APERTIF

APERture Tile In Focus

An update on APERTIF and future PAF activities at ASTRON

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ASTRON

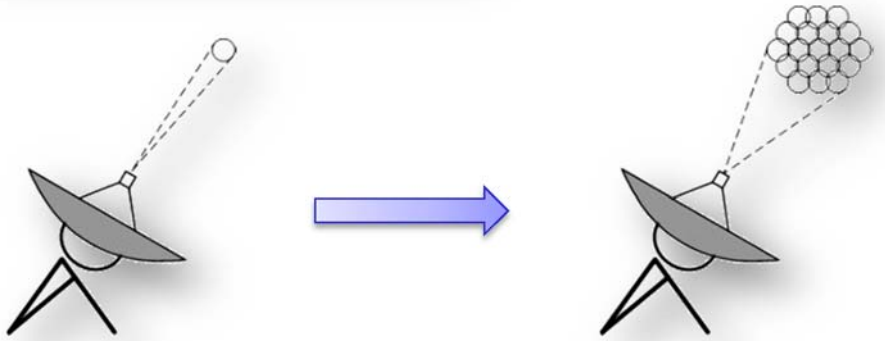
Outline

- Update on APERTIF
- Room temperature vs Cryo cooled
- Future plans
- Conclusions

APERTIF: Phased Array Feeds for the WSRT

- Transform the WSRT into an efficient 21-cm survey facility
- 17x Survey speed increase
- SKA Pathfinder

APERTIF
APERture Tile In Focus

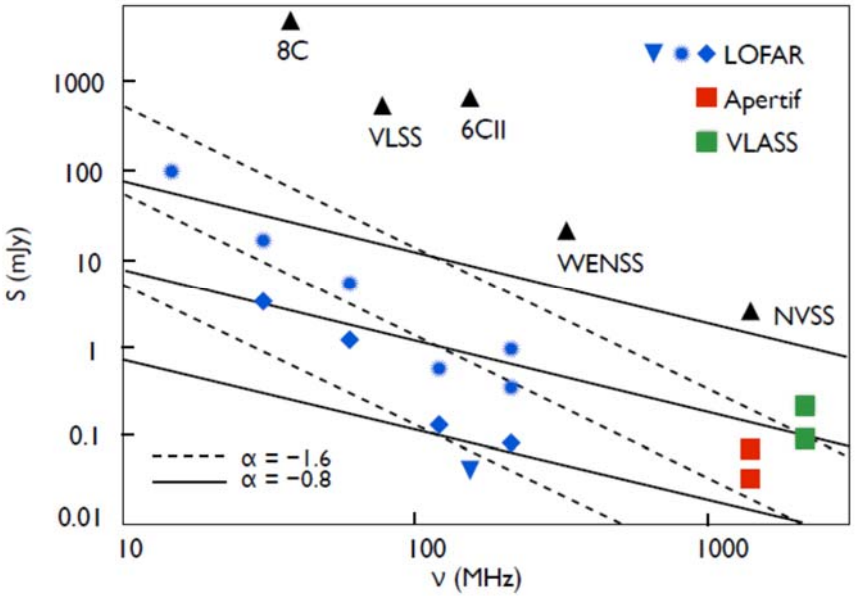


APERTIF Science

- Two main surveys
  - Large-area imaging survey (continuum & spectral line)
  - Large-area transient survey

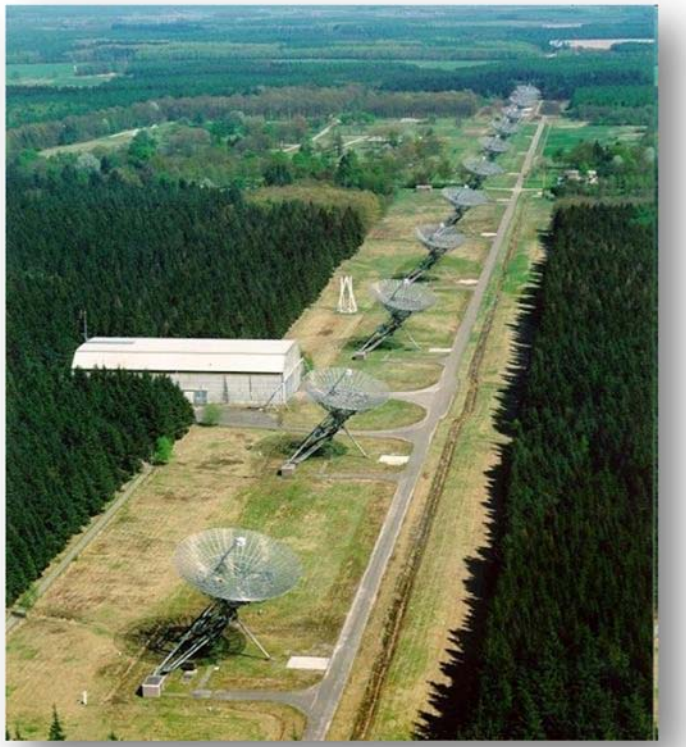
- Unique synergy with LOFAR:
  - Good match in continuum sensitivity and resolution

