RAPID for Dual-Polarized Interferometry of Lightning

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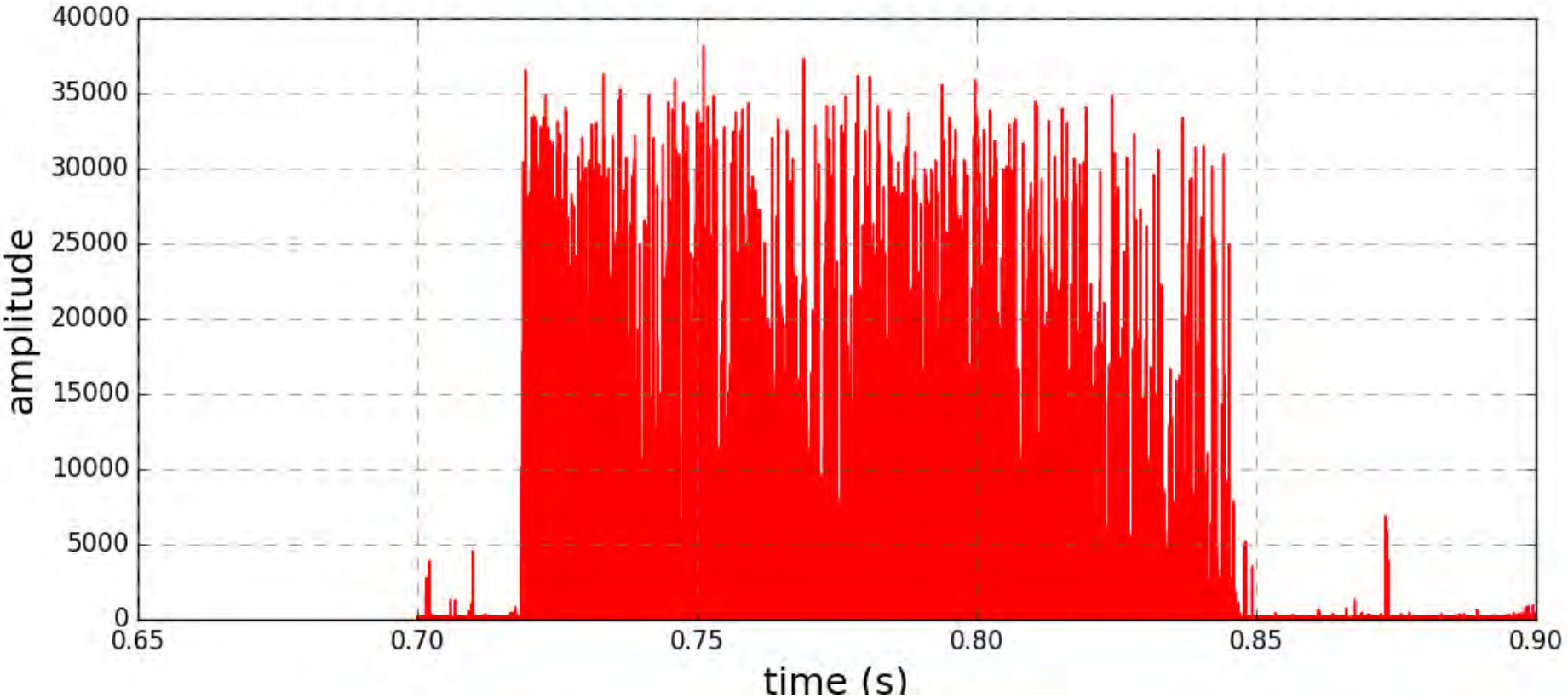
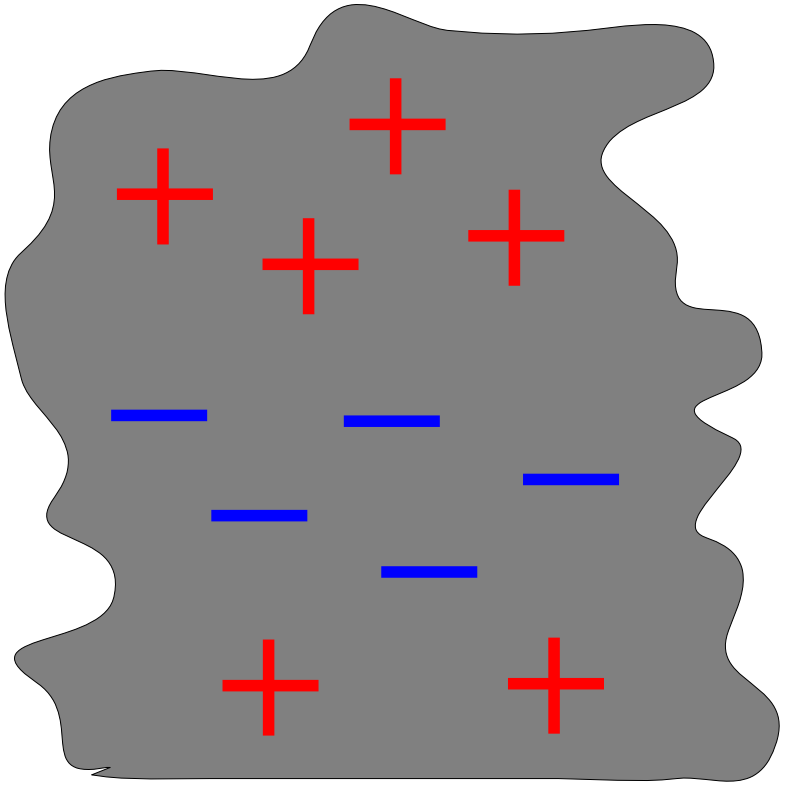
Lightning as a radio source

