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MEDICAL RADIOISOTOPE PRODUCTION AT TRIUMF

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Abstract

The production for research of ^{123}I at TRIUMF via spallation is described, together with some medical applications. The production of ^{123}I of greater isotopic purity, via a third extracted beam from the TRIUMF cyclotron of 60 to 100 MeV energy, is discussed. Other nuclides to be produced for research are listed.

Arrangements with AECL for collaborative commercial radiopharmaceutical distribution are described, together with the necessary hot-laboratory facilities, a second cyclotron, and target irradiation facilities.

The meson factory accelerators are potentially copious sources of radioisotopes (especially for those nuclides which can conveniently be prepared by the spallation process), essentially because of their high beam power. The beam power at TRIUMF is currently about 50 kW (normal maximum). A proton beam intensity of up to about 100 μA provides intense bombardments; and energy of up to 500 MeV allows target thicknesses of many grams per square centimeter (through which spallation cross-sections remain essentially constant) to be employed.

The spallation of cesium has been exploited for some time at TRIUMF, by a TRIUMF-University of B.C.-Vancouver General Hospital team, to produce ^{123}I for research purposes. The cesium heat-pipe target system was designed in collaboration with J. Blue of NASA-Cleveland, and its details together with the ^{123}Xe-^{123}I separation procedure have been described elsewhere.[1] Weekly 12-hour bombardments at 10 μA have resulted in production of ^{123}I in amounts up to about one curie, and this material has been shipped, with support from Health and Welfare Canada, to collaborating hospitals in Toronto, Winnipeg, and Edmonton, as well as to Vancouver General Hospital, for evaluation as a radiopharmaceutical.

Figure 1 shows the result of a rectilinear scan, made with TRIUMF-produced ^{123}I, of a patient who had previously suffered from cancer of the thyroid. Normal thyroid activity had been ablated by radiation treatment; the present image shows no significant iodine uptake in the thyroid, but does show strong iodine activity in the salivary glands, gastrointestinal tract and bladder, together with diffuse activity in the lungs. Of particular interest, however, is the appearance in the area of the right hip (as the figure is viewed) of a small area of localised uptake. This proved to be a metastasised thyroid tumour, and exhibits the characteristic thyroid iodine uptake in its new location.

The ^{123}I produced via the spallation process contains an irreducible 0.5% ^{125}I impurity (which increases relatively with time as the ^{123}I decays); this contributes significantly to the patient dose in imaging operations such as the above, and defeats somewhat the intrinsic low-dose advantages of substituting ^{123}I for ^{131}I in thyroid imaging. (The advantage is a reduction by a factor of about 100 for pure ^{123}I.)

Essentially pure ^{123}I may be produced by the $^{127}I(p,5n)^{123}Xe$ route, with protons of about 70 MeV incident, as has been shown at the SIN meson factory at Zürich,[2] at the University of California, Davis,[3] and elsewhere. This has led at TRIUMF to the extraction of a third external beam from the TRIUMF H⁻ cyclotron, variable in energy from 65 to 100 MeV, and capable of simultaneous operation with the other extracted beams.

A molten NaI target has been developed, along the general lines of the Davis system,[3] for installation adjacent to the cyclotron tank wall, and capable of receiving currents of up to several microamperes. A laboratory has been constructed to receive the ^{123}Xe from this target and to extract the ^{123}I decay product. This will be used for continued production of research quantities of ^{123}I and for some pilot commercial production (see below). Plans call for extension of the 65-100 MeV beam line to a multiple target facility using the thick concrete shielding of the cyclotron vault wall, and capable of receiving much higher beam currents.

Other radionuclide production for medical research applications, presently under development at TRIUMF, includes that of ^{52}Fe, ^{77}Br, ^{11}C, ^{13}N, ^{15}O, and ^{18}F.

TRIUMF has concluded an agreement with Atomic Energy of Canada Ltd. for the cooperative commercial distribution

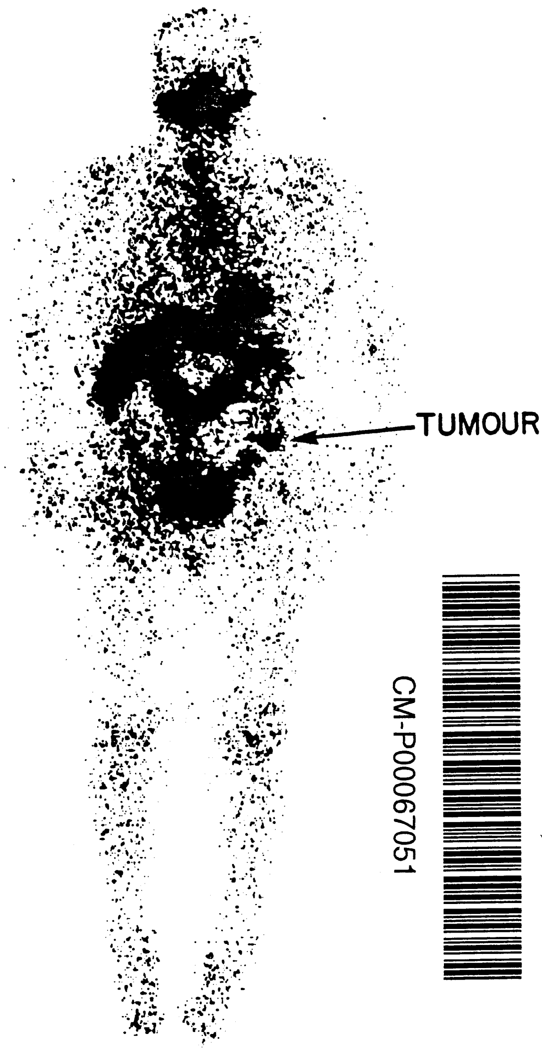

Fig. 1. Rectilinear scanning image taken with TRIUMF spallation-produced ^{123}I of a patient with thyroid cancer. For details, see text.

