2017 CasA transits analysis (episode 2)

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Tianlai zoom
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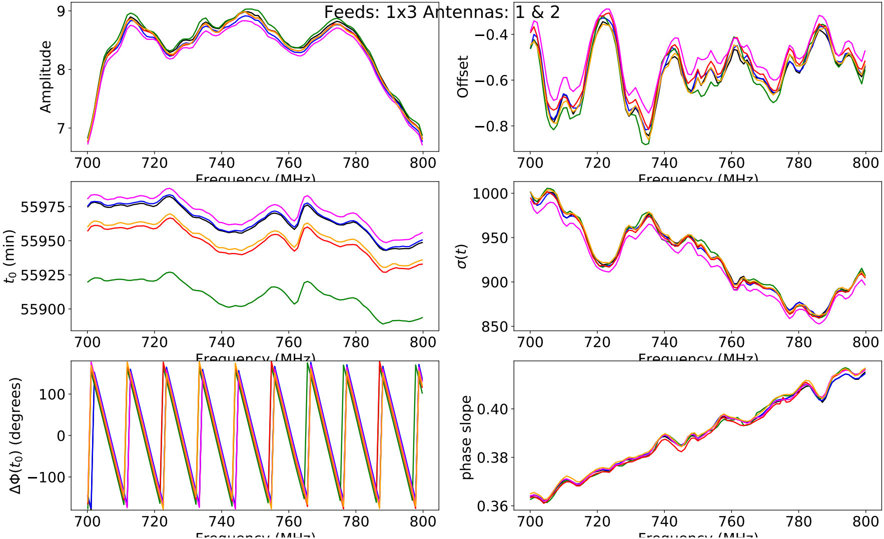
Outline

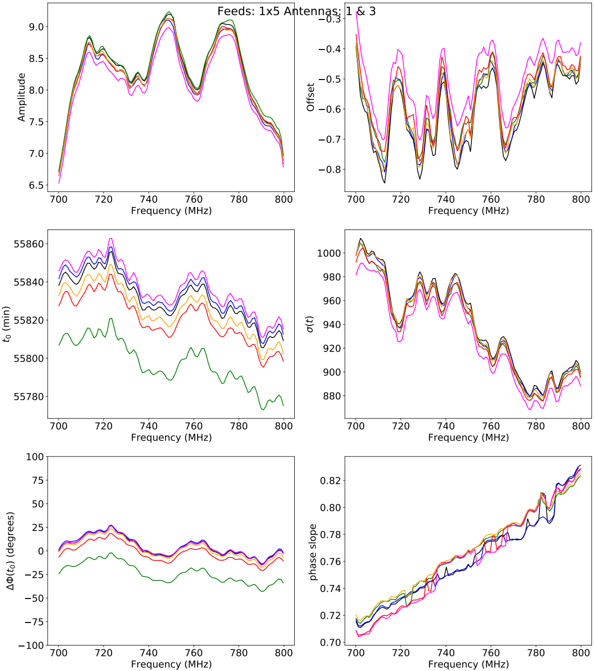
- follow-up of Reza's feb. presentation
- using 2017 Oct. 17th to 23rd data at CasA elevation : 6 transits
- built time-frequency maps of broad baseline selection, one polar only
- $G(\nu)$ obtained by median filter of non NS data
- NS periods flagged out (but averaged for further look)
- no RFI flagging
- first transits' analysis - at each frequency independtly :
  - fit of t_0, amplitude, offset and width using module of visibilities (over central part of transit). NB : express t_0 as sidereal time (236 second/day correction)
  - compute phase around t_0 and extract $\phi(t_0)$ and slope $(d\phi/dt(t_0))$
- Aim : look at data stability


Feeds: 1x3 Antennas: 1 & 2
Amplitude
Offset
t_0 (min)
$\sigma(t)$
$\Delta\Phi(t_0)$ (degrees)
phase slope
Frequency (MHz)

