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Title: Mo99 Production Plant Layout

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^{99}Mo Production Plant Layout

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Summary

The NorthStar Medical Technologies ^{99}Mo production facility configuration is envisioned to be 8 accelerator pairs irradiating 7 ^{100}Mo targets (one spare accelerator pair undergoing maintenance while the other 7 pairs are irradiating targets). The required shielding in every direction for the accelerators is initially estimated to be 10 feet of concrete. With the accelerator pairs on one (ground) level and spaced with the required shielding between adjacent pairs, the only practical path for target insertion and removal while minimizing floor space is vertical. The current scheme then requires a target vertical lift of nominally 10 feet through a shield stack. It is envisioned that the lift will be directly into a hot cell where an activated target can be removed from its holder and a new target attached and lowered. The hot cell is on a rail system so that a single hot cell can service all active target locations, as well as deliver the ready targets to the separations lab. On this rail system, coupled to the hot cell, will be a helium recovery and clean-up system. All helium coolant equipment is located on the upper level near to the target removal point.

System Description

An overview of the upper floor of the plant layout is shown in Figure 1. One can see 8 bays separated by rows of racks and cabinets for accelerator controls and related components (mustard color in the figure). The illustration is conceptual only, the specific function, size and number of cabinets is TBD. Running through the center of the room is a rail track on which a hot cell (in red) traverses from bay to bay for target loading and unloading, the targets being directly below that rail at the lower level with the accelerators. The helium cooling system components are also on this upper floor. Not shown in this figure is the chemistry lab for dissolving the targets, packaging the end product and preparing the unconverted ^{100}Mo for recycling. The size, placement and component details for this lab are TBD. the length of the building as shown is 213 ft. The width of the usable floor area is 75.5 ft, while the overall building width is 115 ft. On either side of the building are hallways for bringing in and servicing the accelerators, and stairways and elevators to the upper level. In this preliminary layout there is considerable unused space here, as the hallways do not need to extend the full length on the upper level. The details of the plant design will be the responsibility of an Architecture and Engineering Firm selected by Northstar.

