LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

*LIGO Laboratory / LIGO Scientific Collaboration*

LIGO-E1300212-v2 *LIGO* 8/25/14

# SLC Acceptance Documentation

Michael Smith

Distribution of this document:
LIGO Scientific Collaboration

This is an internal working note
of the LIGO Laboratory.

**California Institute of Technology**
**LIGO Project**

**Massachusetts Institute of Technology**
**LIGO Project**

**LIGO Hanford Observatory**

**LIGO Livingston Observatory**

http://www.ligo.caltech.edu/

# CHANGE LOG

| Date, version | Summary of Changes |
|---|---|
| 4/9/13<br>V1 | Initial document |
| 9/25/2014 | Added information on OFI Testing |
| | |

**Table of Contents**

# 1 Requirements documentation

*The design requirements document must be brought up to date, and pointers to background material, analyses, etc. added to the Requirements document. Pointers to prototyping endeavors should be included here.*

*a. Design Requirements Document (DRD)*

*b. Supporting documents (models, analyses, …)*

The Requirements for the Stray Light Control subsystem are detailed in T070061 AOS: Stray Light Control (SLC) Design Requirements

The scope of the Stray Light Control subsystem is to control (through a combination of light baffling, beam dumps and attenuators) scattered light and stray/ghost beams in the interferometer, such that phase noise due to this light is negligible. In addition, since the trajectory of ghost beams depends on the COC wedge angle design, the Stray Light Control subsystem will collaborate with the Systems group on the choice of COC wedge angles.

The Stray Light Control subsystem will provide optical baffling around the COC elements and any other optical elements within the vacuum housing in order to reduce glare within the IFO to acceptable levels.

The Stray Light Control subsystem will control the passage of scattered light, which is not in the IFO mode, into the recycling cavity volume.

The Stray Light Control subsystem will provide errant beam baffles to protect the suspended optics from stray light beams if necessary; except in the IO section, which is the responsibility of IO. The IO section is defined as the entire in-vacuum optical plant between HAM 2 and the IO Baffle on HAM3.

The Stray Light Control subsystem will not provide baffling for other parts of the IO optical train, nor for the PSL optical train, nor for the ISC detection optical train.

The Stray Light Control subsystem will provide an ETM telescope baffle to block the excess light transmitted through the ETM that exceeds the clear aperture of the ETM telescope.

## 1.1 Displacement Noise Requirements

### 1.1.1 Direct Requirements

Phase noise due to scattered light fields injected into the interferometer is treated as a technical noise source. Therefore, the total scattered light phase noise, expressed in equivalent displacement noise, must be < $1/10^{th}$ of the quadrature sum of the suspension thermal noise and the test mass thermal noise (referred to as the SRD), as given in Figure 1 of M060056-06, Advanced LIGO Reference Design.

Sources of scattered light phase noise are divided into two categories: 1) those between the interferometer and the interface where AOS delivers beams to ISC for sensing, and 2) those within the ISC sensing chains. The preceding noise requirement applies to all the scattered light; we will apportion the allowed noise equally between SLC (AOS) and ISC. Therefore, since the scattered light phase adds in quadrature, the total scattered light phase from sources and paths within SLC/AOS must be < 1/14th of the thermal noise envelope.

Furthermore, because there can be large uncertainties in the estimation of scattered light, additional margin—beyond the factor of 10—should be designed in where it is prudent and feasible.

### 1.1.2 Implied Requirements for Scattering Surfaces

The scattered light noise analysis will be used to derive implied requirements on the optical properties and vibration levels for each of the SLC components listed in **Error! Reference source not found.**.

## 2 Design overview and detailed design documentation

*The Final Design Document must be brought up to date, and the detailed design made available via a tree structure pointing to the DCC and design vaults. Lower-level software (control laws, basic machine state and reporting) should be documented in this way, pointing to a software version control system.*

The SLC subsystem will include the following components:

