



Astronomy with e-VLBI

(from the EVN perspective)

Huib Jan van Langevelde

- **Why do we do e-VLBI?**
 - **Because it works for our users!**
 - Show some results
 - Show some statistics
 - **Because it works for us!**
 - Progress with e-VLBI
 - Introducing NEXPRoS
 - How it is shaping the EVN
- **Where are we going?**
 - Where we think the best science is...
 - Calls for further integration on a global scale
- **The (non-technical) progress that we made**
 - JIVE and other reviews
 - Challenges ahead



Meet the users:



Meet the users:



e-VLBI 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
- **158 observations since 2006**
 - from 46 different PIs



3. e-VLBI observation classes

e-VLBI observations that can take place on the [scheduled runs](#) fall into the four classes. Time within the first two classes will only be allocated in response to proposals submitted by the standard proposal deadlines of 1st Feb, 1st June and 1st October. Proposals should include in their proposal text which class of observations is being requested.

1) General e-VLBI observations

Any e-VLBI observation during one or several e-VLBI sessions, excluding triggered observations (see below).

General e-VLBI proposals can be for any scientific purpose and do not need to be justified by the rapid data delivery of e-VLBI. Proposals for source monitoring may contain both standard and e-VLBI observations. Note that the e-VLBI portion of monitoring proposals cannot be scheduled on a requested run, as they may be overridden by higher rated, triggered e-VLBI proposals.

General e-VLBI proposals can be either continuum or spectral line. Scheduling will be determined using the technical information included in the proposal; it is therefore vital that all technical details are fully specified in the proposal.

2) Triggered e-VLBI proposals

An observation to be scheduled during an e-VLBI run only if a specific triggering criterion is met. Accurate source coordinates need only be included in the trigger request, not in the proposal. Only continuum observations can be proposed for within this class. Triggered proposals must include precise and justified triggering criterion and a minimum number and configuration of telescopes.

Proposals of successful proposals containing a triggered e-VLBI observation will be informally reviewed by the EVN PC Chair (Tom Muxlow, tom.muxlow@manchester.ac.uk) with copies to the EVN Science Committee (Porcas, porcas@mpifr-bonn.mpg.de) and JIVE/NEXPreS (Bob Campbell, campbell@jive.nl). These trigger requests must be received no later than 0800 UT on the day of the e-VLBI run. The e-mail should provide evidence that the trigger criterion in the original proposal has been met, and give the exact GST range and source position requested. All requests must include parameters that must match those in the original proposal. The PC Chair will evaluate the trigger requests and will decide on priorities if more than one conflicting trigger requests is received) and will inform the EVN PC Chair 1700 UT whether their experiment is to be observed. The experiment will then be scheduled in accordance with the instructions given in the original proposal.

3) Short e-VLBI observations

e-EVN Operational Bandwidth

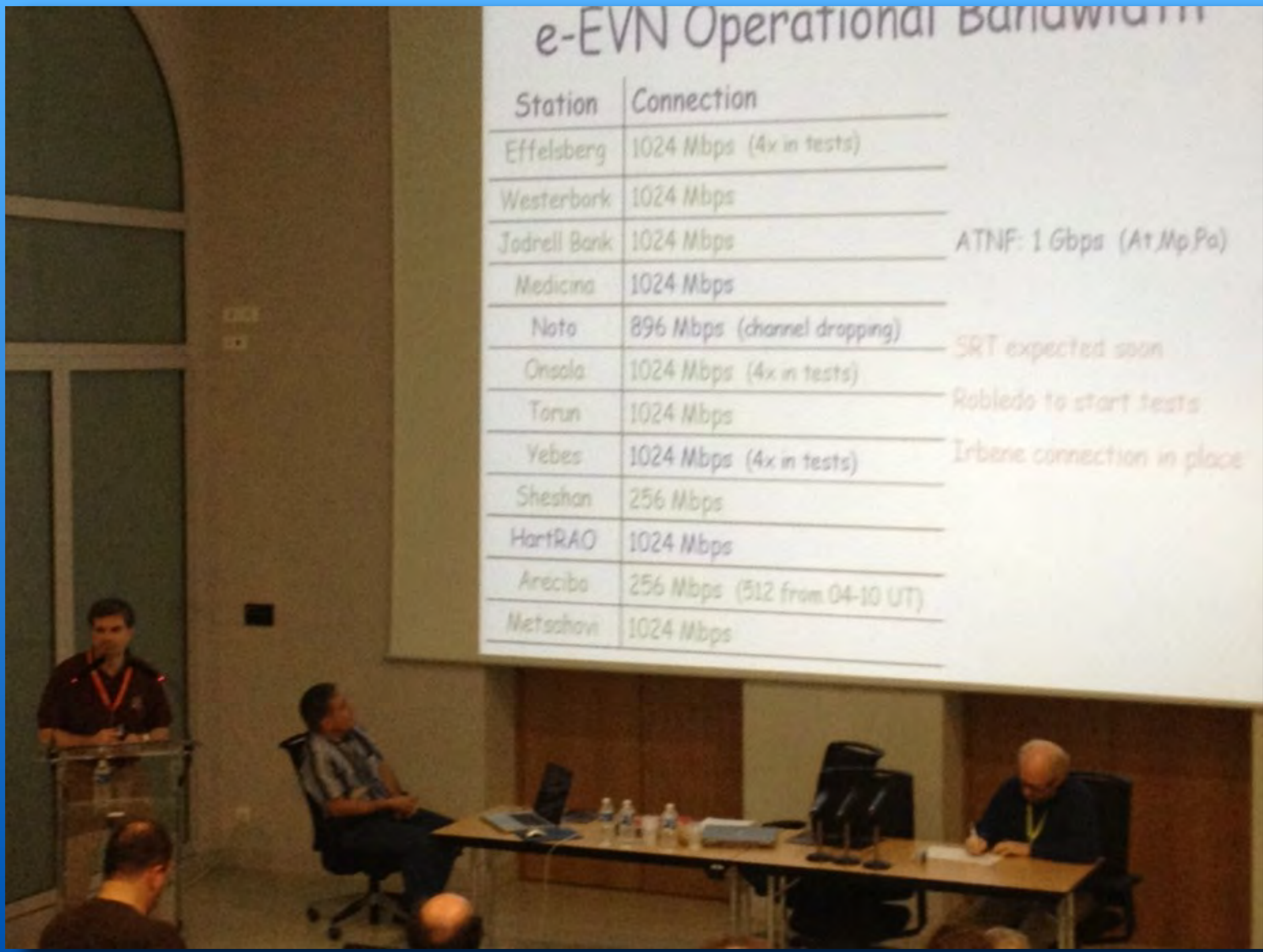
Station	Connection
Effelsberg	1024 Mbps (4x in tests)
Westerbork	1024 Mbps
Jodrell Bank	1024 Mbps
Medicina	1024 Mbps
Noto	896 Mbps (channel dropping)
Onsala	1024 Mbps (4x in tests)
Torun	1024 Mbps
Yebes	1024 Mbps (4x in tests)
Sheshan	256 Mbps
HartRAO	1024 Mbps
Arecibo	256 Mbps (512 from 04-10 UT)
Metschovi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

ATNF: 1 Gbps (At Mp Pa)

