

Correlators

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Interferometer Signal Paths

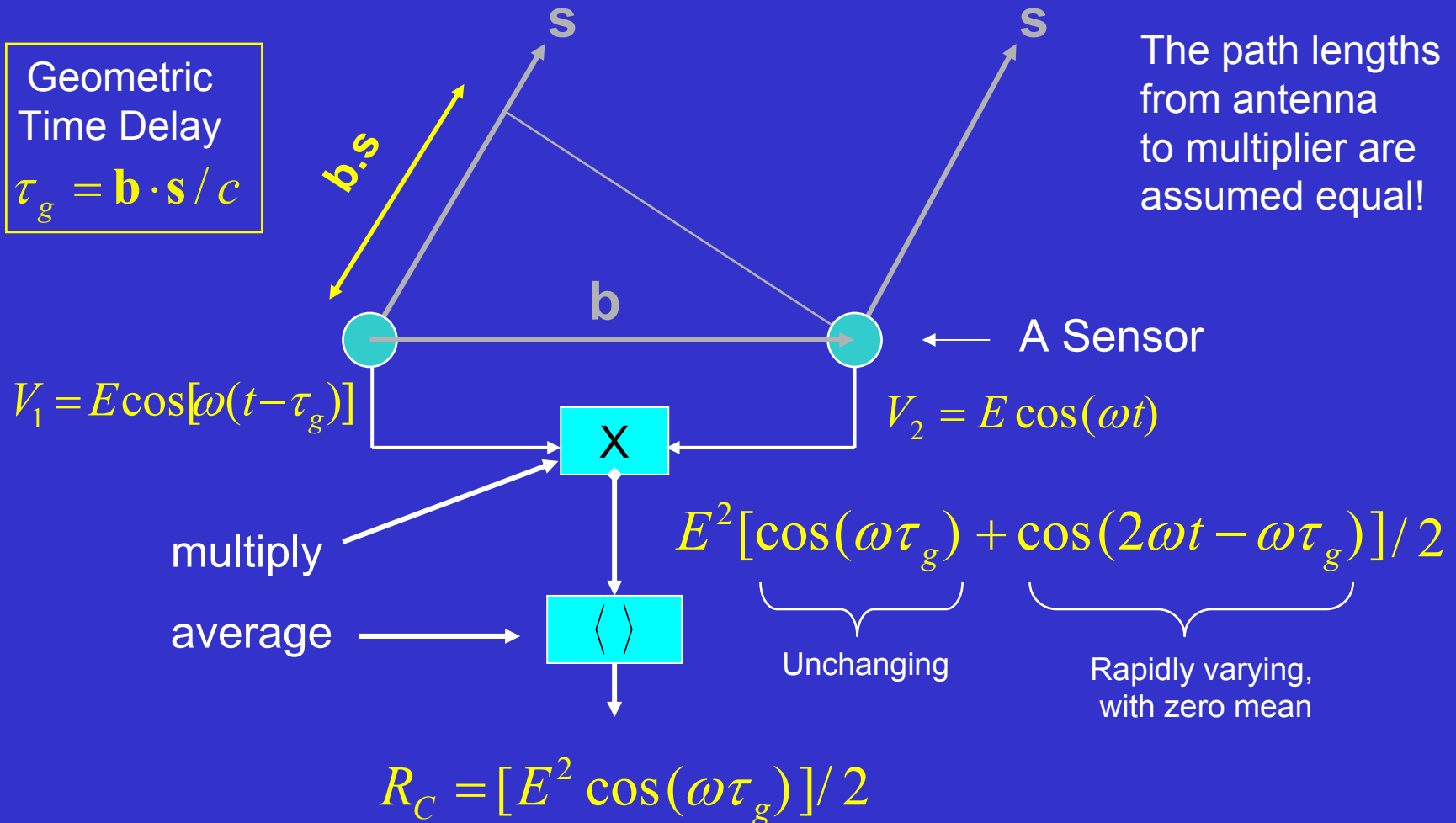
Antennas
Receivers
Correlator
Software

Compact Array Broadband Backend

The Stationary, Quasi-Monochromatic Radio-Frequency Interferometer

Geometric Time Delay
 $\tau_g = \mathbf{b} \cdot \mathbf{s} / c$

The path lengths from antenna to multiplier are assumed equal!



Basic (COS) Interferometer, plus:

Down Conversion

Bandwidth Definition

(SIN Interferometer)

Digitisation

Convert Signals to complex form. Why? Why not??

$$A \cos(\omega t) = A/2 e^{j\omega t} + A/2 e^{-j\omega t}$$

Filter out negative frequencies and just deal with the positive spectrum.

Then we can say:

Correlator's role is to form visibilities, and dig signal out of the noise (T_{sys}).

$$E_1 = Ae^{j\omega(t-\tau_g)}, \quad \tau_g = \mathbf{b} \cdot \mathbf{s}/c, \quad E_2 = Ae^{j\omega(t-\tau_0)}$$

$$V_{12} = E_1 E_2^* = A^2 e^{j\omega(\tau_0 - \tau_g)}$$

Before correlation,

A^2 is proportional to bandwidth.

