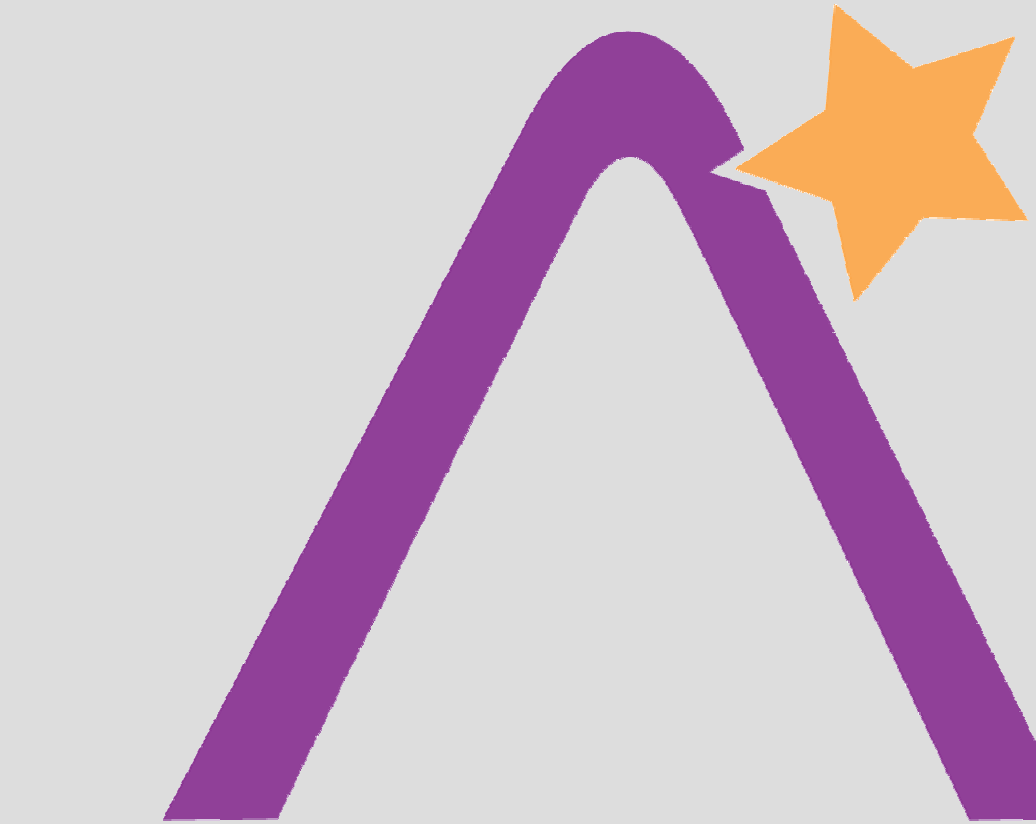
Data processing software for radio astronomy

Huib Jan van Langevelde

In this talk:

- User software in the EVN and software correlation
  - I Learned AIPS in 1987, still be teaching AIPS in 2007
    - Little changed from the user perspective
      - Not quite true: Introduction of (VLBA) cross calibration
    - Still rely heavily on old software, esp for VLBI
    - aips++, now casa concentrates on ALMA
  - Software is crucial for dealing with new opportunities, especially large data-rates
- EVN has an effort in user software

- Introduce ALBUS project, part of RadioNet
- ParselTongue is available for large, complex AIPS projects
- RadioNet is considering projects after ALBUS
- FABRIC is about distributed software correlation



ALBUS

advanced long baseline user software

Overview

- Part 1: Enhancing the product
  - Calibration Transfer (JIVE)
    - Antenna Gains
    - Phase Cal Tones
  - Ionospheric calibration (JIVE)
    - Global GPS
    - Global model
  - Tropospheric calibration (MPI)
    - Using GPS
    - WVR
    - Frequency
  - Post correlator processing (JIVE)
    - PCInt data flow
    - Target selection
    - Web portal

90%, make operational

75%, evaluating tests

60%, started GPS

5%, requirements

- Part 2: Imaging
  - Parallelization (ASTRON)
    - Bottlenecks
    - MIRIAD & scripting
  - Wide Band Imaging (JBO)
    - Analysis
    - Implement
    - Test
  - Wide field Imaging (JIVE)
    - Analysis
    - Implement
- New 3: Software infrastructure
  - ParselTongue
    - Scripting
    - Calibration access
    - Distributed computing

