# Low.CBF Modelling

David Humphrey (CSIRO)
John Bunton (CSIRO)
David Wilson (AUT)

14th February 2019 - C4SKA @ AUT

# Overview

perentie
SKA Low Correlator & Beamformer

**What is low.CBF ?**

**How will it work ?**

**What are the challenges ?**

**Where are we at ?**

# The Low Correlator and Beamformer

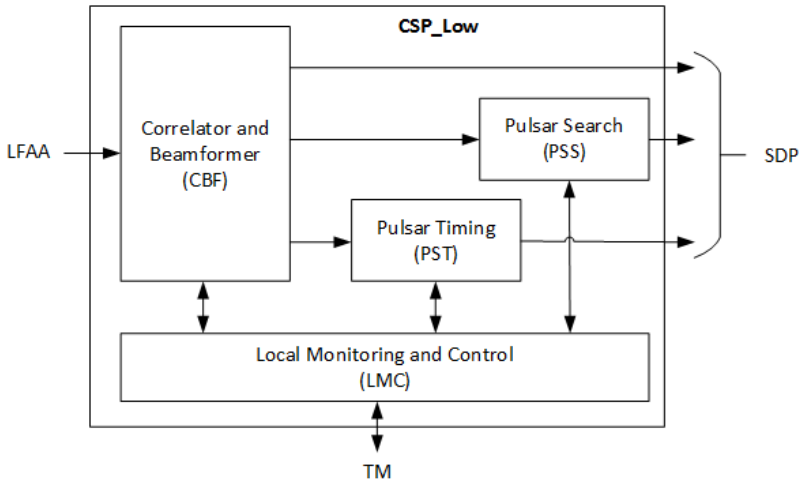
perentie
SKA Low Correlator & Beamformer

## Challenges

Cost/Power/Space/Cooling/Comms

## Goals

- Reduce Risk by developing and testing key functions
  - ITF
  - Modelling algorithms and interfaces
  - Firmware and Software

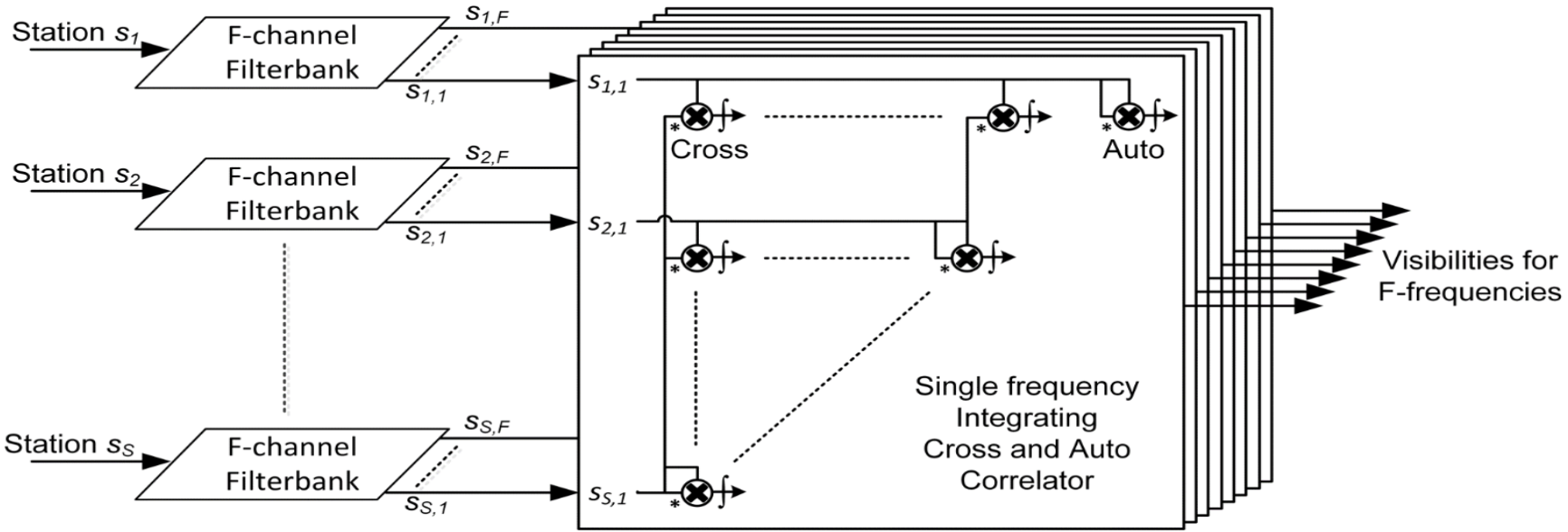


# Correlator

perentie
SKA Low Correlator & Beamformer

- Correlator operates on fine channels 226 Hz wide.
- Total of 300 MHz/226 Hz = 1.3 million
- Need to correlate each station with every other station
- Each FPGA processes data for all stations for a small number of fine channels.

