Microlensing towards the Galactic Centre with OGLE

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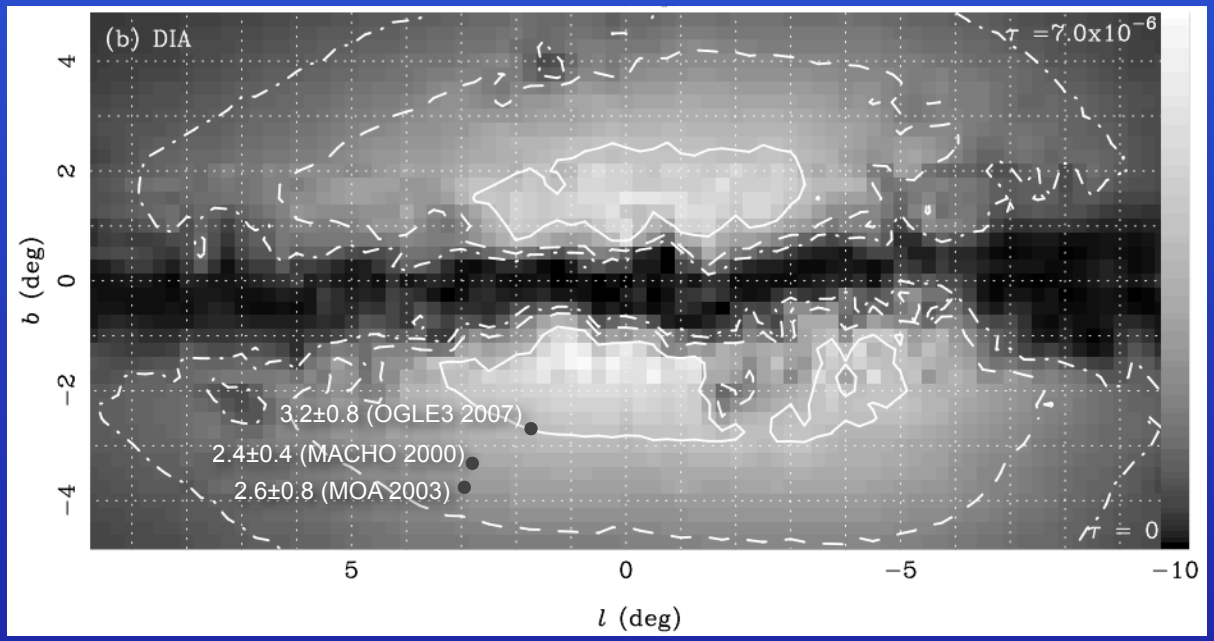
Gravitational microlensing optical depth

- probably the best way to constrain the internal structure of the Milky Way
- the most recent models of the Galactic Bulge: Kerins,Robin,Marshall 2010



Gravitational microlensing optical depth

- review by Marc Moniez 2010

results so far:

reference	sea-sons	field $deg.^2$	stars analyzed	events for τ	$\bar{l}^\circ, \bar{b}^\circ$	$< \tau >_{bulge} \times 10^6$	$< t_E >$ corrected
OGLE [112]	2	0.81	all	9	$\pm 5, -3.5$	3.3 ± 1.2	
MACHO [11]	1	12.	all	45	$2.55, 3.64$	$3.9^{+1.8}_{-1.2}$	
MACHO [16]	3	4.	all/DIA	99	$2.68, -3.35$	$3.23^{+0.52}_{-0.50}$	
EROS [3]	3	15.	bright	16	$2.5, -4.0$	0.94 ± 0.29	
MOA [104]	1	18.	all/DIA	28	$4.2, -3.4$	$3.36^{+1.11}_{-0.81}$	
MACHO [86]	7	4.5	bright	62	$1.5, -2.68$	$2.17^{+0.47}_{-0.38}$	21.6 ± 3
OGLE [105]	4	5.	bright	32	$1.16, -2.75$	$2.55^{+0.57}_{-0.46}$	28.1 ± 4.3
EROS [62]	7	66.	bright	120	GC map		28.3 ± 2.8
EROS [87]	7	20.1	all	22	GSA map		$48. \pm 9.$

- but number statistics way too low to recreate the full map

Optical Gravitational Lensing Experiment

OGLE-I

1992 – 1995

started by Paczyński (Princeton) and Udalski (Warsaw)

pilot program

Swope telescope in LCO, Chile

OGLE-II

1996 – 2000

dedicated 1.3m telescope in Las Campanas Observatory, Chile

2k x 2k single CCD

fov: 0.21 sq deg

OGLE-III

2001 – 2009

8 chip mosaic camera

2k x 4k 0.26”/pix each CCD

fov: 0.34 sq deg

OGLE-IV

2010 – ...

