Blip Glitches in LHO

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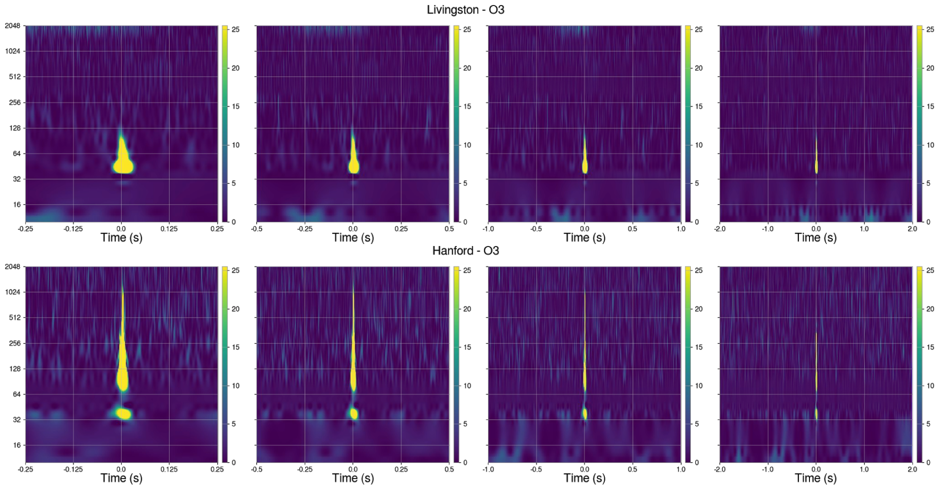
Blip Glitches

- High SNR glitches that occur in both interferometers
- Most power in 30-250 Hz
- Symmetric morphology
- Significant contributor to signal non-stationarity
- Instrumental source
- Little change in form between O2/O3a

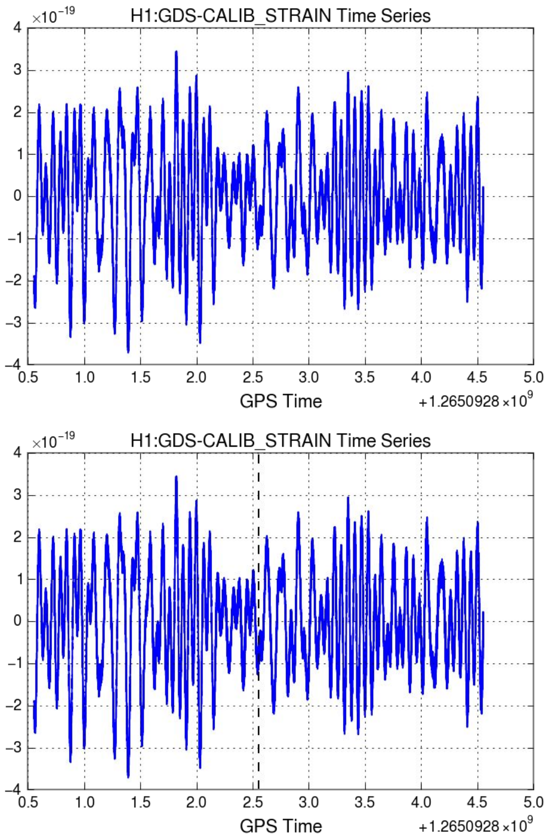
Aerial view of LIGO Hanford Credit: LIGO Scientific Collaboration.



The highest SNR blips with confidence 1 in L1 and H1 in O3b, respectively. Found using GravitySpy.

