Accelerator Systems Management Overview

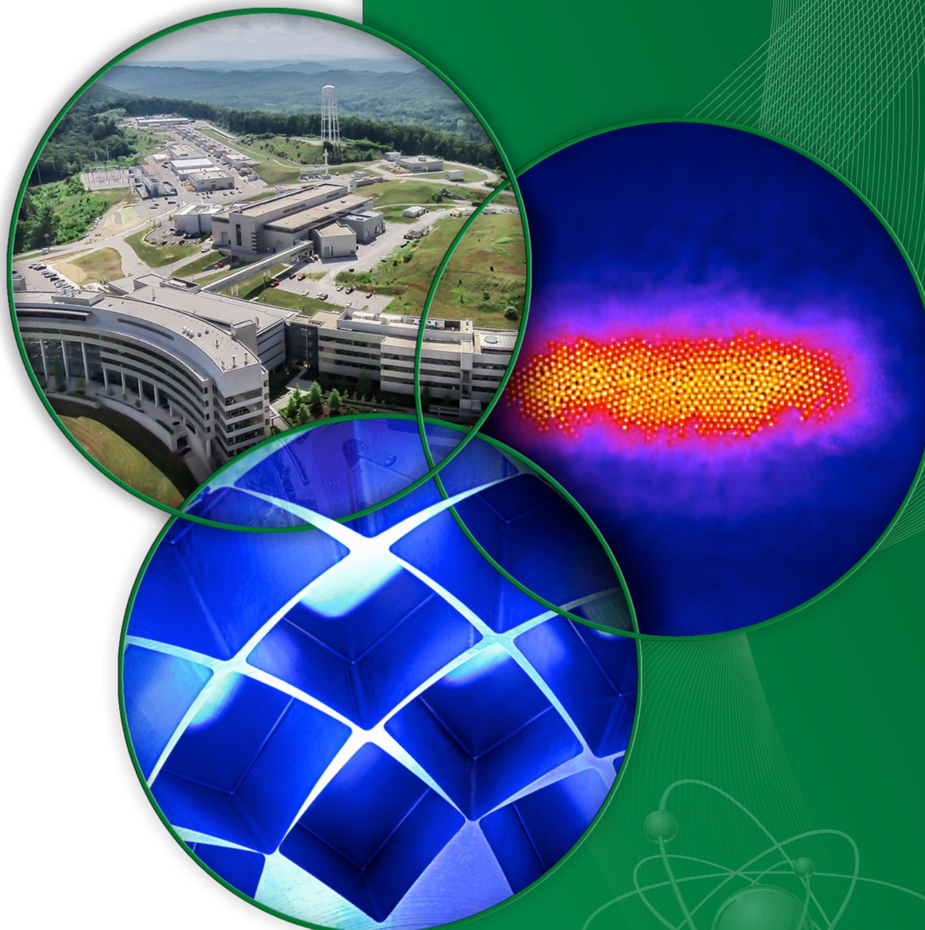
Presented to

SNS Accelerator Advisory Committee

Presented by

Kevin Jones
Research Accelerator Division Director

March 24, 2015



OAK RIDGE National Laboratory | SPALLATION NEUTRON SOURCE

There have been a number of management changes in NScD since the last meeting of the AAC

Associate Laboratory Director
Paul Langan

Deputy Associate Laboratory Director
Rob McQueeney

Chief Scientist
Alan Tennant

Herb Mook, Senior Corporate Fellow Emeritus
Jeanine Evans, Executive Secretary

Joint Institute for Neutron Sciences
Takeshi Egami

Matrix Support
Bonnie Hébert, HR Manager
Lorie Hickey, Business Manager

Scientific and Program Services Office
Crystal Schrof

Directorate Operations
Hans Vogel

Quantum Condensed Matter
Stephen Nagler

Biology and Soft Matter
Volker Urban (Acting)

Chemical and Engineering Materials
Richard Ibberson

Neutron Data Analysis and Visualization
Thomas Proffen

Research Reactors
Tim Powers

Instrument and Source
Don Abercrombie (Acting)

Research Accelerator
Kevin Jones

Likewise, RAD has been reduced in size and scope to accommodate other organizational changes – mission remains focused on site, accelerator and target

