

Rare Event Survey in Light Curves: from Kepler to Tomo-e

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Rare Event Survey: from *Kepler* to *Tomo-e*

1. Possible Targets

Evaporating Rocky Planets ?

Long Period Transiting Jupiters

Hierarchical Triple Eclipsing System

Self-lensing Binary of Black Holes?

Alien Mega-Structure

2. GPU-based Astronomical Data Mining

3. Comparison with TESS and Summary

Kepler

D=0.95 m

N ~ 200,000

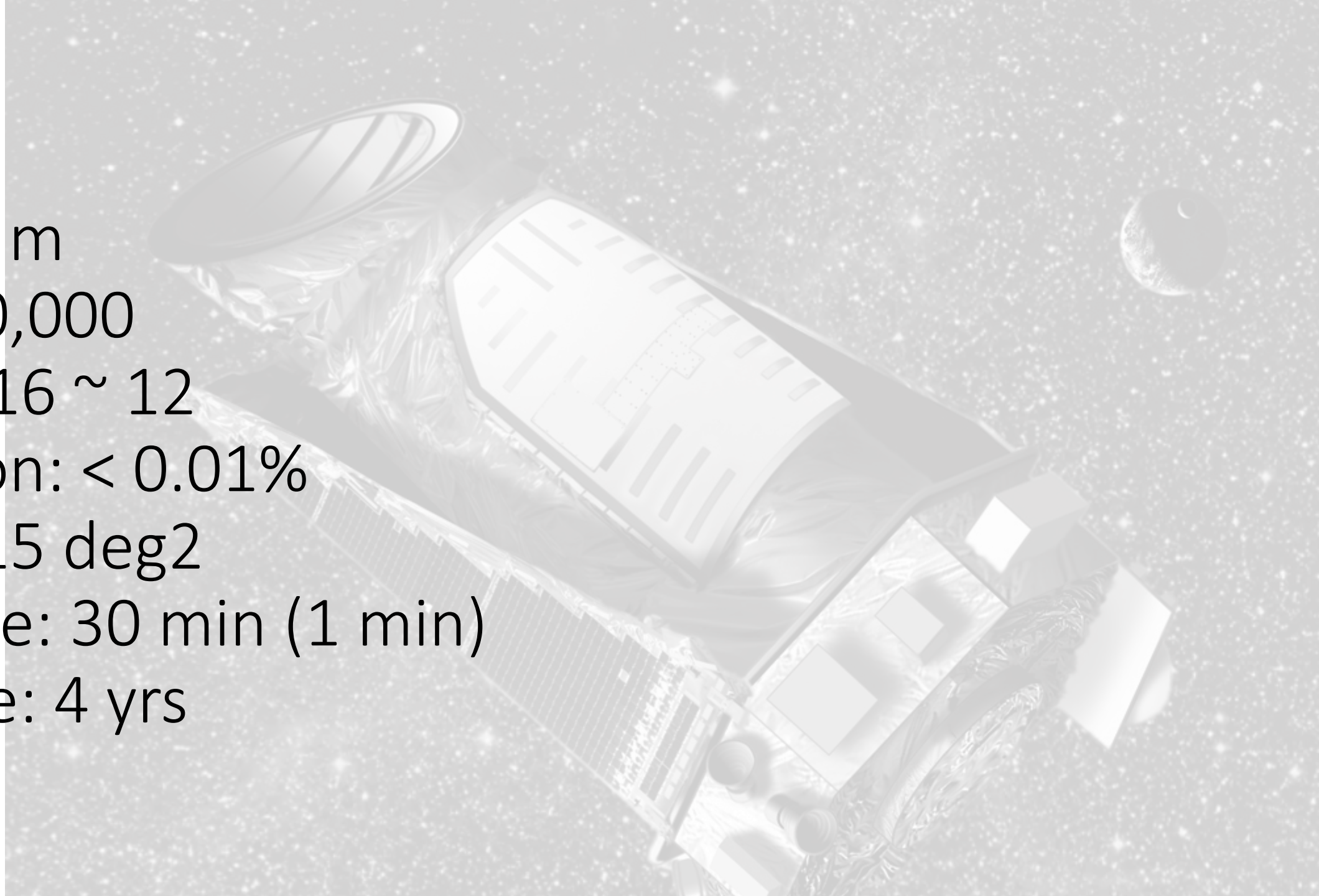
Vmag: 16 ~ 12

Precision: < 0.01%

FOV: 115 deg²

Cadence: 30 min (1 min)

