BRAND EVN (BRoad-bAND EVN)
Joint Research Activity in RadioNet4
Gino Tuccari  &  Walter Alef  plus partners
“digital” VLBI-receiver: 
\(~1.5 - 15.5\) GHz 
for the EVN 
and other telescopes

Prototype for prime focus 
+ research for secondary focus
EVN Observing Bands < 22GHz

Today in the EVN separate receivers cover:

- 18 cm - L band
- 13 cm - S band
- 6 cm - C band
- 5 cm - C (Methanol-OH)
- 4 cm – X band
- In each EVN session ~3 freqs. observed in succession
- No multi-band simultaneous observations
New Opportunities

can develop multi-wavelength VLBI now!

- Broad-band LNAs and feeds (e.g. VGOS, DIVA)
- Backends with very high data rates
  see JRA DIVA: DBBC3 with 2x 4GHz (dual pol) - 32Gbps for VGOS 32 up to 128 Gbps
- High bit-rate recorders: Mark 6
  Flexbuffer
  FILA40G
Scientific motivation - fast frequency switching

- VLBA offers fast frequency switching (~7 s) between 2 or 3 frequencies
  - high user demand
  - saves valuable observing time
  - spectral index maps
  - if phase-referencing is used: precise registration of source positions
  - precise measurement of core-shift
- is wanted for the EVN for more than 15 y!
Scientific motivation - multiwavelength VLBI

• simultaneous multi-frequency observations - a la VGOS
• with fringe-fitting over very wide frequency range (cf. VGOS)
• will determine ionosphere
Observing Frequency Bands

Phase

~2.2 ~ 15 GHz Spanned RF Bandwidth

~1 GHz Data Bandwidth

Group Delay (slope): $\tau_g = \Delta \Phi / \Delta \omega$

Phase Delay: $\tau_\phi = \Phi / \omega$

X-Band

S-Band: Serious RFI

OLD

2010

PHASE (Arbitrary Units)

2 4 6 8 10 12 14

Frequency (GHz)

2012 October 22

IVTW - Haystack
Scientific motivation - multiwavelength VLBI (cont)

- precise registration of simultaneous images at different frequencies
- UV-coverage greatly improved due to wide frequency band

multi-frequency imaging software available
superior to fast switching!
Scientific motivation - multiwavelength VLBI spectroscopy

• study several different maser types in different frequency bands simultaneously
• alignment of different maser species
  • e.g. determine conditions in complex flow patterns
Scientific motivation - multiwavelength VLBI polarimetry

- variations of polarised emission as a function of frequency over a very wide frequency range
- precise unambiguous rotation measures
- improve studies of physical conditions of various astronomical objects
Scientific motivation - multiwavelength single dish

- flux variation studies in several bands simultaneously
  - especially interesting for intraday variability
- pulsar observations over a wide frequency range
  - no timing ambiguities
Scientific motivation - compatibility with VGOS antennas

- joint observations with geodetic VGOS antennas would be possible
- precise positions of astronomical antennas
- celestial reference frame
- huge arrays for astronomical observations if needed
**BROAD BAND 1.5-15.5 GHz**

**PROPOSAL**

- Single cooled receiver covering the broad-band for astronomy with linear polarization feed
- Starting from e.g. the ten years VGOS developed technology (feeds, backends, recorders)
- **New**: Analogue signal processing without any frequency conversion and huge sky frequency range + extremely high bit-rate
BROAD BAND 1.5-15.5 GHz

PROPOSAL (analogue)

• Survey of individual EVN antennas!
  • Feed options (prime/secondary), RFI, interfaces
  • will select prime focus as demonstrator
  • research on options for secondary focus solutions
• aim is to install the BRAND receiver in the whole EVN

• QRFH feed from Onsala (e.g. JRA DIVA)
• DYQSA feed from Yebes
• ELEVEN feed from Onsala
BROAD BAND 1.5-15.5 GHz

- PROPOSAL (analogue)

- Cryogenic HTS (High Temperature Superconductor) filters for strong RFI

- Wide-band LNA (e.g. Yebes)

- Analogue signal processing: only LNA and amplification chain
BROAD BAND 1.5-15.5 GHz

PROPOSAL (digital, firmware)

- Fully digital multi-bit (8) broad-band sampling and data processing
  - starting from the DBBC3H with: sampling 0 GHz - 15.5 GHz
  - output data-rate up to 128 Gbps
- Broad-band digital receiver together with frontend
  - also universal back-end for VGOS, other 'receivers' are included
- Fully digital down-conversion and/or band selection: DSC/PFB/DDC
  - Output channel selection means also selection of the observing band

=> MULTI-BAND SIMULTANEOUS OBSERVATIONS!
BROAD BAND 1.5-15.5 GHz

PROPOSAL (firmware)

- Digital polarization conversion from linear to circular
- Additional digital RFI mitigation
  - Local RFI ‘fingerprint’ determination at stations
- Multi-band total power detector
- Multi-band polarimeter
  - (and spectrometer...
Advantages for EVN

User:
• new improved science
• “more” observing time

Telescopes
• fewer receivers to maintain
• “more” observing time

EVN could take lead in VLBI observing with novel capabilities
Aims / Work packages

- Survey: determine boundary conditions for EVN telescopes (interfaces, focus, RFI ...)
- Develop feed for prime focus
- Investigate feed solutions for secondary focus
- Develop prototype receiver for selected antenna including dewar etc. (prime focus)
- Develop digital sampler, adapt processing unit
- Adapt existing/write new firmware and control software
- Integration and test
PARTNERS

- MPI
- INAF
- OSO
- YEBES
- ASTRON
- VIRAC
Formal Radionet3 project ends in 2015

- 4 GHz IF each producing std 16Gbps@2-bit (max. 64 Gbps@8-bit)
- 1-8 IFs in a single system (max. 512 Gbps@8-bit)
  for EVN dual pol IF (<=32 Gbps)
  for full VGOS 8 IFs dual pol 2-14 GHz (<=128 Gbps)

- input 0-4 GHz / 4-15 GHz pre-filtered adapter
- different architectures possible with VSI-H interfaces and/or 10GE SFP+
DBBC3L  rear view