PROGRESS ON THE PROTON POWER UPGRADE PROJECT AT THE SPALLATION NEUTRON SOURCE

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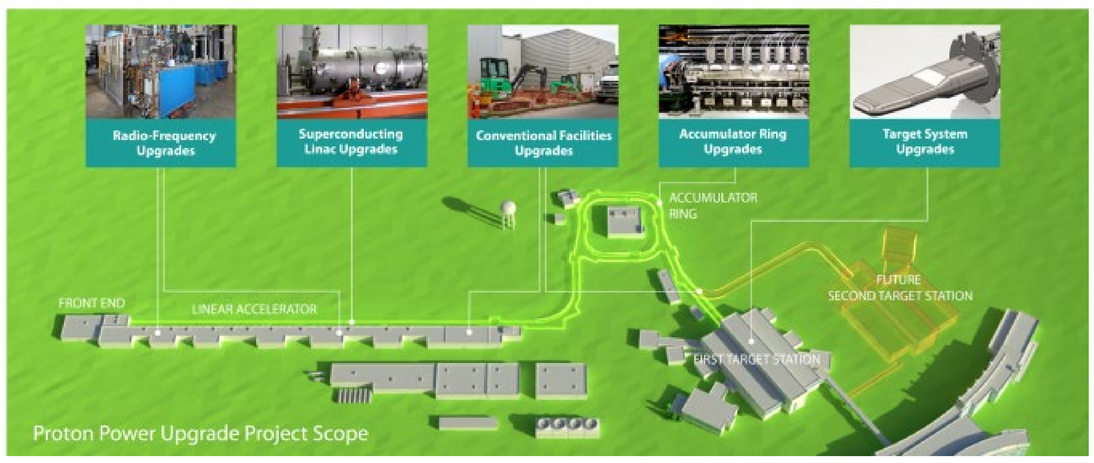
Abstract

The Proton Power Upgrade (PPU) Project at the Spallation Neutron Source at Oak Ridge National Laboratory will increase the proton beam power capability from 1.4 to 2.8 MW. Upon completion of the project, 2 MW of beam power will be available for neutron production at the existing First Target Station with the remaining beam power available for the future Second Target Station. The project will install seven superconducting radiofrequency (RF) cryomodules and supporting RF power systems and ancillaries to increase the beam energy to 1.3 GeV. The injection and extraction region of the accumulator ring will be upgraded, and a new 2 MW mercury target has been developed along with supporting equipment for high-flow gas injection to mitigate cavitation and fatigue stress. Equipment is being received from vendors and partner laboratories, and installation is underway with three major installation outages planned in 2022-2024. The project is planned to be completed in 2025.

Proton Power Upgrade project scope

- Upgrade the SNS accelerator beam power capability from 1.4 MW to 2.8 MW
  - 30% beam energy increase: 1.0 GeV → 1.3 GeV
  - 50% beam current increase: 26 mA → 38 mA
- Includes scope across much of the neutron source



Superconducting Linac

- Eight cryomodules are being produced by Thomas Jefferson National Accelerator Facility (TJNAF)
- Seven cryomodules will be installed; there is one spare
- Four beta=0.81 cavities per cryomodule, 16 MV/m, Qo>5e9 @ 16 MV/m
- Status:
  - Three cryomodules received and tested at SNS exceed performance requirements (4th due in September)
  - Two cryomodules have been installed in the Linac enclosure and will be ready for operation with beam later this year
  - 28 cavities have achieved performance requirements after installation of their helium vessels

The first two cryomodules mounted on their stands in the Linac enclosure

The first chicane magnet coil package insulated and ready for epoxy potting.

Ring Systems

- New injection region chicane and dump septum magnets from Fermilab
- New injection dump quadrupole from industry
- Upgraded extraction kicker charging power supplies
- Injection dump imaging system for monitoring waste beam
- Beam power limit system will prevent beam power greater than 2 MW on the first target station
- Status:
  - First chicane magnet nearing completion
  - Lifetime testing of two options for extraction kicker charging supply nearing completion
  - Injection dump imaging system complete and ready for installation in Mar. 2023
  - Beam power limit system in operation and will become a credited safety system later this year

