Estimating Black Hole Mass from GeV spindown

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7th Galileo - Xu-Guangqui meeting

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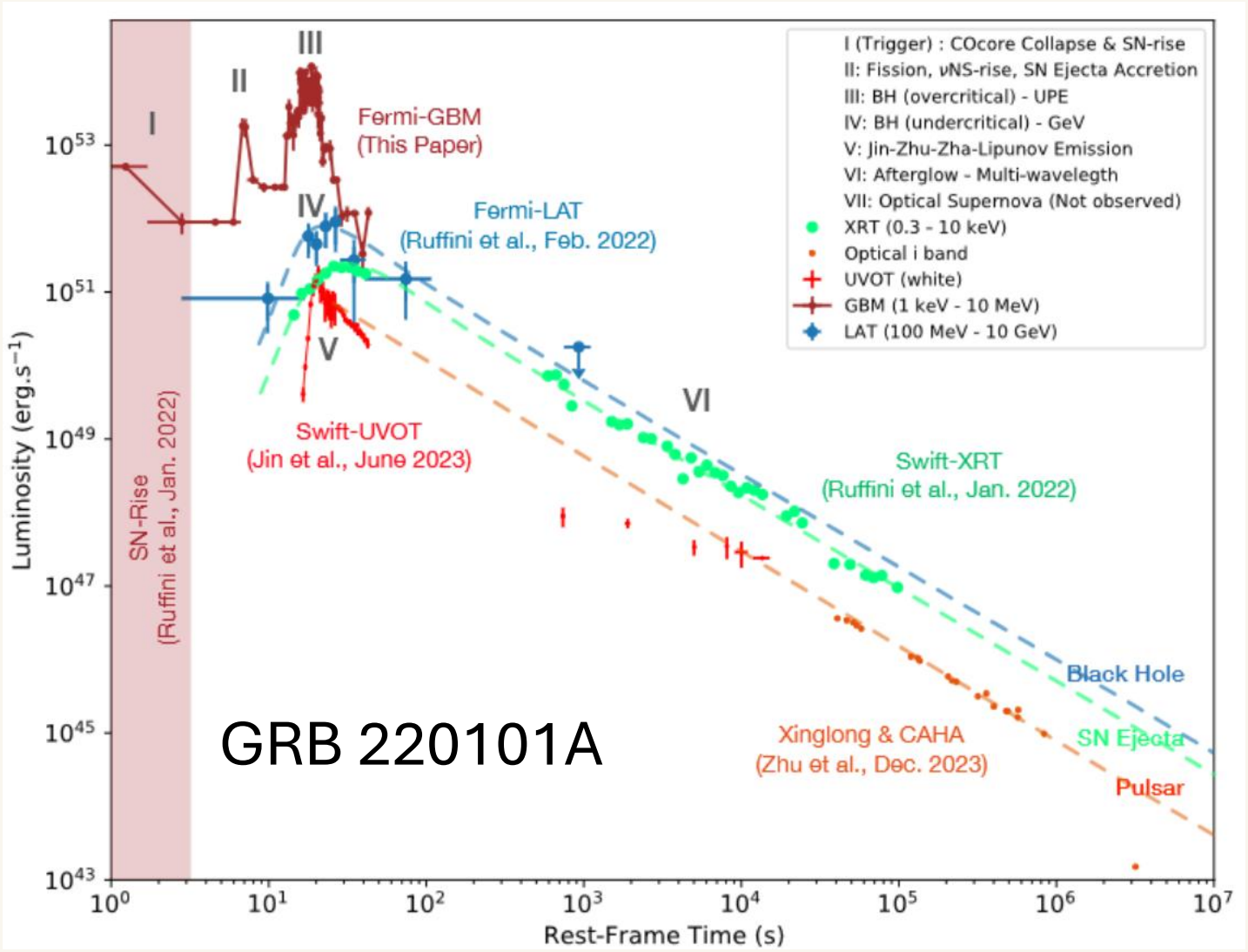
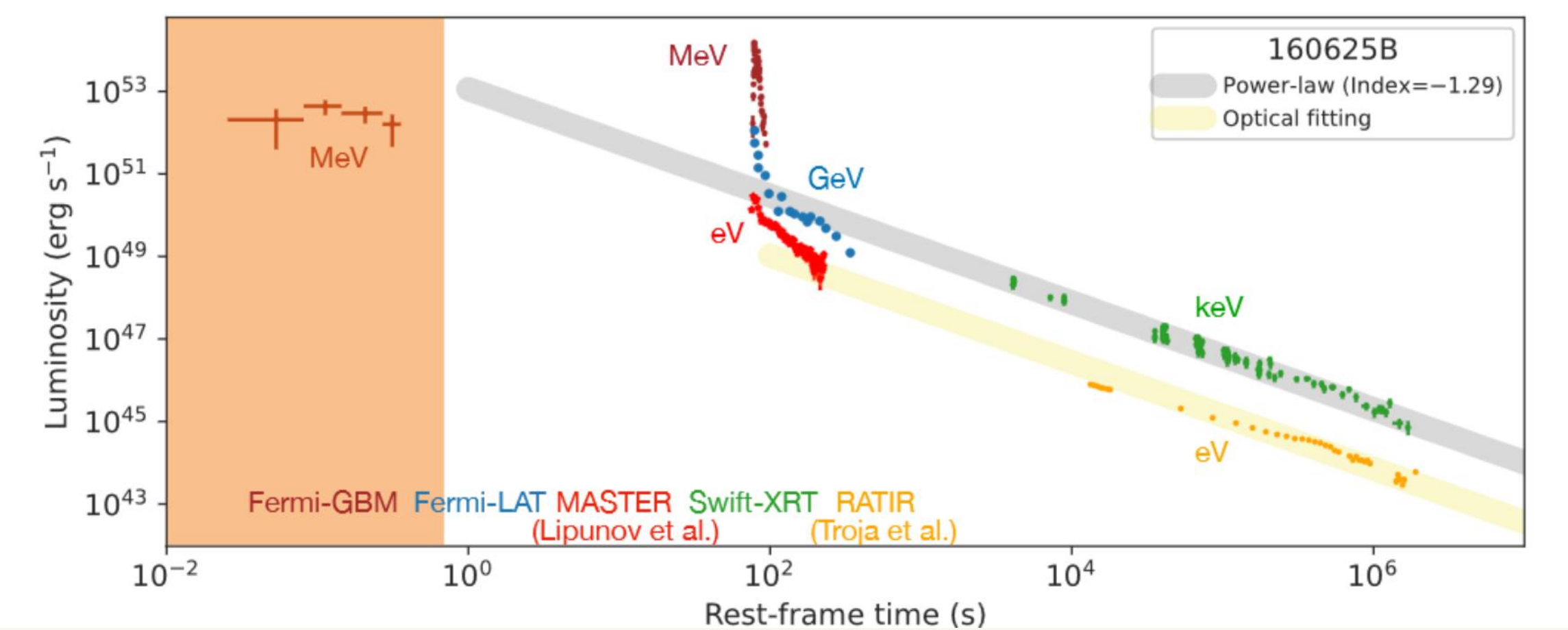
BdHN model


