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STATUS OF PEP AND TPC/2γ*

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The TPC/2γ program at PEP has been upgraded by increasing the PEP luminosity and by the adding a vertex chamber to the TPC detector. These improvements will allow a strong program in B and τ physics, and will contribute to ongoing studies in two-photon physics and hadronization.

The TPC is now the only detector on the PEP storage ring at SLAC.[1] A major strength of the TPC is its charged particle identification over an active region of 87% of 4π; the dE/dx resolution for hadrons is 3.4%. The TPC operates in a 1.325 T magnetic field with a momentum resolution of $(\sigma_p/p)^2 = (0.015)^2 + (0.007p)^2$ where p is in GeV/c. The detector has been upgraded recently with the addition of a 14-layer straw drift chamber[2] (vertex chamber) with the innermost layer 4.9 cm from the beam. The vertex chamber measures tracks in the x–y plane with a 120 μm impact parameter resolution at 1 GeV/c. Both the TPC momentum resolution and the impact parameter resolution will improve as the vertex chamber information is used to correct electric field distortions in the TPC.

Photons are detected with an electromagnetic calorimeter which surrounds a 0.9 radiation length superconducting magnet coil. The energy resolution of the electromagnetic calorimeter is $16\%/\sqrt{E}$ below 1 GeV where E is in GeV, and about 14% for Bhabhas.

The luminosity of PEP has been increased by a factor of roughly 2.5 by moving the quadrupole magnets closer to the interaction point, reducing β_y^* from 12 cm to 5.5 cm. Typical peak luminosities of 6×10^{31} cm^{-2} sec^{-1} were achieved last fall with peak total

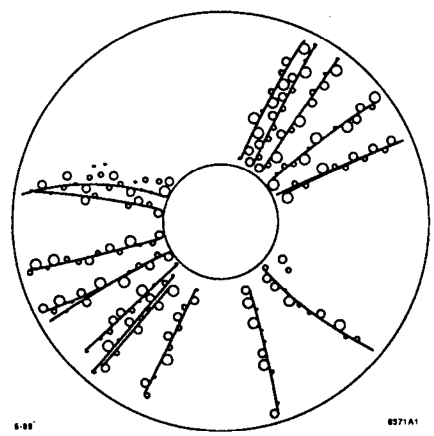

Figure 1: A hadronic event in the TPC vertex detector. Straws that are hit are indicated by circles; the radius of the circle is the drift distance. The two-track resolution of the vertex chamber is between 0.5 and 1.0 mm. The inner and outer walls of the vertex detector are at 4.5 and 15.6 cm, respectively.

currents of about 42 mA. Our current was limited by higher mode losses which caused unacceptable heating of the vertex chamber, and our reduction of β_y^* was limited by background from a 37 m mask that interfered with the beam stay-clear. By removing the mask and water-cooling the vertex chamber, we expect to reduce β_y^* to 4 cm and to increase the current to 52 mA; this

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represents a peak luminosity of 10^{32} cm^{-2} sec^{-1}. The center-of-mass energy of PEP has been reduced from 29 GeV to 27 GeV, allowing more RF clearance to experiment with further increases in the current in the near future. In order to improve our integrated luminosity, the injection to PEP has been upgraded to make use of the low emittance beams from the SLC damping rings.[3] This decreases the positron emittance by an order of magnitude over previous running. The injection has also been upgraded to provide energy feedback from the transport line to the linac so that the beams are stable in energy when they are delivered to PEP. Figure 2 shows a history of PEP running last fall. Towards the end of the running cycle, integrated luminosities in excess of 1 pb^{-1} per day were delivered to the TPC. Most of this was delivered during the 12-hour period when the storage rings were allowed to fill. PEP has been allotted 20% of the linac time to fill. Based on our experience of switching between SLC operation and storage ring filling last fall, we project 250 pb^{-1} of data per six months of running. This number will continue to improve as the stability of SLC improves.

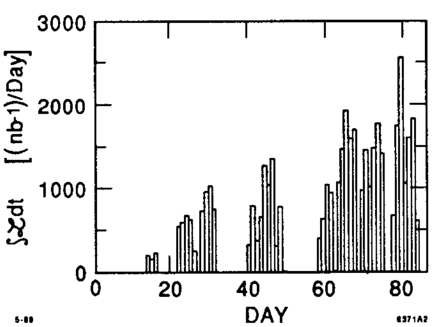

Figure 2: Integrated luminosity delivered to the TPC for each day during Fall 1988.

With the upgraded luminosity, we expect to collect 1 fb^{-1} of data over the next three years. After fiducial cuts are made, these data will provide 36,000 $b\bar{b}$ events in a detector with excellent particle identification and vertex resolution. The B mesons produced at PEP are moving in the laboratory with a 1 mm decay length. This separates the decay products into two jets and allows lifetime measurements. A high transverse momentum (p_T) lepton may be used to tag B mesons with an efficiency of 8% and a charm background of 15%. Using this lepton to perform an impact parameter measurement with the vertex chamber, we expect a measurement of the generic B lifetime to 0.08 psec with 1 fb^{-1} of data.[1] The present average B lifetime is measured to be 1.15 ± 0.14 psec.[4]

It is estimated that 17% of the B mesons produced are B_s which are expected to contribute to a $B^0\overline{B}^0$ mixing signal.[1] The mixing of the $B^0\overline{B}^0$ system will be measured by tagging each jet with a high p_T lepton. We expect 230 such tagged events in 1 fb^{-1} of data. Figure 3 shows the total number of like-sign lepton pairs expected versus the mixing parameter r_s of the $B_s^0\overline{B}_s^0$ system, where $r_i = N(B_i^0 \rightarrow \overline{B}_i^0 \rightarrow l^-\overline{\nu}_l X)/N(B_i^0 \rightarrow l^+\nu_l X)$. The parameter r_d is taken to be 0.20. The TPC should confirm mixing in the B system to at least five standard deviations. There is about a three standard deviation difference between the case of no mixing and maximal mixing in the $B_s^0\overline{B}_s^0$ system.

