PREPARATIONS FOR PARASITIC PRODUCTION OF BIOMEDICALLY USEFUL POSITRON-EMITTERS

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Abstract

The long-time rebuilding of the old GWI-machine into a sector-focussing synchrocyclotron will hopefully be completed within 1985. External beams of protons, deuterons, Helium-3, alpha-particles and heavier ions will be available for physics and biomedical research, and also for direct radionuclide production (e.g. 40 µA of protons 45-110 MeV, less for higher energy protons, cf. Table 1). This being the principal Swedish accelerator undertaking of the eighties, we foresee, however, some difficulties in getting enough and regular beamtime for an increasing demand of cyclotron-produced 'medical' radionuclides (for PET-work etc.). Possibilities for parasitic production are therefore investigated. One example is given by the ^{11}C-production by protons in the cooling water of planned spallation neutron sources and targets for the production of thermal neutrons (reaction: (p,3p3n) on oxygen[1]). The extraction of ^{11}C from cooling water was successfully tested at the thermal neutron facility of TRIUMF[2]. These experiences are used in the construction of water beam dumps with provisions for extraction of medically useful, positron-emitting radionuclides during for instance (n,p)-experiments.

Intentions

In figs. 1 and 2 are indicated the most likely places for realizing a parasitic production of radionuclides parallel to already approved or foreseen future work at the accelerator centre. They are (cf figs.1 and 2):
(A) The regular "non-parasitic" radionuclide production "crypt" down on the cyclotron hall level. The cooling water of the production target system will be traversed by the beam and thus form a source of extractable ^{11}C (and other positron-emitters)[2]. The same holds for water-cooled neutron-producing targets at this site.
(B) The beam dump associated with neutron production for physics research, such as (n,p)-experiments(fig.3). This will probably be the first place where "beam-dump production" can be realized, since the preparations for these experiments are well underway.
(C) Next comes the beam dump for the (p,gamma) experiments. Space is here somewhat less and transport distances for the extraction of the radionuclides produced may turn out to be longer.
(D) Beam dump for physics experiments using the High Energy Spectrometer Magnet (HESM) unit. Due to the CELSIUS storage ring hall this beam dump tunnel is still smaller and backed by special high density radiation protection material. The use of this beam dump for production purposes will come at a later stage.

