



Contribution ID: 53

Type: **Invited Speaker / Conférencier invité**

Multiple-Reflection Time-of-Flight Mass Spectrometry: from nuclear physics experiments to clinical applications

Tuesday, 17 June 2014 09:15 (30 minutes)

Mass spectrometry is a technique, which was developed more than hundred years ago. It led to epochal discoveries and contributed to the foundation to what is now called nuclear and particle physics. Nowadays mass spectrometry is also applied as analytical tool in many directions of science, e.g. in chemistry, biology, geology, space science and many other fields. Time-of-Flight (TOF) mass spectrometry is one of the established methods, where ions are separated in a mass-dispersive flight path. The novel technique of Multiple-Reflection Time-of-Flight Mass Spectrometry (MR-TOF-MS), where ions are reflected multiple times between electrostatic mirrors enhances the range of applications. Arbitrarily long flight paths (typically of several 100 m) can be realized in compact systems (~ 1 m), resulting in a mass resolving power of several 100 000 as well as a mass accuracy of about 10^{-7} . MR-TOF-MS have been commissioned for rare ion beam facilities all around the world and are key devices of several projects. At GSI (Germany) a MR-TOF-MS performs direct ultra-high precision mass measurements of exotic nuclei and allows mass-selective decay spectroscopy. At TRIUMF (Canada) it will serve as an isobar separator to suppress isobaric beam contaminants and enable high accurate mass measurements of very short-lived products. A down-scaled, robust and mobile MR-TOF-MS opens up new applications in different fields e.g. in environment, climate research and in health, nutrition and security applications. In this way an instrument originally invented for nuclear physics experiments can contribute to modern medical diagnostics via fast (~ 1 s) detection of cancerous tissue in electro-surgery. In general, a new era of reliable analysis of breath gas can be made, as well as the microscopic composition of biological samples. Actual achievements and resulting opportunities with the novel method will be discussed in the present contribution.

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Session Classification: (T1-4) Mass Spectrometry and Nuclear Structure - DNP / Spectrométrie de masse et structure nucléaire - DPN

Track Classification: Nuclear Physics / Physique nucléaire (DNP-DPN)