On the Calculation of SHARC Observing Time

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SHARC (Hunter, Benford & Serabyn 1996; Wang et al. 1996) can make maps up to $10'$ wide and $30'$ high with good sensitivity. In good weather (Tau at 225GHz of 0.05), a restored map has a sensitivity of approximately 4 Jy/$\sqrt{\text{seconds}}$ of on-source time per pixel. Maps are typically heavily oversampled and multicovered, so that the final map is binned, usually into $5''$ pixels. In CHOP_SLEWY mode for point sources, about 1Jy/$\sqrt{\text{sec}}$.

SHARC is optimized to operate at either 350 or 450μm; the filter transmission curves (Figure 1A) match the atmospheric windows. Because the peak atmospheric transmission at short wavelengths rarely ever exceeds 50% at Mauna Kea, it is advised to plan observations assuming Tau at 225GHz is less than 0.08, which is the case only 50% of the time. For a very rough estimate of the NEFD for varying Tau, refer to Figure 1B.

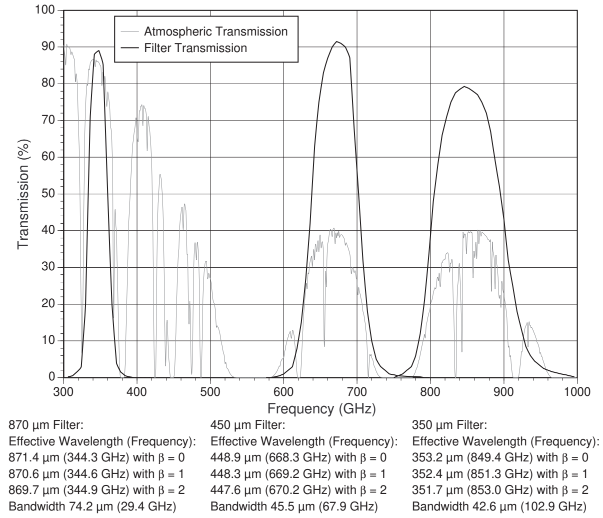

Figure 1. (A) SHARC filter transmission curves.

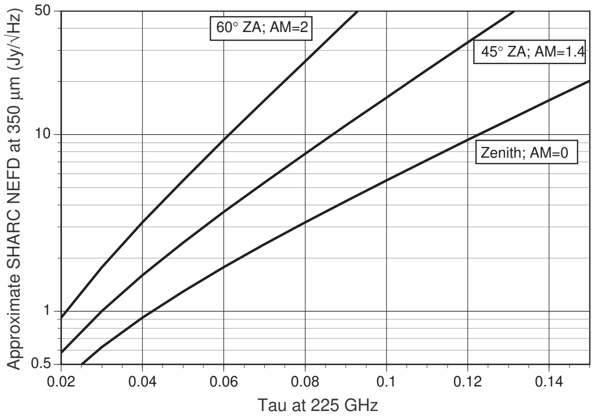

Figure 1. (B) Very approximate NEFD vs. Tau for mapping applications.

SHARC's beam is approximately a diffraction-limited Gaussian with a width of $9''$ at 350μm and $11''$ at 450μm. The array itself is comprised of rectangular bolometers, $5'' \times 10''$, stacked linearly to form an array $10''$ in Azimuth by $2'$ in Zenith. In mapping mode, the array is raster-scanned in Azimuth & Zenith to build up a map, all the while using the chopping secondary mirror to perform rapid (4 Hz) sky subtraction.

In order to calculate the 1σ noise level in a map with no sources (so you're not limited by dynamic range or restoration artifacts), you need to do the following: estimate your source size, increase this for safety and baselining, add the chopper throw in Azimuth, then calculate how long it takes a one-element bolometer to make the map at a given scan rate and step size in Zenith angle. For optimal observing, the total Azimuthal width of the map should be 3 to 6 times the chopper throw, and the time to scan an Azimuthal row should be about one minute. Then figure out how many times this bolometer would pass through a $5''$ pixel and multiply by 20; this is your coverage increase from using an array. Multiply by your integration time per point (usually 0.25 sec) and this is your total integration time per $5''$ pixel. Divide the NEFD by the square root of this number and you get your 1σ sensitivity. Round this up based on the fact that there is some telescope slew time (perhaps a 15% effect) and that the chopping secondary is not perfectly efficient (perhaps another 25%).

