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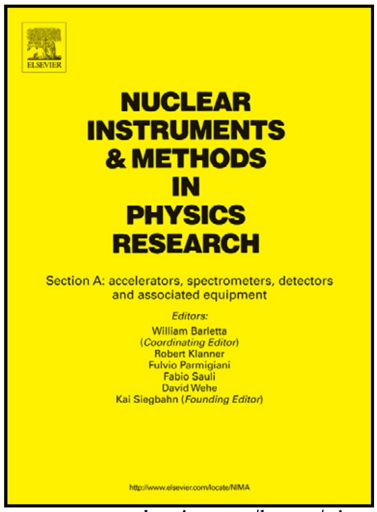

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Multi-Channel Data Acquisition System with Absolute Time Synchronization

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Abstract

We present a low-cost, stand-alone global-time-synchronized data acquisition system. Our prototype allows recording up to four analog signals with a 16-bit resolution in variable ranges and a maximum sampling rate of 1000 S/s. The system simultaneously acquires readouts of external sensors e.g. magnetometer or a thermometer. A complete data set, including a header containing time stamp, is stored on a Secure Digital (SD) card or transmitted to a computer using Universal Serial Bus (USB). The estimated time accuracy of the data acquisition is better than ±200 ns. The device is intended for the use in a global sensor network of optical magnetometers (the Global Network of Optical Magnetometers for Exotic physics – GNOME), which aims to search for signals heralding physics beyond the Standard Model, that can be generated by ordinary spin coupling to exotic particles or anomalous spin interactions.

Keywords
Data acquisition, synchronization, GPS

1. Introduction

Many modern experiments require measurements of various physical quantities in distant locations. Such measurements are for example performed in geophysical studies, in particular, in investigations of Earth's seismic activity. Synchronous detection of seismic waves in different geo-observatories not only provides information about earthquake magnitude and epicenter but also enables imaging of deep geological structures (seismic tomography) [1]. Time resolution of such measurements, however, can be relatively low (~10^{-4} s) due to low speed of the seismic waves (~10 km/s) [2]. To the contrary, various astronomical and astrophysical observations require good time resolution, as the propagation speed of the astrophysical signals is typically close to the speed of light. For example, a microsecond precision is needed to enhance performance of gravitational-wave (see, for example, Ref. [3]) and neutrino detectors [4]. The most sophisticated astronomical studies require measurements with a picosecond time resolution [5].

An interesting new area of application of synchronous measurements is fundamental research, e.g., searches for anomalous spin couplings. To date, these couplings were only investigated locally. However, application of synchronized optical magnetometers enables significant extension of the research. This approach will be used in the Global Network of Optical Magnetometers for Exotic physics (GNOME) [6]. The network will consist of a number of optical magnetometers globally separated (distances between stations from 300 to 10000 km) [7]. Although the devices employ optical monitoring of spin-polarized atomic vapors for magnetic-field sensing, in principle, they can be used to investigate nonmagnetic couplings, including yet undiscovered anomalous spin interactions (see, for example, Ref. [7] and references therein). Due to the signatures of the coupling expected to be detected with the GNOME, a millisecond resolution and microsecond precision of the signal detection in various locations will enable studies of transient spin couplings of a global origin, for example, induced by a jet of exotic particles or generated during a transitions through some exotic field [8].

Currently, several techniques of time distribution are used. For example, time servers distribute timestamps over the Internet [9], which facilitates data exchange and computer-network communication. The accuracy of this