# FX Correlator



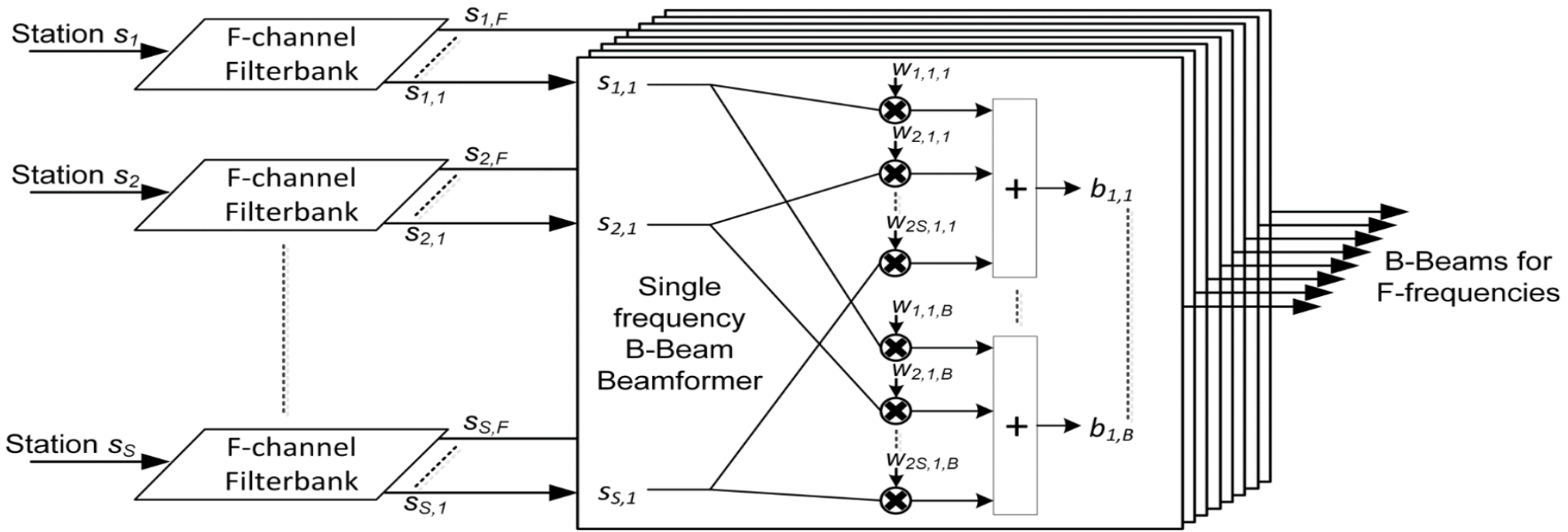
# Beamforming

perentie
SKA Low Correlator & Beamformer

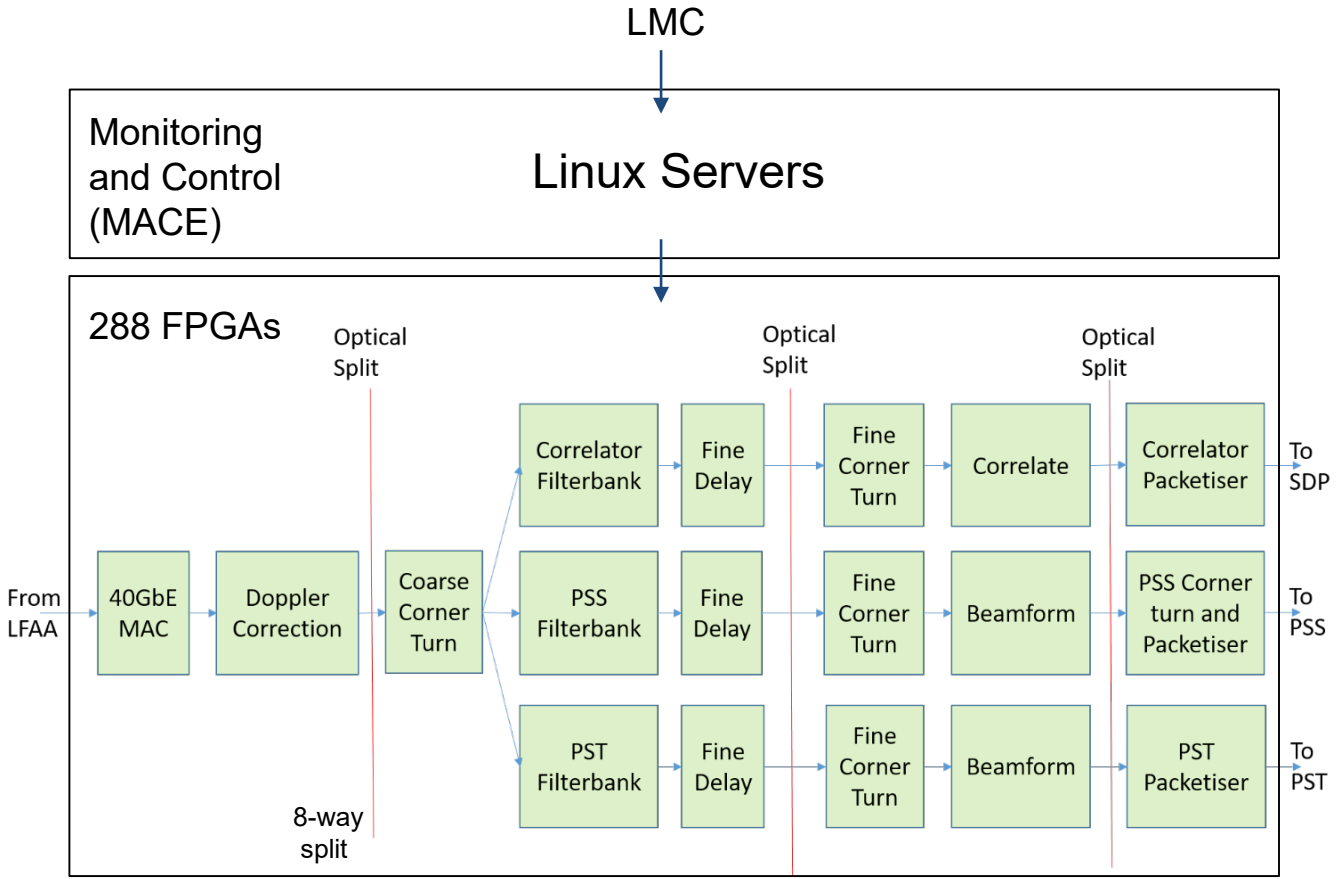
- Each Beam is a weighted sum of appropriately delayed data from all stations.
- PSS
  - 500 beams,
  - 20736 x 14 KHz fine channels
- PST
  - 16 beams
  - 82944 x 3.6 KHz fine channels
- Both cases process data from all stations
  - But each processing element can do a subset of fine channels.

