11th CoRoT Week
La Laguna, Tenerife, Spain
19-22 March 2013

ROLLMOPS

Researches on Low (amplitude) Level Modulations : Observation of Planetary Signals

LESIA
Observatoire de Paris

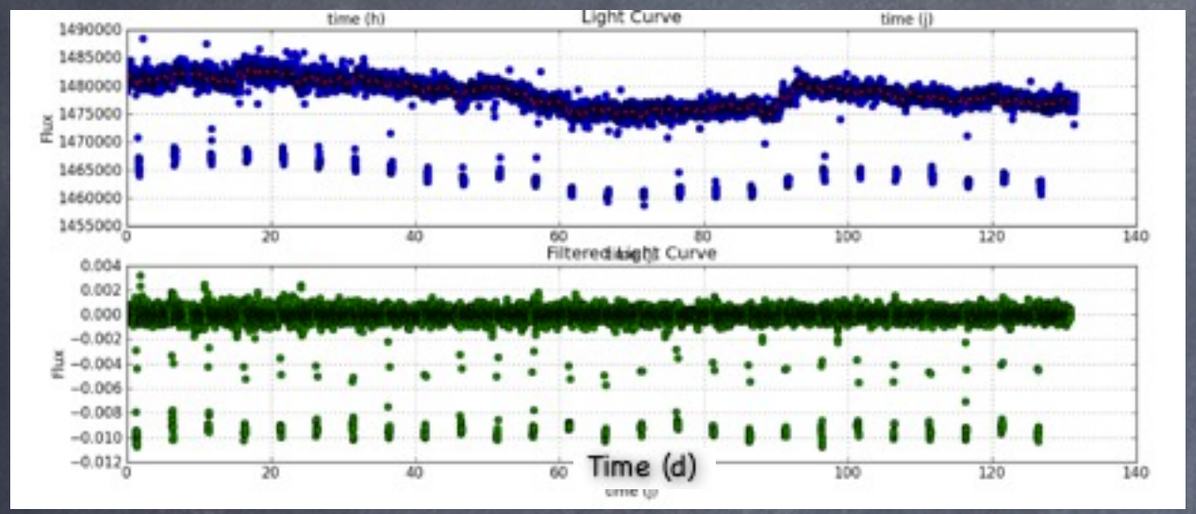
Benjamin SAMUEL
Daniel ROUAN

Transit detection algorithms

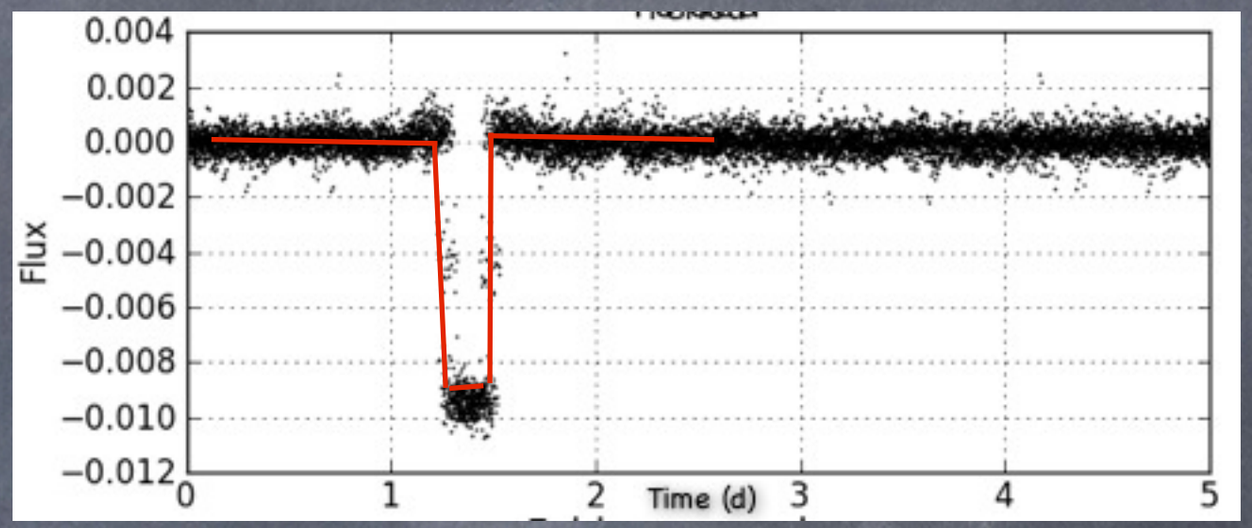
Box Least Square / Matched-Filter

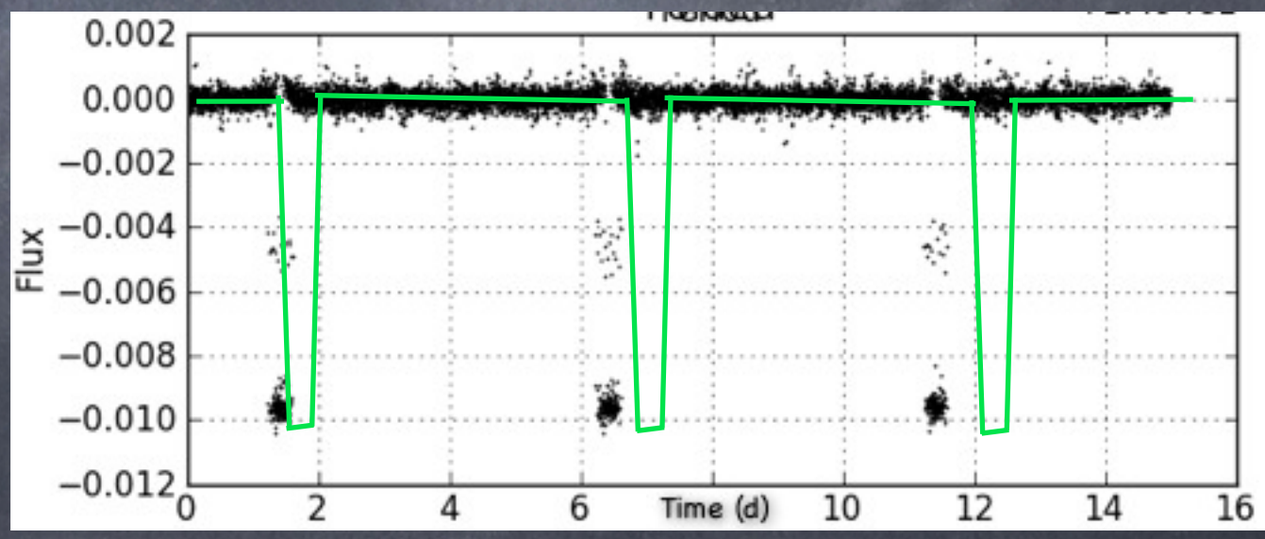
Kovacs *et al.* (2002), Aigrain et Irwin (2004), Bordé *et al.* (2007)

- 1. Detrending (&pre-filtering)



- 2. Folding and Fitting / cross-correlate

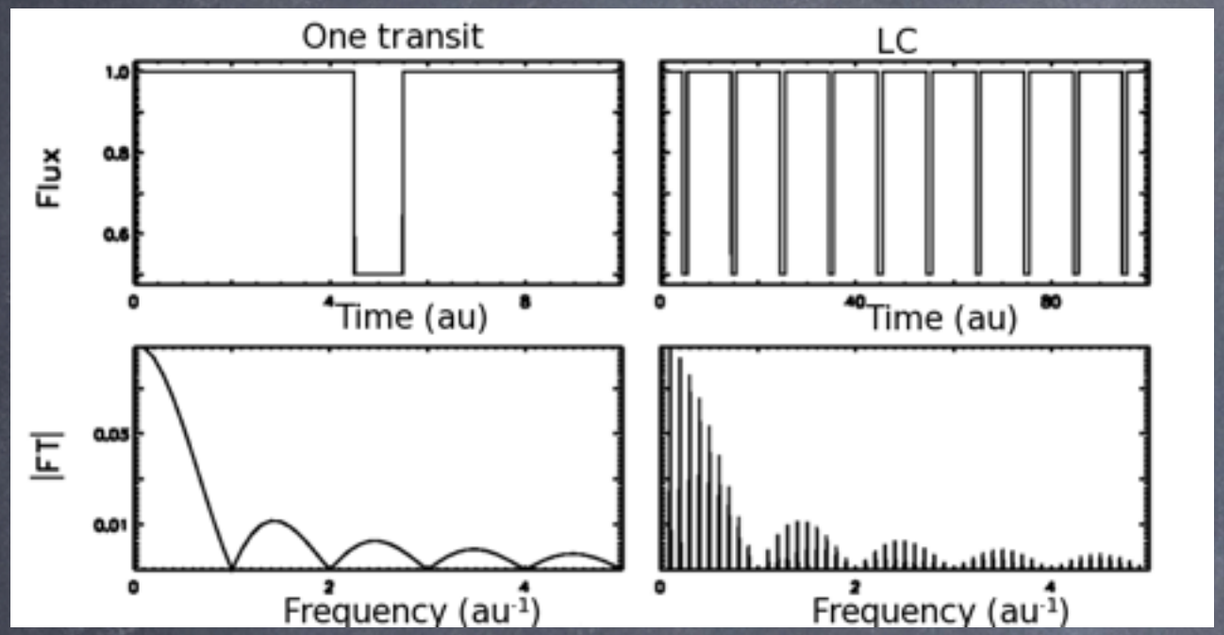




- 3. Deduce the «best» set of parameters (= maximum of likelihood)
- 4. Assess the detection confidence level

=> Use of the *a priori* on shape of the signal.

Search for periodic signals with no information on the shape.



- Fourier Transform?
  Energy of non sinusoidal signal is diluated into harmonics.

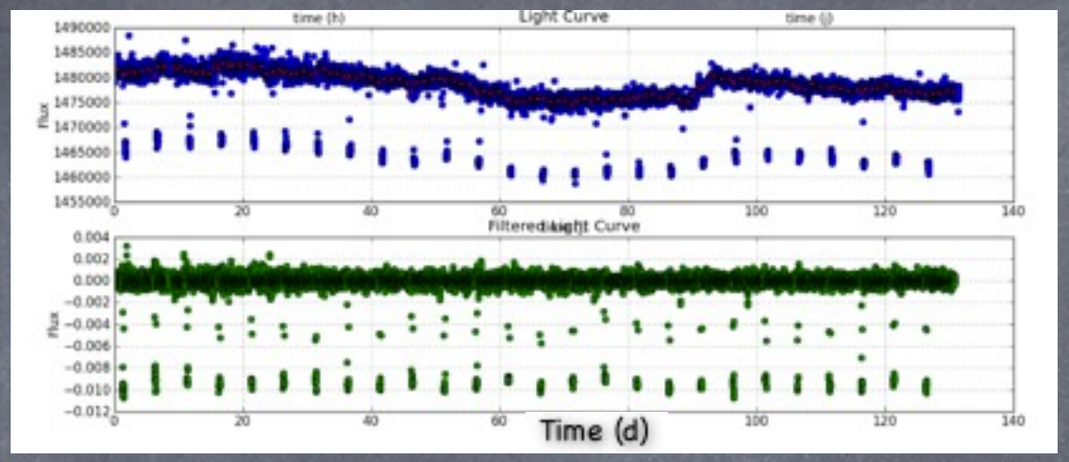
- Other solutions?

=> fold the LC and study the dispersion.

= Phase Dispersion Minimisation **(Stellingwerf 1978)**

The method

- Detrend, fold,...



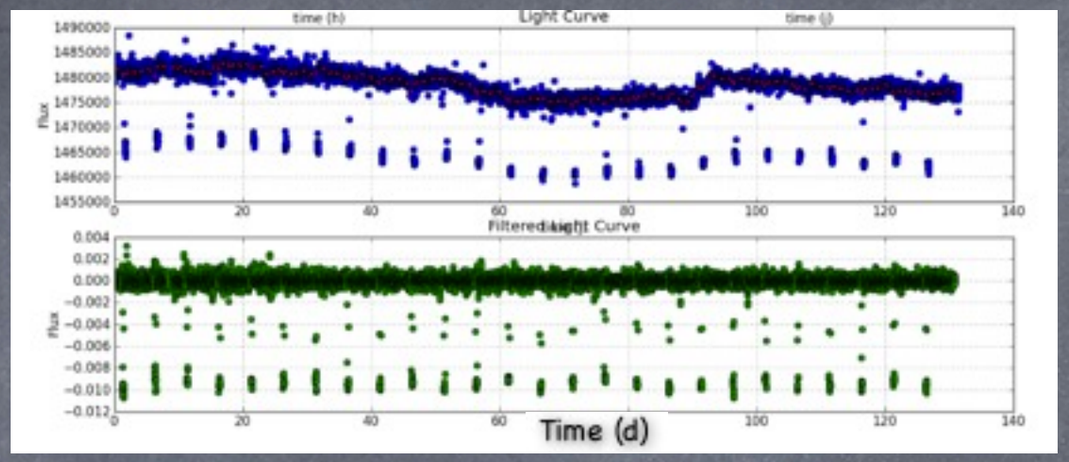
- Split data into evenly sampled bins / phase

- Subtract the median of each bin.

- Compare the energy of the signal before and after subtraction.

The method

- Detrend, fold,...



