PAndromeda

- A dedicated M31 survey with Pan-STARRS 1 -

PIs: Stella Seitz, Ralf Bender

Team Members:
Arno Riffeser, Mihael Kodric, Johannes Koppenhoefer, Ulrich Hopp, Jan Snigula, Claus Goessl
& PS1 Science Consortium

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The PAndromeda Team

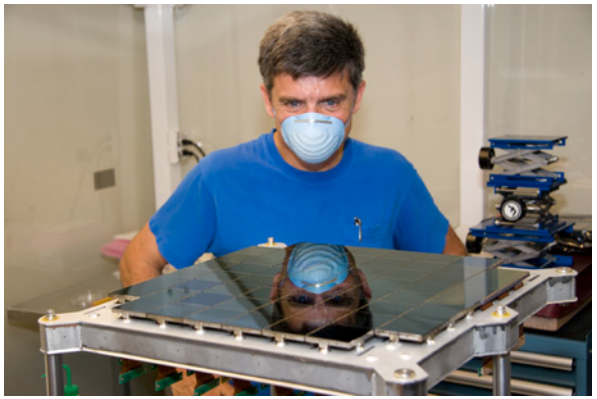
Pan-STARRS 1

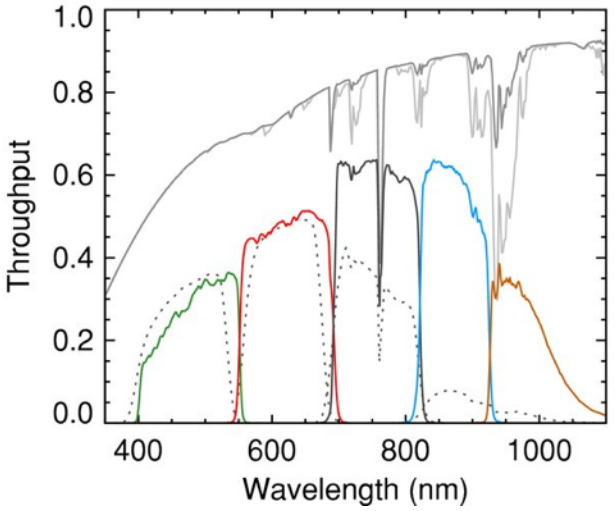
- Panoramic Survey Telescope And Rapid Response System (Pan-STARRS)

- Wide-field imager, 1.4 Giga pixel, ~7 deg^2 F.O.V with 0.25"/pixel

- 3Pi survey (Dec>-30 deg): 30,000 squared degrees in g, r, i, z, and y, about 1 mag deeper than SDSS

- Plus selected deep fields for SNe, planets, M31





Dupuy & Liu 2009

PAndromeda in a nutshell

- Observed M31 in 2010-2012, from July to Dec.

- 2% of the 3yrs PS1 observing time (including overheads)

- 1.8m PS1 telescope, ~7 deg2 F.O.V., 0.25"/pixel

- r_{PS} and i_{PS} : up to 2 visits per night

- g_{PS}, z_{PS}, y_{PS} : sparse exposures in 3 yrs

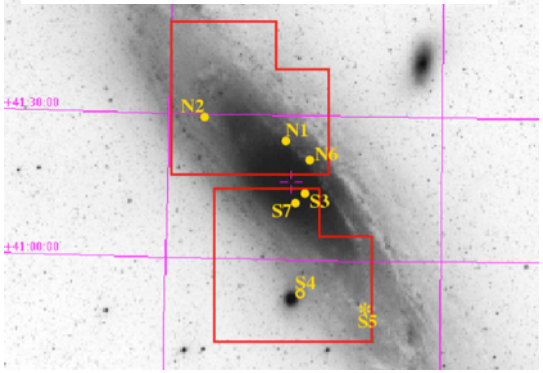
Main goals:

- Constraining the compact matter fraction in the M31/MW halos

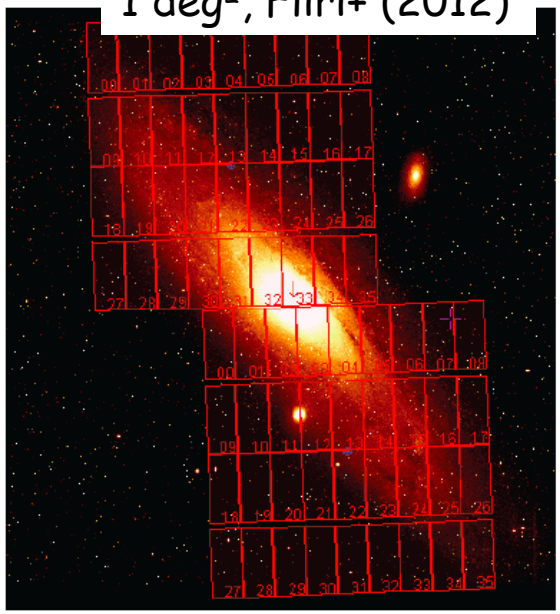
- Inventory of variables in M31, including Cepheids, binaries, long-period variables

PAndromeda footprint

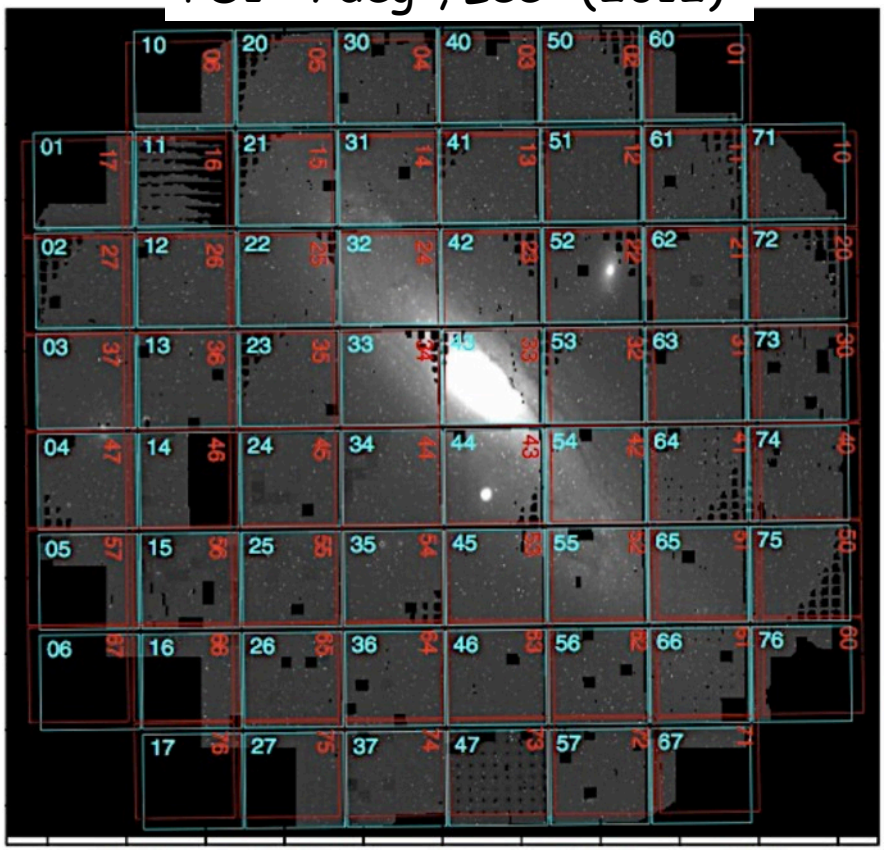
WFC/INT ~0.3 deg^2,
Calchi Novati+ (2005)



