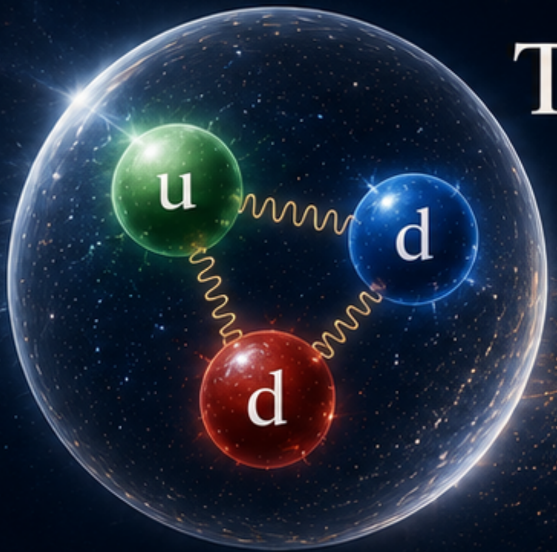
From The Model of Neutron by Enrico Fermi of 939 MeV

to

The Introduction of X-Fermion of 381 keV



FERMI'S MODEL OF NEUTRON
(circa 1934)

939 MeV

Expanding the frontier
from the known
to the subtle

X-FERMION
(new frontier)

381 keV

Remo Ruffini
(ICRANet)

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High Energy Astrophysics and Cosmology in the era of all-sky surveys

Critical Mass of Neutron Star

Planck Mass: Equating the Compton wavelength and Schwarzschild radius

$$M_{\rm Pl} = \sqrt{\frac{\hbar c}{G}} = 2.18 \times 10^{-5} \text{ g} .$$

A Neutron Star described by Oppenheimer-Volkoff Mass: for a star supported by fermion degeneracy pressure

$$M_{\rm cr} \simeq 0.384 \frac{M_P^3}{m_n^2} \approx 0.71\, M_\odot$$

The absolute limit of the critical mass inferred from causality and general relativity (Rhoads and Ruffini):

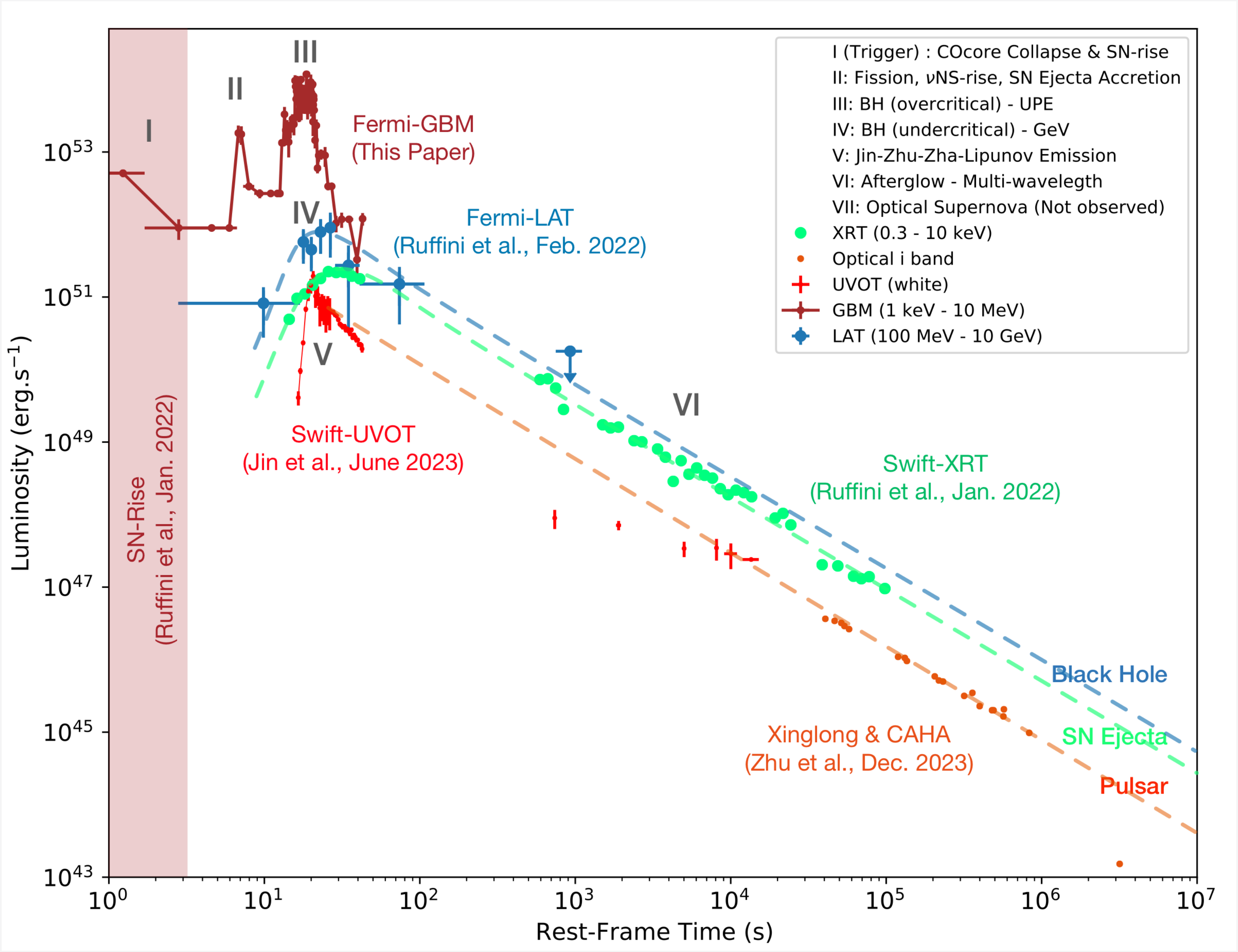
$$M_{\rm max}^{\rm NS} \lesssim 3.2\, M_\odot$$

The maximal mass of observed neutron star (Romani et al., 2025 for PSR J0952–0607)

$$M = 2.35 \pm 0.17\, M_\odot$$

Let us show how to apply these results to GRB 220101A.

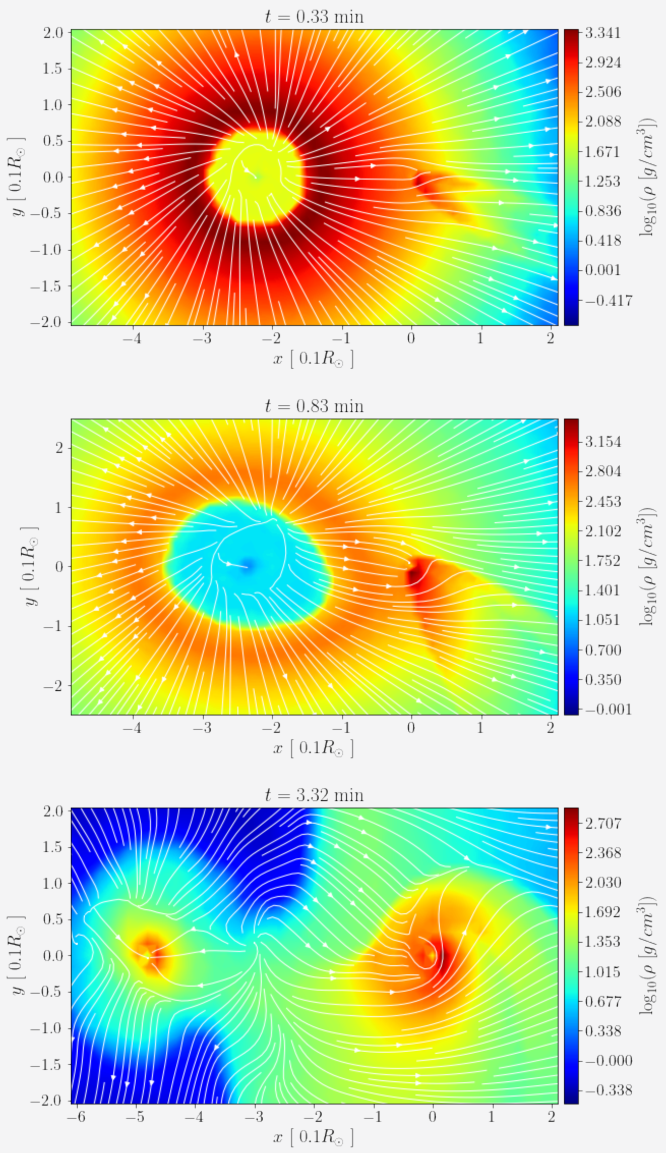
GRB 220101A provides the first of long GRBs with a total energy exceeding 10^{54} erg and further exceptional properties: (1) its redshift z = 4.61 and (2) the high-quality multiwavelength observational coverage from a large number of space-based telescopes and ground-based telescopes. We interpret this source in a modified binary-driven hypernova (BdHN) model. The progenitor is composed of a massive CO core of $\sim 10\,M_\odot$, highly magnetized with $B \sim 10^6$ G, forming a binary with a neutron star (NS) companion with orbital periods from minutes to hours, and a third component, a white dwarf (WD) core. The large GRB luminosity is explained by a sequence of events triggered by a first supernova (SN) originated from the CO core: (1) its ejecta trigger the collapse of the WD core, emitting neutrinos and creating a new NS (νNS), spun up to a period of ~ 1 ms by accretion, generating a pulsar; (2) the binary NS companion magnetosphere originates the UPE emission with energy up to 10^{54} erg; (3) following the UPE, further accretion onto the NS companion leads to the formation of a black hole (BH) of $\sim 2.3\,M_\odot$. Three afterglows are observed: (1) a GeV emission originating from the BH, (2) an X-ray emission from synchrotron radiation by the SN ejecta, and (3) an optical emission by the millisecond pulsar. Most exceptional is the νNS that originates 14.7 s after the first SN trigger.



