# The e-MERLIN Correlator

November 2009

# Correlator Basics 1
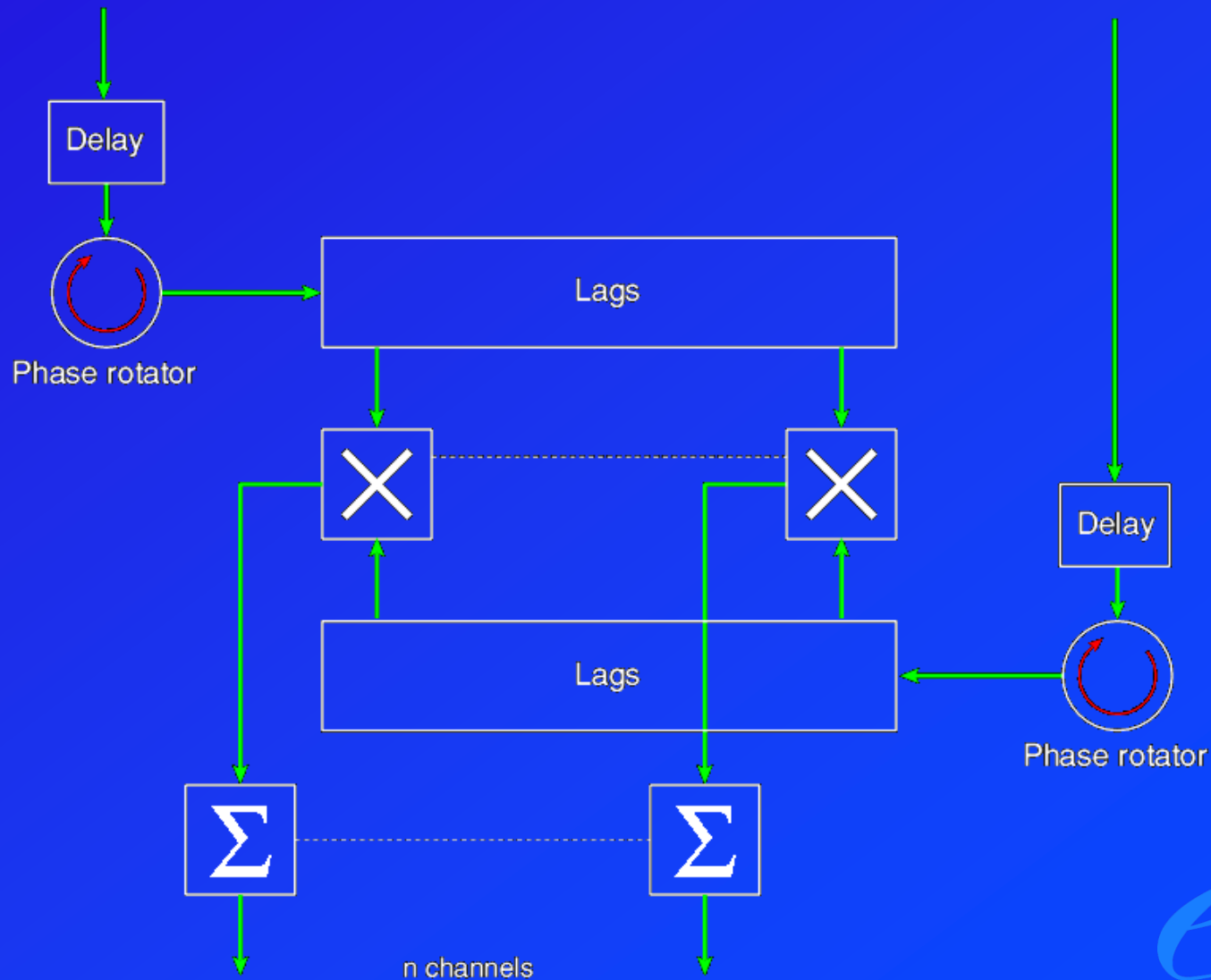
# Correlator Basics 2



- Typically the delay, phase rotation and correlation are carried out on digitised signals.

