Milszt - - 00

NOT ENOUGH STELLAR MASS MACHOS IN THE GALACTIC HALO

≡ latest results from the EROS-2 search for dark matter through microlensing

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Nu 2000, 20 June 2000

EROS2 : DAPNIA Saclay + LAL Orsay + IAP Paris
+ Univ. Ohio + Coll. de France Paris + Obs. Marseille

already published :

SMC 1yr :	Palanque-Delabrouille et al. 1998	A&A 332, 1	5M*
SMC 2yr :	Afonso et al. 1999	A&A 344, L63	5M*
LMC 2yr :	Lasserre et al. 2000	A&A 355, L39	17M*

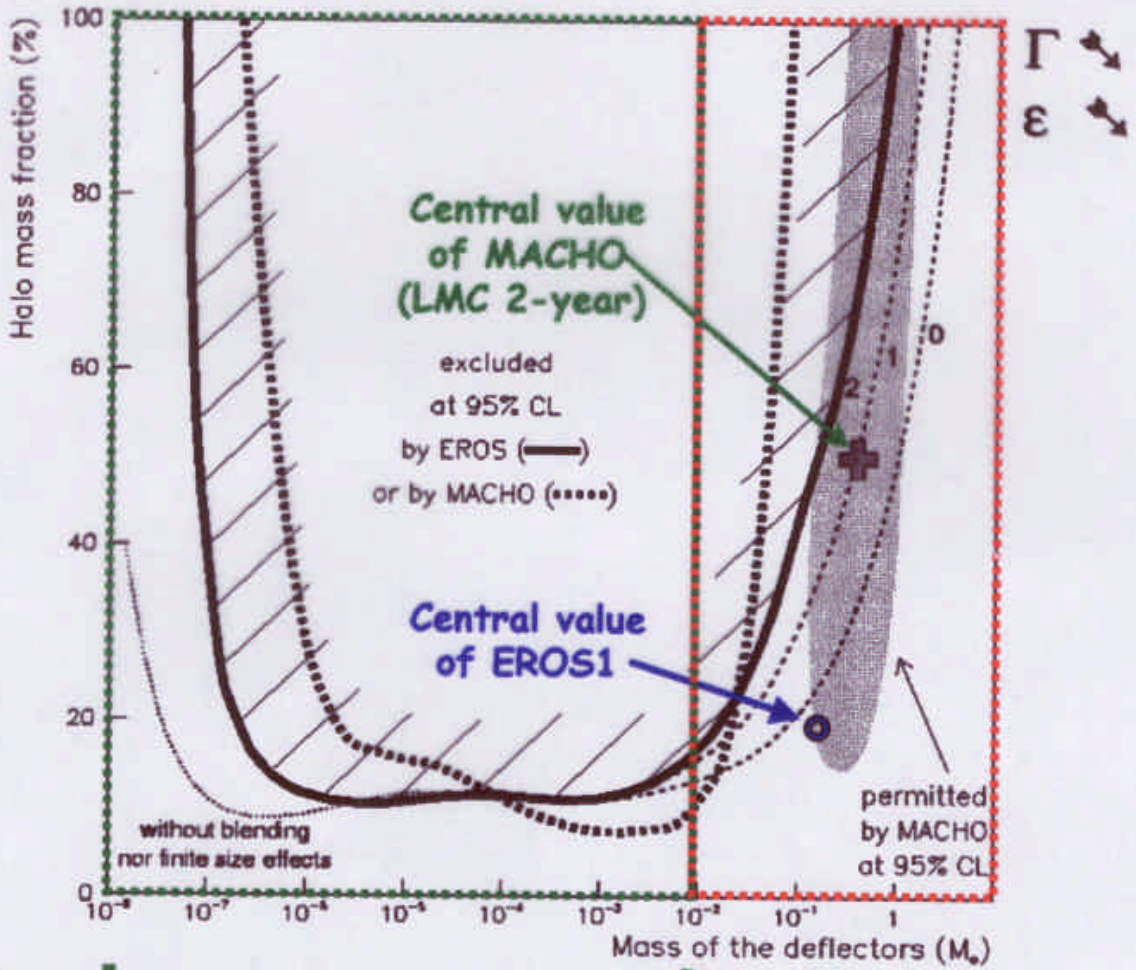
Microlensing status in 1997

Limits on low mass MACHOs (EROS1/MACHO)

MACHO : Positive detection (LMC 2Y 8.10^6 stars)

EROS1 : Upper limit from 2 candidates (LMC 3Y)

