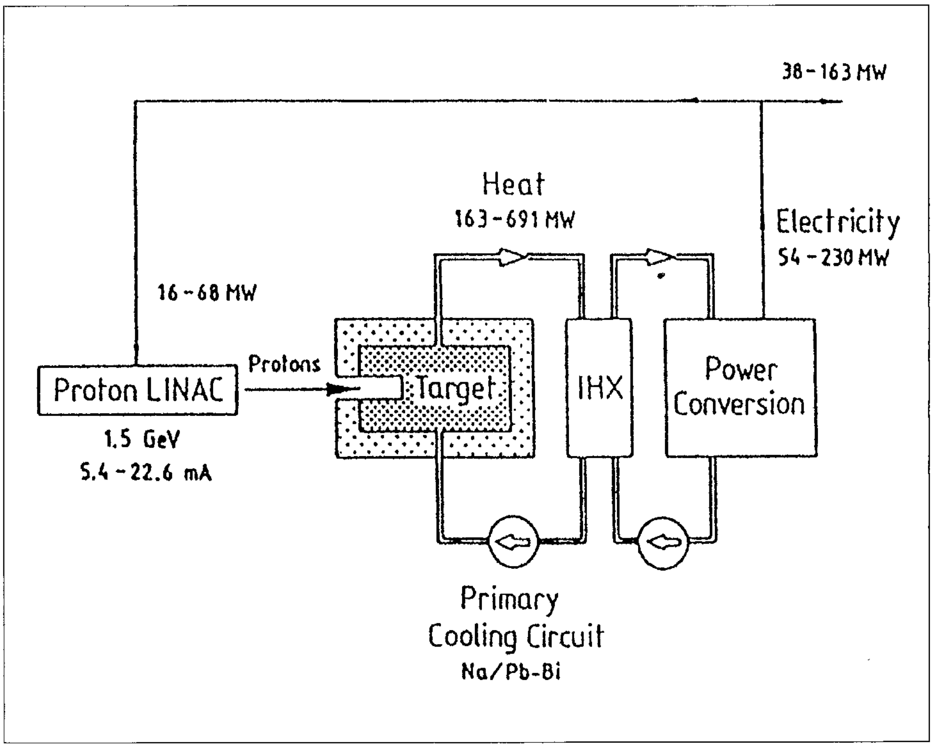

Conceptual design of a system using a proton accelerator to transmute awkward radioactive isotopes produced in course of fission processes. It has been studied at the Japan's Atomic Energy Research Institute for several years. At Los Alamos in the US, similar ideas are being looked at.

Transmuting nuclear waste

With the problems of disposing of nuclear waste material increasingly the cause for widespread concern, attention is turning to possible new techniques for handling discarded radioactive material and even putting it to good use.

One possibility being examined, mainly in the US, Japan and the former Soviet Union, is to irradiate long-lived nuclear waste with particle beams, transforming it into shorter-lived isotopes and/or using it as a breeder reactor.

The idea of using a high energy particle beam to produce fissile material was first put forward by Ernest Lawrence in 1950. The idea then was to ensure a continuous supply of material for nuclear weaponry, irradiating lithium to produce tritium for fusion bombs, and uranium to produce plutonium for fission. In those days the US was anxious to insure its nuclear capability against any interruption in the import of uranium ore.

The idea led to the construction of the Materials Testing Accelerator (MTA) at Livermore, not far from Lawrence's Berkeley Laboratory. However market manoeuvres increased the price of uranium, making lower grade deposits in Colorado exploitable. The US no longer needed a backup plan to make plutonium from scrap uranium. MTA foundered, but the accelerator technology was put to good use at Berkeley.

Now thinking is returning to this idea, but with the emphasis on handling the output from nuclear plant rather than providing the initial input fuel.

This work is reported regularly at accelerator conferences, but was highlighted in an international meeting organized last year by the Moscow Radiotechnical Institute and attended by scientists from Japan and the US as well as the (then) Soviet Union who examined the problems and possible solutions. A draft conclusion written summarized the major objectives.

