Machine Learning Variability Classification in the OGLE Project

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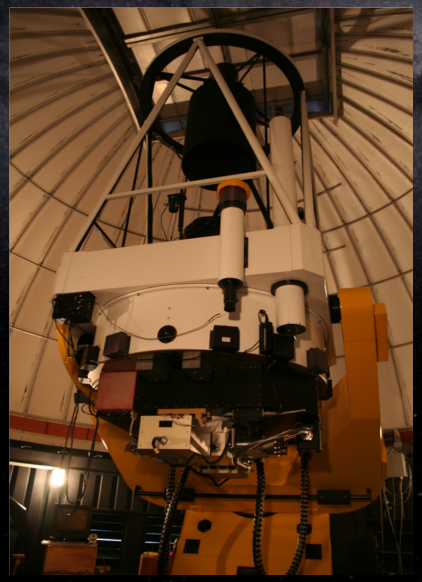
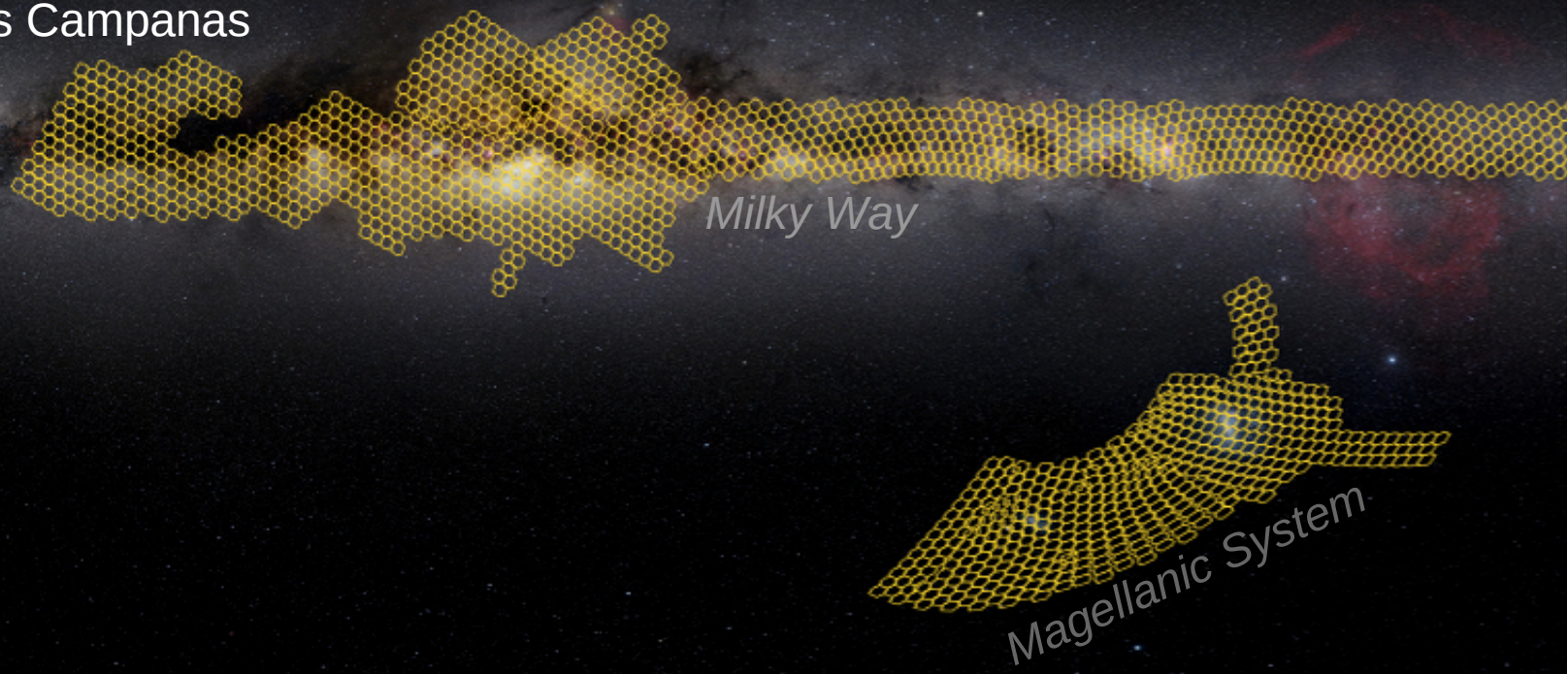
OGLE – a Large Variability Sky Survey

