

Time Domain Astrophysics with CMB Probe+

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CMB Probe+: A full sky millimeter/submillimeter-wave polarimetric imager and spectrometer

Overview

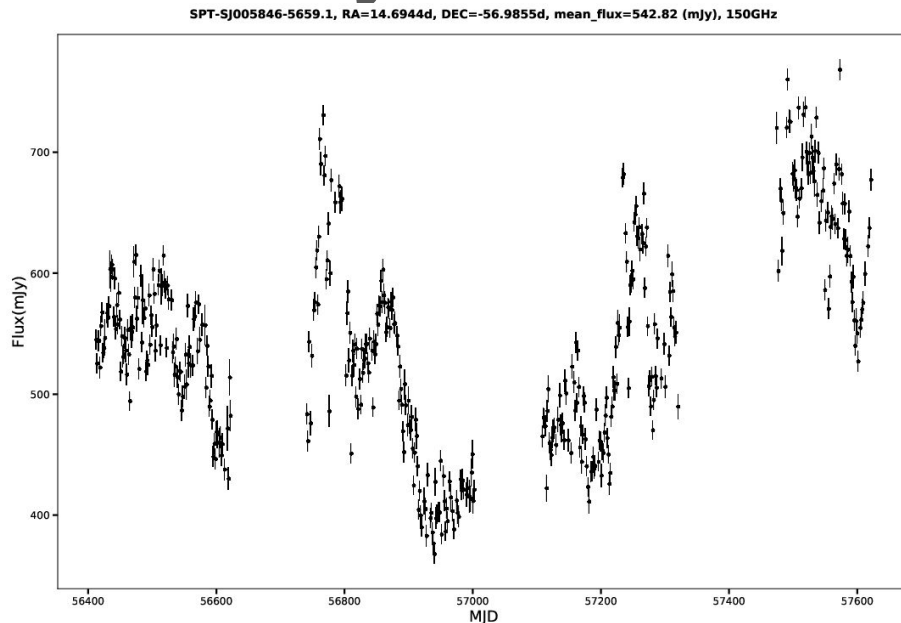
Why CMB surveys are good variability surveys

