WSRT and the EVN

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WSRT Users meeting

Amersfoort, 4 June 2008

WSRT in the EVN

- **Role of WSRT in the European VLBI Network**
  - **Direction of development of the EVN**
    - **e-VLBI happening now!**
    - **More bandwidth coming next**
    - **Developments for next decade**
  - **How does the WSRT fit in?**
    - **And the plans for the WSRT in the future**

- **Phased array corner stone for high sensitivity EVN**
  - **Main selling point of the EVN: BIG telescopes**
  - **Outperforming any other array in pure sensitivity**


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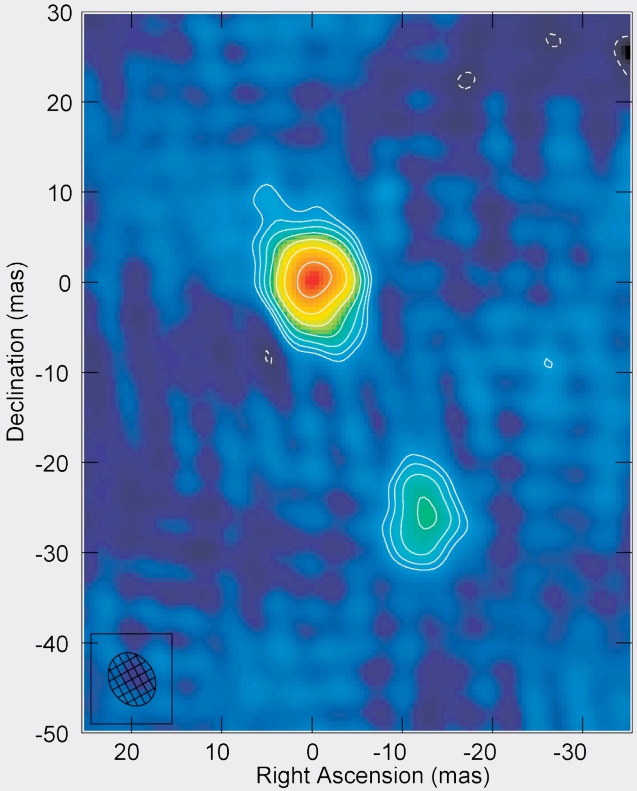
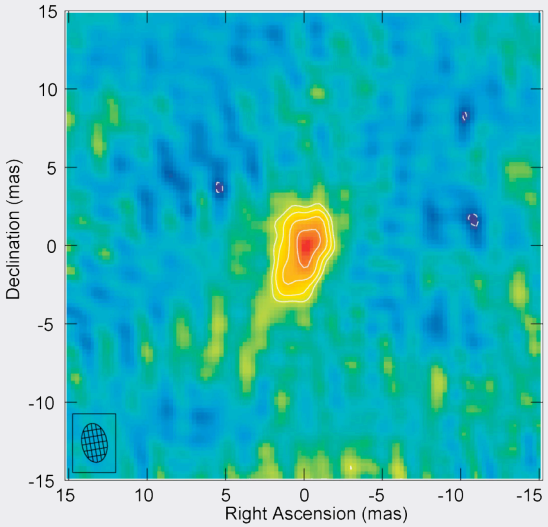
Reaching the µJy universe

- **WSRT in the EVN 69% of experiments in phased array**
  - **At 6cm and 18cm work-horse frequencies for the EVN**
    - **Not available at higher frequencies**
  - **29% Single dish at 5cm (Methanol)**
  - **2% wide-field imaging**