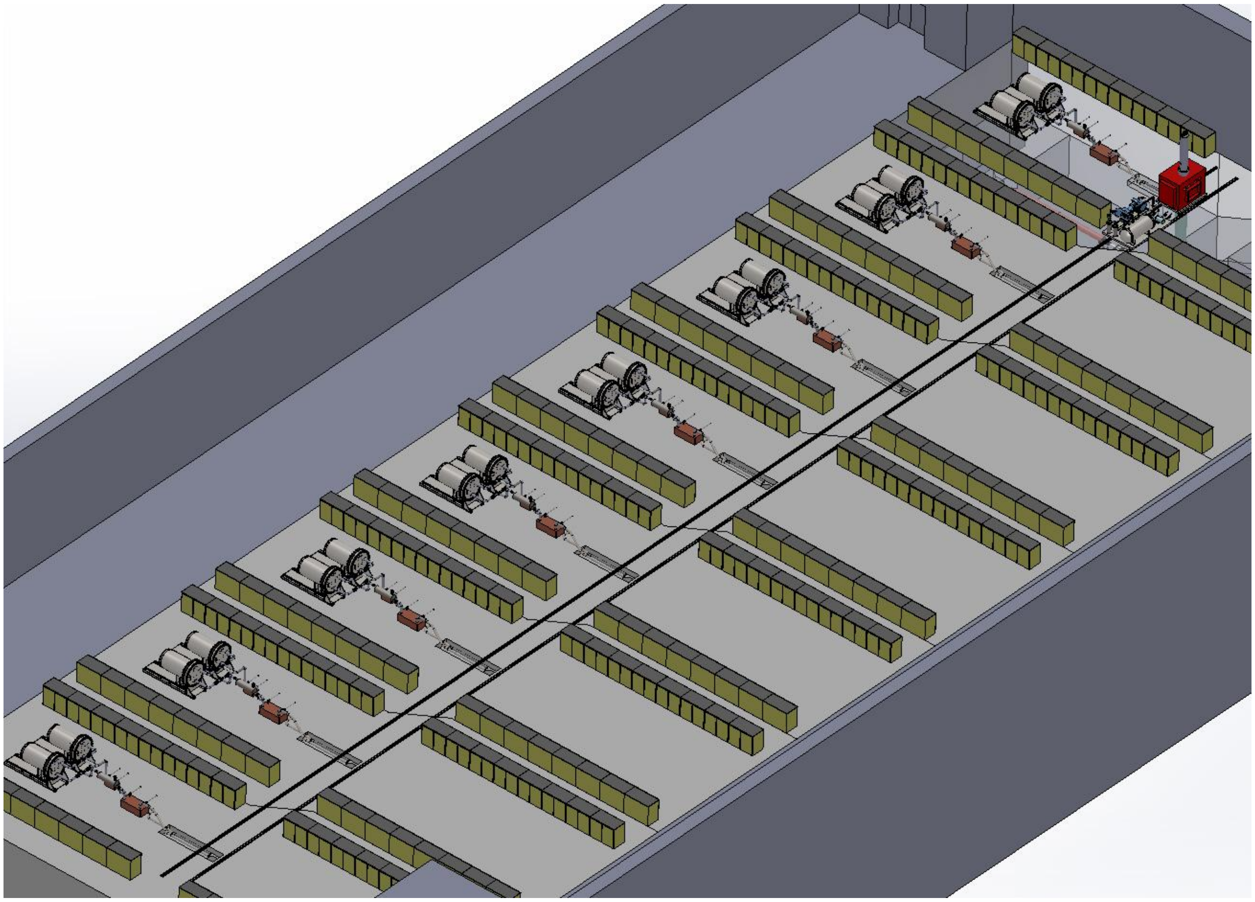

Figure 1. Isometric view of the upper level of the production facility. On this level the targets are inserted and extracted. The helium cooling systems reside here as well. A rail system facilitates target handling with a movable hot cell, shown in red.

Figure 2 shows a close-up view of one helium system and the hot cell [1] positioned over the target removal point. Hot cell size and other details are TBD. A cask could be used here, but a plan for target removal and replacement would be considerably more involved without manipulators. In this configuration, the target can be raised into the hot cell, removed from the target holder, replaced by a new target, and lowered back into the beamline in minimum time. The target insertion shaft is described in more detail below. The helium system is a blower/motor system enclosed in a pressure vessel for operation up to 400 psig, described in more detail in a separate report. 2 pressure vessels with blower/motor pairs are located in each bay for redundancy, the second bing available during maintenance of the first. The vessels will be enclosed for noise control, as shown in Figure 3. Helium system will also include a coalescing filter to remove blower oil vapors (not shown) and instrumentation. The shown components are illustrative only. The shown heat exchangers (red rectangular components) are approximately to scale but not sized with a vendor.

