



**An update on APERTIF
and future PAF activities at ASTRON**

Wim van Cappellen, R.H. van den Brink, B. Hut
ASTRON



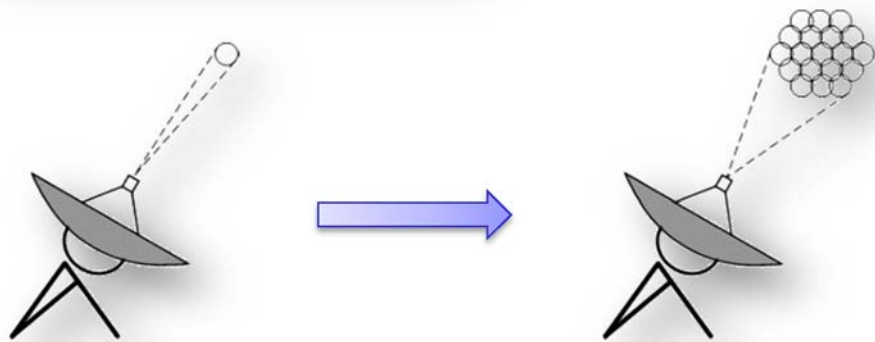
Outline

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

APERTIF: Phased Array Feeds for the WSRT



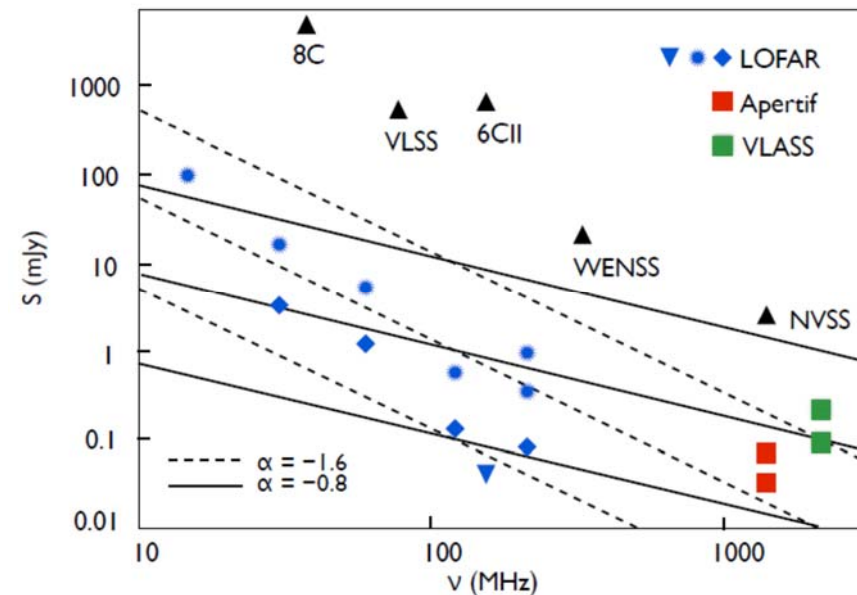
- Transform the WSRT into an efficient 21-cm survey facility
- 17x Survey speed increase
- SKA Pathfinder



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

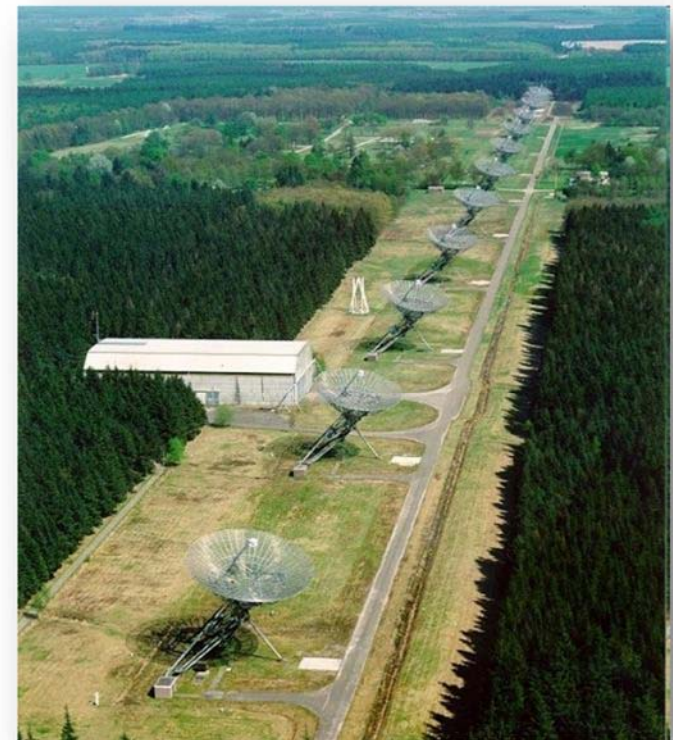
- Unique synergy with LOFAR:
 - Good match in continuum sensitivity and resolution