32 chip mosaic camera

2k x 4k 0.26”/pix each CCD

fov: 1.4 sq deg

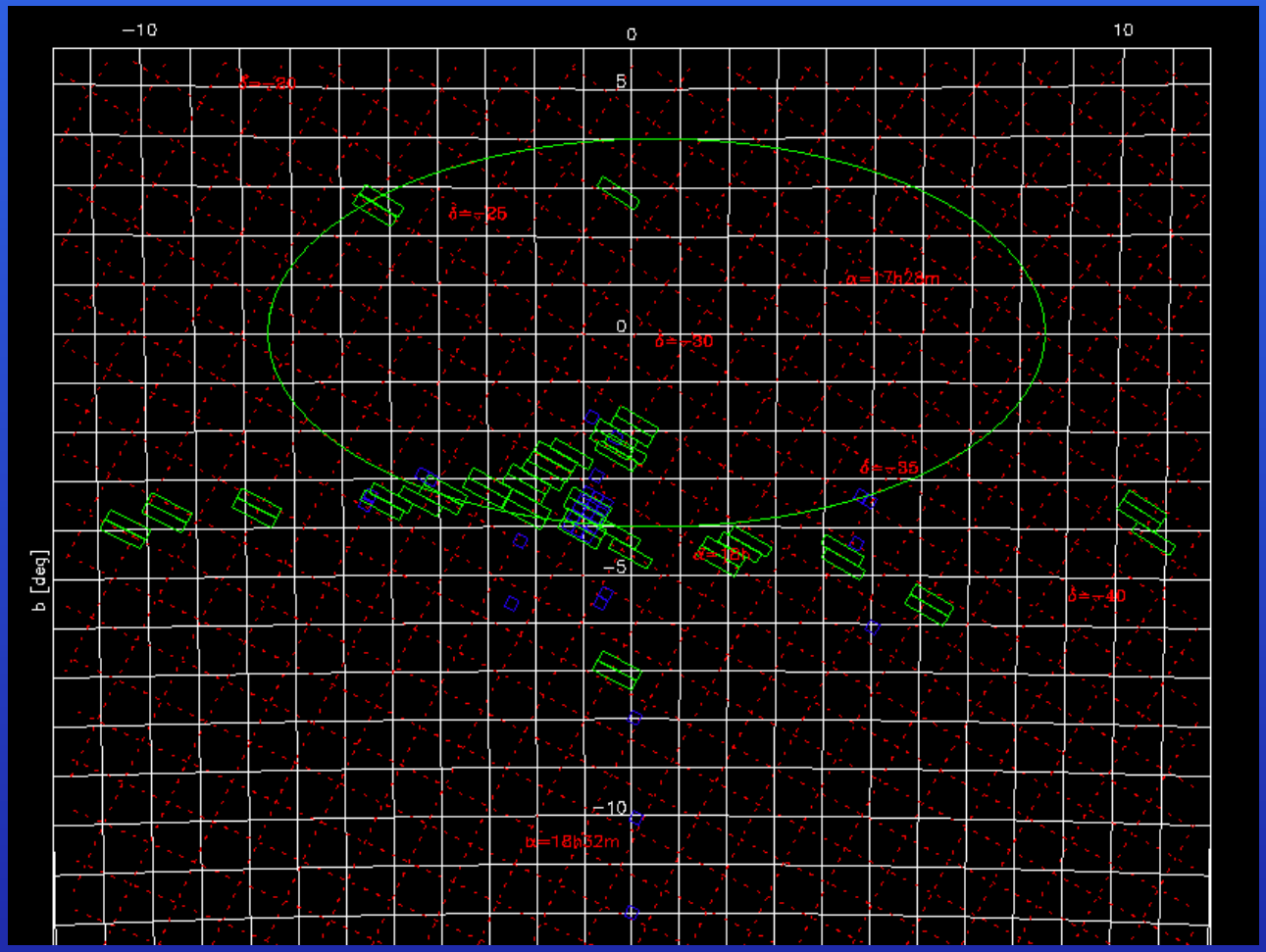
data flow 8 times OGLE-III

OGLE-II Bulge fields

~49 fields

~10 square degrees

about 20 million objects

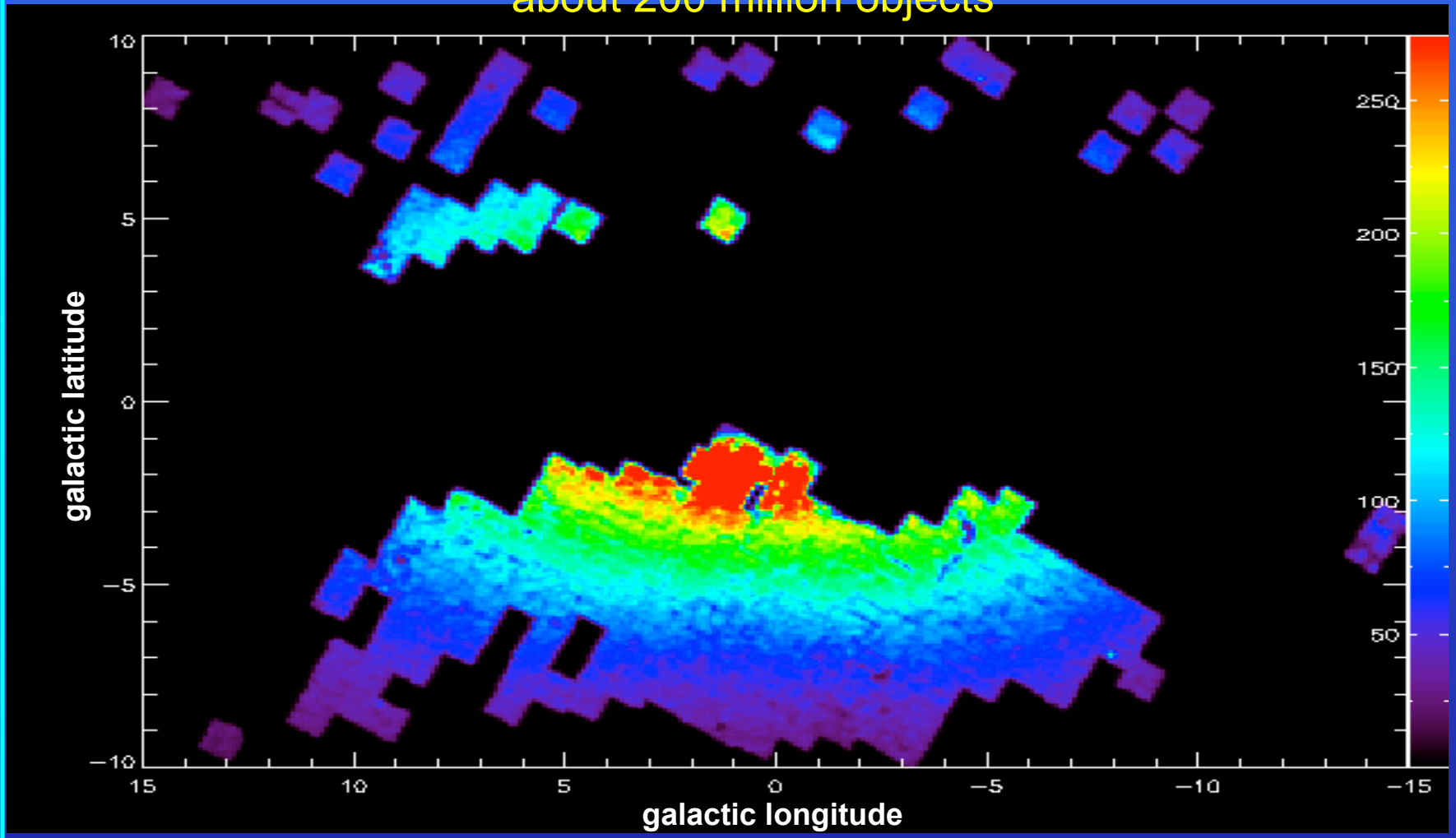


OGLE-III Bulge fields

~300 fields

~100 square degrees

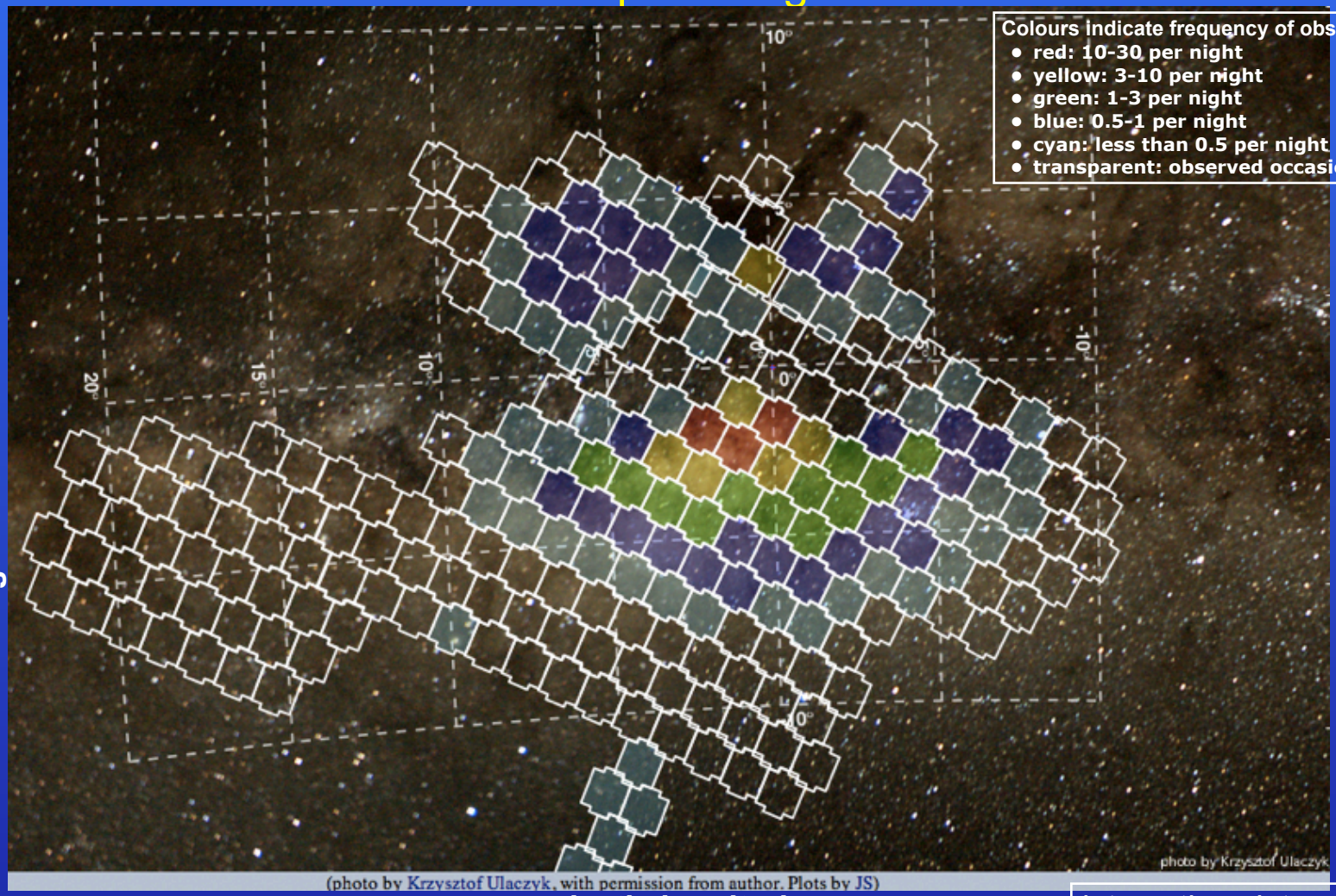