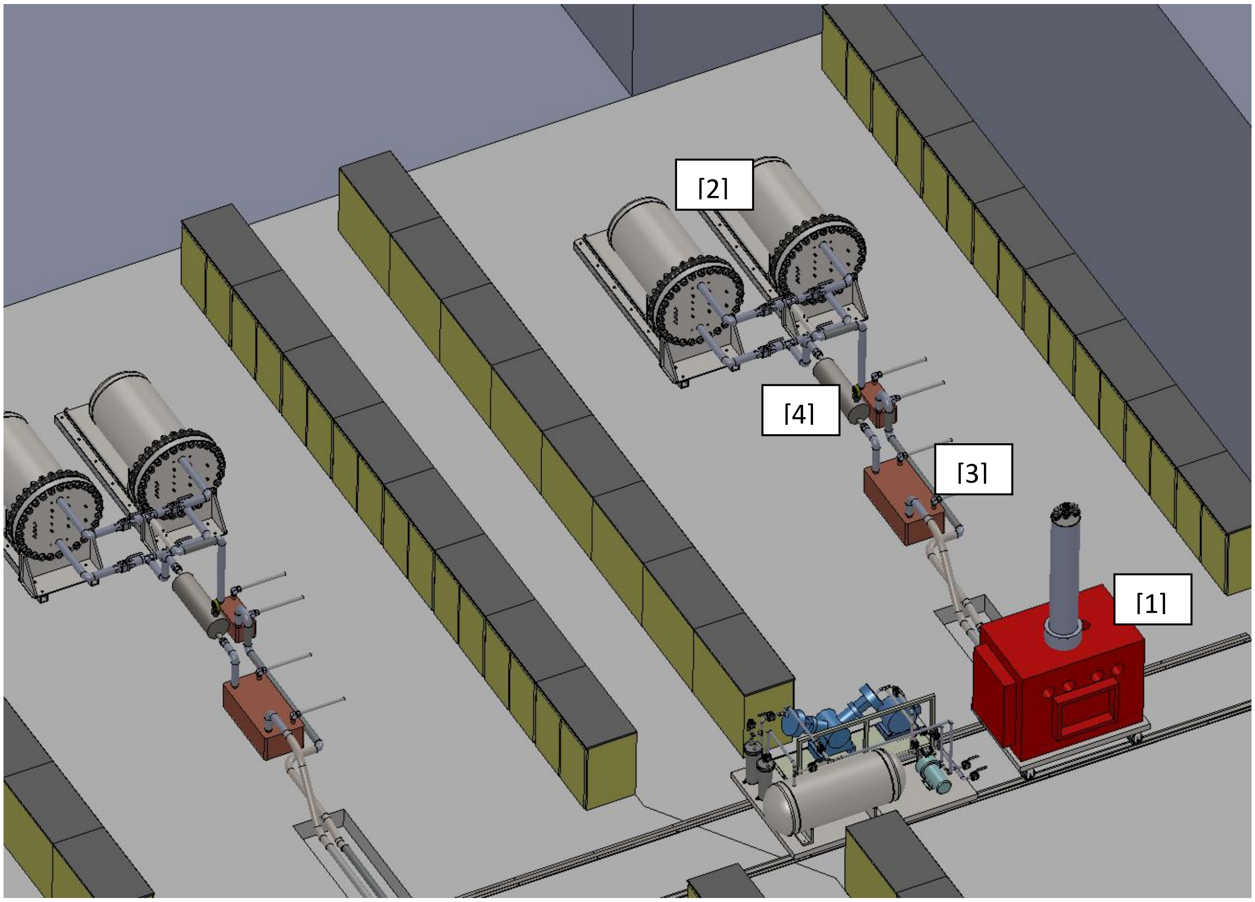

Figure 2. View of one helium cooling system layout showing the hot cell [1] centered over a target insertion shaft. Also shown are the helium blower and motor [2] with back-up, two plate type heat exchangers [3], filter and mass flow meter [4].

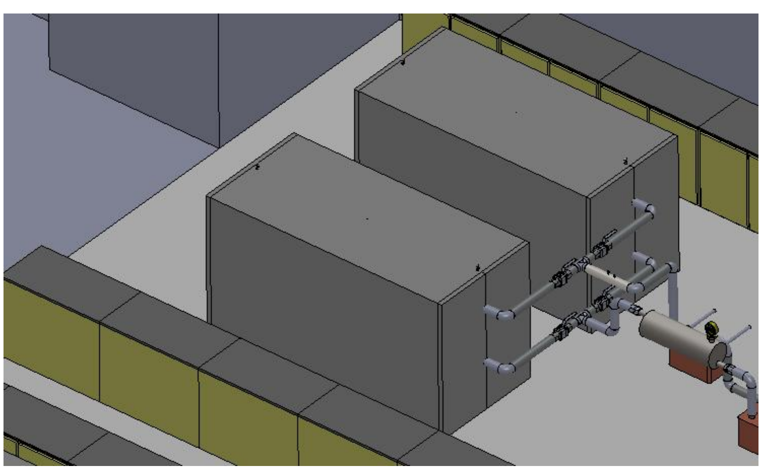

Figure 3. Each pressure vessel will be independently enclosed in a sound control box that would lift off by crane for system maintenance.

Since the target must be inserted through and beyond the bottom of 10 feet of shielding, target extraction requires a vertical lift of nominally 12 feet plus the distance to the center of the hot cell. Allowing space for the crane bridge and hoist the estimated ceiling height above the shielding is 20 feet. An extracted target rod is shown in Figure 2.

