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Published in:
AIP Conference Proceedings - American Institute of Physics

Link to article, DOI:
10.1063/1.4773932

Publication date:
2012

Document Version
Publisher's PDF, also known as Version of record

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Citation: AIP Conference Proceedings **1509**, 21 (2012); doi: 10.1063/1.4773932
View online: http://dx.doi.org/10.1063/1.4773932
View Table of Contents: http://scitation.aip.org/content/aip/proceeding/aipcp/1509?ver=pdfcov
Published by the AIP Publishing

An After-Market, Five-Port Vertical Beam Line Extension For The PETtrace

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Abstract. Most commercial cyclotrons intended for medical isotope production provide a limited number of beam ports crowded into a minimal vault space. Taking advantage of our new lab construction, we planned and installed a beam-line on port #2 of our GEMS PETtrace to bring beam to an additional 5 target positions. These are oriented in the vertical plane, with the downward directed beam well suited for molten target substrates.

Keywords: beam optics, radionuclide production
PACS: 29.20.dg, 29.27.Eg, 29.27.Fh

INTRODUCTION

The GEMS PETtrace is well matched to serve the clinical needs for conventional PET radionuclides: ^{11}C, ^{13}N, ^{15}O and ^{18}F. With 100 μA of 16 MeV protons and 80 μA of 8 MeV deuterons directed onto 6 beam ports, the needs for aqueous ^{18}F$^-$, ^{13}N-ammonia, ^{15}O-gases and ^{11}C-methylating agents are easily met. However, the UW PET research program calls for an expanded list, including ^{10}C, electrophilic ^{18}F and ^{34m}Cl, as well as the entire 3d-shell of transition metals. These synthons require highly specialized targets supporting corrosive and often molten target materials. To accommodate this expanded list, a beam line extension was designed and built by National Electrostatics Corporation (Middleton, WI) with 5 beam ports at 0^o, $\pm15^o$ and $\pm30^o$ oriented in the vertical plane. The critical specifications called for beam optics to focus the beam onto a 5 mm FWHM beam strike, anticipating costly enriched isotopes. The downward-direct ports are intended for targets, some of which are listed in Table 1 with melting points that need gravity to confine the molten target substrates in a horizontal configuration.

MATERIALS AND METHODS

In 2009, the PETtrace (#144) was bunkered in new space in the UW Institute of Medical Research. All targets are made in house. The raised placement and service trench encircling the cyclotron were designed to permit clear access all around, as well

14th International Workshop on Targetry and Target Chemistry
AIP Conf. Proc. 1509, 21-24 (2012); doi: 10.1063/1.4773932

TABLE 1. Problematic target substrates that benefit from a vertical beam strike on the melt.

Reaction	Target Substrate	MP (°C)
$^{10}B(p,n)^{10}C$	$^{10}B_2O_3$	450
$^{34}S(p,n)^{34m}Cl$	S	112
$^{44}Ca(p,n)^{44}Sc$	^{nat}Ca	839
$^{69}Ga(p,n)^{69}Ge$	^{nat}Ga	39
$^{76}Se(p,n)^{76}Br$	Se	217
$^{86}Sr(p,n)^{86}Y$	Sr	769
$^{124}Te(p,n)^{124}I$	Te	452

as 12 feet of clear run from the PETtrace beam ports for the future beam line. Specifications were sent out to three bidders, and the contract was let to NEC in 2010. Their careful beam optics calculations, starting from the emittance characteristics provided by GEMS for port #2 (upward directed by 2.5°), led to five elements shown in Figure 1:

- a ±1° horizontal steerer, followed by
- a few degree vertical steerer to bring the beam to horizontal for entry into
- a quadrupole doublet, focusing the beam through
- a high-power quad slit and drift tube, leading to
- the 5-port, double-focusing switching magnet, supporting the new targets.

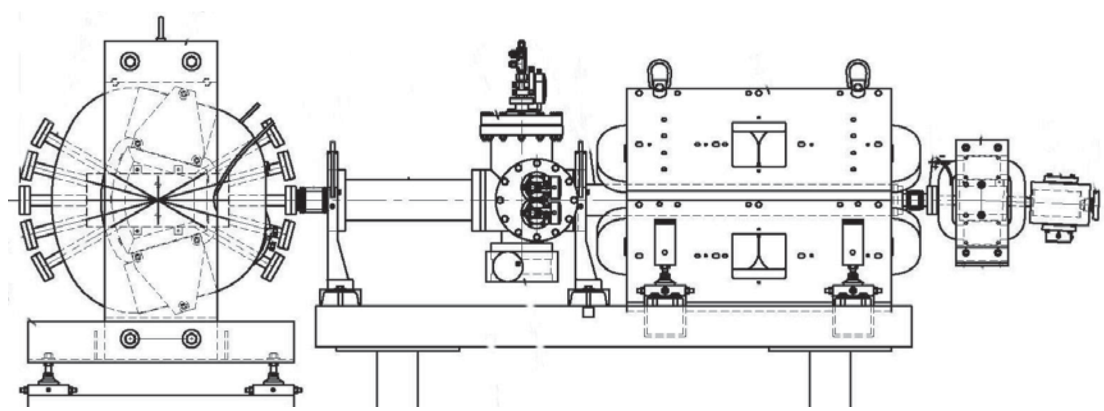

FIGURE 1. Beam line schematic.