about 200 million objects



OGLE-IV Bulge fields

233 fields

~330 square degrees



(photo by Krzysztof Ulaczyk, with permission from author. Plots by JS)

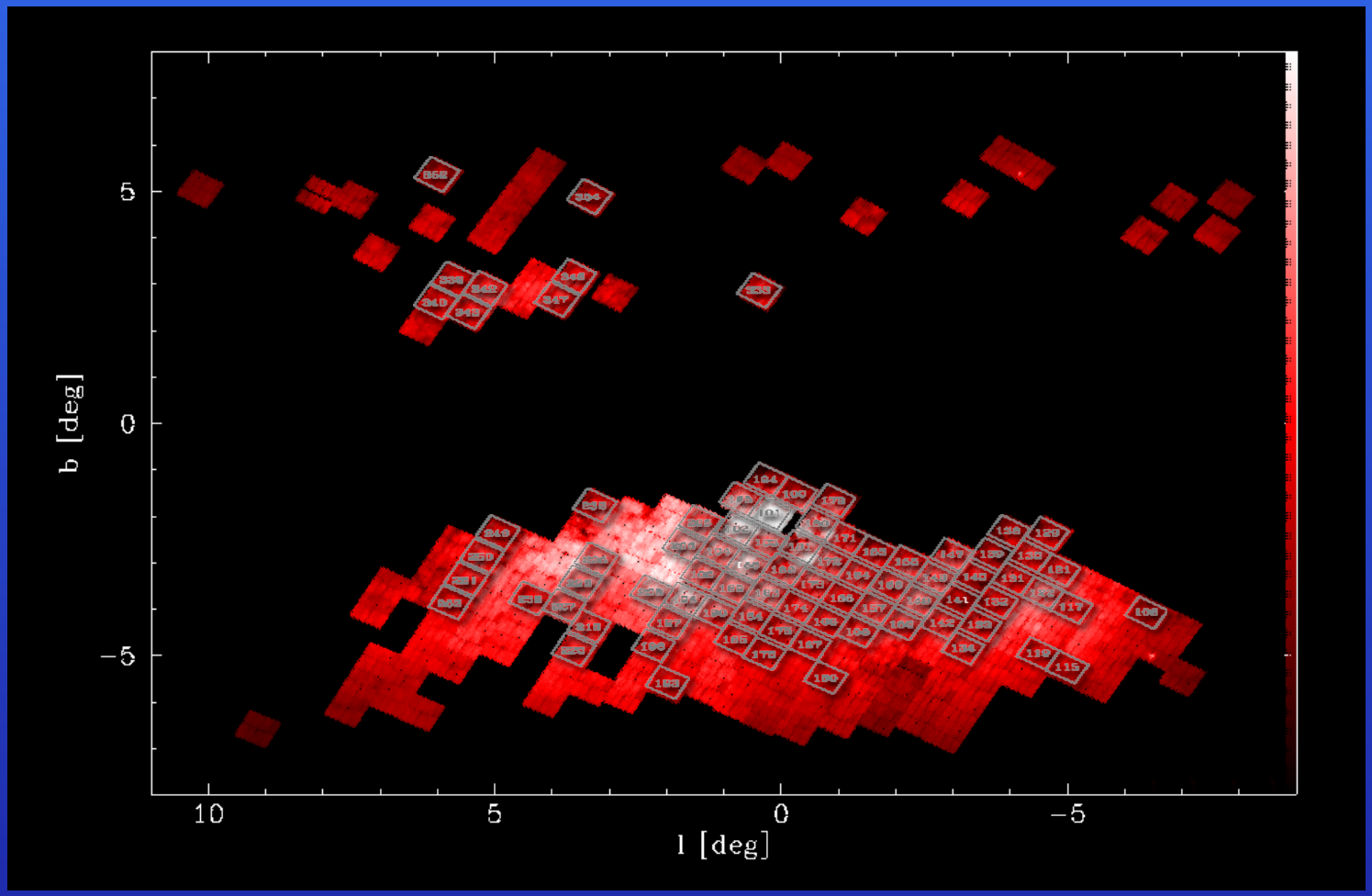
galactic latitude

galactic longitude

interactive plots available at: ogle.astrouw.edu.pl

OGLE-III data search (2001-2004)

