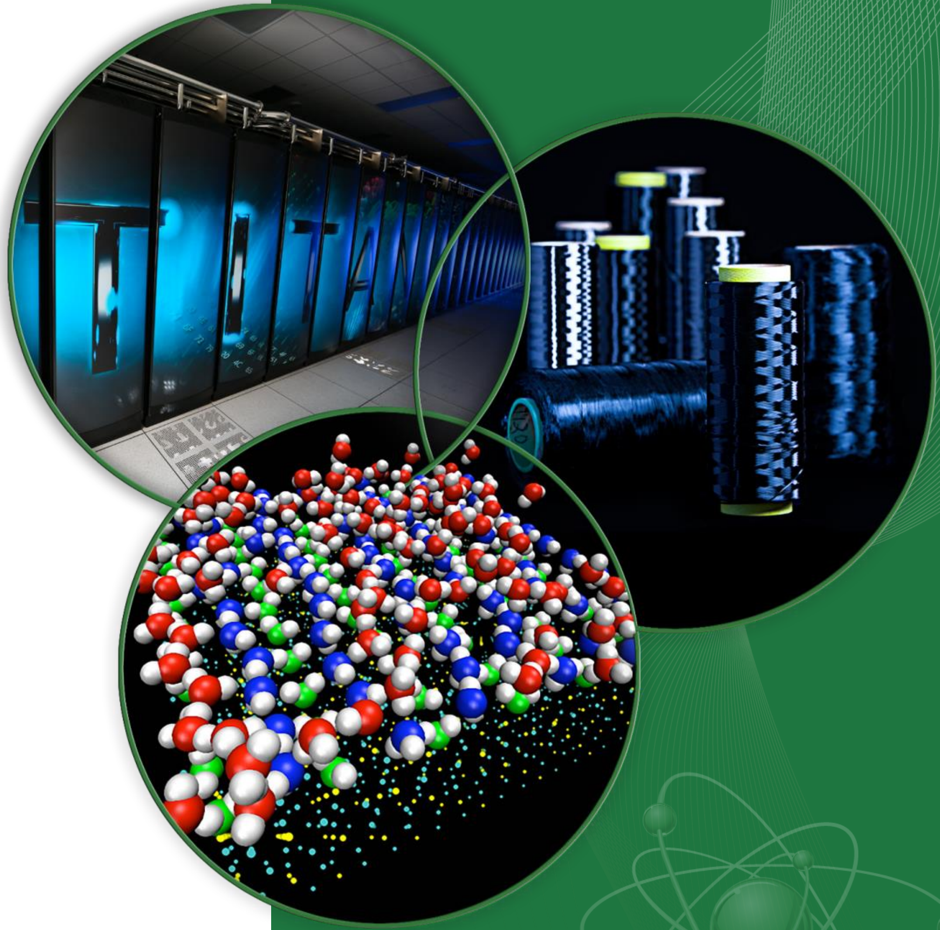
Upgrades to the SNS H- Linac to Support the Second Target Station

Presented to the Workshop on

Upgrading Existing High Power Proton Linacs

ESS
Lund, Sweden

Tuesday, November 8, 2016



Mark E. Middendorf

Agenda

- Introduction
- Proton Power Upgrade (PPU)
  - Parameters
  - Timeline
  - Work Breakdown Structure
  - Scope
- Summary

