Nuclear microprobe and cultural heritage: the benefits of external beams

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The nuclear microprobe is extensively applied to many research fields, due to the combination of remarkable analytical performance of ion beam analysis and good spatial resolution, in the µm range under conventional vacuum operation. However, such vacuum conditions constitute a serious drawback for the analysis of items relevant to art and archaeology. Indeed, their size is generally not compatible with the dimensions of the microprobe chamber and their frequently insulating character necessitates a conductive coating for vacuum operation. Consequently direct analysis on the whole object is exceptional and use of a small sample taken from the object is generally needed, which is not always allowed. The use of an external micro-beam permits to circumvent these constraints, at the expense of lateral resolution which obviously cannot be as good as under vacuum. However, the use of an ultra-thin (100 nm) exit window made of Si_3N_4 and of an helium flow to minimize angular straggling leads to a beam size of about 10 µm for 3-MeV protons and 50 µm for 3-MeV helium ions, sizes sufficient to address most issues of artistic or archaeological significance. This is the set-up developed on the IBA facility of the Louvre which has acted as a pioneer in that respect. All IBA techniques can be implemented simultaneously and elemental maps can be drawn either by electronic scans on the fixed object or mechanical scans under fixed beam, the latter mode permitting maps over quite large areas (several cm^2) out of reach for conventional microprobes. Numerous examples will be given to illustrate the capability of this external microprobe.