- And
  - (Wide-field) VLBI
  - Pulsar timing
  - …

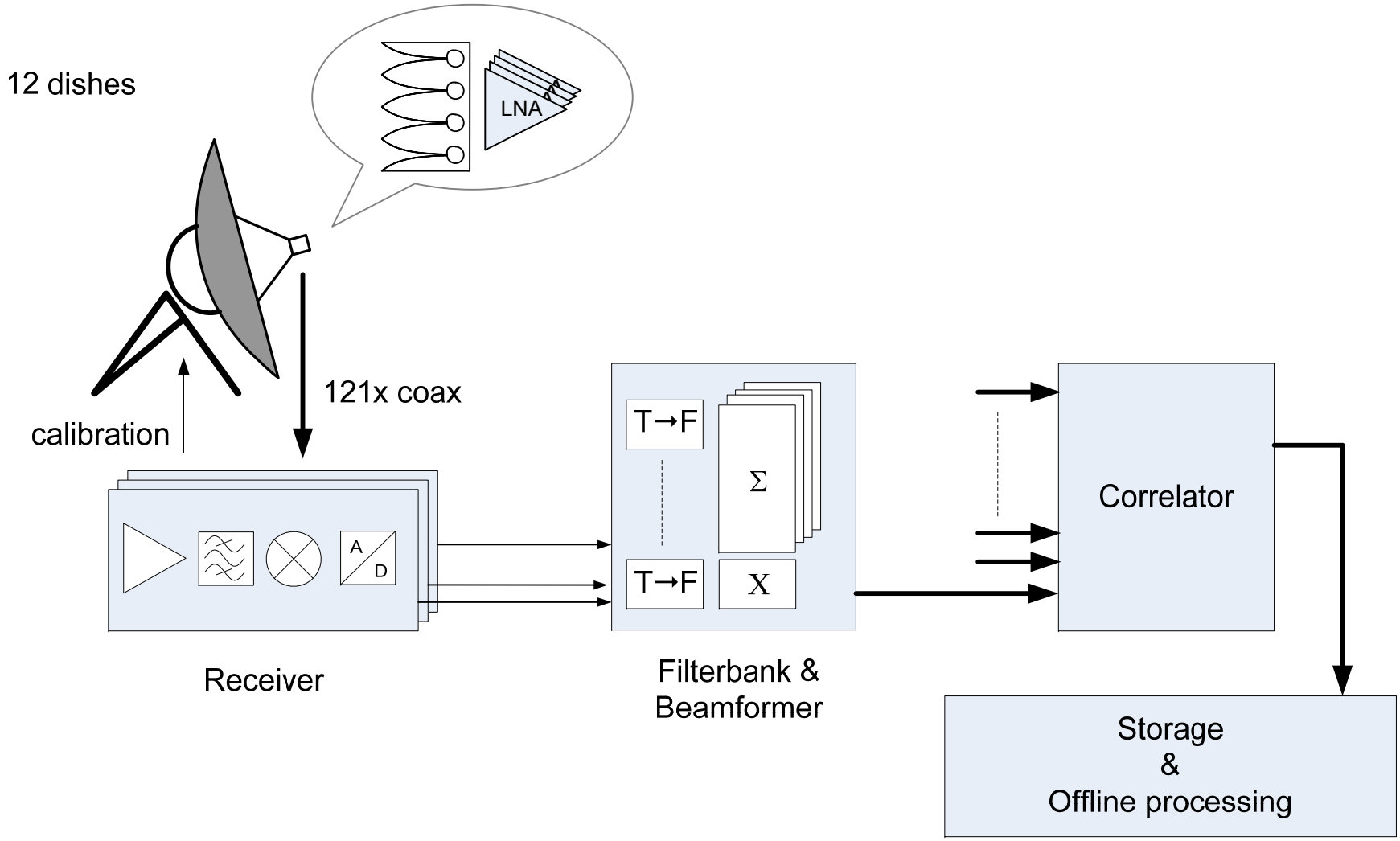


APERTIF specifications

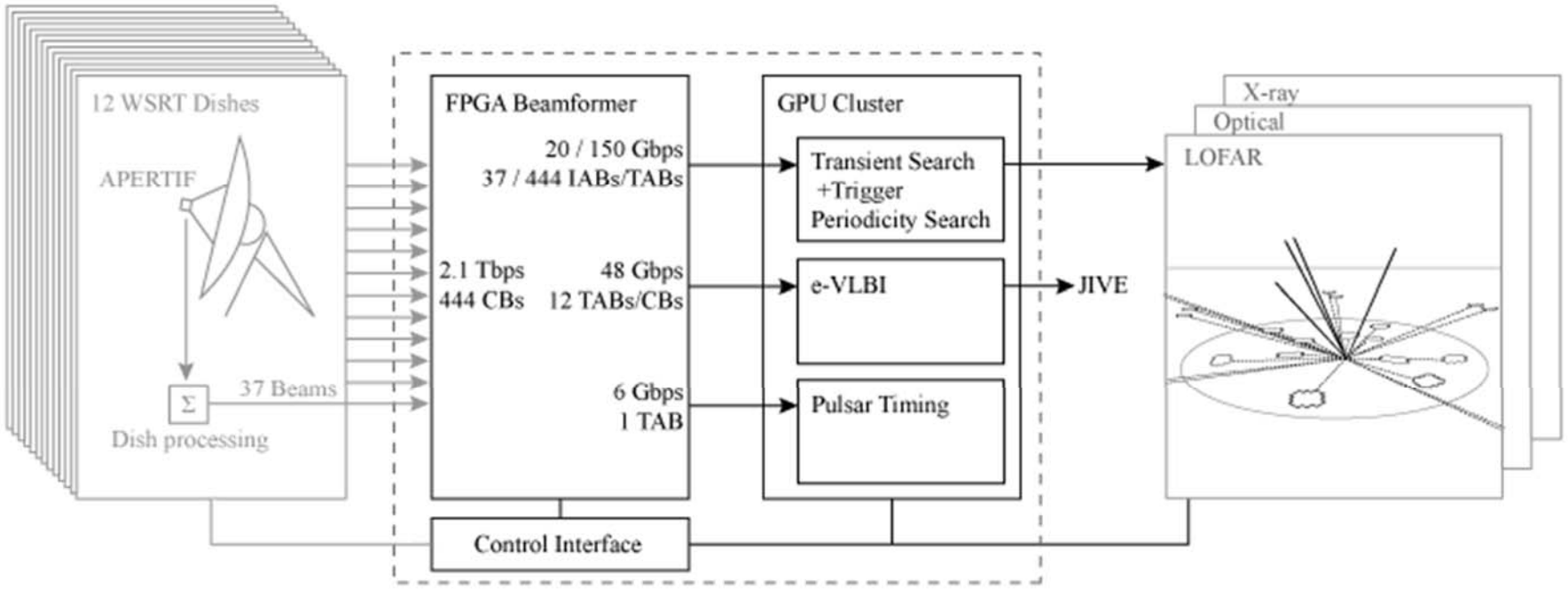
Frequency range	1130 – 1750 MHz
Instantaneous bandwidth	300 MHz
Channel bandwidth	12 kHz
Polarization	Dual linear
Reflectors	12 x 25m
Baselines	36 to 2412 m
System temperature	70 K
Aperture efficiency	75%
Simultaneous beams	37 dual pol
Field of view	8 deg^2
“Survey speed increase”	17x



