

Notes from Reportback:

Chat questions:

BB: The time constant of the detectors will be about 1-2 m-sec, so won't see anything below that.

Nathan Whitehorn: we did do an unpublished search for FRBs with SPTpol, so we have a proof of concept

Tom Crawford to Everyone (11:57 AM)

Following up on Joaquin's answer to Suvodip: Our cadence on the full field is ~1 day (or less for the ultra-deep survey), but if we looked at individual az-scans across the field (not just making a map of the entire observation), we could have repeated observations separated by minutes.

Nathan Whitehorn to Everyone (11:57 AM)

It is not as much part of our planning here, because we don't know what to expect, you can't usefully alert on it, and it's not obvious you would do anything with the instrument design to optimize for it

Tom Crawford to Everyone (11:57 AM)

An example of that are the minute-timescale plots of stellar flares in the ACT & SPT papers.

Nathan Whitehorn to Everyone (11:58 AM)

I'll add to Tom's comment that the recent SPT paper works in very similar ways to what we expect to do for S4

Julian Borrill (he/him) to Everyone (11:58 AM)

It's an important use-case to include in the TOD data access planning.

Suvodip Mukherjee to Everyone (11:58 AM)

I am wondering what is the fraction of the total number of events which we we can detect with the cadence of CMB-S4 and typical event rate of these kind of sources.

Tom Crawford to Everyone (11:58 AM)

Events that are faster than that timescale are REALLY hard, because they are indistinguishable from glitches and human-made things flying through the field of view (like satellites).

Bradford Benson (he/him) to Everyone (11:59 AM)

The SPTpol fast-radio burst search was described in this thesis, by Nick Harrington:

<https://escholarship.org/uc/item/7jv1d54w>

Tom Crawford to Everyone (11:59 AM)

Suvodip: As Nathan has alluded to, we basically have no idea what the expected rates are, except from the initial studies that have just come out.

J. Ruhl to Everyone (12:00 PM)

CMB-S4's LAT cameras have a lot of angular coverage at 90/150, so depending on how the tubes are arranged there's another timescale of about 5-10 seconds where you can use different tubes to verify that something is real.

Nathan Whitehorn to Everyone (12:01 PM)

It's pretty hard for me to imagine a beam-scale tube-specific source of systematics, though

Suvodip Mukherjee to Everyone (12:03 PM)

@Tom, Yes, I understand about the huge uncertainty on the astrophysical rates. But it may be interesting to know for the *known* kind of sources, what fraction we are going to detect (or miss) with CMB-S4 or SPT.

Tom Crawford to Everyone (12:03 PM)

Right, we definitely need to fold in what we have learned from these early studies into S4 forecasting ASAP.

Suvodip Mukherjee to Everyone (12:04 PM)

Yes! +1

Tarraneh Eftekhari to Everyone (12:08 PM)

@Suvodip, are you referring to the known rates for the galactic, minute timescale transients, or for extragalactic transients as well? If the latter, we do fold the volumetric event rates into the simulations when making predictions for S4.

Suvodip Mukherjee to Everyone (12:24 PM)

@Tarraneh: Thanks! I am asking about extragalactic sources. Assuming an isotropic distribution of the sources with a merger rate, what fraction can be detected within the field of view and cadence of CMB-S4 above the detector noise? Some sources will be missed because they will fade away soon, and some objects will be missed because their signal is weak and outside the sky coverage. I am thinking there can be a plot of fraction of detected sources for different signal durations and different source redshift (assuming that the intrinsic luminosity of the sources are same).

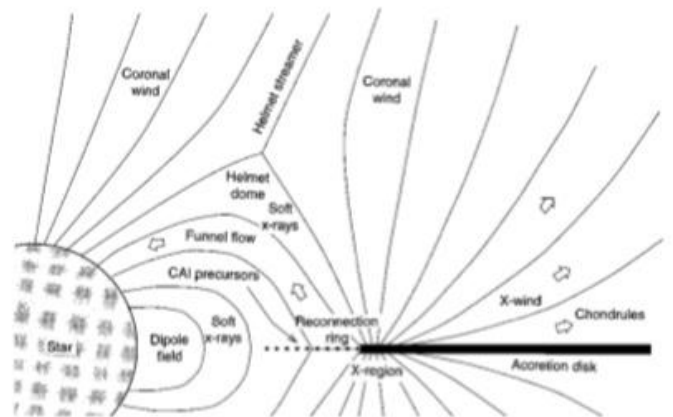
Parallel

Kevin Huffenberger on ACT transients

1. Blind transients, archival/targeted, planet-9, variable AGN, fast transients (i.e. FRBs) searches
2. ACT paper (December 2020) on 3 transients, each close to a bright star – stellar flares consistent with other mm flares but much more luminous than activity from our Sun
 - a. These detections in particular were during a planet-9 search, so it was not optimized at all
 - b. Association argument by proximity
 - c. Event 1
 - i. Peak so bright that it was in top 50 of entire survey, rose very quickly
 - ii. Type M3 V star with indications that it is young
 - iii. Rising? Spectral index