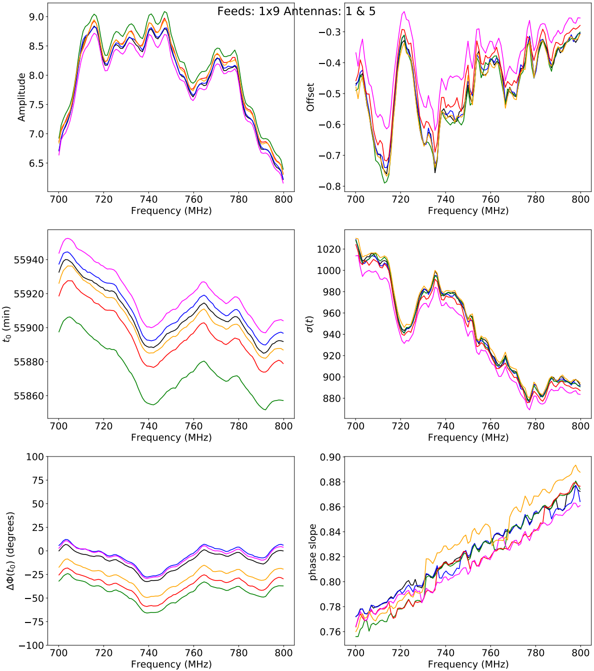
Phase representation

To compare $\phi(t_0)$ vs frequency for different transits of a given baseline :

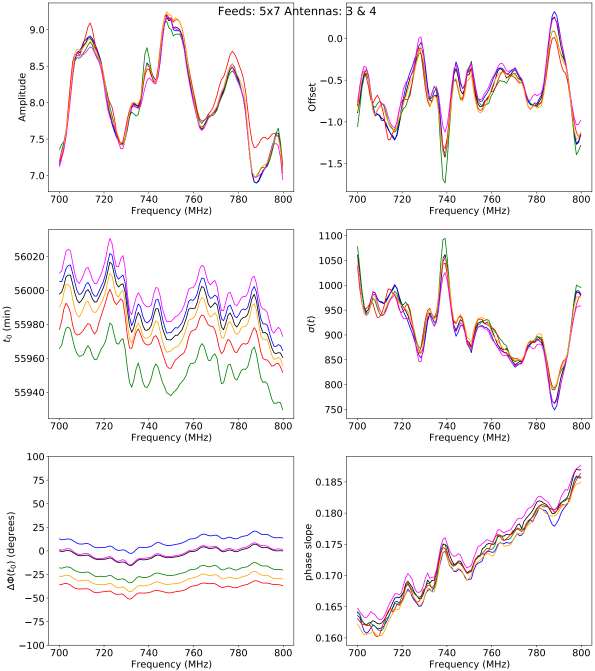
- $\phi(t_0)[\nu] \approx (a * \nu + b)\text{modulo}(2\pi)$
- correct for 2π steps to get one $\sim$ linear shape
- take the first and last point of the first transit to get an approximate $\phi(t_0)$ vs frequency shape
- subtract it for all transits' data and plot residuals
- may help to signal slope change or offset between transits

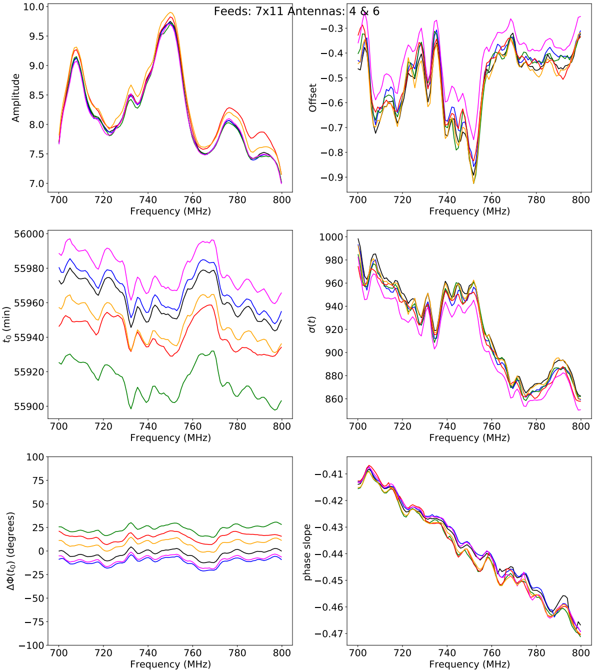


Feeds: 1x5 Antennas: 1 & 3
Amplitude
Offset
t_0 (min)
$\sigma(t)$
$\Delta\Phi(t_0)$ (degrees)
phase slope
Frequency (MHz)



