ASTRON

Netherlands Institute for Radio Astronomy

# Closure phases with the first LOFAR observations

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LOFAR status meeting

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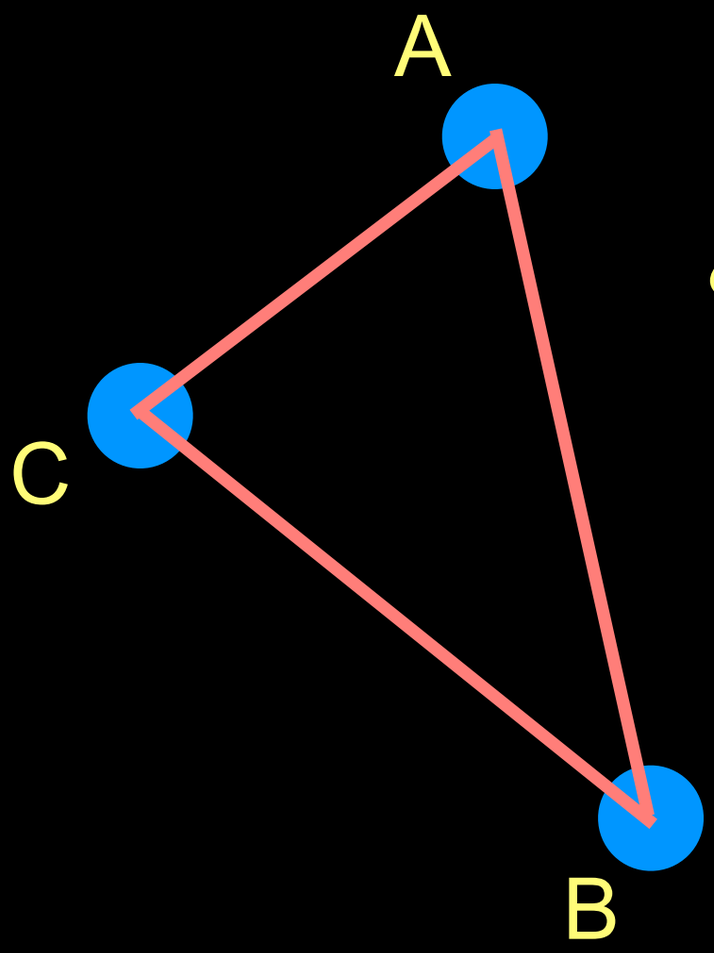
# Closure phases

- A closure phase is a specific combination of phases on sets of three baselines, which eliminates many instrumental errors.




- The phase on each baseline is corrupted by e.g. clock and ionospheric errors:

$$\tilde{\phi}_{\mathrm{AB}} = \phi_{\mathrm{AB}} + \theta_{\mathrm{A,c}} + \theta_{\mathrm{B,c}} + \theta_{\mathrm{A,i}} + \theta_{\mathrm{B,i}} + \mathrm{noise}$$

By adding phases around the triangle, the errors cancel.

$$\tilde{\phi}_{\mathrm{AB}} + \tilde{\phi}_{\mathrm{BC}} + \tilde{\phi}_{\mathrm{CA}} =$$
$$\tilde{\phi}_{\mathrm{AB}} + \tilde{\phi}_{\mathrm{BC}} - \tilde{\phi}_{\mathrm{AC}} =$$
$$\phi_{\mathrm{AB}} + \phi_{\mathrm{BC}} - \phi_{\mathrm{AC}} + \mathrm{noise}$$

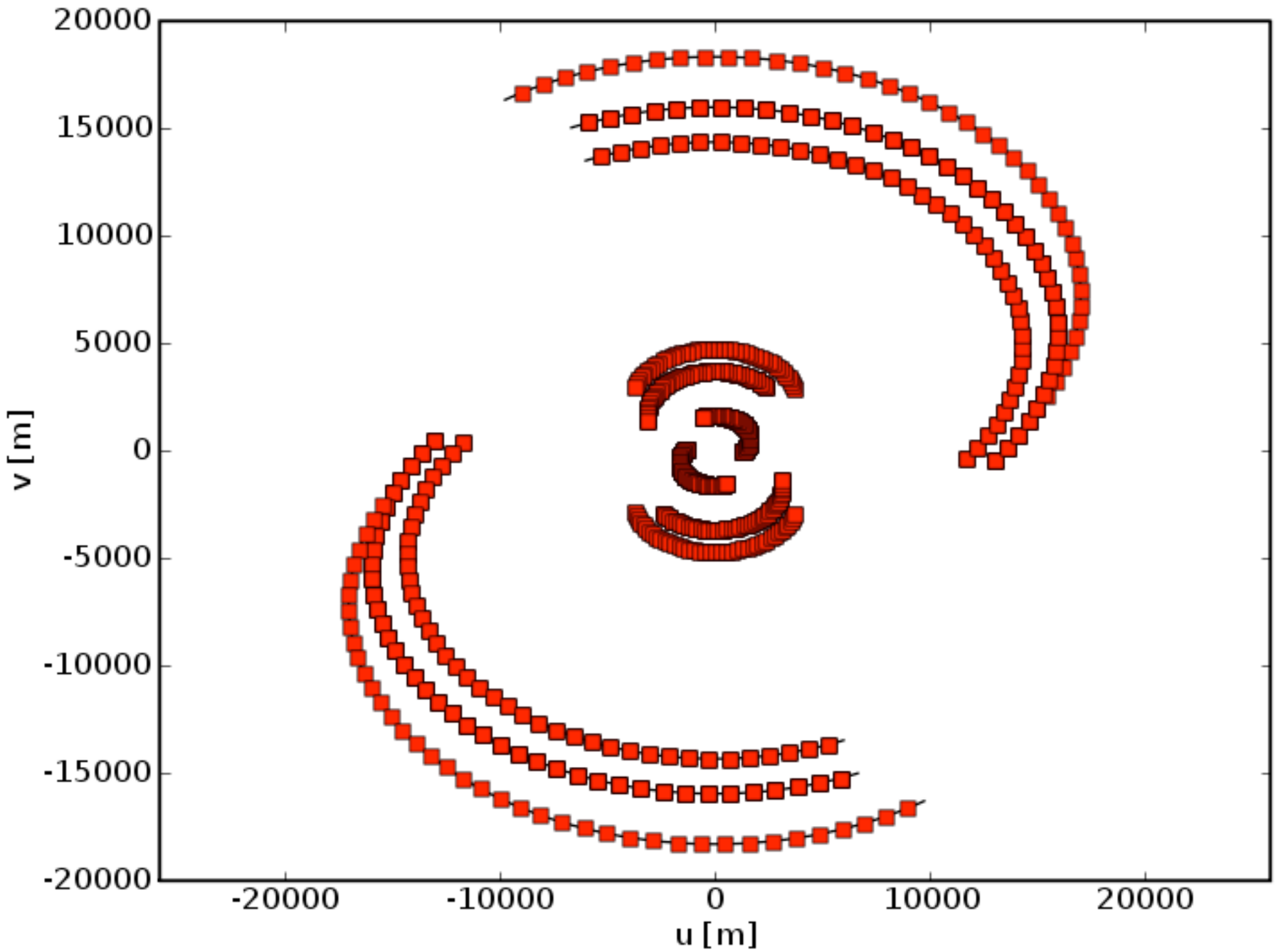
(The sum vanishes for a point source)

# One way to slice the data...

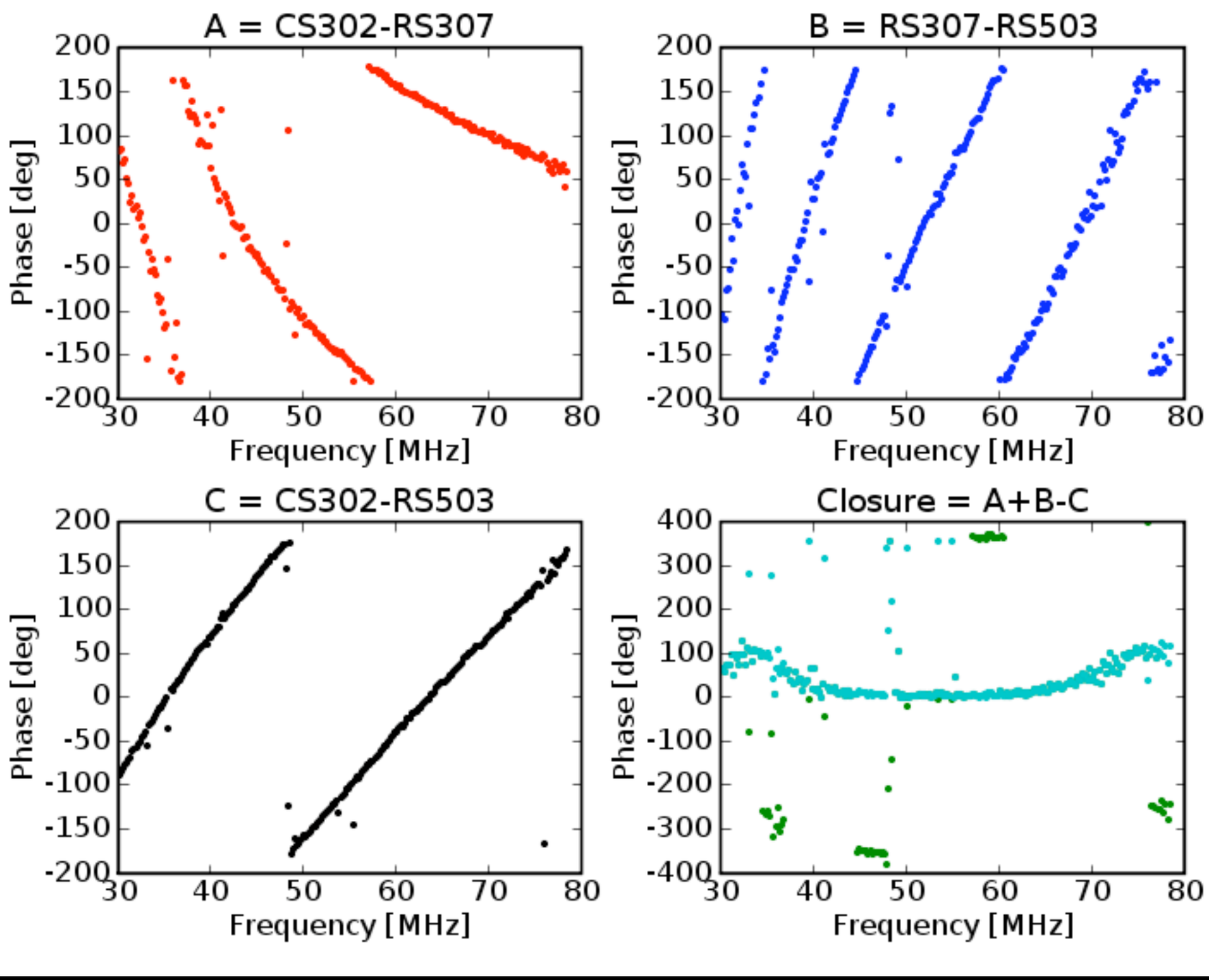
- LBA and HBA observations L2009_13244 and L2009_13255:
  - 1sec integrations, 248 subbands, 256 ch/subband
  - Using pyrap, extracted 1 sec integration from each subband, averaged over central 200 channels. Time separation 15min.
  - Note: No RFI excision.
  - For each sample, closure phase calculated on baseline triangle defined by CS302, RS503, and RS307.

