a: INAF – Osservatorio Astrofisico di Torino
b: Scuola Normale Superiore - Pisa

A curved jet model for the synchrotron emission of the BL Lac object PG 1553+113

C.M. Raiteri[a], A. Stamerra[a,b], M. Villata[a]
for the Whole Earth Blazar Telescope (WEBT) Collaboration.

http://www.oato.inaf.it/blazars/webt/

INTRODUCTION

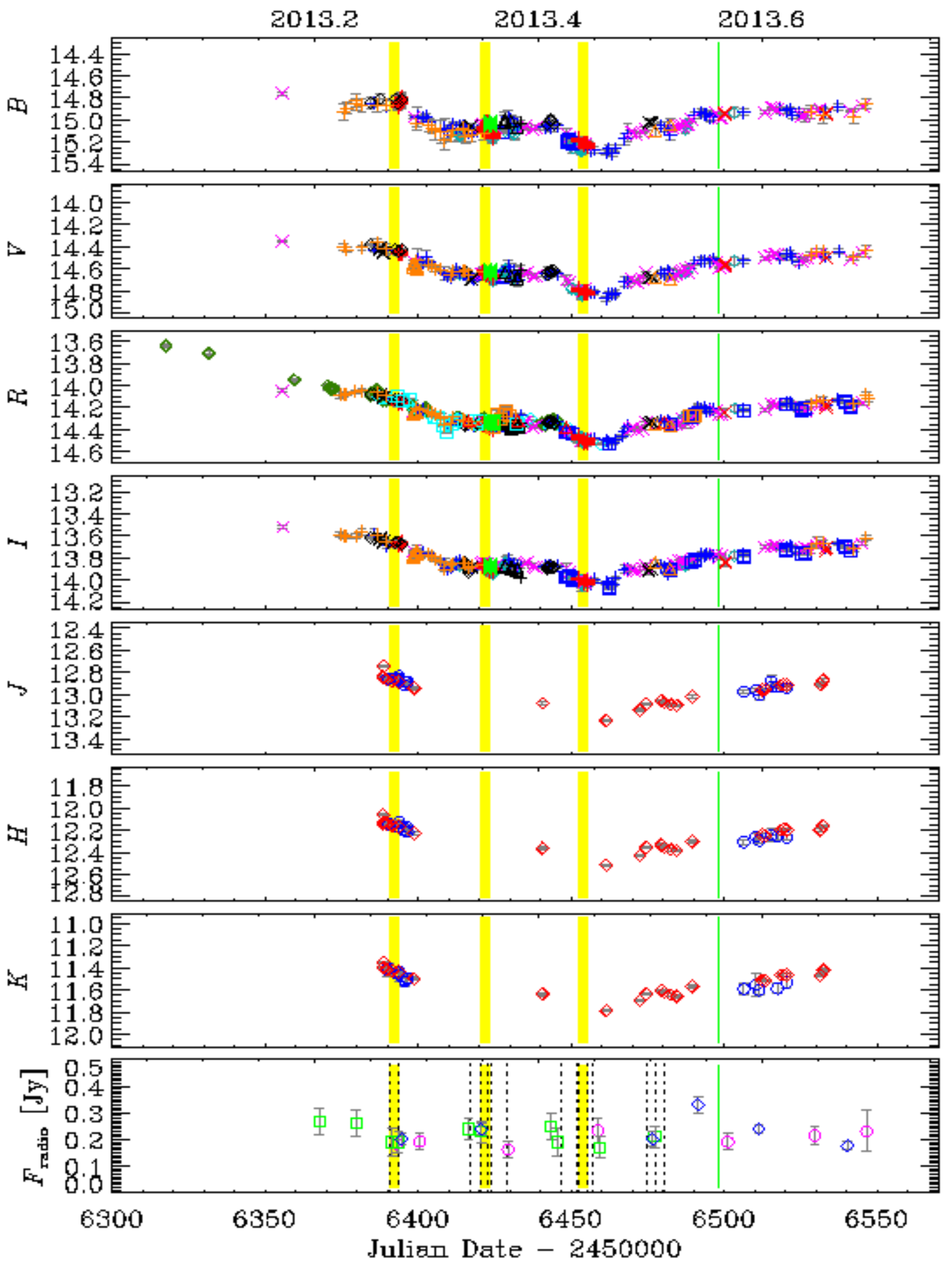
BL Lac objects, together with flat spectrum radio quasars, form the “blazar” class of active galactic nuclei. Their observed properties, such as strong variability at all frequencies, high and variable polarization, apparent superluminal motion of the radio components, are explained as due to beamed emission from a relativistic jet closely aligned with the line of sight.
PG 1553+113 is a high-energy peaked BL Lac (HBL), whose SED shows a synchrotron bump peaking in the UV and an inverse-Compton bump peaking at gamma rays. Its redshift is still unknown, but some observational evidences [1] set it around z ~ 0.5

