A Modest Proposal for SKA Data Processing

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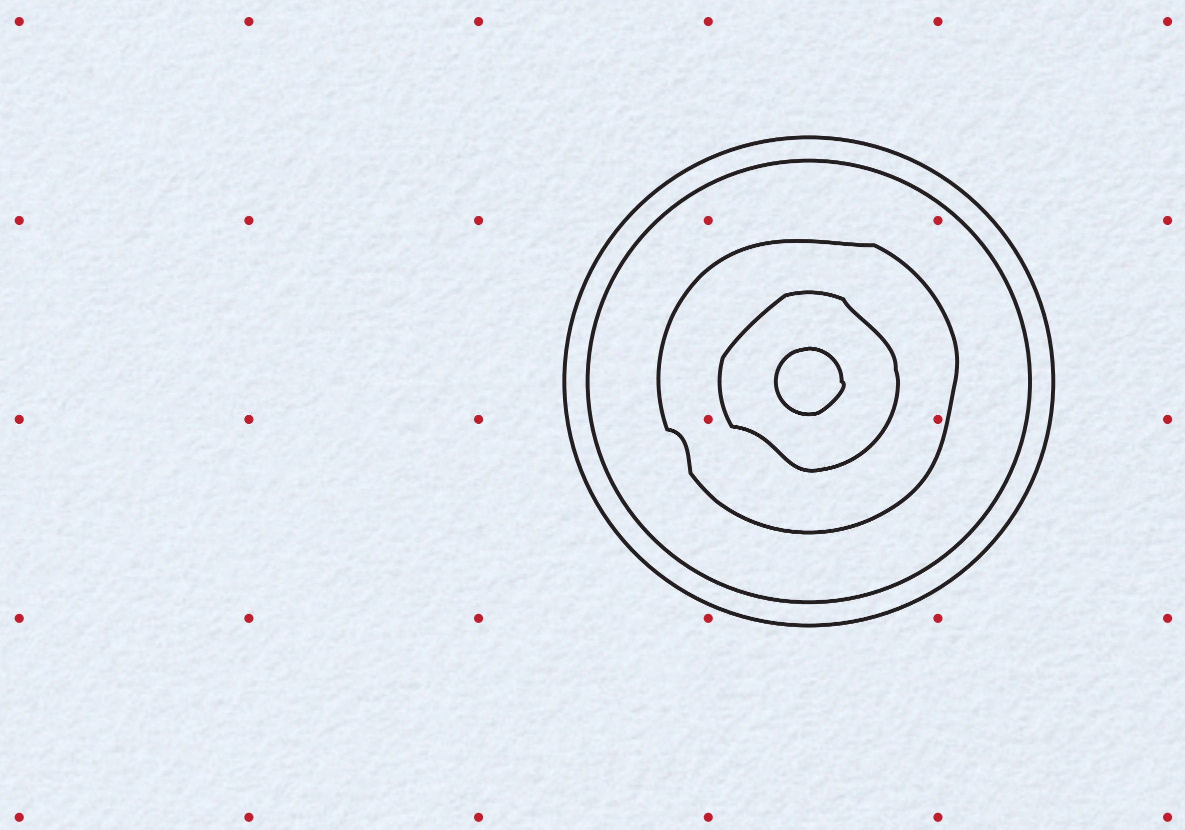
Purpose: develop data processing approach that meets the SKA science requirements and can be performed with today's technology.

Overview

- Review 4 building blocks:
    - A-transpose/Software Holography (A^T/SH)
    - MOFF correlator
    - Correlator beam shaping
    - Gridding FX correlator
- Put them together

