

# SNS Operations Tools and Automation

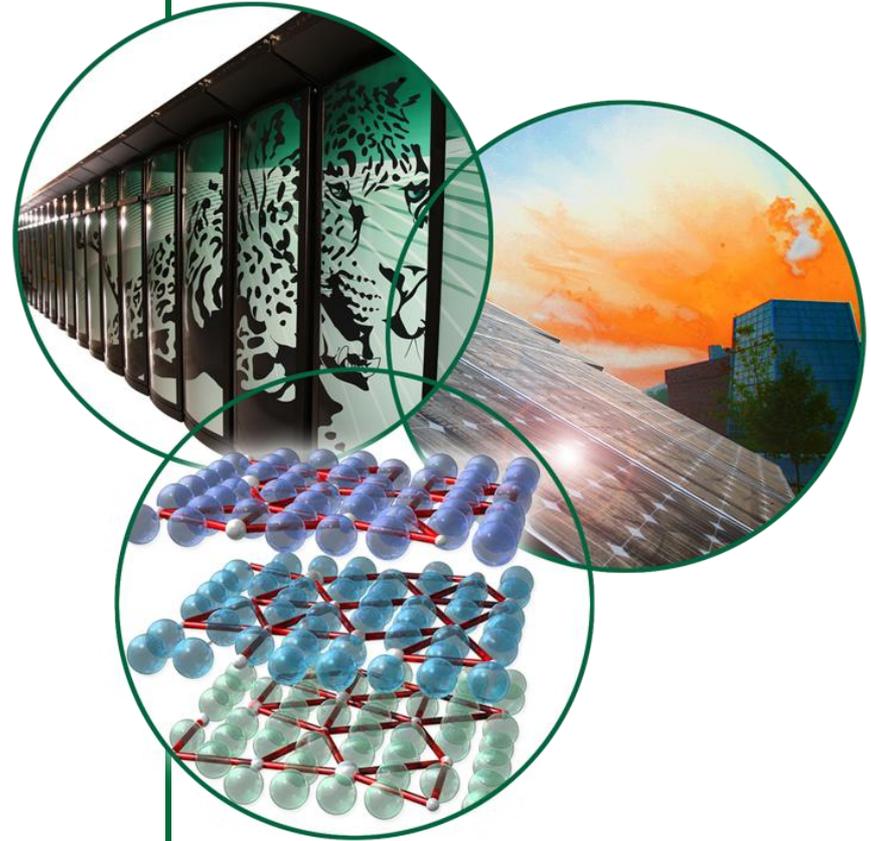
The 7<sup>th</sup> International Workshop on Accelerator  
Operations – Automation and Tools

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C.C. Peters, Accelerator Machine Specialist