The first chicane magnet core at the vendor

The first new high voltage converter modulator installed in the klystron gallery

Radiofrequency Systems

- Twenty-eight new klystron-based RF stations, 805 MHz, 700kW, to power new cryomodules
- Three new high-voltage converter modulators
- Transmitters, circulators, loads, waveguide
- Three stations in the Drift Tube Linac (DTL) will be upgraded to 3 MW klystrons, 402.5 MHz
- DTL modulators will be upgraded to support 3 MW klystrons
- New low-level RF control system
- Status:
  - RF systems installation and testing in progress
  - Phase 1 installation will support operation of first two cryomodules late this year
  - First article 3 MW klystron received; acceptance testing to begin in September
  - New low-level RF system supporting operations for several months on one station in existing Linac
  - New modulators received; first article passed acceptance testing
  - Upgraded modulator for 3 MW klystron has undergone extensive testing

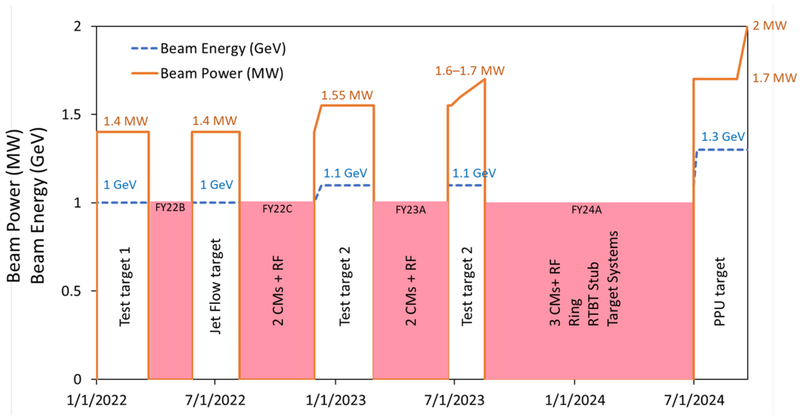
New 700 kW klystrons installed

The first article 3 MW klystron

First Target Station Systems

- New 2 MW mercury target
- New high-flow helium gas injection system for mitigation of fatigue and cavitation damage
- Mercury off-gas treatment system (MOTS) upgrades
- Catalyst converter and diagnostics for control of ortho-para hydrogen fraction in the cryogenic moderator system (CMS)
- Increased capacity of hydrogen refill system for the CMS
- Status:
  - PPU Test Target 1 operated successfully Jan.-Mar. 2022 at 1.4 MW beam power. Validated performance of swirl bubblers. No observable damage to target during post irradiation examination
  - PPU Test Target 2 (first article 2 MW target) being installed now and will operate at 1.1 GeV at beam powers up to 1.7 MW
  - Production 2 MW targets in fabrication at vendor
  - MOTS and gas recirculation component installation underway

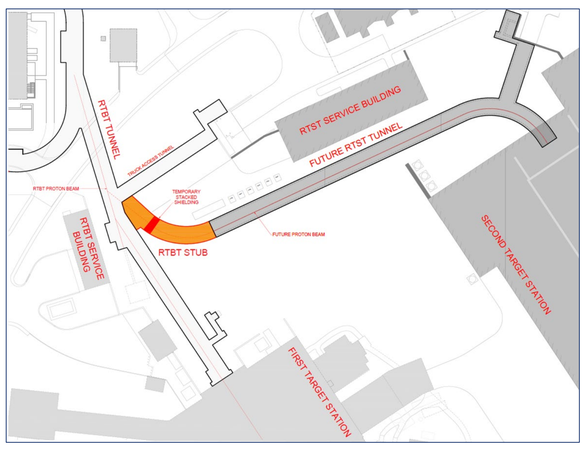
PPU Test Target 2 at the vendor prior to shipping



Proton beam power/energy will increase as components are installed and commissioned over the three installation outages

Conventional Facilities

- Klystron gallery buildout to house new RF systems
- Ring-to-Target Beam Transport (RTBT) tunnel stub to facilitate connection to the future Second Target Station without interrupting First Target Station operations
- Status:
  - Klystron gallery buildout completed in 2021
  - RTBT tunnel stub construction to begin in Aug. 2023



Plan view of the SNS site showing the existing RTBT tunnel, the planned RTBT stub, and the connection to the future Second Target Station

Work performed at Oak Ridge National Laboratory, which is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy.

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