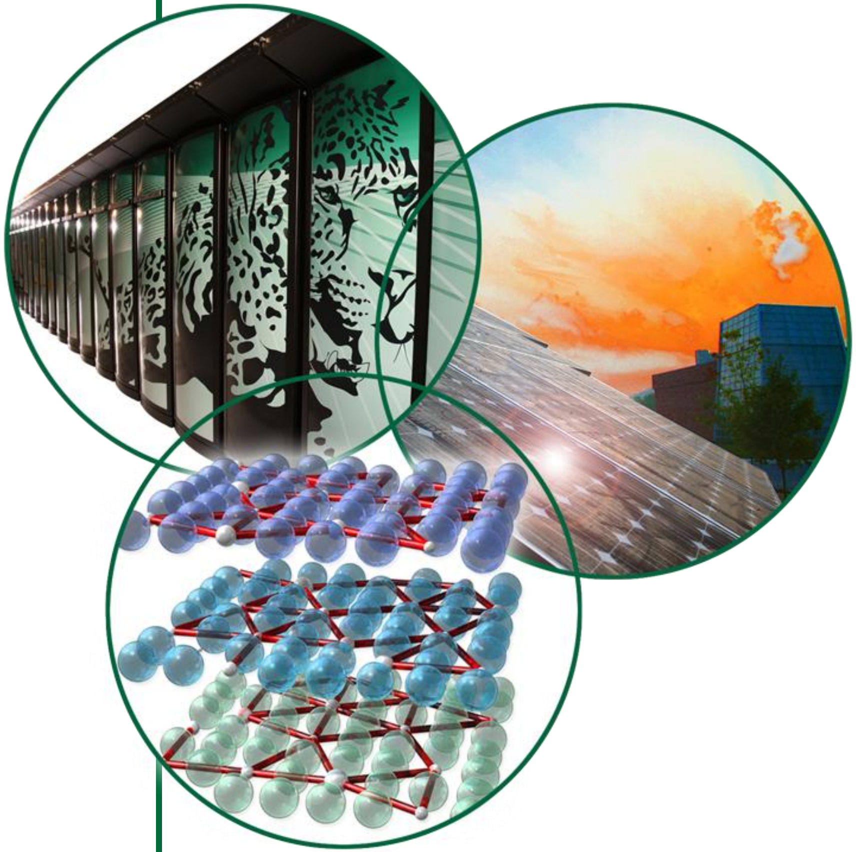
Spallation Neutron Source Status and Plans

J. Mammosser



U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY

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Overview

- SNS linac and ring are operating at 800KW beam power and are capable of meeting design goal of 1MW

- Preparation is underway for the power up grade (PUP) of the linac, currently at CD1

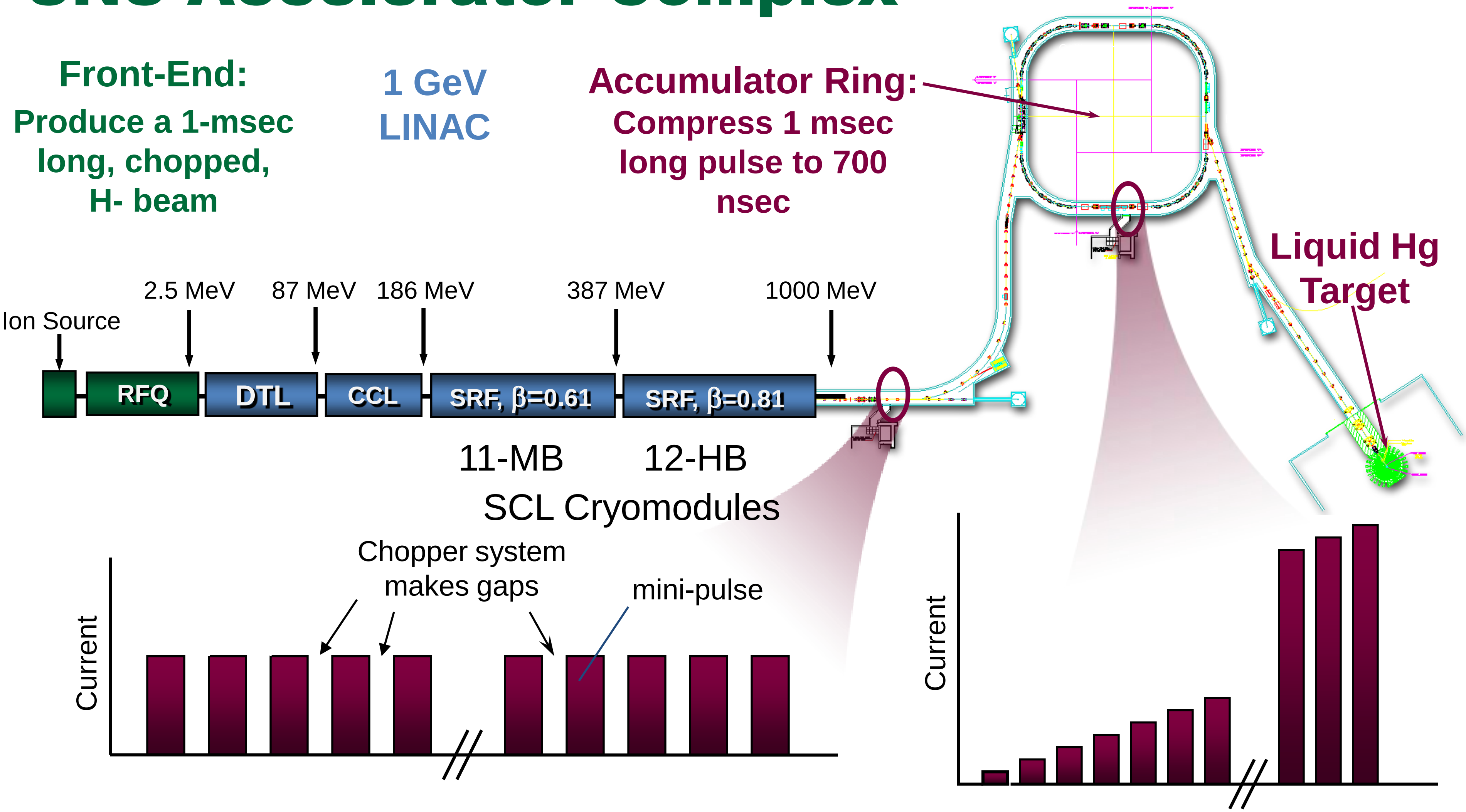
- Second Target Station (STS) planning is underway , currently at CD0