Renault C. et al. (EROS), 1998, A&A 329, 522



Region probed by EROS1/MACHO (no short duration event)

Region ??? → EROS2 MACHO

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EROS 2

- Approved '94 ; Data from July '96
- Aim: 30 M * (4 M* in EROS-1)

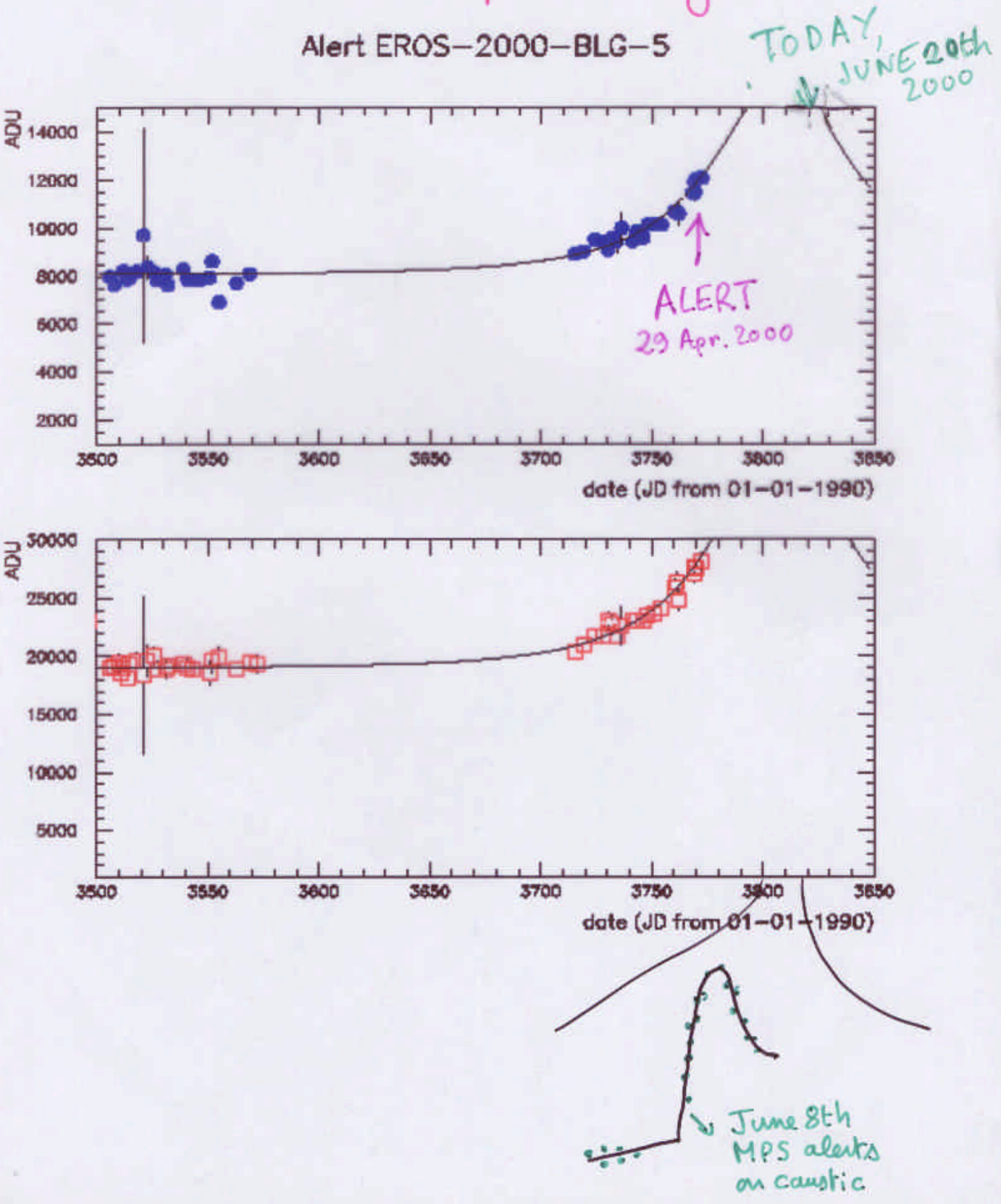
  to improve sensitivity to $> 0.01\, M_{\odot}$ objects