Blip Glitches

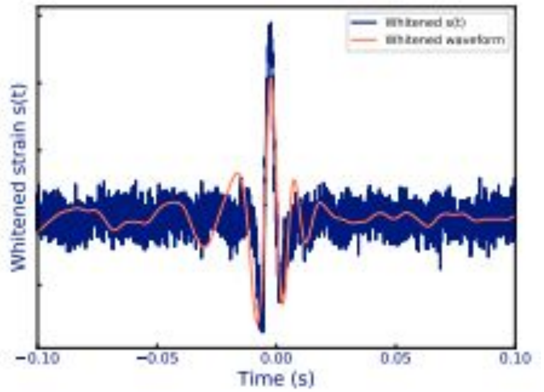
- Problematic for several reasons:
  - Blip triggers are primary contributor to unvetoed, high SNR background
  - Nonstationarity
  - Worse sensitivity to high mass, high spin binaries
  - Could coincide with astrophysical signal
  - No reliable auxiliary witness channel means no reliable veto
- We do not expect blip glitches to be confused with events due to symmetry in time-frequency space



h(t) during a blip glitch. This glitch is the highest SNR glitch with ML confidence 1 found during O3b. The glitch time is denoted by the dashed black line.

Blip Glitches

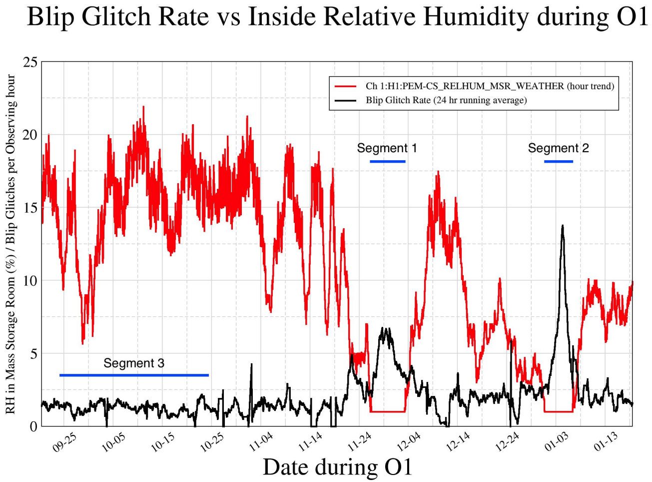
- Proposed causes:
  - Laser intensity stabilization
  - Missed samples as information passed from length to suspension channels
  - Power recycling cavity length

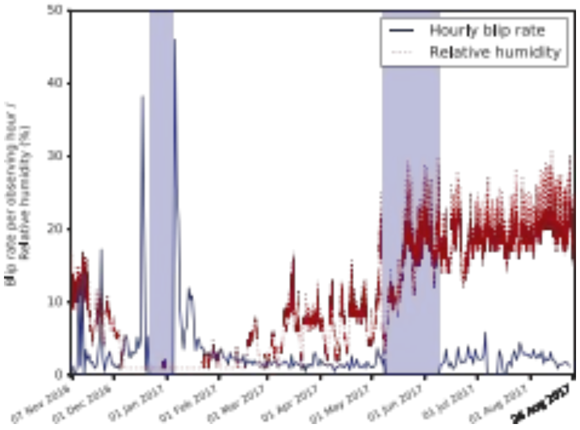


Strain data (blue) with a blip glitch at t=0 after signal processing. A high mass, high mass ratio template is overlaid in orange. From Cabero 2019.

Humidity

- At end of O1, correlation noted between blip glitch rate and humidity at LHO
- Correlation also present in O2





Blip glitch rate in O1/O2. Relative humidity at LHO shown in red. Daily/hourly blip glitch rate shown in black/blue. Lavender sections in O2 denote when the IFO was offline for extended maintenance. Left plot is from Schale, Schofield, Palamos aLog entry, right plot from Cabero 2019.