- **Beam Dumps:** absorb the light from ghost beams and pick-off (PO) beams that originate from the wedged AR surfaces of the core optics mirrors.
- **Arm Cavity Baffles:** absorb the small-angle, scattered light arising from the arm cavity mirrors; this is the light scattered from the arm cavity HR mirror surface that propagates 4km to the end of the beam tube, within the far beam tube aperture.
- **Elliptical Baffles:** absorb the excess light that spills around the clear aperture of the PRM and the tilted BS.
- **Manifold Baffles:** eliminate the reflection of the wide-angle diffuse scattered light from the arm cavity HR mirrors at the viewport spool-piece near the cryopump at the entrance to the arm.
- **Brewster Windows:** provide a vacuum barrier between HAM 1 and HAM 2, and between HAM 5 and HAM 6.
- **Mode Cleaner Tube Baffles**: shield the corners of the mode cleaner tubes from scattered light beams, where they join the flat surface of the viewport adapters. Help protect the triple mirror suspensions from damage by errant beams caused by loss of lock of the recycling cavity.
- **Manifold/Cryopump Baffles:** obscure the reflecting surfaces of the cryopumps within the arm cavity near the input test mass mirrors.
- **Signal Recycling Cavity Baffles:** reduce the passage of scattered light into the IFO from within the signal recycling cavity.
- **Output Faraday Isolator:** attenuates light that is back-scattered into the mode of the interferometer from the output optical chain.

## 2.1 Arm Cavity Baffle (ACB)

The ACB final design is detailed in T1000747 AOS SLC Arm Cavity Baffle Final Design.

## 2.2 BS Elliptical Baffle

The BS Elliptical Baffle final design is detailed in T1200313 AOS SLC BS Elliptical Baffle Final Design.

## 2.3 ITM Elliptical Baffle

The ITM Elliptical Baffle final design is detailed in T1100446 AOS SLC BS Elliptical Baffle Final Design.

## 2.4 Manifold/Cryopump and Mode Cleaner Tube Baffles

The Manifold Cryopump and Mode Cleaner Tube Baffles are detailed in T1100165 AOS SLC Manifold Cryopump and Mode Cleaner Tube Baffle FDR

## 2.5 Output Faraday Isolator (OFI)

The OFI final design is detailed in T1000181 AOS: SLC—OFI Final Design.

## 2.6 Signal Recycling Cavity Baffles

The Signal Recycling Cavity Baffles final design is detailed in T1100445-v5 AOS SLC Signal Recycling Cavity Baffles FD

# 3 Materials and fabrication specification

*Any special materials, or treatment of materials including preparation for in-vacuum use; this may be integrated into the Design documentation.*

## 3.1 Baffle Surface Finish

E1100842-v7 MIRROR FINISH SS SPEC

# 4 Parts and spares inventoried

*All elements of aLIGO must be recorded in the ICS or in the DCC using the S-number scheme. As-built modifications for parts or assemblies should be found here.*

# 5 Assembly procedures

*All assembly procedures must be in the DCC and annotated or updated for lessons learned. Storage, if used, should be described here along with procedures to maintain the equipment in good condition (e.g., purge frequency). Transportation procedures and cautions must be noted.*

## 5.1 Arm Cavity Baffle (ACB)

E1100867-v7 Advanced LIGO AOS Arm Cavity Baffle Assembly Procedure

## 5.2 BS Elliptical Baffle

The BS Elliptical Baffle
E1200660-v2 AOS SLC E1200660-v2 AOS SLC BS Ellip Baf Installation Doc BS Ellip Baf Installation Doc

## 5.3 ITM Elliptical Baffle

The ITM Elliptical Baffle
E1200677-v5 Advanced LIGO AOS ITM Elliptical Baffle Assembly Procedure

## 5.4 Manifold/Cryopump and Mode Cleaner Tube Baffles

The Manifold Cryopump and Mode Cleaner Tube Baffles
E1100607-v2 Manifold-Cryopump Installation Doc

## 5.5 Output Faraday Isolator (OFI)

The OFI Assembly and Alignment Procedure is described in E1201074-v4 Advanced LIGO Output Faraday Isolator Assembly and Alignment Procedure

## 5.6 Signal Recycling Cavity Baffles

T1300340-v1 AOS SLC Signal Recycling Cavity Baffles Assembly and Installation

# 6 Installation procedures

*All installation procedures must be in the DCC and annotated or updated for lessons learned.*