With the disposal of long-lived waste from nuclear power as one of today's most urgent problems, increasing the research and development efforts, combining expertise from different countries, is of prime importance, the conclusion recommends.

Today it looks fairly certain that an incinerator reactor based on a linear accelerator with an energy of 1.5 GeV and a current of 300 mA is practicable. But considerable effort is still needed to develop an accelerator to provide the necessary high proton flux.

As well as the accelerator, additional effort is required to develop schemes to separate out long-lived nuclides from the rest of the waste, to design a blanket target, to check reaction rates, and to obtain energy release figures.

However the use of a powerful accelerator for waste incineration seems quite practical and economically expedient. 'The whole complex of problems connected with radioactive waste handling should become an object for international cooperation'. The report ends by recommending increased international exchanges.

The summary did not indicate the work currently underway elsewhere, mainly in the US and Japan. As well as incinerating waste, either existing or future, these schemes could also provide new and more efficient routes to fission. Most of the ideas

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***Inquiries for the rest of the world:* please see page III.**

currently under consideration use an intense 1.5 GeV proton beam to irradiate a target of liquid heavy metal (e.g. lead) generating neutrons which are subsequently thermalized in a heavy water blanket.

One major radioactivity problem is the actinide (heavier than uranium) isotopes formed in fission environments. However an intense thermal neutron flux would ensure that these troublesome isotopes act as a net producer of neutrons - acting themselves as nuclear fuel.

The other trouble spot is the fission products themselves, and here the intense neutron bombardment would transform many of them into other isotopes which decay in terms of days or even seconds, rather than months and years.

In the US, work is going on at Los Alamos and Brookhaven, while in Japan the Atomic Energy Research Institute has several projects for actinide burning and isotope transmutation as part of the national OMEGA - Options Making Extra Gains from Actinides and fission products - campaign.

In Europe there is interest but little cash encouragement in this potentially very rewarding venture.

At the recent Spin Muon Collaboration meeting in Paris, Anatole Abragam describes the mechanism of dynamical polarization, first for one spin up, then two.

(Photos T. Hasegawa)

Spin collaboration

What makes the proton spin? In 1988, results from the European Muon Collaboration (EMC) experiment at CERN suggested that the spin of the proton is difficult to explain in terms of quark constituents. A range of experiments is now underway to resolve the question.

In 1988, EMC looked at the violent collisions when a high energy spin oriented (polarized) muon beam hits quarks deep inside a polarized proton target, and found that the difference (asymmetry) between the reaction rates for two different spin orientations was not in line with theoretical predictions.

Combining the EMC results with previous SLAC data suggested that very little of the proton spin is carried by the quarks. If this is the case, where can the spin come from? Various ideas have been proposed but only new experimental information can provide the answer. Particularly important is companion data on the neutron.

A fundamental test of the underlying theory is given by the Bjorken polarization sum rule which relates the proton and neutron spin-dependent structure functions to neutron beta decay parameters. Particularly important is accurate information when the struck quark carries only a small fraction of the proton momentum (small x) to improve the extrapolations needed to compare with theory.

Five new experiments using different techniques have been proposed to extend the measurements to the neutron, and to lower values of x. Some of these projects also plan to improve the accuracy of the present results on the proton.

Two experiments have been proposed for the 23 GeV beam at Stanford (SLAC). E-142, scheduled for this fall, uses a polarized helium-3 target at 10 atmospheres as an effective neutron target. E-143, scheduled for 1993, uses ammonia/deuterated ammonia targets. Both experiments will provide high precision data for x between 0.04 and 0.6.

Another experiment (HERMES) using a novel technique has been proposed for the 35 GeV HERA electron ring at DESY, Hamburg. Using a polarized atomic beam and a storage gas cell as an internal target, together with a polarized electron beam, this experiment, still awaiting approval, will explore the x range between 0.02 and 0.08. A letter of intent for the HELP experiment at CERN