- (shown here: LBA data)

# LBA (u,v) samples

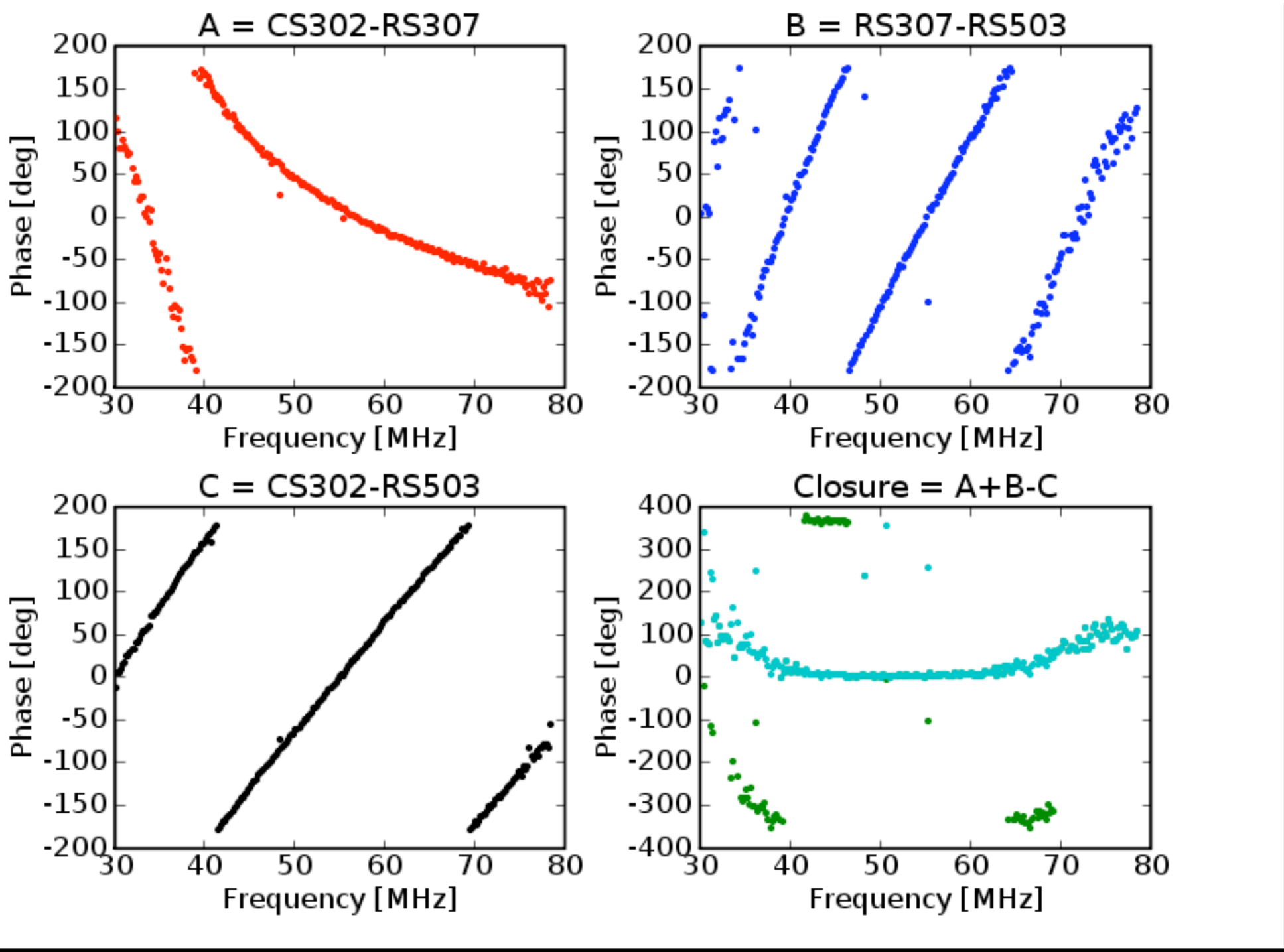


# LBA closure phases (XX)



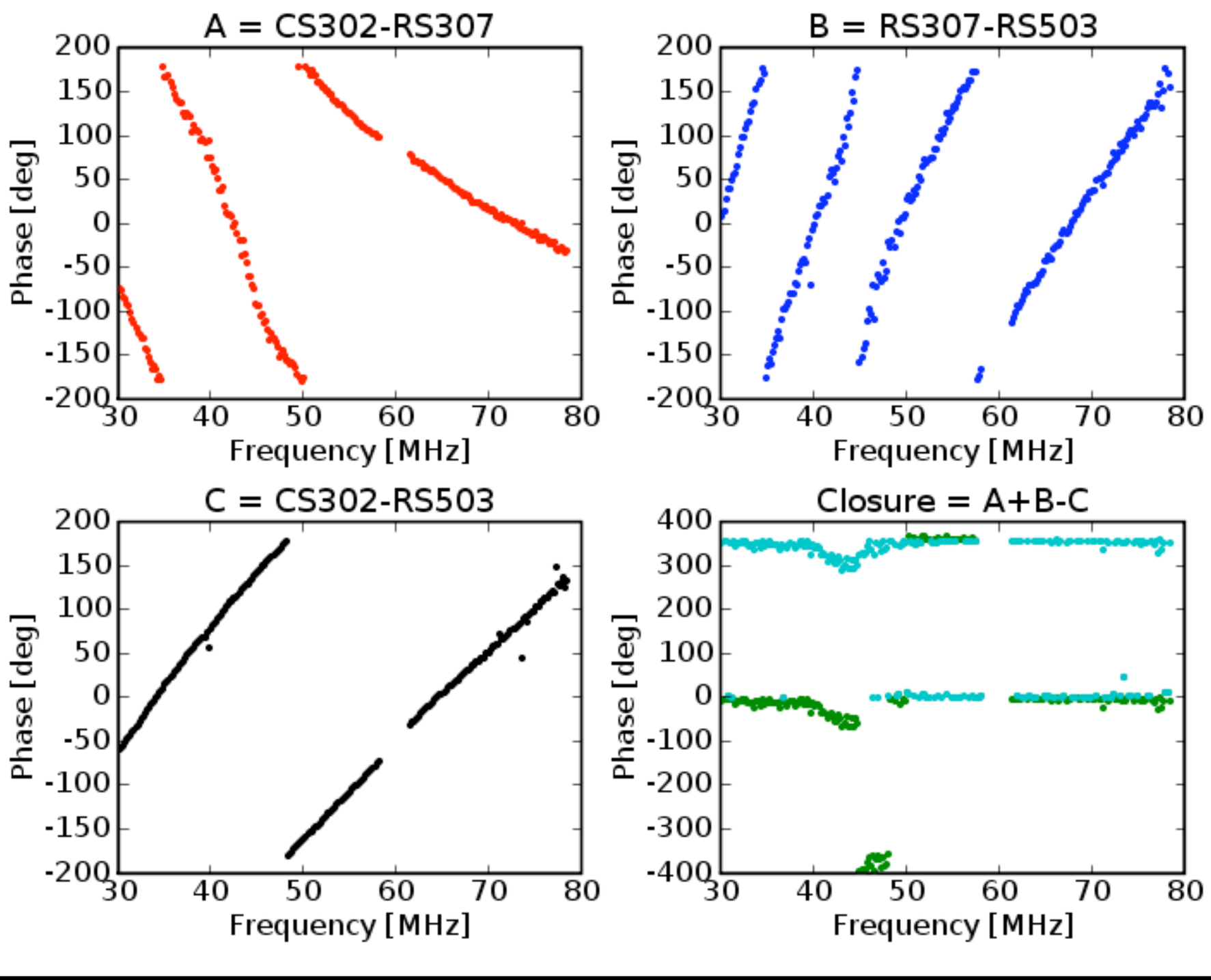

t = 0 min

# LBA closure phases (XX)



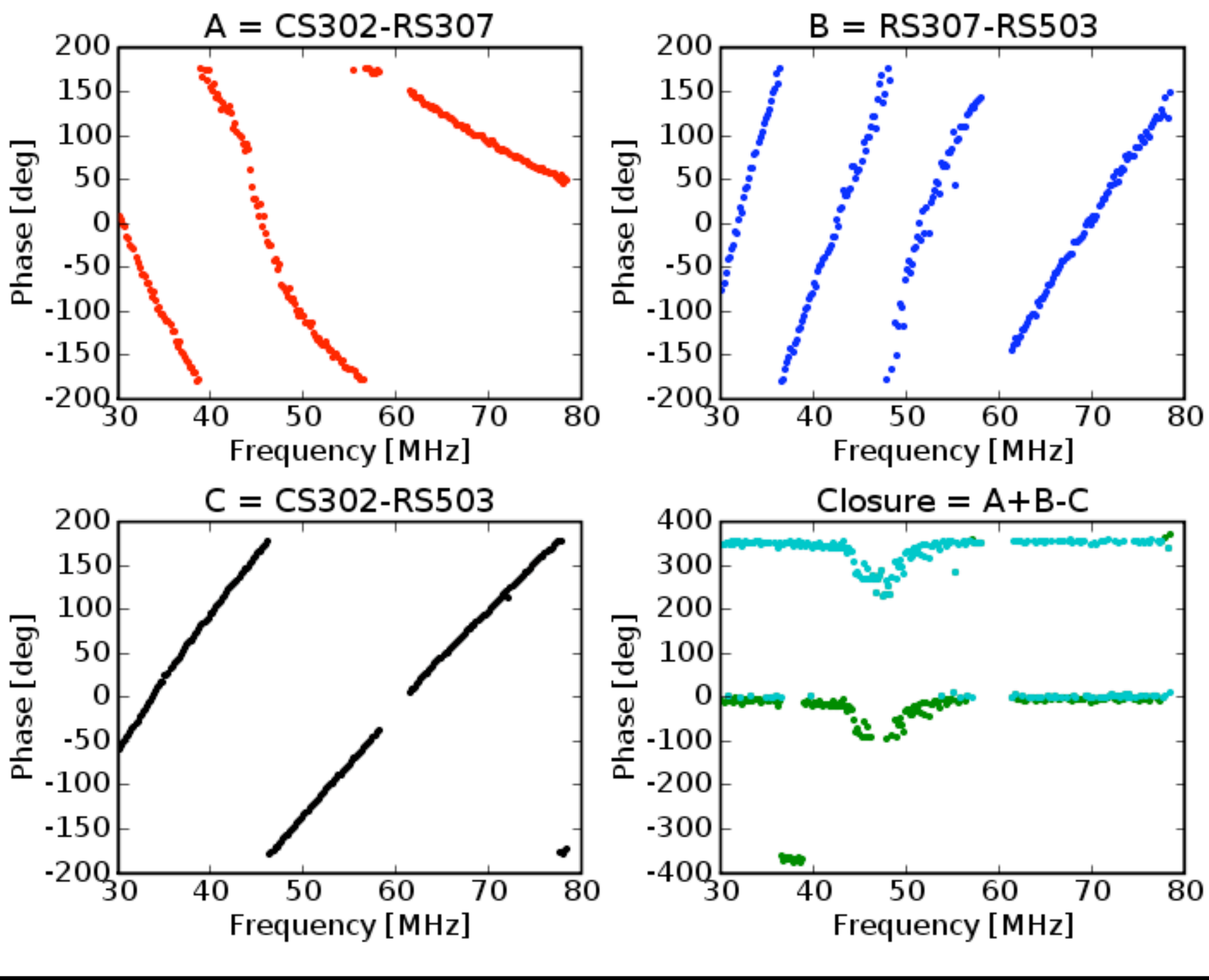

t = 15 min

# LBA closure phases (XX)



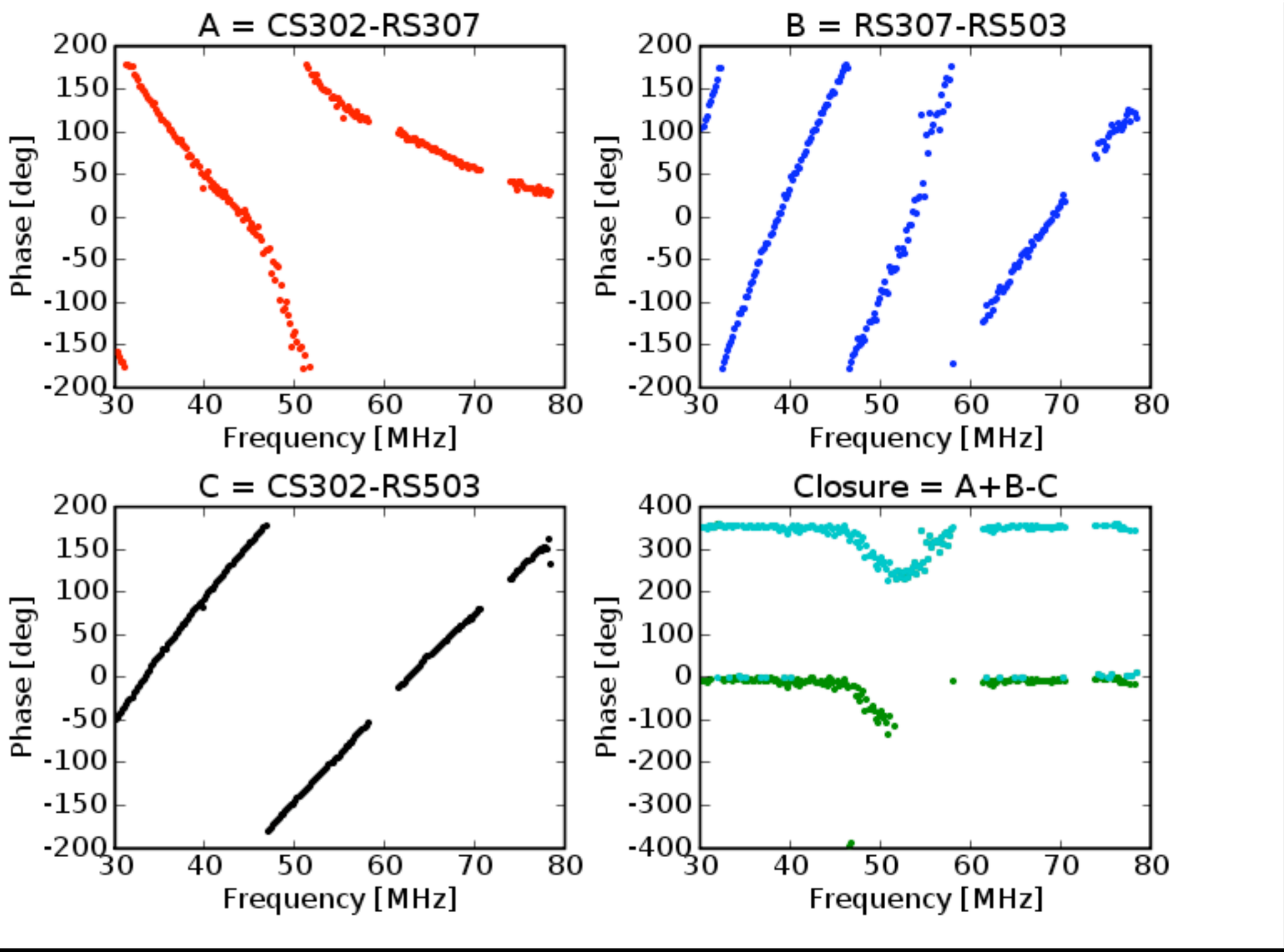

t = 240 min

# LBA closure phases (XX)



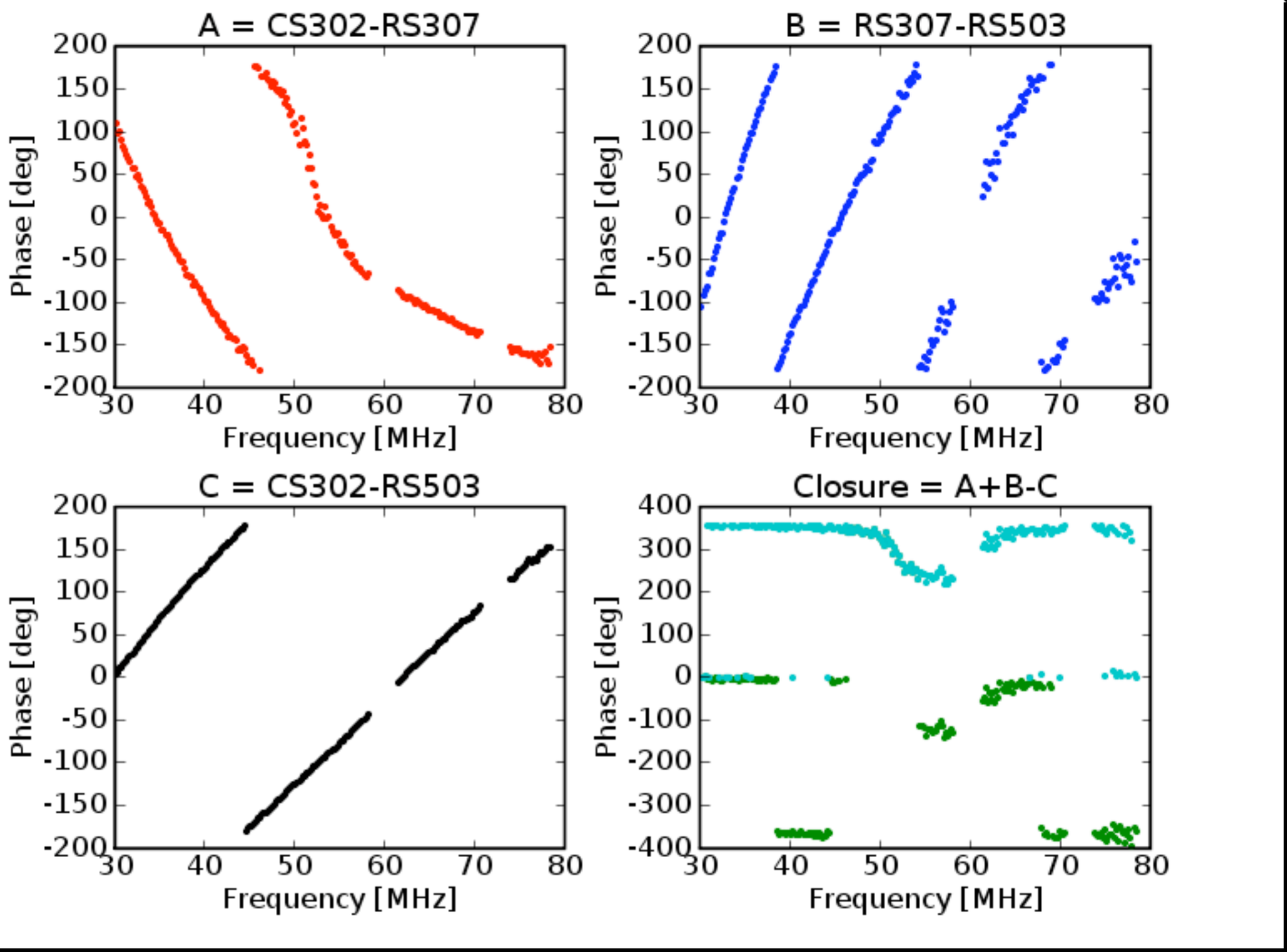

t = 255 min

# LBA closure phases (XX)



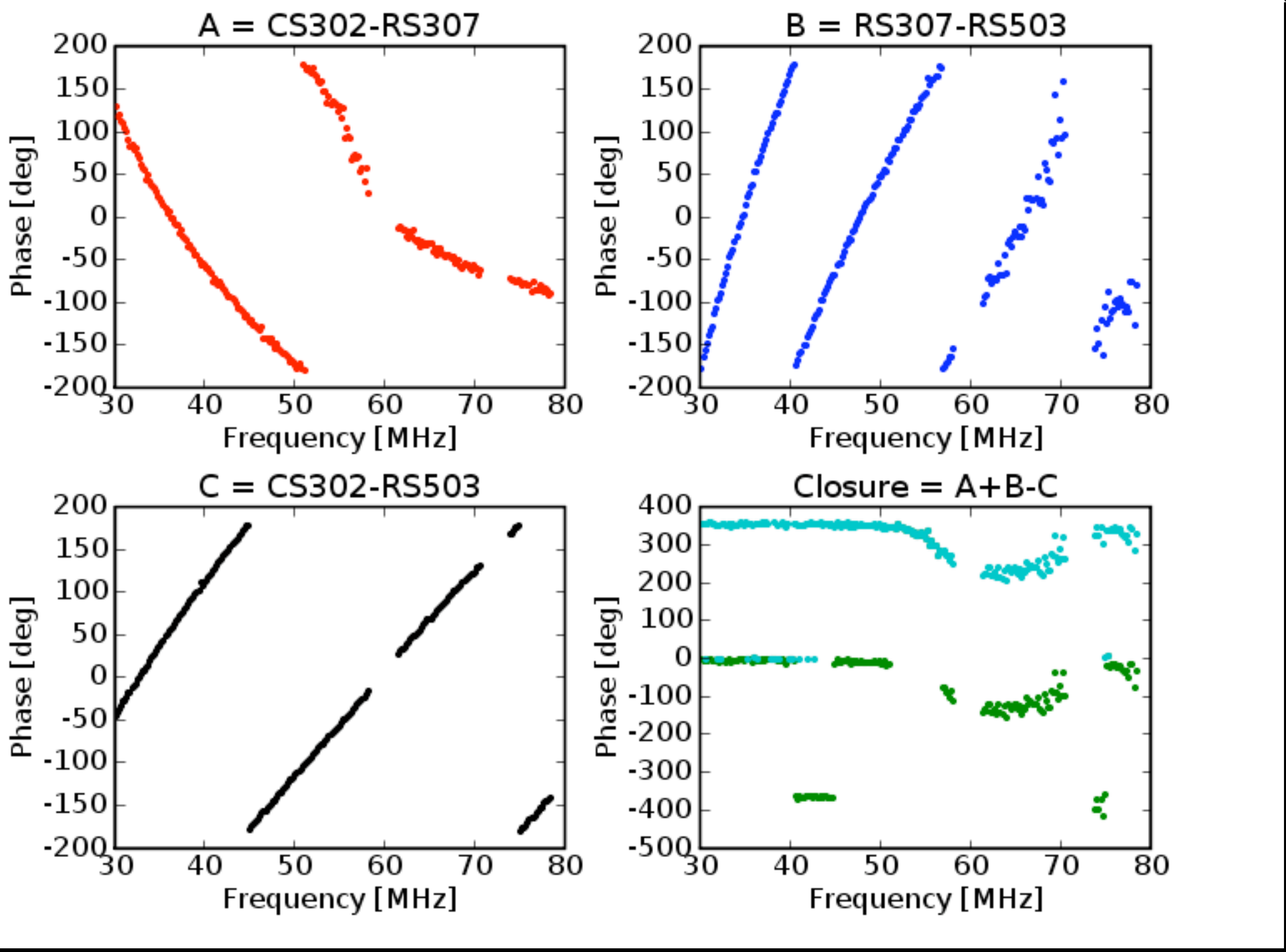