MegaCAM/CFHT
1 deg^2, Fliri+ (2012)



PS1 ~7deg^2, Lee+ (2012)



Observation Cadence

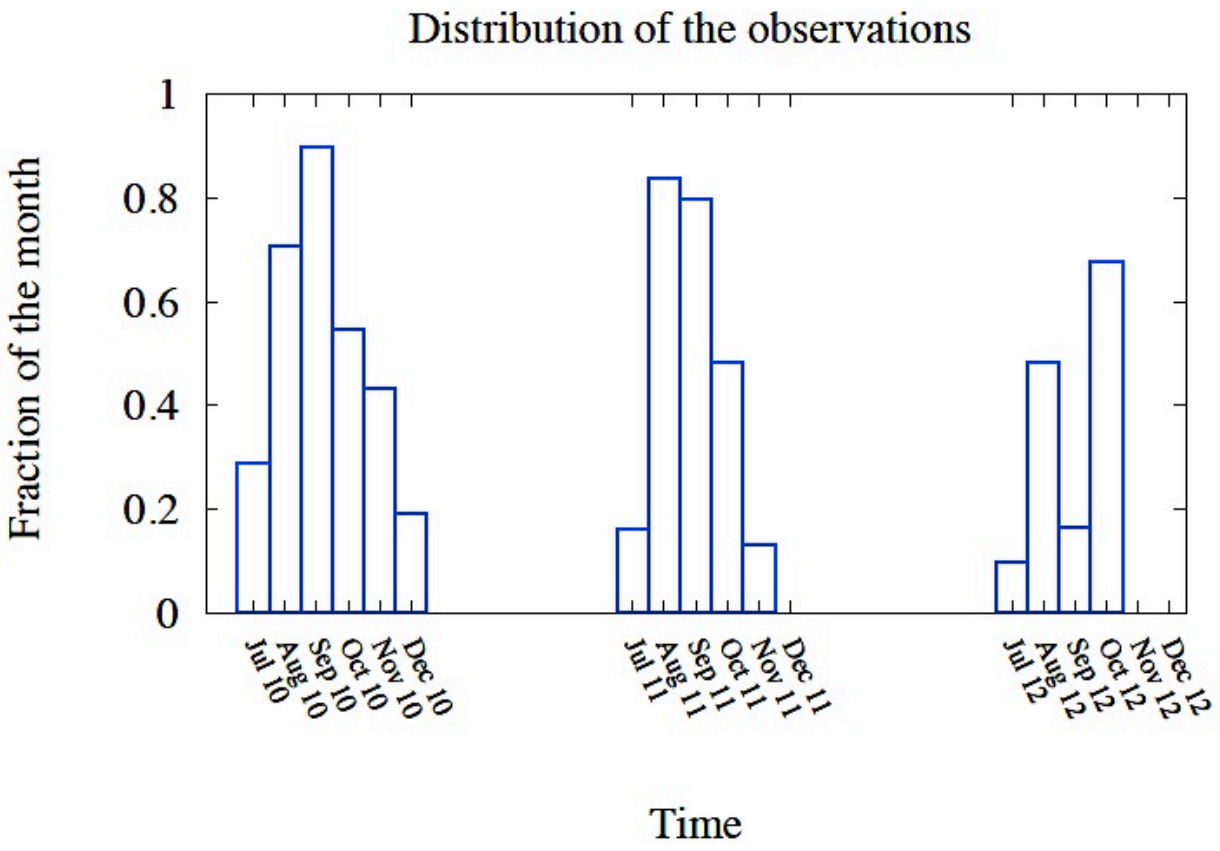
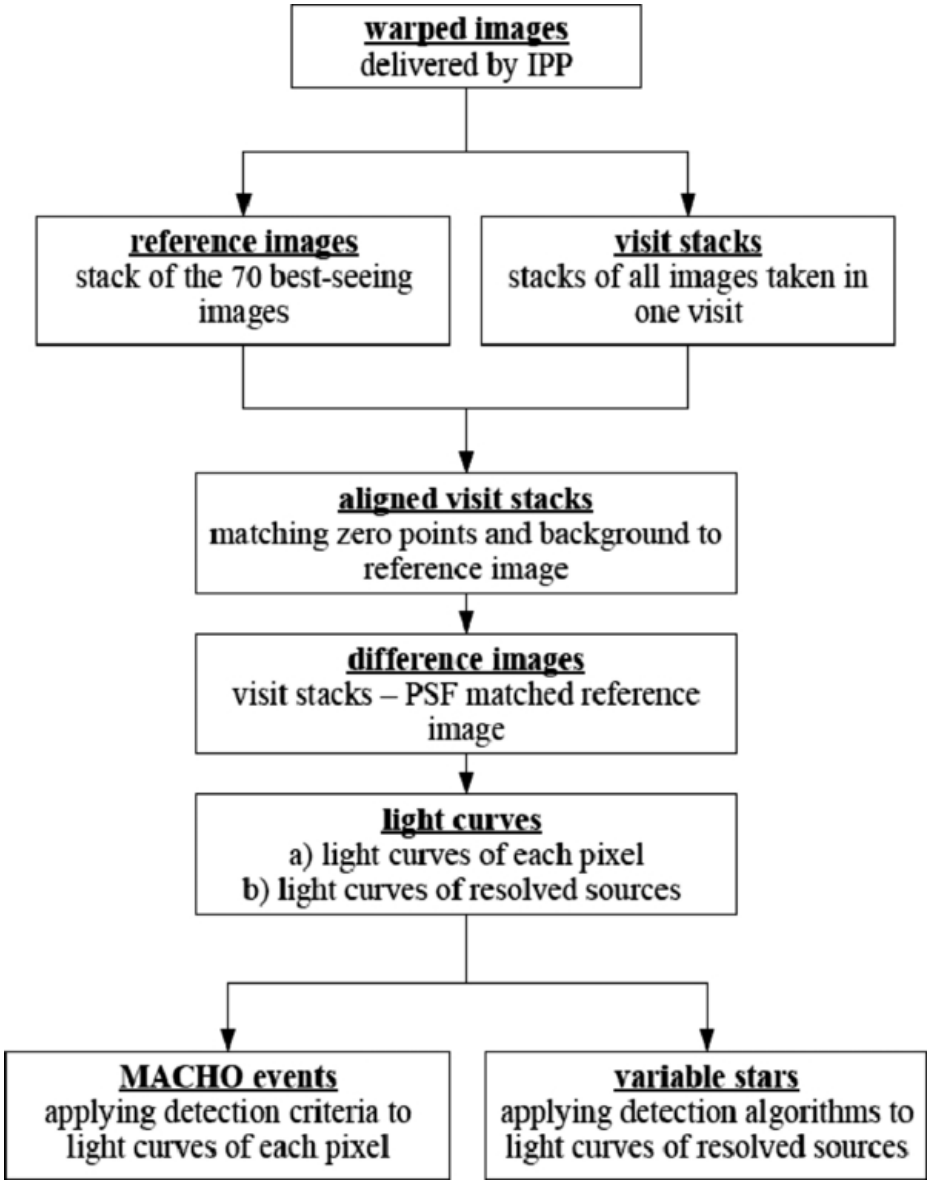


Fig. 1.— The distribution of the observations of PS1 towards M31. We plot the monthly fraction of nights in the r_{P1}-filter during the 2010, 2011 and 2012 seasons. In general, the observations cover most of the time in the second half of each year.

