ATLAS
Australia Telescope Large Area Survey

VLBI observations of 96 sources in the
ATLAS/CDFS field

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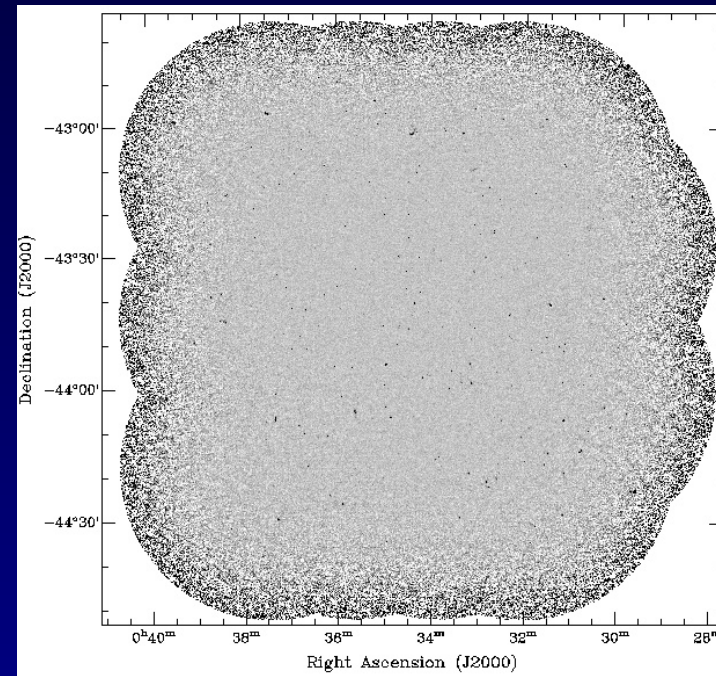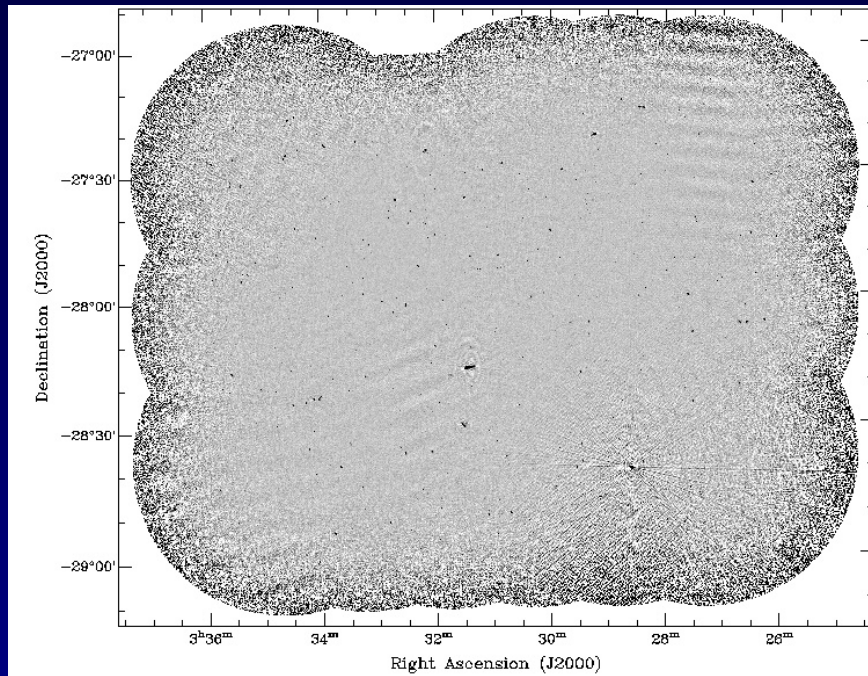Walter Alef
Steven Tingay
Ray Norris
Emil Lenc

ATLAS – Summary

Australia Telescope Large Area Survey:
A study of the evolution of galaxies since z~3
- contributions of AGN and starbursts
- high-z AGN
- radio-FIR relation: function of z / galaxy properties?
- origin of cosmic magnetism
- large-scale cosmic structure
- rare sources
- imaging & techniques

Motivation for a VLBI survey

- source classification
  - where are AGN?
  - do AGN and starbursts frequently occur in the same galaxy?

