# MEGA: Complete Sample

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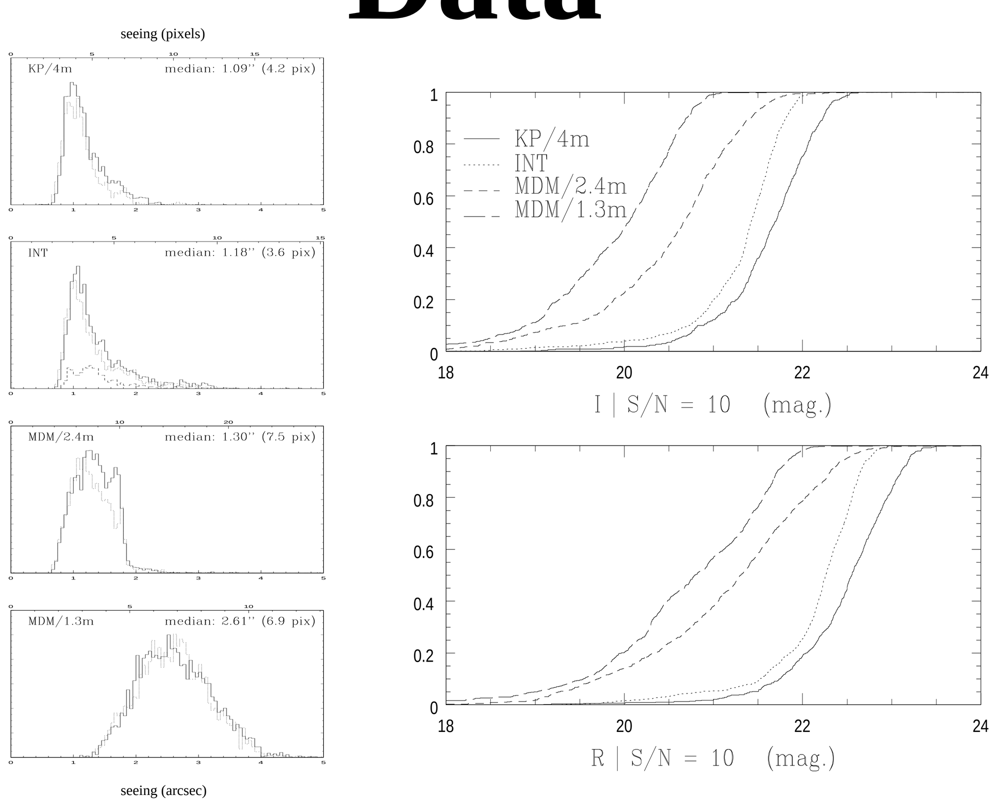
## The Project