Why millimeter variability surveys are valuable

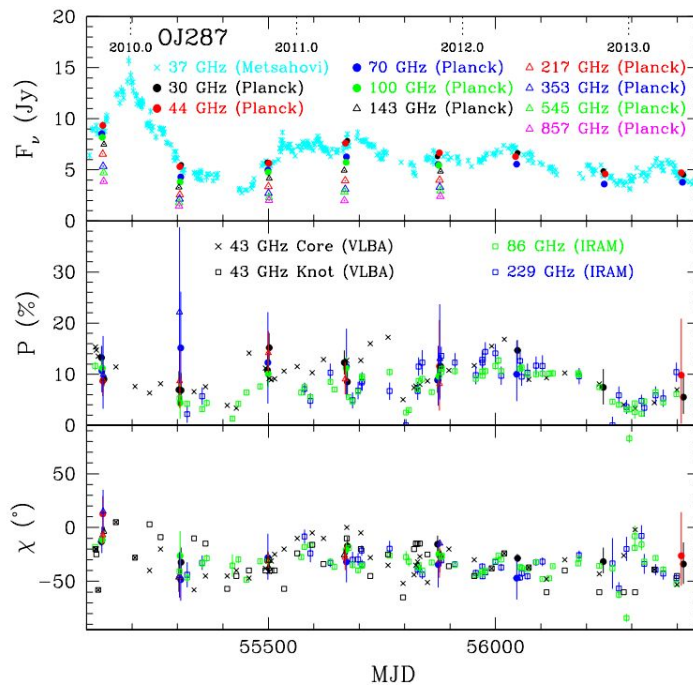
Galactic transient and variable sources

Extragalactic transient and variable sources

CMB surveys sweep the sky giving variability for free



Hood et al. 2026



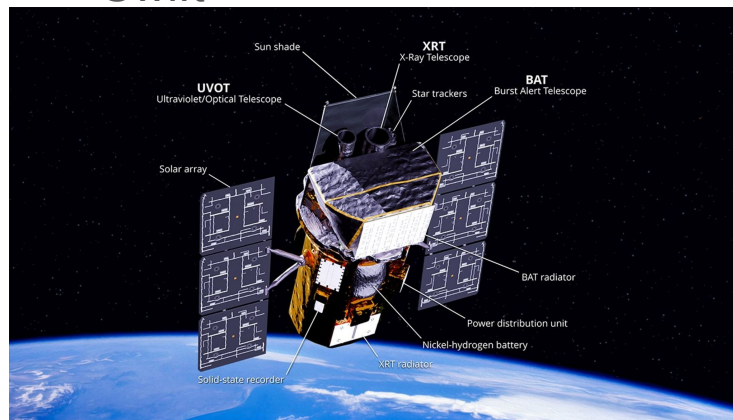
Planck: Rocha et al. 2023

Bright radio/mm source monitoring complements monitoring in other bands

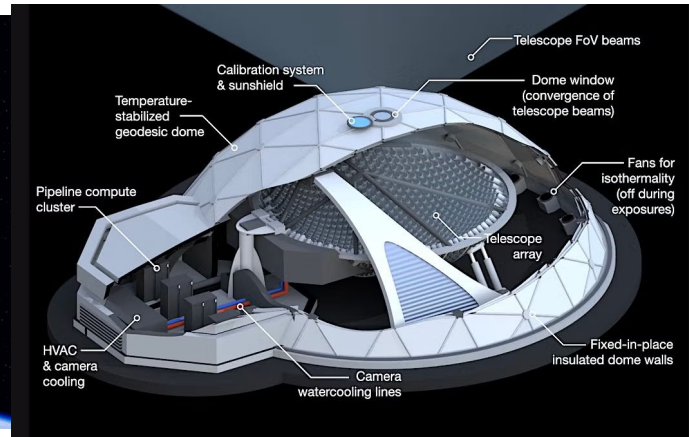
Fermi



Swift



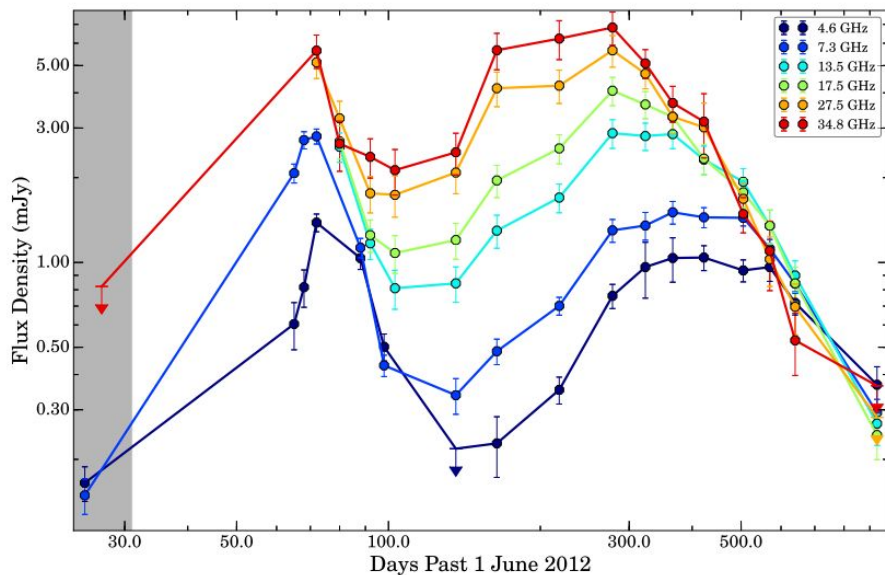
Argus



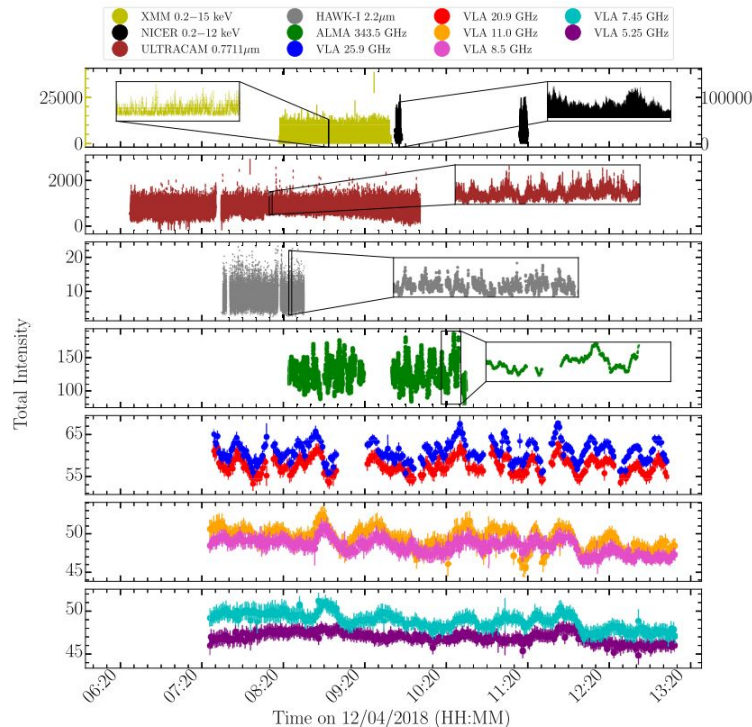
Historically relatively little transient discovery at mm/radio band, but we know there are transients from pointed follow-ups of discoveries at other bands!