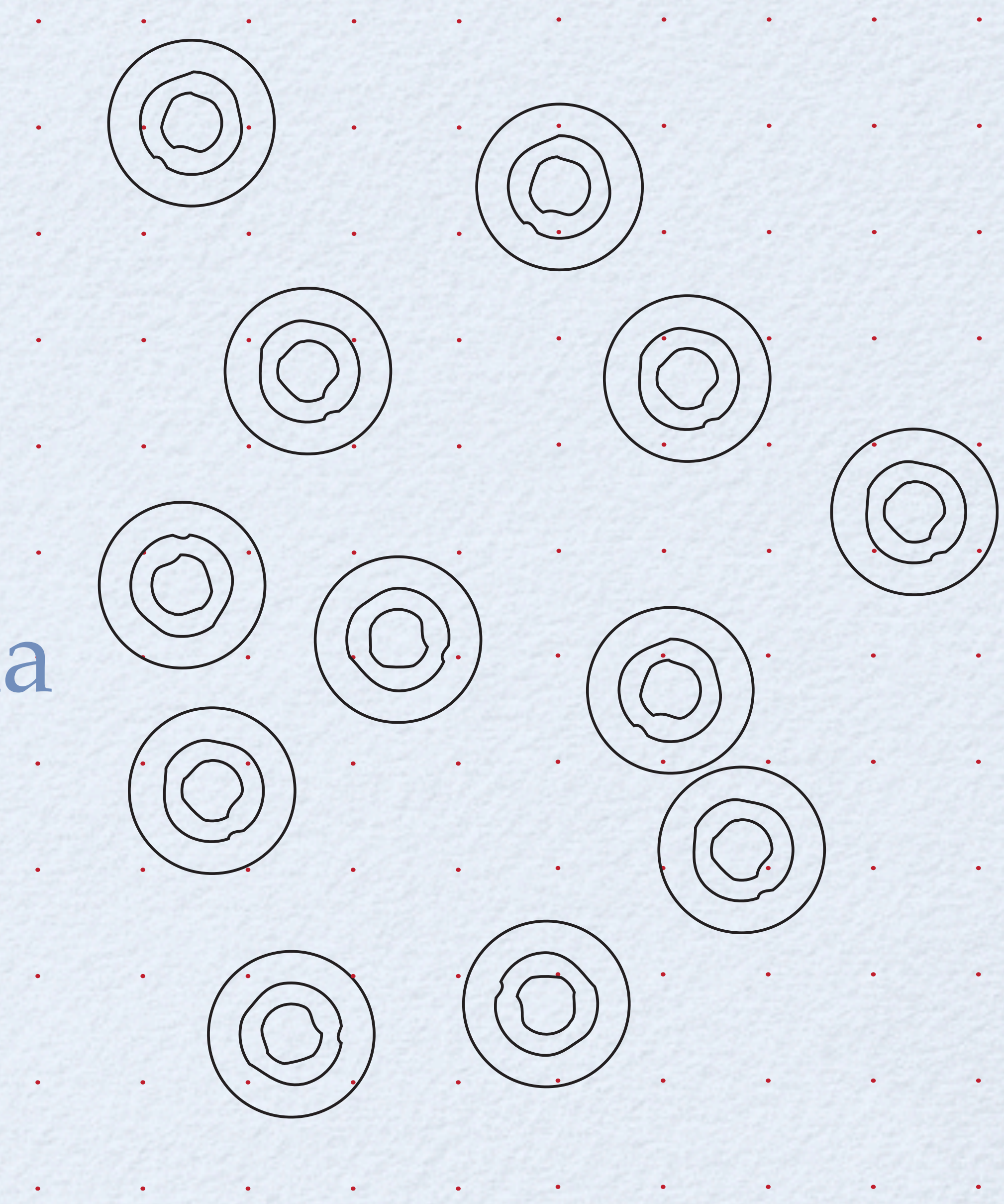
A^T/SH

Grid from visibilities to the uv-plane with holographic antenna pattern, allows direction & antenna dependent calibration and higher dynamic range