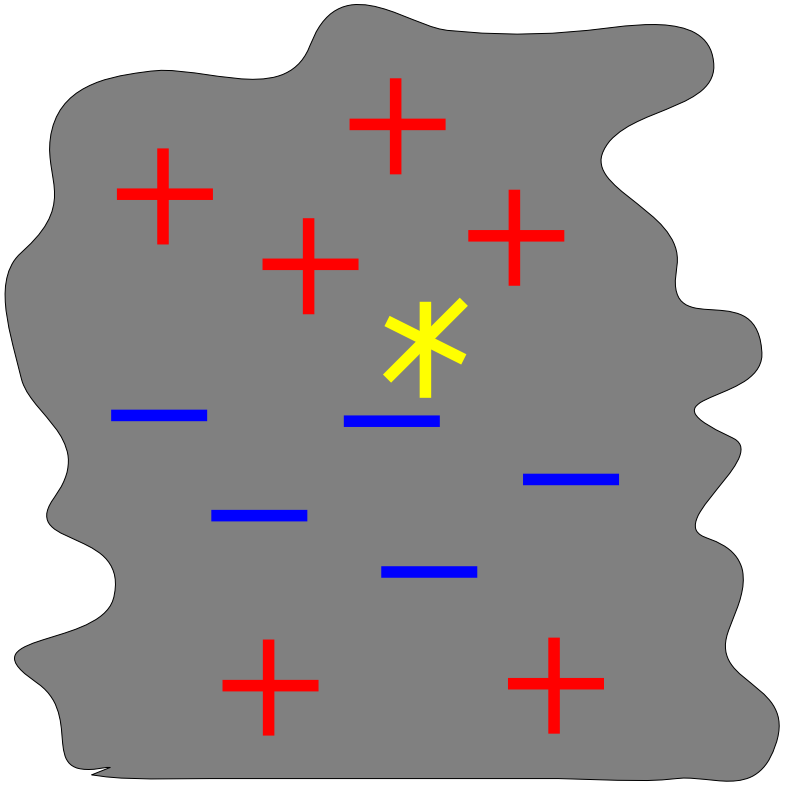
Lightning as a radio source



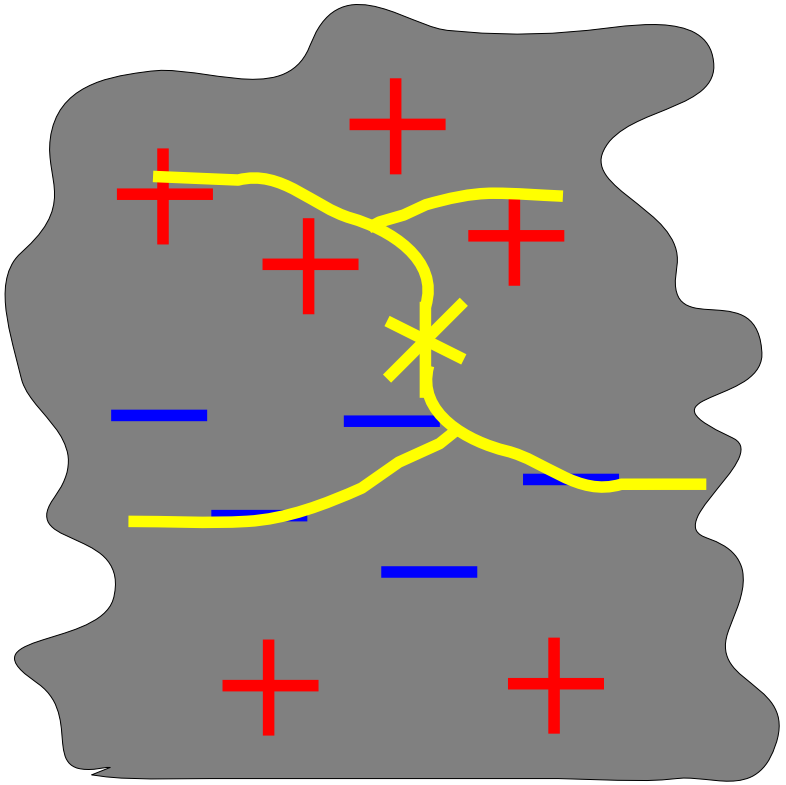
Lightning as a radio source



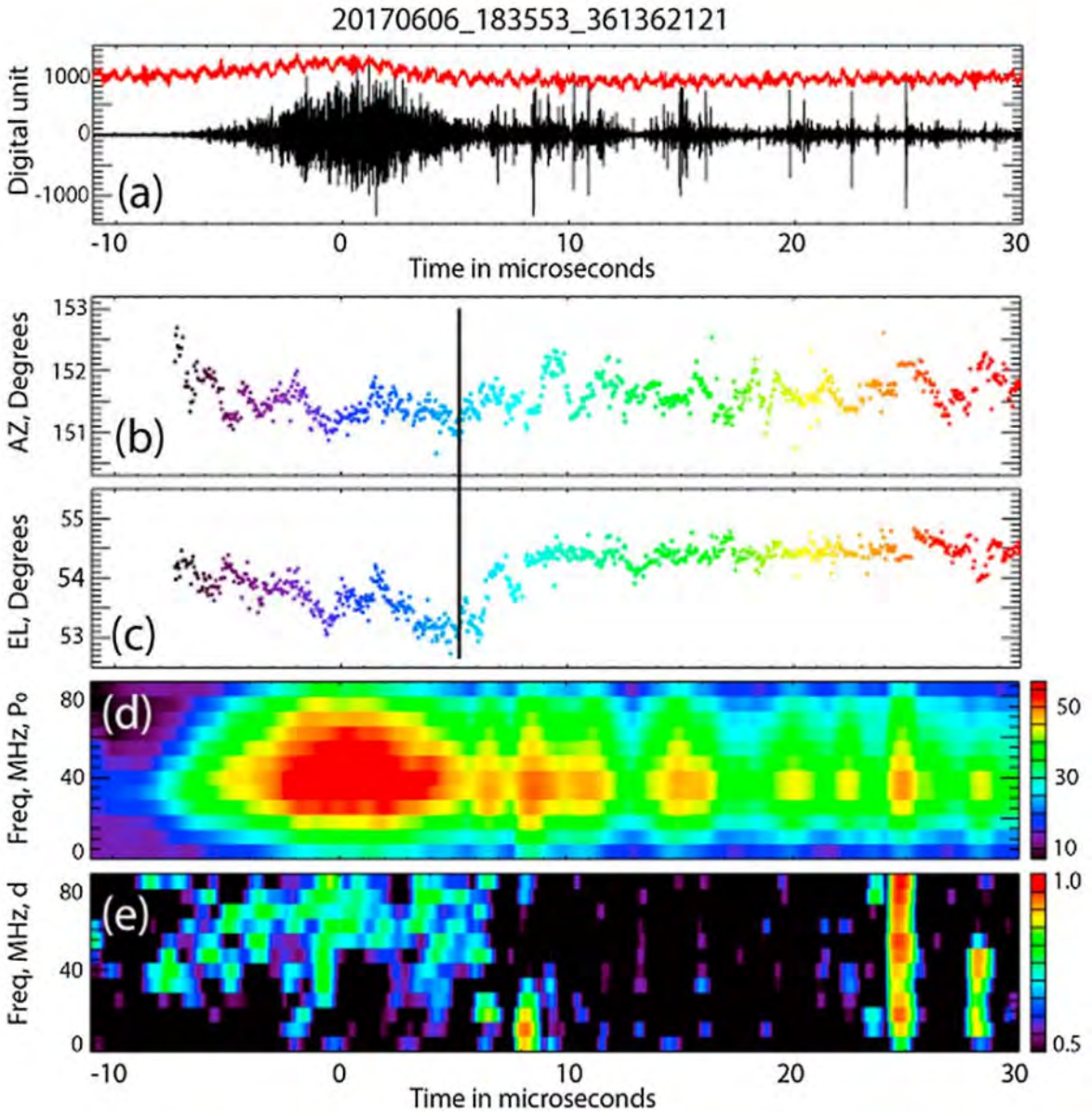
Lightning as a radio source



Lightning as a radio source

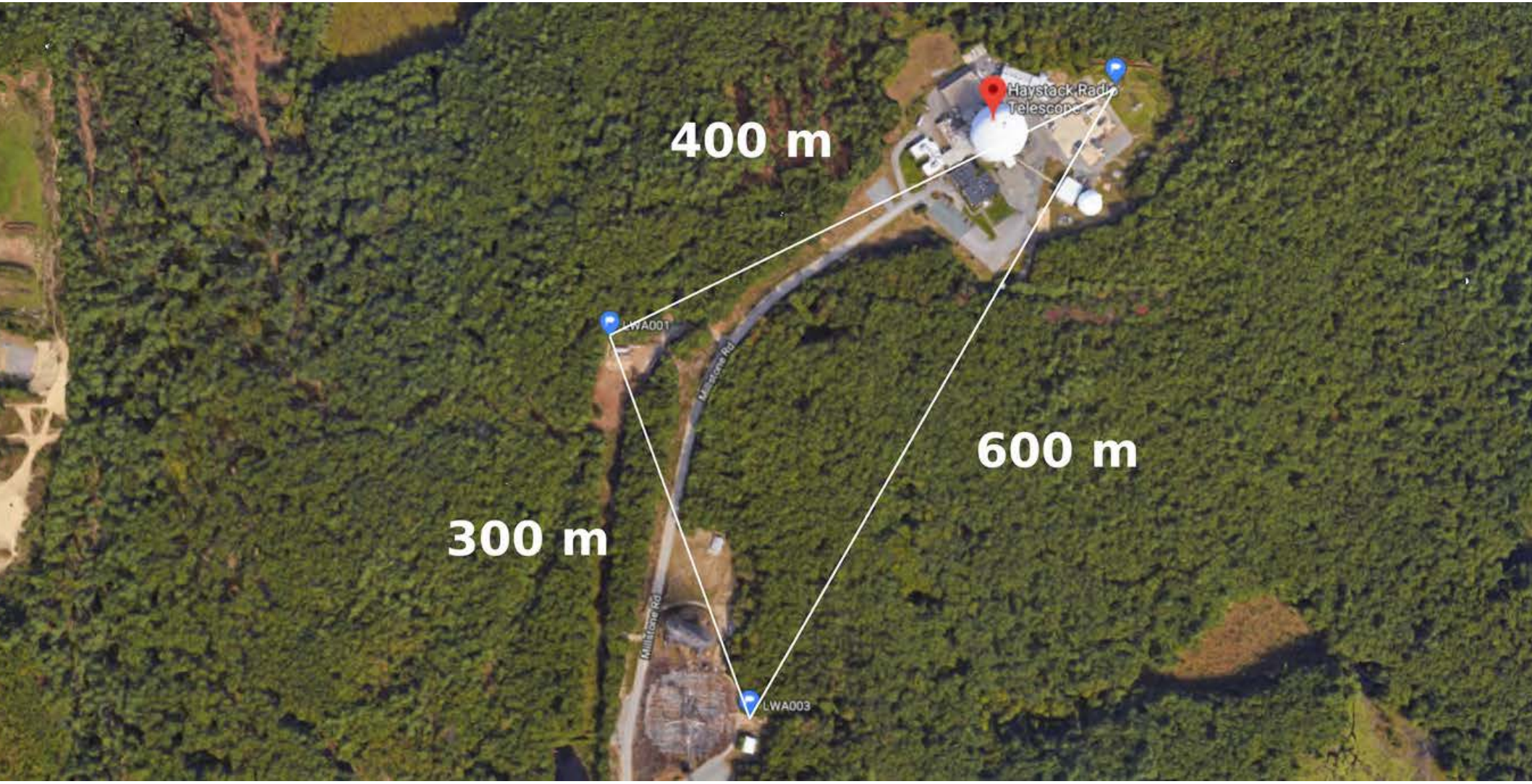


Lightning as a polarized radio source



2018, Shao, etal. "Broadband RF Interferometric Mapping and Polarization (BIMAP) Observations of Lightning Discharges: Revealing New Physics Insights Into Breakdown Processes," *JGR*.

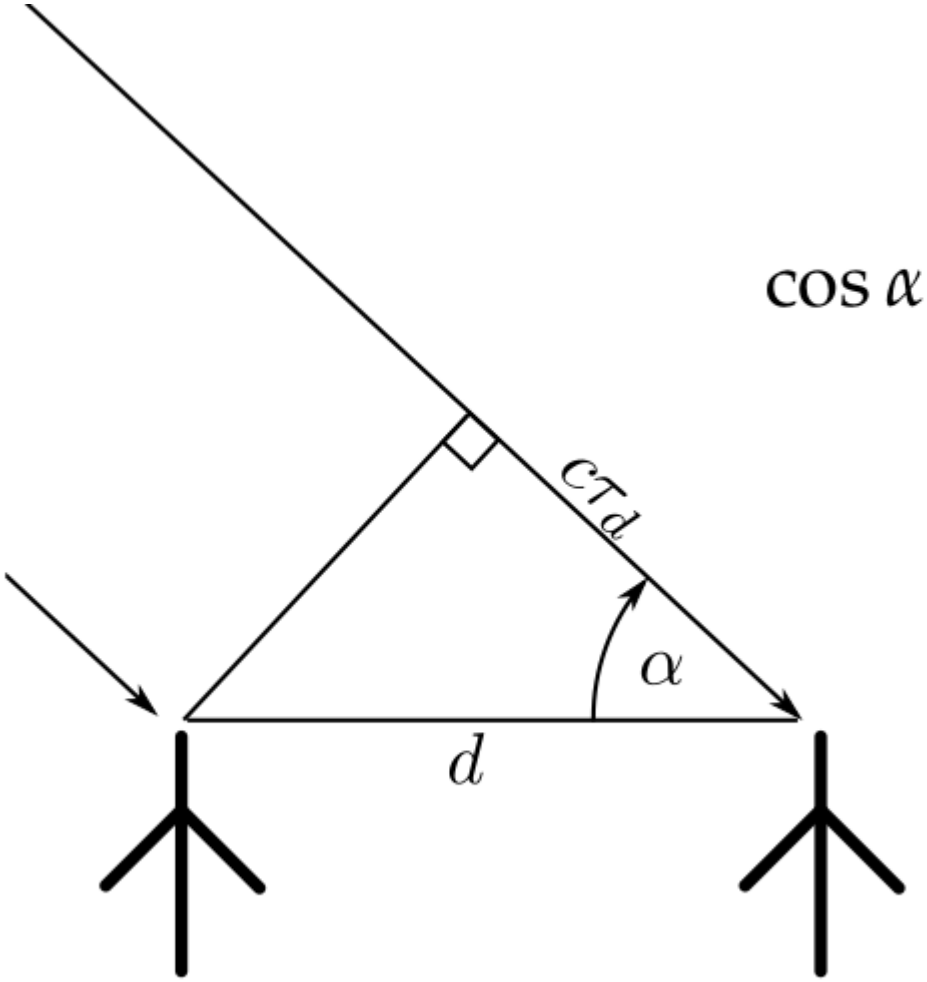
RAPID array configuration



RAPID array configuration

Antennas:	(three) Long Wavelength Array (LWA) antennas
Digitizers:	(three) Ettus X300 radio at 200 Msps IQ
Resolution:	14 bits
Center frequency:	45 MHz
Bandwidth:	50 MHz (10-70 MHz)
Baselines:	335 m, 469 m, and 606 m
Dual-polarization	

