Time Domain Astronomy with the Submillimeter Array

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The SMA Advantage

The streamlined observing model and dynamic flexible scheduling of the Submillimeter Array make it an excellent instrument for fast response target of opportunity observations or flexible long term flux monitoring.

ToO Process

Step 1: Apply for SMA time at either semester deadline requesting triggered observation(s) of a source, or class of sources, and follow-up time if desired. If accepted, 'skeleton' projects are created, requiring only source details upon trigger.

Step 2: Successful PIs are provided a contact number to reach the on-duty SMA Scheduler. When trigger criteria are reached, the PI or designate 'makes the call' to trigger SMA observations.

Step 3: The SMA Scheduler will assist in observing script creation, and direct the operators to run it. If using the current tuning of the array, the SMA can be on source within minutes of triggering if the target is available.

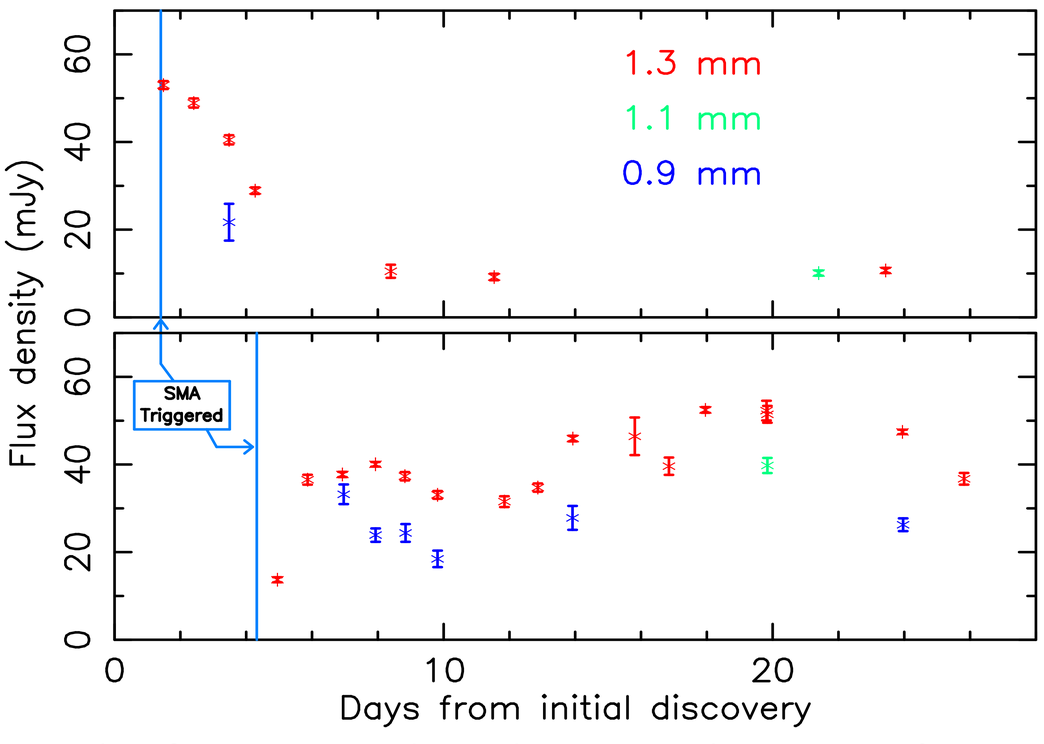
Types of Transient Observations

- **Triggered:** The observation of transient objects such as Gamma Ray Bursts (GRBs) and Supernovae requires a fast response time from trigger to observation to be maximally effective. If the trigger occurs in the evening and the target is available, the SMA can usually be observing the target **within minutes** of receiving the trigger call.

- **Coordinated / Follow-up:** The dynamic scheduling system at the SMA allows straightforward coordinated campaigns with other observatories or follow-up observations based on SMA data. Each night the science project is chosen from a queue of allocated projects requiring the expected weather conditions, with approved coordinated programs and ToO projects typically given priority.