Also shown in Figure 2 is a helium recovery system, on the rail next to the hot cell. This is intended to recover the helium in the target and connecting piping during the weekly target change-out, and also to recover the entire inventory of helium during maintenance. An illustration of the this system is shown in Figure 3, and a P&ID in Figure 4. The cart has a containment vessel nominally the same size as the helium loop pressure vessel. Helium fills that vessel first by pressure difference, then by the compressor (in blue on the right of Figure 3). A scroll pump (in teal, bottom left of Figure 3) feeds the compressor when suction head is not sufficient. The 2 canisters top right in the figure are for oxygen and tritium gettering.

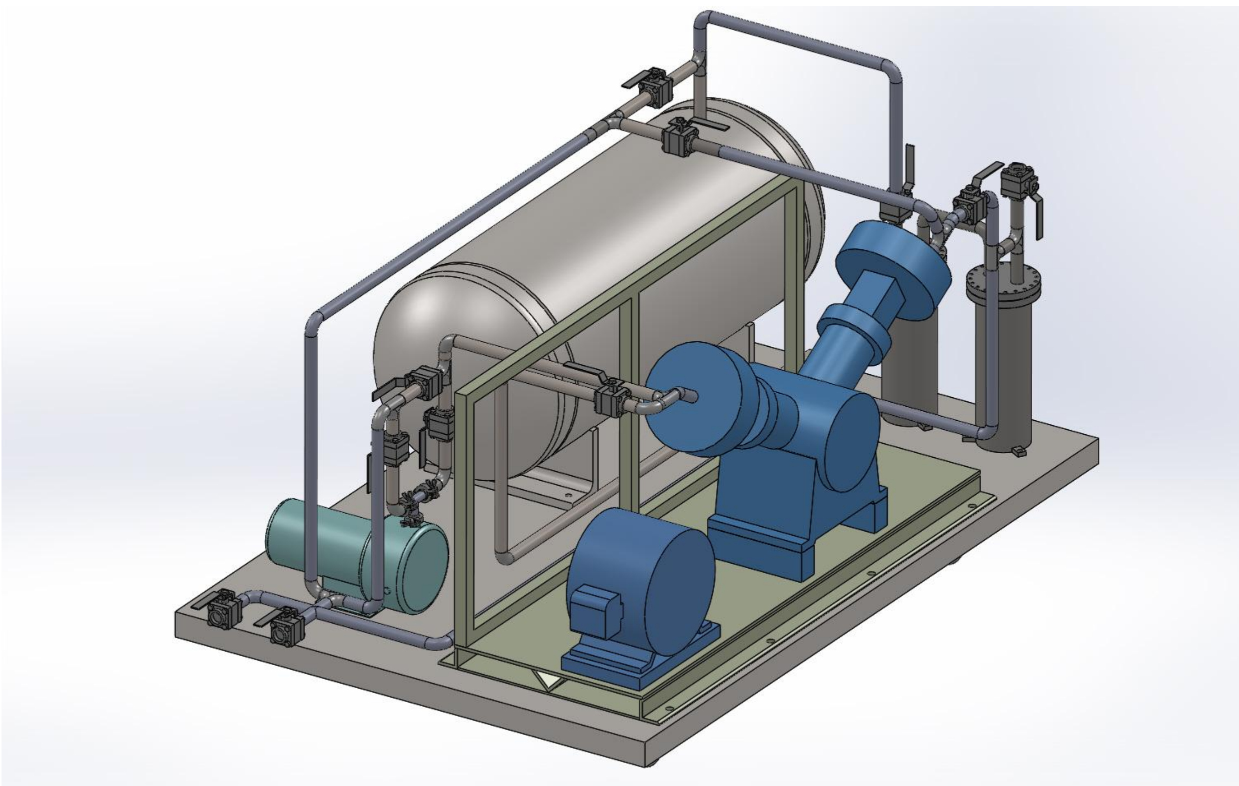

Figure 3. Helium recovery system, as described above.