Millimeter variability is more extreme than radio for most source classes

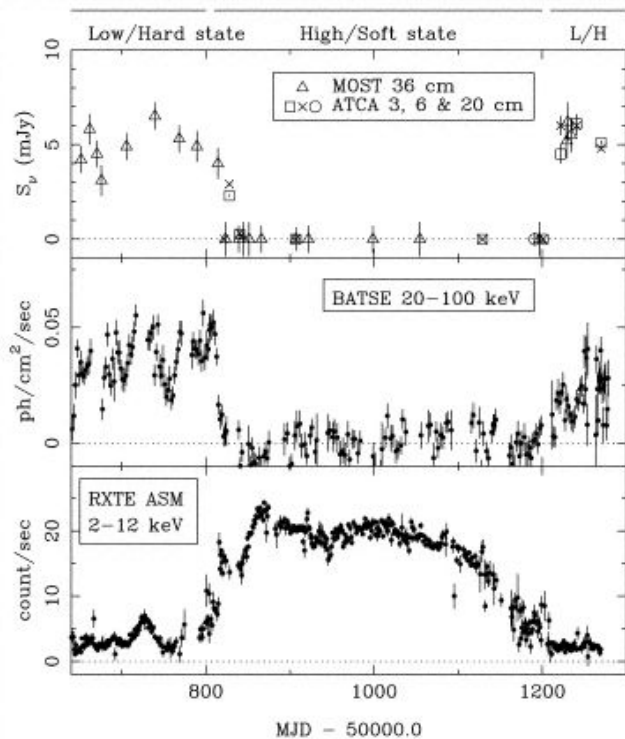
Finzell et al. 2018



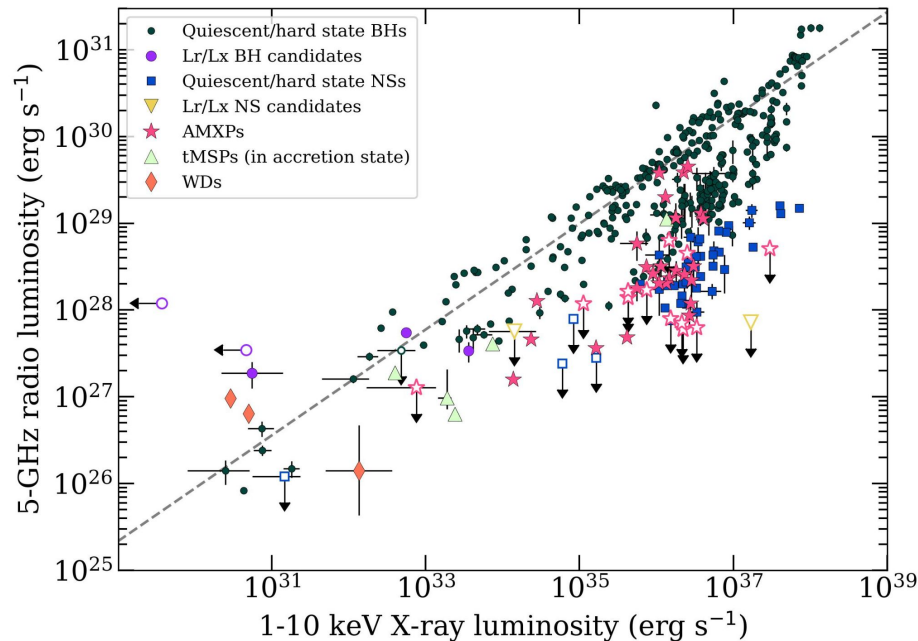
Tetarenko et al. 2021



X-ray binaries: the key to understanding the disk-jet connection

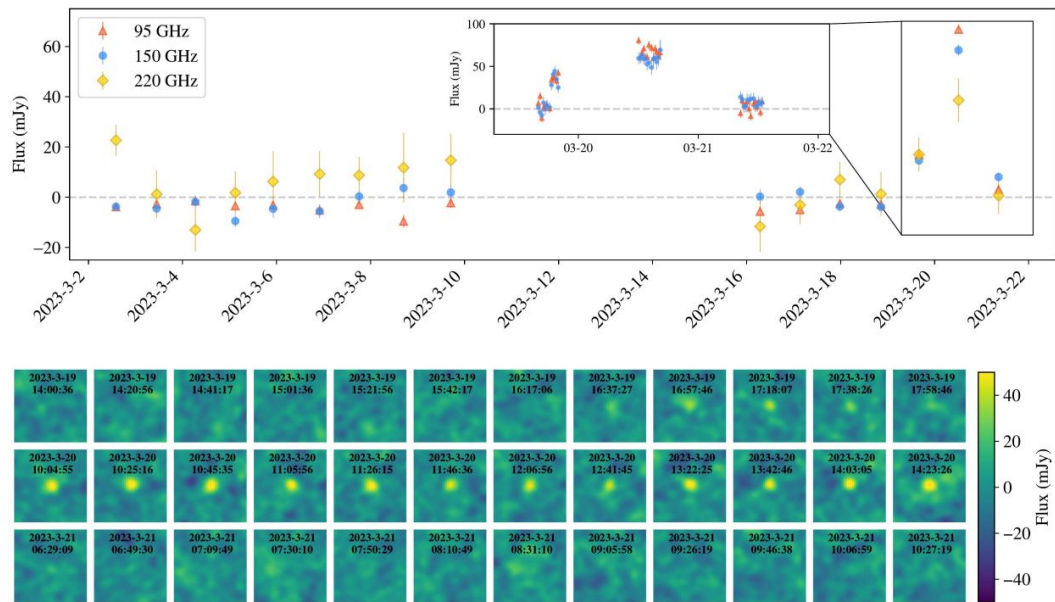


From Fender et al. 1999; see also Tananbaum et al. 1972, Hannikainen et al. 1997



