I. INTRODUCTION

Beam stop for 150 kW, 5 MeV proton beam is required for full power SPES/TRASCO RFQ testing and tuning. Two different concepts for the beam stop, water cooling and thermal radiation cooling options are proposed as possible solutions.

II. CIRCULAR SCANNING BEAM STOP

Circular scanning beam stop uses low-frequency alternating magnetic field for distributing dissipated power. Schematic layout of the beam stop is shown in Fig. 1.

Fig.1. Sketch of the circular scanning water cooled beam stop.

The beam stop is conceived as a set of insulating (Al₂O₃) ring elements with aluminum layer cladding inside. Aluminum has been chosen as stopping material because it produces neither neutrons nor activation when interacting with 5 MeV protons. Each ring element of beam stop is cooled by water. Copper is chosen as material for water cooling system due to its high thermal conductivity. A diagnostic and control system is monitoring the beam current released in each ring (and temperature), acting directly on the accelerator in case of troubles. At the end of the beam stop a simple block of nuclear graphite can be used as emergency dump, in case of failure of the scanning system. The magnetic rastering system make rotates the proton beam with 500 Hz frequency spreading the beam along the dumping system, dissipating totally 150 kW power. The maximum power density is about 170 W/cm². The design parameters of beam stop are: \( l = 2.5 \) m and \( r = 2.5 \) cm.

III. LINEAR SCANNING BEAM STOP

The second option is considering a more simple conceptual geometrical solution and implies the use of a thin pyrolytic graphite plates as stopping material. Pyrolitic graphite operates at very high temperatures and, in principle, does not require any cooling system. In this case, power dissipation by thermal radiation is considered sufficient to allow stable working conditions. The irradiated power may be simply dissipated through the water cooled insulator sandwich” assembly. In such a way beam power is dissipated in a thin layer of a good thermal conductor, separated from the cooling channels by a layer of insulator, which highly decrease the power flux density on water. In addition, insulator protects water cooling system from power jumps. The proton beam impinges on the beam stop surface with small angle and equivalent width

\[
\sigma \approx \sigma_0 \cdot \frac{l}{r} \quad (l >> r)
\]

where \( \sigma_0 \) – beam width, \( l \) – distance from magnetic system and \( r \) – beam stop inner radius. Fig. 2 shown the power distribution along the beam stop elements for parallel gaussian proton beam of \( \sigma_0 = 0.25 \) cm and total power 150 kW. The design parameters of beam stop are: \( l = 2.5 \) m and \( r = 2.5 \) cm.
vacuum chamber. Schematic layout of the beam stop is shown in Fig. 3. This option consists in a simple thin plate of pyrolytic graphite. The thickness of this graphite can be of a few millimeters, enough to give the necessary mechanical rigidity to the system, because the penetration of 5 MeV protons is around 250 µm.

![Fig. 3. Sketch of pyrolytic graphite beam stop.](image)

The proton beam distribution and the total dissipated power set the dimensions of pyrolytic graphite plate and of the rastering system. The thermal radiation power flux of pyrolytic graphite is shown in Fig. 4. Assuming a reasonable working temperature of 2000 °C, the proton beam should be uniformly distributed over an area of 1200 cm² (a plate of 35x35 cm²).

![Fig. 4. Thermal radiation power flux from graphite surface in function of temperature.](image)

**IV. VACUUM SYSTEM**

Because the high outgasing rates due to the dump of the proton beam impinging on the dumping material, differential vacuum system is recommended to separate the beam stop region from the accelerator vacuum. While a vacuum pressure of $10^{-9}$ mbar is required for normal operation of the RFQ, at the beam stop level a vacuum pressure of $10^{-6}$ mbar is difficult to reach. In fact, 30 mA of protons dumped in the beam stop generates about $1.8 \times 10^{17}$ hydrogen atoms per second. To reach the required vacuum level in the beam stop a pumping speed around 10000 liter/s is demanded.

**V. CONCLUSION**

Two different concepts of beam stop are proposed for the SPES/TRASCO RFQ accelerator. At 5 MeV the proton beam generate very low amount of neutrons in the materials involved in the construction, resulting in a low residual activation. In both conceptual designs diagnostic system and emergency controls for safe operations are taken into account. In addition, the diagnostic system provide information about beam distribution, so the beam stops can work as beam profile monitor.