Power Upgrade and Second Target Station Update

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Accelerator Advisory Committee Meeting

May 2013

A Brief History of the Power Upgrade Project (PUP)

- **SNS was designed from the outset to accommodate doubling the SNS proton beam power and adding Second Target Station (STS)**
  - **Both efforts ranked very-high priority in 2003 DOE future facility ranking**

Power Upgrade Timeline

Nov. 2004: CD-0, Double power, beam energy and current increase, CD-4 in 2012, $160 M

2008: PUP changed to energy increase only ($90-96M), current increase through AIP

Jan. 2009: CD-1, same cost as before

Jan. 2010 – July 2011: PUP organization formed, CD-2 basis developed , cost = $131M

July 2011: PUP “indefinitely postponed”, effort bundled with second target

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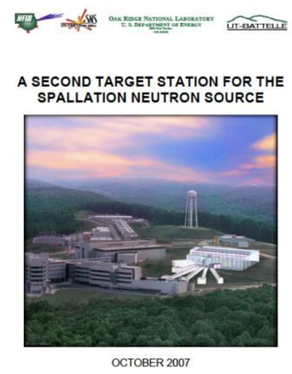
A Brief History of the Second Target Station



2007: STS workshops + study group, recommended long pulse option.

2008-2010: small internal effort, rotating target, site considerations, accelerator parameters

2013 BESAC facility prioritization: STS absolutely central, scientific/engineering challenges to resolve before initiating construction.

STS Time-line

Jan. 2009: CD-0, mission need approval

Mid 2011– present: re-evaluate short pulse / long pulse, option from the user perspective + source moderator optimization

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STS Studies over the Past Two Years Concentrated on the Neutron Source

- 10 Hz, long wavelength neutron source
  - Moderator / target / reflector system optimized for high flux
  - Short pulse
  - 300 – 500 kW beam power
  - Similar to the strategy taken at the ISIS second target station
- This power level requires ultimate single pulse intensity from accelerator

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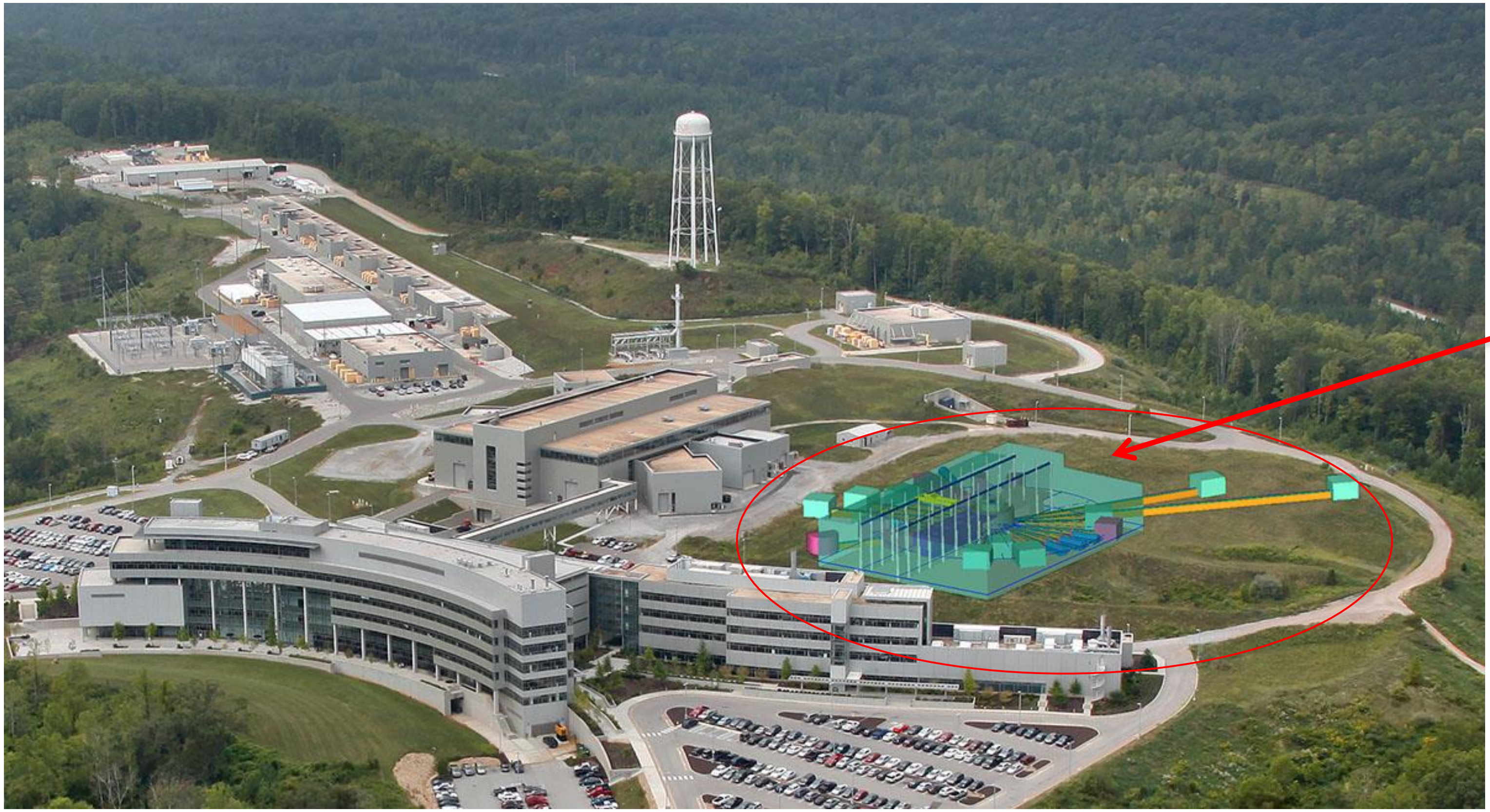
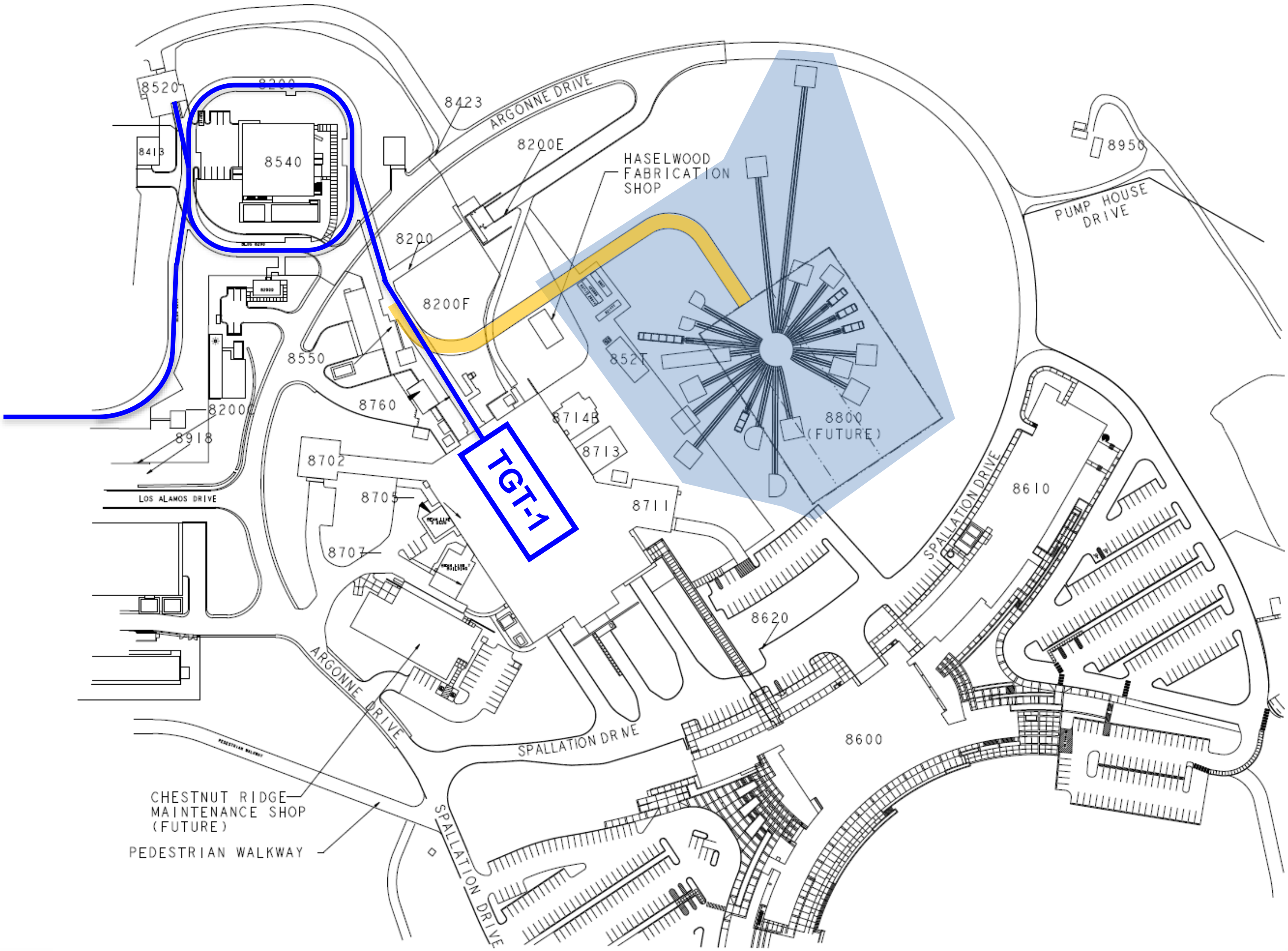
Second Target Station

