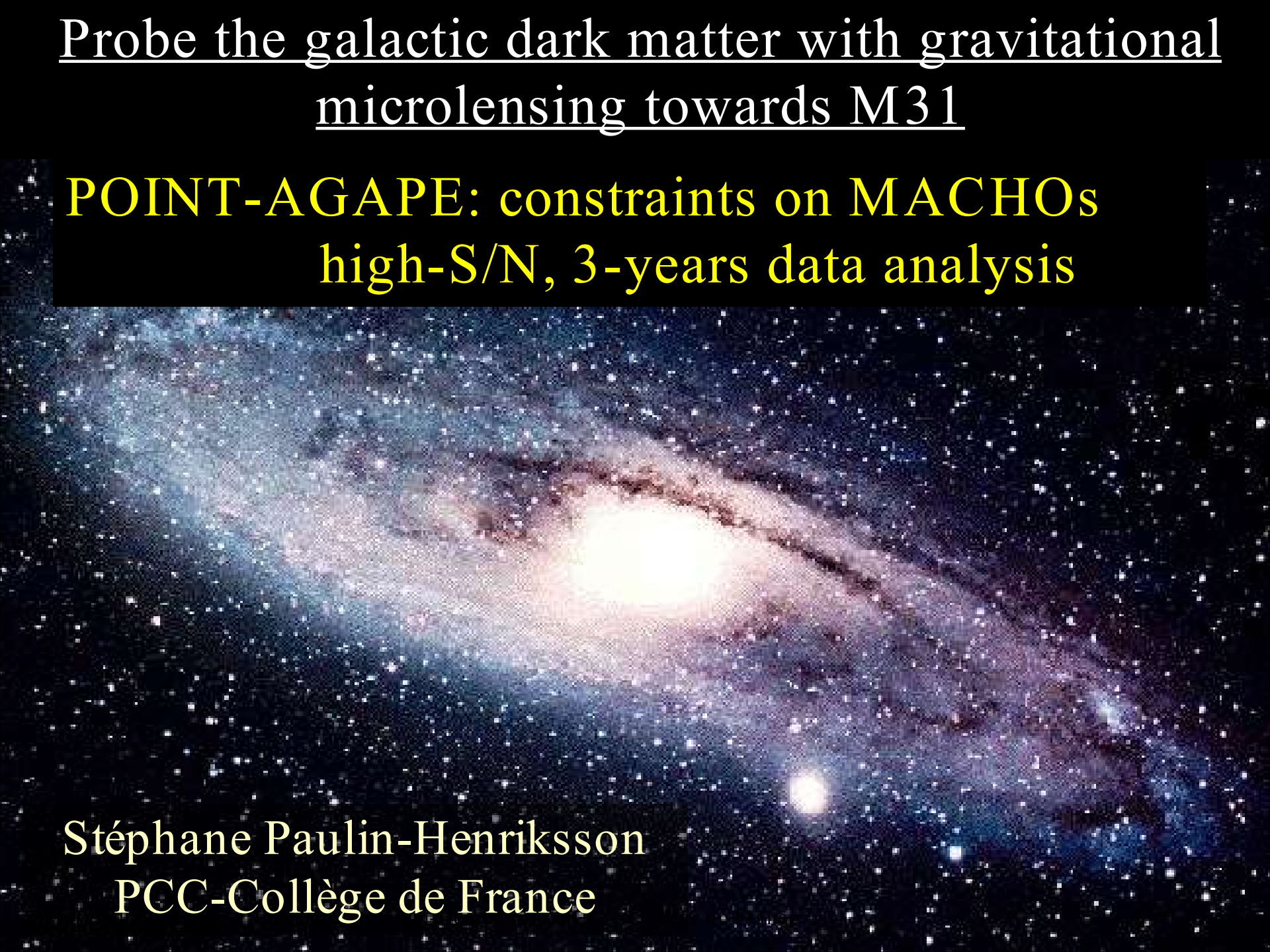


Probe the galactic dark matter with gravitational
microlensing towards M31

**POINT-AGAPE: constraints on MACHOs
high-S/N, 3-years data analysis**

Stéphane Paulin-Henriksson
PCC-Collège de France



The dark matter

Concordance model:

CMB + SNIa + H_0 + nucleosynthesis +
redshift surveys + Ly α

Energy density:

- repulsive energy
- non baryonic matter
- baryonic matter

70%

26%

4%

observations:

DARK

DARK

gas: 2.4% - 3.2%

stars: 0.6% - 0.8%

DARK: 0.2% - 1.0%

Dark baryons contribute to the baryon density
with the same order of magnitude than
luminous matter

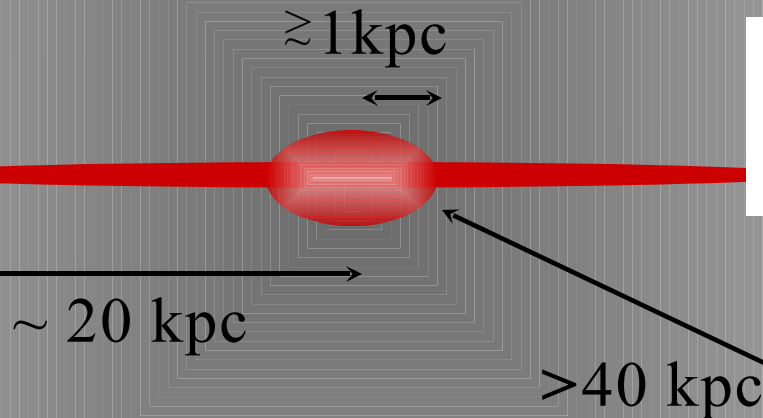
The galactic dark matter

rotation curve \Rightarrow dark halo around the luminous component

$$M_{\text{dark}} / M_{\text{luminous}} \geq 10$$

open question:
dark baryons in the halos ?
 \longrightarrow contribution: 5% - 15%