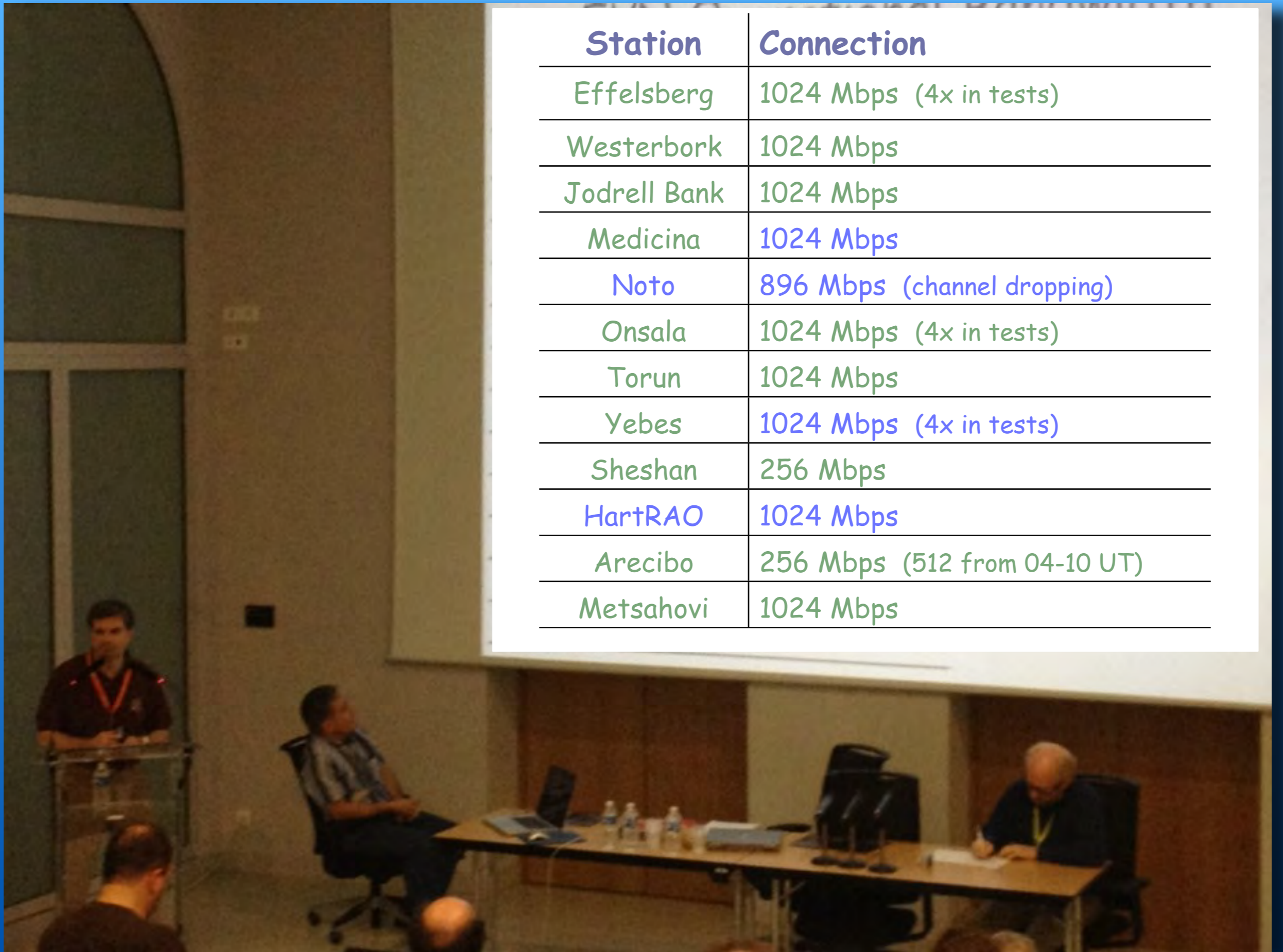
SRT expected soon

Robledo to start tests

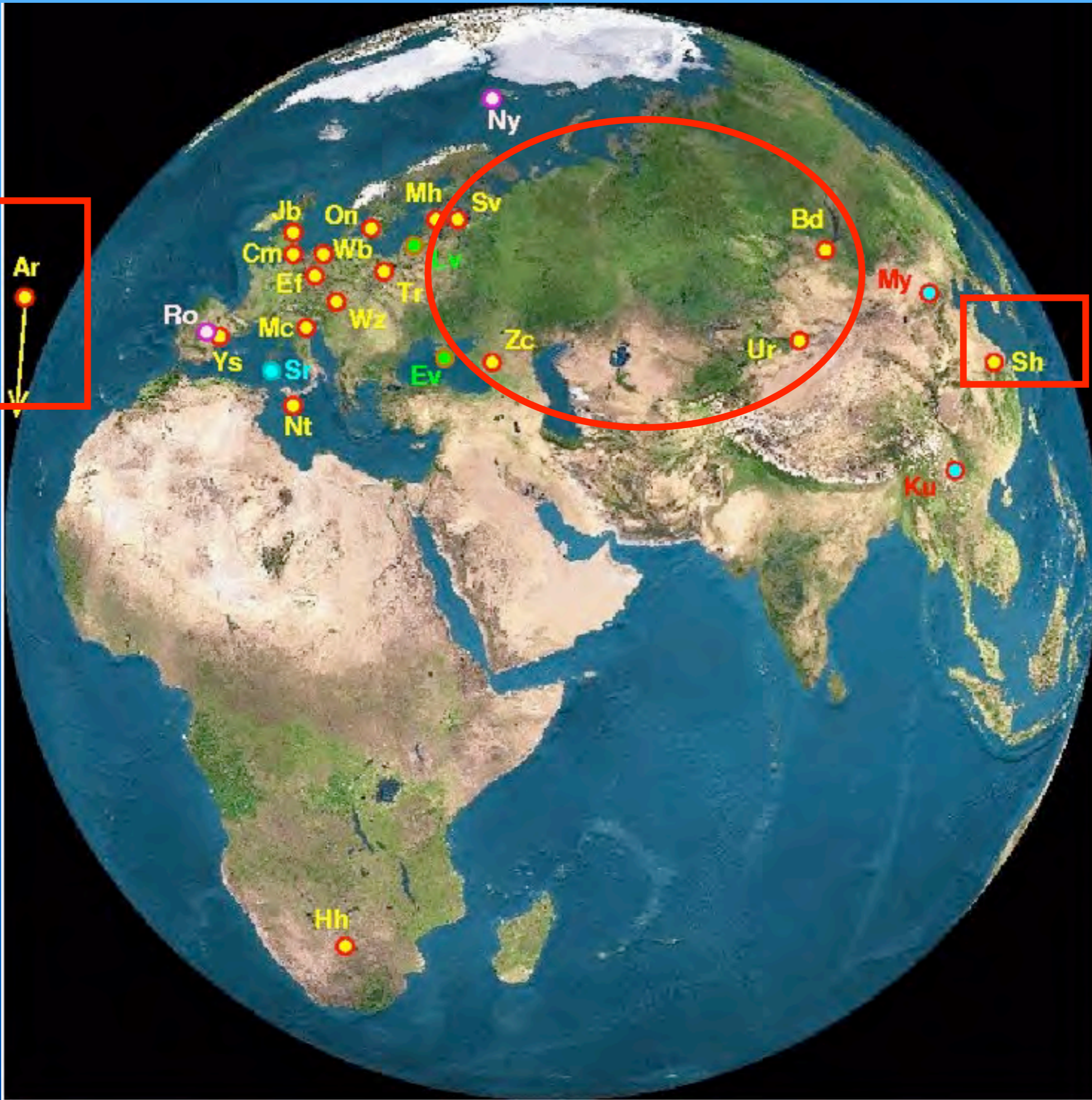
Irbeie connection in place



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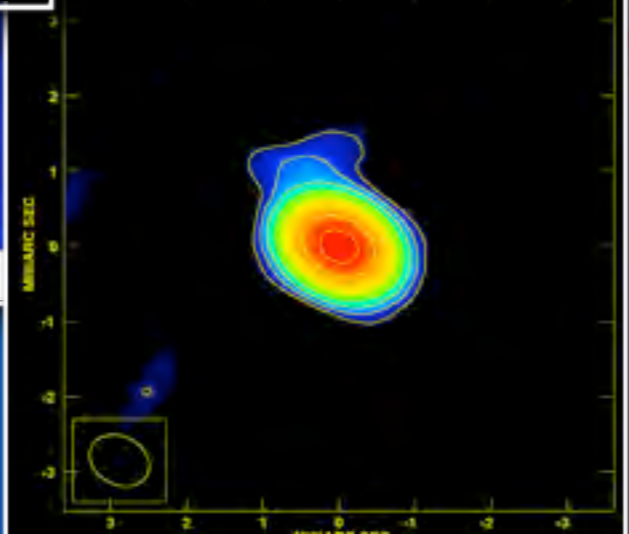
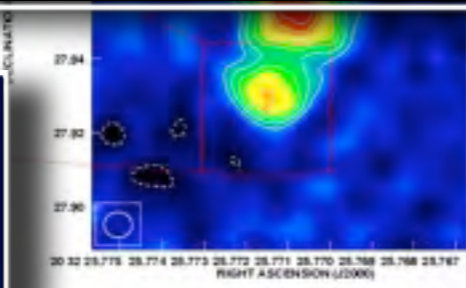
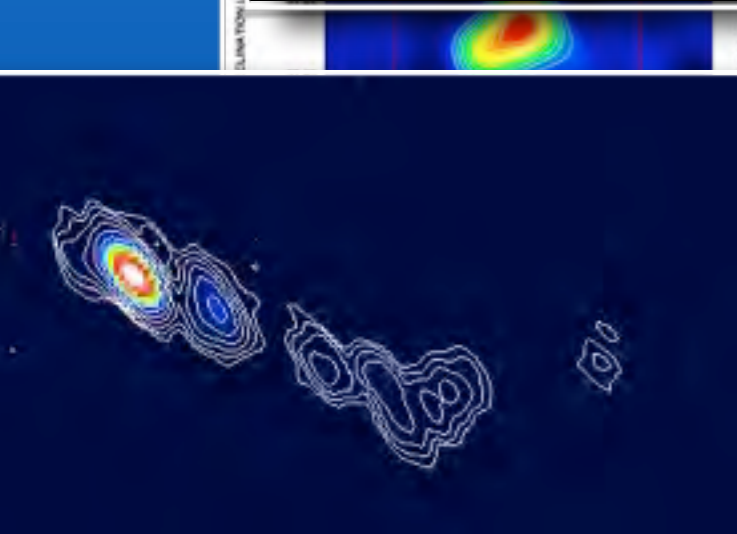
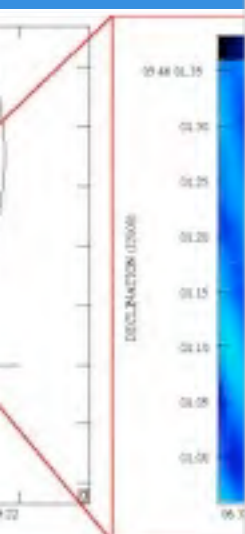
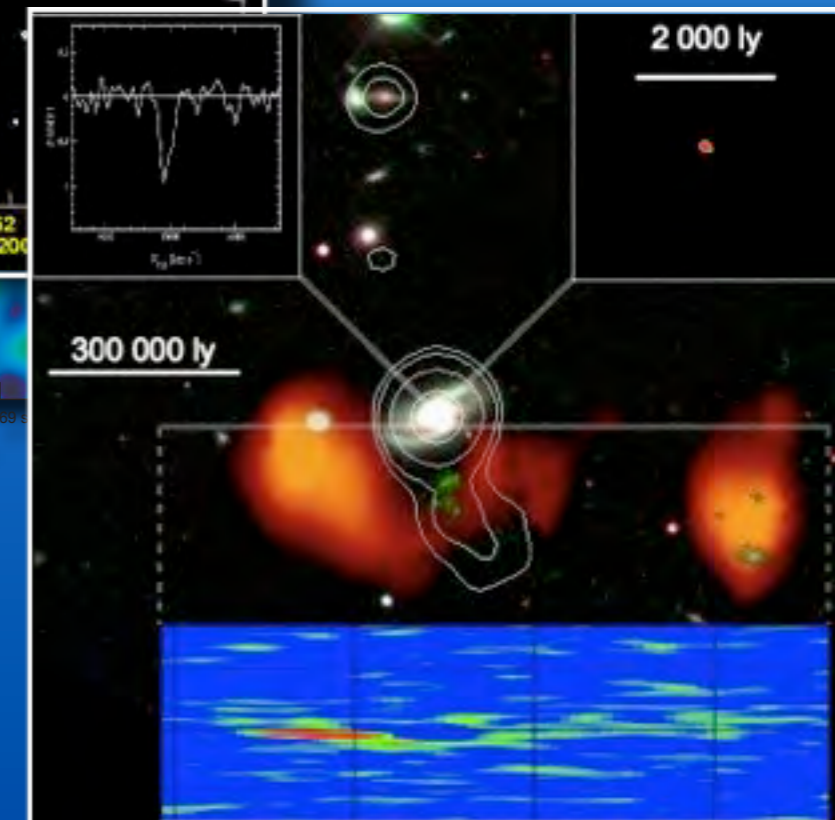
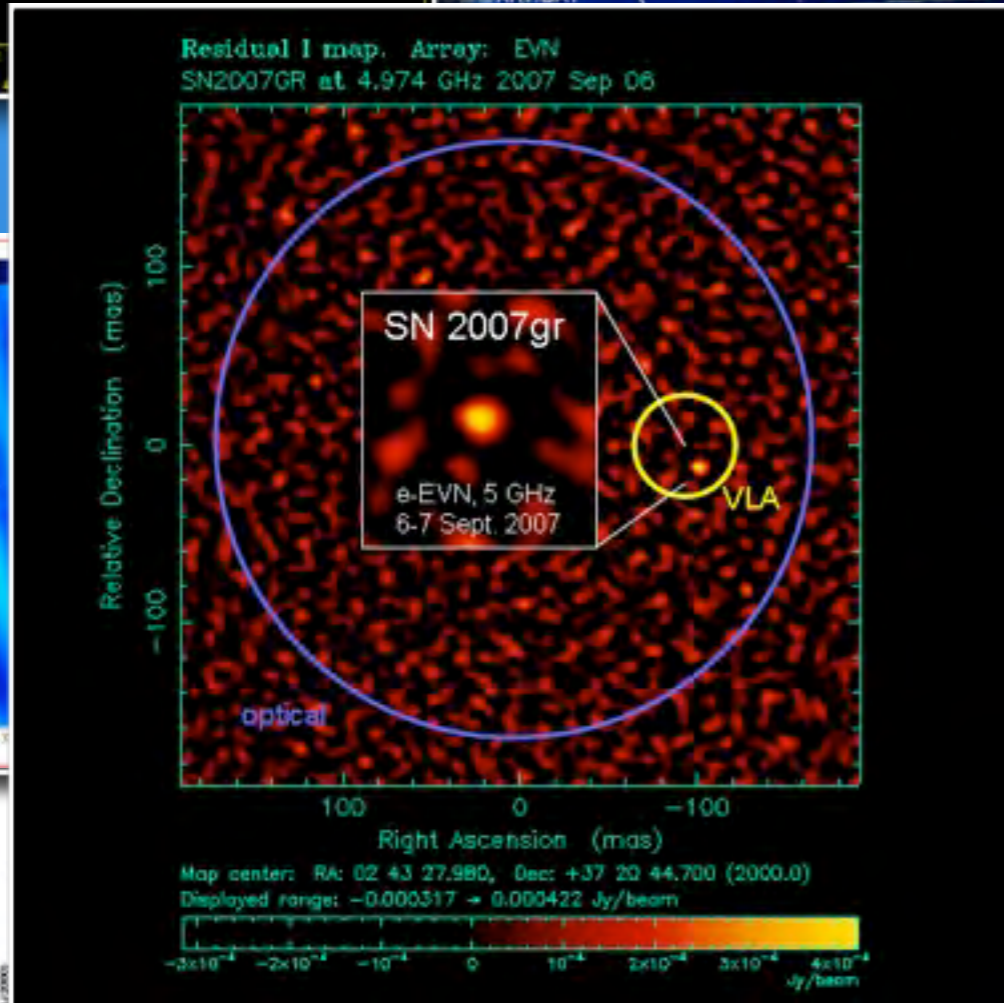
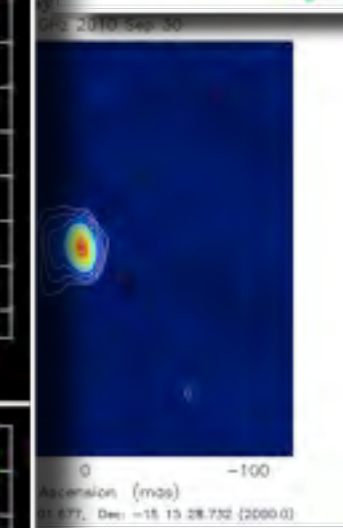
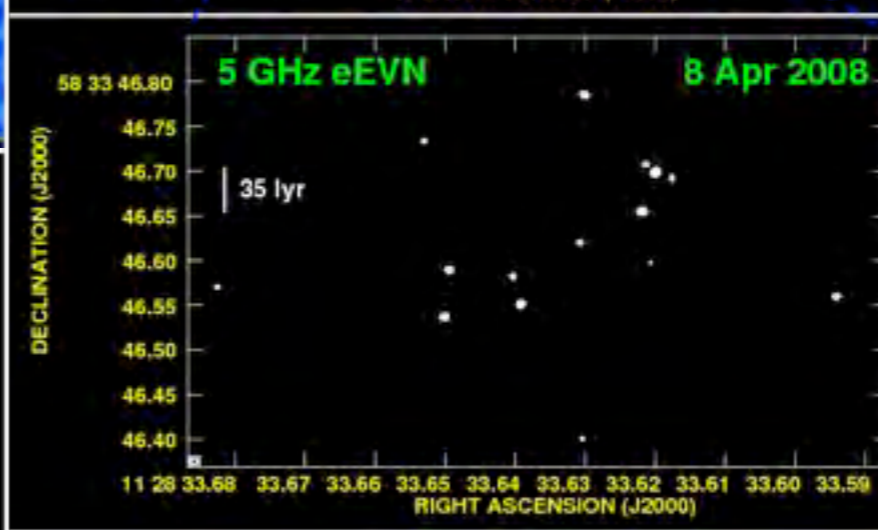
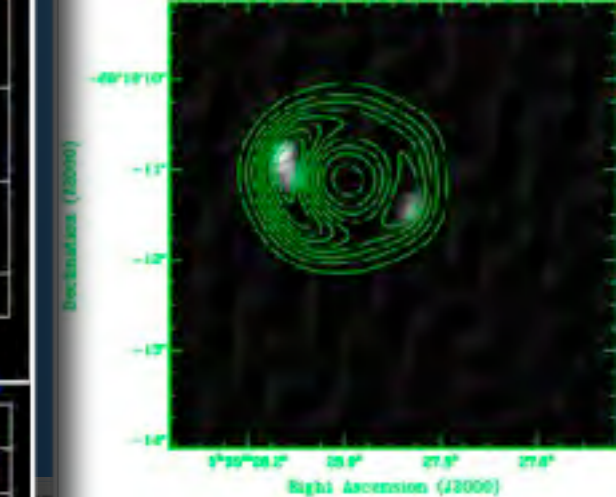
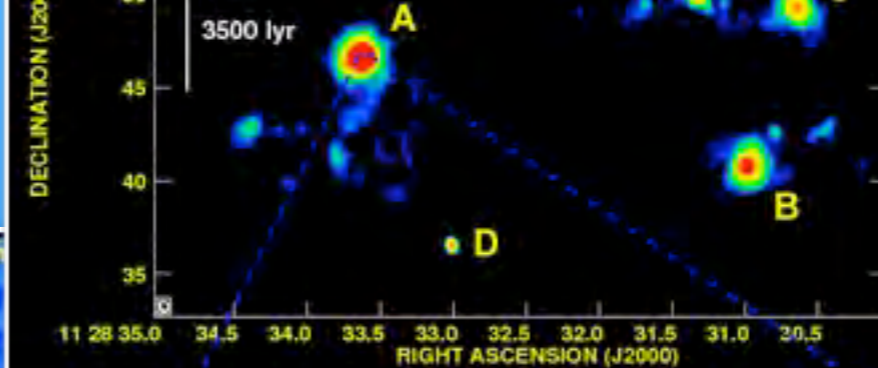
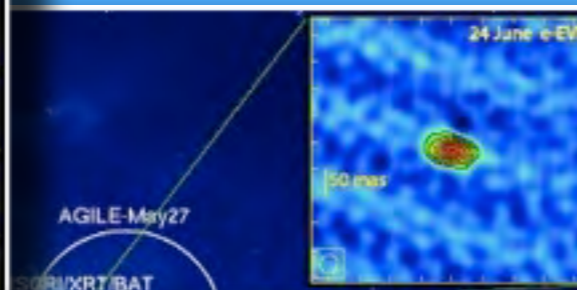
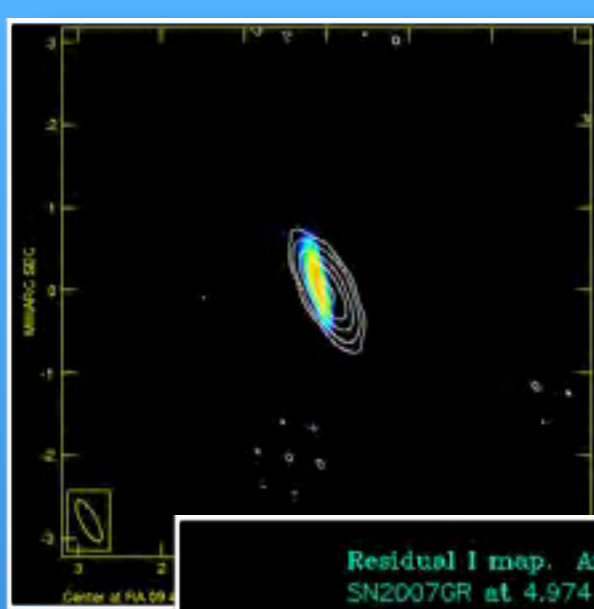


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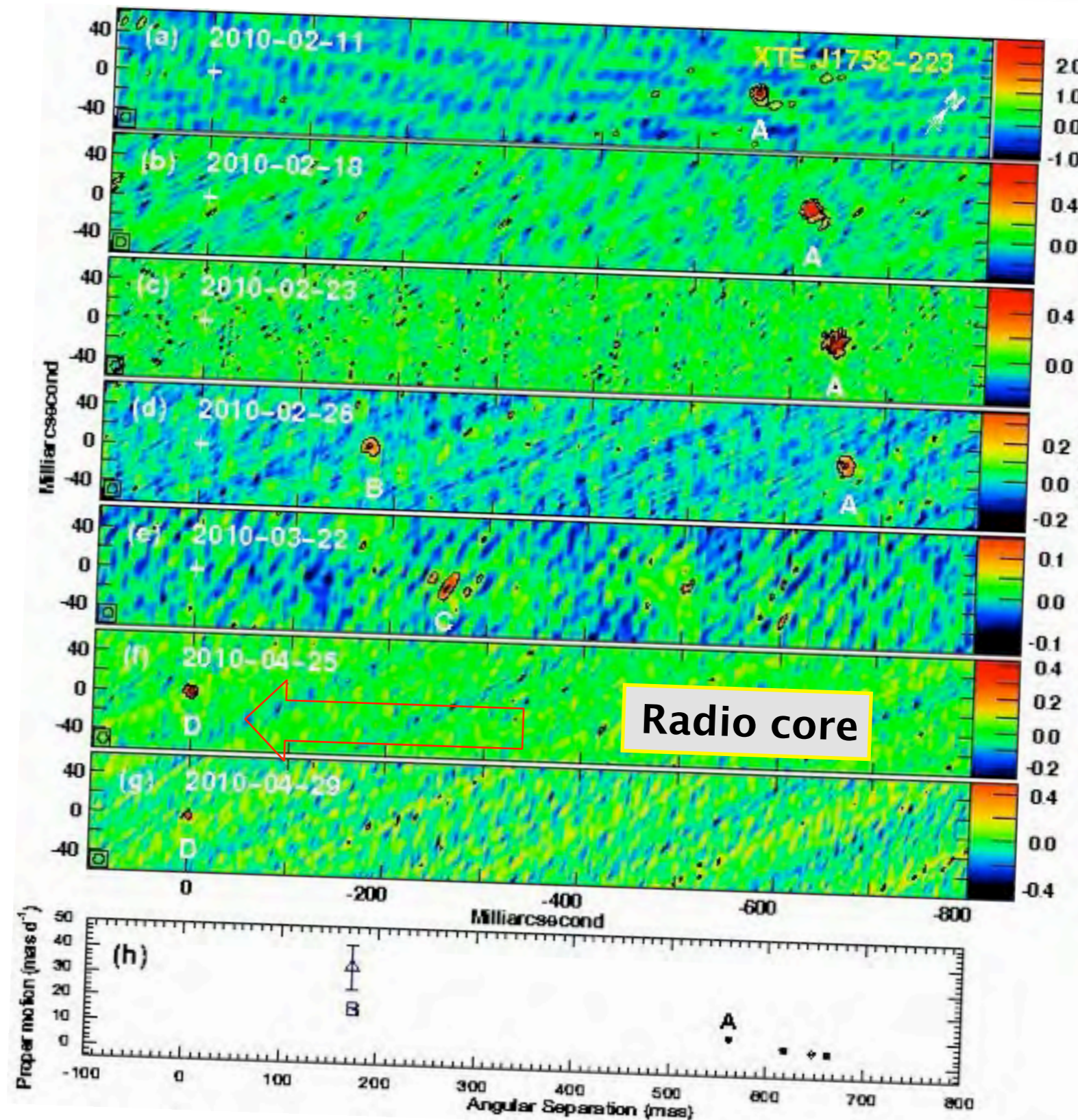
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- **Rapid turn-around; urgency; denser time-sampling:**
 - X-ray, γ -ray binaries in flaring states (including novae)
 - AGN γ -ray outbursts — locus of VHE emission
 - Other high-energy flaring (e.g., Crab)
 - Outbursts in Mira variables (spectral-line)
 - 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**



