Have we detected Dark Matter?

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Image: LIGO collaboration

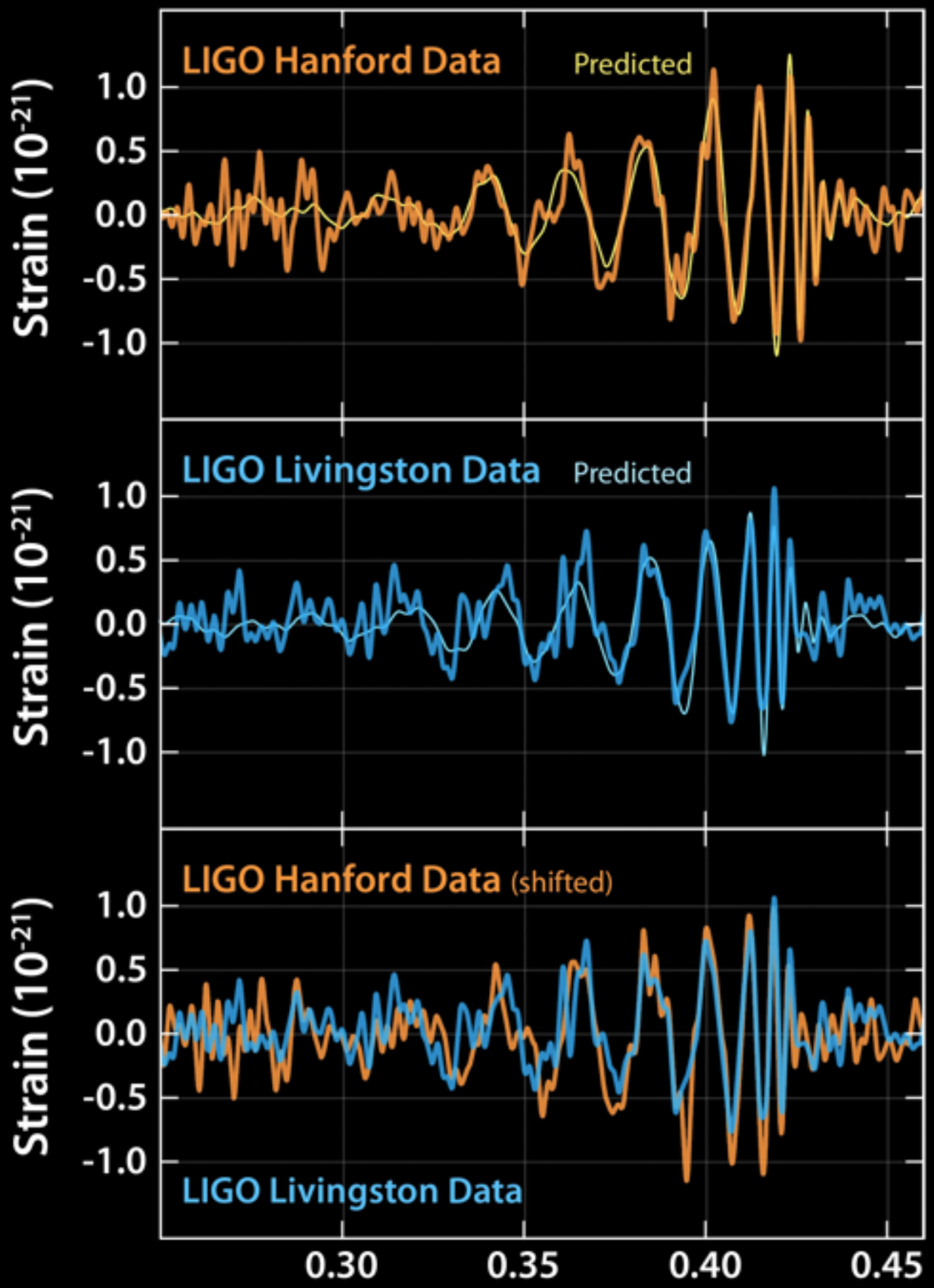
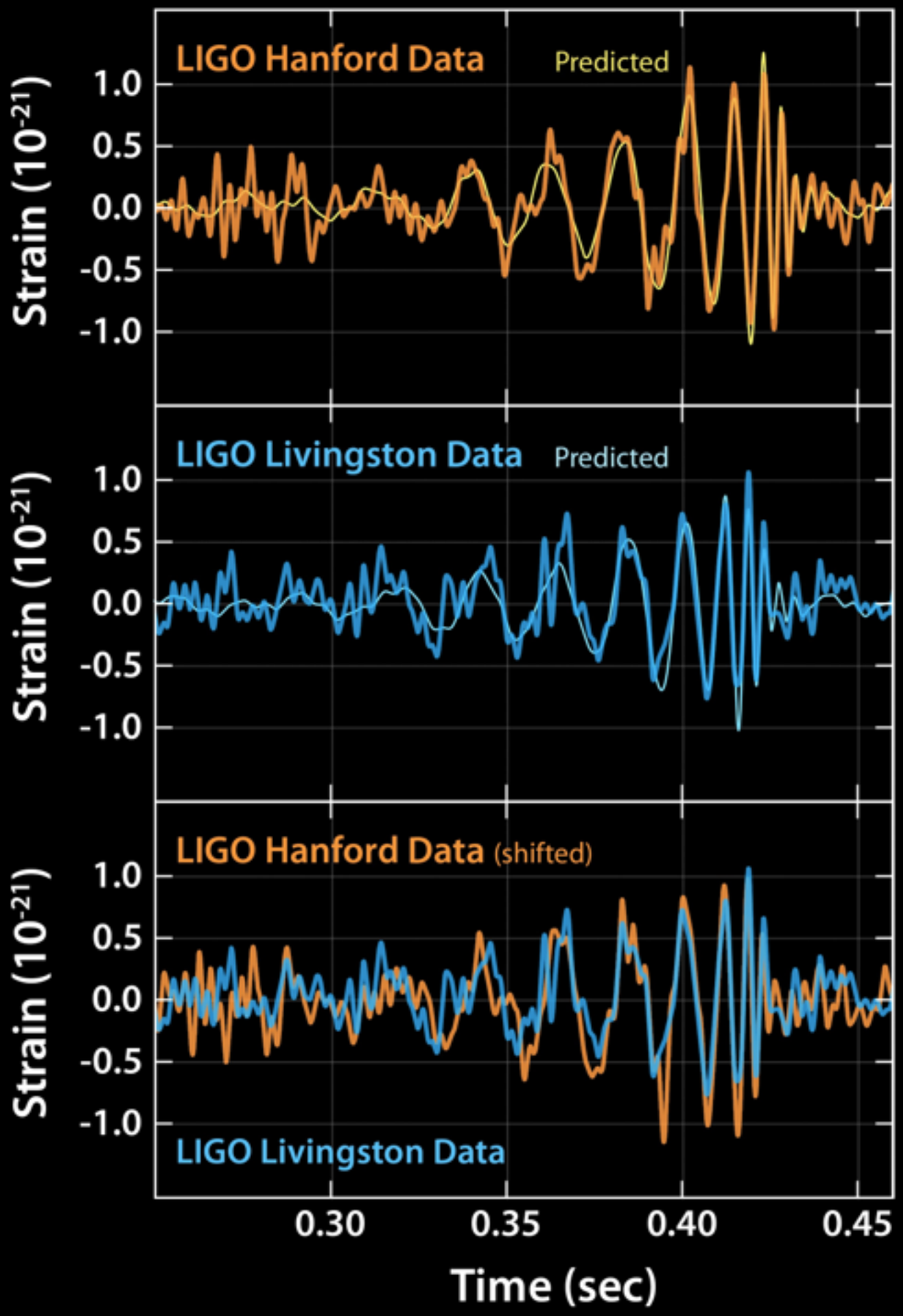


