Status of the Proton Power (PPU) Upgrade Project

Spallation Neutron Source

29th Linear Accelerator Conference-LINAC18

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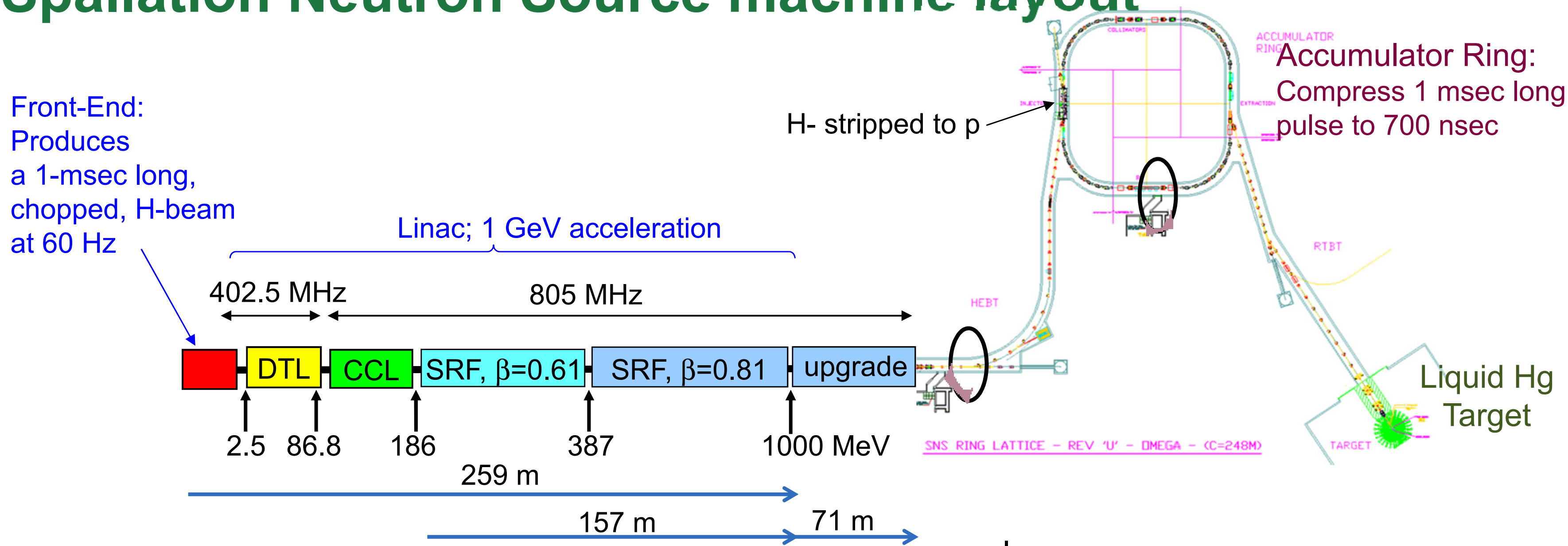
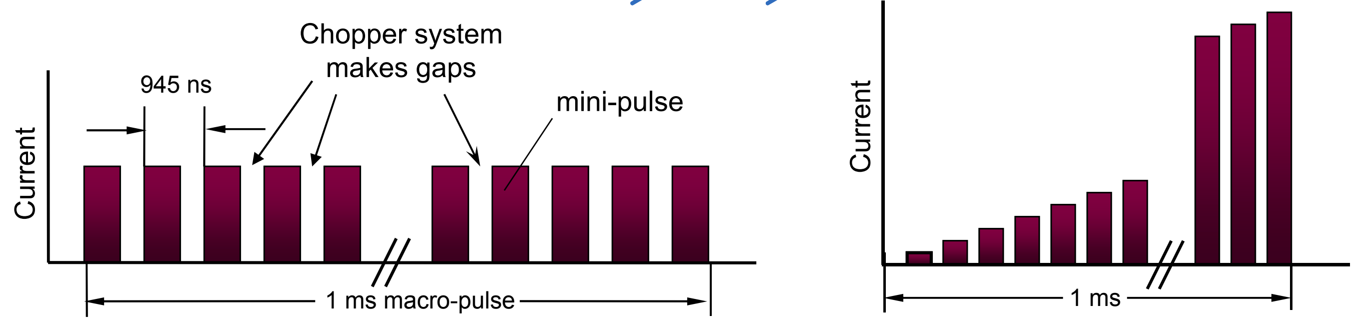
ORNL is managed by UT-Battelle
for the US Department of Energy

