Next-Generation Microlensing: Preliminary Results from a Pilot Experiment

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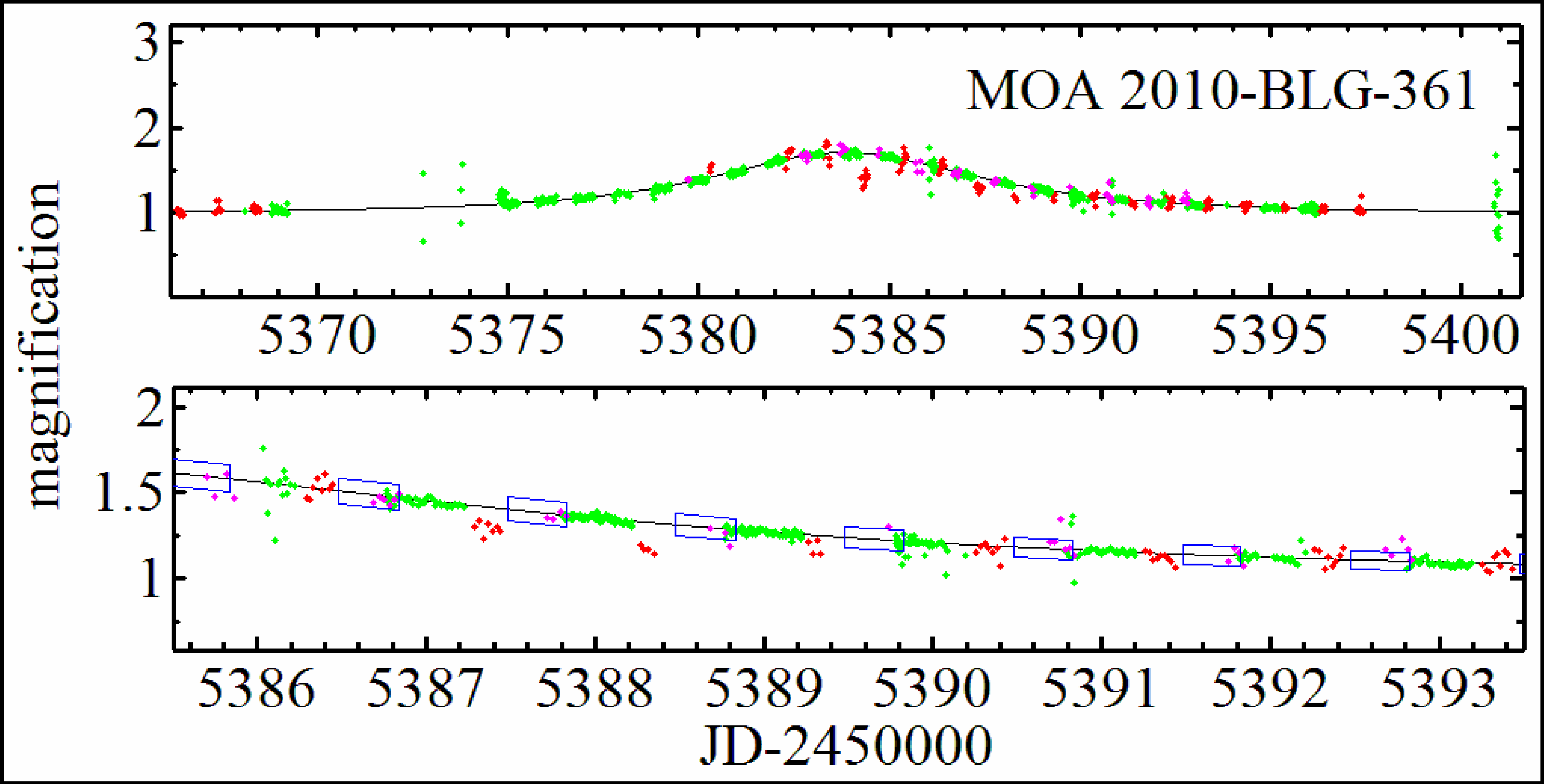
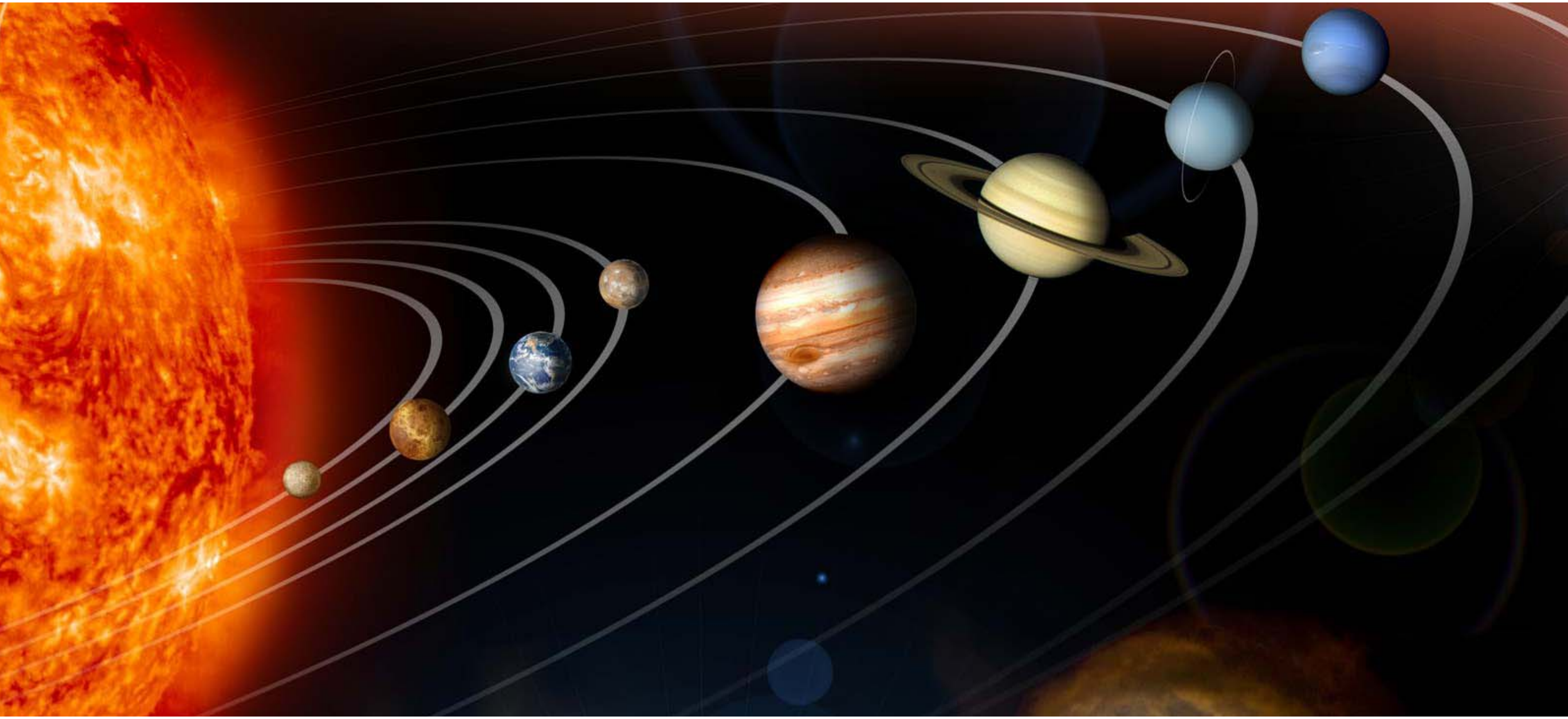
in collaboration with OGLE, MOA, microFUN



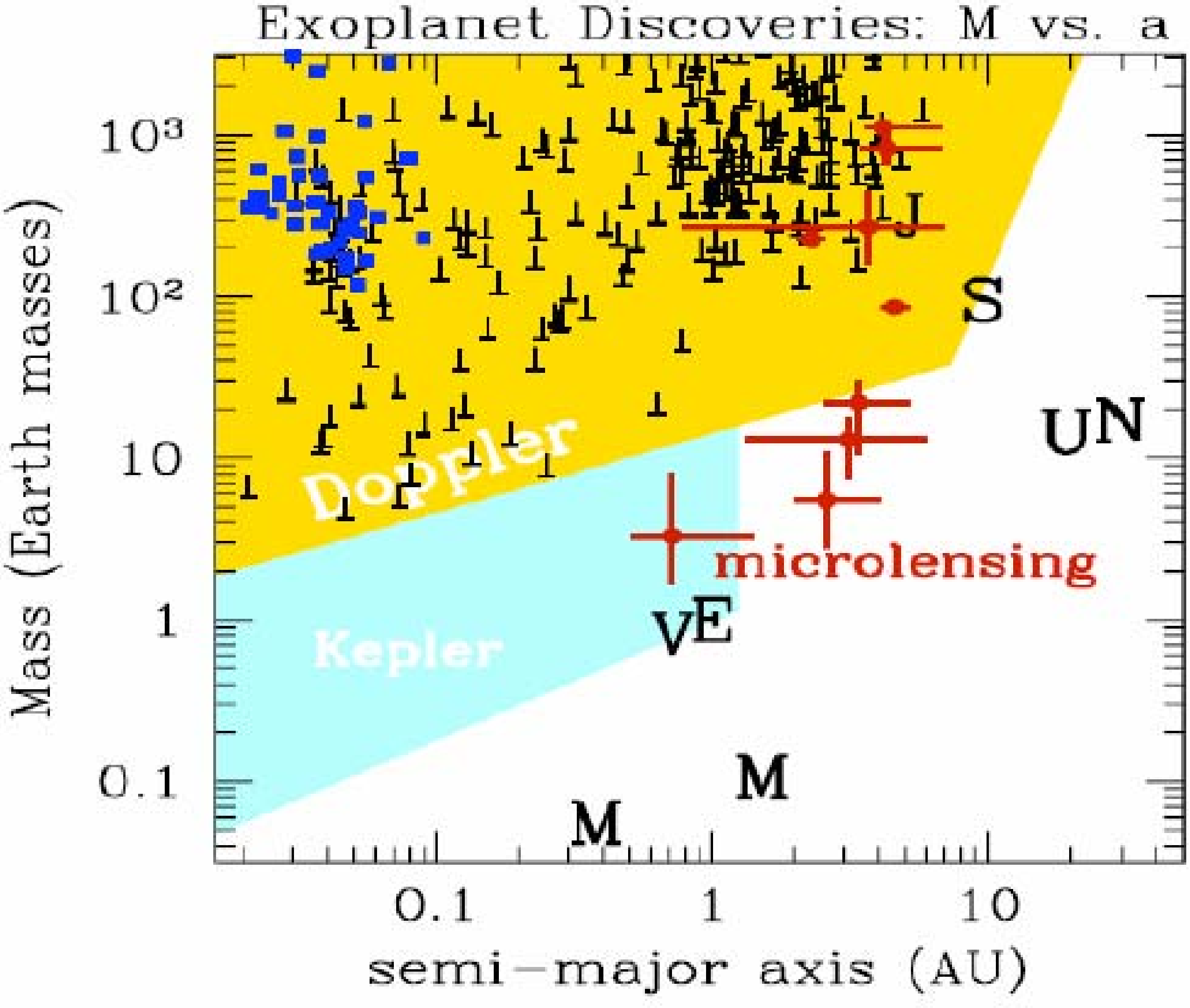
What is the frequency of extrasolar planetary systems?

Are they solar analogs?



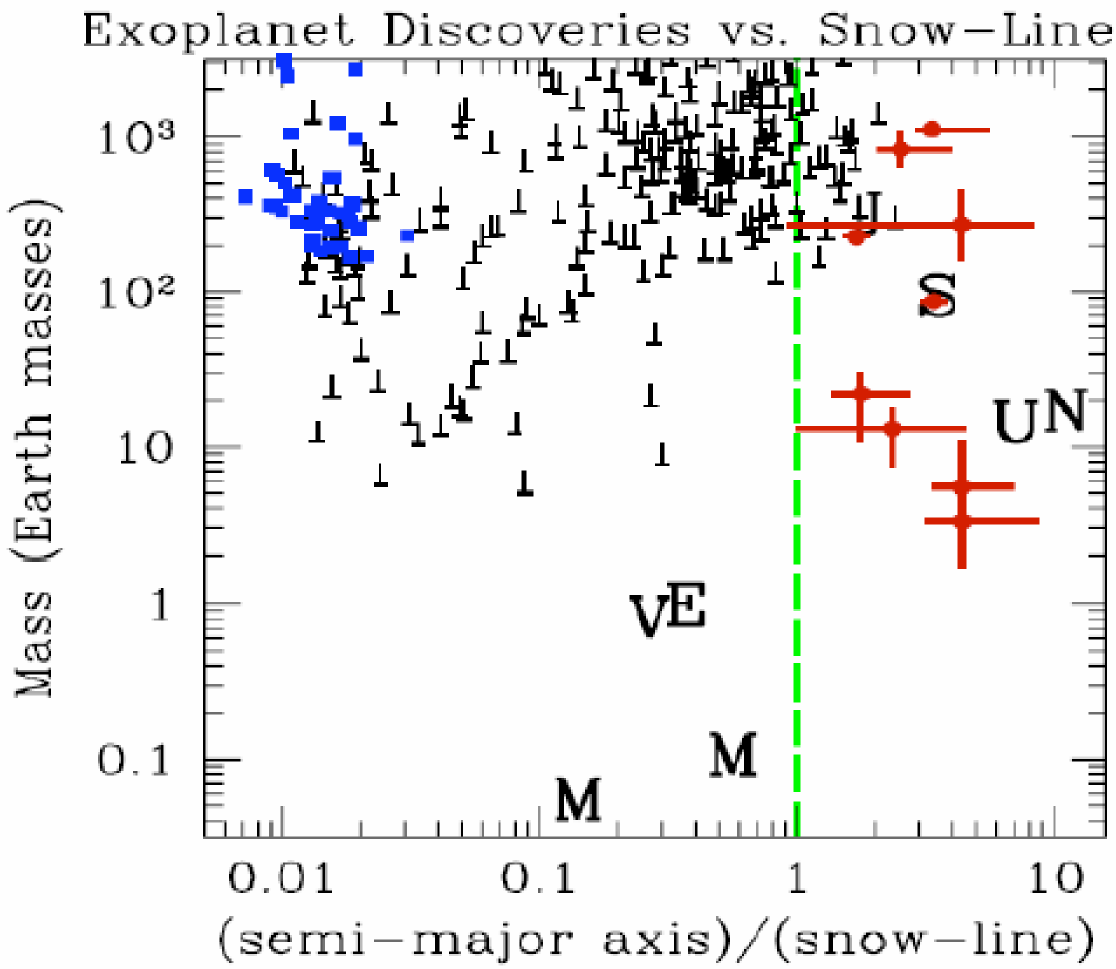
Microlensing has probed a unique region of planetary parameter space…

Gould et al. 2006, 2009



…near the Einstein radii of stars ~ their “snow lines”.

Gould et al. 2006, 2009

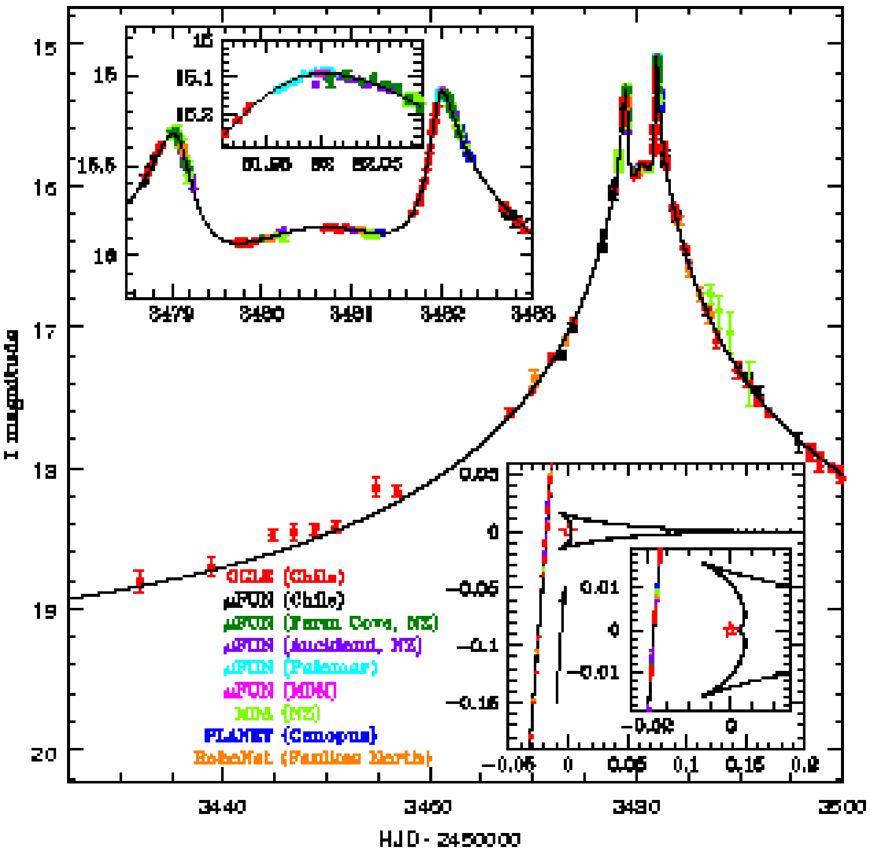


But, only ~15 microlensing planets to date, not competitive with other methods.

