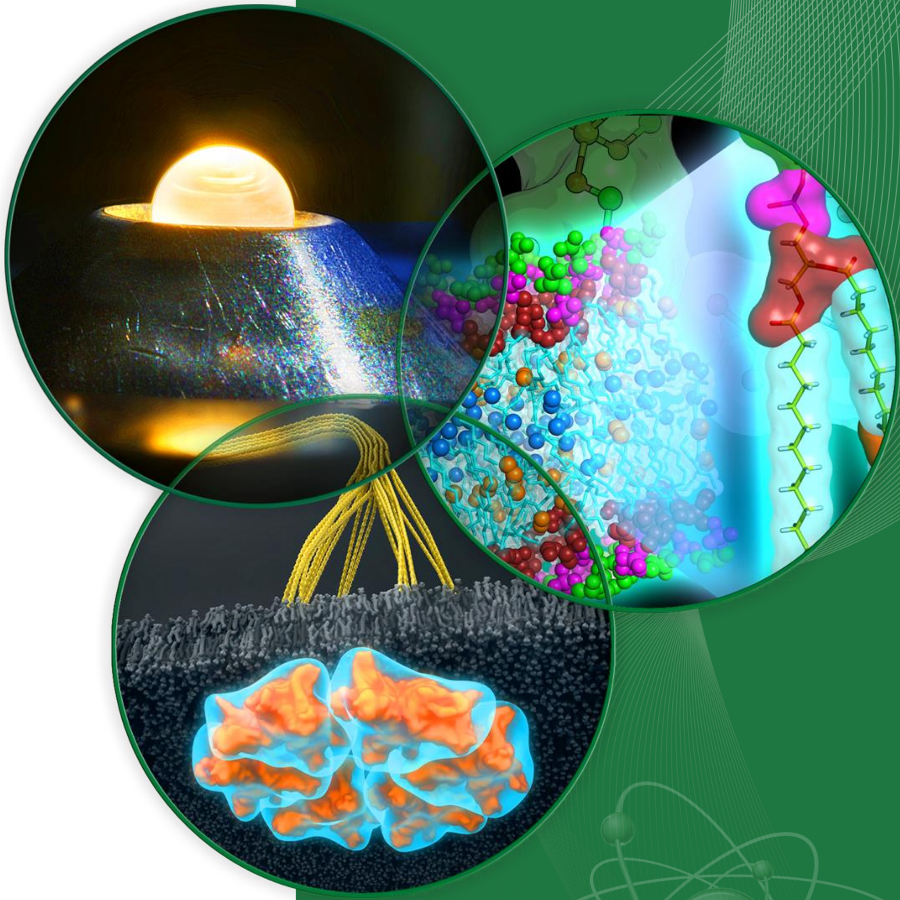
Second Target Station



Presented to
Neutron Advisory Board

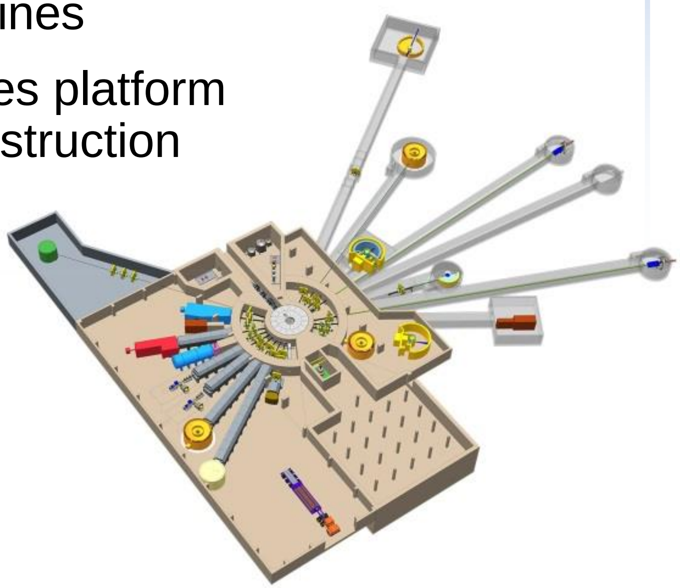
Presented by
John Galambos
STS / PPU Project Office Director