On behalf of:  
N.P. Luciano, T.B. Southern, and many others

Presented by: George Dodson

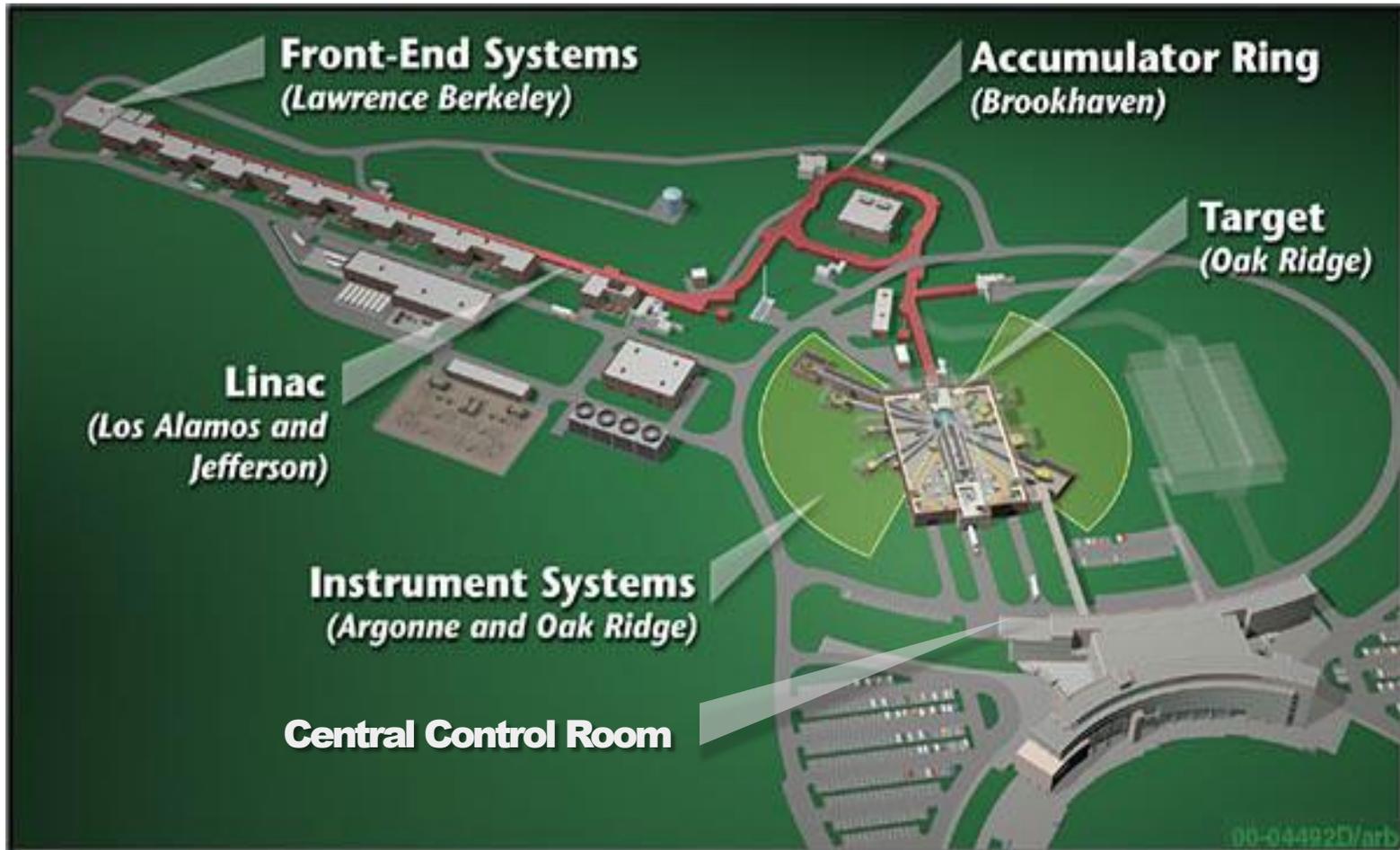


# Outline

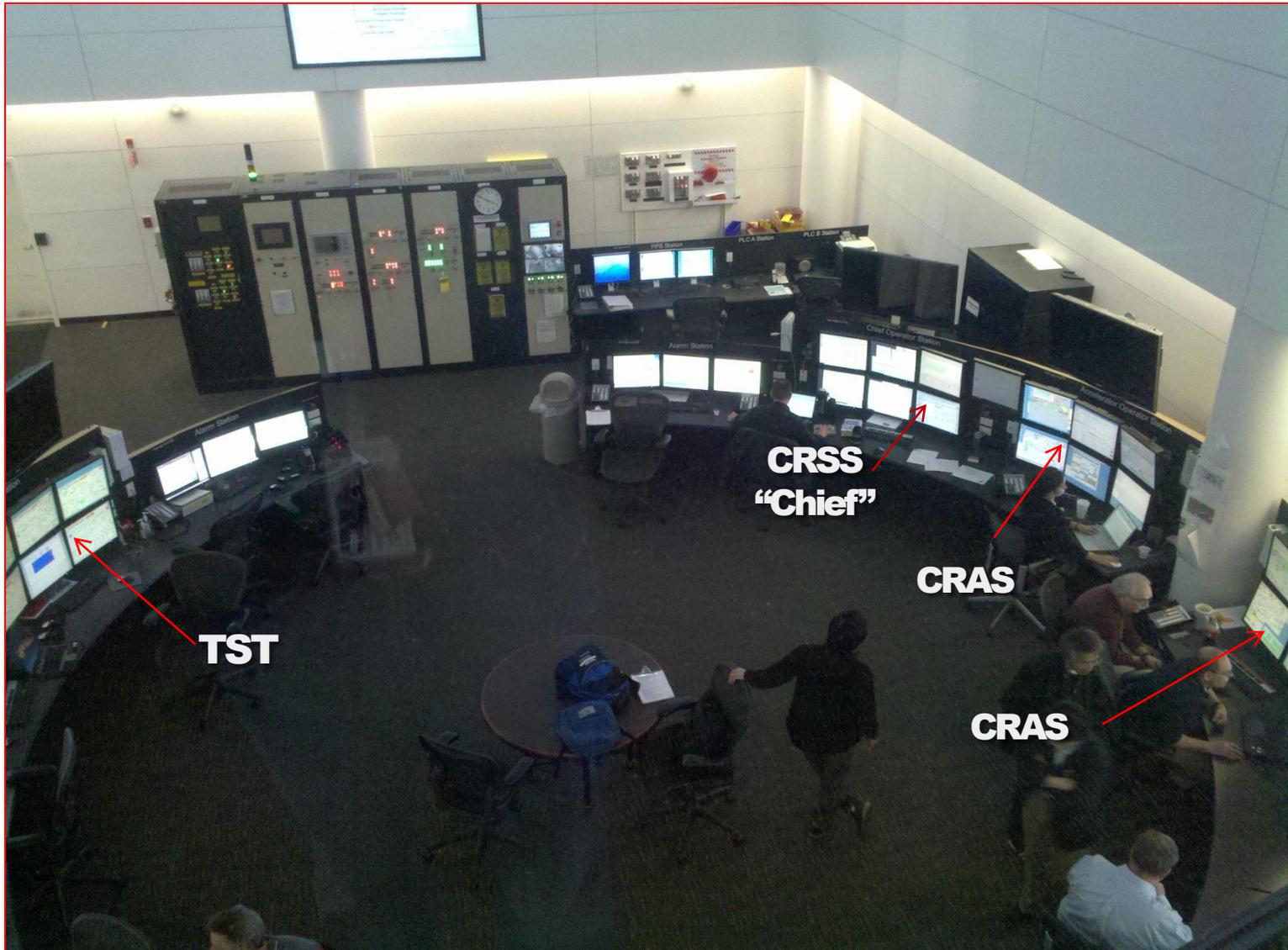
- **SNS Overview**
- **SNS Operations Overview**
- **Operator Downtime**
  - Training
  - Repetitive tasks
  - Communication and Alarms
- **Status and Future Plans**

# SNS Overview

NS is a ~1GeV 1.4 MW 6% DF Pulsed Superconducting  $H^-$  LINAC with a full energy Accumulator Ring



# Central Control Room



# SNS Operations

## RAD Accelerator Operations Personnel Staff List

- **Control Room Shift**
  - 2 Control Room Shift Supervisors (but 1 “Chief”)
  - 1 Control Room Accelerator Specialist1
  - 1 Target Systems Shift Technician
- **On call**
  - Machine Specialist

### Accelerator Operations Manager:

George Dodson

[dodsong@sns.gov](mailto:dodsong@sns.gov)

### Deputy Operations Manager:

TBD

### Operations Coordinator:

Larry Longcoy

[Longcoyla@sns.gov](mailto:Longcoyla@sns.gov)

### Machine Specialist:

Charles Peters

[peterscc@sns.gov](mailto:peterscc@sns.gov)

### Operability Coordinator:

Shane Passmore

[spazmore@sns.gov](mailto:spazmore@sns.gov)

### Control Room Shift Supervisors (CRSSs):

David Brown

[browndl1@sns.gov](mailto:browndl1@sns.gov)

Andy Arvin

[arvina@sns.gov](mailto:arvina@sns.gov)

Bill Krapf

[krapfwa@sns.gov](mailto:krapfwa@sns.gov)

Louis Rupp

[rupplv@sns.gov](mailto:rupplv@sns.gov)

Nick Luciano

[lucianonp@sns.gov](mailto:lucianonp@sns.gov)