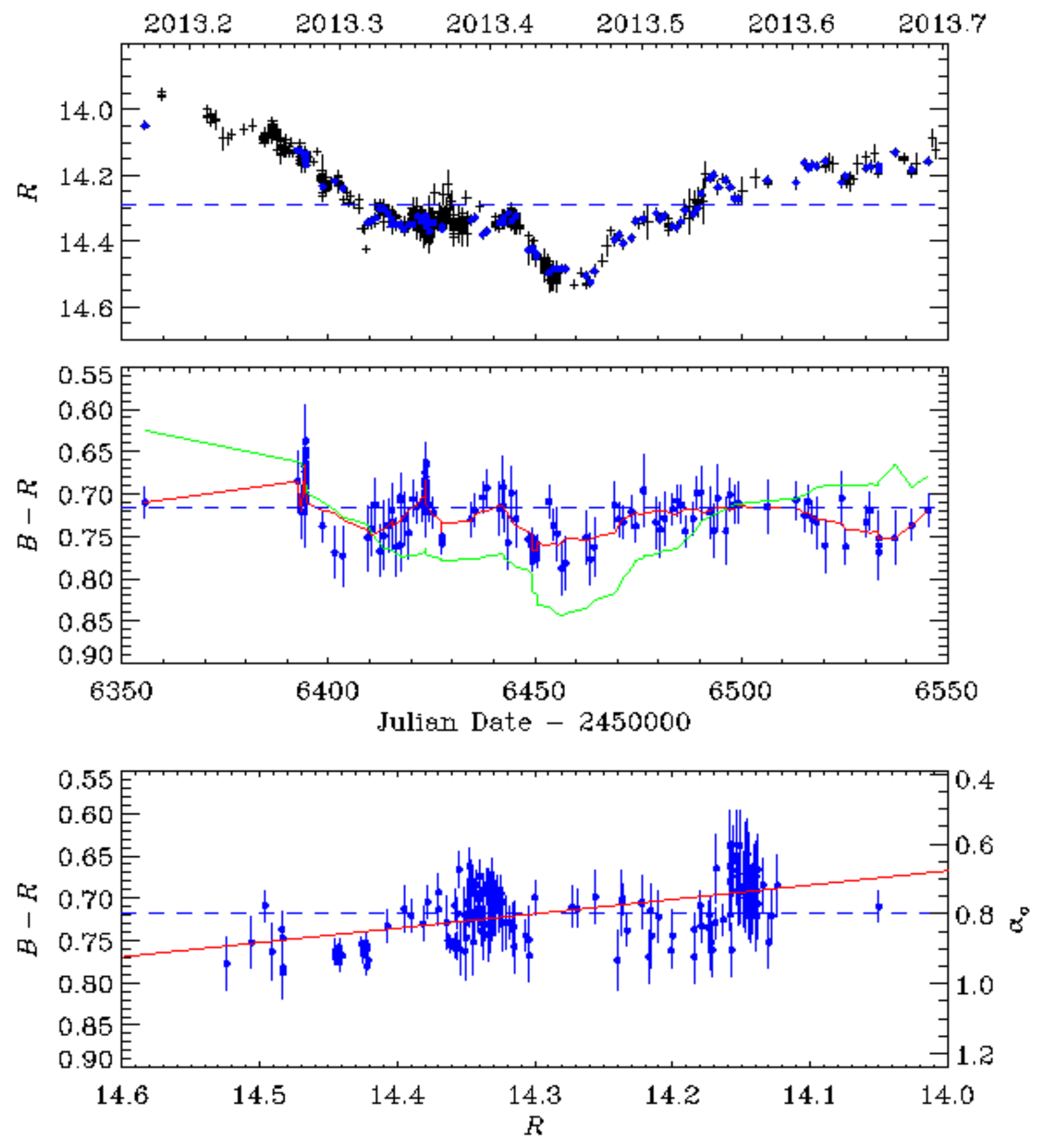
MOTIVATION

In 2013, **planned high-energy observations by MAGIC** in April, June and July [2] **triggered a multi-wavelength campaign by the WEBT Collaboration**. The results were published in Raiteri et al. (2015, MNRAS, 454, 353). Here we summarize the main results.