D O N E

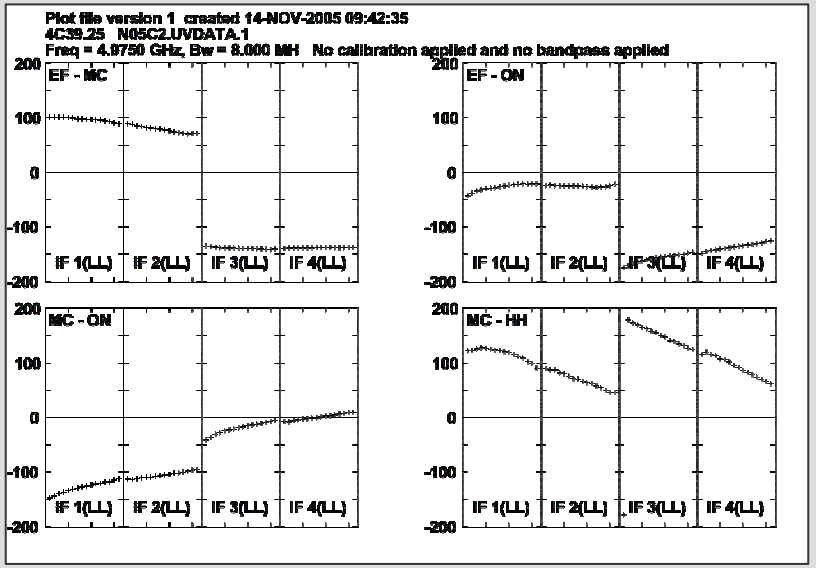
40%, prototyping

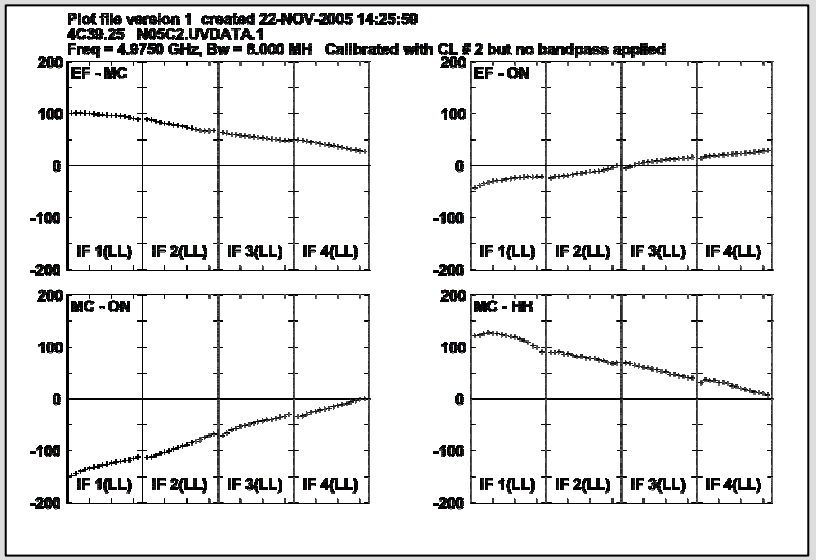
10%, requirements

85%, gone public

Calibration & Phase cal detection

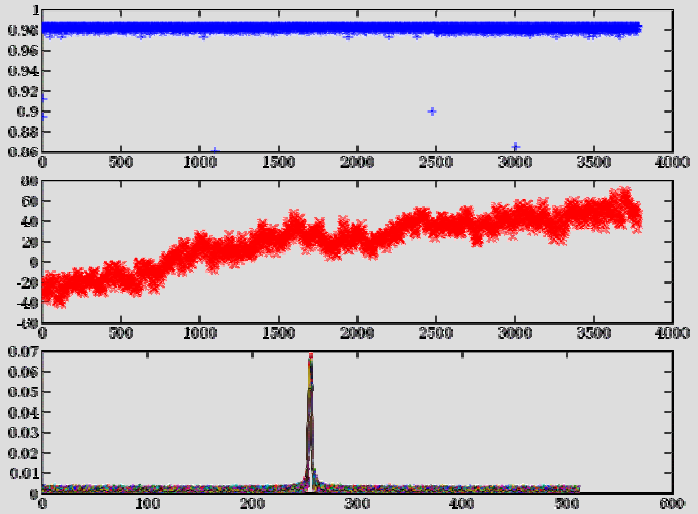
- Enhanced the correlator product
  - Streamlined the T_{sys} into system
  - As well as flagging from telescopes
  - Calibrate van Vleck corrections
  - Work on adding model information
- Capable to do Phase Cal calibration
  - can be processed by PCCOR
  - or by ParselTongue scripts
  - Needs to enter the operational environment yet

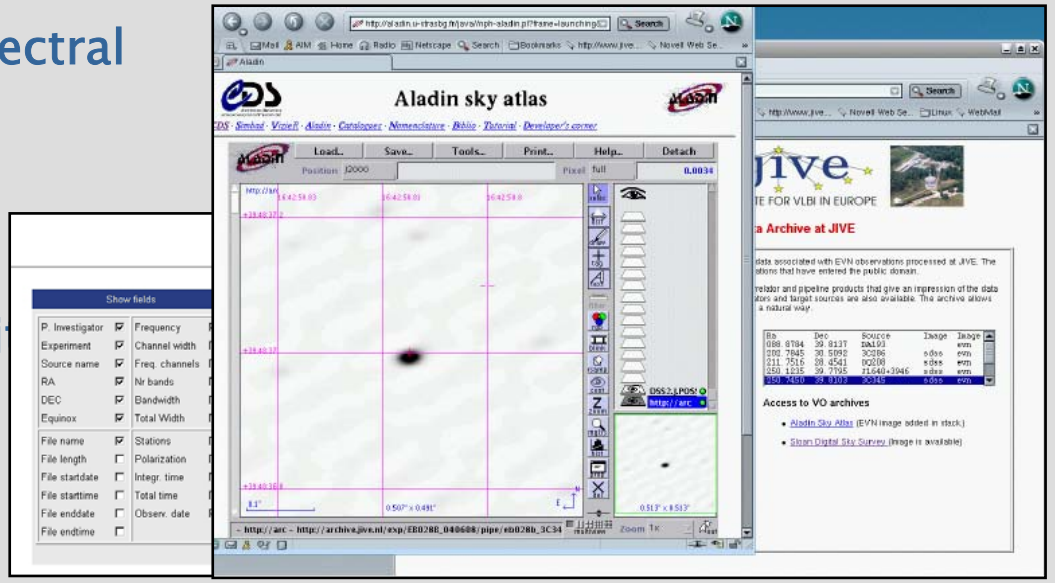




Post-correlation processing

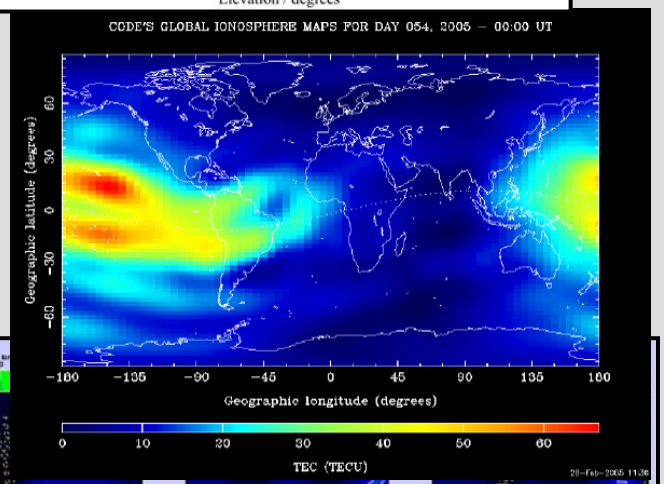
- Related to the PCInt, high speed data product
  - Can do 0.25s integration
    - and faster yet to come
  - Yields the possibility to build up high resolution archive
    - increases sky coverage
- Will develop tools to extract tailor-made products
  - eg selection on source, spectral coverage
  - Or off-set phase center
- Expand archive
  - beyond current functionali
  - Looking to fill job!

