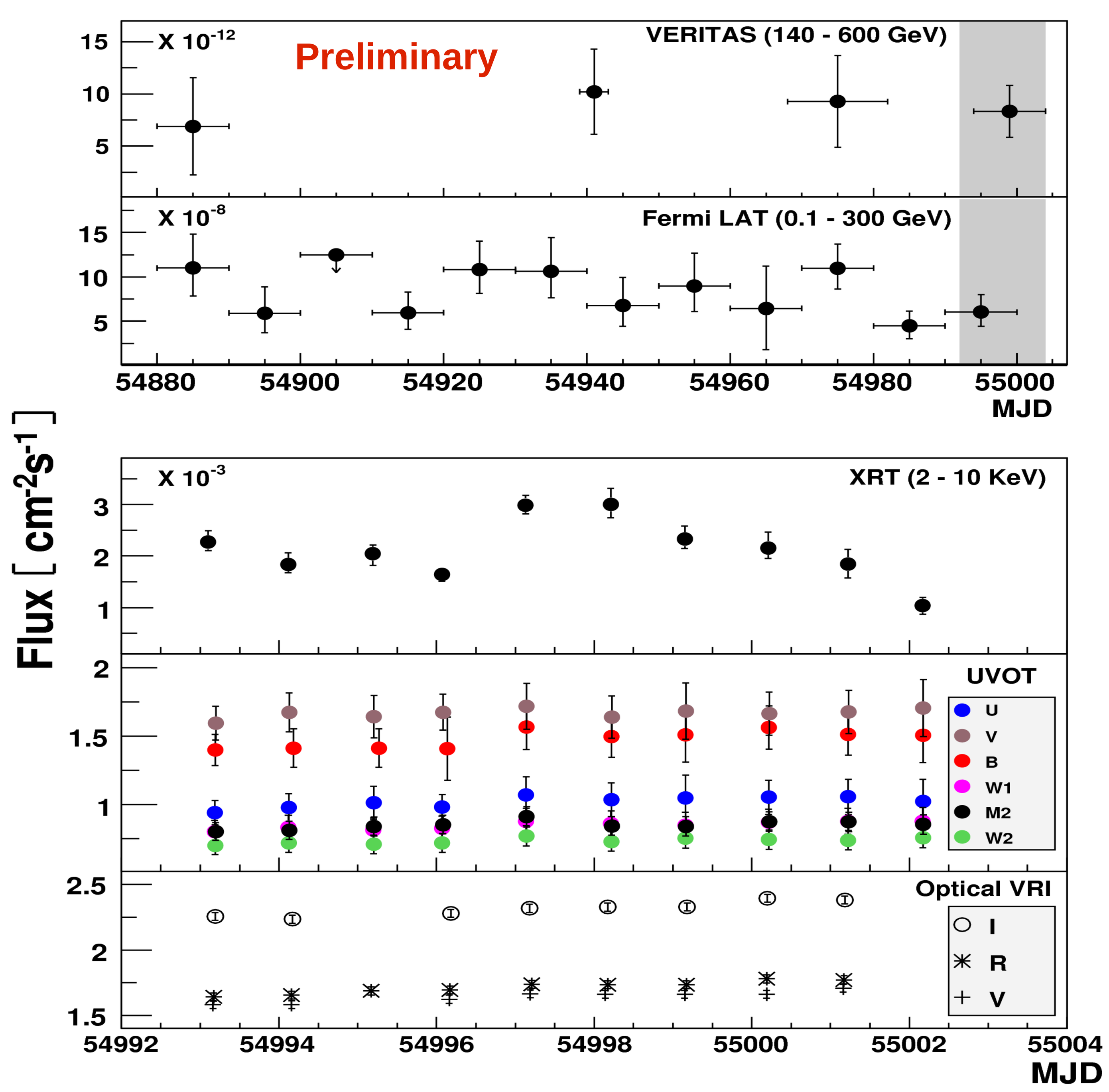
Fermi-Motivated Discovery of Very High Energy Emission from PKS 1424+240 by VERITAS

