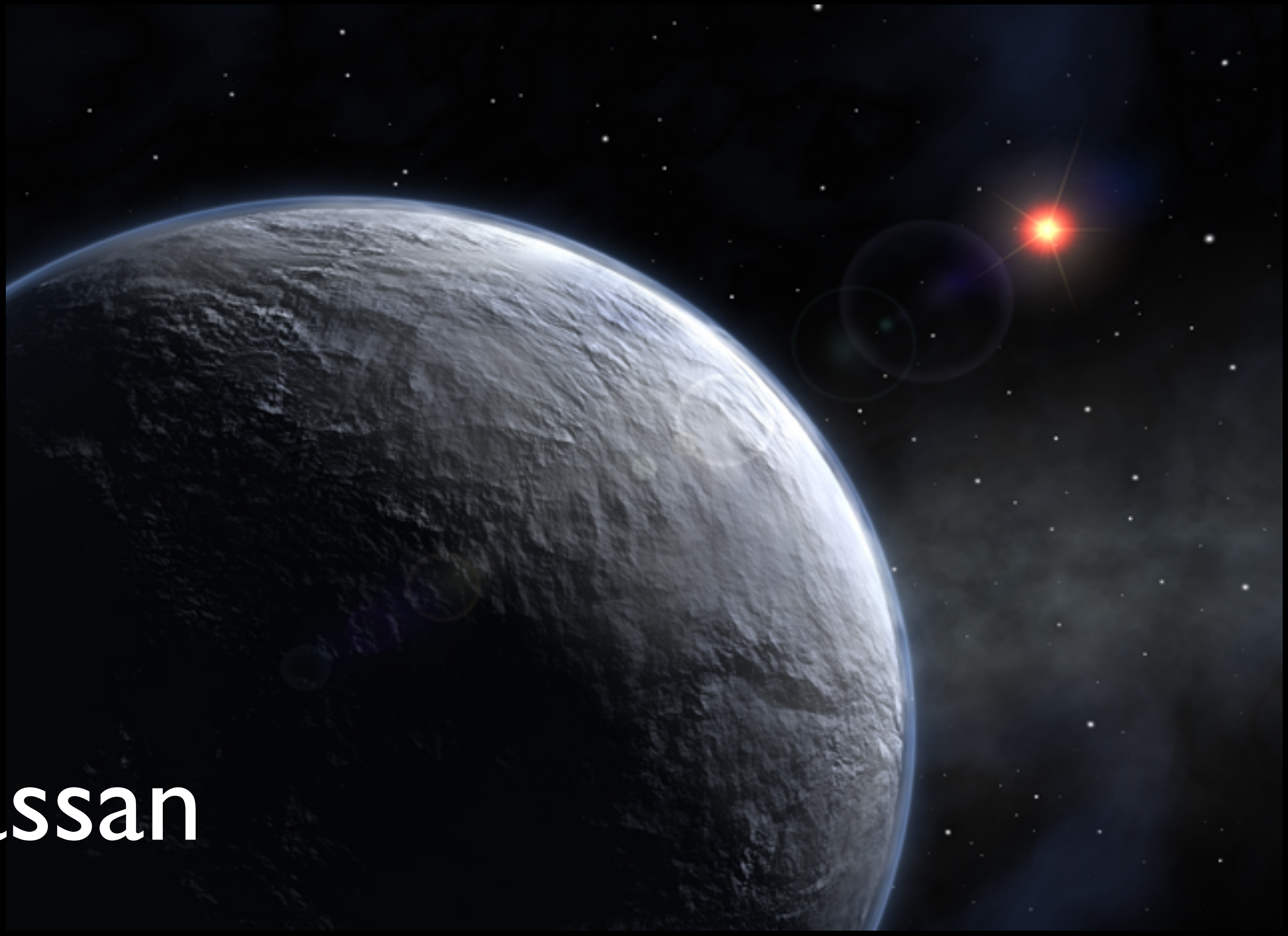
Generating a planetary microlensing light curve model

Hands-on session introduction



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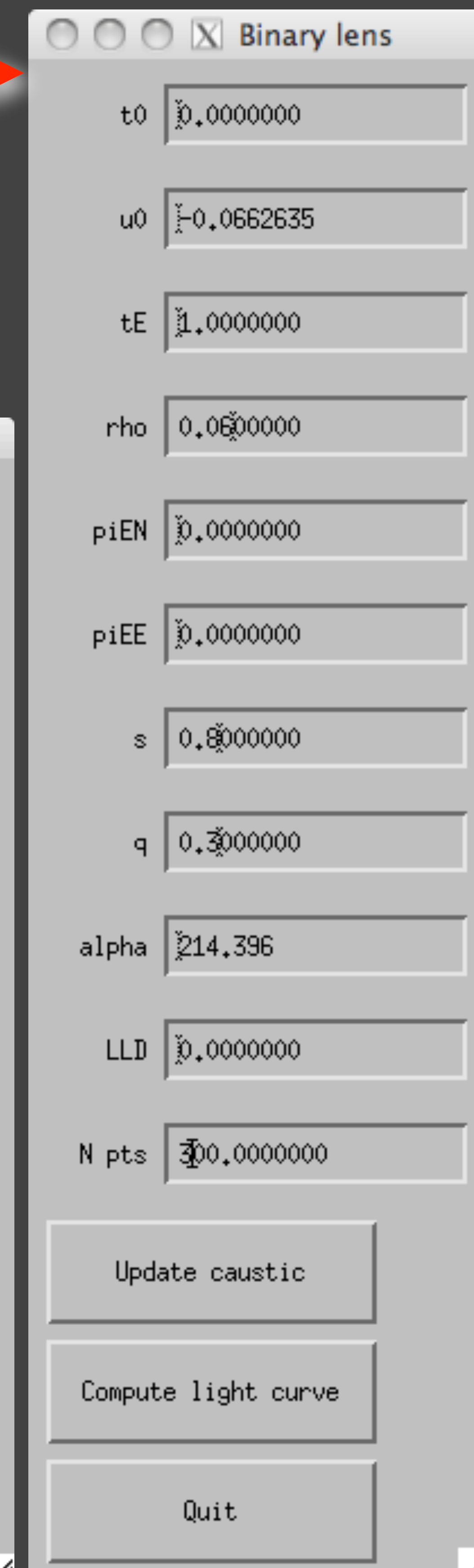
Generating light curves: Software presentation

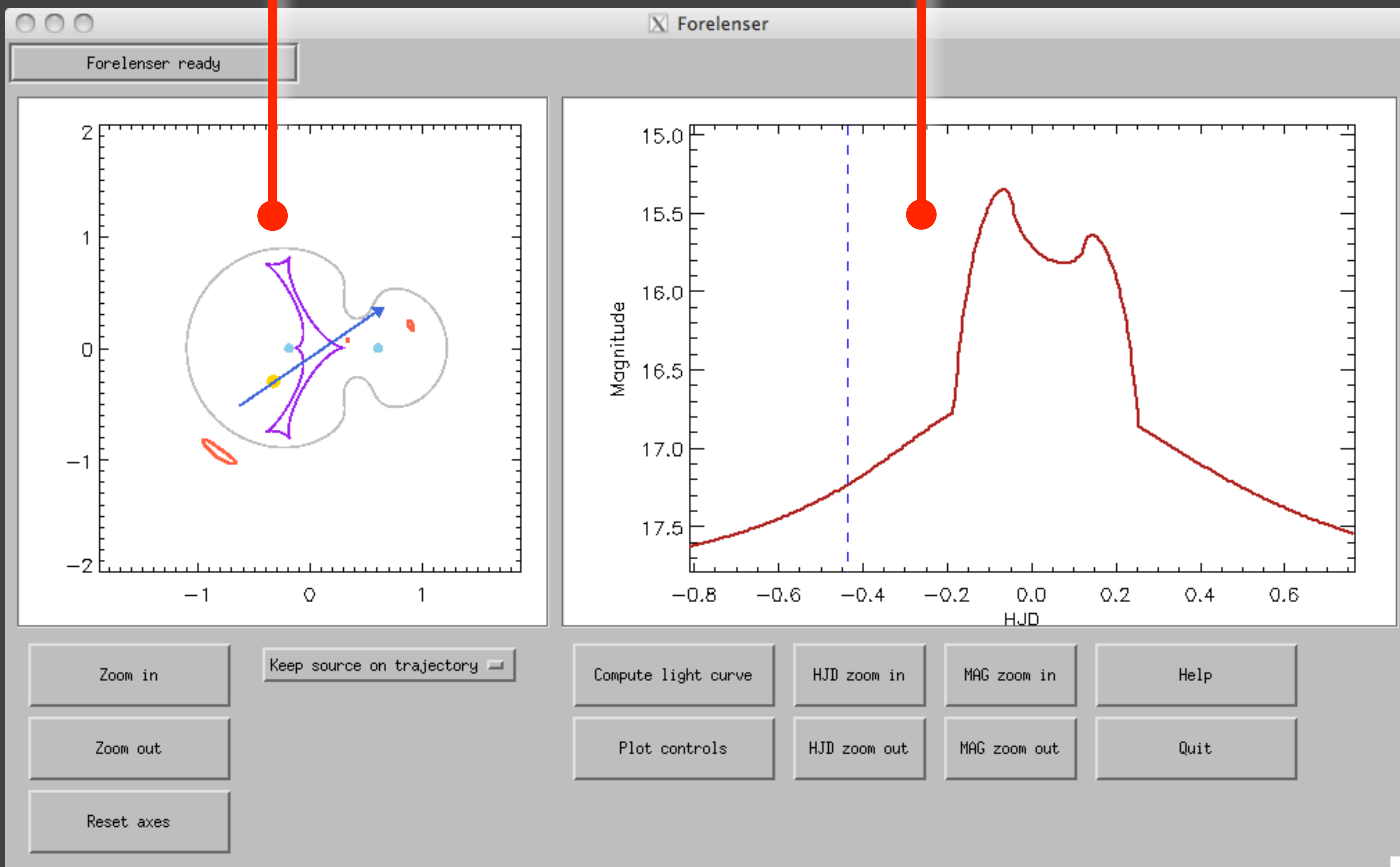
In this presentation, the IDL GUI is used.
The python GUI has similar functionalities