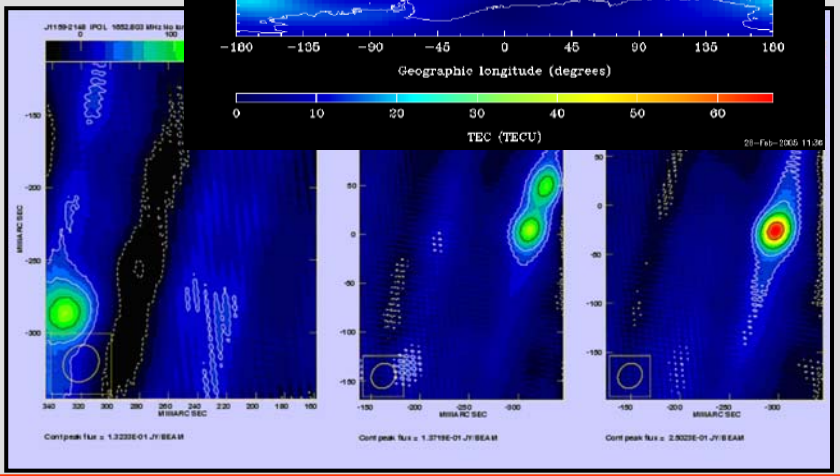




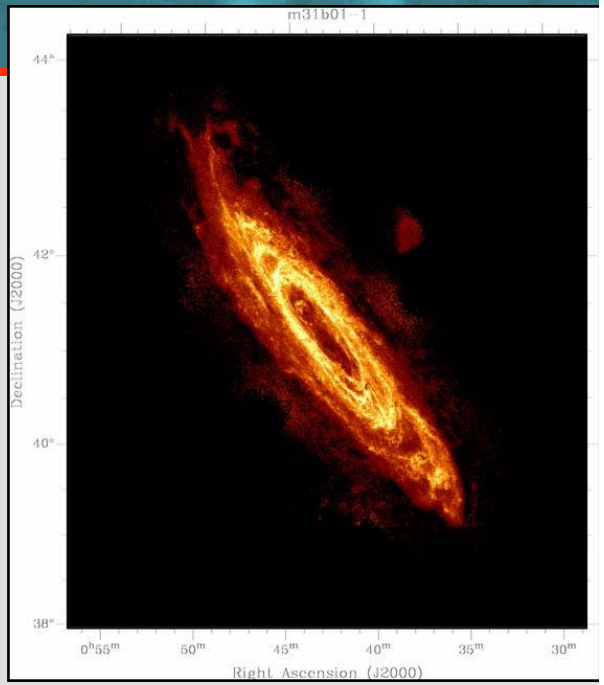
Ionosphere & Troposphere

- Estimate troposphere
  - Using eg Water Vapour Radiometers
  - see talk by Alan Roy
- And estimate ionosphere
  - Work by James Anderson, JIVE
  - Calibration could be derived from
    - Global or local GPS results
    - Mixed with theoretical models
  - Some success, but not robust
    - Phase referencing may improve
    - Allows to estimate gradients
- Map to AIPS calibration
  - Through ParselTongue
  - Need to take out previous correlator model

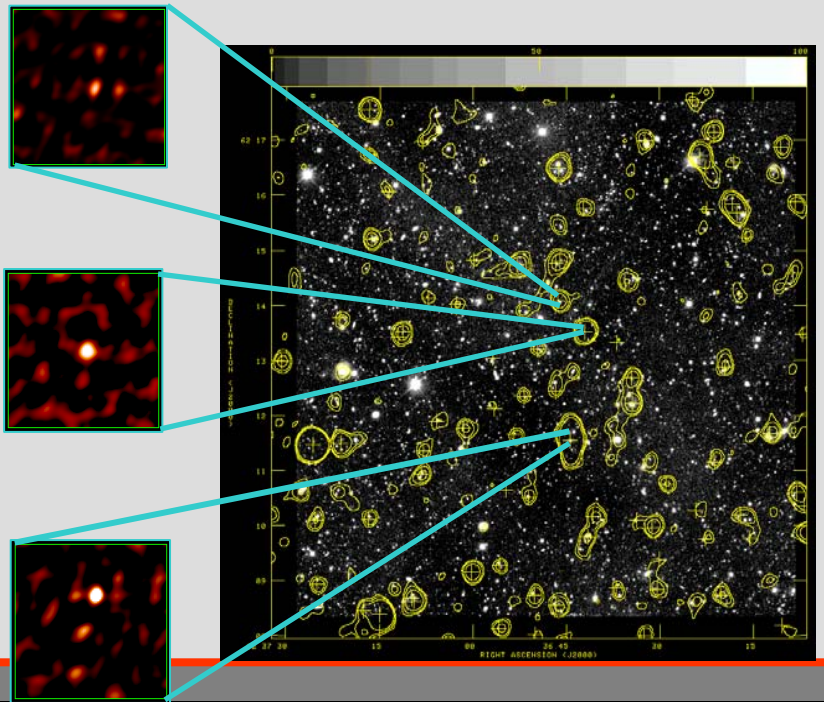




Parallelization & wide field imaging

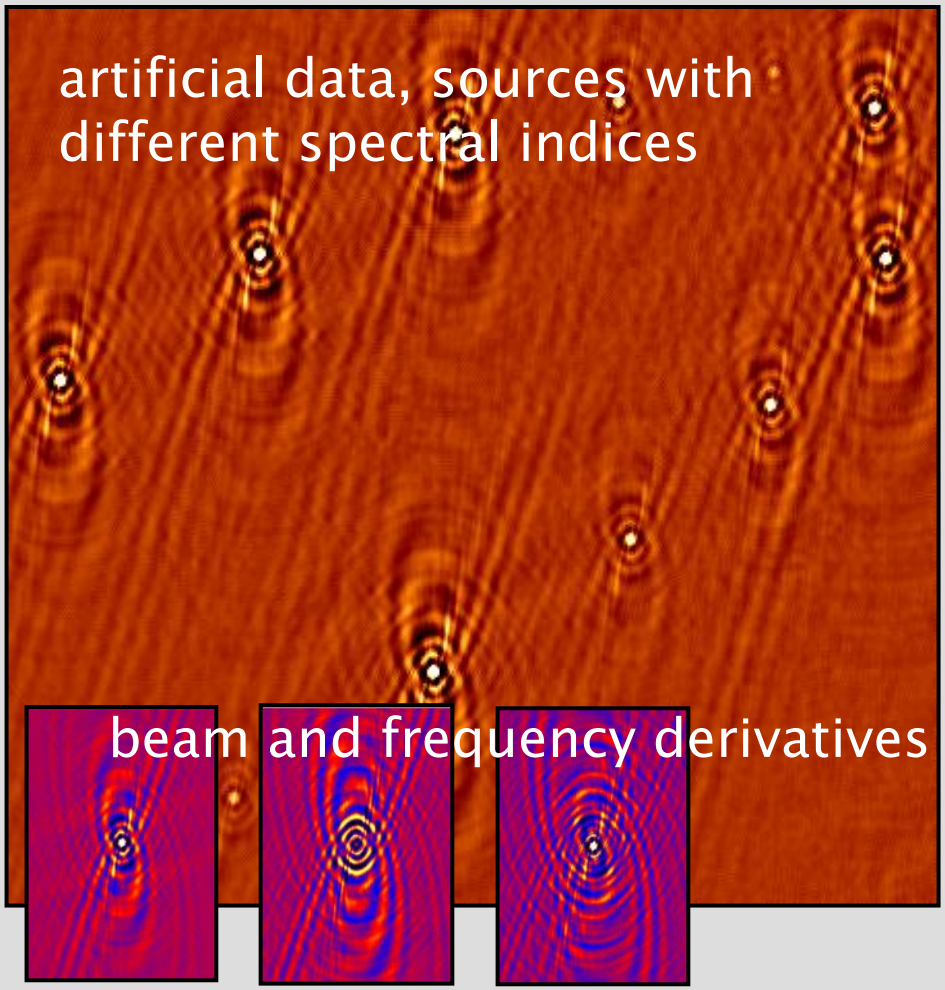


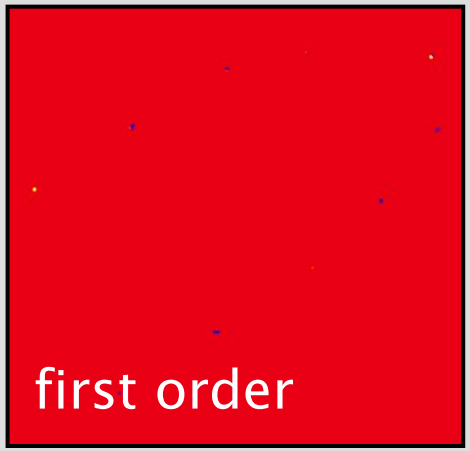
- Investigate the use of cluster computing for radio-astronomy
  - Work done at ASTRON
  - 'Task' parallelization is the way to go
  - Need to distribute data as part of the procedure
    - Too data intensive for messaging
- Approach will require high level scripting to create a workflow
  - Quite feasible for VLBI, where sky is mostly empty
  - Some preliminary work presented at EVN symposium Torun
    - poster by Lenc
    - Poster by Bourke