OAK RIDGE National Laboratory

Spallation Neutron Source machine layout

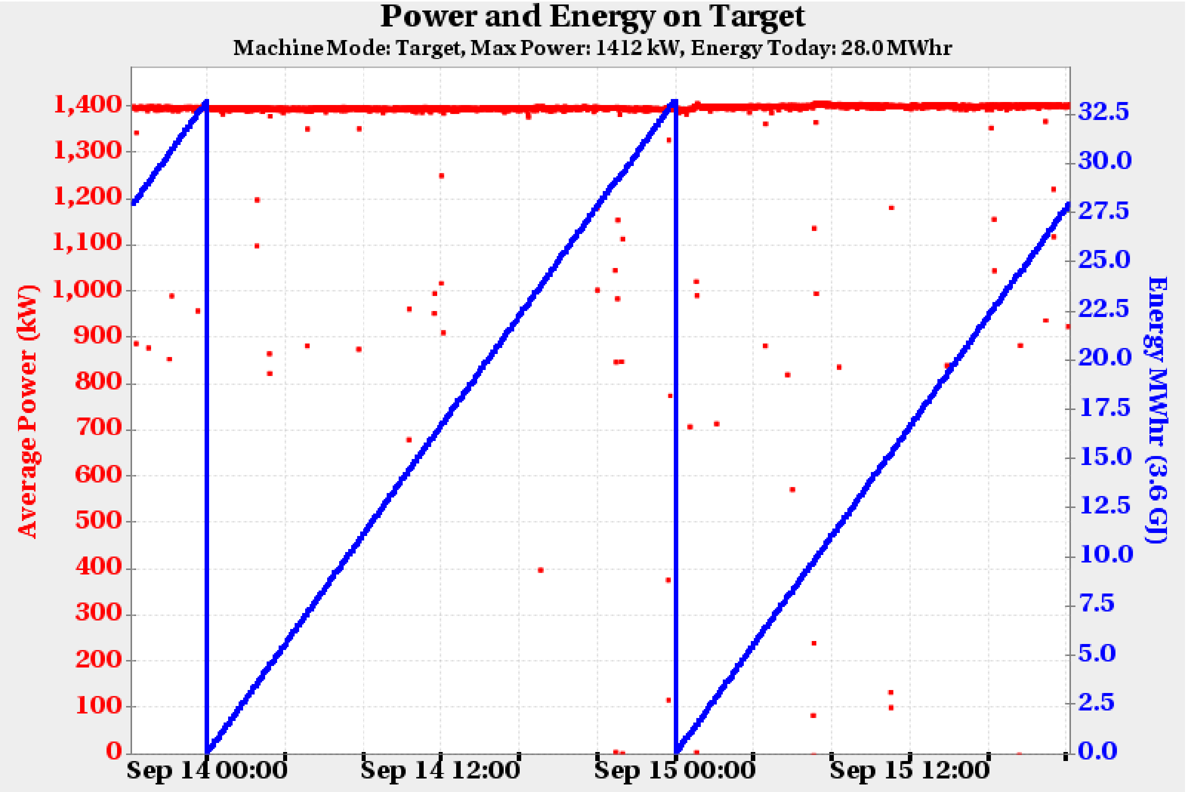




Average macro-pulse beam current: 26 mA

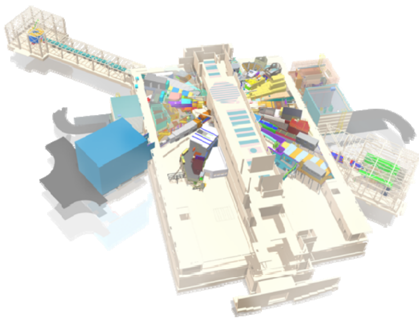
SNS is operating at its design power: 1.4 MW