Lifetime: 4 yrs



Kepler

D=0.95 m

N ~ 200,000

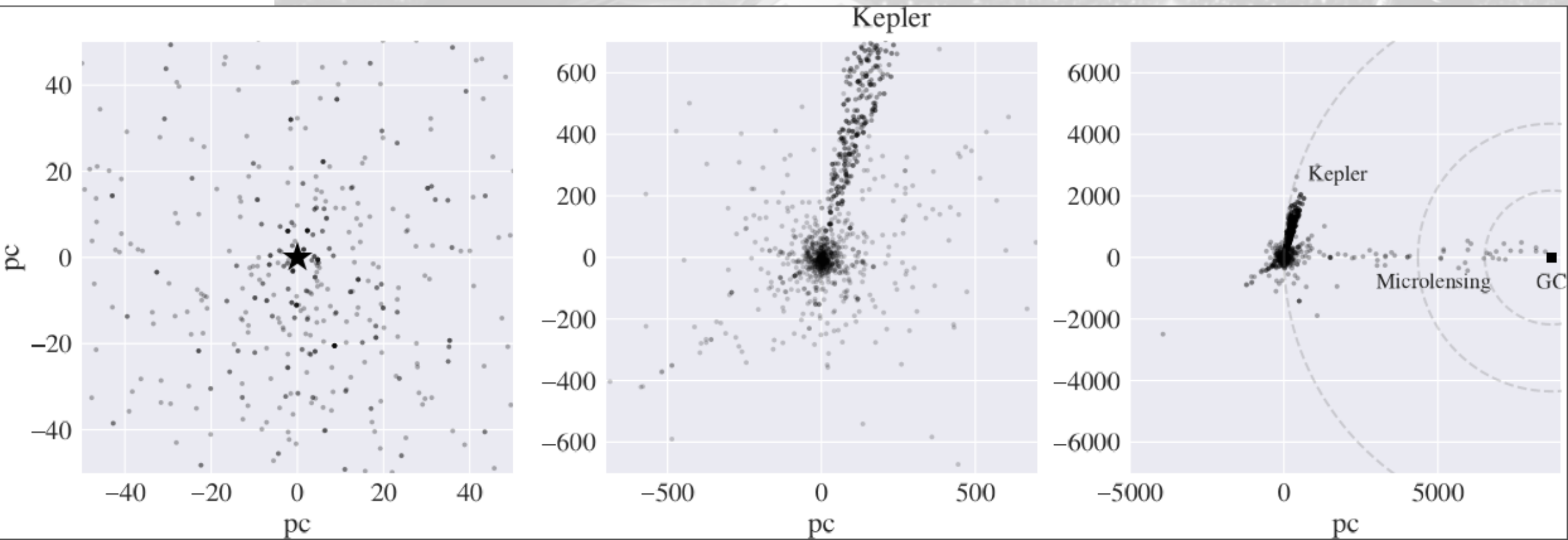
Vmag: 16 ~ 12

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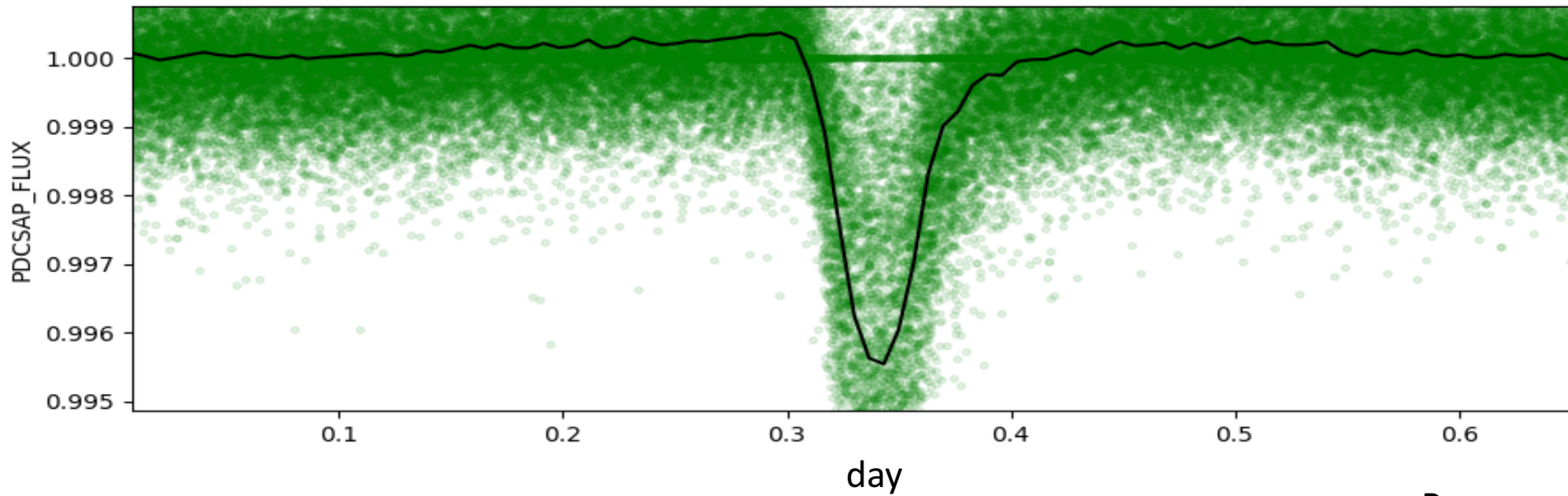
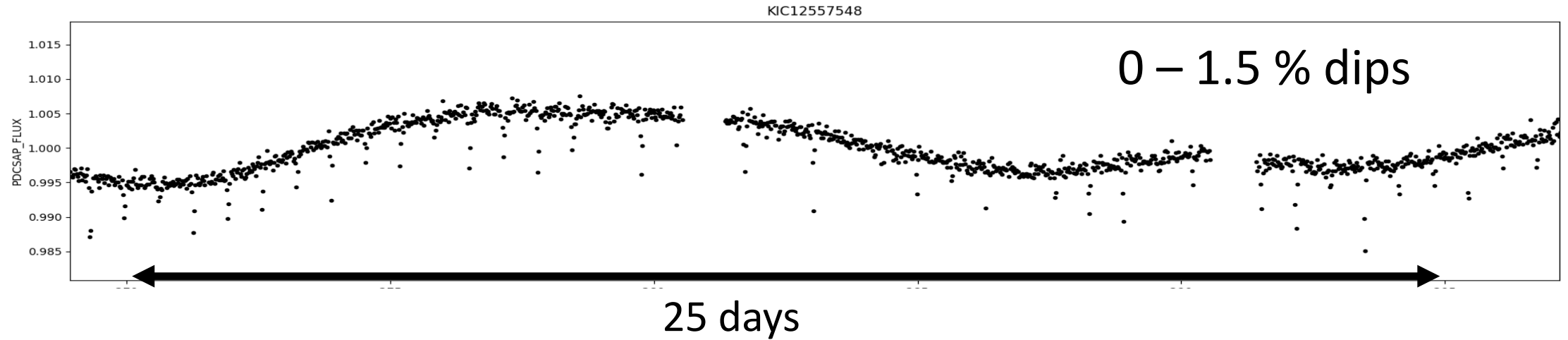
FOV: 115 deg²

Cadence: 30 min (1 min)

