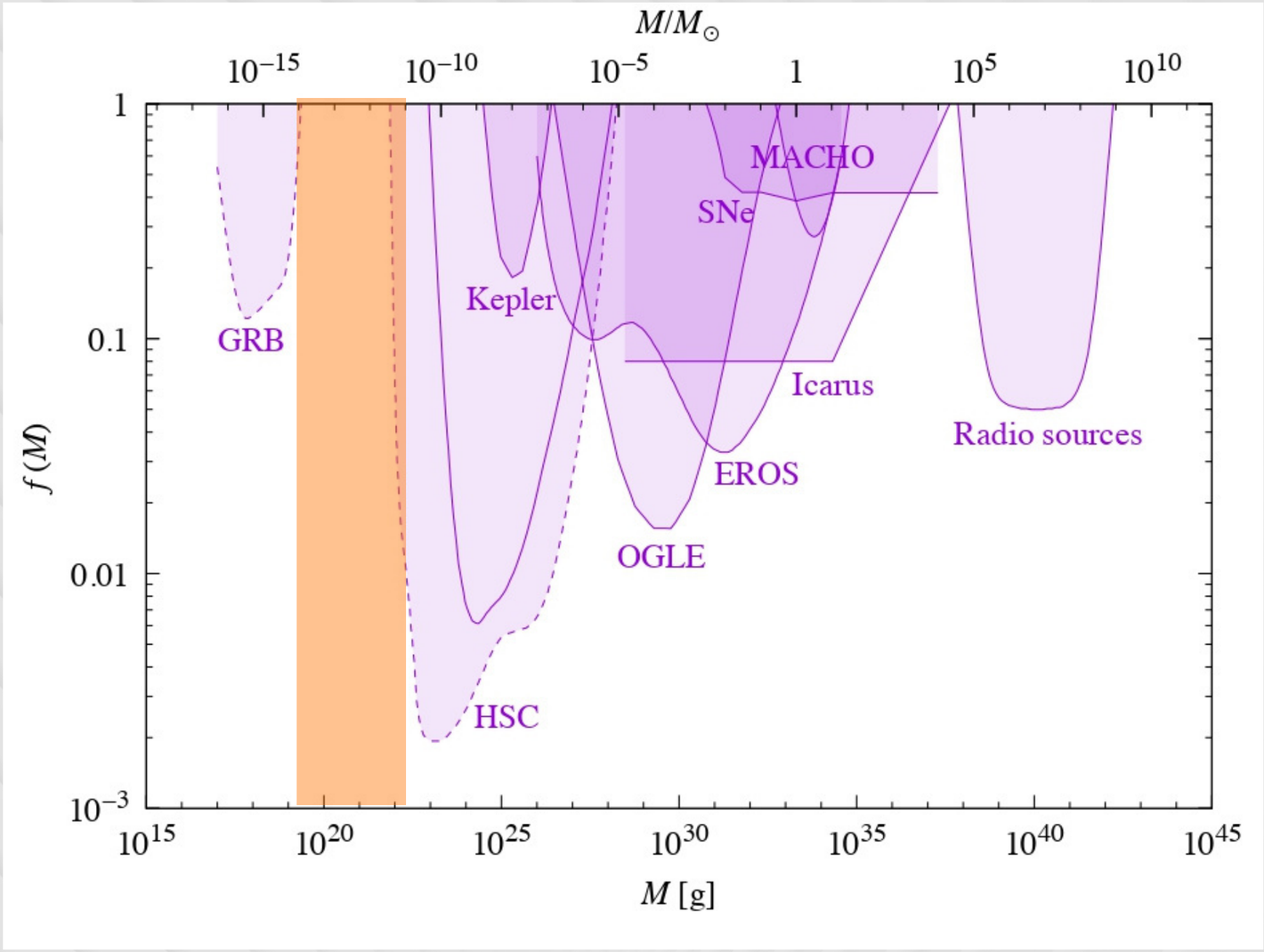
AMPM

Asteroid-Mass Primordial Black Hole Microlensing

Renee Key
Swinburne University of Technology, Melbourne Australia
with Ken Freeman, Alan Duffy, Edward Taylor

NEHOP, 2023



Carr & Kühnel, 2022

AMPM (DECam)

LMC (50kpc)

500,000+ stars

VR filter (626 nm)

40 hours

1 min cadence

HSC (2019)

M31 (781kpc)

15,571 stars

r-band (621 nm)

