The VVV Survey: New Results (Part II)

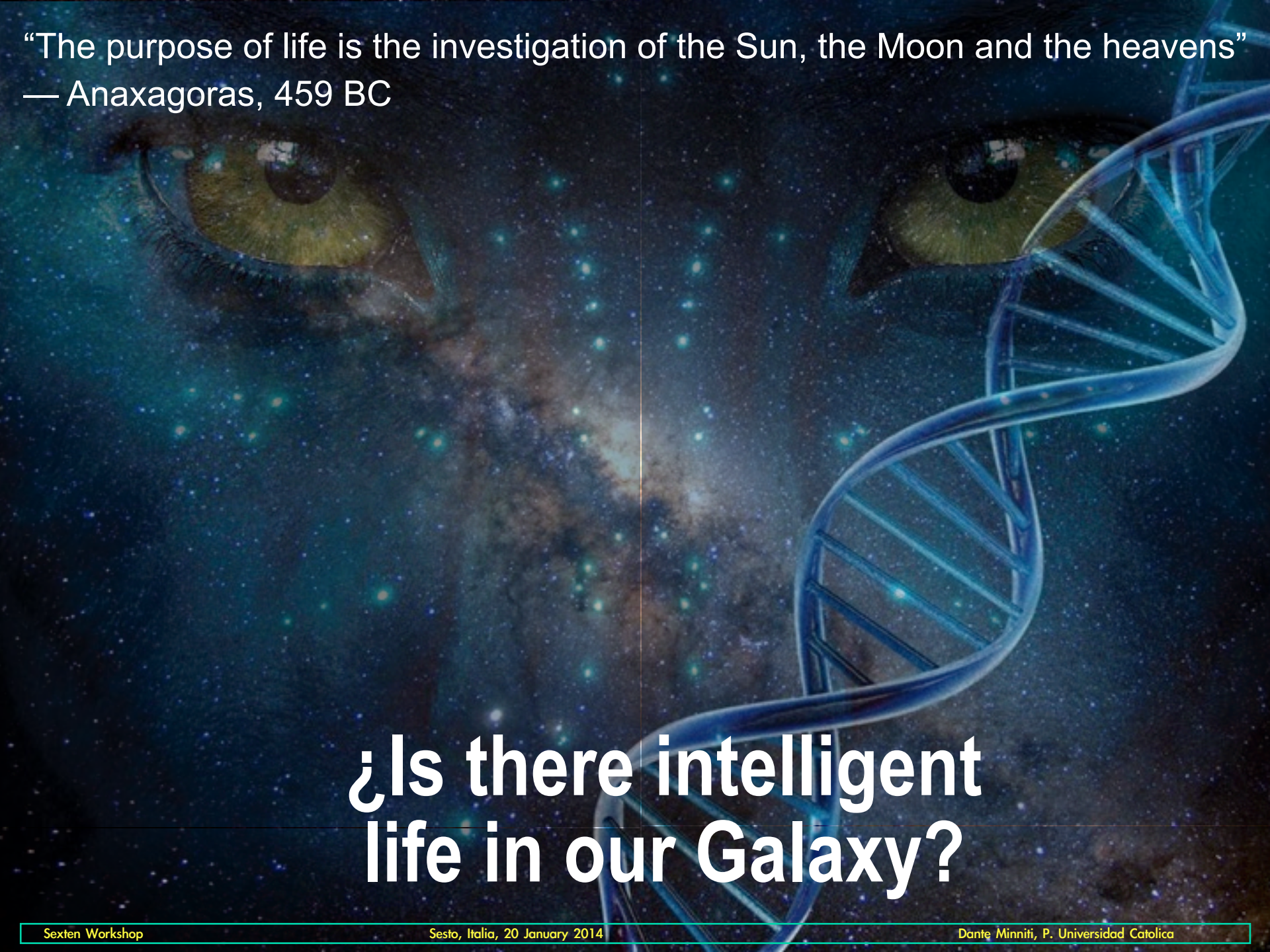
exploring our own galaxy,

fostering Southern collaborations,

promoting Astrophysics at all levels, &

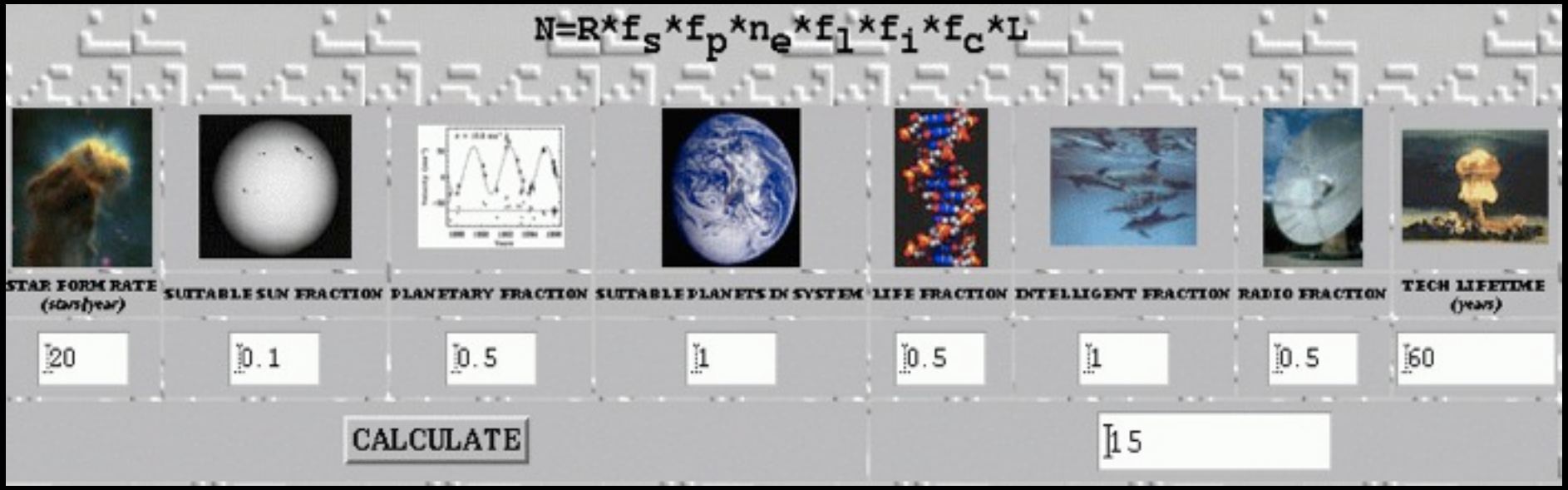
securing resources for the future generations.


“The purpose of life is the investigation of the Sun, the Moon and the heavens”
— Anaxagoras, 459 BC
Image Credit: Joyce Pullen


“The purpose of life is the investigation of the Sun, the Moon and the heavens”
— Anaxagoras, 459 BC
¿Is there intelligent life in our Galaxy?

Number of intelligent civilizations able to communicate

- ✓ N=17.000.000.000 Terrestrial planets in the Milky Way



- ✓ Habitable planets? Moons? Superhabitable Super-Earths?
- ✓ That actually develop life?
- ✓ That have Intelligent Species?
- ✓ With Science and Technology?
- ✓ But what is the Civilization Lifetime?

