What is signal, what is noise?
In their discovery of the cosmic microwave background, Penzias and Wilson famously measured a system temperature ~3K more than expected, and thought it was due to the pigeons leaving dainty bird gifts on their telescope. While cleaning their dish helped lower the noise a little, it didn't get rid of the CMB signal!

Suppose you are observing at 1 cm wavelength with a filled aperture telescope. When pointed toward cold sky, in the zenith, your system noise temperature is twice what you expect. Normally, the receiver (radiometer) noise temperature is 70K and system noise temperature is 100K. Your partner notices that the radio telescope is filled with wet snow. Assuming that the snow has a temperature of 270 K, and is a perfect blackbody at 1 cm, how much of the aperture is covered with snow?

Remember noise temps. join additively!

Here we see on a normal day,

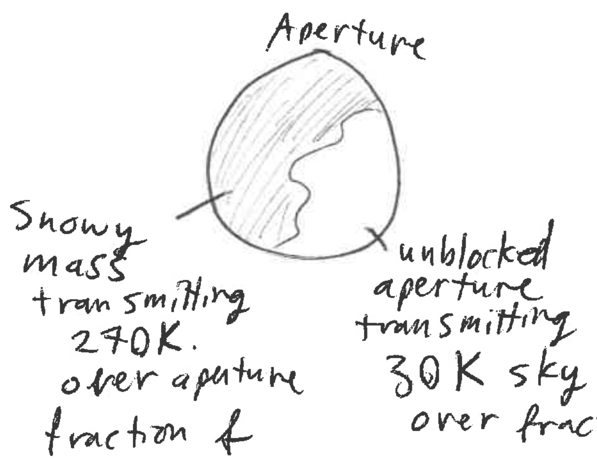
$$T_{sys} = T_r + T_{sky} \Rightarrow 100\,K = 70\,K + T_{sky}$$

So at this freq. and sky position,

$$T_{sky} = 30\,K.$$

On this slushy day, $T_{sys} = 200K$. Let's assume that extra load is all due to the wet snow.

We take the snow as a black body... $T_B = T_{physical}$ and it absorbs all incident light. So it both blocks the aperture from reflecting sky emission, & it transmits thermally at $T = 270K$.



$\Rightarrow$ Here,

$$T_{sys} = 200\,K = T_r + (1-f)\,T_{sky} + f\,T_{snow}$$

$$200\,K = 70\,K + (1-f)(30\,K) + (f)(270\,K)$$

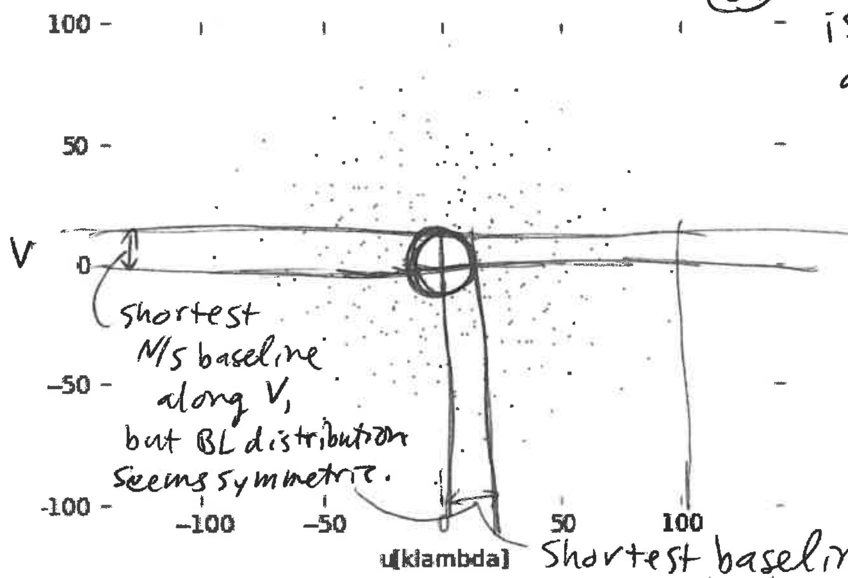
Solve for f

$f \approx 42\%$ coverage!

(measured in meters after λ multiplication)

The u,v plane

Consider the following u,v plane (vertical axis is v in kilolambda, where lambda=wavelength)



Shortest baseline, divided by wavelength. Easier to estimate from bottom plot.