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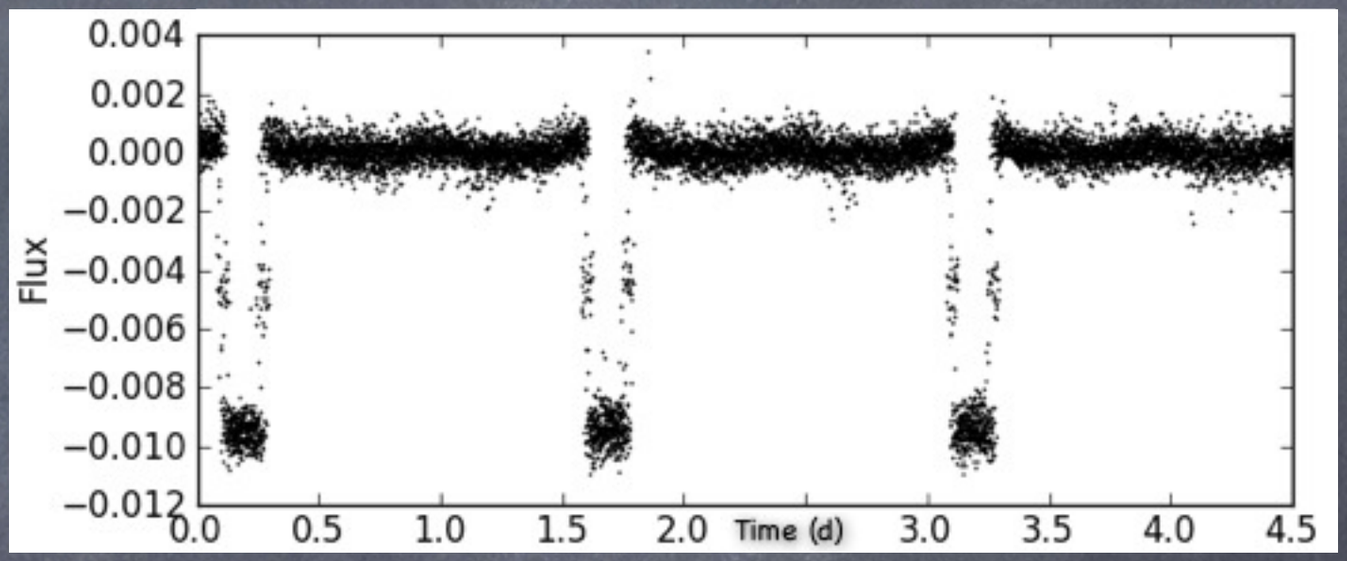

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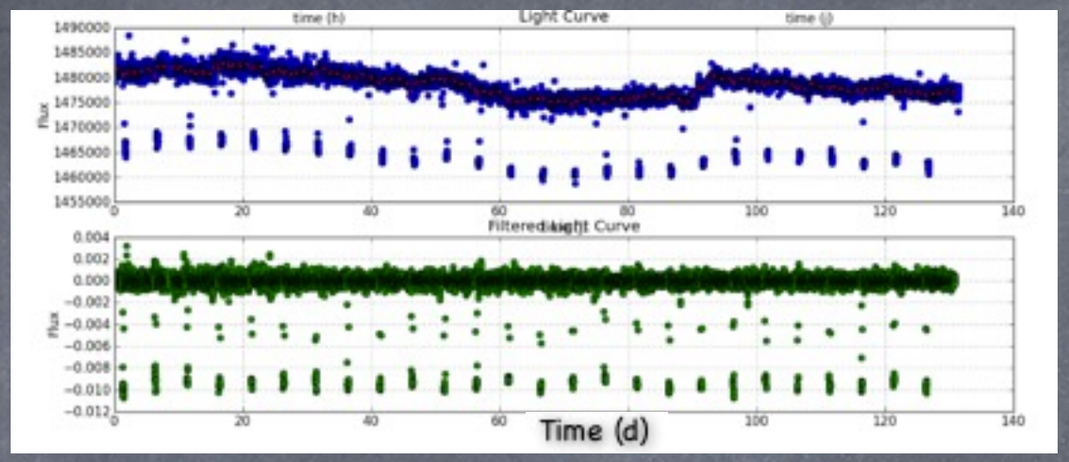

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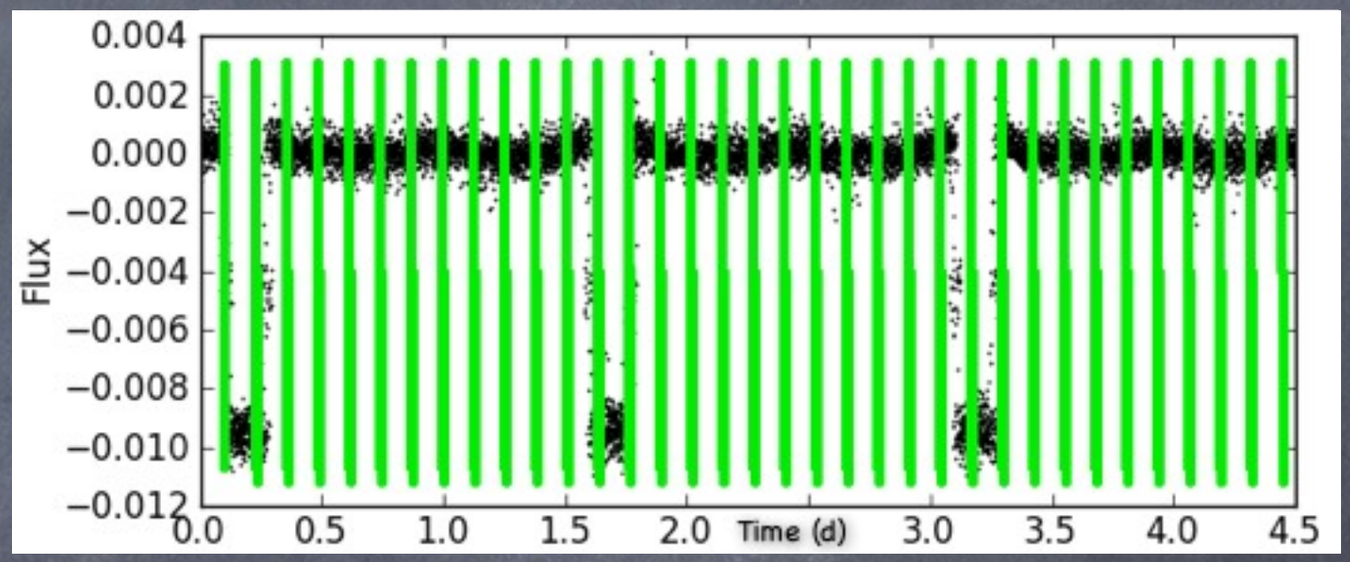

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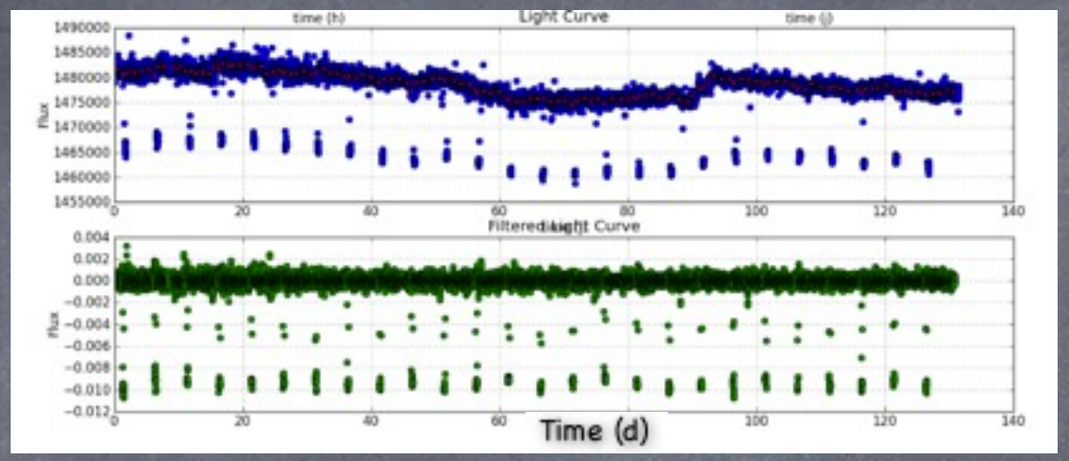

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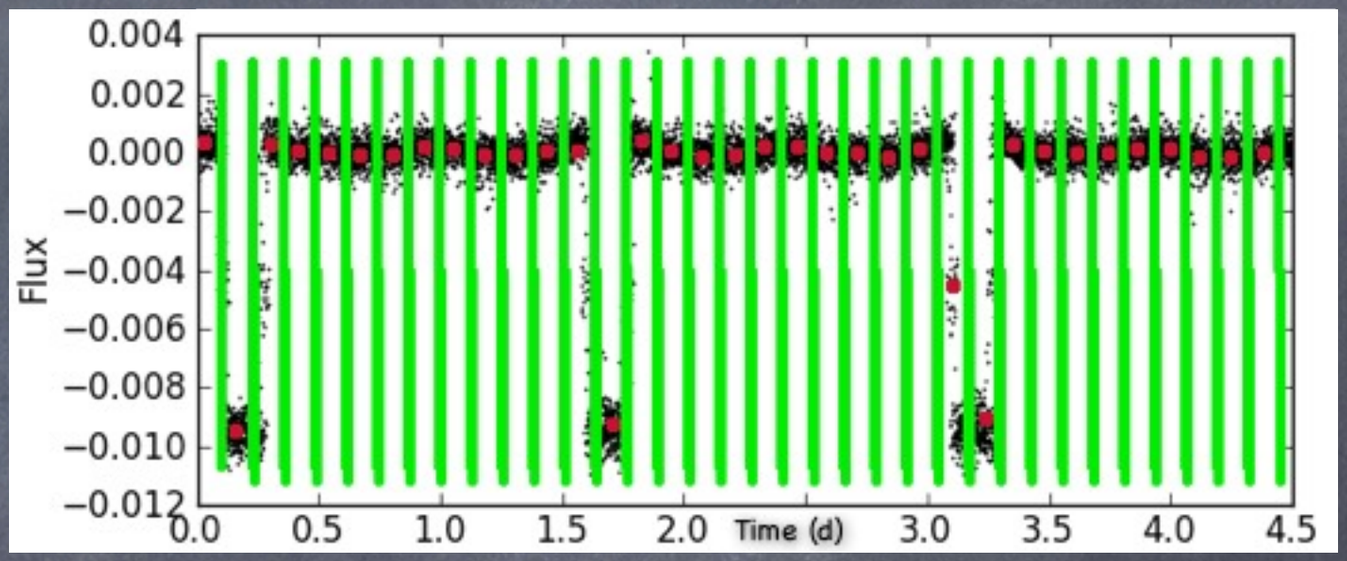

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The method

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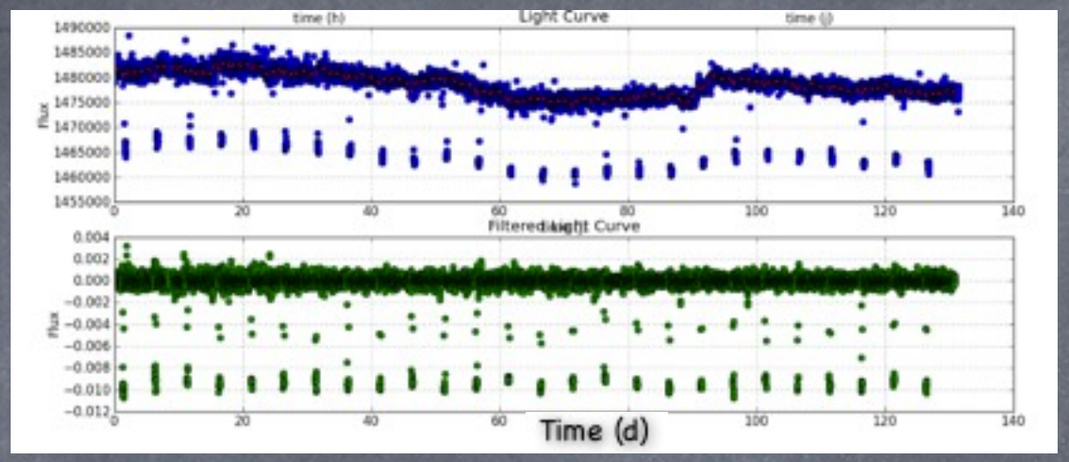

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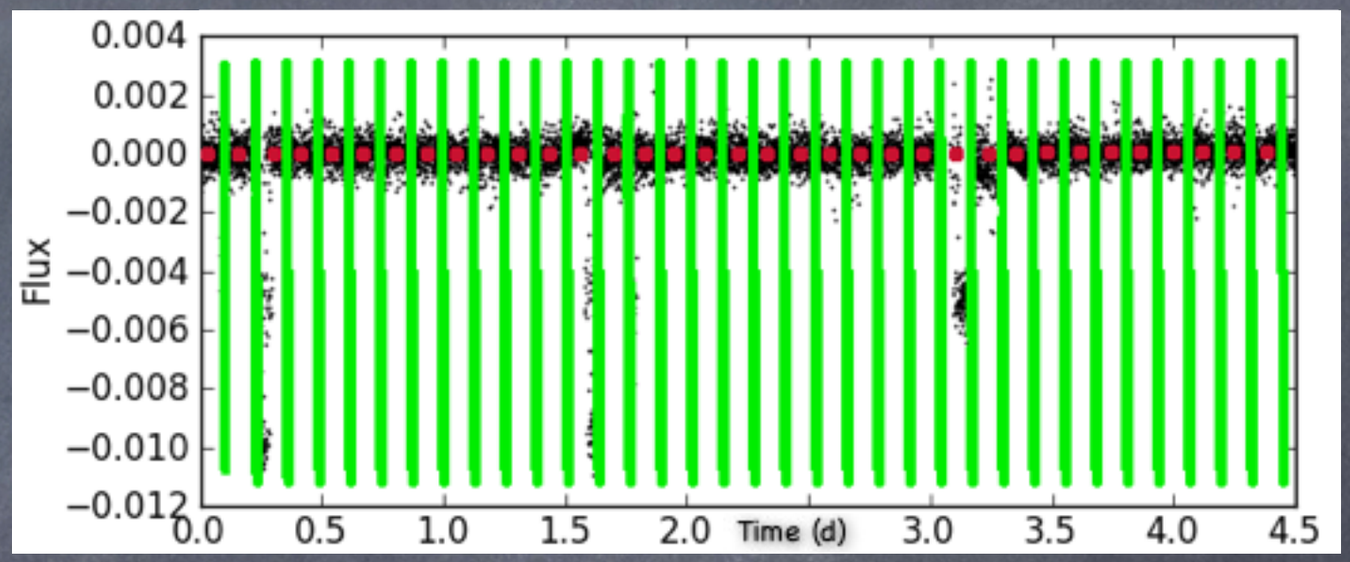

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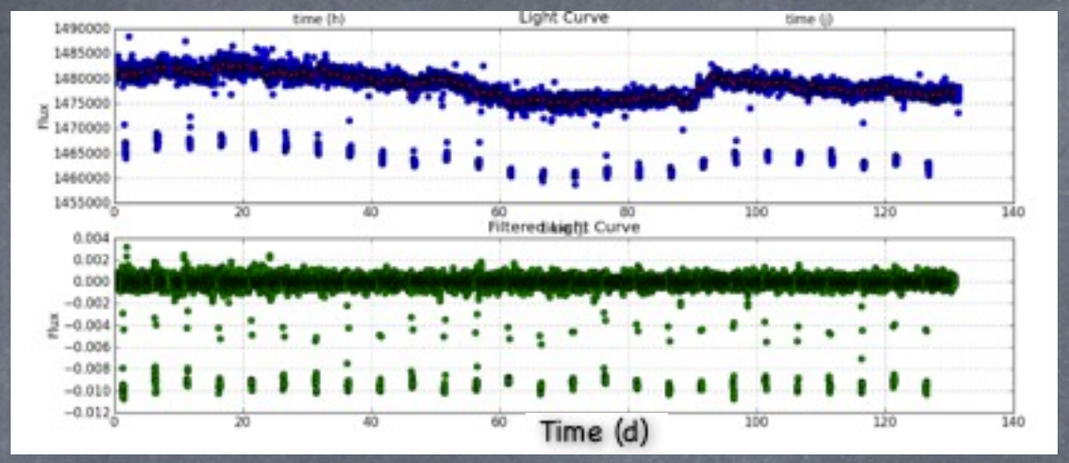
The method

- Detrend, fold,...