- pc-scale morphology as a function of z in unbiased sample
  - more or less terra incognita

- technical aspects
  - can we do it?
  - set up computer cluster, software correlator, investigate strategies
  - learn how to deal with huge data volumes

Wide-field effects
(Bridle & Schwab, ASPC, 180, 371)

- Bandwidth smearing (eq. 18-29):
$$I/I_{0,BW} = (1+\beta^2)^{-1}, \text{ with } \beta = \nu_0/\nu * \theta_0/\theta_{FWHM}$$

- Time smearing (eq. 18-43):
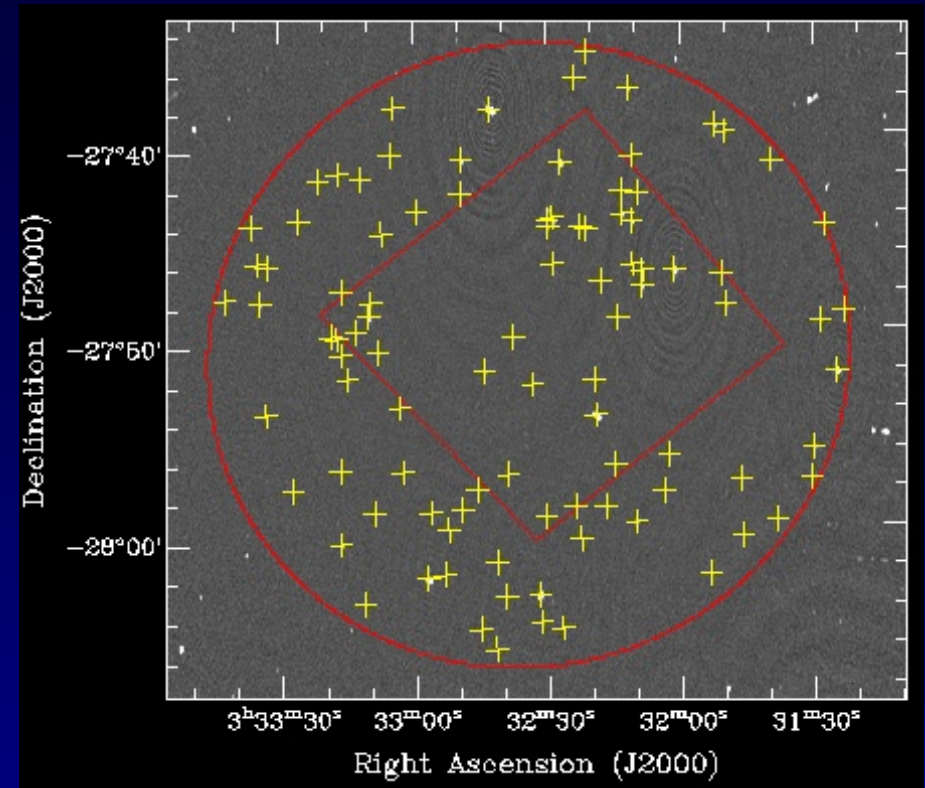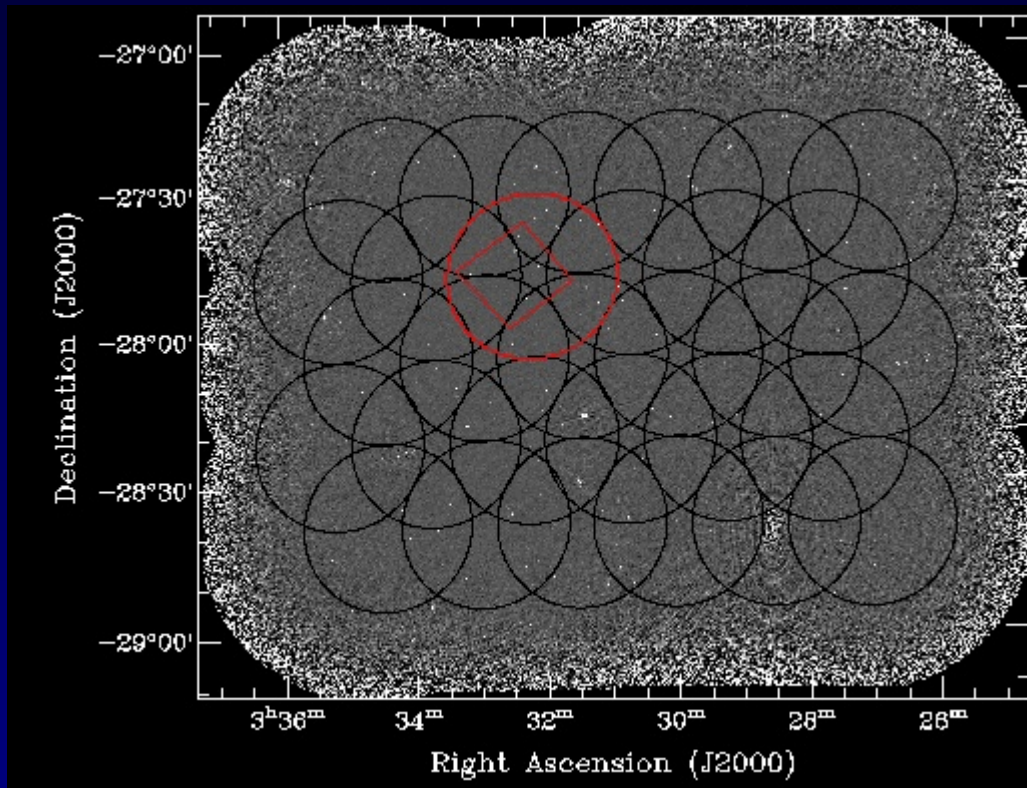$$I/I_{0,t} = 1 - 1.22 \cdot 10^{-9} * (\theta_0/\theta_{FWHM})^2 * \tau^2$$