Arash Bahramian github compilation

Unexpected white dwarf phenomena

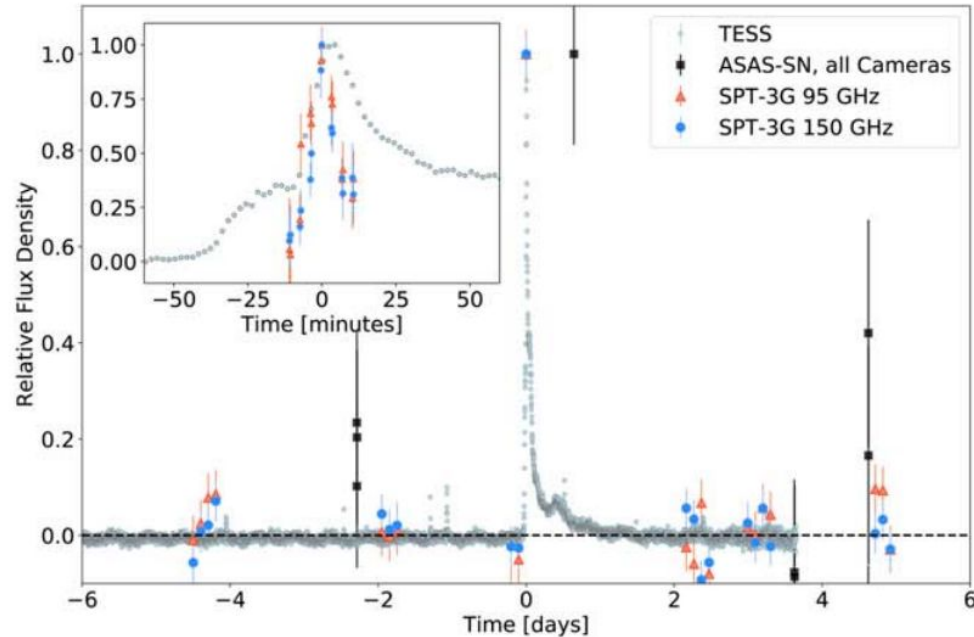


Wan et al. 2026: SPT Galactic Plane survey

Two flaring objects as long period accreting white dwarfs

Magnetic reconnection in accretion disk

The extremes of stellar flaring



Guns et al. 2021

Mm flares require highly relativistic particles!

