to program planning
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Fermi National Accelerator Laboratory,
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Batavia,
Illinois 60510.

John Peoples,
Director,
Fermi National Accelerator Laboratory.

February 10th, 1992.

Dear John,

We would like to express our interest in searching for antiproton decay at the Fermilab antiproton source. The Fermilab $\bar{p}$ source is a unique facility which affords the possibility of significantly improving the present laboratory limits on the antiproton lifetime, or of making the exciting discovery that the antiproton decays. We note that if the antiproton did decay with a lifetime much shorter than the age of the universe then the predominance of matter over antimatter in the universe would be natural. A short $\bar{p}$ lifetime would, of course, require a violation of the CPT theorem. Violations of CPT have been considered in connection with the generation of matter in the early universe[1].

The best published[2] antiproton lifetime limit from a laboratory experiment is $\tau_{\bar{p}} > 32$ hours, which was obtained by observing the time evolution of 240 antiprotons in the ICE ring at CERN, where the beam lifetime was ~ 64 hours. An explicit search for $\bar{p} \rightarrow e^- + \pi^0$ was also made at the ICE ring[3] and yielded $\tau_{\bar{p}} \times BR(\bar{p} \rightarrow e^- + \pi^0) > 1700$ hours at 90% C.L. This search was made during a 10 day period in which the average number of antiprotons in the ring was 7200. The sensitivity of the experiment was limited by antiproton statistics.

Astrophysical considerations also place a limit on the antiproton lifetime. The measured[4] $\bar{p}/p$ ratio in cosmic rays of 5×10^{-4} is consistent with expectations for secondary production of antiprotons in the interstellar medium. This observation suggests that the antiproton lifetime is at least comparable to the cosmic ray storage time in the galaxy

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[1]E. Kolb and M. Turner, "The Early Universe", Frontiers in Physics Lecture Note Series, Addison-Wesley Publishing Company, Inc.
[2]M. Bregman et al., Phys. Lett. 78B (1978) 174.
[3]M. Bell et al., Phys. Lett. 86B (1979) 215.
[4]R.L. Golden et al., Phys. Rev. Lett. 43 (1979) 1196.

(~ 10^7 years). It is therefore desirable that a laboratory experiment searching for antiproton decay should eventually achieve a sensitivity better than or comparable to 10^7 years.

At the Fermilab antiproton source we anticipate typically $O(10^{12})$ antiprotons stored in the accumulator ring which, in the absence of background, is adequate to achieve a sensitivity of better than 10^7 years. For illustration, consider an experimental search for $\bar{p} \rightarrow e^- + \pi^0$, and suppose that the experiment runs for 1000 hours with 10^{12} antiprotons in the accumulator. Let the experiment trigger on a plane of trigger counters which are orthogonal to the beam axis, cover the full azimuthal angle, and extend from an inner radius with respect to the beam axis of 10 cm to an outer radius of 100 cm. The calculated fraction of $\bar{p} \rightarrow e^- + \pi^0$ decays in the accumulator ring for which both final state particles would pass through the trigger counters is 6 x 10^{-3}. Thus, in the absence of background, one observed event in this hypothetical experiment would correspond to a lifetime $\tau_{\bar{p}}$ x BR($\bar{p} \rightarrow e^- + \pi^0$) of $O(10^{12})$ hours (10^8 years).

In practice, we would expect that the sensitivity of the hypothetical experiment described above would depend upon how well background from beam-gas interactions could be rejected. A good understanding of background rates and characteristics is of crucial importance to the design of an antiproton decay experiment at the antiproton accumulator. To help us to develop a proposal for an experiment that would achieve a sensitivity comparable to or better than the cosmic ray limit we would like to first make some background test measurements. These test measurements would be made at the antiproton accumulator during the coming collider running period at times when antiprotons were circulating in the ring, but stacking was not taking place. Measurements would be made parasitically and would not require any dedicated beam time. As a by product, we would expect to achieve a sensitivity for the decay $\bar{p} \rightarrow e^- + \pi^0$ that exceeds the currently published accelerator-based limits but would not approach the cosmic ray limit.

The test we have in mind would be run parasitically when antiprotons are stored at 8.9 GeV/c in the Fermilab antiproton accumulator, and would search for two-body decays of the antiproton (for example $\bar{p} \rightarrow e^- + \pi^0$). The primary goal of the test would be to check our Monte Carlo calculation of expected background rates. We would like to make the test using the forward calorimeter of the E760 experiment, supplemented with veto and trigger scintillation counters. We would therefore wish to leave the forward calorimeter in place during the coming collider run. A sketch of a possible test setup is given in Fig. 1. For this test setup, we calculate that the acceptance for $\bar{p} \rightarrow e^- + \pi^0$ decays is 2.4 x 10^{-4}. We have made a simple Monte Carlo study of the characteristics of background from proton-antiproton annihilation into π mesons. It appears that in these background processes the outgoing particles tend to be emitted at much larger angles with respect to the beam-axis than those from $\bar{p} \rightarrow e^- + \pi^0$ decays. Therefore, the vertex position counters should be quite effective in reducing the background from interactions. The presence of a single electron in the final state is also a potentially powerful signature that we intend to exploit.

In normal E760 running the forward calorimeter has so far received an estimated dose of 200 rads with no significant deterioration in its performance. The Penn. State University group have agreed to leave the E760 forward calorimeter module in place for our test, with the understanding that the radiation it receives should be monitored as in E760 running, be protected by trip monitors during proton setup, and ideally should not exceed more than a further 200 rads during our test. The P.S.U. group require that the calorimeter be removed after our test measurements are complete. This could be done at a convenient time, for example after a store is lost. Removal of the calorimeter is estimated to take less than 8 hours, and does not require breaking the Accumulator vacuum.