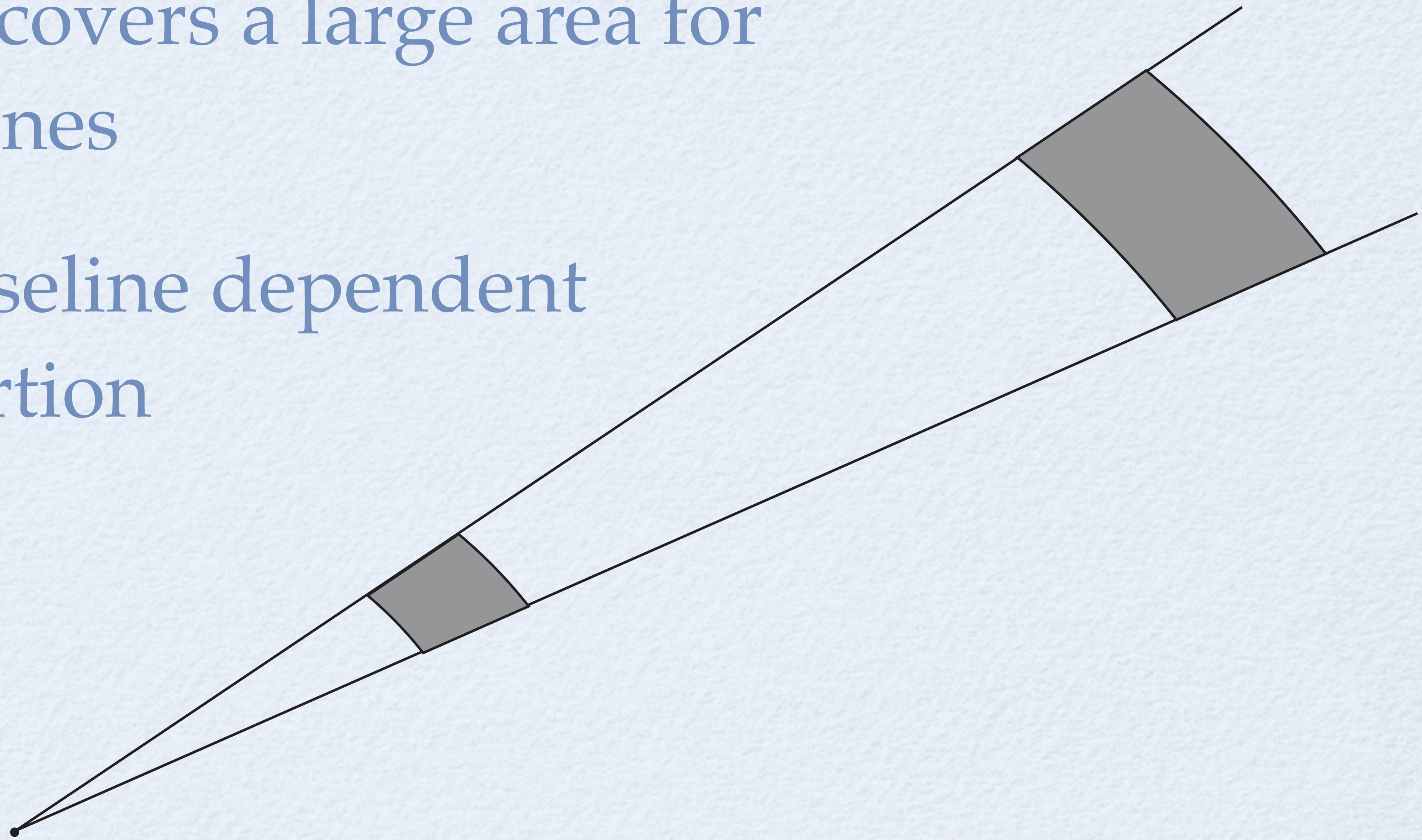
MOFF correlator

- Grids using holographic calibration in E-field domain, then performs spatial FFT & square-accumulate
- Identical result to traditional correlator and A^T/SH
- Very efficient for compact antenna arrays (e.g. stations)
- Intermediate product is fully calibrated electric field image (many beams)