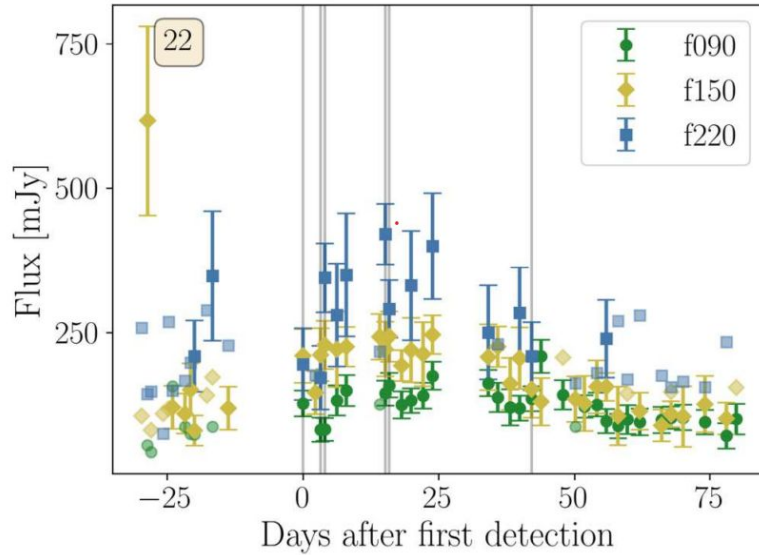
May be most likely to produce exoaurorae, lead to effects on habitability

In Argus era, would have many more events with optical coverage

Would also benefit from instantaneous wide-field X-ray

Classical novae: CMB Probe+ can detect *all* of them in the Milky Way

Nuclear astrophysics, binary evolution and resolved studies of shock-driven explosions