Interferometry – concept

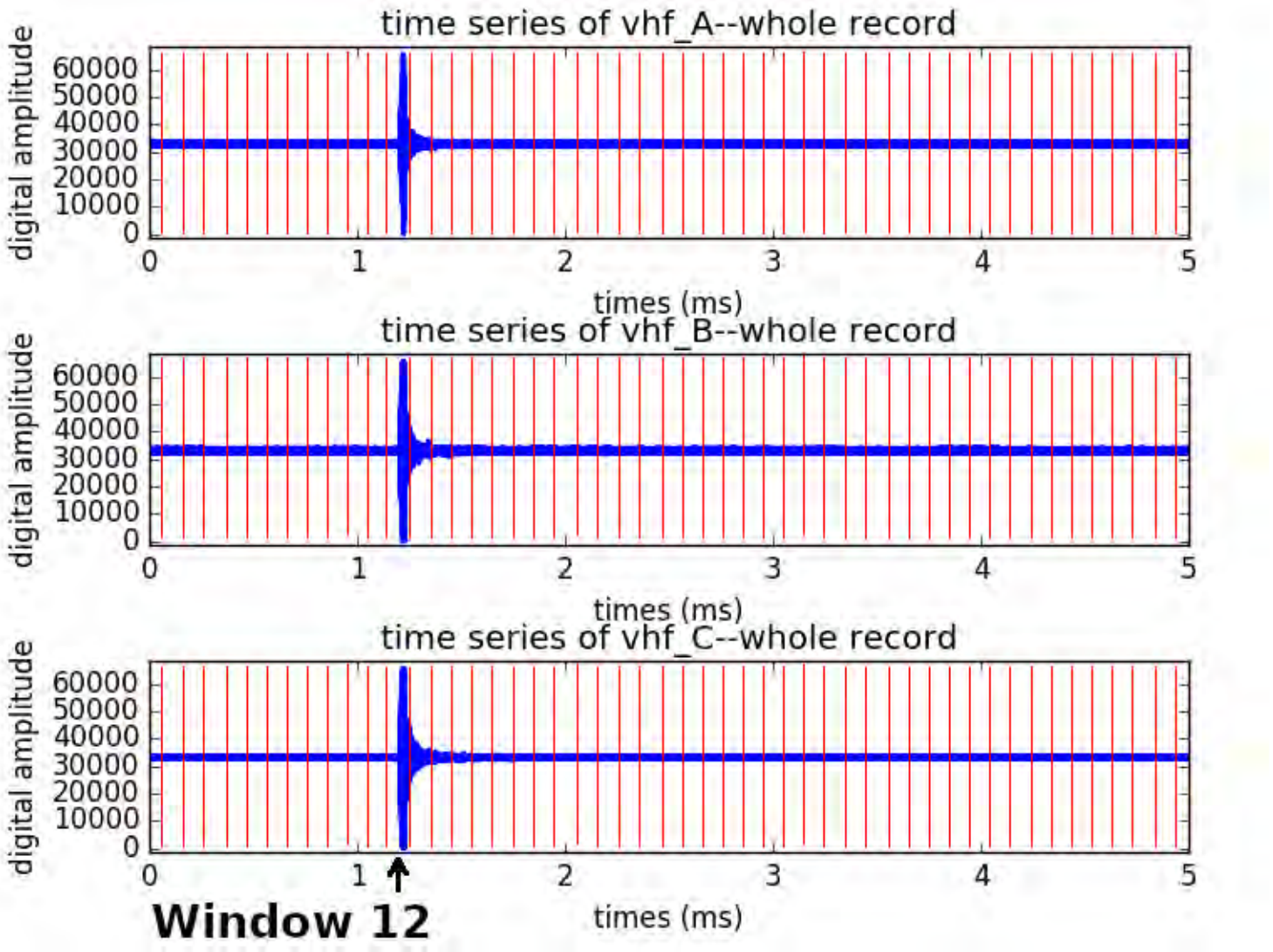


$$\cos\alpha = \frac{c\tau_d}{d} = \left(\frac{\Delta\phi}{2\pi}\right)\frac{\lambda}{d}$$

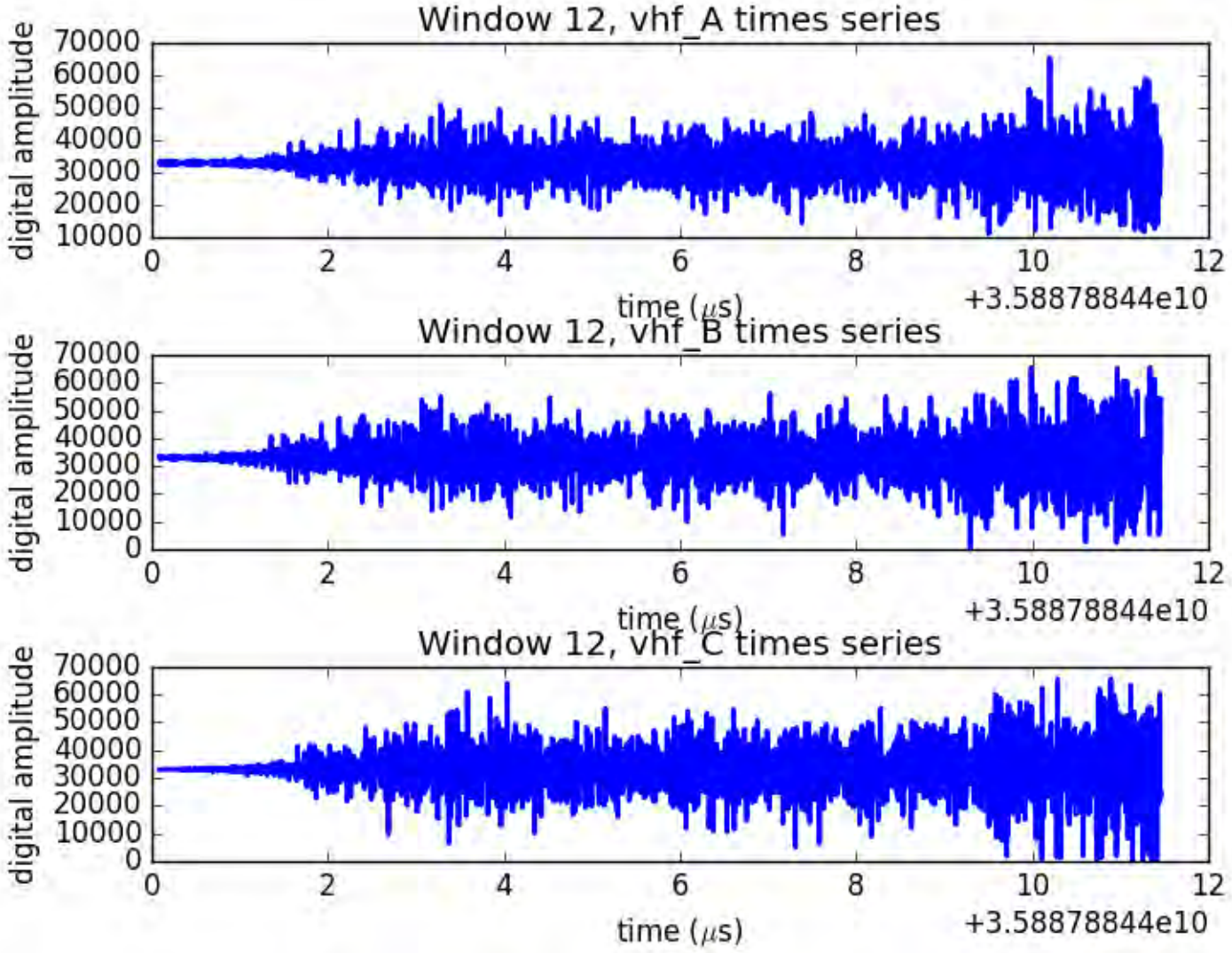
Broadband interferometry of lightning

by *Stock, Michael*, Ph.D., **New Mexico Institute of Mining and Technology**, 2014, 254; 3684400