Lee et al. (2014)

Data Analysis



Use our own image subtraction software *mupipe* (Goessl & Riffeser 2002) and MDia (Koppenhoefer 2013) to obtain high quality lightcurves in crowd fields

Kodric et al. (2013)

Microlensing – Event position

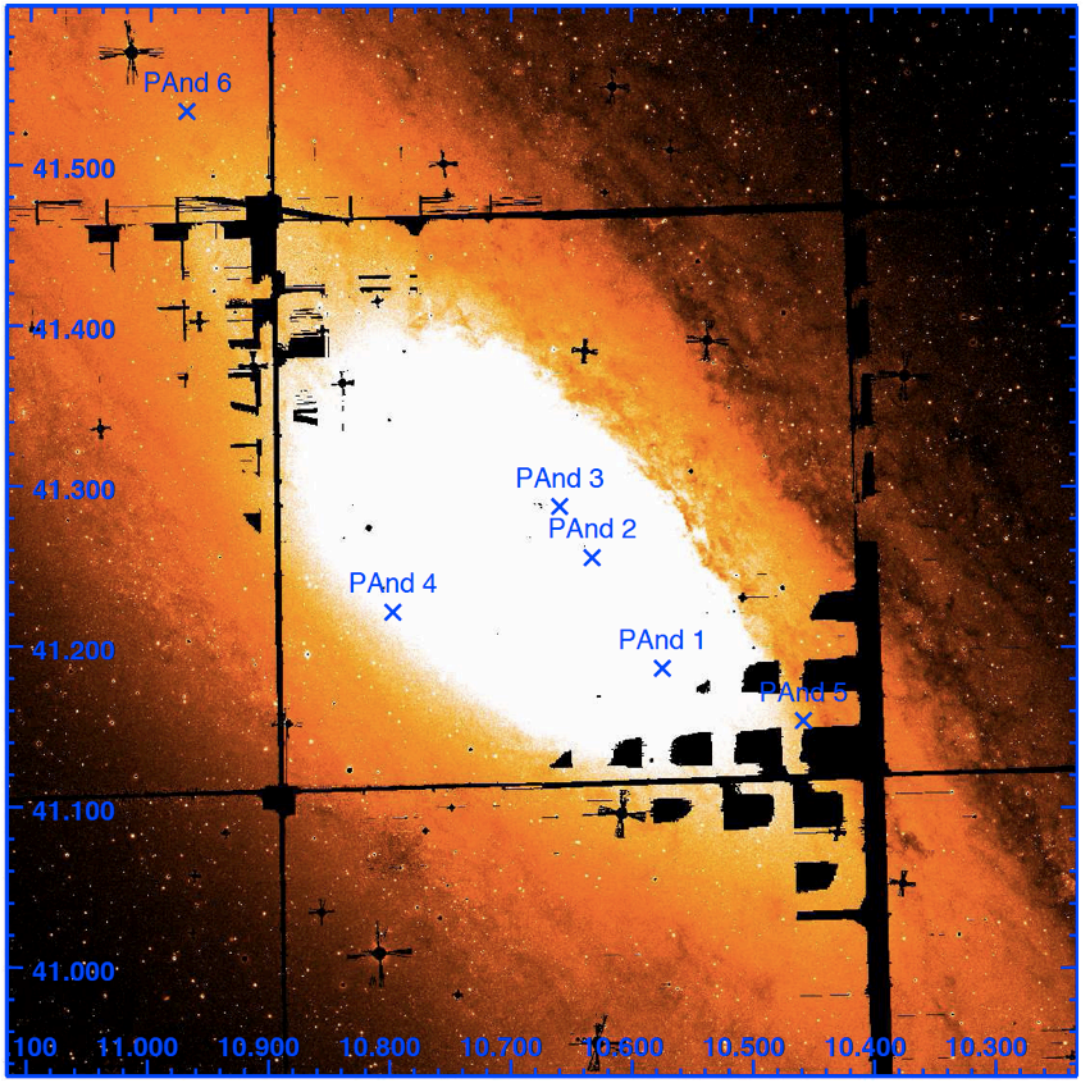
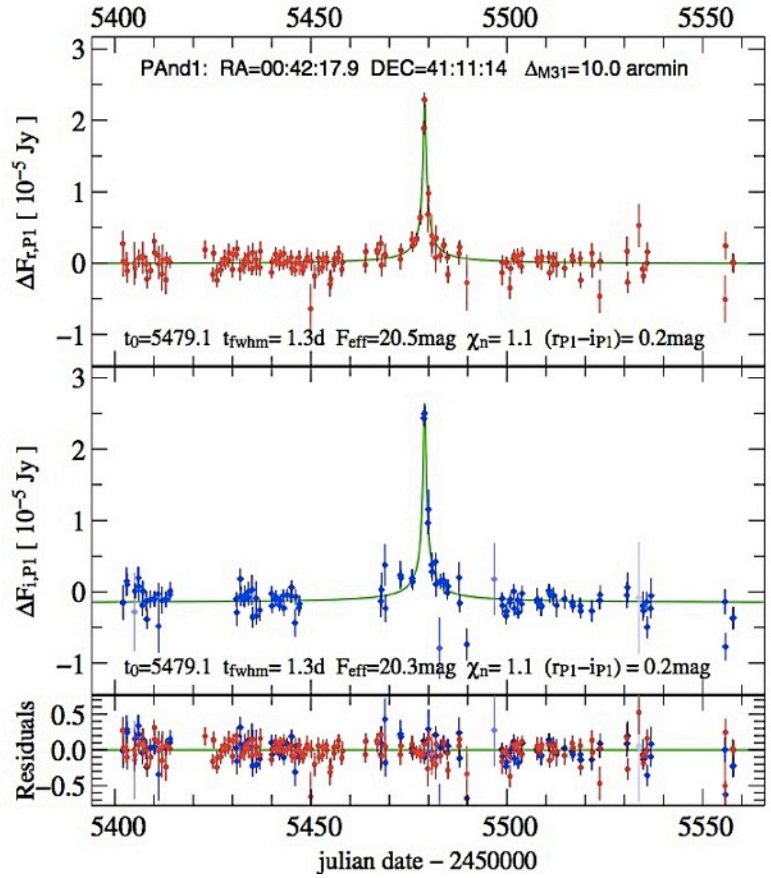
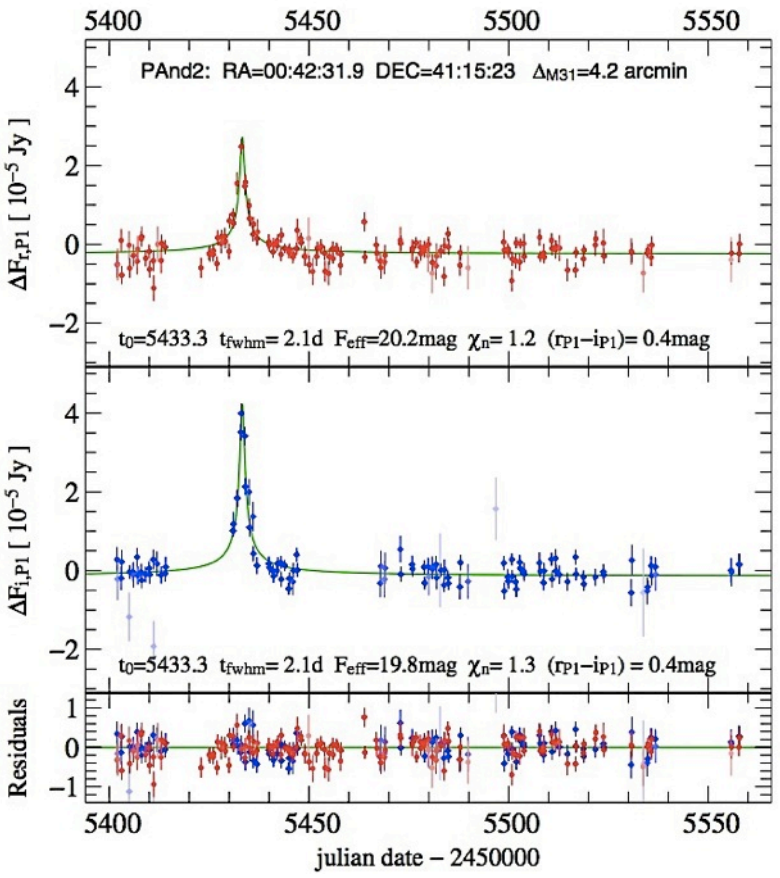