Parameters window
Open with: [Plot controls]

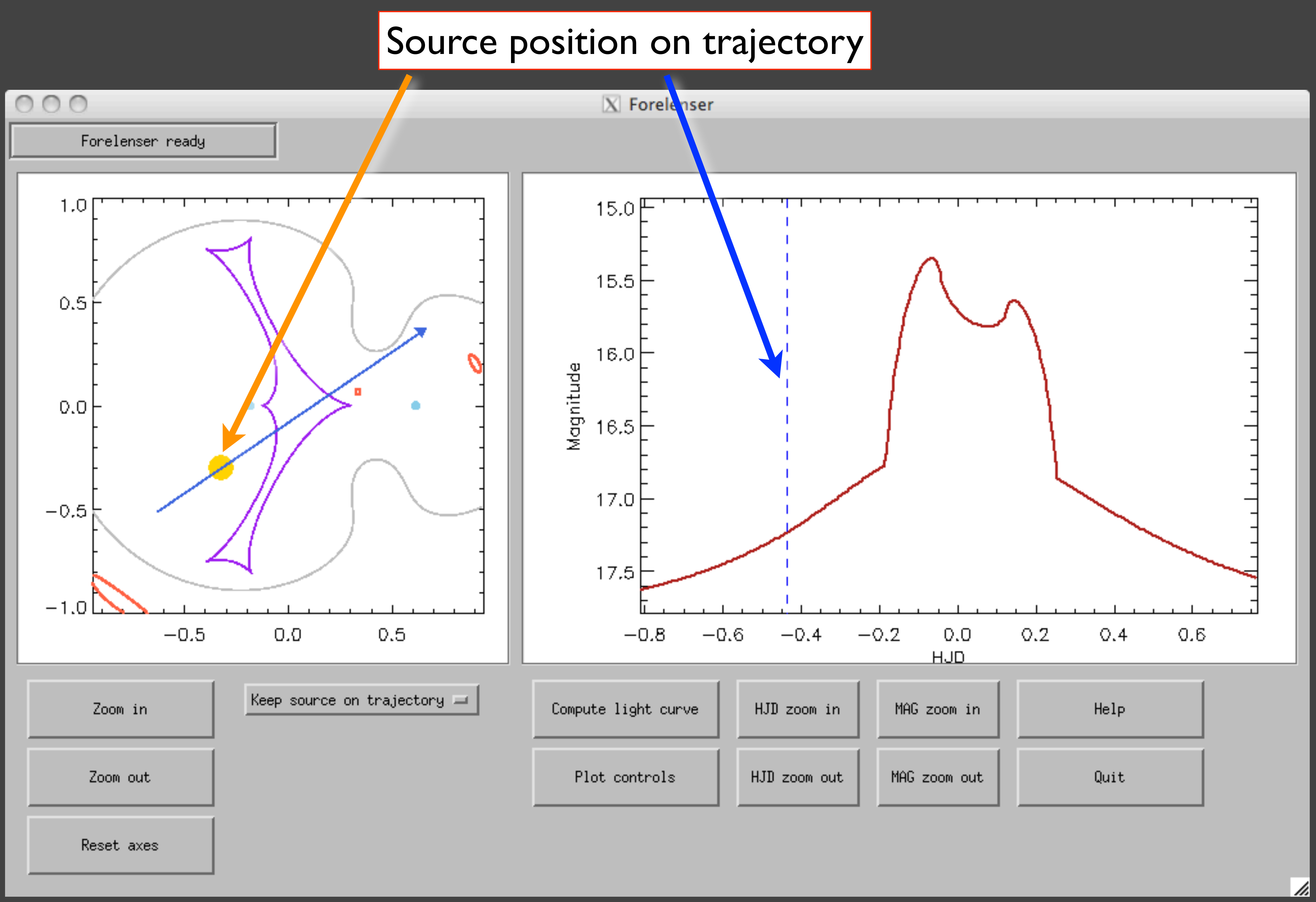


Light curve visualization window

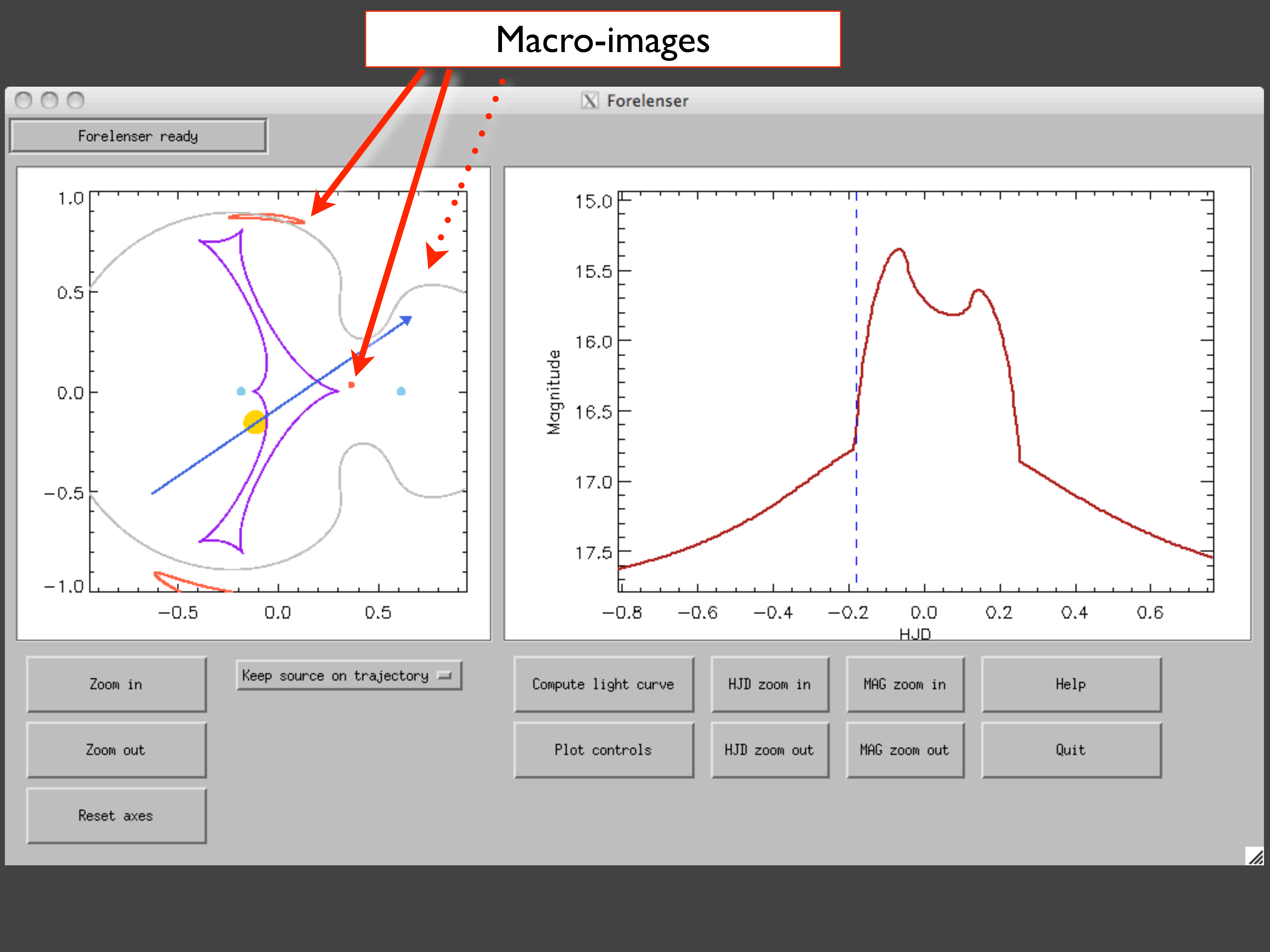
Caustic visualization window



The light curve is not computed by default ('long' computation time)
Press [Compute light curve]



Source position on trajectory
Forelenser
Forelenser ready
1.0
0.5
0.0
−0.5
−1.0
−0.5
0.0
0.5
15.0
15.5
16.0
16.5
17.0
17.5
Magnitude
−0.8
−0.6
−0.4
−0.2
0.0
0.2
0.4
0.6
HJD
Zoom in
Zoom out
Reset axes
Keep source on trajectory
Compute light curve
Plot controls
HJD zoom in
HJD zoom out
MAG zoom in
MAG zoom out
Help
Quit



