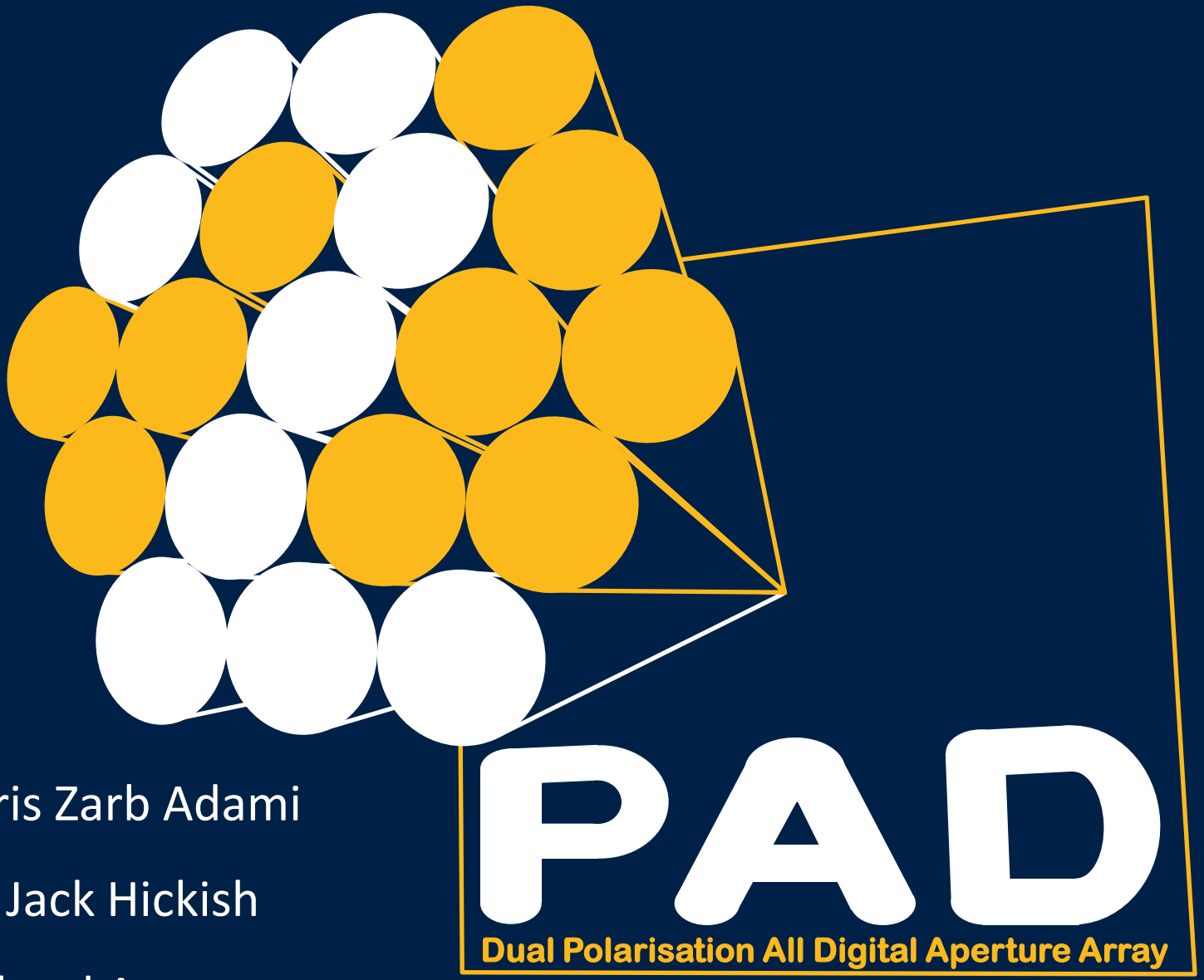


Kris Zarb Adami

Jack Hickish

Richard Armstrong

(jack.hickish@astro.ox.ac.uk)

2-PAD All-Digital Beamforming

Introduction

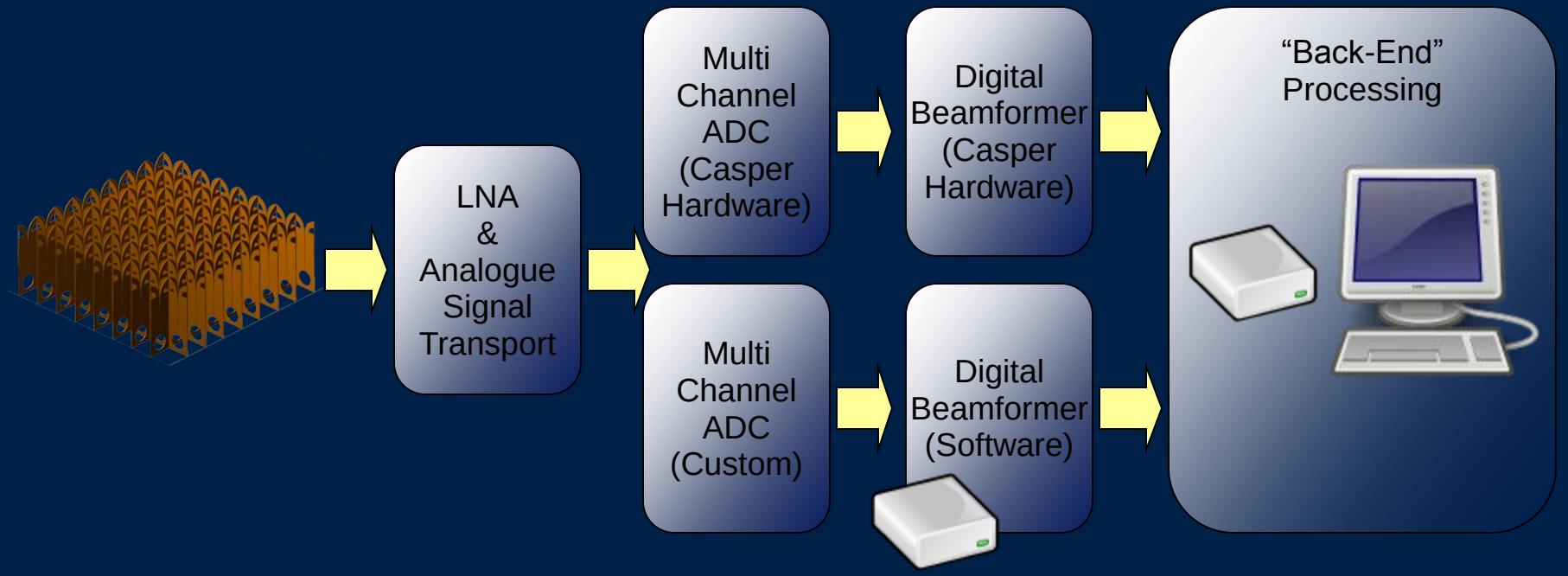
2PAD current digital architecture (CASPER)

