



International LOFAR station hardware

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University of Tromsø, Norway

KAIRA-UIT-PRS-507

January 2018



UiT

NOREGS
ARKTISKE
UNIVERSITET

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Introduction to LOFAR

The pan-European
VHF radio telescope



LOFAR project overview

Pan-European VHF radio telescope

Phased array system

10-90 MHz (LBA)

110-250 MHz (HBA)

$\Delta\nu = 48$ or 96 or 192 MHz

Multi-beam (244, 488 or 976)

Current stations

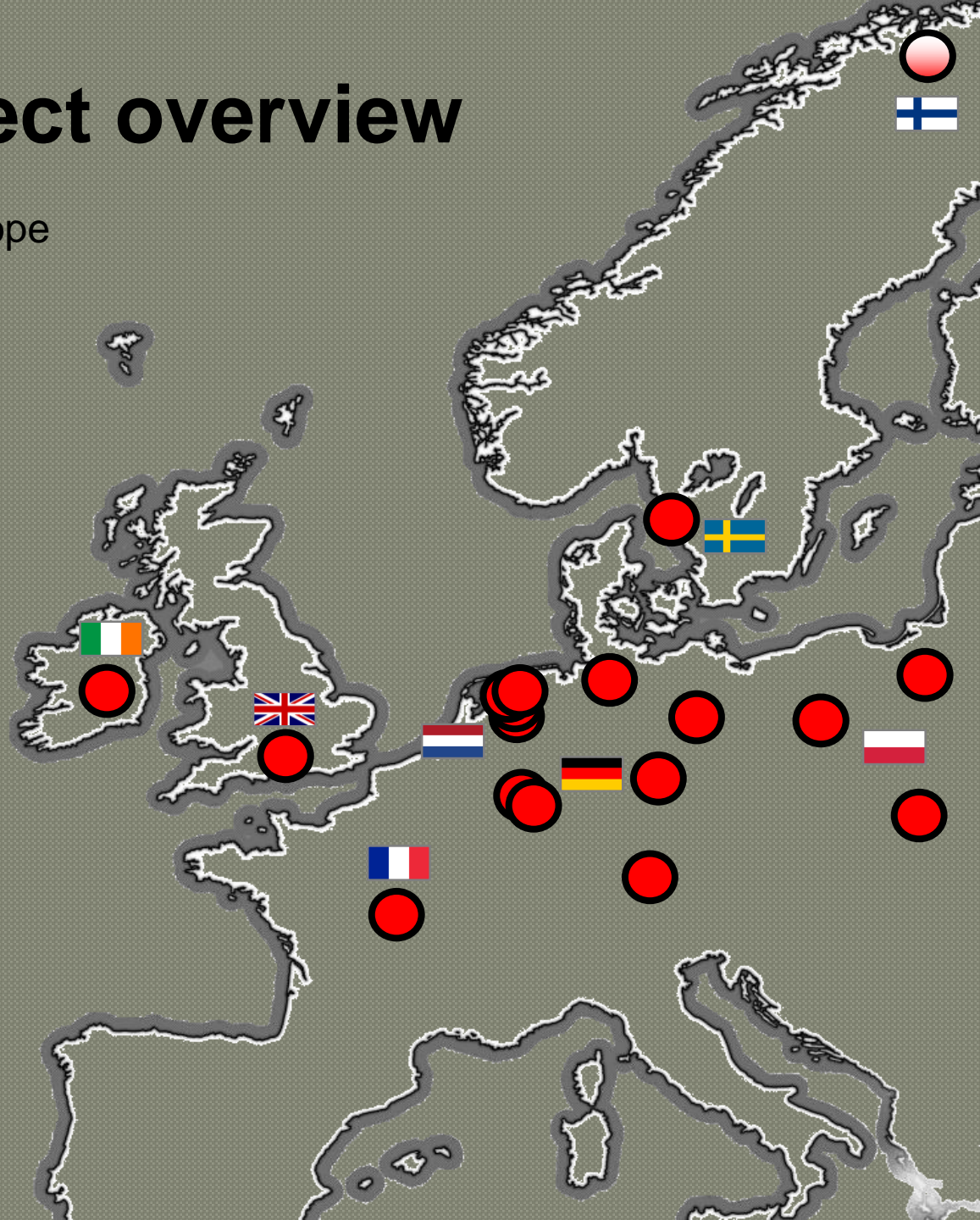
- ~23 core

- ~14 remote

All in the Netherlands

- 13 (+1) international

Germany, France, Sweden, UK, Ireland, Poland (+Finland)



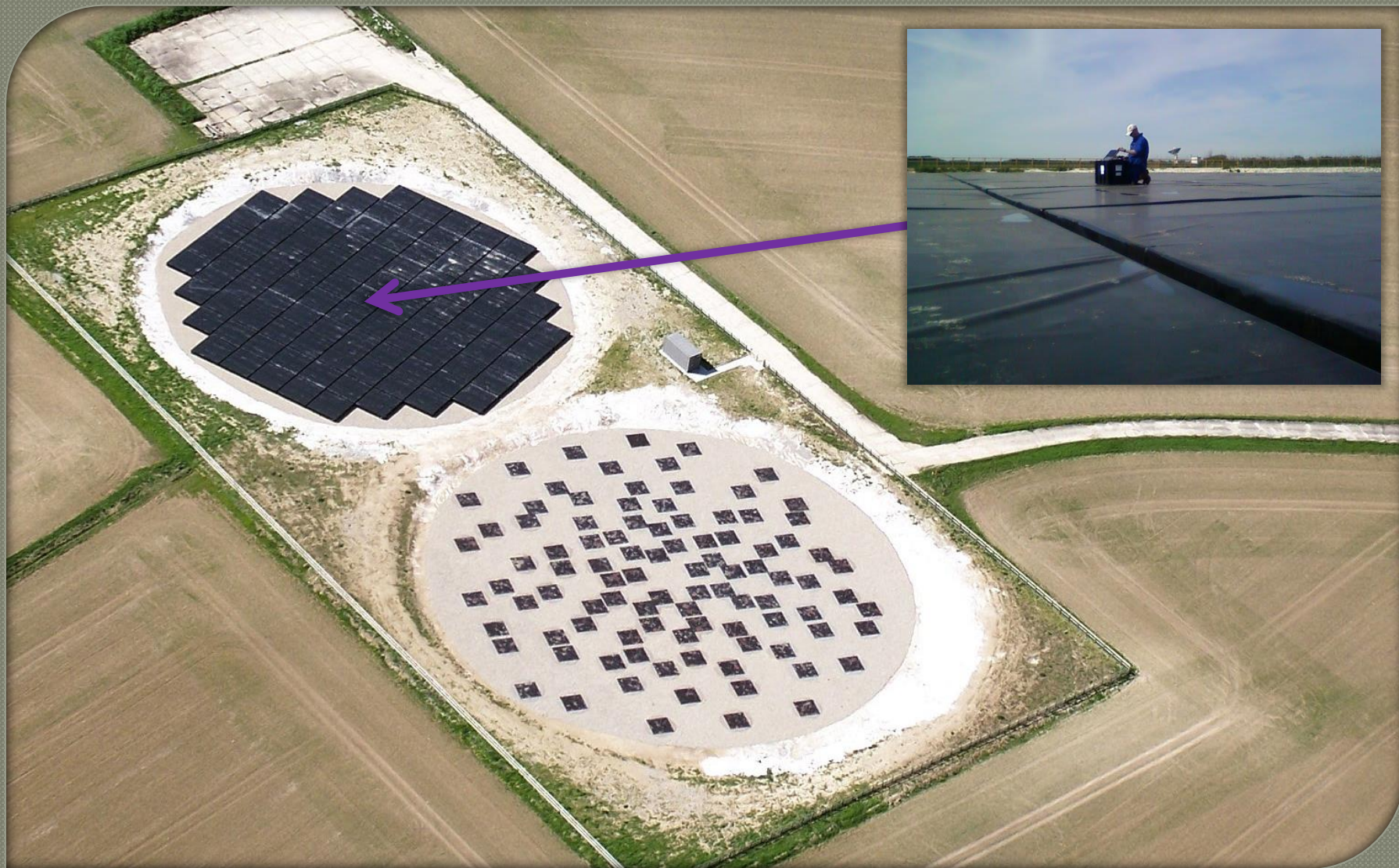


LOFAR UK608 Chilbolton



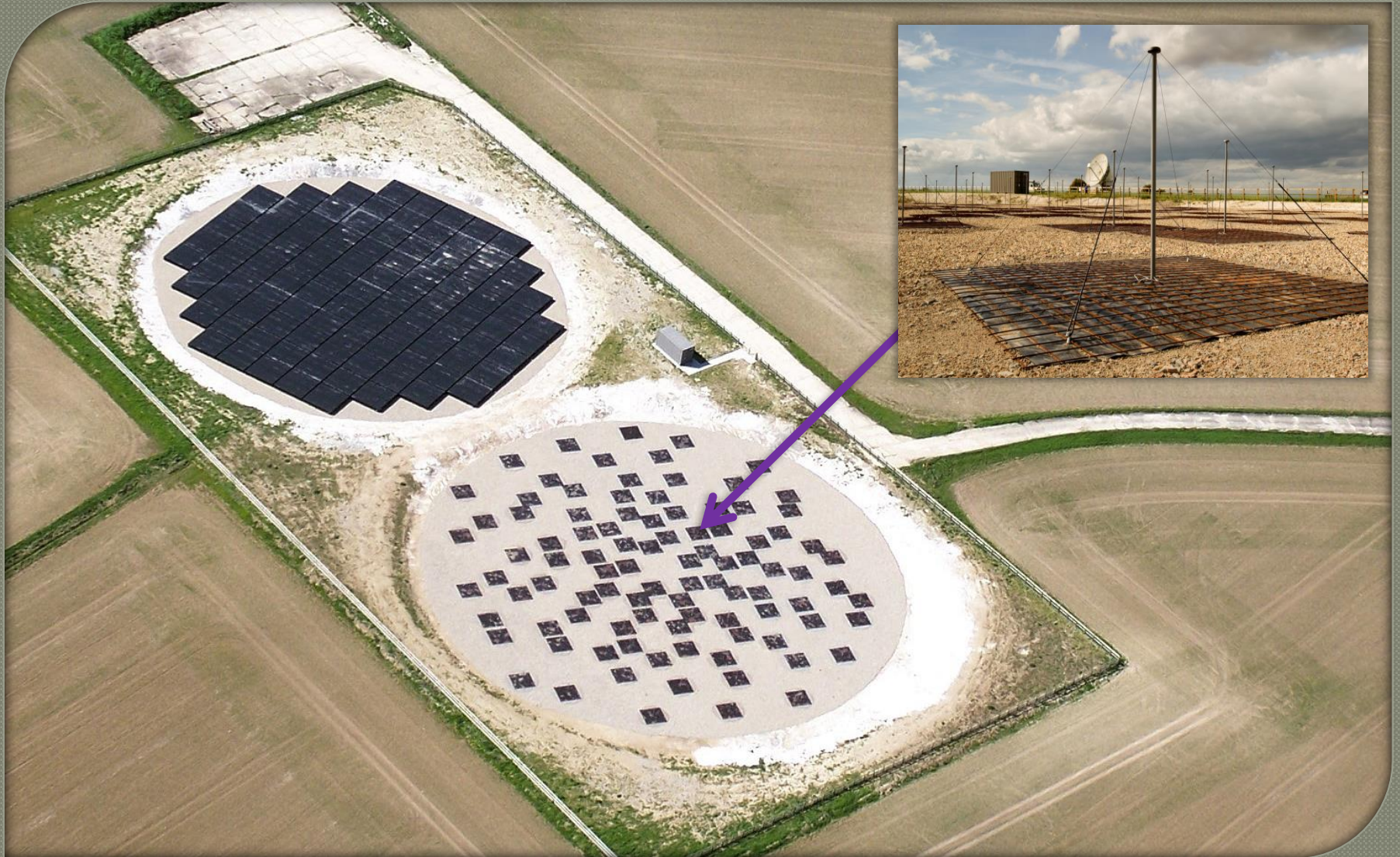


LOFAR High-Band Antenna (HBA)



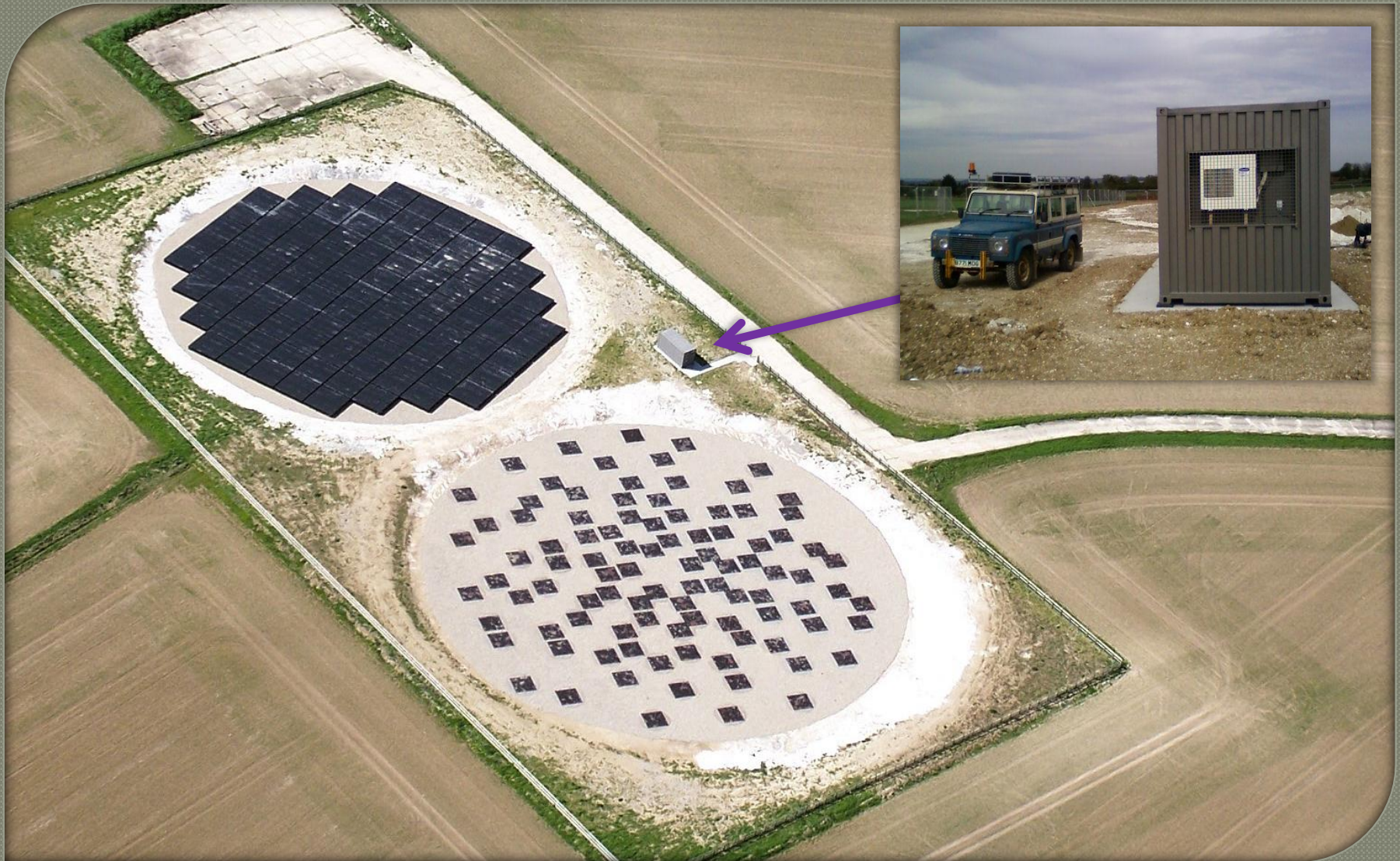


LOFAR Low-Band Antenna (LBA)





LOFAR RF-container

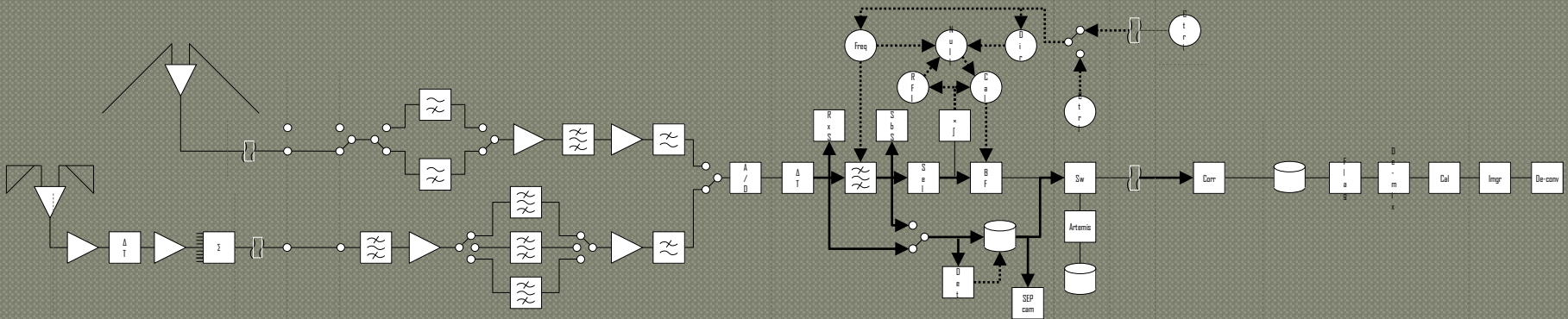


Signal processing

The complete data path

Signal processing

The complete data path





HBA
(site, 96×)

LBA
(site, 96×)



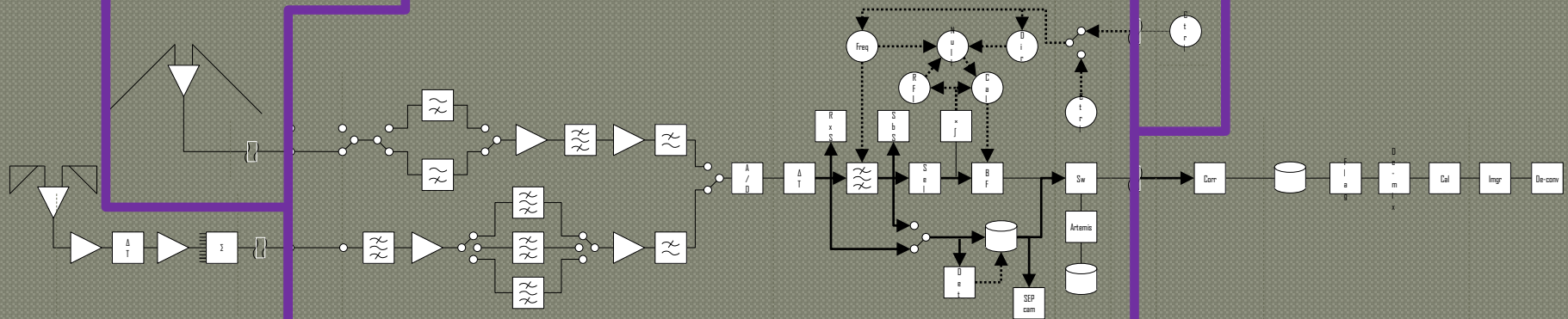
RF-container
(site)

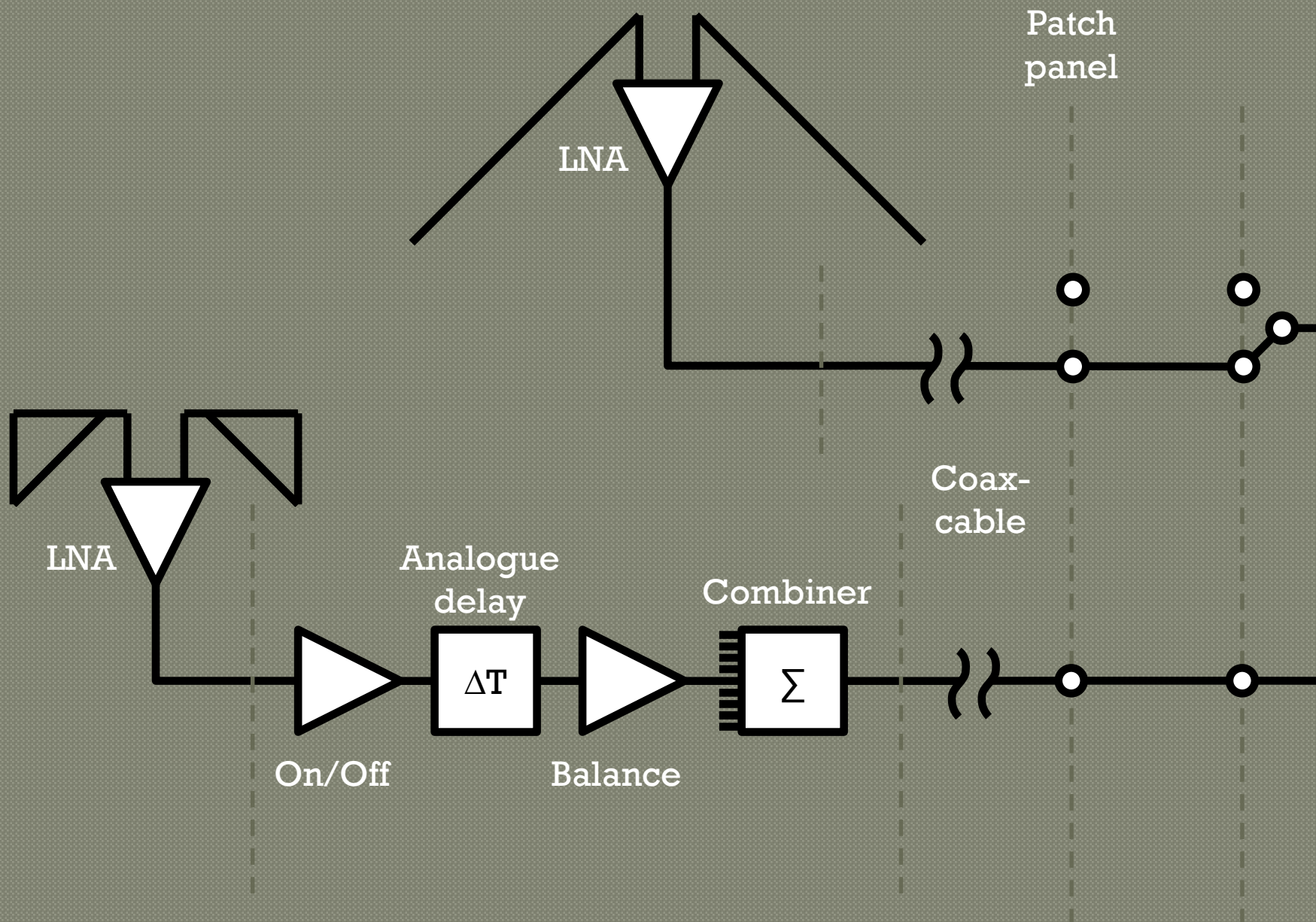


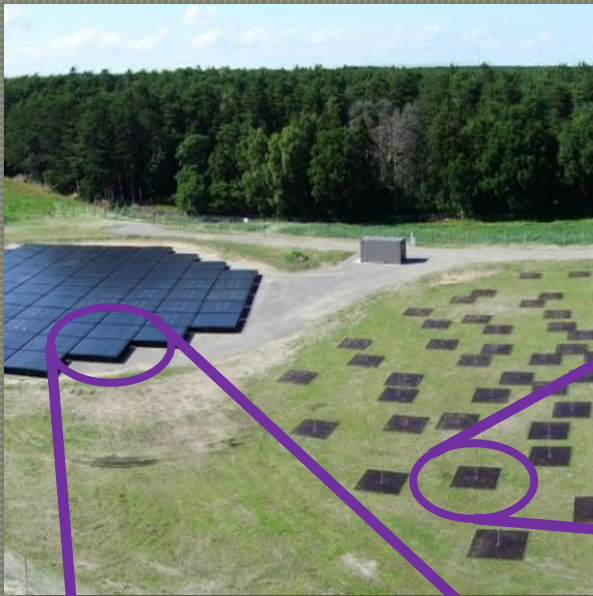
Control Centre
(Dwingeloo)