Biermann et al. 2025: YZ Ret with ACT

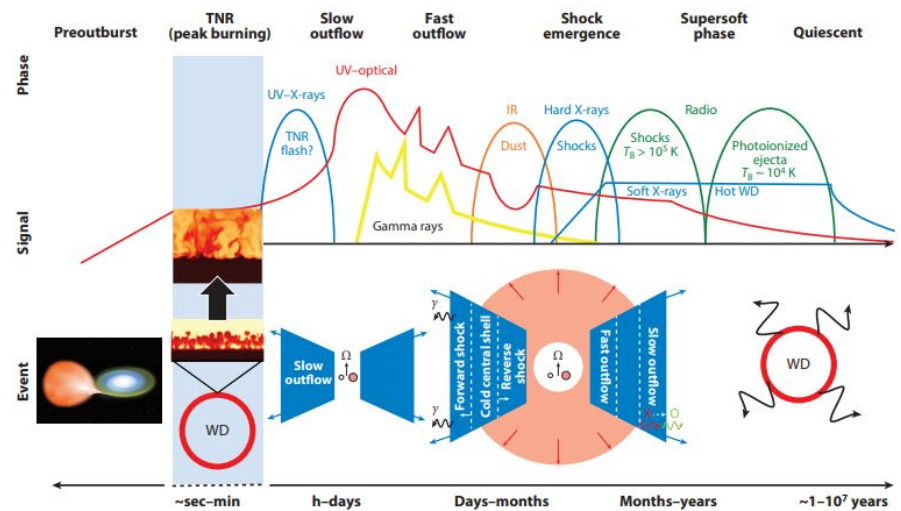


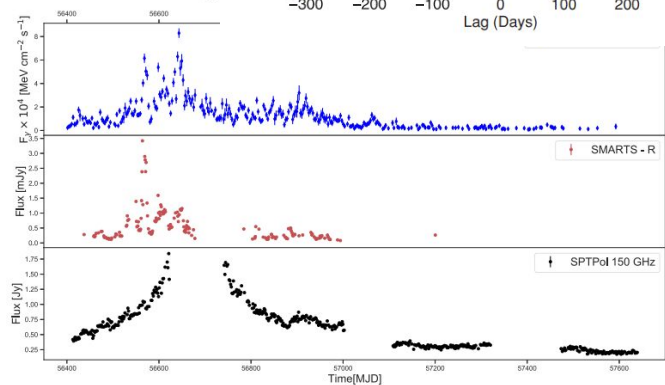
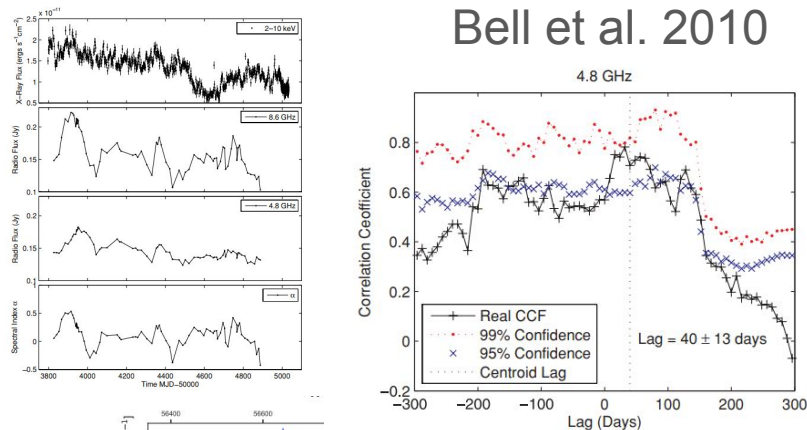
Figure 1