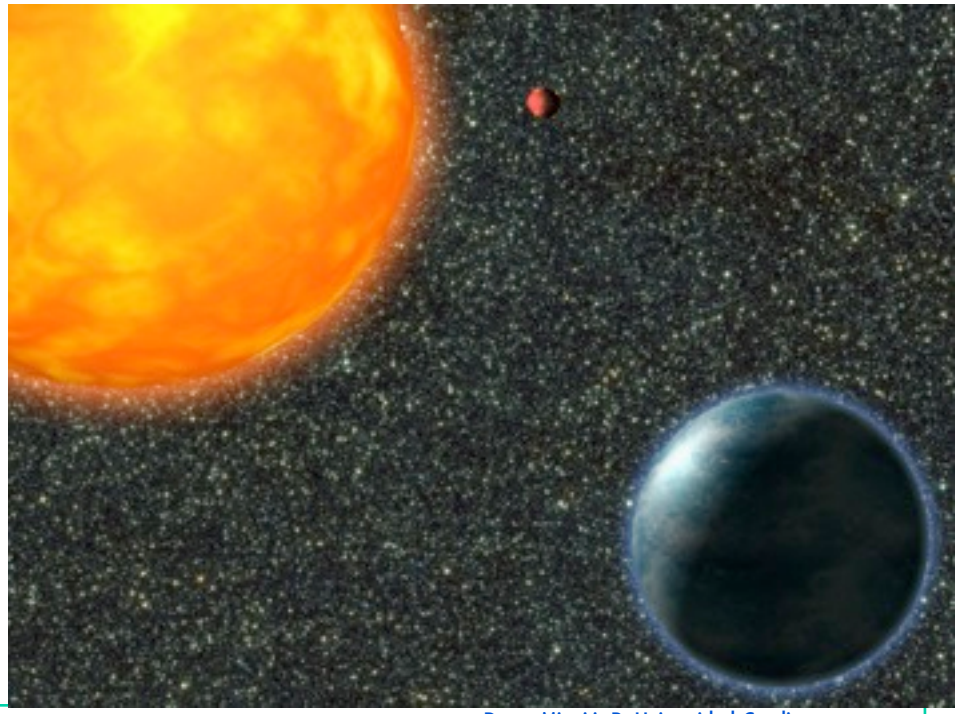
Drake Equation

Microlensing with the VVV Survey

- Characterization of known events

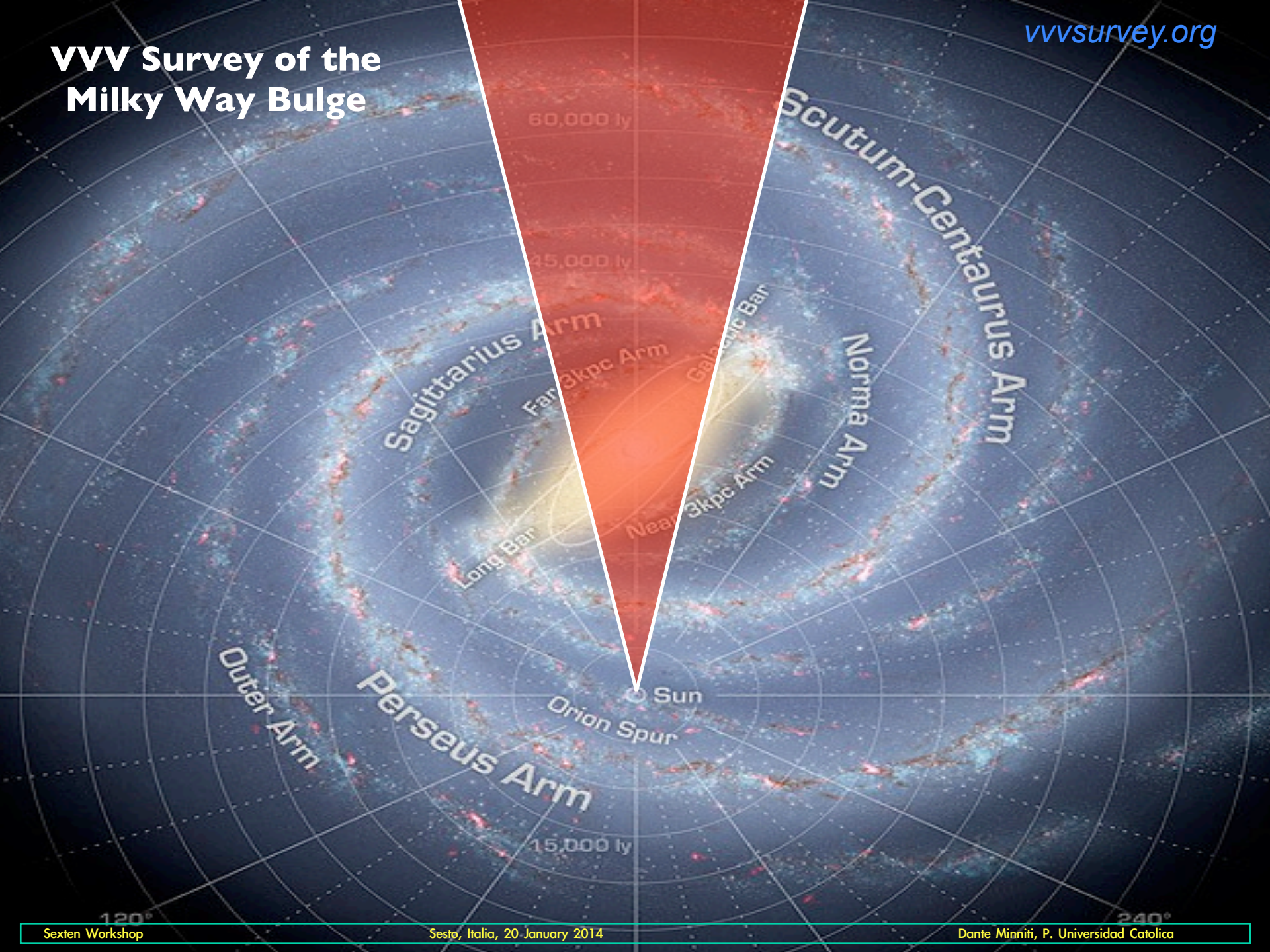
- New microlensing search in the IR

- Free floating planets

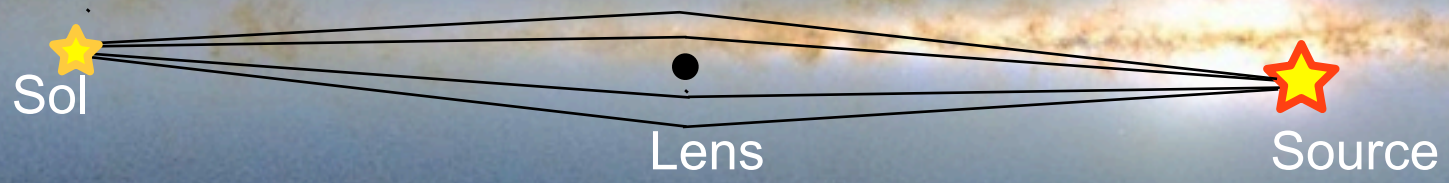


VVV Survey of the Milky Way Bulge

vvvsurvey.org

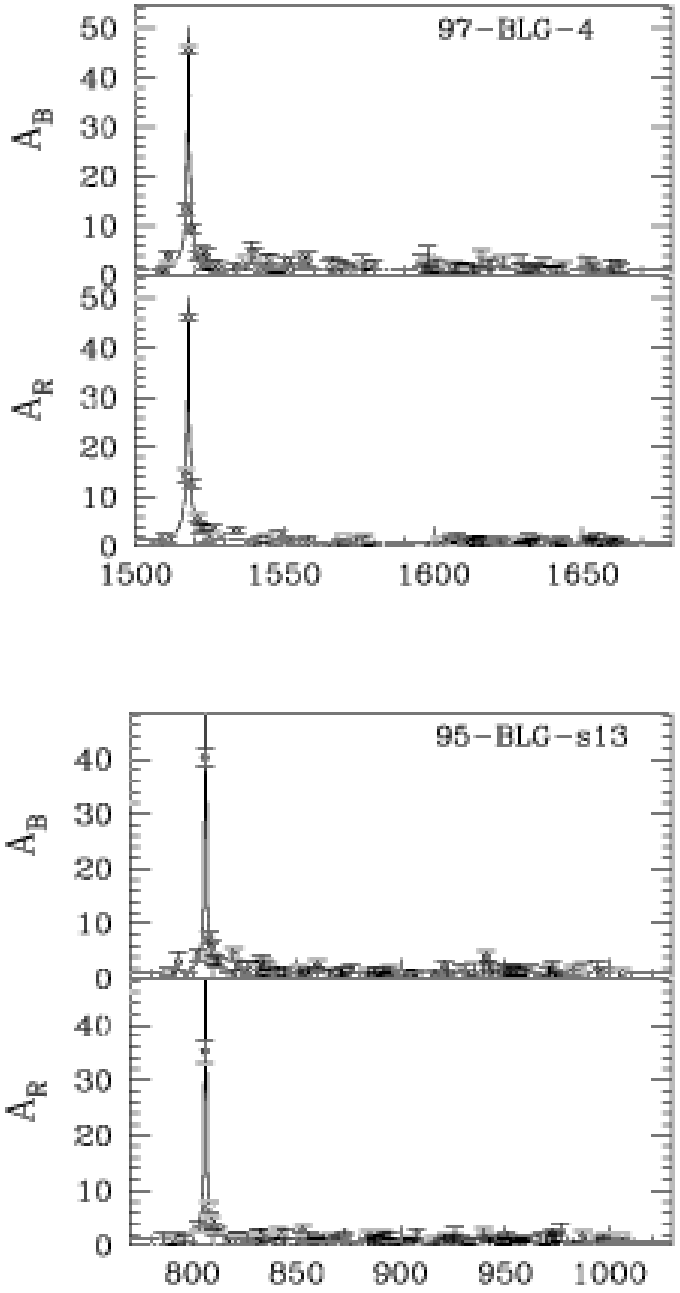


vvvsurvey.org



2MASS IMAGE OF THE MILKY WAY

Bulge Microlensing



Alcock et al. 1999

- **Towards the MW bulge**

  $t = 40\ (M/Mo)^{1/2}$ days

OBJECT	*TIMESCALE*
Sun	*40 days*
Jupiter	*1 day*
Earth	*1 hour*

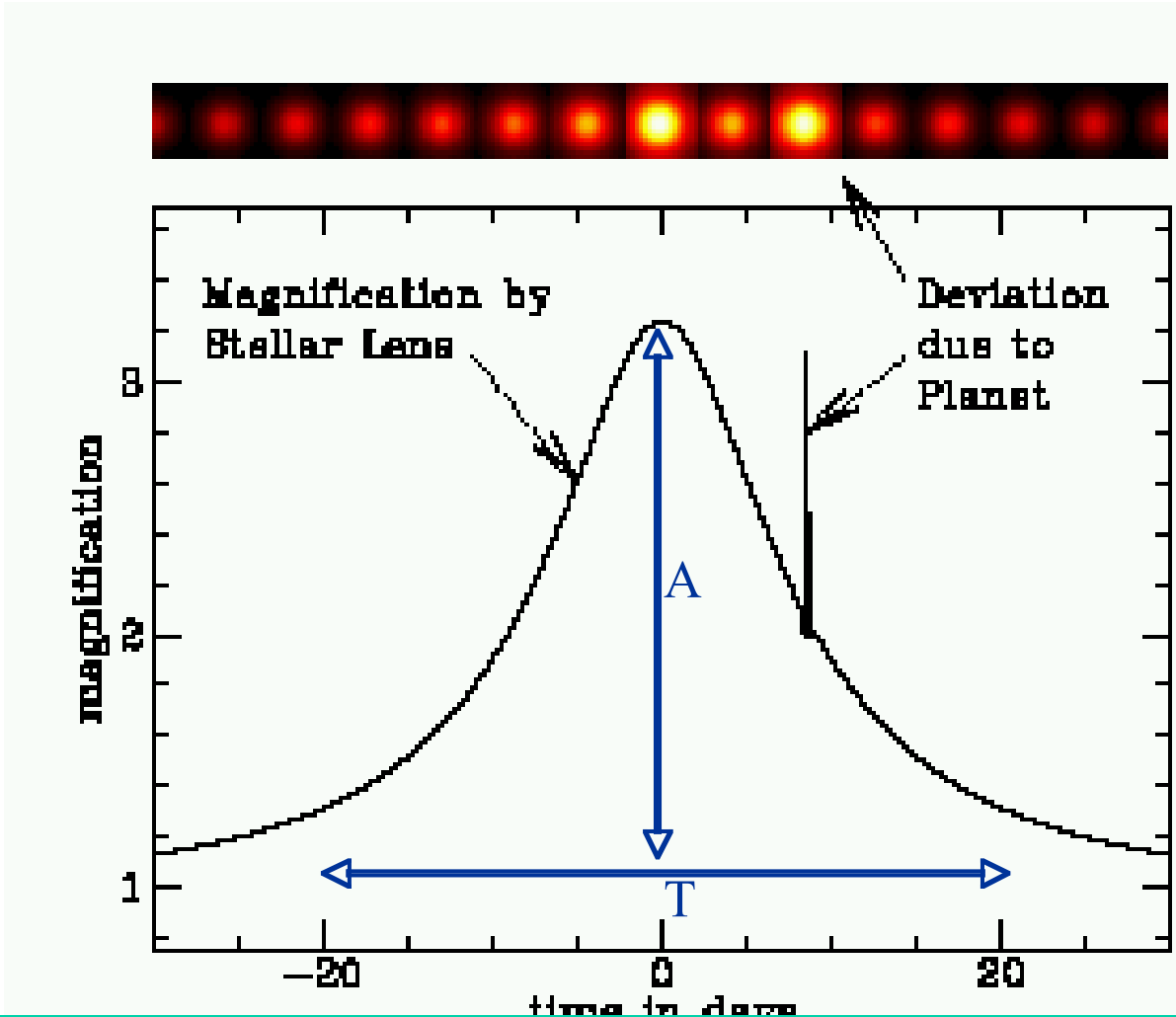