- d. Event 2
 - i. Steady flux after 8 day gap and not observed again in the season
 - ii. Type K0 III star
 - iii. Rising spectral index
- e. Event 3
 - i. Better time coverage – observed for many days after first flare
 - ii. Binary: Type K0 IV + G2 V **or** K0 IV + G2 ..
 - iii. Spectral index is flat
- f. Comparisons to other mm stellar flares: luminous events tend to be in young and/or binary stars, star-forming regions (T Tauri stars)
- 3. Physics – what causes them?
 - a. Stellar flares caused by magnetic reconnection (which is not very well understood)
 - b. Enhanced in young stars where there is interaction with protoplanetary disk
- 4. Conclusions
 - a. Search was unsystematic and done by hand, but indications are that such stellar flares are common
 - b. CMB-S4 to do wide area and rapid cadence searches, complementary to transient detections in i.e. Vera Rubin Observatory
- 5. Questions:
 - a. What's this about associations with the protoplanetary disk?
 - i. (Doug Johnstone drops some knowledge) If disk extends far enough in to reach corotation with the star, inner portion of disk could dump material onto star; this accretion interacting with magnetic field lines
 - ii. Here's an old paper discussing the subject
<https://ui.adsabs.harvard.edu/abs/1997Sci...277.1475S/abstract>

Fig. 1. Schematic drawing of the magnetic field geometry and gas flow in the x-wind model for the production of CAIs and chondrules. While chondrules are being launched from the x-region, cosmic-ray irradiation of CAI precursors occurs by impulsive flares in the reconnection ring, where the distorted dipole field lines make an excursion to the x-region as a part of the magnetic flux trapped there. The figure indicates that thermally driven coronal winds from the star and the disk may help the magnetocentrifugally driven x-wind to open field lines surrounding the helmet streamer, but this aspect of the configuration is not essential to our model.



- iii.
- iv. According to
<https://ui.adsabs.harvard.edu/abs/2019MNRAS.483..917W/abstract> the

- peak frequency for the flare most corresponds to the magnetic field strength (but I believe that there are other parameters that matter also)
- b. (Joaquin Vieira) The sources that don't get observed again ... where are they in the ACT footprint and what implications are there for S4 ?
 - i. At the edges of the area we were surveying, for S4 it will be more regular/improved
 - c. (Joaquin Vieira) Why are ACT stars always x-ray detected ? Is this ROSAT? Are they closer to the galactic plane ?

Sam Guns on SPT transients

1. Previous generation (SPTPol 100d field) revealed one candidate event
2. Mm-wave transients with SPT-3G paper out *yesterday*
 - a. 1500d field using 2020 data has map sensitivity comparable to what CMB-S4 will be (albeit CMB-S4 area much larger)
 - b. Method: using difference maps (single observation) - (2019 coadd) = transients, calculate test statistic (likelihood ratio) to determine presence of a flare
 - c. Results: 10 sources with at least one event $>10\sigma$; sources consisting of 8 stars (i.e. M Dwarf, rotationally variable x-ray emitting star) and 2 extragalactic sources
 - d. Stellar events
 - i. 13 total flares from the 8 stars
 - ii. Brightest is more than 2 Jy, briefest <20 minutes; able to view individual raster scans within an individual 2 hour subfield observation
 - iii. Multiwavelength public data: overlap with TESS observations
 - e. Extragalactic events
 - i. 2 events with factors of 4 and 15 increase in flux compared to 2019 average
 - ii. Super variable AGN? One is an x-ray source – not entirely sure what these objects are
3. Online alert system
 - a. Transient results already <24 hours with goals to decrease further
 - b. Processing and analysis is fully automated – ready for SPT winter season starting up again in 2 weeks
 - c. SPT-3G ATels
4. Outlook/future
 - a. Implementing automatic weather balloon avoidance
 - b. Lower detection threshold to ..., 7 sigma for a future population paper with many more events
 - c. Looking forward to engaging communities beyond cosmologists in order to learn as much as we can about these objects (especially as most of them are stars)
5. Questions

- a. (Ben Floyd) if the sources are near clusters or other targets that have been followed up in other wavelengths, would be good to check i.e. Spitzer

Tarraneh Eftekhari on CMB-S4 transients (theory)

1. Extragalactic transient landscape: GRBs, TDEs, aspherical cows?, SNe (descending luminosity, increasing duration)
2. Extragalactic synchrotron transients: due to shock interaction between outflowing ejecta and ambient medium
3. Using MC simulations to determine which kinds of events S4 will be especially sensitive to
 - a. Inject mock light curves with random time phasing and random distance
 - b. Distances weighted by comoving volume, cosmic SFR, SMBH density, and normalized by transient event rate
 - c. Detection criteria really important and must be set conservatively enough to avoid false detections
 - i. 10sigma
 - ii. Factor of 2 change in brightness during survey duration
4. Simulation results
 - a. Luminous GRBs will dominate detection rate, with Fast Blue Optical Transients (cow-like) just behind, handful of TDEs
 - b. 6 mJy rms, caution against using a 5sigma threshold
 - c. Analysis on cadence is ongoing
5. Questions
 - a. (Anna Ho) At the redshift of these events, can you detect the host galaxy (and cross-match catalogs to reduce false detections)?
 - i. Host galaxies typically around 0.3, so possibly
 - b. (Joaquin Vieira) Counts of TDEs are most uncertain?
 - i. TDEs and FBOTs may be quite uncertain, actually

Discussion

1. HR diagram with mm-wave detections
 - a. M Dwarfs, T Tauri, young, x-ray counterparts – all “weird”!

Action items/takeaways

1. Position on the sky covered by S4 cadence already
2. One takeaway from the last few months is that we thought we'd see many more extragalactic sources, whereas what we're finding is more galactic sources
 - a. How much do we as a community care about alerts for AGN flares?
3. Scan strategy to target minute or hour scale sources?
 - a. Do we need to adapt to these short time scales, or continue serendipitously finding them?