June 30, 2016
Clinch River Cabin
Oak Ridge, Tennessee

STS / PPU: Single Mission, Separate Projects

SNS-PPU

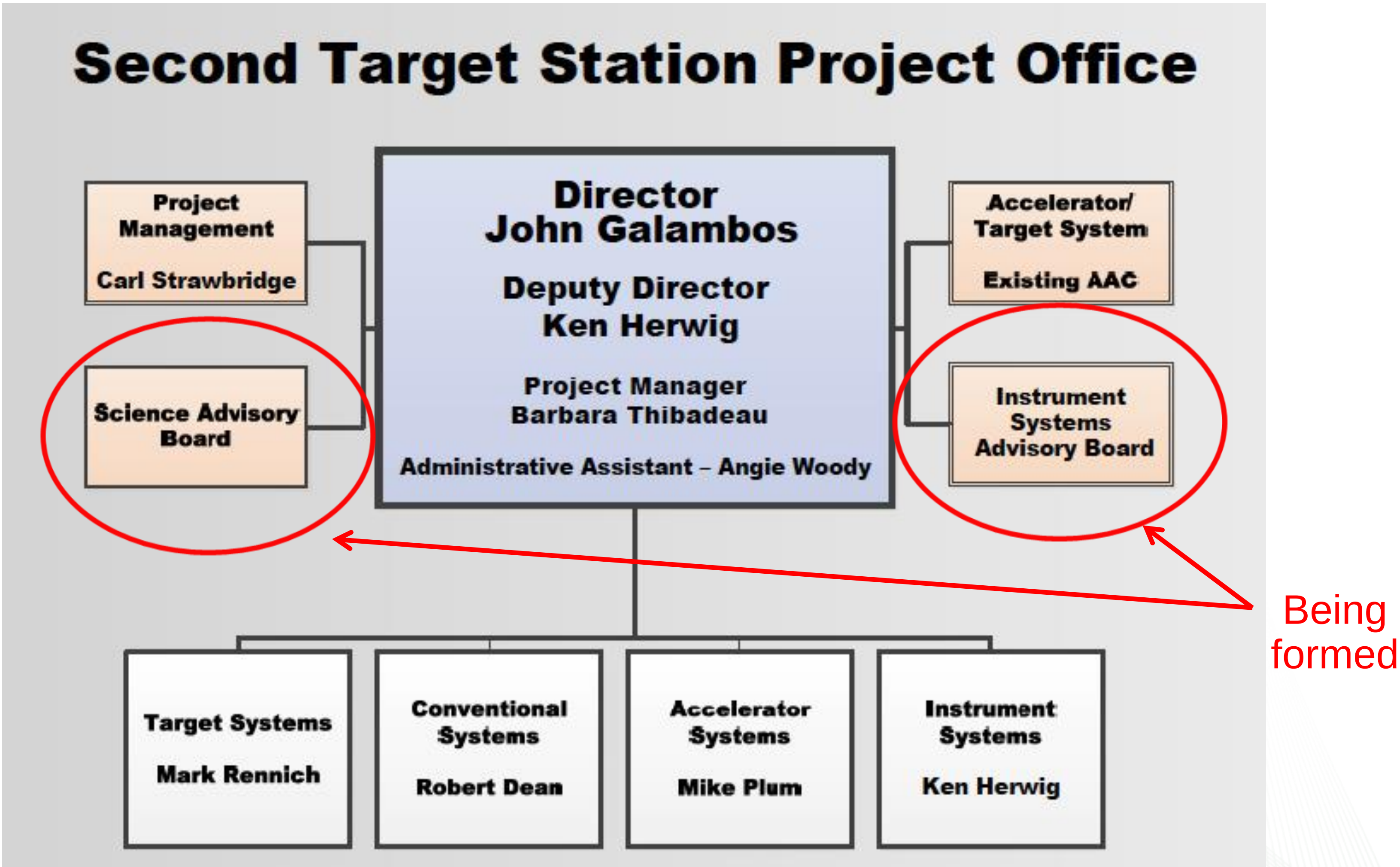
- Increases power capabilities of existing 60 Hz accelerator structure from 1.4 MW to 2.8 MW
- Increases power delivered to first target station (FTS) to 2 MW
- Increases neutron flux on available beam lines
- Provides platform for construction of STS



SNS-STS

- Initial suite of 8 beam lines, with capacity to accommodate 22 beam lines
- 467 kW diverted to STS by additional accelerator systems
- 10 Hz repetition rate, enabling broad dynamic range
- World's highest brightness short-pulse source optimized for cold neutrons
- 380,000 ft^2 of new infrastructure

STS / PPU Project Organizations Formed



STS / PPU: separate structures – common components

Project Framework Established

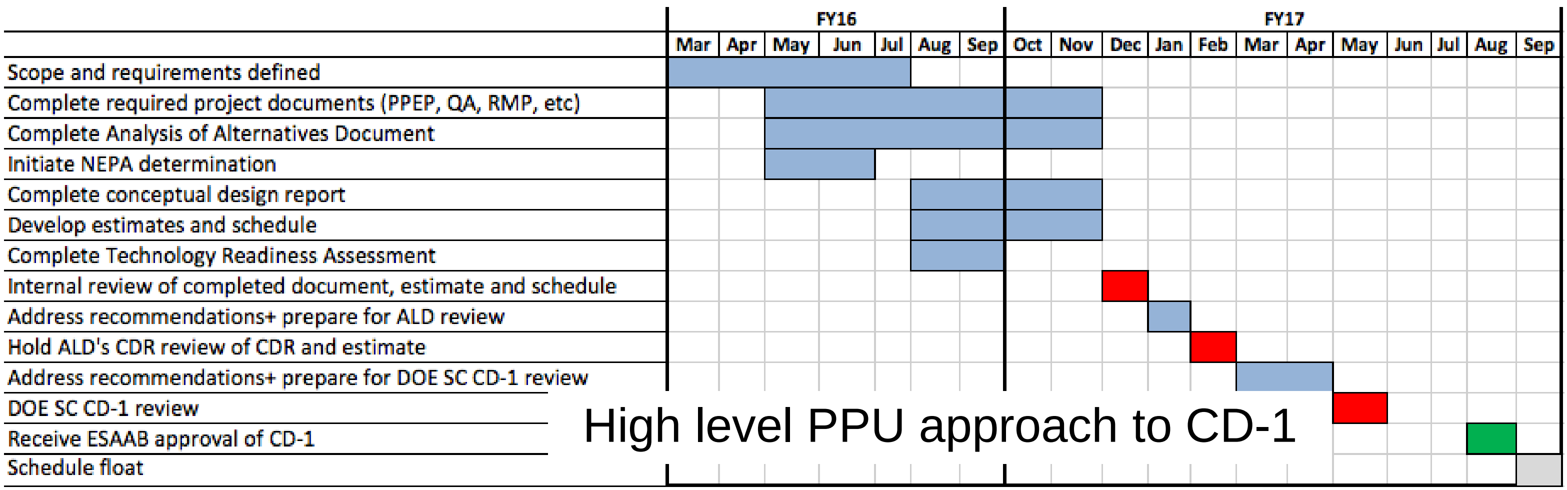
- WBS for PPU and STS are defined
  - Scope definitions to level-6

