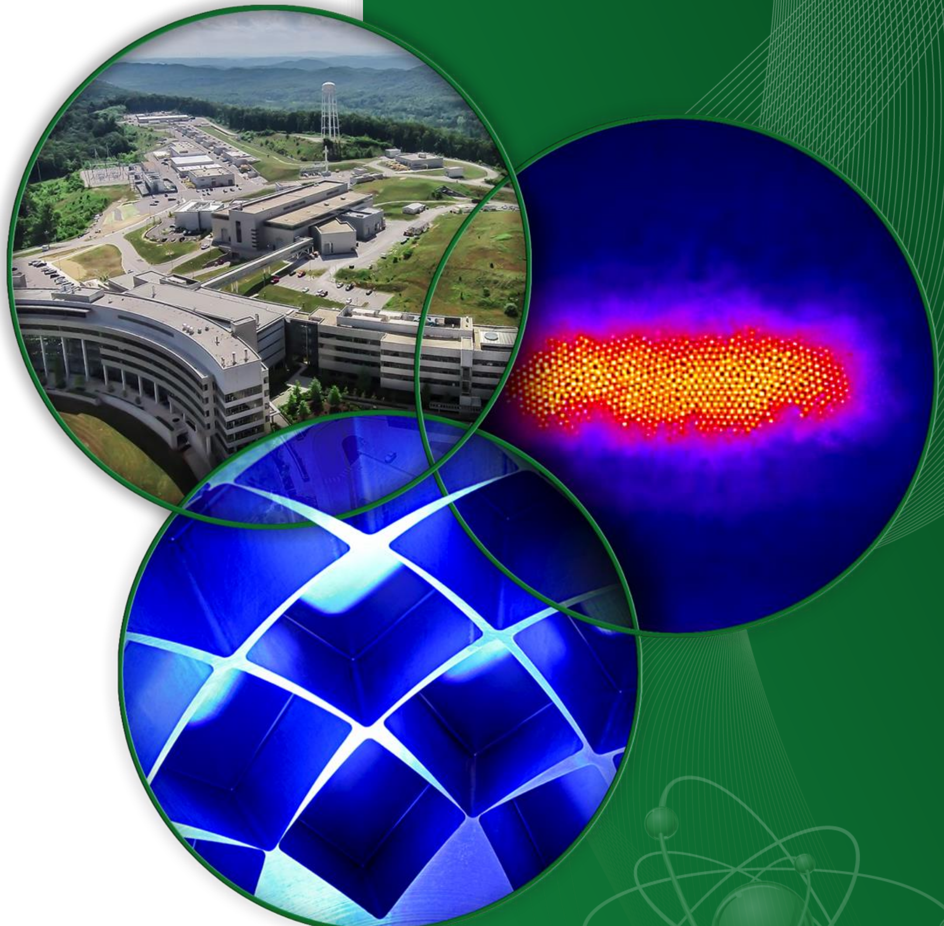
Second Target Station (STS) Plans



J. Galambos

SNS AAC Review

March 24-25, 2015

OAK RIDGE National Laboratory | SPALLATION NEUTRON SOURCE

STS History / Accelerator Upgrade

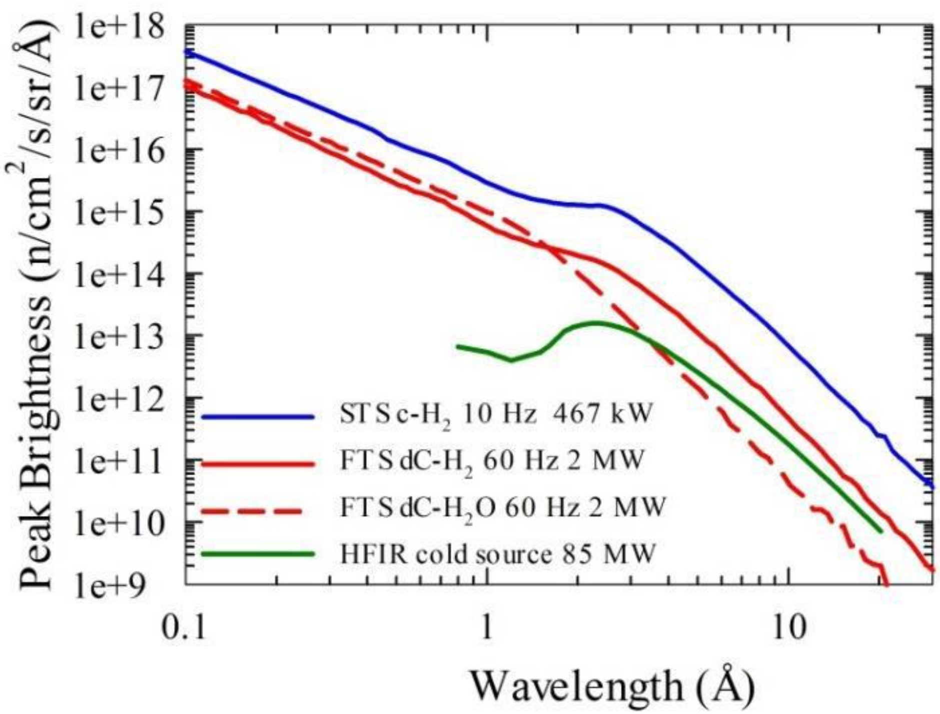
- Accelerator Power Upgrade Project (PUP)
  - CD-0 (double power) Nov. 2004
  - CD-1 (energy only) Jan. 2009
  - Killed (moved to STS) 2011
- Second Target Station
  - Originally did not include accelerator upgrade
  - Internal study in 2007 (long pulse)
  - CD-0 approved Jan. 2009