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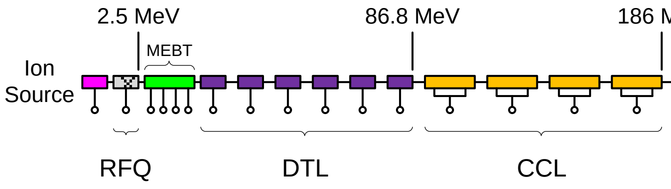
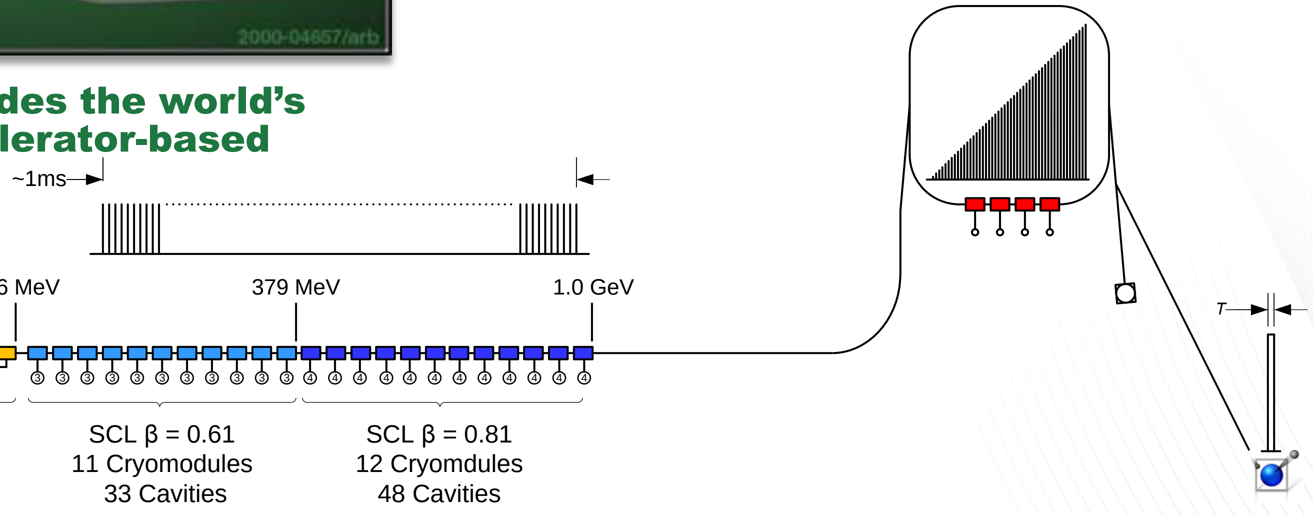
Introduction

	Design	Routine Operation
Kinetic Energy (GeV)	1.0	0.957
Beam Power (MW)	1.4	0.8-1.4
Energy per pulse (kJ)	23	13 - 23
Repetition Rate (Hz)	60	60
RF Duty Factor (%)	8	7
Linac pulse length (msec)	1.0	0.975
Average Linac Current (mA)	26	27
DTL RF Systems	6	6
DTL HVCMs	3	3
CCL RF Systems	4	4
CCL HVCMs	4	4
SCL RF Systems	81	79-80
SRF HVCMs	7	8

The SNS accelerator complex provides the world's highest beam power on target accelerator-based neutron source

