LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
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Airborne Particulate Monitoring at LHO

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General

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of the LIGO Project.

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1 ABSTRACT

Interferometer hardware at the LIGO Hanford Observatory is extremely sensitive to optical scattering caused by particulate contamination. In an effort to reduce airborne particulate levels in the Laser Vacuum Equipment Area (LVEA), Optics Lab, Vacuum Prep and Assembly Area, and the Cleaning Room have been monitored. Measurements were taken on a cycle of a one-minute sample and a 29-minute hold time. Over the course of the project several events were observed and a building trend was found.

2 OVERVIEW OF PROCEDURE

For monitoring airborne particulate levels the Met One model 227 particulate monitor (manufactured by Pacific Scientific of Grants Pass, OR) was used. The particle monitor works by pulling a sample of air into the sensor through an optical detection volume where a laser light source is concentrated. Particles scatter the laser light which is then focused onto a photo diode. The photo diode detects and converts the light signal into electric pulses. The height of the pulse is directly proportional to the particle size. The pulses are counted and measured by electronics on a circuit board containing counter / threshold circuitry, a microprocessor, and communications circuitry. The microprocessor displays the count on the front panel as total particulate count in specified size ranges. Rear panel connectors interface the counter to a computer or printer.[1] The particle monitors provide readings in particles grater than 0.3 microns on one channel and the other channel can be set to one of 4 different selections (> 0.5*u*m, > 1*u*m, > 3*u*m, or > 5*u*m). The Met One 227 monitors have several modes of operation, automatic (automatically takes counts on a timed basis and stores as many as 200 data points per channel), beep (operates similar to a Geiger counter), average (averages 2-100 counts and gives maximum and minimum values as well), and manual operation. The monitors were set in automatic mode on a cycle of a one-minute sample and a 29-minute holding period. This enables the monitors to operate continuously and for convenience, downloaded only twice a week. A program, Universal Utility Software, that was provided by the manufacturer, unloads the buffer of the monitors, and saves the data in comma delimited format. From that format the data is manually converted into Microsoft Excel spreadsheets, copied into monthly logs by location, then graphed by location for the previous week and also the month to date.[2] Also, the readings must be converted for graphing purposes. Since the monitors have a one cubic foot per minute pump, the data points are multiplied by ten to give particles per cubic foot. The integer one is added after multiplying to enable the generation of semi-log plots.

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1. Particle counters for Air: Application and Maintenance Information, Met One Inc. Copyright 1995
2. Date and time are transferred into one cell (so MS Excel will recognize both for graphing) by using the command =VALUE(CONCATENATE(INT(A3/10000),"/",ROUND((100*((INT(A3/100)/100)-INT((INT(A3/100/100)))),0),"/",(INT(100*((A3/100)-INT(A3/100)))),” “,INT(B3/10000,":",INT(100*((INT(B3/100)/100)-INT((INT(B3/100)/100)))))).