7 hours

2 min cadence

Niikura et al.
arXiv:1701.02151v3

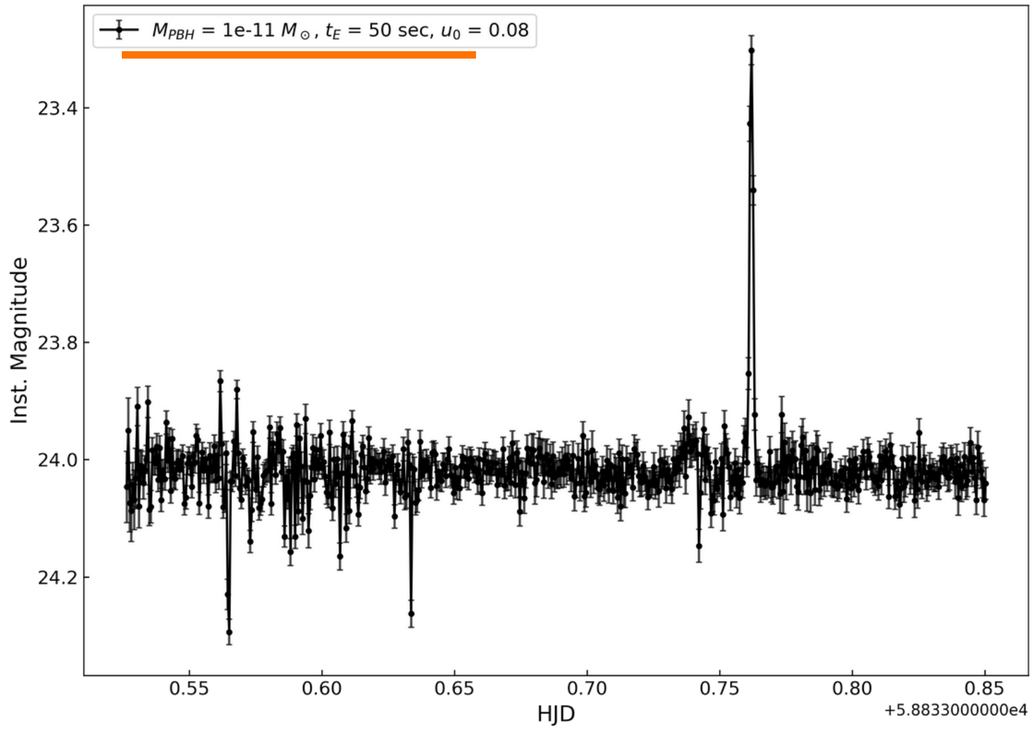
Point Source Point Lens (Paczynski, 1986)

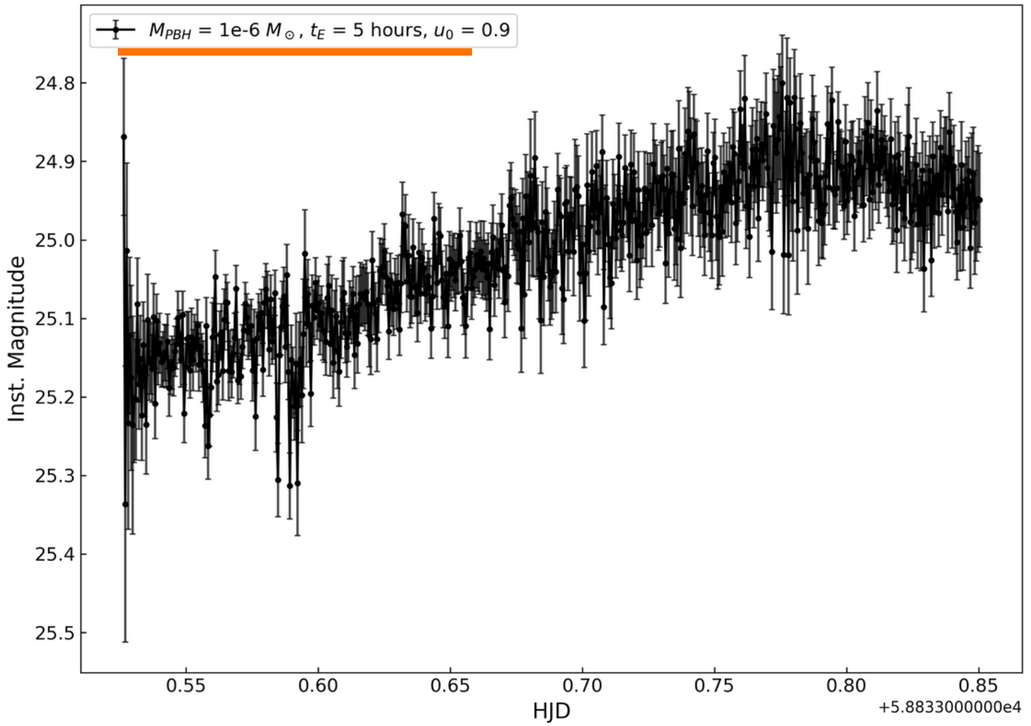
$$A(u(t)) = \frac{u^2+2}{u\sqrt{u^2+4}}$$

$$u(t) = \sqrt{\frac{(t-t_0)^2}{t_E^2} + u_0^2}$$

$t^E \sim \sqrt{M_{PBH}}$

u^0 = Lens-source plane proximity





Generated via MulensModel (Poleski et al. 2018)