Noise variance is too.

After correlation,

A^2 is independent of bandwidth.

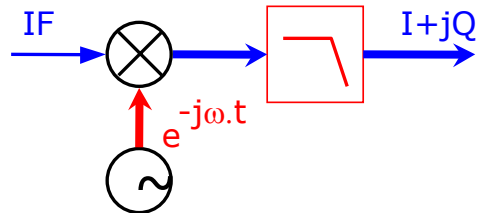
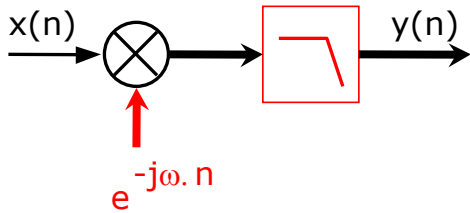
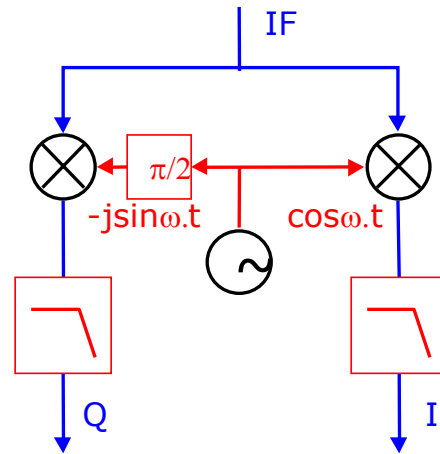
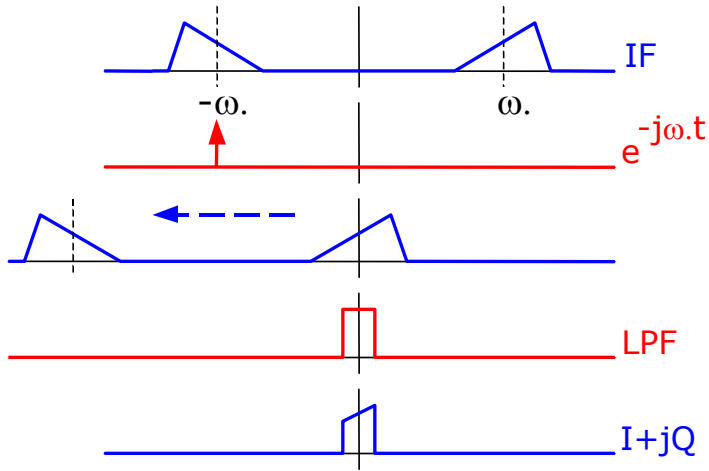
Noise is still dependent.

Noise σ reduced by factor $\sqrt{BW_{in}/BW_{out}}$.

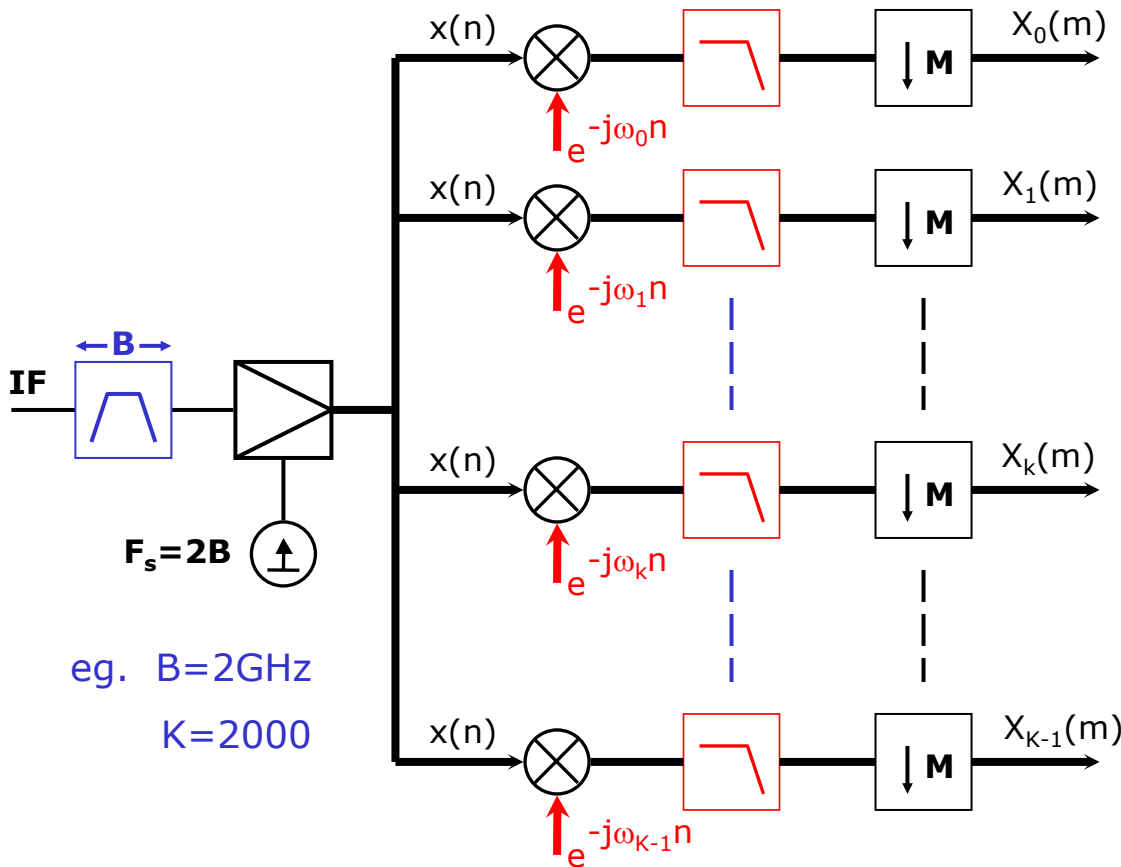
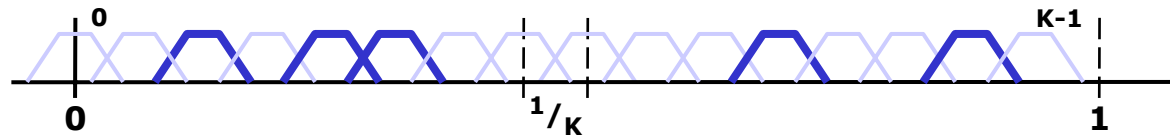
Integrator $BW = 1/T$