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

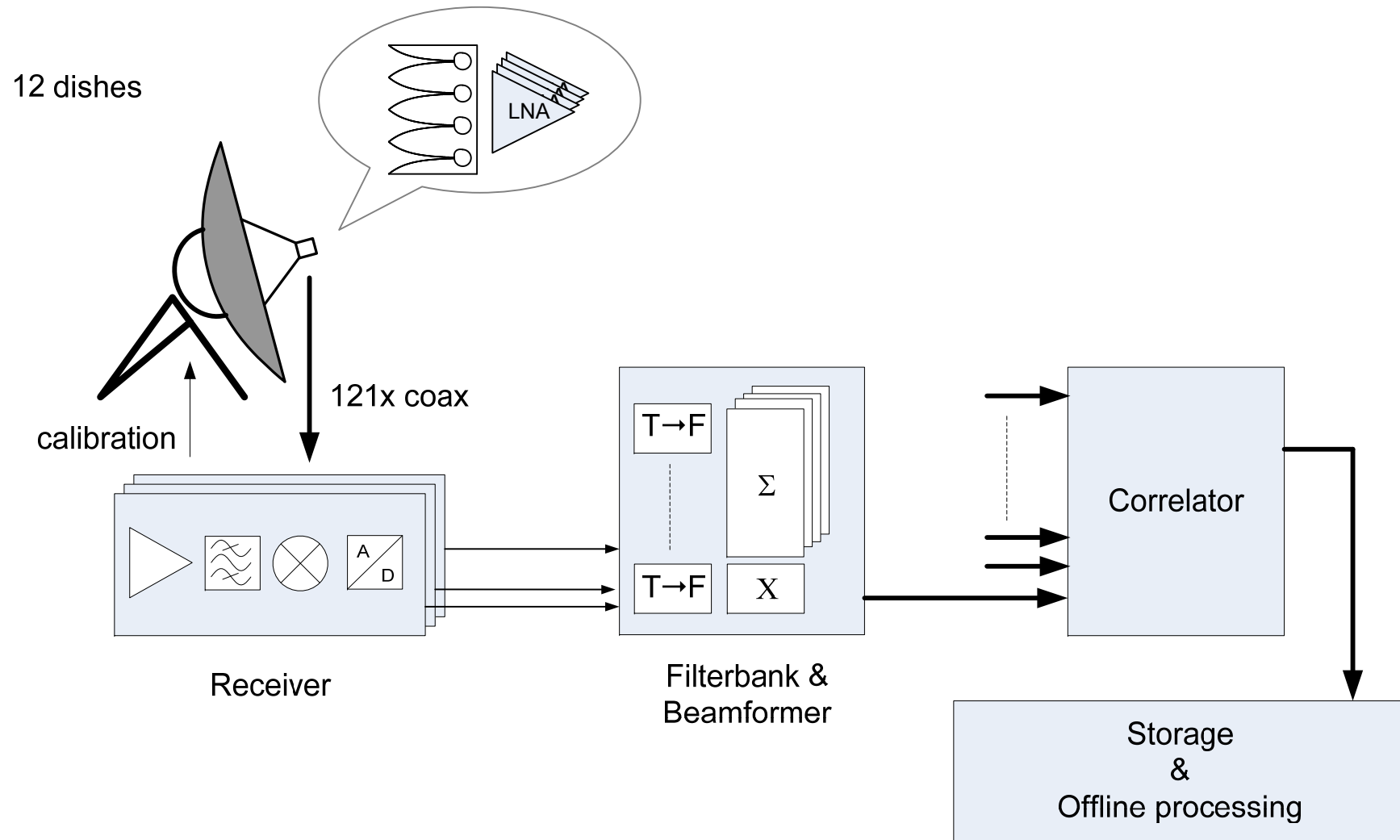


APERTIF specifications

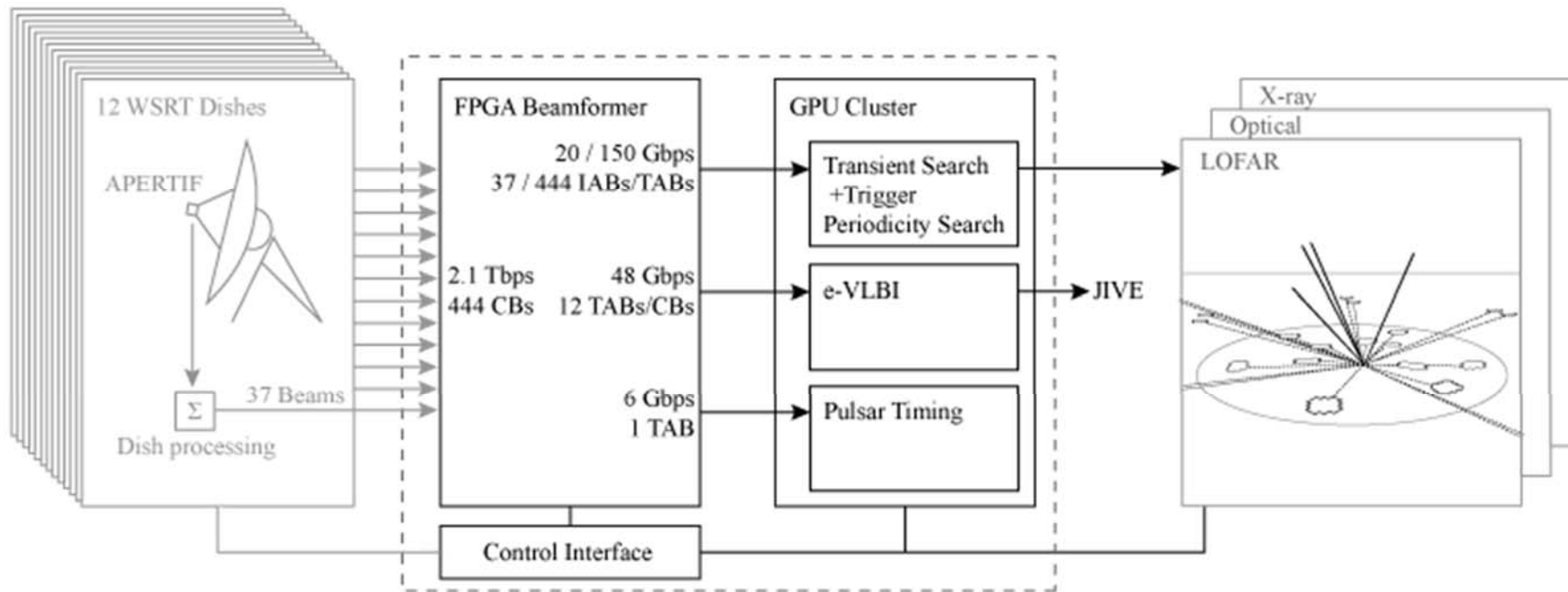
Frequency range	1130 – 1750 MHz
Instantaneous bandwidth	300 MHz
Channel bandwidth	12 kHz
Polarization	Dual linear
Reflectors	12 x 25m
Baselines	36 to 2412 m
System temperature	70 K
Aperture efficiency	75%
Simultaneous beams	37 dual pol
Field of view	8 deg ²
“Survey speed increase”	17x



