# New results on the pion beta decay rate

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for the PIBETA Collaboration

- motivation
- design and experimental method
- preliminary results
- further plans

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## $\boxed{\text{MOTIVATION}}$

Provide a precision test of the Standard Model based on the Cabibbo - Kobayashi - Masakawa (CKM) matrix of weak quark mixing:

$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

CKM unitarity:

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 \quad \stackrel{?}{=} \quad 1 \ .$$

Experimental limits on $V_{ud}$ come from:

(a) superallowed Fermi nuclear $\beta$ decays,

(b) neutron $\beta$ decay.

These have disagreed in the past.

## $\boxed{\text{PION BETA DECAY:}}$

$\pi^\pm \to \pi^0 e^\pm \nu$ BR $\simeq 1 \times 10^{-8}$

Pure vector transition: $0^- \to 0^-$

Theoretical rate: $\dfrac{1}{\tau_{\pi\beta}} = 0.3993 \pm 0.0007\,\mathrm{s}^{-1}$

| Accuracy | Constraints on |
|---|---|
| $4\,\%$ | Present result |
| $\leq 1\,\%$ | CVC and radiative corrections |
| $\sim 0.5\,\%$ | SAF vs. $n$ $\beta$ decay $V_{ud}$ |
| $< 0.3\,\%$ | New check of CKM unitarity:<br>• $4^{\mathrm{th}}$ generation coupling<br>• $m_{Z'}$<br>• $\Lambda$ of compositeness<br>• SUSY viol. of $q$-$l$ universality |

Other $\pi$ decays: $\pi^\pm \to$ $\mu^\pm \nu$ BR $= 1$

$e^\pm \nu$ BR $\sim 10^{-4}$

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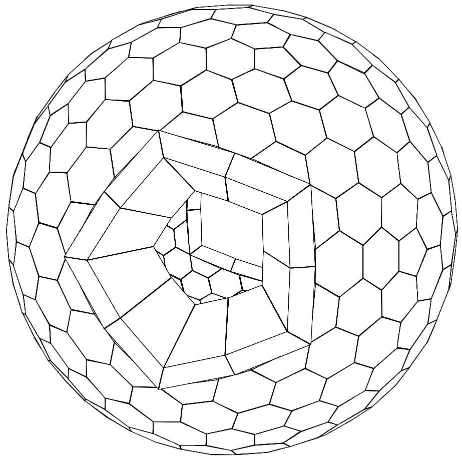
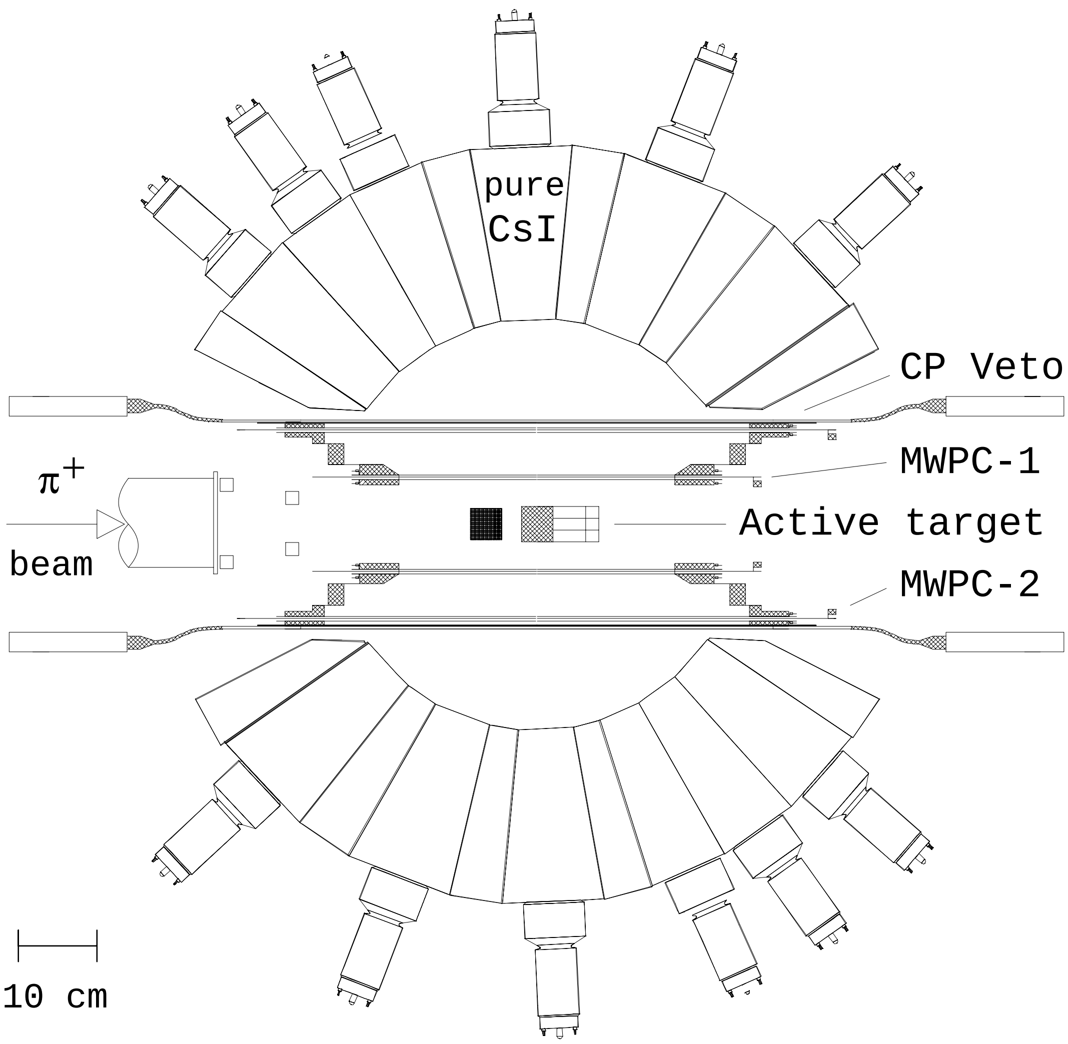
PIBETA experiment:

