# Microlensing observations using the Rosetta spacecraft

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# Microlensing from space

- Advantages
  - Out of atmosphere, no weather or seeing problems
  - No diurnal cycle
  - Large parallax signal relative to Earth

- Disadvantages
  - High cost
  - Low bandwidth

# Microlensing from space

- Advantages
  - Out of atmosphere, no weather or seeing problems
  - No diurnal cycle
  - Large parallax signal relative to Earth
  - Added value for mission
- Disadvantages
  - ~~High cost~~
  - Low bandwidth
  - Camera not designed for microlensing
  - Availability depends on prime mission

"Borrowed" spacecraft

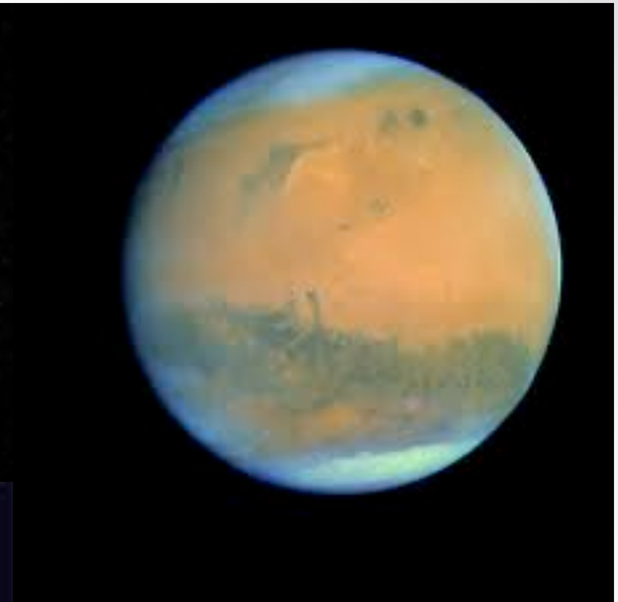
# Rosetta

- ESA Cornerstone mission.
- ~1 Billion Euro cost.
- Rendezvous with comet 67P/Churyumov-Gerasimenko.
- Most complicated comet mission ever flown.
- Will escort comet as it approaches the Sun, watch activity develop.
- 11 instruments, plus 10 on separate lander.

# Mission timeline

- 12 year mission
- 2 year comet phase
- Long hibernation
- Instruments generally off during cruise
- Fly-by targets
- Bonus cruise phase science
-

| Event | Nominal date |
|---|---|
| Launch | 2 March 2004 |
| 1st Earth gravity assist | 4 March 2005 |
| Mars gravity assist | 25 February 2007 |
| 2nd Earth gravity assist | 13 November 2007 |
| Asteroid Steins flyby | 5 September 2008 |
| 3rd Earth gravity assist | 13 November 2009 |
| Asteroid Lutetia flyby | 10 July 2010 |
| Enter deep space hibernation | July 2011 |
| Exit deep space hibernation | January 2014 |
| Rendezvous manoeuvre | May 2014 |
| Lander Delivery | November 2014 |
| Perihelion Passage | August 2015 |
| End of Mission | December 2015 |

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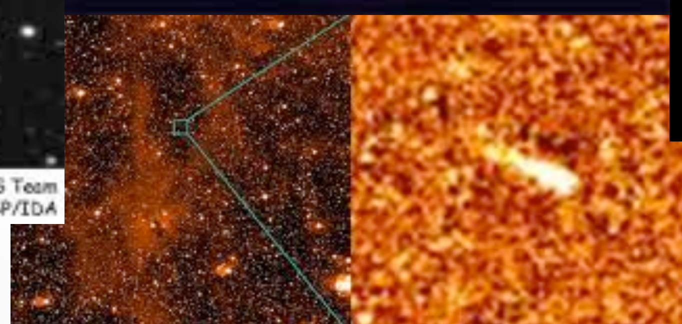
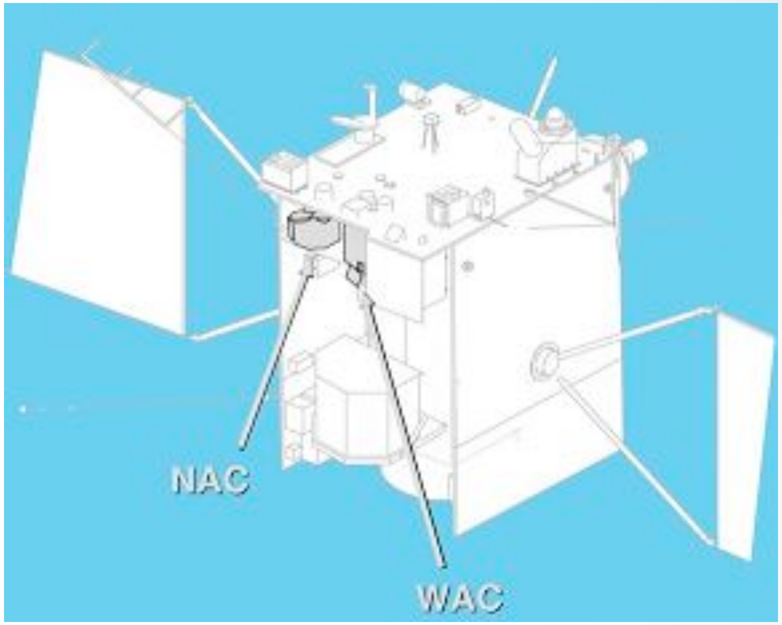
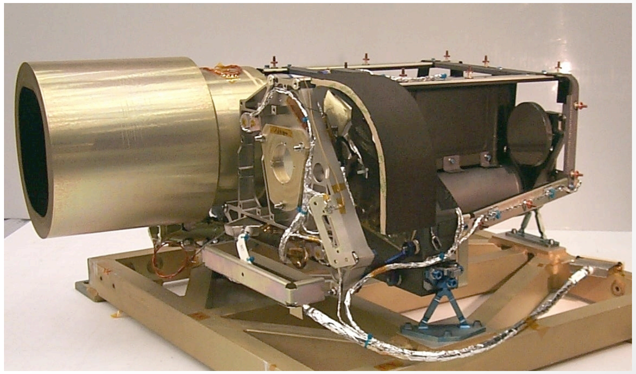