Macro-images
Forelenser
Forelenser ready
1.0
0.5
0.0
−0.5
−1.0
−0.5
0.0
0.5
15.0
15.5
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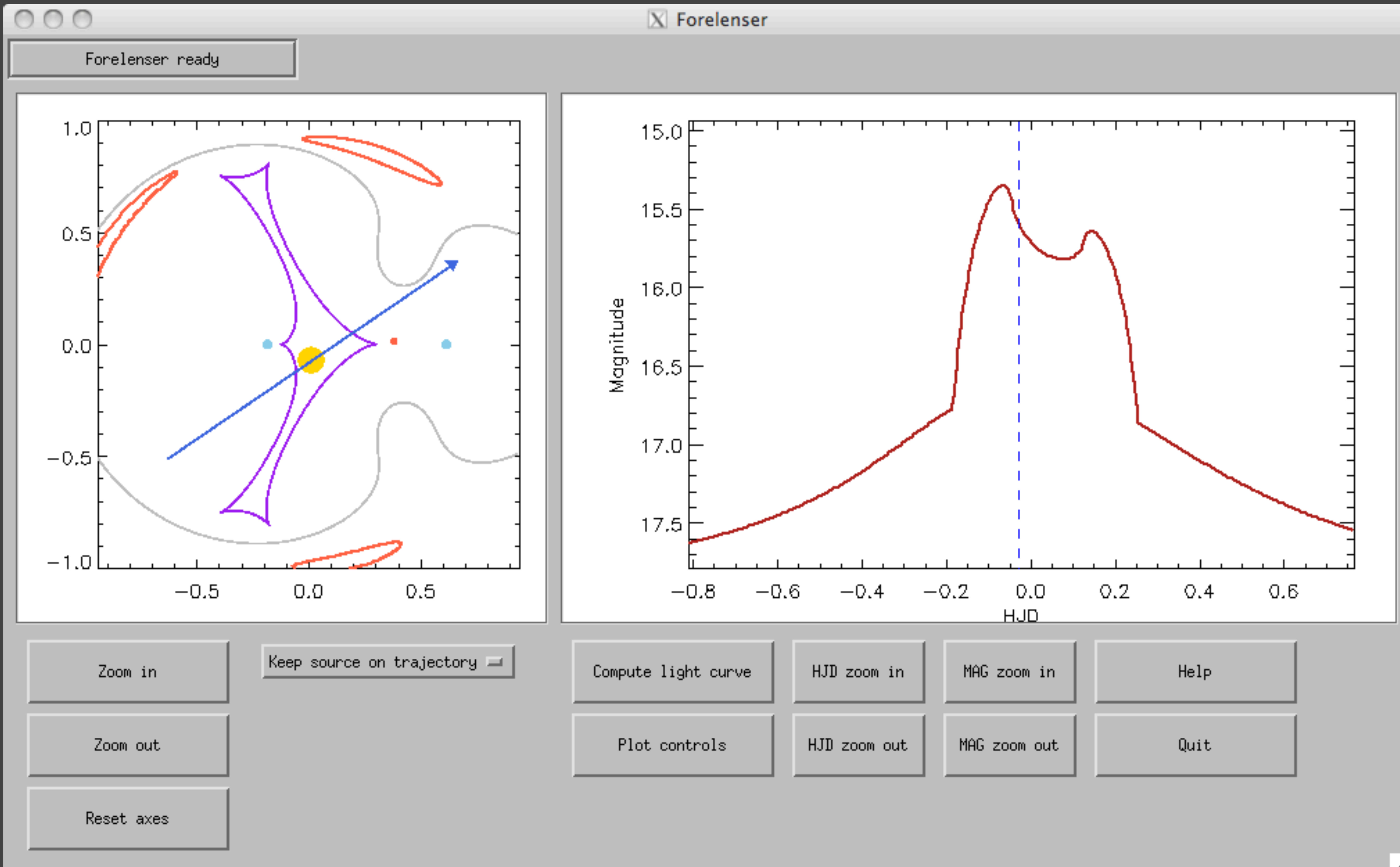
Forelenser
Forelenser ready
1.0
0.5
0.0
−0.5
−1.0
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HJD zoom out
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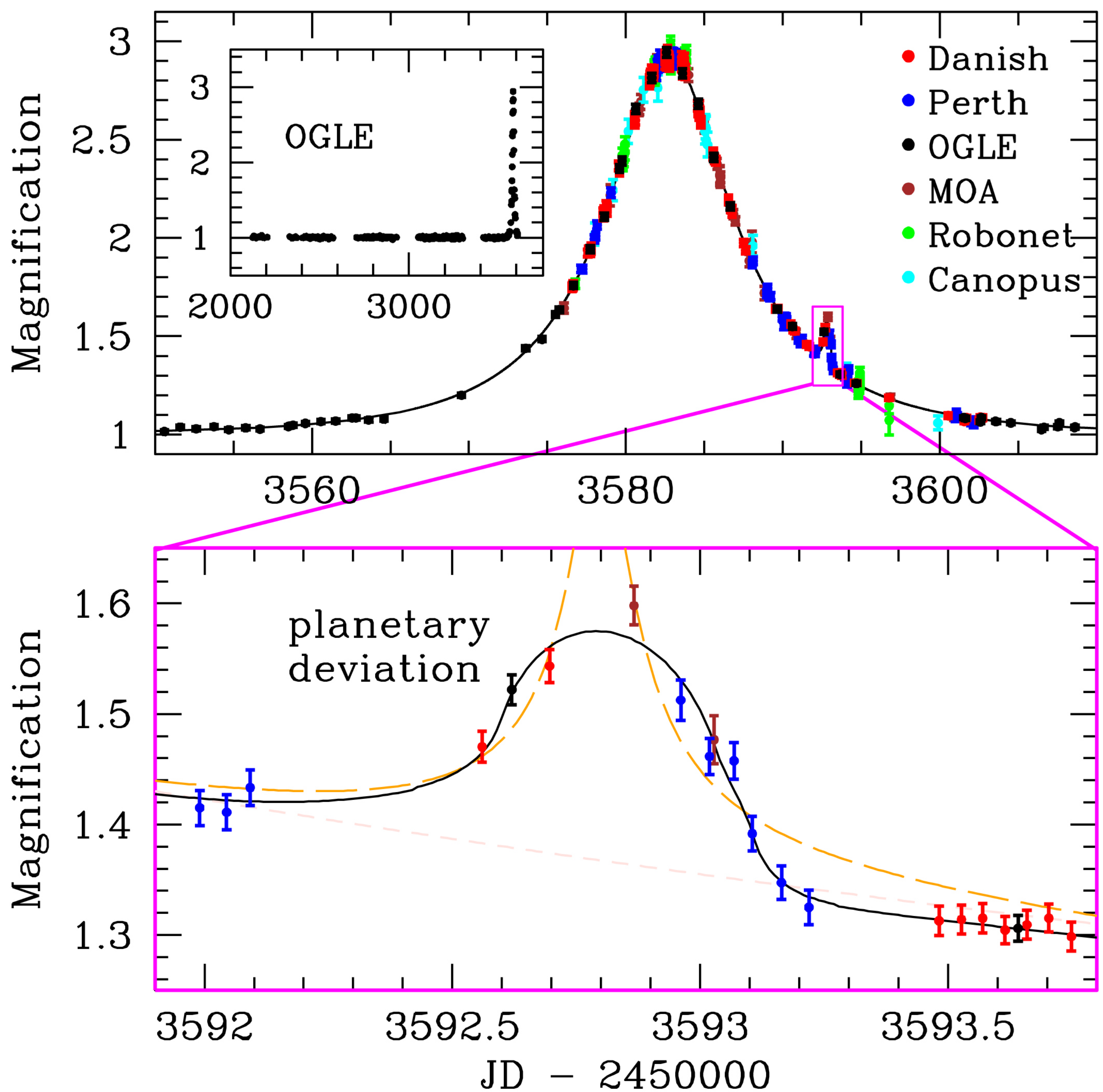
Reset axes

Guesssing model parameters

1. The light curve has a general shape of a single lens with local pertubation features
2. The light curve is strongly affected from a single lens shape, caustic crossing features are identified
3. Model degeneracies