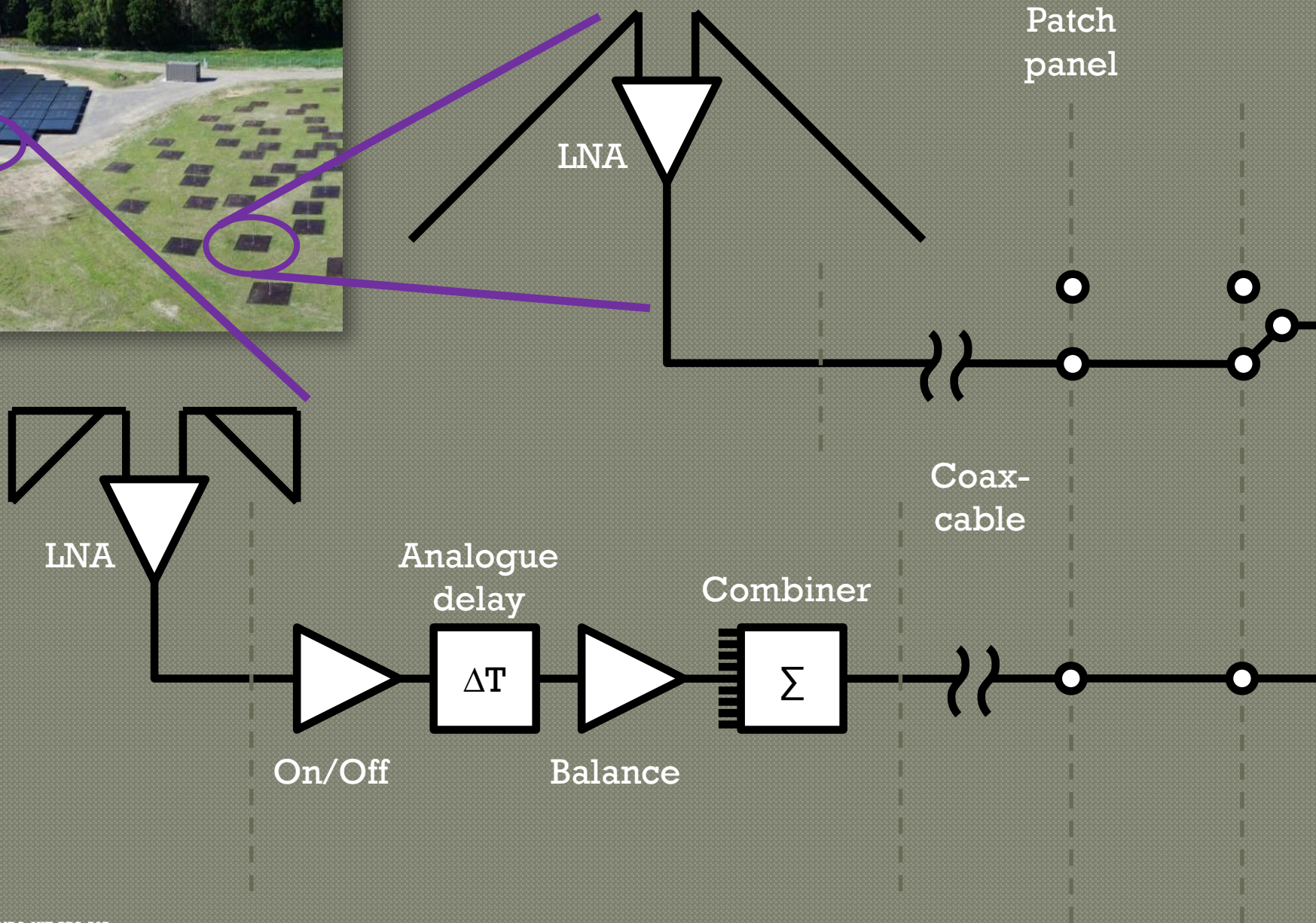
Computing
(Groningen)





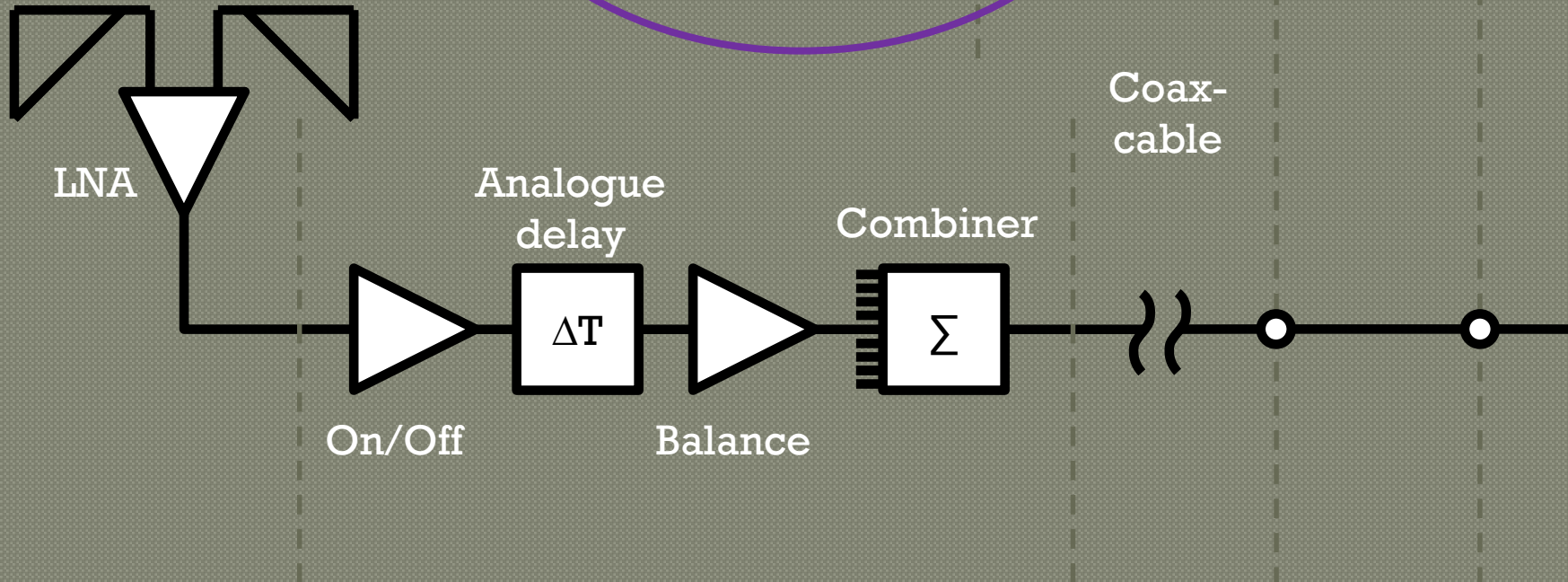
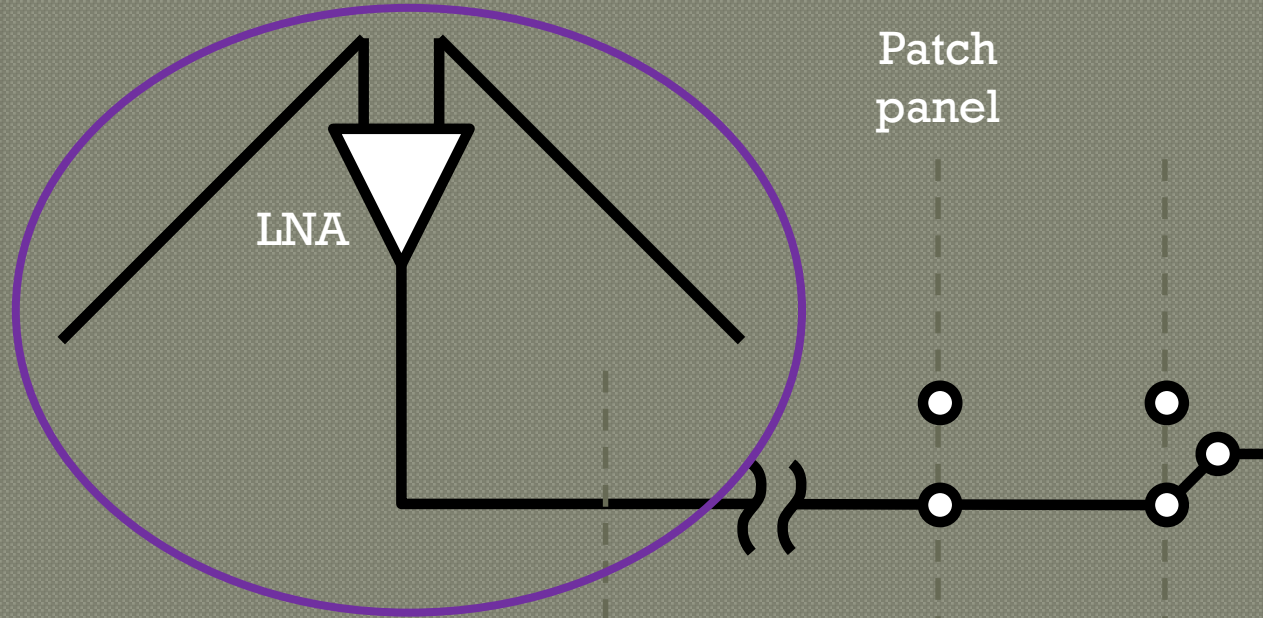


Antenna fields High-Band Array (HBA) and Low-Band Array (LBA)



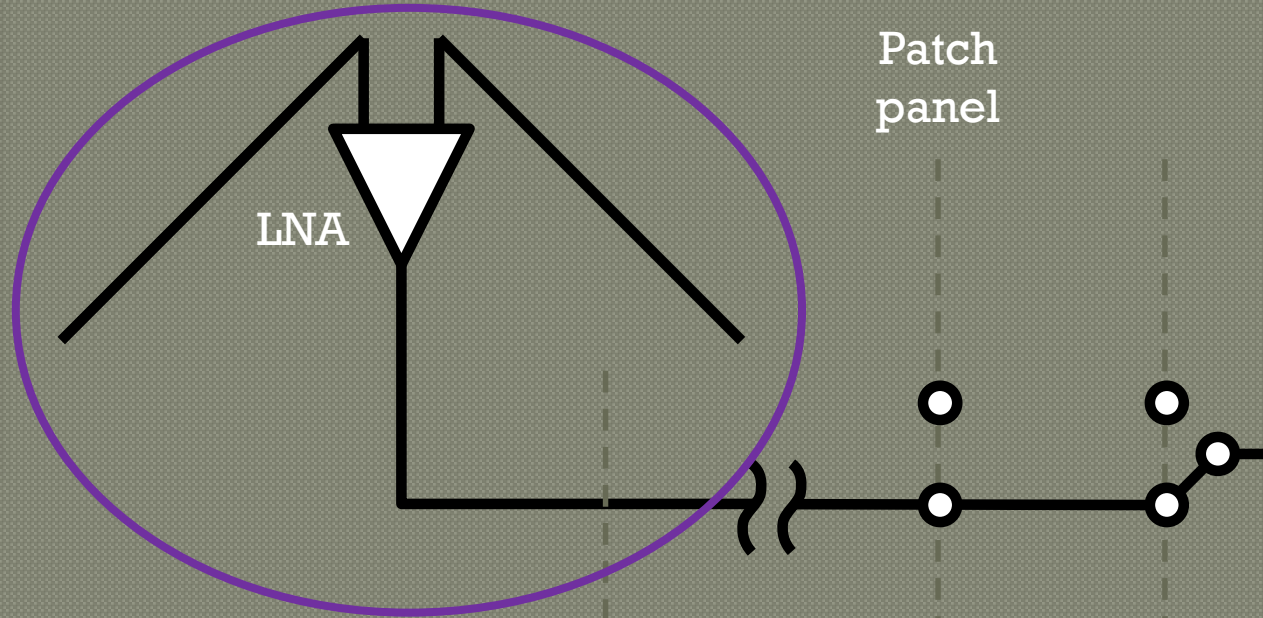


LBA aerial with dual-polarisation angled dipoles
Antenna gain ~ 7 dB

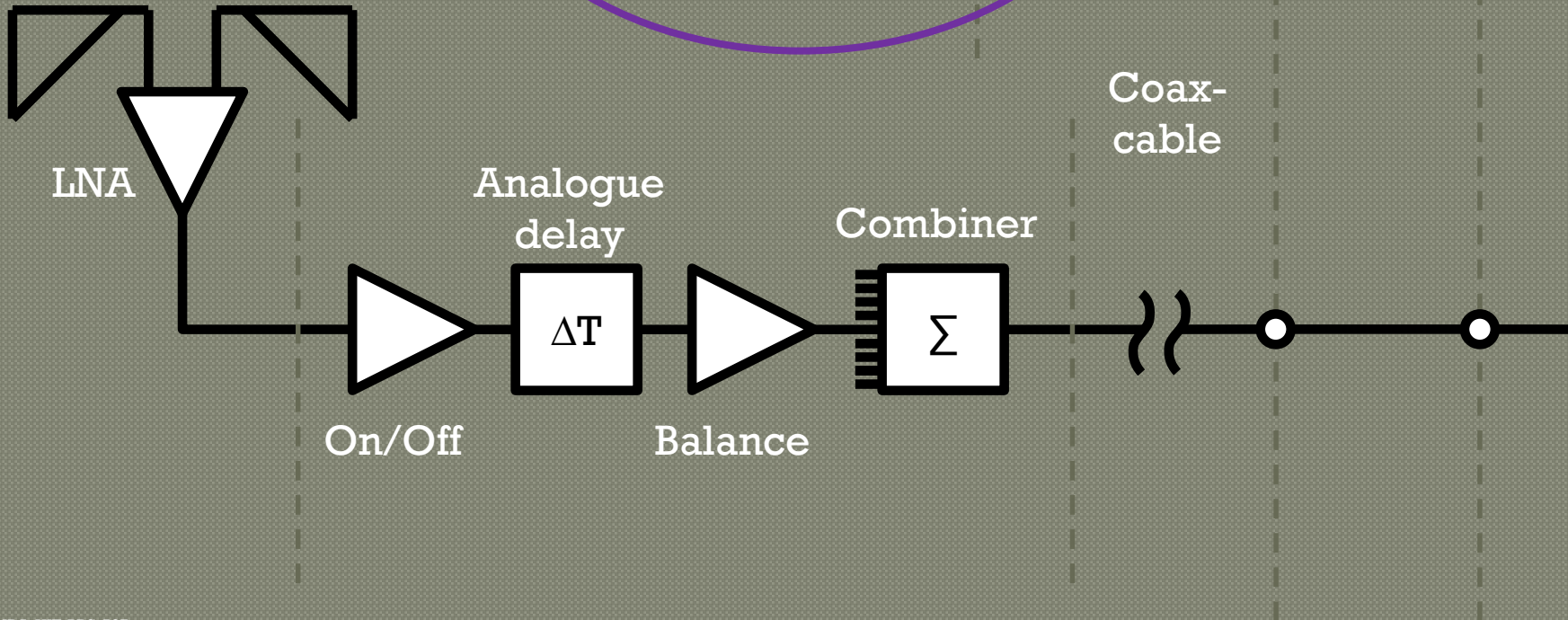




LBA aerial "LNA cap"

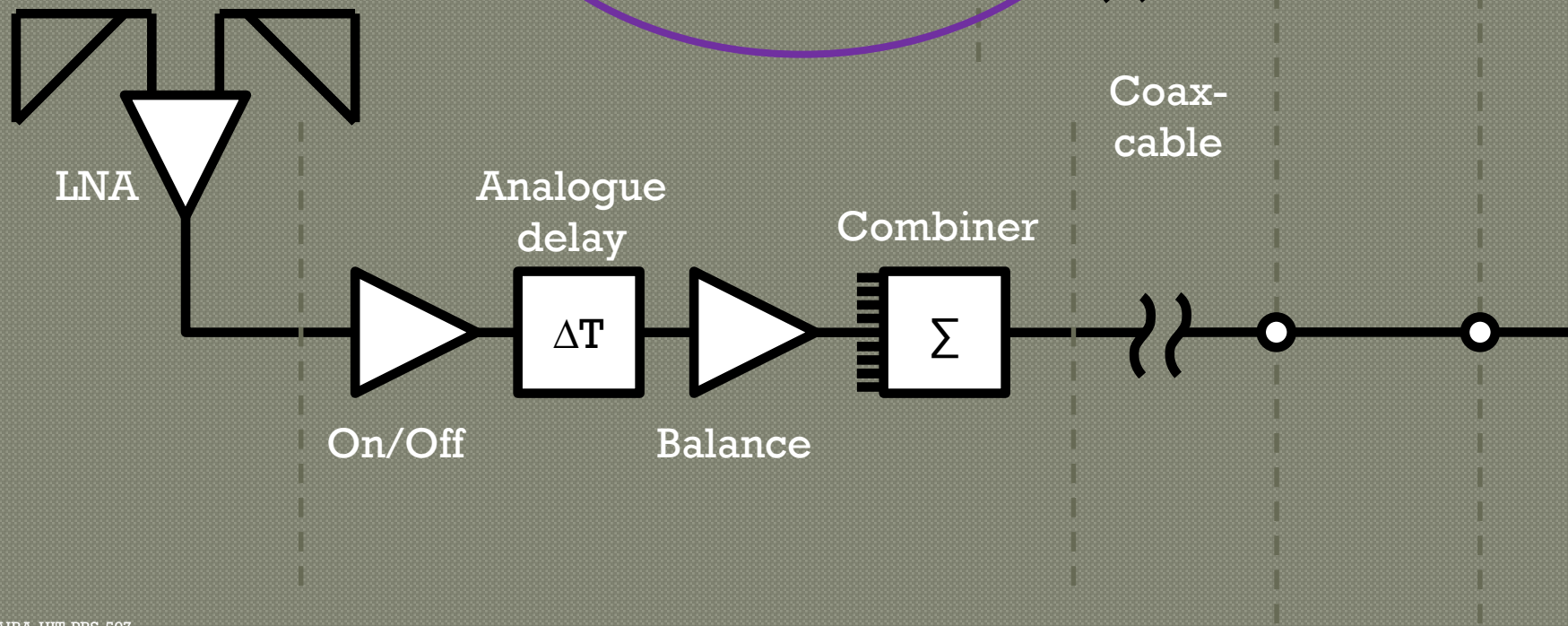
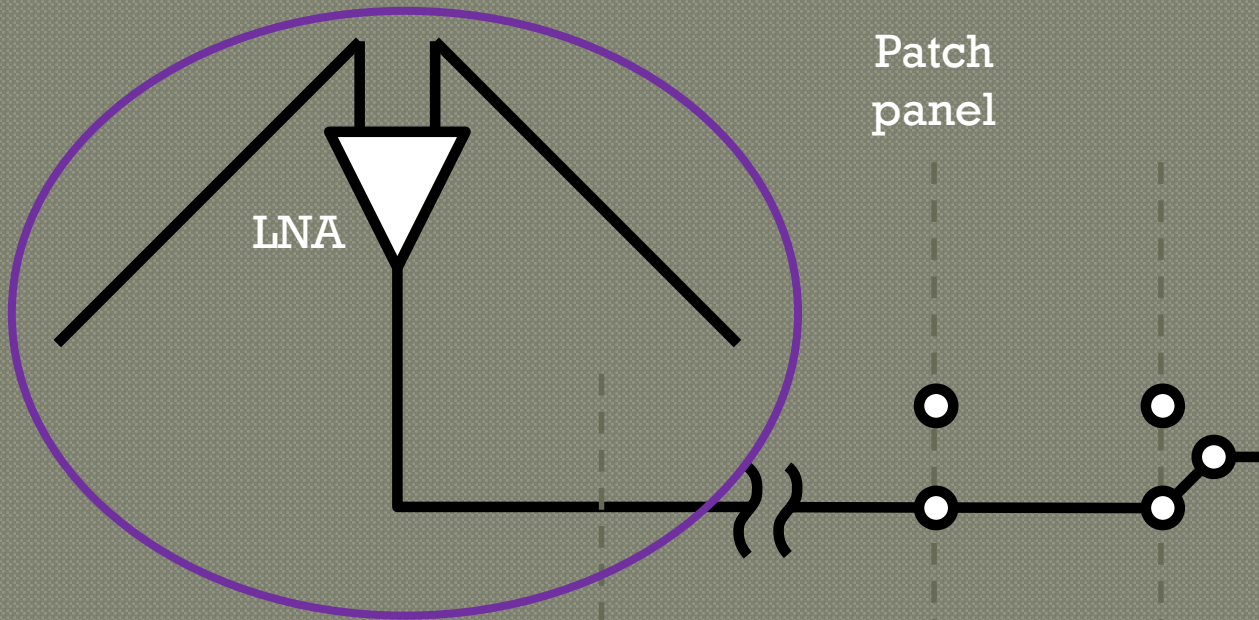


