# Probability of Fission Induced by 1.2 GeV Antiprotons

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A measurement of fission probabilities was undertaken with a new double $4\pi$ detector (PS208) at the LEAR, CERN. This new apparatus combines a $4\pi$ neutron detector — the Berlin–Neutron–Ball (BNB) — surrounding a $4\pi$ silicon–detector for detection of fission fragments and charged particles — the Berlin-Si-Ball (BSiB).

A variety of targets ranging from Cu to U were measured in August 1994. In order to determine absolute probabilities of fission [2] the annihilation cross section for the different targets was measured too. The number of incoming $\overline{\mathrm{p}}$ was registered by a scintillation counter telescope, the number of annihilations in the target was given by the prompt events seen in the BNB caused by the annihilation pions which were in strong time correlation with the $\overline{\mathrm{p}}$ passing the counter telescope. The annihilation cross section $\sigma_{\mathrm{ann}}$ is then given by the formula

$$\sigma_{\mathrm{ann}} = \frac{N_{\mathrm{ann}}}{S_{\mathrm{hit}}} \cdot \frac{A}{N_{\mathrm{A}} d_{\mathrm{T}}}. \qquad (1)$$

Here $N_{\mathrm{ann}}$ is the number of annihilations, $S_{\mathrm{hit}}$ the number of antiprotons registered by the counter telescope, $N_{\mathrm{A}}$ the number density of nuclei and $d_{\mathrm{T}}$ the thickness of the target. The cross sections $\sigma_{\mathrm{ann}}$ in Table 1 agree well with a geometrical one given by the formula

$$\sigma_{\mathrm{ann}}(A) = \pi \left( r_0 A^{1/3} \right)^2, \qquad (2)$$

with $r_0 = 1.38(1)$ fm. Fission events were identified in the TOF-energy-plot of charged particles. The coincidence of two fission events in opposite detectors was demanded to mark an event as fission. The fission probability $P_{\mathrm{f}}$ is defined by the formula $P_{\mathrm{f}} = N_{\mathrm{fiss}}/N_{\mathrm{ann}}$. The fission probabilites are shown in Table 1, too. One interesting fact is, that the fission probability is far from 100% even for the most fissile targets U and Th. A possible explanation is the loss of many nucleons during the intranuclear cascade induced by the annihilation pions and the following pre-equilibrium emission thus reducing the mass number of the fissioning nucleus and his fissility considerably.

| Target | $\sigma_{\mathrm{ann}}$ [b] | Fission Probability $P_{\mathrm{f}}$ [%] |
|---|---|---|
| $^{nat}$U | 2.25(13) | 51(2) |
| $^{232}$Th | | 34(2) |
| $^{209}$Bi | 2.15(13) | 11.9(5) |
| $^{197}$Au | 1.98(12) | 7.8(3) |
| $^{165}$Ho | 1.79(10) | 6.6(3) |
| $^{nat}$Sn | 1.42(9) | 5.2(5) |
| $^{nat}$Ag | | 5.0(6) |
| $^{nat}$Mo | | 7(1) |
| $^{89}$Y | | 6(2) |
| $^{nat}$Cu | 0.99(9) | 6(5) |

Table 1: Measured annihilation cross sections and fission probabilities for 1.2GeV $\overline{\mathrm{p}}$.

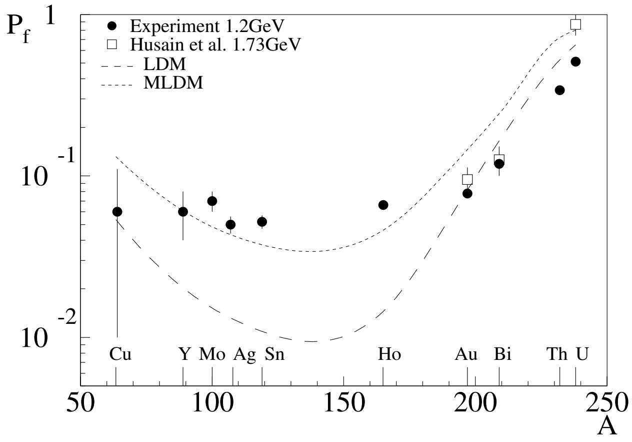


Fig. 1: The picture shows the measured fission probabilities for 1.2GeV and 1.73GeV $\overline{\mathrm{p}}$ [1]. The dashed and dotted lines are calculations following the standard liquid drop model and a modified liquid drop model, respectively.

## References

[1] L. Husain and S. Katcoff, Phys. Rev. **C4(1)** (1971) 263
[2] S. Schmid, diploma thesis, TU München, 1995