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Neutron Facility Possibilities with the TRIUMF Kaon Factory

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I. INTRODUCTION

The accelerator options for a TRIUMF Kaon Factory reported at the ICANS VII meeting[1] have now been resolved in favour of a two stage rapid cycling synchrotron system to be fed by the existing 500 MeV H^- cyclotron facility. The formal proposal[2] for the facility to support a request to the Canadian Government for funding is essentially complete and will be available shortly; it deals exclusively with the accelerator and experimental nuclear, meson and particle physics facilities. The possibilities for a pulsed neutron facility that could be associated with this complex have not been examined in detail although some of the established accelerator characteristics are similar to those of an optimum facility like the SNS.[2] This report will outline the facility that is being proposed and sketch the incremental requirements for a useful pulsed neutron source.

II. PROPOSED ACCELERATORS

The proposed facility for the TRIUMF Kaon Factory is shown in Fig. 1. It consists of five accelerator/storage rings in addition to the present TRIUMF 500 MeV H^- isochronous cyclotron. The H^- ions will be extracted directly without changing their charge state at 440 MeV by a series of orbit perturbing elements and septa and transported (gently) to the beam accumulator (A) ring; the full ($\gtrsim$100 μA) beam current from the cyclotron will be collected for 20 ms periods and injected into the accumulator ring by stripping the H^- ions to protons. At the end of the accumulation cycle the beam is transferred in one turn to the adjacent booster (B) ring shown in Fig. 2 and accelerated to 3 GeV proton energy. At the end of the booster acceleration cycle the protons are transferred, again in one cycle of the accelerating ring, into 1/5 of the circumference in the collector (C) ring in the main accelerator tunnel. Five such cycles are collected in the five circumferential positions in the C-ring; they are then transferred, again in one cycle of the C-ring, to the driver (D) ring that accelerates the protons to 30 GeV. At the end of the acceleration stage the protons can be extracted (again in one turn) either into the fast extraction line for experiments requiring a low duty factor or transferred to the extender (E) ring for slow — essentially continuous — ejection into experimental facilities requiring large duty factors. The proposed initial configuration for the pion, kaon, neutrino, etc. experimental facilities is shown in Fig. 3. Because the various rings all operate simultaneously, with only brief interruptions for the transfer of protons between rings the full 100 μA cyclotron output can be accelerated to 30 GeV.

For a neutron facility the interest is centered on the 3 GeV stage. The output from the booster acceleration stage (B-ring) could be channeled directly to a pulsed neutron facility. As a dedicated facility the pulse repetition rate (50 Hz) and pulse length (0.74 μs) are close to optimum for thermal and near epithermal neutrons. For higher neutron energies the pulse length could be shortened, at the price of correspondingly lower intensity, by chopping the cyclotron output at extraction or the cyclotron input at the ion source-injection system. The limiting case for this technique is the use of only 1 of the 45 phase slots in the accumulator (A-ring) and the booster (B-ring). At the full nominal design intensity this would produce a time averaged beam current of 100/45 = 2.2 μA in ~8 ns wide pulses at 50 Hz repetition rate; this is approximately a factor 6 lower intensity than the Los Alamos PSR,[4] reflecting mostly the lower repetition rate. Correspondingly higher intensities can be obtained by filling more of the 22 ns phase slots in the accumulator ring from the cyclotron; the macro-pulse width is now, however, a multiple of the micro-pulse period rather than the micro-pulse width.

III. ADDITIONAL REQUIREMENTS FOR A NEUTRON FACILITY

The additional hardware required to feed a neutron facility from the booster ring in a dedicated alternate mode will be almost trivial; to provide simultaneous feeds to both a neutron facility and the C-ring of the Kaon facility will not likely present any serious difficulties. The beam line to the center of a 50 m diameter experimental hall and vertical injection into a target assembly could provide horizontal neutron beams over most of the 360° azimuth at, or near, ground level. It would be imprudent however not to leave space between the booster extractor and the neutron facility for a pulsed muon facility and a consolidater (C') storage ring that could multiply the available intensity in either the single or multiple micro-pulse/macro-pulse modes.