SNS Accelerator Complex

Front-End:
Produce a 1-msec long, chopped, H- beam

1 GeV LINAC

Accumulator Ring:
Compress 1 msec long pulse to 700 nsec



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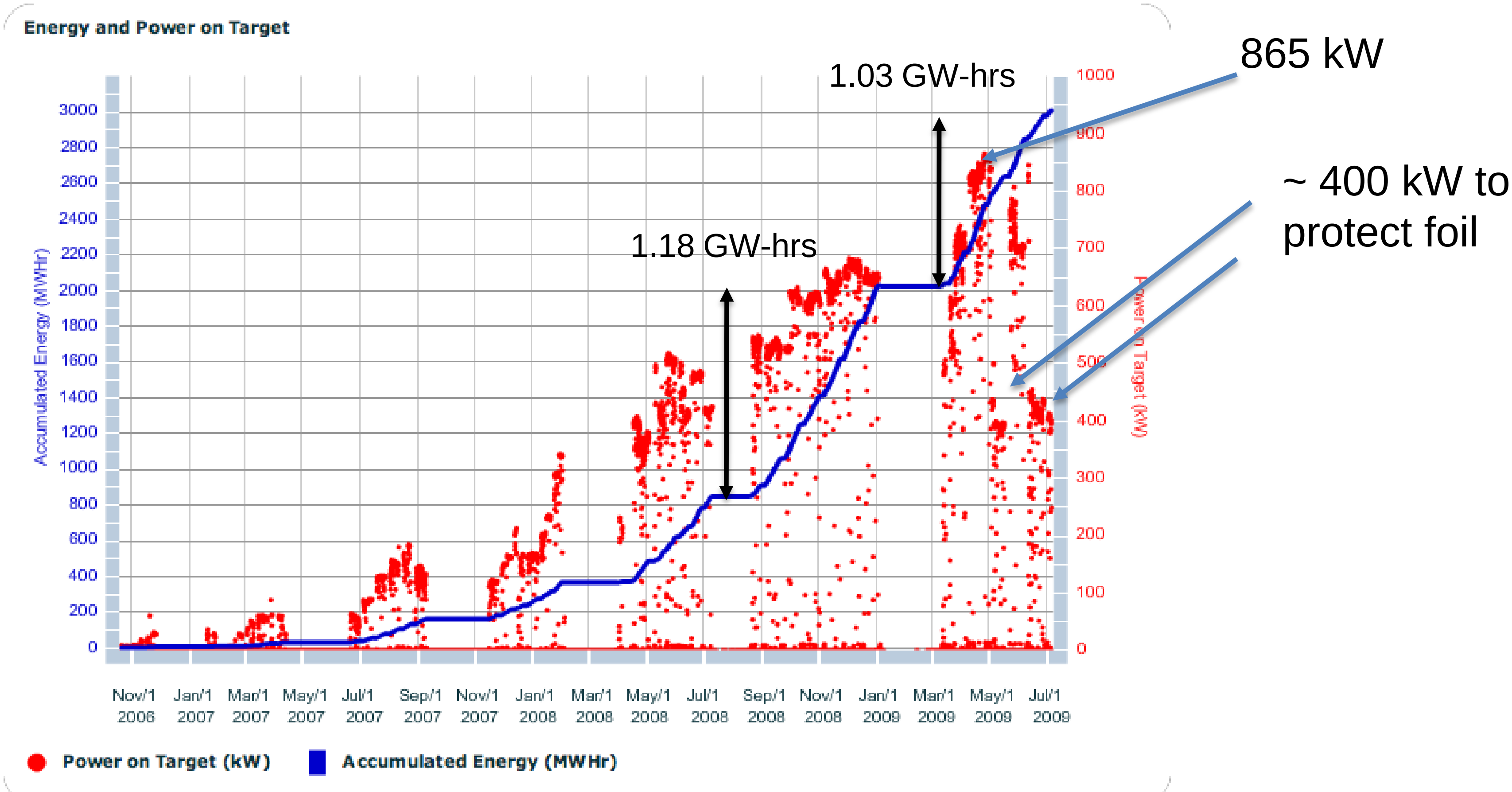
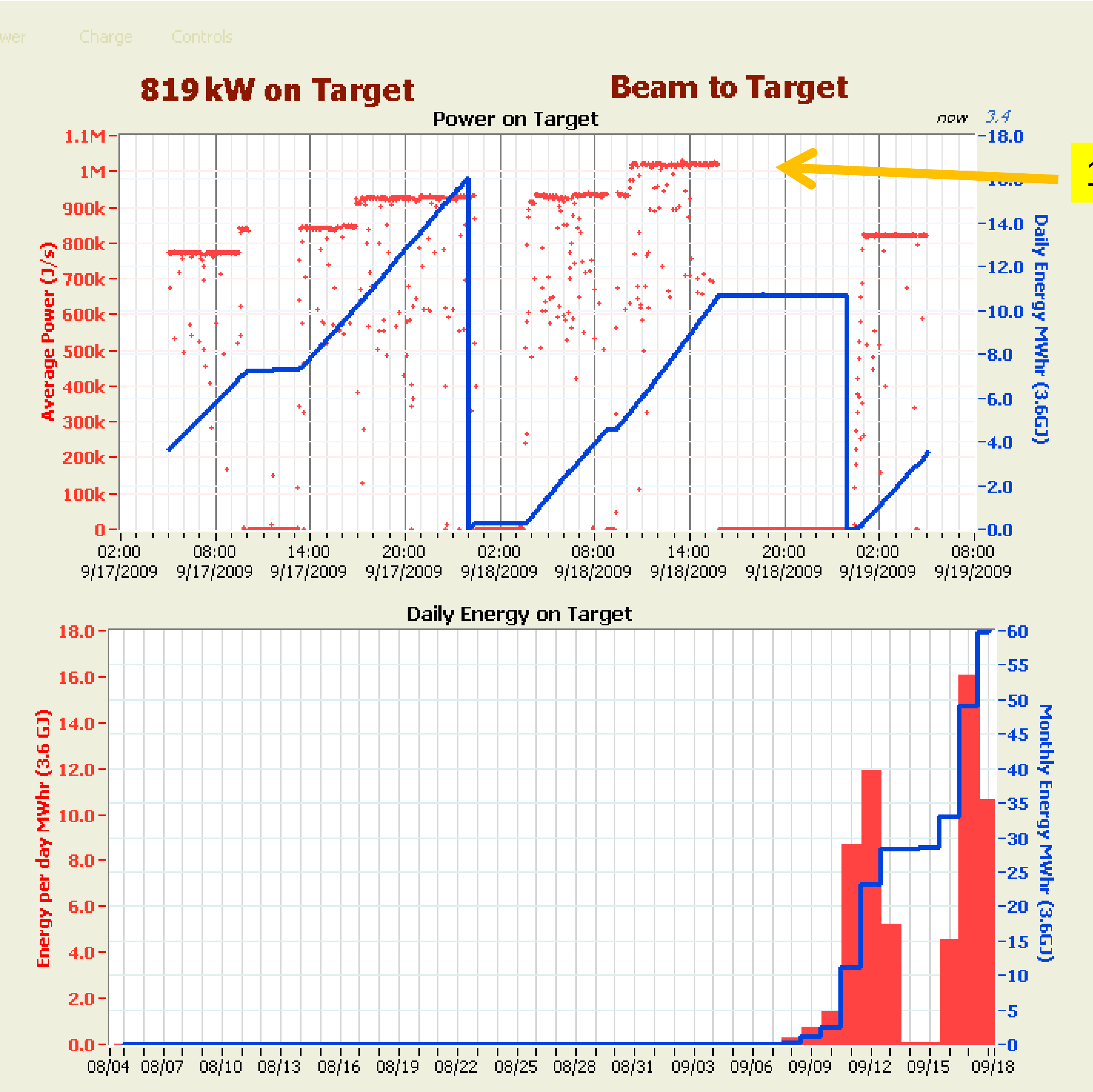
Beam Power

