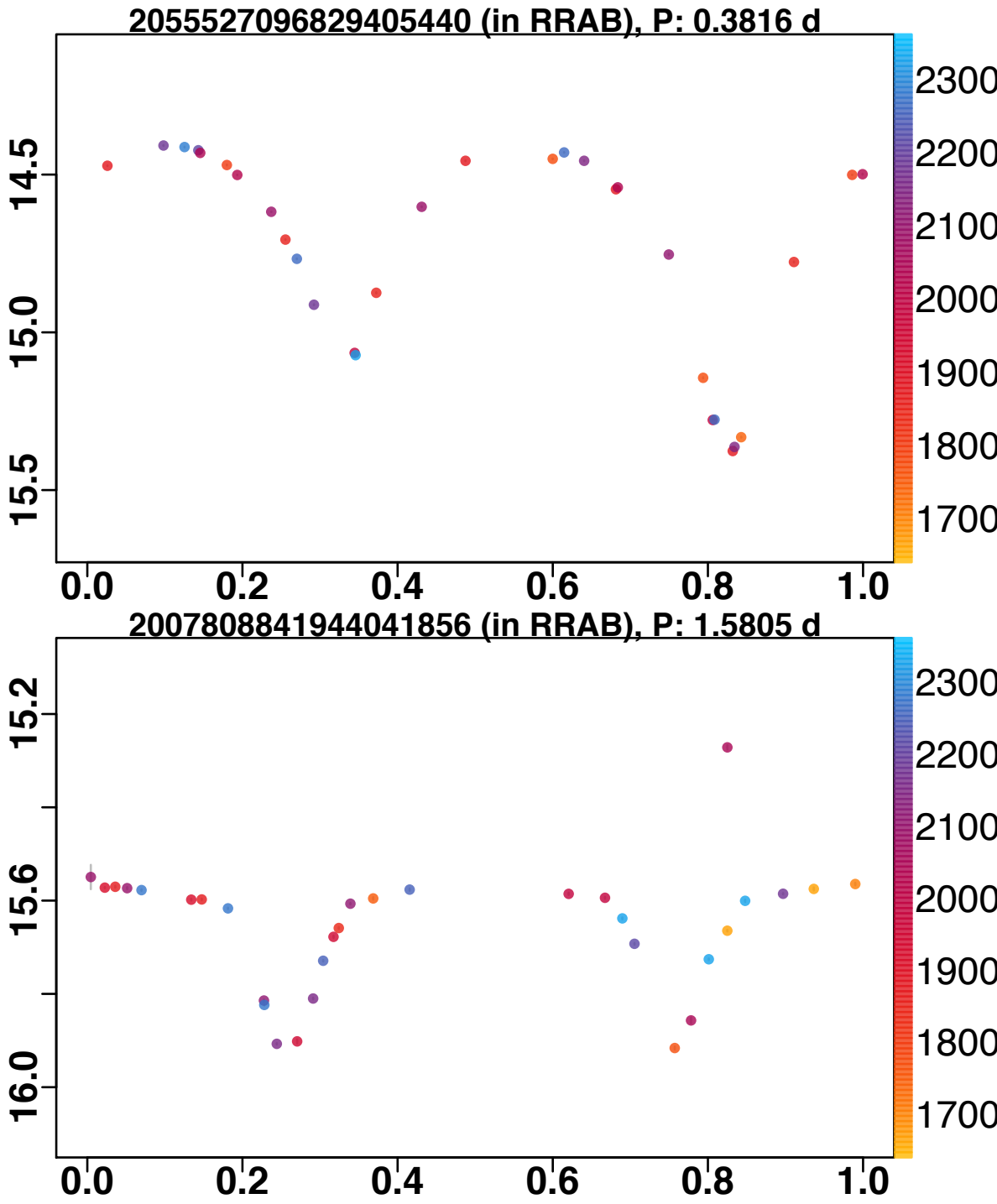
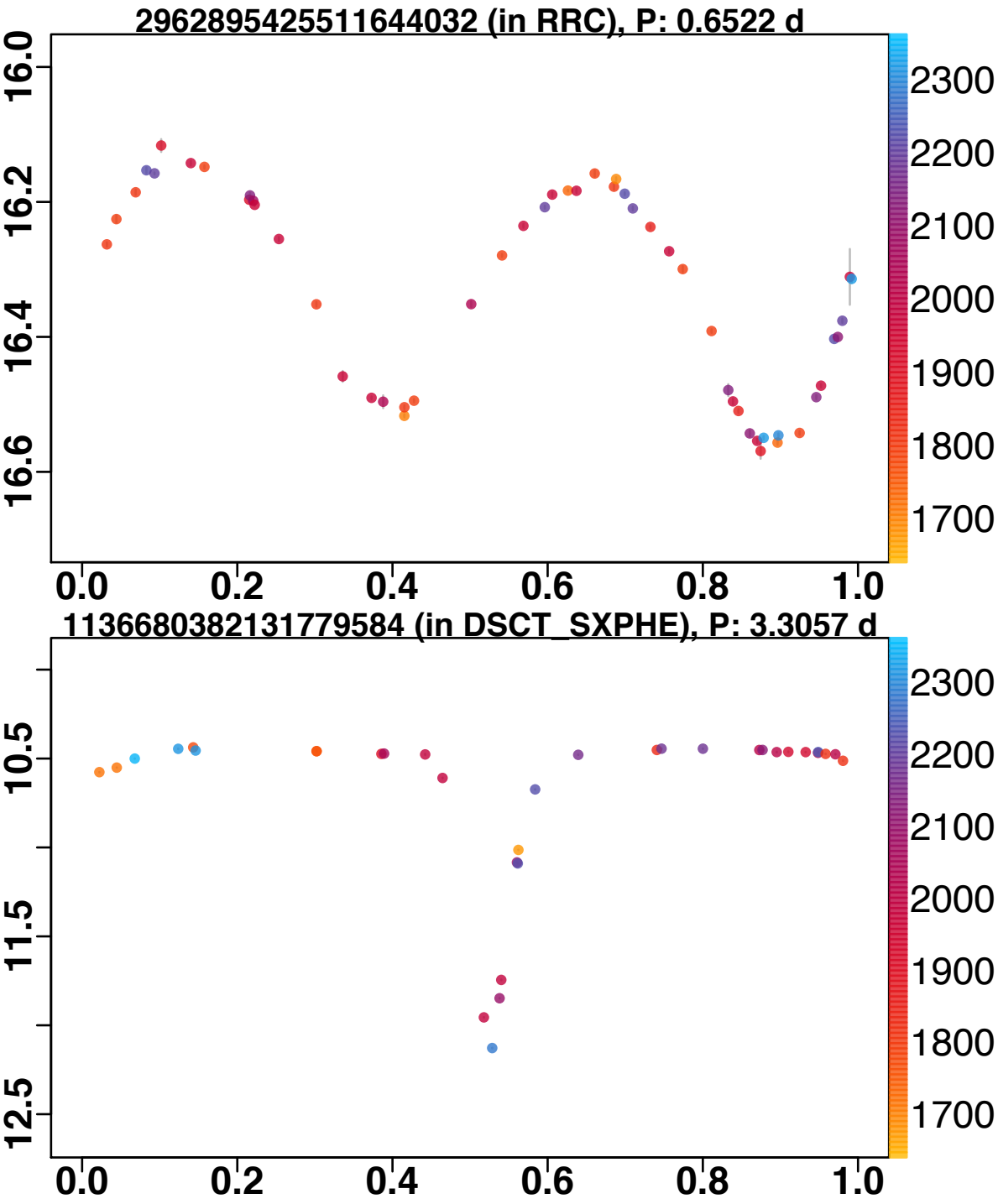