# OSIRIS

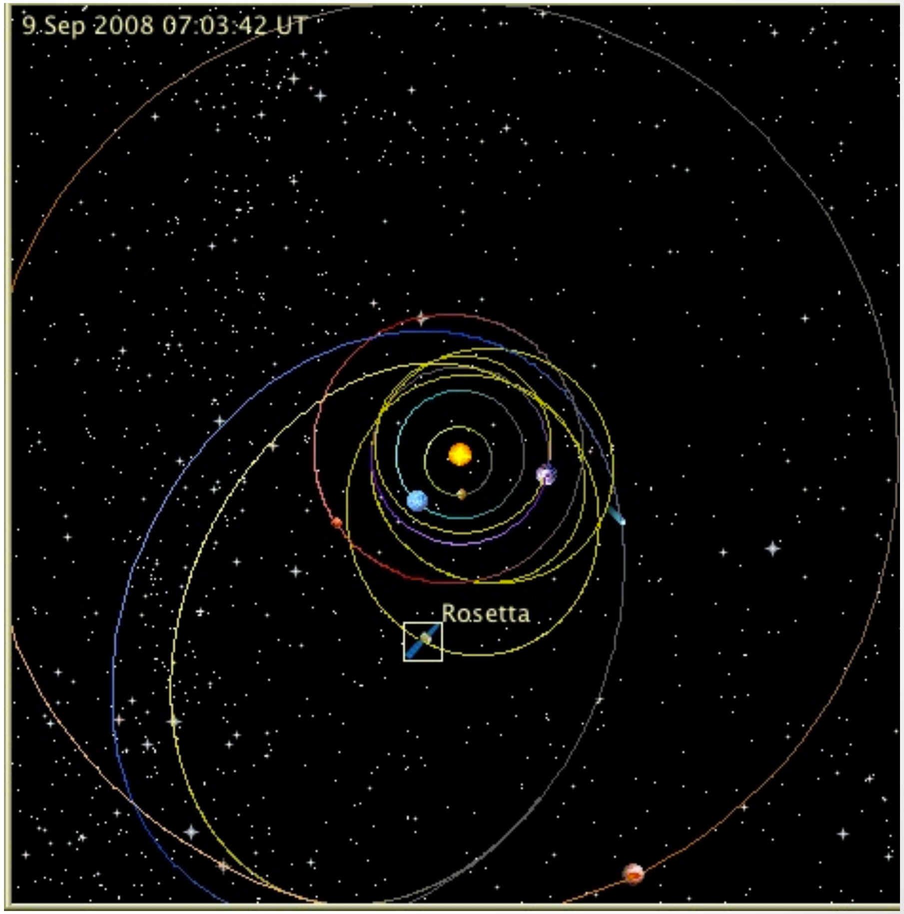
- OSIRIS (Optical, Spectroscopic, and Infrared Remote Imaging System) cameras on Rosetta.
- Narrow and Wide angle cameras (NAC & WAC).
- Designed to return high resolution images from close range.
- Not a space telescope.
- 12cm aperture, pixel scale 3.8 arcsec/pixel (NAC).
- FOV ~2 degrees (NAC).