Image: LIGO collaboration



$$z = 0.09$$

$$\mathcal{R} = 2 - 53\,\mathrm{Gpc}^{-3}\mathrm{yr}^{-1}$$

$$30 - 35 M_\odot$$

Bird et al. arXiv:1603.00464

If Dark matter is PBHs of ~30$M_\odot$

arXiv:1603.00464

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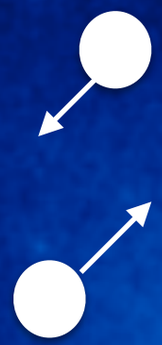


arXiv:1603.00464

If Dark matter is PBHs of ~30$M_\odot$

$$\sigma \propto v_{\rm rel}^{-18/7} M_{\rm pbh}^2$$

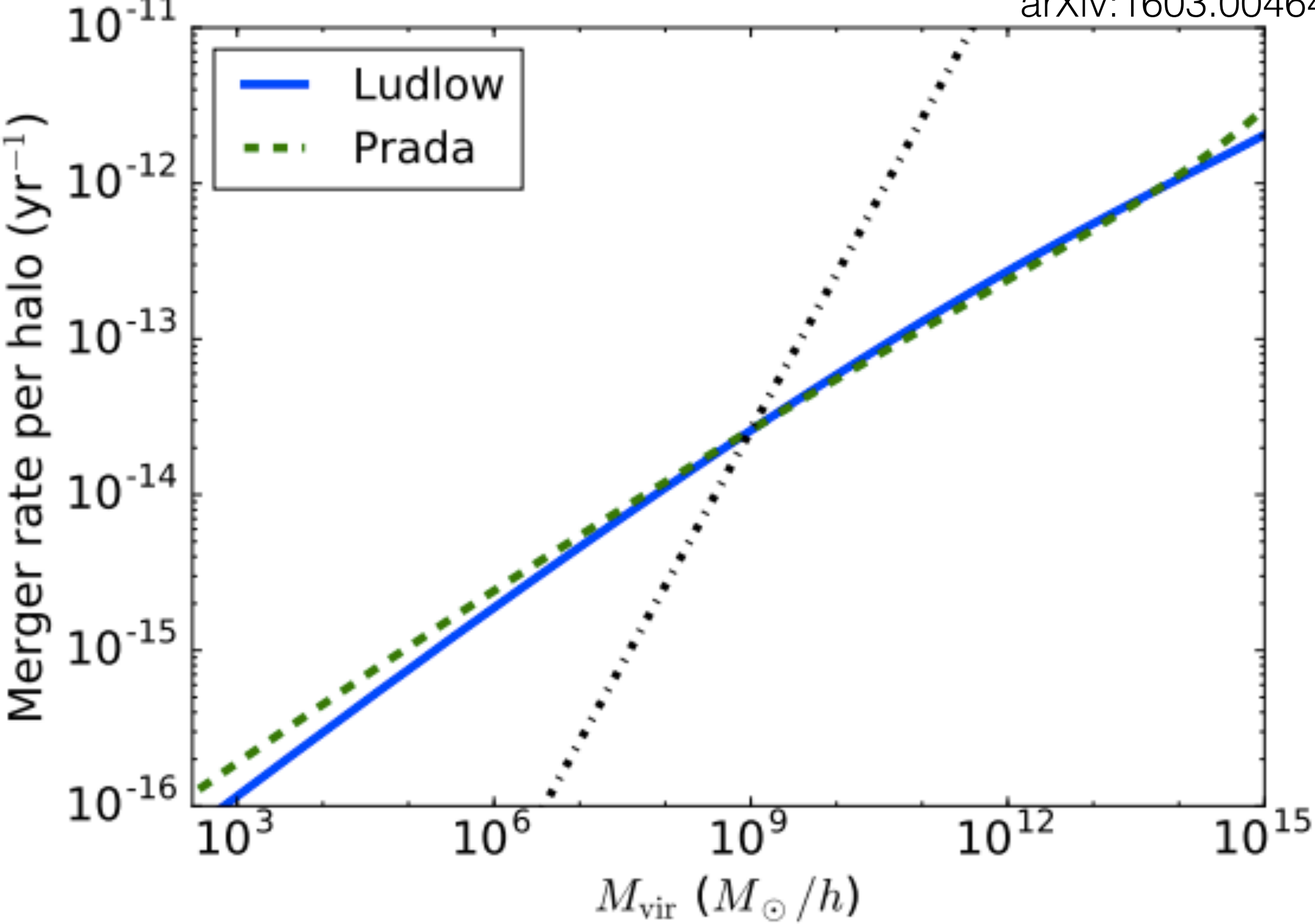
arXiv:1603.00464

Number of events per halo:

$$\sigma \propto v_{\rm rel}^{-18/7} M_{\rm pbh}^2$$

$$\Gamma_{\rm halo} \propto \int {\rm d}^3 r \frac{\rho_{\rm NFW}^2}{M_{\rm pbh}^2} \langle \sigma v \rangle$$