I (Trigger) : COcore Collapse & SN-rise
II: Fission, νNS-rise, SN Ejecta Accretion
III: BH (overcritical) - UPE
IV: BH (undercritical) - GeV
V: Jin-Zhu-Zha-Lipunov Emission
VI: Afterglow - Multi-wavelegth
VII: Optical Supernova (Not observed)
XRT (0.3 - 10 keV)
Optical i band
UVOT (white)
GBM (1 keV - 10 MeV)
LAT (100 MeV - 10 GeV)
I
II
III
IV
V
VI
Fermi-GBM
(This Paper)
Fermi-LAT
(Ruffini et al., Feb. 2022)
Swift-UVOT
(Jin et al., June 2023)
Swift-XRT
(Ruffini et al., Jan. 2022)
SN-Rise
(Ruffini et al., Jan. 2022)
Black Hole
SN Ejecta
Pulsar
Xinglong & CAHA
(Zhu et al., Dec. 2023)
GRB 220101A
Luminosity (erg.s^{-1})
Rest-Frame Time (s)
10^{53}
10^{51}
10^{49}
10^{47}
10^{45}
10^{43}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}

GRB 160625B


160625B
Power-law (Index=−1.29)
Optical fitting
MeV
GeV
eV
keV
eV
MeV
Fermi-GBM
Fermi-LAT
MASTER
(Lipunov et al.)
Swift-XRT
RATIR
(Troja et al.)
Luminosity (erg s^{-1})
10^{53}
10^{51}
10^{49}
10^{47}
10^{45}
10^{43}
10^{-2}
10^{0}
10^{2}
10^{4}
10^{6}
Rest-frame time (s)

