

# SimLIGO :

## A New LIGO Simulation Package

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1. e2e : overview
2. SimLIGO
3. software, documentations and discussions

# e2e overview

- ◆ General purpose GW interferometer simulation framework
  - » Generic tool like matlab or mathematica
  - » Time domain simulation written in C++
  - » Optics, mechanics, servo, ...
    - time domain modal model
    - single suspended 3D mass, MSE - modular mechanical modeling tool
    - analog and digital controller - ADC, DAC, digital filter, etc
- ◆ LIGO I simulation packages
  - » Han2k : used for the lock acquisition design
    - simple seismic noise, all analog servo, 1D mass, etc
    - fast simulation of LIGO
    - cavity response with misalignment - Bill Kells
    - thermal lensing effect on lock acquisition - Biplab Bhawal
  - » SimLIGO : to assist LIGO I commissioning

# A Detailed Model of LIGO IFO

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- ◆ Modal beam representation
  - » alignment, mode matching, thermal lensing
- ◆ 3D mechanics
  - » 6x6 stack transfer function
  - » 3D optics with 4 local sensor/actuator pairs
- ◆ Complete analog and digital electronics chains with noise
  - » Common mode feedback
  - » WFSs
  - » “Noise characterization of the LHO 4km IFO LSC/DSC electronics” by PF and RA, 12-19 March 2002 included
- ◆ All major noise sources
  - » seismic, thermal, sensing, laser frequency and intensity, electronics, mechanical

# SimLIGO

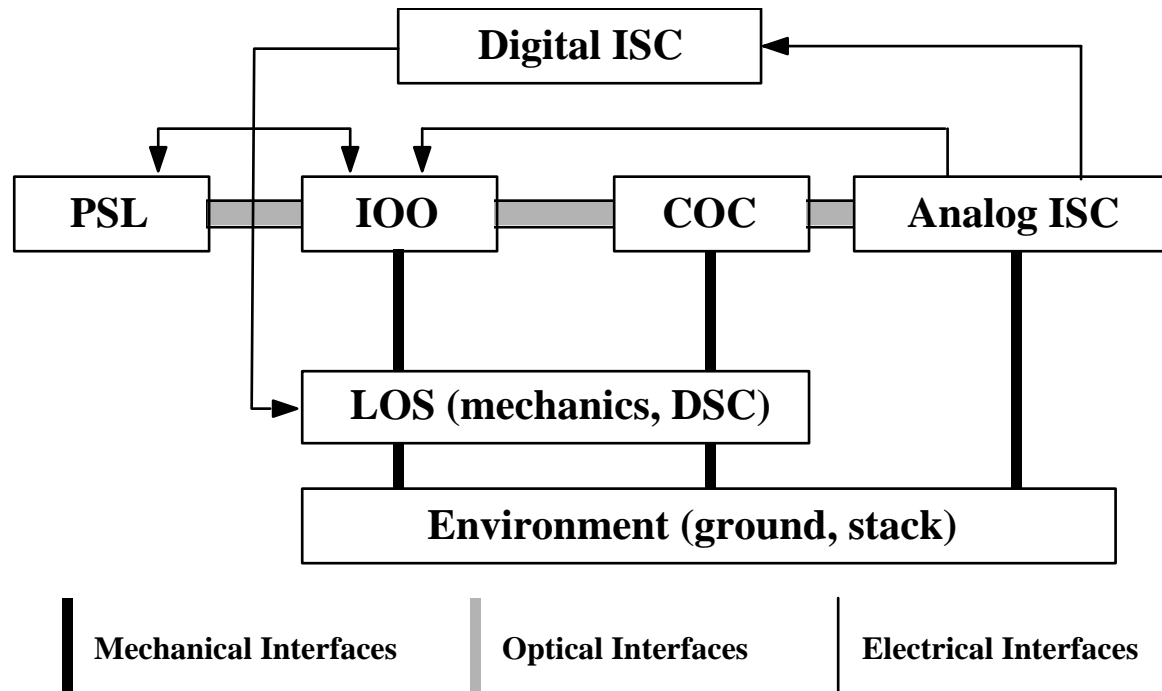
## Purpose

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- ◆ Performance of as-built LIGO
  - » effect of the difference of two arms, etc
- ◆ Noise study
  - » Non-linearity
    - cavity dynamics, electronic saturations, digitization, etc
  - » Bilinear coupling
- ◆ Lock instability
- ◆ Sophisticated lock acquisition
- ◆ Upgrade trade study