Multi-wavelength Luminosity Evolution

Rest-frame luminosity evolution from prompt emission to late afterglow across GBM, LAT, XRT, UVOT, and optical bands.

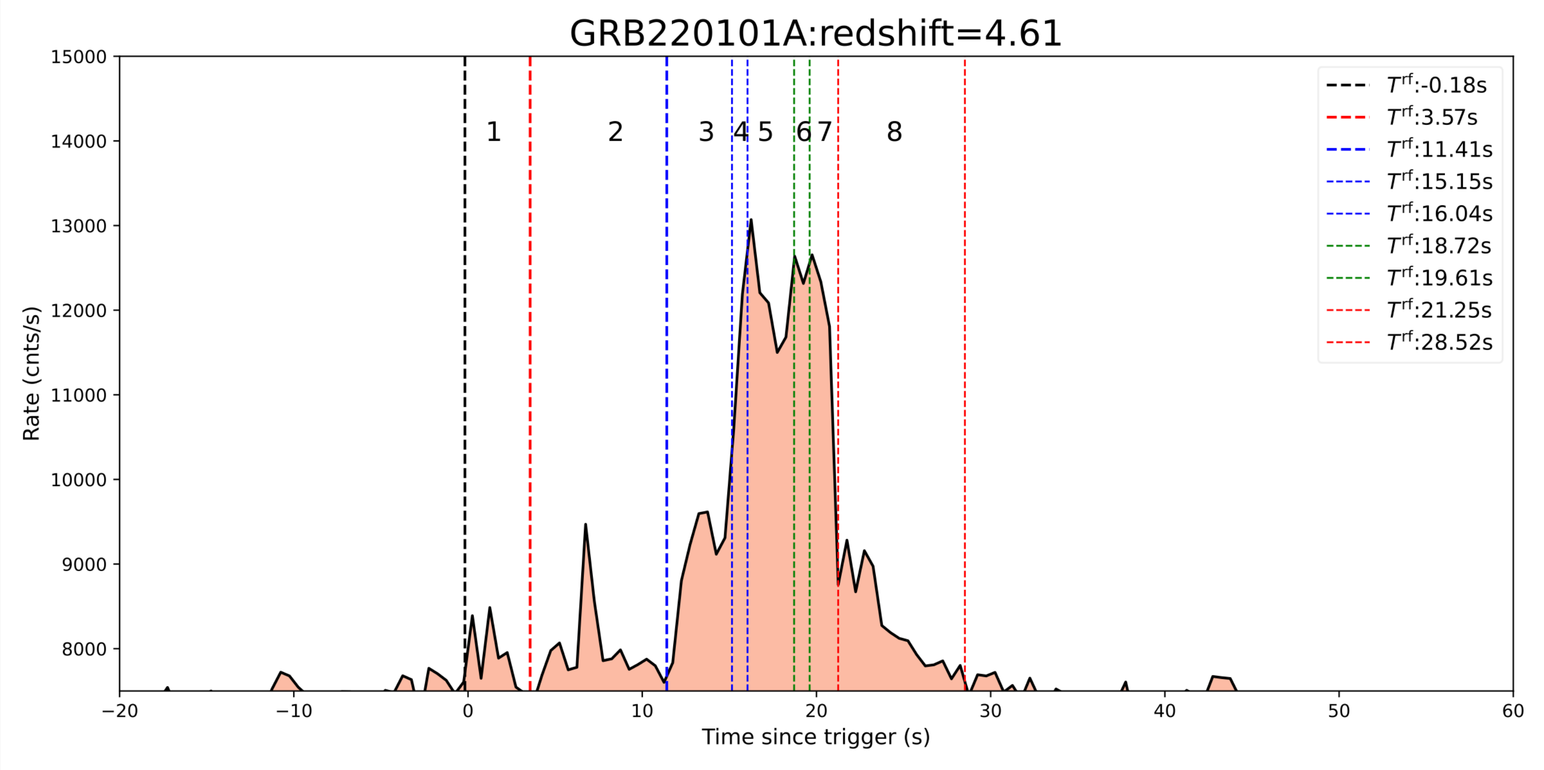
Dashed trends highlight the GeV, X-ray, and optical components associated with the BH, SN ejecta, and pulsar.



Binary Density Maps

Hydrodynamic density maps at 19.2, 49.8, and 190.2 s after SN breakout.

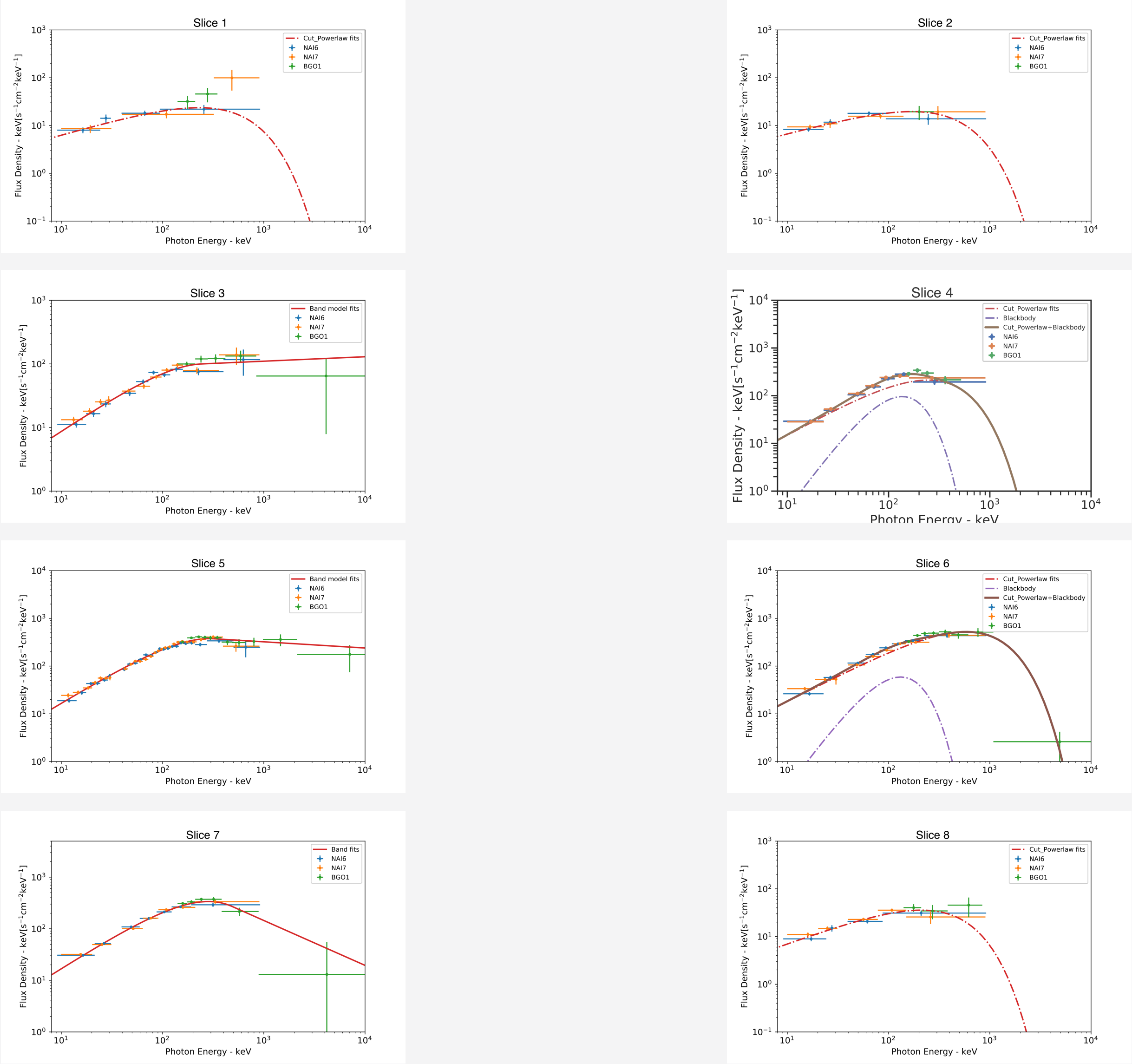
The sequence shows ejecta flow around the NS companion and the development of the accreting structure.