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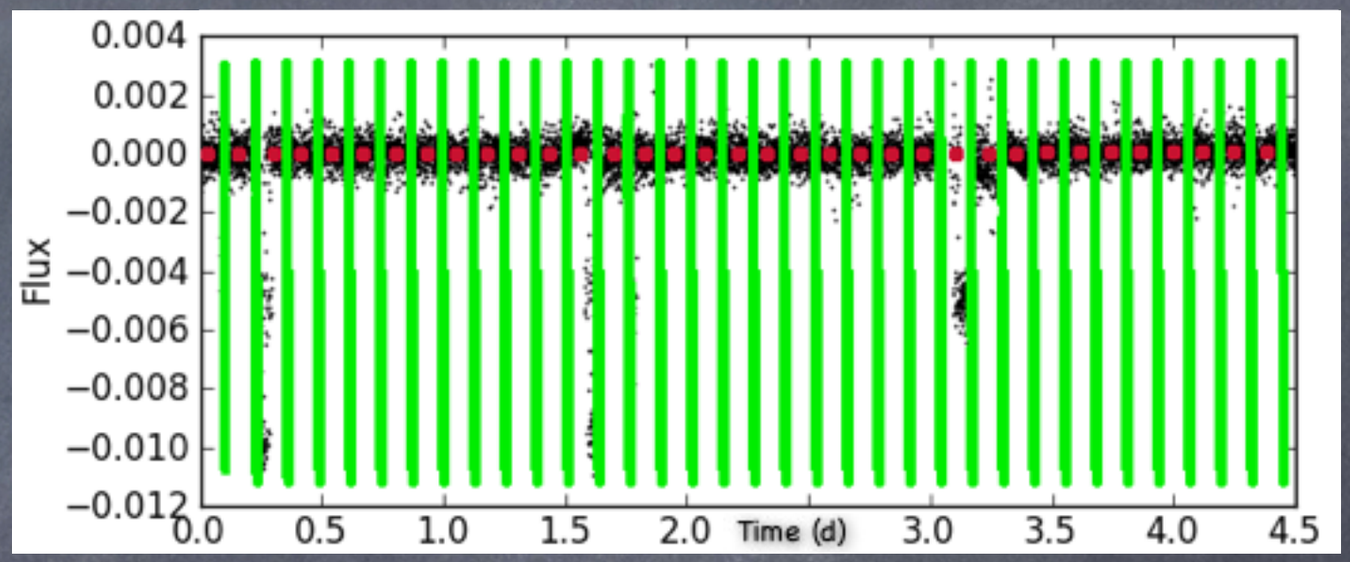
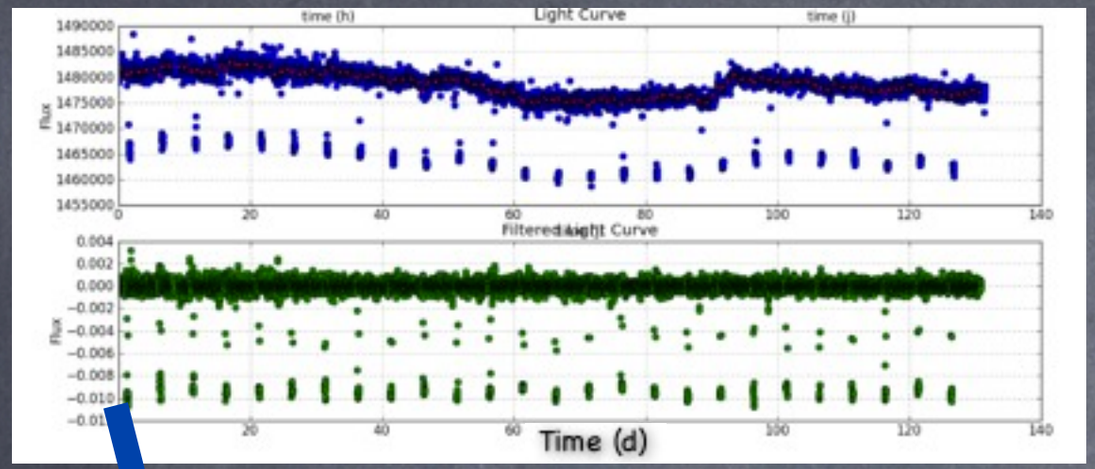
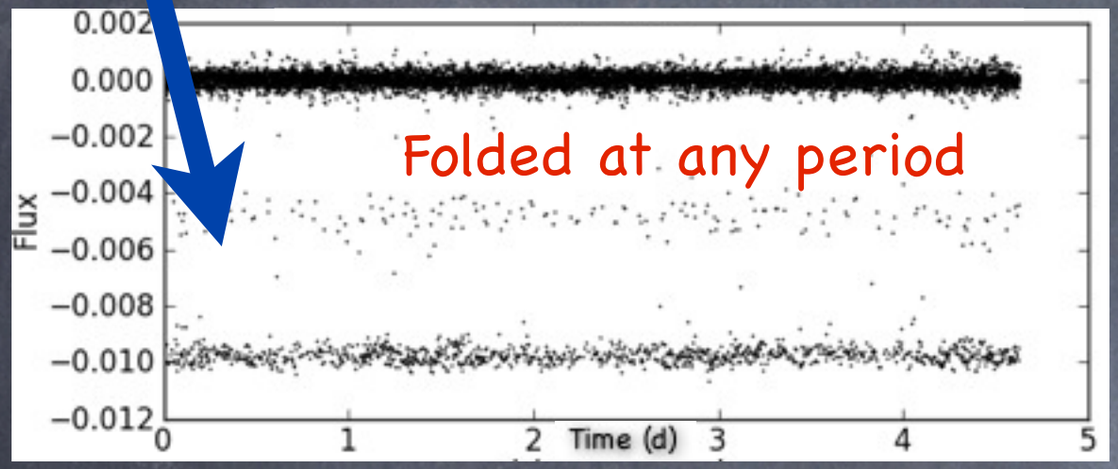


- Subtract the median of each bin.
- Compare the energy of the signal before and after subtraction.

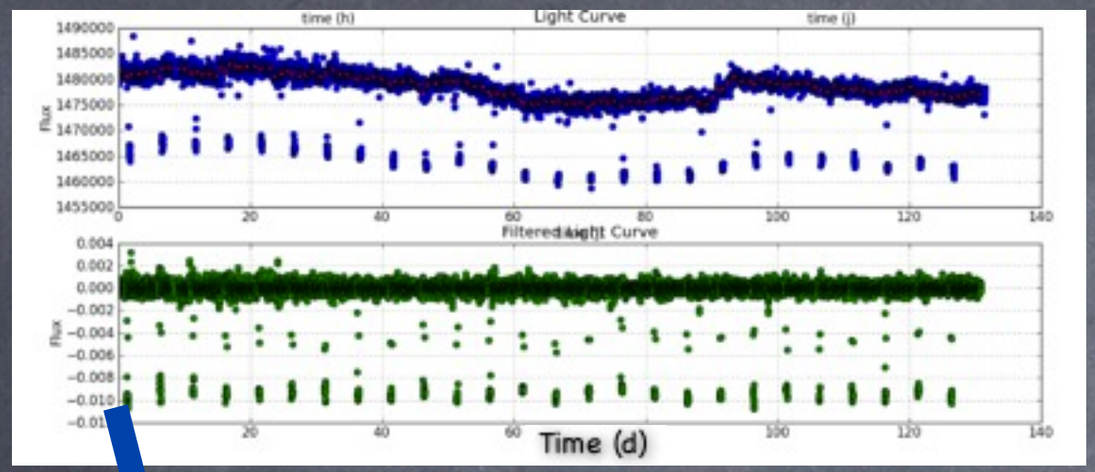
$$\Delta E = \sum_{i,j} x_{i,j}^2 - \sum_{i,j} \left(x_{i,j} - med\left(x_j\right) \right)^2$$

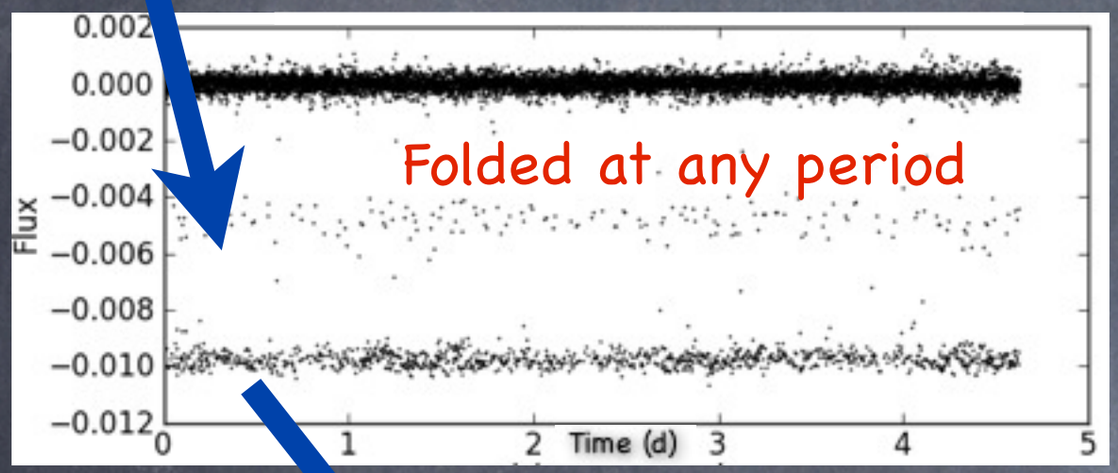
The method

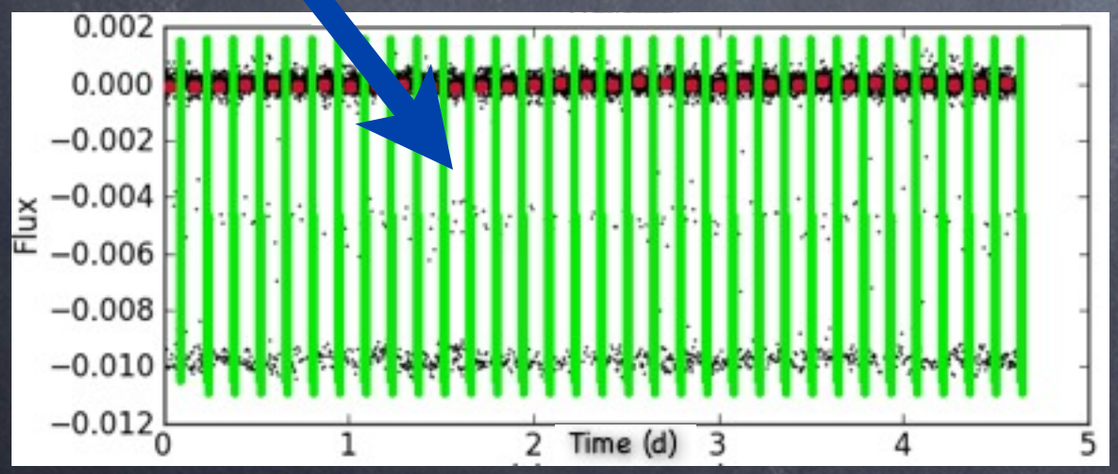

time (h)
Light Curve
time (j)
Flux
Filtered Light Curve
Flux
Time (d)


Folded at any period
Flux
Time (d)

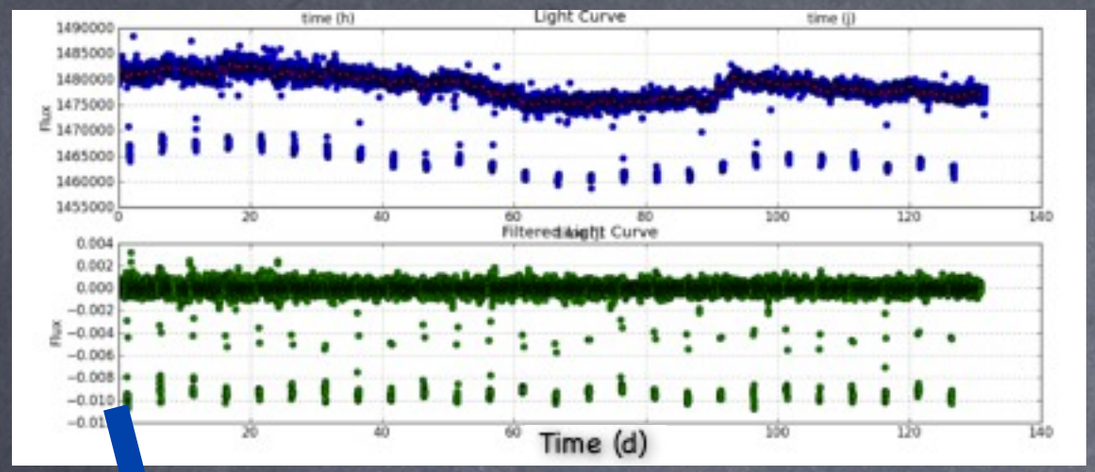
The method

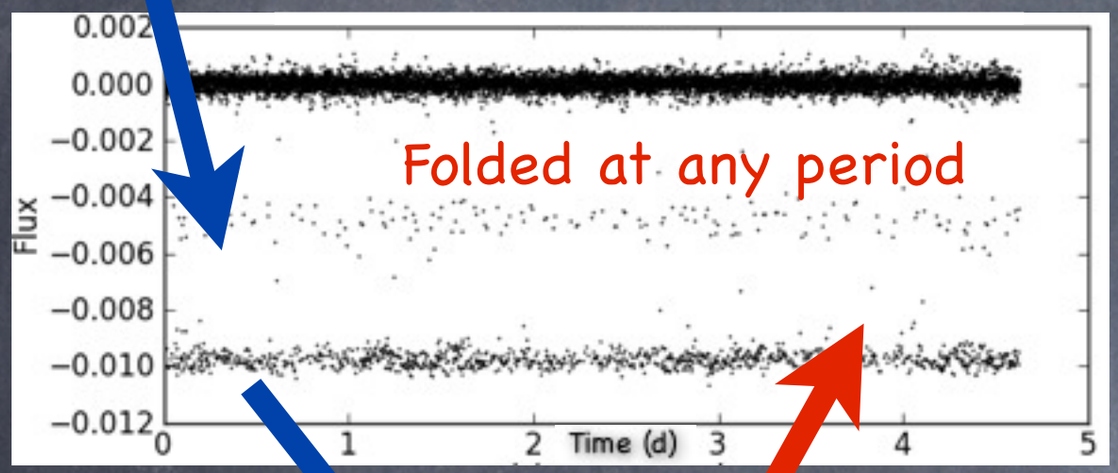

Light Curve
Flux
Filtered Light Curve
Flux
Time (d)

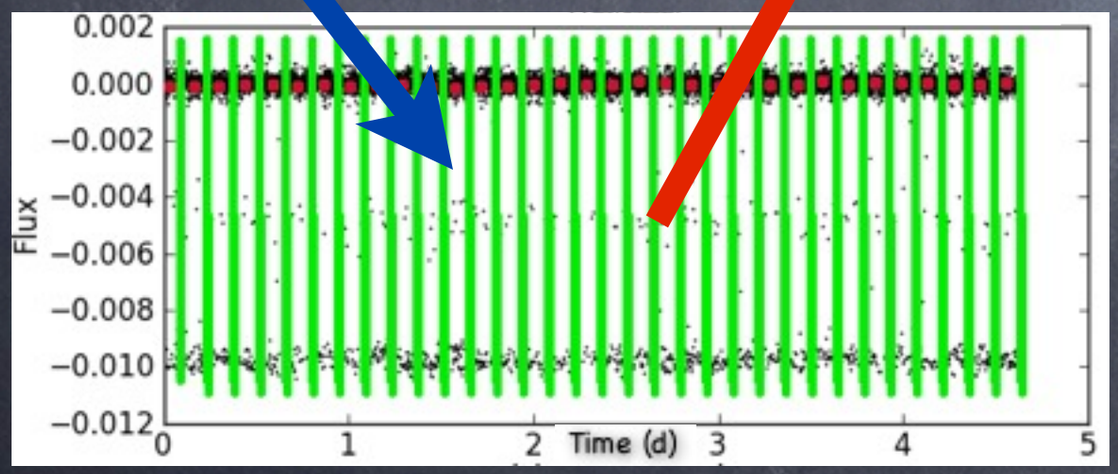

Folded at any period
Flux
Time (d)


Flux
Time (d)