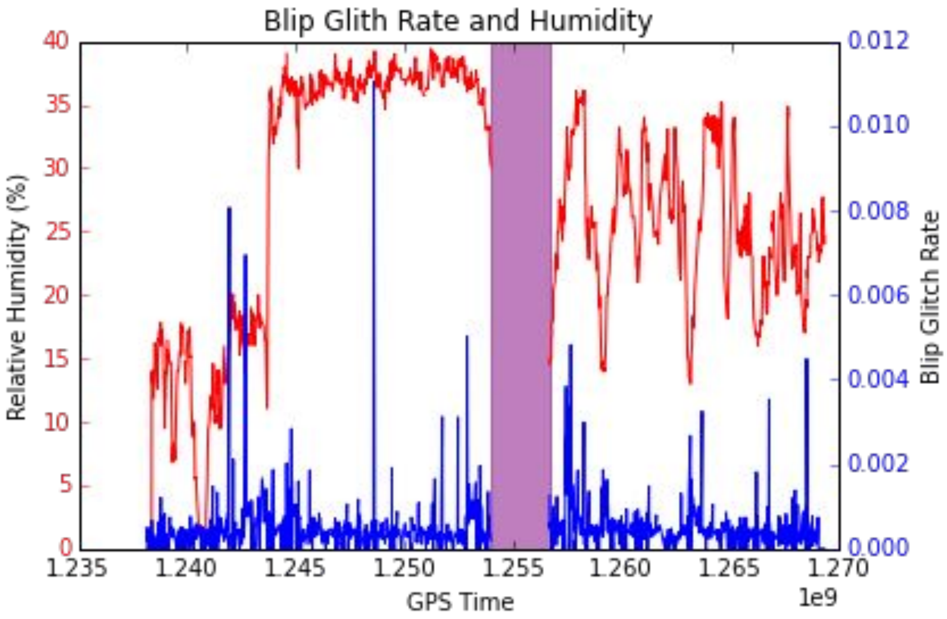
Humidity

- Rationale: when temperature drops, heaters turn on
- Hot dry air being blown around building decreases humidity
- Increase in static electricity discharges from electronics cooling fans in mass storage room (MSR) when dry?
- Increase in static electricity discharges from current leakage paths in MSR when dry?

LHO MSR during iLIGO-aLIGO upgrade. Photo by Dave Barker.

Humidity

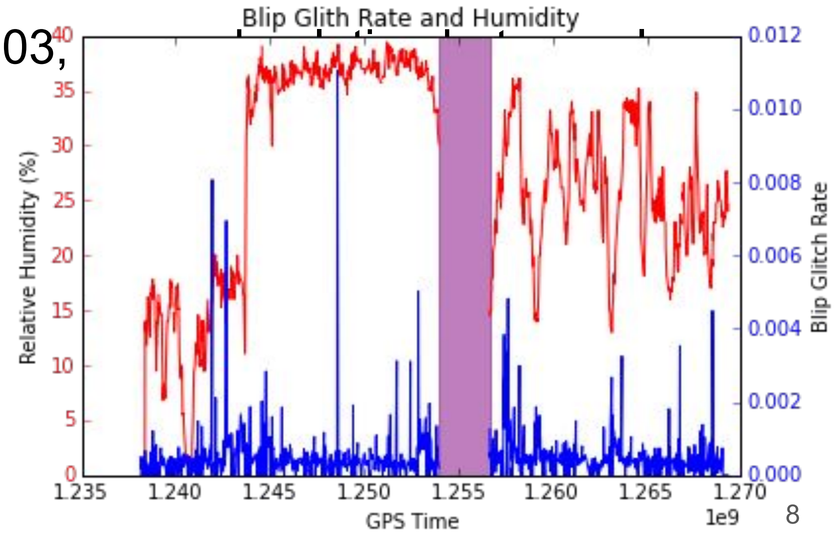
- In O3:



Humidity and blip glitch rate in O3 at Hanford. The purple period with no data represents the commissioning break between O3a and O3b.

