data lifecycle

Hans-Rainer Klöckner

Overview

Genius idea

Feasibility

Proposal

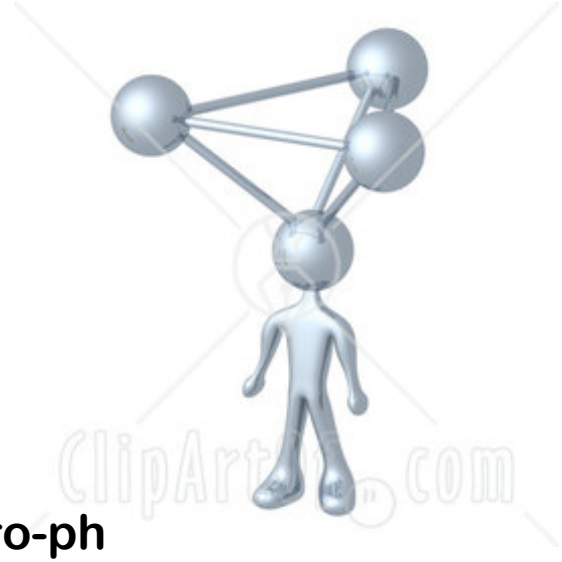
Observation

Data Reduction

Data Analysis

Publish

genius idea



is it a new approach?

check literature:

- astro-ph http://xxx.lanl.gov/archive/astro-ph
- ADS http://adsabs.harvard.edu/abstract_service.html
- www-search engine

data archives:

- VLA, VLBA, GBT http://archive.cv.nrao.edu/
- GMRT http://ncra.tifr.res.in/~gmrtarchive/
- EVN http://archive.jive.nl
- ATNF http://atoa.atnf.csiro.au/
- MERLIN http://www.merlin.ac.uk/archive/

Feasibility

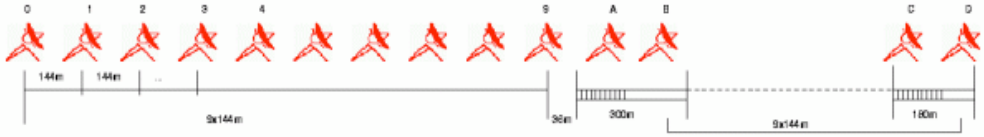
How strong is your source ? (Jy, mJy, μJy, nJy)

Frequency range (< 300 MHz Ionosphere
>15 - 20 GHz Troposphere)

HI at redshift 1 : ν_{obs} = 1420.4/2 = 710.2 MHz

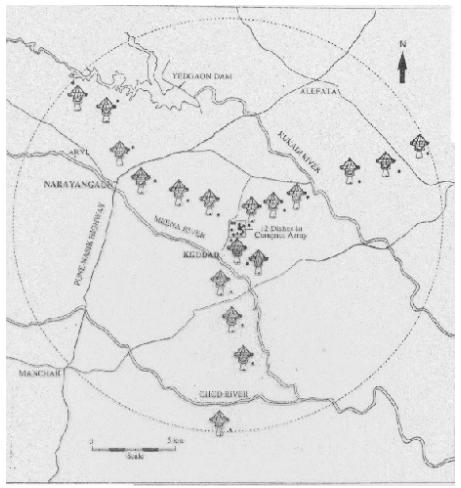
Source position (ra,dec,l,b)

http://nedwww.ipac.caltech.edu/forms/calculator.html



Observable at the observatory

$Latitude_{array} - Dec_{source} > 0$



Feasibility - sensitivity image / baseline

[Wrobel & Walker; Chapter 9, Synthesis Imaging in RADIO ASTRONOMY II]

System Equivalent Flux Density

$$SEFD = \frac{T_{sys}}{K} \qquad K = (\eta_a A) / (2 k_B)$$

equ. (9-5)

A = Area
K_b = Boltzmann
η_a = efficiency
η_s = losses in electronics
τ_{acc} = integration time [s]
$\Delta\nu$ = bandwidth [Hz]

Baseline sensitivity for one polarization

$$\Delta S_{ij} = \frac{1}{\eta_s} \sqrt{\frac{T_{sysi}\, T_{sysj}}{2\, \Delta\nu\, \tau_{acc}\, K_i\, K_j}} \qquad (9\text{–}13)$$

or in terms of the $SEFD$s defined in Equation 9–5:

$$\Delta S_{ij} = \frac{1}{\eta_s} \sqrt{\frac{SEFD_i\, SEFD_j}{2\, \Delta\nu\, \tau_{acc}}} \qquad (9\text{–}14)$$

Image sensitivity for one polarization

$$\Delta I_m = \frac{1}{\eta_s} \frac{SEFD}{\sqrt{N\,(N-1)\,\Delta\nu\, t_{int}}}. \qquad (9\text{–}23)$$

Divide by square root 2 for 2 polarization !

Feasibility

angular resolution = 1.02 λ / D [halve power beam width]

e.g. 1.4 GHz ~ 21 cm; 10 km baselines: 1.02 0.21/10000 * 360/(2 pi) * 3600 = 4.4 arcsec

field of view [FoV] = 1.22 λ / D

[Napier, Chapter 3, page 41]

minimum brightness temperature

$$T_{\mathrm{b,min}} = \frac{2\ln 2}{\pi}\,\frac{c^2}{k_{\mathrm{B}}}\,\frac{\Delta I}{\nu^2\,\theta^2_{\mathrm{HPBW}}}, \qquad (9\text{–}27)$$

VLBI needs strong sources emission on mas scales

general exposure calculator

http://www-astro.physics.ox.ac.uk/~hrk/ARRAY_EXPOSURE.html

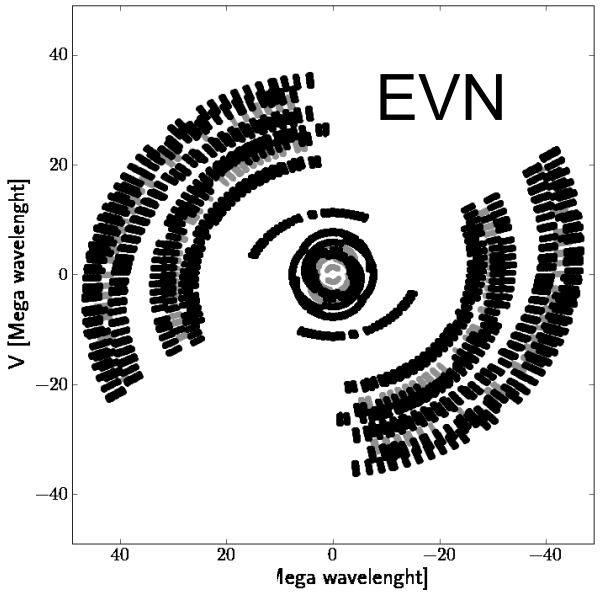
Feasibility

[Bridle &Schwab; Chapter 18, Synthesis Imaging in RADIO ASTRONOMY II]

