mm/submm VLBI
Status and Strategy at IRAM

M. Bremer, M. Torres, S. Sanchez, K.F. Schuster

• The IRAM 30m telescope
• The IRAM PdB Interferometer
• Plans for NOEMA
• Conclusions
**EMIR** a new technology receiver at the IRAM 30m telescope (M. Carter et al)

<table>
<thead>
<tr>
<th>Band</th>
<th>Freq. GHz</th>
<th>Mixer</th>
<th>Tot IF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>83-117</td>
<td>$2P \times 2SB \ 2 \times 8\ GHz$</td>
<td>32 GHz</td>
</tr>
<tr>
<td>2</td>
<td>129-174</td>
<td>$2P \times SSB \ 1 \times 4\ GHz$</td>
<td>8 GHz</td>
</tr>
<tr>
<td>3</td>
<td>200-267</td>
<td>$2P \times SSB \ 1 \times 4\ GHz$</td>
<td>8 GHz</td>
</tr>
<tr>
<td>4</td>
<td>260-360</td>
<td>$2P \times 2SB \ 2 \times 4\ GHz$</td>
<td>16 GHz</td>
</tr>
</tbody>
</table>

- Baseline mode: one band, Dual Pol
- Dual modes via dichroic plate (aka FSS):
  - $B1 + B3$ both dual pol
  - $B2 + B4$ “
  - $B1 + B2$ “
- Loss due to dichroic plate: <5% specification; <2% goal.
Room Temperature Optics

Diagram showing optical components labeled as CAR2, CAR1, AL2, MC1a, MC1b, MC2a, MC2b, W1, W2, W3, W4, MR3, MR4, D12, D24, MR34, D13.
B3 alone
B1 + B3 Cal Cold
$B1 + B2$
Noise Performance

Band 1

SSB noise temperature (K) vs. Freq (GHz)

Band 2

SSB noise temperature (K) vs. Freq (GHz)

Band 3

SSB noise temperature (K) vs. Freq (GHz)

Band 4

SSB noise temperature (K) vs. Freq (GHz)
EMIR had first light in March 09
EMIR Clover Leaf
only one polarization!

EMIR/IRAM–30m RT
32 GHz Spectrum of OriIRC2
WILMA Correlator / Wobbler Switched
30m: Current VLBI Equipment, ongoing and future work

- Maser & BBC + Mark 5a Recorder
- Ref Synth Racal-Dana will be replaced by R&S
- Switching from normal ref syth to VLBI ref will be simplified.
- Seek to increase bandwidth of web connection to Pico for rapid data transfer.
- Study on possible atm phase correction.
The Receivers
PdBI: Current VLBI Equipment, ongoing and future work

• Efos 38 Maser- Mark 5a recorder and BBC
• RS ref synthesizer
• Phasing of total 250 MHz bandwidth, 16 subbands 16MHz
• Receivers currently cover 3mm, 2mm and 1.3mm band in 4GHz SSB dual polarization.

• Change in Phase ref freq to 14 GHz to improve phase noise
• Installation of 350 GHz band (ALMA type 2SB)
• Some work on ¼ wave plate improvements (need precise freq)
• Work on atm phase correction schemes (existing 22 GHz systems)
The NOEMA Project

- Double the number of 15 m antennas from 6 to 12
- Extension of the Baselines from 0.8 to 1.6 km
- Increase of IF bandwidth from 8 GHz to 32 GHz
The Antennas

With aluminum panels 2-year cycle for indoor maintenance is envisaged.
The Receivers
LO Phase Reference Signal, IF transport

- IF transport by analog fiber optic link
  - Copper Coaxial Cable
  - 1.67-2.01 GHz
  - 0.5 MHz
  - 100 MHz
  - HP LP Diplexer
  - HP LP Diplexer
  - YIG
  - 13.4-16.1 GHz
  - > +20 dBm

LO System III
M.T. Feb 2007 rev Mar 09
NOEMA Backends

Signal electronics (one per antenna IF)

Product electronics (one per IF)

DSB IF proc & digitizer

1st Nyquist Window

3.9 GHz LPF

A

D

1 : 4

1 : 8

layers

Demux

Polyphase Tunable Filter Bank

256 MHz

32 ms refreshed coefficients for fractional delay

Wideband Correlator

Fixed resolution (2MHz) spectral correlator

multibit ASIC 2x256 lags
33 chips per board
2 streams per board
16 boards total
32 msec integration time

Multiplies

integrates 32 ms and calculates
8x4096x66 complex products

dumps every 32 msec

Fourier Processor

8 FP’s
4096 ch.
256MHz
16 μsec

Software

TRIPLE HYBRID DIGITAL BACKEND
project for 12 antennas on PdBl

( for the year 201X )
draft version #2
MT Dec 2008
Some Remarks on VLBI with NOEMA

• Submm operation of NOEMA requires winter conditions, this will be the time when the array is in extended configuration (A). Atm. Phase correction will be important.

• Phasing of NOEMA requires a clear plan for direct digital interfacing between backend and recorders.

• This means we need a roadmap for recorder bandwidths and well defined data formats.

• Although so far an extension option, phasing NOEMA can probably be included in a very early stages if these conditions are fulfilled.

• What about dual band VLBI?
Conclusions

• IRAM is ready for high sensitivity 100, 150 and 230 GHz VLBI and runs a continuous effort to improve on the setup.

• 350 GHz at the 30m is available now, 350 GHz upgrade of PdBI is foreseen for fall 2010.

• For the time being no increase of PdBI phased BW is foreseen.

• NOEMA will include requirements for VLBI if a clear roadmap is available.

• IRAMs partner ask for a transparent and efficient VLBI organization with clear technical and science goals.