t = 270 min

# LBA closure phases (XX)



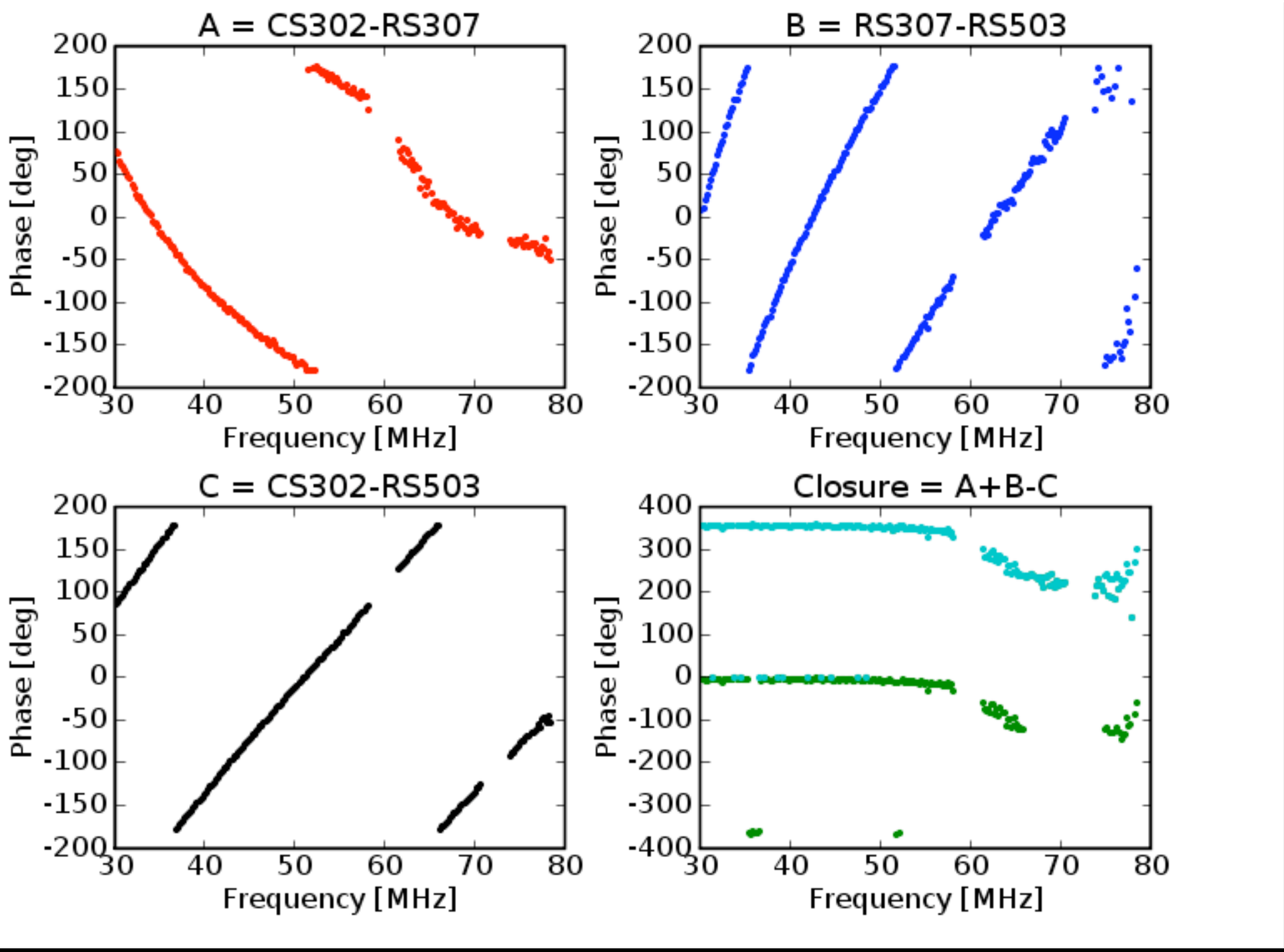

t = 285 min

# LBA closure phases (XX)



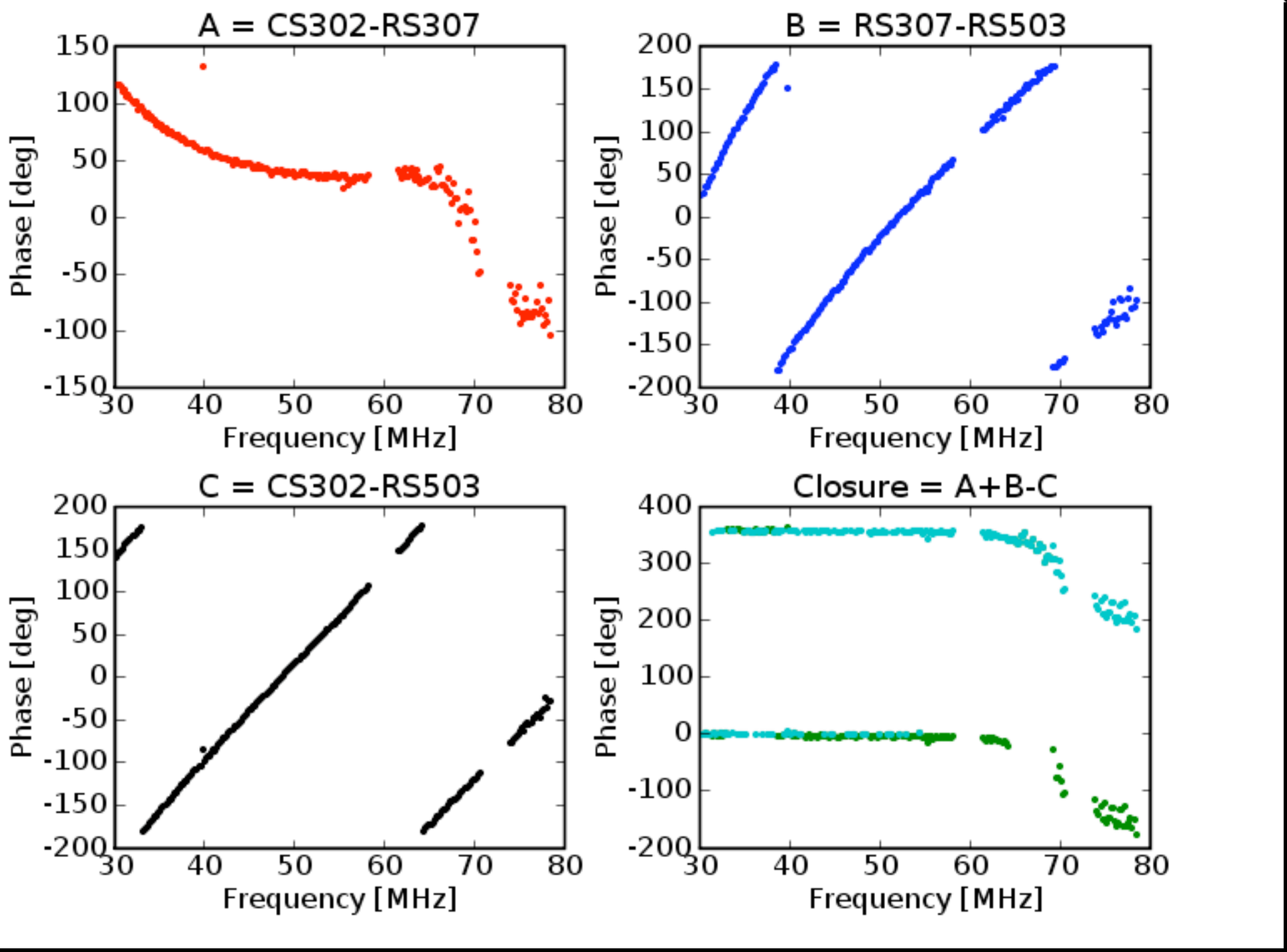

t = 300 min

# LBA closure phases (XX)



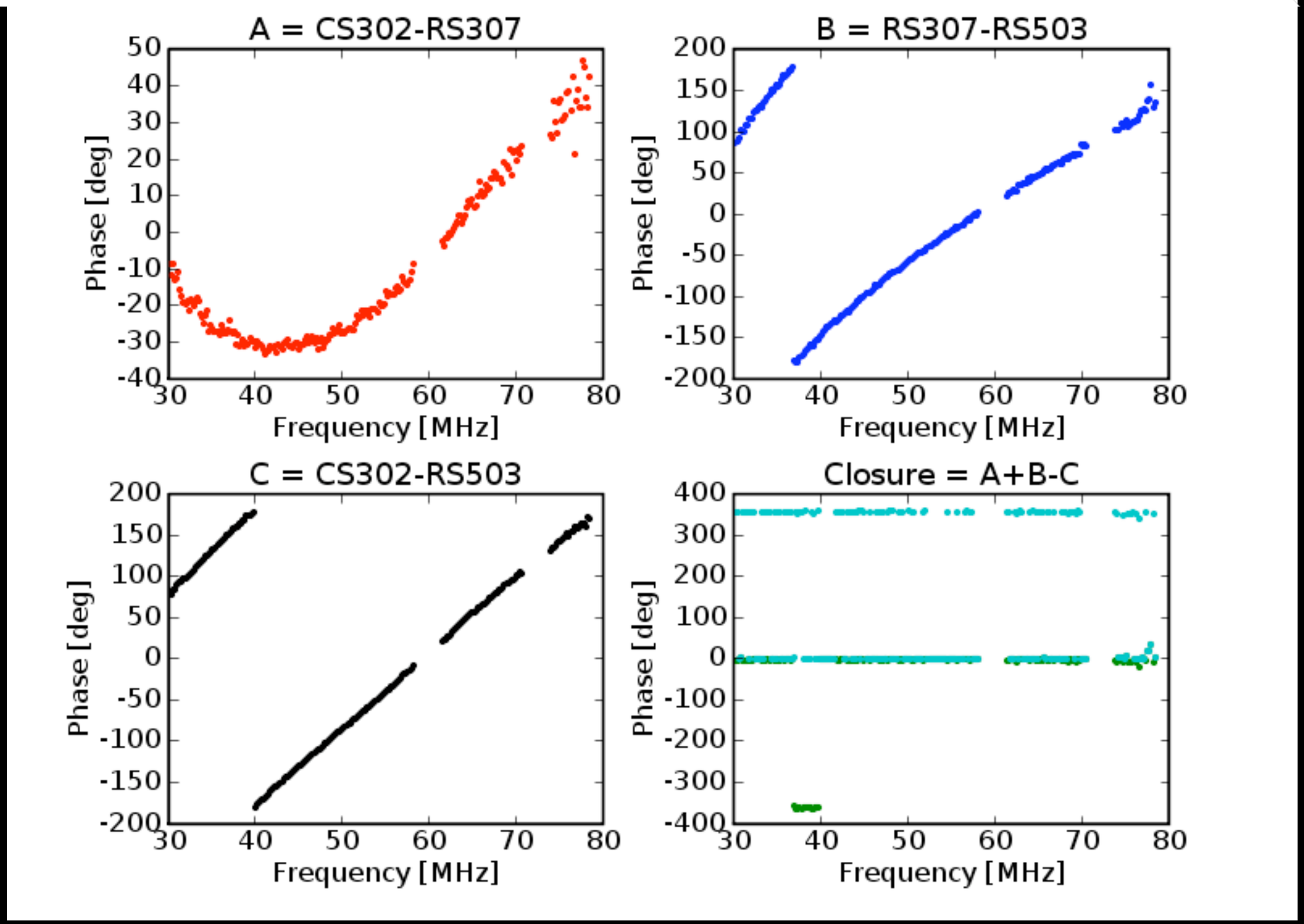

t = 315 min

# LBA closure phases (XX)




t = 330 min

# LBA closure phases (XX)




t = 360 min

# Causes?

- Closure phases are free of antenna phase errors, so it would have to be a baseline