Developing the 2PAD model

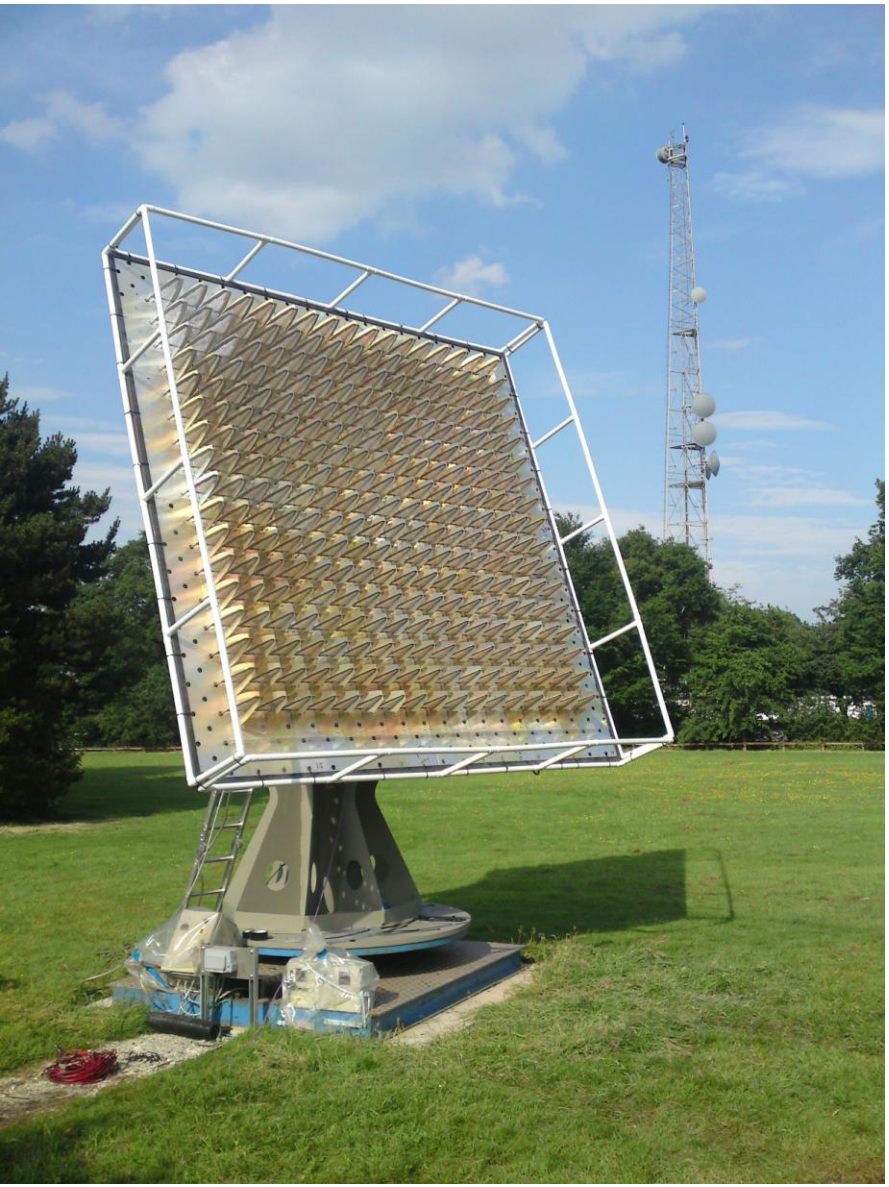
Future Work

Jack.hickish@astro.ox.ac.uk

The 2PAD System



2-PAD – Current Status



200 MHz B/W

16-dual-pol. antennas

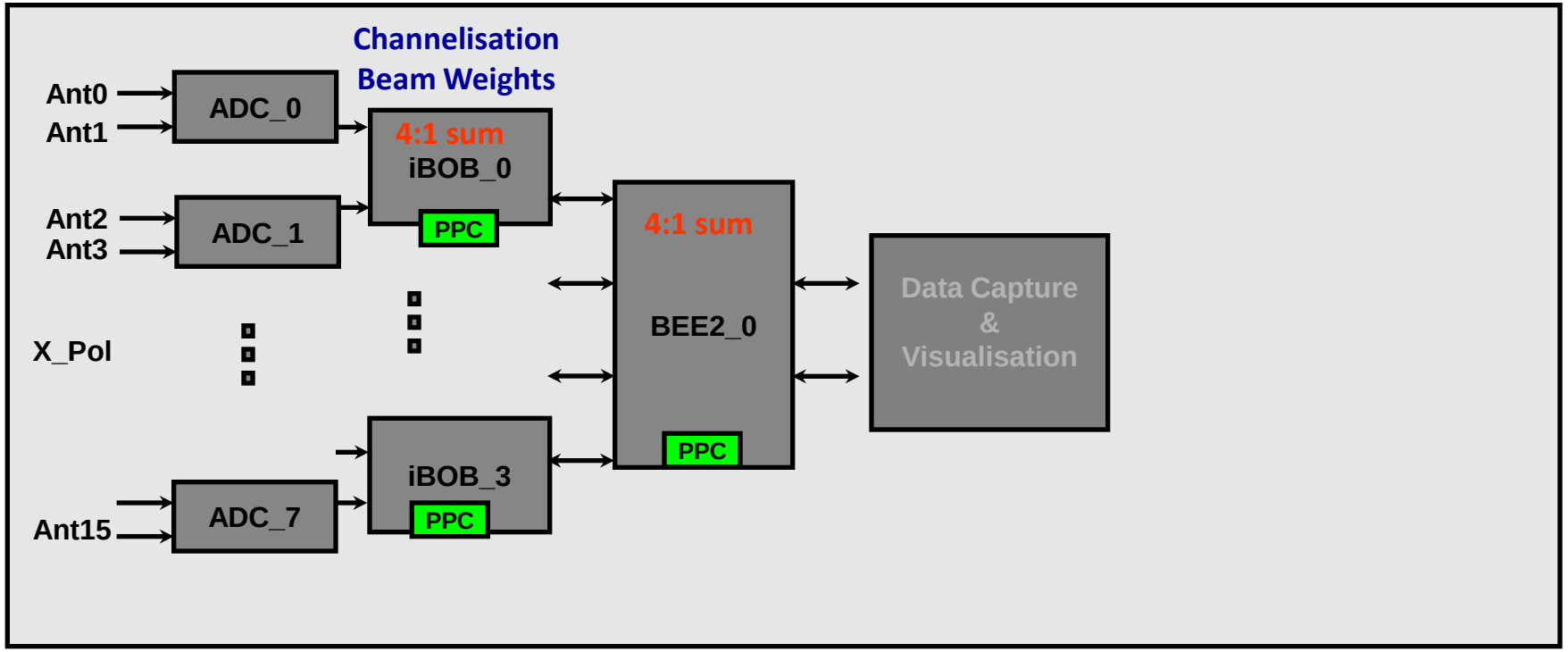
1024 Channels

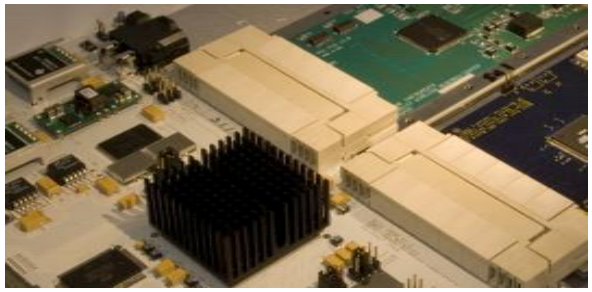
1 Beam

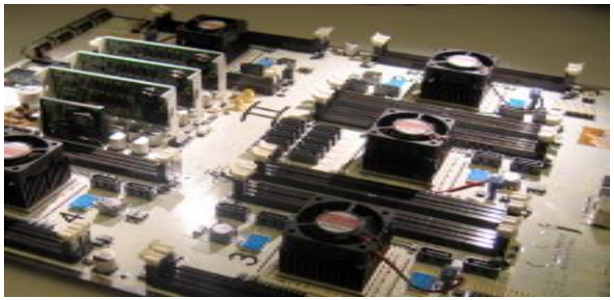
(Virtex-IIP)

