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Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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Dr. R. Klapisch, Director of Research
CERN, CH-1211
Geneva 23
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Dear Dr. Klapisch:

This pre-letter of intent is written, as requested, to inform you and the PSCC of our progress toward submitting a proposal for an experiment at LEAR. As you know, we are specifically excited about research with ultra-low energy antiprotons. To reach the ultra-low energy regime we are planning to build an RFQ decelerator and a Penning bulk storage ion trap. In this brief note we outline our general approach and list some of the wide range of physics opportunities made possible by cold, trapped antiprotons. More general details can be found in the Tignes paper by M. V. Hynes (LA-UR-85-1060, copy enclosed).

In our approach for achieving ultra-low energy antiprotons, we plan to build an RFQ decelerator which would accept the lowest energy LEAR beam. To our knowledge this is the first application of an RFQ as a decelerating structure. In their Tignes paper, Billen, Crandall, Wangler and Weiss (LA-UR-85-140, copy enclosed) demonstrate that from the beam dynamics point of view the idea of an RFQ as a particle decelerator for the LEAR beam is not only feasible but appears to be an excellent solution to the problem of obtaining very low energy $\bar{p}$'s at LEAR. The beam quality can be conserved in all phase planes. In particular, one should be able to obtain an output beam of energy variable between 20 and 200 keV with an energy spread of ∿0.5 keV. The requisite beam gymnastics inside LEAR appear to be of the non-strenuous variety, according to conversations with P. Lefèvre and D. Möhl.

The final RFQ design awaits the September 1985 run when LEAR will attempt operations at 100 MeV/c or lower. The beam characteristics and energy are naturally a crucial input for the design of the RFQ we envision. By January of 1986 we should be in construction which would be completed by the following summer or fall. Upon completion, the RFQ will be thoroughly tested using protons and H^- ions from our Ion Beam Facility whose beam will be specially tailored to match the LEAR beam characteristics.

The Penning bulk storage ion trap we envision will capture, cool and store antiprotons. The output beam of the RFQ decelerator will be captured by a specially designed pulsing system on the trap electrodes. Once in the trap, several approaches for cooling the antiprotons are available. The relative efficiencies of these approaches is now under study. We are currently in the process of building prototype ion traps which will be used to demonstrate the trapping of externally injected protons for the first time. The Texas A&M University members of our collaboration have had extensive experience with ion traps. With their aid we expect to have underway this summer the effort to catch and cool protons and H^- ions. When the RFQ is available the entire deceleration, catching and cooling sequence will be thoroughly tested using protons and H^- ions at Los Alamos before transport to CERN.

Originally our interest in low temperature antiprotons arose from our plans for a gravitational mass experiment. In designing a system to achieve an antiproton temperature appropriate for this measurement it became obvious that many other experimental possibilities could be opened in atomic physics, chemical physics, condensed matter and solid state. We are currently investigating several research areas for our forthcoming proposal. Listed here are some of the specific topics we are considering. We do not include the measurement of the mass of the antiproton since we understand that it is the subject of a separate proposal (PS189).

1. Gravitational Constant for Antimatter. In the reknowned experiment of Witteborn and Fairbank, their goal was to measure the effect of gravity on electrons and positrons in order to detect the possible existence of antigravity. Although they succeeded in measuring the expected value for electrons, the experiment was never performed for positrons. Using trapped antiprotons and protons, the experiment should be a factor of $\sim$2000 times easier. We are in consultation with F. Witteborn regarding the experimental aspects of this measurement. Current theoretical prejudices, as well as a novel concept that would allow $g(\bar{p}) \neq g(p)$, were presented at Tignes by T. Goldman and M. Nieto. A copy of their talk (LA-UR-85-1092) is enclosed with this letter.

2. Polarized $\bar{p}$'s. Cold antiprotons confined to a bulk storage trap invite consideration of possible techniques for polarizing them. We are actively pursuing several of these schemes. Compared to alternative methods of achieving polarized $\bar{p}$'s, some of these look extremely promising at present. Clearly the advent of a polarized $\bar{p}$ source would precipitate many new developments on a broad scale in antiproton physics. We will have more to say about this in the near future.

3. $\bar{p}p$ Atoms and Annihilation. The investigation of $\bar{p}p$ atomic transitions and annihilation channels can be made with unprecedented accuracy in an extraordinarily clean and controlled environment. The $\bar{p}$'s extracted from our trap could be injected into a low density hydrogen target at velocities appropriate for efficient capture into atomic orbits. The absence of Stark

mixing, the small dimensions of the interaction region, and the open geometry around this region would be some of the attractive new features of such an experimental setup.

4. <u>A Bulk Storage Trap as a $\bar{p}$ Source</u>. A bulk storage antiproton trap can be considered to be a $\bar{p}$ source. Up to 10^{11} $\bar{p}$'s/cm^3 can be stored in the traps we are constructing. Such a trap could be the initial stage of a device for duty factor magnification and time shifting compared to what LEAR currently delivers. In this regard, recall that cold trapped antiprotons represent a near zero emittance $\bar{p}$ source.

5. <u>Condensed Matter Experiments</u>. Interesting questions and speculations abound in this virgin research area. Can $\bar{p}$'s be trapped on superfluid surfaces? Are there metastable states of $\bar{p}$'s in normal matter? Although further in the future these and other possibilities open up interesting avenues of research.

The experimental collaboration which is currently being formed will include investigators from Los Alamos, Rice University, Texas A&M University, UCLA and others, as well as investigators from CERN member states. In addition a theoretical collaboration is being formed to study the avenues of research open to cold, trapped and possibly polarized antiprotons. We expect to submit a formal Letter of Intent prior to the June meeting of the PSCC. We look forward to participating in the interesting physics which can be achieved with cold antiprotons. Thank you for your interest and efforts on our behalf toward this goal.

Sincerely,

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