dependent error. The “closure dip” also appears in the YY correlation!
- Could it be the source? Cygnus A has a double lobe structure separated by ~80”, which corresponds to a 20km baseline at ~7.75m wavelength = 40 MHz !
- Simple model constructed:
  - two point sources separated by 80” at the right PA
    - 110 degrees, which = the value at higher freq (108±2)
  - used relative lobe flux ratio 1.25 (E lobe brighter than W)
  - extracted (u,v) from MS, calculated theoretical closure phases for each time, compared with data closure phases

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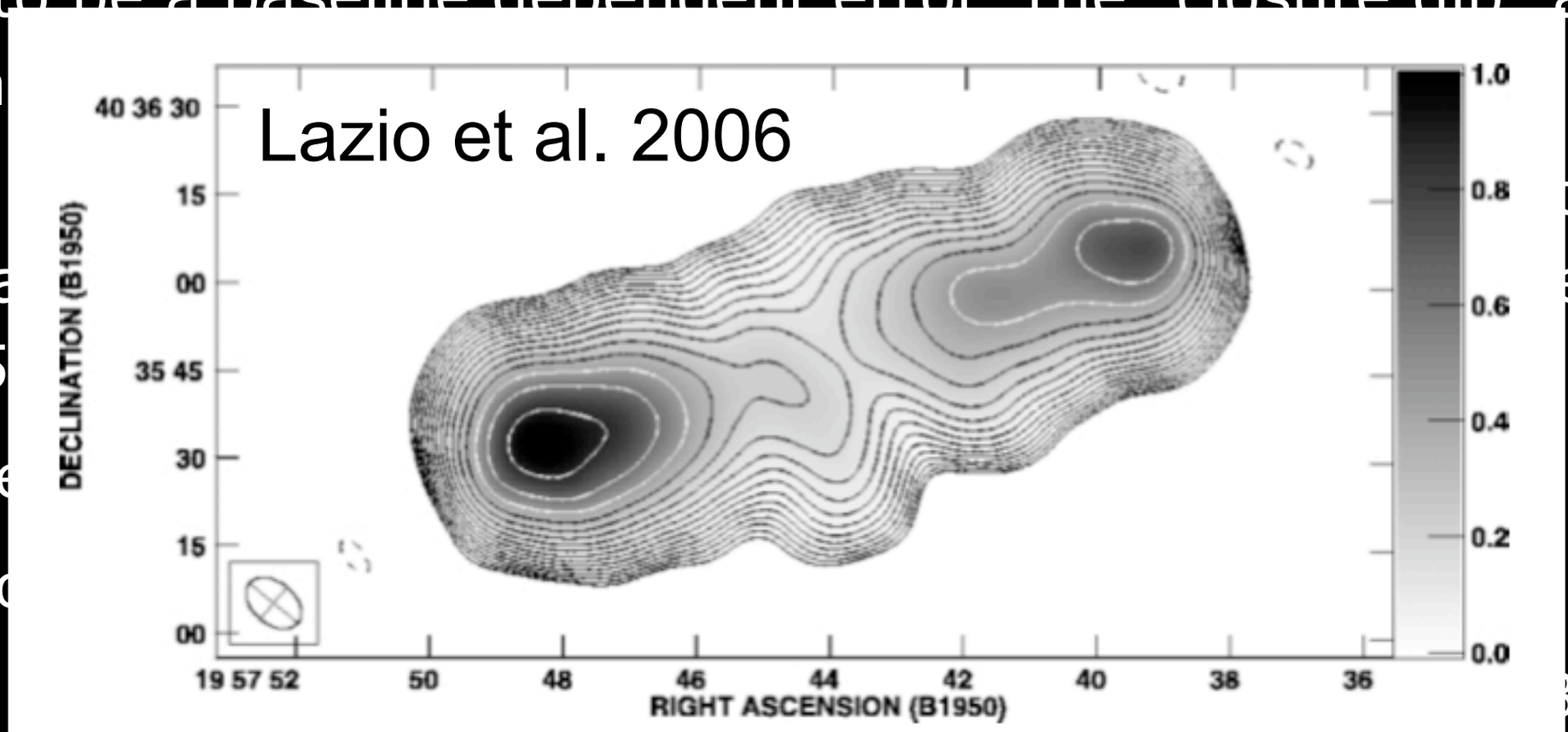


FIG. 1.—Cyg A at 74 MHz as observed with the VLA+PT link interferometer. The angular resolution is 10″.7 × 7″.1, and the rms noise level is 0.97 Jy beam$^{-1}$. The contours are 0.97 Jy beam$^{-1}$ × −5, 5, 7.07, 10, 14.1, …, and the gray scale is linear between 0 and 1000 Jy beam$^{-1}$.

