Variability of the Mg II 2798λ Emission Line during the 2017 Nonthermal Outburst in the Gamma-Ray Bright Quasar 1156+295

BOSTON UNIVERSITY

Melissa K. Hallum[1,*], Svetlana G. Jorstad[1,2], Valeri M. Larionov[2] (St. Petersburg U., Russia), Alan P. Marscher[1],

[1]Boston University, USA, [2]St. Petersburg University, Russia, *mhallum@bu.edu

Abstract

The quasar 1156+295 (4C 29.45, Ton599) underwent a dramatic nonthermal outburst in late 2017, with detection at energies > 100 GeV. The outburst was essentially simultaneous at gamma-ray and optical bands, indicating co-spatiality of the emission regions. We present multi-epoch optical spectra of 1156+295 obtained with the 4.3 m Lowell Discovery Telescope at various times, including the outburst period. We find that the flux of the Mg II 2798-Angstrom emission line, as well as blended Fe II lines at shorter wavelengths, increased with the optical synchrotron continuum with a delay less than 2 weeks. We interpret such a correlation within a scenario that the line-emitting clouds lie alongside the jet, well outside the canonical broad-line region. These extended polar clouds have the properties needed to be the source of seed photons that are scattered to gamma-ray energies.

This research was supported in part by NASA Fermi guest investigator program grants 80NSSC19K1504 and 80NSSC20K1565.

