



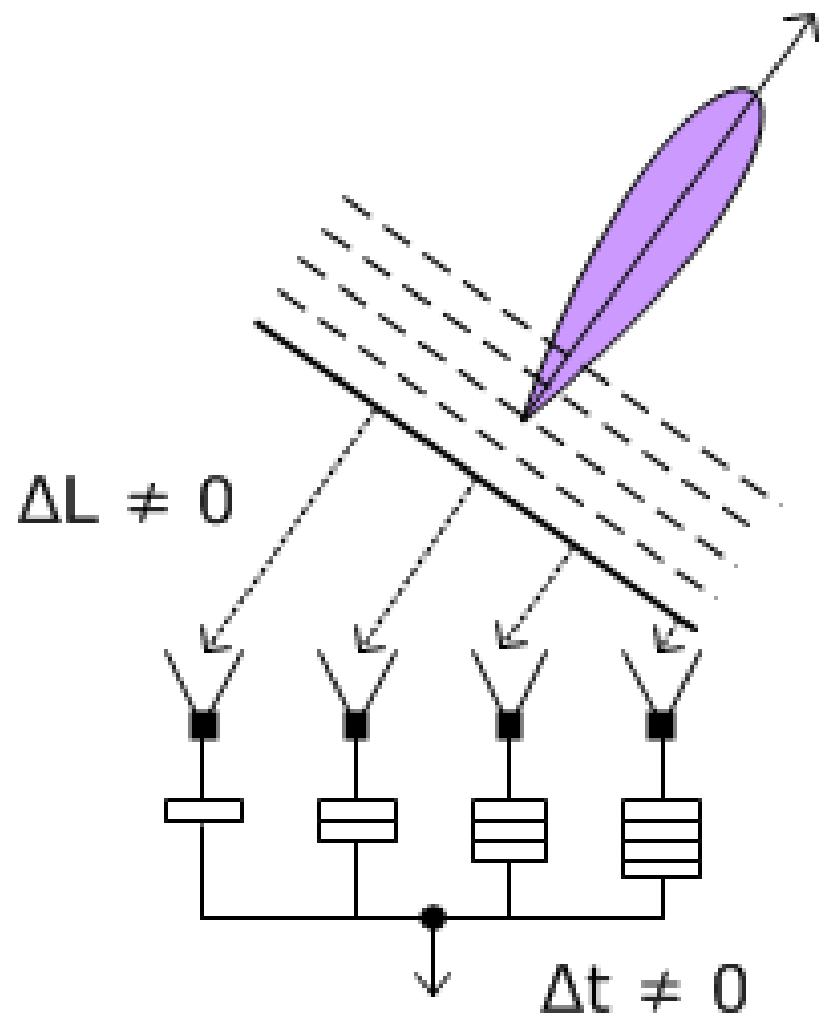
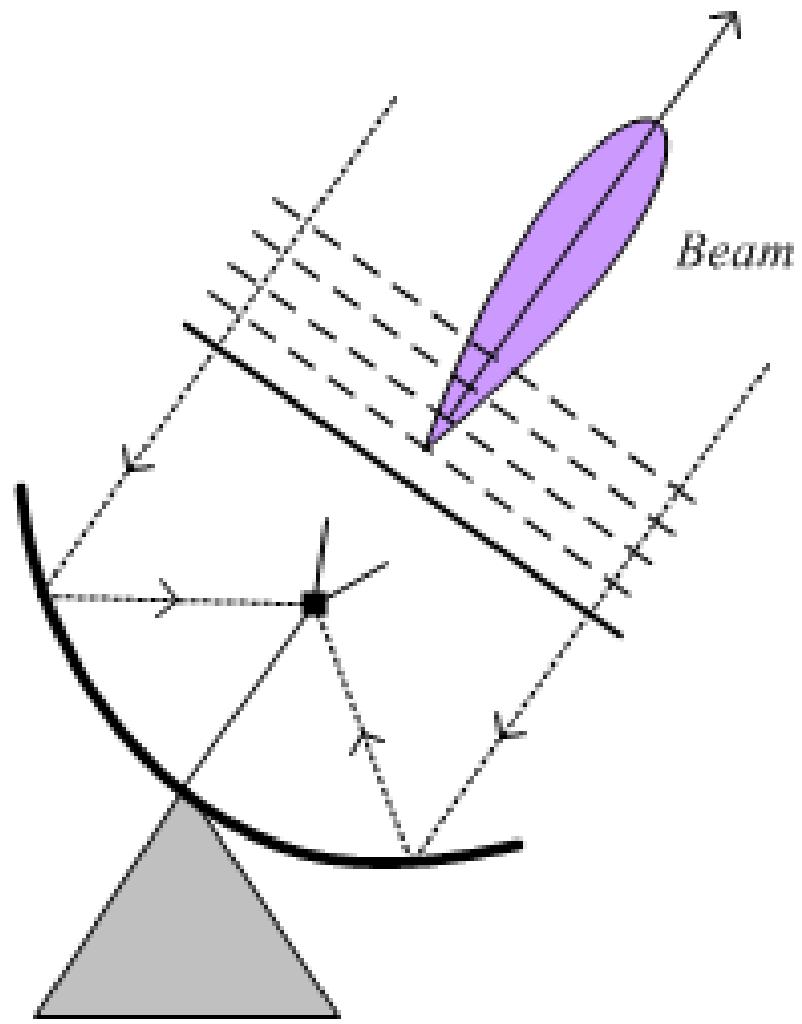
Netherlands Institute for Radio Astronomy

