GEO600 – Status and Plans

Benno Willke
for the LSC

GWDAW 06
Potsdam, Germany 2006
LIGO-G060629-00-Z
container cluster 2005

- Workshop
- Central Building
- Offices
- Bathrooms
- Control Room / Visitor Center
Clean Room / Control Room
Tube / Trench
GEO600 optical layout

- 12W laser
- Mode cleaner
- Interferometer with dual recycling
- Detector

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Sensitivity Improvements

Typical Sensitivity: Past Science Runs

<table>
<thead>
<tr>
<th>Run</th>
<th>Date</th>
<th>Frequency</th>
<th>ASD [h/√Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Aug 26 `02</td>
<td>1kHz</td>
<td>10^{-16}</td>
</tr>
<tr>
<td>S3I</td>
<td>Nov 5 `03</td>
<td>350Hz</td>
<td>10^{-17}</td>
</tr>
<tr>
<td>S3II</td>
<td>Dec 31 `03</td>
<td>1kHz</td>
<td>10^{-17}</td>
</tr>
<tr>
<td>S4</td>
<td>Feb 22 `05</td>
<td>1kHz</td>
<td>10^{-17}</td>
</tr>
<tr>
<td>S5</td>
<td>Jan 26 `06</td>
<td>1kHz</td>
<td>10^{-17}</td>
</tr>
<tr>
<td>Design 1kHz</td>
<td></td>
<td></td>
<td>10^{-21}</td>
</tr>
<tr>
<td>Design 350Hz</td>
<td></td>
<td></td>
<td>10^{-22}</td>
</tr>
</tbody>
</table>
Reaction Pendulum

- Rotational stage
- Stack stabiliser flex-pivot
- Passive layer
- Active layer
- Spacer
- Cantilever spring
- Damping arm
- Upper mass
- Lower mass
- Intermediate mass
- Reaction mass
- Test mass

2 stacks have been omitted for clarity.
Thermal Noise / Monolithic Suspension

Silicate (Hydroxy-Catalysis) Bonding
commissioning challenges

- thermal compensation of a ROC mismatch
- couplings in triple-monolithic-suspension
- dual recycling
  - lock acquisition – coupling alignment – SRC slope, 2f signal, definition of downtuning parameter
  - resonance conditions of MI sidebands
  - frequency dependent distribution of GW signal on P/Q quadratures
- scattering
- low noise electronic (rf system, ESD HV, digital control)
- radiation pressure effects
Displacement sensitivity

LSC detectors - displacement in S5

- LHO4k
- LHO2k
- LLO4k
- GEO600 far mirror

ASD [m/√Hz]

Frequency [Hz]

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GEO600 uses Advanced Technology

- Signal recycling
  - lock acquisition
  - optimal calibration method for dual recycled detectors
  - importance of resonance conditions for heterodyne sidebands in detuned detectors
- monolithic suspensions
  - welding and bonding technique
  - careful design of fiber neck is required
  - longterm stability test
- electrostatic actuation
  - square root law
  - charges on test masses

the high displacement sensitivity of GEO600 allows for a meaningful demonstration of new technologies
Last year’s work on GEO600

- Commissioning in late 2005:
- Joined S5 in *overnight & weekend mode* (January 20th)
- Joined S5 in *24/7 mode* (May 1st)

Total science time: 141.7 days, Overall Duty Cycle: 90.8%

Instrumental duty cycle: 94.3% (1.5.-2.10.)
Science time duty cycle: 90.8% (1.5.-4.10.)
Longest lock: 102 hours
Noise Projections

Projections to H for 2006-09-24 22:35:47

- MID_OAN
- P Dark
- MID AA FB Rot
- MID AA FB Tilt
- SRC_FP-MSR
- MID_VIS
- MID_OPN
- MID_OAN
- MIC_EP
- Uncorr. Sum
- Proj: H

Frequency [Hz]

ASD [μm/√(Hz)]
Stationarity & Glitch Rate

HACR H: Time origin from 2006-09-30 22:59:46 (B43692400)

Time origin from 2006-09-30 22:59:46 (B43692400)

Time origin from 2006-08-31 22:59:46 (B41100400)
Detector Characterization

segments of 8 hours:
• $h(f)$, best single and max/min
• inspiral monitor
• HARC events ($h(f)$, null-stream, detector channels (13 channels))
• band-limited rms
• calibration quality
• line, glitch, saturation monitor

http://www.geo600.uni-hannover.de/georeports/
talk by Martin Hewitson Monday 14:20
Veto methods

- GEO600 data is most significant in search for burst-like events
- for unknown waveforms the reduction of false alarms is very important
- experimentally reduced glitch rate in detector
- worked on veto strategies and pipelines that use additional detector information (transfer functions) to make veto “safe”
- ‘GW burst vetoes using known instrumental couplings’
  P. Ajith (Monday 15:00)
- ‘A statistical veto method employing a back-coupling consistency check’
  S. Hild (Monday 15:20)
GEO meeting Oct: Strategic Decision

- Continue to run GEO600 with L1/H1/H2 (Virgo) in S5?
- Concentrate on commissioning break of H1, (H2), L1 and Virgo?
  - improve GEO sensitivity
  - make necessary infrastructure an detector changes before start of L1 downtime to achieve high duty factor
- Start GEO-HF upgrades after S5?
strong LSC involvement
- asked data groups how useful GEO in its current sensitivity is during S5
- discussed options in LSC operations committee
- asked LIGO directorate for advice

commissioning team was charged to analyze how GEO could be improved and what “maintenance” work was required to prepare GEO for a long science run in 2008
- possible benefit
- risk
- resources required
- how useful is this for GEO-HF?
Investigation 'week' in November
- Power glitches (2-3 d)
- Power measurements / shotnoise investigation (2 d)
- Tuning to higher SR freq. (1 d)

Time to January:
- Preparations
- Glitch investigations

Commissioning period in Jan. ... +-March (9-12 w)
- HEPA filter for cleanroom (2 d)
- MI ESD autoalignment (2 w)
- Power glitches (1-4 w)
- Power build-up investigation (2 d)
- Mains (6 d)
- TCC venting: scattering, transl. Stages, HV feedthroughs (~3 w)
- Few more small items (2f-LO, lenses, AC-decoupl., TCOc only if 2.HPD, ...) (~1 w)
November Performance

Running time: 28.0 days
Total science time: 17.6 days (62.75%)

- major power shut down on Dec 1st (longer than UPS last)
- no science data from Dec 2nd – Dec 12th
- recovering but less actuation range on ESD
Plans of the GEO collaboration

- operate GEO600 / GEO-HF as LSC detector
- LSC data analysis
- laser and suspensions for AdvLIGO (laser for Enh. LIGO)
- contribute to AdvVIRGO design
- R&D and design towards third generation detectors