Humidity

- Note that highest blip glitch rate (BGR) occurs during period of highest humidity
- Linear regression: more than 97% of variation in BGR unaccounted for by variation in humidity
- More generally: Spearman correlation of -.03, humidity and BGR



Cosmic Rays

- Cosmic rays can affect the IFOs in several ways that could lead to blip glitches:
  - Momentum transfer - particles impact suspension/test mass
  - Heat transfer - particles cause thermal and thermo-acoustic deformation of mirror, change index of refraction
  - Charge - particles can change the charge configuration of the mirrors, affecting its interaction with suspension/vacuum enclosure or they can charge the circuitry in the DAQ system
- Increase in displacement noise due to cosmic ray strikes a factor of 100 smaller than aLIGO design

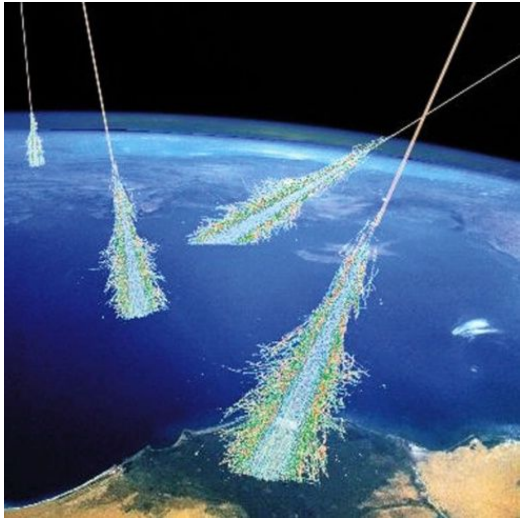
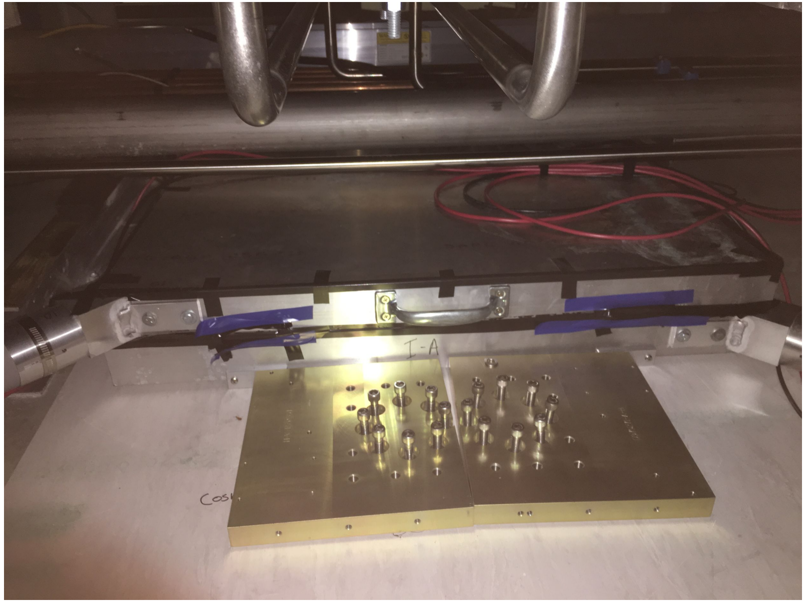