Realm of the Micro Microlens

Low mass PBH = small lensing radius

comparable to angular radius of star

Finite Source Effects

M = $10^{-6} M_{\odot}$ or 10^{28} g

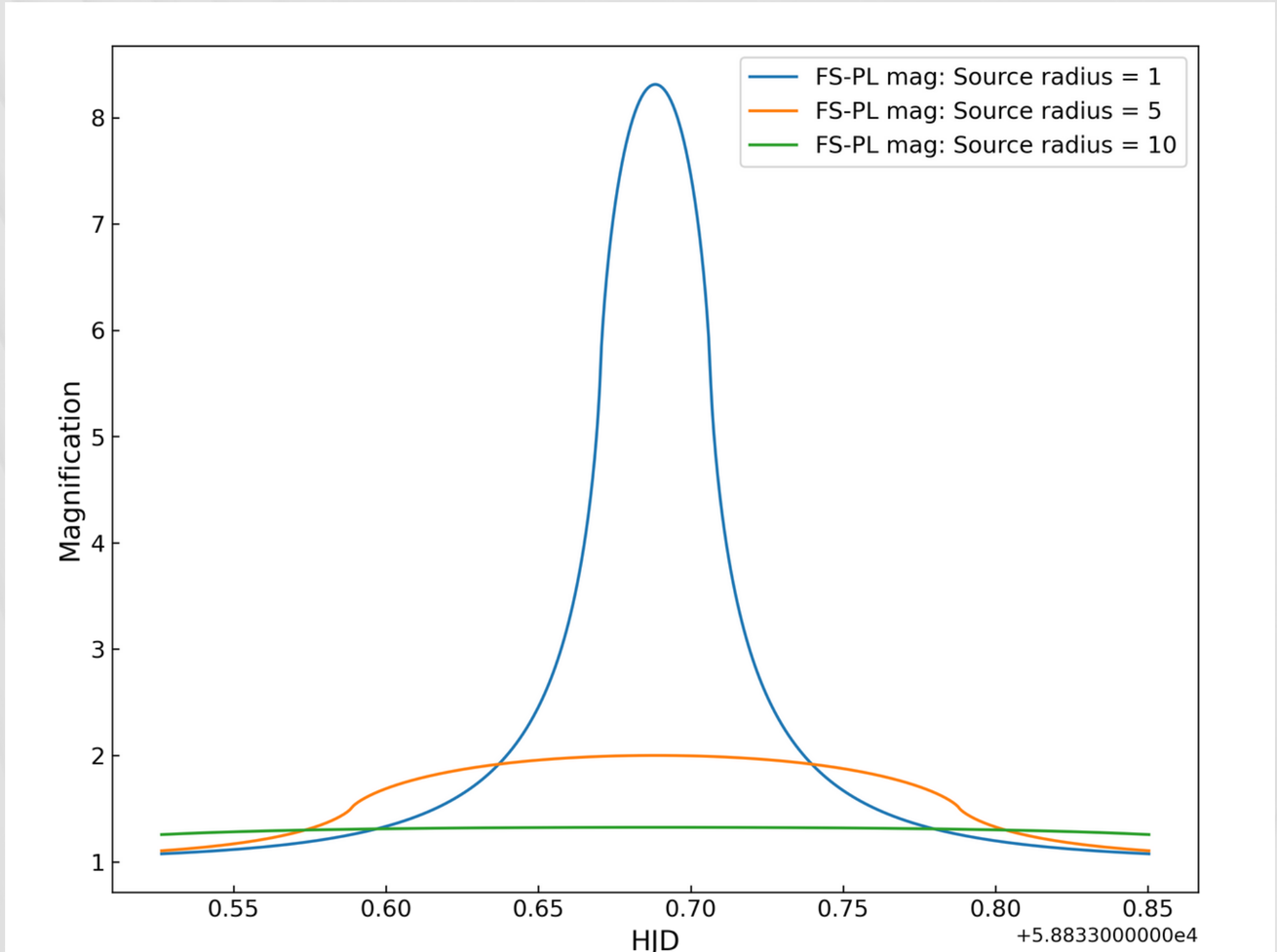
u^{0} = 0.1

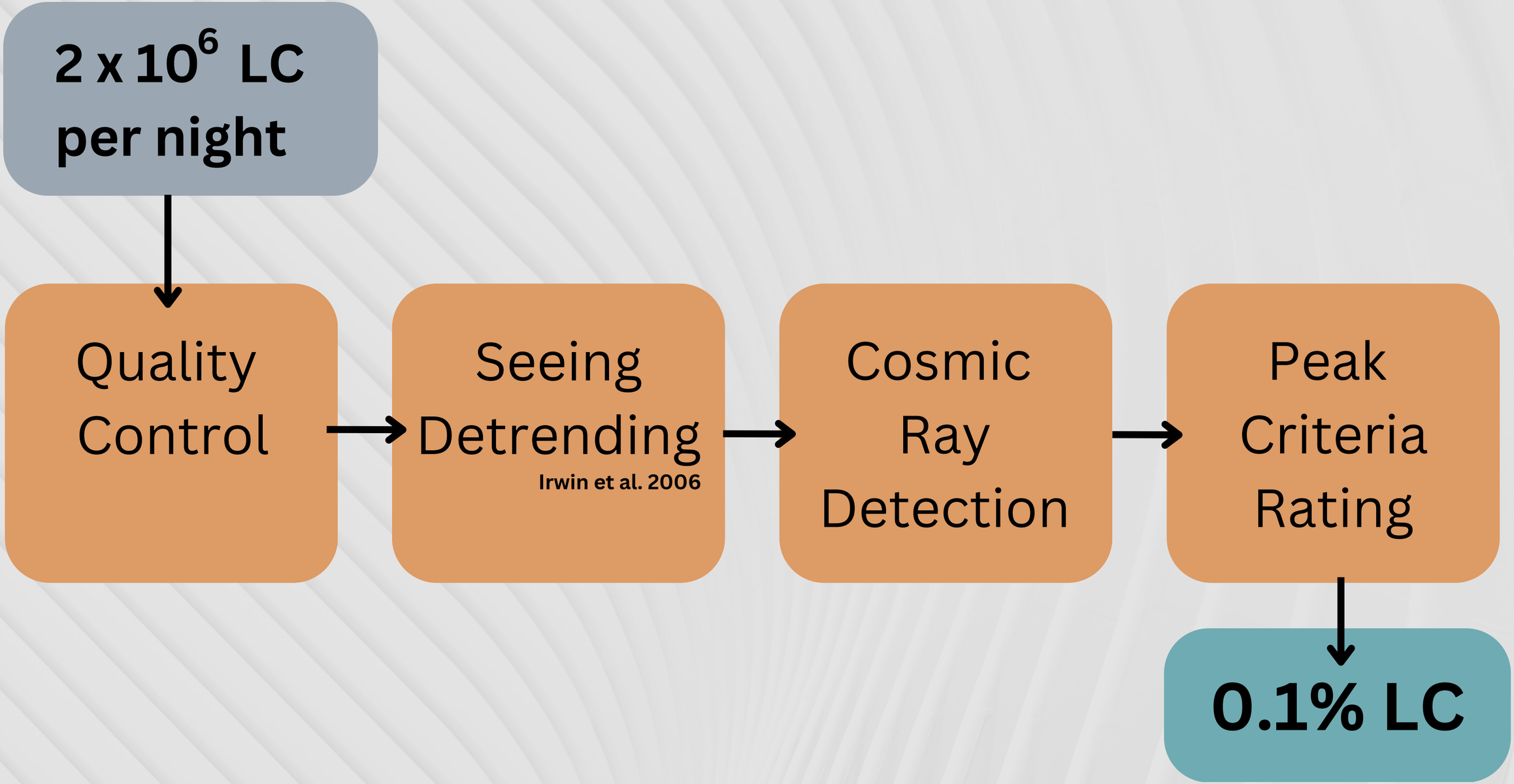
Lens dist. = 25 kpc

Lens vel. = 220 km/s

Source dist. = 50 kpc

