

PTF and Kepler Projects: An Overview

PTF 與克卜勒計畫

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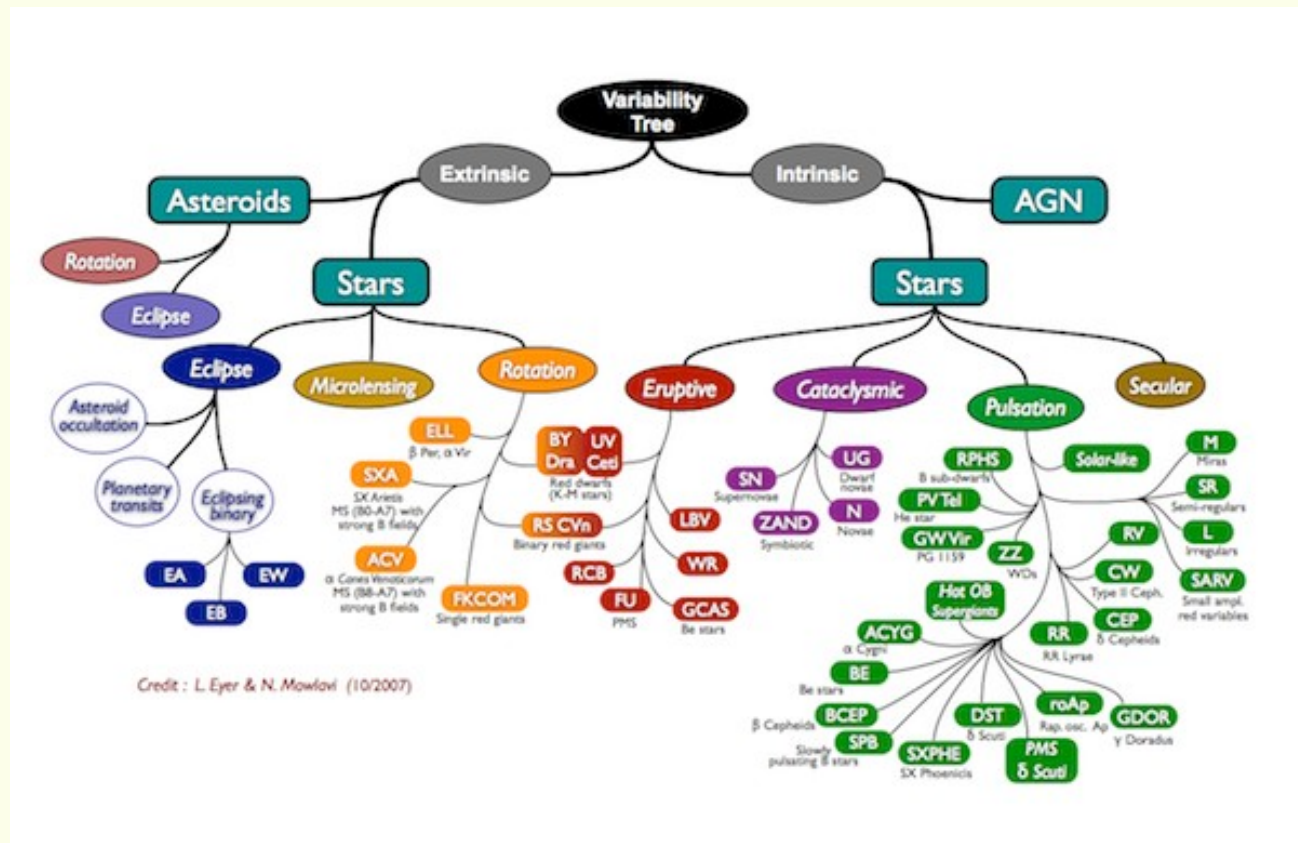
Before We Start ...

- Photometry = measurement of brightness (or flux)
- Astrometry = measurement of positions
- Variable stars = changes brightness with various time-scale
- Transients = objects suddenly appear, or become “bright”
- Magnitude = logarithmic scale of flux
 - $\Delta m = 2.5 \rightarrow$ can see 10x's fainter; $\Delta m = 5 \rightarrow$ 100x's fainter
- Angular units
 - 1 arcminute = (1/60) degree.
 - 1 arcsecond = (1/3600) degree. Typical limit due to “seeing”.

Science with Time-Domain Astronomy

- Asteroids motions and rotations
- Many types of variable stars and their activities
- Explosive events such as novae and supernovae
- Micro-lensing
- Extra-Solar planets transit

Magnitude/flux/position varies with time



Time Domain Astronomy

The data-centric problem statement:

- **Databases**: Given ~1 petabyte of image data, extract sources and create a **database** of ~1 billion objects.
- **Machine learning**: In near real time, analyze ~Gbytes/minute of image data to identify which of millions of “candidates per night” are true astronomical **transients**. Similarly, identify fast-moving **near earth asteroids**.
- **Time-frequency algorithms**: Using efficient queries on the database, determine which of the ~10’s of millions of **variable** sources are “interesting sources”

Requires highly automated data exploration
Reduce false positives to manageable level

Many existing optical time- domain surveys

(+ SDSS Stripe 82, ASAS,...)
(+ many more to come)

La Silla Schmidt



Palomar Schmidt



Catalina Schmidt

Uppsala Schmidt



SkyMapper

PanStarrs



MOA telescope

OGLE IV



CTIO



VST

(From B. Schmidt talk)

Focus on PTF and Kepler here

The Palomar Transient Factory (PTF)

- Dedicated time-domain survey for transients discoveries
- Main survey telescope: 48-inch Schmidt Telescope or P48
 - Wide-field mosaic CCD
 - Single band observation, mainly in R-band (also in g or H-alpha bands)
 - Fixed exposure time of 60 second (occasion with shorter exposure time)
 - Variable cadence from few minutes to few days
- Follow up with P60 and P200, and other telescopes
- P48, P60 and P200 → located at the Palomar Observatory

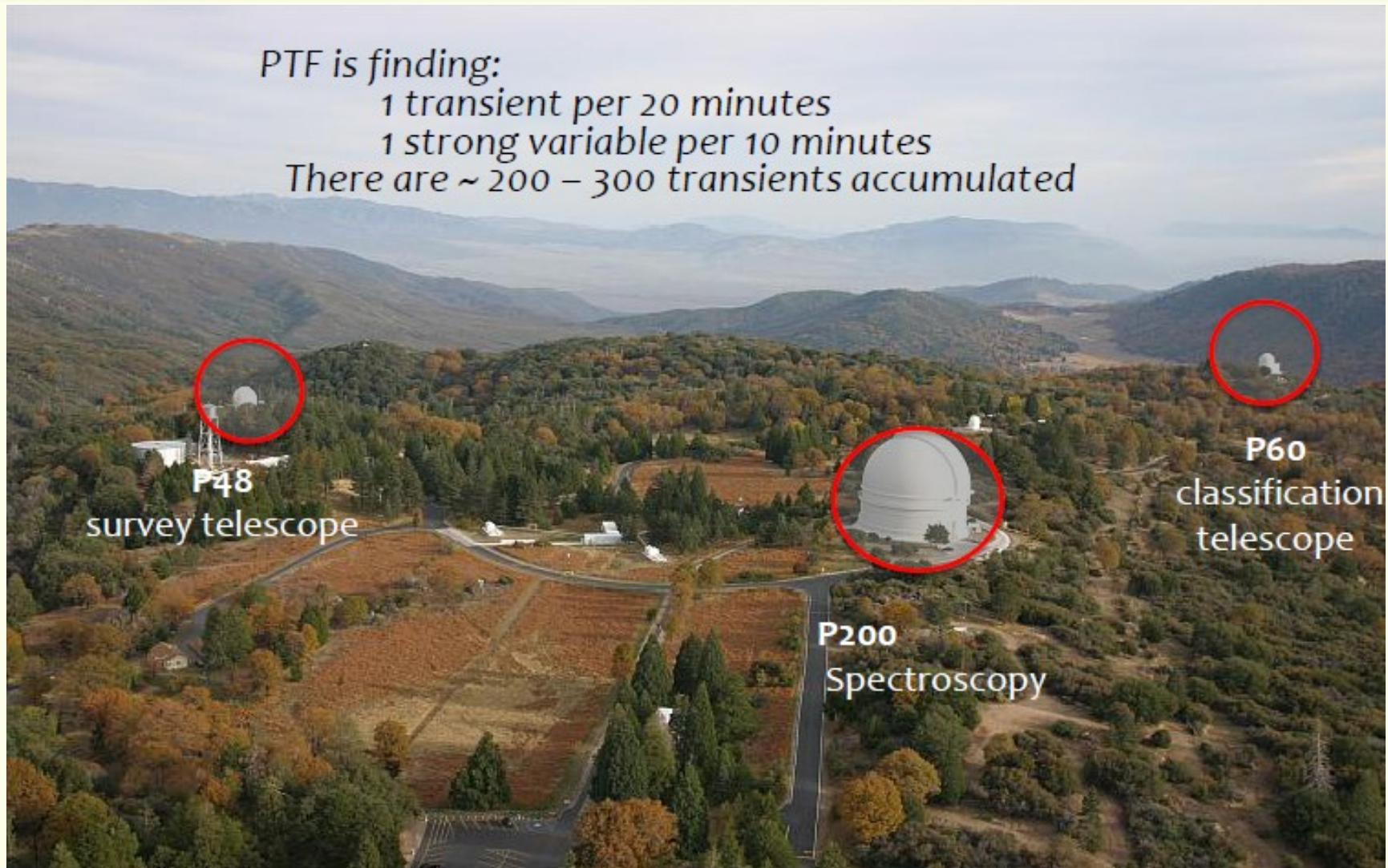
PTF @ The Palomar Observatory

PTF is finding:

1 transient per 20 minutes

1 strong variable per 10 minutes

There are ~ 200 – 300 transients accumulated

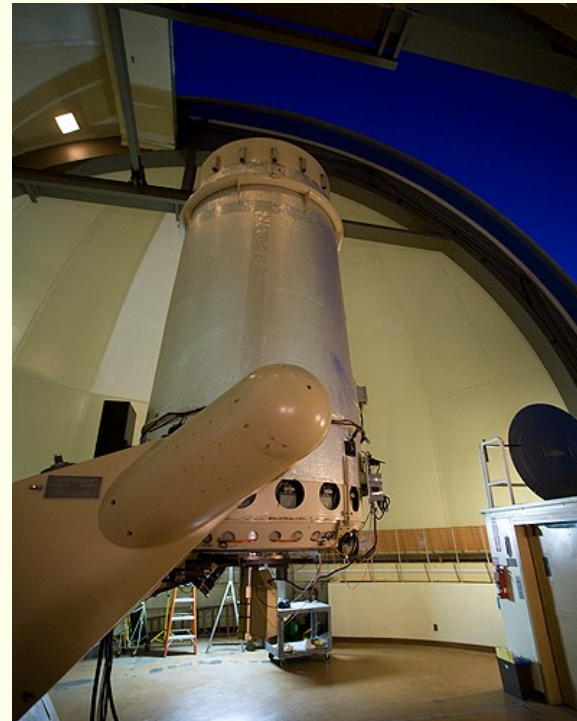


PTF, iPTF and ZTF

- PTF = Palomar Transient Factory (2009 – 2012)
- iPTF = Intermediate PTF (2013 – 2016)
- ZTF = Zwicky Transient Facility (2017 - ~2020)



P48: Survey Telescope



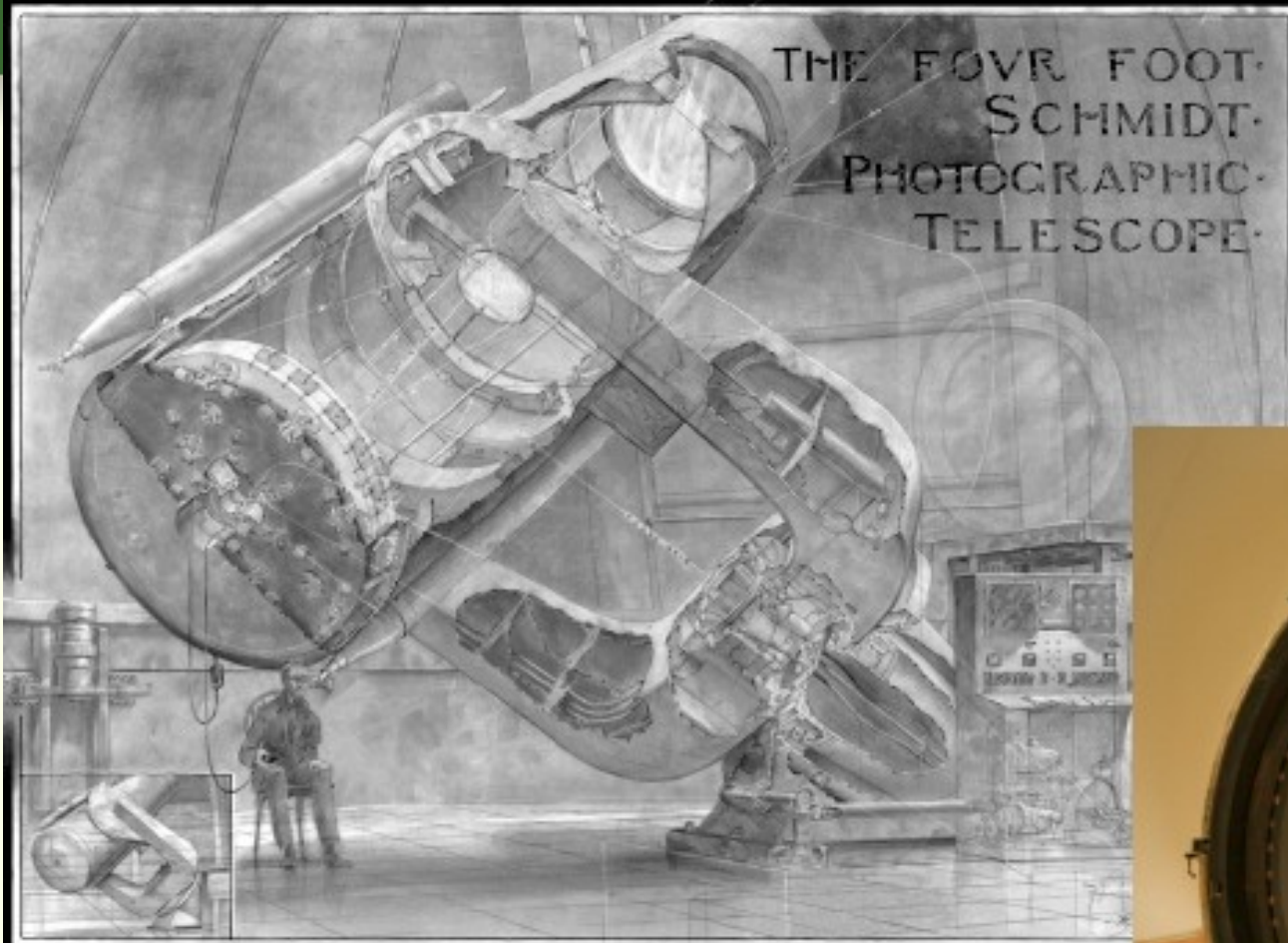
P60: Follow-Up Telescope

In Honor of Fritz Zwicky



- Dark Matter & gravitational lens
- Separate out supernova and nova (with W. Baade)
- Systematic search of SN with wide-field telescopes

The P48 is a larger survey telescope with a distinguished history.

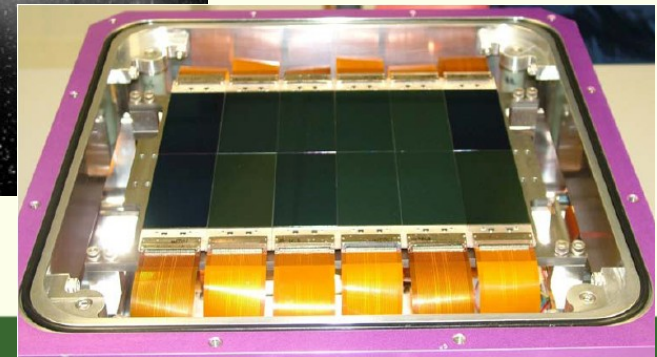
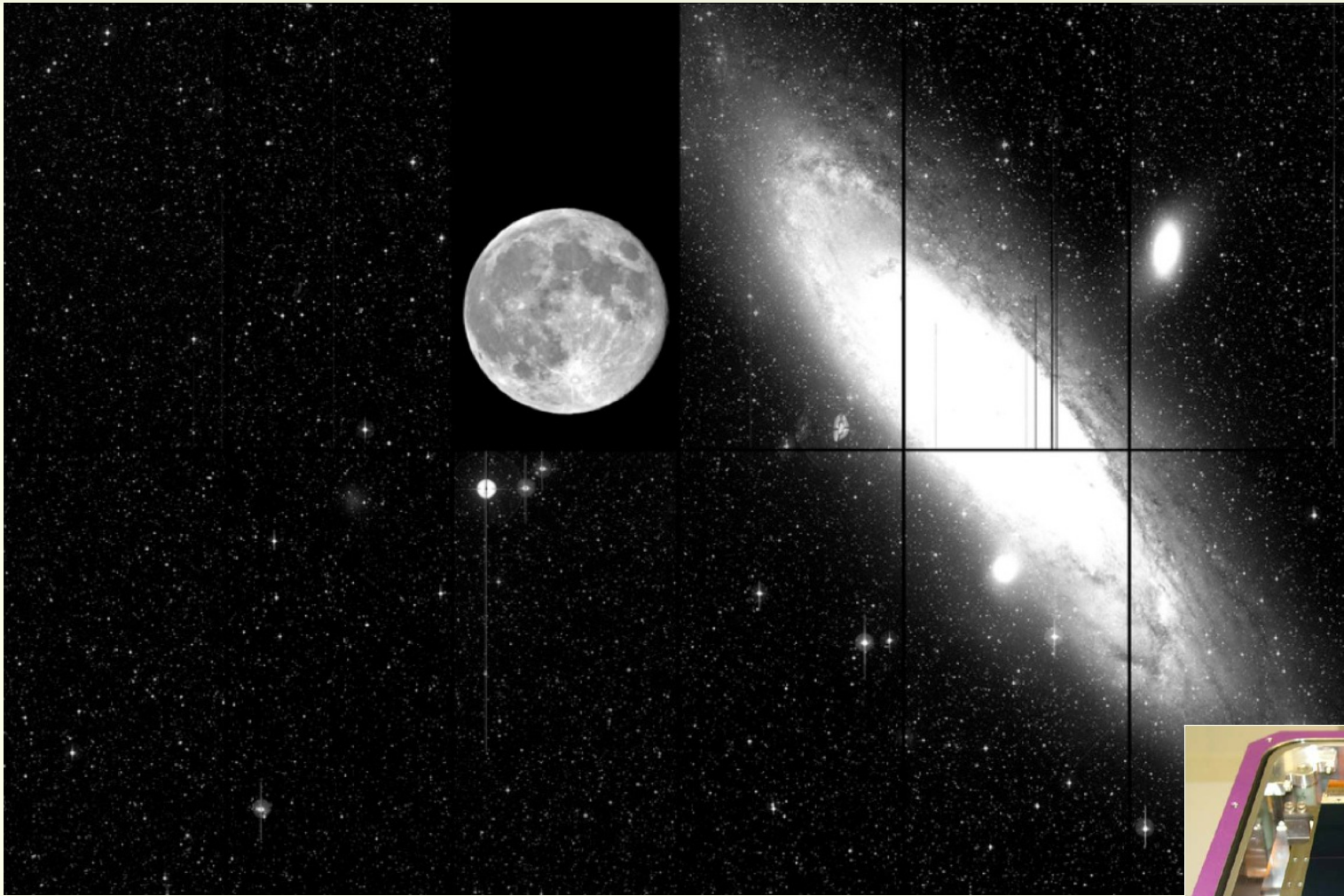


POSS I & II
NEAT, QUEST, PTF

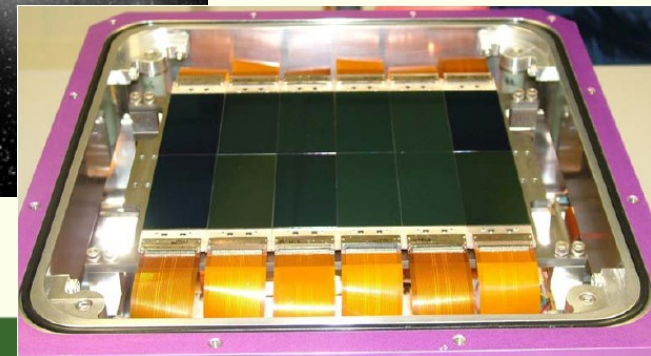
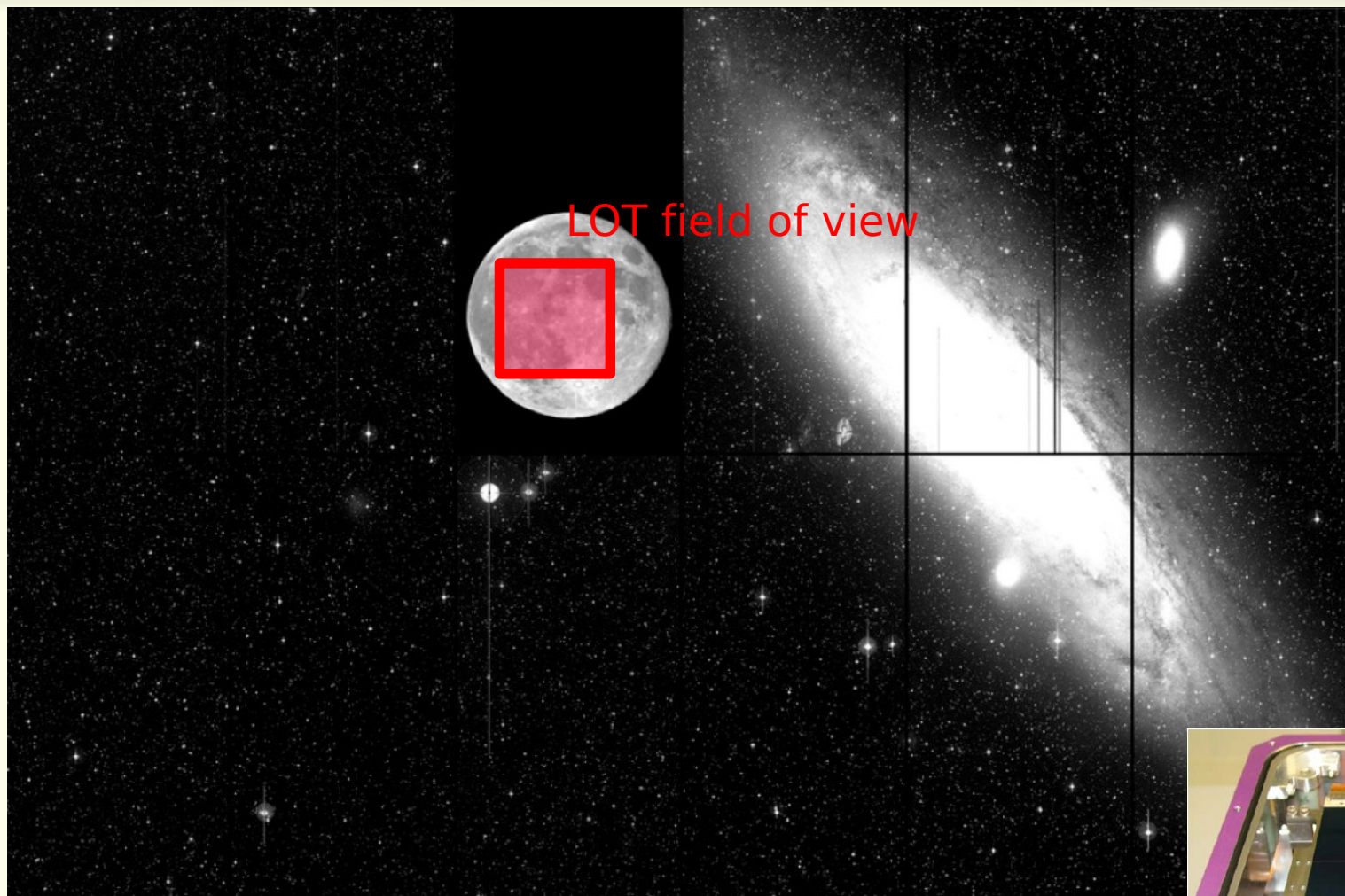
large sky surveys
supernovae
asteroids and KBOs



