

The MACHO Project

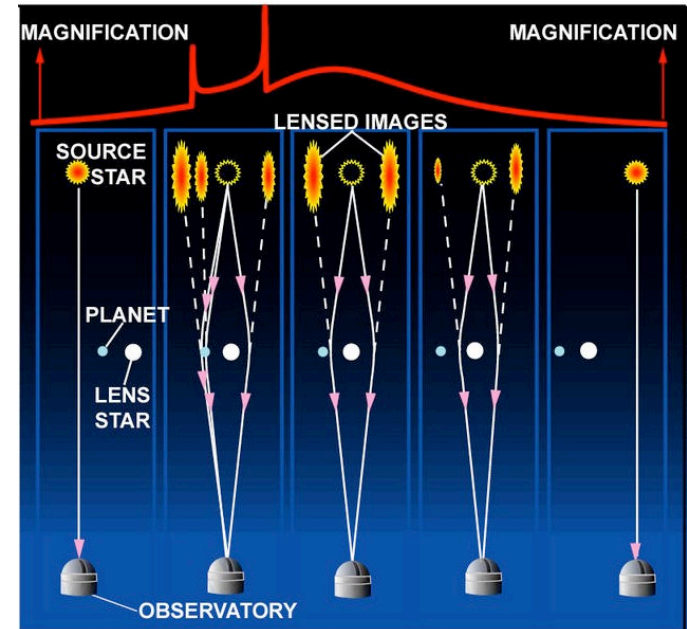
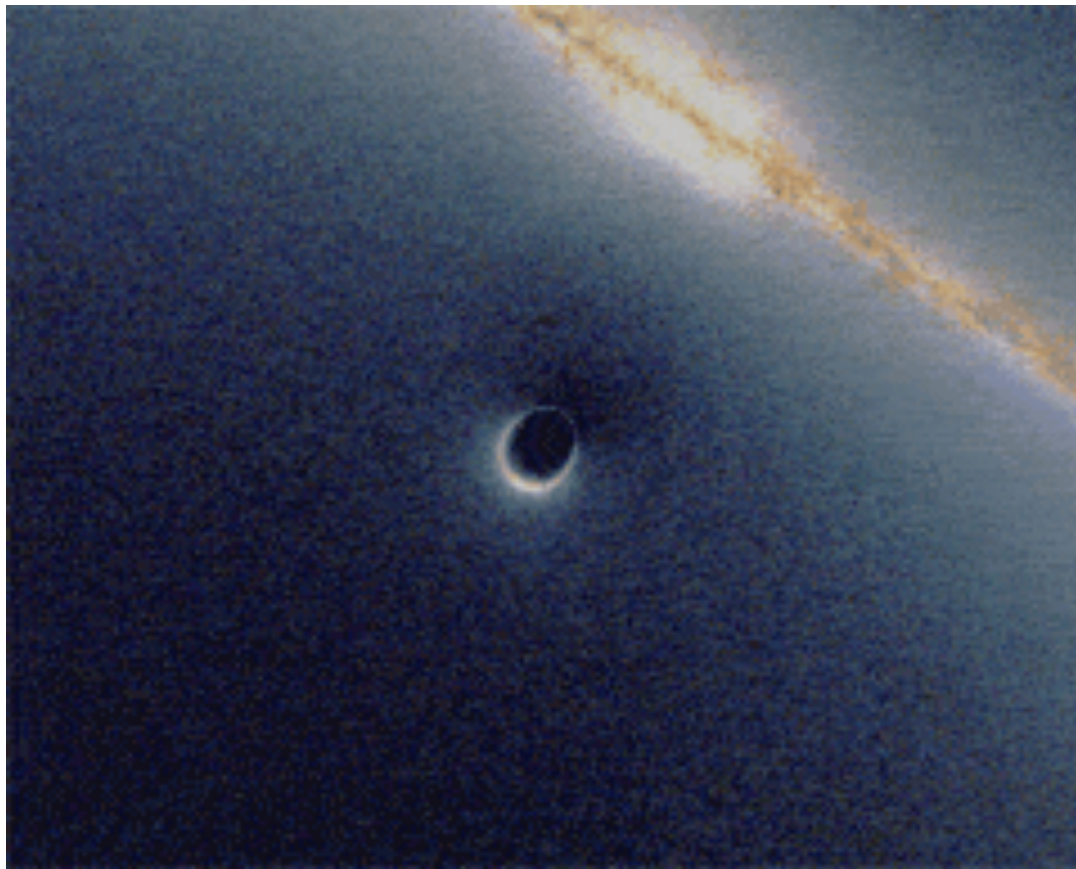
Microlensing Results from 5.7
Years of LMC Observations

