The DiFX Software Correlator at IRA: Latest Developments

John Morgan

Istituto di Radioastronomia, Bologna, Italy

Estrela Meeting
Bologna
January 2009

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)
- Also have to model the Earth's rotation.
- We also have to manage other data such as T_{sys}

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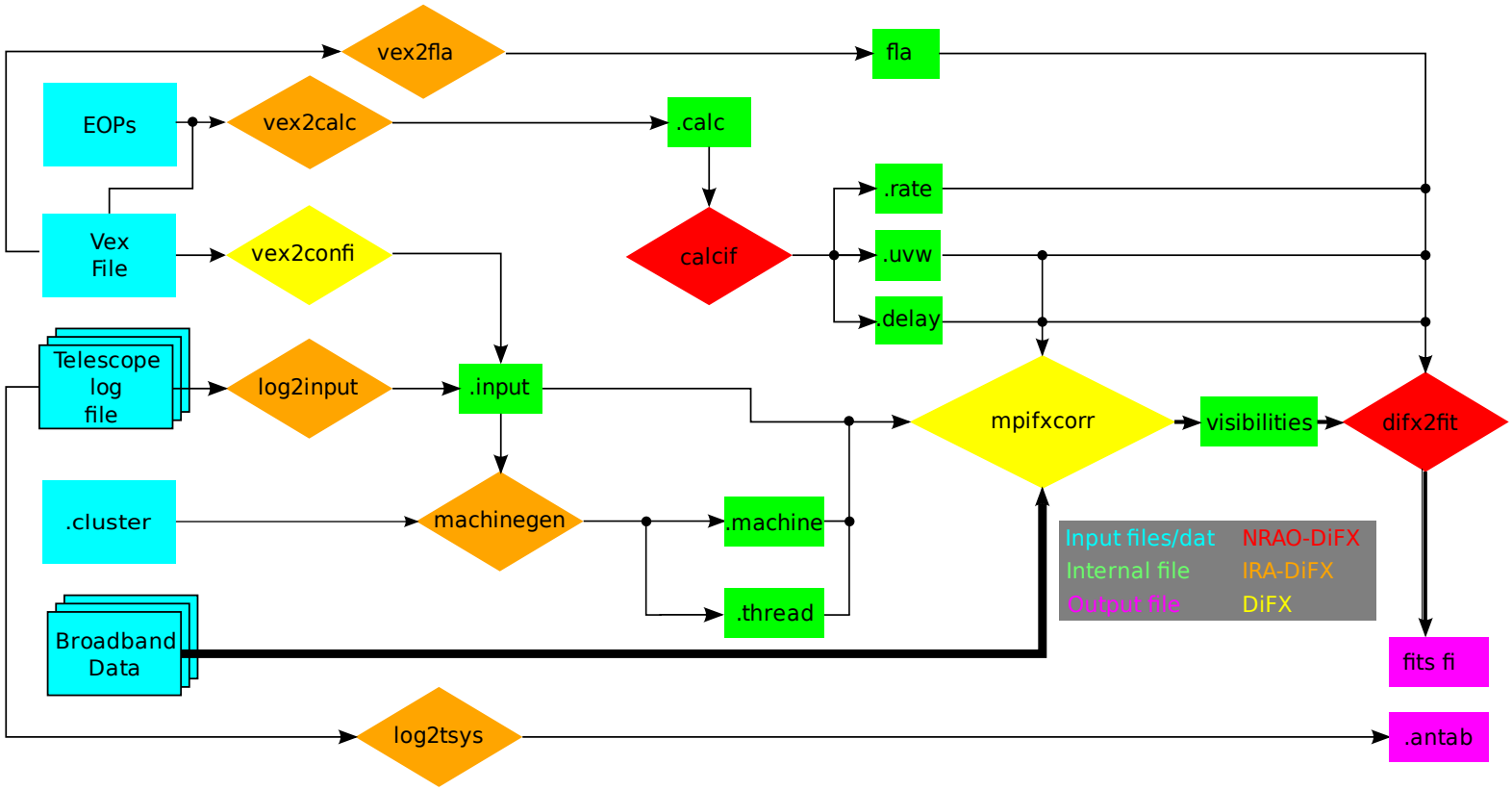
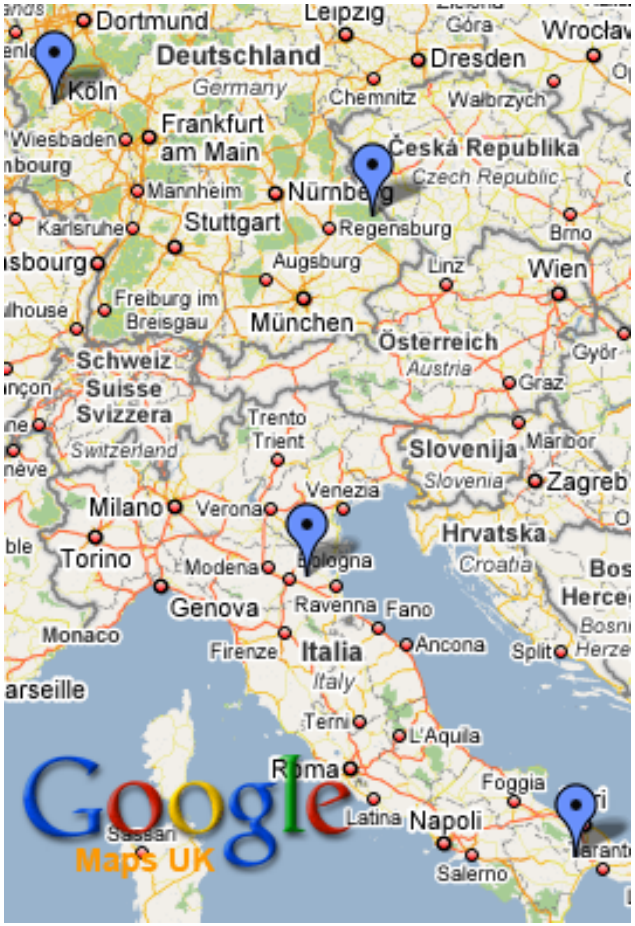
An Overview of the Software Correlator