Feeds: 1x9 Antennas: 1 & 5
Amplitude
Offset
t_0 (min)
$\sigma(t)$
$\Delta\Phi(t_0)$ (degrees)
phase slope
Frequency (MHz)


Feeds: 5x7 Antennas: 3 & 4
Amplitude
Offset
t_0 (min)
$\sigma(t)$
$\Delta\Phi(t_0)$ (degrees)
phase slope
Frequency (MHz)


Feeds: 7x11 Antennas: 4 & 6
Amplitude
Offset
t_0 (min)
$\sigma(t)$
$\Delta\Phi(t_0)$ (degrees)
phase slope
Frequency (MHz)

Observations/questions

- coherence between baselines
- "structured" amplitude (+offset, width) vs frequency maybe (partly) due to limited fitting range ? two component $G(\nu)$ ("electronics only", " with signal/beam") ?
- negative offsets - same reason ? fit of module only ?
- t_0 vs frequency : O(1min) variation with frequency, O(1 min) variation between transits (similar from baseline to baseline) ?
- $\Delta\phi(t_0)$: constant (vs freq) change (20 to 40 degrees) between transits

A second model

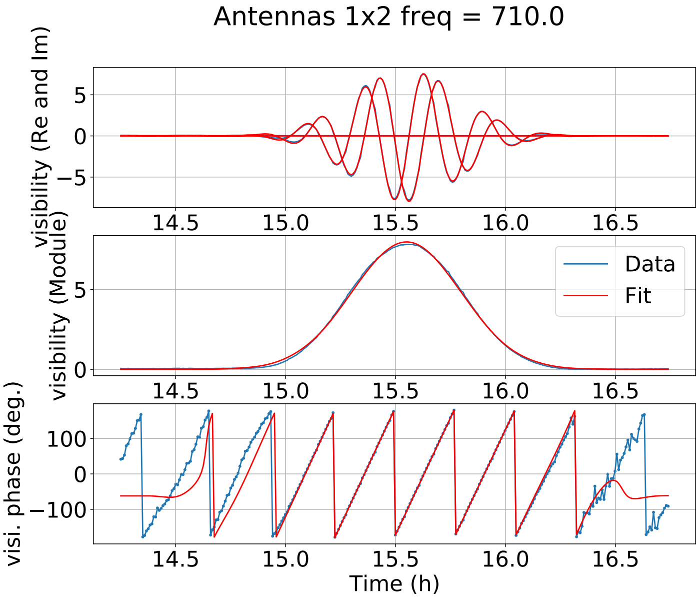
8 parameters model of real and imaginary parts of visibility

$$Re(V(t)) = o_r + A\frac{\exp(-(t-t_0)^2/\sigma^2)}{\sigma\sqrt{2\pi}}\cos\left(\omega(t-t_0)+\eta(t-t_0)^2+\phi\right)$$

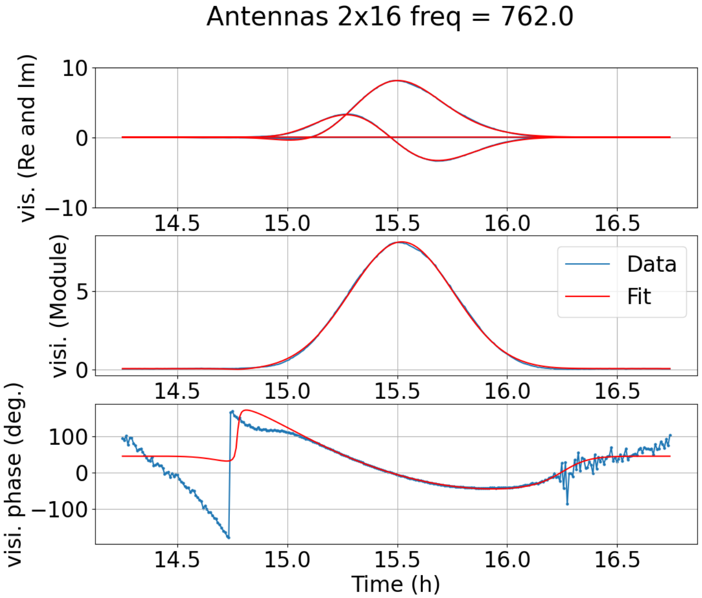
$$Im(V(t)) = o_i + A\frac{\exp(-(t-t_0)^2/\sigma^2)}{\sigma\sqrt{2\pi}}\sin\left(\omega(t-t_0)+\eta(t-t_0)^2+\phi\right)$$

