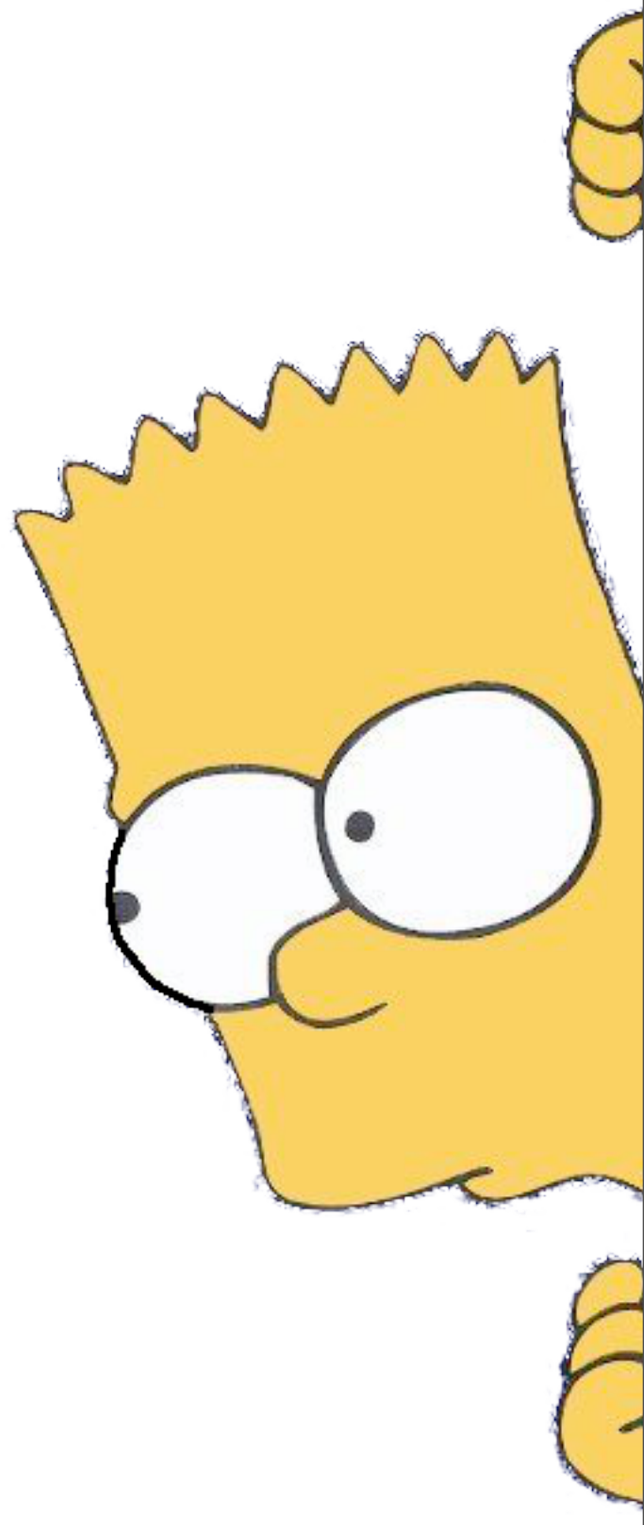
Bayesian Analysis for the Ranking of Transits



Olivier Demangeon
Pascal Bordé, Marc Ollivier, Alain Léger

Layout

I. What is BART and what are its objectives ?

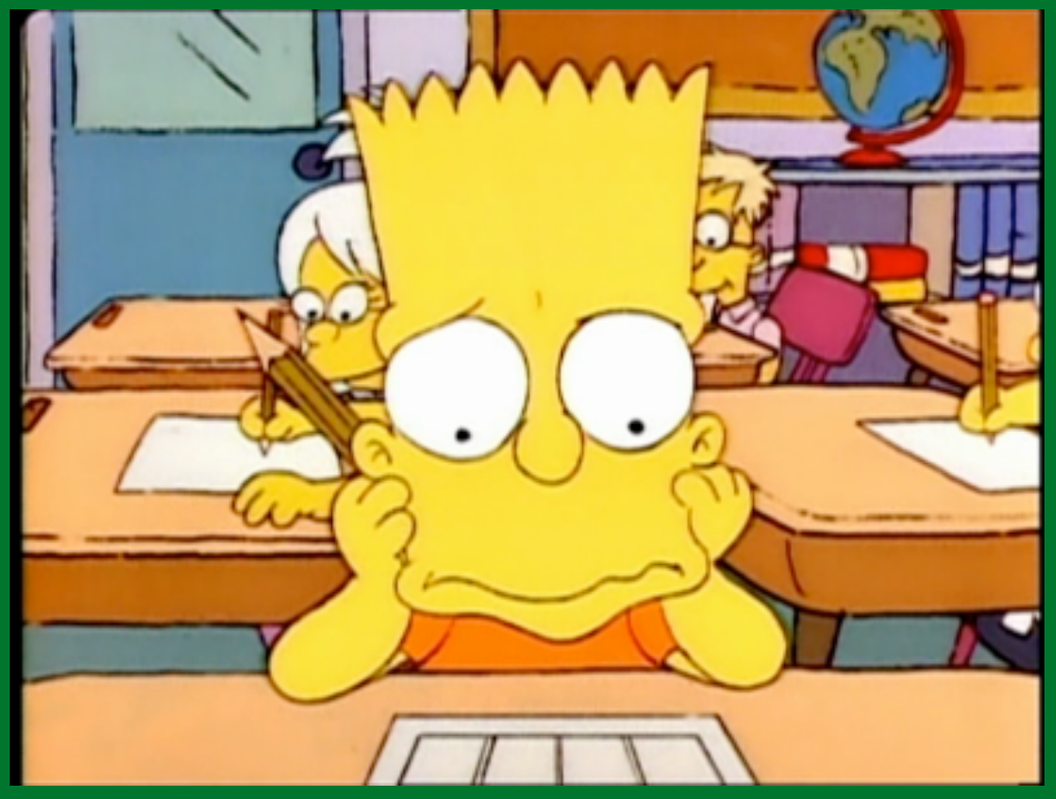
II. Description of BART

III. Current results

IV. Conclusions and outlooks

I. What is BART and what are its objectives ?

I.1) Issues



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- Most targets with magR $> 15 \sim 16$ can't be followed (especially in RV).
- Probabilistic validation (BLENDER, PASTIS) is a long (computer time) and complex task (CoRoT-22b).

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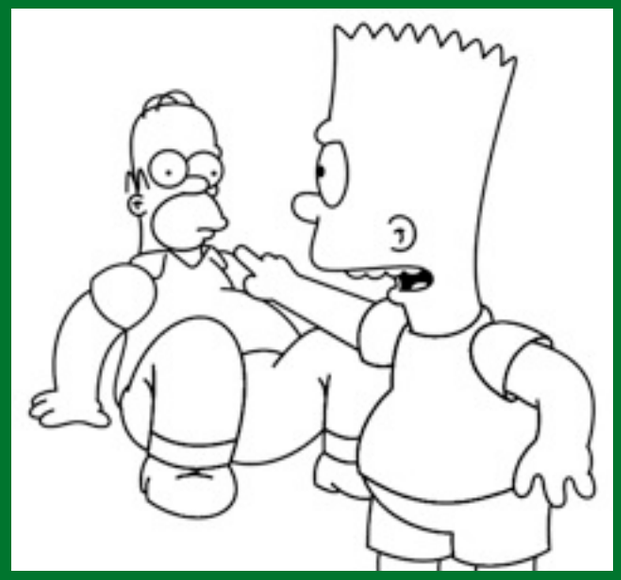
- Point at the most promising transits for follow-up observations and probabilistic validation;