- The phase rotation, lags, multiplication and accumulation are done in purpose-designed correlator chips.
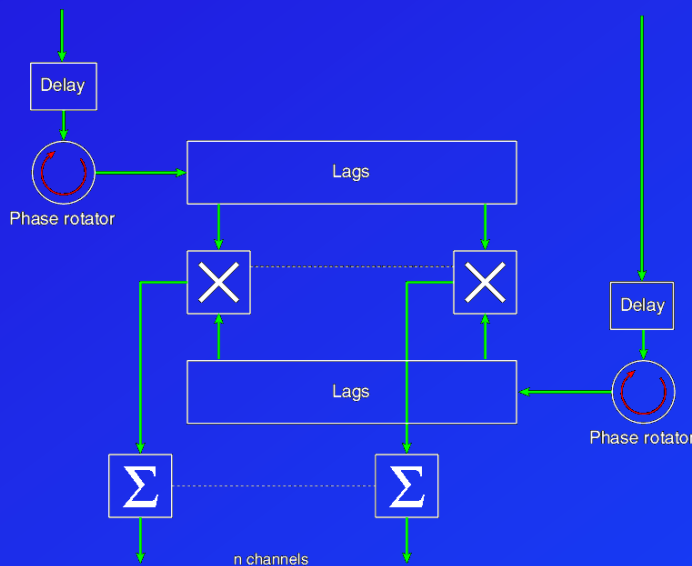
eMERLIN

# The e-MERLIN Correlator

- The simple correlator just described is unsuitable for e-MERLIN, because e-MERLIN has up to a 2 GHz bandwidth.

- E-MERLIN uses the WIDAR correlator developed by Brent Carlson at DRAO. The same (but larger) correlator is used for the eVLA.

- The WIDAR approach splits the wideband signal into a number of narrower *sub-bands* which are practicable to deal with.