NB first model fits A^* instead of $A/\sigma\sqrt{2\pi}$ here
fit over larger time interval (1-3h), implemented in python
Approximate formula (small hour angle $\Rightarrow$ $t-t_0$ development)
Bessel $J_1(x)/x$ function also implemented

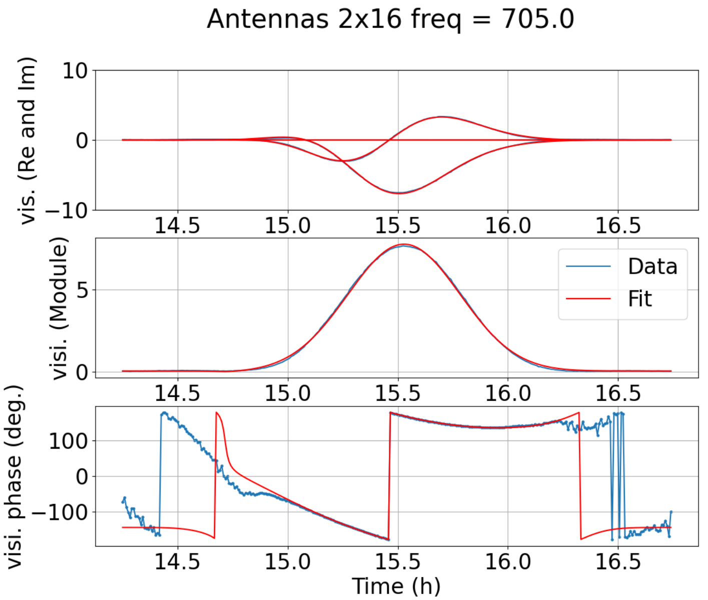
Examples of visibility fits



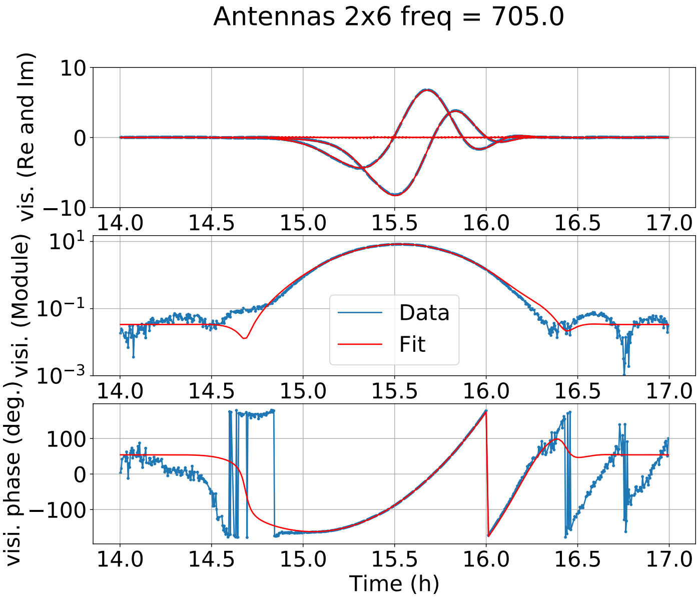
Examples of visibility fits



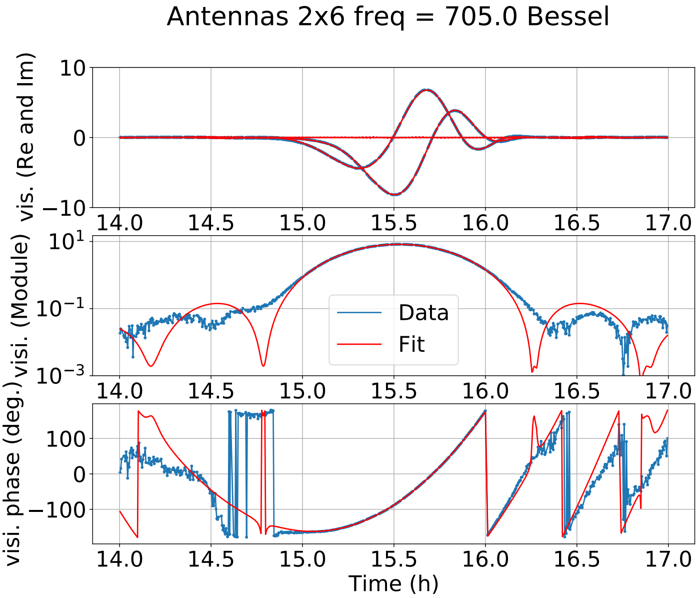
Examples of visibility fits



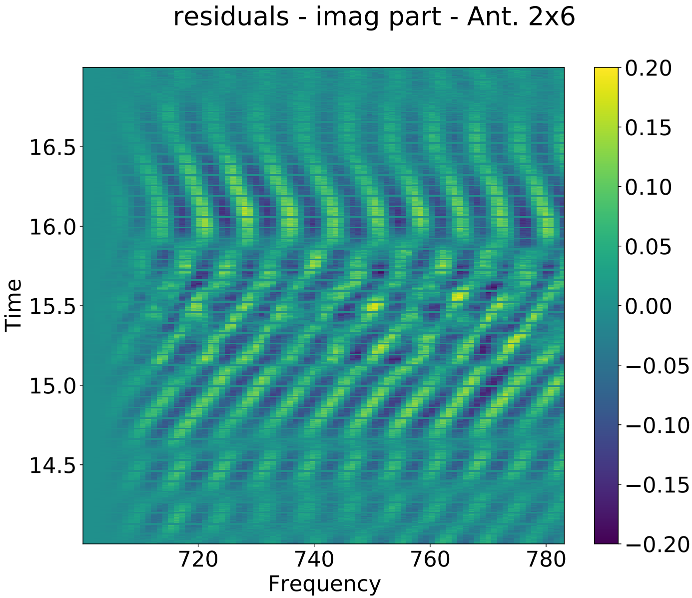