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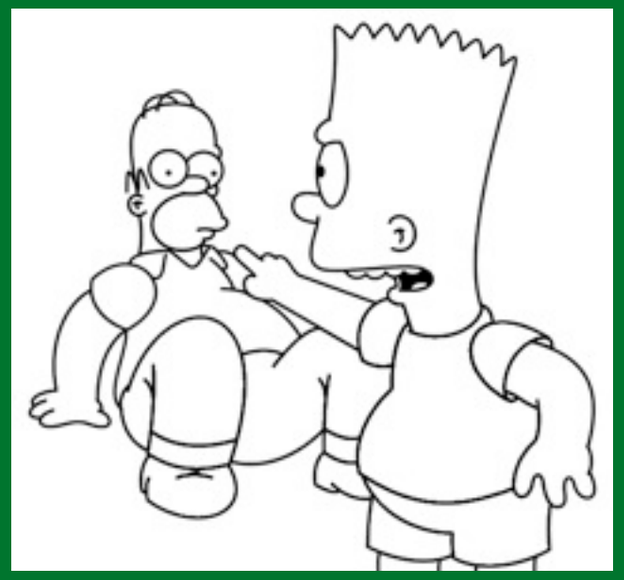
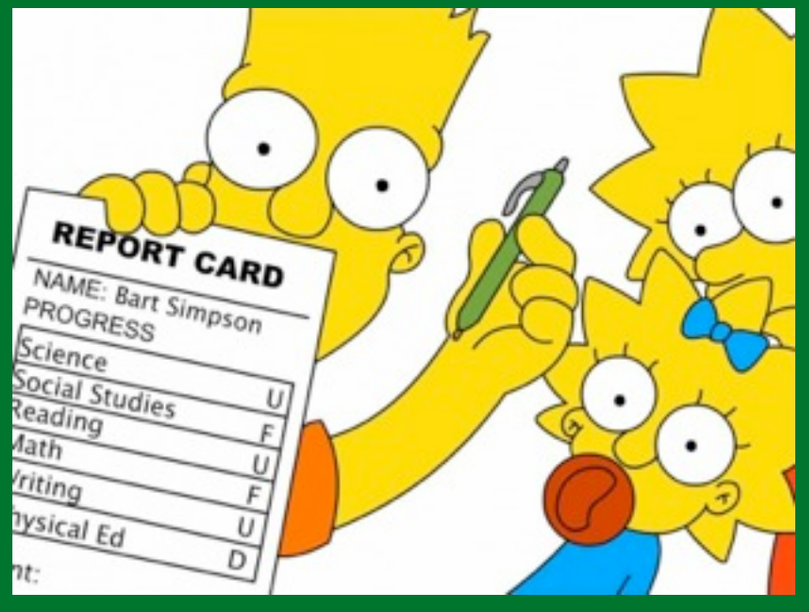


- Make a report on what we can infer with the light curve alone on each transit.



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- Produce a ranking of transit based on the probability of each transit to a be PS;
- Use bayesian inference of parameters to obtain the probability density function of all the parameters (density, radius ratio, ...) of all the scenari (PS, EB, ...)

II) Description of BART

II.1) Bayesian model comparison

Posterior probability

Likelihood

Prior probability

$$\Pr(M|d,\mathrm{I}) = \frac{\Pr(d|M,\mathrm{I})\ \Pr(M|\mathrm{I})}{\Pr(d|\mathrm{I})}$$

Marginalized likelihood (Normalization factor)

M : model (PS, EB, CEB …)
d : data
I : context of the measurement

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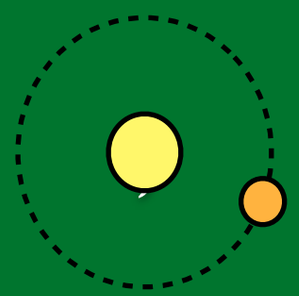
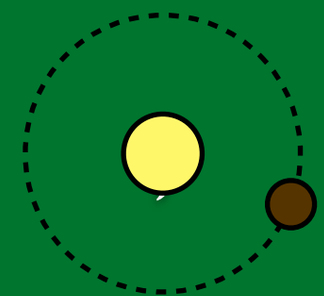
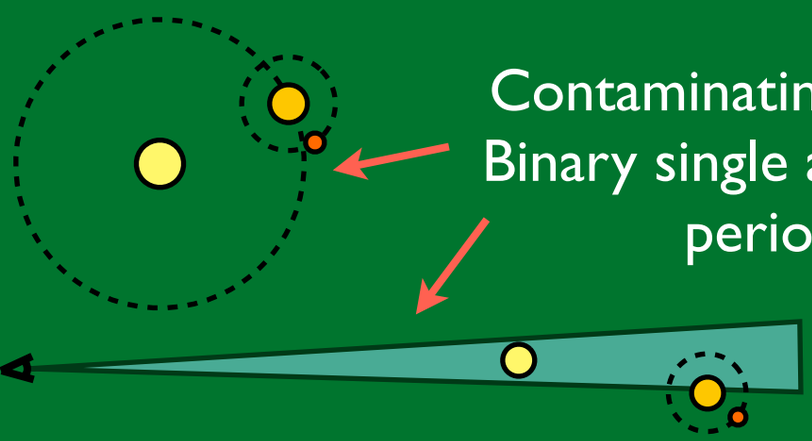
Models, M



Eclipsing Binary single and double periode

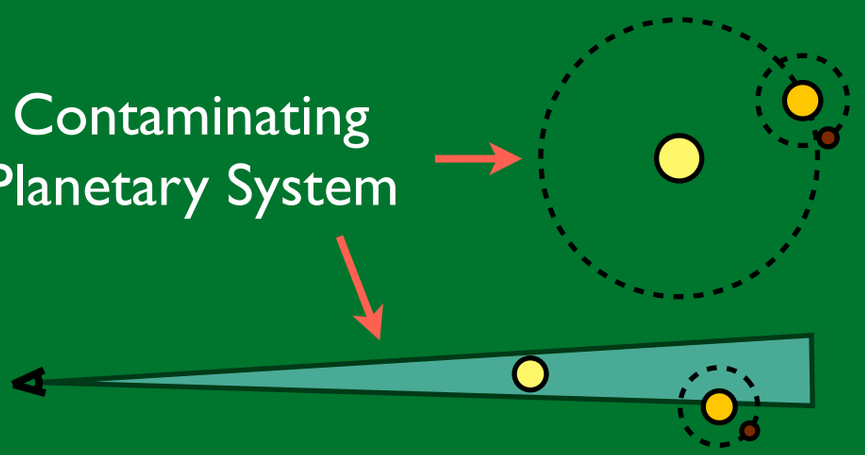
Planetary System





Contaminating Eclipsing Binary single and double periode

Contaminating Planetary System



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Marginalized likelihood (Normalization factor)

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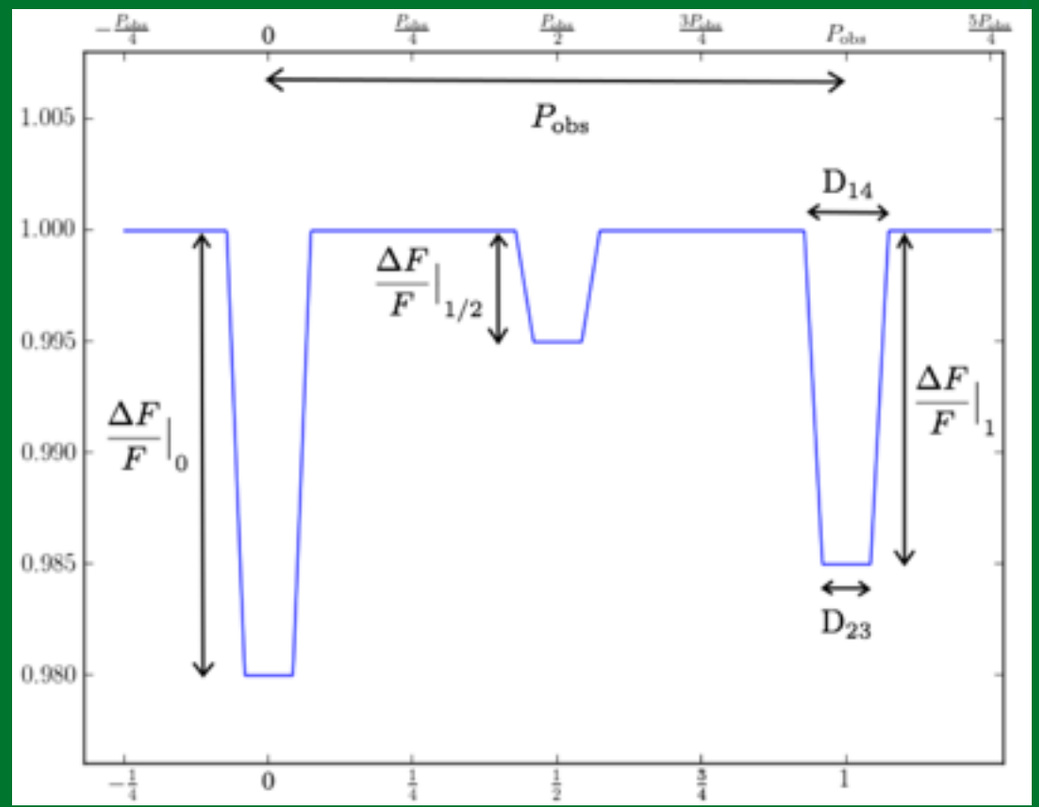
Data, d