compatible with the
EROS/MACHO results



Topics

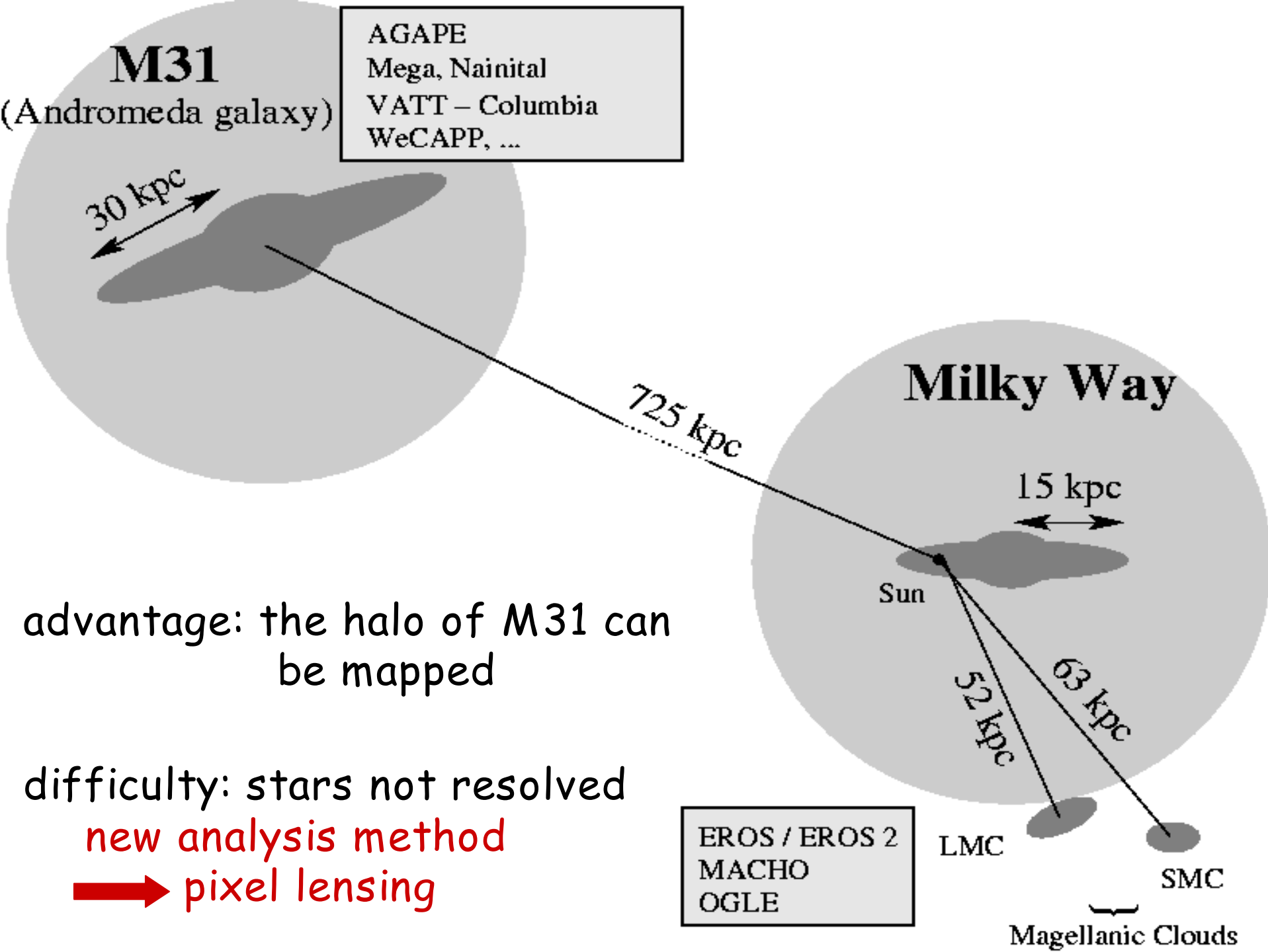
1. Searching for MACHOs towards M31

➔ The (POINT-)AGAPE experiment

2. High-S/N, 3-years data analysis

➔ 7 bright and short microlensing events

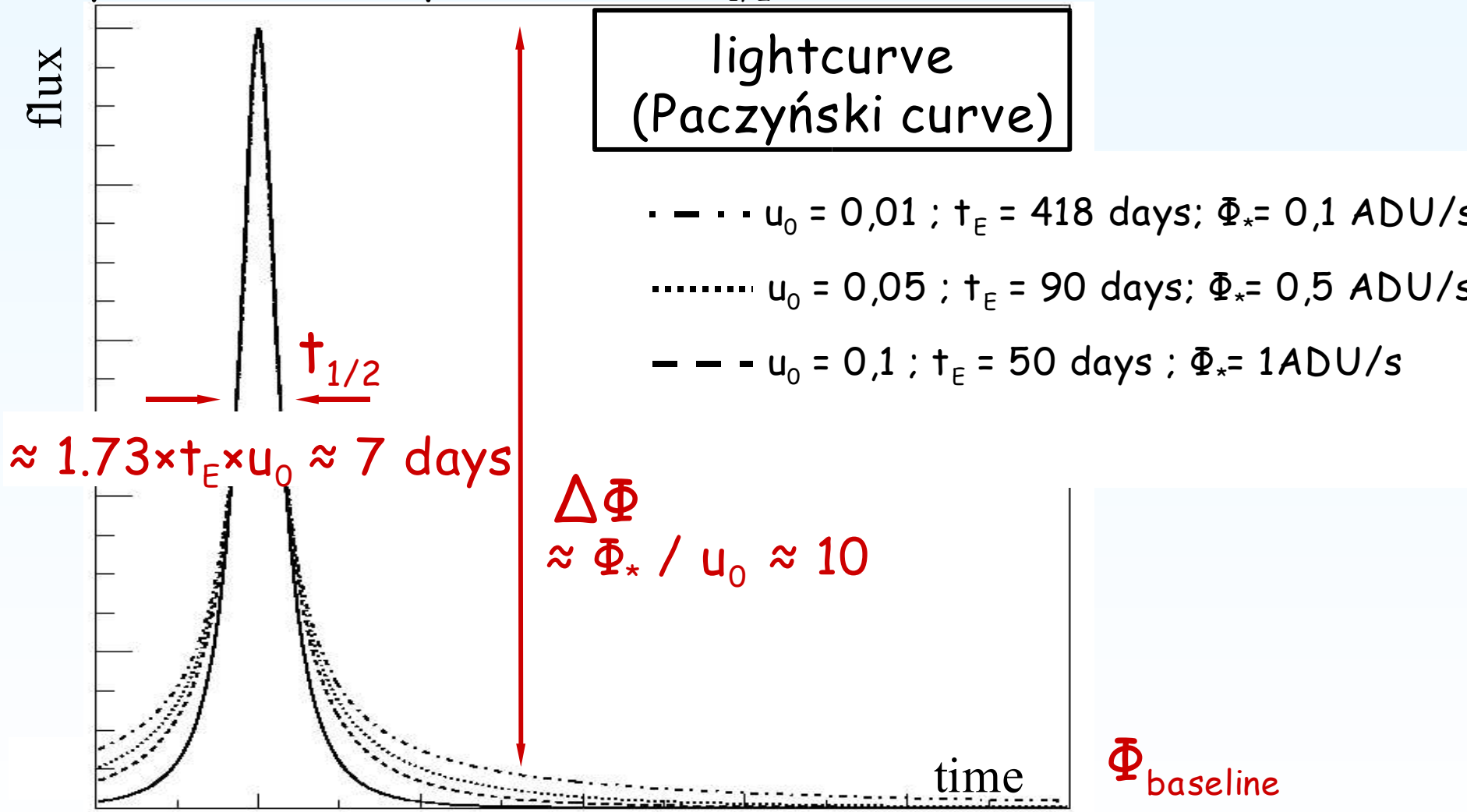
3. constraints on MACHOs



The gravitational microlensing effect

unresolved star $\Rightarrow \Phi_{\text{baseline}} = \Phi_* + \Phi_{\text{bkg}}$