arXiv:1603.00464



arXiv:1603.00464

More events at lower halo masses

More concentrated
Lower velocities

$$\sigma \propto v_{\rm rel}^{-18/7} M_{\rm pbh}^2$$

arXiv:1603.00464

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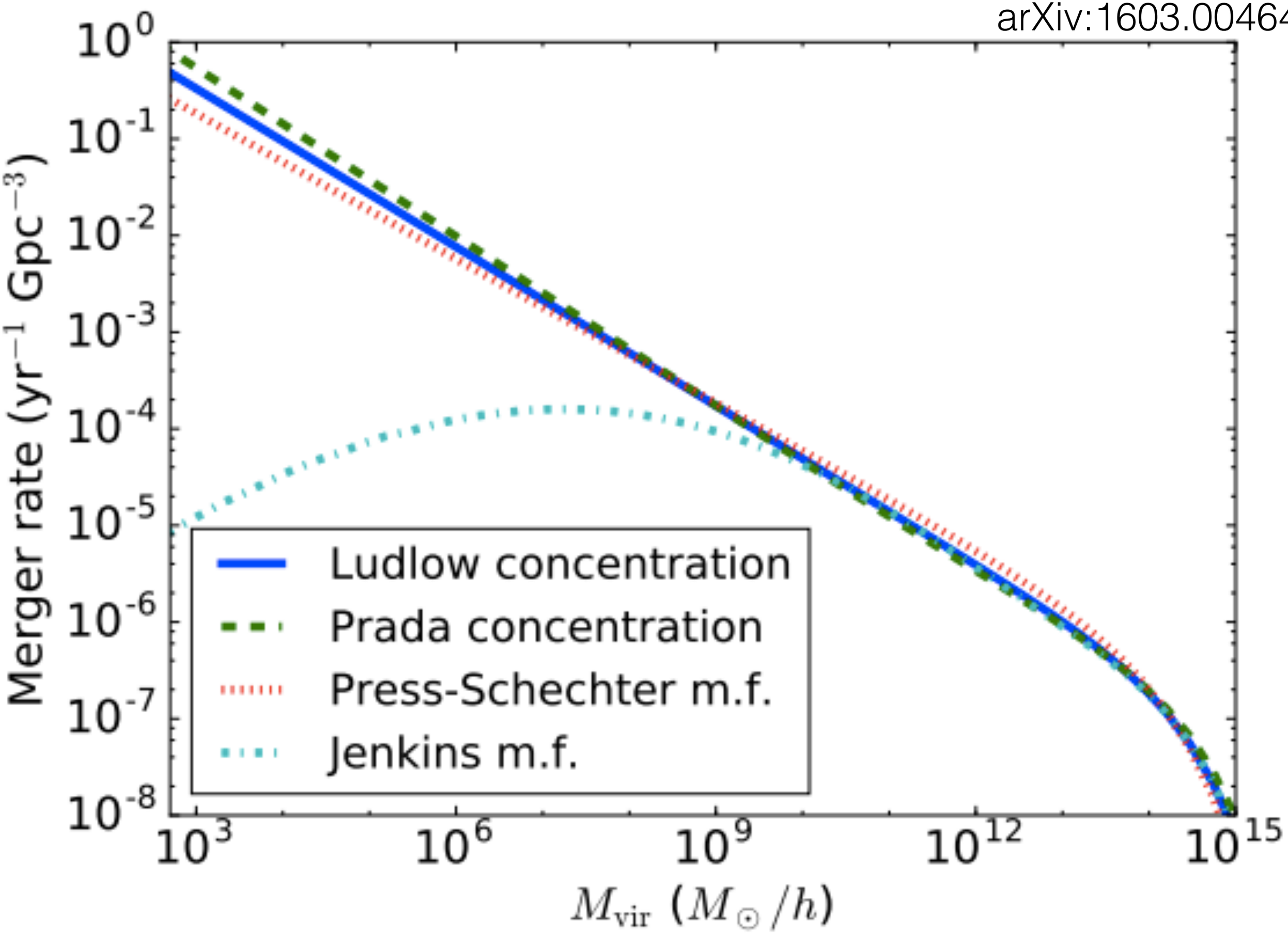
We convolve with a halo mass function

arXiv:1603.00464



arXiv:1603.00464

More events at lower halo masses

More concentrated
Lower velocities

$$\sigma \propto v_{\rm rel}^{-18/7} M_{\rm pbh}^2$$

We cut off at halos of $400\,M_\odot$
Lower-mass halos would evaporate

arXiv:1603.00464

So integrating the rate:

$$\mathcal{R} = 2 - 30\,\mathrm{Gpc}^{-3}\mathrm{yr}^{-1}$$

To be compared with LIGO:

$$\mathcal{R} = 2 - 53\,\mathrm{Gpc}^{-3}\mathrm{yr}^{-1}$$

So it actually is consistent!

Any way to confirm this?

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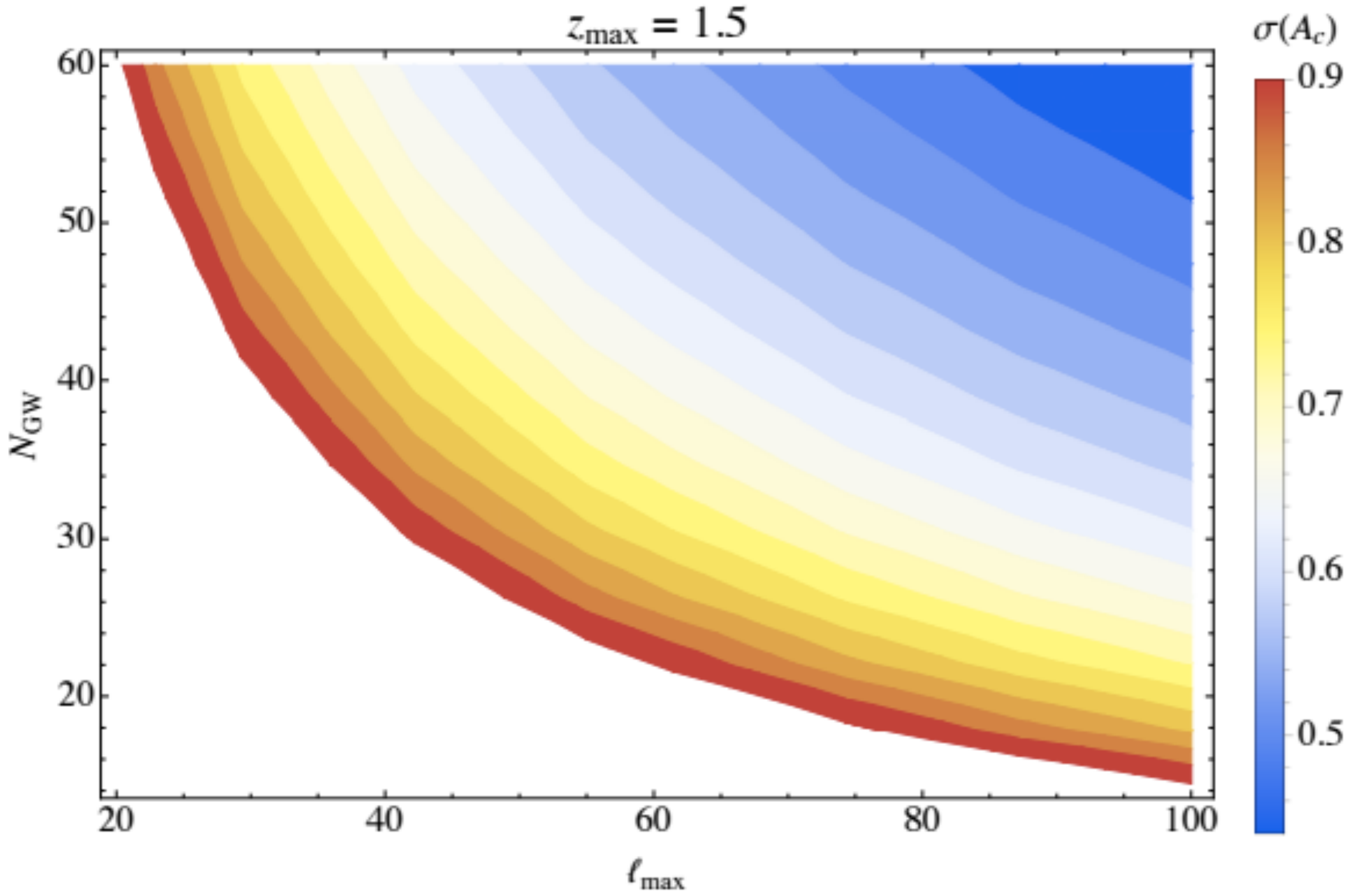
-GW events would be distributed as small halos