82 (out of 260) fields selected - frequently observed in 2001-2004 seasons
~27 sq. deg, ~50 million stars



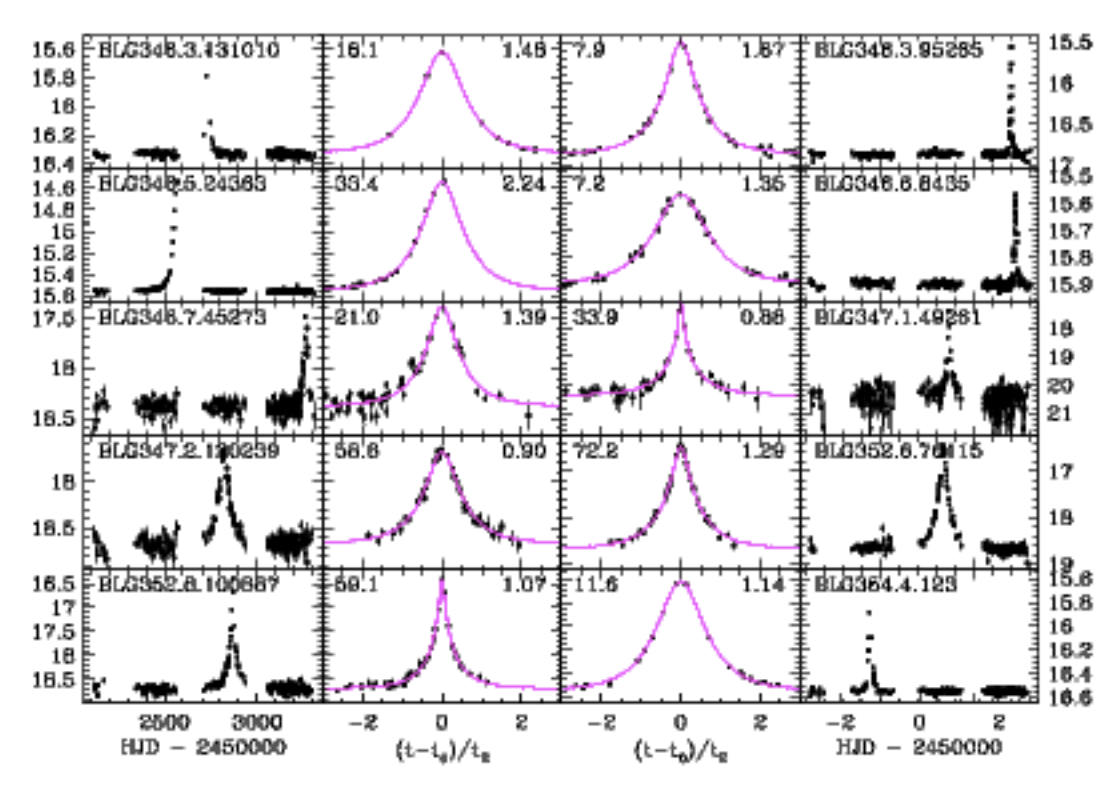
Outline of the search procedure

I < 21.0 mag : ~50 million stars monitored for 4 years

significant brightening over baseline: ~12,000 objects

artefacts removed: 2290 candidates

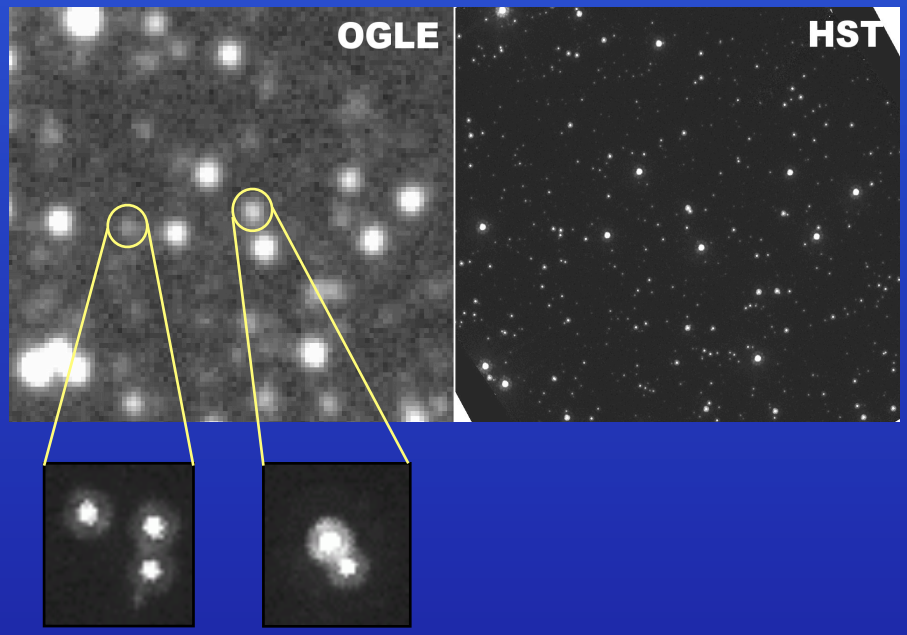
standard microlensing fit ok: 610 standard events

