Using the Plateau de Bure Interferometer

Jan Martin Winters

IRAM, Grenoble
Why should you use the Plateau de Bure Interferometer?

Because the signal is weak…
… and PdBI is sensitive!

Well,….. Yes.
But now there’s ALMA!

PdBI is on the northern hemisphere…
and
the pressure factor is only about 3!

C$^+$ at 256.17GHz in J1148+5251 @ z = 6.42

Walter et al. 2009 (Nature 457, 699)

Spectrum: 3.5hrs in D-configuration

11hrs in D with WideX

Maiolino et al. 2012 (MNRAS 425, L66)
Proposal tech-sheet

IRAM Plateau de Bure Interferometry: Proposal Technical Summary

- **Category and Project type:** [Enter text here]
- **Source position and velocity:**
  - Source: [Enter text here]
  - RA: [Enter text here]
  - DEC: [Enter text here]
  - Velocity: [Enter text here]
  - Velocity: [Enter text here]
- **For all projects (detection, mapping, mosaic, and snapshot):**
  - Calibration required: [Enter text here]
  - No. of tracks required: [Enter text here]
  - Observation time requested (in hours): [Enter text here]
  - Team size: [Enter text here]
- **For Mosaic projects:**
  - Field positions: [Enter text here]
- **Size of target structure (in arcseconds):** [Enter text here]
- **Continuum part:**
  - Expected continuum flux in Jy
  - Expected continuum source size (arcsec)
  - Preferred observing frequency (for continuum projects)
- **For line projects:**
  - Initial set of frequencies (in GHz) (to enter power in GHz)
  - Expected width of spectral line (in km s⁻¹)
  - Declared frequency: [Enter text here] GHz

Point source sensitivity

\[
\delta S = \frac{2k}{\eta_a A \cdot \eta_j \eta_C} \cdot \frac{\langle T_{sys} \rangle}{\eta_p \sqrt{N(N-1)} \sqrt{\delta \nu} \ t_{on}} \cdot \frac{1}{\sqrt{N_{pol}}}
\]

- \(A\): collecting area of a single antenna (176.7m\(^2\))
- \(\eta_a\): aperture efficiency (0.80 @ 3mm, 0.75 @ 2mm, 0.65 @ 1mm)
- \(\eta_j\): instrumental decorrelation \( \eta_j = e^{-\sigma_j^2/2} \) (0.90 to 0.98)
- \(\eta_C\): correlator efficiency (\(\eta_C = 0.88\))
- \(k\): Boltzmann constant
- \(\langle T_{sys} \rangle\): average system temperature [K]
- \(\eta_p\): atmospheric decorrelation \( \eta_p = e^{-\sigma_p^2/2} \) (0.6 to 0.98)
- \(N\): Number of antennas (5 or 6)
- \(\delta \nu\): Spectral Bandwidth [Hz] (39kHz to 2.5MHz, 2MHz to 3.6GHz)
- \(t_{on}\): On-source integration time [s], \(t_{obs} = 1.6 \ t_{on}\)
- \(N_{pol}\): Number of polarizations (1 or 2)

\[
\frac{2k}{\eta_a A \cdot \eta_j \eta_C} = J_{pk}: \text{Conversion factor Kelvin to Jansky}
\]

- 22 Jy/K @ 3mm, 26 Jy/K @ 2mm,
- 35 Jy/K @ 1mm, 45 Jy/K @ 0.8mm
Sensitivity (II)

Expected point source continuum sensitivities in one hour with WideX:

- @ 100 GHz in a FOV of 50"
  \[
  \approx 22 \cdot \frac{90}{0.90 \cdot 0.88 \cdot \sqrt{30} \cdot 3600 \cdot 10^6 \cdot 3600 \sqrt{2}} \cdot \frac{1}{\sqrt{2}} \approx 0.09 \text{ mJy/beam}
  \]