DELTA SCUTI STARS



ECLIPSING BINARIES

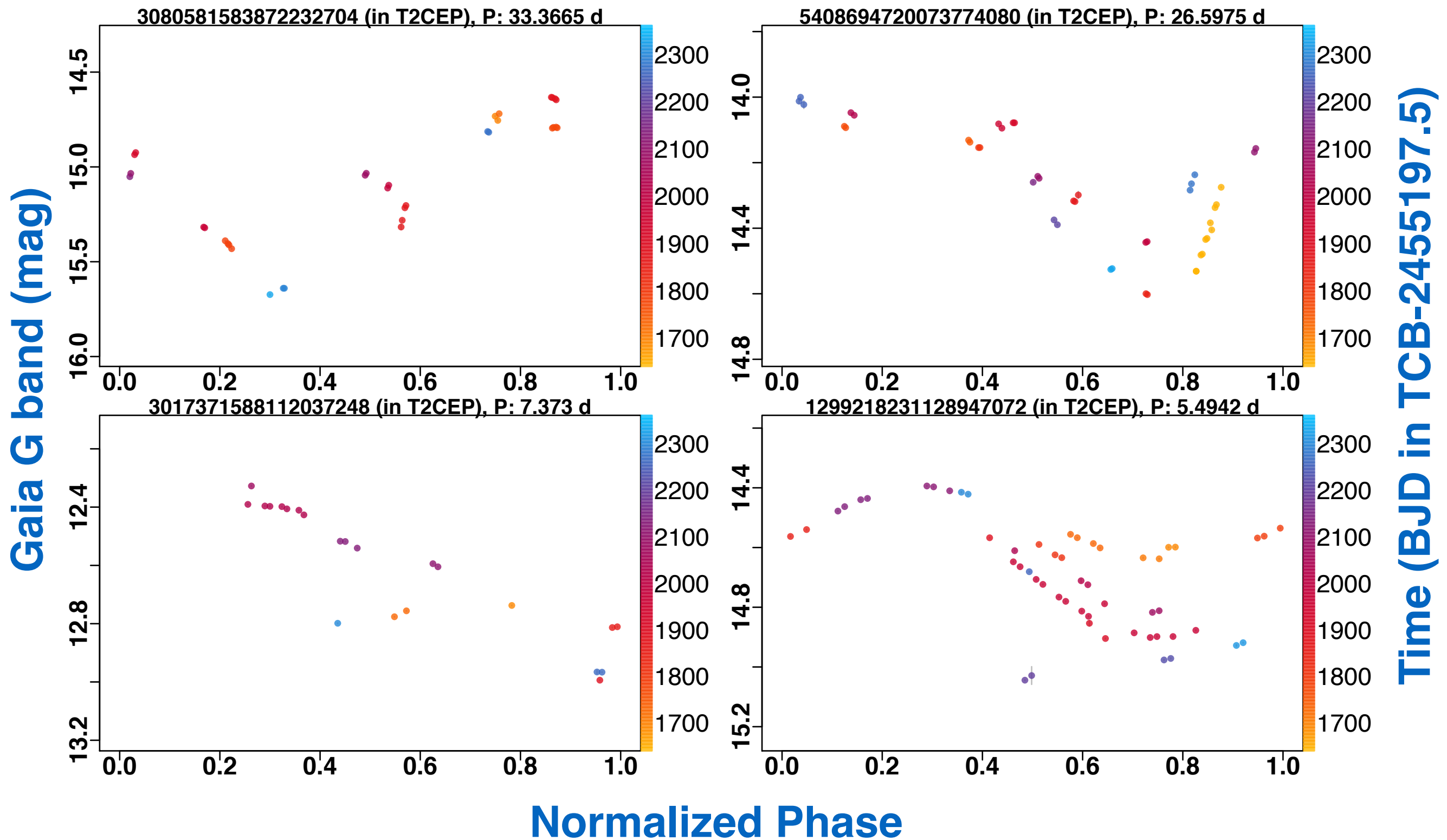
Gaia G band (mag)



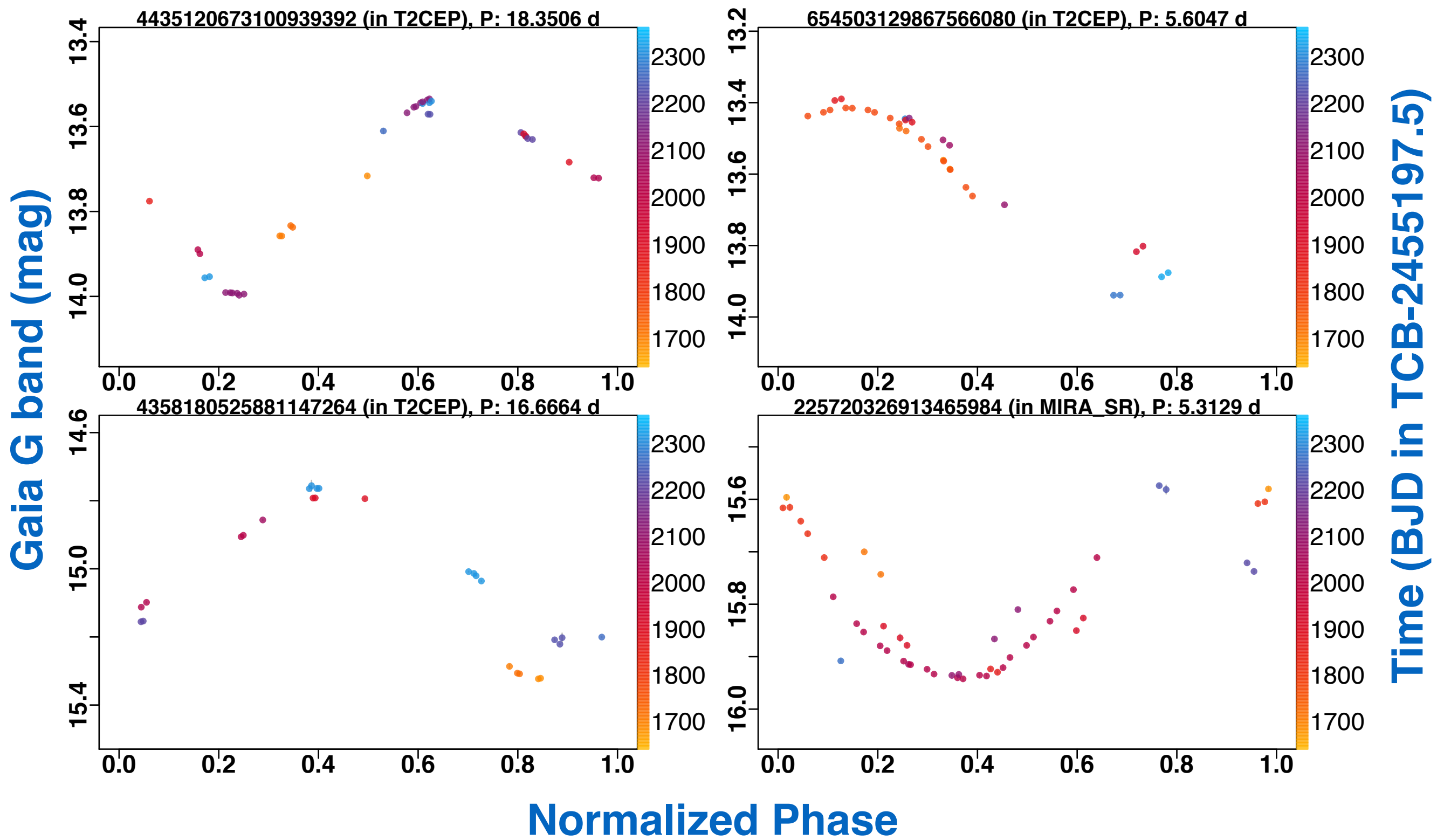
Time (BJD in TCB-2455197.5)