- ~ 850 kW max. operational power





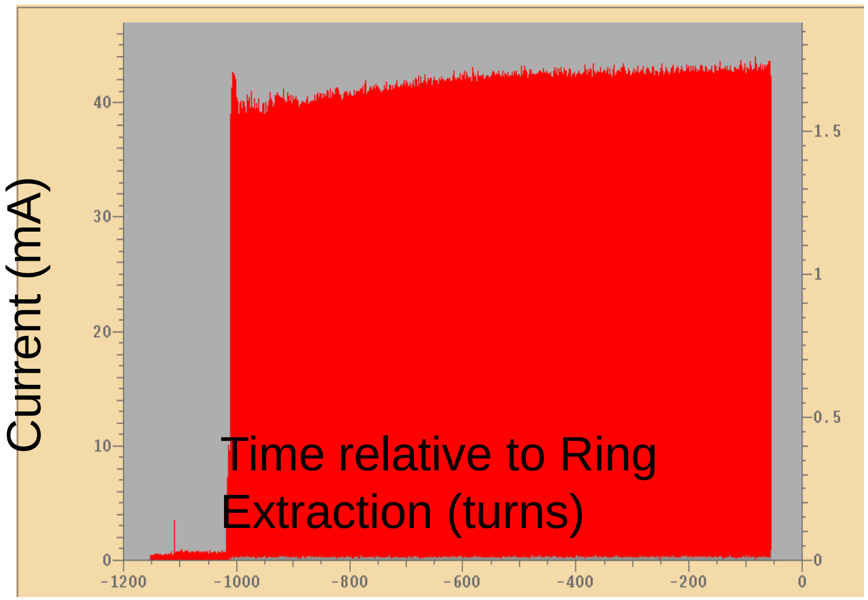
1MW Beam Power

Major Parameters achieved vs. designed

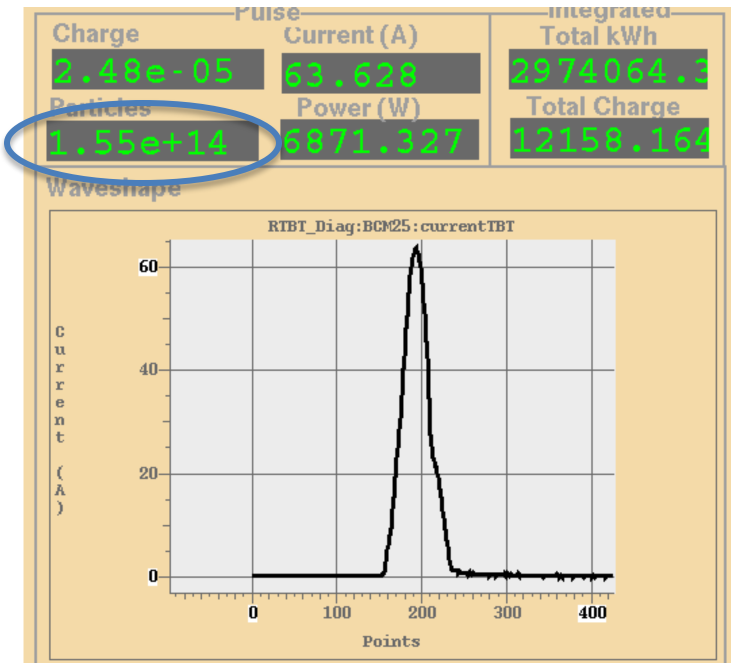
Parameters	Design	Individually achieved	Highest production beam
Beam Energy (GeV)	1.0	1.01	0.93
Peak Beam current (mA)	38	40	40
Average Beam Current (mA)	26	24	24
Beam Pulse Length (μs)	1000	1000	670
Repetition Rate (Hz)	60	60	60
Beam Power on Target (kW)	1440	880	880
Linac Beam Duty Factor (%)	6	4.0	4.0
Beam intensity on Target (protons per pulse)	1.5×10^{14}	1.3×10^{14}	1×10^{14}
SCL Cavities in Service	81	80	80

High Intensity Beam Studies – 7/11/2009

Linac Beam waveform:
- ~ 1 msec long
- produces the design intensity

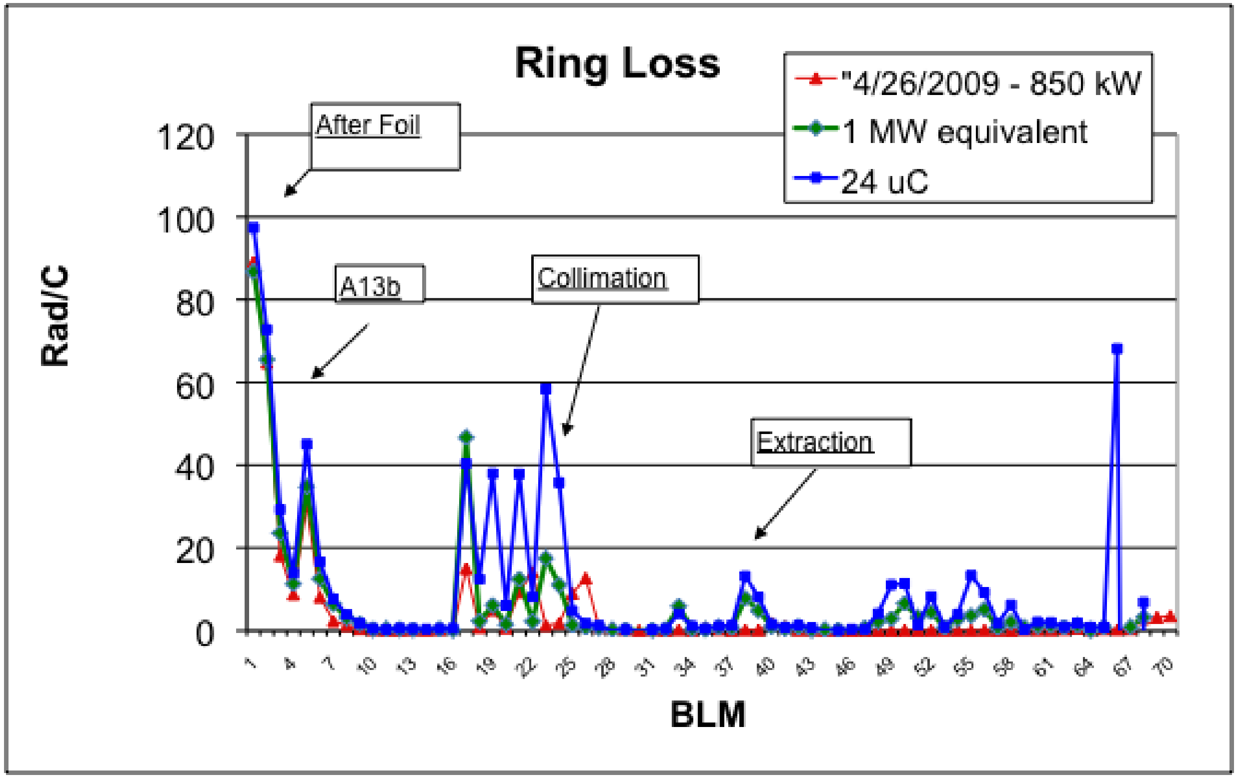


Beam Pulse Extracted from the Ring:
- Full baseline design intensity stored and extracted
- No gross instability observed



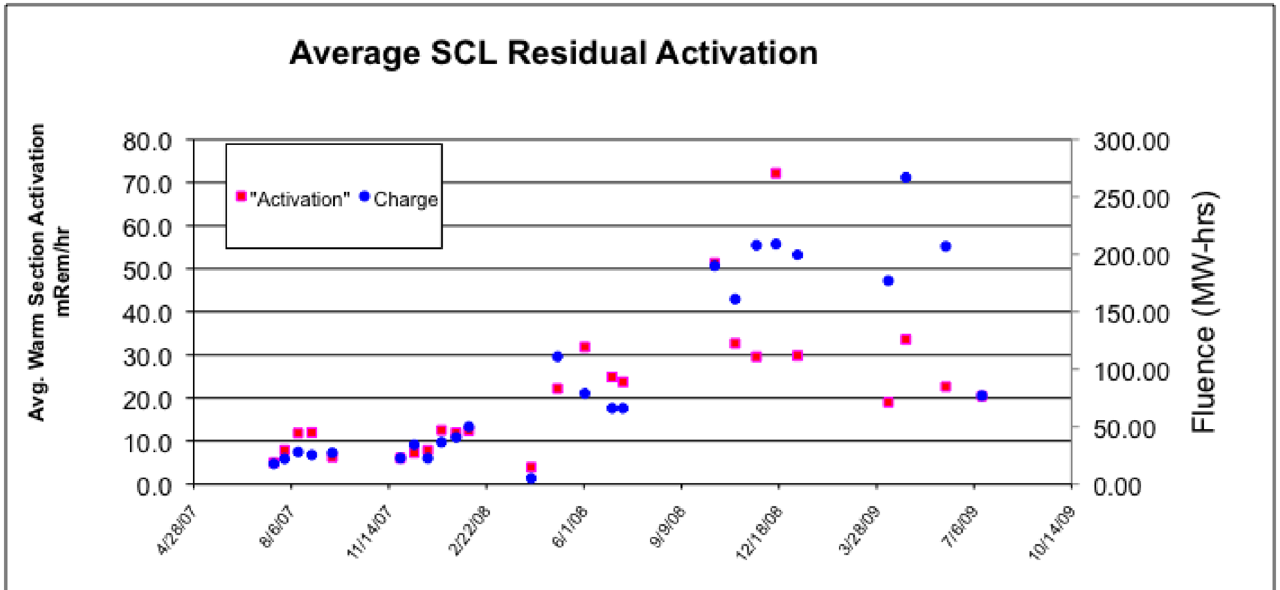
- **The linac delivered the full pulse length at full power**
- **For the first time we verified the Ring can stably store and extract the design intensity of 1.5 x10^{14} ppp**