- 3 parameters: flux of the source Φ_* , impact parameter u_0 , Einstein time t_E
- only 2 observable parameters: $t_{1/2}$ and $\Delta\Phi$



The POINT-AGAPE collaboration

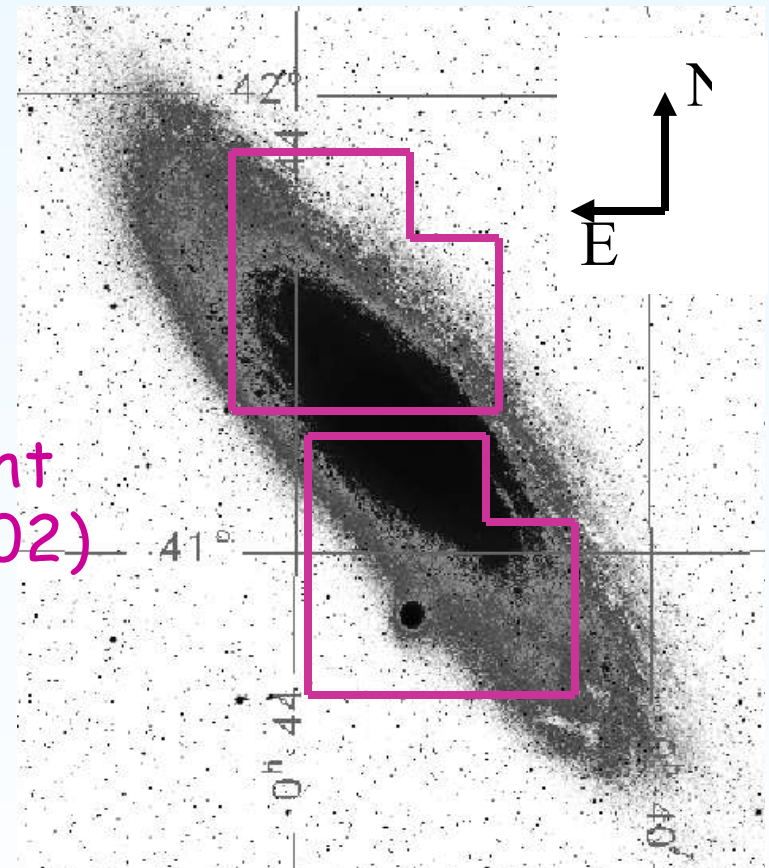
(Pixels Observation at INT)

(Andromeda Galaxy Amplified Pixel Experiment)

ARI – Liverpool, IoA – Cambridge, ITP – Zurich, OMP – Toulouse, Oxford University
PCC-Collège de France – Paris, QWM – London, Université Bretagne-sud – Vannes

Photometric survey of M31:

- Isaac Newton Telescope (INT)
 $\varnothing = 2,5\text{m}$ (La Palma, Canaries)
- Wide Field Camera (WFC)
- 180 observation nights (1 h/night
between aug. 1999 and jan. 2002)
- 3 filters : Sloan i' , r' et g'
- field : $0,55 \text{ deg}^2$



Topics

1. Searching for MACHOs towards M31

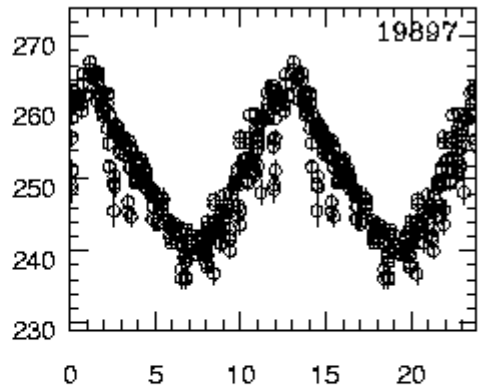
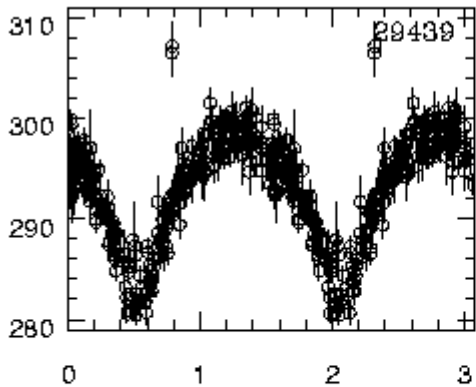
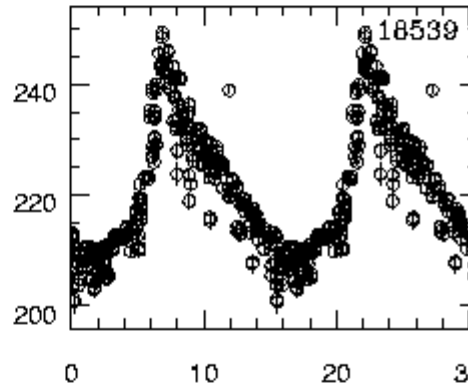
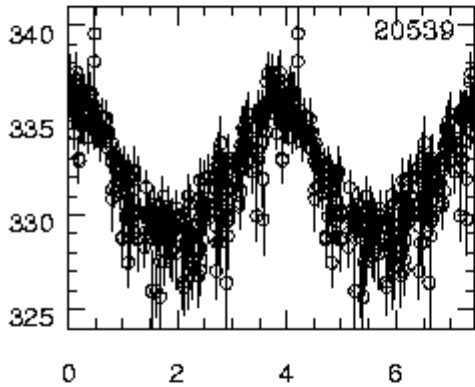
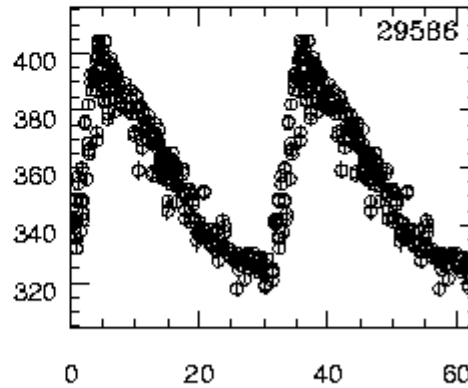
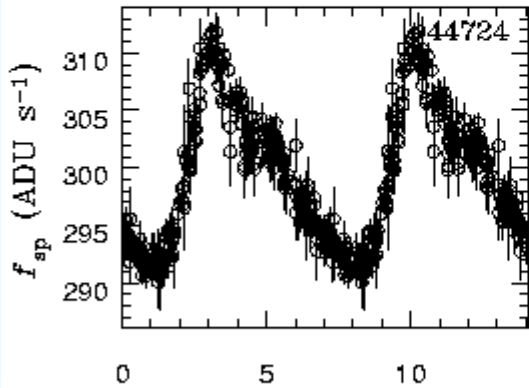
→ The (POINT-)AGAPE experiment