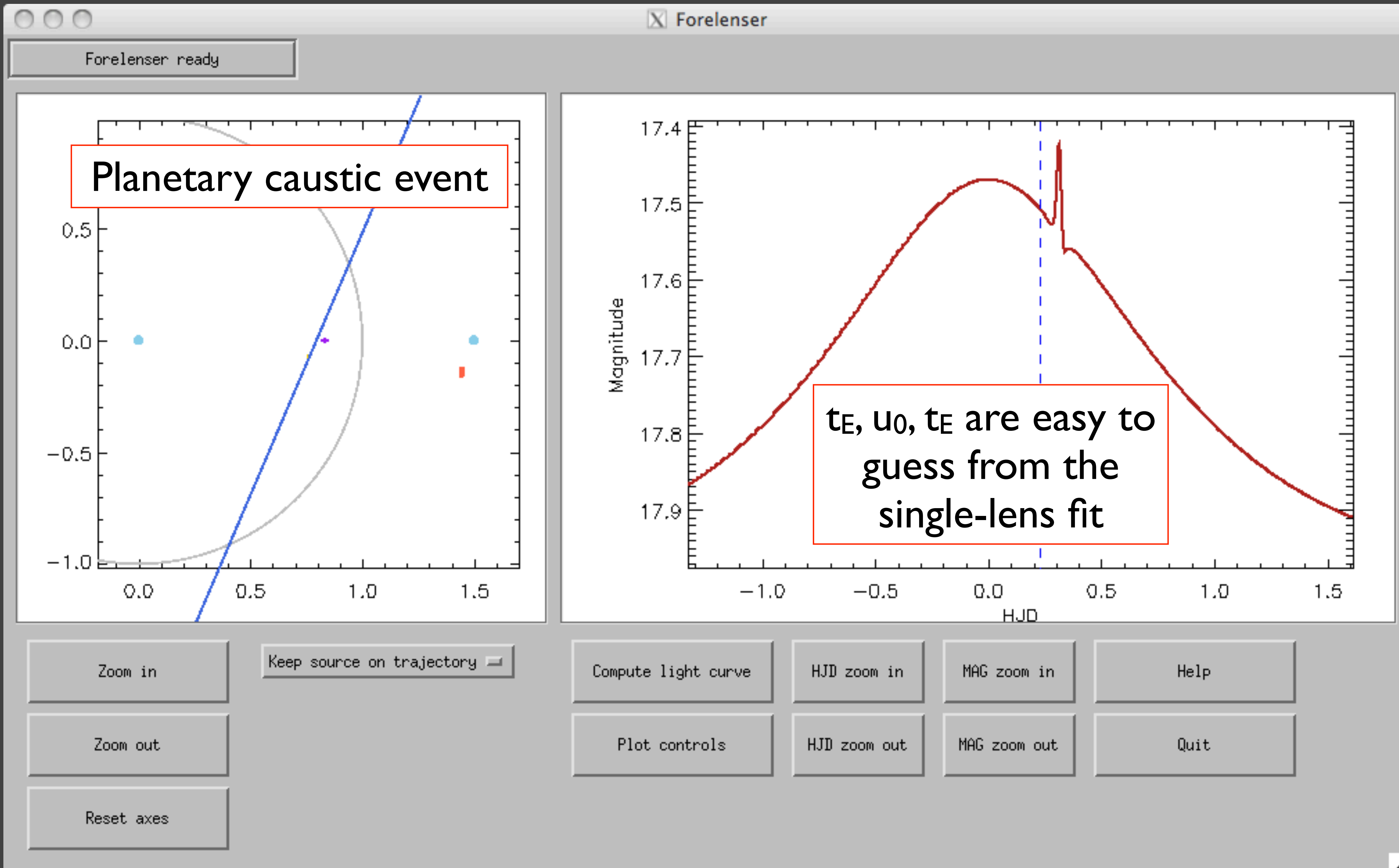
I. Light curve shape: single lens with local pertubation features

eg. OGLE 2005-BLG-390Lb [Beaulieu *et al.*, 2006]



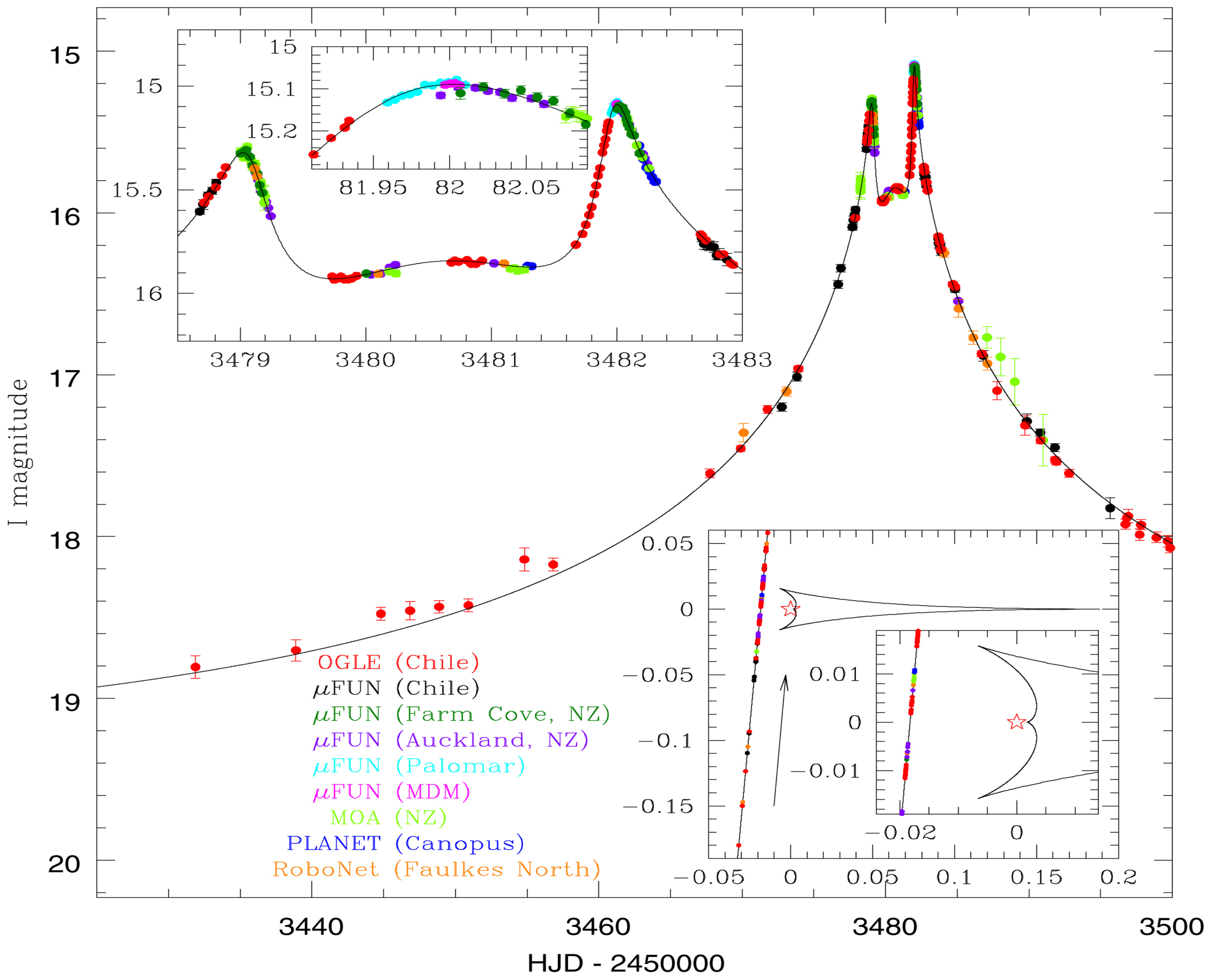
Planetary caustic event

I. Light curve shape: single lens with local pertubation features



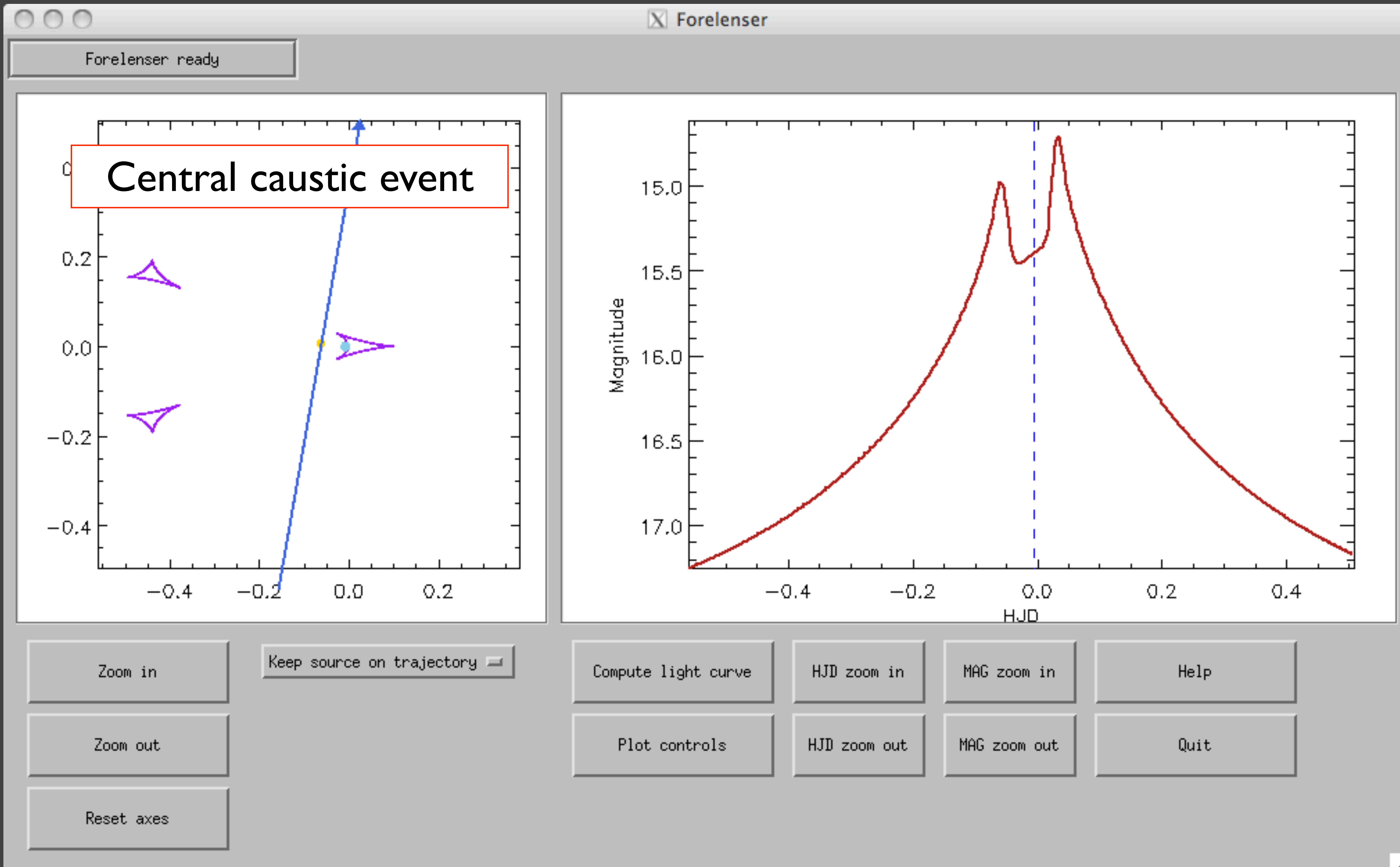
I. Light curve shape: single lens with local pertubation features

eg. OGLE 2005-BLG-071Lb [Udalski *et al.*, 2005]