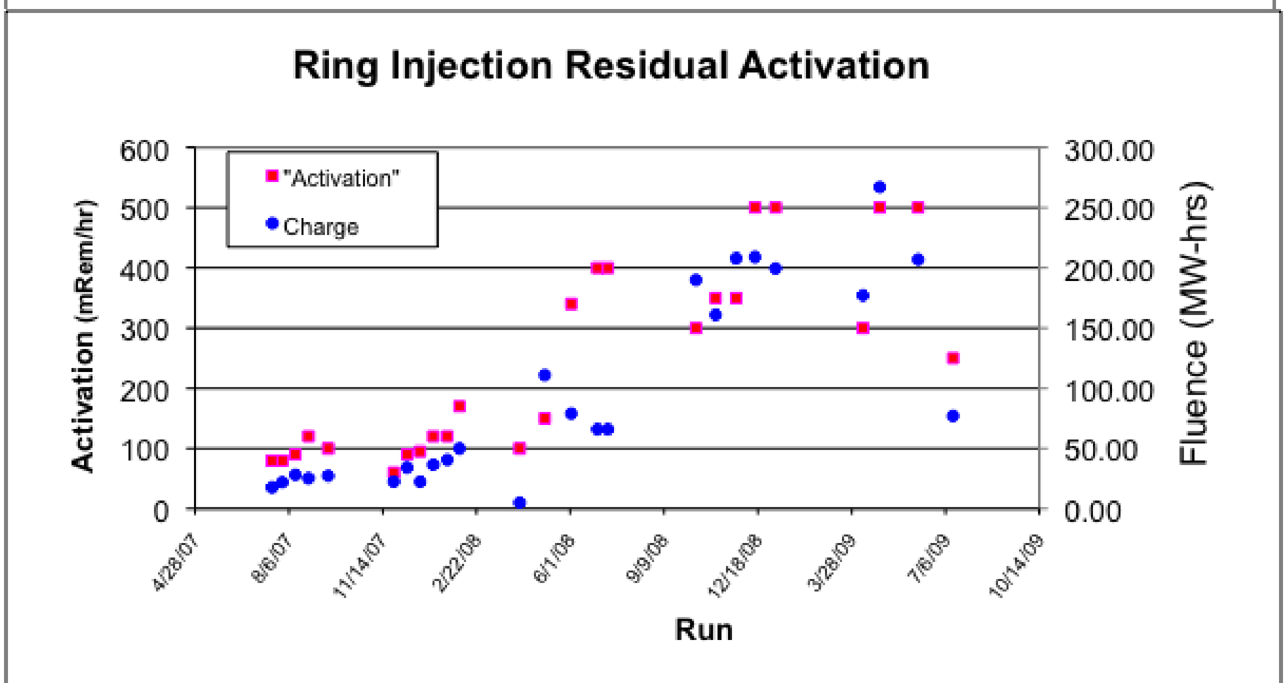
Ring Beam Loss at High Intensity



- No serious tuning done
  - 1 MW – ready for prime-time
  - 24 μC –not that bad – needed 20 kV of 2nd harmonic RF
    - 1.44 MW @ 60 Hz (1 GeV)

Residual Activation Buildup





- SCL Activation Buildup “saturated”
- Injection Activation at 865 kW similar to 650 kW level (but no extended run time)

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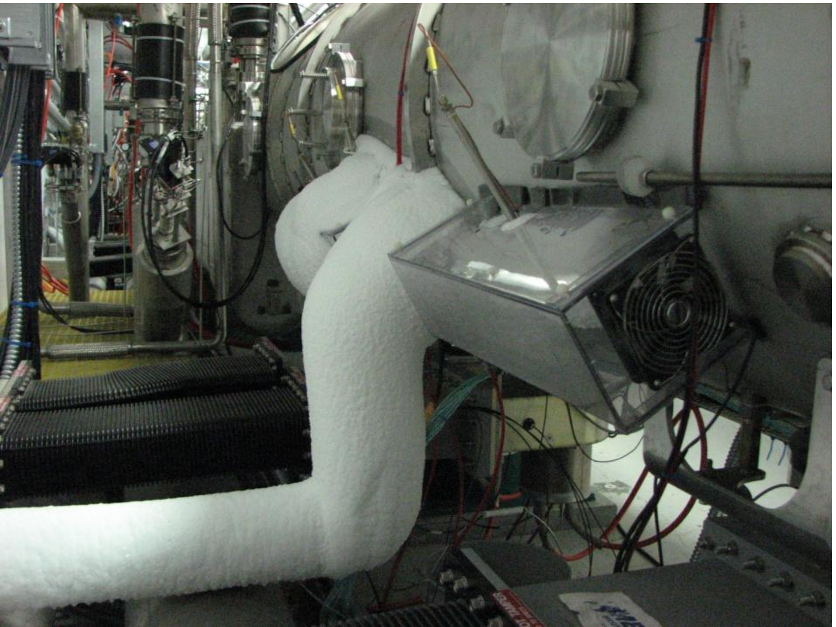
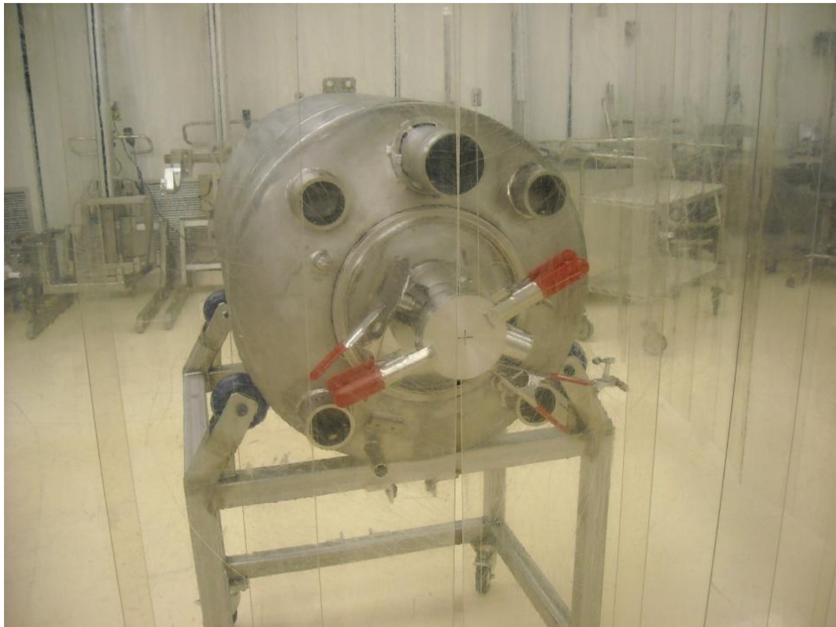
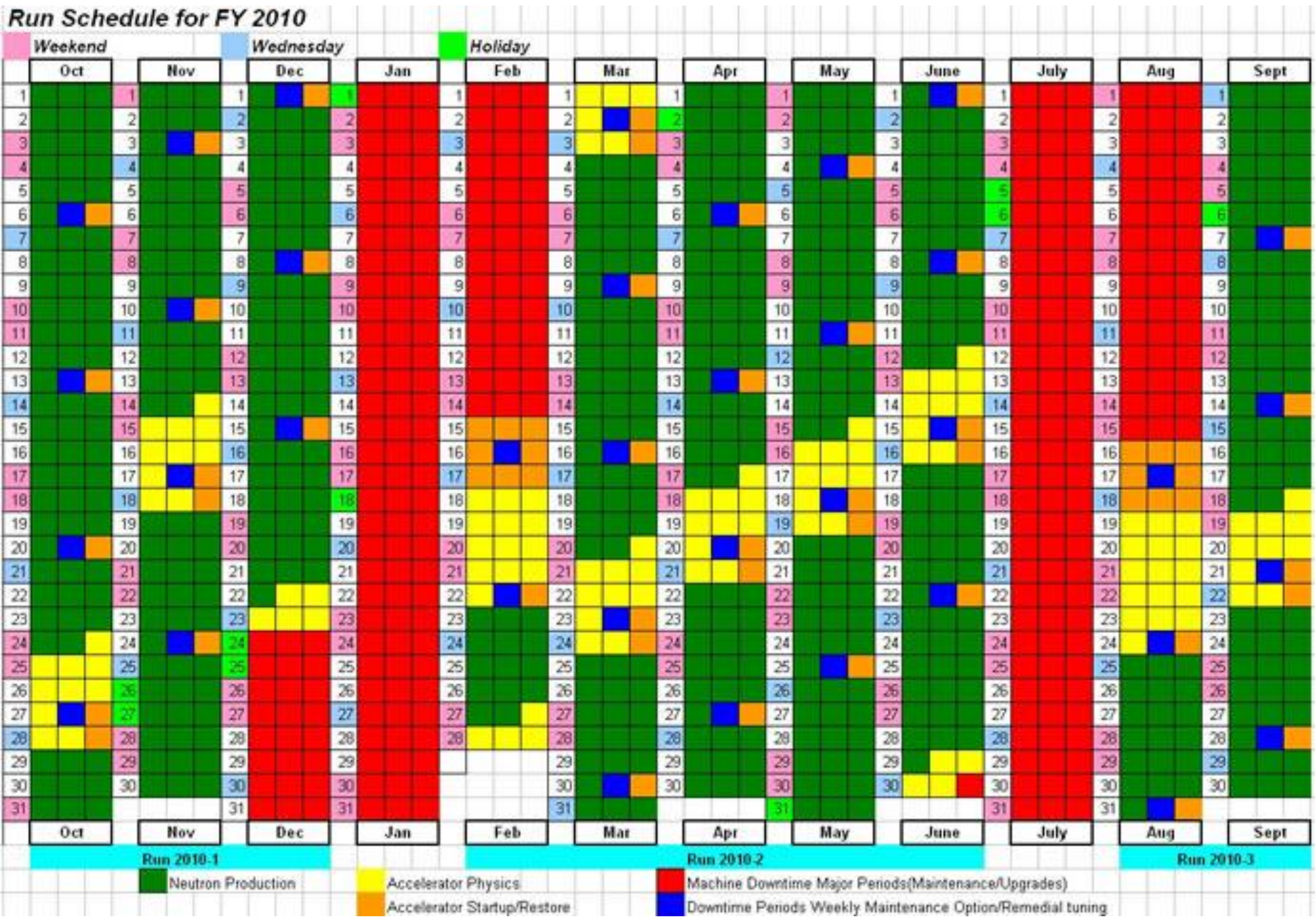
Operating and Repairing of Cryomodules