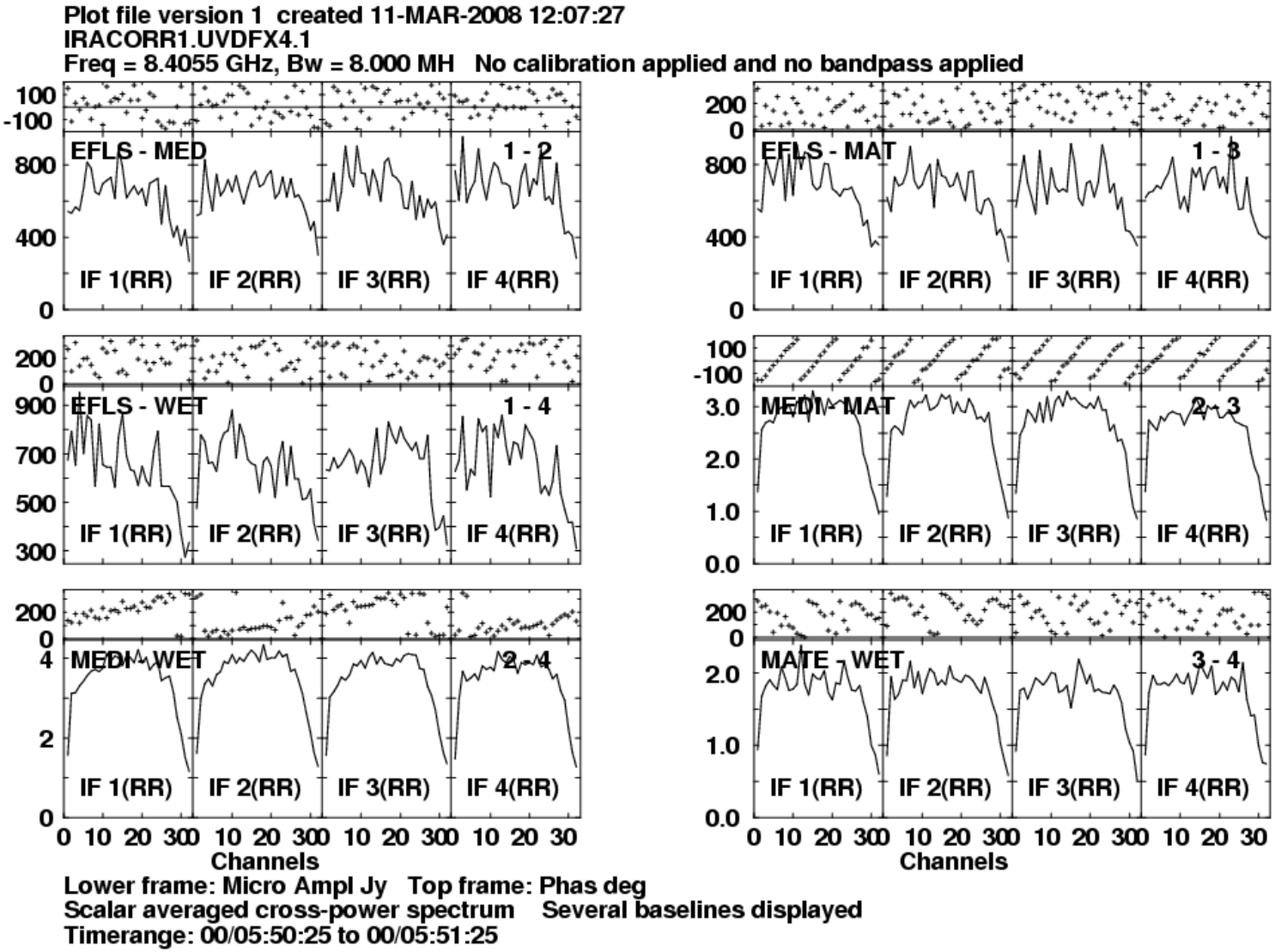


First Correlation



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

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
EFLS - MED
1 - 2
EFLS - MAT
1 - 3
EFLS - WET
1 - 4
MEDI - MAT
2 - 3
MEDI - WET
2 - 4
MATE - WET
3 - 4
IF 1(RR)
IF 2(RR)
IF 3(RR)
IF 4(RR)
Channels
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

Correct at the sub-integration level:

- Correlator correlates small chunks of data ($\sim \mu S$)
- These are then averaged.