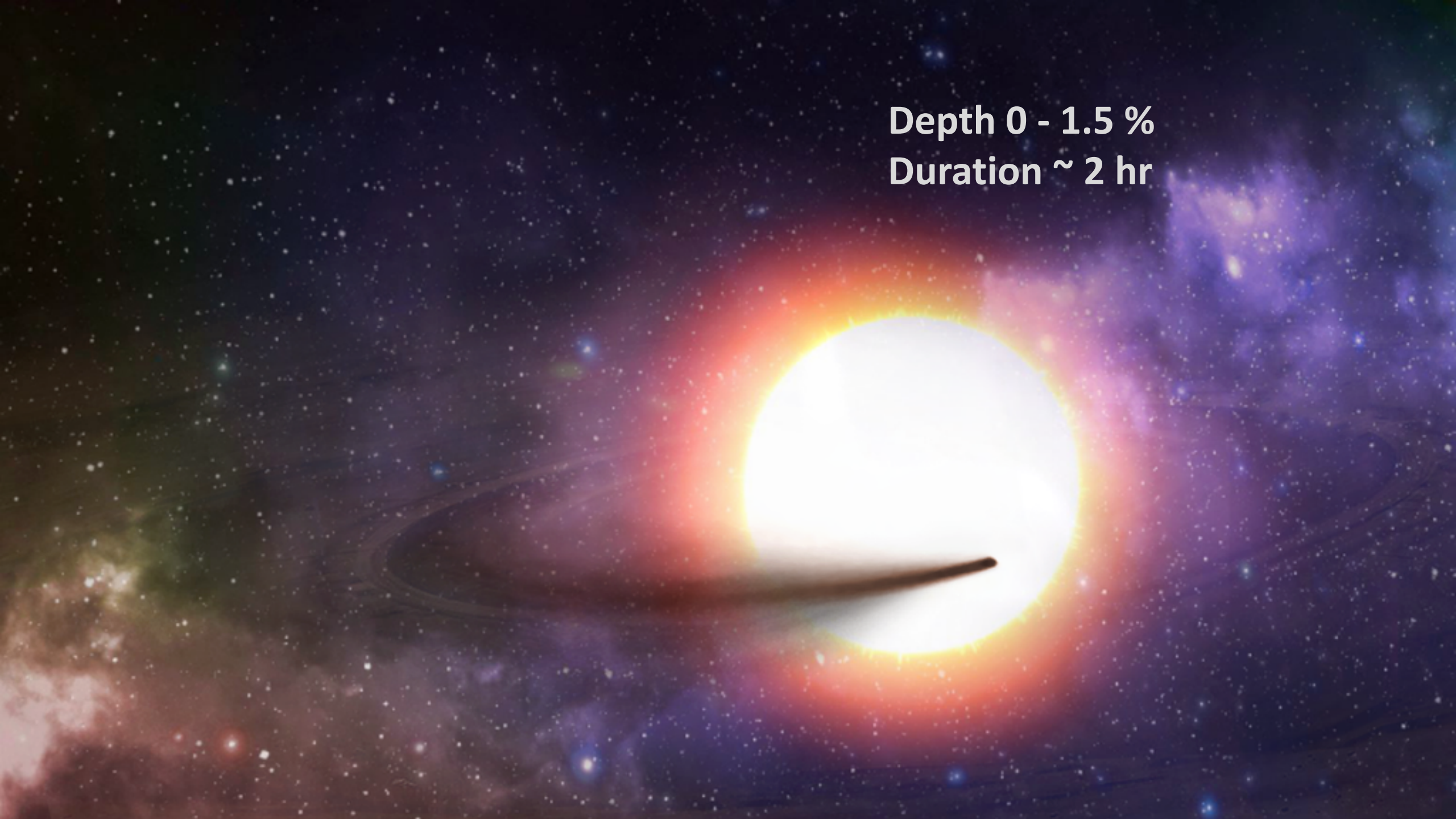
Lifetime: 4 yrs



Evaporating rocky planets in Kepler ?



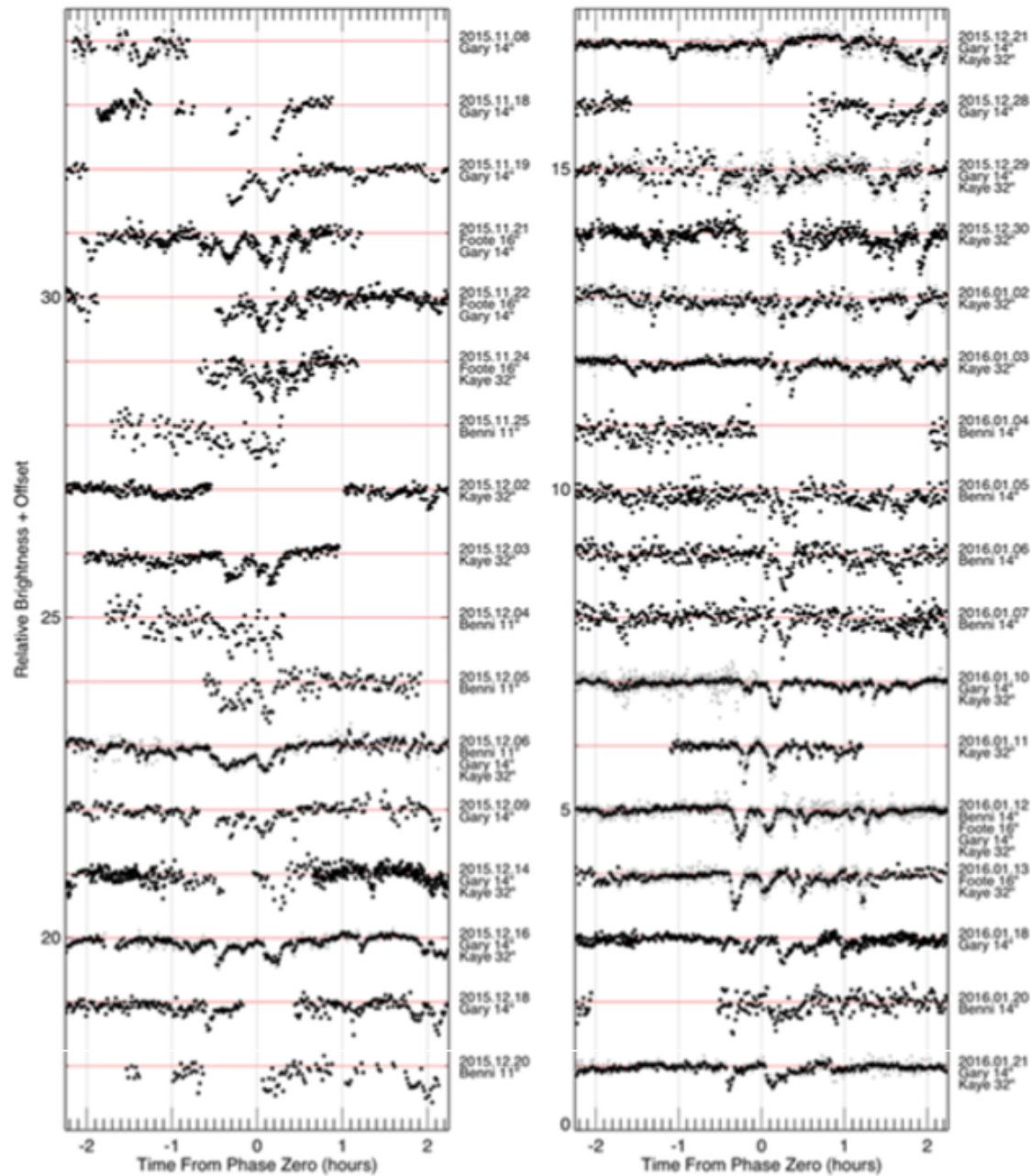
Depth 0 - 1.5 %
Duration ~ 2 hr



Disintegrating rocky planetesimal(s) around a white dwarf WD 1145+017?

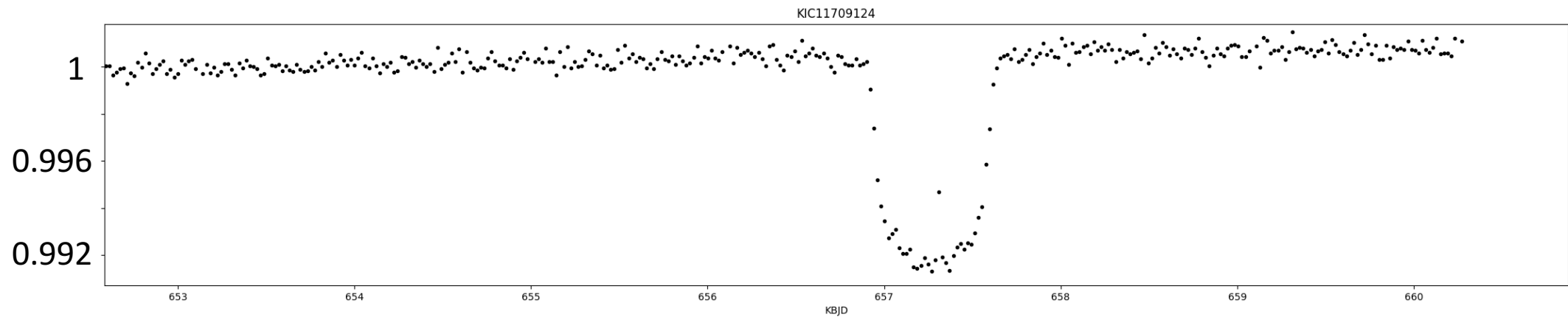
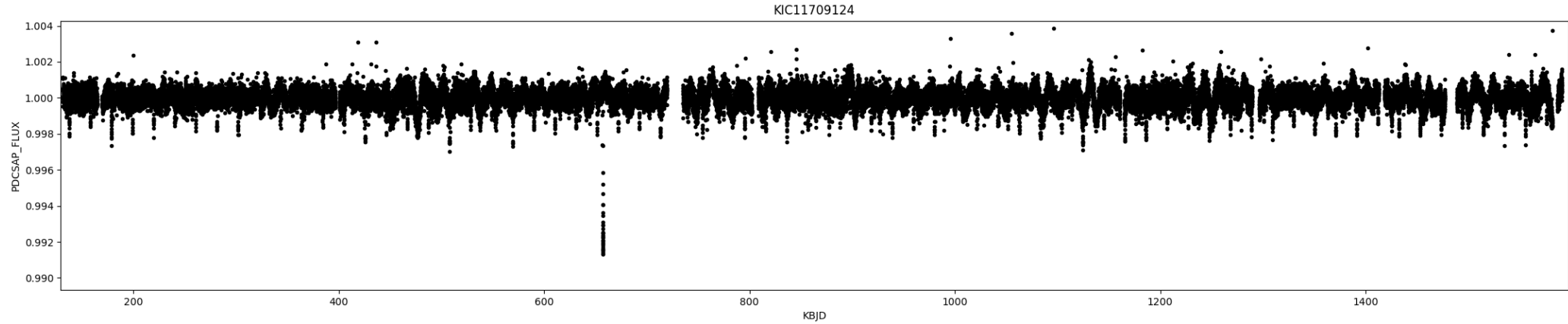