- stopped $\pi^+$ beam
- segmented active tgt.
- 240-elem. CsI(p) calo.
- central tracking
- digitized PMT readout
- cosmic $\mu$ antihouse
- stable temp./humidity



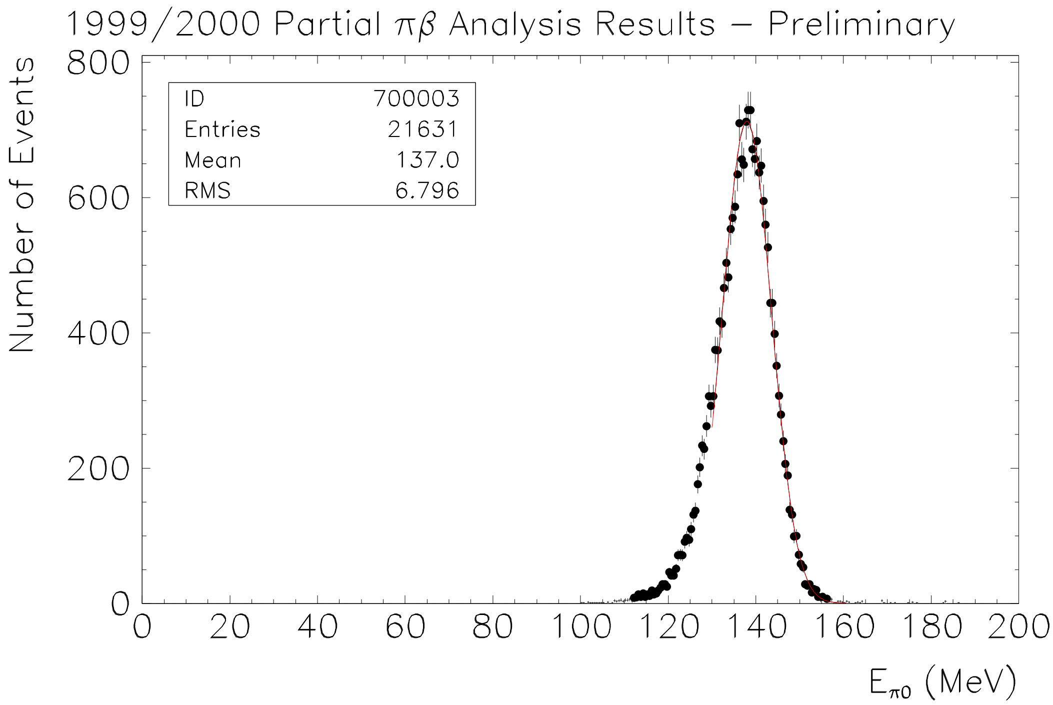