1.4 MW →



SNS upgrade plans

Today



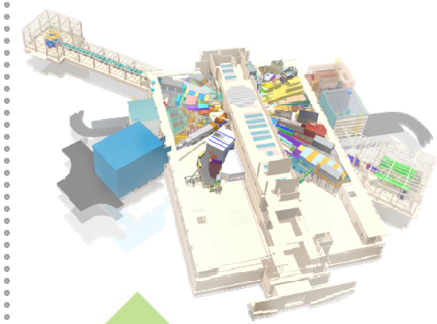
First Target Station

- 24 instrument positions
- 19 instruments built

1.4 MW

Accelerator today

Future



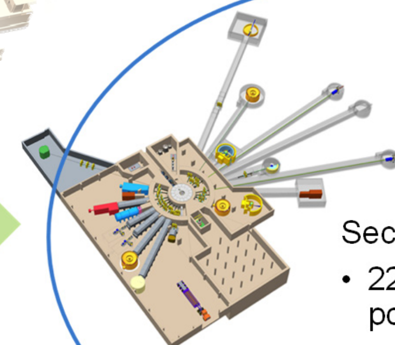
First Target Station

- 24 instrument positions
- 21 instruments built

2 MW

0.8 MW

After PPU Upgrade



After STS Upgrade

Second Target Station

- 22 instrument positions
- 8 initial instruments

Upgrade parameters: power increase with energy and current

- PPU delivers 2.8 MW capable accelerator
- Prior to STS, accelerator will run at 2 MW to First Target Station (FTS)

	SNS 1.4 MW	PPU full upgrade capability	PPU FTS 60 Hz operation
Proton beam power capability (MW)	1.4	2.8	2.0
Beam energy (GeV)	1.0	1.3	1.3
RFQ output peak beam current (mA)	33	46	46
Average linac chopping fraction (%)	22	18	41
Average macropulse beam current (mA)	25	38	27
Energy per pulse (kJ)	23	47	33
Pulse repetition rate (Hz)	60	60	60
Macro-pulse length (ms)	1	1	1
FTS decoupled moderator brightness/pulse (AU)	1	2.04	1.43
FTS coupled moderator brightness/pulse (AU)	1	2.16	1.51

30% energy increase

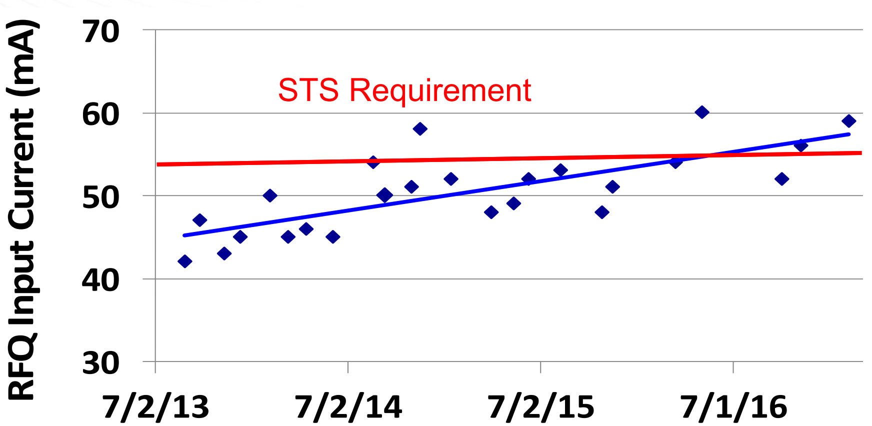
50% current increase

No change

Accelerator front-end is “STS ready”