*Image credit: Mark A. Garlick
(Harvard/CfA)*



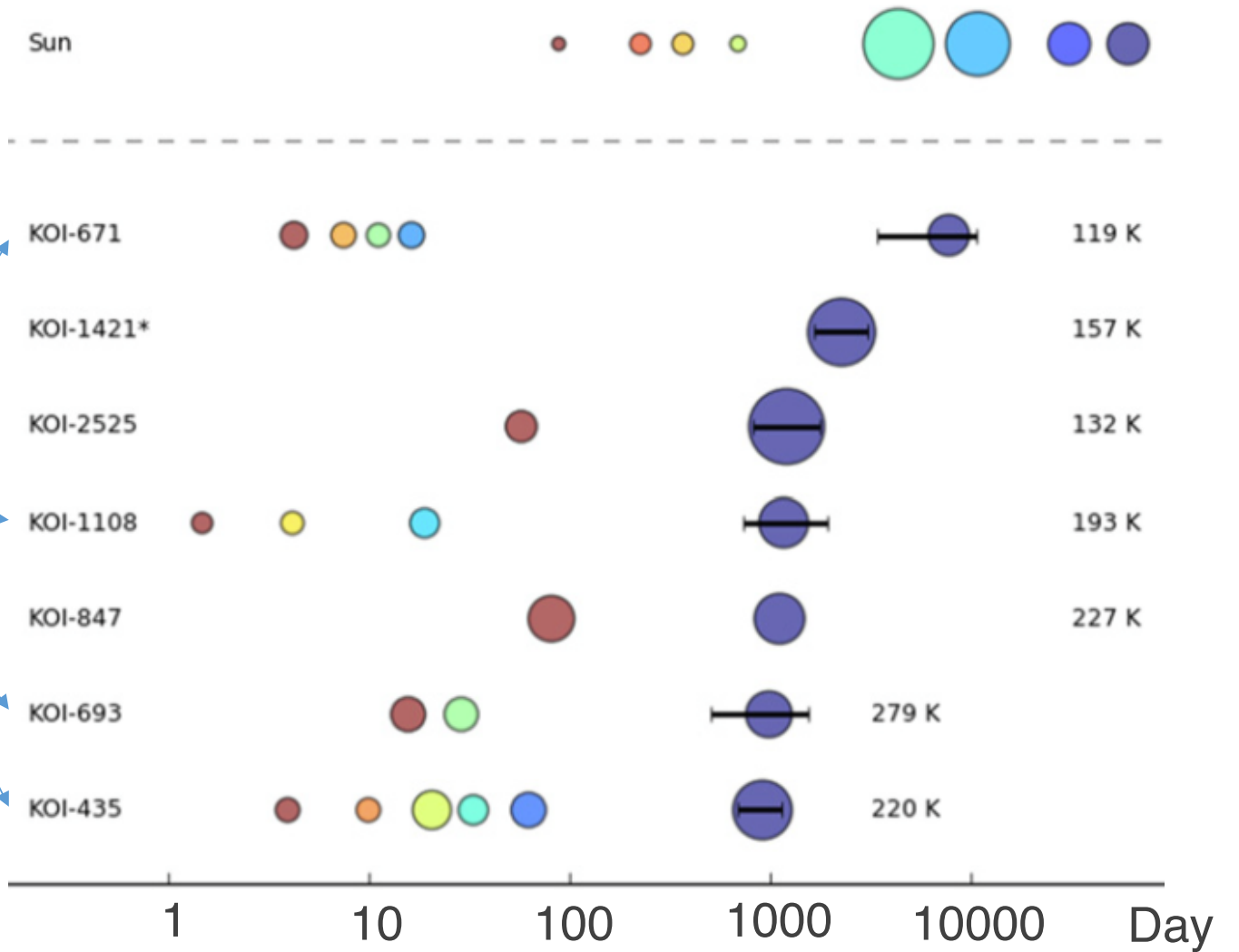
Rappaport et al. (2016)