2. High-S/N, 3-years data analysis

→ 7 bright and short microlensing events

3. Constraints on MACHOs

Catalogue of 5×10^4 variable stars



$$19 < R(\Delta\Phi) < 24$$

$$0 < V-R < 2$$

$$-1 < R-I < 2.5$$

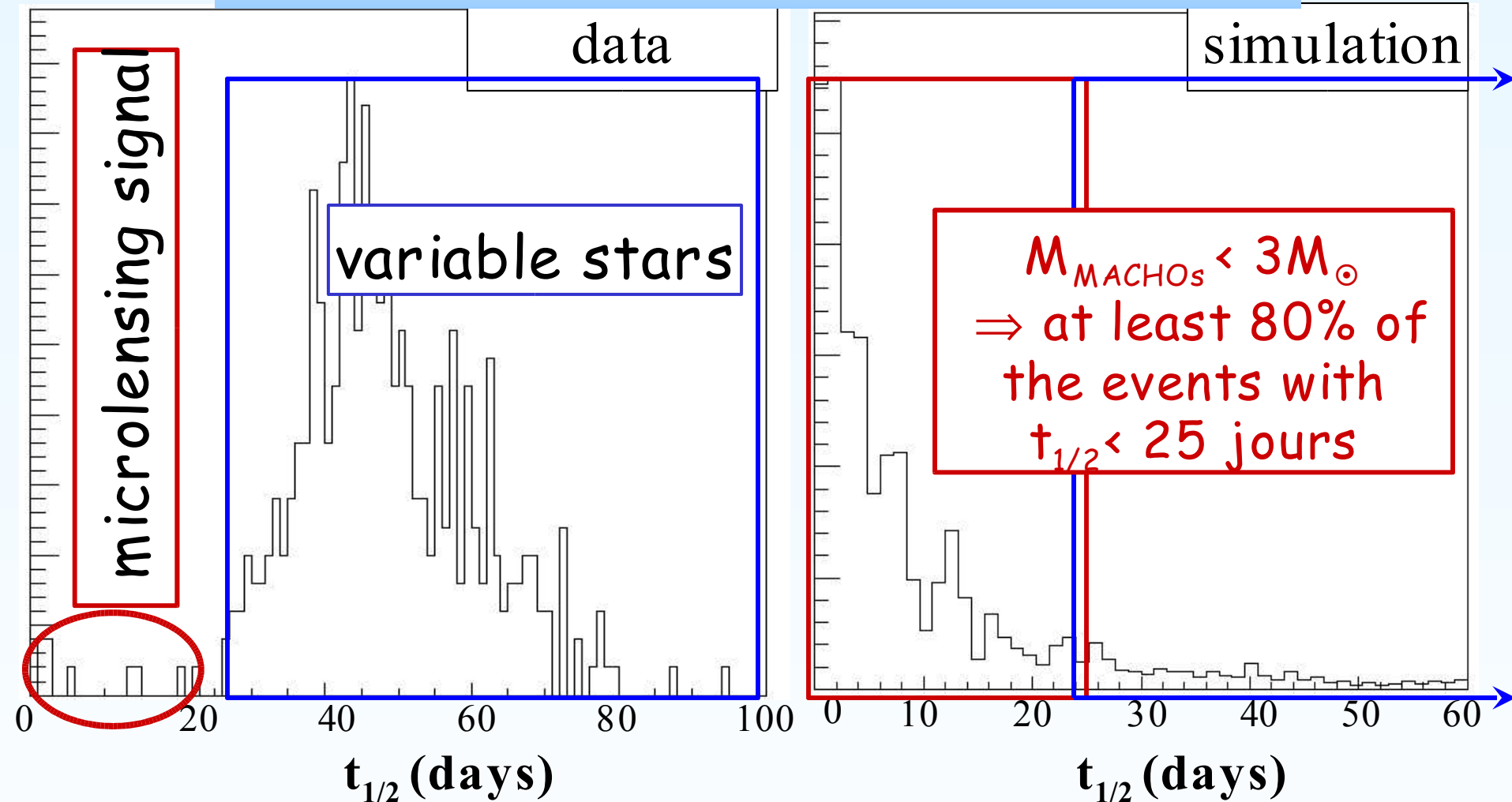
microlensing search:

✓ microlensing fit test of symmetry & achromaticity ($\chi^2/\text{d.f.} < 5$ & $S/N > 20$)

