

120+ μA Single $^{18}\text{F}^-$ Target and Beam Port Upgrade for the RDS/Eclipse

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A high power (>1.3 kW) target platform has been developed for the RDS-111/Eclipse and RDS-112 cyclotrons. This fully engineered solution includes upgrades to four subsystems: target, beam port, target support unit and deionized water cooling system. This platform has been in service 6 days per week since August 2009. The target is operated within an intensity range of 100 to 120 μA with a mean ^{18}F saturation yield of 121 mCi/ μA . Only 2300 μL of [^{18}O]enriched water is consumed each irradiation, resulting in one of the highest aqueous ^{18}F target power densities to date (570 W/cc). In addition to offering unprecedented performance, the single target platform greatly simplifies operation and improves the overall robustness of the cyclotron system.

The water target model CF-1000 is a conventionally pressurized cousin to the highly optimized, bottom pressurized *Thermosyphon* target. Due to the small volume of the target and the simplicity of using the OEM target support unit software, bottom pressurization was not viable. The target insert is constructed of either EB melted or arc cast tantalum or niobium, and is housed in a 6061 aluminum body. The conduction layer between cooling water and target medium is less than 0.030" for all chamber surfaces except the target window, and the flow regime is fully developed turbulent in all cooling water passages. To achieve turbulent conditions a conservative minimum flow rate of 2.5 GPM is required for this specific geometry. Window cooling is provided by nucleate boiling in the target medium.

The single target port replaces the rotating "turret" target changer on the 111/Eclipse cyclotron. The port includes a beam tube, vacuum isolation valve, water cooled graphite collimator, and vacuum roughing line. The assembly is constructed primarily of hard anodized 6061 aluminum

for ruggedness and electrical isolation. Some PEEK is used sparingly in high wear areas and critical insulating layers. The ring collimator is made of very low porosity ATJ grade graphite to mitigate water absorption during target changes. This greatly shortens subsequent pump down time. The graphite is baked out at 150C under 10 microns partial vacuum prior to installation. The assembly mounts to the cyclotron steel via the carrier plate which allows for independent adjustment in x and y via small lead screws. The collimator, port and beam tube section interface with the carrier plate via a spherical bearing, which is clamped in place after alignment

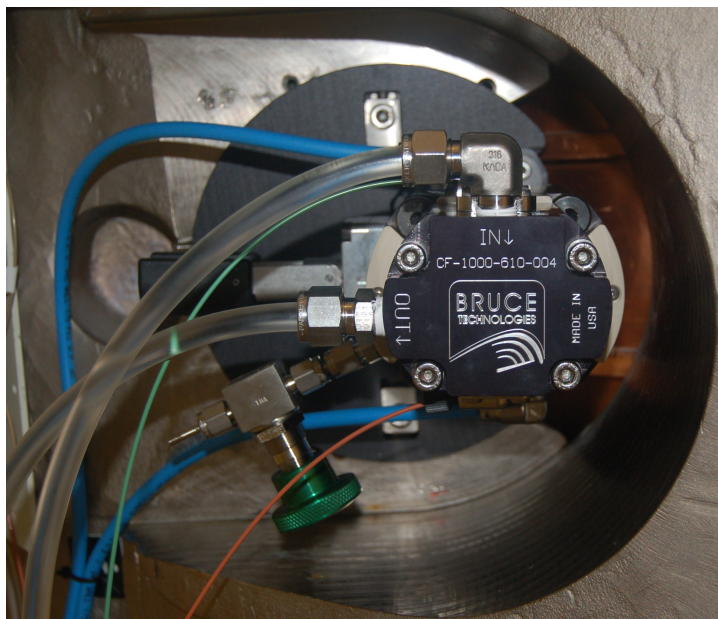


Figure 1: CF-1000 Installed on RDS-111 Cyclotron

adjustments are made. This ensures that the collimator and target are coaxial at all times and provides an extremely rigid yet easily adjustable mount.