Examples of visibility fits



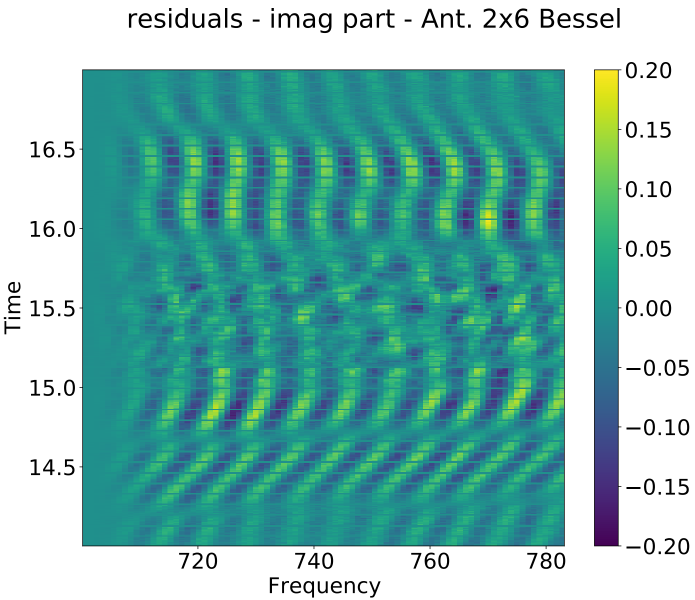
Examples of visibility fits

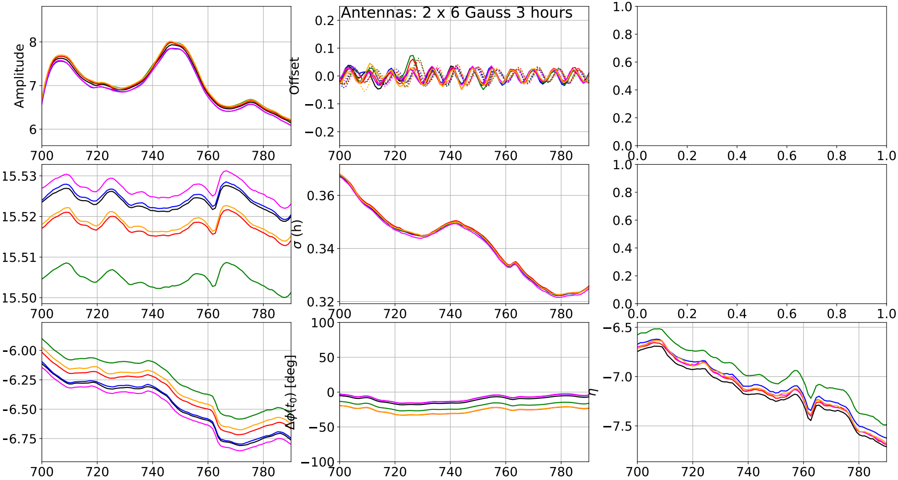


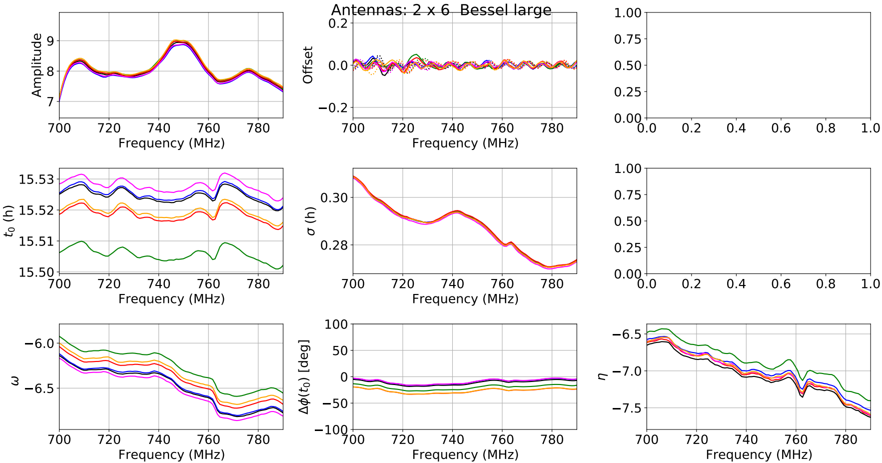
2D Residuals

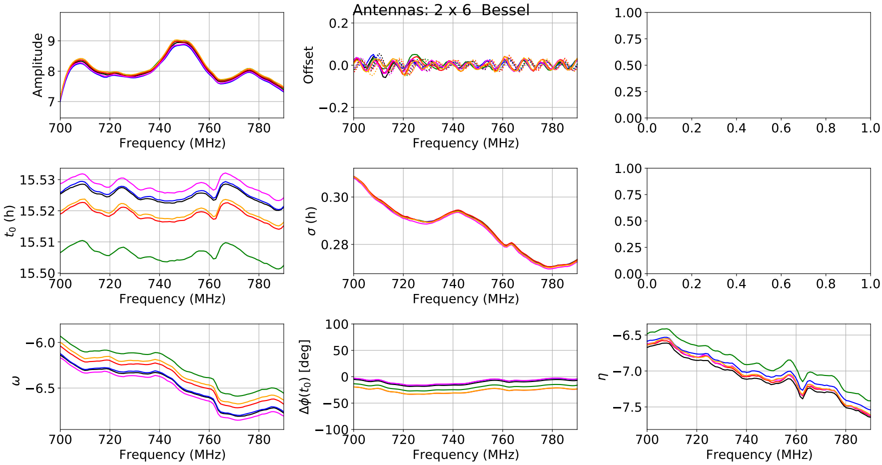


2D Residuals