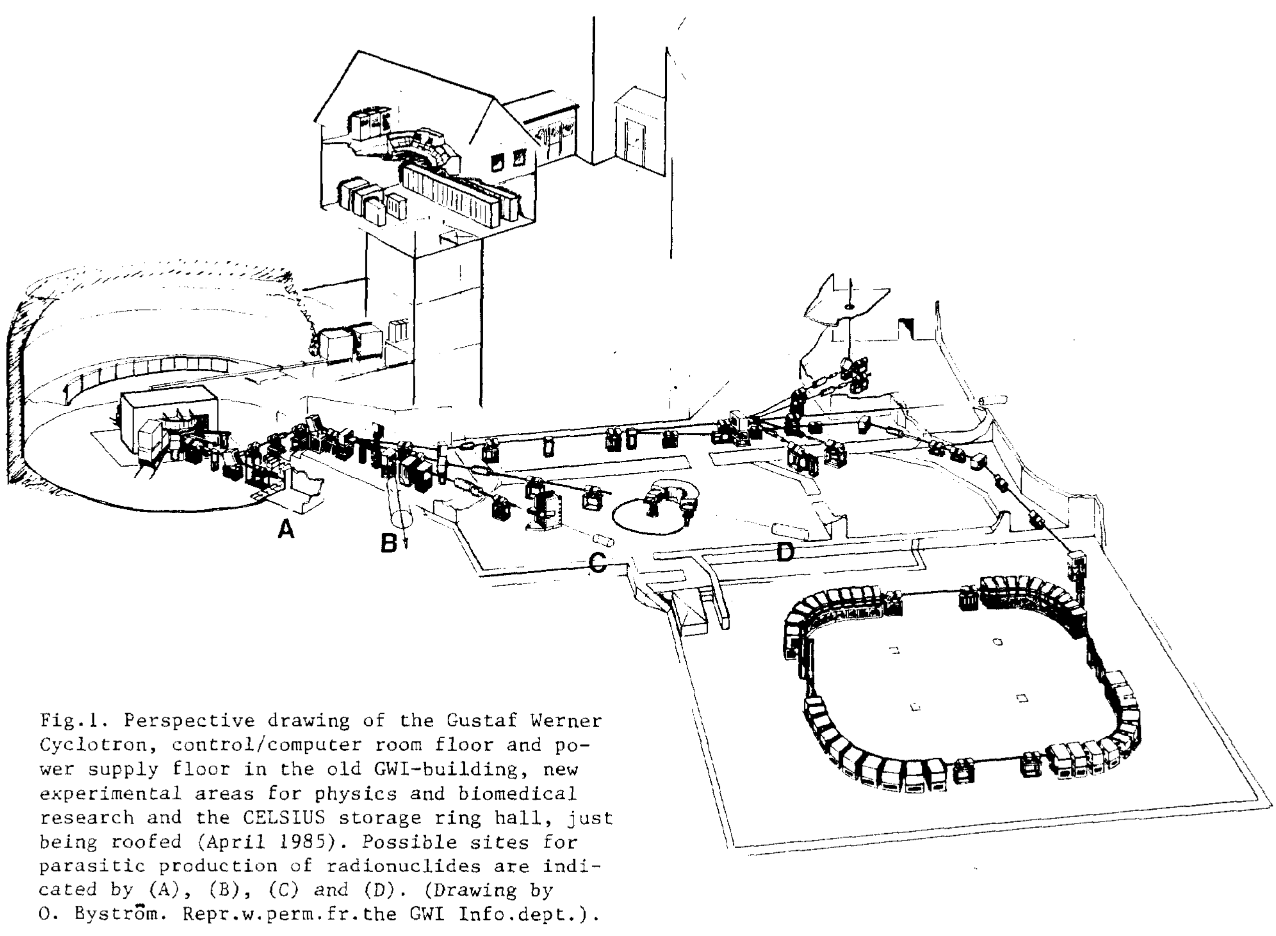

Fig.1. Perspective drawing of the Gustaf Werner Cyclotron, control/computer room floor and power supply floor in the old GWI-building, new experimental areas for physics and biomedical research and the CELSIUS storage ring hall, just being roofed (April 1985). Possible sites for parasitic production of radionuclides are indicated by (A), (B), (C) and (D). (Drawing by O. Byström. Repr.w.perm.fr.the GWI Info.dept.).

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Table 1. Expected performance of the reconstructed Gustaf Werner Cyclotron. (From ref.3 and the GWI Info.Dept.)

ION	ENERGY (MeV)	ACCELERATION MODE	EXTRACTION METHOD	ENERGY RESOLUTION(%)	HOR.EMITTANCE (mm-mrad)	INTENSITY (estim.eμA)
p^+	110-200	1-FM	regenerative	0.22	6 - 8	10 - 1
p^+	45-110	1-CW	regenerative	0.5	4 - 5	40
p^+	45-110	1-CW	precessional	0.17	20	40
d^+	25-100	2-CW	precessional	0.17	20	40
$^3He^{2+}$	250-267	1-FM	regenerative	0.22	6 - 8	2
$^3He^{2+}$	137-250	1-CW	regenerative	0.5	4 - 5	20
$^3He^{2+}$	35-137	2-CW	precessional	0.17	20	20
$^4He^{2+}$	50-200	2-CW	precessional	0.17	20	20
$^{12}C^{4+}$	133-267	2-CW	precessional	0.17	20	5
$^{16}O^{5+}$	167-312	2-CW	precessional	0.17	20	10
$^{20}Ne^{7+}$	223-490	2-CW	precessional	0.17	20	0.1