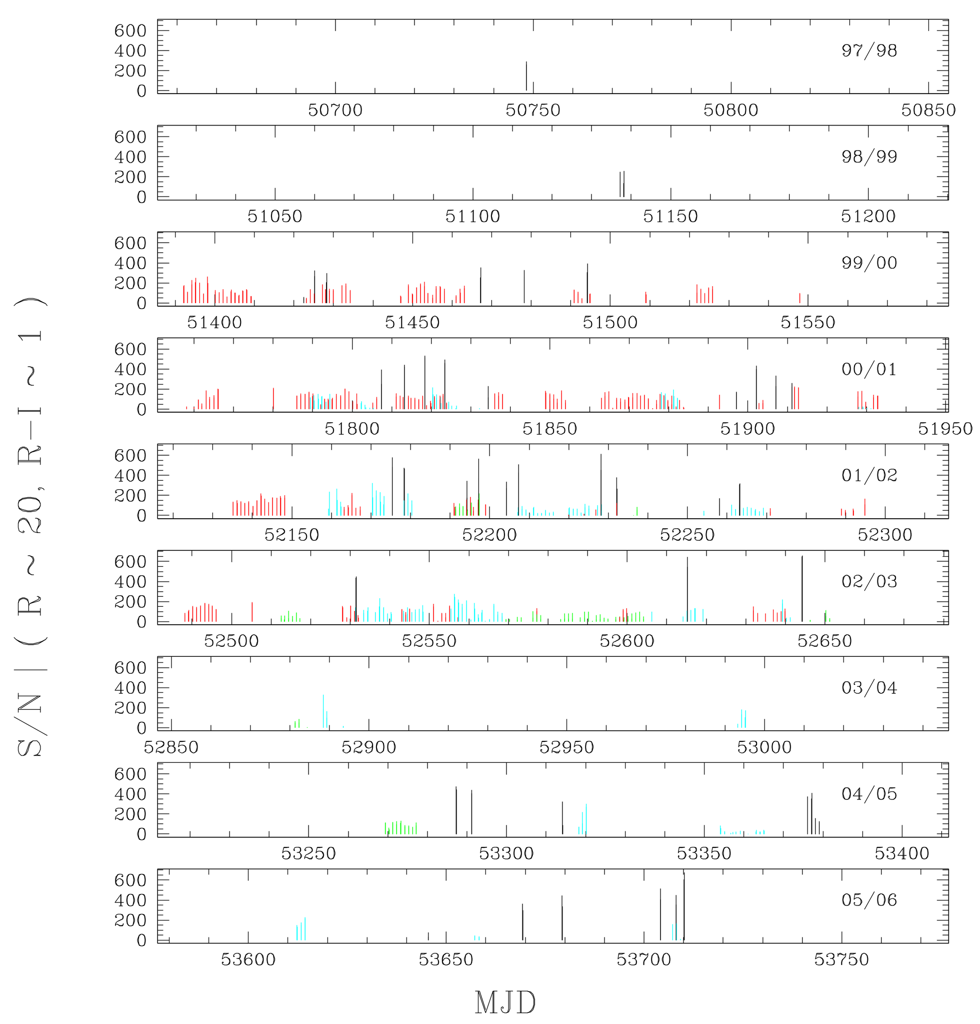
MEGA (Microlensing Exploration of the Galaxy and Andromeda) surveyed a roughly 1 deg$^2$ field in central M31 where the magnitude and variation of microlensing optical depth is suspected to be greatest. These observations were concentrated in 1999-2003, but with extended coverage spanning 1997-2007 (continuing now at sparse cadence). The imaging observations were performed primarily on the 2.5-meter Isaac Newton Telescope (INT), the Kitt Peak National Observatory (KPNO) 4-meter and MDM Observatory 2.4-meter and 1.3-meter telescopes. The current work signifies our merging of these four datasets into a single time sequence.