No study has been carried out on the design of neutron production targets that would be required for the relatively high proton energy (3 GeV) available from the booster. Although this energy is probably higher than optimum it will not likely present any difficulties significant enough to indicate reduction, although this might be possible at the cost of a more expensive circuit for tailoring the power wave form to the booster accelerator ring.

IV. CONCLUSIONS

The accelerator complex being proposed for the TRIUMF Kaon Factory has intensity, pulse width and repetition rates from the 3 GeV booster stage that make it very interesting as a source of protons for a pulsed spallation neutron facility. A conceptual design with enough detail to make reliable cost estimates is required for the additional components needed for such a facility. Because of the obvious competition for the available intensity that this addition would produce with the primary Kaon facility all design parameters affecting intensity in the present proposal should be examined closely, e.g., booster synchrotron cycling frequency. One obvious advantage of this additional component would be the earlier potential research yield from the construction of the lower energy stage.

V. ACKNOWLEDGEMENTS

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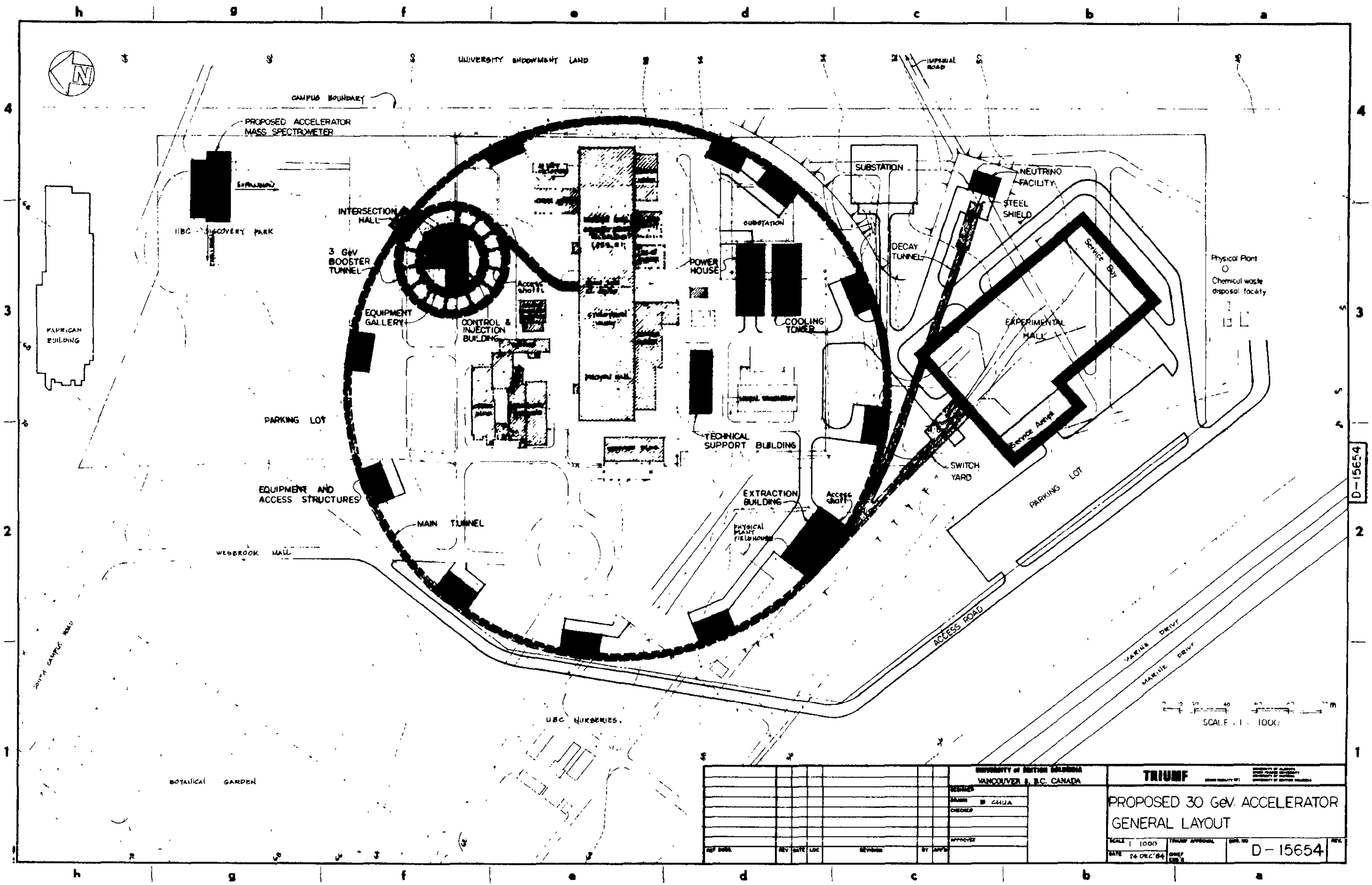