Normalized Phase

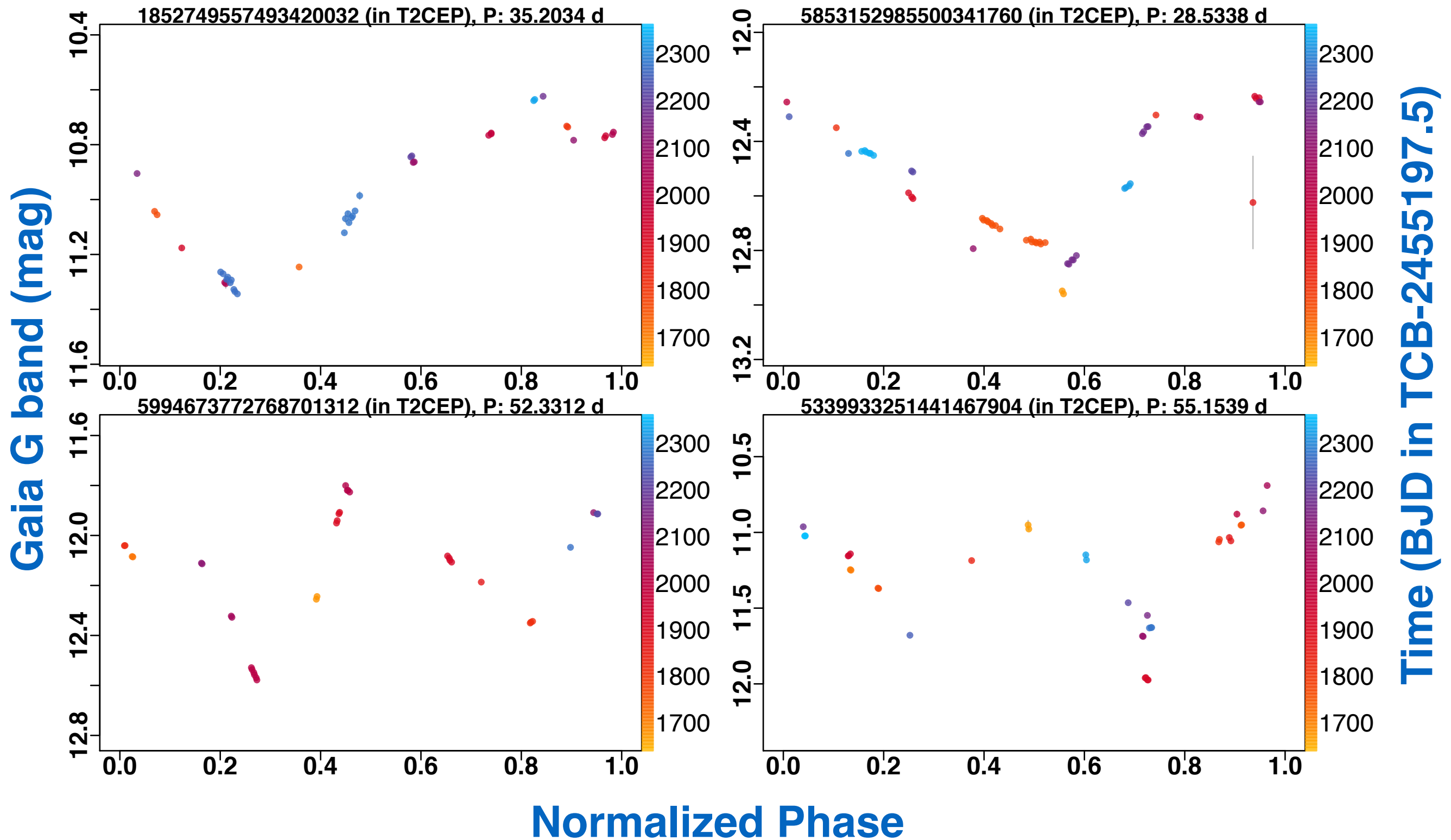
YOUNG STELLAR OBJECTS



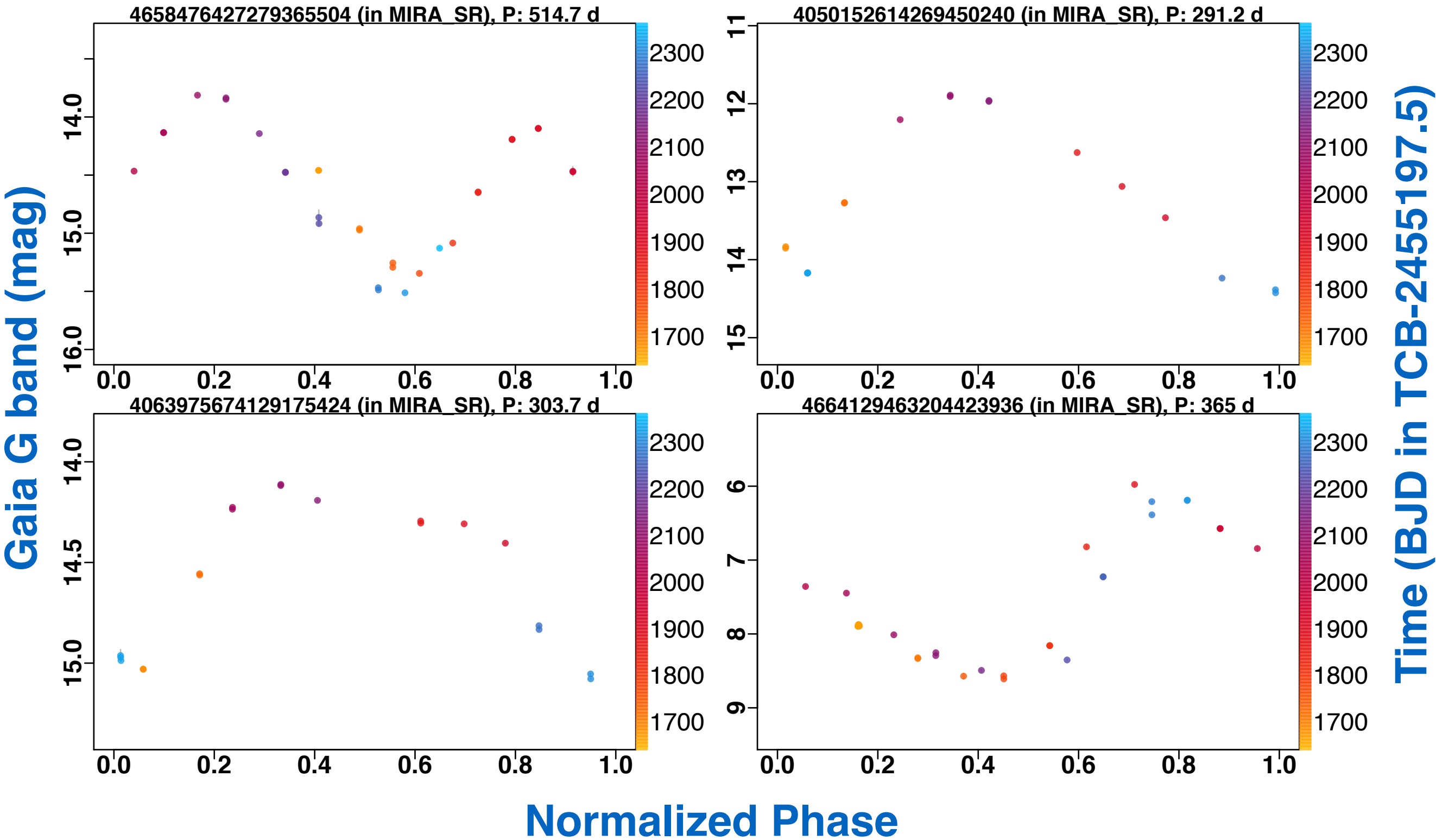
RS CANUM VENATICORUM STARS