Top level block diagram, imaging



Transient + VLBI backend



Feed array

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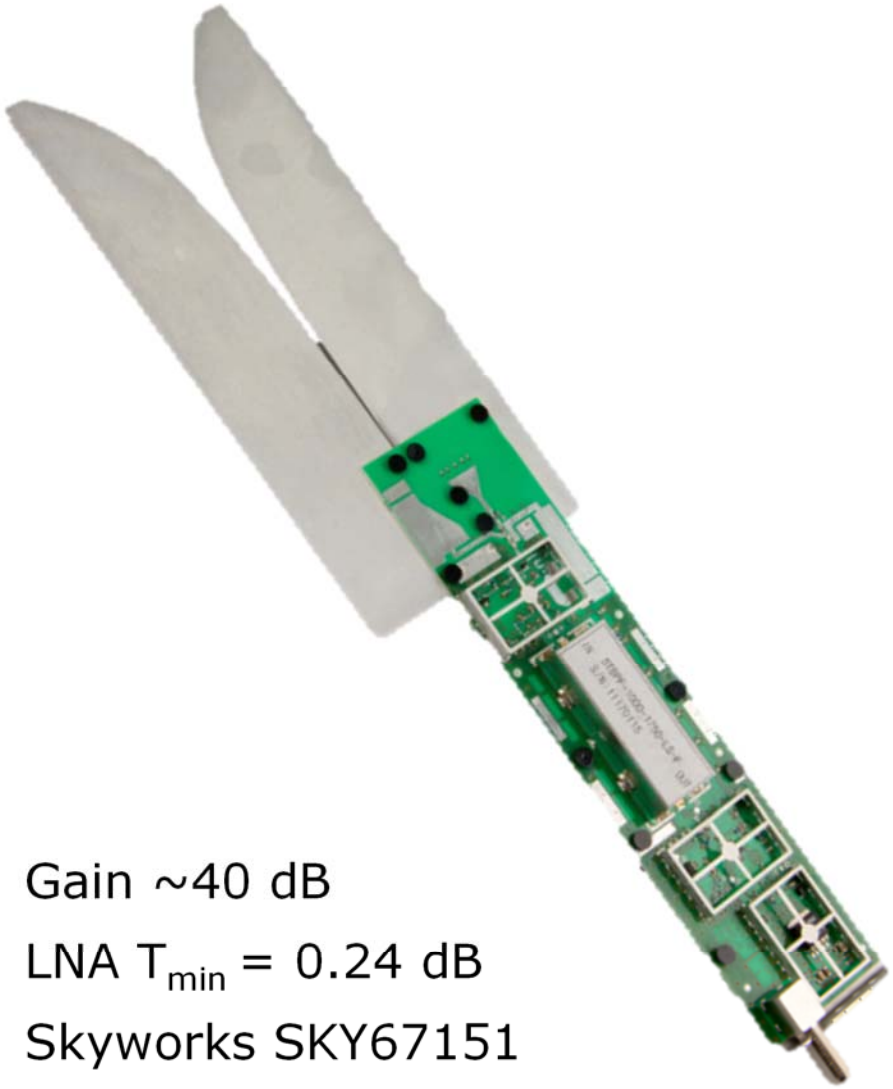
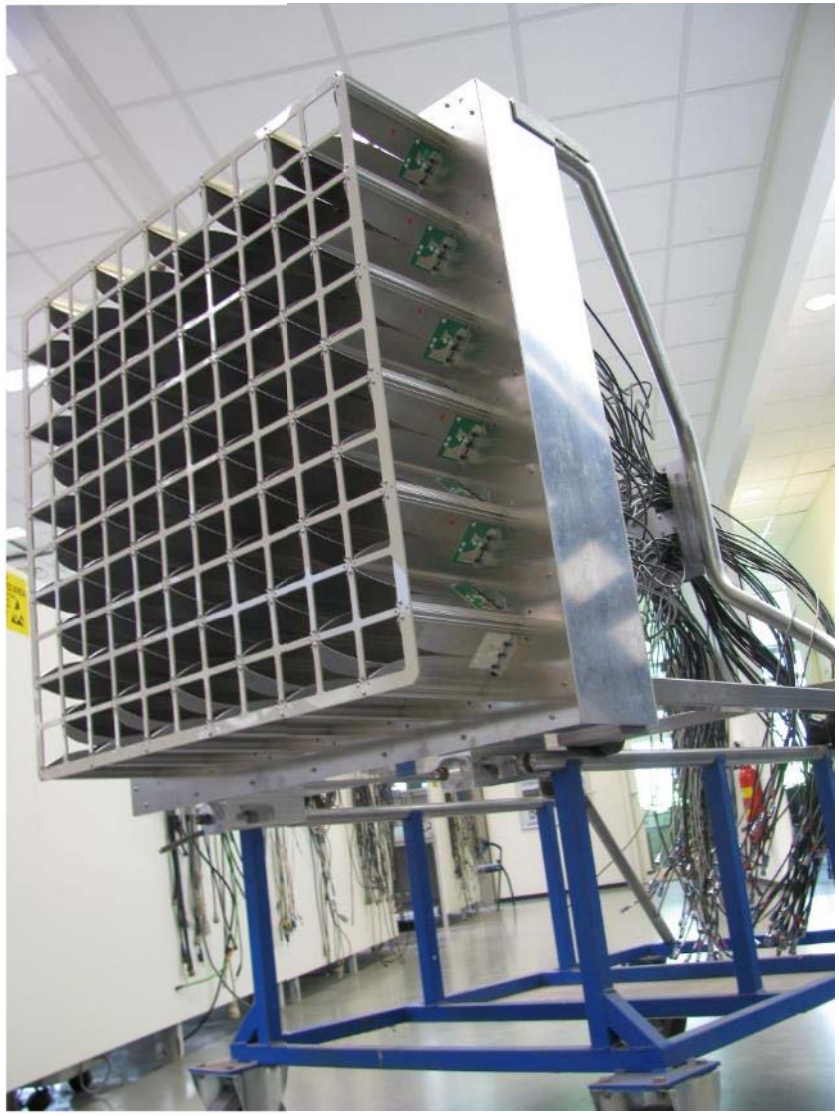
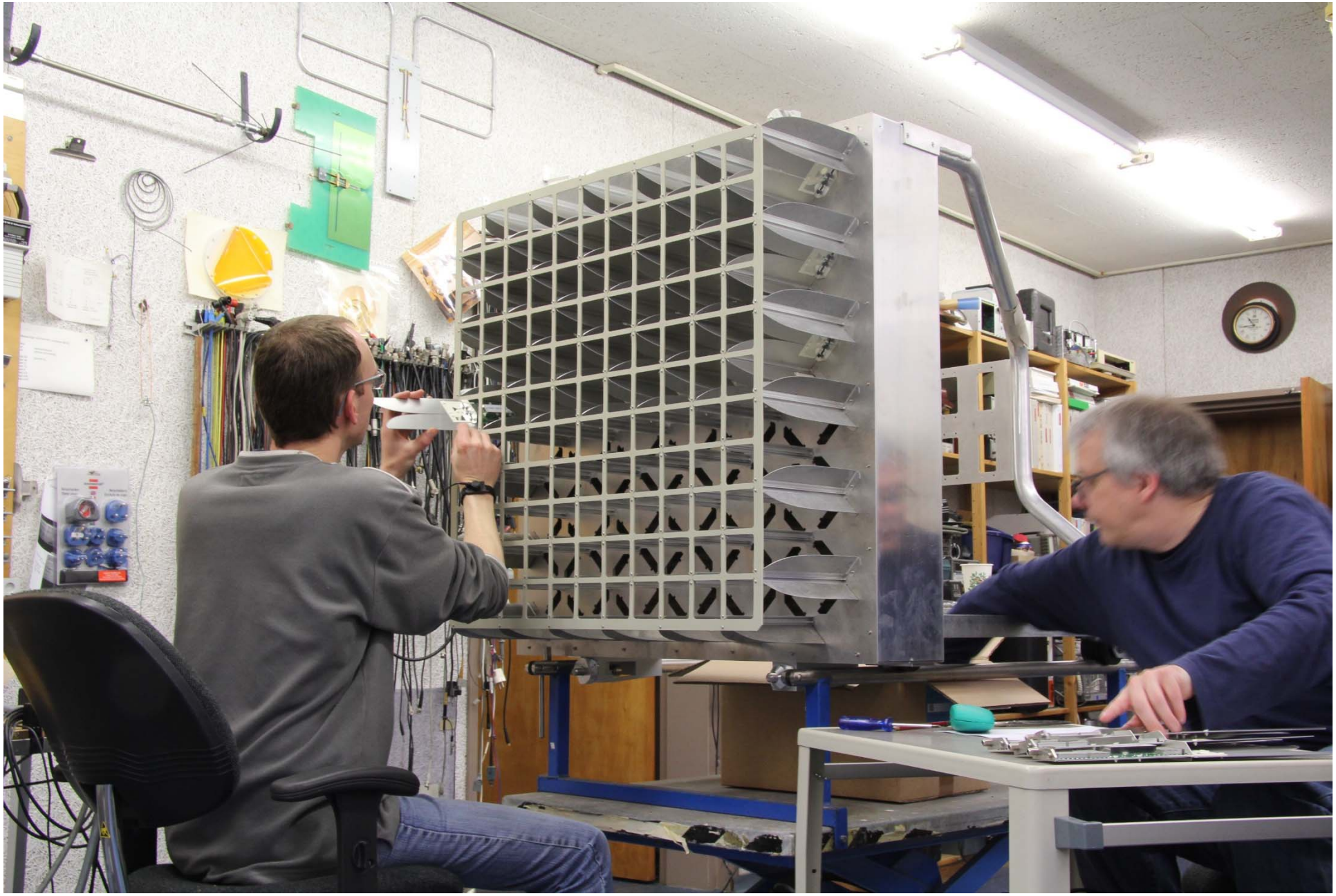