Fermi-GBM Count Light Curve

Fermi-GBM count light curve divided into eight spectral slices.

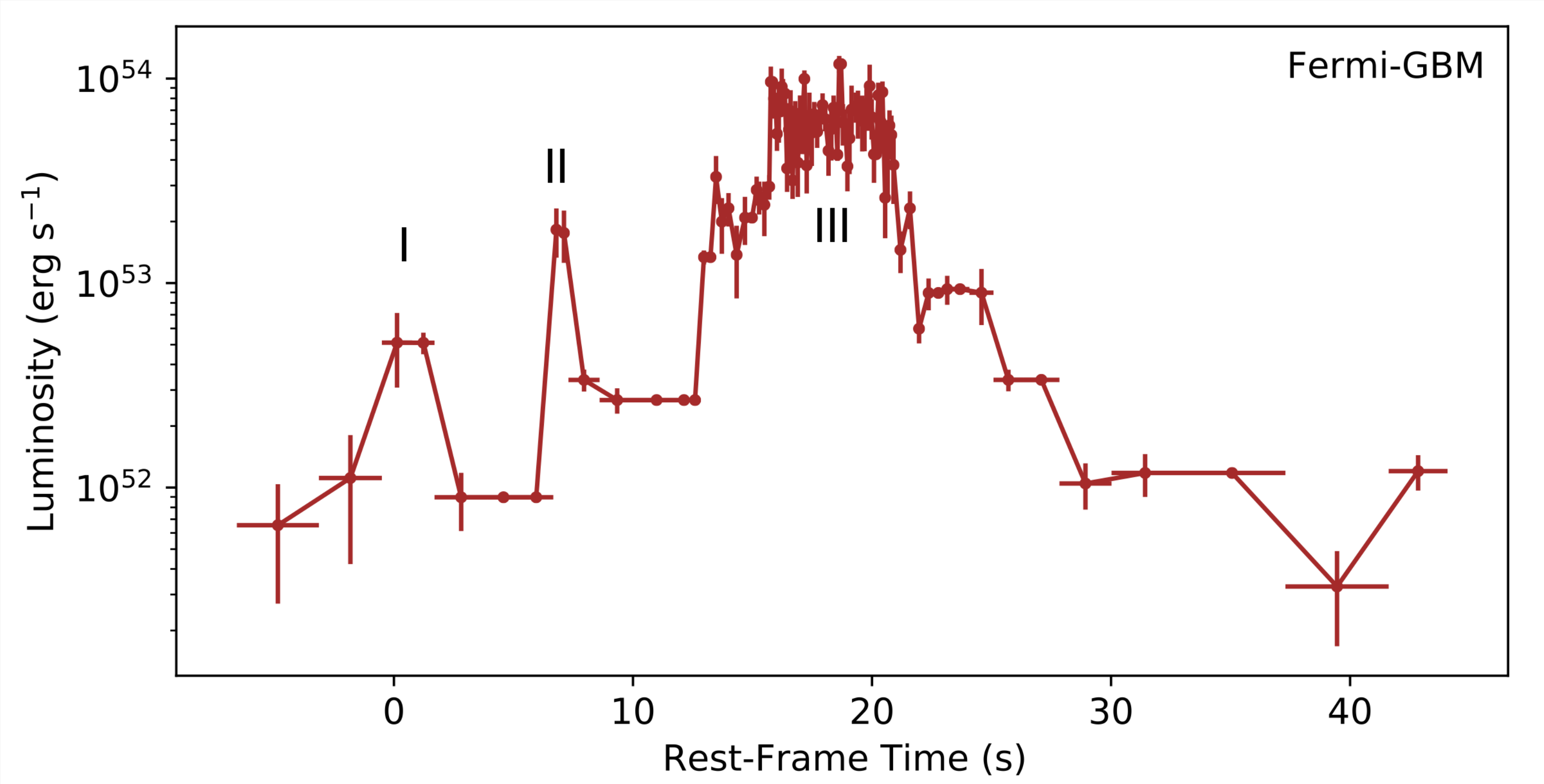
The slice boundaries follow the prompt-emission morphology and guide the time-resolved spectral analysis.



Fermi-GBM Time-resolved Spectra

Time-resolved Fermi-GBM spectra for slices 1-8.

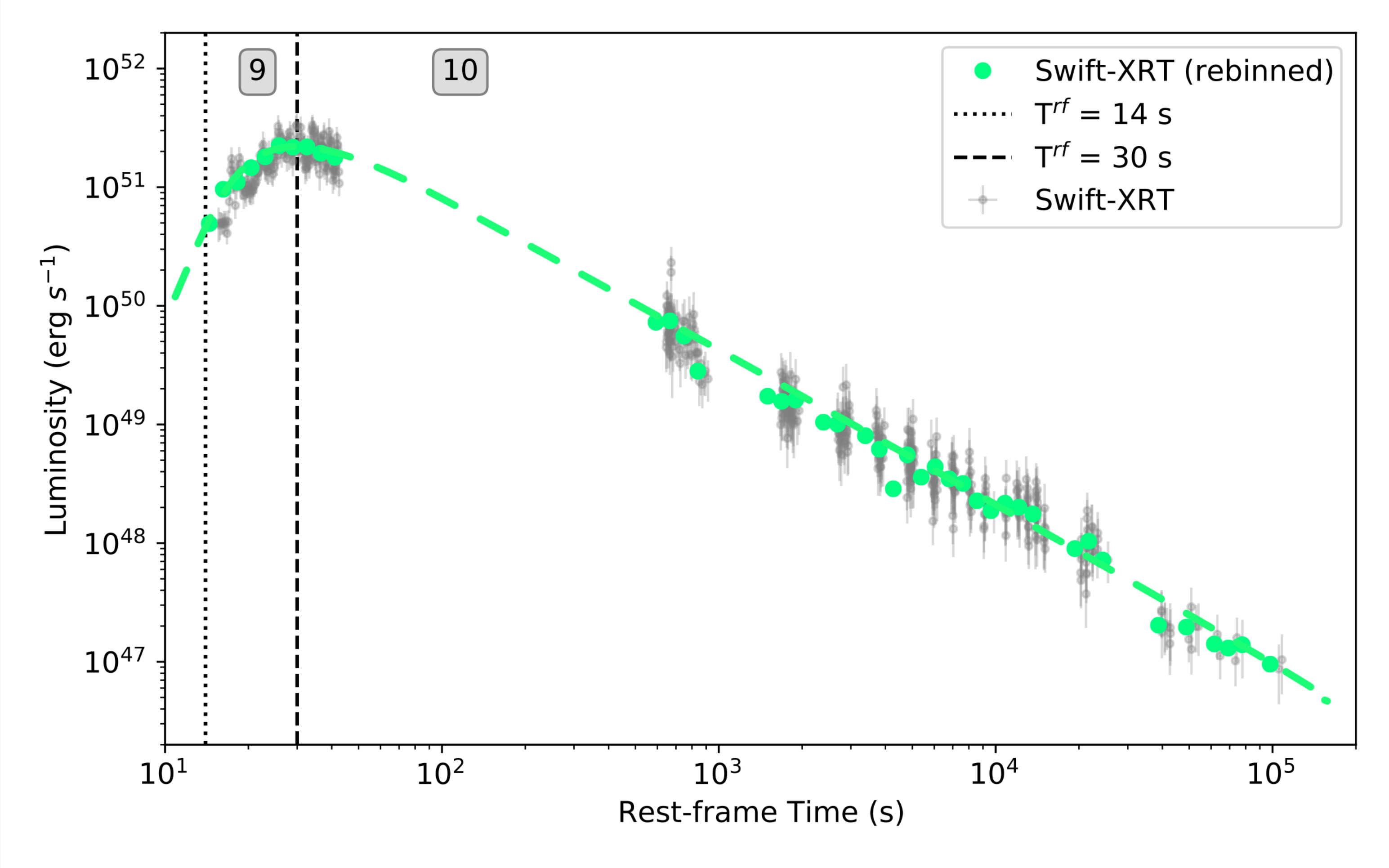
The sequence traces how the prompt-emission spectrum evolves across the main pulses.