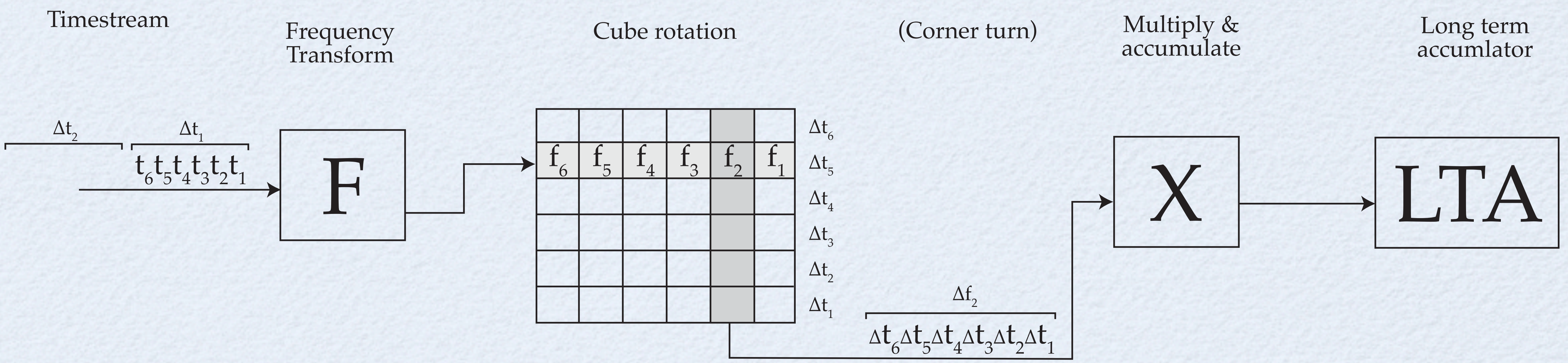


Correlator beam shaping

- In uv-plane, frequency & time averaging covers a large area for long baselines
- Creates baseline dependent FOV distortion