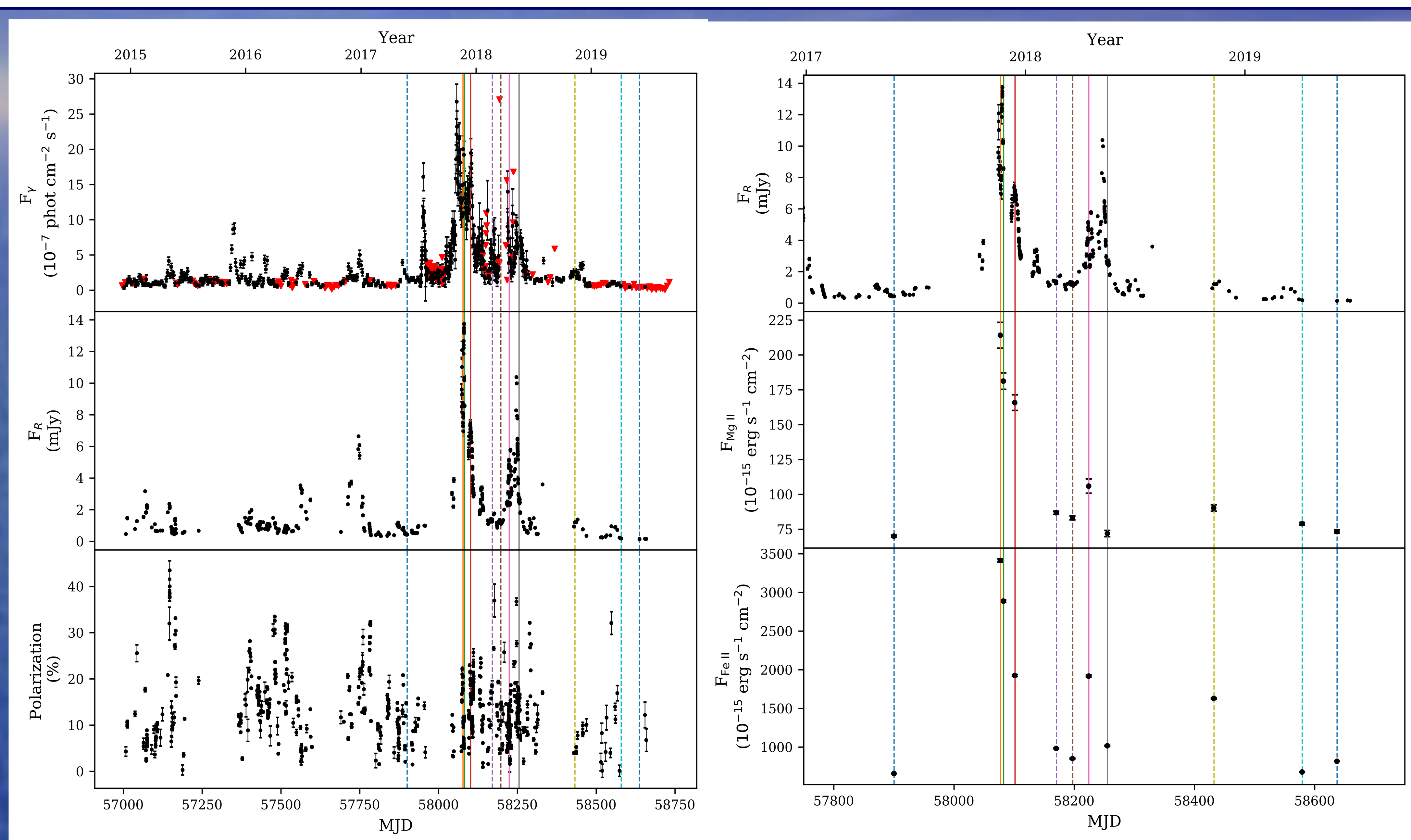

Fig. 1: (*left*) Gamma-ray flux light curve and polarization parameter curves of 1156+295 over observation period. The red triangles represent upper limits. The dashed colored lines correspond to dates corresponding to epochs of the spectral observations (see Fig. 2). (*right*) Optical flux density, Mg II 2798 flux, and Fe II flux light curves of 1156+295. Cross correlation analysis confirms a time delay of less than two weeks between the optical and gamma-ray light curves. This short time delay indicates that the source of the gamma-ray and optical emission are co-spatial.