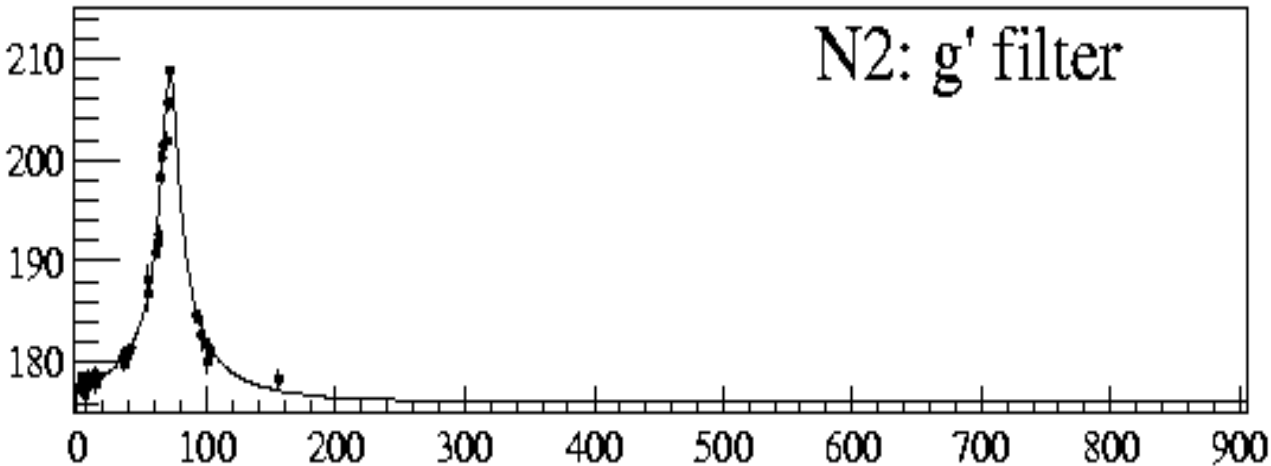
✓ one bump test of unicity

✓ bright: $R(\Delta\Phi) < 21$
⇒ restriction to 15% of the catalogue

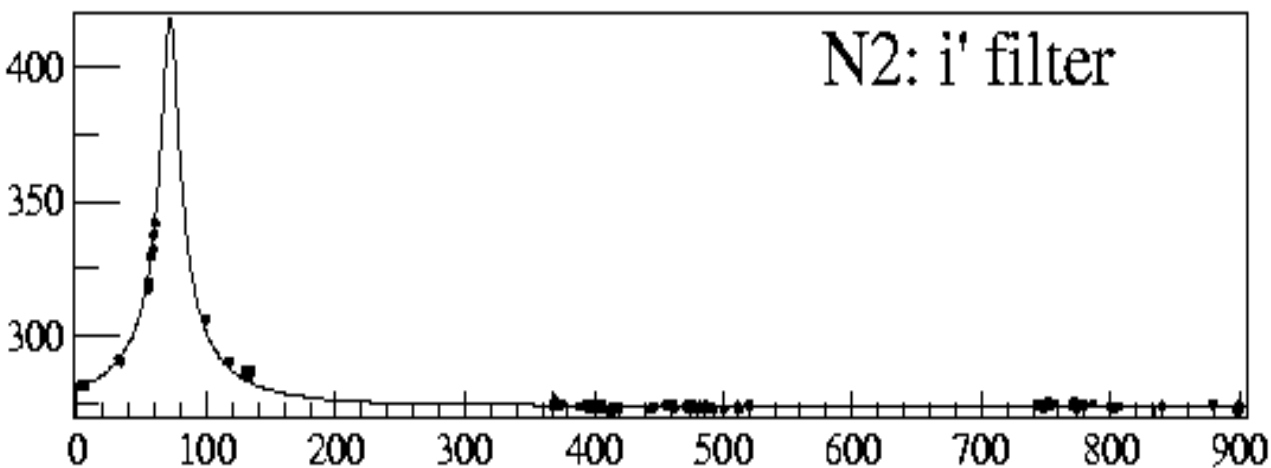
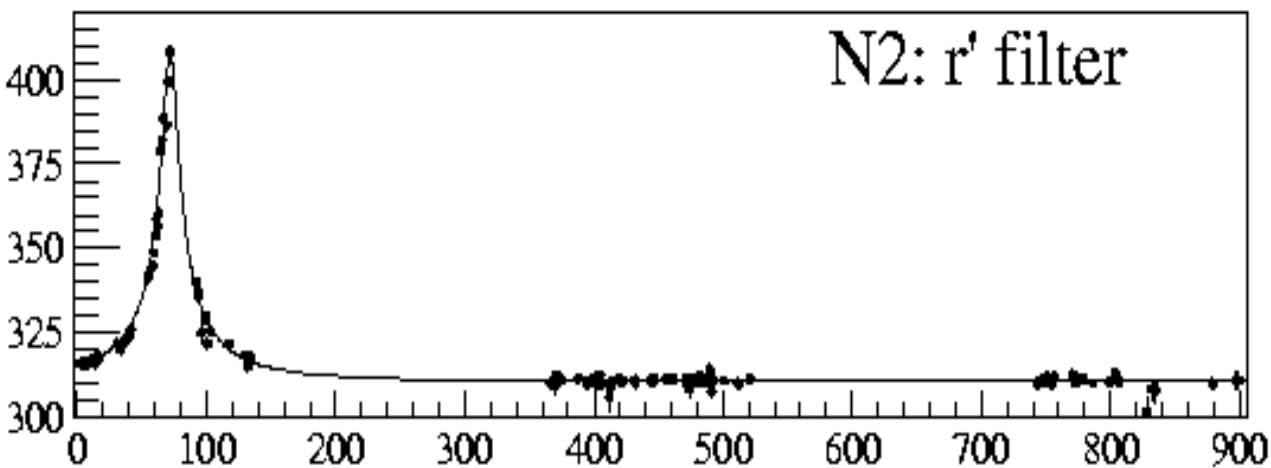
Timescale distribution