## Data




### Seeing and S/N of the images

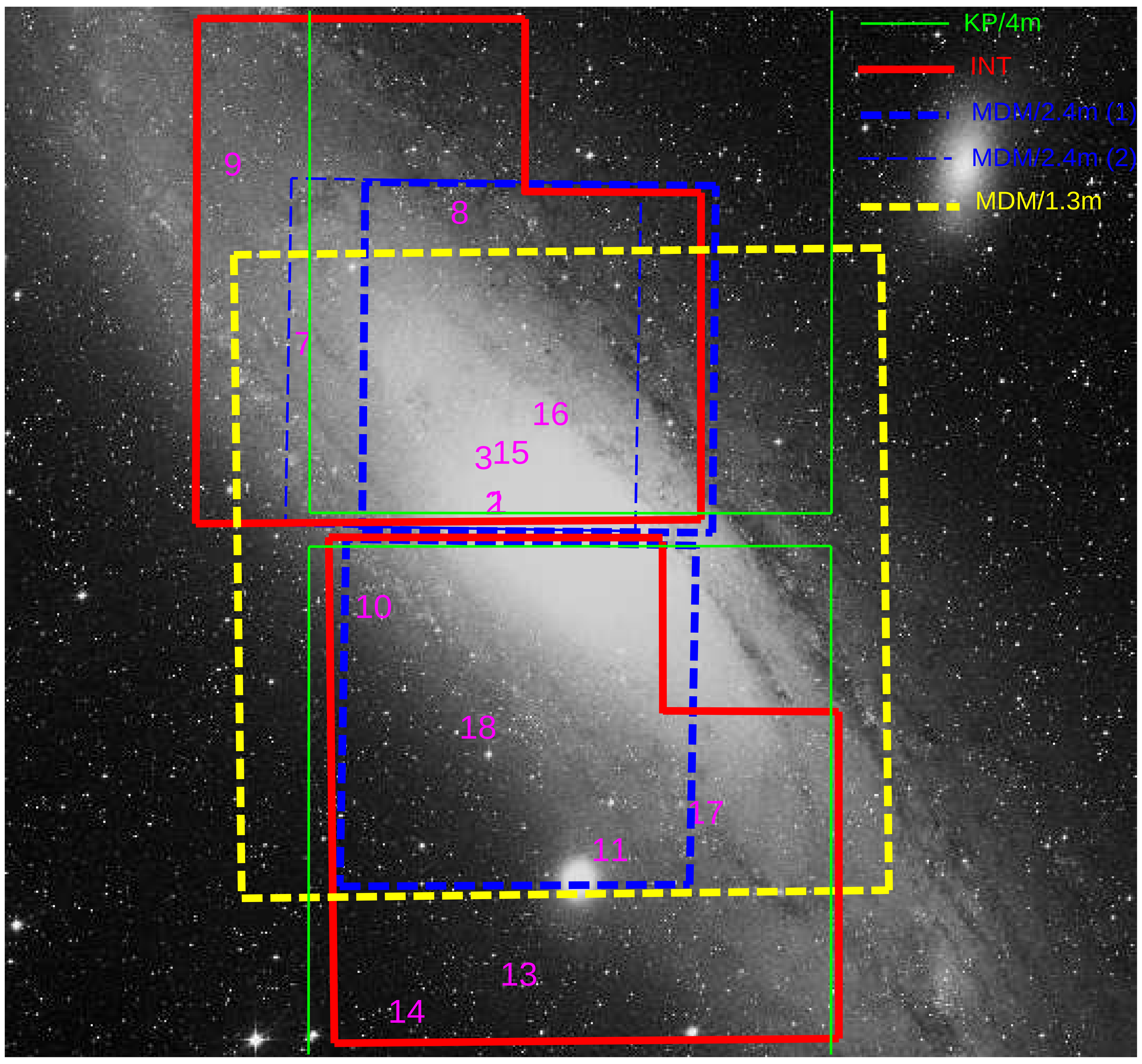
**Left:** Seeing distributions for the different telescopes. Solid (resp. dotted) line represents the R (resp. I) filter. Kitt Peak, INT, and MDM/2.4 data have a similar seeing (median ∼1.1-1.3"). MDM/1.3 on the other hand has a very poor seeing (median 2.6").
**Right:** The plots show the cumulative distributions of the magnitude of a star of signal to noise of 10 for all the images of the database. One can see that Kitt Peak and INT have similar limiting magnitude (but there are more images per night for Kitt Peak). MDM data (both 1.3m and 2.4m are approximately 2 magnitudes less deep.

