Report from the event supported by RadioNet

TITLE	*PHASED ARRAY FEED WORKSHOP*
DATE:	*16-18 SEP. 2018*
LOCATION:	*BONN, GERMANY*
MEETING WEBPAGE:	*https://events.mpifr-bonn.mpg.de/indico/event/108/*
HOST INSTITUTE:	*MAX PLANCK INSTITUTE FOR RADIO ASTRONOMY*
RADIONET BENEFICIARY / NO:	*MPG / 01*

RadioNet has received funding from the EU's Horizon 2020 research and innovation programme under the grant agreement No 730562

Report:

1 SCIENTIFIC SUMMARY

Workshop Webpage:

https://events.mpifr-bonn.mpg.de/indico/event/108/overview

The scope of the workshop is to exchange ideas and solutions among the developers of radio-astronomical instrumentation in the frequency range below 100GHz, specially under the aspect of phased array feed systems. After single pixel systems and discrete array receivers have been developed to sensitivities close to the physical limits, phased array feed systems are now the next logical step to further increase the science output of the observing facilities. These receiving systems with up to several hundred receiving channels introduce new technological challenges in all areas.

Contributions covered the following technological topics:

- *PAF systems*

  Contributions targeting mainly the PAF system as a whole, e.g. system layout, commission strategy, performance, …

- PAF theory and simulations

  Contributions, e.g. on the PAF theoretical background, beam-forming algorithms, RFI-mitigation schemes, system simulations, system optimization, ...
- PAF frontend technology
  Contributions targeting technologies of the receiver frontend, e.g. Antenna-array, analog signal processing, ADC,...
- Digital data processing and backend technology
  Contributions targeting technologies of the digital part, e.g. beam-former, network-topology, computer cluster, data processing, backend software, ...
- PAF science applications
  Contributions related to possible (new?) science cases of PAFs, new observing strategies, data calibration, ...
- Misc (but PAF related)
  Misc topics which do not directly fit into the other topics, e.g. cryogenic cooling, large diameter vacuum windows, ...

1.1 SCIENTIFIC SUMMARY

The workshop stimulated an intensive discussion and exchange on PAF developments. This covers the following areas including open questions:

- *First generation of PAF's are now in science operations.*

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- *Wide field of view provides ground-breaking advances for imaging surveys and transient detections*
- *System complexity (monitoring, control, amount of data) is a challenge*
- *Providing an important reference point in terms of performance and costs of PAF technology*

- Currently, PAF's are envisaged to be very effective on (existing) large reflectors
  - Increased field of view
  - RFI mitigation, beam optimization
  - Requirement: Little compromise on single-beam sensitivity, leading to cryo-cooled systems.
- Next generations of PAFs
  - Most new developments are aim to reduce system temperature, mostly by cryo-cooling, improved antenna and RF electronics design
  - Reduce backend costs, but limited control over key component costs
  - Cryo PAFs may reduce spillover to ~1 K
- open Questions
  - Are different beamformers used other than max-SNR?
  - Beam stability, characterization, and maintenance is generally more important than controlled beam shape (Aaron Chippendale)
  - What is the optimal reflector shape for a given PAF?

1.2 RADIONET RELEVANCE

Phased Array Feed systems are considered as a future receiver option for the single dish telescopes, providing additional functionalities compared with currently used single dish receivers. Effelsberg as well as Jodrell Bank have implemented a phased array for first evaluation, while Westerbork is operating the Apertif PAF for science and a significant RadioNet Partners are involved in the development of the Pharos II Phased array.

1.3 IMPACT

The workshop fostered the exchange and interaction between the RadioNet community on the Phased Array Feed technologies. Especially and cryogenic PAF system has shown a high complexity, requiring technological interaction in-between the RadioNet community. Several technological cooperation have been discussed during the workshop and are going to be initiated.