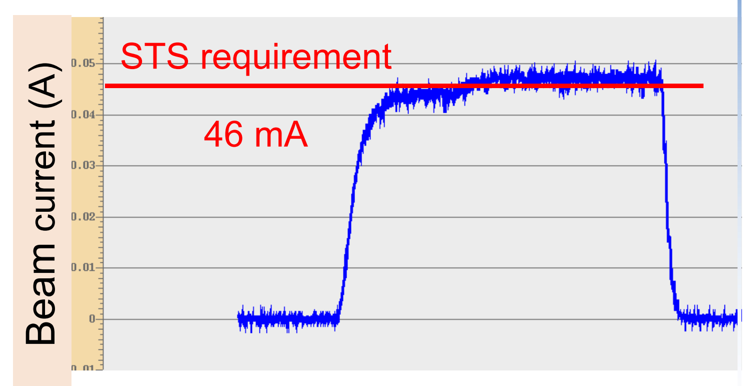
Ion source output

Operation production source has demonstrated required output



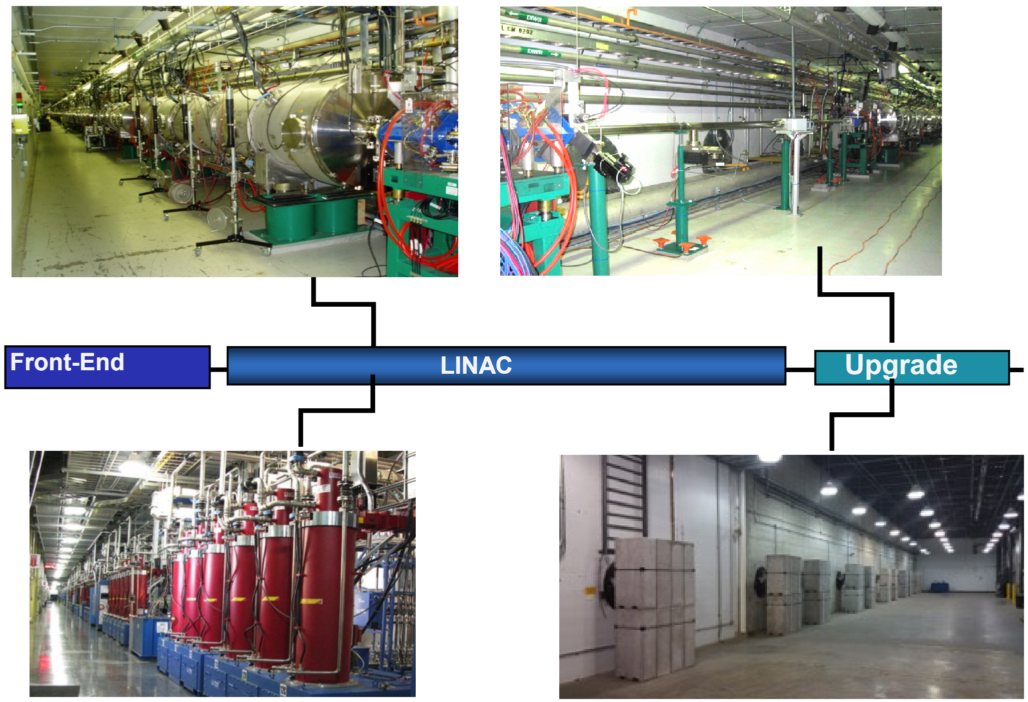
RFQ output

Measured beam at RFQ output



Accelerator Built with Upgrade Provisions

Tunnel: 9 empty drift sections: fill 7 with cryomodules

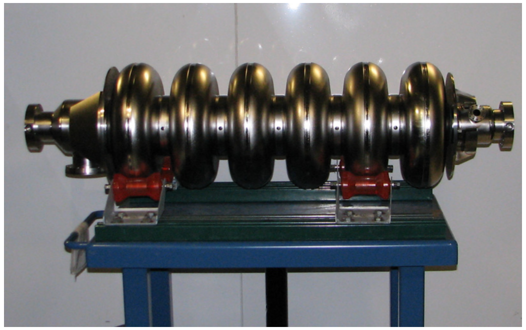


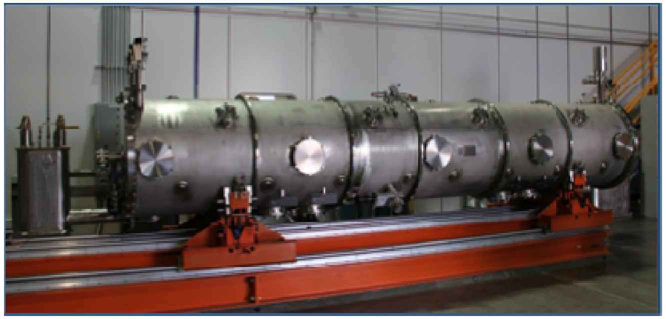
Klystron gallery: empty area for new SRF