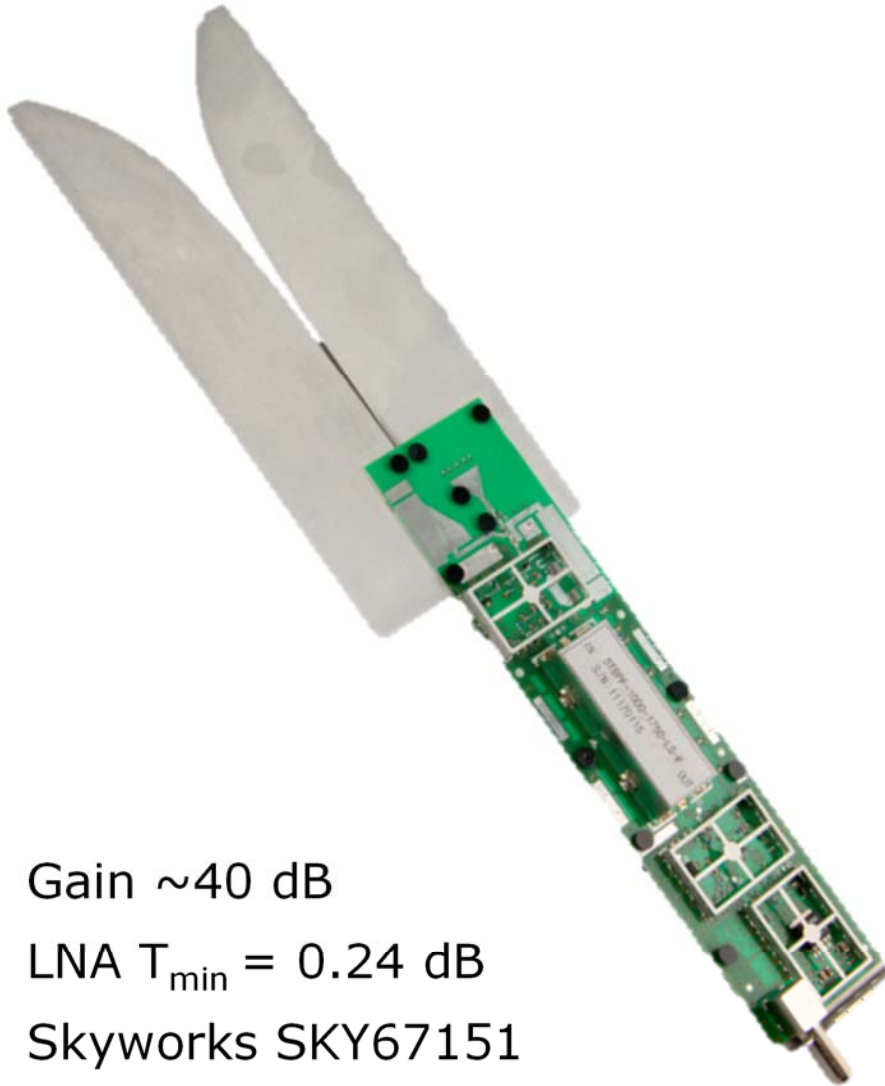
Top level block diagram, imaging



Transient + VLBI backend



Feed array

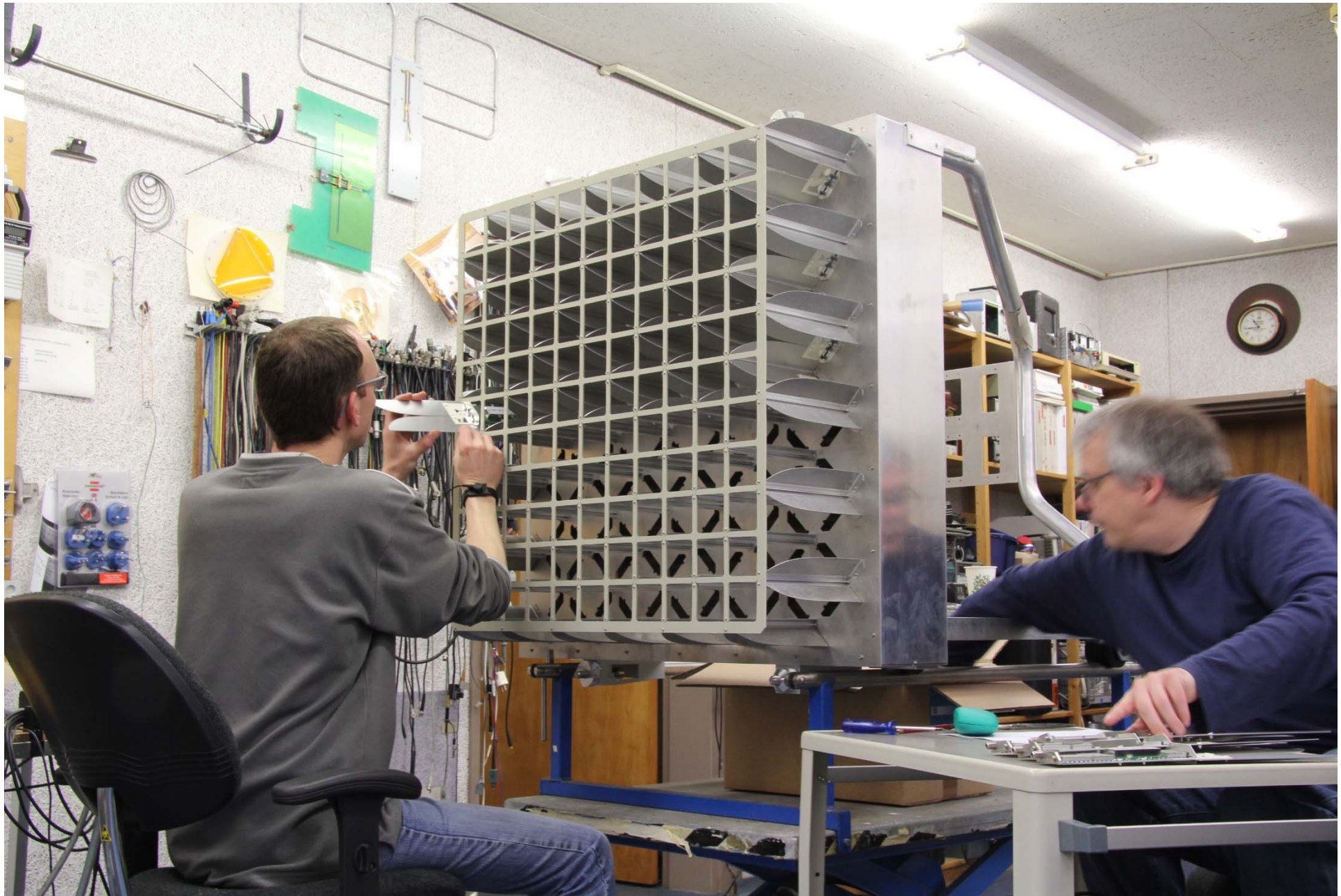


Gain ~ 40 dB