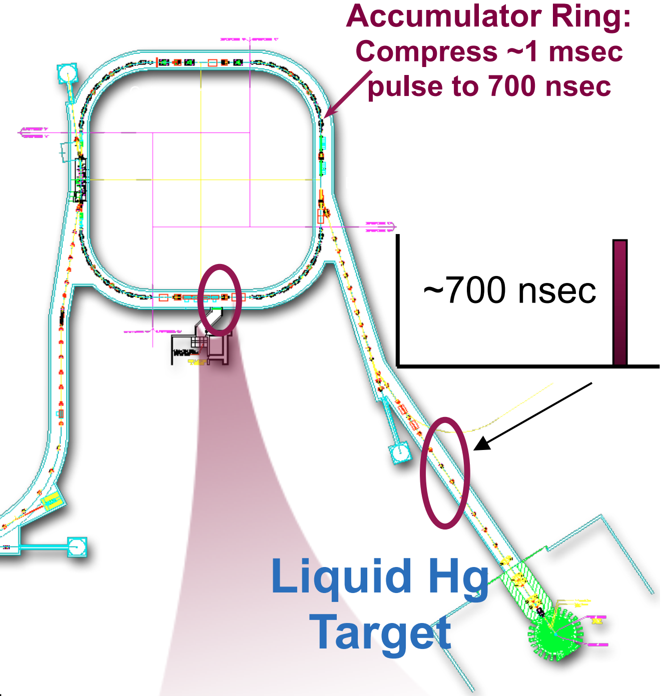
- **Research Accelerator Division** – Kevin Jones, Director
  - **Maintenance Management & Information Systems** – George Dodson
  - **Conventional Facility Operations** – Sam McKenzie
    - **Facility Maintenance – Chestnut Ridge** – Sam McKenzie
    - **Site Services** – Tom McLaughlin
  - **Data Operations** – Karen White
    - **Control Systems** – Karen White
    - **Instrument Data Acquisition and Controls** – Steve Hartman
  - **Accelerator and Target Operations** – George Dodson
    - **Accelerator Physics, Beam Instrumentation and Ion Source** – John Galambos
    - **Accelerator Operations** – Glen Johns
    - **Electrical and RF Systems** – Mark Champion
    - **Mechanical Systems and Operations** – Michael Baumgartner
    - **Superconducting Linac Systems** – Sang-ho Kim
  - **SNS ESH&Q** – Greg Rowland (Interim)
    - **NRPD Assignment – Radiological Control** – George Stephens

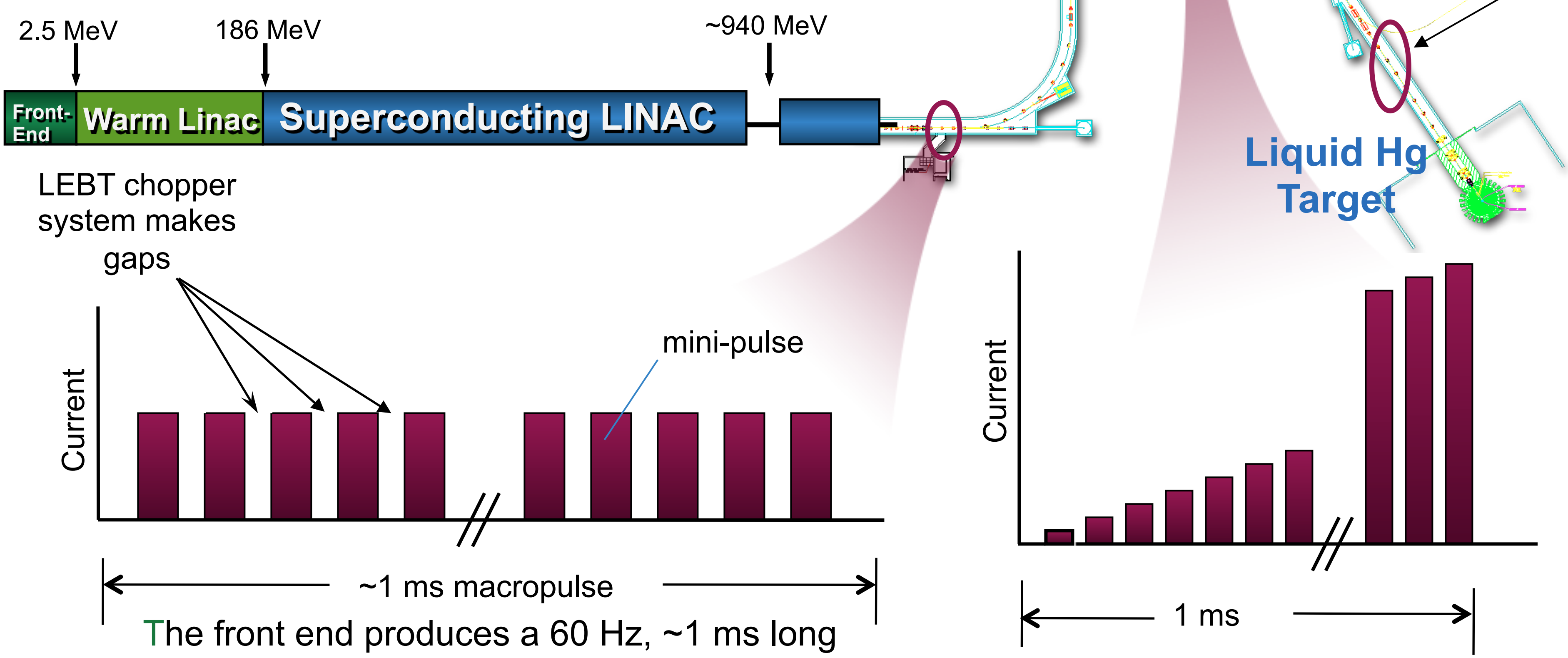
Transferred to other organizations:

