APEX Telescope Status

Alan Roy

Nasmyth A Cabin

Instrument Container

Wobbler

Compressor Platform

Telescope base + cable wrap
APEX Instrumentation

Heterodyne instruments

Facility: SHFI
APEX1 211-275 GHz
APEX2 275-370 GHz
APEX3 385-500 GHz
APEX T2 1250-1390 GHz

PI-Instruments
FLASH: 430-492 GHz
THz RX: 980-1005 GHz
CHAMP+: (2×7 pixels, 602-720 + 790-950 GHz)

Bolometers

LABOCA: 295 elements at 870 µm
SABOCA: 37 elements at 350 µm
APEX SZ Camera: 330 elements at 1.4 + 2 mm
(PI Instrument Berkeley)
ARTEMIS: 256 elements, 450 & 350 & 200 µm
(in development at Saclay)

To be used for VLBI in 2010/11
VLBI at APEX: System Block Diagram
VLBI at APEX: spending profile

VLBI at APEX Cumulative Spending Estimate (as at 08.01.2010)

Cumulative spending / EUR

- All items (excluding contingency)
- Maser
- All items except maser
- 2 Gbit/s one Mark5C
- 16 Gbit/s two Mark5C

Year

2009.5 2010 2010.5 2011 2011.5
**Nominal Specifications on T4Science maser for APEX (iMaser56)**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency stability</td>
<td>1 s: $1.5 \times 10^{-13}$, 10 s: $2 \times 10^{-14}$, 100 s: $5 \times 10^{-15}$</td>
</tr>
<tr>
<td>Frequency sensitivity to temperature</td>
<td>$\leq 5 \times 10^{-5}$ °C$^{-1}$</td>
</tr>
<tr>
<td>Frequency sensitivity to magnetic field</td>
<td>$\leq 1 \times 10^{-13}$ gauss$^{-1}$</td>
</tr>
<tr>
<td>Frequency sensitivity to acceleration</td>
<td>$\leq 5 \times 10^{-9}$ g$^{-1}$ at frequencies $&gt; 1$ Hz</td>
</tr>
<tr>
<td>Frequency sensitivity to power supply</td>
<td>$\leq 1 \times 10^{-14}$ volt$^{-1}$</td>
</tr>
<tr>
<td>Outputs</td>
<td>10 MHz on coaxial cable, type N connector, 4 of 1 PPS, BNC connector, 1 of</td>
</tr>
<tr>
<td>Monitor interface</td>
<td>Ethernet, web server, ftp server</td>
</tr>
<tr>
<td>Size</td>
<td>60 cm x 80 cm x 91 cm (W x D x H)</td>
</tr>
<tr>
<td>Weight</td>
<td>110 kg</td>
</tr>
<tr>
<td>Power consumption</td>
<td>$&lt; 100$ W, typically 70 W.</td>
</tr>
<tr>
<td>UPS</td>
<td>included by T4Science as external box, provides 18 h of operation or 2 days standby mode.</td>
</tr>
<tr>
<td>Oscilloquartz BVA 8607B oscillator</td>
<td>Provides enhanced short-term phase noise</td>
</tr>
</tbody>
</table>

Stability: $5 \times 10^{-15}$ in 100 s $\Rightarrow$ coherence = 0.9 at 345 GHz

Better quartz oscillator than Symmetricom $\Rightarrow$ 9 dB lower short-term phase noise
Maser Location

old APEX control room

Environmental housing to stabilize temperature ± 0.5 °C
Downconverter

APEX-VLBI IF-Converter

credit: C. Kasemann
Synthesizers for Downconverter

Phase noise of Micro Lambda and Luff synthesizers

- $\text{rms phase noise} = 0.16^\circ$
- known to work at APEX

- $\text{rms phase noise} = 0.03^\circ$
Location of DBBC and Downconverter

Instrument Container

Location for DBBC, 10 MHz distributor, baseband splitter, coherence check equipment, and counter.

Nasmyth A Cabin

Location for IF power splitter and VLBI downconverter
Data Transmission: 10 GE from DBBC

Fila-10G board - connects:
- HSI (DBBC internal bus),
- 2 x VSI output,
- 2 x 10 Gbit/s optical ethernet.

Fila-10G connected to A/D.2 board,
-> sending raw sampled data over ethernet (prototypes)

credit: HAT-Lab, MPIfR, INAF
Polarizer

Location for quarter-wave plate on APEX 1 receiver

Grooved dielectric quarter wave plate in HDPE by Miroslav Pantaleev (OSO) finished.

(Quartz plate by Dan Marrone (U. Chicago) under development, for lower loss)
Pressure Box for Recorders

Preliminary design of pressure housing contains:
  - two Mark 5C recorders
  - four additional 8-packs.