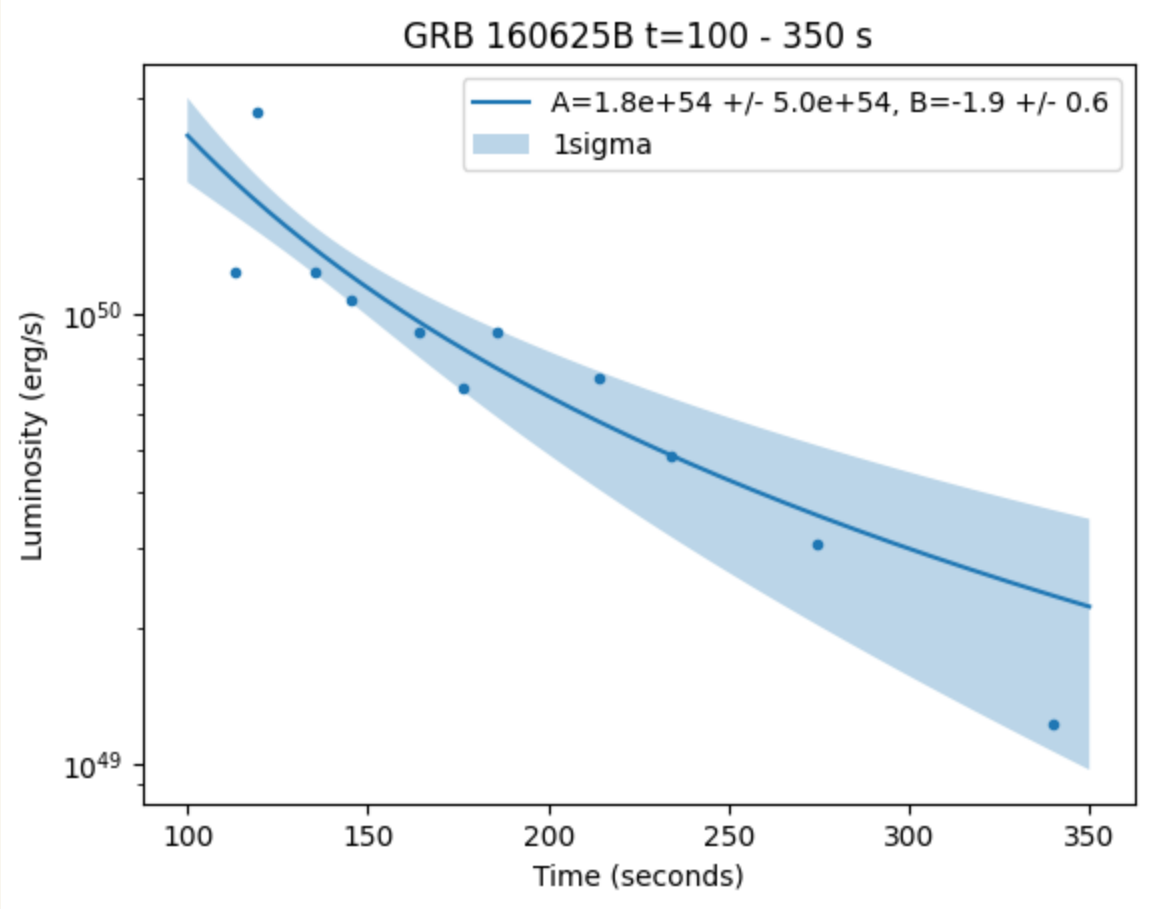
Lower bound for initial mass

$$L_{GeV} = A t_0^{\beta}$$

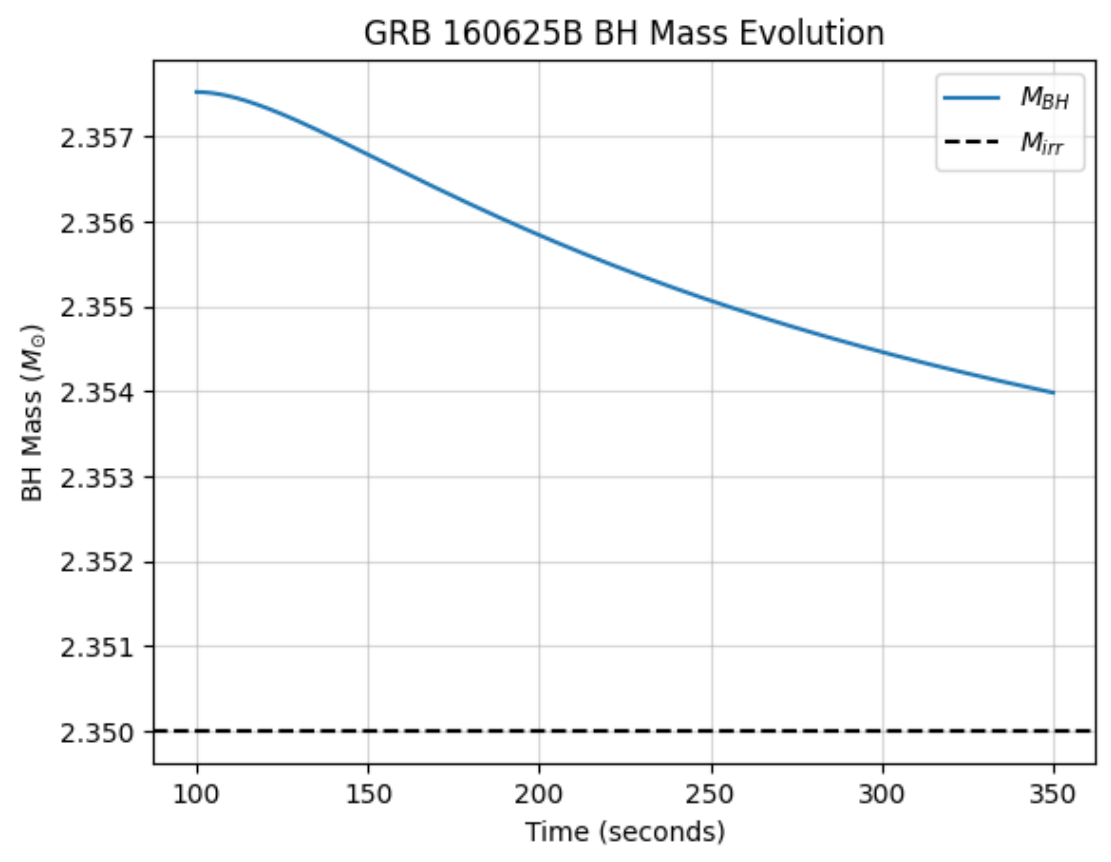
$$E_{GeV} = \int L_{GeV} dt = A \frac{t_0^{1+\beta}}{|1+\beta|}$$