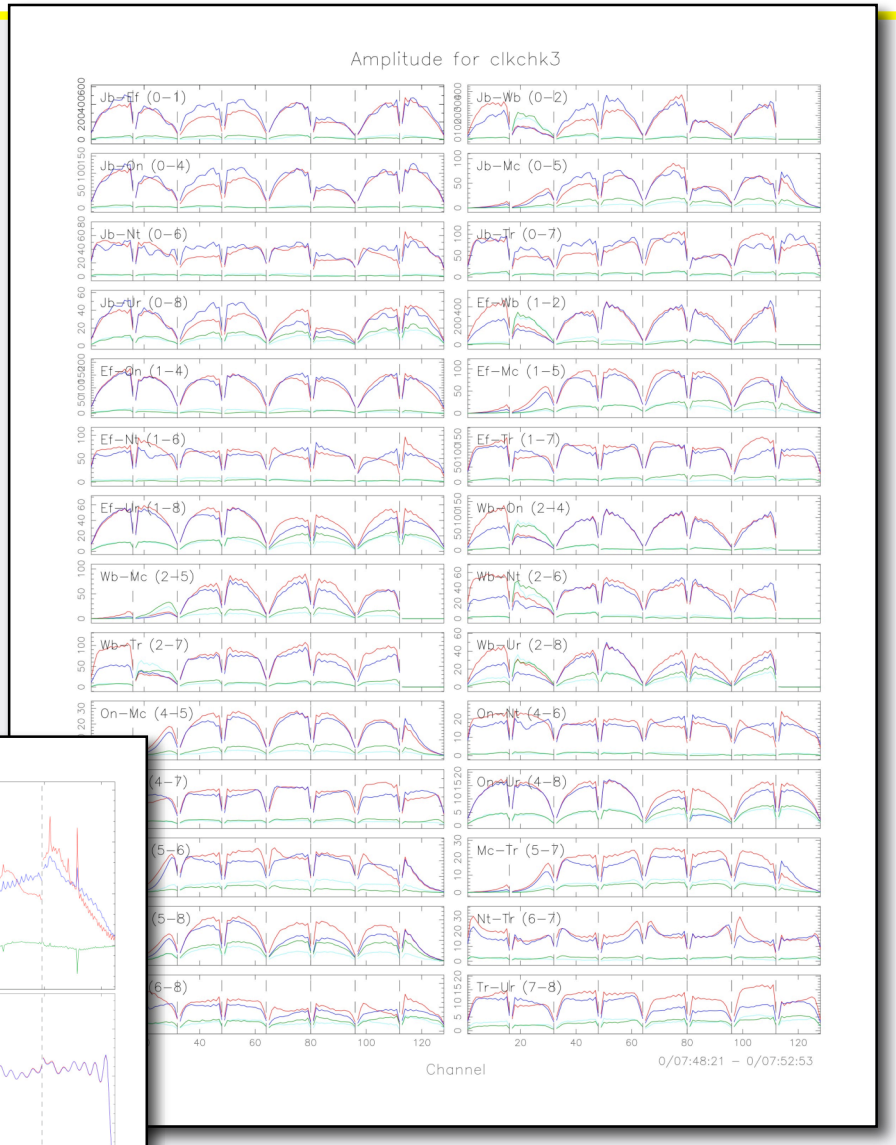


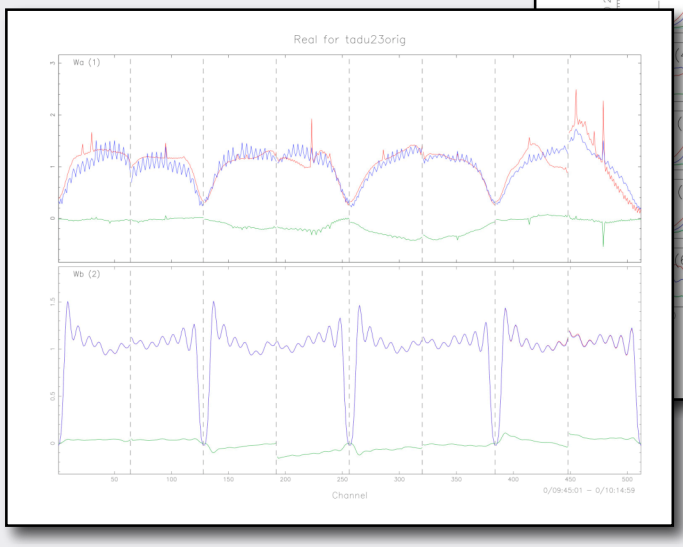
- J1427+3312, the most distant known radio loud QSO (z=6.12),
- Observed with 10-telescope EVN configuration in 2007, incl WSRT
- 1.6 and 5 GHz 1.4 and 0.8 mJy at L- and C-band, respectively
- Noise level at ≈ 17µJy for both frequencies
- WSRT provided crucial total flux density measurements

Frey, Gurvits, Paragi, Gabanyi, 2008, A&A (issue of 5 June 2008), arXiv:0805.0474