    - "Costs approximately $800M - $1 500M (a rough order of magnitude cost range) with a project completion date about 2020"

FY 2014 / 2015 Activities

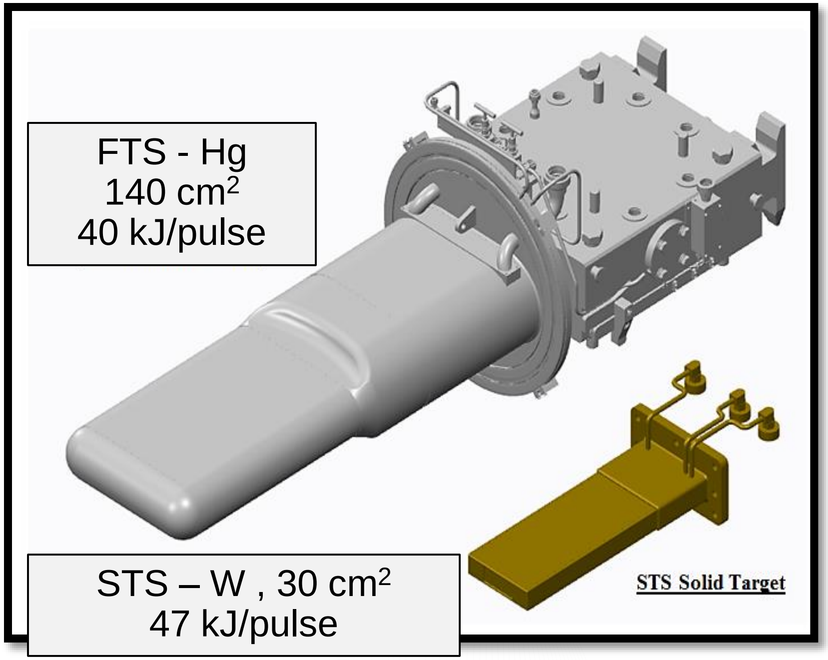
- Baseline design established
  - Technical Design Report written
- Scientific community engagement
  - Workshops identifying emerging scientific challenges that neutrons address
- Laboratory investment
  - FY15 LDRD support for next generation neutron techniques and “heroic” experiments
- Working towards FY-2017 start for CD-1 prep

https://www.dropbox.com/s/g5phzf356zrcjbb/SNS%20STS%20Report%20%28012215%29_5.pdf?dl=0