Ring + transport lines:
96% magnets and power supplies are 1.3 GeV ready

Superconducting Linac Systems

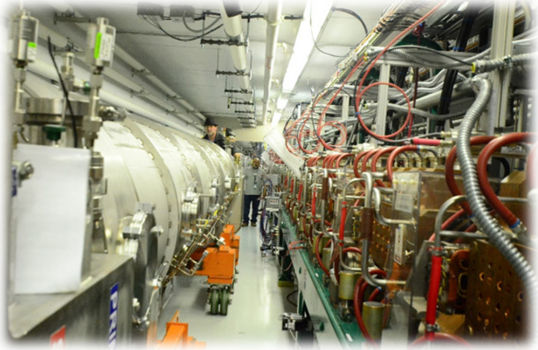
- 7 cryomodules, 28 cavities,
  - 16 MV/m gradient
  - 700 kW couplers
- SNS is responsible for cavity procurement
  - Most cavity features same as original design
  - Modifications: higher quality Nb end groups, no HOMs, no piezo tuners
- Cryomodules will be fabricated by partner lab: JLab
  - Jlab built the original SNS cryomodules
- SNS built a spare cryomodule in 2012, with PPU required gradients

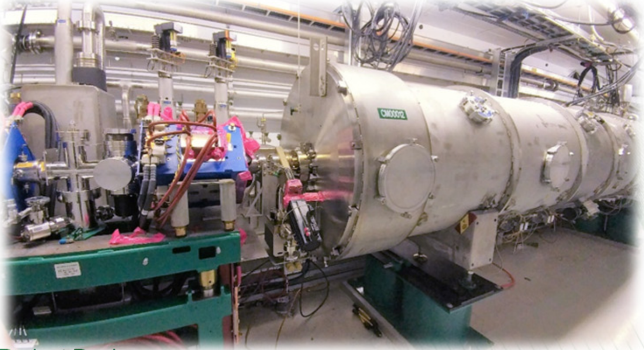




Will install some of the new cryomodules during normal maintenance outages

SNS has experience swapping cryomodules during maintenance outages

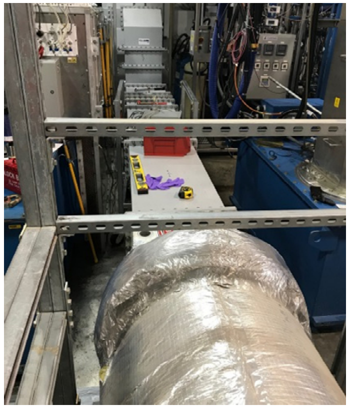


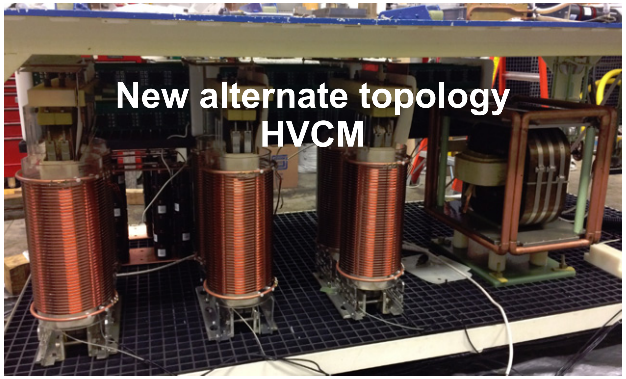


RF Systems

- Existing RF needs to support higher beam loading
  - Drift Tube Linac klystrons require upgrade from 2.5 to 3 MW
  - Couple Cavity Linac and existing Superconducting linac systems are OK
- New Superconducting linac RF systems
  - 28 new 700 kW klystrons: same as presently being purchased/used
  - 3 new high voltage convertor modulators
- New LLRF system to support “dual mode” beam to 2 target stations

