the Future of VLB

Huib van Langevelde JIVE

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Today, entirely from the EVN/JIVE perspective

Huib van Langevelde JIVE





Joint Institute for VLBI in Europe



Promote the use and advance of VLBI for astronomy

 Central correlation; User services; Network support; Innovation; EC liaison/representation

Founded in 1993

- Base budget from partners in 7 countries:
 - China, France, Germany, Italy, Spain, Sweden, United Kingdom, Netherlands
- Large number of external projects
- Hosted by ASTRON

Just been reviewed

Next 5-year funding cycleIn a newly build wing



The European VLBI Network



- $\boldsymbol{\cdot}$ Big telescopes in number of European countries
- 20+ possible antennas
 - Ef, Mc, On, Jb, Nt, Tr, Wb, Sh, Ur, Hh, Ar, Mh, Ys, Sv, Ro, Ku, My, Wz, Sm, Ny, Ka
 - Ran by up to 14 different organizations
 - And 12 more antennas for "Globals" with NRAO
- Covering range of frequencies
 - Workhorse frequencies 18cm, 6cm,
 - Also available: SX, 5cm, 1.2cm
 - And at limited stations 90cm, 21cm, UHF, 50cm, 2cm, 0.7mm

Reaching mas resolutions

- From 15mas for 1.4 GHz EVN (can add MERLIN for brightness sensitivity)
- To 1 mas at 5GHz with Asian, African or American baselines

Sensitivity of 5µJy in 8hr at 1.4 GHz

- Combination of Big Antennas and 1 Gbps bandwidth
- Big antennas also vital for spectroscopy (mJy sensitivity)

Operational approximately 60 days/year

 $\boldsymbol{\cdot}$ 3 sessions augmented with e-VLBI once a month













Medicina IT

AN THE WORK











pork

















Sardinia 64m

NAF-ON

-









Amplitude for PR012B.sen41 First fringes to Irbene, near Ventspils, Latvia







He Good Strength

On-Tr (0-2)

-lr (0-3)

Tr-ir (2-3)



The EVN software correlator at JIVE (SFXC)

9 stations 1Gbps real-time

- Pulsar gating
- Space craft applications
- Spectral polarimetry
- Many field of views



100

n

Right Ascension (mas)



-100

R+D: Introduced e-VLBI as operational facility:



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R+D: Introduced e-VLBI as oper

Number of telescopes @ data rate





Observations

Now an operational facility

- Guaranteed 10 x 24h per year
 - And quite bit more in practice (>30%)



Flexible ways to get into e-VLBI

Request e-VLBI for fast response

Can be approved by PC for existing sessions

Or for triggered proposals

- To be submitted at regular proposal dates
- Requires specific trigger criteria
- Short requests <2hr
 - •e.g. calibrator checks
- Target of Opportunities
 - EVN agreed to have substantially more of these
- Or just because you prefer to e-VLBI
- Or just because the EVN prefers to do e-VLBI
 - Because of logistics or (disk) resources

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Observations

EVN observing hours

1170



• Because of logistics or (disk) resources

New project: NEXPReS



Novel EXplorations Pushing Robust e-VLBI Services

NEXP

RTS 12, Manchester, 20 April 2012

13/23

2008

Time (years)

2007

New project: NEXPReS

- Correlate in real time what you can,
 Correlate later what you need
- Allow multiple correlator passes
- Continue to connect more telescopes
- Reliable operations
 - addressed by simultaneous recording
 - and get the best of both worlds

NEXPReS maintains expertise

- Collaborations with NRENs
- 3.8 M€ for 3 years, 15 partners

Novel EXplorations Pushing Robust e-VLBI Services





New opportunities

New requests for (new) observing types

- Impact on policy discussions
 - RadioAstron
 - Observations of spacecraft (planetary/fundamental)
 - Monitor programmes/astrometry/joint observations
 - Triggers set by other observatories (link with LOFAR)

Must try to keep procedures simple

- Complex for telescope & correlator operators
- Even more complex for users!
- Data ownership for triggers, concurrent observations

Must offer new services

- Offer tailored arrays?
- More e-VLBI days, "VLBI every Friday"?
- Central scheduling?
- Large programmes
 - Contribute to resources?