- @ 150 GHz in a FOV of 33"
  \[
  \approx 26 \cdot \frac{130}{0.85 \cdot 0.88 \cdot \sqrt{30} \cdot 3600 \cdot 10^6 \cdot 3600 \sqrt{2}} \cdot \frac{1}{\sqrt{2}} \approx 0.16 \text{ mJy/beam}
  \]

- @ 230 GHz in a FOV of 21"
  \[
  \approx 35 \cdot \frac{160}{0.80 \cdot 0.88 \cdot \sqrt{30} \cdot 3600 \cdot 10^6 \cdot 3600 \sqrt{2}} \cdot \frac{1}{\sqrt{2}} \approx 0.29 \text{ mJy/beam}
  \]
The brightness sensitivity is related to the point source sensitivity by

\[ \delta T = \frac{\lambda^2}{2k\Omega} \cdot \delta S = \rho \frac{\lambda^2}{\Theta_1\Theta_2} \cdot \delta S \]

- \( \delta T \): brightness sensitivity [K]
- \( \lambda \): observing wavelength [mm]
- \( k \): Boltzmann constant
- \( \Omega \): synthesized beam solid angle [sr]
- \( \rho \): \( \approx 15 \) [K Jy\(^{-1}\) (arcsec/mm)\(^{-2}\)]
  for untapered maps and natural weighting
- \( \Theta_1, \Theta_2 \): axes of synthesized beam [arcsec]

**Brightness sensitivity depends on angular resolution!**
Brightness sensitivity (II)

Expected line brightness sensitivities in 8 hours (12h track)

1km/s bandwidth, dual polarization:

- @ 100 GHz in a beam of 1'' × 1'': $\delta T \approx 434\,\text{mK}$
  5'' × 5'': $\delta T \approx 17\,\text{mK}$

- @ 150 GHz in a beam of 0.6'' × 0.6'': $\delta T \approx 916\,\text{mK}$
  3.3'' × 3.3'': $\delta T \approx 30\,\text{mK}$

- @ 230 GHz in a beam of 0.3'' × 0.3'': $\delta T \approx 2000\,\text{mK}$
  2.2'' × 2.2'': $\delta T \approx 40\,\text{mK}$
### Receivers

<table>
<thead>
<tr>
<th>Feature</th>
<th>Band 1</th>
<th>Band 2</th>
<th>Band 3</th>
<th>Band 4</th>
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<tbody>
<tr>
<td>RF range [GHz]</td>
<td>80 - 116</td>
<td>129 - 174</td>
<td>201 - 267</td>
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<tr>
<td>Trec/[K] LSB</td>
<td>40 - 55</td>
<td>30 - 50</td>
<td>40 - 60</td>
<td>30 - 50</td>
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<tr>
<td>Trec/[K] USB</td>
<td>40 - 55</td>
<td>40 - 80</td>
<td>50 - 70</td>
<td>30 - 50</td>
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<td>$G_{im}$ [dB]</td>
<td>-10</td>
<td>-12 … -10</td>
<td>-12 … -8</td>
<td>-20</td>
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<tr>
<td>RF LSB [GHz]</td>
<td>80 - 104</td>
<td>129 - 165</td>
<td>201 - 264</td>
<td>277 - 359</td>
</tr>
</tbody>
</table>
When?

• **Summer:**
  compact configurations (C and D)
  => Low resolution studies, detection experiments
  at 3mm and 2mm,
  only 5 antennas available in D-configuration from May to September/October

• **Winter offers best observing conditions:**
  Best atmosphere (transparency, phase stability)
  All four configurations (compact to extended)
  All 6 antennas available

• **Observations at 1.3mm:** only possible from September to April
• **Observations at 0.8mm:** 2-4 weeks, most likely in Jan/Feb
Sensitivity considerations

• Caution:
  At 115GHz the atmospheric O$_2$ line degrades sensitivity by about 40% already in good observing conditions

• Request a configuration for mapping
  e.g. AB configuration = 2 tracks (8hrs each)
  … but evaluate the sensitivity as well!