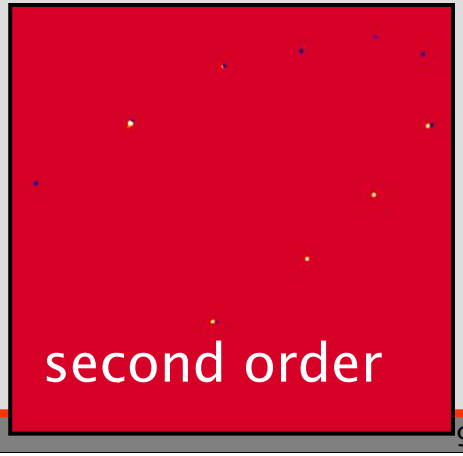


Wideband processing

- Ian Stewart at JBO
  - wide band imaging
  - takes into account source spectrum

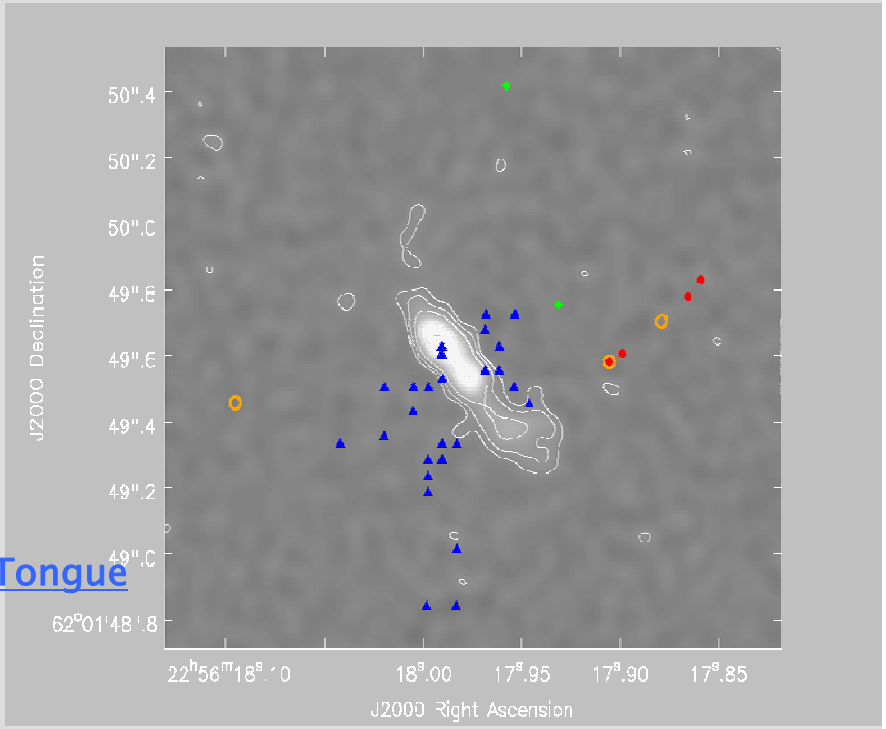






ParselTongue, why?

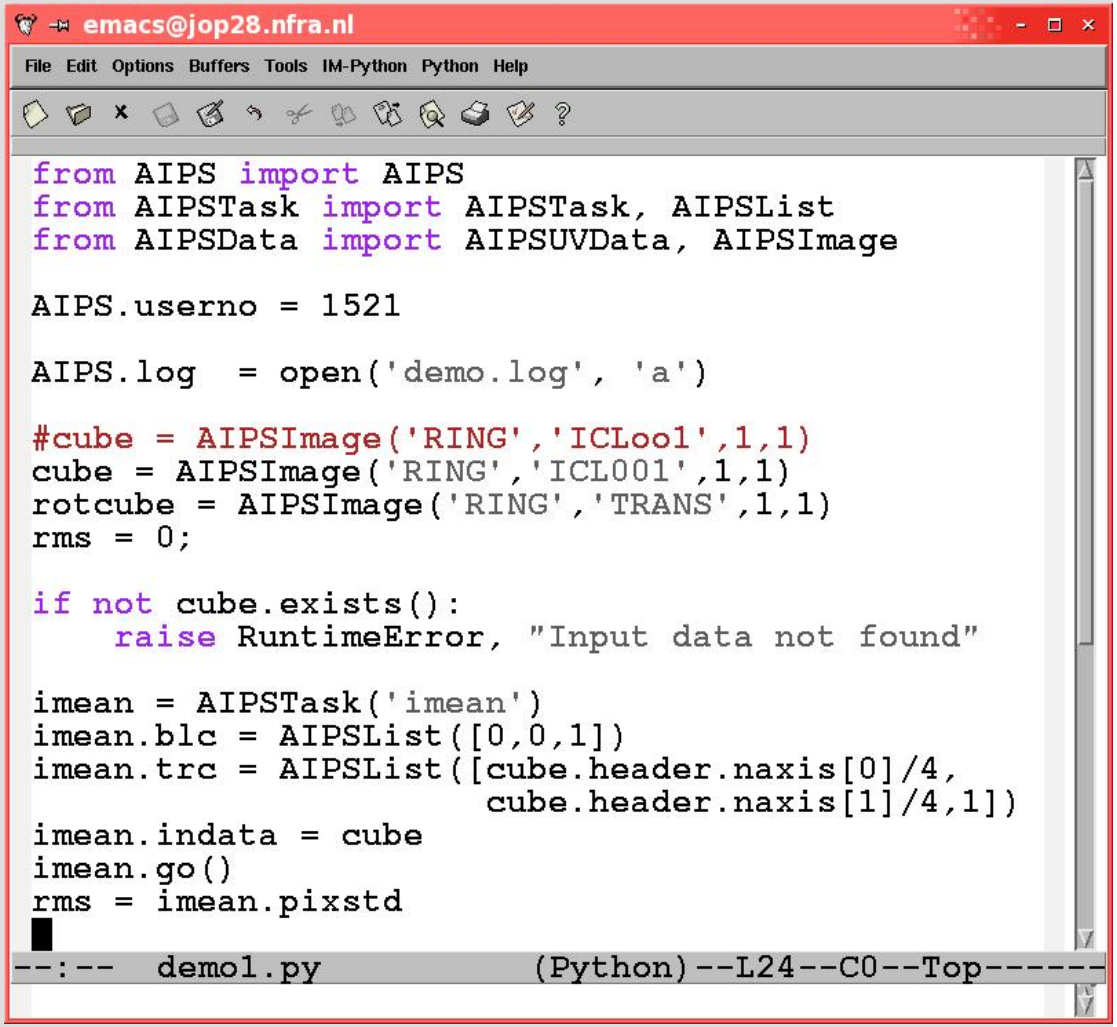
- Python interface for classic AIPS
  - Vehicle for implementing algorithms
    - access AIPS calibration
    - scripting for distributed computing
  - And distributing ALBUS results to users
- Version 1.0 released in January
  - Maintained on RadioNet wiki
    - http://www.radionet-eu.org/rnwiki/ParselTongue
    - Currently on version 1.05
  - And ParselTongue e-mail exploder
    - User support by Mark Kettenis, JIVE
    - Depends Obit layer by Cotton
- Also attractive to outside users
  - Automating large or complex data reduction
  - Accountable procedures of data flow
  - Interaction with outside world



