SEARCHING BLAZARS IN THE EARLY UNIVERSE

Vaidehi S. Paliya, C. S. Stalin
Indian Institute of Astrophysics, Bangalore, India (vaidehi@iiap.res.in)

Blazars are radio-loud active galactic nuclei (AGN) with powerful relativistic jets directed at a small angle from the line of sight of the observer. Due to the fact that the emitted radiation is strongly Doppler boosted, blazars are expected to be visible at very high redshifts (z > 4). High redshift blazars are generally found to be hosting more than a billion solar mass black holes at their centers. Their numbers put strong constraint on the density of billion solar masses black holes at high redshift as for each blazar pointing at us, there must be hundreds of similar sources pointing elsewhere. It also throws the light on the super massive black hole evolution theory. This makes the search of high redshift blazars of utmost importance. With this goal, a flux limited sample of highly radio-loud quasars at high redshifts is selected and studied to find candidate blazars among them. The focus is on two properties, high radio-loudness and intense X-ray flux characterized by a hard spectrum. With the subsequent spectral energy distribution modeling of the sources exhibiting these features, candidate blazars are identified. General physical characteristics of these sources are presented.

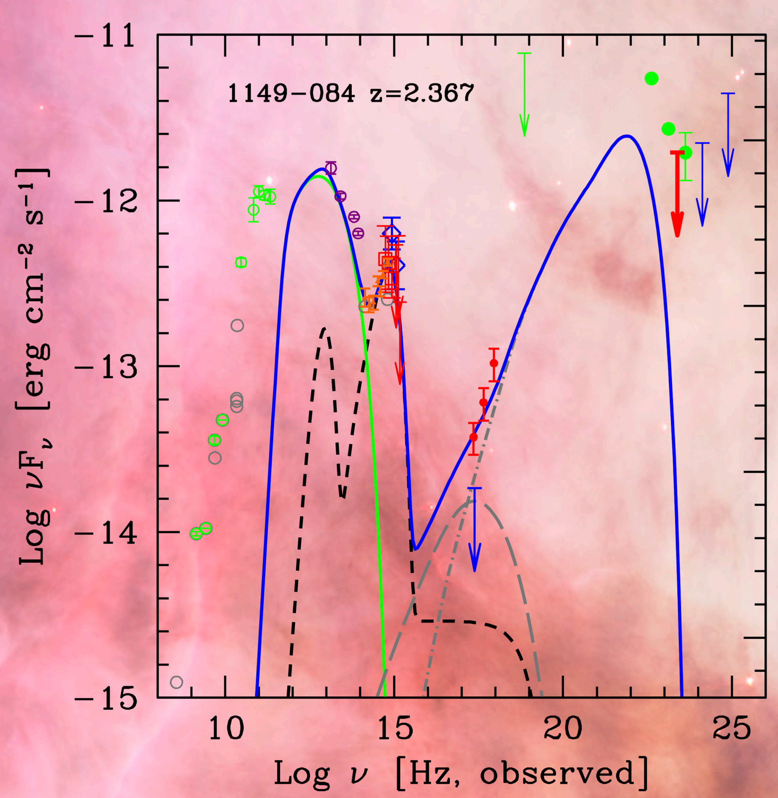
Introduction

☞ Blazars are AGN with powerful jets aligned close to the line of sight to the observer

☞ The emitted radiation is mostly non-thermal, highly variable, polarized, & Doppler boosted

☞ SED of blazars consists of two humps
→ Low energy hump due to synchrotron
→ High energy peak due to IC scattering

☞ High redshift blazars are the most powerful FSRQs and generally harbor > 10^9 $M_\odot$ BHs at their centers
→ Syn. peak lies in sub-mm region & IC hump peaks at MeV energy range
→ Due to shift of the low energy hump, the radiation from the accretion disk should be visible and is observed
→ Shift in the high energy hump causes them to be more luminous at hard X-rays than in γ-ray band



(Ghisellini+, MNRAS, 2013, 428, 1449)