THE WEBT CAMPAIGN

The final light curves in the near-IR and optical filters are plotted in the figure on the right, where the yellow and green stripes mark the times of the MAGIC and XMM-Newton observations, respectively, and dotted lines those of Swift pointings.
The figure on the left shows a general **bluer-when-brighter optical trend**, which is typical of BL Lac objects.

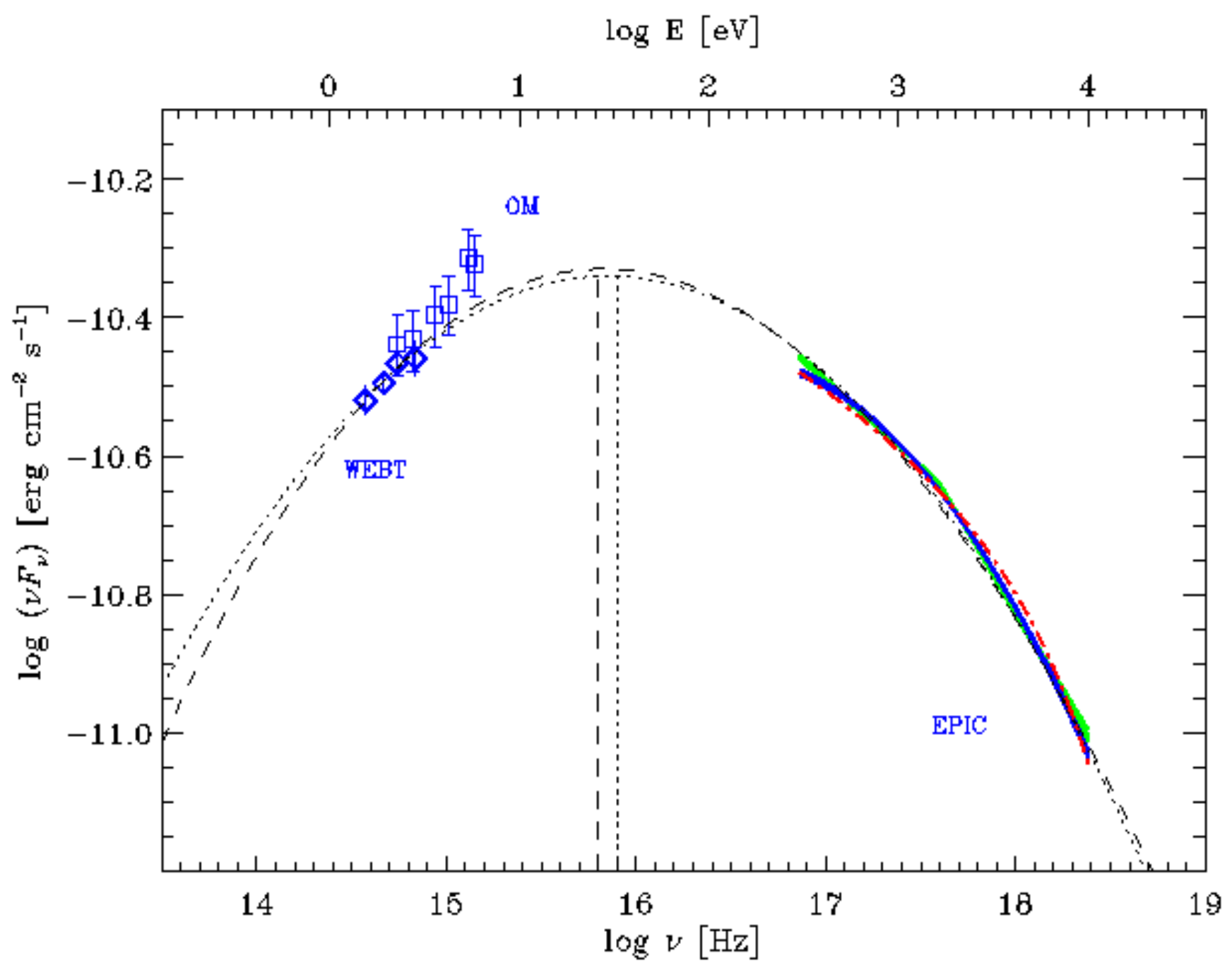




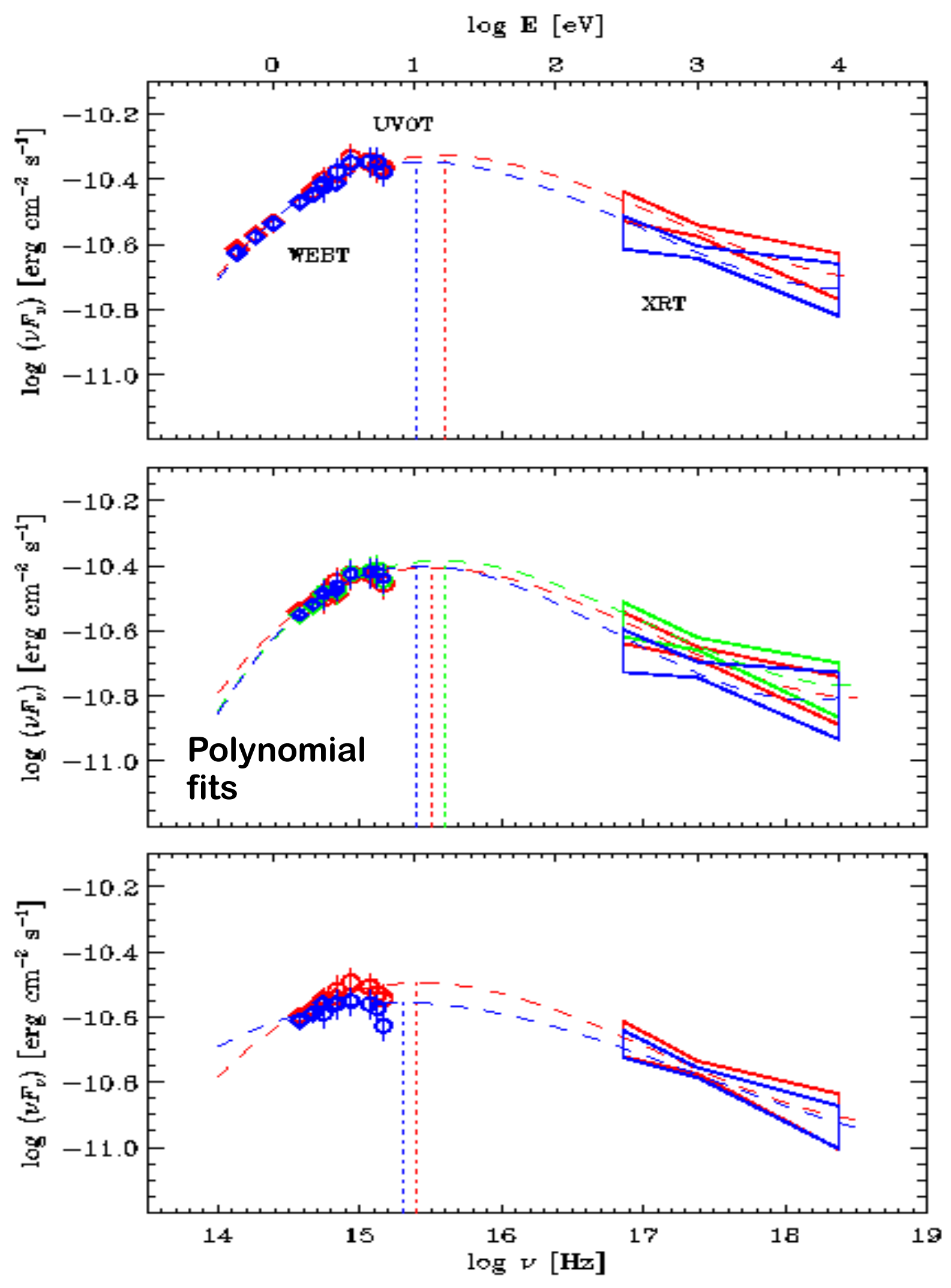
Optical observations were done with 19 telescopes in 17 observatories around the globe: Abastumani (Georgia), Belogradchik (Bulgaria), AstroCamp (Spain), Crimean (Russia), Michael Adrian (Germany), Mt. Maidanak (Uzbekistan), New Mexico Skies (USA), Plana (Bulgaria), Rozhen (Bulgaria), San Pedro Martir (Mexico), Siding Spring (Australia), Skinakas (Greece), St. Petersburg (Russia), Teide (Spain), Tijarafe (Spain), Valle d'Aosta (Italy), Astronomical Station Vidojevica (Serbia). In total, 3908 optical data points were collected in the BVRI bands.
In the ***infrared****, data were acquired at the Campo Imperatore (Italy) and Teide (Spain) observatories.*
Radio *data at 37 GHz come from the Metsahovi Observatory (Finland, green squares), at 43 GHz (purple circles) and 8 GHz (blue diamonds) from the Noto and Medicina stations in Italy.*