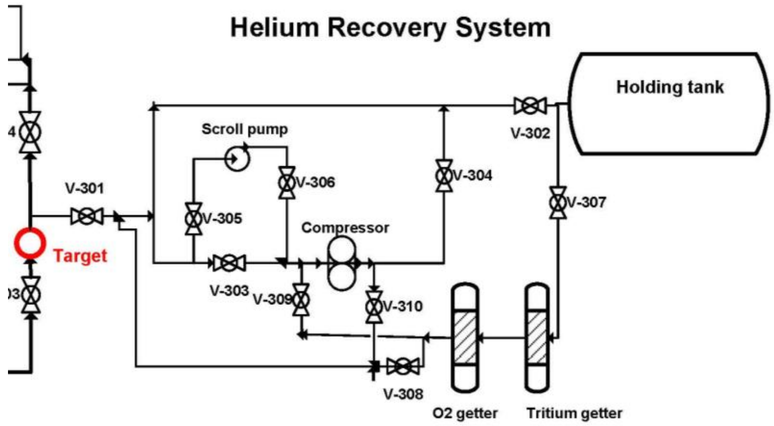

Figure 4. Helium recovery system piping diagram.

Efforts are also underway at LANL to evaluate technology options and costs for a tritium removal system that would remove tritium from the Northstar loop that will be generated in the Mo-99 photonuclear production reaction. Tritium removal capability is needed for worker protection, contamination control and ALARA for off-site member of the public. An initial concept has been developed and is being assessed. The initial concept uses a traditional tritium removal approach of catalytic oxidation of tritium to water and collection on molecular sieves. This approach is well-established and used widely in tritium facilities. Low oxygen concentrations in helium cooling system are driving the tritium recovery system to large size. Alternative cleanup methods are being considered, such as hydrogenation of gas phase organic species and collection on activated carbon (gas phase organic getter). The presence of pump oil vapor in system may be sufficient to do this. This system would be plumbed in parallel with the target, continuously stripping tritium from a helium slip stream during production

Figure 5 shows the details of a target insertion shaft. The target insertion shaft is a 14" diameter pipe that is permanently encased in the 10' shielding block. This pipe is flanged at the top and sealed to the removable target insertion pipe. The 14" pipe is the beamline vacuum containment. That is, this pipe is closed at the bottom and has 2 flanged connections to the 2 smaller diameter beam pipes. The target is 2 feet below the bottom of the 10 foot thick vertical shielding to bring it to 5 feet from the floor, the presumed beam height. In principle, the beam can be raised to closer to the ceiling and thereby slightly reduce the vertical lift requirement. Also, local shielding may feasibly reduce the 10' concrete requirement. Detailed shielding calculations are needed.