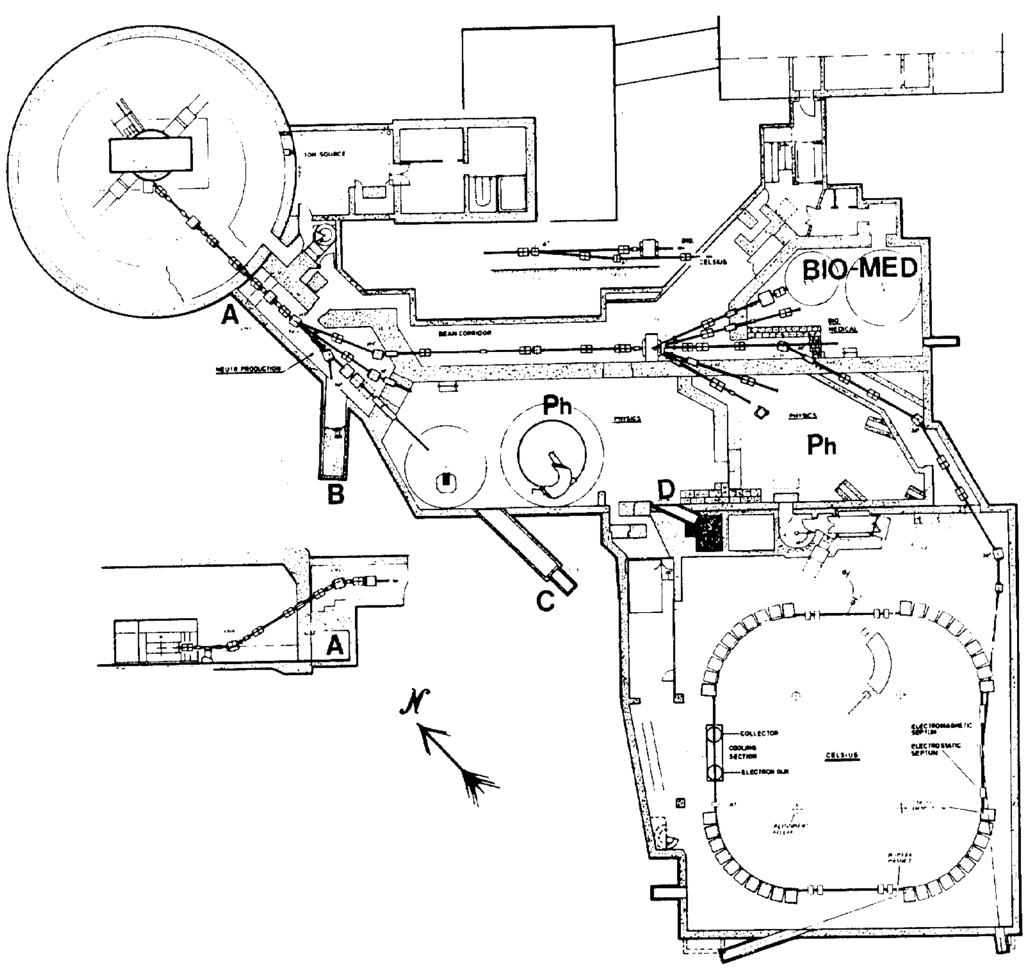

Fig. 2. Floor plan of the cyclotron hall with the rebuilt Gustaf Werner Cyclotron, new external beam experimental areas for physics (Ph) and biomedical research (BIO-MED), and the 1000 m^2 hall for the CELSIUS storage ring. (A), (B), (C) and (D) indicate possible sites for parasitic production of radionuclides. (From the GWI Drawings Office. Reproduced with permission from the GWI Info-Dept.)

Extensions

To utilize the full potential production capacity of the beam-dumps, more complicated target machinery will be needed, which can then be moved from one beam dump tunnel to the other to be used at the ongoing experiment. Suggested components:

a) Water absorber tank producing ^{11}C etc...

b) Means to place the desired target at the right "depth" (along the beam axis) to have it irradiated by particles of the required energy. The target must be moved along the beam axis as the primary experiment particle energy or target thickness is changed.

Example: For the indirect production of high purity ^{123}I via ^{123}Xe, protons of energy 70-45 MeV are optimal[5], and this energy range has to be kept on the target. For batchwise production, remote-controlled removal of the target is needed (rabbit system). For continous ^{123}Xe-removal[4] the molten salt target must be placed in a movable air or vacuum gap to avoid water boiling.