To take advantage of the work done by the detection teams, I use as data measured on the transit



II.2) Bayesian inference parameters

Posterior probability density

Likelihood

Prior probability density

$$\mathrm{p}(\boldsymbol{\theta}|d, M, \mathrm{I}) = \frac{\mathrm{p}(d|\boldsymbol{\theta}, M, \mathrm{I})\ \mathrm{p}(\boldsymbol{\theta}|M, \mathrm{I})}{\mathrm{p}(d|M, \mathrm{I})}$$

$\boldsymbol{\theta}$: Parameters

Marginalized likelihood (Normalization factor)

PS

- b impact parameter
- $\frac{R_{\rm pl}}{R_{\rm st}}$ radius ratio
- ρ_{st} stellar density
- P orbital periode

CPS

- b impact parameter
- $\frac{R_{\rm pl}}{R_{\rm st}}$ radius ratio
- ρ_{st} stellar density
- P orbital periode
- c contamination factor

EB (P, 2P)

- b impact parameter
- $\frac{R_{\rm prim}}{R_{\rm sec}}$ radius ratio
- $\rho_{\rm som}$ system density
- P orbital periode
- $\frac{T_{\rm prim}}{T_{\rm sec}}$ effective temperature ratio

$$\rho_{\rm som} = \frac{M_{\rm prim} + M_{\rm sec}}{4/3\pi R_{\rm prim}^3}$$

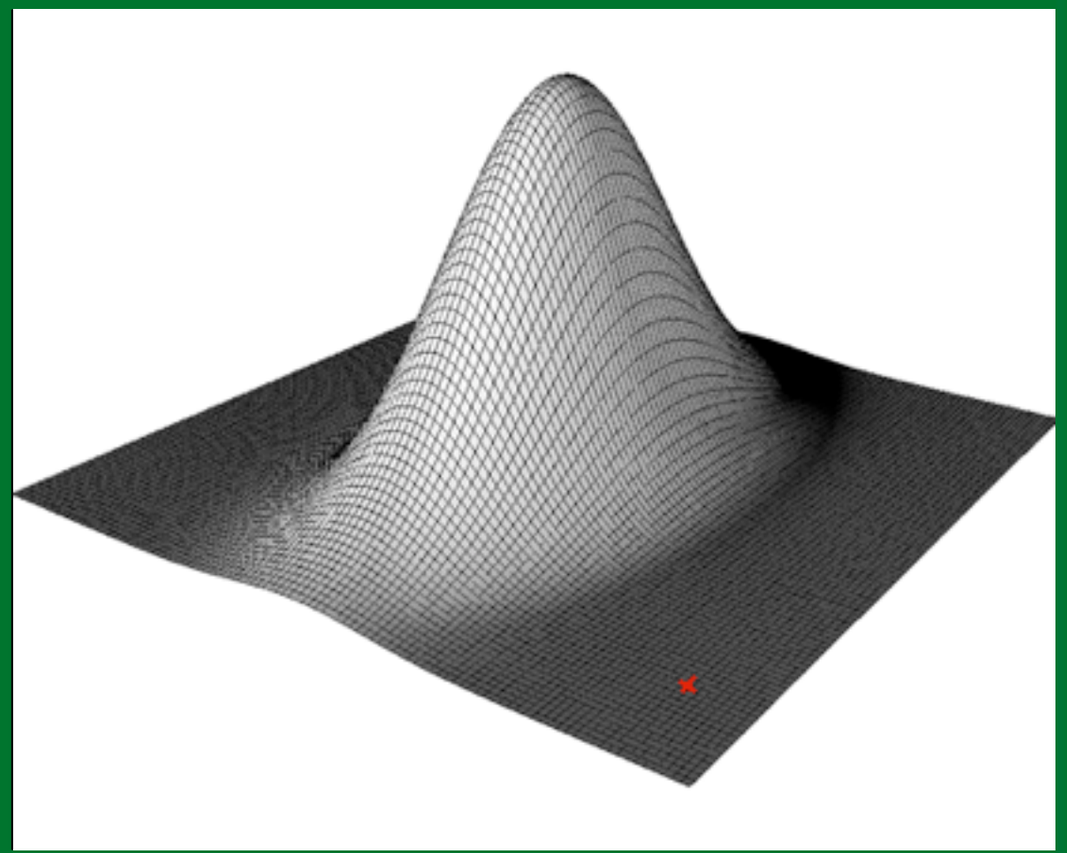
CEB (P, 2P)

- b impact parameter
- $\frac{R_{\rm prim}}{R_{\rm sec}}$ radius ratio
- $\rho_{\rm som}$ system density
- P orbital periode
- $\frac{T_{\rm prim}}{T_{\rm sec}}$ effective temperature ratio
- c contamination factor

II.3) Exploration of parameter space and integration

- Fasten execution time :
MCMC exploration
Monte carlo integration

- Automatisation : Personal adaptation of P.C. Gregory (2005) Adaptative Metropolis-Hasting algorithm (acceptance rate and trace correlation feedback) more efficient with correlated parameters



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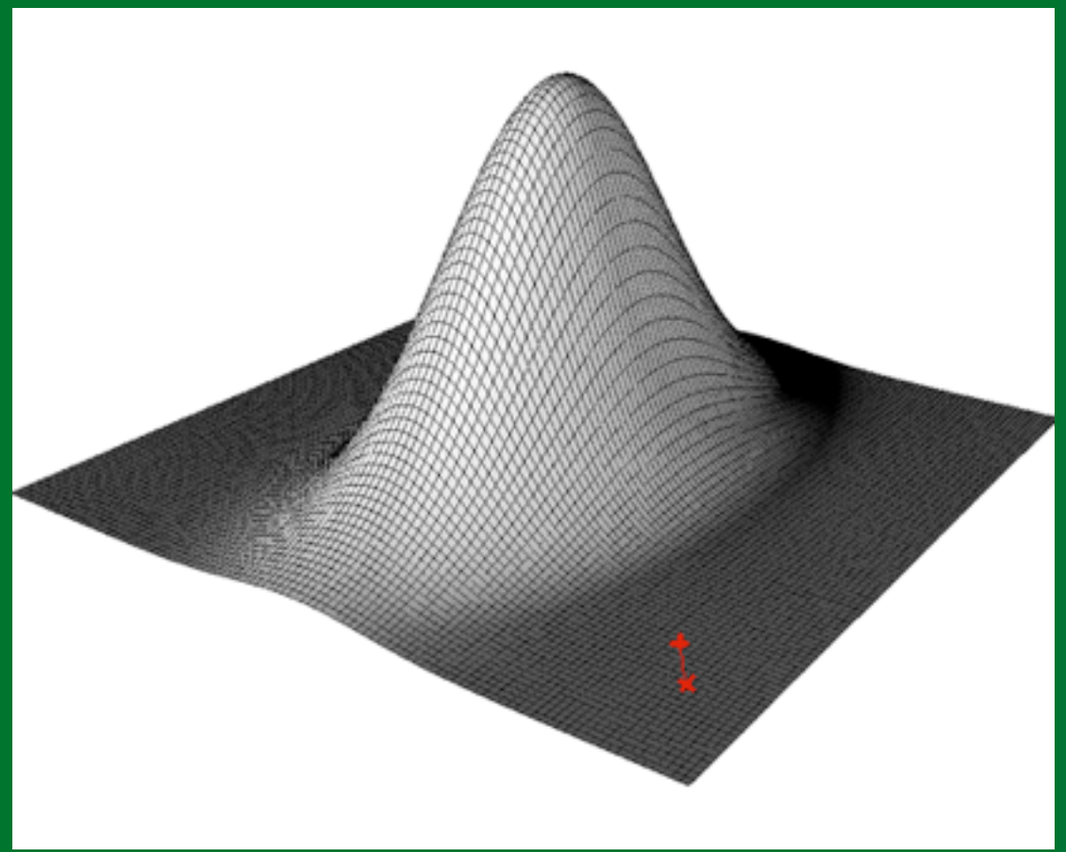

