

# The DiFX Software Correlator at IRA and Italian VLBI

John Morgan

Institute of Radio Astronomy, Bologna

IRA Coffee Talk  
28 March 2008

- 1 Correlators
- 2 Managing the Software Correlator
- 3 Italian VLBI
- 4 First Correlation

# Correlation: From Broadband to UV Data

We start with Broadband data (Mark 5 for VLBI)

- 1 file per antenna per scan

After correlation we have UV data (fits file)

- time
- baseline
- (IF)
- (channel)
- (polarisation)

We also have to manage other data such as  $T_{sys}$ , *Earth Orientation Parameters*, etc.

## Correlation: From Broadband to UV Data

We start with Broadband data (Mark 5 for VLBI)

- 1 file per antenna per scan

After correlation we have UV data (fits file)

- time
- baseline
- (IF)
- (channel)
- (polarisation)

We also have to manage other data such as  $T_{sys}$ , *Earth Orientation Parameters*, etc.

# Correlators

Traditionally these steps are done by a hardware correlator

- Hardware correlators are still a common approach
- Telescopes:
  - ALMA
  - EVLA and e-MERLIN
- VLBI
  - Bonn
  - JIVE
  - VLBA

# Correlators

Traditionally these steps are done by a hardware correlator

- Hardware correlators are still a common approach
- Telescopes:
  - ALMA
  - EVLA and e-MERLIN
- VLBI
  - Bonn
  - JIVE
  - VLBA

# Software Correlators

Software Correlators becoming more popular

- LOFAR
  - IBM blue gene
  - Ranked 37 in the world

There are also software correlators that run on consumer hardware:

- We are using DiFX
  - Developed at Swinburne, Australia
  - Allows any x86 cluster to be used as a correlator
  - Many groups are exploring its potential
    - Bologna
    - Cagliari
    - Bonn
    - NRAO

# Software Correlators

Software Correlators becoming more popular

- LOFAR
  - IBM blue gene
  - Ranked 37 in the world

There are also software correlators that run on consumer hardware:

- We are using DiFX
  - Developed at Swinburne, Australia
  - Allows any x86 cluster to be used as a correlator
  - Many groups are exploring its potential
    - Bologna
    - Cagliari
    - Bonn
    - NRAO

# Advantages of Software Correlation

- No hardware constraints on number of channels or integration time
  - Spectral-line VLBI
  - Wide-field VLBI
- Speed of correlation is only limited by computing power available
  - e-VLBI is possible if the correlator is real-time
- DiFX also has a pulsar binning mode
- Several correlations can be done with different parameters
  - Can correlate the calibrator first
  - Can correlate several times shifting the centre of the field

# Managing the Correlation

- Correlation itself is extremely simple

But

- There are lots of inputs which have to be handled

Our system is based on the NRAO-DiFX pipeline

- Collection of software tools
- Designed to give identical output to the VLBA Correlator
- However VLBA observations use different control files

# Managing the Correlation

- Correlation itself is extremely simple

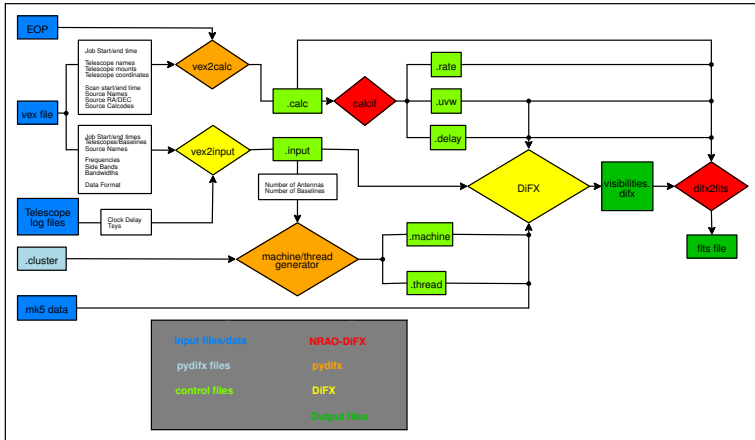
But

- There are lots of inputs which have to be handled

Our system is based on the NRAO-DiFX pipeline

- Collection of software tools
- Designed to give identical output to the VLBA Correlator
- However VLBA observations use different control files

# Managing the Correlation



# Managing the Correlation

- Control the process using python scripts
  - Can access AIPS tasks via ParselTongue
  - casa also has a python interface
- Can control the entire process from broadband data to imaging in a single script
- Correlation is just another step in the data reduction process

# Managing the Correlation

- Control the process using python scripts
  - Can access AIPS tasks via ParselTongue
  - casa also has a python interface
- Can control the entire process from broadband data to imaging in a single script
- Correlation is just another step in the data reduction process