Source pm = 1.7 mas/yr



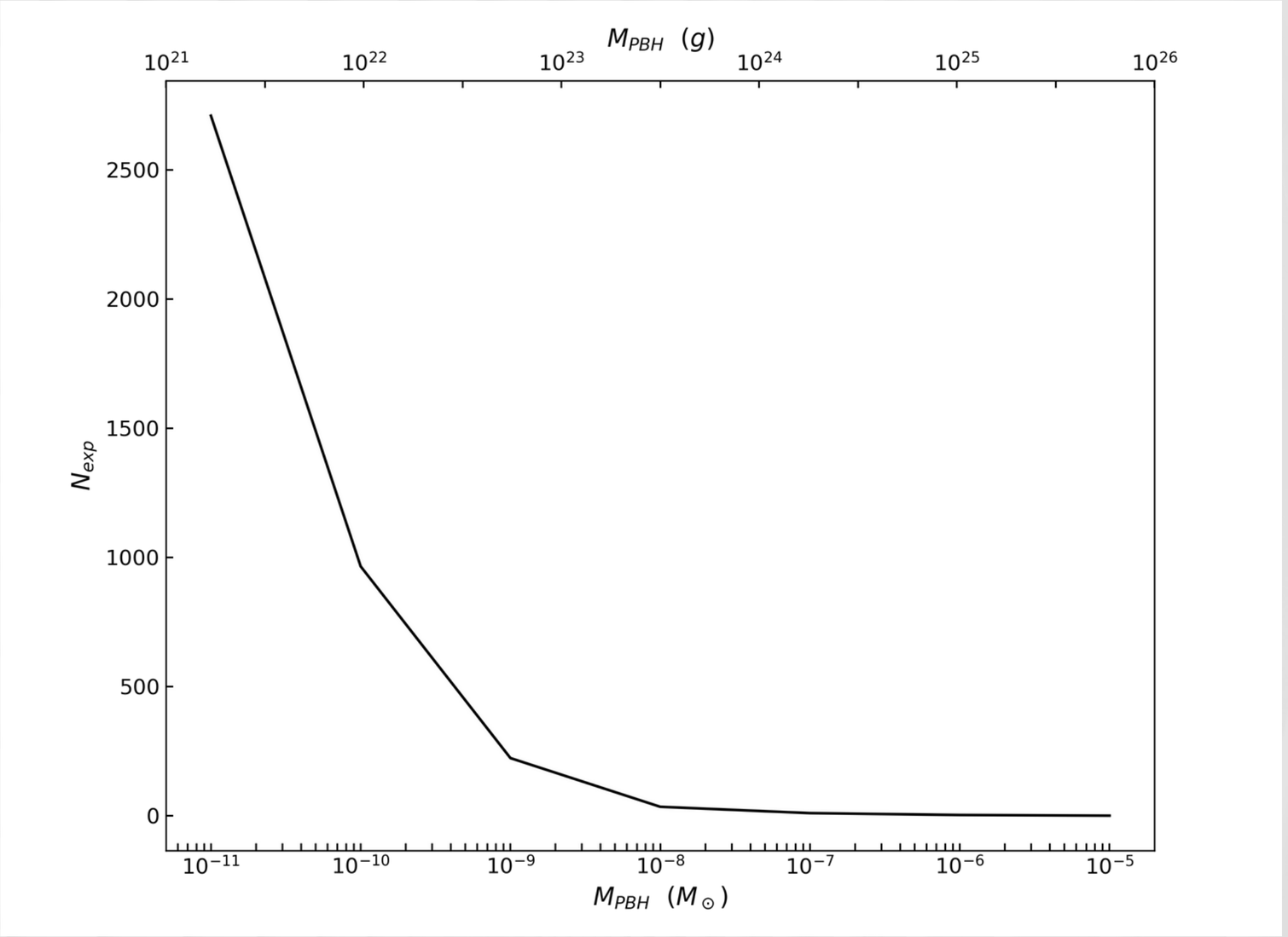

2 x 10^6 LC per night
Quality Control
Seeing Detrending
Irwin et al. 2006
Cosmic Ray Detection
Peak Criteria Rating
0.1% LC

Number of Expected Events

$$N_{exp} = N_{stars} N_{hours} \mathcal{E}(M) \; f \; P(M)$$

- Up for tuning/ realistic modelling