The off-axis beam ports at ±15° and ±30° have colinear view ports for visual monitoring with IRtc and CCD TV telemetry. A USB color TV camera (ImagingSource DFK21AU618; 640x480, equipped with a varifocal lens) is mounted on the 150° viewport to image the -30° target, shown in Figure 2.

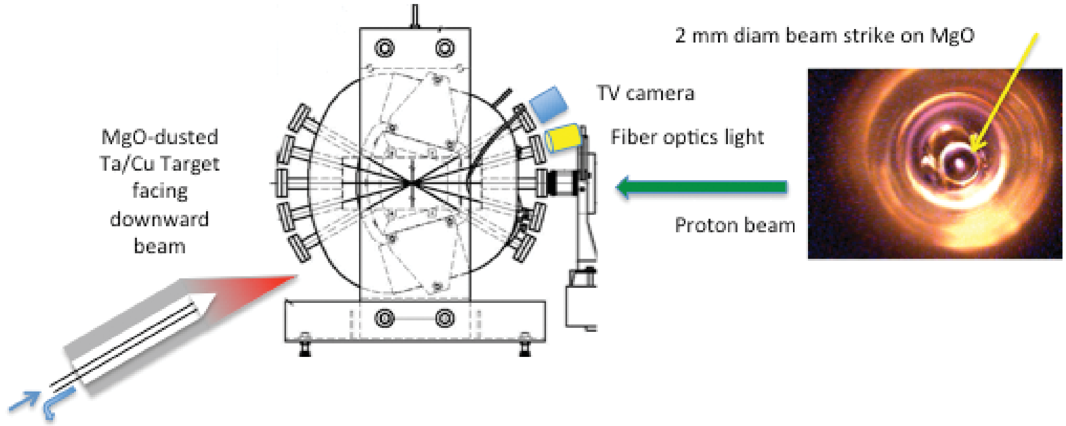

FIGURE 2. Several microamps of 16 MeV proton focused onto a horizontal surface dusted with MgO to provide a visual signal of the 2 mm (FWHM) beam strike.

RESULTS AND DISCUSSION

A Balzers-Pfeiffer TPU 240 turbopump holds the vacuum to mid-10^{-7} mm Hg. Installation and alignment made use of a laser mounted on an overhead bridge crane. Irradiations employ the service laptop for cyclotron control, with manual control of the steerers, quads and switching magnet power supplies. The fine control and stability of these supplies are essential, since a change of 100 mA on the 55 amp switching magnet current swings the beam over the entire "vertical" target span at 30^{o}. Irradiation parameters, as well as prompt neutron and gamma signals are monitored by LabView . Correlating changes of the neutron rate against the visual signal of the centered beam strike on the MgO-dusted target builds a sixth sense needed to hit small depositions of enriched materials. Transmission from the PETtrace stripper to final target position is ≈77% with losses mainly at the short length of 25 mm ID entrance to the first vertical beam steerer. Until we improve this transmission, we are limiting the beam at our final target positions to 50 μA.

CONCLUSIONS

Outfitting the modern cyclotron with multiple beam ports has taken various pathways: magnetic beam switching, Gatling-gun turrets, linear slide arrays, wobbled flexible bellows and in-line series targets. The freedom afforded by our new construction, and the need to present our molten targets to a down-ward-directed beam led us to this beam line configuration. Our experience with a truly vertical beam line following a 90^{o} switching magnet on our legacy RDS 112 has convinced us (1,2) that the gravitational containment of corrosive liquid targets is essential. The choice of a vertically angled beam permits even higher power irradiation while maintaining a horizontal surface.

ACKNOWLEDGMENTS

The support of the NCI Training Grant T32 CA09206 and the skills of the staff at National Electrostatics Corporation are gratefully acknowledged.

REFERENCES

1. R. J. Nickles, *J. Nucl. Med.* **32**, 1091 (1991).
2. M. Jensen, G. Wolber, J. Nickles and A. Runz, "Gravity Can Offer Help: Stable Production of C-10 by Bombarding a Molten Sea of Boron Oxide with a Vertical Proton Beam" in *Proceedings of the IX Workshop on Targetry and Target Chemistry*, Turku, Finland, 2002, pp. 58-61.