XTE J1752-223

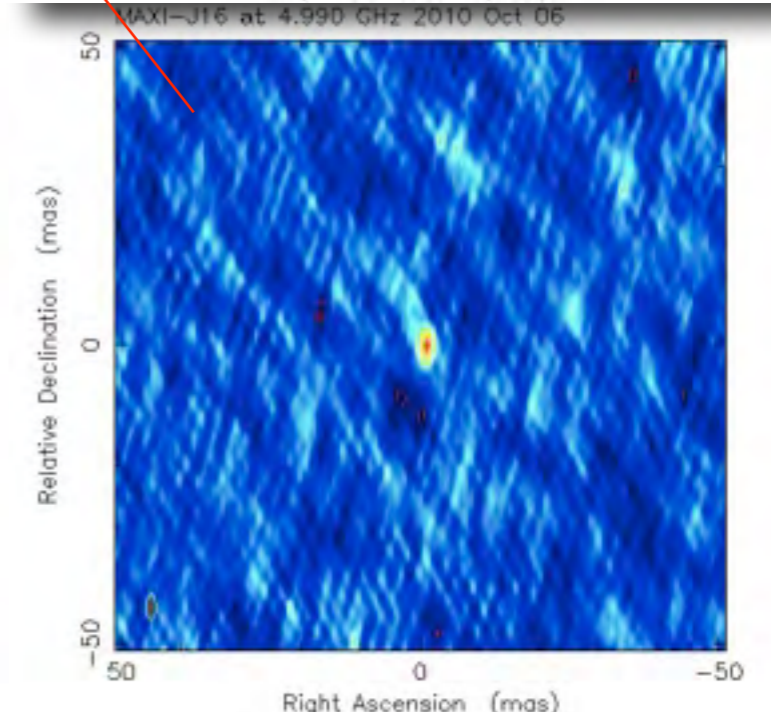
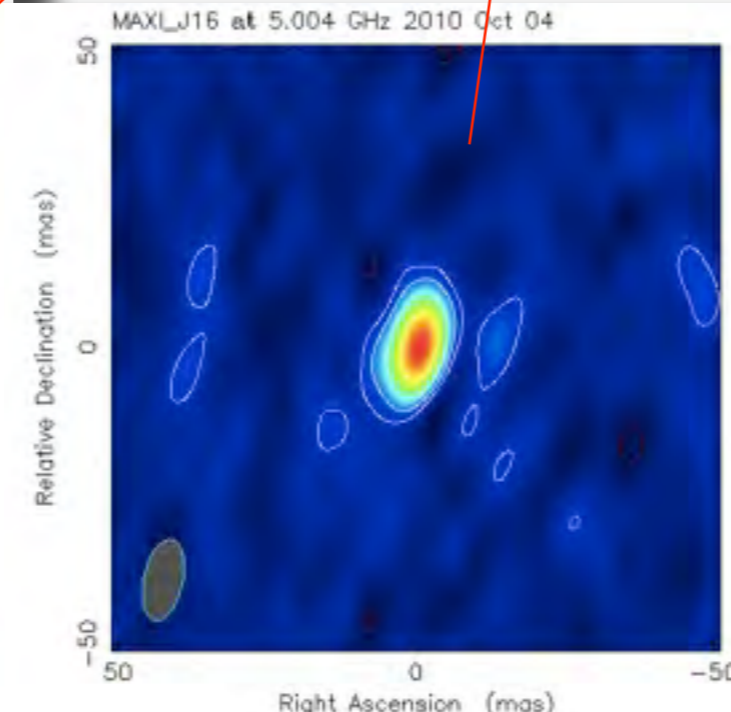
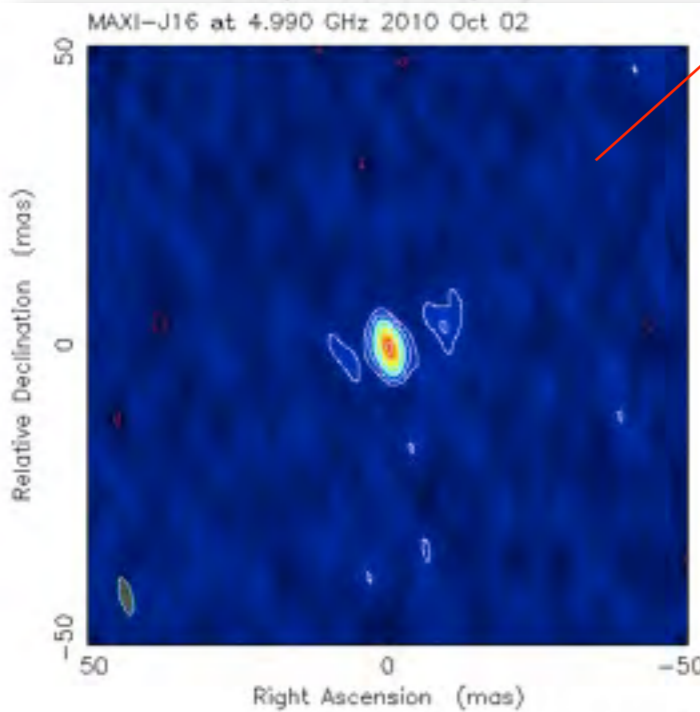
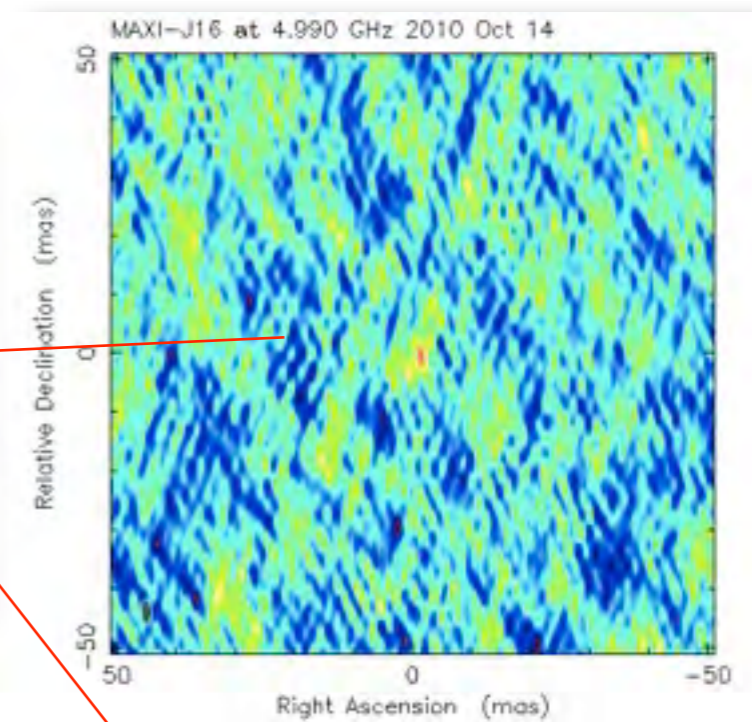
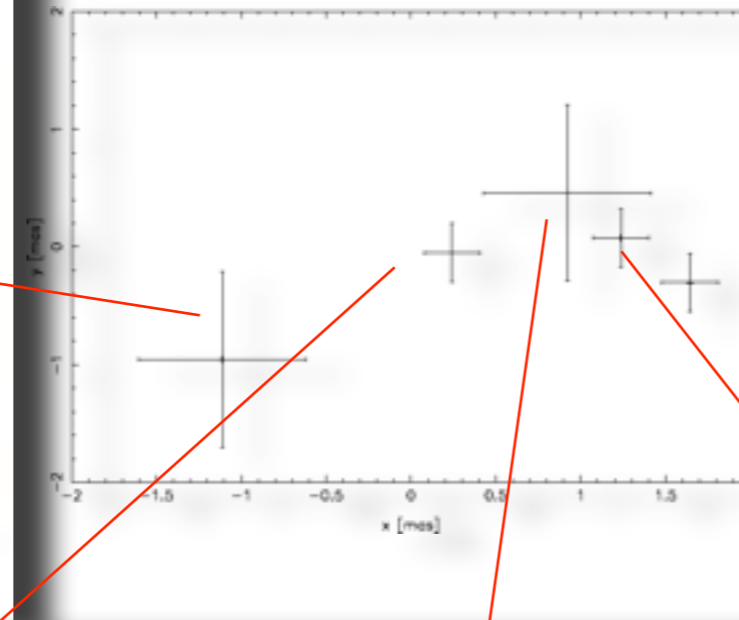
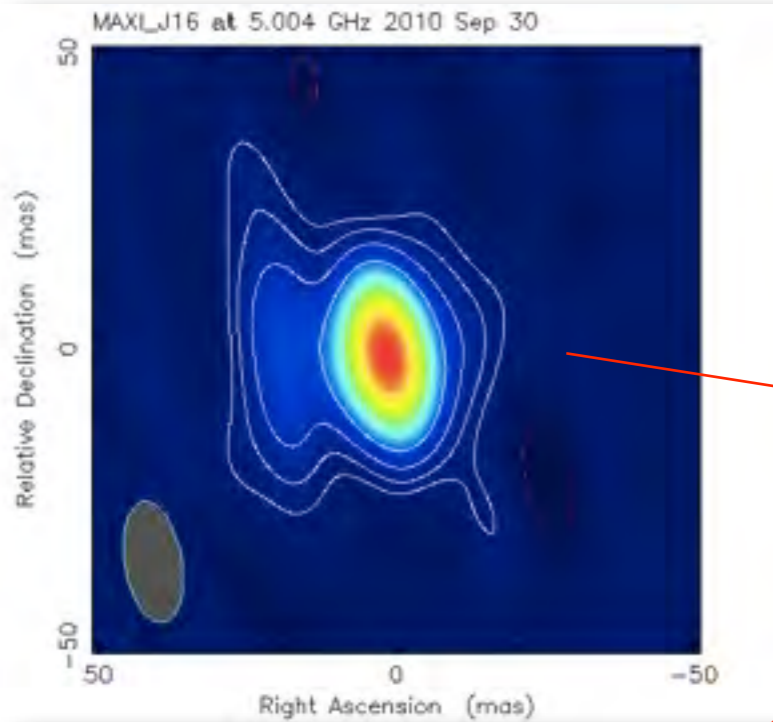
- X-ray transient discovered by RXTE
- Initial EVN/e-VLBI detection last year
- Eventually in the hard state the radio core is detected
- High Proper motion detected



Yang et al 2011

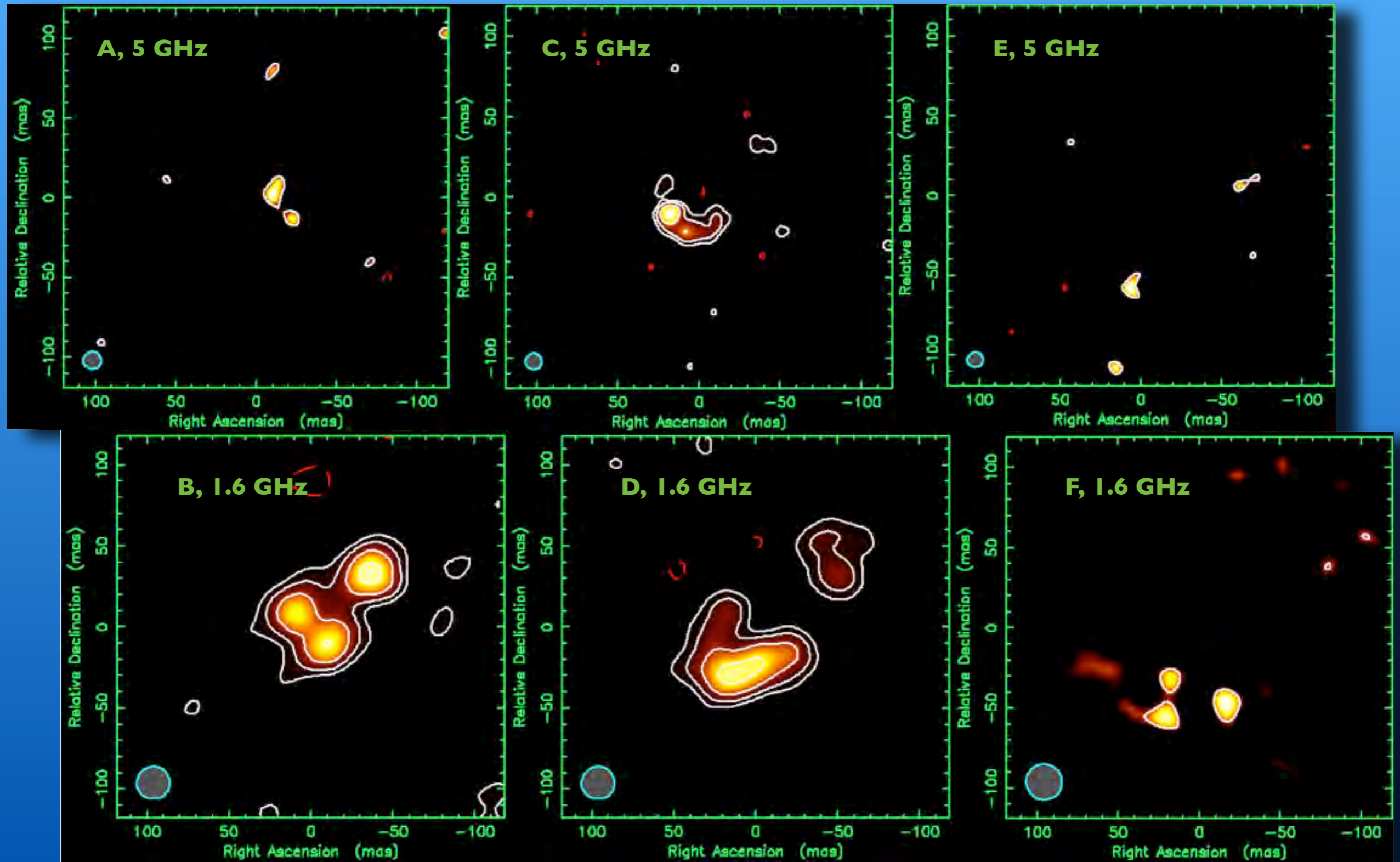
MAXI J1659-152

Peak position



- the shortest orbital period BHXRBB
- Possible runaway microquasar in the Galaxy (Yamaoka et al. 2011, Kuulkers et al. 2012)
- Astrometry limited by source structural changes; proper motion requires new outburst (Paragi et al., submitted)

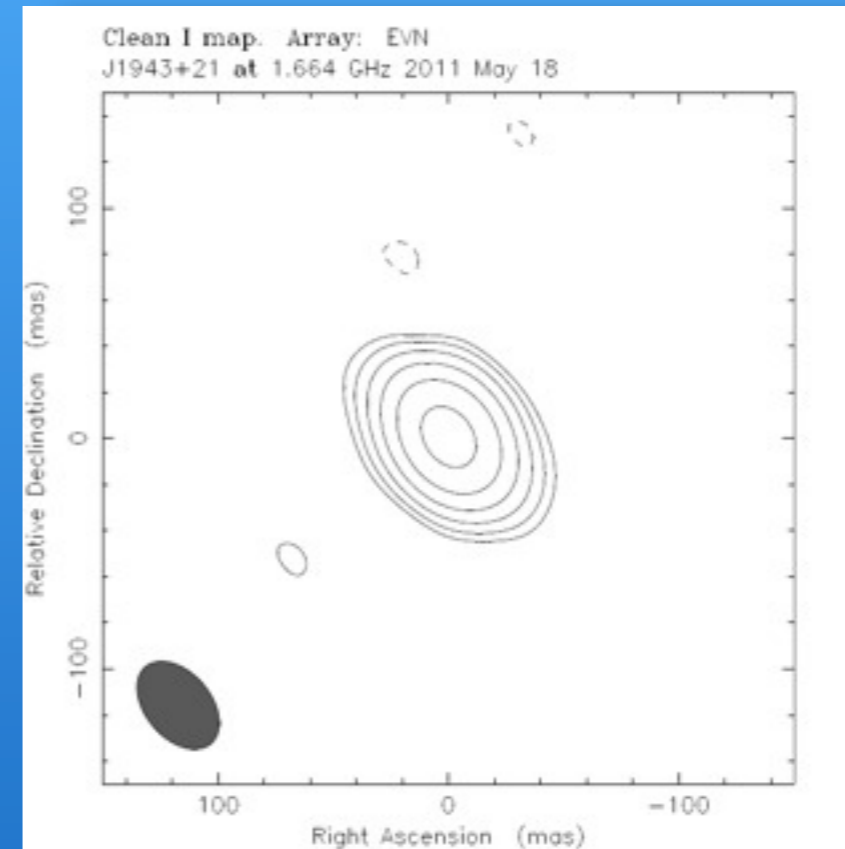
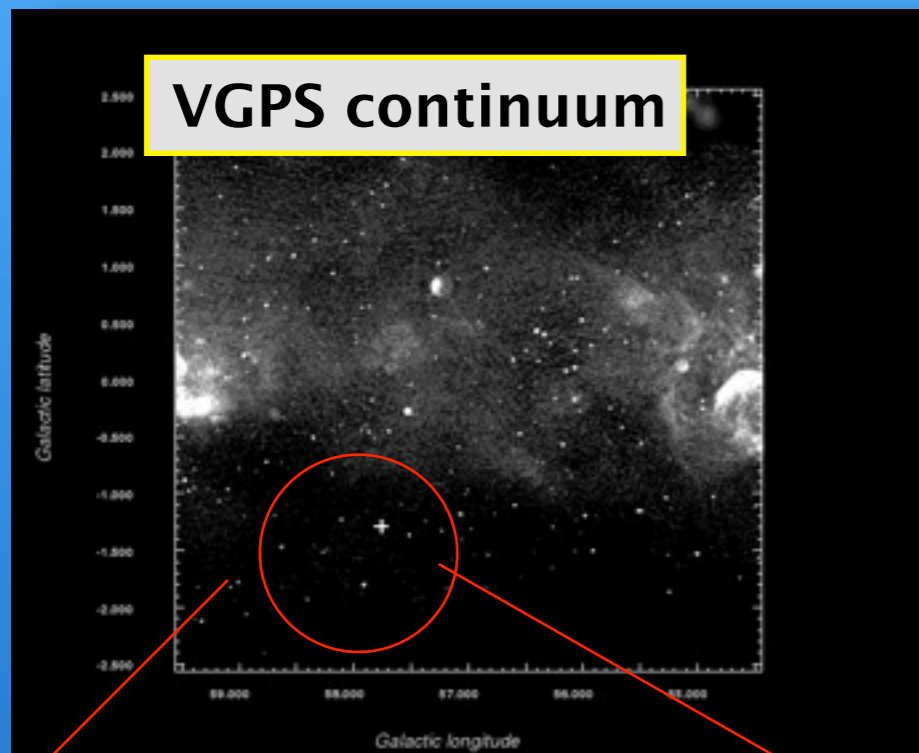
V407 Cyg Nova, associated to gamma ray event



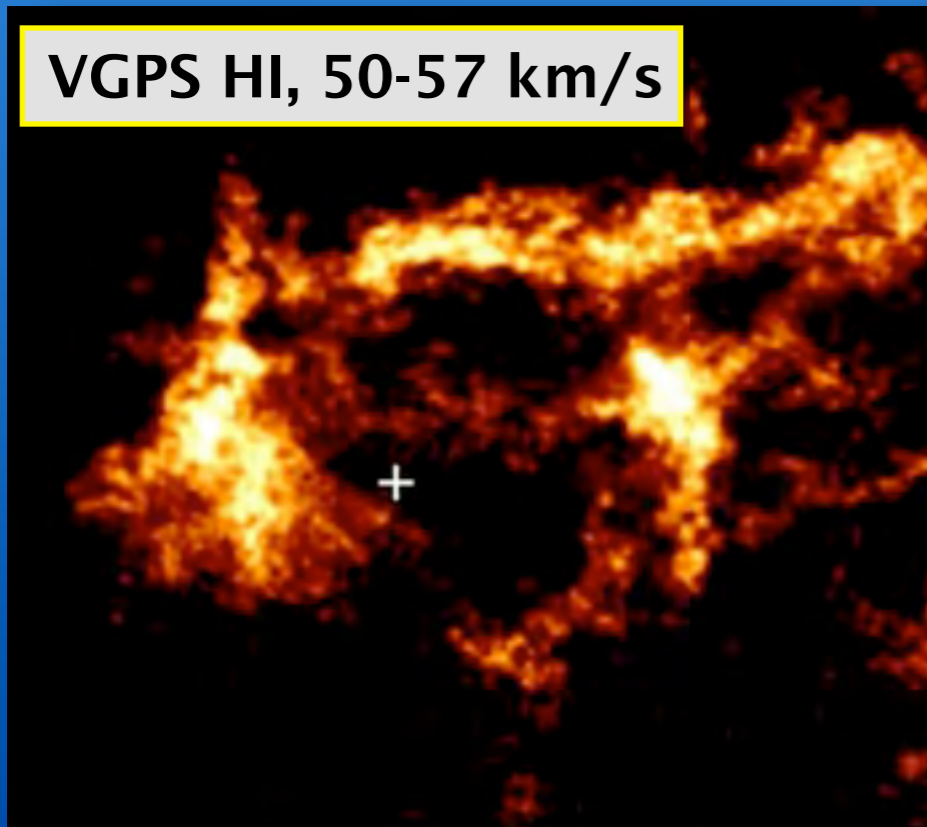
All eVLBI (4 done as ToO) Few mJy at 1.6, sub mJy at 5 GHz, Giroletti et al

HESS J1943+213

e-EVN at 1.6 GHz
Featureless but
resolved, $T_B \sim 8 \times 10^7$ K

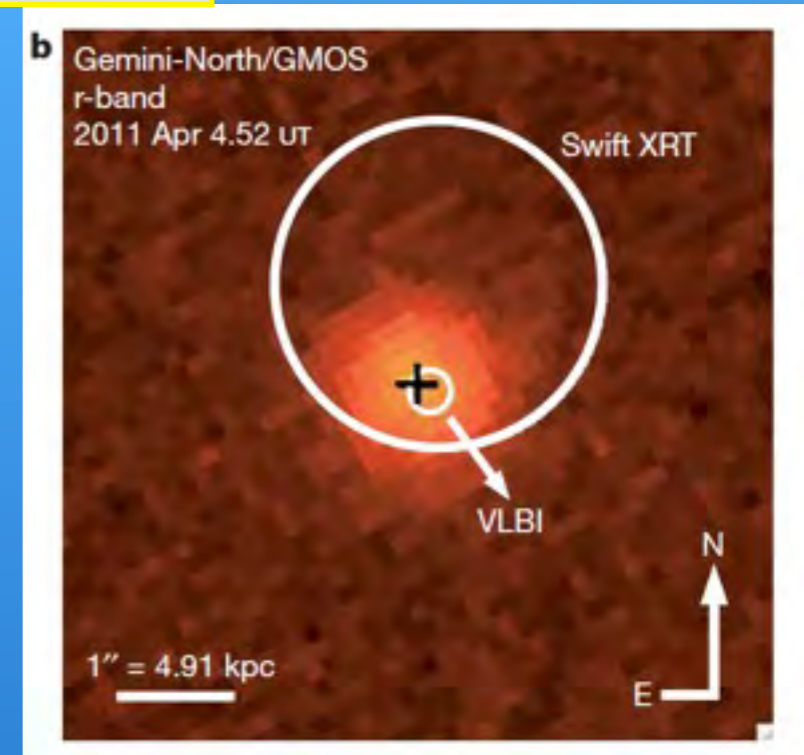


VGPS HI, 50-57 km/s



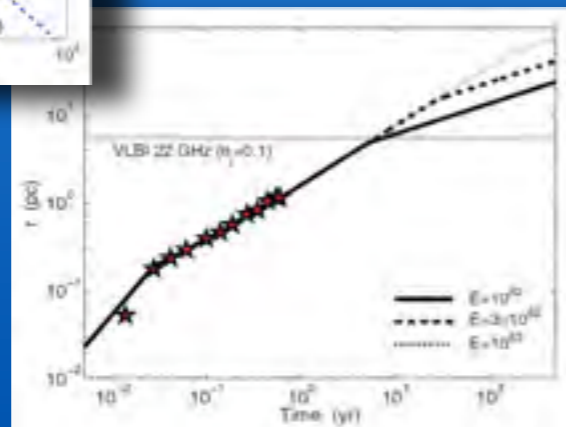
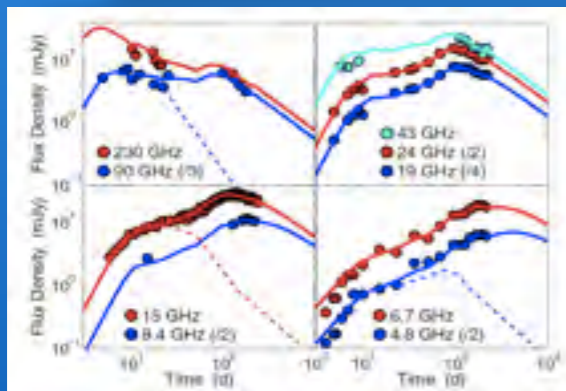
- Coincides with an optically unidentified hard X-ray, likely IR and radio counterparts
- Detected by Fermi, ROSAT, Chandra, Swift, narrowing down the X-ray error circle
- Several options: Planetary wind nebula, Gamma-ray binary AGN/BL Lac object
- Either a very unusual AGN, or, could be a PWN at the far edge of the Galaxy (Gabanyi et al., submitted)