Fermi-GBM Luminosity Light Curve

Isotropic luminosity light curve from Fermi-GBM in the 1 keV to 10 MeV band.

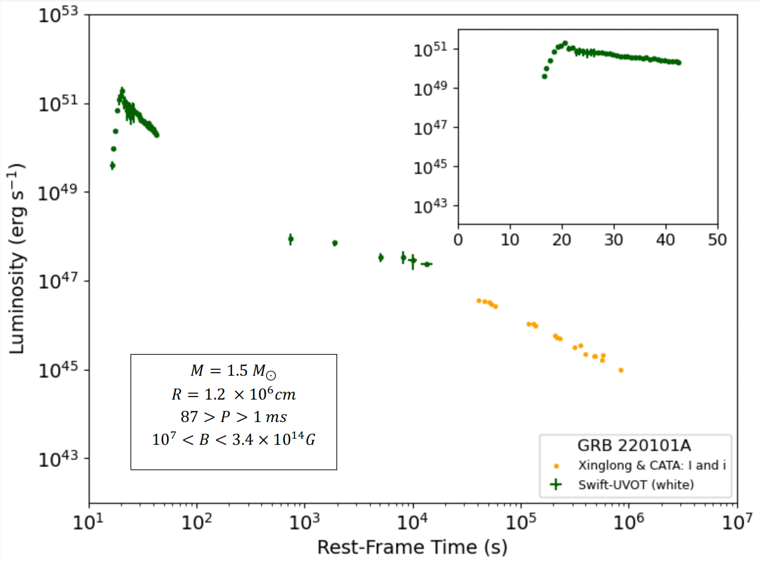
The plot marks Episodes I, II, and III.

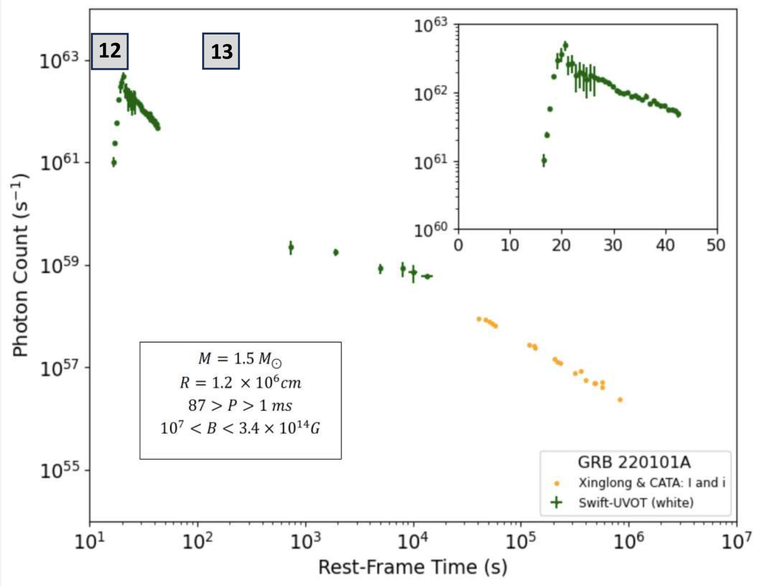


Swift-XRT Luminosity Light Curve

Swift-XRT luminosity evolution from the early X-ray emission to the late afterglow.

The two marked intervals correspond to slices 9 and 10.