Saul Matovu

[matovuss@sns.gov](mailto:matovuss@sns.gov)

Elisa Rodriguez

[rodriguezrej@sns.gov](mailto:rodriguezrej@sns.gov)

Geoff Milanovich

[milanovichgw@sns.gov](mailto:milanovichgw@sns.gov)

Tim Southern

[southernmtb@sns.gov](mailto:southernmtb@sns.gov)

### Control Room Accelerator Specialists:

Vaughn Patania

[pataniavp@sns.gov](mailto:pataniavp@sns.gov)

Roger Housman

[housmanrw@sns.gov](mailto:housmanrw@sns.gov)

Heidi Arvin

[lesserh@sns.gov](mailto:lesserh@sns.gov)

Michael Spaar

[spaarmt@sns.gov](mailto:spaarmt@sns.gov)

David Dunthorn

[dunthorndc@sns.gov](mailto:dunthorndc@sns.gov)

Thomas Hanlon

[hanlonte@sns.gov](mailto:hanlonte@sns.gov)

# Operator Downtime

- **Operators do not “own” systems which cause downtime**
- **Unfortunately operators do cause downtime**
  - **Training**
    - **Lack of training sets up personnel for failure**
  - **Repetitive Tasks (Human Performance Issues)**
    - **Slow and/or incorrect machine turn on**
    - **Tasks with many steps that are not automated with will produce errors.**
  - **Communication and Alarms**
    - **Even with training and automation, communication is needed to assure operators receive accurate, up-to-date information.**
    - **Alarms must be configured correctly (limits) and communicate the problem, severity and point to actions which should be taken or areas to investigate.**

# SNS Operations Training Program

- **Basic steps in the Systematic Approach to Training**
  - **Develop a Training Manual (defines goals, Roles Responsibilities, Authorizations and Accountabilities)**
  - **Determine and Develop Objectives of the Training including Evaluation Standards**
  - **Develop Assessment Tools (Tests)**
  - **Develop Training Materials**
  - **Maintain the Training Program**

# Training

- **Control Room Accelerator Specialist Qualification Levels**
  - **New Hire**
  - **Control Room Accelerator Specialist I**
  - **Control Room Accelerator Specialist II**
  - **Control Room Shift Supervisor**
  - **Mentor (mentors are assigned by Operations Management)**

# Training

- **Control Room Accelerator Specialist I**
  - Secure area Sweep Team Qualification
  - Provides training on basic accelerator concepts and systems technology
  - Intended to especially assist training of personnel with little or no previous accelerator experience
- **Control Room Accelerator Specialist II**
  - Provide training that is more specific to SNS systems, their operation, and machine tuning
  - Includes both knowledge and performance requirements (written tests and hands-on training)
  - Training areas divided into major global systems (e.g. PPS, Timing System) and by areas of the machine (Front End, SCL)
  - Upon completion, considered fully qualified to operate facility
- **Training is done, but there people still make mistakes!**

# Repetitive Tasks - Breakdown

- Breakdown time is divided into 4 areas.
- Diagnosis and Recovery times are operator downtimes
  - Diagnosis – time it takes for operators to find the cause of a problem.
  - Recovery – time from equipment turnover to when beam is returned to target.

Event Type	Timer Start Date	Description
<a href="#">Edit</a>	Downtime Start	23-MAR-2010 00:05
		Ion source antenna failure

1 - 1

## Current Timer

[Use Current Timestamp for All](#)

Current Event Type: Downtime Start Current Event Started: 23-MAR-2010 00:05

Action	Completed At
Diagnosis	23-MAR-2010 00:25
Transit	23-MAR-2010 01:25
Repair Time	23-MAR-2010 06:25
Recovery Time	23-MAR-2010 07:05

[Save Changes](#) [Delete Timer](#) [Minimize Timer](#)

## Shift Summary

\* Group

SubGroup3

\* Beam Loss Downtime Amount (ie 1.2)  Beam Downtime Max 12

\* Continuing from Previous Shift  Yes  No

\* Notes

Description:  
Ion source antenna failure

00.33 hours	-	Diagnosis
01.00 hours	-	Transit
05.00 hours	-	Repair Time
00.67 hours	-	Recovery Time