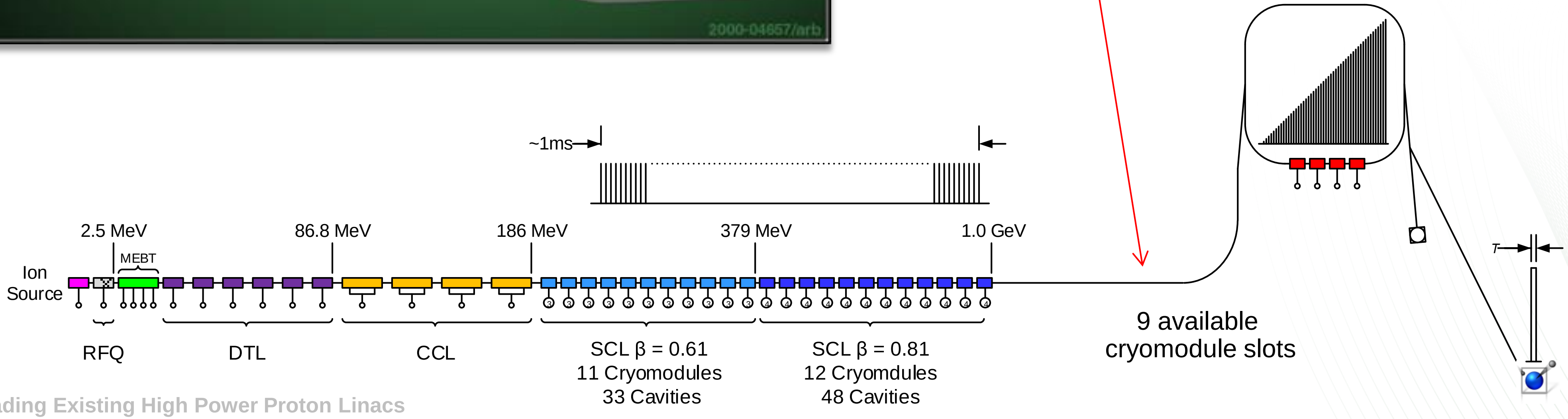




Introduction

Designed from the outset to accommodate two major upgrades

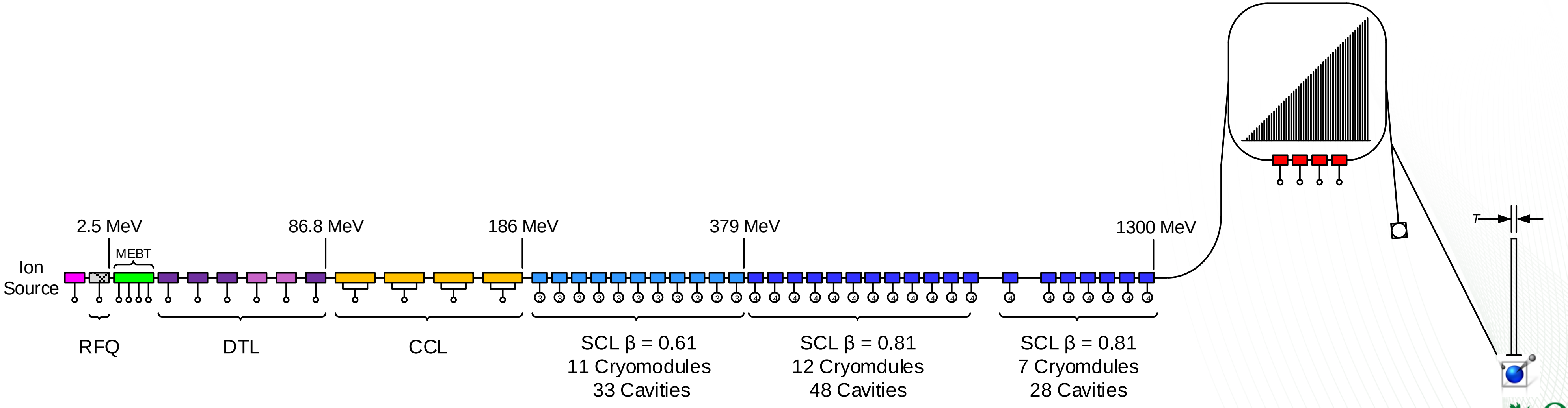
- **Second target station**
- **Power upgrade**



PPU - Parameters

- Upgrades the SNS accelerator to provide sufficient RF to support proton beam-on-target capability of 2.8MW
  - Upgrades target to handle 2MW
  - Increases energy and current