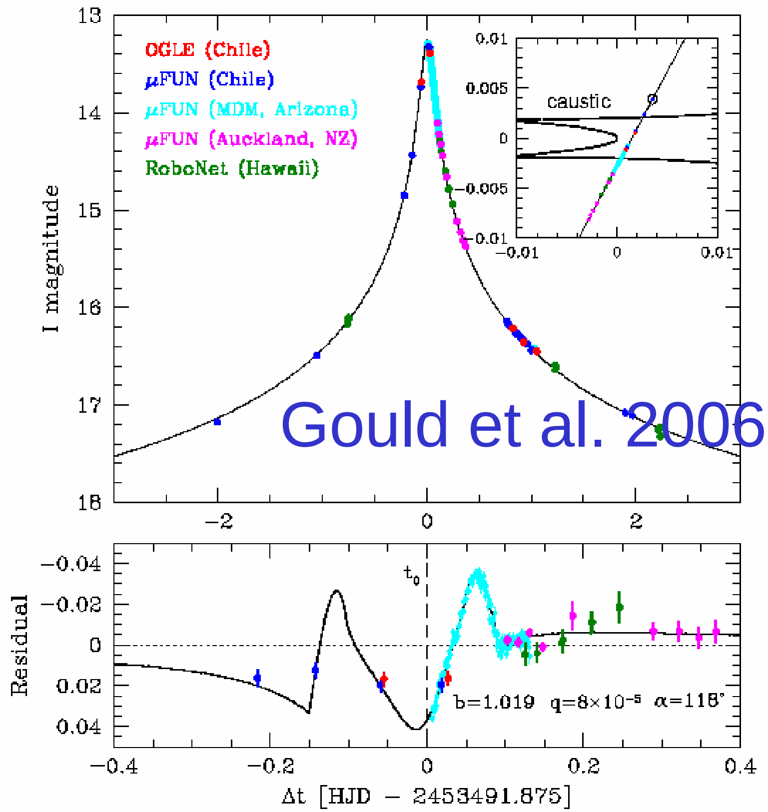
Why so few?

Observational focus on bright, high-magnification (~100) events.

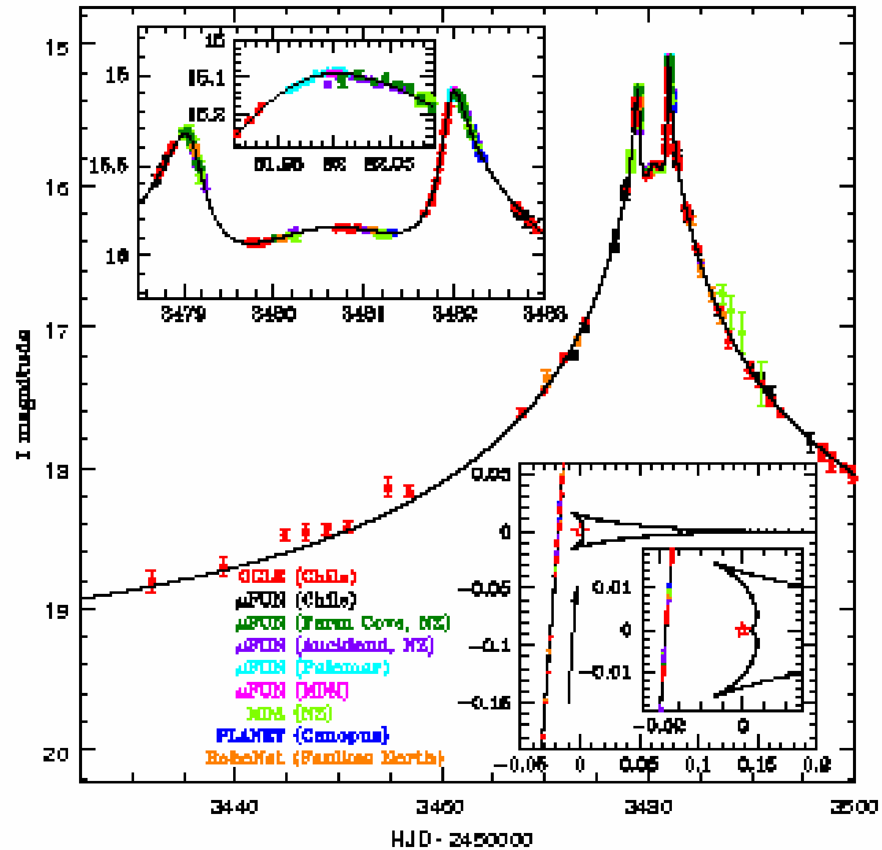
Udalski et al. 2005

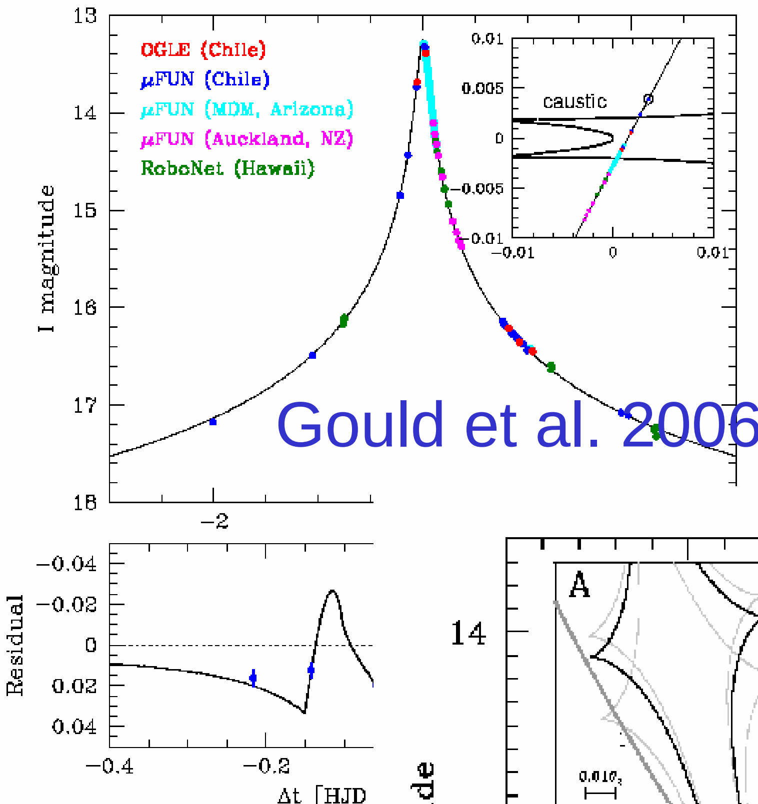


Udalski et al. 2005

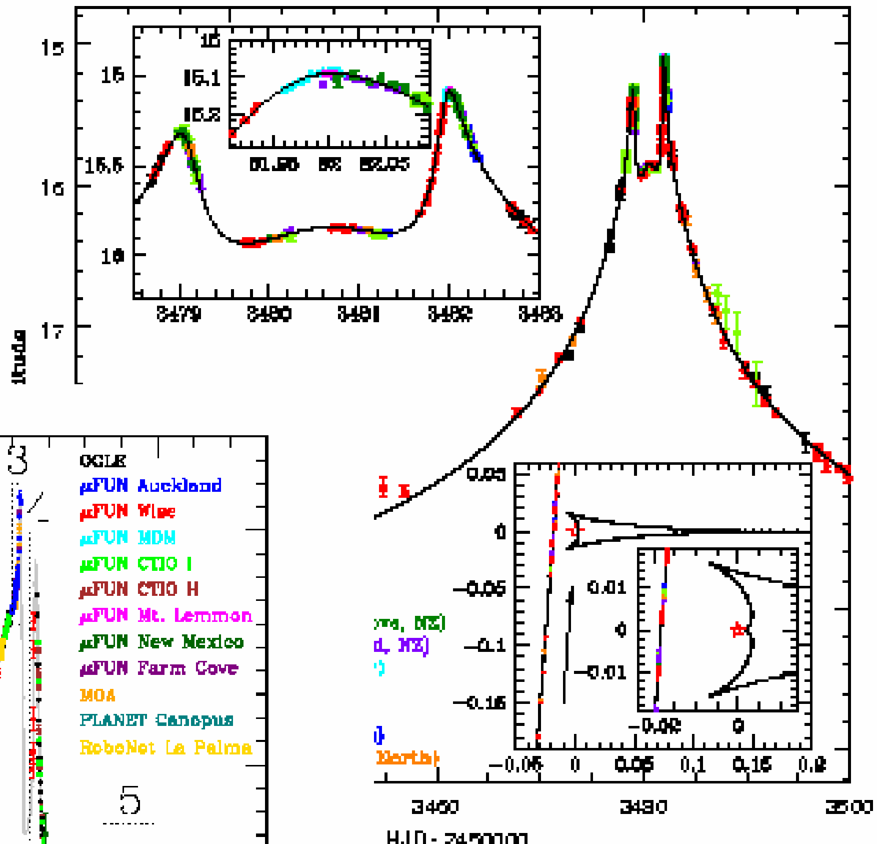


Gould et al. 2006

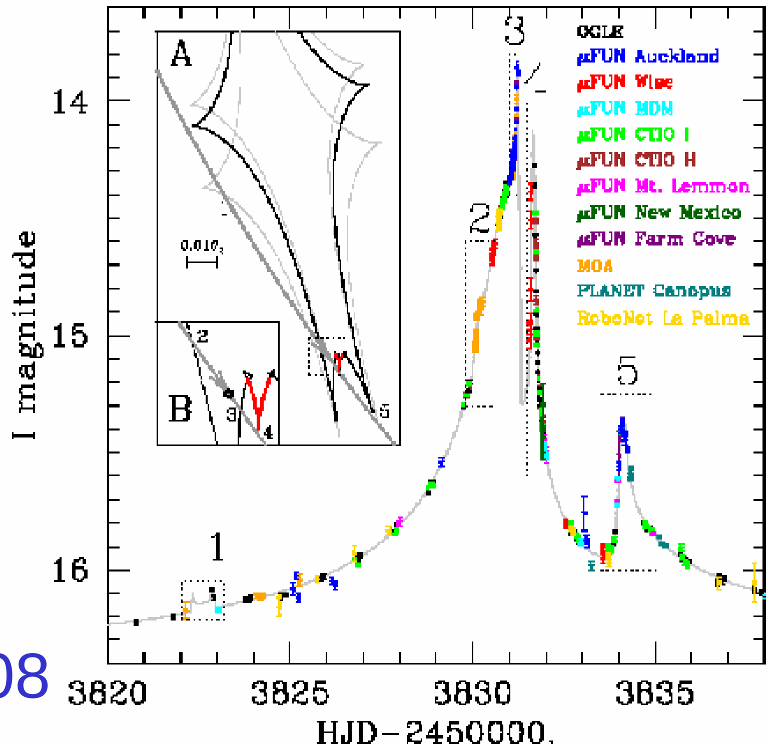




Gould et al. 2006



Udalski et al. 2005



Gaudi et al. 2008

High-magnification (~100x) events are:

Good: ~100% sensitivity to planets projected near Einstein radius,

+ high S/N light curves even with small and amateur telescopes.

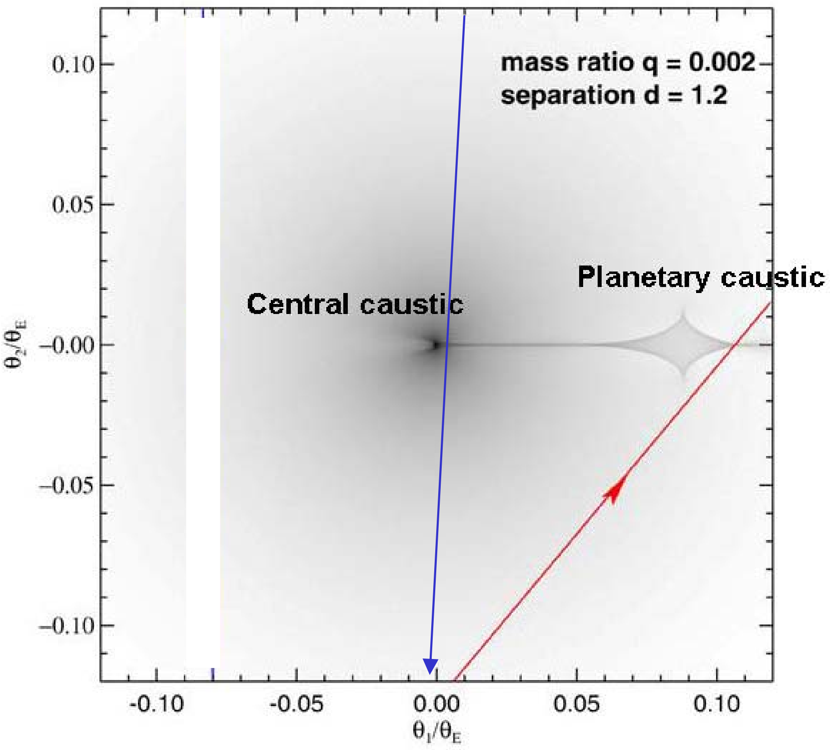
Bad: Rare events (~1%) → ~7 events/year → 1-2 planets/year.

As opposed to high-mag (central caustic) events,

Low-magnification (planetary caustic) events:

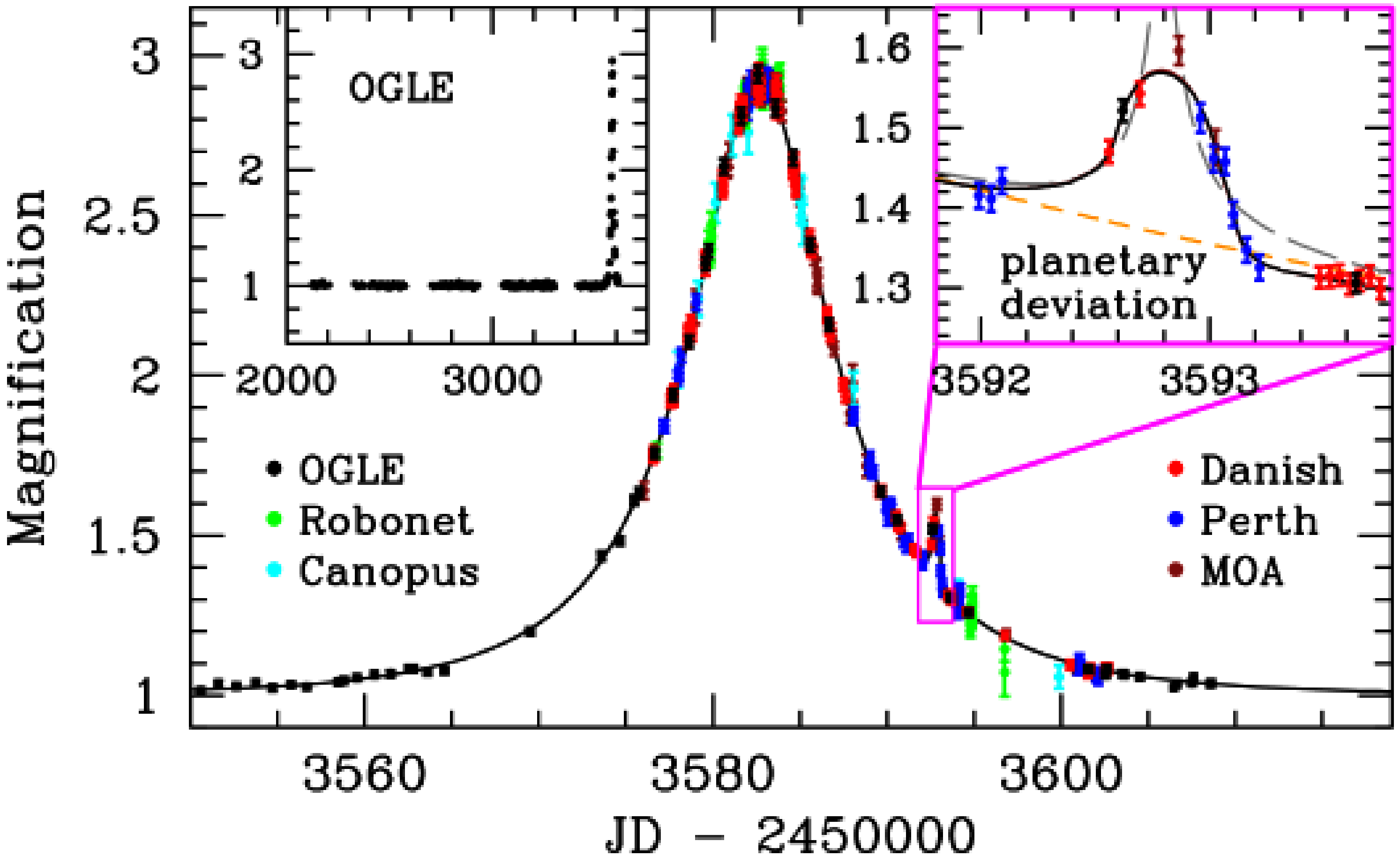
Lower planet detection efficiency, but much more common:

Potential for tens of microlensing planets/year.



