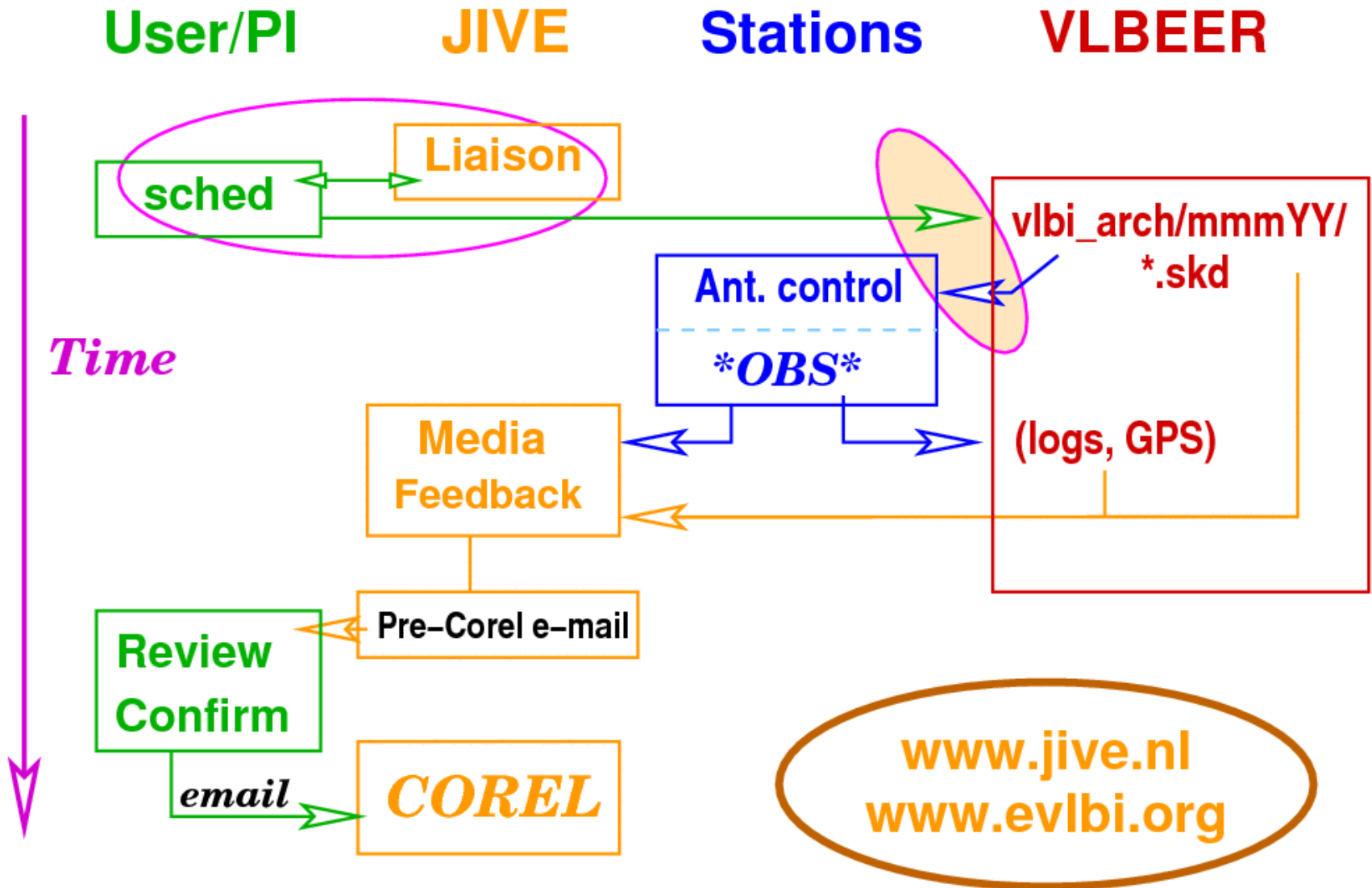


Software Correlation at JIVE & Real-time e-VLBI in the EVN

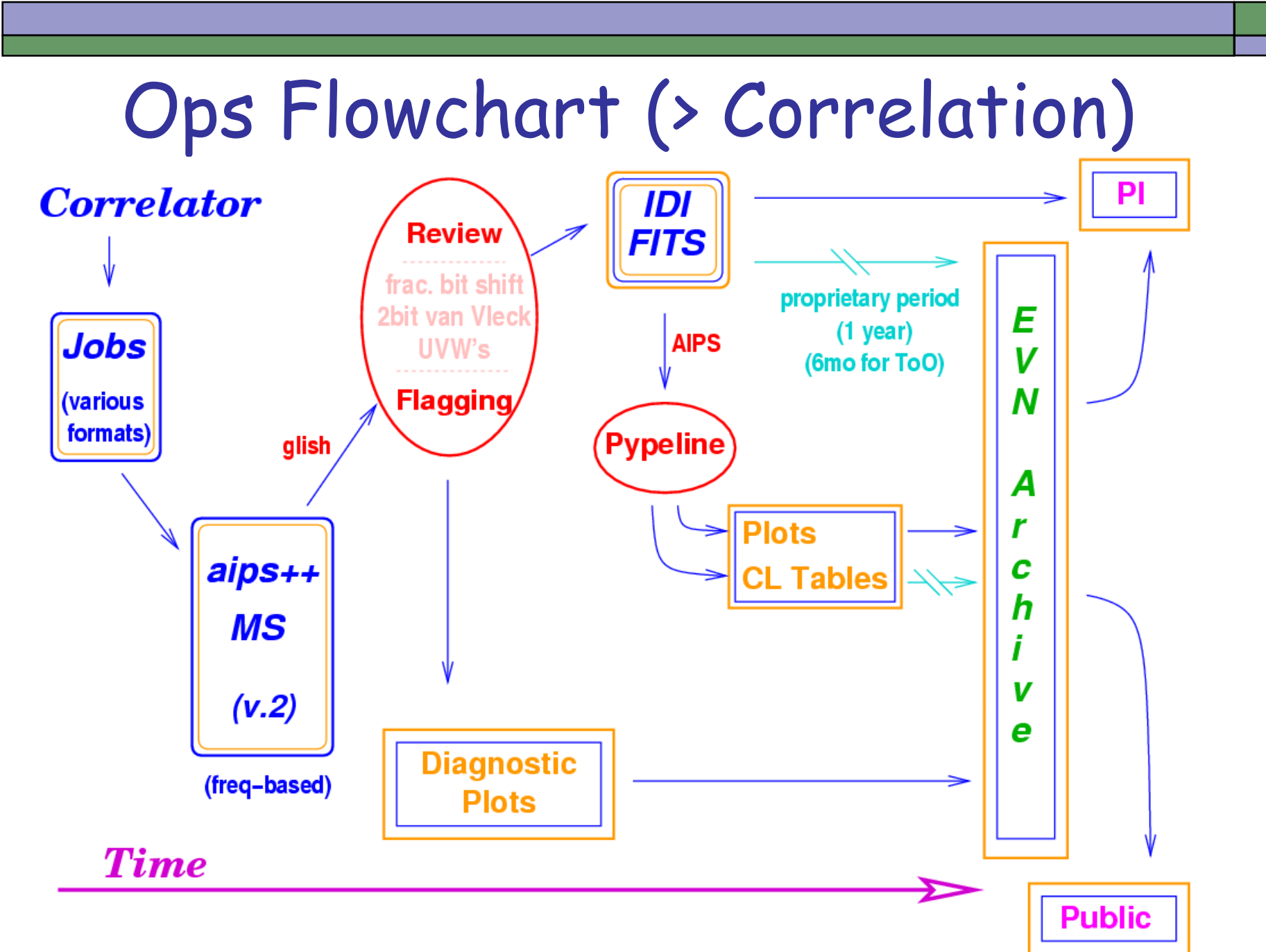
Bob Campbell, JIVE

- Operations and PI Interaction
- Software Correlation at JIVE
- Real-time e-EVN Astronomy
- *RadioNet3 EVN Trans-National Access*

Ops Flowchart (≤ Correlation)



| | |
|--|--|
| | |
| | |



Software Correlation at JIVE

- SFXC (based on correlator for tracking Huygens descent*) *{Pstr}*
 - vex-driven + configuration file with correlation parameters
 - Mark 5A, 5B, VLBA, and VDIIF support
 - Post-correlation processing → IDI-FITS (as for MkIV)
- Now running on a dedicated 256-core cluster (9.5 kW)
 - “Real-time” processing currently = 9 stations at 1 Gbps
 - Replacement of MkIV ~ 4x this; EVN2015 concept ~ 64x
- NEXPreS: integration of SFXC with e-EVN(+) *{Pstr}*
 - Globally distributed correlation (dynamic resource demand)
 - Bandwidth on demand
 - Data buffering (to blur the e-/disk-VLBI distinction)

MkIV \rightarrow SFXC: Astronomy Gains

- N_{sta} limited only by available input devices (was 16)
- Arbitrary total bit-rate & BW_{SB} (was 1 Gbps & 16 MHz)
- ~arbitrarily large number of frequency points (was 2048)
 - Velocity resolution improvements w/o cont. sensitivity penalty
- ~arbitrarily small integration times (was $\frac{1}{4}$ s)