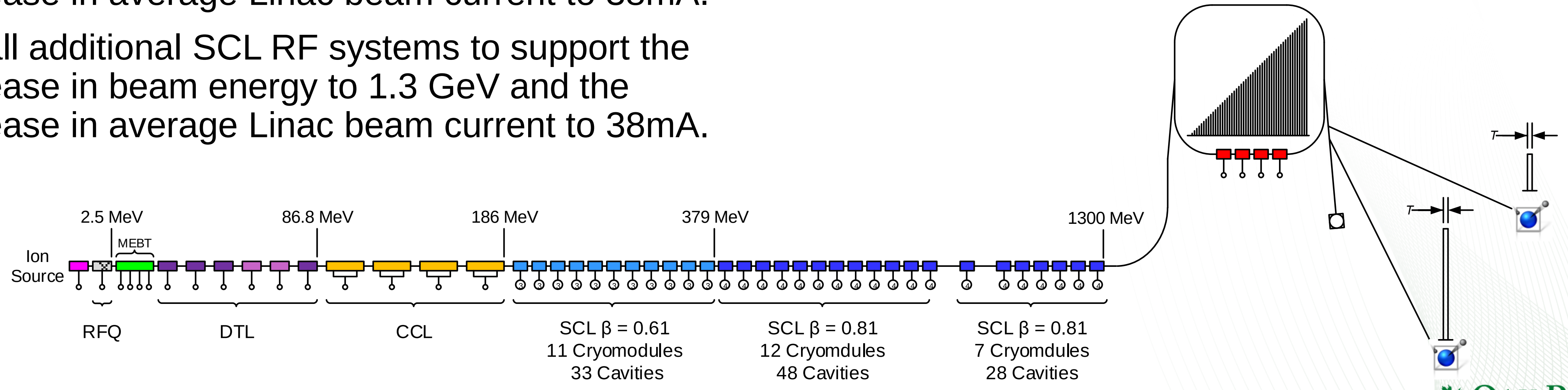
	Design	Routine Operation	PPU
Kinetic Energy (GeV)	1.0	0.957	1.3
Beam Power (MW)	1.4	0.8-1.40	2
Energy per pulse (kJ)	23	13 - 23	33
Target Material	Hg	Hg	Hg
Repetition Rate (Hz)	60	60	60
RF Duty Factor (%)	8	7	7
Linac pulse length (msec)	1.0	0.975	0.975
Average Linac Current (mA)	26	27	30
SCL HVCMs	7	8	11
SRF Cavities	81	79-80	109



PPU - Parameters

- Upgrades the SNS accelerator to provide sufficient RF to support proton beam-on-target capability of 2.8MW
  - Upgrades target to handle 2MW
  - Increases energy and current
- Installs all HPRF required for Second Target Station
  - Upgrades existing RF systems to support the increase in average Linac beam current to 38mA.
  - Install additional SCL RF systems to support the increase in beam energy to 1.3 GeV and the increase in average Linac beam current to 38mA.

	Routine Operation	PPU	FTS	STS
Kinetic Energy (GeV)	0.957	1.3	1.3	1.3
Beam Power (MW)	0.8-1.40	2	2	0.47
Energy per pulse (kJ)	13 - 23	33	40	47
Target Material	Hg	Hg	Hg	Tungsten
Repetition Rate (Hz)	60	60	50	10
RF Duty Factor (%)	7	7	7	7
Linac pulse length (msec)	0.975	0.975	0.975	0.975
Average Linac Current (mA)	27	30	38	38
SCL HVCMs	7	8	11	11
SRF Cavities	79-80	109	109	109



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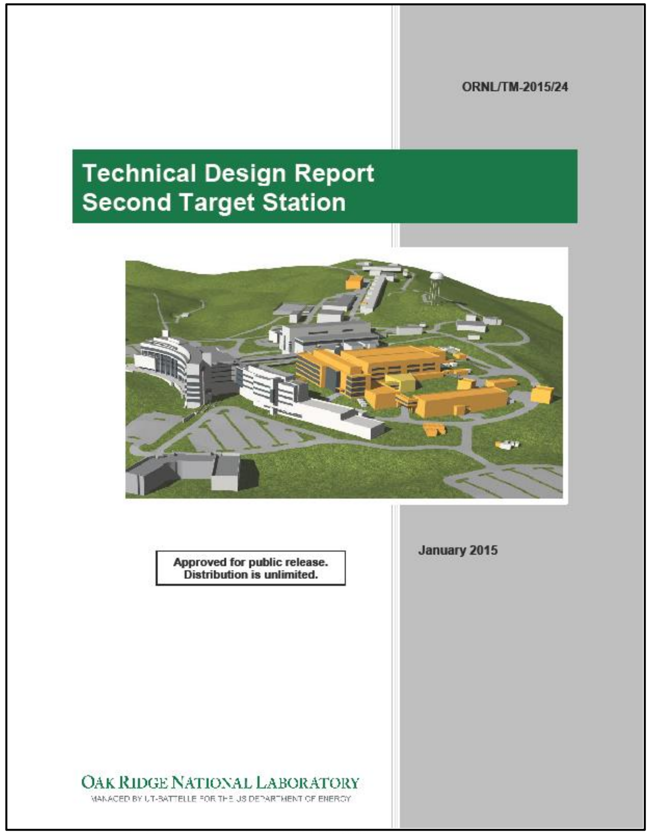
PPU - Timeline