$\Rightarrow \sigma$ reduced by factor $\sqrt{BW_{in}T}$.

Complex Down Converter



CDC Array = Filterbank



$$\omega_k = 2\pi k/K$$

$$W_K = e^{j2\pi/K}$$

$$n = mM + \rho = mK + \rho$$

$$e^{-j\omega_k n} = e^{-j2\pi k(mK + \rho)/K}$$

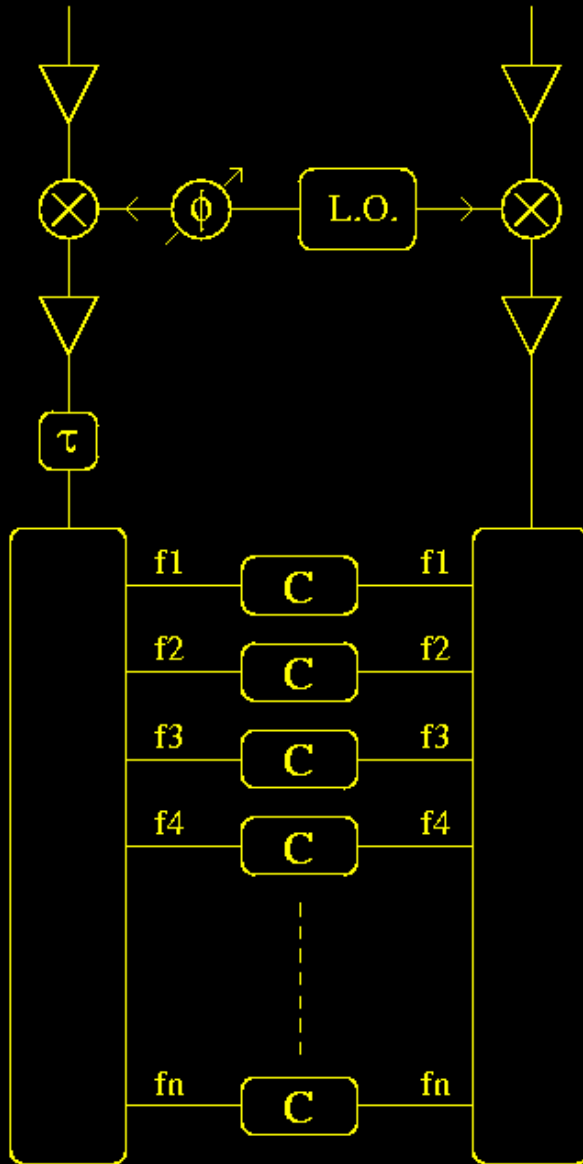
$$= e^{-j2\pi k\rho/K}$$

$$= W_K^{-k\rho}$$

eg. $B=2\text{GHz}$