- **Einstein radius**

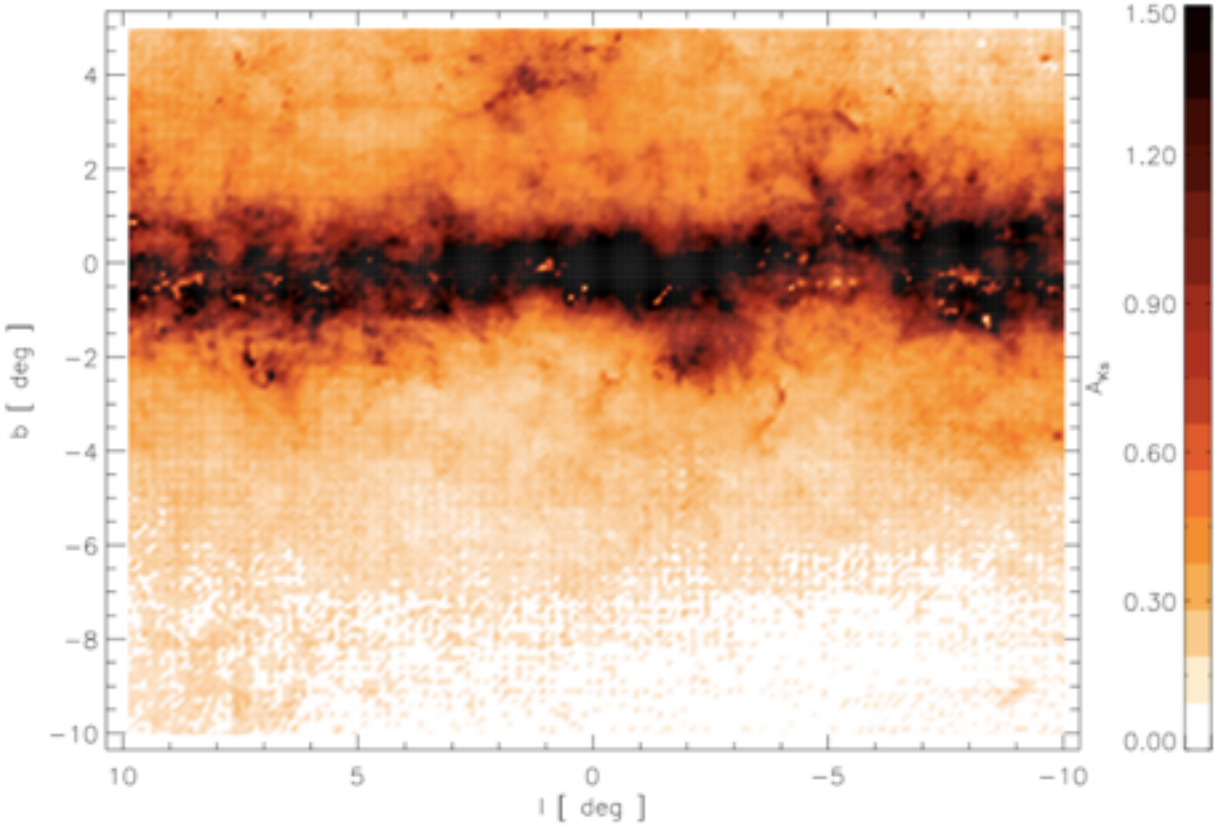
  $R_E = 3\ (M/Mo)^{1/2}$ AU

Binary microlensing events → planets

Observable: timescale
Unknowns: mass, relative distances, transverse velocity

- Gravitational microlensing: searching the short perturbation due to a planet orbiting the lensing star. We can think a star+planet as a special case of a binary star.





Oscar Gonzalez, Marina Rejkuba A&A 2011

Characterizing microlensing exoplanets

Step 1:

reddening maps using clump giants

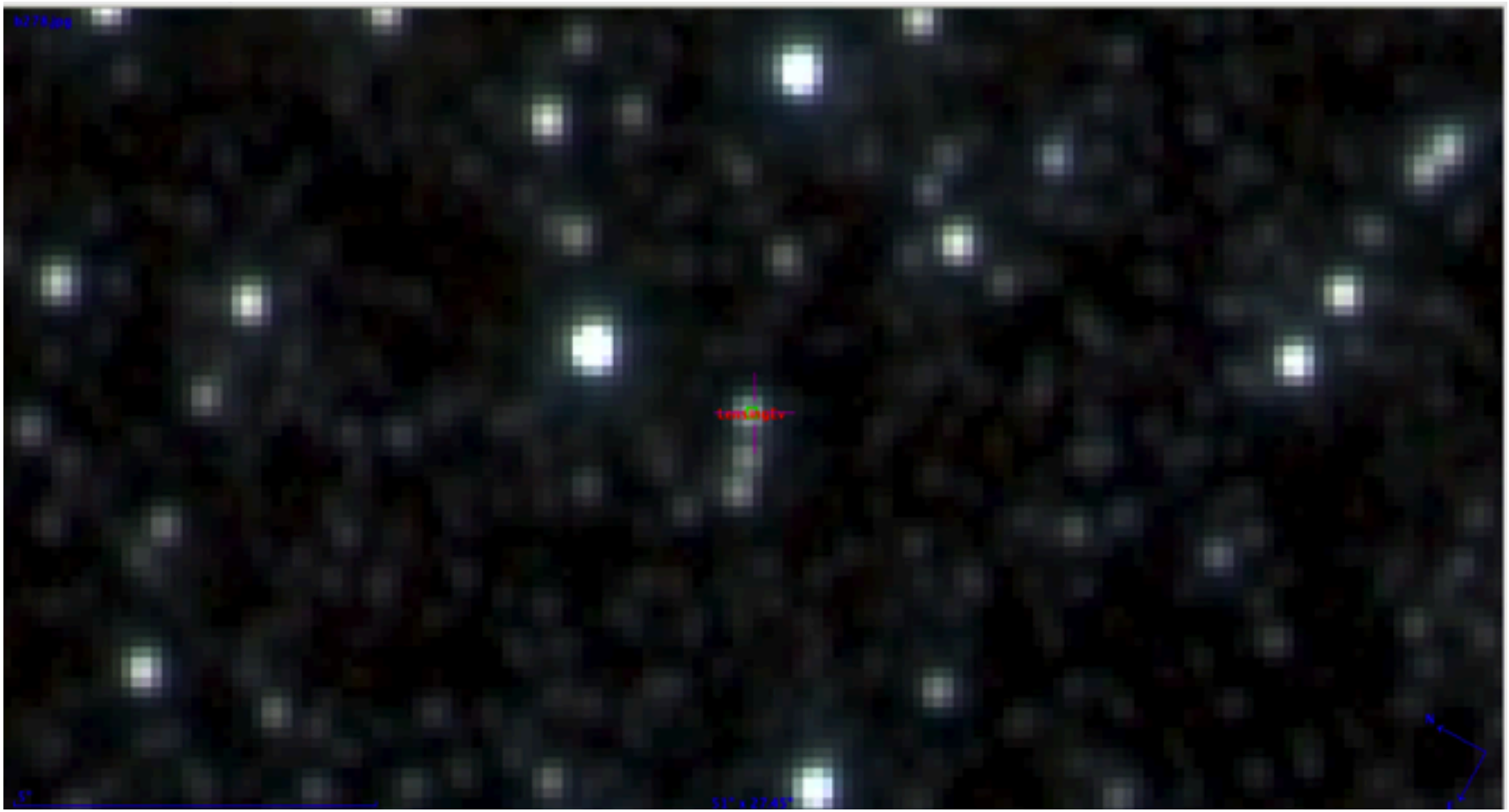
Step 2:

characterize the source star (kind, distance)

Step 3:

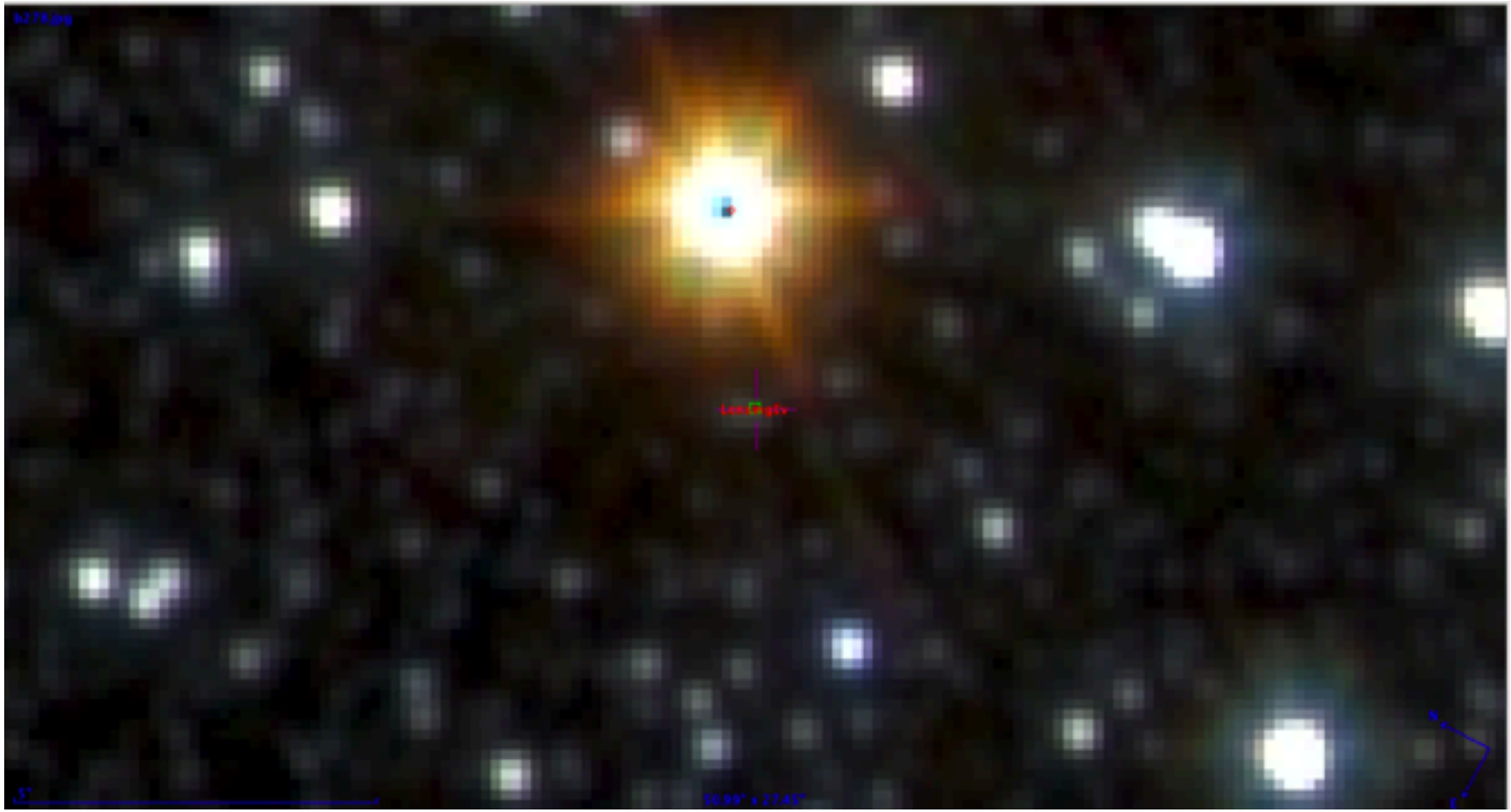
refit the microlensing curve

Known microlensing events



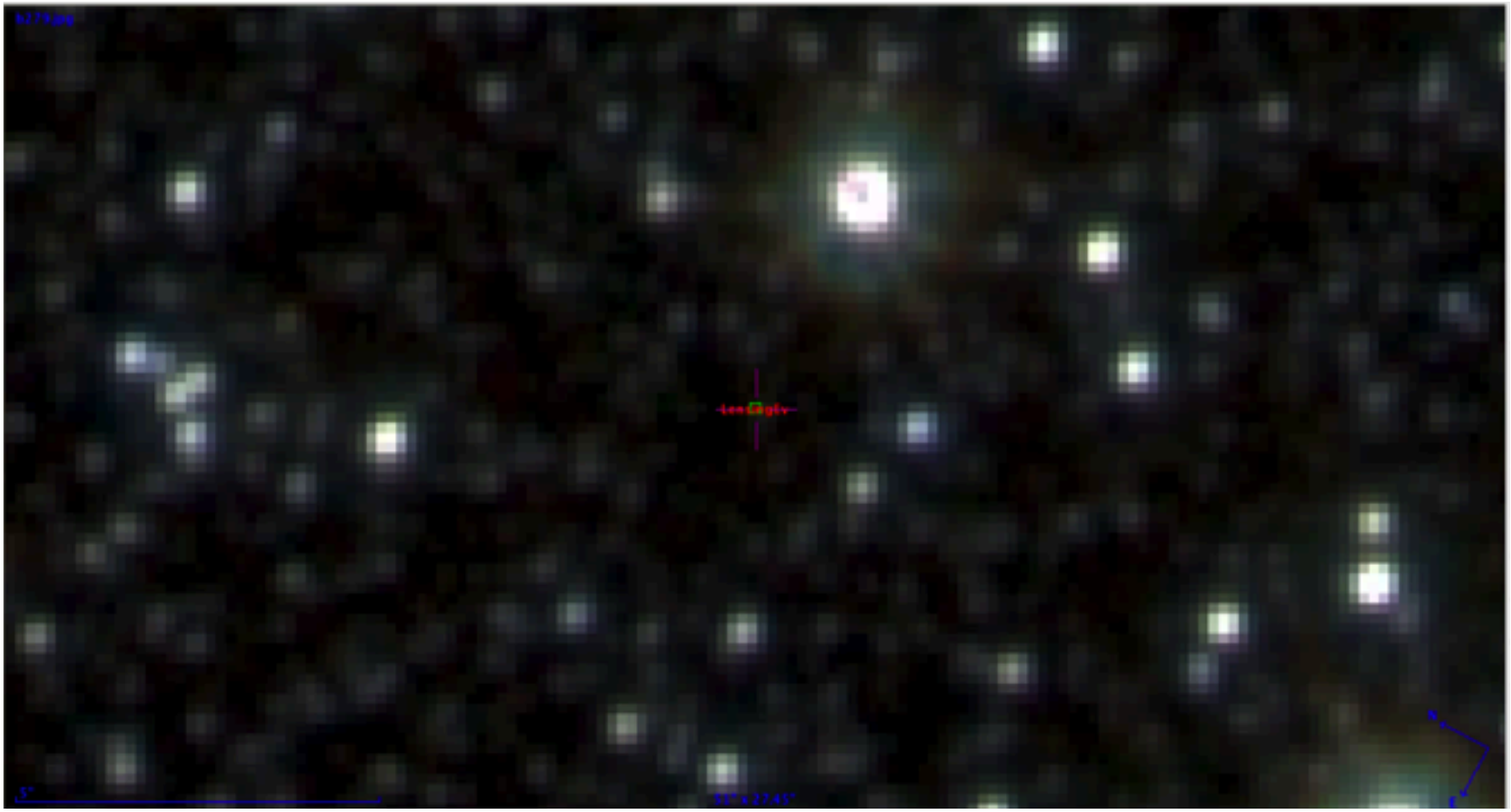
VVV will help to characterize known microlensing events.
E.g. blended sources.

Known microlensing events



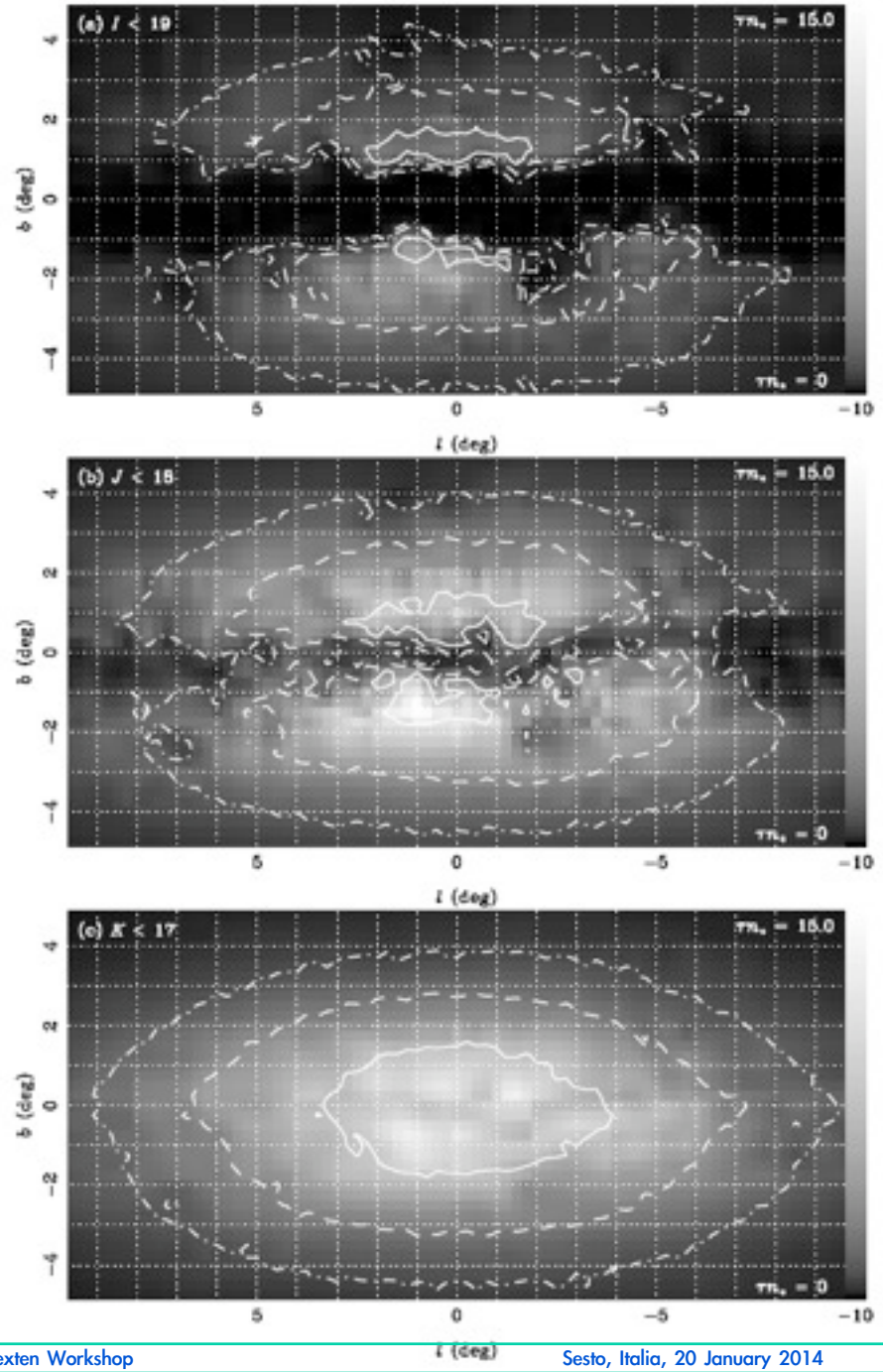
VVV will help to characterize known microlensing events.
E.g. sources contaminated by bright nearby bright stars.

Known microlensing events



VVV will help to characterize known microlensing events.
E.g. absense of the source.