WBS L2	WBS L3	WBS L4	WBS L5	WBS L6	CAM
P.1	Project Management- John Galambos				
	P.1.1	Project Management			
		P.1.1.1	Management	Project Director, Project Manager, Administrative support, Travel	CAM name
		P.1.1.2	Reviews and committees	Reviews, advisory committees, etc.	CAM name
	P.1.2	Project Support			
		P.1.2.1	Project Controls	Project controls staff, software licenses, training, travel	CAM name
		P.1.2.2	Finance	Finance staff (including M&S and travel if appropriate)	CAM name
		P.1.2.3	Procurement	Various support staffs and associated M&S	CAM name
		P.1.2.4	IT/Information Management	Various support staffs and associated M&S	CAM name
		P.1.2.5	HR	Various support staffs and associated M&S	CAM name
		P.1.2.6	Communications	Various support staffs and associated M&S	CAM name
	P.1.3	ESH&Q	ESH&Q	CAM name	
		P.1.3.1	ESH&Q	ESH staff, QA staff, associated M&S and travel, costs for ARRs and safety related reviews	
P.2	SCL- Matt Howell				
	P.2.1	System Management			
		P.2.1	Management and Intra-System Integration	Costs for management of this particular system, admin support dedicated to system, travel and M&S that does not directly benefit one of the individual systems, includes integrated testing within subsystem	CAM name
	P.2.2	Cavities- Senoir SRF engineer			
		P.2.2.1	Management and Intra-System Integration	Costs for management of this particular system, admin support dedicated to system, travel and M&S that does not directly benefit one of the individual systems, includes integrated testing within subsystem	CAM name
		P.2.2.2	Cavity Procurement- Senoir SRF engineer		
			P.2.2.2.1	Integration	Labor costs associated with management of cavity procurement.
			P.2.2.2.2	Design	This WBS includes design of the cavities, incorporating all lessons learned from previous operation and development of the high beta cavities. T
			P.2.2.2.3	Fab/Procure	Twenty eight 0.81 beta cavities will be procured with bulk chemical processing and vacuum bake out. Vendors will be evaluated based on technical capability, past performance, and the ability to respond to the schedule. Previously, it has benefitted the project to procure the niobium and niobium/titanium alloy material separately and supply that

- Technical Design Report (Jan, 2015) is design basis
- Staff
  - Largely matrixed from operations (similar to APS-U)
    - 78 people have charged to PPU or STS through May
  - 6 contracts for outside individual support
  - Subcontracts for AE and system measurements
- Meetings
  - STS & PPU weekly
  - Level 2 teams have own meetings

PPU: Process towards detailed design evaluation

- DOE project critical decisions:
  - CD-0: Mission Need (STS has this)
  - CD-1 Approve baseline performance (conceptual design + initial cost estimate)



High level PPU approach to CD-1

- PPU: proceed to CD-1 in FY-17
  - Conceptual Design Report this summer
  - System reviews early next year
  - DOE CD-1 review May 2017

OAK RIDGE National Laboratory

SNS-PPU: Path to increased power

Accelerator power =	Energy ×	Current ×	Pulse length ×	Repetition rate
1.4 MW	0.94 GeV	26 mA	1 ms	60 Hz
2.8 MW	**1.3 GeV**	**38 mA**	1 ms	60 Hz

SRF linac

7 new SRF cryomodules

Associated RF support equipment

→

Copper linac

Upgrade some RF equipment

→

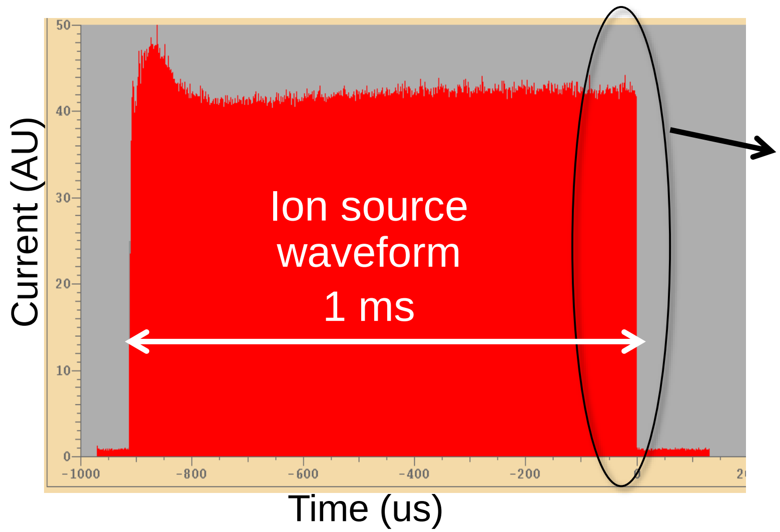
Ring

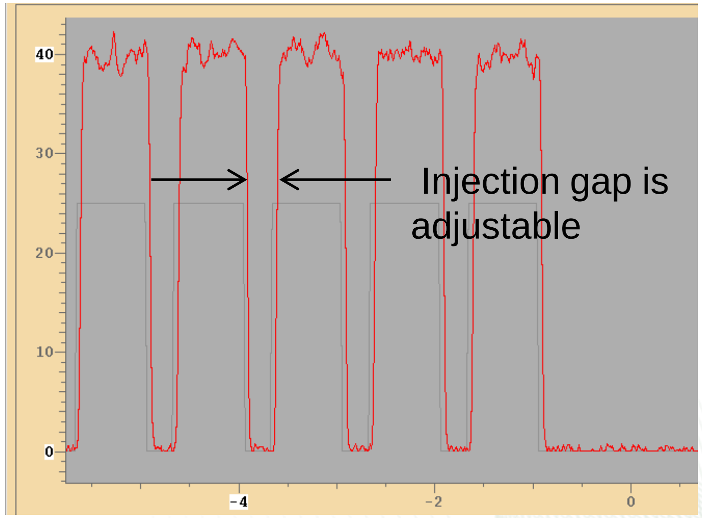
New injection magnets

2 new extraction kickers

PPU and STS are technically decoupled

- PPU provides 47 kJ per pulse – needed for STS
  - 2.8 MW at 60 Hz
- Can modulate power delivered to each target
  - Adjusting the linac chopping fraction, can reduce power to FTS
- 10 Hz /20 Hz
  - Pulses can be diverted to STS at any frequency