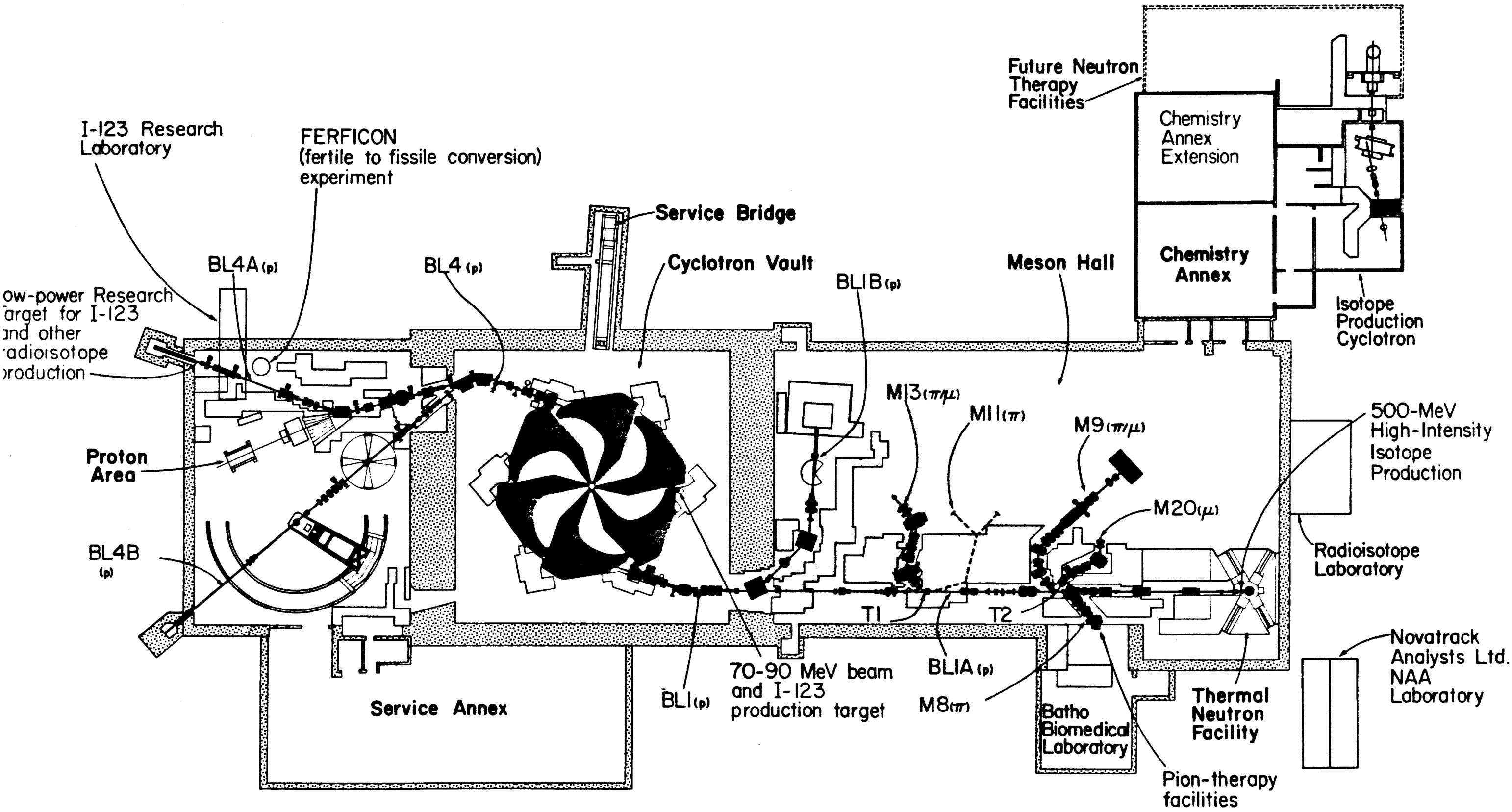

Fig. 2. Ground plan of TRIUMF, showing *inter alia* the various isotope production facilities described in the text.

of TRIUMF-produced radiopharmaceuticals. Financing, secured through the British Columbia Development Corporation, plus supplemental funding from the B.C. Provincial Government, has allowed construction of further facilities at TRIUMF for radioisotope and radiopharmaceutical research, together with hot-laboratory facilities for commercial production. The latter include hot cells of an AECL design[4] for operations at the level of hundreds of curies of gamma-activity.

At the same time, a facility has been designed and constructed to permit irradiation of multiple thick targets in the 500 MeV, 100 μA beam from the TRIUMF cyclotron, and their safe withdrawal and transfer to the processing hot cells. This facility is described in the succeeding paper.[5]

In addition, a second H^- cyclotron (The Cyclotron Corporation, Berkeley, California; Model CP-42) has been purchased for installation at TRIUMF in 1980. This will be a prime source for certain radionuclides, and will provide back-up production for others to be produced by the main TRIUMF cyclotron when that machine is shut down for development. With this added cyclotron, TRIUMF will have proton beams covering most of the energy range from 11 to 525 MeV, with currents at or above 100 μA over much of it.

The list of nuclides presently intended for commercial production includes $^{201}T\ell$, ^{67}Ga, ^{123}I, ^{127}Xe, ^{109}Cd, ^{111}In and ^{68}Ge. Full operation is scheduled for 1981.

Figure 2 shows a floor plan of the TRIUMF project with the locations of the above-described facilities.

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