EVN data on methanol masers in CepA, calibrated with ParselTongue

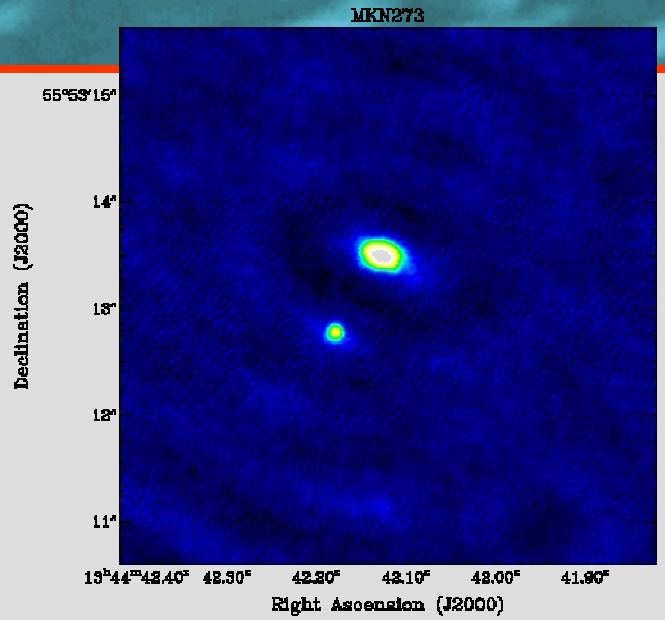
ParselTongue, how?

- No changes to AIPS
- Use all Python functionality
  - libraries for everything
- Run all batch tasks
  - input parameters as local attributes
- Direct access to data
  - headers and tables
  - even data values
  - can be changed
  - demo in user meeting

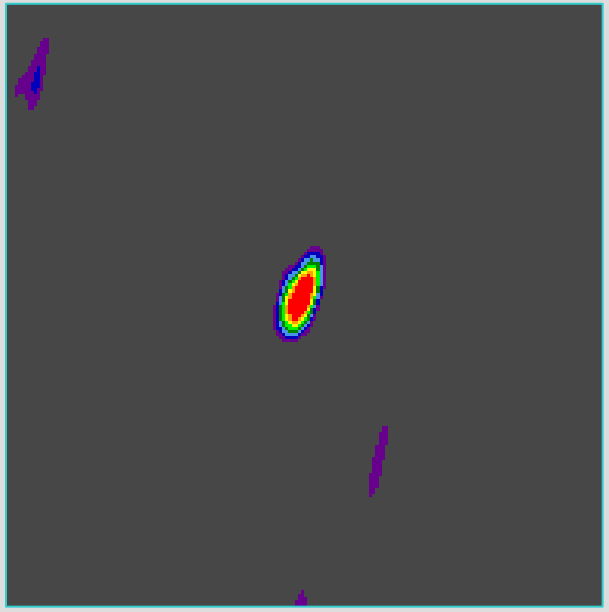


ParselTongue, what?

- Useful for automation large scripts
  - Adapted by EVN and MERLIN pipeline
- Superior interface to environment
  - Direct access to archive
  - Read data base, deliver plots
  - Create web pages on command
  - Build VO(-like) access
- Can be used to exercise complex or experimental calibration
  - Mixed bandwidth calibration
    - extrapolate in frequency
  - external data for e.g. ionosphere
- Built in remote execution
  - Scripting on cluster computers
  - Wide field imaging
    - eg search masers in wide field