# SimLIGO

## System structure



# SimLIGO

## Environment, PSL, IOO

### ◆ Seismic motion

- » Correlated ground motion based on seismic psd and coherence data
  - rotation and tilt are assumed to be induced by the translational motions of piers
    - $\lambda$  talk this afternoon, work starting with S.Yoshida
  - need data for LLO (day and night)
- » 6x6 transfer functions for BSC and HAM

### ◆ PSL and IOO

- » Laser with frequency and intensity noise
- » 2 phase modulators
- » Frequency feedback
- » Built using filters to function as is designed
- » To study the MC dynamics, triangular cavity with suspended mirrors needs to be and can be placed

# SimLIGO

## Core Optics Components - 1

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- ◆ Large Optics Suspensions
  - » Driven by suspension point motion
  - » Single suspended 3D mirror
    - 4 sensors and actuators
    - optical levers
    - Pitch-position coupling
    - bounce mode and wedge angle effect
  - » Digital Controller
    - Dual sampling rate
    - pitch-position decoupling filter
    - Adjustable output filter

# SimLIGO

## Core Optics Components - 2

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- ◆ Optical Components
  - » Customizable for each IFO
  - » Mirror aberration causing mode coupling - tbd
  - » Radiation pressure - tbd
- ◆ Sensing Electronics
  - » LSC and ASC detectors with shot noise
  - » Detailed electronics chain leading to Pentek ADCs
  - » Detectors can have proper mechanical motion
- ◆ Scattering noise - tbd



# SimLIGO

## Digital ISC

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### ◆ LSC

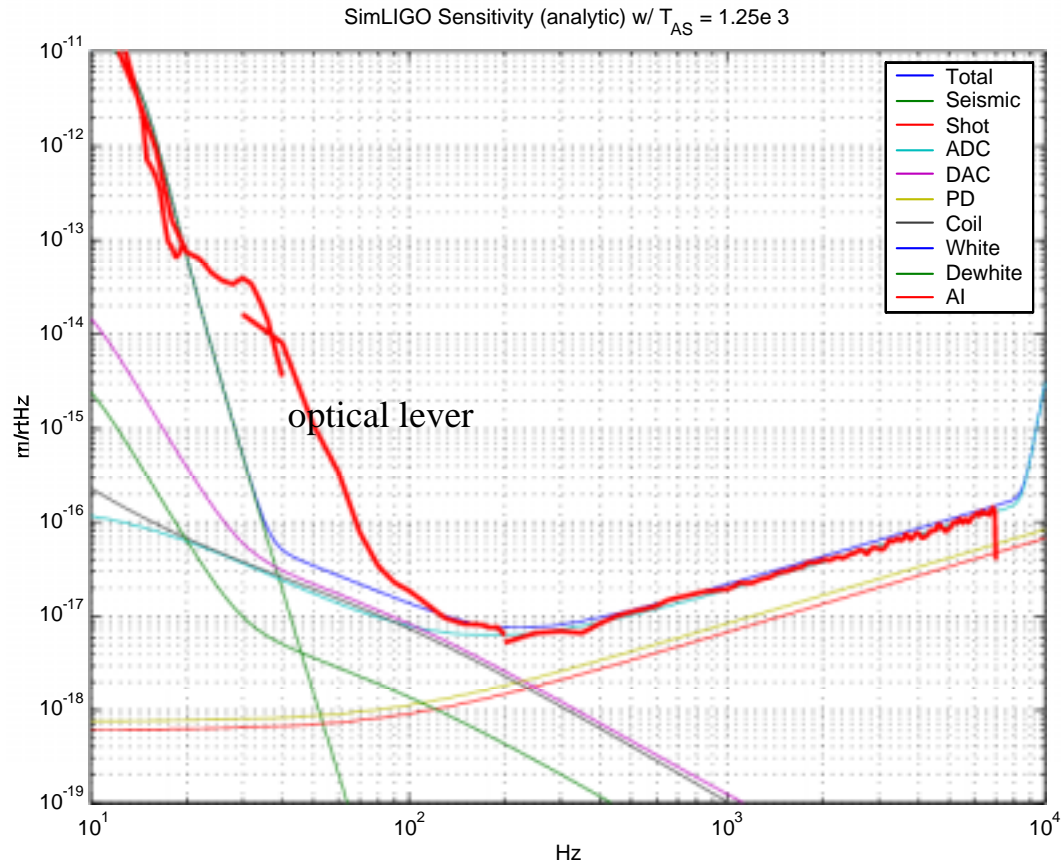
- » Switchable input matrix
  - full detection mode
  - automated acquire mode - tbd
- » Full output matrix
- » Digital filter banks identical to on-site filters
- » Error and control signal test points