STS: Optimized for Cold Neutrons / High Brightness

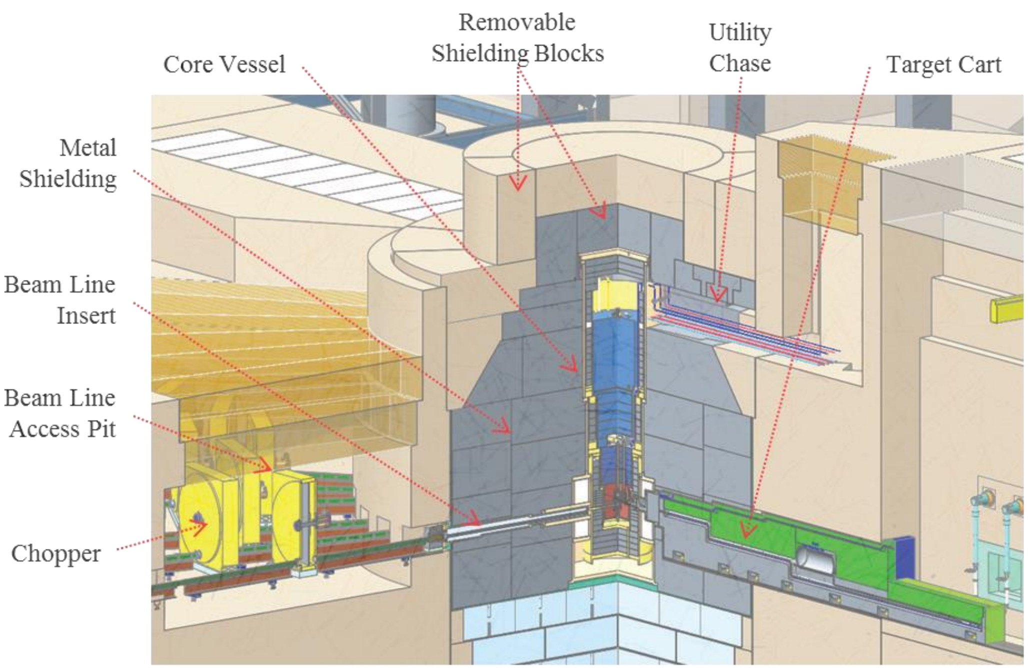


Target Comparison



- Need high intensity/pulse (500 kW / 10 Hz)
- Compact target design

Target / Instrument Systems Defined



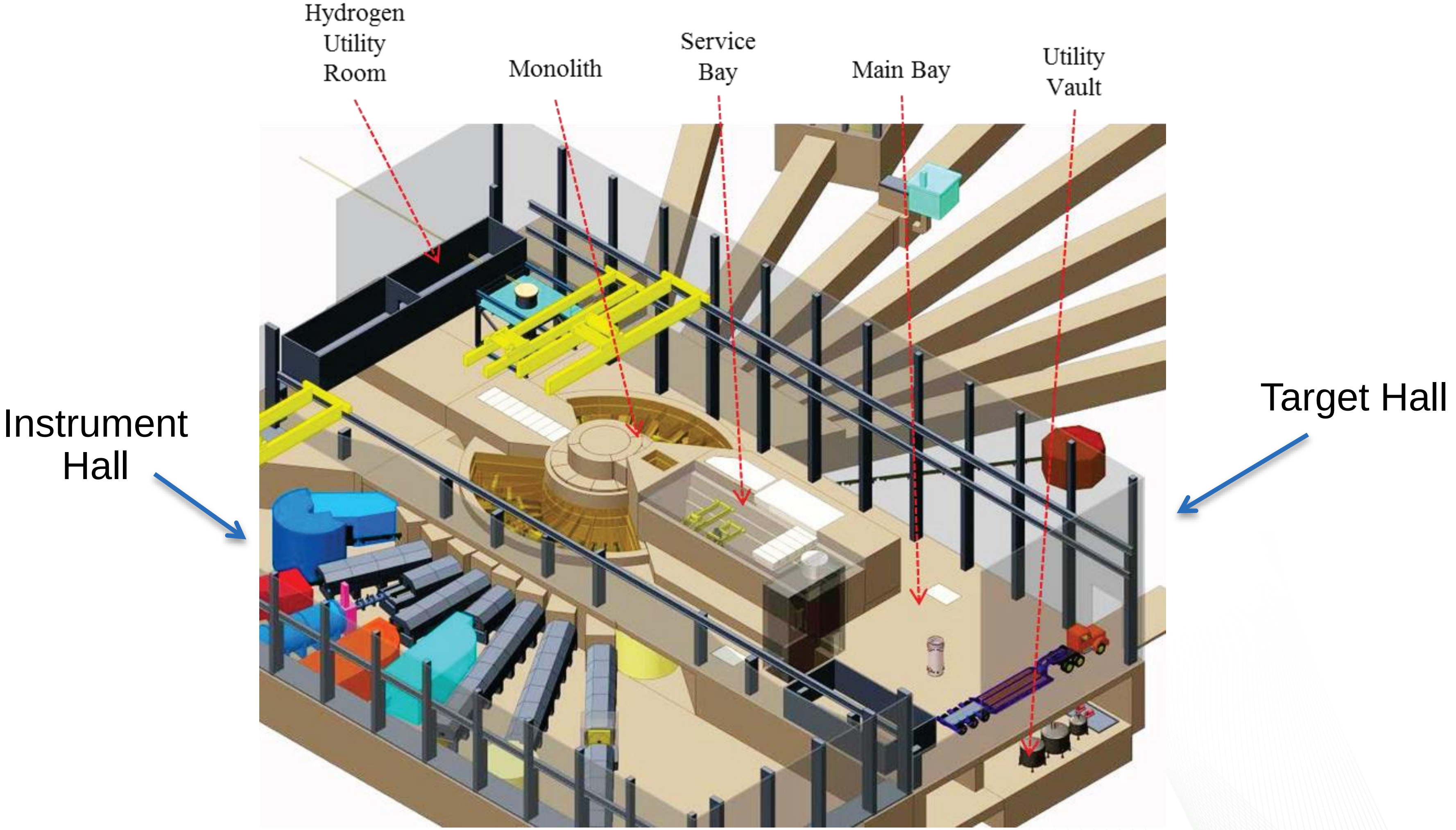
Target core vessel

Initial instrument suite proposal

Table 5.1. Initial planning suite of neutron scattering instruments

Beam line	Name	Description	[a]Nominal length (m)	Moderator type
1	[b]Zeemans	Versatile instrument designed for studies at the highest magnetic fields (integrated high-field magnet)	60	HICM
2	[b]QIKR	Kinetics Reflectometer—horizontal sample reflectometer optimized for rapid measurements	20	HICM
3	[b]HiRes-SWANS	High Resolution Small/Wide Angle Neutron Scattering—SANS/diffractometer optimized for length scales from the molecular to tens of nanometers	17	HICM
4	VBPR	Variable Beam Profile Reflectometer optimized to illuminate millimeter-size samples	30	HPCM-a
5	FLOODS	Flux-Optimized Order-Disorder SANS for fast kinetics and out-of-equilibrium behavior	25–40	HPCM-a
6	M-WASABI	Magnetism-Wide and Small Angles with Big Intensity—optimized for complete polarized reflectometry (specular, off-specular, GISANS)	38–40	HPCM-a
7	M-STAR	Magnetism-Second Target Advanced Reflectomer—optimized for magnetic studies of small samples	32	HPCM-a