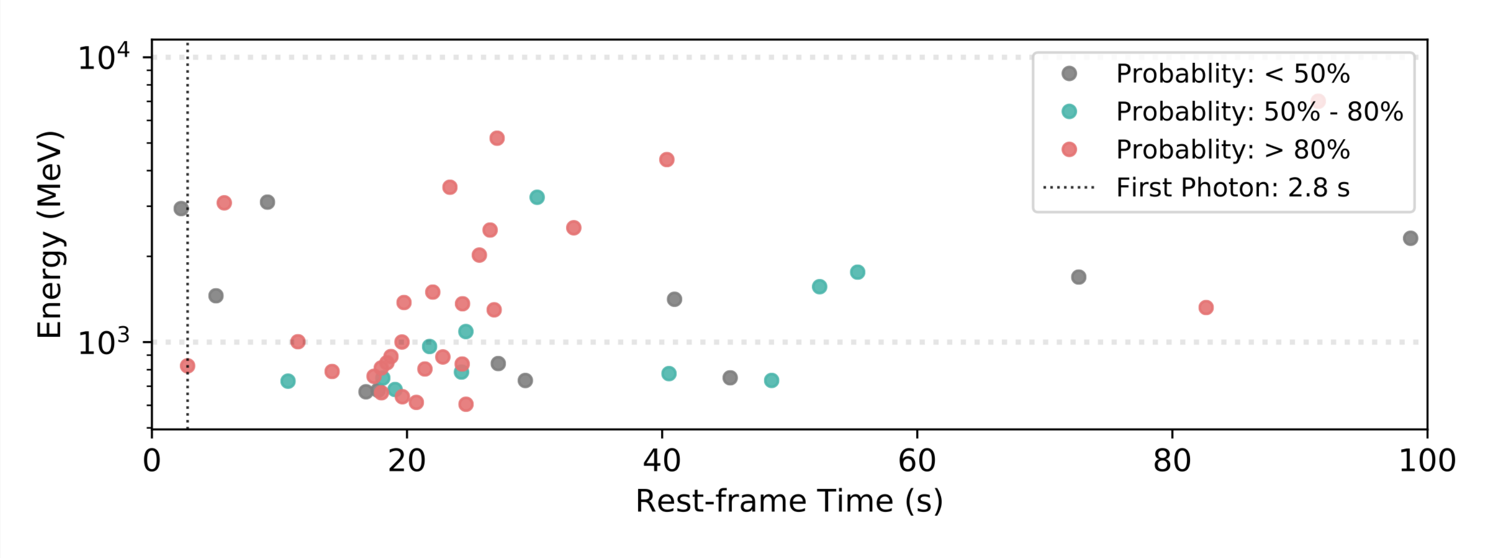


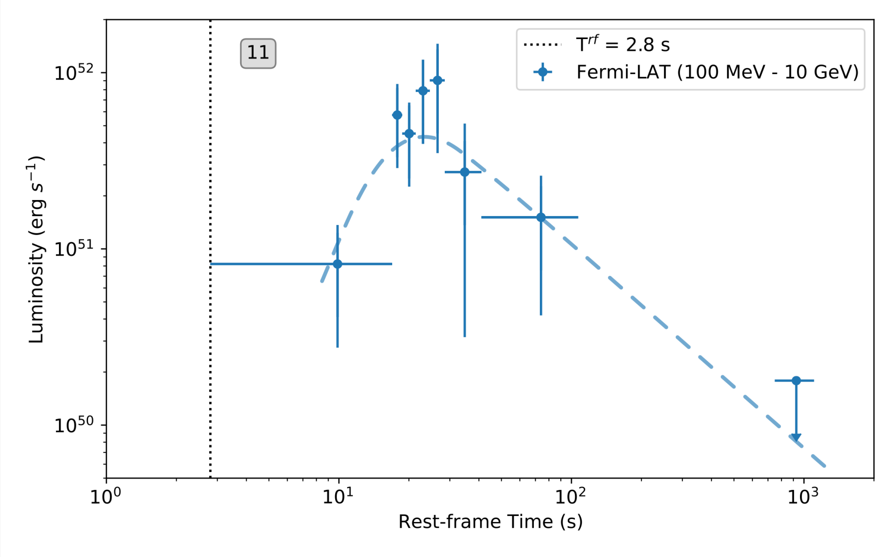


Swift-UVOT Optical Light Curve

Optical luminosity and count-rate evolution observed by Swift-UVOT, Xinglong, and CAHA.

The early rise is associated with nuNS spin-up, followed by spin-down after about 21 s.

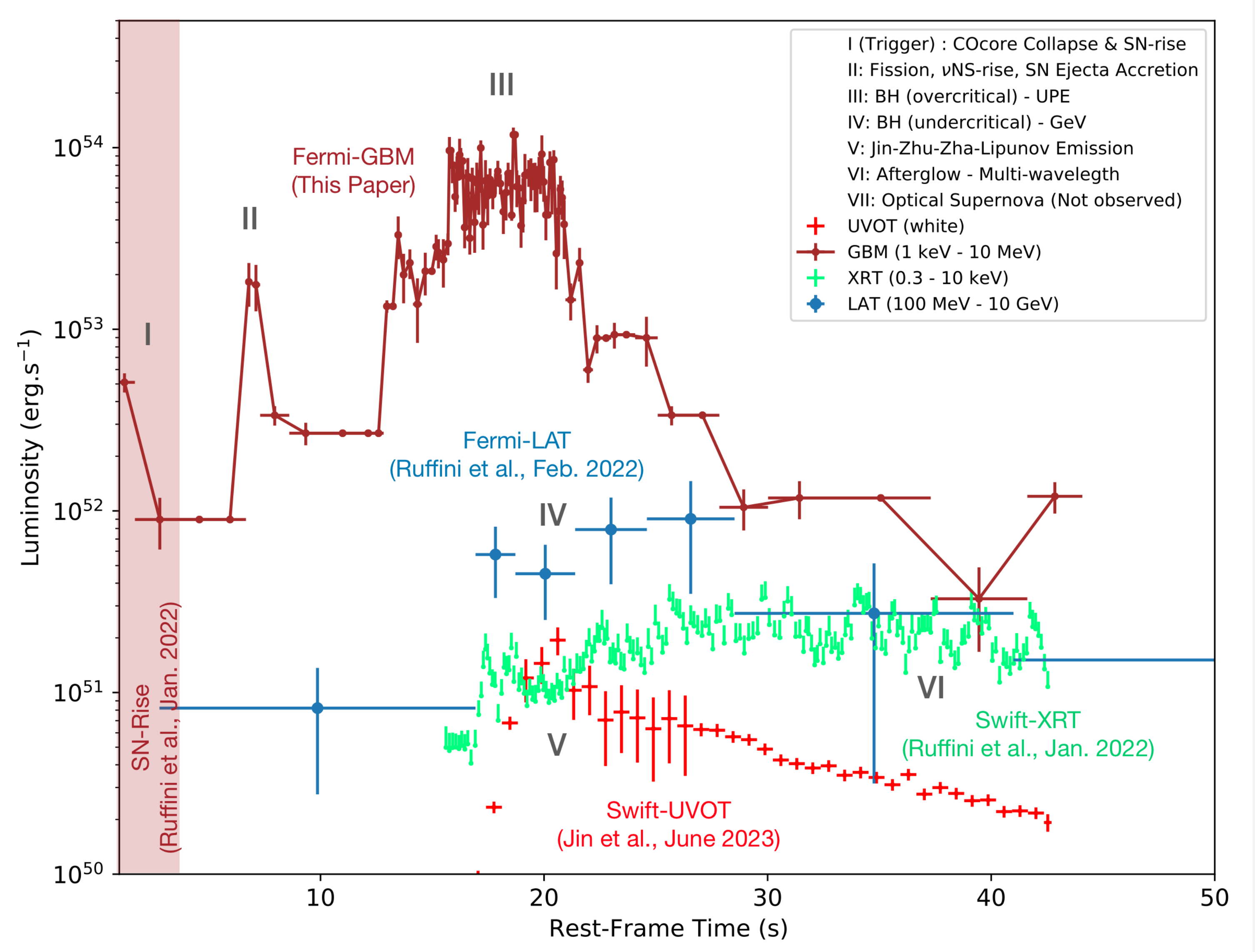




Fermi-LAT Photon and GeV Emission

Fermi-LAT photon arrival times and GeV luminosity light curve.

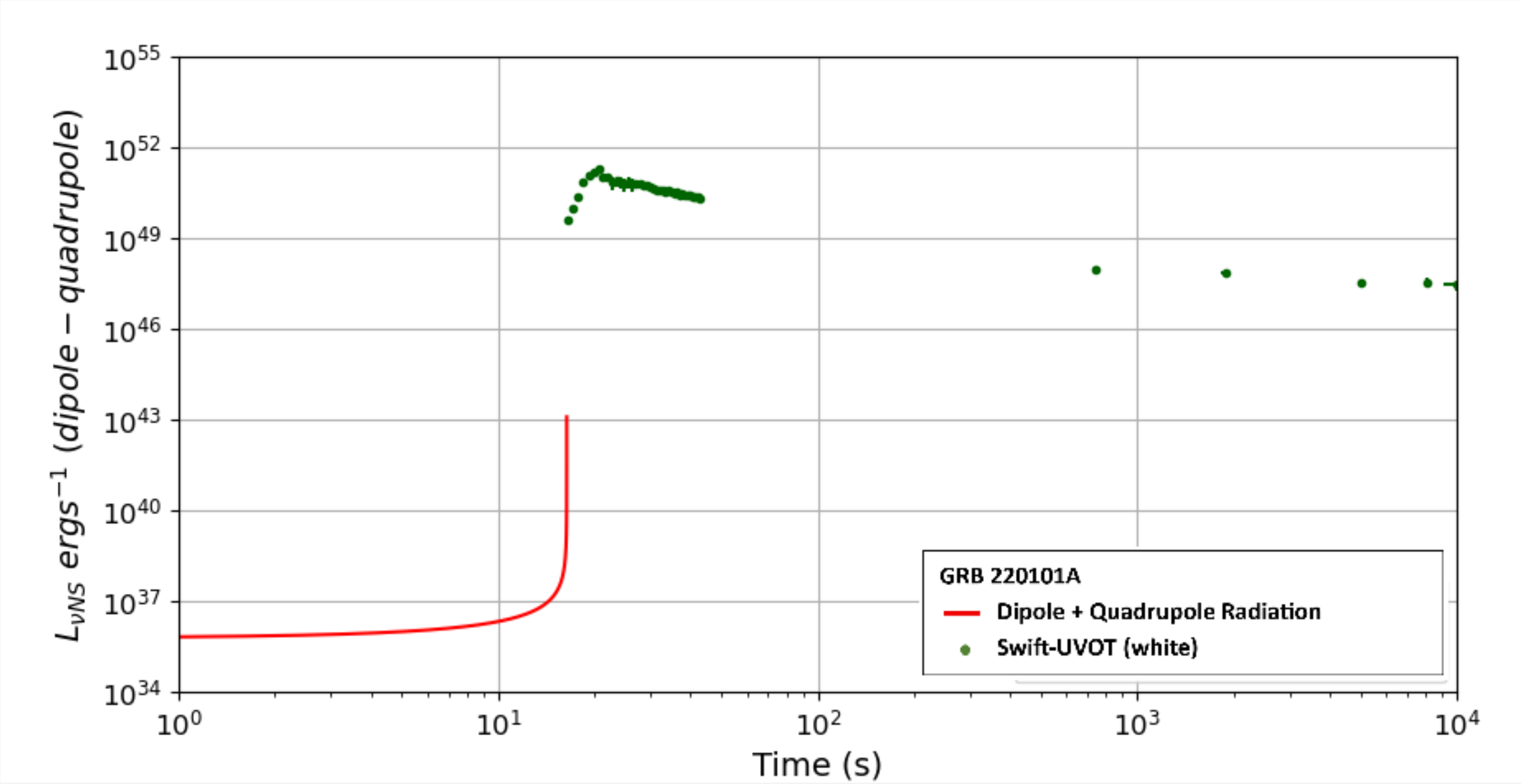
The emission begins around 2.8 s in the rest frame and decays over the LAT observation interval.