## 6.1 Arm Cavity Baffle (ACB)

E1100810-v14 SLC Arm Cavity Baffle Installation-deinstallation Procedure

## 6.2 BS Elliptical Baffle

The BS Elliptical Baffle
E1200660-v2 AOS SLC BS Ellip Baf Installation Doc

## 6.3 ITM Elliptical Baffle

The ITM Elliptical Baffle
E1101021-v5 AOS SLC ITM Ellip Baf Installation Doc

## 6.4 Manifold/Cryopump and Mode Cleaner Tube Baffles

The Manifold Cryopump and Mode Cleaner Tube Baffles
E1100607-v2 Manifold-Cryopump Installation Doc

## 6.5 Output Faraday Isolator (OFI)

The Output Faraday Isolator Installation Procedure is detailed in E1300056-v1 Advanced LIGO Output Faraday Isolator Installation Procedure

## 6.6 Signal Recycling Cavity Baffles

T1300340-v1 AOS SLC Signal Recycling Cavity Baffles Assembly and Installation

# 7 Test documents

*Test rationale, plans, and data for each unit must be documented as described in M1000211. That tree structure should be pointed to by the overall tree structure laid out in this Acceptance* *prescription. The top-level objective is to make clear how the measurements performed, which often will not directly measure a required performance parameter, give confidence that the subsystem will fulfill the requirements.* Arm Cavity Baffle (ACB)

## 7.1 Arm Cavity Baffle (ACB)

Test Plan for the ACB is detailed in:

E1000892_Arm Cavity Baffle Fabrication, Installation, and Test Plan

## 7.2 BS Elliptical Baffle

Test Plan for the BS Elliptical Baffle is detailed in:
E1200661-v1 BS Ellip Baffle Fabrication, Installation, and Test Plan

## 7.3 ITM Elliptical Baffle

Test Plan for the ITM Elliptical Baffle is detailed in:
E1101022-v1 ITM Ellip Baffle Fabrication, Installation, and Test Plan

## 7.4 Manifold/Cryopump and Mode Cleaner Tube Baffles

Test Plan for the Manifold Cryopump and Mode Cleaner Tube Baffles is detailed in:
E1100481-v1_Mode Cleaner Tube Baffle and Manifold-Cryopump Baffle Fabrication, Installation, and Test Plan

## 7.5 Output Faraday Isolator (OFI)

Test Plan for the OFI is detailed in: T1000192-v4_OFI test plan. All of the testing results are archived in E1300428.

## 7.6 Signal Recycling Cavity Baffles

Test Plan for the Signal Recycling Cavity Baffles is detailed in:

E1101023-v1 Signal Recycling Cavity Baffles Fabrication, Installation, and Test Plan

# 8 User interface software

There is no user interface software in the Stray Light Control System.

# 9 Operation Manual

*A manual appropriate for operators, written in accordance with M1200366, covering setup/initialization, check-out, operating instructions, calibration, maintenance, storage/transport and troubleshooting. It must be accessible from standard user screens.*

# 10 Safety

*Safety documentation must be in the DCC for all phases of the subsystem development, including any needed for normal use or foreseen maintenance/repair scenarios.*

## 10.1 Arm Cavity Baffle (ACB) Hazard Analysis

Hazard Analysis for the ACB is detailed in:

E1000890-v1 ACB Hazard Analysis

## 10.2 BS Elliptical Baffle Hazard Analysis

Hazard Analysis for the BS Elliptical Baffle is detailed in:
E1200659-v1 AOS SLC BS Ellip Baf Hazard Analysis

## 10.3 ITM Elliptical Baffle Hazard Analysis

Hazard Analysis for the ITM Elliptical Baffle is detailed in:
E1101018-v1 AOS SLC ITM Ellip Baf Hazard Analysis

## 10.4 Manifold/Cryopump and Mode Cleaner Tube Baffles Hazard Analysis

Hazard Analyses for the Manifold Cryopump and Mode Cleaner Tube Baffles are detailed in:
E1100491-v6 Mode Cleaner Tube Baffle Hazard Analysis
E1100482-v1 Manifold-Cryopump Hazard Analysis

## 10.5 Output Faraday Isolator (OFI) Hazard Analysis

Hazard Analysis for the OFI is detailed in:

E1300283-v3_OFI Hazard Analysis

## 10.6 Signal Recycling Cavity Baffles Hazard Analysis

Hazard Analysis for the SLC Signal Recycling Cavity Baffles is detailed in:

E1100984-v4 AOS SLC Signal Recycling Cavity Baffles Hazard Analysis