FY2010 Run Schedule

- Red = extended maintenance
- Yellow = physics
- Green = production
- Blue = Maintenance Days



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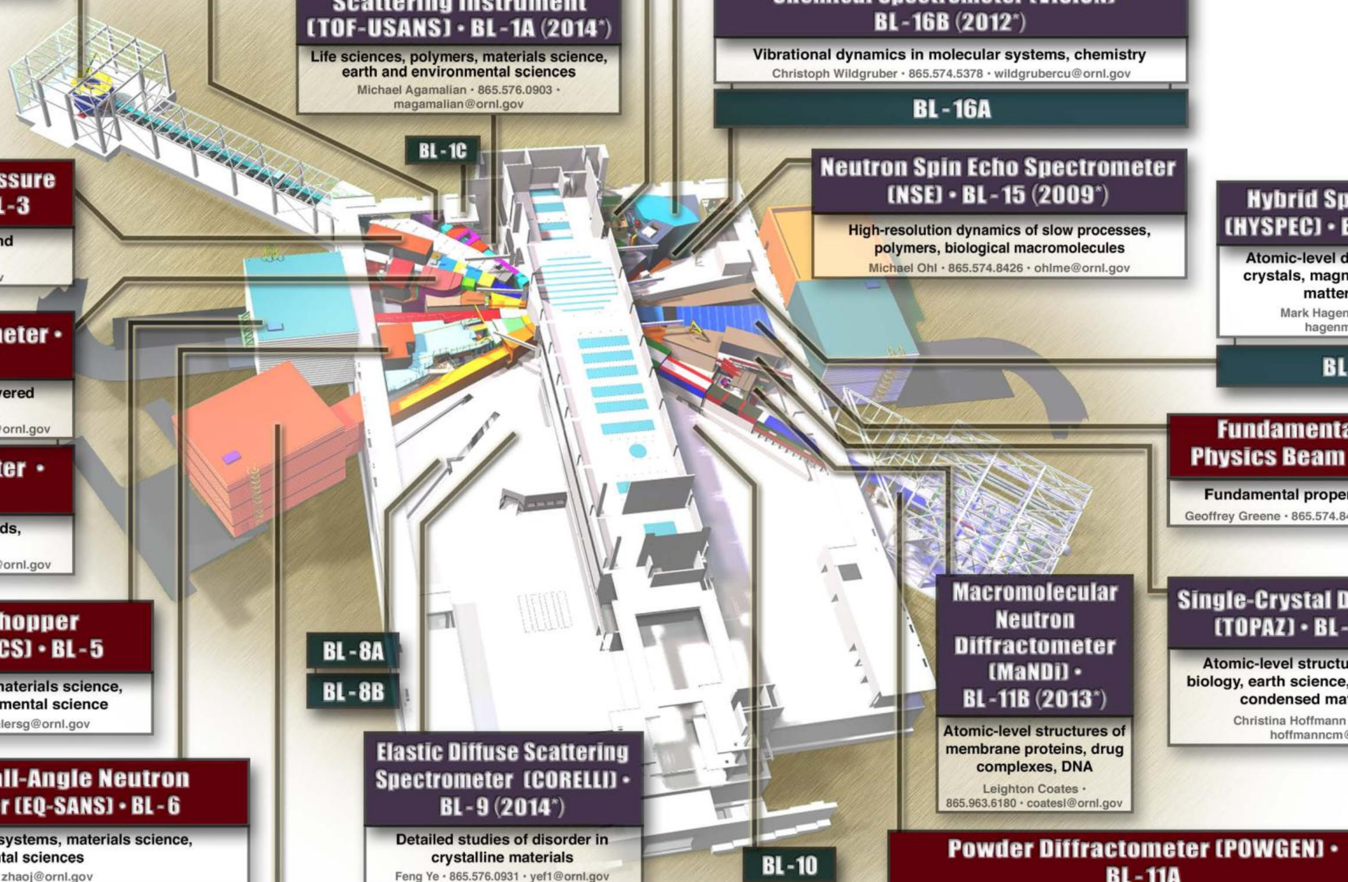
Spallation Neutron Source at Oak Ridge National Laboratory

The world's most intense pulsed, accelerator-based neutron source

SNS SPALLATION NEUTRON SOURCE



Backscattering Spectrometer (BASIS) • BL - 2
Dynamics of macromolecules, constrained molecular systems, polymers, biology, chemistry, materials science
Eugene Mamontov • 865.574-5109 • mamontove@ornl.gov

Nanoscale-Ordered Materials Diffractometer (NOMAD) • BL - 1B (2010*)
Liquids, solutions, glasses, polymers, nanocrystalline and partially ordered complex materials
Joerg Neuefeind • 865.241.1635 • neuefeindjc@ornl.gov

Wide Angular-Range Chopper Spectrometer (ARCS) • BL - 18
Atomic-level dynamics in materials science, chemistry, condensed matter sciences
Doug Abernathy • 865.576.5105 • abernathydl@ornl.gov

Fine-Resolution Fermi Chopper Spectrometer (SEQUOIA) • BL - 17
Dynamics of complex fluids, quantum fluids, magnetism, condensed matter, materials science
Garrett Granroth • 865.576.0900 • granrothge@ornl.gov

Ultra-Small-Angle Neutron Scattering Instrument (TOF-USANS) • BL - 1A (2014*)
Life sciences, polymers, materials science, earth and environmental sciences
Michael Agamalian • 865.576.0903 • magamalian@ornl.gov

Chemical Spectrometer (VISION) • BL - 16B (2012*)
Vibrational dynamics in molecular systems, chemistry
Christoph Wildgruber • 865.574.5378 • wildgrubercu@ornl.gov

Spallation Neutrons and Pressure Diffractometer (SNAP) • BL - 3
Materials science, geology, earth and environmental sciences
Chris Tulk • 865.576.7028 • tulkca@ornl.gov

Neutron Spin Echo Spectrometer (NSE) • BL - 15 (2009*)
High-resolution dynamics of slow processes, polymers, biological macromolecules
Michael Ohl • 865.574.8426 • ohlme@ornl.gov