LNA $T_{\min} = 0.24$ dB

Skyworks SKY67151





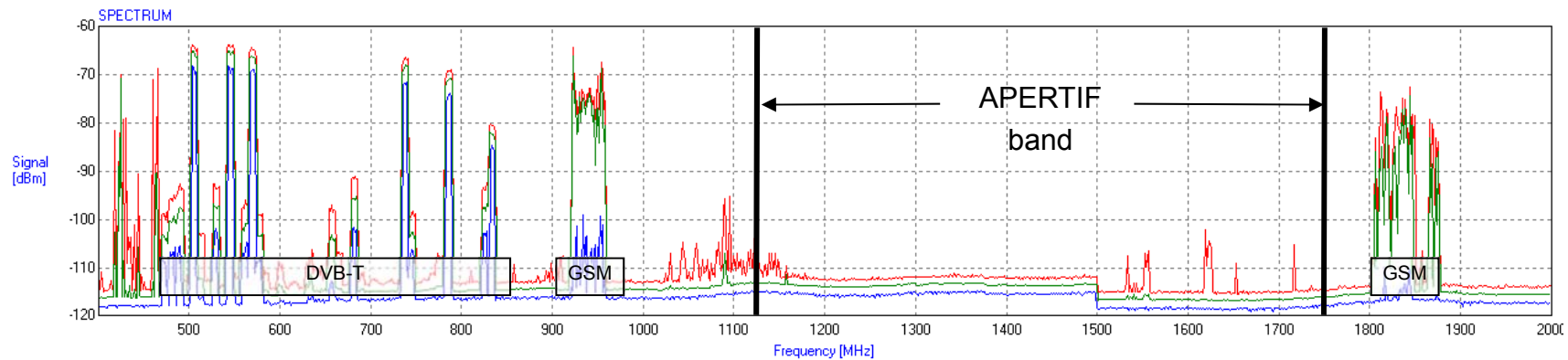


PAF Workshop 2016, Cagliari, Italy

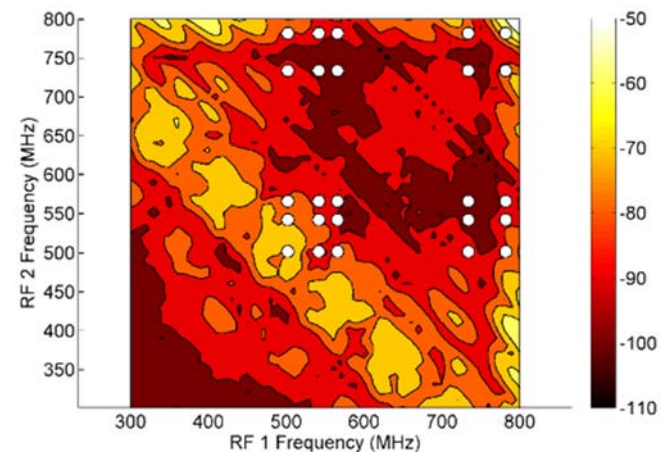
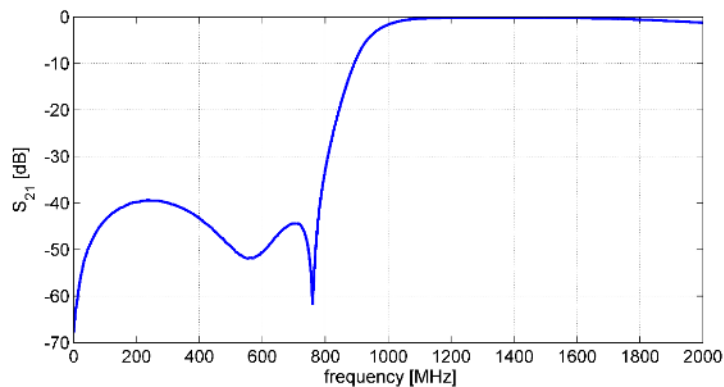
WvC, 2016/08/24

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)



File: Wb20100303_001 ; Station: WSRT, ASTRON, The Netherlands ; BandWidth: 30 kHz