8	SPHIINX	Spherical Indirect Inelastic Xtal Spectrometer—optimized for broad-band inelastic measurements of small samples	40	MSDT
9	XTREME-X	Extreme Multi-Energy Spectrometer with Xtal analyzers—optimized for measurements restricted to the horizontal plane by extreme sample environments	45	MSDT
10	JANUS	A hybrid indirect geometry spectrometer coupled with a low-angle direct geometry spectrometer optimized for inelastic measurements of irreversible phenomena and in situ manipulation of samples	40	MSDT
11	TBD		TBD	MSDT
12	BWAVES	Broad-range Wide Angle Velocity Selector—an indirect geometry spectrometer that provides very high resolution coupled to a broad dynamic range in energy transfer	16	HPCM-b
13	HERTZ	High Energy Resolution Terahertz spectrometer —a cold neutron chopper spectrometer optimized for large samples and relatively high energy resolution	25–30	HPCM-b
14	[b]VERDI	Versatile Diffractometer—a diffractometer optimized for magnetic structure studies of both powders and single crystals	40–60	HPCM-b
15	[b]DYPOL	Dynamically Polarized crystallography instrument—optimized for study of small hydrogen-containing single crystals, particularly proteins	91	HPCM-b
16	NeSCry	Neutron Single Crystal diffractometer—optimized for study of small single crystals and high, low-Q resolution with an emphasis on magnetic structure	30–50	HPCM-b
17	TBD		TBD	HPCM-c