Fig. 1. The layout of the proposed TRIUMF KAON factory accelerators and experimental facilities

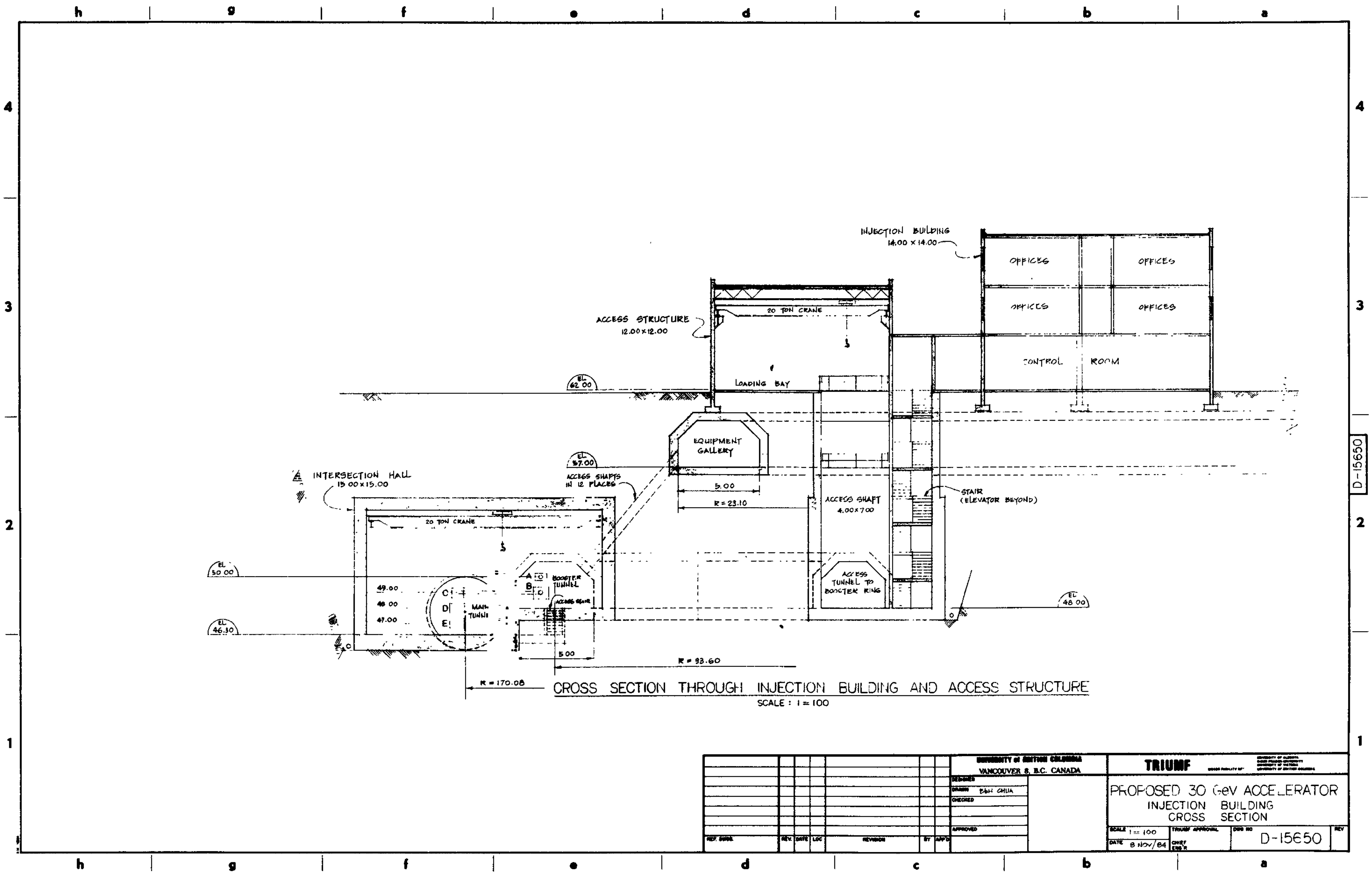

Fig. 2. Section through injector and