HIGH-ENERGY OBSERVATIONS

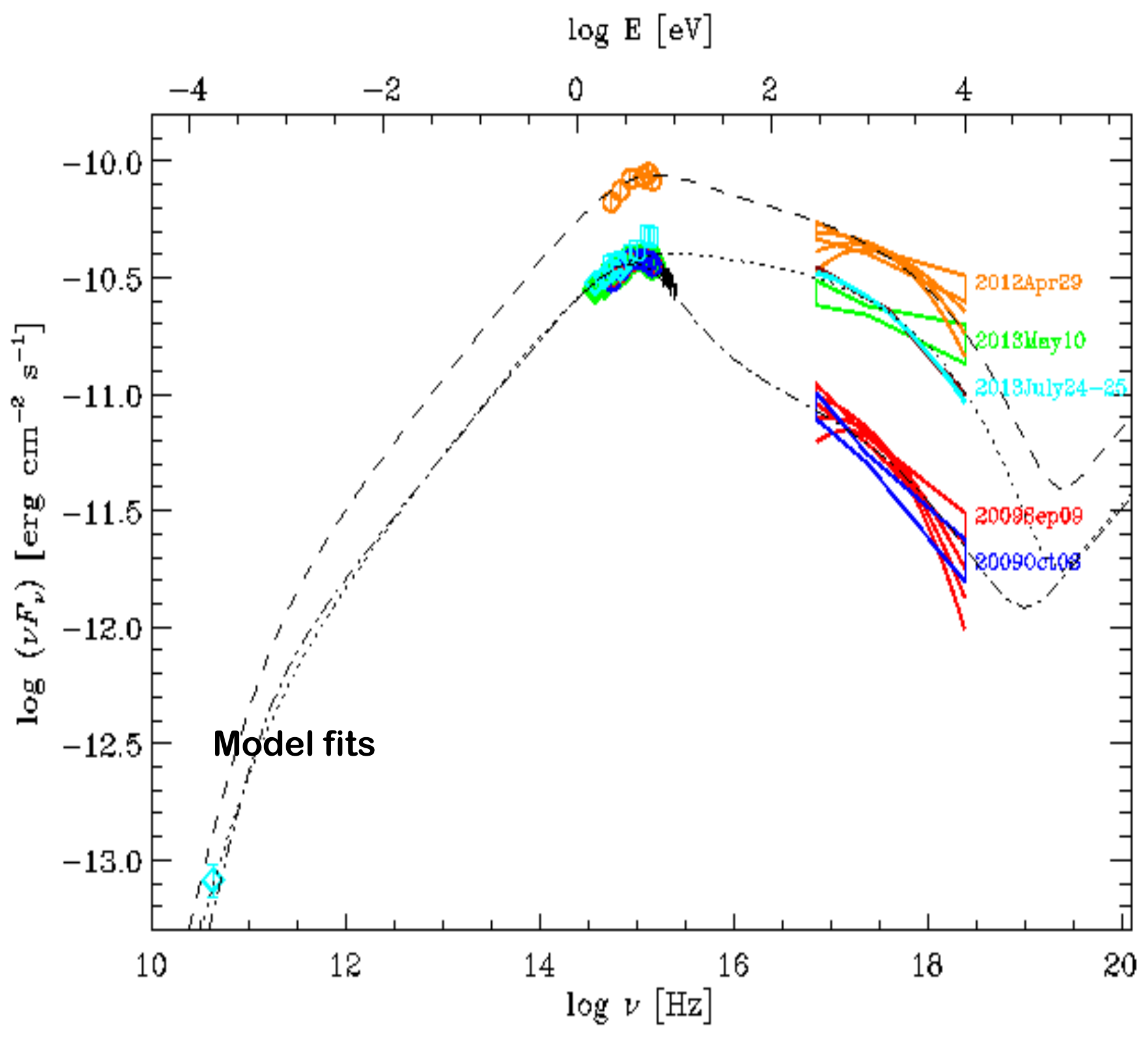
The SEDs built with WEBT and **Swift data** in the periods of MAGIC observations **show an optical-UV concave spectrum** (right) whose connection with the corresponding X-ray spectrum requires an inflection point.