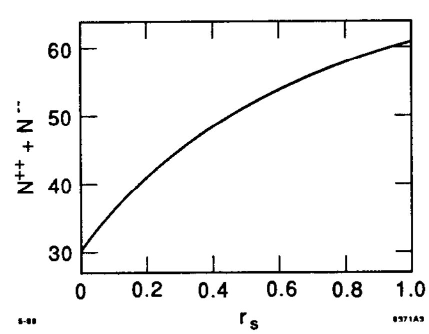

Figure 3: Number of like-sign lepton pairs versus B_s mixing for $r_d = 0.20$ for 1 fb^{-1} of data at PEP.

At a 27 GeV center-of-mass energy, the cross section for $\tau^+\tau^-(\gamma)$ production is 156 pb^{-1}. This represents a large sample of moving τ's for a lifetime measurement ($\gamma\beta c\tau_\tau = 650\ \mu$m) and for branching ratio studies. The PEP–TPC/2γ program should begin to make an important contribution to the study of exclusive τ decays with 300 pb^{-1} of data.

The τ lifetime is directly related to B_e, which is the branching ratio for the decay $\tau^- \to e^-\overline{\nu}_e\nu_\tau$: $\tau_\tau = (m_\mu/m_\tau)^5\tau_\mu B_e$. Hence, a measurement of τ_τ using a vertex chamber should agree with a measurement of B_e. The world average for τ_τ from vertex chamber measurements is $(3.04 \pm 0.08) \times 10^{-13}$ sec.[5,6,7] Using the world average for B_e ($17.5 \pm 0.4\%$), we have $\tau_\tau = (2.80 \pm 0.06) \times 10^{-13}$ sec.[5] The discrepancy between the two numbers suggests that the measurement of B_e may be too small, but the errors are too large to conclude anything. With 1 fb^{-1} of data, the TPC will have 16000 one-one prong τ events and 8000 one-three prong events after all selection cuts are applied. This allows a measurement of τ_τ to the same precision as the present world average.

There still remains a discrepancy between the sum of exclusive one-prong branching ratios of the τ and the inclusive one-prong branching ratio.[8] This discrepancy is four standard deviations if CVC and isospin are used to set limits on exclusive τ decay modes where only experimental upper limits are available (these are typically modes where multiple neutral mesons are present). One example of this "one-prong problem" concerns the TPC measurement of the decay $\tau^- \to \pi^0\pi^0\pi^-\nu_\tau$. The average branching ratio is $7.5 \pm 0.9\%$.[5] Isospin restricts this branching ratio to be no larger than the branching ratio of the charged mode: $\tau^- \to \pi^-\pi^-\pi^+\nu_\tau$.[9] The average branching ratio measurement for the charged mode is $6.8 \pm 0.6\%$.[5] This implies that $BR(\tau^- \to \pi^0\pi^0\pi^-\nu_\tau) \leq 7.8\%$ at the 95% confidence level. However, the TPC measures $BR(\tau^- \to \pi^0\pi^0\pi^-\nu_\tau) > 8.3\%$ at the 95% confidence level.[10] This measurement will be repeated at a higher integrated luminosity.

To summarize, the TPC/2γ experiment at PEP has the advantages of high luminosity, a newly installed precision vertex chamber, and excellent charged particle identification. The program provides a unique facility for the study of hadronization and two-photon physics, and we expect it to make important contributions to our understanding of B and τ decays.

References

1. "Proceedings of the Workshop on e^+e^- Physics at High Luminosities," SLAC Report 283 (1985).
2. M. T. Ronan et al., "Readout and Trigger Electronics for the TPC Vertex Chamber," presented at the Nucl. Sci. Symp., San Francisco, CA, October 1987; LBL–24156.
3. M. T. Ronan et al., "Timing and RF Synchronization for Filling PEP/SPEAR with the SLC Damping Rings," presented at the 1989 Conf. on Part. Acc., Chicago, IL; SLAC–PUB–4906.
4. D. Muller, "Review of c, b, and τ Lifetimes from e^+e^- Experiments," presented at the 24th Int. Conf. on High Energy Physics, Munich, Germany, August 1988.
5. M. Aguilar-Benitez et al., "Review of Particle Properties," Phys. Lett. **204B** (1988).
6. W. Braunschweig et al., "A Measurement of the Tau Lifetime," Z. Phys. **C39** (1988) 331.
7. C. Kleinwort et al., "A Measurement of the Tau Lepton Lifetime," Z. Phys. **C42** (1989) 7.
8. M. L. Perl, "The Tau and Beyond: Future Research on Heavy Leptons," presented at the 8th Int. Conf. on Physics in Collision, Capri, Italy, October 1988; SLAC–PUB–4819.
9. F. J. Gilman and S. H. Rhie, "Calculation of Exclusive Decay Modes of the Tau," Phys. Rev. **D31** (1985) 1066.
10. H. Aihara et al., "Measurement of the Inclusive Branching Fraction $\tau^- \to \nu_\tau\pi^-\pi^0 +$ Neutral Mesons," Phys. Rev. Lett. **57** (1986) 1836.