Microlensing Search



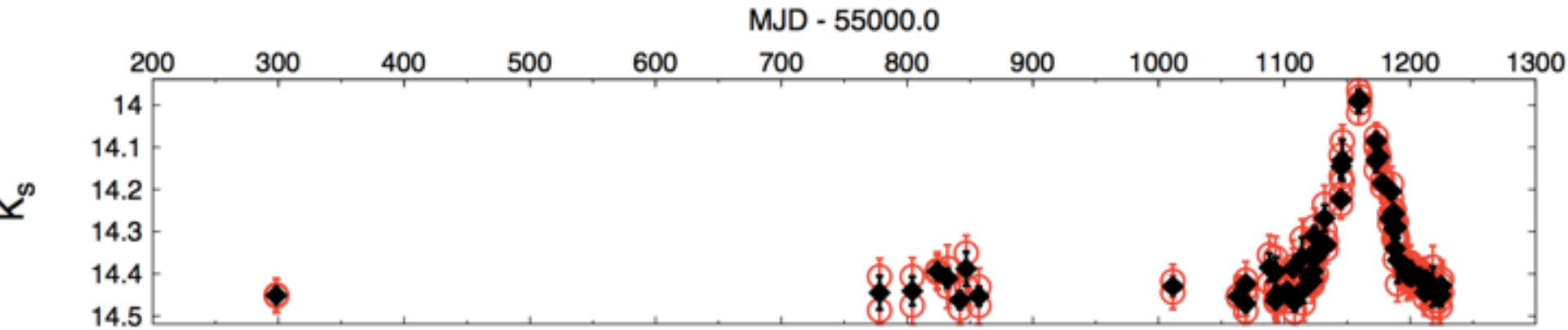
VVV will search for reddened bulge microlensing events, and produce a map of the optical depth T, tracing the 3D bulge mass distribution.

The near-IR advantage:

I, J and Ks-map event rates for sources with K<17.

Contours = 17.5, 35, 52.4 per sqdeg per year.

E. Kerins et al. 2008



Candidate Microlensing events from the VVV Survey

- at first serendipitous discoveries

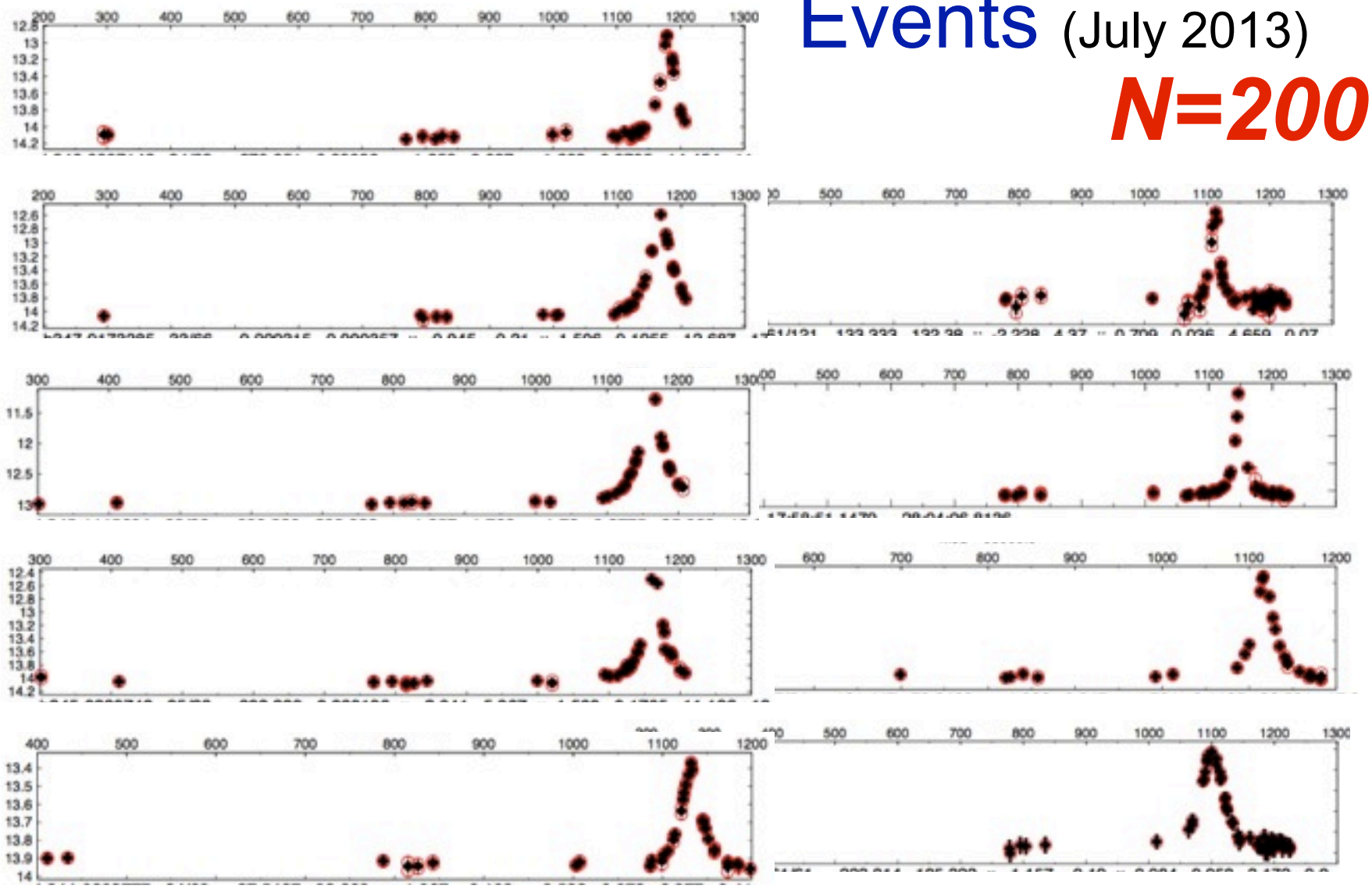
- proof of concept that allows us to explore the parameter space covered and plan future strategies

- new approach complementary to optical surveys

Eamonn Kerins, Roberto Saito, Istvan Dekany, Veronica Motta, Gabriela Muro, Felipe Gran, Karina Rojas, Mario Soto, Oscar Gonzalez, Leo Huckvale ...

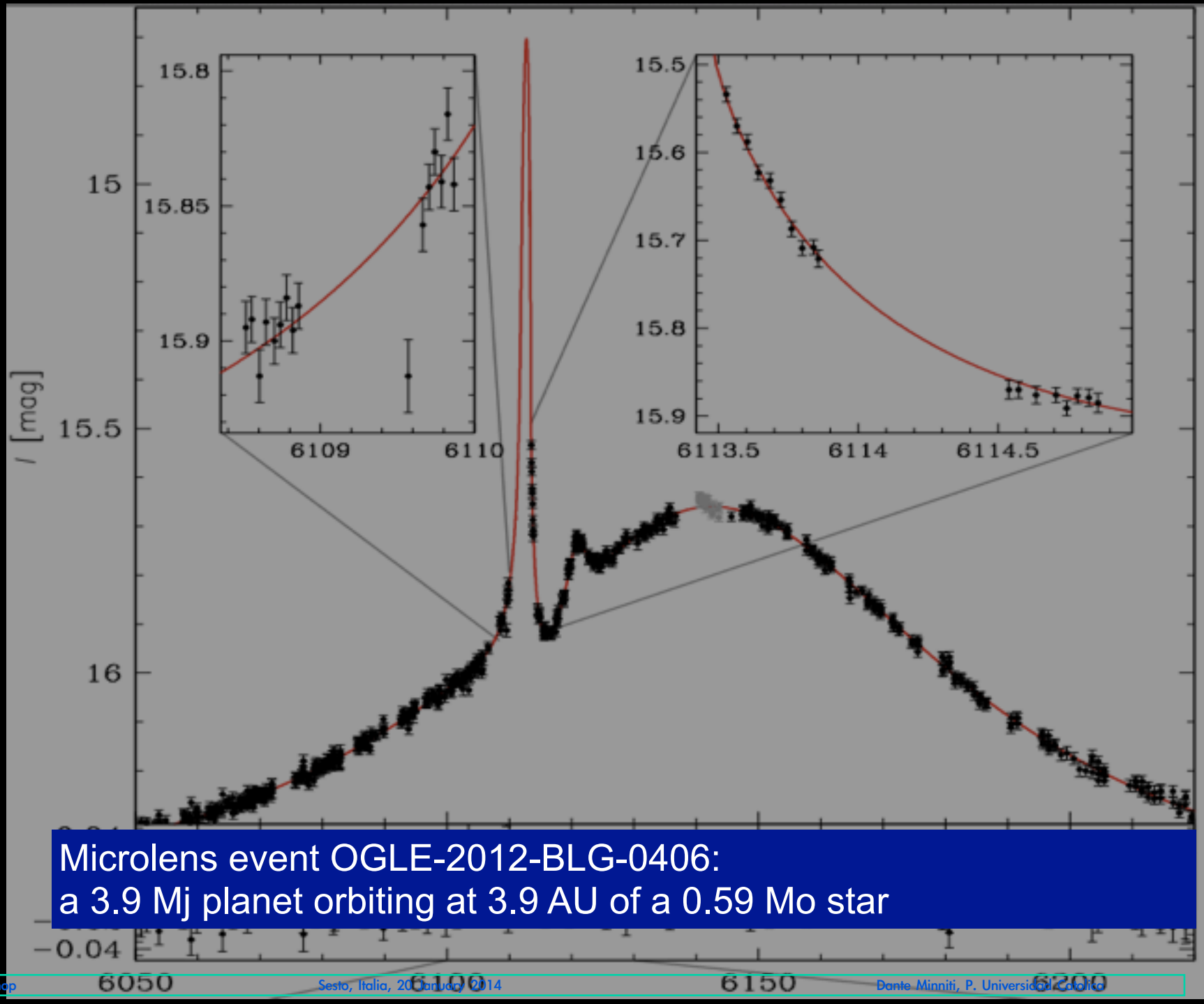
Microlensing Events (July 2013)

N=200!