- **A second target station is planned for SNS. Will probably require 300 – 500 kW, short pulse from ring (< 1 us)**



Second target station

Second target station and instrument suite fits well onto SNS site



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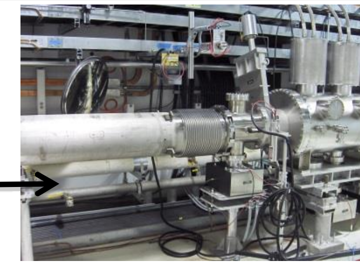
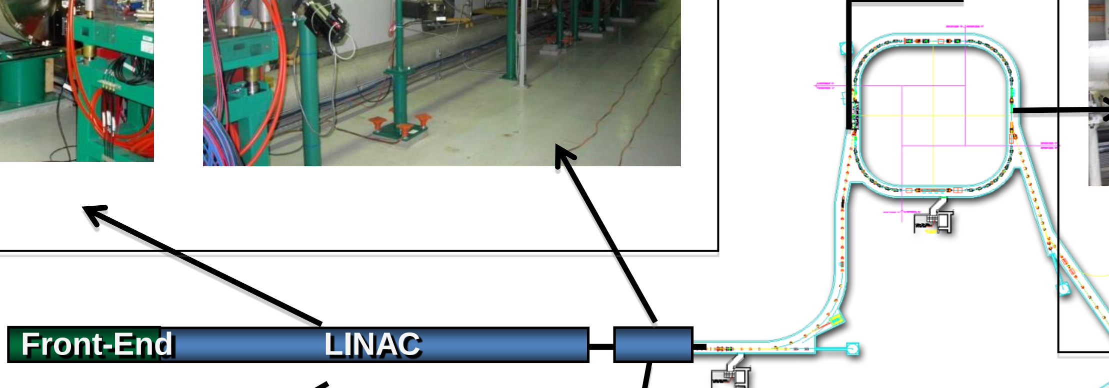
Primary PUP Impact Areas

Tunnel: fill in empty drift sections with cryomodules



Extraction: fill in empty space with kickers



Klystron gallery: fill in area provided with high power RF equipment

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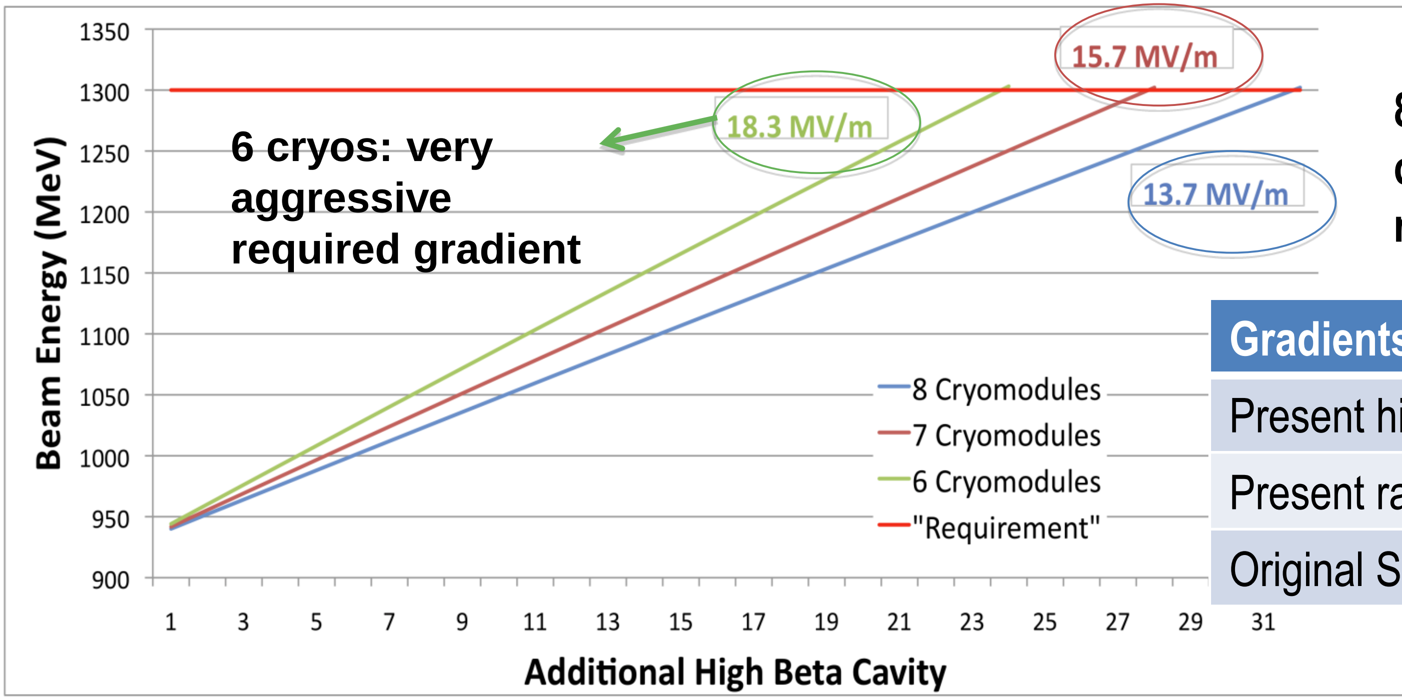
PUP Superconducting Cavity Gradient Requirements Are Modest