- Example:
Standard VLBA observation ($\Delta\nu = 500$kHz, $\tau = 2$s), 1' phase centre offset:
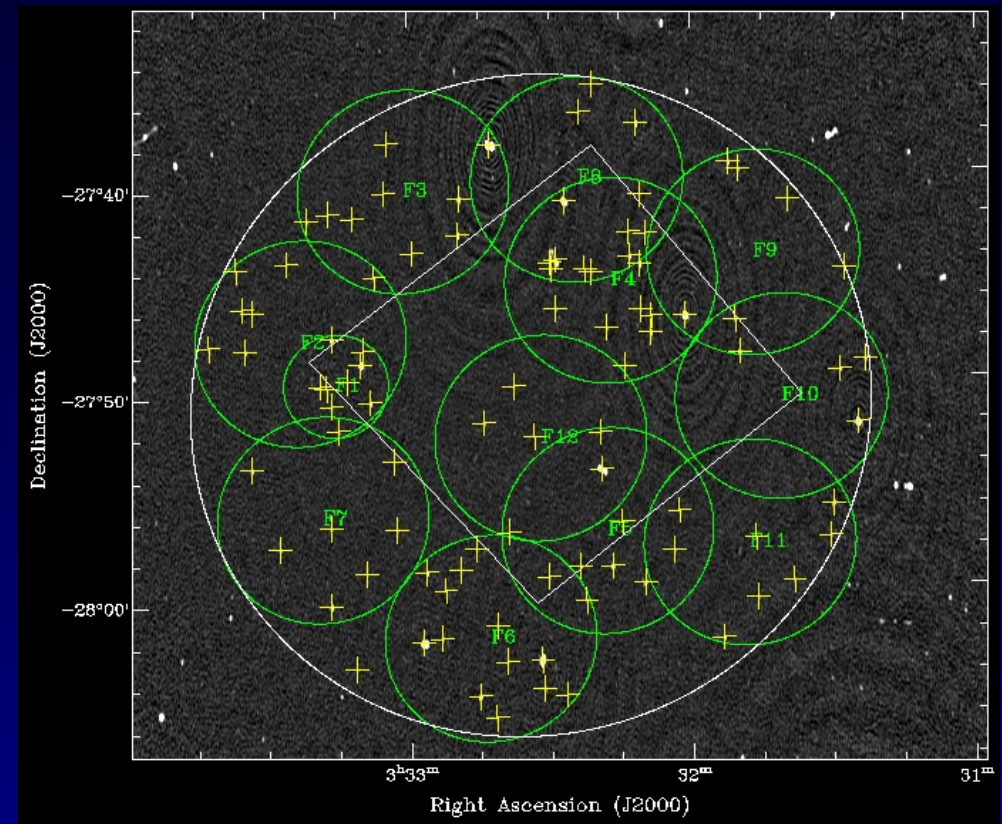$$I/I_{0,BW} = 0.43, \quad I/I_{0,t} = 0.22$$