$b_{\rm SFG} \sim 1.4$

$b_{\rm pbhGW} \sim 0.5$

Raccanelli et al. arXiv: 1605.01405

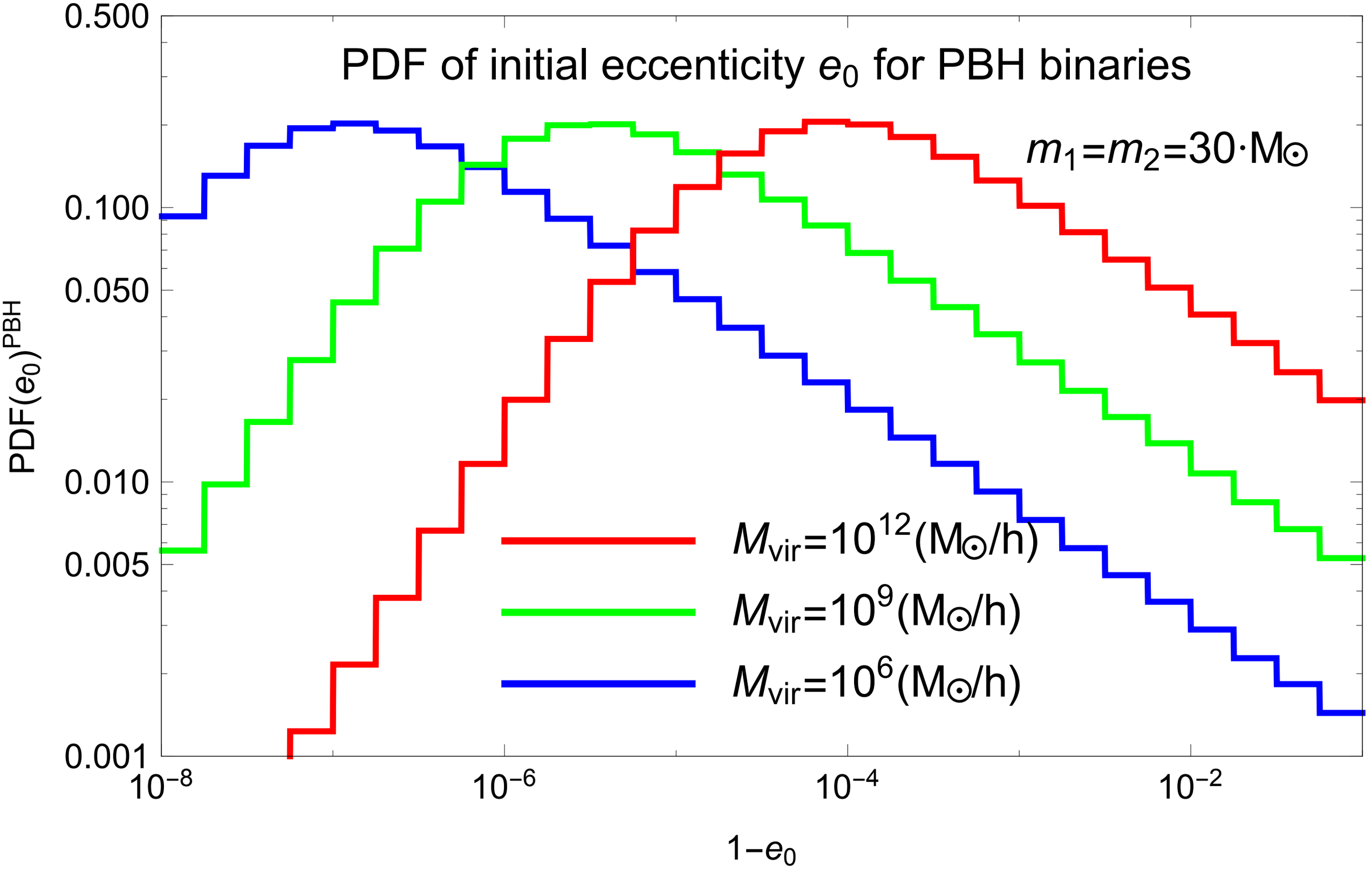


Any way to confirm this?

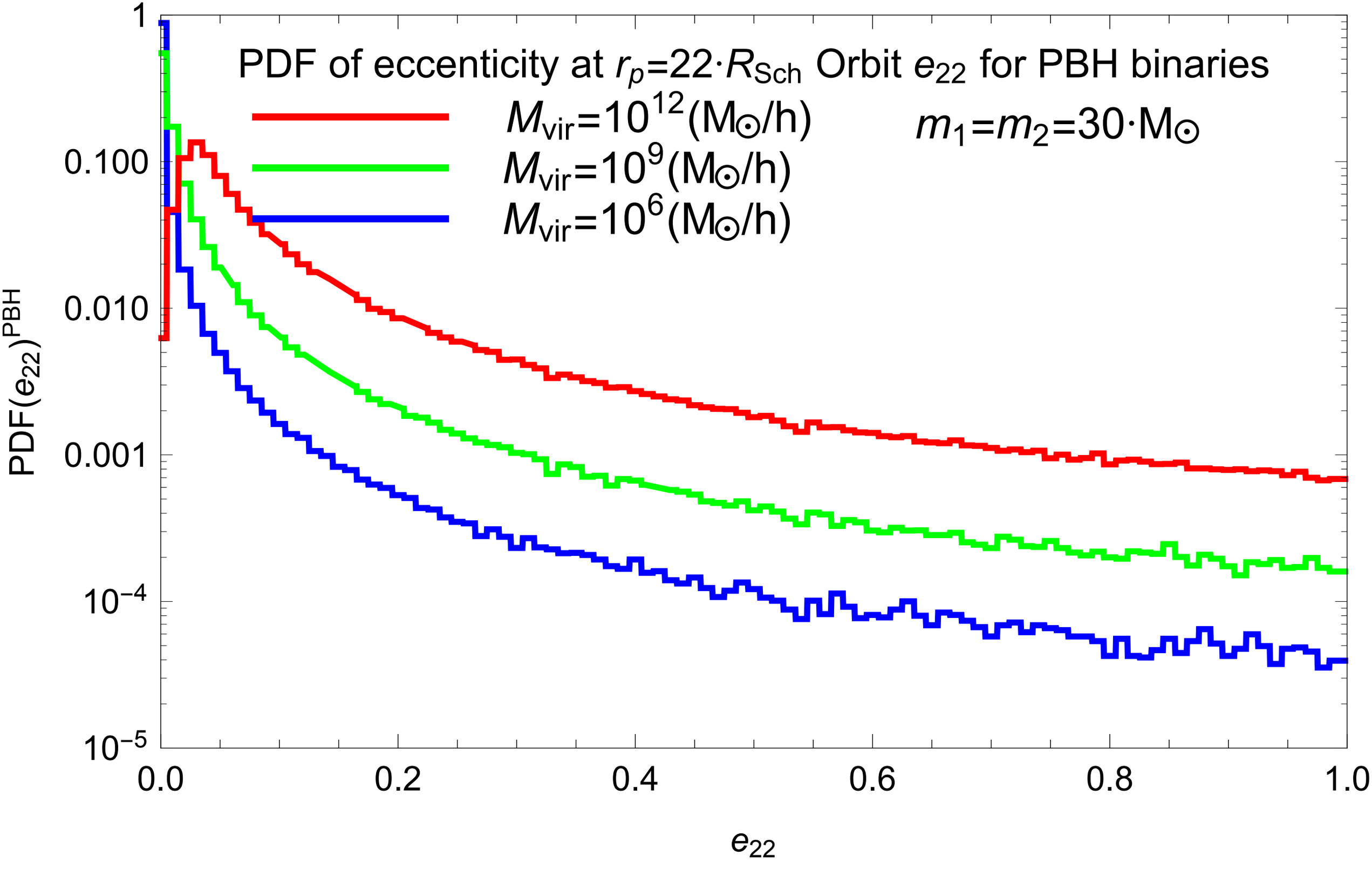
-GW events would be distributed as small halos