- SCL requirements: 8 cryomodules to reach 1.3 GeV
  - There are 9 empty slots available, one for spare
    - Tech note PUP0-300-TR0001-R00
  - Long term SNS power upgrade impacts included
    - Tech note STS02-21-TR0001-R00

7 cryos: aggressive required gradient



8 cryos: conservative required gradient

Gradients	MV/m
Present high beta	12.8
Present range	7.7-15.4
Original SNS design	15.6

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Cryomodules are a Large Part of the Power Upgrade

- **PUP SCL cryomodules are based on spare cryo-module design (see M. Howell's talk)**
  - Required accelerating gradients are low for upgrade (spare cryomodule averaged higher, ~ 16 MV/m)
  - Simplify the design based on lessons learned (no Higher Order Mode couplers, no piezo tuners, etc.)
  - Pressure vessel code compatible

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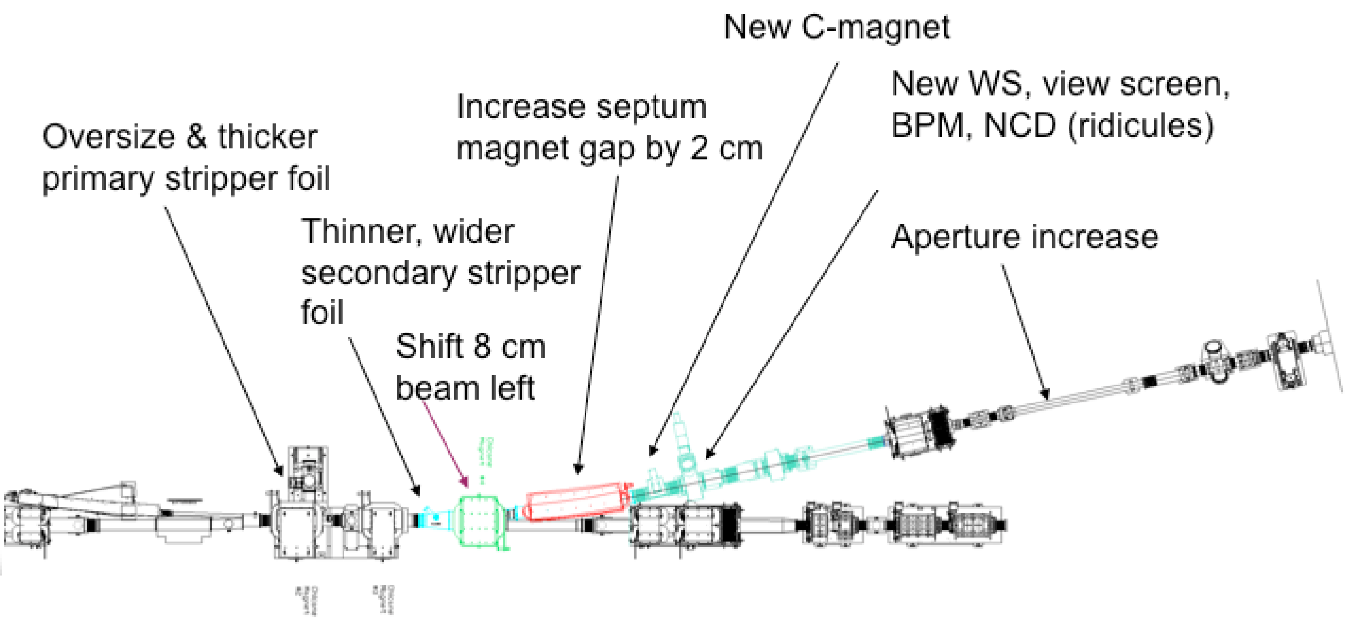
Ring / Transport Lines Upgrade Needs

- Most of the transport and Ring are 1.3 GeV capable
  - Tested the Ring systems at 1.3 GeV – some cooling system upgrades will be included
- Injection region needs upgrade
  - 2 new chicane magnets + injection dump septum
- Extraction line needs 2 extra kickers



We have experience upgrading the Ring Injection area

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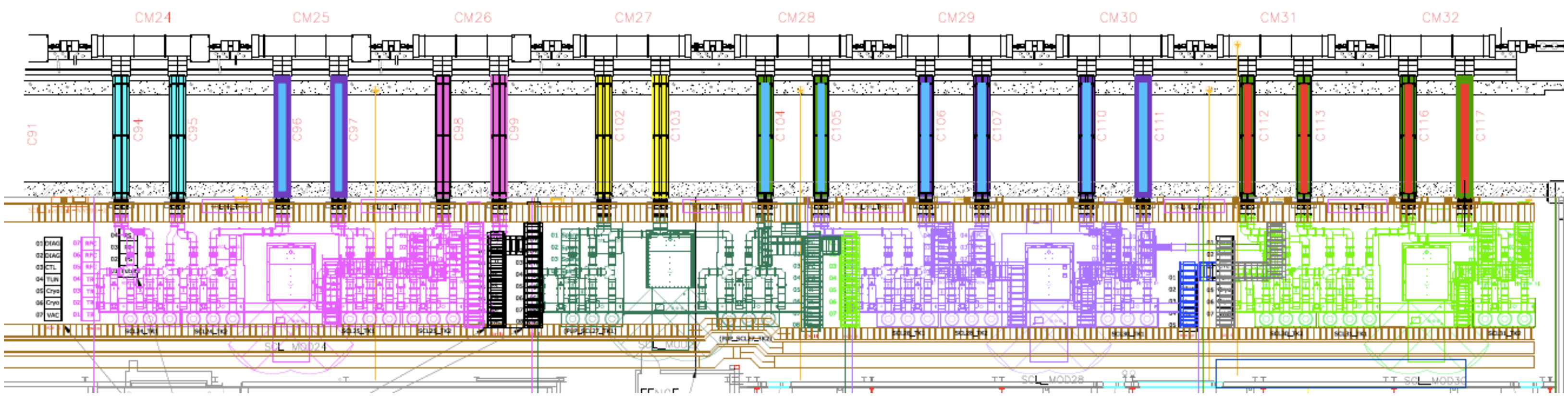
Klystron Gallery Layout Based on Experience