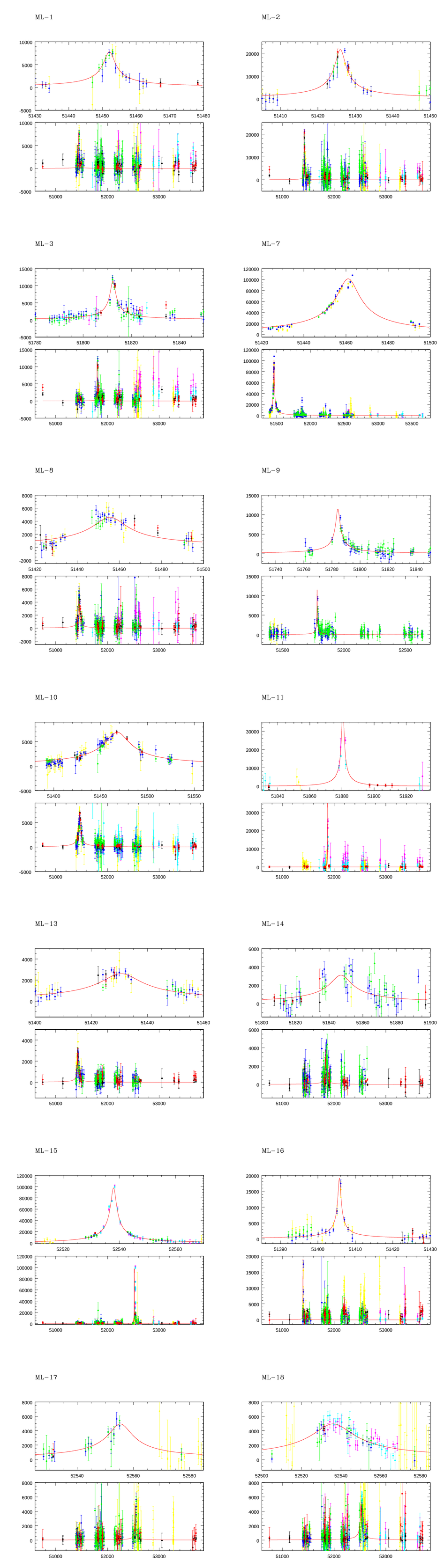



### Sampling

The INT dataset may be thought of as the "backbone" of the survey, in that this telescope could be regularly scheduled in smaller blocks of time to deliver imaging of our fields in an almost nightly cadence. In contrast, the KPNO 4-meter was scheduled more rarely (weekly cadence or less dense), but usually produced higher signal-to-noise ratio ($S/N$) epochs than did the INT. The two MDM telescopes tended to be scheduled in blocks of time, lasting several nights to few weeks, with the longer blocks often shared with other programs targeting non-M31 sources.

## Events



### Event descriptions

- **ML1** This moderate S/N event has been sampled by all the telescopes. Located in the bulge, probably a self-lensing event.
- **ML2** Same remarks as ML1, except that it is of much higher S/N.
- **ML3** Also a self-lensing event located in the bulge. The bumpy baseline is due to a variable located ∼ 0.25" away.
- **ML7** This is a very high S/N event located in the disk. Irregularities in the peak show that it might be a binary event (An et al. 2002)
- **ML8** This low S/N event is located in the disc. HST imaging show that if falls close to a background galaxy, so it might be a Supernova. If not, models predict a mass of $0.31^{+0.48}_{-0.21}M_\odot$ for a halo lens, and $0.05^{+1.65}_{-0.03}M_\odot$ for a disc lens.
- **ML9** This event, located far out the disc, has been sampled only by INT data.
- **ML10** The combination of all telescopes provide an excellent sampling of the peak for this disc event. HST imaging constrain the mass to $0.33^{+1.04}_{-0.23}M_\odot$ for a halo lens, and $0.05^{+0.09}_{-0.04}M_\odot$ for a disc lens.
- **ML11** This high S/N event is probably caused by a lens located in M32 (Paulin-Henriksson et al. 2002). HST imaging shows that the source star is very blue (R-I=0.15).
- **ML13** This is a low S/N event with a stable baseline located far out the disc.
- **ML14** This is the most far out event. The noisy lightcurve is caused by a nearby variable.
- **ML15** This is a bulge event with very high S/N. The best peak sampling is provided by MDM/2.4 data.
- **ML16** Only INT data in the peak for this high S/N event located in the bulge. No source seen in HST images, the lens mass cannot be constrained.
- **ML17** This is a low S/N event located in the disc.
- **ML18** This is also a low S/N event located in the disc. HST imaging show that it falls on a bright region (background galaxy or cluster), showing that it might be a supernova.

## Conclusion

From de Jong et al. (2006) the 95% confidence interval (for a range of reasonable halo models) tends to be $0 < f < 30\%$; this is for just the INT sample. Our new analysis would indicate that $f$ must be still lower. First, while we have not completed the efficiency analysis for the full four-telescope sample, it must be higher than for the INT-only sample, but the number of candidate microlensing events has not increased. Given the significantly better coverage of the four-telescope sample, the optical depth must be significantly lower. Merge this with the effect of the first round of our *HST* follow-up observations (Cseresnjes et al. 2005): of five candidate source fields observed, one seems to have been nearly certainly a background supernova, and a second might well have been. We are conducting similar observations for the entire candidate microlensing sample, but the possible number of bona fide events has decreased since the de Jong et al. analysis and seems likely to decrease further. This seems likely to further decrease $f$ significantly. We can say with some certainty that the final result for the total rate will be consistent with zero halo fraction. The best-fit halo contribution will be calculated using a maximum likelihood fit taking into account not only the total rate, but also near-side/far-side asymmetry, and radial density profile (which tends to be more shallow for a halo lens component). We will also include information from *HST* for all or most of the events, which will allow better determination of the einstein parameters and constraints on the lensing mass.