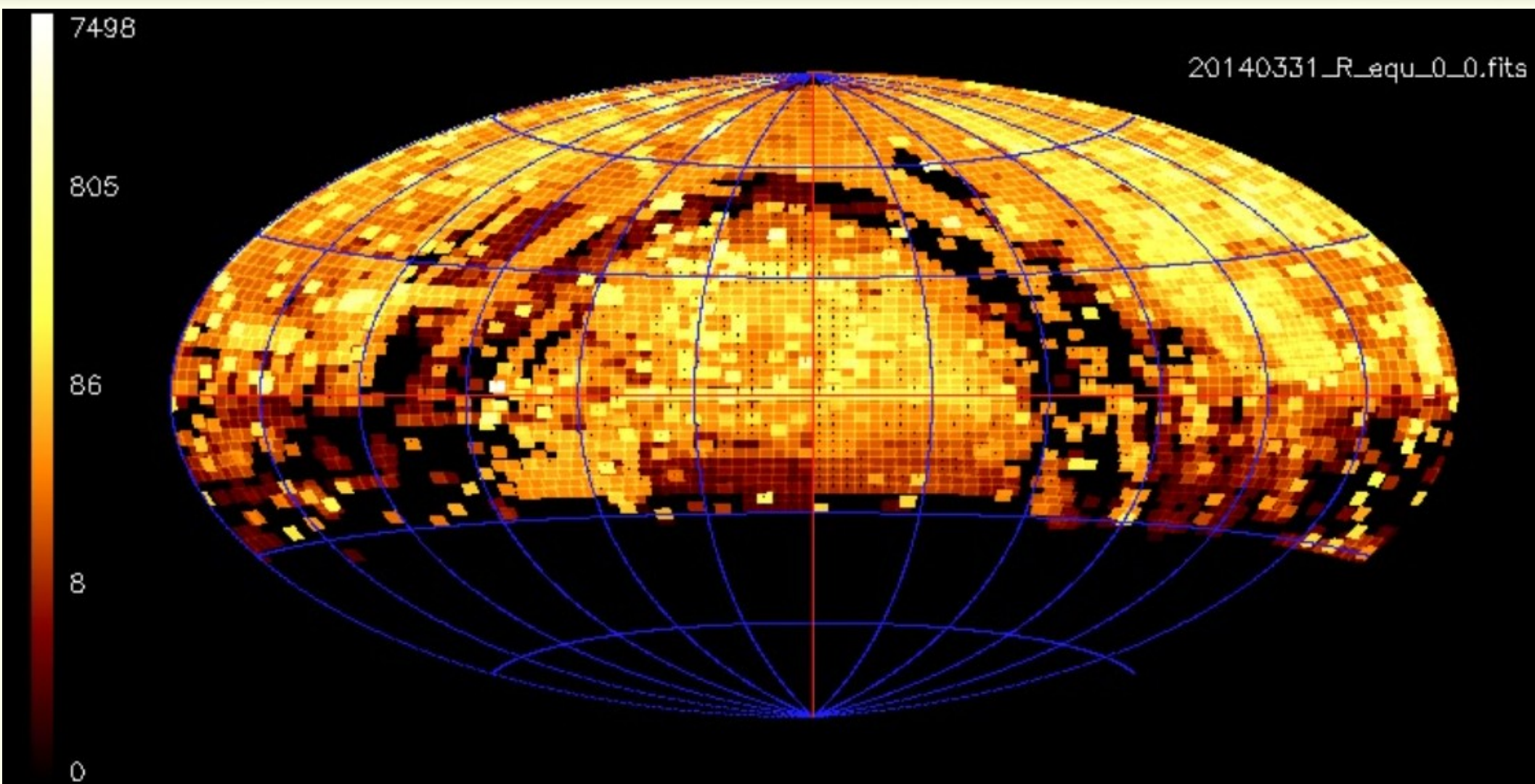
Wide-Field Mosaic CCD at P48



Wide-Field Mosaic CCD at P48



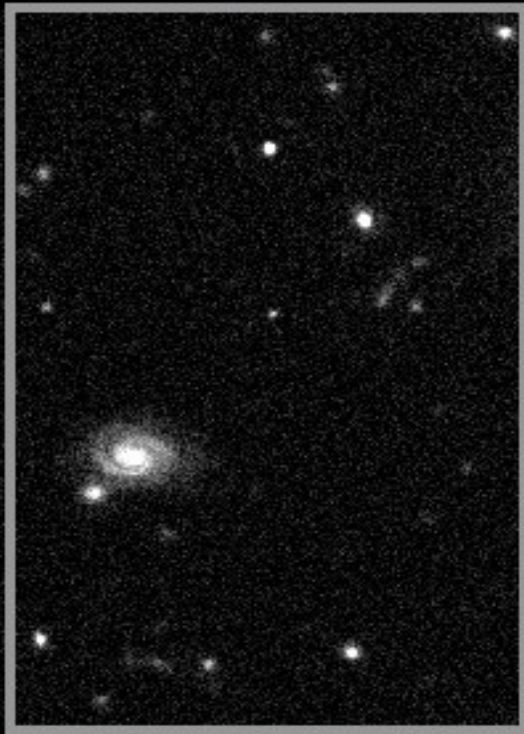
Accumulated Sky Coverage in R-Band



Finding Transients with Image Subtraction

Image Subtraction

Epoch 1



Epoch 2 (3 weeks later)

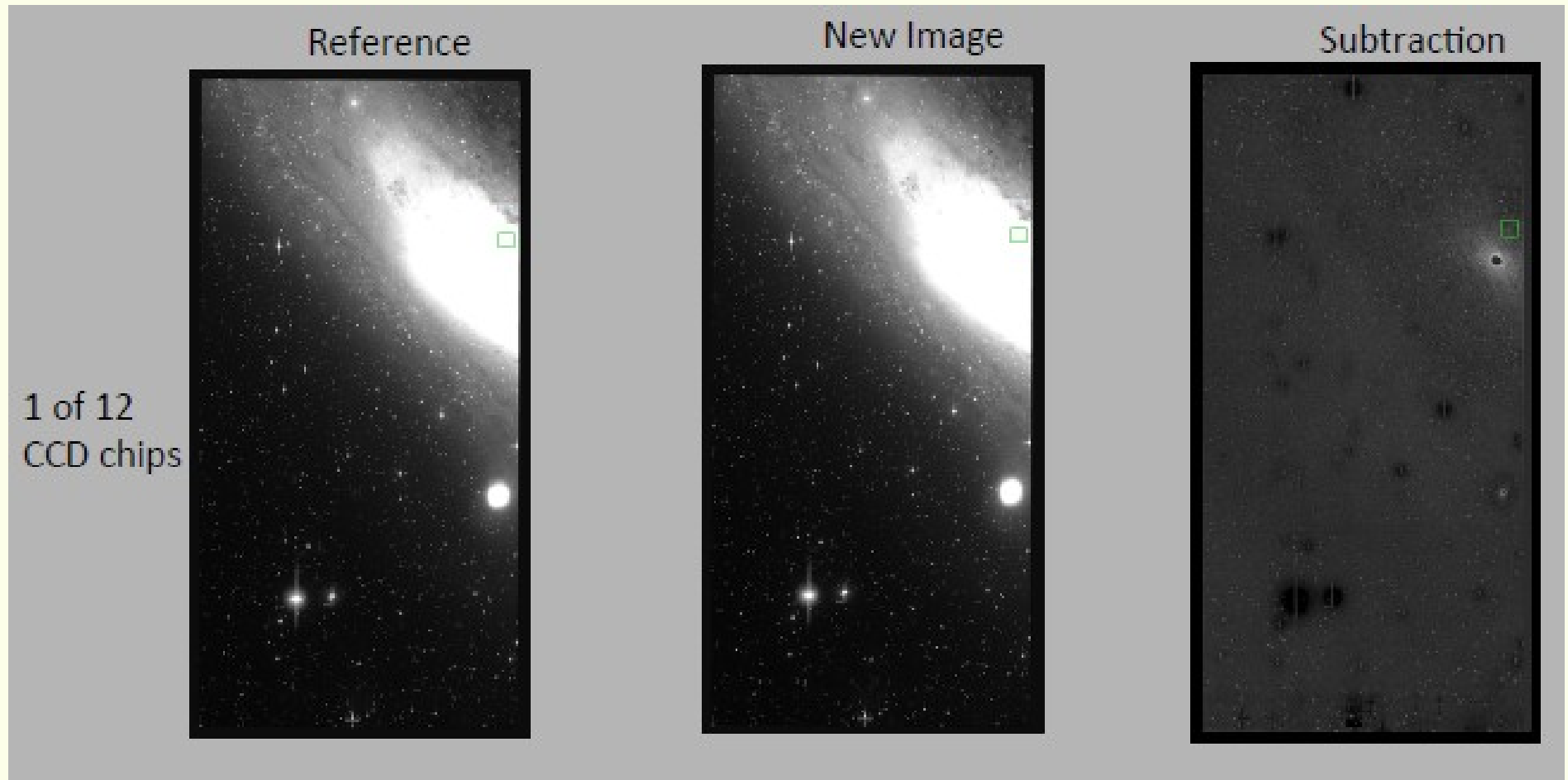


Epoch 2 - Epoch 1



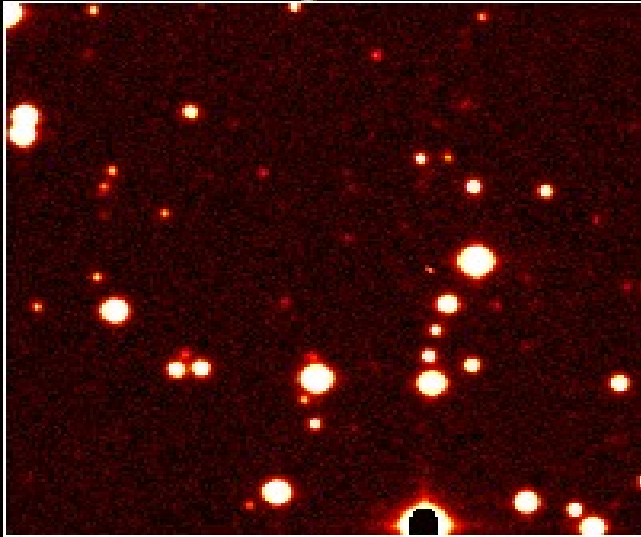
(High-z Supernova Team)

Finding Transients with Image Subtraction

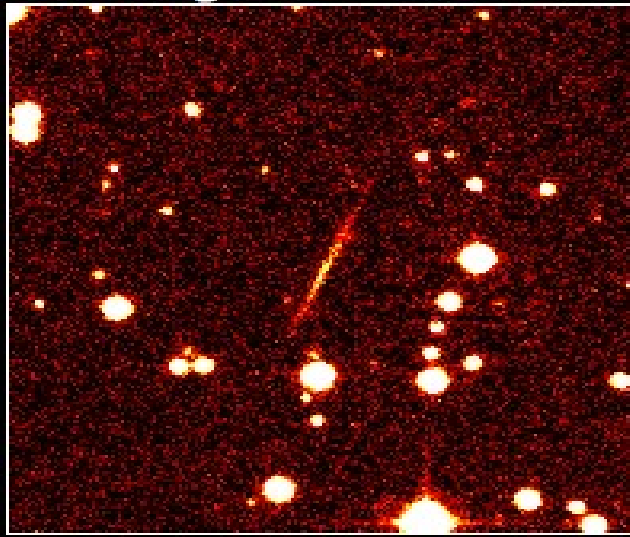


Finding Fast Moving Asteroids with Image Subtraction

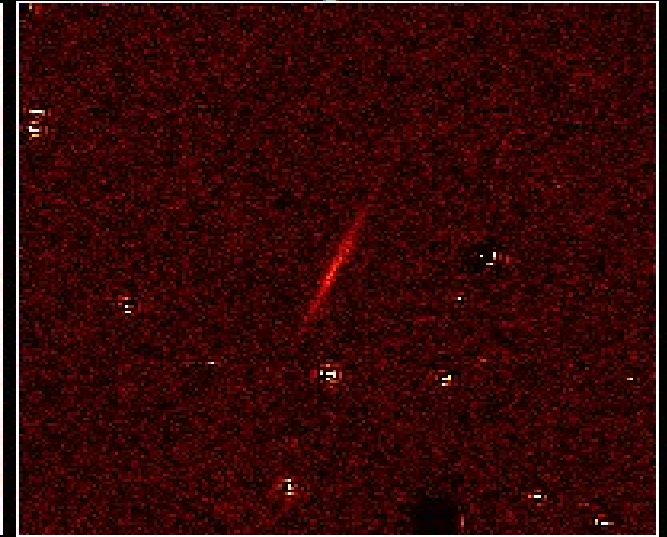
Reference Image



New Image

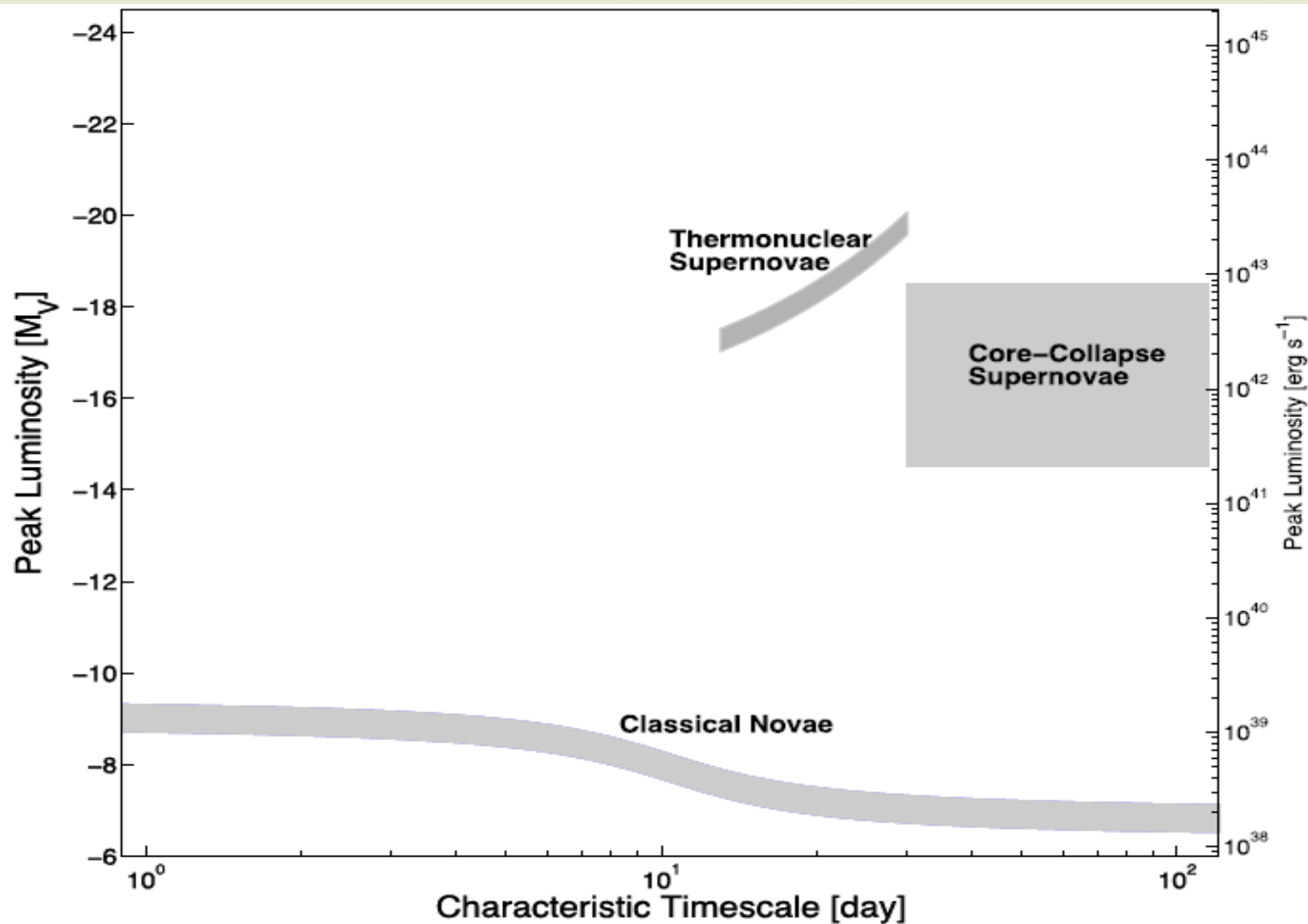


Difference Image

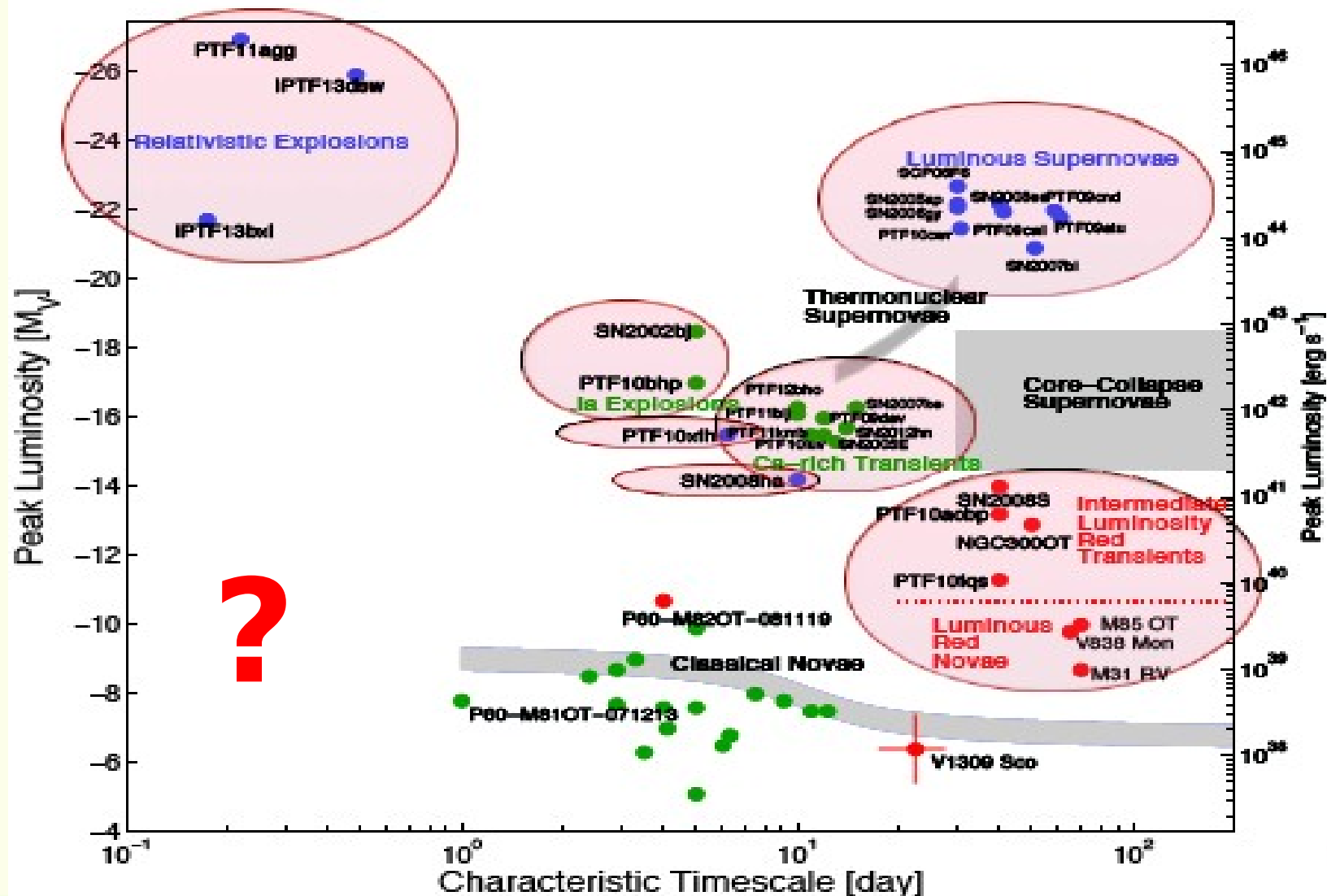


Fast moving asteroids leave “streaks” on images

PTF Discoveries on Transients (Before)

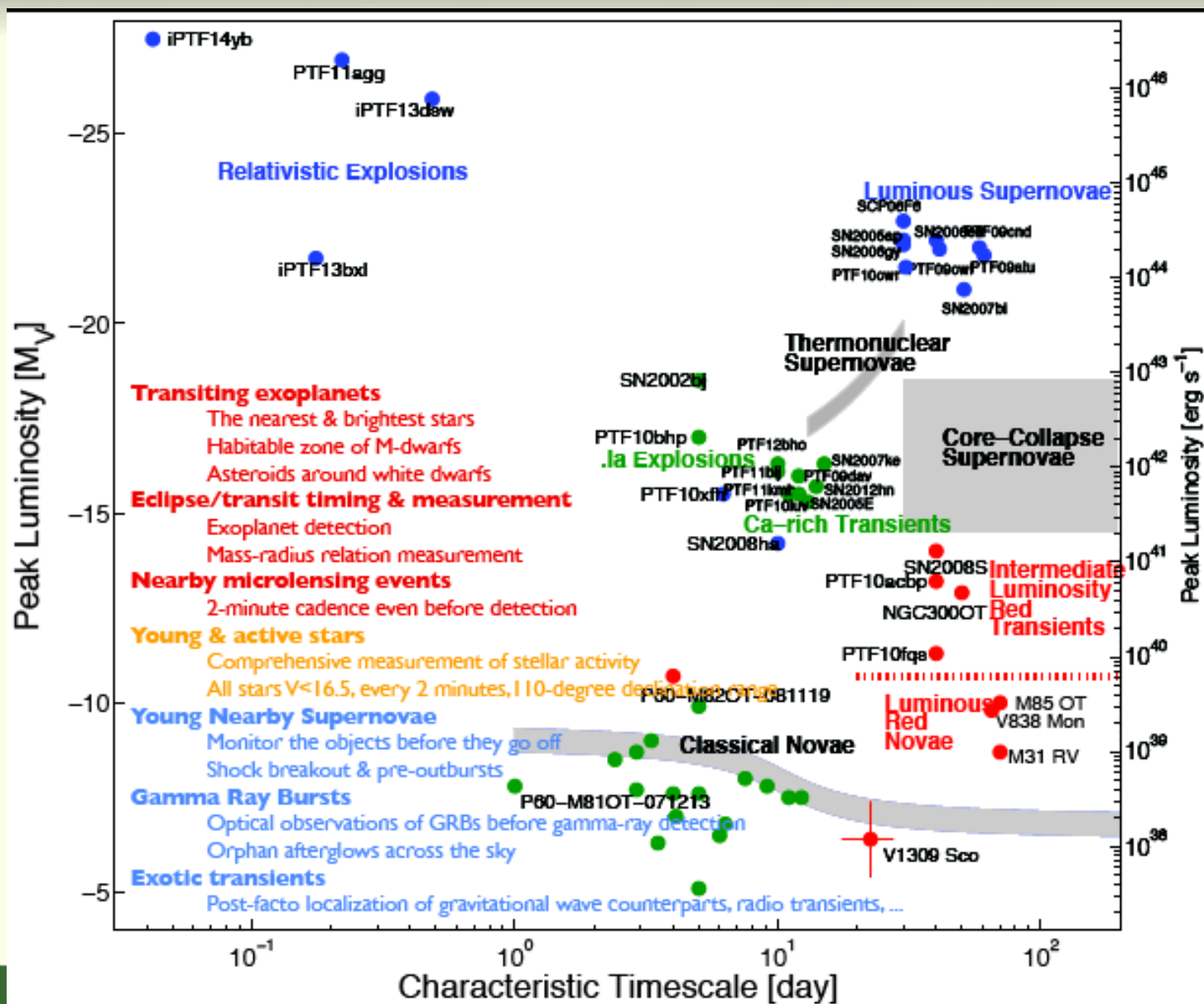


PTF Discoveries on Transients (After)



