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Compact cylindrical muon detectors for geophysical researches and industrial applications

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A large number of position-sensitive muon detectors for volcano monitoring, tsunami forecasting, fundamental researches of cosmic radiation and nuclear power station monitoring has been developed worldwide [1]. Most of such detectors are massive, having lateral size over 1x1 m2. However, in the geophysical research and geological fields, especially in the situations where detectors have to be placed inside the boreholes or mines, compact detectors with diameter less than 10 cm are required.
In 2018 IDEON (Canada) company has developed [2] a cylindrical borehole muon detector for geological exploration with less than 10 cm diameter based on scintillating fiber. This detector is in active use for searching mineral deposits. In 2021-2023 Italian research group has developed and tested [3] cylindrical muon detector with less than 25 cm diameter based on semi-rings of organic scintillator. In 2024 r. SSC RF «TRINITY» (Russia) has developed and tested [4], the cylindrical borehole muon detector for geological exploration based on scintillating fiber.
This work proposes the development of compact position-sensitive cylindrical muon detector with diameter ~10 cm, length about 1 m and mass no more than 5 kg. The detector will be based on three embedded cylindric layers upon which the scintillating fiber will be laid. Scintillator signal acquisition will be done using SiPM silicon photomultipliers and electronic circuit based on FPGA and comparators. A Monte Carlo simulation of the detector's operation was performed, which showed that expected angular resolution is ~20 mrad for a 20-90° range of zenith angles. For the detector prototype the efficiency has been measured as well as angular distribution of muon flux.
Going forward the developed detector can be used for industrial applications to search for underground lakes, tunnels and cavities in the ground etc.

References:
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