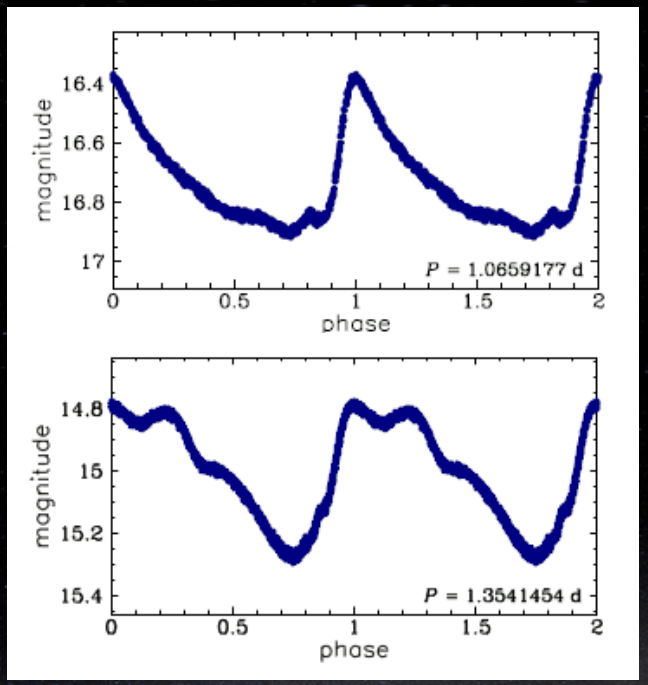
Warsaw 1.3-m @ Las Campanas



- in operation since 1992
- since 2010 as OGLE-IV (Udalski *et al.* 2015)
- 3500 deg^2 sky coverage
- 1.3 billion sources monitored every night
- 10^{12} photometric measurements by 2016
- over 17,000 microlensing detections
- more than 50 extrasolar planets discovered
- 500,000 new variable stars



The OGLE Collection of Variable Stars



- about 500,000 new variable stars in
  Galactic Bulge, Galactic Disk and Magellanic Clouds
- pulsating stars: Cepheids, RR Lyraes, LPVs:
  Soszyński *et al.* 2004, ..., 2015
- eclipsing and ellipsoidal binaries:
  Graczyk *et al.* 2011, Petrukowicz *et al.* 2013
  Pawlak *et al.* 2013
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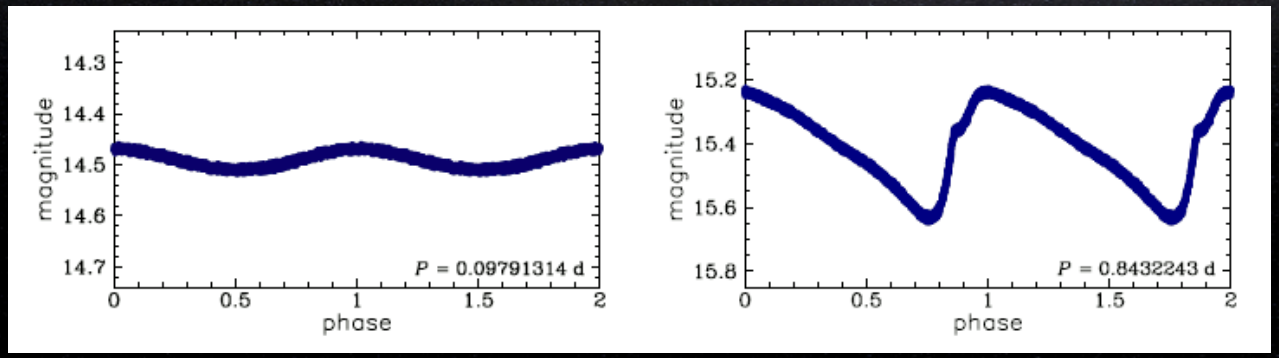
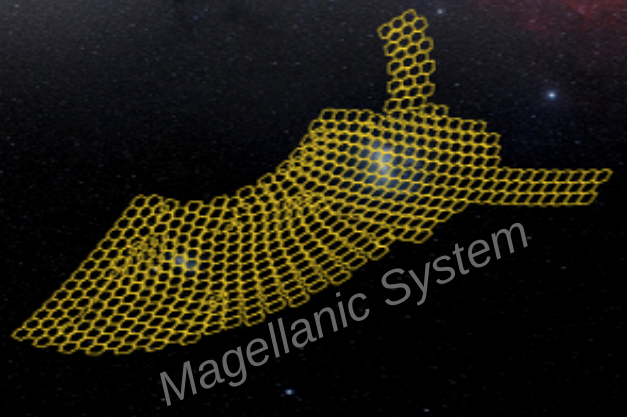