Effects of time averaging

Circular UV coverage without tapering

$$\overline{\langle R_\tau \rangle} = 1 - 1.08 \times 10^{-9} \left(\frac{\theta}{\theta_{\mathrm{HPBW}}} \right)^2 \tau_a^2 , \qquad (18\text{–}42)$$



Effects of frequency averaging

Assuming square bandpass, square UV coverage

$$\eta = \pi A \theta_{\mathrm{HPBW}} = 3.79 ,$$

$$\alpha = \frac{\Delta\theta}{\theta_{\mathrm{HPBW}}} = \text{offset from peak response in undistorted HPBW's, and}$$

$$\beta = \frac{\Delta\nu}{\nu_0} \frac{\theta_0}{\theta_{\mathrm{HPBW}}} = \text{fractional bandwidth} \times \text{radius in HPBW's} ,$$

$$\mathrm{Si}(x) \equiv \int_0^x \frac{\sin t}{t}\, dt \qquad (18\text{–}17)$$

$$R_{\Delta\nu} = \frac{I}{I_0} = \frac{2}{\eta\beta} \mathrm{Si} \frac{\eta\beta}{2} . \qquad (18\text{–}19)$$

Feasibility averaging effect

[Cotton; Chapter 17 Synthesis Imaging in RADIO ASTRONOMY II]

bandwidth smearing

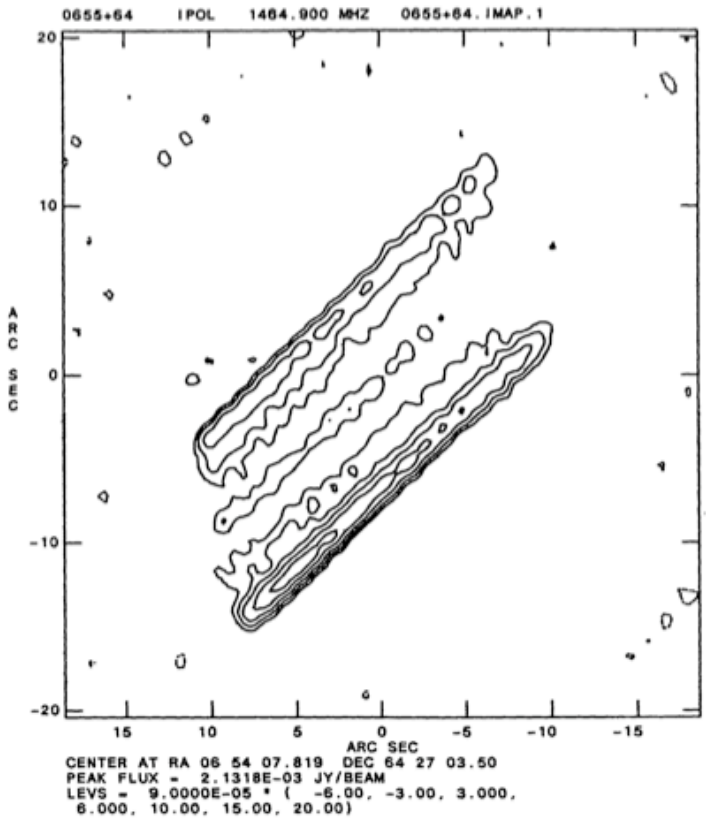


Figure 17–2. The effect of bandwidth smearing on a source 12.9′ northeast of the delay tracking center. The smearing is along the radial direction.

time smearing

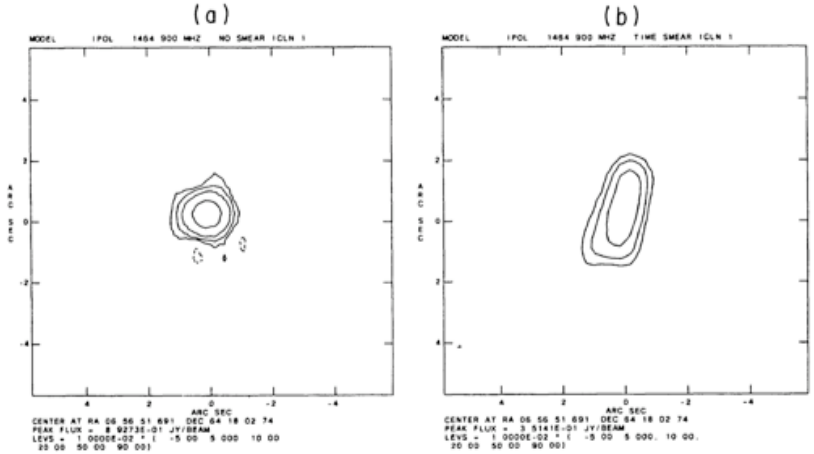
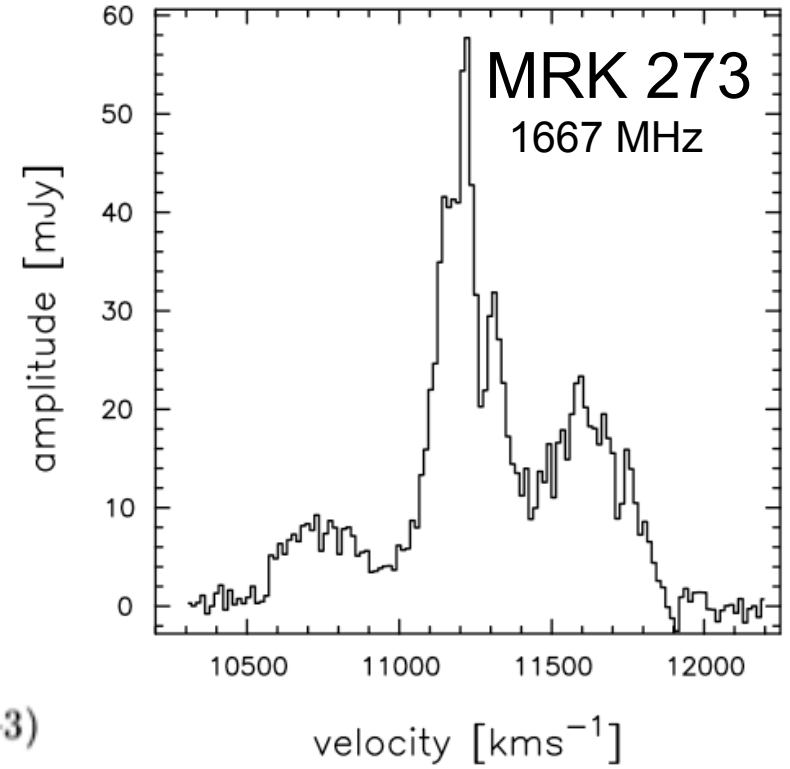