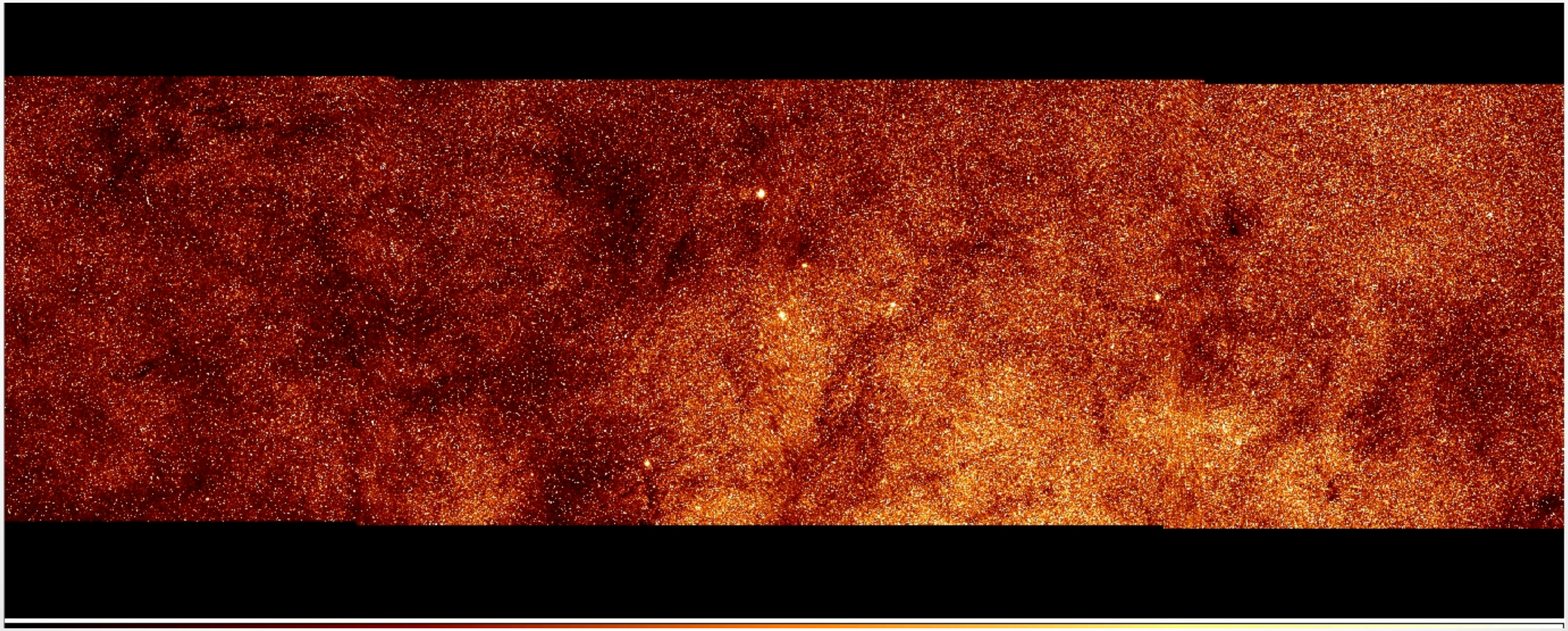



# Rosetta microlensing

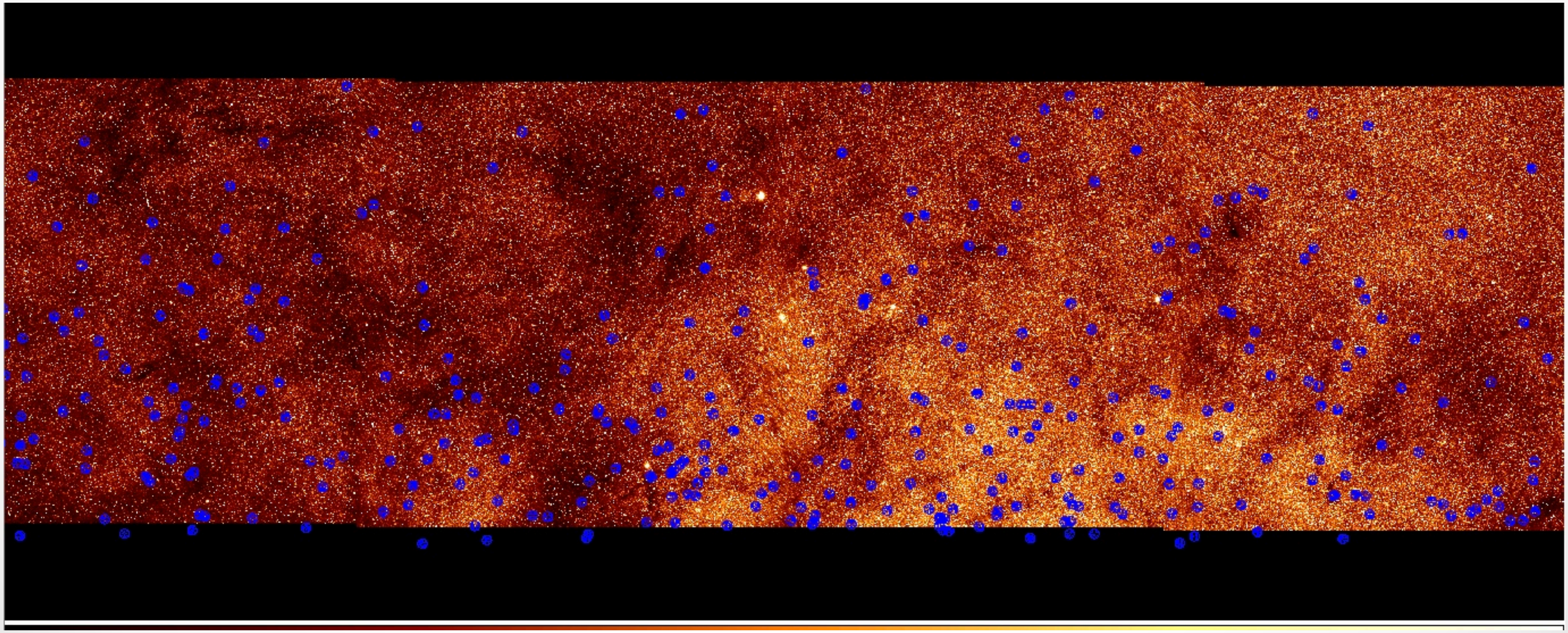
- End of 2008 bulge season.
- Immediately after Steins flyby (Sept/Oct 2008).
- At this point, Rosetta 2.4 – 2.8 AU from Earth.
- 7 visits to each of 8 fields.
- 300s exposure.
- “Orange” filter.