# WIDAR Basics
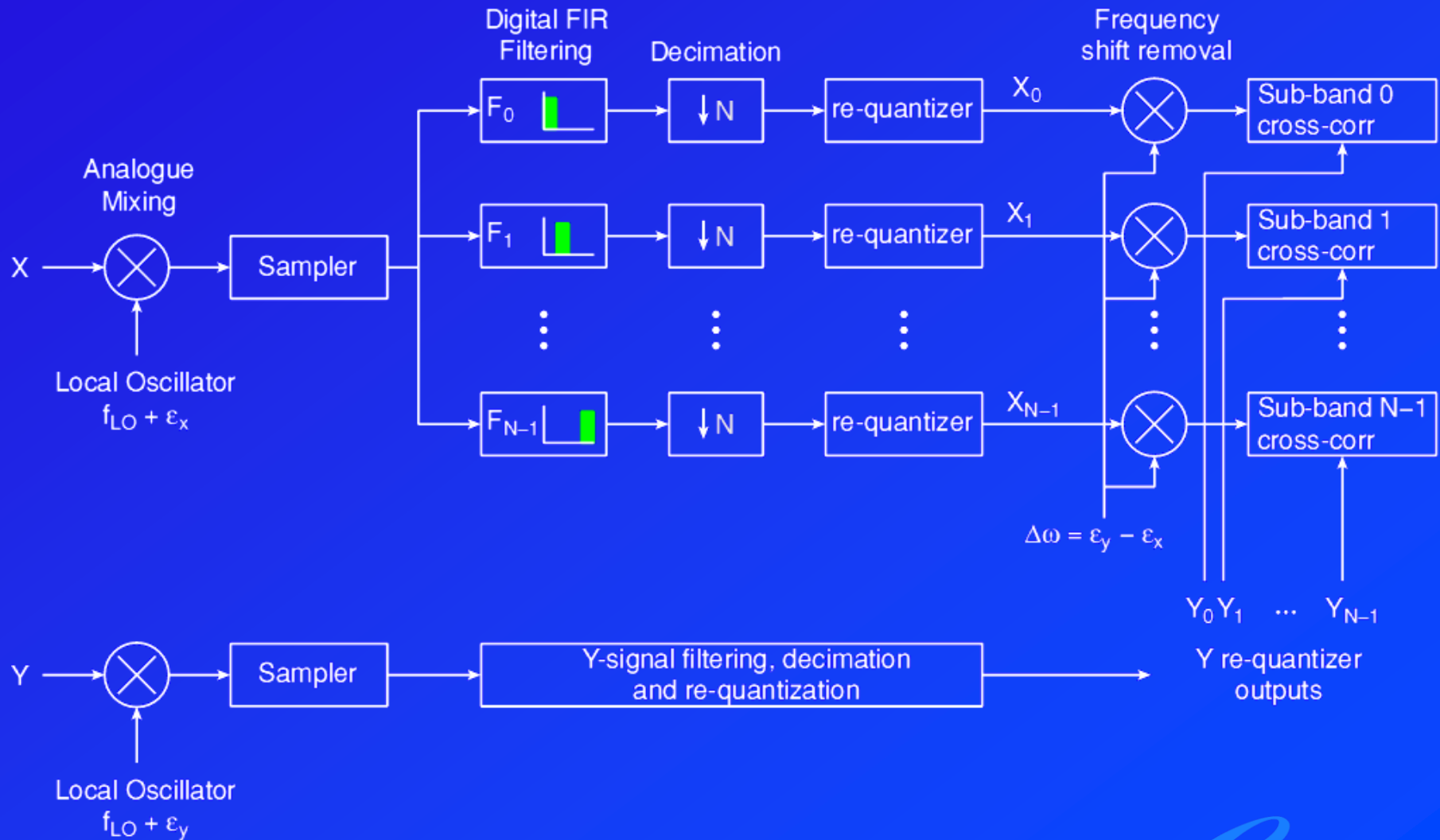
# WIDAR Aliasing 1

- In theory the resultant sub-bands can be stitched together to reconstruct the wideband spectrum.

- However there is a problem with the "transition-bands" ─ the out-of-band response of the FIR filters.

- Signals in these parts of the band will aliased into the "in-band" part.

**e**MERLIN

# WIDAR Aliasing 2

- The aliasing problem can be effectively removed by applying a different frequency offset to each telescope.