Patch panel

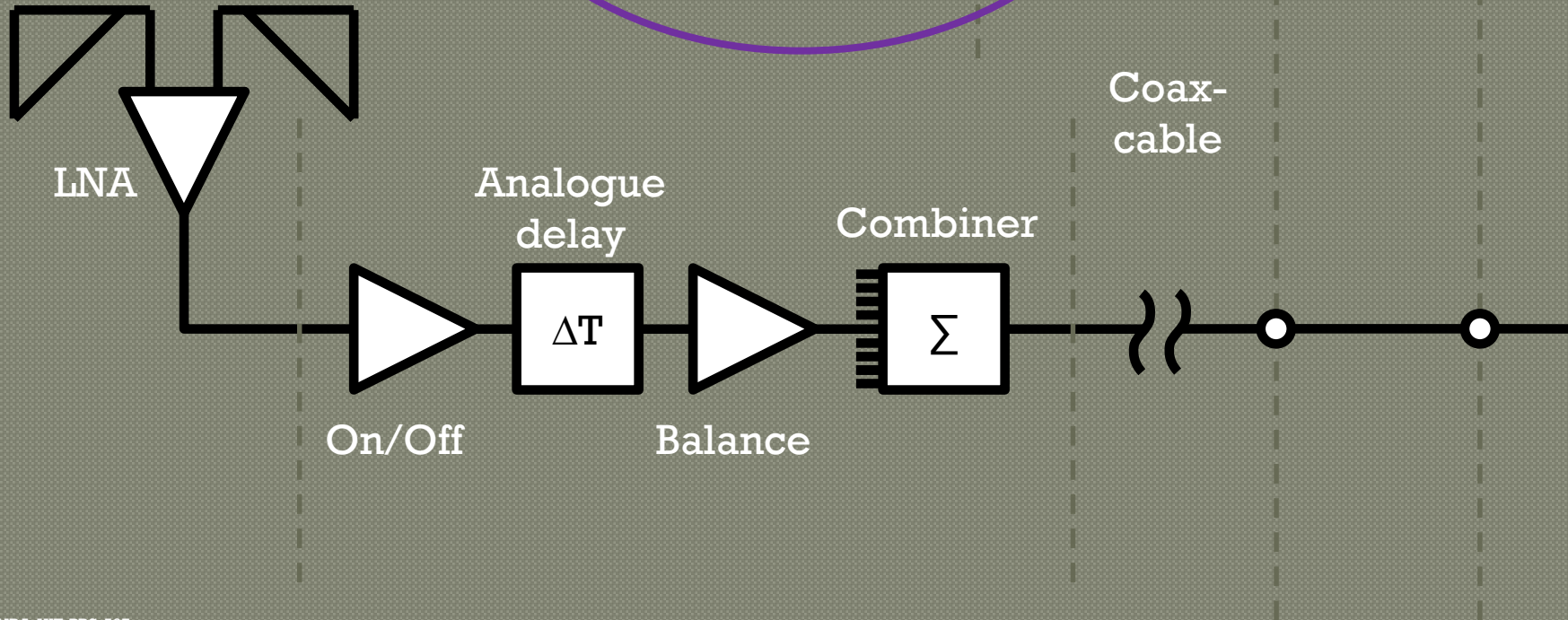
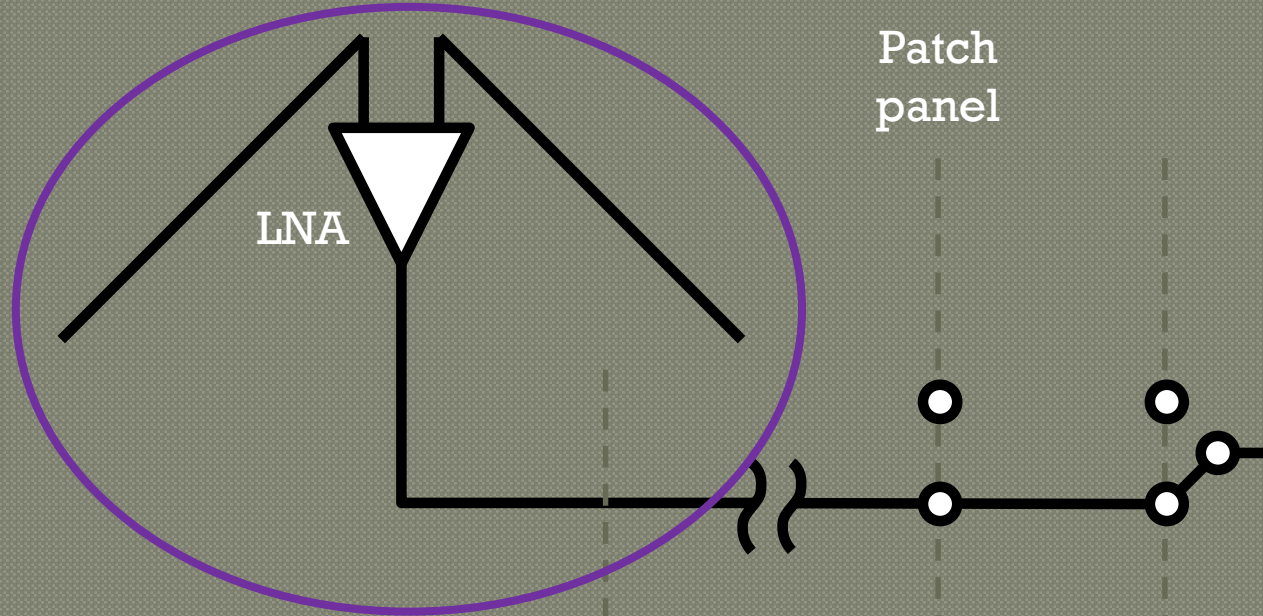


Coax-cable

Potted-resin electronics cap

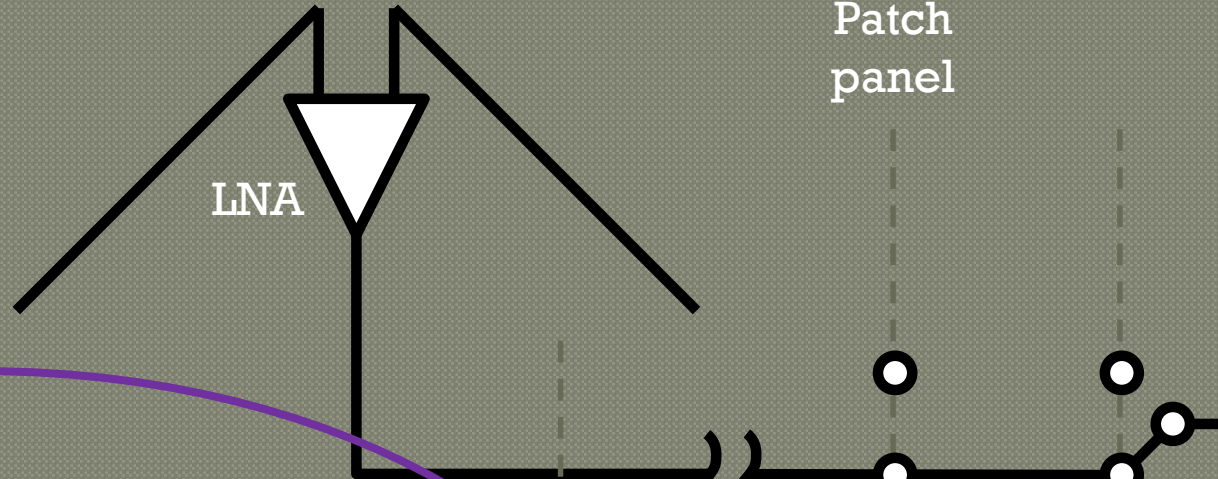


Low-Noise Amplifiers (LNAs) and F-type connectors

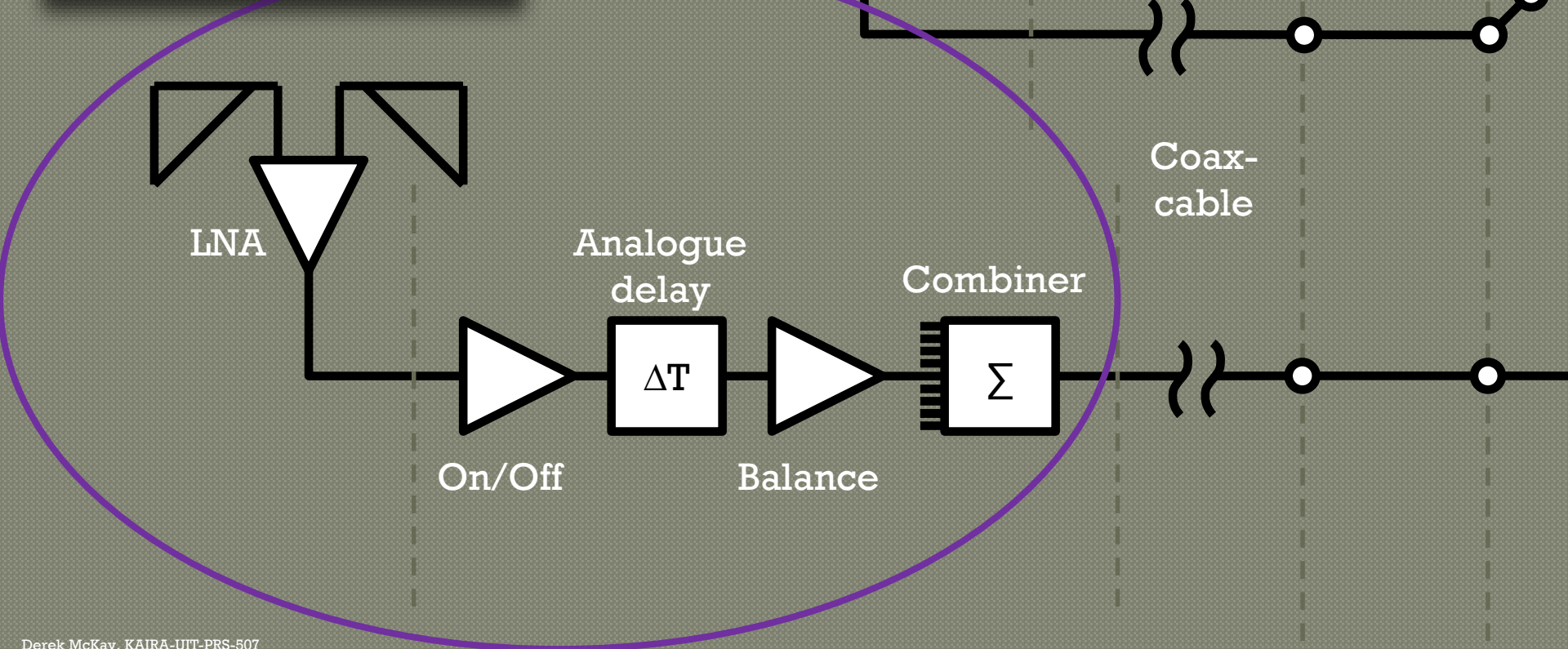




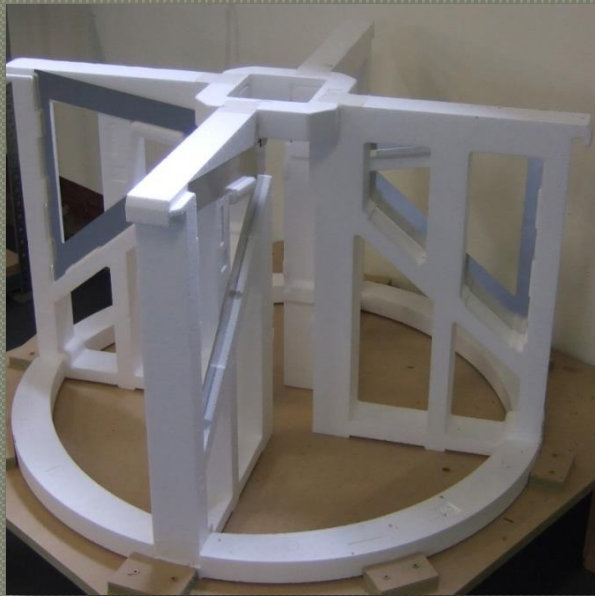
HBA tile
Antenna gain $\sim 30\text{dB}$