3 LOCATION OF MONITORS

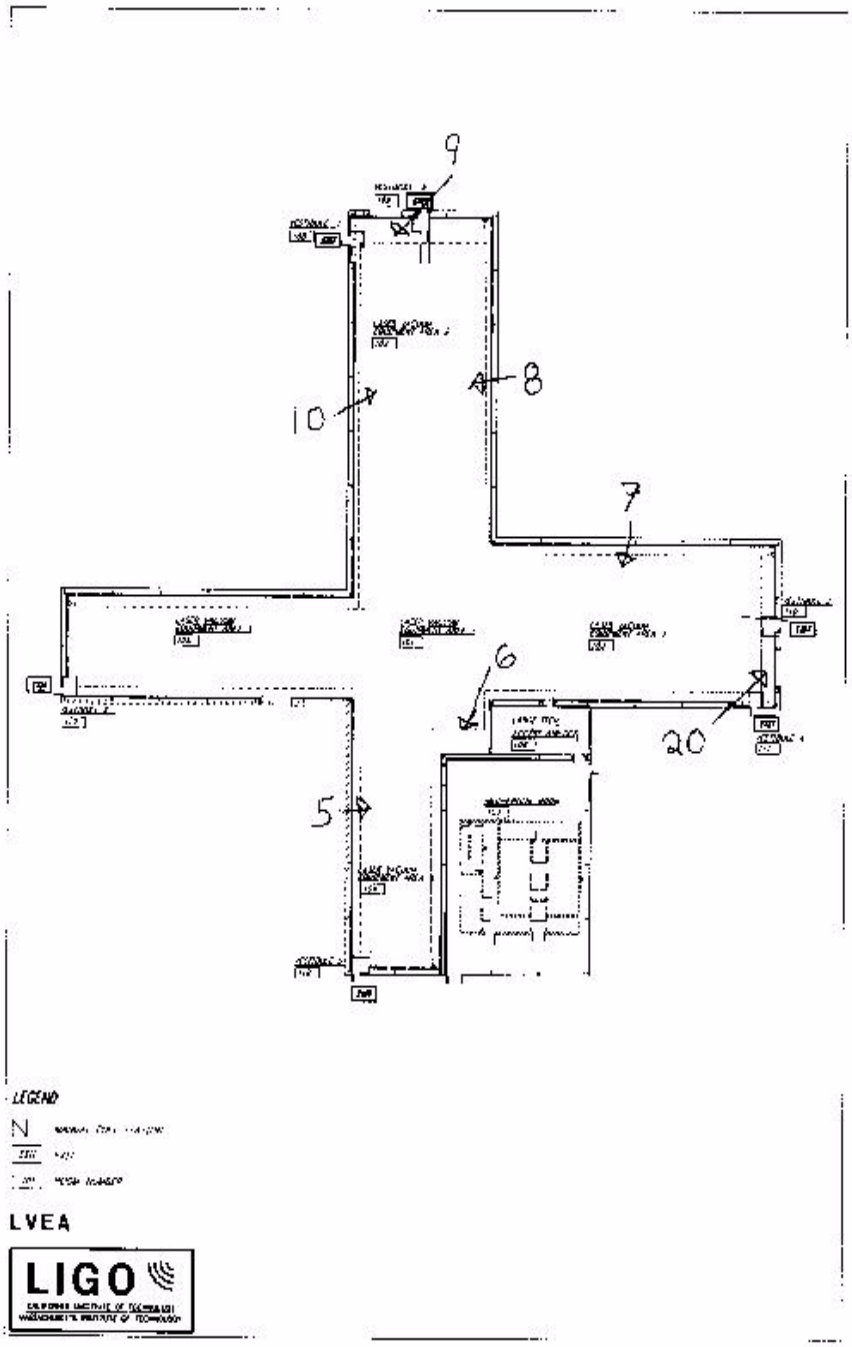
3.1. Description of Locations

Eleven monitors were located in the LVEA, Optics Lab, Vacuum Prep. and Assembly Area, and the Cleaning Room. They were mounted on the walls approximately five feet above the floor. Table 1 gives the assigned location number, and a description of the corresponding location.

Table 1:

Location #	*Description*
1	OPTICS LAB
2	VACCUM PREP AND ASSEMBLY AREA
3	CLEANING ROOM
5	LVEA SOUTH WALL NEAR DARK PORT
6	LVEA EAST WALL NEAR LRG. EQUIP ACCESS
7	LVEA WEST WALL NEAR PSL 2K LASER ENCLOSURE
8	LVEA NORTH WALL NEAR HAM 12
9	LVEA NEAR Y1 BULKHEAD
10	LVEA SOUTH WALL BETWEEN BSC-8 & Y1 BULKHEAD
13	HAM UNDER SOFT WALL
20	LVEA NEAR X1 BULKHEAD