# Images



# Images



# Detectable events

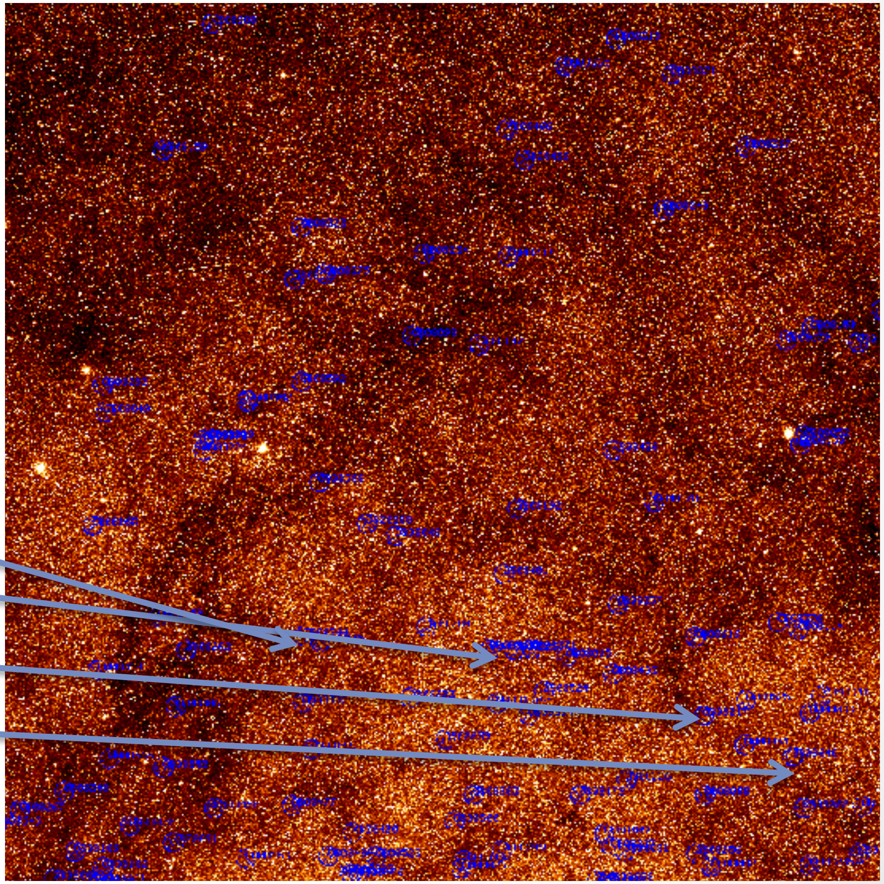
- 30 – 100 events per field.
- Most back at baseline by this point.
- Others too faint.