Updated from Kasliwal 2011 (PhD)

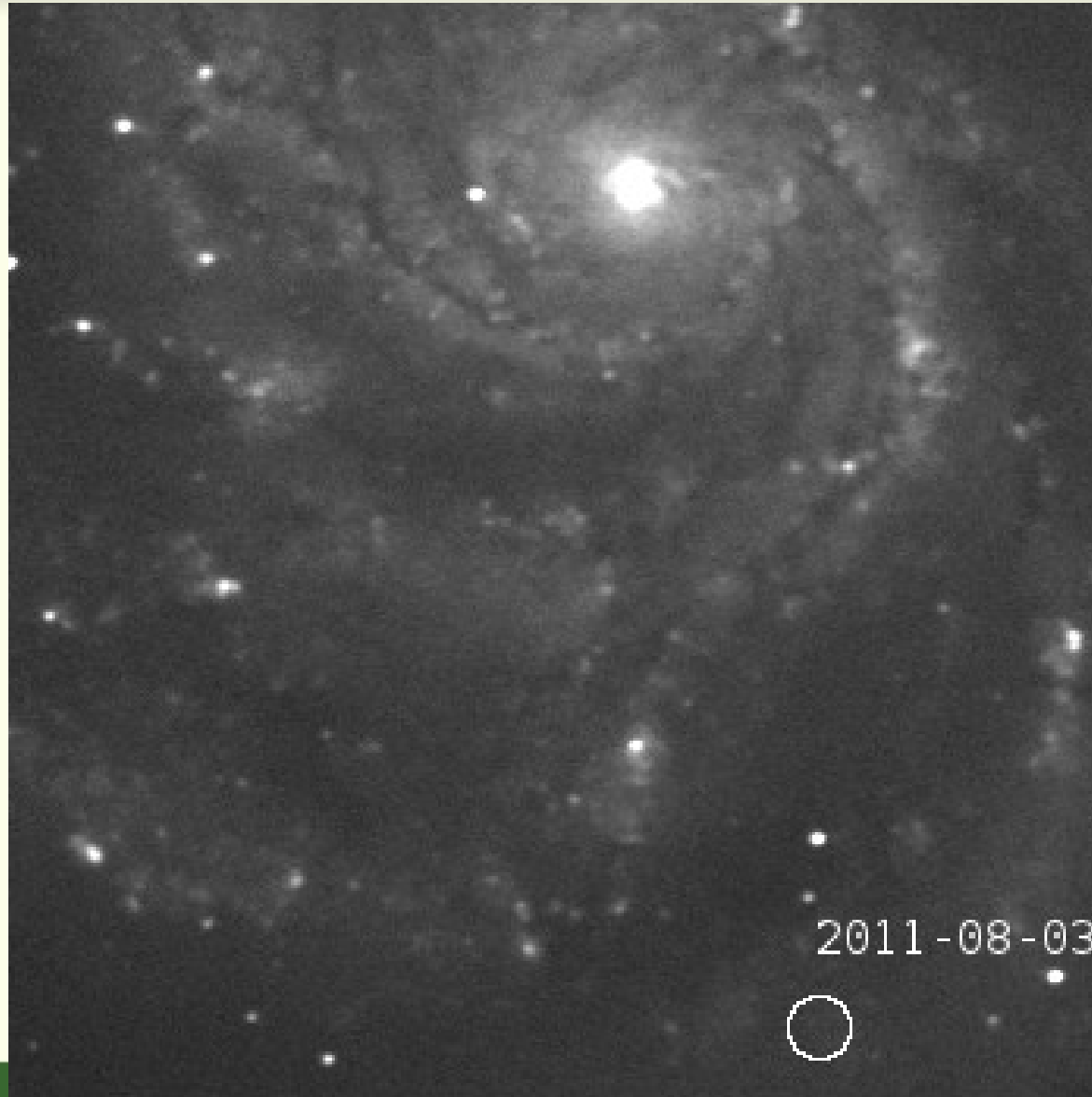
PTF Discoveries on Transients (Future)



Example: PTF Discovered SN in M101



Example: PTF Discovered SN in M101



P48 Survey Telescope

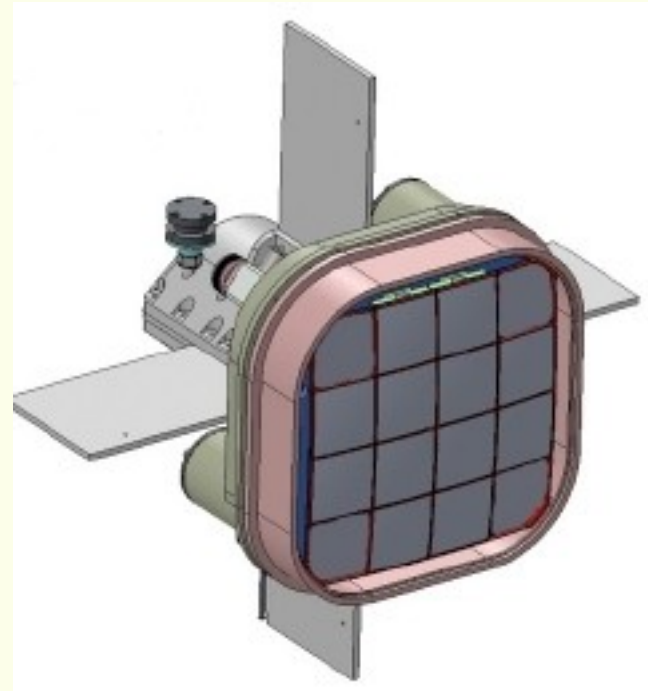
PTF & iPTF



ZTF



- 11 2k x 4k mosaic CCD (CFH12K)
- 1.01 "/pix $\rightarrow$ ~ 7.26 deg² FOV
- Mould R (main), g' & H α filters

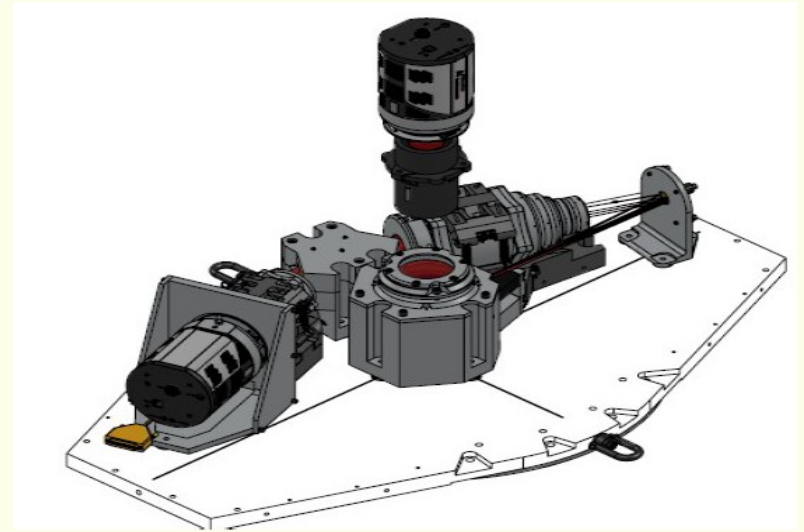


- 16 6k x 6k e2V CCD
- 1 "/pix $\rightarrow$ ~ 47 deg² FOV
- Mould R & g'

P60 Follow-Up Telescope

PTF $\longrightarrow$ iPTF $\longrightarrow$ ZTF

Property	Amplifier 1	Amplifier 2	Full Chip
Array Size	2048×1024	2048×1024	2048×2048
Pixel Size (μm)	...	...	24
Plate Scale (arcsec pixel^{-1})	...	...	0.378
Field of View (arcmin)	12.9×6.5	12.9×6.5	12.9×12.9
Gain ($\text{e}^- \text{ ADU}^{-1}$)	2.2	2.8	...
Read Noise (e^-)	5.3	7.8	...
Dark Current ($\text{e}^- \text{ s}^{-1}$)	10^{-3}	10^{-3}	...
Charge Transfer Efficiency	$> 99.999\%$	99.999%	...
Full Well Capacity (e^-)	130,000	140,000	...
Bias Level (ADU)	610	445	...
Saturation Limit (ADU)	50,000	45,000	...



- Fully robotic
- Standard broadband filters (UBVRI + griz)

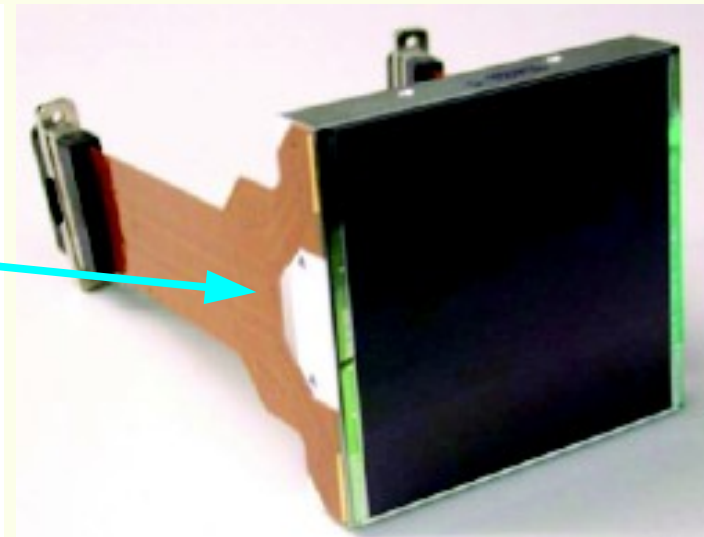
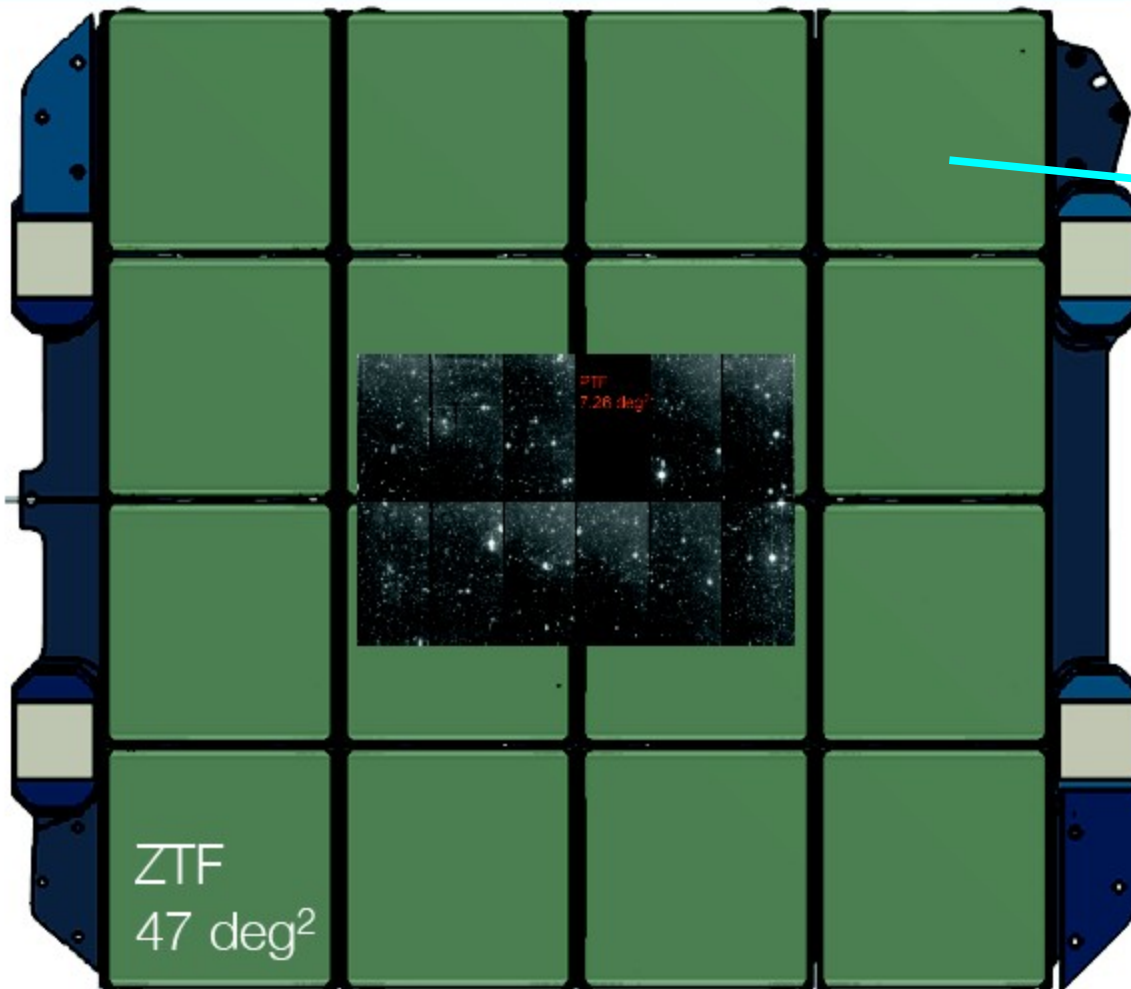
- Low resolution ($R \sim 100$) IFU using lenslet array
- Simultaneous 4-band imager for flux calibration
- Fast classification of SNe

“GRB”Cam

SED Machine

Next Step: ZTF and Its Camera

A new camera will fill the P48 focal plane.



e2v	
dimension	9.2 x 9.2 cm
pixels	6.1k x 6.1k
pixel size	15 micron
pixel scale	1"/pixel
outputs	4

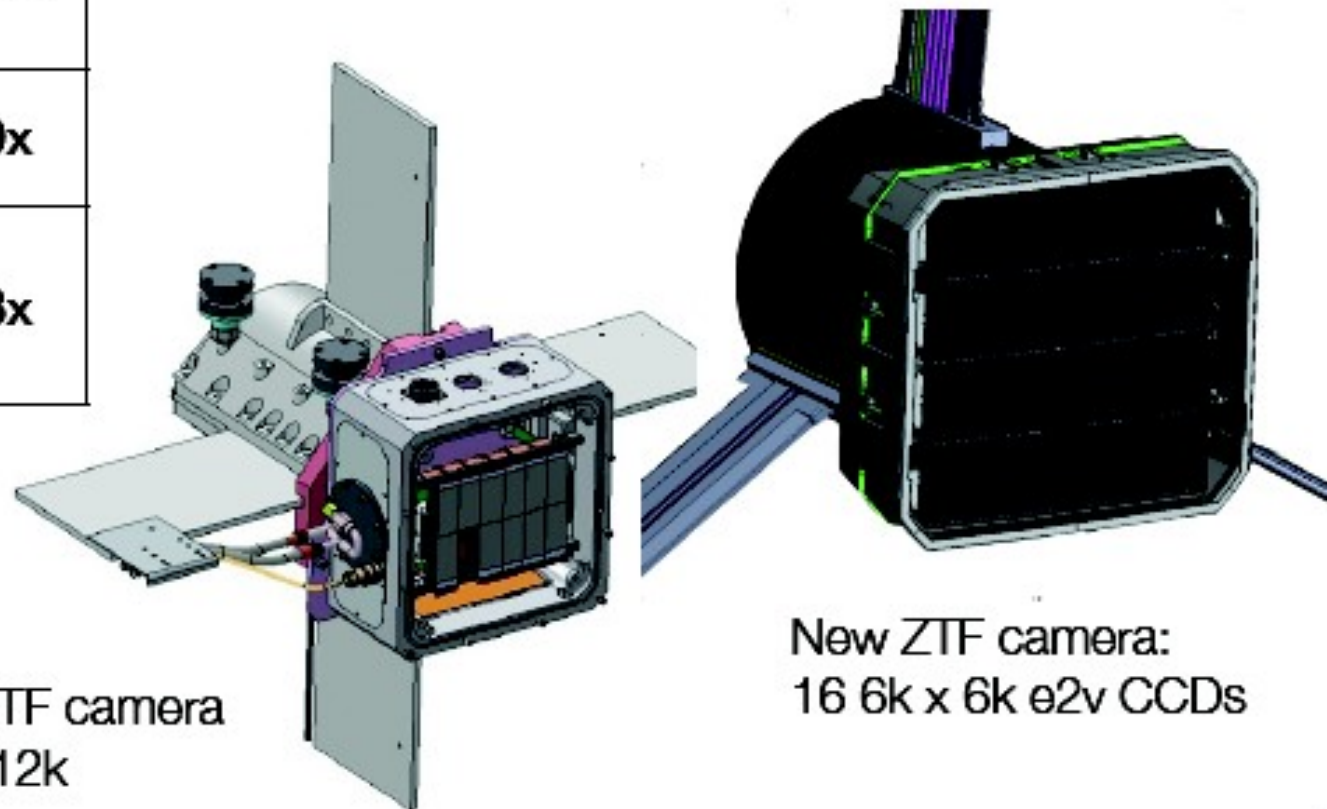
ZTF will survey an order of magnitude faster than PTF.

	PTF	ZTF
Active Area	7.26 deg ²	47 deg ²
Overhead Time	46 sec	<15 sec
Optimal Exposure Time	60 sec	30 sec
Relative Areal Survey Rate	1x	15.0x
Relative Volumetric Survey Rate	1x	12.3x

3750 deg²/hour

⇒ 3 π survey in 8 hours

>250 observations/field/year
for uniform survey



Existing PTF camera
MOSAIC 12k

New ZTF camera:
16 6k x 6k e2v CCDs

http://www.ptf.caltech.edu/



www.ptf.caltech.edu/iptf



convert keynote to ppt



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Supernovae Discovered by PTF

All SNe	SNe Ia	SNe Ibc	SNe II
2,203	1,479	103	545

[See All Data](#)

Recent NEAs Discovered

Name	Found	Size*	Orbit
2013 VV4	11-03-13	530 m	Amor
2013 PV6	08-02-13	730 m	Amor
2013 OOS	07-30-13	330 m	Amor
2013 JH14	05-05-13	180 m	Apollo
2013 JE1	04-30-13	760 m	Apollo
2013 HN11	04-18-13	200 m	Amor
2013 GZ79	03-31-13	530 m	Amor
2013 EW128	03-15-13	440 m	Apollo

News



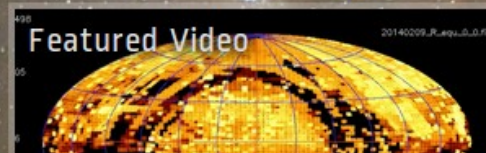
M42

Observation • March 4, 2014

This is a g- and R-band image from PTF of a segment of M42, the Great Nebula in Orion, one of the largest and nearest star-forming regions.

[Explore Image →](#)

Featured Video



Publications

Total Publications: 79

Connection between optical and γ-ray variability in blazars
Hovatta, T., et al. 2014

The rise and fall of the Type Ib supernova iPTF13bvn - Not a massive Wolf-Rayet star
Fremling, C., et al. 2014

First Searches for Optical Counterparts to Gravitational-wave Candidate Events
Aasi, J., et al. 2014

The host galaxies of Type Ia supernovae discovered by the Palomar Transient Factory
Pan, Y.-C., et al. 2014

The discovery of SN2014J in the nearby starburst galaxy M82
Goobar, A., et al. 2014

[See All Publications](#)

www.ptf.caltech.edu/image/ptf140304b

PTF Public Released Data: DR1

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First Data Release

M 81

M 44

Orion

Kepler Survey Field

Stripe 82

Cassiopeia A

Second Data Release

Documentation

Getting Survey Data

The first data release in Spring of 2014 (DR1) consists of data from specific fields taken by the PTF collaboration between 2009 and the end of 2012. The specific fields are:

- [M 81](#) (NGC 3031, a nearby spiral galaxy. Also includes M 82. Approximately 1170 epochs, 7 deg²)
- [M 44](#) (the Beehive Cluster. 195 epochs, 29 deg²)
- [M 42](#) (an extremely high cadence field in Orion. 5000 epochs, 15 deg²)
- [The Kepler Survey Field](#) (48 epochs, 167 deg²)
- [SDSS Stripe 82](#) (8–250 epochs, 225 deg²)
- [Cassiopeia A](#) (4–8 epochs)

and were chosen to provide a scientifically useful subset of the survey data, highlighting its high-cadence, multi-epoch nature. Because the release is only a subset of the data, users should read the linked subsections above. In particular, they contain hints about the best way to search for the data. The released data (in FITS format) are:

Epochal (single exposure) Images - one image per CCD exposure, astrometrically and photometrically calibrated. Each exposure also has an accompanying mask file, whose bits encode information about specific pixels.

Photometric Catalogs - each individual exposure image is accompanied by a catalog file containing all detected objects in that exposure, with photometrically calibrated aperture photometry. The individual catalog files are in binary FITS format (with a ".ctlg" file suffix).

Getting the PTF Public Data

The screenshot shows the Palomar Transient Factory (PTF) website. The header features a navigation bar with links: HOME, NEWS, IMAGES, VIDEOS, ABOUT, DATA ACCESS, PUBLICATIONS, MEETINGS, and PEOPLE. The 'DATA ACCESS' link is highlighted. On the left, a sidebar menu lists: Data Access, First Data Release, Second Data Release, Documentation, Getting Survey Data (highlighted with a red box), GUI Interface (highlighted with a green box), Program Interface, and Asteroids. The main content area contains a paragraph about the GUI interface, a large green button labeled 'Click here to access the GUI interface.', and a link to download a 'Quick User's Guide to Using the PTF Archive GUI'. A small thumbnail image of a telescope is in the bottom right corner.

INTERMEDIATE PALOMAR TRANSIENT FACTORY

HOME | NEWS | IMAGES | VIDEOS | ABOUT | DATA ACCESS | PUBLICATIONS | MEETINGS | PEOPLE

Data Access

First Data Release

Second Data Release

Documentation

Getting Survey Data

GUI Interface

Program Interface

Asteroids

The [GUI interface](#) is based on a standardized toolkit used by IRSA for all of its mission data. If you are familiar with the Spitzer Heritage Archive or the WISE archive, you are already probably already familiar with workings of the PTF archive. The GUI interface offers several different search types. It has numerous capabilities, described below, as well as in the general documentation available directly in the tool. This also allows you to download data.