- The observed GWs may contain eccentricity

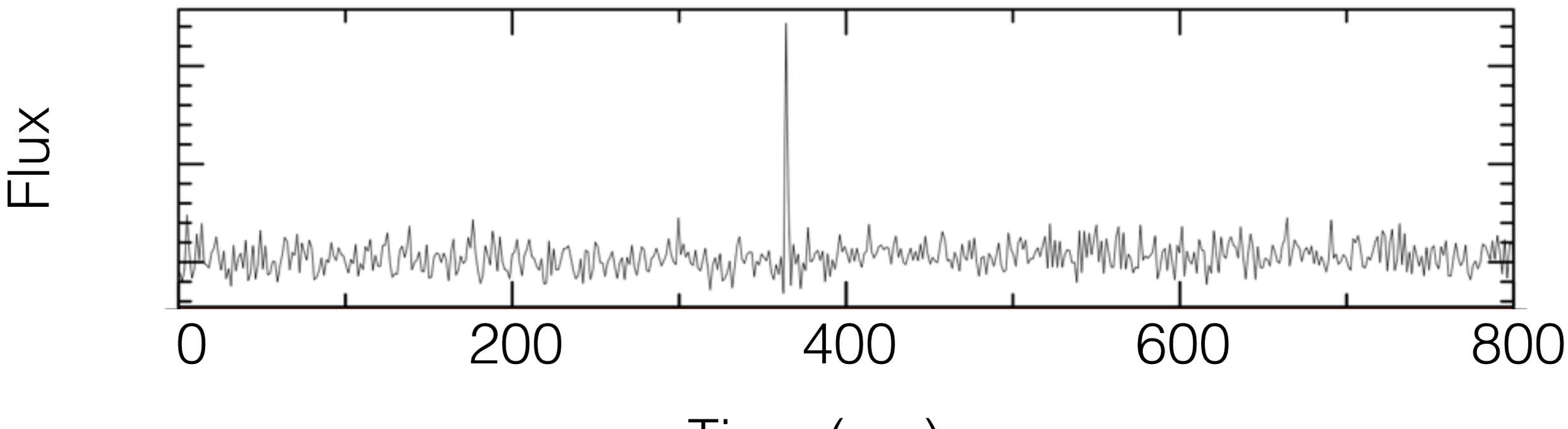
Cholis et al. In prep.



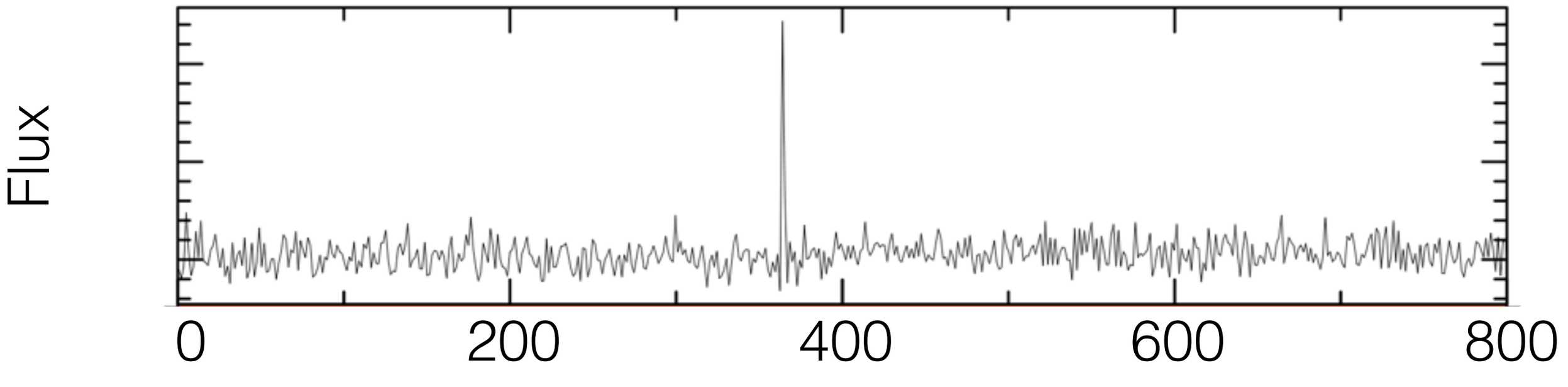
Cholis et al. In prep.



Any (other) way to confirm this?



Any (other) way to confirm this?