Fig. 14.— Position of the six microlensing event candidates detected in the central $40' \times 40'$ region of M31 from PAndromeda. The coordinates, RA (J2000) in hour and Dec (J2000) in degree are also shown in the figure. The FOV of this image is $40' \times 40'$. Lee et al. (2012)

Microlensing – Lightcurve examples

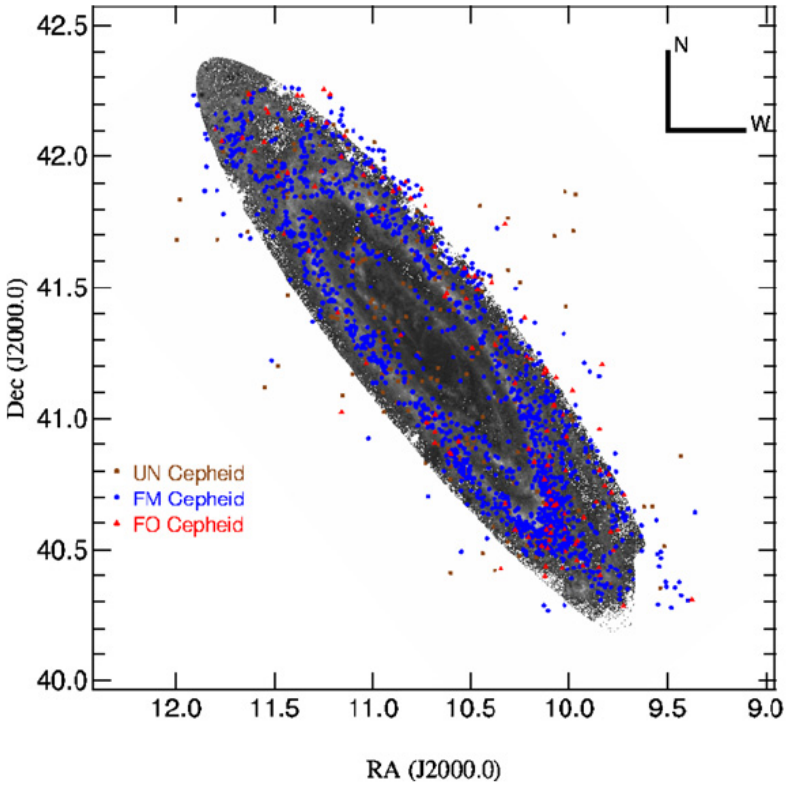




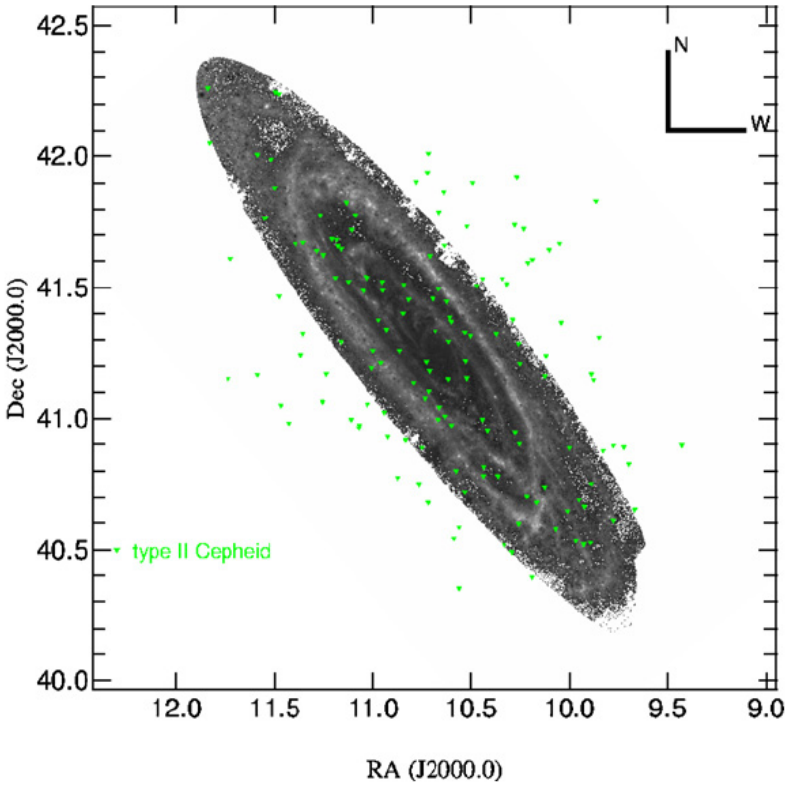
6 short duration events, Lee et al. (2012)