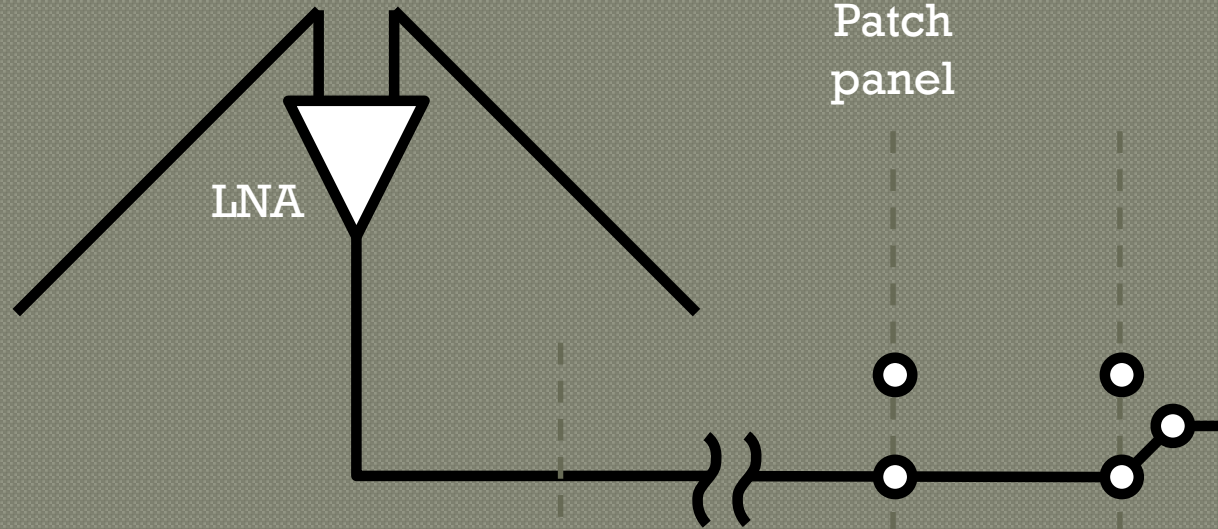
Patch panel



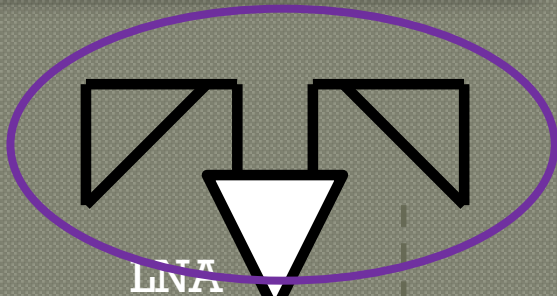
Coax-cable



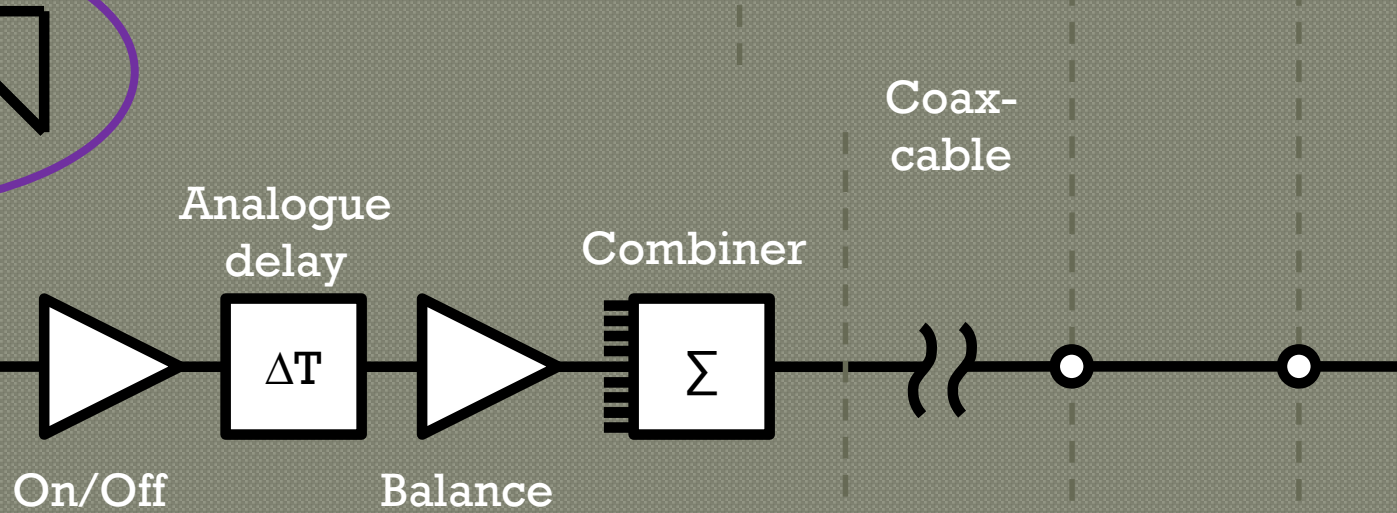
Bow-tie antenna



Patch panel



LNA



Analogue delay

Combiner

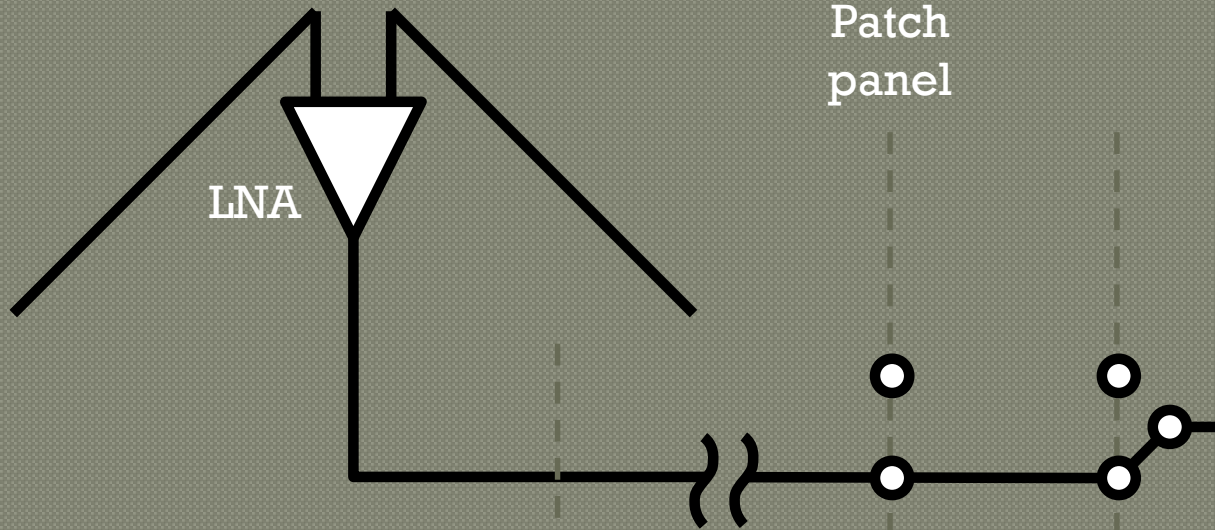
On/Off

Balance

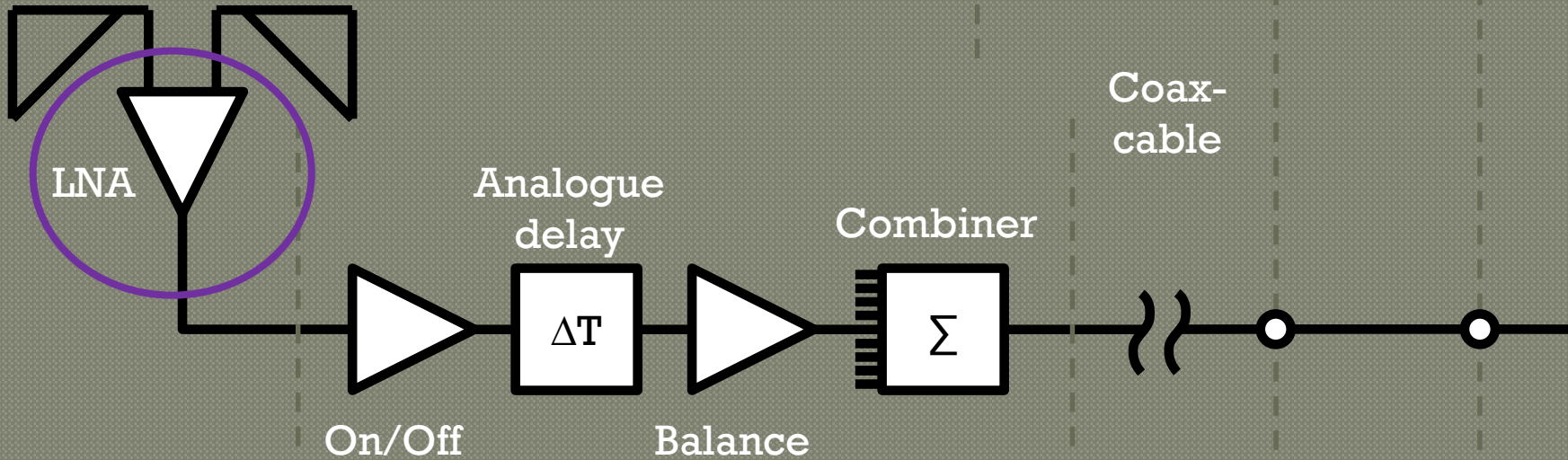
Coax-cable



LNA



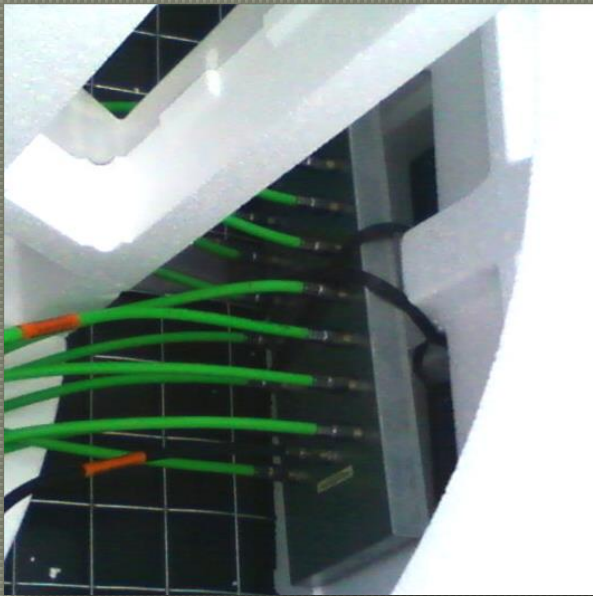
Patch panel



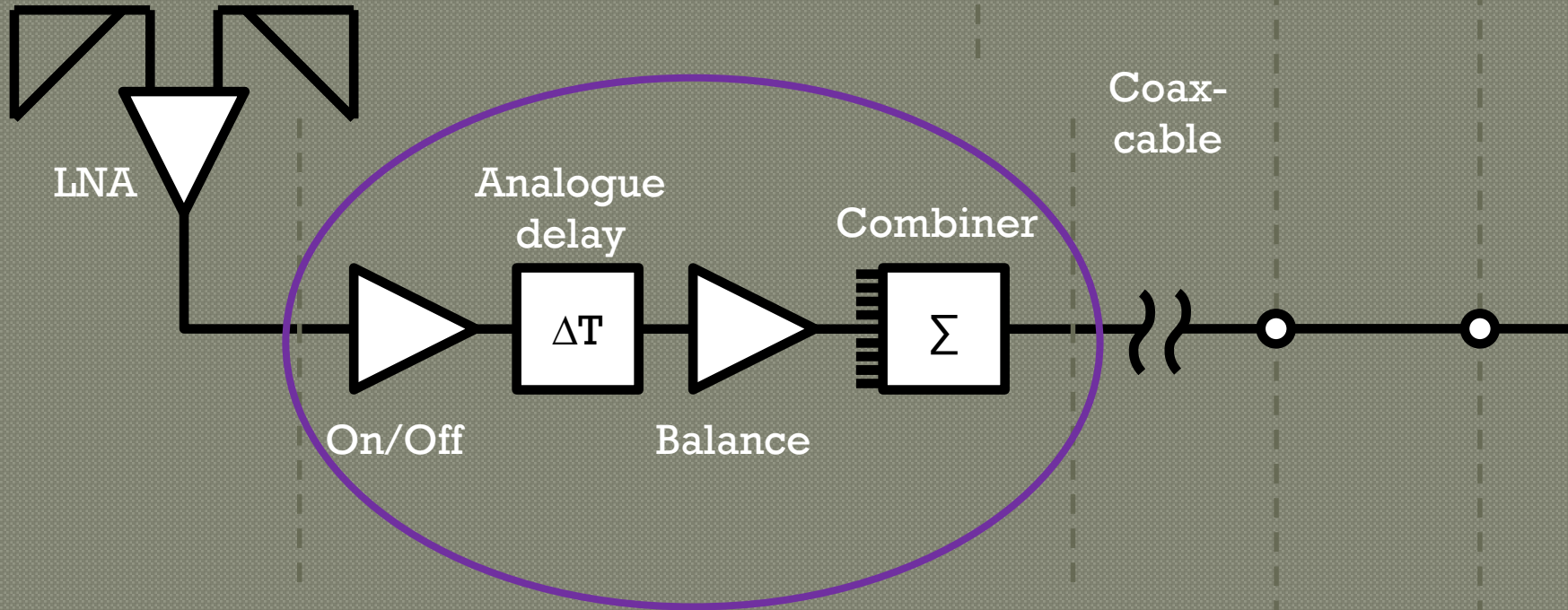
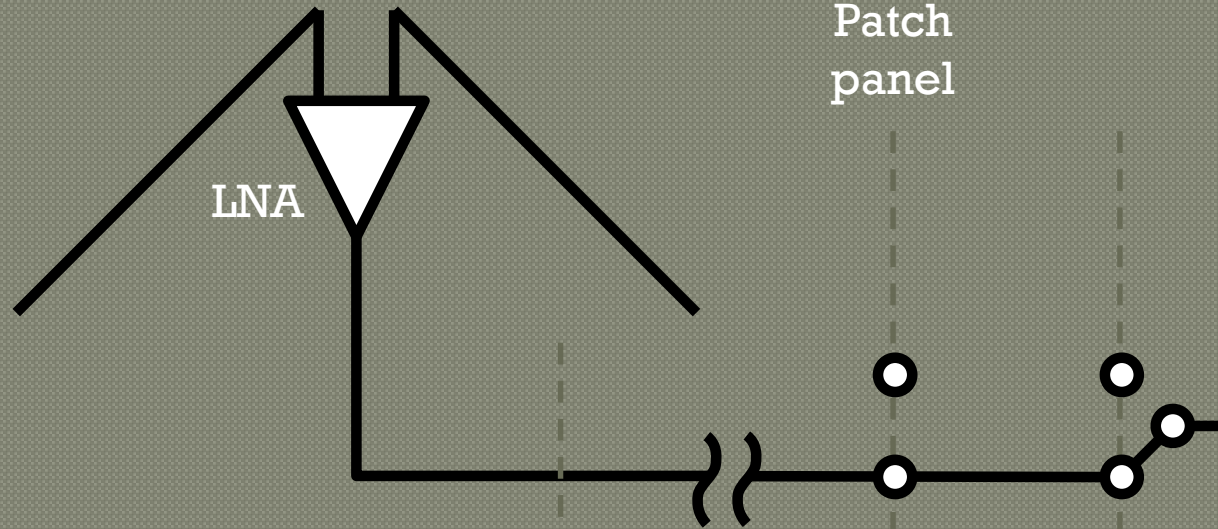
Coax-cable

On/Off

Balance

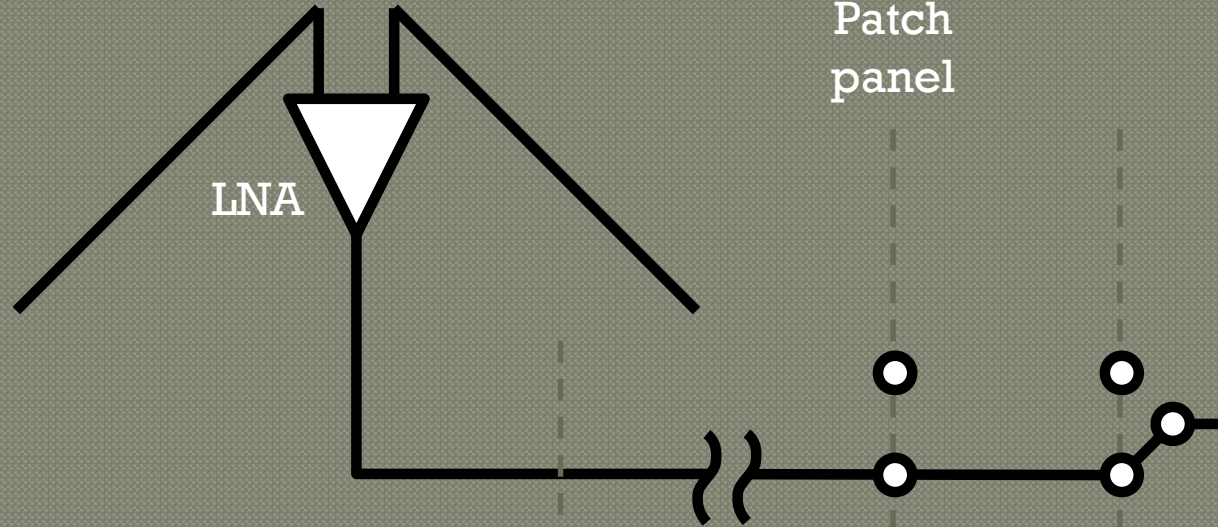


Cell-selection, analogue beam-former
5-bit control, 0.47 ns steps, ± 0.1 ns accuracy

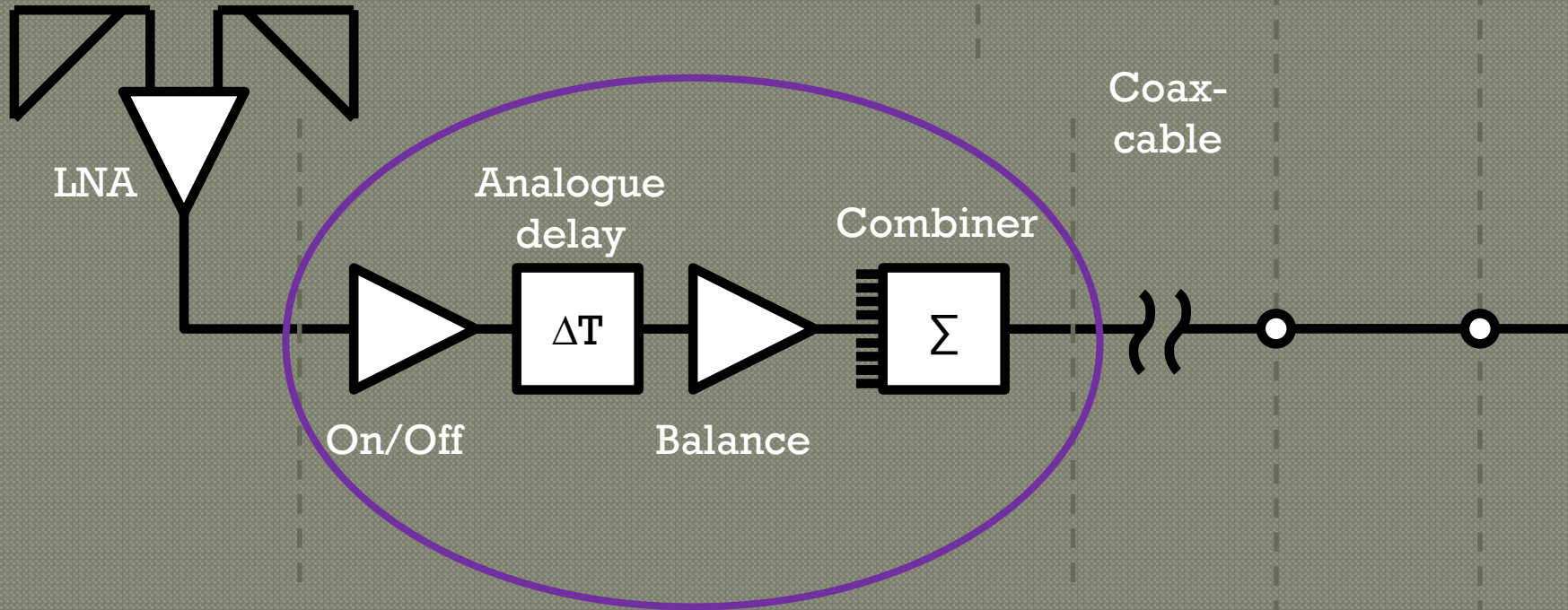




16 cells are combined to form a single tile
Total tile gain = ~30dB



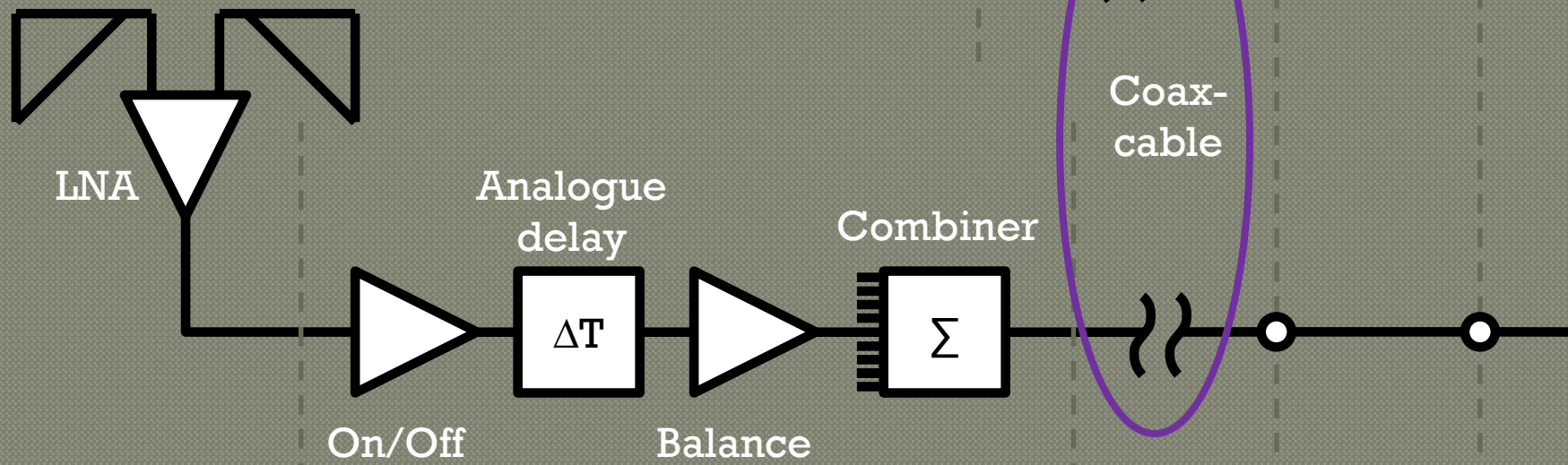
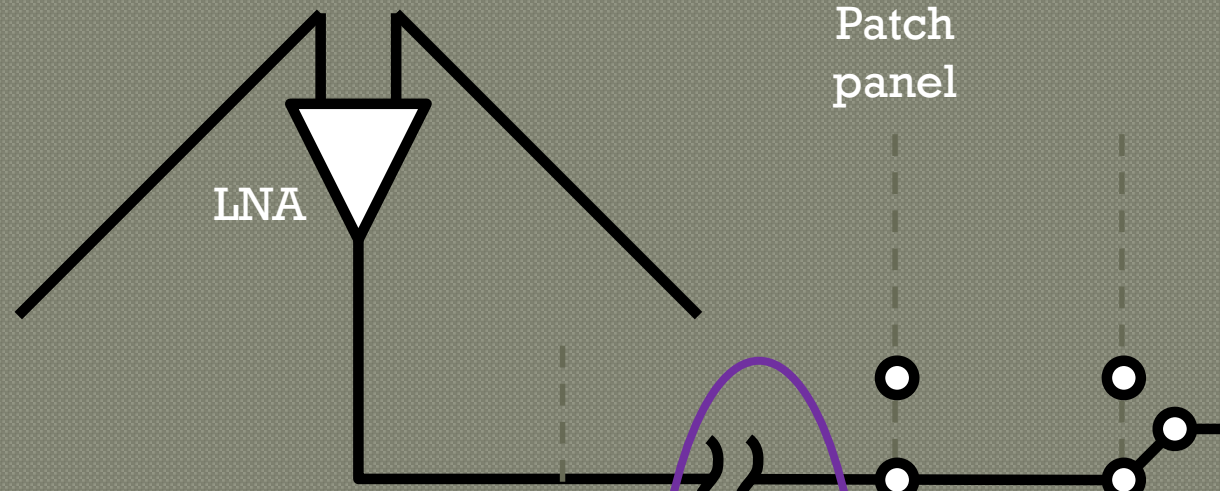
Patch panel



Coax-cable



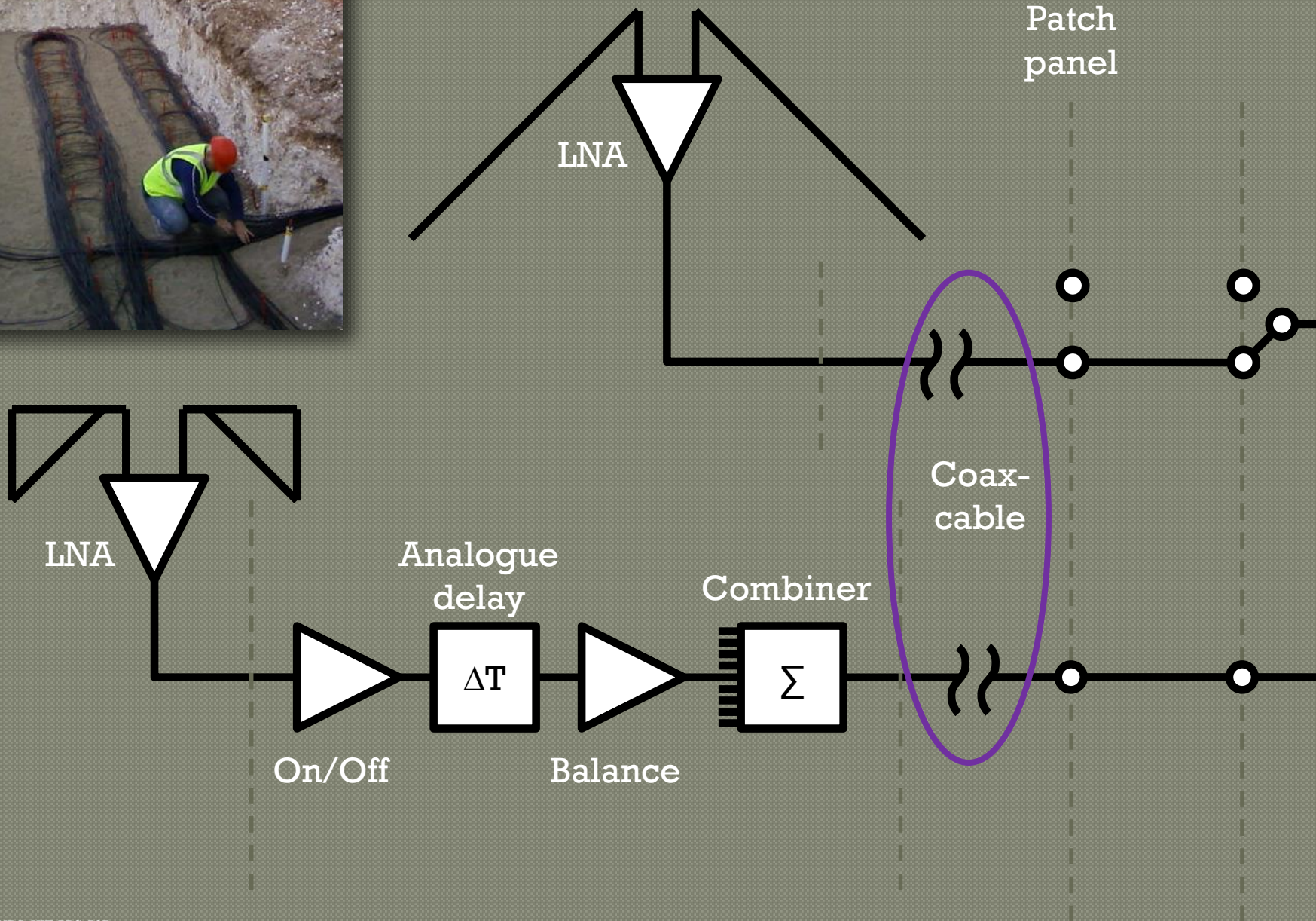
RF-cables, 2 per element, set lengths from 50 to 130m,
Coax9, 86dB shield, 75Ω, F-type, $S_{11}=20\text{dB}$, $S_{12} = 10 \text{ dB}$

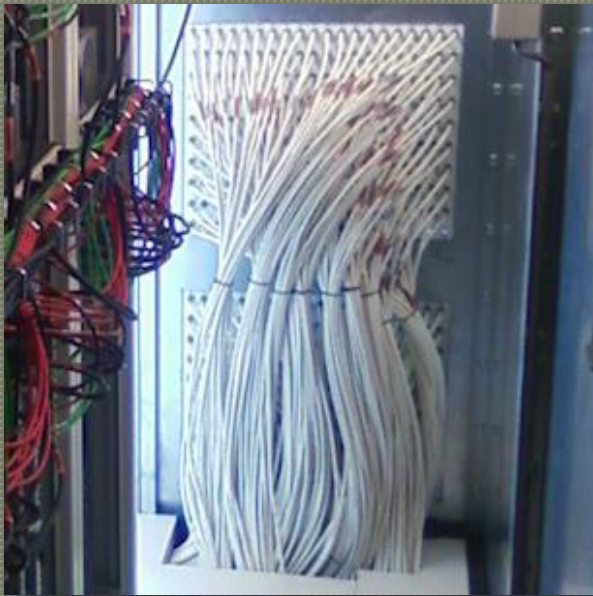


$S_{12} = 1.5\text{dB} @ 10 \text{ MHz}, 9 \text{ dB} @ 280 \text{ MHz} (100 \text{ m cable})$

