SUMMARY OF CYCLOTRON OPERATIONS FOR 1988

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INTRODUCTION

Mount Sinai Medical Center operates a CS-30 cyclotron (TCC) installed in 1972 having capability of accelerating protons to 26.6 MeV. Protons are the only particles currently being accelerated. The machine is used both for in-house research and clinical purposes and for radiochemical sales to outside contractors.

The direction of operation over the last several years has been driven primarily by economics. The facility has almost always been funded by commercial sales of radionuclides to outside contractors. The decision was made in late 1986 to dedicate the machine exclusively to radionuclide production for PET; this resulted in a significant staff reduction. However, during late 1987 it was decided to terminate PET operations in mid-1988. As a result, the cyclotron was again used to produce radionuclides for commercial sales.

In 1988 the cyclotron was operated for a total of 2240 hours with 1336 of those hours between September and December. The staff has increased from 6 to 9 since the start of 1988 by the addition of a Nuclear Pharmacist, a radiochemist for production, and a Cyclotron Engineer (Table I). The facility currently operates a licensed Nuclear Pharmacy for sale of radiopharmaceuticals, sales of bulk radiochemicals to outside contractors, is developing ^{18}FDG for commercial sales, and initiating several research projects. Most R&D is related to the preparation of the commercial products. Mount Sinai does not at this time have an operational PET facility.

Table I. Current Operations

Cyclotron/Radiochemistry Staff

1 - Faculty Director, Ph. D., Chemist
1 - Senior Radiochemist, Ph.D.
2 - Production Chemists
1 - Quality Control Chemist
1 - Nuclear Pharmacist
3 - Cyclotron Engineers/Operators

SUMMARY OF RADIONUCLIDES PRODUCED

A. Internal Irradiations- Products such as Gallium-67, Lead-201 (Thallium-201), and Indium-111 are irradiated internally. The following is a summary of the internal irradiations for the year:

1. Radionuclide Produced:	Gallium-67
Reaction:	^{68}Zn(p,2n)^{67}Ga
Target Material:	^{68}Zn metal on copper
Total Number of Irradiations:	36
Typical Current on Target:	130 μA
Average Length of Irradiation:	32.2 hours
Typical Activity per Irradiation:	20.6 Ci

Product summary: The Ga-67 is primarily sold as bulk radiochemical Gallium Chloride; some bulk radiochemical Gallium Citrate was prepared.

2. Radionuclide Produced: Thallium-201
   Reaction: $^{203}Tl(p,3n)^{201}Pb \rightarrow {}^{201}Tl$
   Target Material: ^{203}Tl metal on copper
   Total Number of Irradiations: 50
   Typical Current on Target: 70 μA
   Average Length of Irradiation: 12 hours
   Typical Activity per Irradiation: 8-10 Ci as ^{201}Pb
   Product summary: Thallium-201 was used to prepare radiopharmaceutical grade Thallous Chloride for in-house clinical use and for local sales through our Nuclear Pharmacy. Some radiochemical Thallous Chloride was prepared for bulk sales.

3. Radionuclide Produced: Indium-111
   Reaction: $^{112}Cd(p,2n)^{111}In$
   Target Material: ^{112}Cd metal on copper
   Total Number of Irradiations: 7
   Typical Current on Target: 110 μA
   Average Length of Irradiation: 7 hours
   Typical Activity per Irradiation: 5.0 Ci
   Product summary: Indium-111 was sold as bulk radiochemical Indium Chloride.

B. External Irradiations:

The following external targets were used during the year:

1. Radionuclide Produced: Oxygen-15
   Reaction: $^{16}O(p,pn)^{15}O$
   Target Material: O_2 gas
   Total Number of Irradiations: 52
   Typical Current on Target: 15 μA
   Average Length of Irradiation: 5 minutes
   Typical Activity per Irradiation: 40 - 80 mCi as O-15 water
   Product summary: Oxygen-15 was used to prepare O-15 water for PET.