Test load for DTL klystron



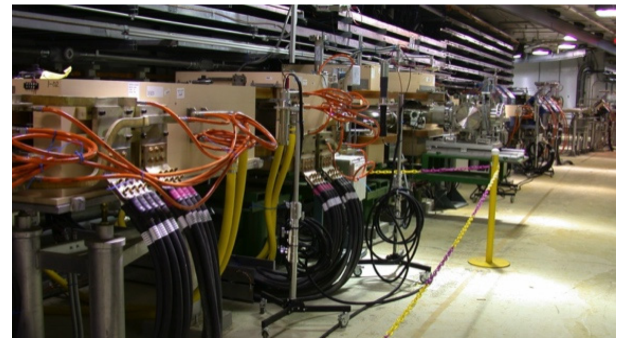


Ring systems

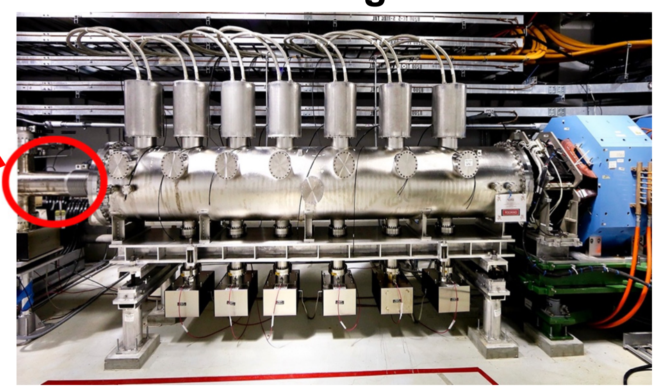
- Injection region upgrades
  - New chicane magnets
    - Working with FNAL
  - Adding a view screen diagnostic in the injection dump

- Extraction region
  - Baseline plan: add additional kickers in provided space

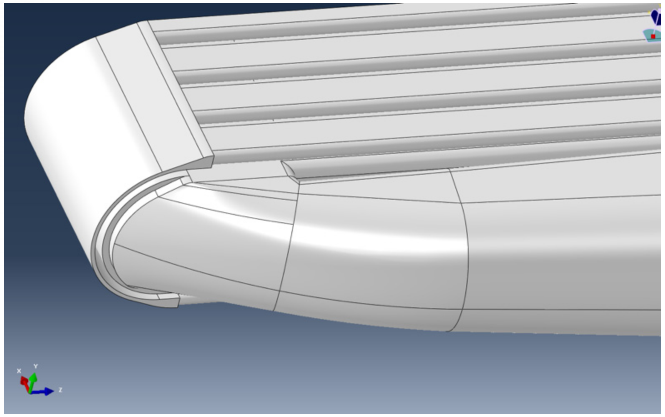
Injection chicane



Kicker magnets



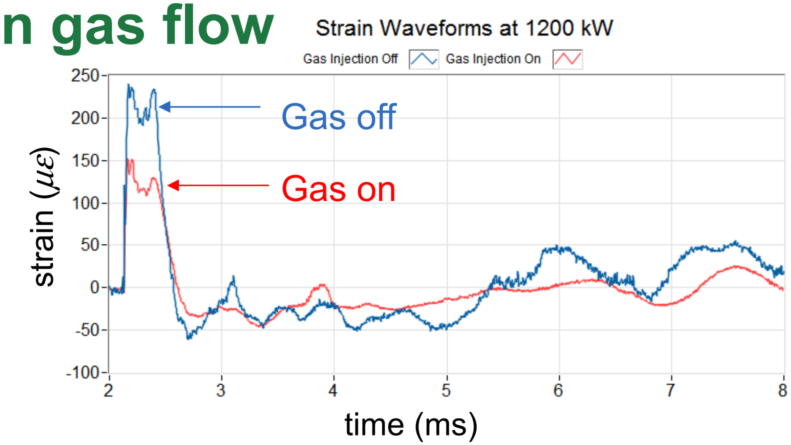
Target Vessel Design



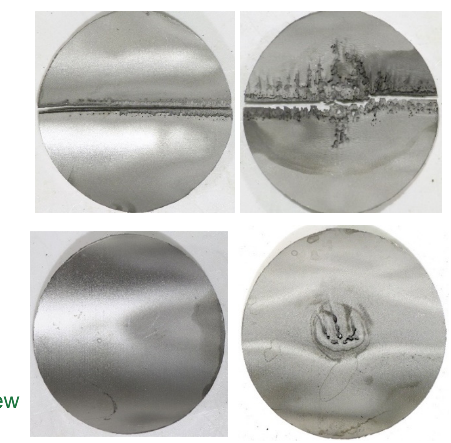
- 2 MW target design developed
  - Simplified flow deployment in corners (tapered shape)
  - Eliminate unneeded features from operational design
  - Includes a gas-wall “curtain” in the nose region

