Status Update of PSI Experiment R-89.01.1

A PRECISE MEASUREMENT OF THE $\pi^+ \to \pi^0 e^+ \nu$ DECAY RATE

THE PIBETA COLLABORATION

10 December 2001

The PIBETA project at PSI is a program of measurements with the aim of making a precise determination of the pion beta decay rate, initially to $\sim 0.5\,\%$. This document presents a condensed update of the current status of the experiment.

1. Activities in 2001

In 2001 we focused in parallel on "production" running, and on the replay of our 1999 and 2000 data sets. While both activities generally proceeded according to plans, due to a combination of unusually unstable beam delivery, problems with magnet control in the PiE1 beam line, and a few failures of our equipment, we will finish the 2001 running with fewer pion beta decay events than planned. Instead of a total of $\sim 80,000$ events, it now appears that we will have, in all, somewhere between 60 k and 70 k events in our entire data set.

2. Current status of data analysis and simulation

In our previous status report of 25 January 2001 we presented a detailed account of the performance of our detector, its instrumental resolutions, agreement with Monte Carlo simulations, all for several different triggers and decay processes. While these have all been improved in our subsequent analysis, we will not update them here, as we are currently working on finishing a cycle of analysis that is to yield a $\sim 1\,\%$ result for the pion beta decay branching ratio, and a preprint in the near future. This forthcoming document will provide a more complete account of the present stage of our work.

At this point, as an illustration of our current analysis we present our preliminary working result for the $\pi^+ \to \pi^0 e^+ \nu$ branching ratio:

$$BR \simeq 1.040 \pm 0.007(\text{stat.}) \pm 0.015(\text{syst.}) \times 10^{-8} \ .$$

The above conservatively large systematic uncertainty reflects the fact that we are not finished evaluating the corrections fully in the current analysis at the time of this writing, a situation that will soon change. This result is to be compared with the previous most accurate measurement of McFarlane et al. (Phys. Rev. D 1984):

$$BR = 1.026 \pm 0.039 \times 10^{-8} \ ,$$

as well as with the SM Prediction (Paricle Data Group, 2000):

$$\begin{aligned} BR &= 1.038 - 1.041 \times 10^{-8} \quad (90\%\text{C.L.}) \\ & (1.005 - 1.008 \times 10^{-8} \quad \text{excl. rad. corr.}). \end{aligned}$$

We see that even our working result strongly confirms the validity of the radiative corrections. Another interesting comparison is with the prediction based on the most accurate evaluation of the CKM matrix element V_{ud} based on the CVC hypothesis and the results of measurements of superallowed Fermi nuclear decays (PDG 2000):

$$BR = 1.037 \pm 0.002 \times 10^{-8} \ .$$

Thus, our current preliminary working result is in very good agreement with the predictions of the Standard Model and the CVC hypothesis. The quoted systemaic uncertainties will be soon reduced as our analysis progresses.

We are simultaneously recording a large set of radiative decay events for the processes $\pi^+ \to e^+\nu\gamma$ and $\mu^+ \to e^+\nu\bar{\nu}\gamma$. The former will be used to extract the ratio F_A/F_V of the axial-vector and vector pion form factors, a quantity of great and longstanding interest to low energy effective QCD theory, particularly chiral perturbation theory (χPT). Both processes are furthermore very sensitive to non-(V$-$A) admixtures in the electroweak lagrangian, and thus can reveal information on physics outside of the present SM. We are currently analyzing these data with the objective to extract new constraints on both F_A/F_V and non-(V$-$A) physics, and expect results soon.

Table 1: Current PIBETA experiment event statistics, compared with the world data set.

Decay	PIBETA to date	World data set
$\pi^+ \to \pi^0 e^+\nu$	> 50 k events	1.77 k events
$\pi^+ \to e^+\nu$	> 580 M events	0.35 M events
$\pi^+ \to e^+\nu\gamma$	> 58 k events	1.35 k events
$\mu^+ \to e^+\nu\bar{\nu}\gamma$	> 500 k events	8.5 k events

3. Plans for 2002

As of this writing we have not requested beam time in 2002, and do not have plans to run in the first half of that year. We will focus on the analysis of the data in hand. In parallel, during the beam shutdown we will perform maintenance on the detector; the main agenda will be to replace Chamber 2 with a new one, as the original has aged.

If a need for beam time should arise in 2002, we will inform the Program Advisory Committee of it well before the BVR 34 meeting, presumably to be held in June or July 2002. At that time we expect to be in a position to furnish a more complete report on our project.