VLBA observations –
the pilot project

- in July 2007, observed the GOODS/CDFS with the VLBA at 1.4GHz, using 512Mbps recording in 8 dual-pol IFs
- processing on PC cluster at MPIfR in Bonn, using the DiFX software correlator (Deller et al. 2007)
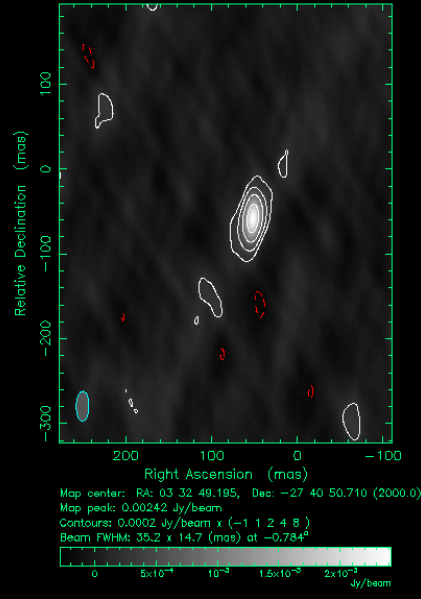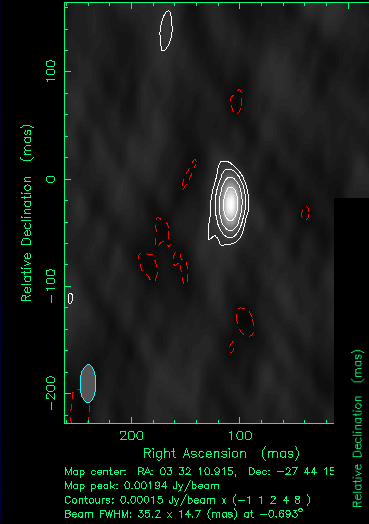
Technical challenges / Strategy

- wide field requires high resolution
  - τ=50ms, $\Delta\nu$=4kHz, requires software correlator

- required resolution yields 3TB per 9h of observing
  - need to find other solution

- break correlation down into smaller pieces
  - 250GB/data set, 3TB total

- correlate a field, recompute uvw/phase/delay for each source, average, make an image
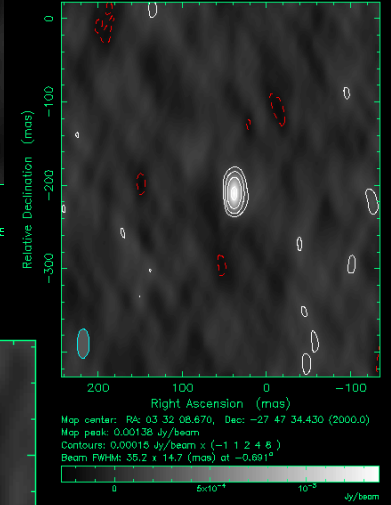
Clean I map. Array: ATLBA
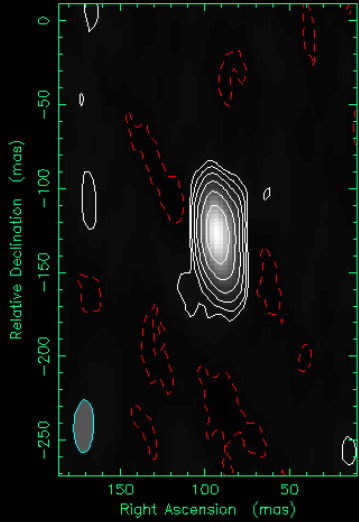FIELD3 at 1.382 GHz 2007 Jul 03