Tidal Disruption Events: Sw J1644+57

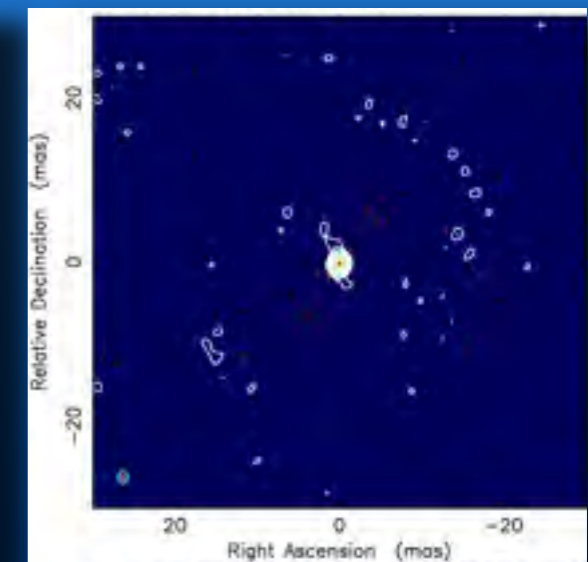
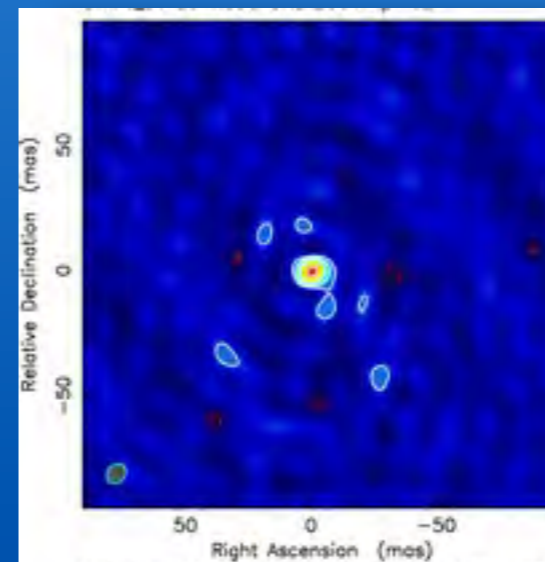


Zauderer et al. 2011

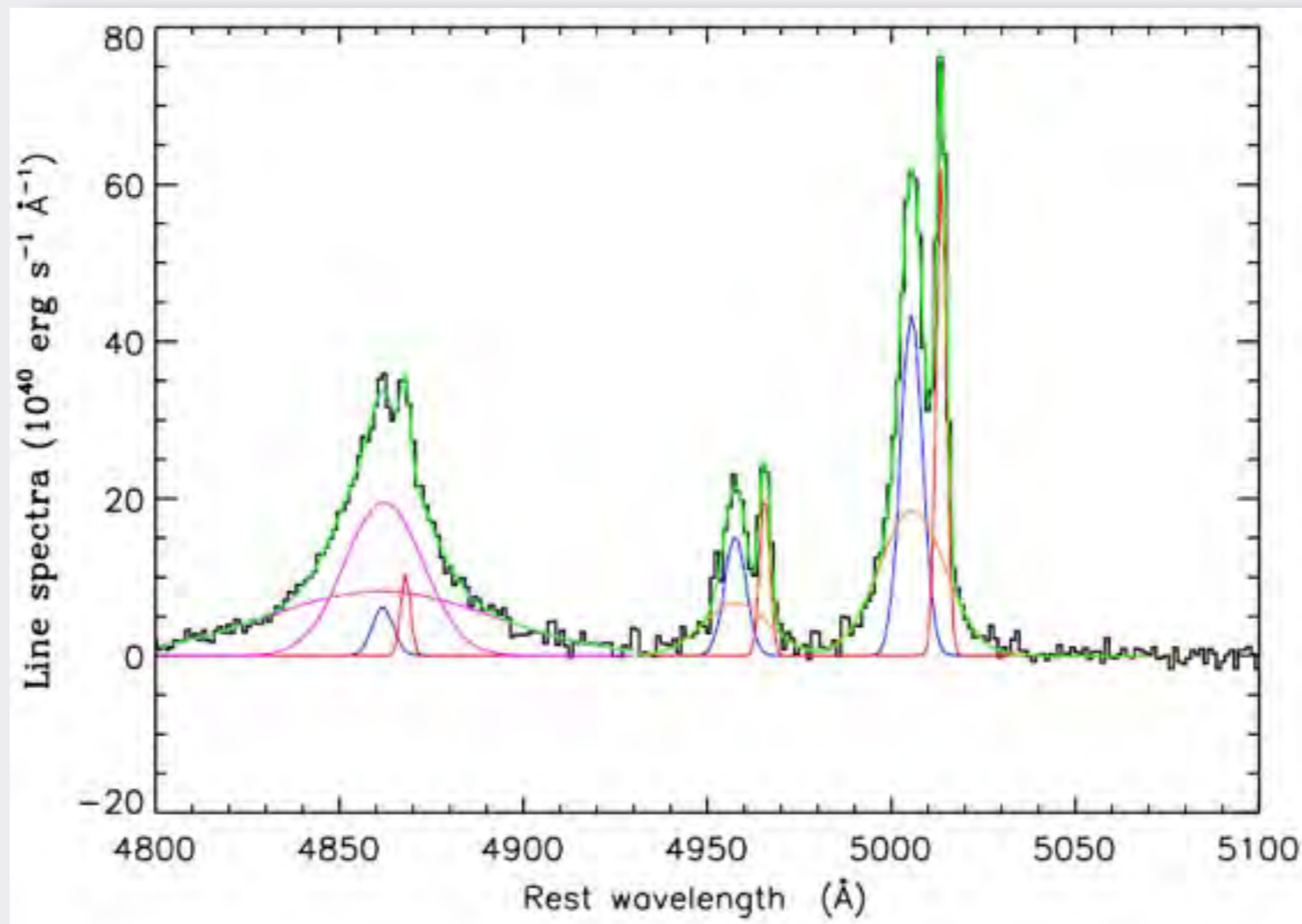
VLBI monitoring:
2011 Apr 12, 2012 Mar 8

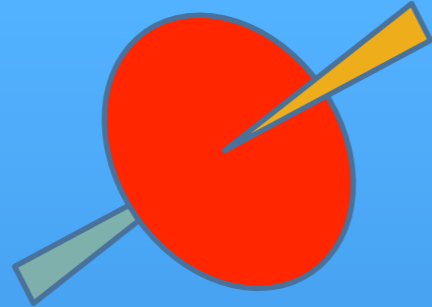


Light curves and predicted source evolution (Berger et al. 2012)

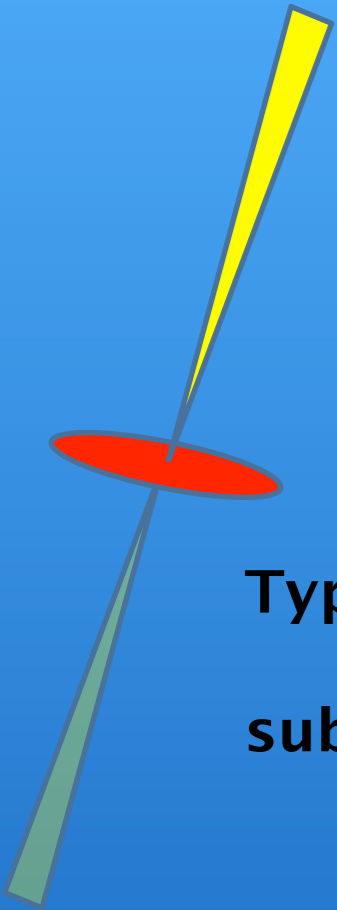


- **Double narrow-line region quasar from SDSS**
 - A short exploratory e-EVN experiment
 - While the discovery paper was still on arXiv only
- **Detection led to follow-up experiment at 5GHz**
- **EVN sensitivity made the difference**
 - No dual sources detected before in other (VLBA) samples

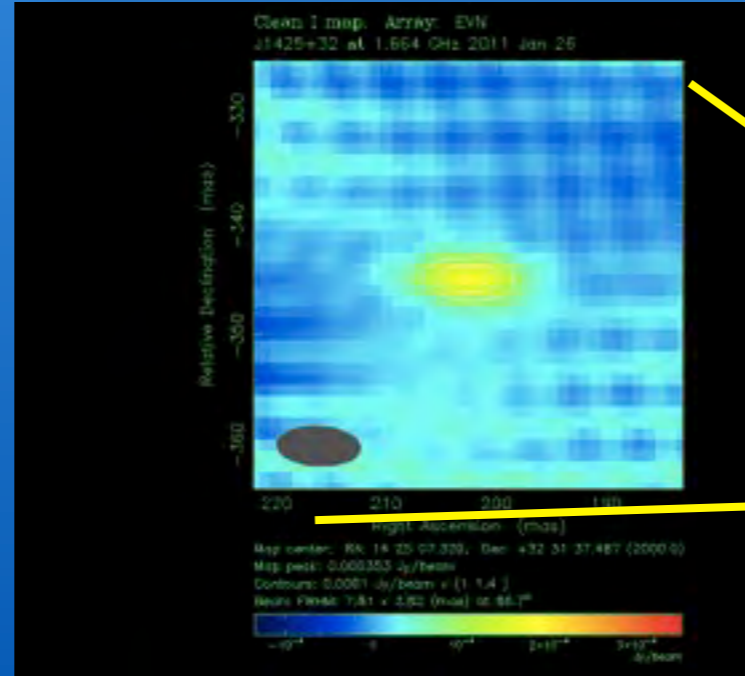
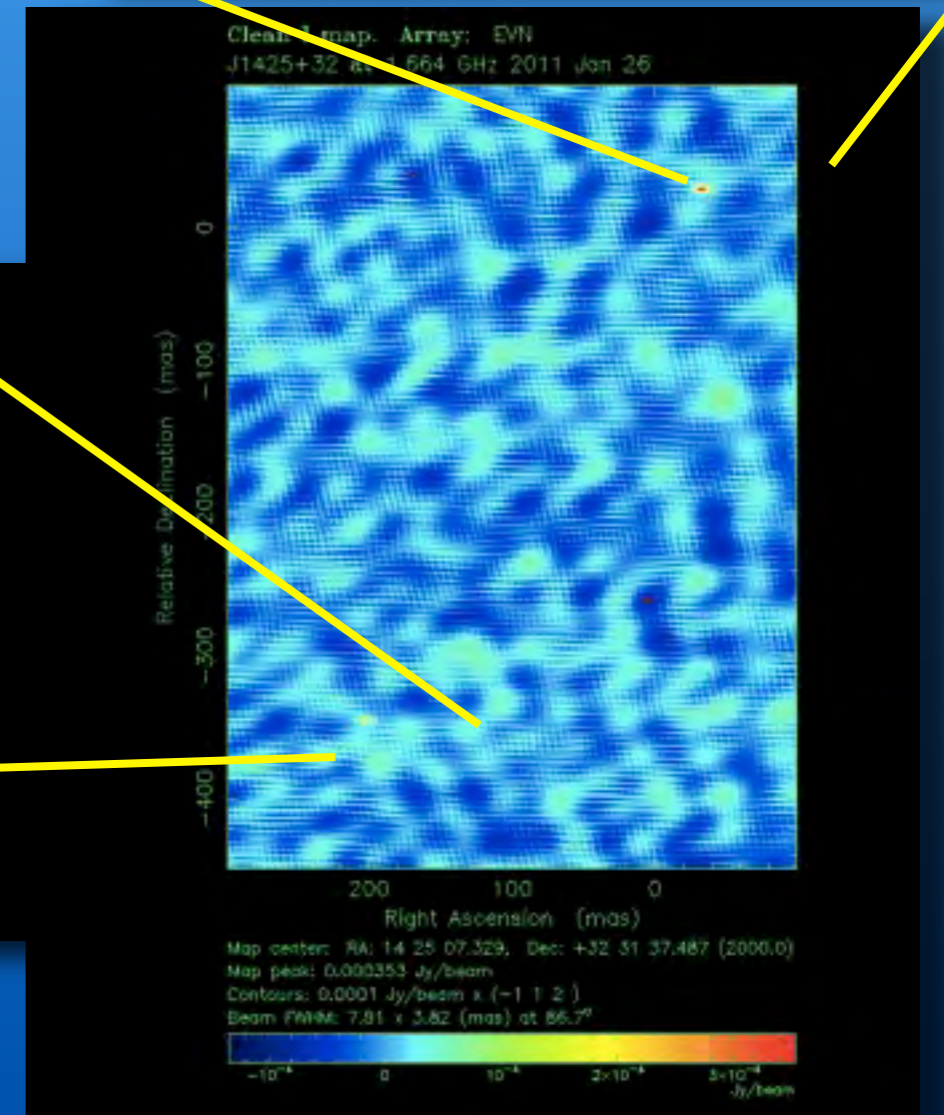
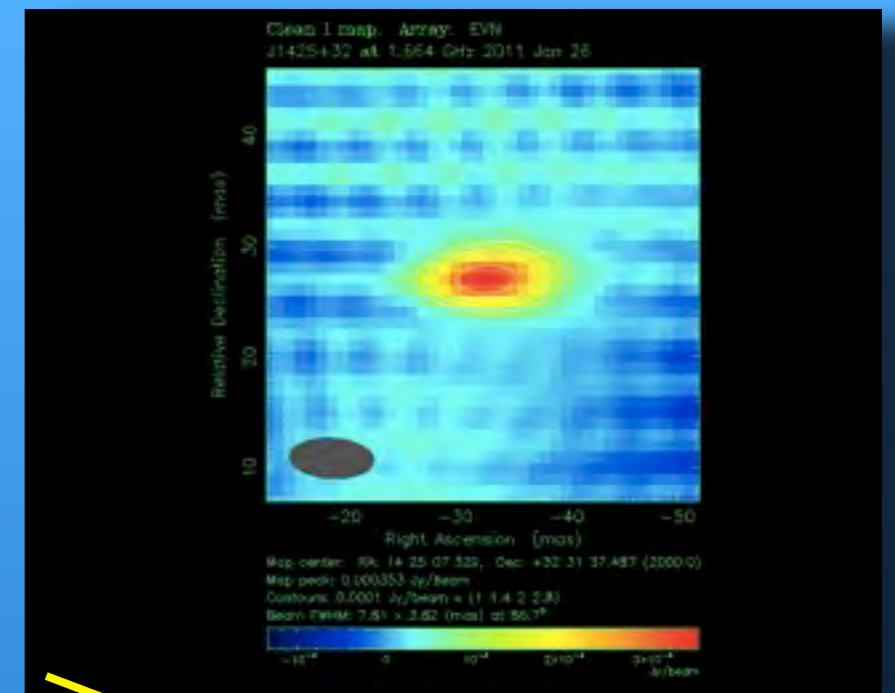




Type I
source
 $M \sim 108 M_{\odot}$

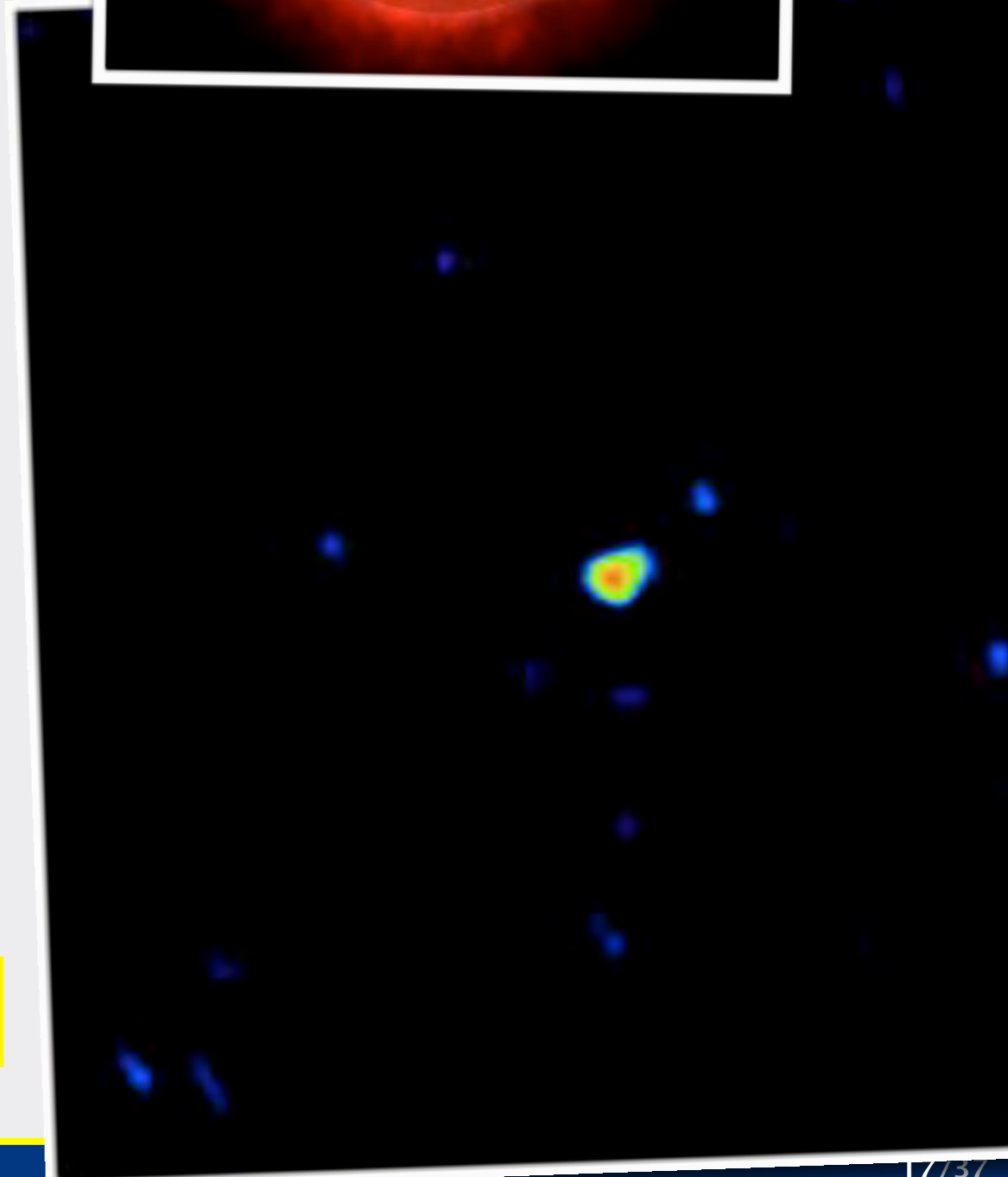
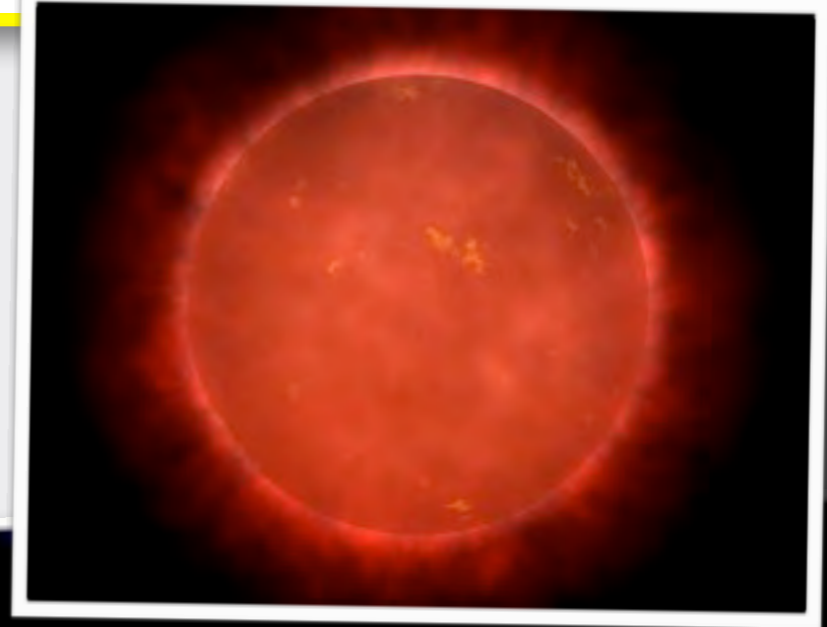