Central caustic event

I. Light curve shape: single lens with local pertubation features



Guesssing model parameters

1. The light curve has a general shape of a single lens with local pertubation features
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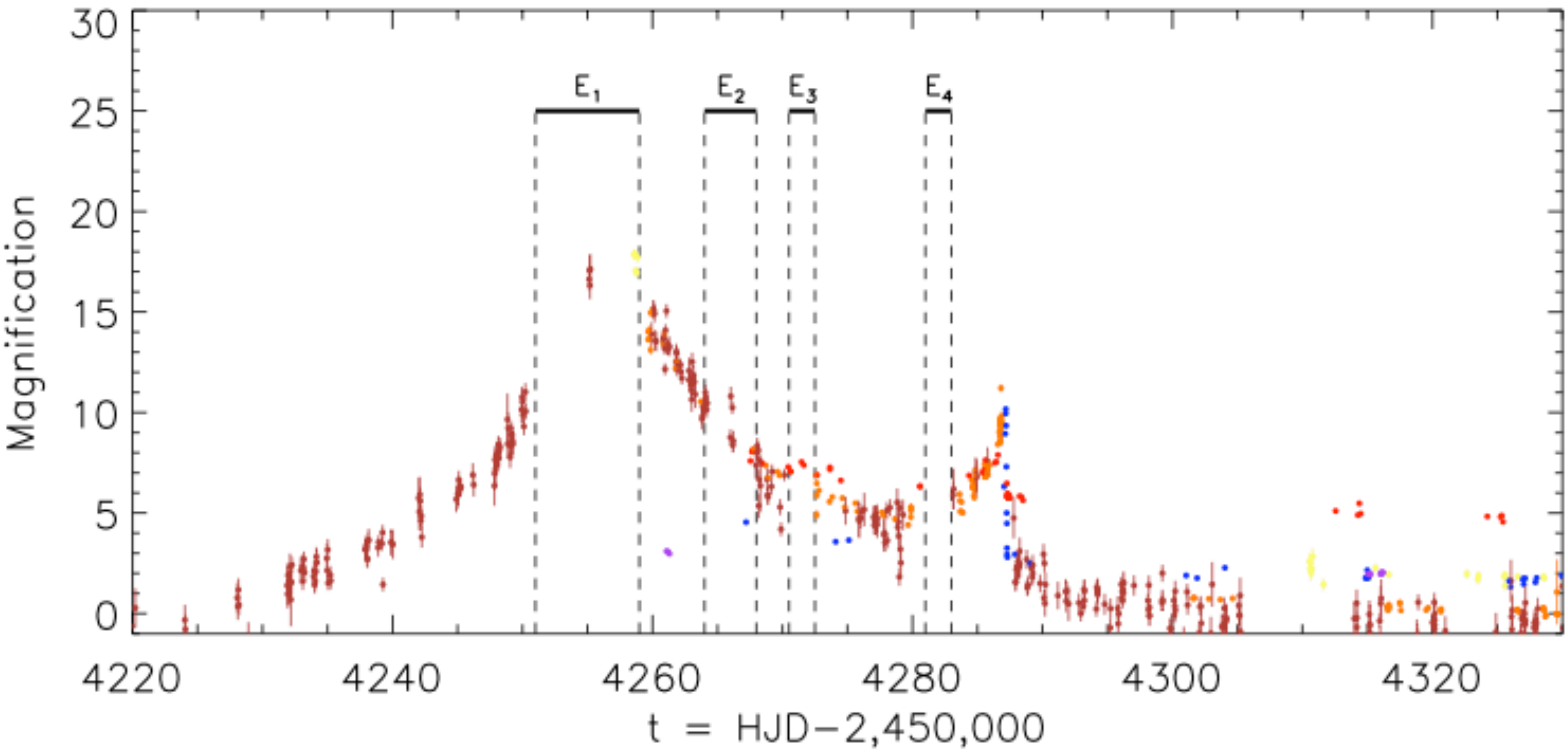
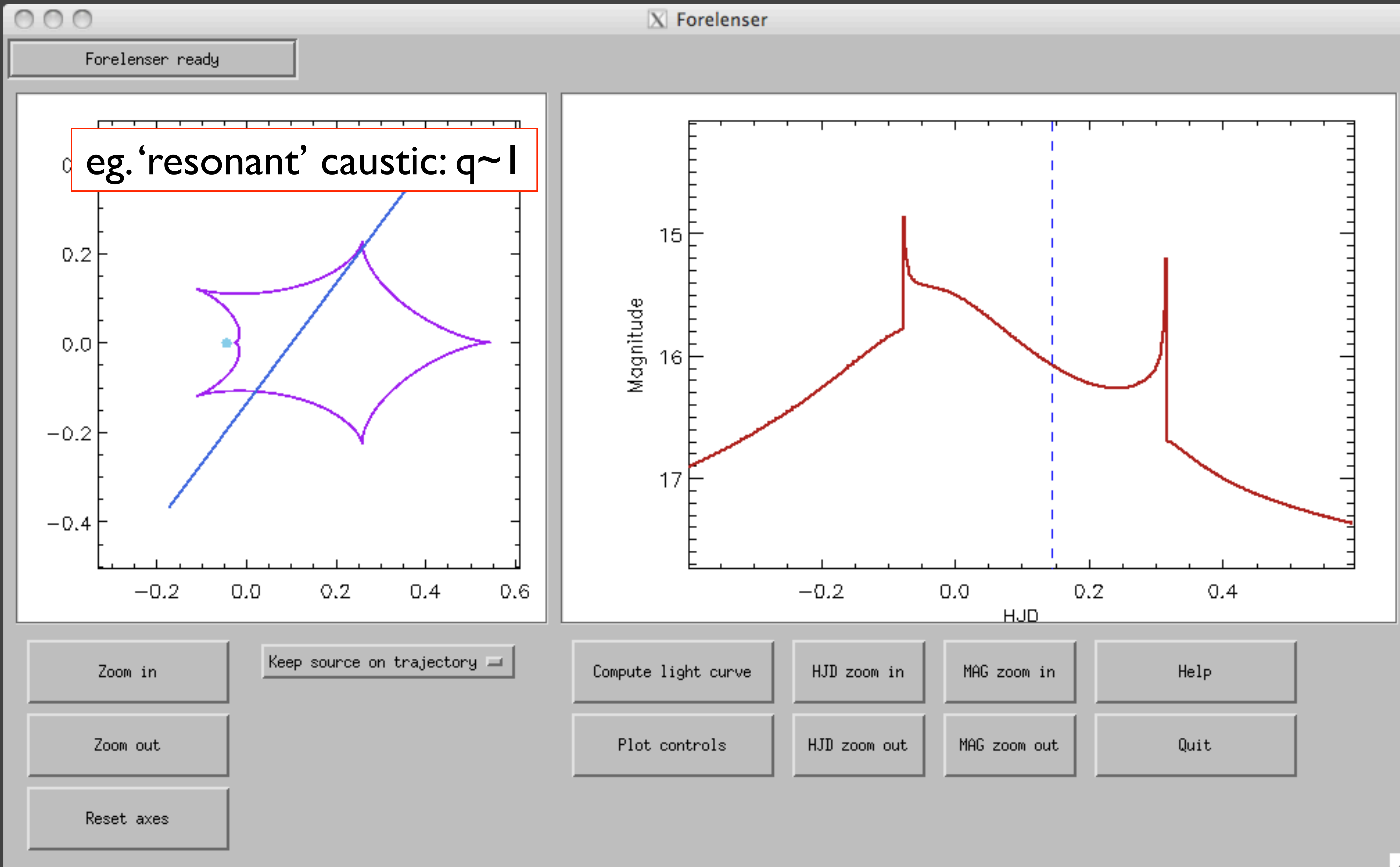
II. Light curve shape: pronounced anomaly features