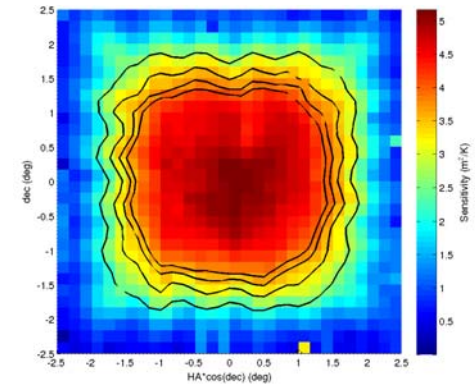
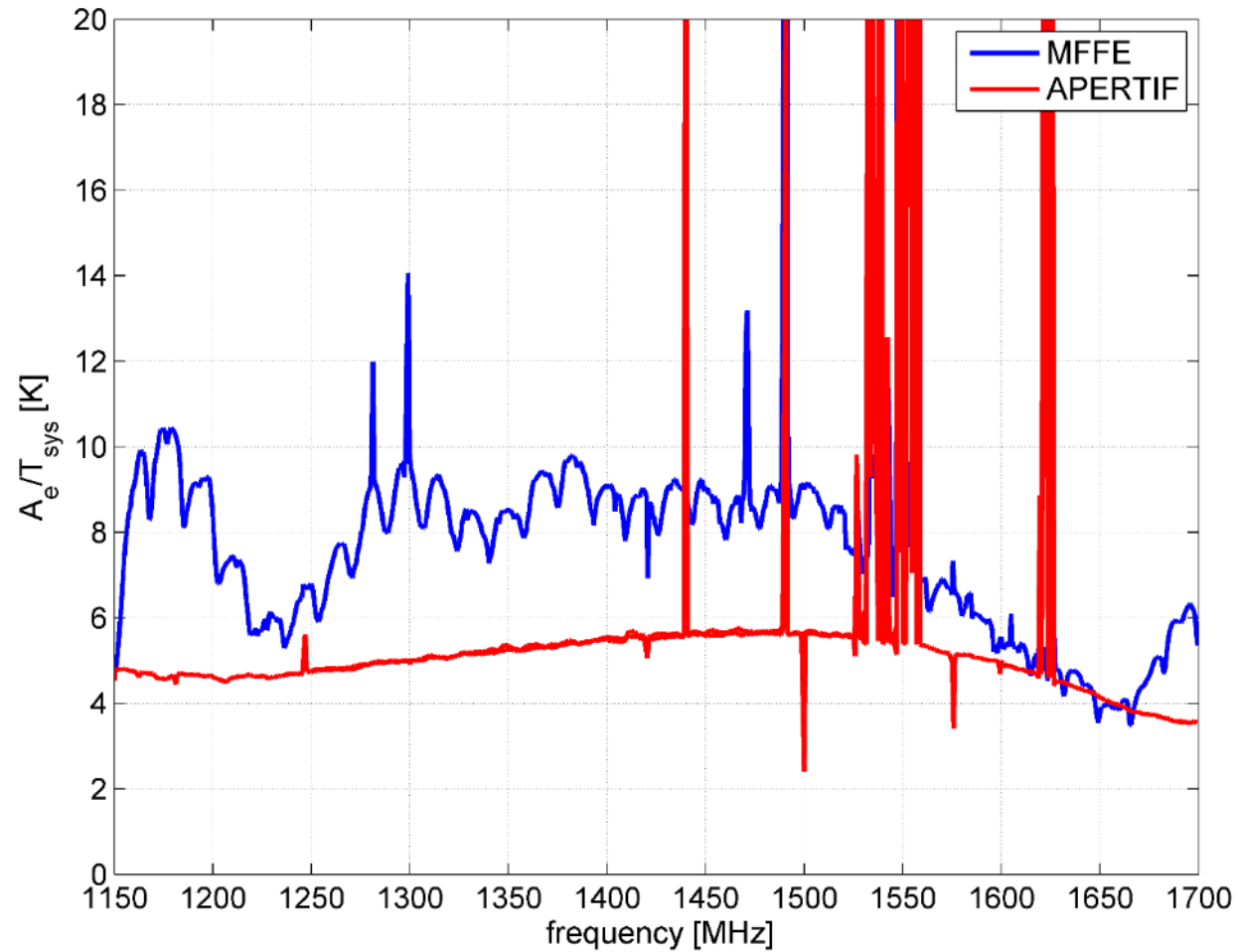


System performance

<i>Description</i>	<i>T_{sys} contribution</i>	<i>Remarks</i>
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?

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

Expected System Temperature

	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 €/m²
- "SKA1-Survey" (15m reflector) 4800 €/m²

- APERTIF PAF 5kW / 491 m² = 10 W/m²
- "SKA1-Survey" 7 kW/175 m² = 40 W/m²

- MFAA ~1200 €/m², <50 W/m² 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

The poster features a background of a colorful nebula. At the top center, the text 'PAF2016' is displayed in white on a blue rectangular background. Below this, the text 'PHASED ARRAY FEED WORKSHOP' and '24-26 AUGUST, 2016, CAGLIARI, ITALY' is written in white. On the left side, under the heading 'Scope:', there is a bulleted list of topics. On the right side, there is the INAF logo and a photograph of a radio telescope dish.

PAF2016


PHASED ARRAY FEED WORKSHOP
24-26 AUGUST, 2016, CAGLIARI, ITALY

Scope:

- engineering feedback from commissioning and early science observations
- element and array design with ultra-wide bandwidth
- analog and mixed-signal electronics
- traditional beam forming and innovative solutions
- beam former calibration
- array characterization and testing
- sensitivity and field of view limits
- cryogenic PAFs
- systems integration
- telescope optics for PAFs
- imaging, and lessons learned from PAF deployments

Contact: PAF2016@oa-cagliari.inaf.it

INAF
ISTITUTO NAZIONALE
DI ASTRONOMIA
NATIONAL INSTITUTE
FOR ASTROPHYSICS



Summary

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