Early Multi-wavelength Light Curve

Zoomed-in view of the first 50 s in the rest frame.

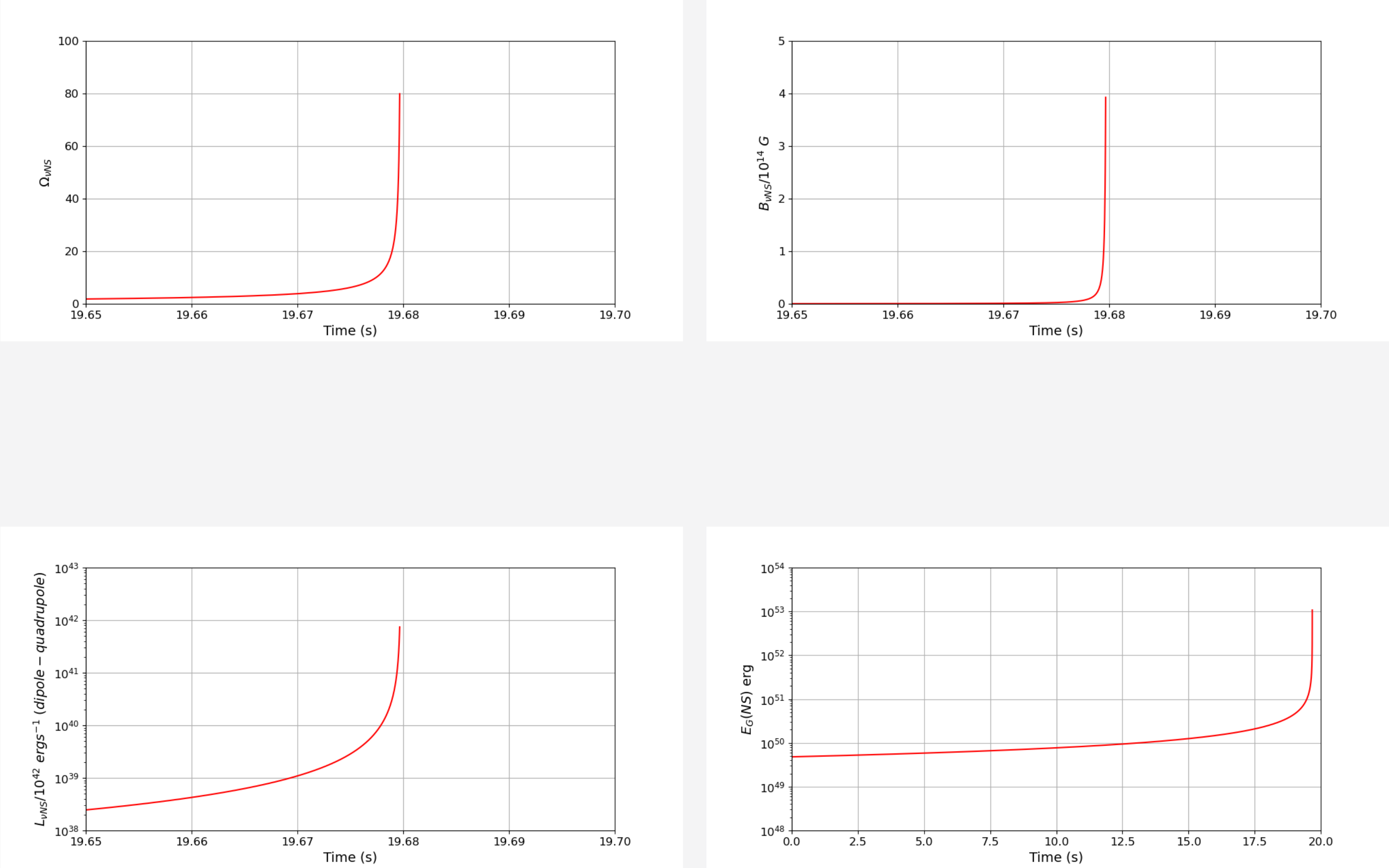
GBM, LAT, XRT, and UVOT data show the temporal overlap of the early emission Episodes.



Pulsar Dipole and Quadrupole Luminosity

Dipole and quadrupole luminosity of the pulsar during formation.

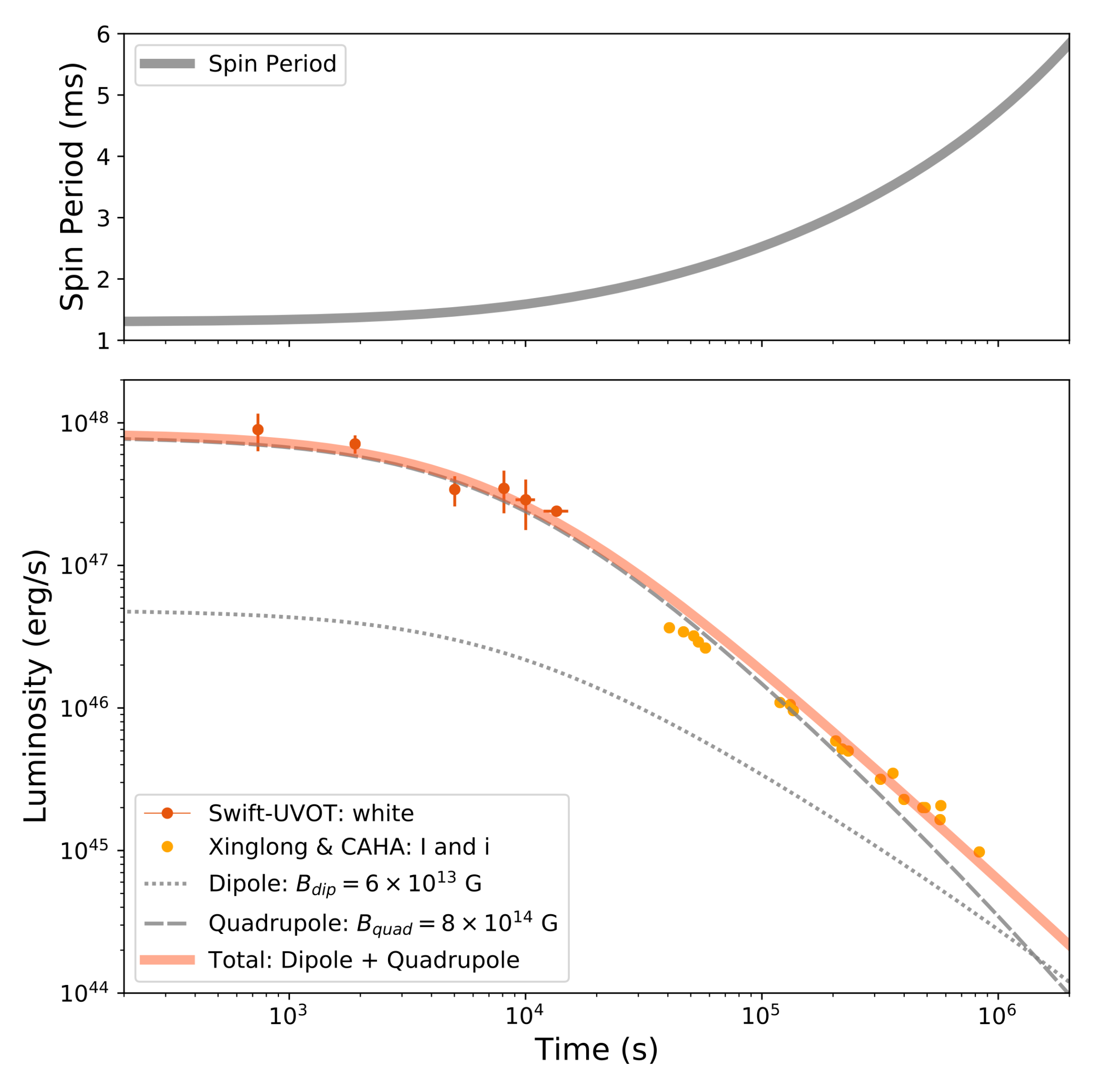
The green points show the Swift-UVOT optical observation.