Motivation & Methodology

☯ The detection of each blazar at $z > 4$ with $M_{BH} > 10^9$ $M_\odot$ hints for the presence of analogous $2\Gamma^2$ (Γ is the bulk Lorentz factor) sources that are equally massive with their jets pointed elsewhere

☯ The existence of radio-loud jetted quasars with $M_{BH} > 10^9$ $M_\odot$ at z > 4 is problematic since higher accretion efficiency (for a rapidly spinning BH) implies a slower BH growth (see e.g., Ghisellini+, 2015 MNRAS, 450, L34 & references therein)

☯ Only few high z blazars are known and their collective general physical properties are also not well studied.

☯ This motivates our search for them. We focus on two characteristic features

☯ Large radio-loudness: is a good indicator of the alignment of their jets with the line of sight, that boosts the non–thermal emission because of relativistic beaming

☯ Strong and hard X-ray flux: it is an additional signature of small viewing angle (see Dermer 1995, ApJ, 446, L63)

Sample selection

- All the sources having z > 3.1 are selected from the ROMA-BZCAT catalog, SDSS DR12, & other serendipitious discoveries

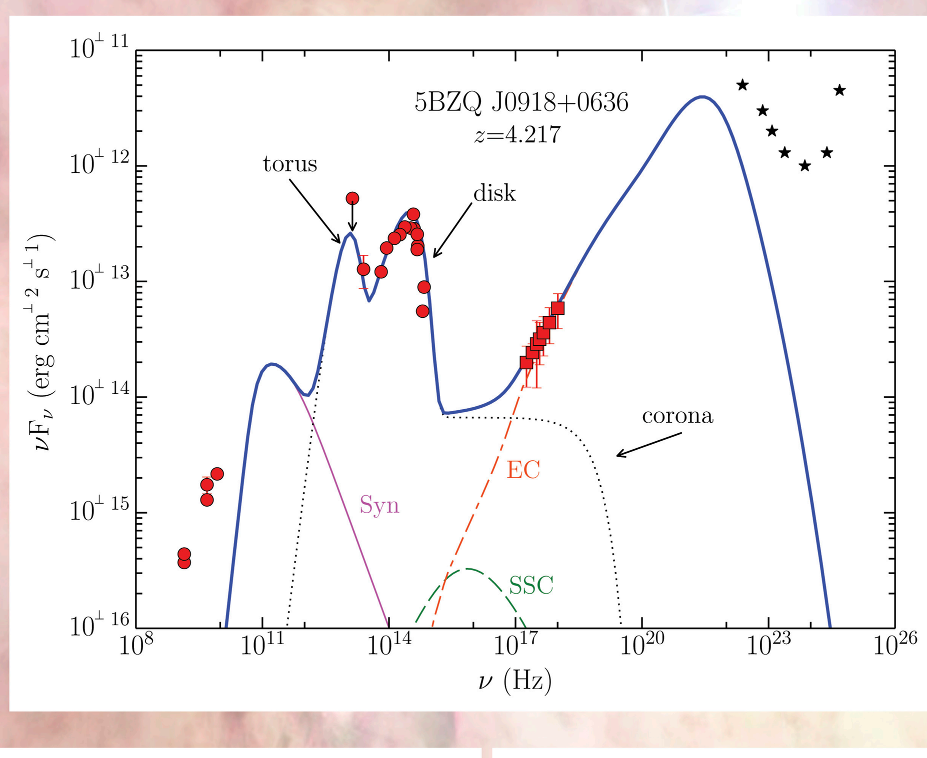
- The radio loudness parameter R (f5 GHz/f2500 in AGN frame) is calculated and sources with R < 10 are rejected from the sutdy