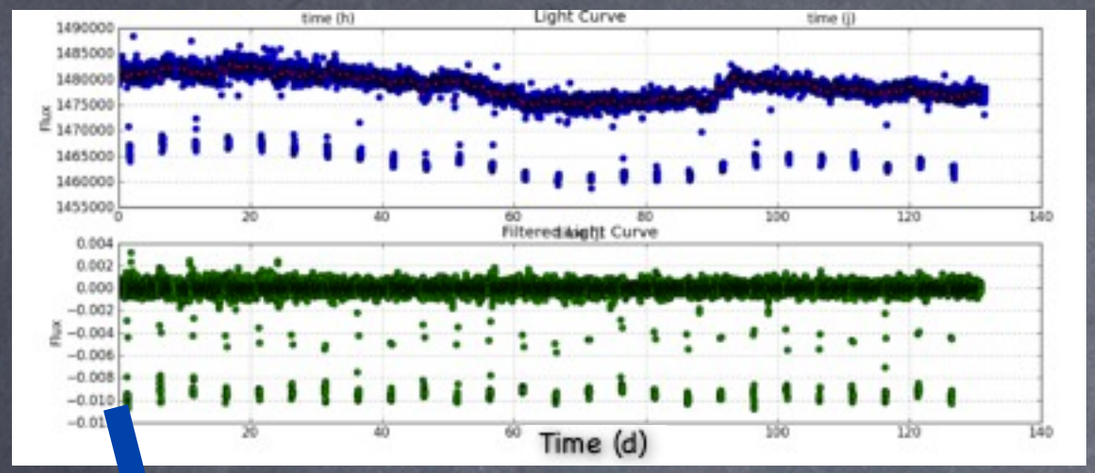
The method

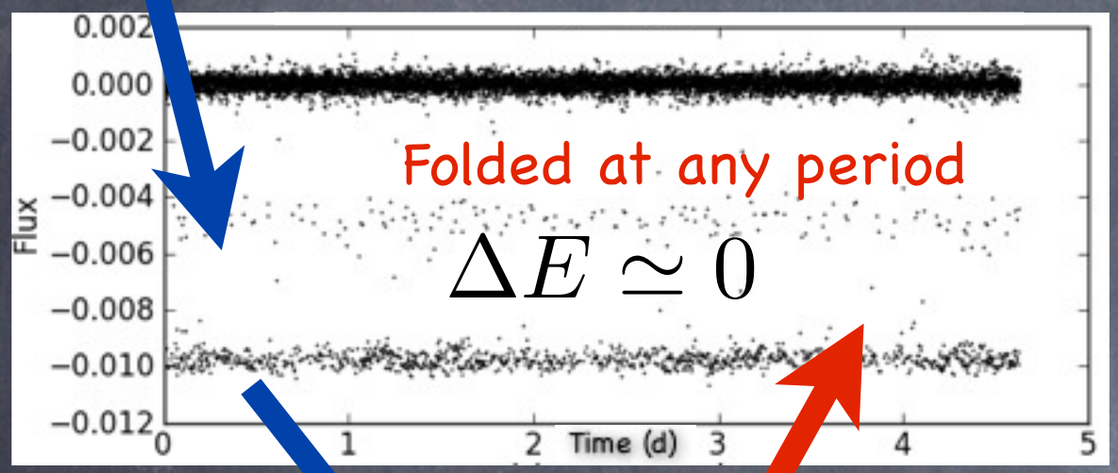

Light Curve
Flux
Filtered Light Curve
Flux
Time (d)

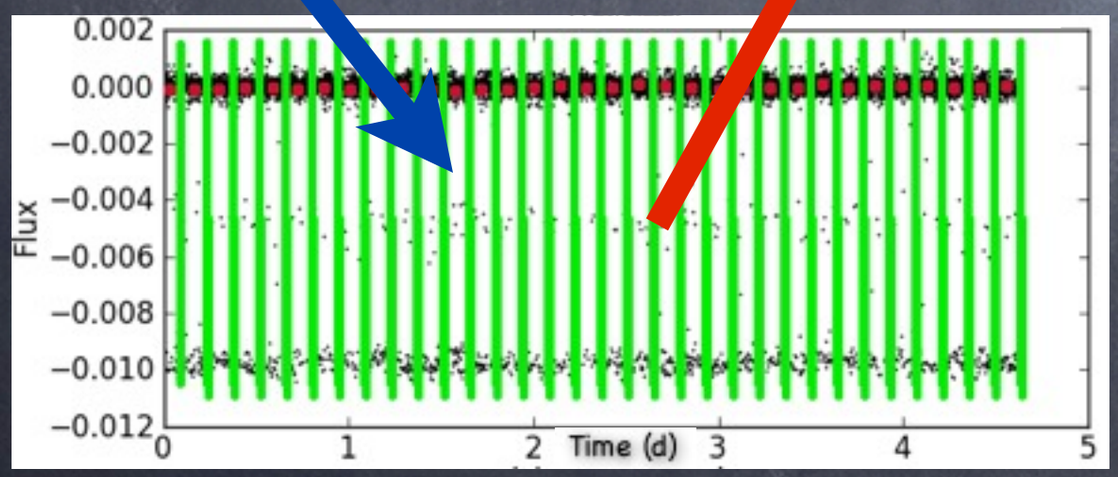

Folded at any period
Flux
Time (d)


Flux
Time (d)

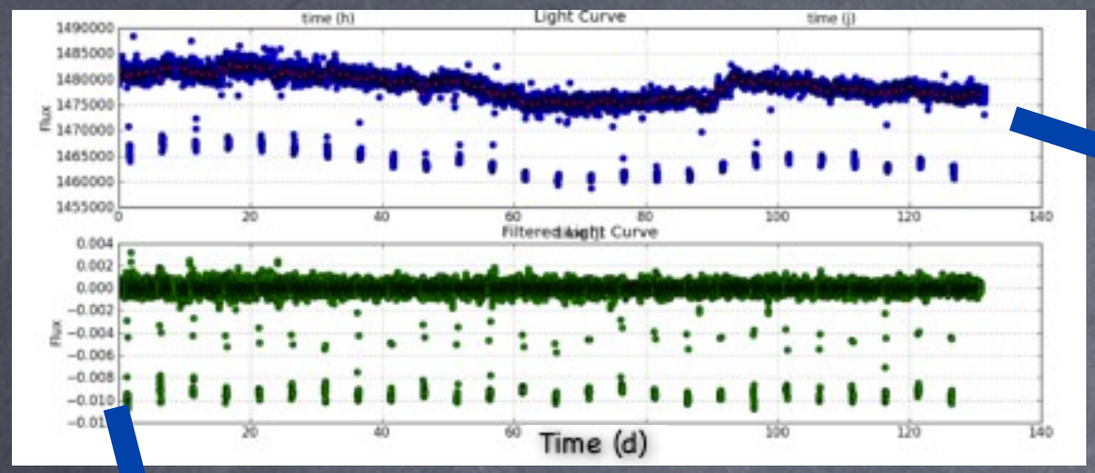
The method

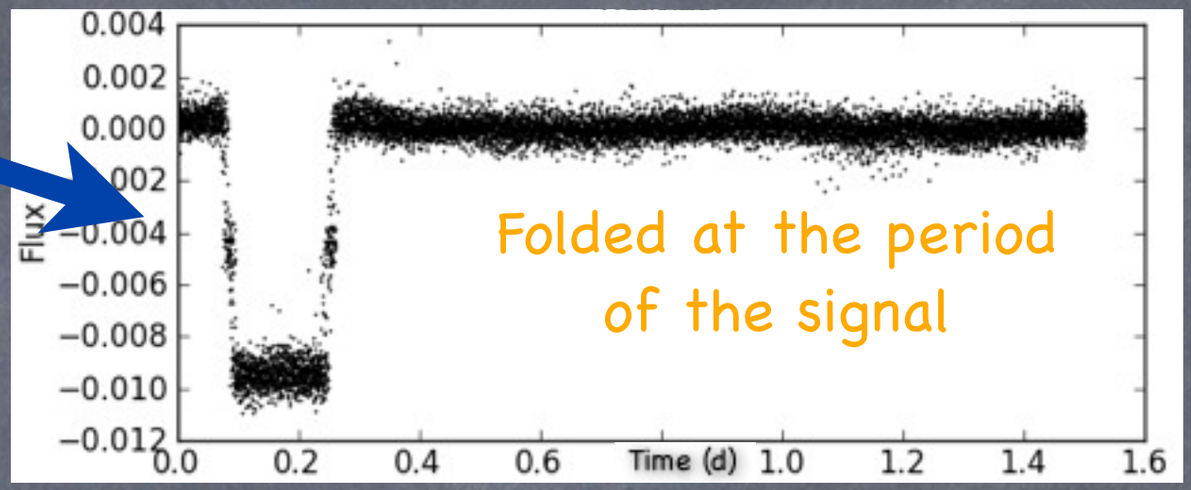

Light Curve
Flux
Filtered Light Curve
Flux
Time (d)

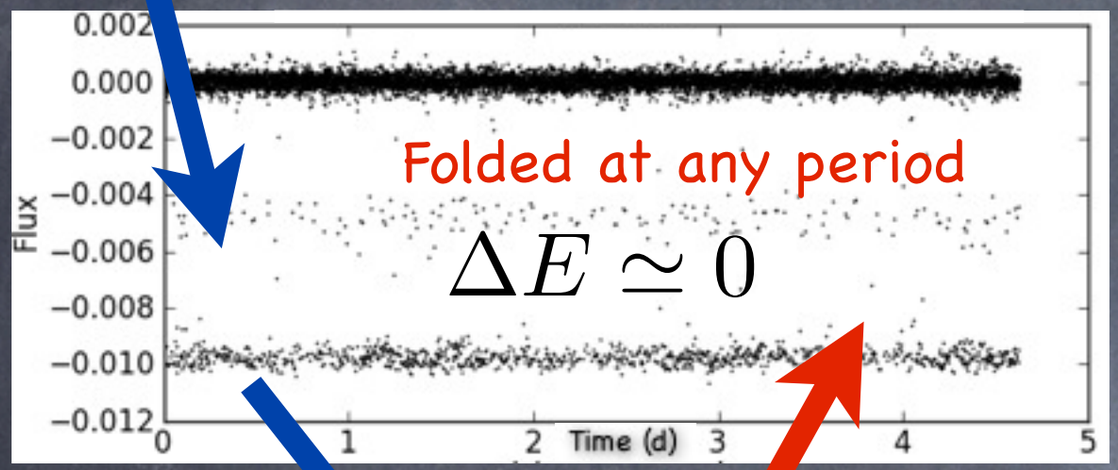

Folded at any period
$\Delta E \simeq 0$
Flux
Time (d)


Flux
Time (d)

The method


Light Curve
Filtered Light Curve
Flux
Time (d)


Folded at the period
of the signal
Flux
Time (d)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Flux
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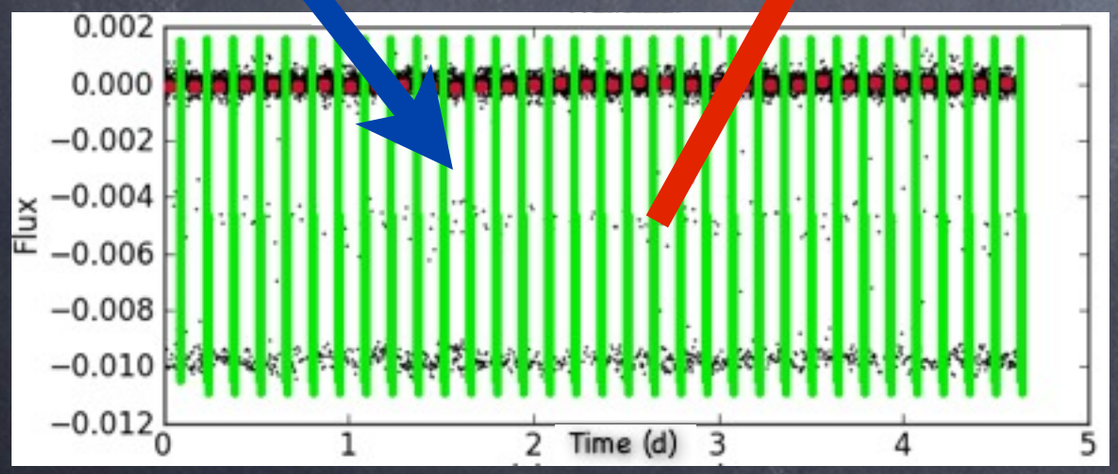
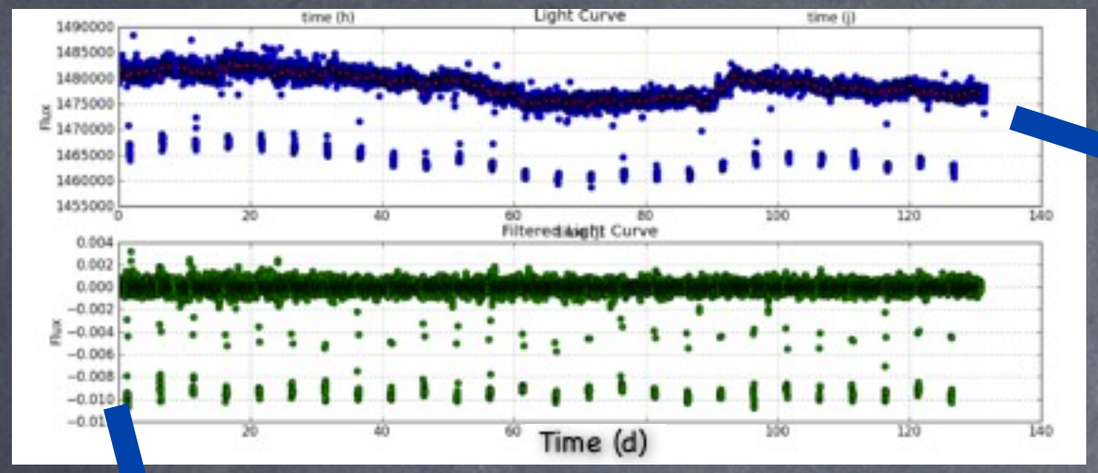

Flux
Time (d)

