BIGCAT Update

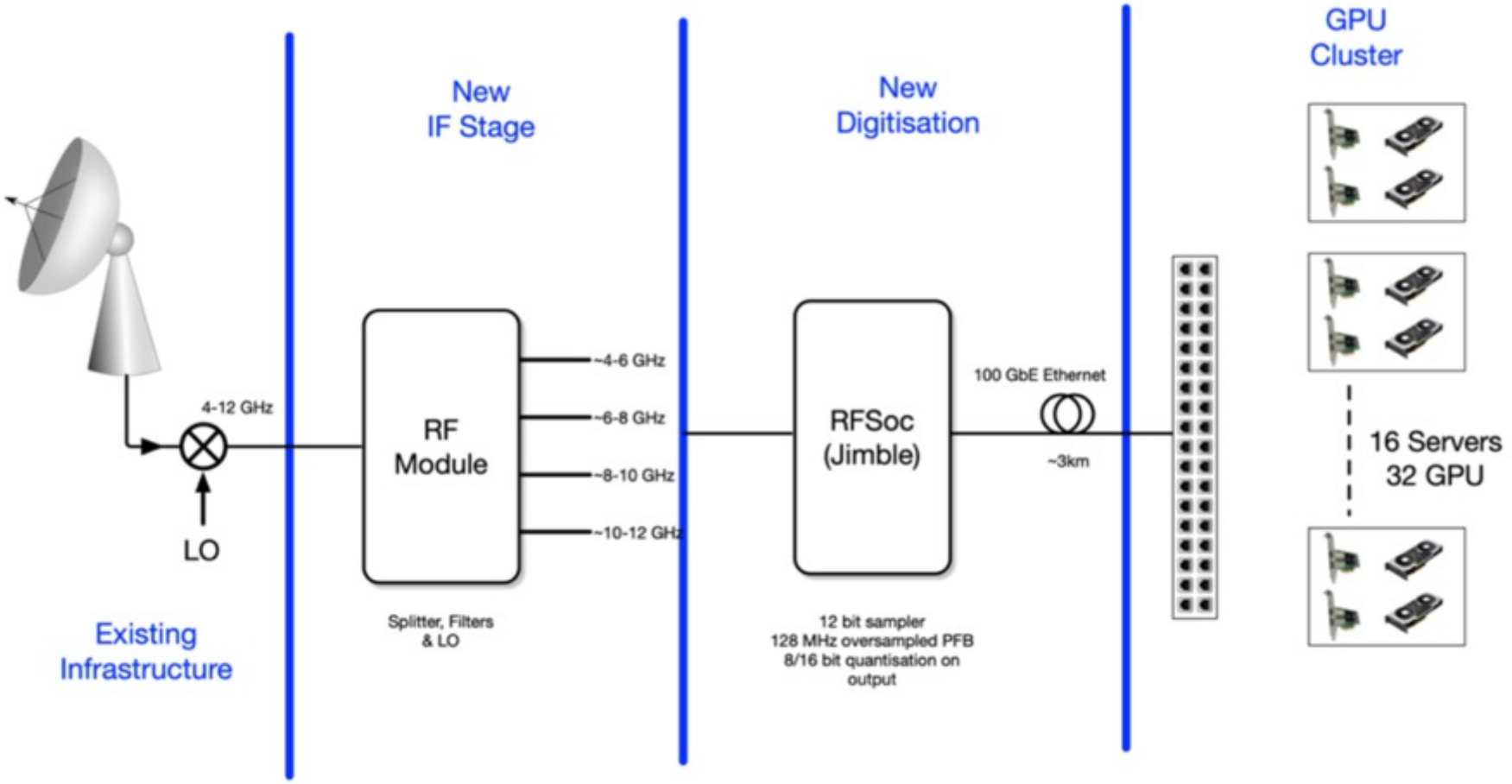
Chris Phillips | BIGCAT Project Lead

8th November 2021

ATCA-BIGCAT upgrade

- BIGCAT: Broadband Integrated Gpu Correlator for ATca
  - Replacement of CABB digitisers and correlator with a hybrid FPGA+GPU backend
- LIEF funded, lead by WSU (PI Ray Norris)
- Key aspects of BIGCAT:
  - Double instantaneous bandwidth to ~8 GHz
  - Flexible spectral resolution
  - Improved reliability
  - More flexibility:
    - Many more options wrt. frequency resolution and integration times
    - Ability to change quickly between different observing modes
  - More adaptable to automated observing (e.g. rapid ToO follow-up)
  - Retain standard CABB features (e.g. mosaicing)