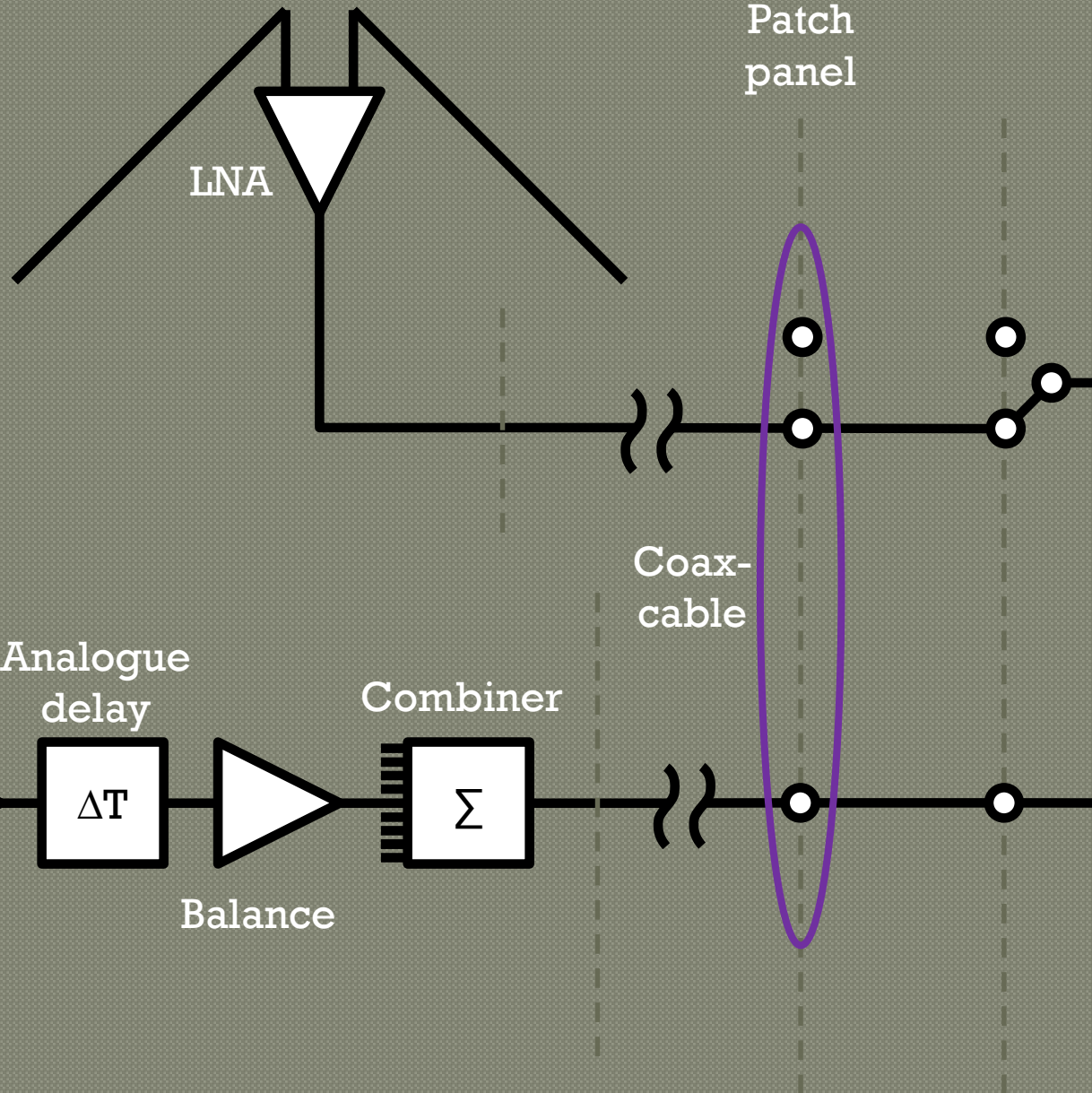


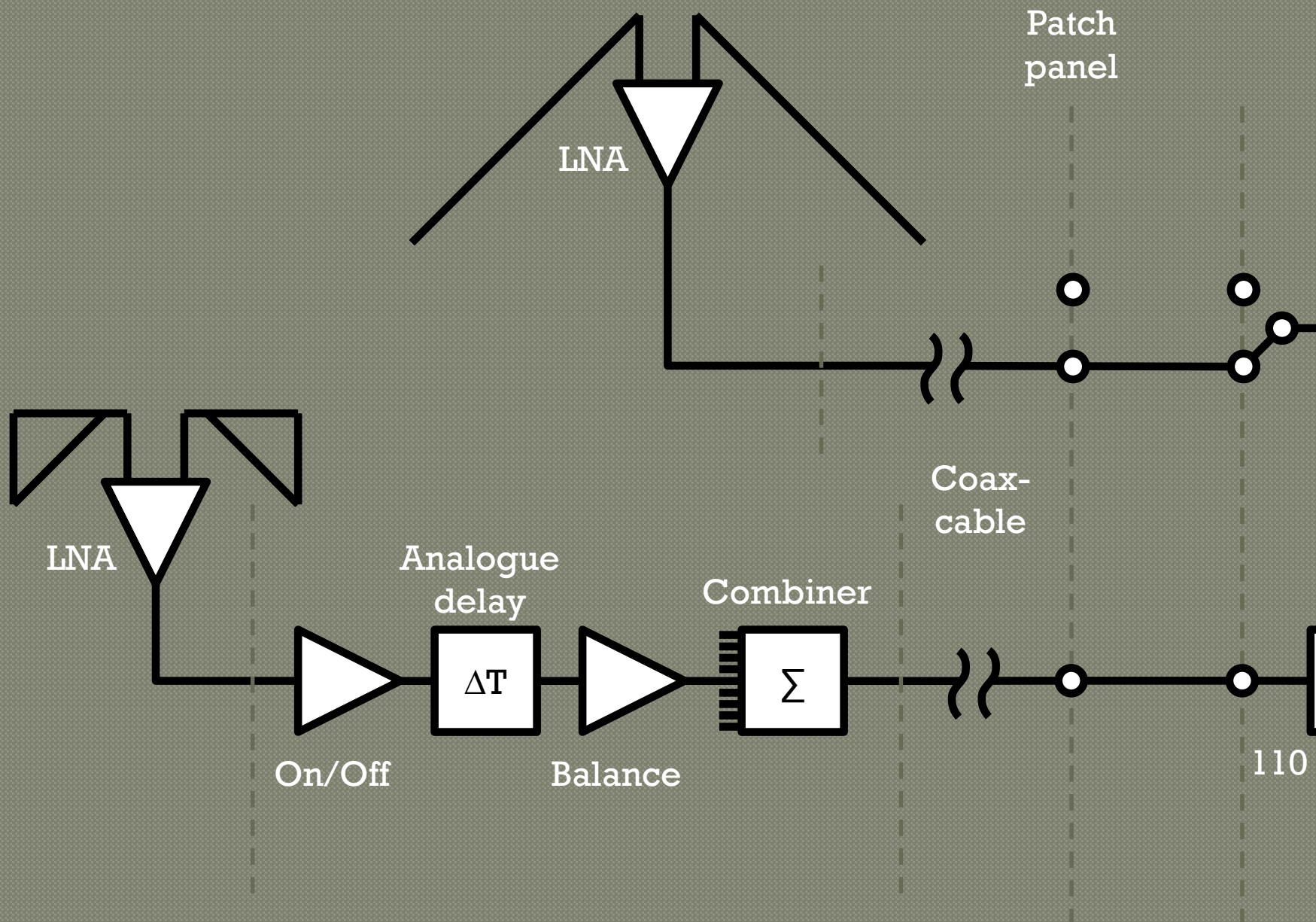
RF-cables, buried into the ground for thermal stability
Additional length zig-zagged into cable graves



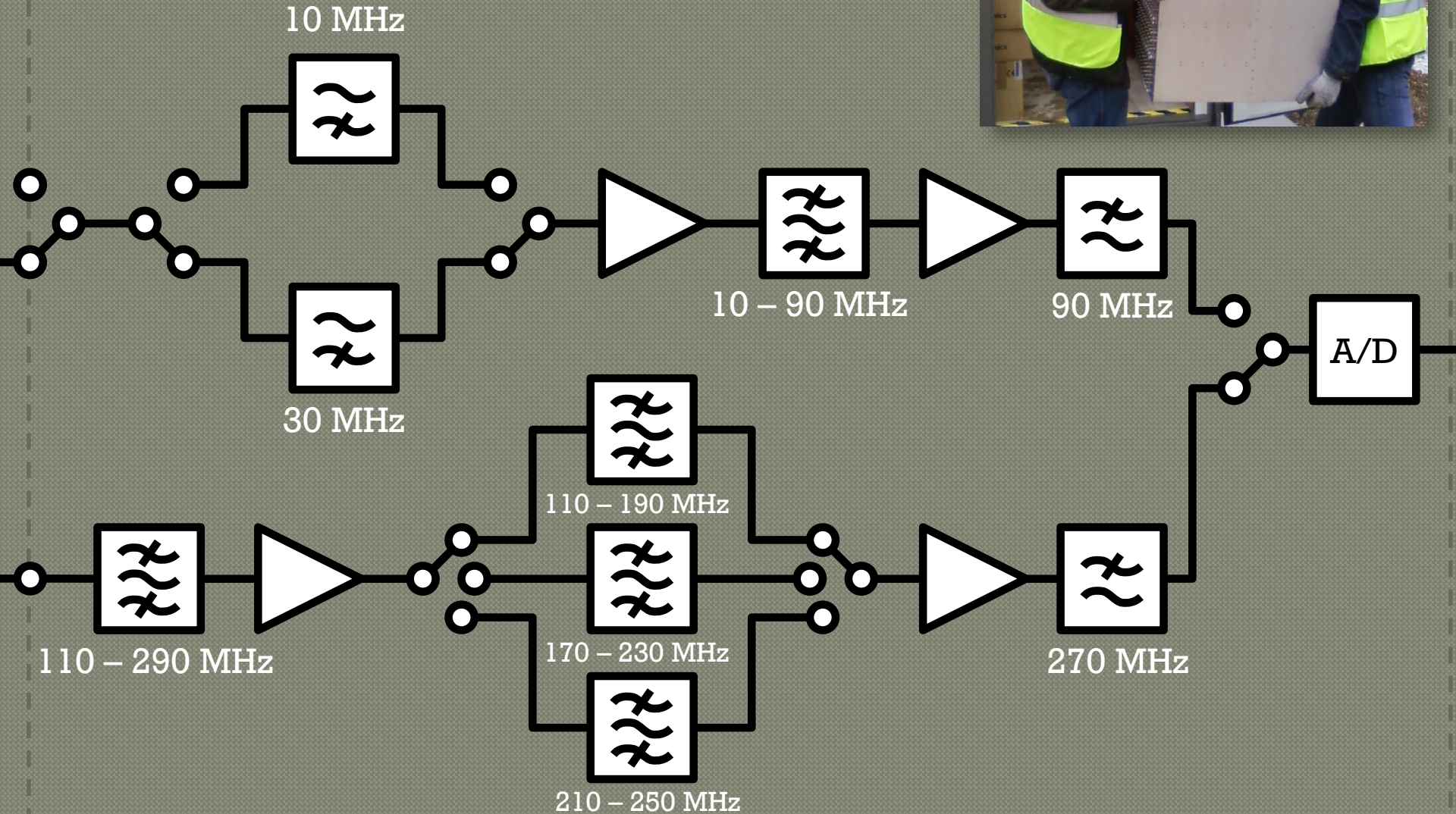


Patch panel into the Faraday cage



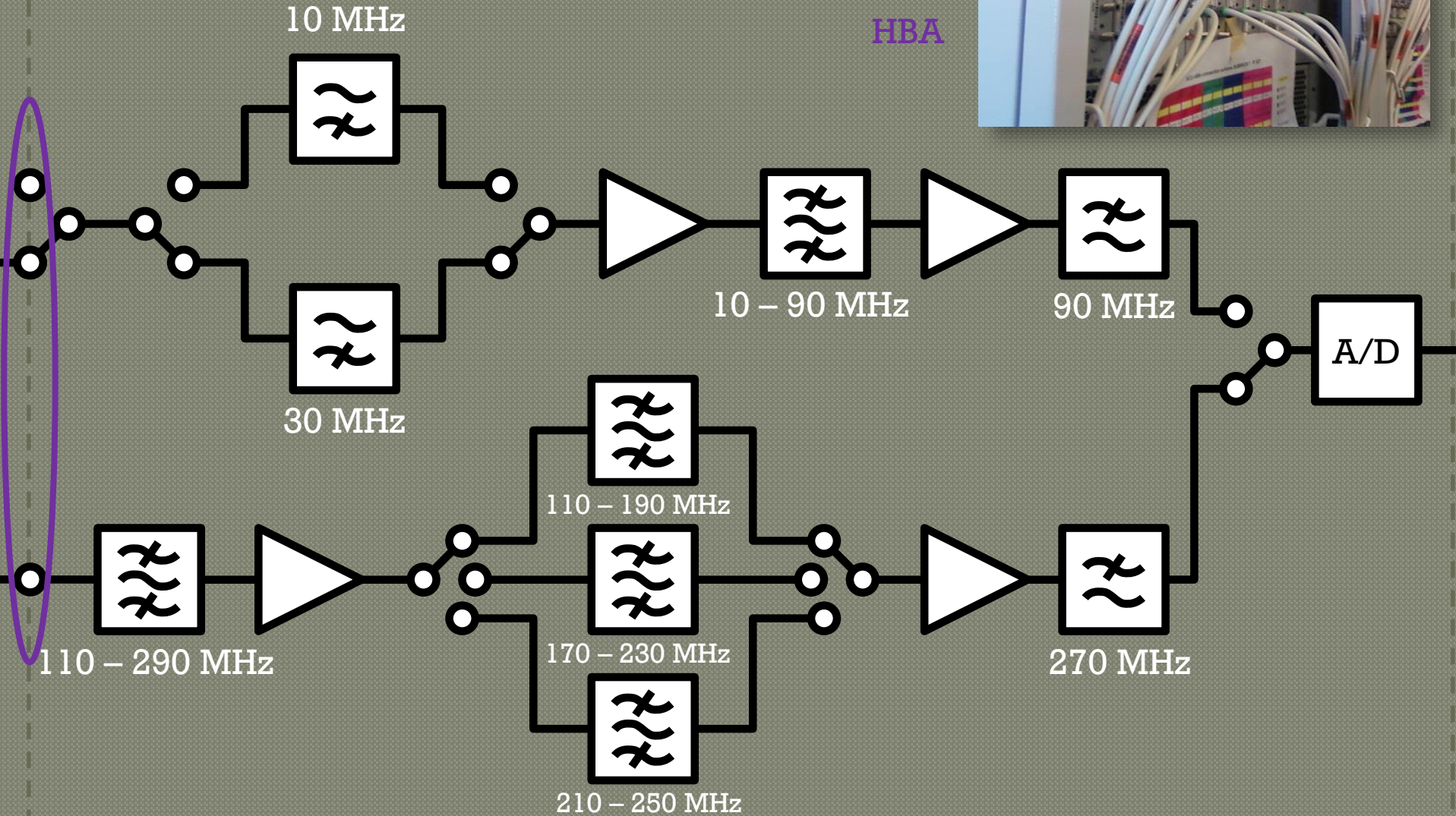
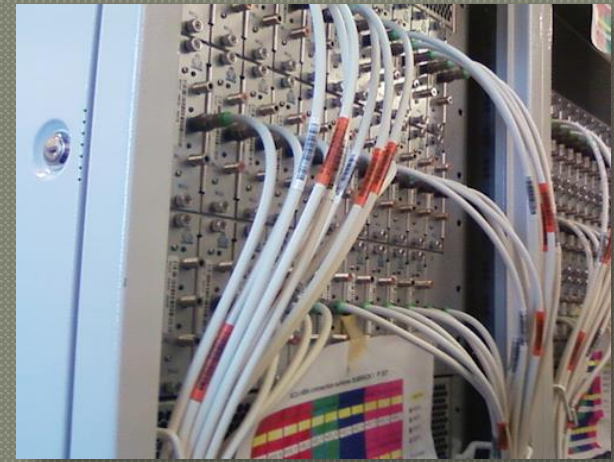


6 × Sub-rack assemblies
Contain the receiver units and analogue filters
Front-end switches include 75:50Ω transformer

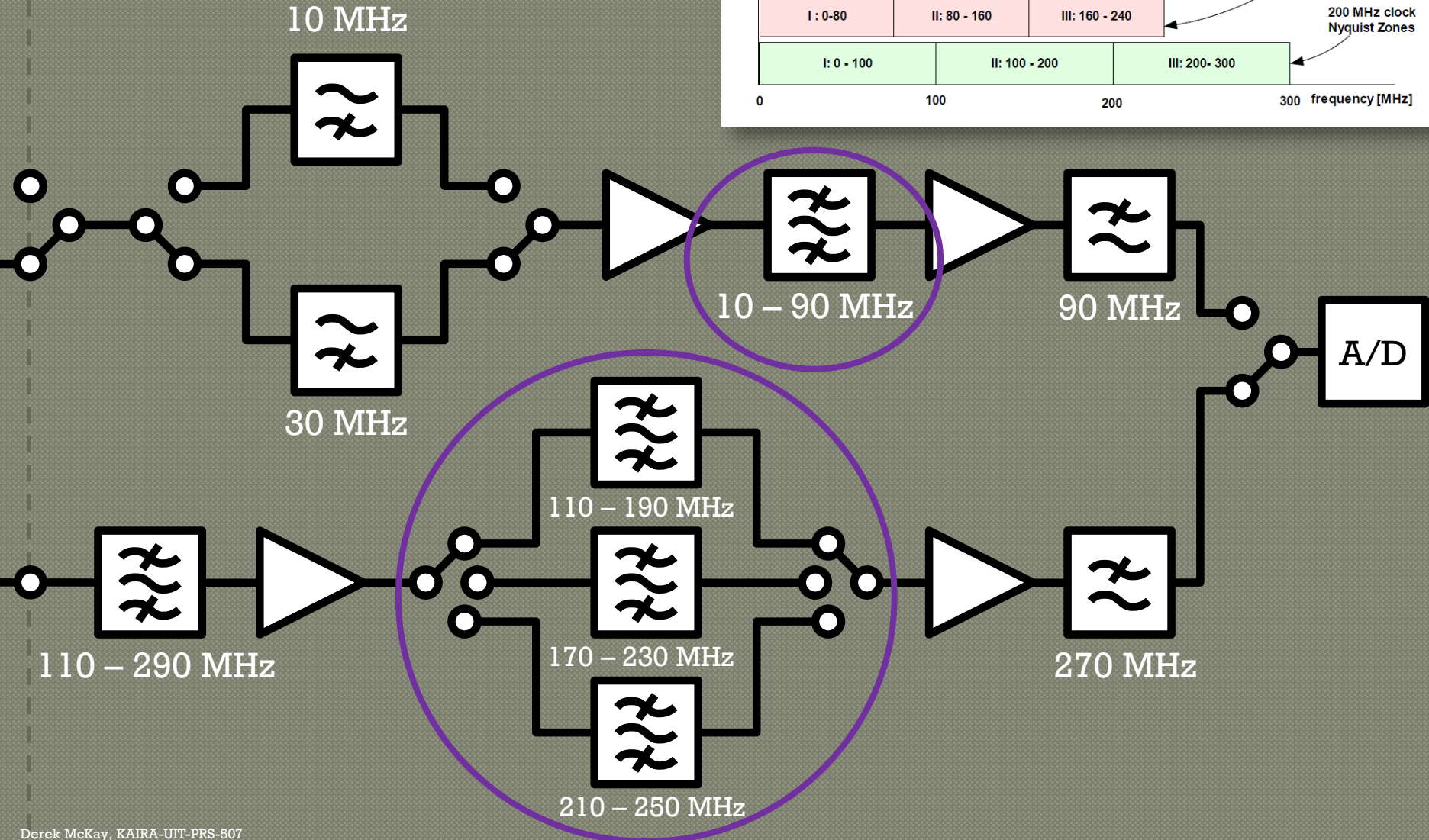
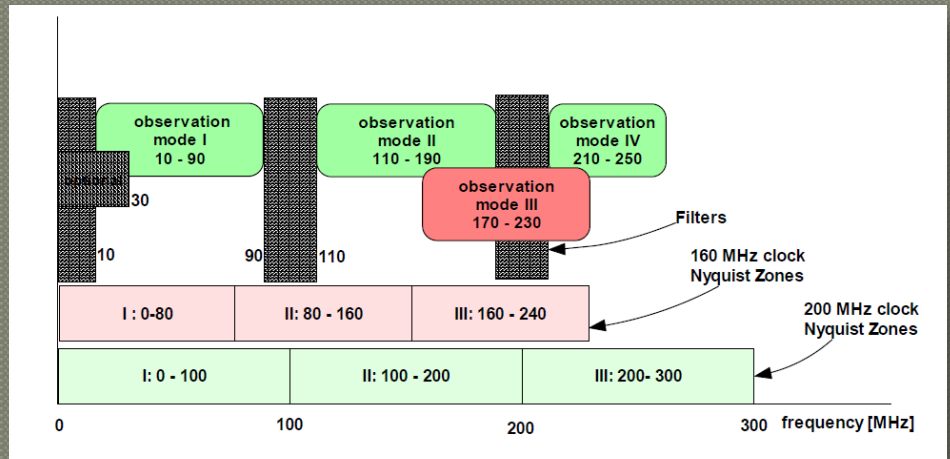


Receiver unit
3-channel input

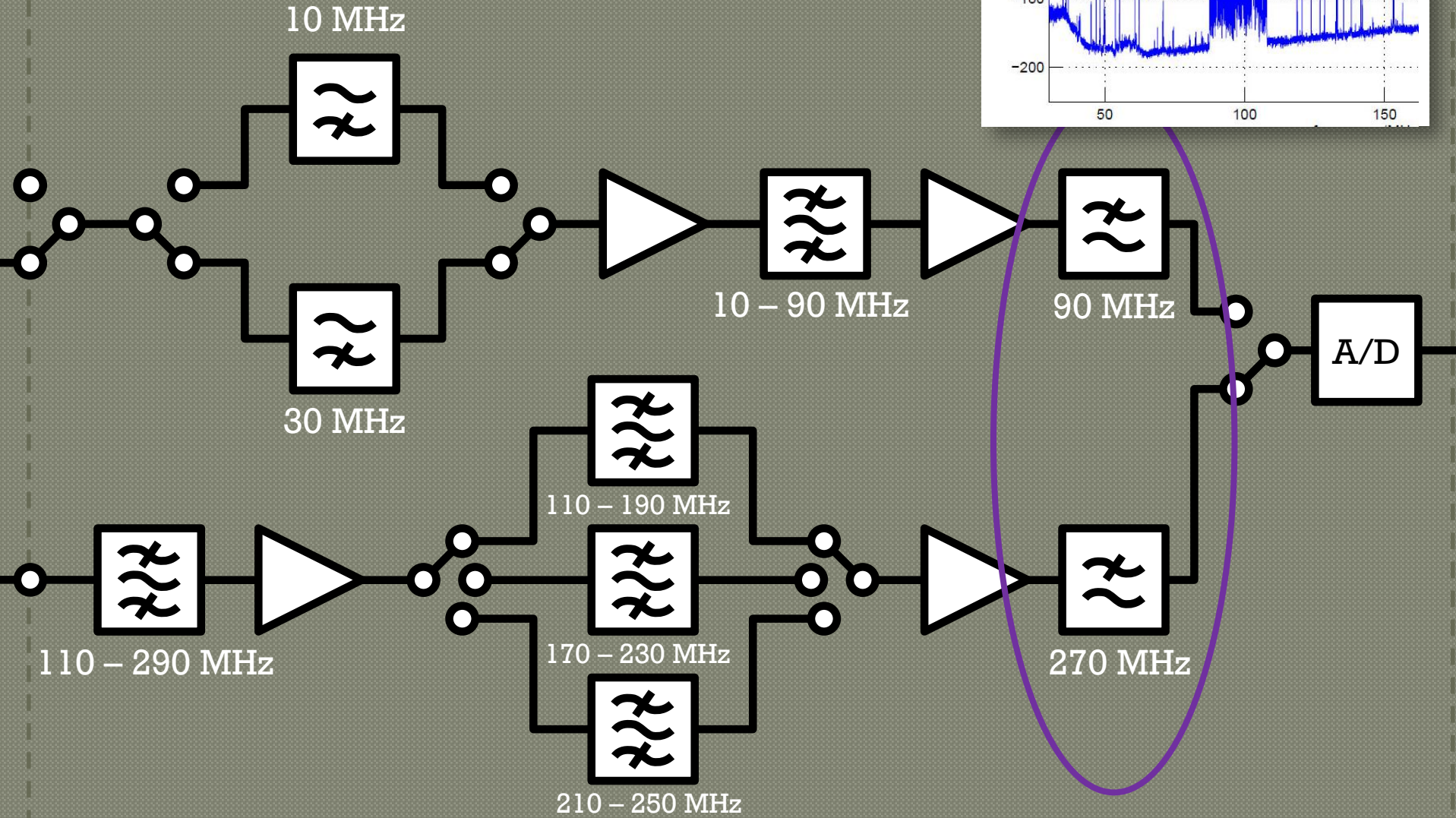
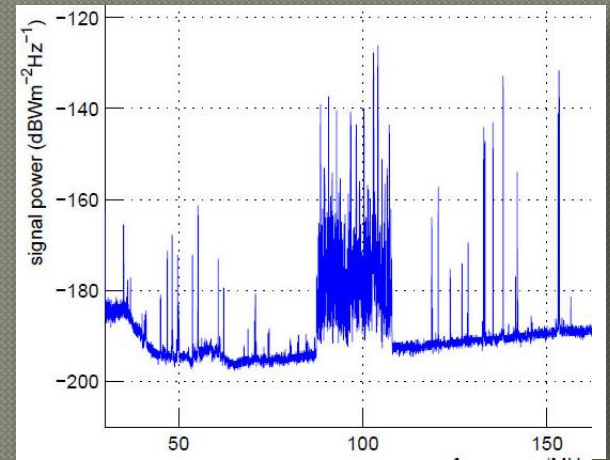
LBL
LBH
HBA



