Precise Measurement of the $\pi^+ \rightarrow e^+ \nu$ Branching Ratio Progress Report and 2009 Beam Request

The PEN Collaboration

Dubna-PSI-Swierk-Tbilisi-Virginia-Zagreb-Zürich

PSI BV40 19 February 2009

PEN Collaboration (PSI)

Progress Report Feb 2009

PSI BV40/19 Feb '09 1 / 20

Outline

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Physics Agenda and Motivation

PIBETA/PEN Program PEN Goals and Motivation

Summary of Activities in 2008

System Improvements Run Synopsis

Preliminary Results of 2008 Run Analysis Detector Performance

Plans for 2009

Modifications and Improvements Beam Time Request PEN Collaboration

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Progress Report Feb 2009

PSI BV40/19 Feb '09 2 / 20

PEN follows the PIBETA experiment

PIBETA program (precision checks of SM and QCD predictions):

• $\pi^+ \rightarrow \pi^0 e^+ \nu_e$ – main goal o SM checks related to CKM unitarit

▶ $\pi^+ \rightarrow e^+ \nu_e \gamma$ (or $e^+ e^-$)

• F_A/F_V , π polarizability (χ PT prediction)

 \circ limits on tensor coupling besides $\mathbf{V}-\mathbf{A}$

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The **PEN** experiment

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Progress Report Feb 2009

PSI BV40/19 Feb '09 3 / 20

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PSI BV40/19 Feb '09 3 / 20

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Progress Report Feb 2009

PSI BV40/19 Feb '09 3 / 20

$\pi ightarrow {f e} u$ decay: SM predictions; measurements

Modern theoretical calculations: $B_{calc} = \frac{\Gamma(\pi \to e\bar{\nu}(\gamma))}{\Gamma(\pi \to \mu\bar{\nu}(\gamma))}_{calc} =$

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Experiment, world average [current PDG]:

$$\frac{\Gamma(\pi \to e\bar{\nu}(\gamma))}{\Gamma(\pi \to \mu\bar{\nu}(\gamma))}_{exp} = (1.230 \pm 0.004) \times 10^{-4}$$
PEN goal: $\frac{\delta B}{R} \simeq 5 \times 10^{-4}$.

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Progress Report Feb 2009

PSI BV40/19 Feb '09 4 / 20

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Progress Report Feb 2009

PSI BV40/19 Feb '09 4 / 20

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PSI BV40/19 Feb '09 4 / 20

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The PEN Apparatus

stopped π⁺ beam
active target counter
240-det. Csl(p) calo.
central tracking
digitized PMT signals
stable temp./humidity



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Stated goals of the 2008 run were:

- \blacktriangleright enable the DAQ system to handle a $\pi_{\rm STOP}$ rate of $2\times 10^4~\pi/{\rm s}$, with dead time fraction <15 %, and
- ► to record at least $4 \times 10^6 \pi \rightarrow e\nu$ events with well controlled systematics.

Improvements for the 2008 run:

- thicker B0 upstream beam detector, and
- a new 4-piece wedged beam degrader was introduced midway through the run.

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Summary of Activities in 2008 System Improvements

Central detector region in 1st half of 2008 run



Summary of Activities in 2008 System Improvements

Wedged Degrader: 2008 Run





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PSI BV40/19 Feb '09 8 / 20

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- during 111 calendar days of our run, RA delivered 4.17 Ah of proton beam on Tgt E (nominal availability fraction 0.67),
- PEN experiment took pion beam for 6.51 × 10⁶ s, i.e., 75.4 days, or ~ 90 % availability fraction),
- ▶ we observed 7.46×10^{10} tagged pion stops in the target detector, and recorded a total of $\sim 4.6 \times 10^6 \pi \rightarrow e\nu$ decays before cuts,
- \blacktriangleright started the run with \sim 3,000 π^+ /s w/p $_{\pi}=$ 68 71 MeV/c,
- ▶ ran 2nd half with 15,000 20,000 π^+ /s w/p $_{\pi}$ = 82 ± 4 MeV/c,
- \blacktriangleright as a systematics check finished run with \sim 40,000 π^+/s .

Main goals of the run have been realized.