Target design: gas injection helps
PPU design includes large increase in gas flow

- Measured operational vessel strain reduced with gas injection
  - Even with small amounts of gas injection, 10-70% reduction in strain



- Core samples from target nose indicate cavitation erosion mitigation with gas injection

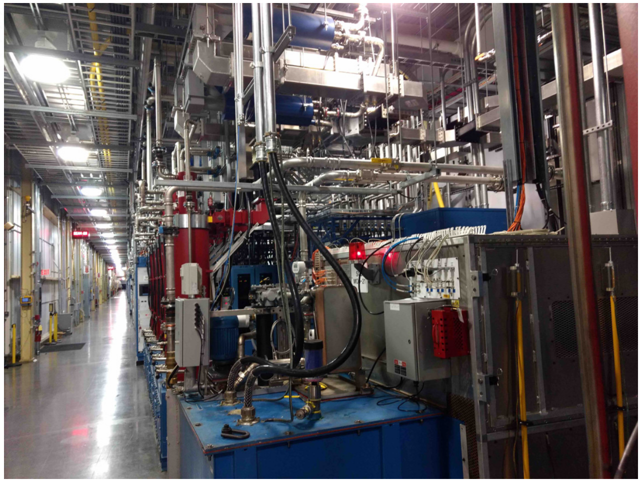


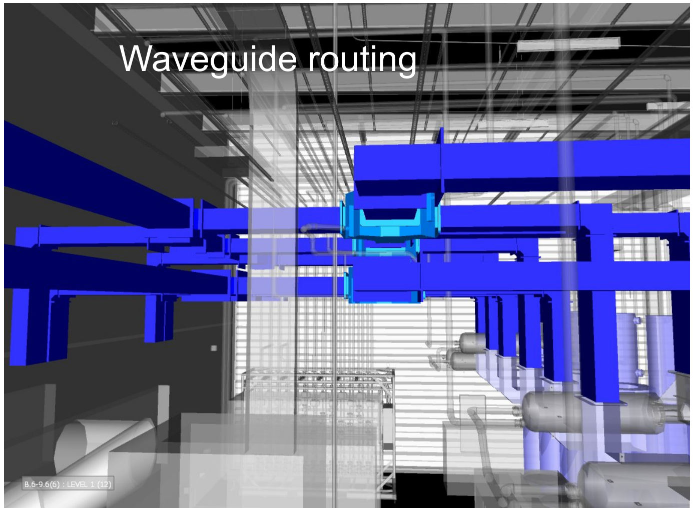
Gas off: Target 17

Gas on: Target 18

Conventional Facilities

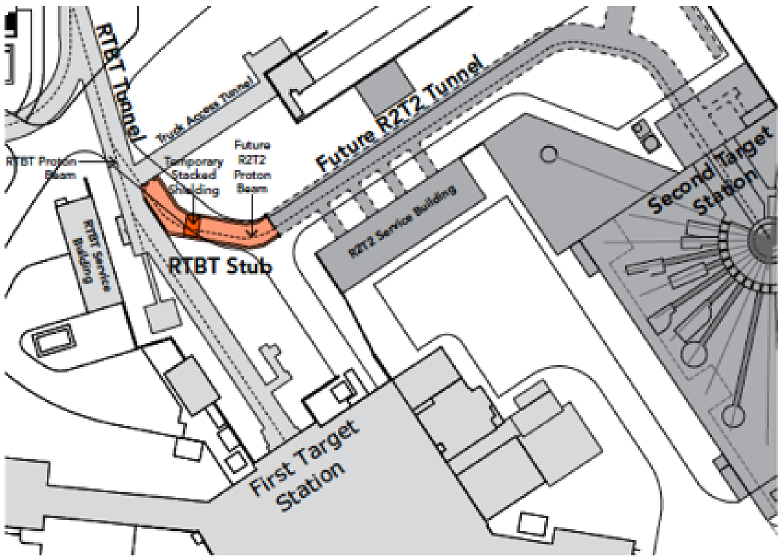
- Klystron gallery building build out
  - Finish the high energy end of the building
  - ”BIM” approach for 3-D model integration of cooling, RF and other technical equipment





Conventional Facilities: transport line stub

- Tunnel "stub" in the line from the ring to target
  - Facilitate future tie in to STS without interrupting operations

