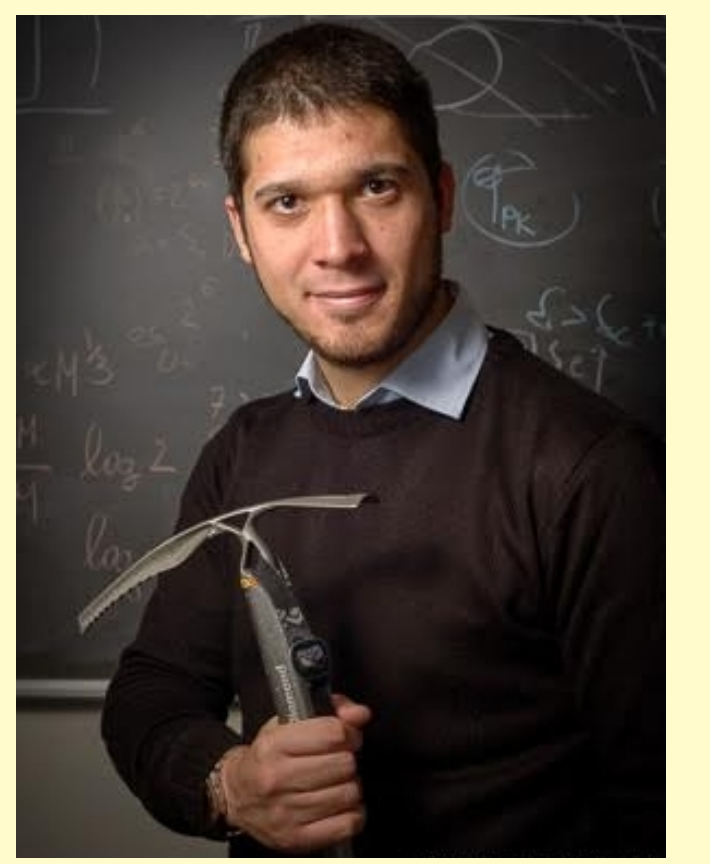




TeV-candidate extreme blazars among Swift-BAT sources

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Abstract

Blazars spectral energy distributions are dominated by non-thermal emission from the jet, consisting of two main bumps. For the so-called extreme blazars (EHLs), these components each peak in the X-ray and GeV-TeV bands. Recent TeV observations have revealed a few of these objects whose second peak exceeds several TeV (e.g. 1ES 0229+200). Such intriguing sources have been objects of different studies regarding the contribution of lepto-hadronic processes to their emission mechanism, the possible origin of extragalactic high-energy neutrinos, the implications of their TeV spectra on the extragalactic background light indirect estimates, and the intergalactic magnetic field measurements. In order to increase the number of TeV EHLs, we developed a criterium in order to select good EHL candidates. Our sample is composed of six EHL detected both in the hard X-ray band by the Swift-BAT telescope and in the high-energy band by the Fermi-LAT telescope, each of them not yet detected in the TeV band. We provide a multi-band study of their spectral energy distribution, discussing their potential detectability by the current and next generations of TeV gamma-ray telescopes.

Extreme blazars

- Emerging class of BL Lac objects (EHL, Extremely High-peaked BL Lac objects)^[1] characterized by
 - synchrotron emission peaking in the **X-ray band** (exceeding 10^{17} Hz)
 - gamma-ray emission in the **GeV to TeV** range
- Standard leptonic emission models require extreme parameters
- Cosmological probes for their implications on
 - indirect measurements of the extragalactic background light (EBL)
 - the intergalactic magnetic field estimate
- Important targets for their relation with **cosmic-rays physics** as possible origin of extragalactic high-energy **neutrinos**^[3,4]
- Few sources have been characterized as TeV-detected EHLs: the main archetypal is 1ES 0229+200

We propose a list of **new EHL candidates** and discuss their potential detectability by the current and next generations of TeV gamma-ray telescopes.

Method

- EHL synchrotron peaks should be well detected in the medium and hard X-ray band, but rather faint in the *Fermi*-LAT domain
- The selection of EHL candidates is based on a sample of blazars with a firm detection in the **Swift-BAT 70-months survey**^[5].
- In this work, both **Fermi-LAT 3LAC**^[6] detected and undetected sources were considered.
 - *Fermi*-LAT **detected** sources are good candidates given the high synchrotron peak location and their good spectral extrapolation in the HE range.
 - *Fermi*-LAT **undetected** objects, instead, are particularly relevant because the second peak could lie completely in the VHE γ -ray band for very extreme objects.