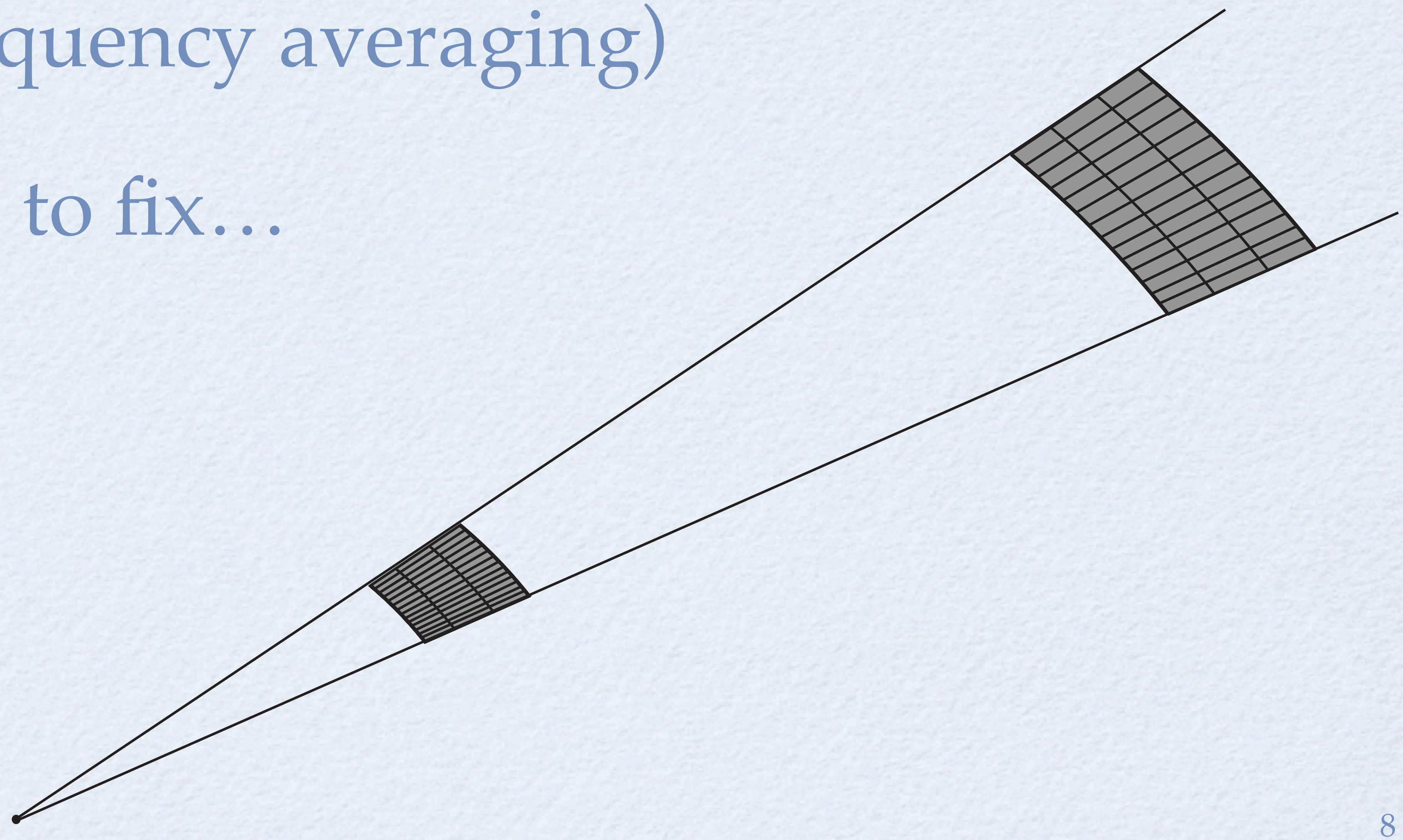
FX data ordering



Must reorder data so X operation can accumulate successive products & keep bandwidth to the LTA sane.

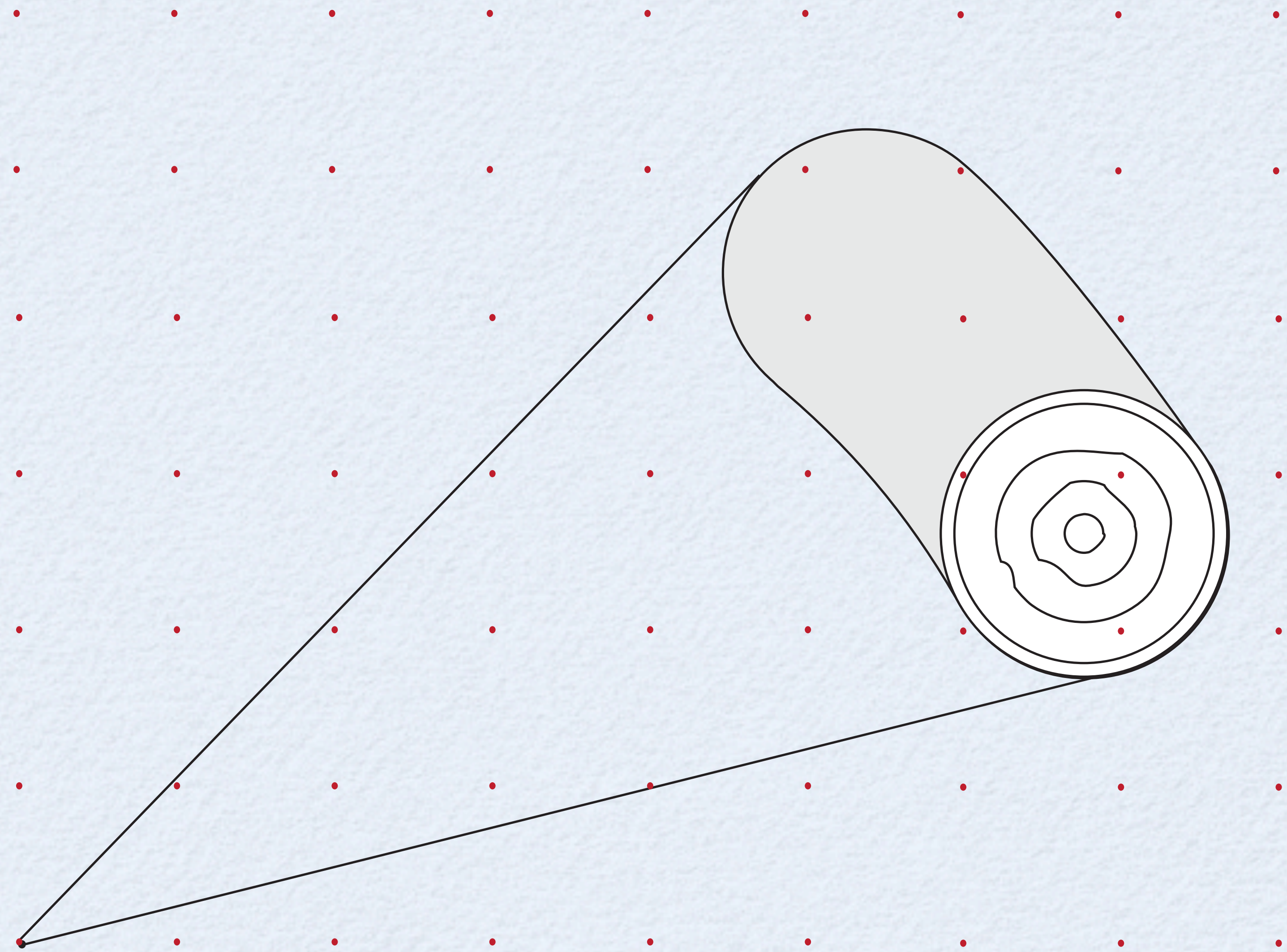
Correlator shaping

- Small uv-plane averaging within X
- LTA produces longer averages (often including frequency averaging)
- Several ways to fix…



