The most luminous FBOT AT2024wpp: unprecedented evolution in the X-rays and radio

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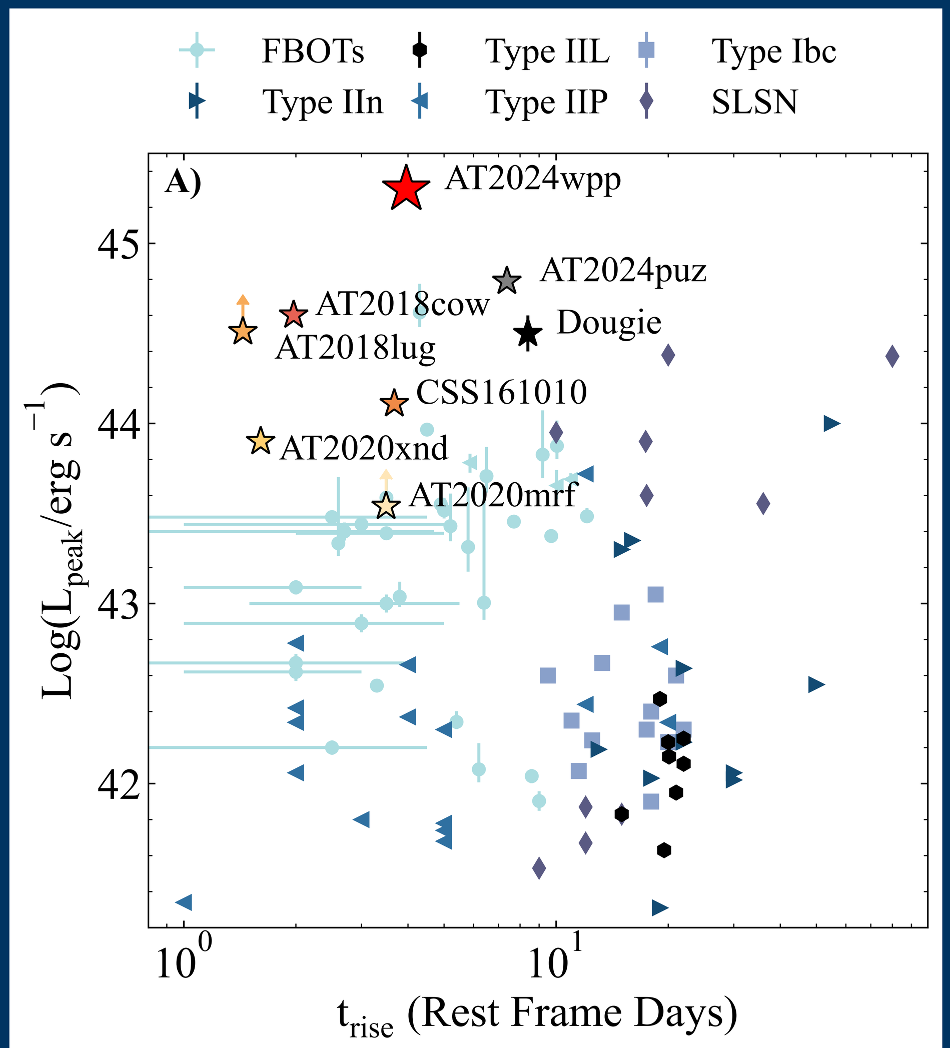
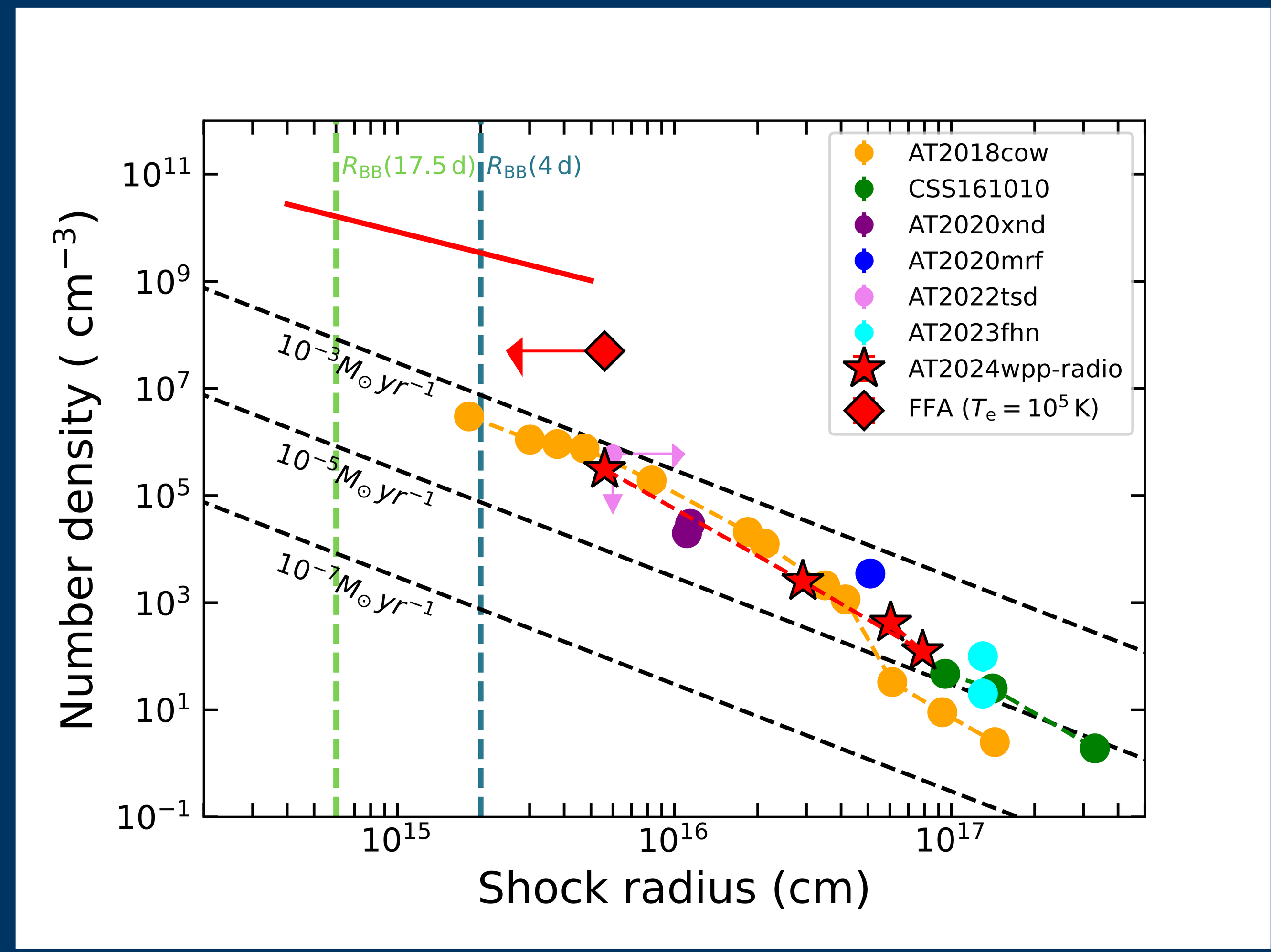
Fast Blue Optical Transients (FBOTs) are among the most energetic and short-lived transients, and their physical origins remain elusive. AT 2024wpp, discovered at z = 0.0868, is the most luminous FBOT (LFBOT) detected so far, reaching $L_{\rm pk} \gtrsim 10^{45}\,{\rm erg\,s^{-1}}$ and showing unprecedented spectral evolution in both the X-ray and radio bands. We present comprehensive broadband observations spanning 0.3–79 keV (Swift, Chandra, XMM-Newton, NuSTAR) and 0.25–203 GHz (GMRT, MeerKAT, ATCA, ALMA). The X-ray spectrum reveals a transient Compton hump and strong variability, consistent with emission from an embedded central engine shining through expanding ejecta. Multi-epoch radio spectra trace an accelerating ($\Gamma\beta c \approx 0.07$ to $0.42c$) synchrotron shock propagating through a steep circumstellar density profile ($\rho_{\rm CSM} \propto r^{-3.1}$). These results point to super-Eddington accretion onto a compact object launching mildly relativistic disk winds. Together, the X-ray and radio properties of AT 2024wpp provide one of the most complete pictures yet of the FBOT phenomenon, establishing it as a benchmark for studying engine-driven stellar explosions and their dense environments (Nayana et al. 2025).