Type II source, $M \sim 106 M_{\odot}$
sub-galactic separation

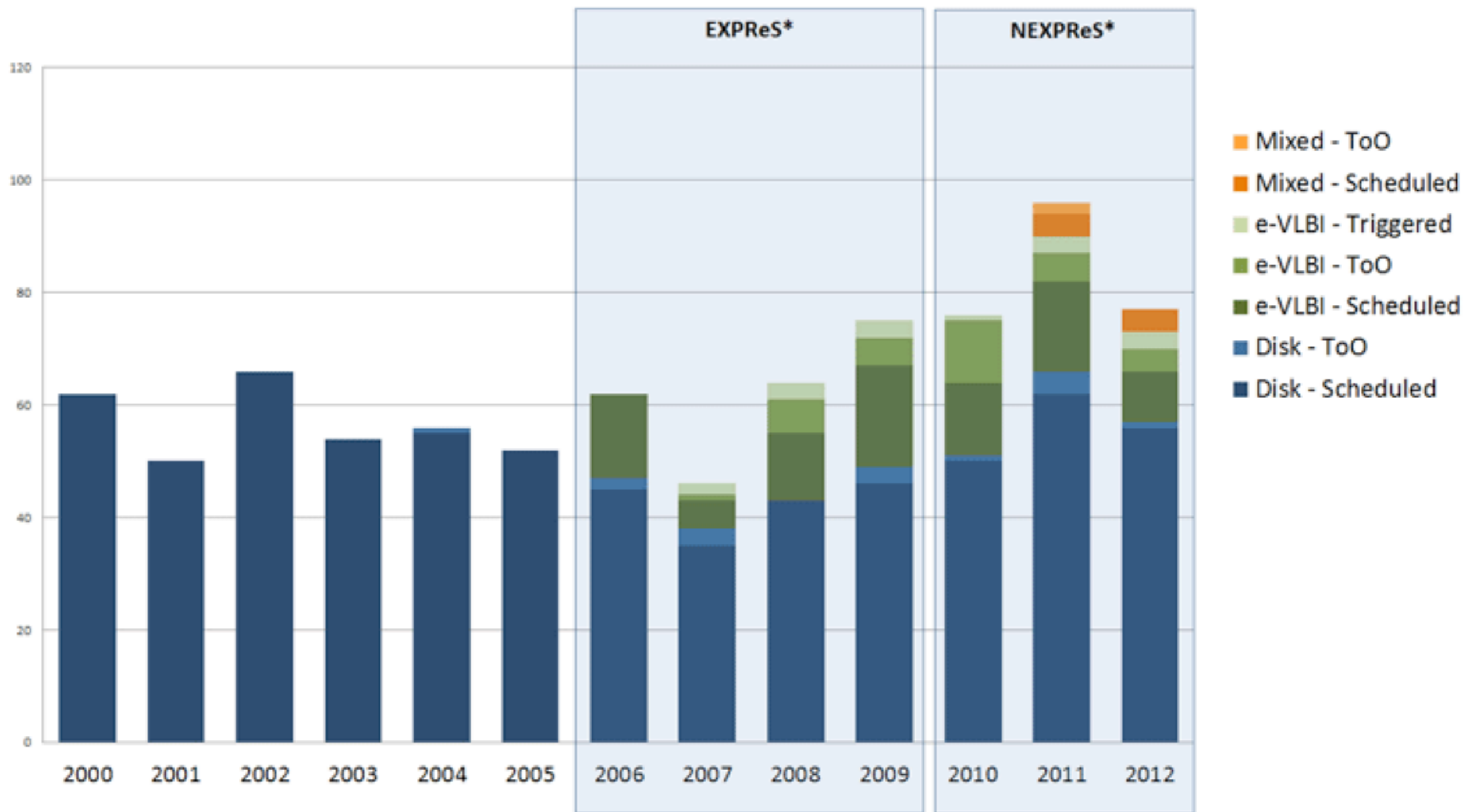


- **Radio Interferometry Survey of Active Red Dwarfs**
 - young, magnetically active stars (<1 Gyr)
- **Astrometric survey (<15pc)**
 - Jupiters and brown dwarfs
 - non-biased planetary statistics
 - proper motions and parallaxes
 - studies of radio emission RDs
- **Very successful start**
 - Detected 12/17 candidates based on X-ray selection
 - Astrometry done in eVLBI

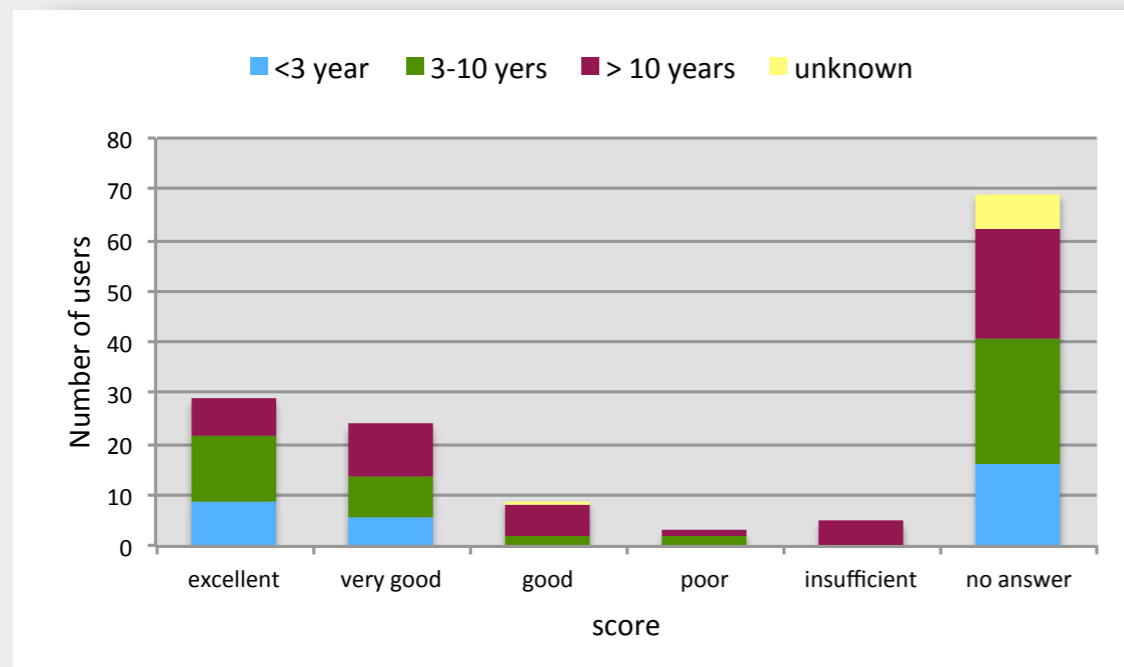
Team led by Gawronski
TcfA, Torun



EVN Observation Proposals



- Recent survey among user base
 - 33% of the respondents have done e-VLBI
 - And are very happy with JIVE scheduling
- Excellent to very good response on e-VLBI
 - Turn-around is important
 - Quality is good
 - Interest in new, NEXPREs features
 - Limited interest in array with small telescopes



Would you prefer to see more e-EVN observing runs?

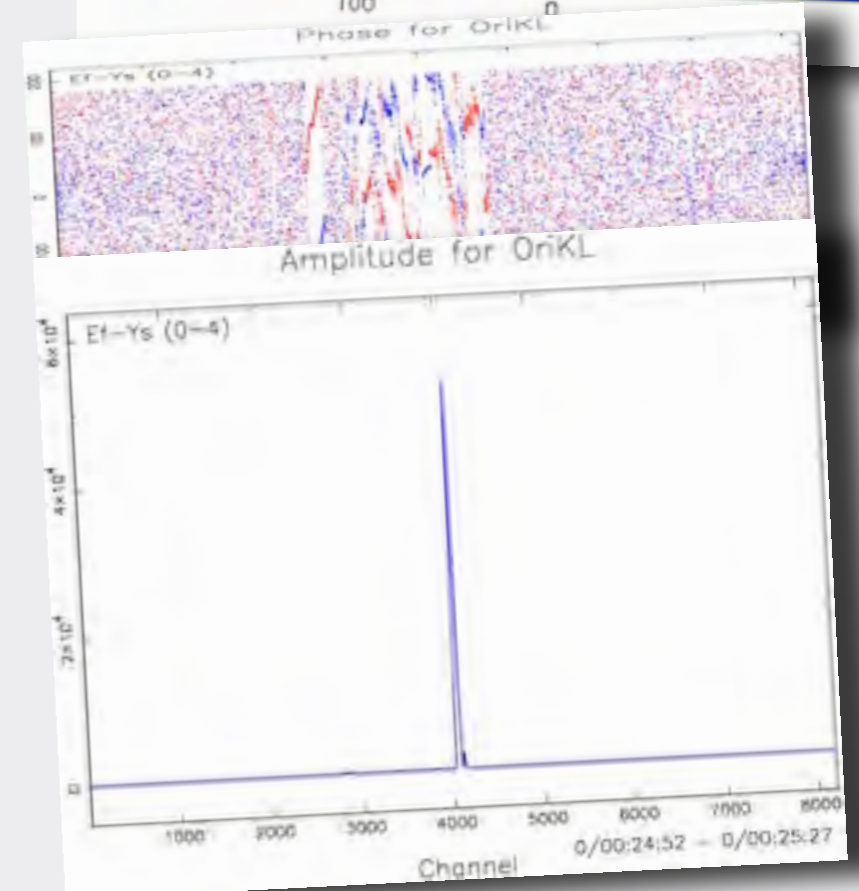
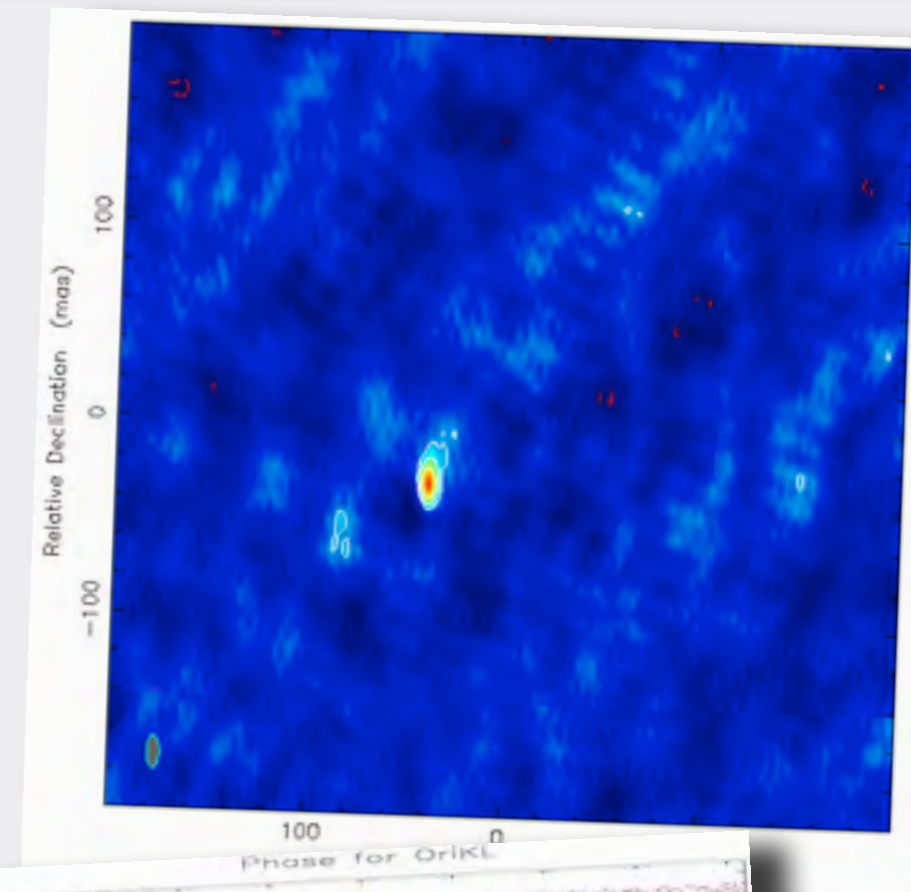
- **More resources**

- Can we have more observing time?
 - On subset of small telescopes even
- Can we lift the limits set by other resources?
 - Disk supply still a problem
- How can we make room for bigger projects?

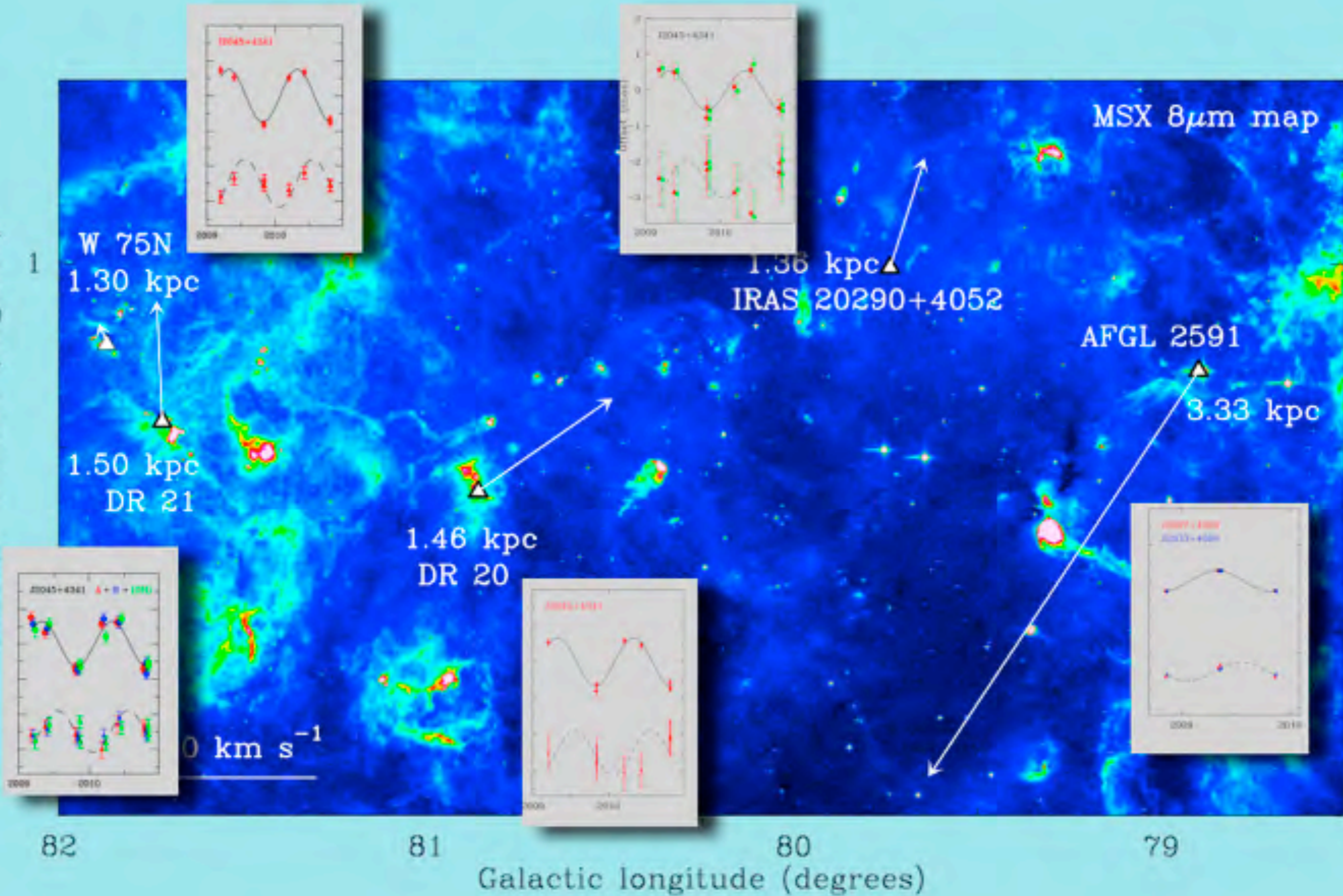
- **Making non-standard observations**

- **On flexible SFXC platform**

- Pulsar gating, eg for astrometry
 - Even total VLBI timing experiments
- Maser astrometry
 - Usually done in mixed bandwidth mode
- High spectral resolution for polarimetry
- Many fields of view
 - Weak cosmological targets
 - In-beam calibrators
- Spacecraft observations
 - Including RadioAstron



Galactic latitude (degrees)



VLBI for Space applications...

