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Development of grazing incidence devices for space-borne time of flight mass spectrometry

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Time of flight mass spectrometer is widely used to study space plasmas in planetary and solar missions. This space-borne instrument selects ions in function of their energy through an electrostatic analyzer. Particles are then post-accelerated to energies in the range of 20 keV to cross a carbon foil. At the foil exit, electrons are emitted and separated from ion beam in the time of flight section. A first detector (a Micro-Channel Plate or MCP) emits a start signal at electron arrival and a second one emits a stop signal at incident ion end of path. The time difference gives the speed of the particle and its mass can be calculated, knowing its initial energy.

However, current instruments suffer from strong limitations. The post acceleration needs very high voltage power supplies which are heavy, have a high power consumption and imply technical constraints for the development. A typical instrument weighs from 5 to 6 kg, includes a 20 kV power supply, consumes a least 5 W and encounters corona effect and electrical breakdown problems. Moreover, despite the particle high energy range, scattering and straggling phenomena in the carbon foil significantly reduce the instrument overall resolution. Some methods, such as electrostatic focus lenses or reflectrons, really improve mass separation but global system efficiency remains very low because of the charge state dependence of such devices.

The main purpose of our work is to replace carbon foil by grazing incidence MCP's – also known as MPO's, for Micro Pore Optics – for electron emission. Thus, incident particles would back-scatter onto the channel inner surface with an angle of a few degrees. With this solution, we can decrease dispersion sources and lower the power supplies to post accelerate ions. The result would be a lighter and simpler instrument with a substantial resolution improvement. We have first simulated MPO's behavior with TRIM and MARLOWE Monte-Carlo codes. Energy scattering and output angle computed are promising, but imply some limitations in terms of input ion beam control. An experimental device has been designed and built to confirm these theoretical results from samples supplied by PHOTONIS. We will also be able to test other parameters concerning MPO's and their coating. Finally, we have developed an optimization software, which manages simulation programs, to find the best way to implement MPO's in a direct time of flight mass spectrometer. For the instrument definition, we have been led to deal with critical points, such as MPO – electrostatic analyzer coupling, electron beam control, or attainable mass resolution. We are now starting the prototype electronic and mechanical development.

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