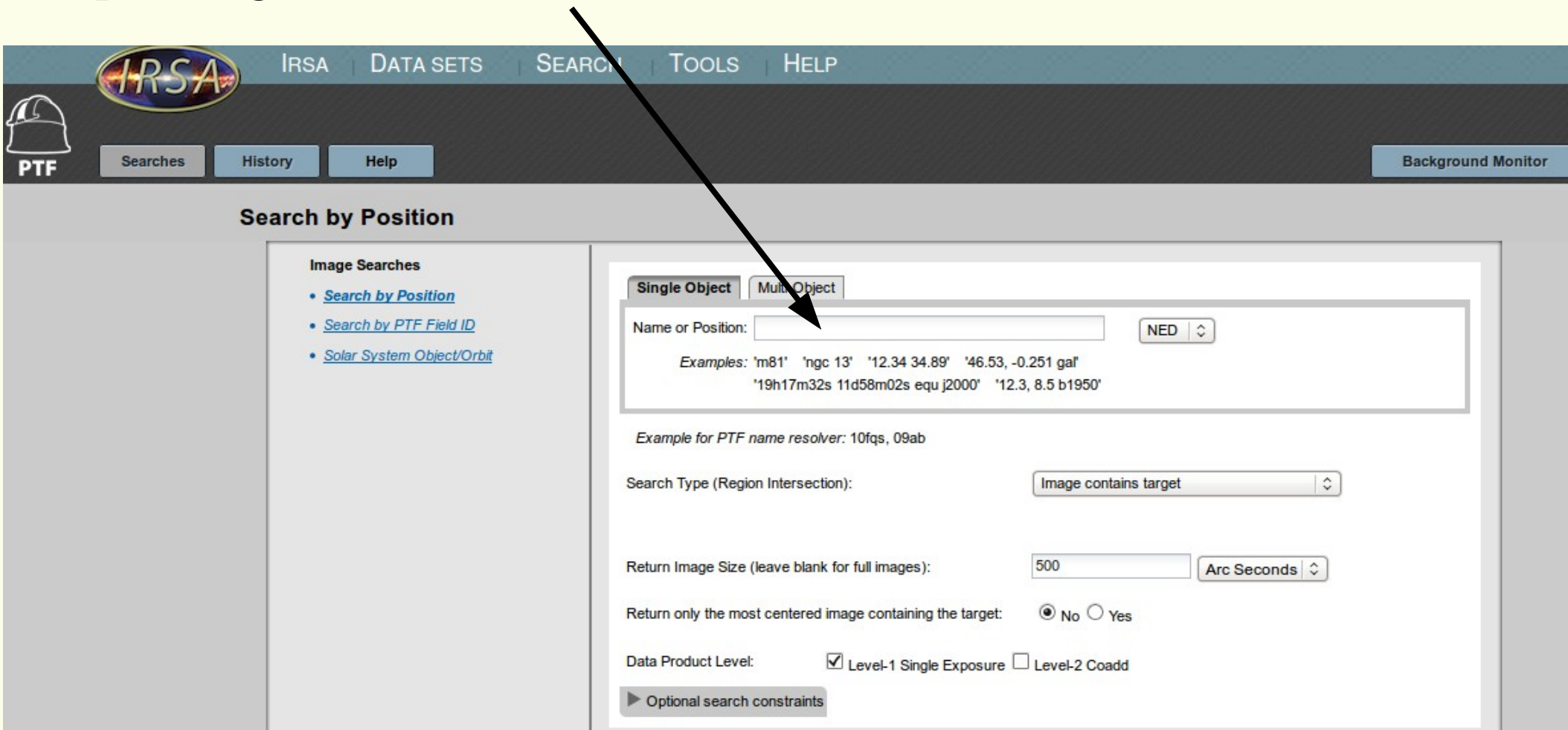
[Click here to access the GUI interface.](#)

Download the [Quick User's Guide to Using the PTF Archive GUI](#)

Palomar Transient Factory
Archive Graphical User Interface
Search and Retrieval Basics

Getting the PTF Public Data

Input target's coordinate (RA/DEC) here



The screenshot shows the IRSA PTF search interface. At the top, there is a navigation bar with links for IRSA, DATA SETS, SEARCH, TOOLS, and HELP. Below this is a secondary bar with a PTF logo, buttons for Searches, History, and Help, and a Background Monitor button. The main section is titled 'Search by Position'. On the left, under 'Image Searches', there are three links: 'Search by Position', 'Search by PTF Field ID', and 'Solar System Object/Orbit'. The main search area has two tabs: 'Single Object' (selected) and 'Multi Object'. Below the tabs is a text input field labeled 'Name or Position:' with a dropdown menu set to 'NED'. An arrow points to this input field. Below the input field, there are examples of coordinate formats: 'm81', 'ngc 13', '12.34 34.89', '46.53, -0.251 gal', '19h17m32s 11d58m02s equ j2000', and '12.3, 8.5 b1950'. Below the examples, there is a text field for 'Example for PTF name resolver: 10fq5, 09ab'. Further down, there is a 'Search Type (Region Intersection):' dropdown menu set to 'Image contains target'. Below that is a 'Return Image Size (leave blank for full images):' text field set to '500' and a unit dropdown menu set to 'Arc Seconds'. Below that is a radio button group for 'Return only the most centered image containing the target:' with 'No' selected. At the bottom, there is a 'Data Product Level:' section with a checked box for 'Level-1 Single Exposure' and an unchecked box for 'Level-2 Coadd'. Finally, there is a button labeled 'Optional search constraints'.

IRSA | DATA SETS | SEARCH | TOOLS | HELP

PTF | Searches | History | Help | Background Monitor

Search by Position

Image Searches

- [Search by Position](#)
- [Search by PTF Field ID](#)
- [Solar System Object/Orbit](#)

Single Object | **Multi Object**

Name or Position: NED

Examples: 'm81' 'ngc 13' '12.34 34.89' '46.53, -0.251 gal'
'19h17m32s 11d58m02s equ j2000' '12.3, 8.5 b1950'

Example for PTF name resolver: 10fq5, 09ab

Search Type (Region Intersection): Image contains target

Return Image Size (leave blank for full images): 500 Arc Seconds

Return only the most centered image containing the target: ☒ No ☐ Yes

Data Product Level: ☒ Level-1 Single Exposure ☐ Level-2 Coadd

Optional search constraints

Getting the PTF Public Data

Select data and download

The screenshot displays the PTF web interface. At the top, there's a navigation bar with 'PTF', 'Searches', 'History', 'Help', and 'Catalogs'. A 'Background Monitor' button is on the right. Below the navigation bar is a search bar with the text 'Search by Position 285.2448916666667;48.74508333333333;EQ_J2000; Type=CENTER; Image Size=0.1389 deg; Product Level=1'. A green arrow points from the text 'Select data and download' to the 'Prepare Download' button in the table's toolbar. The table has columns: expid, obsdate, crval1, crval2, filter, ccdid, ptffield, seeing, and airmass. The first row is highlighted in green. To the right of the table is an 'Image Preview' window showing a grayscale image of a star field.

PTF

Searches History Help Catalogs

Background Monitor 1

Search by Position 285.2448916666667;48.74508333333333;EQ_J2000; Type=CENTER; Image Size=0.1389 deg; Product Level=1

Level-1

Prepare Download

1 of 1 (1 - 38 of 38)

☐	expid	obsdate	crval1	crval2	filter	ccdid	ptffield	seeing	airmass	r
☐	266135	2012-08-04 04:47:08.733000	284.8095489	49.0519037	R	2	4726	1.54	1.06	-0
☐	266149	2012-08-04 05:36:04.983000	284.8095442	49.0520489	R	2	4726	1.47	1.04	-0
☐	266474	2012-08-05 06:34:47.082000	284.8095357	49.0521530	R	2	4726	1.74	1.05	-0
☐	266496	2012-08-05 07:18:35.133000	284.8095286	49.0521987	R	2	4726	1.75	1.08	-0
☐	266512	2012-08-05 08:02:43.882000	284.8095253	49.0519785	R	2	4726	1.79	1.14	-0
☐	266732	2012-08-06 05:41:51.383000	284.8095204	49.0521636	R	2	4726	1.85	1.04	-0
☐	266748	2012-08-06 06:15:11.033000	284.8095172	49.0521190	R	2	4726	1.60	1.04	-0
☐	267231	2012-08-08 04:11:43.829000	284.8095153	49.0518113	R	2	4726	1.72	1.08	-0

Image Preview Coverage

PTF Image 1x

Accessing PTF FITS Catalogs

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The IPTF and ZTF collaboration organizes regular science meetings, workshops and summer schools:

Ongoing:

- [The 2015 IPTF Summer School at Caltech, August 24 - 28, 2015](#)
- [ZTF Summer Undergraduate Astronomy Institute, 2015](#)

Past:

- [The PTF/IPTF Workshop at Taiwan, Sept. 15-18, 2014](#)
- [The IPTF Summer School at Caltech August 25 - 29, 2014](#)
- [The Transient Universe as Seen by IPTF and ZTF June 2 - 5, 2014, Stockholm, Sweden](#)

Accessing PTF FITS Catalogs

Overview

Agenda

Posters

Registration

Participants

Cahill Logistics

Local Hotels

Summer S

The latest News: Sept. 2

Palomar Tour After the Summer

After the successful Summer School, v
[pictures](#) taken during the tour.

Update on the summer school, August

Required Preparatory Wo

The summer school has multiple hand:
[the instruction](#) here to install the nec
start of the summer school.

• Day 2: PTF and Other Surveys (Tuesday, 26 August 2014)

◦ Morning Session: 9:00am (Chair: Eran Ofek)

- [PTF Operation](#) (9:00-9:30) [25+5] Tom Barlow
- [PTF Data Flow](#) (9:30-10:00) [25+5] Jason Surace
- [IPAC Photometric Pipeline](#) (10:00-10:30) [25+5] Russ Laher
- Break: 20 minutes
- [PTFIDE & Forced Photometry](#) (10:50-11:20) [25+5] Frank Masci
- [IPAC PTF Archive](#) (11:20-11:50) [25+5] Jason Surace

◦ Lunch Break

◦ Afternoon Session: 1:30pm (Chair: Tom Barlow)

- [NEO with PTF](#) (1:30-2:00) [25+5] Adam Waszczak
- [Streakers with PTF](#) (2:00-2:30) [25+5] Adam Waszczak
- [PTFMOPS](#) (2:30-3:00) [25+5] Frank Masci
- Break: 20 minutes
- [ToO observations with PTF](#) (3:20-3:50) [25+5] Leo Singer
- [PTF Data Caveats & Cautionary Notes](#) (3:50-4:05) [10+5] Mansi Kasliwal
- [Case Studies and Hands-on session with PTF data](#)

▪ Session 1:

- [How to use PTF data to make light curves](#) (4:05-4:45) [40 min] Adam Miller
- Office Hours: questions-and-answers (4:45- 5:15) [30min] TAs

Python packages installation

Accessing PTF FITS Catalogs

Collecting Catalog Files

PTF SExtractor catalogs can be obtained from the [IRSA PTF image archive](#). Images and source catalogs can be searched for via position or PTF field ID, more details are available on the [PTF Data Access website](#). The example below uses source catalogs from images of the open cluster M44.

We begin with the assumption that the images have been downloaded and unzipped in the present working directory.

Making a Light Curve: I. The Basic Solution

For PTF a nightly photometric solution is determined for each image (for further details see Ofek et al. 2012), thus, the easiest way to create a light curve for a given star is to grab its measured brightness on each of the PTF images. This is simple to implement in python using a for loop.

```
import numpy as np          # array manipulation
import astropy.io.fits as fits # fits file manipulation
import glob                 # to grab source files

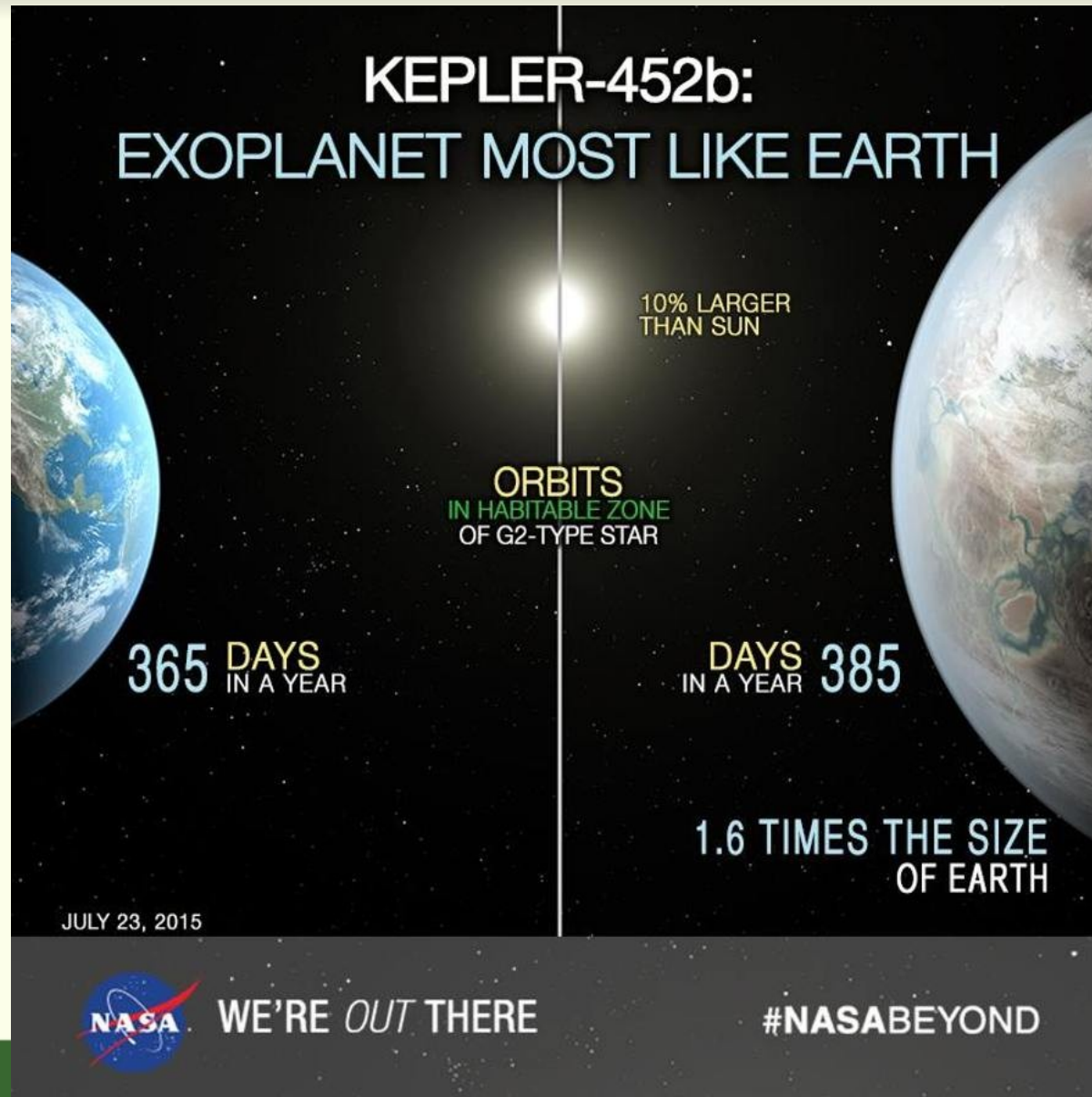
files = glob.glob("PTF*ctlg") # list of all source files
targ_ra = 128.86346           # right ascension of target
targ_dec = 19.75875           # declination of target
match_r = 2.0                 # source matching radius in arcsec
```

Python!!

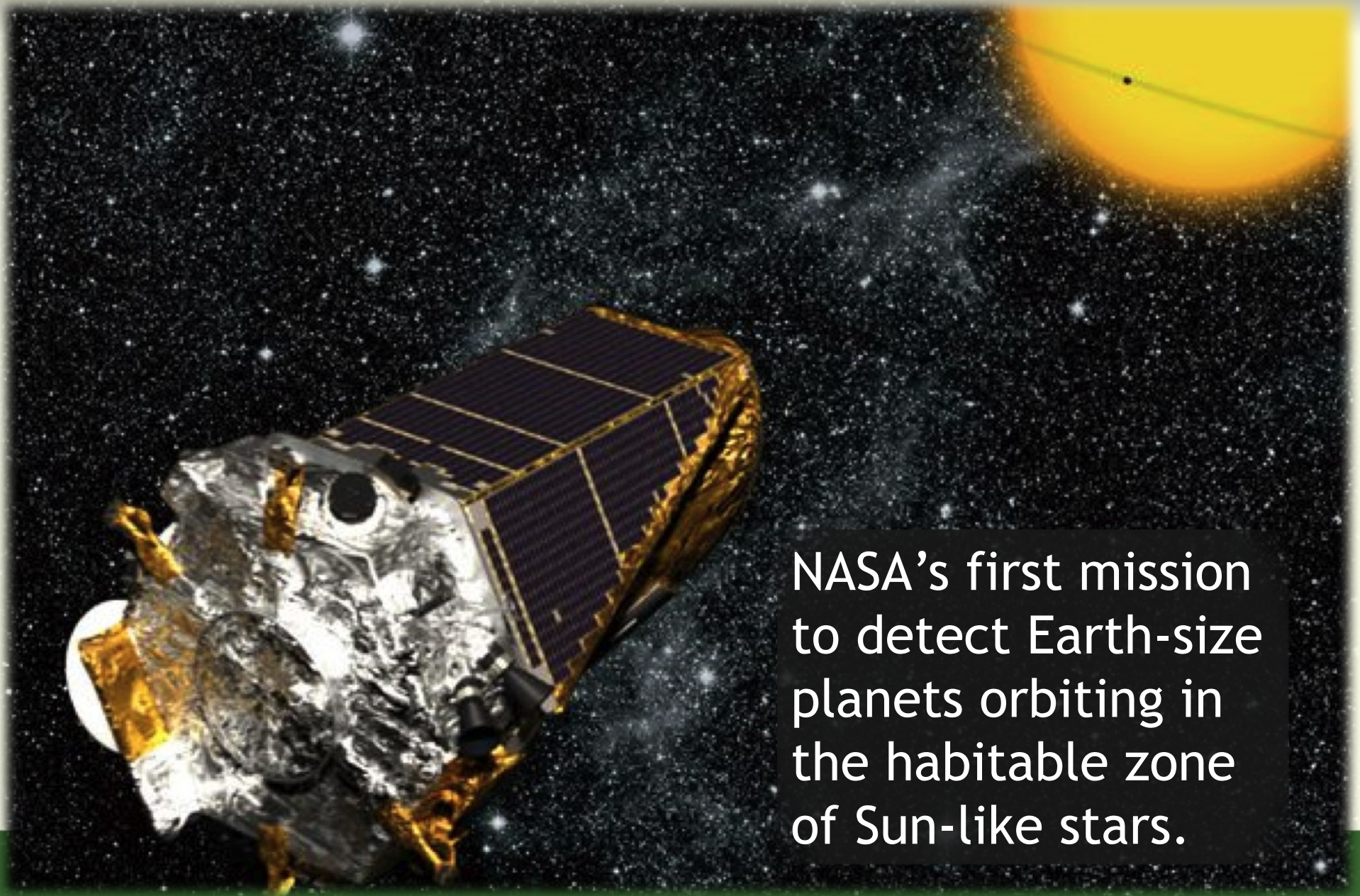
PTF/iPTF/ZTF and NCU

- Our institution (IANCU) joined PTF in 2012 (last year of PTF) and fully participate in iPTF under the TANGO Project (PI: W.-H. Ip)
 - Science interest: asteroids and variable stars
- We plan to join the ZTF under TANGO-II Project
 - Year 1 funded, Year 2 and beyond pending on funding
- Participation to PTF/iPTF/ZTF under UST (台聯大 , both NCU and NTHU)

Latest News on Kepler's Discovery

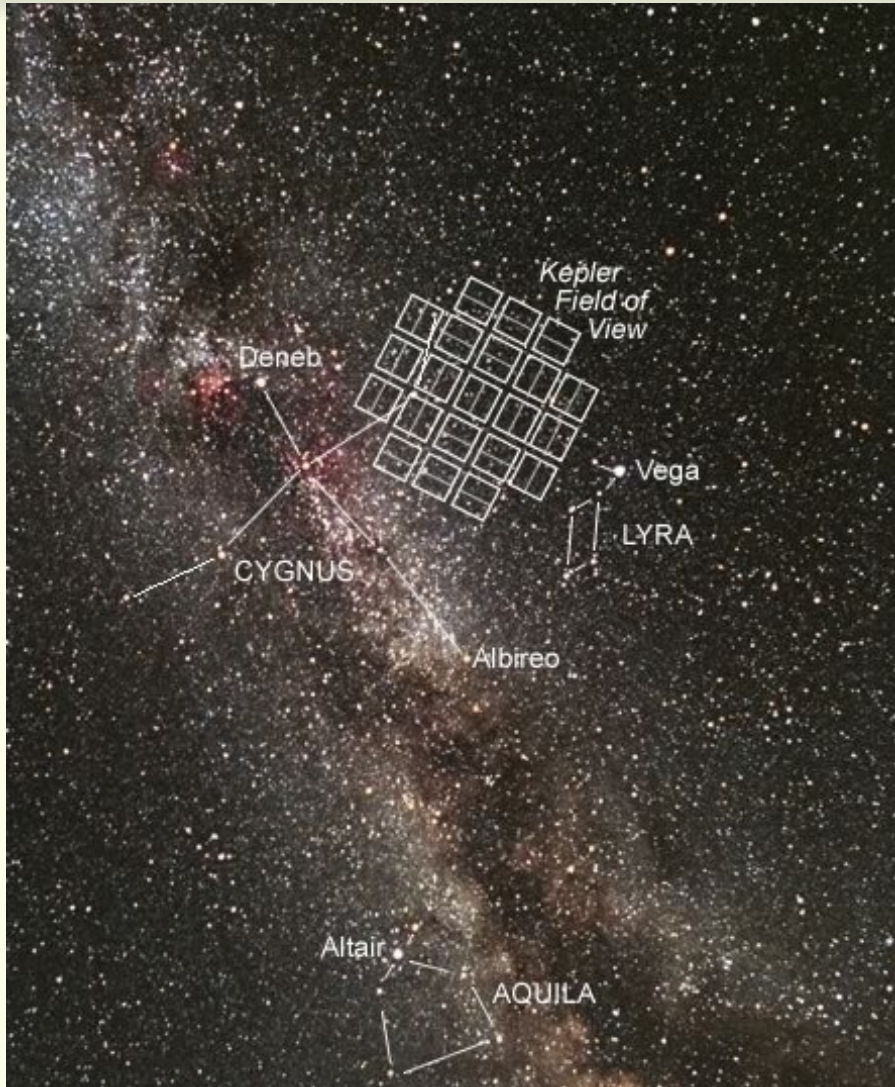


NASA's Kepler Space Telescope



NASA's first mission to detect Earth-size planets orbiting in the habitable zone of Sun-like stars.