- Instrument Operations (ISD)
- Scientific Information Systems (SPSO)
- Deployed SNS IT (SPSO)

The RAD is responsible for the operation, maintenance and improvement of the SNS accelerator complex

- **SNS is the highest power pulsed neutron source in the world**
- **The machine has over 100,000 control points and cycles ~5.2 million times a day**
- **Power (and base neutron flux) is the product of:**
  - **Beam Energy**
  - **Peak Current**
  - **Chopping Fraction**
  - **Pulse Length**
  - **Repetition Rate**





The front end produces a 60 Hz, ~1 ms long chopped H- beam

SNS design parameters

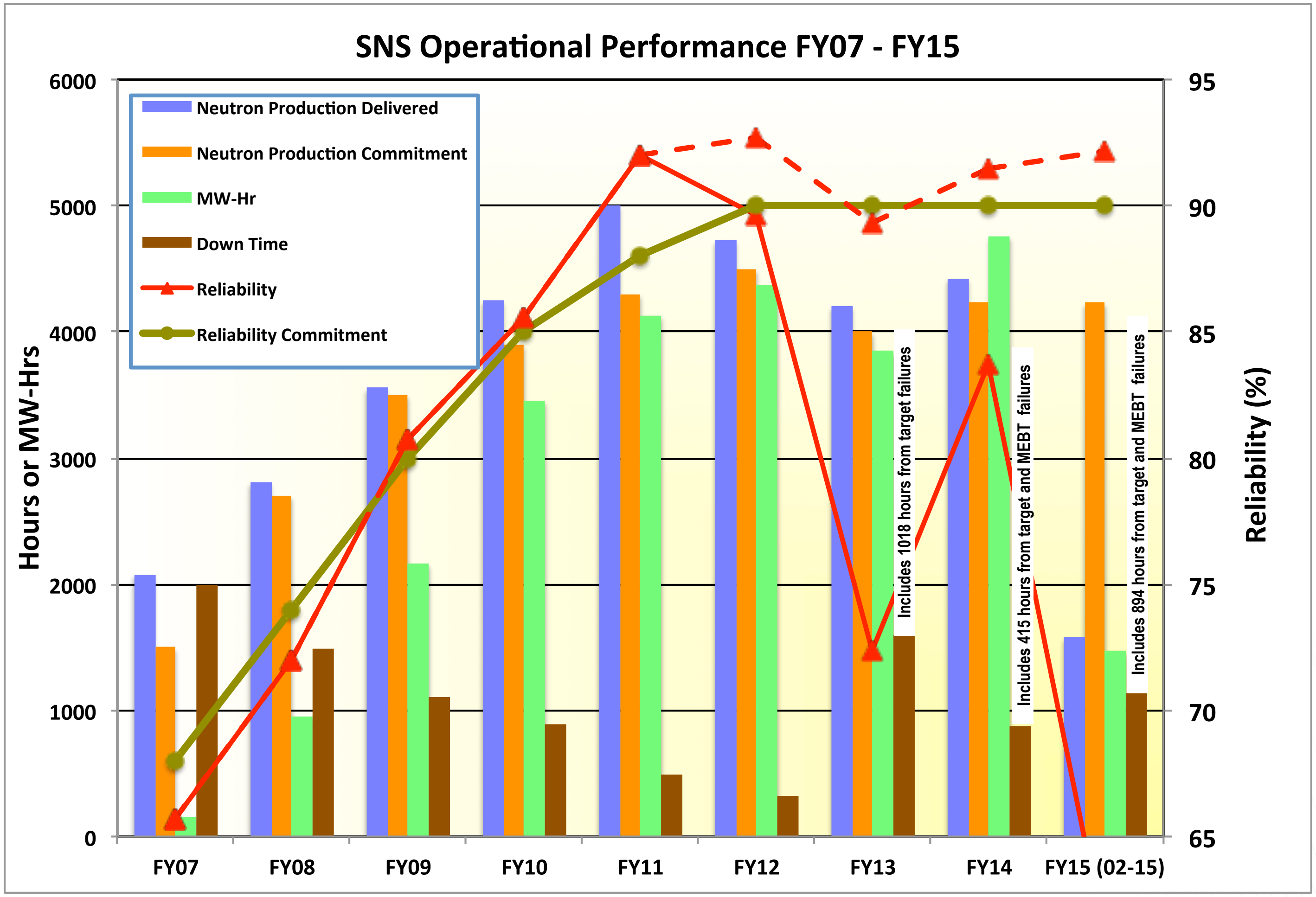
Kinetic Energy	1.0 GeV
Beam Power	1.4 MW
Linac Beam Duty Factor	6%
Modulator/RF Duty Factor Specification	8%
Peak Linac Current	38 mA
Average Linac Current	1.6 mA
Linac pulse length	1.0 msec
Repetition Rate	60 Hz
SRF Cavities	81
Ring Accumulation Turns	1060
Peak Ring Current	25 A
Ring Bunch Intensity	1.5×10^{14}
Ring Space Charge Tune Spread	0.15

SNS performance relative to design

	Design	Best Ever	Routine Operation
Kinetic Energy [GeV]	1.0	1.07	0.939
Beam Power [MW]	1.4	1.427	0.8-1.35
Linac Beam Duty Factor [%]	6	6	5
Modulator/RF Duty Factor [%]	8	8	7
Peak Linac Current [mA]	38	42	35
Average Linac Current [mA]	1.6	1.6	1.1
Linac pulse length [msec]	1.0	0.98	0.8-0.9
Repetition Rate [Hz]	60	60	60
SRF Cavities	81	80	80
Ring Accumulation Turns	1060	1020	825
Peak Ring Current [A]	25	26	18
Ring Bunch Intensity	1.5×10^{14}	1.55×10^{14}	1.1×10^{14}
Ring Space Charge Tune Spread	0.15	0.18	0.12

The SNS neutron source has achieved stable 1MW operation capability for 4500 hours at ≥90% reliability