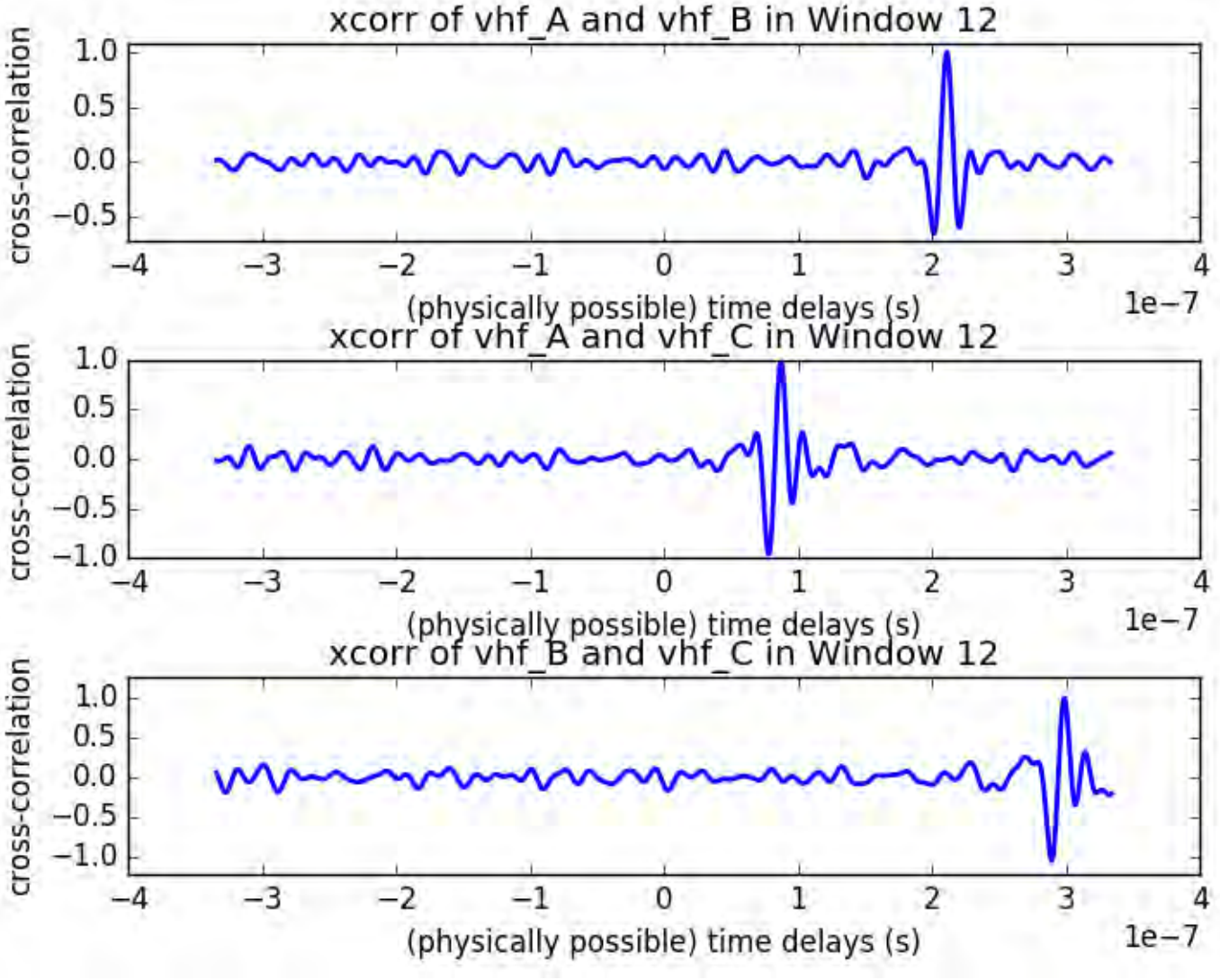
Interferometry – VHF waveforms



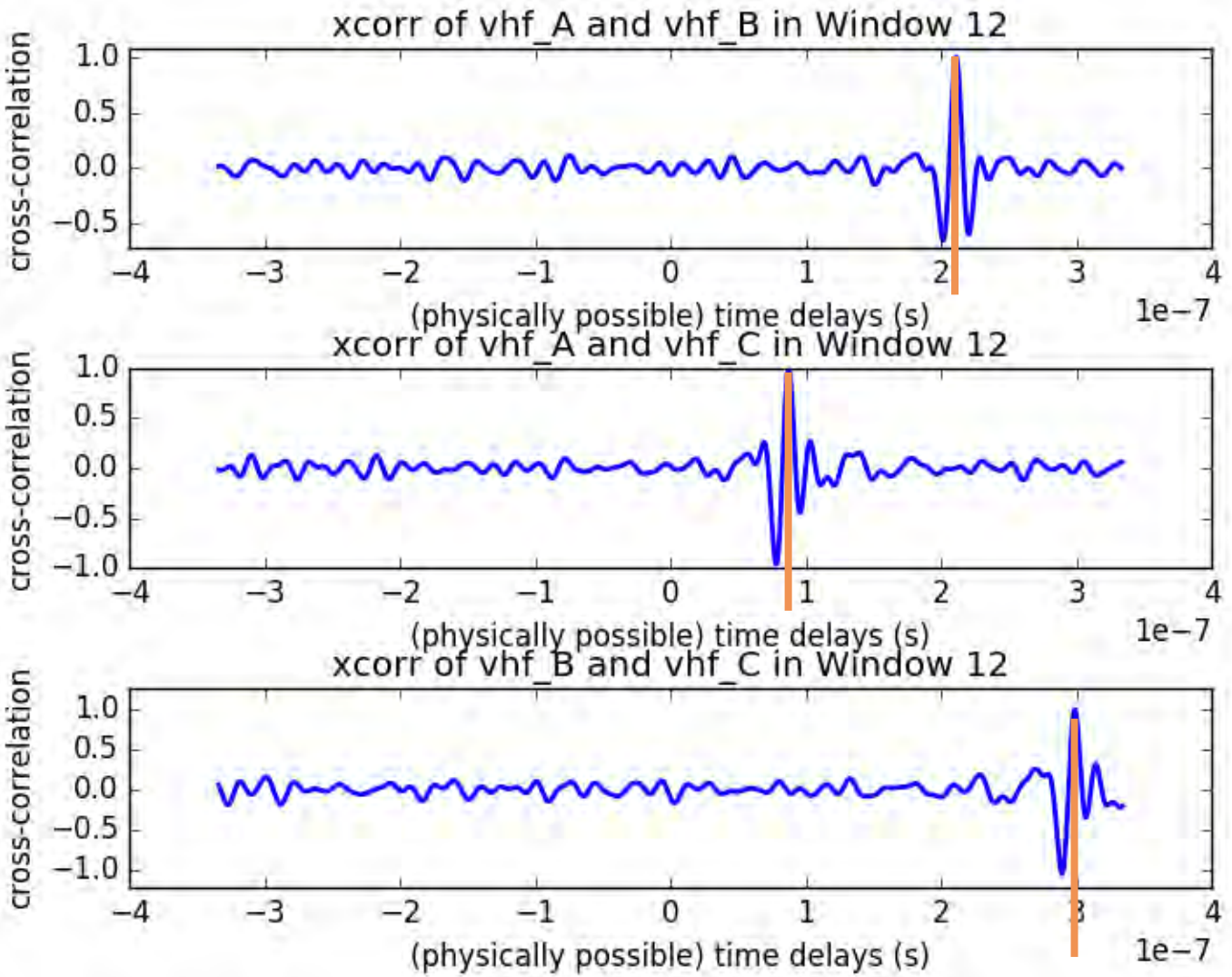
Interferometry – VHF waveforms



Interferometry – cross correlations

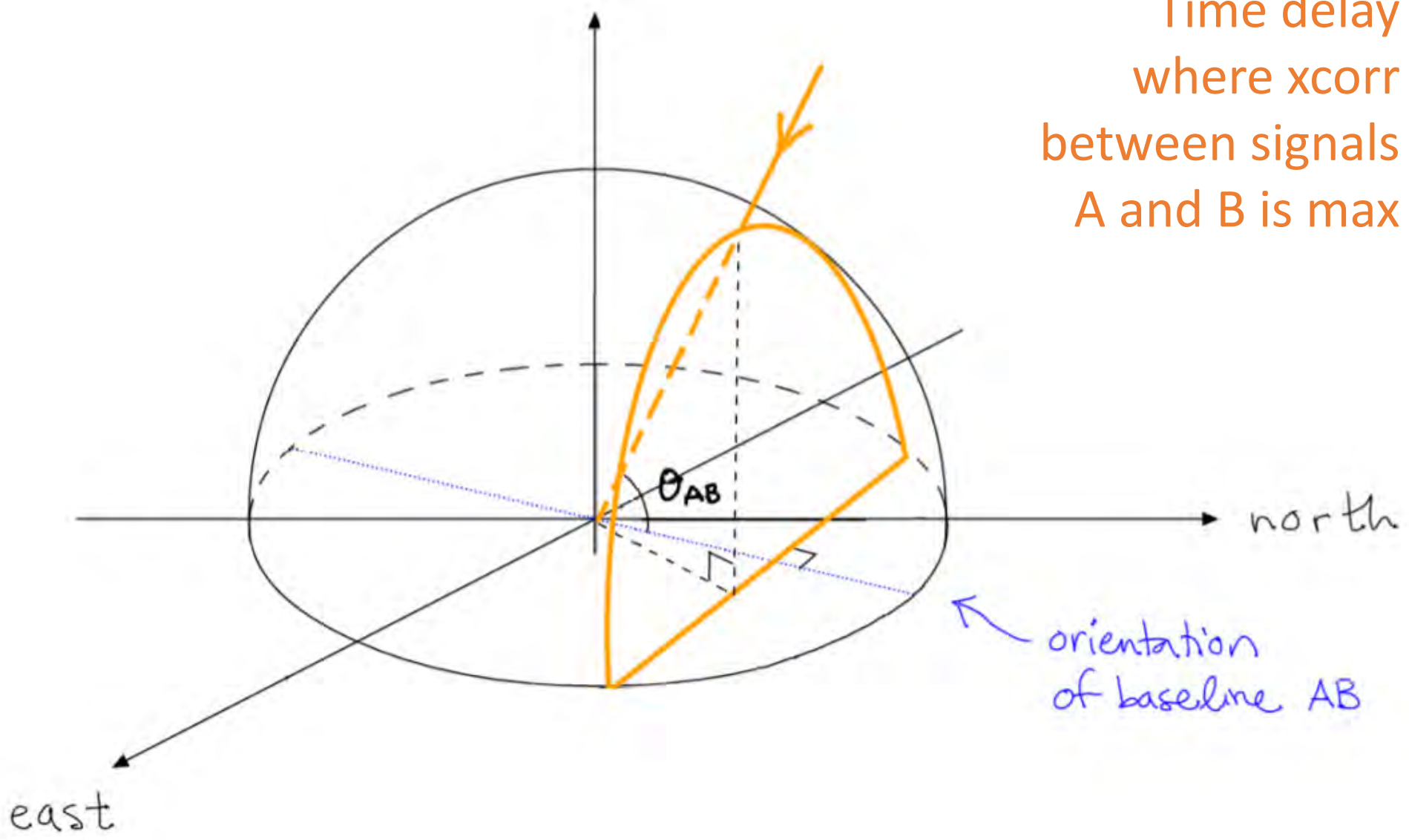


Interferometry – cross correlations



Time delay where xcorr is max

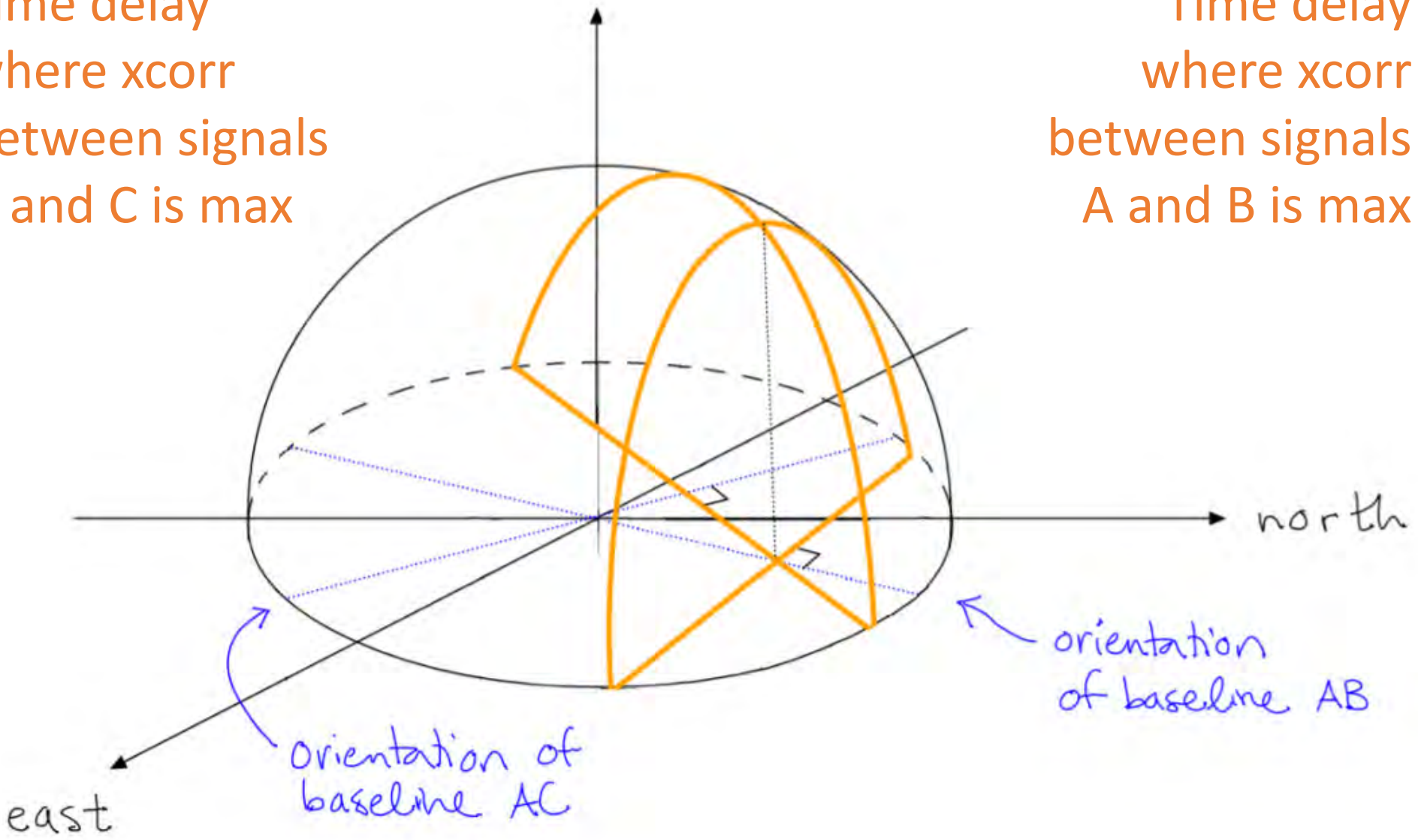
Interferometry – cosine plane projection



Interferometry – cosine plane projection