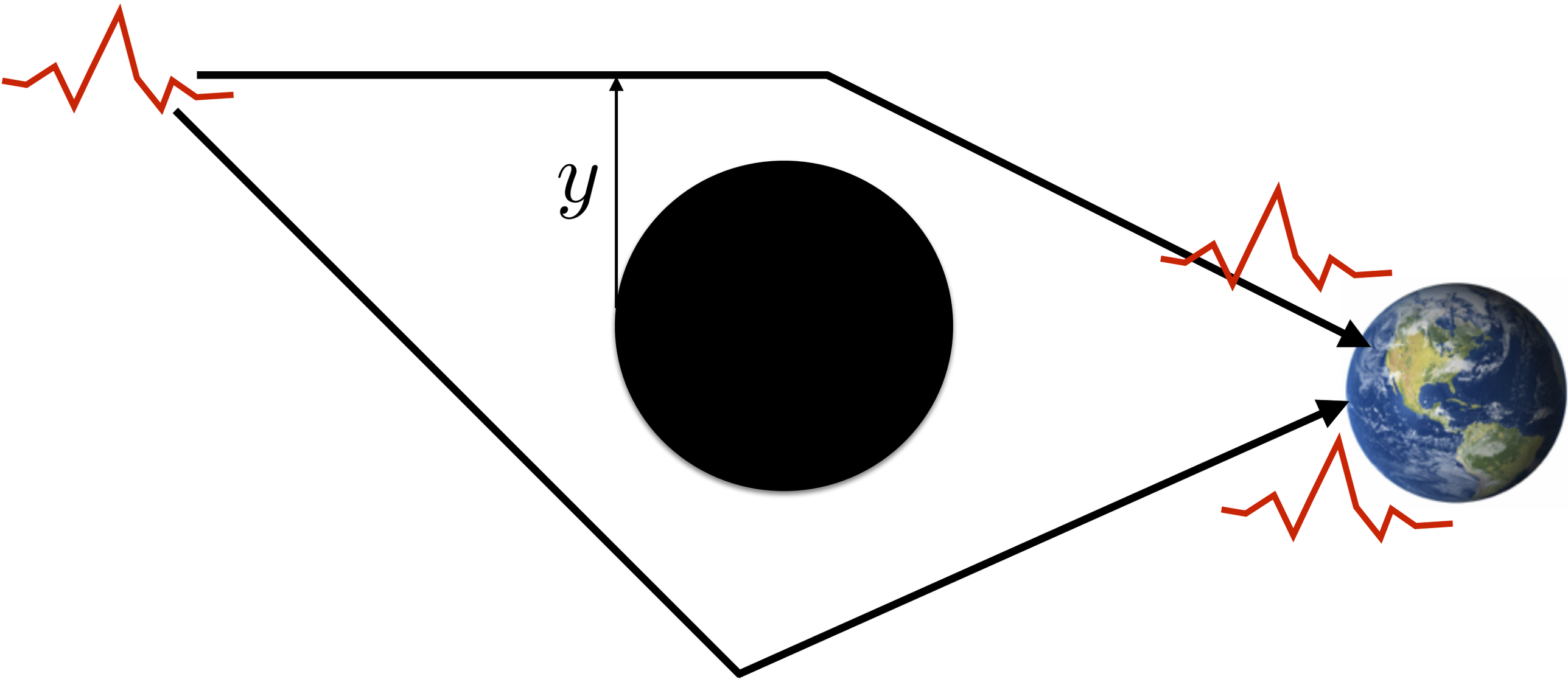


Fast ~ms long

Radio ~1 GHz

Bursts D~1 Gpc

(Gravitational) Lensing of FRBs!



Munoz et al. arXiv:1605.00008

$$\Delta t = 4 M_L f(y) \sim 1\,\mathrm{ms} \times \frac{\mathrm{M_L}}{30\,\mathrm{M}_\odot}$$

$$\frac{F_1}{F_2} = g(y)$$

arXiv:1605.00008

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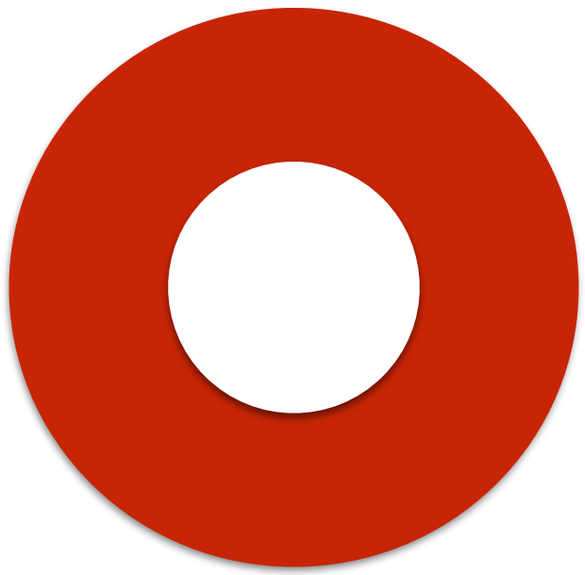
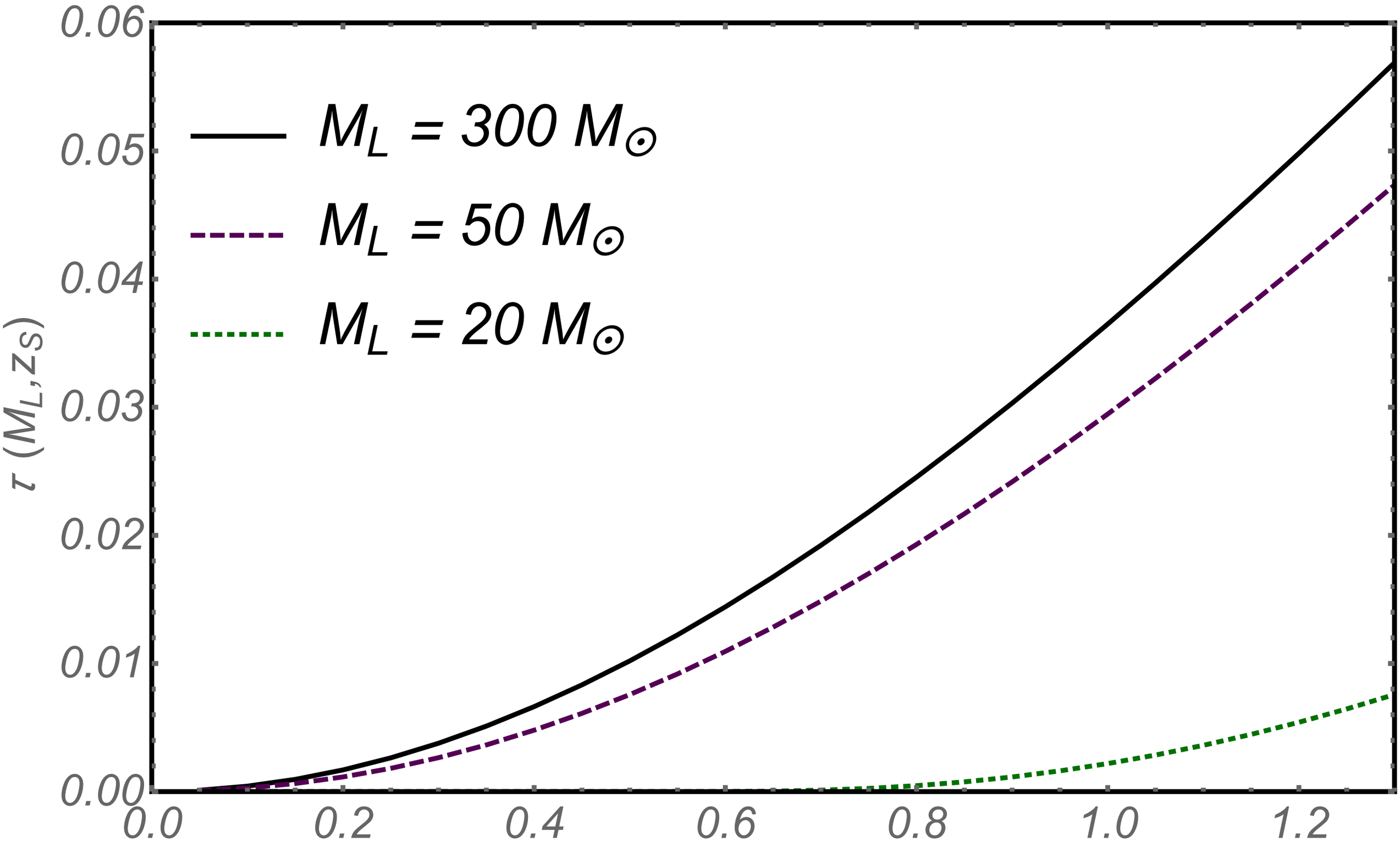
$$\frac{F_1}{F_2} = g(y)$$