- Large N_{frq} & small t_{int} together \rightarrow wider-field mapping
 - Multiple output phase centers within a wider field
- Pulsar Gating/Binning (was never available operationally)
- Near field model (was never available)
- Improvements in correlated data
 - Pure station-based fringe rotation to center of earth
 - Consistent cross-polarization handling
 - Control over spectral windowing function

MkIV → SFXC: as seen by user

MkIV

$$N_{\text{sta}}^2 \cdot N_{\text{sb}} \cdot N_{\text{pol}} \cdot N_{\text{frq}} \leq 131072 \cdot \mathcal{R}$$

$$N_{\text{sta}} = (4, 8, 12, 16); N_{\text{pol}} = (1, 2, 4); N_{\text{chan}} \leq 16; N_{\text{frqmax}} = 2048$$

Recirculation: $\mathcal{R} < 16 \text{ MHz} / \text{BW}_{\text{sb}}$; N_{frqmax} still 2048

(if 8 MHz SB) 9–16 Sta 1 SB 2 Pol 512 Frq ($\mathcal{R} = 2$)

(if 2 MHz SB) 9–16 Sta 1 SB 2 Pol 2048 Frq ($\mathcal{R} = 8$)

Maximal velocity spacings ($N_{\text{frq}}=2048$, Δv in [m/s])

| BW_{sb} [MHz] | Δv [Hz] | Δv_{1420} | Δv_{1665} | Δv_{6668} | Δv_{22235} |
|-------------------------------|-----------------|-------------------|-------------------|-------------------|--------------------|
| 16 | 7813 | 1651 | 1408 | 351 | 105 |
| 2 | 977 | 206 | 176 | 44 | 13 |

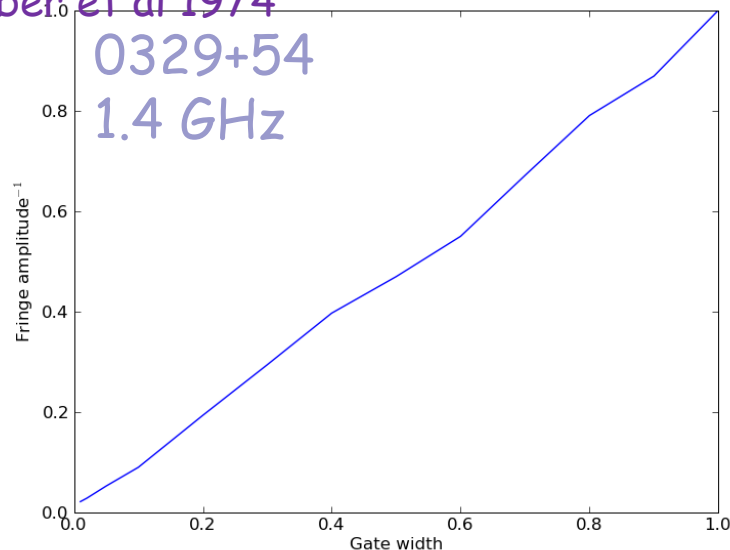
SFXC

Specify desired velocity spacing & required continuum sensitivity (set BW_{sb} , then N_{frq})