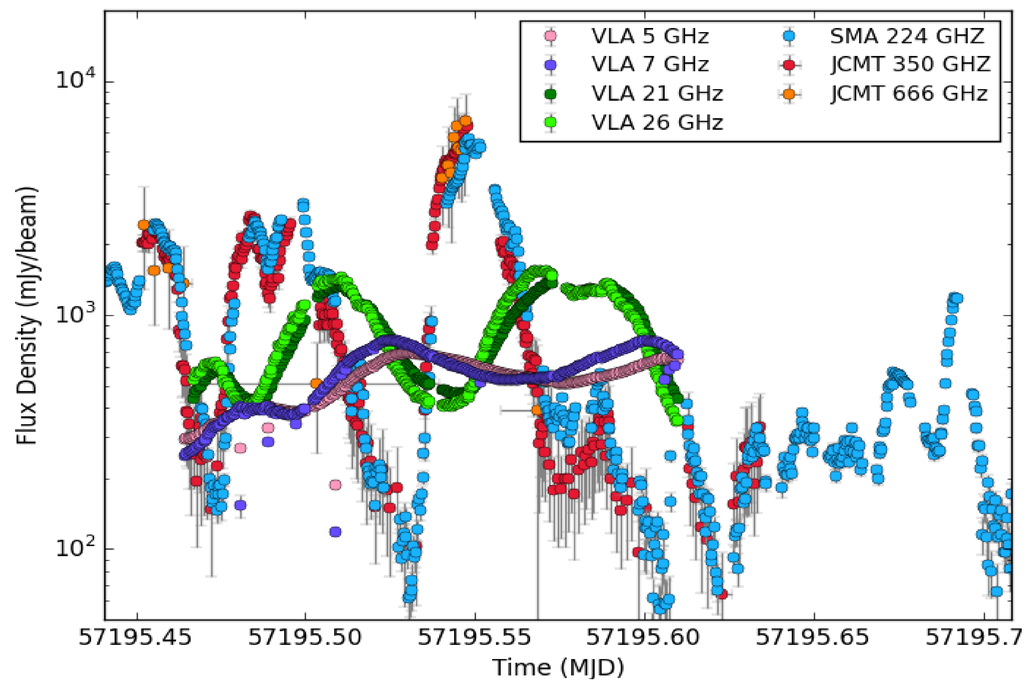
- **Monitoring:** Flux density measurements not requiring imaging or long integration times are feasible to be run daily, weekly, or monthly depending on science goals and frequency tolerance. Targeted campaigns can even span several semesters, and utilize multiple frequency tunings (e.g. 1.3mm and 870m simultaneously).

Triggered: Transient Detection and Monitoring



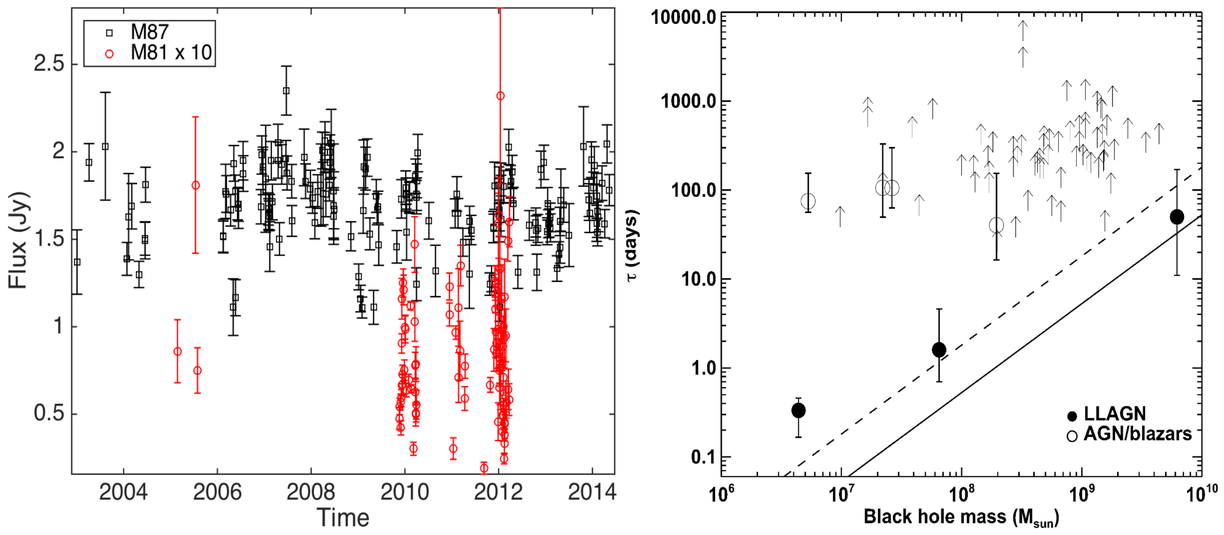
Examples of recent triggered SMA detections and monitoring of transient events. Once triggered, the SMA can be on source within minutes if the target is observable from Hawaii.

