TABLE II

UPGRADING OPTIONS

| Option | RC | LA |
|---|---|---|
| Higher average beam current | Not feasible, problems with beam instability and extraction | Increase of factor of 3 feasible with no modification to system but increase of power consumption from 21 to 56 MW |
| Higher peak beam current | Not possible | Depends on confidence in beam losses and development of peak power amplifiers |
| Higher beam energy | Feasible by additional cyclotron stage by ~ factor of 3 but hi-current extraction questionable; Capital cost high | Feasible by continuous increase of accelerator length; Capital cost high |
| Storage ring added to accelerator | Feasible but limited current capability | Feasible, time structure can be matched; $H^+/H^-$ acceleration possible; ultimate current limit to be evaluated |

K. Mode of Operation and Target Layout for ILSE, G. S. Bauer, KFA Jülich

An Intense Linac-driven Spallation-neutron source for Experimental purposes (ILSE) is being considered as an alternative to a new medium-flux reactor for beamhole research in West Germany. According to the preliminary concept for the linac to drive the source, a proton energy of 600 MeV, mean current of 10 mA with pulsed operation of 10% duty cycle at 150 Hz is foreseen.[1] Initially it was intended to operate the source with a large $D_2O$ moderator tank in a continuous fashion very much like a steady-state reactor. It is, however, recognized that the pulsed operation of the linac can be taken advantage of to improve the experimental conditions if it is possible to provide sufficiently efficient "fast" moderators, that is, moderators which do not smear out the neutron pulses excessively. It seems likely, that a peak-to-average ratio of 6:1 can be obtained. This would open up the following possibilities:

- synchronization of TOF experiments to the source gives a gain factor of 6
- gating the detectors of all instruments such that they are insensitive at the moment of the proton pulse drastically reduces the background
- gating the detectors of triple-axis spectrometers and diffractometers such that they are only sensitive when the neutrons of the desired energy arrive eliminates higher order contamination and reduces the overall background.

Since it is not anticipated that decoupling or poisoning of the moderators would become necessary, a good target/moderator coupling should still be possible. In addition to the above, fast and reflected moderators would have the following advantages:

- short lifetime of neutrons makes them less sensitive to thermal neutron absorption in the target and hence gives greater flexibility in the choice of target material
- small size allows shielding to begin closer to the target, thus saving a large amount of iron at the outer circumference of the shield.

In order to avoid having a separate moderator for each beamhole, a horizontal target arrangement seems to be preferable, with moderators arranged above and below the target and each viewed by several beamholes.

In view of the high heat density ($\sim 10$ MW/$\ell$) which has to be dissipated in the target, a flowing Pb-Bi-eutectic as proposed for the Canadian ING project[2] and for the SIN target[3] seems to be a good choice, although a window, as in the SIN concept would probably not be feasible in our case. The advantages of a vertically streaming Pb-Bi/target, as shown in Fig. I-K.1, are:

- full access to the outer circumference of the shield
- continuous removal of certain hazardous species of active nuclei possible
- no mechanical stresses in target
- high potential for increasing target power.

The following disadvantages should be noted:

- no possibility of diluting target material to increase length of neutron source
- no flexibility in choice of target material
- vacuum/target interface allows evaporation of volatile species such as Hg or Po produced in the target
- choice of structural materials in target region limited by corrosion effects (Zr cannot be used without cladding)
- high temperature is likely to enhance swelling and He embrittlement of structural materials
- beamholes arranged in a tangential fashion with respect to the target cannot use common fast moderator
- proton-beam line above the target building and bending magnets add complexity to the whole system
- zero absolute pressure at target surface limits maximum flow velocity
- secondary Na-K cooling circuit is needed for heating the whole Pb-Bi; circuit also makes the system very complex.