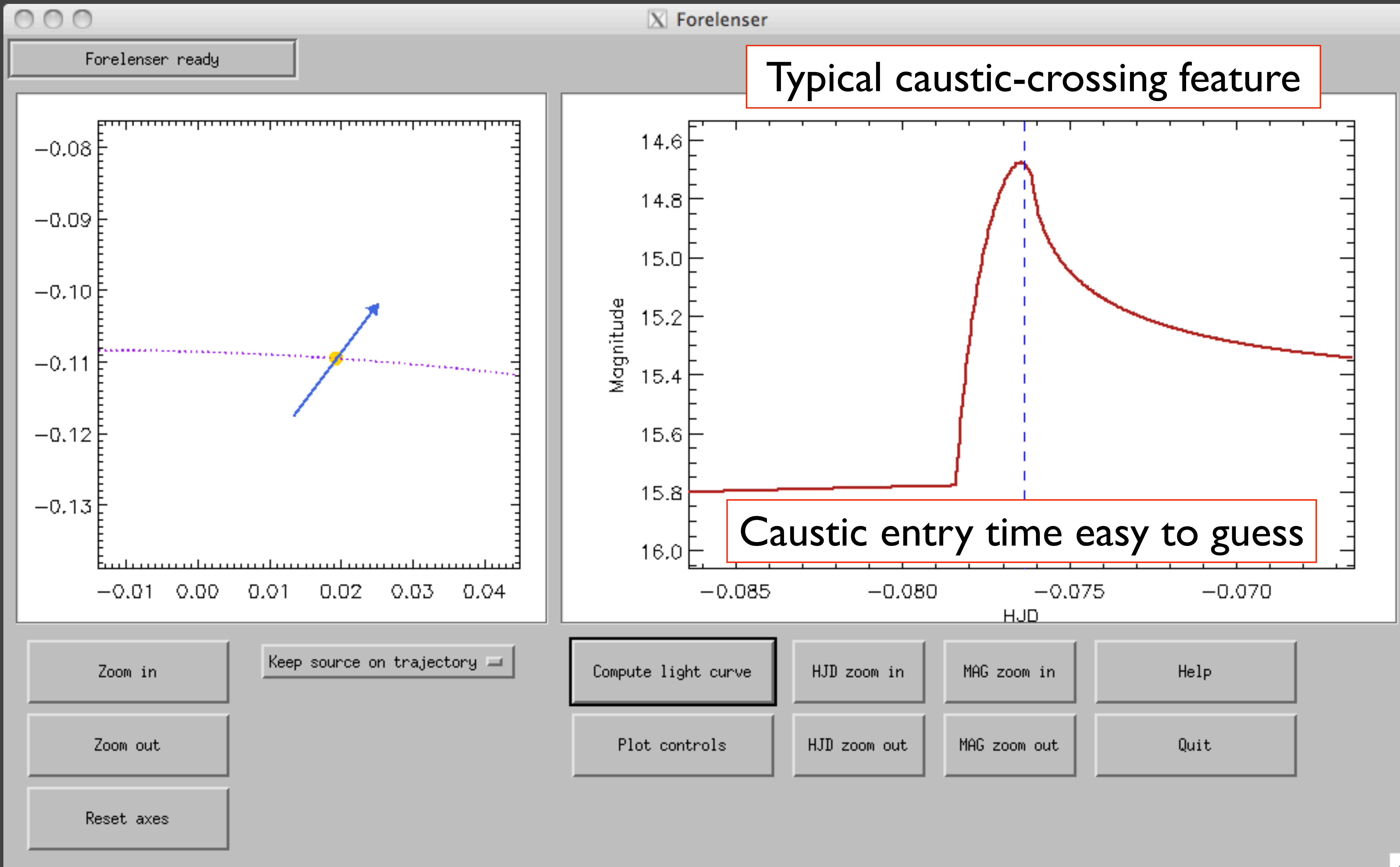
eg. MOA 2007-BLG-197



II. Light curve shape: pronounced anomaly features



II. Light curve shape: pronounced anomaly features



✎ Alternative parameters linked to the caustic entry/exit dates may be used

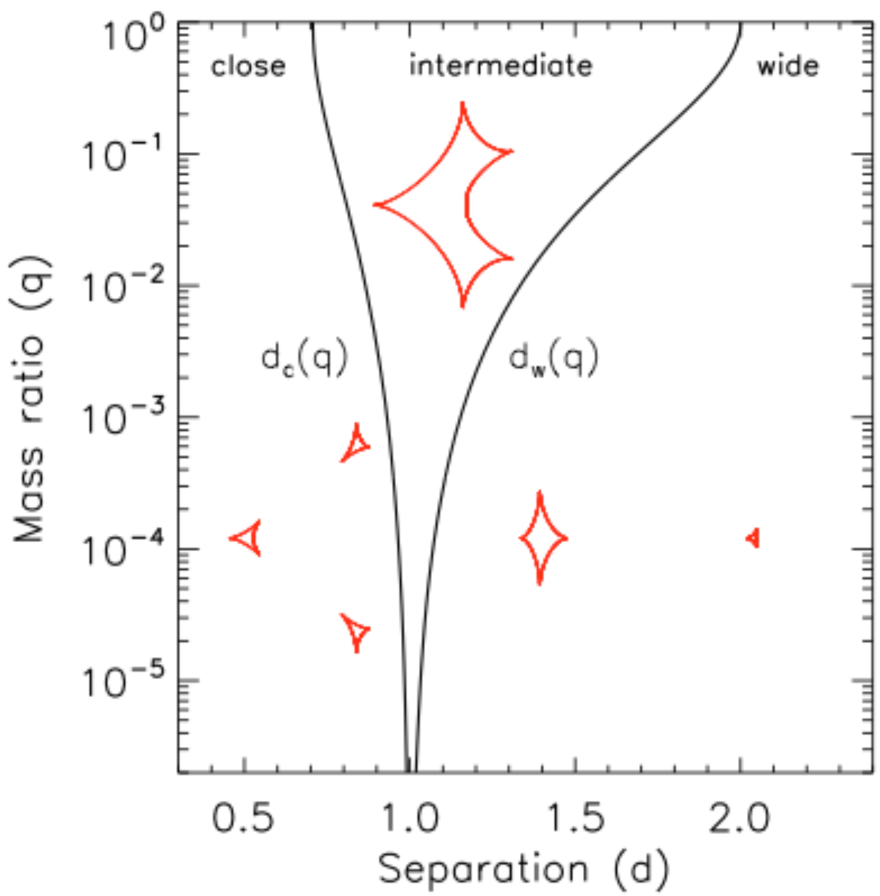
Alternative parameters for caustic-crossing event fitting

[Cassan, 2008 ; Cassan *et al.*, 2010]

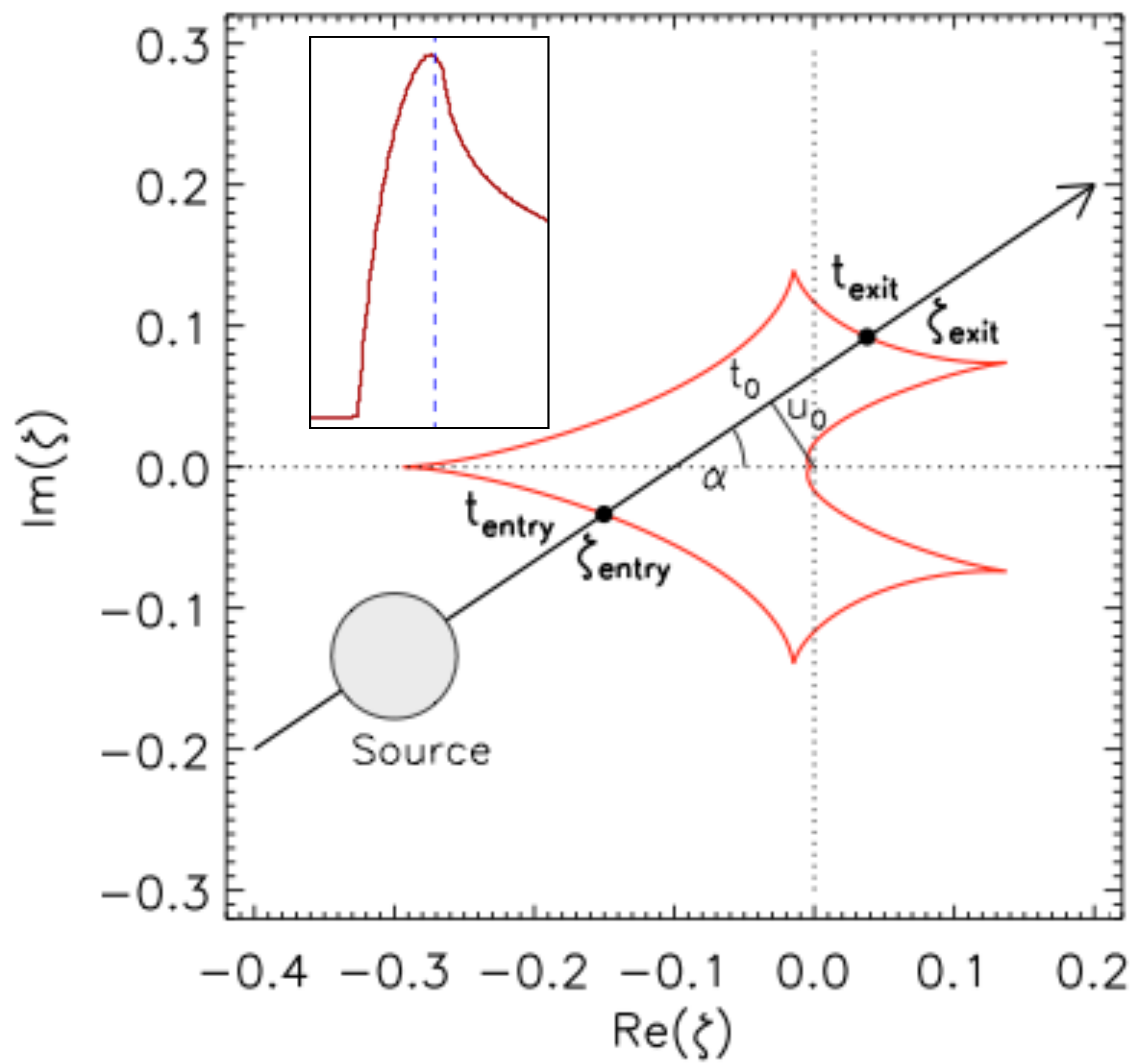
- Basic idea: caustic-entry and exit dates can be guessed from the light curve (alternatively, different scenarii of crossing dates can be studied)
- Goal: probing efficiently all possible static binary-lens models
- Locate all local minima in the parameter space. Use the static lenses as starting parameters for further higher-order effects (parallax, binary rotation, ...)