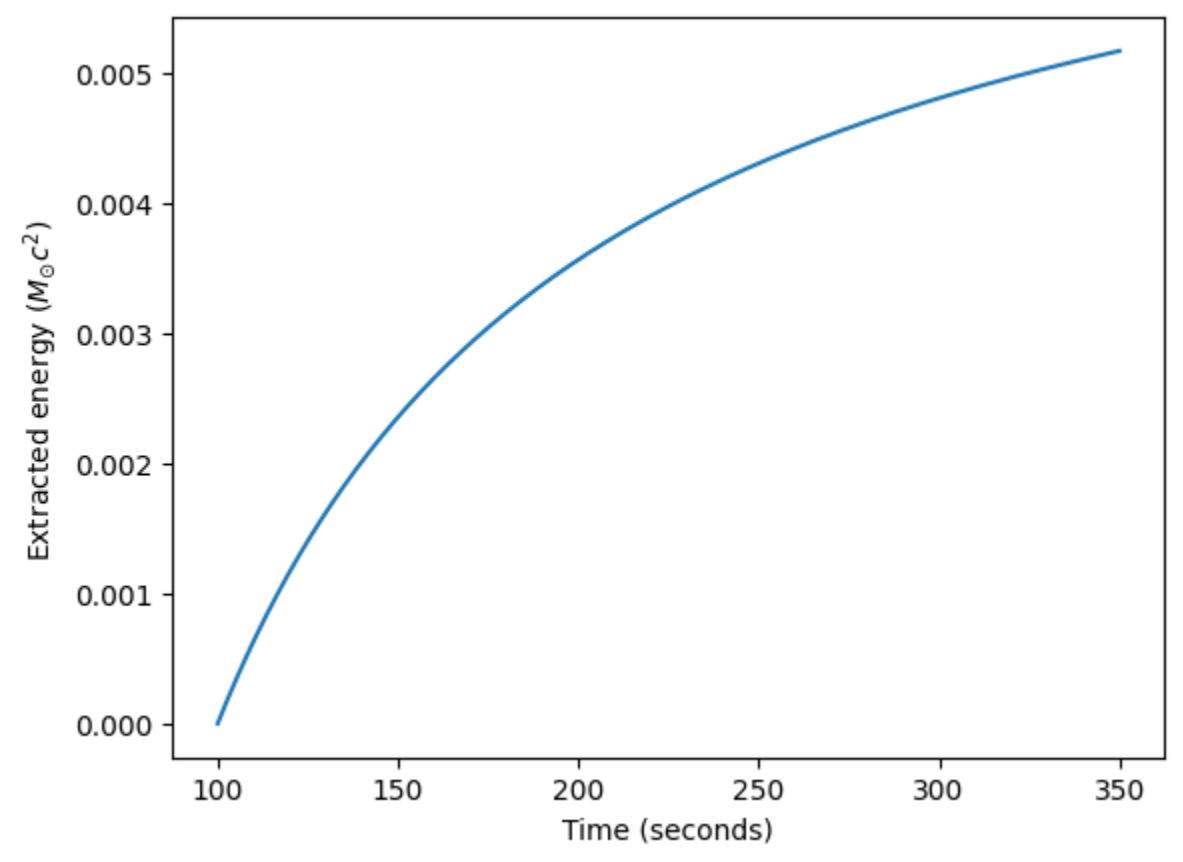
$$\tilde{E}_{GeV} = E_{GeV}(1 - cos\theta)$$

$$M_{BH,0} = M_{GeV} + M_{irr}$$



$$M_{BH} = \overset{2.36\,M_\odot}{M_{BH,0}} - \overset{2.35\,M_\odot}{M_{irr}} - M_{ext}$$