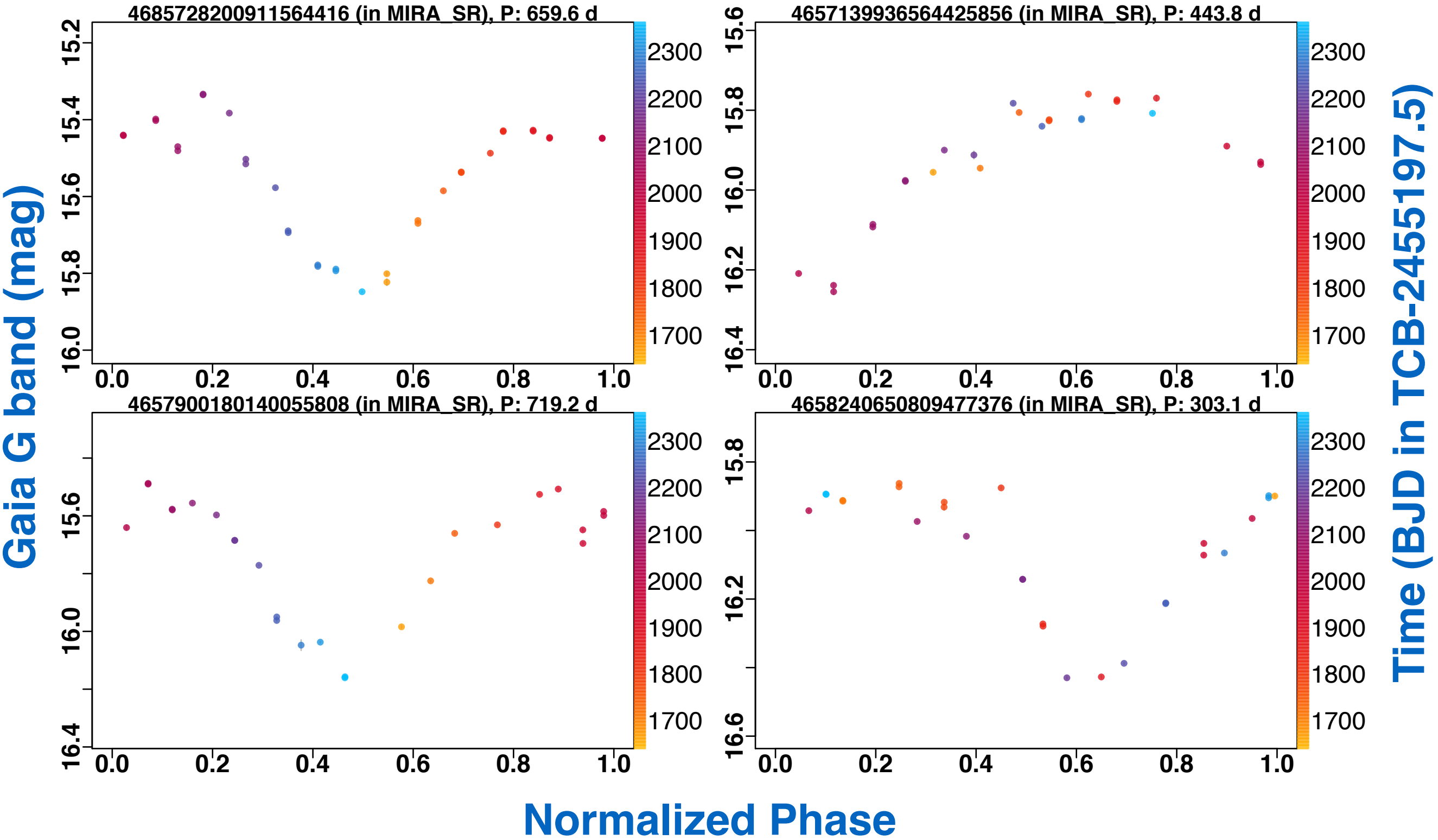
RV TAURI STARS



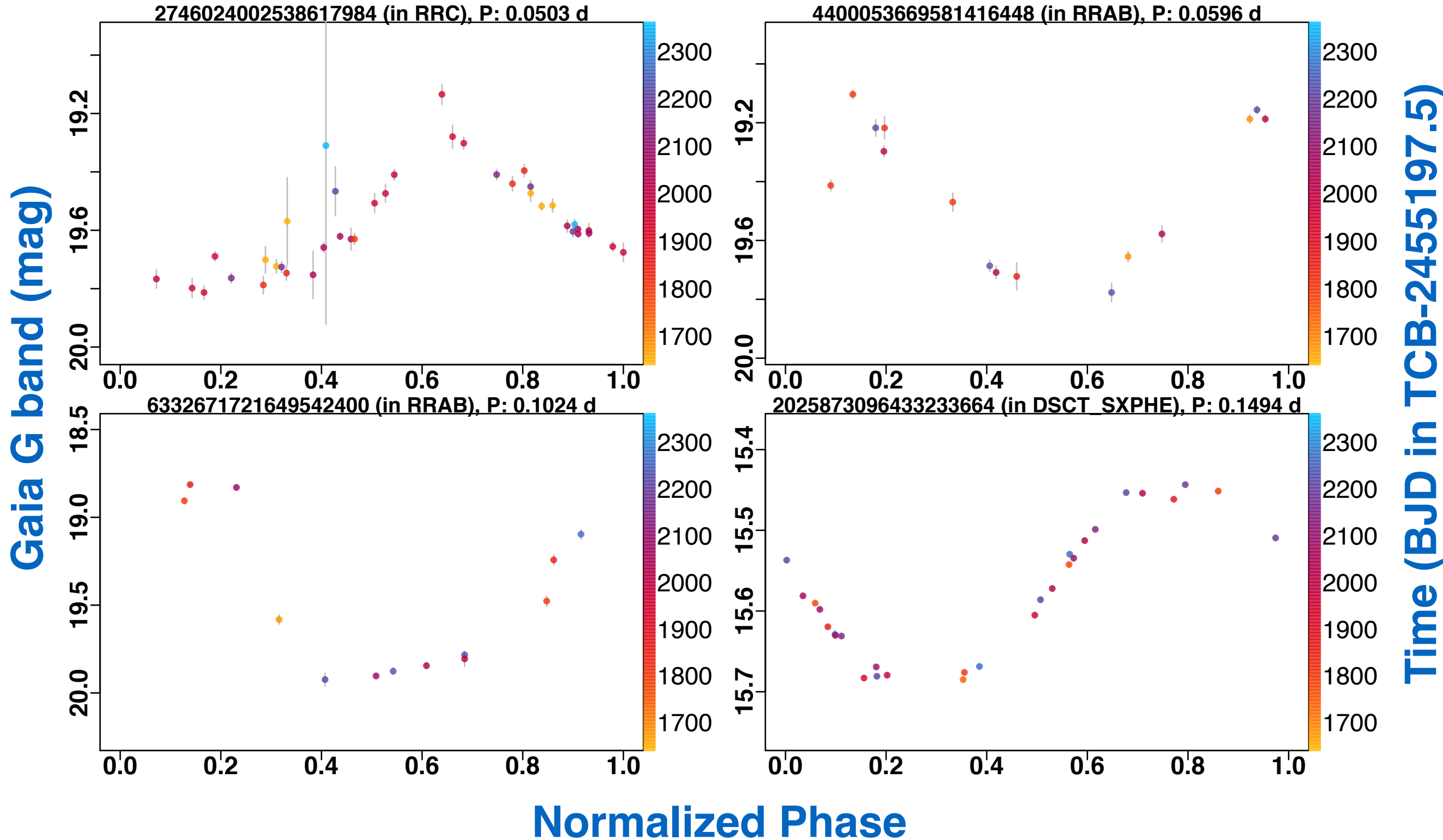
MIRA VARIABLES



OGLE SMALL AMPLITUDE RED GIANTS