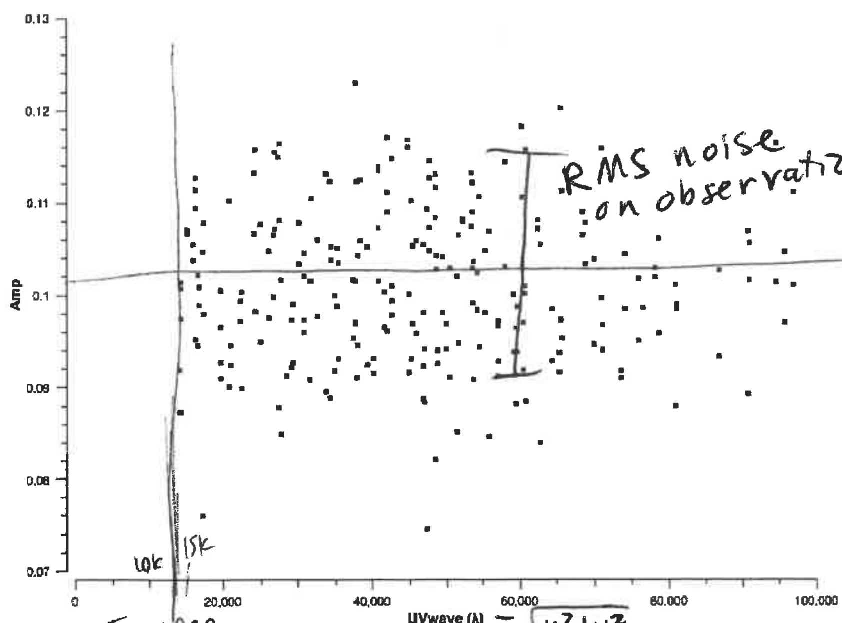
(a) Longest baseline is 100 000 wavelengths across, so $10^5 \cdot \lambda$. The resolution is $\theta_{res} \simeq \frac{\lambda}{B_{max}}$

So $\theta_{res} \simeq \frac{\lambda}{10^5 \lambda} = 10^{-5}$ rad

$\theta_{res} = 2$ arcsec.

(a) If this observation was at 230 GHz at zenith, what is the approximate resolution of the observation? (b) What is the smallest separation (in meters) between two antennae in the N/S direction?

Here is the same data plotted as Amplitude vs. uvwave = $\sqrt{u^2 + v^2}$:



(b) $\sqrt{u^2+v^2} = 13000$ → i.e. Shortest baseline is ~13000 wavelengths across. 1λ is $\frac{c}{230\,GHz} = 1.3$ mm

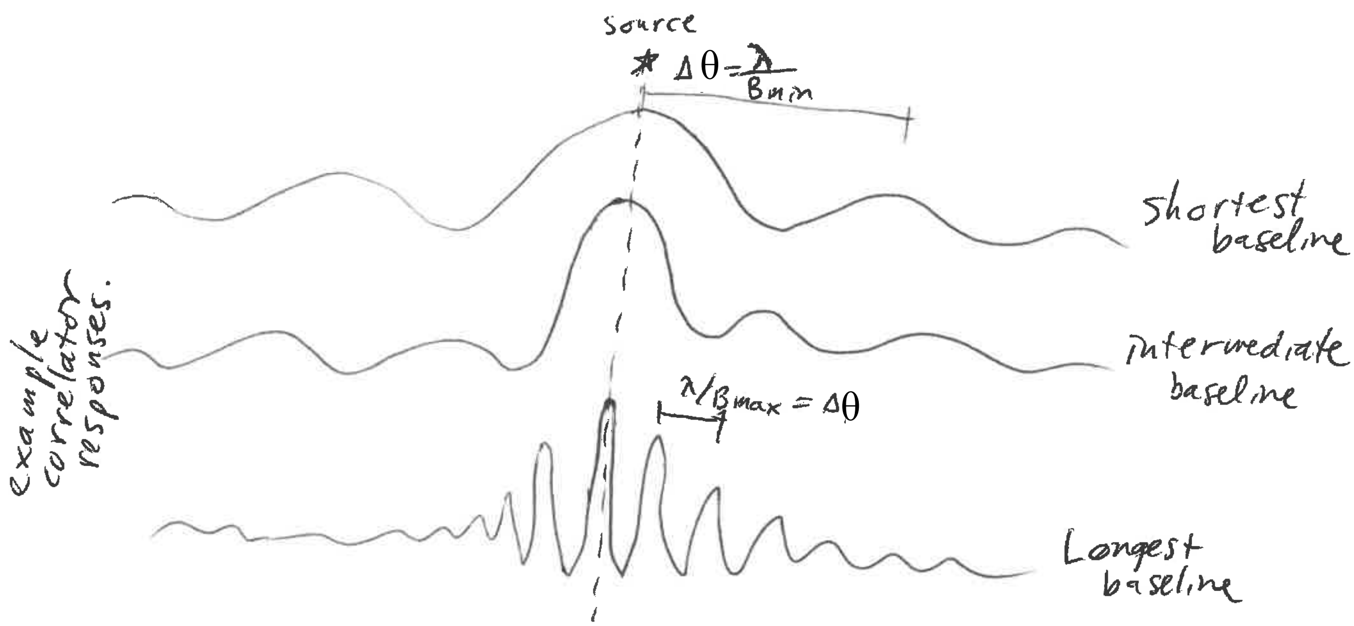
So shortest baseline is ~20 m (= 13000 × 1.3 mm)

What does this source look like in the image plane?

SEE NEXT PAGE.

The fringe spacing for the correlator response for a given baseline is $\frac{\lambda}{B\sin\Psi}$. ($B\sin\Psi$: projected baseline.)

Recall that the correlator response fring period can be thought of as probing the sky with a given resolution (given by $\Delta\theta = \frac{\lambda}{B\sin\Psi}$). We have discussed how therefore changing λ or B (or θ) will give larger or smaller resolutions. Here, λ is fixed — so what kind of source would give the same measurement no matter the resolution?



Only a point source — any other flux distribution would have a beam-integrated visibility that changes with correlator response distribution, & hence changes with baseline.