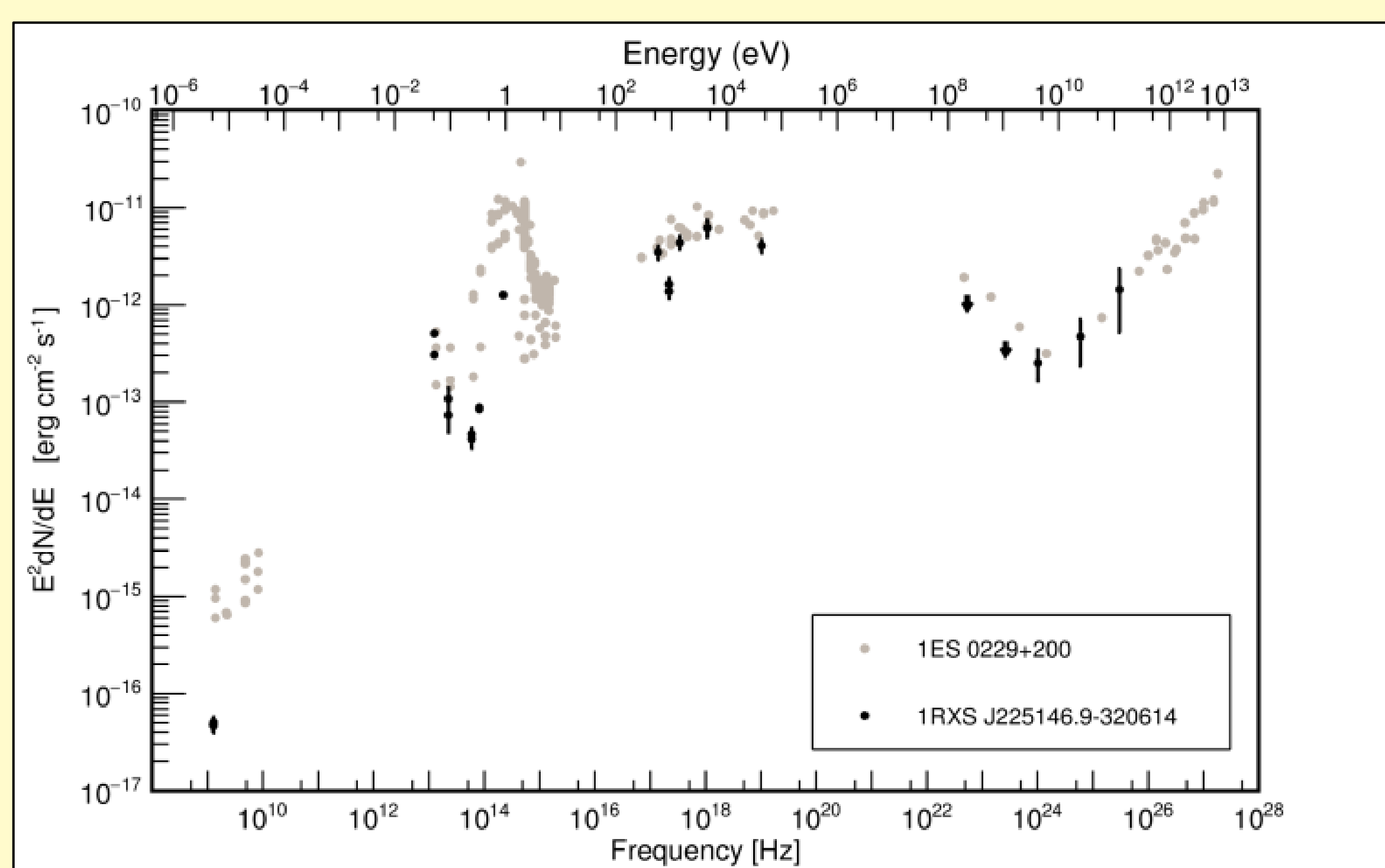


Figure 2
Multiwavelength archival data and nine-years *Fermi*-LAT analysis of 1RXS J225146.9-320614 (black) with respect to 1ES 0229+200 (grey).