2009 Cepheids
– Largest published sample to-date

Type I Cepheids trace the spiral arms

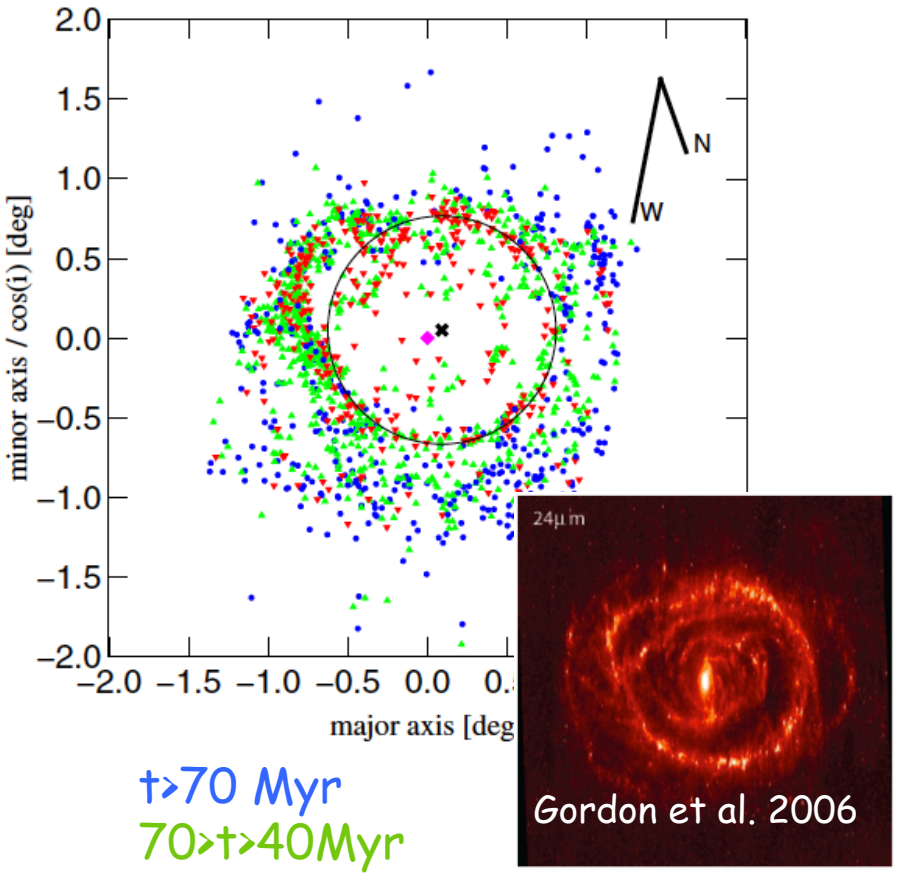


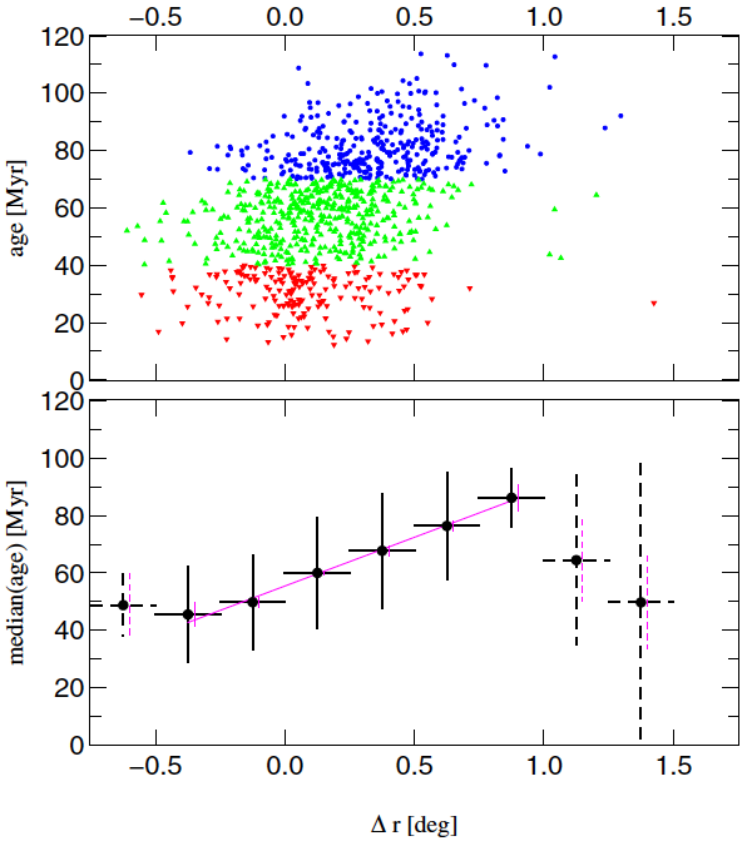
Type II Cepheids trace M31 halo



Kodric et al. (2013)

Cepheids
– Age distribution





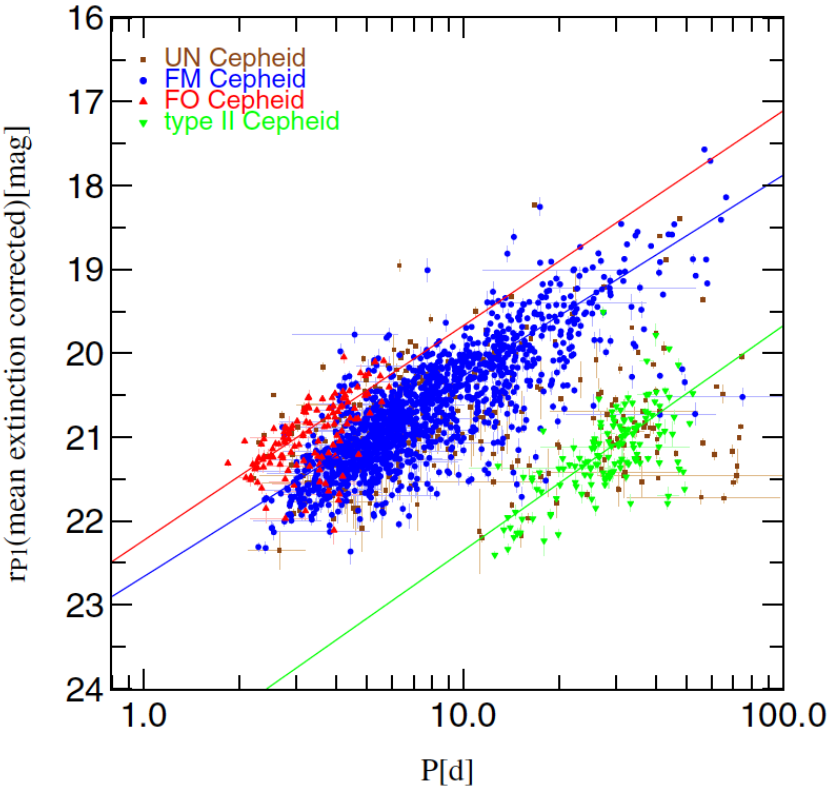
t>70 Myr
70>t>40Myr
t<40 Myr

Star formation ring at 10 kpc

Kodric et al. (2013)