• Request a point source sensitivity for detection
  … but evaluate the integration time as well!
The diagram illustrates the atmospheric transmission of water vapor ($H_2O$) and oxygen ($O_2$) at various frequencies. Key frequencies are marked on the x-axis, including 60 GHz, 118 GHz, 183 GHz, 325 GHz, and 380 GHz. The y-axis represents atmospheric transmission, with values ranging from 0 to 1.

- At 22 GHz, the peak transmission is indicated with a width of approximately 3 mm.
- At 60 GHz, the peak transmission is shown with a width of about 2 mm.
- At 183 GHz, the peak transmission is depicted with a width of approximately 1 mm.
- At 368 GHz, the peak transmission is illustrated with a width of around 0.8 mm.

The diagram also highlights the pwv (path water vapor) in millimeters, with values ranging from 0 to 10. The background includes a blue section and text at the bottom indicating the context of the image: Eighth IRAM Millimeter Interferometry School, 15-19 Oct. 2012.
(standard) Observing sequence

**Calibrator 1**
- Bandpass: 2x5sec
- Auto: 1x4sec
- Cali: 2(3)x5sec
- Corr: 3x45sec
- Focus: 5x5sec
- Point: 2x30sec

**Calibrator 2**
- Bandpass: 2x5sec
- Auto: 1x4sec
- Cali: 2x5sec
- Corr: 3x45sec

**Source 1**
- Bandpass: 2x5sec
- Auto: 1x4sec
- Cali: 2x5sec
- Corr: 30x45sec

**Track sharing:**
- Source 1: ~((30/Nsources)x45sec
- Source 2: ~((30/Nsources)x45sec
- Source 3: ~((30/Nsources)x45sec
- Source N: ~((30/Nsources)x45sec

Observing time

\[ t_{\text{tot}} \approx 1.6 \times t_{\text{on}} \]
Has my object already been observed?

- Consult the CDS (Strasbourg)
- Consult the Science Operation Group (SOG; sog@iram.fr)
- The raw data archive is not (yet) public
VizieR Search Page - Mozilla Firefox


Simple Constraint | List Of Targets
Target Name: resolved by Sesame or Position: Clean RS Cnc J2000
Target dimension: 2 arcmin

Simple Constraint | List Of Constraints
Query by Constraints applied on Columns (Output Order: + - ○)

Show | Sort Column | Clear | Constraint | Explain (UCD)
-----|-------------|-------|------------|-----------------------------------------------------
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0 | Nw | | | [11,18] Internal indicator (meta.code)
1 | Prog | (char) | | Identification code of the program (meta.code-obs)
1 | Name | (char) | | Source name, as mentioned in the observing program (meta.id)
The 3 columns in *color* are computed by VizieR, and are **not part of the original data**.


Post annotation The Plateau de Bure Interferometer Observation Log between 1991-12-01 and 2010-03-31 (14955 rows)

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• Four configurations are needed to take properly into account baseline range and operation with 6 antennas

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<th>Configuration</th>
<th>Stations</th>
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<tr>
<td>D</td>
<td>W08 W05 E03 N02 N07 N11</td>
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<tr>
<td>C</td>
<td>W12 W09 E04 E10 N11 N17</td>
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<tr>
<td>B</td>
<td>W27 W12 E12 E23 N20 N46</td>
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<td>A</td>
<td>W27 E04 E24 E68 N29 N46</td>
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• The A and B configurations are scheduled during the winter period only
Which configuration is appropriate?