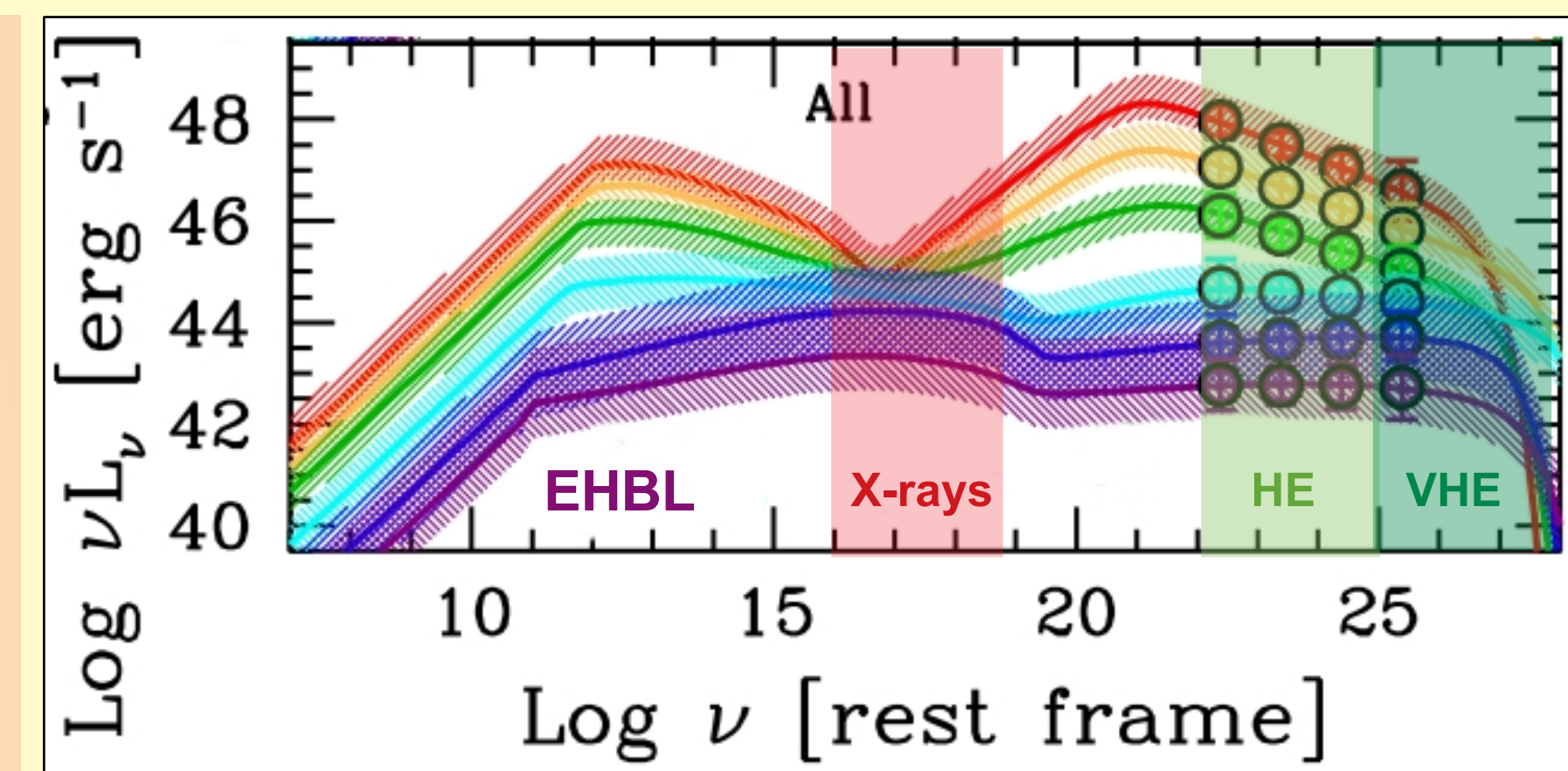
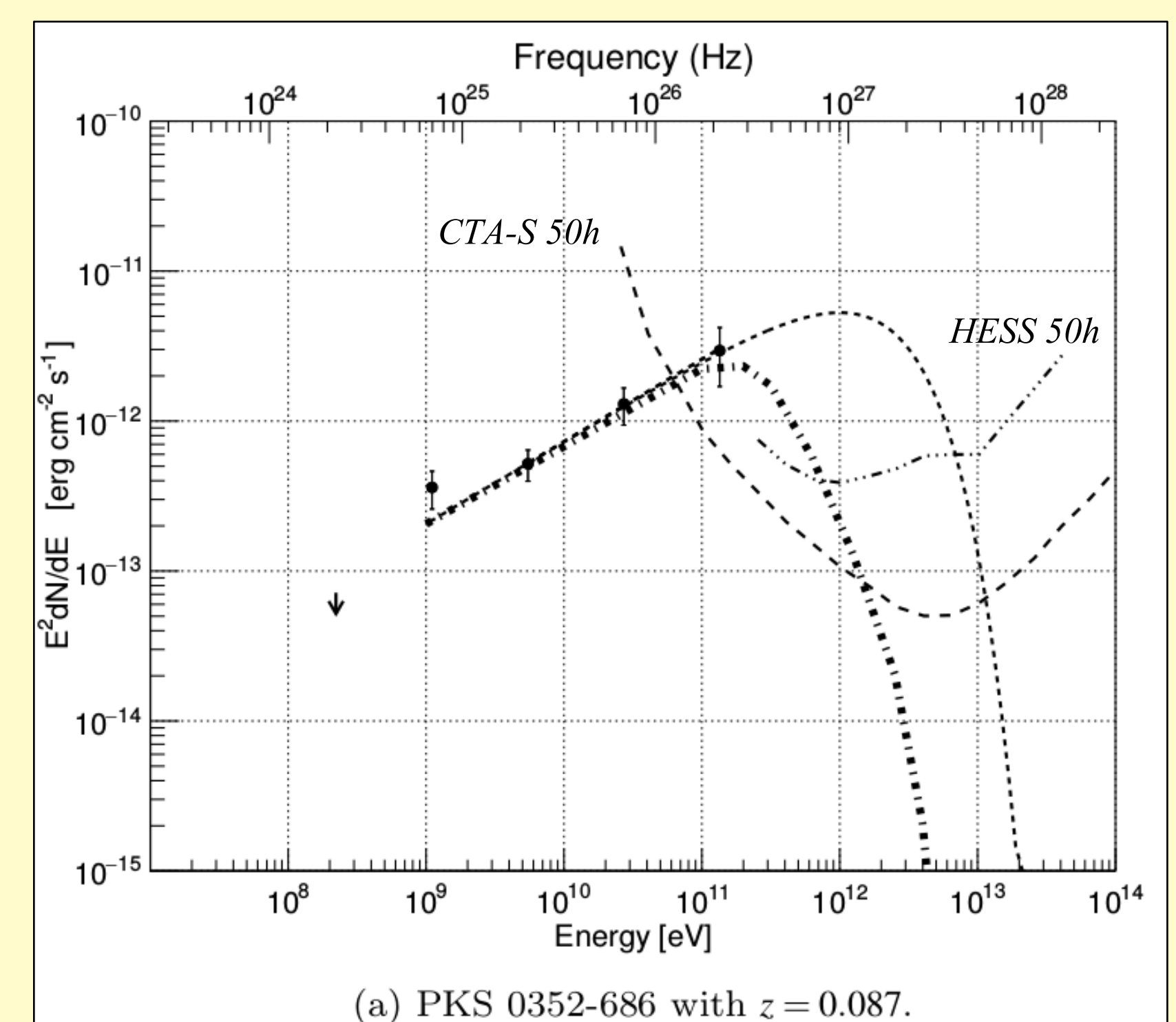