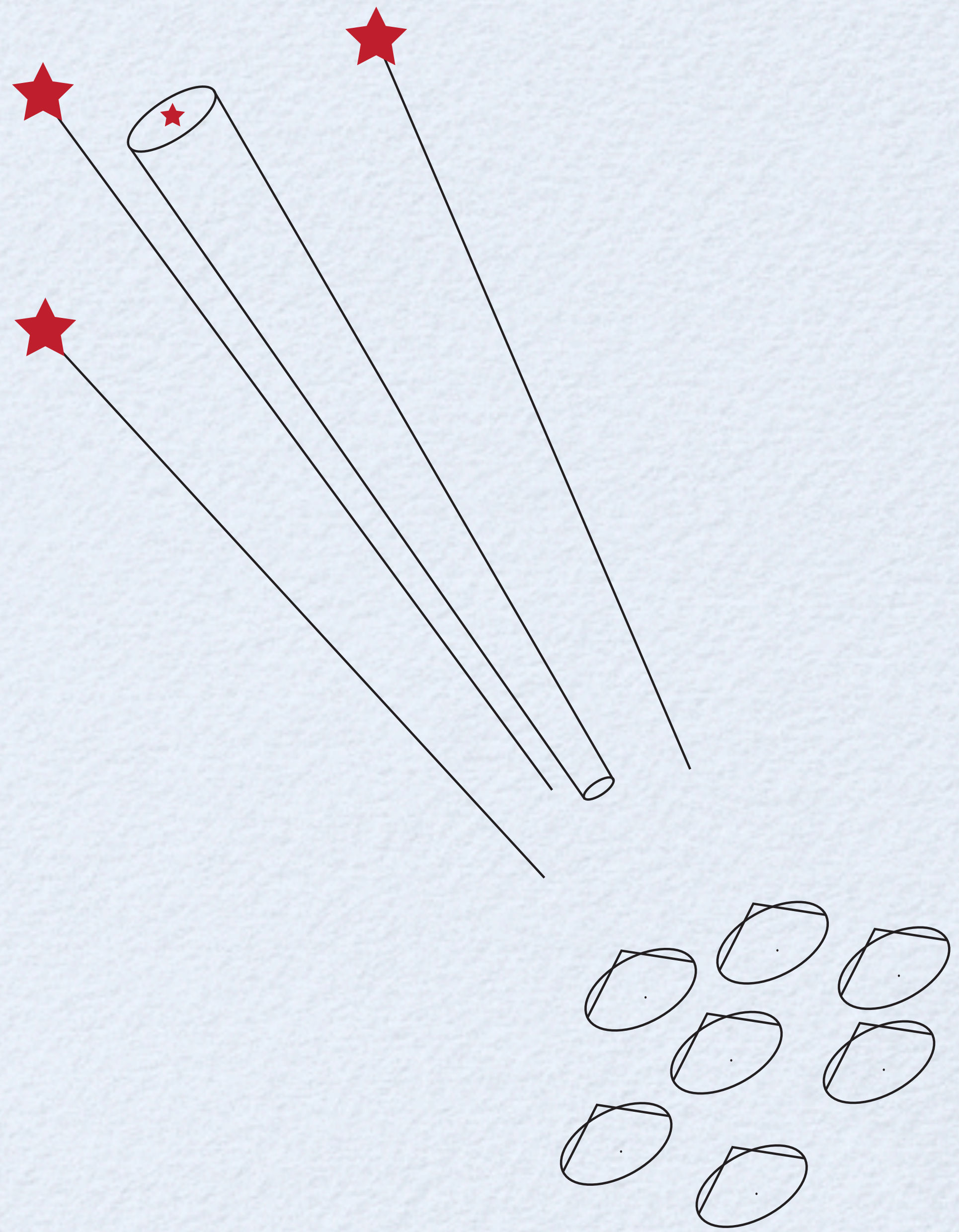
Gridding FX correlator

- Replace LTA with a gridding step, going straight to uv-plane using the holographic beam pattern