Receiver unit Nyquist-zone selection (13th order BP filters)



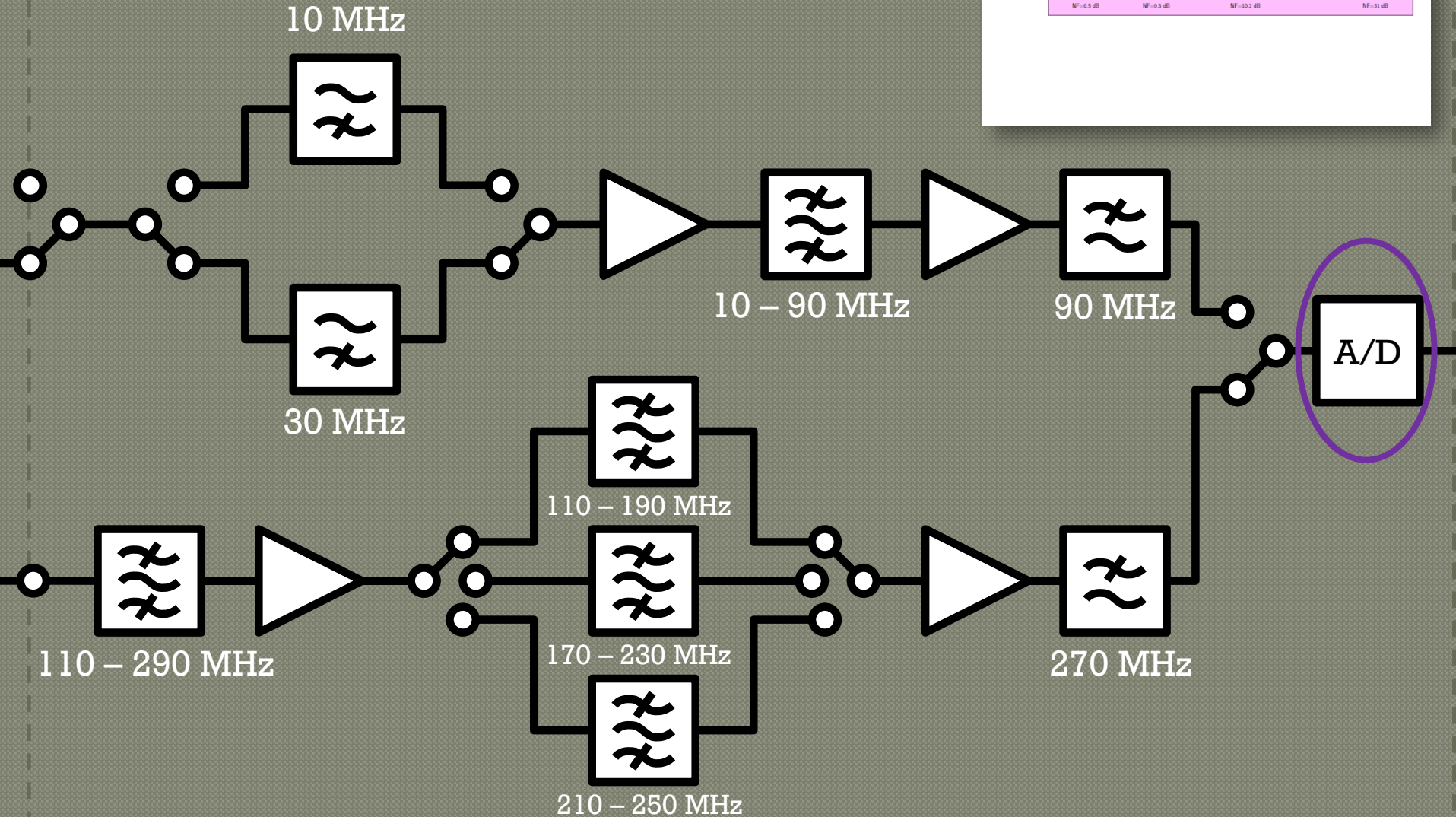
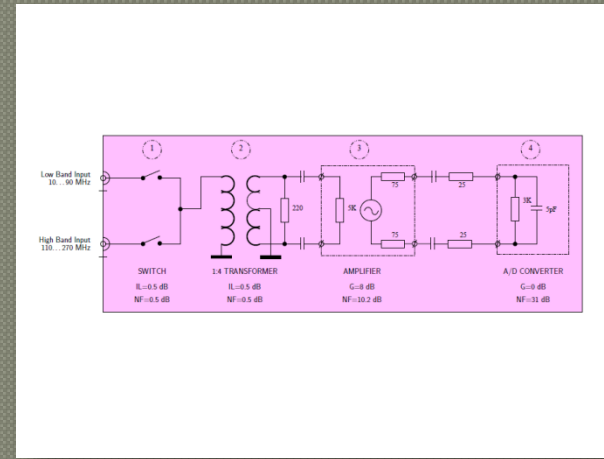
More filters FM radio and Television

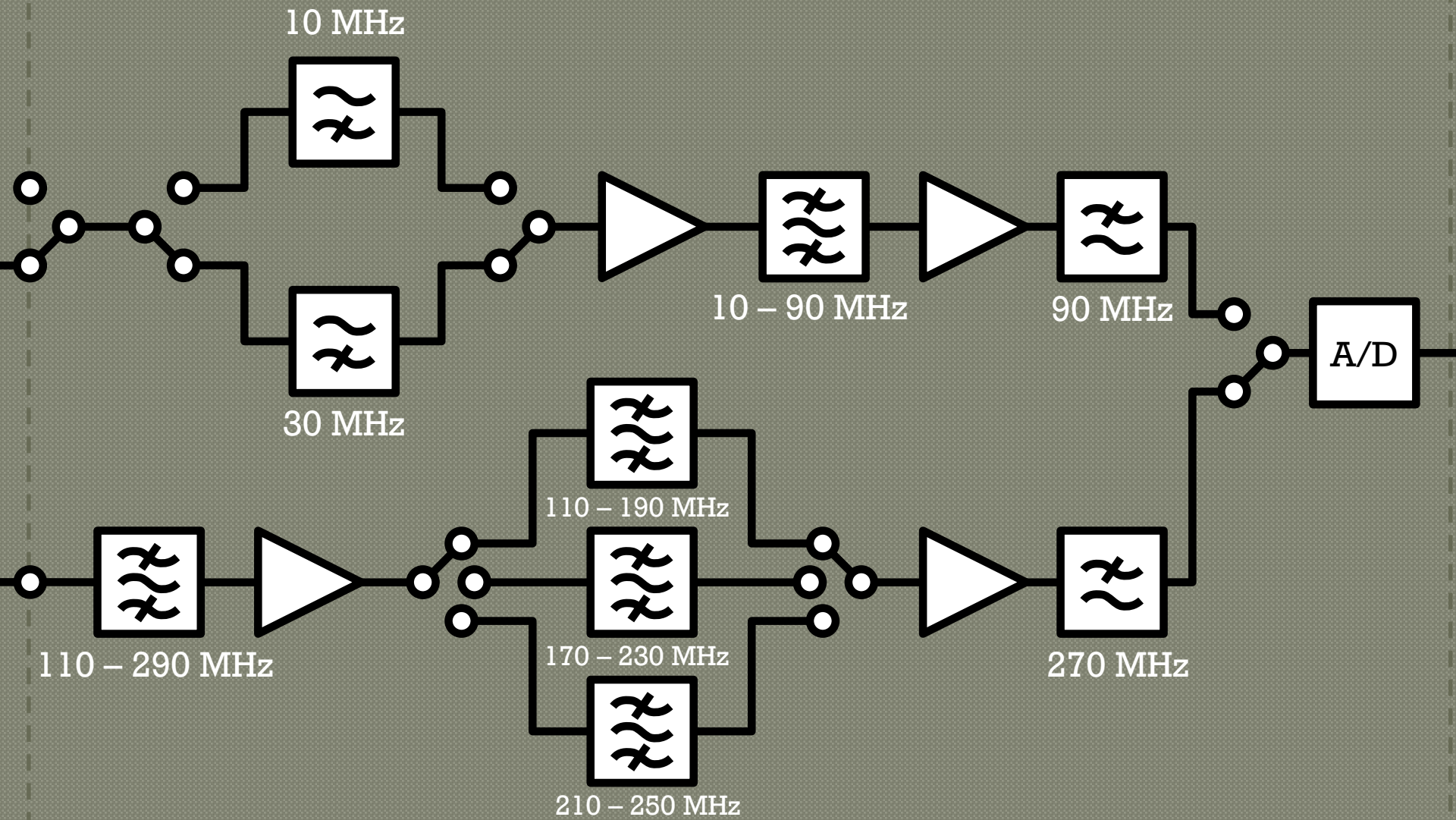


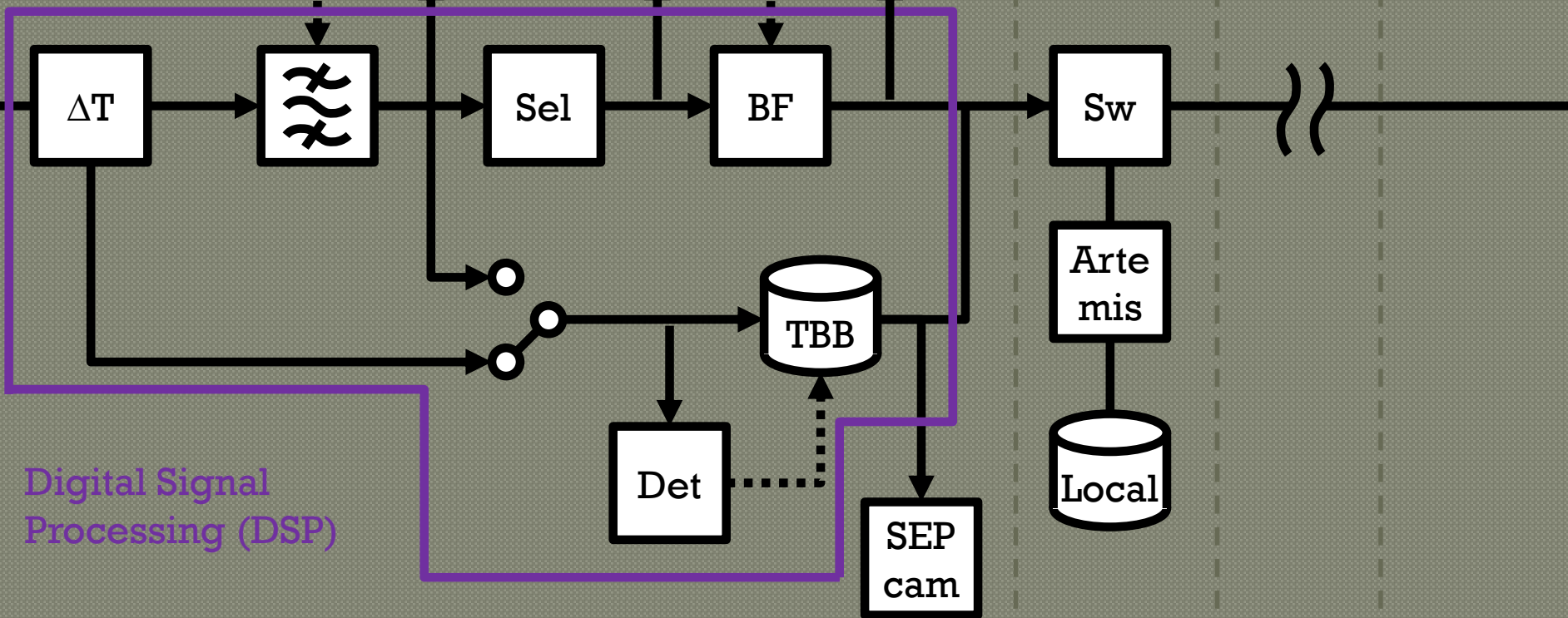
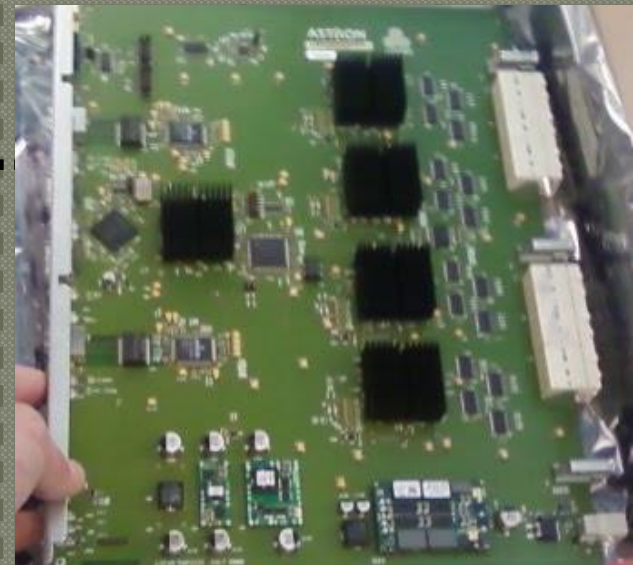
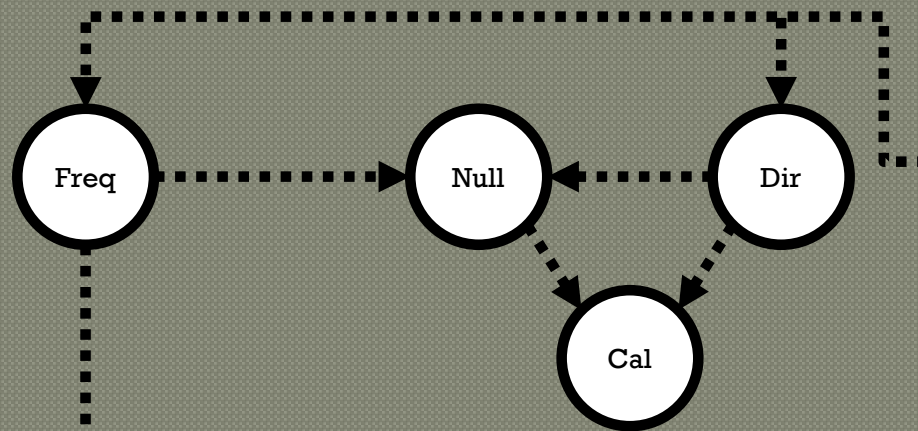
Receiver unit

Analogue-to-Digital (A/D) converter, 200MS/s, 12-bit

2 clock frequencies (160/200 MHz)

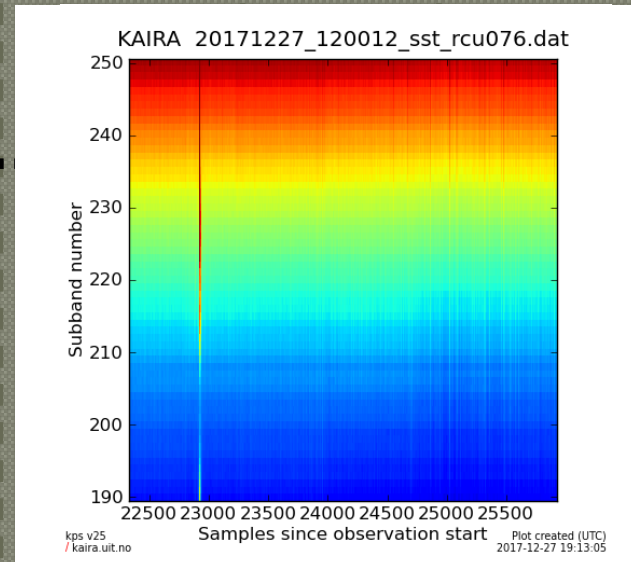
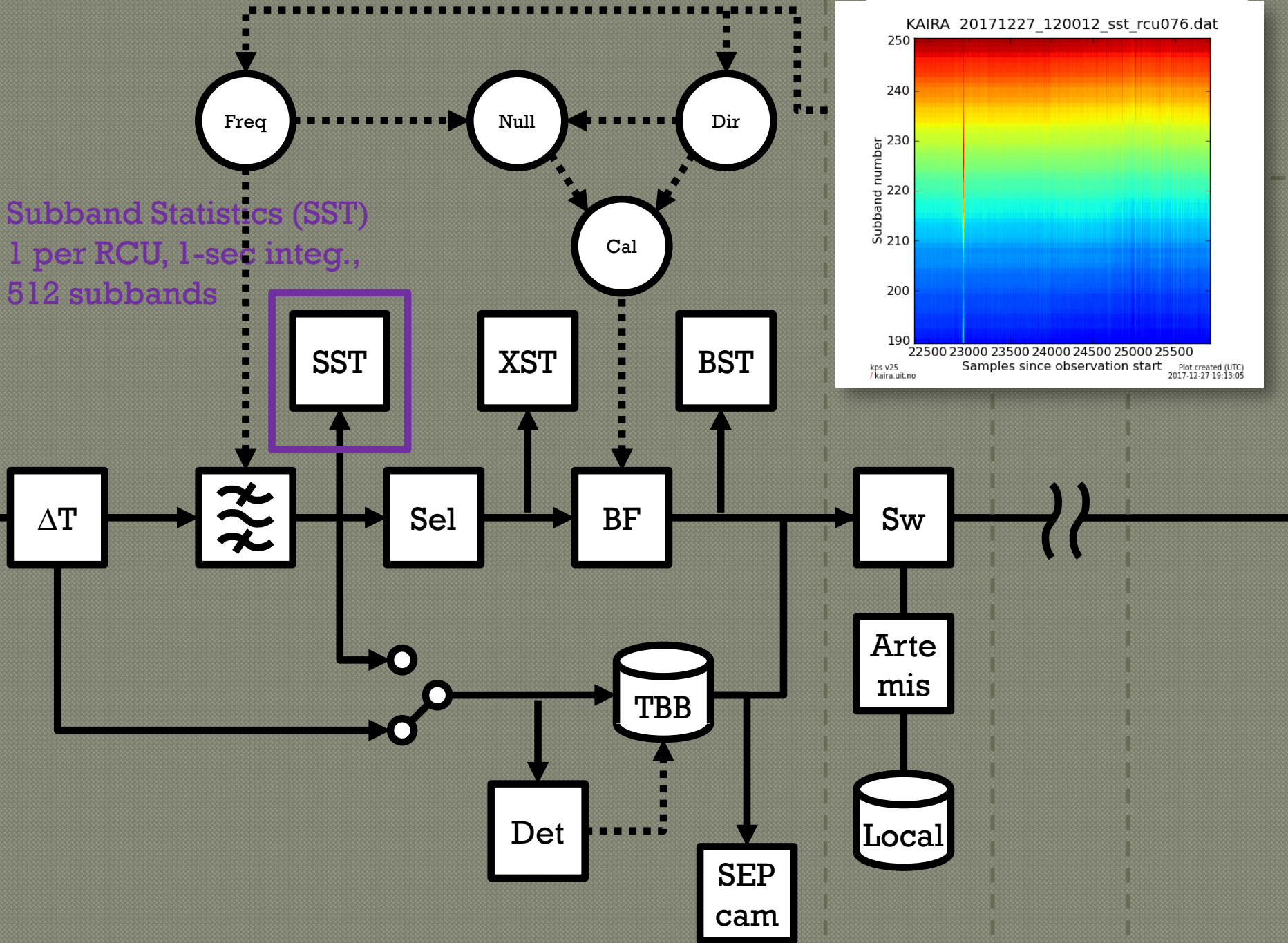




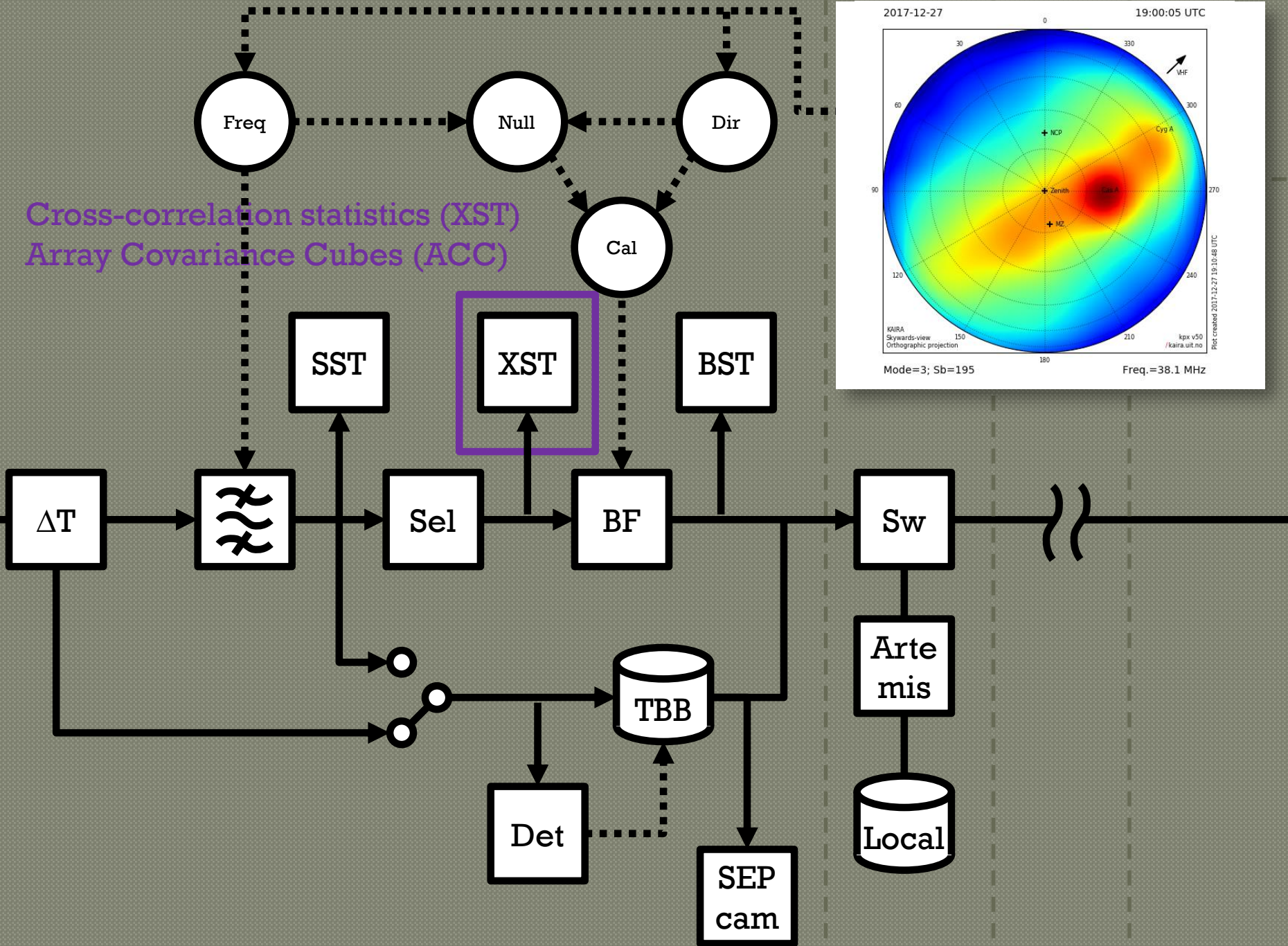


Digital Signal Processing (DSP)