OB08344, I0 ~ 15

OB08517, I0 ~ 15

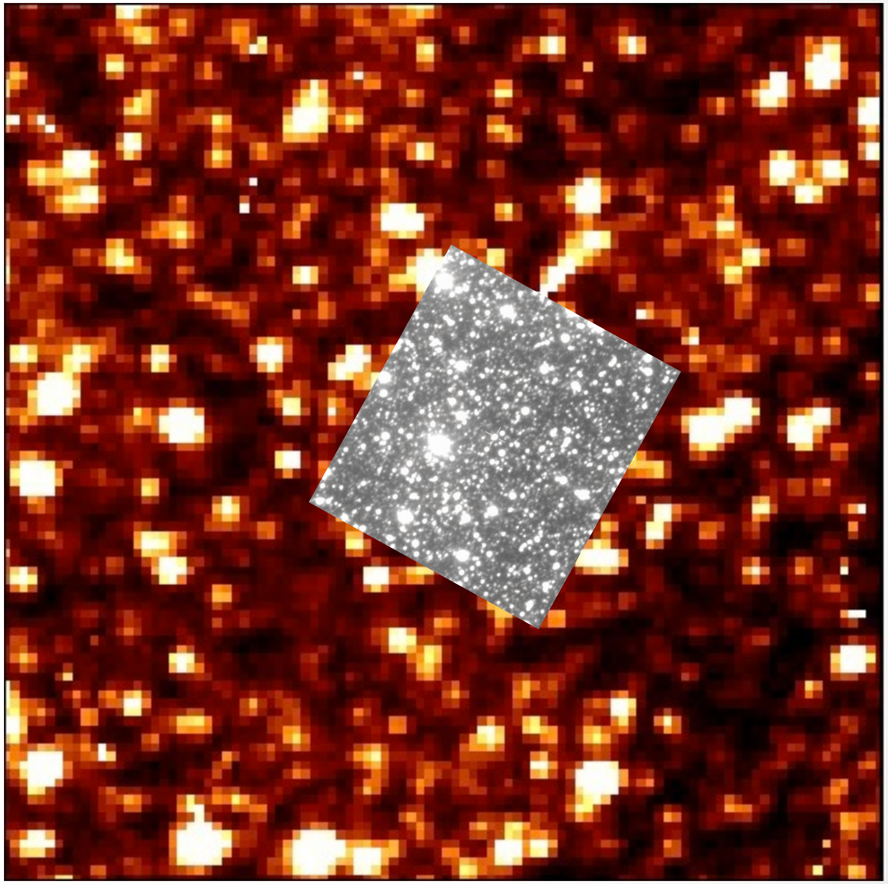
OB08525, I0 ~ 15

OB08640, I0 ~ 17



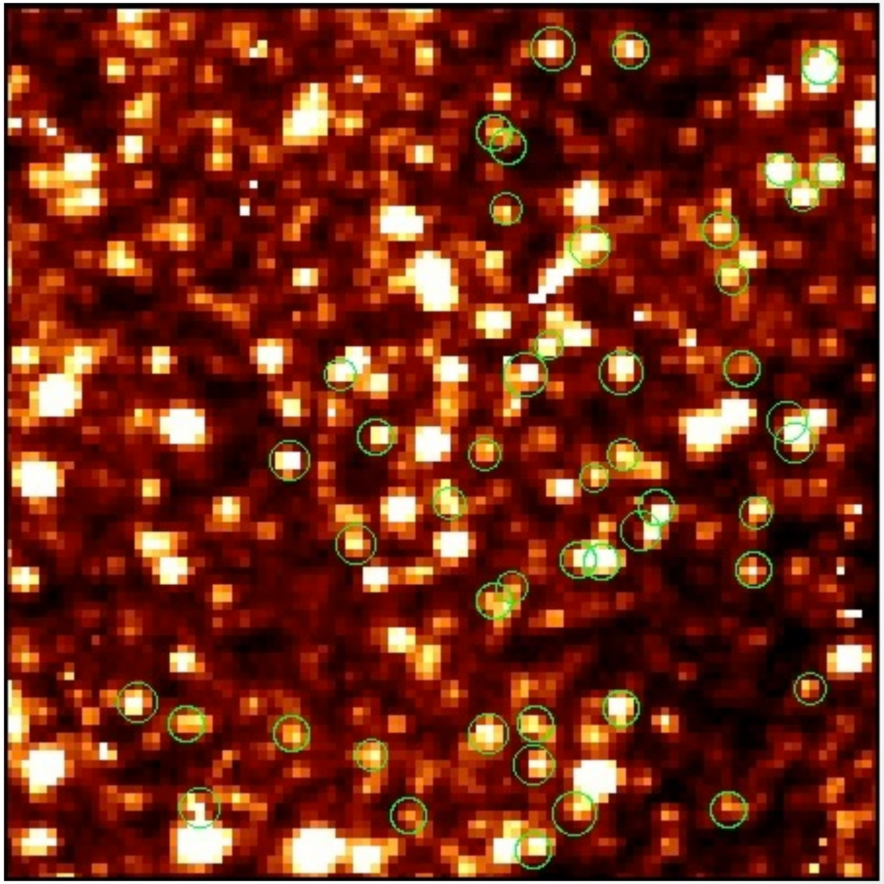
# OB-08-601

- 100 x 100 pixels subframe.
- ~6x6 arcmin
- Identification of source challenging.
- Sufficient bright isolated stars for comparison photometry

