4.2.3 Target

The neutrino beam is produced by pion decay. Those pions are produced by interactions of the primary proton beam with the target. The proton beam spot size should be no smaller than 1.0 mm RMS horizontally and vertically at full baseline beam intensity to limit beam induced stress on the target.

The target material is graphite, type ZXF-5Q (POCO Graphite), density 1.78 g/cm^3. The graphite segments are machined as narrow fins and mounted to stainless steel water-cooling pipes, as shown in **Figure 4.2-12** and **Figure 4.2-13**. The airtight casing has beryllium windows for the primary beam entrance and exit.

The main target is 47 vertical target segments, each 20.0 mm long, with 0.3 mm spacing between segments, for a total length of 95.38 cm. The segments are 6.4 mm wide. The height is sculpted (see Figure 2). A 48th segment (not shown) is mounted horizontally, in the target canister, with the fin center 157.3 mm upstream of the upstream edge of the main target.

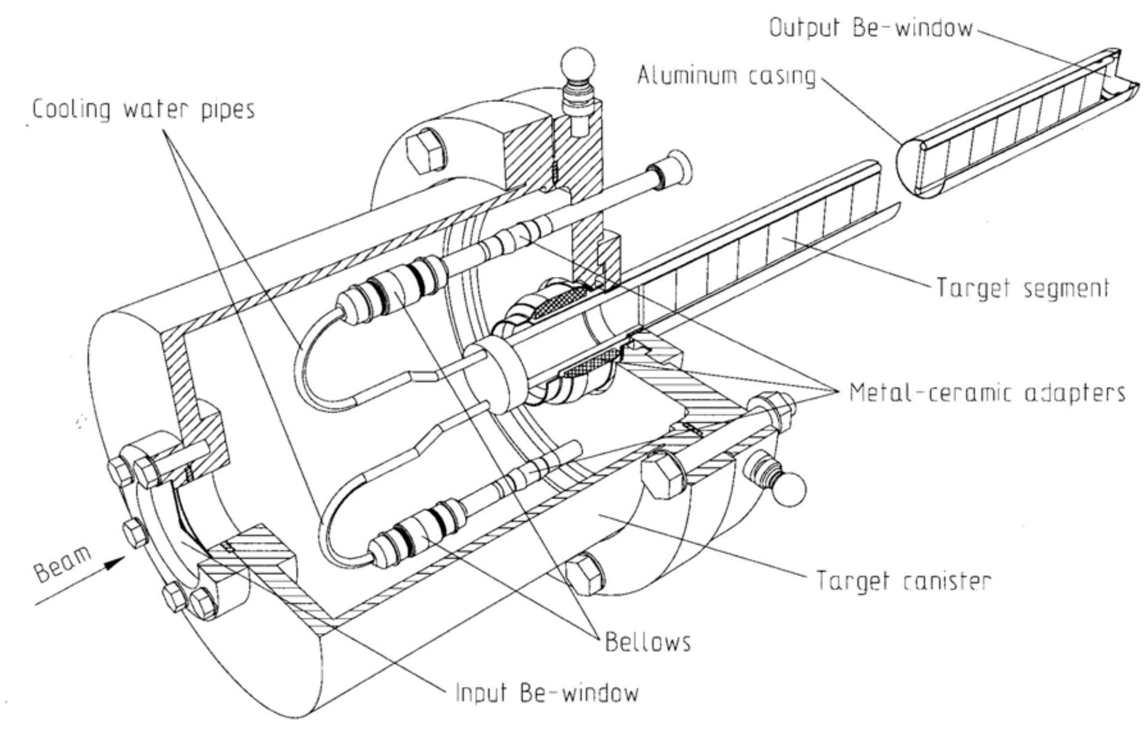

Figure 4.2-12 The target and target vacuum canister.