$$y_{\mathrm{min}} < y < y_{\mathrm{max}}$$



arXiv:1605.00008

Time delay longer than 1 ms.



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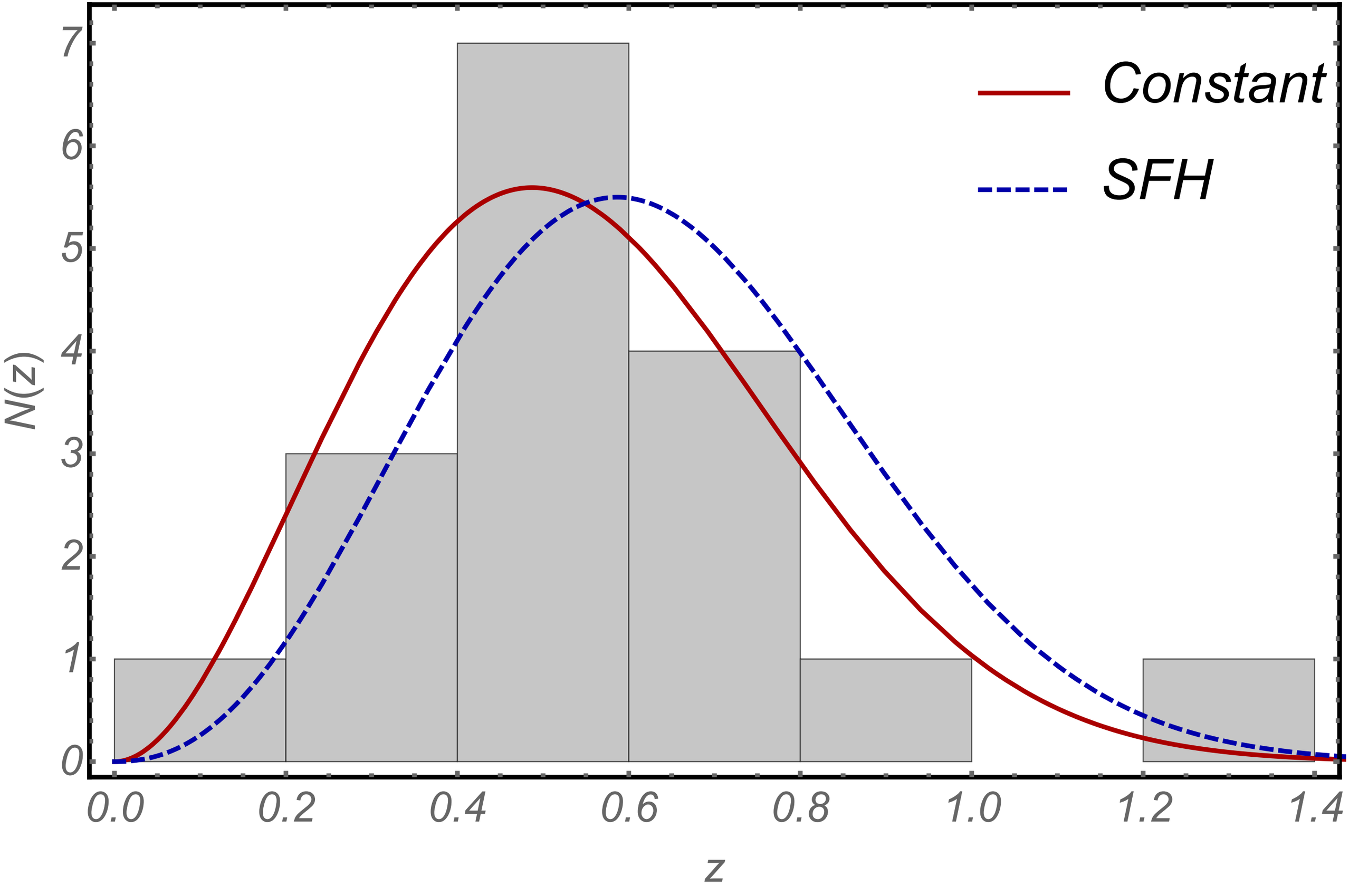
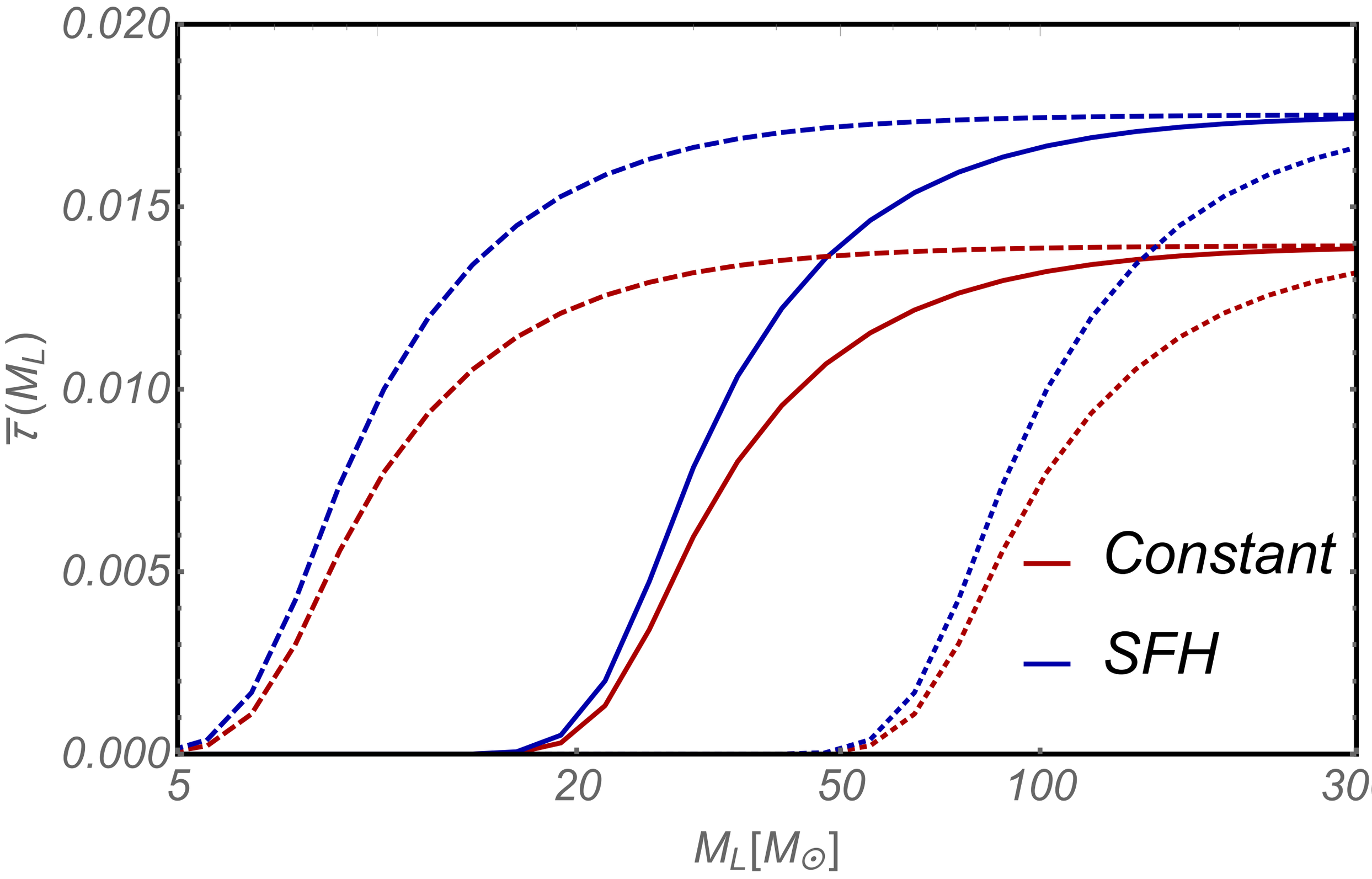