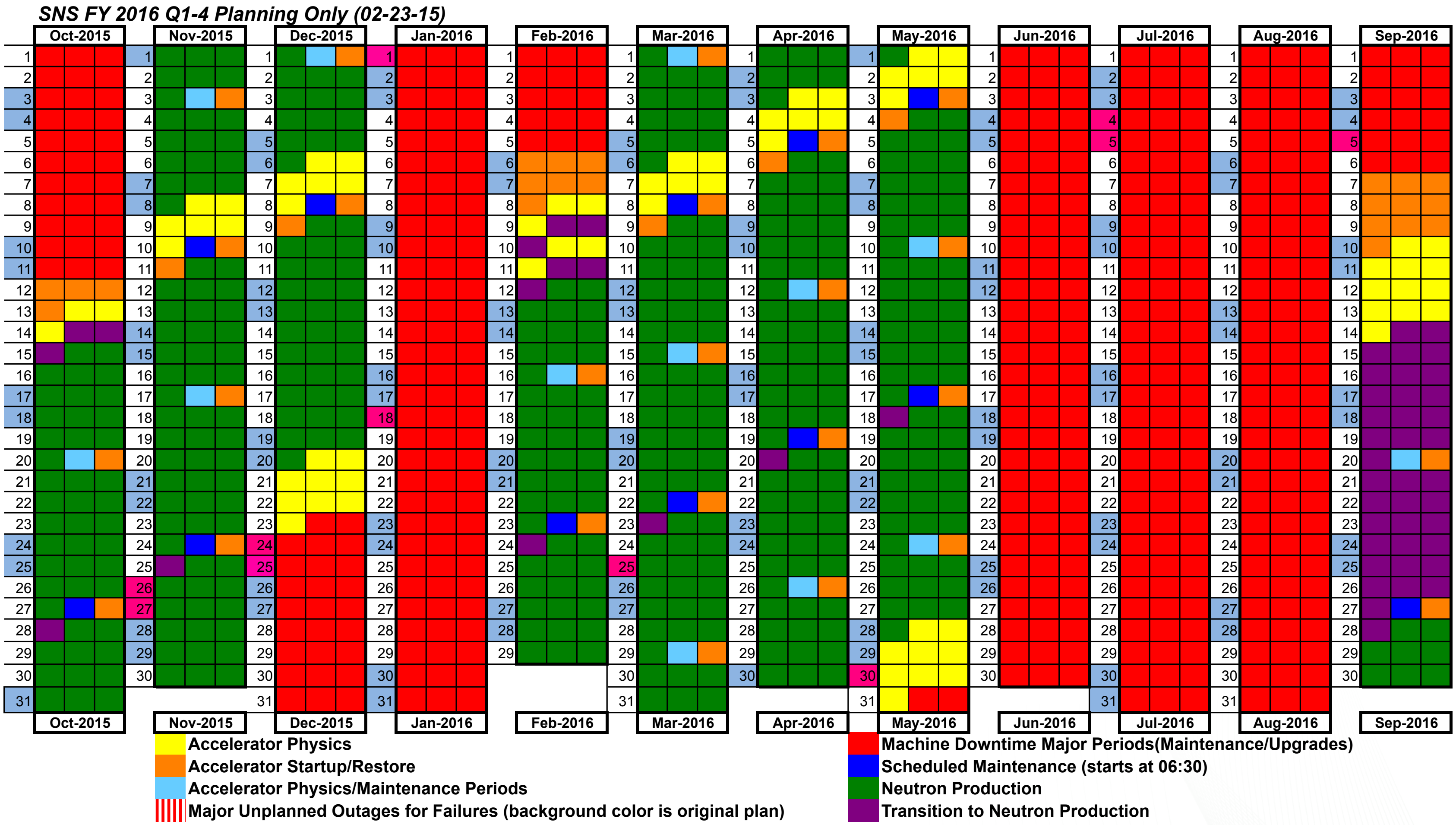
Since FY09 the SNS neutron source has exceeded all DOE PMM operational commitments for hours delivered and availability



DOE PMM Hours and Availability are not the same as scheduled hours and availability:

- Annual DOE BES Facility Questionnaire submitted in October sets **planned** hours for that FY
- Neutron Production Commitment is 90% of planned hours
- Schedule has contingency and is published quarterly one month in advance
- Additional hours are provided
- Possible to meet DOE PMM of 90% while not meeting 90% against published schedule

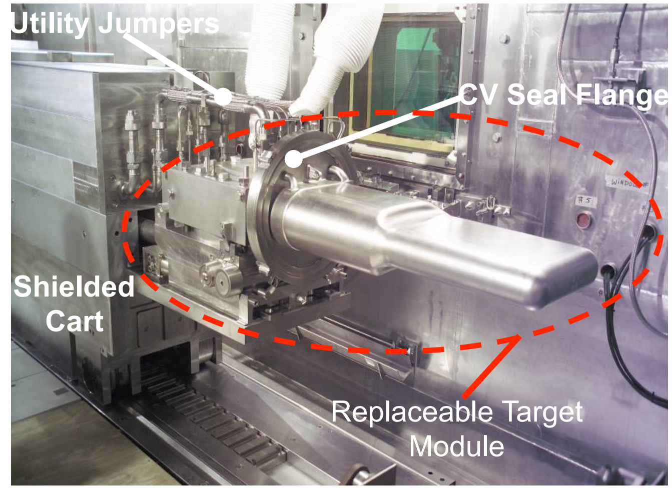
SNS will have a significantly reduced operating schedule in FY2016 - ~3,500 scheduled hours for neutron production