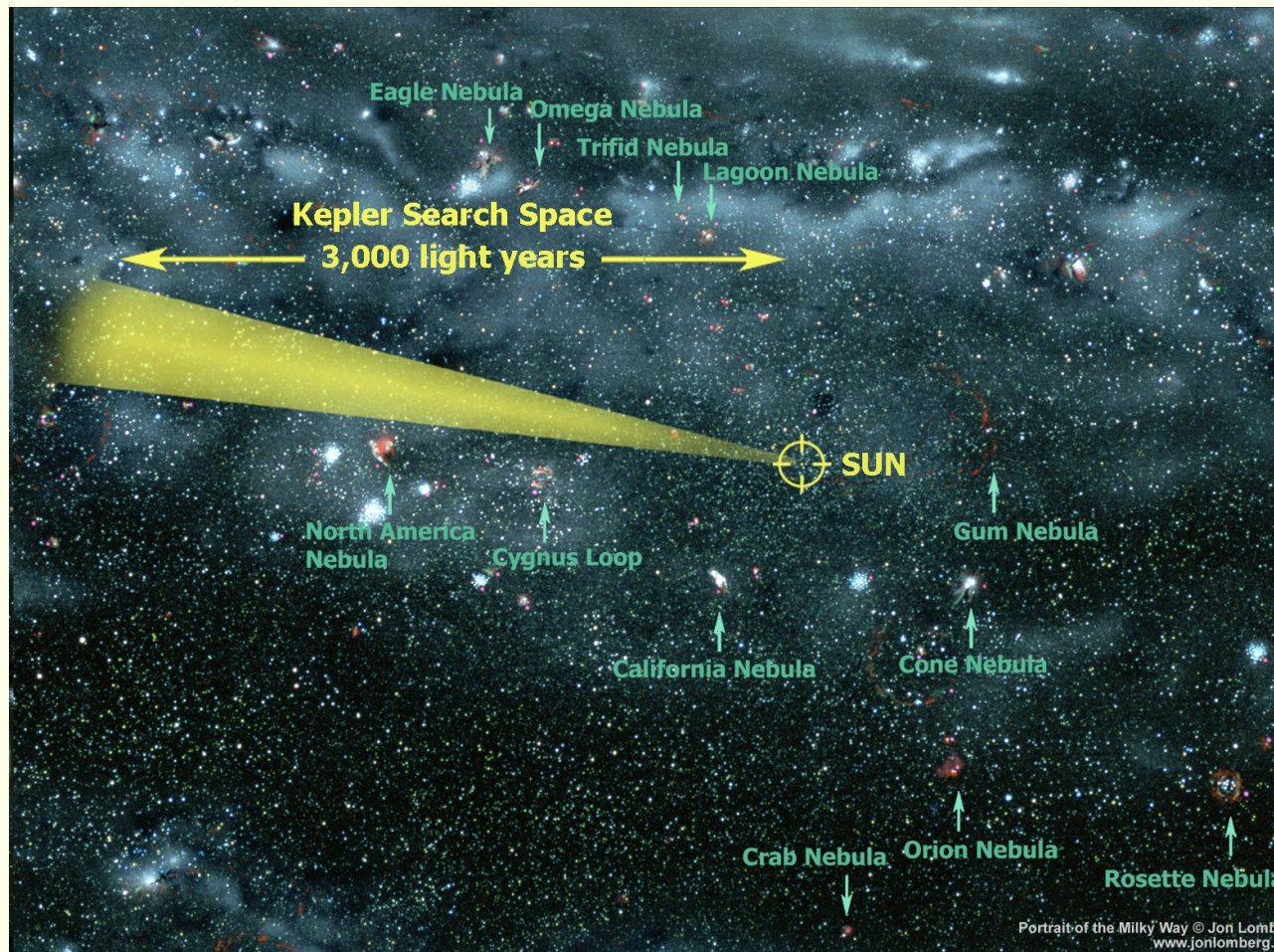
Kepler's Mission: An Overview



- NASA mission launched in 06 March 2009
- 105 square degrees ($10^\circ \times 10^\circ$) just above galactic plane in the constellation Cygnus (and Lyrae)
- Single field for ~4 years, **150,000** stars 30 minute sampling, 512 at 1 minute
→ BIG DATA!

Continuously and simultaneously monitoring same area of sky!

Kepler's Observations

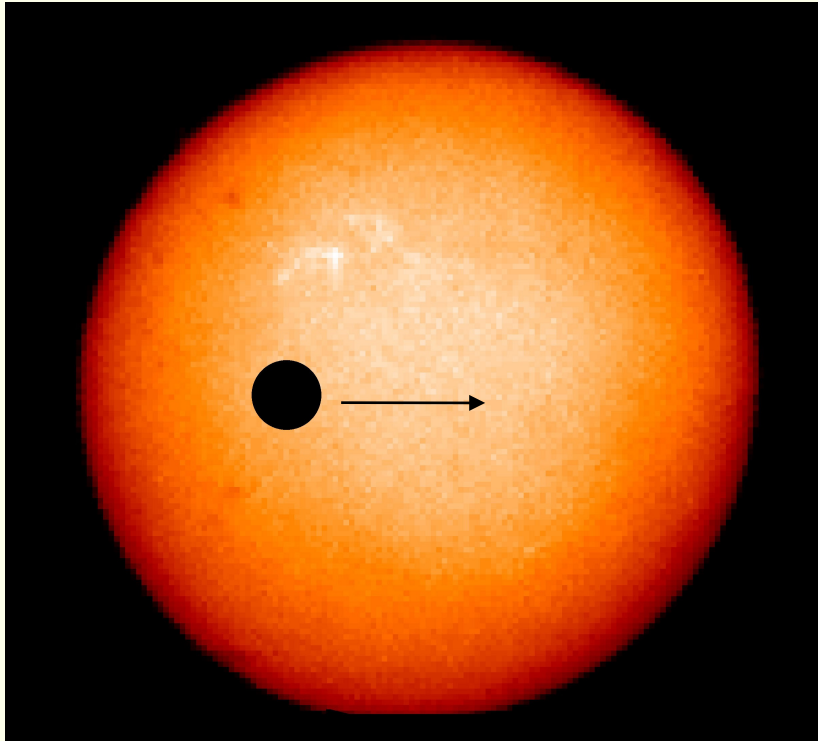


To detect two or more orbits of each planet orbiting in the **habitable zone** of sun-like stars.

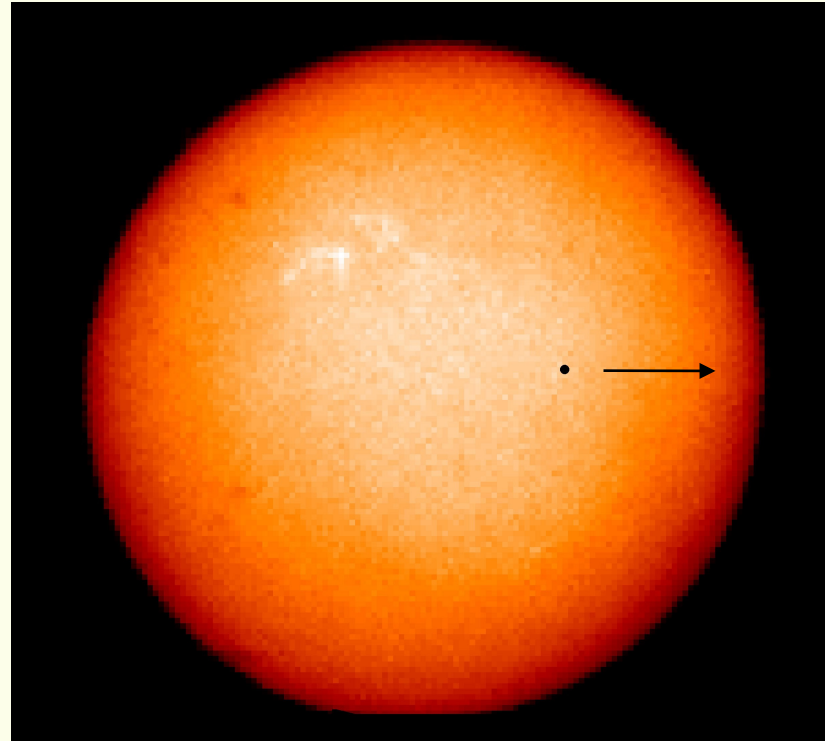
The probability that a planet in the habitable zone is aligned properly to transit the star is about 0.5%.

Kepler's ST Main Goal: Detecting Exo-Planets Transits

Size of Jupiter:
1% area of the Sun (1/100)

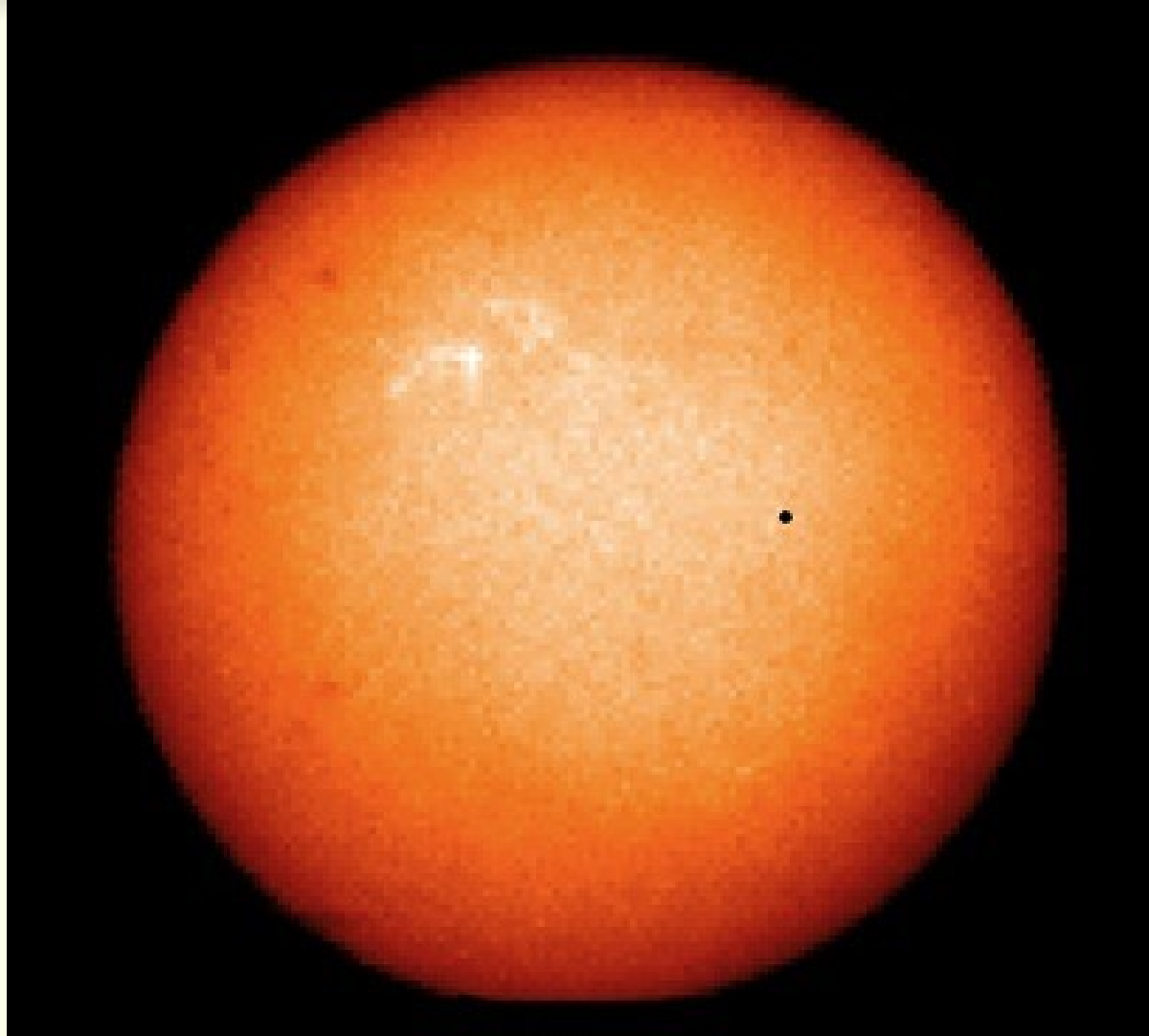


Size of Earth or Venus:
0.01% area of the Sun (1/10,000)



A transit occurs when a planet crosses the line of sight between an observer and a star and blocks a small amount of light from the star, causing the light from the star to dim slightly for a few hours.

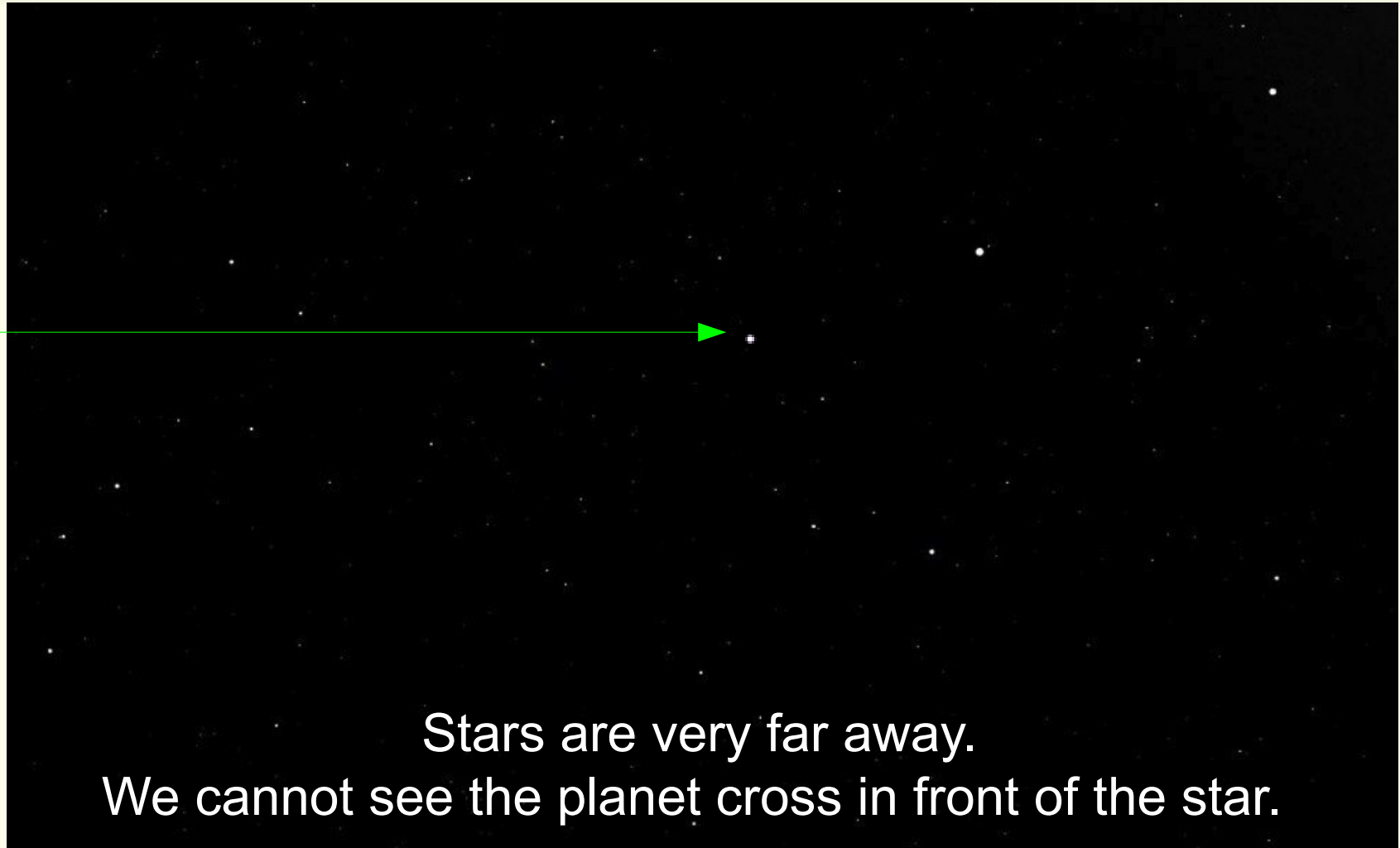
Stars Are Very Far Away ...



Stars Are Very Far Away ...

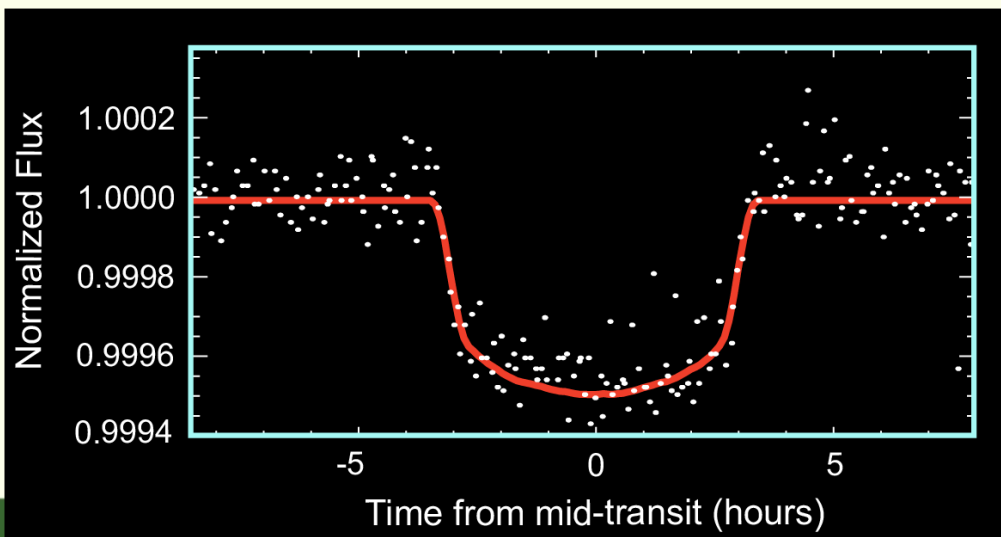
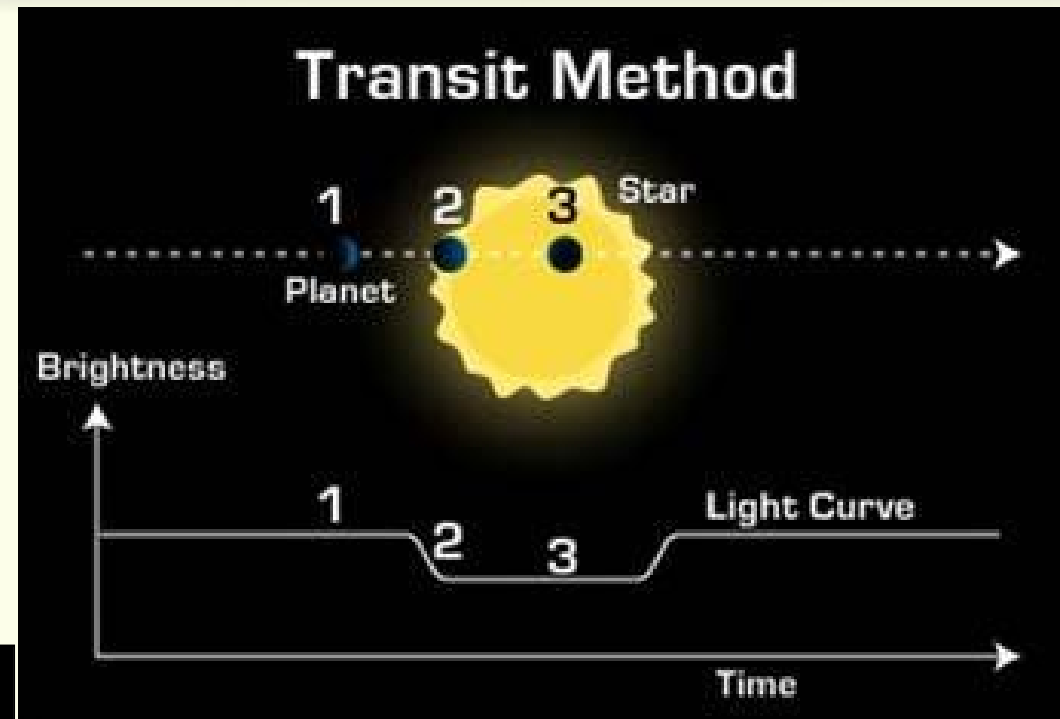
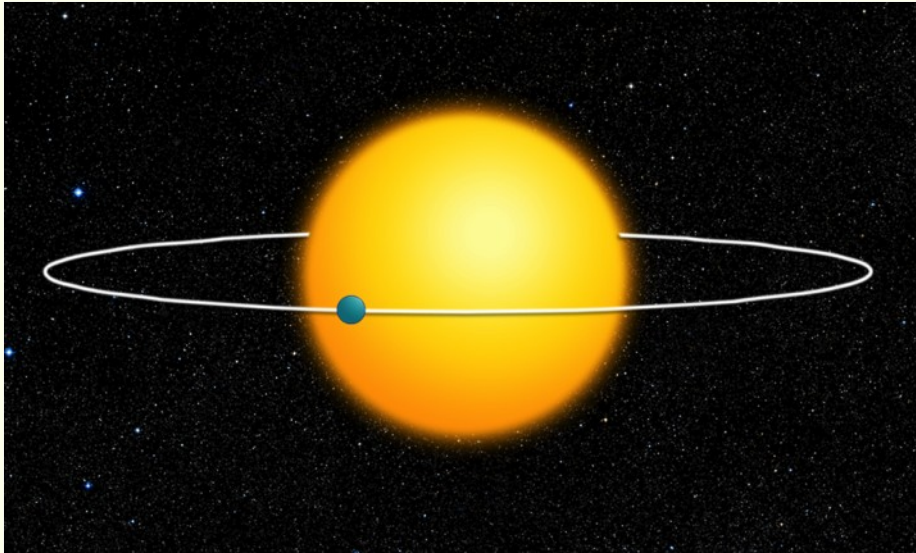


Stars Are Very Far Away ...



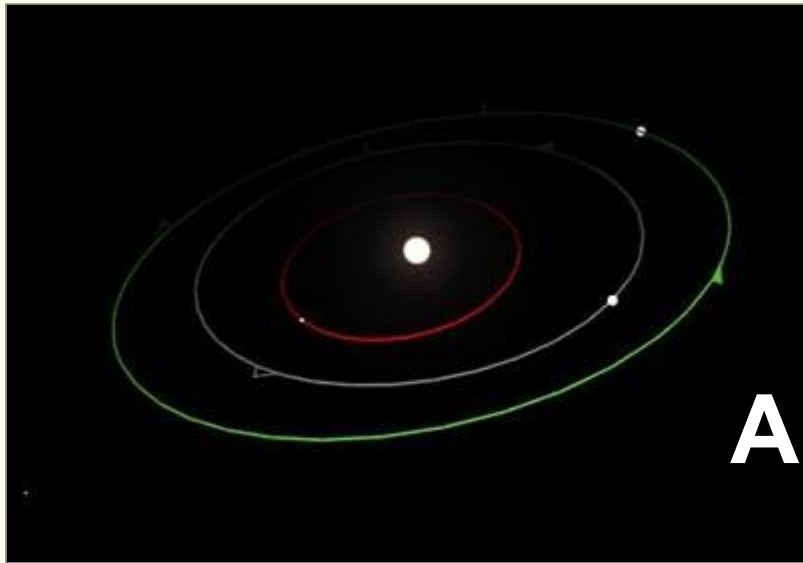
Stars are very far away.
We cannot see the planet cross in front of the star.

The Transit Technique



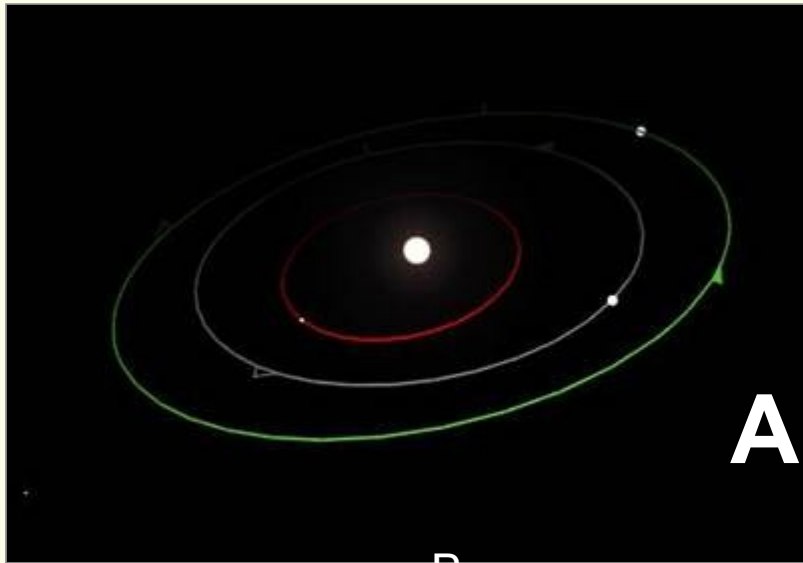
Orientation of the Planetary Systems

For which of these systems would Kepler be able to detect transiting planets?



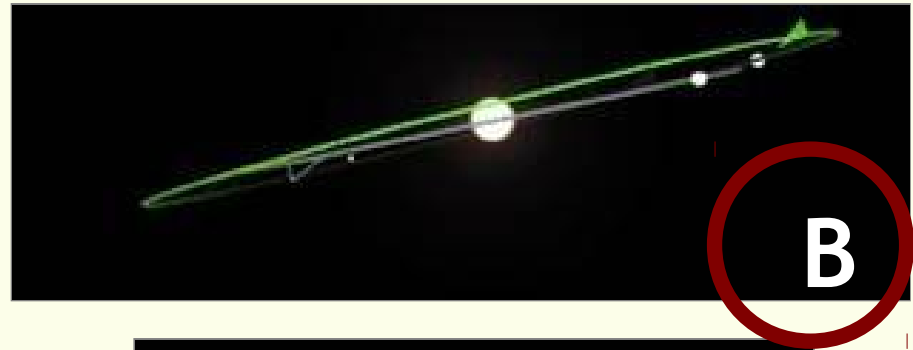
Orientation of the Planetary Systems

For which of these systems would Kepler be able to detect transiting planets?