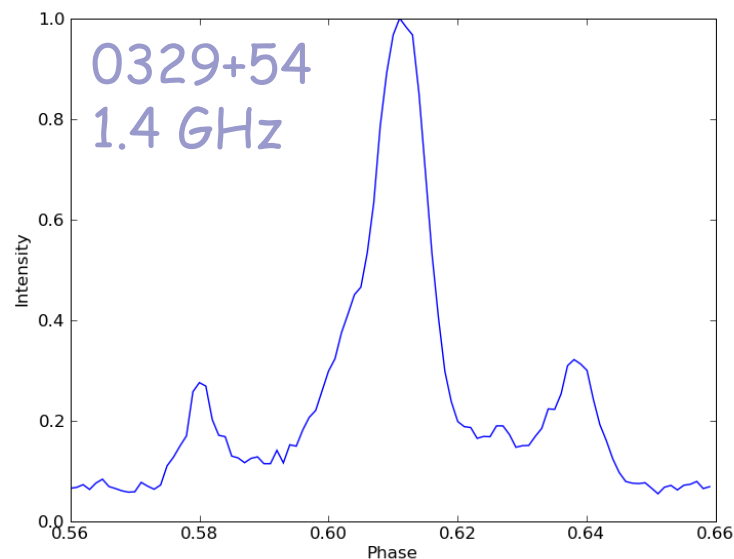
SFXC: Pulsar Gating/Binning

- Gating = arbitrary interval within a PSR period
- Binning = arbitrary number of bins within the gate
 - Each bin \rightarrow separate correlation / output IDI-FITS file

Siebert et al 1974



Expected inverse relation
between amp & gate-width
(y-axis = 1/amp)



Pulse profile (1 gate [0.1 Per],
100 bins)

SFXC: Pulsar Gating/Binning

- Gating = arbitrary interval within a PSR period
- Binning = arbitrary number of bins within the gate

ation / output IDI-FITS file

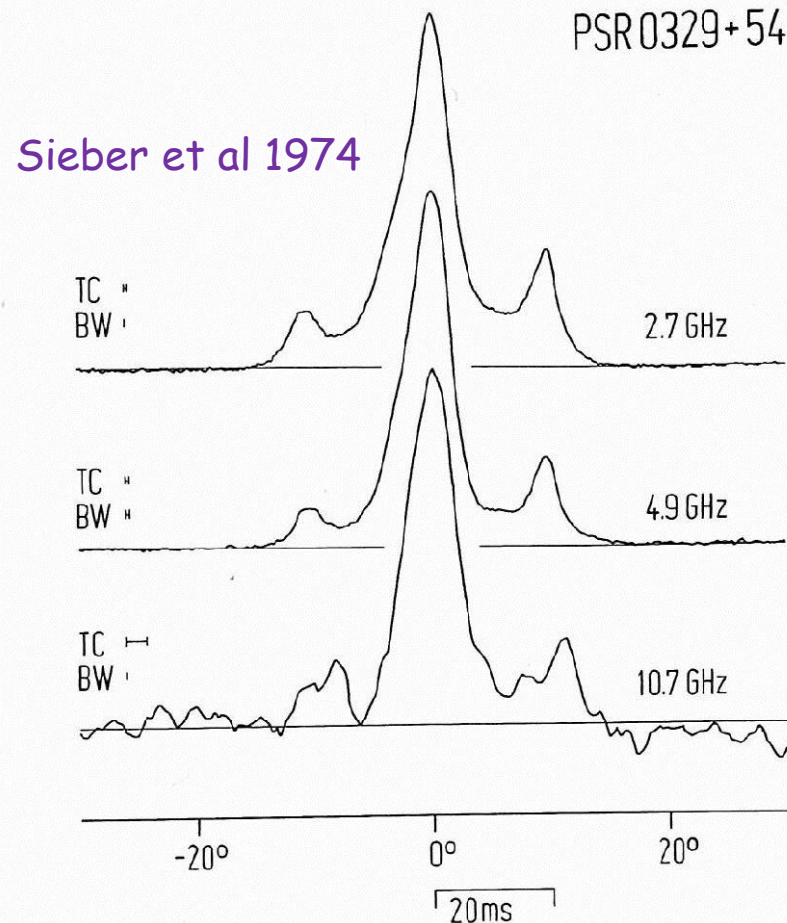
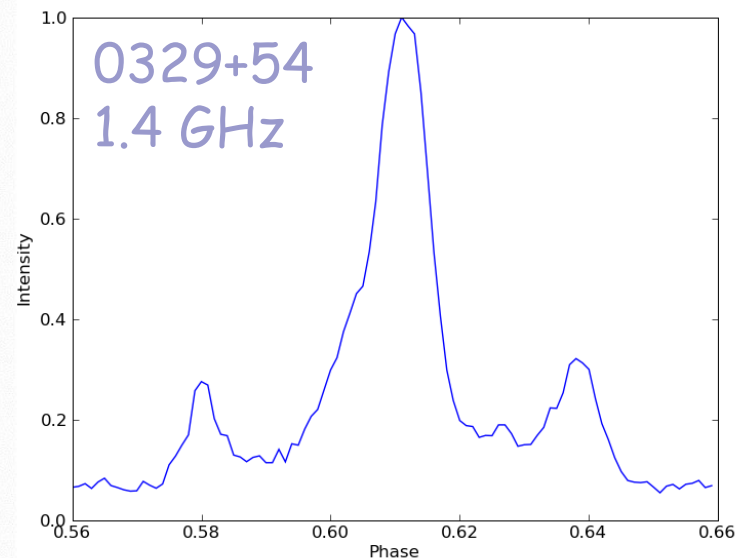