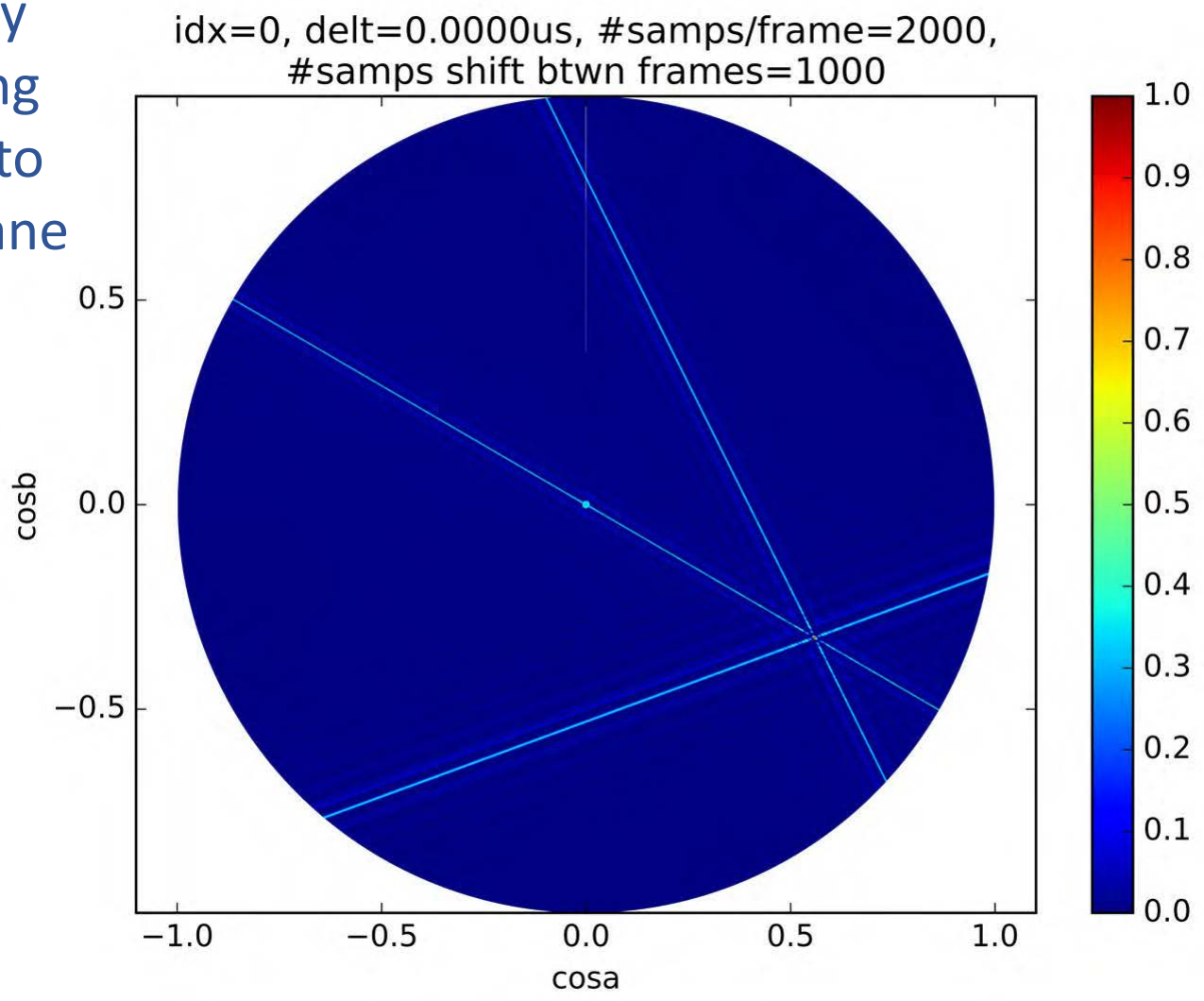
Time delay where xcorr between signals A and C is max

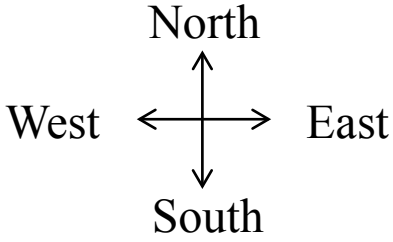
Time delay where xcorr between signals A and B is max



Interferometry – ideal point source

Image by projecting xcorrs into cosine plane





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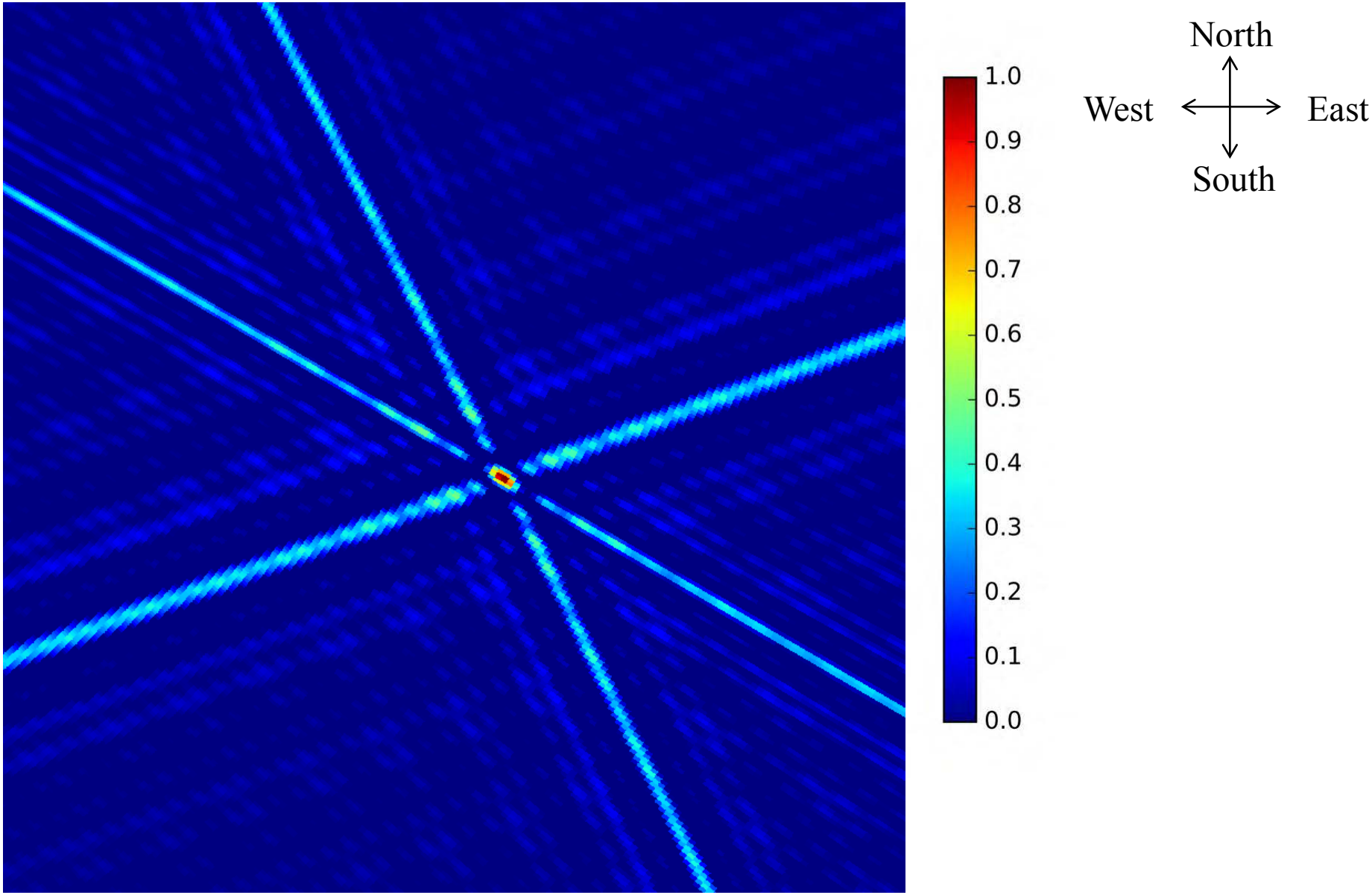
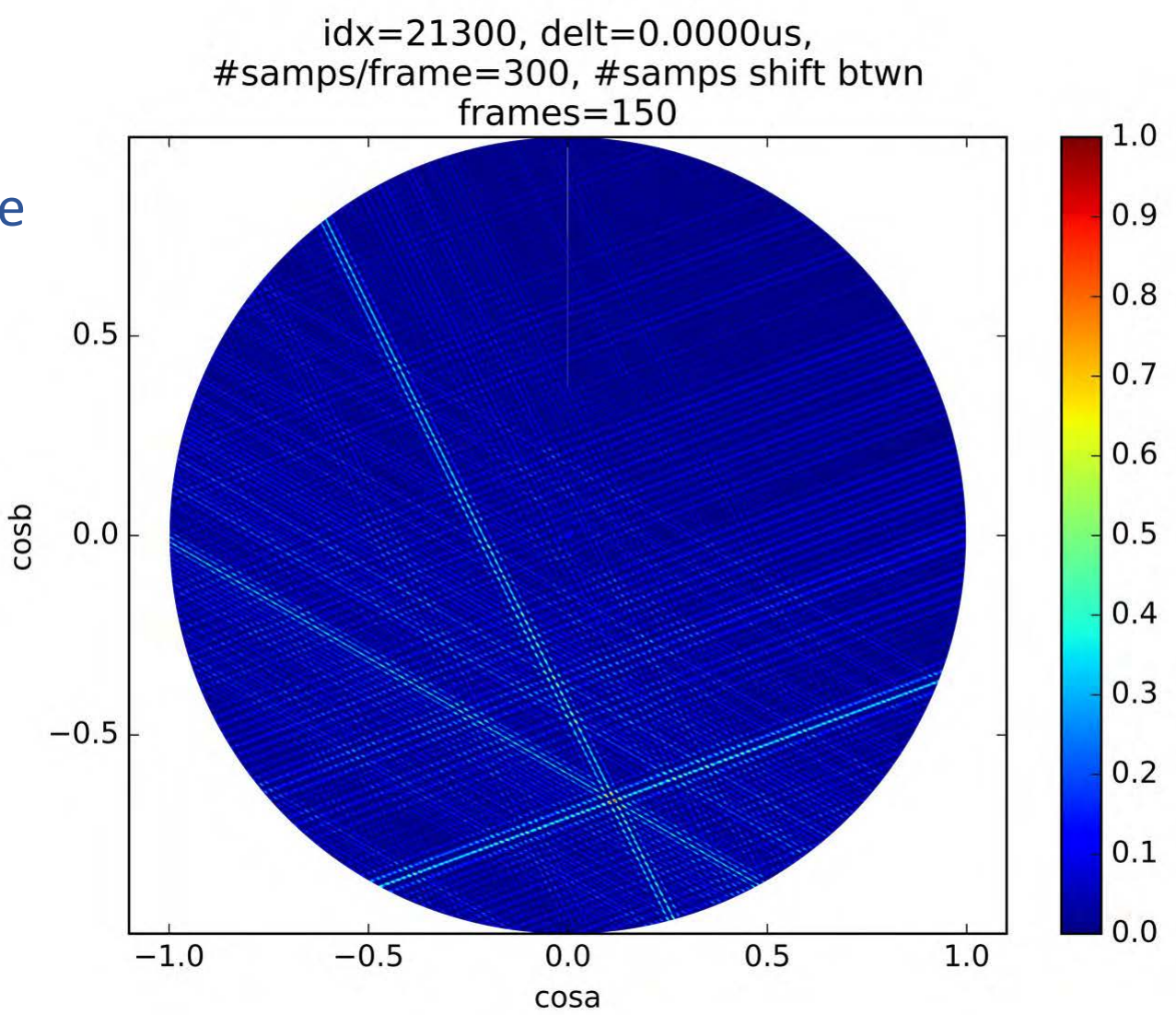
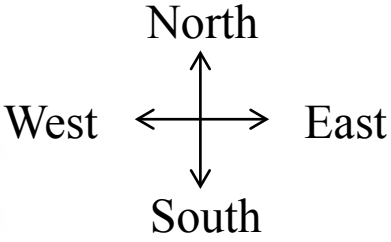