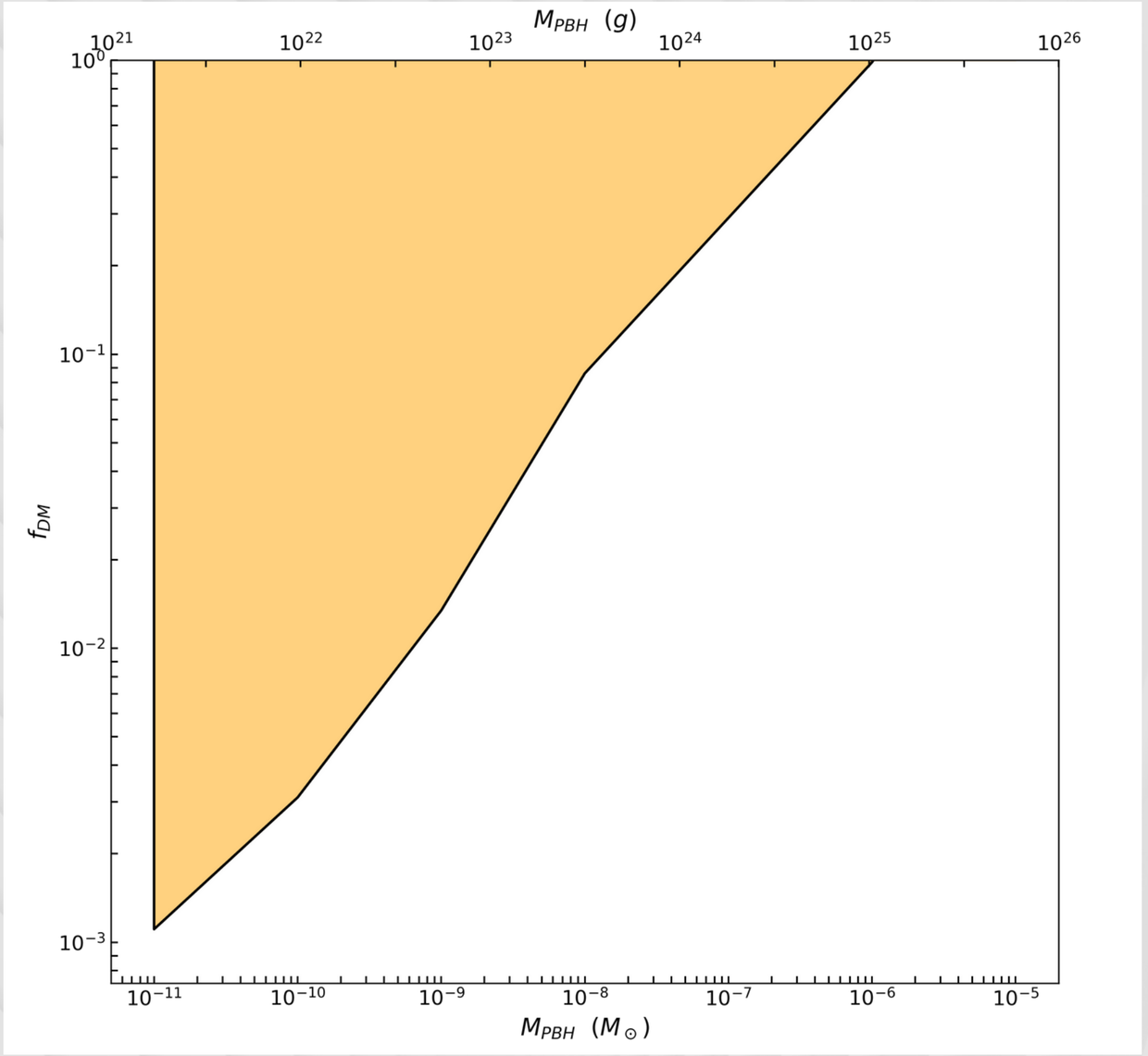
Halo Model	S Halo (Cored PITS, a = 5) (MACHO Model/ Freeman et al, 2019)
Mass Function	Monochromatic
Lens Velocities	Maxwellian (220 km/s)
Source/observer motion	Co-moving (vel = 0 km/s)
Stellar Radius	1 Rsol
Finite Radius Model	Constant stellar brightness
Total # Lens per mass	100,000 LC /1 million samples