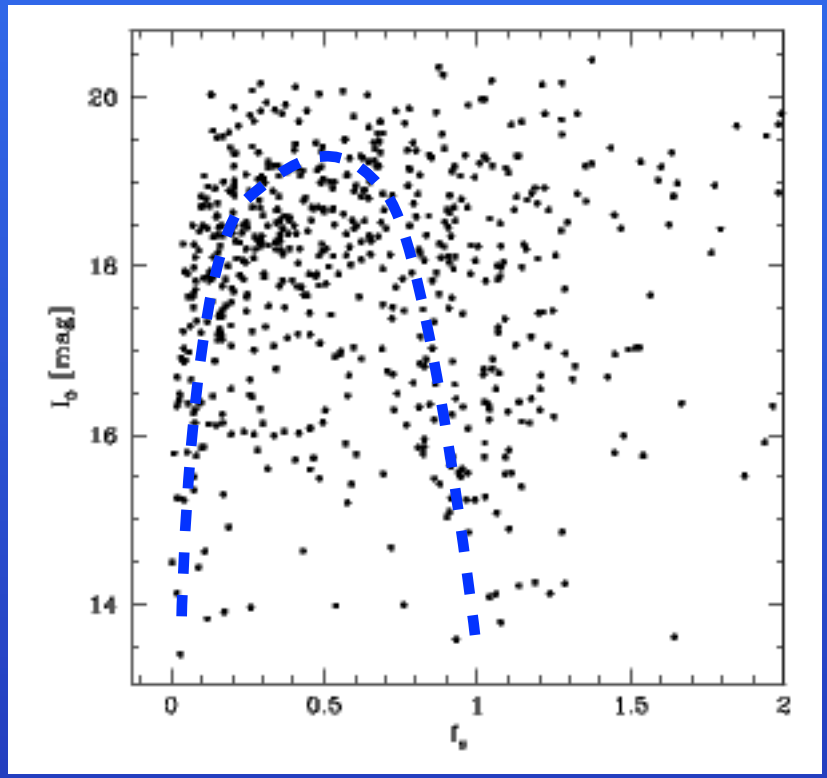


Simplified blending distribution

- derived using standard events fits
- follows characteristic U shaped distribution (Sumi+2005)
- to be used in efficiency calculation

- in the full study the HST-OGLE comparison will be done

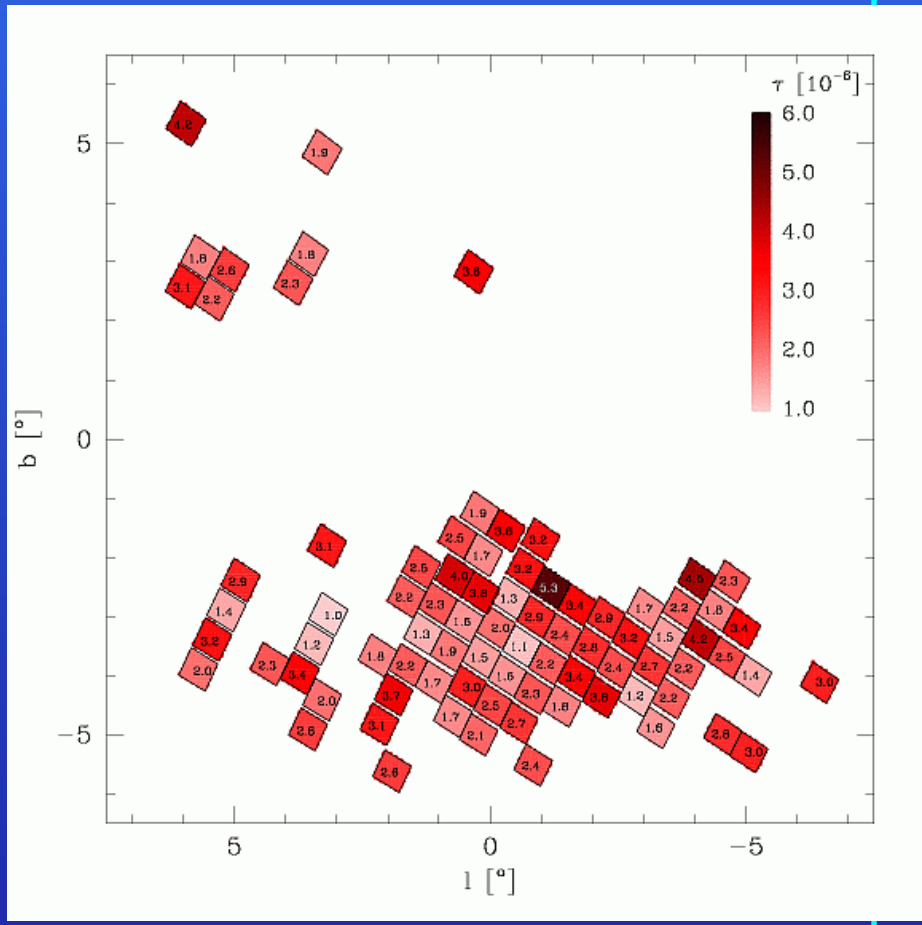




Optical depth towards the bulge from partial OGLE-III data (2001-2004)

PhD thesis of Łukasz Wyrzykowski (2005)

the largest sample so far (OGLE-III):
610 events, 27 sq.deg, 50 million stars



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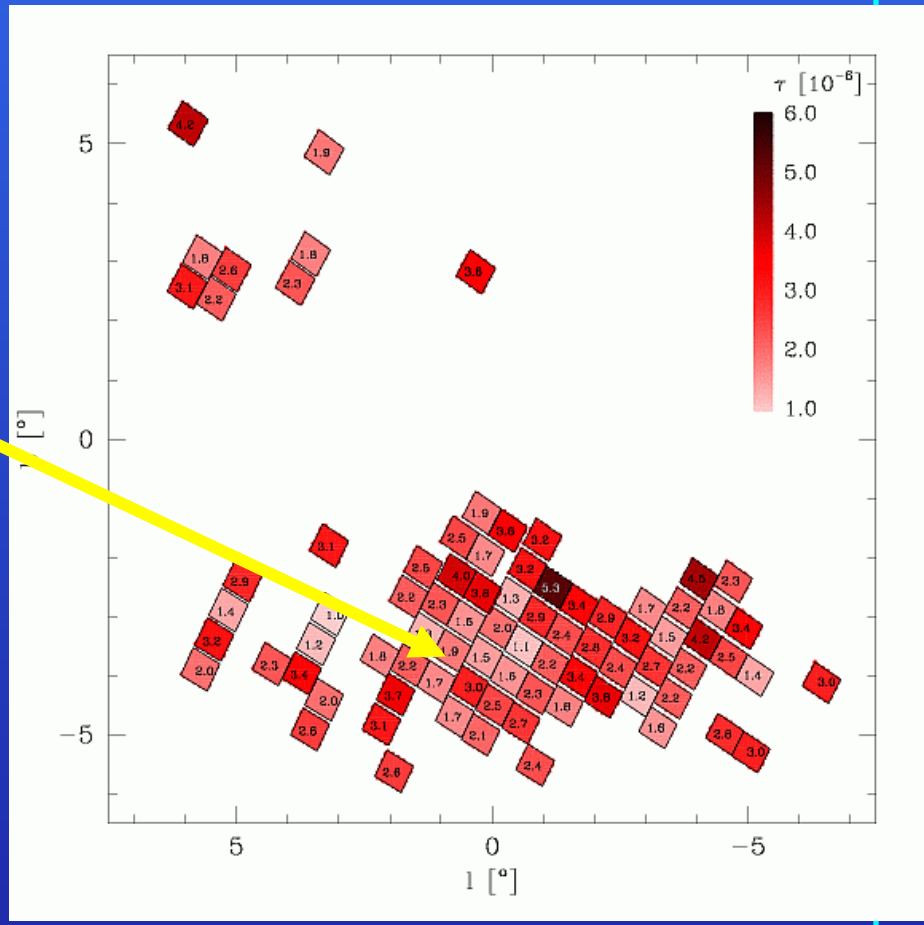
τ_{BW}= 1.9±0.3 10^{-6}