Amy Furniss for the VERITAS and Fermi LAT Collaborations

Results from contemporaneous multiwavelength observations and synchrotron self-Compton modeling of the PKS 1424+240 broadband spectral energy distribution

We report on the detection of the very high energy (E > 100 GeV) gamma-ray emission from the BL Lacertae object PKS 1424+240 by VERITAS and the study of the spectral energy distribution using additional data from Fermi-LAT and Swift. PKS 1424+240 is the first Fermi-motivated VHE discovery and was observed with VERITAS from February 19th through June 21st of 2009, after being selected from the Fermi Bright Source List as a promising VHE candidate. The observed integral flux above 140 GeV is 9.9 ± 3.9 X 10^{-12} photons cm^{-2} s^{-1} and shows no evidence for variability in the VERITAS data. Contemporaneous multi-wavelength data were obtained with Swift (X-ray & optical/UV), Fermi-LAT (MeV-GeV gamma-ray) and MDM (optical) during the VERITAS observations. The redshift of the object is unknown, with the spectral energy distribution (SED) described by a synchrotron self-Compton (SSC) leptonic jet model favoring a redshift of less than 0.4.

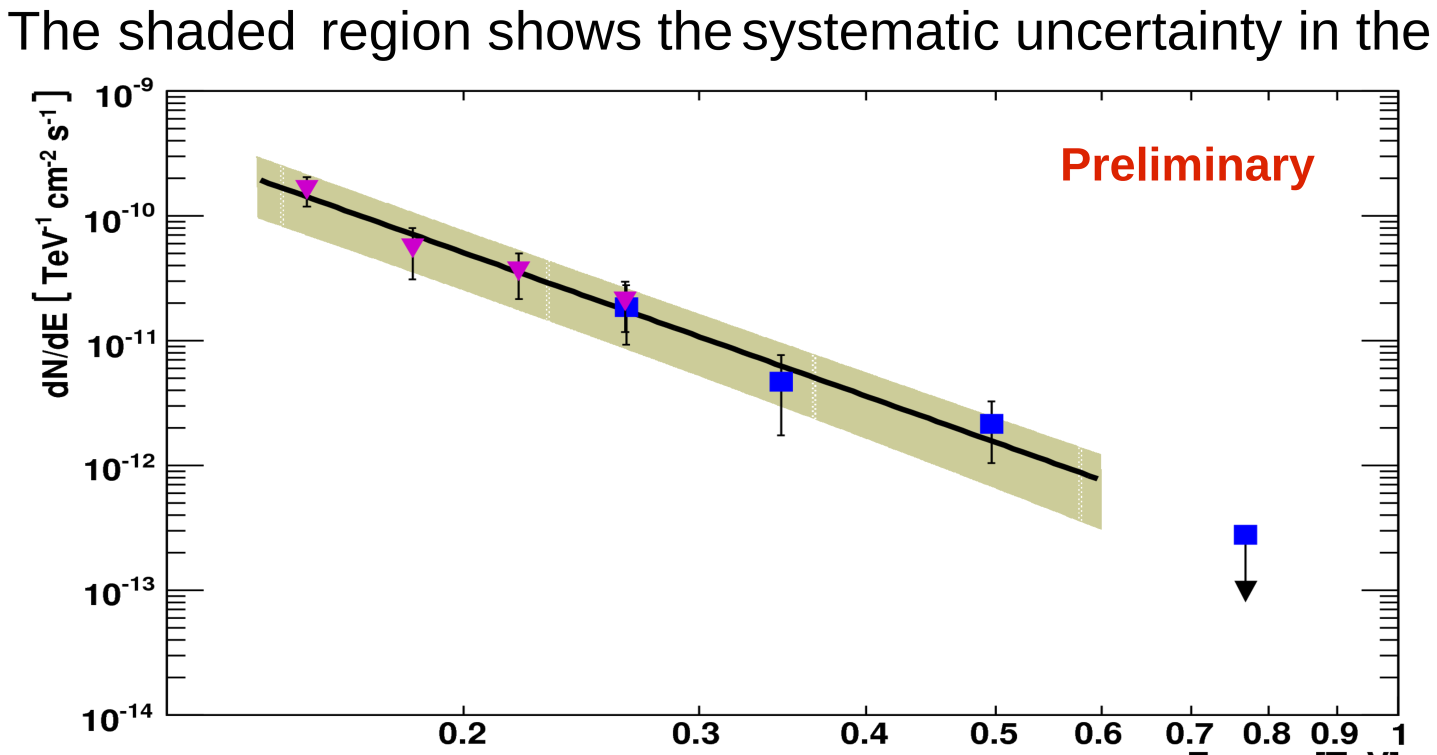
Multiwavelength Observations



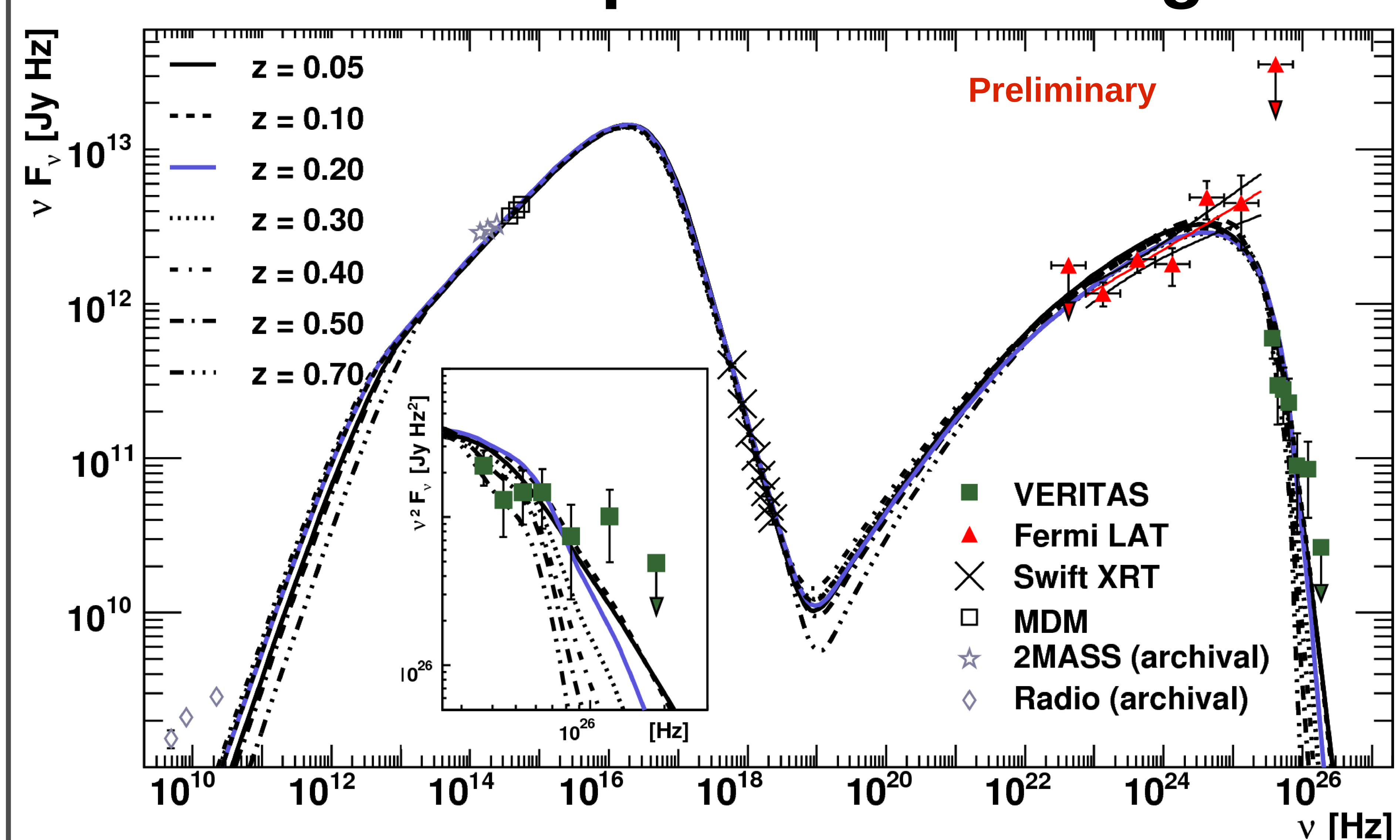
Light curves of PKS 1424+240 in VHE gamma rays (VERITAS), HE gamma rays (*Fermi*-LAT), X-rays (*Swift* XRT), UV (*Swift* UVOT) and optical (*Swift* UVOT, MDM). The X-ray, UV and optical light curves span the time represented by the shaded region in the VHE and HE plots. The hotizontal bars in the VHE and HE plots show the range over which the flux was integrated. The upper limit in the *Fermi*-LAT light curve is for 95% confidence.