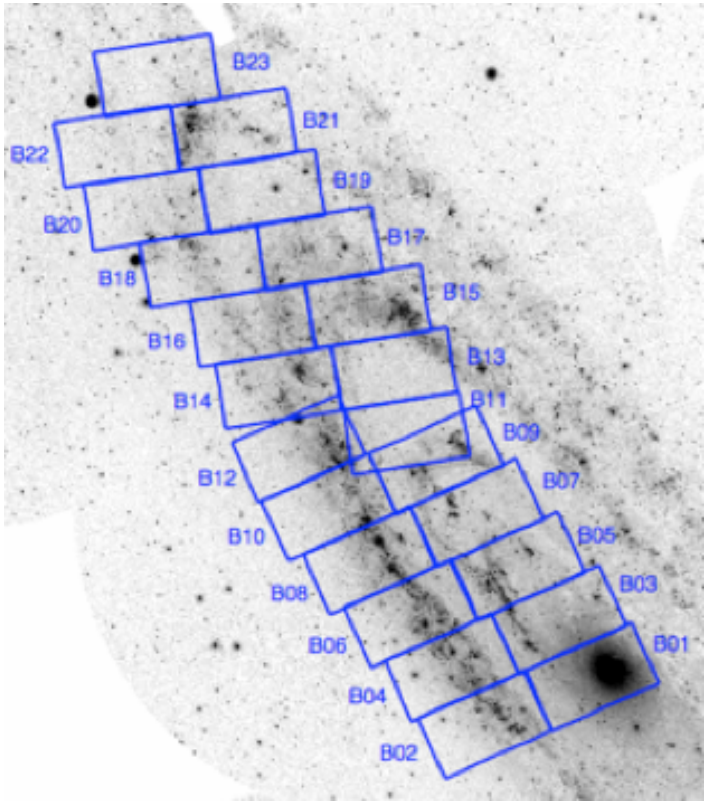
Cepheids - PL relation

PS1 optical photometry



Kodric et al. (2013)

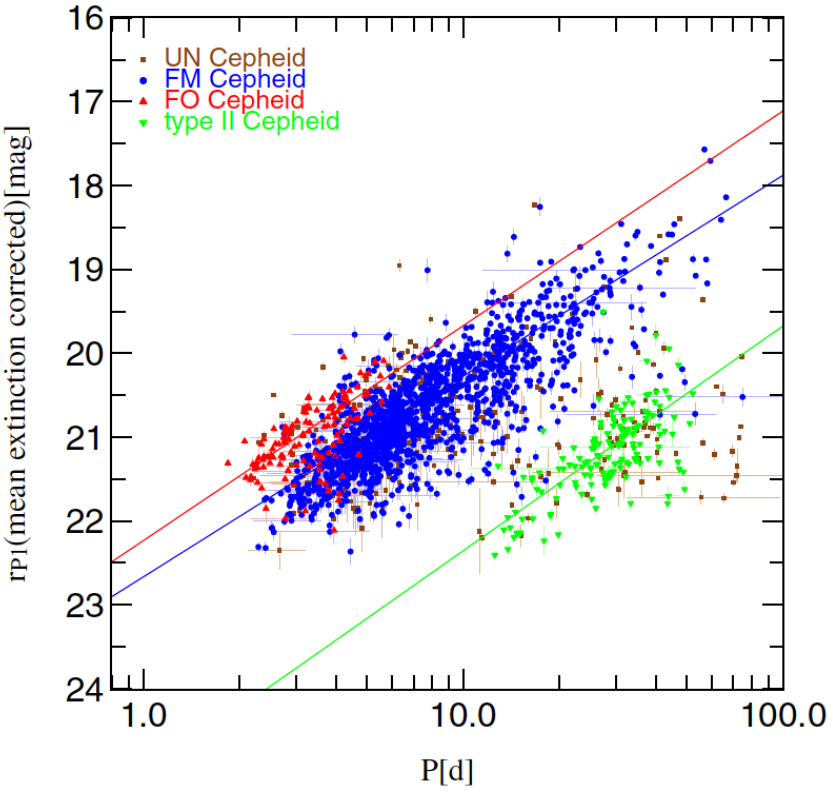
Pan-chromatic Hubble Andromeda Treasury (PHAT)



Dalcanton et al. (2012)