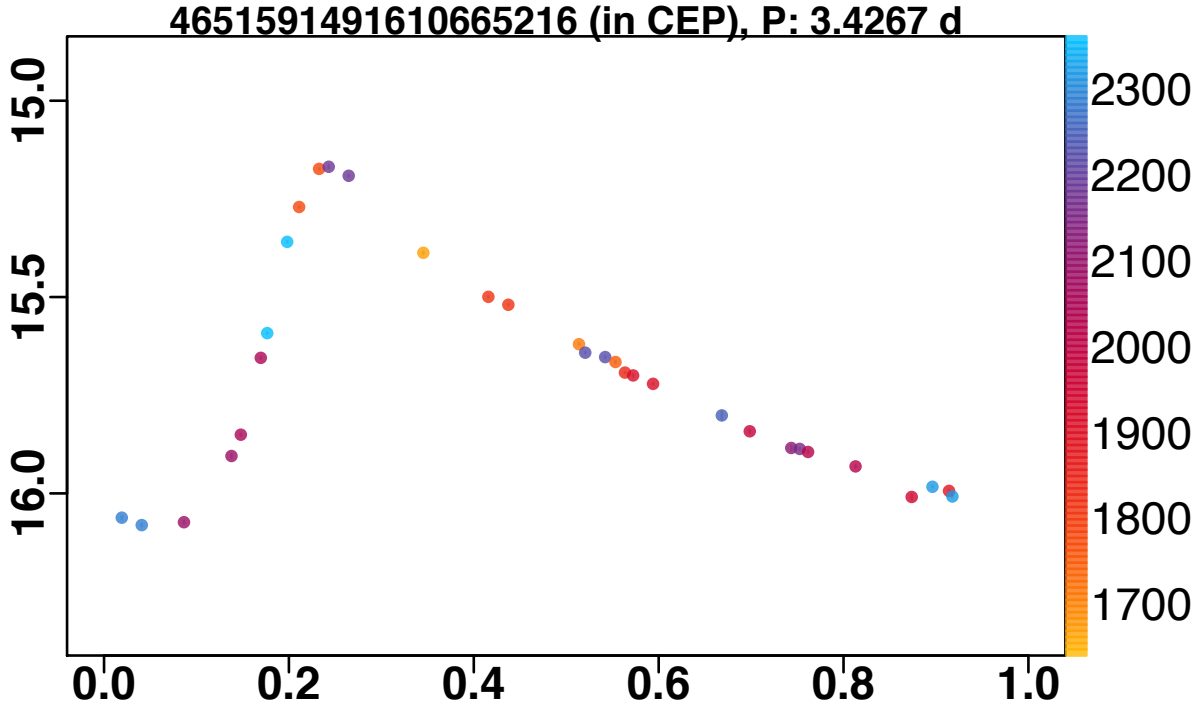
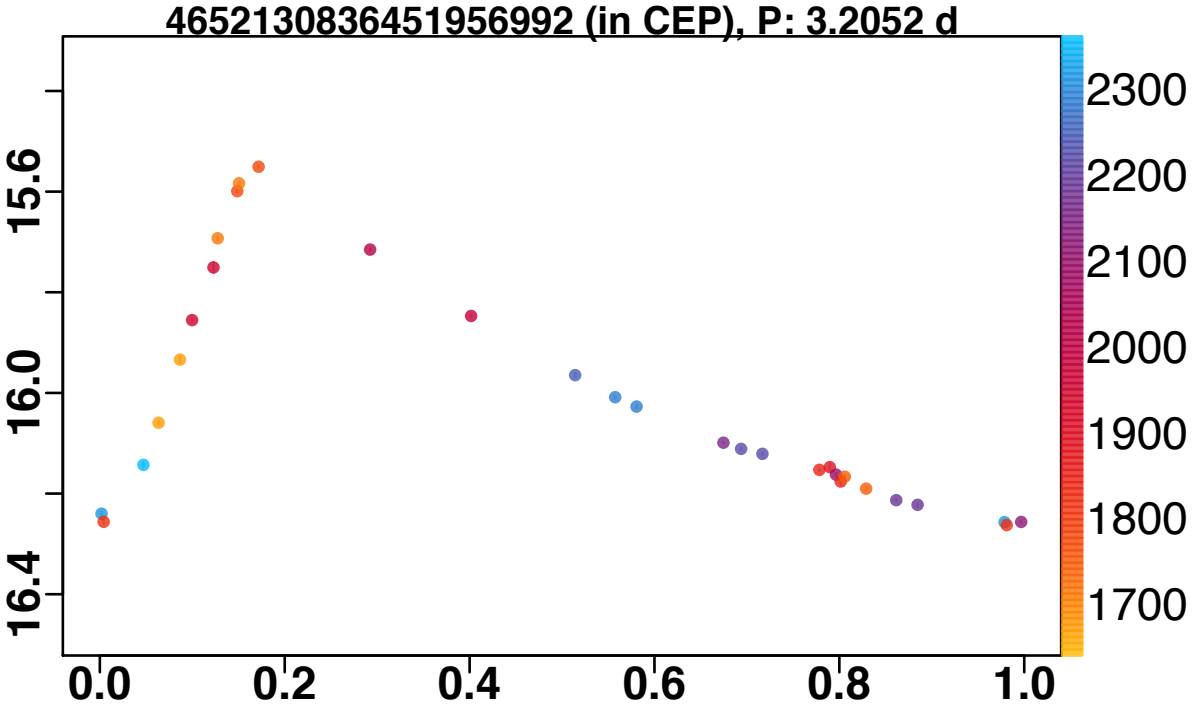
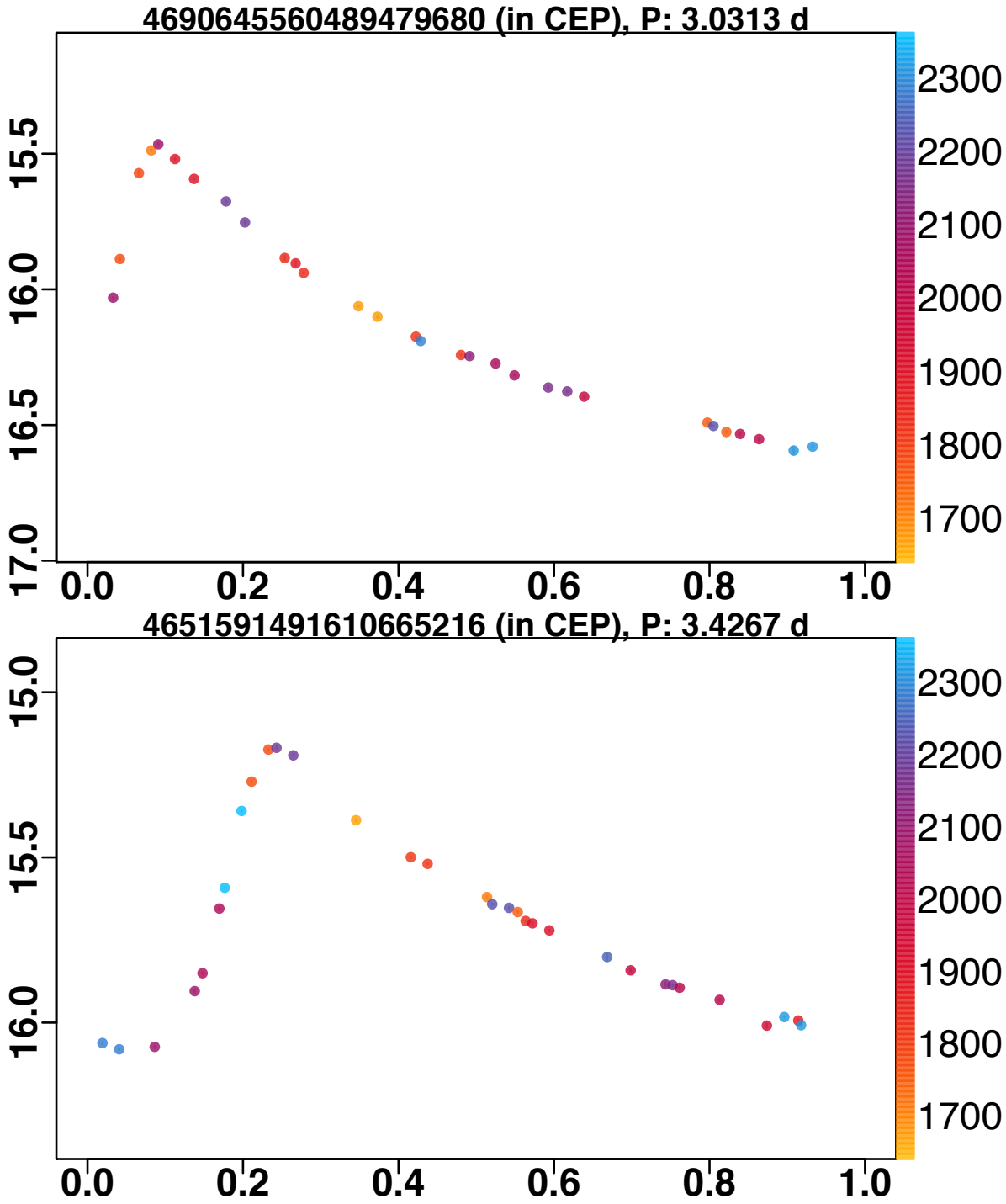
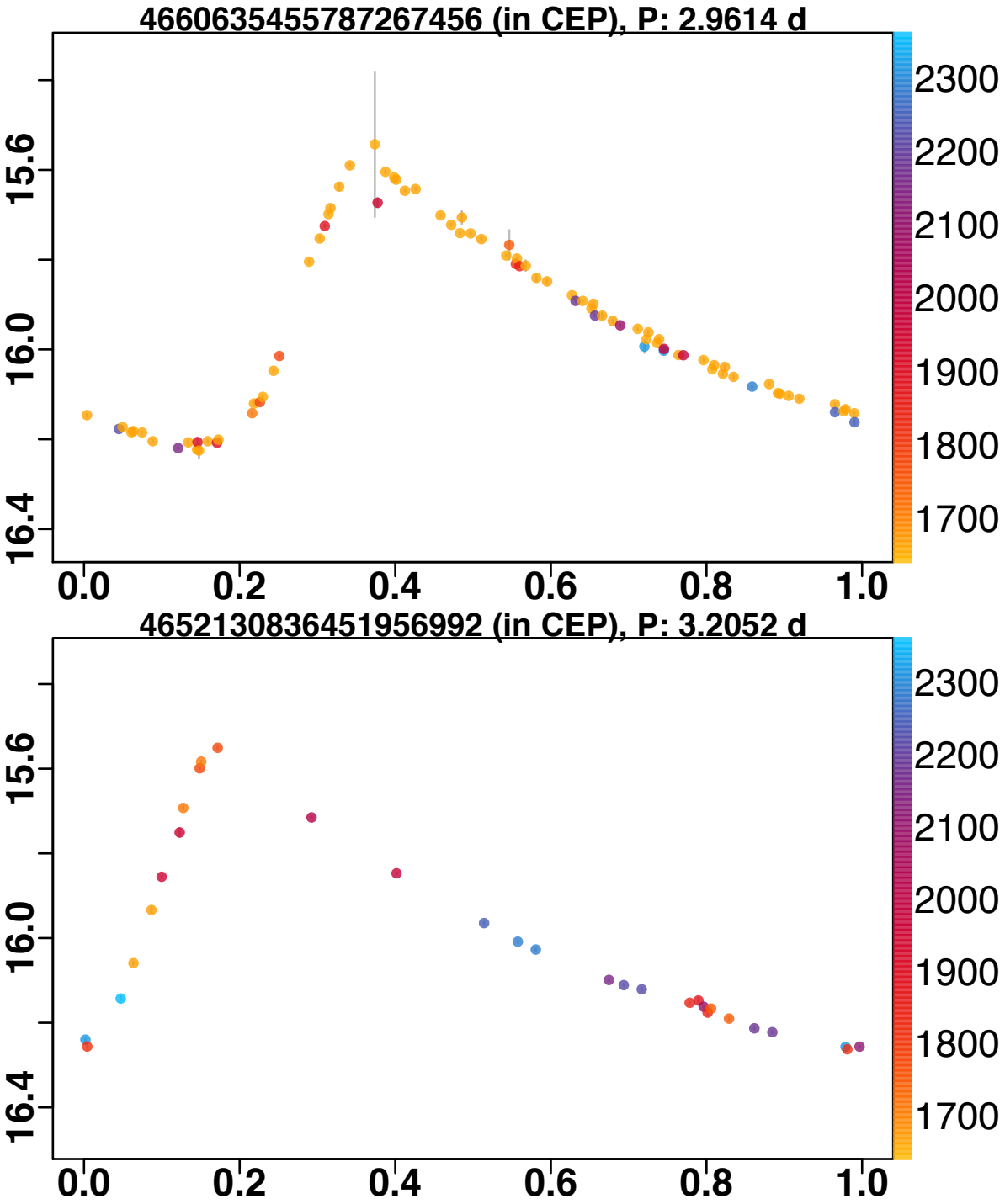