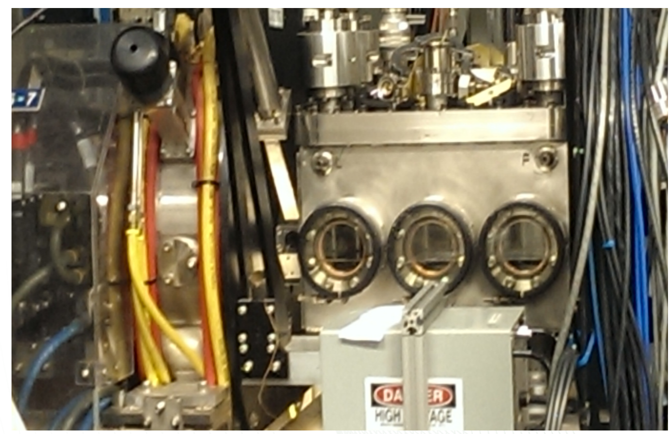
- Current target may survive to end of FY2015 – will be at or near water shroud radiation damage limit
- Inner Reflector Plug (IRP) is nearing end-of-life of ~32 GW-Hr (neutronic burn-up of moderator poisons) – could reach 32 GW-Hr in December depending on operating conditions after April
- New IRP scheduled for installation next summer – assumes delivery on schedule at end of CY2015
- Possible change-out of RFQ in parallel with IRP in Summer 2016

SNS experienced three major equipment failures in September – November 2014

- At 10:30 pm on September 11, 2014 Target 10 indicated a mercury leak into the interstitial space that was confirmed using standard techniques
- While the target change was in progress, at 12:30 pm on September 15, 2014 the chopper target in the MEBT ruptured catastrophically, filling the MEBT vacuum envelope with water that vented through pressure relief valves
- At 11:45 pm on October 27, 2014 Target 11 indicated a mercury leak into the interstitial space that was again confirmed using standard techniques
- Again reduced to one spare target – entered target conservation mode with operation at 850 kW



SNS Target Module on Cart – Retracted Position

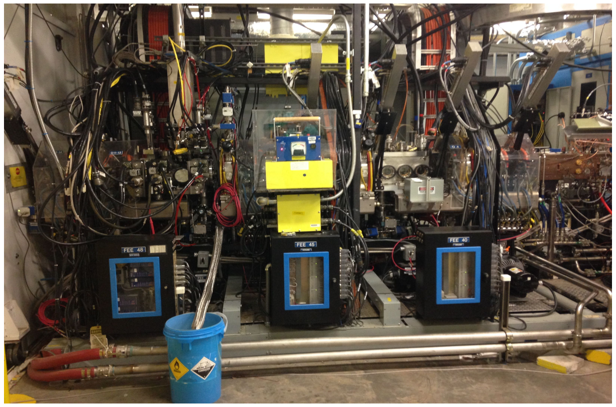


MEBT Chopper Box – water visible in view ports

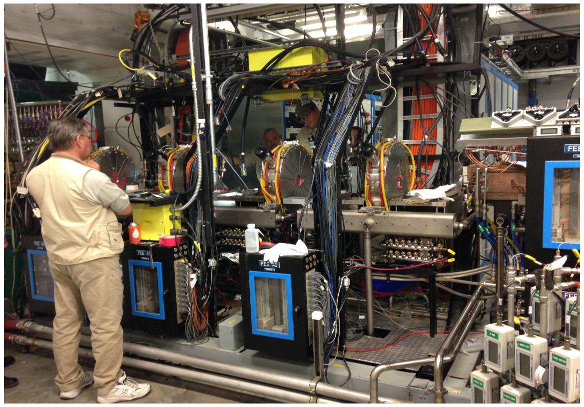
OAK RIDGE National Laboratory | SPALLATION NEUTRON SOURCE