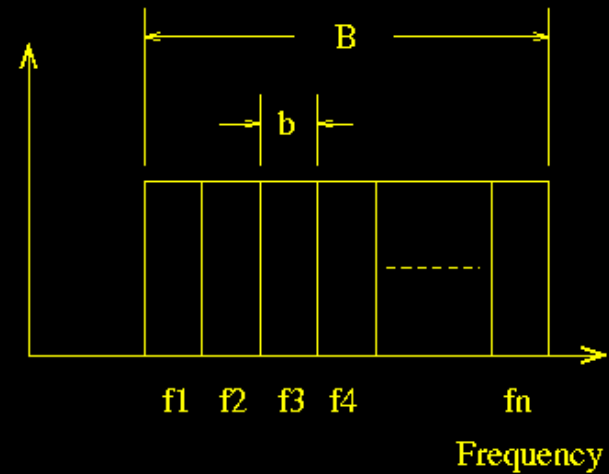
$K=2000$

Spectro-Correlator



$B = \text{Total bandwidth}$

$b = \text{Channel bandwidth}$



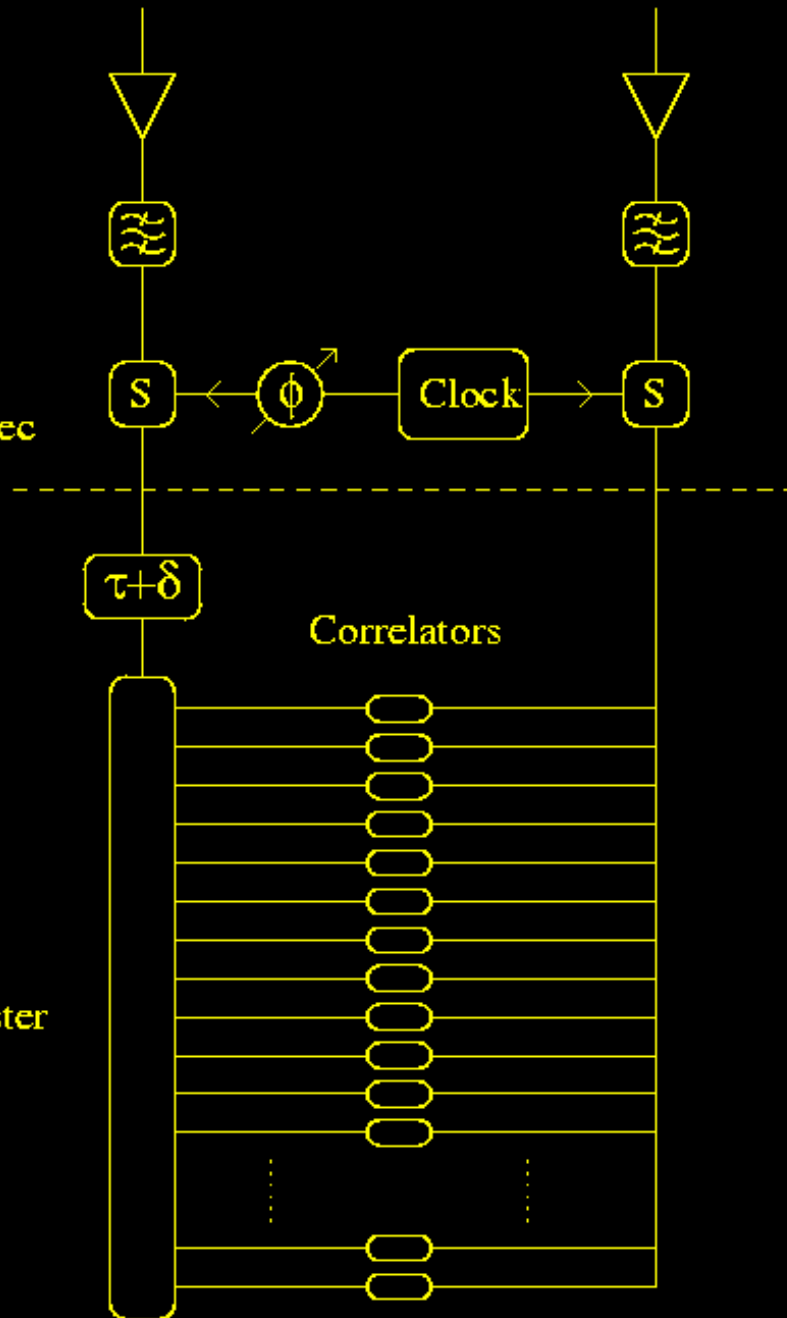
Filter Banks

Correlators

Cross-correlation Spectro-Correlator

Bandwidth = B

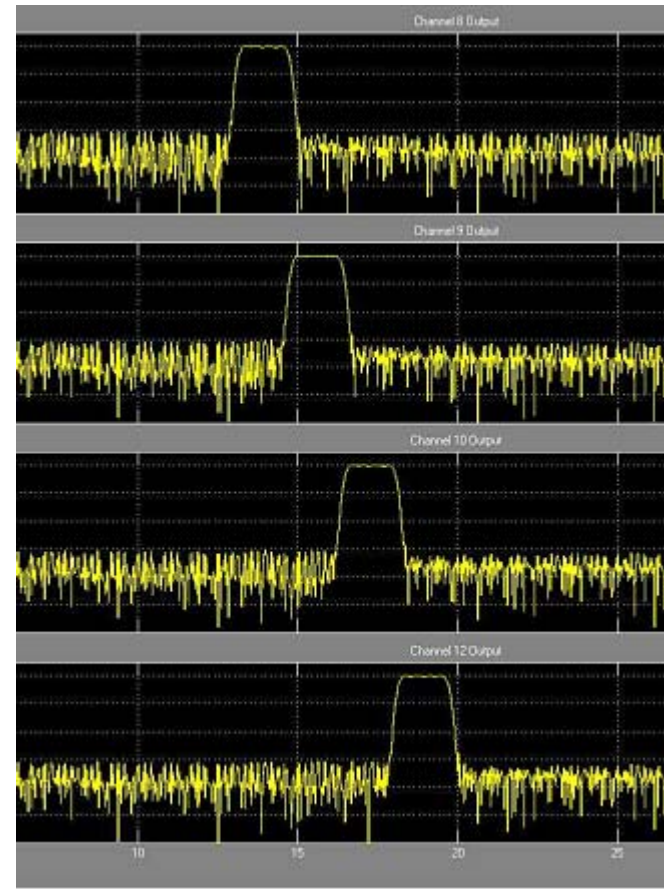
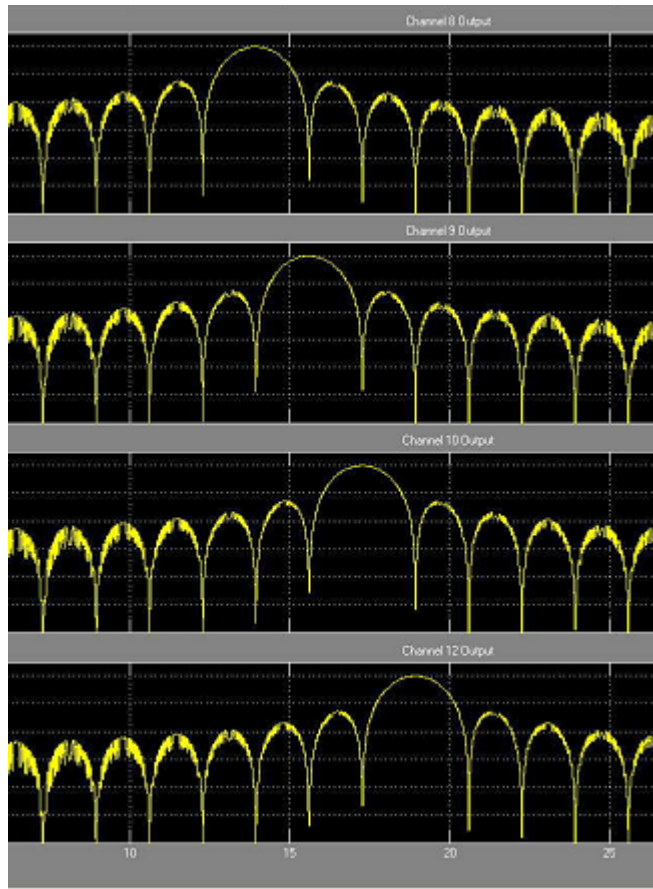
Digitise at $\geq 2B$ samples/sec



