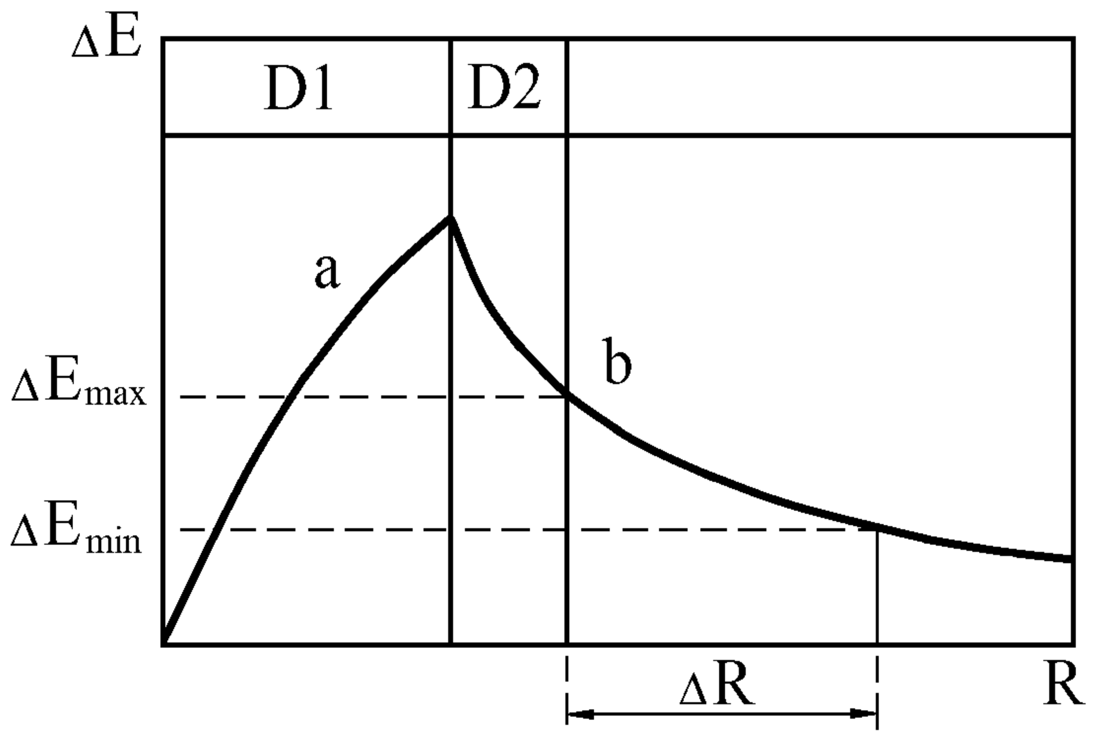
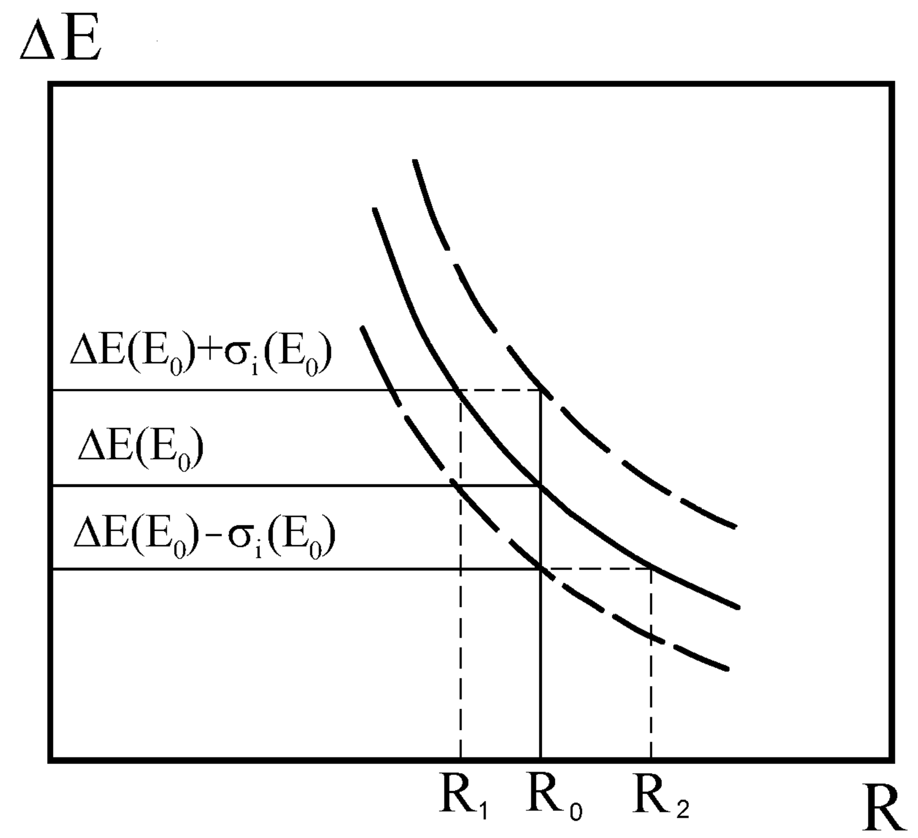
Characteristics of semiconductor pion stop tagging system