- Layout of RF equipment based on HVCM experience
  - One additional modulator needed relative to original expectations
  - Addition to the klystron gallery has been added for this



Klystron gallery "bump-out" finished, will accommodate additional space needs

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"Chases are Full" Problem Represents a Major Scheduling Headache

- During the original construction project, corners were cut
- Some upgrade RF chases (klystron gallery to tunnel) were filled with cables
  - These need to be properly re-routed
  - Have a plan for staged clean-up during normal 2x/year extended outages
- Now is an opportune time to address this problem

Example chase, tunnel side with high voltage cables

STS Accelerator Ongoing Activities

AAC 2012: "At a low level of effort, the design concepts for a power upgrade to 3 MW should continue to be refined, so that a final design can be more quickly developed when the funding environment improves"

- **The funded STS efforts do not involve accelerator studies**
  - **Need to define the neutron source requirements first**
- **But some specific accelerator developments that impact support for the STS are ongoing**
  - **HVCM, RF, ion source development**
- **Looking at alternate applications for the SNS accelerator**

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Path to 3 MW: Basic Parameters are Known

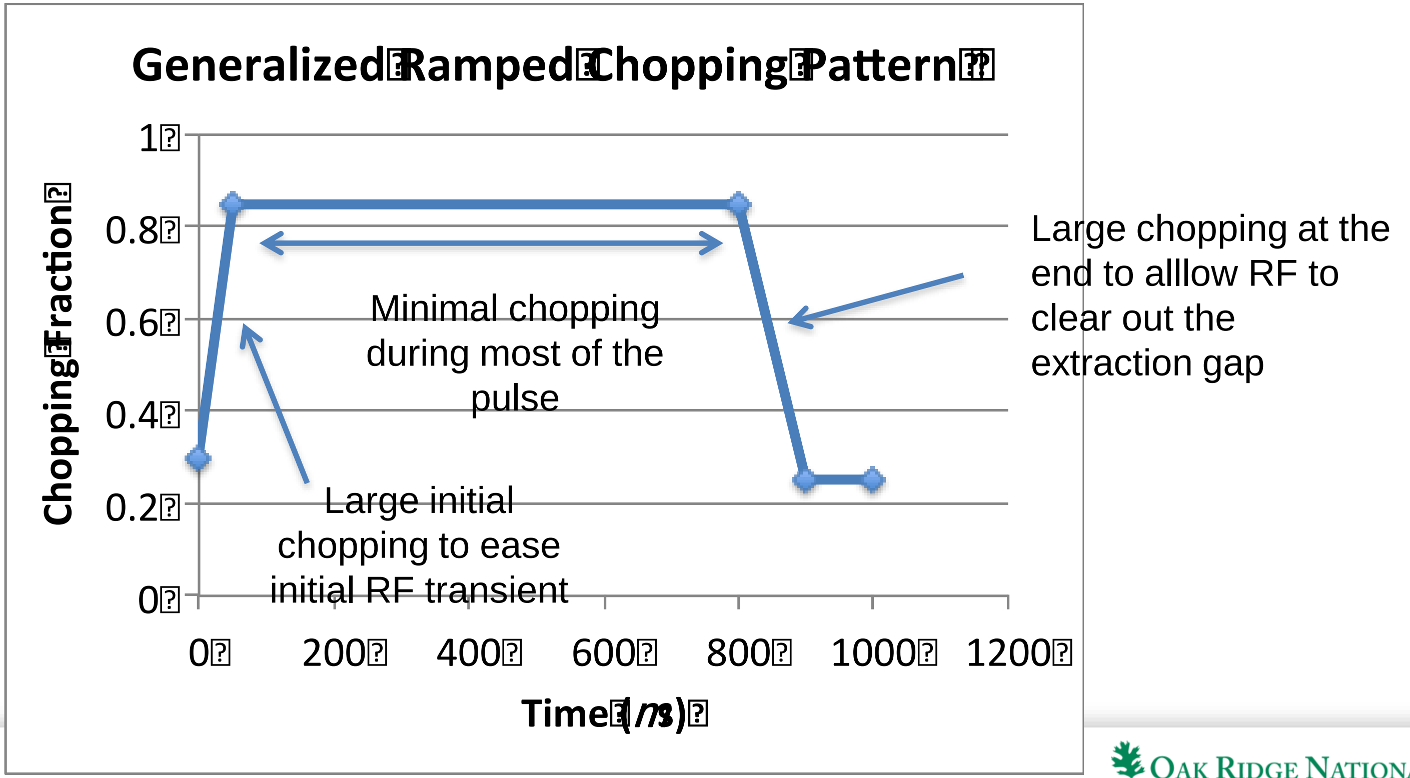
At 60 Hz

	<I> (mA)	Pulse Length (ms)	Energy (GeV)	Linac Power (MW)
Present	23	0.82	0.935	1.1
Design	26	1	1	1.5
Energy Upgrade	26	1	1.3	2.0
Energy + Current Upgrade	42	1	1.3	3.2

Need to push on energy, pulse length and beam current to reach 3 MW

Beam Current Increase Option

- Original plan was to develop a 60 mA peak ion source, with ~30% chopping to get 42 mA average
- But intelligent chopping can reduce needed peak current
  - Simulations show may be able to use 80-85% of beam current
  - Original design is 67% un-chopped



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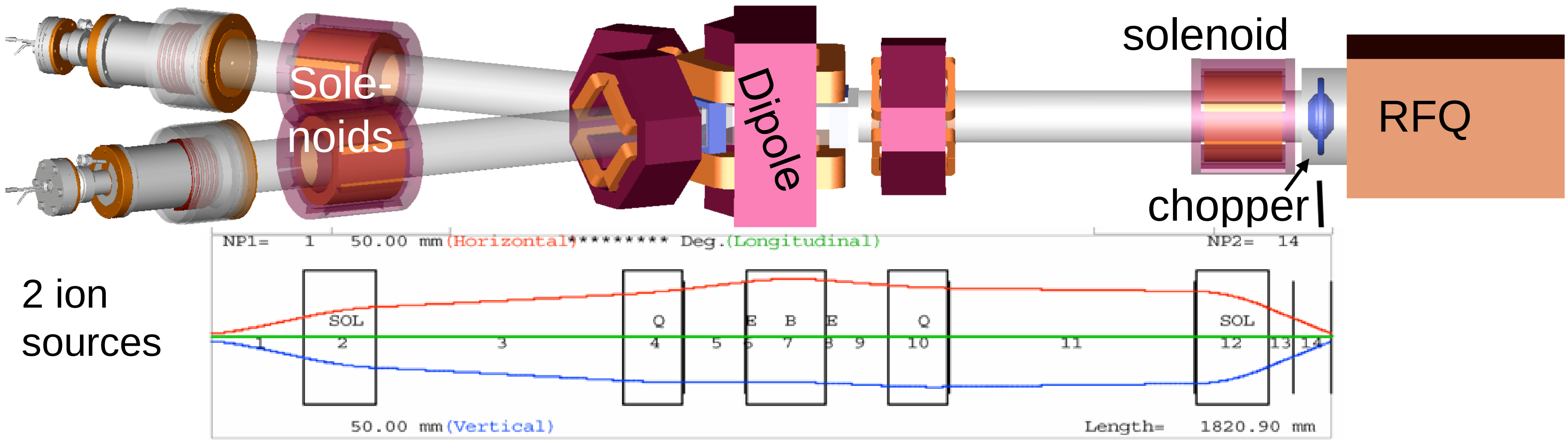
Long Term Plan Includes a 2 source Front End for Reliability