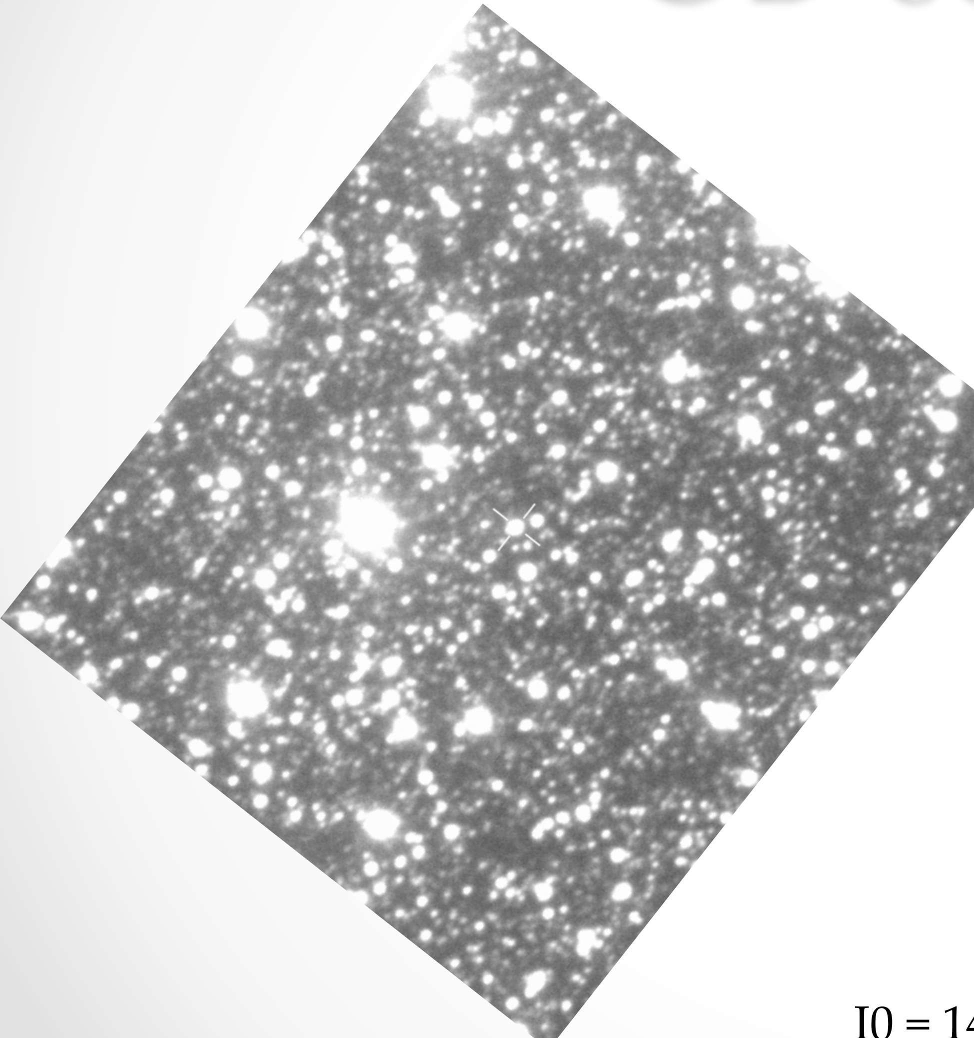


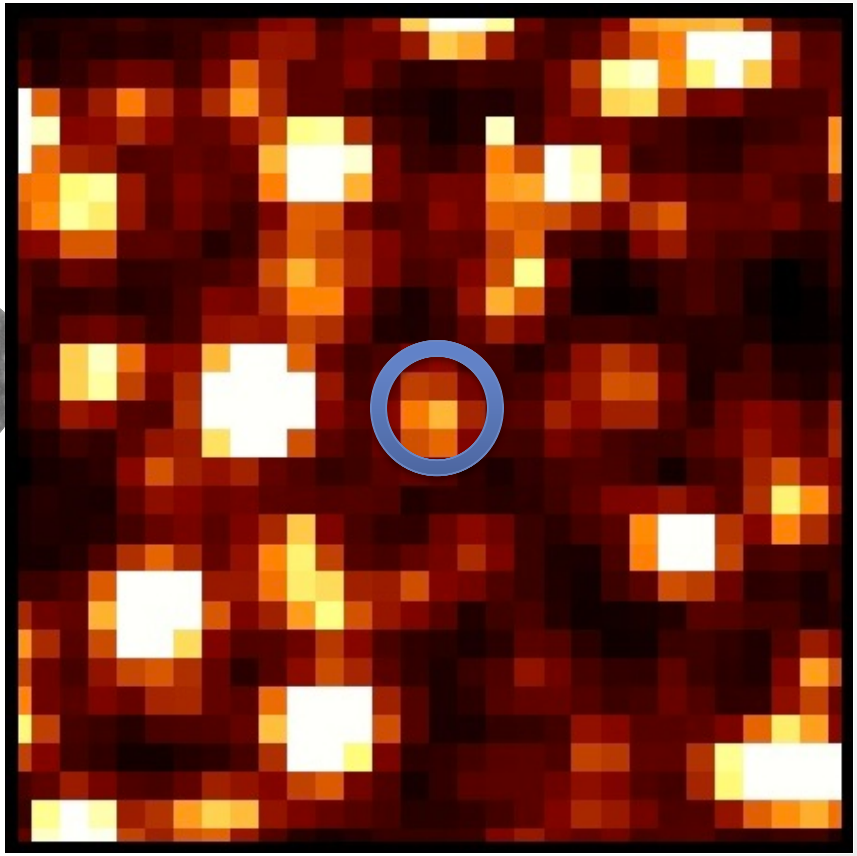
# OB-08-601

- 100 x 100 pixels subframe.
- ~6x6 arcmin
- Identification of source challenging.
- Sufficient bright isolated stars for comparison photometry
- 59 OGLE stars brighter than V=16 in BLG242.5