Fig. 1.2

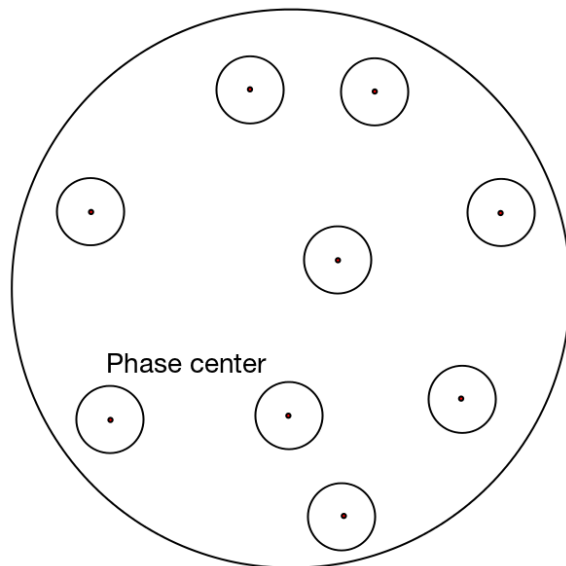


Pulse profile (1 gate [0.1 Per],
100 bins)

SFXC: Wide-Field Mapping

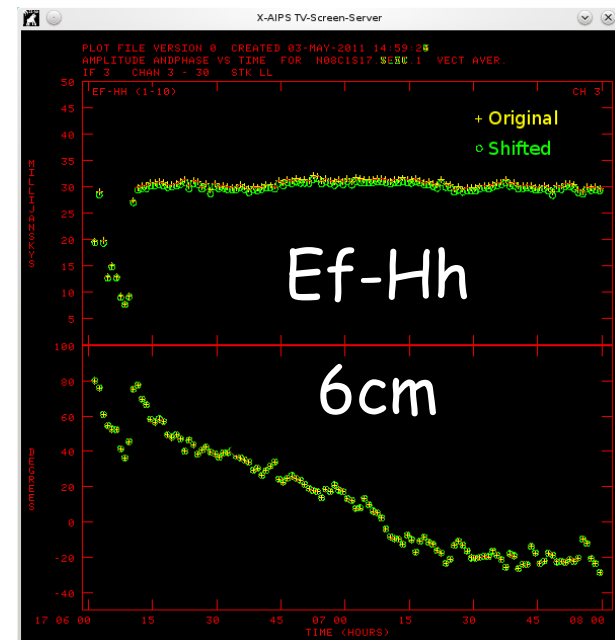
- Essentially unlimited $\max-N_{\text{frq}}$, $\min-t_{\text{int}}$: can map area on the sky \sim single-dish beam w/ minimal smearing
 - Price = huge output data sets
- Multiple phase-center correlation: outputs only subsets of the full area (user expts. so far up to 50 phs. centers)

Station Field of View



Typical initial correlation:
 $N_{\text{frq}} \sim 16\text{k}$; $t_{\text{int}} \sim 4\text{--}15\text{ ms}$
Further processing-factor
"penalty" small

Example validation run:
same source correlated at
two positions 1.4' apart;
 $|\Delta\phi|_{\text{Ef-Hh}} = 0.3^\circ$ pk-to-pk.



Transition: MkIV→SFXC

SFXC-correlated observations impossible on MkIV:

