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

26 November 1999

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 and a beam time request for 2000.

1. Activities completed in 1999

During 1999 our collaboration has successfully completed the commissioning of the PIBETA detector system and has initiated data taking. Some of the notable achievements are:

(1) Before our beam time which started in June, we implemented a number of improvements in the trigger electronics. This in particular concerns the introduction of a new PSI-built fast overlap logic module LB 500. This device has enabled us to reconfigure our trigger logic in a more flexible, more reliable and faster implementation than was possible with commercially available units. We also implemented the top, most important plane of the cosmic muon veto house.

(2) Making use of the new trigger logic electronics during June and early July we optimized the trigger adding new event classes useful for beam diagnostics and monitoring, thus improving our systematics.

(3) During the July running period we implemented the domino sampling chip (DSC) readout for the beam detectors, and had it operational for the August part of the run.

(4) Thanks to the flexibility built into the MIDAS data acquisition system, as well as to a concerted effort of several collaborators, by the end of the summer running period we had a system that was running virtually autonomously, almost free of human intervention. Automatic control includes not only very tight regulation of running parameters (e.g., calorimeter temperature), but also all of the routine run activities and monitoring. This was perhaps the most important development that enables us to continue long term data taking with minimal staffing, freeing much of the manpower of our collaboration to be devoted to the analysis tasks.

2. Preliminary results of the 1999 run

As of this writing the fall beam period is still under way. We are, therefore, still in the process of analyzing these data, and can only present partial and preliminary results.

The most important result of this year's beam running period concerns our pion beta decay data. In our previous report to the Program Committee we have demonstrated the quality of our $\pi \rightarrow e\nu$ data. The spectra included below correspond to our $\pi\beta$ events in a first pass analysis of about 1/3 of the 1999 data sample. We emphasize that the cuts applied in these spectra are conservative and are not our final cuts.

Fig. 1 shows the spectrum of energy deposited in the CsI calorimeter by the two gammas following π^0 decay in $\pi^+ \rightarrow \pi^0 e^+ \nu$. The histogram shows a clean peak centered very close to the π^0 mass, as expected, virtually free of backgrounds.

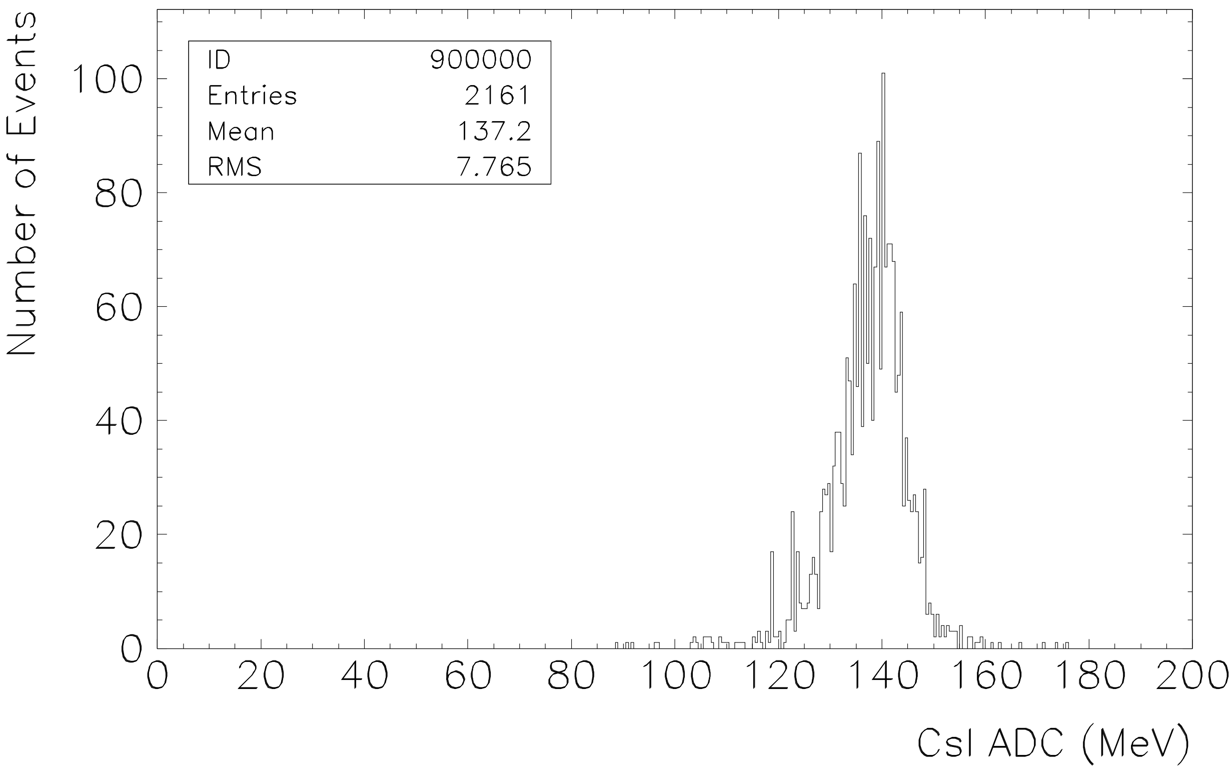

Fig. 1. Distribution of energy deposited in the CsI electromagnetic shower calorimeter by events satisfying $\pi\beta$ cuts (preliminary).