A. Cassan

Beaulieu et al. 2006



Need network of 1-2m class telescopes with degree-scale imagers for continuous monitoring of many low-mag events in search of planetary perturbations:

“Generation II microlensing”

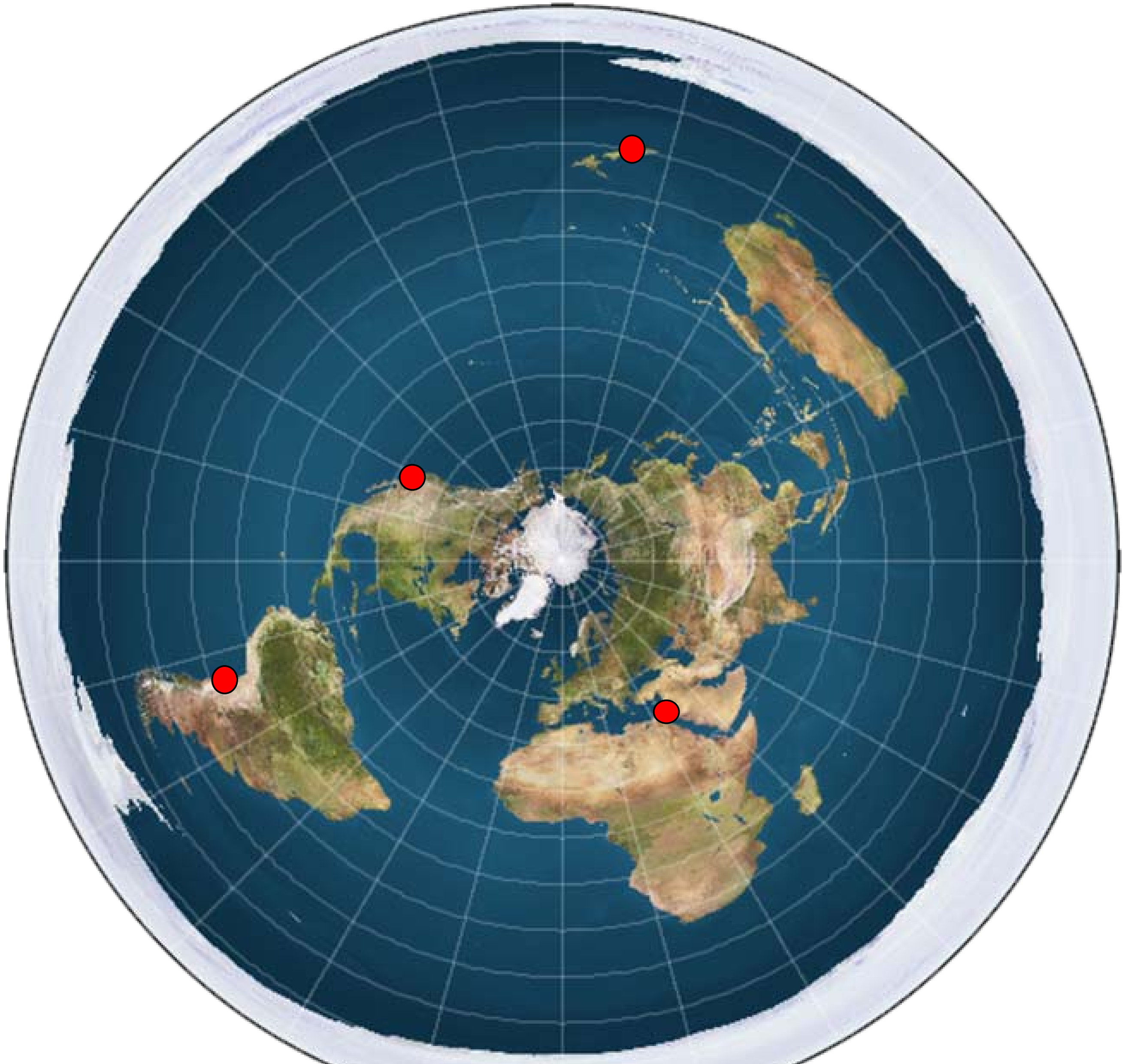
June-July 2010: A generation-2 pilot experiment:

Wise Obs., Israel, 1m, 1 deg^2

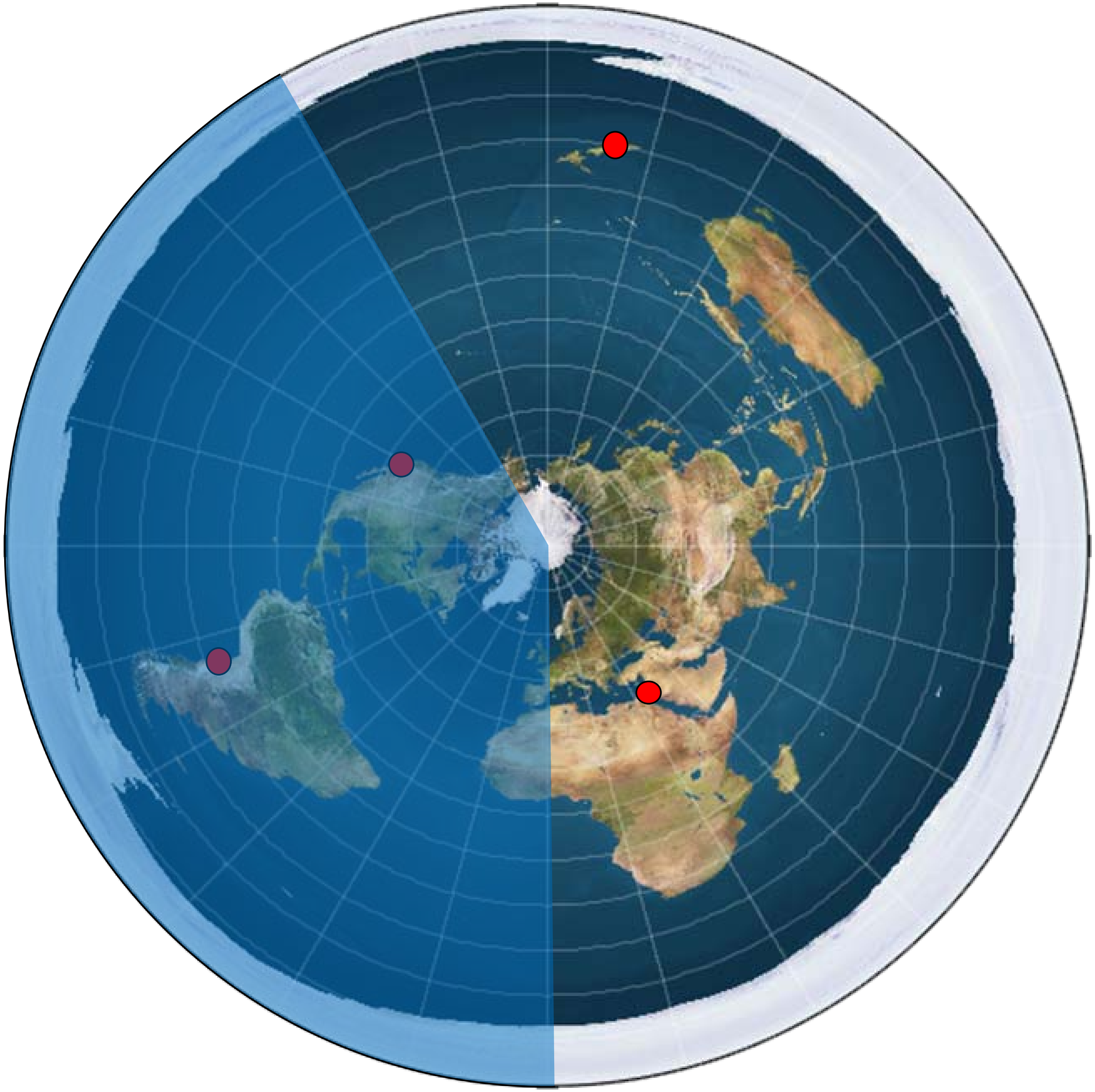
PTF, California, 1.2m, 7.8 deg^2

OGLE IV, Chile, 1.3m, 1.4 deg^2

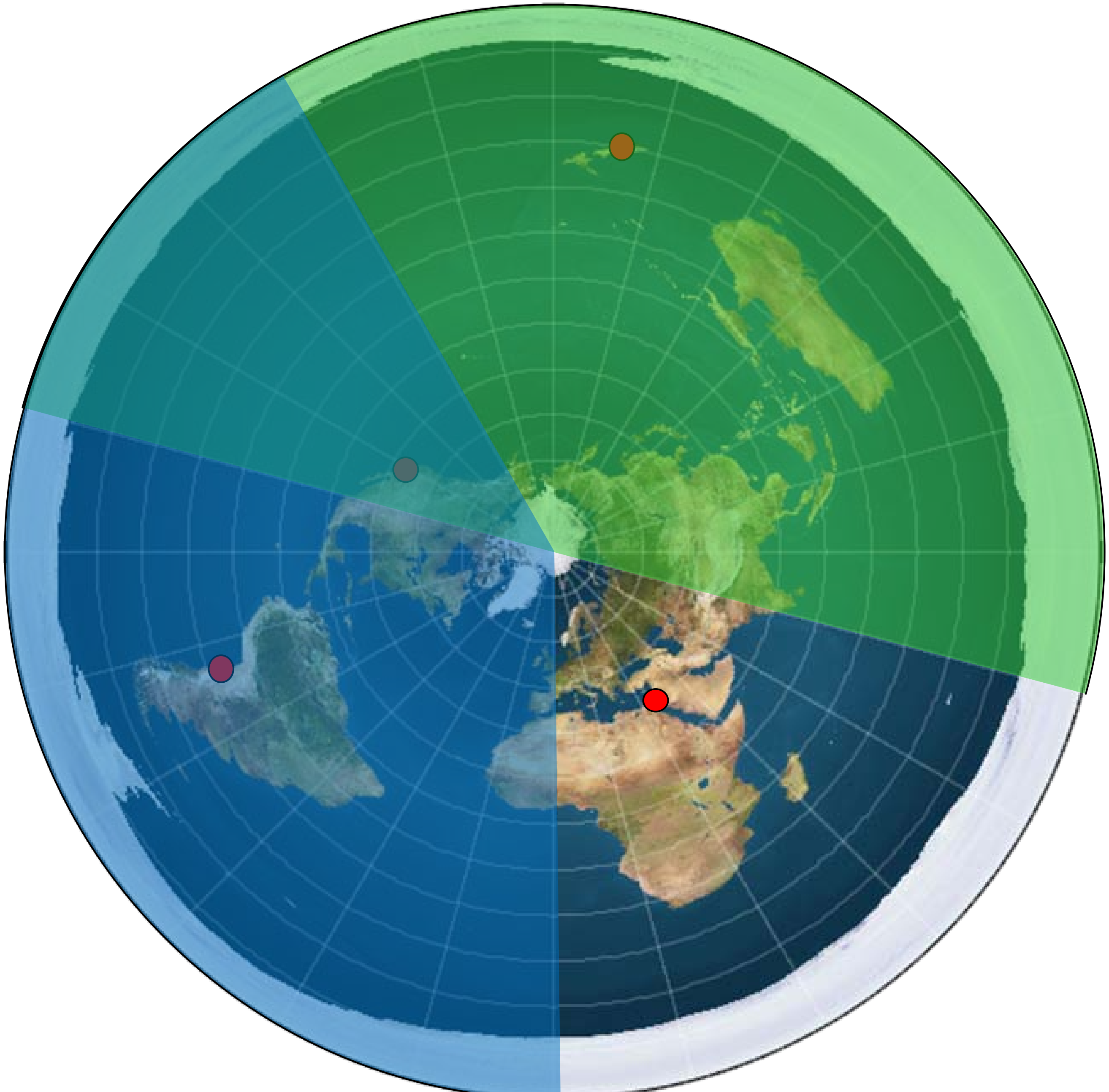
MOA-II, NZ, 1.8m, 2.3 deg^2



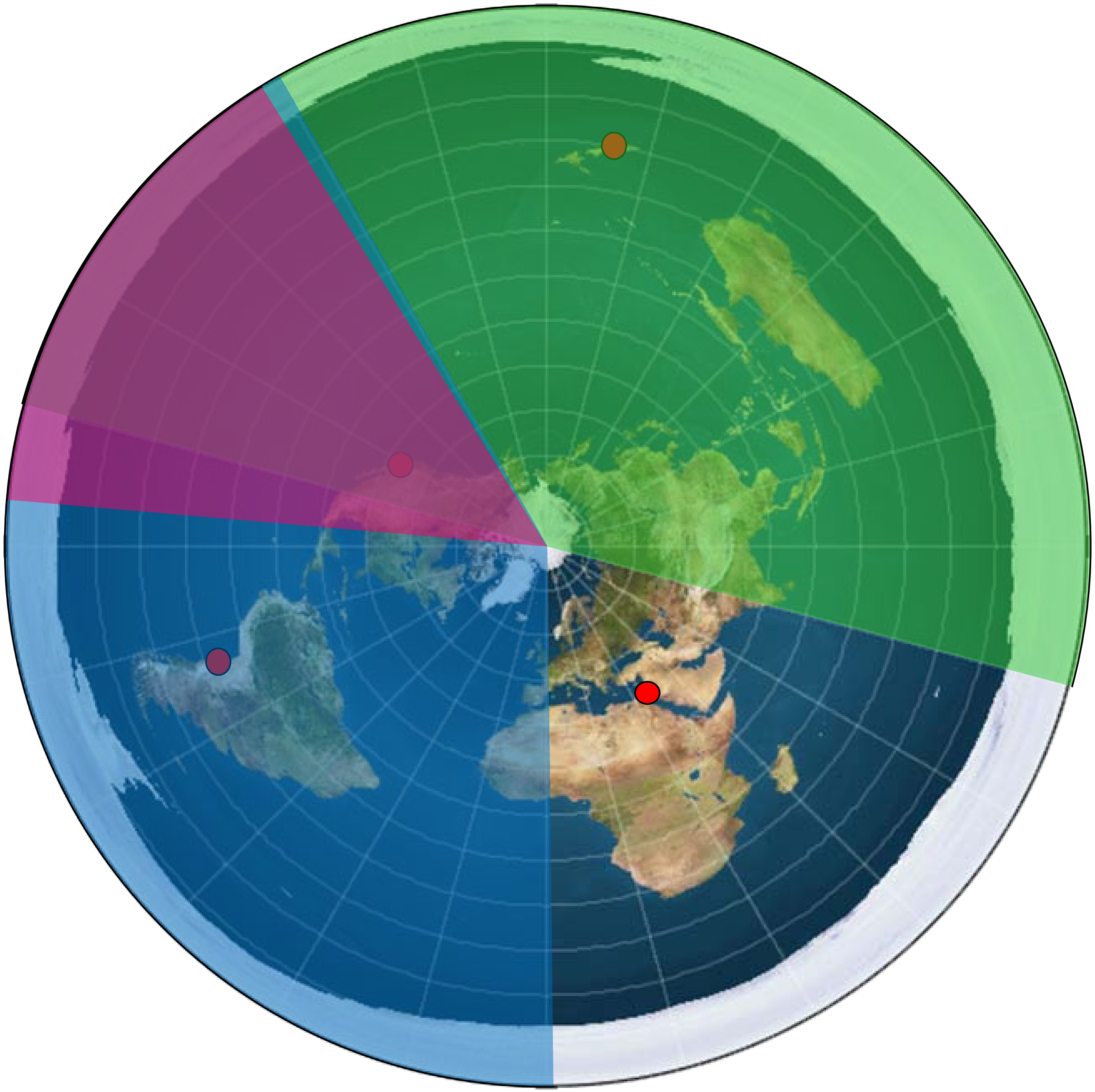
OGLE

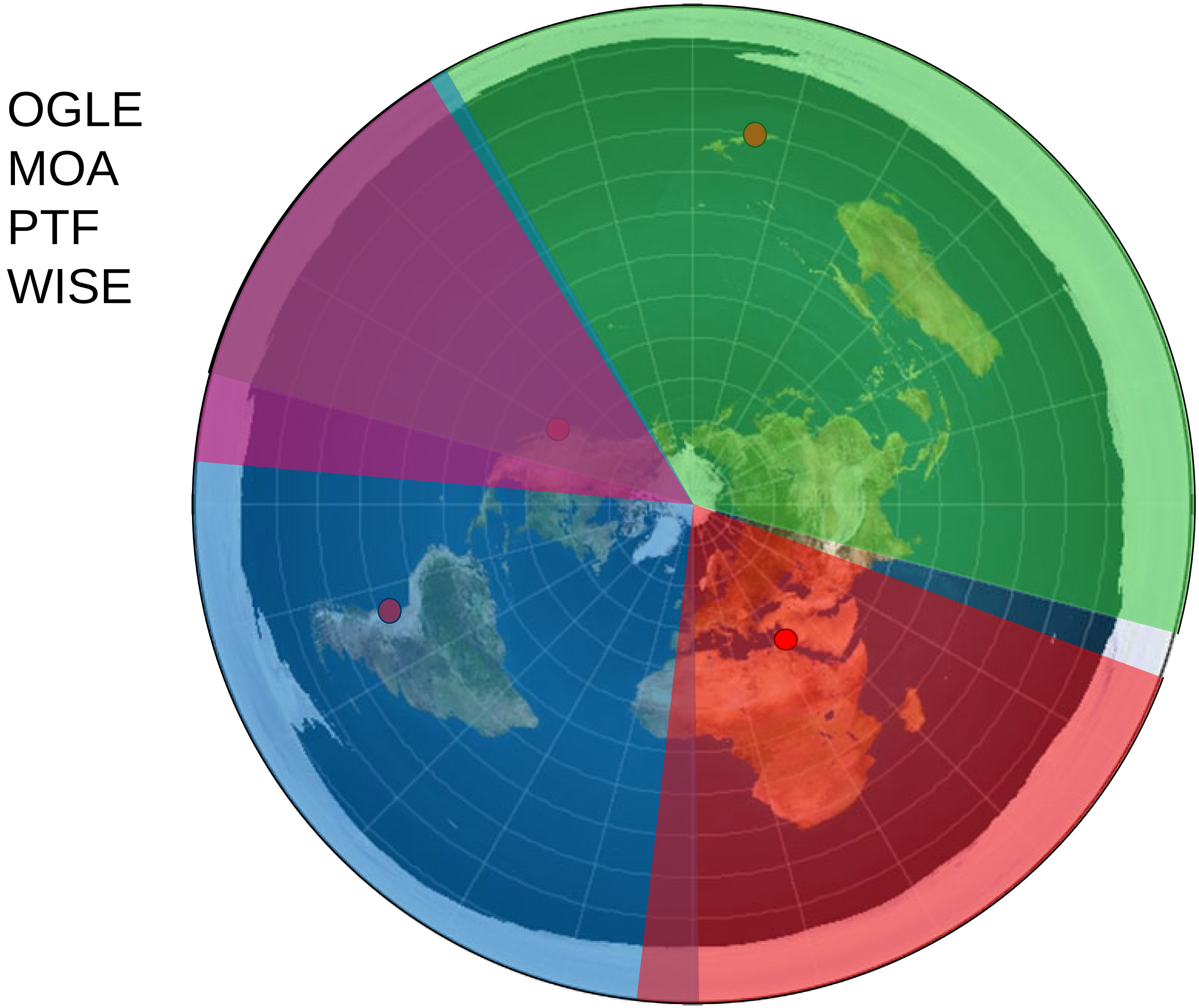


OGLE
MOA



OGLE
MOA
PTF





OGLE
MOA
PTF
WISE

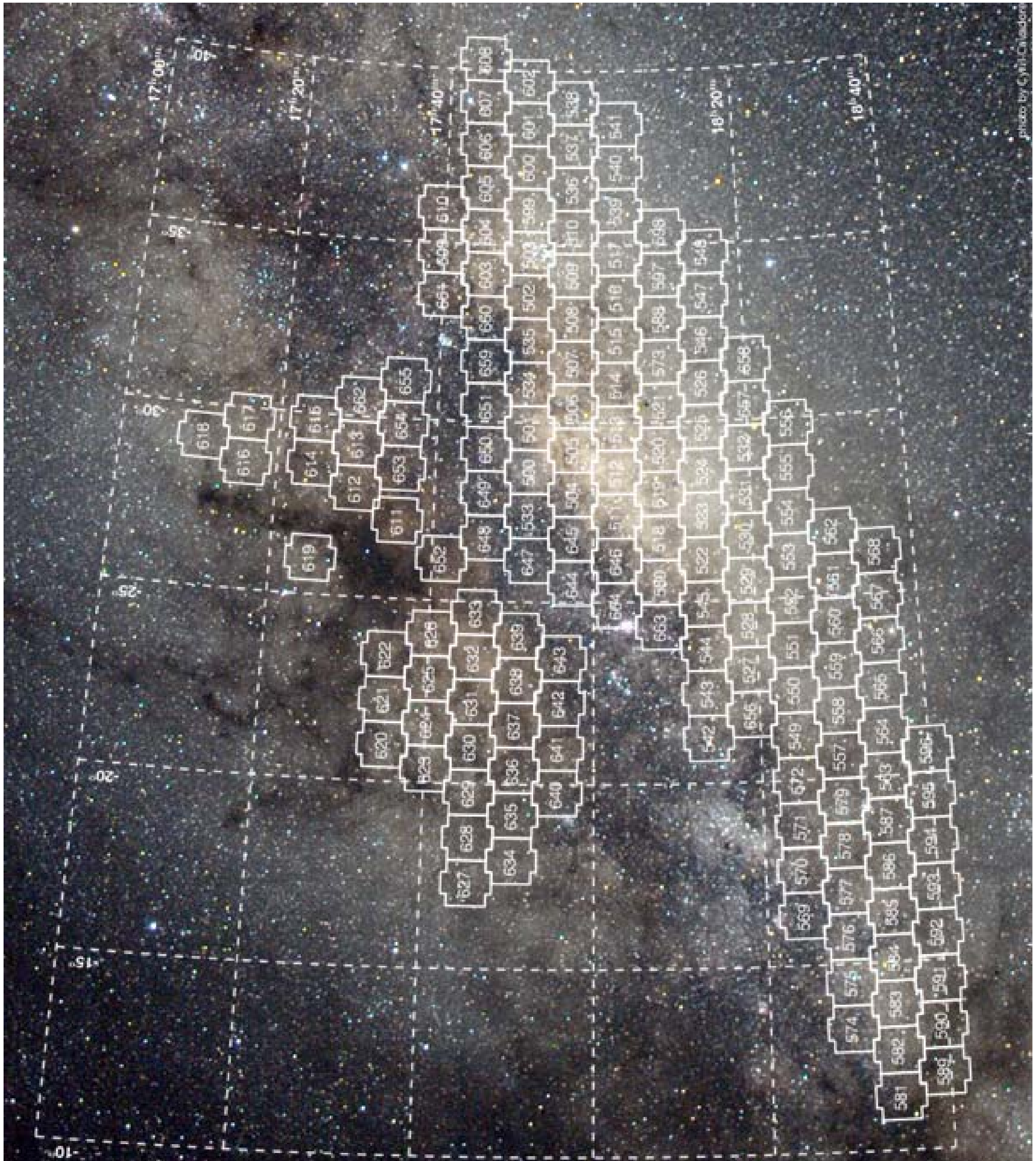
June-July 2010 pilot experiment:

two 3-week periods,

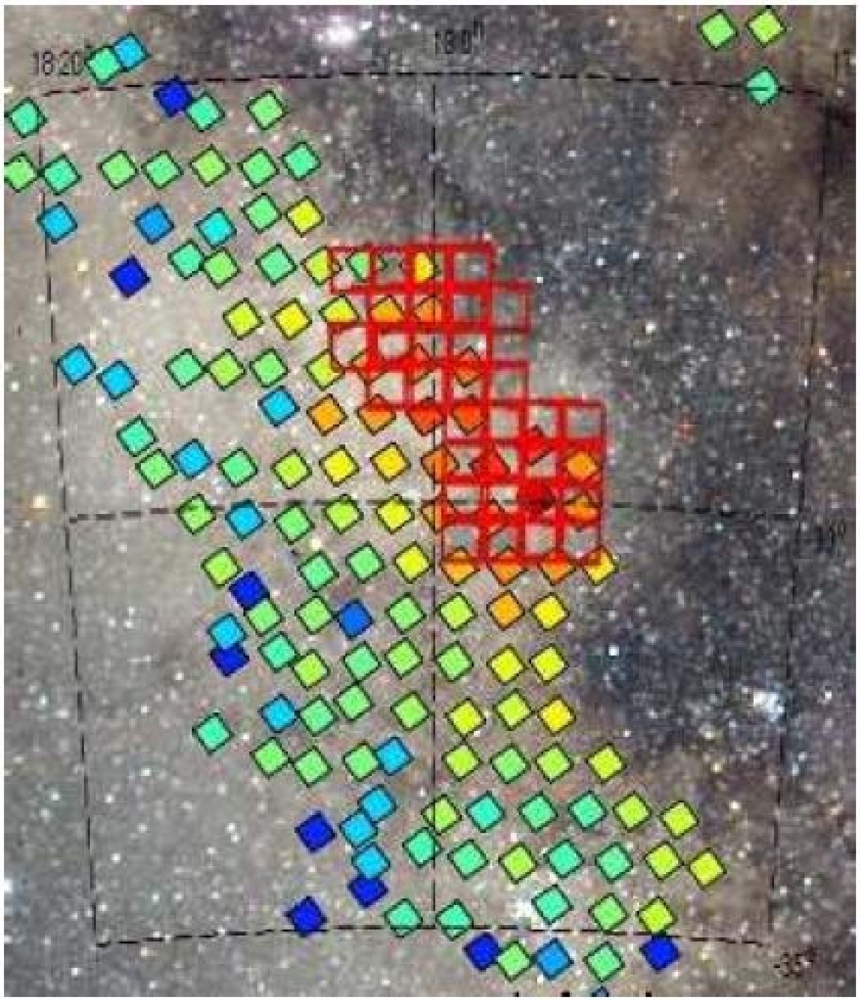
8 deg^2 of bulge with highest lensing rate covered quasi-continuously by all 4 telescopes,

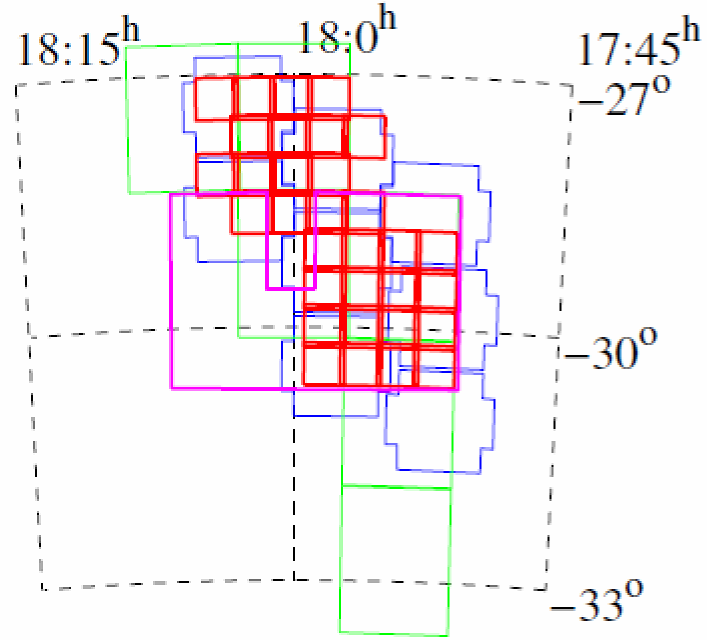
cadences 20-40 min


17h00m
17h20m
17h40m
18h20m
18h40m
-40°
-35°
-30°
-25°
-20°
-15°
-10°
photo by Cyril Cavadore



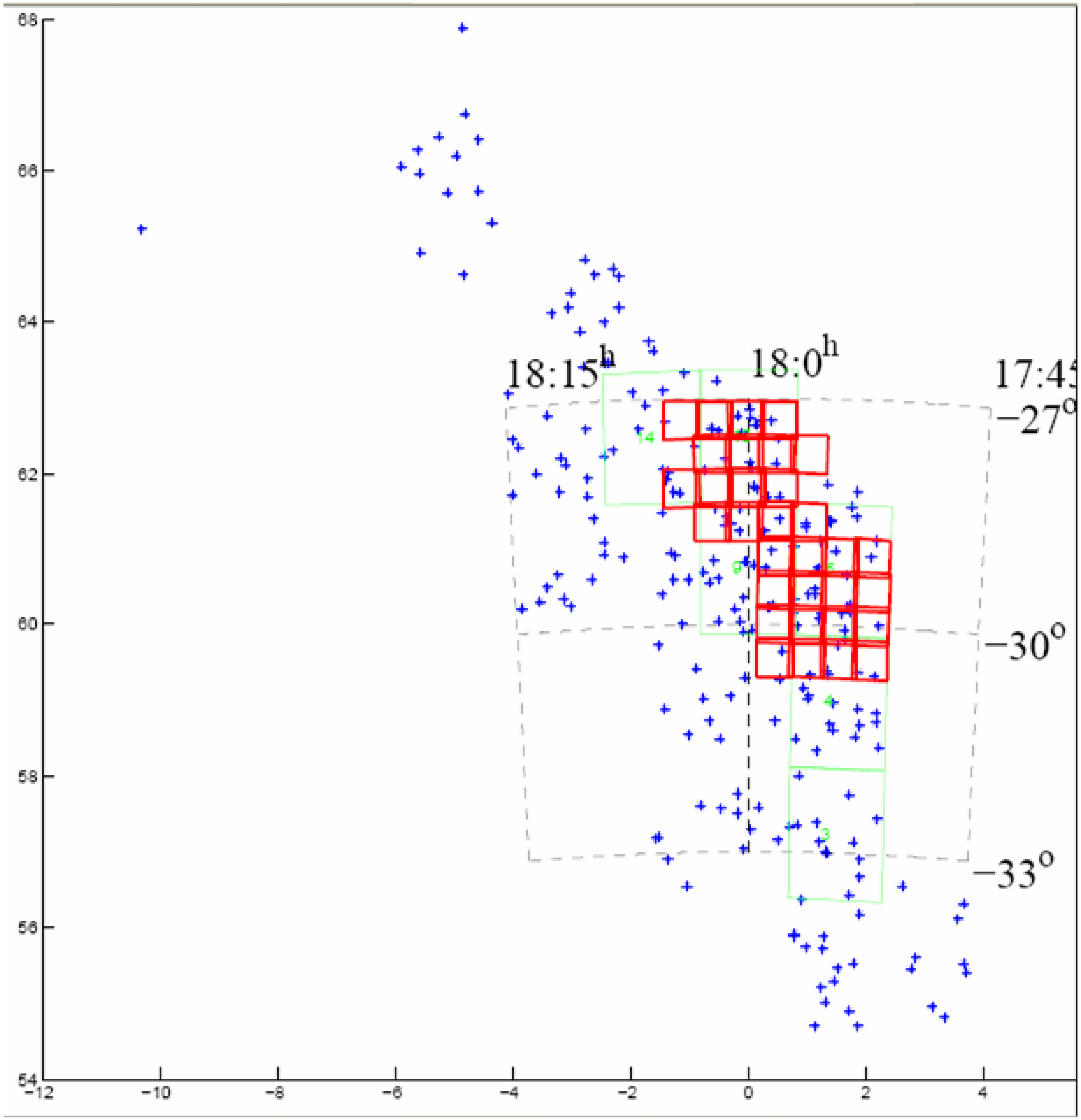
17h00m
17h20m
17h40m
18h20m
18h40m
-40°
-35°
-30°
-25°
-20°
-15°
-10°
photo by Cyril Cavadore