Multiple ϕ -centers: 10

mixed fixed/slewing skds

Pulsar gating: 7

>2048 frq.pts: 4

record to date: 8192

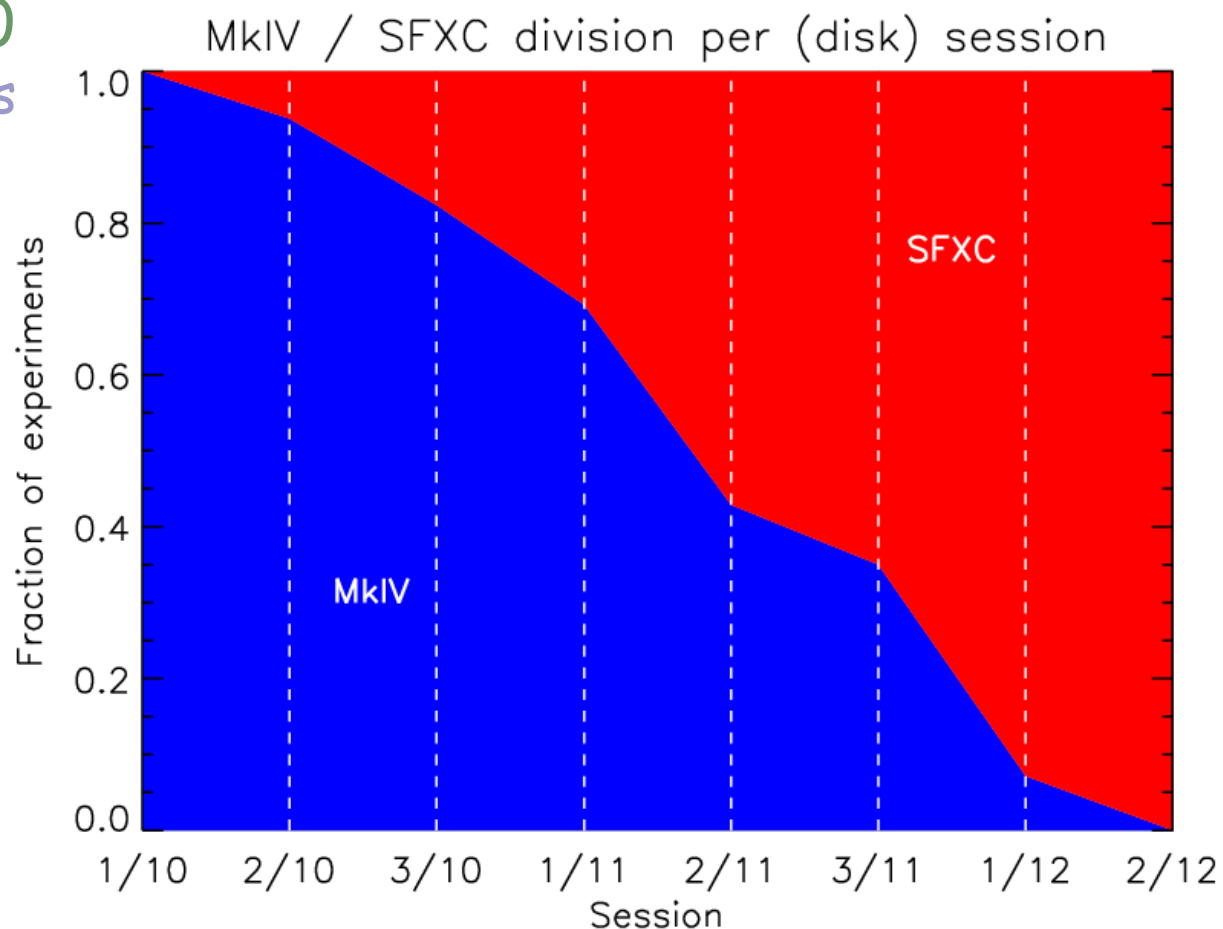
>16 stations: 3

rtd: 20, sess.3 exp: 24

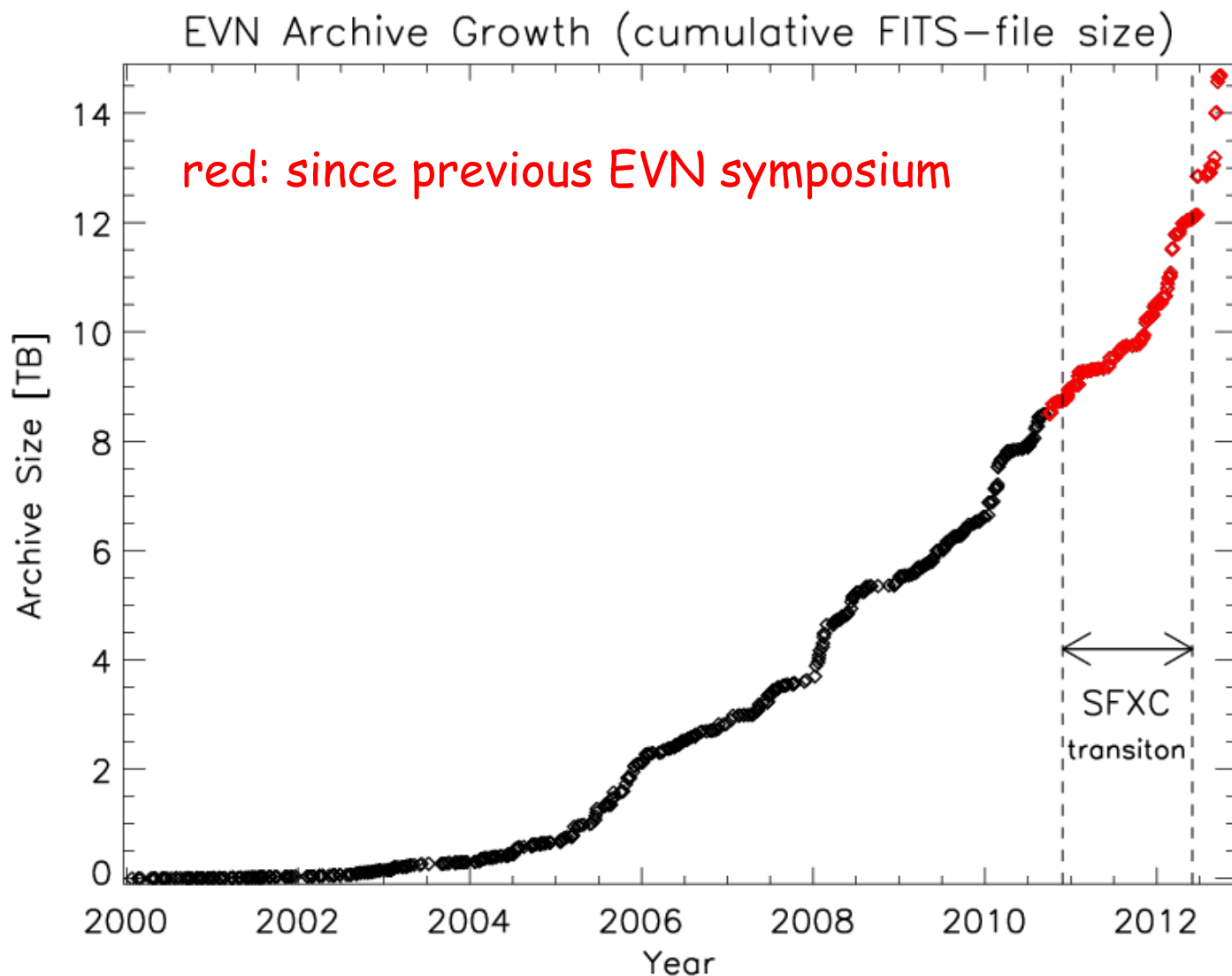
other >MkIV: 17

$\{N_{sta}, N_{sb}, N_{pol}, N_v\}$ too big

X-pol spectral line: 13



MkIV→SFXC: Archive Growth



Real-time e-EVN Science

- Proposal-driven e-VLBI science observations (stats thru 9-10 Oct)
 - 1st observation = 16 Mar 2006 (6 stations at 128 Mb/s)
 - Nowadays, network of 8-9 stations at Gbps is routine
 - 158 observations from 105 proposals (1226.5 network hours)
 - 46 different PI's
- Evolution of e-EVN procedures
 - ~monthly 24-hour runs (+4hr prelim. test) on fixed dates
 - Proposals now within standard proposal-submission cycles
 - Proposal Class for “**triggered**” observations (9 since Apr'08)
 - Proposal Class for “**short**” observations (25 since May'08)
 - Target of Opportunity Observations (36 since Sep'07)
 - e-EVN in regular disk sessions also now common (runs of >24hr)
 - NorthStar proposal tool modifications



e-EVN Operational Bandwidth

| Station | Connection |
|--------------|------------------------------|
| Effelsberg | 1024 Mbps (4x in tests) |
| Westerbork | 1024 Mbps |
| Jodrell Bank | 1024 Mbps |
| Medicina | 1024 Mbps |
| Noto | 896 Mbps (channel dropping) |
| Onsala | 1024 Mbps (4x in tests) |
| Torun | 1024 Mbps |
| Yebes | 1024 Mbps (4x in tests) |
| Sheshan | 256 Mbps |
| HartRAO | 1024 Mbps |
| Arecibo | 256 Mbps (512 from 04-10 UT) |
| Metsahovi | 1024 Mbps |