Current bandwidth

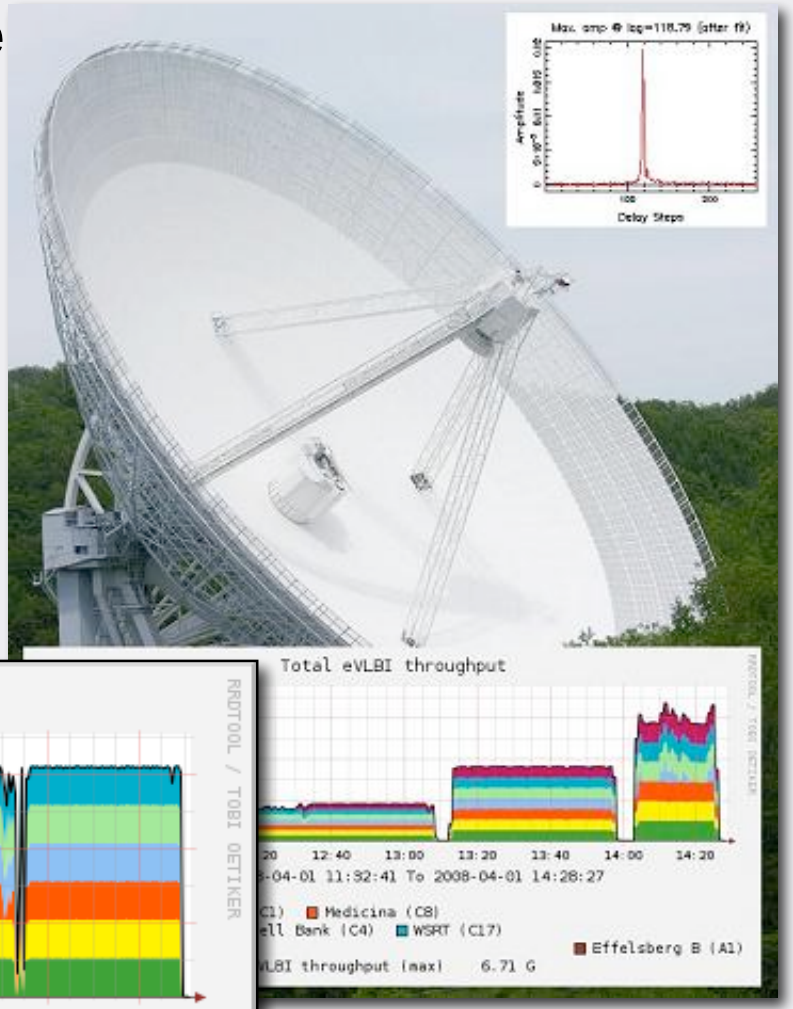
- EVN operates at 1 Gbps
  - Mk5A disk recording
  - Mk5B soon
    - Aiming at 4 Gbps
  - Requires 2 x 128 MHz @ 2 bits
- WSRT phased array
  - Dual pol 128 MHz bandwidth
  - With TADU system
    - Limited by WSRT IF system
  - TADU-Max will be fully digital