Hybrid Spectrometer (HYSPEC) • BL - 14B (2011*)
Atomic-level dynamics in single crystals, magnetism, condensed matter sciences
Mark Hagen • 865.241.9782 • hagenme@ornl.gov

Magnetism Reflectometer • BL - 4A
Chemistry, magnetism of layered systems and interfaces
Valeria Lauter • 865.576.5389 • lauterv@ornl.gov

Liquids Reflectometer • BL - 4B
Interfaces in complex fluids, polymers, chemistry
John Ankner • 865.576.5122 • anknerjf@ornl.gov

Fundamental Neutron Physics Beam Line • BL - 13
Fundamental properties of neutrons
Geoffrey Greene • 865.574.8435 • greenegl@ornl.gov

Cold Neutron Chopper Spectrometer (CNCS) • BL - 5
Condensed matter physics, materials science, chemistry, biology, environmental science
Georg Ehlers • 865.576.3511 • ehlersg@ornl.gov

Macromolecular Neutron Diffractometer (MaNDi) • BL - 11B (2013*)
Atomic-level structures of membrane proteins, drug complexes, DNA
Leighton Coates • 865.963.6180 • coatesl@ornl.gov

Single-Crystal Diffractometer (TOPAZ) • BL - 12 (2009*)
Atomic-level structures in chemistry, biology, earth science, materials science, condensed matter physics
Christina Hoffmann • 865.576.5127 • hoffmanncm@ornl.gov

Extended Q-Range Small-Angle Neutron Scattering Diffractometer (EQ-SANS) • BL - 6
Life science, polymer and colloidal systems, materials science, earth and environmental sciences
Jinkui Zhao • 864.574.0411 • zhaoj@ornl.gov

Elastic Diffuse Scattering Spectrometer (CORELLI) • BL - 9 (2014*)
Detailed studies of disorder in crystalline materials
Feng Ye • 865.576.0931 • yef1@ornl.gov

Powder Diffractometer (POWGEN) • BL - 11A
Atomic-level structures in chemistry, materials science, and condensed matter physics including magnetic spin structures
Jason Hodges • 865.576.7034 • hodgesj@ornl.gov

Engineering Materials Diffractometer (VULCAN) • BL - 7 (2009*)
Mechanical behaviors, materials science, materials processing
Xun-Li Wang • 865.574.9164 • wangxl@ornl.gov

* Scheduled commissioning date

LEGEND
- Installed, commissioning, or operating
- In design or construction
- Under consideration

06-G00400L/arm

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Linac Cryomodule Performance:

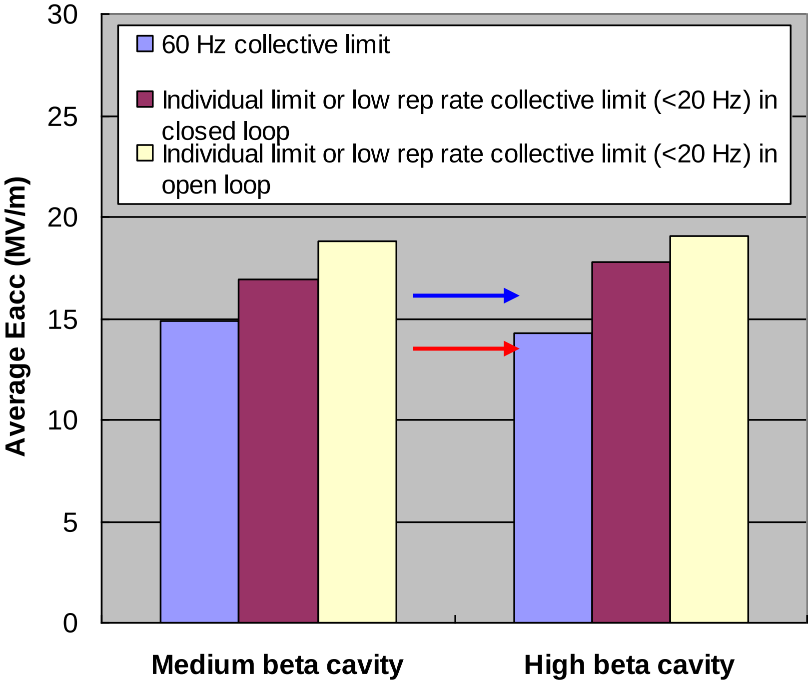
- Linac Energy at 930 MeV + 10MeV energy reserve
- 80 of 81 cavities in service

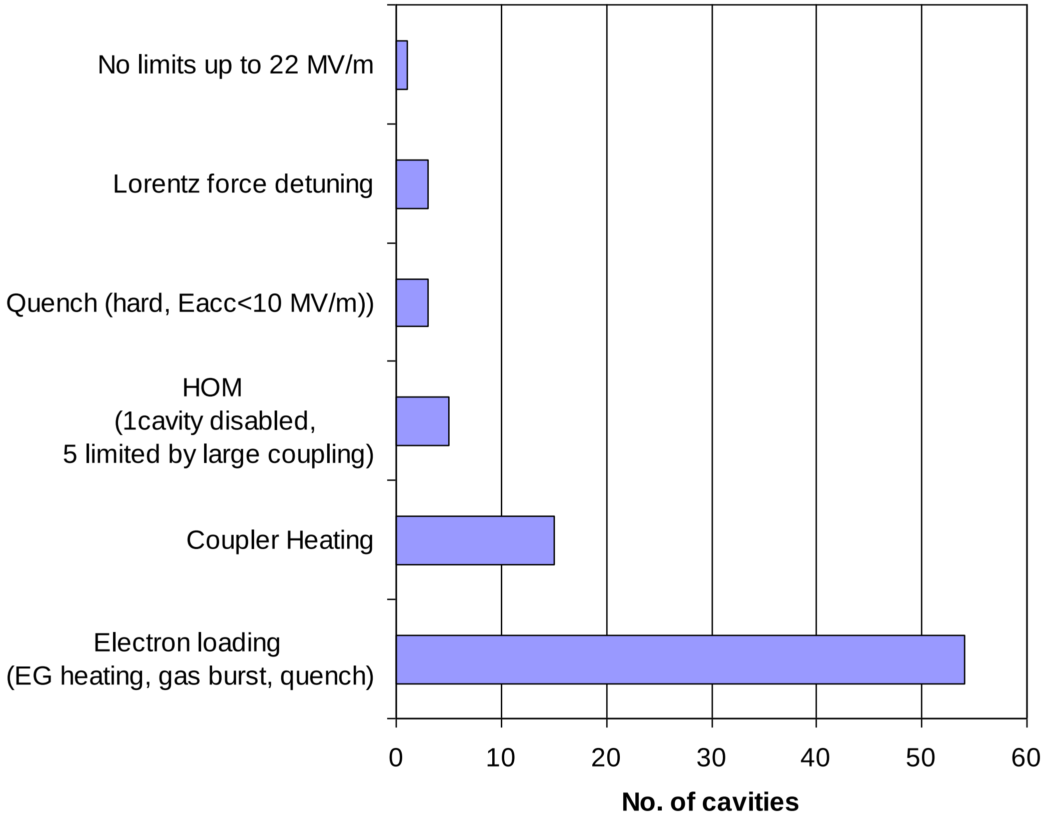
- Cavity performance has been very stable and reliable
  - MB cavities performing above specifications
  - HB cavities are performing slightly below specifications
  - No degradation in performance so far (field emission stable)
  - Trip rates are very low (1 per day)

- Plans are to apply plasma cleaning to installed cryomodules to reduce the collective effects from field emission

Linac Energy Limiting factor (I)

- Cavity performances
  - Field emission (major limiting factor)
  - Coupler heating
  - Others

