Rapid phasing of CARMA

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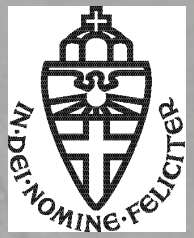
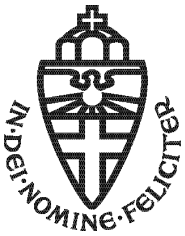
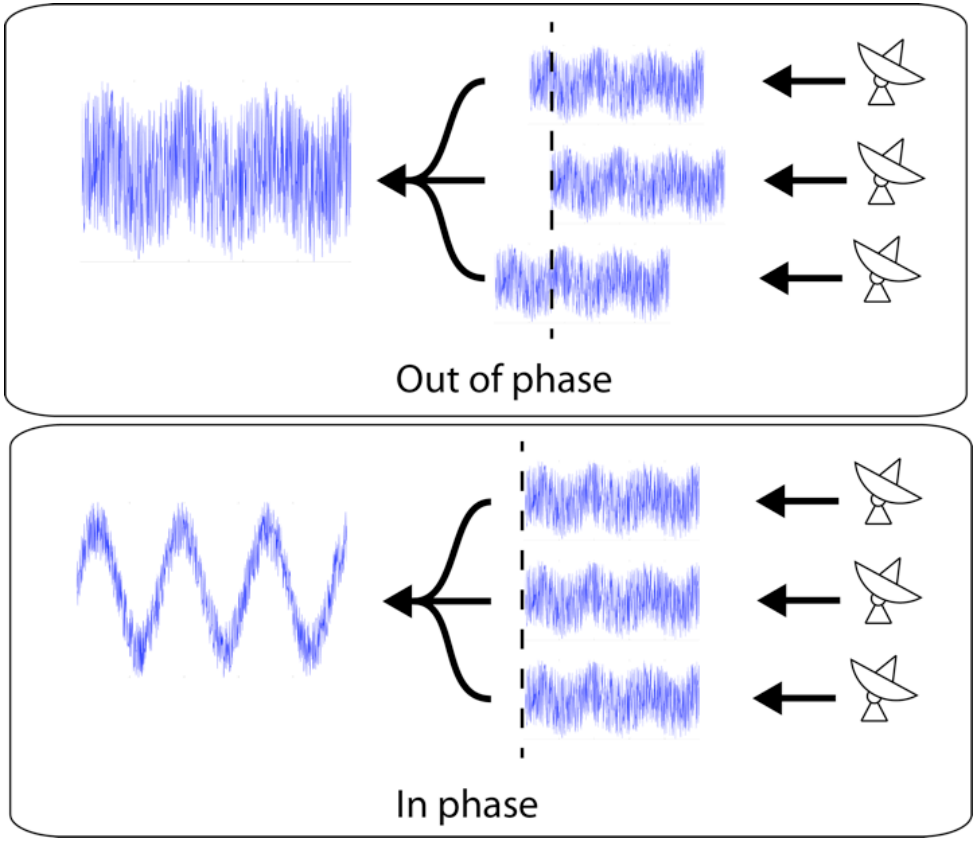