Jack.hickish@astro.ox.ac.uk

Hierarchical Structure

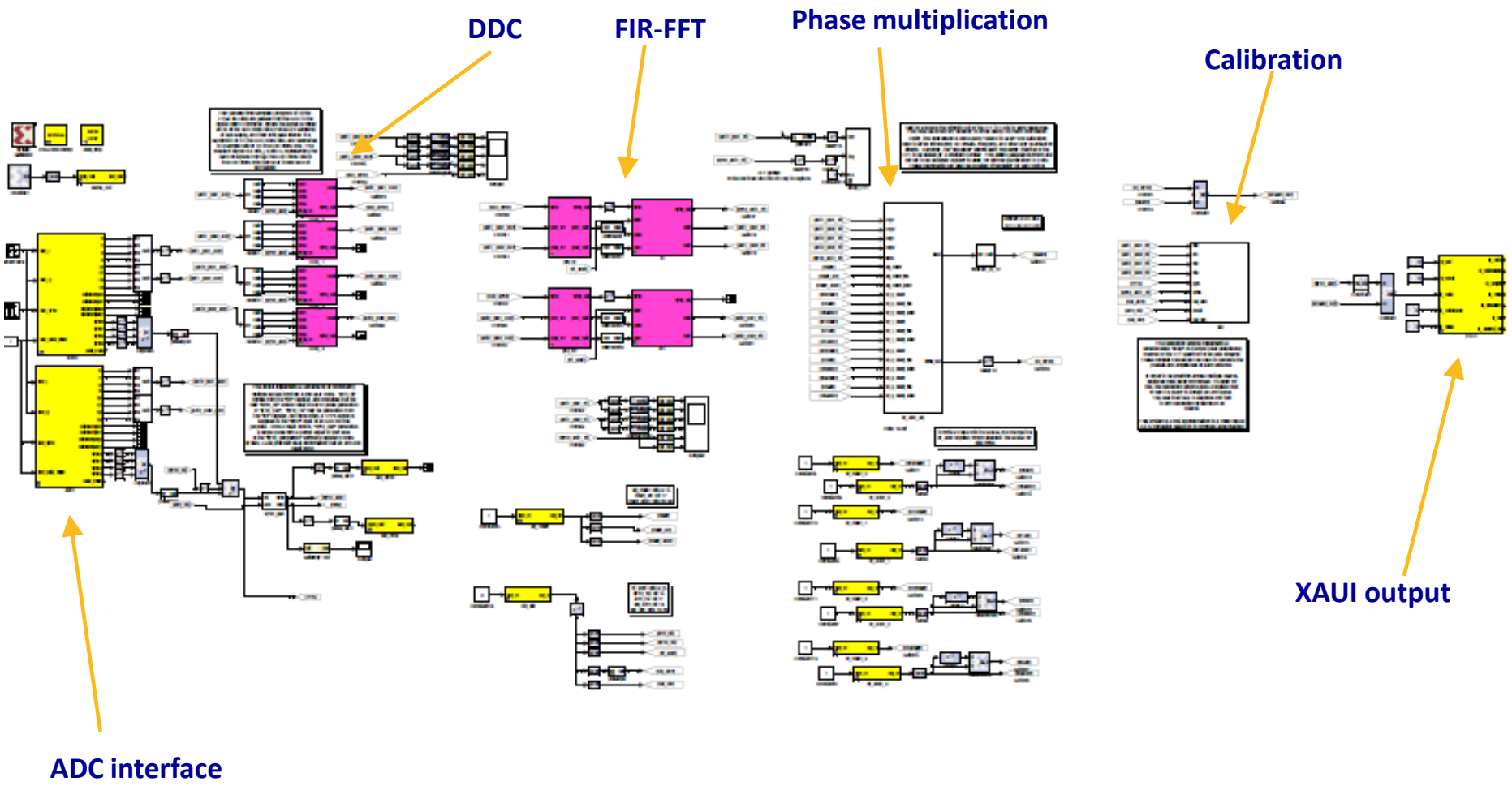






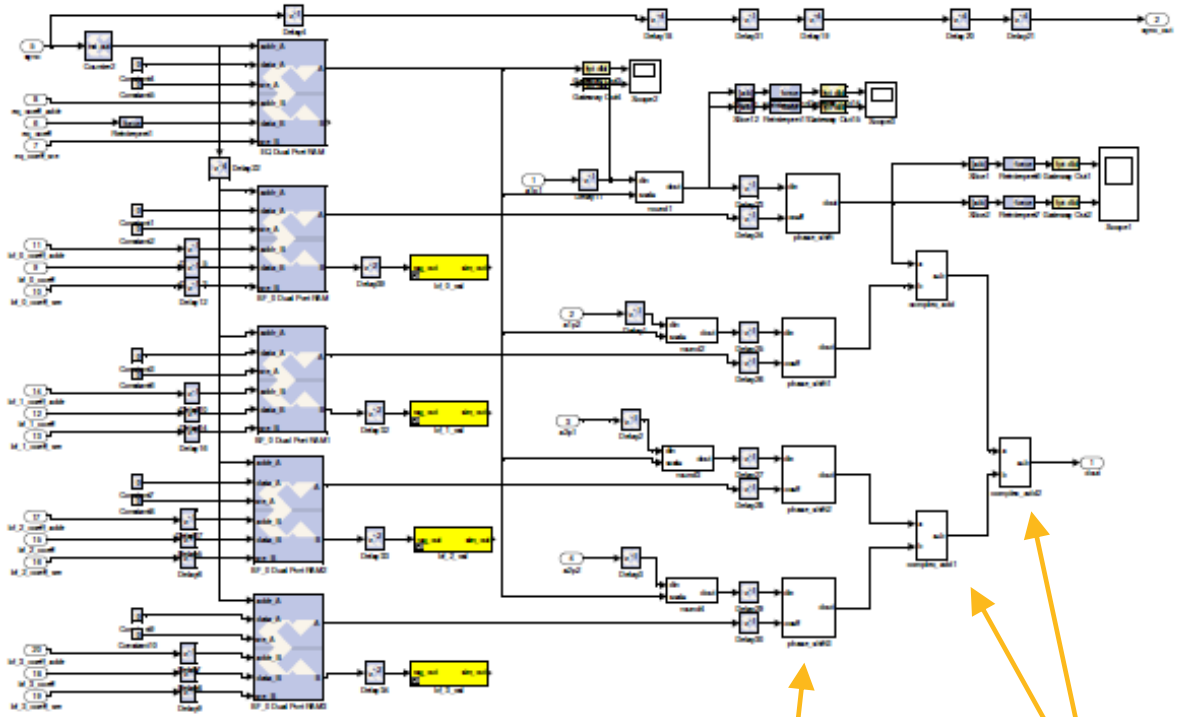
Jack.hickish@astro.ox.ac.uk

iBOB design



Jack.hickish@astro.ox.ac.uk

Beamforming Block



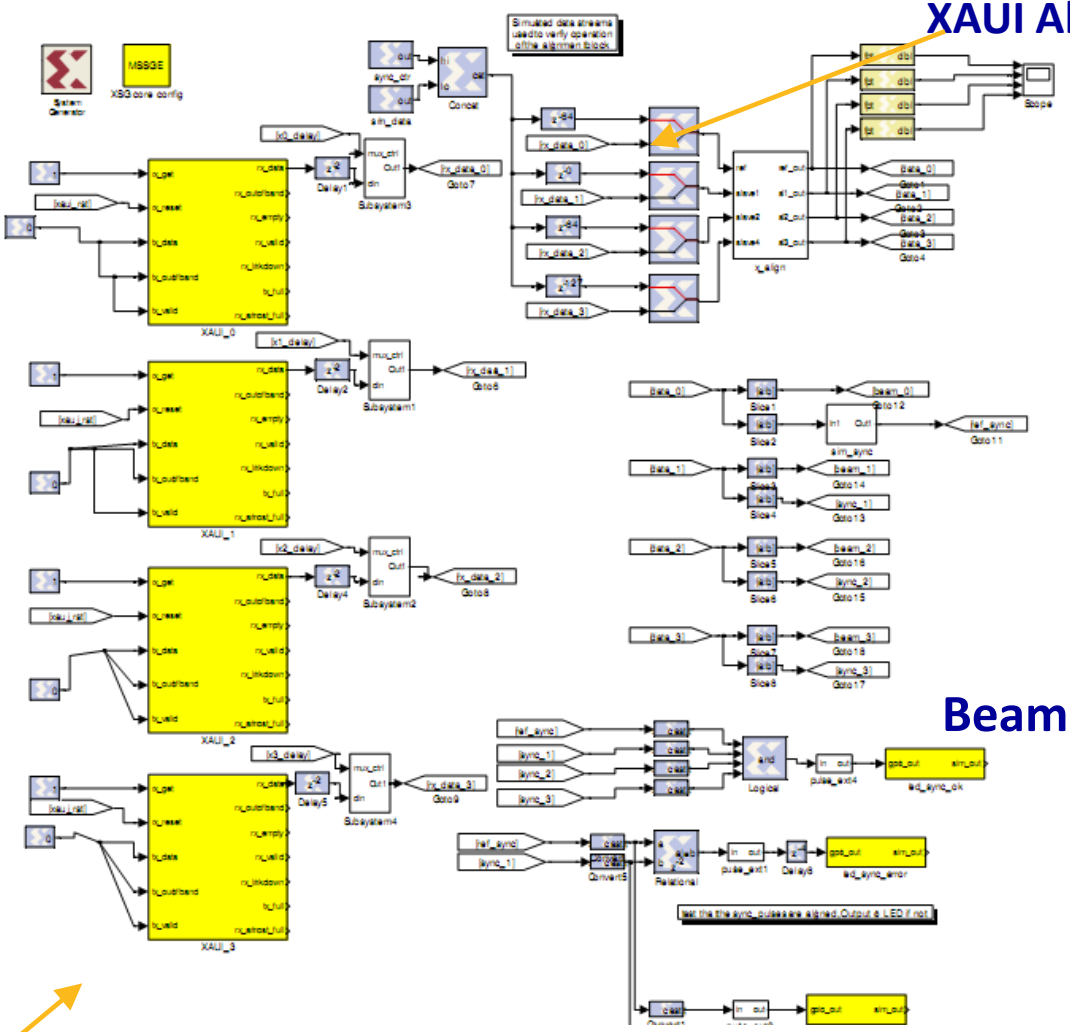
Coefficient bram

Complex multiplier

Complex Adder

Jack.hickish@astro.ox.ac.uk

BEE2 design



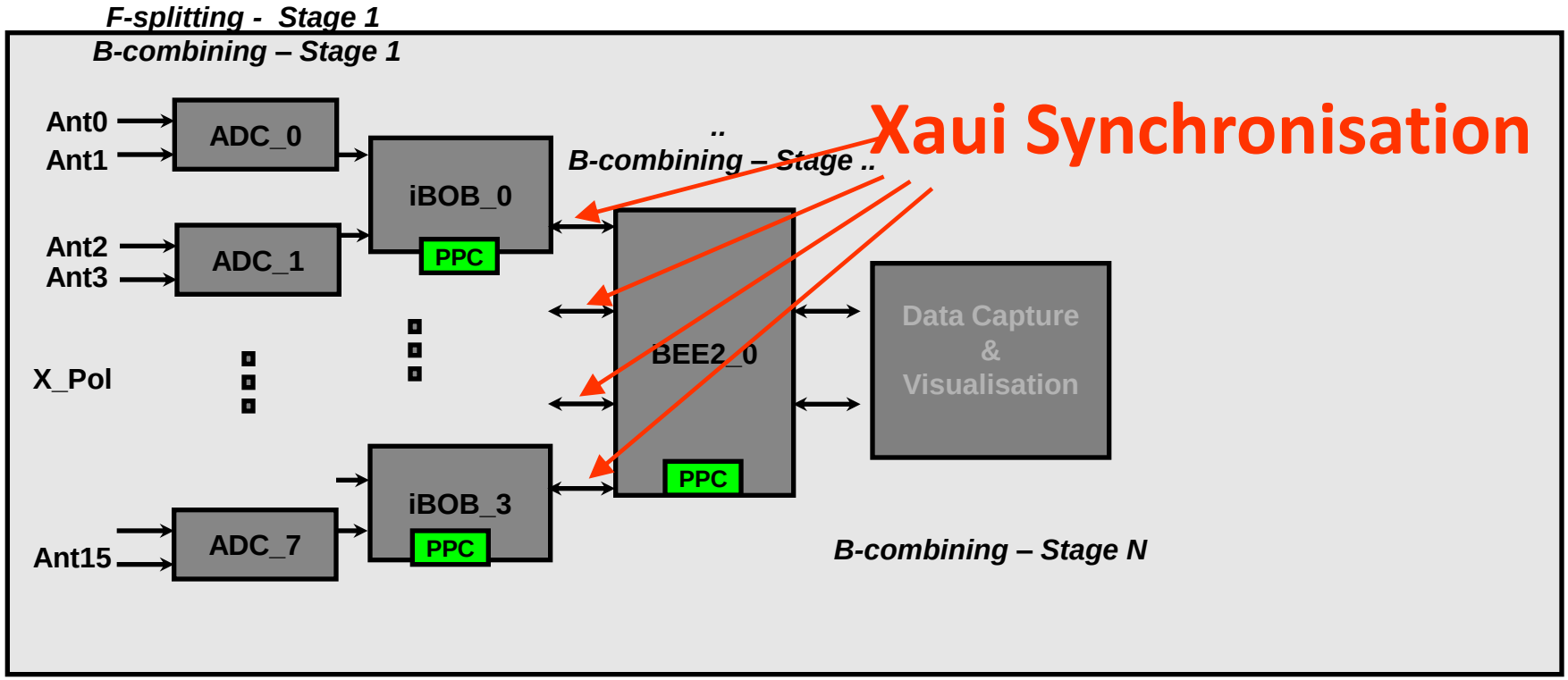
XAUI Alignment

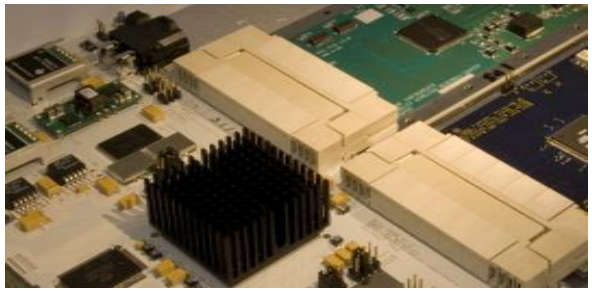
Beamlet addition

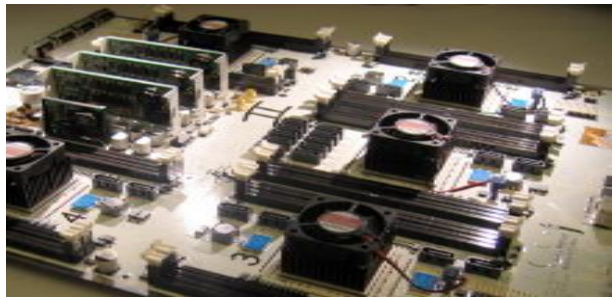