PPU leverages technology developed for 1.4 MW

Ion source test stand
has led to current increases,
demonstrating capability
required for PPU

Ring damper system
is operational, providing
insurance against
instabilities at higher
PPU intensities

Spare SRF cryo-module
operational since 2012,
demonstrating PPU
required cavity gradient

Spare RFQ is ready
for beam tests and
is expected to provide
required PPU transmission

Plasma processing
for in situ cavity gradient
recovery, needed to improve
poorly performing installed
cryo-modules,
has been demonstrated

2015 Accelerator Advisory Committee*:*

"… decision to utilized existing accelerator technology is to be commended."

"supports the decision to reduce the number of cryo-modules from 9 to 7"

2016 Accelerator Advisory Committee:

"Many of the present upgrades will provide a good foundation for the PPU."

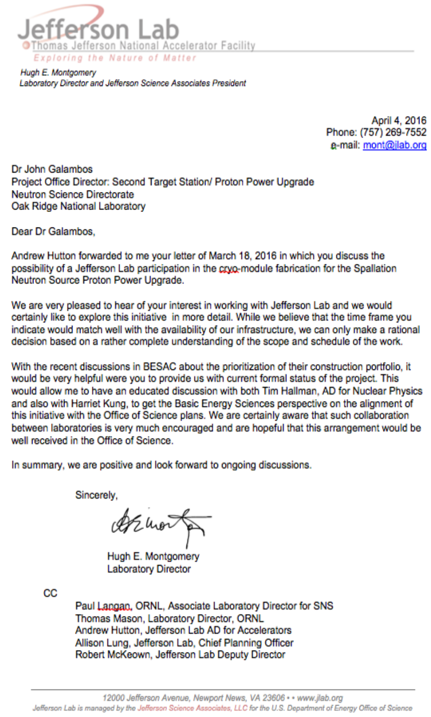
Oak Ridge National Laboratory

PPU: Movement towards CD-1

- Defining approach for PPU equipment delivery: minimize in house effort
  - Statements of interest from partner labs (FNAL and J-Lab) for building superconducting RF cryo-modules
  - Partner with industry for high voltage modulator fabrication
  - Magnet fabrication

- High level schedule produced
  - Defines activity linkages
  - Understand operational interfaces

J-Lab director letter of support for SRF fabrication



Jefferson Lab
Thomas Jefferson National Accelerator Facility
Exploring the Nature of Matter

Hugh E. Montgomery
Laboratory Director and Jefferson Science Associates President

April 4, 2016
Phone: (757) 269-7552
e-mail: mont@jlab.org

Dr John Galambos
Project Office Director: Second Target Station/ Proton Power Upgrade
Neutron Science Directorate
Oak Ridge National Laboratory

Dear Dr Galambos,

Andrew Hutton forwarded to me your letter of March 18, 2016 in which you discuss the possibility of a Jefferson Lab participation in the cryo-module fabrication for the Spallation Neutron Source Proton Power Upgrade.

We are very pleased to hear of your interest in working with Jefferson Lab and we would certainly like to explore this initiative in more detail. While we believe that the time frame you indicate would match well with the availability of our infrastructure, we can only make a rational decision based on a rather complete understanding of the scope and schedule of the work.

With the recent discussions in BESAC about the prioritization of their construction portfolio, it would be very helpful were you to provide us with current formal status of the project. This would allow me to have an educated discussion with both Tim Hallman, AD for Nuclear Physics and also with Harriet Kung, to get the Basic Energy Sciences perspective on the alignment of this initiative with the Office of Science plans. We are certainly aware that such collaboration between laboratories is very much encouraged and are hopeful that this arrangement would be well received in the Office of Science.

In summary, we are positive and look forward to ongoing discussions.

Sincerely,

Hugh E. Montgomery
Laboratory Director

CC

Paul Langan, ORNL, Associate Laboratory Director for SNS
Thomas Mason, Laboratory Director, ORNL
Andrew Hutton, Jefferson Lab AD for Accelerators
Allison Lung, Jefferson Lab, Chief Planning Officer
Robert McKeown, Jefferson Lab Deputy Director

12000 Jefferson Avenue, Newport News, VA 23606 • • www.jlab.org
Jefferson Lab is managed by the Jefferson Science Associates, LLC for the U.S. Department of Energy Office of Science