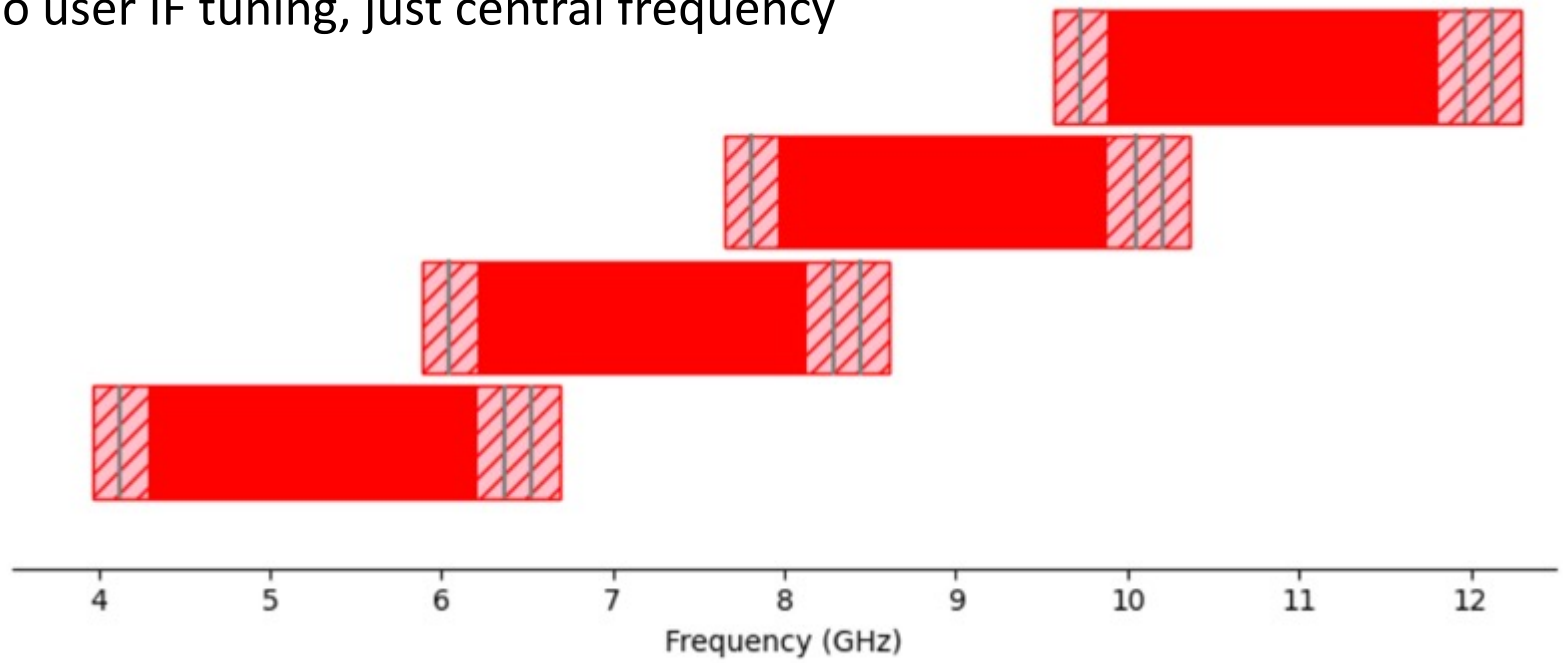
ATCA-BIGCAT signal chain



https://www.atnf.csiro.au/research/bigcat/BIGCAT_Overview.pdf

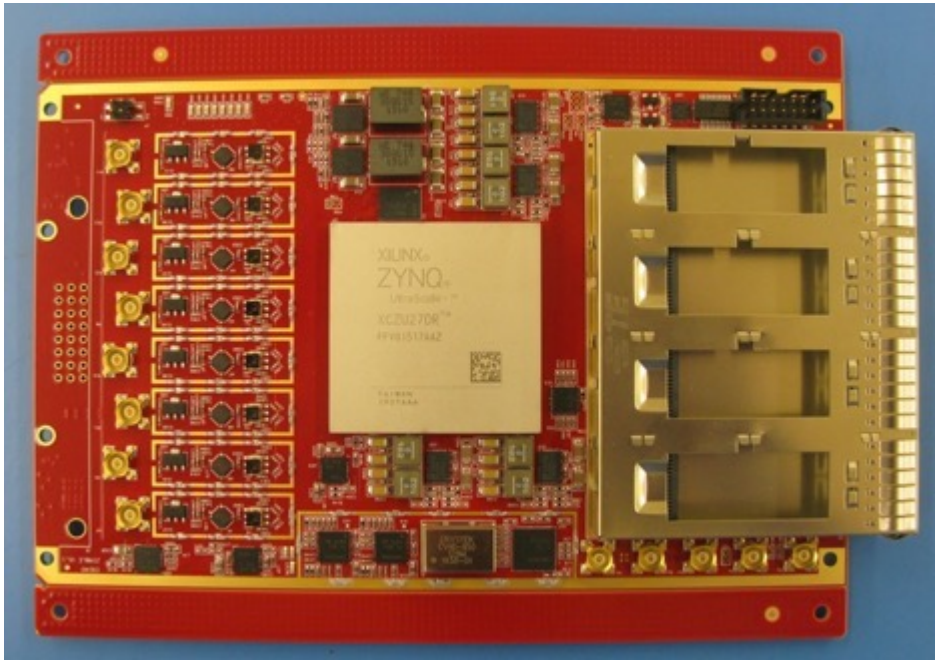
BIGCAT Frequency Bands

- 4 x 1.92 GHz IFs stitched together to form a contiguous 7.68 GHz bandwidth
- Limited tunability in 160 MHz steps
- Single ”8 GHz” IF chunk for higher frequencies
- No user IF tuning, just central frequency



