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Acoustic detection of high energy ions

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First ideas to use thermoacoustic phenomena for particle detection date back to the fifties. The technique has intensely been considered for underwater ultra-high neutrino detectors [1] and appropriate detector arrays are under development [2]. There have been also attempts to use the acoustic signal induced by the characteristic dose deposition of a proton pulse in context of radiation therapy [3]. Recently, the method has seen a resurgence due to technical improvements in proton therapy, where the so-called ionoacoustic signal promises a simple, but very accurate means to measure the Bragg peak position during patient irradiation [4]. In this talk, we will demonstrate the potential of an ionoacoustic particle detector to monitor intense light and heavy ion bunches. For GeV-ions, experiments were performed by exposing a water beam dump to short and intense bunches of various heavy ions (U, Xe, C) with energies around 200 to 300 MeV/u, delivered by the upgraded SIS-18 synchrotron at GSI. The measured ion ranges in water are in good agreement with Geant4 simulations, opening a new method for stopping power determination at relativistic energies. In another example, Ionoacoustics offers an almost unrivaled detection technique for laser accelerated ions, which are produced in ultrashort bunches with large particle numbers accompanied by an interfering electromagnetic pulse (EMP). Acoustic detectors take advantage of a huge dynamic range and, moreover, the acoustic signal is separated from the EMP due to the transit time of the sound wave. First experimental results will be presented for protons accelerated by state-of-the-art PW class lasers, where the full energy distribution of energetic protons could be reconstructed from the ultrasound signal measured with a single PZT transducer.

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