The method


Light Curve
Filtered Light Curve
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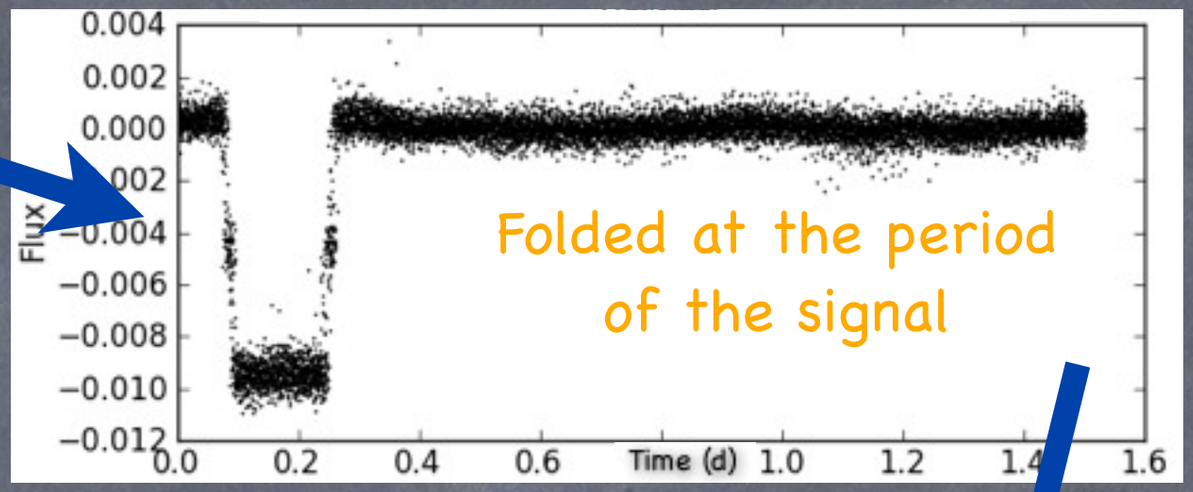
Folded at the period
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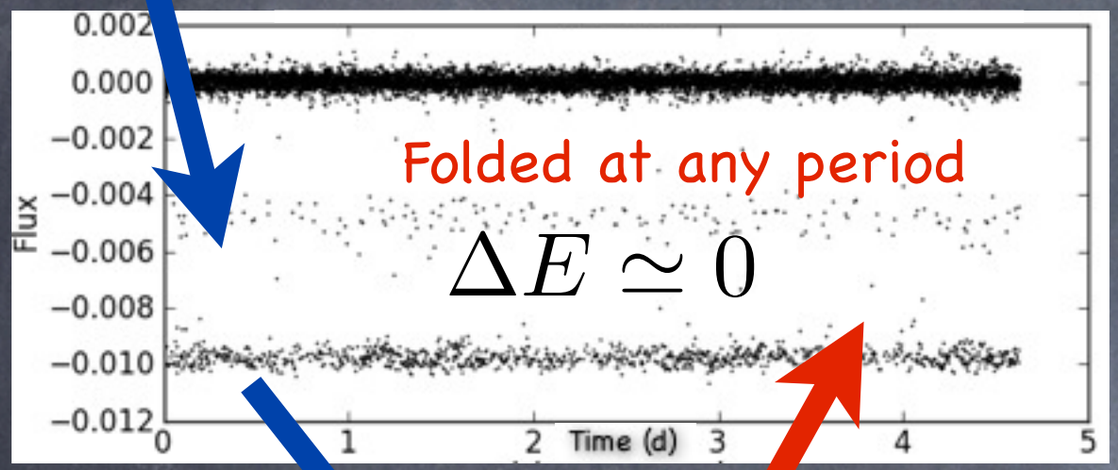
Flux
Time (d)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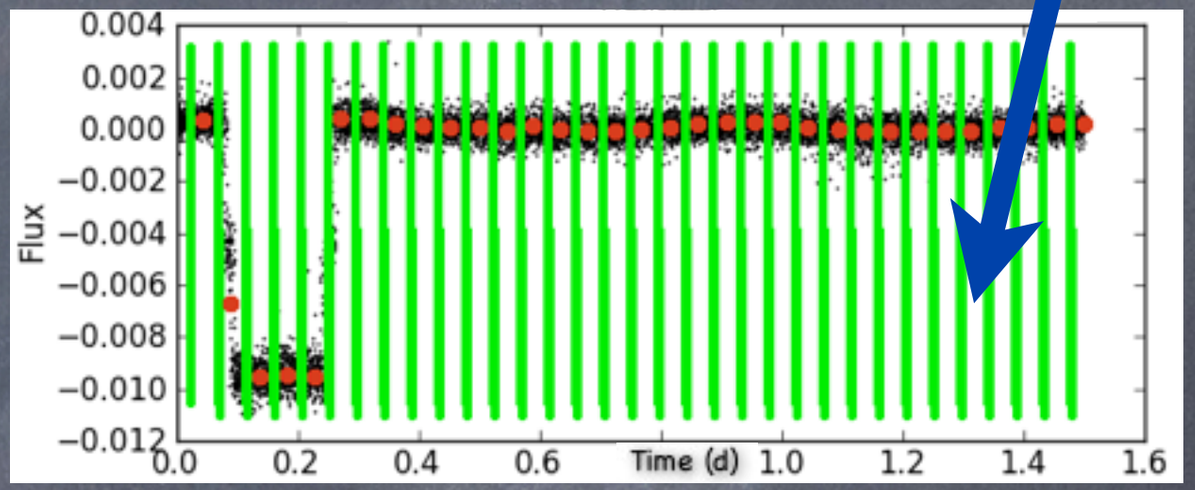
Flux
Time (d)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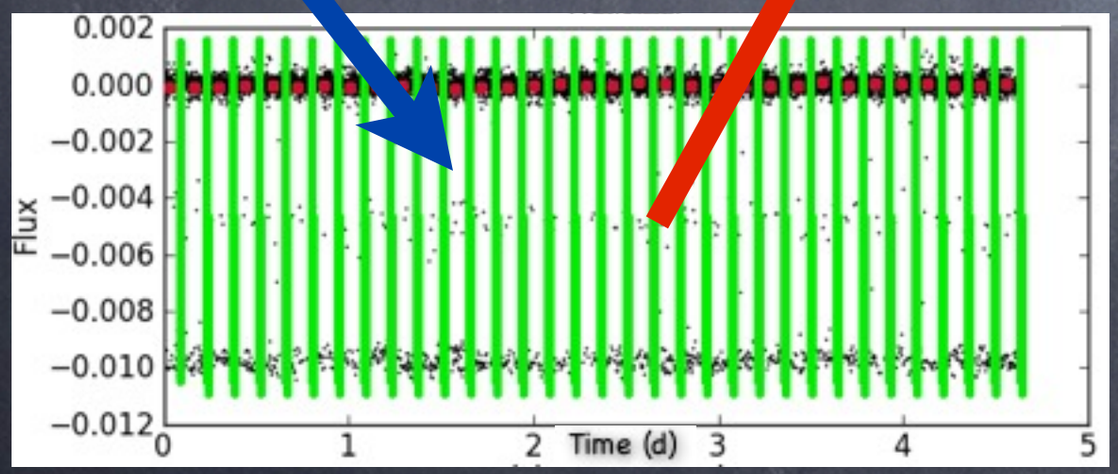
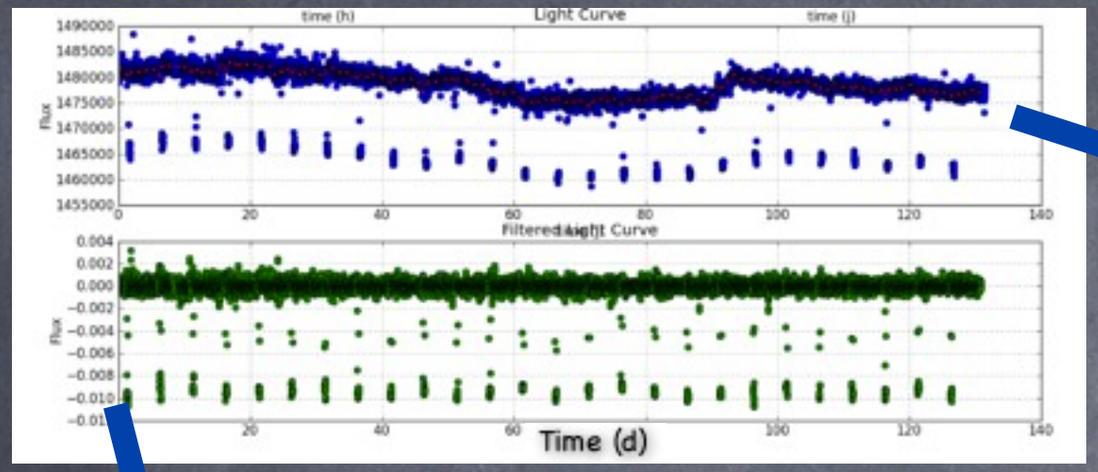
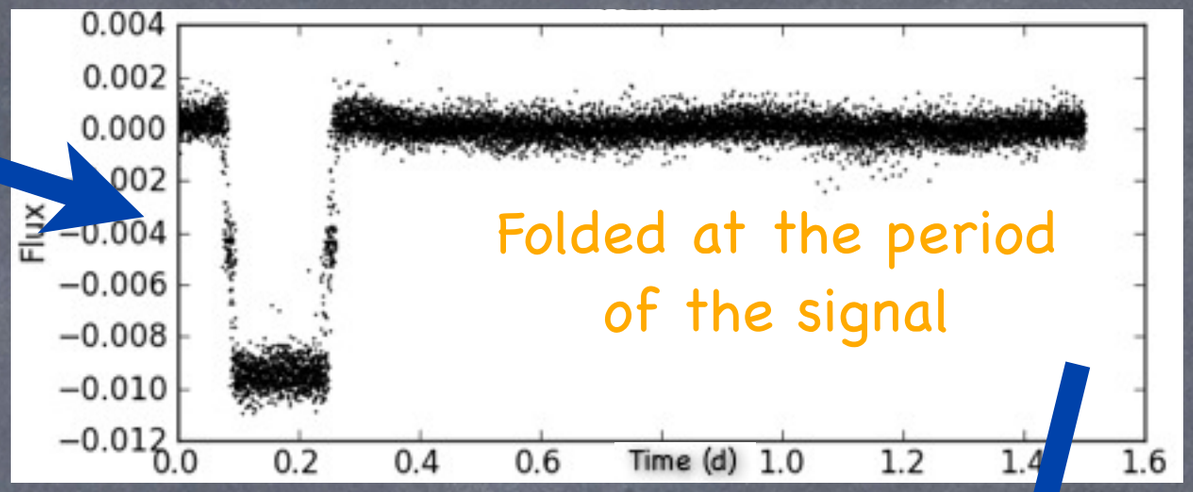
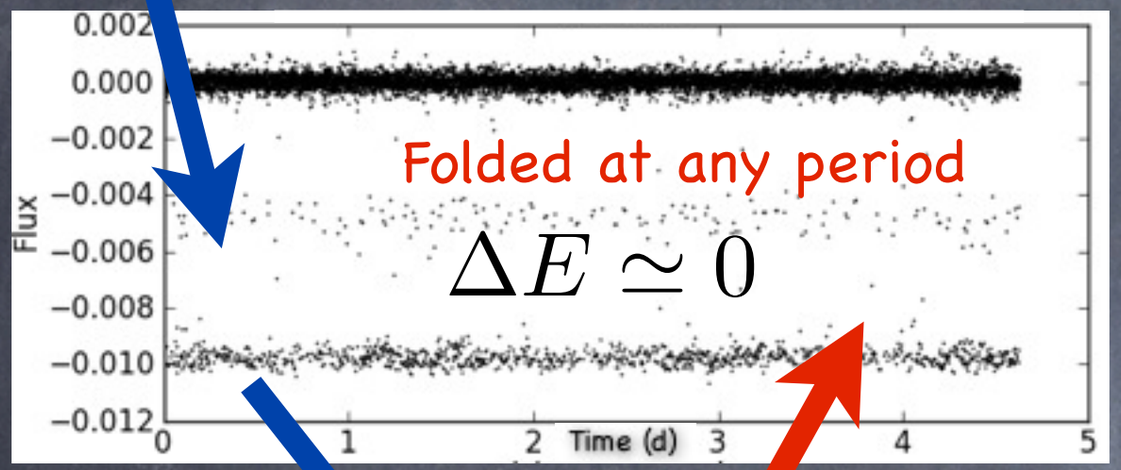

Flux
Time (d)

The method


Light Curve
Filtered Light Curve
Flux
Time (d)


Folded at the period
of the signal
Flux
Time (d)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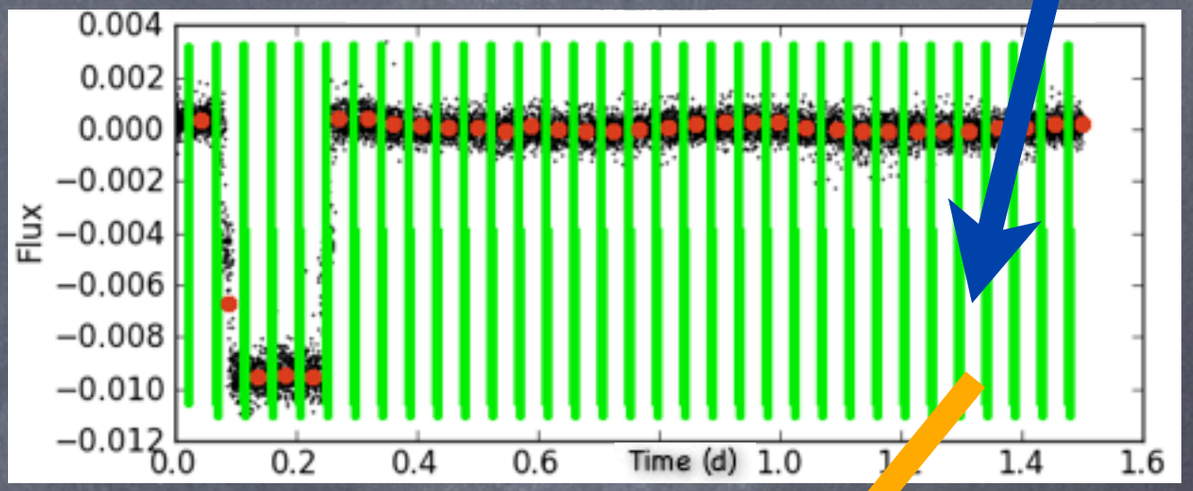
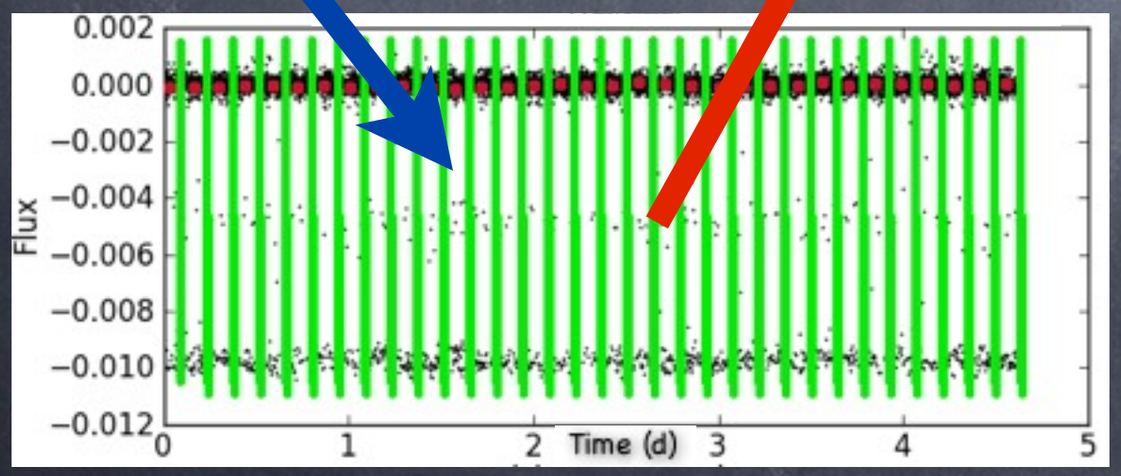
Flux
Time (d)


Flux
Time (d)