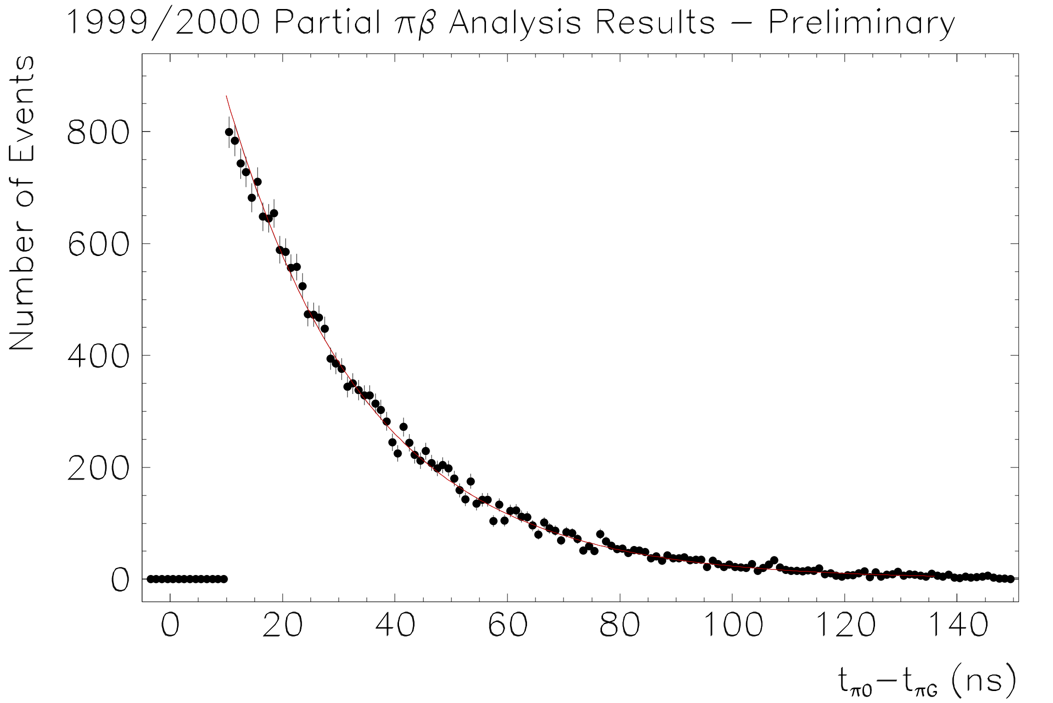
# CURRENT

# PRELIMINARY

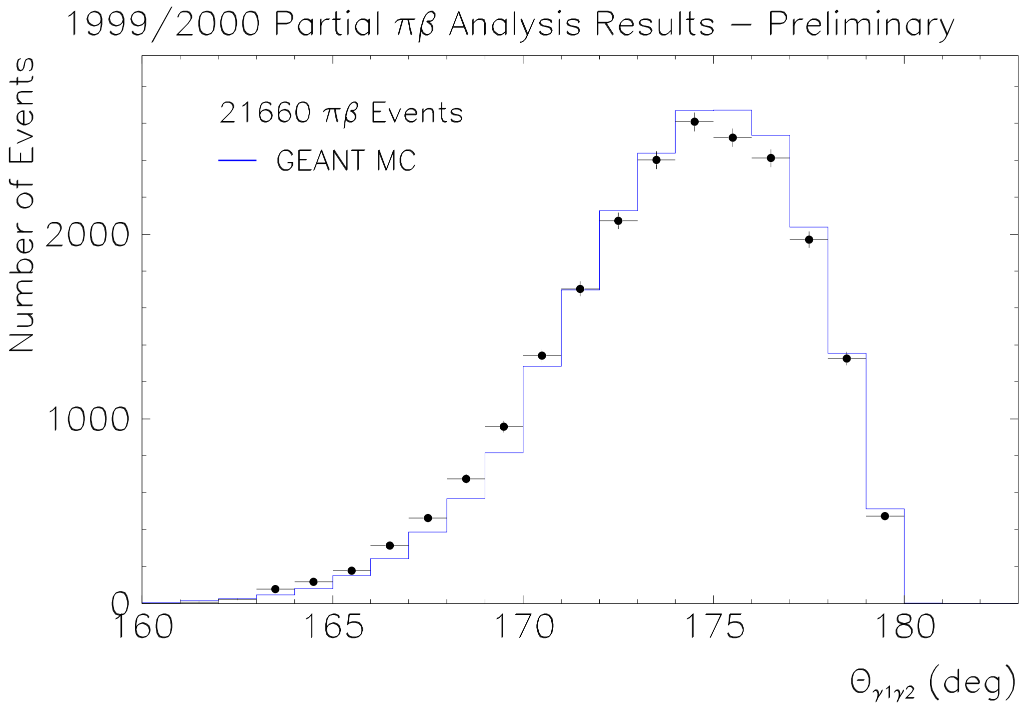
# RESULTS

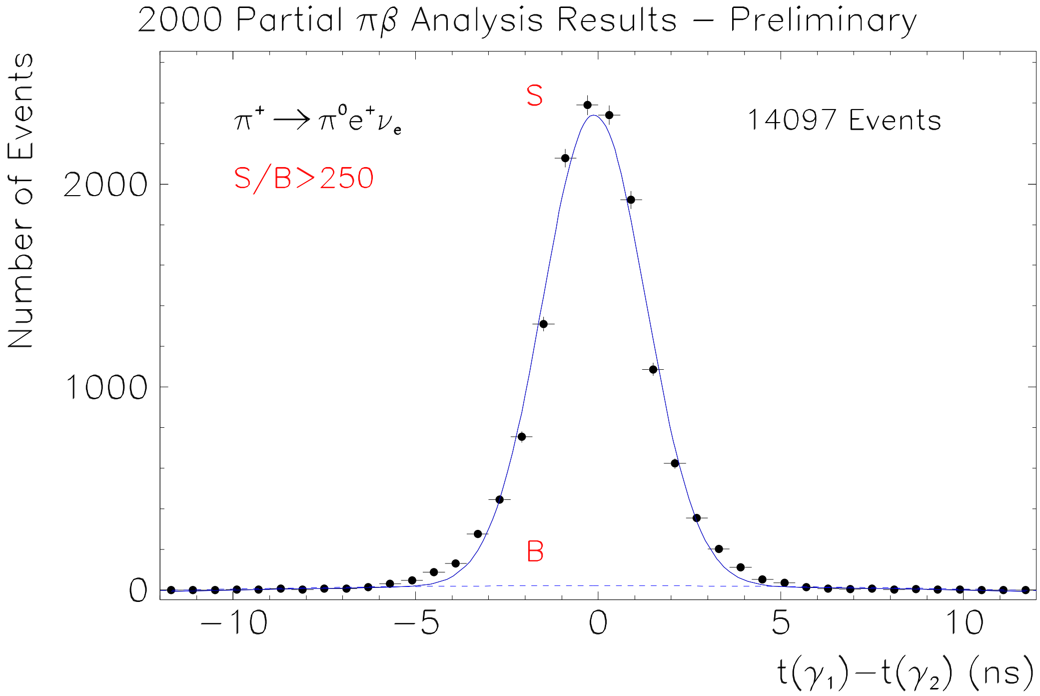
# 1999/2000 RESULTS: $\pi^+ \to \pi^0 e^+ \nu$