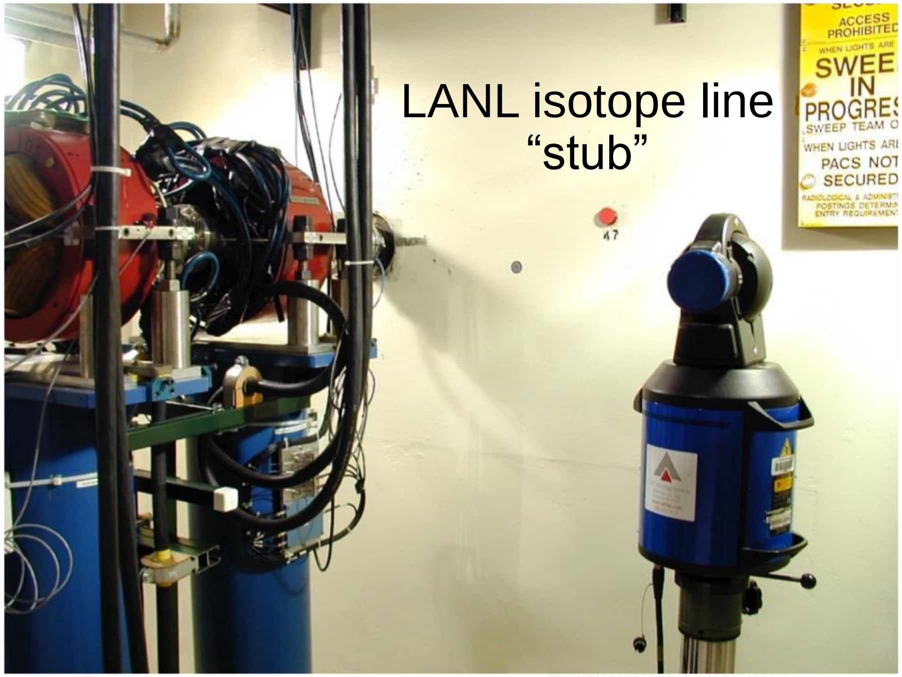
Other CD-1 Preparations

- Alternates: examining higher power options
  - Increased risk as we move farther from our established technology base
- Schedule: be poised to start spending project funds in FY18
  - Securing space to clear out klystron gallery Jan. 2018
  - Statements of work prepared
- NEPA documents

PPU: Managing SNS operations impact

- Tunnel activities during normal maintenance outages

- One 6 month outage at the project end
  - Ring injection chicane
  - Last cryo-module install
  - Install a “stub” in the RTBT for connection to STS tunnel
  - Coincide with 3 month IRP replacement



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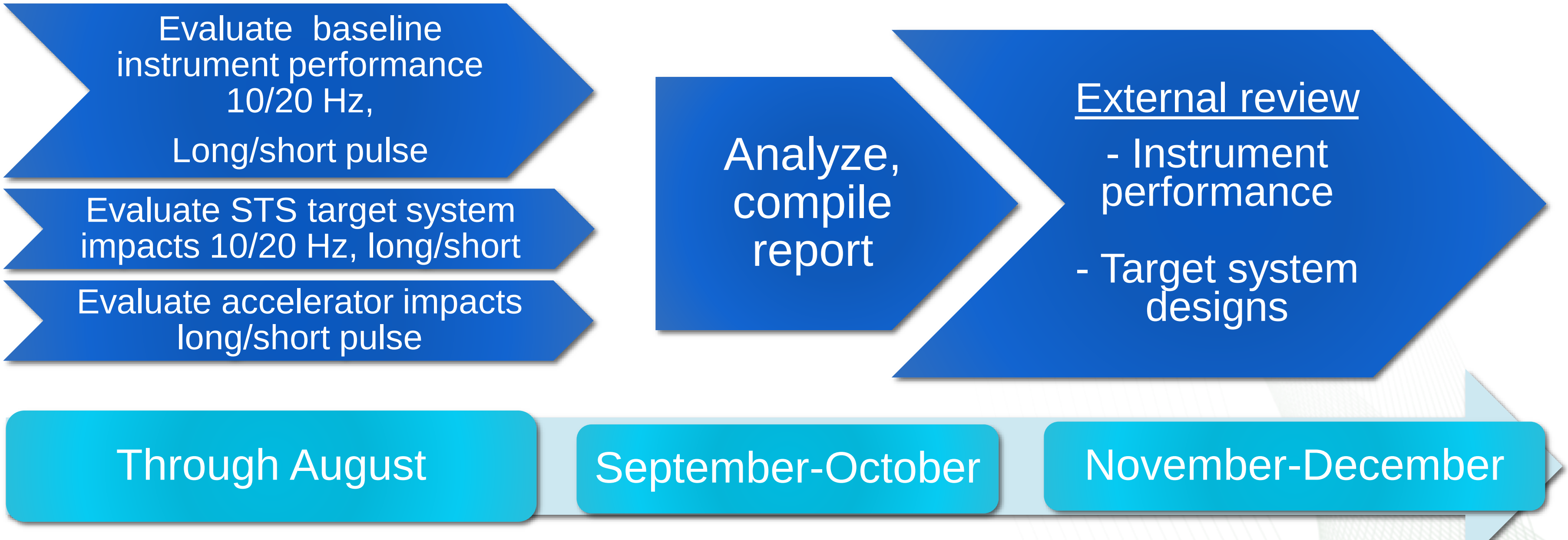
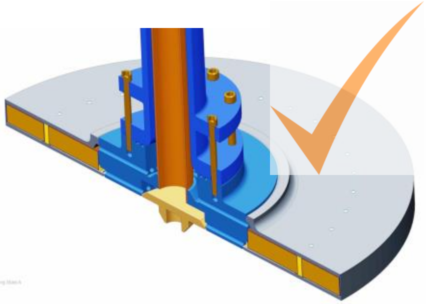
STS: Process towards detailed design evaluation

- Refine the design
  - Target concept
  - Conventional facility building requirements and site layout
  - Instrument concepts, requirements
- Address 10/20 Hz, long pulse
  - Instrument performance and target system impacts