The MEBT water event was difficult to recover from

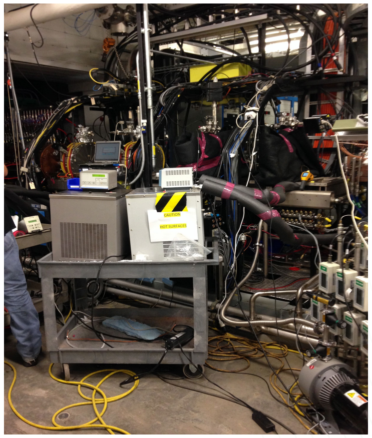
- DTL was also affected (isolation valve unseated under water pressure) requiring replacement of subset of ion pumps
- Electrically complex environment – needed comprehensive approach to hazardous energy control
- Required full disassembly of the MEBT (except for removing the 4 rebunching cavities) to properly dry and rehabilitate equipment
- Dewatering the rebunchers was tricky – final solution was to circulate heated glycol mix through the cooling passages at temperatures >100C but below O-ring limits of ~120C
- Excellent performance by a large team of people – no safety issues and only two minor equipment events during recovery



MEBT before disassembly



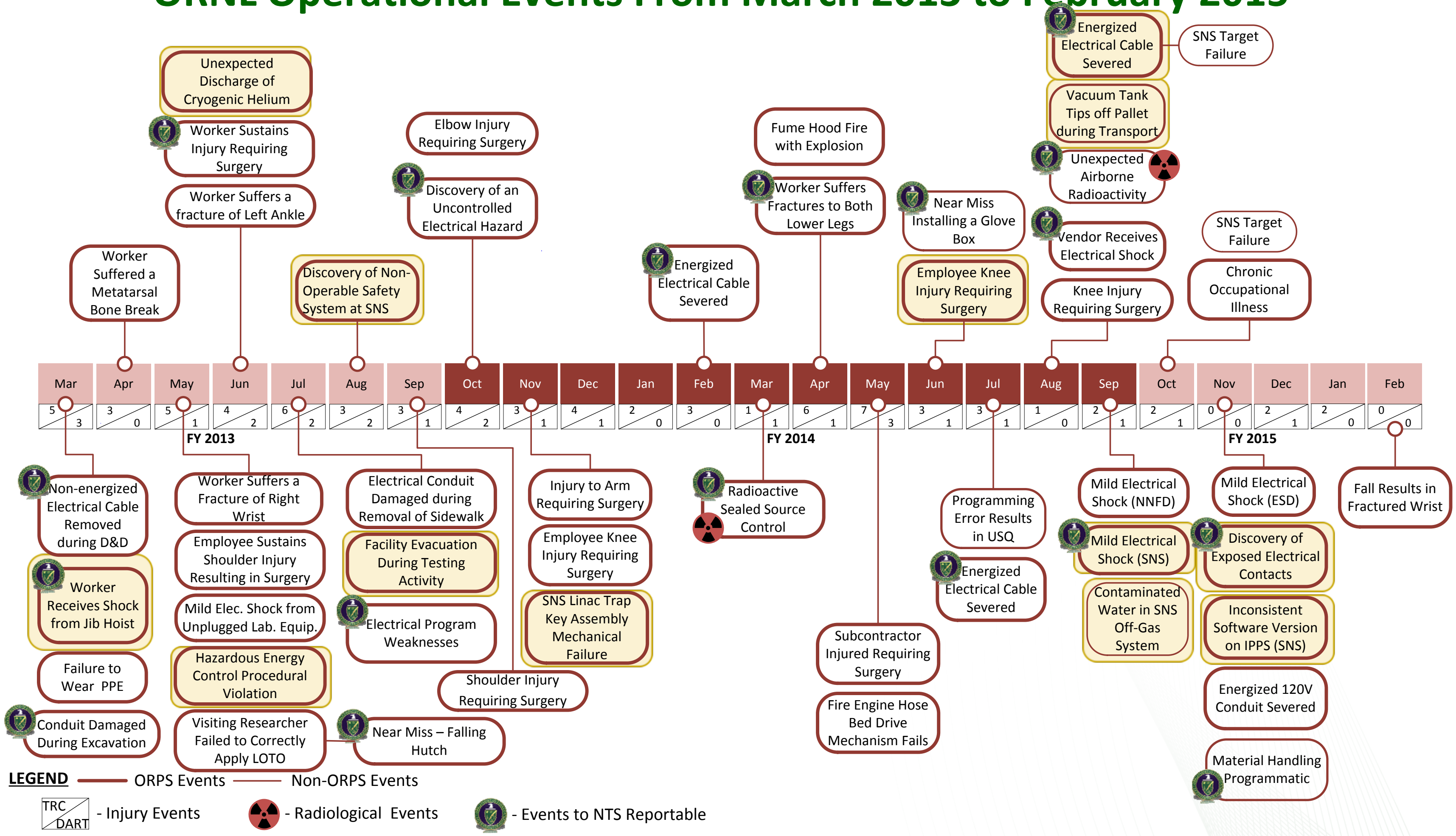
MEBT after disassembly



Dewatering rebunchers

SNS has also experienced a number of other operational events since March 2013

ORNL Operational Events From March 2013 to February 2015



- The PPS event of August 2013 was very significant – ASE violation, and required DOE concurrence for restart, which was achieved in 9.5 days

OAK RIDGE National Laboratory | SPALLATION NEUTRON SOURCE

The outcome of the DOE Cost Review in November 2013 was generally positive for accelerator aspects

- The advice received from this committee was helpful in our preparations
- “The reviewers noted the benefits and efficiencies of the new organization:
  - “The integration of the facility operations groups and crafts into the accelerator operations division.”
- “Other items of special mention from the reviewers:
  - “The high reliability of the accelerator and the continuing efforts to push toward the 1.4 MW design power level.
  - “The effort to improve quality control and lifetime predictability of the SNS Hg target following the disastrous sequential failure of two targets in October 2012.”
- “SNS Specific Recommendations:
  - “SNS must continue to make improvements that will facilitate sustained operation at the 1.4 MW power level while maintaining better than 90% reliability. A timeline for 1.4 MW operation should be provided to BES.
  - Target reliability and lifetime issues must be quantified so that a predictable run schedule can be maintained without major concern over unexpected target failures.”