XAUI interfaces

Jack.hickish@astro.ox.ac.uk

XAUI Synchronisation

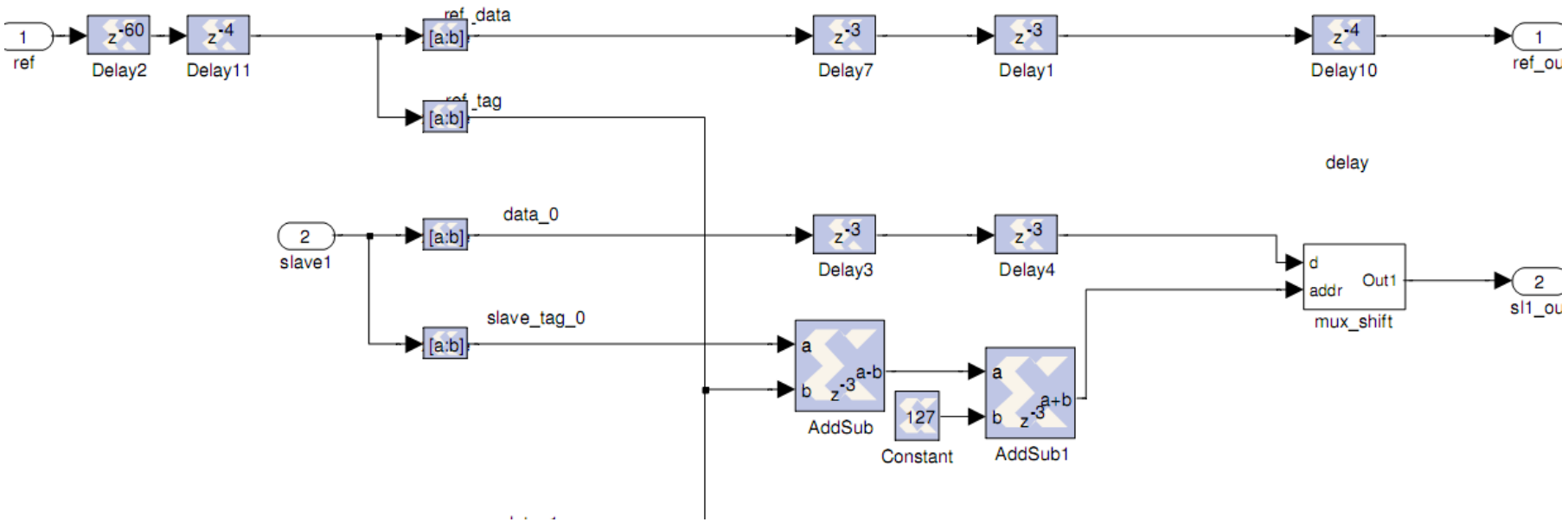






Jack.hickish@astro.ox.ac.uk

XAUI Synchronisation



Tag data streams with n bit counter → Allows alignment of $\pm 2^{n-1}$ clocks

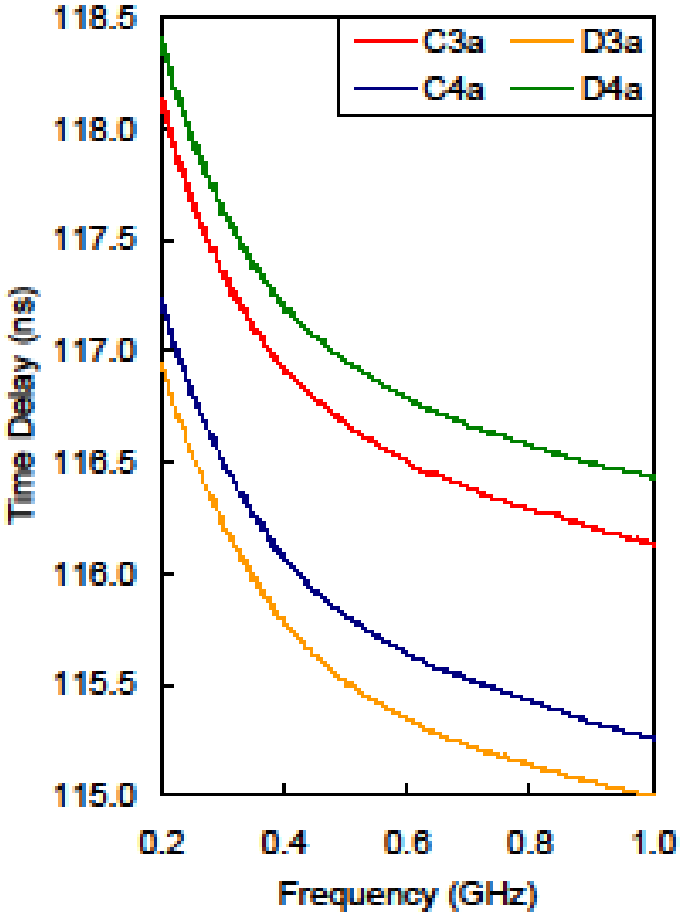
Jack.hickish@astro.ox.ac.uk

Results

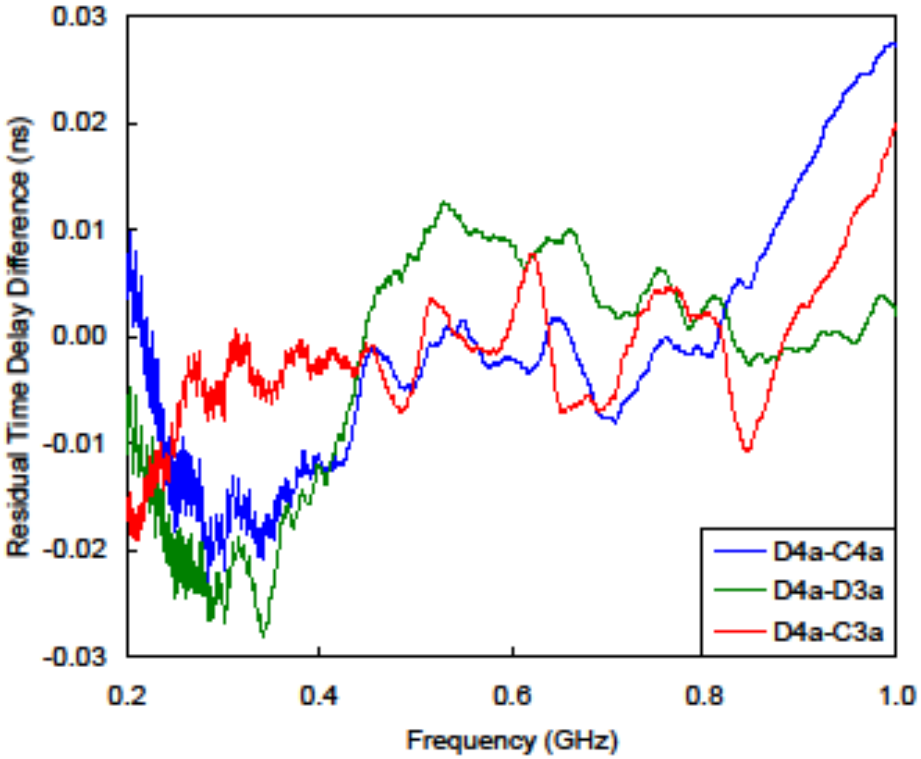
Jack.hickish@astro.ox.ac.uk

Current Measurements 4x1

2PAD: delays between 4 analogue channels (D. Price & S. Schediwy, 2009)



Relative delays across band for 4 2PAD channels (Price & Schediwy, 2009)