Gain ~40 dB

LNA T_{min} = 0.24 dB

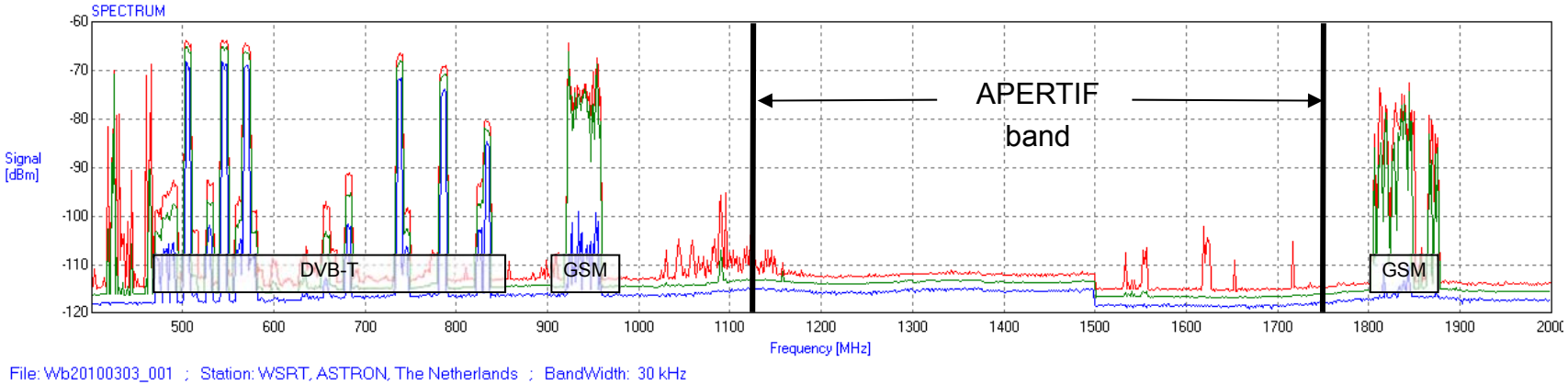
Skyworks SKY67151

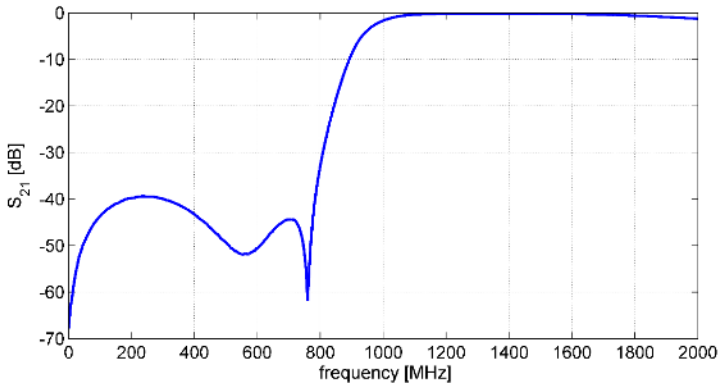


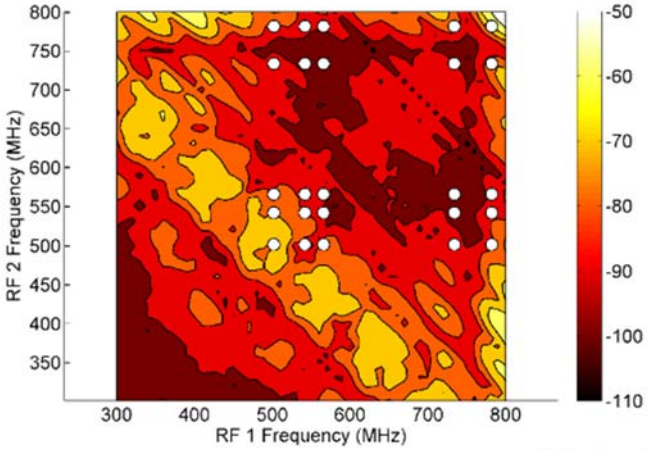


RFI immunity

- High-pass filter between the antenna and LNA
  - System temperature penalty ~15 K
  - Measured IP2 products now > 70 dB below system noise (well below RA.769)