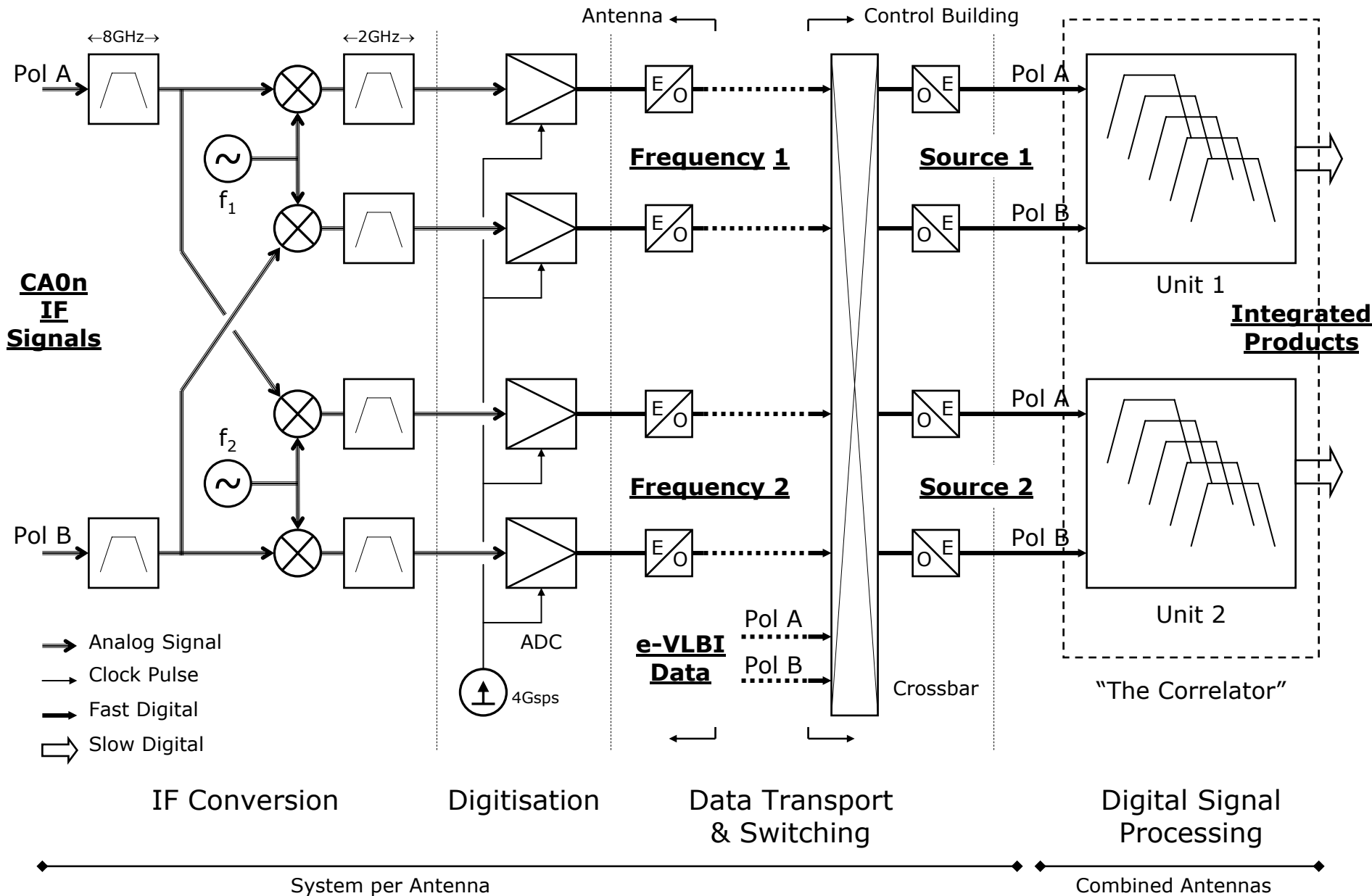
Digital Cross-correlator