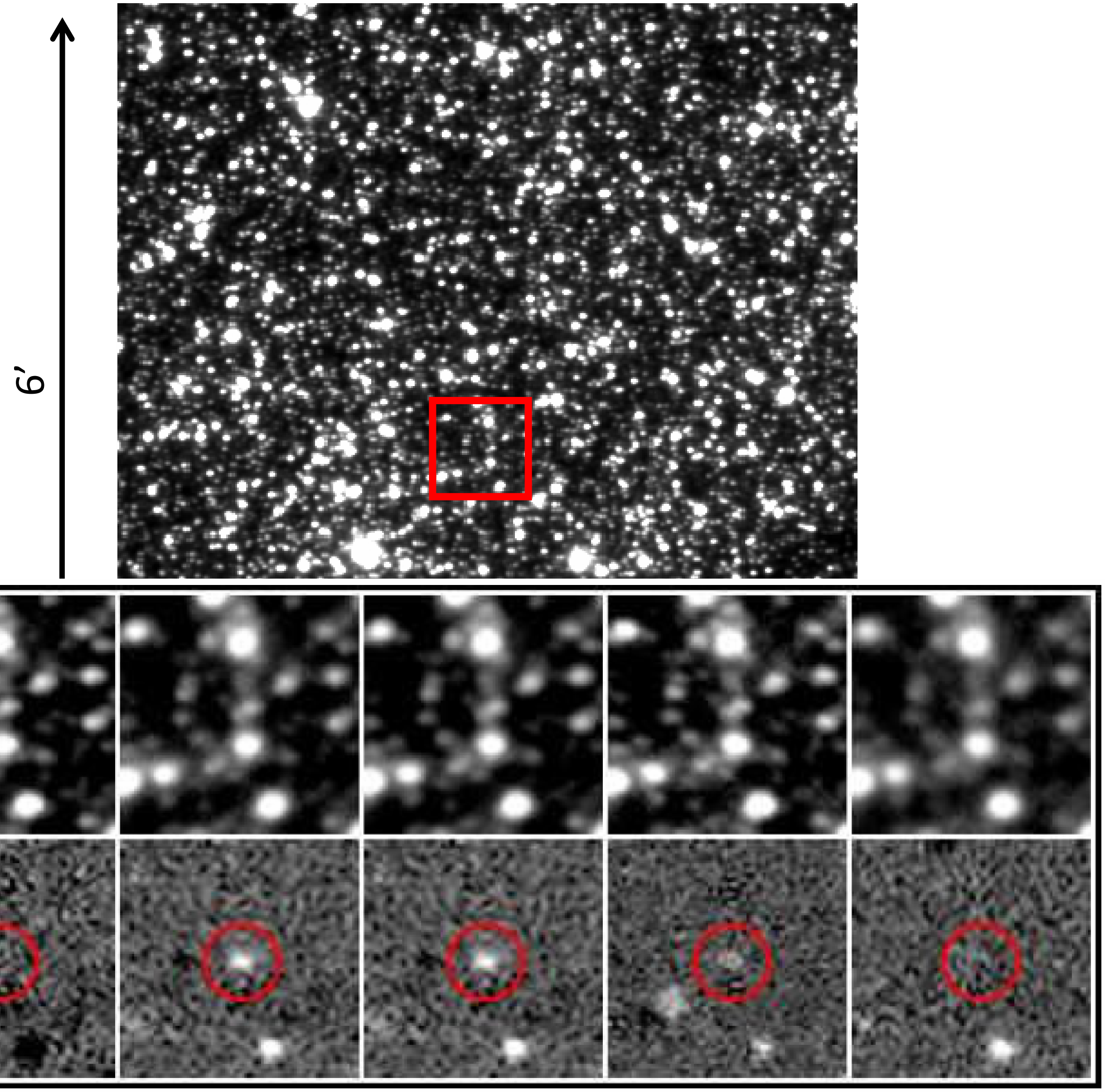


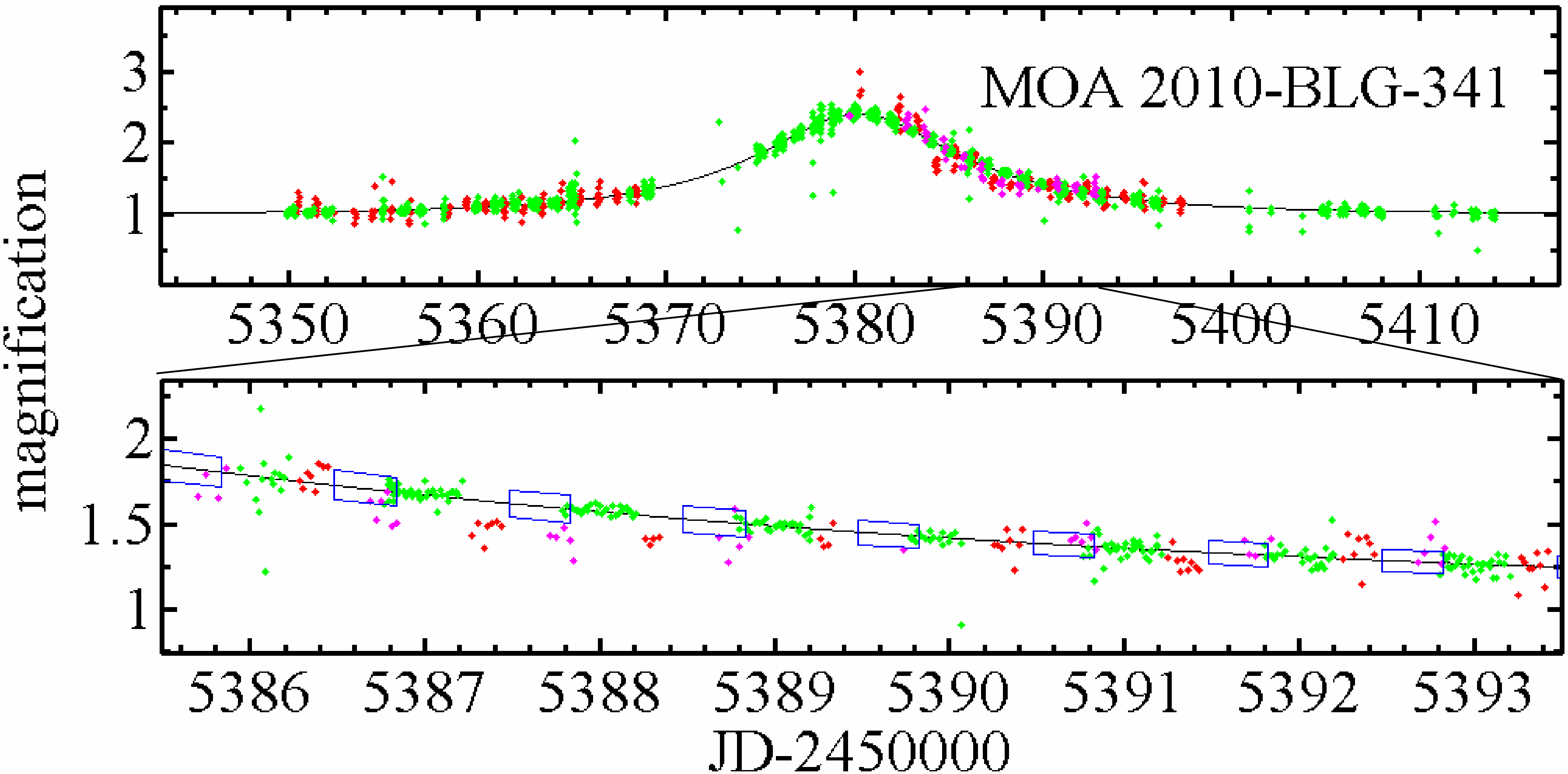
18:15h
18:0h
17:45h
−27°
−30°
−33°

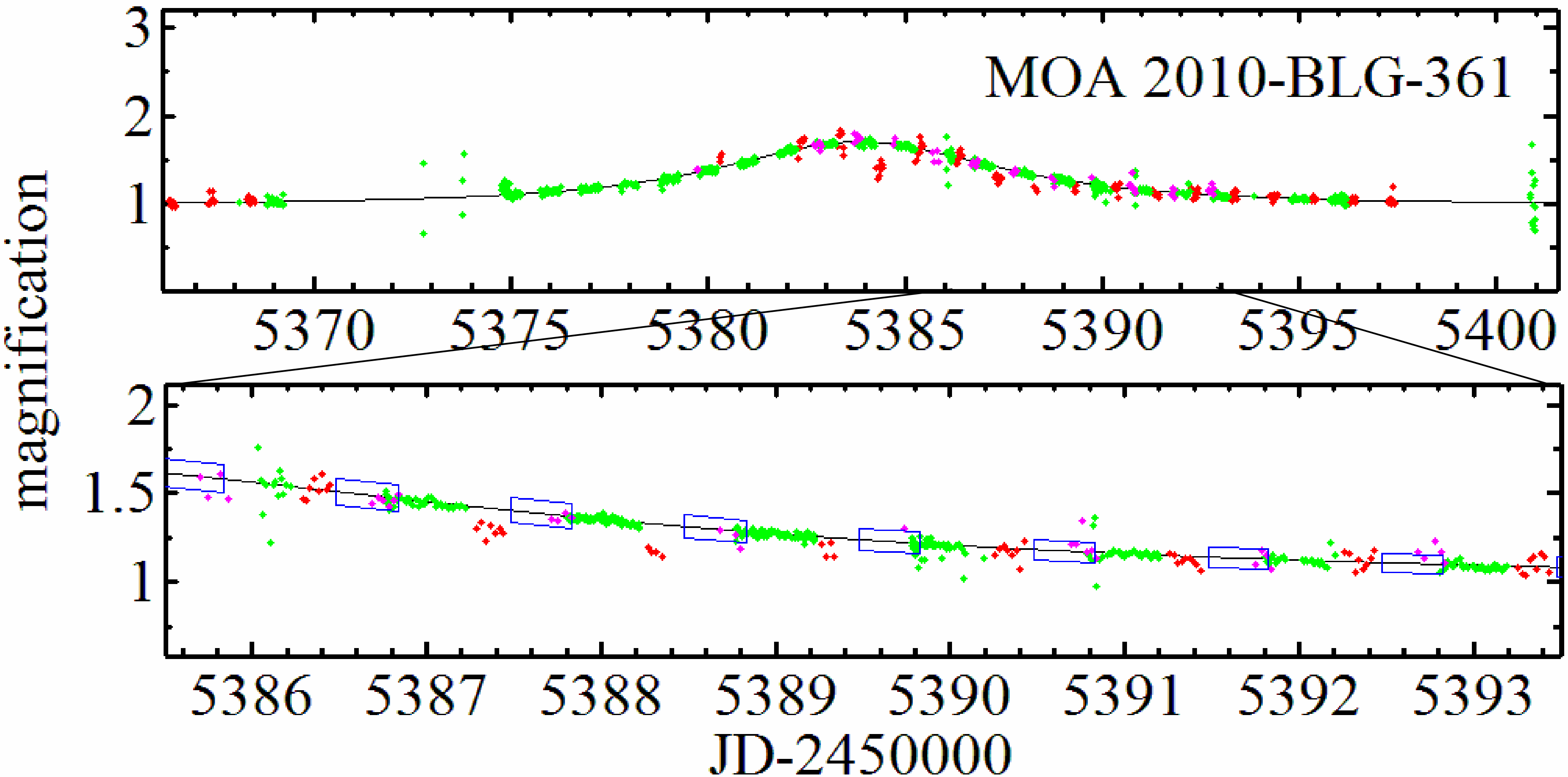
238 ongoing events during pilot, 81 inside 3-telescope footprint