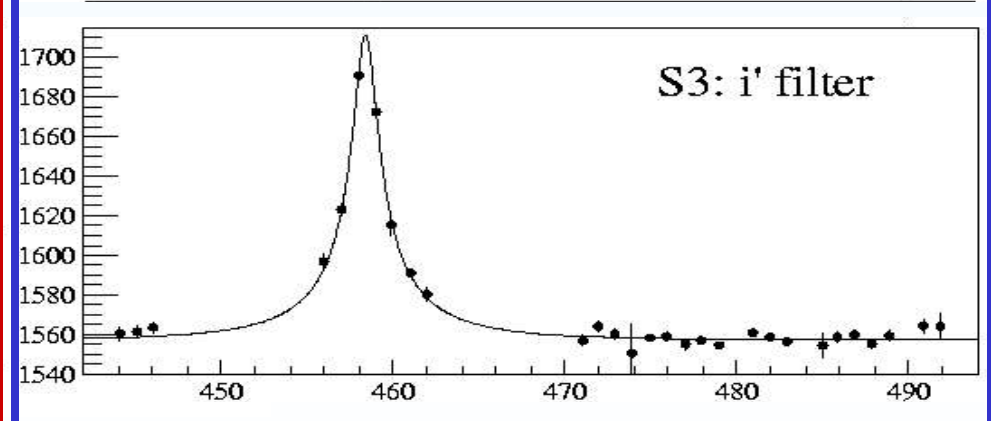
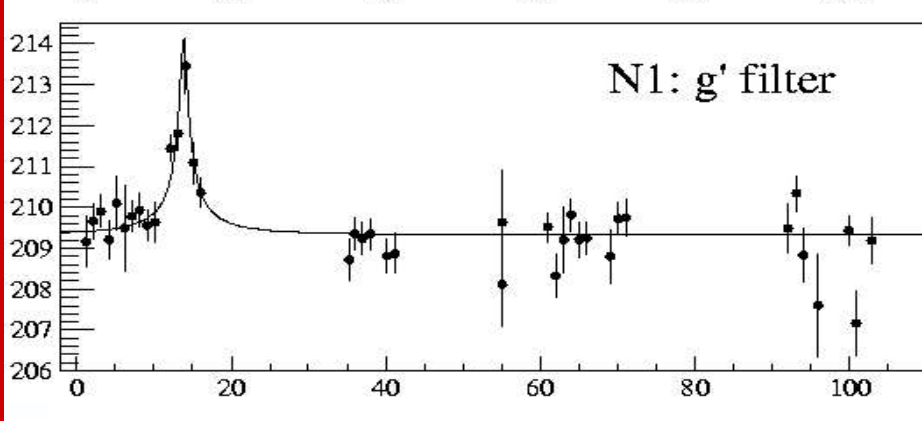
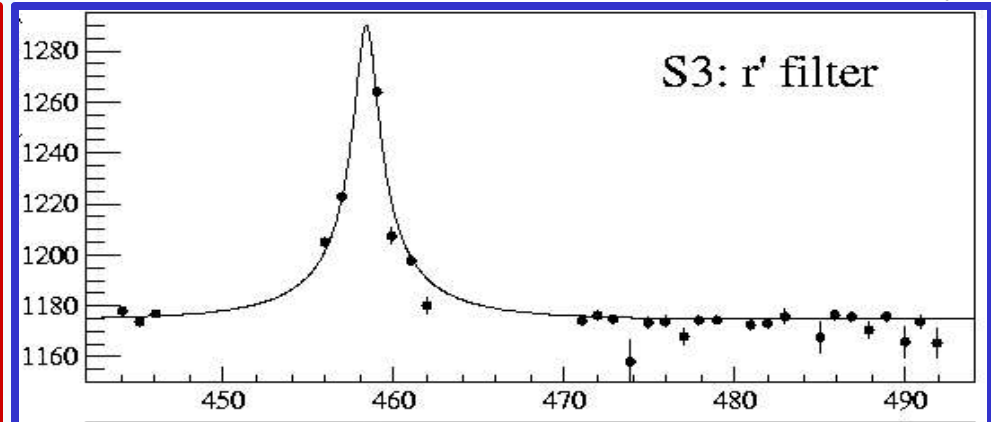
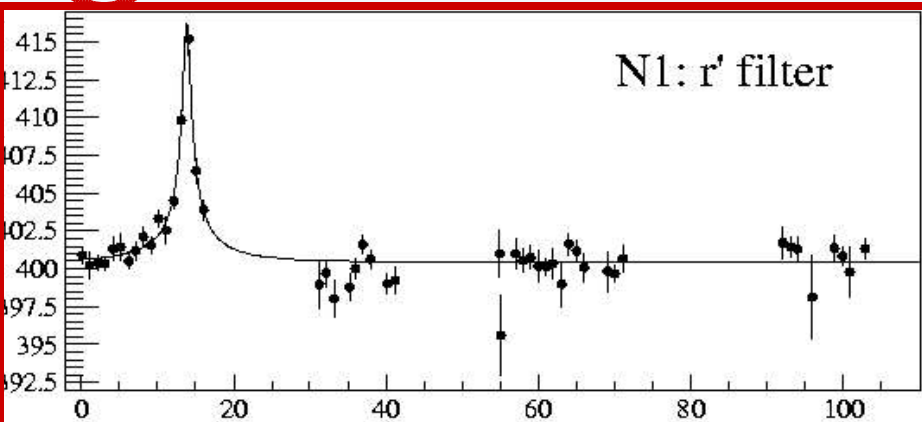
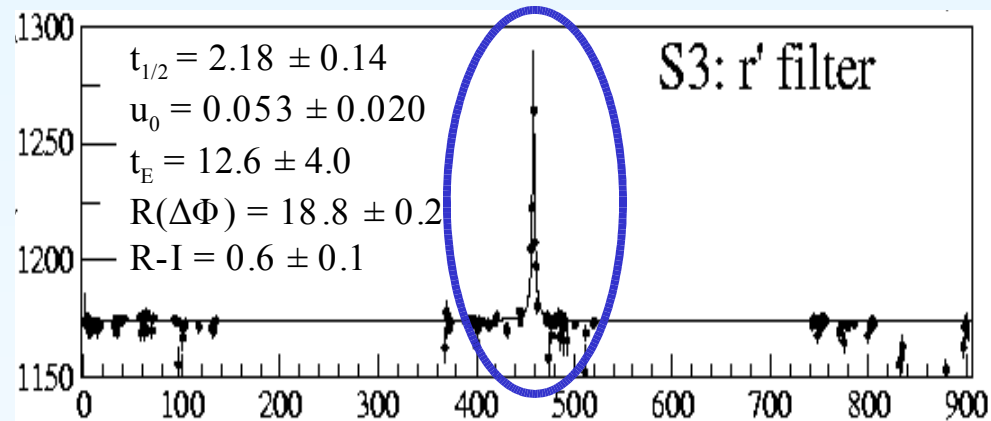
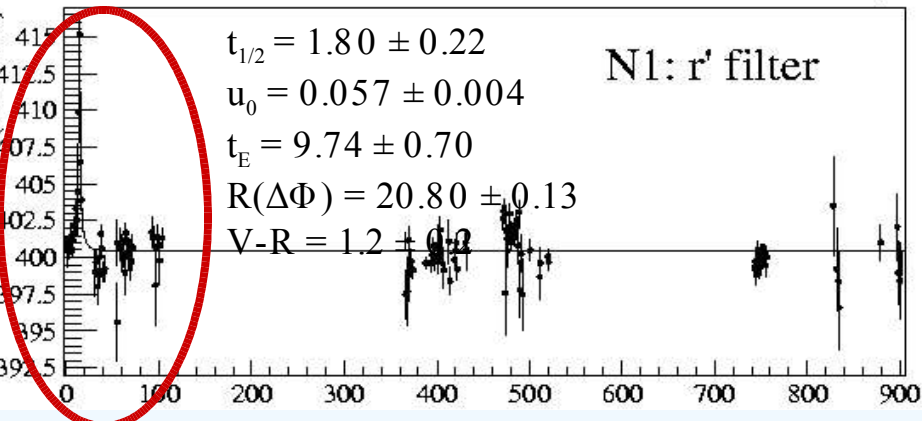
maximum Signal-to-Noise ratio for short events