Machine Learning in the OGLE Project - overview

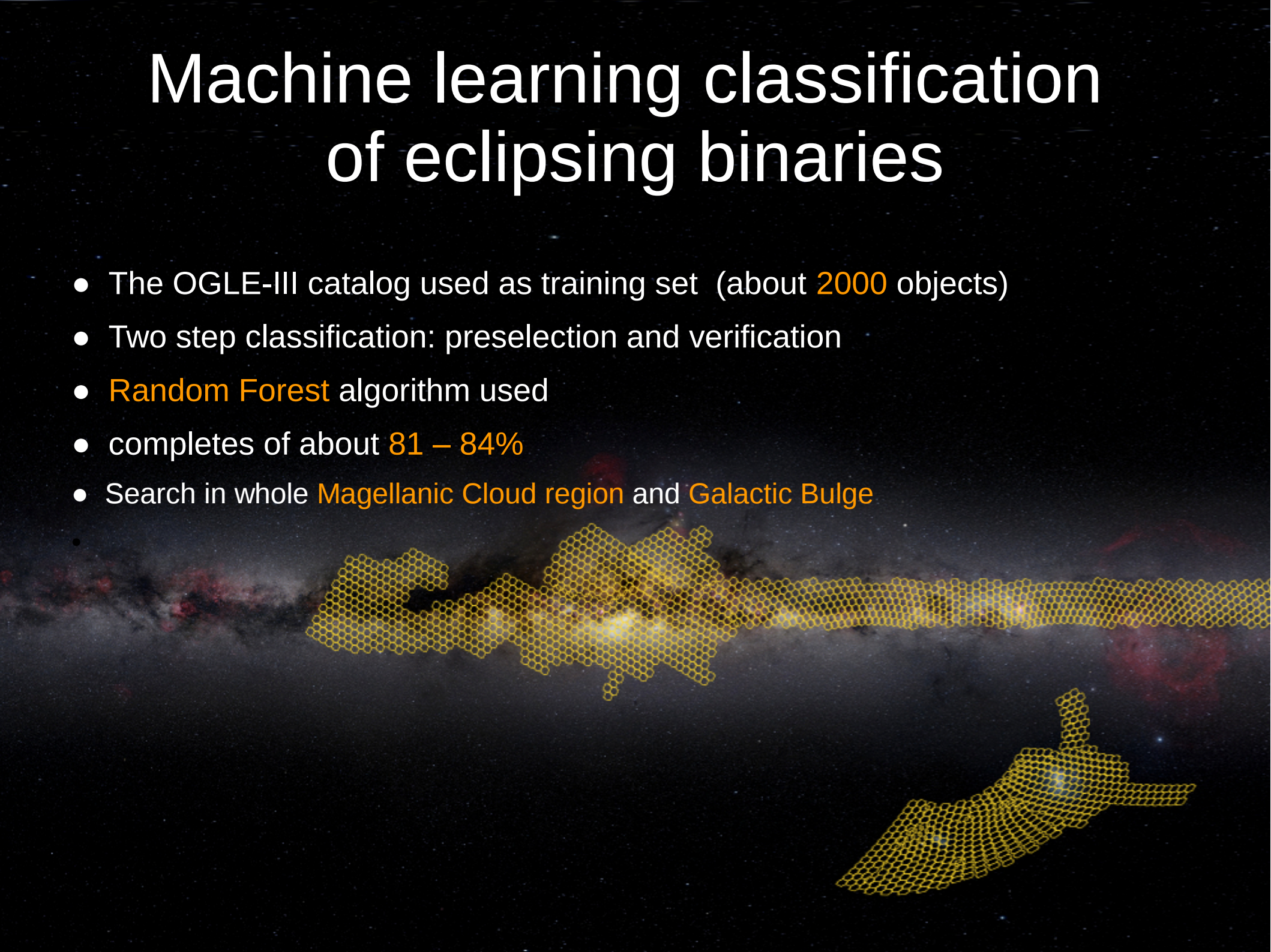
- search for eclipsing binaries with Artificial Neural Networks: (Wyrzykowski *et al.* 2003, 2004)
- search for eclipsing binaries with Decision Trees: (Pawlak *et al.* (2013)
- search for microlensing events with Random Forest: (Wyrzykowski *et al.* 2015)
- real-time transient detection with Self-Organizing Maps: (Klencki & Wyrzykowski 2016)