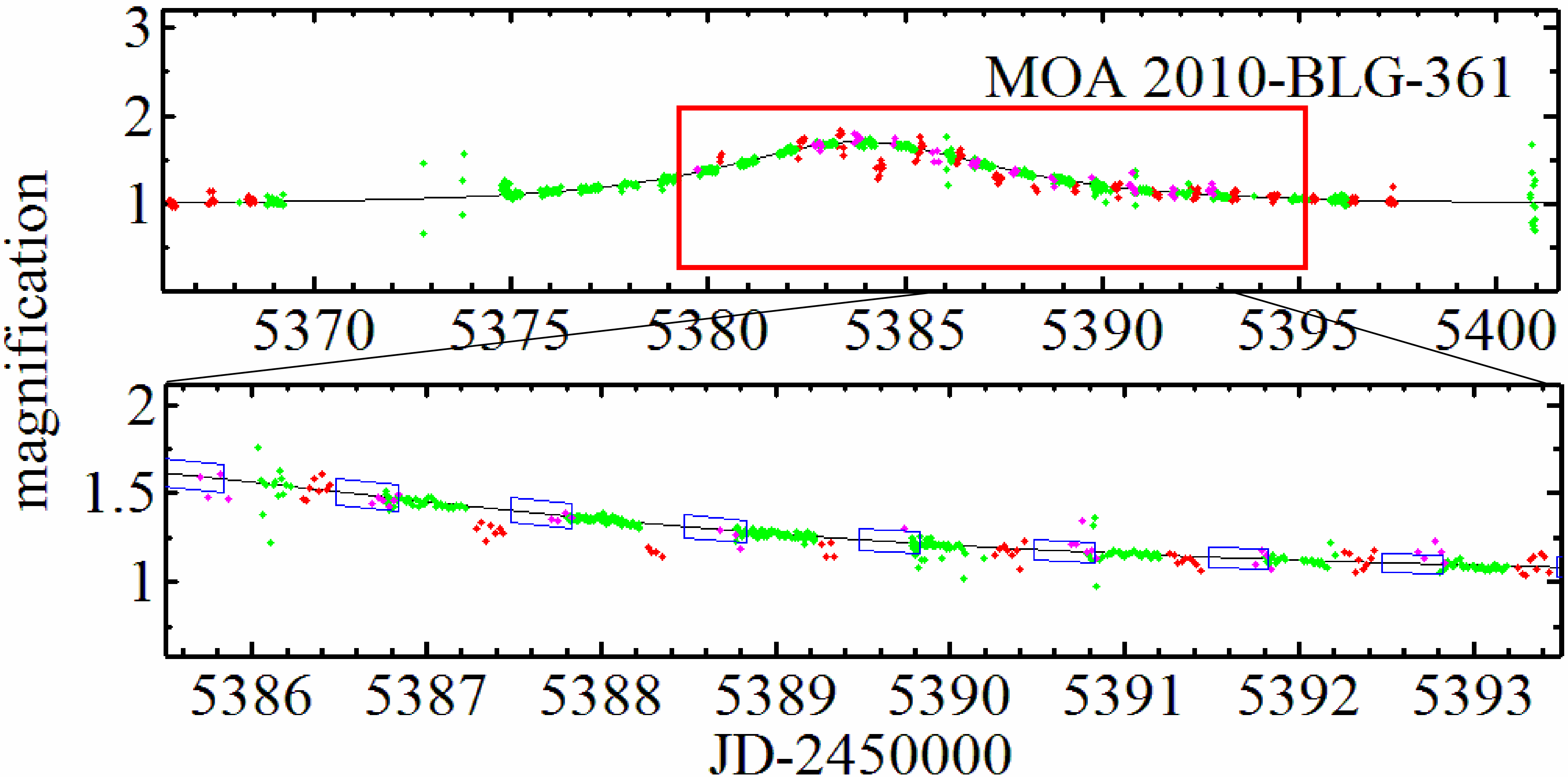


MOA 2010-BLG-341

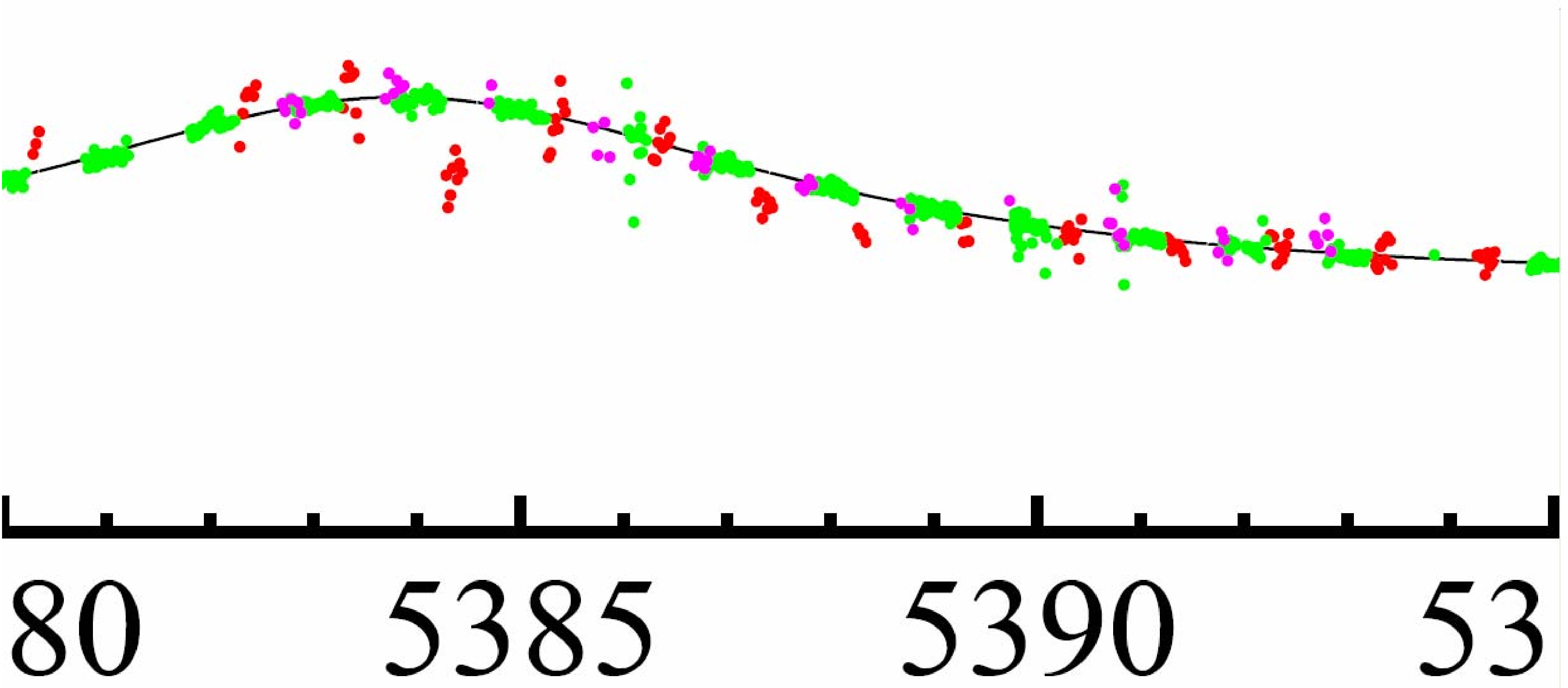


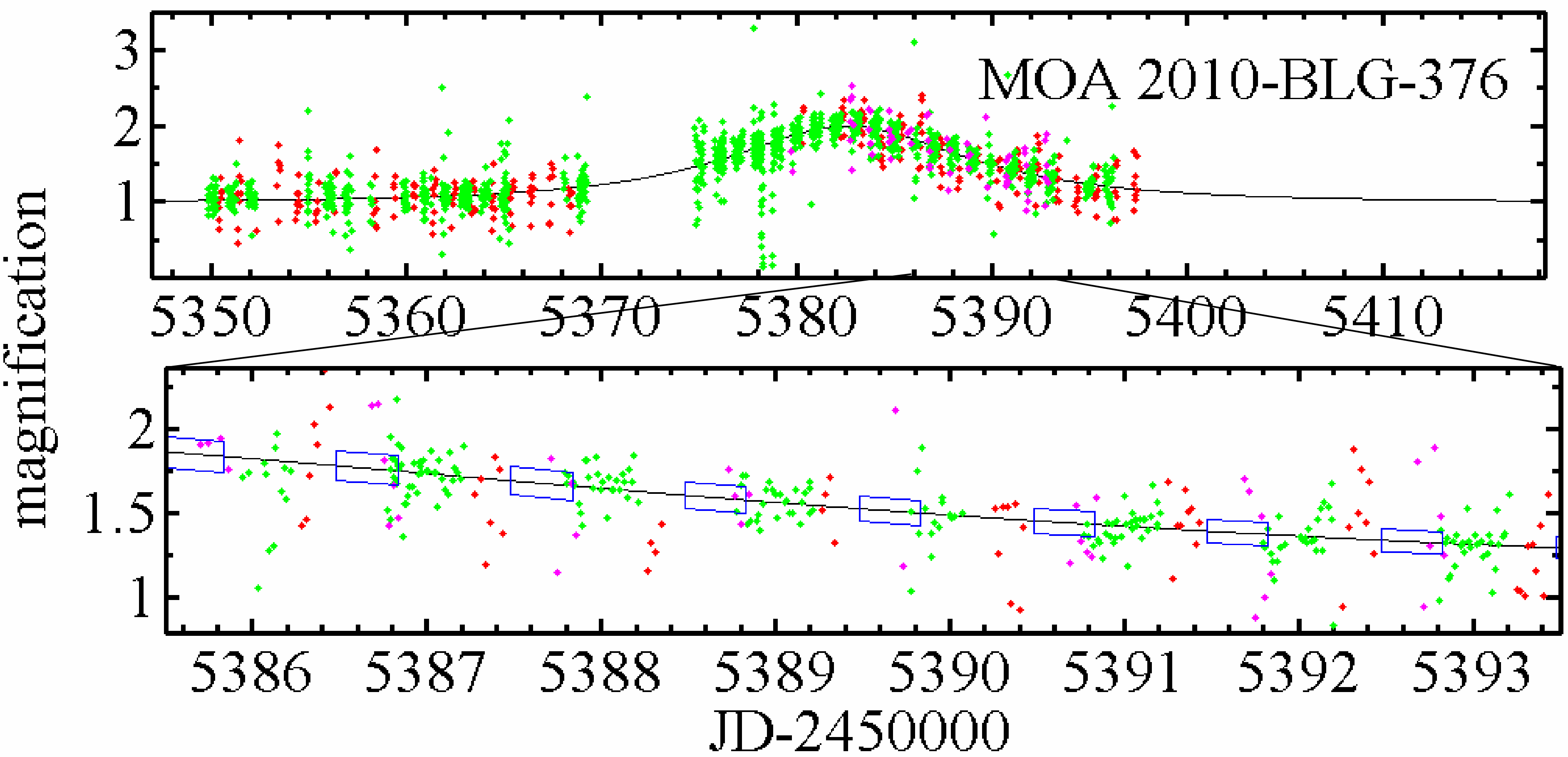

MOA 2010-BLG-341
magnification
3
2
1
5350
5360
5370
5380
5390
5400
5410
2
1.5
1
5386
5387
5388
5389
5390
5391
5392
5393
JD-2450000


MOA 2010-BLG-361
magnification
3
2
1
5370
5375
5380
5385
5390
5395
5400
2
1.5
1
5386
5387
5388
5389
5390
5391
5392
5393
JD-2450000

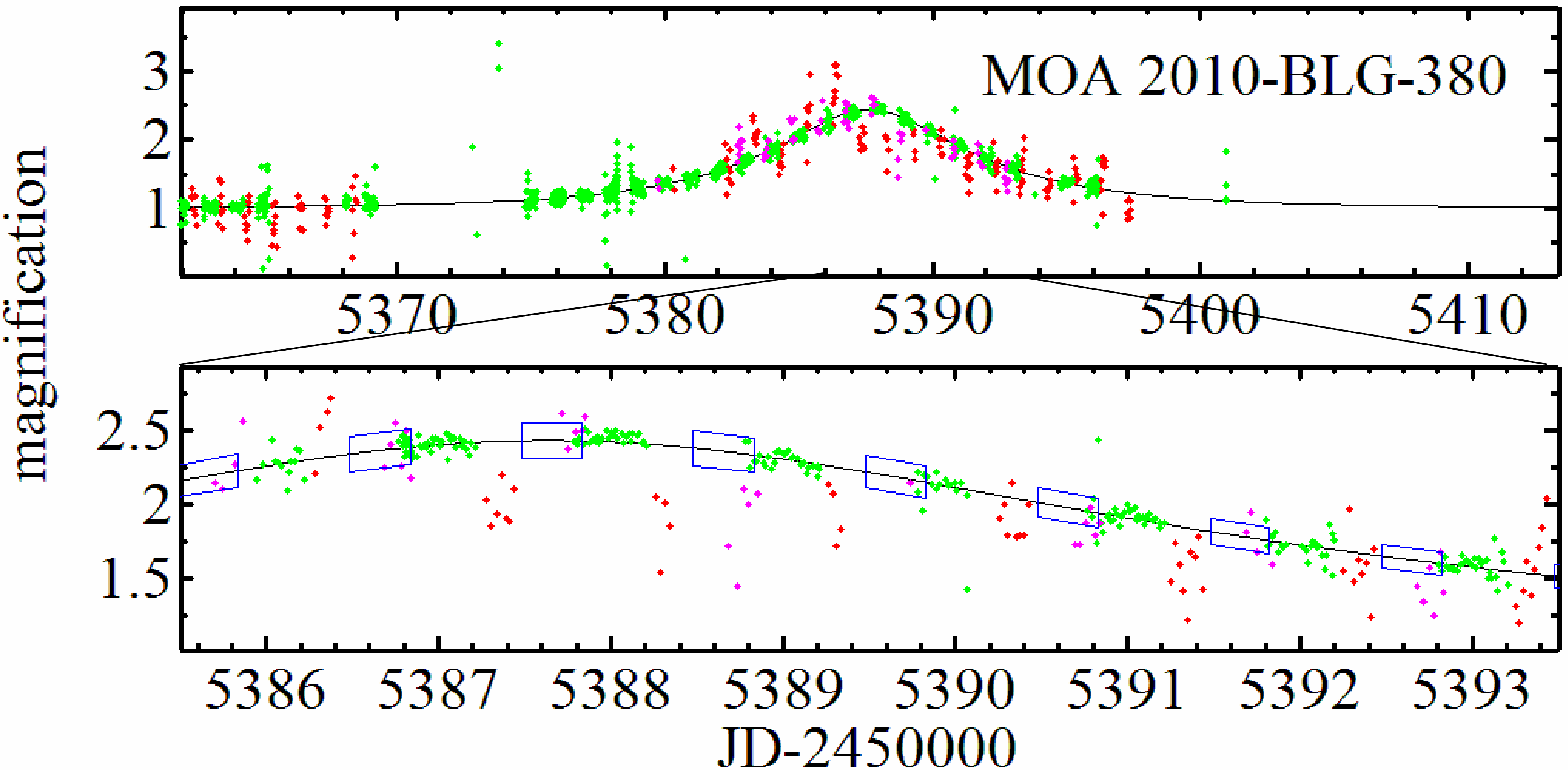


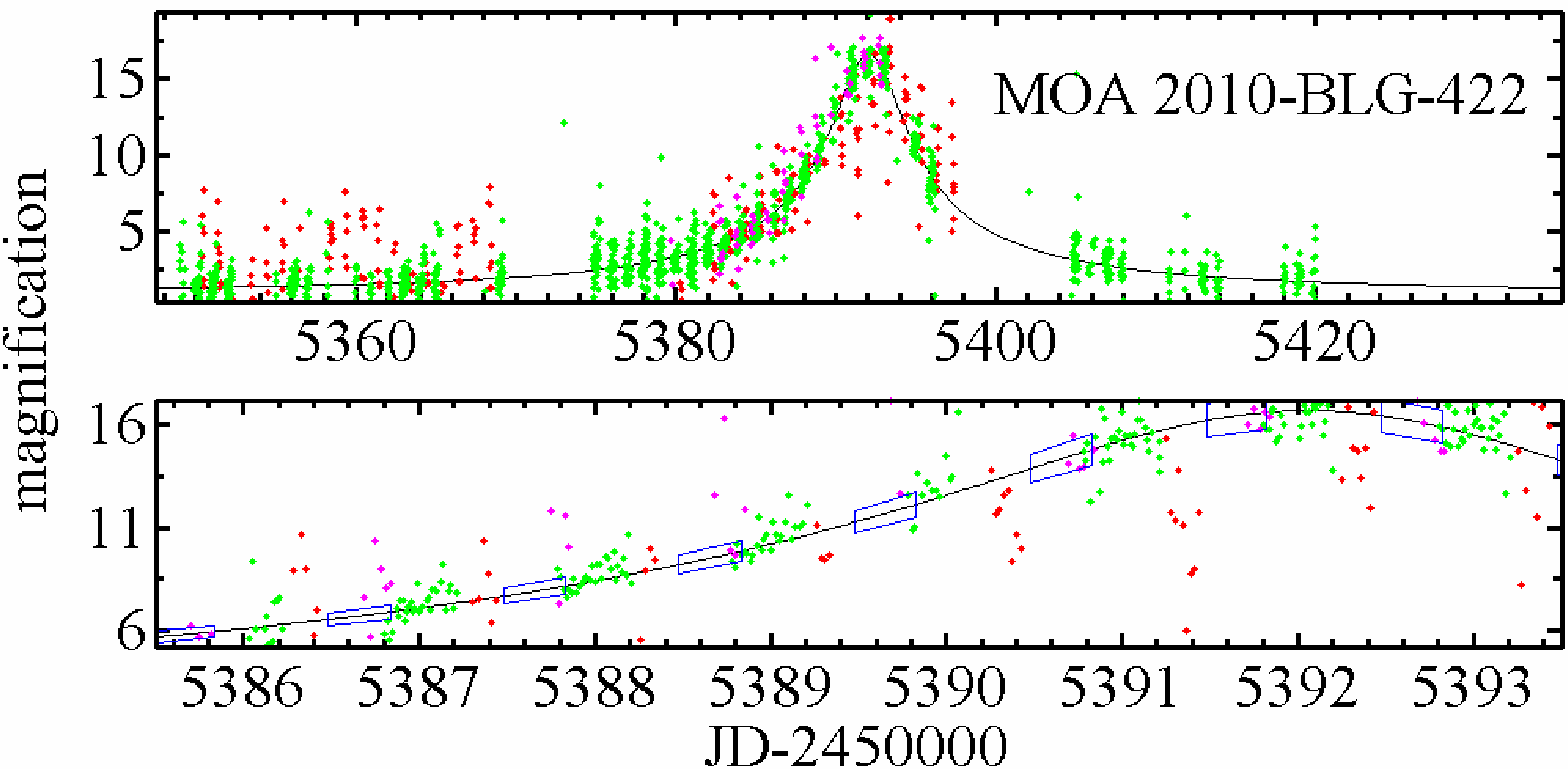
MOA 2010-BLG-361
magnification
3
2
1
5370
5375
5380
5385
5390
5395
5400
2
1.5
1
5386
5387
5388
5389
5390
5391
5392
5393
JD-2450000