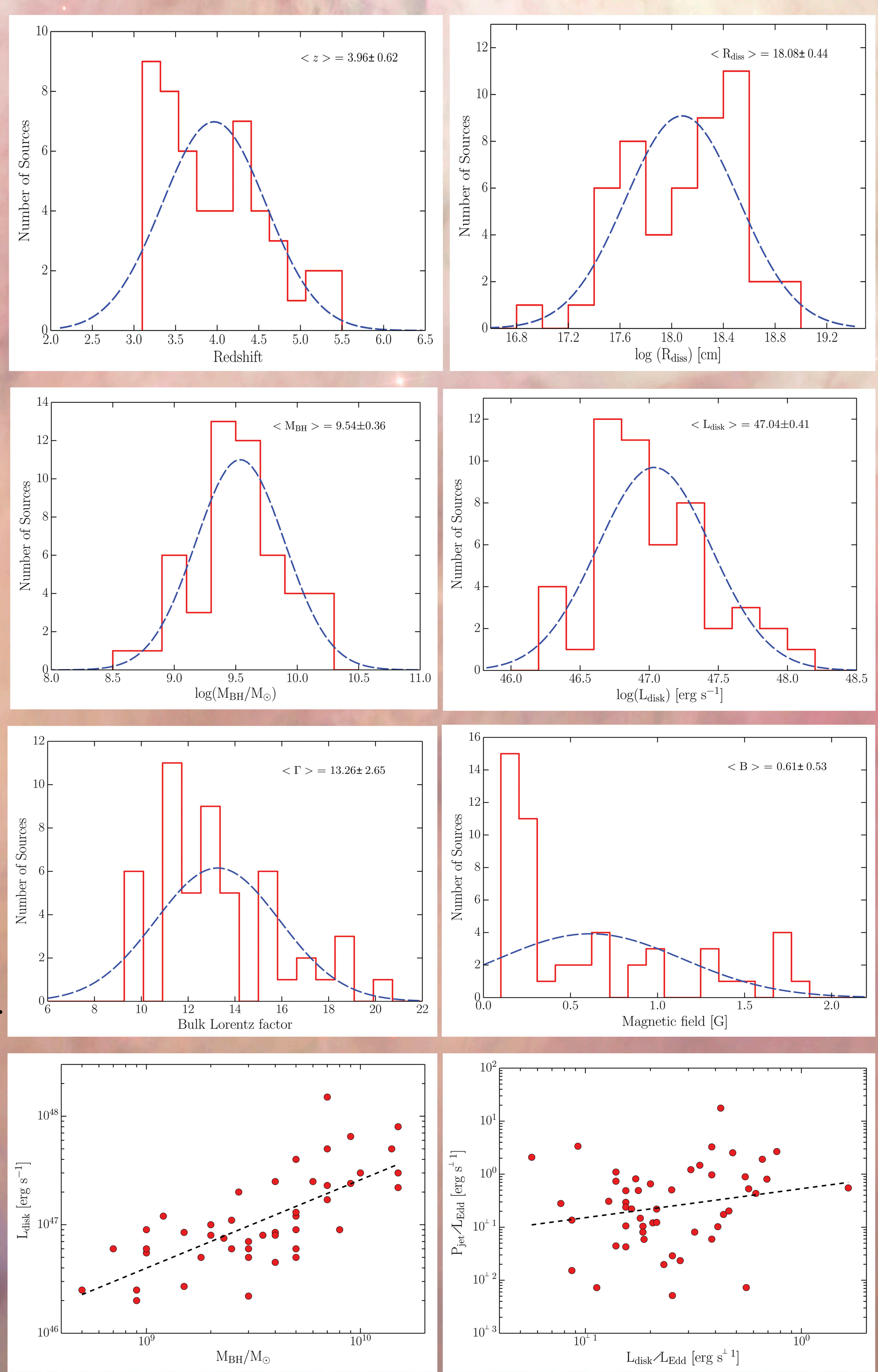
- The X-ray data for remaining sources are searched in archive and analyzed following standard procedures