Long Period Transiting Jupiters in Kepler

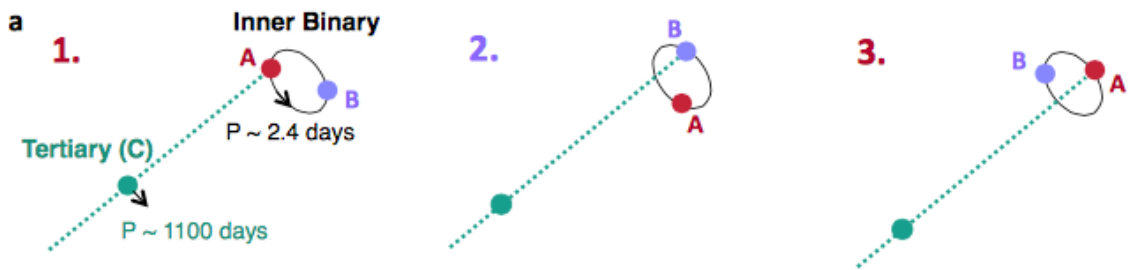
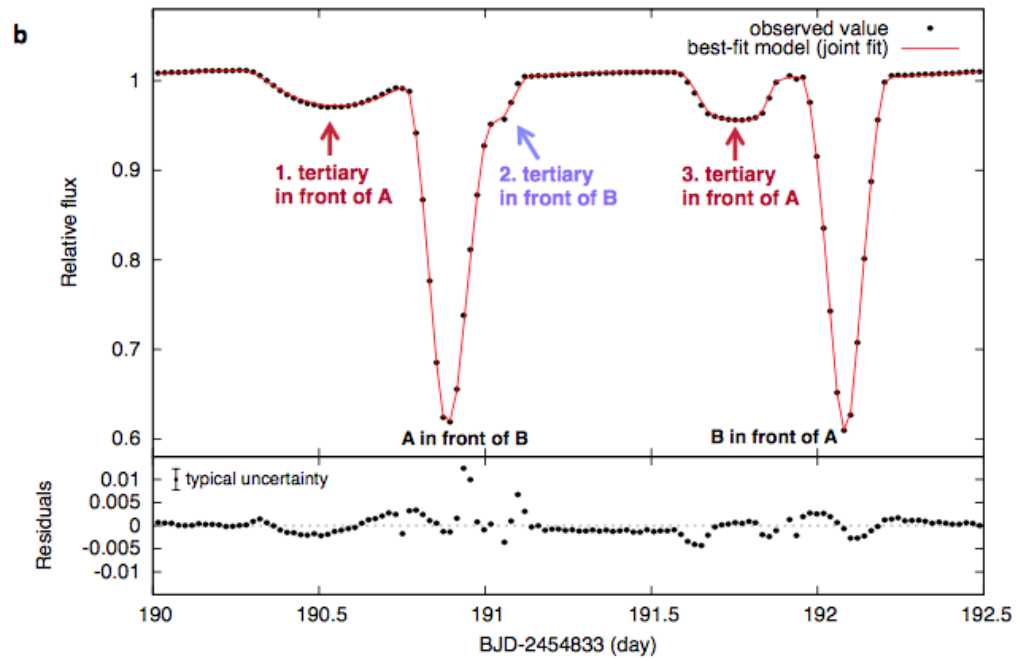
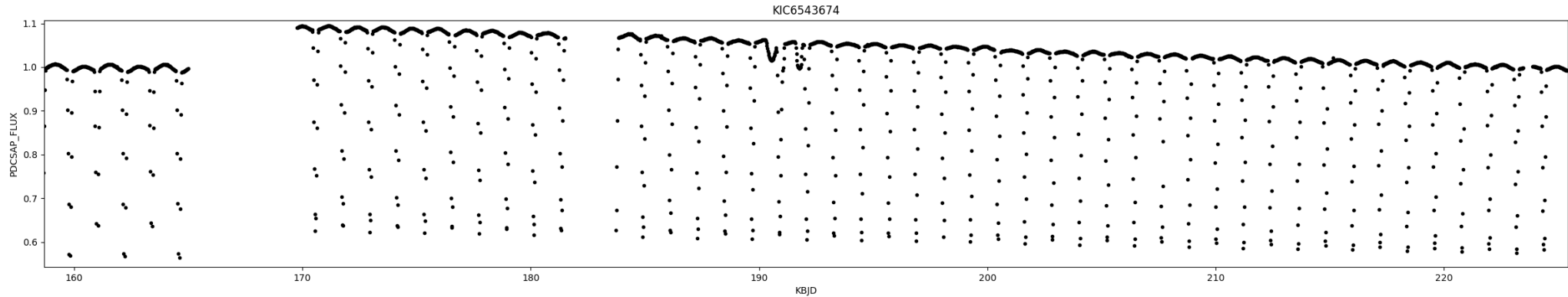


1 week

At least, **1 in 5** compact multis has a gas giant/neptune beyond/near the snow line



Hierarchical Triple System in Kepler



Self-Lensing White Dwarf Binaries in Kepler

$$\mu \sim 1 + 2 \left(\frac{R_E}{R_\star} \right)^2$$

$$\frac{R_E}{R_\odot} = 0.04 \left(\frac{M}{M_\odot} \right)^{1/2} \left(\frac{a}{1au} \right)^{1/2}$$

G star + 0.5 Msol WD: 0.1 %



Self-Lensing Black Hole Binaries in Tomoe?

$$\mu \sim 1 + 2 \left(\frac{R_E}{R_\star} \right)^2$$

$$\frac{R_E}{R_\odot} = 0.04 \left(\frac{M}{M_\odot} \right)^{1/2} \left(\frac{a}{1\text{au}} \right)^{1/2}$$