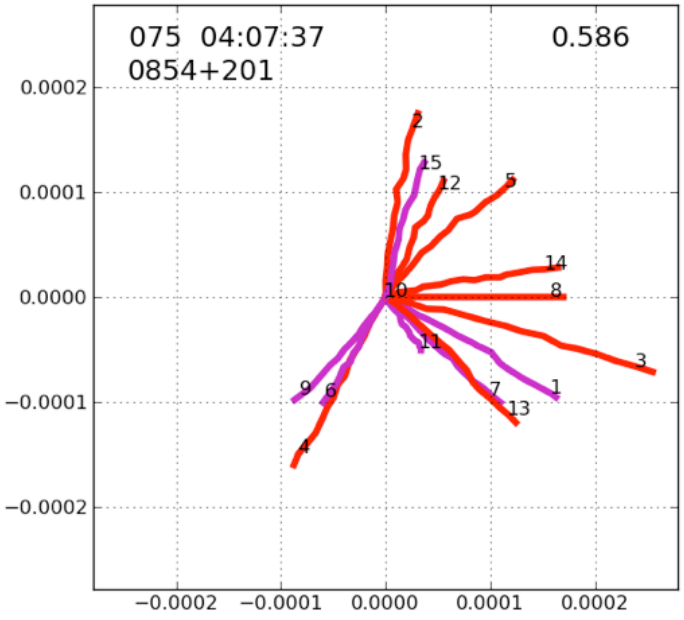
Phasing: the basics



- Summing signals from multiple telescopes can increase sensitivity
- But: the signals need to be in phase!
- Try to monitor and correct relative phase fluctuations
- These fluctuations mainly come from atmospheric water vapour