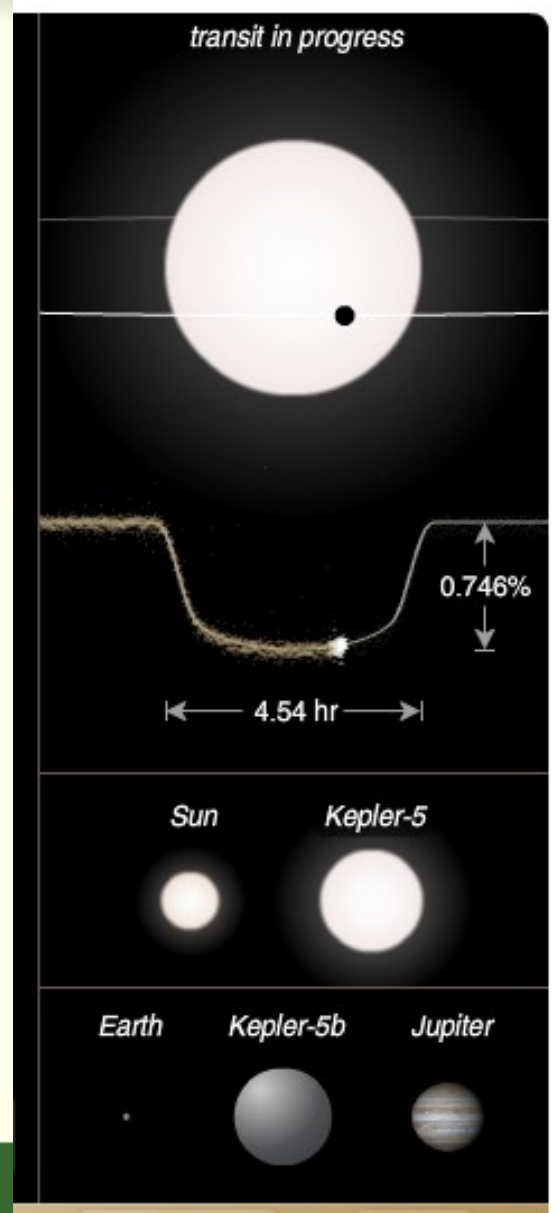
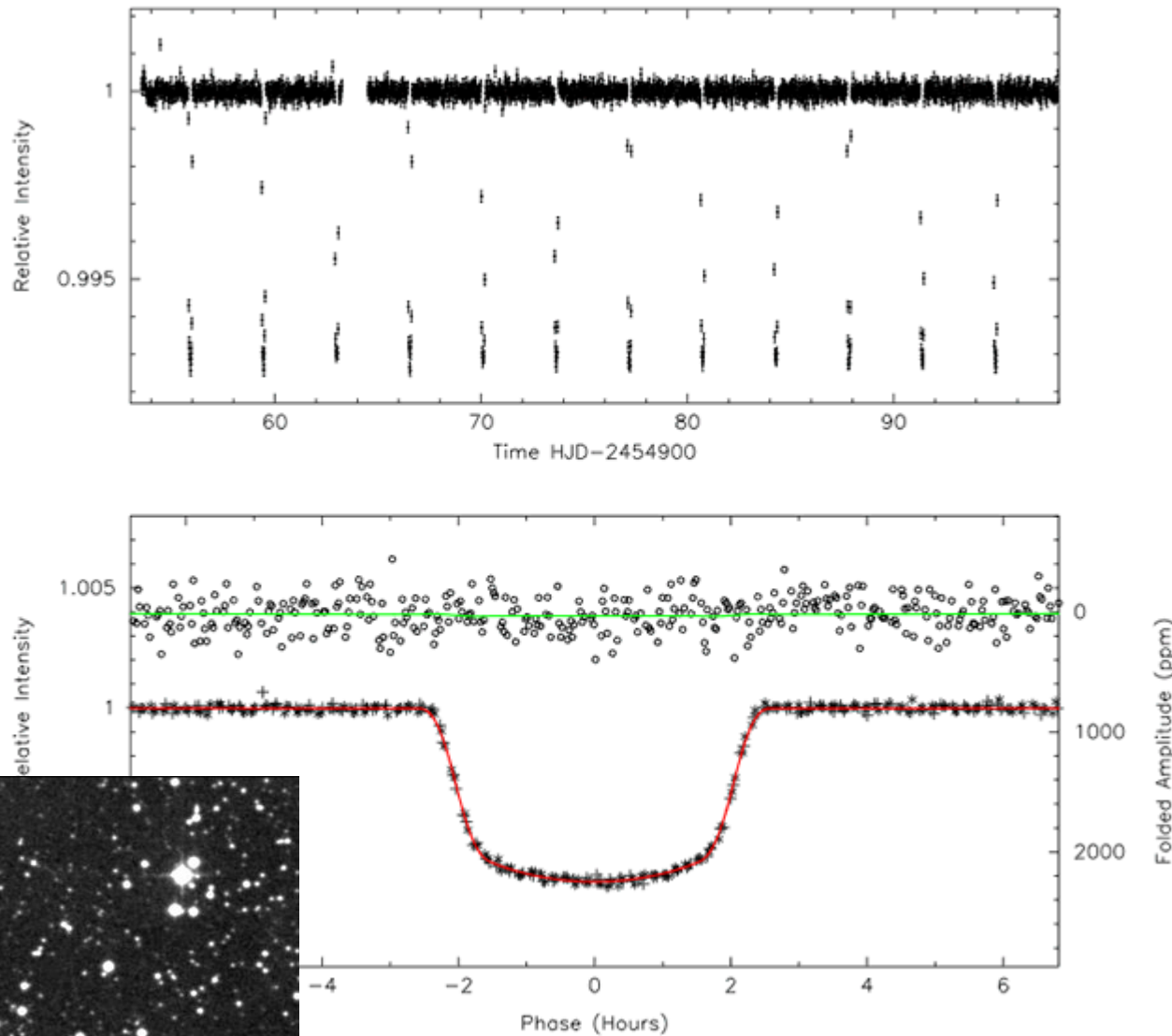


B.

The star's planets must orbit the star edge-on from our viewpoint! Not all planetary orbits are aligned this way. So we must watch thousands of stars to find several that are correctly oriented.



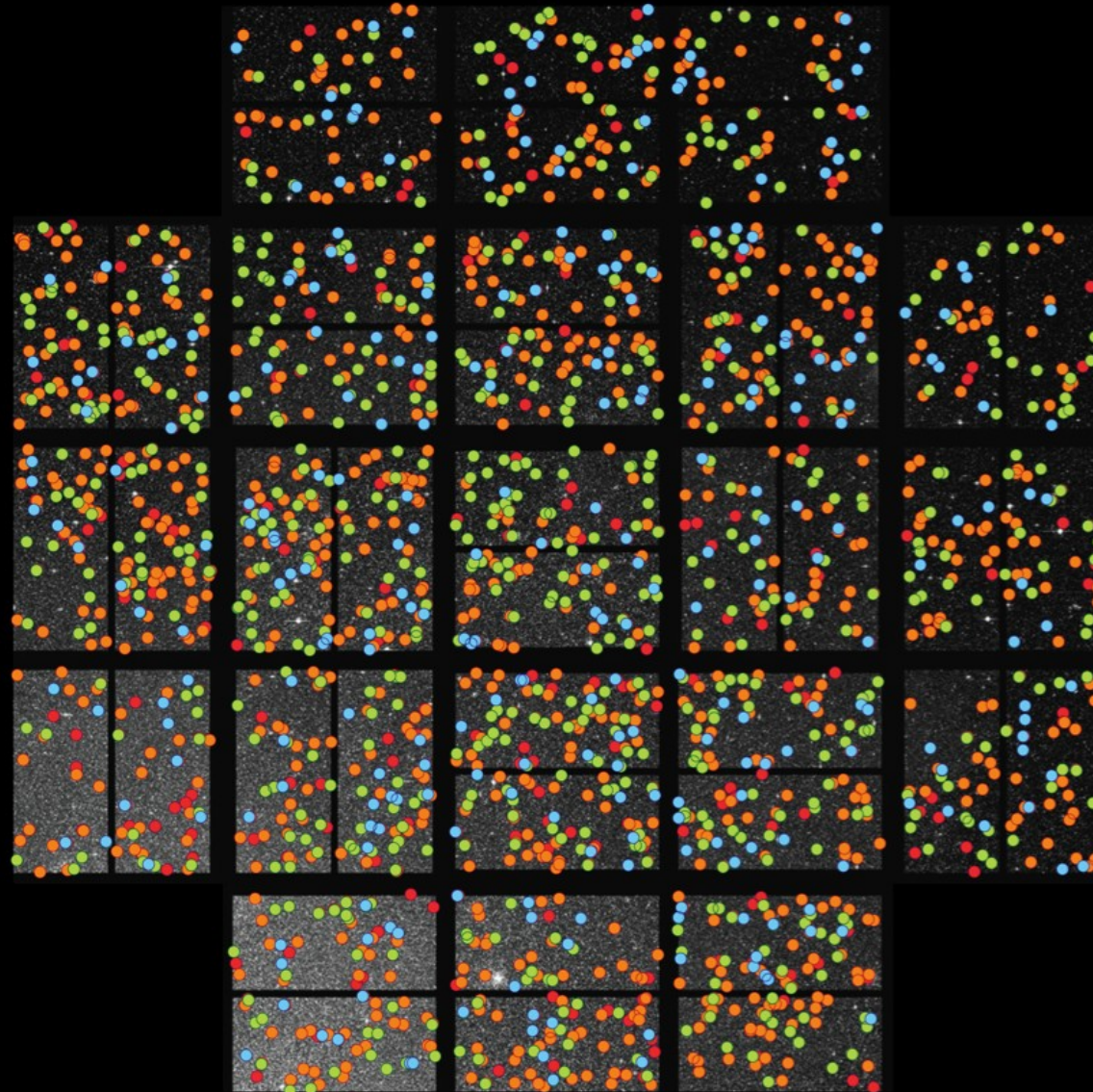
Example: Kepler 5-b Light Curve



Locations of Kepler Planet Candidates

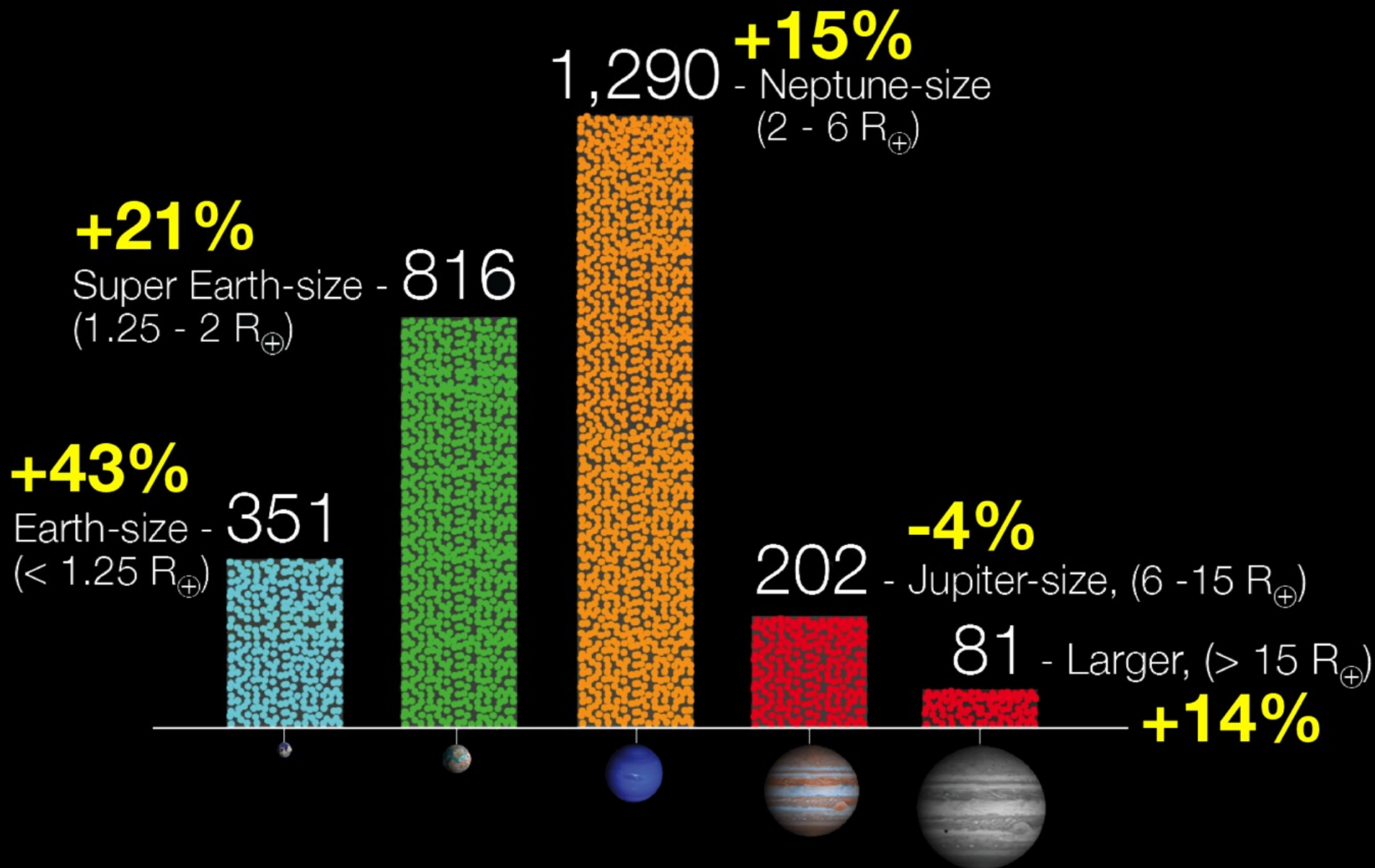
As of January 7, 2013

- Earth-size
- Super-Earth size
1.25 - 2.0 Earth-size
- Neptune-size
2.0 - 6.0 Earth-size
- Giant-planet size
6.0 - 22 Earth-size



Sizes of Planet Candidates

As of January 7, 2013

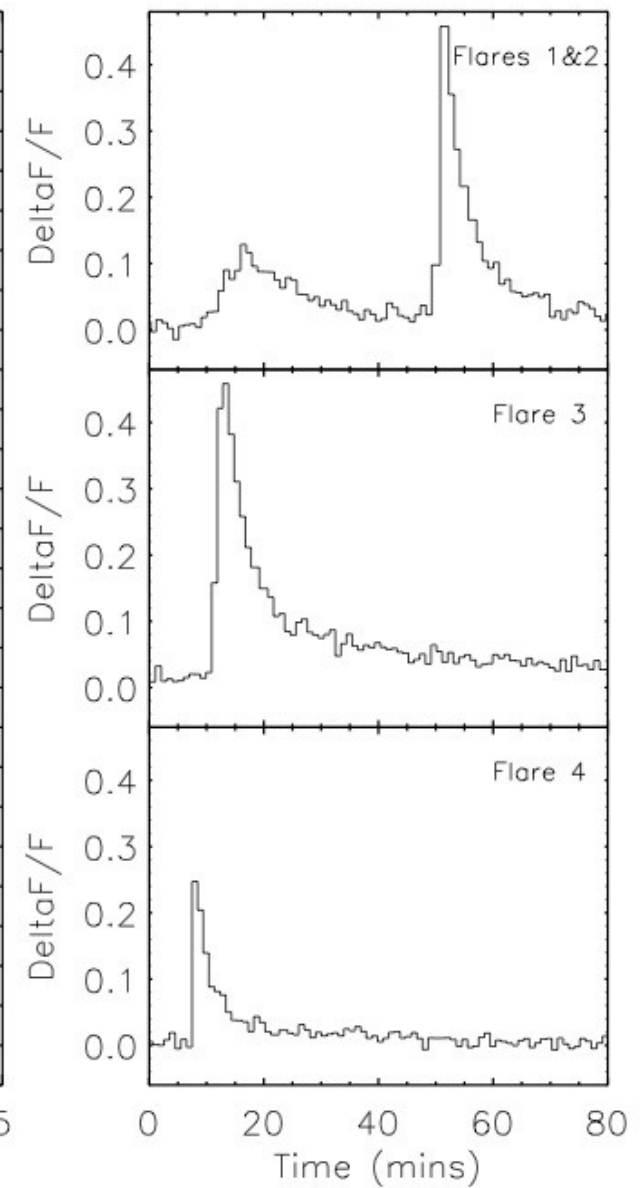
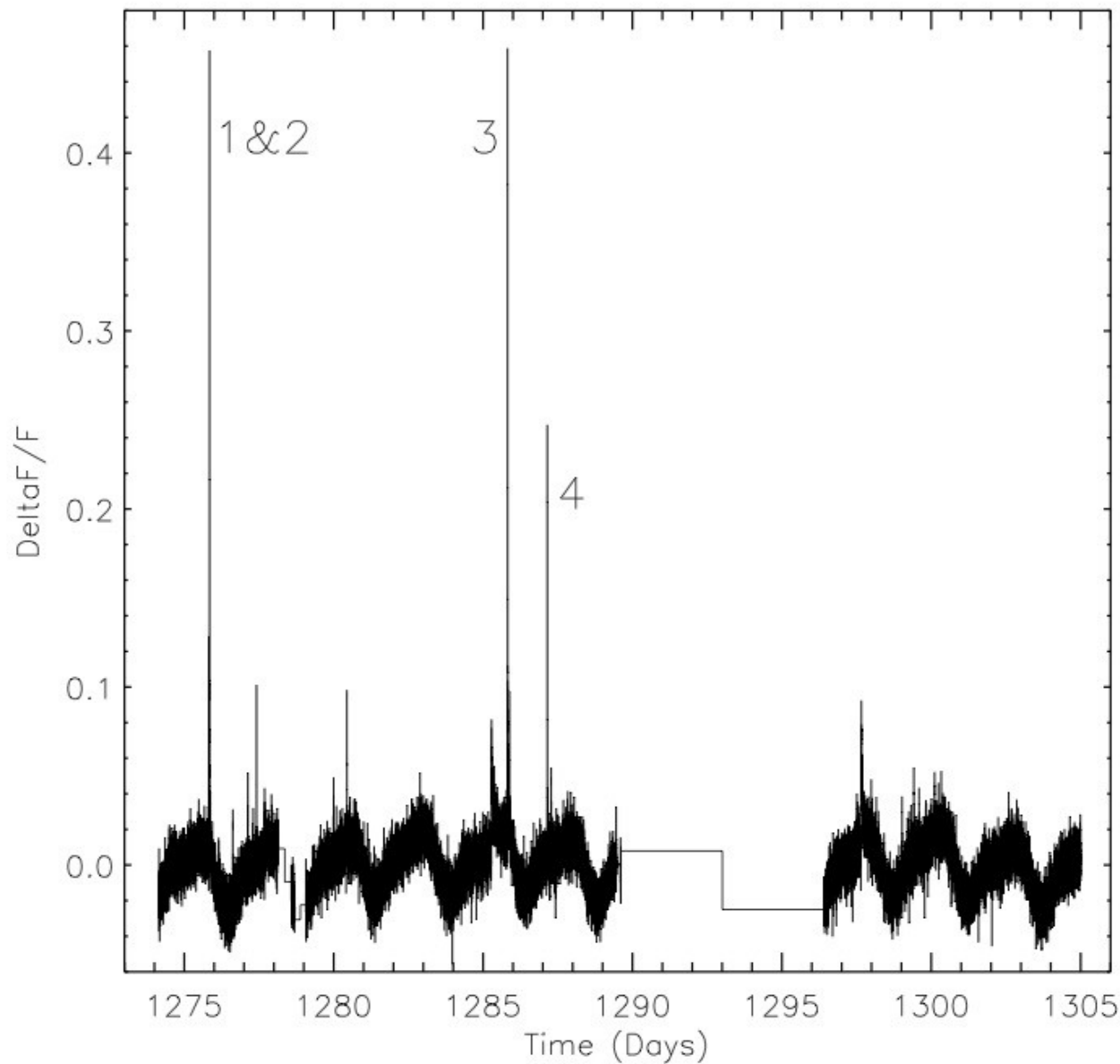


Not Just Transit: Kepler's Flare Stars

- Stellar flares: unpredictable eruption of corona's flares



Not Just Transit: Kepler's Flare Stars

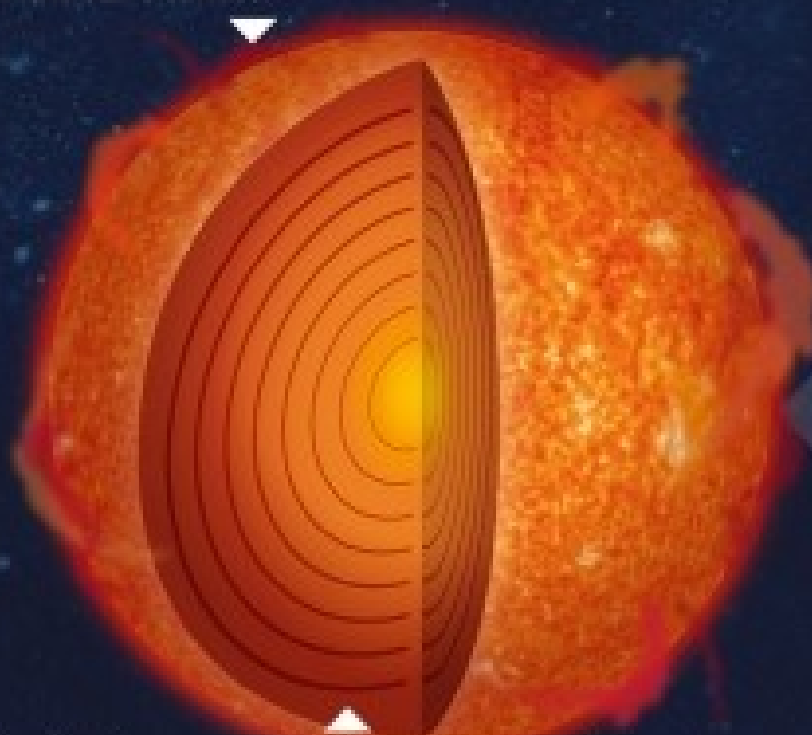


Not Just Transit: Asteroseismology

Celestial music

In the same way as a sound wave resonates inside an organ pipe to create a musical tone, sound waves on a far vaster scale can resonate inside a star. By measuring the frequencies of these waves, astronomers can learn about the star's internal structure.

Vibrations are generated by turbulence on the star's surface.

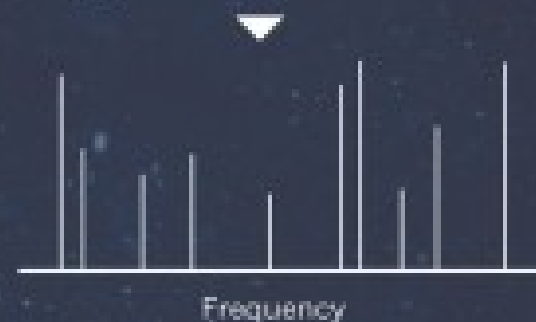


The vibrations penetrate deep into the star's interior, setting up resonant oscillations at frequencies depending on the star's size, density and rotation.

Astronomers see these oscillations as subtle, rhythmic changes in the star's brightness.