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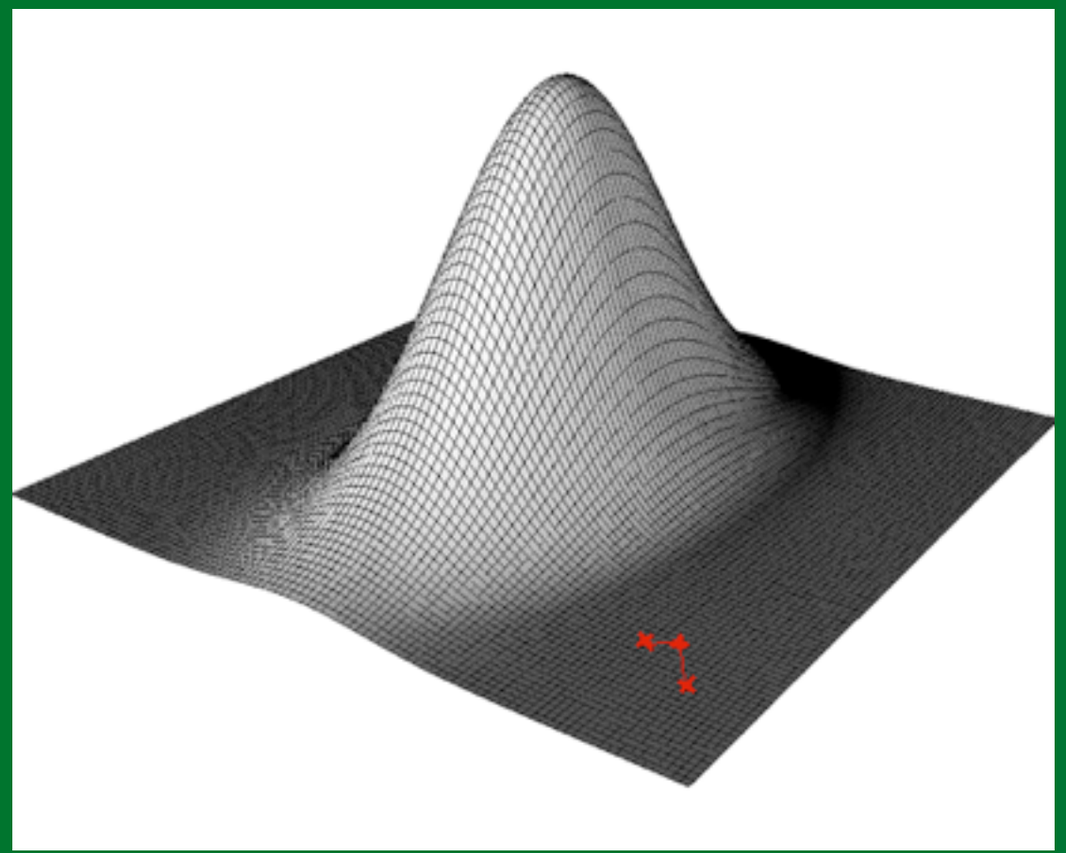

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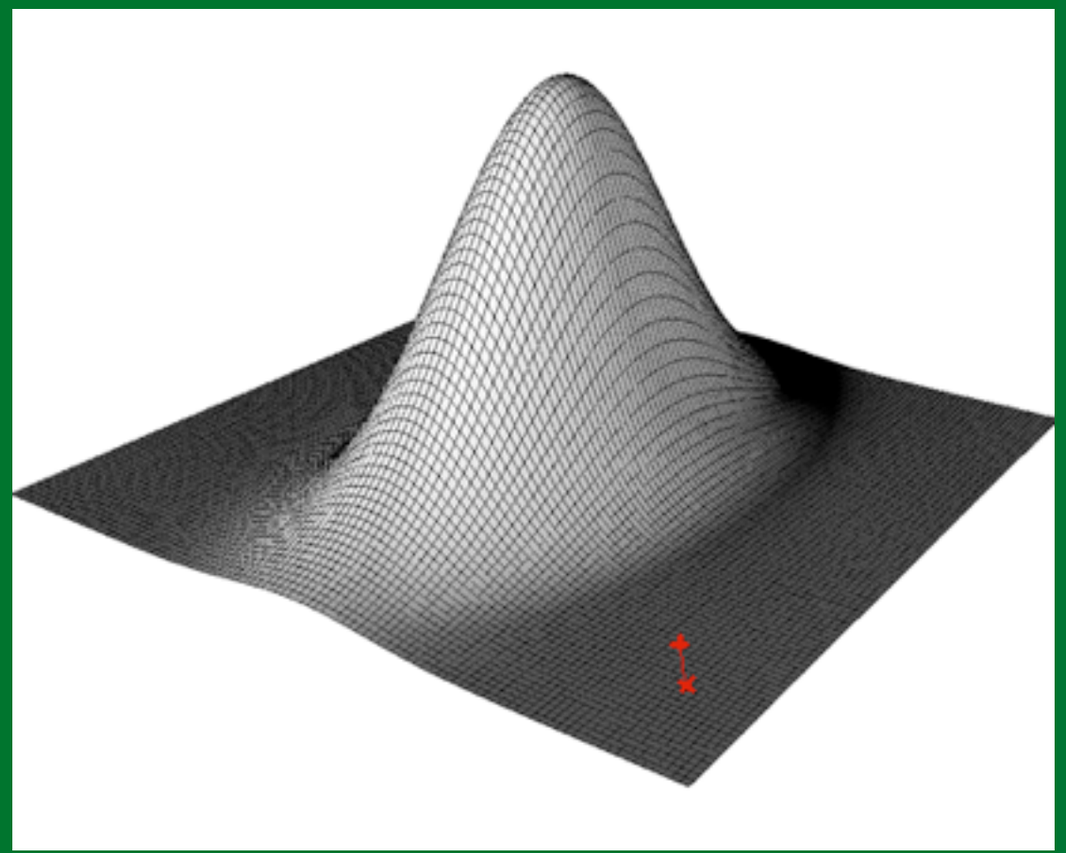

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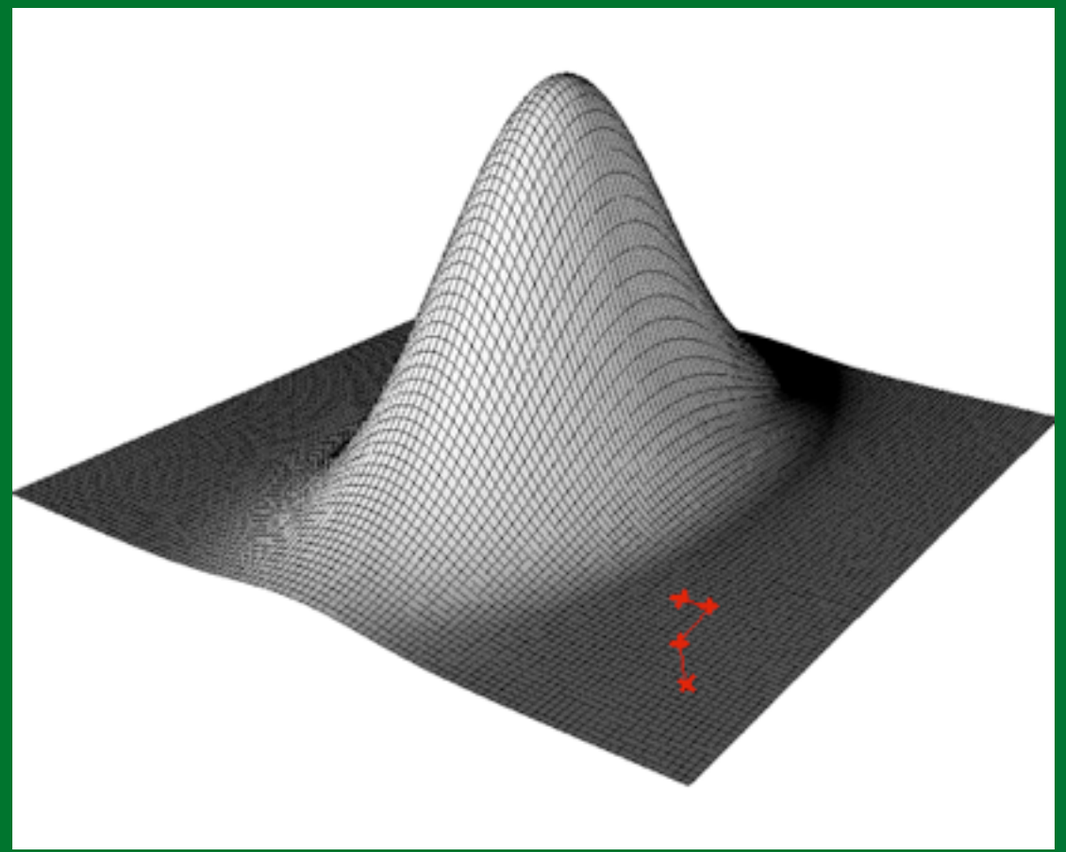