# UniBoard<sup>2</sup>, a high performance digital processing board applied in the Square Kilometer Array

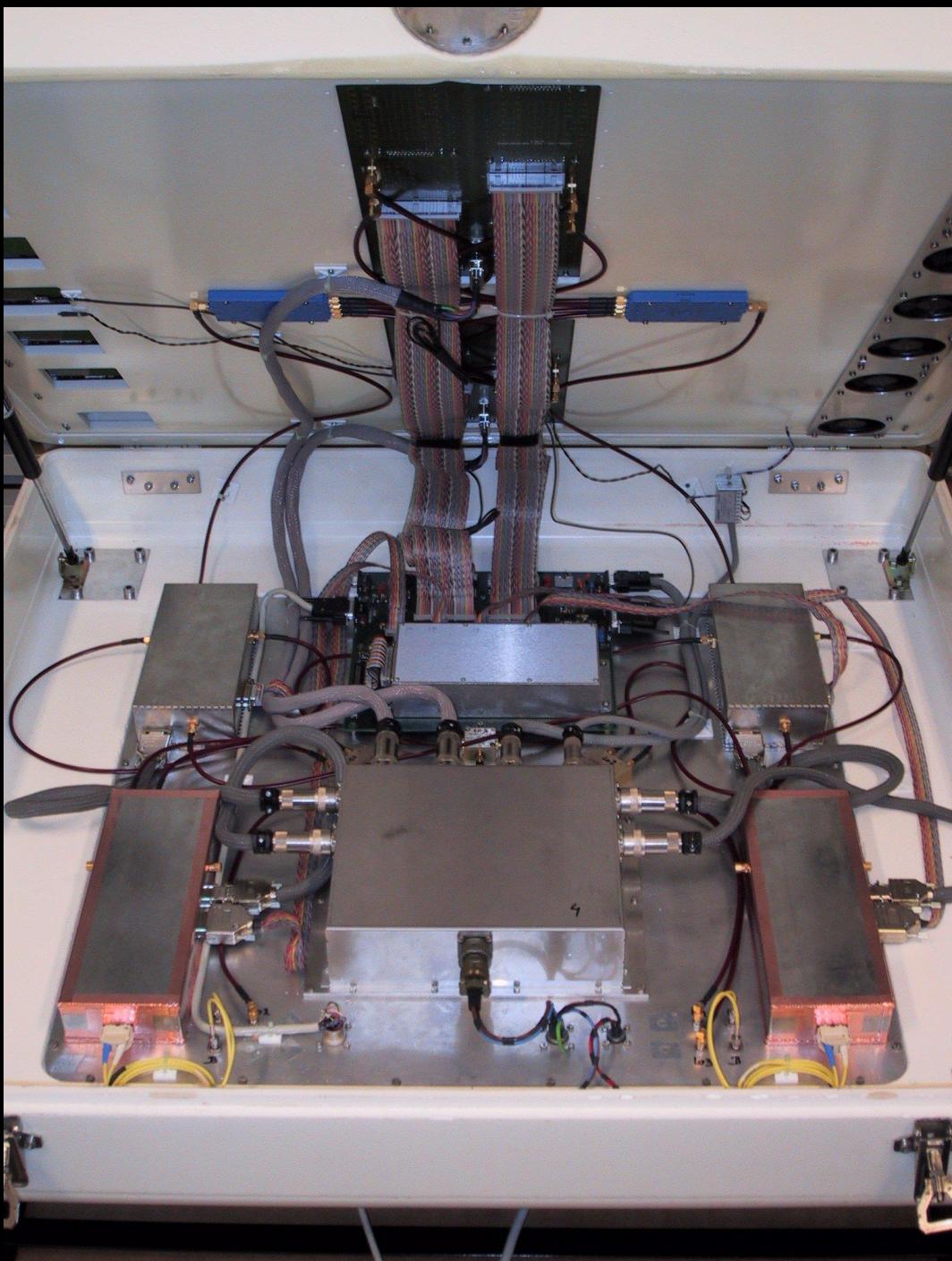
André Gunst  
28-10-2014

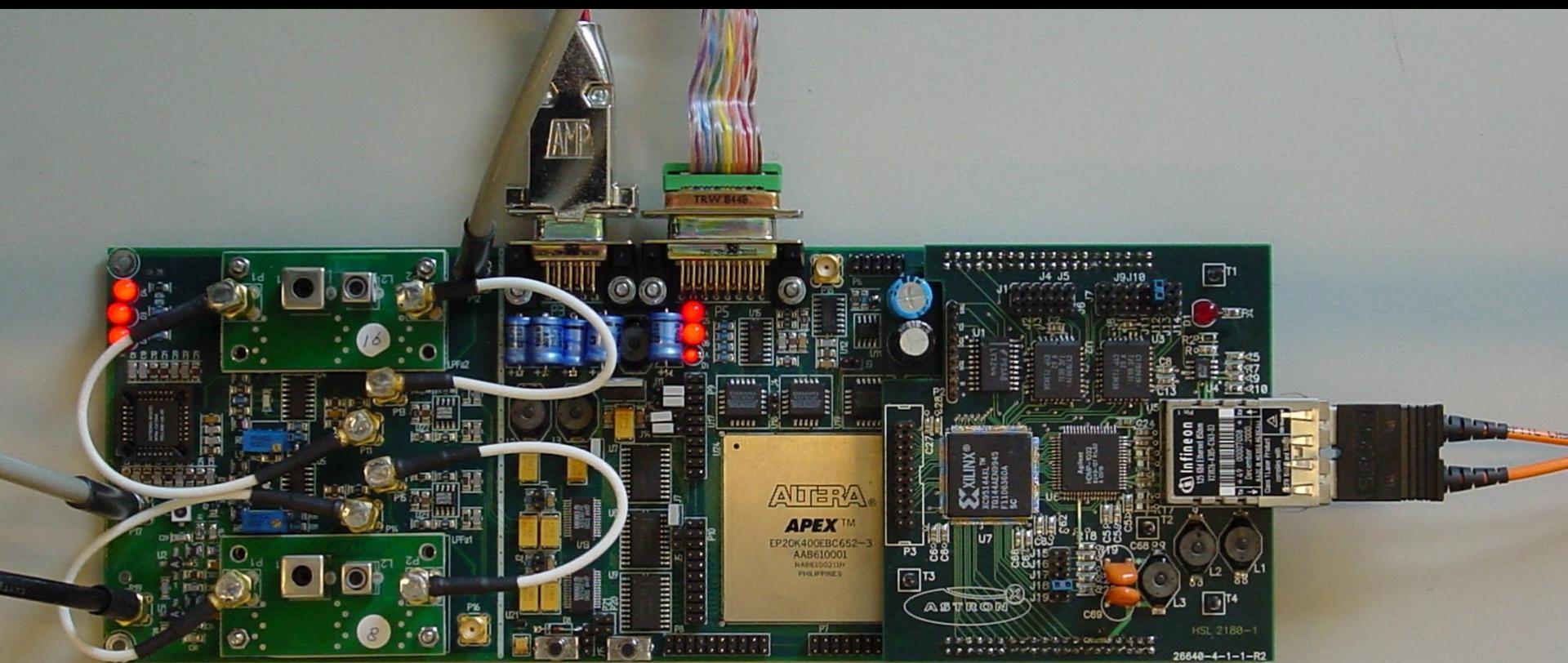
















2011 © AEROPH

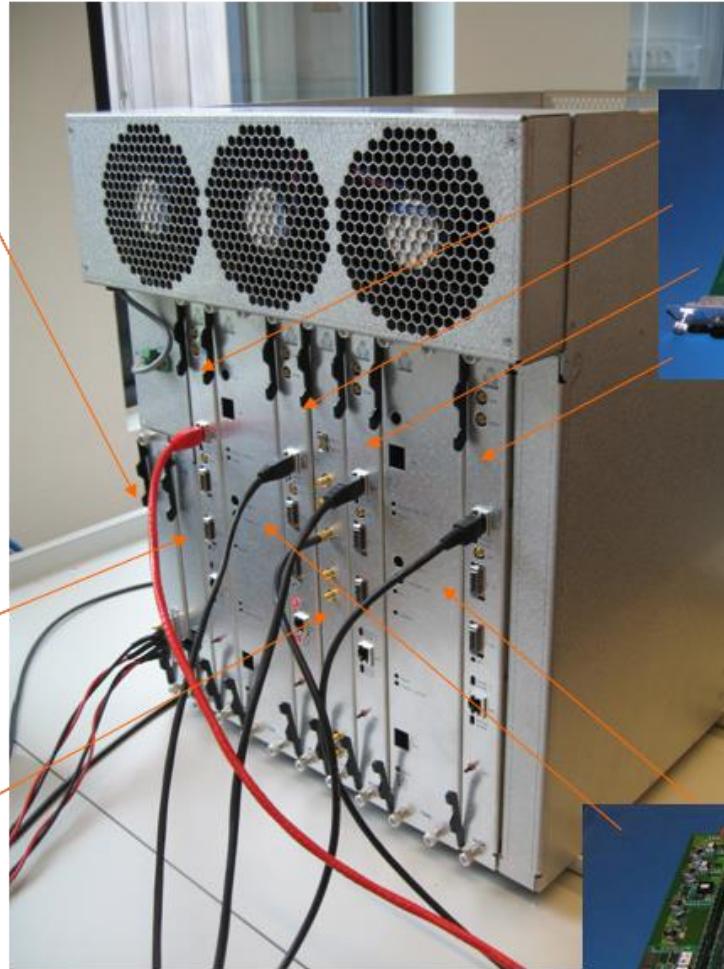


Core Station





SPU



RSP



JTB



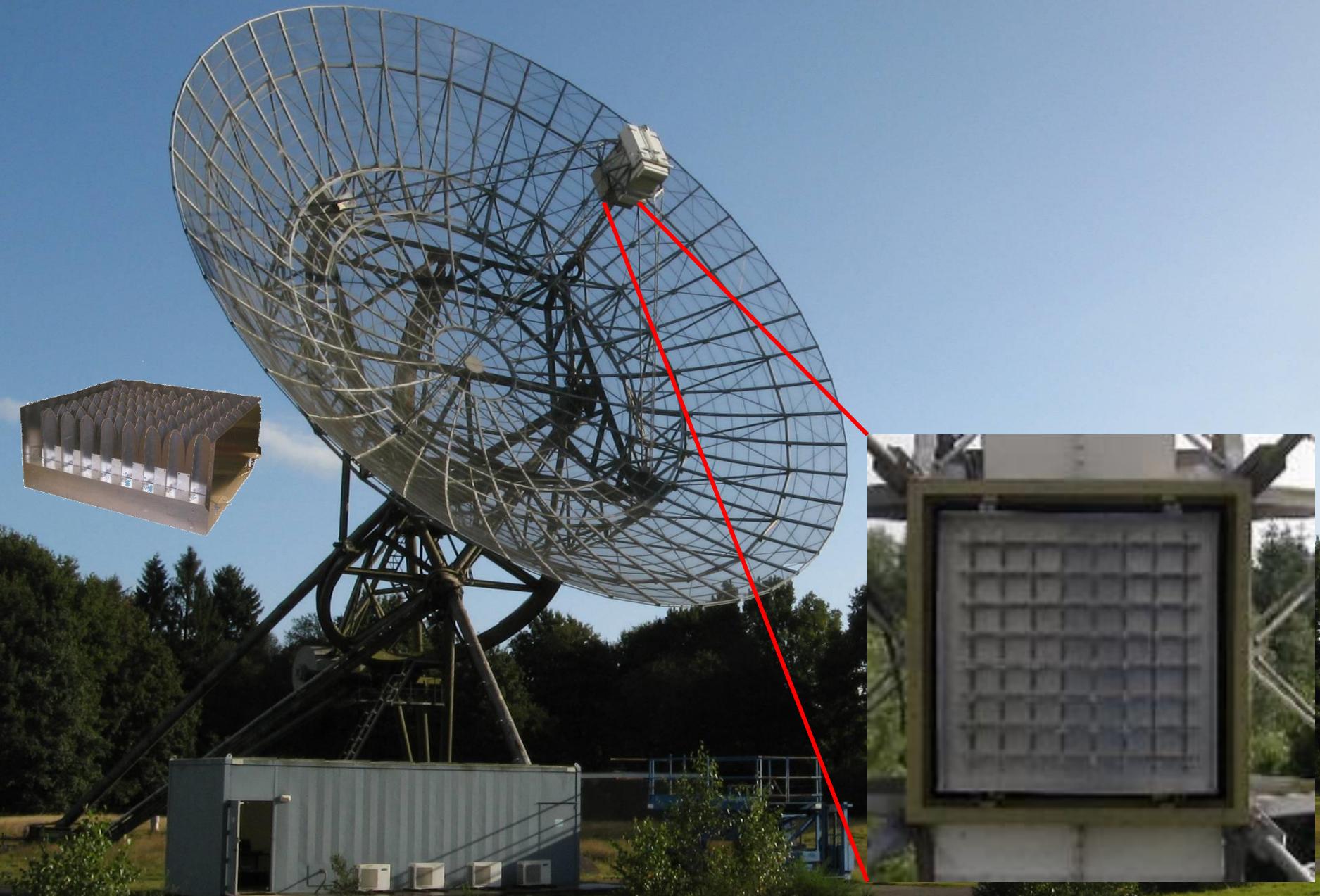
TDS



TBB

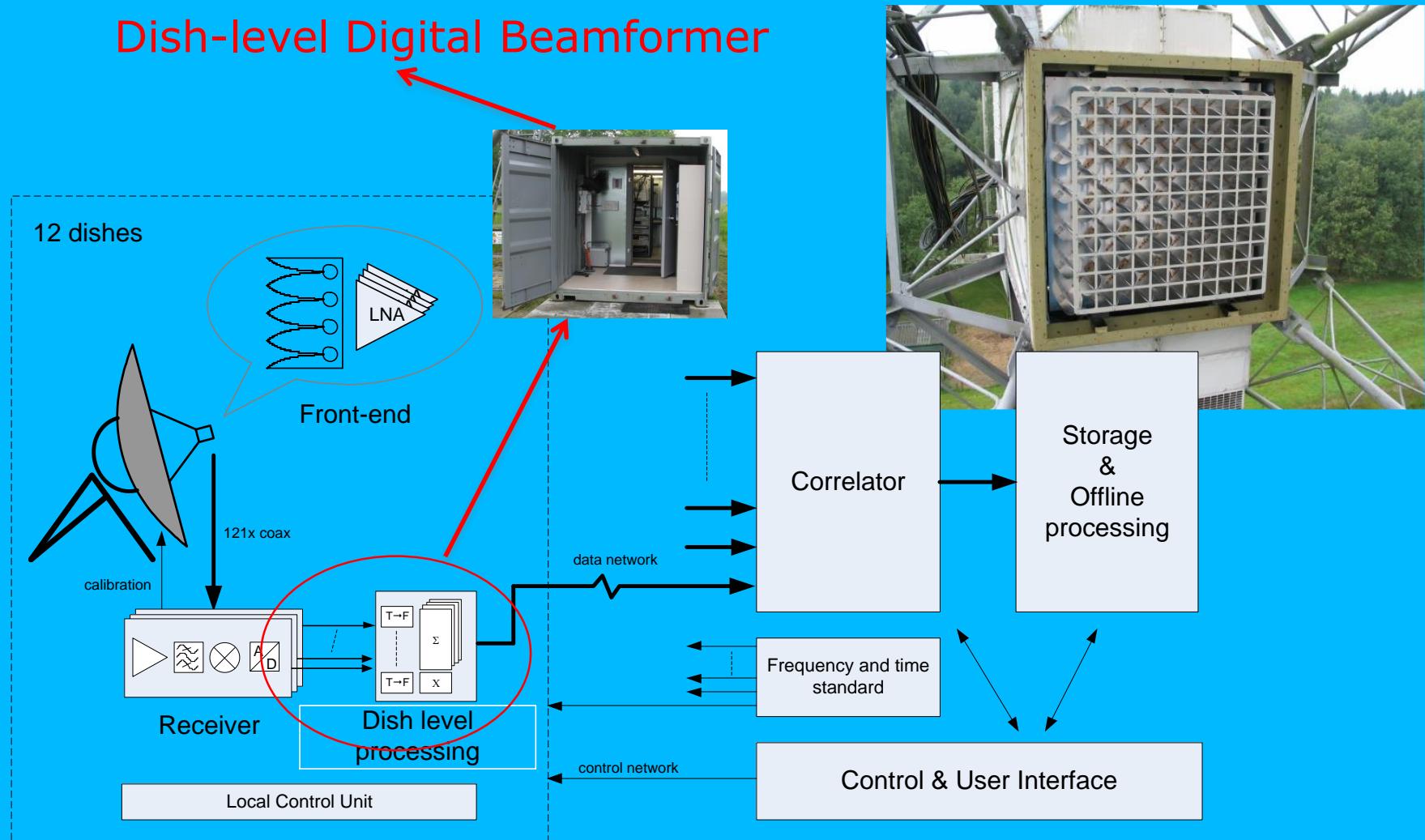


# APERTIF



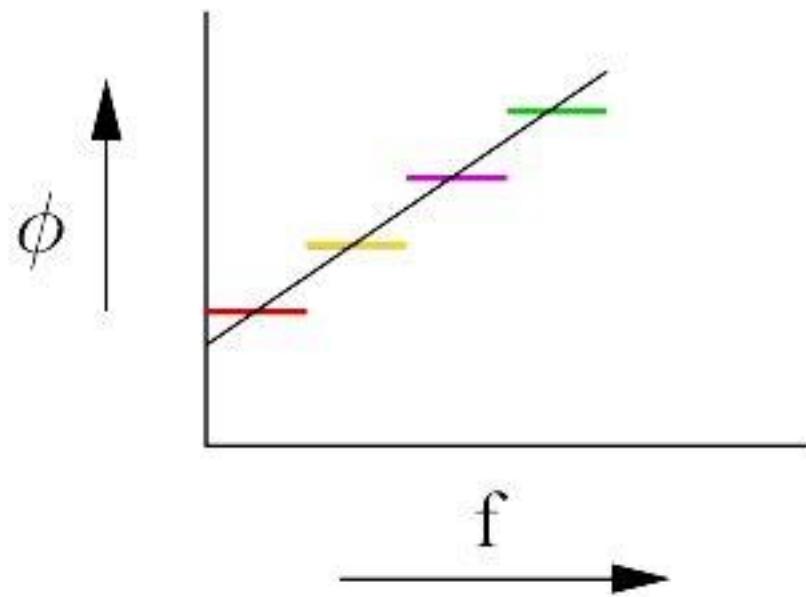
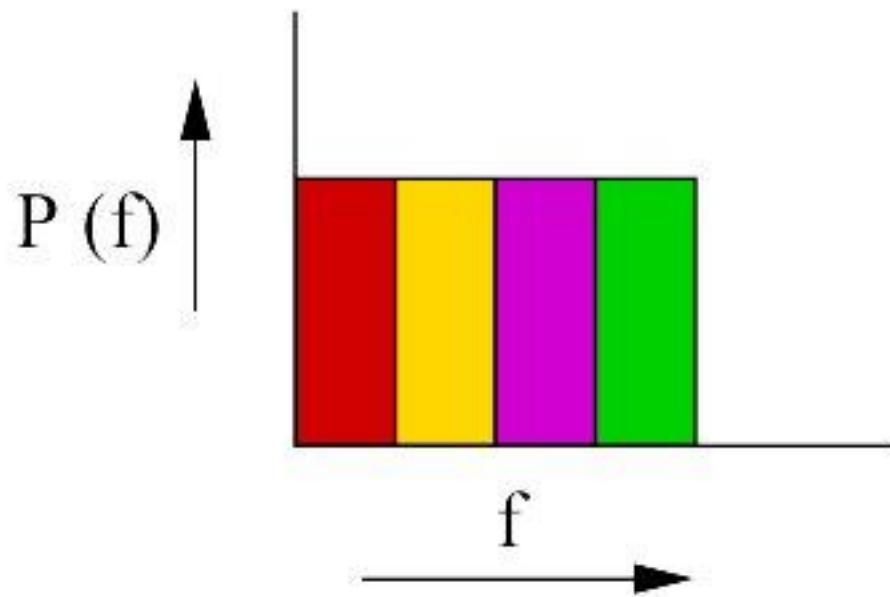
# Definition

ASTRON



# Beamforming

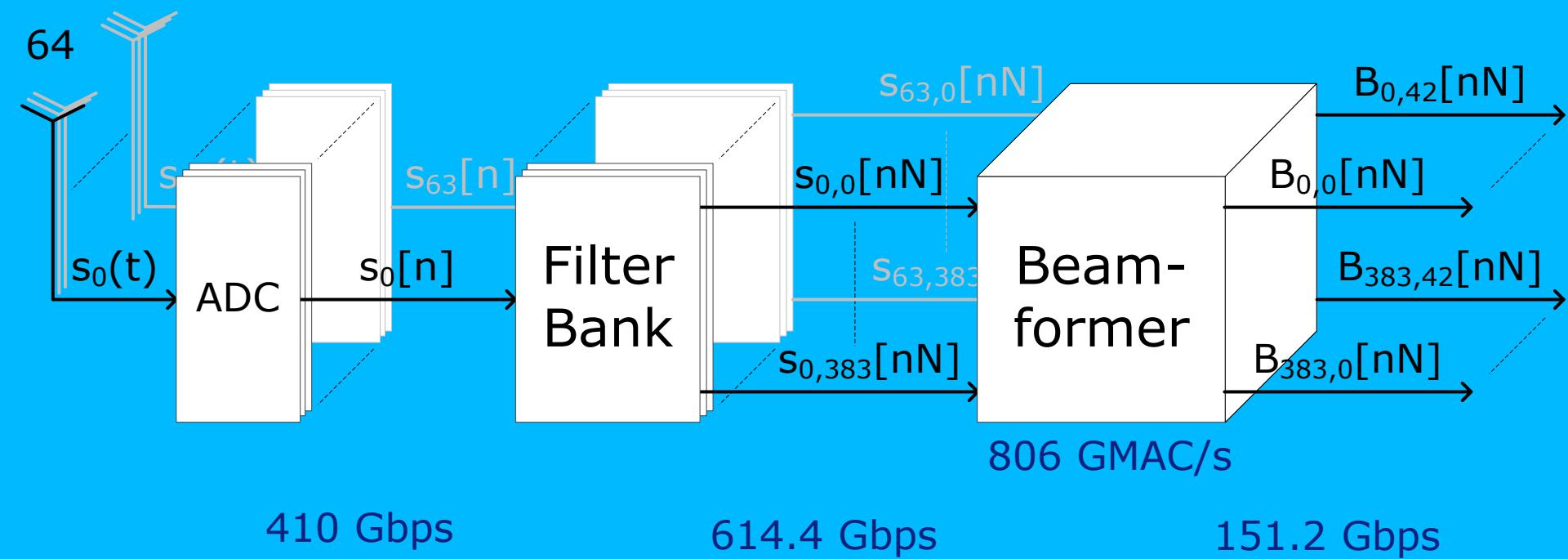
ASTRON



# Beamformer Block Diagram

## - single polarization

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# Beamformer Implementation

## - subband select

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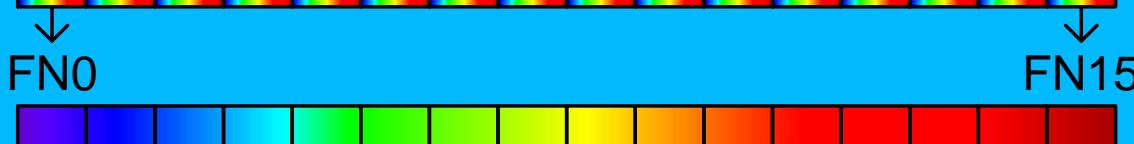
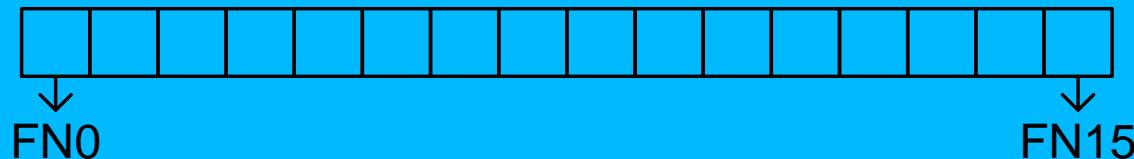
## Filterbank output:

512 Subbands:



$$16 \times 24 = 384$$

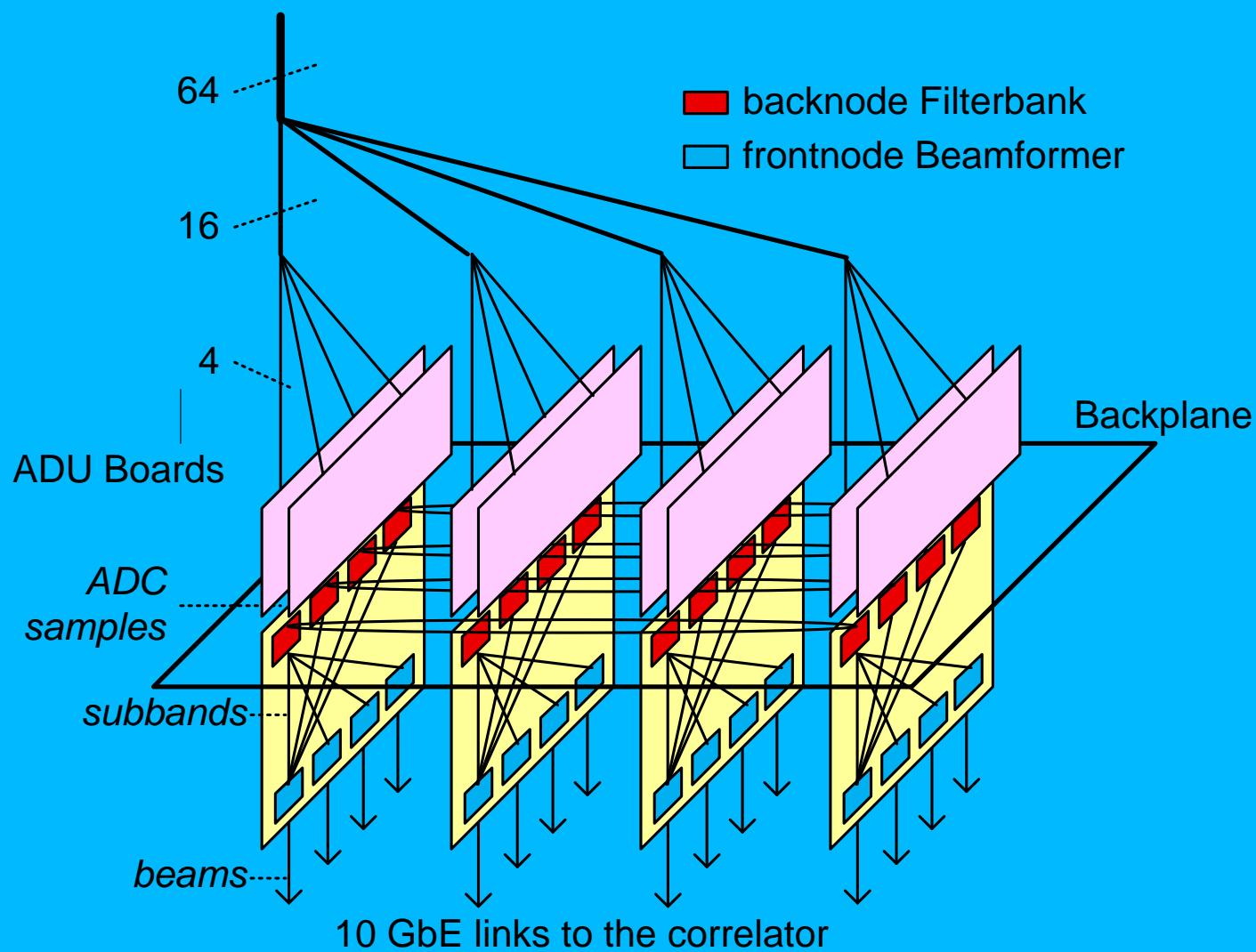
Selected Subbands:



Very  
Flexible

# Beamformer Implementation

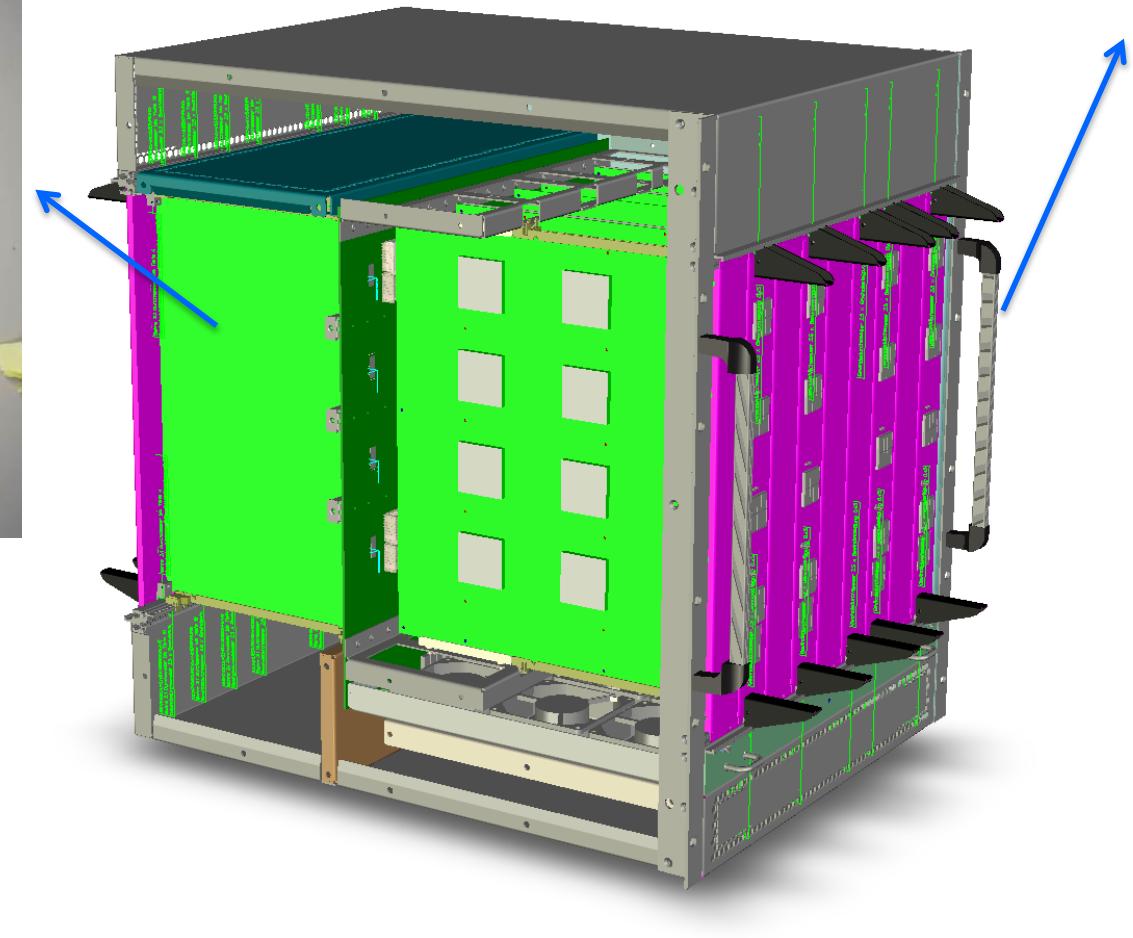
ASTRON





# UniBoard in a Sub-rack

ADU



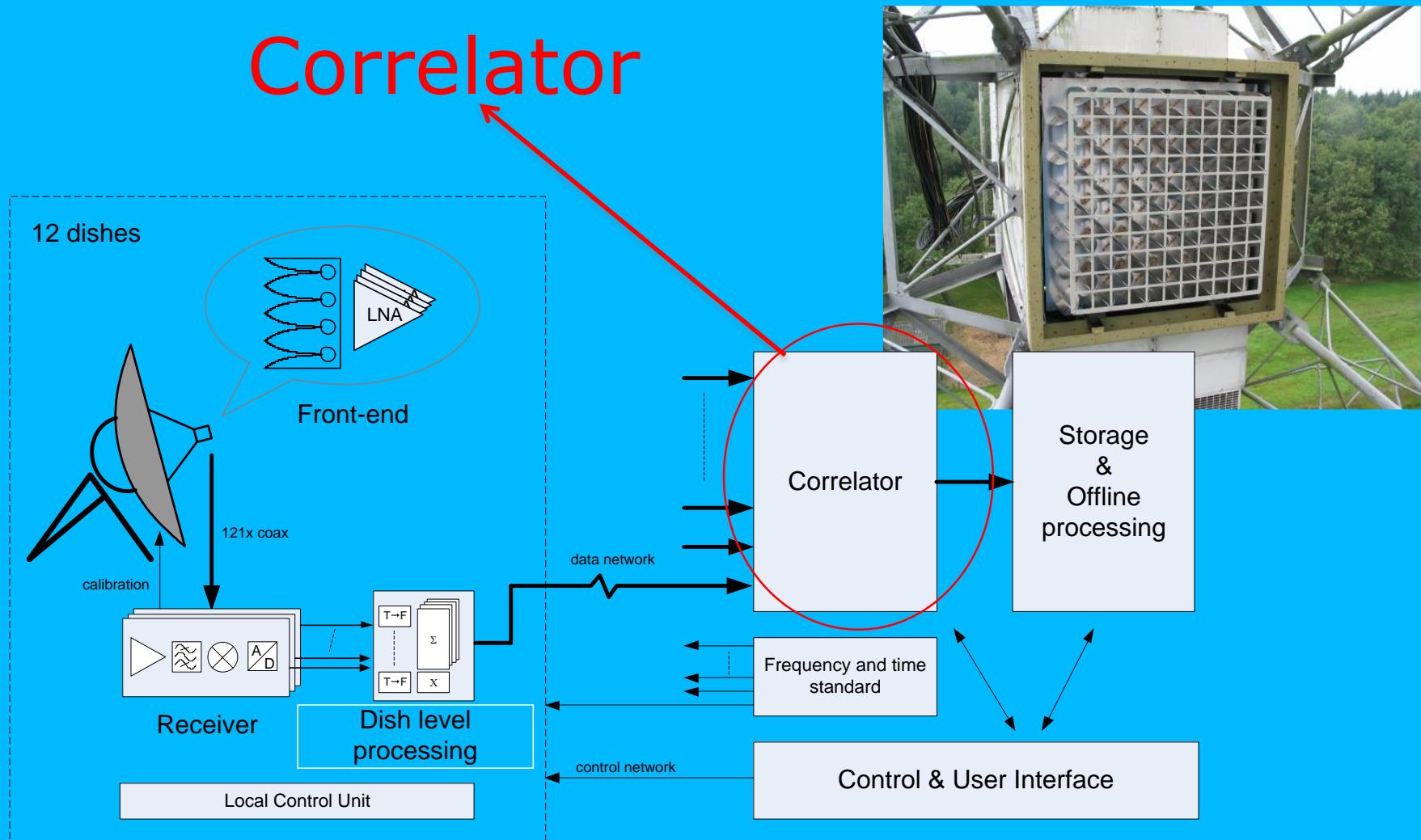
UniBoard





# Correlator

ASTRON

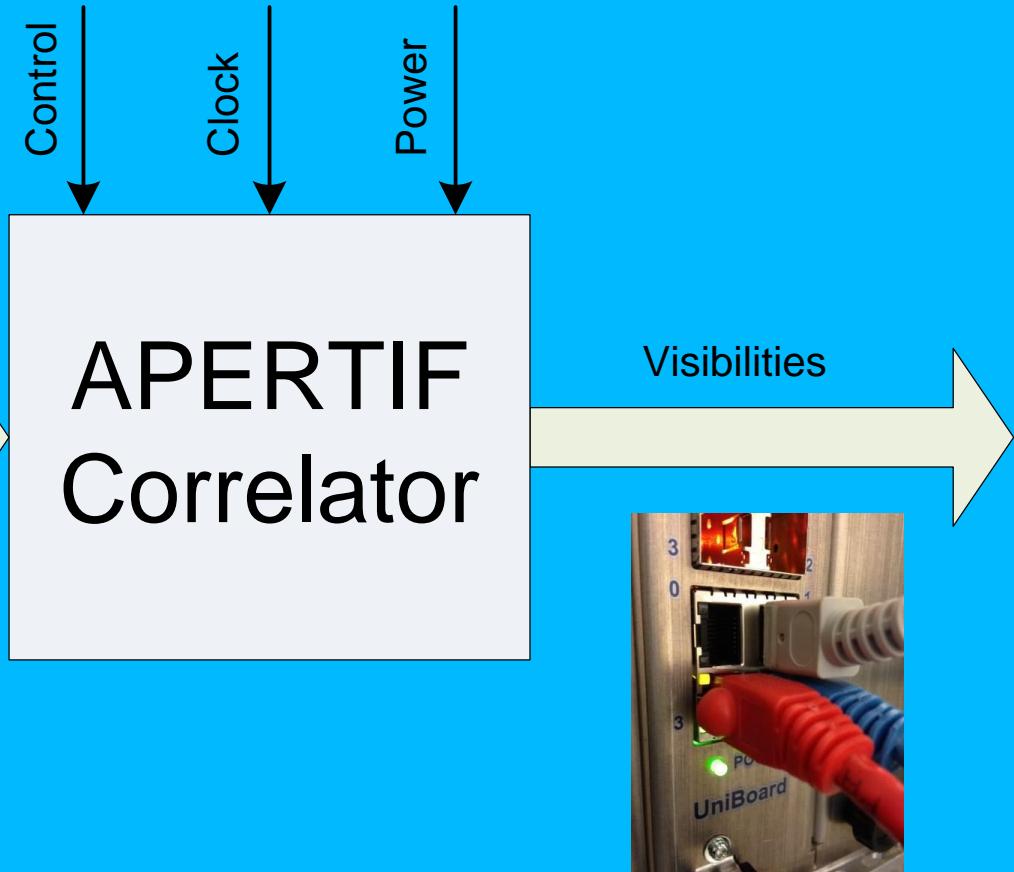


# APERTIF Correlator

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polarizations  
↓  
 $12 \times 2 \times 37$  Beams  
↑  
dishes

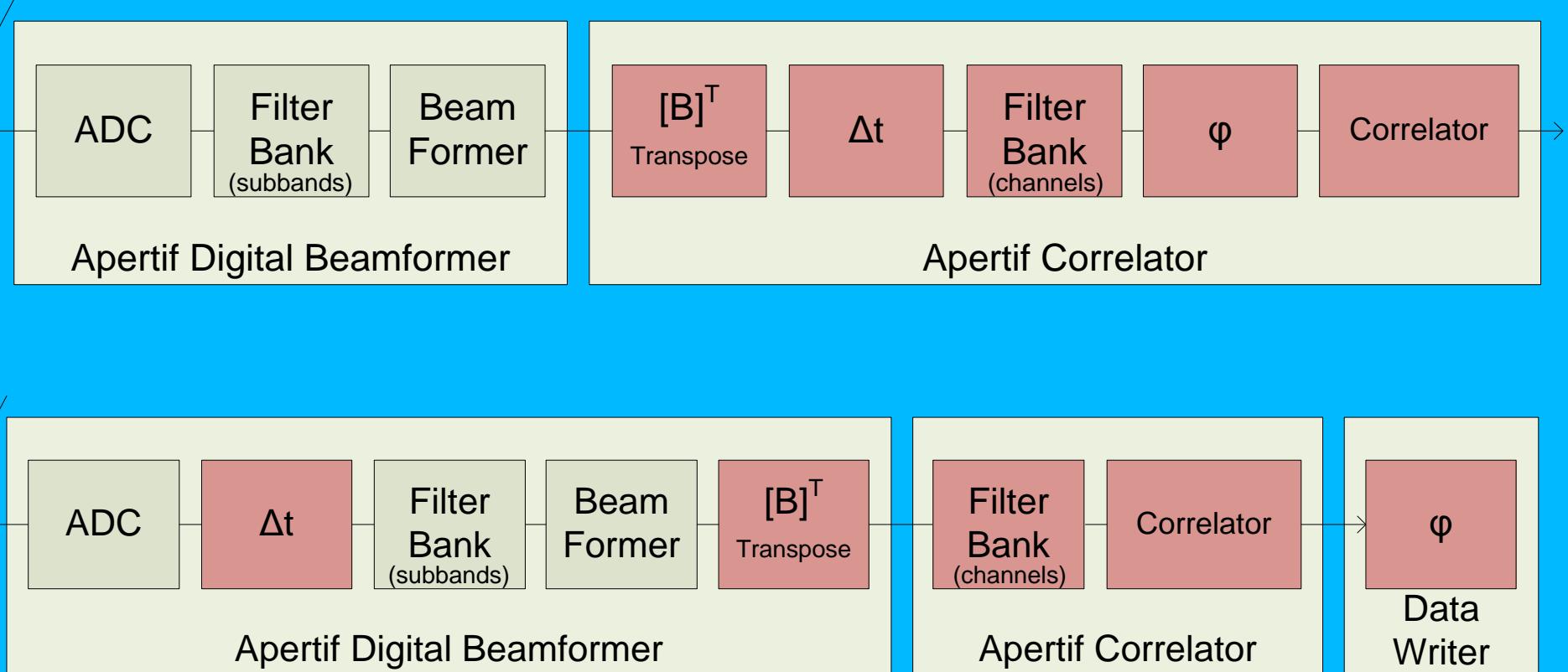


Data Input:  
 $24 \times 16 \times 10\text{GbEthernet}$

Data Output:  
 $32 \times 1\text{GbEthernet}$

# Correlator Block Diagram - functional

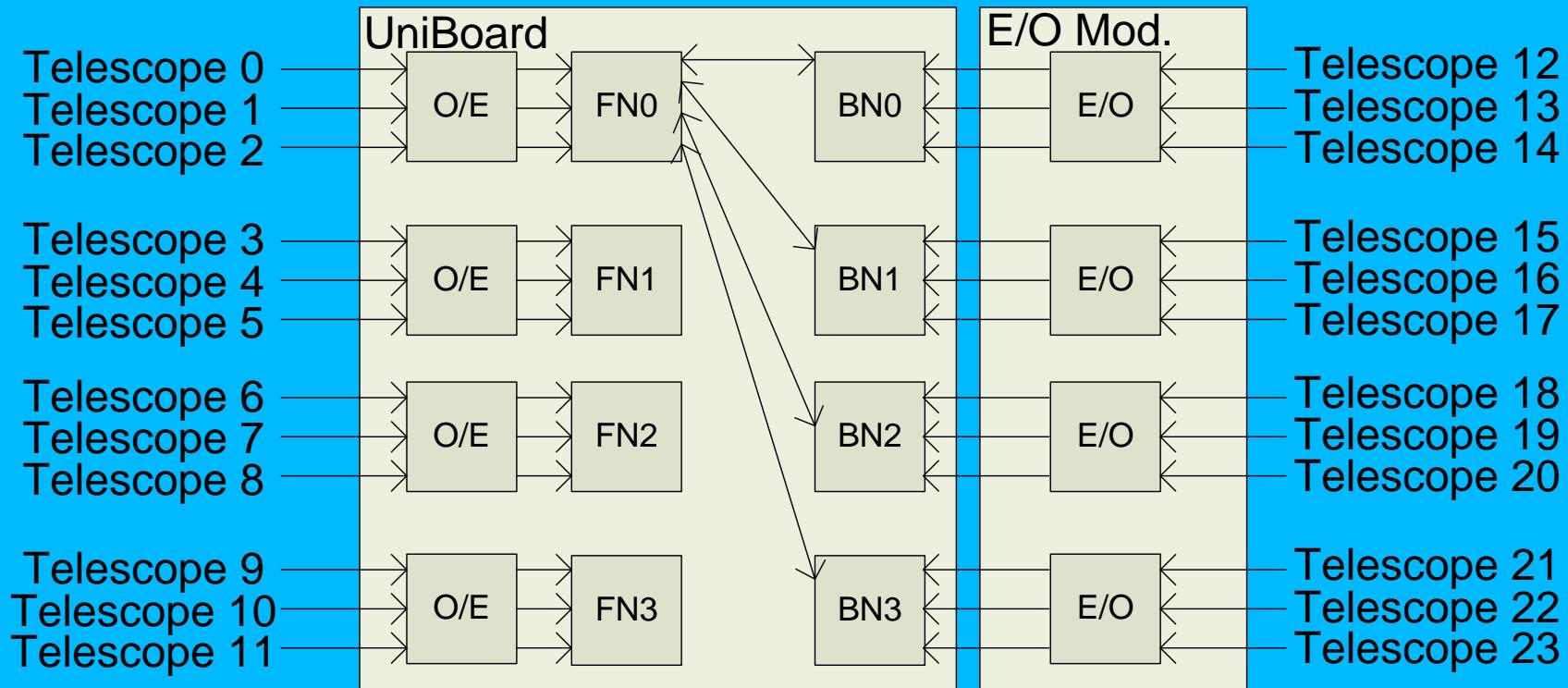
ASTRON



# Correlator Implementation

## - Single Board option

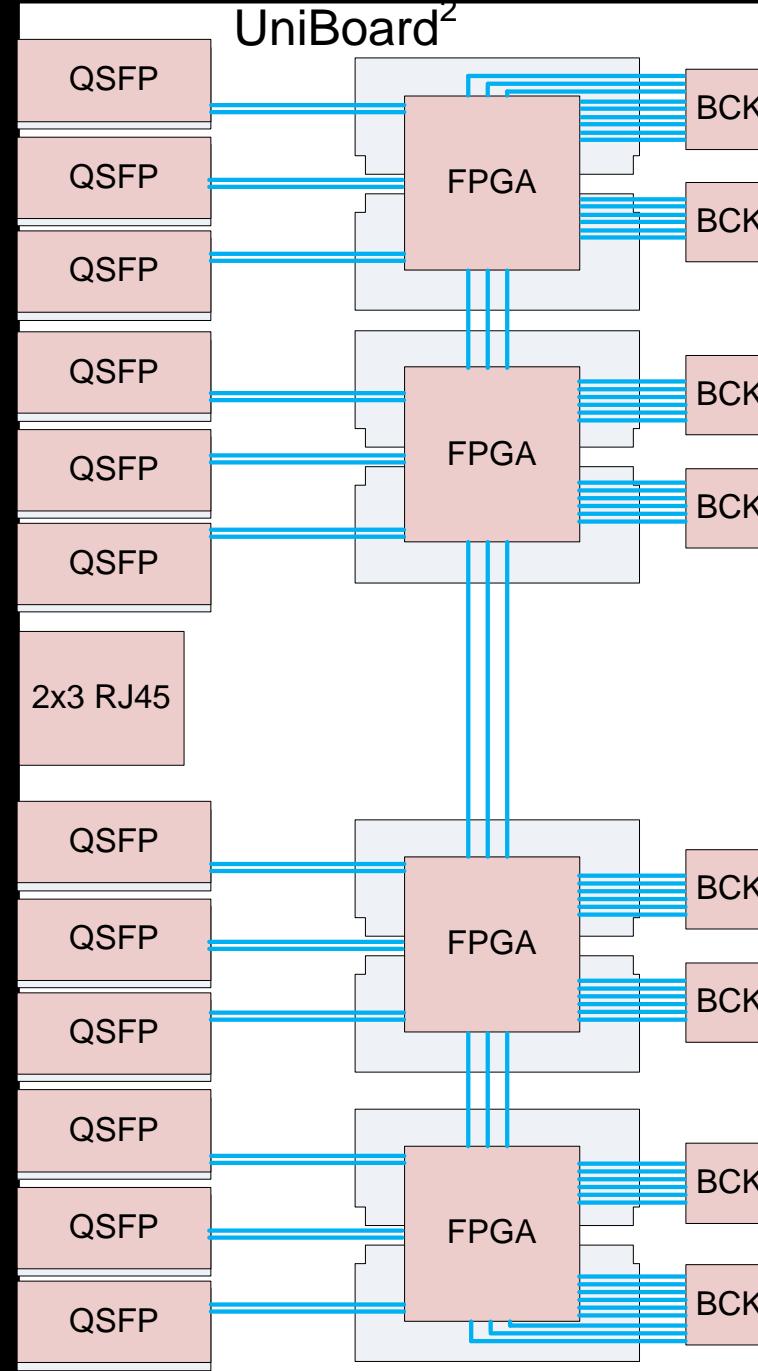
AST(RON)