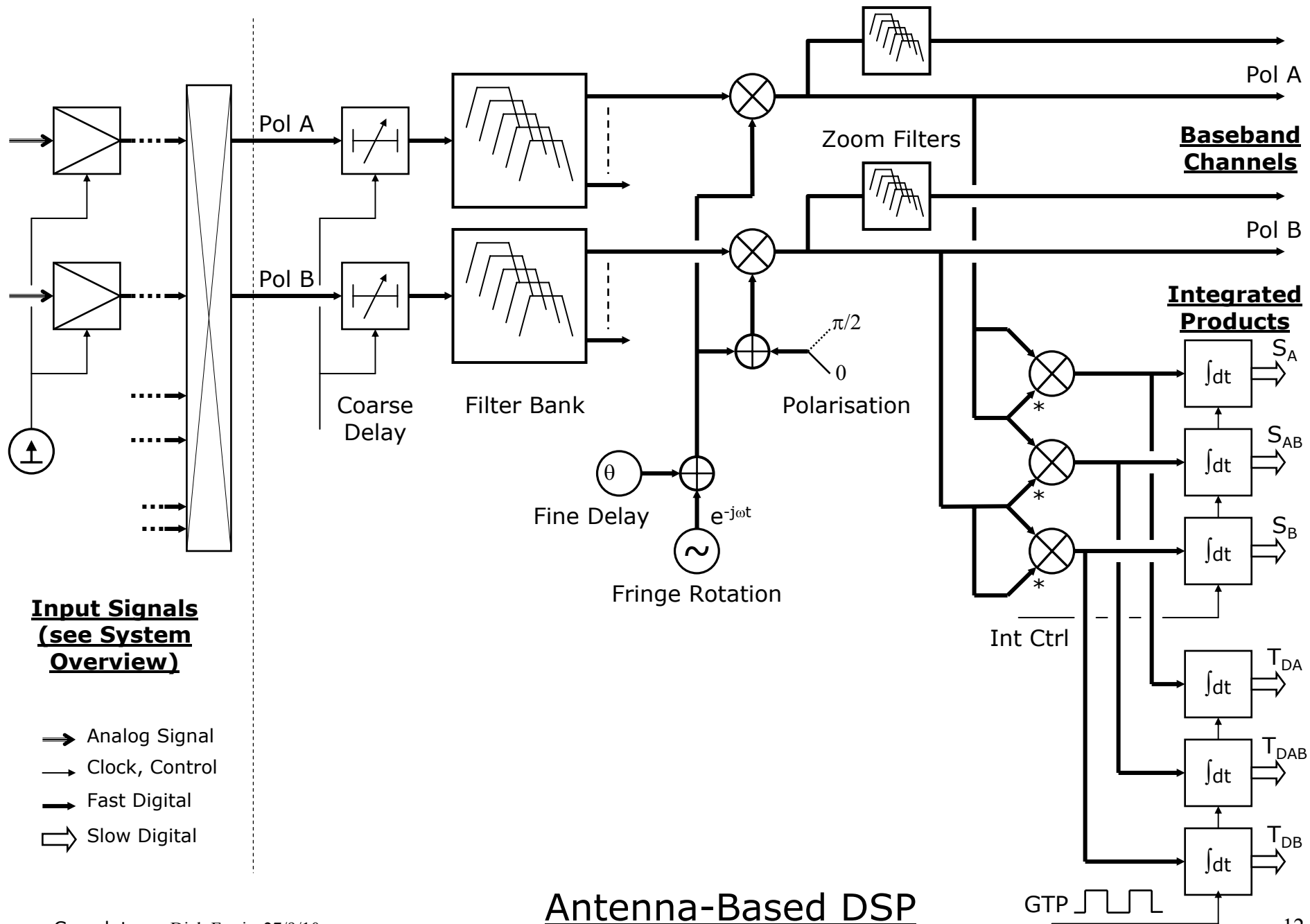
$$C(\tau) = \langle E_1(t) \bullet E_2(t + \tau) \rangle$$