At 1GHz 0.03ns → 5 degree pointing error [OSKAR Simulator]

Jack.hickish@astro.ox.ac.uk

Calibration

$$X(\omega) = e^{i\emptyset}$$

$$Y(\omega) = X(\omega)e^{i\theta}$$

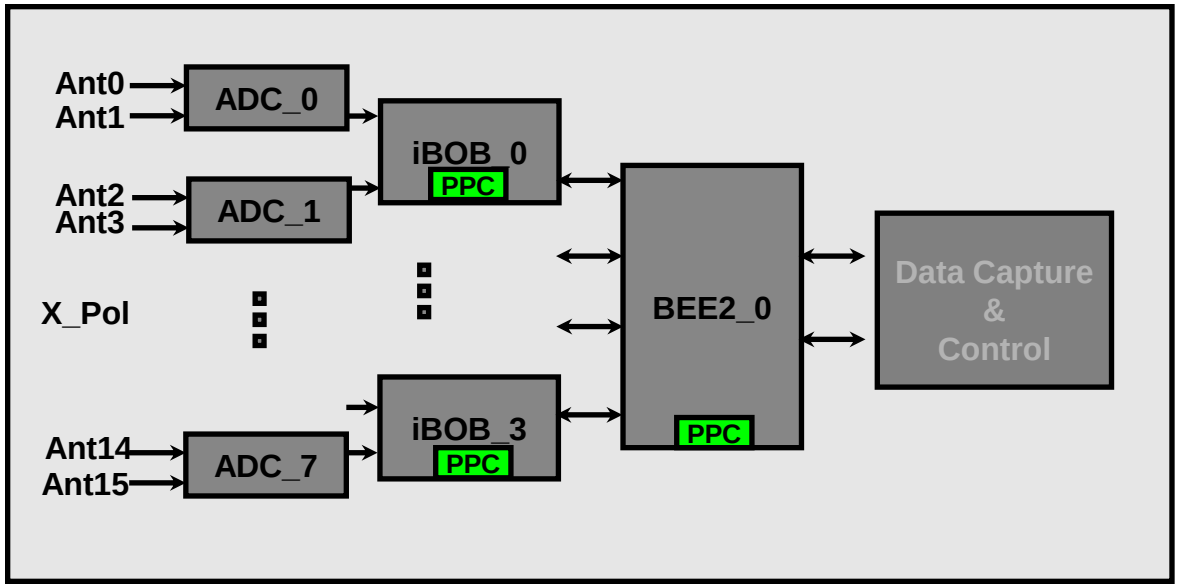
Correlation:

$$Y^*X = |X|^2 e^{-i\theta}$$

Beam forming phases are modified with the phase of the correlation Y*X

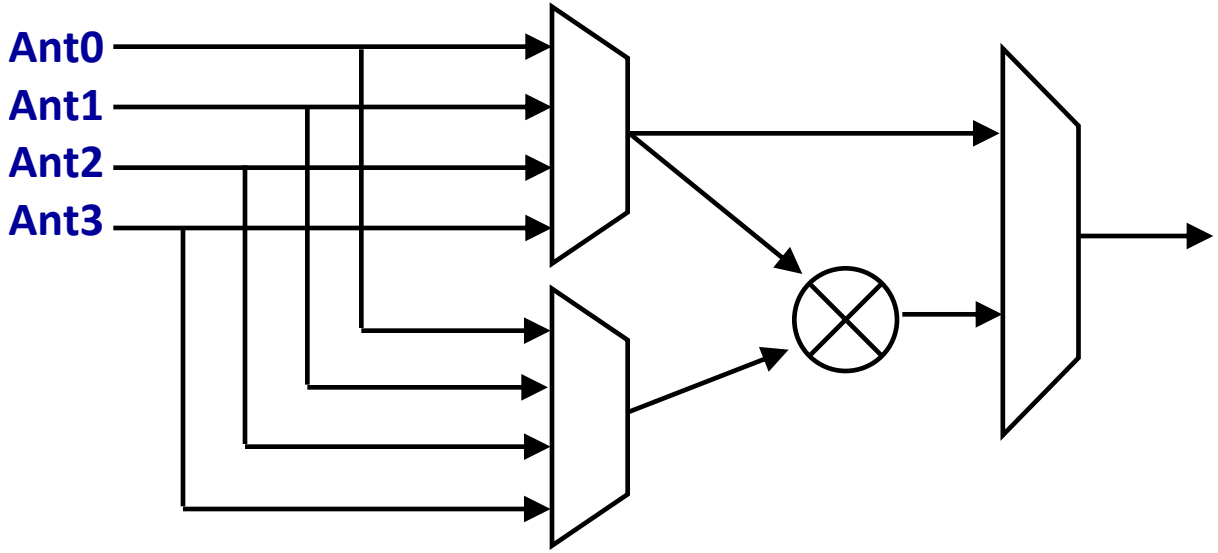
Jack.hickish@astro.ox.ac.uk

Calibration



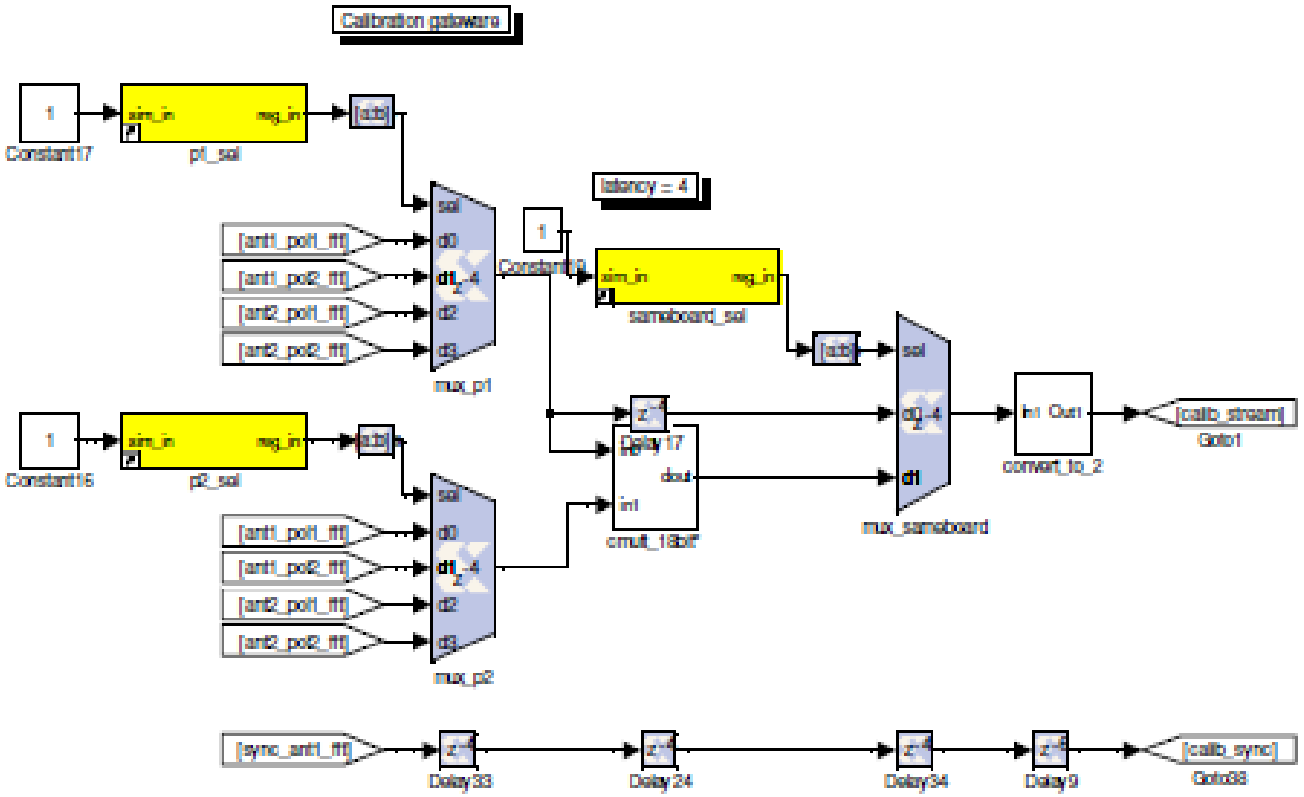
Time Multiplexed Nx1 (Potentially NxN) Correlation