Segregated Target / Instrument Buildings



- Separate function – separate building

Conceptual Site Layout – 3D

STS Accelerator Scope:
Double the "power" (intensity/pulse)

	1.4 MW	STS	
		First Target	Second Target
Energy / pulse (kJ)	23.3	40	46.6
Beam Energy (GeV)	.94	1.3	1.3
Rep rate (Hz)	60	50	10
Average current (mA)	27	33	38
Power (MW)	1.4	2.0**	0.47

* Use beam chopping (average current) to independently throttle FTS / STS power

** Shielding / target system limit, may be possible to increase

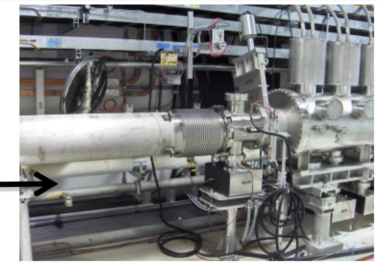
Doubling the Accelerator Intensity
- *use operational lessons*

	1.4 MW Operation	Present STS Upgrade	Original STS Upgrade
Energy (GeV)	0.94	1.3	1.3
Macro-pulse length (ms)	0.97	0.97	1
RFQ output beam current (mA)	35	46	55
Macro-pulse un-chopped fraction	0.78	0.82	0.7

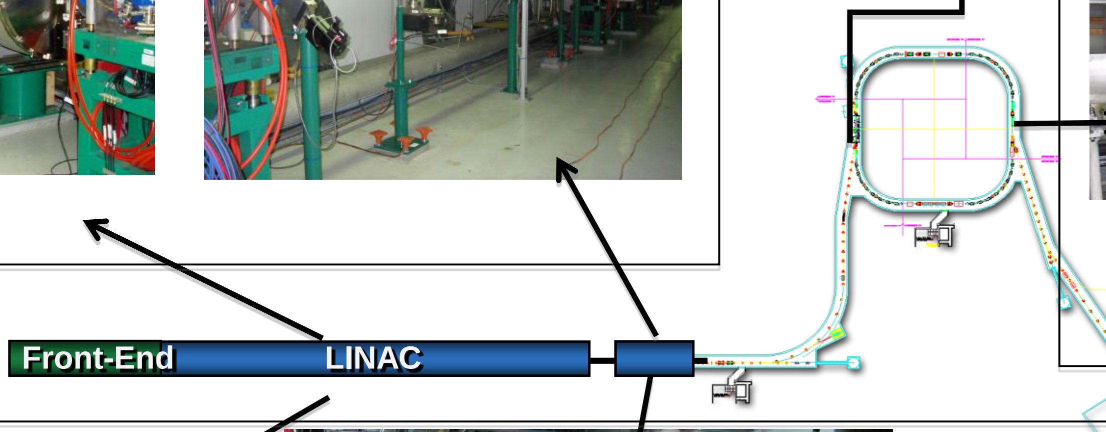
- New approach significantly eases the ion source requirements
  - Leverages lessons learned on the way to 1.4 MW
- Need ~ 46 mA out of RFQ, 55 mA into RFQ
  - Reduced ion source requirements
  - No dual source / hot-spare, magnetic LEBT