- Having a hot spare source has been a long term plan for reliable source operation
- Requires transitioning to a magnetic LEBT
  - Integrated Test Stand with RFQ will include magnetic LEBT

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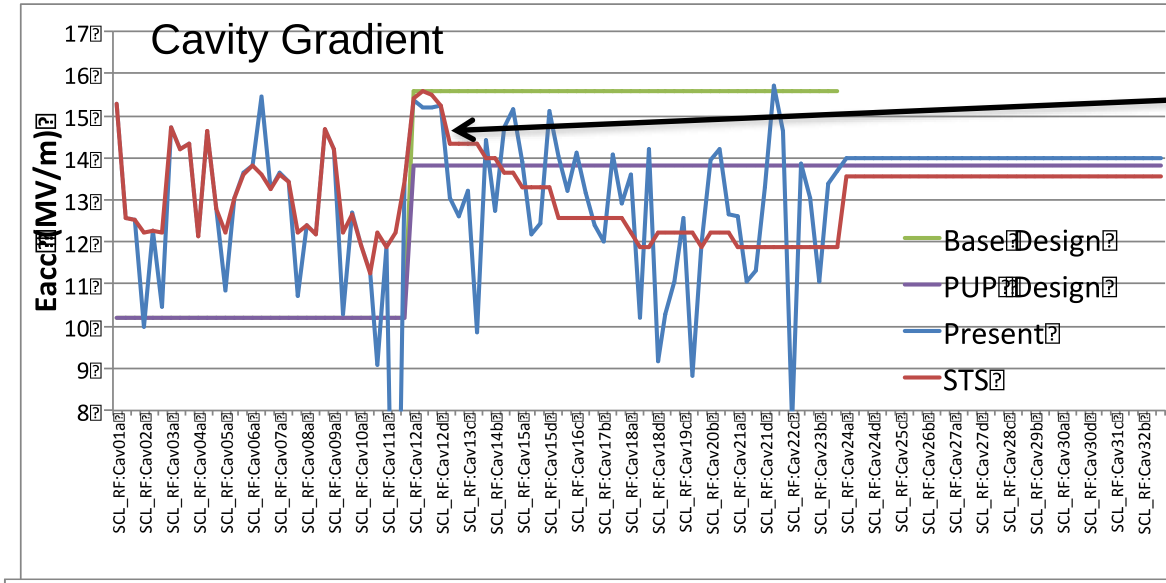
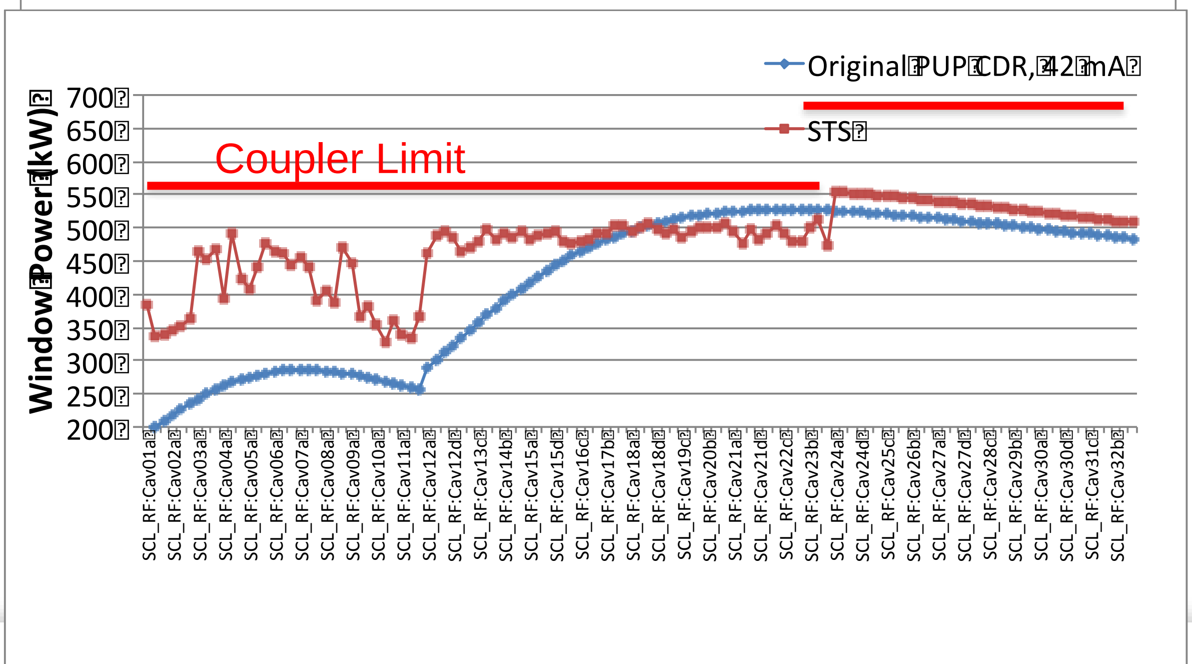
STS Gradient Strategy: Equalize Cavity Power