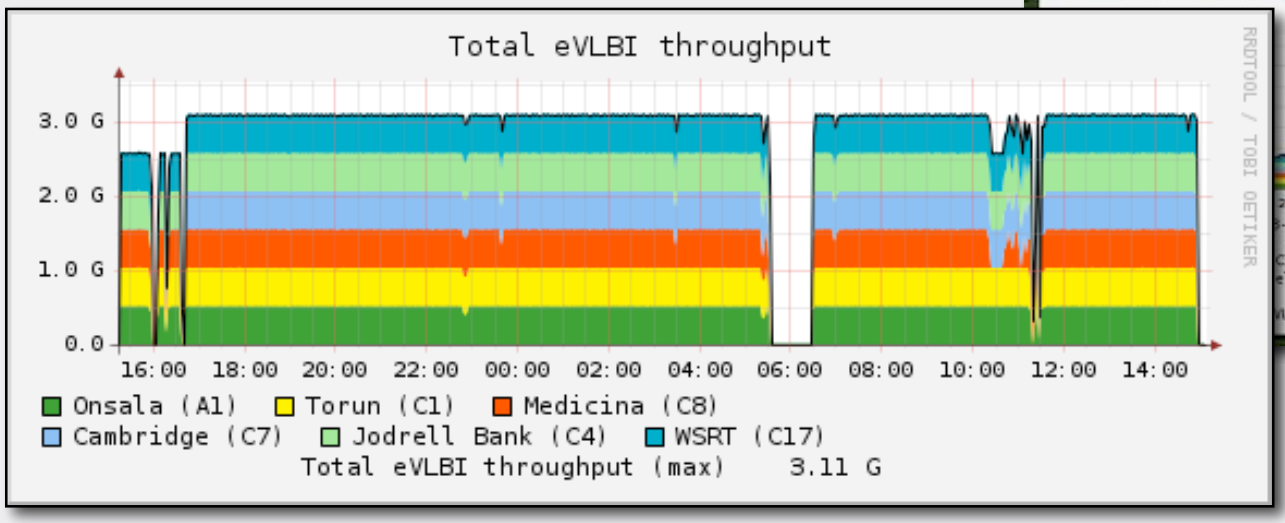




Revolutionizing VLBI:

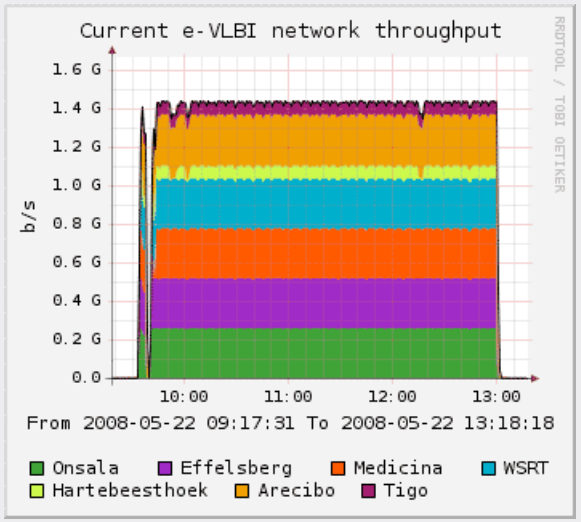
- **e-VLBI now operational, reliable and with full sensitivity**
  - **Effelsberg on-line on 1/4/08**
    - **Extremely important for science**
    - **Boosts the sensitivity**
- **Routinely running 6 (7) telescopes at 512 Mbps**





World-wide e-VLBI

- EC project EXPReS has partners in 6 continents
  - All gave real-time fringes
  - As of last week
- Shows that e-VLBI is feasible on Global scale