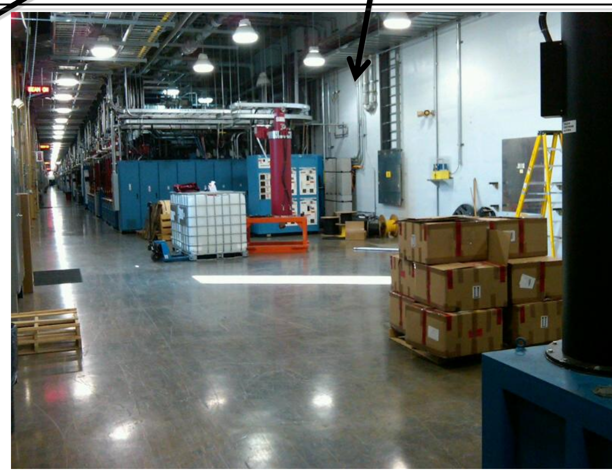
Primary Accelerator Power Upgrade Areas

Tunnel: fill in empty drift sections with cryomodules: space for 9



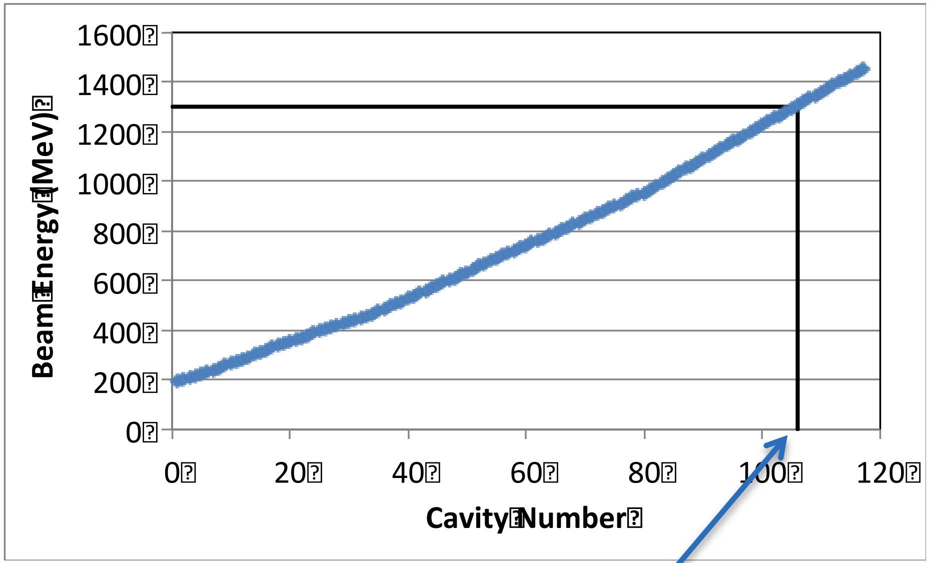
Extraction: fill in empty space with kickers





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

STS Energy Profile: 7 New Cryomodules



	E_{out} (MeV)	
	Now	STS
Cryomodule 23	948	970
Cryomodule 30		1358

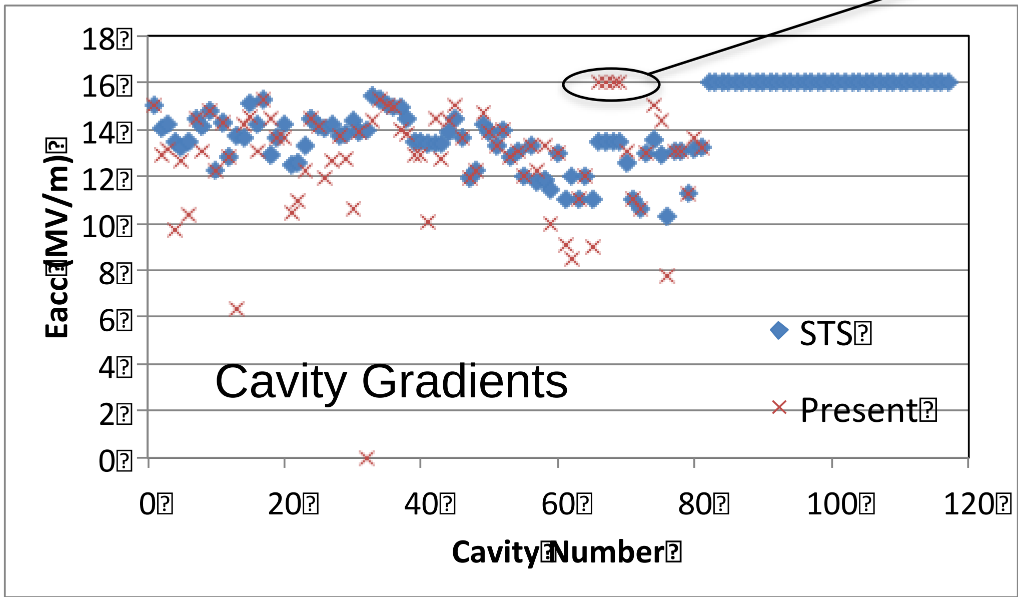
Need 25 new cavities at 16 MV/m for 1.3 GeV
("6.25" cryo-modules)