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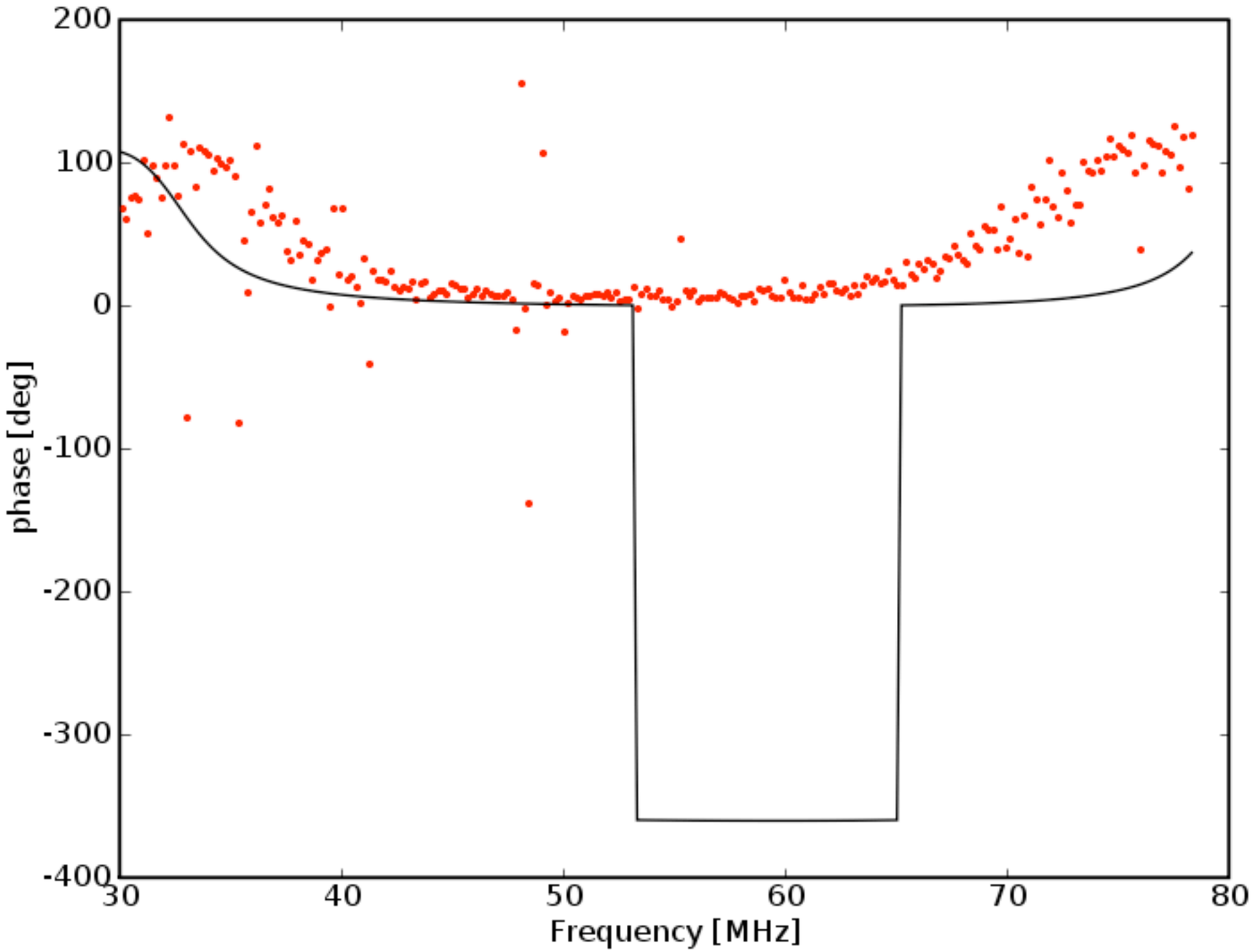
# Comparison with the model



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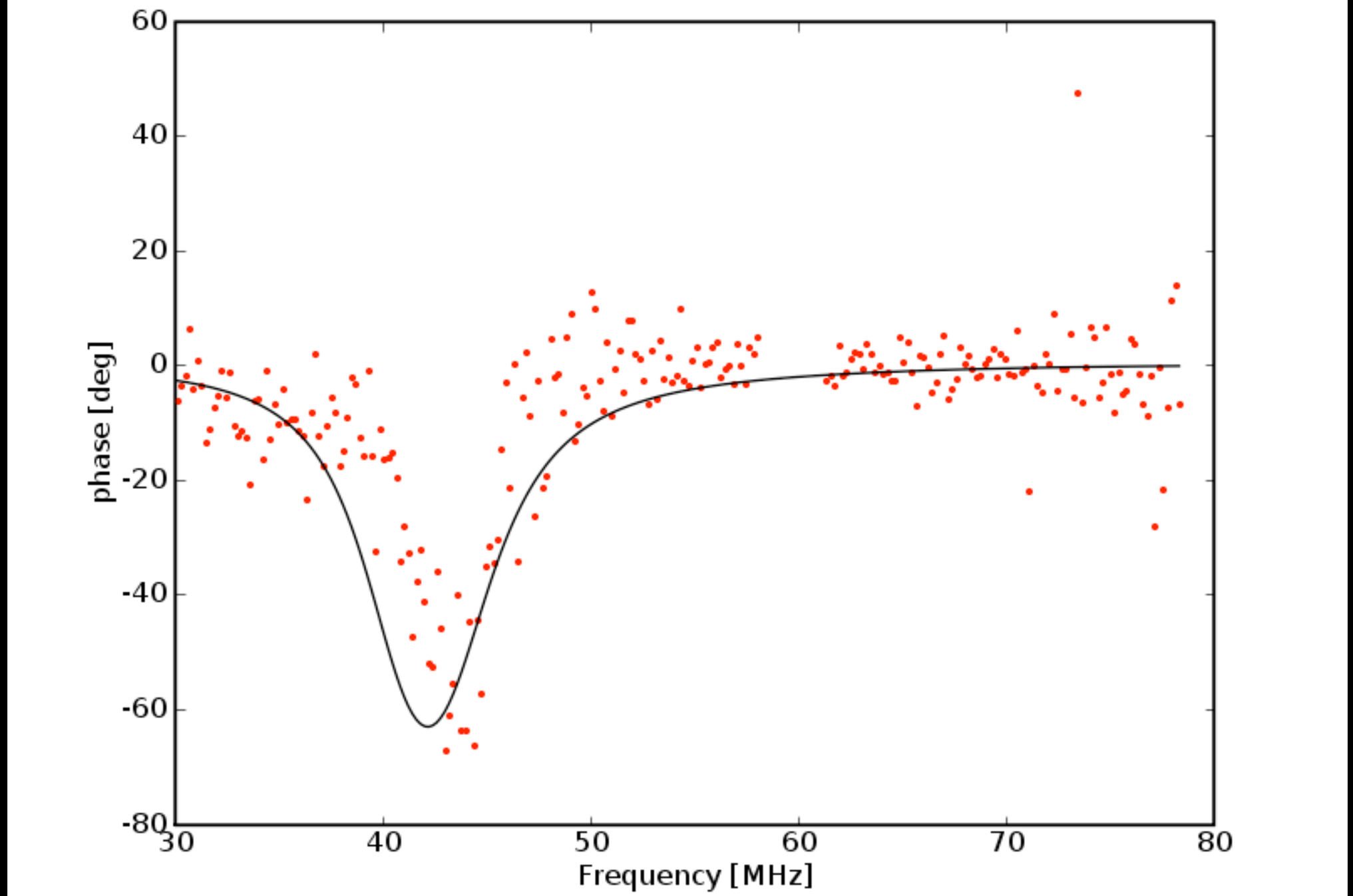
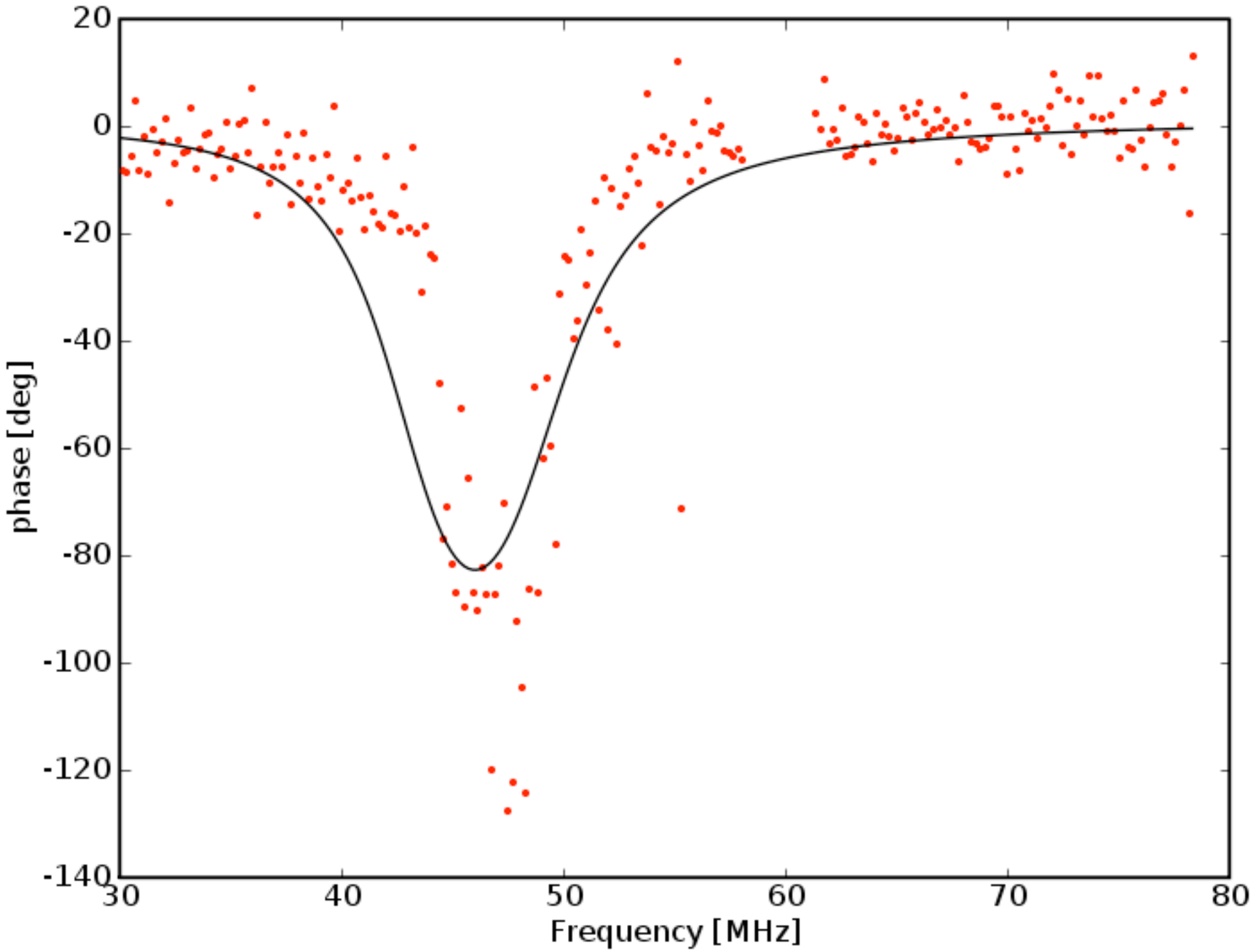