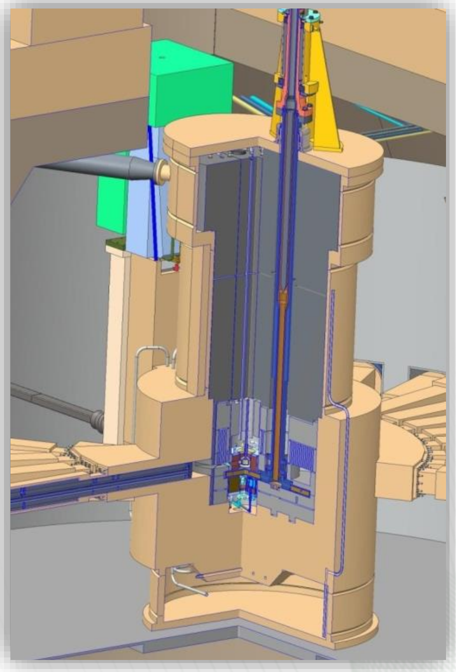


STS 2016 Target System Activities

- Solid W target: rotating target adopted
  - Facilitates higher power



- Target systems reconfigured
  - Vertical maintenance
  - No hot-cell
  - Bunker approach for beam-line / target interface



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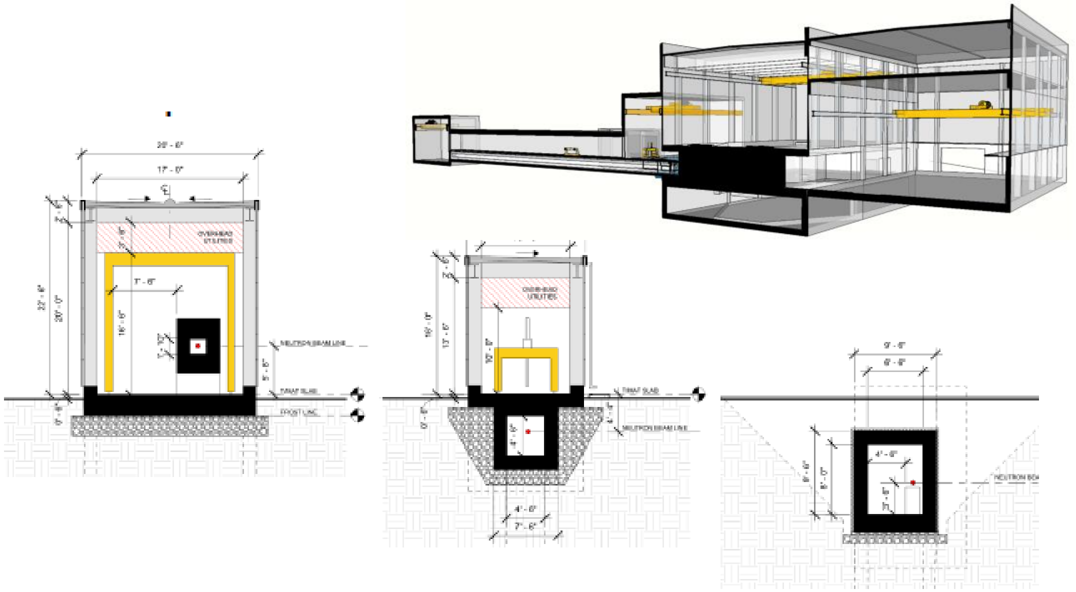
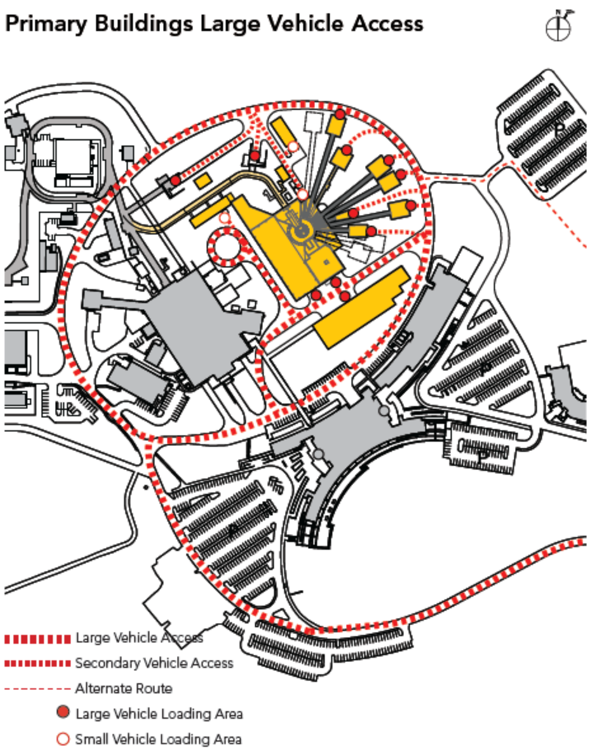
STS 2016 Conventional Facilities Activities

- Evaluating neutron beam-line and new target hall elevations
  - Decisions this summer



"Above Grade" "Trench" "Tunnel" Opt A



- Site Layout
  - Building access
  - Building size requirements

Summary

- STS/PPU project office is formed
  - Organizations are moving forward

- Process is defined for design evaluation
  - PPU: CD-1 in FY17
  - STS: Refine the technical design and review this calendar year

Questions?