iBOB routing requirements



Jack.hickish@astro.ox.ac.uk

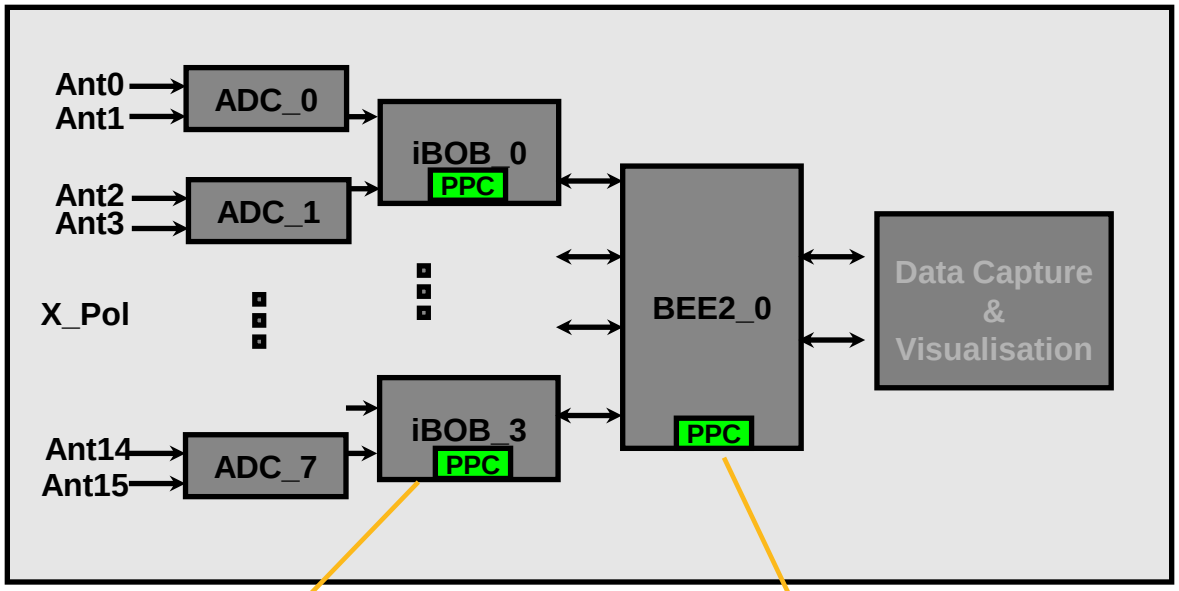
Calibration



Jack.hickish@astro.ox.ac.uk

Calibration

Hierarchical Calibration at board level?