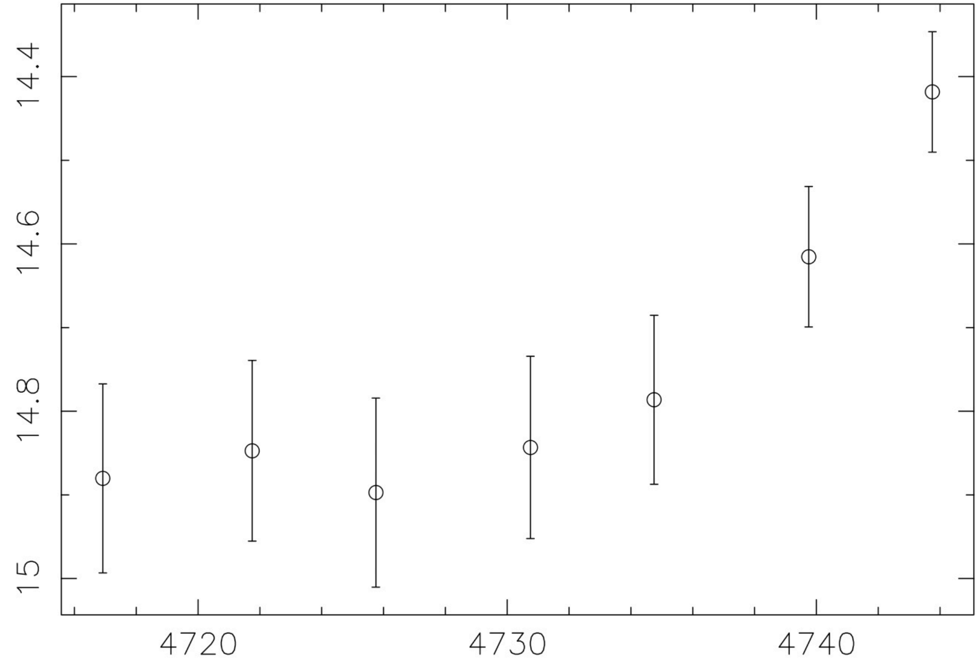
# OB-08-601



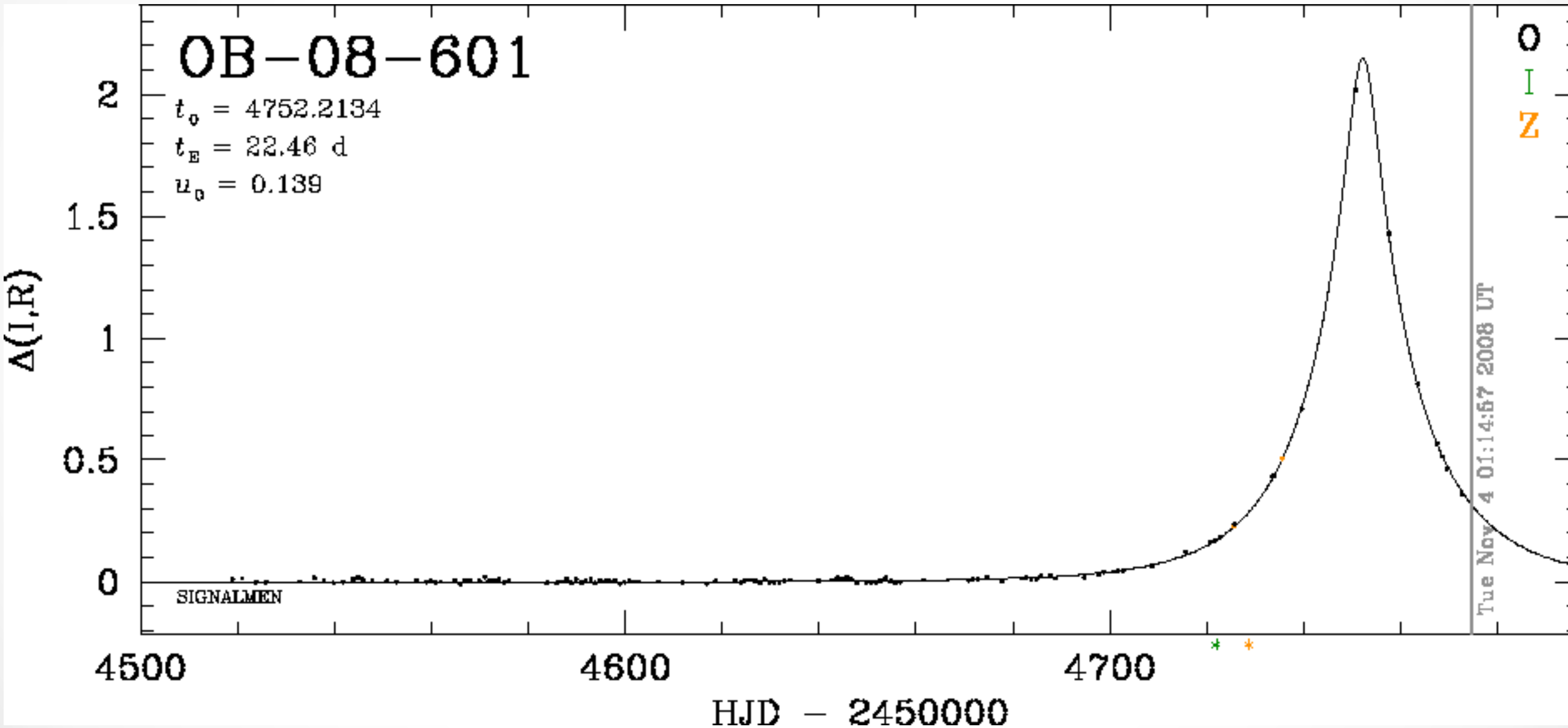


I0 = 14.6

# OB-08-601



# OB-08-601



OB−08−601
$t_0$ = 4752.2134
$t_E$ = 22.46 d
$u_0$ = 0.139
SIGNALMEN
O
I
Z
Tue Nov 4 01:14:57 2008 UT
Δ(I,R)
2
1.5
1
0.5
0
4500
4600
4700
HJD − 2450000

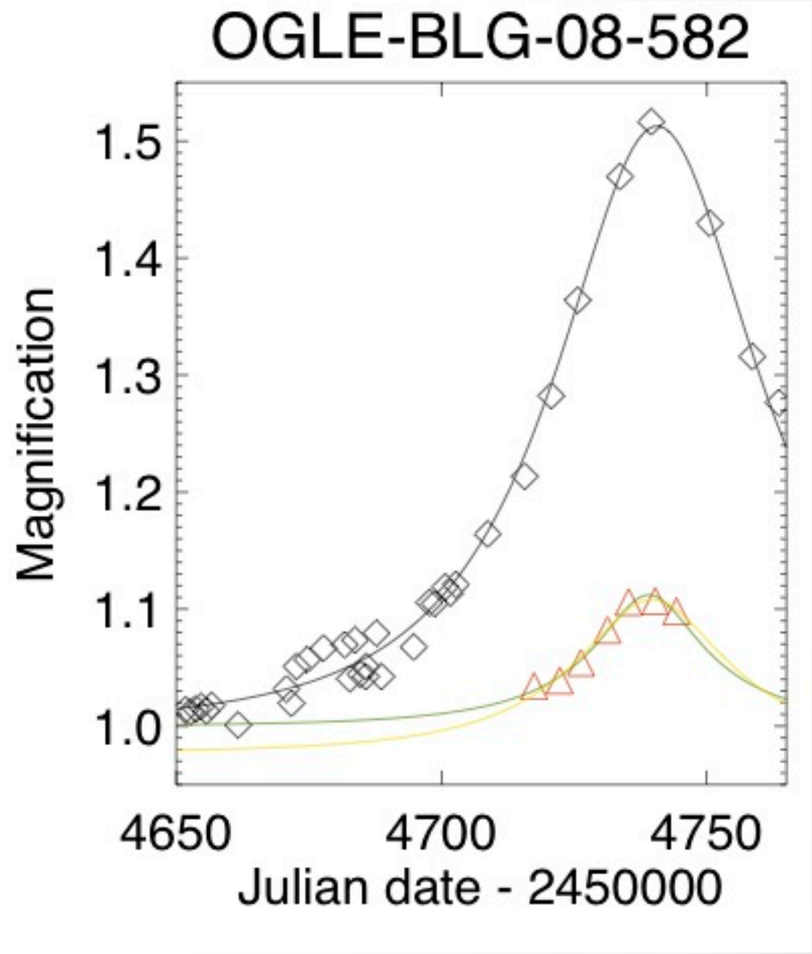
# OB-08-601

- Fixing t_E from ground based (22.9 days), and fitting for t0 and u0 with OSIRIS.
- Difference in t0 ~ 9 days.