Coordinated: V404 Cyg *(Tetarenko, A. et al., 2017, MNRAS 469, 3141)*



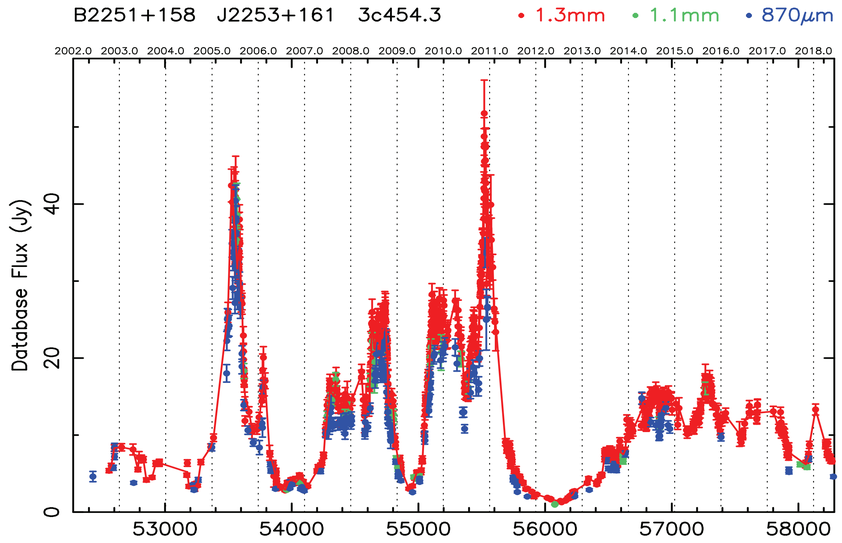
Coordinated SMA, JCMT, and VLA observations of BHXB V404 Cygni on 22 June 2015 during a rare outburst state. The time delay at lower frequencies is likely due to optical depth effects. The initial SMA observations of V404 Cygni two days earlier started just **9 minutes** after the PI triggered the observations.

Monitoring: AGN Variability *(Bower et al. 2015, ApJ, 811, L6)*



Long term campaign to monitor low luminosity AGN (LLAGN) using weekly SMA observations at 230 GHz, along with archival data over full SMA history (left). LLAGN Sgr A*, M81, and M87 display linear relationship between black hole mass and variability time scale (right); consistent with variability originating within 5 R_S of black hole. Most blazars have timescales that are much longer, likely the result of highly beamed emission detected at large radii in the jet.

Long-term Monitoring: SMA Flux Density Calibrator Database



The Calibrator Flux Density Database (http://sma1.sma.hawaii.edu/tools.html) of the SMA is a rich, unique resource on mm/submm variability. To date, it contains over 28,500 measurements from 416 sources, primarily blazars, at 1.3mm, 1.1mm, and 870μm. SMA monitoring data is used in at least **70 peer-reviewed publications since 2008.** The SMA also solicits and actively supports monitoring programs of specific targets.