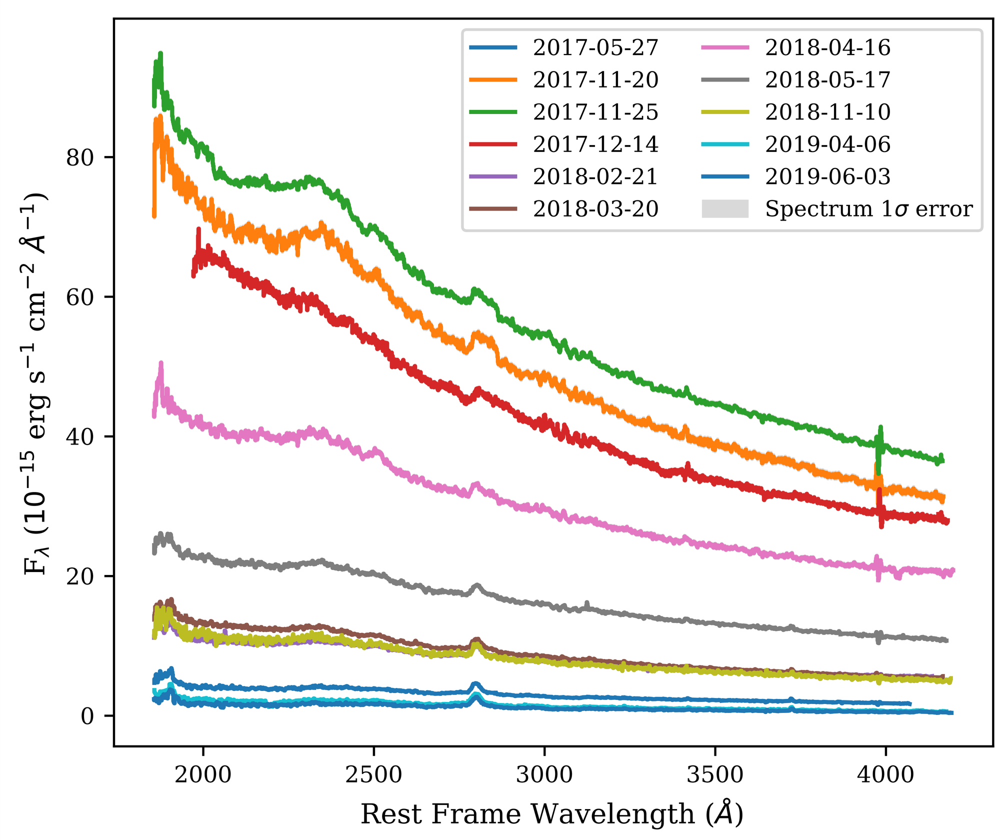

Fig. 2: The rest frame spectra of 1156+295 observed with the Lowell Discovery Telescope at the Lowell Observatory. Variability of the Mg II 2798 emission line is apparent.