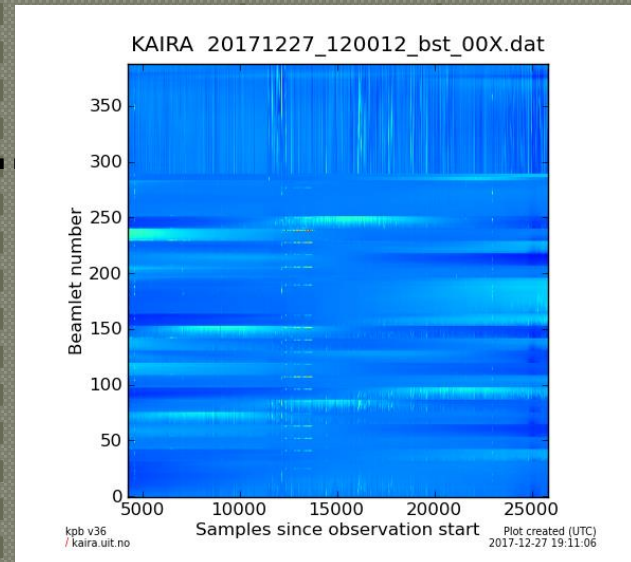
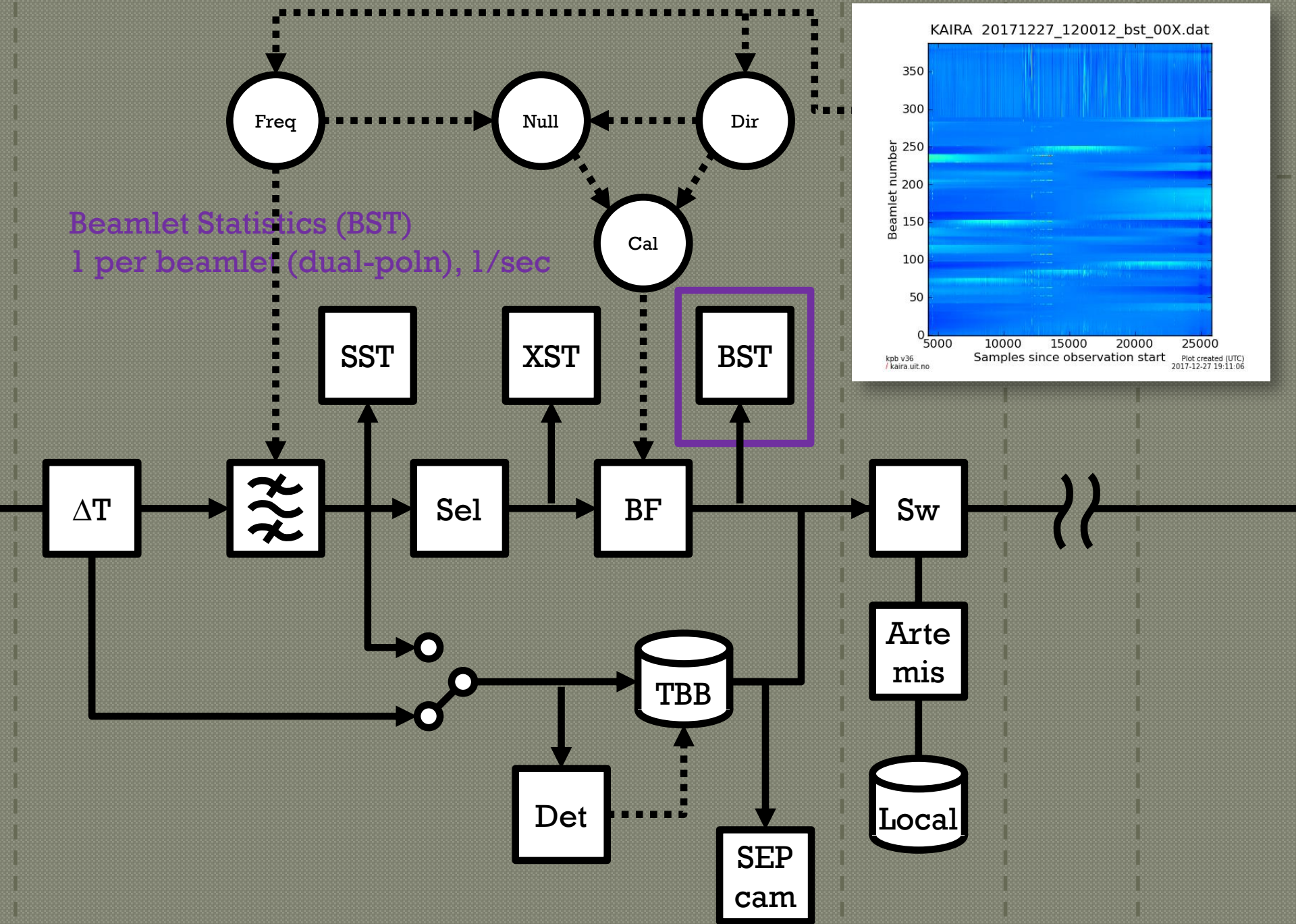
Subband Statistics (SST)
1 per RCU, 1-sec integ.,
512 subbands

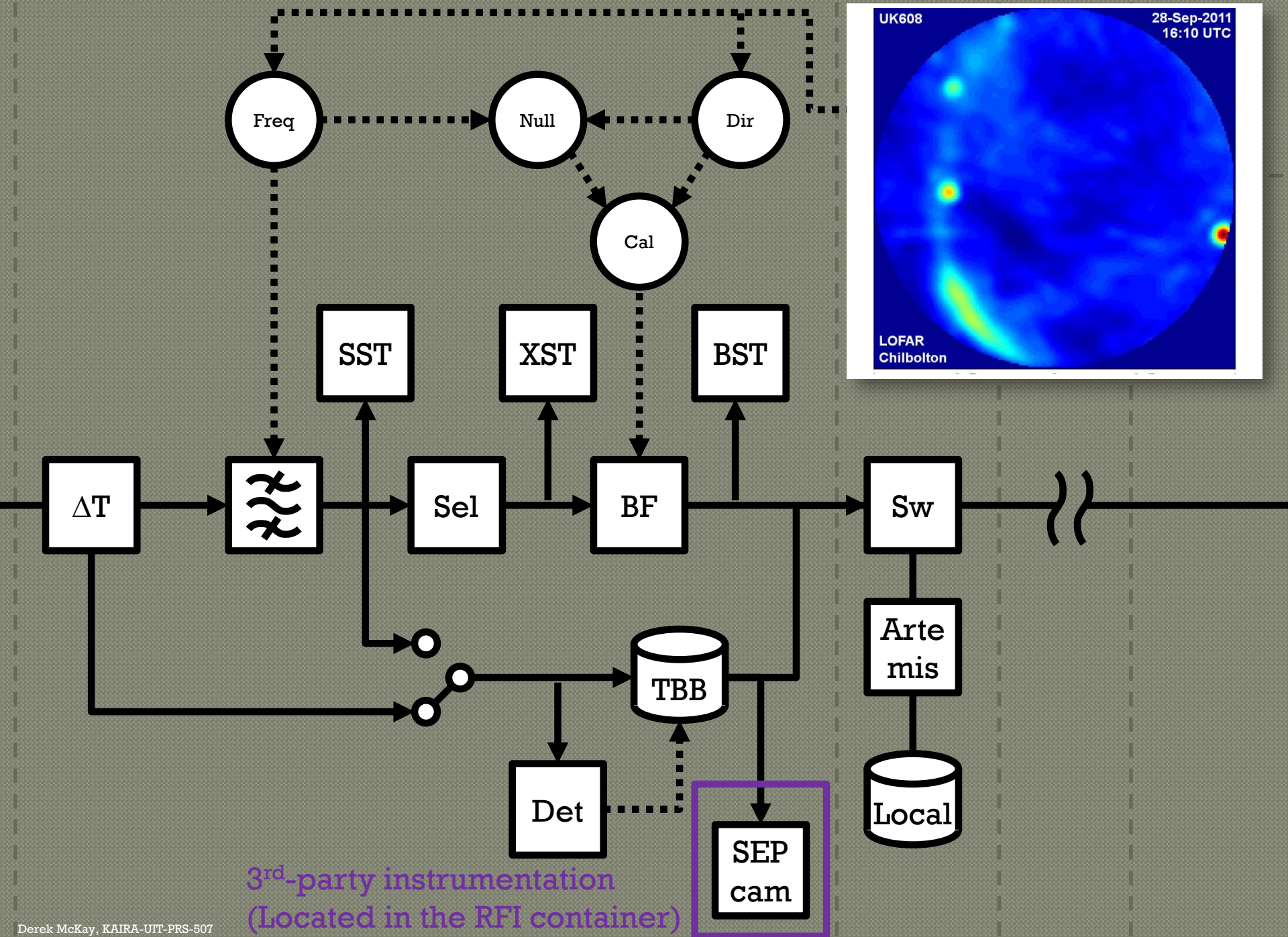


Cross-correlation statistics (XST)
Array Covariance Cubes (ACC)

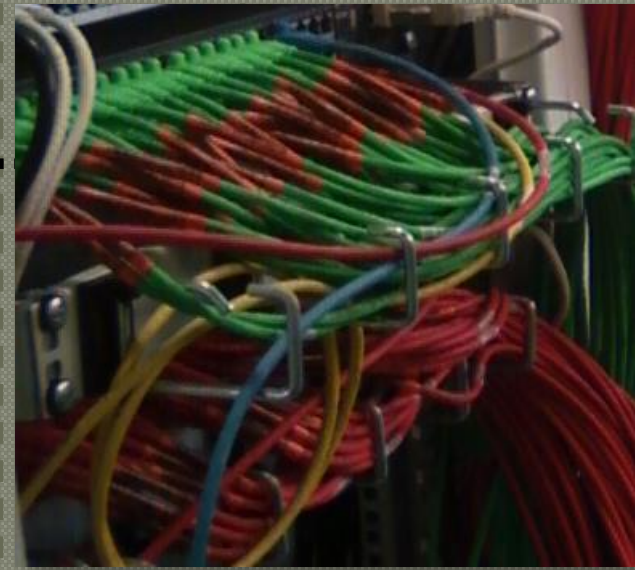
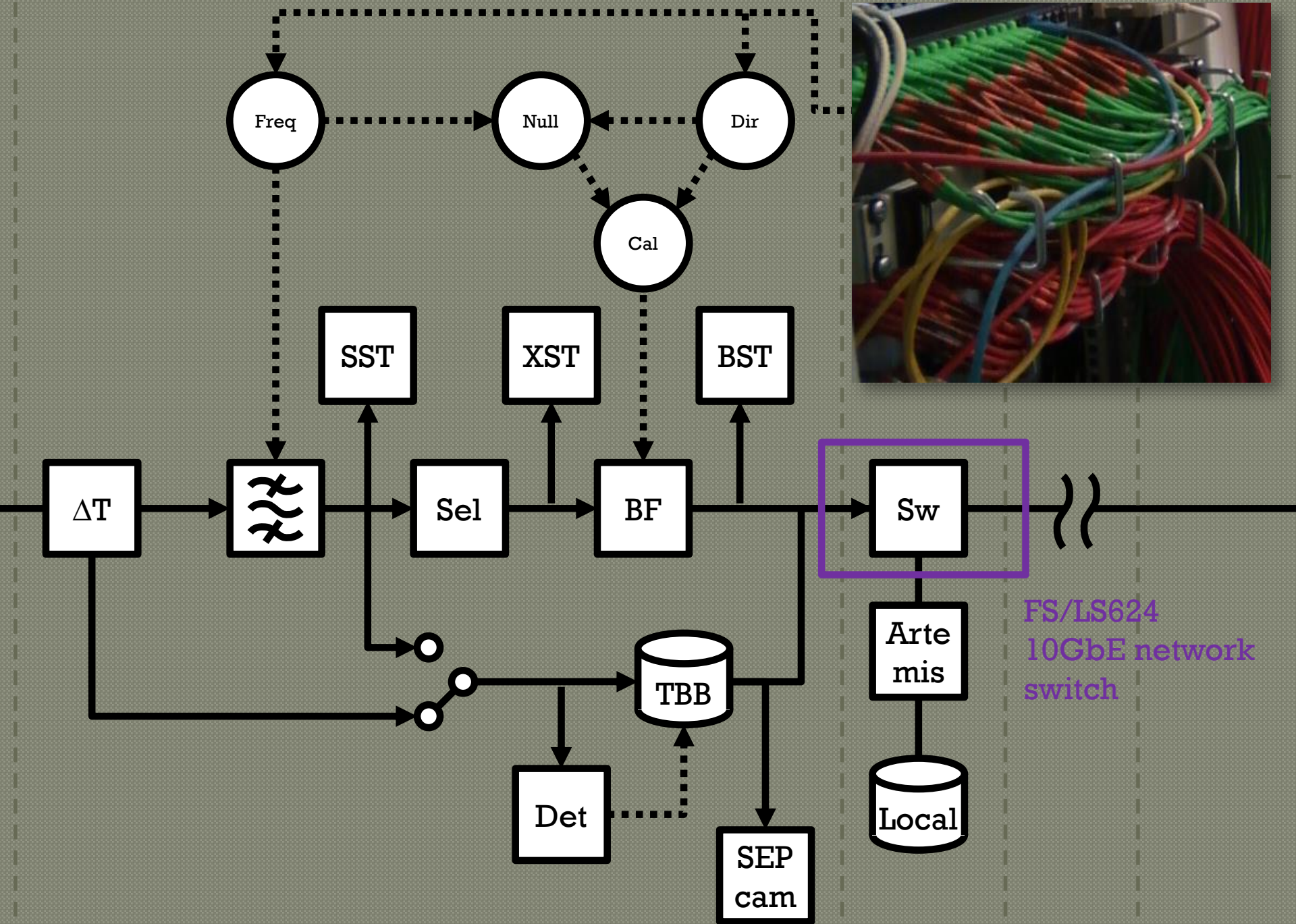


Beamlet Statistics (BST)
1 per beamlet (dual-poln), 1/sec

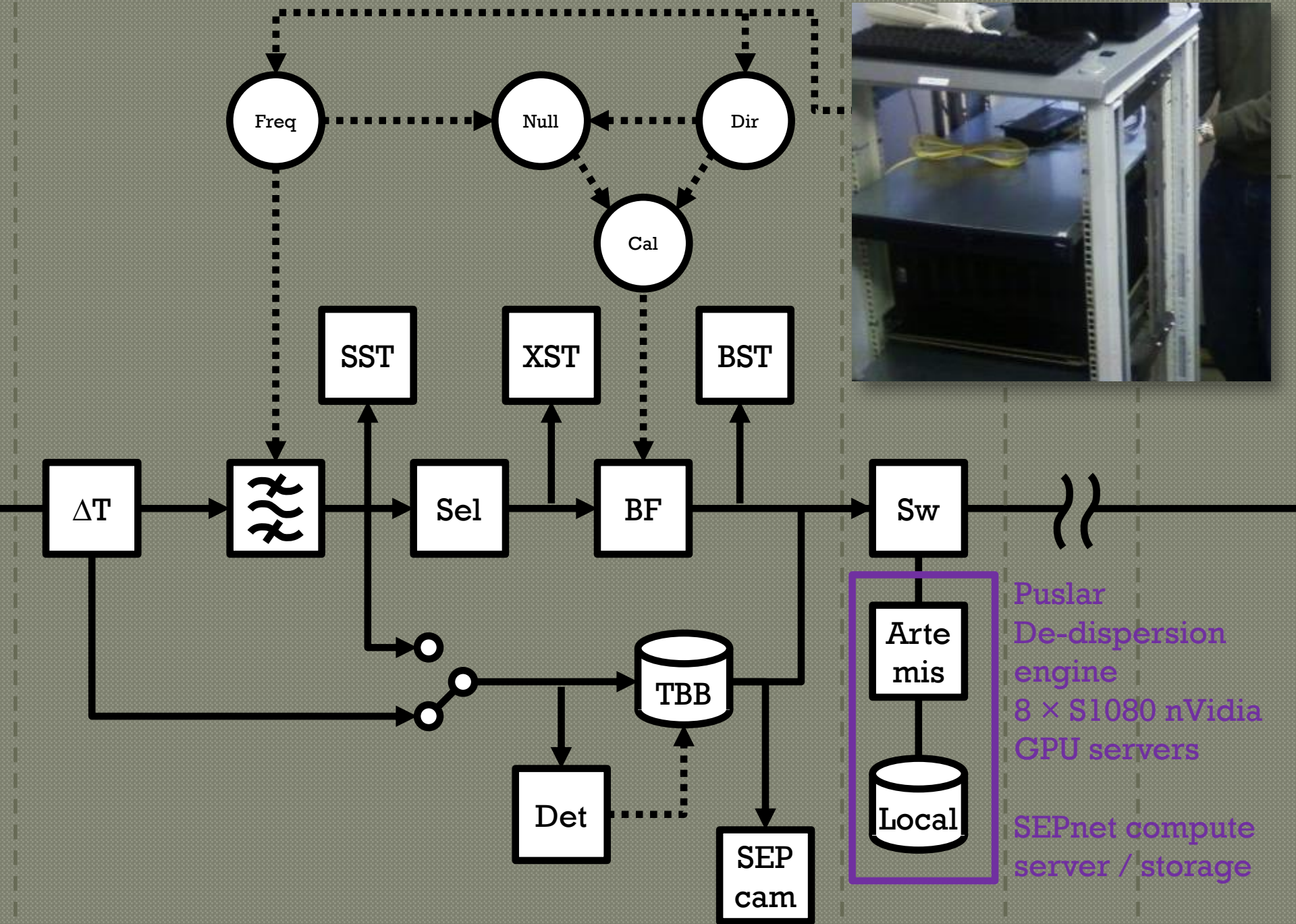




3rd-party instrumentation
 (Located in the RFI container)

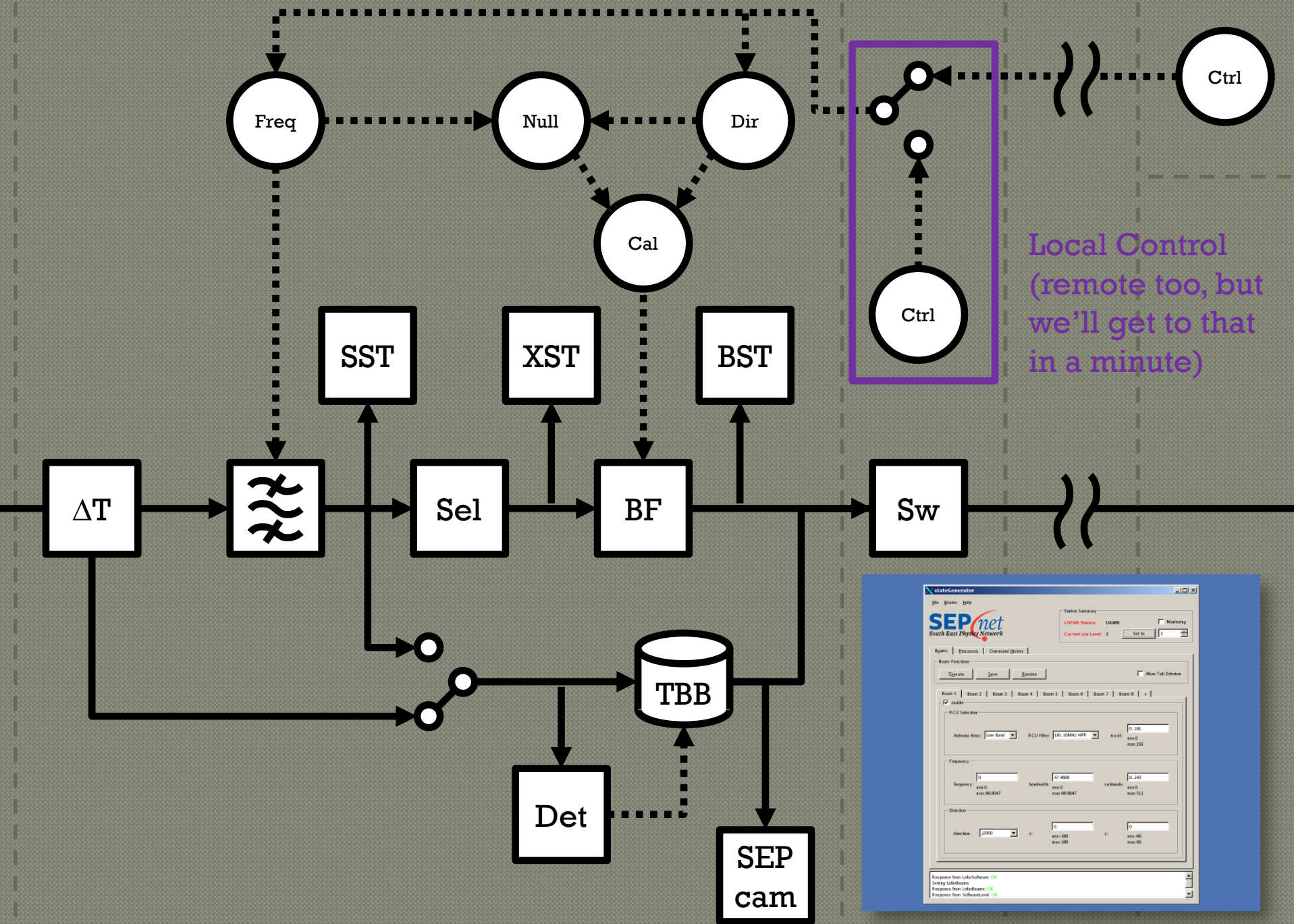


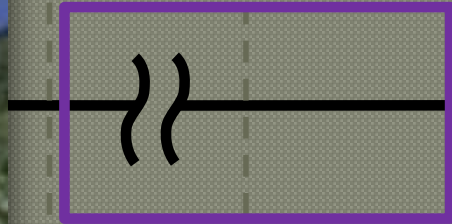
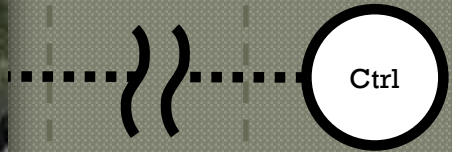
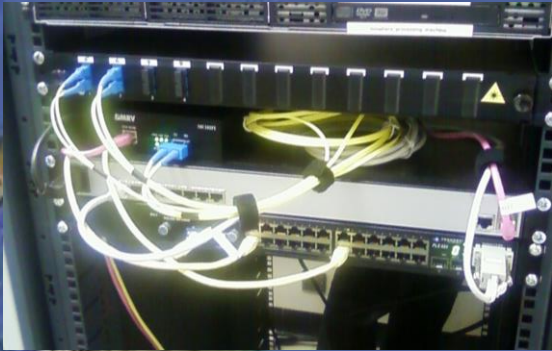
FS/LS624
 10GbE network
 switch