# Beamformer Data Flow

perentie
SKA Low Correlator & Beamformer



# Processing Overview




55,000 channels at 5.4kHz resolution, up to 7 Tb/sec output

500 PSS beams, 118 MHz bandwidth each

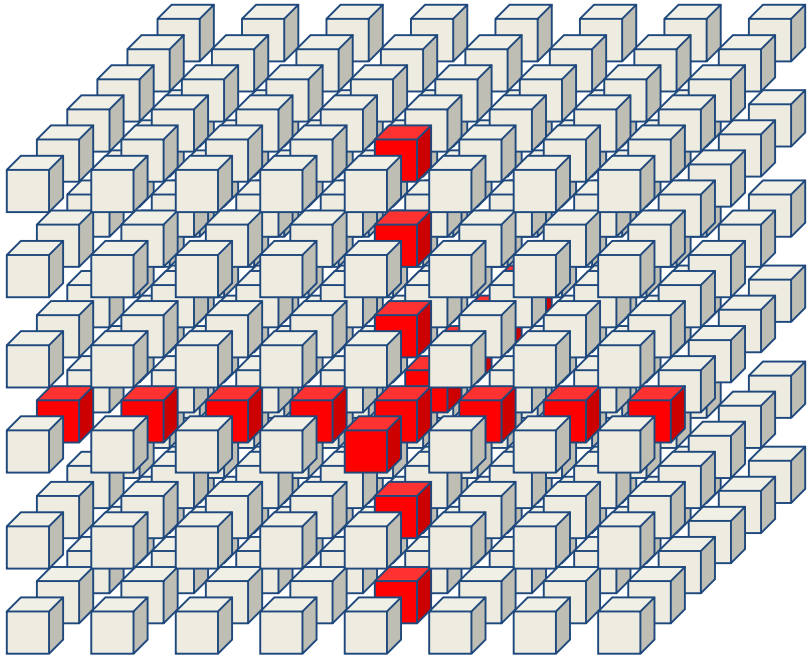
16 PST beams, 250 MHz bandwidth each

# Full Scale System

perentie
SKA Low Correlator & Beamformer

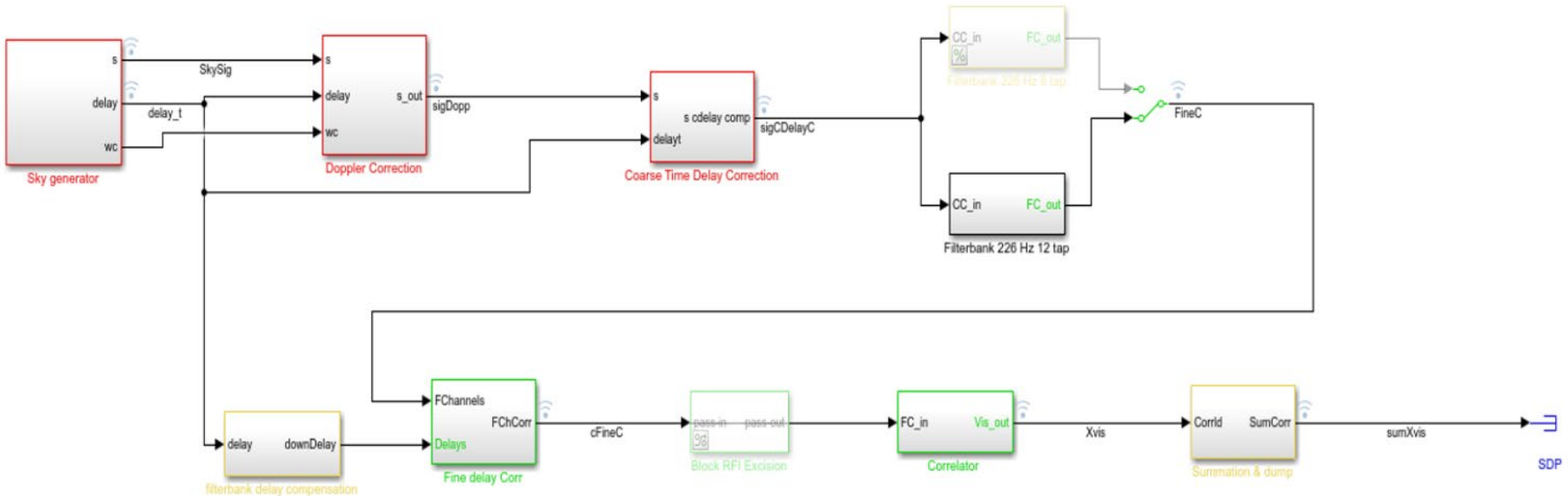
**288 FPGAs arranged in an array, 8x6x6**

- **Lots of communications - see Will's talk**
  - **All optical, total per FPGA of about 1Tb/s**
- **Total input and output data rates both over 5 Terabits/sec**
  - **E.g. LFAA 11 Gbit/sec x 512 stations = 5.6 Tbit/sec**
- **Total computation in the realm of 2 Peta ops/second**
- **Total power about 50 kW**



