The ISIS target halo monitors

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First halo monitor

The first ISIS target halo monitor was installed in July 1985 and was located some 360 mm in front of the input beam window of the target. It was provided because there was concern with the size and alignment of the extracted proton beam impacting the target. Size was important because of the unknown effects of energy depositions at the outer radius of the uranium disc (45 mm), on the circumferential uranium-zircaloy intermetallic bond, and on the zircaloy cup-to-stainless-steel picture frame compression fit. Alignment was important because of asymmetry effects on neutronic coupling, risk of increased charged-particle escapes (especially towards the lower, liquid-methane moderator), and of asymmetric energy deposition across the zircaloy and stainless-steel picture frame.

For an expected proton beam spot on target of parabolic intensity distribution of base 70 mm, the halo monitor diameter was 80 mm. Of the possible electrical or mechanical devices considered, a simple passive system was chosen of an annulus of metal (stainless steel) intercepting the beam halo. The annulus was thermally isolated and used reactor-grade thermocouples to measure the temperatures. The annulus was made into four quadrants to give some directivity, and each quadrant carried two thermocouples. Figure 1 is a drawing of the halo monitor, resting in its support frame. Though half the thermocouples were intended to act as spares, in practice all eight thermocouples were monitored and the resulting display gave a very graphic indication of the transmission of the beam through the aperture. In action the halo monitor was rather sluggish, with slow temperature rise and fall times and with a slow scanning speed (about 30 seconds per scan).

New halo monitor

A new halo monitor was built and installed in March 1988 to overcome the limitations of the first one. Figure 2 gives a back view of the new device, where the thermocouples were mounted on eight smaller stainless-steel fingers (octants): four, at N, E, S, W have an inner diameter of 75 mm and the other four at 85 mm diameter. The resulting display (in color) thus gives a better indication of alignment and a first order indication of intensity distribution. A new scanner, based on a dedicated PC, is to be implemented to reduce the total scan time to four seconds. Figure 3 shows the halo-monitor display in a normal operating state with a 100-µA proton beam. The circles based on the center cross indicate alignment and uniformity of distribution. Alarm states are shown by a change of color (from green to blue) of any thermocouple or pair of thermocouples. If a temperature difference across a diameter exceeds 15°, the beam is ramped off; if a single thermocouple temperature exceeds 90°, the beam is tripped off. In either event, a message is displayed to this effect.

Target diagnostic plate

In the initial construction of the Target Station, the target center was located well within a sphere of radius 1/2 mm and the center line lay within a cylinder of 1/2 mm radius. For reasons indicated in paragraph 1 above, the proton-beam alignment tolerance on target was sought at ±2 mm. After several years operation the alignment of the target relative to the EBP or the neutron beams is no longer known to any great accuracy. Indeed surveys carried out in 1986 and 1987 showed the target to have "sunk" by between 5 and 10 mm! A resurvey is now difficult because access is limited for mechanical reasons and radiation safety. Yet, as the intensity and reliability of ISIS increase, the need to know the target alignment becomes more important.

Starting with target number 5 we propose to install a proton-beam monitor within the target itself, which will be used together with the external monitor (2 above) to define the target alignment. The system is dynamic, i.e., it gives the information all the time the proton beam is on. The present plate number 15 (of the 23 target plates) will be replaced by a solid zircaloy plate containing 8 thermocouples, as can be seen in Fig. 4. The thermocouples will be mounted in a similar format to the external halo monitor. From Ref. 1 it can be seen that despite the high energy cascade process, the beam still retains its parabolic distribution, at least as far as plate 15 (160 mm into the target), but its base has broadened from 70 to 76 mm diameter. Accordingly, the thermocouples will be located at 19-mm radius and 27-mm radius, corresponding to 0.75 and 0.5 time peak intensity, respectively. Energy density will be less than for uranium, so the expected peak temperature in the plate will be 203° C, rather than 216° C for uranium, at full intensity. There will be a penalty of less than 2-3% in sub-15 MeV neutron escapes; however, since the plate is situated between the two moderators (as can be seen in Fig. 5), the coupled effect should be less.

The opportunity is also being taken to change the distribution of thermocouples in the target: from alternate plates to 1 through 14, 15, 17, 18, 19, and 21. The new target may well be brought into operation in 1989.