PULSATING WHITE DWARFS



CEPHEIDS

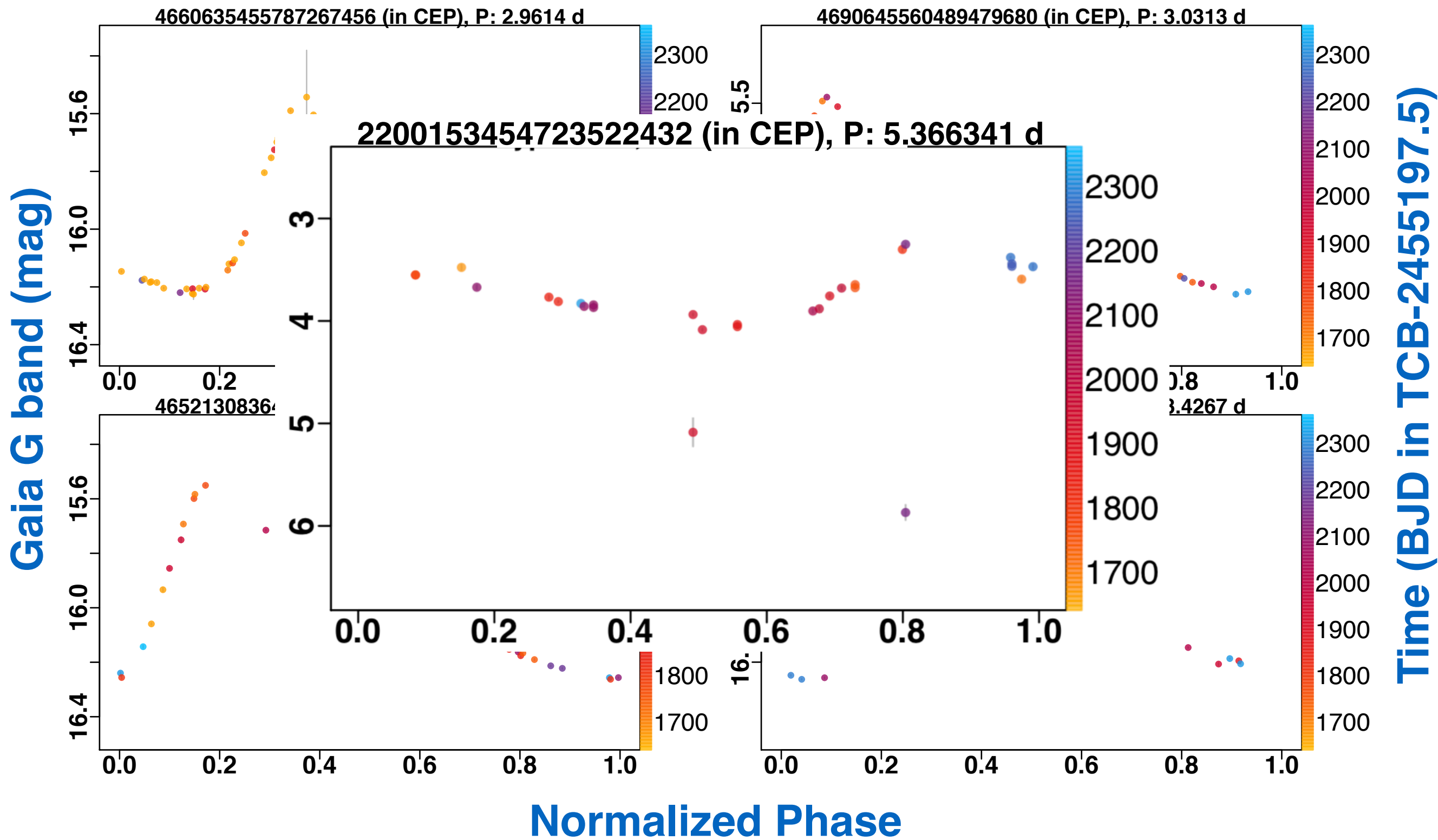
Gaia G band (mag)



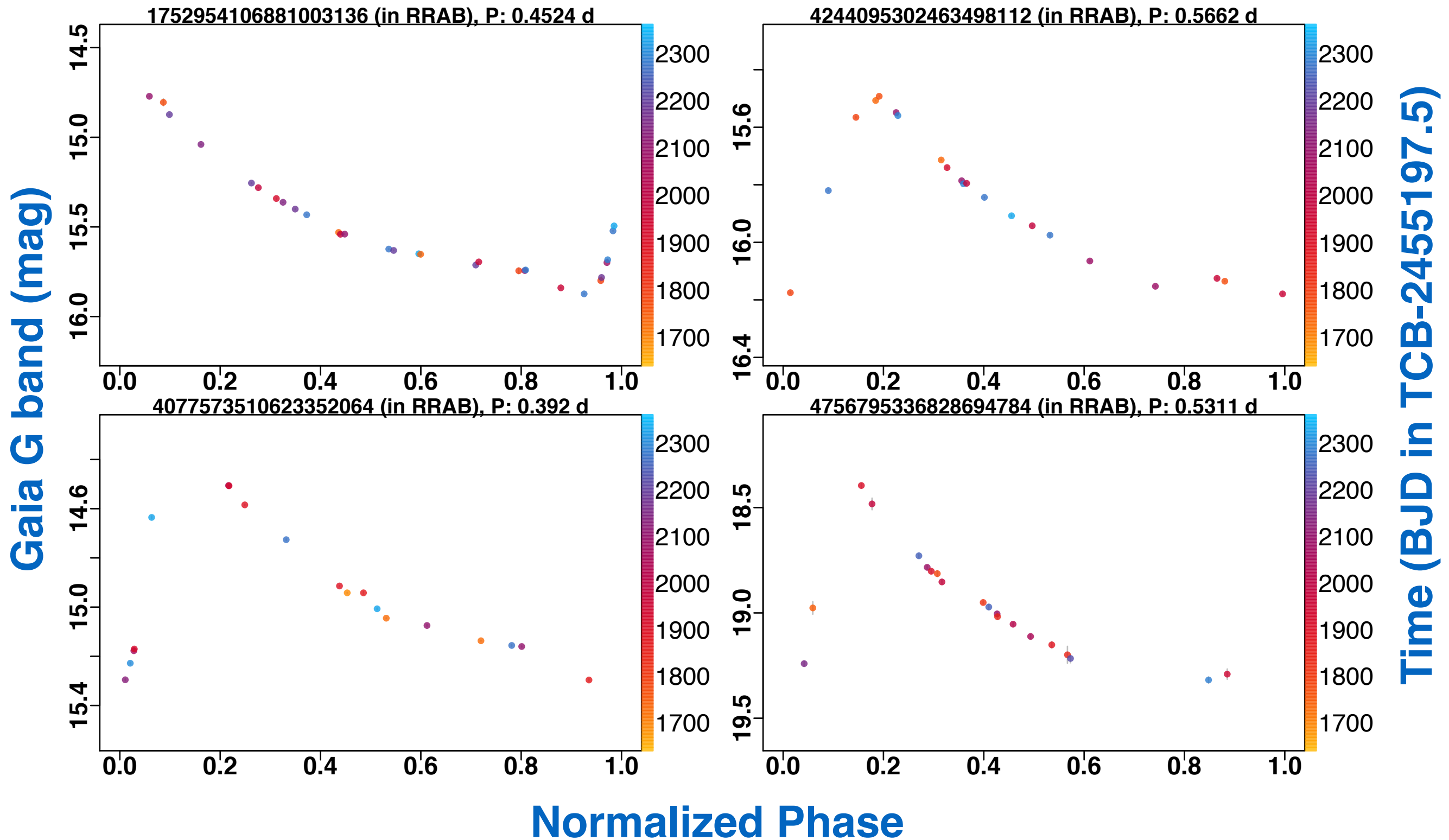
Time (BJD in TCB-2455197.5)