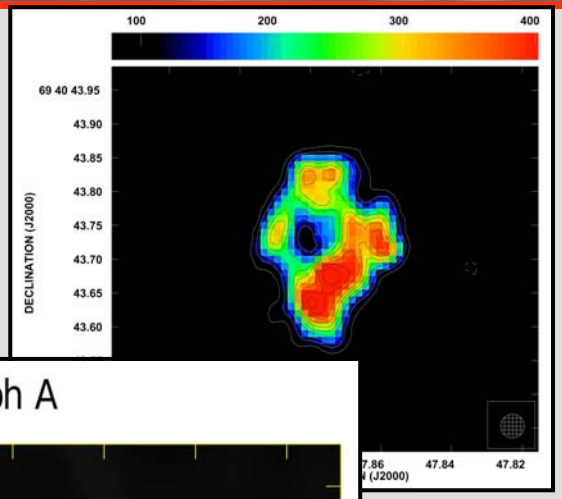
Example from MERLIN archive

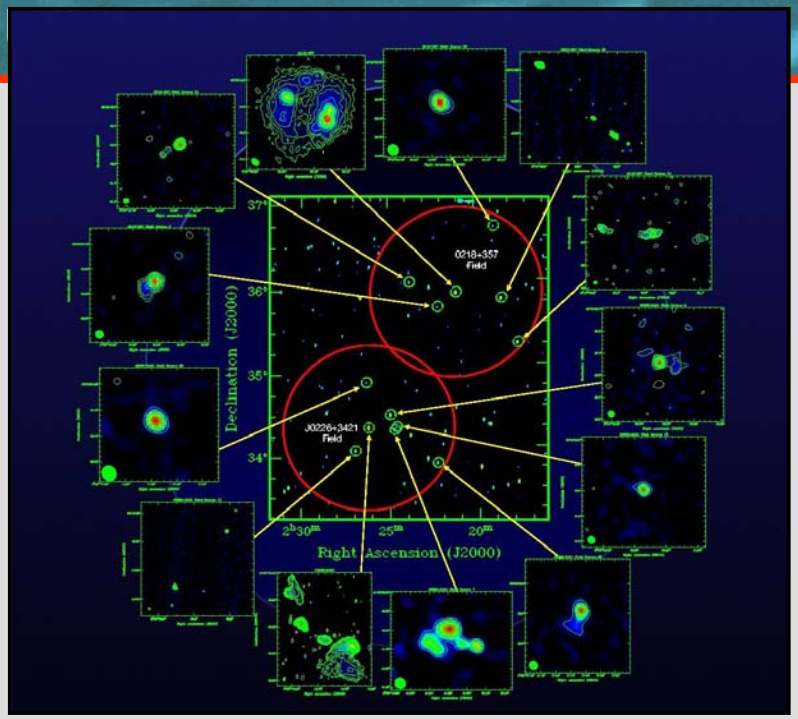


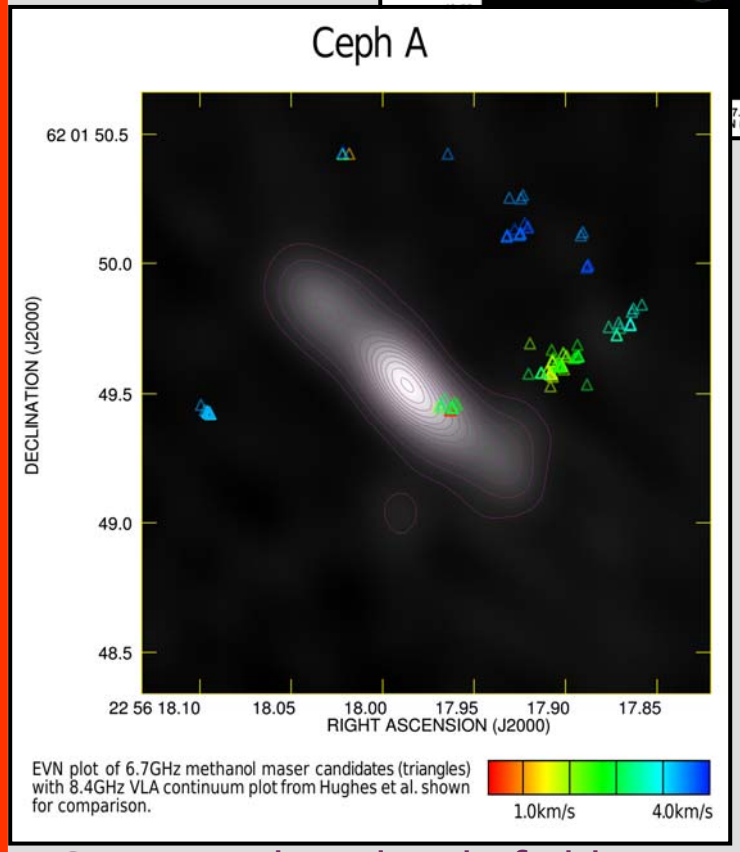
mixed bandwidth calibration for OH astrometry, Vlemmings & van Langevelde

ParselTongue in this symposi

M82 SNR,
Fenech et al

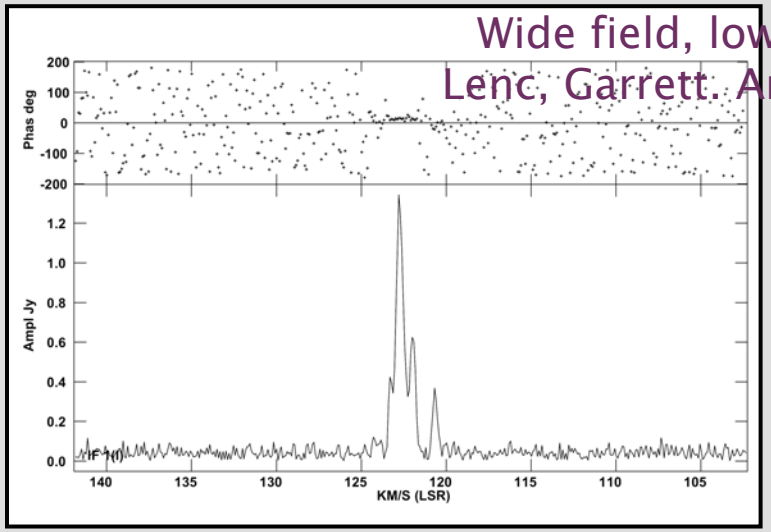






Cep A methanol wide field
Bourke, van Langevelde et al

Wide field, low frequency VLBI
Lenc, Garrett, Anderson, Tingay



MERLIN Methanol Parkes multibeam follow up
Green, Cohen, Richards, Pestalozzi

huib 26/09/06

Long term perspective:

- Need to think about next EU funding cycle
  - How should this evolve?
  - Data from classical radio instruments
    - Upgraded considerably (eVLBI, eMERLIN, eVLA)
  - New telescopes with new software tools
    - ALMA, LOFAR, SKA pathfinders
    - Will use casa or something similar or deliver calibrated images

But there will be radio-astronomers who want to keep control over calibration & imaging

- Work towards interoperability
  - Python will be a common interface for more than one package
    - Build on the ParselTongue layer
  - Port traditional algorithms to casa/LOFAR environment
    - This is a way to continue support for recent (or upcoming) ALBUS algorithms

more advanced long baseline user software
or
advanced long baseline interoperable user software

FABRIC

Future Arrays of Broadband Radio-telescopes on Internet Computing

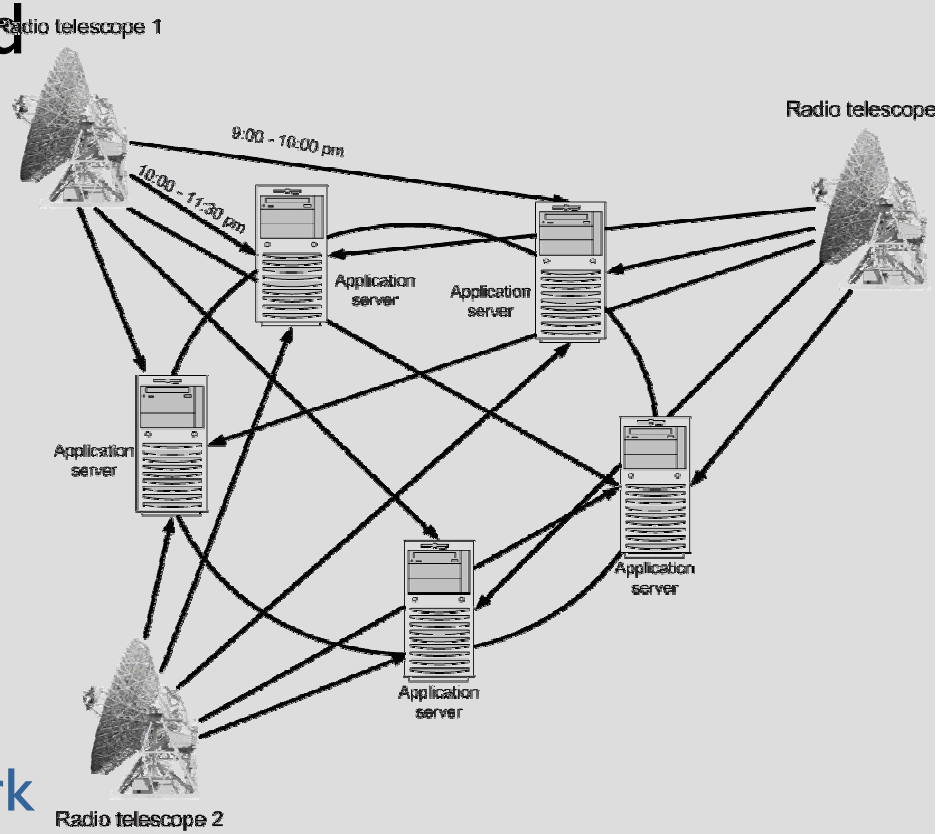
2nd meeting in Poznan last Monday

EXPreS::FABRIC

- EC funded project EXPReS (03/2006)
  - To turn eVLBI into an operational system
  - Including 1 Joint Research Activity: FABRIC
- Future Arrays of Broadband Radio-telescopes on Internet Computing
  - A work-package on 4Gb/s data acquisition and transport
    - Jodrell Bank, Metsahovi, Onsala, Bonn, ASTRON/LOFAR
    - Builds on expertise with PC-EVN data acquisition
    - And studies interfaces to eMERLIN and LOFAR
  - A work-package on distributed correlation
    - JIVE, PSNC Poznan
    - Matched by Dutch NWO funded project SCARIe (10/2006)
    - Explores the possibility of Grid correlation
    - On the roadmap for next generation correlator
      - Although not necessarily the optimal solution