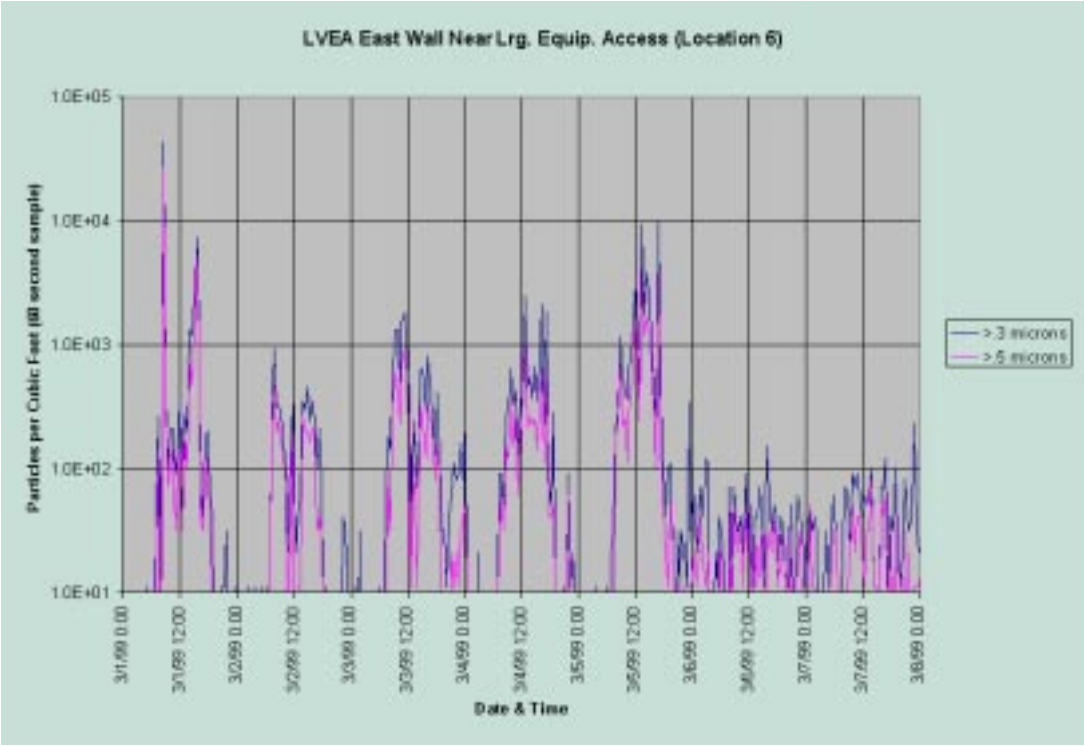
3.2. Location Map



4 OBSERVATIONS

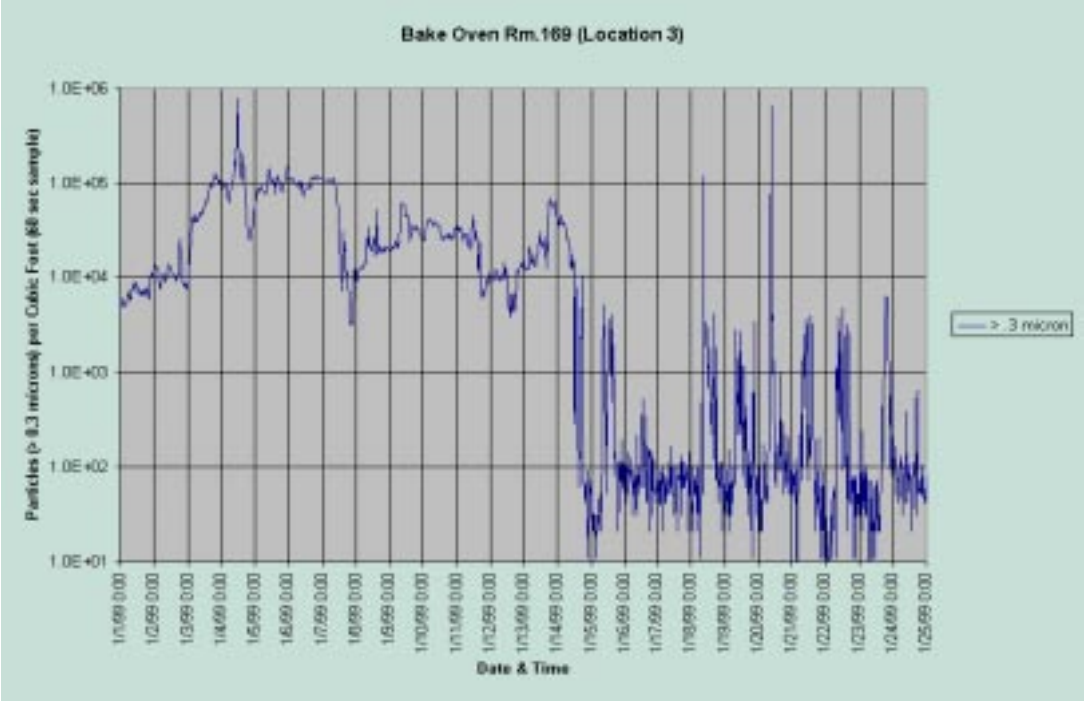
4.1. LVEA Trend

The major trend noticed while monitoring was that the particulate levels in the LVEA rise during working hours and fall at night, during weekends and also holidays. During the day levels rise to as high as 1,000 to 10,000 particles greater than 0.3 microns per cubic foot and fall at night to between 10 to 100 particles greater than 0.3 microns per cubic foot. No tests have been conducted investigating why this is so but the data is not inconsistent with the idea that airborne particles are being brought in by people, (fibers from clothes, dust on items etc.). Another possibility is that particles are in the area initially and at rest on surfaces within the LVEA and that air currents created by movement send particles into the air.