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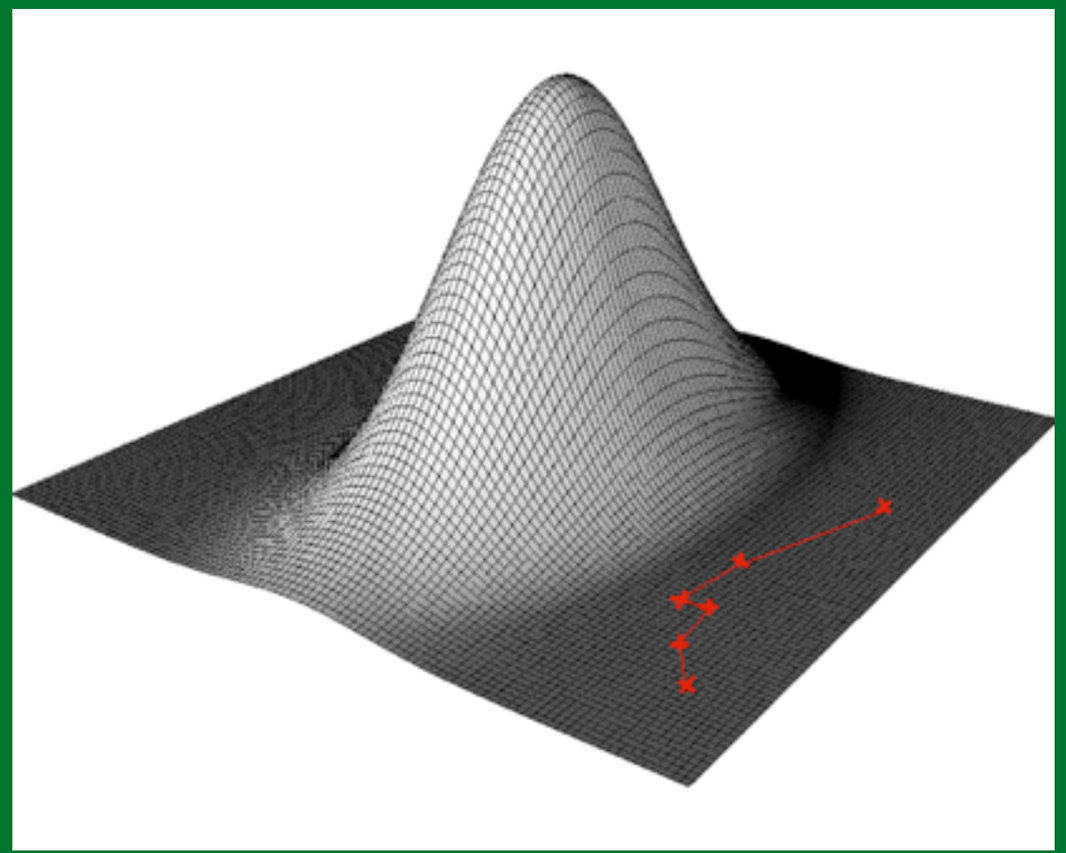

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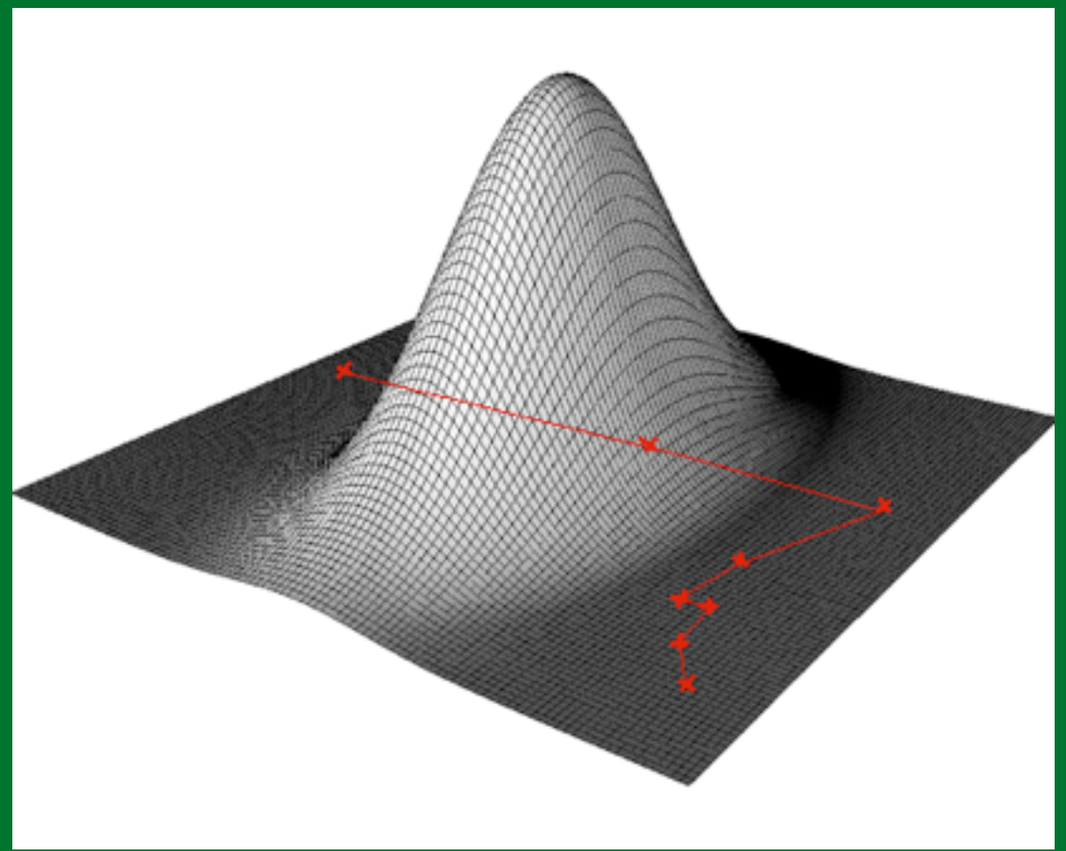