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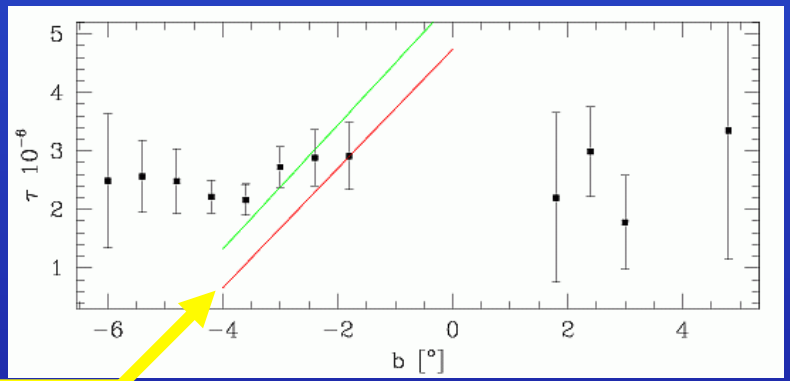
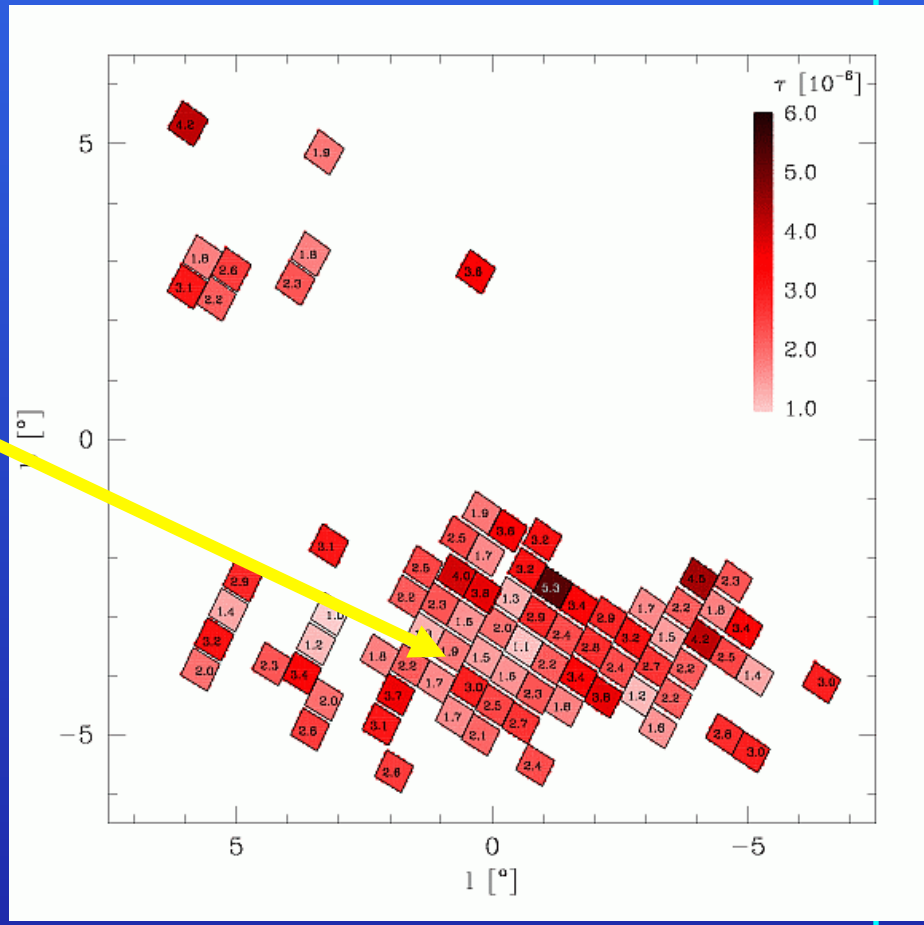
weak dependence of tau on b
- contamination with disk sources



Sumi+2005

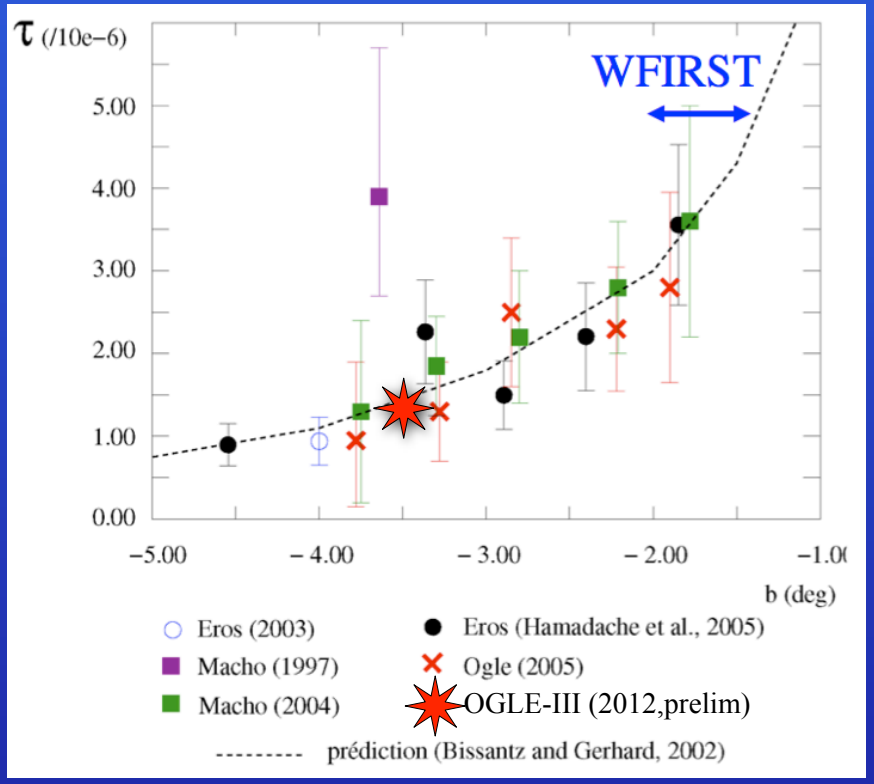


Optical depth towards the bulge from full OGLE-III data (2001-2009) ***Preliminary results***

- calculation for Baade's Window fields with 13.8 million stars
- only high quality events chosen
- 111 standard events found