M_{PBH} (g)
10^{21}
10^{22}
10^{23}
10^{24}
10^{25}
10^{26}
2500
2000
1500
1000
500
0
N_{exp}
10^{-11}
10^{-10}
10^{-9}
10^{-8}
10^{-7}
10^{-6}
10^{-5}
M_{PBH} $(M_\odot)$

No definitive microlenses in Night 1

but lots of interesting rapid transients!

Null detection for Night 1 (8 hours, 300,000 stars)



Toy Sim

What's Next

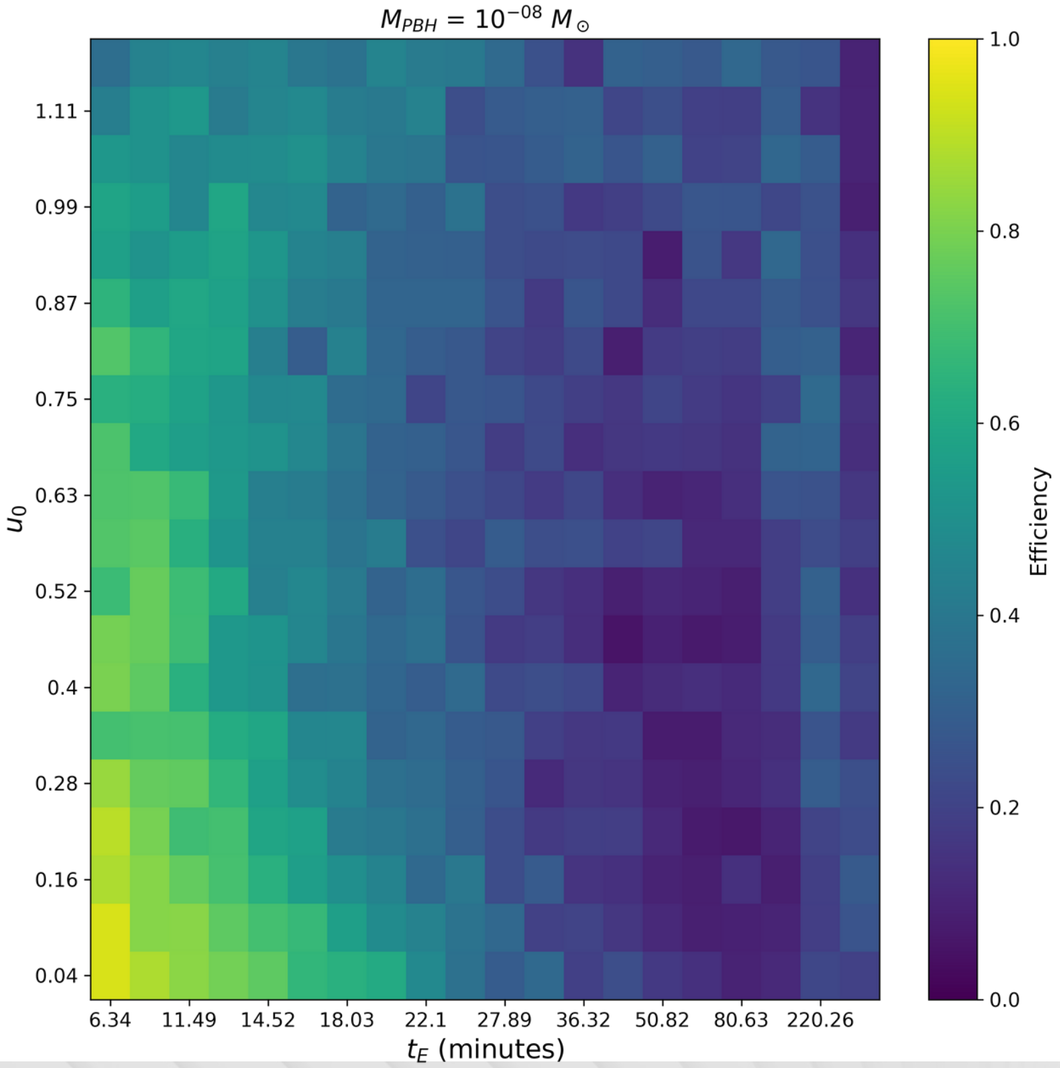
Detection and Limits for all 5 nights

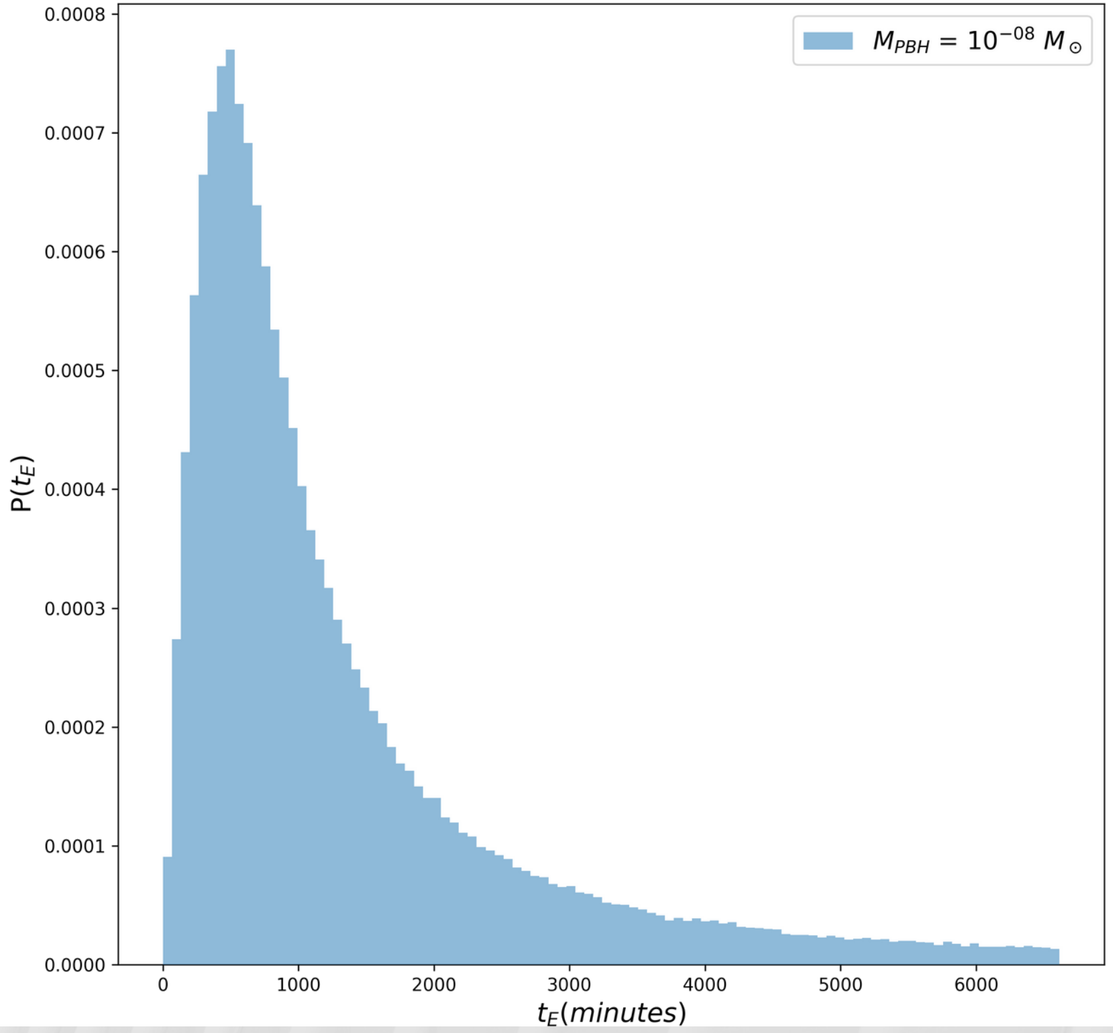
The full limits simulation (+ more lens sampling)