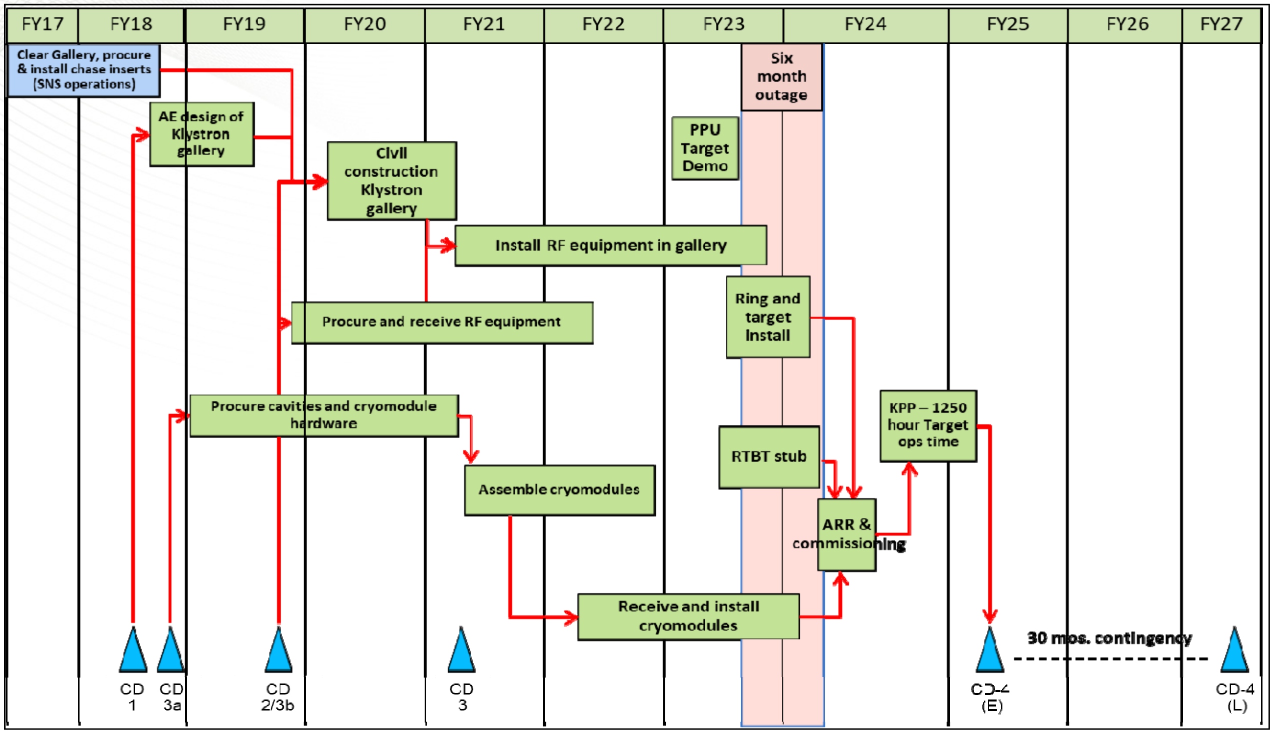


Project Cost

- Present baseline cost estimate is ~ $240 M

WBS	Totals
P Proton Power Upgrade (PPU) Project	**173,281,533**
P.01 PPU Project Management	18,102,585
P.02 SCL Systems	35,975,950
P.03 RF Systems	57,601,780
P.04 Ring Systems	11,130,342
P.05 First Target Station Systems	26,175,718
P.06 Conventional Facilities	13,433,287
P.07 R&D	3,279,767
P.08 Pre-Ops	637,480
P.09 Pre-CD1 Activities	6,944,625
Contingency (40%)	**65,462,548**
	238,744,081

PPU proposed schedule



- No interruption of operations through 2023
  - Use regular maintenance outages for tunnel activities
- One long 6-month outage in 2023
  - Upgrade ring injection, target systems, and tunnel stub
- Transition to operations at high power in 2024

Summary

- Proton Power Upgrade (PPU) project is aimed at doubling the SNS accelerator power capability
- Leveraging built in upgrade provisions
- Partnering with JLab for cryomodules and FNAL for Ring upgrades