Constant
SFH
N(z)
z
0
1
2
3
4
5
6
7
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4


0.020
0.015
0.010
0.005
0.000
$\overline{\tau}(M_L)$
5
20
50
100
300
$M_L[M_\odot]$
Constant
SFH

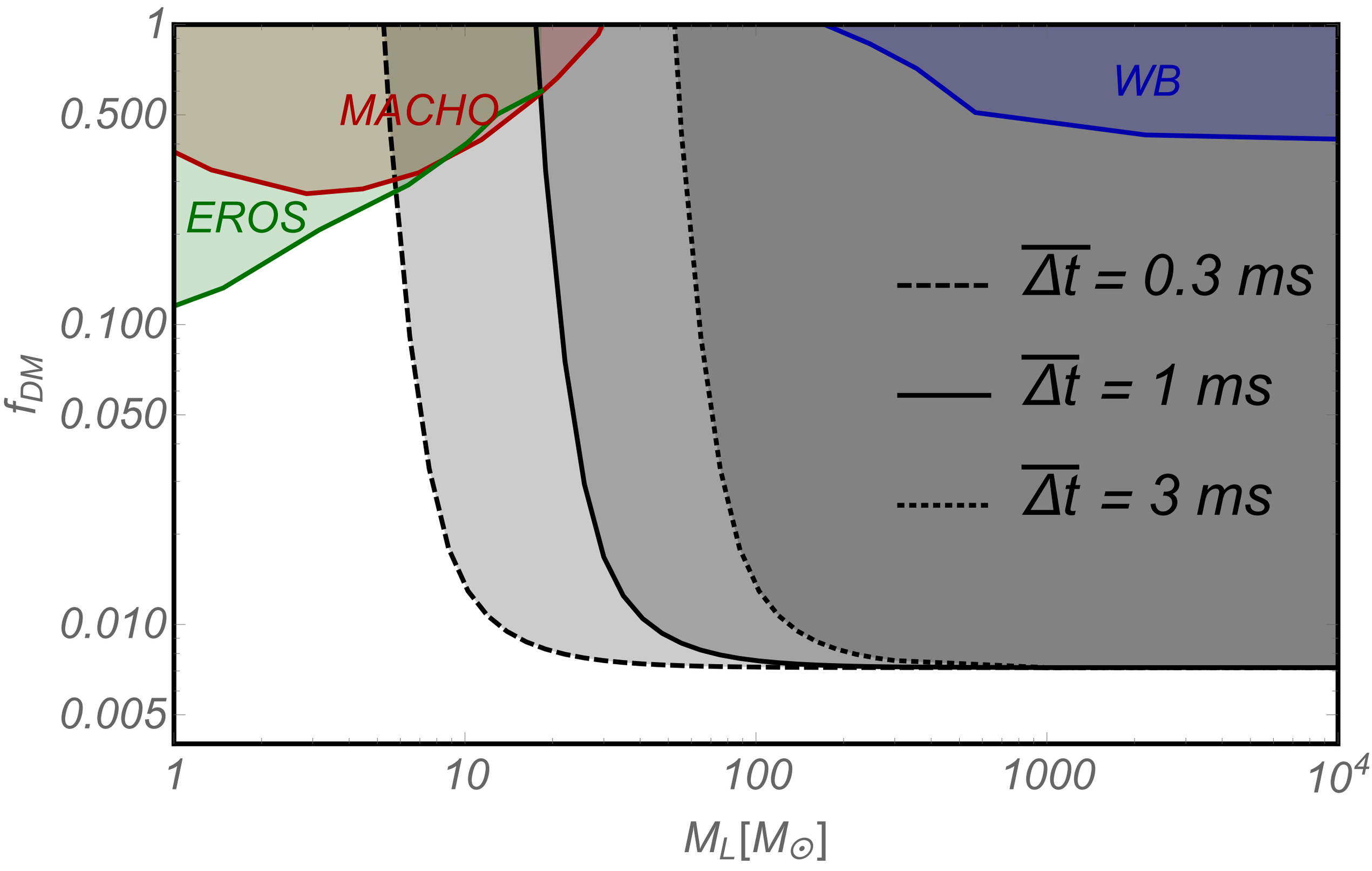
CHIME will see 10^4 FRBs per year!

$$N_{\rm lensed} = \tau N_{\rm FRB}$$

$$N_{\rm lensed} \sim 10 - 100$$

arXiv:1605.00008

If you do not see any lensed FRBs:



To sum up

We **might** have detected Dark Matter

Future tests with GWs will tell
(clustering, eccentricity)

Lensing of FRBs (or other similar probes, as in Bernard's talk) will settle the issue

FRB 121002 might be lensed!