Clean I map. Array: ATLBA
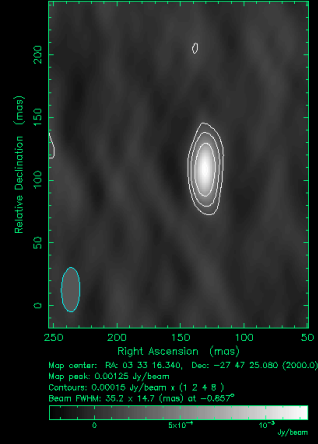FIELD2 at 1.382 GHz 2007 Jul 03

Clean I map. Array: ATLBA
FIELD2 at 1.382 GHz 2007 Jul 03

Clean I map. Array: ATLBA
FIELD4 at 1.382 GHz 2007 Jul 03

Clean I map. Array: ATLBA
FIELD4 at 1.382 GHz 2007 Jul 03

Map center: RA: 03 33 10.191, Dec: −27 48 42.060 (2000.0)
Map peak: 0.011 Jy/beam
Contours: 0.0002 Jy/beam x (−1 1 2 4 8 16 32)
Beam

Map center: RA: 03 33 16.340, Dec: −27 47 25.080 (2000.0)
Map peak: 0.00125 Jy/beam
Contours: 0.00015 Jy/beam x (1 2 4 8)
Beam FWHM: 35.2 x 14.7 (mas) at −0.857°

Map center: RA: 03 32 49.195, Dec: −27 40 50.710 (2000.0)
Map peak: 0.00242 Jy/beam
Contours: 0.0002 Jy/beam x (−1 1 2 4 8)
Beam FWHM: 35.2 x 14.7 (mas) at −0.784°

Map center: RA: 03 32 10.915, Dec: −27 44 15
Map peak: 0.00194 Jy/beam
Contours: 0.00015 Jy/beam x (−1 1 2 4 8)
Beam FWHM: 35.2 x 14.7 (mas) at −0.693°