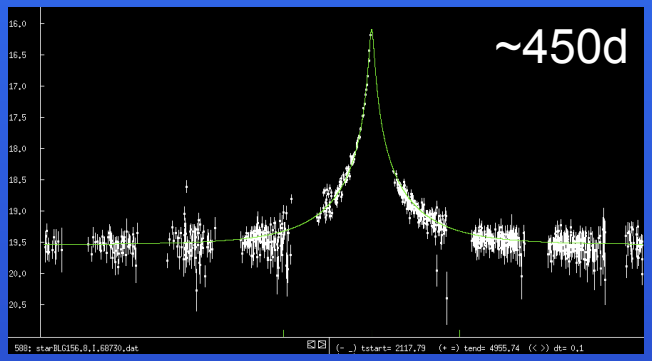
$$\tau_{BW} = 1.3 \pm 0.2\ 10^{-6}$$

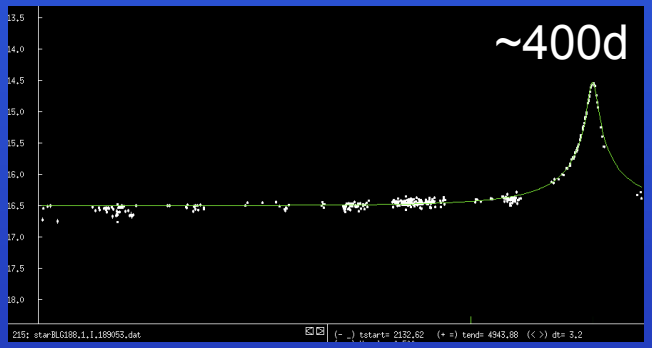
- in agreement with expected value
- based on all stars down to 20.5 (not only bright) - and still in agreement with bright stars results
- 5,000 events expected - enough for detailed map of the optical depth for *-7<l<+7* and *-5<b<-2*