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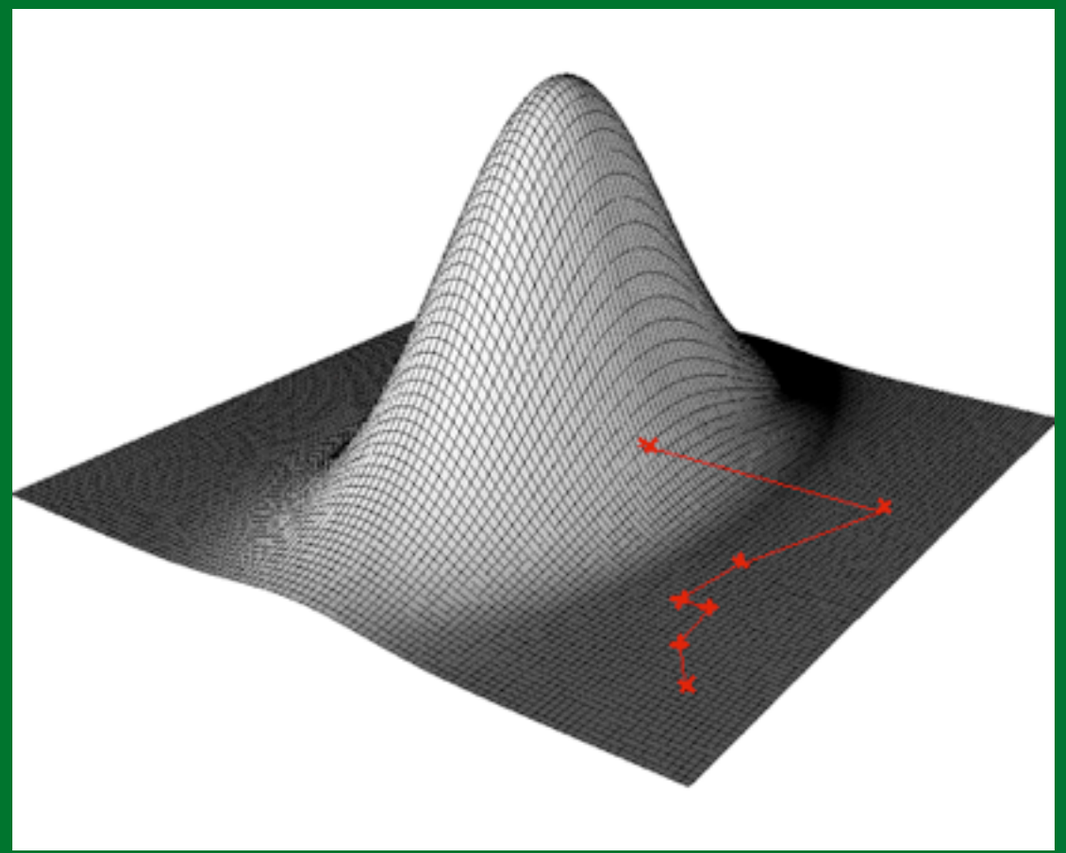

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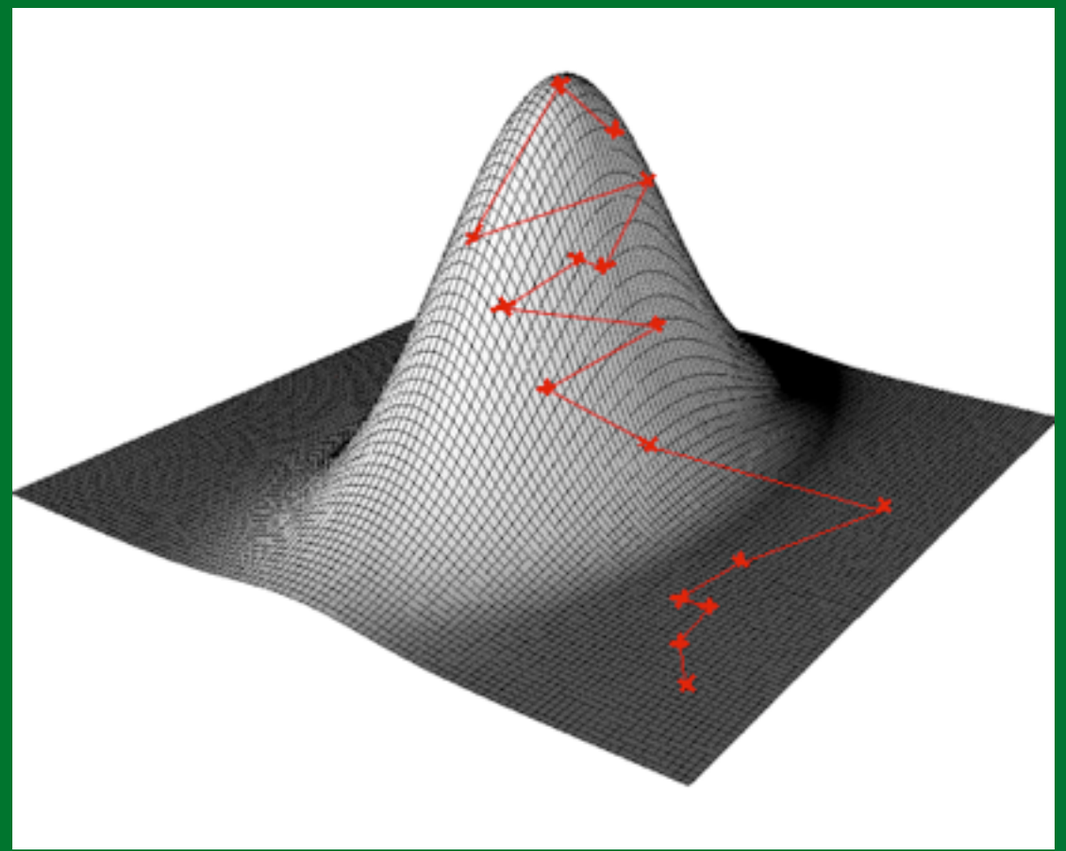