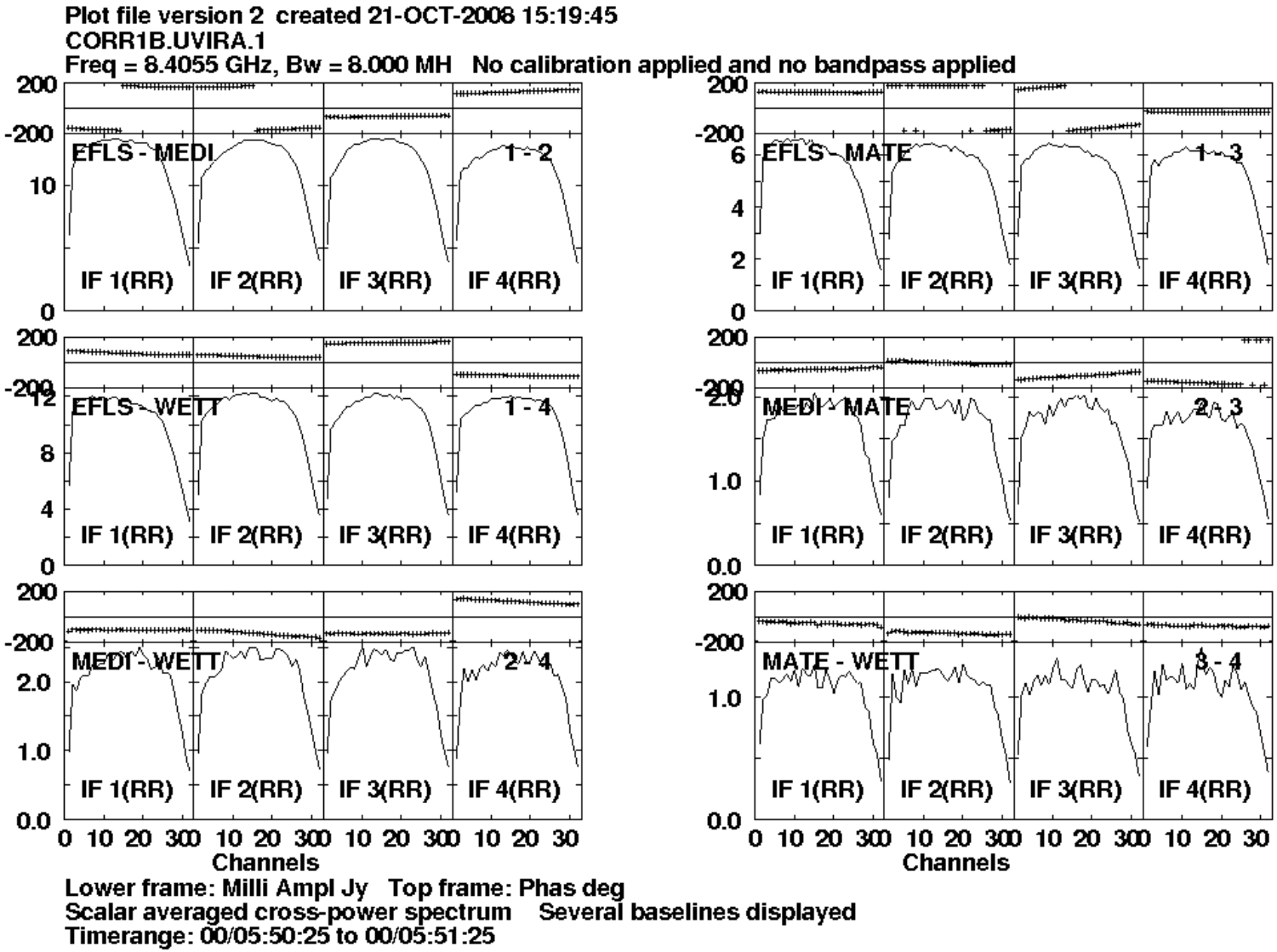
Can adjust the phase at this stage

Modifying the correlator


```
if(LOOffset != 0.0)
{
  //Correct for an offset frequency

  timesec = offsetseconds + (offsetns/1e9)
            + (index*2.0*numchan*samptime) / 1e6);
  LOOffsetPhase = TWO_PI*((timesec * LOOffset)
                          - int(timesec * LOOffset));
  status = vectorAddC_f32_I(LOOffsetPhase,
           fracmult, numchannels+1);
}
```

Fringes


Plot file version 2 created 21-OCT-2008 15:19:45
CORR1B.UVIRA.1
Freq = 8.4055 GHz, Bw = 8.000 MH No calibration applied and no bandpass applied
EFLS - MEDI
1 - 2
EFLS - MATE
1 - 3
EFLS - WETT
1 - 4
MEDI - MATE
2 - 3
MEDI - WETT
2 - 4
MATE - WETT
3 - 4
IF 1(RR)
IF 2(RR)
IF 3(RR)
IF 4(RR)
Channels
Lower frame: Milli Ampl Jy Top frame: Phas deg
Scalar averaged cross-power spectrum Several baselines displayed
Timerange: 00/05:50:25 to 00/05:51:25