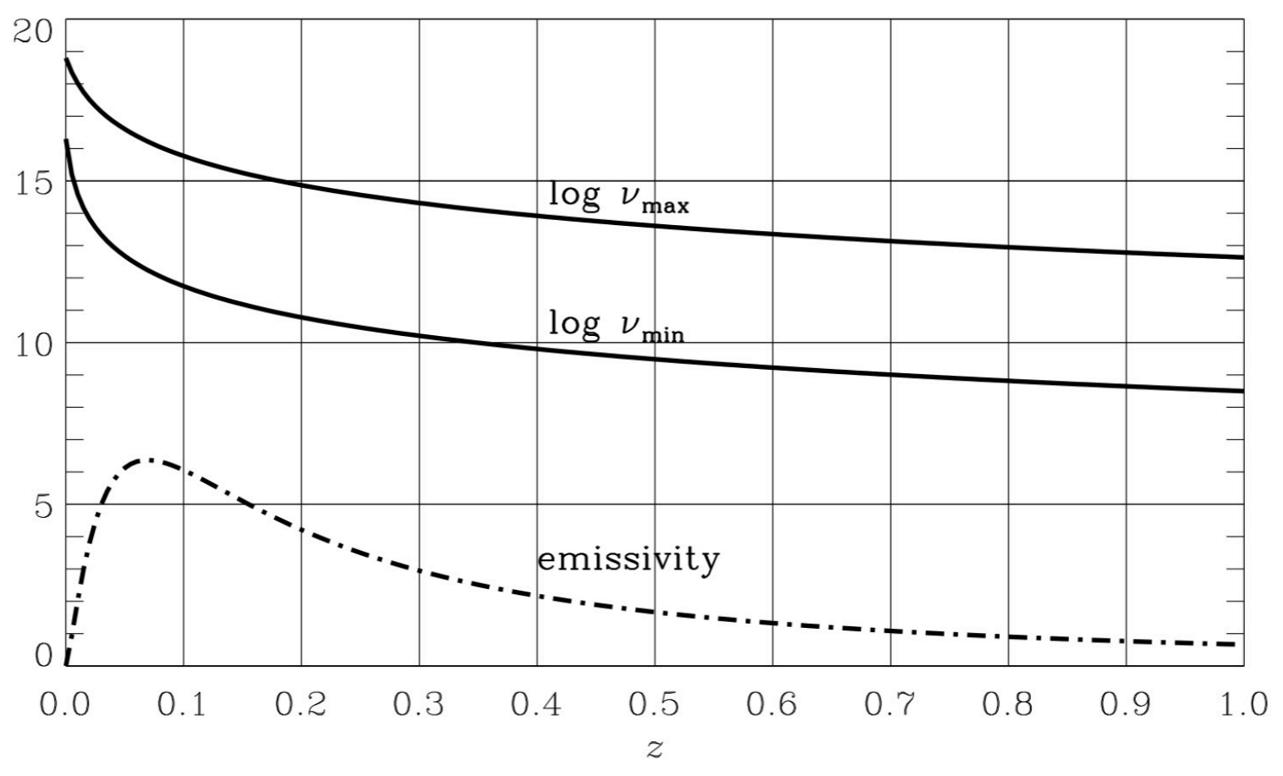
The Swift data have not enough statistics to investigate the presence of a spectral curvature in the X rays. **In contrast, the optical-UV spectrum derived from the XMM-Newton data is flat**, and the X-ray spectrum is clearly curved (left).
To clarify the issue we looked for other optical-UV and X-ray data. In particular, we found an HST-COS spectrum acquired in 2009 September 22, in between two Swift observations in 2009 September 9 and October 3. **The HST-COS data** (black points in the SED shown in the bottom panel, left figure) **confirm the optical-UV spectral curvature shown by the Swift data.**
Different brightness states of the source are characterized by different ratios between the optical-UV and the X-ray fluxes .