Newborn NS Evolution

Evolution of the newborn neutron star during collapse.

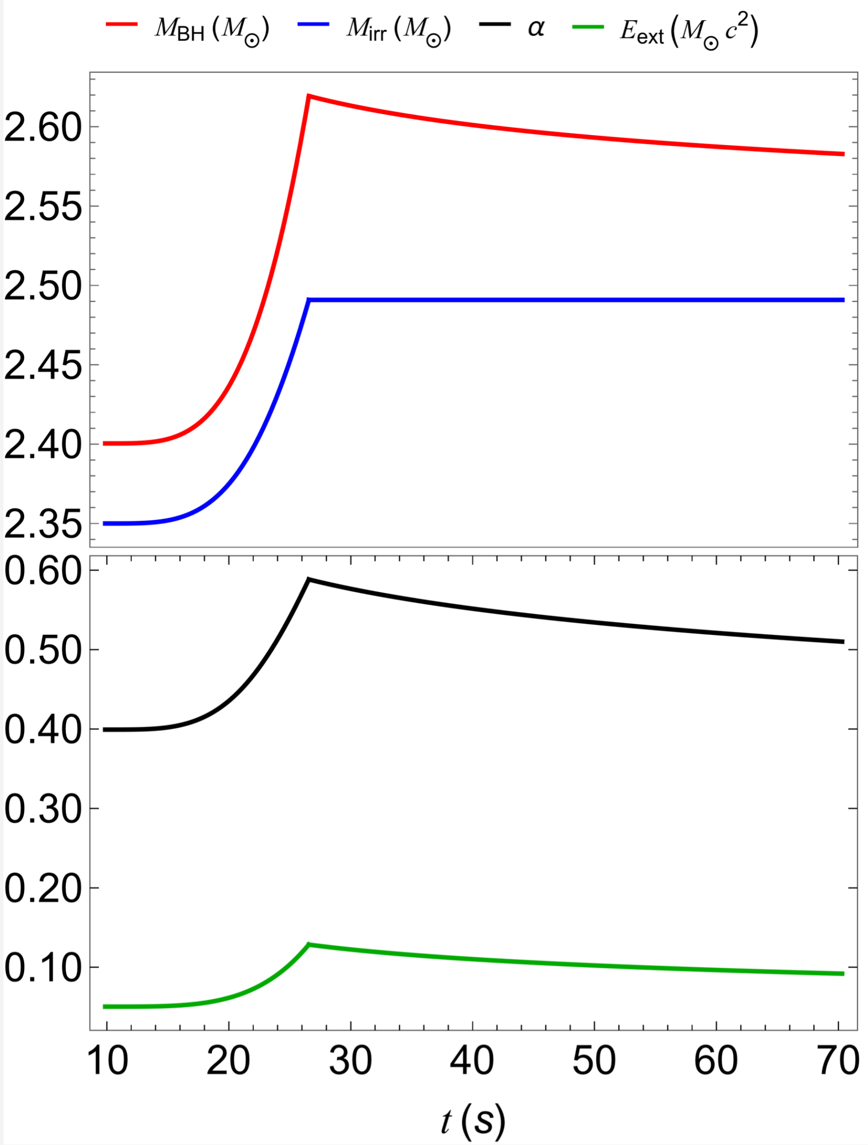
The panels show angular velocity, magnetic field, dipole luminosity, and released gravitational energy.



Newborn NS Spin-down Optical Fit

Optical emission fit powered by the spin-down energy of the newborn neutron star.

The upper panel shows the spin period evolution.



Black Hole Parameter Evolution

Black hole mass, irreducible mass, spin, and extractable energy during the GeV emission phase.

The evolution is shown for an initial irreducible mass of 2.35 solar masses, and total mass

$$M_{\mathrm{BH,220101A}} = 2.62 \pm 0.17\, M_\odot$$

From the data analysis of GRB 220101, we can infer that a massive magnetized binary of 10 solar masses with a magnetic field of 10^16 gausses, with initial zero angular momentum but surrounded by two binary companions composed of binary neutron star and a white dwarf can undergo gravitational collapse induced by the fast rotating binary companion, and generate the Homi-Bhabha supernova (HB supernova) which induces the UPE emissions of the GRB, as well as the collapse of the white dwarf core, creating a fast spinning millisecond neutron star at 1.46 second. The HB supernova ejecta accreting onto the companion binary neutron star originating a black hole of 2.6 solar masses. The interaction of the ejecta with the remnant gives origin to the observed X-ray emission with a characteristic spectrum of multi-wavelength rainbow emission from synchrotron mechanism.

Details will be given by Remo Ruffini, Jorge Rueda, Taghi Mirtorabi, Gregory Vereshchagin, Shurui Zhang and Yu Wang.

The X-Fermions and the Black Hole in Sgr A*

The same reasoning applied to the Sgr A* at the Galactic Center, with a mass of $4.61 \times 10^6\, M_\odot$