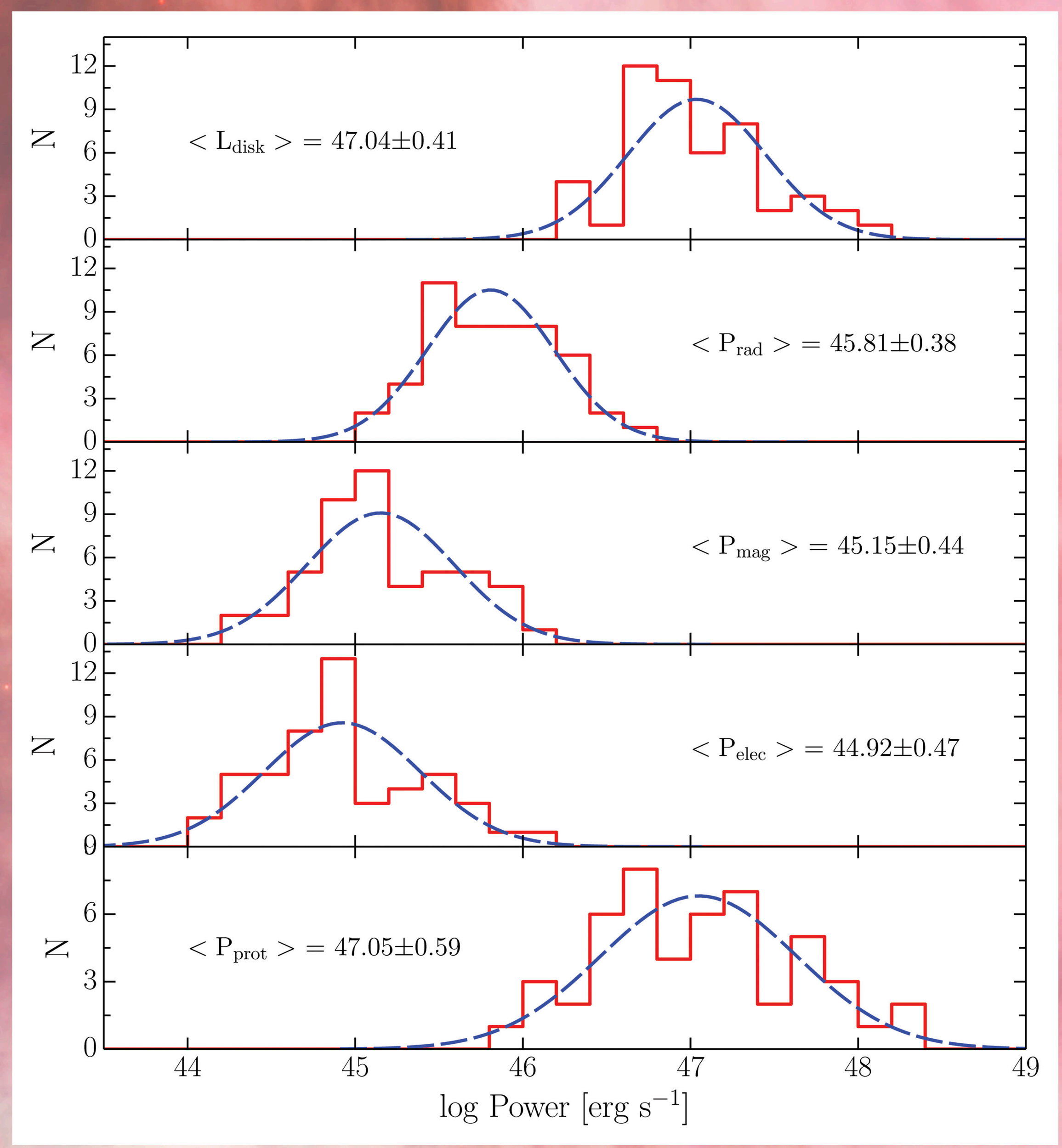
- Finally, 50 sources (40 BZCAT + 10 others) are left exhibiting hard X-ray spectrum ($\Gamma_x < 1.74$)

- These candidates are further subjected to broadband SED modeling, so as to understand the physical characteristics of the entire sample

Results







Conclusions

- A total of 50 potential candidate high z blazars are found (including ~15 known blazars)