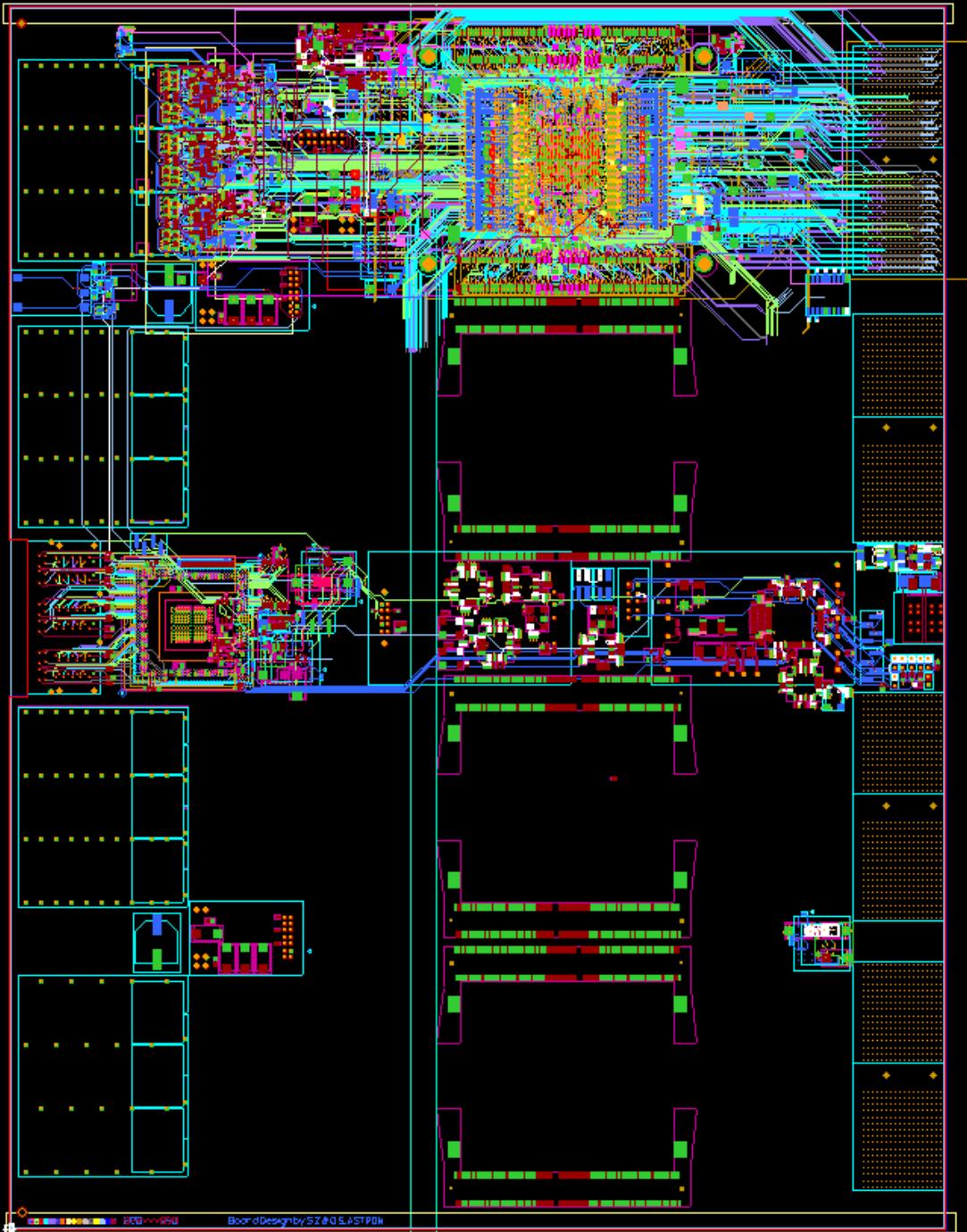


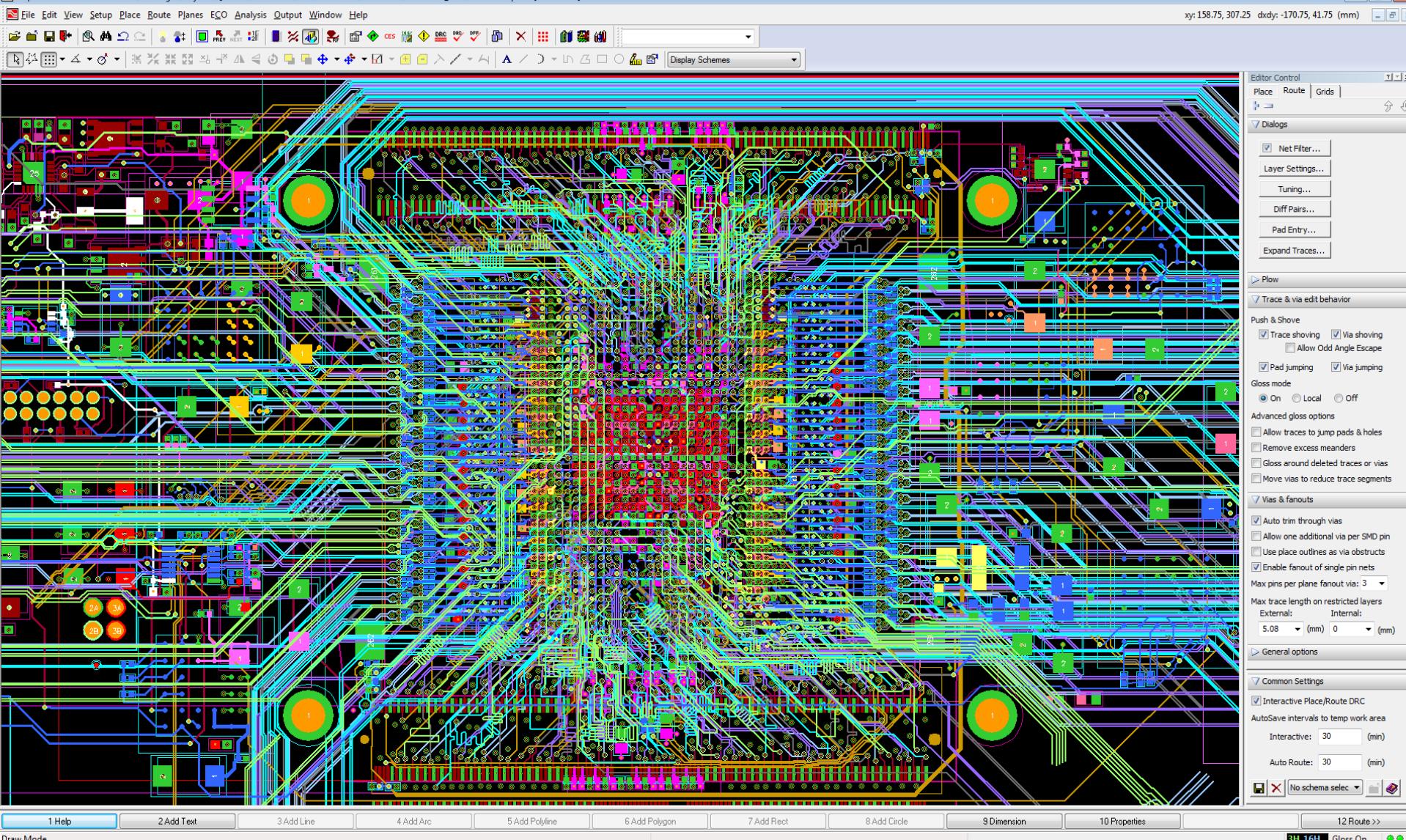
- 16 UniBoards → 16384 beamlets
- 1 UniBoard → 1024 beamlets
- 1 Node → 128 beamlets

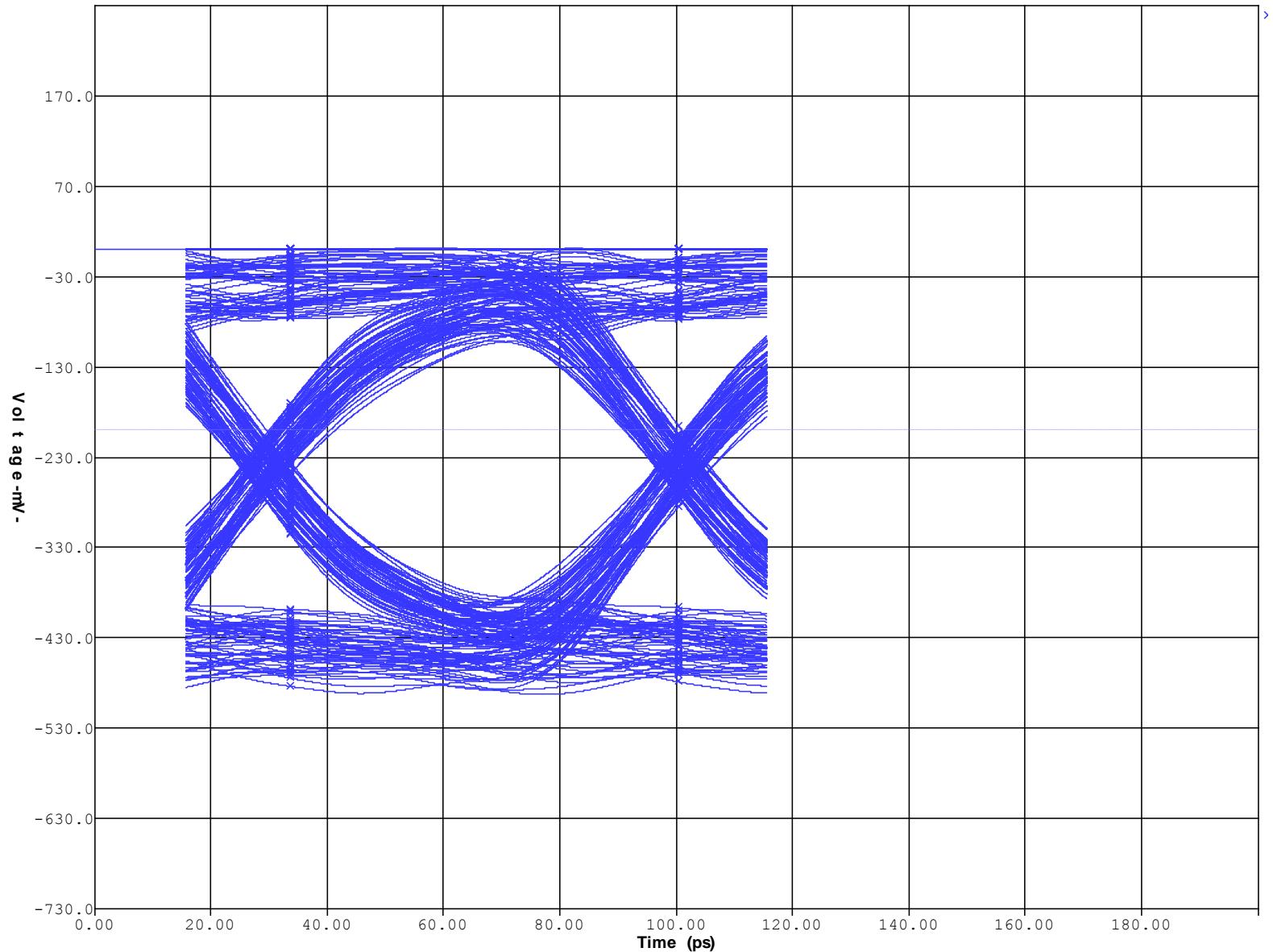


The Next Generation is  
Coming...









