The MIDI-Infrared Instrument for the VLTI

Two beam interferometry at 7-14 µm

The MIDI project - problems and solutions

Uwe Graser, Ringberg, 1.-5. September 2003
The MIDI project

" The MIDI consortium/organization
" MIDI milestones
" MIDI basics

The challenges:

" New field: mid-IR interferometry on very large telescopes
" Interfaces (Paranal/VLTI/ESO/consortium)

MIDI critical points:

" Fluctuating high background
" Alignment
" Vibrations
" .......
The MIDI consortium/Organization:

" Max-Planck-Institute for Astronomy, Germany
   PIs: Leinert (P-Scientist), Graser (P-Manager)

" NOVA, Netherlands:  Co-PI: Rens Waters
   ASTRON/Dwingeloo (Cold optics)
   NEVEC/Leiden (SW: NRTS, EWS, SW-Manager: W.Jaffe)

" France:  Co-PI: Guy Perrin
   Paris/Meudon, France (Fiber, SW: DRS)
   Observatoire de Nice (Chair of science group: B. Lopez)

" Kiepenheuer Institut, Freiburg, Germany
   (Warm optical bench)

" Landessternwarte Tautenburg, Germany (Calibrators)
   (ESO Instrument-scientist: M. Schöller/Andrea Richichi)
**MIDI Milestones**

16/17 Jun 1997  First MIDI-meeting at MPIA  
15-17 Jul 1997  ISAC-Meeting at ESO  
9 Dec 1997  Steering committee at ESO  
15-17 Jul 1998  Internal concept Review at MPIA  
15 Dec 1998  Concept Design Review at ESO  
29 Jul 1999  Final Design review Optics  
29 Feb 2000  Final Design Review MIDI  
10 Sep 2002  Preliminary Acceptance Europe  
4.11.-15.12.2002  Assembly, Installation, Verification, Paranal  
15 Dec 2002  MIDI first fringes with UT's (UT1, UT3)  
20-24 Feb 2003  First commissioning, Paranal (2 $n_{\text{eff}}$)  
16-21 May 2003  Second commissioning, Paranal (3 $n_{\text{eff}}$)  
7-13 Jun 2003  First GT- and SDT observations, Paranalization  
Aug, Sep 2003  Paranalization  
6-9 Nov 2003  SDT  
11.-15. Dec003  Third Commissioning  
27.1-9.2. 2004  Paranalization, GTO, SDT  
spring 2004  Open for community (in commissioned modes only)

(SDT = Science demonstration time, GTO = Guaranteed time observation)
MIDI basic parameter:

MIDI: 2-beam pupil plane interferometer at m-IR wavelengths

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Wavelength coverage</td>
<td>N (8 µm - 13 µm), expandable to Q (17 - 26 µm)</td>
</tr>
<tr>
<td>Spectral resolution</td>
<td>up to 300 (prism, grism)</td>
</tr>
<tr>
<td>Sampling time for fringe motion</td>
<td>100 ms ... 1 sec</td>
</tr>
<tr>
<td>Atmospheric stability for chopping</td>
<td>200 ms (estimated)</td>
</tr>
<tr>
<td>Detector pixel size</td>
<td>50 µm</td>
</tr>
<tr>
<td>(320 x 240) Full well</td>
<td>2 \cdot 10^7 electrons (Raytheon Si:As HiB IBC)</td>
</tr>
<tr>
<td>Read noise scale</td>
<td>~ 800 electrons</td>
</tr>
<tr>
<td>Background noise from sky+VLTI</td>
<td>3.5 \cdot 10^9 photons/sec</td>
</tr>
<tr>
<td>from tunnel (at UT in Airy disk)</td>
<td>4.6 \cdot 10^9 photons/sec</td>
</tr>
<tr>
<td>FOV on sky, beam-diameter in MIDI</td>
<td>2 '', 18/10 mm</td>
</tr>
</tbody>
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VLTI:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>UTs</th>
<th>ATs</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLTI baselines</td>
<td>47 ... 130 m</td>
<td>8 ... 202 m</td>
</tr>
<tr>
<td>VLTI spatial resolution at 10 µm</td>
<td>0.044&quot; ... 0.016&quot;</td>
<td>0.26&quot; ... 0.010&quot;</td>
</tr>
<tr>
<td>Airy disk (FWHM) at 10 µm</td>
<td>0.26&quot;</td>
<td>1.14&quot;</td>
</tr>
<tr>
<td>Limiting N-magnitude</td>
<td>(without/with external fringe tracking)</td>
<td>3-4 / 8-9 mag</td>
</tr>
</tbody>
</table>
**Principle of MIDI - the Mid-Infrared Interferometer for the VLTI**