In progress:

- search for eclipsing binaries with Random Forest: (Pawlak *et al.* 2016)

Machine learning classification of eclipsing binaries

- The OGLE-III catalog used as training set (about 2000 objects)
- Two step classification: preselection and verification
- Random Forest algorithm used
- completes of about 81 – 84%
- Search in whole Magellanic Cloud region and Galactic Bulge



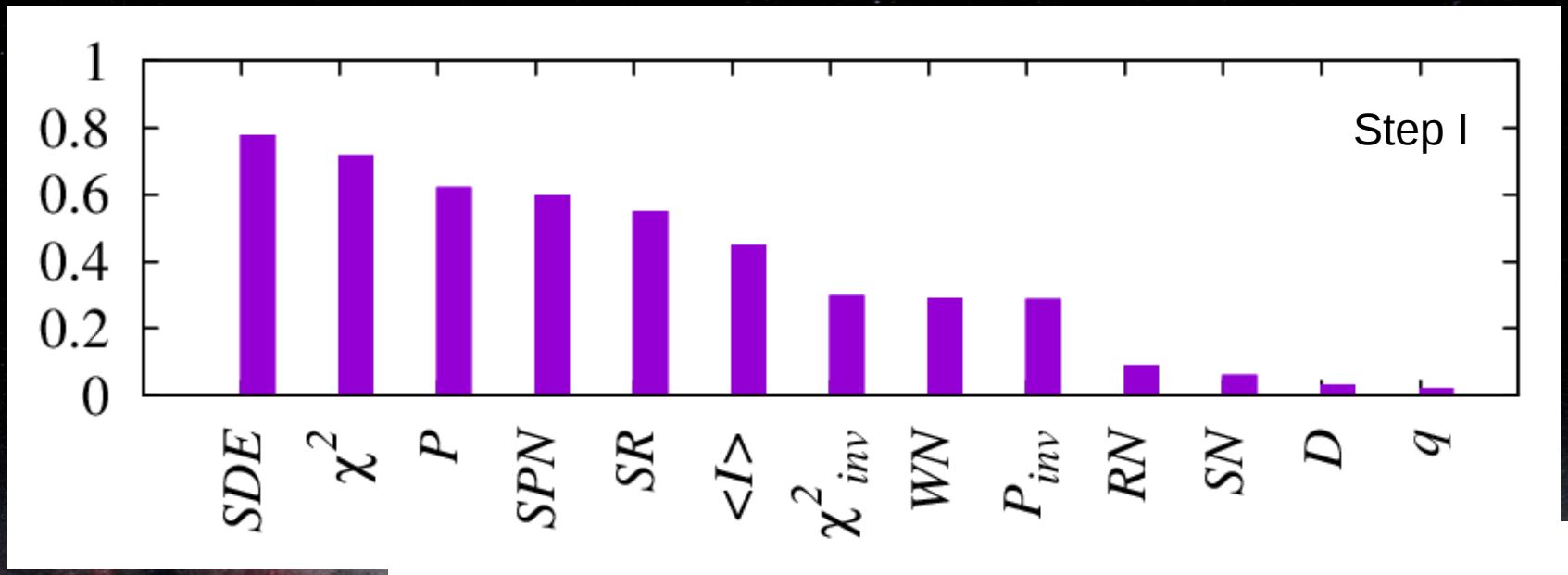
Machine learning classification of eclipsing binaries - parameters