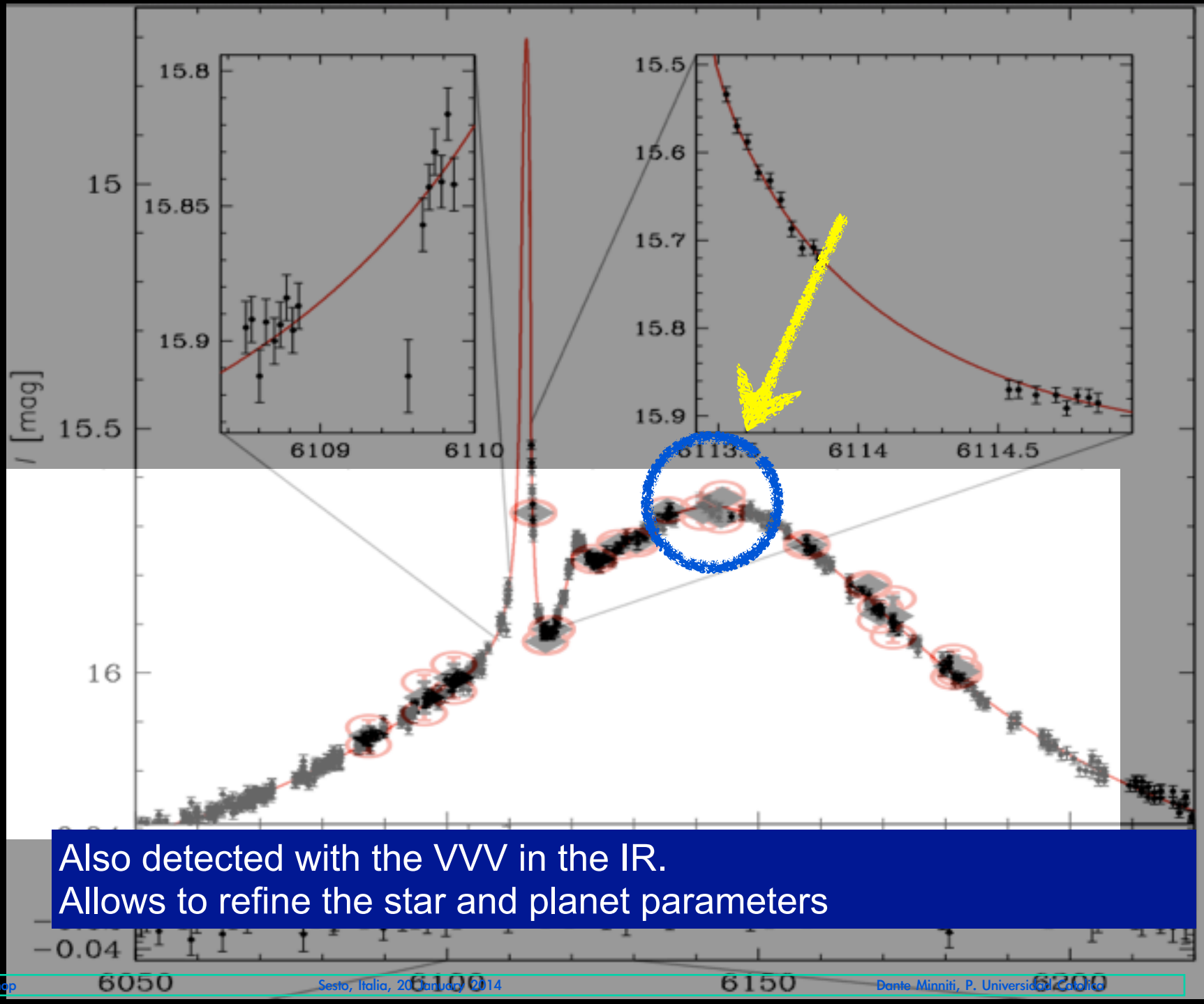
Istvan Dekany

OGLE Extrasolar Planet



Microlens event OGLE-2012-BLG-0406:
a 3.9 Mj planet orbiting at 3.9 AU of a 0.59 Mo star

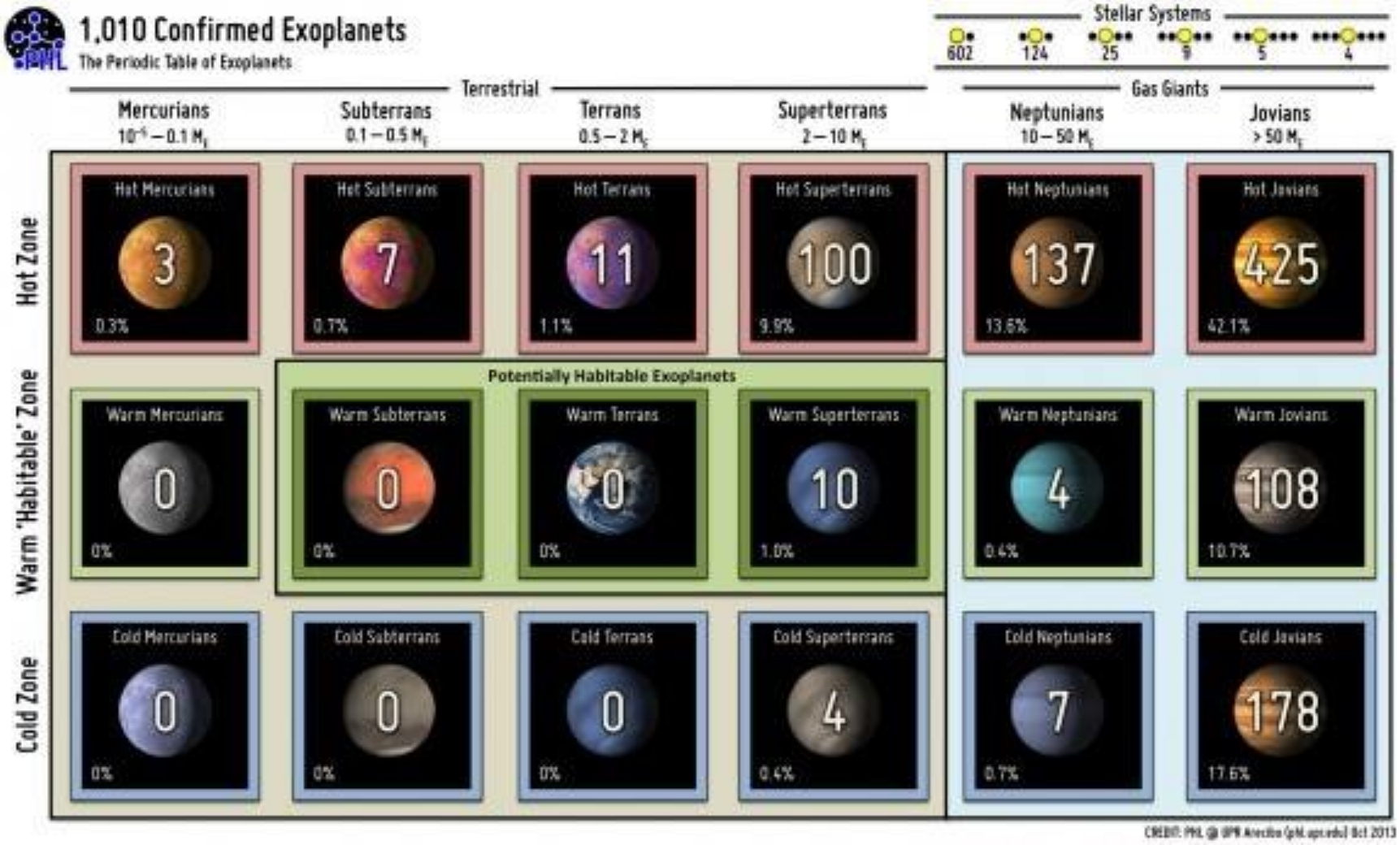
OGLE Extrasolar Planet



Also detected with the VVV in the IR.
Allows to refine the star and planet parameters

Extrasolar Planets

More than 1000 exoplanets discovered so far!



Extrasolar Planets

Advantages of the microlensing method for planet searches:

- Sensitive to massive planets beyond the snow line.

- Sensitive to low mass planets in the habitable zone of solar type stars.

- Capable of detecting free floating planets as very shortscale events.

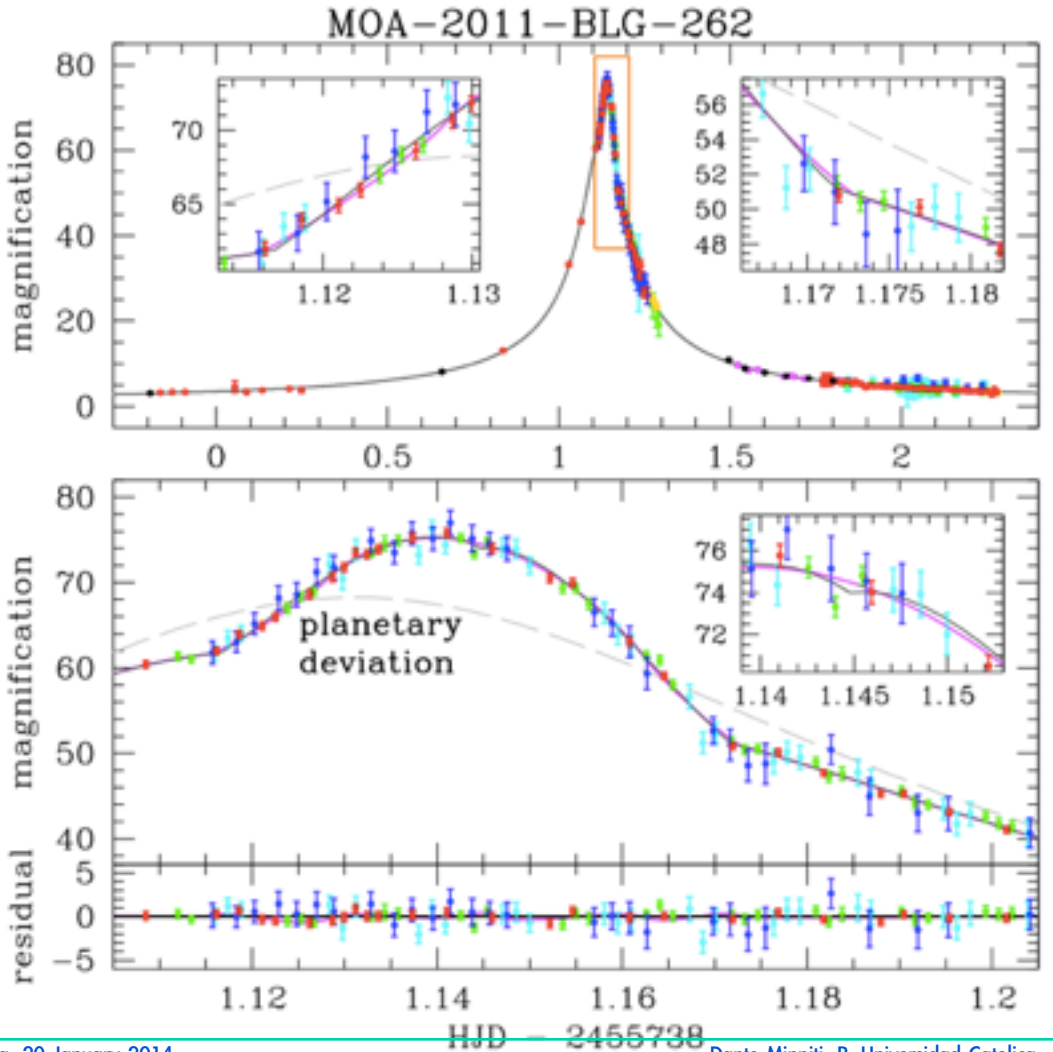
- Sensitive to exomoons.