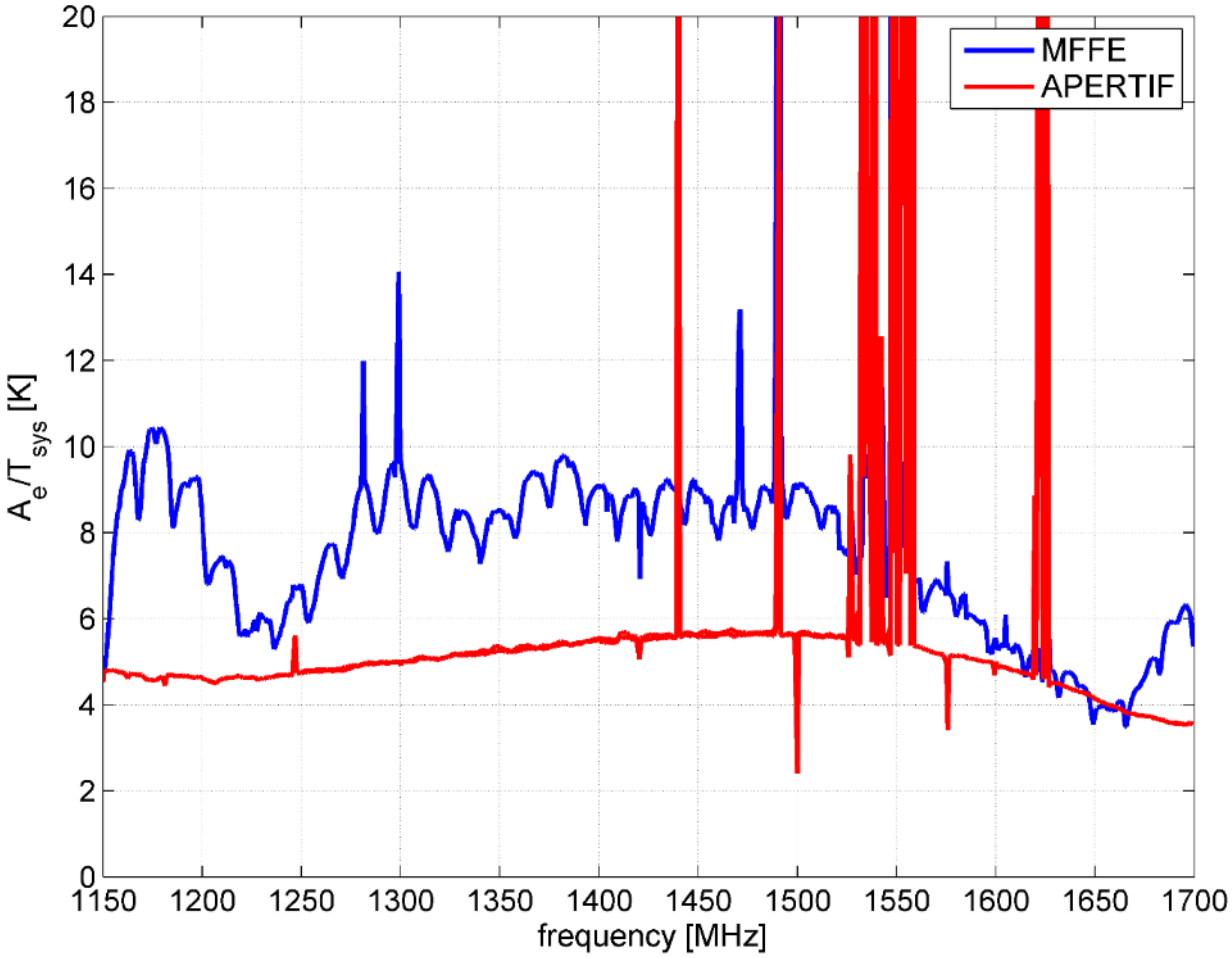


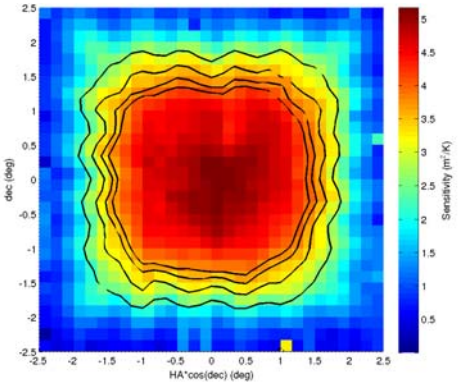
System performance

Description	T_{sys} *contribution*	*Remarks*
Antenna and radome	6	Measurement + simulation [RD.33]
LNA (incl. pre-LNA filter)	40	Measurement, [RD.5]
Noise coupling	5	Simulation, [RD.38]
Receiver and ADC	6	Measurement, [RD.5]
Spill-over	6	Simulation, [RD.38]
Sky noise	5	Literature
Total	68 K	

APERTIF vs MFFE single-dish sensitivity

- Lower, but MUCH smoother (good for calibration)