Map center: RA: 03 32 08.670, Dec: −27 47 34.430 (2000.0)
Map peak: 0.00138 Jy/beam
Contours: 0.00015 Jy/beam x (−1 1 2 4 8)
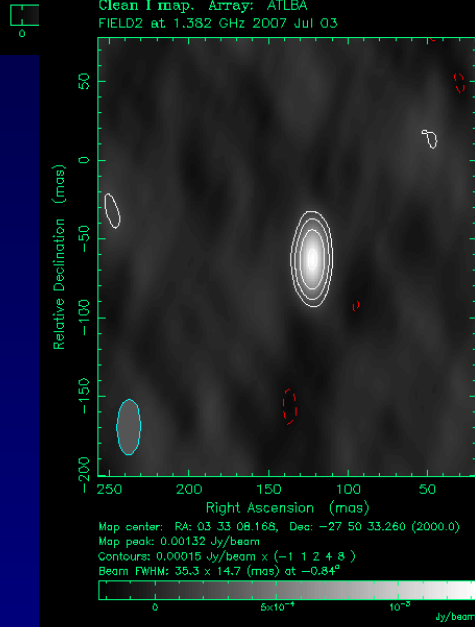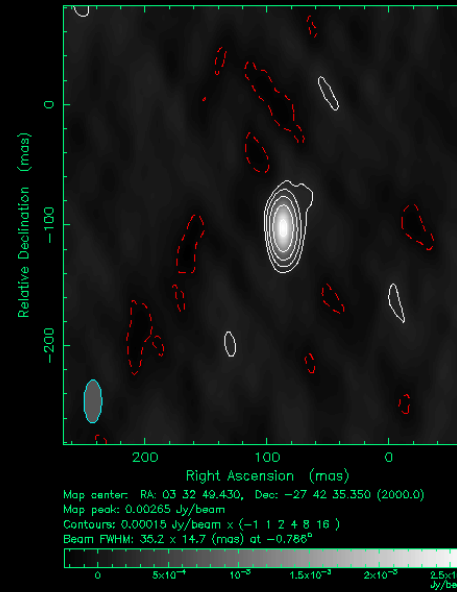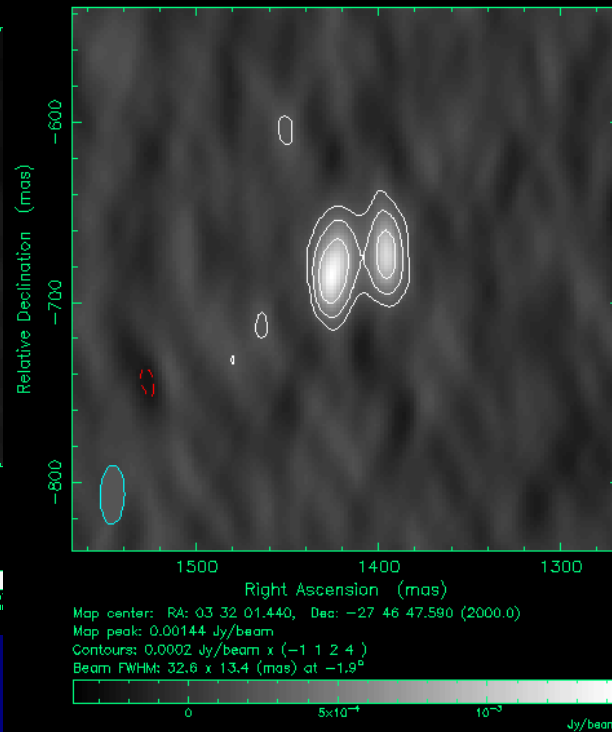Beam FWHM: 35.2 x 14.7 (mas) at −0.691°

Clean I map. Array: ATLBA
FIELD2 at 1.382 GHz 2007 Jul 03

Clean I map. Array: ATLBA
FIELD3 at 1.382 GHz 2007 Jul 03

Clean I map. Array: ATLBA
FIELD4 at 1.382 GHz 2007 Jul 03

Map center: RA: 03 33 08.168, Dec: −27 50 33.260 (2000.0)
Map peak: 0.00132 Jy/beam
Contours: 0.00015 Jy/beam x (−1 1 2 4 8)
Beam FWHM: 35.3 x 14.7 (mas) at −0.84°

Map center: RA: 03 32 49.430, Dec: −27 42 35.350 (2000.0)
Map peak: 0.00265 Jy/beam
Contours: 0.00015 Jy/beam x (−1 1 2 4 8 16)
Beam FWHM: 35.2 x 14.7 (mas) at −0.786°