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2 AGENDA OF THE EVENT

Tuesday, 17 September, 2019

Time	Title/Event
8:00 – 9:00	**Workshop: Registration desk (*Hotel Collegium Leoninum*)**
9:00 – 9:10	**Workshop: Introduction and organization**
9:10 – 9:40	**Session 1: PAF Science Applications** ***Chair: G. Wieching***
9:10 - 9:40	Scientific Use Cases for a Phased Array Feed Laura Spitler
9:40 – 12:10	**Session 2: PAF Theory and Simulations** ***Chair: K. Warnick***
9:40 - 10:10	Beamforming Basics Douglas Hayman
10:10 - 10:35	Poster Introduction – 3 min. Each
10:35 - 11:10	**Poster Session and Coffee Break**
	Wide Scan Range PAF Telescope for Massive MIMO 5G Base Stations *(poster presentation)* A. Elsakka, U. Johannsen, O. Iupikov, M. N. Johansson, M. Ivashina and A. B. Smolders
	A room temperature Phased Array Feed for Arecibo telescope *(poster presentation)* Anish Roshi
11:10 - 11:30	Prediction of PAF Performance Through a Simplified Model Chengjin Jin, Bo Peng, Bin Liu, Shenghua Yu, Xiaoming Chai, Yang Cao, Yan Zhu and Jun Wang
11:30 - 11:50	Attempts to Simulate the Mutual Coupling Matrices of a Small PAF Titus Oyedokun and Stefan Heyminck
11:50 - 12:10	Beam-forming and RFI Mitigation Stefan Heyminck
12:10 - 16:50	**Session 3: PAF systems** ***Chair: S. Barker***
12:10 - 12:40	The Operational Challenges of APERTIF, a 40 Beam Phased Array Feed Interferometer Van Cappellen, Wim

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12:40 - 13:00	Deploying ASKAP's Phased Array Feeds: Lessons from the Field Aaron Chippendale
13:00 - 14:00	**Workshop: Lunch Break**
14:00 - 14:30	Update on ALPACA and FLAG Karl F. Warnick on behalf of the ALPACA and FLAG Teams
14:30 - 14:50	Digital Beamforming with PHAROS2 PAF: Updates on Warm Receiver Section, Digital Backend and Beampattern Characterization Results A. Navarrini, A. Scalambra, A. Melis, S. Rusticelli, R. Concu, P. Ortu, G. Naldi, G. Pupillo, A. Maccaferri, A. Cattani, A. Ladu, L. Schirru, F. Perini, M. Morsiani, J. Monari, J. Roda, P. Marongiu, A. Saba, M. Poloni, M. Schiaffino, A. Mattana, G. Bianchi, G. Comoretto, R. Nesti, E. Urru, T. Pisanu, F. Schillirò, K. Zarb Adami, A. Magro, R. Chiello
14:50 - 15:10	Calibrating ASKAP's Phased Array Feeds with External Noise Sources Aaron Chippendale
15:10 - 15:40	**Coffee Break**
15:40 - 16:00	Pharos 2 – Upgraded C-band PAF Simon Melhuish, Mike D'Cruze, Keith Grainge, Michael Keith and Mark McCulloch
16:00 - 16:50	Phased Array Developments for Purposes Other Than Radio Astronomy D. Heberling
16:50 - 17:00	**Workshop: Closing Remarks**
18:15 - 22:00	**Social Event (Bonn City Center)**

Tuesday, 17 September, 2019

Time	Title/Event
9:00 - 9:30	**Workshop: Registration desk (*Hotel Collegium Leoninum*)**
9:30 - 9:40	**Workshop: Organization**
9:40 – 13:00	**Session 4: PAF frontend technology** ***Chair: W. Van Cappellen***
9:40 - 10:00	A Cryogenic Phased Array Receiver for the Parkes Radio Telescope

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	Alex Dunning, Douglas Hayman, Les Reilly, Peter Roush, Sean Severs, Nick Carter, Steve Barker, Paul Doherty, Paul Roberts, Jeganathan Kanapathippillai, Yoon Chung, Robert Shaw and Santiago Castillo
10:00 - 10:20	Cryogenic PAF Receiver Design for the Parkes Telescope Australia K. Jeganathan, A. Dunning, Y. S. Chung, M. Bourne, S. Castillo, N. Carter, P. Doherty, D. B. Hayman, S. Mackay, L. Reilly, P. Roberts, P. Roush, S. Severs, K. Smart, R. D. Shaw, S. Barker, J. Tuthill and J. Bunton
10:20 - 10:40	A Digitization and Data Transmission Module for a Full Size Cryo-PAF on the Parkes Telescope Paul Roberts
10:40 - 11:10	**Coffee Break**
	Low Noise Amplifiers technology at the MPIfR Sener Türk and Frank Schäfer
11:10 - 11:40	PAF Developments at MPIfR Stefan Heyminck, Gundolf Wieching, Christoph Kasemann, Frank Schäfer and Ewan Barr
11:40 - 12:00	Frontend Technologies for an S-Band Phased Array Feed Mark McCulloch, Keith Grainge, Michael Keith and Simon Melhuish
12:00 - 12:20	Advanced Low Noise Ambient-Temperature Amplifiers Sander Weinreb and Jun Shi
12:20 - 12:40	Low Noise Amplifier Development at the University of Manchester William McGenn, Claudio Jarufe, Daniel White, Danielle George, Gary Fuller
12:40 - 13:00	LNAs Developments for Cryo-PAFs Frank Schäfer and Sener Türk
13:00 - 14:00	**Workshop: Lunch Break**
14:00 - 14:40	**Session 5: Digital Data Processing and Backend Technology** ***Chair: J. Chengjin***
14:00 - 14:20	Real Time GPU-Based Digital Back-end for PAFs Hariharan Krishnan
12:20 - 14:40	MPIfR Backend Developments Jason WU
	SNAP2 & GPU Design for wideband and multichannel Backend *(poster presentation)* Dongliang Liu, Shenghua Yu, Xiaoming Chai, Bin Liu, Lei Yu, Yezhao Yu, Hongwei Xi
	Session 6: PAF Related