Fig. 2 shows the timing difference spectrum between the CsI calorimeter and the beam degrader (the latter giving essentially the beam π stop time) for "$\pi\beta$" events. The histogram shows a clean exponential decay spectrum consistent with the π^+ lifetime. The first bin reflects partial averaging due to a first pass cut. The experiment actually records earlier decays that we will focus on in the second pass of our analysis. At the statistical level of the current analysis there is no evidence of a non-pion decay background.

Fig. 3 shows the histogram of the γ–γ opening angle as reconstructed from the CsI shower distribution for the same sample of events satisfying the "$\pi\beta$" cuts. As expected, the distribution is peaked near 180°. $\pi \rightarrow e\nu\gamma$ events coming from an important background that would not be distinguishable from pion beta decay in the timing distribution, but would

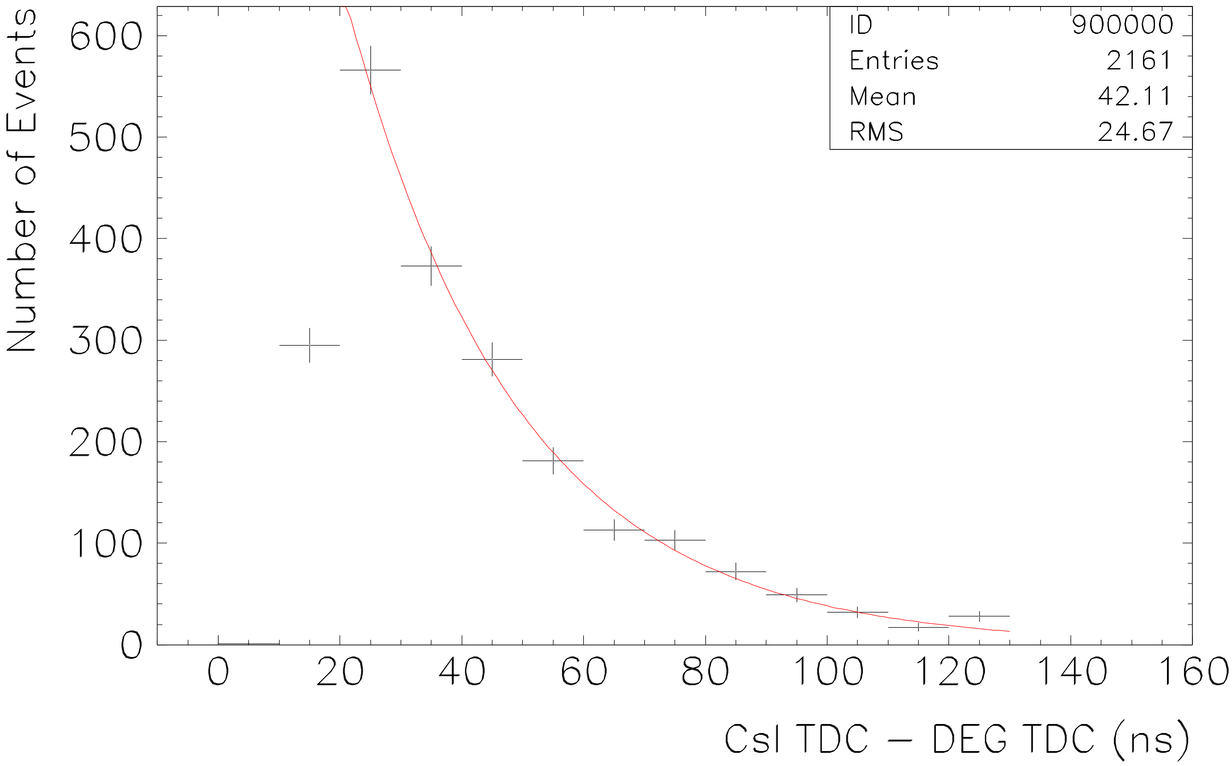

Fig. 2. Distribution of the time difference values between the π^+ stop and the CsI electromagnetic shower calorimeter for events satisfying $\pi\beta$ cuts (histogram, preliminary). The curve is an exponential function with $\tau = 26.02\,$ns.

deviate strongly from the 180° peaking, are absent at the statistical level of this data sample.

We summarize this discussion by noting that:

- We have demonstrated our ability to detect very clean $\pi^+ \to \pi^0 e^+ \nu$ events. This was the primary goal of the first pass analysis.
- We are in the process of optimizing our analysis, and will, in light of the results of the second pass, review critically those details of our setup that may improve the overall efficiency and systematics.
- By the end of December, our 1999 running will have resulted in at least 10,000 analyzed $\pi\beta$ events. This should enable us to extract a branching ratio with close to $\sim 1\,\%$ uncertainty, as we aimed for the first year of operation.
- In our running so far we have satisfied ourselves that the apparatus can handle the pion stop rates of our proposal. We are, however, at present still optimizing the overall running conditions (see below).
- As of this writing, we are within a factor of about 2 of the data acquisition rate specified in our proposal. In our second pass analysis, starting presently, we will focus on tightening and refining our currently conservative prompt background rejection cuts in order to increase our overall data rate.