Figure 17–3. **(a)** shows the 'CLEAN'ed image of a point model ~500 synthesized beamwidths west of the phase center without time-averaging, and **(b)** shows the 'CLEAN'ed response to averaged data for the same model, showing the effects of time-average smearing.

feasibility

[Westpfahl; Chapter 11, Synthesis Imaging in RADIO ASTRONOMY II]

Line width versus bandwidth



velocity definition

$$\nu = \nu_0 \frac{\sqrt{1-\frac{v}{c}}}{\sqrt{1+\frac{v}{c}}}. \qquad (11\text{–}3)$$

$$\frac{v}{c} = \frac{\nu_0^2 - \nu^2}{\nu_0^2 + \nu^2}. \qquad (11\text{–}4)$$

$$\frac{v_{\rm radio}}{c} = \frac{\nu_0 - \nu}{\nu_0}. \qquad (11\text{–}5)$$

$$\frac{v_{\rm optical}}{c} = \frac{\nu_0 - \nu}{\nu}. \qquad (11\text{–}7)$$

CAUTION
need to get that right!

Feasibility - observing modes

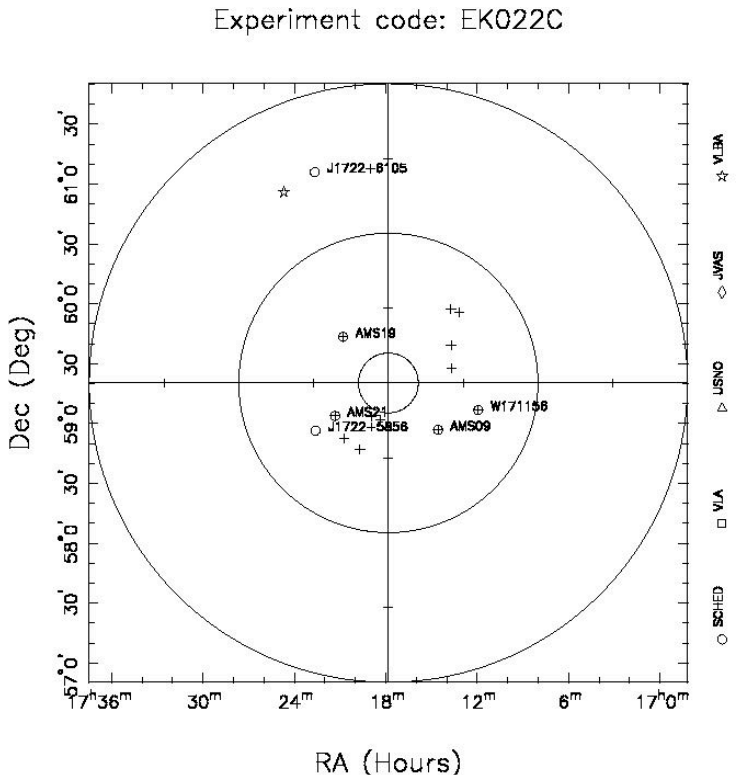
line / continuum observation

polarization

multi epoch

dual frequency switching

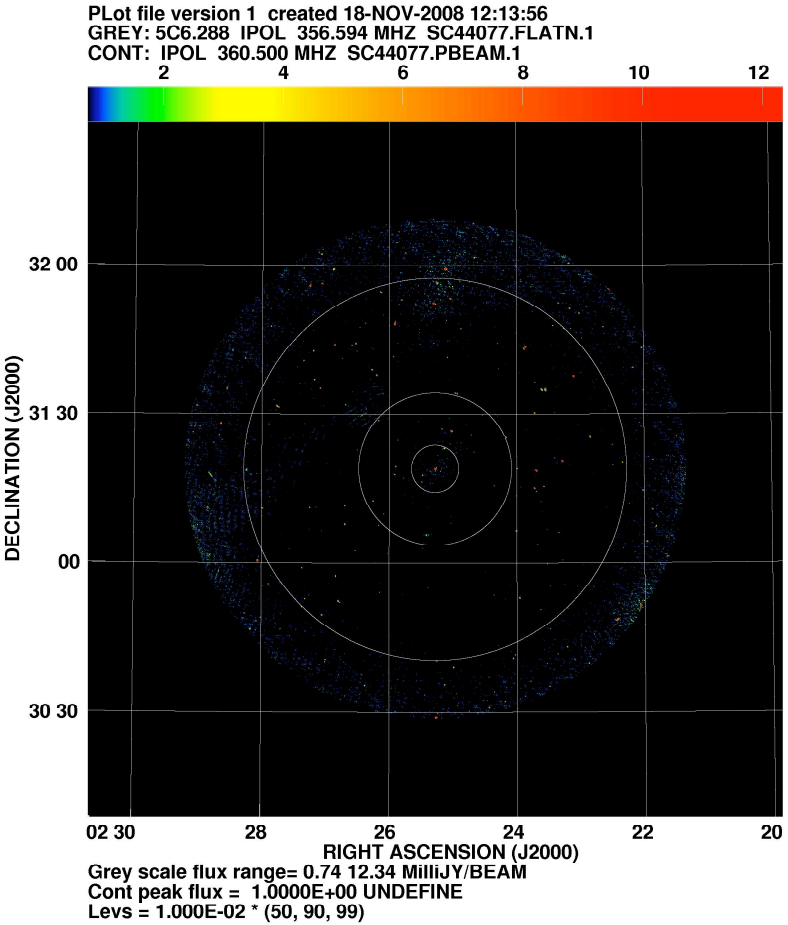
phase referencing
in beam calibration



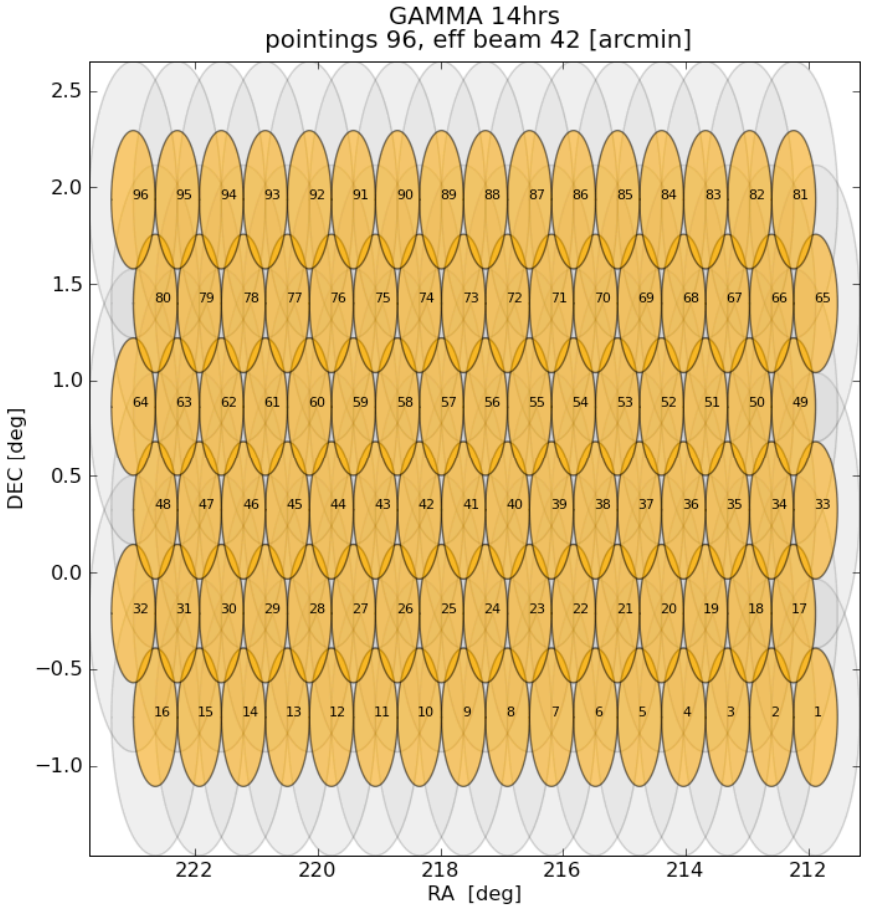
Feasibility - observing modes

mosaicing

primary beam



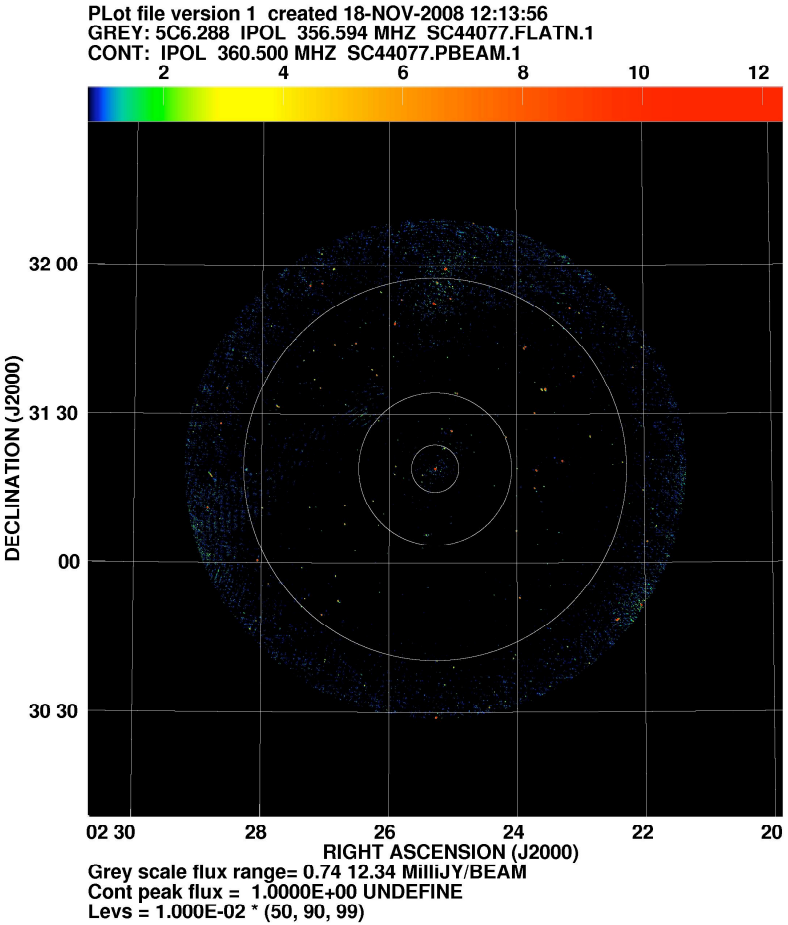
surveying a field or very extended source



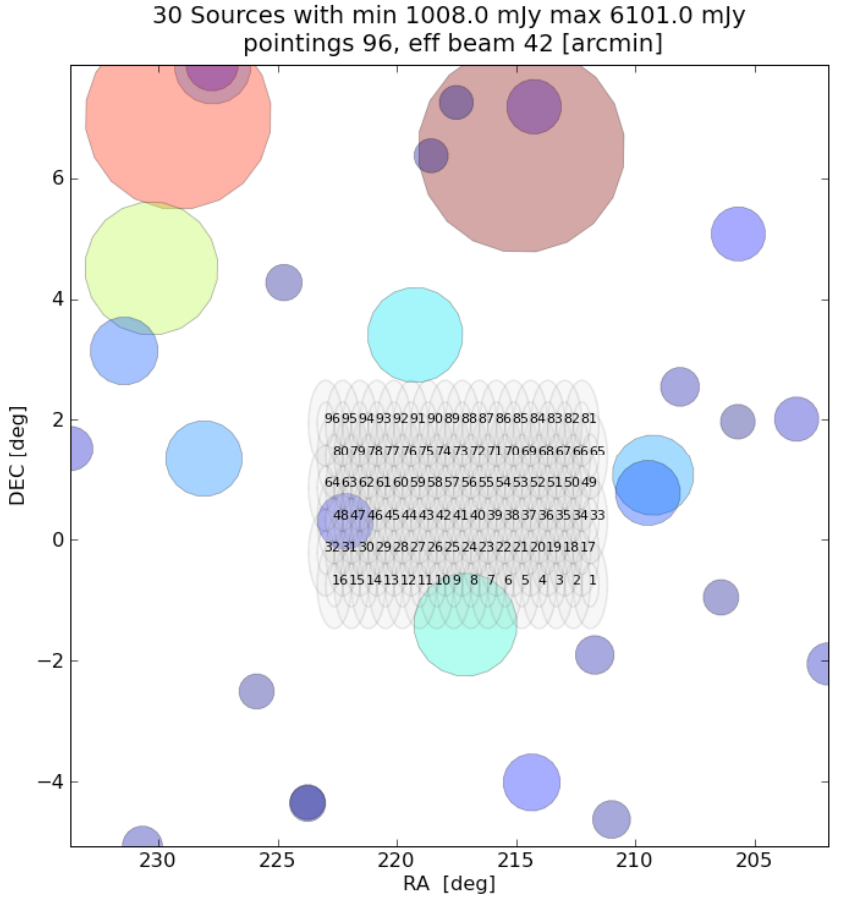
Feasibility - observing modes

mosaicing

primary beam



surveying a field or very extended source



need to check for calibrators

Feasibility - calibrators

calibrators:

4 absolute amplitude calibrator know

3C147, 3C48, 3C286 (~few percent polarized), 1934-638

phase-calibrator should be a point source !

data base:

VLA - http://www.aoc.nrao.edu/~gtaylor/csource.html

NVSS - http://www.cv.nrao.edu/nvss/

VLBA - http://www.vlba.nrao.edu/astro/calib/index.shtml

Fring Finder - http://www.aoc.nrao.edu/~analysts/vlba/ffs.html

Proposal

[see Roberts tutorial in the afternoon]

- What do you want to do
- Why is that of interest
- Do you have a backup if the signal is not detected

Proposal deadlines [no liability]

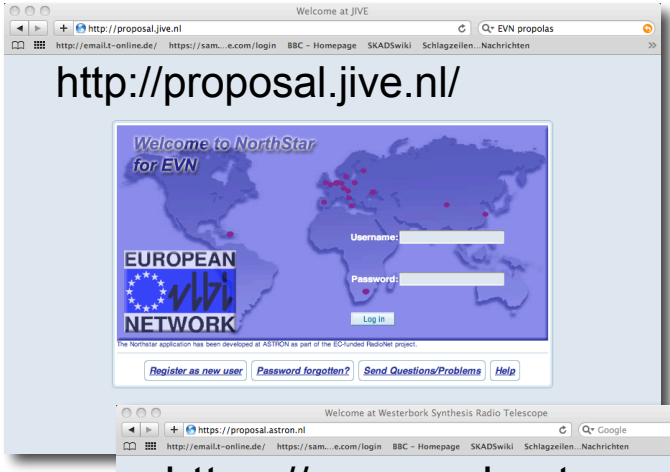
EVN, VLBA & VLBI	1st Februray, June and October
WSRT	15th September next March 2010

http://www.astron.nl/radio-observatory/pc-pages/wsrt-call-proposals/wsrt-call-proposals

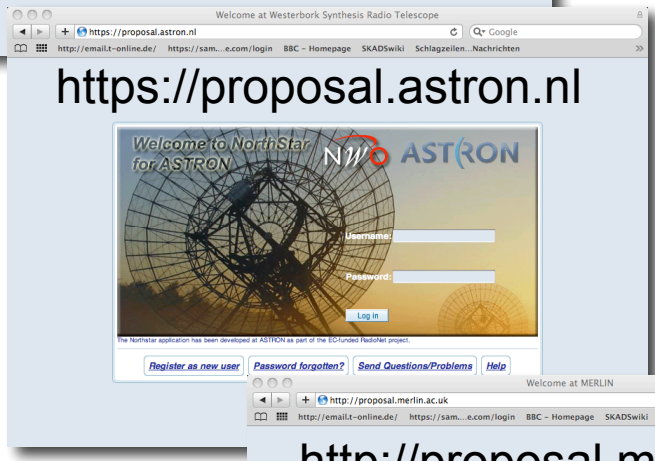
VLA	1st and 1st October
GMRT	2 times a year http://www.ncra.tifr.res.in/~yogesh/quickstartguide.html
MERLIN	15 th March & 15th September
ATNF	15 th June 15th December