VVV Microlensing:

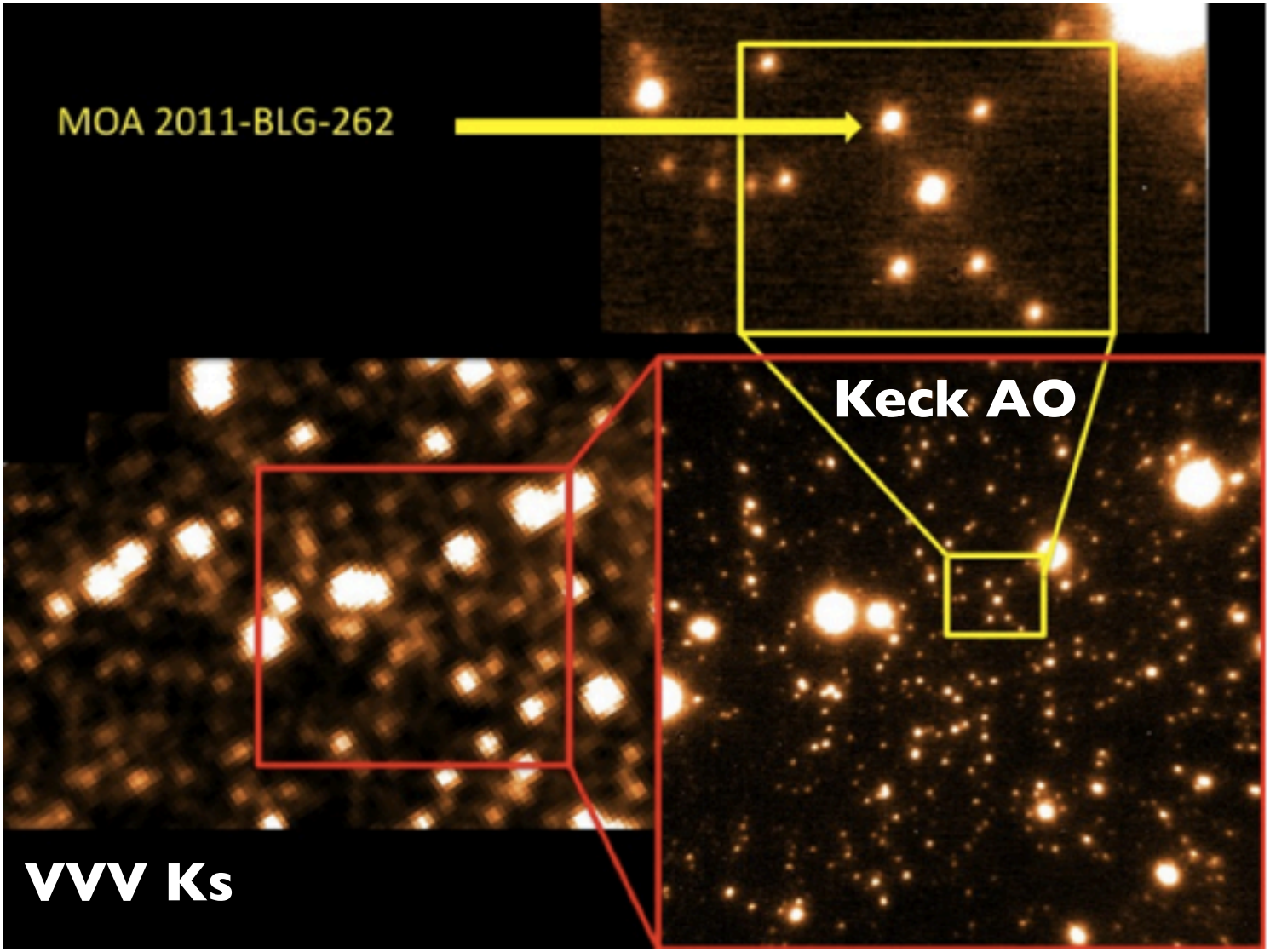
Free Floating Planets

MOA-2011-BLG-262Lb:
A Sub-Earth-Mass Moon Orbiting a Gas Giant Primary
or
A High Velocity Planetary System in the Galactic Bulge

D. Bennett et al.
(arXiv:1312.3951)



MOA-2011-BLG-262Lb:



The VVV data was used to calibrate the Keck AO photometry in order to constrain the lens parameters.

A free-floating exoplanet-exomoon system:
ML = 3.2MJup orbited by a moon of Mm = 0.47M⊕ separated by a = 0.13AU, with the lens system at a distance of DL = 0.56kpc.

or

A high velocity planetary system in the bulge:
A star with ML = 0.11+0.21M⊙ orbited by a planet of mass Mp = 17+28M⊕ separated by a = 0.95 AU at a distance of DL = 7.2 kpc.

