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# LIGO

## THE DETECTION OF GRAVITATIONAL WAVES

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# WHAT IS LIGO ?

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LIGO STANDS FOR:

- **LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY**
- **DIRECT DETECTION OF GRAVITATIONAL WAVES**
- **JOINT CALTECH/MIT PROJECT**
  - FUNDED BY THE NATIONAL SCIENCE FOUNDATION

# GRAVITATIONAL WAVES

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- WHAT ARE THEY:
  - » OSCILLATIONS OF THE “*FABRIC*” OF SPACETIME
  - » COHERENTLY EMITTED BY BULK MOTION OF ENERGY
  - » NO INTERACTION WITH MATTER
- SO?
  - » MOST GRAVITATIONAL SOURCES CAN NOT BE SEEN AS ELECTROMAGNETIC WAVES
  - » POTENTIAL FOR GREAT SURPRISES
  - » UNCERTAINTY IN THE STRENGTHS OF THE GRAVITATIONAL WAVES

# WHAT ARE THE SOURCES?

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GW SOURCE SLIDE

# INTERFEROMETER

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DRAW

# TWO SITES

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USE EXISTING VG

# THE PARTS OF LIGO

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- THE DETECTOR
  - LASER INTERFEROMETER, CONTROL AND DATA SYSTEM
- THE VACUUM EQUIPMENT
  - HOUSES THE INTERFEROMETER, ULTRA HIGH VACUUM
- THE BEAM TUBE
  - PROVIDES A “CLEAN” PATH FOR THE LASER BEAM;
- THE FACILITY
  - BUILDINGS AND INFRASTRUCTURE TO HOUSE THE VACUUM EQUIPMENT AND DETECTOR
  - PROVIDES THE FOUNDATION AND PROTECTION FOR THE BEAM TUBE
  - LABORATORY AND OFFICE SPACE

# THE DETECTOR

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- **WORLD'S MOST SENSITIVE OPTICAL INSTRUMENT**
  - » RESEARCH AND DEVELOPMENT IS ONGOING AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY (CALTECH) AND THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT)
  - » DESIGNED BY CALTECH AND MIT'S SCIENTISTS AND ENGINEERS
  - » FABRICATED BY SPECIALTY VENDORS
  - » ASSEMBLED AND INSTALLED AT THE SITES BY A TEAM OF LIGO SCIENTISTS AND ENGINEERS



# VACUUM EQUIPMENT

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- **VACUUM ENVELOP**
  - 34 LARGE CHAMBERS
  - ~1000 FT OF 72 IN, 60 IN, 48 IN, 30 IN VACUUM PIPES
- **VACUUM PUMPS**
  - 10 ROOTS PUMPS, 20 TURBOMOLECULAR PUMPS, ~100 LARGE ION PUMPS, 12 LARGE CRYOGENIC PUMPS
- **VALVES**
  - 4X60 INCH, 32X48 INCH, ~100X10 INCH GATE VALVES
- **MONITORING AND CONTROL**
  - CONTROLLERS, GAUGES, INTERLOCKS
- **BAKE OUT SYSTEM**
  - ~10,000 SQ. FT OF HEATING BLANKETS

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# SEVERAL VG OF VACUUM EQUIPMENT

# BEAM TUBE

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- **LIGHT MUST TRAVEL THE FULL 4 KM WITHOUT ATTENUATION OR DEGRADATION**
  - 48 INCH STAINLESS STEEL TUBE
  - REQUIRES 400, 20 M LONG TUBE SECTIONS
  - EXPANSION BELLOWS
  - SUPPORT STRUCTURE
  - BAFFLES, TO MINIMIZE STRAY LIGHT INTERFERENCE
- **BEAM TUBE MUST BE SHELTERED FROM THE ENVIRONMENT**
  - 8 INCH CONCRETE TUBE SLAB, PRECISION ALIGNED
  - CONCRETE PRE CAST ENCLOSURE

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# SEVERAL BEAM TUBE PICTURES

# THE FACILITY

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- MAJOR CONTRACTED EFFORTS
  - DESIGN
  - CLEARING AND ROUGH GRADING
  - BUILDING AND INFRASTRUCTURE
  - CONCRETE SLAB AND PRE-CAST ENCLOSURES
  - SUPPORT CONTRACTS

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# DESIGN DRAWINGS

# BUILDING AND INFRASTRUCTURE

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- HENSEL PHELPS CONSTRUCTION
  - SINGLE FIXED PRICE CONTRACT WITH CALTECH
- WORK SCOPE SUMMARY
  - » CORNER STATION
    - APPROXIMATELY 57,000 SQUARE FEET OF HIGH BAY, LABORATORIES AND OFFICES
    - HIGH BAY, CRANES, 32 FEET CEILING HEIGHT
  - » TWO END STATIONS
    - APPROXIMATELY 8,000 SQUARE FEET, HIGH BAY
  - » TWO MID STATIONS
    - SMALL MINIMAL BUILDINGS WITHOUT FACILITIES
  - » INFRASTRUCTURE
    - CHILLER PLANTS, ROADS, PARKING, POWER DISTRIBUTION

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# BLD VG'S



# CONCRETE SLAB AND PRECAST ENCLOSURES

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- WOODROW WILSON CONSTRUCTION
  - SINGLE FIXED PRICE CONTRACT WITH CALTECH
- WORK SCOPE SUMMARY
  - CONSTRUCT APPROXIMATELY 5 MILES OF SERVICE ROAD, 20 FEET WIDE
  - 5 MILES OF PRECISION LEVELED CONCRETE SLAB, 14 FEET WIDE, 8 INCHES THICK
  - FABRICATE AND DELIVER 2,600 PRECAST CONCRETE ENCLOSURES
  - INSTALL ENCLOSURES OVER THE BEAM TUBE, GROUT AND SEAL

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# CONSTRUCTION VG'S

# OUTREACH

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- LIGO IS COMMITTED TO TO USE ITS FACILITIES, SCIENTISTS AND ENGINEERS TO SUPPORT AND PROMOTE SCIENTIFIC EDUCATION AT THE LOCAL STATE AND NATIONAL LEVEL
  - MARK COLES, HEAD OF LIGO LIVINGSTON OBSERVATORY IS ACTIVELY PURSUING OUTREACH ACTIVITIES
  - CALTECH IS SUPPORTING ACTIVITIES
  - NSF IS ENCOURAGING AND SUPPORTIVE OF EDUCATIONAL OUTREACH ENDEAVORS