# “Golden” model

perentie
SKA Low Correlator & Beamformer



# Software modelling

perentie
SKA Low Correlator & Beamformer

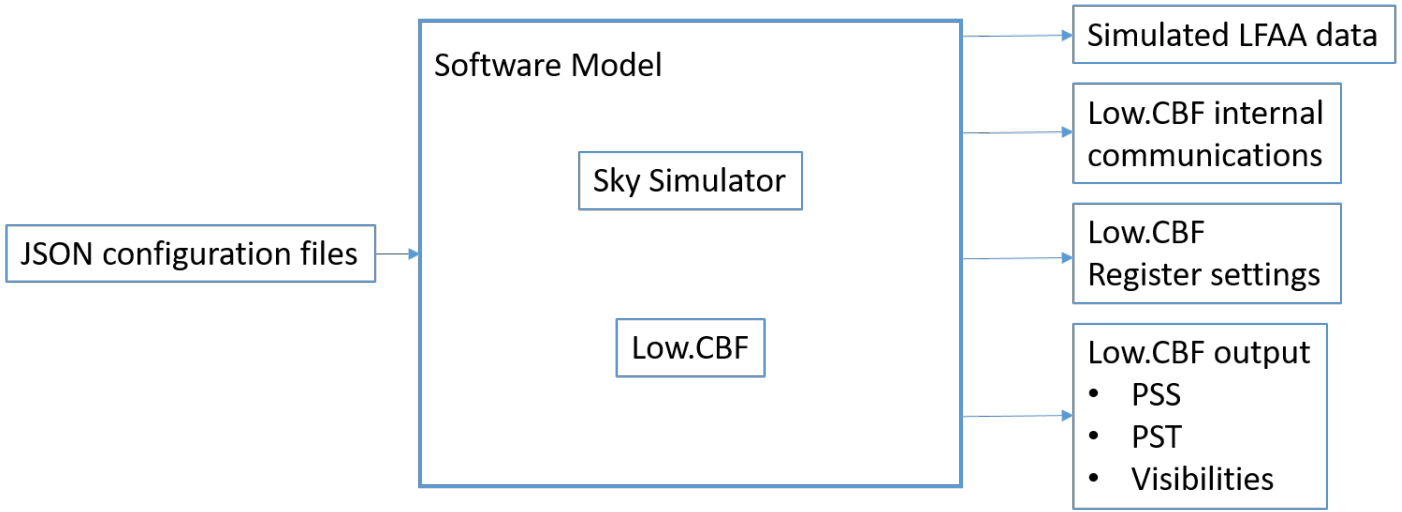
**System Modelling Goals**

- **Flexible**
  - **Used for firmware module verification**
  - **Used for stimulus/checking in the ITF**
  - **Used to verify register configuration**
  - **Many configurations possible**
- **Realistic**
  - **Model Configuration to match the TM/LMC parameters in the ICDs**
  - **Top level parameter specifications for a run in json files.**
- **Verification at multiple levels**
  - **low.CBF Algorithms**
  - **Generate expected input and output of firmware modules**
  - **Generate firmware register settings**

# More Modelling

perentie
SKA Low Correlator & Beamformer

- Model Configuration specified using JSON - matches with ICDs
- Able to limit processing to a small number of processing elements and frequency bands
- Efficient formats for raw data files
  - 22 Gb/s of traffic per LFAA input !



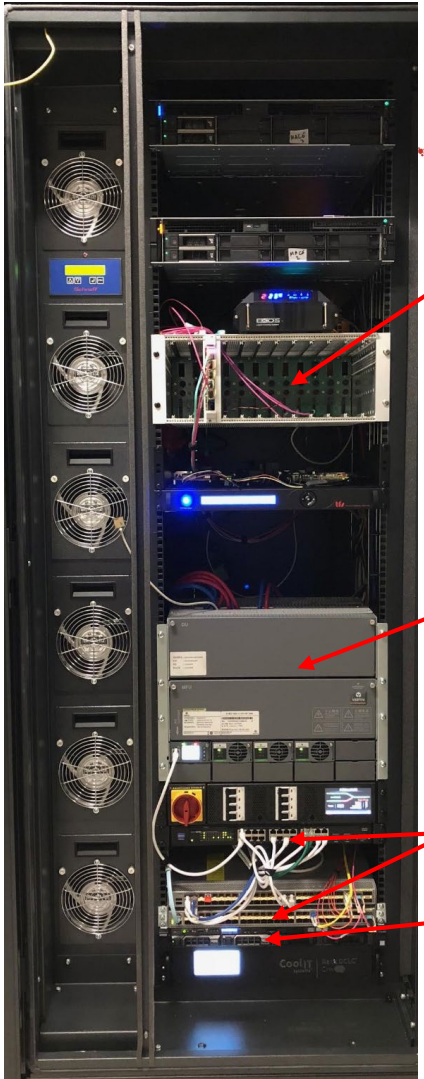
# Expected FPGA Utilisation

perentie
SKA Low Correlator & Beamformer

| Resource | Available (Virtex Ultrascale+ VU37P) | Expected Utilisation |
|---|---|---|
| Multipliers | 9024 | 6000 |
| 6 input Look up tables | 1.2 million | 600,000 |
| On Chip Memory | 40 Mbytes | 20 Mbytes |
| High Bandwidth Memory | 8 Gbytes | 8 Gbytes |
| DDR4 | 8 Gbytes (on board) | TBD |
| High Speed Serial links | 96 GTY transceivers, can run up to 32 Gbit/sec | 100 GbE (4 GTYs)<br>40 GbE (4 GTYs)<br>10 GbE (1 GTY)<br>24 x 25 Gb (24 GTYs) |

# Progress to Date

- Send simulated LFAA packets to the ITF.
- Key firmware modules underway
  - Correlator
  - Filterbanks
  - Ethernet Comms
- More on some of these things later...




perentie
SKA Low Correlator & Beamformer

# Still to do...

perentie
SKA Low Correlator & Beamformer

**Lots of things still to do...**

- **Testing of HBM part.**
- **Finish software model.**
- **More firmware to write, and integrate.**
- **Running all communication links.**

# Questions / Discussion?

## Thank-you!