JUICE-Laplace

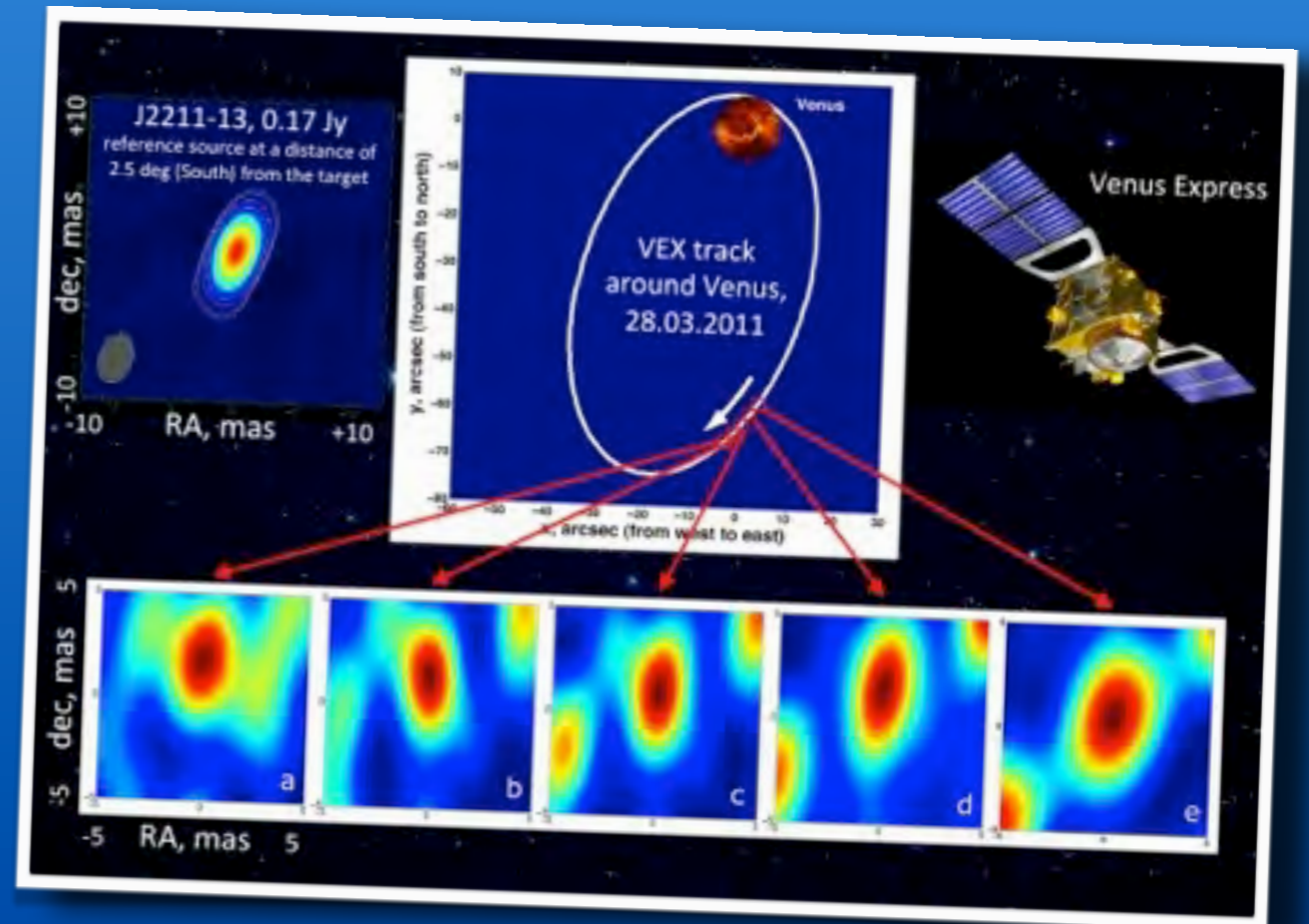
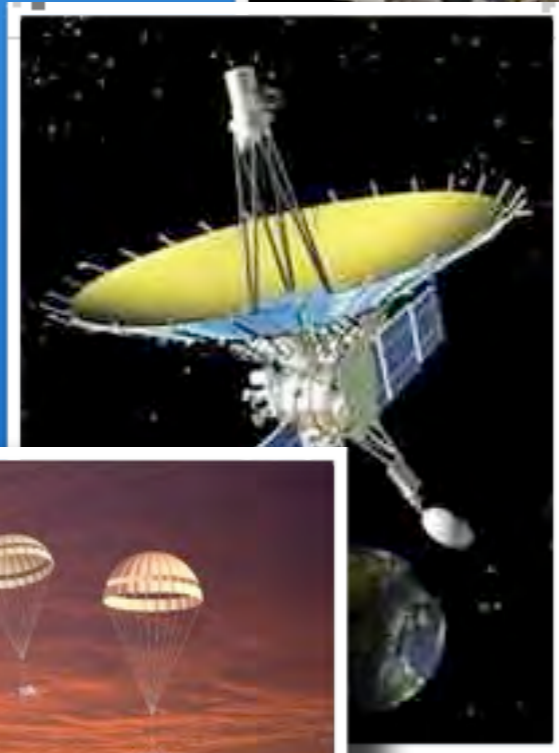
MarcoPolo-R?

ExoMars

BepiColombo

RadioAstron

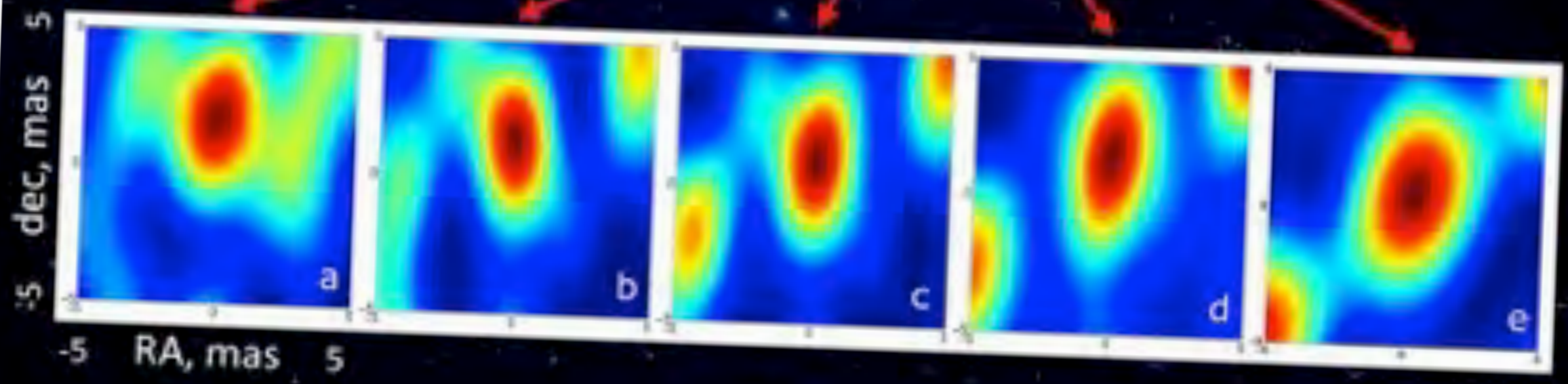
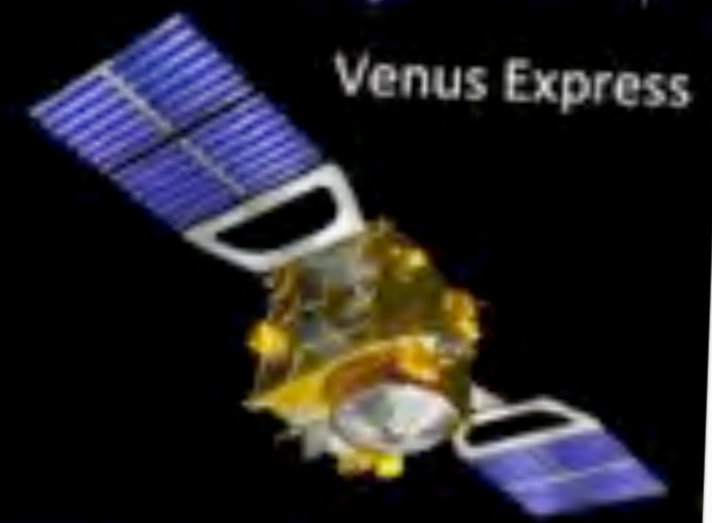
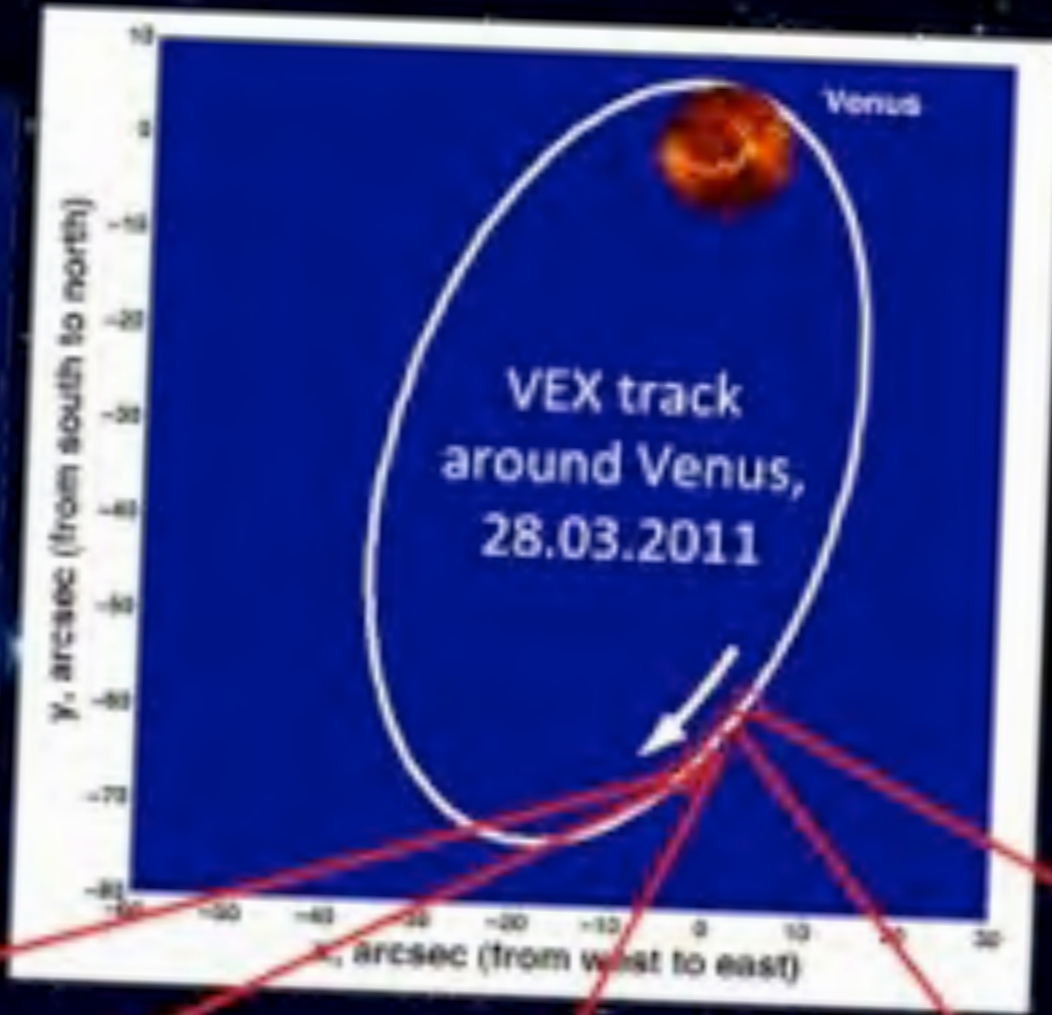
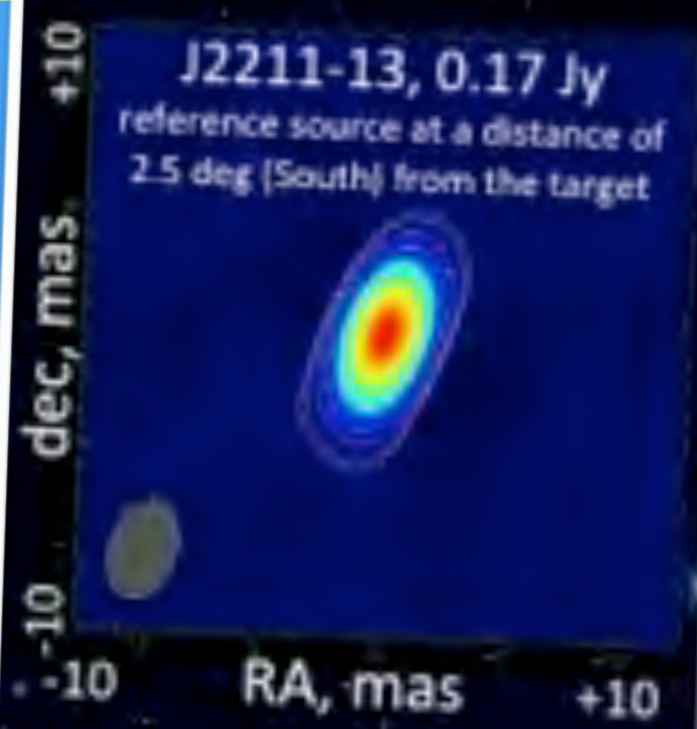
Huygens



VLBI for Space appl

Europa Jupiter System Mission

JUICE-Laplace



Rad
Huy



NEXPRoS

*Novel EXplorations Pushing
Robust e-VLBI Services*

- 'owns' the e-VLBI operations and outreach
- Also some LOFAR transport and storage issues
- And link to SKA development

New project: NEXPReS



- Aims for

- Correlate in real time what you can,
- Correlate later what you need

- Allow multiple correlator passes

- Overcoming correlator limitations

- Buffer for more reliable operations

- Addressed by simultaneous recording

- Be more sensible about resource allocation

- Bandwidth on demand, limit physical shipping

- Reach for higher bandwidths (10 - 40 Gbps)

- But also:

- Continue to connect more telescopes

- NEXPReS maintains expertise

- Collaborations with NRENs

- 'owns' the e-VLBI operations and outreach

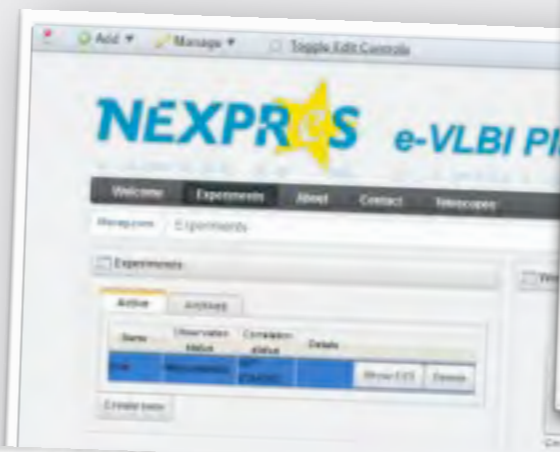
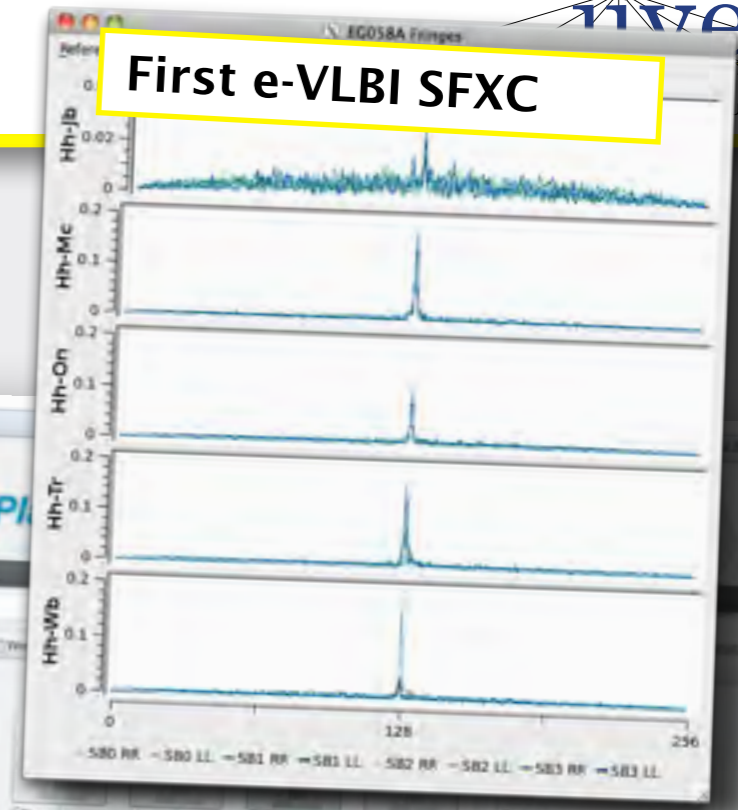
- Also some LOFAR transport and storage issues

- And link to SKA development

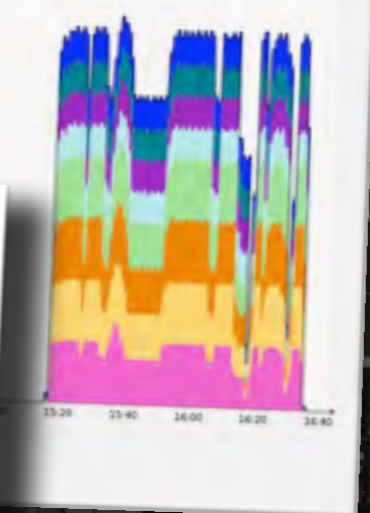
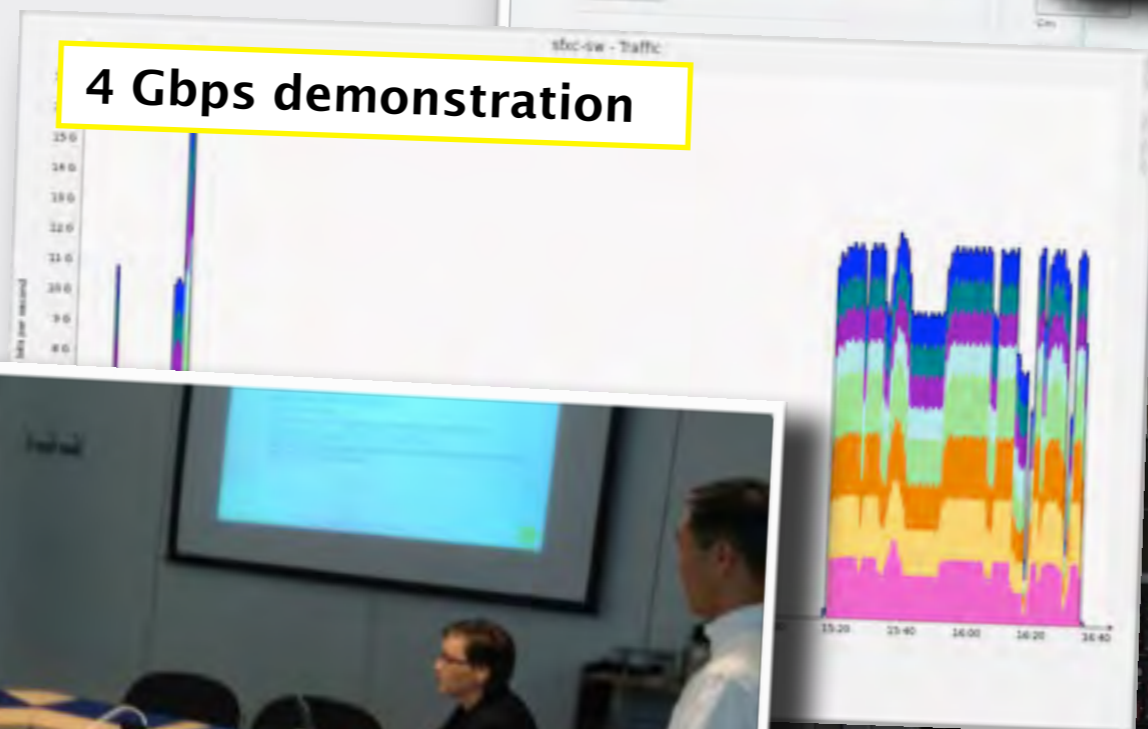
'Excellent' progress