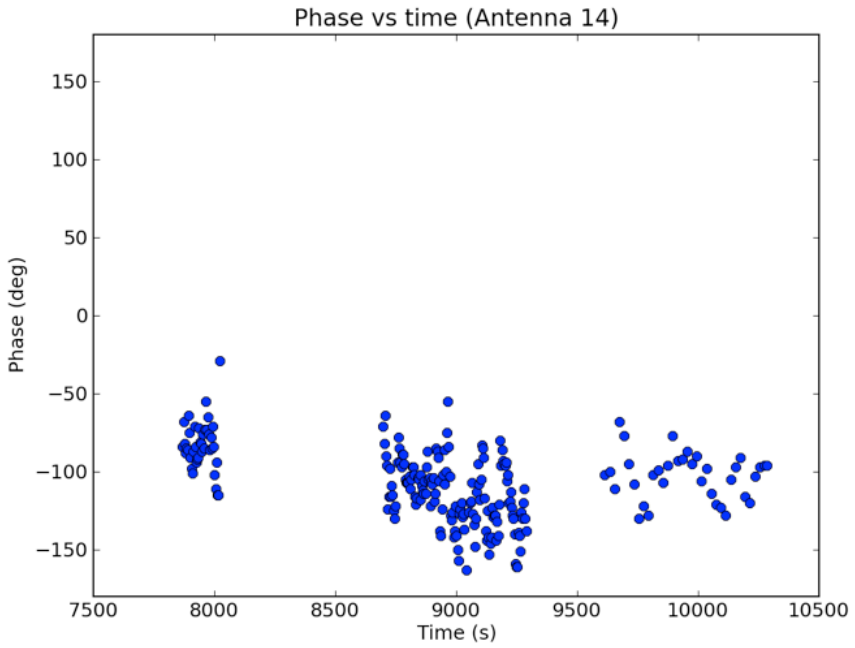
Phasing: illustration





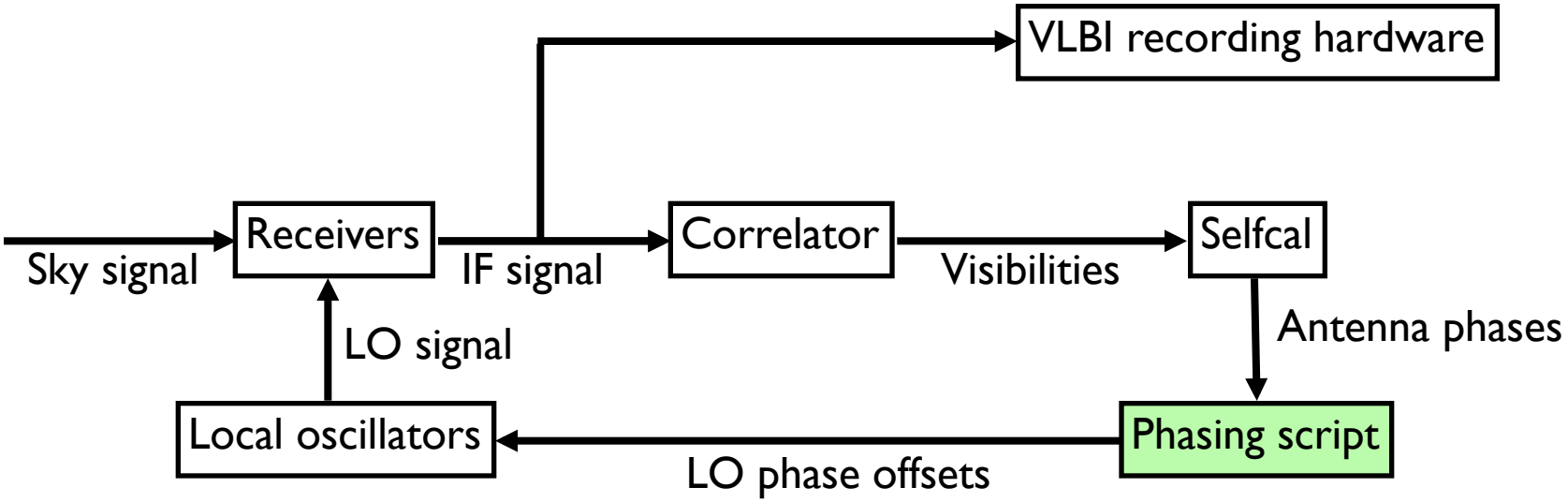
Phasing

- Phase shows variations on different temporal scales
- Quick phasing necessary: for VLBI, it cannot be done after the fact!
- We need a fast feedback loop



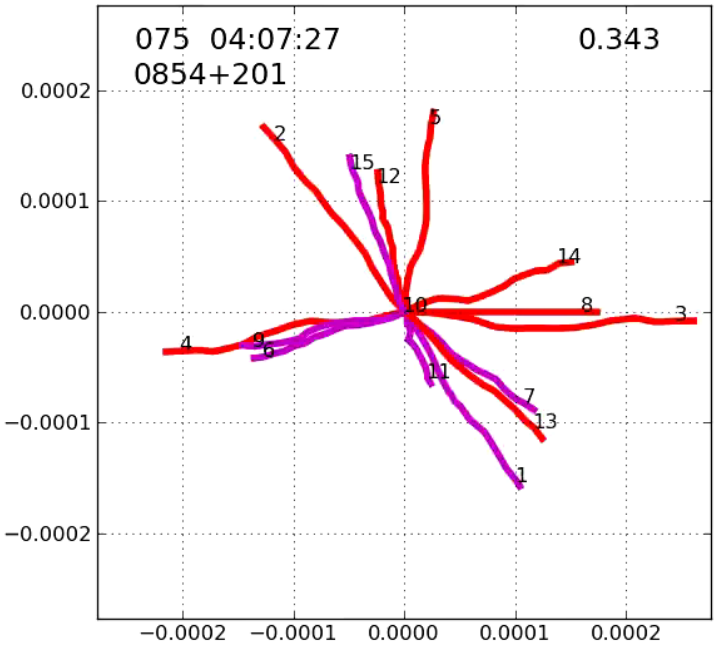
The feedback loop

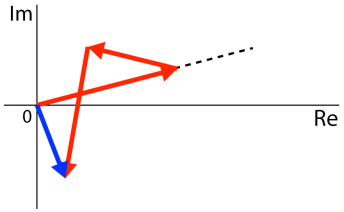
- Strategy for recent VLBI campaign @ CARMA: use Python script running independently from observing script for phasing (1mm and 3mm)