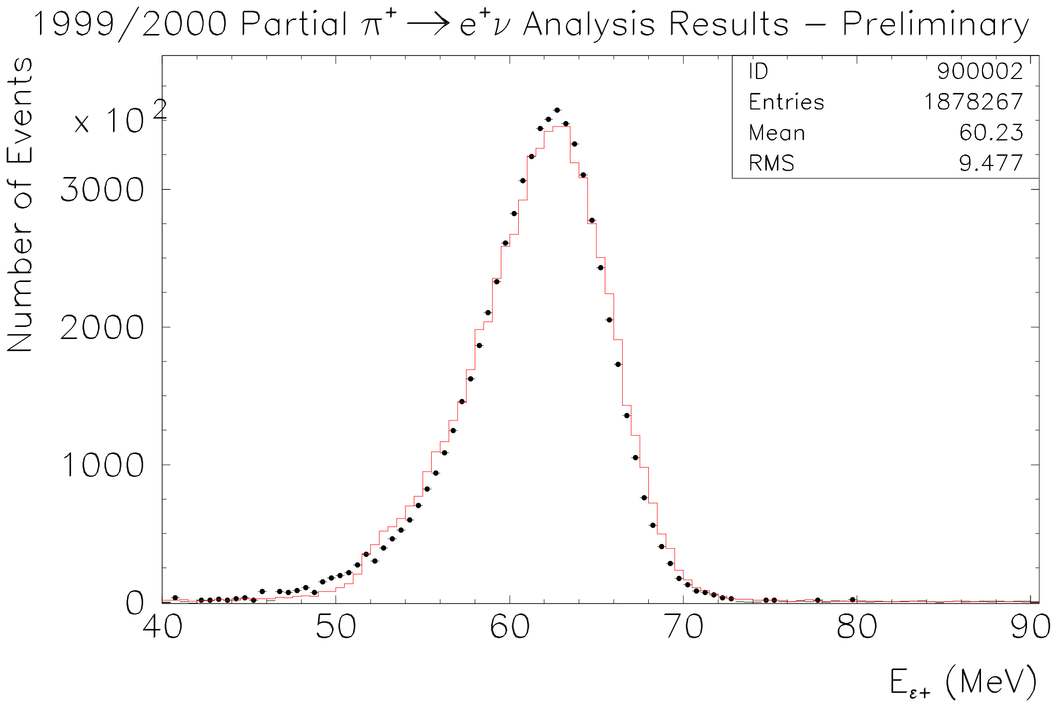



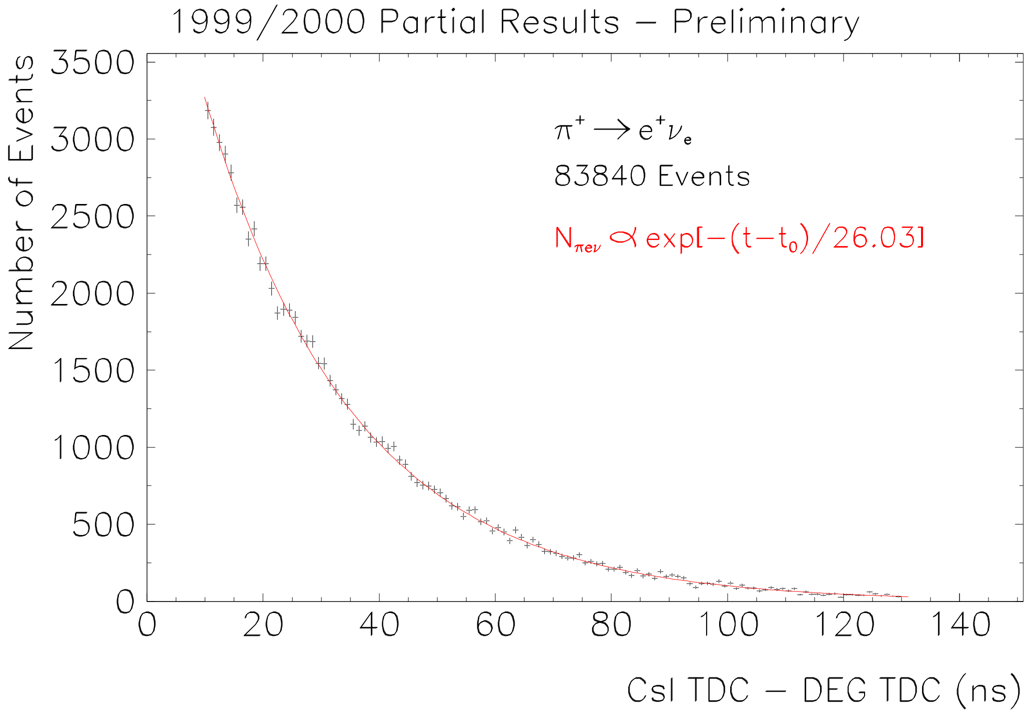
# 1999/2000 RESULTS: $\pi^+ \to \pi^0 e^+ \nu$



# 1999/2000 RESULTS: $\pi^+ \to e^+\nu$



## $\boxed{\text{Branching Ratio for } \pi\beta \text{ Decay}}$

Our Preliminary Interim Result:

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



McFarlane et al. (Phys. Rev. D 1984):

$$\mathrm{BR} \simeq 1.026 \pm 0.039 \times 10^{-8}$$

SM Prediction (PDG, 2000):

$$\mathrm{BR} = \quad 1.038 - 1.041 \times 10^{-8} \qquad (90\%\ \mathrm{C.L.})$$

$(1.005 - 1.008 \times 10^{-8}$ excl. rad. corr.)

CVC + Fermi Nucl. Decays (PDG 2000):

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

## PLANS FOR 2001 AND BEYOND

- Run $\sim 8$ months, collect another $\sim 40–50$ k $\pi\beta$ events.
- Bring analysis up to the proposed level of uncertainty.
- Prepare new proposal and collaboration for a precise $\pi \to e\nu$ measurement.

http://pibeta.phys.virginia.edu/~pibeta
http://pibeta.psi.ch/~pibeta