Reference

1. Atchison, F., 1981, "A Theoretical Study of a Target Reflector and Moderator Assembly for SNS", RL-81-006.

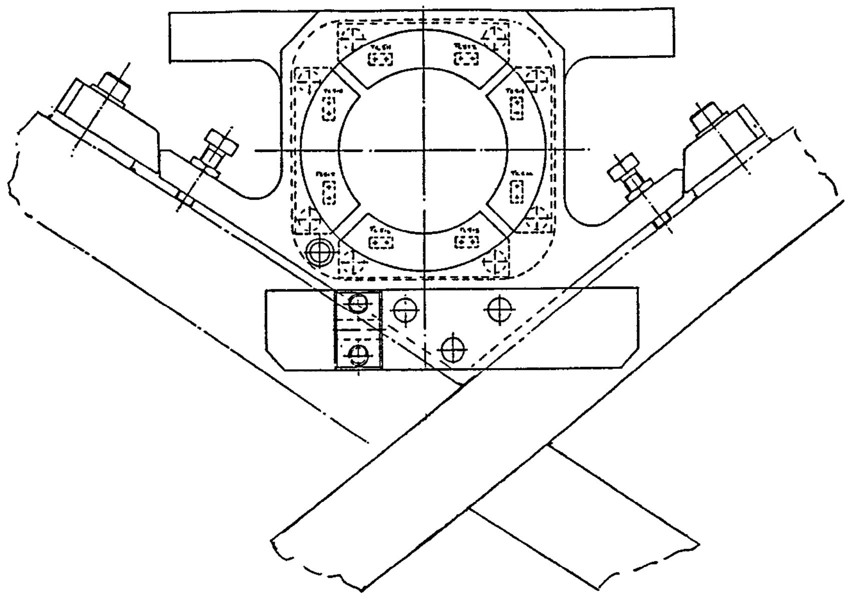

Fig. 1 Original quadrant halo monitor, front view.

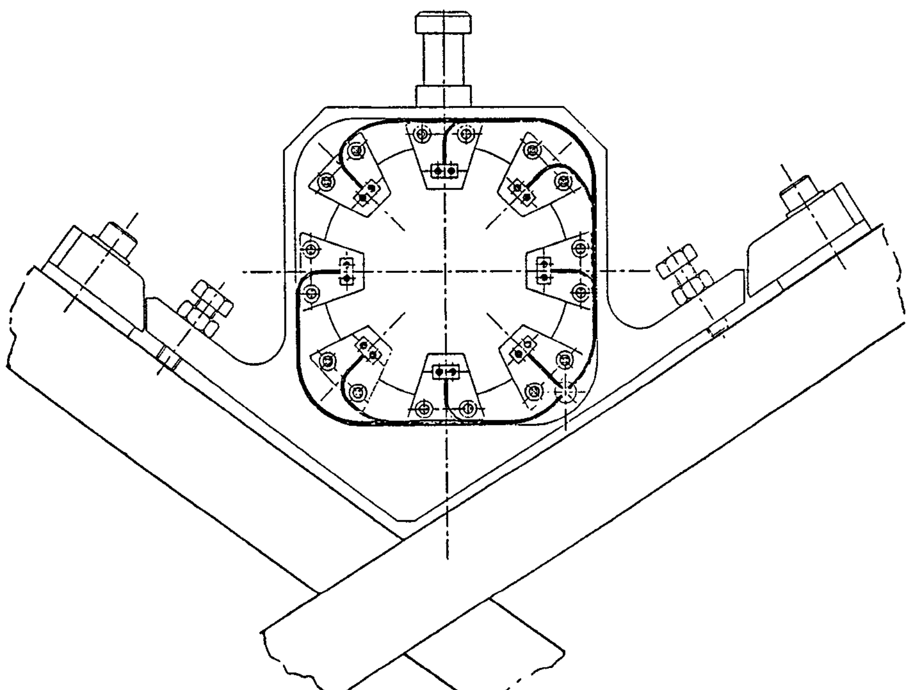

Fig. 2 New octant halo monitor, rear view.

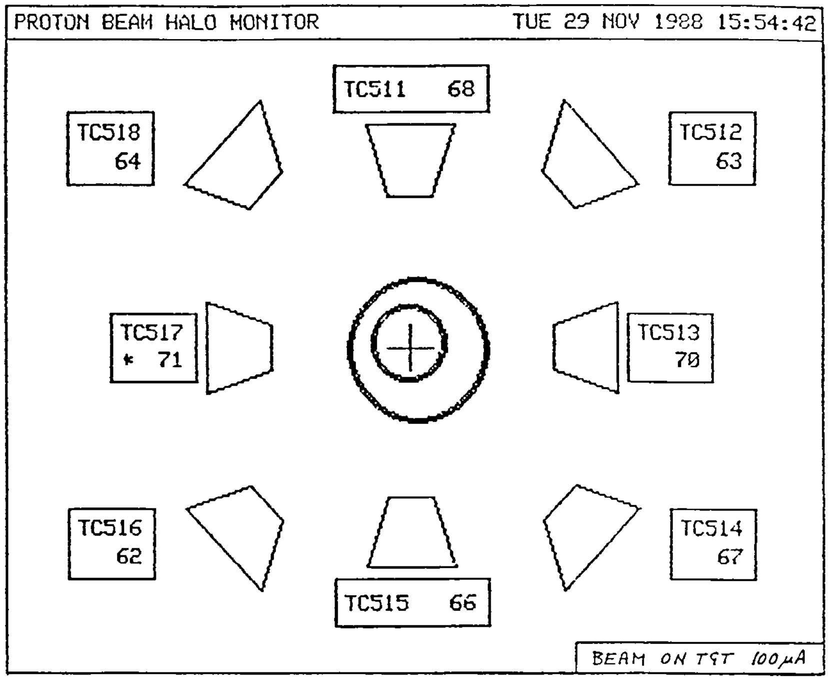

Fig. 3 Halo monitor display.

