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Suzaku observations of AGN and synergy with GLAST

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Abstract.
In next five years, dramatic progress is anticipated for the AGN studies, as we have two important missions to observe celestial sources in the high energy regime: GLAST and Suzaku. Suzaku is the 5th Japanese X-ray astronomy satellite which was successfully launched in July 2005. It carries four X-ray sensitive imaging CCD cameras (0.2-12 keV) located in the focal planes of X-ray telescope, and a non-imaging, collimated hard X-ray detector, which extends the bandpass of the observatory to include the 10-600 keV range. Simultaneous monitoring observations by the two instruments (GLAST and Suzaku) will be particularly valuable for variable radio-loud AGN, allowing the cross-correlations of time series as well as detailed modeling of the spectral evolution between the X-ray and gamma-ray energy bands. In this paper, we show early highlights from Suzaku observations of radio-loud AGNs, and discuss what we can do with GLAST in forthcoming years.

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INTRODUCTION

Observations with the EGRET on board *Compton Gamma – ray Observatory* (*CGRO*) have opened a new era for studies of AGN jets in the MeV-GeV γ-ray band, especially for blazars, a sub-class of radio-loud AGNs[1]. The bright γ-ray emission and rapid (day-scale) variability require Doppler boosting, suggesting that the emission of blazars originates in relativistic jet pointing close to our line of sight. The overall spectra of blazars (plotted as νF_ν) have two pronounced continuum components: one peaking between IR and X-rays and the other in the γ-ray regime[2]. The lower energy component is believed to be produced by synchrotron radiation from relativistic electrons, most likely accelerated via shocks in the jet, while inverse Compton (IC) scattering by the same electrons is responsible for the high energy γ-ray emission. Most blazars vary on a day-scale, but sometimes rapid variability as short as minutes/hours has been observed in both the X-ray and γ-ray bands. These extreme characteristics of blazars inevitably require high sensitivity instruments such as GLAST and Suzaku, spanning across wide energy bands. Below we briefly present early observational results from recent Suzaku observations, and future synergy with GLAST.

BLAZARS

TeV emitting sources

Mrk 421 is one of most famous blazars detected for the first time in the TeV energy band in 1990s. Suzaku observed Mrk 421 in April 2006 with a total exposure of 40 ksec. It was in a very bright phase ($F_{2-10\rm keV} \sim 18$ mCrab) and we could measure its X-ray spectrum over a wide energy range, spanning from 0.3 to 60 keV. As shown in Figure 1 ($left$), the X-ray spectrum curves gradually towards high energy, where the differential photon spectral index significantly changes from 1.9 to 3.0. This clearly confirms the "power of Suzaku", which can actually detect a wide-band synchrotron emission from its peak onwards, only using a single observatory. Furthermore, we detected a rapid variability on time scale as short as hours, even above 30 keV[3]. This kind of time-resolved, broad-band X-ray study is only possible with Suzaku. Second example is PKS 2155-304, which was observed for a 65 ksec simultaneously with H.E.S.S in November 2005[4]. Even though the object was in a historically low state ($F_{2-10\rm keV} \sim 1.4$ mCrab), still, Suzaku could determine the energy spectrum up to 50 keV (Figure 1: *right*). TeV results are given in [6]. Note the future collaborations with Suzaku, GLAST and H.E.S.S will provide real snapshots of TeV emitting sources almost every day.