Operate at 5100 m altitude (530 hPa)
Pressurize air by 200 hPa -> 730 hPa internal
Water cooling to remove 800 W
## Equipment Preparation Status (1 mm 4 Gbps)

**OK (done or ordered, low risk)**

- H-maser
- H-maser foundation and environmental control
- Test tone generator
- Test tone coupler
- Frequency synthesizer for LO
- Frequency synthesizer for test tone generation
- Oscilloscope for coherence check
- GPS receiver
- Equipment racks
- Disk module kits
- Disks for modules
- FS computer (can be on Mark 5C)
- Mark 5C recorder
- Station position determination
- Quarter-wave plates
- Software for logging maser housing monitor points
- 1 PPS distribution
- Counter for GPS-FMOUT

**Active, some risk**

- Downconverter for VLBI
- DBBC construction
- Fila 10G firmware
- Mark 5 pressure container
- Pressurized disk storage
- Cabling
- 10 MHz distributor
- Software for downconverter-APEX control
- Software for logging maser monitor points
- Converter GPIB to ethernet

**No activity yet**

- Software for FS and APEX telescope control
- Divider for coherence check
- 10 kHz filter for phase coherence check
- 3 dB splitter for IF to downconverters
- Power splitter 0-2GHz, four-way for IF to DBBC
**Milestones: big picture**

<table>
<thead>
<tr>
<th>MS</th>
<th>Event Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Order maser</td>
<td>31.07.2009</td>
</tr>
<tr>
<td>5</td>
<td>DBBC firmware validated</td>
<td>30.06.2009</td>
</tr>
<tr>
<td>6</td>
<td>Decide DBBC / DBE</td>
<td>31.07.2009</td>
</tr>
<tr>
<td>7</td>
<td>Fringe test in Europe successful</td>
<td>15.11.2009 (dropped)</td>
</tr>
<tr>
<td>8</td>
<td>Equipment for 1 mm ready for shipping</td>
<td>30.11.2009 (slip to 02.02.2010)</td>
</tr>
<tr>
<td>9</td>
<td>Site preparations complete</td>
<td>31.01.2010</td>
</tr>
<tr>
<td>10</td>
<td>Software preparations complete</td>
<td>30.11.2009 (slip to 15.03.2010)</td>
</tr>
<tr>
<td>11</td>
<td>Installed equipment for 1 mm at APEX</td>
<td>21.03.2010</td>
</tr>
<tr>
<td>12</td>
<td>Fringe test with APEX</td>
<td>23.03.2010</td>
</tr>
<tr>
<td>13</td>
<td>Observation in 1 mm global network</td>
<td>31.03.2010</td>
</tr>
<tr>
<td>14</td>
<td>Correlation finished - fringes with APEX</td>
<td>30.06.2010</td>
</tr>
<tr>
<td>15</td>
<td>Publication of 1 mm VLBI observations</td>
<td>30.09.2010</td>
</tr>
<tr>
<td>16</td>
<td>Decide on 0.8 mm and 16 Gbps recording</td>
<td>07.07.2010</td>
</tr>
<tr>
<td>17</td>
<td>Equipment 0.8 mm and 16 Gbps ready to ship</td>
<td>30.11.2010</td>
</tr>
<tr>
<td>18</td>
<td>Installed 0.8 mm and 16 Gbps at APEX</td>
<td>31.01.2011 subject to coordination</td>
</tr>
<tr>
<td>19</td>
<td>Fringe test with APEX</td>
<td>28.02.2011 subject to coordination</td>
</tr>
<tr>
<td>20</td>
<td>Observation in 0.8 mm global network</td>
<td>31.03.2011 subject to coordination</td>
</tr>
<tr>
<td>21</td>
<td>Correlation finished - fringes with APEX</td>
<td>30.06.2011</td>
</tr>
<tr>
<td>22</td>
<td>Publication of 0.8 mm VLBI observations</td>
<td>30.09.2011</td>
</tr>
</tbody>
</table>
# Milestones: near-term

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>APECS software upgrade at APEX (Muders visit)</td>
<td>25 Jan 2010</td>
<td></td>
</tr>
<tr>
<td>Maser environmental housing ready for shipping</td>
<td>25 Jan 2010</td>
<td></td>
</tr>
<tr>
<td>Maser ready for shipping</td>
<td>31 Jan 2010</td>
<td></td>
</tr>
<tr>
<td>Ship equipment for installation 1</td>
<td>31 Jan 2010</td>
<td>(absolute latest)</td>
</tr>
<tr>
<td>Installation 1 (Roy visit APEX)</td>
<td>15-28 Feb 2010</td>
<td>(two weeks)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ship equipment for installation 2</td>
<td>28 Feb 2010</td>
<td>(absolute latest)</td>
</tr>
<tr>
<td>Installation 2 (Roy, Bach visit APEX)</td>
<td>15-22 Mar 2010</td>
<td>(one week)</td>
</tr>
<tr>
<td>ASTE fringe check</td>
<td>21-22 Mar 2010</td>
<td></td>
</tr>
<tr>
<td>Observation in 1 mm global network</td>
<td>23-30 Mar 2010</td>
<td></td>
</tr>
</tbody>
</table>