4.2. Cleaning Room (#169)

Initially, inside the Cleaning Room (also known as the Bake Oven Room), the only fresh air supply is through one vent in the ceiling and no return air supply. At the beginning of January 1999 when readings were first taken, airborne particle levels in the Cleaning Room (#169) were constantly over 10,000 particles greater than 0.3 microns per cubic foot.

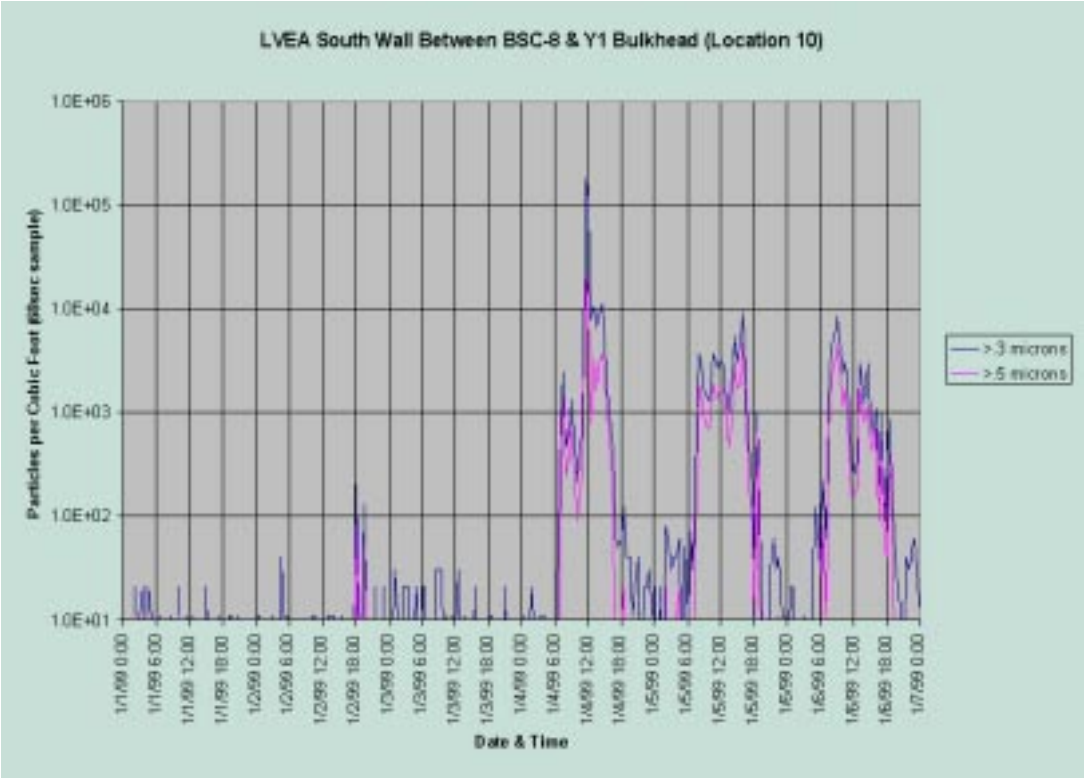


When the extreme particulate levels were discovered in the Cleaning Room, steps were taken to lower the particulate levels. The room vacuumed with a High Efficiency Particle Arrestor (HEPA) vacuum and caps and frocks (along with previously required over shoe covers) are now required garb in the Cleaning Room.

After vacuuming out the room with a HEPA vacuum and requiring frocks and caps inside the room airborne particle levels dropped to between 5,000 and 1,000 particles greater than.3 microns per cubic foot during the workday and 100 to 10 particles greater than 0.3 microns per cubic foot at night and on the weekend.