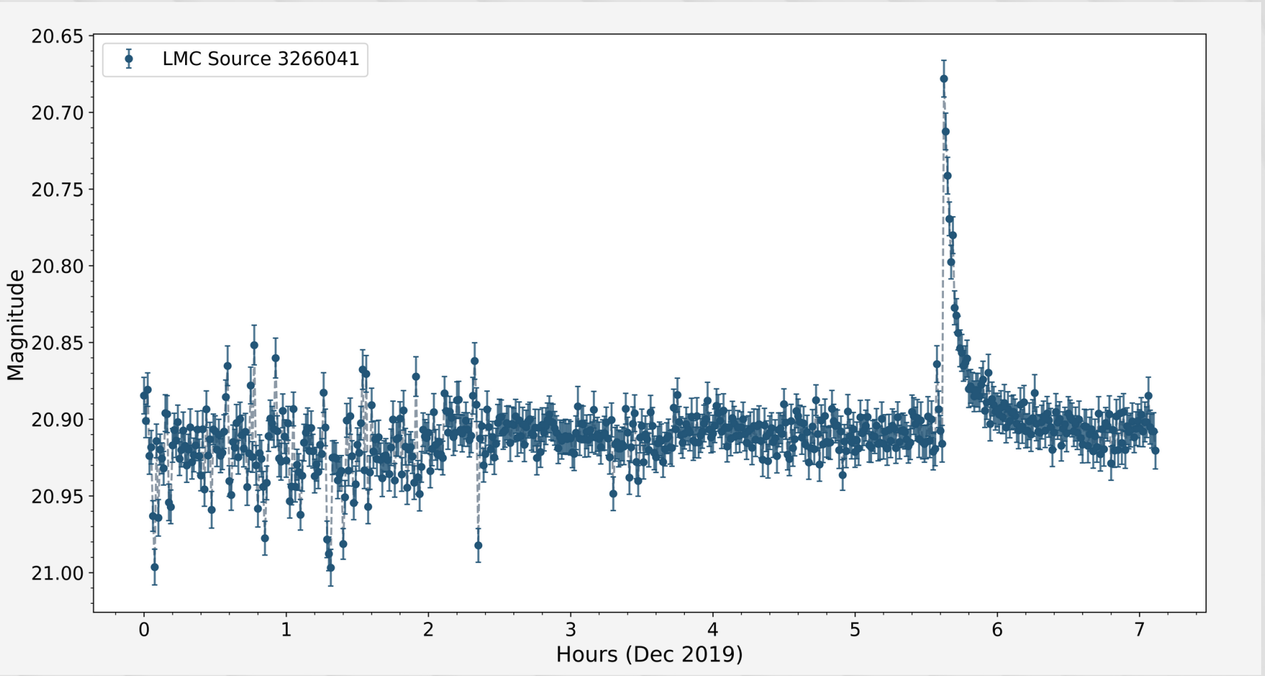
- Finite source effects for LMC sources (white dwarfs - Red Giants)
- Limb Darkening (!!)
- LMC transverse motions
- Wave optics for LMC demographics

$\mathcal{E}$(M)

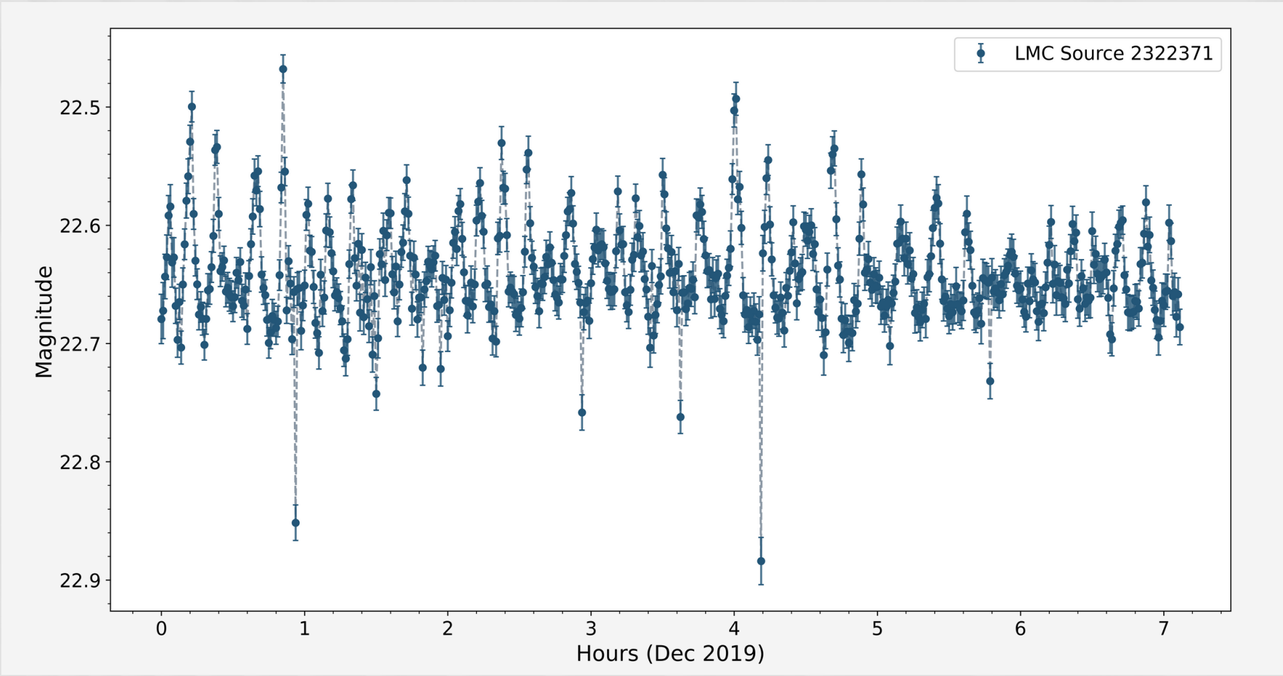
P(M)







A Solar Flare that explodes for less than 30 minutes



A pulsating White Dwarf in front of the LMC with period of 12 minutes