Taking as a first stage a concept with a target of low-absorption cross section (Pb or Bi) and a LINAC of 600 MeV, 10 mA time average, 10% duty cycle at 150 Hz, the following options to improve the performance of the facility can be seen:

1) increase energy to increase peak flux
2) increase peak current in accelerator to increase peak flux
3) increase duty cycle to increase time-average flux
4) change target material to $^{238}U$ to increase neutron yield
5) add storage ring and reduce proton current such that it can be bunched and the source operates as a pulsed source
6) add storage ring, split off 10-15% of proton beam for bunching, and add second target station for pulsed source.

Option 1 through 3 entail increased operational cost, options 5 and 6 require mainly additional capital cost, with extra operational cost for option 6 and reduced operational cost for option 5. Option 4 seems to be the most economical one, but not feasible with a liquid-metal concept.

For these reasons an alternative target concept has been considered which avoids some of the difficulties of the liquid-metal target and gives the flexibility of choosing any of the above options.

The target material is arranged on the circumference of a 2.5 to 3.0-m diam wheel whose shaft is mounted vertically and consists of two concentric pipes bring the cooling water for the target down and back up the shaft (Fig. I-K.2). The beam hits the wheel at its outer circumference entering through the water-cooled window which is rotating with the target. In this way both the effective beam window and the target volume are about 200 times bigger than the "active" region at any given instant. A proton pulse of 100 mA and 700 μs duration will increase the target temperature in the target volume it hits by 25 °K at the hot spot. Between proton pulses, the target volume and the beam window are moved out of the beam region, which requires about 1.25 rev/s of the rotating target. If the target is initially subdivided into individual segments, it is possible to keep its maximum temperature below about 150 °C. Such an arrangement has the following advantages:

- low temperature pervents fatigue swelling, radiation swelling, and He-embrittlement both in the target and the beam window
- solid target provides first containment of spallation products
- target is completely inside shielding
- free choice of target material according to optimum flux production
- possibility of a heterogeneous target
- free choice of structural material for minimum neutron absorption
- horizontal proton beam allows use of fast moderators above and below the target
- changes needed for pulsed operation can be accomplished relatively easily
- in pulsed operation with $^{238}U$ target, the background from delayed neutrons and decay γ-radiation is considerably reduced.

Both a liquid metal and a rotating target concept will be evaluated in detail during the anticipated study period for the ILSE.

References
1. J. E. Vetter, this meeting.

2. G. A. Bartholomew and P. R. Tunnicliffe, "The AECL Study for an Intense Neutron-Generator," AECL-2600 (July 1966).

3. W. E. Fischer, this meeting.

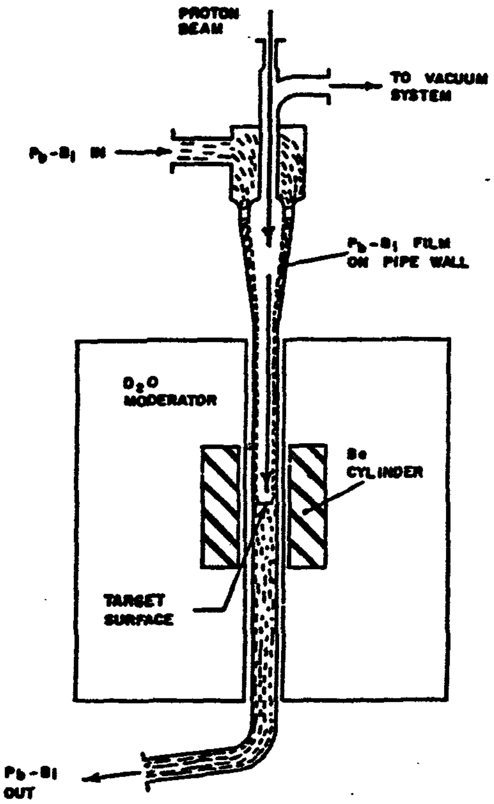


Fig. I-K.1. Schematic layout of liquid metal target system with vaned head as proposed for the ING-project. Power in target is expected as 4.5 MW. Some characteristic parameters are: Velocity v = 1 m/s, pressure drop $\Delta P$ = 4.3 bar, temperature rise $\Delta T$ = 125 °K.