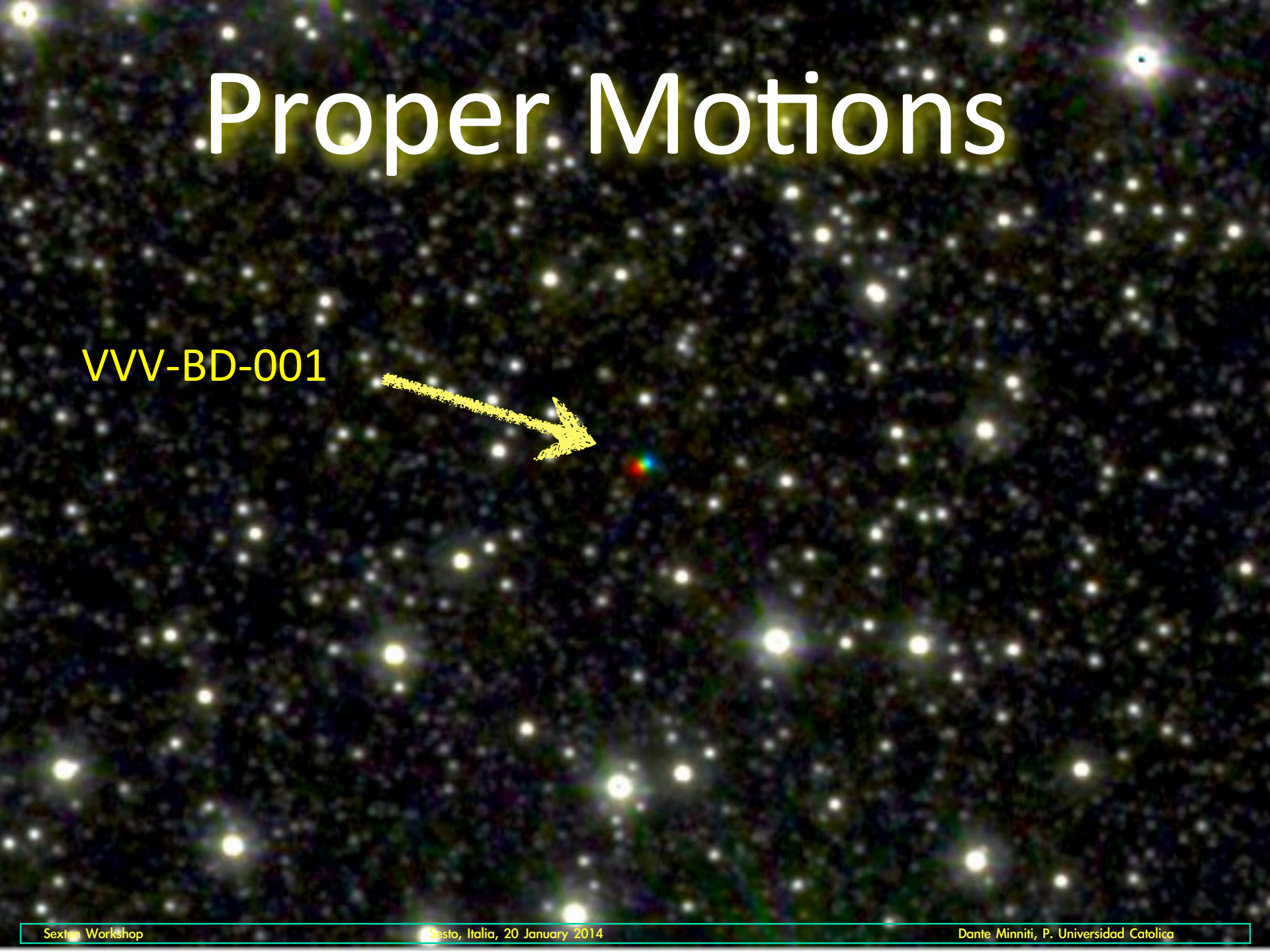
AVATAR

A terrestrial moon orbiting a giant planet


3000 millions


1000 VVV surveys

Proper Motions

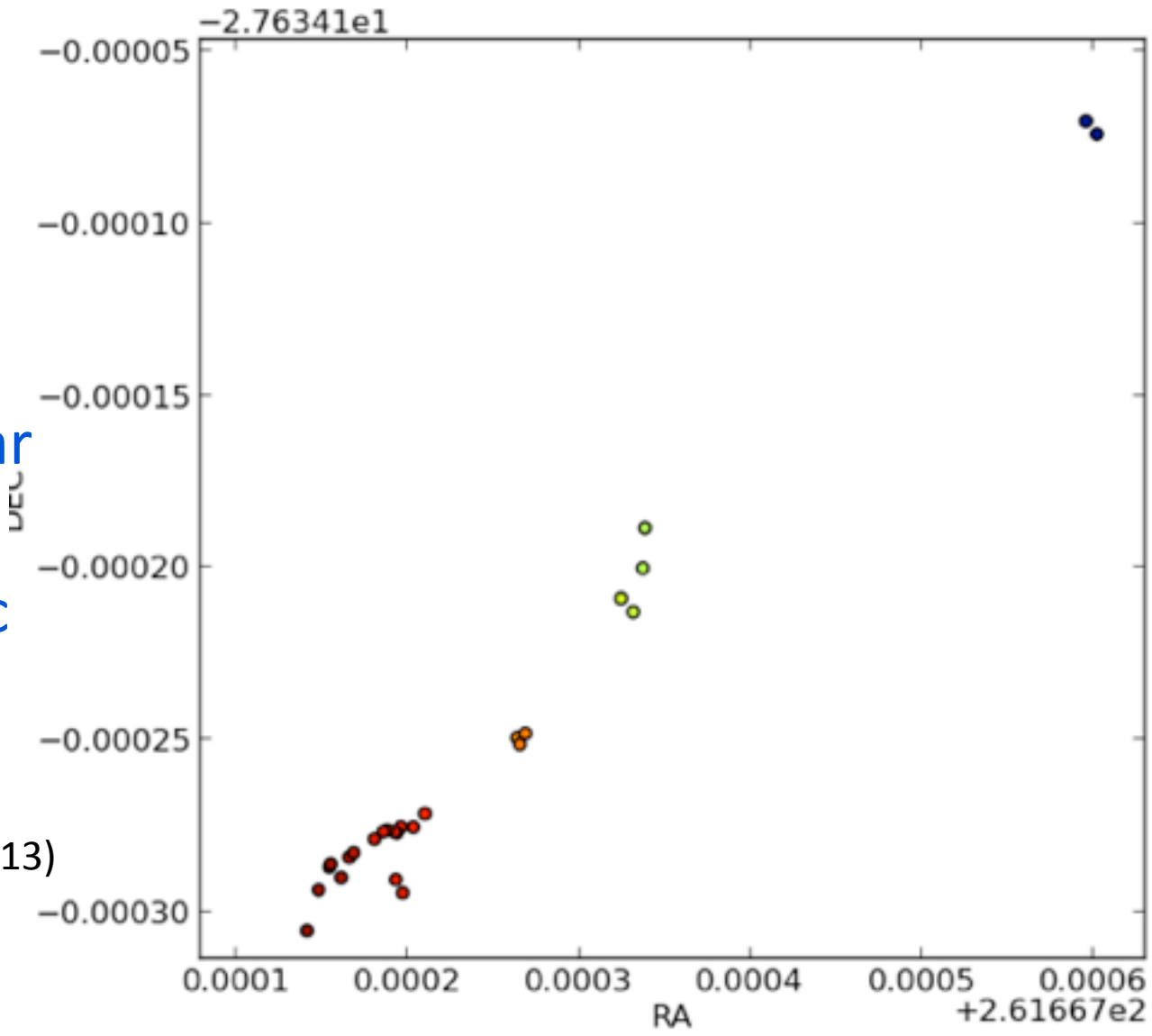


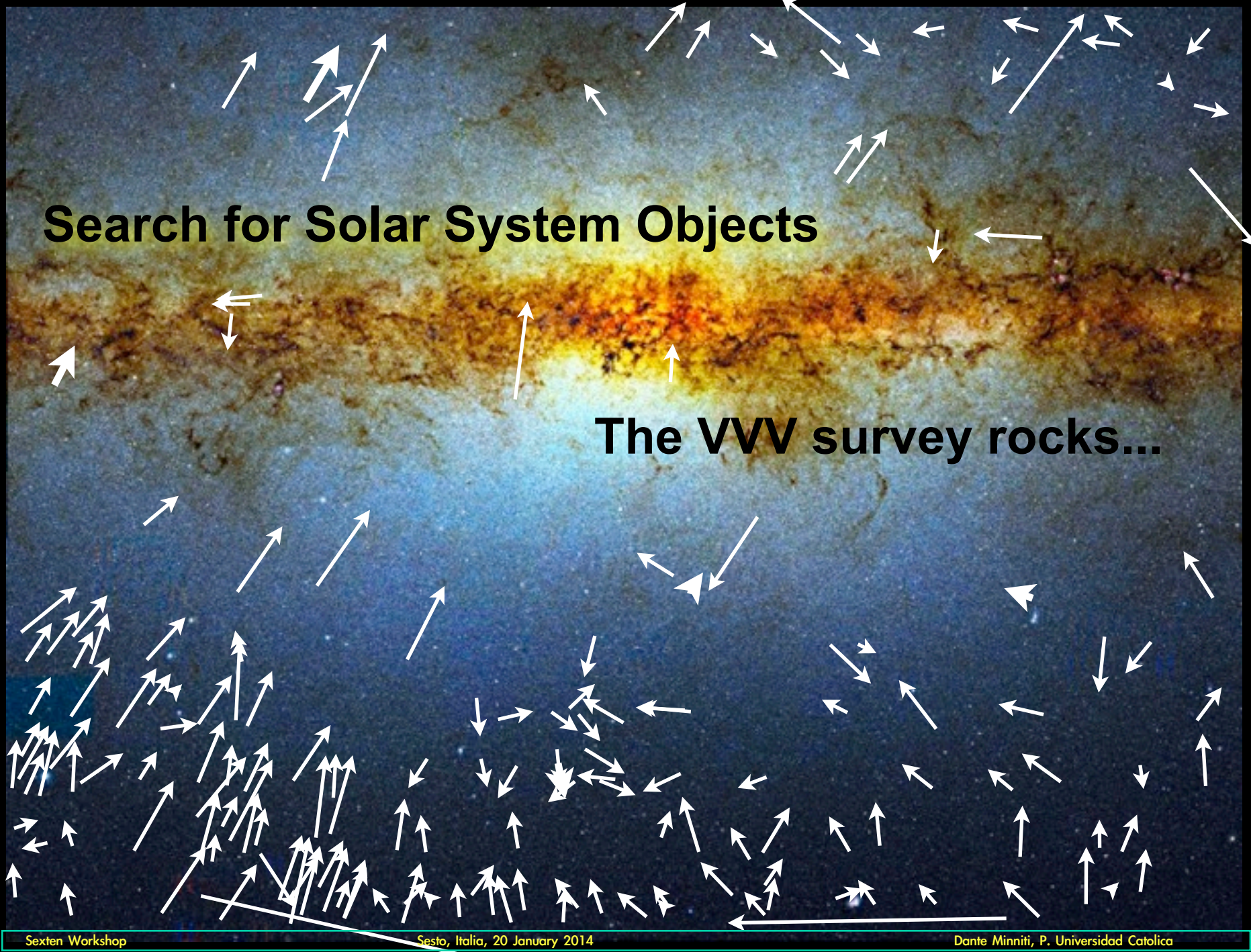
Search for Brown Dwarfs

VVV-BD-001

a peculiar new solar neighbor (blue BD) showing parallactic motion at 17 pc

J. C. Beamin, et al. (A&A 2013)

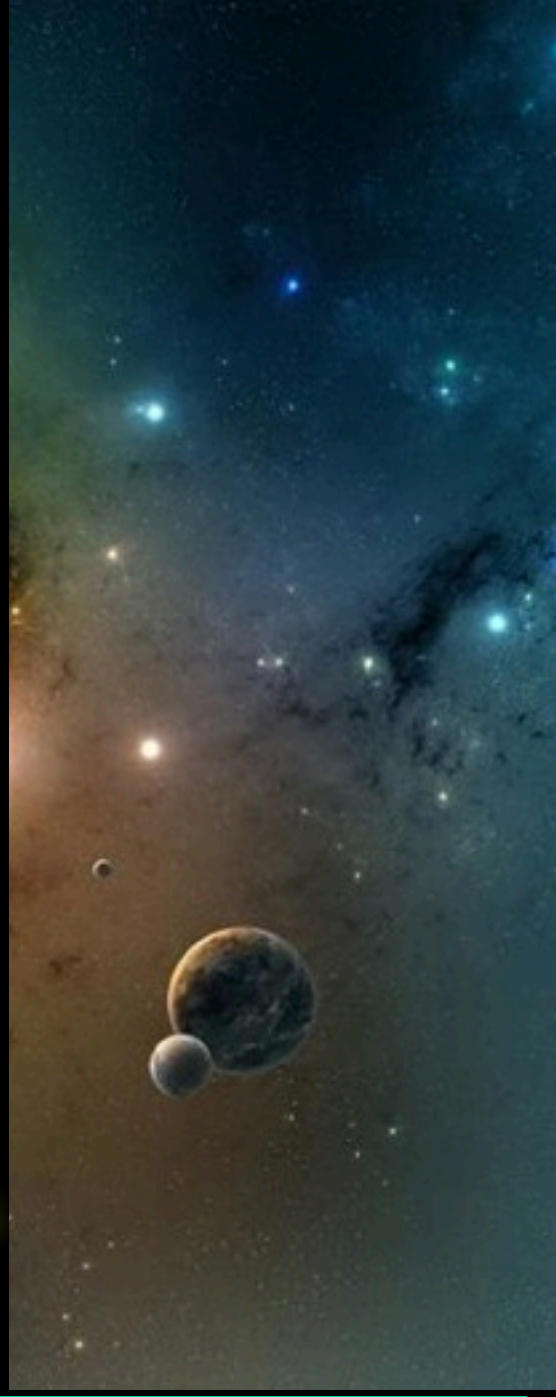



Search for Solar System Objects
The VVV survey rocks...

Conclusions:

Microlensing

We are just getting started...
but there is a large potential of the VVV Survey for the discovery of extrasolar planets.



Logo: Joyce Pullen

2014-2023

Acknowledgments:

The Scientist (Coldplay)
“Nobody said it was easy
No one ever said it would be so hard
I’m going back to the start”