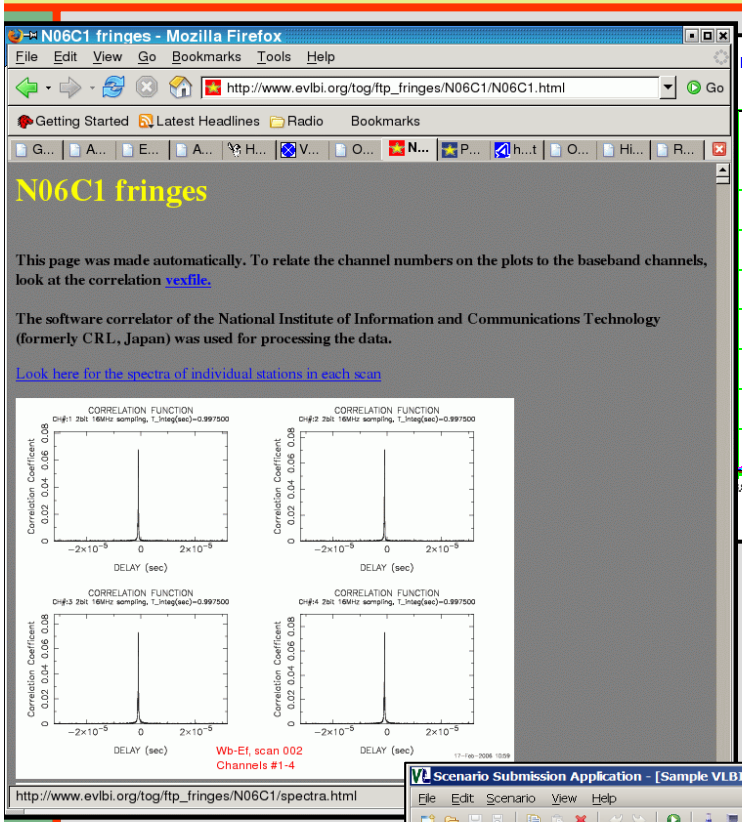
Distributed correlation

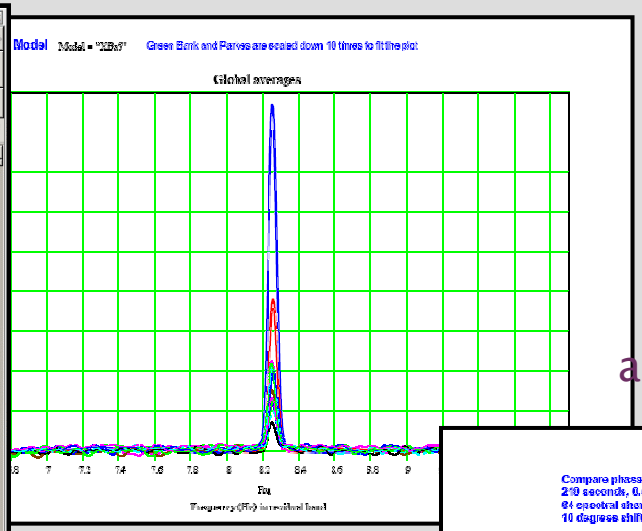
- Get CPU cycles from the Grid
  - Explore software correlation
    - Better accuracy and flexibility
    - Portable, Grid friendly code
  - Use net as crossbar switch
    - a-synchronous correlation
  - Seek boundaries of the Grid
    - "Real time" applications
    - data transfer limitations
- Possible demo applications:
  - Monitoring EVN network
  - Continuous small eVLBI network
    - Monitoring transient sources
    - Astrometry, spectral line sources
  - spacecraft navigation
  - pulsar gating



typical VLBI problems					
description	N telescopes	N subbands	data-rate [Mb/s]	N spect/prod	Tflops
1 Gb/s full array	16	16	1024	16	83.89
typical eVLBI continuum	8	8	128	16	2.62
typical spectral line	10	2	16	512	16.38
FABRIC demo	4	2	16	32	0.16
future VLBI	32	32	4096	256	21474.84