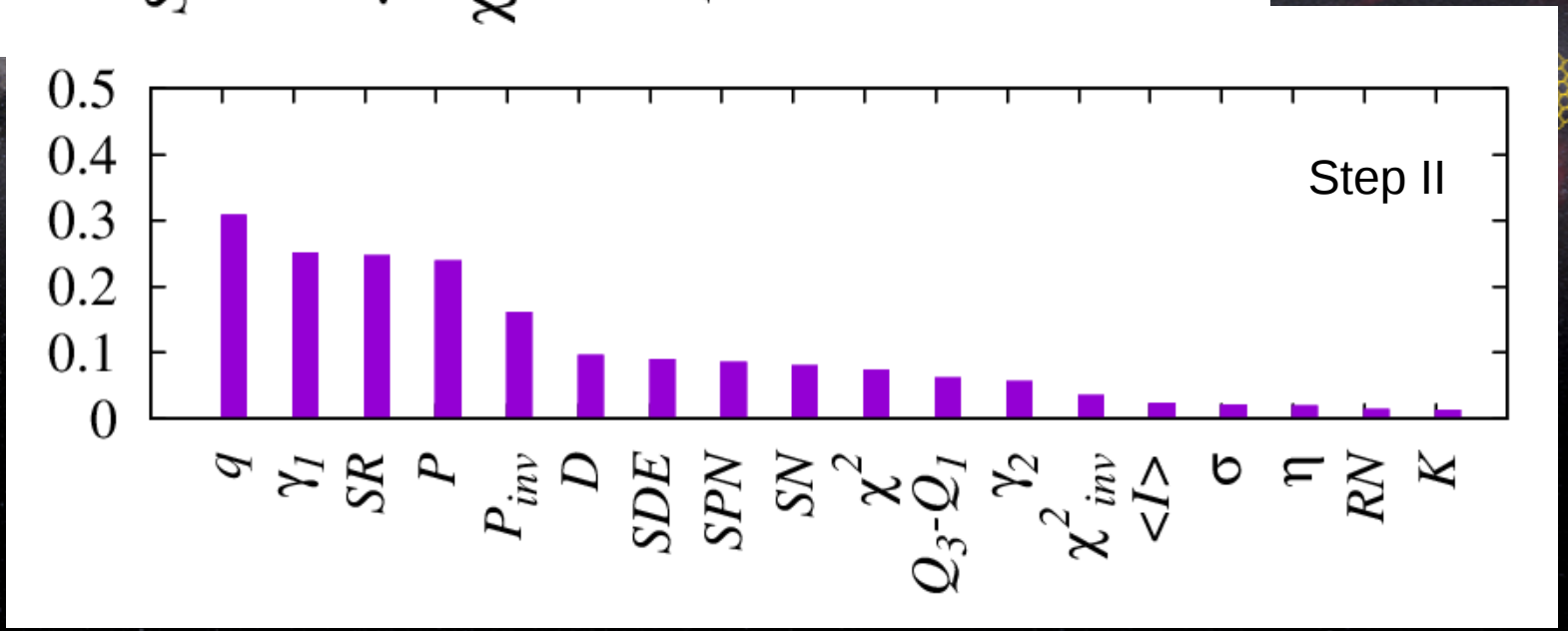
Parameter	Description
P	Period
SR	Singnal Residue
SN	Signal to Noise Ratio
SDE	Signal Detection Efficiency
D	Depth of transit
q	Fraction of the phase in ransit
χ^2	χ^2 of the transit model fit
RN	Red Noise
WN	White Noise
SPN	Signal to Pink Noise Ratio
$P_{\rm inv}$	Period of inverse transit
$\chi^2_{\rm inv}$	χ^2 of the inverted transit model fit
I	mean I-band magnitude

BLS, Kovacs *et al.* (2002)

Parameter	Description
σ	standard deviation
γ_1	skewness
γ_2	kurtosis
$Q_3 - Q_1$	difference between third and first quartile
η	Von Neumann index
K	Stetson K index