| | | |
|---|---|---|
| Event | = | OB-08-601 |
| Fitted base brightness | = | 0.0390827979 |
| Fitted background brightness | = | 1.12128841 |
| Fixed t_E [d] | = | 22.8700008 |
| Ground based t_0 [JD] | = | 4752.50635 |
| Fitted t_0 [JD] | = | 4743.63158 |
| Ground based u_0 | = | 0.131999999 |
| Fitted u_0 | = | 0.101989537 |
| Tagential distance [R_E] | = | 0.388052618 |
| Radial distance [R_E] (1) | = | 0.0300104618 |
| Radial distance [R_E] (2) | = | 0.233989537 |
| Distance [R_E] (1) | = | 0.389211333 |
| Distance [R_E] (2) | = | 0.453140086 |
| Distance [AU] | = | 1.60000002 |
| R_Einstein [AU] (1) | = | 4.11087727 |
| R_Einstein [AU] (2) | = | 3.53091698 |

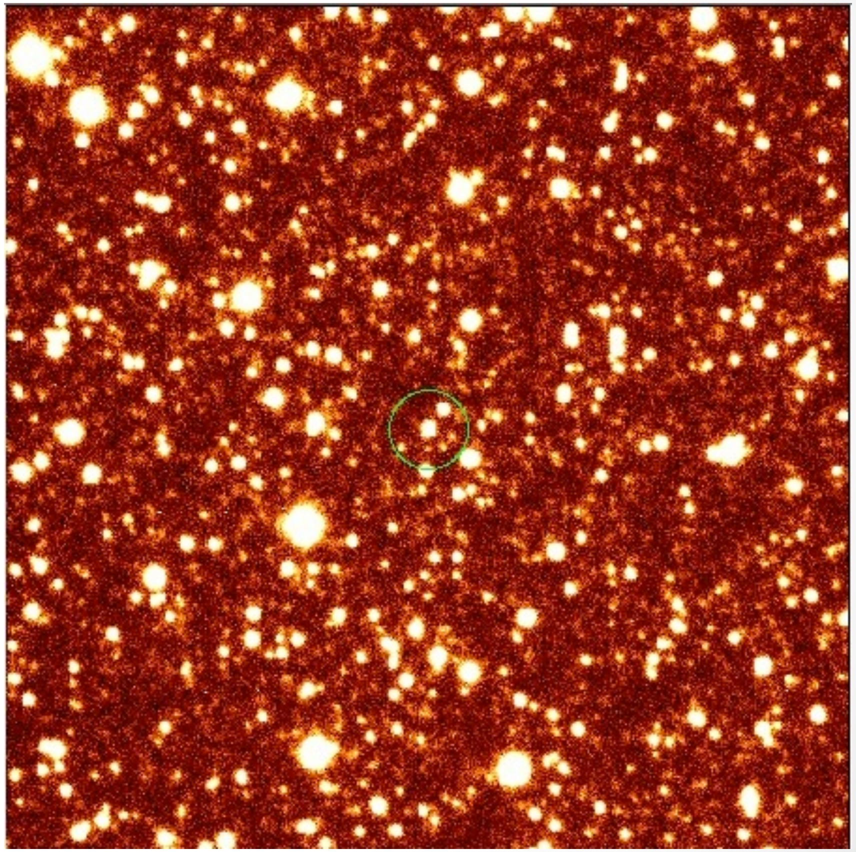
# OB-08-582

Event = OB-08-582
Fixed t_E [d] = 34.7890015
Ground based t_0 [JD] = 4740.60791
Fitted t_0 [JD] = 4739.65212
Ground based u_0 = 0.612999976
Fitted u_0 = 0.423104525
Tagential distance [R_E] = 0.0274739346
Radial distance [R_E] (1) = 0.189895451
Radial distance [R_E] (2) = 1.0361045
Distance [R_E] (1) = 0.191872612
Distance [R_E] (2) = 1.03646869
Distance [AU] = 1.60000002
R_Einstein [AU] (1) = 8.33886611
R_Einstein [AU] (2) = 1.54370319



# Blending

- Large pixels give strong blending.
- Only 7 points per curve, baseline not well measured.
- Observations the following year with ground based telescopes.
- Link with OGLE photometry calibrates this.
- Large aperture matches OSIRIS aperture.
- Create synthetic baseline magnitude for OSIRIS.



# Summary

- Rosetta/OSIRIS took images covering 2x16 degrees of the galactic bulge in September/October 2008.
- Seven epochs per object.
- Limiting magnitude $I \sim 17$.
- Large pixel scale makes photometry challenging.
- Large distance from the Earth ( > 2 AU, ~1.6 AU projected) gives strong parallax potential.
- Ground based imaging at baseline to constrain blending, relative to typical ground based observations.
- Use of OGLE-III photometric catalogue to provide flux calibration between different instruments.