- Nov., 2004 — CD-0 Power Upgrade Project (energy only)
- Jan., 2009 — CD-1, PUP
- 2009 — CD-0 STS
- 2011 — PUP indefinitely postponed
- 2013 — Pre-conceptual design, STS (included power upgrade)
- 2015 — Published Technical Design Report
- Early 2016 — PPU was split out (STS mission need is present basis for PPU)
- Nov. – Dec., 2016 — Conceptual Design - System Reviews

- Feb., 2017 — Director’s Review
- May, 2017 — Meador Review
- 2018 — CD-2
- 2023 — CD-4

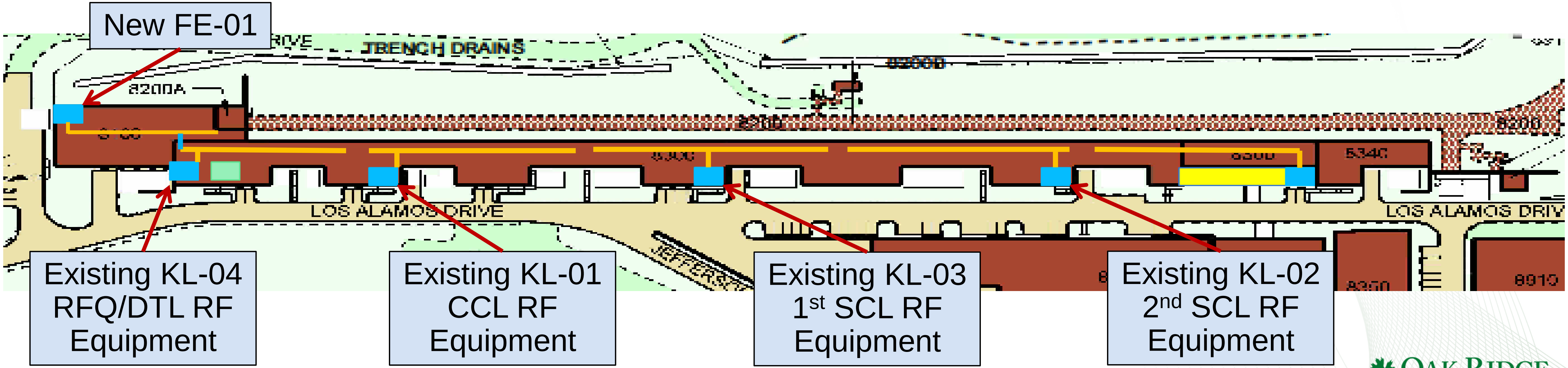


PPU - WBS Structure

P.1	Project Management	
P.2	Superconducting Linac	Cavities, Cryomodules, Plasma Processing
P.3	RF Systems	NCL and SCL RF Systems
P.4	Accumulator Ring Systems	Injection and Extraction Upgrades
P.5	First Target Station	Target Vessel, High Volume Gas Injection
P.6	Conventional Facilities	Tunnel Stub, Klystron Gallery
P.7	R&D	
P.8	Other Project Costs	

PPU - Scope

- Upgrade existing RF systems - NCL
  - New cooling system (FE-01) for the ion source, RFQ, MEBT systems
  - Upgrade existing DTL cooling system (KL-04) to increase flow and heat transfer
  - Upgrade DTL4 and DTL5 transmitters to support 3MW klystrons
  - Modification of DTL HVCM to support 3MW klystron operation
  - Only minor modifications to most of the NCL HVCMs anticipated



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PPU - Scope

- Upgrade existing RF systems - SCL
  - Existing SCL HVCMs have remaining margin and are expected to be capable of supporting the required increases in voltage.
  - SCL cooling systems will be upgraded to allow for an increase in flow and heat transfer.