C. Alcock et. al.

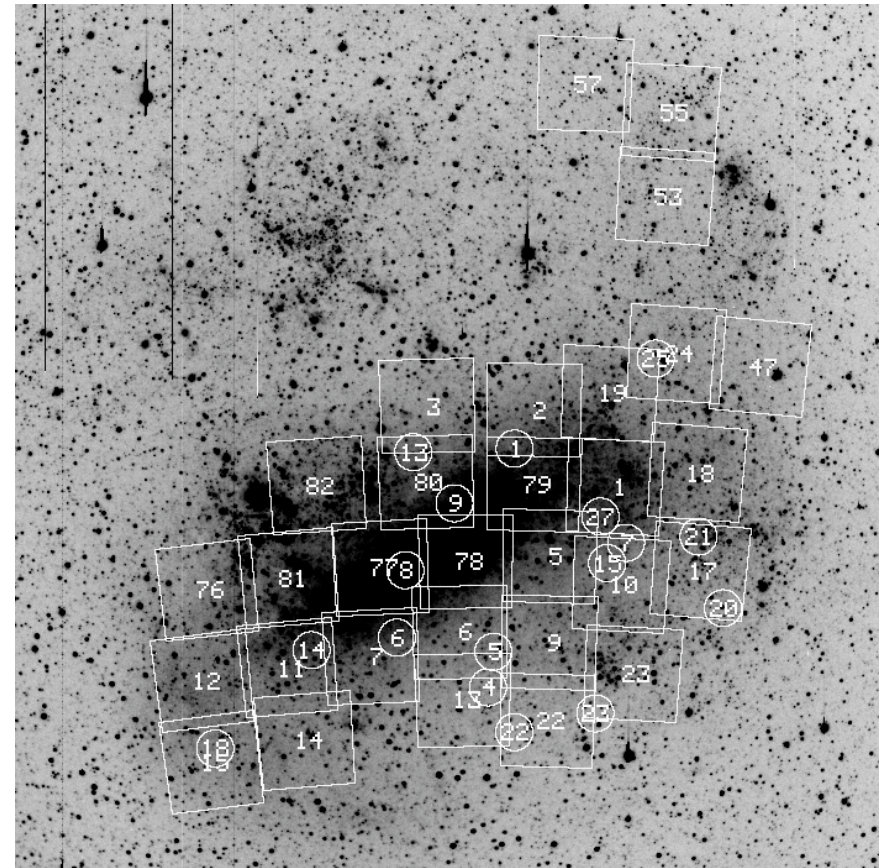
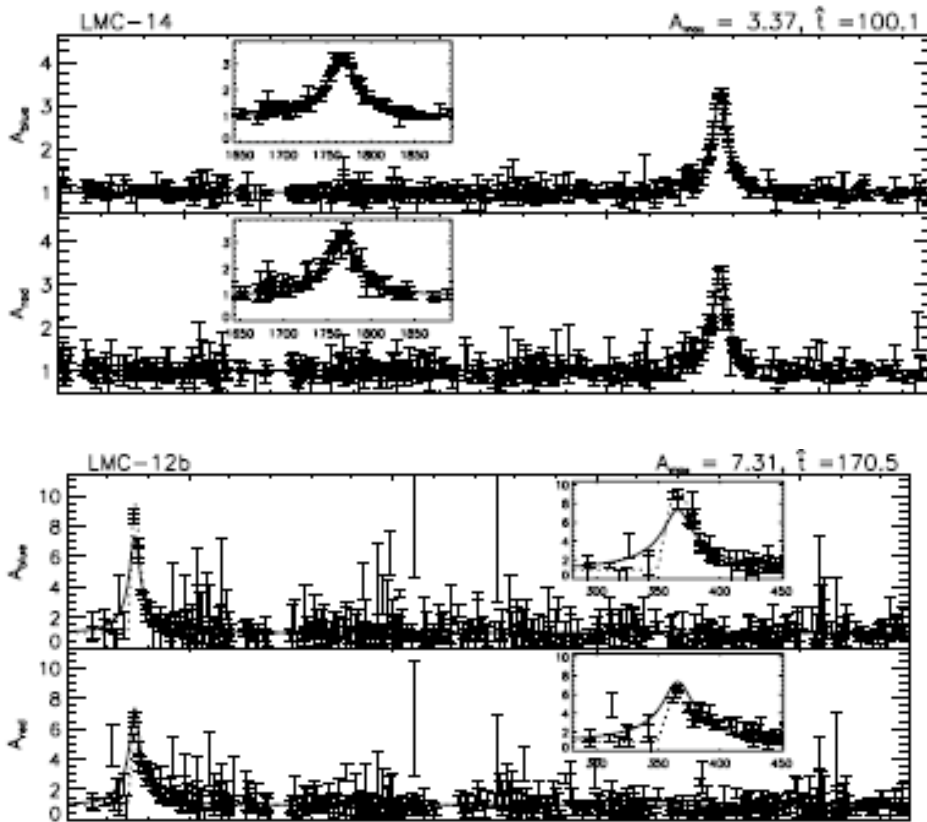
Main Results

