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The application of the Rasnik 3-point alignment system in seismic instrumentation (in-person)

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For high-precision measurement of the momentum of muons, the alignment of three (inner, middle and outer) muon tracking detectors, placed at some mutual distance in the magnetised volume, is essential. Since accurate alignment can not be realised mechanically, the alignment is continuesly monitored instead. For this, a back-illuminated coded mask is attached to the inner detector, and a positive lens, attached to the middle detector, projects an image of the mask pattern onto an image pixel sensor attached to the outer detector. The images from the sensor are analysed and contain high-precision info about the alignment. By correcting the measured muon sagittas with alignment data, the actual positions of the three muon trackers is no longer relevant.
Since 2008, some 8000 Rasnik systems are operational in the ATLAS experiment. The data suggests a much higher operational precision than the original ATLAS requirement of order 10 microns.
Simulations have revealed that spatial resolutions of order 1 nm ***per image*** can be expected, and that this precision is only limited by the quantum fluctuations of the light detected by the pixels of the image sensor. This precision was confirmed by a measurement using the MERCURY-41-302 sensor.
By replacing the positive singlet lens by a microscope objective (Newport M-20X), the magnification lever arm is expected to amplify the image displacement by a factor 20. With 275 fps, a value of 7 pm /sqrt(Hz) has been reached, and by applying new hardware a value of 0.2 pm /sqrt(Hz) is expected. As a simple and straightforward 2D displacement monitor, Rasnik could be applied in the seismic instruments used in Gravitational Wave detectors, replacing commonly used interferometers.

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