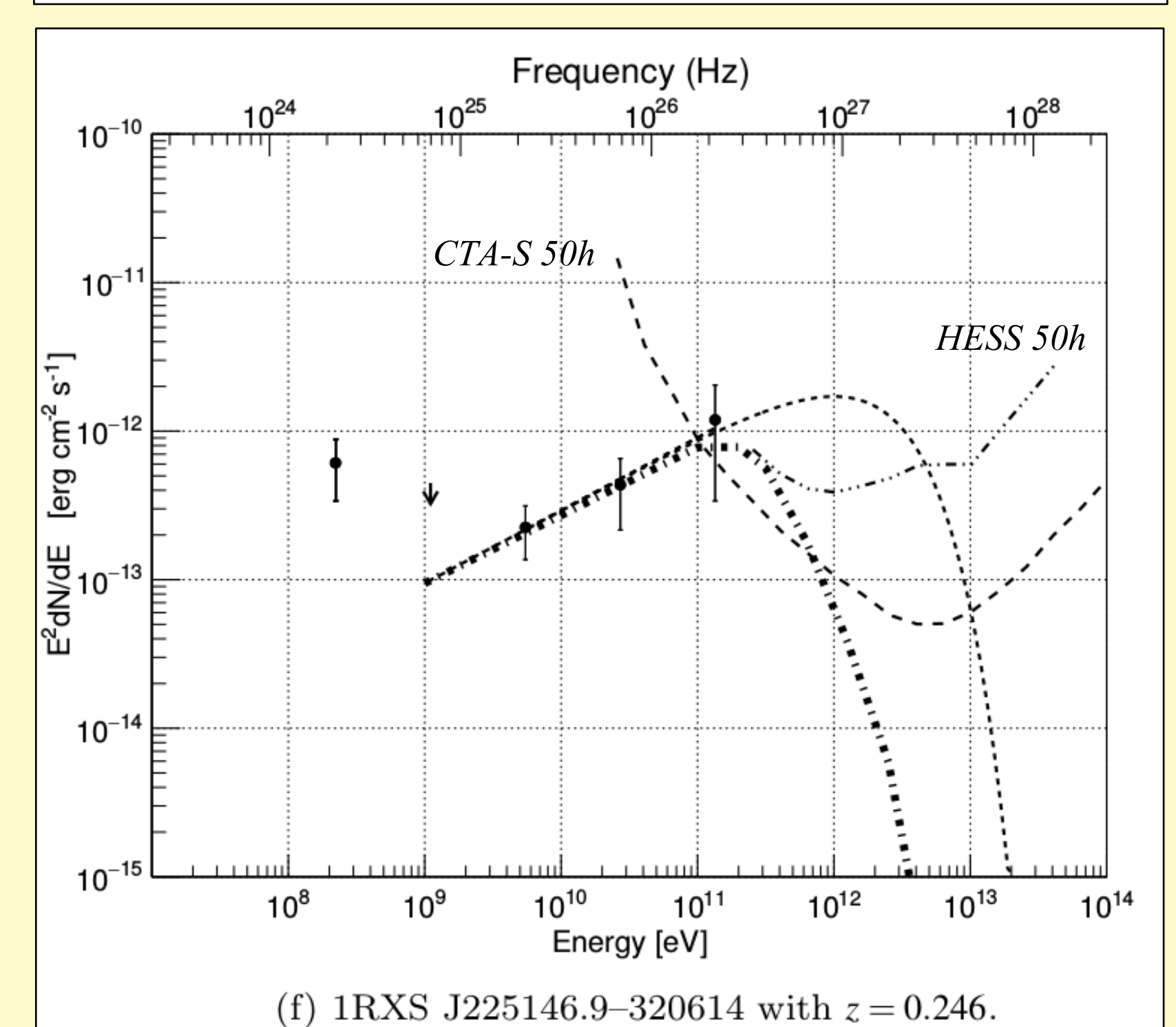