Flux
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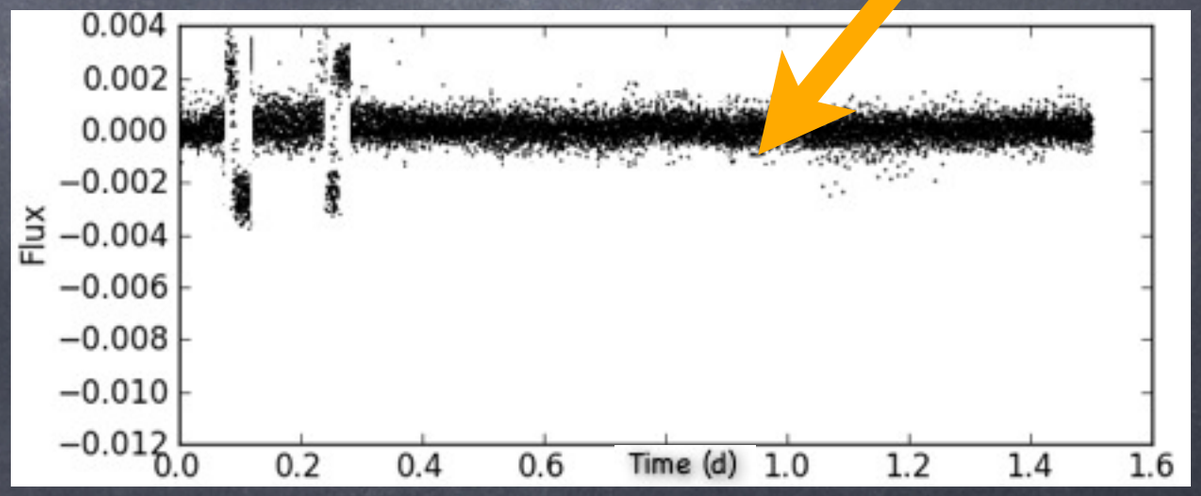
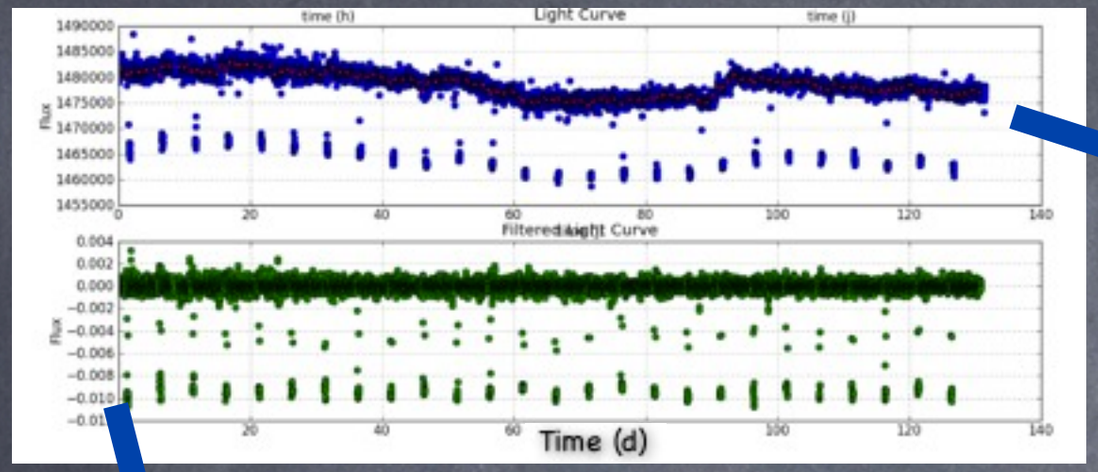
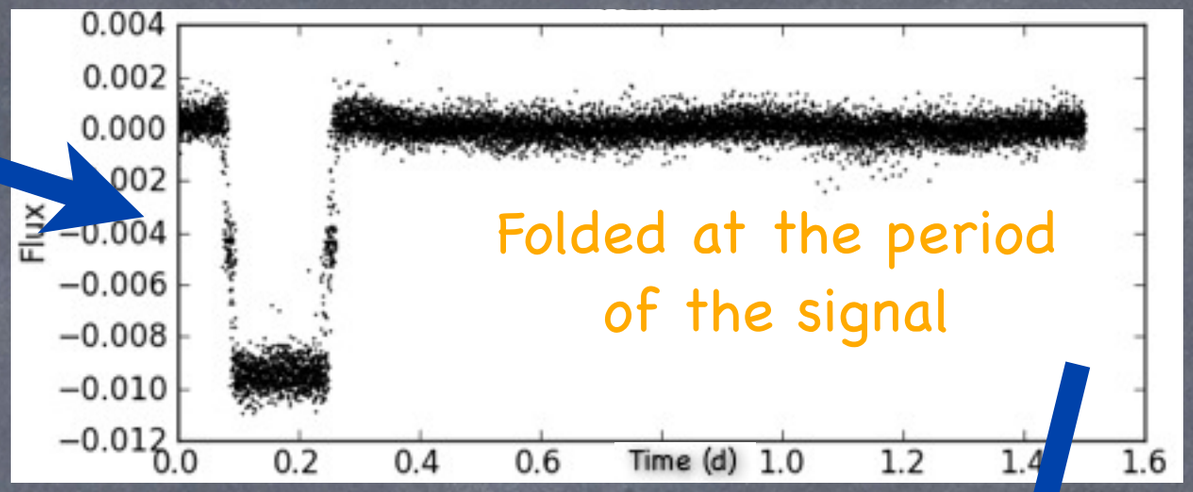

Flux
Time (d)

The method


Light Curve
Filtered Light Curve
Flux
Time (d)


Folded at the period
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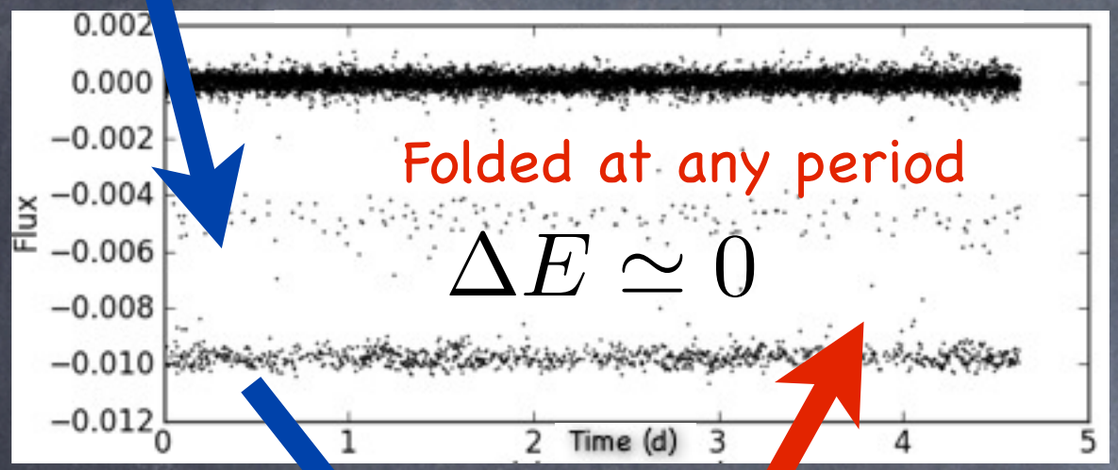
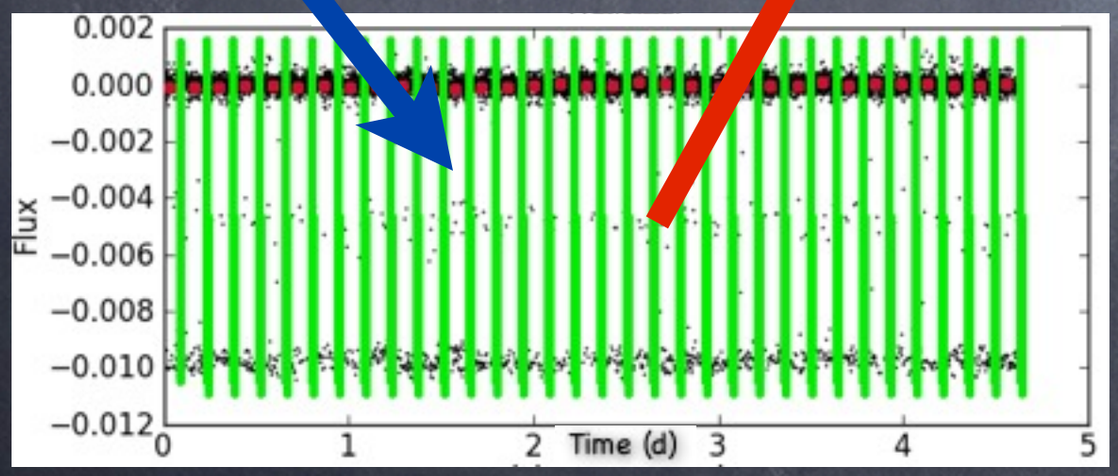
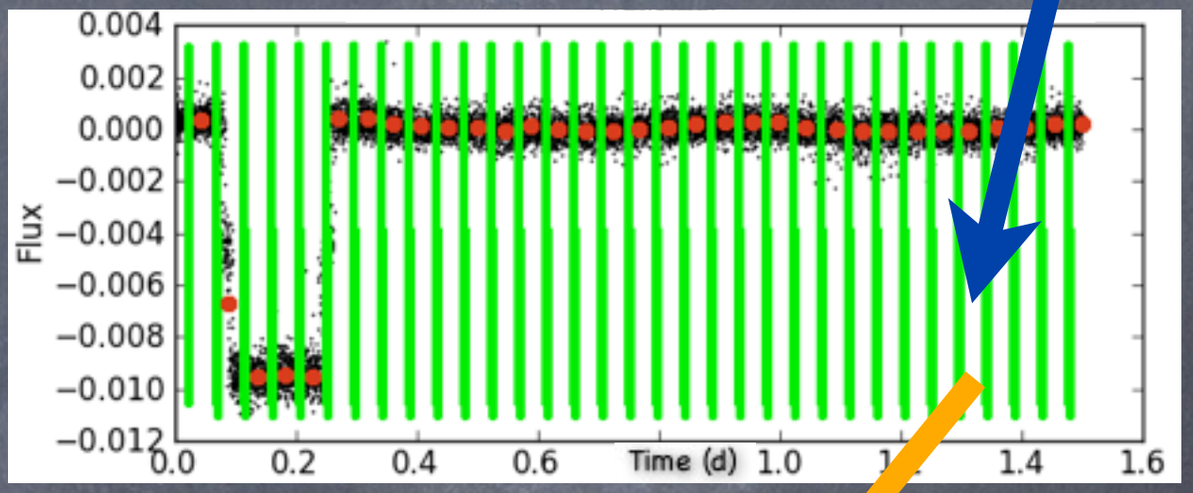
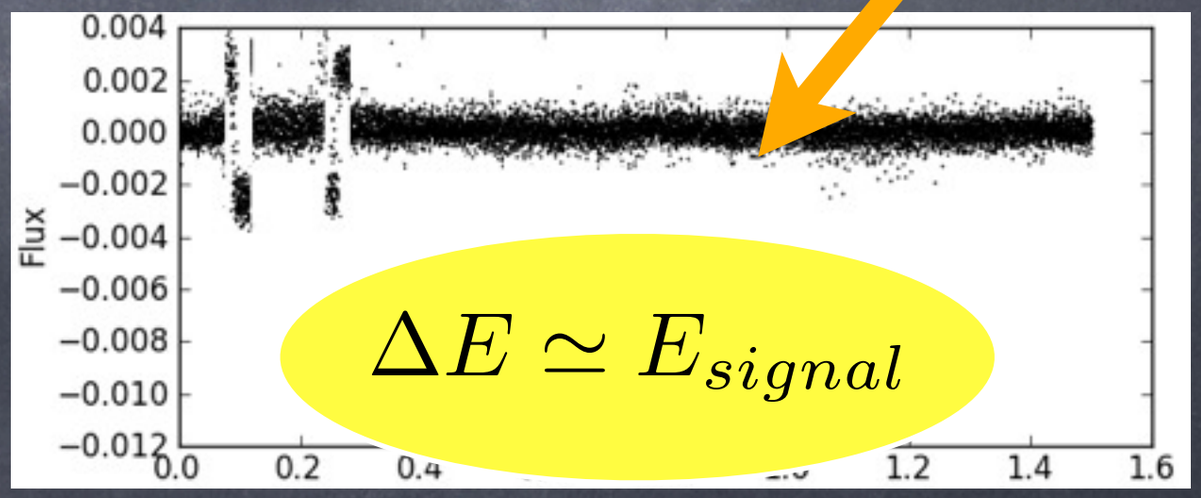
Flux
Time (d)


Folded at any period
$\Delta E \simeq 0$
Flux
Time (d)

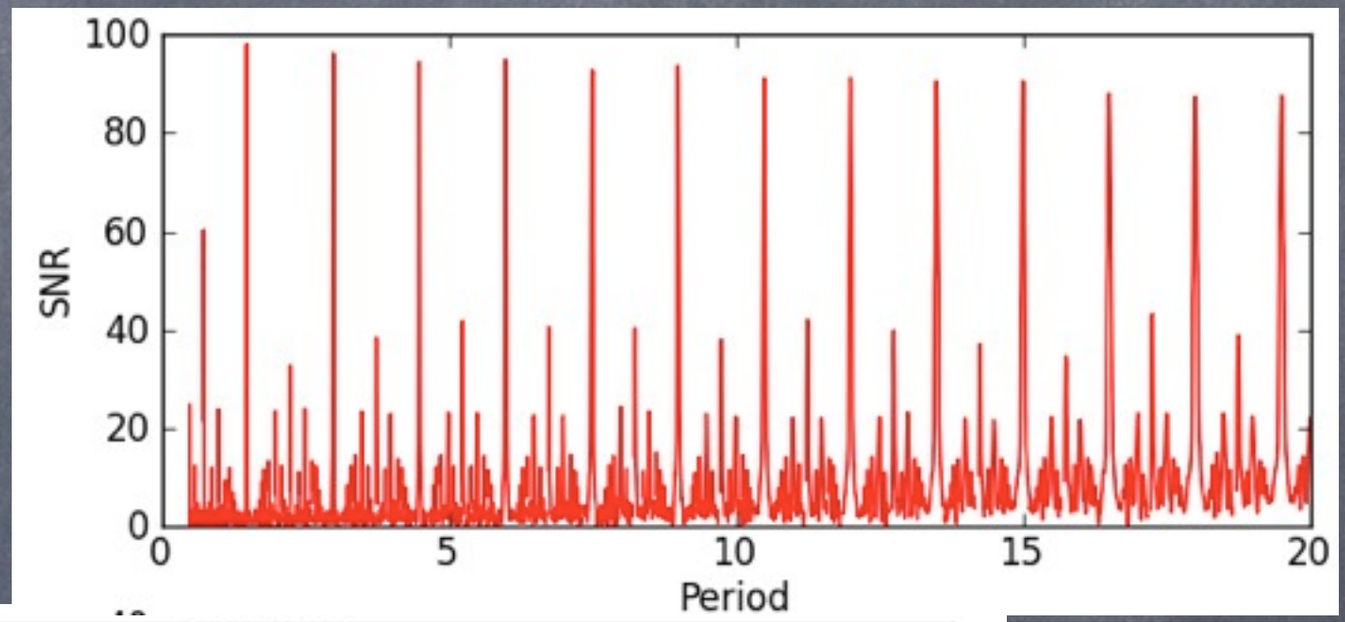

Flux
Time (d)