AT 2024wpp



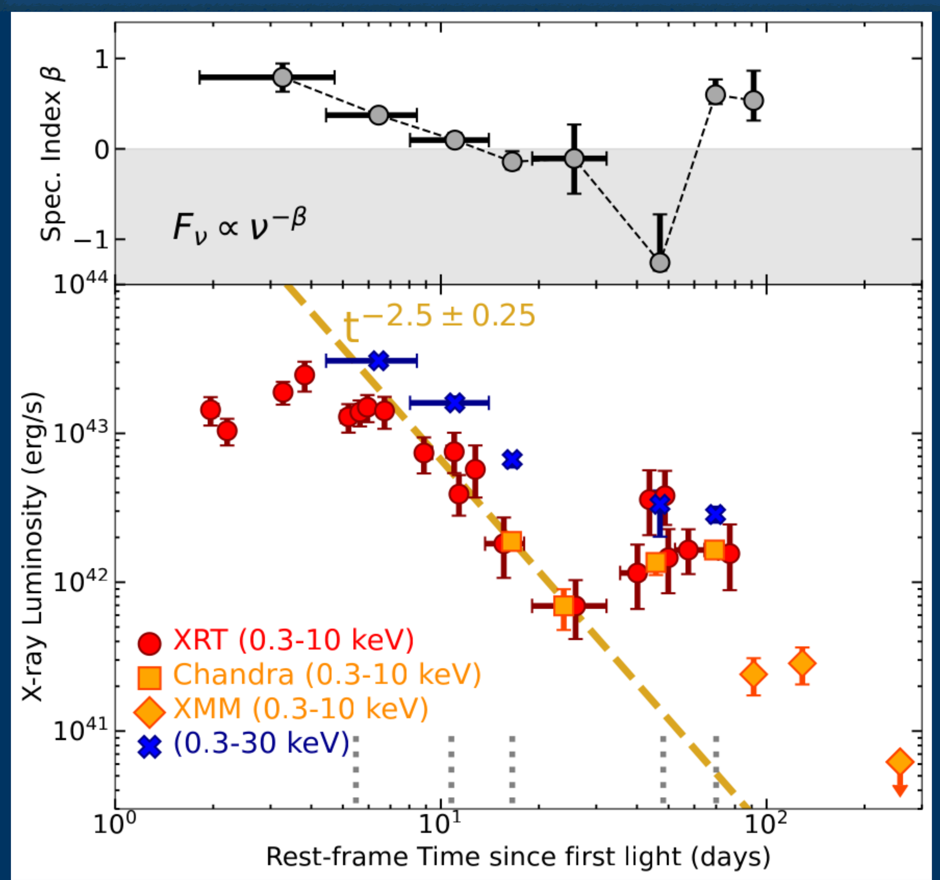
AT 2024wpp is the most luminous $L_{\rm pk} \approx (2-4)\times 10^{45}$ ergs member yet identified in the emerging class of FBOTs. Discovered on 2024 Sep 25 at z = 0.0868, AT2024wpp rose to an absolute magnitude of about –22. The UV-optical spectrum remains featureless and dominated by blue thermal continuum emission for weeks (LeBaron et al. 2025). The blackbody temperature at the optical peak is T ~ 30000 K and remains at $T \gtrsim 20000$ K for weeks. At $\delta t \approx 35$ days, faint H and He spectral features are detected. LeBaron et al (2025) also report evidence for an NIR excess of emission, which might be related to pre-existing dust or free-free emission in a high-density medium. We conducted detailed X-ray and radio observations to investigate its progenitor scenario, energetics, and environmental properties.