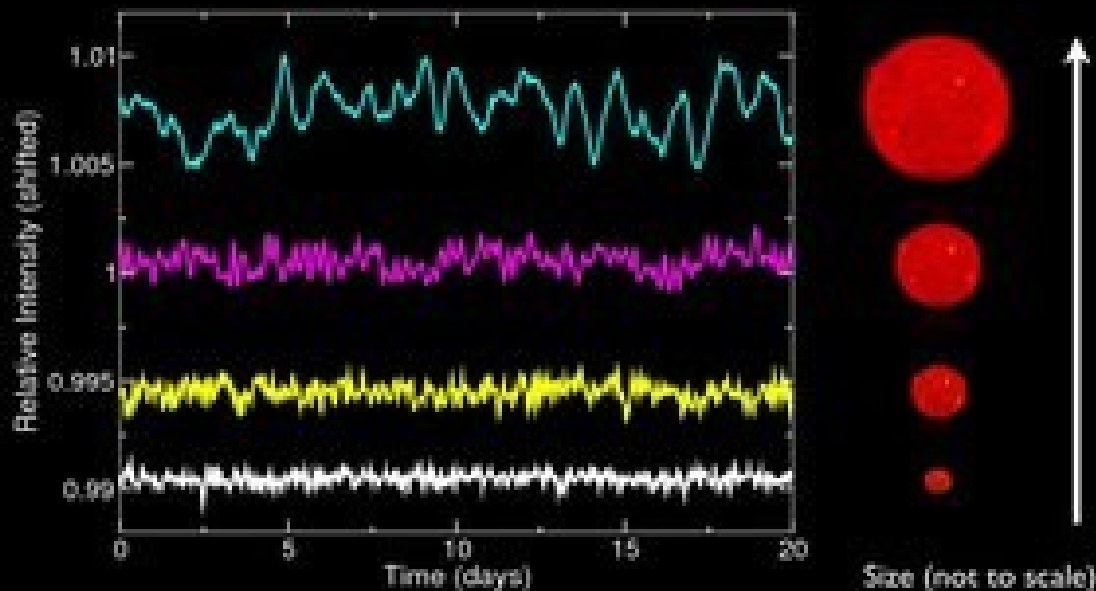


Resonant frequencies can vary from one every few minutes in Sun-like stars to one every few hundred days in red giants.

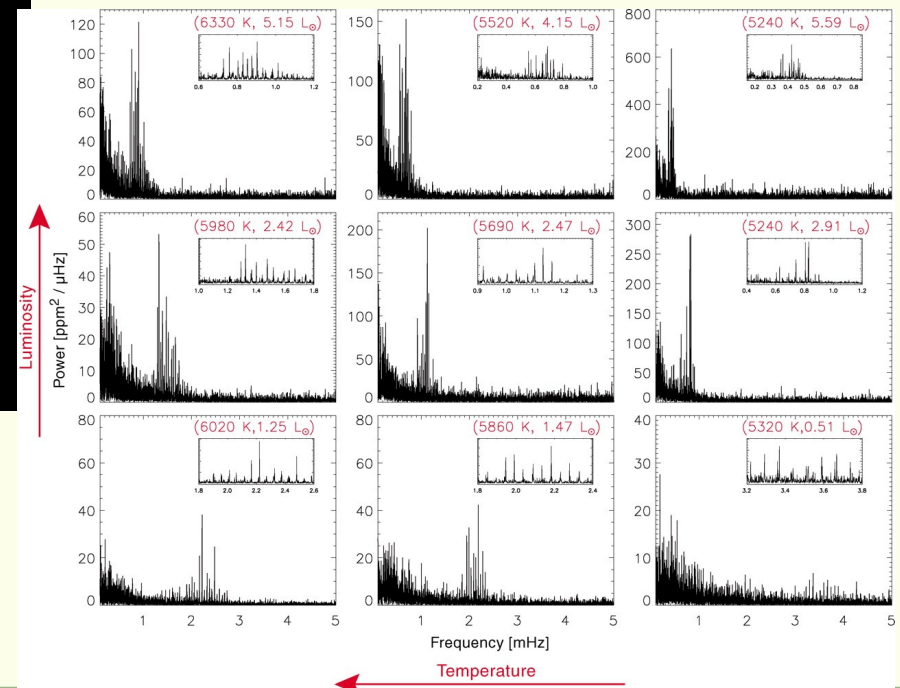


Not Just Transit: Asteroseismology

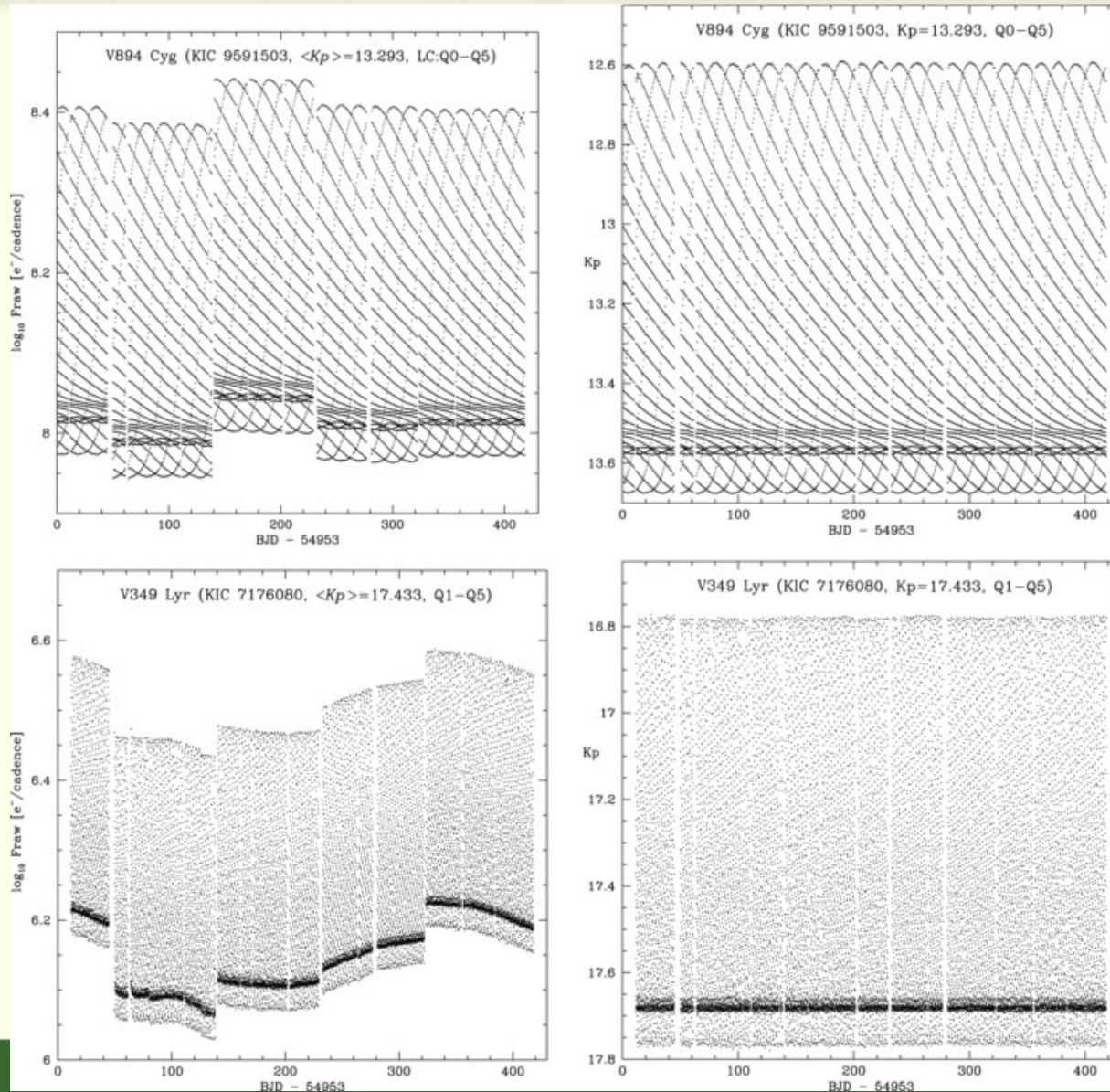
A Kepler "concert" of Red Giant Stars



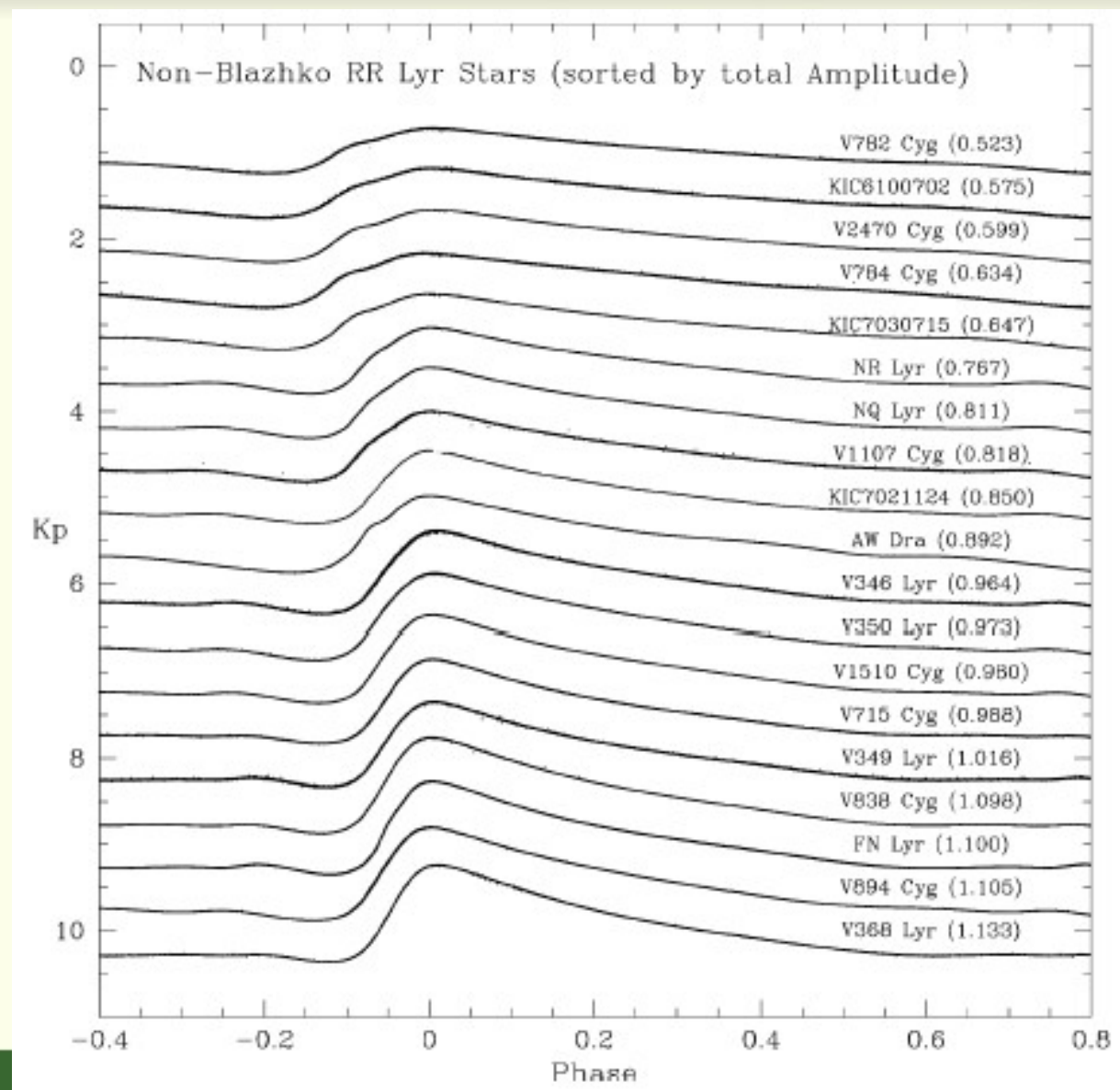
“continuous” light curves data is key success