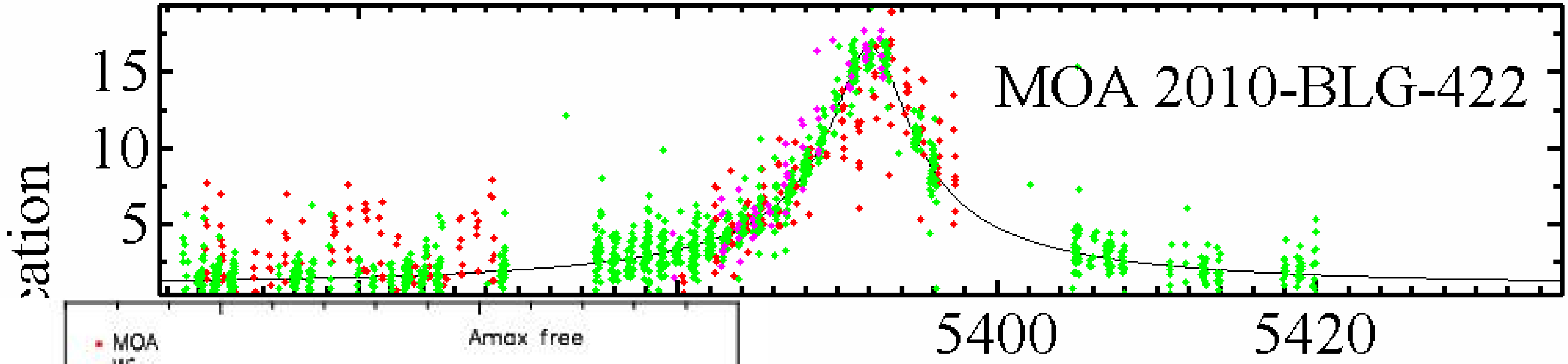

80
5385
5390
53

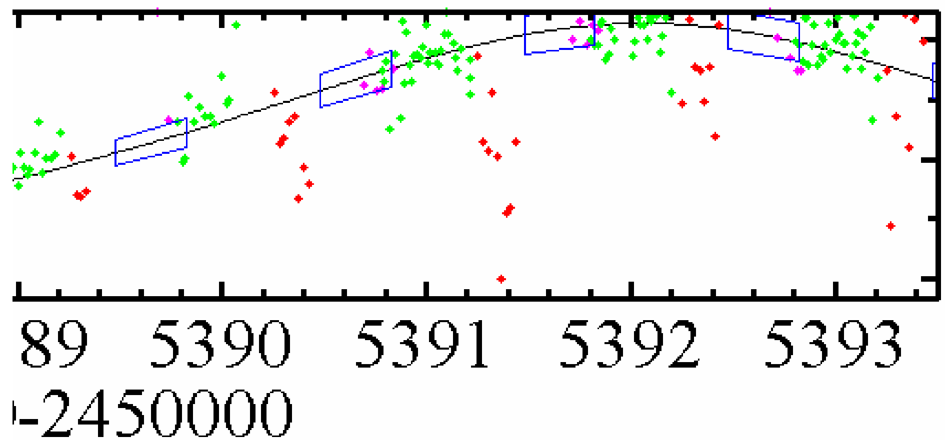


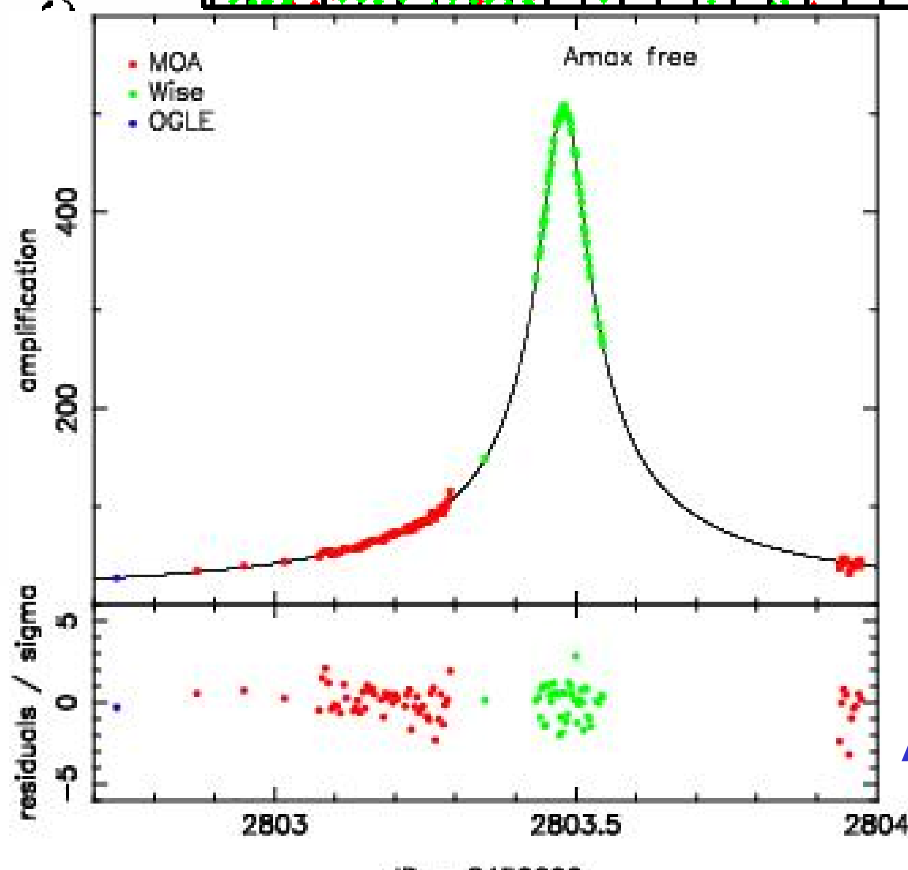
MOA 2010-BLG-376
3
2
1
5350
5360
5370
5380
5390
5400
5410
magnification
2
1.5
1
5386
5387
5388
5389
5390
5391
5392
5393
JD-2450000


MOA 2010-BLG-380
magnification
3
2
1
5370
5380
5390
5400
5410
2.5
2
1.5
5386
5387
5388
5389
5390
5391
5392
5393
JD-2450000


MOA 2010-BLG-422
magnification
15
10
5
5360
5380
5400
5420
16
11
6
5386
5387
5388
5389
5390
5391
5392
5393
JD-2450000







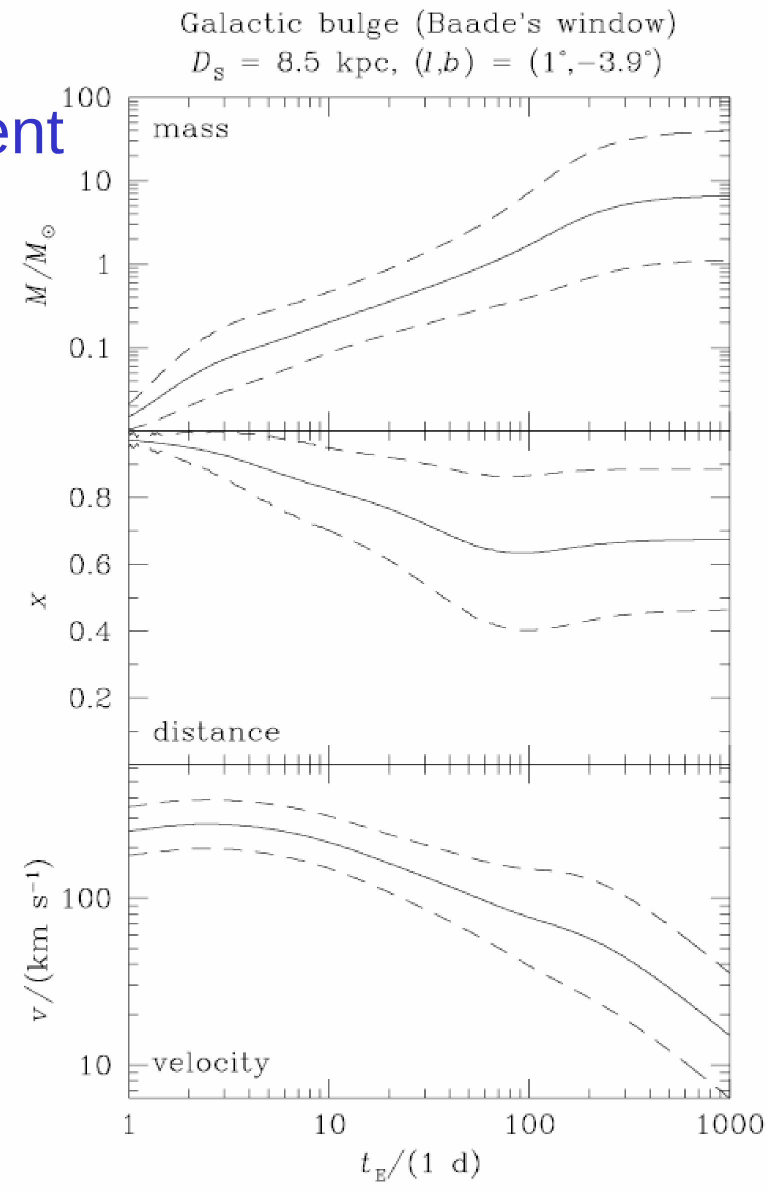
Abe et al. 2004

What can we discover?

A numerical simulation of the experiment

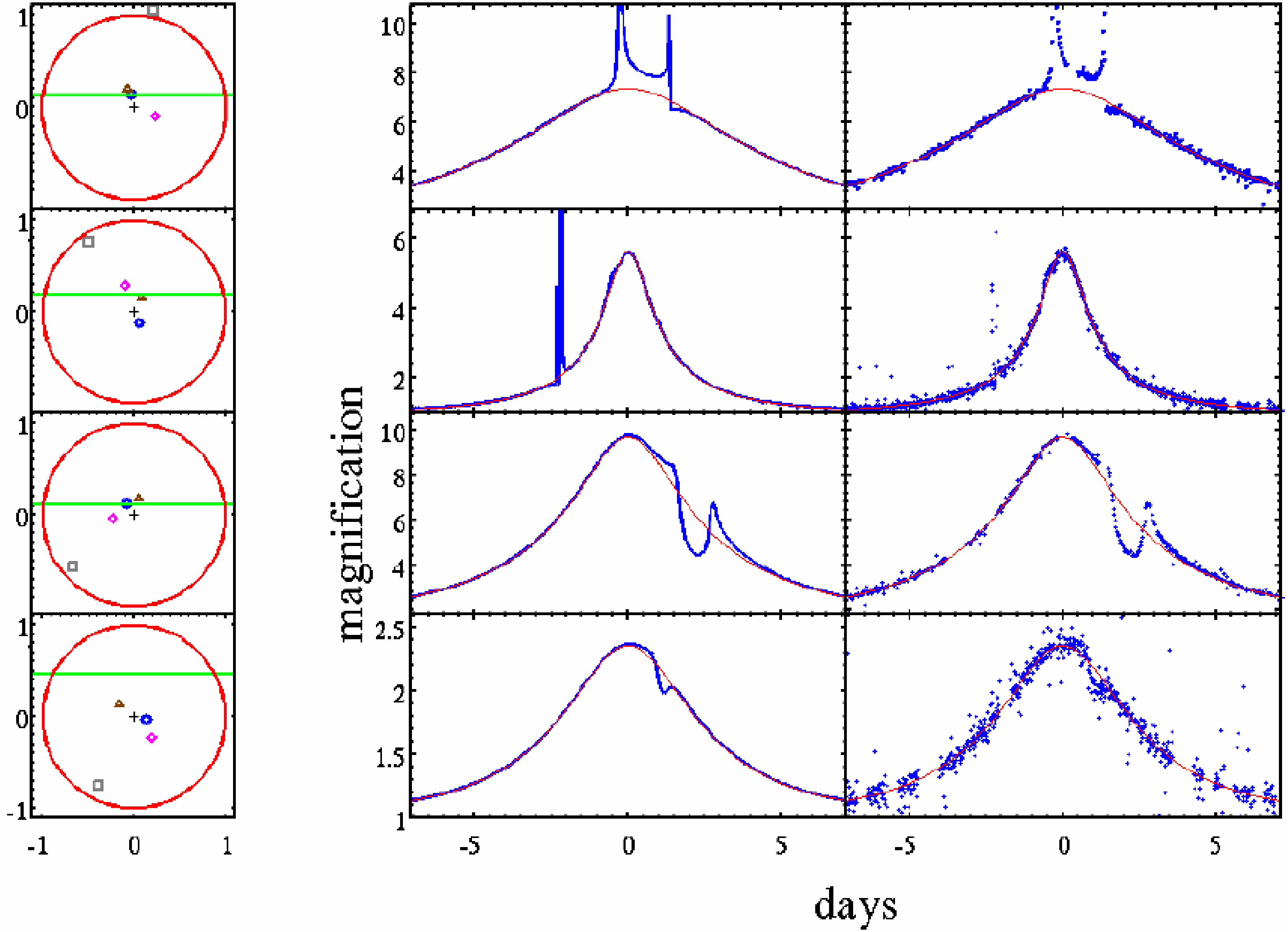
- Lens population with:
- Distributions of primary lens mass, distance, velocity that produce observed distribution of event timescales
- Add solar-like planetary system at random inclination, each planet at random phase
- "Snow line" scaling of system size:

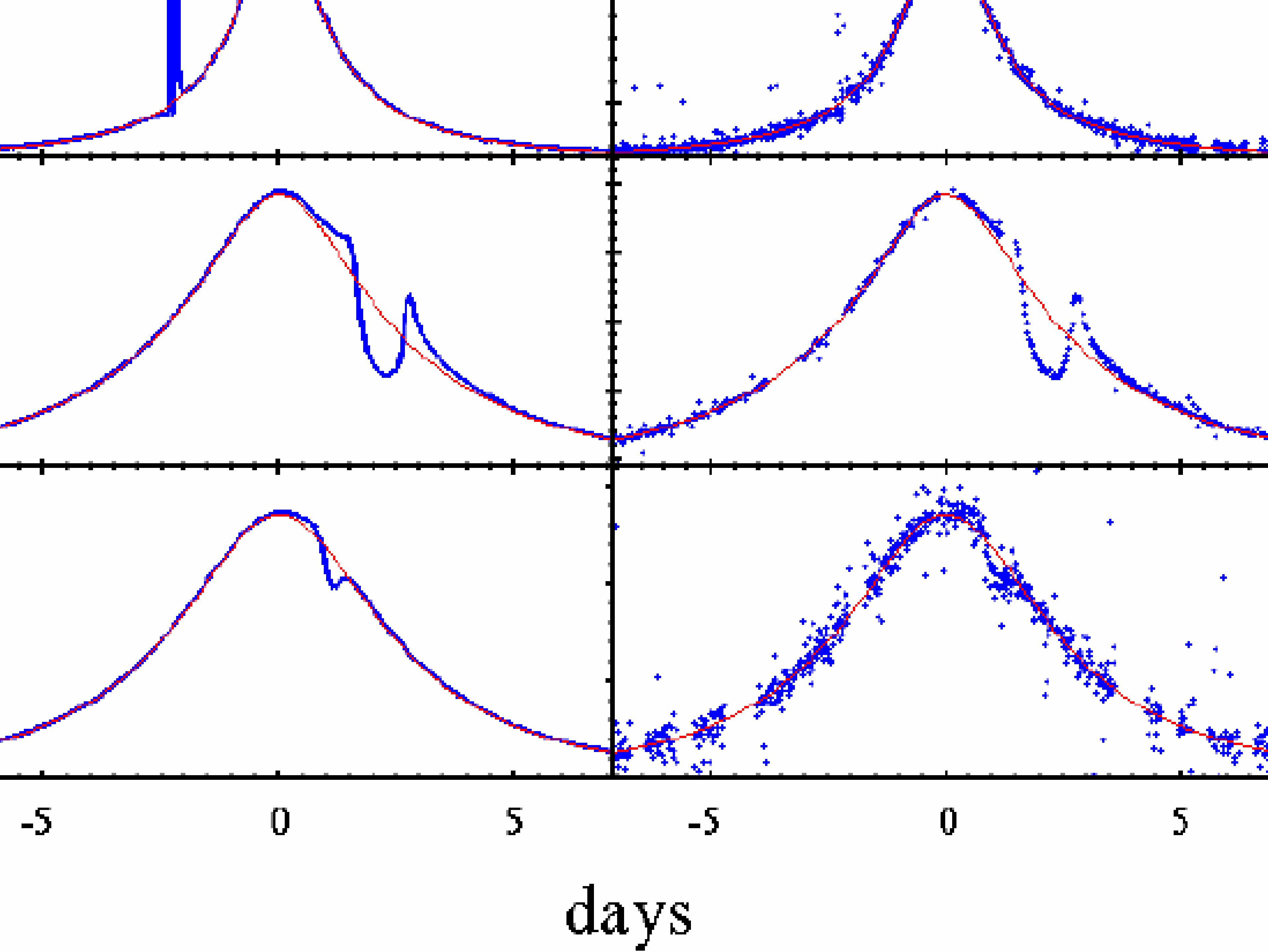
$$(M/M_{\odot})^s$$



Dominik 2006

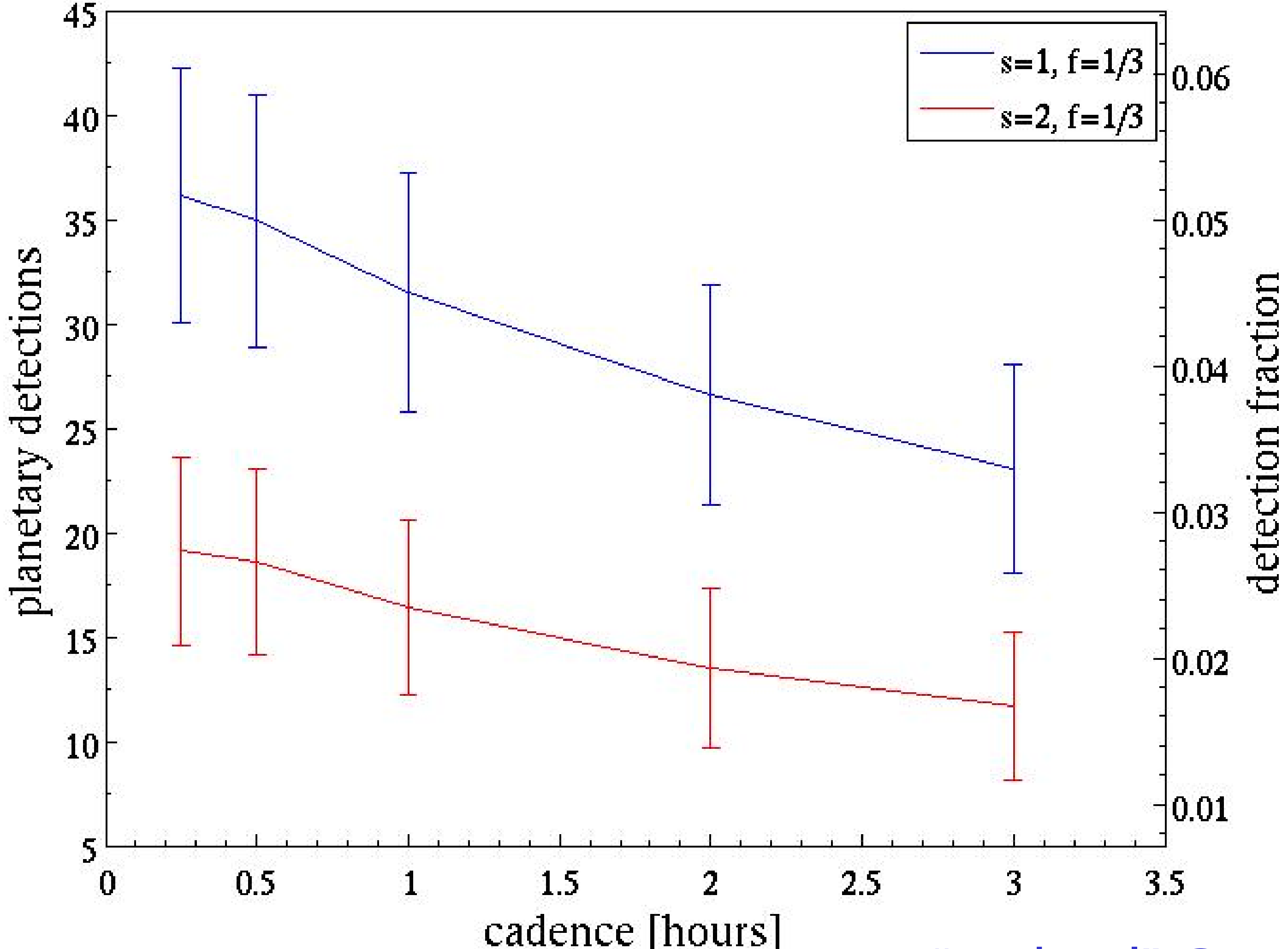
Ray tracing to generate light curves; apply time sampling and photometric errors from the real experiment; search for perturbations.



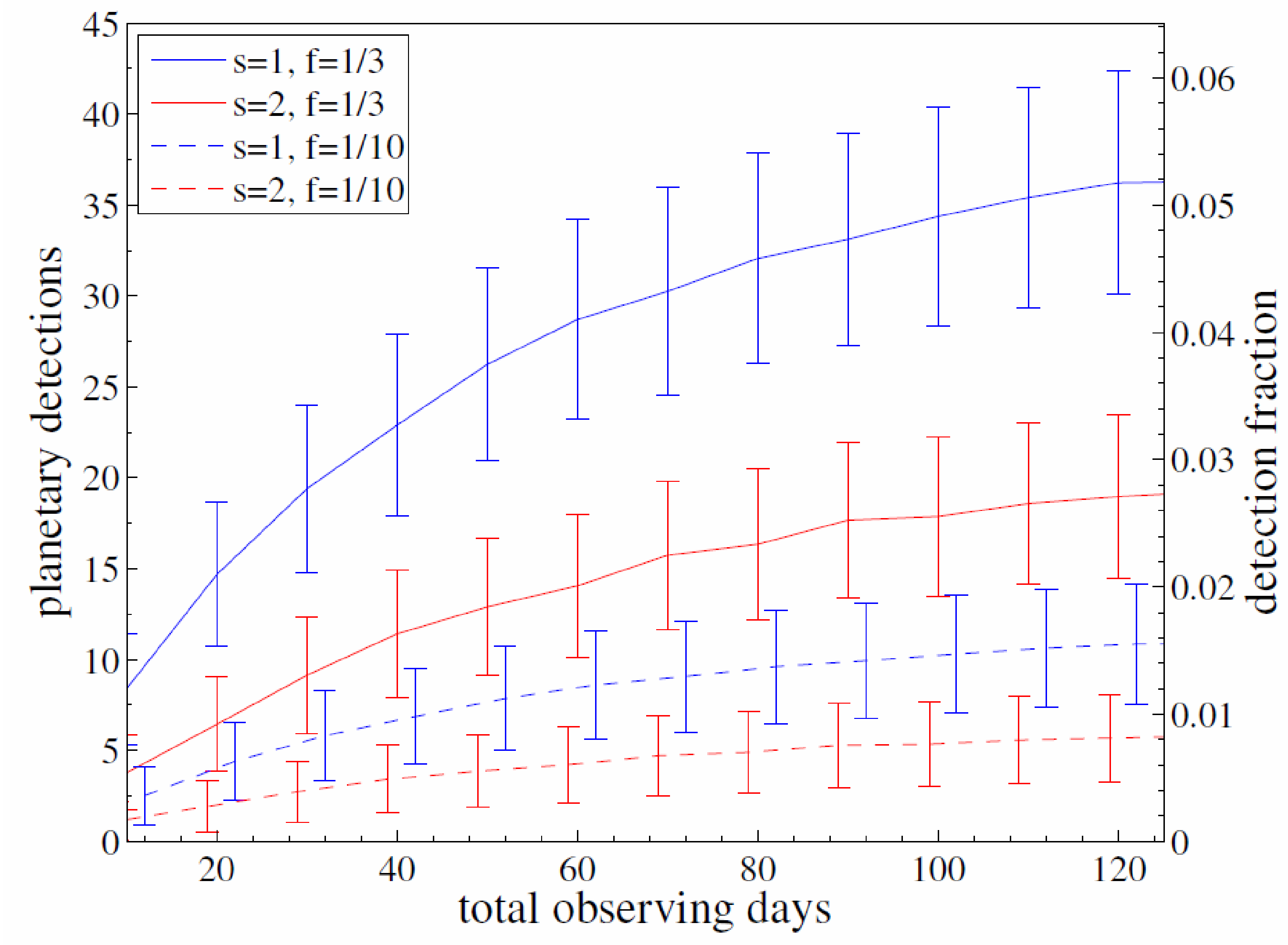


-5
0
5
-5
0
5
days

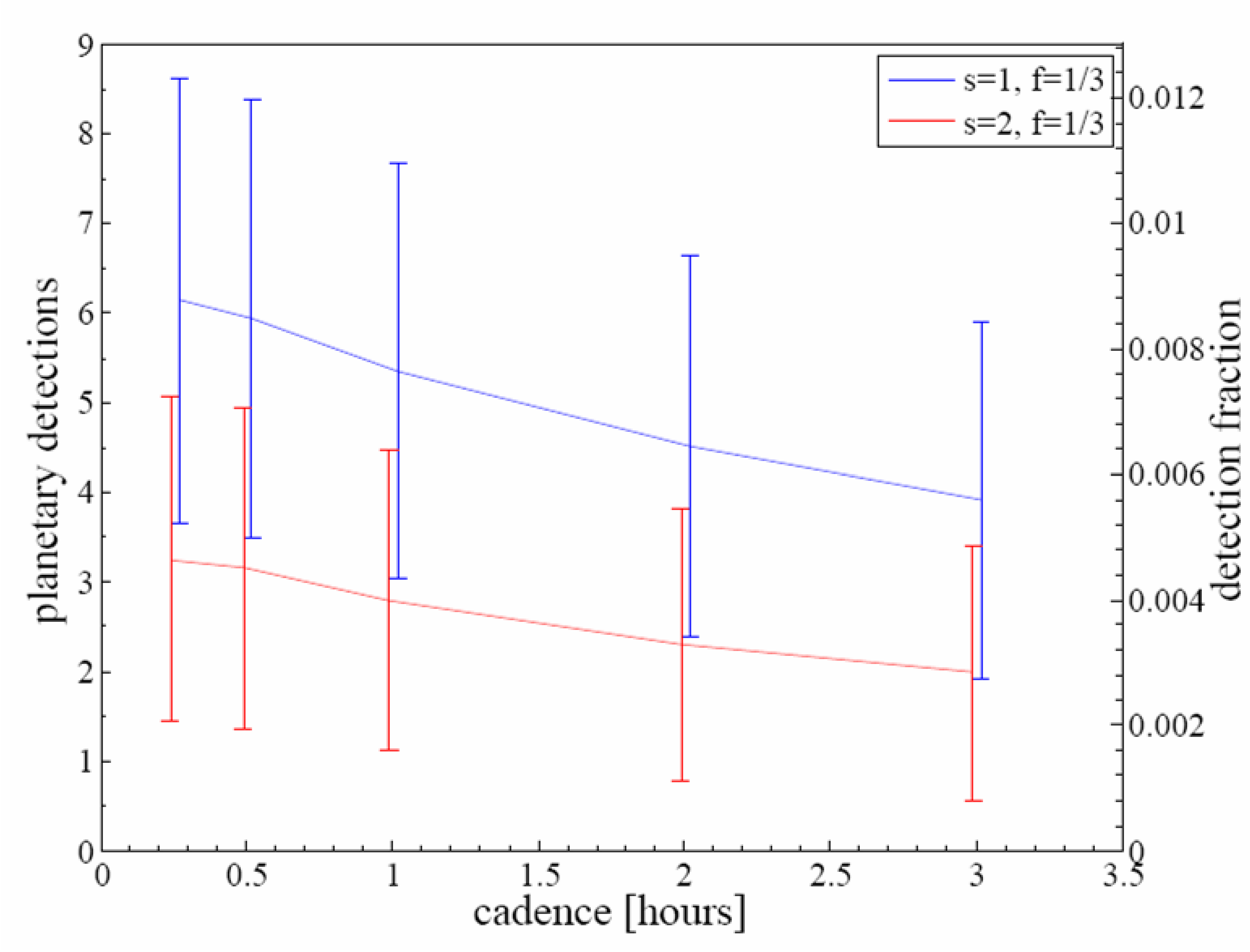
For set of physical parameters (e.g. fraction of stars with planets, snow-line index) and experimental parameters (e.g. duration, cadence) repeat simulated experiment many times.



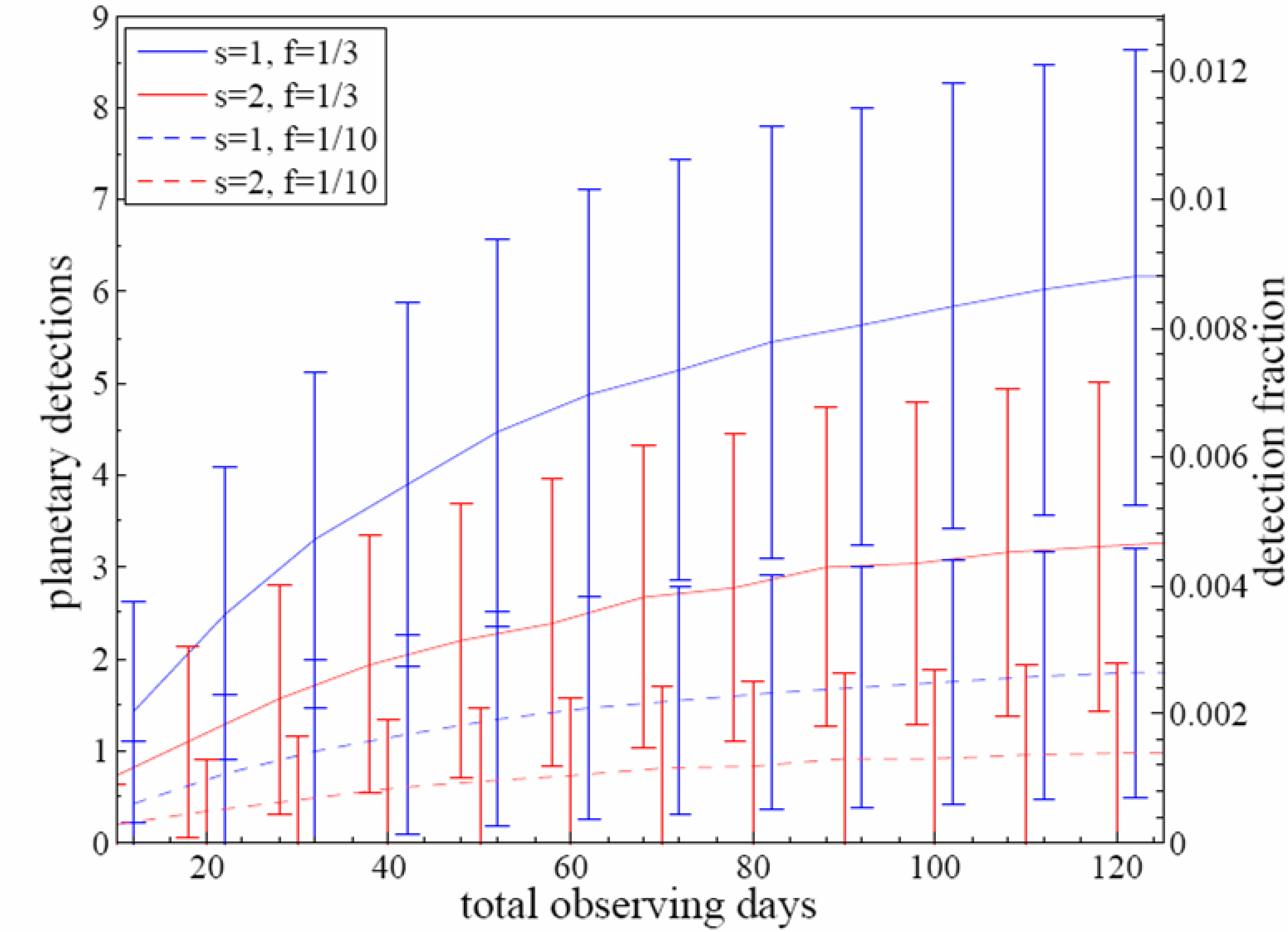
“optimal” Gen-2



"optimal" Gen-2



"minimal" Gen-2



"minimal" Gen-2

Summary and Outlook

1. Generation-2 has begun – challenging but feasible

2. Potential for few to tens of planets/year

3. Improved constraints on planetary frequency and properties in unique regions of planetary parameter space.