Date: Monday Sep. 8, 2014 Time: 12:13:35



# SKA Receptors

ASTRON

Site:  
Western  
Australia



ASKAP Phase Array Feeds

Low Frequency Aperture Arrays

Site:  
Southern  
Africa



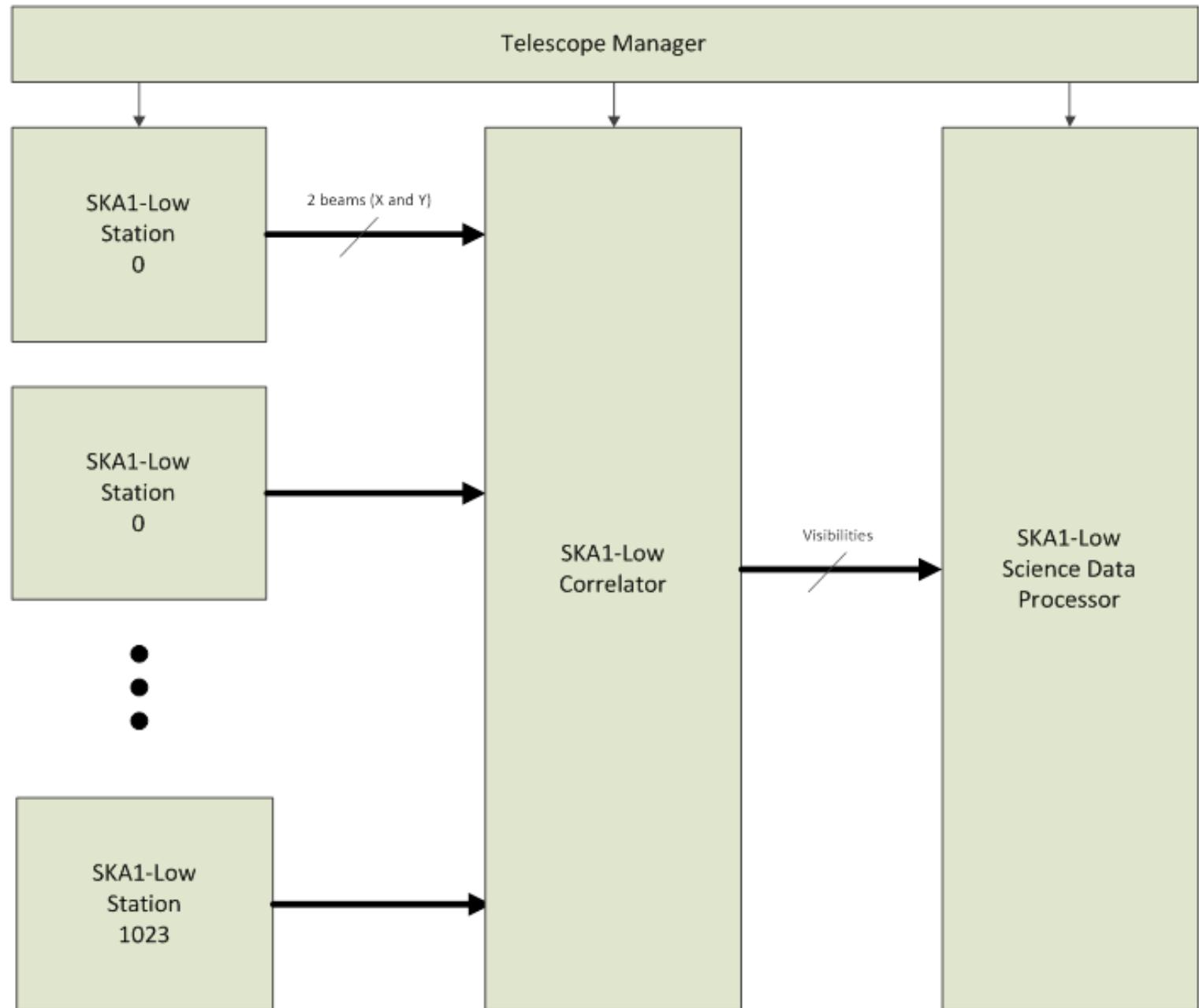
SKA Dishes



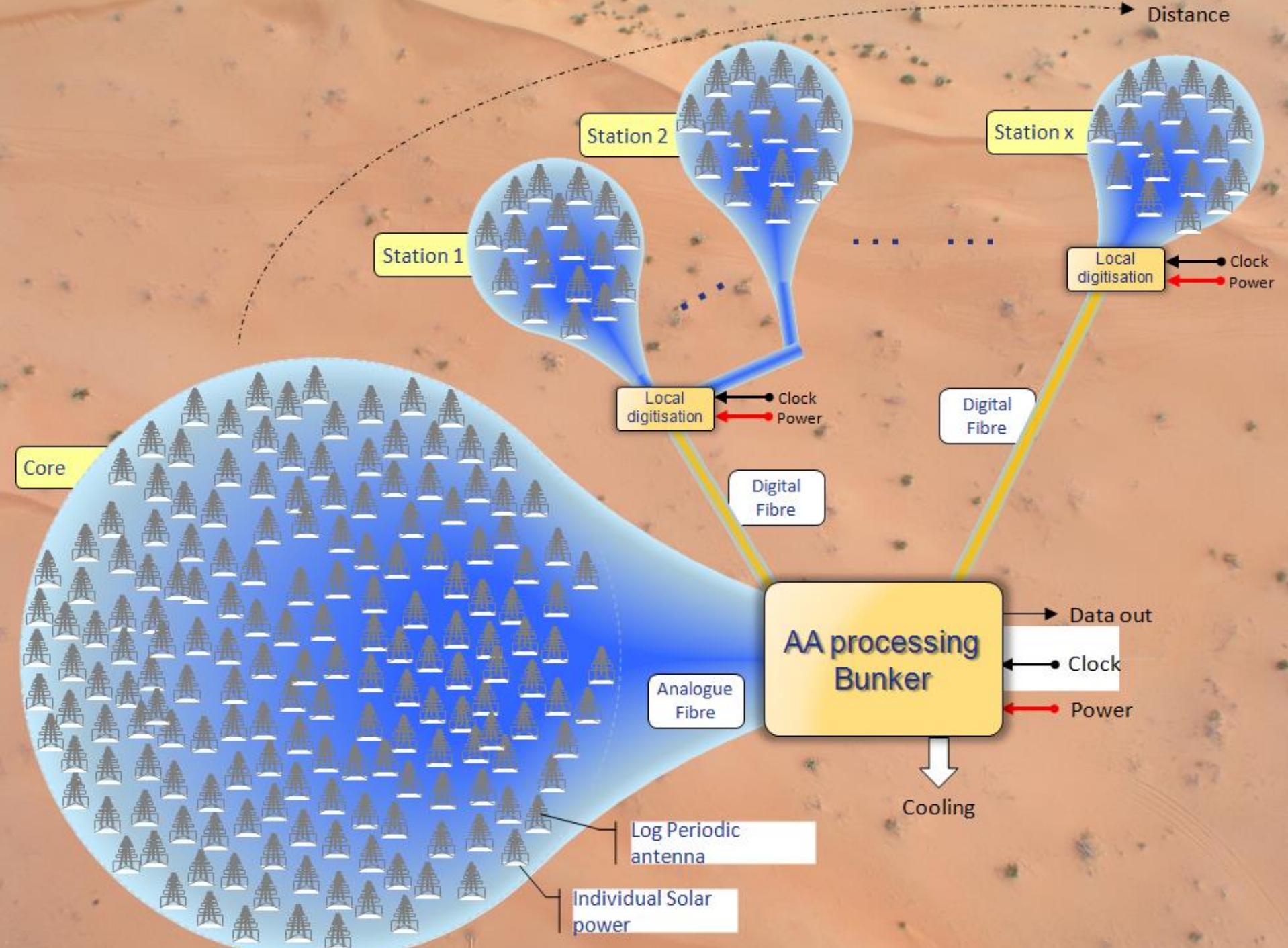
Mid Frequency Aperture Arrays



Meer KAT Dishes

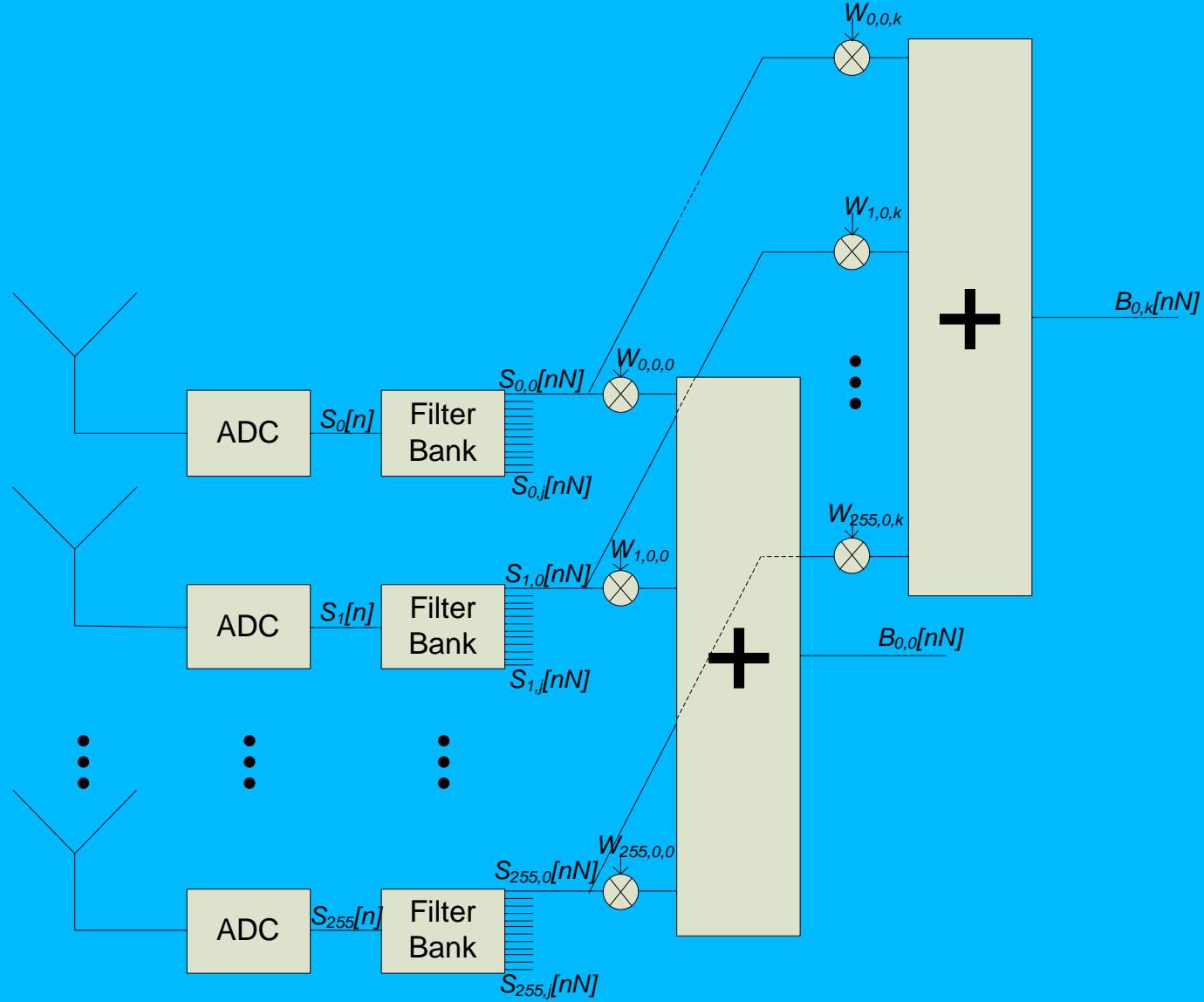


► Distance



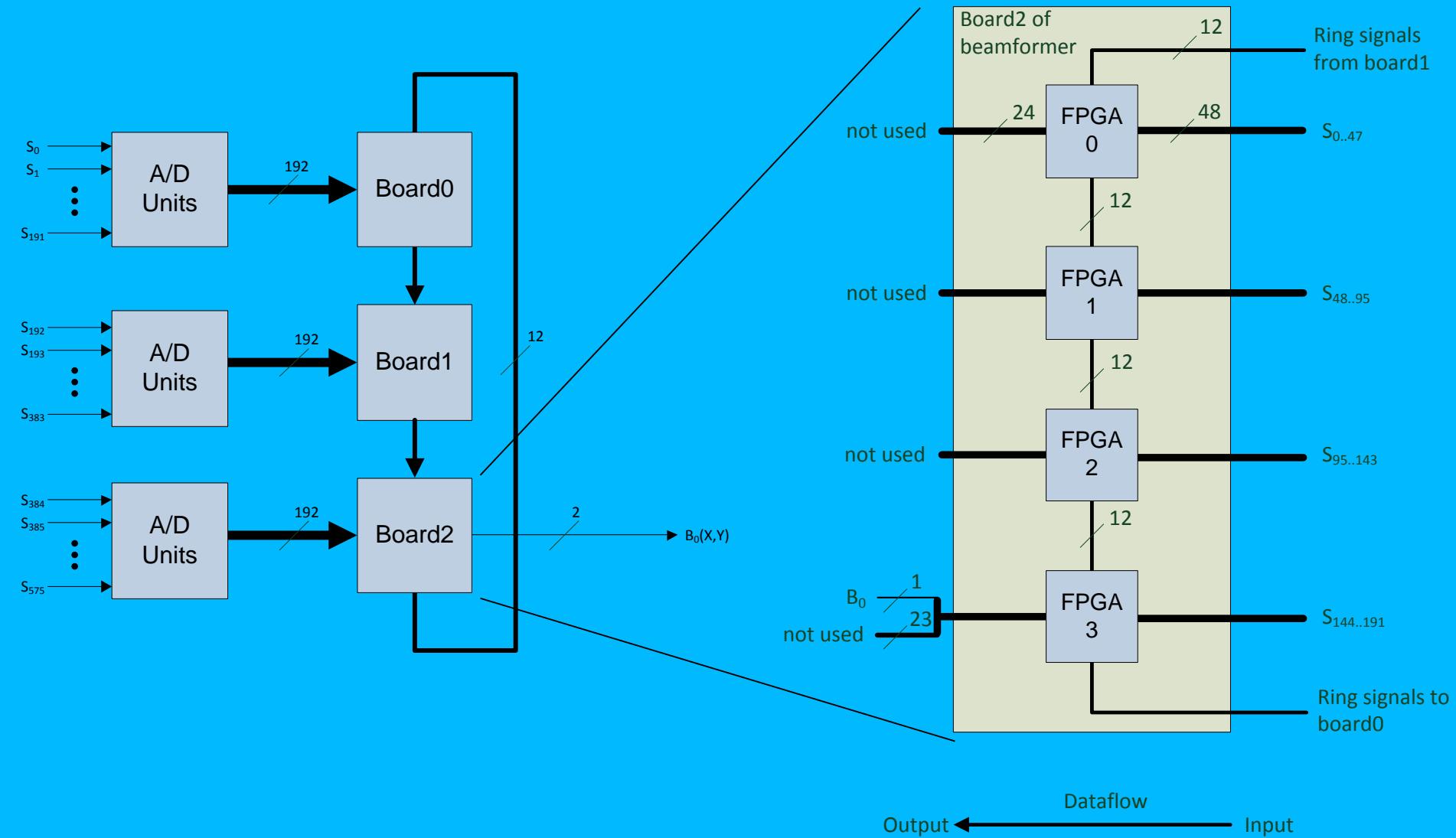
# LFAA Station Functional Diagram

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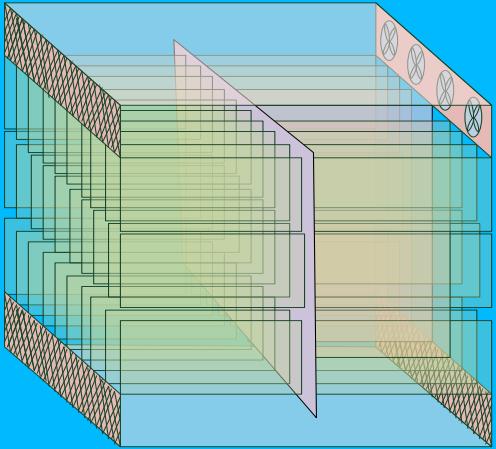


# Proposed LFAA Beamformer Implementation

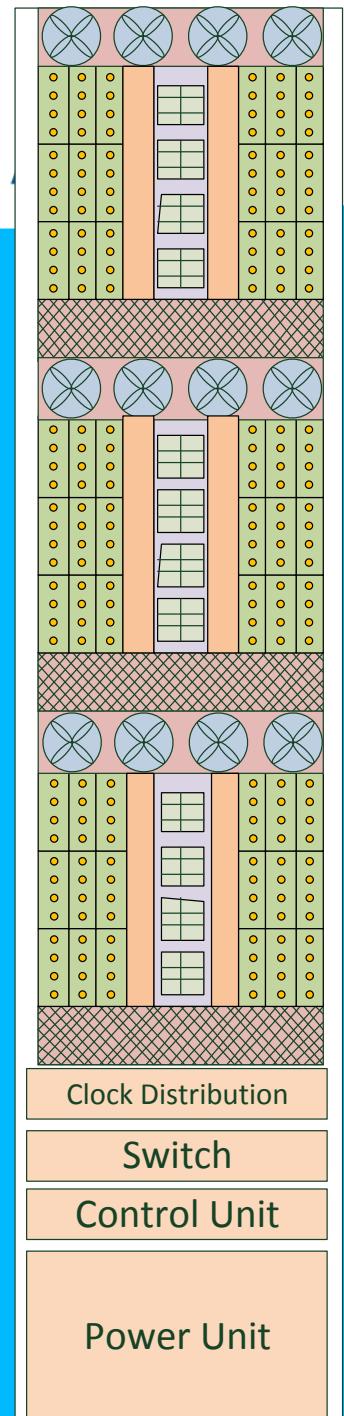
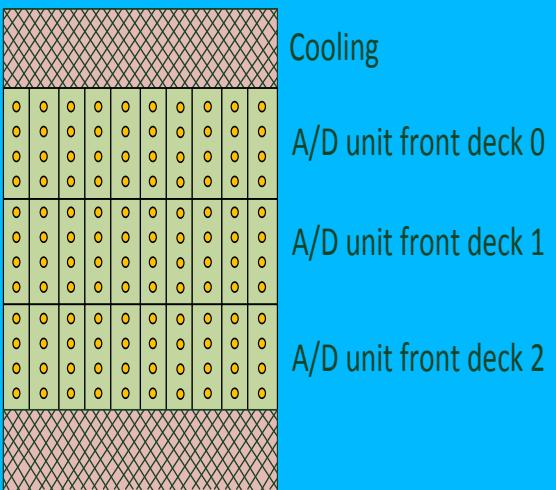
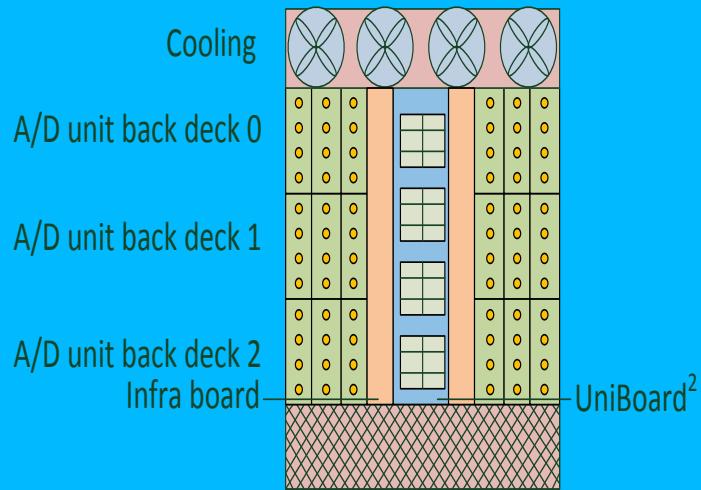
**ASTRON**