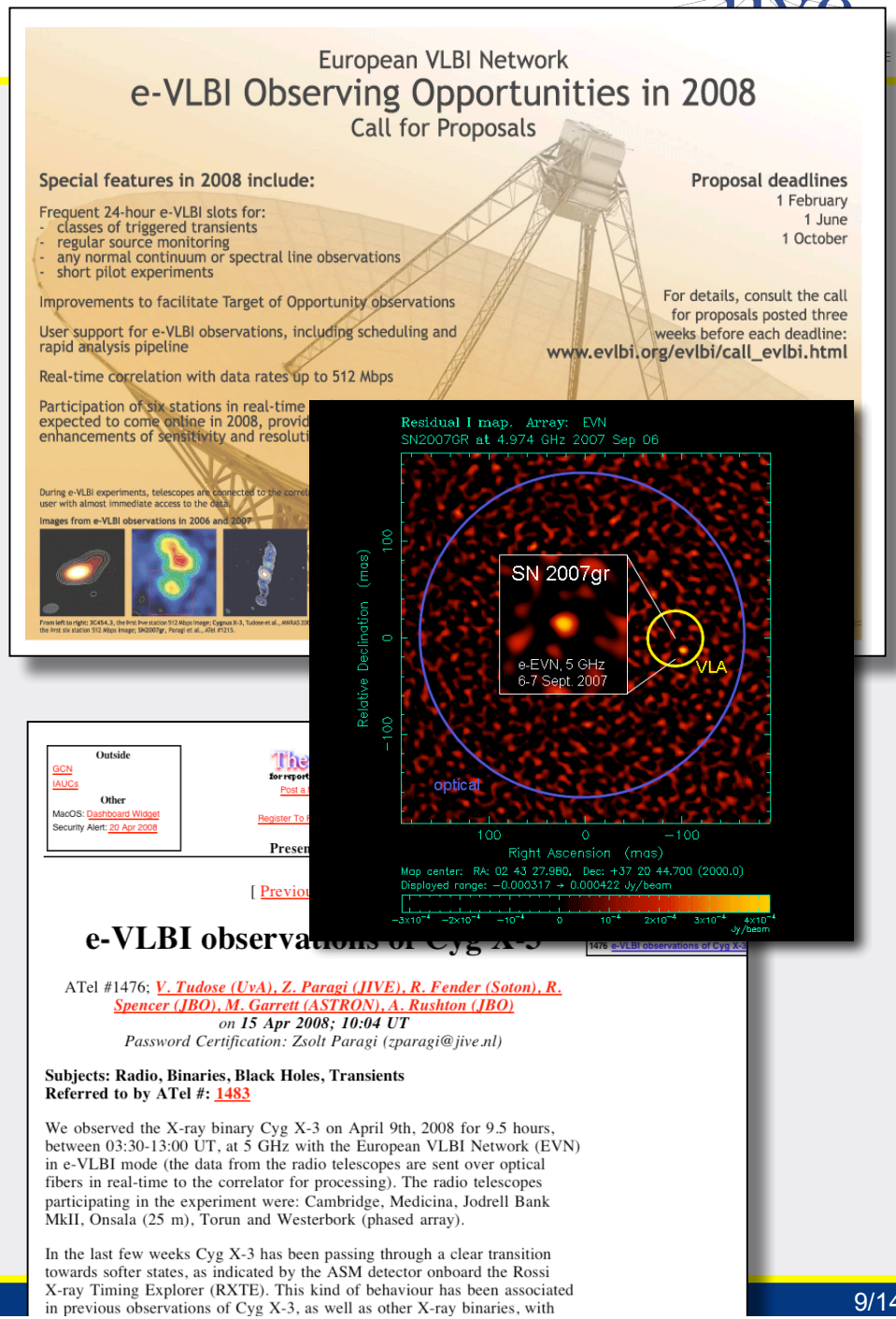


Why is e-VLBI exciting for astronomy?

- **Rapid response for rapid variability**
  - Fast response to requests
  - Immediate analysis of data, adapt observing parameters
  - Coordination with current and future observatories
- **Immediate feedback**
  - More robust data
- **Fewer consumables, logistics**
  - Constantly available VLBI network
    - Monitoring: for example astrometry
    - Spacecraft tracking
- **Growth path for more bandwidth**
  - More sensitive astronomy

e-VLBI policy

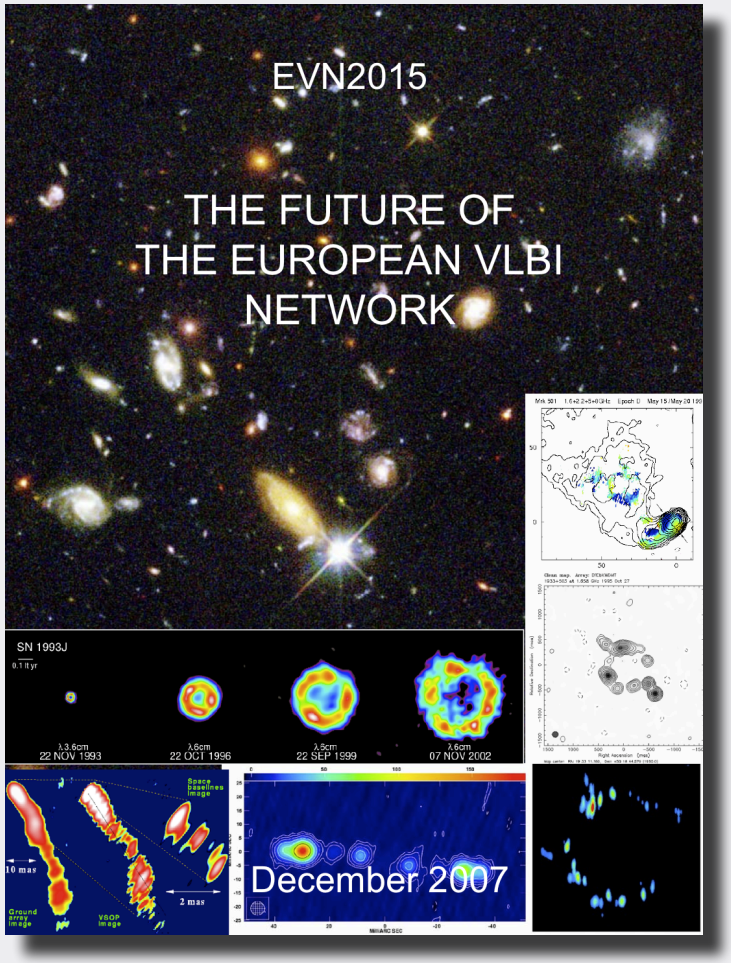
- **Required a cultural change**
  - **Peer review process is careful**
  - **The EVN is a distributed facility**
  - **The telescopes are involved in other programmes as well**
- **Policy changes adopted in Nov 2007**
- **Now e-VLBI is booming in 2008!**
  - **Had several e-VLBI runs this year**
  - **Some use trigger conditions**
  - **Also 3 epoch ToO observation**
  - **And big telescopes available**