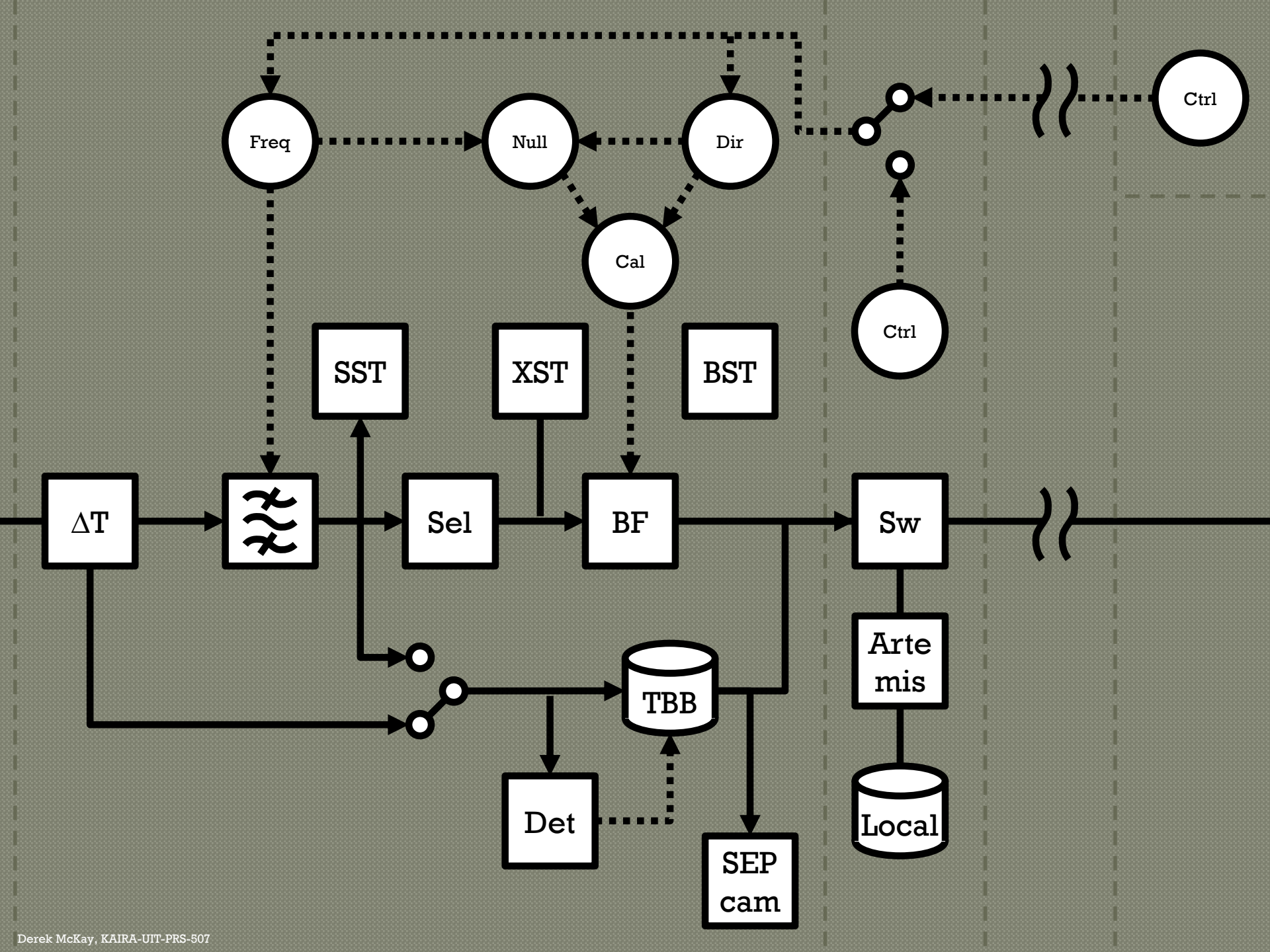
Puslar
De-dispersion
engine
8 × S1080 nVidia
GPU servers

SEPnet compute
server / storage





Fibre link





Remote control
for the entire LOFAR
International Telescope

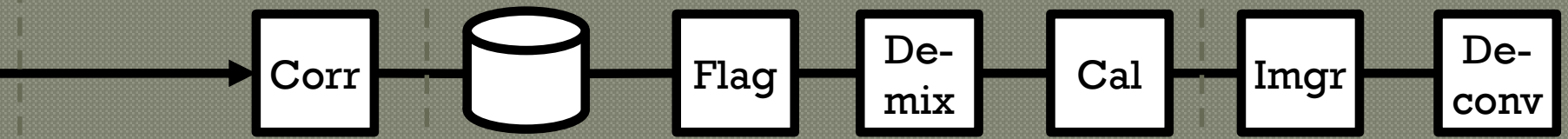


Groningen

BG/P

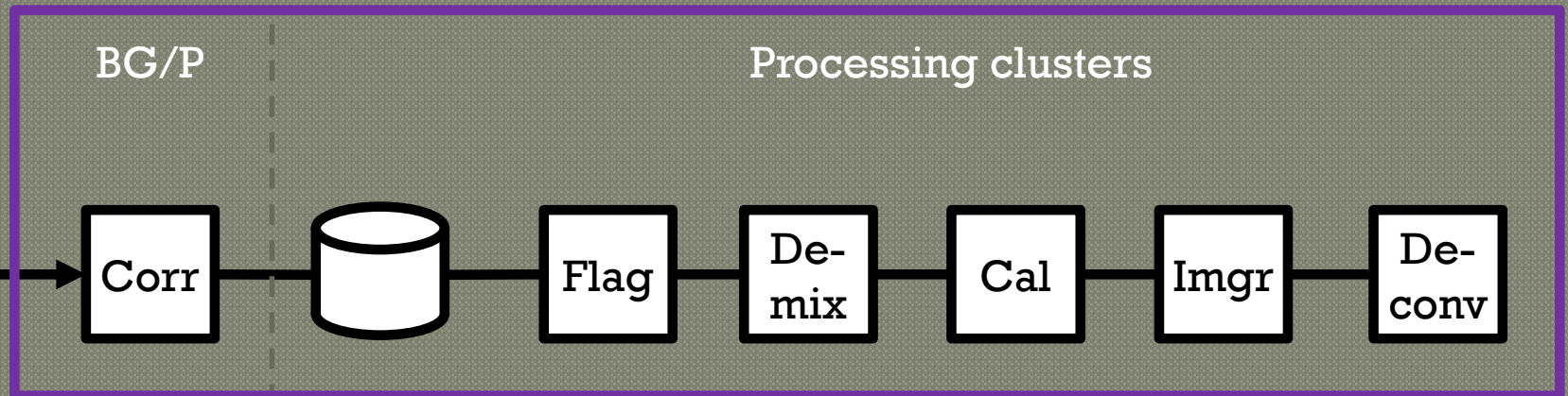
CEP-2

CEP-1





Groningen

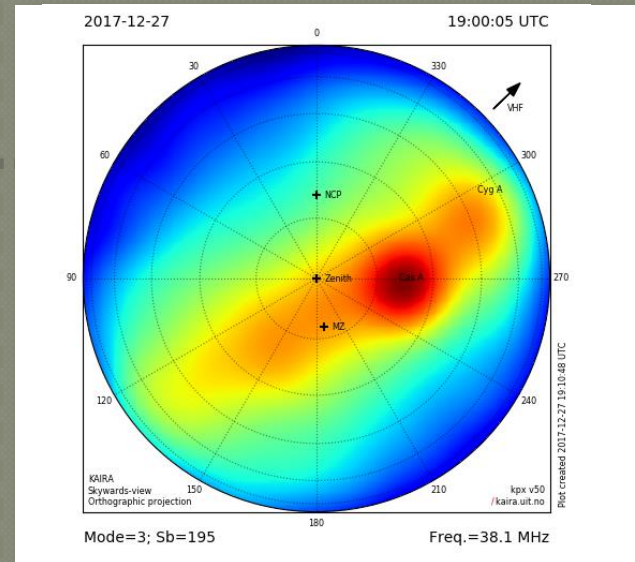
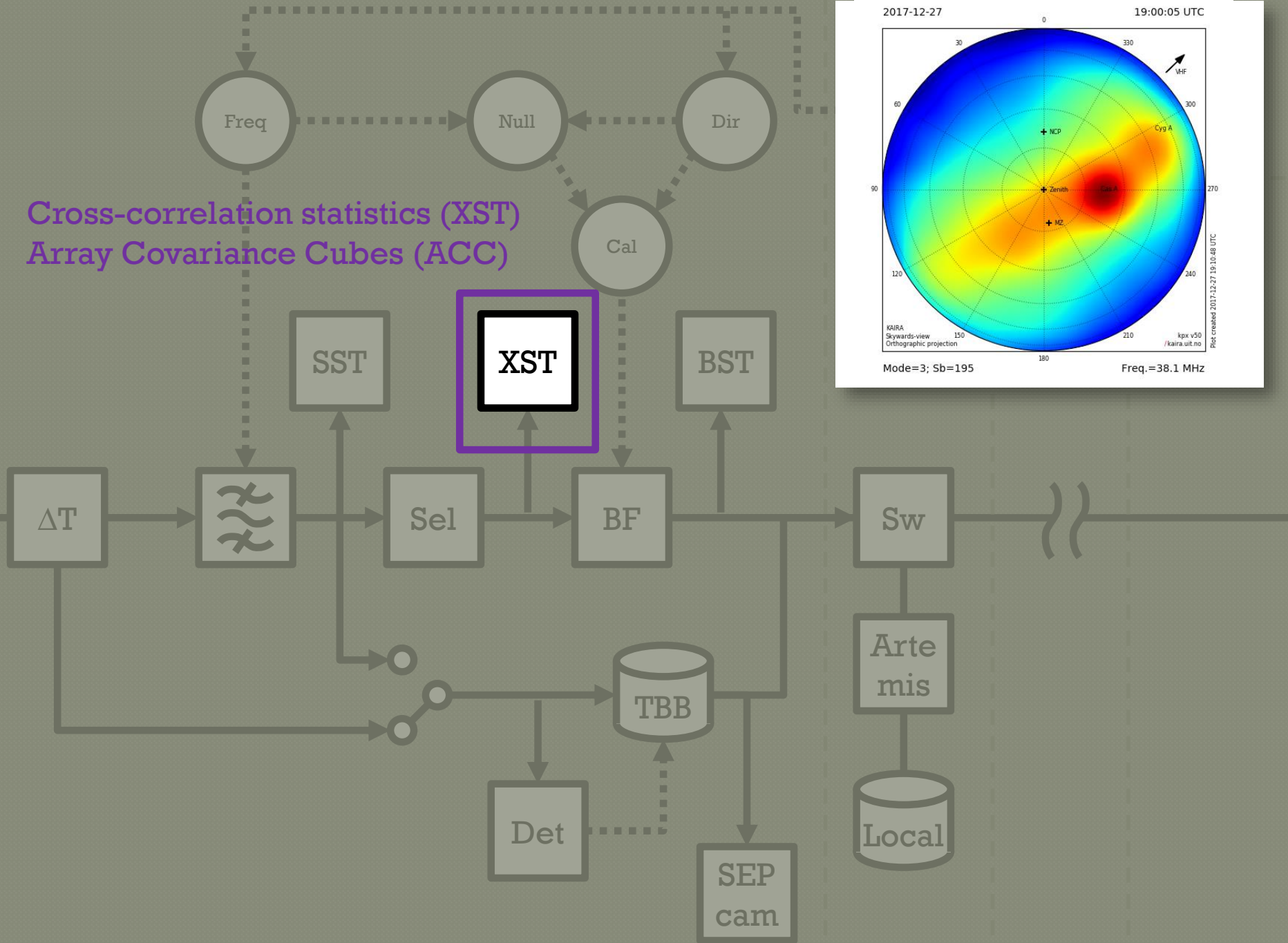


Zernike Supercomputer Centre
Groningen, Netherlands

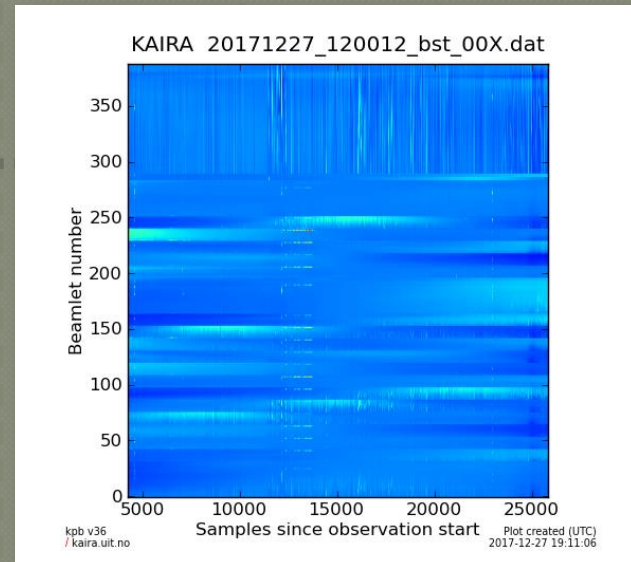
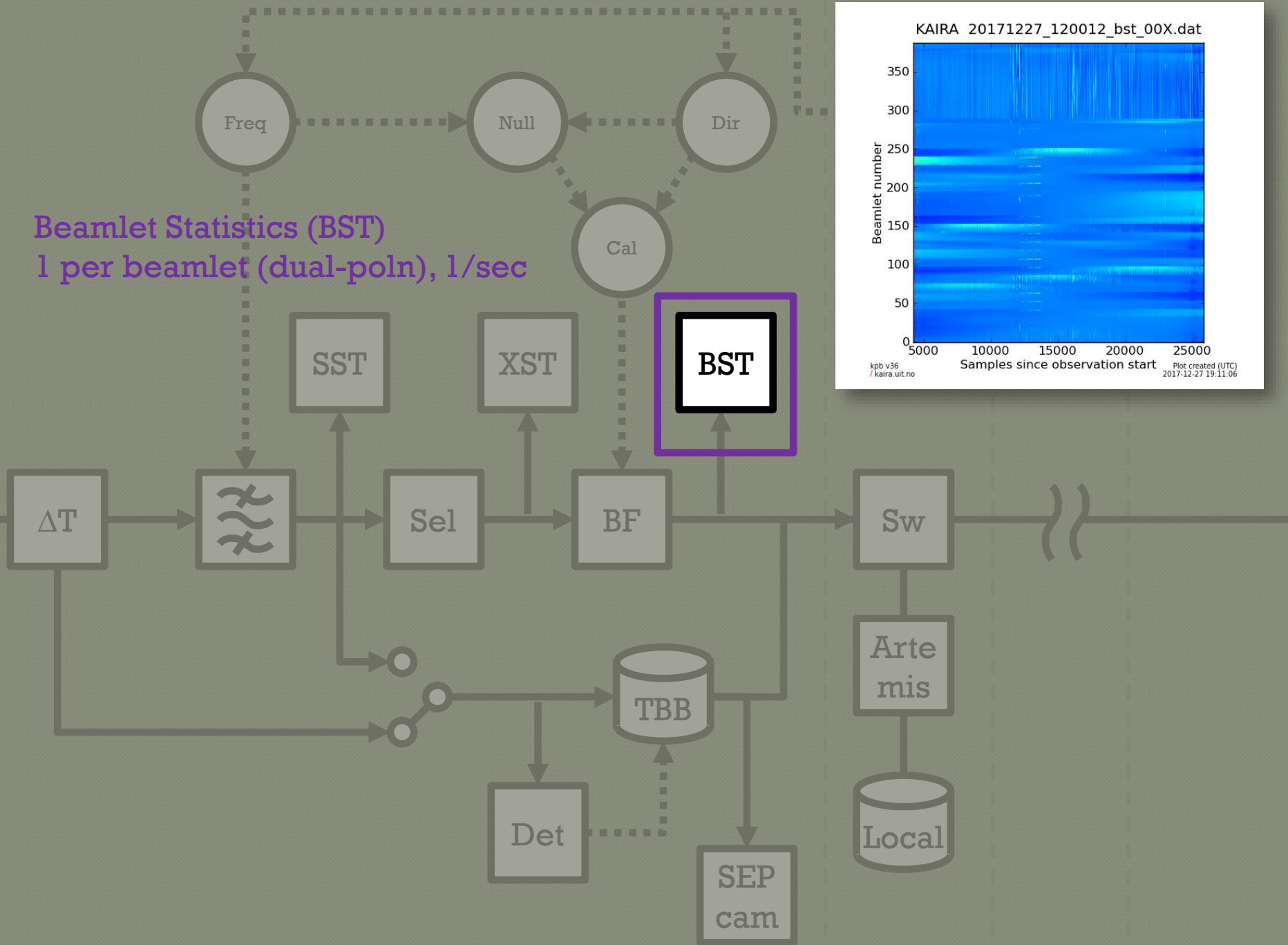
Summary

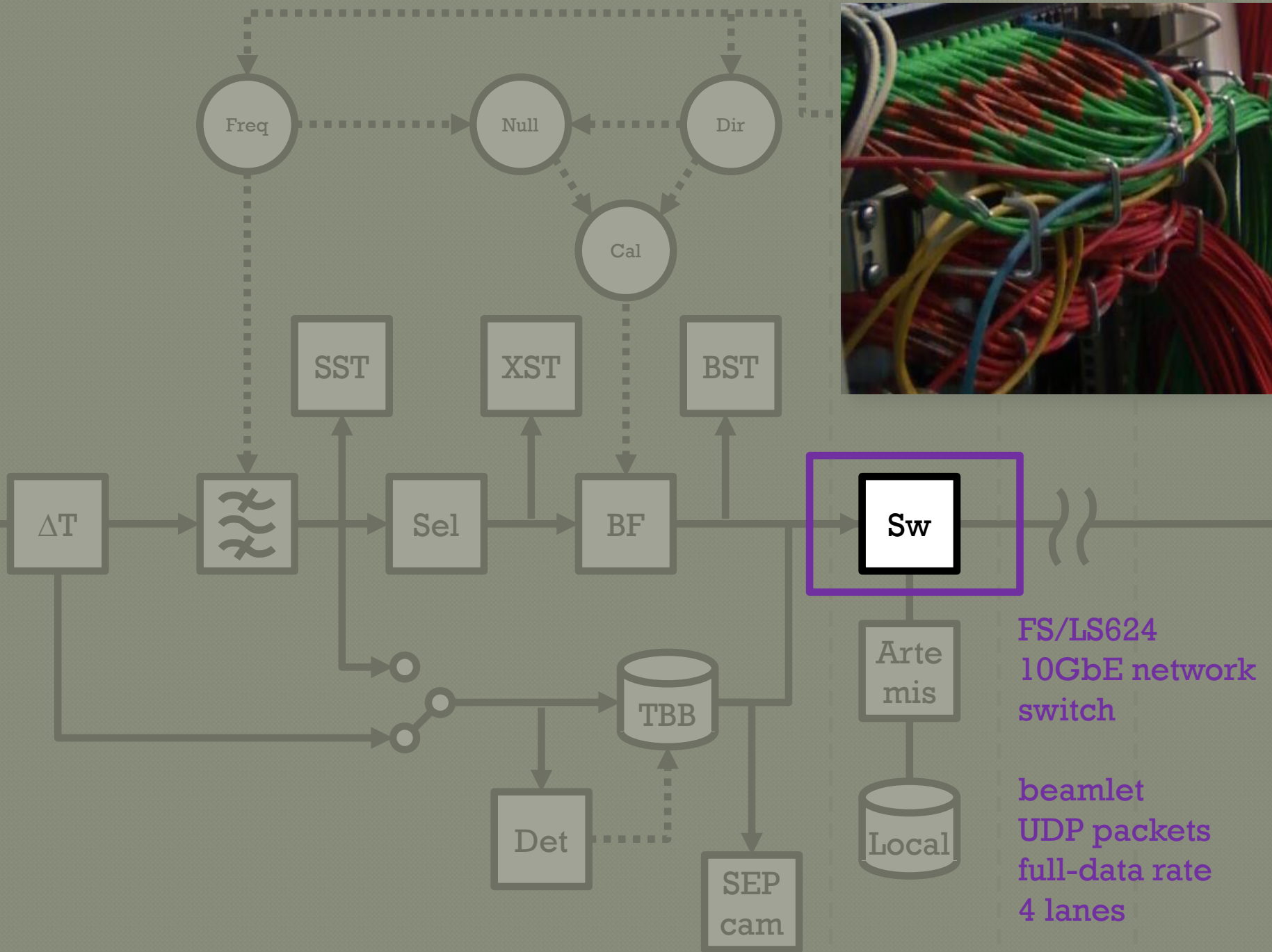
The data products of
an International LOFAR station

Cross-correlation statistics (XST)
 Array Covariance Cubes (ACC)



Beamlet Statistics (BST)
1 per beamlet (dual-poln), 1/sec





FS/LS624
 10GbE network
 switch

beamlet
 UDP packets
 full-data rate
 4 lanes

End

Questions?