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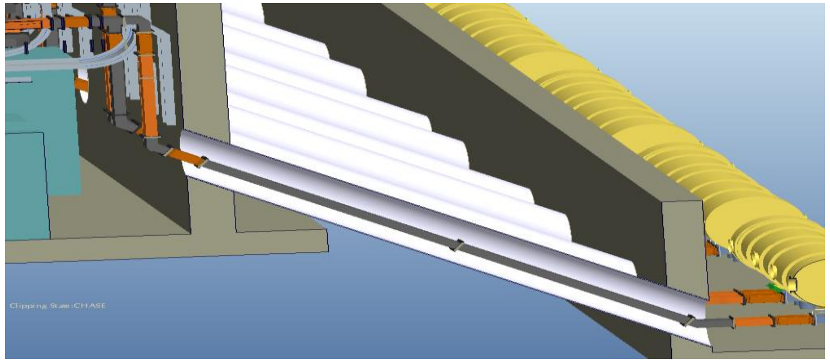
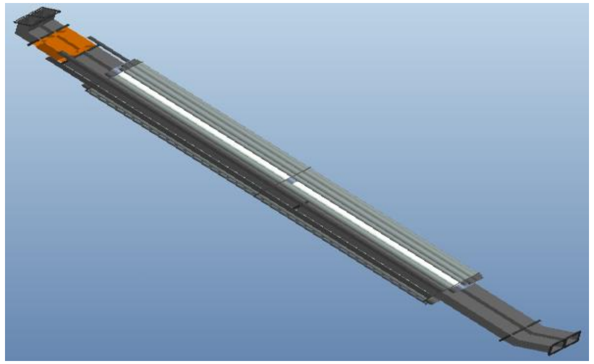
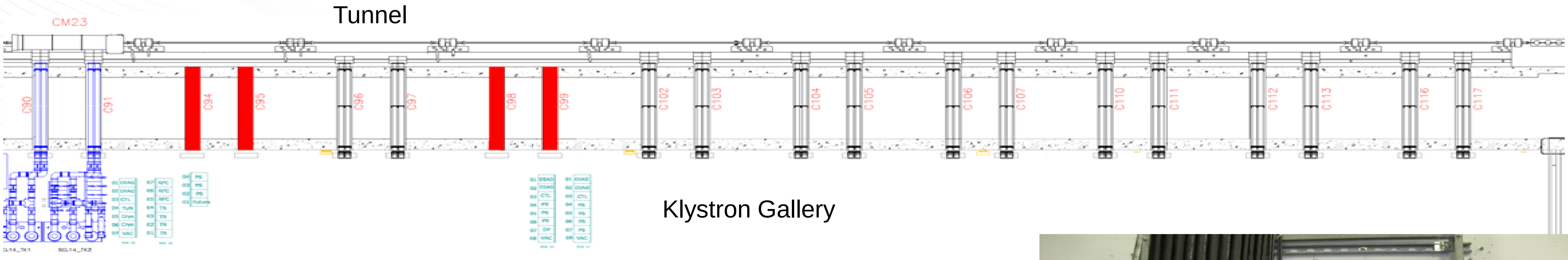
PPU - Scope

