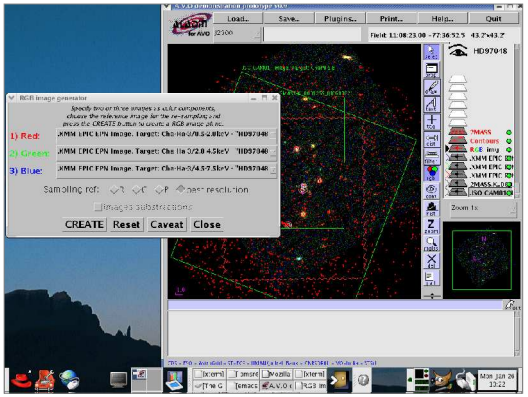
Access to (X-ray Event), Radio and Interferometry Data

S.T.Garrington, P.A. Harrison, A.M.S. Richards, A.M. Stirling, N. Winstanley (JBO); M.D. Allen, B. Vollmer (CDS); P. Lamb, R. Power (CSIRO); T. Venturi (EVN) et al. and all who replied to the radiovo@ivoa.net and RadioNet mailings

- Advances in radio astronomy
  - Wide band-width
  - Multiple products
  - High data rates
  - Current access prototypes
- Radio Data Providers questionnaire
  - VO awareness
  - Data supply requirements
  - Pointers to specialised tools
- RadioNet

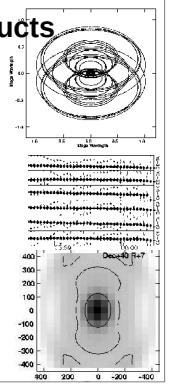
X-Ray data

- Usually stored as event list
- Calibration available, can be applied without decisions
  - i.e. by machine or unskilled user
- Commonest product is x-ray spectrum extracted in chosen patch or annulus on sky.
  - Could these be extracted by user-driven remote pipeline?
- Also images, light curves...
- Units are counts, need to know source as well bandpass characteristic to convert to physical units
  - can be done roughly using standard spec. indices
    ➔e.g. YSO, Extragalactic source...
- XMM multi-band images available via AVO-Aladin
- CHANDRA Goods images available
- Some catalogues in physical units (GOODS, 1XMM)



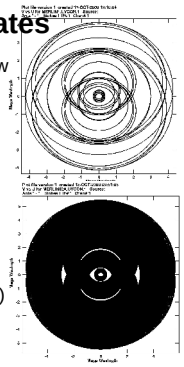
Interferometry Data Products

- Calibrated complex visibilities
  - Model fitting
  - 'Light' curves
  - Edit *before* imaging
  - Combine data from other arrays
- Image (Fourier Transform, CLEAN) *selected regions*
  - Field of view determined by
    ➔Individual antenna radii
    ➔Channel width
    ➔Integration time
  - Quality - baseline coverage
  - Beam size - weighting
    ➔Sensitivity *or* resolution
- Data cubes, spectra, polarization



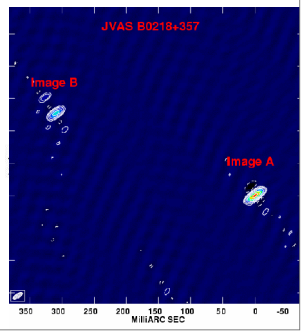
Interferometry Data Rates

- MERLIN sensitivity limit:16 MHz b/w
- e-MERLIN 2 GHz b/w (v>4 GHz)
  - Optical fibres (dedicated)
  - B/W fills aperture plane
- 10 - 30 x sensitivity
- FOV 15 arcmin at 18cm
  - 18kx18k pixel potential images
- Data rate 1-100 Gb/s (x10^3 present)
- Similar upgrades of other arrays
  - e.g. eVLA



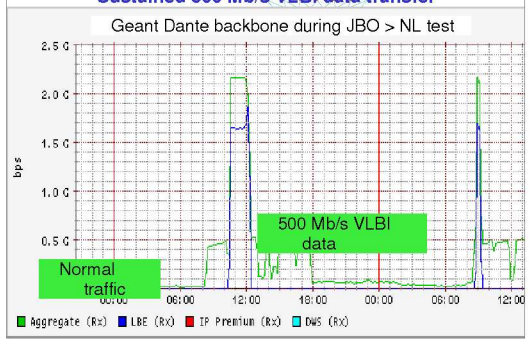
Real-time VLBI correlation

- Transatlantic real-time fringes
  - 25 March 2004
  - Onsala (Sweden), Westford (USA)
  - Haystack correlator
- EVN real-time imaging
  - 28 April 2004
  - Onslala, JBO(UK), Westerbork (NL)
  - No buffering
  - 32 Mb/s
  - JIVE correlator (NL)



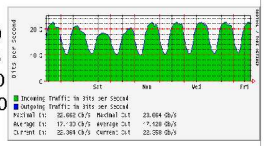
i-Grid & ER2002 demo transfers

Sustained 500 Mb/s VLBI data transfer



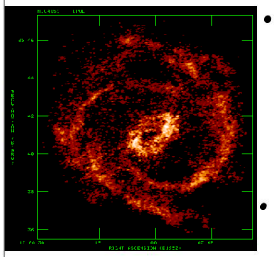
Data bandwidth requirements

- E-MERLIN, NMA 30-120 Gb/s/site 200-5000 km
- EVN/Global/Geo-VLB ~ 1 Gb/s/site 2000-8000 km
- Total IP **traffic** US: 300 Gb/s
  UK: 20
  Geant: 3
  widest pipes 10
  lit capacity NY-DC 140