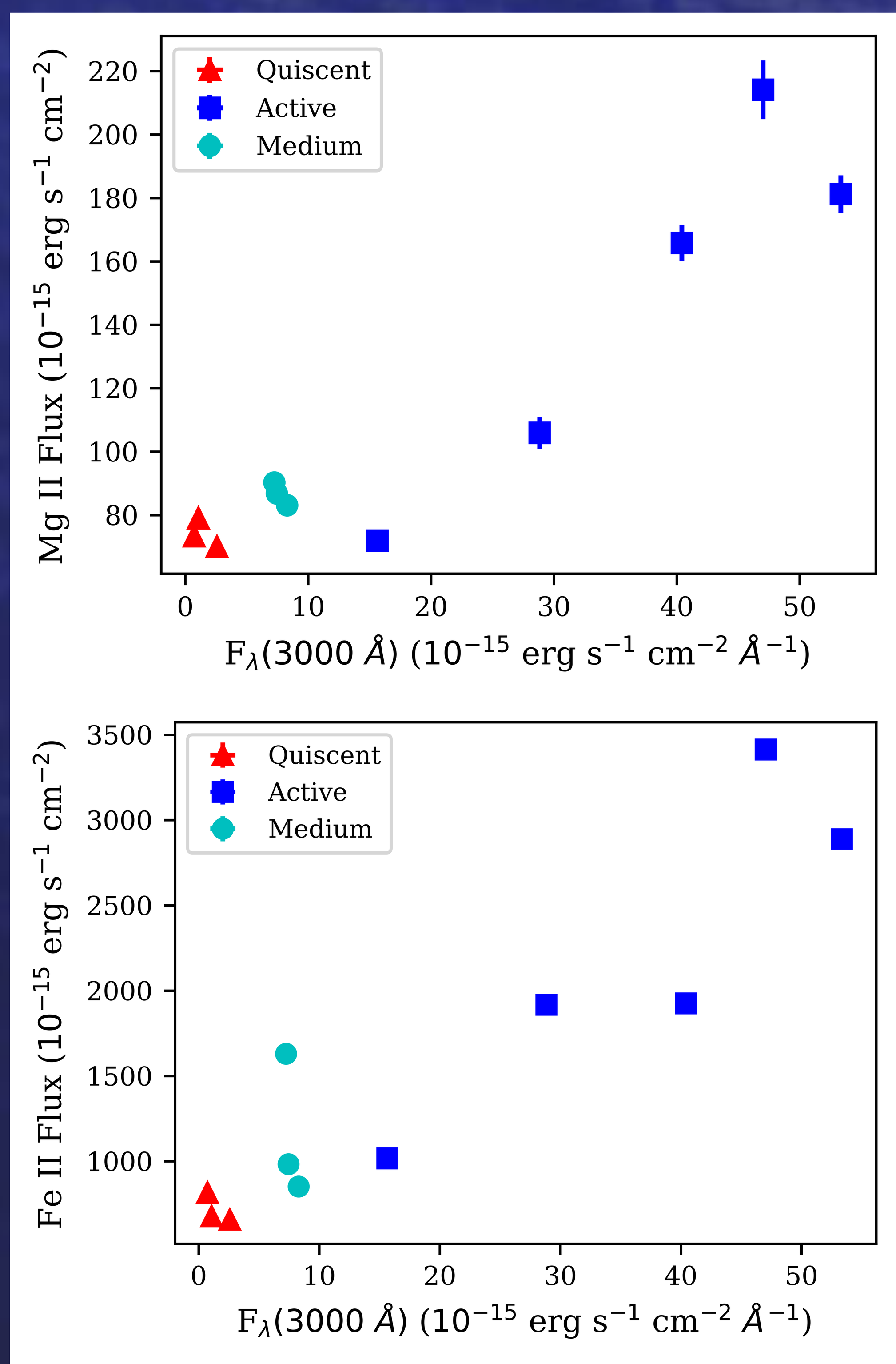

Fig. 4: (*top*) The flux of the Mg II 2798 emission line vs. the flux density of the continuum at 3000 Angstroms. (*bottom*) The same in the case of Fe II. The Mg II and Fe II emission both increase with the continuum, We thus conclude that the broad line region clouds producing the Mg II and Fe II lines are co-spatial with the source of the synchrotron continuum.

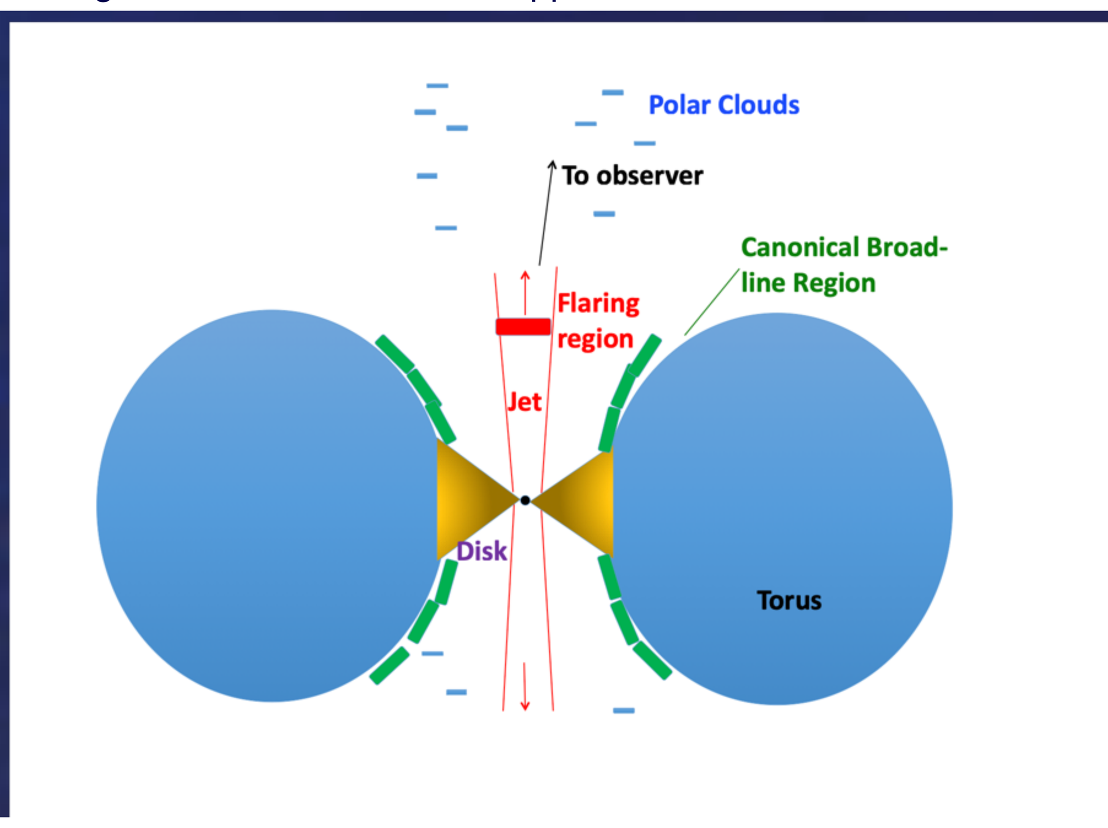

Fig. 5: A sketch of a model of a Blazar showing possible locations of its main components. The short time delay between the optical, gamma-ray, Mg II, and Fe II emission (see Fig. 1) indicates that the sources of each emission must be co-spatial.