References

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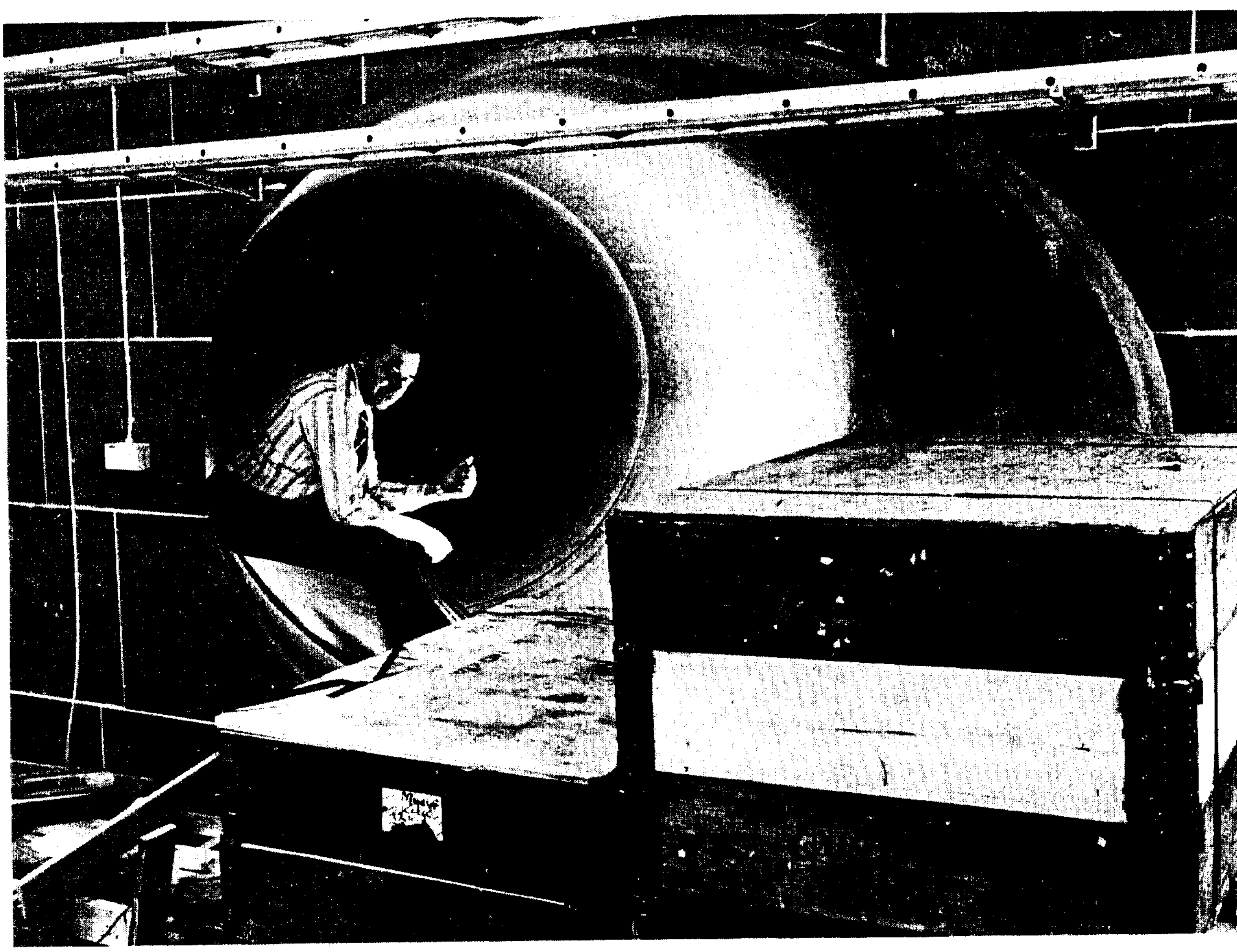

Fig.3. Matchboxing P.M. Author pointing into the 8 m deep beam-dump tunnel (B) (cf figs. 1 and 2). This is the most probable site for the first radionuclide-producing beam-dump. Left-over protons from the production of neutrons for (n,p)-experiments will be directed into the tunnel by two bending magnets and focussed on the beam dump by a quadrupole. (Photo. T Thörnlund. Reproduced with permission from the GWI Info-Dept.)