Illustration of cosmic rays striking Earth's atmosphere. Credit: NASA

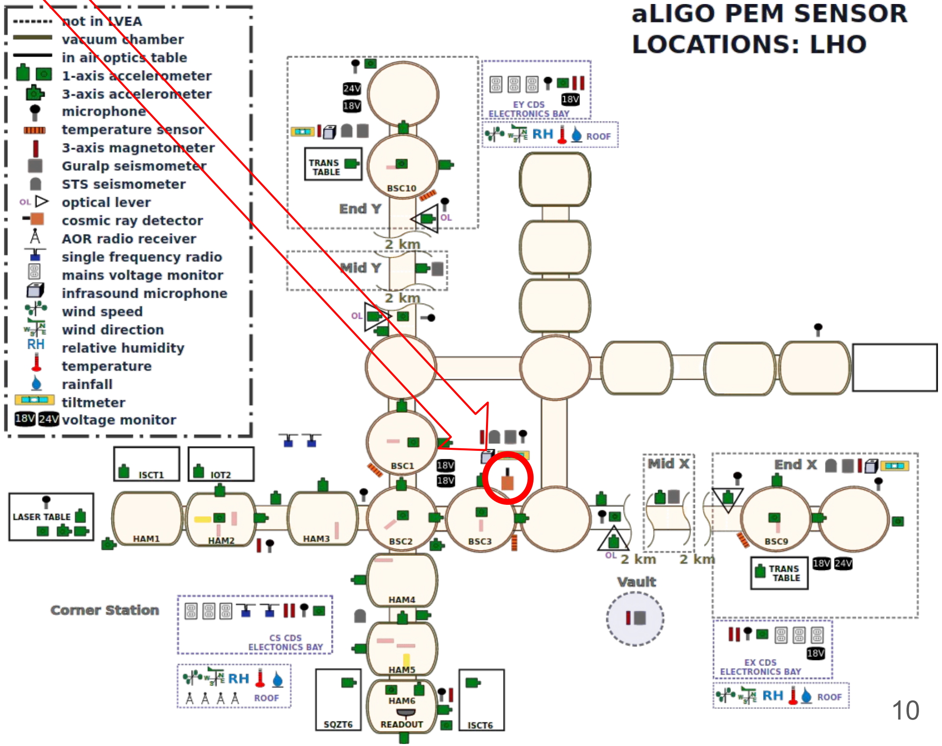
Cosmic Rays

- Cosmic ray detector installed at LHO



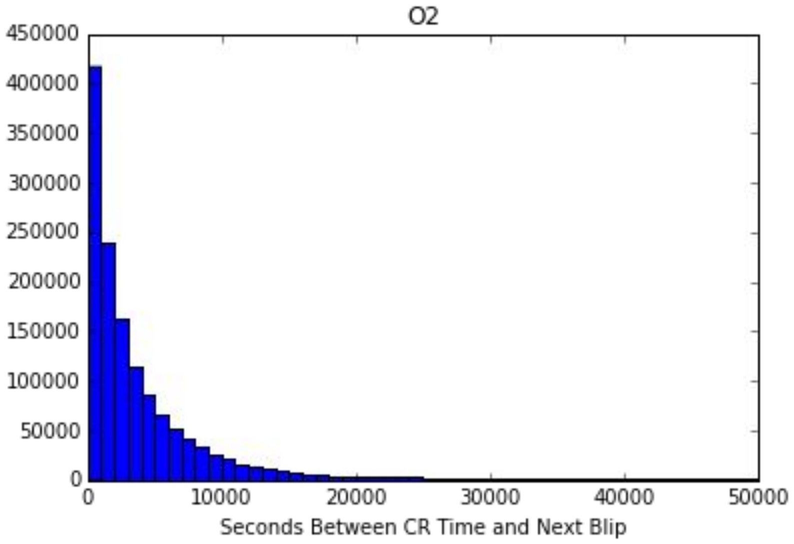
Cosmic ray sensor installed near BSC3. From pem.ligo.org. Credit: PEM team.

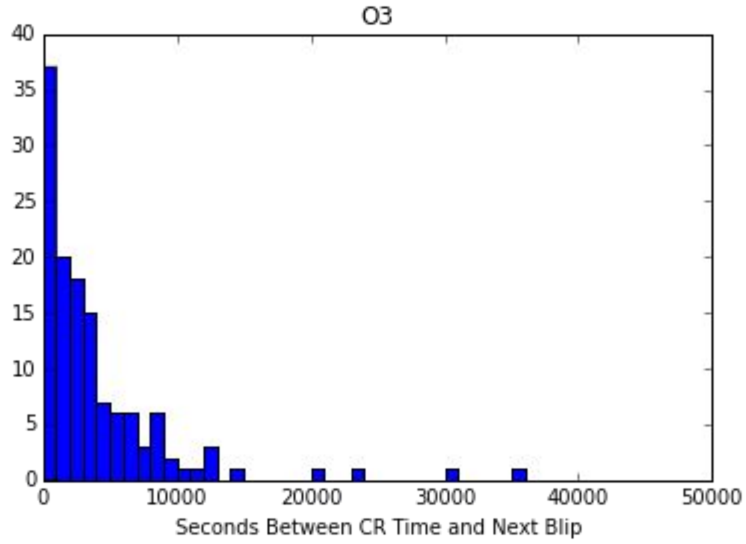
Screenshot from pem.ligo.org highlighting the general position of the cosmic ray sensor.