G star + 0.5 Msol WD: 0.1 %

※KeplerはほとんどFGK stars

G star + 50 Msol BH @1 au: 1 %

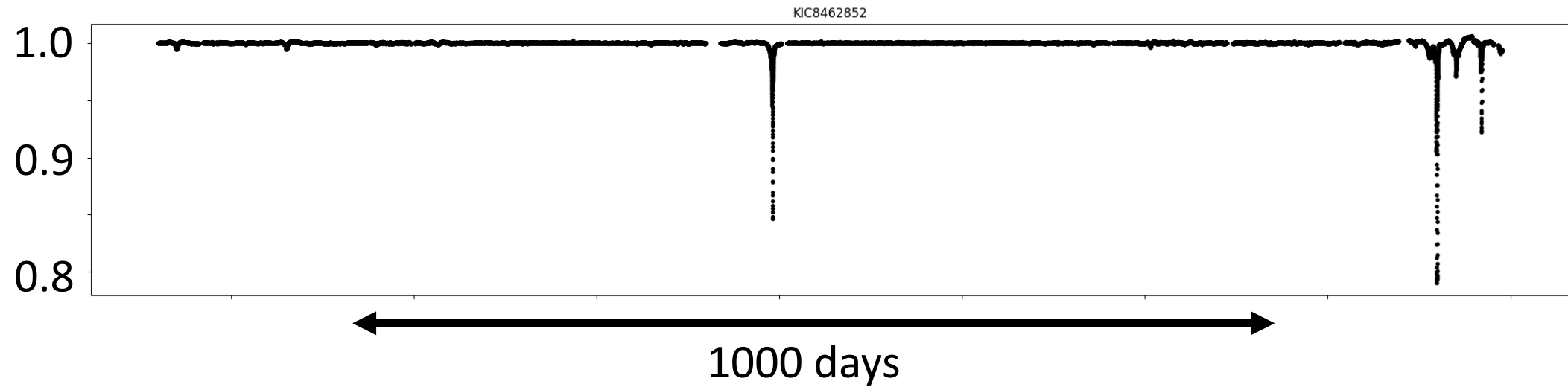
M star + 0.5 Msol WD @1 au: 2 %

M star + 10 Msol BH @1 au: 30 %

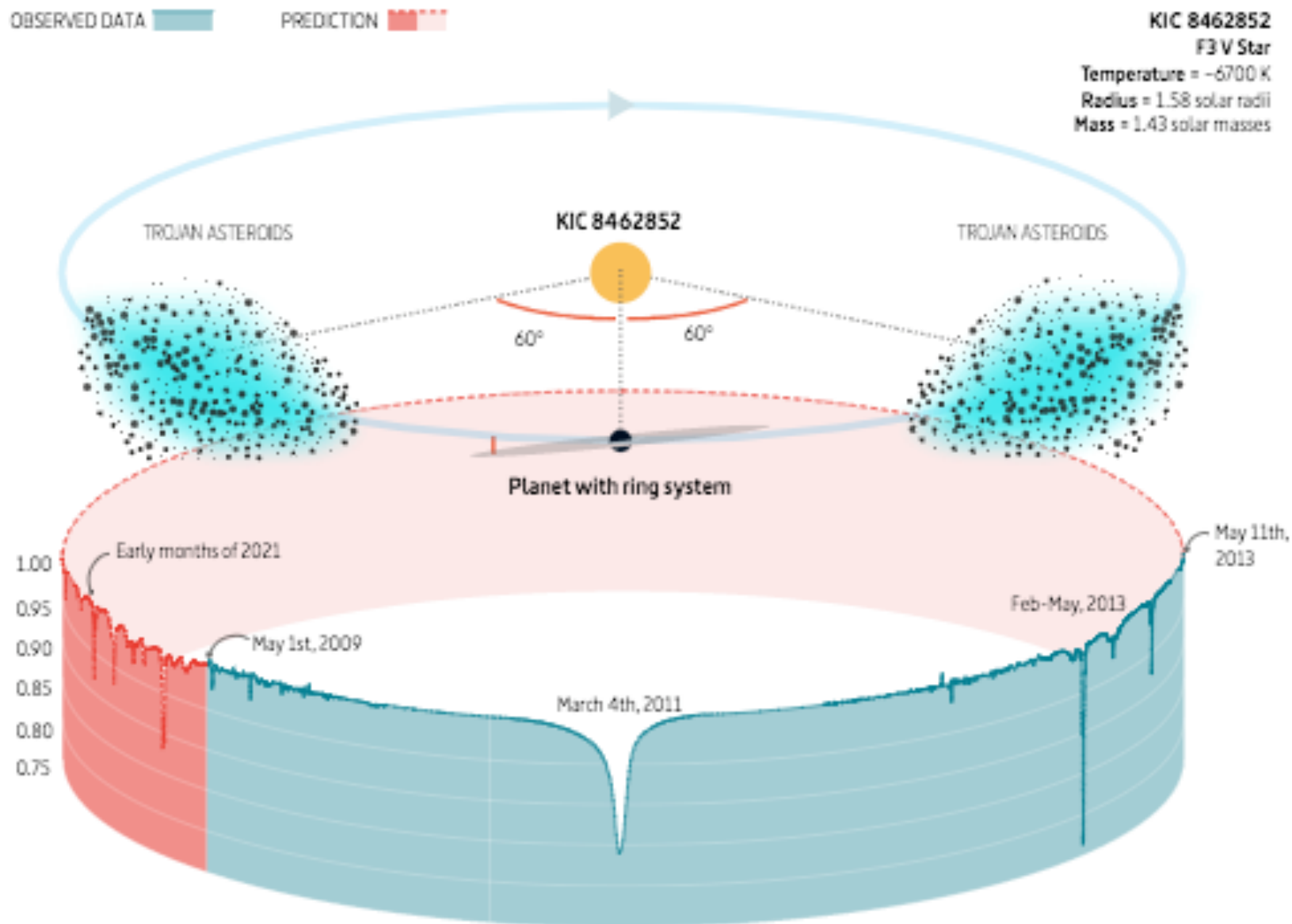
M star + 10 Msol BH @0.1 au: 4 %



Alien Mega-Structure KIC 8462852



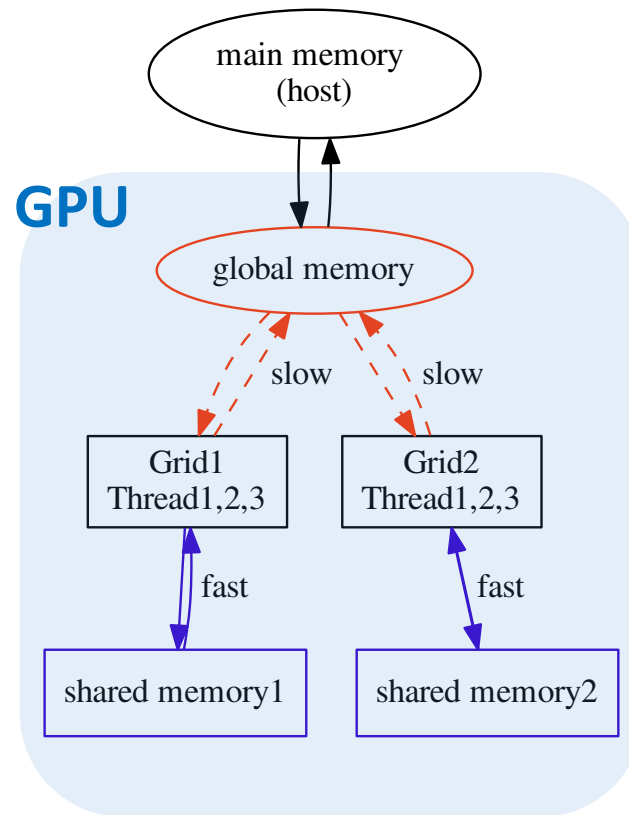
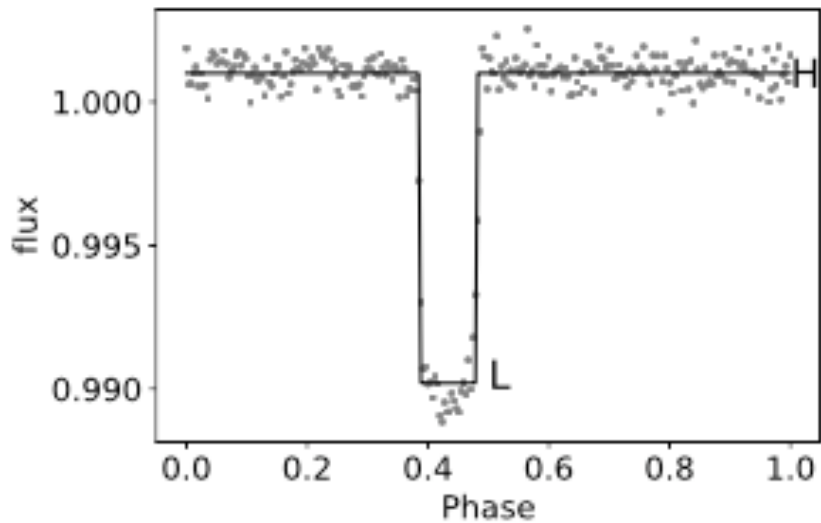
Citizen scientists found this system.
Such a star in 200,000 targets