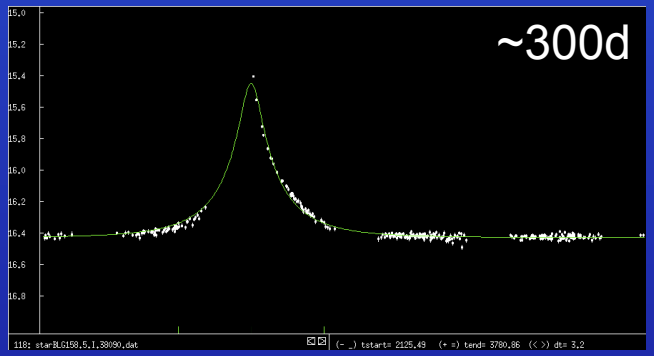


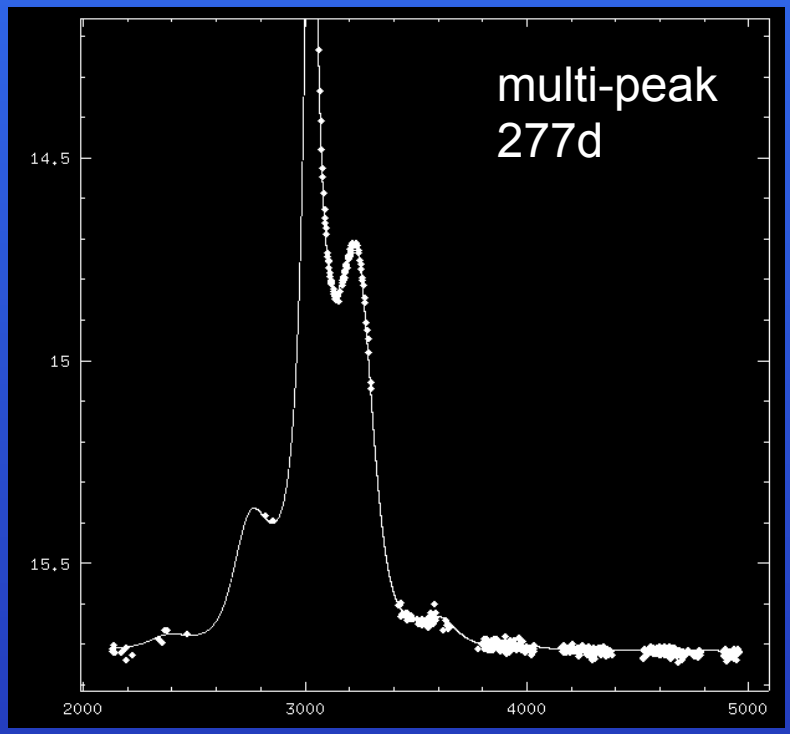
from D.Bennett

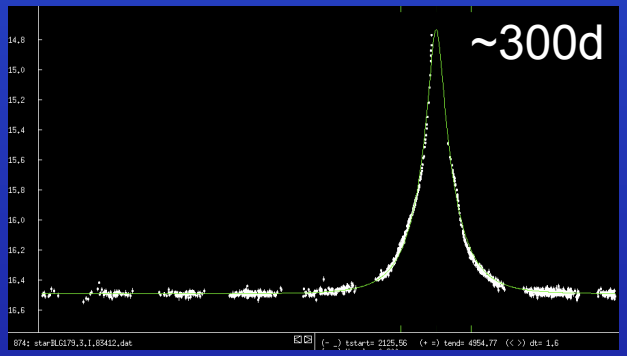
new long events, t_E>200d



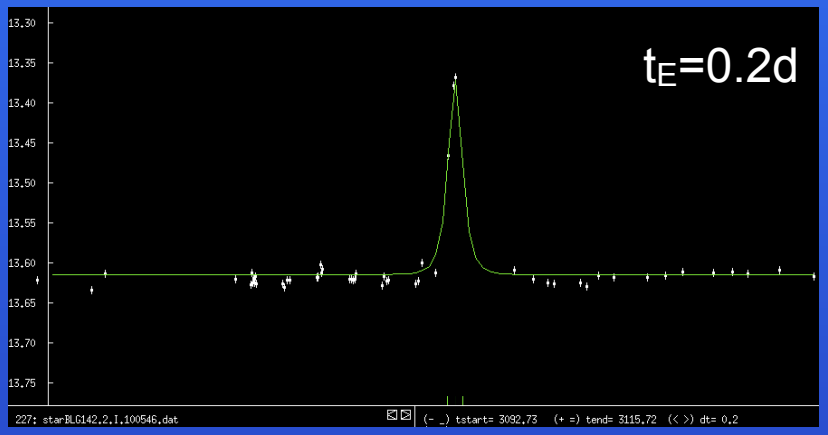




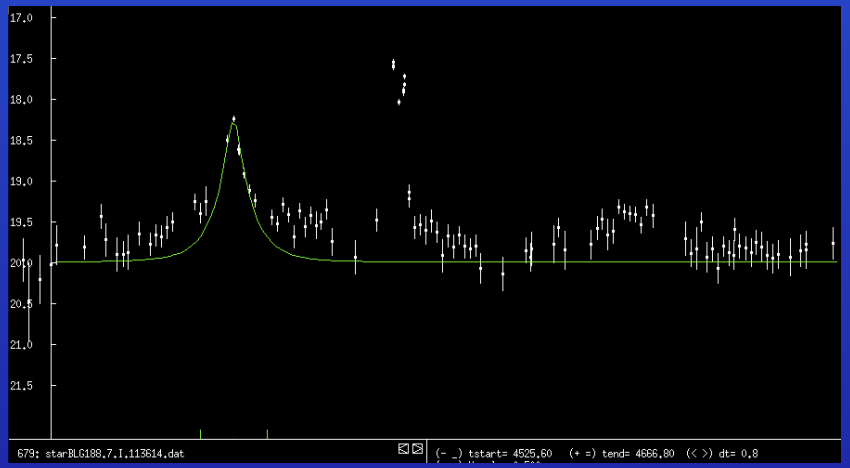




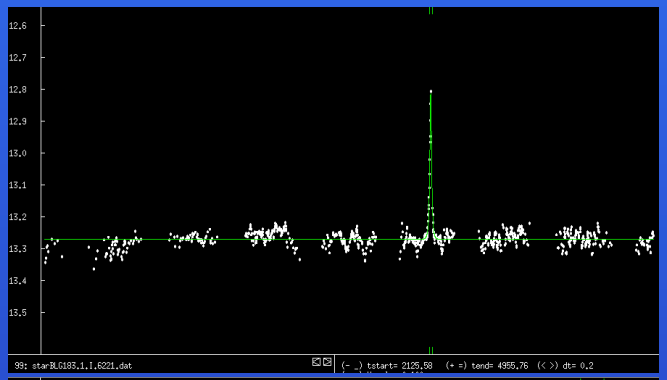
very short events

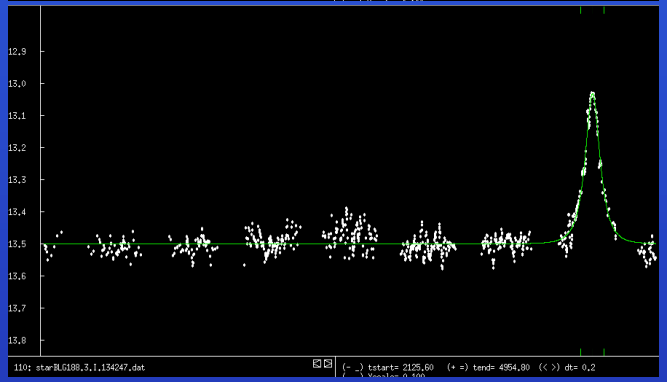


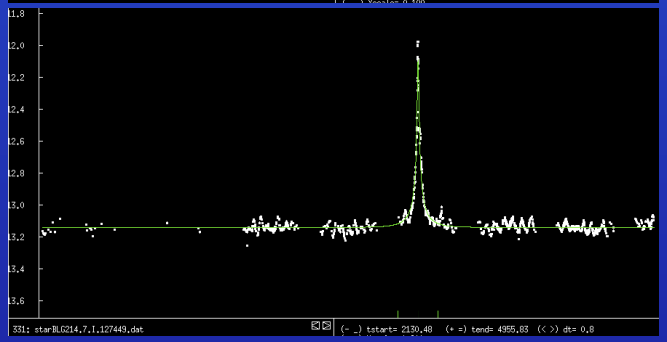
t_E=6d + caustic crossing

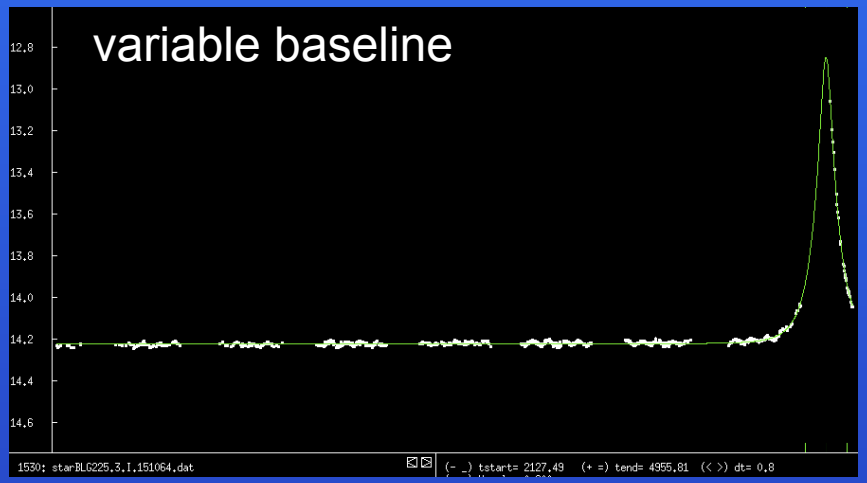


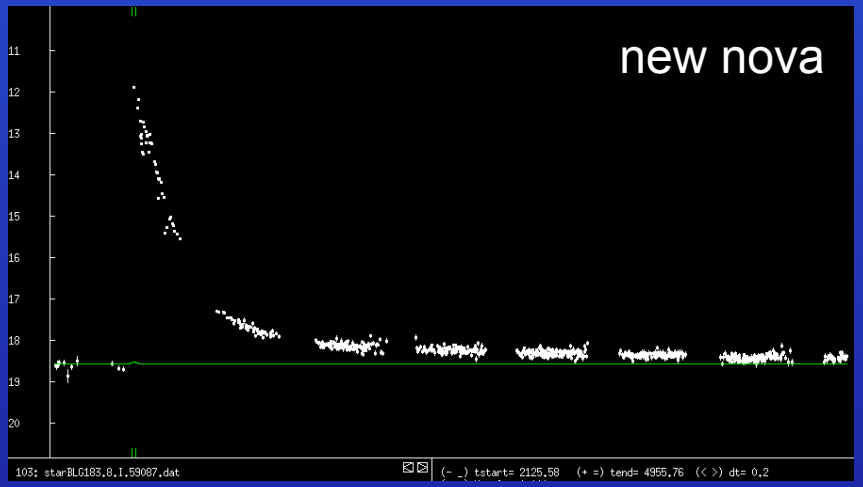
other interesting events











Future of Galactic optical depth studies

- OGLE-III (2001-2009) events catalogue to be published soon
- next step: map of the optical depth towards the Galactic Bulge with OGLE-III events
- OGLE-IV (2010 - ...) is monitoring the Bulge and the Plane
- VVV NIR Bulge/Plane survey at low *b* to complement OGLE I-band tau studies
- ESA's Gaia mission (2013-2018) will detect microlensing events with t_E>30 from all over the sky; Bulge not very well covered

Thank you !