4.3. Event on January 4, 1999

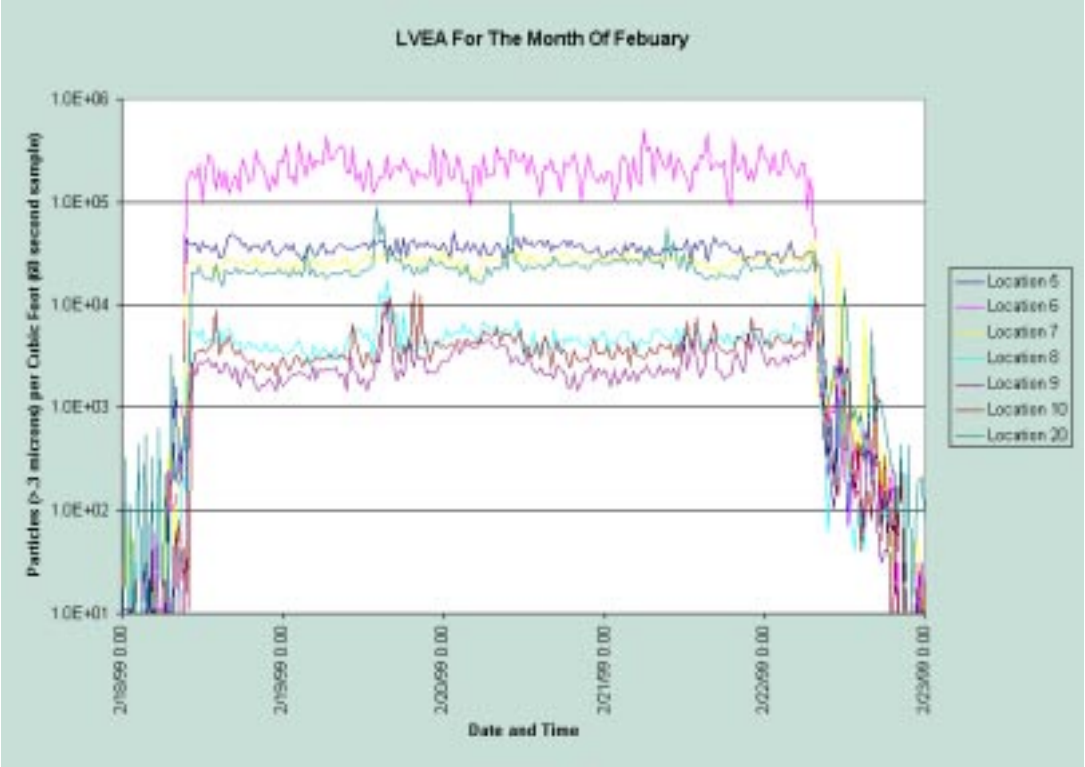
On January 4, 1999 the particle levels inside the Corner Station exceeded 500,000 particles per cubic foot. (greater than 0.3 microns) (see figures #3,4,5) The most likely cause of the contamination is the fire alarm being triggered. When the fire alarm is set off inside the Corner Station, the air handling system for the whole Corner Station is shut down. (During a fire alarm test, air handling systems remain on-line)[1] Contamination control procedures may want to be reviewed, so that sensitive hardware can be left as is without fear of contamination in the event of a fire alarm.



1. Private communication: O. Matherny

4.4. Event from February 14-22, 1999

Starting February 18, 1999 the particulate levels inside the LVEA rose to extreme levels and maintained those levels throughout the weekend. (see figure #6) The levels rose in groups. Location 6 was between 500,000 and 100,000 particles greater then 0.3 microns per cubic for the weekend. Locations 5, 7, and 20 rose to between 100,000 and 10,000 particles greater then 0.3 microns per cubic foot while locations 8, 9, and 10 were between 10,000 and 1,000 particles per cubic foot. All locations rose uniformly and fell uniformly



as well. There have been several ideas as to why this anomaly occurred. One is that a door was left open over the weekend. Another is that the fresh air supply to the LVEA was blocked. However, no tests have been done to determine the cause.

5 PRESENT STATUS OF MONITORING

Particulate monitoring at the LIGO Hanford Observatory has now been automated. The monitors are now tied in to the Controls and Data System, (CDS). Data from the monitors can be accessed in the LHO control room. The system allows continuous logging of particulate levels and also real-time graphing of data. Back data can also be viewed in the control room using the CDS system.