# High-Precision Measurement of Total Fission Cross Sections in Spallation Reactions of $^{208}$Pb and $^{238}$U*

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Since the accelerator-driven system (ADS) is considered as an option for the incineration of radioactive waste, intense effort has been made in providing experimental data on interactions of intermediate-energy protons and neutrons with the neutron-production target, with construction material, and with materials that undergo transmutation in the ADS. In last two decades, the experimental knowledge on the production of individual nuclides in spallation reactions has improved substantially also thanks to the results of an experimental campaign executed at GSI [1] with a high-resolution magnetic spectrometer. Also improved codes, e.g. [2, 3] have been developed on the basis of this new generation of experimental results.

The situation has not so much improved, however, concerning total fission cross sections. Experimental uncertainties are often rather large, and the results of different experiments severely contradict each other in many cases, as discussed in Ref. [4]. In the present work, we report on the first results of a new generation of high-precision measurements of total fission cross sections in spallation reactions of $^{208}$Pb and $^{238}$U at energies between 0.5 and 1 *A* GeV. The experiments were performed with a novel experimental approach in inverse kinematics using a full-acceptance detection system. This technique has decisive advantages and copes with several problems of most conventional direct-kinematics experiments performed up to now: The most important feature is that, due to the inverse kinematics, all fission fragments (FFs) leave the target with high energy in a narrow cone in forward direction. In addition, the individual projectiles are registered and identified with the same detectors which also register the FFs. The angular range where FFs are emitted is fully covered. Further on, both FFs are registered and identified simultaneously, and their velocity vectors are determined. Finally, the multiplicity of the reaction products is accessible. All these features are crucial for obtaining total fission cross section with high precision.

The fission set-up used in the present work was developed at the GSI experimental facility and was situated behind the fragment separator (FRS), see Fig.1 Details on the experimental setup and data analysis can be found in ref. [5].

The total fission cross sections measured in the present work are shown in Table 1.

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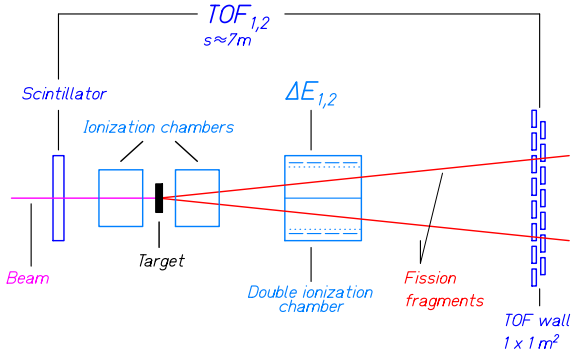


Figure 1: Side view of the fission set-up mounted behind the FRS at GSI Darmstadt. Two ionization chambers (MUSIC1 and MUSIC2) with the target mounted in-between form an active target. A double ionization chamber (TWIN) and a TOF wall detect the two fission fragments.

Table 1: Measured total fission cross sections.

| Reaction | $\sigma_{tot}$ / mb |
|---|---|
| $^{208}$Pb(500 *A* MeV)+ $^{1}$H | (146 ± 7) |
| $^{208}$Pb (500 *A* MeV) + $^{2}$H | (203 ± 9) |
| $^{238}$U (545 *A* MeV) + $^{1}$H | (1.49 ± 0.10) ·1E+3 |
| $^{238}$U (935 *A* MeV) + $^{1}$H | (1.55 ± 0.10) ·1E+3 |

High precision between 5% and 7% could be achieved due to the fact that the experimental set-up detects the FFs with efficiency close to 100% and that fission events are unambiguously identified and distinguished from other reactions by the dedicated high-resolution detection system. In addition, the projectiles are individually counted using the same detectors. More details can be found in [5].

## References

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