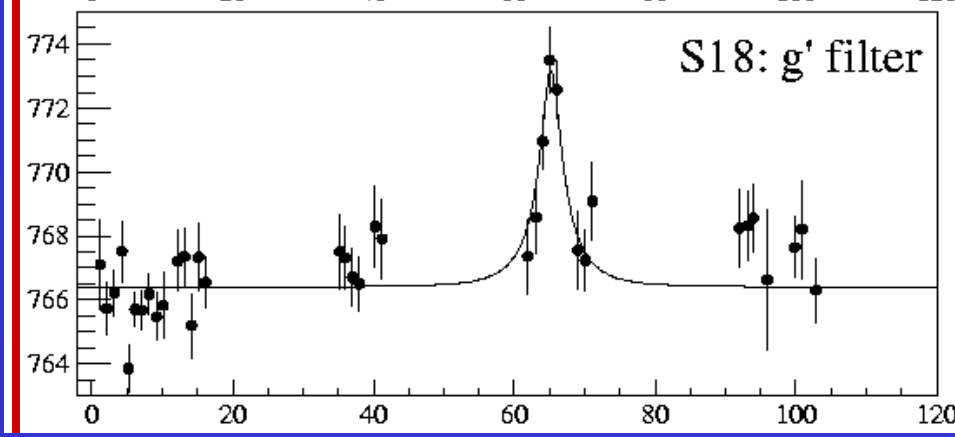
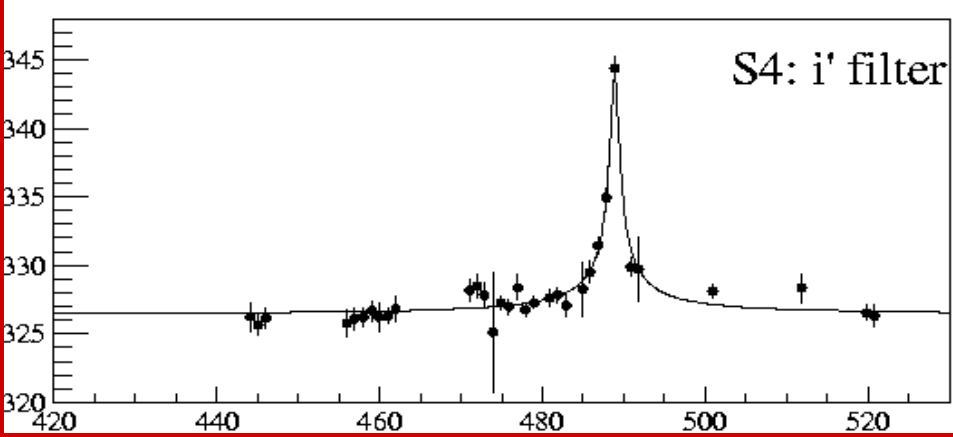
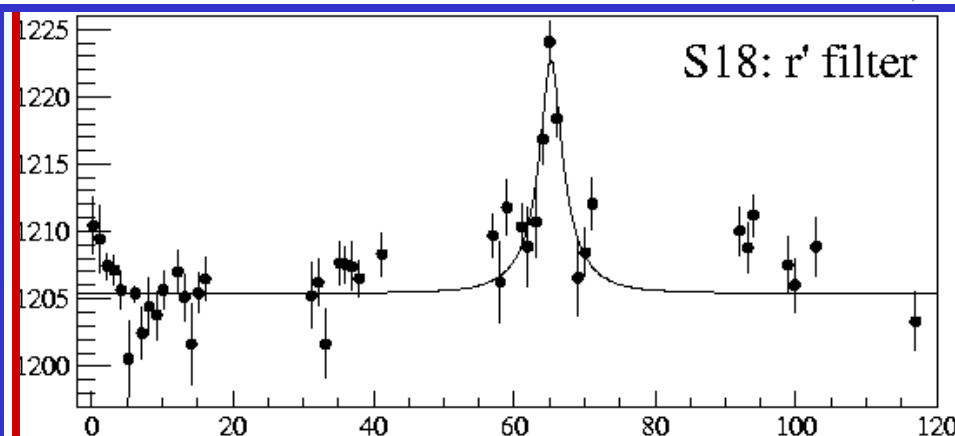
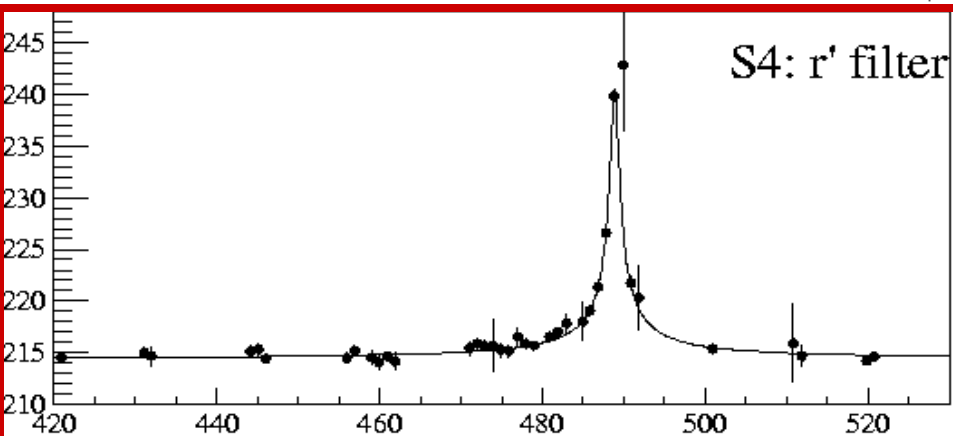
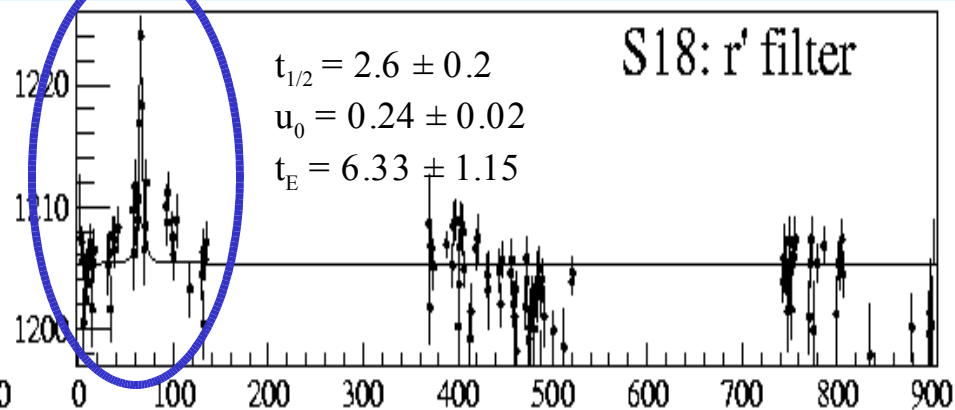
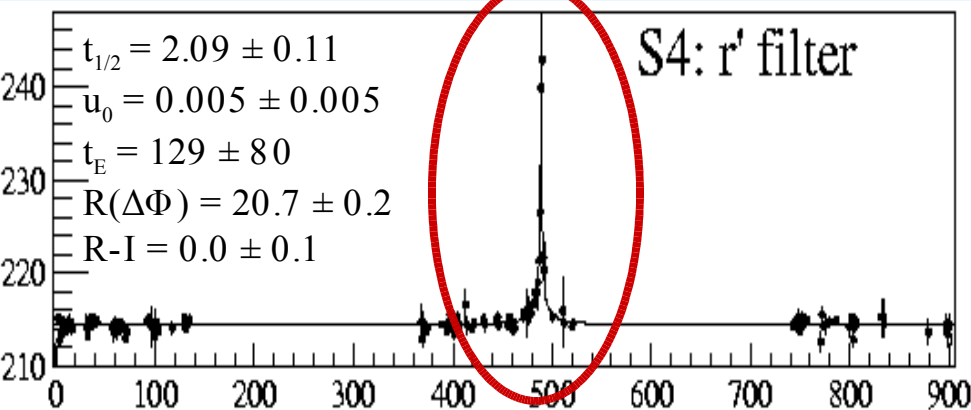
$$t_{1/2} = 21.75 \pm 0.20$$
$$u_0 = 0.075 \pm 0.004$$
$$t_E = 91.9 \pm 4.0$$
$$R(\Delta\Phi) = 19.0 \pm 0.2$$
$$V-R = 1.0 \pm 0.1$$