In order to make our test measurements and develop a proposal to search for antiproton decay at the antiproton accumulator, we require some modest support from the antiproton source, the physics department, the computer division, and a modest budget. The attached list is intended to define the scope of this proposed effort.

Sincerely,

Steve Geer*), John Marriner, Ron Ray, Jon Streets (Fermilab)
Tom Armstrong (Penn. State University)
Thomas Muller, John Quackenbush (UCLA)

*) Contact Person

cc Taiji Yamanouchi

Table 1: Support Required for the Test Measurements.

Item	Materials	Labor*) (man days)	Institution
Forward Calorimeter	-	-	Penn.
4 Trigger Scintillators (30 x 30 cm^2 each)	$3 000	4	UCLA
4 Veto Scintillators (100 x 10 cm^2 each)	$3 000	4	UCLA
2 Vertex Position Counters (100 x 15 cm^2 each)	$3 000	2	UCLA
Photomultiplier Tubes, Bases and Supports	$9 000	7	UCLA
HV Supplies	Borrow from PREP		Fermilab
NIM Logic	Borrow from PREP		Fermilab
Cables	$3 000	4	Fermilab
Vax 3200 with VMS+Ethernet**)	Borrow from Comp. Div.		Fermilab
8mm Tape Drive**)	Borrow from Comp. Div.		Fermilab
Disk (WREN VII)**)	Borrow from Comp. Div.		Fermilab
CAMAC Jorway**)	Borrow from Comp. Div.		Fermilab
CAMAC LAM Latch module**)	Borrow from Comp. Div.		Fermilab
QBUS SCSI Controller**)	Borrow from Comp. Div.		Fermilab
Beam-pipe preparation***)			Fermilab
Miscellaneous	$10 000	5	Fermilab
SUBTOTAL (UCLA)	**$18 000**	**-**	
SUBTOTAL (Fermilab)	**$13 000**	**26*)**	
TOTAL	**$31 000**	**26**	

*) Counters and supports paid for by UCLA will be made at Fermilab.
**) It may be possible to use the E760 readout system, in which case these items are not needed.
***) High temperature bakeout is desirable.

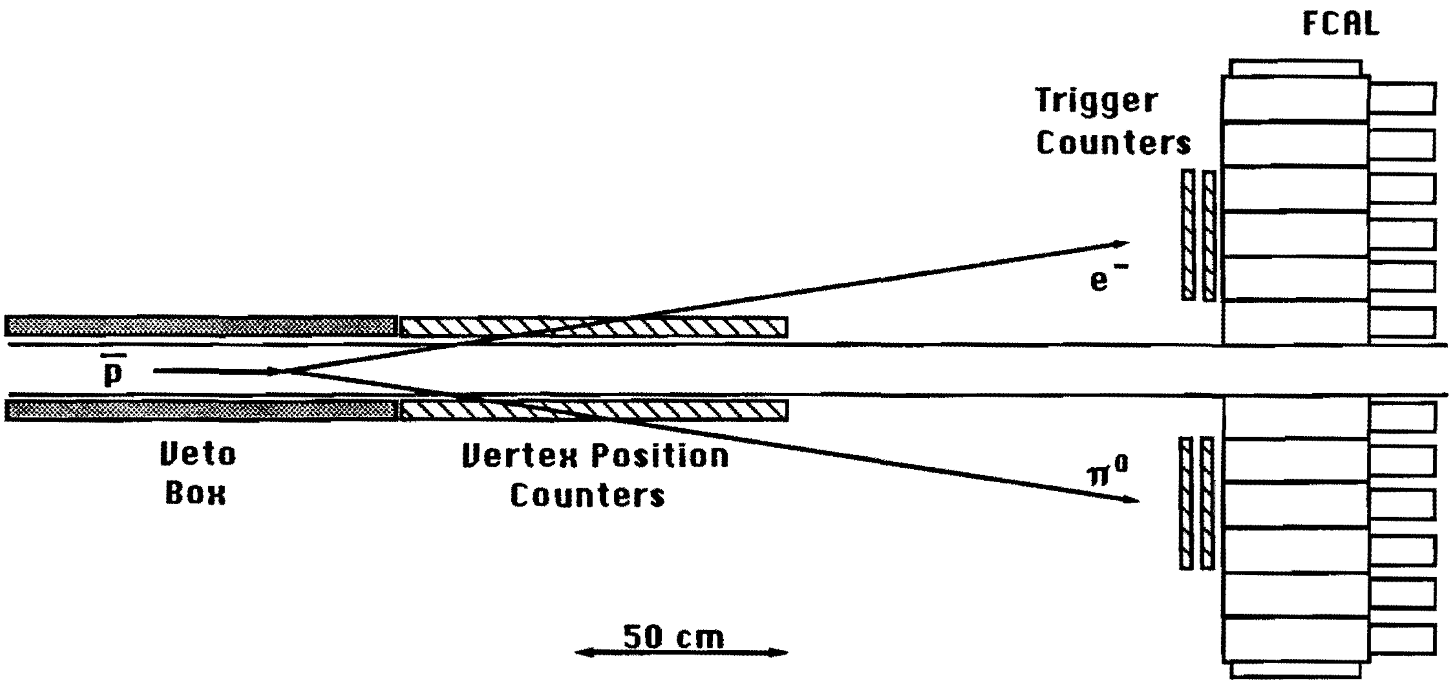
FCAL
Trigger
Counters
e⁻
p̄
Veto
Box
Vertex Position
Counters
π⁰
50 cm

Figure 1