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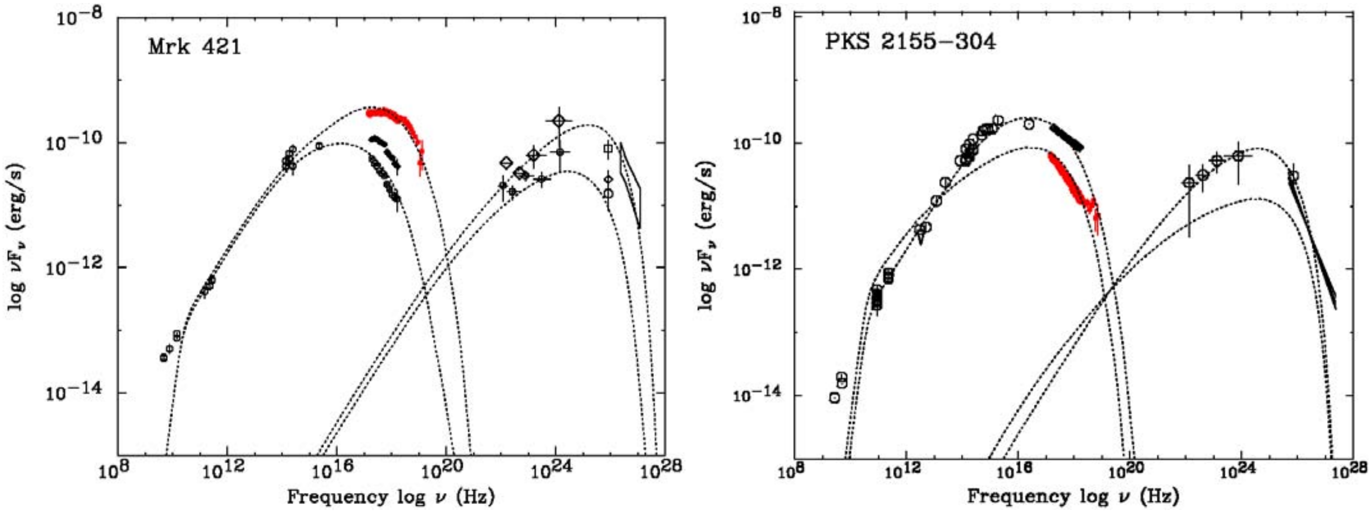

FIGURE 1. The SEDs of TeV blazars recently observed with Suzaku. *left*: Mrk 421 from [3], *right*: PkS 2155−304 from [4]. TeV data is an average H.E.S.S flux given in [5].

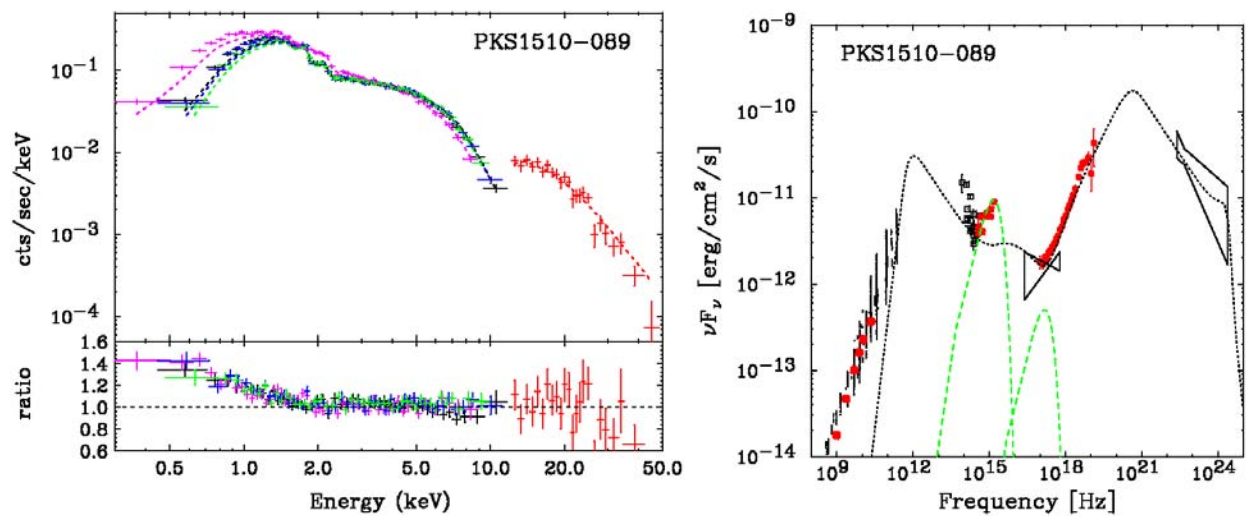

FIGURE 2. Suzaku observation of PKS 1510-089. *left*: residual to a power-law fitting above 2 keV, *right*: simultaneous data from multiwavelength campaign. Dotted line shows emission model given in [7].

