Contribution ID: **101** Type: **Oral**

Design, Control, and Monitoring of the SpinQuest Polarized Target System

The SpinQuest experiment leverages a transversely polarized solid-state target to investigate the orbital angular momentum of the nucleon by probing sea quarks through the Drell-Yan process, enabling a measurement of the Sivers asymmetry. The Drell–Yan process is initiated by Fermilab's 120 GeV Main Injector proton beam, delivering intensities of up to 3E12 protons per 4-second spill. The target system employs Dynamic Nuclear Polarization (DNP) to polarize irradiated ammonia (NH_3/ND_3) at a magnetic field of 5T and a base temperature of 1 K, maintained by a 5 W helium evaporation refrigerator. The polarized material is housed in an 8 cm-long oval-shaped target cell. Efficient cooling is facilitated by a high-capacity roots pump stack, providing a pumping rate of 17,000 m^3/h. Polarization is driven by a 140 GHz Extended Interaction Oscillator (EIO) that induces the necessary spin transitions for DNP. To ensure stable and reliable operation, an intelligent monitoring and control system is proposed that leverages Artificial Intelligence for real-time condition monitoring, fault detection, and diagnosis. This talk presents an overview of the SpinQuest polarized target system, along with the design and future implementation of the associated diagnostic and control framework.

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Track Classification: Application of spin and nuclear polarization techniques