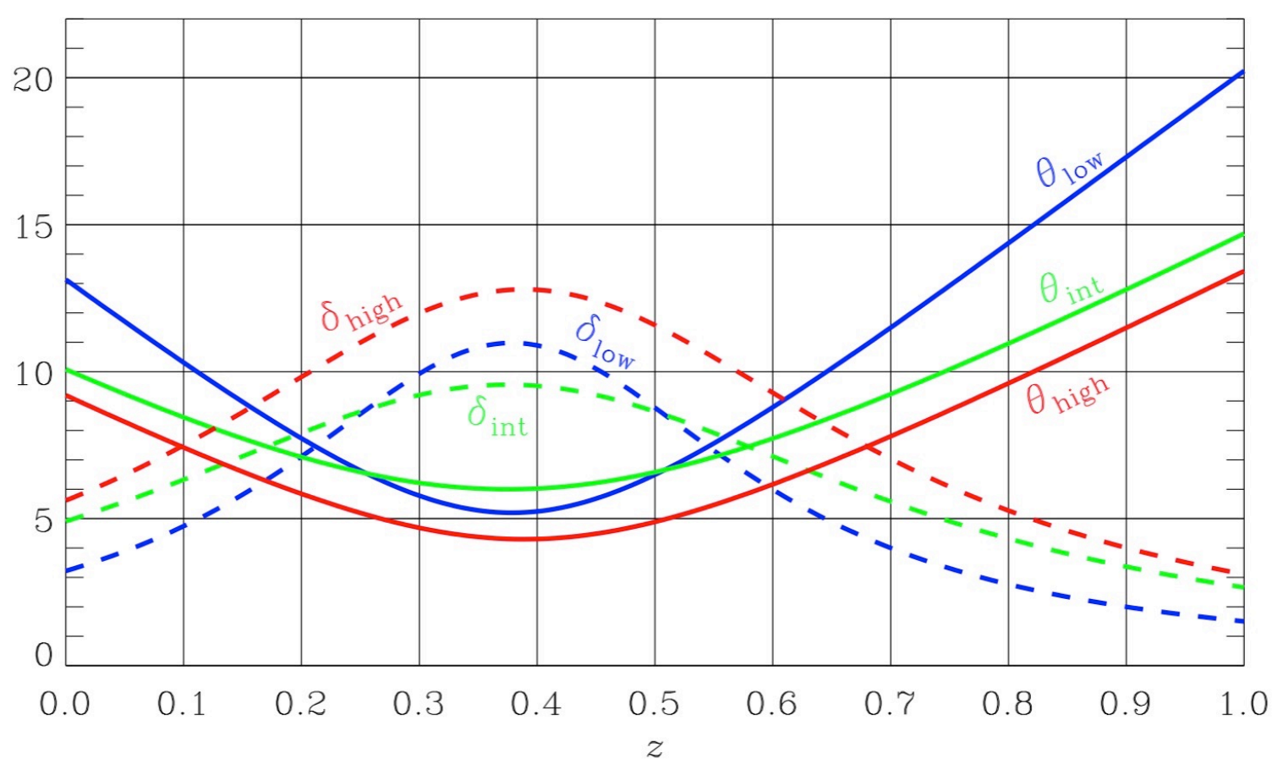


SED INTERPRETATION



We interpreted the SED behaviour in terms of the helical jet model by Villata & Raiteri (1999, A&A, 347, 30). The jet is inhomogeneous, i.e. synchrotron radiation of decreasing frequency is emitted from jet regions at increasing distance from the jet apex, which have different angles and thus different Doppler factors.
In the right figure we show the trend of the maximum and minimum emitted frequencies and that of the emissivity (arbitrary units) as a function of the distance z along the helical jet axis.
We also plot the viewing angle theta and Doppler factor delta along the jet axis for the three fits to the source SEDs shown in the left figure. **The three different fits were obtained by changing only the three parameters defining the jet orientation.**
This suggests that the jet geometry can play a major role in determining the jet emission behaviour.





References:
[1] Danforth et al., ApJ, (2010), 720, 976
[2] G. Hughes et al. (MAGIC Collaboration), 28th Texas Symposium - Geneve, (2015)
[3] Villata & Raiteri, A&A, (1999), 347, 30.
This work: Raiteri et al., MNRAS, (2015), 454, 353

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