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Options for VLBI

- Increasing data rate will not stop any time soon:
 - •New stations: Africa, Goonhilly, Madeira, Brasil....
 - Joint observations with e-MERLIN
 - Joint observations with ALMA
- Need for better sensitivity, more digital bandwidth
 - with more bit sampling against interference
 - Accommodating number of space applications
- Science synergy with new survey instruments
 - Apertif, LOFAR, MeerKAT, ASKAP
 - •eMERLIN, EVLA



VLBI future science case



5 GHz VI

33.67 33.66 3

Science case has been developed

•http://www.evlbi.org/publications/ publications.html

Fit well with scientific priorities

- A. Extremes of the universe
- **B.** Evolution of Galaxies
- **C.** Birth of stars and planets

VEX track around Venus 28.03.2011

arcsec (from west to east)

D. How do we fit in

J2211-13, 0,17 Jy

RA, mas

RA, mas 5

+10







Rygl et al. 2012

ianchester, 20 April 2012

VLBI Future



Unique science: long baselines and high frequencies

- Keep up with EVLA/MERLIN sensitivity
 - Going for 4Gbps in 2012
- Follow up LOFAR, MeerKAT, ASKAP

Even in the SKA era

- At least for phase I
- Most certainly phase II
- Spacecraft applications (and geodesy) need Northern Hemisphere coverage

Global baselines for better images

- And better time coverage
- Data quality and image fidelity for SKA users
- Only single (or two) user communities for all of us
 - Critical mass reached on continental scale or larger

Needed: next generation correlator



Aiming for 32 station 10+ Gbps FPGA correlator

- Flexibility of software correlator
- Power consumption should be much better
- Started in RadioNet::UniBoard, next step in RadioNet3
- Feeding into the SKA programme
 - As well as being used for EVN, LOFAR, WSRT, Effelsberg



Synergy with the SKA



Lots of overlap with SKA technology

- Benefit from digital components
- Connectivity
 - Data en timing
- Processing software
- Maybe even antennas

Important for SKA

- Community building
- Training aspects
- Home telescope
- Outreach





JIVE Review

- •public at <u>http://www.jive.nl/</u>
- Excellent marks in all areas
 - Only imperfection on spreading the VLBI gospel

Endorsing JIVE strategy

- Current SFXC processing
- FPGA correlator
- Space programme

Good recommendations

- VLBI can be more widely visible
- Keep score on publications
- Proceed careful with governance







ERIC option

• European Research Infrastructure Consortium

- Legal entity in Europe established 25 June 2009
 - Addresses establishment of European scale facilities
- Members are countries
 - Needs to be approved by EC
 - May have VAT exemption
 - Status of international, public body

Some obvious advantages for JIVE/EVN

- Personal responsibility of board members is lifted
- No VAT on personnel, large investments
 could include EVN equipment
- Directly eligible for (future) EC funding schemes
- Attractive for new prospective members

JIVE partners looking into this

Not equally attractive to all, but best for JIVE



Letter of Intent European partnership concerning the ERIC on V This Letter of Intent concerns the establishment of a Europe Ins Letter or mean concerns the establishment of a burdpe Infrastructure Consortium (ERIC), which will encompass all activities of the Joint Institute for VLBI in Europe (JI Preamble The European VLBI Network (EVN) is a consortium that offers a astronomical observing facility through joint observations of radi across Europe and other continents. The consortium provides the Carry out the observations, develops the necessary equipment and policies needed to make this facility available for researchers. Within the EVN, the JIVE has been established in 1993 ; legal entity (Stichting/Foundation) to handle the central processir (correlation) of the telescope data. It offers the users of the EVN sup proposing, processing and interpreting the observations of the EVN provides feedback on the data quality delivered by the telescopes. J active role in enhancing the capabilities of the EVN by developing ne active role in entrancing the capabilities of the EVIN by device/Ping in techniques, notably concerning the central processing. In this and oth techniques, notably concerning the central processing. In this and oth activities JIVE can act as the representative of the EVN, in particular v carrying out EC programmes. JIVE is a long-standing foundation, cur its funding is based on a 5 year. Mol Letructure As a legal framework, the ERIC model is deemed to be a better match t science mission and ambitions of the JIVE. Besides the current activities Science mission and anionous or the JIVE. Desides the current activities JIVE, it could be explored whether the ERIC could absorb responsibility concerning the VI BL equipment and expressions at the toloresponsibility. concerning the VLBI equipment and operations at the telescopes Additionally, the ERIC implementation may offer operational advantage the benefit of the partners in the EVN. The signatories intend to establish an ERIC with the aim to strengthen the Ine signatories imenu to establish an EKIC with the auti to strengthen the long-standing collaboration that their national research institutes have in radio actronomy by adopting a local framework to provide more radio astronomy by adopting a legal framework to provide more The signatories aim to continue the existing collaboration with all the EVN. partners and structure and align this with the ERIC. It is intended that the ERIC will be financed at a lovel circ



Future of JIVE



Mission clear on all different timescales

- Deliver the best possible science
 - Push e-VLBI and reach 4Gbps
 - Accommodate space programmes
- Global baselines and high frequency
 - Needs a big correlator
 - Implement large-scale VLBI programmes
- Participate in European SKA operations
 - As recognized European entity

JIVE on the right course

- •The Schilizzi course!
 - be consistent, transparent, positive
 - have a drink (afterwards)







Thank