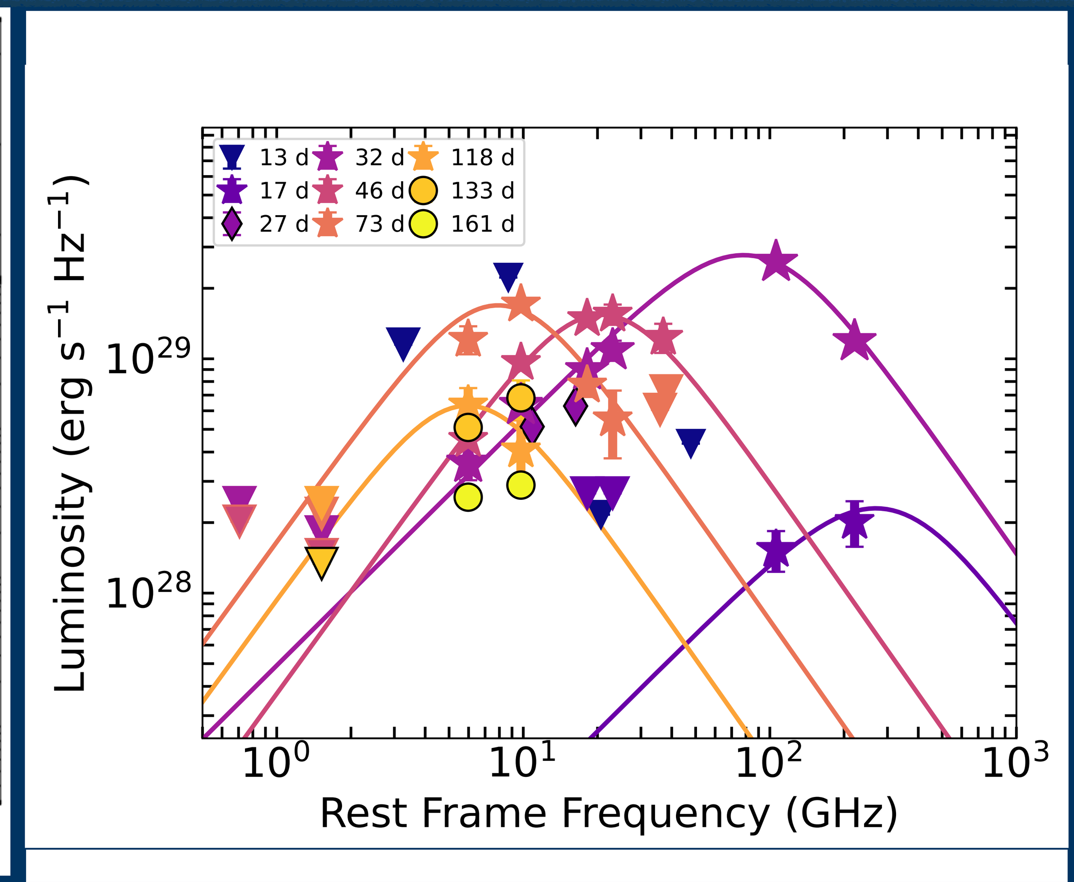
CSM densities



The inferred radio outflow velocities are $\Gamma\beta c \approx 0.07-0.42c$ at $\delta t \approx 32-73$ days. We interpret the radio SED evolution in a scenario in which the shock propagates through a dense shell of radius $\approx 10^{16}$ cm, then accelerates into a steep density profile of $\rho_{\rm CSM} \propto r^{-3.1}$ at $R \gtrsim 10^{16}$ cm. The environmental densities of all radio-bright LFBOTs are strikingly similar (shown in Fig), with $n \approx 10^{6}\,{\rm cm^{-3}}$ at $R \approx 10^{16}$ cm, and an approximate profile of $\rho_{\rm csm} \propto r^{-3}$ at $R \approx$ a few $10^{15}-10^{17}$ cm. These broadly similar CSM density profiles are likely manifestations of similar stellar evolution processes.