Normalized Phase

CEPHEIDS



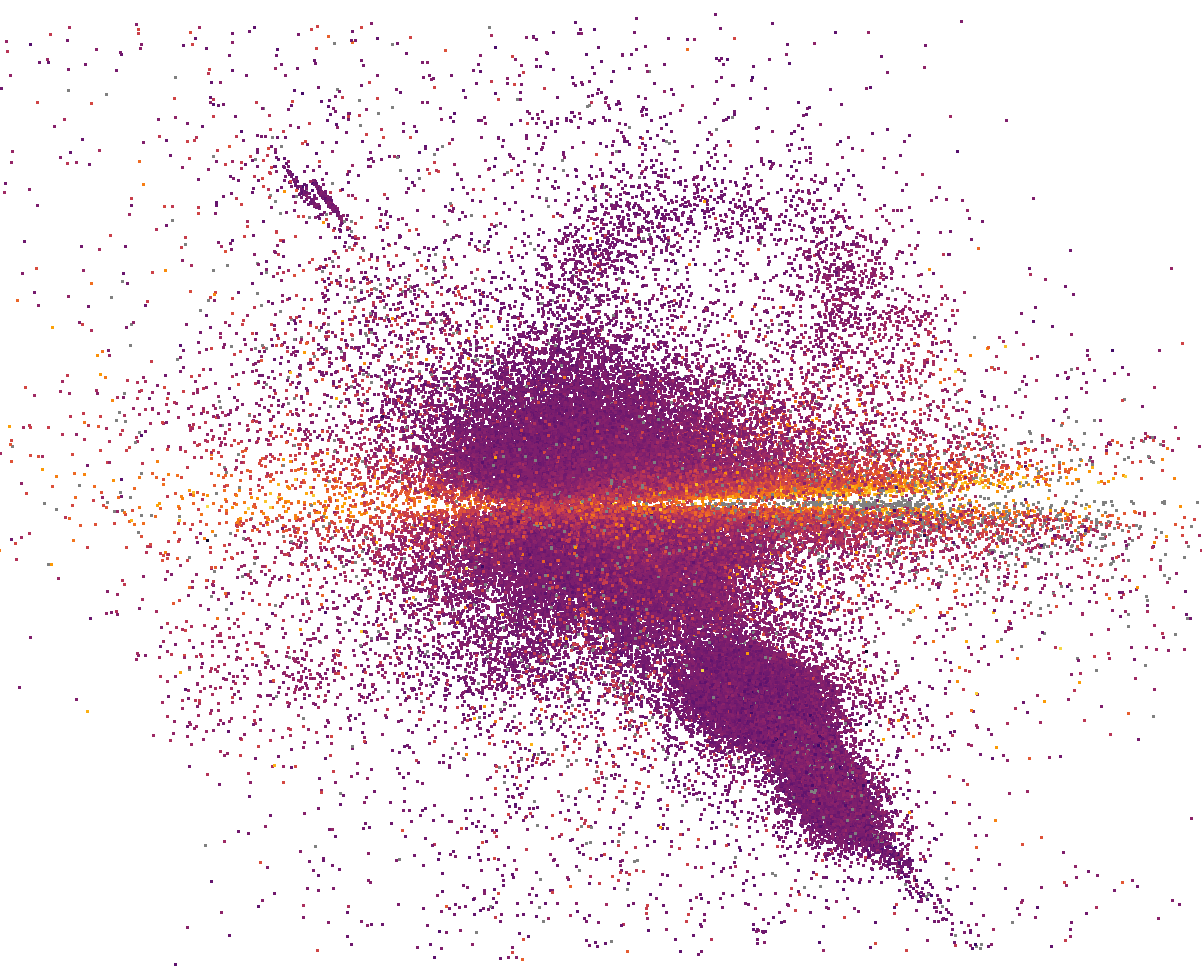
RR LYRAE STARS



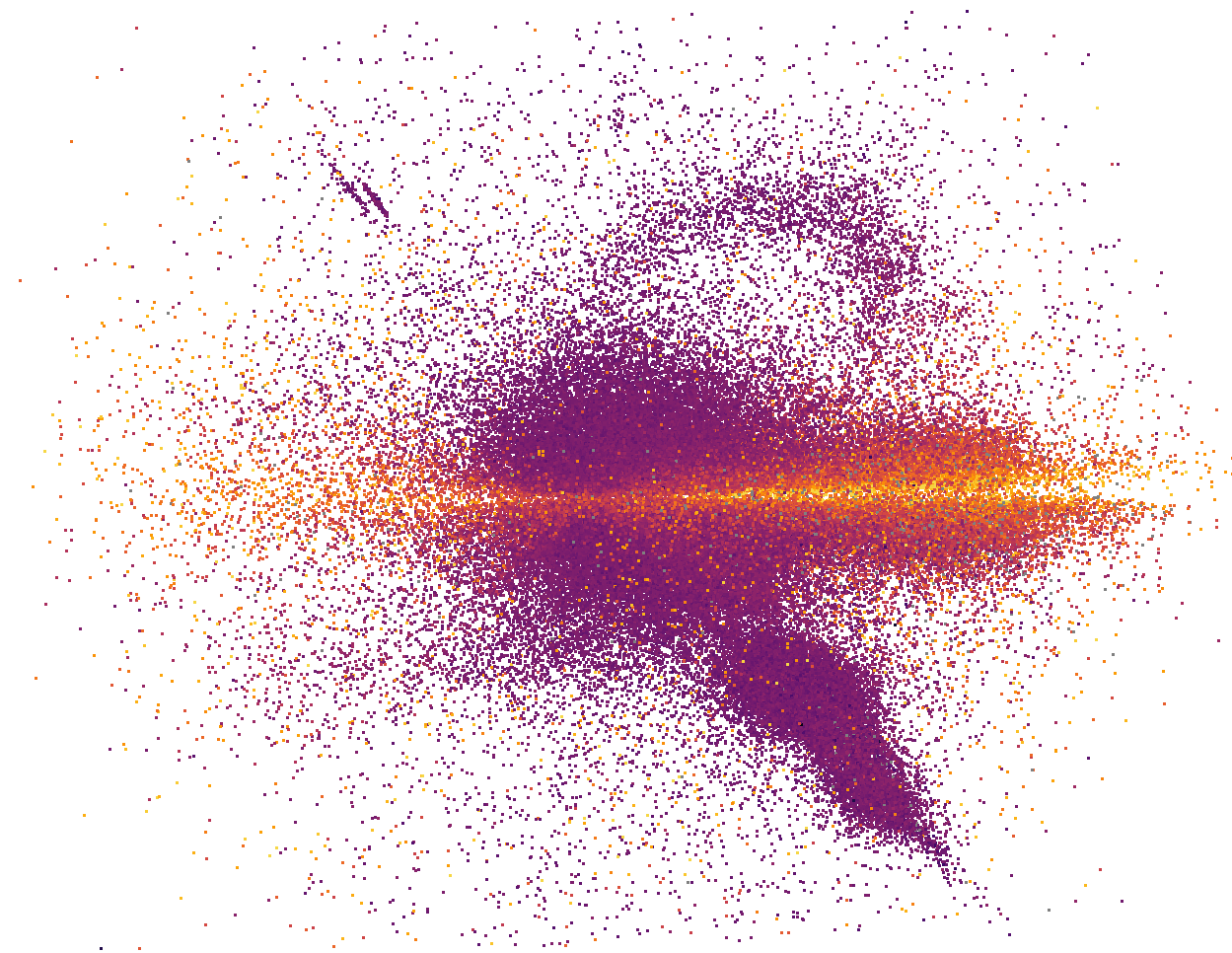
RR LYRAE STARS

3D view assuming abs mag RRL in G ~ 0.6 mag (...)