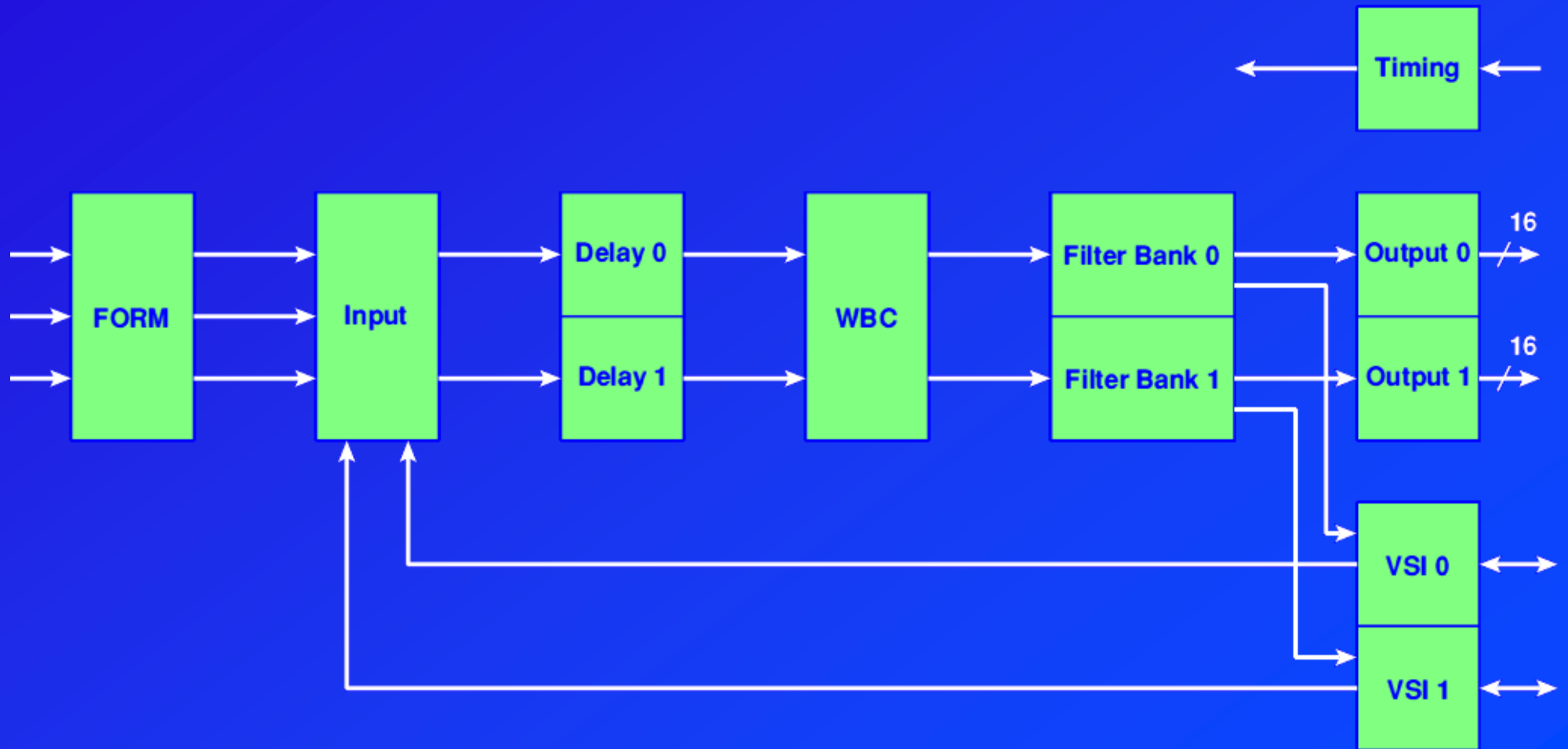- In this case, the aliased signals will de-correlate after the removal of the offset in the correlator.