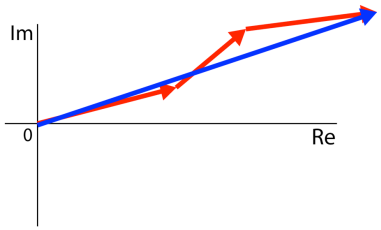


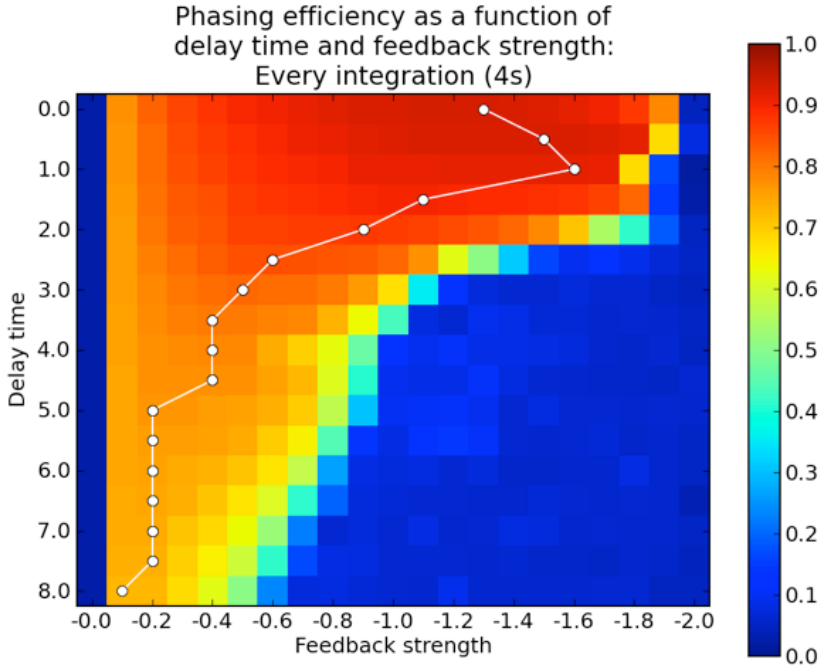
The results

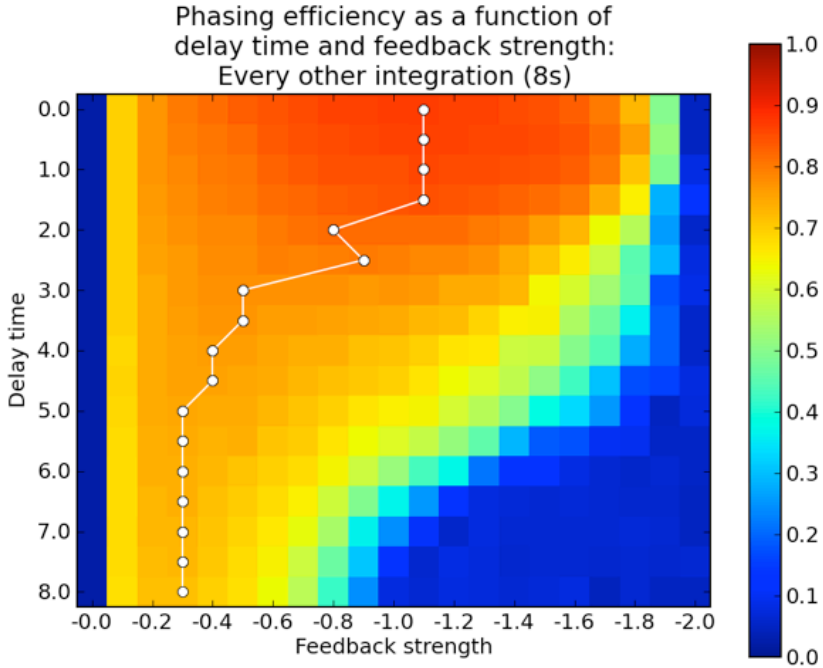
- Lines: individual antenna gains, orientation according to phase
- Wriggly lines: lower SNR (less effective bandpass correction)