Main Conclusion: Since gamma-rays cannot escape the inner parsec of the AGN due to pair-pair production, The clouds producing the emission must lie beyond the canonical broad line region. We therefore propose the possibility of broad line emitting polar clouds located beyond inner-parsec (see Fig. 5).

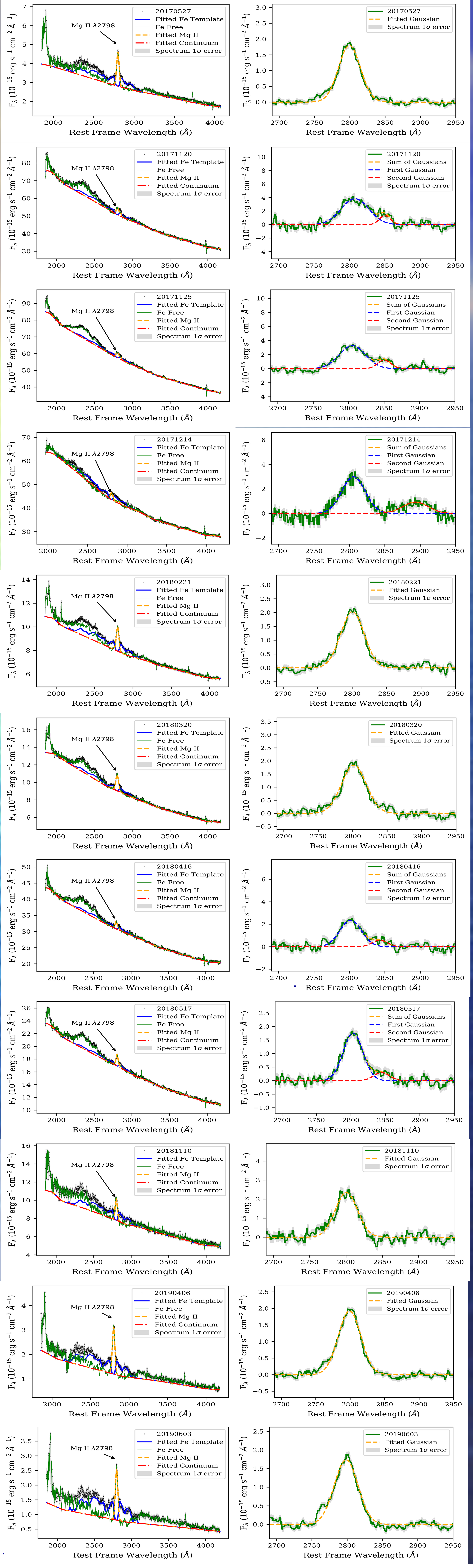

Fig. 3: *Left Column*: Each spectrum plotted with its fitted continuum, fitted Fe II complex template, and fitted emission line profile. The continuum was fit using the baseline removal algorithm described in Zhang, Z.-M., Chen, S., & Liang, Y. Z. 2010, The Analyst, 135, 1138. The Fe template was fit by broadening the template lines to 5000 km/s, then determining the best scaling factor using the Levenbrg-Marquardt least squares method in the Fe emission region near the Mg II line. *Right Column:* The continuum and Fe subtracted spectrum with one or two Gaussians fit to the Mg II 2798 emission line. At high flux states, a redwing of the Mg II becomes apparent and requires a two Gaussians fit. The presence of a redwing indicates a possible inflow.