B Chernyshev[1], Yu Gurov[1], S Lapushkin[1] and V Sandukovsky[2]
[1]National Research Nuclear University MEPhI, 115409, Moscow, Russia
[2]Joint Institute for Nuclear Research, 141980 Dubna, Russia



The tagging system consists of two Si detectors (D1 and D2) located in front of the target. The proposed method is based on the dependence of ionization losses in the detector on the particle energy. The dependence of the average energy loss in the D1 detector on the particle range is shown in Fig. 1. It can be seen that the measurement of energy loss in D1 makes it possible to determine the residual path of the particle.



The method for determining σ_R (accuracy of determining the range) is shown in Fig. 2**.** For a particle with an initial energy E_0 the solid curve shows the dependence of the energy loss ΔE on the value of the residual path R. The energy losses $\Delta E(E_o) \pm \sigma_i(E_o)$ correspond the ranges R_1 and R_2. Then according to the proposed method, the spatial resolution for particles with residual range in the target R_f is defined as $\sigma_R \approx (R_2 - R_1)/2$.

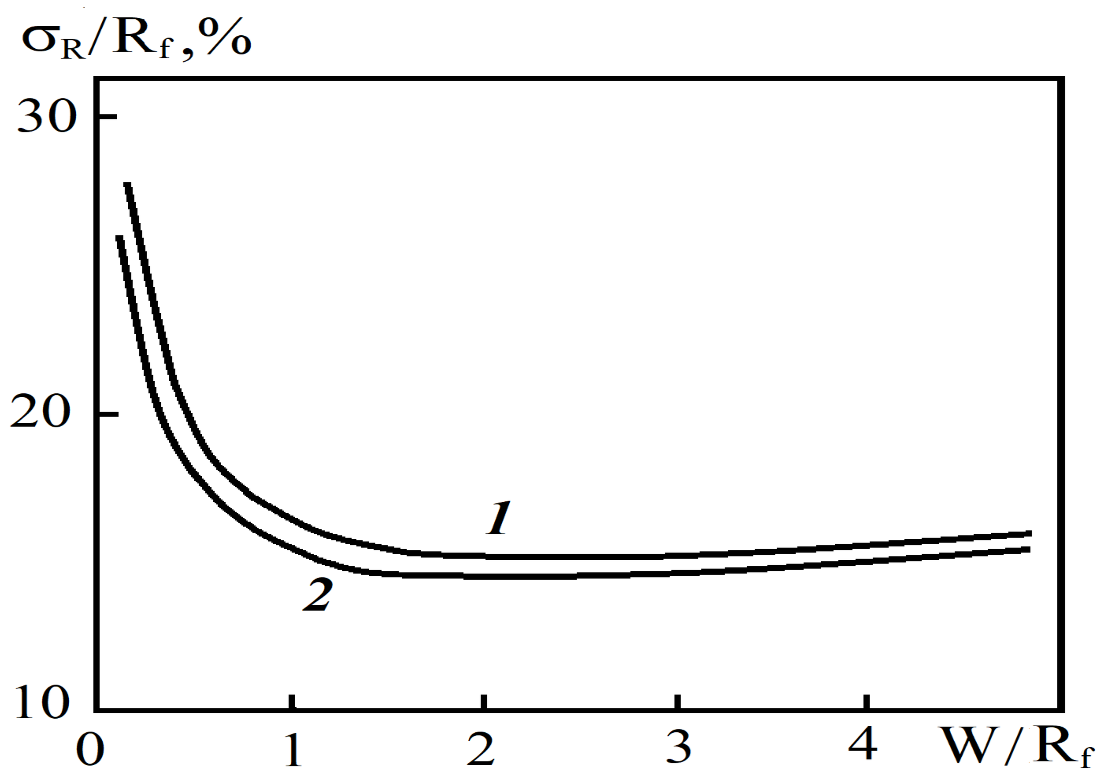
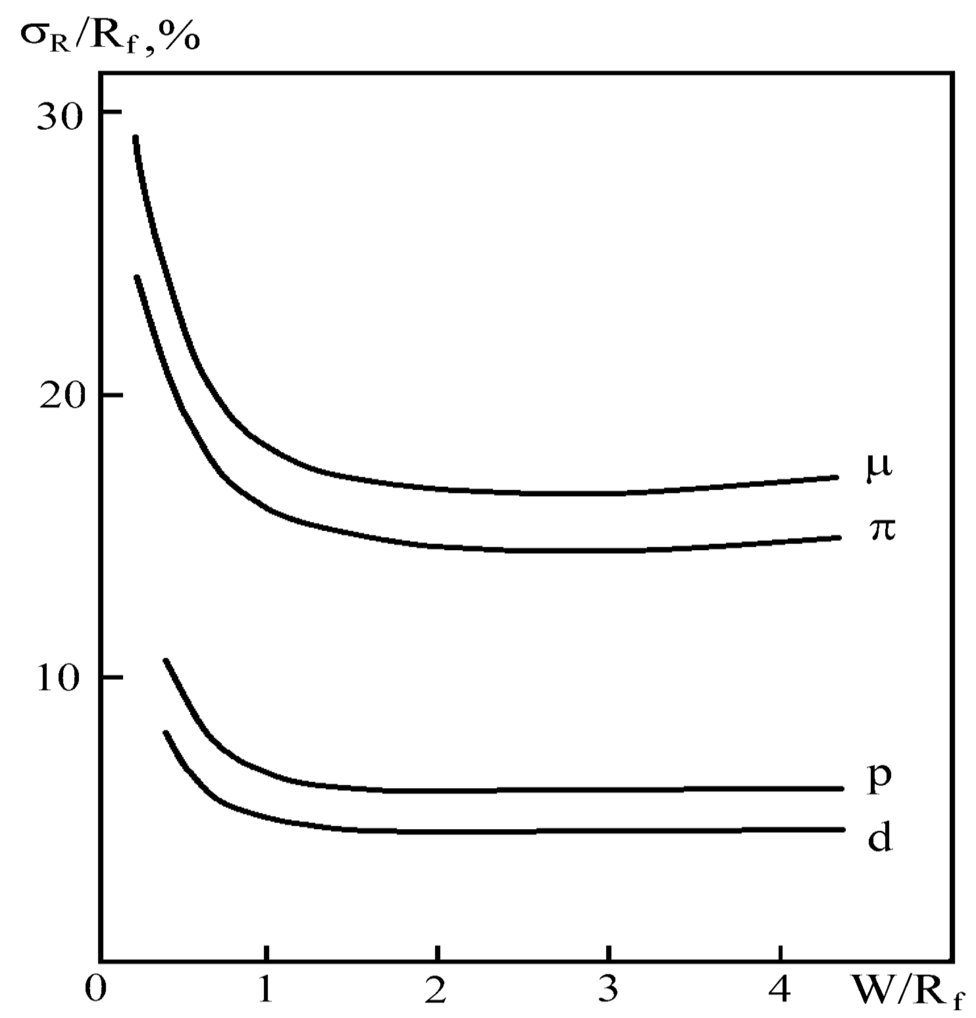


Fig. 3 shows the results of calculations of the relative spatial resolution for π^--mesons as a function of the W/R_f for two values of the residual range $R_f = 0.25$ and 2 mm (W is the thickness of D1). The calculations assumed that