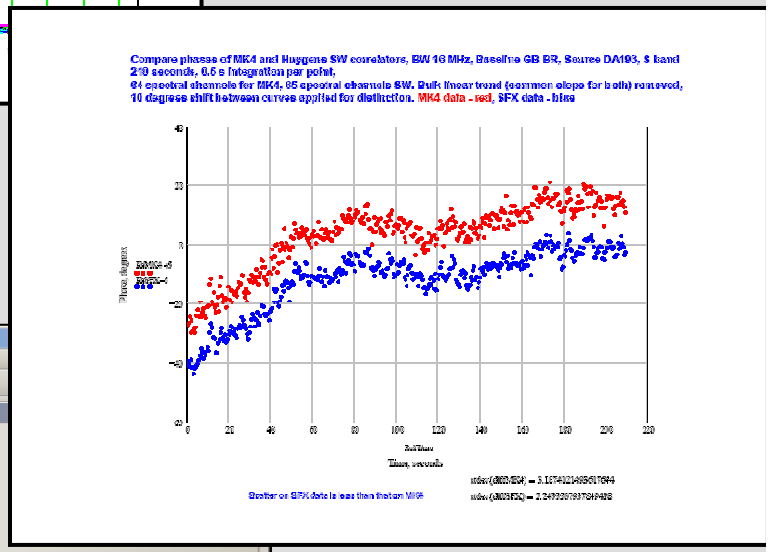
Progress and previous experience

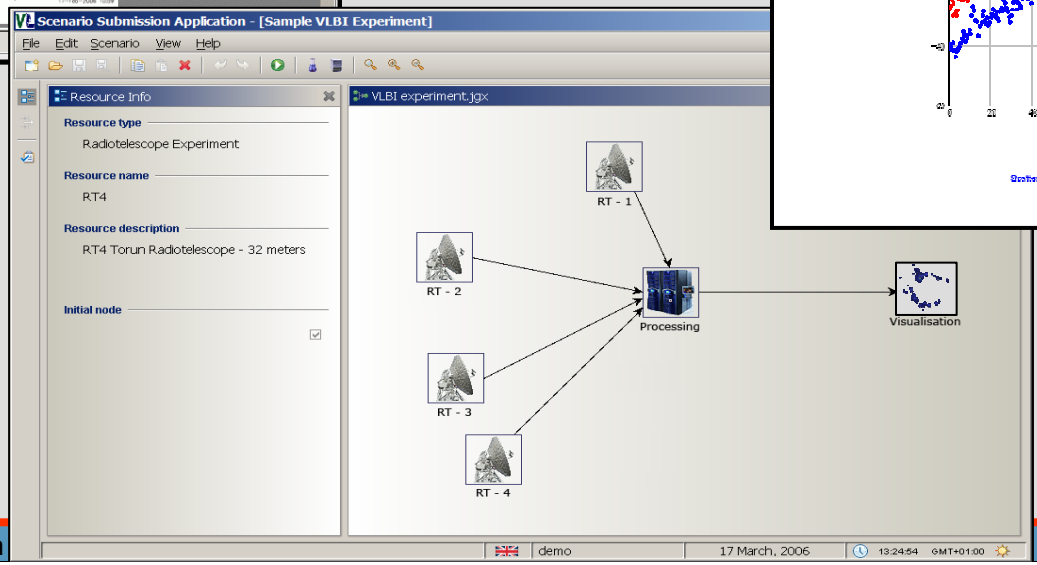




High accuracy
Huygens detections

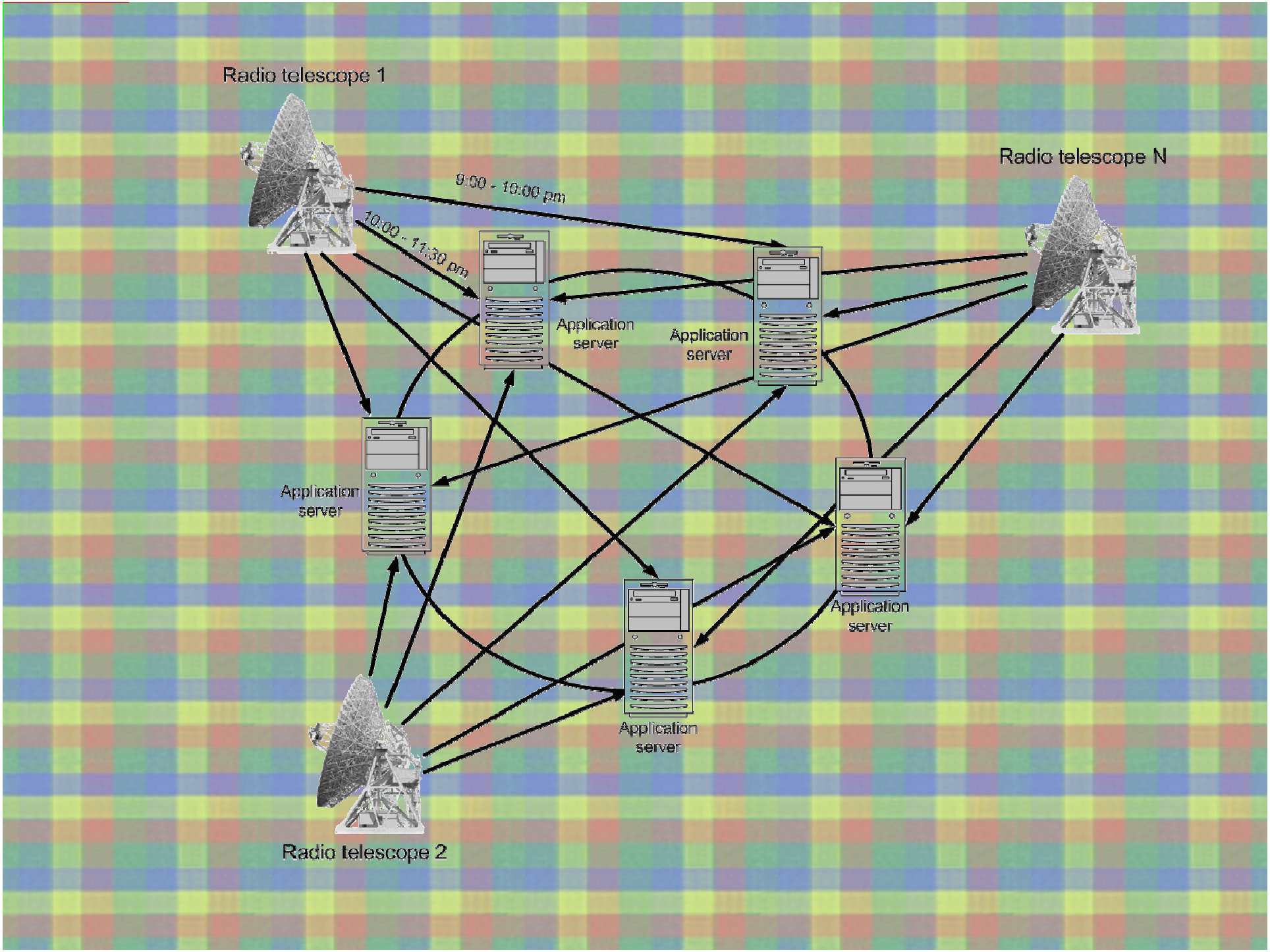
Comparison software
and hardware correlation



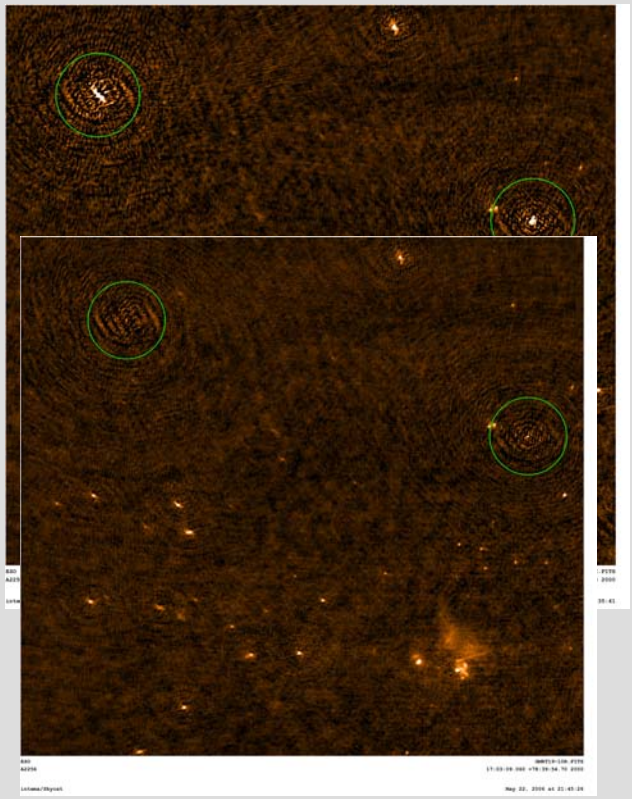


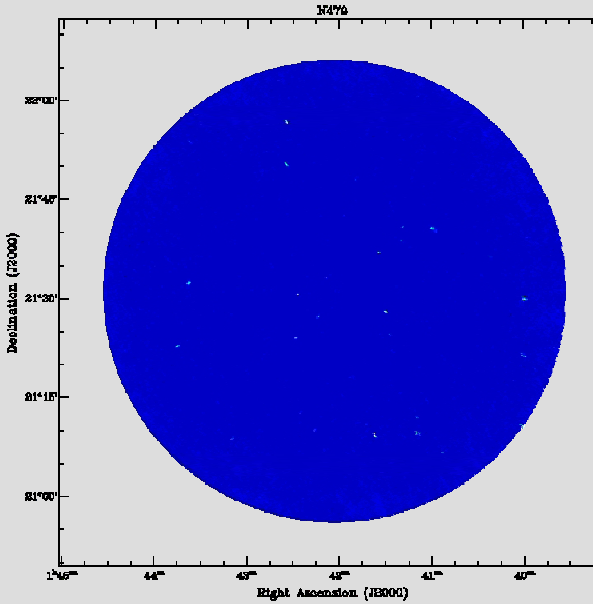
ftp VLBI
EVN monitor

Virtual Lab
developed at Poznan


Radio telescope 1
Radio telescope N
9:00 - 10:00 pm
10:00 - 11:30 pm
Application server
Application server
Application server
Application server
Application server
Application server
Radio telescope 2

User all over Europe





Multi-facet processing of 610 MHz data GMRT, Kloeckner Oxford