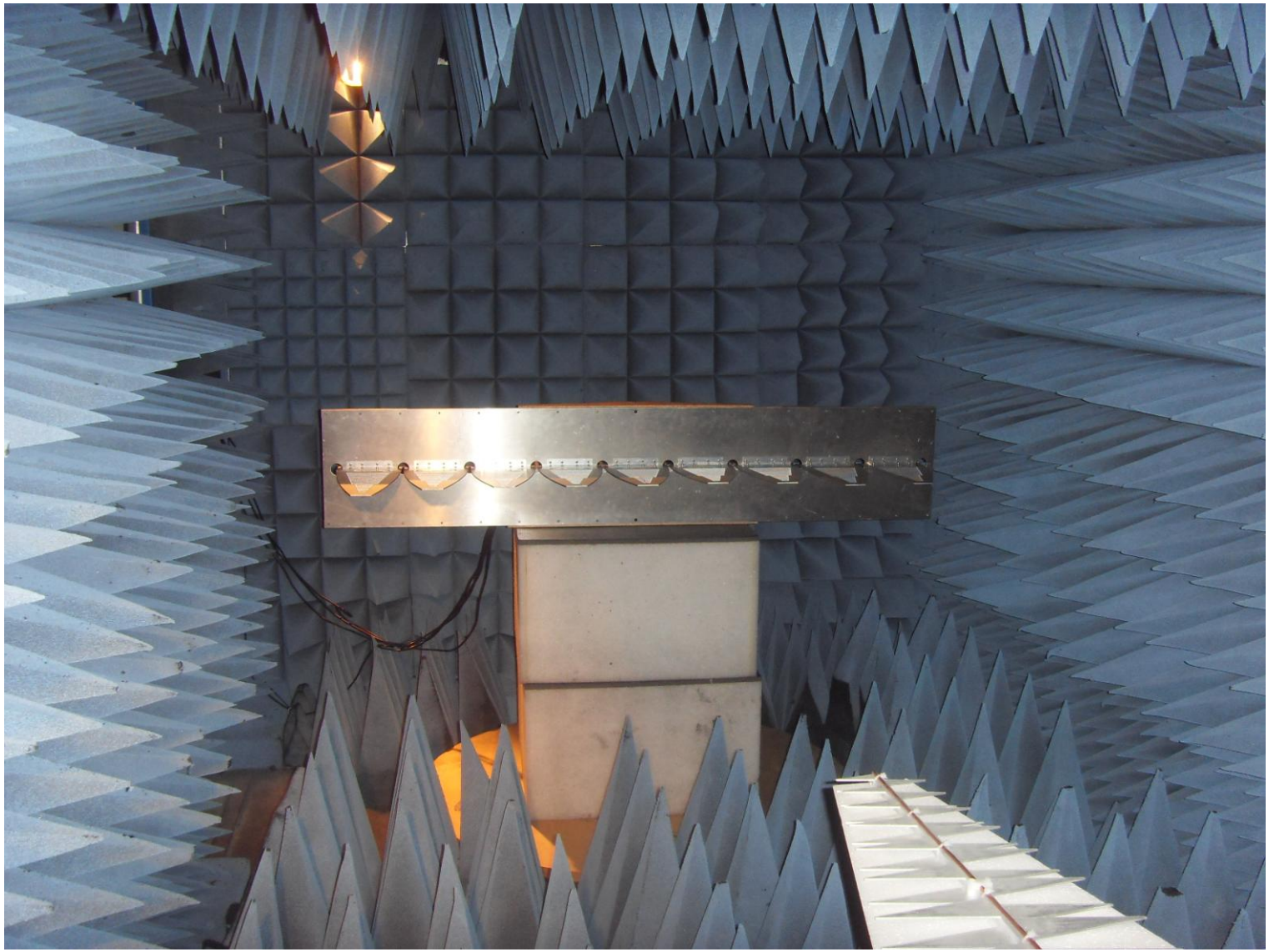
Correlate 4 inputs

Correlate 4 Beamlets

UNIVERSITY OF OXFORD

Current Measurements 4x1

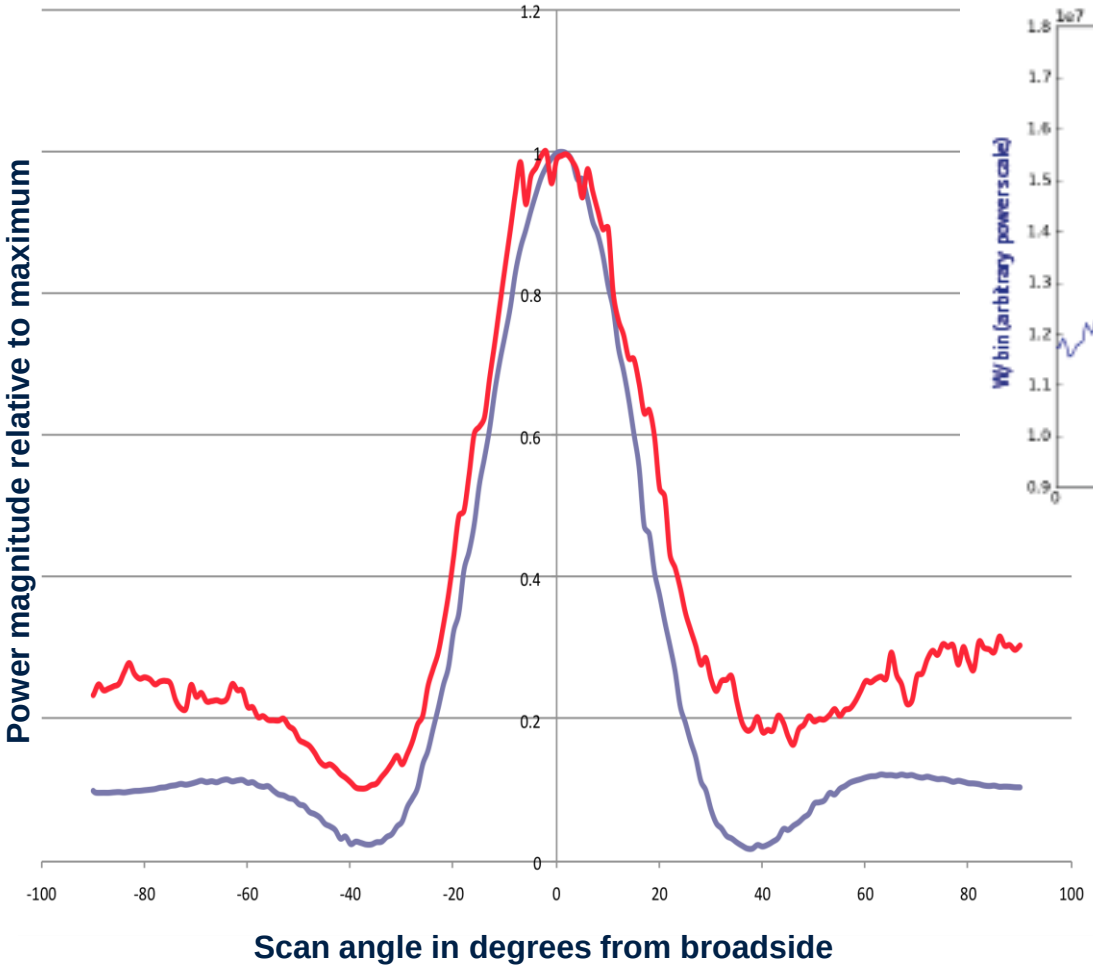
PAD



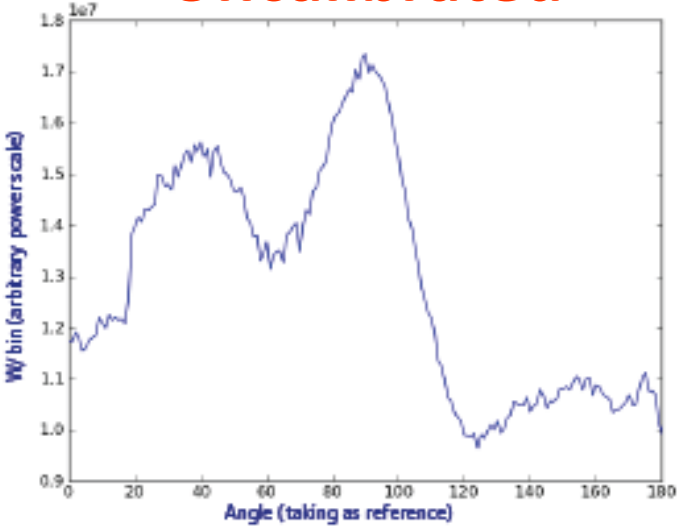
Jack.hickish@astro.ox.ac.uk

First Measurements 4x1

Anechoic vs Field Beam

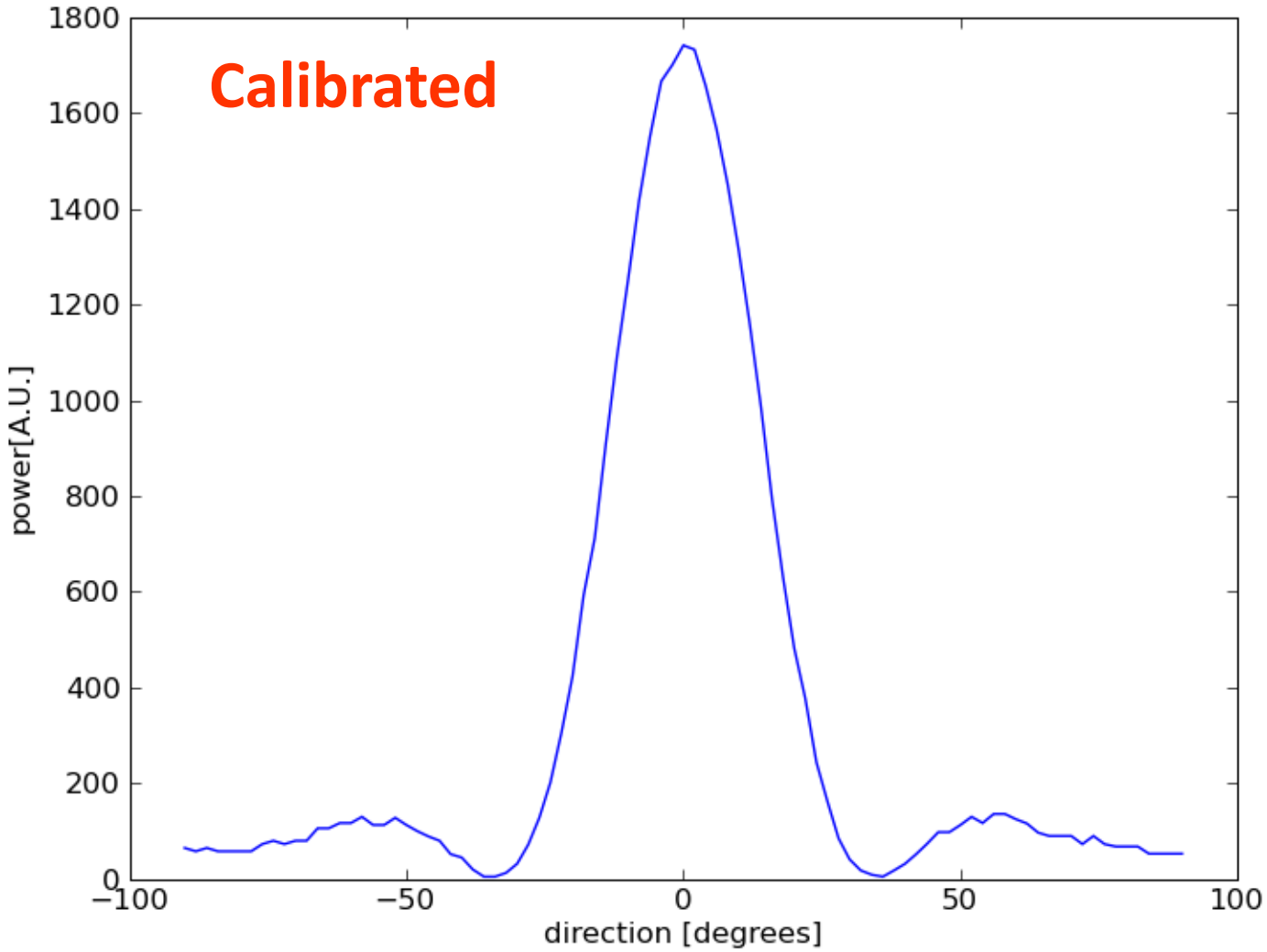


Uncalibrated



Jack.hickish@astro.ox.ac.uk

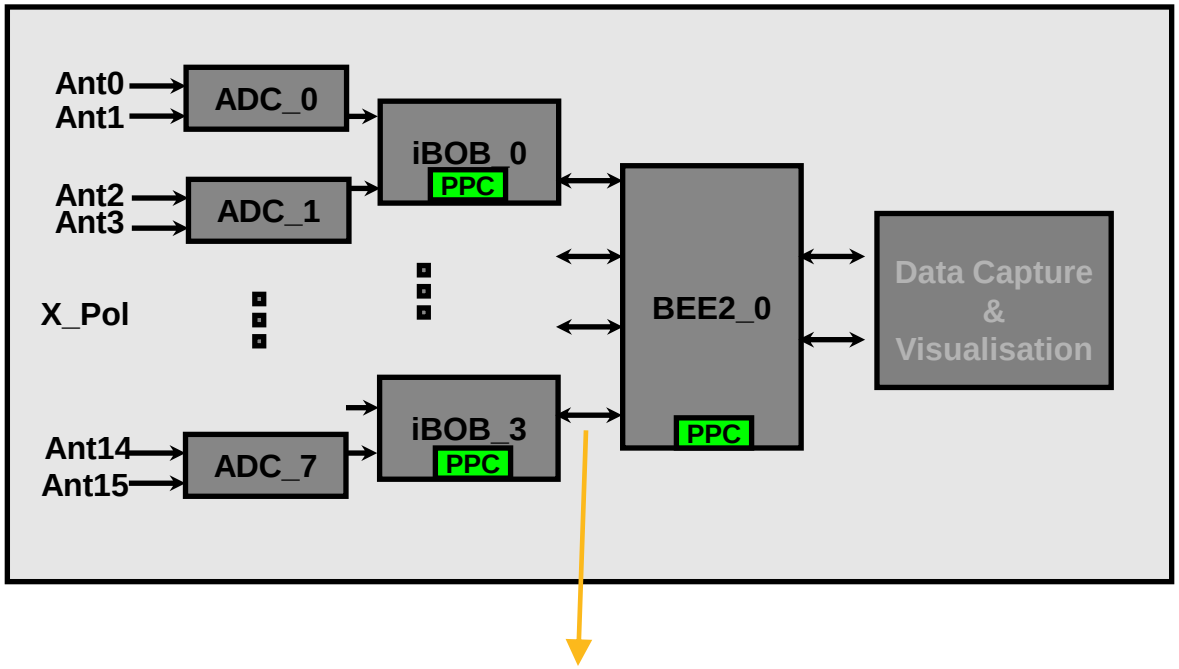
BEE2 Beams in the Lab



Jack.hickish@astro.ox.ac.uk

Hierarchical Beamforming

The Bandwidth problem



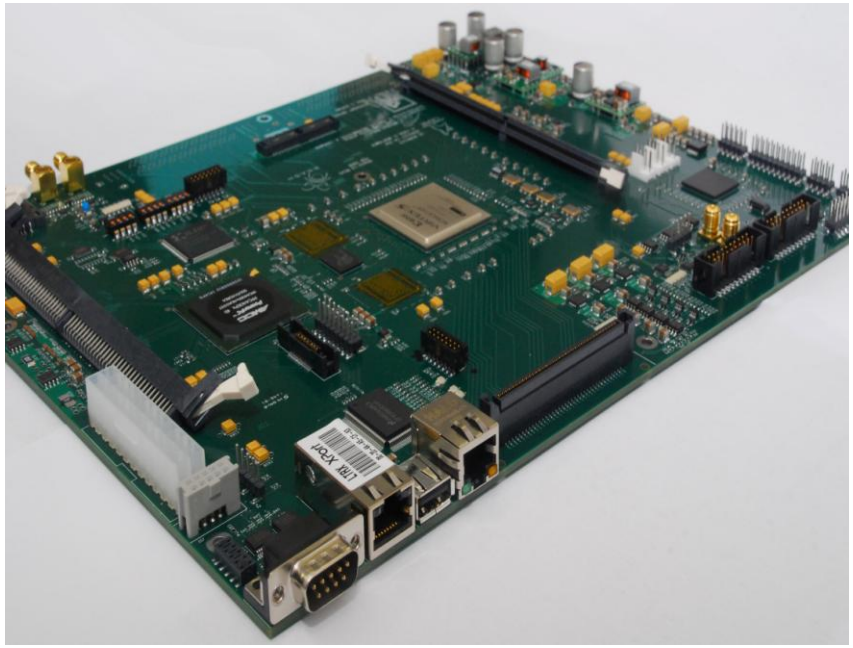
32bit / clock
(max 10Gb/s)

7 bit counter	sync	12 bit real	12 bit imag

Jack.hickish@astro.ox.ac.uk

Hierarchical Beamforming: The Bandwidth problem

Solution 1: Upgrade Hardware



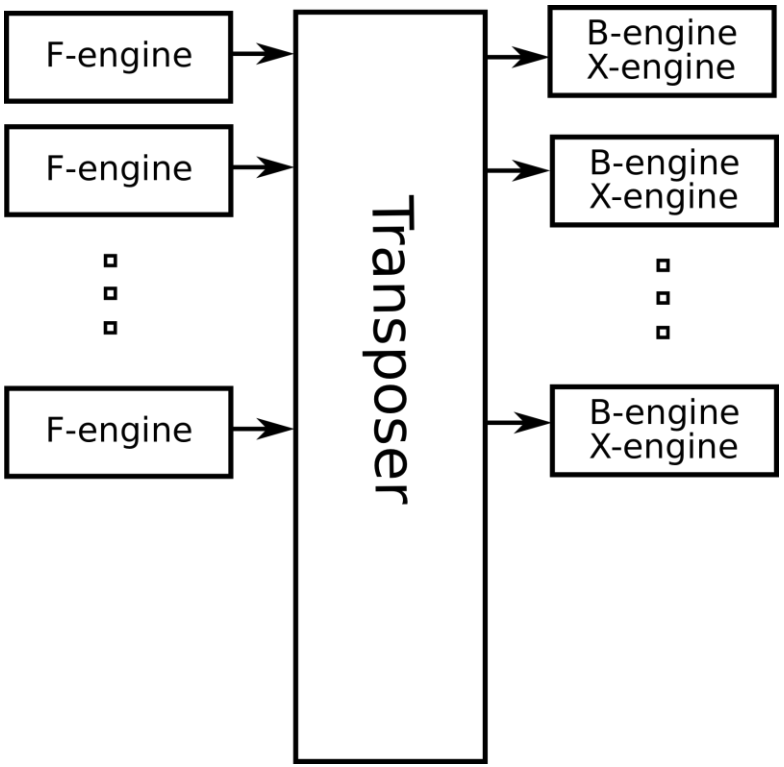
4 x 10GbE outputs