- Chases



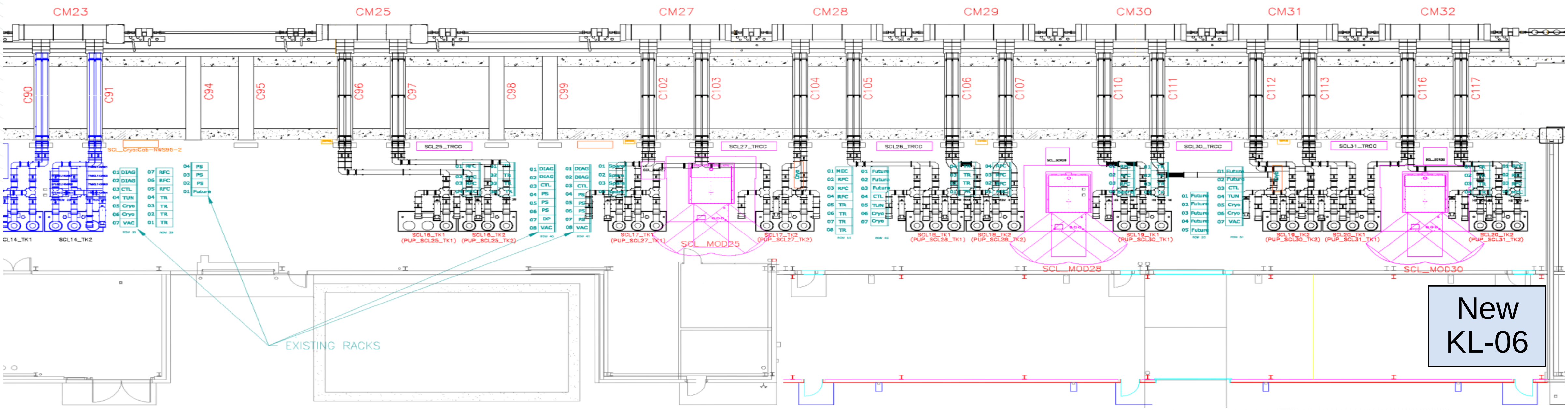




- Reconfigure cabling and install 12 chase inserts
  - An insert has already been installed in chase 105

PPU - Scope

- Install additional SCL RF systems to support increase in beam energy



- Additional pump room (KL-06)
- Low impedance ground
- AC power distribution
- Cable tray, cable routing, equipment racks

- 28 high-β cavities in 7 cryomodules
- 28 LL/HPRF systems
  - 5 transmitters (6 tubes per transmitter)
  - 5 cooling carts
- 3 “alternate topology” HVCMs

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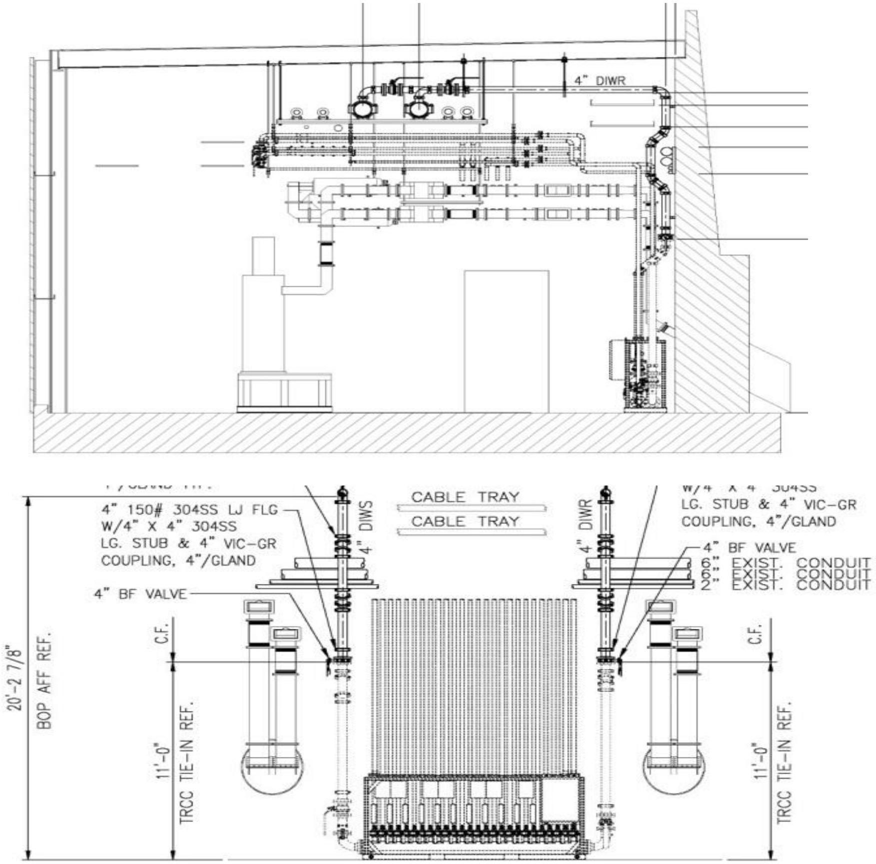
PPU - Scope