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Progress Report Feb 2009

PSI BV40/19 Feb '09 9 / 20

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PSI BV40/19 Feb '09 9 / 20

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Positron identification



10 / 20

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Waveform fitting

delay degrader - target [ns] Inputs for waveform fitting: 1500 -0.2 Pion stop time in TGT $\sigma_{t}^{DEG-TGT} = 62 \text{ ps}$ 1000 -0.4 -500 Pion energy in TGT \Downarrow -0.6 10 12 14 pion energy [MeV] 14 observed pion energy [MeV] 2000 12 1500 10 1000 8 500 14⁰ 6 12 6 8 10 predicted pion energy [MeV] PEN Collaboration (PSI) Progress Report Feb 2009 PSI BV40/19 Feb '09 13 / 20 Preliminary Results of 2008 Run Analysis Detector Performance



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Progress Report Feb 2009

PSI BV40/19 Feb '09 14 / 20

월 6000 70000 <u>لَ</u> 5000 PEN 2008 πue rms=1.93 mm PEN 2008 π2e 60000 rms=1.85 mm ž 4000 50000 ₹ 3000 40000 30000 2000 20000 1000E 10000 x Vertex (mm) x Vertex (mm) 5000 60000 PEN 2008 πμε 4000 rms=2.23 mm -PEN 2008 π2e rms=2.17 mm 50000 40000 3000 30000 2000 20000 1000E 10000 y Vertex (mm) y Vertex (mm) 70000 6000 60000E PEN 2008 πμe rms=2.47 mm 5000 PEN 2008 π2e rms=2.13 mm E-50000 4000 40000 3000 30000E 2000 20000E 1000 10000 05 05 10 12 10 12 14 z Vertex (mm) z Vertex (mm)

Wedged degrader performance

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PSI BV40/19 Feb '09 15 / 20

Total positron energy (preliminary)



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PSI BV40/19 Feb '09 16 / 20

Mini TPC: Replace the WD with a mini-TPC ⇒ achieve superior beam particle tracking ⇒ improve pion DIF suppression.

DAQ upgrade: Replace **FastBus** TDC's with **VME** ones. \Rightarrow achieve the required PH Δ t resolution.

Implement VME digitizer readout for the **mini-TPC**.

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Progress Report Feb 2009

PSI BV40/19 Feb '09 17 / 20

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PSI BV40/19 Feb '09

17 / 20

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Plans for 2009 Modifications and Improvements

Contours of V

Electron drift lines from a track

Dubna mini-TPC: Design and construction









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Progress Report Feb 2009

PSI BV40/19 Feb '09 18 / 20

Plans for the 2009 run:

- Prior to run implement the planned mini-TPC and DAQ upgrades.
- Run with approx. 15k pion stops/s.
- Run for 15 weeks (plus 4 weeks of set-up and calibration) starting in
- Complete the event statistics needed to reach $(\delta B/B)_{\text{stat}} \simeq 3 \times 10^{-4}$

Resources requested are modest, similar to the 2008 level:

- material costs of operating the detector (MWPC gas, other supplies
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Experiment R-05-01 (PEN) collaboration members:

L. P. Alonzi^a, V. A. Baranov^b, W. Bertl^c, M. Bychkov^a, Yu.M. Bystritsky^b, E. Frlež^a, V.A. Kalinnikov^b, N.V. Khomutov^b, A.S. Korenchenko^b, S.M. Korenchenko^b, M. Korolija^d, T. Kozlowski^e, N.P. Kravchuk^b, N.A. Kuchinsky^b, D. Mekterović^d, D. Mzhavia^{b, f}, A. Palladino^{a, c}, D. Počanić^{a*}, P. Robmann^g, A.M. Rozhdestvensky^b, S.N. Shkarovskiy^b, U. Straumann^g, I. Supek^d, P. Truöl^g, Z. Tsamalaidze^f, A. van der Schaaf^{g*}, E.P. Velicheva^b, and V.P. Volnykh^b

^aDept of Physics, Univ. of Virginia, Charlottesville, VA 22904-4714, USA ^bJoint Institute for Nuclear Research, RU-141980 Dubna, Russia ^cPaul Scherrer Institut, CH-5232 Villigen PSI, Switzerland ^dInstitut "Rudjer Bošković", HR-10000 Zagreb, Croatia ^eInst. Problemów Jądrowych im. Andrzeja Sołtana PL-05-400 Swierk, Poland ^fIHEP, Tbilisi State University, GUS-380086 Tbilisi, Georgia ^gPhysik Institut der Universität Zürich, CH-8057 Zürich, Switzerland

Web page: http://pen.phys.virginia.edu

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PSI BV40/19 Feb '09 20 / 20