# Italian VLBI

- Once the SRT is built there will be 4 Italian dishes
  - Sardinia
  - Medicina
  - Noto
  - Matera
- All will be fibre linked
  - Medicina has already participated in international e-VLBI experiments
- It should be possible to do Italian VLBI
- The only thing missing is the correlator

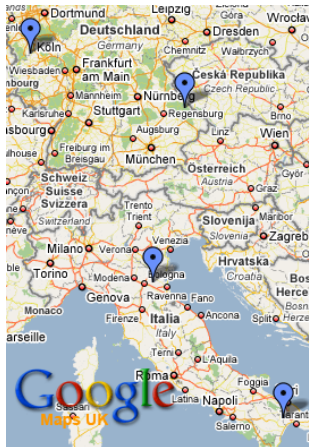
# Italian VLBI

- Once the SRT is built there will be 4 Italian dishes
  - Sardinia
  - Medicina
  - Noto
  - Matera
- All will be fibre linked
  - Medicina has already participated in international e-VLBI experiments
- It should be possible to do Italian VLBI
- The only thing missing is the correlator

# Italian VLBI

- Once the SRT is built there will be 4 Italian dishes
  - Sardinia
  - Medicina
  - Noto
  - Matera
- All will be fibre linked
  - Medicina has already participated in international e-VLBI experiments
- It should be possible to do Italian VLBI
- **The only thing missing is the correlator**

# Is it feasible to do our own correlation?



- We scheduled a 4 station VLBI experiment
  - Observed in December 2007
    - Effelsberg
    - Wettzell
    - Medicina
    - Matera
  - 3 hour observation
  - $4 \times 8$  MHz bandwidth
  - $4 \times 8$  Mbit/s
  - $\sim 100$ GB per station

## Results

- With our (modest) test cluster
  - 4 machines with 2 × Intel Xeon 3GHz CPU
  - 4 machines with 2 × Dual Core AMD Opteron 270 2 GHz CPU
  - total of 24 cpu cores
- We can correlate a 6 minute observation in around 8 minutes
- 75% real time
- A 4 station real time correlator would cost ~€1000s

## Results

- With our (modest) test cluster
  - 4 machines with 2 × Intel Xeon 3GHz CPU
  - 4 machines with 2 × Dual Core AMD Opteron 270 2 GHz CPU
  - total of 24 cpu cores
- We can correlate a 6 minute observation in around 8 minutes
- 75% real time
- A 4 station real time correlator would cost ~€1000s

## Results

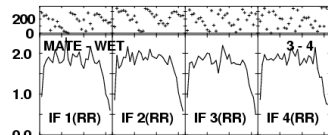
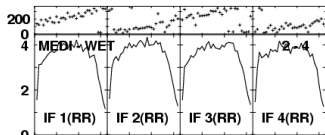
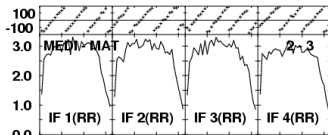
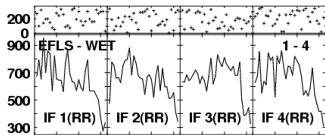
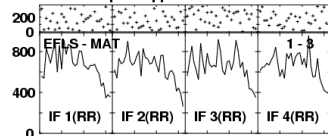
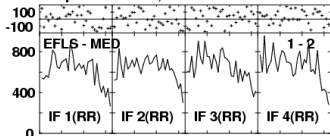
- With our (modest) test cluster
  - 4 machines with 2 × Intel Xeon 3GHz CPU
  - 4 machines with 2 × Dual Core AMD Opteron 270 2 GHz CPU
  - total of 24 cpu cores
- We can correlate a 6 minute observation in around 8 minutes
- 75% real time
- A 4 station real time correlator would cost ~€1000s

# Fringes

Plot file version 1 created 11-MAR-2008 12:07:27

IRACORR1.UVDFX4.1

Freq = 8.4055 GHz, Bw = 8.000 MH No calibration applied and no bandpass applied



Lower frame: Micro Ampl Jy Top frame: Phas deg  
 Scalar averaged cross-power spectrum Several baselines displayed  
 Timerange: 00/05-50:25 to 00/05-51:25

## Next Steps

In the future:-

- Continue with the data reduction process
- We do intend to get real science from our data
- Experiment with advanced techniques

## References



Deller, Tingay, Bailes & West

DiFX: A Software Correlator for Very Long Baseline Interferometry Using Multiprocessor Computing Environments  
[PASP](#), 119, 318 2006



Walter Brisken

A Guide to Software Correlation Using NRAO-DiFX Version 1.0

<http://www.aoc.nrao.edu/~wbrisken/NRAO-DiFX-1.0/NRAO-DiFX-UserGuide.pdf>