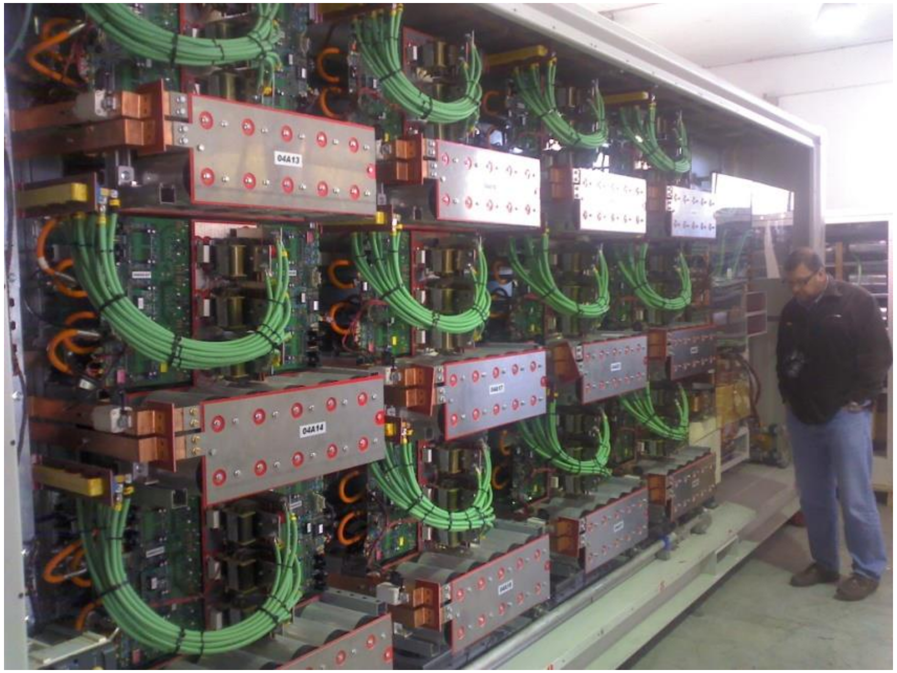
Tailoring the cavity gradients…



Results in constant power: eases modulator and RF requirements

STS HVCM Development Paths (D. Anderson's talk)

- Currently planned upgrades plus others should support STS power levels
  - Snubbers, controller, new gate drivers and alternative bus to achieve higher voltage and a flat pulse with current system reliaiblity levels – also supports 1.4 MW
  - Alternate topology and possible redundancy to improve STS HVCM design w/ improved reliability



- JEMA modulator specified to meet STS requirement to drive 12 × 700 kW CPI klystrons (85 kV, 160 A)

- Factory acceptance testing scheduled for mid-May through June, delivery early August

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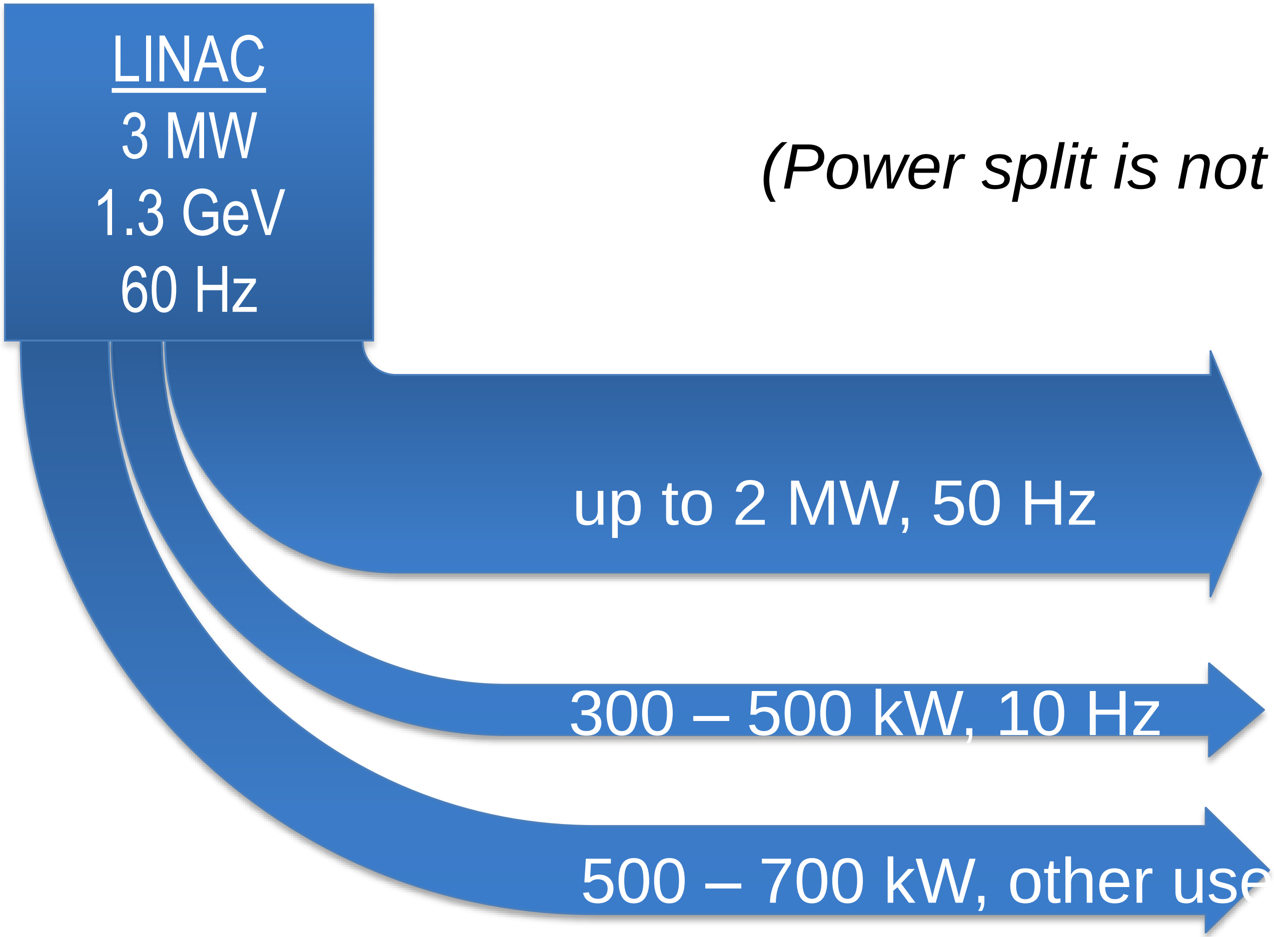
With a 10 Hz 300-500 kW STS, Where Will all the Power Go ?

(Power split is not finalized)



First target station

Second target stat
(presently being
considered)

Other application

With the power upgrade, the accelerator has potential to drive additional applications

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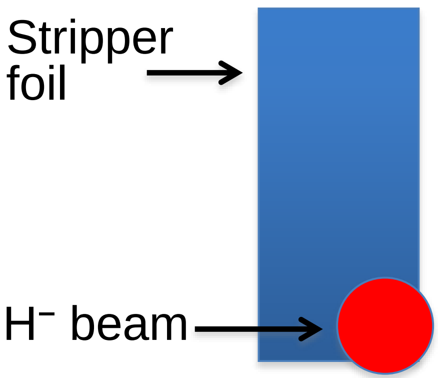
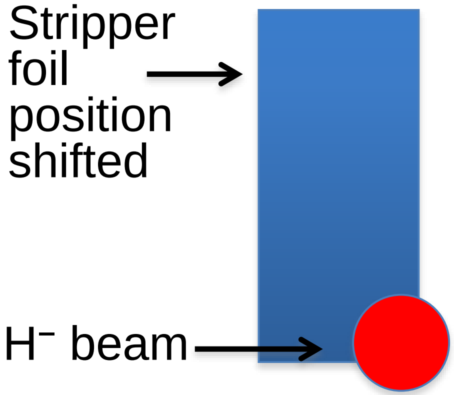
The Injection “Waste Beam” can be Used