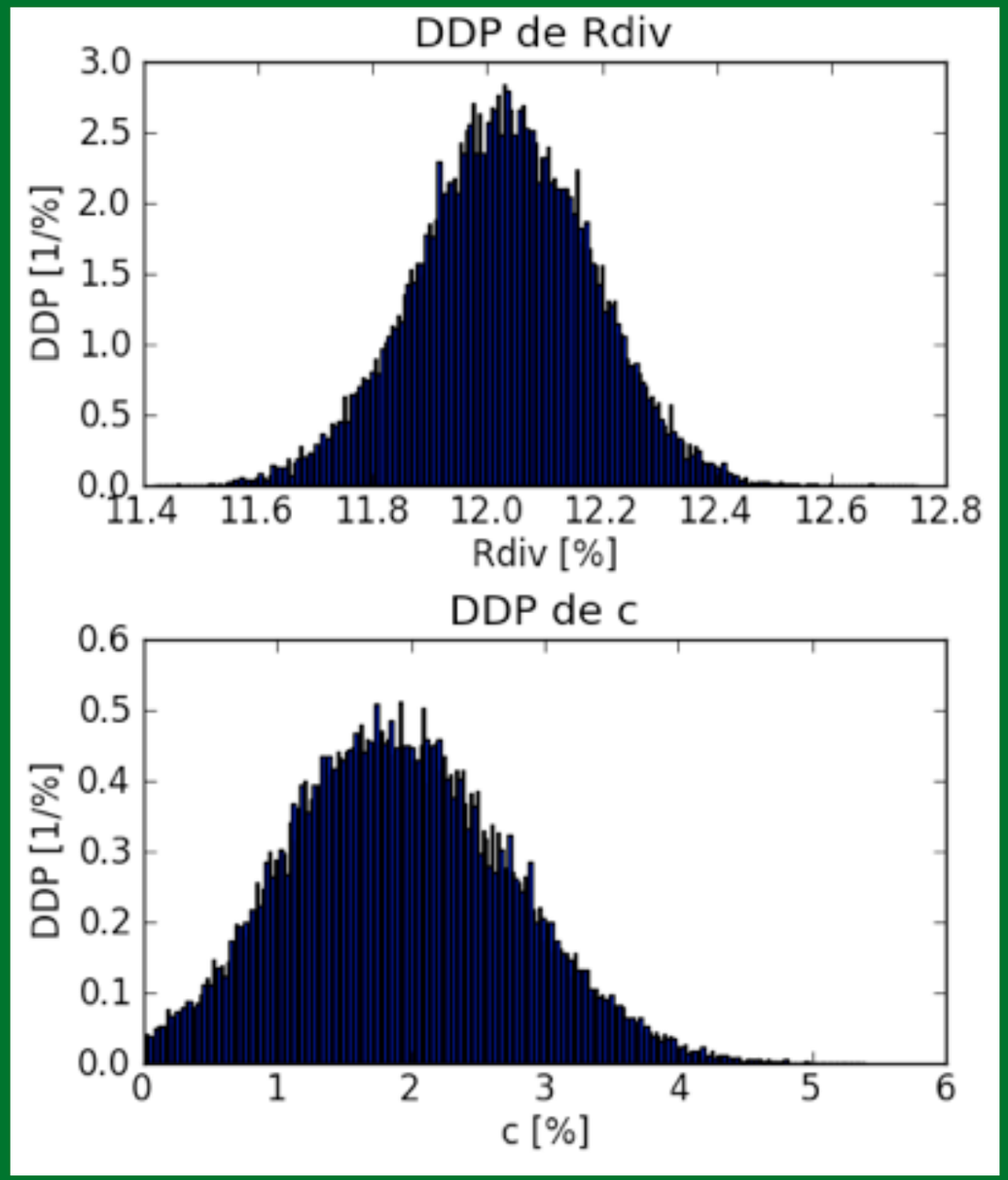
III) Current results

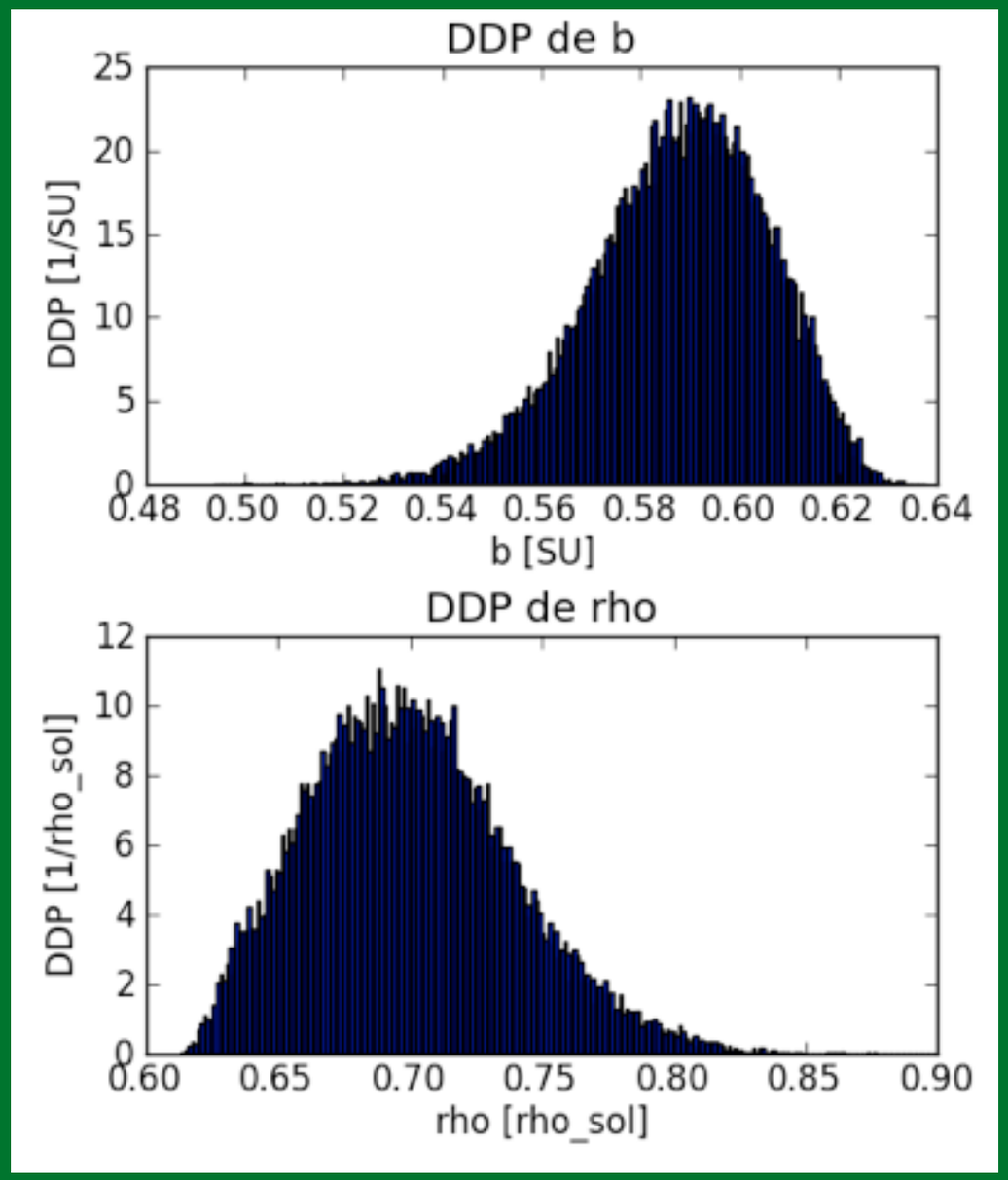
III.1) Current results : Ranking of 22 candidates from LRc02

Rank	Candidate	PS Probability (without Exodat Density prior)	Nature (Wiki CoRoT)	Nature (My tool)
1	LRc02-E1R-632	9,98E+01	PS (CoRoT-6b)	PS
2	LRc02-E1L-249	9,98E+01	P3 (Slightly chromatic)	PS
3	LRc02-E1R-1280	9,95E+01	PS (CoRoT-25b)	PS
4	LRc02-E2R-4630	9,93E+01	P1 (Faint but nice candidate)	PS
5	LRc02-E1L-3424	1,07E-02	P3 (Conflit with Exodat density)	CPS
6	LRc02-E1R-3179	6,09E-03	P3 (Conflict with exodat density)	CEBP
7	LRc02-E1L-2870	5,54E-04	CEBP (Highly colored)	EBP
8	LRc02-E1L-3654	2,63E-06	P3 (Significant Odd/Even transit depth)	CEB2P
9	LRc02-E2R-293	3,83E-07	CEB (Highly Chromatic)	CPS
10	LRc02-E1R-591	6,24E-12	PS (CoRoT-22b)	CEBP
11	LRc02-E1L-202	4,05E-15	PS (CoRoT-11b)	CPS
12	LRc02-E1L-981	3,92E-35	SB1 (HARPS+McDonald)	EBP
13	LRc02-E1L-3088	6,69E-45	P2 (Conflit with Exodat density)	CPS
14	LRc02-E1L-1192	1,56E-46	CEB (Euler: likely CEB)	CPS
15	LRc02-E1R-483	4,19E-54	CEB (Sophie: 2pt, no var)	CEB2P
16	LRc02-E2R-2879	7,06E-58	P3 (Shape difference between Odd&Even)	CEBP
17	LRc02-E1L-1284	3,49E-110	P3 (Conflict with Exodat density+Several significant Contaminant)	CEB2P
18	LRc02-E2L-4747	6,44E-143	PS (CoRoT-26b)	CEBP
19	LRc02-E1R-136	3,25E-302	CEB (Sophie+HARPS+Higly Chromatic)	CEBP
20	LRc02-E1R-1427	0,00E+00	P3 (Phot:On-target, Period estimation issue)	CPS
21	LRc02-E1R-2282	0,00E+00	P3 (Conflict with exodat density+Odd/Even transit depth variation)	CEB2P
22	LRc02-E2L-2731	0,00E+00	P3 (Secondary eclipse seems to be there)	EBP