eMERLIN
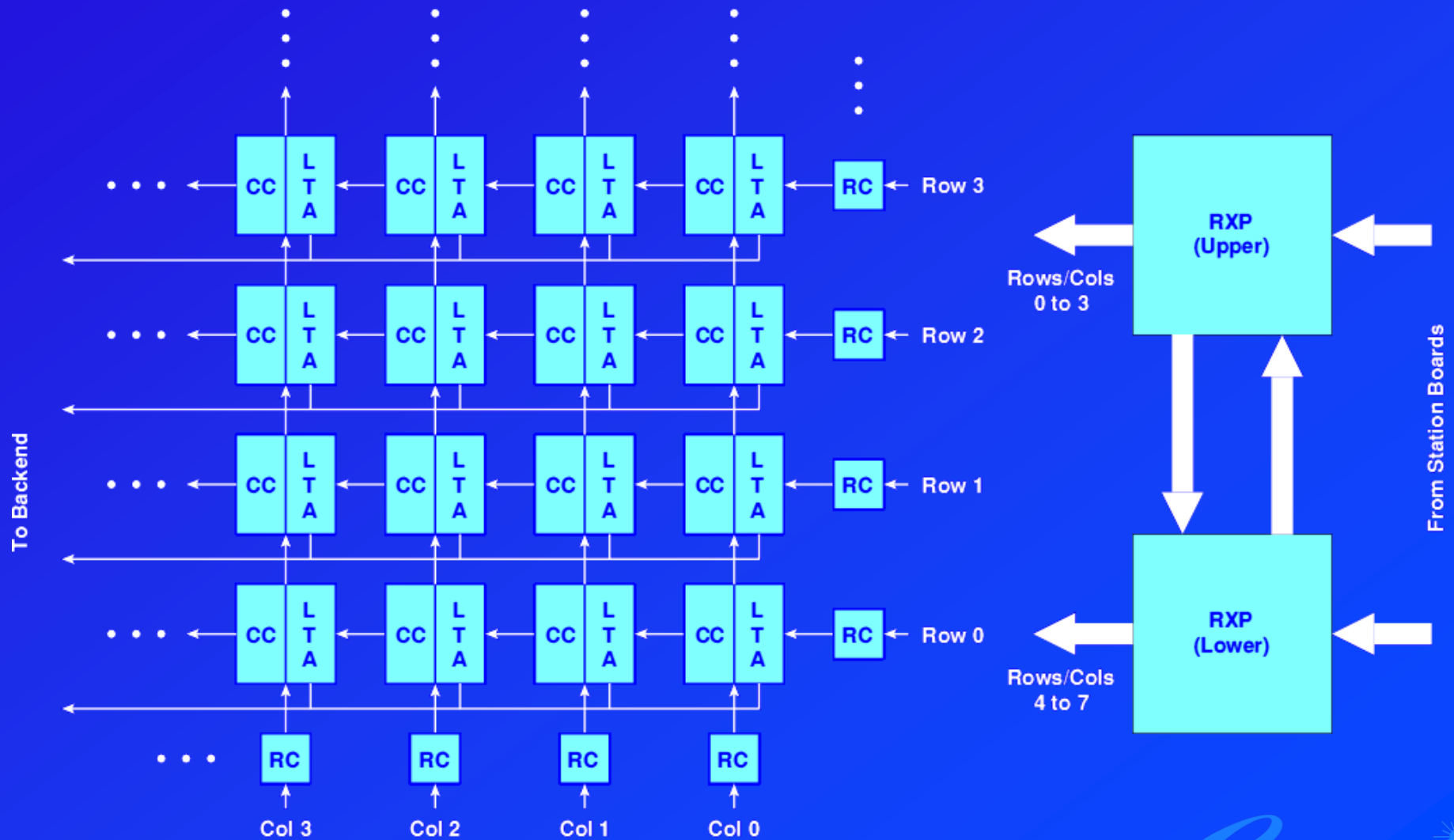
# WIDAR Aliasing 3