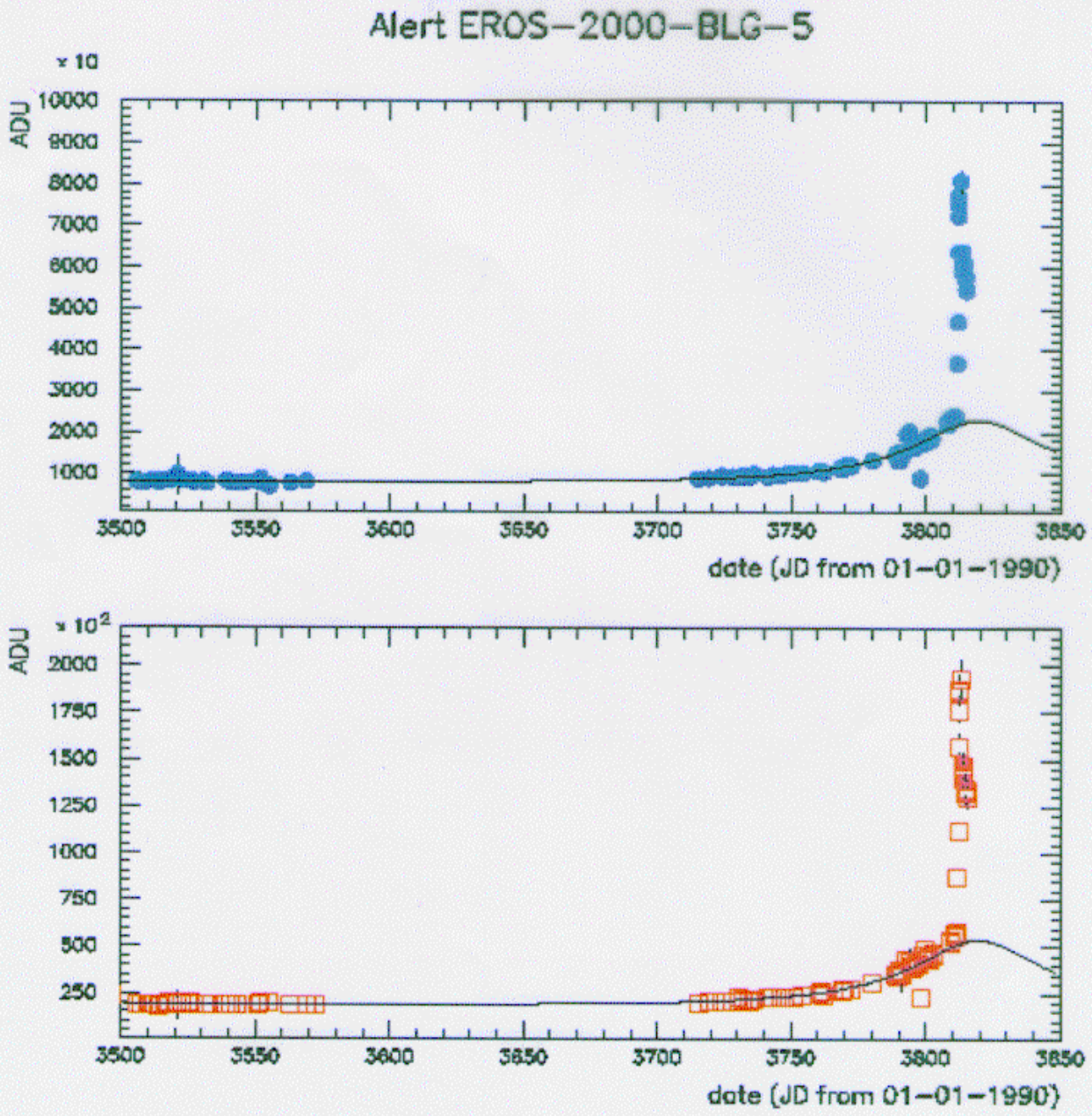
  +

  Compare SMC and LMC

- Dedicated 1 meter telescope at ESO (La Silla)
- Two wide CCD mosaic cameras (32 M pixels each, 1 sq. degree in sky)
- Alert system
- Other programs:
  - ↳ microlensing towards Gal. Bulge and Disk
  - ↳ Type Ia S.N. at $z \sim 0.1$
  - ↳ Search for nearby, dim, high proper-motion objects (Halo White Dwarfs ?)
  - ↳ Variable stars
- Data expected by 2002 : ~ 15 T bytes

An on-going galactic bulge event (On-line processing)