- 1.3 GeV is a fairly hard upper energy limit
  - Avoid H^- magnetic stripping in existing HEBT line
  - Use the last 3 cavities as "spares"

SCL: What Gradient to Use?

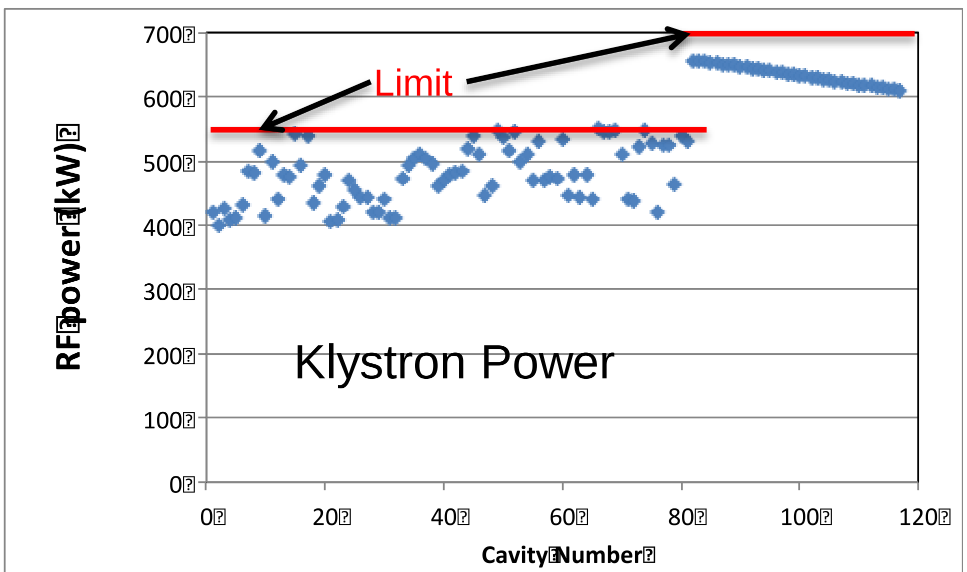
(M. Howell)

Existing spare cryomodule performance



Gradients are reasonable

- 16 MV/m for new CMs
- Same as spare CM we just built
- Higher than 13 MV/m for PUP
- ESS: 18.5 MV/m
- LCLS-II: 16 MV/m



RF power

- Existing cryomodules limited to 550 kW/ klystron
- New ones will be 700 kW capable

SCL Upgrade Strategy

- Upgrade some existing cavities (plasma process)
- Add 7 new cryo-modules, 4 cavities/cryo-module
  - Requires 3 more HVCMs (9+9+10)
  - Previous Power Upgrade Project had 9 new cryomodules + 4 new HVCMs
    - Used all 9 available empty slots
- “Chases-are-full” problem alleviated with the flexibility of 2 empty slots