- Dark Matter Halo of our galaxy is not composed entirely of MACHOs.
- Constraint on contribution of MACHOs to the halo of our galaxy between 8% – 50%.
- Constraint on the Mass of MACHOs between $0.15 M_{\odot}$ – $1 M_{\odot}$.

Gravitational Microlensing



Gravitational Microlensing

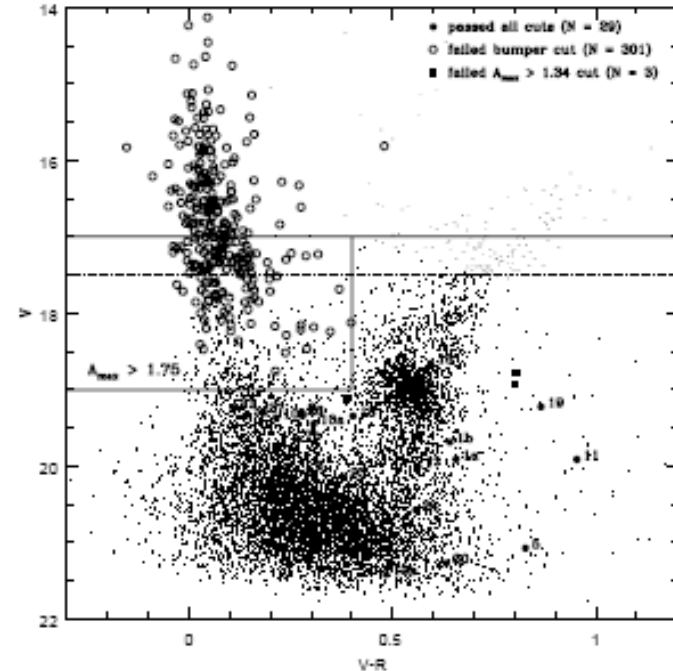
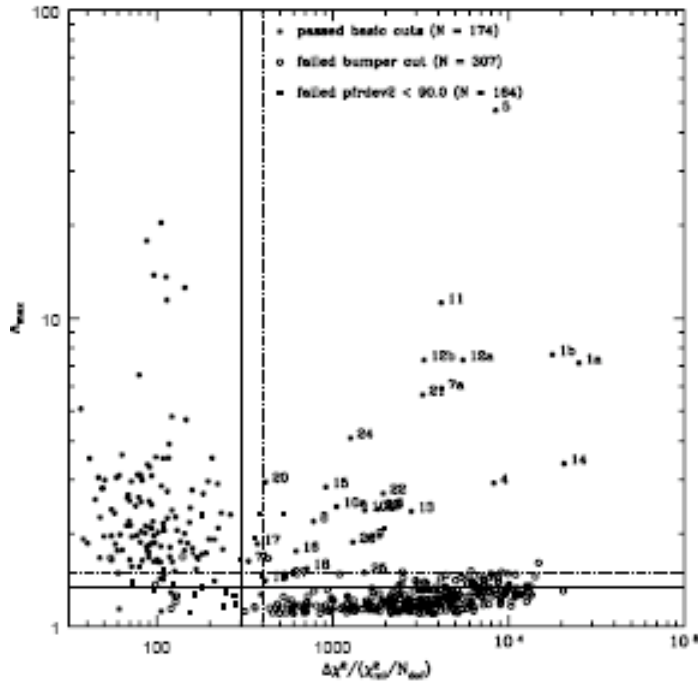