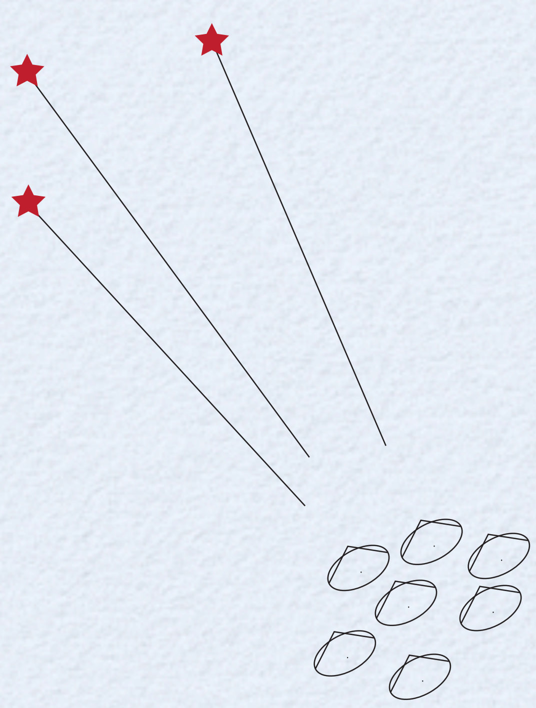
Putting it all together, step 1

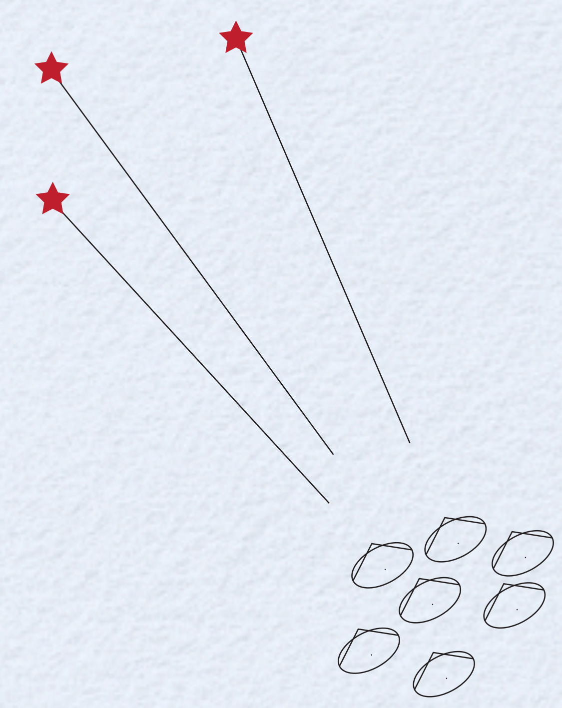
- Use MOFF correlator for each station & select calibrated science beam(s) and 3 or more atmospheric calibrator beams
- MOFF provides continuous holographic antenna calibration



Step 2

- Use calibrator beams to phase calibrate science beam(s) between stations
  - continuous phase calibration
  - interpolated phase calibration (linear + curvature atmospheric terms)





Step 3

- Use gridding FX correlator on science beam(s) to produce a sparse uv-gridded map (fully calibrated)
- The gridding is just the holographic station pattern (stations may be heterogenous)

Disadvantages

1) Does not provide full resolution over full FOV

- BAO & pulsars only need station based MOFF correlations…

2) Cannot recalibrate data

Advantages

1) Much lower computation (3 orders of magnitude typical), station-bandwidth, and data storage volume. (~doable with today's technology)

2) Continuous holographic antenna calibration, interpolated atmospheric calibration, high baseline dynamic range

3) Full FOV for short baselines, full resolution FOV upgradable as bandwidth & FX correlator improve

4) Small antennas okay (NlogN, survey speed)

5) Higher dynamic range (?)

Hopefully a fruitful starting point for discussions…