# Comparison with the model



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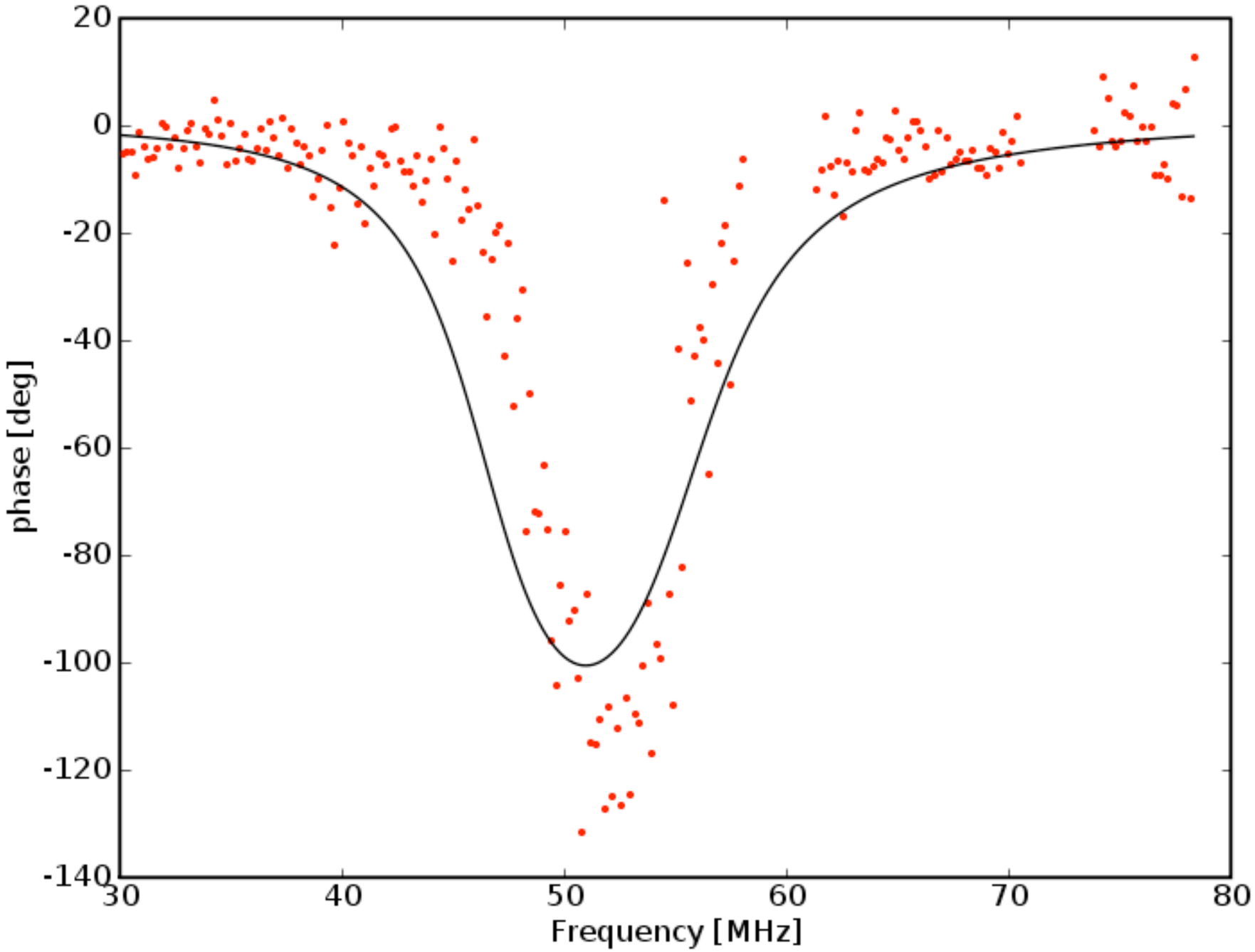

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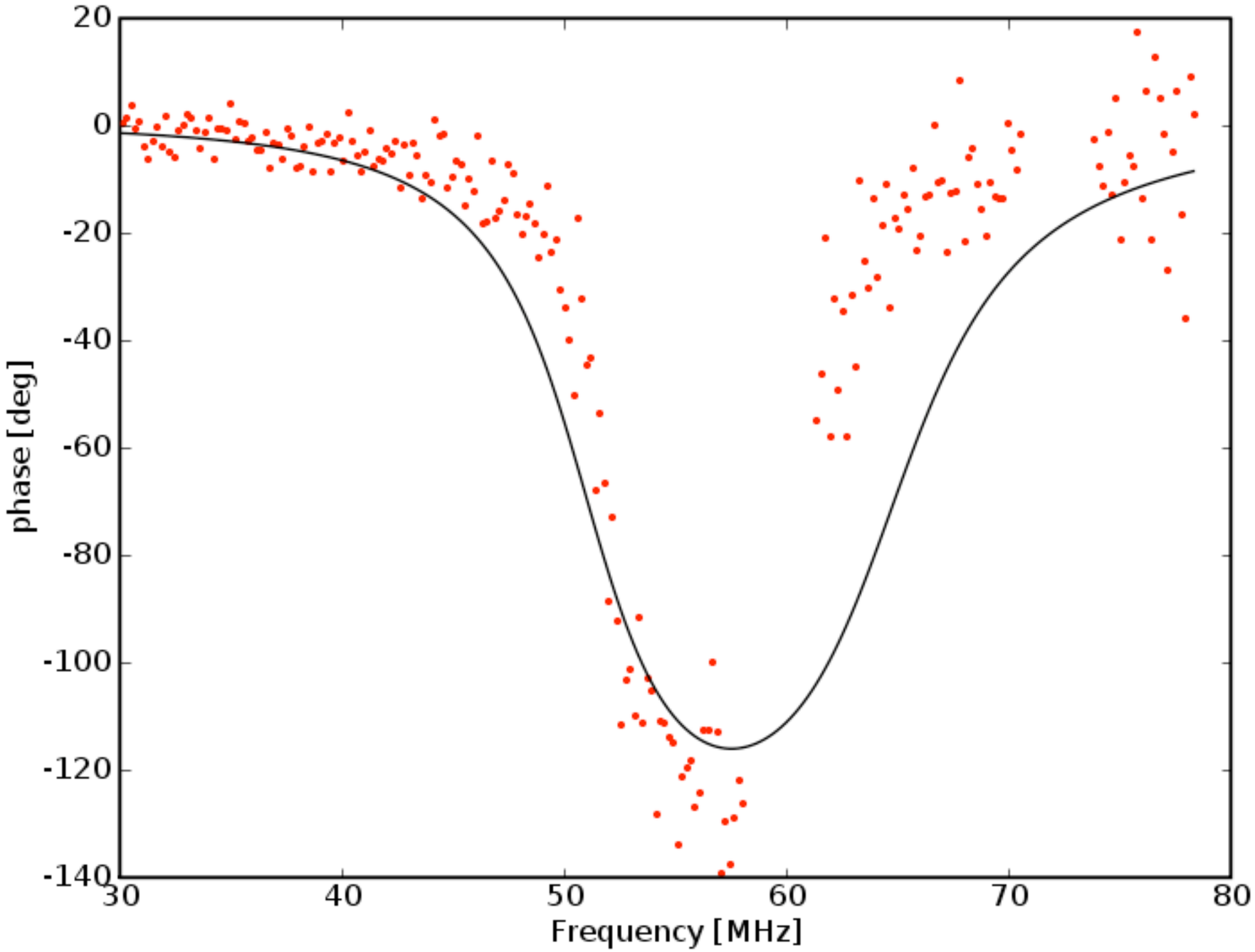