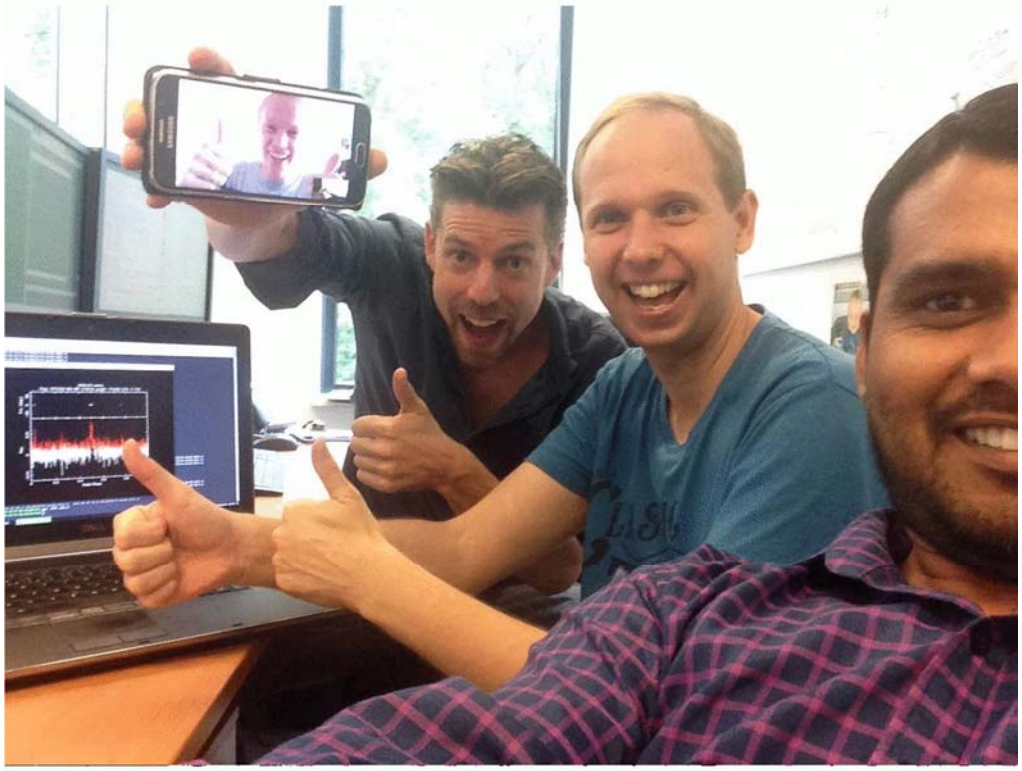


Rollout Status

- WSRT switched-off in June 2015 (except 2 VLBI dishes)
- First-light on 2 dishes in October 2015
- All hardware of 12 APERTIF dishes and the correlator is installed
- High activity on firmware and software development/debugging

ARTS First Light

- Initial hardware, firmware and software has been installed
- 3-dish tied-array
- First light on August 11, 2016



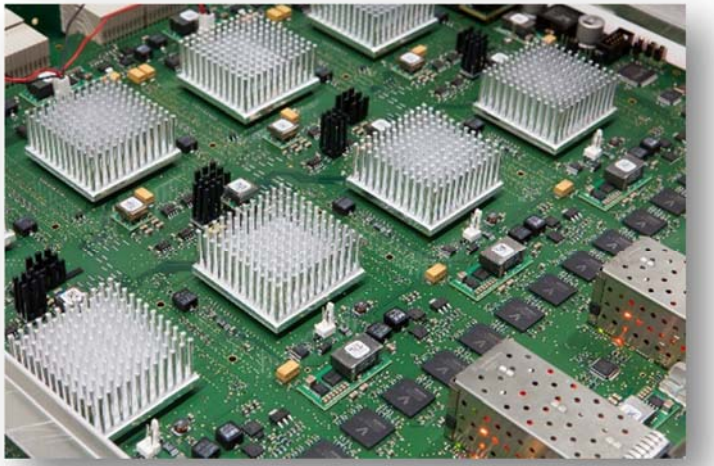
Future PAF work at ASTRON

- APERTIF commissioning and operation

- ASTRON is looking for opportunities to collaborate on a cryogenic PAF development
  - SKA: LFAA/MFAA for frequencies < 1.5 GHz
  - PAF's at higher frequencies
- Feasibility studies to determine direction
- Significant industry interest in PAFs

  (satellite, point-to-point comms,

  low-cost multi-function radar)



Cryo or Room temp?

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- For APERTIF, room temperature and cryo cooled systems were considered.
- It was concluded that a room temperature PAF resulted in the most competitive system

- Bert Woestenburg considered the same trade-off for a 4-12 GHz PAF

- Conclusion: Tsys of present and future cooled PAF's can be 3x – 4x better than room temperature PAF's at 10 GHz.

Expected System Temperature

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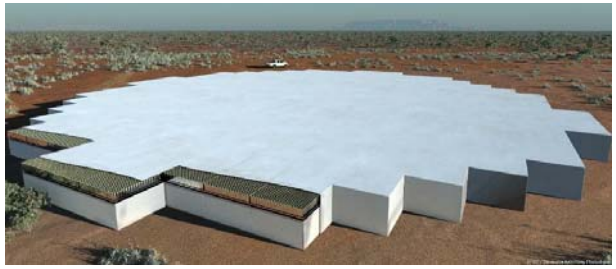
	Room Temperature	Cryo
Present	105 K	25 K
Future	56 K	18 K

- Cooled PAF (“CryoPAF”)
  - Present:
    - Rohacell: freq dep. loss, rel high (9K) at 10 GHz
    - Ten Cate: dominated by dielectric reflection losses.
  - Future:
    - 50% reduction of LNA noise and losses

- Room Temperature (“RTPAF”)
  - Present: Dominated by LNA and losses before LNA (antenna, feed)
  - Future: 50% reduction of LNA noise and losses

Future work

- SKA PAF consortium is being formed
  - CSIRO, NRC, ASTRON, INAF, UMan, JLRAT
  - AIP phase (now-2018) leading to CoDR and SRR



- Costs
  - Capital costs, Operational costs

– APERTIF (25m reflector)	~250k€ per PAF, ~500 €/m^2
– “SKA1-Survey” (15m reflector)	4800 €/m^2
– APERTIF PAF	5kW / 491 m^2 = 10 W/m^2
– “SKA1-Survey”	7 kW/175 m^2 = 40 W/m^2

- MFAA ~1200 €/m^2, <50 W/m^2 in 2025 (all-in)
- Work is needed on both!

A final suggestion

- My suggestions for the wrap-up of this workshop:
  - A summarizing statement on the progress of PAF technologies and the increasing interest
  - Performance vs frequency, realized and expectations & costs
  - Signal innovative developments/opportunities

Summary

- APERTIF is going strong!
- ASTRON is looking for opportunities to collaborate on a cryogenic PAF development