Map center: RA: 03 32 01.440, Dec: −27 46 47.590 (2000.0)
Map peak: 0.00144 Jy/beam
Contours: 0.0002 Jy/beam x (−1 1 2 4)
Beam FWHM: 32.6 x 13.4 (mas) at −1.9°
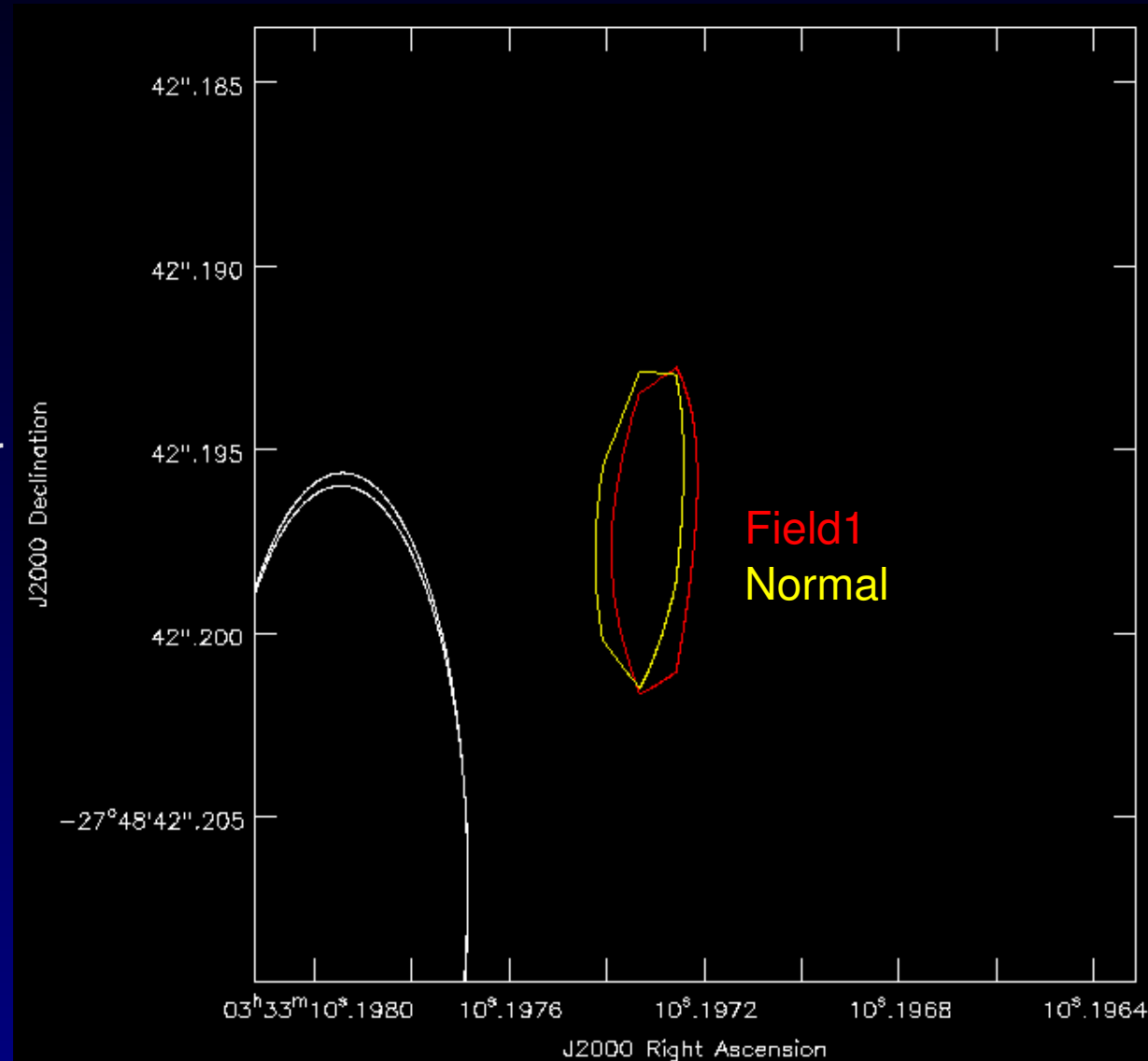
Status of the project

- Processed 3 sub-fields, 44 sources imaged, 8 detected (18%)