- **Presently we send ~ 50-75 kW beam to the Ring injection dump (not fully stripped)**
  - **Can easily divert most of this to another facility**
  - **Can easily increase this beam power by small movements of the foil**
  - **Pulse structure = 60 Hz x 1 ms (long-pulse)**



Normal operation: ~ 5% of the beam power to the dump



Few mm of foil movement could allow 100’s of kW to the dump

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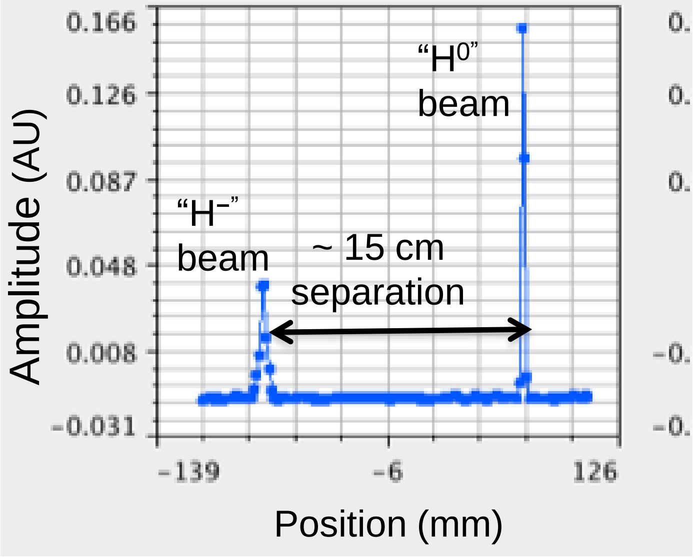
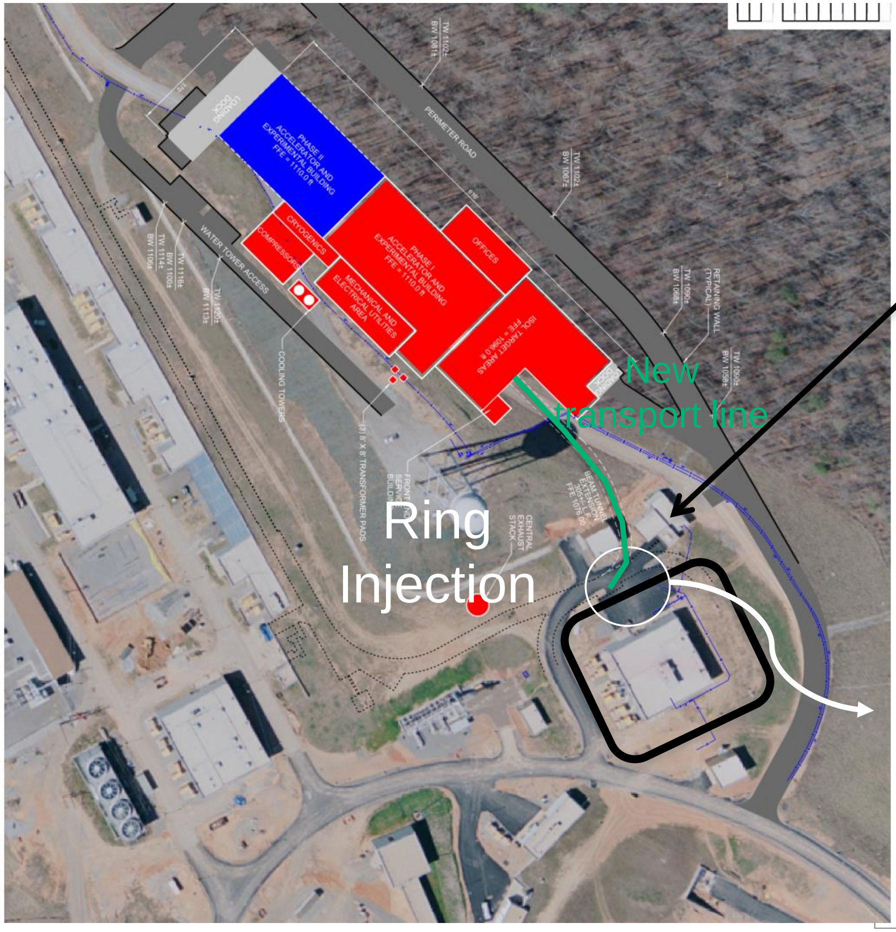
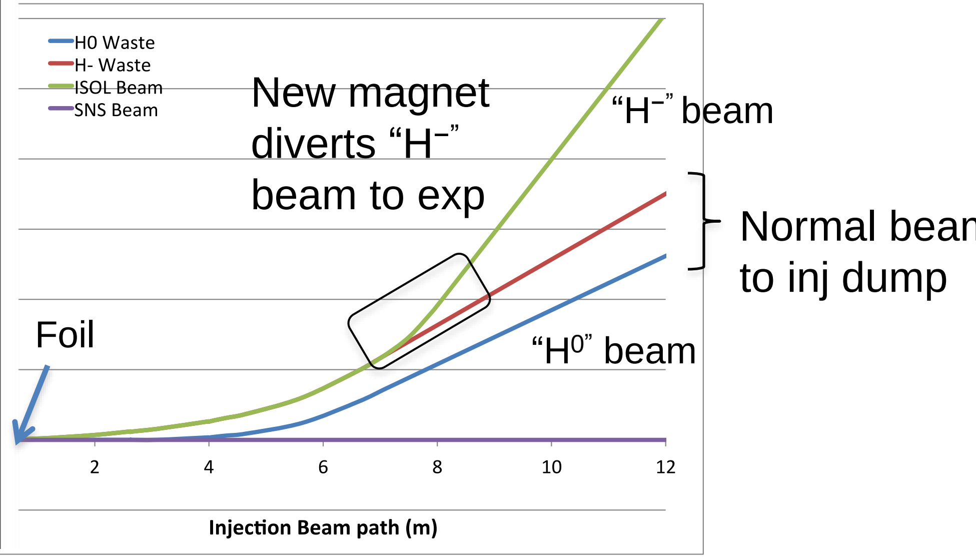
Example of diverting beam from the injection dump