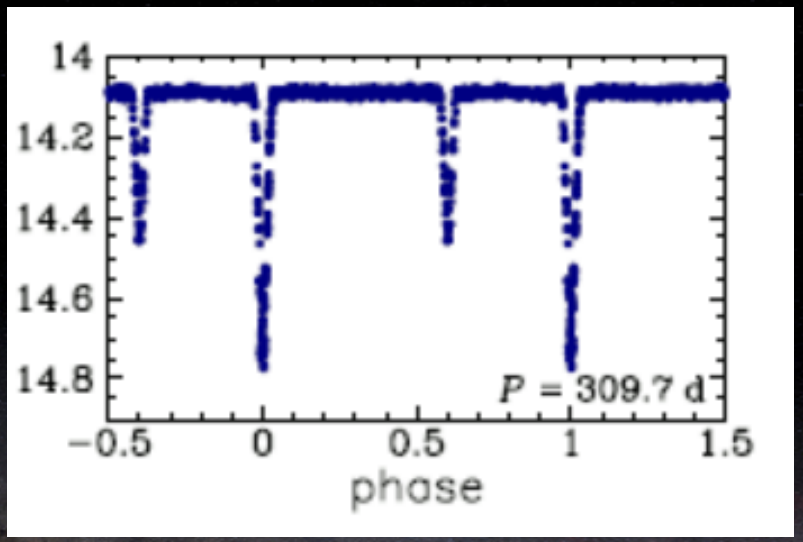
Machine learning classification of eclipsing binaries – information gain

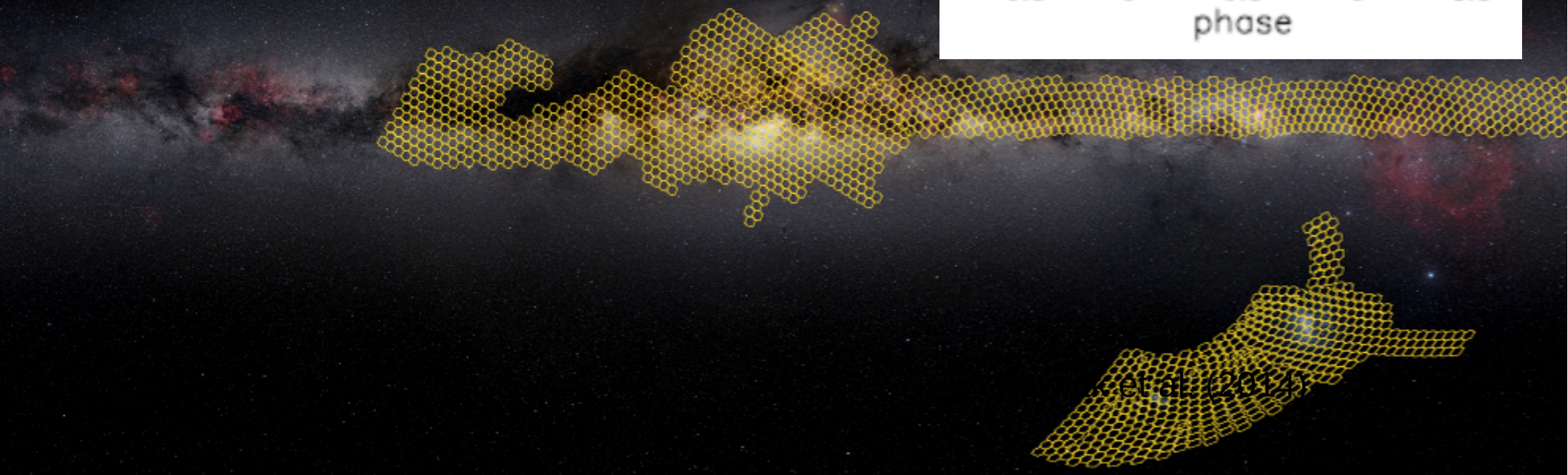




OGLE-IV Catalogs of Eclipsing Binaries

- Magellanic Clouds: over 48 000 objects
  (Pawlak *et al.* 2016)
- Galactic Bulge: about 400 000 objects
  (Soszyński *et al.* 2016)
- Coming soon!





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Thank you for your attention!

Acknowledgment
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