Backup

SNS upgrade is packaged as 2 projects: SNS-PPU and SNS-STS

SNS-PPU upgrades the existing accelerator structure

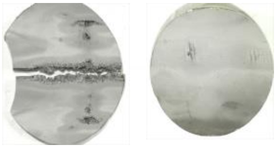
Increases neutron flux to existing beam lines

Provides a platform for SNS-STS

SNS-STS constructs a second target station with an initial suite of 8 beam lines

Mission need and science case for SNS-PPU and SNS-STS are the same

PPU target plan: coupled to FTS activities



Ongoing target post irradiation examination, instrumentation

Input to design evolution

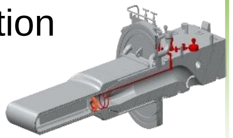
2016

2018

2021

2023

FTS Target Reliability
- Structure/fabrication
- Gas injection
- Flow



1.4 MW reliable operations

PPU final target design

Internal goal is 2 MW

PPU complete

Gas wall injection development

Evaluation of auxiliary target systems (shielding, cooling, …)

Red = PPU Activities

STS target systems 10/20 Hz impact assessment

- ~ 35 impacted systems are identified
  - Cooling, rad waste, shielding, choppers, …
- Cost impact estimate has begun
  - S9ome systems remain to be evaluated – complete for fall review
- Target systems are not expected to be a major cost driver for the 10/20 Hz decision

System	Aspect/Subsystem	Impact of Higher Rep Rate	Reasoning	20 Hz Cost Impact	Cost Inflection Rate	Operating Inpact
Shielding						
	Bulk Shielding	Modest size increase	Only a small increase in shielding thickness would be needed for a factor of 2 or 3 increase in power -ANALYSIS REQUIRED	Small	None	None
	Shutters; Beam on	None	Only a small increase in shielding thickness would be needed for a factor of 2 or 3 increase in power-ANALYSIS REQUIRED	None	None	None
	Shutters; Beam off	Possible depth increase	Shutter beam-off requirmeents are based on target area activation; increased beam on target time will increase activation proportionately - shutter depth could increase up to xxx% for a doubling of the rep rate	???	None	None
Vessel						
	Size/configuration	Modest size increase	The vessel exterior defines the active cooled outer limit. Thus, the lower portion of the vessel will increase in diameter and height by several inches-ANALYSIS REQUIRED	<$100K	None	None
	Actively cooled shielding inside vessel	Size Increased	The power increase will lengthen the actively cooled shield plugs; Likewise the dpa damage boundary will increase thus increasing the diameter of the plugs.ANALYSIS REQUIRED	????	None	None
Moderators						
	Size/configuration	None	In order to maintain the physics performace of the system the basic moderator size and configuration must remain constant	None	None	None
	Cryogenics	Cryogenic system and piping must be increased in size in proportion to the time average power increase	Deposited heat will increase proportional to rep rate.-ANALYSIS REQUIRED TO CONFIRM ASSUMPTION	????		???
	Life	Life could be decreased	Increasing the thickness of the poison layer could compensate for the increased dpa damage	None	???	Possible decrease in moderator neutronic efficiency for same lifetime, Possible increase in reflector plug change-out rate
Reflector						

…

STS FY 2016 Project Activities

STS project office formed

STS - PPU split

Funds arrive ($10M)

AAC review

Oct 2015 | Nov | Dec | Jan | Feb | Mar | Apr | May | June | July

STS user workshop

Kickoff

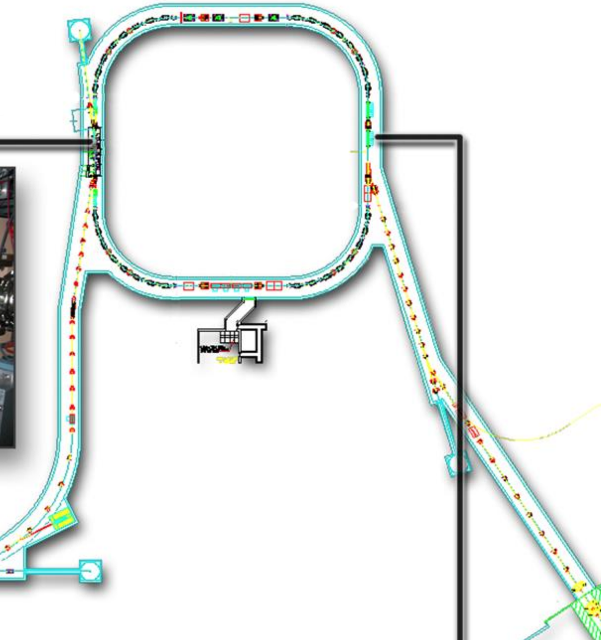
Sub-committee

Report

BESAC Facility Upgrade Panel Reports
- STS science case
- 3 source strategy
- Technical basis

Ready to proceed: Accelerator provisions exist for beam energy increase

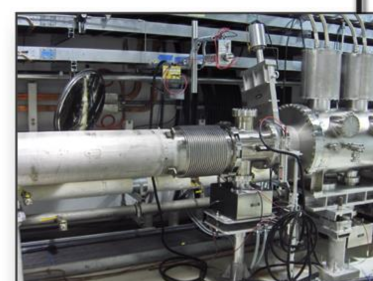
96% of ring/transport magnets are 1.3 GeV ready