the detector has a high intrinsic energy resolution . It is seen that the obtained functions differ by no more than 5% . Therefore, we can assume that the relative spatial resolution depends only on the W/R_f ratio.



Similar calculations were performed for other types of particles. Fig. 4 shows the results for muons (μ), pions(π), protons (*p*), and deuterons (*d*) (R_f = 1 mm). It can be seen that the curves have a similar form and the approximate relation exists:

$$\frac{f_i(W/R_f)}{f_j(W/R_f)} \approx \sqrt{\frac{m_j}{m_i}},$$

where m_i, m_j are the particle masses. Thus, the relative spatial resolution is determined by the universal function:

$$\frac{\sigma_R(R_f)}{R_f} \approx \sqrt{\frac{m}{m_\pi}} \cdot f_\pi(W/R_f) = \sqrt{m} \cdot F(W/R_f),$$

where m is the mass of the incoming particle and m_π is the mass of the pion. The dependence has a wide minimum in the range of values W/R_f ~ 2, which corresponds to the equality of energy losses in the detector and the residual energy.

The best resolution is achieved when the detector thickness is approximately twice the distance to the stop point. It follows that $W_{opt} \approx 2 \cdot T$, where T is the distance from the detector D1 to the edge of the target, i.e. the sum of the thicknesses of the second detector and the target. It is shown that the best spatial resolution is achieved when the detector thickness is equal to twice the residual range.