- **Beam compressors**: 80 → 18 mm
- **Detector**: (240 x 320)
- **Grism/Prism**
- **Filter**
- **Beam combiner**
- **Field stop/ Spatial filter**
- **Photometric channels**
- **Cold box**: 40 K radiation shield
- **Intermediate focus**
- **Off-axis paraboloids** ($P_1$, $P_2$)
- **Pupil stop**
- **Spatial filter**
- **Path length variation** by movable roof mirrors (on Piezo stages)
- **Cold box**: 70 K radiation shield
- **Optics**: $T < 40$ K
- **Detector**: $T = 8$ K
- **Detector** (240 x 320)
- **VLTI**
- **MIDI**
- **Dewar window (ZnSe)**
- **Off-axis paraboloids**
- **Intermediate focus**
- **Cameras**
- **ZnSe plate**: 50:50 Coating
- **Photometric Beamsplitter**: (30:70)
- **Filter**
- **Grism/Prism**
- **Camera**
- **Path length variation by movable roof mirrors (on Piezo stages)**
Critical points for MIDI: the interfaces

- Interface to ESO: VLTI group in process of formation .... (JMM, AGl) (ICD 1.0: Nov 99, SOW: June 2000)

- Interface to Paranal: S. Morel at MPIA for 1 year (knowledge transfer)

- SW-interface to ESO (... in process of ....)
  \[\Rightarrow\] new data fits format (table fits)

- SW-interface in collaboration ([OS, DCS, ICS] - [NRTS, EWS] - [DRS])
  \[MPIA\quad NEVEC\quad Meudon\]
  \[\Rightarrow\] software manager (SW-M)
Critical points for MIDI: the hardware

"High Background: 3.5 \cdot 10^9 \text{ e}^-/\text{sec}  \text{ from sky+VLTI (on UT in Airy disk)}  \text{ (full well: } 2 \cdot 10^7 \text{ e}^-)"

\(\Rightarrow\) dispersion of the signal: prism, grism
\(\Rightarrow\) short integration times: 0.2 - 20 msec
detector: Read-out-time: 1 .... 6.9 msec
\(\Rightarrow\) high frame/data rate: 1 - 36 Mbyte/sec (3 Mb/sec to archive)

"Background fluctuations: \(\Rightarrow\) Chopping (for accurate photometry)
(Photometric mode, AO, fringe tracker)

"Coherence time with filter: \(\sim\) 100 msec

"Cooling: Closed cycle cooler \(\Rightarrow\) vibrations

"Alignment of optics: to keep alignment when cooling to < 40 K
Background in the mid-infrared

Eta Carina (~ 11000 Jy)

Tunnel background
~17 °C

Sky background
~5-10 °C

Z CaM (~ 100 Jy)

UT1 Beam A
Vibrations:

Paranal: no liquid He $\Rightarrow$ use of a closed cycle cooler  
$\rightarrow$ 1 Hz vibrations  
$\rightarrow$ Separate mount for CCC (650 kg)  
$\rightarrow$ connection via metallic bellow  
$\rightarrow$ damping feet, copper braid, ...  

$\Rightarrow$ internal jitter on detector: 0.04 pixel
The Alignment of MIDI:

1) Separate alignment/adjustment in the warm with visible light
   - alignment of "cold optics" (MIDI open)
   - alignment of warm optical bench

2) Cooling down of MIDI
   - shrinking homologous,
   - position/direction correction by 5-axis mount

→ Iteration:
   - alignment of warm optical bench to cold optics
   - alignment of MIDI to VLTI (5-axis mount)
Conclusion:

MIDI: December 97 ..... December 2002 →

Installation and first commissionings/measurements have shown that MIDI works as planned ......

....... yet up to now only in the commissioned mode(s) (i.e. self-fringe-tracking with prism or filter)

Still to come:

More commissioning .... (up to now only 5 UT-nights !):
- Commissioning of further modes (grism, ....)
- Commissioning with external fringe tracker
  (available by begin of 2004)
- Commissioning with ATs (available by autumn 2004)

MIDI extensions: 20 µm, Apres-MIDI