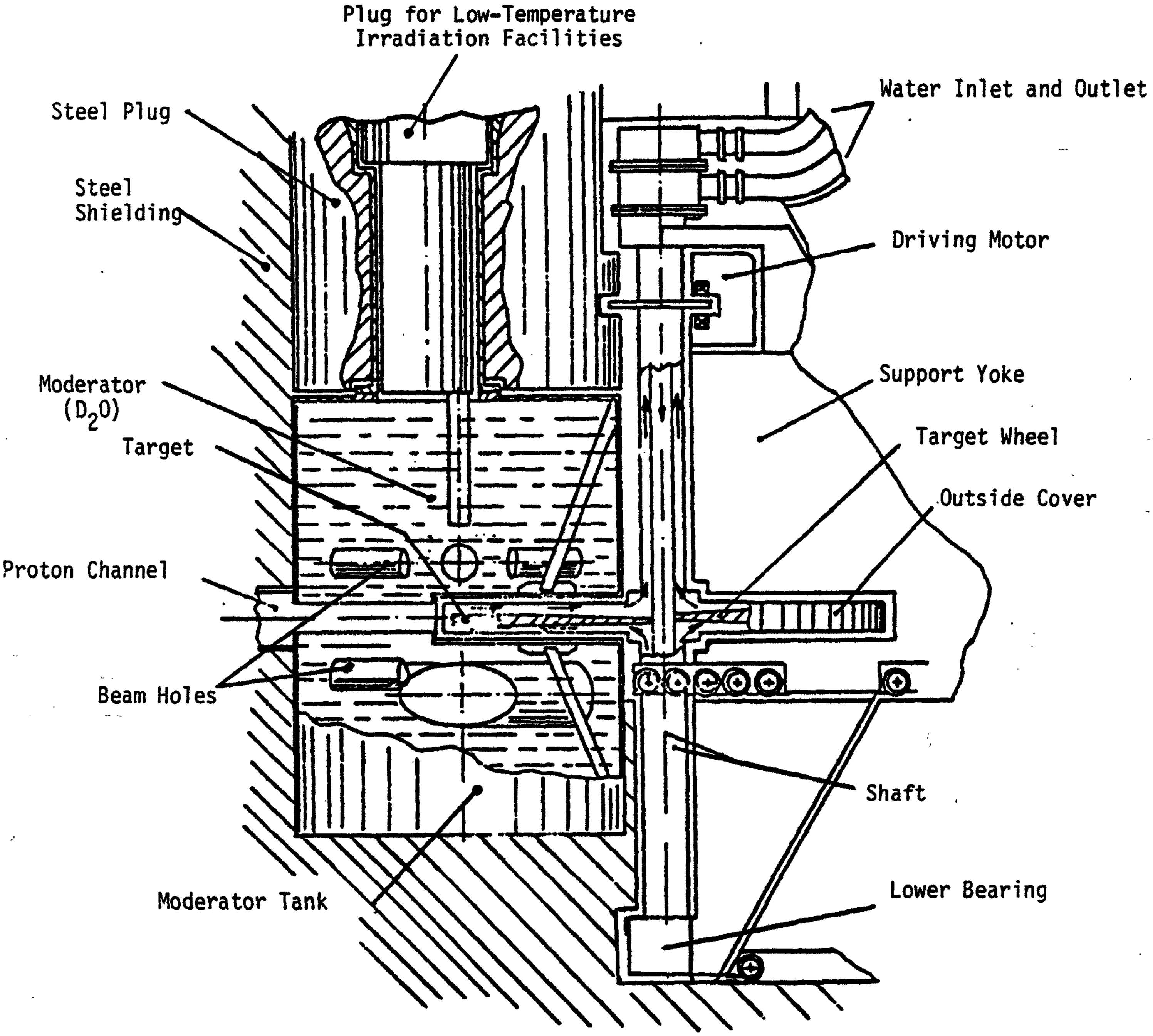


Fig. I-K.2. Schematic of target station with rotating target and big $D_2O$-moderator tank.