Cosmic Rays

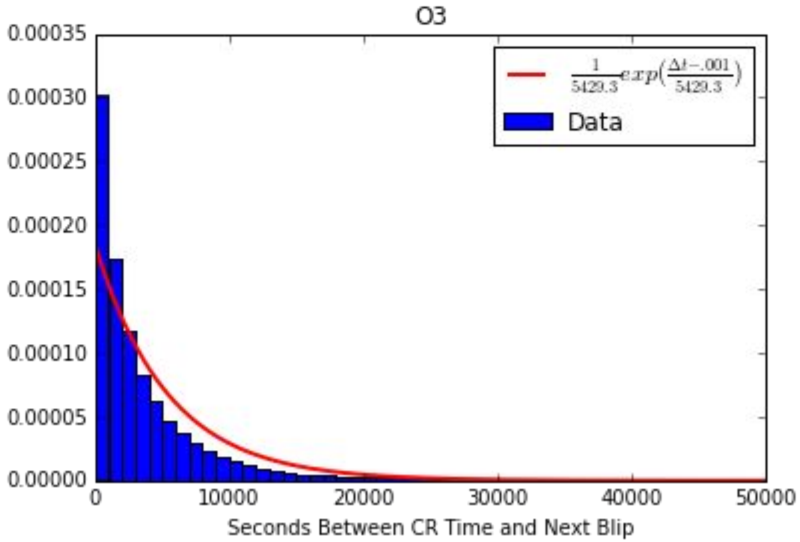
- Examined entire population of O2 and O3 blip glitches with ML confidence greater than .90
- Fewer cosmic rays probably due to a change in trigger threshold, this is okay

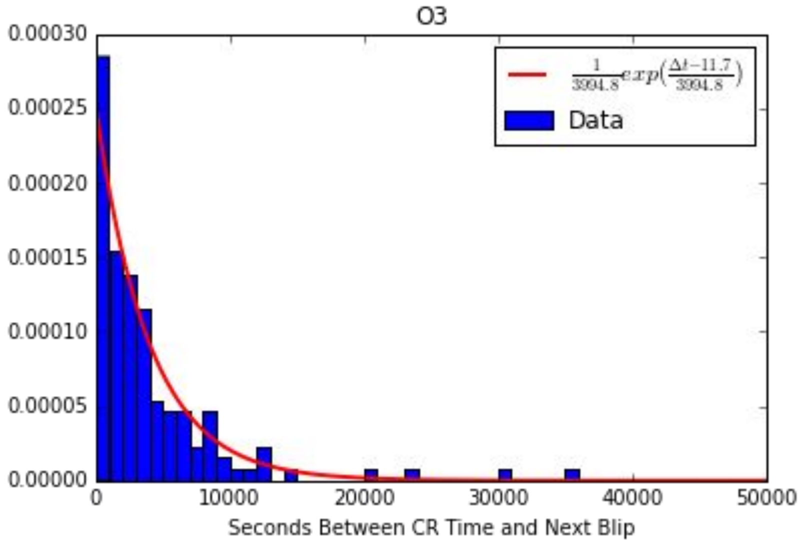




Cosmic Rays

- These are well-described by an exponential distribution or a Poisson process
- Blips probably uncorrelated with cosmic rays
- No apparent connection between cosmic ray and blip properties





Future Directions

- Continue to work on PEM/Detchar tasks
- Get to the bottom of the O2/O3 PMT threshold switch, assess cosmic ray needs for O4 (e.g. energy data from PMT)
- DAQ workbench being set up to test whether computer infrastructure is at fault

Further Information

M Zevin *et al* 2017 *Class. Quantum Grav.* 34 064003
B P Abbott *et al* 2016 *Class. Quantum Grav.* 33 134001
M Cabero *et al* 2019 *Class. Quantum Grav.* 36 155010
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