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Spectrometers for particle measurements in space based on surface reflection

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This is a review talk on space particle spectrometers based on the surface reflection technique. We sum up the experience in development and operation of such instruments accumulated for the last 15 years at the Swedish Institute of space Physics, Kiruna, Sweden in close cooperation with University of Bern, Bern, Switzerland. The technique is relatively new and used in space for measurements of few eV – few keV particles. It was first introduced for neutral atom detection in the GAS instrument onboard the ESA/NASA Ulysses mission (Witte et al., 1992) and later for ion measurements (Barabash et al., 2007) onboard Indian Chandrayaan-1.

When a particle hit a surface, secondary electrons release and the particle is either absorbed by the surface or get scattered or reflected. The charge state of the reflected particles normally does not depend on the initial charge state and is neutral but also includes a fraction of negative and positive ions. These charged particles can be analyzed by conventional ion optics. The secondary electrons can be used for triggering a time-of-flight system. The surface reflection technique is close to the usage of foils/ulta-thin foils for particle detections but has a number of advantages. First, it does not require high pre-acceleration potentials and thus allows making more compact and light weight instruments. Secondly, it permits detection of neutral atoms down to 10 eV. Despite the interaction with the surface modifies the original particle velocity, the proper design of the following analyzer section and ion optics can mitigate this effect.

We shortly introduce main characteristics of the particle – surface interactions important for this application, describe designs of the instruments flown in space, and show performances of the surface reflection based ENA and ion spectrometers developed for Mars / Venus Express, Chandrayaan-1, BepiColombo, Phobos-Grunt, and Swedish PRISMA.