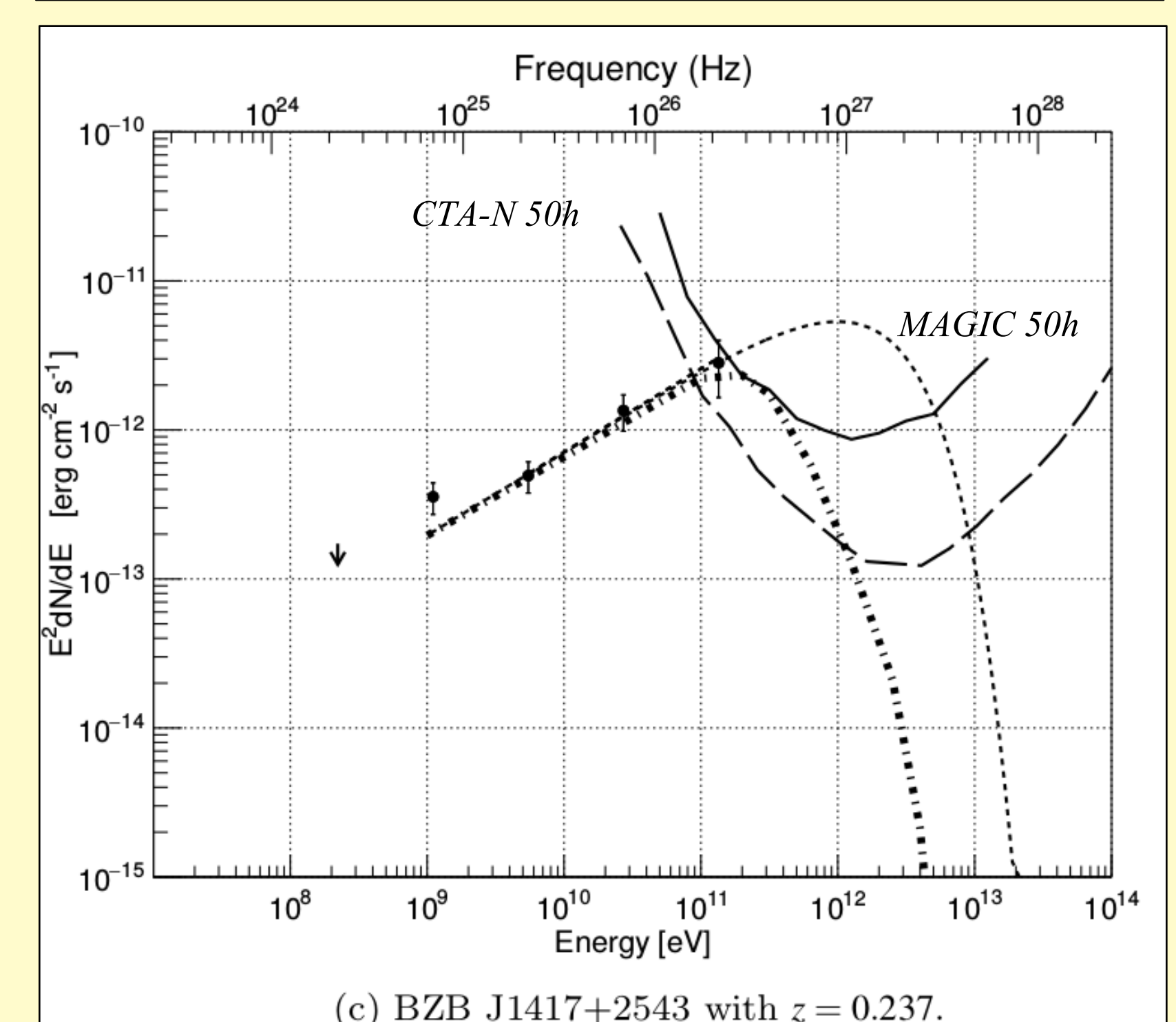
Figure 1
Extreme blazars in the so-called blazar sequence [2].