### ◆ ASC

- » under construction
  - waited until a design is completed

# SimLIGO

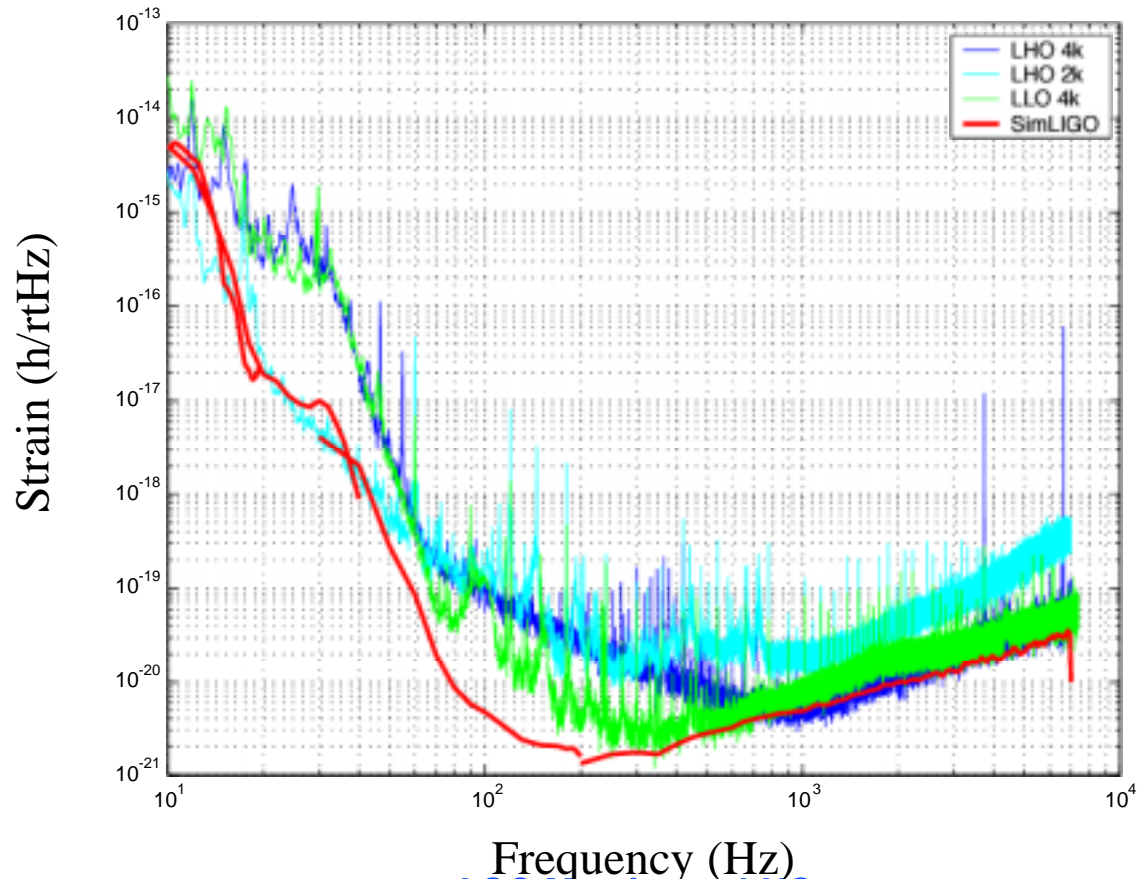
## Noise components



# LIGO data vs SimLIGO

Triple Strain Spectra - Thu Aug 15 2002

rana-1029490757.pdf



Frequency (Hz)  
*LSC Meeting at LHO*  
*LIGO-G020364-00-E*

- ◆ Homepage

- » [www.ligo.caltech.edu/~e2e/](http://www.ligo.caltech.edu/~e2e/)

- ◆ e2e tarball downloadable from e2e homepage

- » [e2e-version.tar.gz](#), [SimLIGO.tar.gz](#), [Han2k.tar.gz](#)

- ◆ Documentations

- » all downloadable from e2e homepage

- » Han2k users manual

- » SimLIGO

- System structure

- How to guide

- Physics (to be completed)

## discussions via maillist

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- ◆ Communications among e2e users using mail list
  - » ligo-e2e-announcement
    - announcement about new release
  - » ligo-e2e-physics
    - discussion about simulation related issue
  - » ligo-e2e-GUI
    - alfi - graphical front end of e2e - related issues
  - » ligo-e2e-programming
    - C++, JAVA, thread, etc