Proposal - online

http://proposal.jive.nl/

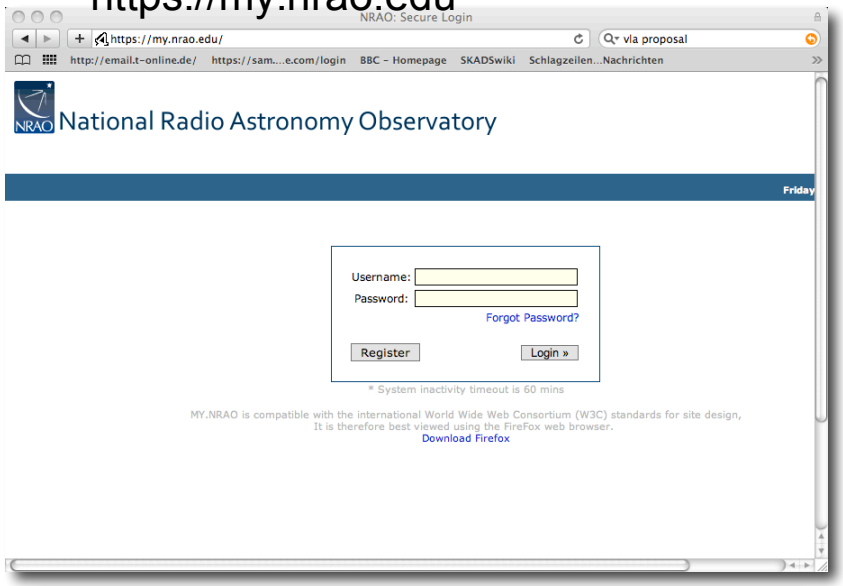


https://proposal.astron.nl

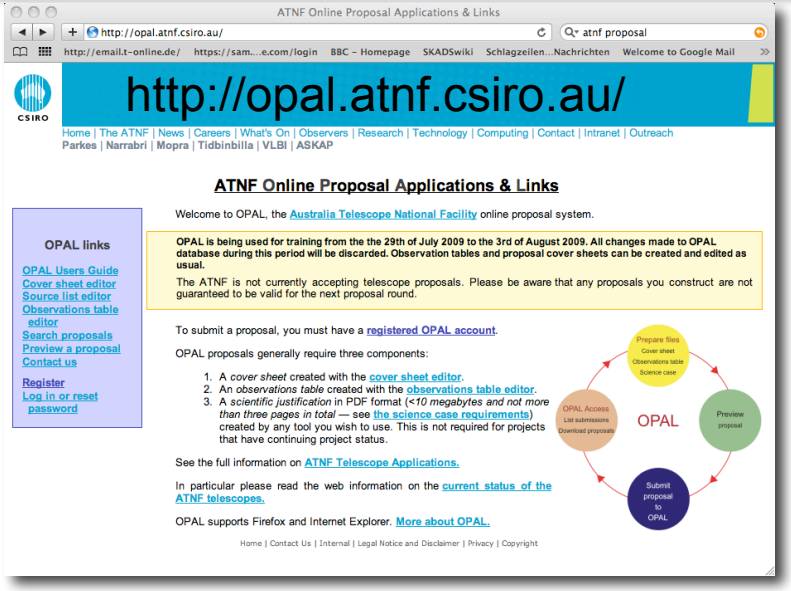


http://proposal.merlin.ac.uk

https://my.nrao.edu



http://opal.atnf.csiro.au/



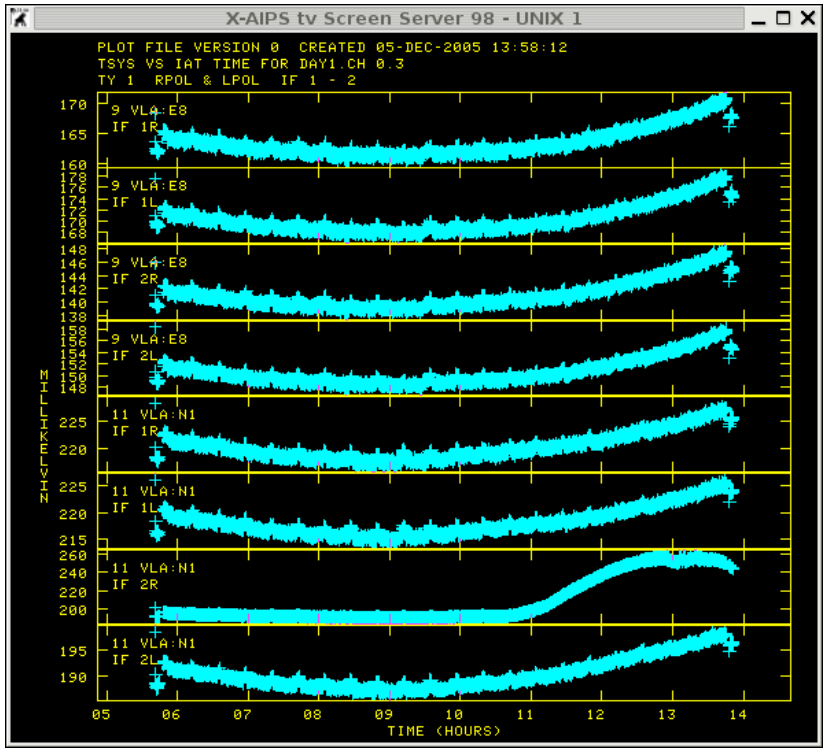
Data - reduction

Get the proposal

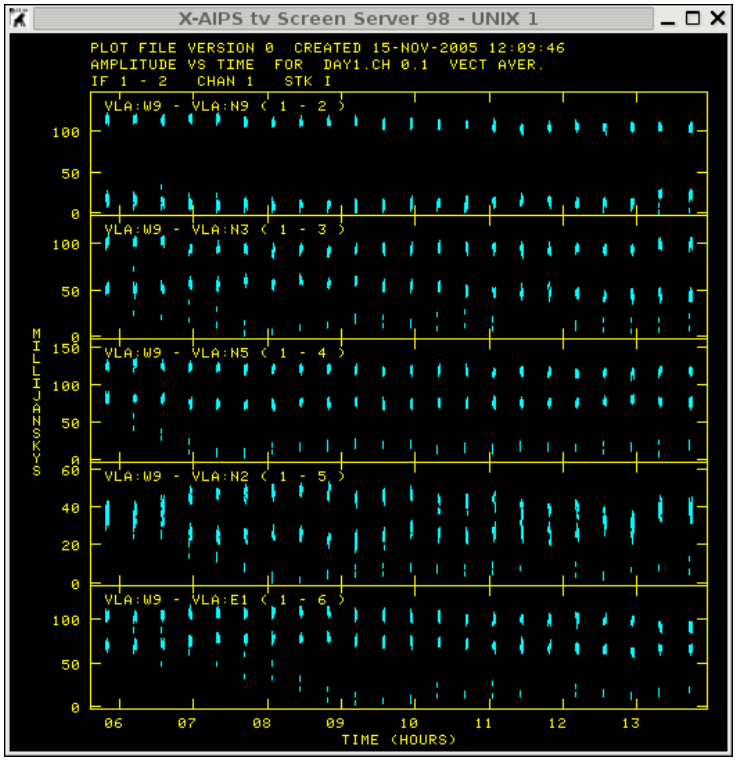
Load data into preferred software package