Flat Radio QSOs

PKS 1510-089 (z = 0.361) is a powerful radio-emitting quasar detected by EGRET. We conducted an intensive multiwavelength campaign in August 2006, which was started by a deep Suzaku observation lasting for a 120 ksec (continuous for three days), and subsequently monitored over 18 days by Swift to fill in GRB observations[7]. Also the ground-based optical (REM and Heidelberg) and radio telescopes (RATAN 600 and ATCA) provided new data, which are useful to constrain the spectral energy distribution over ten decades in frequency, from 10^{9} Hz to 10^{19} Hz. The X-ray spectrum was well represented by an extremely hard power-law with its photon index $\Gamma \simeq 1.2$, plus an additional soft component, described as a black body emission of $kT \simeq 0.2$ keV, that accounts for an excess emission below 1 keV (Figure 2 *left*). Assuming that the soft excess is due to the bulk-Comptonization of accretion disk photons by cold jet plasma[8], we can constrain the composition and the efficiency of electron acceleration in the relativistic jet, which is completely new for GLAST era (Figure 2 *right*).

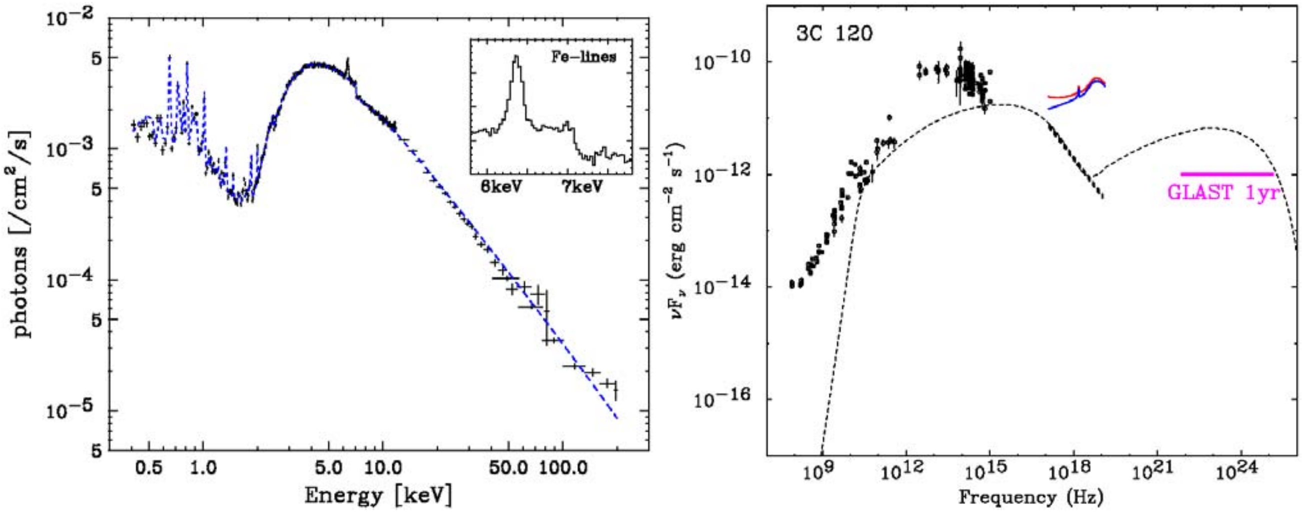

FIGURE 3. *left*: Suzaku spectrum of Cen A, *right*: SED of 3C 120 observed with Suzaku and expected GeV flux.

“NEW” GAMMA-RAY AGNS?

In addition to classical γ-ray blazars discussed above, we expect that several nearby FR-I and FR-II radio galaxies can be detectable by GLAST as “mis-aligned” blazars. This is actually expected if a unification scheme between blazars and radio galaxies is indeed applicable. In fact, Suzaku revealed that a power-law continuum of Cen A extends up to 200 keV without spectral break or reflection component[9], and the SED is well fit by synchrotron and inverse Compton model as usually applied for blazars[10]. Another interesting possibility is to detect broad line radio galaxies (BLRGs) with GLAST. Suzaku observed one of the famous BLRGs, 3C 120, on four occasions in Feb−Mar 2006. An interesting discovery made by Suzaku is that the variability of 3C 120 is mainly caused by a steep power-law component with its photon spectral index 2.7[11]. If this variable power-law originates from the synchrotron emission of a “hidden” jet, as discussed in detail in [11], inverse Compton emission can be easily detectable with GLAST (Figure 3 *right*). Finally, an important new area of investigation will be via ToO (Target of Opportunity) observations of AGNs by “GLAST trigger.” Assuming a large flare as that observed for 3C 279 in 1991, Suzaku can determine the X-ray spectrum up to 300 keV with an unprecedented accuracy. Coordinated observations between GLAST and Suzaku are crucial for further understanding the nature of AGN jets.

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