- Most sources are point-like, only few have substructure

- Annoying position error, common in Aips and Casapy
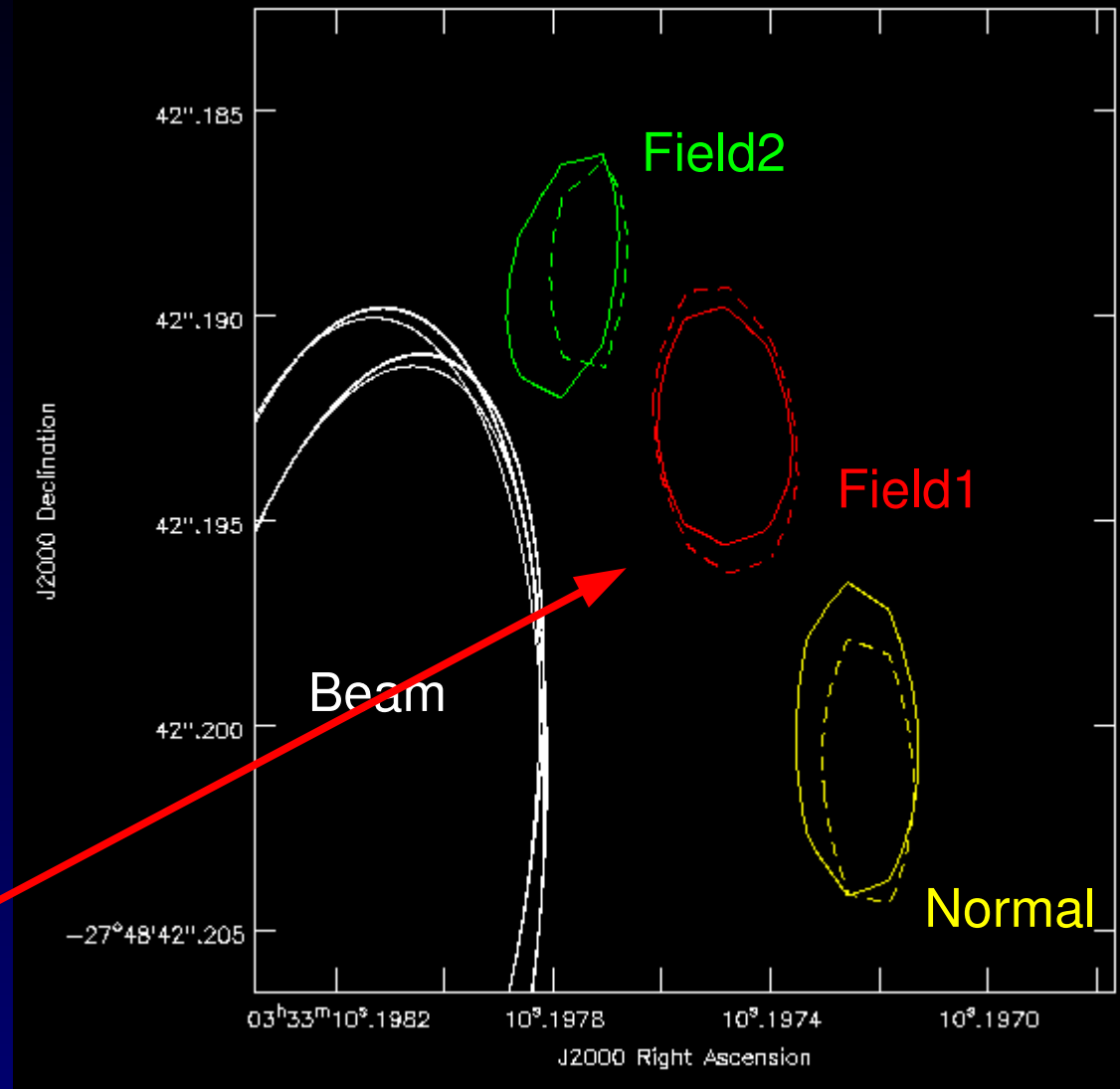
Contour plot of S503 made in three different ways, using Aips and Casapy

Status of the project

- New additions to DiFX resolve the problem

- New way to calculate uvw from Calc9 delays

- Correlate once, shift+average in FITS file creation

- Position inconsistencies of order 1/5...1/5 of beam

Status of the project

- About to redo correlation & processing of pilot

- Calibrator survey completed in March to prepare for survey: 10 sources enable 17 pointings

- Survey as much of ATLAS/CDFS as possible (requires ~20 runs, or 180h)

Summary

- Wide-field VLBI is about to become manageable
- requires some effort
- requires big disks