### Standard sets of configurations are:

<table>
<thead>
<tr>
<th>Set</th>
<th>Purpose</th>
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<tbody>
<tr>
<td>D</td>
<td>5” @ 100 GHz detection/lowest resolution</td>
</tr>
<tr>
<td>CD</td>
<td>3.5” @ 100 GHz</td>
</tr>
<tr>
<td>(C</td>
<td>2.7” @ 100 GHz detection at low declination)</td>
</tr>
<tr>
<td>BC</td>
<td>1.7” @ 100 GHz</td>
</tr>
<tr>
<td>AB</td>
<td>0.95” @ 100 GHz</td>
</tr>
<tr>
<td>A</td>
<td>0.82” @ 100 GHz</td>
</tr>
</tbody>
</table>
D configuration

@100 GHz, HA = -4 to 4 weight NA

 contours 5, 10, 20, 50%
CD configuration

@100 GHz, HA = -4 to 4 weight NA

Dec = 60
Dec = 30
Dec = 0
Dec = -20
A configuration

AB configuration
Correlators (I)

Narrow-Band correlator: 8 units, 2x1GHz, spectral resolution 39kHz-2.5MHz
Correlators (II)

WideX: 4 units, 2x3.6 GHz (dual polar, fixed spectral resolution 2 MHz)
Spectral settings (I)

• Use the ASTRO command LINE:

ASTRO> LINE H2COcent 218.65 LSB

NB:
Spectral settings (II)

• Make use of IF processor and NB correlator flexibility
- NB correlator can process 2 x 1GHz (100MHz to 1100MHz)

**ASTRO> NARROW Q3 Q3**
**NB Correlator Modes**

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<th>Subband</th>
<th>Channels</th>
<th>Spacing</th>
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<td>DSB</td>
<td>2 x 64</td>
<td>2.5 MHz</td>
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<tr>
<td>160 MHz</td>
<td>SSB</td>
<td>1 x 128</td>
<td>1.25 MHz</td>
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<tr>
<td>160 MHz</td>
<td>DSB</td>
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<td>SSB</td>
<td>1 x 512</td>
<td>0.039 MHz</td>
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- Beware of Gibbs Phenomenon: (perturbs the central channels in DSB mode)
- Avoid line in subband center (320, 160, 80)

Spectral settings (III)

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<td>610</td>
<td>/NARROW 1</td>
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<tr>
<td>Astro&gt; SPECTRAL 2</td>
<td>40</td>
<td>775</td>
<td>/NARROW 1</td>
<td></td>
</tr>
<tr>
<td>Astro&gt; SPECTRAL 3</td>
<td>20</td>
<td>925</td>
<td>/NARROW 1</td>
<td></td>
</tr>
<tr>
<td>Astro&gt; SPECTRAL 4</td>
<td>40</td>
<td>1030</td>
<td>/NARROW 1</td>
<td></td>
</tr>
</tbody>
</table>

Can my object be observed at any time? (I)

• Watch the IRAM Web or Newsletter for the submission deadlines

  - March deadline: June 1 to November 30
    Committee meets 2\textsuperscript{nd} half of April

  - September deadline: December 1 to May 31
    Committee meets 2\textsuperscript{nd} half of October

  - Urgent? Submit ToO/DDT proposal (email to ddt@iram.fr)

  - Interested in global 3mm-VLBI observations?
    Two sessions per year:
    5 days in May, 5 days in October
    deadlines: February 1\textsuperscript{st}, August 1\textsuperscript{st}
Can my object be observed at any time? (II)

- **Watch out for sun avoidance period (35°)**
  
  ASTRO> catalogue mysource.sou
  
  ASTRO> horizon /sou
  
  IRC+10216 : Sun distance 61.1 ; avoidance 11-JUL-2013 to 23-SEP-2013

- **Self-calibration on strong (300mJy and more) continuum feasible?** **Ideal time filler for periods where the atmospheric phase stability is poor!**

- **Check declination of the object:**
  
  Galactic center is at the very limit
Observing time

Detection

• Choose compact configuration
  - lower phase noise
  - source is unresolved: no flux is lost, all baselines are used
  - if you have a detection, do not over-interpret it. A $5\sigma$ detection is not a map; CLEANing is not helpful
  - weak line on a strong continuum:
    Current limitation on Bure line/continuum > 3% (for a $5\sigma$ detection)
Mapping/Imaging