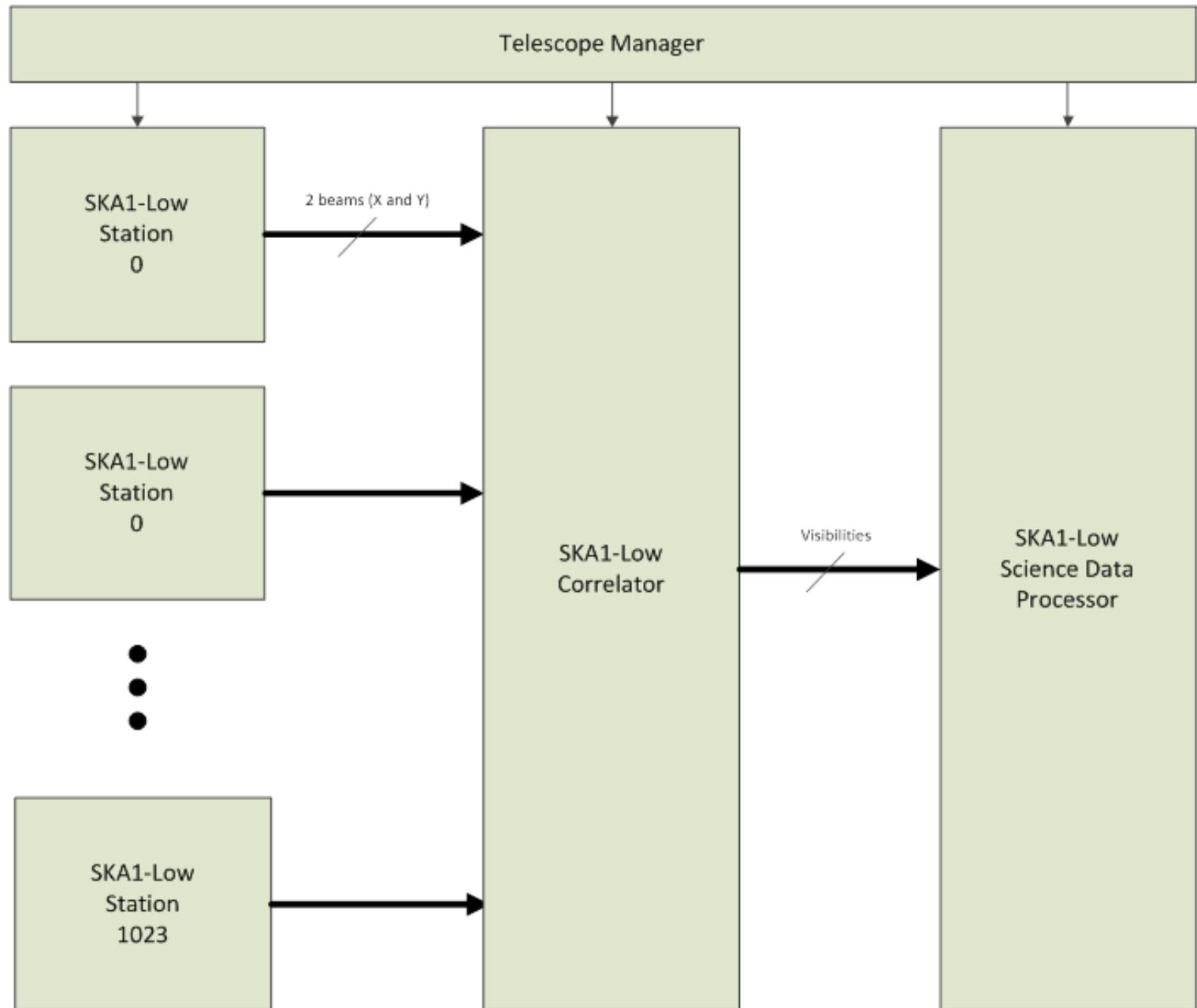


# Routing the Data



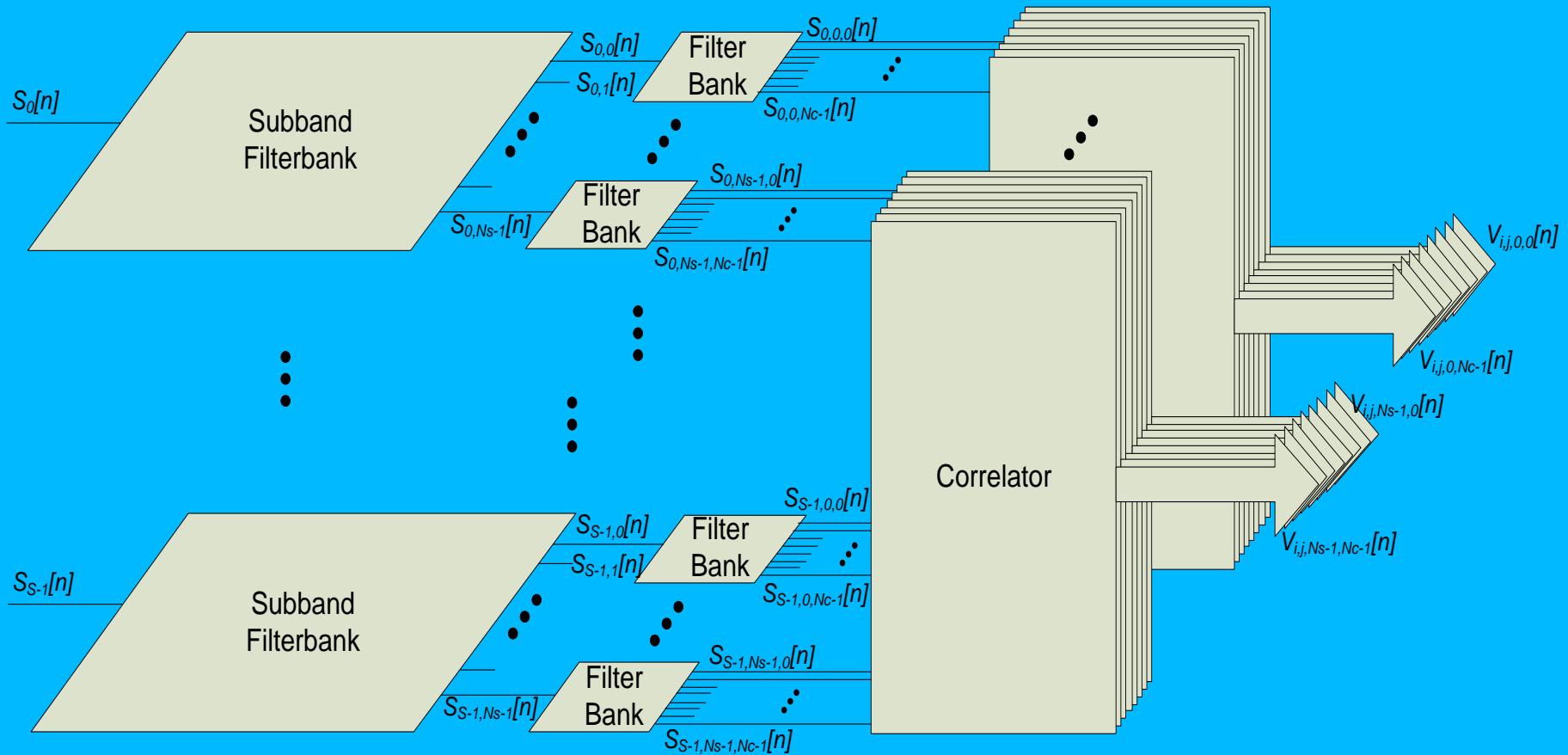
192 signal paths /  
UniBoard<sup>2</sup>