Beam injection: Upgrade injection magnets

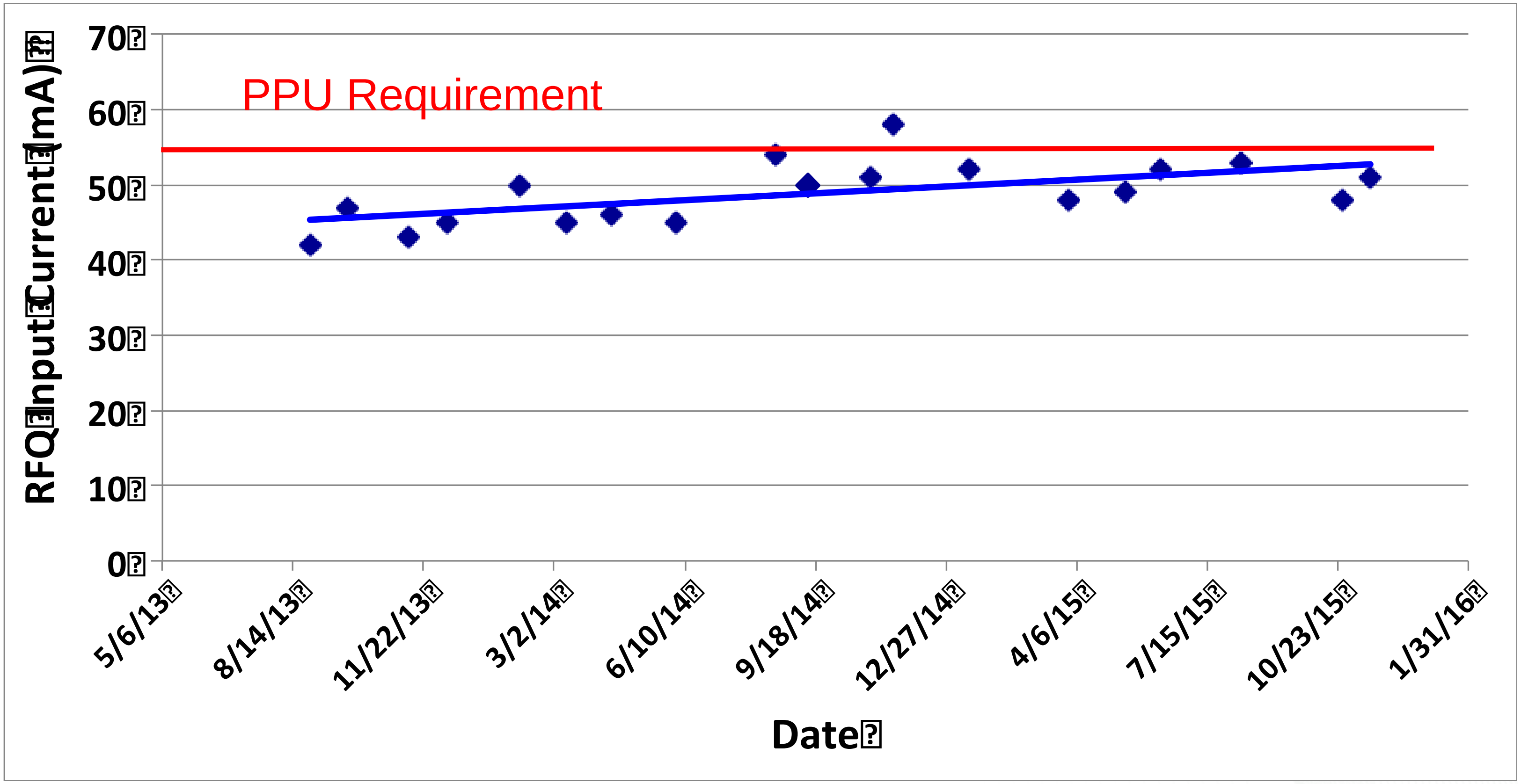
Tunnel: Fill 7 empty drift sections with cryo-modules (space available for 9)

Klystron gallery: Fill empty area with high-power RF equipment



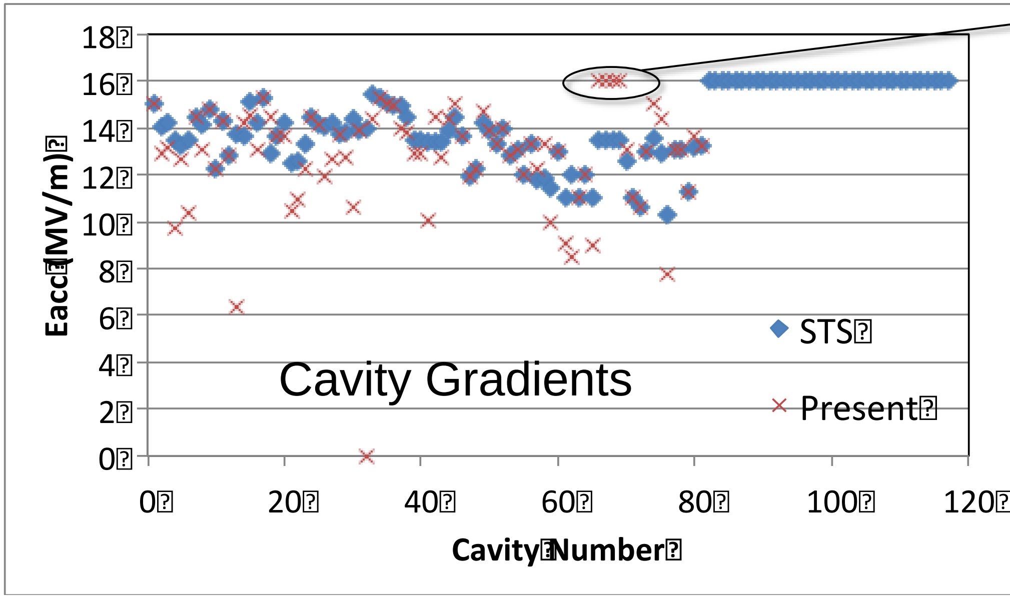
Beam extraction: Fill empty space with kickers

Ion source current: PPU requirement demonstrated



- We would like 10-20% margin: keep improving

SRF for 1.3 GeV: leverage operations developments



Existing spare cryomodule performance

<u>Gradients</u>

- PPU gradient is the same as the 2012 spare CM
- Poor performers are improved by plasma processing
- Only need 7 new cryo-modules: space exists for 9