Interferometry – real source

Image by projecting xcorrs into cosine plane





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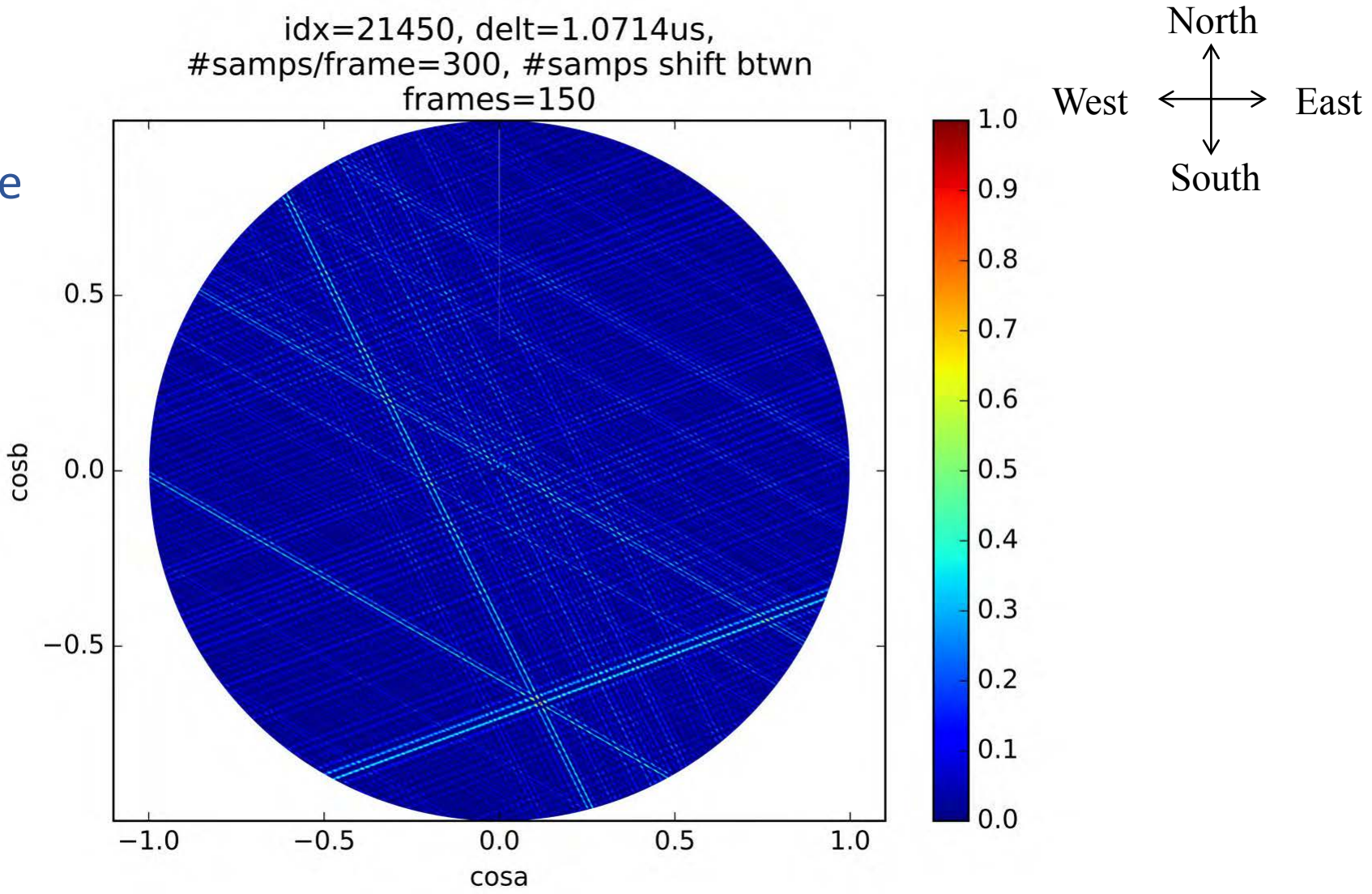

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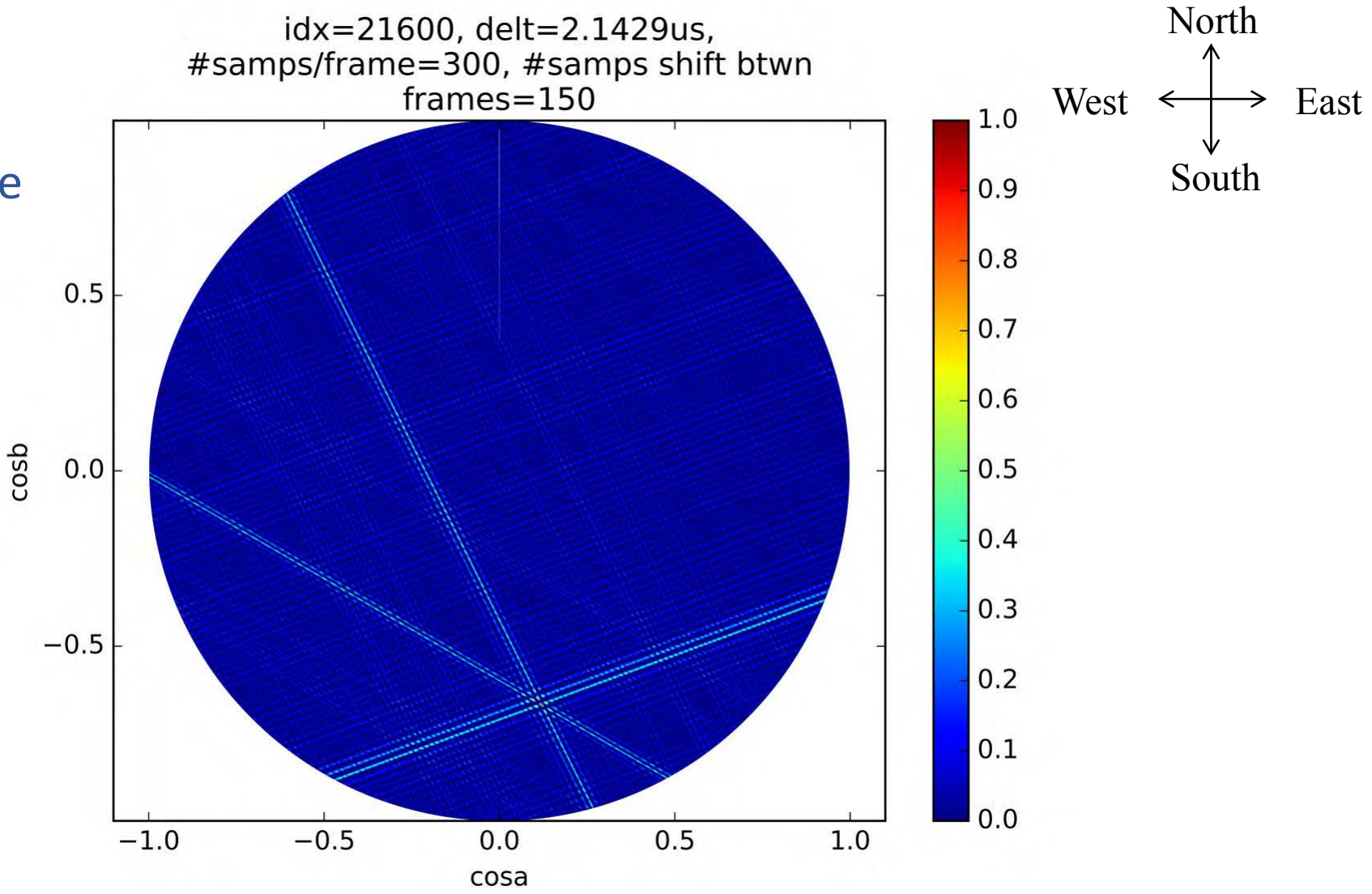