- E-MERLIN @ 30 Gb/s/tel
  VLBA @ 120 Gb/s/tel
- 20-50% IP traffic in 2007, assuming continued growth

The SKA vision: imaging high-Z galaxies in HI with <1" resolution

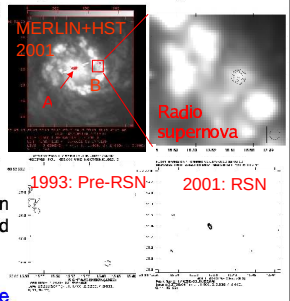


VLA image NGC 4151

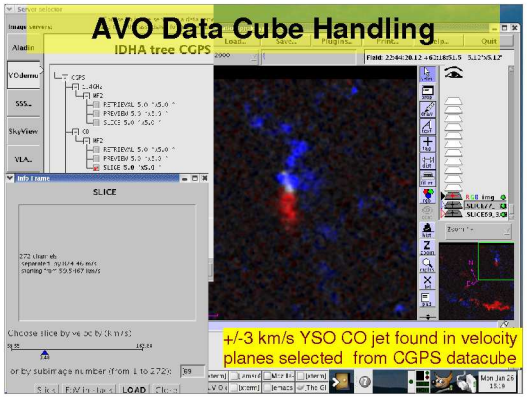
- 100x VLA sensitivity
  - Testing gravity(PSR,BH)
  - Dark ages e.g.high z CO
  - Cosmic magnetism
  - Cradle of life
  - Evolution of galaxies & large-scale structure
- Date-rate-limited
  - SKADS low-v test array
  - Initially can't correlate all element pairs

On-demand processing

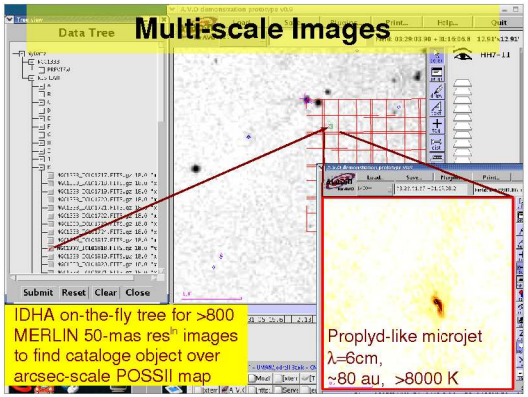
- MERLIN *uv* data on-line
  - http, cgi, AIPS
  - On-the-fly imaging
    →just fill in position, resolution, size
- NGC7469 supernova
  - Colina et al. 2001
- 1993 obs. HI absorption against core A
  - Off-centre RSN position B imaged from archived visibilities
- There it was gone!
- Also see ATCA prototype
  - on-demand imaging using web services



AVO Data Cube Handling



Multi-scale Images

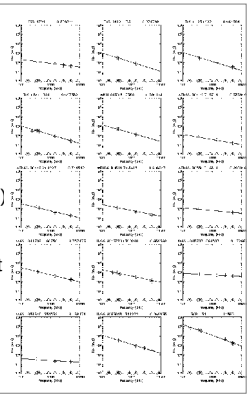


IVOA Radio Data Provider Quest'aire

- Replies from λ<0.001 - λ>1m, fixed-link and VLBI
  - ATNF, BIMA, IRAM, JIVE, MERLIN, NRAO, JCMT, (ALMA, CARMA)
- Developing data models, VO involvement
  - AVO, AstroGrid, NVO (incl. cone search), Aus-VO
- Archive ID by experiment, pointing position, date
  - Registry needs to know FoV
- Most interferometry data on ICRF, WCS
- Various data retrieval paths:
  - Visibility FITS on request by FTP
  - Plots and cal data
  - Some web access to FITS images
  - Metadata

Catalogues

- Obs. catalogues on-line
  - Some published via VO
- Published surveys
  - WENSS, SUMSS, NVSS
  - SIMBAD radio ID
    - Spectral indices (Vollmer)
- Extend publication of catalogues and archives
  - CADC GPS - development
  - HIP/JASS
    - AG/AusVO prototype
  - + MIGALE discussion
  - SCUBA survey - request
  - VLBI calibrators - sort out!



Requirements

- Consistent metadata, integrated data handling
  - Clean images ready for analysis/multi-λ comparison
  - High spatial, spectral resolution, datacubes
  - Full history and quality characterisation
  - Calibrated *uv* data e.g. combine from different arrays
  - Fast (parallelised) user-driven processing
  - Options depending on user experience
    - Standard software *or* VO interface to local package
- Specialised VO-linked data centres
  - VO to understand Jy/beam, polarization, μas precision
- One path for all users
  - Authorisation filter if access is restricted
- Liaise with related projects
  - Pulsar VO (linked to gravitional wave grid proposal)
  - Planck VO working group

RadioNet

- Collaboration between European facilities (Synergy)
- Science workshop and training group
- European Radio Astronomy engineering forum
- Software and users forum
  - ALBUS joint research activity
  - Parallelization
  - Software package evaluation
  - Wide-band/wide-field imaging
  - Archives and VOs
- ALMA forum
- Astronomy across Europe
  - Opticon, ILIAS
  - JENAM
- Radio frequency management