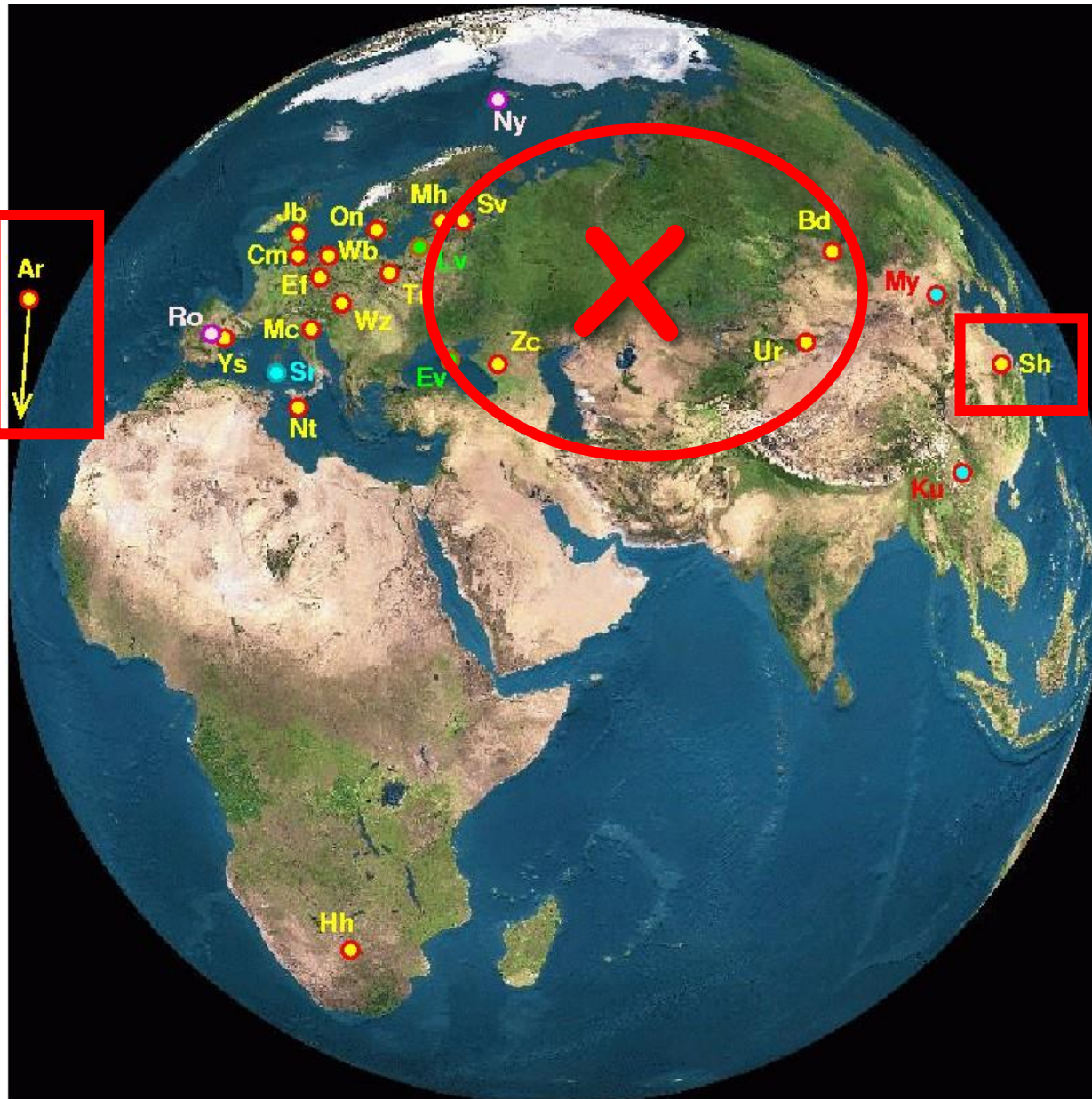
ATNF: 1 Gbps (At,Mp,Pa)

SRT expected soon

Robledo to start tests

Irbene connection in place

256



256



Gbps EVN:

current
exceptions
for e-EVN
observations
annotated

Real-time e-EVN Science Topics

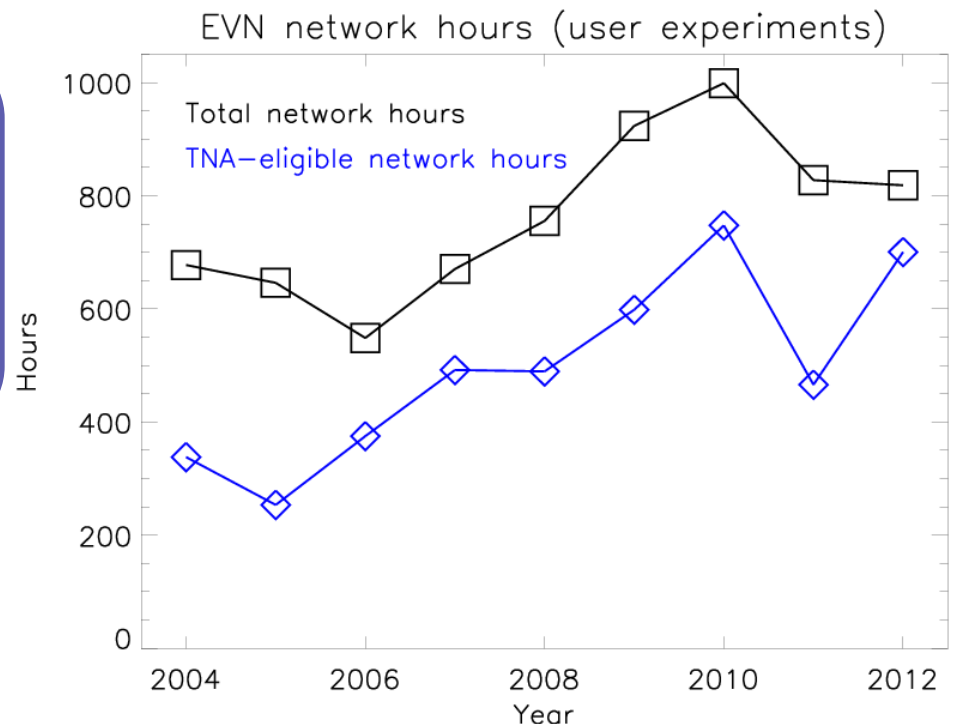
- Rapid turn-around; urgency; denser time-sampling:
 - X-ray, γ -ray binaries in flaring states (including novae)
 - AGN γ -ray outbursts — locus of VHE emission
 - Other high-energy flaring (e.g., Crab)
 - Outbursts in Mira variables (spectral-line)
 - Just-exploded GRBs, SNe
 - Binaries (incl. novae, XRBs) at specific orbital/outburst phases
 - Exo-planet searches
 - Monitoring SNe population/birth in starburst galaxies
 - Monitoring HST-1 jet component in M87
 - Binary-AGN candidates
 - AGN vs. starburst contributions in high- z sources
 - Seeking IMBH via compact radio emission in ULX
- Pre-proposal detection exp. / reference-source search

EVN Transnational Access (I)

- RadioNet3 EVN TNA eligibility rule:
 - {PI && $\geq \frac{1}{2}$ team members} from institutes in {EU+}
- TNA "bennies": reimbursement of travel costs to JIVE or other EVN institute(s) for a member of the team

Acknowledgement for
RadioNet on
"Access to the EVN"
web-page

*People do seem to be
learning the system.....*



EVN Transnational Access (II)

- TNA responsibilities:
 - Project Summary (prior to travel reimbursement)
 - Questionnaires (1 each for RadioNet3 office & EC)

Ideally, all eligible projects submit their reports

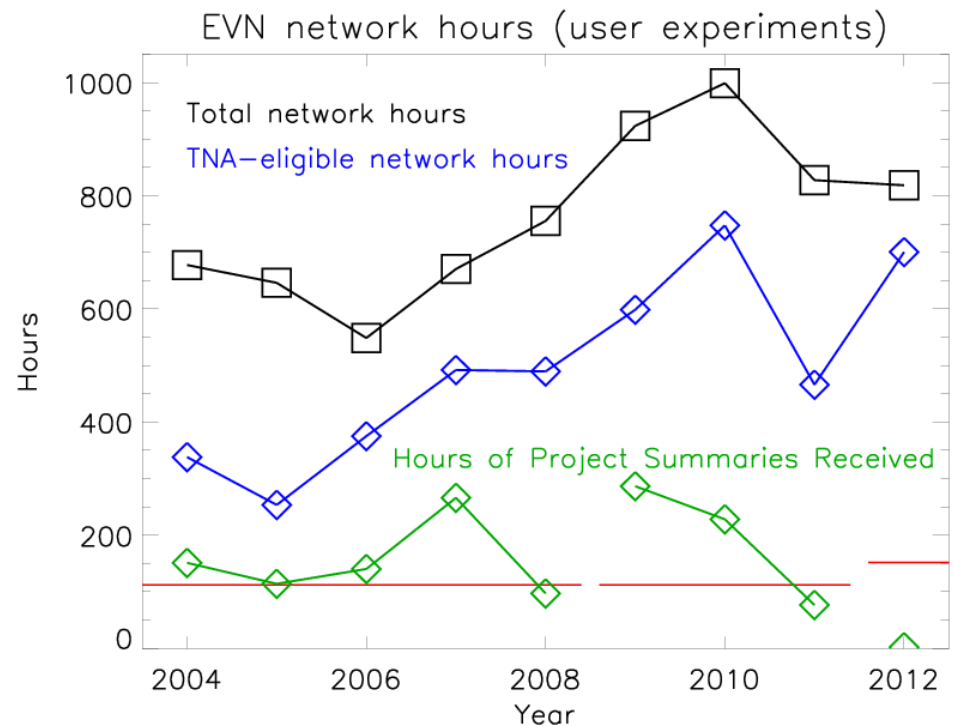
→ Must have enough to account for contracted number of acces hours

FP6: 2004—2008

FP7 : 2009—2011

RN3: 2012—2015 (still "in" FP7)

-> **KEEP BRUSSELS HAPPY!!**



First half of an animated slide

Where are these TNA Reports?

RadioNet3 Homepage | RadioNet3 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

★ RadioNet3 Homepage | RadioNet3

www.radionet-eu.org

RadioNet Advanced Radio Astronomy in Europe

Home Networking Activities **Transnational Access** Joint Research Activities

RadioNet3

- Front page
- Objectives
- Consortium
- Management
- News
- Events
- Travel
- Vacancies
- Contacts

Links & Resources

- RadioNet3 Wiki
- RadioNet Partners

RadioNet3 Homepage

RadioNet is an I3 that coordinates all of Europe's leading radio facilities in an integrated cooperation to achieve transform improvement in the quality and quantity of the scientific research of European astronomers. RadioNet3 includes 27 partners of world-class radio telescopes and/or performing cutting-edge range of technology fields important for radio astronomy.

RadioNet3 builds on the success of two preceeding I3s and but it also takes a leap forward as it includes facilitation of ALMA via a dedicated NA, and 4 pathfinders for the SKA in India. It has a transparent and efficient management structure and optimally support the implementation of the project.