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14:40 - 16:40	***Chair: S. Heyminck***
14:40 - 15:00	Prospects for the SKA Observatory Development Program Tim Stevenson and Joseph McMullin
15:00 - 15:30	**Coffee Break**
15:30 - 15:50	Solar Power Mirror Arrays for Radio Astronomy Olaf Wucknitz and Alan Roy
15:50 - 16:10	Studies Towards a Cryo-Cooled Phased Array Radar System for Space Surveillance Andreas Froehlich, Hicham Barbri, Nadya Ben Bekhti, Oliver Grenz, Felix König, Lukas Naumann, Michael Pricher, Sergiy Putselyk, Florian Rahlf, Moritz Schneider and Marco Tiesing
16:10 - 16:40	Development of a Next Generation Digital Front-end for ALMA and Outlook for Submm PAFs Andrei Baryshev
	Introduction of Korea Radio Astronomy Facilities *(poster presentation)* Hyunwoo Kang
	PAF Systems: An Application for 3D Printing *(poster presentation)* Majid Norooziarab
	Superconducting Filters, Not Only for Cryogenic Phased Array Feeds *(poster presentation)* Przemyslaw Michal Bryndza and Sener Türk
16:40 - 17:00	**Summary** ***Karl Warnick***

Wednesday, 18 September, 2019

Time	Title/Event
08:30 - 09:00	**Visit to 100m Effelsberg: Bus transfer from Bonn (City-center) to MPIfR** *Bonn City-center*
09:00 - 10:00	**Visit to 100m Effelsberg: Bus transfer from MPIfR to Effelsberg** *MPIfR*
10:00 - 12:00	**Visit to 100m Effelsberg** *Effelsberg 100m Telescope*
12:00 - 12:30	**Visit to 100m Effelsberg: small Lunch in Effelsberg** *Effelsberg 100m Telescope*
12:30 - 13:30	**Visit to 100m Effelsberg: Bus transfer from Effelsberg to MPIfR**

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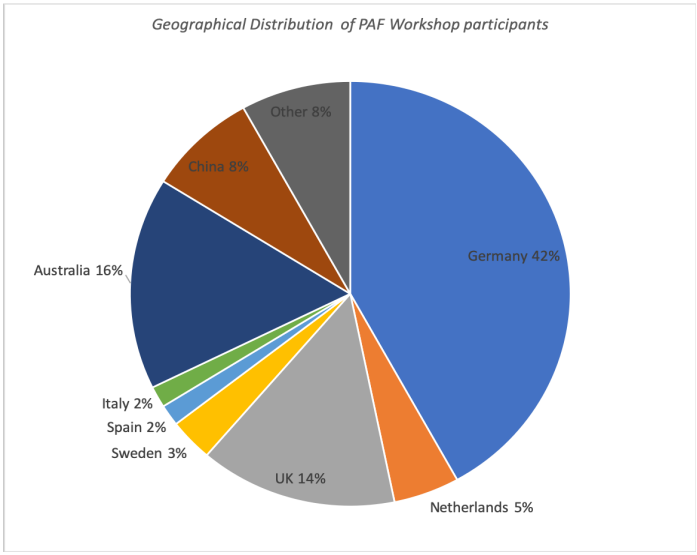
	Effelsberg 100m Telescope
13:30 - 14:00	**Visit to 100m Effelsberg: Bus transfer from MPIfR to Bonn (center)** *MPIfR*
14:00 - 17:00	**SKA-PAF Consortium: Consortium Meeting (by invitation)** *2.05, MPIfR* ***Organized by S. Barker***

3 PARTICIPANTS

The 63 participants came from various institutes within (68%) and without (32%) the EU. A more detailed geographical distribution can be found in the following graph:



Picture of the Workshop:

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4 RADIONET FINANCIAL CONTRIBUTION

The RadioNet financial contribution of 3600€ has been used to co-fund the venue and technical equipment to hold the workshop.

5 PUBLICATIONS

In case of future publication - please provide additional information: place & date. Remember to insert the acknowledgment of the RadioNet support:

The project leading to this publication has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet]

6 CONFIRMATION:

I (the organizer) confirm that RadioNet is allowed to publish this report, incl. participants lists, statistic´s details, pictures, etc.