- Observations of 11.9 million stars in the LMC over a period of 5.7 years.
- Number of microlensing events: 13-17

Event Selection Criteria

TABLE 3
SELECTION CRITERIA

Description	Year 2 (A97)	Criteria A	Criteria B
Minimum coverage	$bmrN \geq 7 > 40$ baseline points, $\hat{t} < 300$	$rN > 0$ and $bN > 0 > 45$ baseline points, $\hat{t} < 600, t_{\text{max}} > 310$	> 65 simultaneous baseline points, $\hat{t} < 600, t_{\text{max}} > 310$
SN 87A echo	$10' \times 10'$ square excluded	$10' \times 10'$ square excluded	$10' \times 10'$ square excluded
Crowd and PSF	$f_{\text{CRD}} < [\Delta\chi^2/(X^2/N_{\text{dat}})]^{10/9}/520$ and $\text{crdrej} < 0.05$	None	$\text{pkcrdrej} + \text{pkpsfrej} < 0.2$
Bumper cut	$V > 17.5$ and $V - R < 0.9$	$V > 17.5$ and $V - R < 0.9$	$V > 17$ and ($A_{\text{max}} > 1.75$ or $V > 19$ or $V - R > 0.4$)
Variable cut	None	$\text{bauto}/\text{rauto} > 0.75$	$\text{pfwsr} > 0.6$ and $\text{rbcrossout} < 0.75$
High points	6 points $> 2\sigma$ and ≥ 1 point on rise and fall	7 points $> 2\sigma$	10 points $> 2\sigma$ and $N_{\text{H}}/N_{\text{pk}} > 0.9$
Baseline fit	$\chi_{\text{ml-ov}}^2/N_{\text{dat}} < 4$	$\chi_{\text{ml-ov}}^2/N_{\text{dat}} < 1.8$	$\chi_{\text{ml-ov}}^2/N_{\text{dat}} < 4$ and $\chi_{\text{robust-ov}}^2/N_{\text{dat}} < 1.5$
Second S/N	$\Delta\chi^2/(X_{\text{peak}}^2/N_{\text{dat}}) > 200$	$\Delta\chi^2/(X_{\text{peak}}^2/N_{\text{dat}}) > 350$	None
Main S/N	$\Delta\chi^2/(X_{\text{ml}}^2/N_{\text{dat}}) > 500$	$\Delta\chi^2/(X_{\text{ml}}^2/N_{\text{dat}}) > 400$	$\Delta\chi^2/(X_{\text{ml}}^2/N_{\text{dat}}) > 300$
Magnification	$A_{\text{max}} > \max(1.75, 1 + 2\sigma)$	$A_{\text{max}} > \max(1.49, 1 + 3\sigma)$	$A_{\text{max}} > \max(1.34, 1 + 4\sigma)$
Second peak	None	None	$\text{pfrdev2} < 90$
Supernova cut	By eye	$\Delta\chi_{\text{SN-ml}}^2 > 0$ and not event 22	$\Delta\chi_{\text{SN-ml}}^2 > 0$



Sources of Uncertainty

- Main source of error is from uncertainty in models of the Milky Way and LMC.
- Criteria Set B is has low S/N
- Crowding
- Supernova
- Cosmic Rays
- Variable Stars which produce background microlensing (bumpers)

Interpretation

- One explanation is that MACHOs comprise 20% of Milky Way halo mass.
- Total implied mass of MACHOs within 50 kpc, of $9 \times 10^{10} M_{\odot}$.
- Another explanation is that the LMC halo dominates microlensing, and there are no MACHOs in our galaxy.
- Some MACHOs may be white dwarf stars.