Existing injection dump



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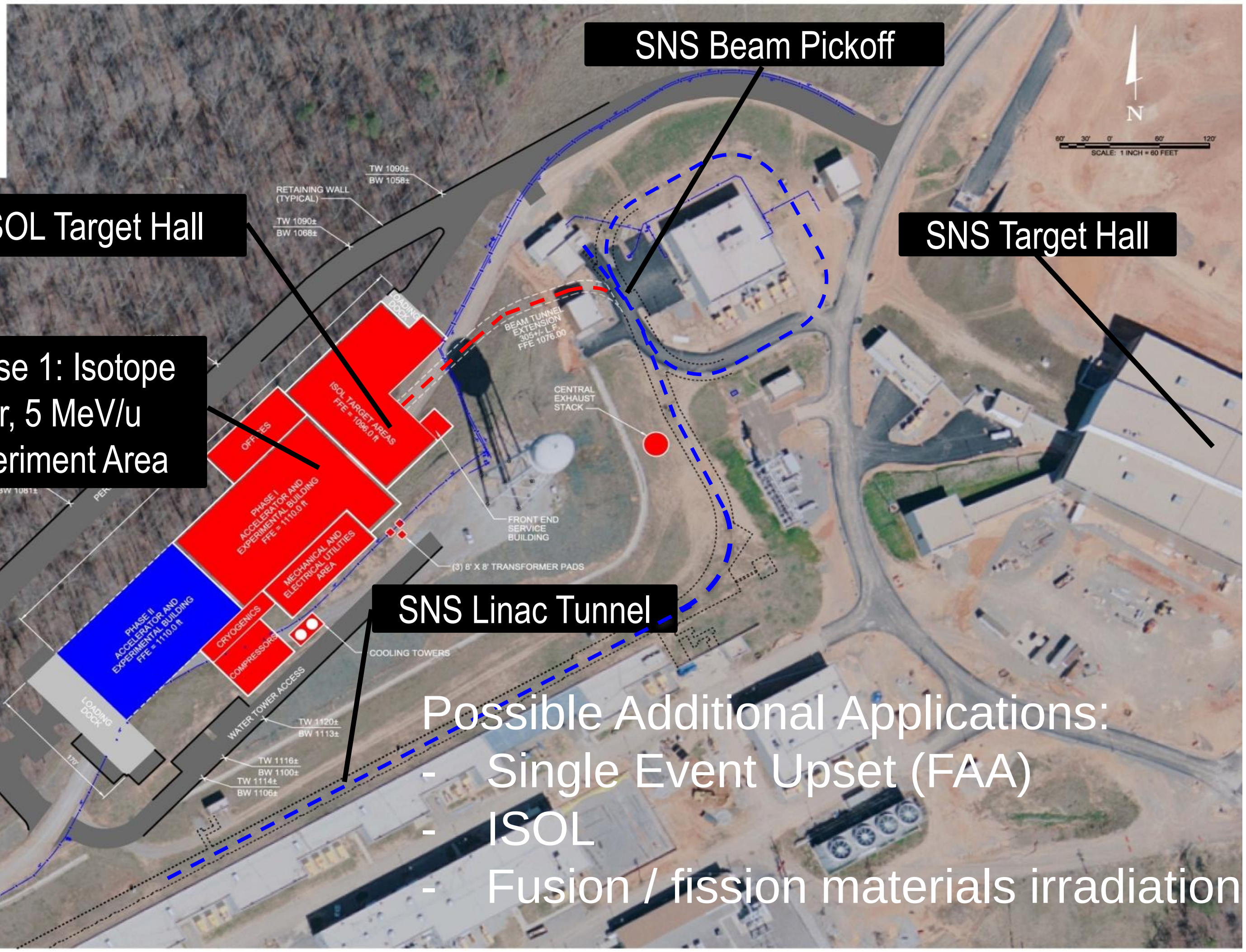
Example site plan at the SNS - large space is available in the ring injection area

PHASE I

FACILITY	SQ. FT.
TARGET AREA	46062
PHASE 1 EXPERIMENTAL	29680
CRYOGENICS	2140
COMPRESSORS	4800
MECH/ELEC UTILITIES	7200
OFFICES	6250
FRONT END BUILDING	832

PHASE II

FACILITY	SQ. FT.
PHASE II EXPERIMENTAL	23760



Possible Additional Applications:

- Single Event Upset (FAA)
- ISOL
- Fusion / fission materials irradiation

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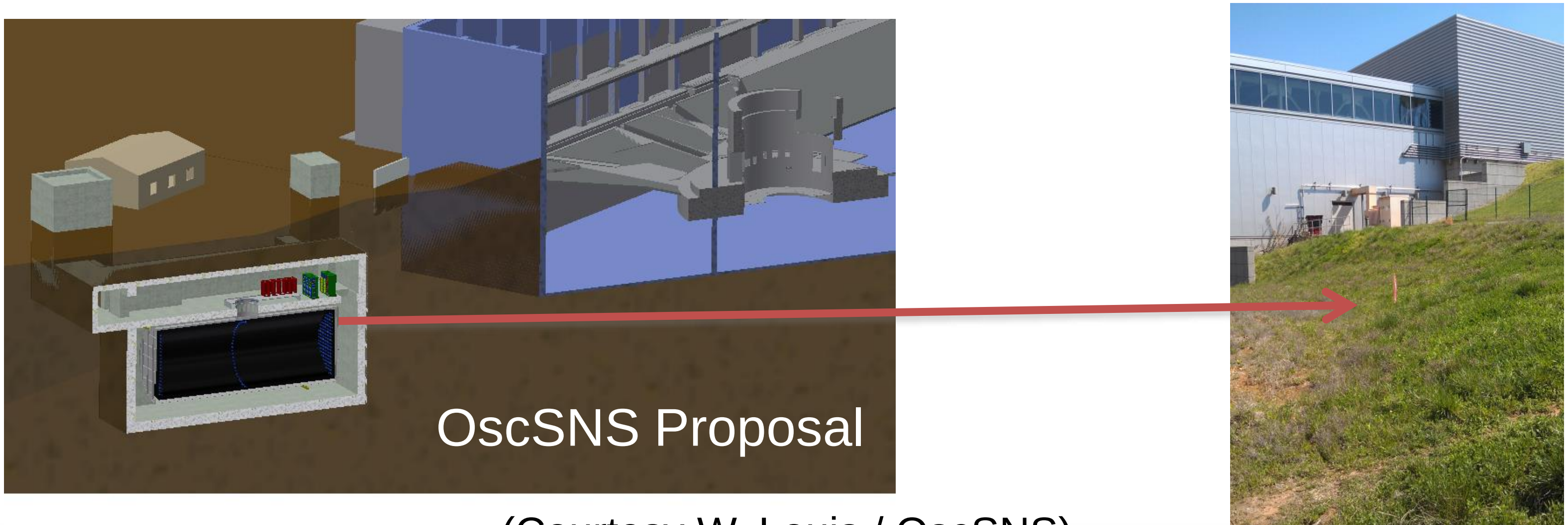
Parasitic Application, No STS Impact: Neutrino Physics

- The SNS spallation target is an excellent source of low energy DAR neutrinos due to the high intensity, extremely low duty factor beam
  - Well defined, intense ν_u , $\overline{n}_m$ and ν_e , with very high background rejection due to short duty factor are desirable
  - Requests for sterile neutrino searches, cross section measurements for ν-nucleus interactions to understand supernova nucleo-synthesis and ν-nucleus scattering for supernova interpretation
  - Snowmass intensity frontier capability workshop identified the SNS beam as one of the desired proton beam capabilities



(Courtesy W. Louis / OscSNS)

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Summary

- There is a nominal path forward for the power upgrade
- Funded STS activity is on the neutron source development
  - Need to "activate" the accelerator upgrade effort
- Alternate applications of the SNS proton beam are being pursued

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