SPECIFIC OBJECT STUDIES



CLASSIFICATION

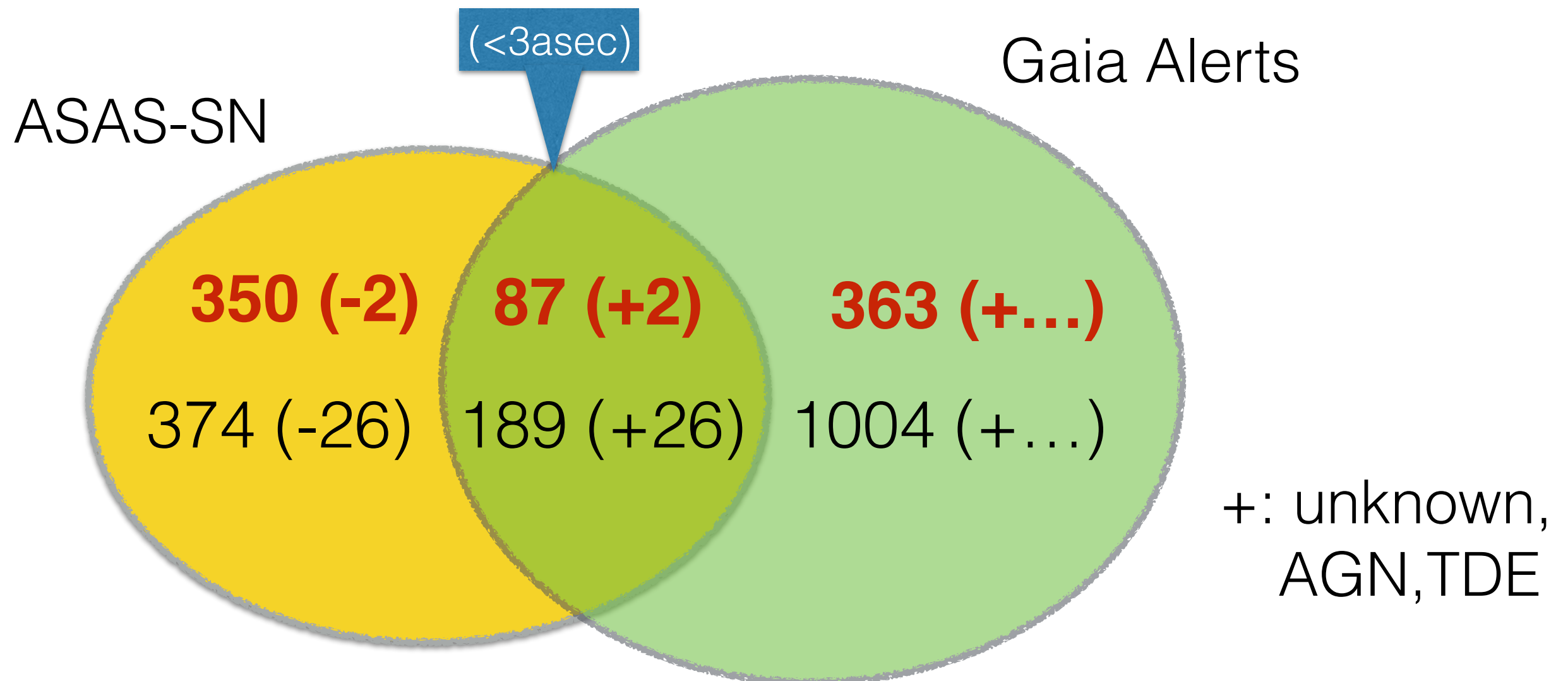


SN's in ASAS-SN vs Alerts

from 2014-09-01 to mid 2017 (Gaia DR3)

from Gaia DR3 to 2019-10-18.31 (UTC)

(ASAS-SN: $g, V \sim 9-18$ mag)



ASAS-SN SN: http://www.astronomy.ohio-state.edu/asassn/sn_list.html

Gaia Alert SN: `(Class.endsWith("SN") || Class.startsWith("SN")) && !(Class=="SN imposter")`

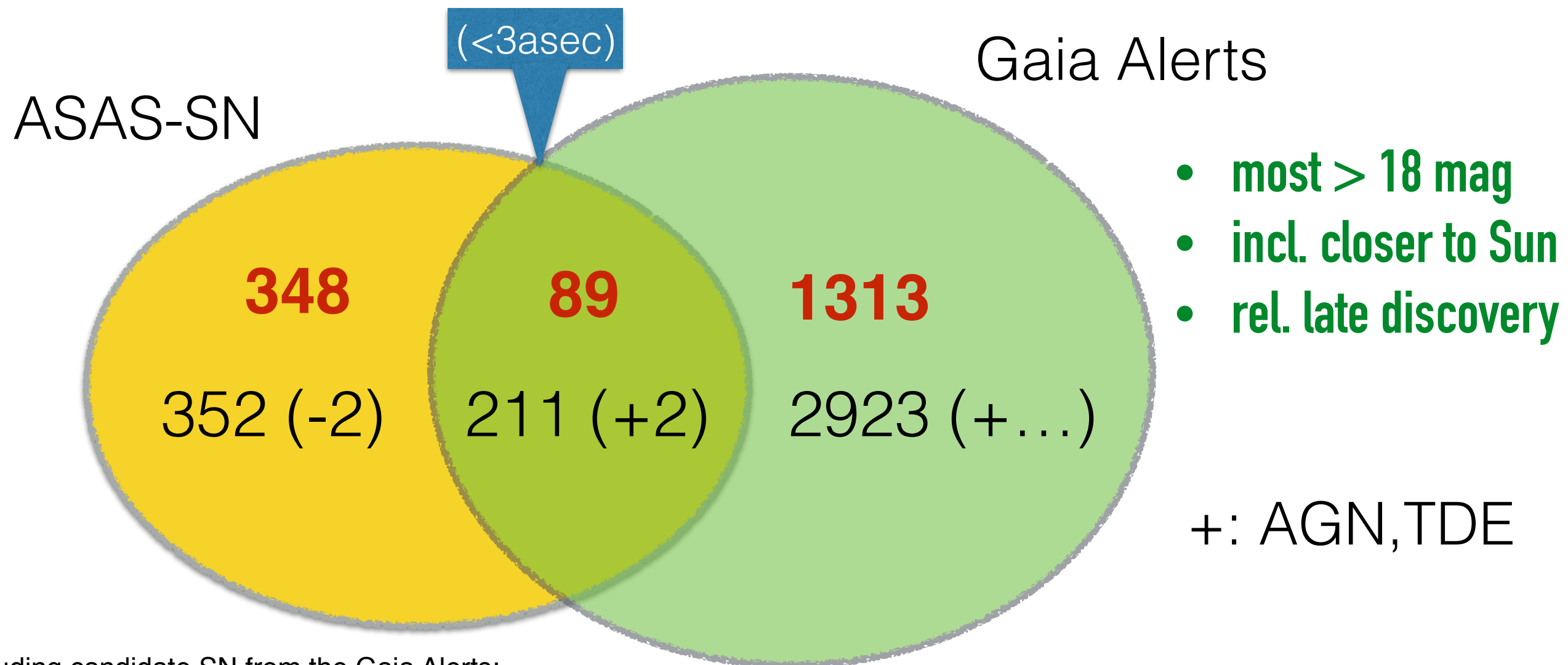
INCLUDING SN CANDIDATES IN THE GAIA ALERTS

SN's in ASAS-SN vs Alerts

from 2014-09-01 to mid 2017 (Gaia DR3)

from Gaia DR3 to 2019-10-18.31 (UTC)

(ASAS-SN: $g, V \sim 9-18$ mag)



Including candidate SN from the Gaia Alerts:

1) `grep -e "SN" -e "candidate SN" -e "Candidate SN" -e "predicts SN" -e "predict SN" -e "possible SN" alerts.csv > alerts_grep.csv`

2) on alerts_grep.csv: `(Class.endsWith("SN") || Class.startsWith("SN") || (Class=="unknown")) && !(Class=="SN imposter")`

VARIABILITY RESULTS	Gaia DR1 (14 Sept 2016)	Gaia DR2 (25 Apr 2018)	PLANS	
			Gaia DR3 (S2 2021) EDR3: Q3 2020	Gaia DR4 (TBD)
Time Span	14 months	22 months	34 months	5.x years
Variable obj.	3.2 10 ³	5.5 10 ⁵	~10 ⁷	~10 ⁸
Published Classes	2	7	15-25	All possible
Trained Classes	8	22	25-35	All possible
Crossmatch Catalogs	7	70	>100	All possible
Classification	weka	weka	H20	(H20)
Input Data	G	+ BP, RP	+ XP spectra, RV	+ per-CCD, all spectra..
Classes	RR Lyrae Cepheid	+ δ Scuti SX Phoenicis Miras Semi-Regulars Rotating (spots) Short time scale	+ YSOs, MS vars. eclipsing bin. ellipsoidals flaring/eruptive white dwarfs pulsing events exo-planets (super)novae AGNs/QSOs/Blazars	All possible