Appendix 2

Determination of the ionization efficiency

Total number of particles ablated per pulse:

$$N_{tot} = \frac{V \times \rho}{M} \qquad \text{[particles/pulse]}$$

For 200 fs pulses at 4 J/cm^2 irradiating a sapphire target, we have:

$$N_{tot} = 0.8 \times 10^{12} \qquad \text{[particles/pulse in the gentle phase]}$$

$$N_{tot} \geq 5 \times 10^{12} \qquad \text{[particles/pulse in the strong phase]}$$

where:

$M = \frac{3M_O + 2M_{Al}}{5}$ is the average mass for sapphire, M=20.4 u, V is the volume ablated per pulse and ρ is the material density [g/cm^3].

The total ion yield is determined by the following procedure:

The measured yield for a fixed angle and extraction time is is given by the integral of the ion peak in the mass resolved TOF spectra as in Fig. 2.2-2 middle and bottom part: *I(t)* [mVxµs]

The corrected yield in the velocity space is *n(v)=I(t)t/D* [mVxµs^2/m] where *t* is the extraction time, *v* is the velocity, *v=D/t*, and *D* is the separation between the extraction zone and the sample (see Fig. 2.2-1).

Total ion yield at a fixed angle is:

$$Y(\theta) = \int_v n(v)dv \qquad \text{[mVxµs}^2\text{/s]}$$

The density of counts is determined by the active area of the extraction grids (covered by the solid angle determined by the MSP aperture).

$$\sigma(\theta) = Y(\theta)/A = \sigma f_r(\theta)$$

Total number of counts is given by the integration of the angular distribution $f_r(\theta)=cos^p(\theta)$ over the hemisphere

$$N = 2\pi r^2 \sigma \int_0^1 f^p(\cos(\theta))d\cos(\theta) = \frac{2\pi r^2 \sigma}{p+1} \qquad \text{[V s]}$$

Since the MSP output has R=50 Ω impedance, the measured charge is given by:

$$Q = \frac{N}{R} \qquad \text{[C]}$$

The number of measured elementary charges is:

$$Q_{measured} = \frac{Q}{e}$$

The absolute number of ions is:

$$Q_{absolute} = \frac{Q_{measured}}{T\eta F}$$

where T is the grids transmission n_{grids} x 90%, η is the detector efficiency, taking into account the active area (~30%) and F is the amplification factor (~10^3).

The ionization degree is thus given by:

$$\alpha = \frac{Q_{absolute}}{N_{tot}}$$