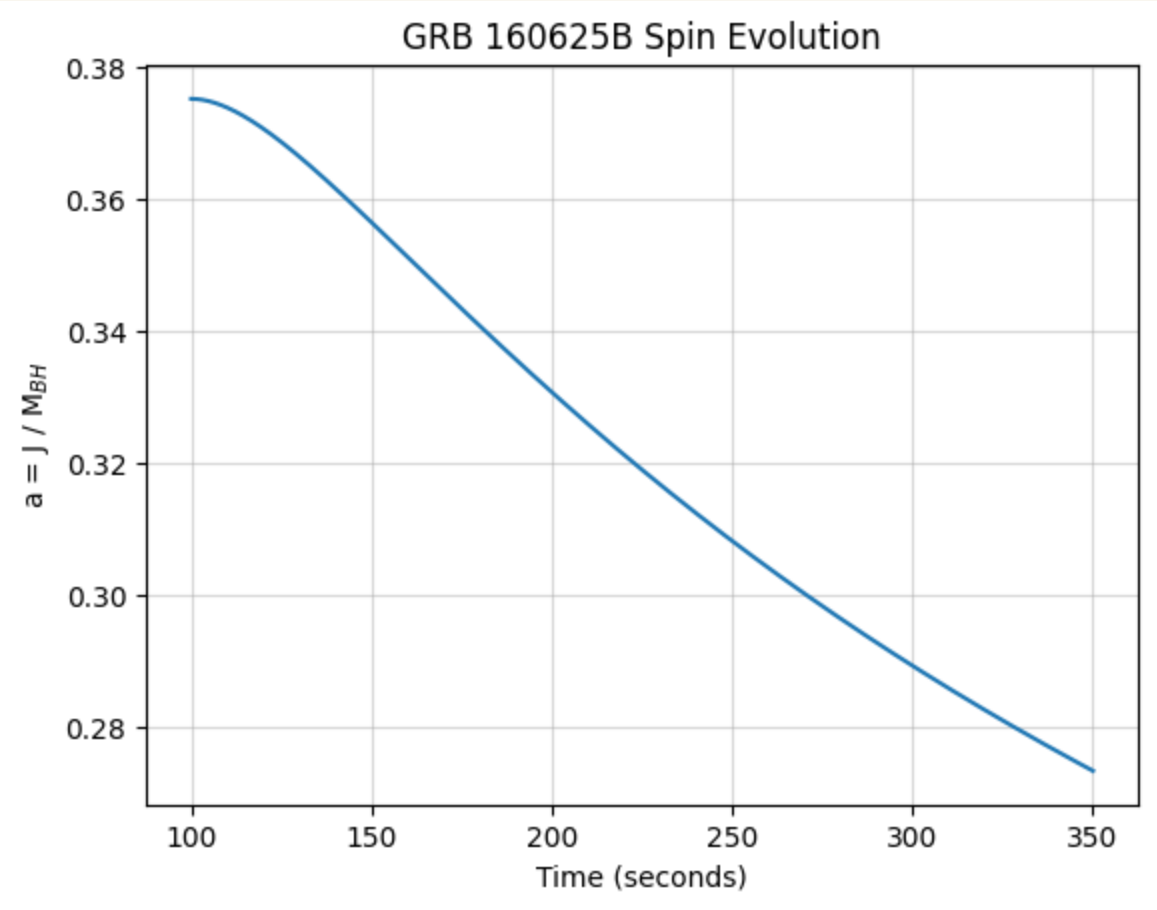




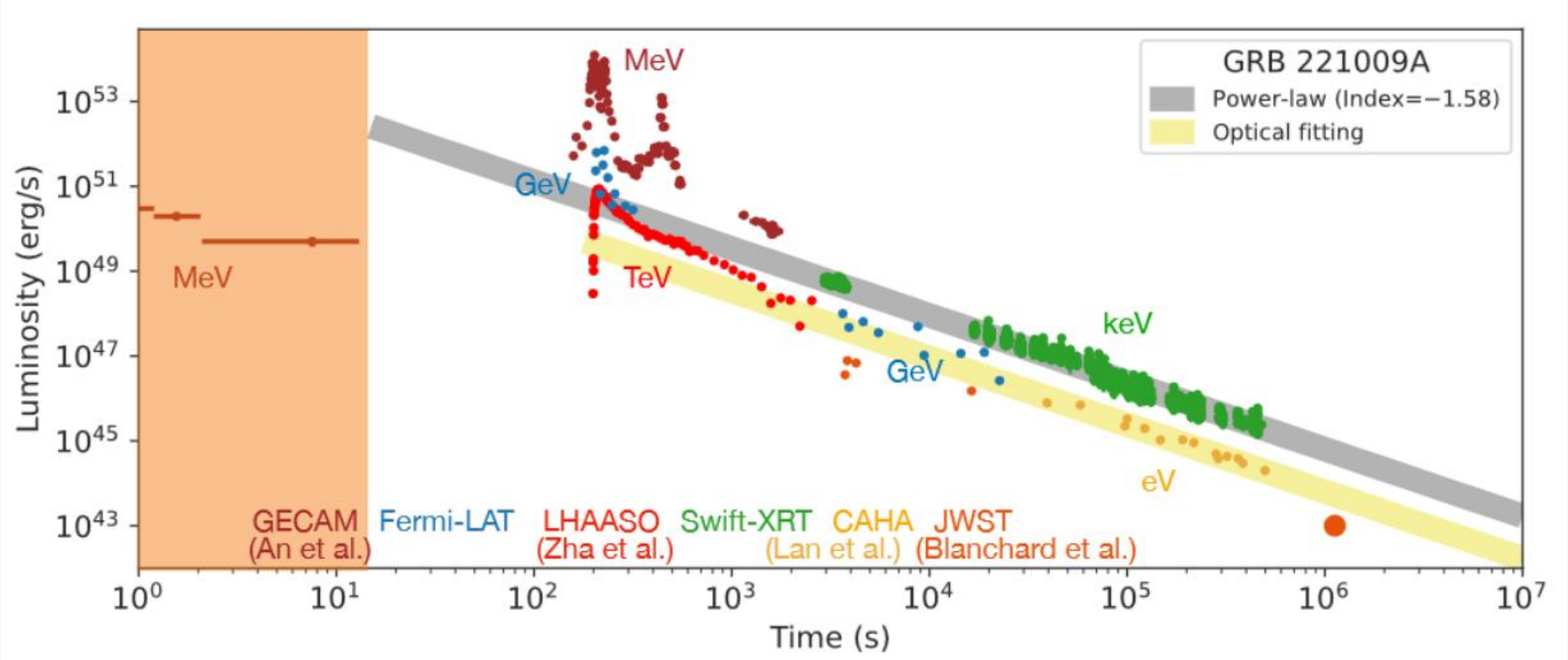
Spin evolution

$$M_{BH}^2 = M_{irr}^2 + \frac{a^2\, M_{BH}^2}{4\, M_{irr}^2}$$