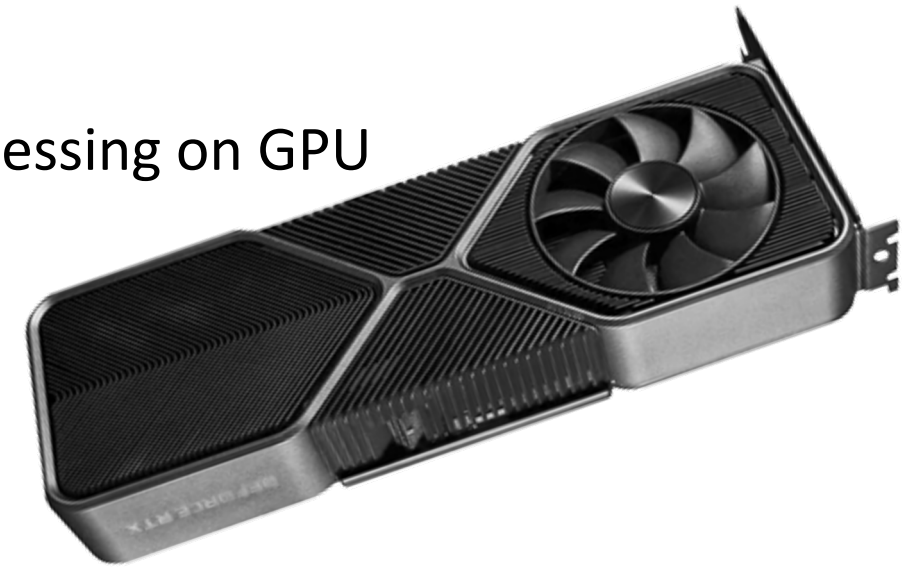
BIGCAT Digitisers

- 2 GHz IFs sampled using Xilinx RFSoC ADC
  - 8 samplers and FPGA fabric on single chip
  - 12 bits/sample
- Built into CASS “Jimble board”
  - 4x 2 GHz per board
  - 2x 100 GbE output
  - 128 MHz PFB, oversampled
  - 8/16 bit streamed to GPU
- Jimble common to CryoPAF project
  - Plan to upgrade for Parkes UWB systems using same firmware as BIGCAT



GPU Backend

- GPU backend 16 servers, each with 2 GPU and 2x100 GbE
  - RTX 3000 series current plan (High end gaming card)
  - 58 Gbps/GPU (without reference antenna)
- Each 128 MHz coarse frequency channel processed independently
  - Same frequencies from all telescopes (ATCA + reference) to single GPU
    - No GPU cross connect planned
    - 2 coarse channels/GPU (except LS)
- Plan to allow bespoke “user” processing on GPU



BIGCAT Science Requirements

- Prepared by Elizabeth Mahony and distributed to LIEF members, ATUC, ATCA users
  - Continuum (~ 1 MHz, Mosaicing supported, on-the-fly)
  - Spectral line (flexible frequency setup)
  - VLBI, voltage beams, multiple beams
  - Pulsar binning (up to 1024 bins, 128 kHz spectral resolution)
  - Fast dump visibilities (up to 60 Gbit/s)
  - Satellites & near field asteroids

https://www.atnf.csiro.au/research/bigcat/bigcat_techreq.pdf

Spectral Flexibility

- Up to 18.5 kHz over entire 1-3 GHz band (4 km/s)
- Up to 74 kHz over 8 GHz at > 4 GHz (5.5 km/s @ 4 GHz)
  - “Spectral window” selectable to reduce data rate
- Up to 0.01 km/s over limited bandwidth (zoom bands)
  - Up to 8 zoombands per 128 MHz
  - Maximum 262144 spectral channels over ALL spectral windows and zoom
- Specific spectral resolutions will be ”pre-canned” modes, but new modes easily created then tested before being offered to astronomers
  - E.g. 4 zoom bands (per 128 MHz) of 16 MHz, each with 4096 spectral points
  - Constrained by GPU resources and visibility data rate
  - Zoom bands and spectral windows “tunable” by observer

Timeline

- RF design being worked on
  - Competition with CryoPAF and Quasar
  - RF prototypes expected to be built and tested over 2022
  - Production 2023
- Jimble hardware to be assembled by May 2022
  - Currently CryoPAF firmware being designed. Will be then ported to BIGCAT
  - Completed mid-2022
- Install 4 GHz BIGCAT system (with existing IF system) October 2022
  - Decommission CABB
  - Unclear if practical to have overlap period
- RF upgrade second half of 2023
- Catastrophic failure of CABB “unlikely”, degradation possible

BIGCAT Processing Software

- Plans to continue to support Miriad and CASA
  - RPFITS to be deprecated so new ingest code to be written
- No major changes to processing code planned
  - “Only” 2x bandwidth change

Feedback and questions:

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BIGCAT Overview: https://www.atnf.csiro.au/research/bigcat/BIGCAT_Overview.pdf

BIGCAT Requirements: https://www.atnf.csiro.au/research/bigcat/bigcat_techreq.pdf

