The Transition to GEO HF

Harald Lück
for the LSC

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The limits

Noise projection to h 2009-01-27 01:20:00
The Master Plan
Experimenter’s Notation
The GEO600 Interferometer

2 sequential mode-cleaners (8 m round-trip)
12 W injection locked master-slave laser system

Output bench

3.2 W

BDIPR

MPR T=0.09%

MSR T=1.9%

BS

2.7 kW

600 m north arm (folded in vertical plane)

- 1

600 m east arm (folded in vertical plane)

P(t) Q(t)

MFe

MCen

MFn

MCn
Upgrade Plan A

2009
- DC readout
- Squeezing
- Tuned SR
- OMC
- Adv. Ligo CDS system for SQZ, OMC, GEOcontrols

2010
- Increase Power (8x, Laser 5x, 1.5x IMC throughput, Shadow-sensors)
- Thermal Compensation
- Increase SR Bandwidth
Upgrade Plan B

2009
- DC readout
- Squeezing
- Tuned SR
- OMC
- Adv. Ligo CDS system for SQZ, OMC, GEOcontrols

2010
- Increase SR Bandwidth
- Increase Power (8x, Laser 5x, 1.5x IMC throughput, Shadow-sensors)
- Thermal Compensation
The GEO600 Interferometer

2 sequential mode-cleaners
(8 m round-trip)

2.7 kW

600 m north arm
(folded in vertical plane)

600 m east arm
(folded in vertical plane)

12 W injection-locked master-slave laser system

Output bench

P(t) Q(t)

-1

MC2

MC1

BDIPR

MPR
T=0.09%

MSR
T=0.9%

MFe

MCn

MFn
Recent DC-Readout vs. Heterodyne

Poster available:
Jerome Degallaix: *Commissioning of the tuned DC readout at GEO600*
+ Control Electronics
Initial Performance

Henning Vahlbruch (Fri, 11:20):
Squeezed light for Gravitational Wave Astronomy

Graph showing magnitude vs. frequency with different types of noise:
- anti-squeezed noise
- shot noise
- squeezed noise
- electronic detection dark noise

8 dB difference between anti-squeezed and squeezed noise.
Extending the central building
Detection Bench Changes

- Moved AA / Lock acquisition off
- Shift / Rotate Detection Bench
- Install new HV Vacuum tank
Poster available: Simon Chelkowski

*How to inject a squeezed vacuum field into a gravitational wave detector*
New Vacuum Chamber

TCOc

Faraday Rotator
OMC
Vibration Isolation Inside TCOc

Minus-K Isolators

Stainless Steel plate ~80kg

Viton
3D Seismic Isolators: ’Minus-K‘

>40dB Isolation
Inside TCOc

Payload + breadboard ~ 36kg

Payload

Aluminium breadboard + Eddy current damping

Minus-K Isolators

Stainless Steel plate

Viton

Faraday Isolator

OMC
- Finesse 150
- Rejection of HOM and RF SBs power > 100
- Finesse 150
- Rejection of HOM and RF SBs power > 100
Poster available:
Mirko Prijatelj: *Control and Automatic Alignment of the Output Mode Cleaner of GEO*
Jerome Degallaix: *Commissioning of the tuned DC readout at GEO600*
Power increase

Decrease MC Finesse
- $T = 0.1\% \rightarrow T = 0.8\%$

Increase Laser Power
- $P = 6\text{W} \rightarrow P = 35\text{W}$

Increase Power into PRC by factor $\sim 10$

Shadow Sensor Read-out
- DC $\rightarrow$ AC
Shadow sensors @ high power
GEO Shadow Sensors
change to AC operation
Thermal compensation

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Output bench

P(t) Q(t)

BS

3.2W

BDIPR

MPR T=0.09%

MSR T=1.9%

2.7 kW

600 m north arm (folded in vertical plane)

600 m east arm (folded in vertical plane)

MFe

MCn

MFn
Thermal compensation

The Problem:  

The Solution:

Heating the BS surface

Need about 10 W of heating power for full 25W of Laser power
CO₂ Laser Intensity Noise

CO₂ RIN = 10⁻⁵ assumed, RIN required < 10⁻⁸
Thermal compensation
GEO-HF Sensitivities
DC readout, Tuned SR

![Graph showing strain vs. frequency with different lines and labels for BS Thermorefr. and Coating Br.](image)
GEO-HF Sensitivities
DC readout, Tuned SR, 6dB Squeezing

Strain [1/sqrt(Hz)]

Frequency [Hz]

BS Thermorefr.  Coating Br.
GEO-HF Sensitivities
DC readout, Tuned SR, 6dB Squeezing, MSR 10%, 3.2W input
GEO-HF Sensitivities
DC readout, Tuned SR, 6dB Squeezing, 2% MSR, 25W input

- Strain $[1/\text{sqrt(Hz)}]$
- Frequency $[\text{Hz}]$

Graph showing strain versus frequency with different lines representing different coatings.
GEO-HF Sensitivities
DC readout, Tuned SR, 6dB Squeezing, MSR 10%, 25W input

Frequency [Hz]

Strain [1/sqrt(Hz)]

10^{-21}
10^{-22}
10^{-23}

10^2
10^3

BS Thermorefr.
Coating Br.
GEO-HF Sensitivities
DC readout, Tuned SR, 6dB Squeezing, MSR 10%, 25W input

Frequency [Hz]

Strain [1/sqrt(Hz)]

-10^{-23}
-10^{-22}
-10^{-21}

E-LIGO
BS Thermorefr.
Coating Br.

10^2
10^3
Various detunings + Squeezing

MSR Trans = 10%, Dc readout, 6dB Squeezing, 25W input

- Thermorefractive BS
- Coating Brownian
- 10x DC offset
- 10x DC offset
- 1x DC offset
- 1xDC
- GEO600