Alert EROS-2000-BLG-5
x 10
ADU
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
3500
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3600
3650
3700
3750
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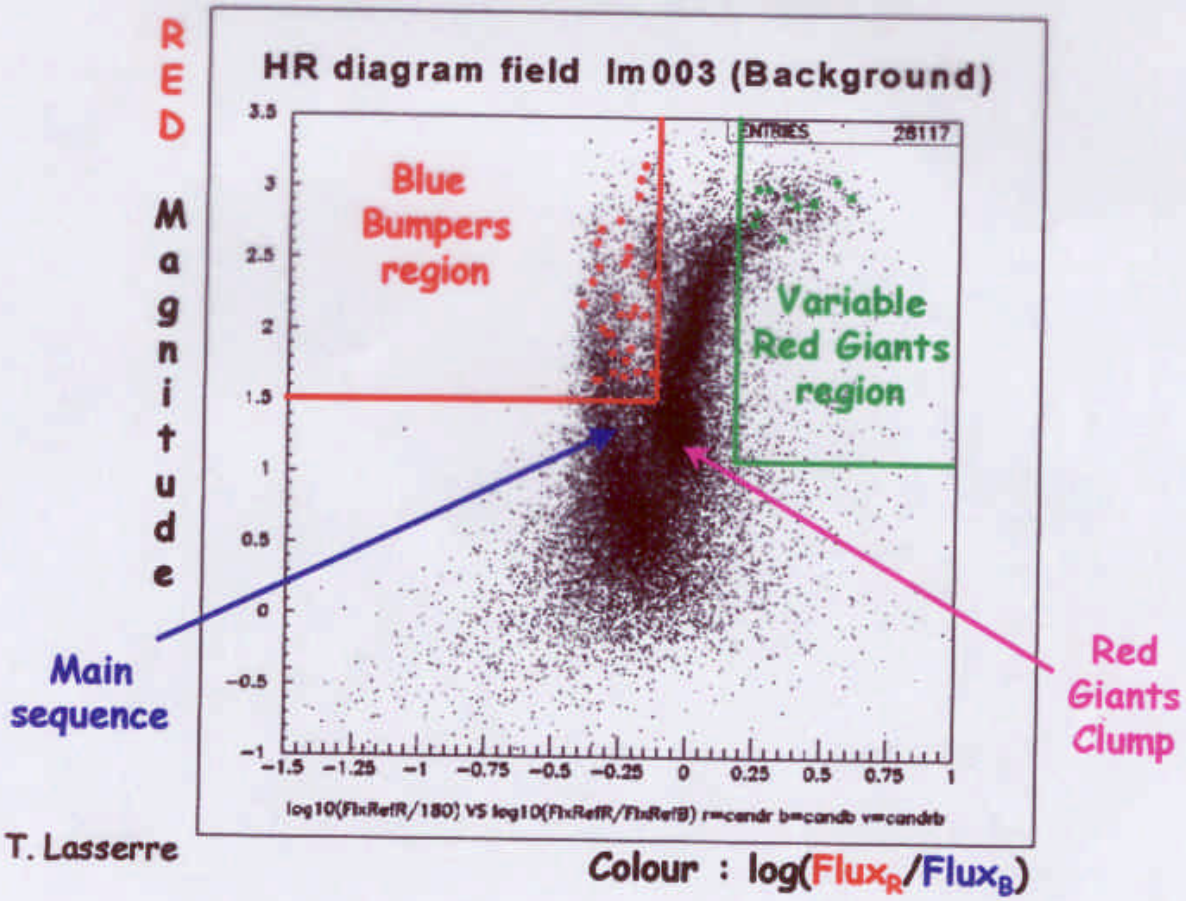
3850
date (JD from 01-01-1990)
x 10²
ADU
2000
1750
1500
1250
1000
750
500
250
3500
3550
3600
3650
3700
3750
3800
3850
date (JD from 01-01-1990)

Expected Background (1)
Intrinsic variable stars

« special places » in the C-M diagram
can mimic a microlensing signal

2 solutions : 1- Cut on the C-M diagram
(but losing statistics)