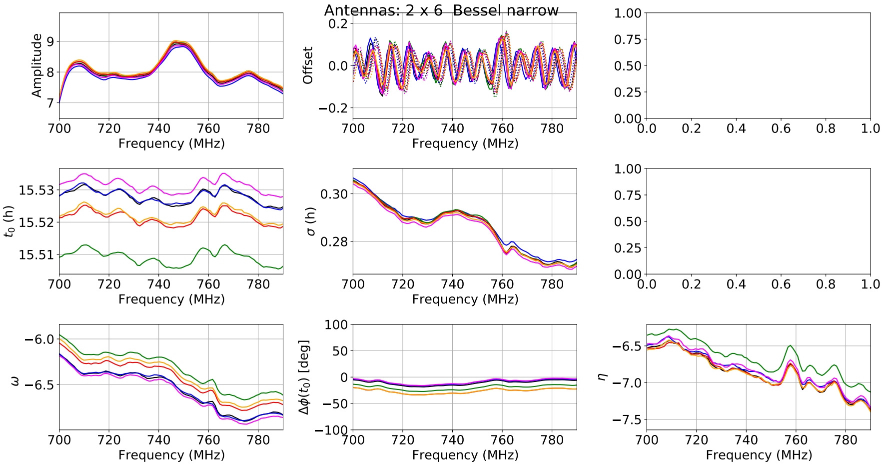



Antennas: 2 x 6 Gauss 3 hours
Amplitude
Offset
σ (h)
Δφ(t0) [deg]
η

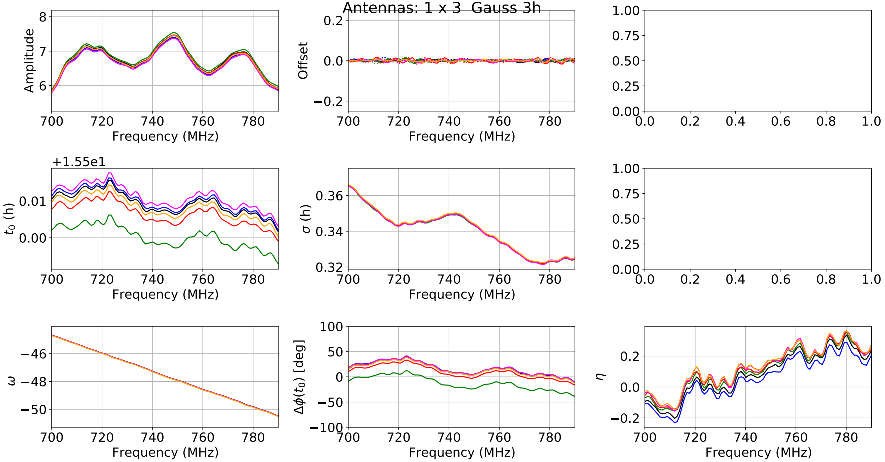

Antennas: 2 x 6 Bessel large
Amplitude
Offset
t_0 (h)
σ (h)
ω
$\Delta\phi(t_0)$ [deg]
η
Frequency (MHz)