2. Radionuclide Produced: Fluorine-18 (^{18}F)
   Reaction: $^{18}O(p,n)^{18}F$
   Target Material: O^{18} enriched water
   Total Number of Irradiations: 66
   Typical Current on Target: 9.0 μA
   Average Length of Irradiation: 90 minutes
   Typical Activity per Irradiation: 625 mCi
   Product summary: Fluorine-18 was used for the preparation of ^{18}FDG for PET and for limited research purposes.

EXTERNAL TARGETS AVAILABLE

Seven beam lines are available and operational. Currently, six beam lines have operational targets:

1. +40° target for preparation of $^{11}CH_4$; 94.5% N_2/5.5% H_2 gas mixture.
2. +20° target for preparation of $^{11}CO_2$; N_2 gas target.
3. 0° target is a TCC supplied target station with remote target removal system. Has been used over the years for a variety of purposes, such as preparation of ^{123}I from ^{124}Te, preparation of ^{18}F, and for numerous research projects.
4. -20° target is a tandem target for separate or concurrent preparation of ^{13}N and ^{15}O. ^{13}N prepared from water; ^{15}O from O_2 (see below).
5. -40° target for preparation of ^{18}F using ^{18}O enriched water; 5.1 ml target of nickel with nickel window.
6. -60° target for preparation of ^{18}F using ^{18}O enriched water. This target has been in operation since early 1987 and has been used 130 times. The average number of runs without encountering target problems is 18 (range 7 to 42). Target problems are defined as solenoid failure, tubing leak, discoloration, particulates, or unreactive fluoride ion.

Target Specifications:

26.5 MeV to 20.1 MeV with 0.020" copper window
20.1 MeV to 19.9 MeV with 0.001" titanium window
19.9 MeV to 4.0 MeV with O-18 enriched water
4.0 MeV to 0 MeV with 0.010" titanium window

Depth:	0.151" in 316 stainless steel
Diameter:	0.65" cylindrical shaped
Total Volume:	1 ml

-20° Target (tandem)

Back Target: $^{16}O(p,\alpha)^{13}N$ (energy range 18.0/19.4 - 0 MeV)

Dimensions:		
	Depth	0.250" (0.635cm)
	Height	1.575" (4.0cm)
	Width	0.787" (2.0cm) (box shaped)
	Target Volume	0.31ci (5.1cc)

with front target loaded:

24.1 MeV ------ 2.38 (6.0cm) air @ 1 atm ------ 23.9 MeV
23.9 MeV ------ 0.045" (0.114cm) aluminum window ------ 18.0 MeV
18.0 MeV ------ 0.250" (0.635cm) water ------ 0 MeV *
* proton stopped in 0.136"

with front target empty (1 atm):

25.7 MeV ------ 6.5" (16.5cm) oxygen @ 1 atm ------ 25.4 MeV
25.4 MeV ------ 0.003" (0.0076cm) aluminum window ------ 25.1 MeV
25.1 MeV ------ 2.38" (6.0cm) air at 1 atm ------ 25.0 MeV
25.0 MeV ------ 0.045" (0.114cm) aluminum window ------ 19.4 MeV
19.4 MeV ------ 0.250" (0.635cm) water ------ 0 MeV *
* proton stopped in 0.154"

-20° Target (tandem)

Front Target:	^{16}O (p,pn) ^{15}O (energy range 25.7 - 24.4 MeV)	
Dimensions:	Depth	6.5" (16.5cm)
	Diameter front	1.0" (2.54cm) (truncated cone)
	Diameter rear	0.5" (1.27cm)
	Target volume	$3.0in^3$ (49cc) loaded to 50 psig
	Gas volume	$10.2in^3$ (167cc) @ stp

26.5 MeV ------ 0.003" (0.0076cm) aluminum window ------ 26.2 MeV
26.2 MeV ------ 2.38 (6.0cm) air @ 1 atm ------ 26.0 MeV
26.0 MeV ------ 0.003" (0.0076cm) aluminum window ------ 25.7 MeV
25.7 MeV ------ 6.5" (16.5cm) oxygen gas at 3.4 atm ------ 24.4 MeV
24.4 MeV ------ 0.003" (0.0076cm) aluminum window ------ 24.1 MeV