Studying Active Galactic Nuclei with SNAP

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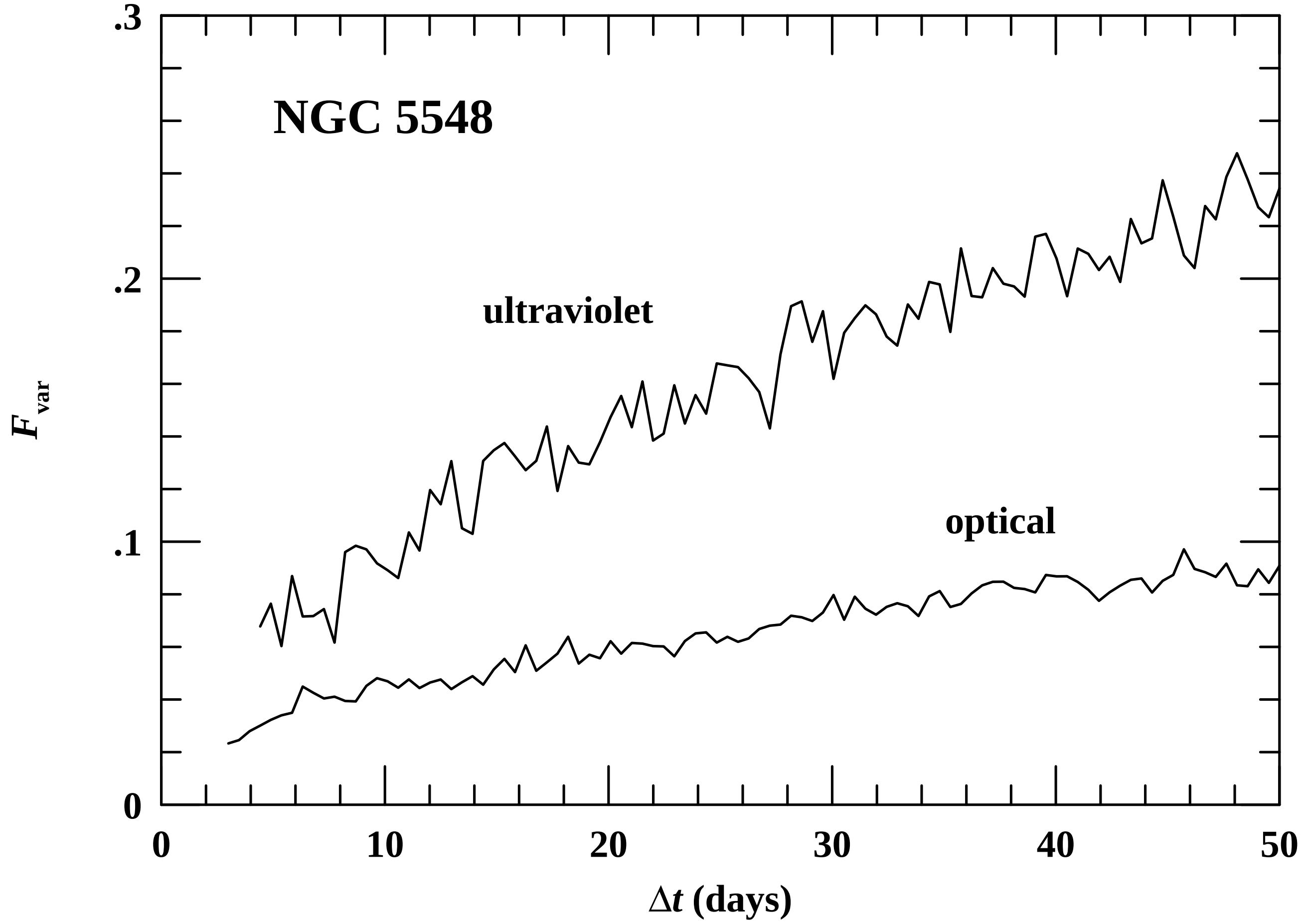
- The proposed SuperNova/Acceleration Probe (SNAP) offers the chance to study thousands of active galactic nuclei (AGN) just in its primary imaging of 20 square degrees of sky to a coadded AB=32.

- Time sampling of every two days or better for 1.5 years will yield the largest sample to date of variability-selected AGN. The few AGN which might not be sufficiently variable for detection on the observed timescales can be found by fitting models including nuclear point sources to the observed galaxy light profiles and using color selection to distinguish AGN from compact starbursts.

- The very complete AGN sample in the primary SNAP imaging area would consist of ∼5000 quasars and ∼100,000 AGN to M_B=−16. This sample will enable studies of variability as a function of luminosity and many other parameters at $z \lesssim 2$. It will also map the redshift evolution of the L_{nuc}-L_{bulge} relation to $z \sim 2$.

- Time sampling of so many AGN (and other galaxies with supermassive black holes) enables detection of strong flares; e.g., ∼20 flares from the tidal disruption of a star by a supermassive BH.