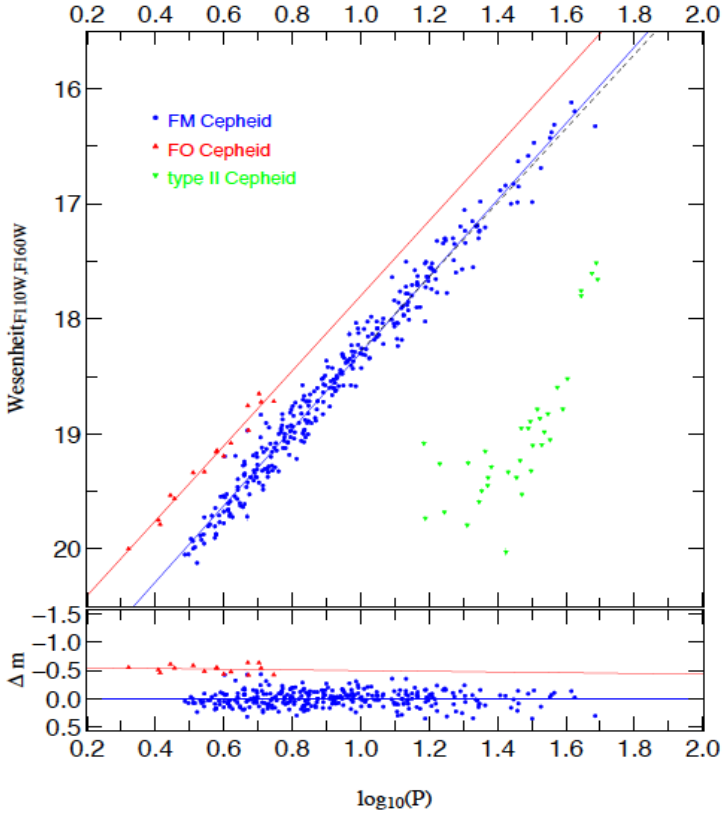
Cepheids - PL relation

PS1 optical photometry



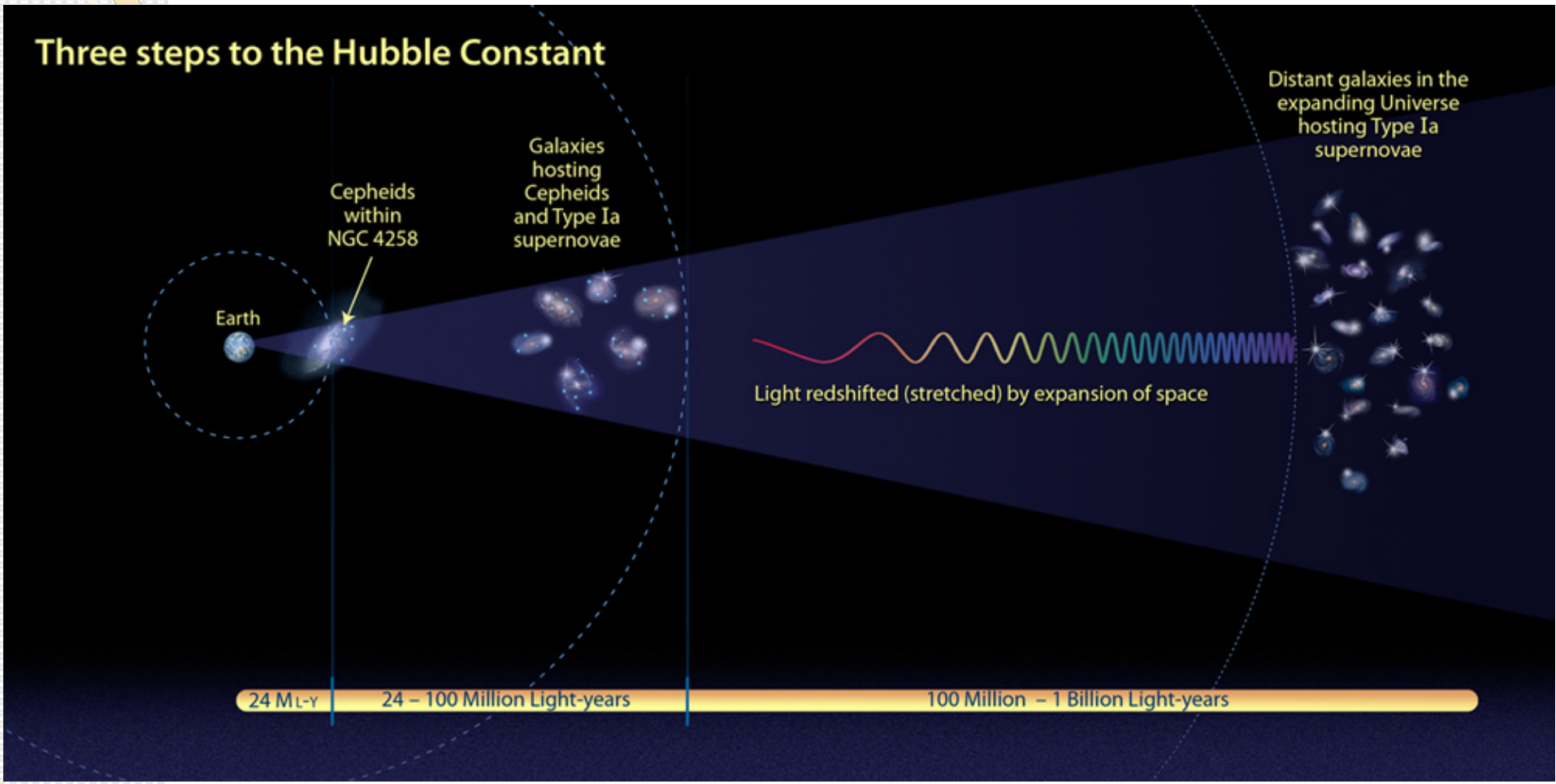
Kodric et al. (2013)

HST IR photometry



Kodric et al. (2014)

Eclipsing binary
- M31 as a distance anchor

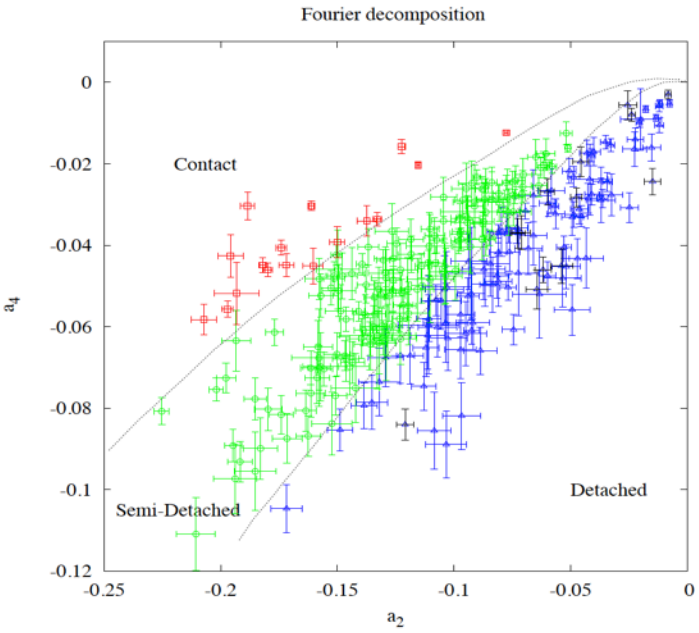


Credit: NASA, ESA, and A. Feild (STScI)

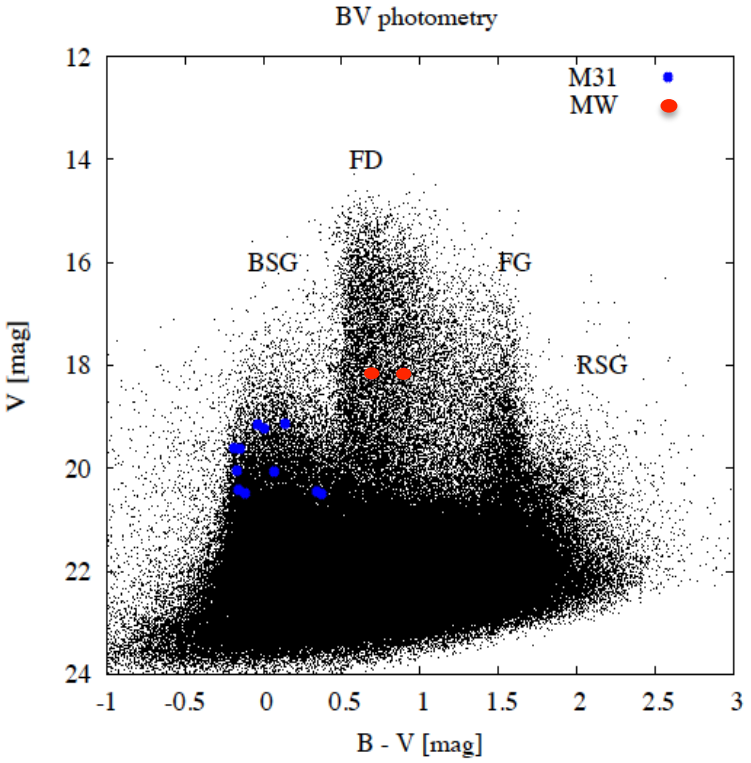
298 Eclipsing binaries

- Classification (Rucinski 93, Pojmanski 02):