In the case of pointed observations, which are primarily appropriate for unresolved sources, the calculation is much simpler. Take half the NEFD from mapping as a starting point sensitivity. Pick an amount of wall-clock time and divide it by 4 (for slewing time (80% efficiency) on/off time (50%) and chopping secondary efficiency (70%)). Divide the sensitivity by the square root of this time and you have an approximat 1σ sensitivity after that amount of integration time. Detecting a point source at 3σ is pretty safe, since you have two pixels for every beam to provide verification of any detection.

For simplicity, we present here a tabulation of what kind of sensitivities you might expect to achieve, as a function of weather. Keep in mind that maps smaller than $2' \times 2'$ are usually a poor use of telescope time due to overheads associated with mapping, while larger than $10' \times 10'$ is difficult due to stability and sky rotation considerations. For $\tau_{225} > 0.10$, you might as well not even try to use SHARC. The times listed here are wall-clock times in hours, not on-source times.

Weather:	Tau_{225}	Chance†	Map $2' \times 2'$	Map $10' \times 10'$	Pointed (CHOP_SLEWY)
Excellent	$\tau < 0.05$	28%	500mJy/$\sqrt{\mathrm{Hr}}$	2.5 Jy/$\sqrt{\mathrm{Hr}}$	35mJy/$\sqrt{\mathrm{Hr}}$
Good	$\tau < 0.07$	47%	1.5 Jy/$\sqrt{\mathrm{Hr}}$	8 Jy/$\sqrt{\mathrm{Hr}}$	80mJy/$\sqrt{\mathrm{Hr}}$
Moderate	$\tau < 0.10$	66%	3 Jy/$\sqrt{\mathrm{Hr}}$	15 Jy/$\sqrt{\mathrm{Hr}}$	150mJy/$\sqrt{\mathrm{Hr}}$
Poor	$\tau < 0.15$	82%	10 Jy/$\sqrt{\mathrm{Hr}}$	50 Jy/$\sqrt{\mathrm{Hr}}$	1 Jy/$\sqrt{\mathrm{Hr}}$

† Based on data from Jan 97 - Oct 98.

Table 1: 1σ Sensitivity vs. Time and Weather.

Keep in mind that SHARC is sensitive to surface brightness. When you calculate sensitivities and required integration times, try to be realistic about the flux density. For instance, a 100 Jy IRAS source at 100μm spread over a $60''$ diameter could have a surface brightness of only 250 mJy/beam at 350μm!

It's not worth tracking sources below 30° elevation (2 airmasses) - at that point, if Tau=0.08, the transmission is only 2%. The table below indicates the amount of time for which a source is observable. Although this is just a rough guideline, the 4 Jy/$\sqrt{\mathrm{Hz}}$ number is quoted at $\sim$ 20% transmission, so 2% is more like 40 Jy/$\sqrt{\mathrm{Hz}}$. Tau at 350μm is roughly 25 times the value measured by the 225 GHz tipping radiometer.

Dec	Time
δ <-40 or δ >80	0 hours
-40< δ <-35 or $\delta \sim 78$	2 hours
-35< δ <-20	4 hours
-20< δ <10 or 70< δ <75	6 hours
10< δ <70	8 hours

Table 2: Tracking Time vs. Declination

Finally, since SHARC requires good pointing & calibration, you should propose to observe at times when planets are visible. Failure to do this may result in large pointing & absolute flux calibration uncertainties. There are other pointing & calibration sources in the sky besides planets, but the uncertainties associated with them are larger. Being careful about flux calibration requires that you observe a calibration source several times throughout the night, so plan on spending 25% of your observing time looking at calibrators. Skydips are not yet possible (though we're working on it), so you must measure Tau from astronomical soures. Also, since there is no internal calibration load, all measurements must be referred to an absolute calibrator such as a Mars and Uranus. Jupiter and Saturn are also useful; Venus and Neptune less so.

For your proposals, it would be wise to summarize briefly the sensitivity calculation which led to your requested time, in addition to the likelihood of the assumed weather conditions during your run. An idea of what you might do with better or worse conditions would help solidify your case.

Being a relatively new instrument, it is advised that anyone new to SHARC contact someone for help with the proposal or observing. In fact, collaboration is welcomed for this sort of endeavor. Send email to Tom Phillips [phillips@submm.caltech.edu], Dominic Benford [dbenford@submm.caltech.edu], or Darek Lis [dcl@submm.caltech.edu] for further assistance.

References

Hunter, T.R., Benford, D.J. & Serabyn, E. 1996, PASP, 108, 1042.

Wang, N., Hunter, T.R., Benford, D.J., Serabyn, E., Lis, D.C., Phillips, T.G., Moseley, S.H., Boyce, K., Szymkowiak, A., Allen, C., Mott, B. & Gygax, J., 1996, Appl. Opt., 35, 6629.