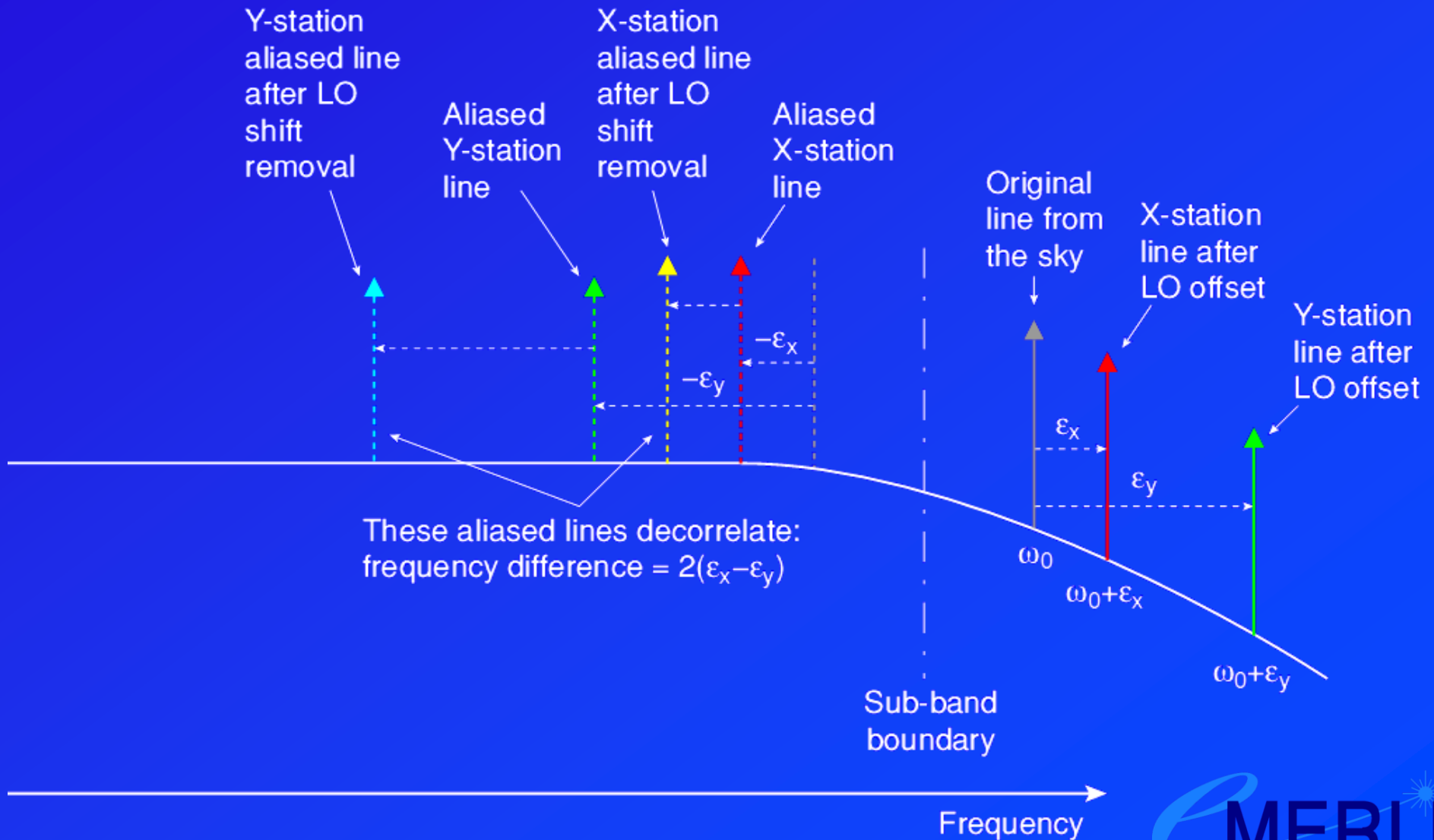
# The e-MERLIN Correlator in Practice