$$a = 2M_{irr}\sqrt{1 - \left(\frac{M_{irr}}{M_{BH}}\right)^2}$$



GRB 221009A – Ultra Long BOAT



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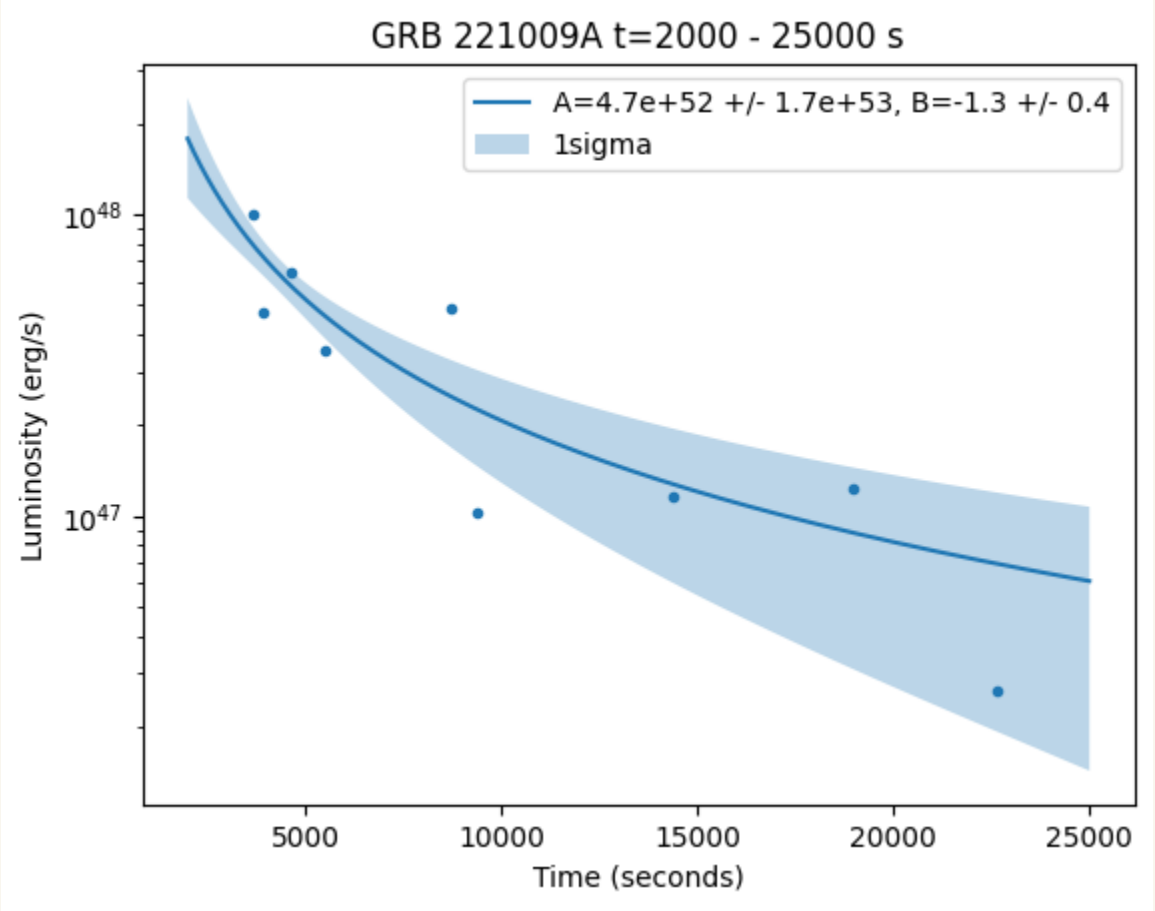
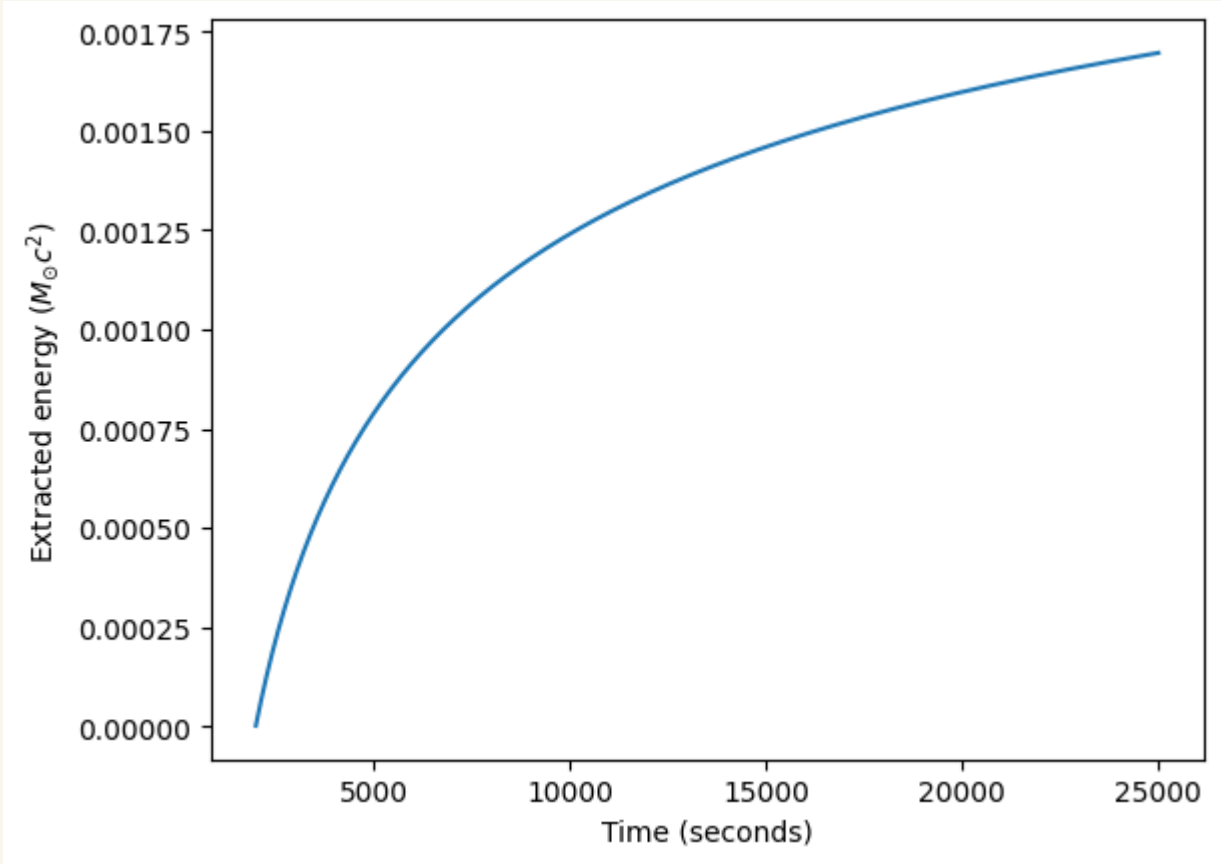
$$\tilde{E}_{GeV} = E_{GeV}(1 - cos\theta)$$