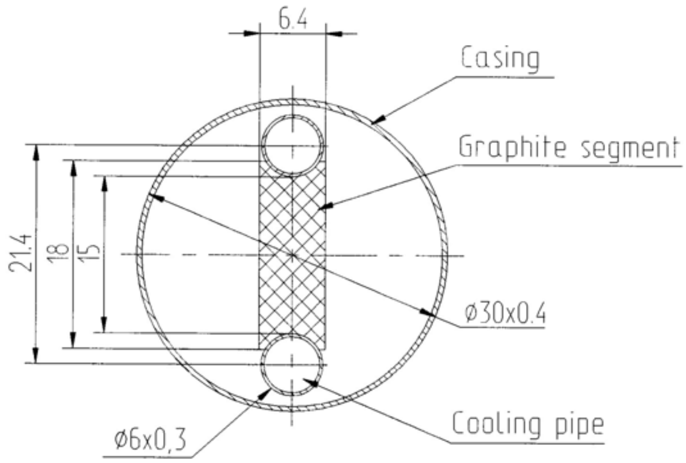

Figure 4.2-13 Beam's eye view of target. Dimensions shown in mm.

The target fin plus cooling tube is electrically isolated from the casing by ceramic spacers and water line breaks. A wire connected to the cooling tube allows measurement of the delta-ray charge knocked out of the target when it is hit by beam. This horizontal "Budal monitor" provides a cross check of the position of the target by measuring the response as the beam is scanned horizontally across the target.

The Budal signal on the 48th target segment is separately read out, and provides a position check as the beam is scanned vertically across the target. The cooling for this segment is provided by conduction through its clamping plates to the canister. The clamping plates are anodized to provide the required electrical isolation.

The aluminum casing around the target is electrically insulated from the base canister. This provides an electrical break from possible voltage from the horn inner conductor. A wire connected to this casing can be used to check if the casing is touching the horn (there is only 2.7 mm clearance between the target casing and horn).

The target casing may be evacuated during low intensity beam scans, which should improve the signal-to-noise of the Budal monitor. During high intensity running, the target canister will be He filled, to provide heat transfer from the aluminum casing to the cooling pipes.

During continuous operation, the center of the highest temperature segment will cycle between 58 deg C and 330 deg C, with resultant stresses, energy deposit and water cooling parameters shown in **Table 4.2-4** through **Table 4.2-6**.

	Center of segment	Corner of segment
Max. equivalent stress	27.4 MPa	23.5 MPa
Type of stress	All-axis-compression	All-axis-stretch
Strength limits	210 MPa compressive	95 MPa tensile
Derating factor high cycle fatigue endurance	0.5 to 0.6	0.5 to 0.6
Resulting safety factor after many cycles	2.2	1.8

Table 4.2-4 Thermal stresses in target segment with highest energy deposition density.

Graphite Segments	2.96 kw
Cooling pipes and water	0.42 kw
Aluminum casing	0.15 kw
Total	3.52 kw

Table 4.2-5 Energy deposition in target for baseline beam intensity (4e13 protons per 1.87 seconds).

Velocity of cooling water	**2 m/s**	**3 m/s**	**4 m/s**
Heat transfer coefficient, $kW/m^2/K$	10	14	18
Pressure drop, atm	0.32	0.68	1.2
Water flow rate, l/min	2.7	4.1	5.5
Water temperature rise, K	18	12	8.8

Table 4.2-6 Water cooling parameters as a function of water velocity.

The construction drawing set for the target is IHEP 7589-00-00-00. See also “Advanced Conceptual Design of the Low Energy Target and Beam Plug” (NuMI-B-543), “Dynamic Stress Calculations for ME and LE Targets and Results of Prototyping for the LE target” (NuMI-B-675), “Further Studies of Target for the Low Energy NuMI Beam” (March 30, 2001), “Temperature and Stresses in the LE Target with 6.4 mm Wide Segments” (June 20, 2001), and “NuMI LOW ENERGY TARGET SPECIFICATION” (June 25, 2001), for more details.