Measure over a range of (positive and negative) delays



Conventional XF and FX vs PDFB

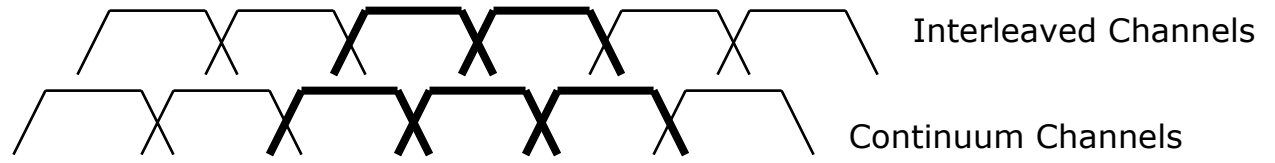




Derivation of Zoom Modes

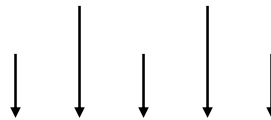
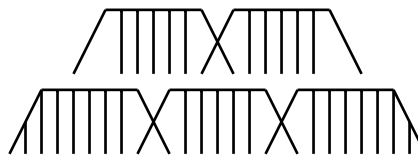


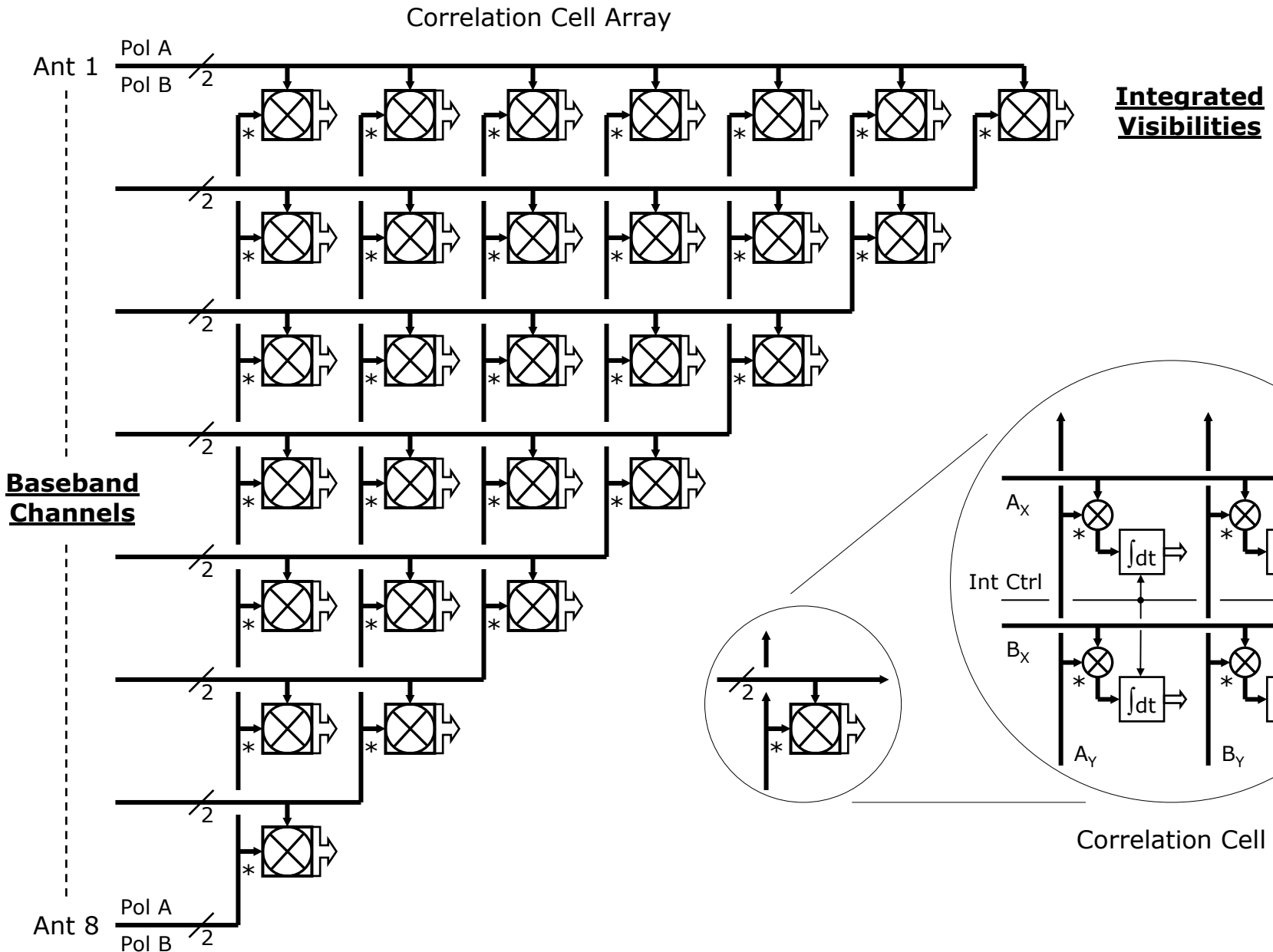
Normal Wideband Mode

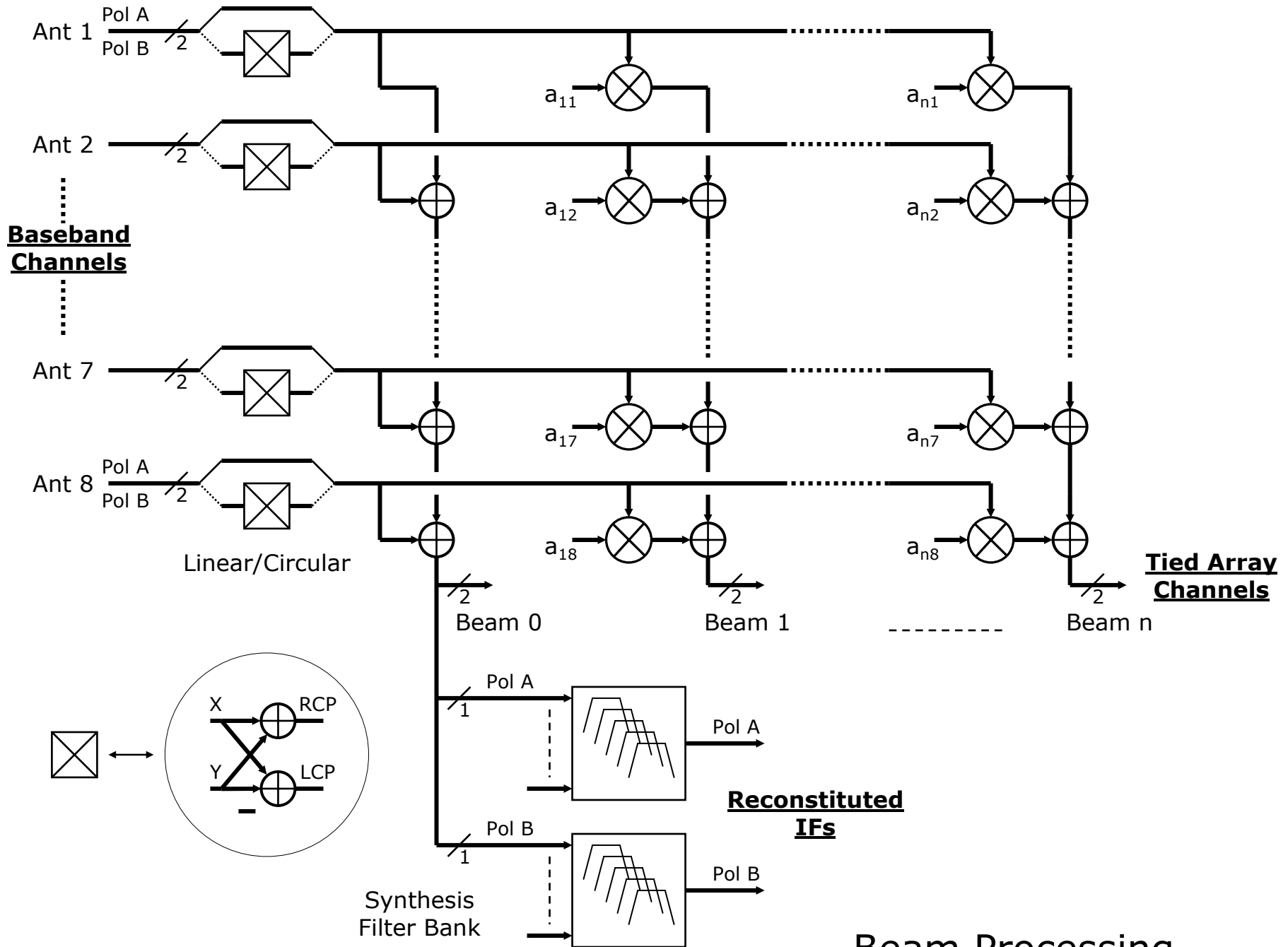


Zoom Band

Simultaneous Continuum
and Line Modes







9-bit ADC data, constant gain not constant power

17+17-bit data into final products

No clipping or requantising

Controlled rounding and aliased noise

ADC dynamic range preserved throughout

No gain modulation by satellites in antenna sidelobes or sidelobes sweeping transmitters

No settling time during mosaics and cals

>> Linear, time-invariant (LTI) instrument <<

High Dynamic Range in the
Time Domain