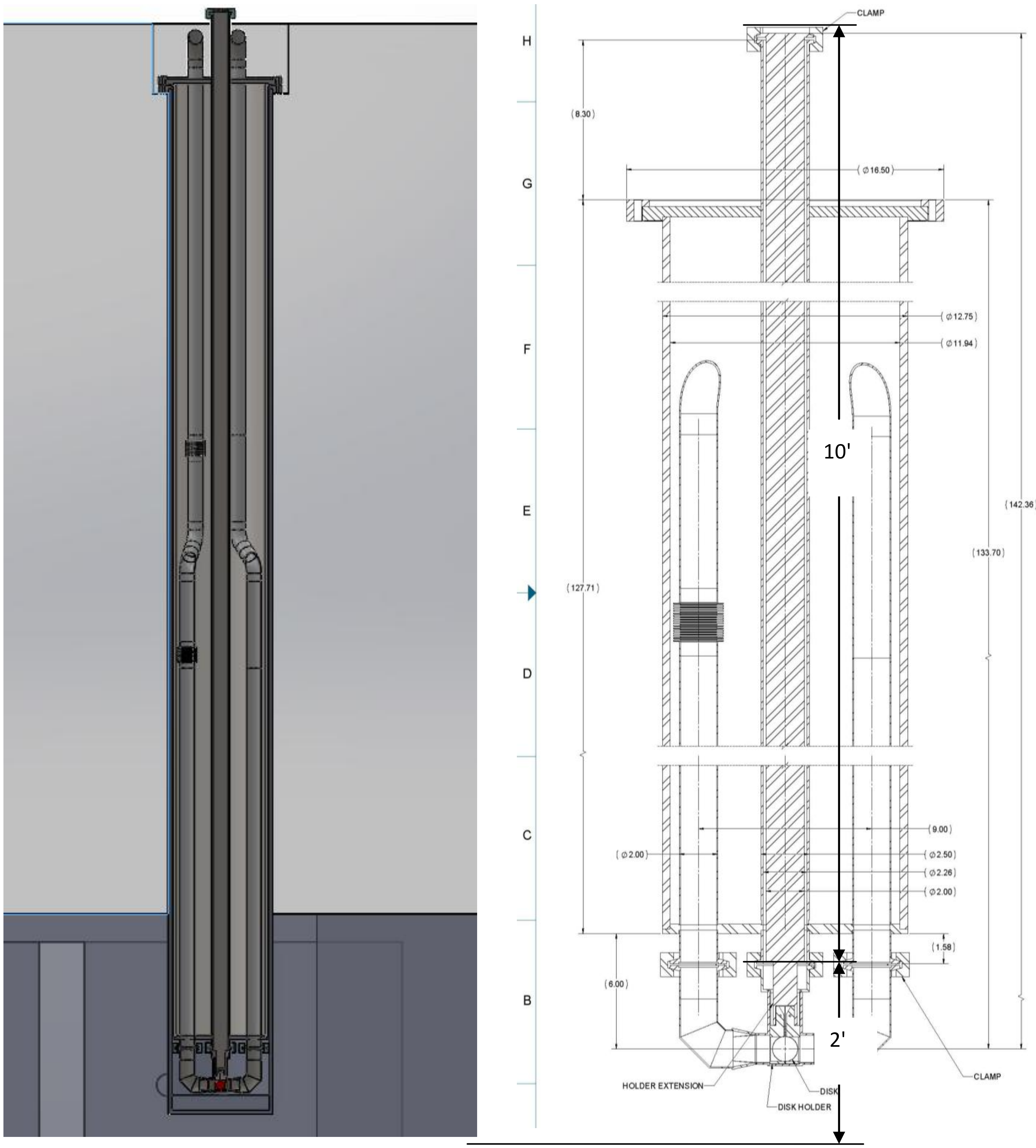

Figure 5. Views of the target insertion assembly.

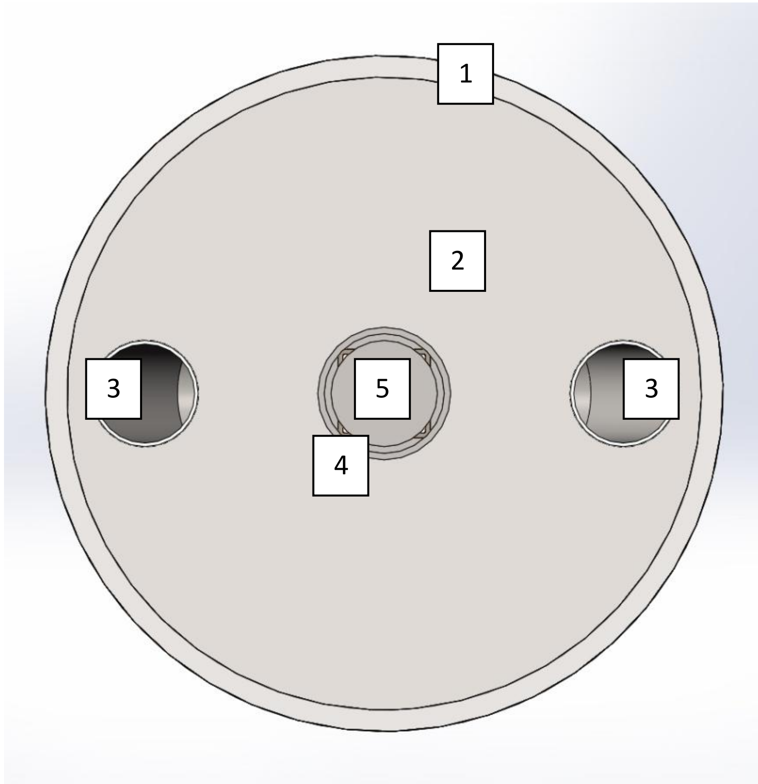

Figure 6. Cross sectional view of the target service pipe. Nomenclature used in this report: [1] Target servicing pipe (nests inside the target insertion shaft); [2] Granular shielding; [3]Helium supply and return pipes; [4] Target access pipe (helium containment boundary); [5] Target insertion rod.