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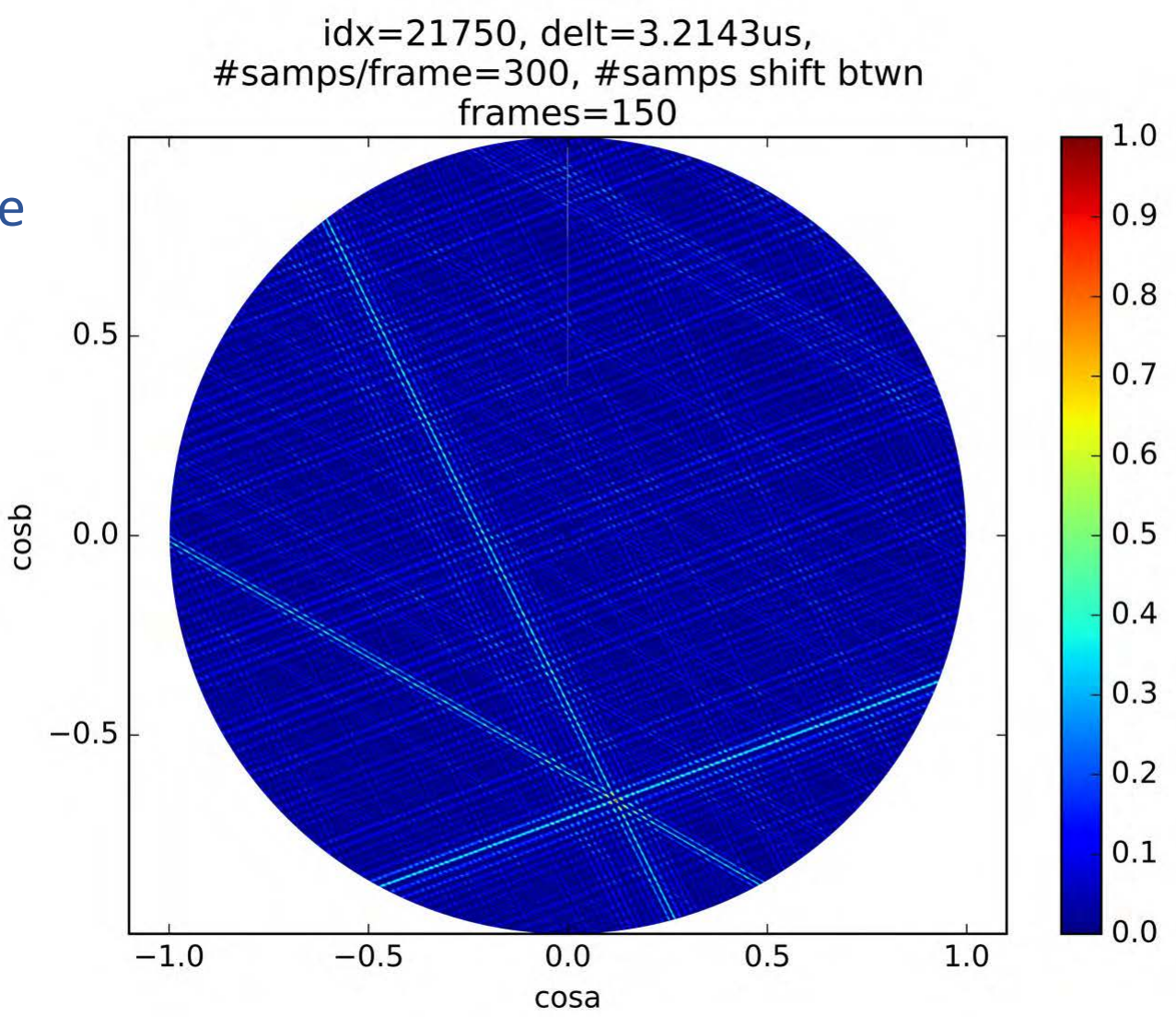
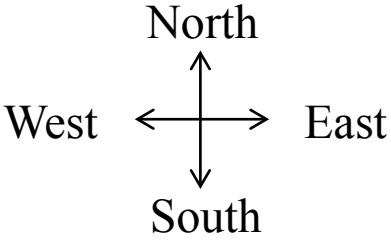
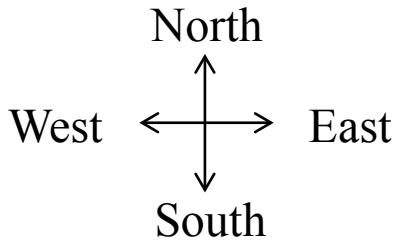
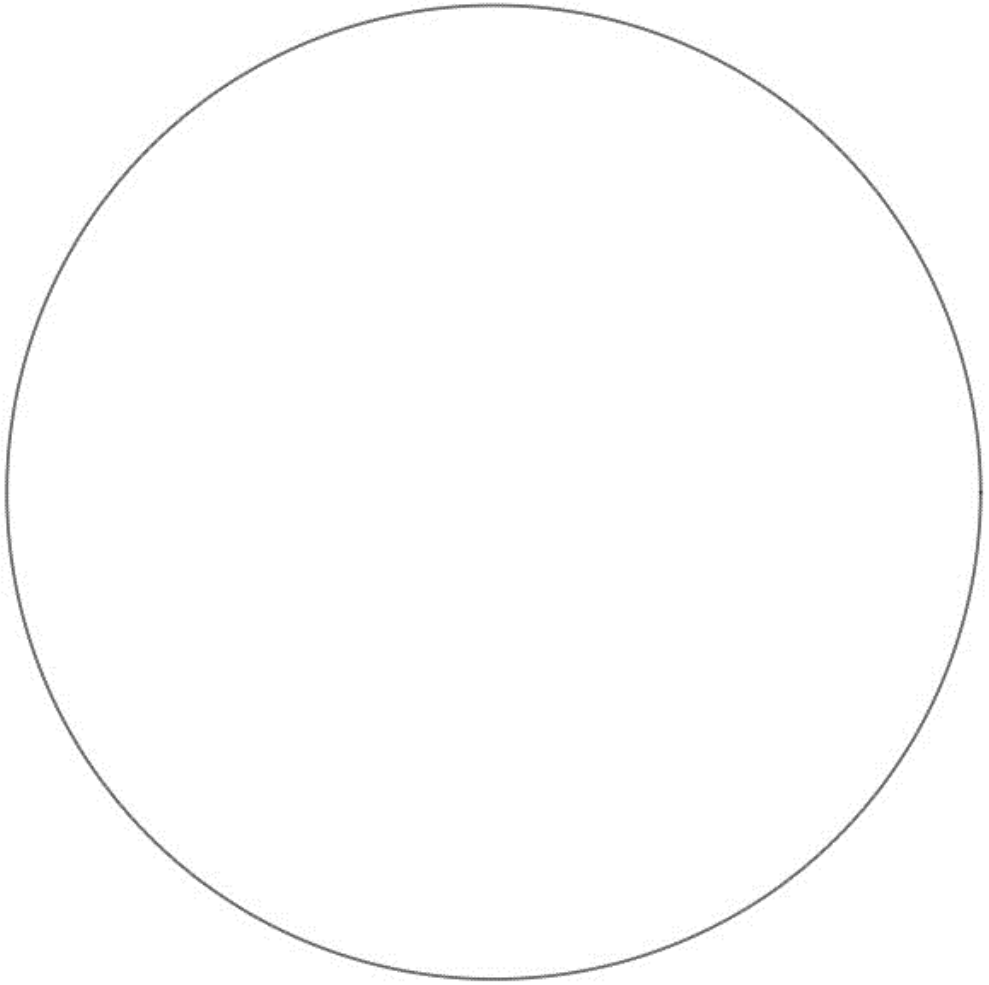