- Made most deliverables
 - Enhancing correlator interfaces
 - Software correlator
 - Make ready for e-VLBI
 - Distributed topology
 - On-demand connections
 - Storage methods

First e-VLBI SFXC

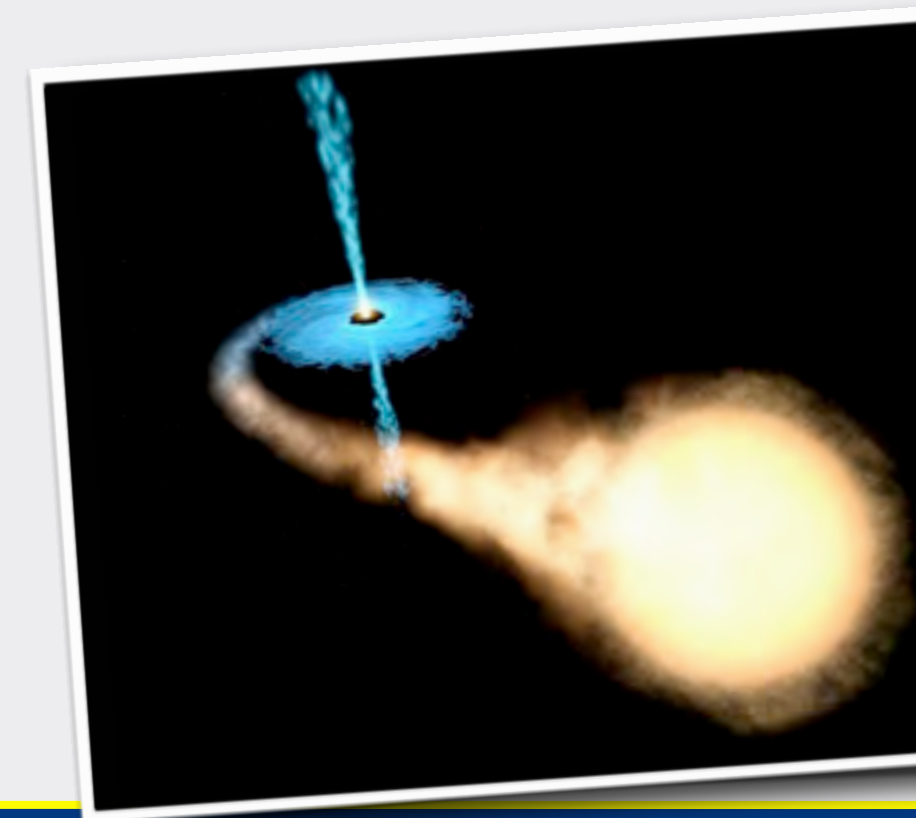


4 Gbps demonstration



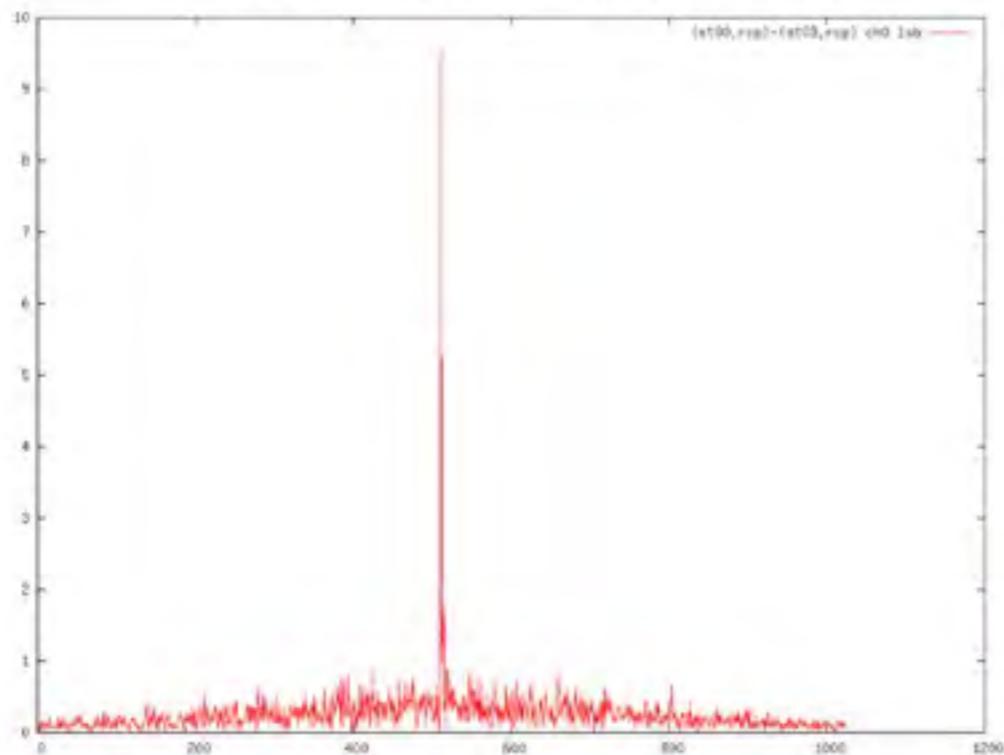
NEXPRoS impact

- **Continuity in e-VLBI expertise**
 - Vital for keeping in touch with NRENs
 - Continued effort in outreach/dissemination
- **NEXPRoS upgrades e-VLBI**
 - Notably Mk5Cs at JIVE
- **Step towards all EVN in e-VLBI**
- **Raise level of availability**
 - Discussion on EVN practices ongoing
 - New requests for (new) observing types
 - RadioAstron telescope in orbit
 - Observations of spacecraft (planetary/fundamental)
 - Monitor programmes/astrometry/joint observations
 - Triggers set by other observatories (link with LOFAR)
- **Must offer new services**
 - Offer tailored arrays, with smaller telescopes
 - For fast response on transients
 - And astrometry
 - More e-VLBI days, every Friday

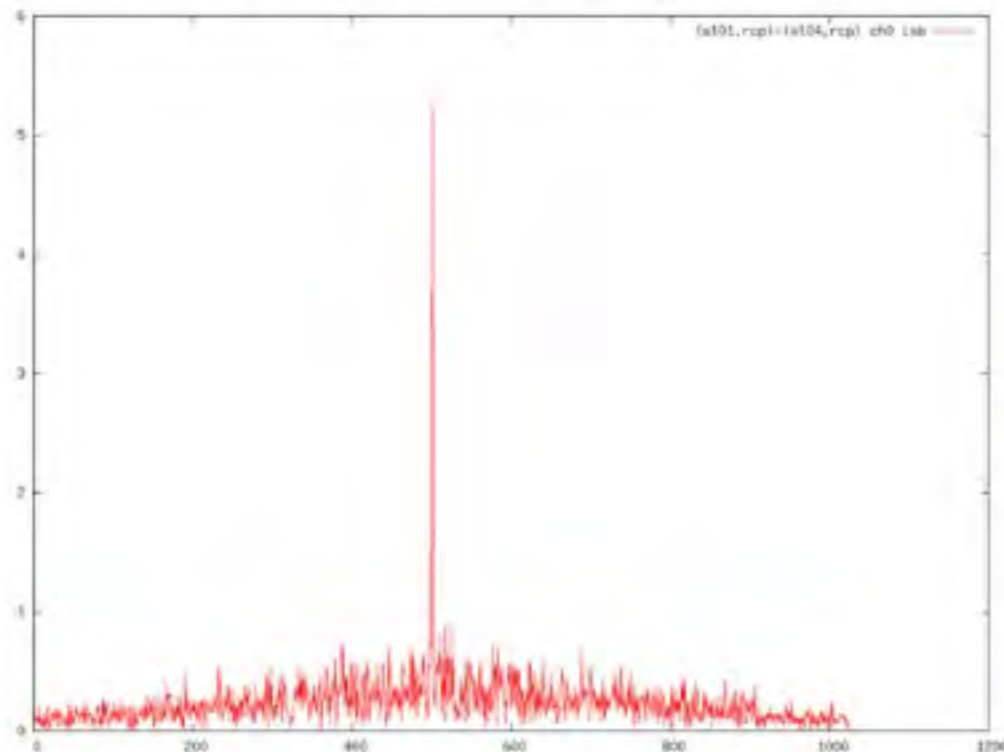


Noto came back as e-VLBI

5 cm Ef-Nt fringe (N12M1)



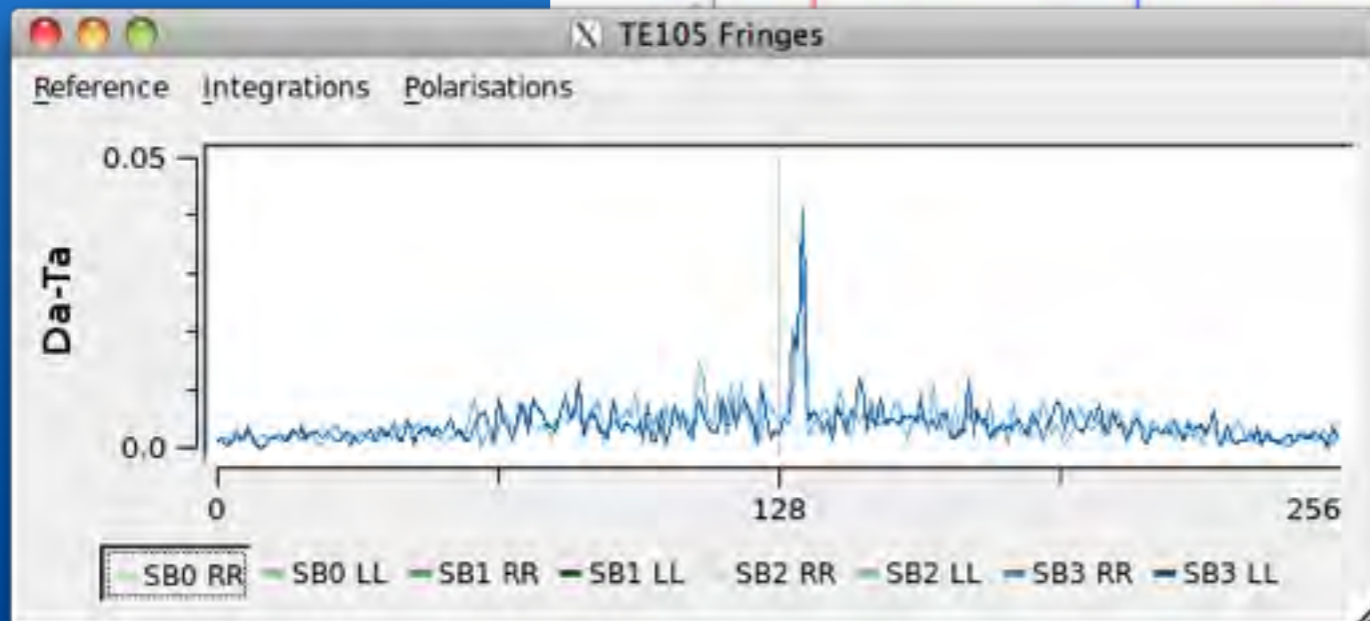
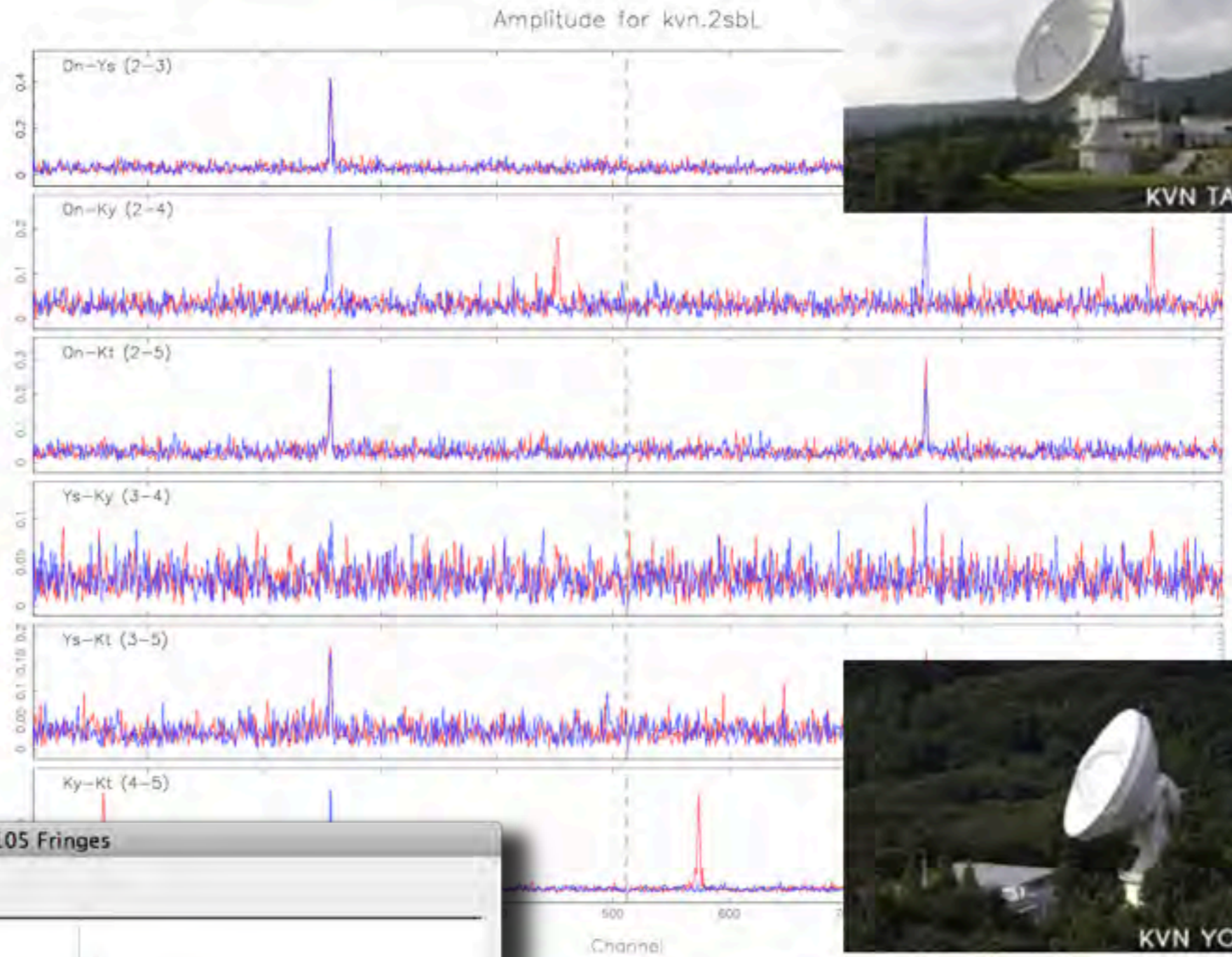
X band Ef-Nt fringe (F12X1)