A 12" diameter target service pipe fits inside the fixed shaft. This pipe is shown in cross-section in Figure 6. This pipe houses the target insertion rod down its center, which is separately flanged at the top the helium inlet and outlet pipes and shielding. It is closed at the bottom, with the target housing connected below. The target servicing pipe is removable but it is only necessary to remove it if the target housing or window fail. That is, the target is normally removed without removing this pipe via the target insertion rod. The shielding in this pipe is granular, and poured into place. The composition of the shielding is TBD, and may vary with vertical location. The helium pipes have a vertical path adjustment at the pipe midpoint to prevent radiation streaming. The location and number of such path jogs is TBD. The return helium line also has some flex joints to accommodate thermal expansion caused by the hot (nominally 100°C) return gas. The location of the joints and the arrangement for pipe movement imbedded in shielding are design details TBD.

The top of the target service pipe is shown in Figure 7. The 2 helium pipes terminate below grade so that they can traverse beneath the hot cell rails. The target is loaded and unloaded in the central bore closed with a pressure-rated KF type flange. The target insertion rod runs the length of this bore and connects to the target holder. This rod is for target insertion and extraction but also for shielding. A step change in diameter may be required to eliminate radiation shine path (not shown). The target housing attached to th ebottom of the insertion pipe is shown in Figure 8.

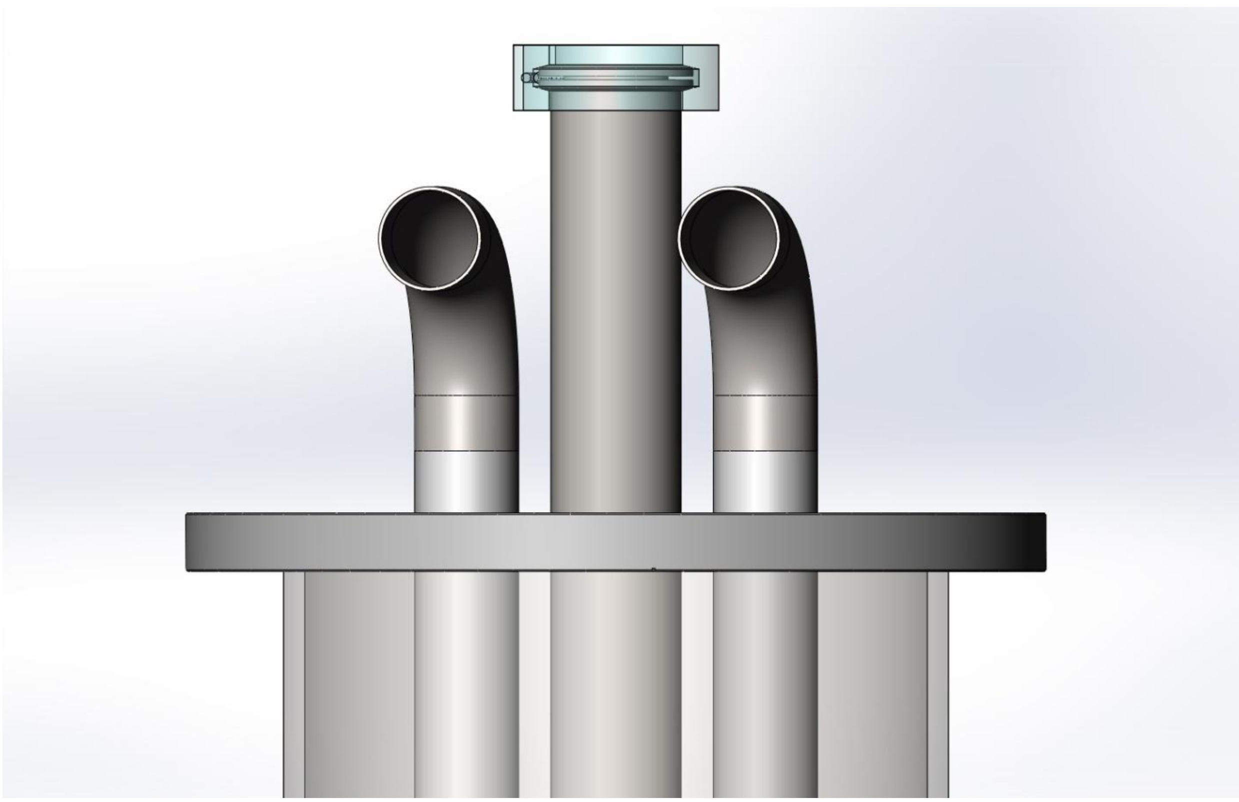

Figure 7. Top detail of the target pipe showing the supply and return helium pipes and the target access pipe.