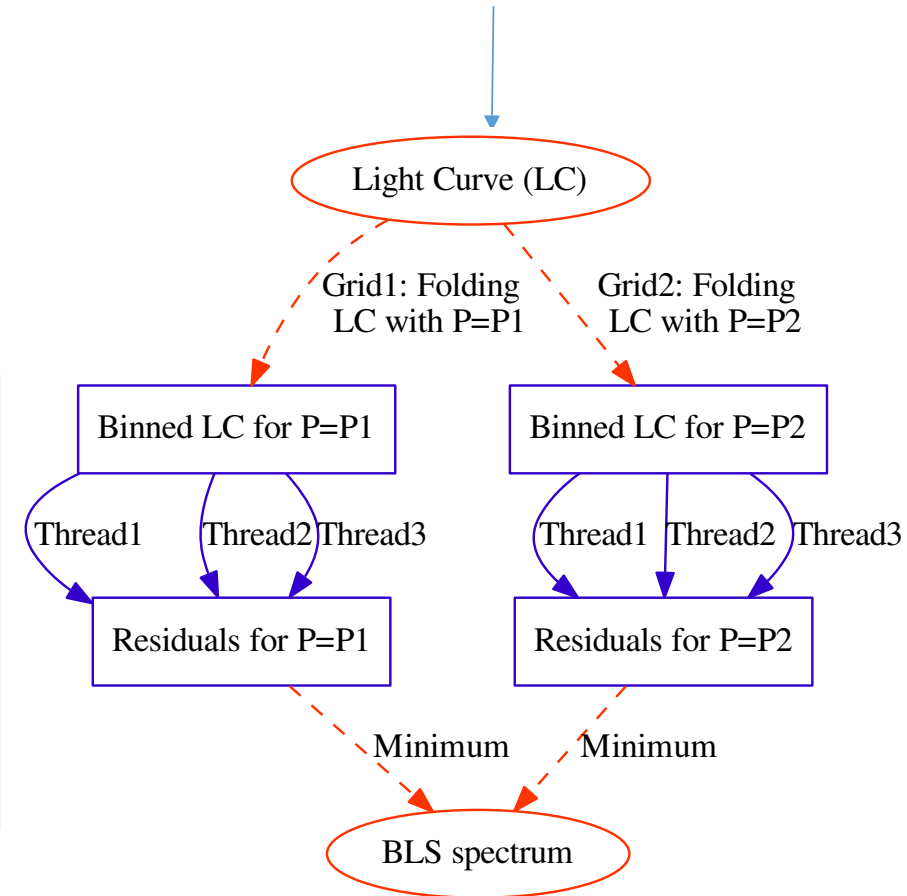
GPU-based Box Least Square (gbls)