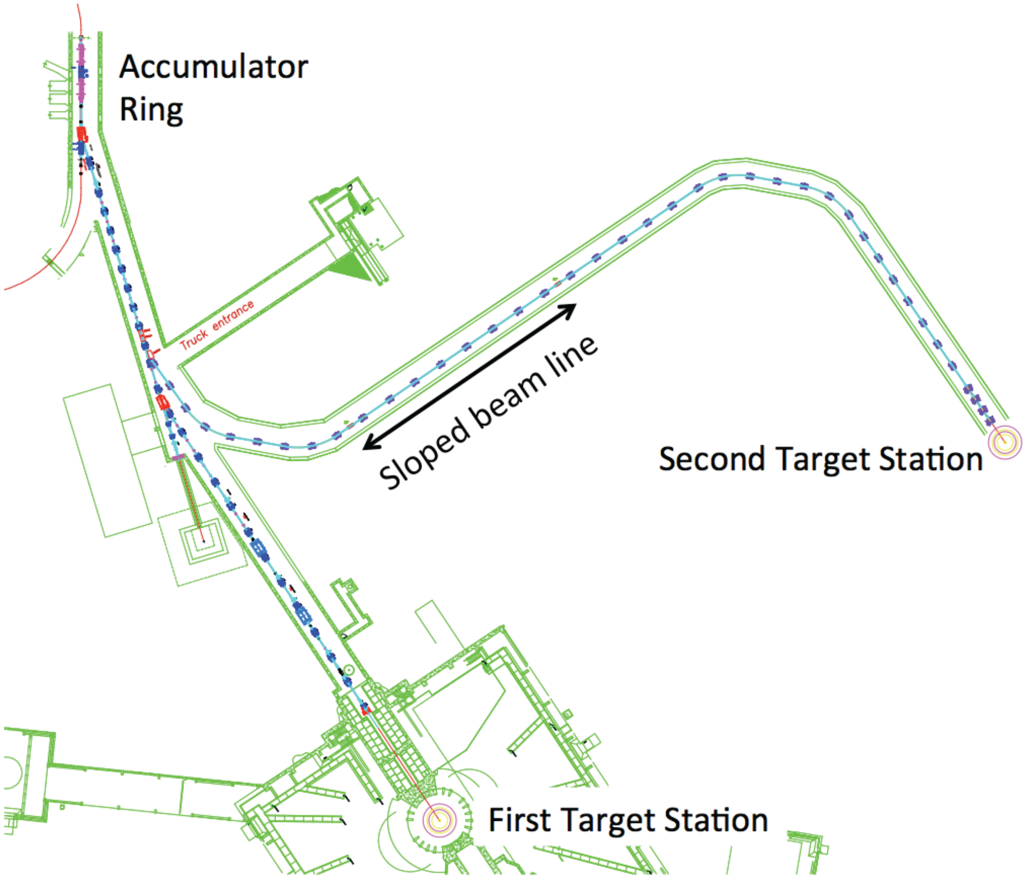
Cables in upgrade chases that should be empty

SCL Energy Upgrade Summary

	STS	Previous PUP Plan
Cavity gradient (MV/m)	16	13
Additional cryomodules	7	9
Additional modulators	3	4
Number of operational spare cavities	3	4

- Present plan is more aggressive than previous PUP plan
  - See M. Howell + D. Anderson talk

New Beamline to STS



- Horizontal extraction kick scheme from existing transport line
- Vertical drop of ~ 15 ft
- Large aperture transport line (21 cm quads)

2013 AAC Recommendation

33. We encourage the laboratory to invest the appropriate resources in accelerator R&D to support 3MW operation for the second target station.

- Design TDR supported
- HVCM and plasma processing supported

Summary

- We have a conceptual STS design
  - Meets the science mission
    - High brightness, low rep-rate
    - Achievable with low power (500 kW)
  - Leverages experience from operation
    - Target: move from Hg to solid target
    - Accelerator uses existing technologies
      - More of the same for SCL
      - Stay the path for ion source/LEBT

Backup

STS: Beam Loss

- Double the intensity per pulse from present 1.4 MW level
  - X 1.38 in energy (0.94 to 1.3 GeV)
  - X 1.45 in charge per pulse
- Linac:
  - Loss generally proportional to accelerated charge
  - Continue effort to increase beam size (decrease intra beam stripping)
- Ring
  - Space charge / collective effects ($\sim n/\beta^2\gamma^3$)
    - Net 20% decrease for STS parameters
  - Injection losses will increase by 45%
- Worst case: we can live with 50% increase in beam loss