- We have 3 sources within 30 arc seconds
- One is associated with a quasar

Sources

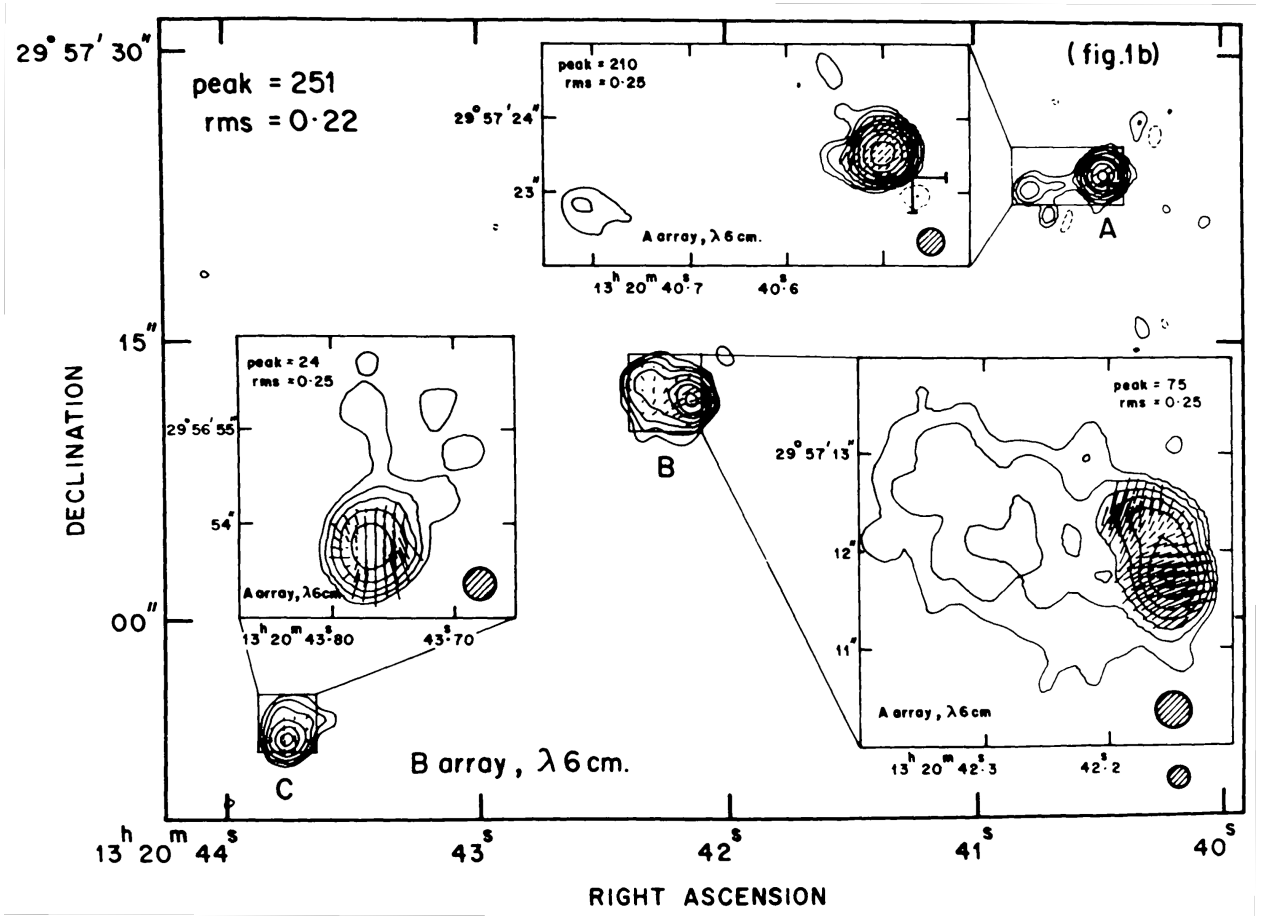
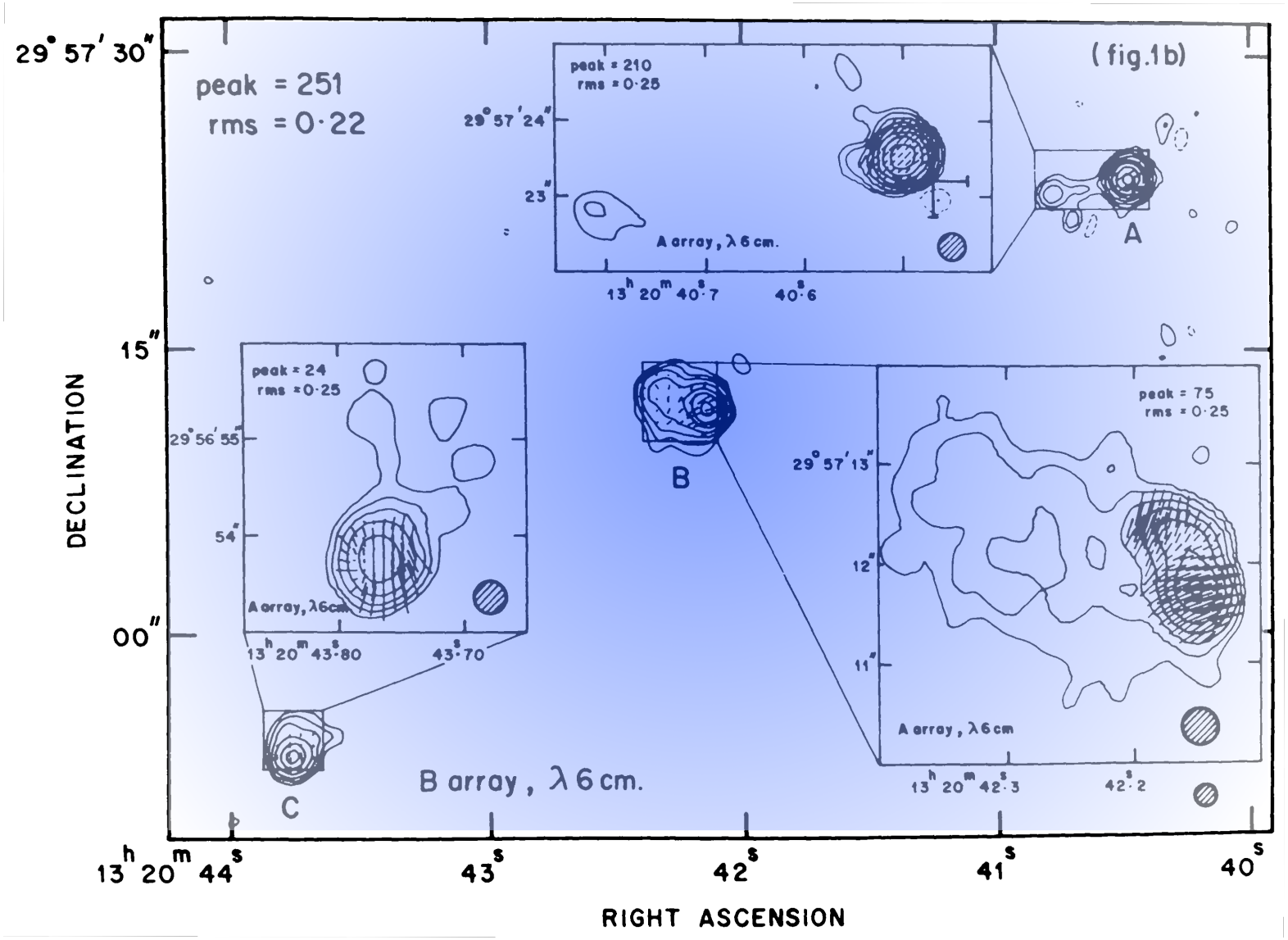