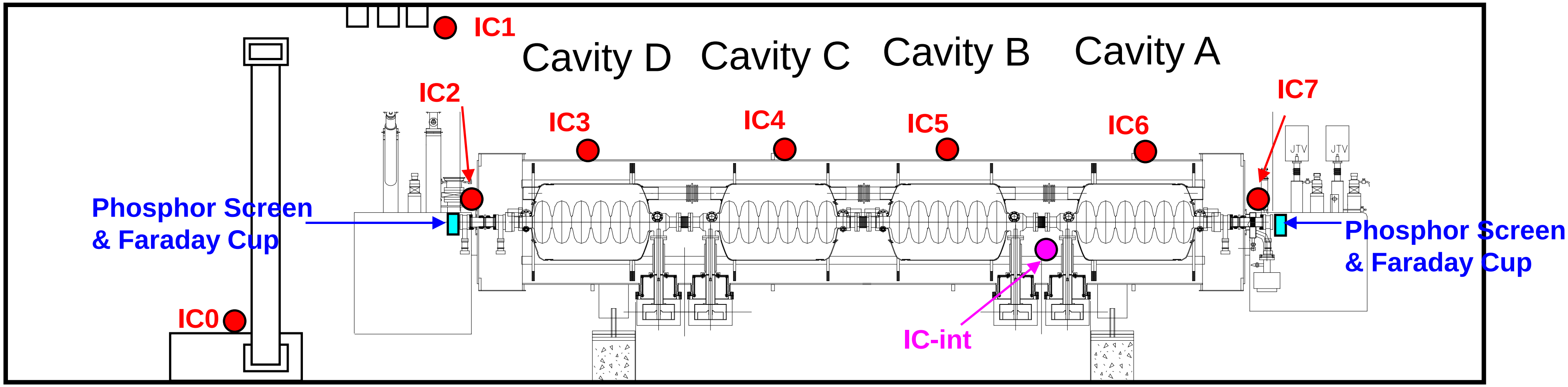


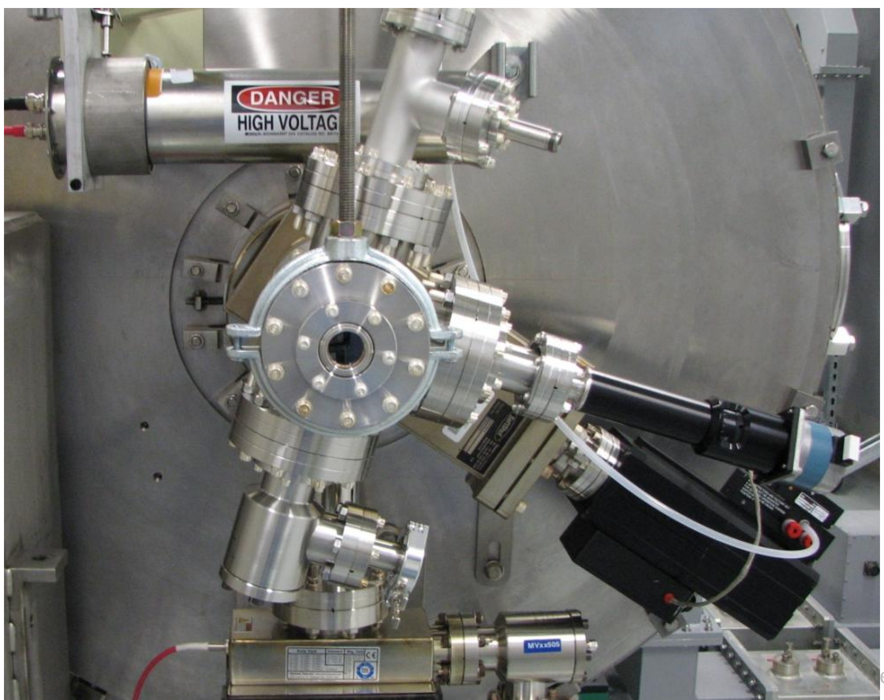


SRF Activities Supporting PUP

- Preparation of SRF supporting facilities currently underway
  - New facilities will include
    - Vertical test dewar
    - Horizontal test cryostat
    - Cryogenic refrigeration upgrade to support vertical and horizontal cavity testing
- Production of a spare HB cryomodule
  - Design changes to cryomodule envelope
  - Study of cavity performance limitations (field emission/ multipacting)
  - Development of new design for the cryogenic heat exchanger
- Developing Plasma Processing for Cleaning Niobium Surfaces

Radiation/electron activity diagnostics in the Test Cave





- Ionization Chamber
- Internal Ionization Chamber
- Phosphor Screen, Camera, Faraday Cup

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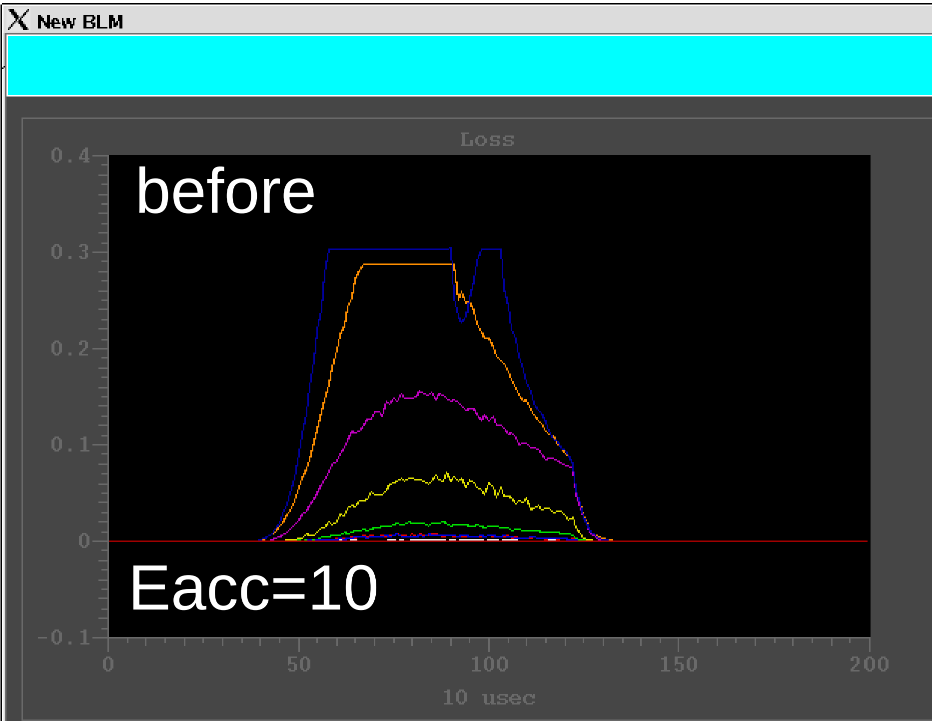
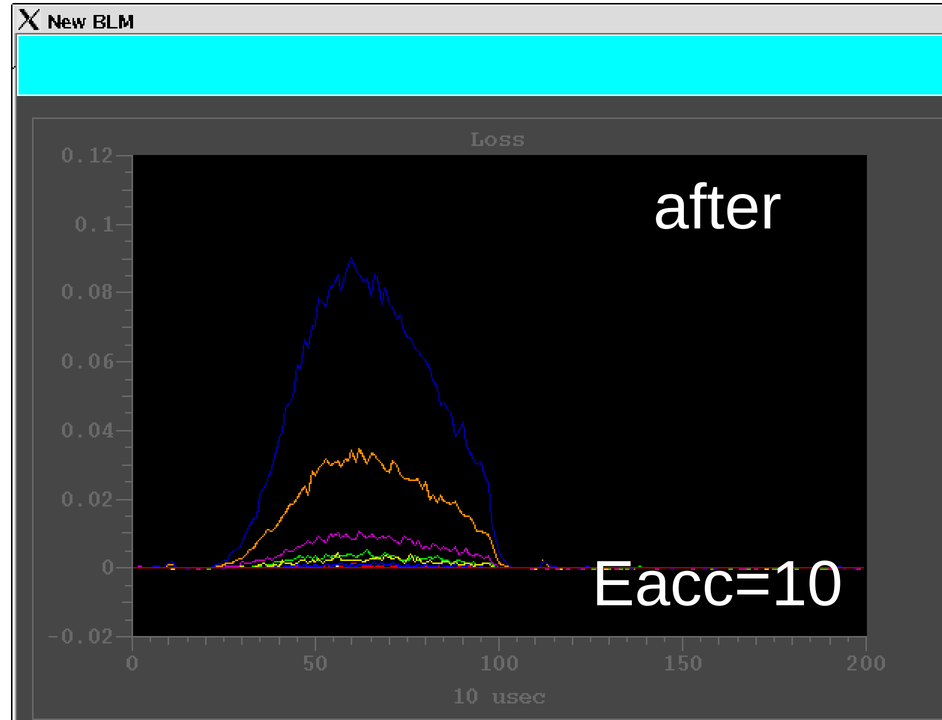
Radiation (before and after plasma processing)