$$M_{BH,0} = M_{GeV} + M_{irr}$$



$$M_{BH} = \underbrace{M_{BH,0}}_{2.358\,M_\odot} - \underbrace{M_{irr}}_{2.350\,M_\odot} - M_{ext}$$



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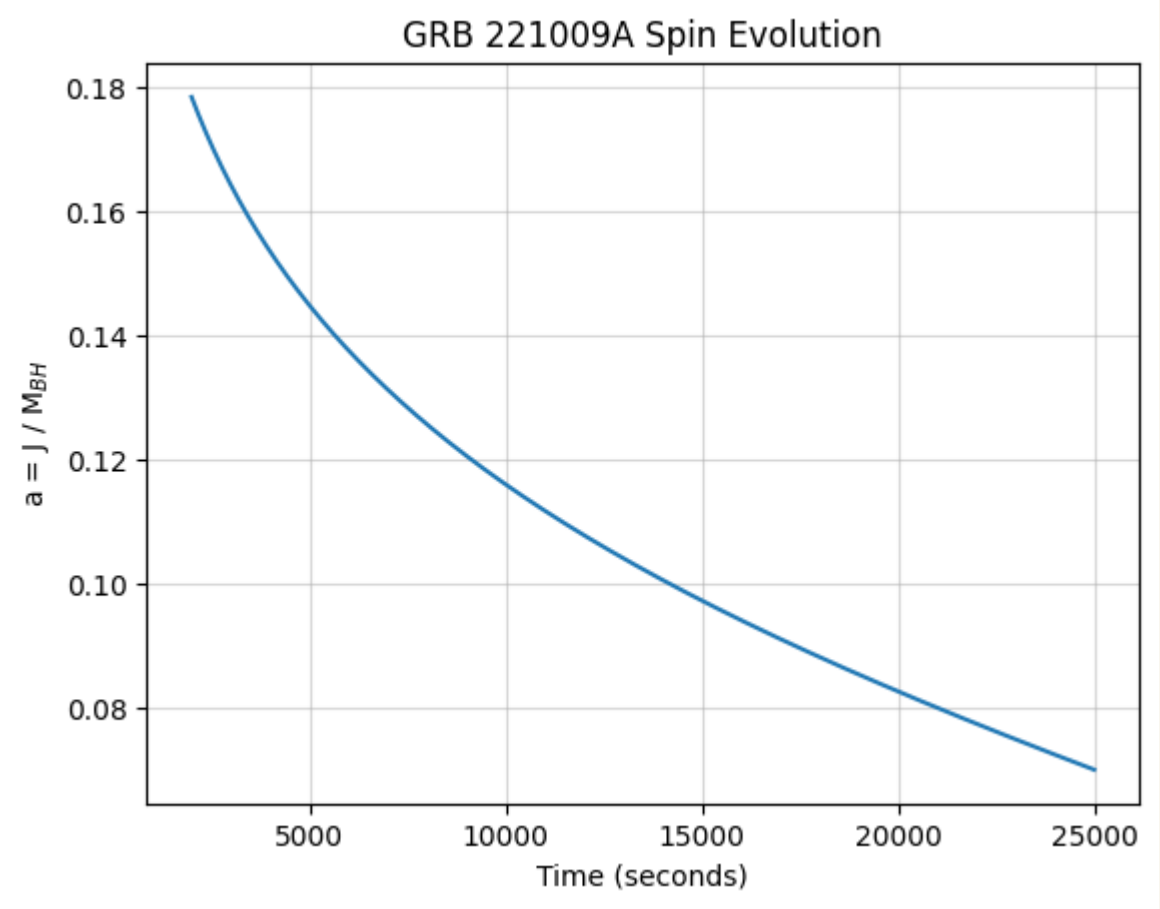

Summary

GRB	Initial BH mass ($M_\odot$)	At the end of GeV emission ($M_\odot$)	Initial a	At the end of GeV emission
160625B	2.3575	2.3540	0.38	0.27
221009A	2.3517	2.3503	0.18	0.07
220101A	?	?	?	?