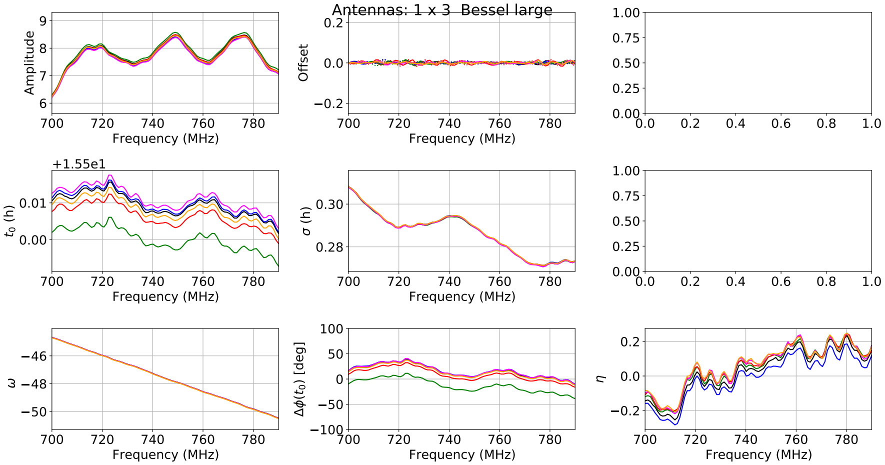


Antennas: 2 x 6 Bessel
Amplitude
Offset
t_0 (h)
σ (h)
ω
$\Delta\phi(t_0)$ [deg]
η
Frequency (MHz)



1h width ⇒ affects offsets and widths

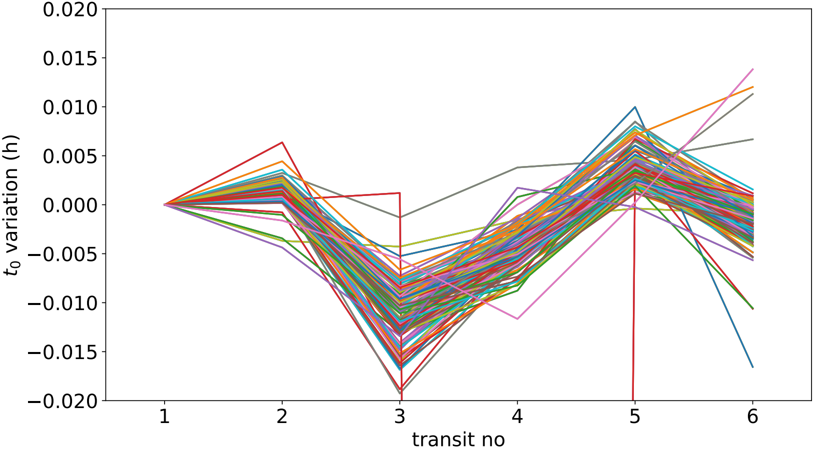

Antennas: 1 x 3 Gauss 3h
Amplitude
Offset
+1.55e1
t_0 (h)
σ (h)
ω
$\Delta\phi(t_0)$ [deg]
η
Frequency (MHz)


Antennas: 1 x 3 Bessel large
Amplitude
Offset
Frequency (MHz)
+1.55e1
t_0 (h)
σ (h)
ω
$\Delta\phi(t_0)$ [deg]
η

Observations

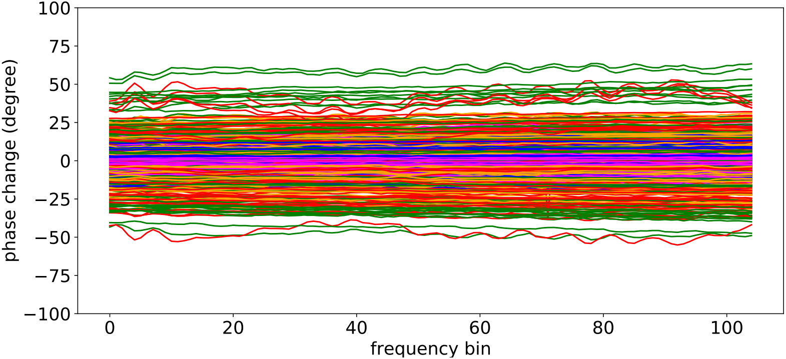
- similar/identical behaviour of ampli vs frequency in both models (c++ vs python)
- width/σ, slope/ω seems smoother
- complex offset around 0+j0
- very similar variations of t_0 and $\Delta\phi$ vs freq in both models
  NB t_0 and $\Delta\phi$ seem correlated with each other ?
- Bessel beam helps a bit far from transits, small parameter changes
- further questions...

t_0 variations are correlated between baselines ! ?



variation of t_0 at one frequency, for all baselines

phase variation between transits



for most baselines, phase change between transits is ∼ an offset constant vs frequency

detailed comparison with what's expected from noise source under way - which seems different ...

Link between t_0 and $\phi(t_0)$?