(a) PKS 0352-686 with $z = 0.087$.



(f) 1RXS J225146.9-320614 with $z = 0.246$.



(c) BZB J1417+2543 with $z = 0.237$.

Results

- Our work results in a sample of **18 EHLs**, of which 12 sources are known TeV-emitters and **6 sources** are **TeV EHL candidates**.
- The most promising TeV candidates are **1RXS J225146.9-320614** and **PKS 0352-686**
- They show spectral properties similar to those of the archetypal EHL 1ES 0229+200, namely:
 - the extremely high synchrotron peak frequencies and the high-peaked second bump of the SED
 - the relatively low and slightly variable flux of both the peaks
 - the relatively low redshift (always below 0.36 in our final sample), where the EBL absorption of TeV gamma-rays is not yet too severe and the detection may need a reasonable integration time to be detected in the VHE γ -ray band

Further applications

- Extend this method to
 - **Swift-BAT 105-months survey**^[7]
 - unidentified Swift-BAT sources

References:

[1] Costamante & Ghisellini 2001, [2] Ghisellini et al. 2017, [3] The MAGIC Collaboration, ApJL 863, L10 (2018) arXiv:1807.04300, [4] The IceCube Collaboration et al., Science 361, 146 (2018), [5] Baumgartner et al. 2013, [6] Fermi-LAT Collaboration 2015b, ApJ, 810, 14, [7] Kyuseok Oh et al. 2018

Figure 3
Extrapolation to the VHE of nine-years *Fermi*-LAT SED.