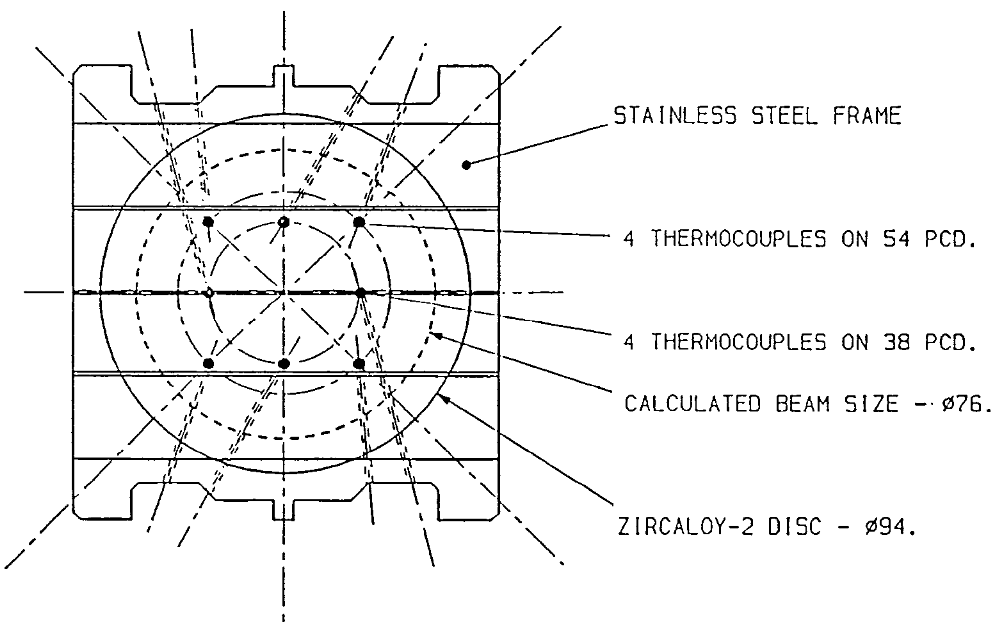

Fig. 4 Target (internal) diagnostic plate.

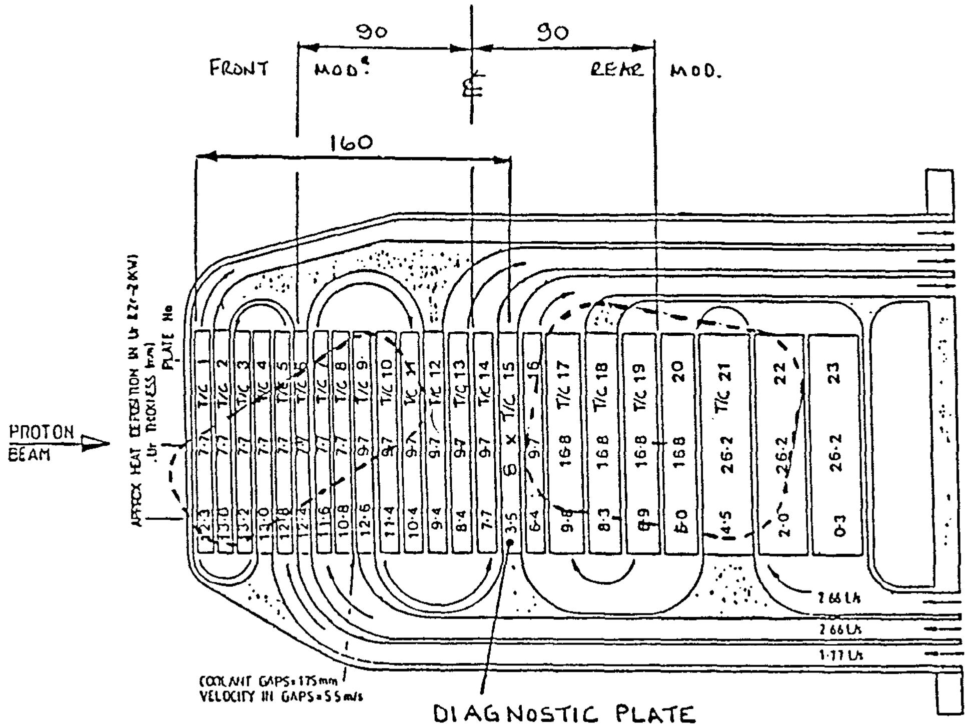

Fig. 5 Location of diagnostic plate in target.