# Station Board

# Baseline Board 1

# Baseline Board 2

- The correlator chips are arranged in an 8 x 8 matrix.

- Each chip contains 4 Quads (CCQ) each of 4 independent 128 complex-lag Correlator Chip Cells (CCC). Each Quad can therefore correlate all four polarisation products.

- Adjacent CCCs and CCQs can be concatenated to dedicate more lags to a particular product.

- Each chip has 8 X and 8 Y inputs.

eMERLIN

# Correlator Chip Multiplier Module
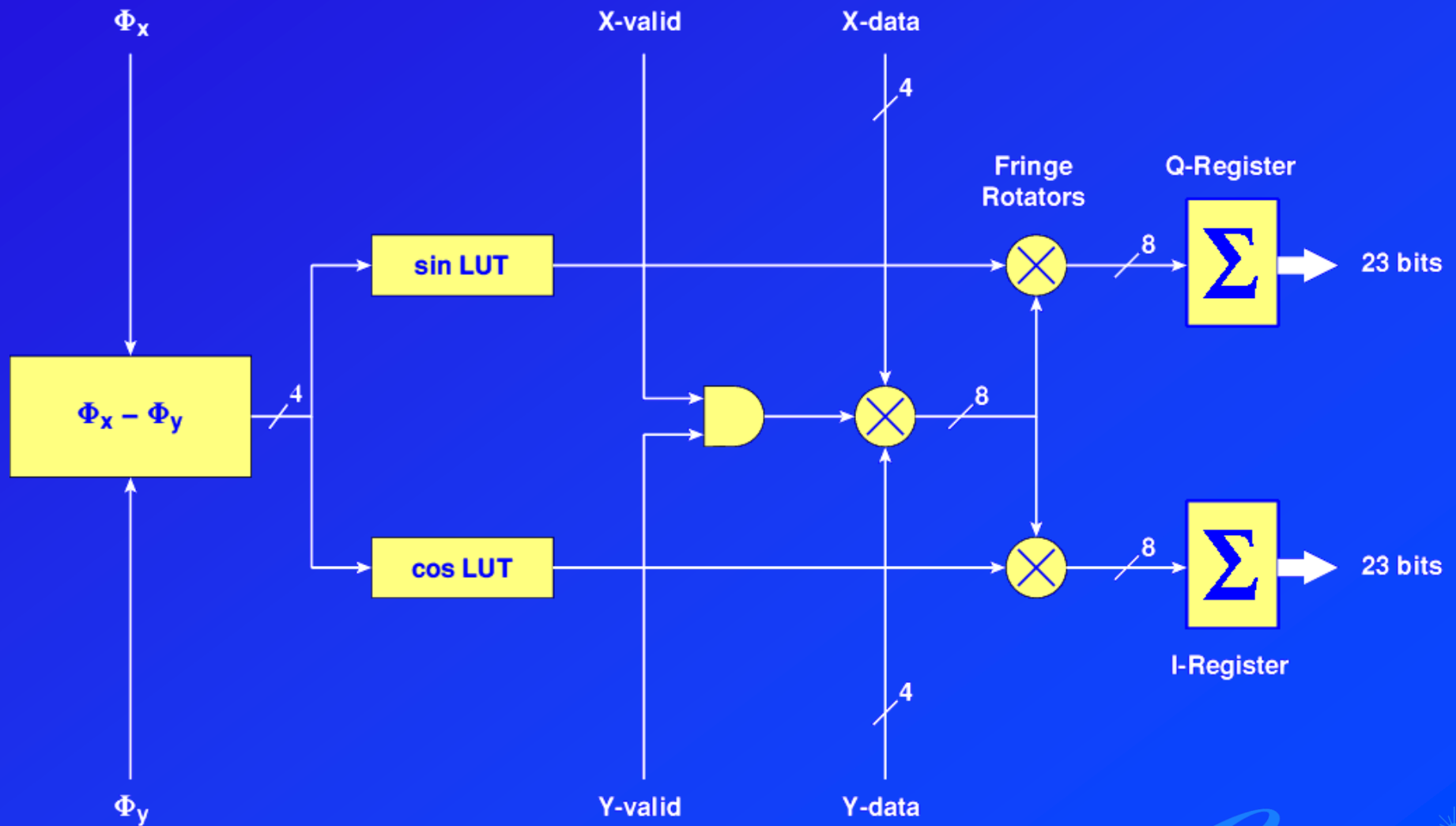
# Correlator Control

- Each board has its own processor running Linux which is responsible for loading and servicing the FPGAs and related items. The programming is largely in C.

- The correlator itself is controlled by a separate computer (also Linux) which serves out the OS to the board processors. This talks to the outside world via the "Virtual Correlator Interface", and via engineering GUIs. Programming is in C and Java.

# E-MERLIN Control Software

- The e-MERLIN control software provides the interface to the operators, configures the correlator, sequences the observations, and captures the data from the correlator.

- It talks to the correlator using the VCI and to the telescopes via the Outstation Telescope Control Computer.

- It is programmed entirely in C++.

e MERLIN

# Things I Haven't Mentioned

- Input and output state counts.

- Clip counts.

- Power counts.

- Noise diode binning.

- Pulsar binning and gating.

- Phase tone extraction (not used by e-MERLIN).

- Phasing (not used by e-MERLIN).

eMERLIN

# Summary of Correlator Capabilities

- Bandwidth 2 GHz (3-bit sampling) or 1 GHz (8-bit sampling).

- Can provide 4 GHz bandwidth with only one polarisation.

- 512 spectral channels per sub-band per polarisation without recirculation. (1024 with only two polarisations.)

- Up to 131072 spectral channels per sub-band per polarisation with recirculation.