GPU : CPU = 1s : 50s

Titan X Pascal, core-i7 6700K/4GHz



地味だけど重要
HDF : 圧縮され読み込みも速い
fits : ノーコメント

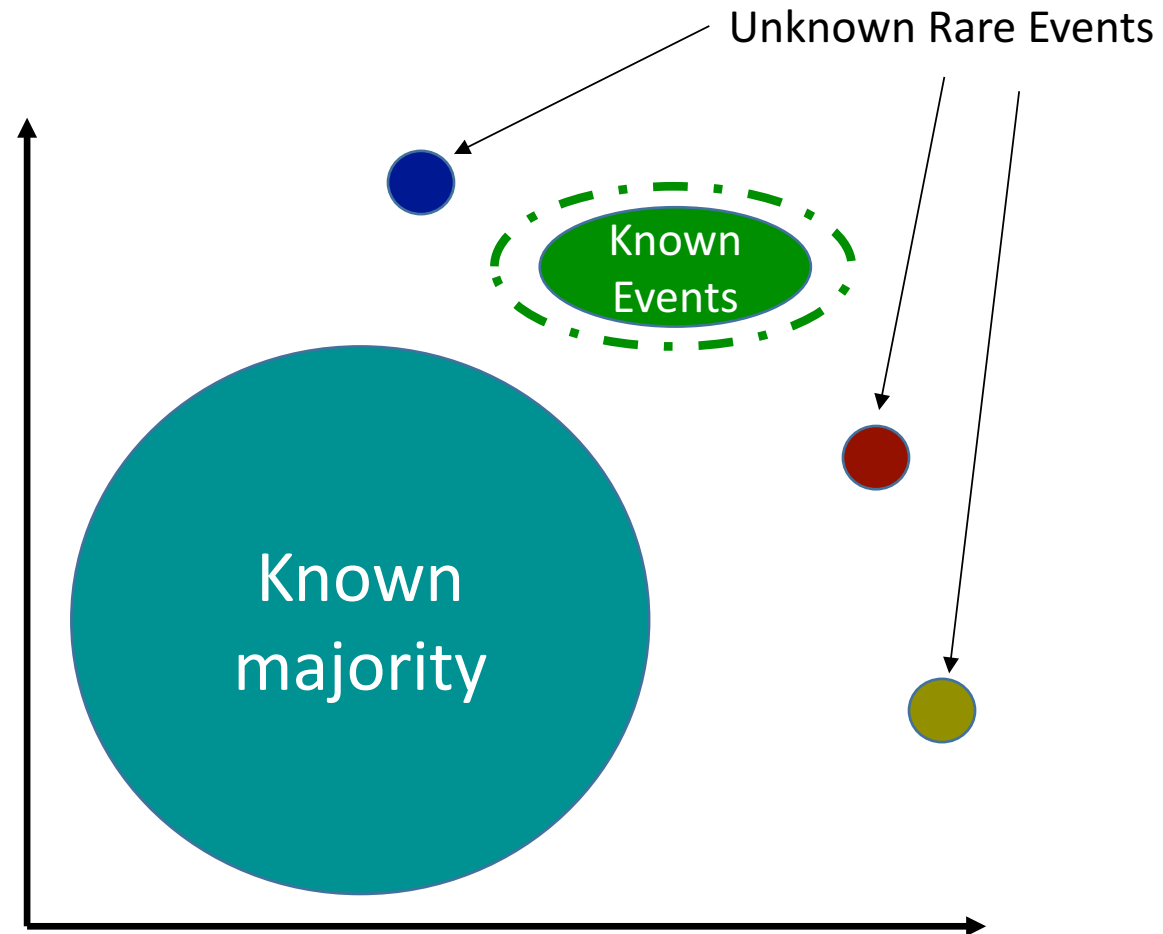


紹介した5種類は(最初は)偶然見つけたもの

現状のRare Eventサーベイ

1. 特定の検出アルゴリズム
2. 目視検査

→ 異常検知的アプローチへ

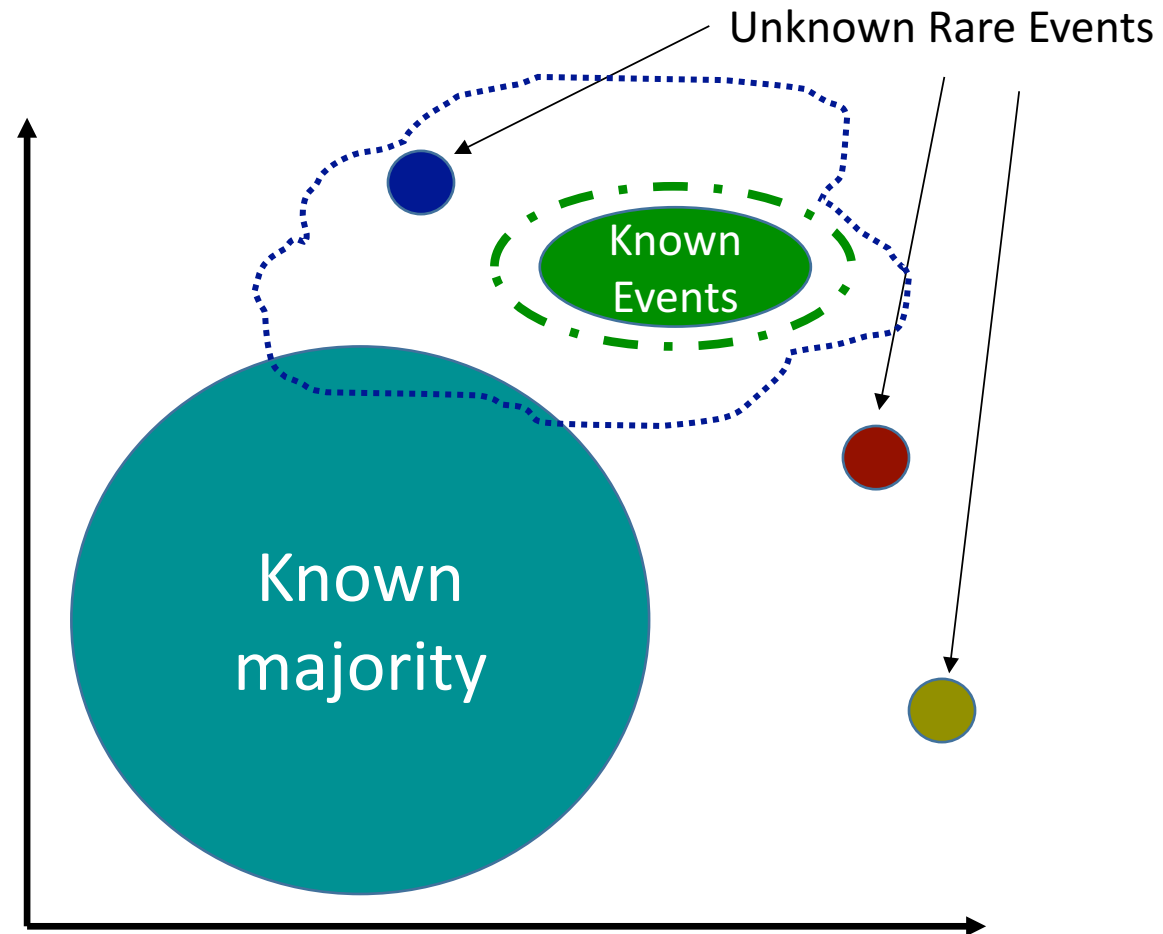


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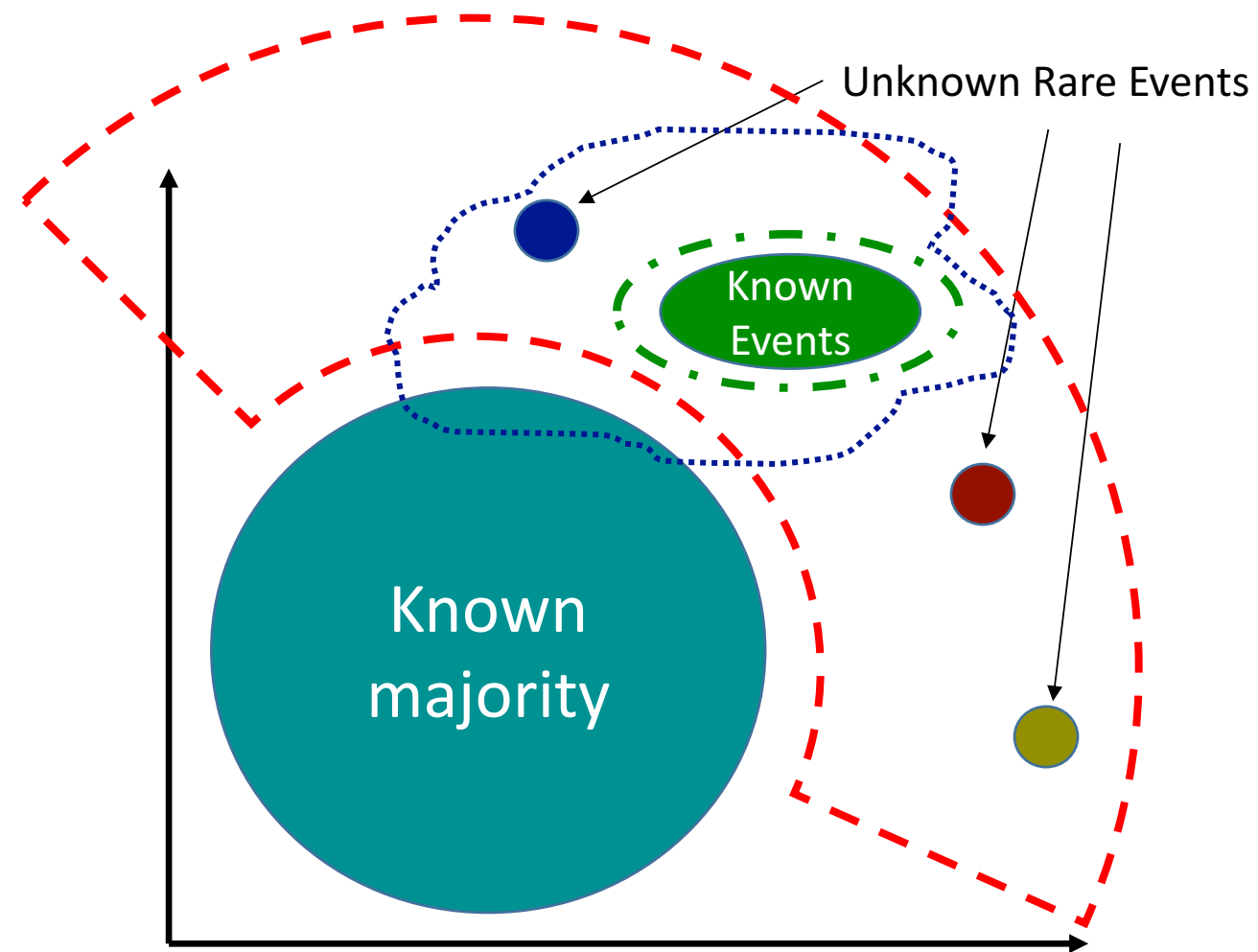


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TESS 2018-

All Sky Survey

Brightest Stars ($\sim 10^5$) $V_{\text{mag}} < 12$

2min cadence

0.01% precision

Many analyzers all over the world.

“Tomo-e Rare Event Survey” should focus on ...

$\sim 1\%$ signal, but extremely rare ($\sim 1/10^6$)

Or very short times scales (~ 1 min) \Rightarrow unknowns

Or unknown unknowns

Signal > 1 % precision	Period	Signal Duration	Cadence (detection) (I want)	Known ?	My Excitation Index
Evaporating Planets	< 1 day (Quasi Periodic)	~ 1 h	30 min 1 min	3 knowns (but faint)	A
Long period Transiting Jupiters	Non-Periodic	~ 1 day	1.5 h 30 min	Now many (but faint)	B
Hierarchical Triples	Various	1 h – 1 day	1.5 h same	~ 10	B
Self-Lensing Binary Black holes	1 month ~ a few yrs	1h - 1 day	10min - 1.5h	Not yet	A+
Alien Magastructure	Non-Periodic	~ 1 day	1.5 h	1	A A++ if true
Unknown Short (Quasi) Periodic	< 1 min	Unknown	Unknown	Unknown	Unknown