Thank you

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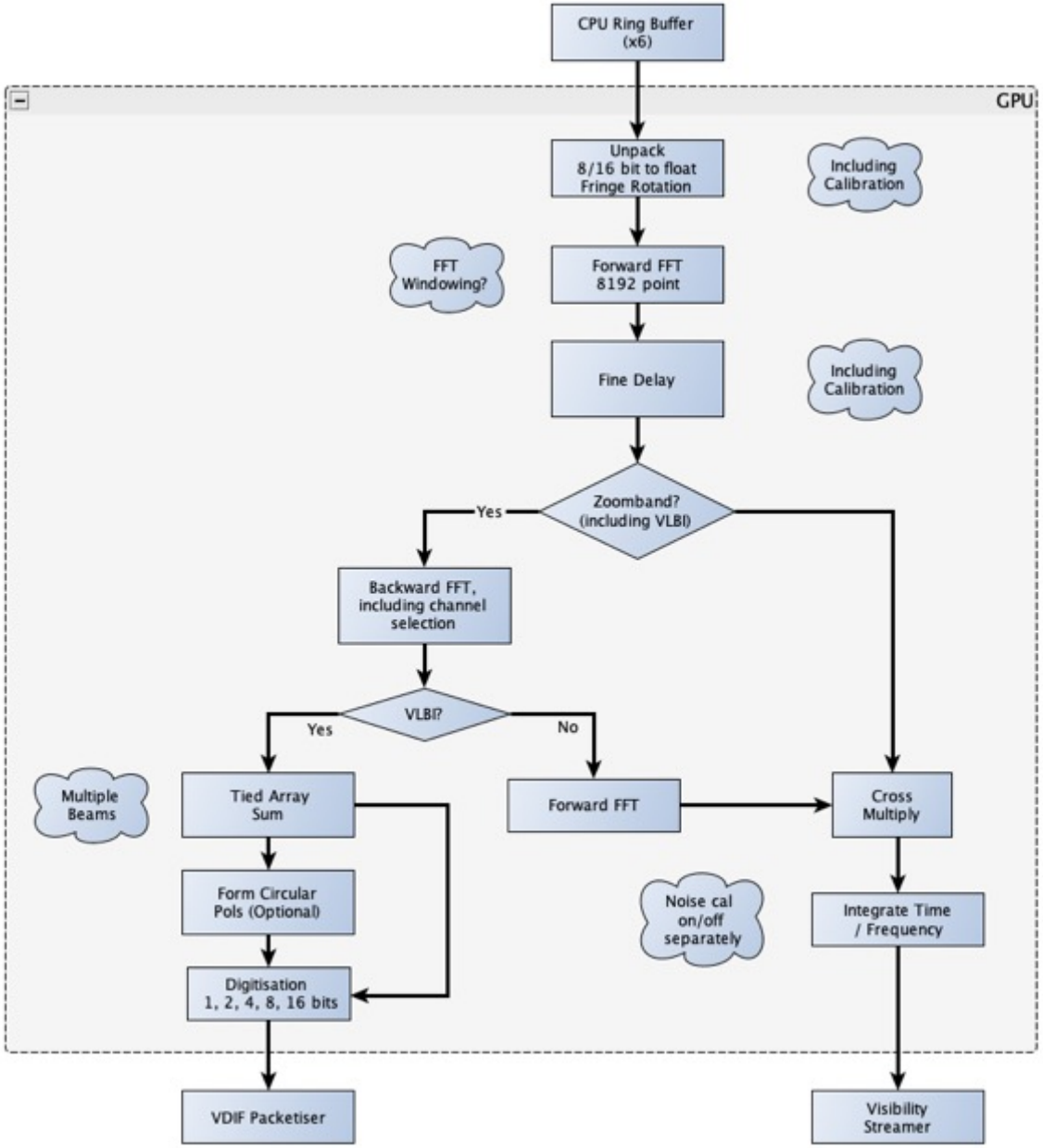
CPU Ring Buffer
(x6)
GPU
Unpack
8/16 bit to float
Fringe Rotation
Including
Calibration
FFT
Windowing?
Forward FFT
8192 point
Fine Delay
Including
Calibration
Zoomband?
(including VLBI)
Yes
Backward FFT,
including channel
selection
VLBI?
Yes
No
Multiple
Beams
Tied Array
Sum
Forward FFT
Cross
Multiply
Form Circular
Pols (Optional)
Noise cal
on/off
separately
Integrate Time
/ Frequency
Digitisation
1, 2, 4, 8, 16 bits
VDIF Packetiser
Visibility
Streamer