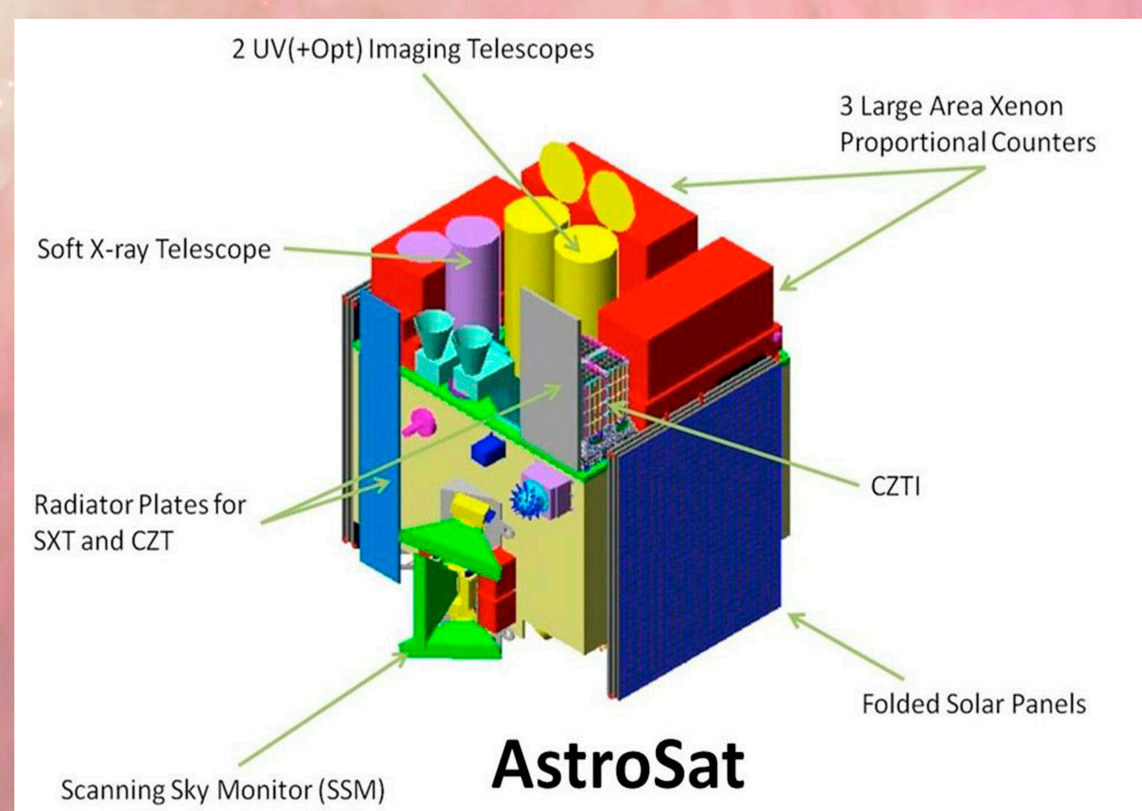
- Majority of them harbor more than a billion solar mass BHs at their centers and the accretion disk luminosity (L_d) exceeds 10^{46} erg s^{-1}

- A positive correlation between L_d & M_{BH} and jet power & L_d is seen

- Most importantly, L_d is found to be of the same order of that of total jet power (see Ghisellini+, Nature, 2014, 515, 376, for a comparison)

- However, above inferences are drawn from non-simulatneous data sets and hence can be questioned

- We need simultaneous observations, optical-hard X-rays (NuSTAR, ASTROSAT)



☺ Ultra-violet Imaging Telescope
[130-320 nm BW, sensitivity 21 mag (5σ) in 3 min]

☺ Soft X-ray Telescope
[0.3-8 keV, 10 μCrab (5σ) in 10 ksec]

☺ Large Area X-ray Proportional Counter
[3-100 keV, 0.1 mCrab (3σ) in 1 ksec]

☺ CdZnTe Imager
[10-150 keV, 0.5 mCrab (3σ) in 1 ksec]

☺ Scanning Sky Monitor
[2-10 keV, 30 mCrab (3σ) in 300 sec]