• Single field:
  - Do not forget to correct for primary beam attenuation when comparing maps

• Mosaics:
  - Fully sample the mosaic to be sensitive to large scales

• Adding short spacings:
  - good calibration required at single dish
  - good sensitivity
  - should cover at least the field mapped by the interferometer

(see IRAM Memo 2008-2 by Rodríguez-Fernández, Pety & Gueth)
Other observations

• Size measurements:
  - Requires good SNR, not a $5\sigma$ detection
  - Compare to point source (calibrator)

• Position measurements:
  - absolute astrometric precision < 0.3”
The Plateau de Bure Interferometer (PdBI) is currently the most advanced millimeter array in the world. Situated on the Plateau de Bure at 2355 m altitude in the French Alps, the geographical position of its phase center is:

Longitude: 05 54 28.5, East. Latitude: 44 38 02.0

During its history, the PdBI underwent several track extensions, received additional antennas (all of 15m diameter and similar construction as the first ones) and technical upgrades. From a three antenna interferometer with a maximum baseline of 233 meters in 1986, it has evolved to a six-antenna array with baselines up to 700 meters in 2005. A new generation of powerful dual-polarisation receivers for the 3mm and 1mm observing bands was installed in 2009, and extended to the 2mm observing band in late 2007.

The antennas of the IRAM interferometer can move on rail tracks up to a maximum separation of 760 m in the E-W direction and 368 m in the N-S direction, corresponding to a resolution of 0.5 arcsec at an observing wavelength of 1.3 mm (230 GHz).

Since 1990, the interferometer is open to the world-wide scientific community, and issues twice a year a call for observing proposals. Because of its complexity and to make it attractive to the wide community, observations at the PdBI are not performed by the astronomers who propose them, but by the telescope operators and IRAM staff astronomers, who also provide assistance at various stages of the data.
Proposals for observations with the IRAM telescopes may be submitted twice per year to the

IRAM Scientific Secretariat
Domaine Universitaire de Grenoble
380, rue de la Piscine
F-38406 St. Martin d’Hères, France

Submission should be made through the Electronic proposal submission facility. The facility is opened about three weeks before a deadline. Submission deadlines are currently around mid of March and mid of September each year for the summer (03 June - 30 November) and winter (01 December - 31 March) scheduling periods. Expiration dates and all other relevant information are given in a separate Call for Proposals. Additional detailed technical information can be found on the web pages for the interferometer and for the 30m telescope.
IRAM Scientific Secretariat  
Domaine Universitaire de Grenoble  
300, rue de la Piscine  
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Submission should be made through the Electronic proposal submission facility. The facility is opened about three weeks before a deadline. Submission deadlines are currently around mid of March and mid of September each year for the summer (01 June - 30 November) and winter (01 December - 31 May) scheduling periods. Exact dates and all other relevant information are given in a separate Call for proposals published on the web site and in the IRAM Newsletter usually about a month ahead of the deadline. Additional detailed technical information can be found on the web pages for the interferometer and for the 30m telescope.

Calendar
Semester: 01 December 2012 - 31 May 2013

- Submission deadline: 13 September 2012 at 17:00 CET (UT-2 hours)
- Opening of proposal submission facility: Closed now
- Program committee meeting: 25-26 October 2012
- Publication of PC grades: mid November 2012

Non-electronic submission is discouraged; submission by Email is not possible. Shortly after a submission deadline the scientific secretariat sends acknowledgements of receipt to the principal investigators of all proposals received. These receipts are sent by Email and contain the official registration number of the proposal.