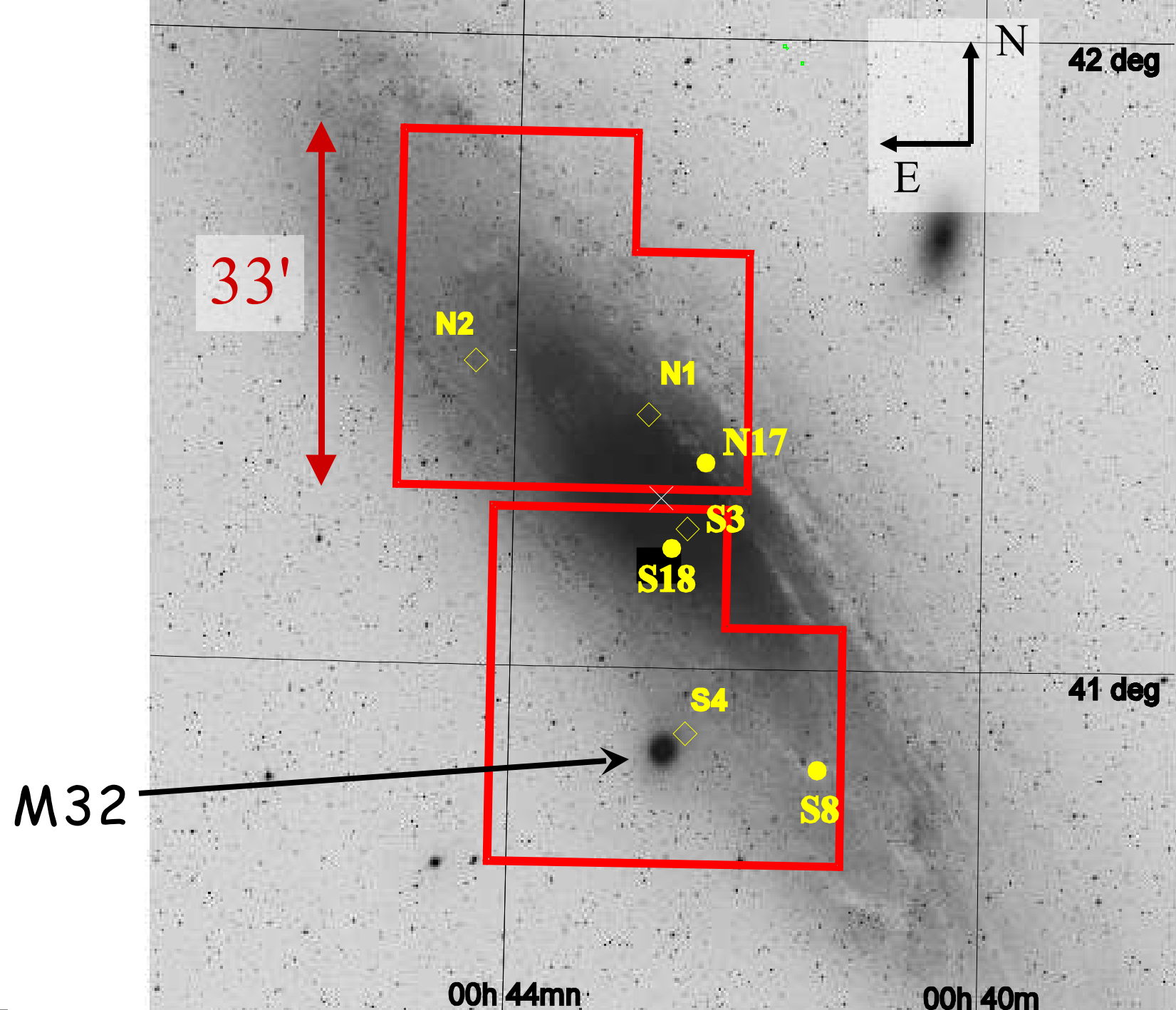


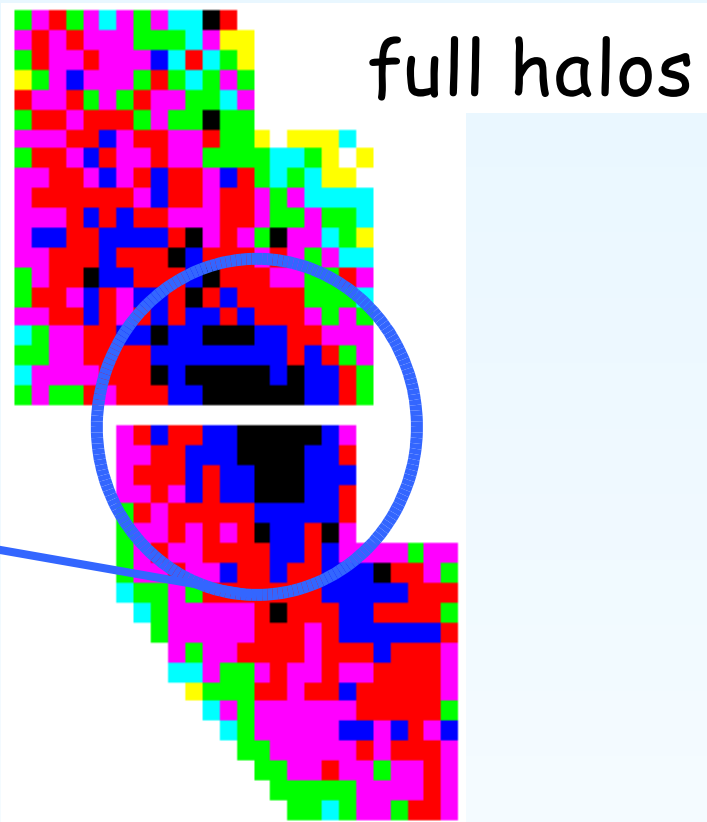
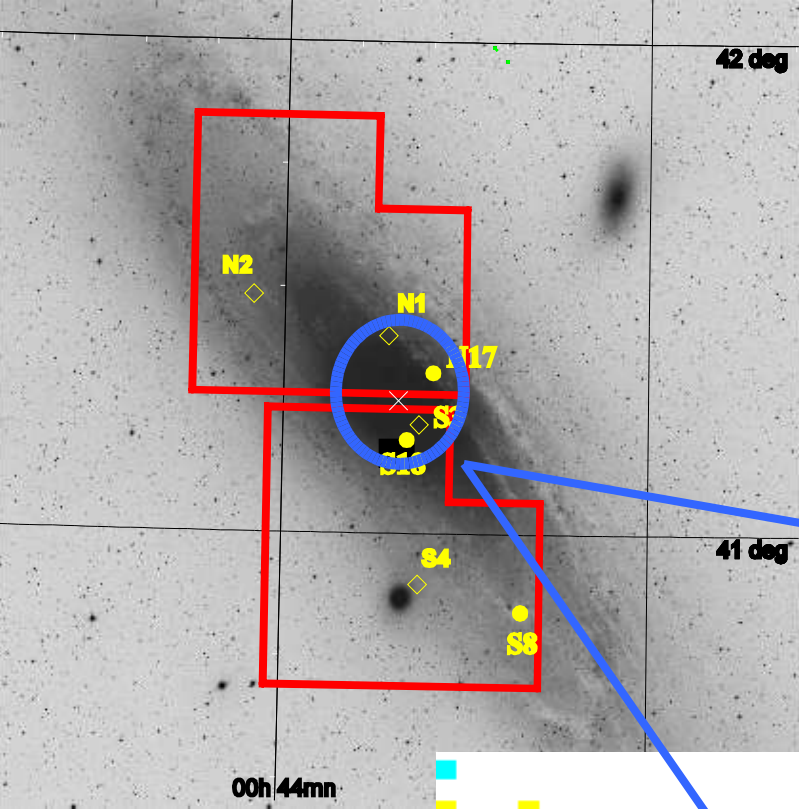
7 bright-short microlensing events



7 bright-short microlensing events







self-lensing only



Topics

1. Searching for MACHOs towards M31

→ The (POINT-)AGAPE experiment

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3. constraints on MACHOs