2- Characterisation and rejection
of the background



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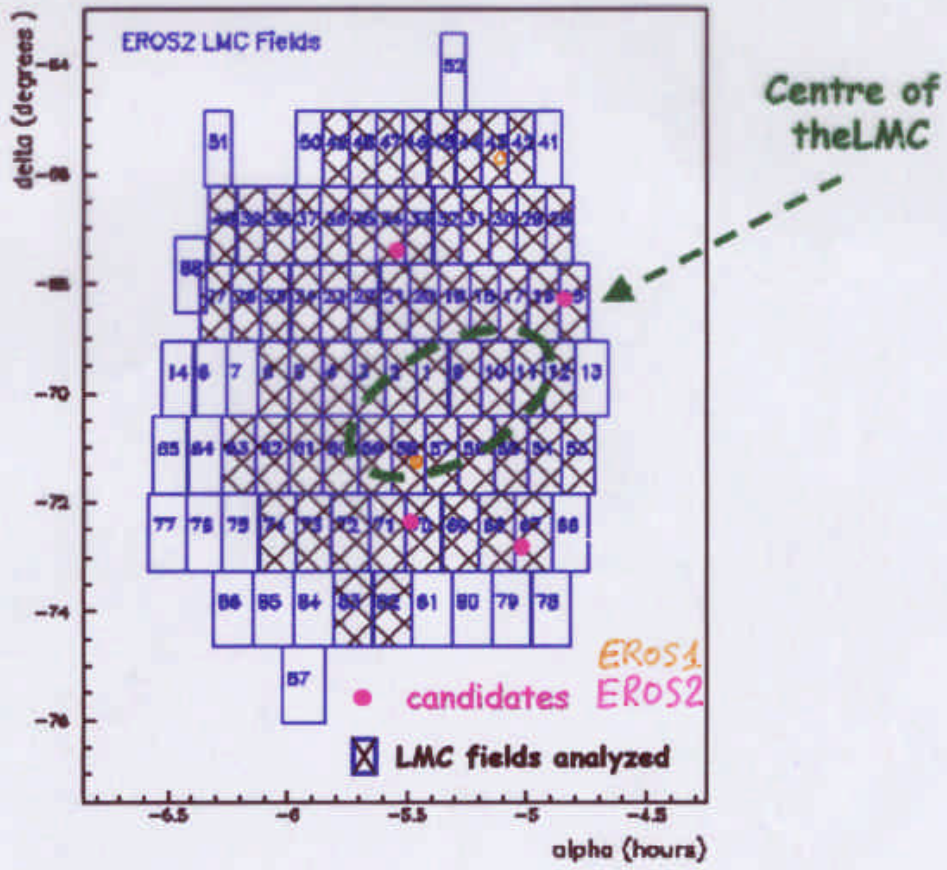
LMC analysis 1996-99

4 years of data

- 3 years have been analysed
- 39 deg^2 covering 64 fields
- 25.5 million stars
- Sampling : 1 measurement/4-7 days
- 4 candidates (ε(50 date) ~ 16%)



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Combined limit LMC/SMC EROS 1990-99

- EROS 1 CCD (1991-95)
- EROS 1 Plaques (1990-93)
- EROS 2 SMC (1996-98)
- EROS 2 LMC (1996-99)

} Independent programs

The whole EROS is now considered as a "single-experiment" with 5 candidates

	Candidate(s)	$S(t_E) \propto N_* T_{obs} \varepsilon(t_E)$ at t_E = 50 days
- EROS 1 CCD	0	~ 0.01
- EROS 1 Plaques	1	0.17
- EROS2 SMC	0	0.10
- EROS2 LMC	4	0.73
-EROS (98) 99 (02)	5	(0.7) 1 (1.9)
-MACHO 2 y & 6 y	6(8) & 13(17)	0.3 & 1.5

↑ This talk.