X-ray and Radio Observations

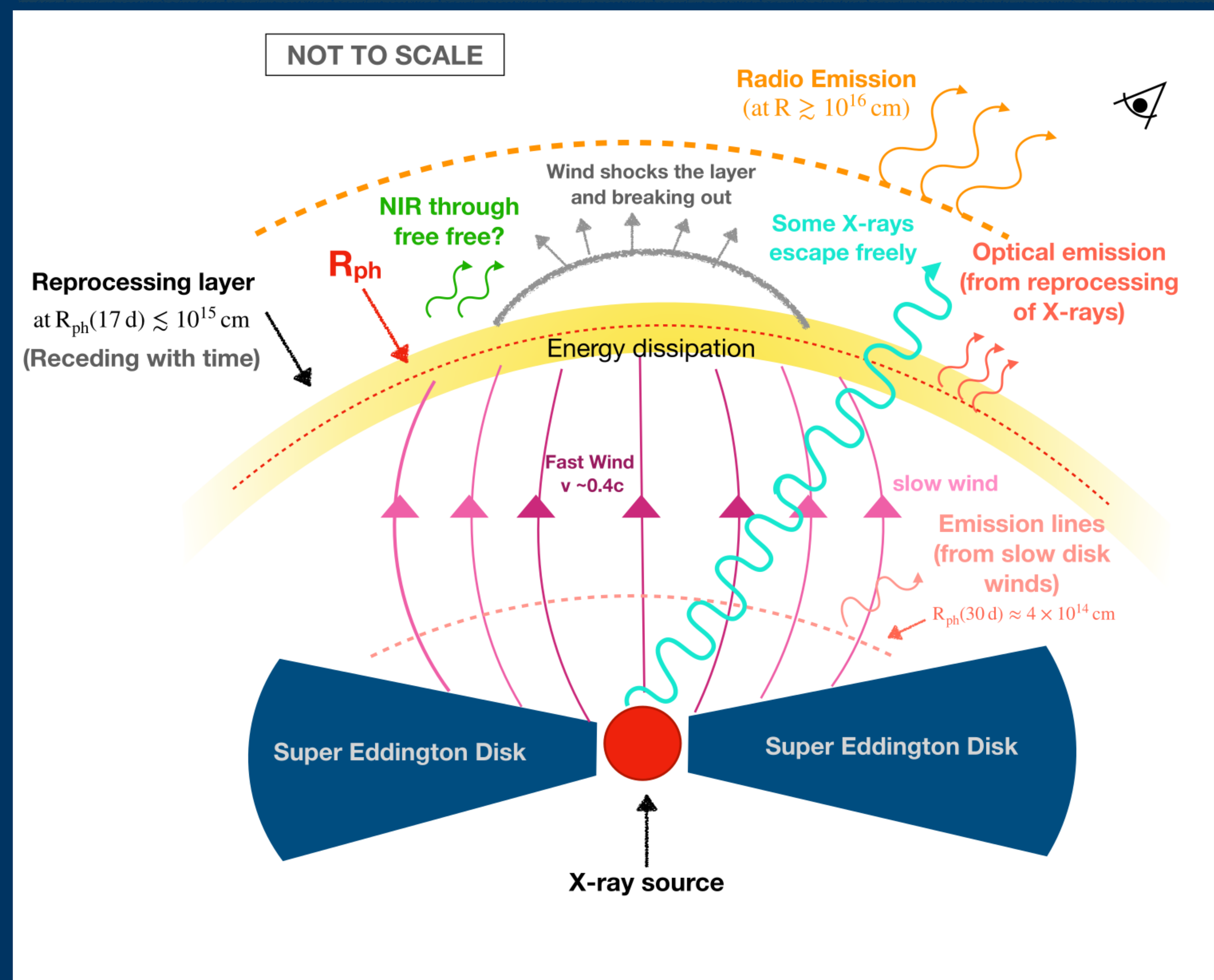




Left panel: X-ray light curves of AT2024wpp from combined Swift, Chandra, XMM-Newton, and NuSTAR observations. *Right panel:* Radio spectral energy distribution (SED) evolution from our near-simultaneous GMRT, MeerKAT, ATCA, and ALMA Observations.

AT 2024wpp exhibits luminous and highly variable X-ray emission with a Compton hump peaking at $\delta t \approx 50$ days. This indicates the gradual emergence of a central high-energy source through asymmetric expanding ejecta. In the radio, the flux densities rise rapidly at early times, reach a peak around 30 days after the explosion, and then decline gradually. The spectral peak shifts from higher to lower frequencies over time, consistent with an expanding and evolving synchrotron-emitting region.

Comprehensive Physical Picture



A Cartoon diagram showing the geometry of AT2024wpp and various emission components in the context of an engine-driven progenitor model. A Super-Eddington outflow onto a compact object drives powerful, anisotropic disk winds. X-rays are produced near the inner accretion region, and the interaction between the outflow and the surrounding dense circumstellar medium powers the observed radio emission. This framework naturally explains the combination of luminous, variable X-ray emission and the accelerating radio shock observed in AT2024wpp, along with the UV-Optical properties (LeBaron et al. 2025).