radioactive wastes from the operation of the plant will not require isolation from the environment for geological timespans; that the release of radioactivity and other wastes during normal operation and maintenance will be acceptable; that decommissioning and dismantling of the plant is feasible at acceptable cost and radiation exposures. These issue are as important as technical questions and they should be considered at a very early stage of future projects: indeed, they should be an integral part of their design concept. World-wide collaboration should also be directed at these tasks. Without such a policy it will be difficult to create the necessary acceptance for ICF among the general population.

Antihydrogen as a Probe

New particles tend eventually to be used as probes for something else so the once exotic positron is now widely used in condensed matter studies. For positrons, one generally measures the Doppler shift of the characteristic energy (511 keV) of the two photons produced by the rapid (picosecond) annihilation of a positron by electrons. This shift is caused by changes in the positron's momentum due to trapping in crystalline defects (*e.g.*, vacancies) or, as discovered recently, by temporary potential wells formed by fluctuations in conducting liquids.

The antiproton may now become a probe since a University of Tokyo group showed last year [Iwasaki M., *et al.*, *Phys. Rev. Lett.* **67** (1991) 1246] that 3.6% of the antiprotons fired into liquid He were trapped for up to 30 ms whereas the remainder were annihilated some 10^8 times faster (within a few ps, the theoretically predicted time). As long ago as 1964, G.T. Condo suggested that the quantum numbers of some exotic He atoms formed by replacing one of the electrons in Bohr-like orbits around the nucleus with an antiproton does not mean that the remaining electron is ejected immediately (as assumed by others in calculating the antiproton lifetime). The Pauli exclusion principle would then disallow the collisions by surrounding atoms which bring about a short-circuiting of the antiproton's slow cascade through a series of atomic states — a cascade that ends with the antiproton being within range of the strong interaction causing annihilation. So it is thought that a few percent of the He atoms are special in some fascinating way.

A joint experiment PS205 (involving Tokyo University, MPI für Quantenoptik and CERN) at CERN's LEAR accelerator which produces the world's cleanest, monoenergetic, low energy antiproton beam of small spot size has reproduced the effect. Further work is in progress using the various forms of He to identify what accounts for the stability of the long-lived metastable He atoms (the ''trapping states''), to look for light emission, and to laser pump the metastable atoms to prolong their lifetimes even further to allow precision spectroscopy. Reacting metastable atoms with positrons and positronium may produce antihydrogen — which could be used as a physics ''laboratory'' ... and as a probe.

Antihydrogen Workshop

30 - 31 July 1992

Ludwig-Maximilians-Universität, Munich, Germany

Organised by:
CERN and MPI für Quantenoptik

Topics: why antihydrogen?; ultra-low energy antiprotons; positron accumulation & positronium; routes to antihydrogen production; antihydrogen: trapping, spectroscopy & laser simulated recombination.

Contact:
C. Zimmermann, MPI für Quantenoptik, Postfach 15413, W-8046 Garching (Fax: +49-89-32 95 52 00).