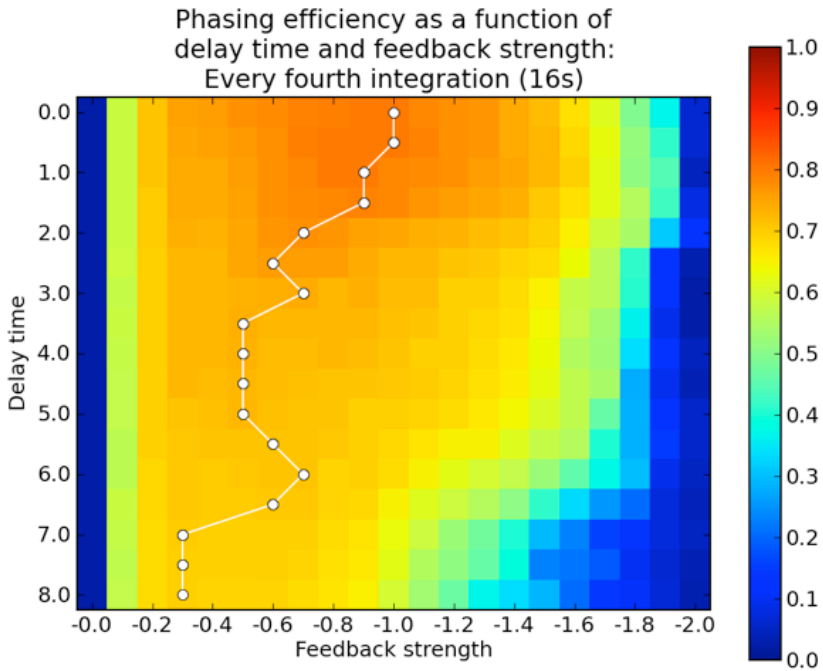


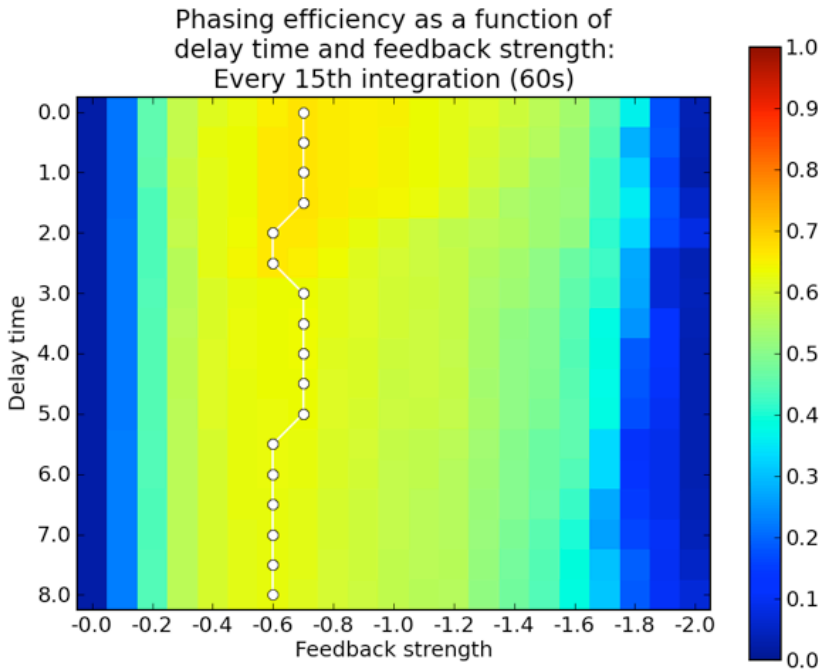




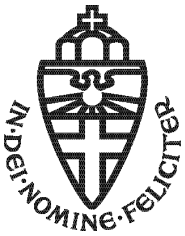

Phasing efficiency as a function of
delay time and feedback strength:
Every integration (4s)
Delay time
Feedback strength
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
-0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1


Phasing efficiency as a function of
delay time and feedback strength:
Every other integration (8s)
Delay time
Feedback strength
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
-0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1


Phasing efficiency as a function of
delay time and feedback strength:
Every fourth integration (16s)
Delay time
Feedback strength
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
-0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1


Phasing efficiency as a function of
delay time and feedback strength:
Every 15th integration (60s)
Delay time
Feedback strength
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
-0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

The results

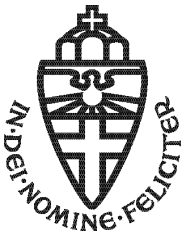


- Phasing efficiency improved from ~0.2 to ~0.7
- We want short delays
- We want rapid phasing (as often as possible)
- But: we will always lag behind!

Phasing is done using behaviour of 'old' measurements to improve 'new' measurements

Solution: Buffered Beamformer

The Buffered Beamformer



The Buffered Beamformer (a UCB-RUN collaboration) will be a hardware system that:

- Stores all samples within an integration in memory...
- Applies selfcal...
- Corrects the phases...
- Releases the data to the VLBI recording system

Useful for CARMA, SMA, PdB, ALMA...

Further developments

Phase difference measurements also tell us about the structure of the atmosphere!

Dependence of phase structure function with baseline direction and distance gives information about turbulence structure.