The new parameters that describe the trajectory

The three binary-lens caustic topologies

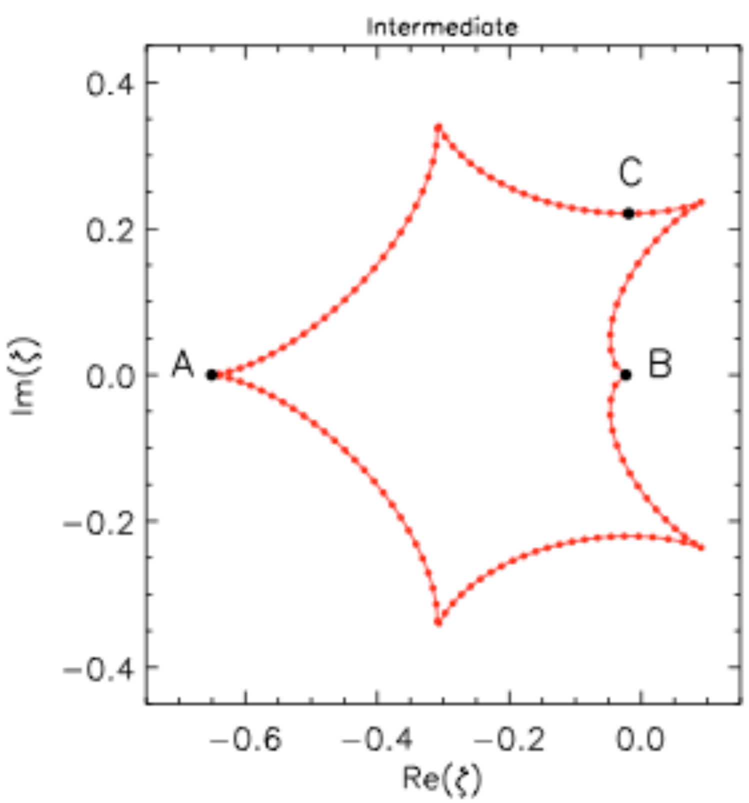


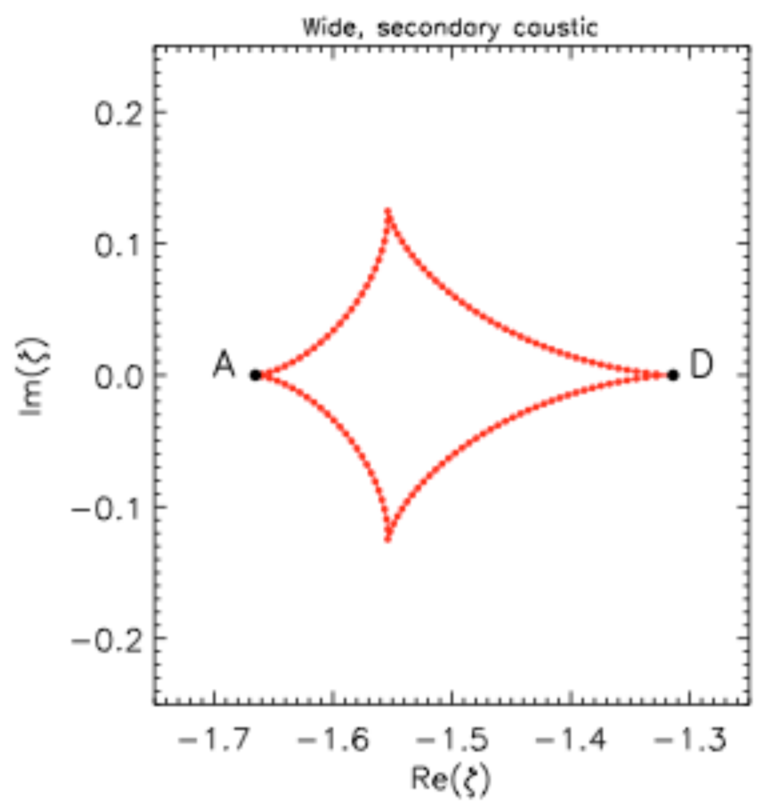
Alternative fitting parameters:
- Caustic crossing dates
- Positions on the caustic



Generating a trajectory with the alternative parameters

a) Parametrize the caustic: each point is a possible caustic entry/exit

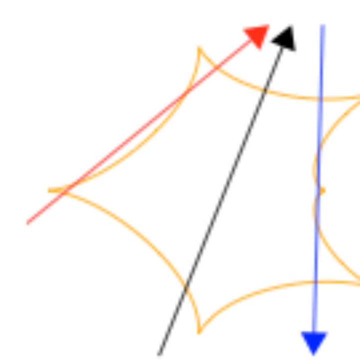




etc...

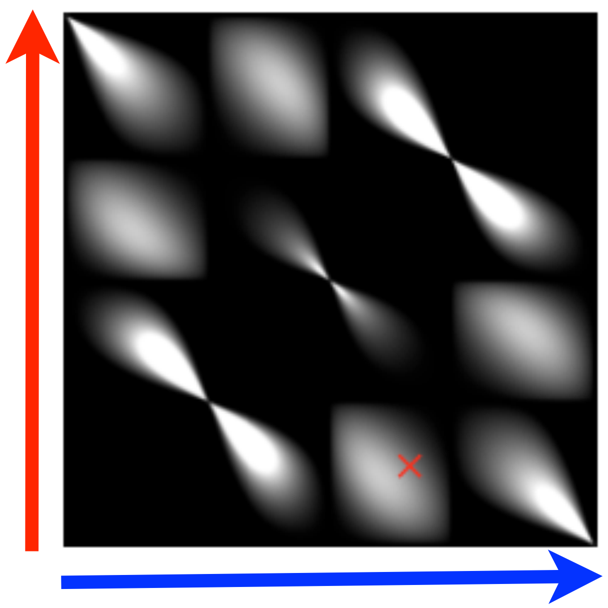
b) Draw the trajectory between the chosen entry/exit points and compute the light curve

c) Optimize by varying the entry and exit points



Efficient exploration of the alternative parameter space

Exit position on the caustic

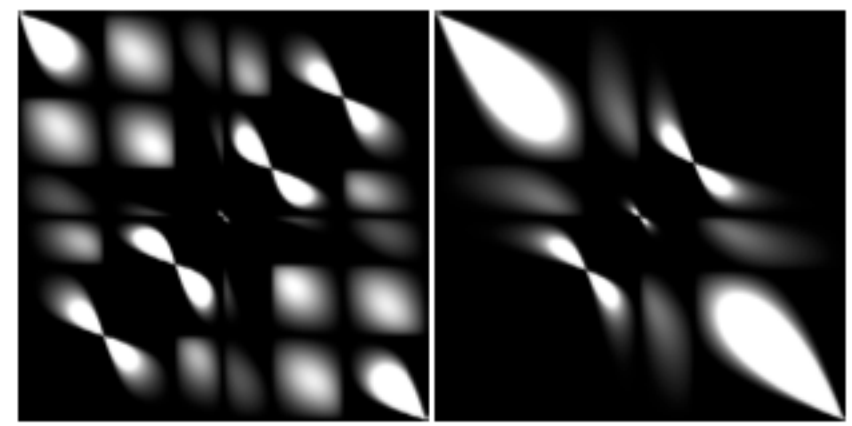


d=0.5
q=0.6

Entry position on the caustic

Assumption:
Trajectories are uniformly distributed in angle and impact parameter

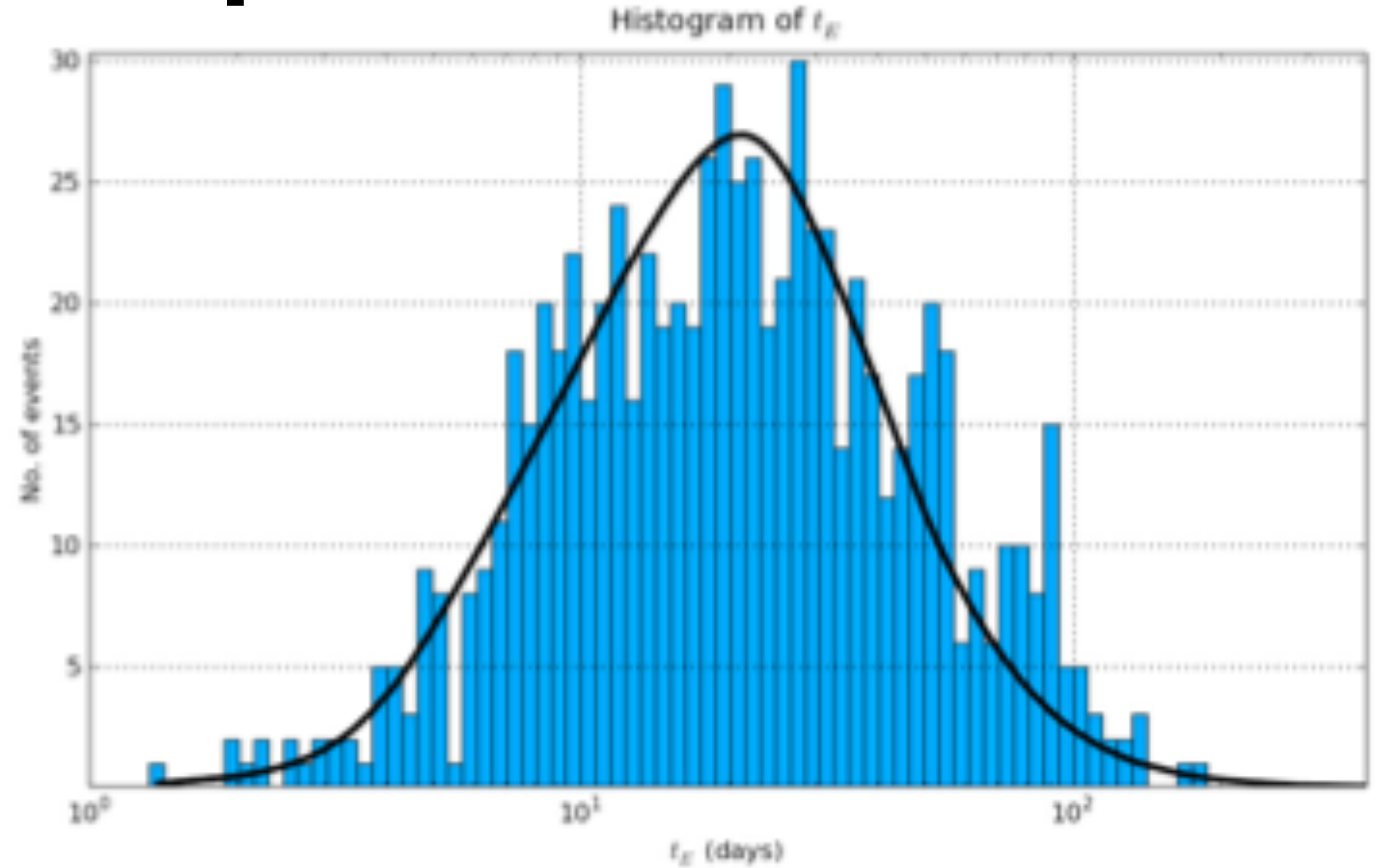
... and for other (d, q) configurations:

