EXPERIMENTAL STATUS OF PIONIUM AT CERN

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The experiment DIRAC [1] aims to measure the lifetime of the $\pi^+\pi^-$ atom (pionium) in the ground state with 10% precision. DIRAC is a magnetic double arm spectrometer and uses the high intensity 24 GeV/c proton beam of the CERN PS. Since this lifetime τ of order 10^{-15} s is dictated by *strong* interaction at low energy, a precise measurement of τ enables to determine *strong* S-wave pion scattering lengths to 5% [2]. In Chiral Perturbation Theory (ChPT) pion scattering lengths are studied since many years, resulting in better and better predictions, now at an accuracy around 2% [3]. Such a measurement would submit the predictions of ChPT and hence the understanding of chiral symmetry breaking of QCD to a crucial test.

The experimental method to measure the pionium lifetime (~ 3 fs) takes advantage of the Lorentz boost of relativistic pionia produced in high energy proton nucleus reactions at 24 GeV/c. After production in the target (e.g. 0.1 mm thin Ni foil) these relativistic ($\gamma \simeq 15$) atoms may either decay into $2\,\pi^0$ or get excited or ionized in the target material. In the case of ionization or breakup, characteristic charged pion pairs, called "atomic pairs", will emerge, exhibiting low relative momentum in their pair system ($Q < 3$ MeV/c), small pair opening angle ($\theta_{+-} < 3$ mrad) and nearly identical energies in the lab system ($E_+ \simeq E_-$ at the 0.3% level). The task of the spectrometer is to identify charged pion pairs and to measure their relative momenta Q with high resolution of $\delta Q \simeq 1$ MeV/c. By these means, it is possible to determine the number of "atomic pairs" above background, arising from pion pairs in a free state ("free pairs"). For a given target material and thickness, the ratio of the number of observed "atomic pairs" to the total amount of produced pionia depends on τ in a unique way.

The experiment consists of coordinate detectors, a spectrometer magnet (bending power of 2.3 Tm) and two telescope arms, each equipped with drift chambers, scintillation hodoscopes, gas Cherenkov counters, preshower and muon detectors.

After tuning the primary proton beam as well as all detectors, the experiment started to accumulate data in 1999. The setup performance has been studied by analysing data collected with a platinum target. In order to track the relative momentum resolution, the invariant mass spectrum of p and π^-

— Λ decay products — was investigated. The position of the mass peak in Fig. 1 corresponds to Λ particles reconstructed in the DIRAC spectrometer. The width of the Λ peak, mainly given by the momentum resolution, is found to be 0.43 MeV.

A preliminary search for "atomic pairs" in the 1999 platinum data sample is presented in Fig. 2. As mentioned above, "atomic pairs" are characterized by low relative momentum $Q < 3$ MeV/c or equivalently $F < 3$ [a]. The distribution of "reals" $N_{\rm real}(F)$ is the sum of two distributions: "atomic pairs" (for $F < 4$) and "free pairs". In the region $F > 4$ the "free pair" distribution $N(F)$ has been approximated by a fit function $A(F)$, based on "accidental pairs". In Fig. 2 the difference between the experimental distribution $N_{\rm real}(F)$ and $A(F)$ is shown. The excess of $\pi^+\pi^-$ pairs with $F < 2$ amounts to 160 ± 45, which is compatible with the expected number of "atomic pairs" ≈ 240.

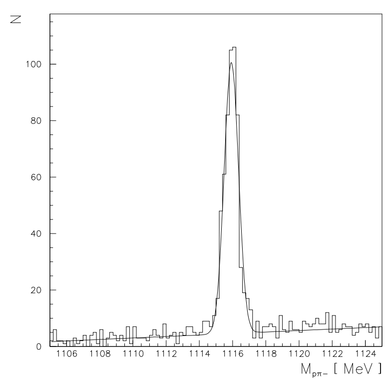

Figure 1. Invariant mass distribution of $p\pi^-$ from Λ decay ($\sigma_\Lambda = 0.43$ MeV).

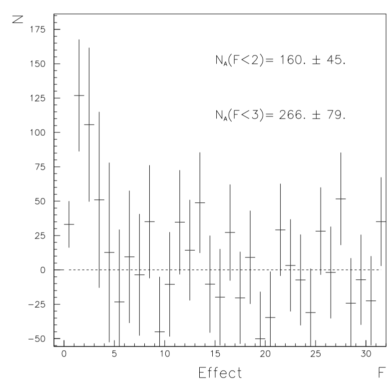

Figure 2. Candidates of "atomic pairs" in the *low* F region.

References

1. B. Adeva *et al.*, Proposal to the SPSLC, CERN/SPSLC 95-1 (1995).
2. A. Rusetsky, these Proceedings (see also *Phys. Lett.* B **471**, 244 (1999)).
3. G. Colangelo, these Proceedings (see also hep-ph/0007112).

[a] Definition: $F = \sqrt{(Q_L/\sigma_{Q_L})^2 + (Q_X/\sigma_{Q_X})^2 + (Q_Y/\sigma_{Q_Y})^2}$ with resolutions σ_Q.