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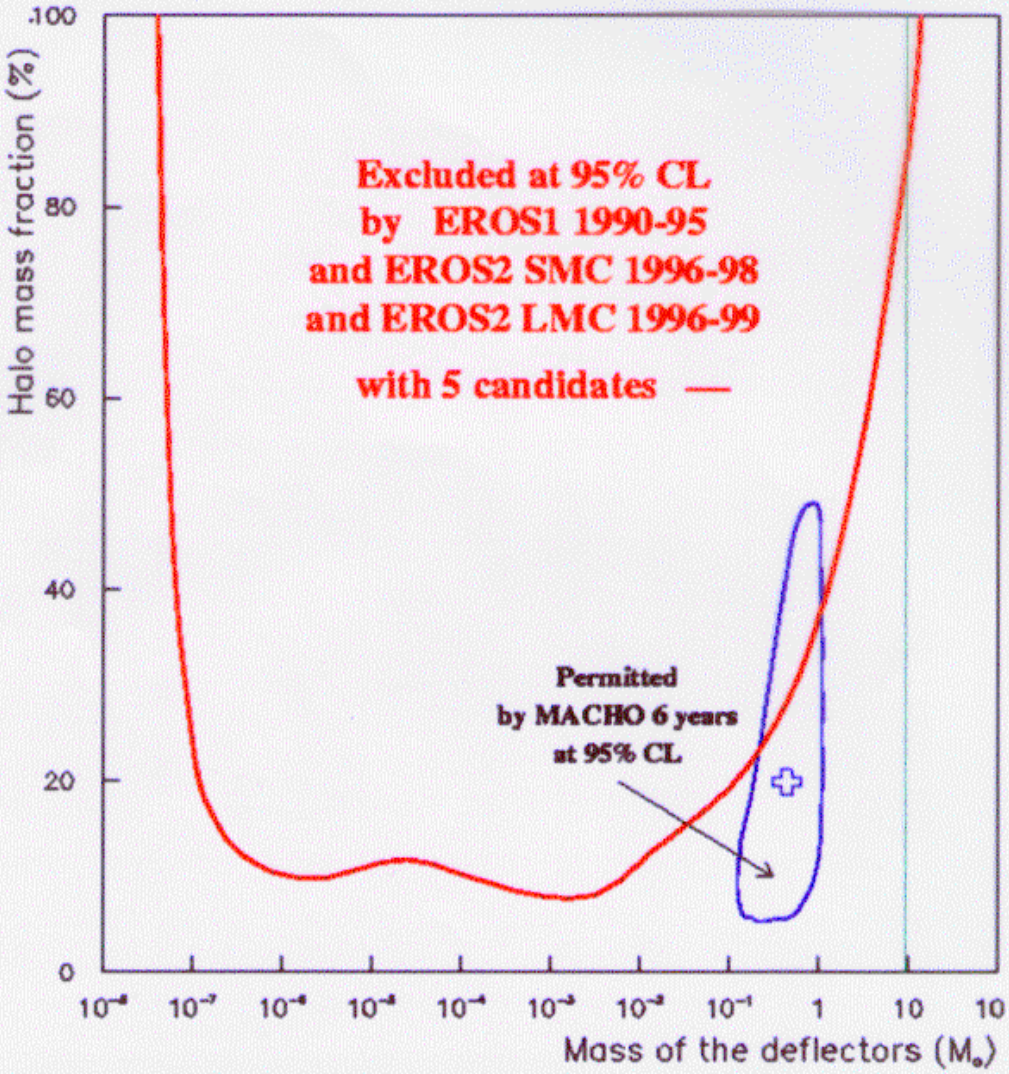
Combined limit LMC/SMC EROS 1990-99

Spherical standard halo : M=4 10^{11} M. within 50 kpc



1996/98 Limit confirmed and improved

Standard Halo fully comprised of MACHOs excluded à 95% C.L. for $M_{LENS} < 10\ M_\odot$

JUNE 2000 CONCLUSIONS

↳ Few 100 microlensing events seen, (> 300) TOO MANY!
mostly towards gal. center
(including "exotic" events)

↳ By-products: stellar luminosity profile
stellar atmospheres (?)
search for planets ...

DARK MATTER

↳ No Low Mass Objects (10^{-7} - few $10^{-2} M_\odot$)
EROS1 + MACHO

↳ MACHO: 13-17 LMC candidates +2 SMC
Halo: 20% of $0.4 M_\odot$ objects
(a few candidates are excellent candidates)

↳ EROS: 1+4 LMC candidates (+1 SMC)
no "very nice" candidate
quotes 95% CL upper limits
(central value $\lesssim \frac{1}{2}$ MACHO)

↳ present results are insensitive to
$t_E > 300$ days ($M > 10 M_\odot$)

Questions :

↳ is the EROS-MACHO difference real ?

MACHO : 15 sq. deg

EROS : 40 sq. deg less blending

↳ is it normal that there are no candidates towards SMC that are due to halo lenses?

presently ~ YES , but ...

↳ is there a residual background of var. stars?

"Predictions"

If the MACHO result corresponds to halo lenses

↳ EROS-2 should have soon more lenses ($\gtrsim 10$)
Spatially flat

↳ Both EROS and MACHO should have a few $t_E \sim 50$ days SMC candidates

↳ $0.5 M_\odot$ objects are likely to be White Dwarfs:
should be found by direct searches for dim, high proper motion objects

CLAIMS : Ibata et al. 1999, 2000

NEG. RESULTS: EROS

If not ...
"self-lensing" ?

Number of expected Halo White Dwarfs

and preliminary

Exclusion diagram for a standard halo model