booster/main ring intersection structure of TRIUMF KAON Factory

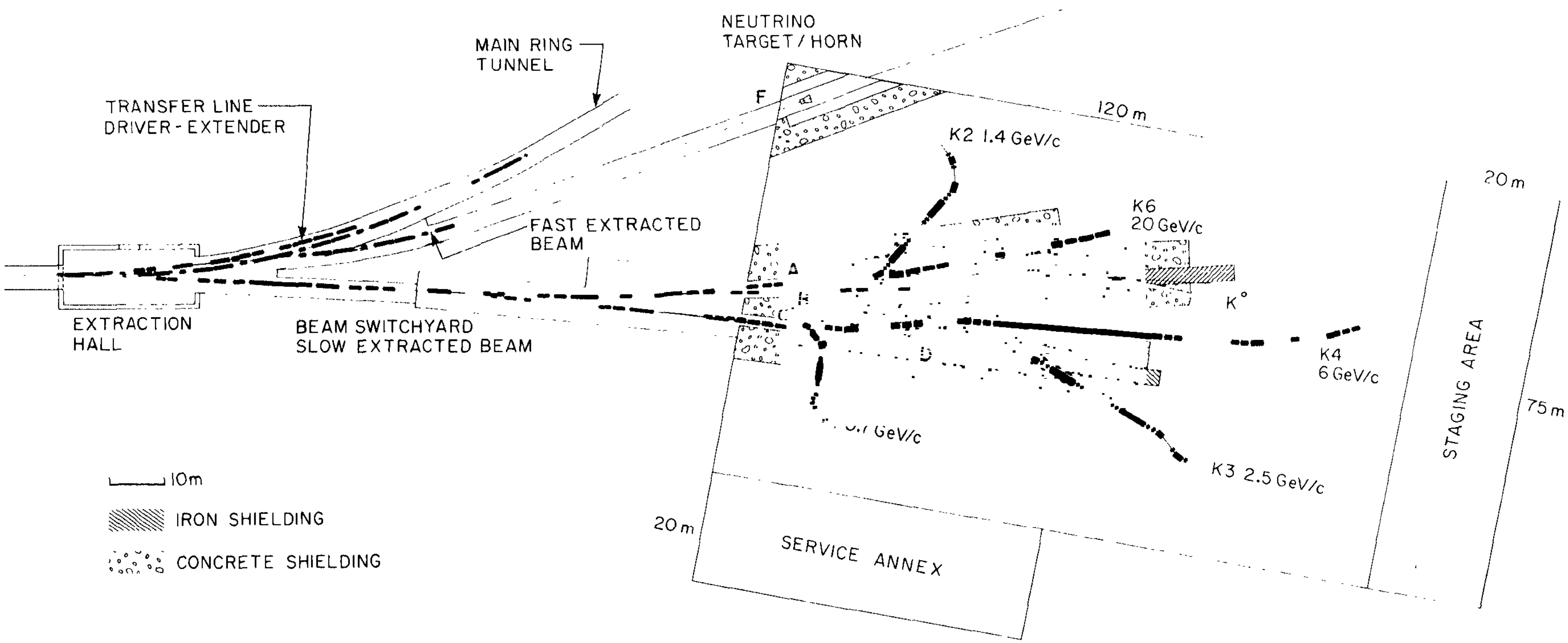

Fig. 3. TRIUMF KAON Factory extraction hall and experimental facilities