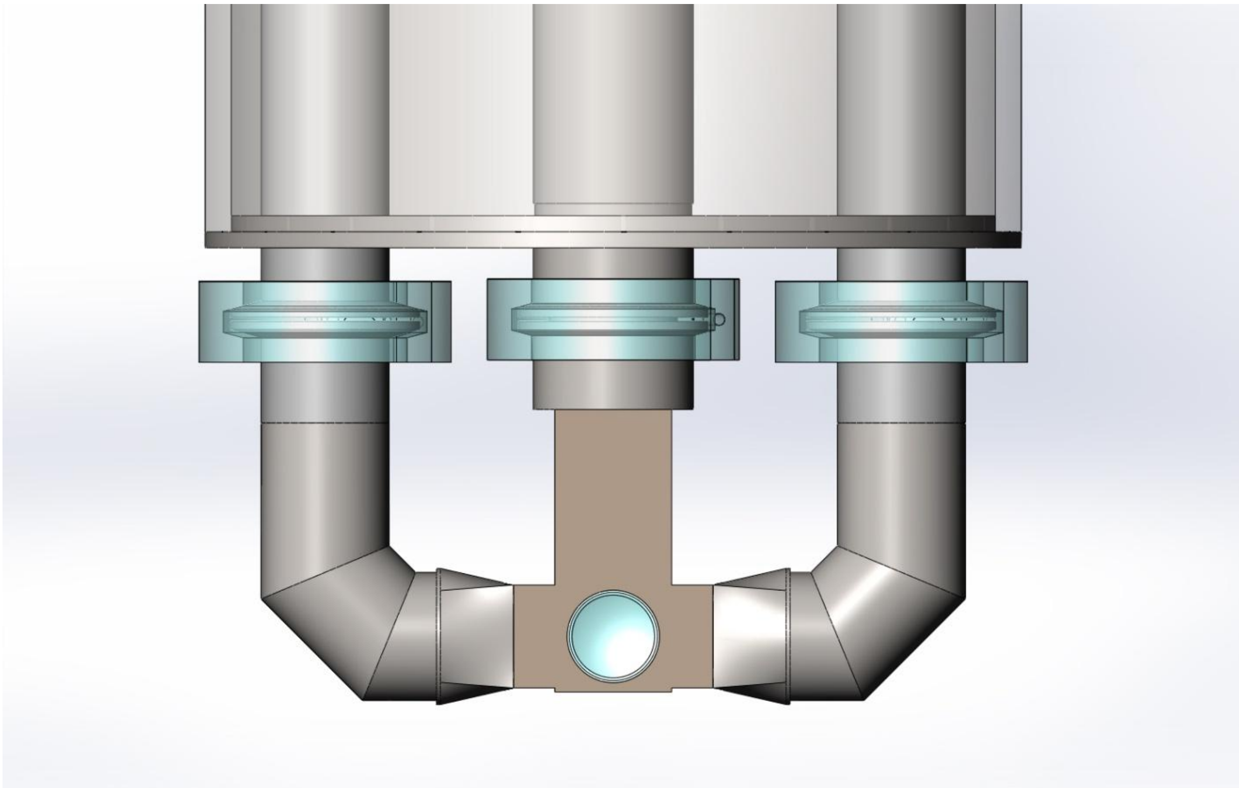

Figure 8. The target, mounted at the bottom of the target service pipe.

Concluding Remarks

The preliminary scheme described above allows for reliable and rapid target change-out with near zero possibility of personnel injury or radiation dose if proper procedures are followed. The helium systems are fully accessible and serviceable. The target will connect to the target insertion rod with a quick disconnect designed for ease of release and new target insertion with manipulators. The rail system can be modified to transport the targets directly to the separations lab within the hot cell, or, if necessary, transfer the target to a cask for transport.

This report frequently uses the acronym TBD. While the scheme is fully workable as imagined, there are many details yet to be refined. Full definition and design will depend upon final selection of the accelerator, detailed shielding calculations and considerations of target handling and processing efficiency and convenience.