VERITAS Results

Below: The time averaged differential photon spectrum of PKS 1424+240 measured during VERITAS observations. The triangles are from soft-cuts analysis optimised for objects with spectra softer than the Crab in the VHE range and the squares are from medium-cuts analysis optimised for Crab-like spectra. The flux point at 260 GeV agrees in both analysis. The solid line shows the fit with the powerlaw $dN/dE = F_o(E/E_o)^{-\Gamma}$ with Γ = 3.8 ± 0.5_{stat} ± 0.3_{syst} and F_o = (5.1 ± 0.9_{stat} ± 0.5_{syst}) X 10^{-11} TeV^{-1} cm^{-2} s^{-1} with E_o = 200 GeV. The shaded region shows the systematic uncertainty in the fit.



SSC Spectral Modeling



The broadband spectrum of PKS 1424+240 is shown above, where the lines show SSC-model fits to the data assuming different redshifts. The SED is modeled using an improved version (see [1]) of the leptonic one-zone jet model as described in [2]. All model fits are within the fast-cooling regime. The plot inset shows a $\nu^2 F_\nu$ representation of the VERITAS data fit clarity. The Fermi-LAT data are represented with a powerlaw fit and contour lines which represent one standard deviation of uncertainty. The upper limits correspond to a 95% confidence level.

Parameter	*z* = 0.05	*z* = 0.1	*z* = 0.2	*z* = 0.3	*z* = 0.4	*z* = 0.5	*z* = 0.7
L_e [10^{43} erg/s]	1.60	4.12	10.7	18.9	29.2	47.1	88.8
L_B [10^{43} erg/s]	1.66	5.47	16.9	31.1	45.9	49.8	66.2
γ_1 [10^4]	3.7	3.7	3.6	3.4	3.2	3.6	3.7
γ_2 [10^5]	4.0	4.0	4.0	4.0	4.5	4.0	4.0
D	15	18	25	30	35	45	60
B [G]	0.37	0.31	0.25	0.24	0.25	0.18	0.14
ε_B	1.04	1.33	1.59	1.65	1.57	1.06	0.75
R_B [10^{16} cm]	1.2	2.2	3.4	4.0	4.0	4.5	5.0

Table Above: Parameter fits are shown for the SSC model fits for various redshifts. We define L_e as the energy flux of electrons propagating along the jet and L_B as the Poynting flux derived from the magnetic energy density. γ_1 and γ_2 are the low and high energy cutoffs for the broken powerlaw electron distribution, respectively. D is the Doppler factor and B is the magnetic field within the electron population. ε_B is the magnetic field equipartition ($\varepsilon_B = L_B/L_e$) and R_B represents the size of the emitting zone. A redshift of less than 0.4 is favored by the model.

[1] Acciari et al. 2009, ApJ, in press; arXiv: 0910.3750
[2] Böttcher, M., & Chiang, J. 2002, ApJ, 581, 127

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