**Welcome back
Noto!!!**



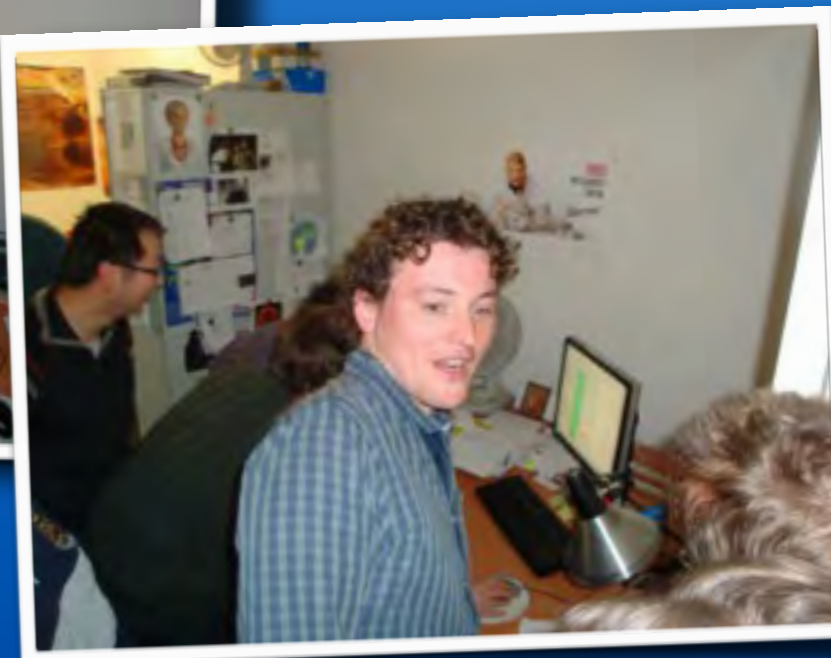
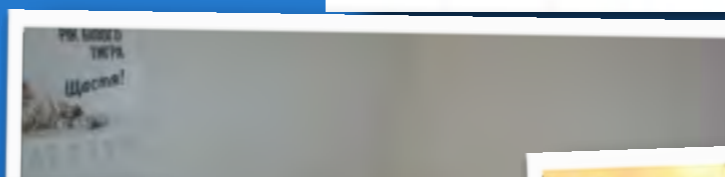
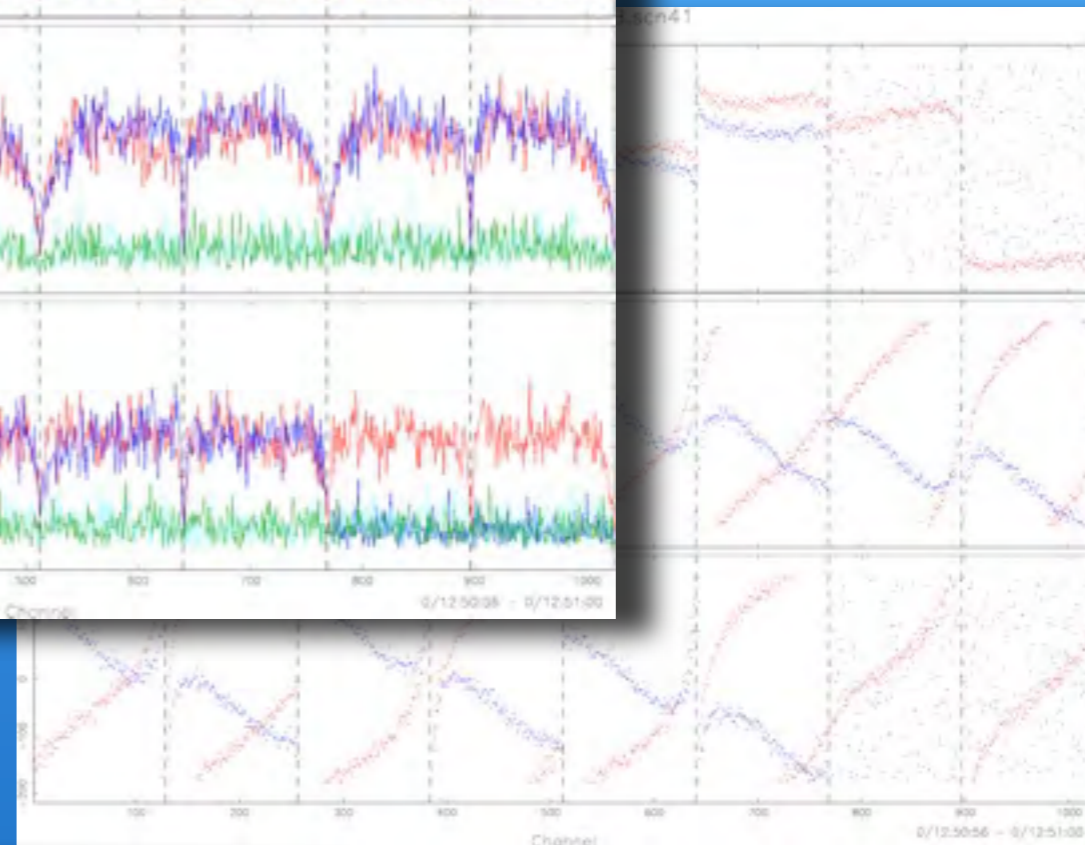
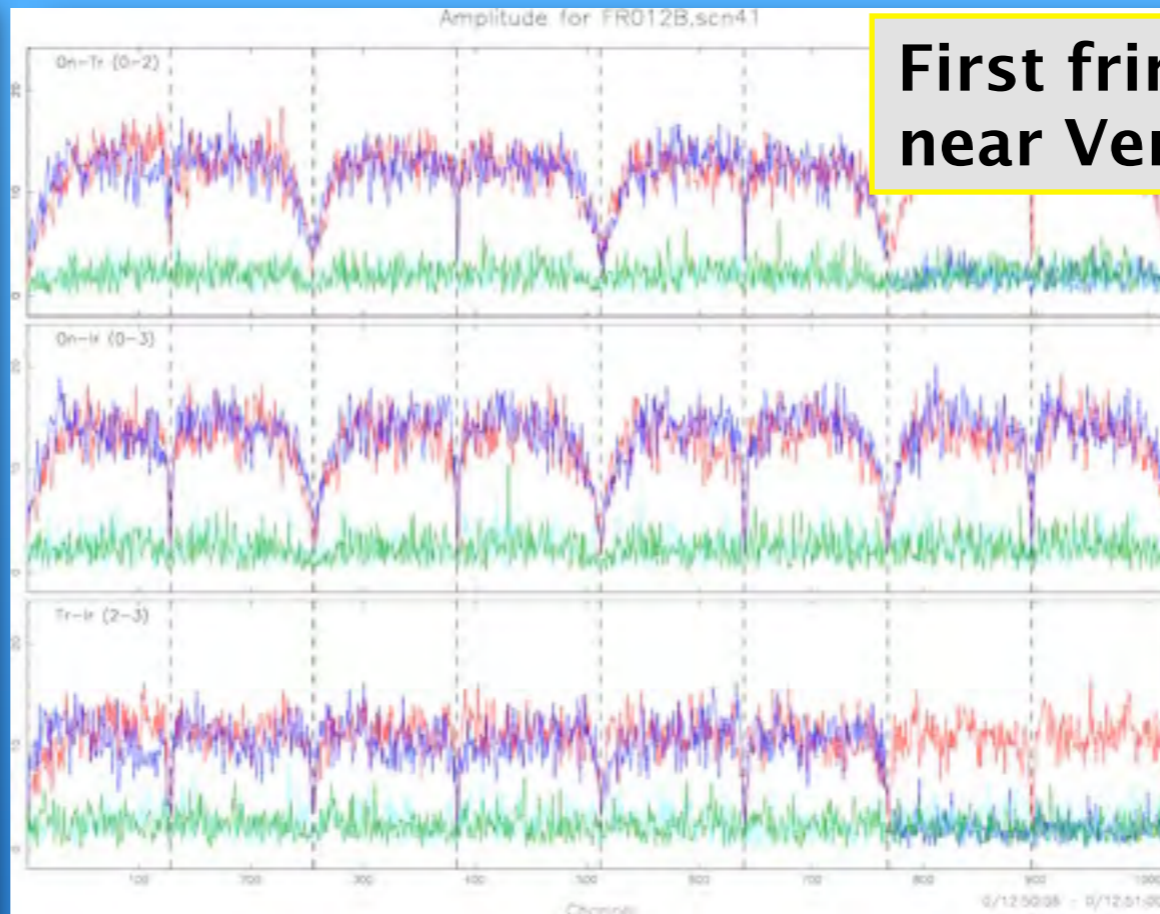
First 22 GHz e-fringes Korea



eMerlin hint of fringes

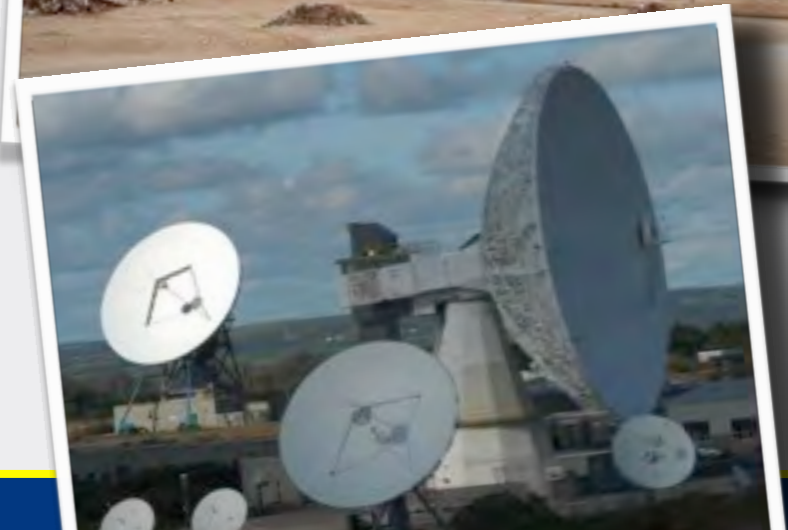
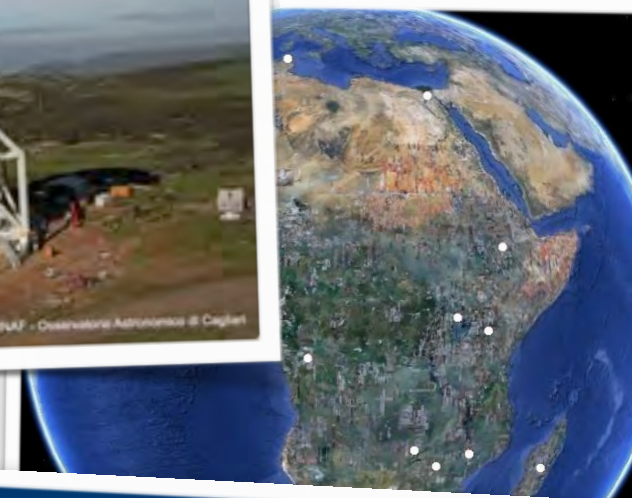


First fringes to Irbene,
near Ventspils, Latvia



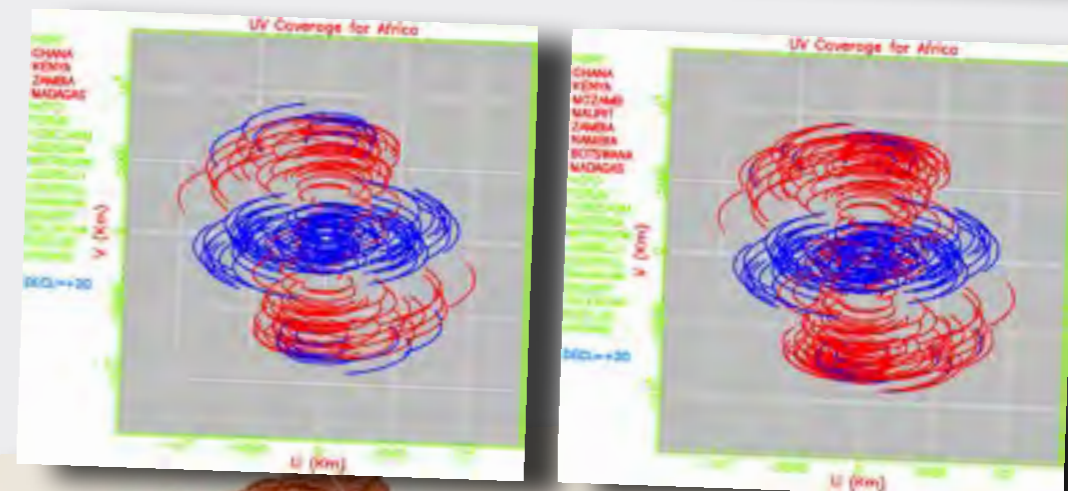
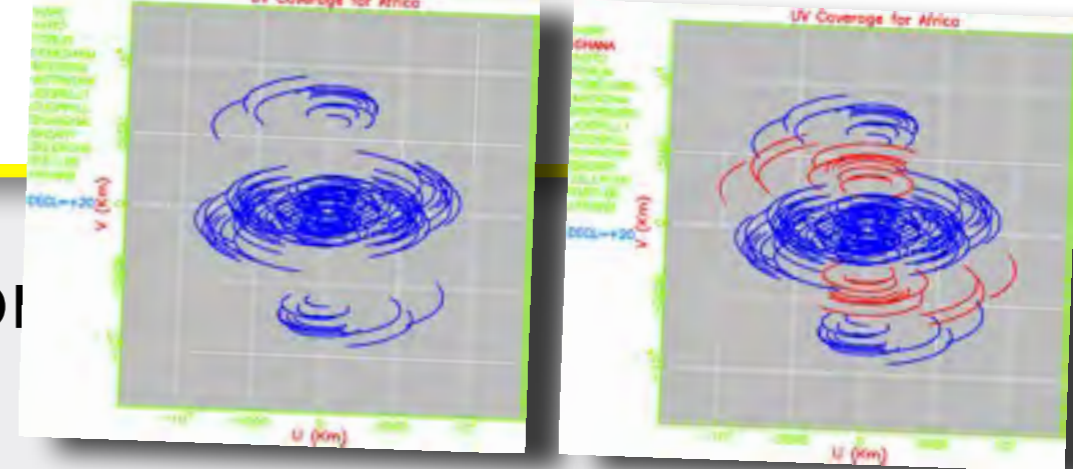
Opportunities for VLBI

- **Science case is in good shape!**
 - **Extremely broad**
 - Fits to almost all themes that they can come up with
 - **Can do unique science**
 - Especially at global baselines
 - With very many telescopes
- **Constantly improving capabilities**
 - **Increasing number of stations**
 - Must merge operational procedures
 - Use of ALMA for VLBI
 - **African VLBI Network especially promising**
 - EC Written Declaration 45 on science collaboration
 - **With better sensitivity, more digital bandwidth**
 - More flexibility, tailored to user needs
- **Science synergy with new technology (survey) instruments**
 - SKA pathfinder in South Africa
 - LOFAR, Apertif
 - eMERLIN, EVLA
 - Eventually observe with SKA elements in Africa



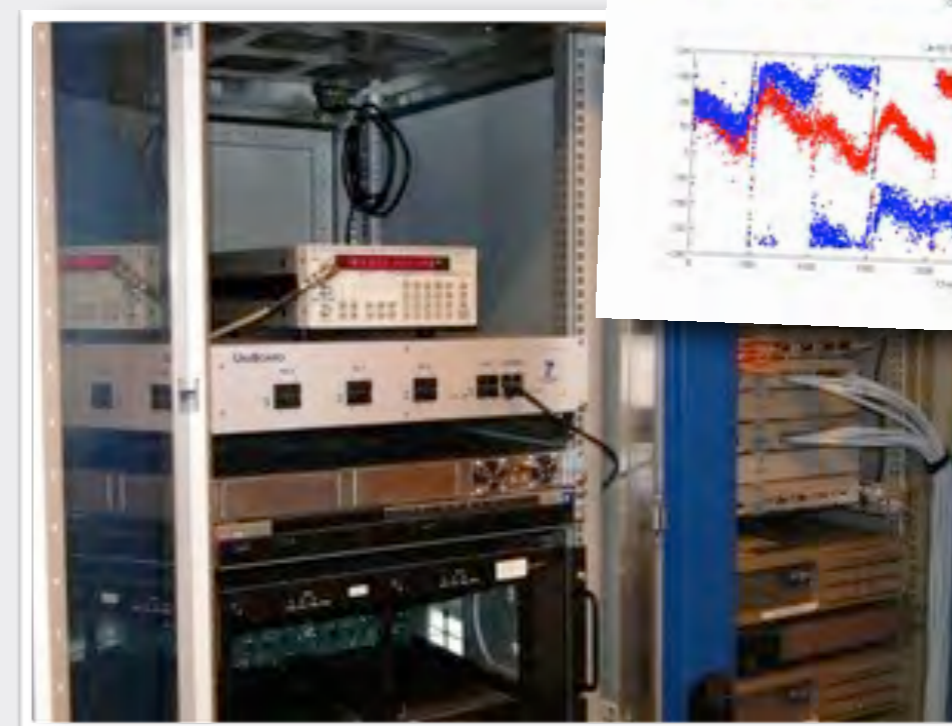
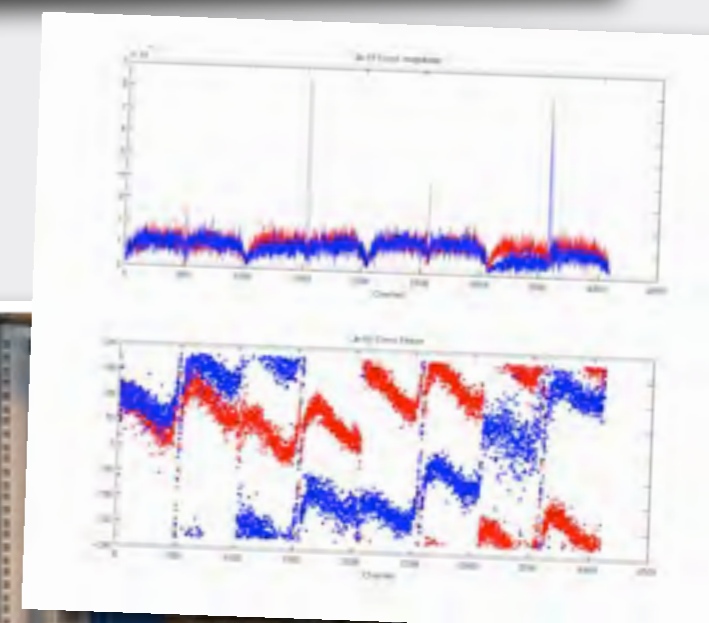
African VLBI Network

- **Based on abandoned communication**
 - Large commitment by South Africans
 - Huge engineering task in various countries
- **Interesting for capacity building**
 - In relation to African SKA
- **Very interesting for EVN**
 - Essential baselines
 - But will require some patience
 - And some commitment
- **Looking for EC support**
 - Politics seem favourable
 - MEP's using the word 'VLBI'



The future of VLBI in the SKA era

- **Square Kilometre Array**
 - Very real with European funders
- **Important progress in 2012**
 - Company with country members
 - Site selection, merge with precursors
- **eEVN recognized as an SKA pathfinder**
 - Complements SKA-1
 - with sensitive long baselines
 - Essential part of a global network
- **Important for SKA success:**
 - Technology development
 - Digital equipment
 - Processing techniques
 - People (aka capacity building)
 - Training radio astronomers
 - And technical experts
 - Prepare for operations and user support



UniBoard first fringes

The JIVE strategy:

- **Keep EVN on the forefront of VLBI**

- Deliver the best possible science
- Help the EVN to upgrade to 4 Gbps
- Push e-VLBI into next level
- Position for attracting FP8 EC financing (ERIC?)
- Accommodate space programmes

Short term: 5 yr

- **Global baselines and high frequency**

- Needs a big correlator
- Implement large-scale VLBI programmes (monitor, survey)
- Various easy interfaces for data stream
- Stimulate new programmes, like African Network
 - Japan, Korea, Ukraine, Australia, New Zealand, US, Brazil
- Cheap antennas for new members?

Mid term: 5 - 10 yr

- **Take a role in European SKA operations**

- Recognized European entity
- Collaborator in SKA realization
- Specialize in correlator, data curation, user software, user support

Long term: > 10 - 15 yr

Review by expert panel in March 2012



- **JIVE report excellent**

- Impressed with breadth of science
- Could not be done more effectively, cannot imagine EVN without JIVE
- Endorses technical development programme
- e-VLBI, SFXC implementation, UniBoard correlator, Space Programme

- **Start of process**

- **Renew funding for next 5y cycle**
 - Against background of on-going reviews
 - And the economic reality
 - And SKA ambitions overshooting...?
- **Become a European Research Infrastructure Consortium**
 - Legal entity in Europe established 25 June 2009
 - Addresses establishment of European scale facilities
 - Needs to be approved by EC
 - May have VAT exemption
 - Status of international, public body
 - Personal responsibility of board members is lifted
 - Directly eligible for (future) EC funding schemes
 - Attractive for new prospective members



The End

(but not before having announced the Paragi meeting)

JULY 1998



The End

(but not before having announced the Paragi meeting)

Lorentz Center

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Locating Astrophysical Transients

from 13 May 2013 through 17 May 2013

Venue: Lorentz Center@Oort



- [Description and aim](#) of the workshop
- Scientific organizers:
 - Felix Aharonian** (Heidelberg, Germany) 
 - Francisco Colomer** (Alcalá de Henares, Spain) 
 - Bryan Gaensler** (Redfern, Australia) 
 - Stefanie Komossa** (Bonn, Germany) 
 - Chryssa Kouveliotou** (Huntsville, USA) 
 - Joeri van Leeuwen** (Dwingeloo, The Netherlands) 
 - Gijs Nelemans** (Nijmegen, The Netherlands) 
 - Zsolt Paragi** (Dwingeloo, The Netherlands) 
 - Steven Tingay** (Perth, Australia) 
- Workshop Coordinator: **Ikrâm Çakır**, Tel: +31-71-5276146

[Organizational Log-in \(restricted\)](#)

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The End

(the start of the JIVE the movie....)