$$f(\phi) = \Sigma_{i=1}^{4} a_i cos(2\pi i\phi) + b_i sin(2\pi i\phi)$$

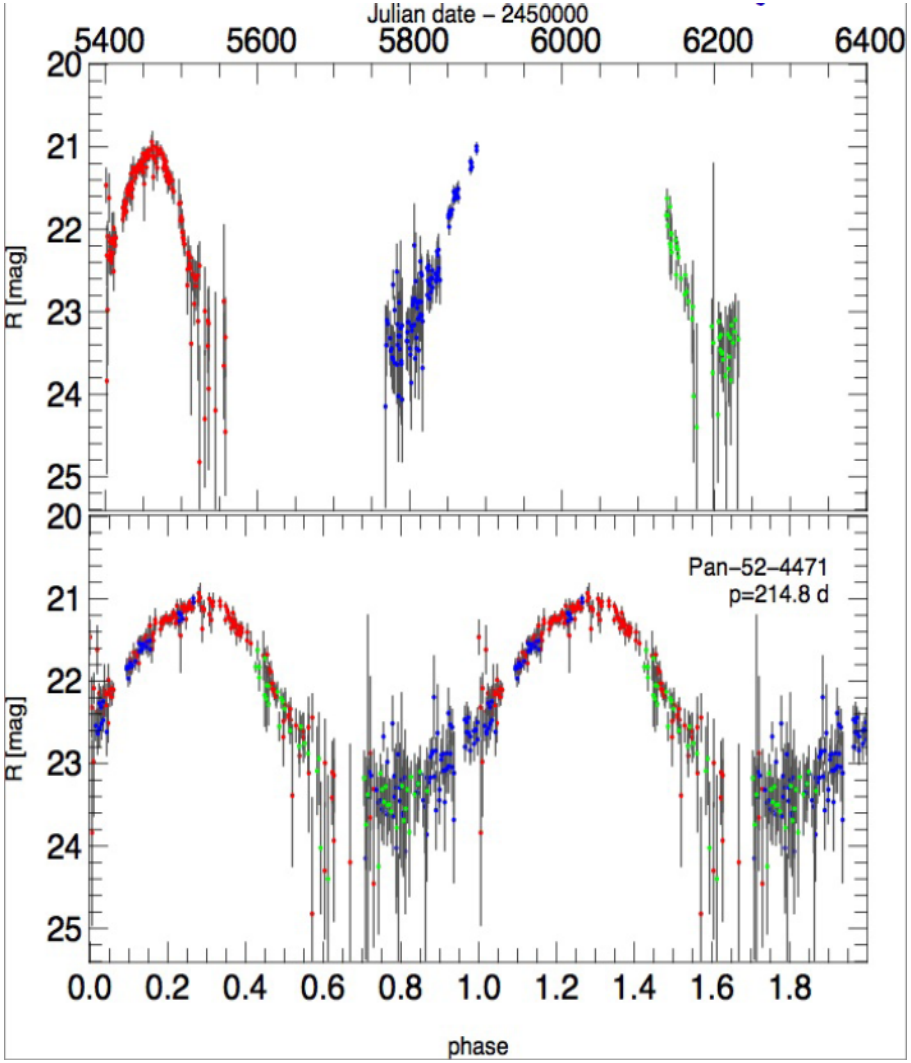


- Select bright detached systems for spec. follow-up:



Lee et al. 2014

Long-period variables



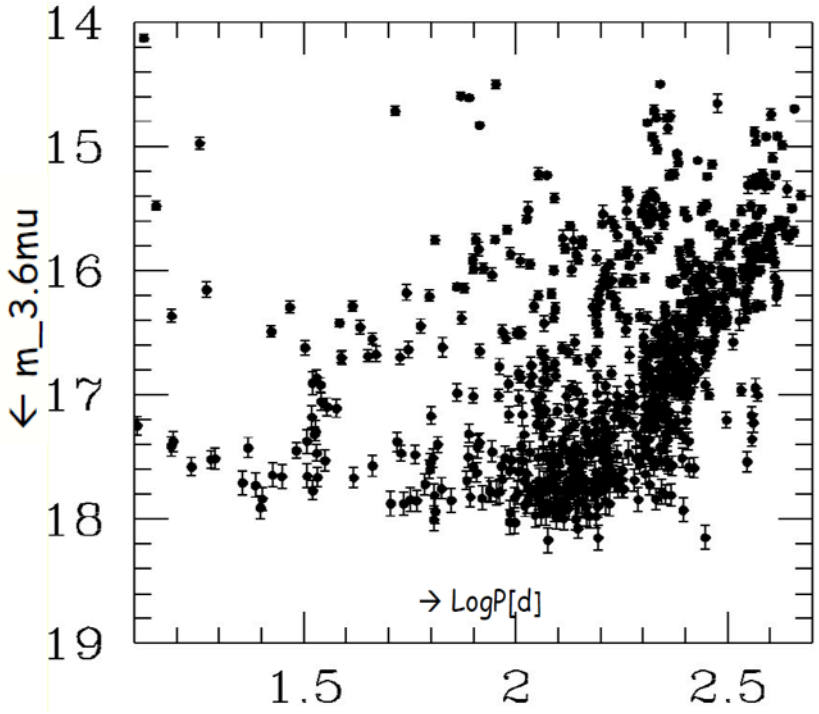
We found 5900 LPVs, among them 3800 with P>100d (mainly Miras)

600 semi-regular variables (SRVs)

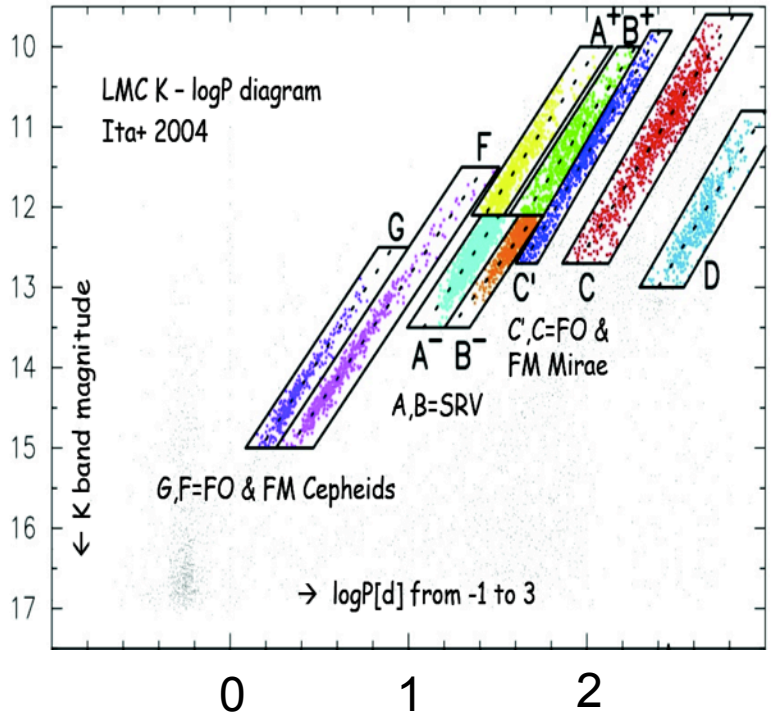
Snigula et al. (in prep.)

Long-period variables - IR P-L relation

M31 3.6 um – log P



LMC K – log P



Summary

- PAndromeda provides a wide, high-cadence view of M31.

- With image subtraction method, we are able to detect microlensing events and identify different classes of variables.

- The 3-year light curves, as well as classification of variables, will be released to the public.