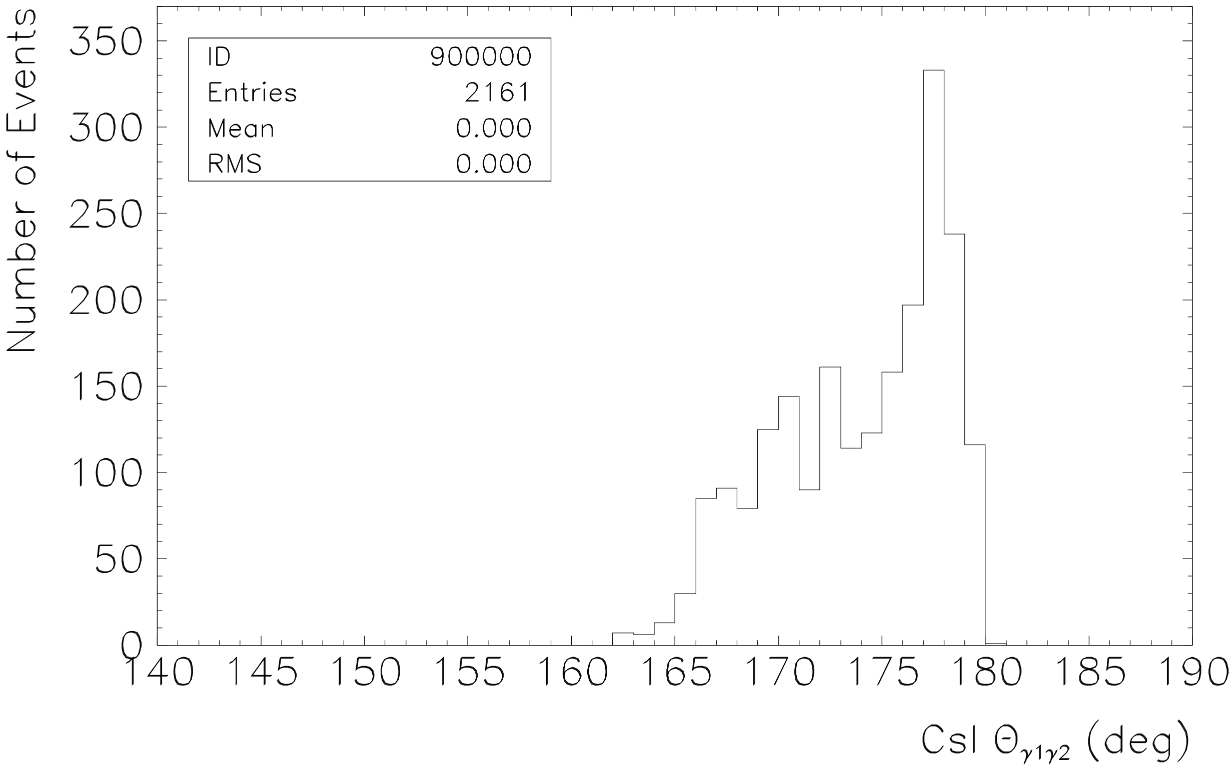

Fig. 3. Distribution of the opening angle values between the two electromagnetic showers in the CsI calorimeter for events satisfying $\pi\beta$ cuts (preliminary).

- Based on the data sample presented here (over 2000 $\pi\beta$ events) we have attempted to evaluate a preliminary branching ratio with about 2.5 % uncertainty, as an overall test of the method. The result happens to be in excellent agreement with the expected value.

In early January 2000, before the BV meeting, we plan to present to the PSI Program Committee a detailed accounting of the efficiencies and rates in the experiment based on our second pass analysis, as well as an update on the branching ratio result. We expect those numbers to be more reliable than the ones available to us as of this writing.

3. Experiment timetable and beam request for 2000

Based on the data in hand and the current status of our analysis we can ascertain that by the end of the year we should have at least 10,000 $\pi\beta$ events, or approximately 1/5 of the total required for the first phase of the experiment.

We have planned several instrument upgrades for the January–March beam break, mainly implementing the remainder of the cosmic muon veto housing, and a full implementation of the DSC.

In light of the above, we propose that our apparatus remain in the area over the winter break. We further propose that PIBETA run during the entire year 2000 beam period with a break of 4–6 weeks in the middle (summer) to allow for possible modifications or repairs. Such a break would also give other users access to the πE1 area, should that be required.

Based on our current analysis we expect to acquire most of the remaining first-phase data in 2000. Running in 2001 will be likely necessary, though. As stated above, we will present an accounting of our rates and efficiencies before the January 2000 BV meeting at the PIBETA home page:

http://pibeta.psi.ch (Europe), or

http://helena.phys.virginia.edu/~pibeta (America),

as well as orally at the meeting itself.