$$M_{\mathrm{SgrA}*} \simeq 0.384 \frac{M_P^3}{m_X^2}$$

leads to the X-Fermion mass

$$m_X \simeq 381\, \mathrm{keV}$$

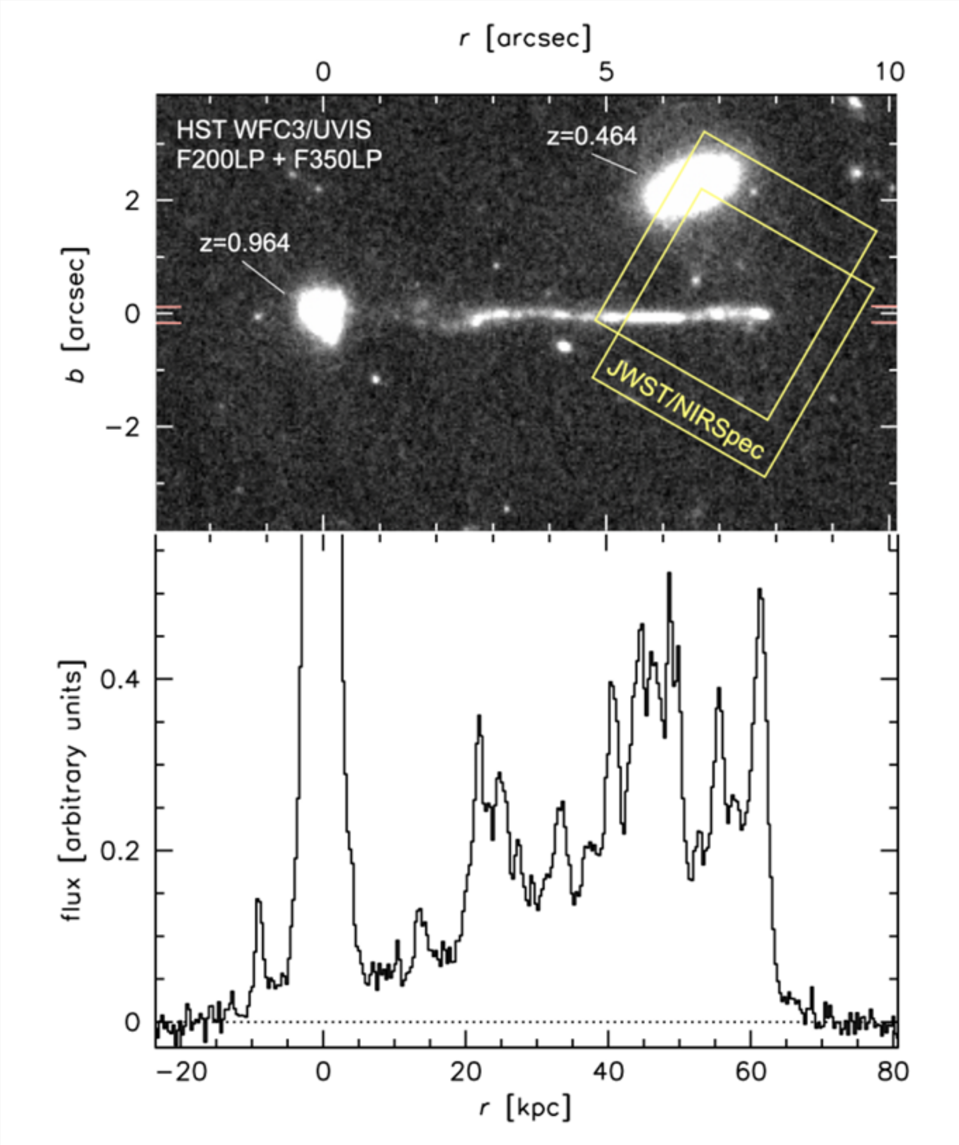
This results complete the final agreement of 50 years of contention of Charles H. Townes and Reinhard Genzel.

Indeed the central Sgr A* is composed of X-Fermion, consistent with the observational mass of $4.61 \times 10^6\, M_\odot$.

Is there any system in nature corresponding to this prediction?

The overwhelming evidence of this new component of dark matter self-gravitating X-Fermion may be found in the Little Red Dots (See presentation from Yu Wang) and in Jacob Bekenstein's prediction of ejection in binary mergers. And finally marvelous result obtained by two following two images.

Ruffini & Vereshchagin (2025), Eur. Phys. J. C 85, 753.

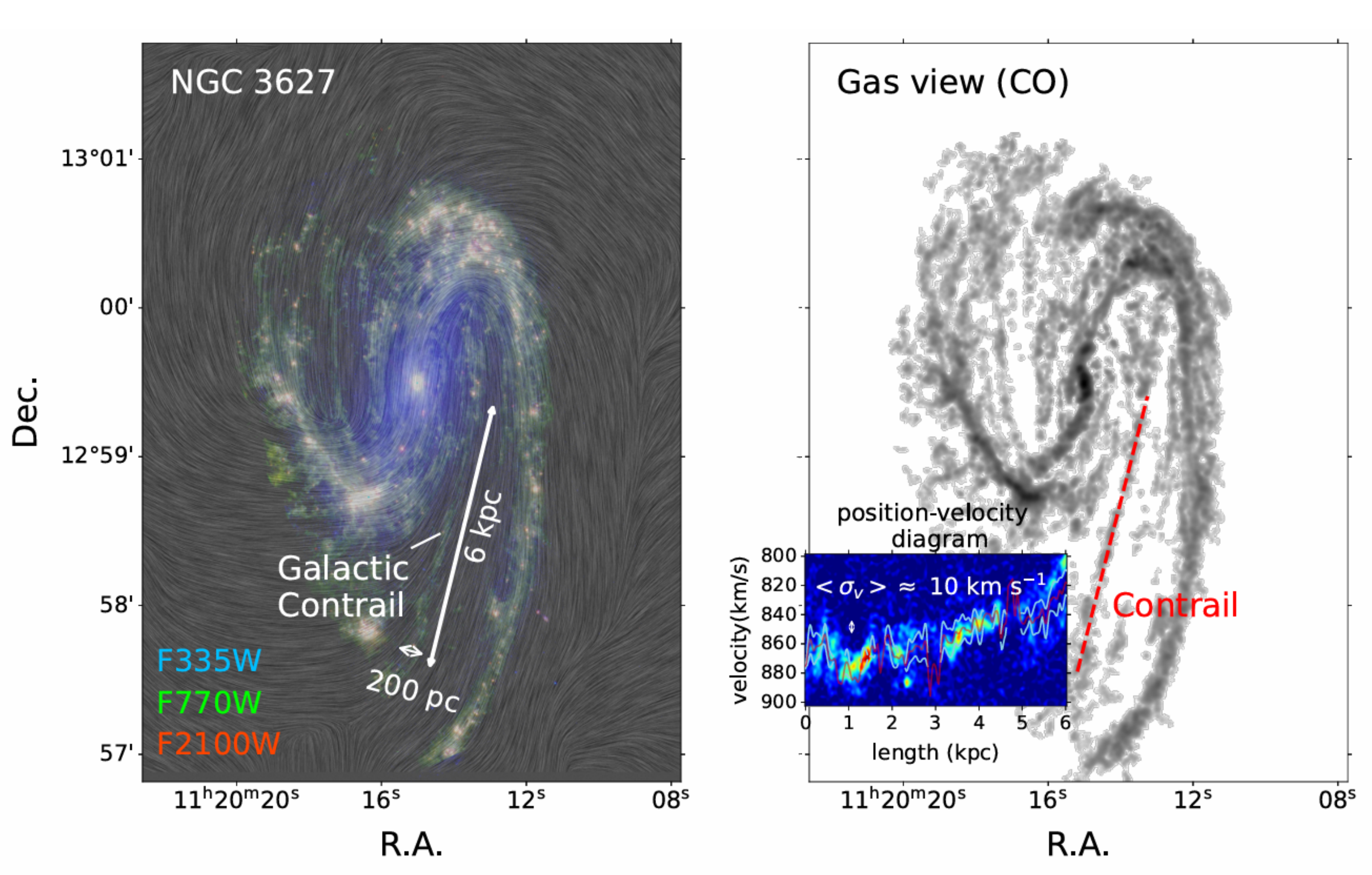


Runaway SMBH Wake RBH-1

JWST/NIRSpec confirms RBH-1 as a supersonic runaway SMBH at z = 0.96, powering a 62 kpc linear wake.

The HST image shows continuous emission from the host galaxy to the tip, followed by an abrupt flux drop that marks the shock-front region targeted by NIRSpec.

van Dokkum et al. 2026, JWST Confirmation of a Runaway Supermassive Black Hole via its Supersonic Bow Shock.



Galactic Contrail in NGC 3627

Zhao and Li identify a narrow molecular contrail in NGC 3627, at least 6 kpc long and about 200 pc wide, seen in JWST mid-infrared dust and PHANGS-ALMA CO(2-1).

It could be produced by the recent flyby of a compact massive object, either a dwarf galaxy nucleus or a wandering massive black hole with a mass of at least ~10^6 M⊙ moving at ≳300 km s^{-1} through the galactic disk.

Zhao and Li 2025,, Galactic Contrail in NGC 3627 caused by Dwarf Galaxy Candidate or Massive Black Hole Flyby.

In addition, many new systems introduced in this meeting by Yongquan Xue from USTC observed by their Wide Field Survey Telescope (WFST).

Only TWO fundamental particles, leading to the black hole mass. The neutron mass of baryon matter for black holes seen from gamma-ray burst; the X-fermion mass of dark matter for the mass of Sgr A* and little red dots.

How certain are we in front of dark matter? The prove comes from the X-ray emission from baryonic matter in Sgr A*, which is 10^{-3} of the mass of the black hole. We thank William Brandt, Roman Krivonos and Valentin Nezabudkin.

Details will be given by Remo Ruffini, Gregory Vereshchagin, Shurui Zhang and Yu Wang.

We thank Narek Sahakyan and his group for providing this splendid opportunity.

Yerevan, June 15, 2026