- SCL Transmitters



- Form factor and functionality identical to baseline installation
- Minor modifications to transmitters based on 10 years of operations
- Sole source with original vendor
- 700kW klystrons
- New compact water cart design using ultrasonic flow detection

PPU - Scope

- SCL HVCMs
  - 3 “alternate topology” HVCMs
    - Identical form factor
    - Reduces HV stress
    - Eliminates boost capacitor
      - Prone to failure
    - Topology is load tolerant
  - Next generation controller
    - Provides new capabilities
      - Pulse flattening
      - High speed data logging
      - Enhanced fault analysis

High-Voltage Converter Modulator (Alternate Topology)

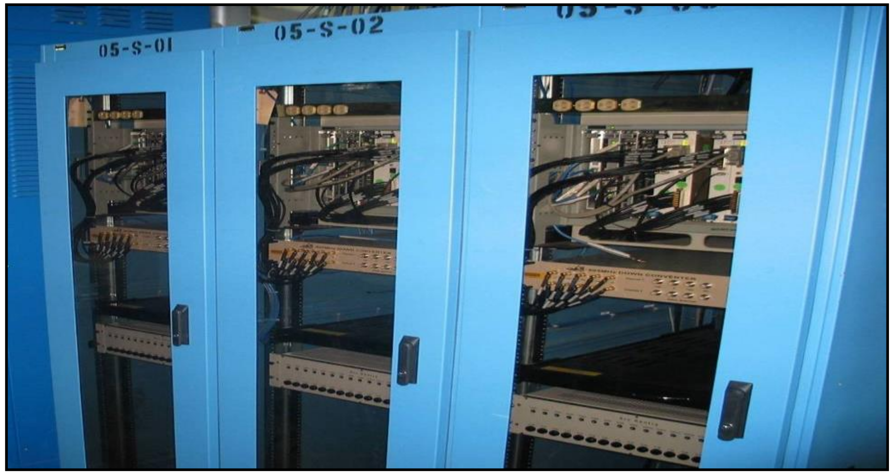
Next Generation Controller

1.5MVA Transformer, 13.8kV/2.1kV 3Φ

SCR Cabinet

PPU - Scope

- LLRF
  - The current LLRF system for the Linac is obsolete
  - There are sufficient spares
  - The current LLRF system does not meet Second Target Station requirements
  - Baseline approach is to develop replacement LLRF system on µTCA.4 platform
    - Allows for use of commercial-off-the-shelf hardware
    - Controls group is also considering the µTCA platform
    - Other platforms being evaluated
  - 28 systems will be installed



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PPU - Scope

- Controls – Linac
  - EPICs interfaces to AT-HVCMs and the LLRF
  - Software interfaces to new RF transmitters
  - SCL cavity tuner motor controls
  - SCL coupler bias power supply controls
  - SCL coupler cooling water

PPU - Scope

- Controls – Global
  - Timing system
  - Machine Protection System (MPS)
  - Personnel Protection System (PPS)
  - Linac water system controls
  - Linac cryomodule controls
  - Linac water system controls
  - Beam line vacuum controls
  - Insulation vacuum system controls

Summary

- PPU installs all the HPRF required for STS
- Incorporate lessons learned from 10 years of operation
- Retain compatibility with existing systems wherever possible
- Leverage existing system designs to implement upgrades and improvements
- Address obsolescence issues
- Adopt common open-standard COTS high-speed digital platform
- Use COTS components wherever possible
- Currently preparing for CD-1

Thank you for your attention!