A larger recirculation pump is installed in the water system to accommodate the additional flow requirements. To ensure that proper flow balance is maintained, adjustable distribution manifolds are installed at the recirculation pump inlet and outlet. The supply manifold has a back-pressure regulating valve to allow bypass flow. This prevents both dead heading and overpressure conditions when the cyclotron is shut down. The upgrades to the water system are a small fraction of the total system fabrication cost and critical to high performance operation.

The target support unit(TSU) geometry was redesigned to mitigate the pressure rise from elevated vapour fraction at high intensity and to improve liquid recovery. The OEM software is used to operate the TSU so the functionality remained the same. Significant improvement is made from a maintenance perspective as a much more suitable pressure transducer is used resulting in smaller hysteresis, increased robustness and a reduction in replacement cost of more than a factor of five.

The performance history of the target system is shown in figure 2. The product was used exclusively for clinical ^{18}F FDG, and showed radiochemical yields consistently within specifications for both synthesis modules used. Note that the discontinuity at run number 65 is due to change in the Capintec CRC-15PET dose calibrator settings. This is the result of a technical bulletin issued by Capintec in 2009.

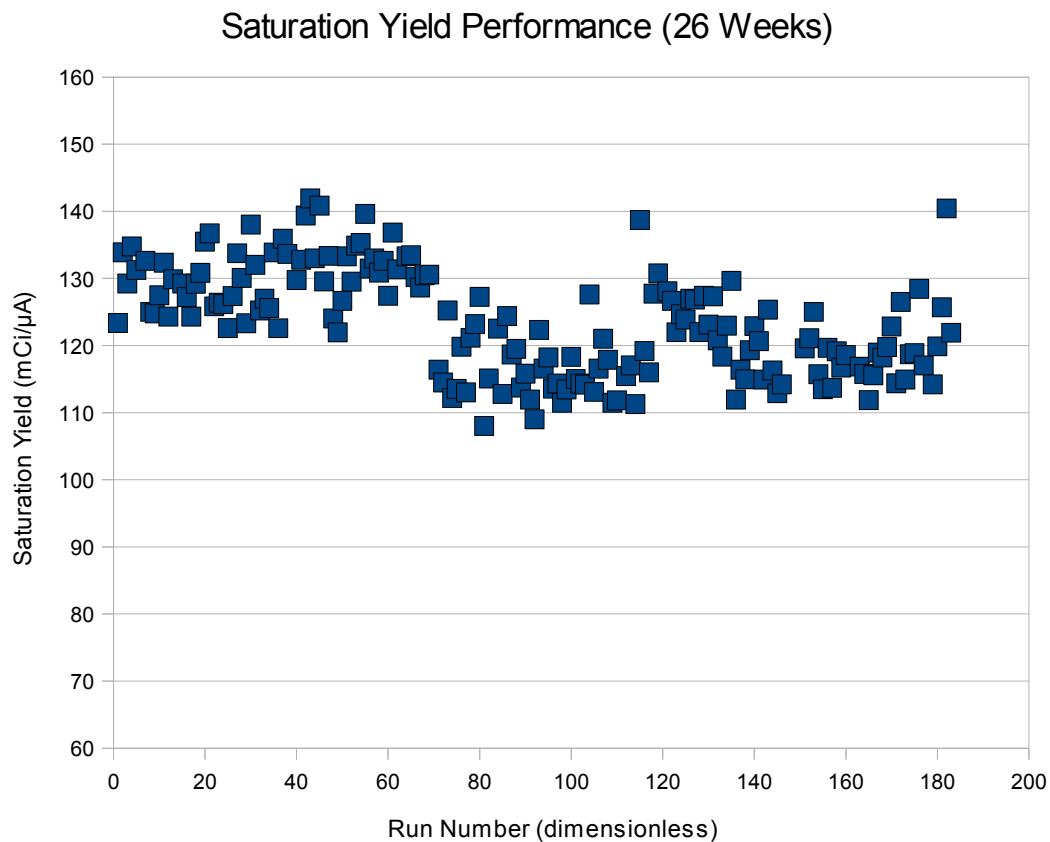


Figure 2: Operational Performance from DV3