NGC 5548
ultraviolet
optical
.3
.2
.1
0
0
10
20
30
40
50
F var
Δt (days)

What AGN can be expected from the primary SNAP imaging?

(20 deg^2 of sky sampled at $0\farcs1$/pixel to 10σ AB=28 every 2 days for 1.5 years.)

- In 20 deg^2, we expect there to be at least:

  $\sim$5000 quasars to $M_B = -23$ (250/deg^2)

  $\sim$100,000 AGN to $M_B \simeq -16$ (5000/deg^2)

SNAP would produce two distinct (but overlapping) AGN samples:

Multicolor selected and **Variability selected**

- Multicolor selected: ground-based multicolor surveys for distant low-luminosity AGN suffer from host galaxy light contamination. A SNAP survey can avoid this problem by doing aperture photometry of only the nuclear regions of galaxies. Confusion with nuclear starbursts and compact bulges will still exist, but the more filters used, the more accurate the selection of AGN will be.

- Variability selected: All AGN are variable at some level, but only the fraction which vary at a detectable level on the timescale(s) probed will be recovered in a given survey. In NGC 5548 ($M_B = -17.3$), the mean fractional variation on a timescale of 50 days is 10% in the optical and 20% in the UV. Variations at this level should be detectable at 10σ significance in all nuclei to AB$\sim$28. In any case, in nuclei fainter than AB=28 only stronger variations will be detectable at the same significance, leading to increasing incompleteness. [Actually, SNAP will probably *define* the ensemble fractional variation function for AGN on these timescales, by comparison to the much larger population of *in*active nuclei.]

Science with the SNAP AGN samples

- Photometric redshifts for 10^5 AGN host galaxies: study colors, morphologies, spatial clustering, and correlations of same with L, z.

- Number density & luminosity function (LF) evolution of AGN to $M_B \sim -16$. Sarajedini et al. [ApJ 514, 746] find evidence for mild number density evolution of AGN to $z \sim 1$ at such M_B. The observed evolution appears to be neither pure luminosity evolution, nor pure density evolution. SNAP could characterize this evolution.

- Redshift evolution of the fraction (and B/D ratios) of galaxies hosting AGN (~1-3% BLAGN & ~10-30% NLAGN at z<1).

- Redshift evolution of the L_{nuc}-L_{host} relation: Rix et al. [astro-ph/9910190] show that 5 of 6 AGN at $z \sim 2$ have less luminous (less massive) hosts than similarly luminous AGN at $z \sim 0.2$.

- L_{nuc}-L_{bulge} relation difficult to study, since bulges & nuclei are somewhat degenerate at this resolution [Sarajedini et al. ApJ 514, 746]. High SNR of coadded SNAP data will help, as will the fact that minimum detectable L_{nuc} is lower for less luminous galaxies.

- Dependence of AGN variability on M_B & redshift, even host galaxy type (since LINER:Sy2:Sy1 abundance is a function of galaxy type).

- Simultaneous X-ray monitoring for X-ray-UV-optical variability? Contemporaneous ground based spectrophotometry for reverberation mapping of quasar BELRs?? (Lag time ~100 days at B~21)

Flares from Galactic Nuclei with SNAP

• X-ray flares with $\Delta L/L \sim 100$ have been seen with ROSAT

• If these flares are from the tidal disruption of stars, they can occur not only in AGN, but in any galaxy with a supermassive black hole. In fact, one of the ROSAT flares occurred in an apparently inactive galaxy (RXJ 1625.9+7554; see Grupe astro-ph/0108398 for others).

• Ulmer [ApJ 514, 180] discusses the tidal disruption of stars by supermassive BHs. When this happens, half the debris is gravitationally bound to the BH. A flare occurs when this debris returns to the BH, probably via disk accretion. Such flares are:

- rare: 1 per year per 10,000 L^* galaxies
- short: decay timescale $\sim$ 1 month (good match to SNAP; allows multi-λ observations to study disruption and emission processes)
- luminous and blue: a $10^7 M_\odot$ BH with a thick accretion disk and a $2.5L_{edd}$ flare will have M_V=–19.5 (face-on) or M_V=–17.5 (edge-on), and would be $1\overset{m}{.}5$ brighter in the rest-frame U band. A flare around a $10^6 M_\odot$ BH would be 4^m fainter.

• Majority of bright flares produced by $M_{BH} \sim 2 \times 10^7 M_\odot$ objects. Above $5 \times 10^7 M_\odot$ the flares are weaker ($L_{flare} < L_{edd}$) due to a slower return rate. Above $2 \times 10^8 M_\odot$, stars are swallowed whole.

• Flares are $\sim$100$\times$ less frequent than SNe, but SNAP still might detect >20 flares. (Since flares occur in nuclei, they may have been overlooked even if present in existing SNe search data.)