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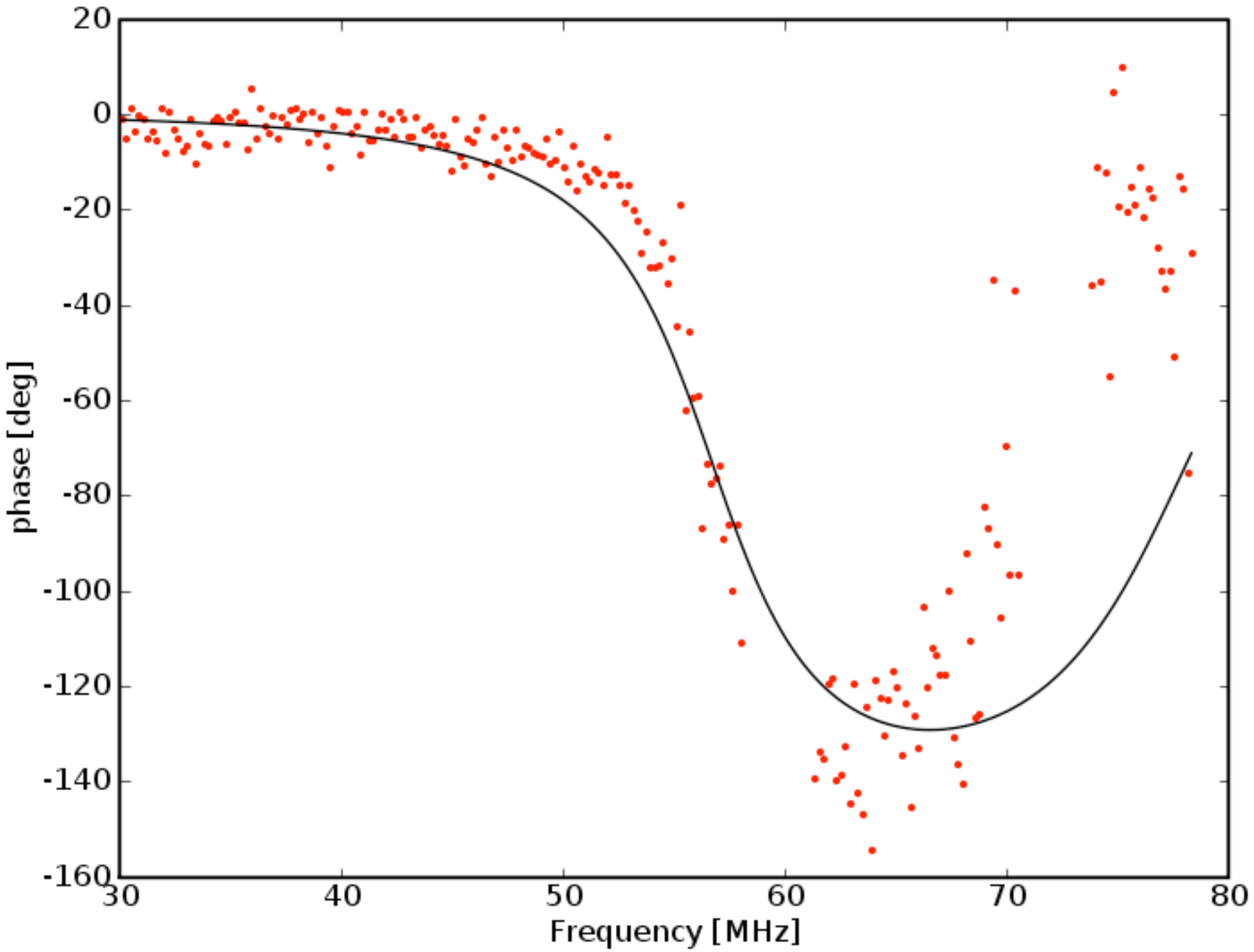

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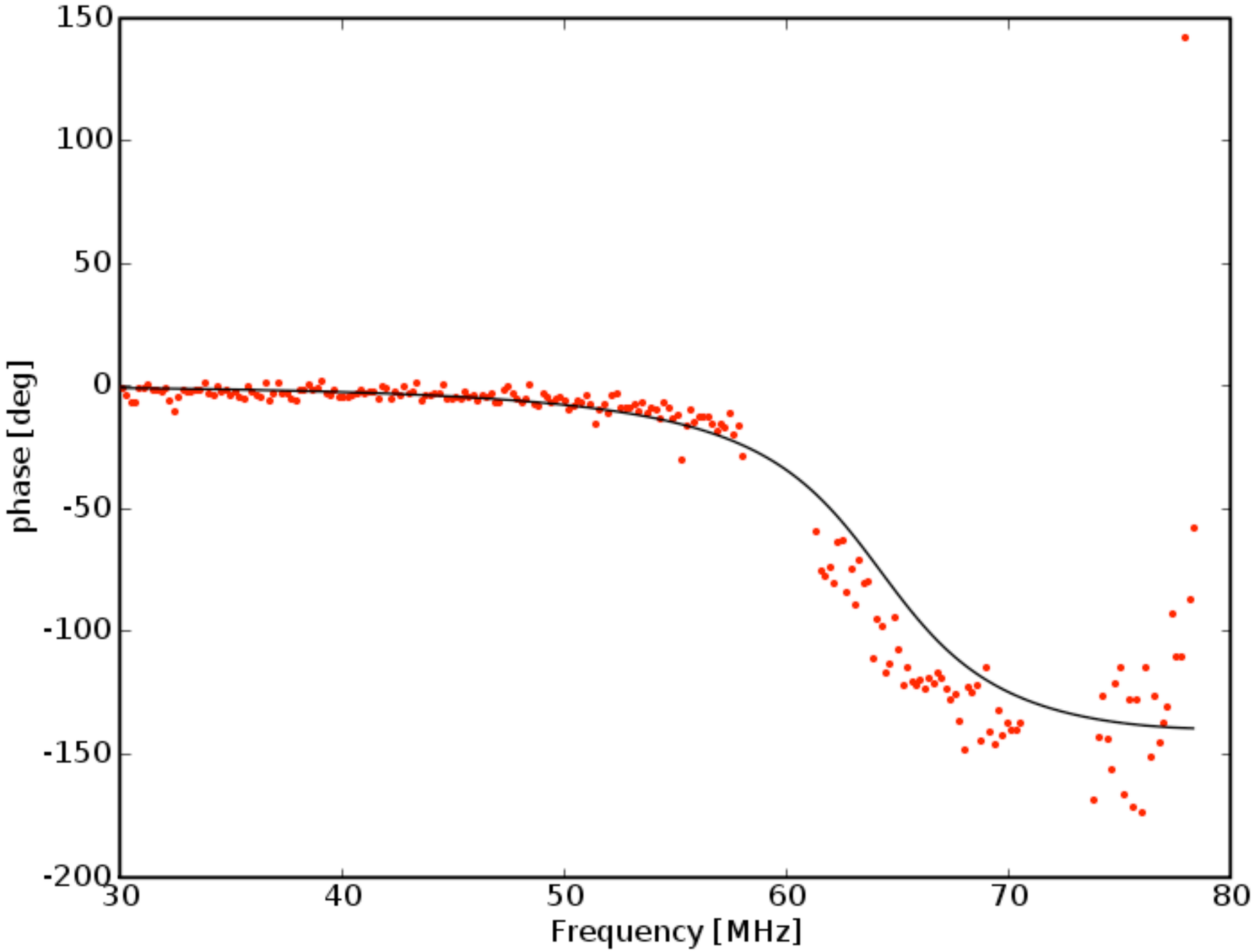
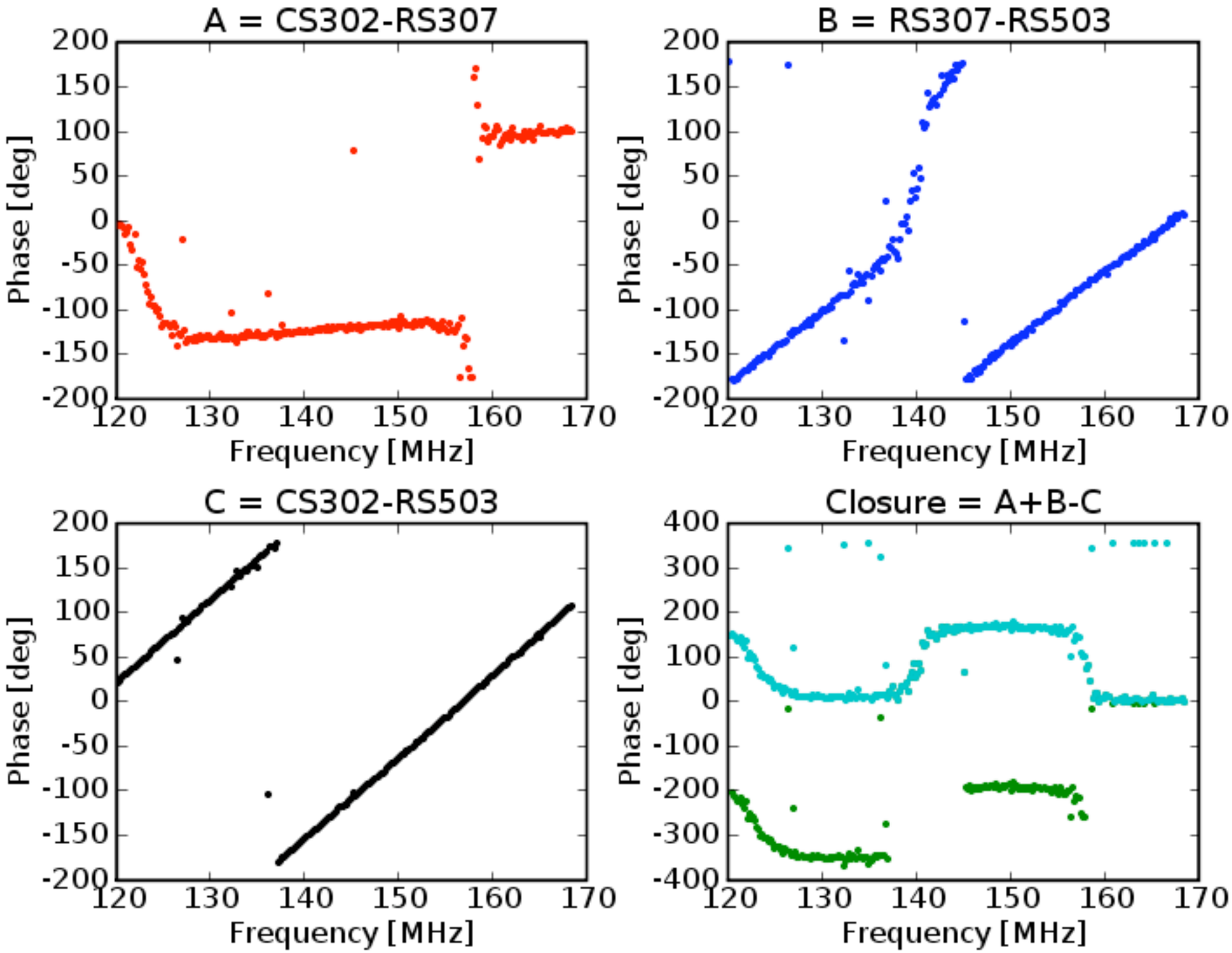


# A peek at the HBA closure phases...



# Conclusions

- The closure phases seem to have the right sort of behavior, but the details have to be worked out to be sure....
  - Note: checks with a point source observation should be done; small baseline dependent errors would be confused with imperfections in the extremely simple model used here.
- Can potentially use this data (also HBA) + model to refine source properties: separation, PA, **relative flux of lobes**
- Remaining structure on single-baseline phase traces is due to combination of clock errors and ionospheric phase, which have different frequency dependences and can be fitted out
- Much more to do with these extremely rich data sets.....