- “The SNS and HFIR have demonstrated great progress over the past two plus years in reaching the goal of providing world leading scientific facilities for neutron scattering. … Optimization of …. must be the overarching priority for the facilities to meet or exceed their potential in producing high impact science. The management and staff are to be congratulated for embracing this goal and refocusing their efforts to achieve maximum scientific productivity.”

This committee is asked to assess our operations, our path to sustainable 1.4 MW operation, and the plans for the Second Target Station

1. Assess the performance of the accelerator complex and neutron source since the last meeting.
2. Assess and provide advice on the plans for sustainable beam operation with availability at the ≥90% level at ~1.4MW beam power for 5000 operating hours per year in a constrained funding environment. Consider the lessons learned from the high power run in the first half of 2014 and current maintenance strategy.
3. Assess the adequacy of our approach to sustaining and developing critical systems, including High Voltage Converter Modulators, Superconducting Cavities (plasma processing), Injection Stripping (Foils, lasers), Personnel Protection System and Controls (including high level applications) and the Integrated Front End Test Stand facility.
4. Is the SNS response to the observed RFQ issues adequate?
5. Does the AIP investment strategy align with the 1.4MW reliable, sustainable operation and STS path?
6. Provide advice on the accelerator systems components of the draft technical design report for the Second Target Station and provide guidance on the reasonableness of the updated plan for the power upgrade in the SCL, with fewer new Cryo-modules than originally planned.

OAK RIDGE National Laboratory | SPALLATION NEUTRON SOURCE

Summary

- We can operate reproducibly with beam power ≥ 1 MW and availability ≥ 90%
- While we meet or exceed operating commitments many significant challenges remain
- Our immediate focus is on sustaining availability and continuing operation at the highest possible power subject to Target and RFQ limitations
- Our medium term effort will achieve reliable 1.4MW operation by 2017, lay the foundation for 3MW capability and maintain the potential to carry out the Second Target Station project
- Institutional commitment has been essential to our success

The hard work, dedication and talent of the SNS staff enable these achievements