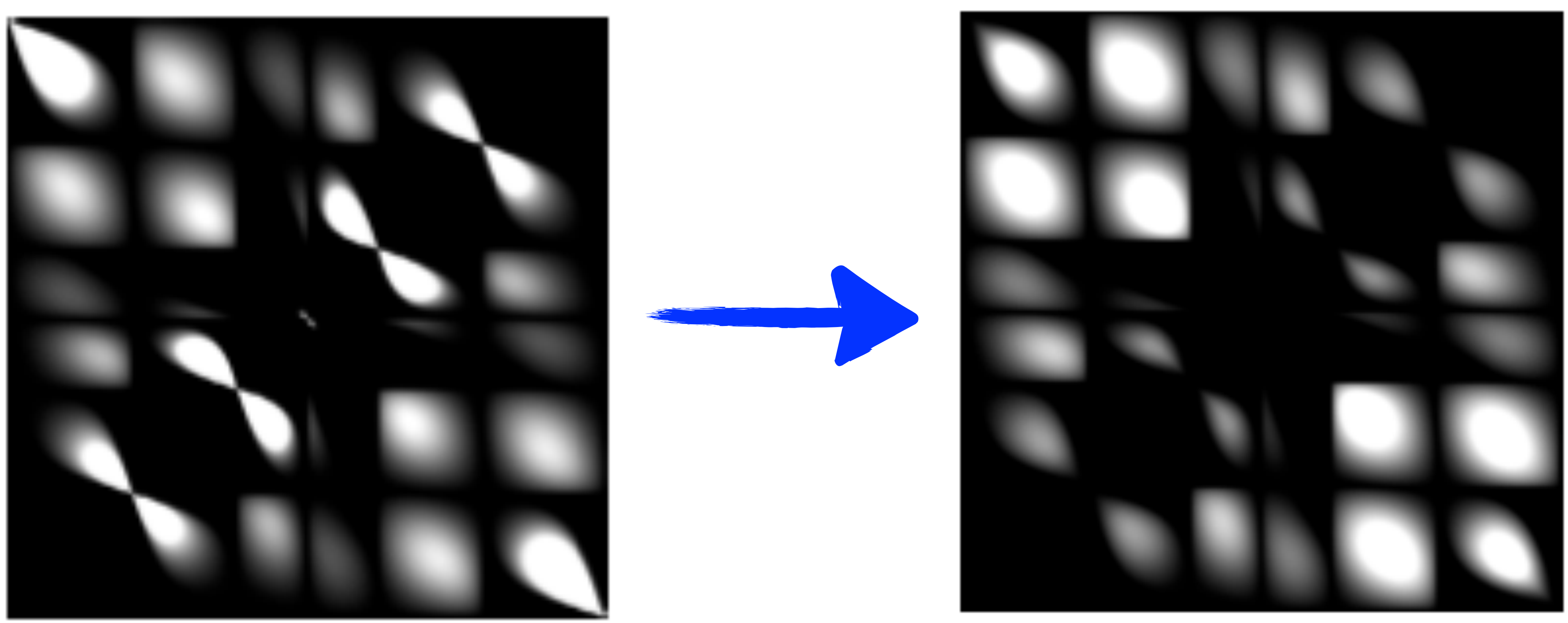


etc...

- The black regions are impossible configurations (eg. exit before entry)
- The probability of a given entry+exit configuration is highest for white regions
- Only models that produce the features seen in the light curve (caustic-crossings) are computed

Example using an **observational prior** on the distribution of t_E





Guesssing model parameters

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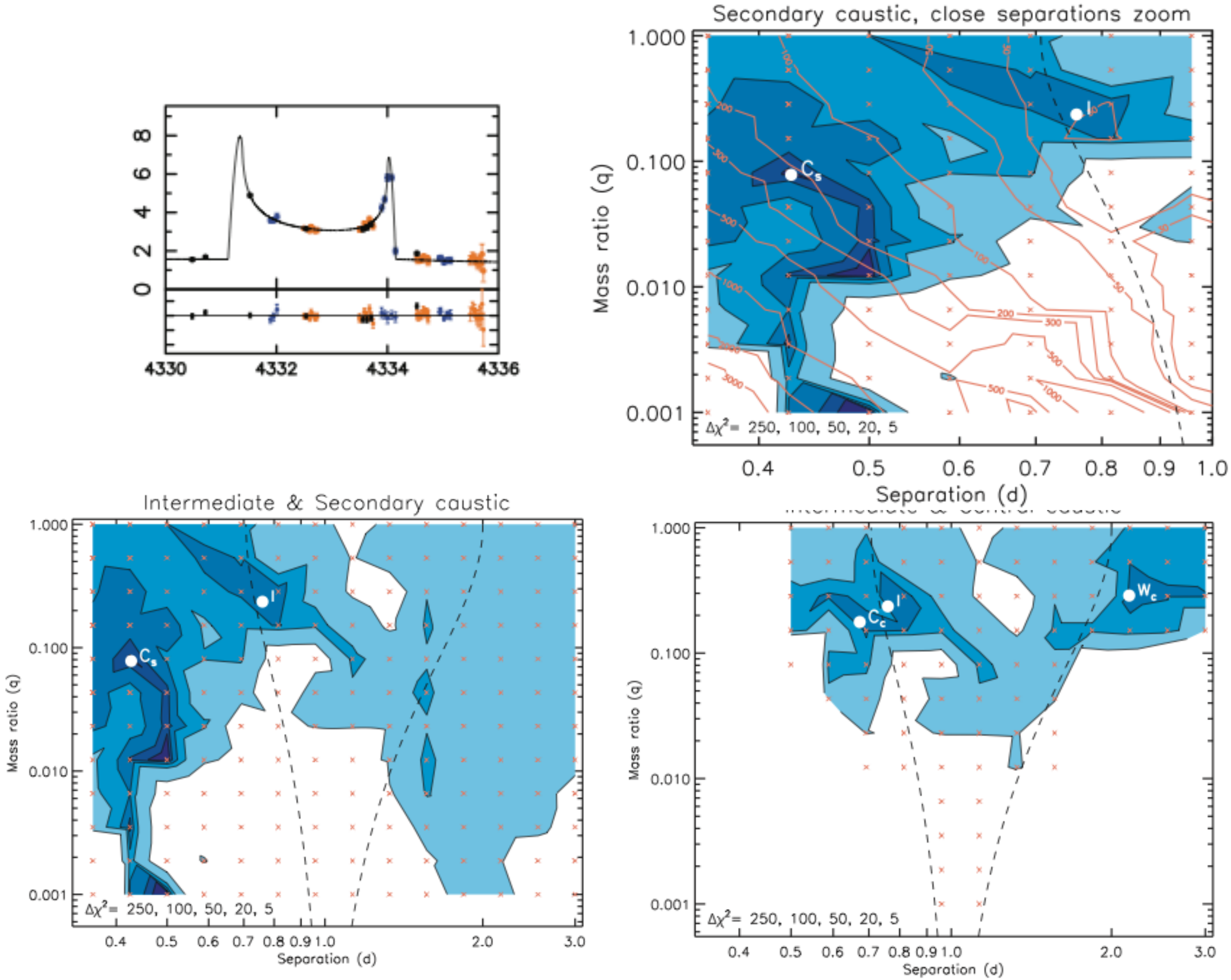
OK, you've found a model nicely fitting the data – but the work **is not finished yet**!

- Remember that you always probe local minima, even when good guess parameters can be extracted from the light curve shape or features. Other guessed parameters may have led to other models with comparable goodness-of-fit

- Exploring widely and completely the parameter space is thus a requirement

Example of a very pathetic case... [Kains *et al.* 2009]



Your turn to play!