Evaluate the raw data

Tsys versus time

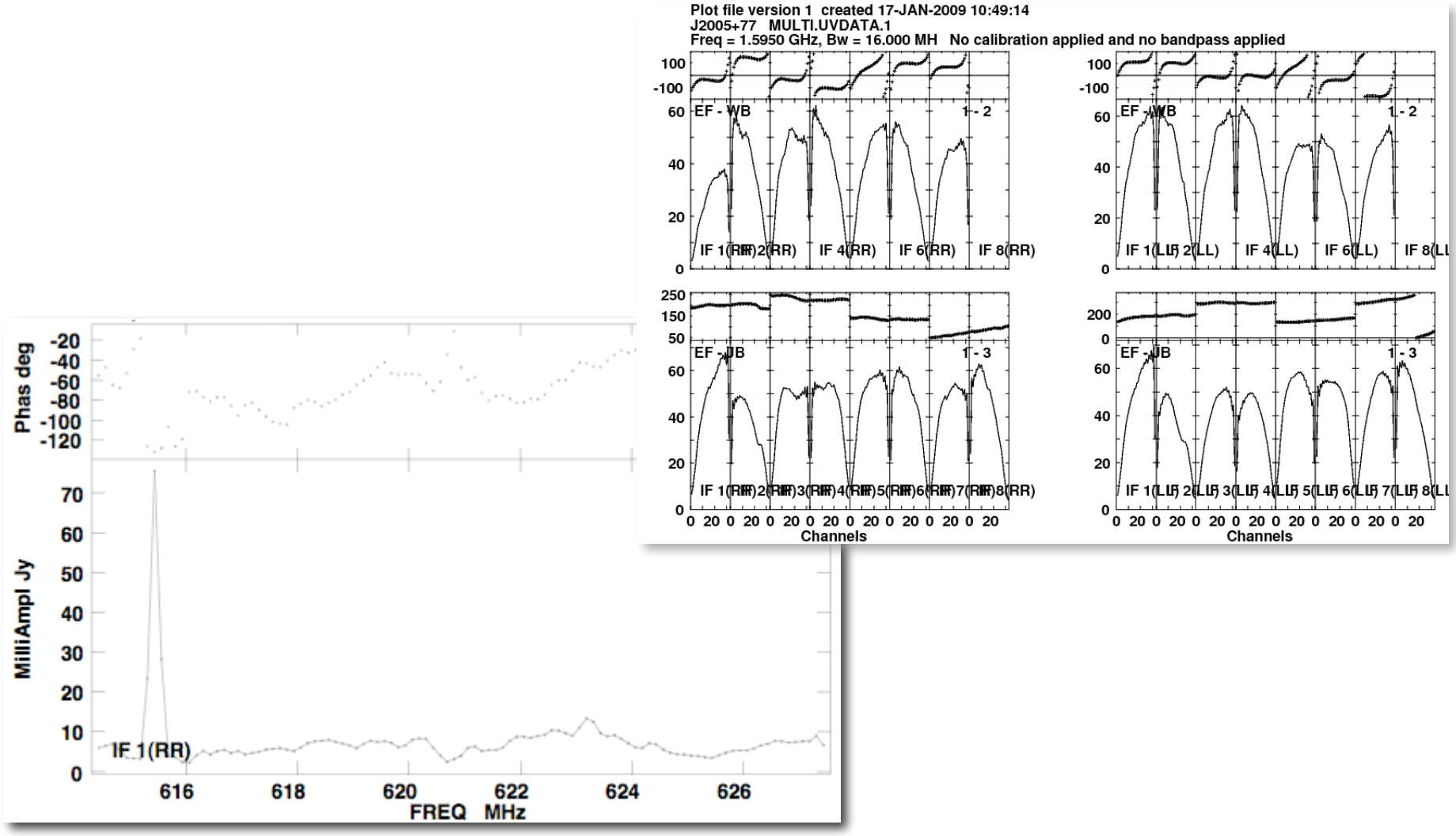


amplitude versus time



Data - reduction

Check the individual IF and/or the spectrum



Data - reduction

Apply absolute amplitude calibration

3C147, 3C48, 3C286 (~few percent polarized), 1934-638

Cross check that calibration does make sense!

Optional if observed in this mode

bandpass

Can be any strong point source

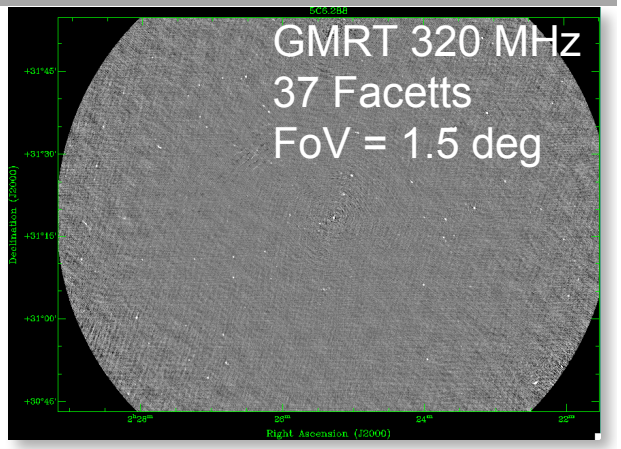
Use Equation 9-13 or 9-14 and the $\Delta\nu$ of one channel

polarization

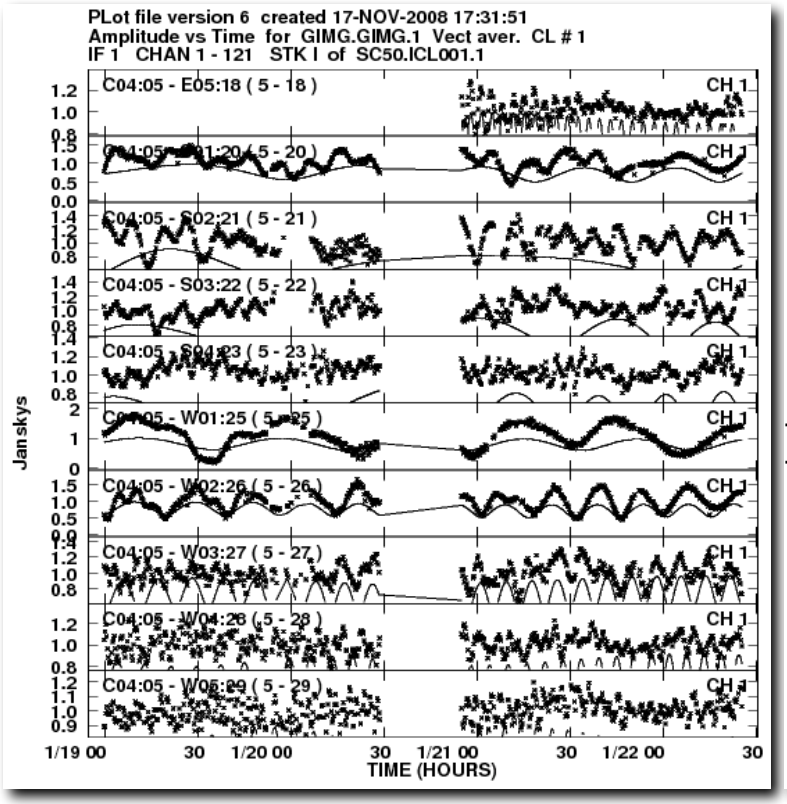
[see Rick Perly tutorial and lecture]