Radiation reduced by factor of 5 to 100

Showed promising results for in-situ processing



Rads/Pulse		Rads/Sec		Rads/Sec/Volt
5.982e-07	0	3.743e-05	0	1.430e-01
2.979e-06	1	1.814e-04	1	1.110e-01
9.251e-06	2	5.848e-04	2	3.480e-01
3.466e-06	3	1.976e-04	3	3.650e-01
3.272e-05	4	1.954e-03	4	1.510e-01
8.434e-05	5	5.077e-03	5	1.910e-01
1.534e-04	6	9.329e-03	6	8.200e-02
1.824e-04	7	1.083e-02	7	8.600e-02



Rads/Pulse		Rads/Sec		Rads/Sec/Volt
8.623e-08	0	3.909e-06	0	1.430e-01
1.998e-07	1	1.408e-05	1	1.110e-01
1.894e-06	2	1.117e-04	2	3.480e-01
6.951e-07	3	3.270e-05	3	3.650e-01
1.282e-06	4	8.019e-05	4	1.510e-01
4.664e-06	5	2.844e-04	5	1.910e-01
1.564e-05	6	9.620e-04	6	8.200e-02
4.105e-05	7	2.522e-03	7	8.600e-02

Radiation (before and after plasma processing)

Radiation reduced by factor of 5 to 100

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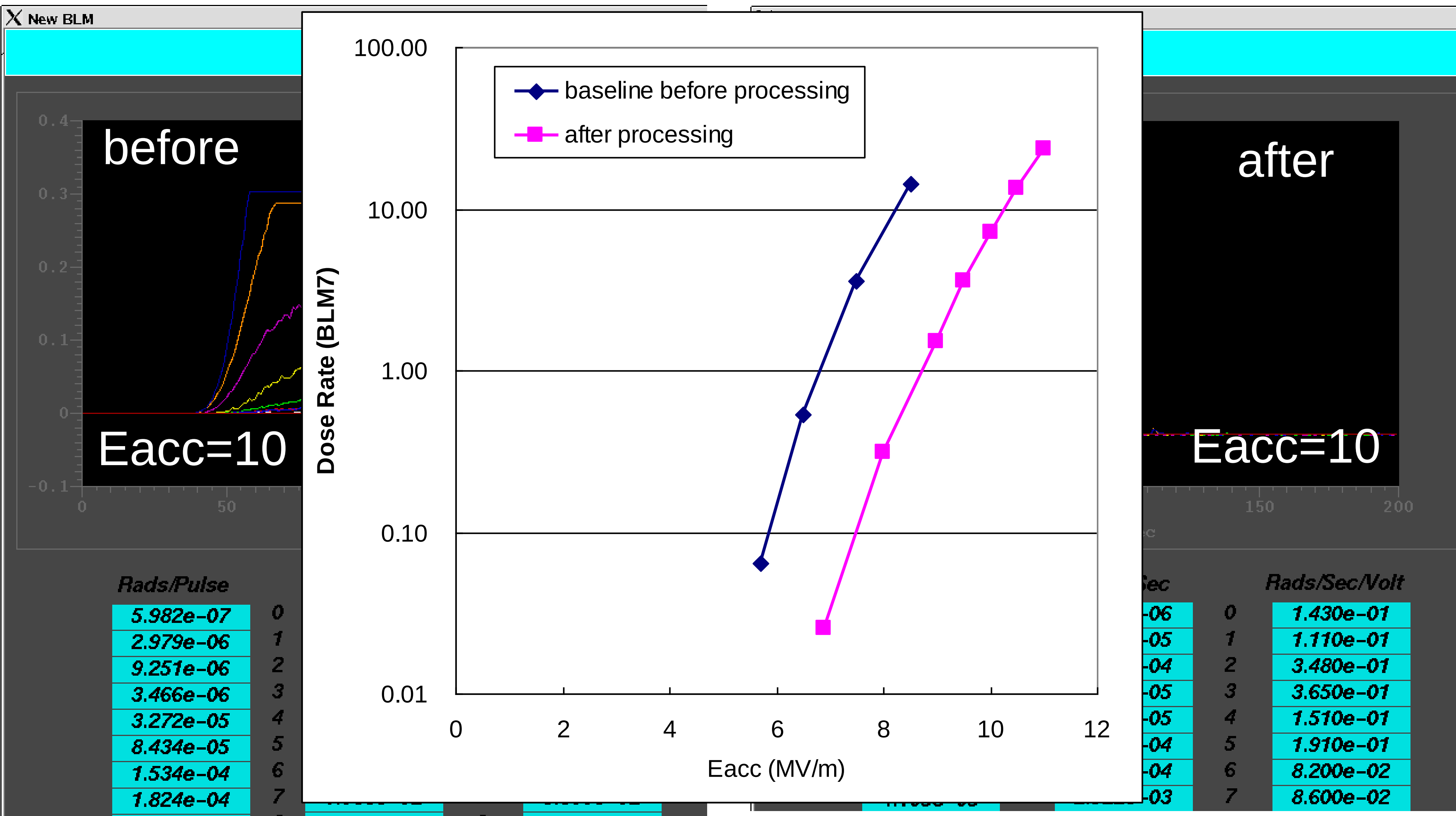

SNS Upgrade

- PUP (Power Upgrade Project)
  - CD-1 approved Jan. 2009
  - "complete" in 2015
  - 8+1 additional cryomodules → 1.3 GeV +reserve
  - AIP current increase 26→42mA

- STS (Second Target Station)
  - CD-0 approved Jan. 2009
  - "Complete" in 2019
  - FTS:40 Hz short (chopped) + STS:20 Hz long (unchopped)

PUP Parameters

	SNS Project Baseline	Present Operation (best to date)	Energy Upgrade (PUP)	CU AIPs
Beam kinetic energy, MeV	1000	928	1300	1300
Design goal beam power, MW	1.4		1.8	3
Required beam power (min), MW	1	0.86	1.3	2
Linac beam macro pulse duty factor, %	6	4	6	6
Average macropulse H- current, mA	26	24	26	42
Peak macropulse H- current, mA	38	38	38	59
Linac average beam current, mA	1.6	0.97	1.6	2.5
Linac average beam pulse length, ms	1	0.67	1	1
SRF cryo-module number, med-beta	11	11	11	11
SRF cryo-module number, high-beta	12	12	20 (+1 reserve)	20 (+1 reserve)
SRF cavity number	81	80	113 (+4 reserve)	113 (+4 reserve)
Operational gradient (E_{acc}) (β=0.61 cavity), MV/m	10.1 (+/- 1.0)	12.2	10.1 (+/- 1.0)	10.1 (+/- 1.0)
Operational gradient (E_{acc}) (β=0.81 cavity), MV/m	15.6 (+1.1/-3.5)	12.3	13.8	13.8
Ring injection time, ms / turns	1.0 / 1060	1.0 / 1060	1.0 / 1060	1.0 / 1100
Ring frequency, MHz	1.058		1.098	
Ring bunch intensity, 10^{14} (ppp)	1.6	1	1.6	2.5
Ring space-charge tune spread, ΔQSC	0.15	0.1	0.09	0.15
Pulse length on target, ns	695	700	695	691

- **Need to get 1.3 MW + 1.3 GeV for PUP**

- New DI Water Plant Installed
- E1 Grade
- 15GPM, 10GPM RO

- HPR Pump Installed
- New HPR Cabinet Completed (Niowave)

The SRF Challenges Next 3 Years:

- Bring up the linac energy to1 GeV
  - Develop good procedures for applying plasma cleaning and apply to the linac during maintenance periods

- Prove out design changes applied to the spare HB cryomodule (PUP baseline design)
  - Determine what can be done to reduce field emission limitations in new cryomodules
    - Technical options :Removal of HOM resonant structures, Electropolish
  - Develop in-house skills to support procurement of new cryomodules
  - Develop steps for meeting pressure vessel code requirements

- Install and commission new facilities