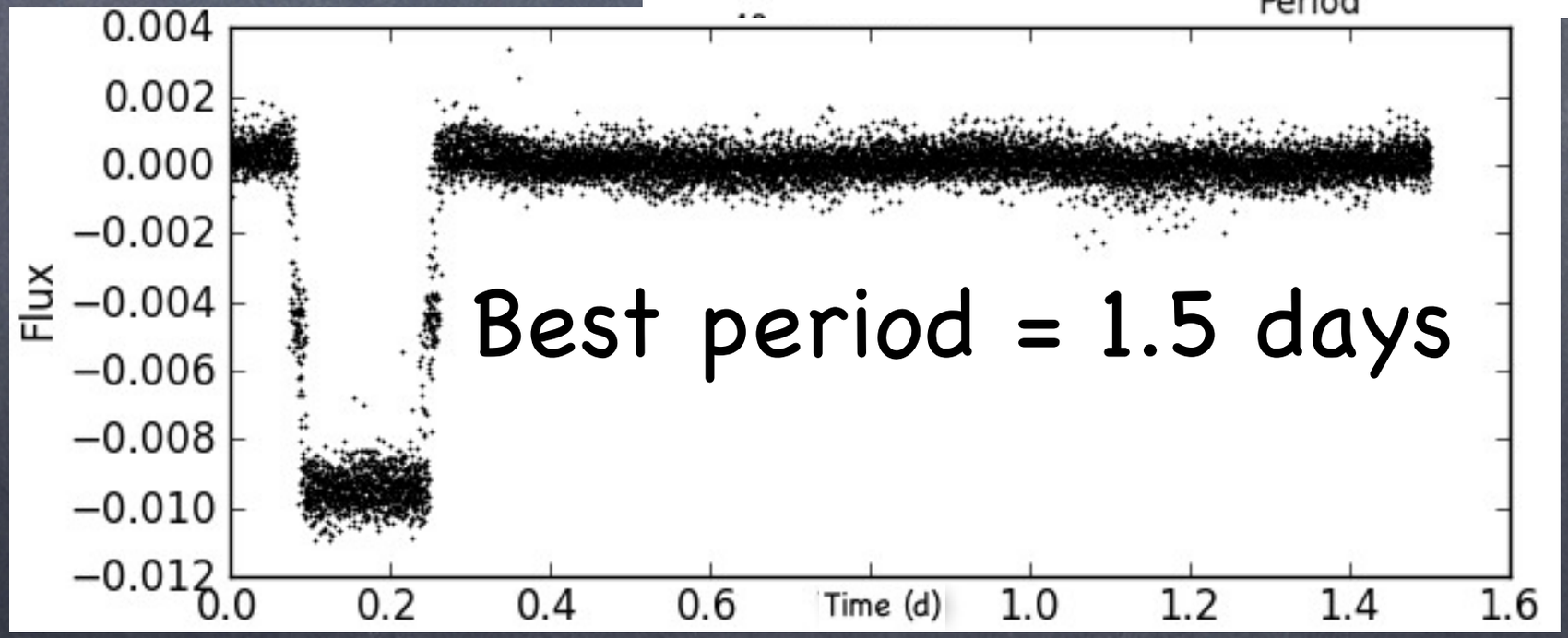

Flux
Time (d)


$\Delta E \simeq E_{signal}$
Flux
Time (d)