Virtex 5: Approx 2x DSP resources of VIIP

Jack.hickish@astro.ox.ac.uk

Hierarchical Beamforming: The Bandwidth problem

Solution 2: Change Architecture



2PAD & the SKA

2PAD is a modular test bed

It is *OBVIOUSLY* not a mini-SKA!

Currently have digital beams, can now begin playing:

- **1st stage analogue beamforming? (cf EMBRACE)**
- **New Beamforming/Calibration Architectures/Algorithms**
- **New digital hardware – Custom FPGA boards/ASIC**
- **Something else…?**

Jack.hickish@astro.ox.ac.uk

2PAD & the SKA

The Balance of Power…

SKA demands < 1W per signal chain

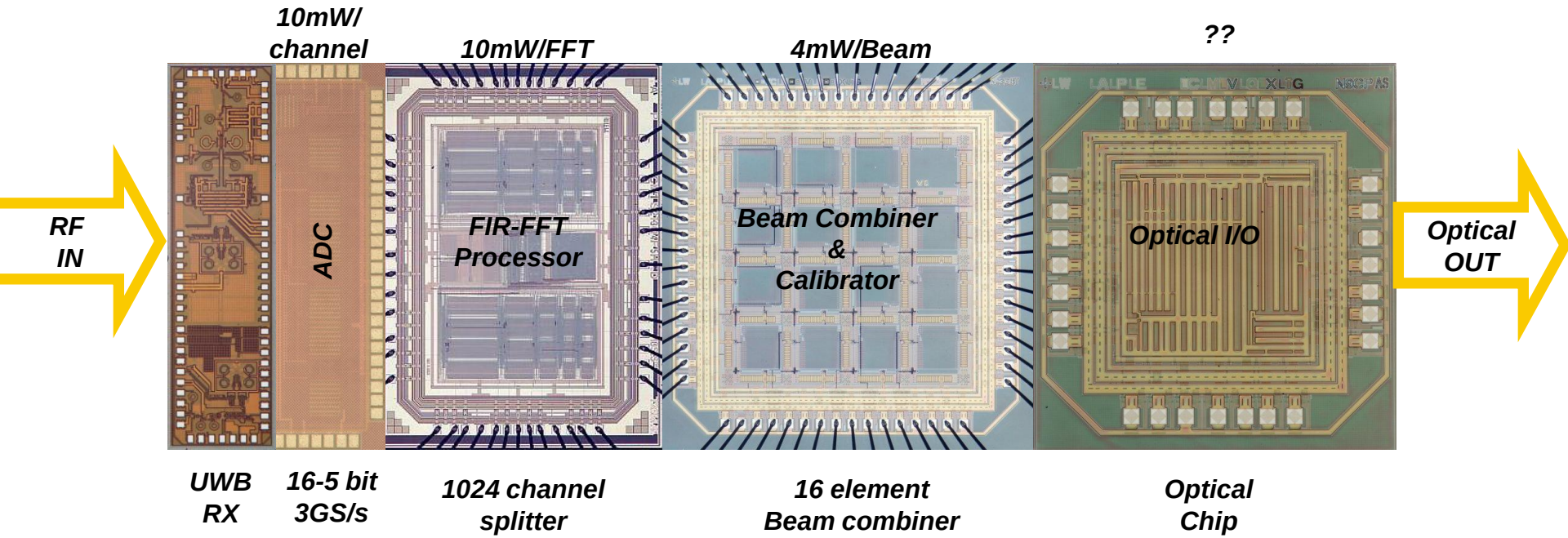
2PAD: >5W (Digital only)

2PAD: 500mW for ADC (inc. interface)

High speed I/O is a significant power consumer
(and does not follow Moore's Law)

Jack.hickish@astro.ox.ac.uk

Future Work…



Jack.hickish@astro.ox.ac.uk