Sensor used at CERN could help gravitational wave hunters

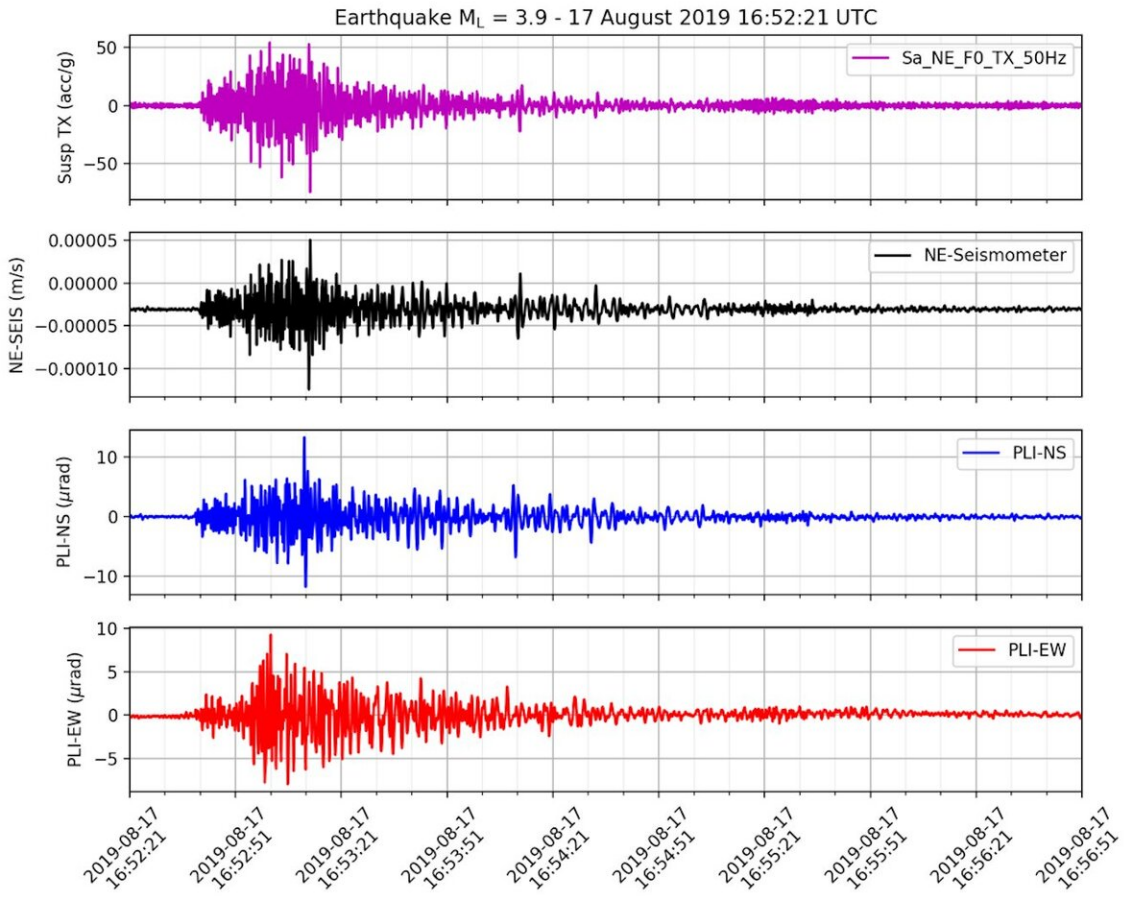
September 2 2019

Aerial view of the Advanced Virgo detector, where a precision laser interferometer used at CERN was installed and is being tested. Credit: Virgo collaboration

It started with a relatively simple goal: create a prototype for a new kind of device to monitor the motion of underground structures at CERN. But the project—the result of a collaboration between CERN and the Joint Institute for Nuclear Research (JINR) in Dubna, Russia—quickly evolved. The prototype turned into several full-blown devices that can potentially serve as early warning systems for earthquakes and can be used to monitor other seismic vibrations. What's more, the devices, called precision laser inclinometers, can be used at CERN and beyond. The researchers behind the project are now testing one device at the Advanced Virgo detector, which recently detected gravitational waves—tiny ripples in the fabric of space-time that were predicted by Einstein a century ago. If all goes to plan, this device could help gravitational-wave hunters minimize the noise that seismic events have on the waves' signal.

Unlike traditional seismometers, which detect ground motions through their effect on weights hanging from springs, the precision laser inclinometer (PLI) measures their effect on the surface of a liquid. The measurement is done by pointing laser light at a liquid and seeing how it is reflected. Compared to weight–spring seismometers, the PLI can detect angular motion in addition to translational motion (up-and-down and side-to-side), and it can pick up low-frequency motion with a very high precision.

"The PLI is extremely sensitive, it can even detect the waves on Lake Geneva on windy days," says principal investigator Beniamino Di Girolamo from CERN. "It can pick up seismic motion that has a frequency between 1 mHz and 12.4 Hz with a sensitivity of 2.4×10^{-5} $\mu rad/Hz^{1/2}$," explains co-principal investigator Julian Budagov from JINR. "This is equivalent to measuring a vertical displacement of 24 picometers (24 trillionth of a meter) over a distance of 1 meter," adds co-principal investigator Mikhail Lyablin, also from JINR.



The PLI (bottom two plots) picked up the same signals as devices already installed at Virgo (top two plots) for an earthquake in Northern Italy on 17 August. Credit: Beniamino Di Girolamo/CERN

The team assembled and tested the PLI prototype at JINR and at CERN's TT1 tunnel. It performed so well that it showed potential to be a helpful early warning seismic system for the High-Luminosity Large Hadron Collider (HL-LHC) and other machines and experiments. The Large Hadron Collider and its proton beams are extremely robust to seismic activity, but the HL-LHC will use narrower beams to increase

the number of proton–proton collisions and as a result the potential for particle-physics discoveries. This means beams are more likely to go off center in the event of a high-magnitude earthquake with an epicenter relatively close to CERN. PLIs located at several points along the machine could serve as early warning systems for such events.

Given the PLI's potential, the HL-LHC project has supported the team to construct several new PLIs. One PLI is already installed at the Garni Seismic Observatory in Armenia and another has been deployed with the support of CERN's Knowledge Transfer group and Italy's INFN institute to the European Gravitational Observatory, Italy, where Advanced Virgo is located. The Virgo PLI is the result of a collaboration that started after the APPEC conference in November 2018, triggered by the JINR Director-General and encouraged by CERN management. The collaboration went so smoothly that, less than a year after, the Virgo PLI was tested.

The results from the first tests are encouraging. With just 15 minutes of data taken on 6 August, the PLI picked up the same signals as devices already installed at Virgo, and from that day onwards it started running continuously and detected several small-magnitude earthquakes. The Virgo and PLI teams are now setting up the flow of data from the PLI to the Virgo data system. This will make it easier to compare data from different seismic devices and to assess the PLI's potential impact on Virgo's operation and detection of gravitational waves. "Virgo and the two LIGO detectors in the US have recently began another search for gravitational waves, one that will reach deeper into the universe than previous searches," says former Virgo spokesperson Fulvio Ricci from La Sapienza University, Rome. "We're confident that the PLI can play a part in this important search," he added.

Provided by CERN

Citation: Sensor used at CERN could help gravitational wave hunters (2019, September 2) retrieved 25 April 2024 from https://phys.org/news/2019-09-sensor-cern-gravitational-hunters.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.