Proposals are evaluated at the next meeting of the IRAM program committee and recommendations are made to the IRAM Direction. Proposals are rated A (accepted), B (backup, scheduled under certain favourable conditions), or C (rejected). The program committee has twelve non-IRAM members plus the ex-officio members: IRAM direction, 30m station manager and 30m scheduler and the coordinator of the interferometer.
Electronic Proposal Submission

Astronomers who wish to submit a proposal for one of the IRAM telescopes should read the following general information:

- Preparation of proposal submission
- Read our response and check your submission
- Modify a proposal already submitted

Should the electronic submission facility not be available because of poor network connections or other difficulties, please submit your proposal either by postal mail or fax. In case of malfunction, please contact berjaud@iram.fr. Proposals submitted by electronic mail will not be accepted.

Submission Form

- Title of the proposal
- Full name of the PI
- E-mail of the sender
- Comments you wish to transmit to the scientific secretariat (optional)
Submission Form

- Title of the proposal
- Full name of the PI
- Comments you wish to transmit to the scientific secretariat (optional)
- E-mail of the sender

Submit this file

Submit Proposal or Clear Submission Form

The title of the proposal has to be identical to the one in the cover page of a submitted LaTeX proposal (plain ascii format, no TeX symbols). The full name of the PI is the last name followed by the first name of the principal investigator. The E-mail address refers to the person who submits the proposal.

Preparation of proposal submission

Proposals must be written on the standard IRAM LaTeX proposal template. No other format, in particular no PostScript version of your proposal will be accepted. At the stage of submission authors will have to provide one compressed archive file. This archive file needs to contain the following individual files:
Proposal Forms

A LaTeX style file, `proposal.sty`, is provided in this directory for preparing IRAM proposals, both for the 30m telescope and the interferometer. To get and save this file, first click on the link, then click "File" and "Save As..." on your browser. Two template files, `prop-30m.tex` and `prop-pdb.tex` are available as starting points for writing your 30m or interferometer proposals. For the preparation of your proposal, we ask you to follow the guidelines for the electronic proposal submission.

NOTE: These files have been updated for the next deadline (September 13, 2012 at 17:00 CET (UT+2 hours) for the observing period December 01, 2012 - May 31, 2013); please use the new versions of proposal.sty AND prop-30m.tex or prop-pdb.tex. Do not mix them with older versions.
Local Contacts

An IRAM staff astronomer is appointed as Local Contact to every A and B rated project without IRAM internal collaborator. His/Her role will assist you from the beginning to the end of your project. Should no IRAM astronomer be collaborating with you, feel free to contact them after you get the project report with the recommendations of the program committee. The role of the local contact is to help you set up the observing procedure. You should check the source coordinates and other parameters, the source velocity, the spatial resolution, the total flux, the source position, the spectral index, and the observing frequency. The local contact also helps you to arrange your stay in Grenoble and get started with data reduction. He will keep an eye on the data quality. He/she will check the data quality of the very latest data you remove in the system.

Note also, that the IRAM interferometer is operated as a service instrument by the IRAM staff. Observations will in general carried out without your presence on the site (in absence).

Local contacts for the current and previous periods are:

June 2012 - November 2012
December 2011 - May 2012
June 2011 - November 2011
December 2010 - May 2011

http://www.iram-institute.org/EN/content-page-114-7-56-90-92-114.html
Data publication policies

The following footnote should appear on the first page of papers based on observations made with the PdBI.

"Based on observations carried out with the IRAM Plateau de Bure Interferometer. IRAM is supported by INSU/CNRS (France), MPG (Germany) and IGN (Spain)."

In addition, publications that arise from work supported by the European Community funded RadioNet project should include the following acknowledgement:

"This work has benefited from research funding from the European Community’s Seventh Framework Programme."

IRAM welcomes an acknowledgement to the IRAM staff for help provided during the observations and for data reduction.

IRAM provides preprints free of charge for publication upon receipt of a manuscript. Papers which are accepted in refereed journals and addressed to the IRAM librarian will be published as IRAM preprints.
Any questions on how to request time for the Plateau de Bure array?

- Check the IRAM Web pages
- Ask the Science Operations Group (sog@iram.fr)
Looking forward to YOUR proposals next March!