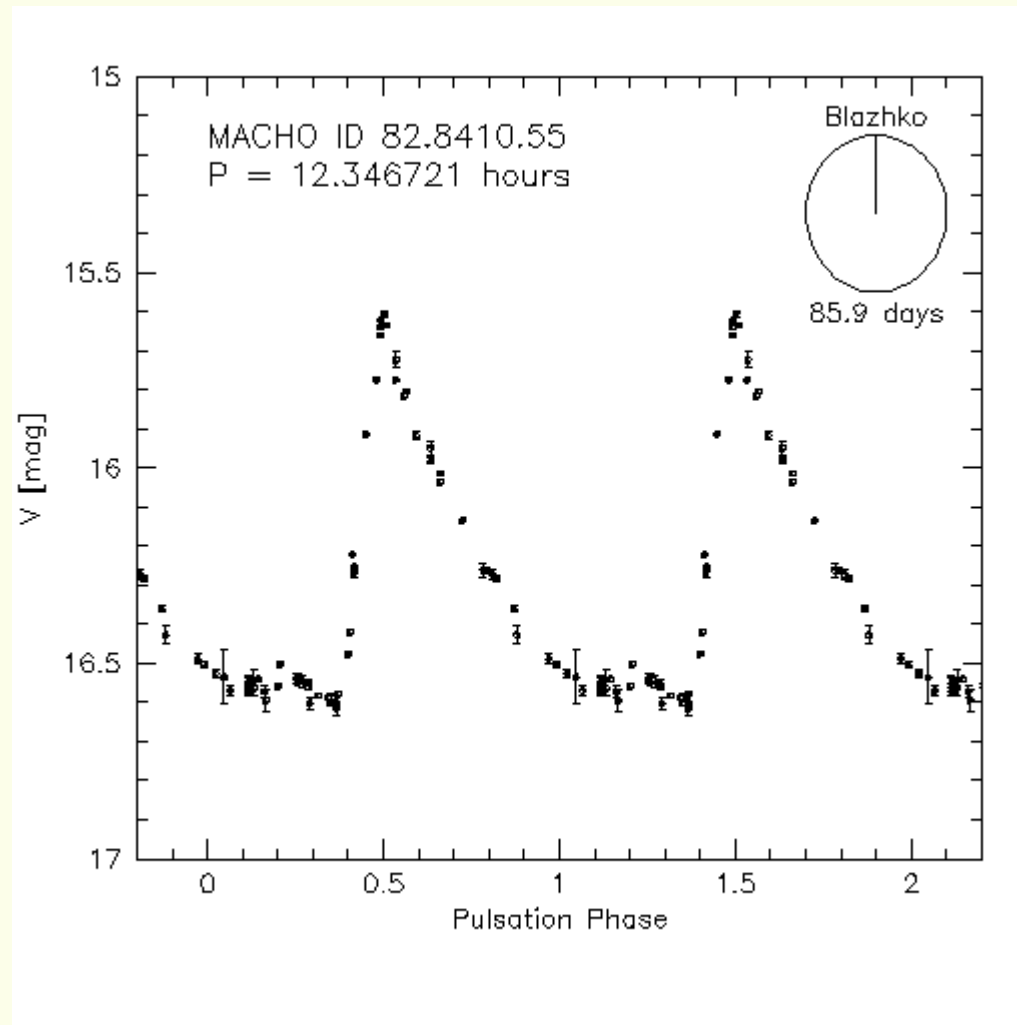
Not Just Transit: RR Lyrae



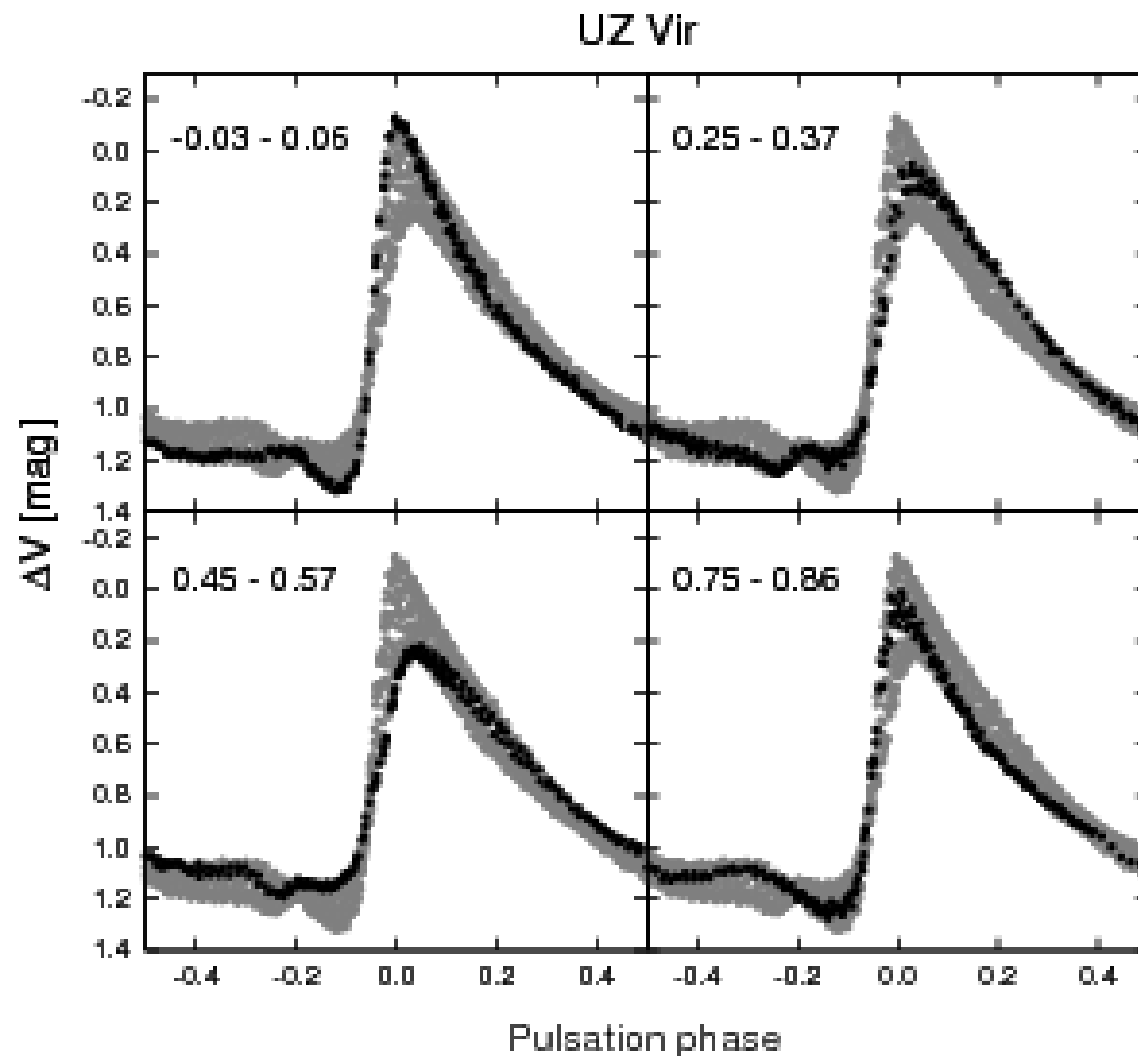
Not Just Transit: RR Lyrae



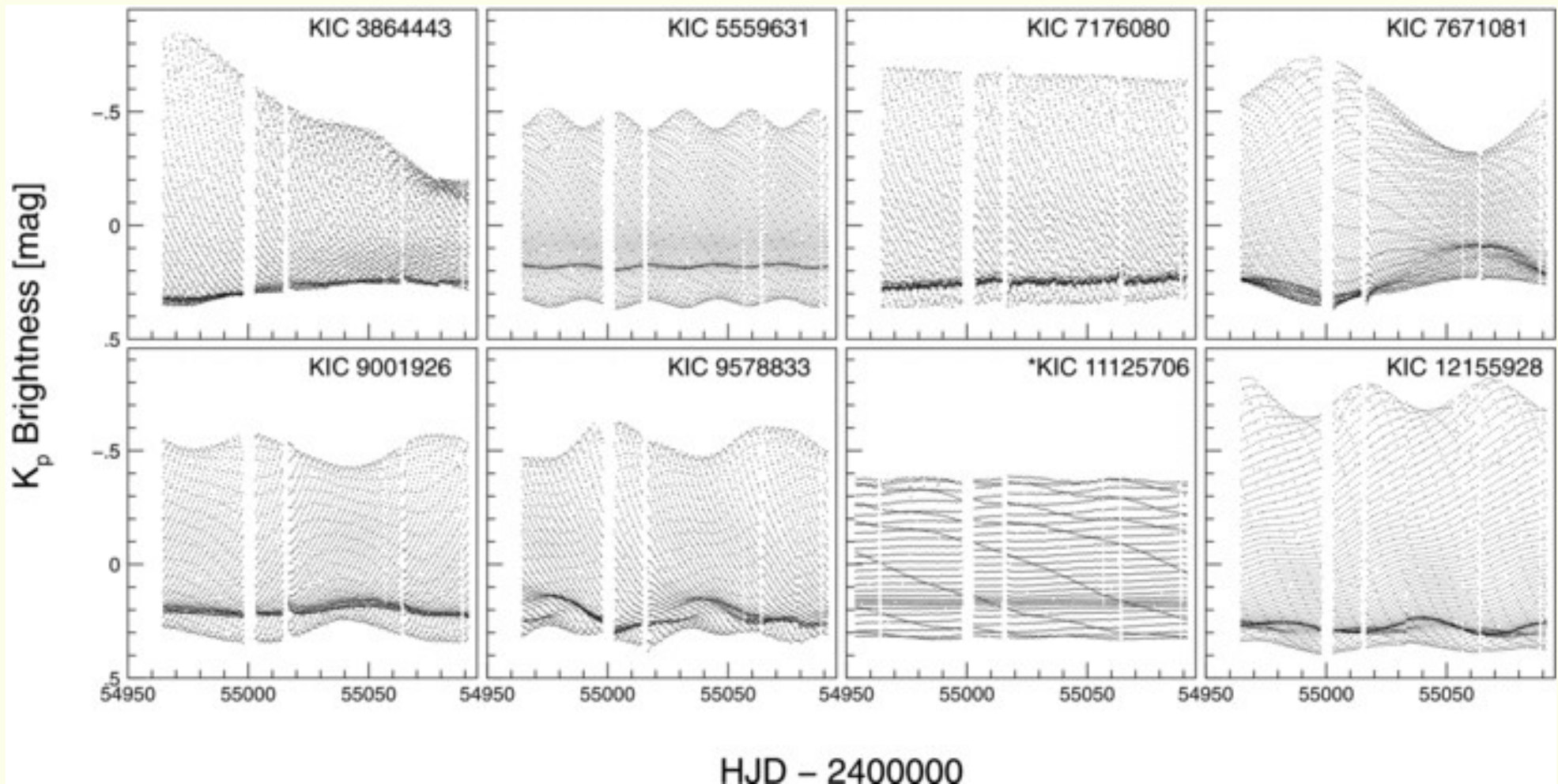
The Blazhko RR Lyrae



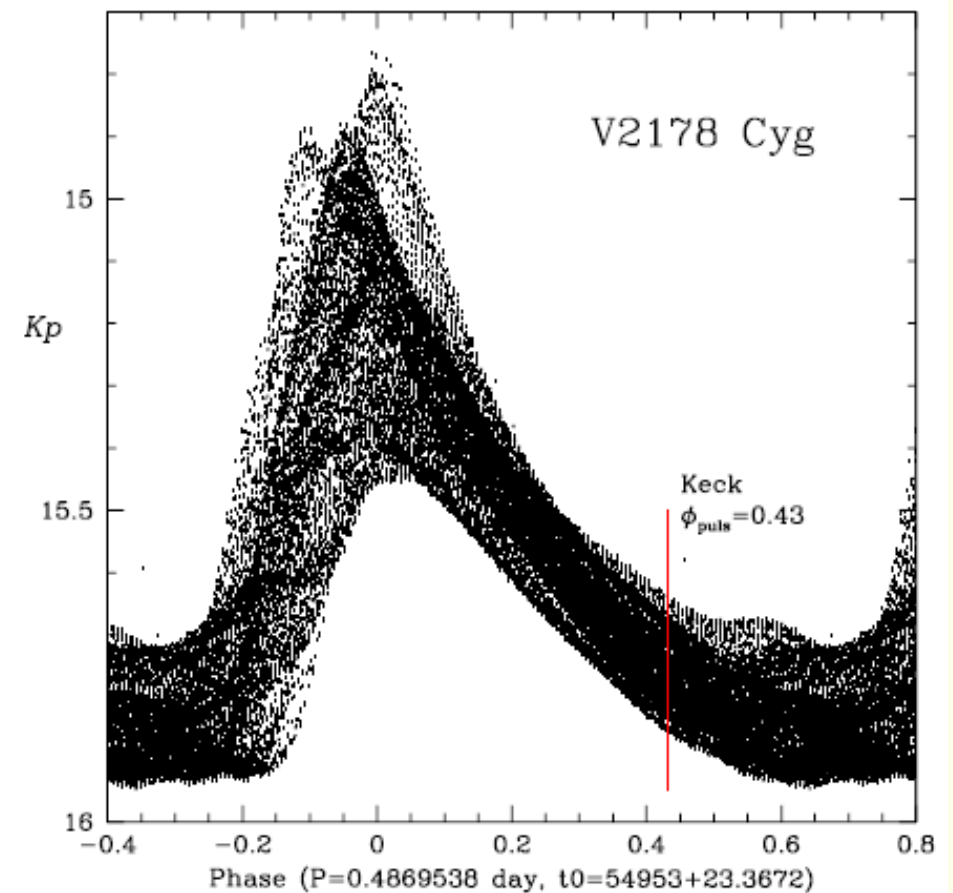
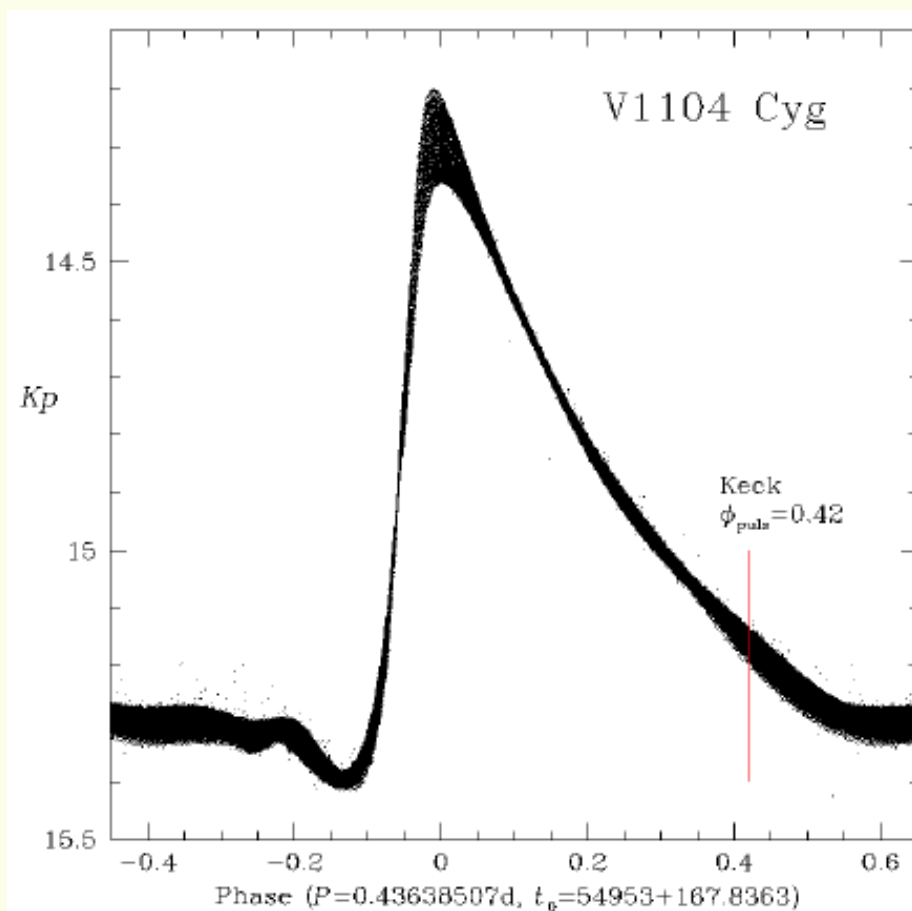
The Blazhko RR Lyrae



Not Just Transit: RR Lyrae with Blazhko Effect



Not Just Transit: RR Lyrae with Blazhko Effect



RR Lyrae's [Fe/H]-Light Curve Relation

- RR Lyrae: Old population II periodic ($P \sim 0.3$ to ~ 0.8 days) pulsating variables located in horizontal branch (HR diagram)
 - Constant absolute V-band magnitude $\rightarrow$ standard candle
- $M_V = a[\text{Fe}/\text{H}] + b$
- Measuring metallicity $[\text{Fe}/\text{H}]$:
 - Spectroscopy: expensive
 - Photometric: from LC shape

Astron. Astrophys. 312, 111–120 (1996)

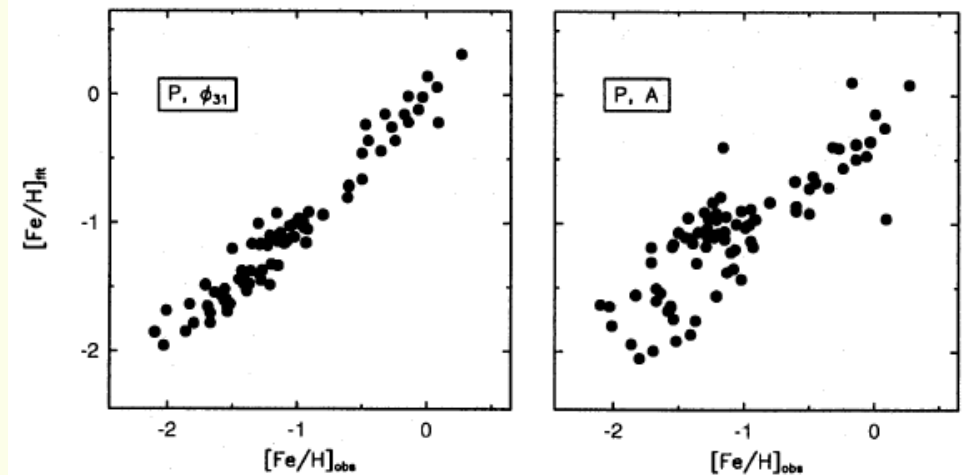
ASTRONOMY
AND
ASTROPHYSICS

Determination of $[\text{Fe}/\text{H}]$ from the light curves of RR Lyrae stars*

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Konkoly Observatory, P.O. Box 67, H-1525 Budapest, Hungary (jurcsik@buda.konkoly.hu and kovacs@buda.konkoly.hu)

Received 19 July 1995 / Accepted 4 January 1996



$$[\text{Fe}/\text{H}] = -5.038 - 5.394P + 1.345\varphi_{31} .$$

Science Case with PTF Public Data: [Fe/H]-LC Relation for RR Lyrae in Kepler Field

- JC relation only valid in V-band, yet PTF observed in R-band
- RR Lyrae in Kepler fields have both spectroscopic [Fe/H] and PTF light curves data from public release of DR1

Table 7
Spectroscopic Iron-to-Hydrogen Abundances (VWA) for the *Kepler*-field RR Lyrae Stars

Star	Obs.	ϕ_{puls}	S/N	FWHM	$T_{\text{eff}} / \log g / \xi_t$	[Fe/H] _{spec}		
						Fe I Lines	Fe II Lines	Adopted
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(a) 17 Non-Blazhko RRab-type stars								
NR Lyr	CFHT	0.29	37	0.163 (02)	6500/2.6/2.5	-2.54 ± 0.13 (6)	-2.53 ± 0.17 (5)	-2.54 ± 0.11
FN Lyr	CFHT	0.28	32	0.209 (19)	6300/2.44/2.5	-2.00 ± 0.13 (10)	-1.97 ± 0.12 (12)	-1.98 ± 0.09
NQ Lyr	CFHT	0.32	30	0.197 (15)	6000/1.80/2.5	-1.88 ± 0.19 (11)	-1.90 ± 0.10 (3)	-1.89 ± 0.10
V350 Lyr	Keck	0.53	34	0.293 (11)	6180/2.9/2.6	-1.84 ± 0.15 (12)	-1.81 ± 0.14 (10)	-1.83 ± 0.12
V894 Cyg	CFHT	0.39	28	0.193 (08)	6200/2.46/2.0	-1.65 ± 0.18 (11)	-1.66 ± 0.16 (9)	-1.66 ± 0.12
AW Dra	CFHT	0.30	38	0.202 (05)	6540/2.40/2.5	-1.33 ± 0.13 (9)	-1.33 ± 0.12 (6)	-1.33 ± 0.09
KIC 7030715	CFHT	0.26	19	0.26 (04)	6500/2.64/2.5	-1.32 ± 0.07 (6)	-1.34 ± 0.15 (3)	-1.33 ± 0.08
V1107 Cyg	Keck	0.48	21	0.220 (17)	6300/2.8/3.0	-1.23 ± 0.42 (33)	-1.31 ± 0.18 (11)	-1.29 ± 0.23
V368 Lyr	Keck	0.43	20	0.183 (02)	6300/2.8/3.0	-1.33 ± 0.31 (22)	-1.25 ± 0.24 (10)	-1.28 ± 0.20
KIC 9658012	Keck	0.84	37	0.413 (16)	6500/2.8/3.0	-1.22 ± 0.26 (26)	-1.31 ± 0.12 (11)	-1.28 ± 0.14
KIC 9717032	Keck	0.23	19	0.262 (06)	6620/2.8/3.5	-1.27 ± 0.17 (14)	-1.26 ± 0.17 (13)	-1.27 ± 0.15
V715 Cyg	Keck	0.51	21	0.241 (13)	6400/3.0/3.0	-1.13 ± 0.12 (25)	-1.14 ± 0.14 (12)	-1.13 ± 0.09

Science Case with PTF Public Data: [Fe/H]-LC Relation for RR Lyrae in Kepler Field

- Using 16 non-blazhko ab-type RR Lyrae stars in Kepler fields
- PTF's DR1 light curves data fitted with Fourier expansion

$$m(t) = m_0 + \sum_{i=1}^n A_i \sin \left(\frac{2i\pi t}{P} + \phi_i \right)$$

$$R_{ij} = \frac{A_i}{A_j}; \quad \phi_{ij} = \phi_i - i\phi_j.$$

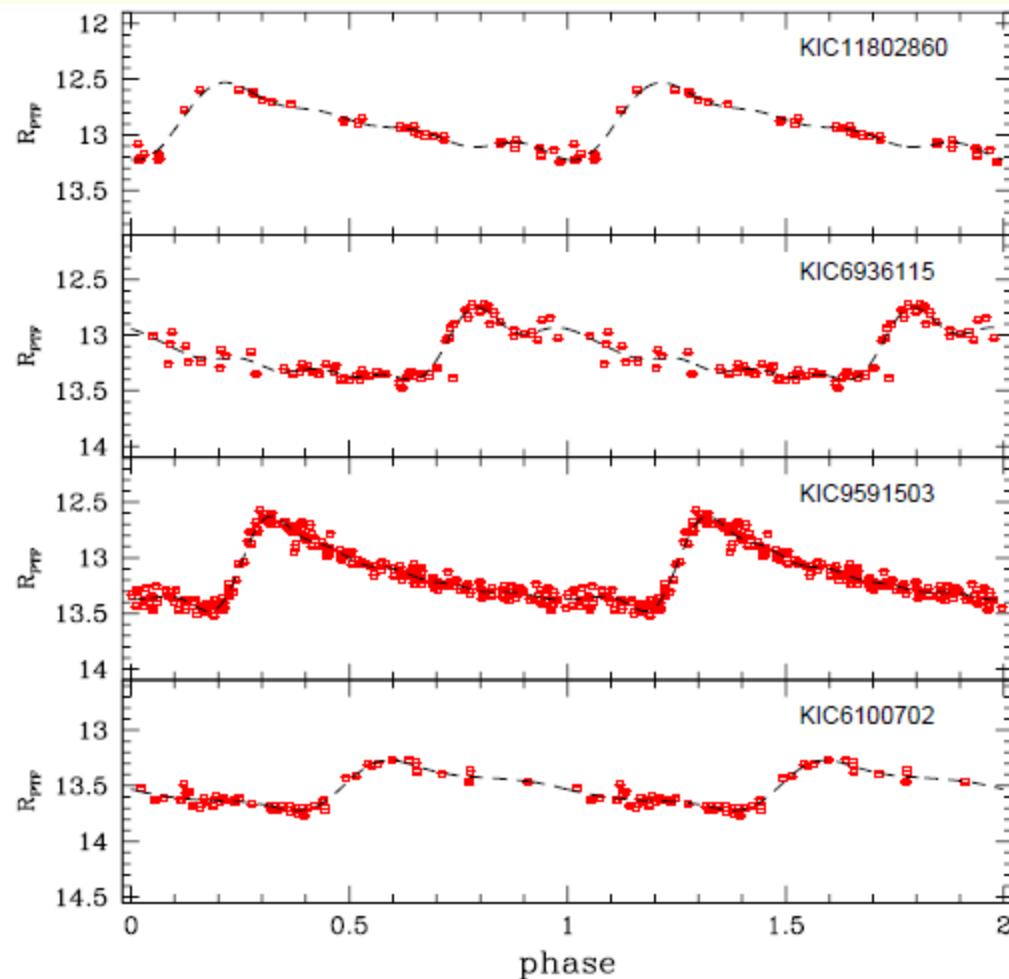
- Found that need to split to two groups:

- Group A: 8 RR-ab brighter than ~ 14 mag
- Group B: 8 RR-ab fainter than ~ 14 mag

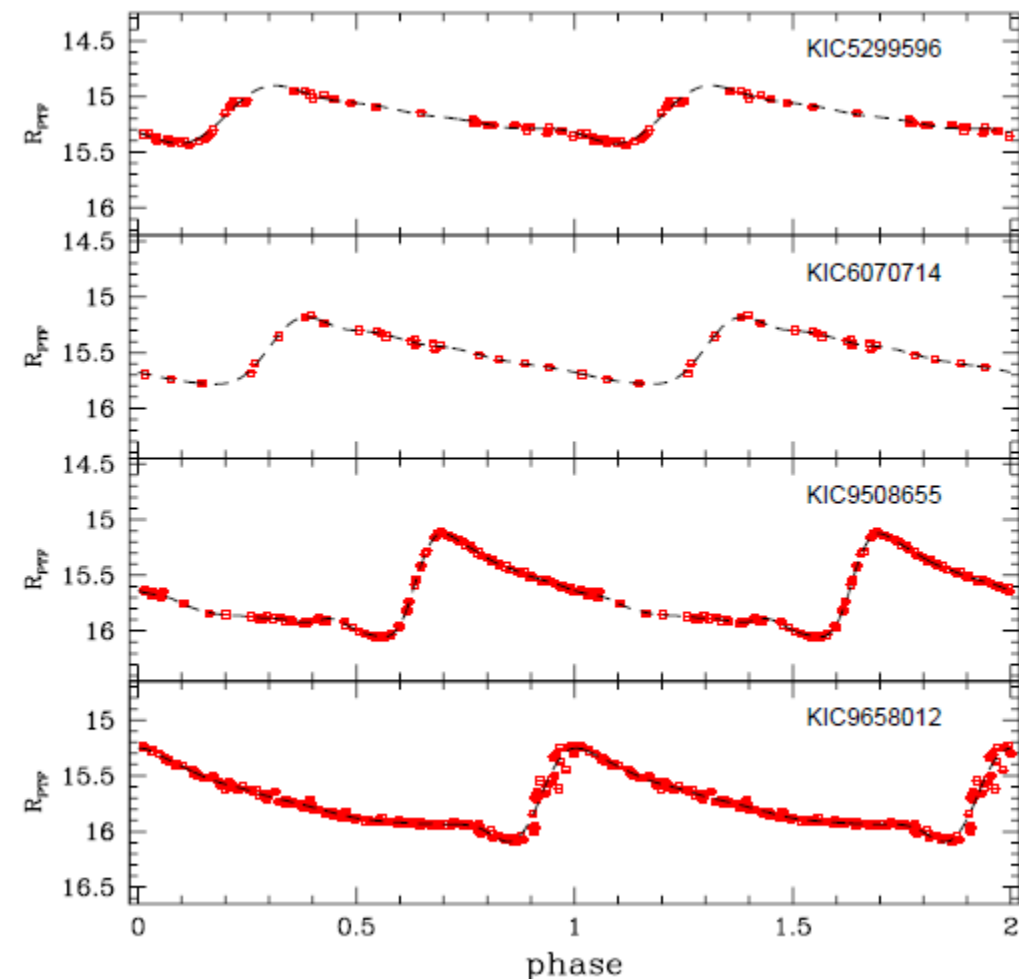
where ~ 14 mag is the saturation limit in PTF data

Science Case with PTF Public Data: [Fe/H]-LC Relation for RR Lyrae in Kepler Field

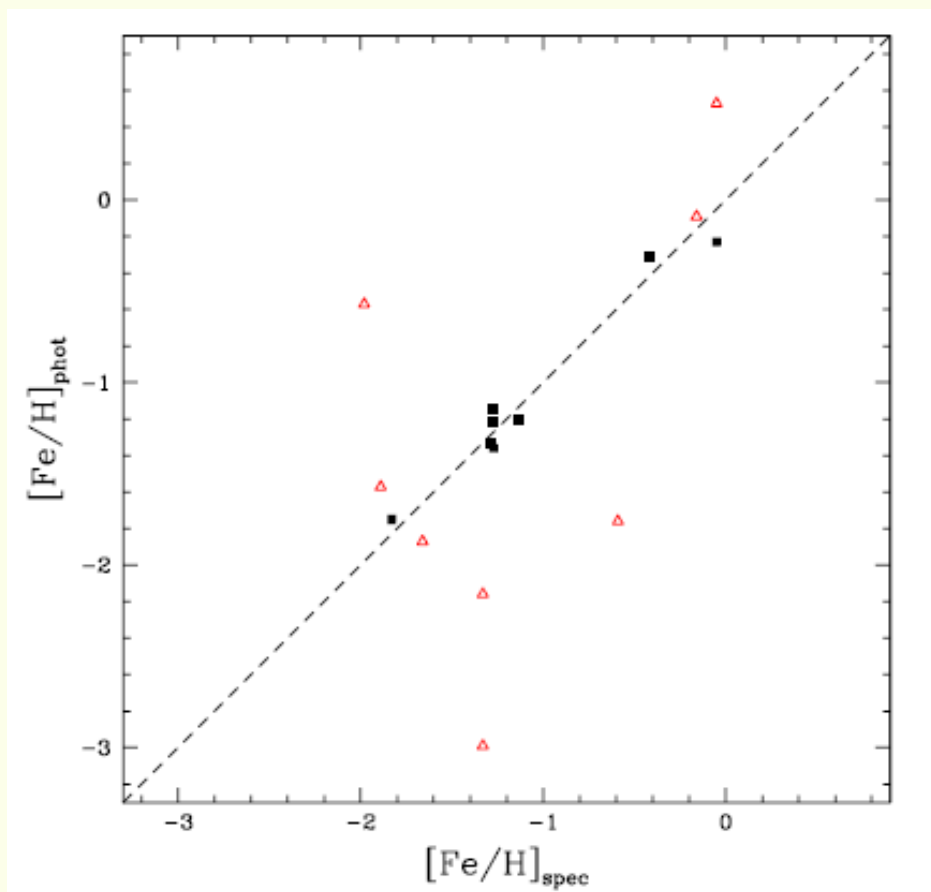
Group A example LCs



Group B example LCs



Science Case with PTF Public Data: [Fe/H]-LC Relation for RR Lyrae in Kepler Field



- Using RR-ab in Group B (and one RR-ab in Group A with acceptable LC), the [Fe/H]-LC relation in PTF R-band is found to be:

$$[Fe/H] = -3.261 - 8.274P + 1.219\phi_{31}.$$

Conclusion

PTF *yesterday*

The Palomar Transient Factory
(2009-2012)

General synoptic transient survey

iPTF *today*

Intermediate Palomar Transient Factory
(2013-2016)

Focused mini-surveys

101+ papers, 3283+ citations

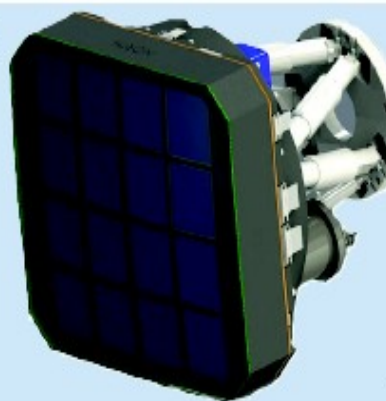


ZTF *tomorrow*

The Zwicky Transient Facility
(2017-2020)

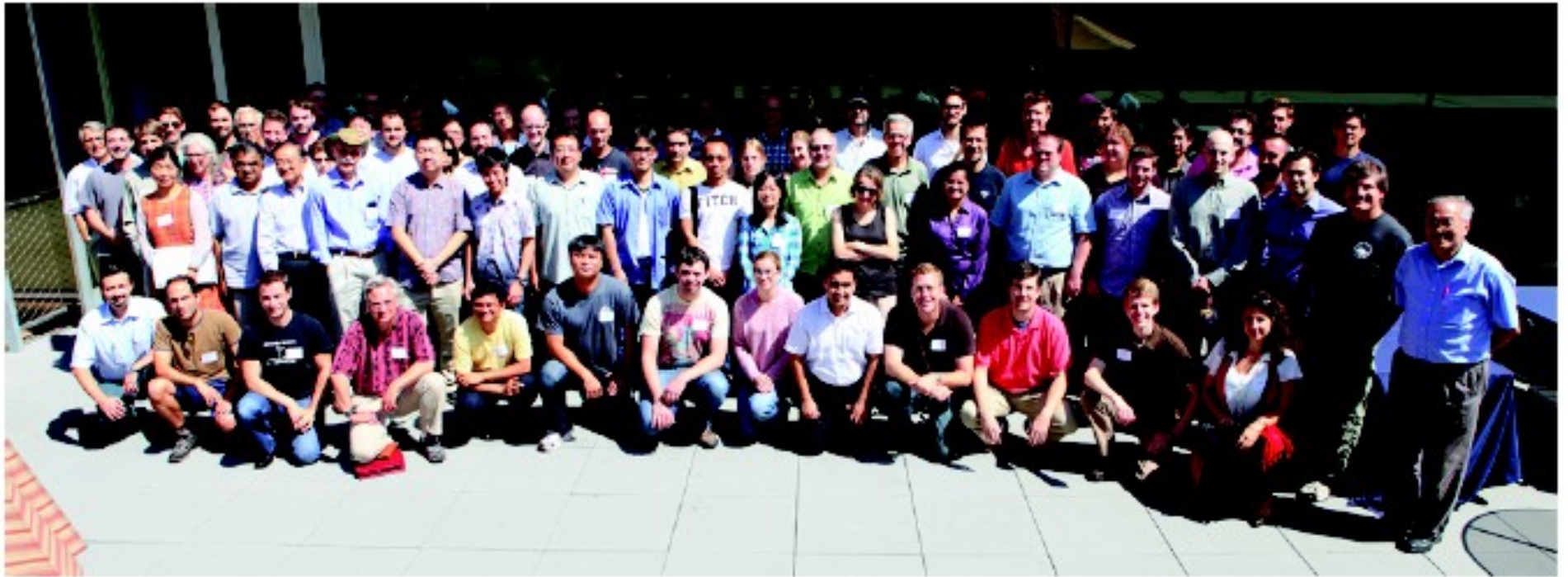
High-cadence, wide-area survey

new 47 deg²
camera



- Kepler main goal: exo-planet using transit method
- Continuous light curves good for variable stars

~ THANK YOU ~



המכון למדע
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