III.2) Current results : Parameters inference

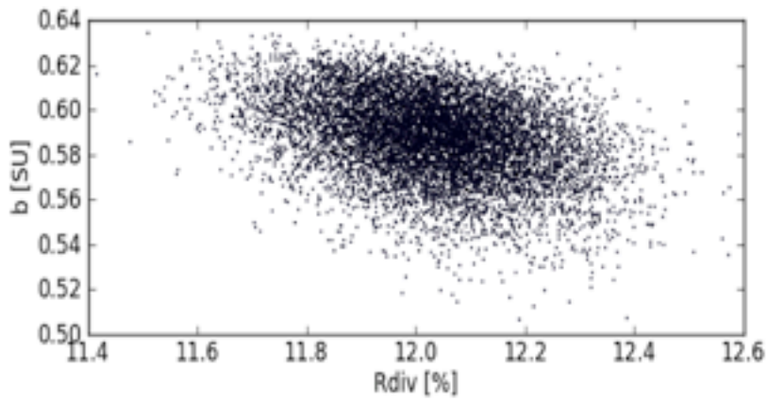
CoRoT-6b -- PS

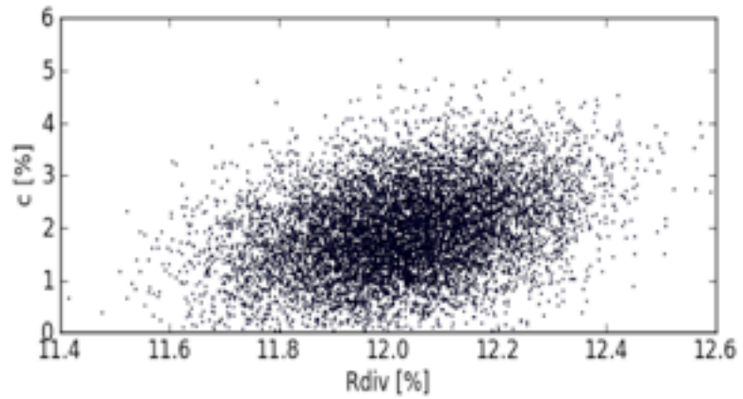


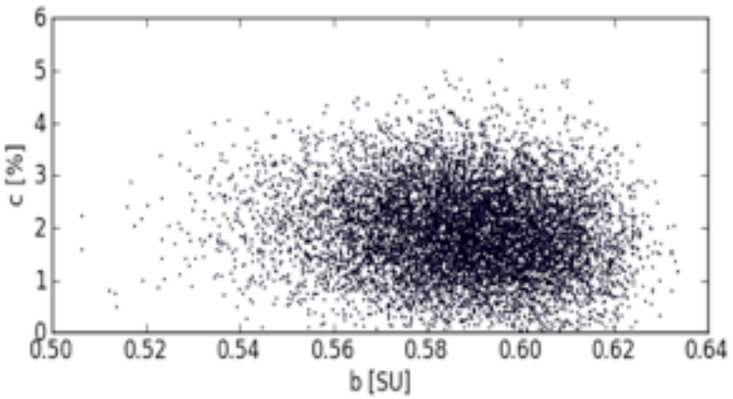


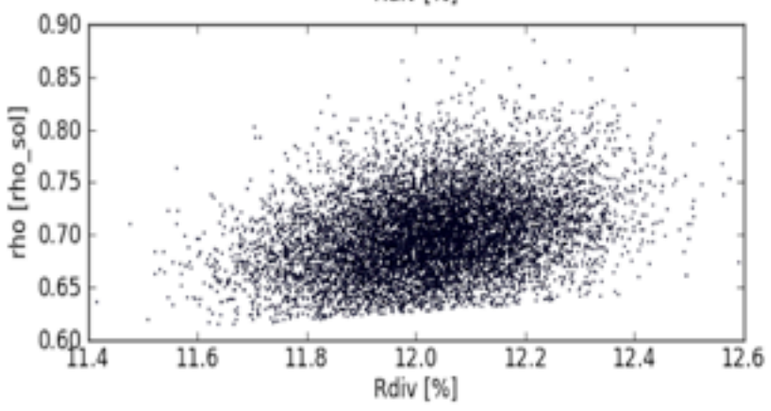
III.3) Current results : Correlation diagrams

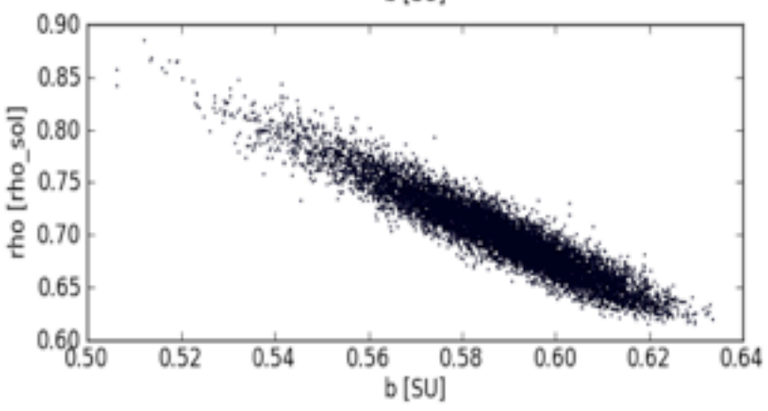
CoRoT-6b -- PS

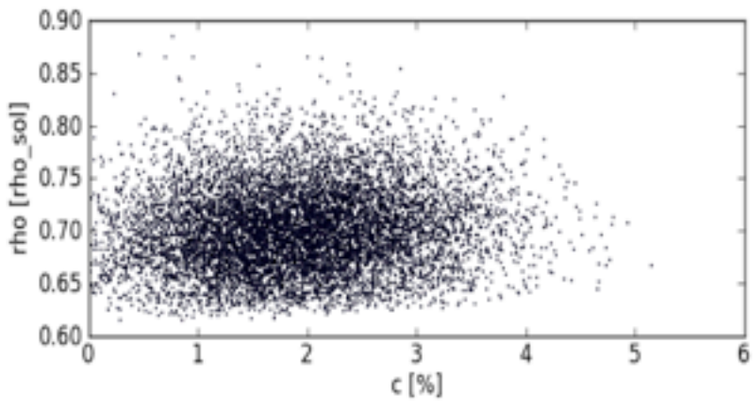






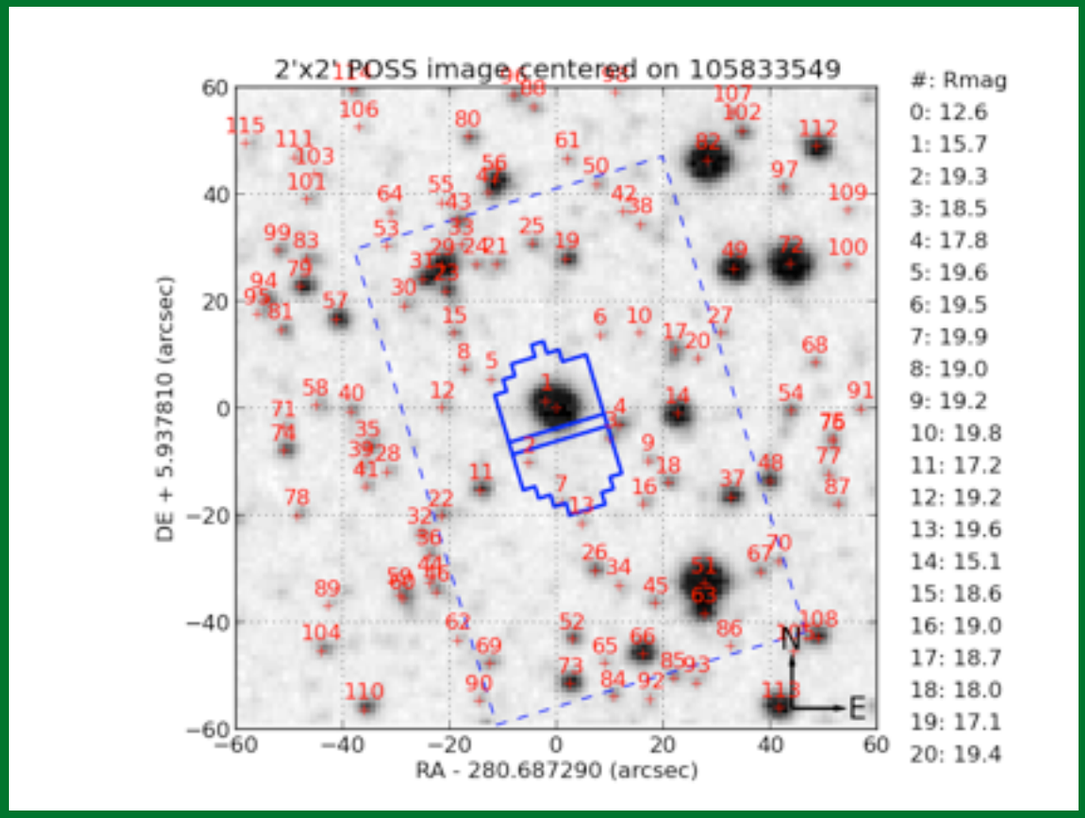






IV) Conclusions and outlook

- The ranking is already quite good (except for high impact parameter planets) ;
- I think that it could be even better with a more detailed description of contamination (contaminant list and colors);
- Development of more detailed prior probabilities on models and parameters



Thank you for attention !