EVN2015 science case

- **Has been finalized and distributed**
  - Available on the web. http://www.evlbi.org/publications/publications.html
  - Wide range of science applications

- **Some highlights include**
  - Nature of starburst/AGN in cosmological fields
  - The fate of black holes/radio quiet AGN
  - Jet physics close to the event horizon (VSOP2)
  - Determining star burst activity, resolving SNR's
  - The nature of the ISM in active galaxies
  - Fundamental distances from astrometry
  - The accretion physics in transient radio sources
  - The detailed 3D kinematics of star formation
  - Pulsar astrometry
  - Monitoring spacecraft in the solar system



Technology path EVN

- **Real-time connected VLBI**
  - No doubt here, only thing that sells, SKA pathfinder
  - Transient science, modern users are impatient
    - Buffer system will be required for robustness
- **Improved sensitivity by increased bandwidth**
  - Requires coordinated upgrade of IF systems
  - And many bit system for RFI robustness
- **Much better coverage at high frequency**
  - Where the sensitivity matters and can be obtained
  - And frequency flexible, of course
- **A different operational model, tighter control**
  - Faster, more robust, accurate calibration
- **High fidelity images require many telescopes**
  - Extend the EVN with new members and new antennas

Technology path correlator

- **VLBI input changes**
  - Multiple data streams of 10 - 100 Gbps
  - 32 stations, or at least more than 16
  - Multiple bit representation
  - High bandwidth at higher frequency

- **Calls for a hundred fold more powerful correlator**
  - Compares to EVLA correlator
  - Similar size as some (other) SKA pathfinders
  - Probably needs FPGA based solution
    - Software correlators can be intermediate solution

  - Allowing for some specific applications
    - Spectral line, requires much better mixed bandwidth facilities
    - Pulsar gating
    - Atmospheric calibration
    - Multiple beam VLBI

Future of radio-astronomy

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- **Community is preparing to build the SKA**
  - **And is constructing a number of SKA pathfinders**
    - **LOFAR will open up the transient radio-sky**
    - **e-MERLIN will probe new regime in sensitivity**
  - **Includes the e-EVN, exercising long-range connectivity**

- **Changing priorities: a challenge and an opportunity**
  - **Must concentrate on very specific science case**
    - **Long, Very Long Baselines, Northern hemisphere**
  - **Take advantage of technology investments**
    - **Correlators, connectivity, data acquisition**
    - **But possibly also receptors**

- **Maintaining the distributed expertise is vital for SKA**
  - **European radio-astronomy must develop a single roadmap**
  - **I think there will be a strong case for Europe based telescopes: LOFAR, VLBI**
    - **Training of future radio-astronomy users**
    - **Technology development, evaluation**
    - **Outreach: visit a telescope near you!**

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Future WSRT in the future EVN

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- **Current: Important collecting area at 18cm & 6cm**
  - **BUT: limited bandwidth to follow EVN upgrades**
    - **Hard to beat sheer collecting area**
    - **In fact difficult at 18cm where bandwidth is limited anyway**
  - **Limited lifetime?**
- **APERTIF: would loose 6cm phased array capability**
  - **Assume a single MFFE antenna would remain for frequency coverage**
  - **BUT: potentially gain 21cm bandwidth?**
    - **Synergy with next generation correlator**
    - **Extend lifetime of the WSRT operations for VLBI?**
    - **Single antenna upgradeable to wider bandwidth?**
  - **BUT APERTIF: would loose 6cm phased array capability (repeat)**
- **Long term future: coverage of higher frequencies**
  - **For example: cluster of small high frequency antennas**

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