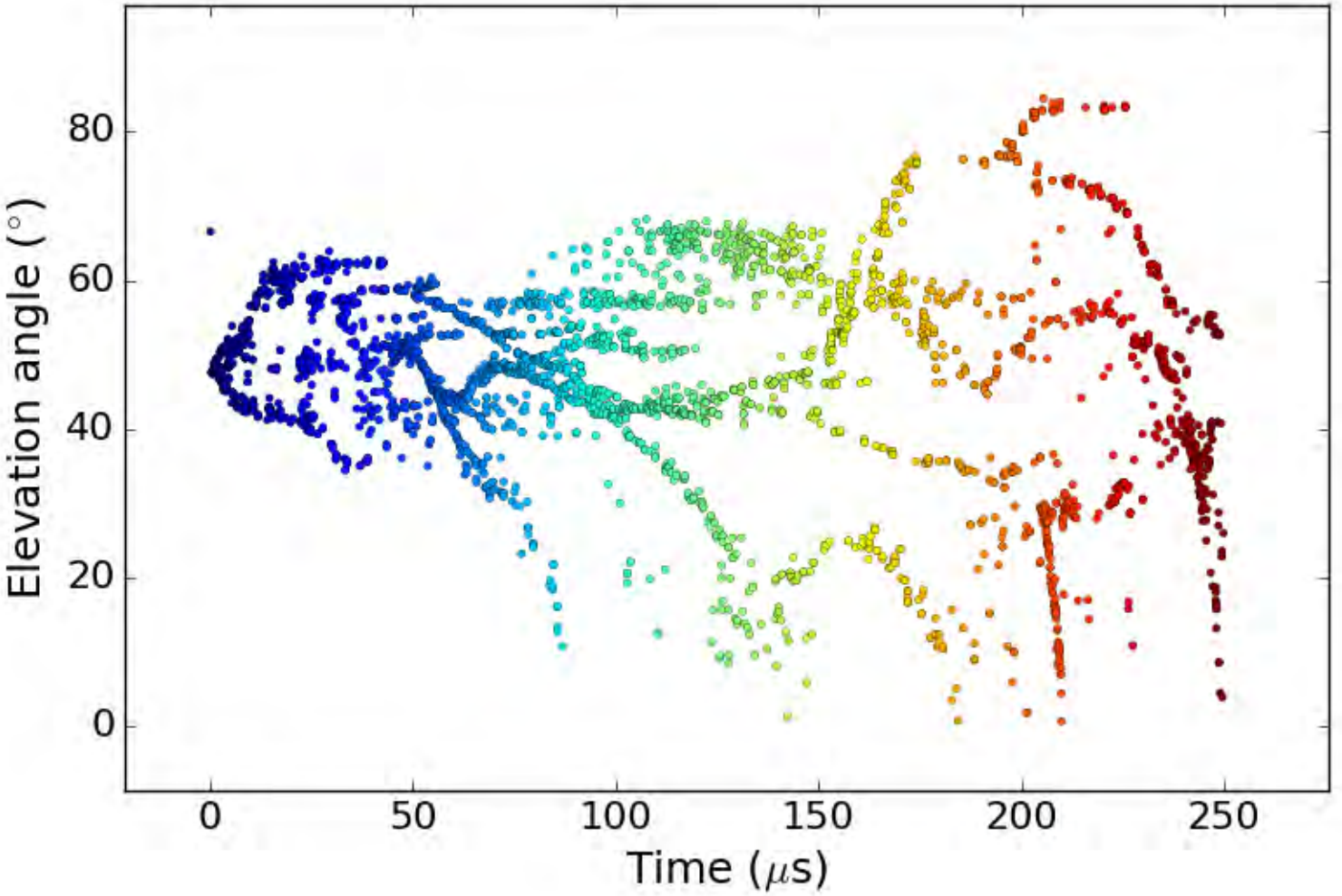


Interferometry – flash 1

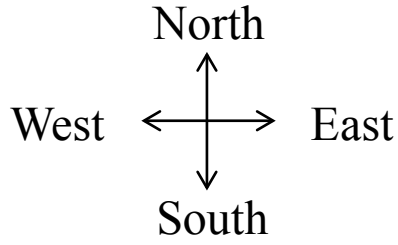


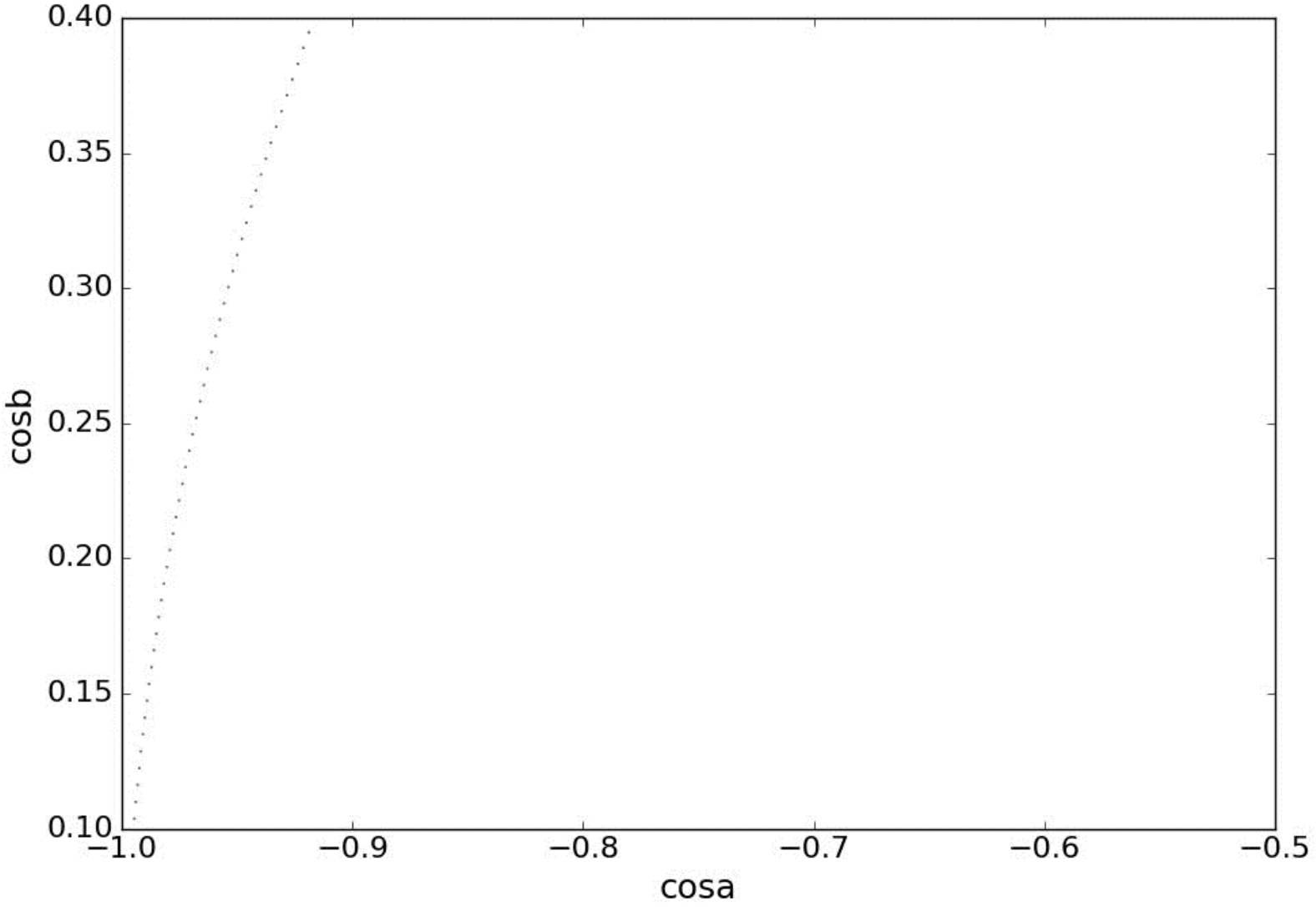


Interferometry – flash 1

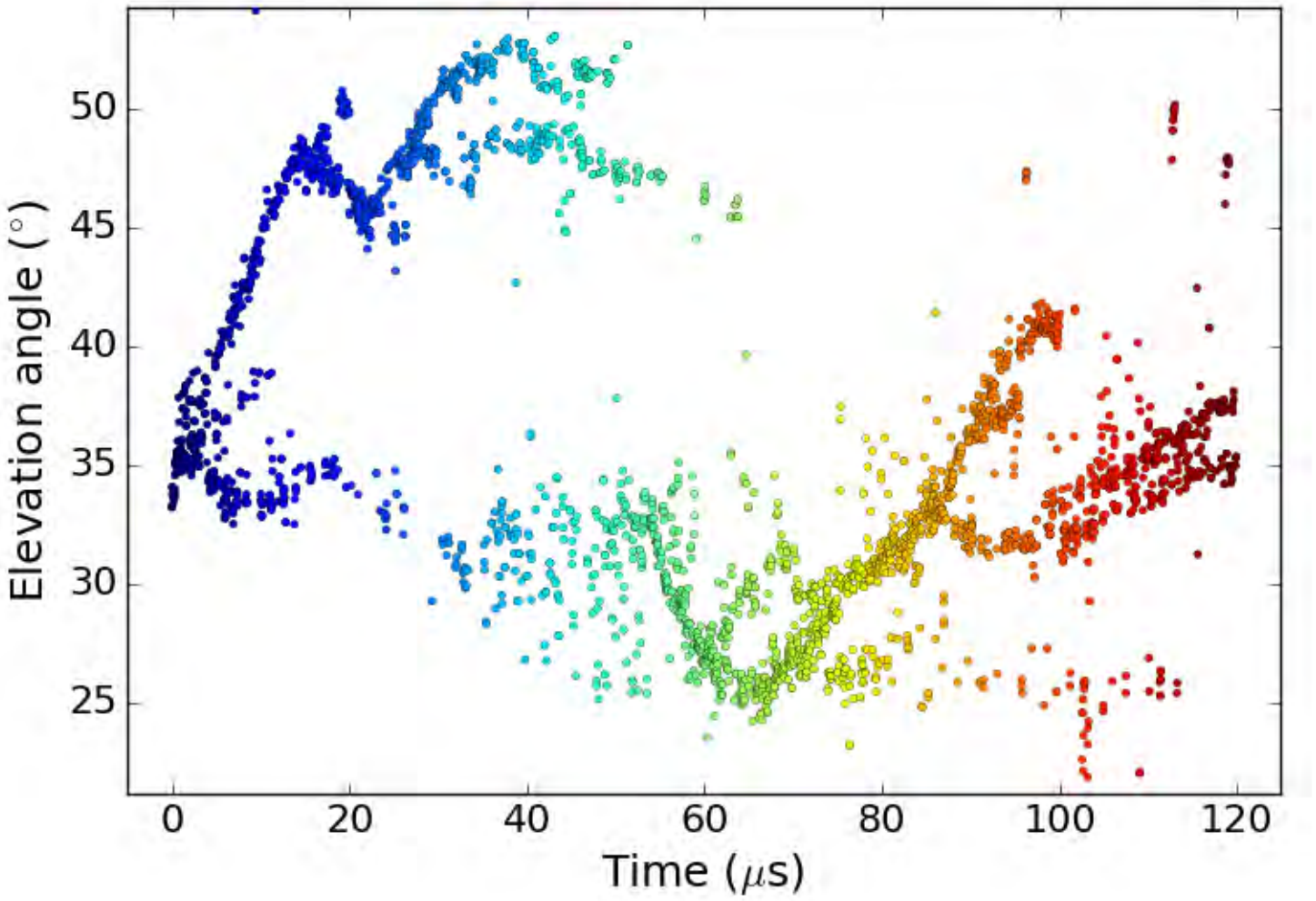


Interferometry – flash 2





Interferometry – flash 2



Interferometry + Polarization

$$I = \langle E_{NS}^2 \rangle + \langle E_{EW}^2 \rangle$$

$$Q = \langle E_{NS}^2 \rangle - \langle E_{EW}^2 \rangle$$

$$U = 2\langle E_{NS} E_{EW} \cdot \cos(\Delta\phi_{NS} - \Delta\phi_{EW}) \rangle$$

$$V = 2\langle E_{NS} E_{EW} \cdot \sin(\Delta\phi_{NS} - \Delta\phi_{EW}) \rangle$$

$$d = \frac{\sqrt{Q^2 + U^2 + V^2}}{I}$$

Next step…