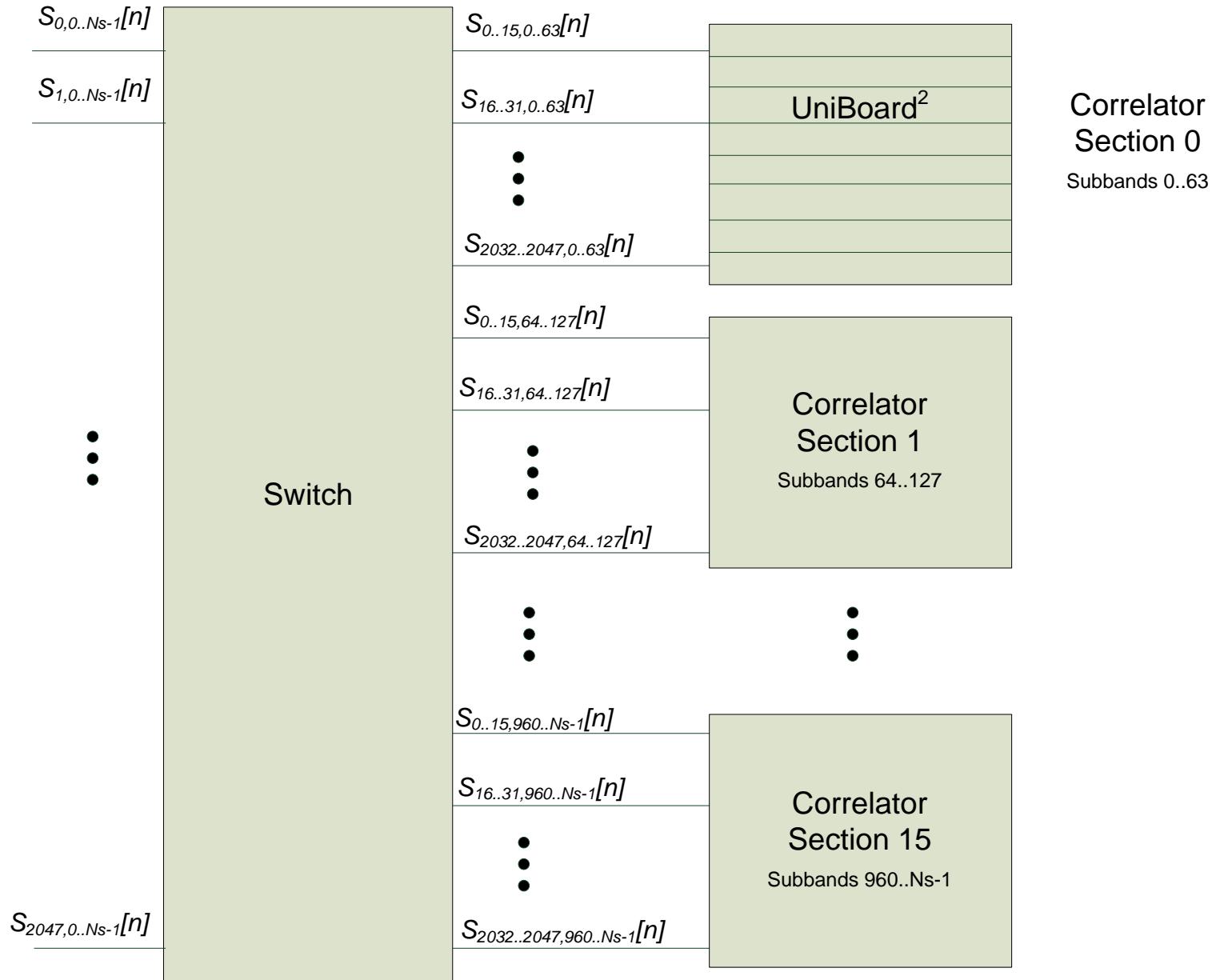




# SKA Low Correlator

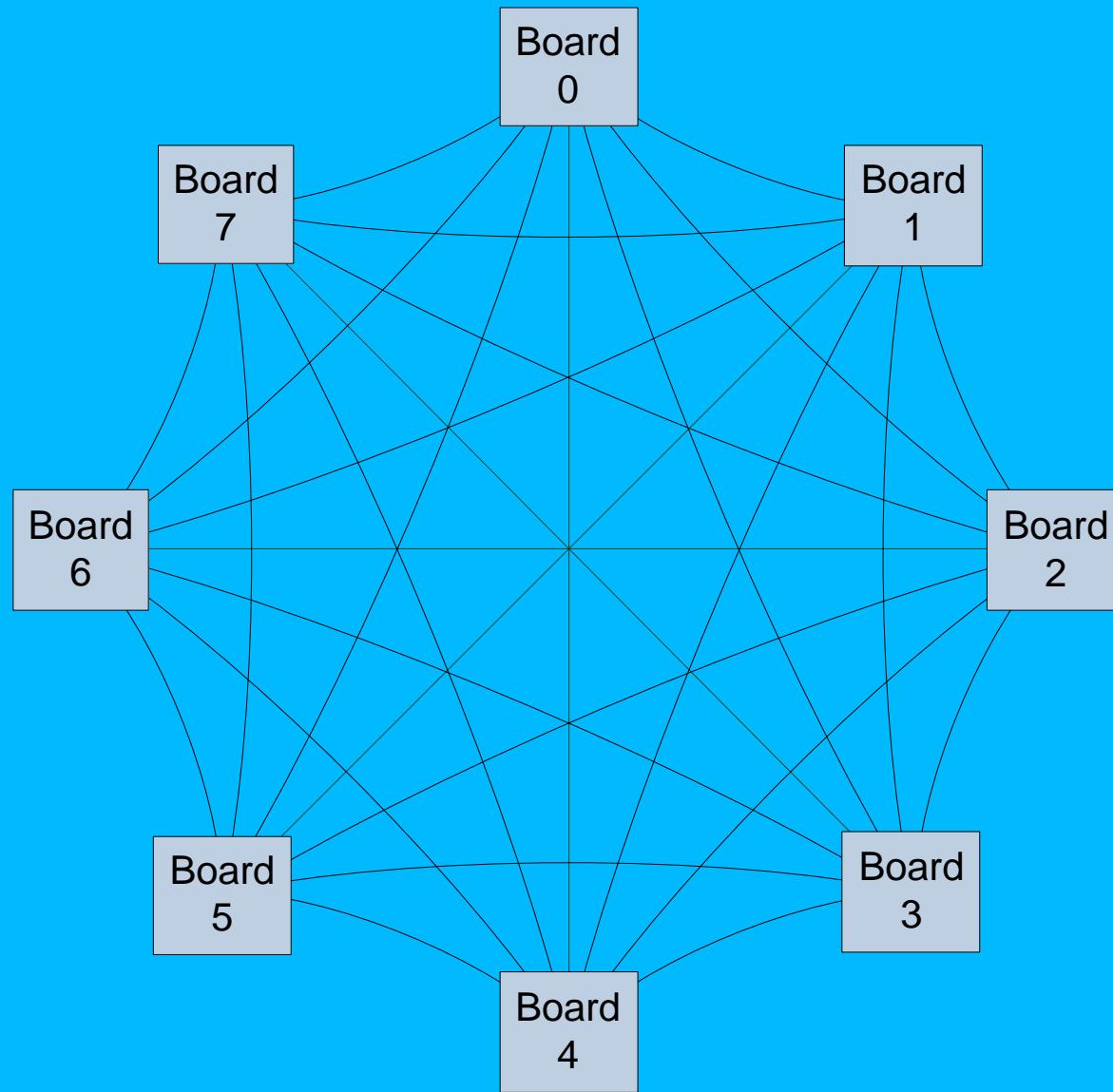
ASTRON

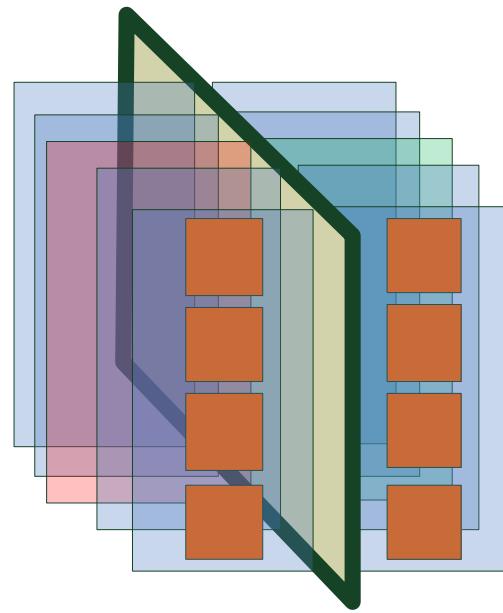




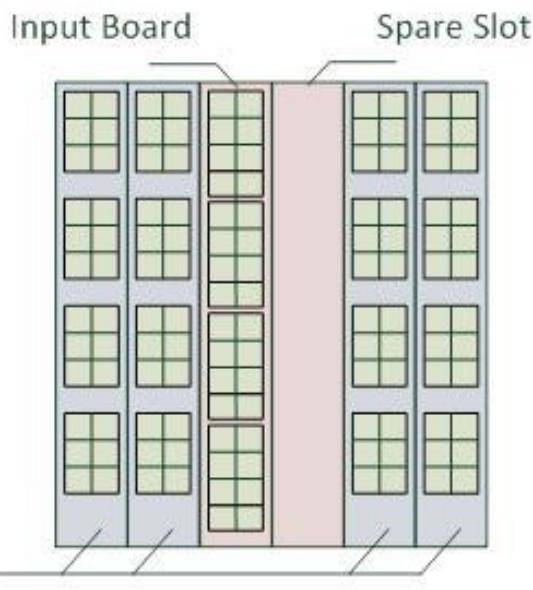
# Correlator Section Interconnections

ASTRON

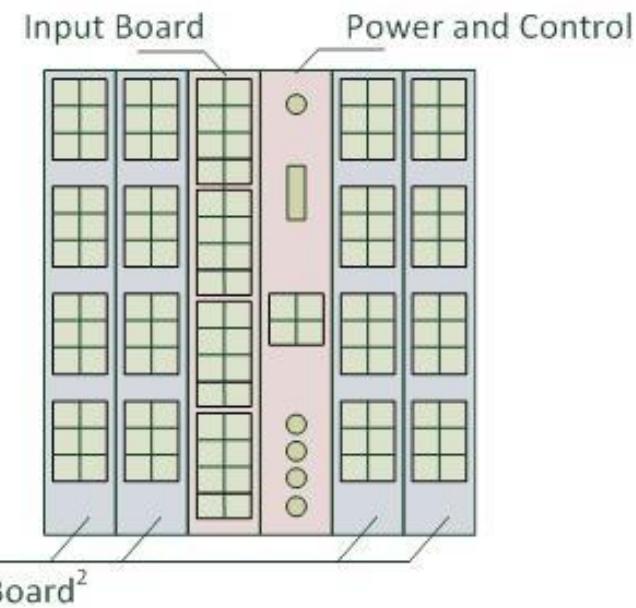


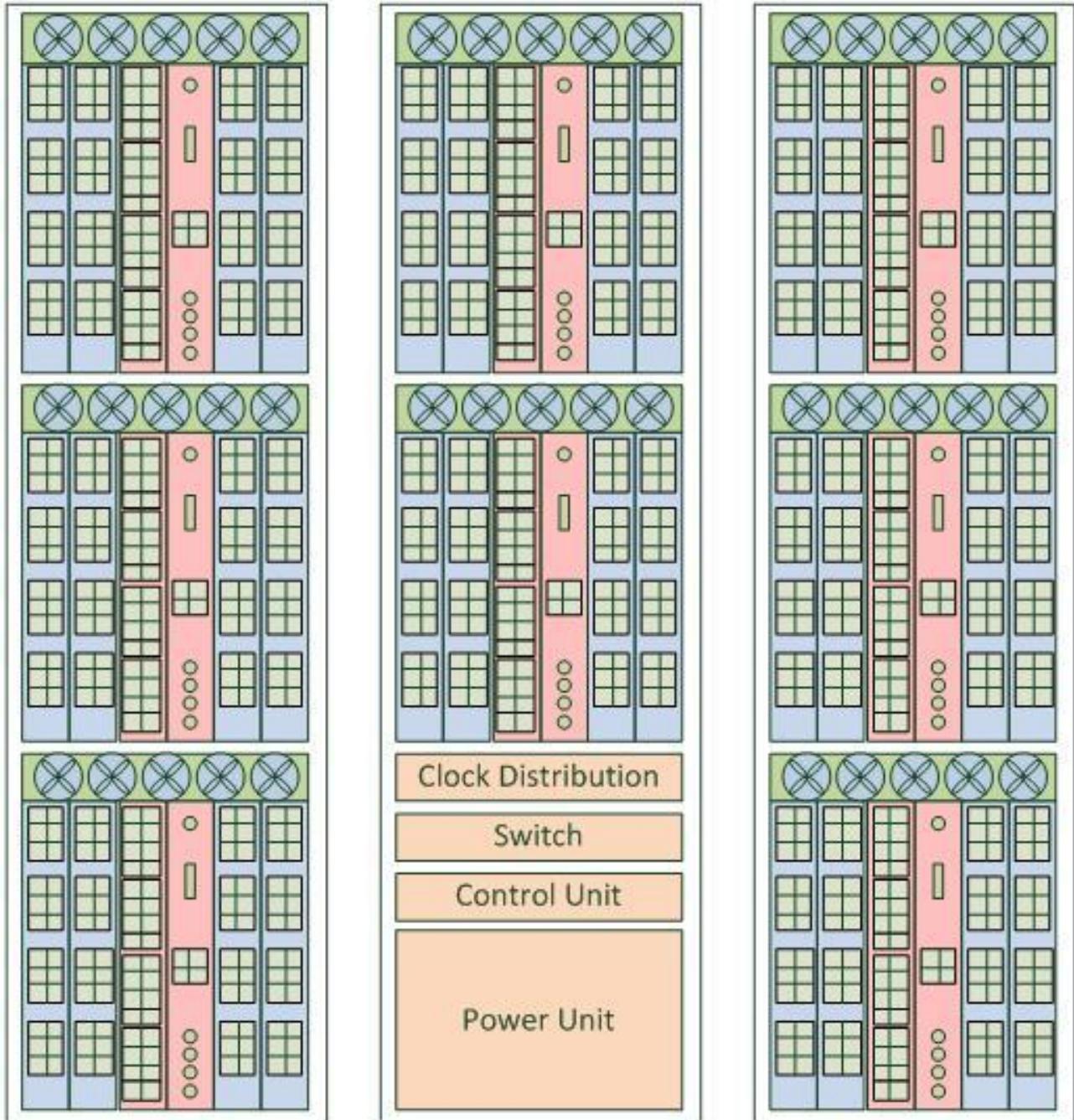


Front Side



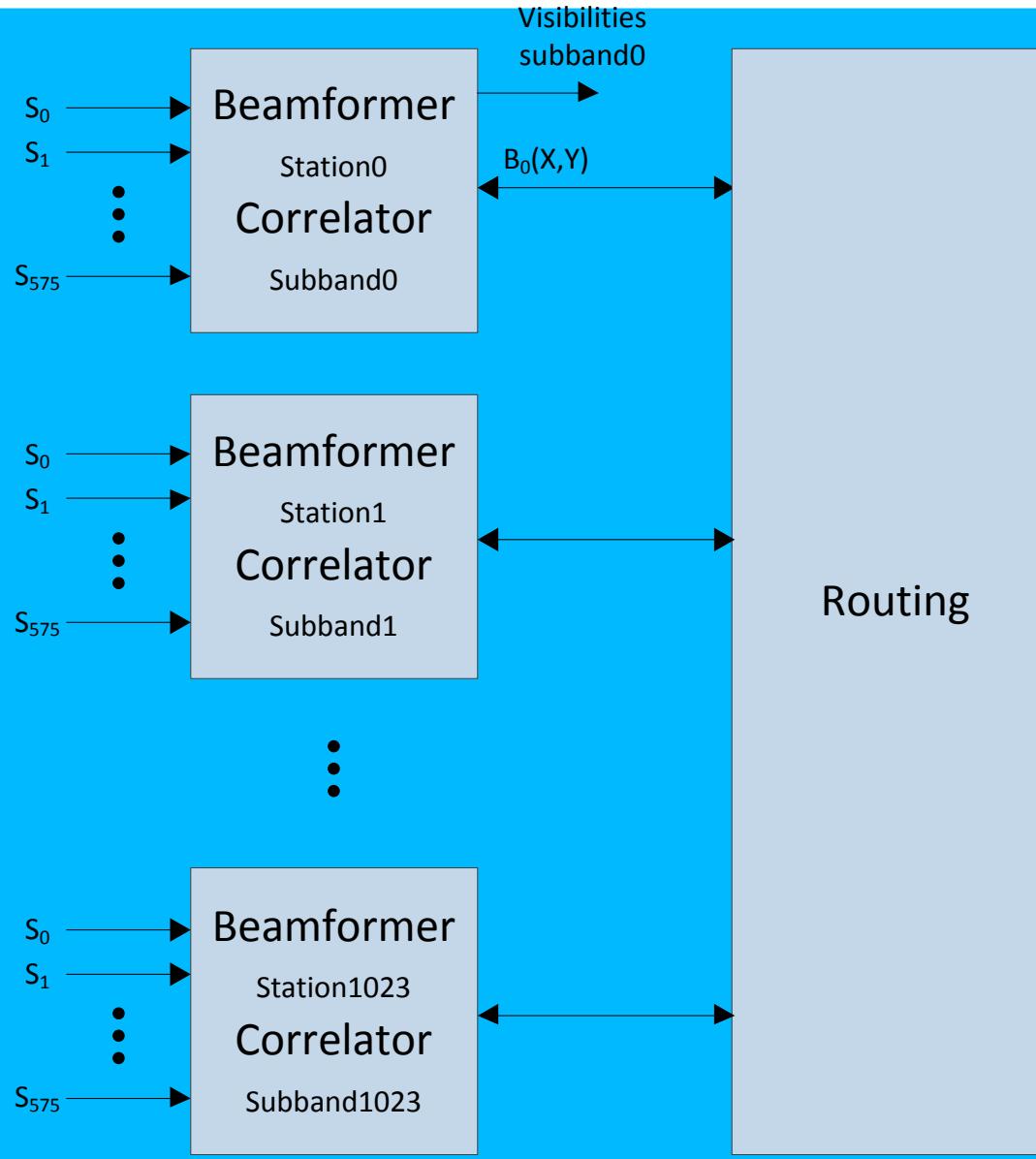
Back Side





# Integrated Beamformer & Correlator

ASTRON



# Conclusions



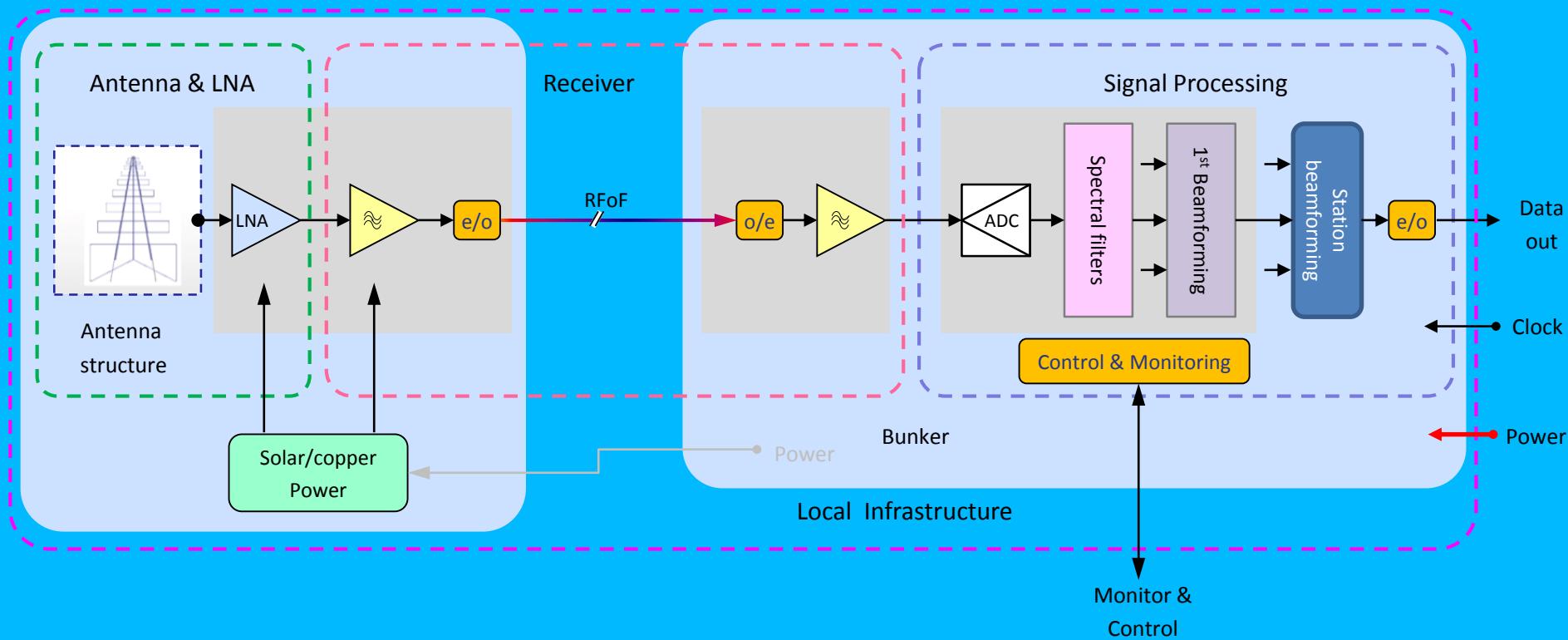
- UniBoard<sup>(2)</sup> aims for data intensive and streaming systems using simple operations on loads of data
- UniBoard<sup>(2)</sup> targeted for large systems (like the SKA)
- Standard interfaces increases the usability (not restricted to radio astronomy)
- UniBoard<sup>2</sup> is built on the experiences with UniBoard
  - System
  - Board
  - Firmware
  - Software

The End



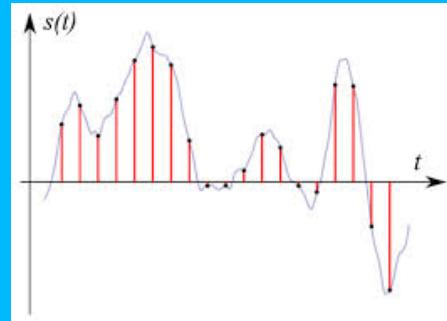
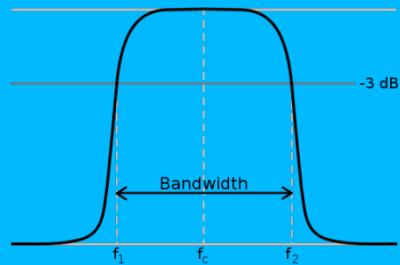
# Signal Path

ASTRON



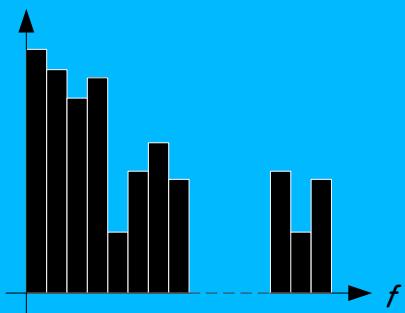
# Beamformer requirements - single polarization (I).

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Input: 400 MHz

8 bits @  
800 MSps



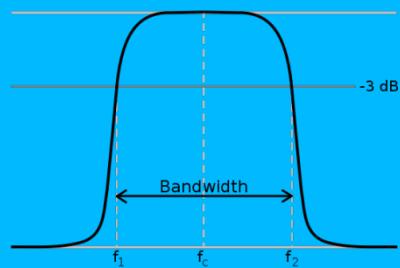
512 subbands @  
781250 Hz



64 signal inputs

# Beamformer requirements - single polarization(II).

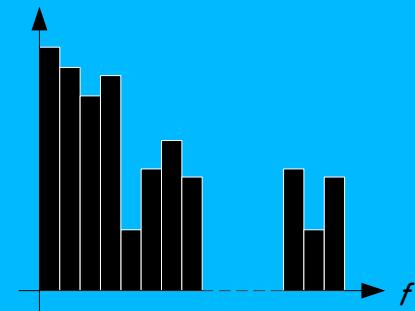
ASTRON



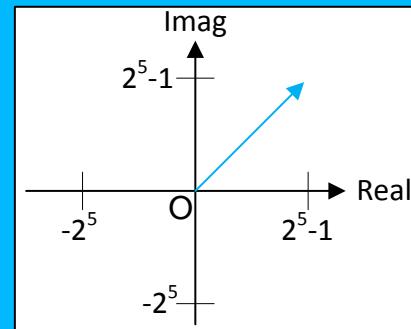
Output: 300 MHz



$\overline{37}$  beams



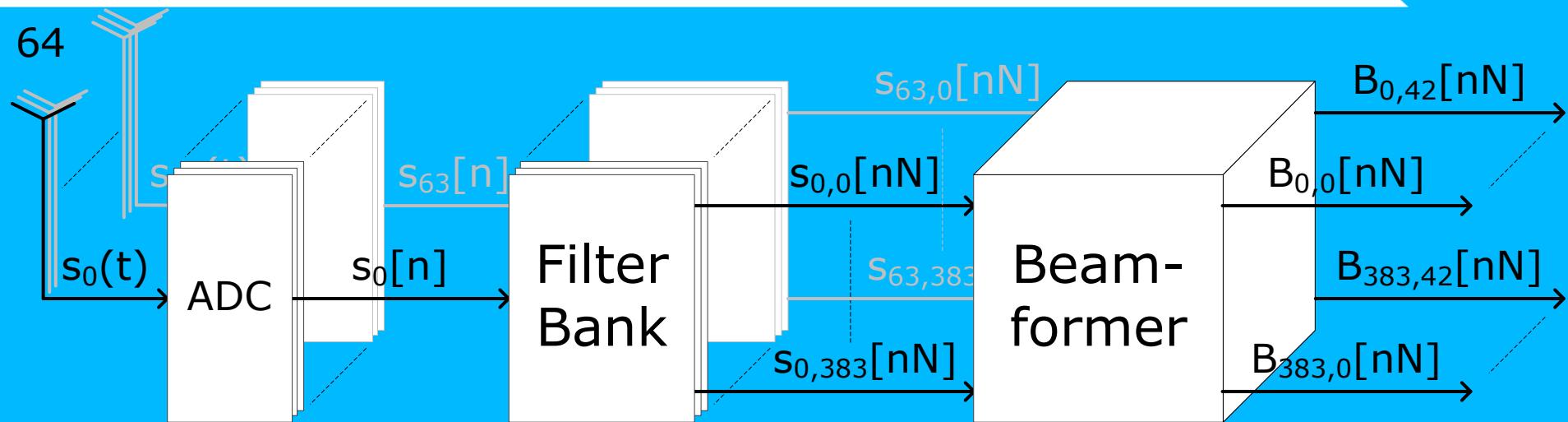
384 subbands @  
781250 Hz



6 + 6 bits  
complex

# Beamformer Block Diagram - single polarization

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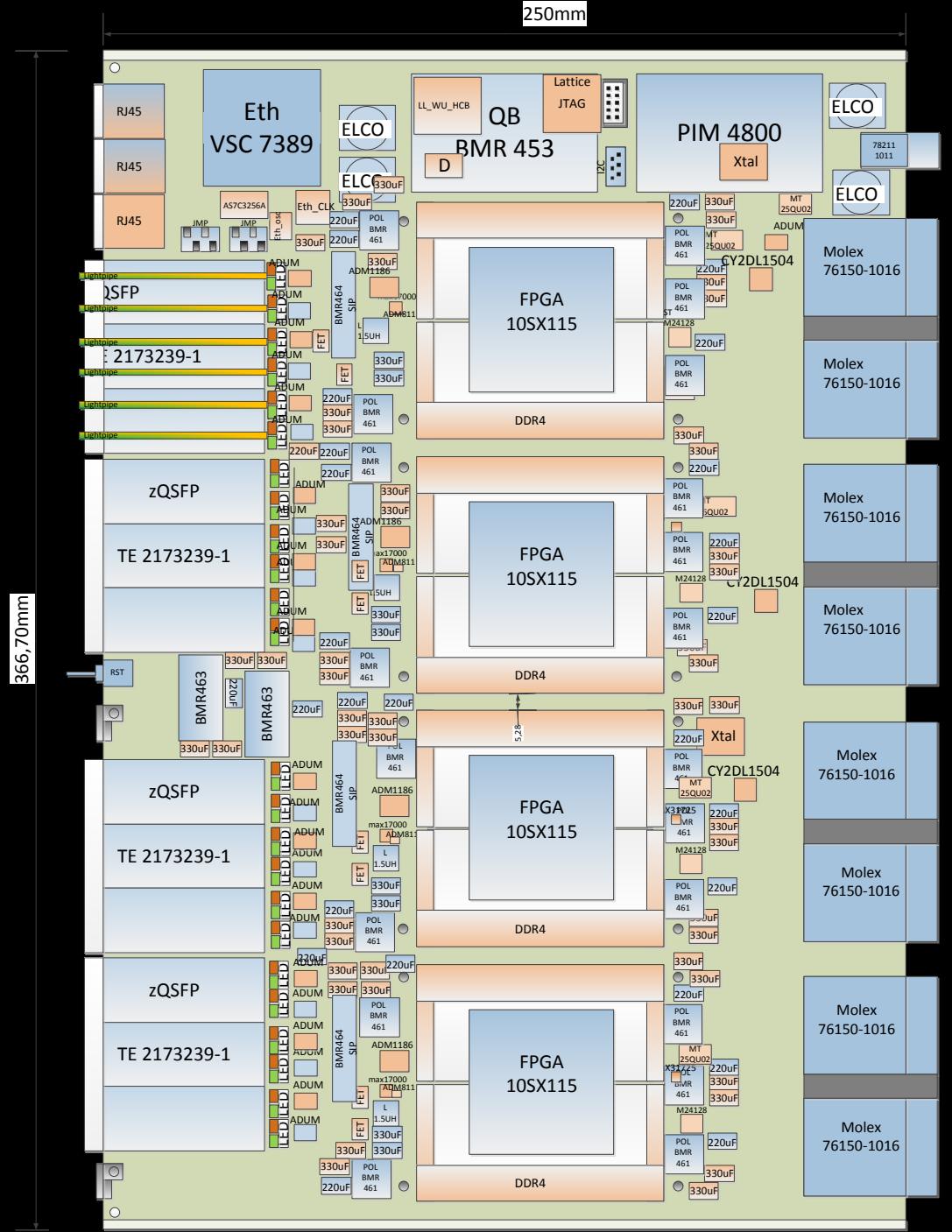