Figure: Cornwell et al 1986

Sources


29° 57′ 30″
peak = 251
rms = 0·22
peak = 210
rms = 0·25
29° 57′ 24″
23″
A array, λ 6 cm.
13h 20m 40·7
40·6
(fig.1b)
A
15″
peak = 24
rms = 0·25
29° 56′ 55″
54″
A array, λ6cm
13h 20m 43·80
43·70
B
peak = 75
rms = 0·25
29° 57′ 13″
12″
11″
A array, λ 6 cm
13h 20m 42·3
42·2
C
B array, λ 6 cm.
00″
DECLINATION
13h 20m 44s
43s
42s
41s
40s
RIGHT ASCENSION

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- One is associated with a quasar

Data Reduction

Three techniques to compare:

- Correlating with different phase centres
- Direct Widefield Imaging
- Correlating, transforming and averaging

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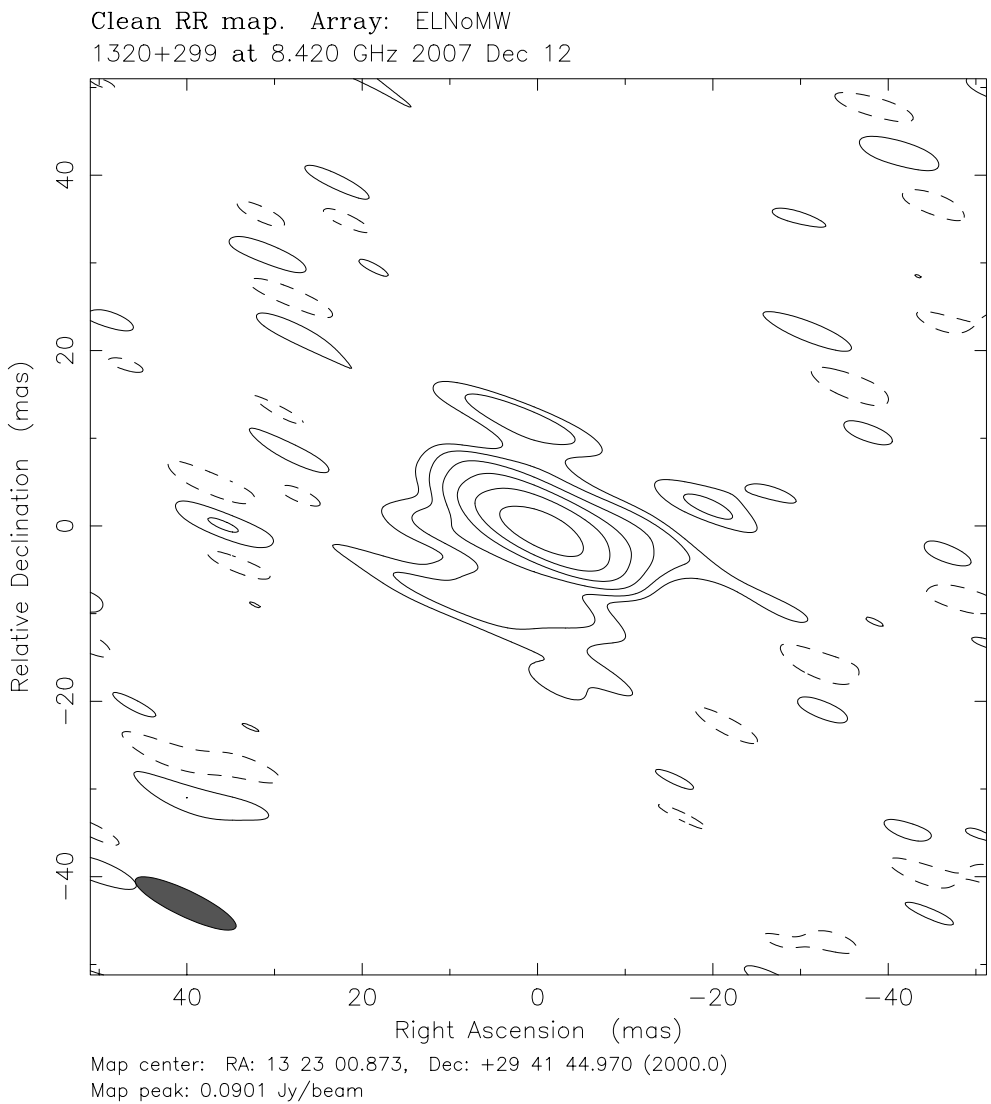

Other projects

- Observations
  - Venus Express Occultation
  - 22 GHz Survey
  - Northern Cross and LOFAR
- Software Development
  - Geodesy
  - Pulsar Gating

Venus Express Occultation

- On December 1st Venus was occulted by the Moon
  - Grazing occultation in Noto
- Non trivial to correlate since the target is in the optical near-field

Northern Cross (BEST2) and LOFAR

- Real LOFAR data is very unwieldy
  - Hundreds of sub-bands
  - Thousands of channels
  - Just holding a single time integration in memory is difficult.
- We have a simpler goal:
- Use a smaller band and treat as VLBI data.

Northern Cross (BEST2) and LOFAR

After beam-forming the data isn't so different from normal VLBI data

- (Probably) offline
- Pack the raw data in Mark 5 format
- (with timing information)

As far as the correlator is concerned this is a normal VLBI observation.

Software Development

Software development is required to make DiFX usable for geodetic experiments

- Another output file to be supported
- Phase-cal extraction
- Data validation

Also have VLBI data for crab pulsar observations

- Code already exists for pulsar gating
- Refinement may be required for ms pulsars

Thank you!