Chomiuk et al. 2021

CMB Probe+

Disk-jet connection in AGN

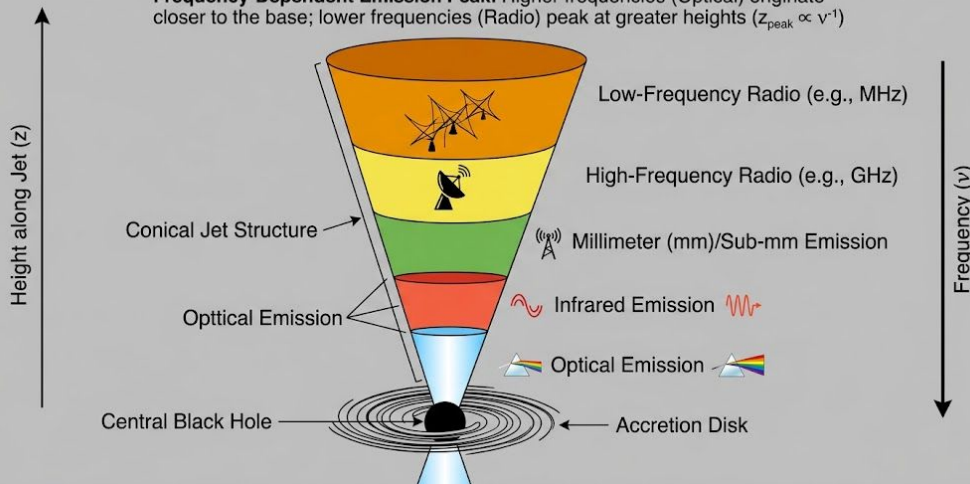
Bell et al. 2010



Hood et al. 2023

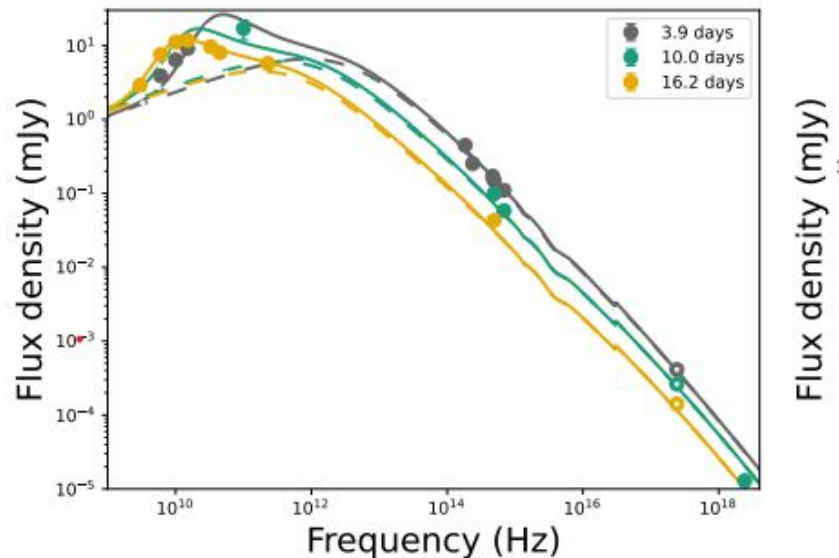
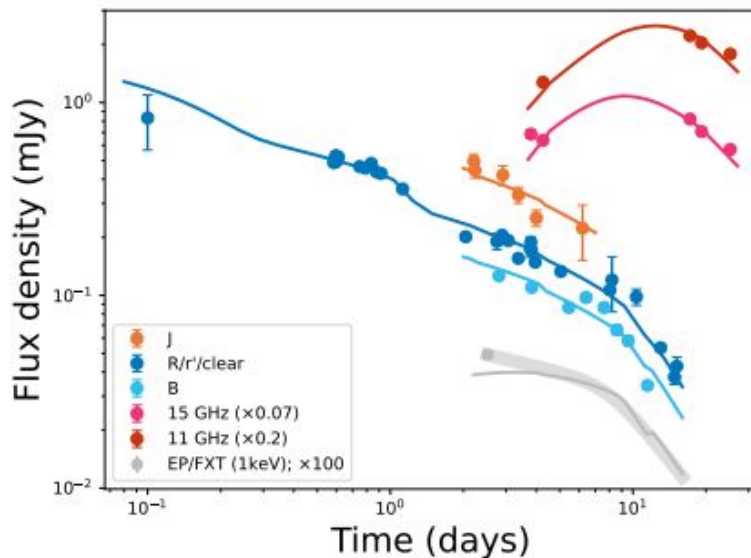
Schematic of Blandford-Königl (BK) Conical Jet Model

Frequency-Dependent Emission Peak: Higher frequencies (Optical) originate closer to the base; lower frequencies (Radio) peak at greater heights ($z_{\text{peak}} \propto \nu^{-1}$)



CMB Probe+

Explosive transients?



Christy et al. 2006: GRB afterglow, probably a reverse shock

CMB Probe+ scanning and sensitivity match well to these science cases!

Sky coverage in 10 hours: approx 50% (see good fraction of targets with 10 hour cadence!)

Yearly sky coverage: ~100%

Cadence: 10 hours

Better than past monitoring cadence for AGN and X-ray binaries

Sensitivity: few mJy in 10 hours if averaging out in frequency, few hundred mJy in each band

Lots of AGN, blazar and non-blazar

Nearly every Galactic classical novae, regardless of extinction

The bright, rapidly variable parts of X-ray binary outbursts (very hard to do)

Trade Space

Mostly in Cadence

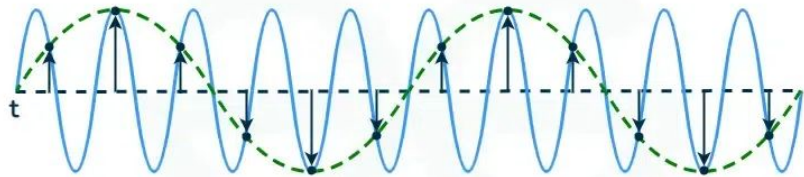
Even spacing not ideal for periodic phenomena (math is easier, but aliasing is worse)

10-hour spacing may be awkward for some types of strictly simultaneous observations (e.g. VLA in the Inner Galaxy region)

10-hour cadence also may sample typical flare stars poorly

Aliasing

Aliasing occurs due to sampling rate being too low with respect to Nyquist Rate



Aliasing Effect



Is it practical to vary the sampling to quasi-random?

Will this jeopardize or enhance core CMB science?

Summary and conclusions

All sky, near continuous observation in long wavelengths is a missing capability to complement other bands

Small fields with existing CMB telescopes already producing unexpected, exciting results

CMB Probe+ would give wide-band, good cadence, $\sim$ mJy sensitivity, opening up discovery space!