Output ADCs:  $64 \times 800\text{MHz} \times 8 \text{ bit} = 410 \text{ Gbit/s}$

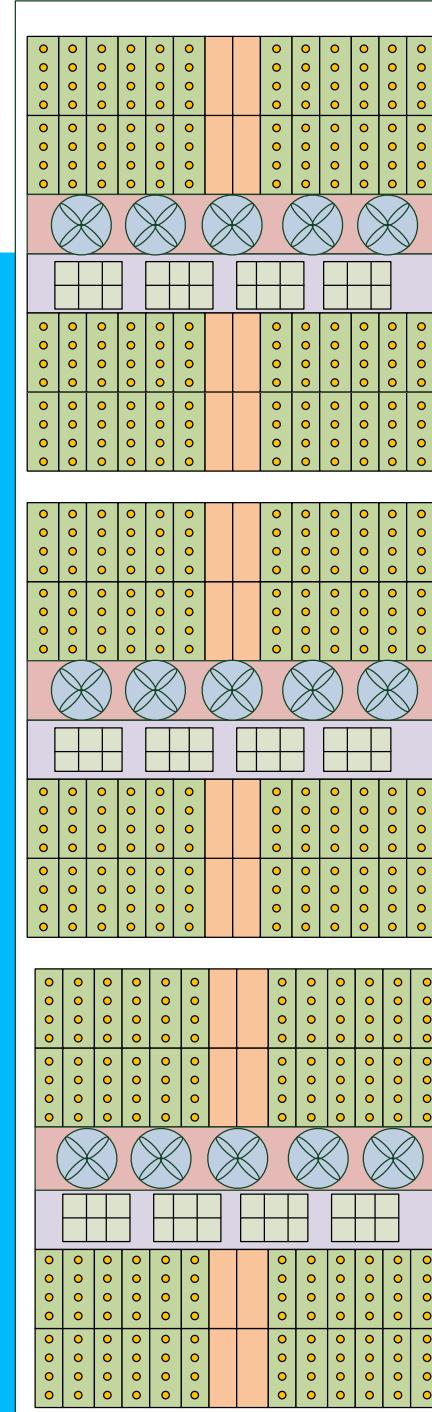
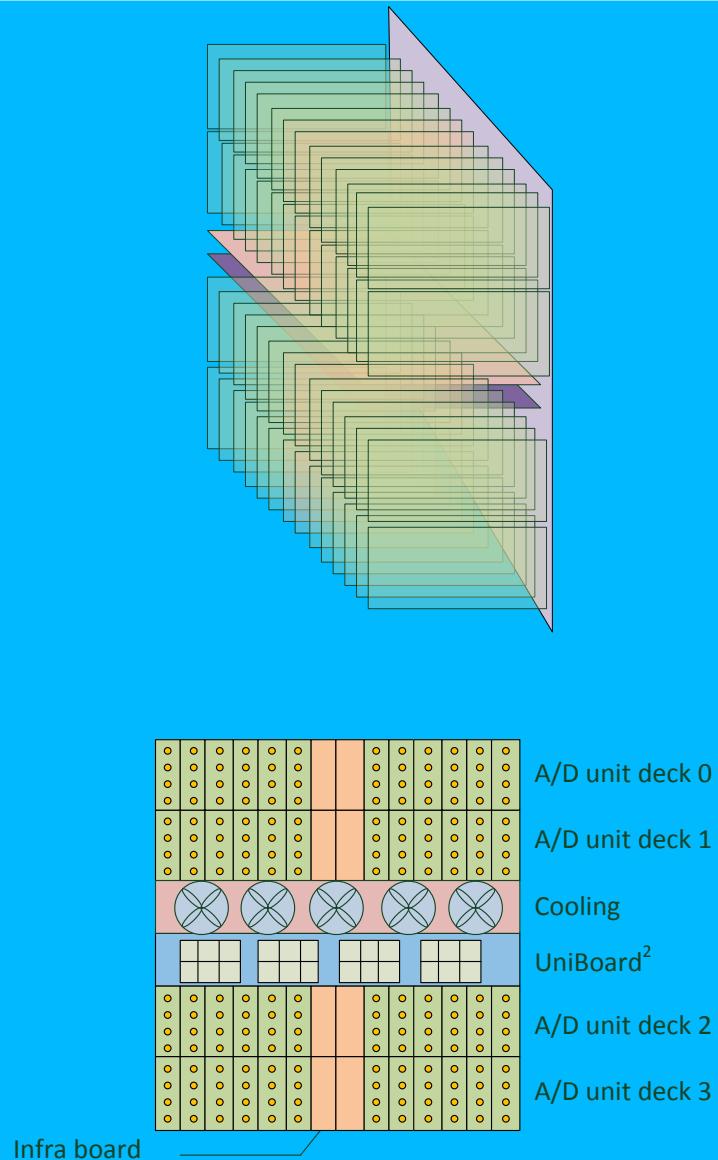
Input Beamformer:  $64 \times 384 \text{ subbands} \times 781.25 \text{ kHz} * (16 + 16) \text{ bit} =$   
**614.4 Gbit/s**

Output Beamformer:  $42 \times 384 \times 781.25 \text{ kHz} * (6 + 6) \text{ bit} =$   
**151.2 Gbit/s**

Processing: **806 Giga-multiplications per second**



# Alternative Solution



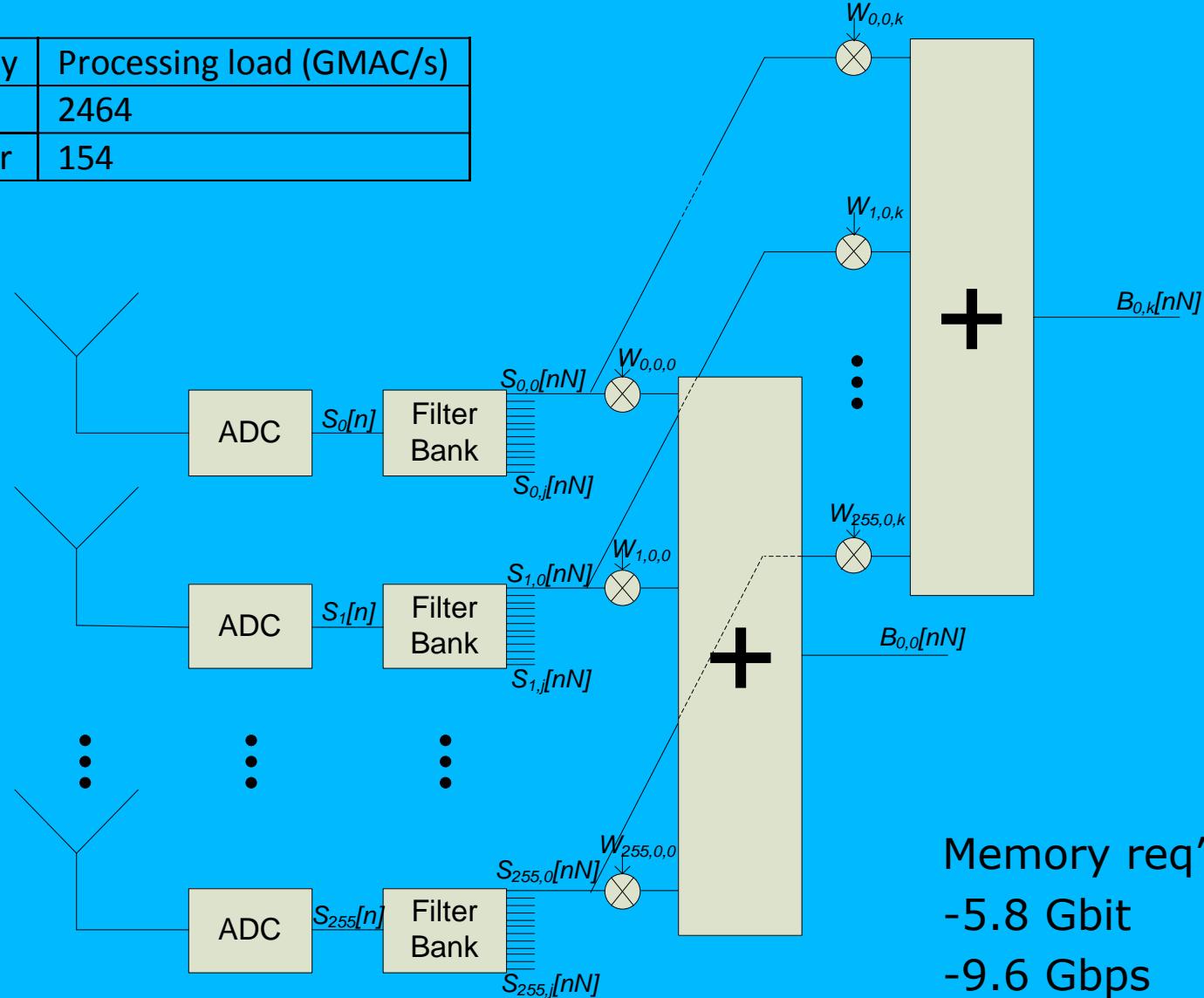
Legend:

- Clock Distribution
- Switch
- Control Unit
- Power Unit

# LFAA Station Functional Diagram

**ASTRON**

Functionality	Processing load (GMAC/s)
Filterbank	2464
Beamformer	154

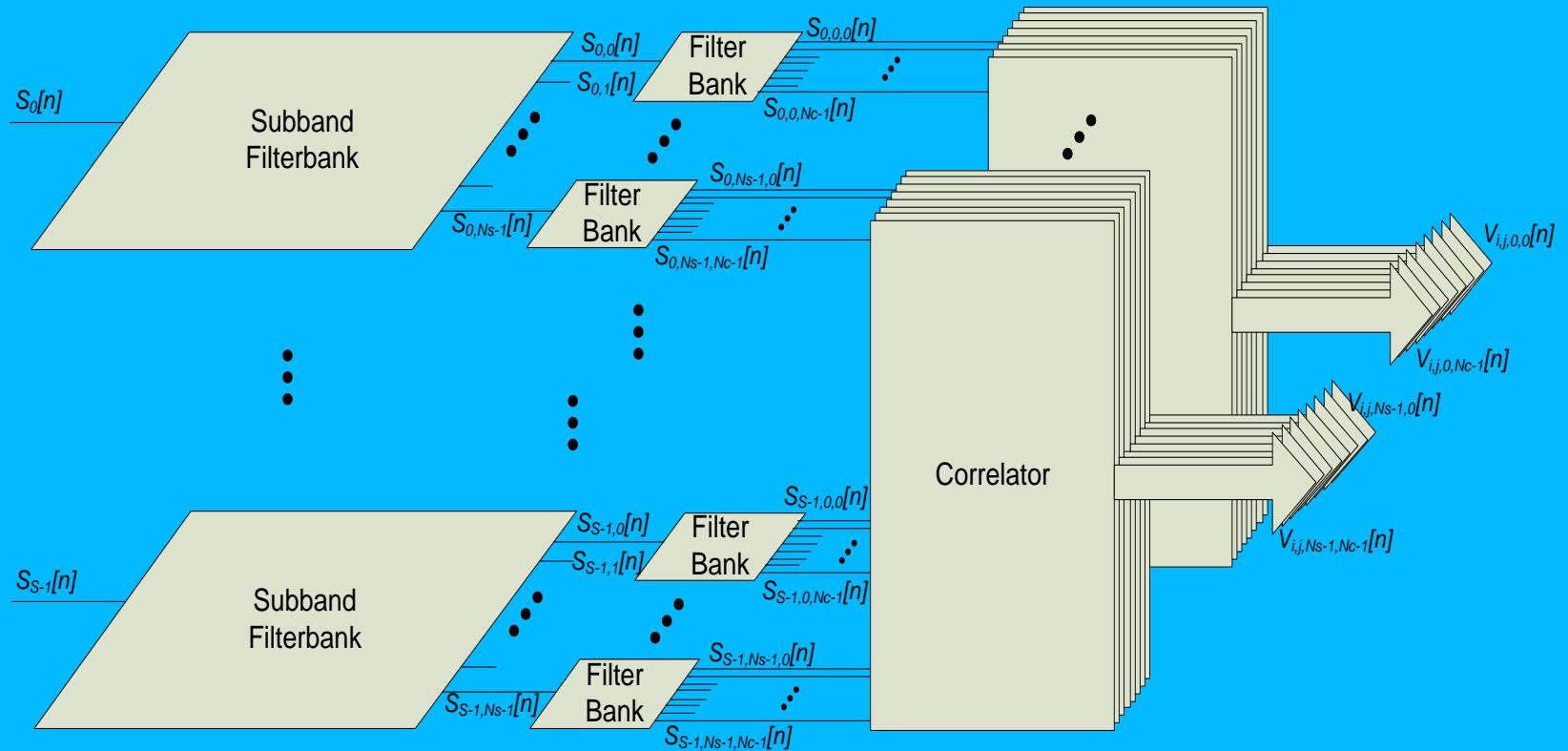


Memory req's/station:  
 - 5.8 Gbit  
 - 9.6 Gbps

# SKA Low Correlator

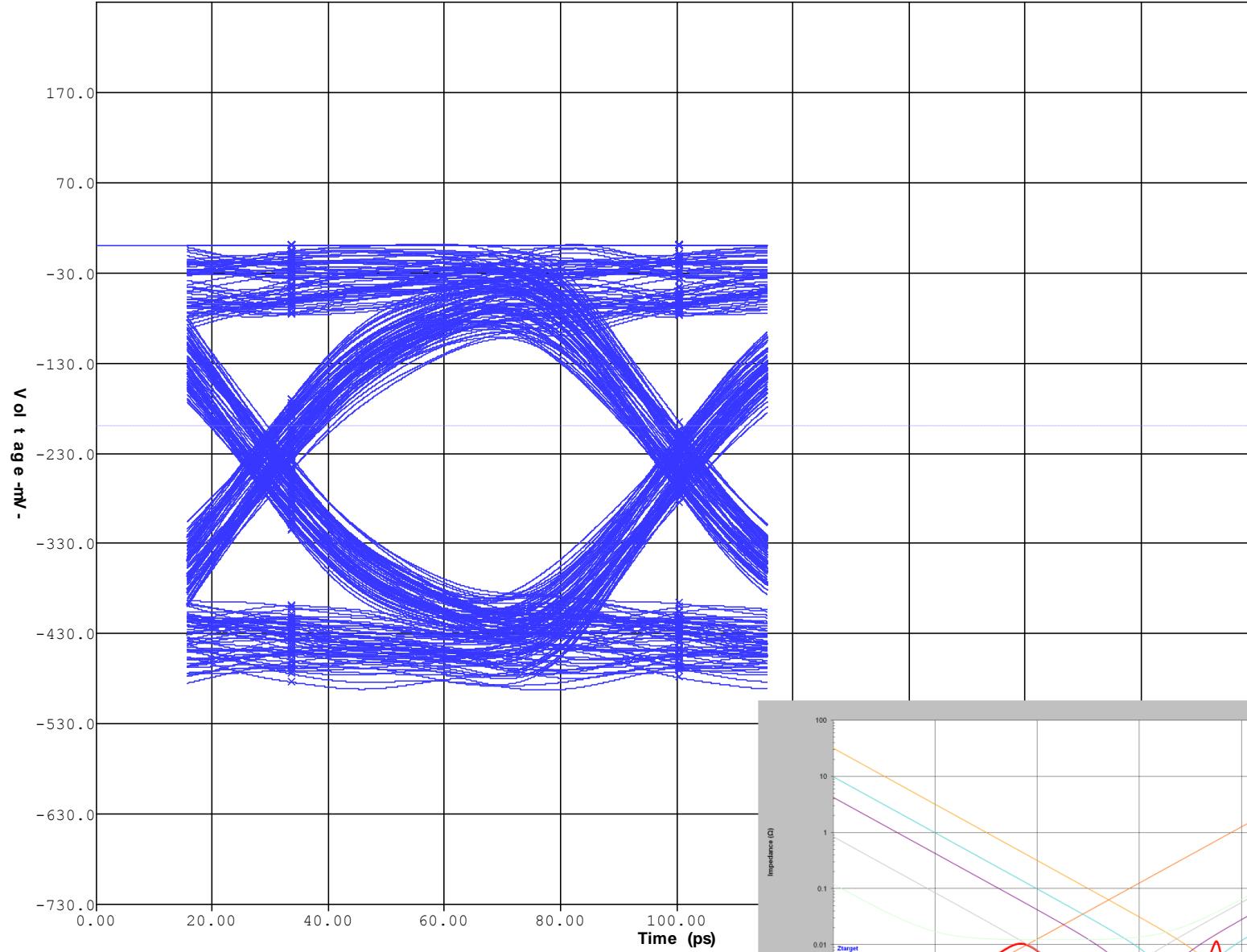
ASTRON

Functionality	Processing load (TMAC/s)
Filterbank	23.6
Fringe stopping	1.5
Correlator	2519



$\sim 20$  Tbps

59 Tbps



Date: Mon