The method

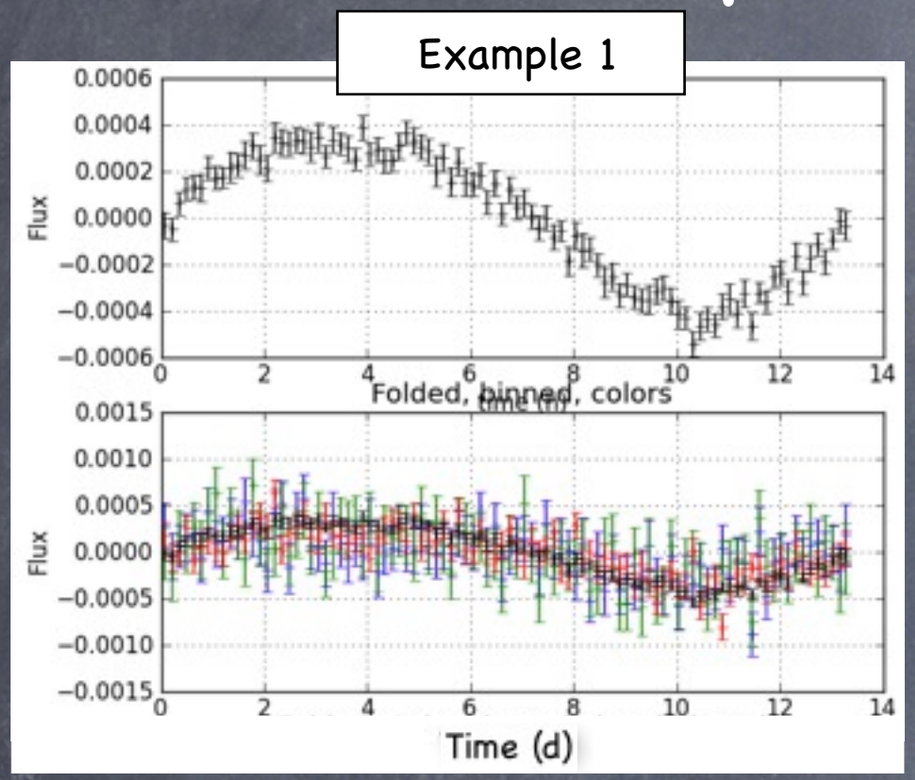
SNR as a function of the period





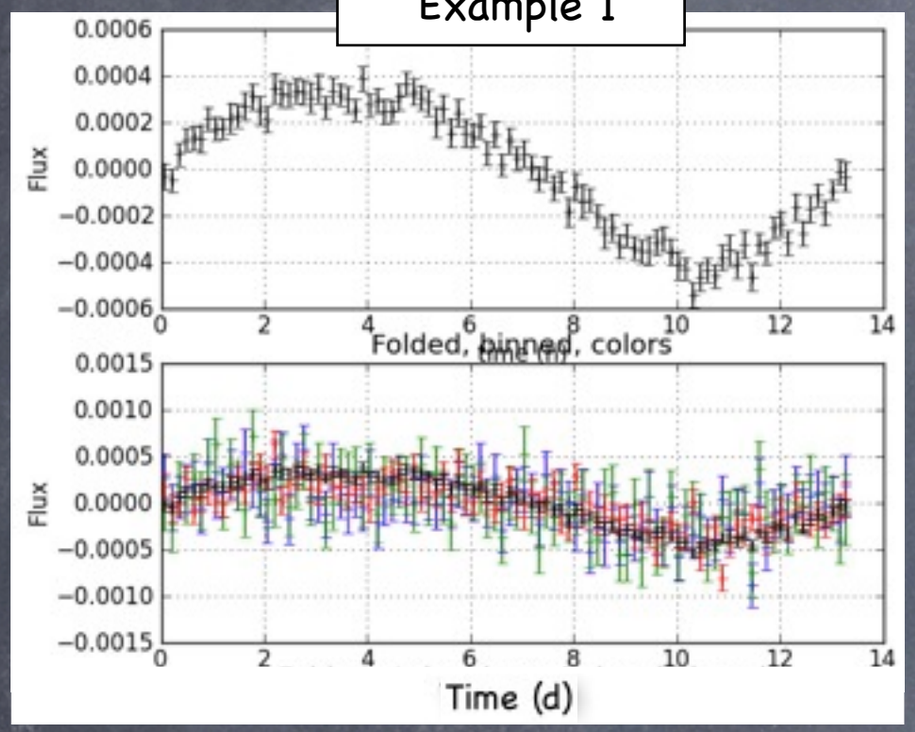
Best period = 1.5 days

Detection of all kind of periodic signal

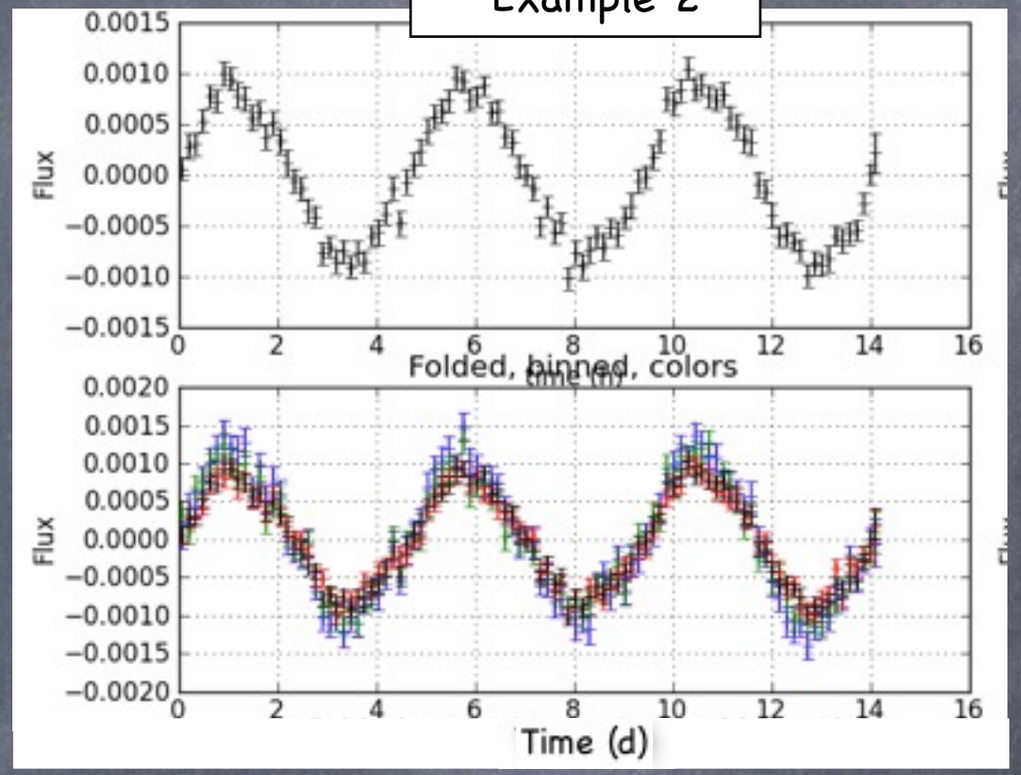


Detection of all kind of periodic signal

Example 1

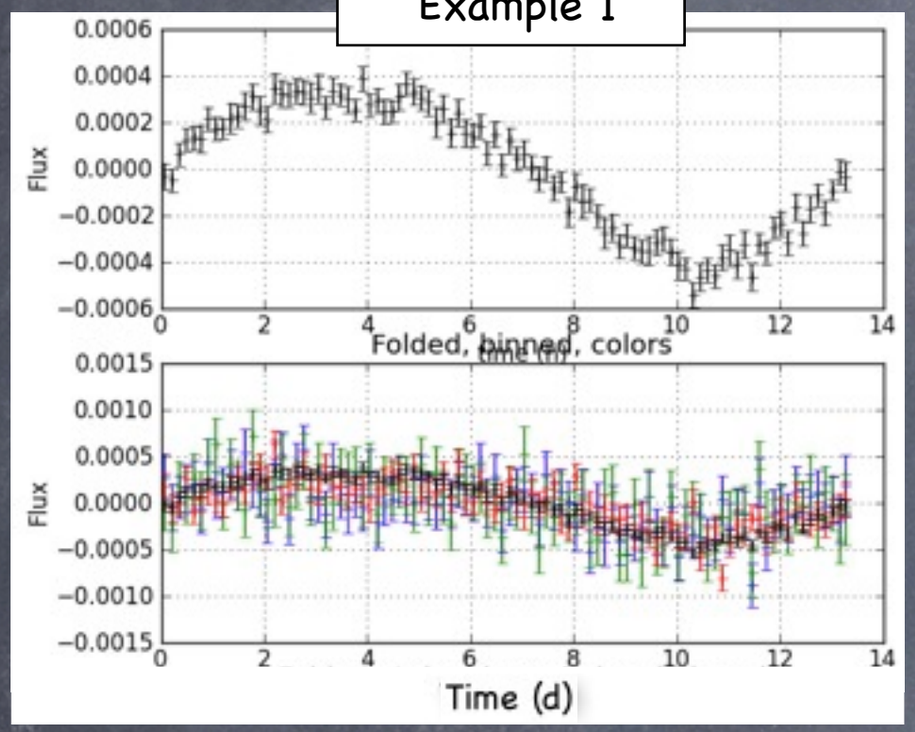


Example 2

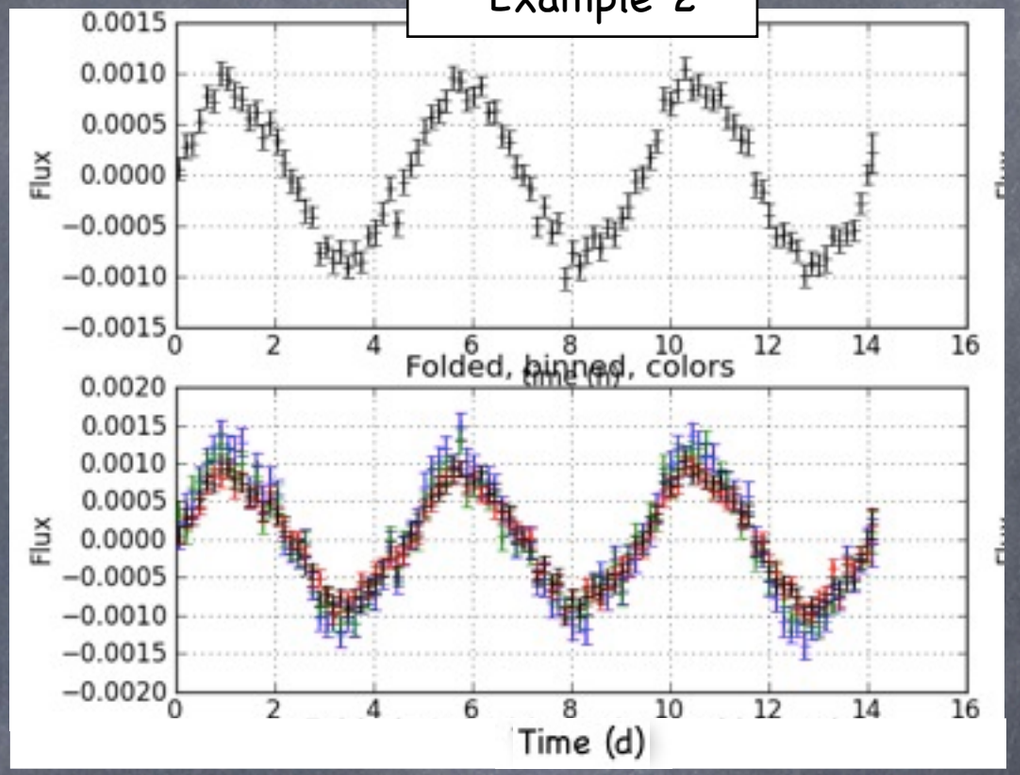


Detection of all kind of periodic signal

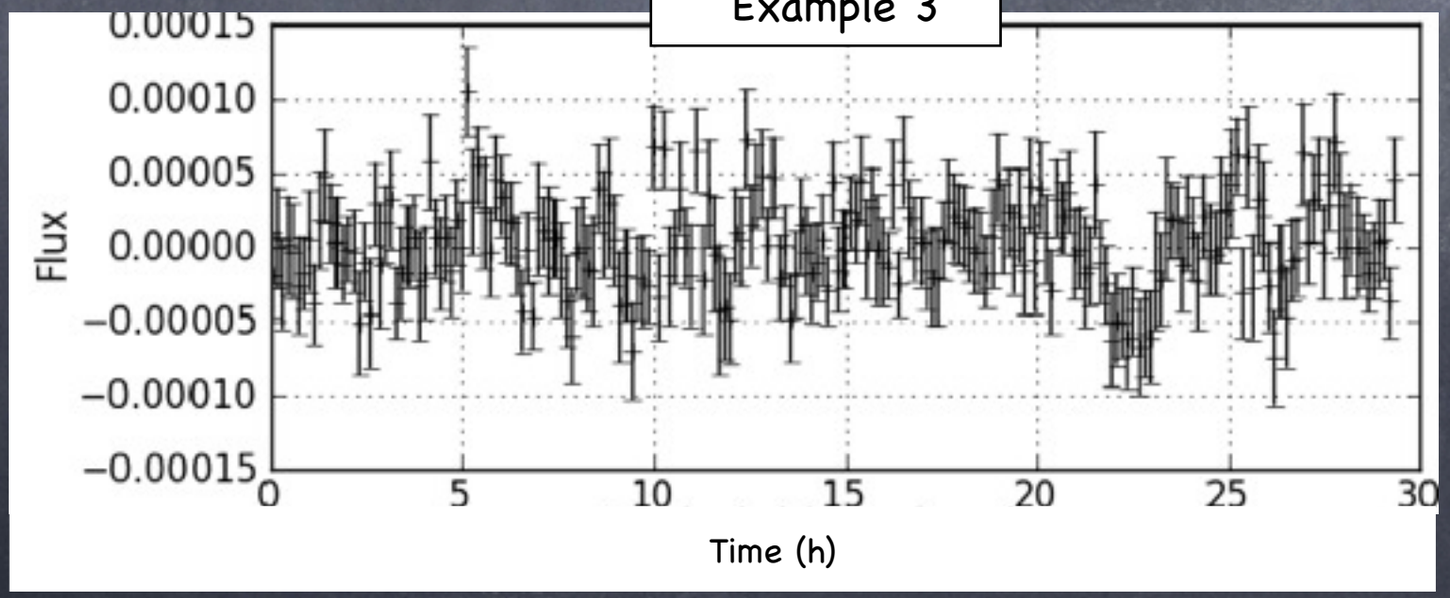
Example 1



Example 2

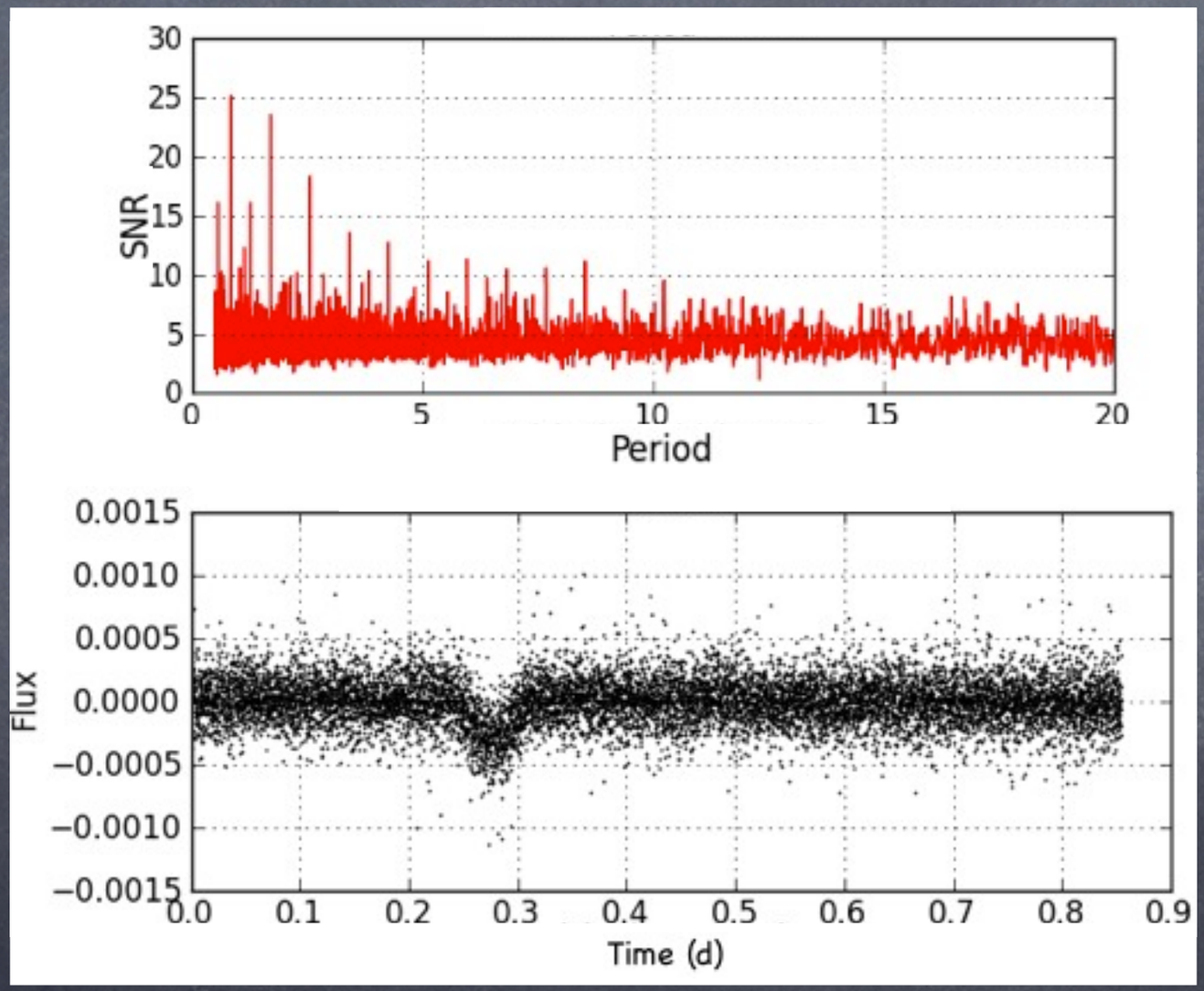


Example 3

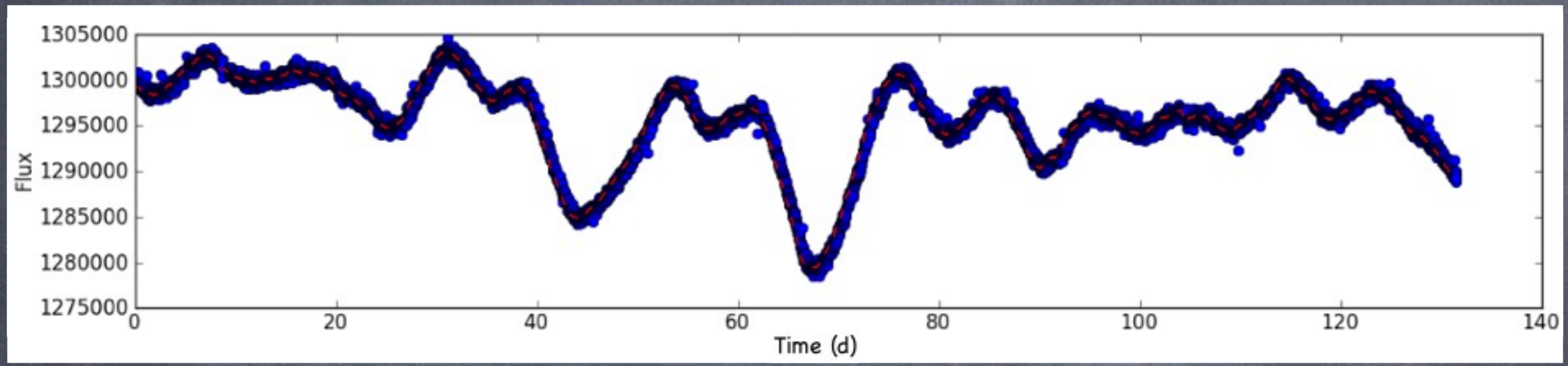


Test on known or simulated data

- Could we find CoRoT-7b with this method?



Transit signal detection in the best situation



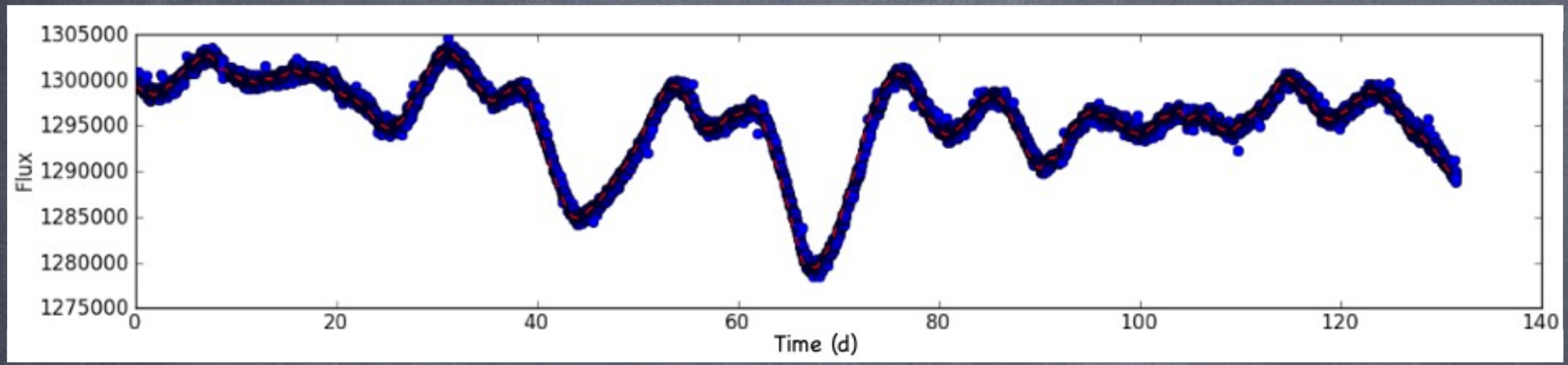
Simulated transits:

P=0.75d

d=1.5h

$R \geq 0.3\ R_{EARTH}$ <=> $dF/F \geq 10^{-5}$

Transit signal detection in the best situation



Results

No signal found:

$dF/F < 8.\ 10^{-5} <=> R < 0.8\ R_{EARTH}$

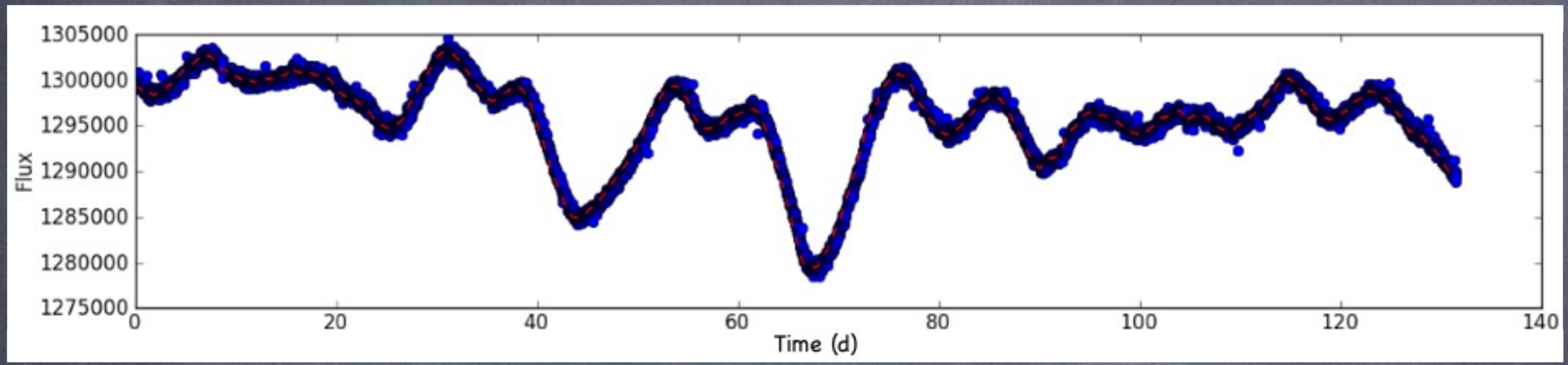
Parameters retrieved (but low SNR):

$dF/F \geq 8.\ 10^{-5} <=> R \geq 0.8\ R_{EARTH}$

Detection (SNR ok):

$dF/F \geq 10^{-4} <=> R \geq 0.9\ R_{EARTH}$

Transit signal detection «best situation»



Results

No signal found:

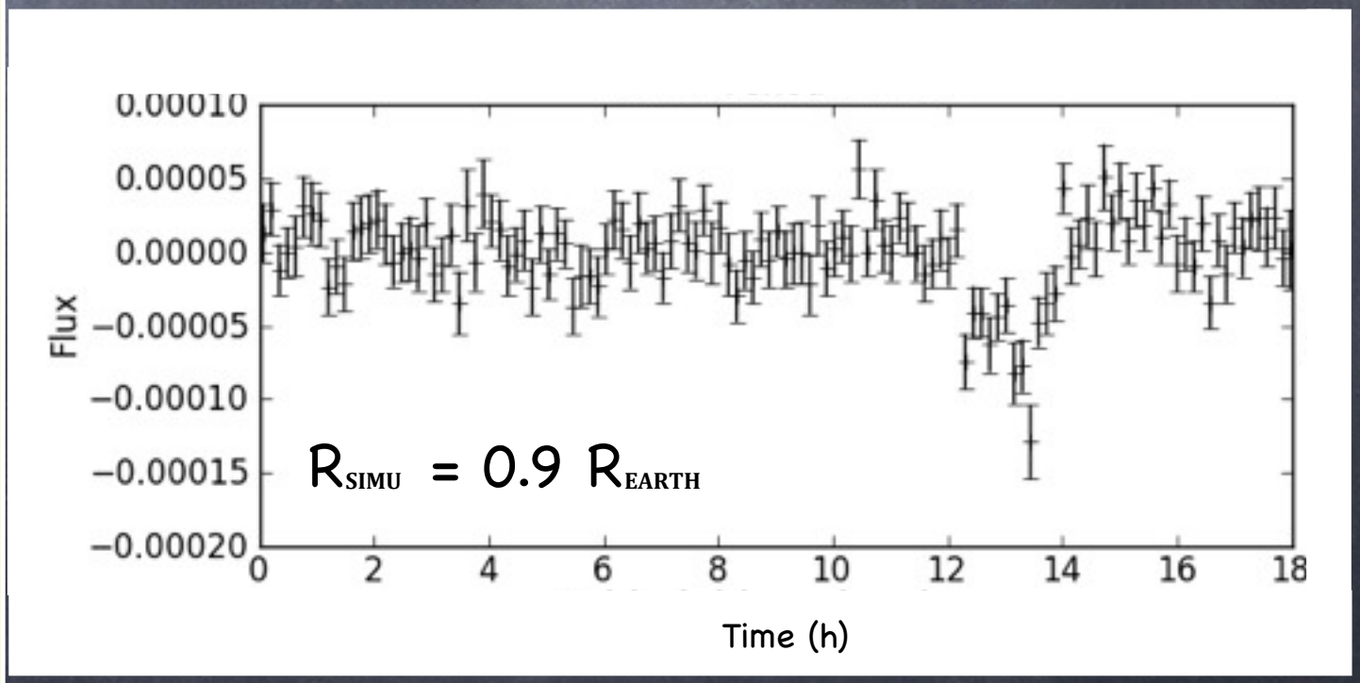
$dF/F < 8.\ 10^{-5}$ <=> $R < 0.8\ R_{EARTH}$

Parameters retrieved (but low SNR):

$dF/F \geq 8.\ 10^{-5}$ <=> $R \geq 0.8\ R_{EARTH}$

Detection (SNR ok):

$dF/F > 10^{-4}$ <=> $R > 0.9\ R_{EARTH}$



Conclusion

Results :

- Find/subtract (any) periodic signals => filter
- Transit detection: ok (used on the last runs)

TBD :

- Fine tuning
- Full characterization of the methods

Please have a look...

- ... to J. Devor's poster.