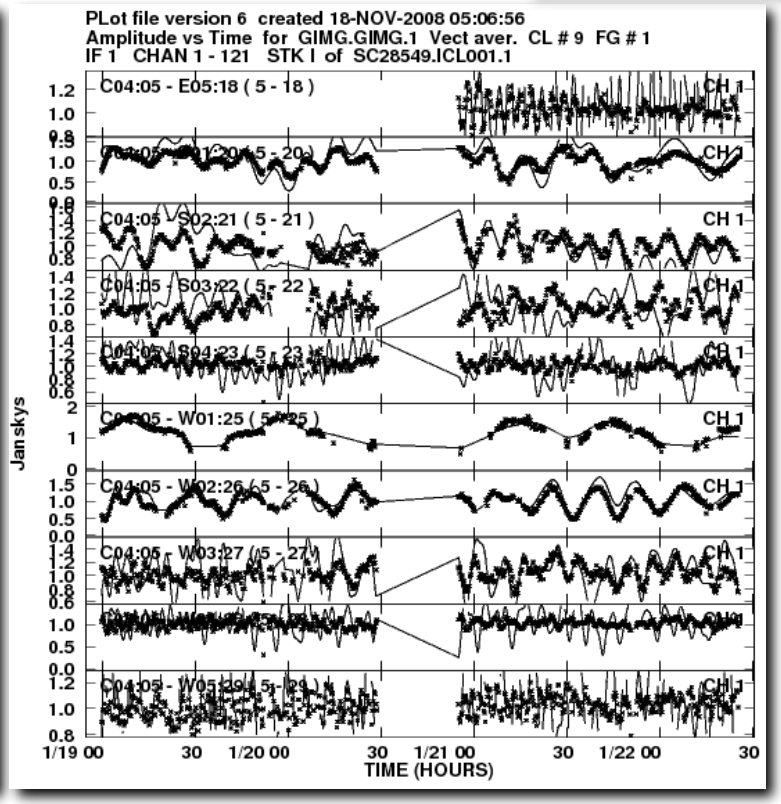
Data - reduction

Imaging and all problems involved



Self-calibration [Chicken and egg problem]

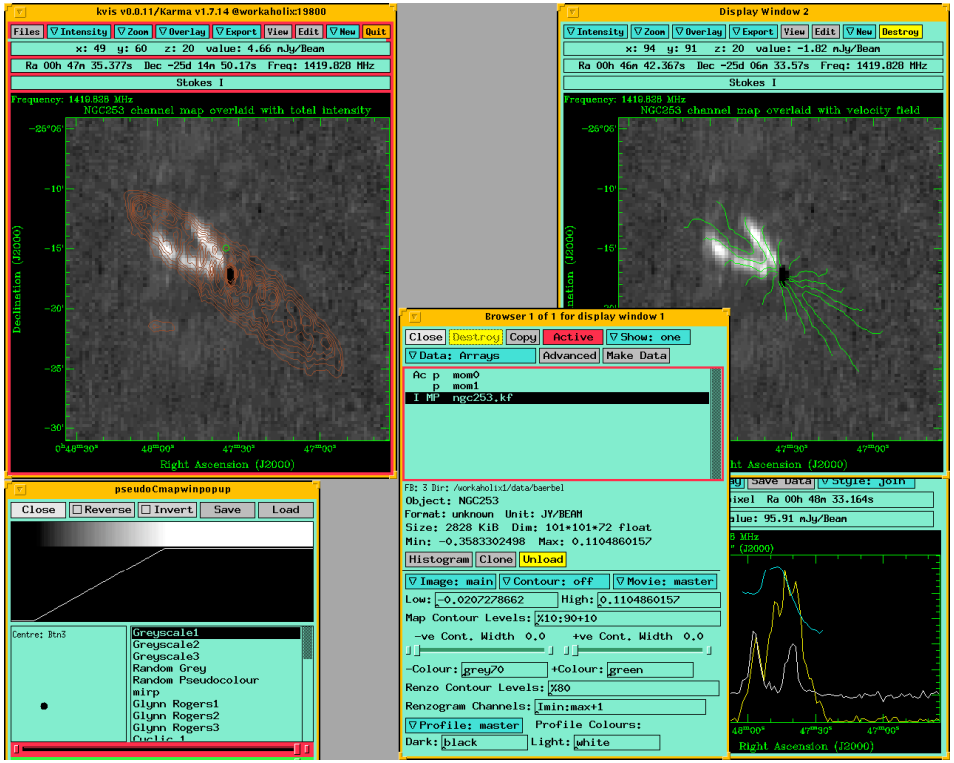




Data - analysis

[see Roberts and Tiziana tutorial on Tuesday]

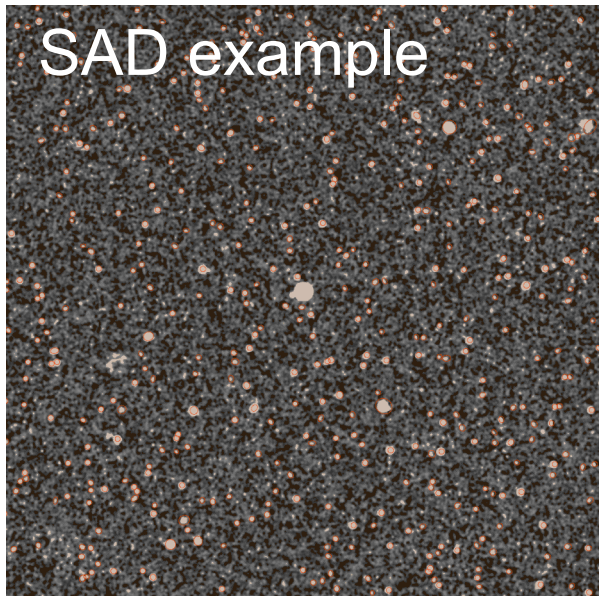
Karma - package

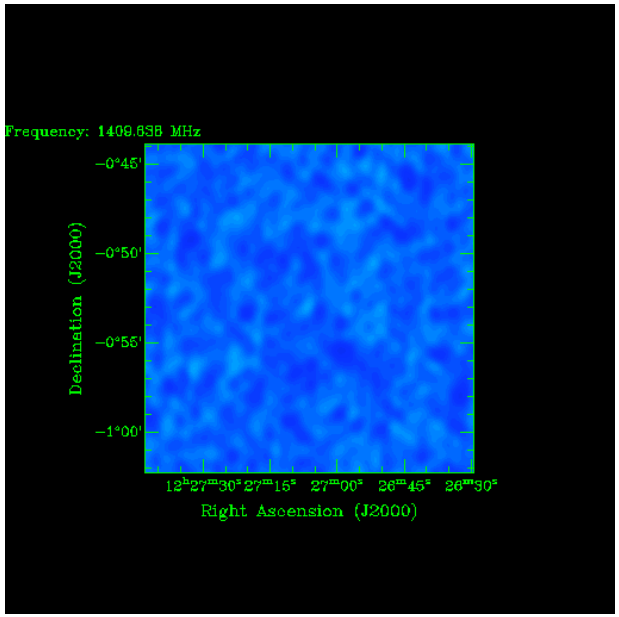


http://www.atnf.csiro.au/computing/software/karma/index.html

make good notes how you determine physical quantities

SAD example





Publish

metadata

history

calibration output

catalogues

VO http://www.euro-vo.org/pub/

CDS http://cdsarc.u-strasbg.fr/

astro-ph don't hide tables people can use them by extracting the tar file

Writing a paper no pipelining for that !