Once the observing or data reduction run has been completed, the travel expense voucher and associated receipts must be sent by post to the TNA contact for the facility. The group leader is also required to complete the **Project Summary Report** (digital form: [Digital Summary Report](#)), and will also be invited to submit the **User Group Questionnaire**. These questionnaires, treated in the strictest confidence by the RadioNet Project Manager and the EC, will help the whole RadioNet consortium to provide better scientific, technical and logistic support to visiting astronomers.

Once we have received your voucher and receipts and the required **Project Summary Report** (digital form: [Digital Summary Report](#)), the astronomer supported by the grant will be reimbursed for his/her expenses without delay.

Observer's Feedback

One of the aims of the European Community Research Infrastructures Action is to provide scientists from anywhere within the Community with easy access to Europe's major research infrastructures. The Action is implemented through contracts between the European Commission and major European research infrastructures. These contracts serve to support, among others, the mobility costs of visiting scientists and their costs of using the infrastructure.

To enable the Commission to evaluate the Research infrastructures Action, to monitor the individual contracts, and to improve the services provided to the scientific community, **each Group Leader of a user-project** supported under an EC Research infrastructure contract is requested to complete a **User Group Questionnaire**. In addition, in order for RadioNet to continually improve its TNA services to the astronomical community, user group leaders are also requested to complete a similar questionnaire which will be sent directly to RadioNet management. Each of the **two** questionnaires should be completed **once** by each user group as soon **as the experiments on the infrastructure come to an end**.

All replies will be treated in the strictest confidence. The information given will only be used for monitoring and assessment purposes.

Qstnr. (2)

| EC Questionnaire | RNet Questionnaire |
|---|--|
| ONLINE ↗ Complete the EC questionnaire online. Please make sure you select the "correct" RadioNet project: RadioNet3 | PDF ↗ Complete the questionnaire and send electronic or paper copies to: dr. Izabela Rottmann RadioNet Project Manager MPIfR Auf dem Hügel 69 53121 Bonn Germany rn3@mpi-fr.de Tel: +49 (0)228 525424 Fax: +49 (0)228 525229 |

Where are these TNA Reports?

ProjectSummaryReport extra question digital.pdf (application/pdf Object) - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.radionet-eu.org/sites/radio

Most Visited openSUSE Getting Started Latest Headlines

Transnational Access | Radi... ProjectSummaryReport extra...

Please fill out the following form. You cannot save data typed into the form. Please print your completed form if you would like a copy for your records.

RadioNet: Project Summary Report

RadioNet Trans-national Access (TNA) users are required to complete the following Report. The report should be completed once by each User Group leader as soon as the infrastructure comes to an end or data reduction is completed. TNA travel and be reimbursed until the Project Summary Report has been submitted to the TNA Facility.

All reports will be treated in the strictest confidence. The information given will only be used for assessment purposes.

PROJECT SUMMARY REPORT

- RadioNet TNA Facility
- User Project Acronym
- User Project Title
- User Group Leader
- Address of Home Institution
- E-mail address
- Telephone/FAX numbers
- Please give a brief description of the scientific objectives of your project.

RadioNet Project Summary Report

beagle is indexing http://www.radionet-eu.org/sites/radionet-eu.org/files/cn

European Commission: CORDIS: FP7 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://cordis.europa.eu/fp7/capacities/questionnaire_en.html

Most Visited openSUSE Getting Started Latest Headlines Mozilla Firefox

USER GROUP QUESTIONNAIRE

- Number of the EC Grant Agreement that financed the user group's access to the research infrastructure Please select
- User Project Acronym note 1
- Person filling in the questionnaire (normally the User Group Leader)

Family name
 First name(s)
- Where did you first find out about the possibilities of access supported through the EC grant agreement?

☐ EC Research Infrastructures Action web-site
 ☐ Announcement in journal
 ☐ CORDIS databases
 ☐ Announcement at conference
 ☐ Grant Agreement web-site
 ☐ Direct mailing from infrastructure
 ☐ Infrastructure web-site
 ☐ Personal contact (please specify)
- Without the support of this EC grant agreement would you still have been able to carry out your work at this research infrastructure?

☐ Yes ☐ No
 If no, please indicate the reason (you may indicate more than one choice)

☐ Not otherwise eligible to apply for access to the infrastructure(s)
 ☐ Too difficult to obtain access by applying directly
 ☐ Unable to pay the user fee
 ☐ Unable to pay travel & subsistence for one or more of the group members
 Other (please specify)
- assess the services provided by the grant agreement with respect to the following points rating them on a scale from 'very poor' to 'very good'.

(Please provide at least 4 ratings. Leave blank when the point is not applicable)

| | |
|---|--|
| Publicity, made by the infrastructure, concerning the access financed by the EC | |
| Practical information provided on how to apply for access | |
| Advice to use the most appropriate installation or infrastructure note 2 | |
| Information provided, once your project was accepted, on how to use the facility | |
| Scientific support to set up your experiments and interpret the results | |
| Technical support to make best use of the installation(s) | |

RadioNet3 (283393)

beagle is indexing http://cordis.europa.eu/fp7/capacities/questionnaire_en.html



Topics being worked on

- New stations: e-MERLIN, KVN, Irbene 32m;
Sardinia 64m, Shanghai 65m, Urumqi 110m
- New digital back-ends (→ beyond 1 Gbps)
- e-EVN via SFXC
- Primary beam corrections
 - TOG discussion — gathering information from stations
- SFXC & AIPS
 - Array vs. Correlator (CVEL, BPASS)
 - IM/MC tables
- SFXC Documentation: Web pages / paper



Summary

- Pre-/Post-correlation PI Support
 - Help available — **don't have to wait until last minute**
 - Archive: FITS, pipeline, standard plots, feedback
 - **RadioNet3 EVN Trans-National Access program**
- EVN Software Correlator at JIVE (SFXC)
 - Astronomical applications beyond the MkIV correlator
 - More straightforward capacity limitations
- e-VLBI now standard/indispensable facet of EVN
 - New kinds of astronomy enabled
 - 25—30% of network observing hours over last 4 yr