---

01.00 hours	-	Operational Downtime:
07.00 hours	-	Total Downtime:

[Add Timer Only To Shift Summary](#)

[Add to Shift Summary AND Submit Downtime](#)

\* SubGroup1  \* SubGroup2

SubGroup4  SubGroup5

Non Beam Downtime Amount

Datastream WO Number

# Repetitive Tasks

- **Automate most tasks**
  - **Magnet power supply turn on (operator written php script)**
  - **RF power supply turn on (EDM script)**
  - **Tunnel entry preparation “LAZEE” (operator written python script)**
  - **Beam repetition rate ramp up (operator written python scripts and then EDM sequencer)**
  - **In process Machine Protection System mode change (EDM sequencer)**

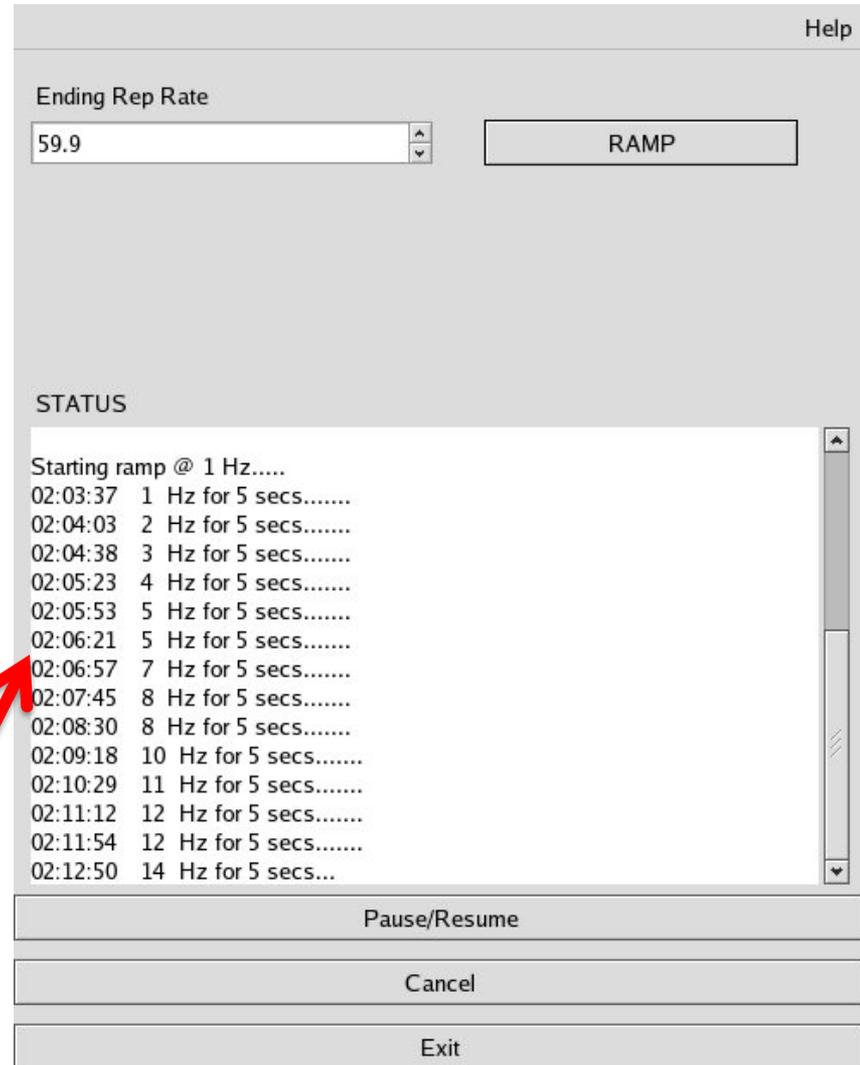
# Repetitive Tasks

- **Example**

- **Beam repetition ramp up**

- Python gui crashed, ran slow, too many Channel Access “Gets” and ended up being very complicated
- An Operator came up with the idea of using an EDM program based on the LLRF State Sequencer.

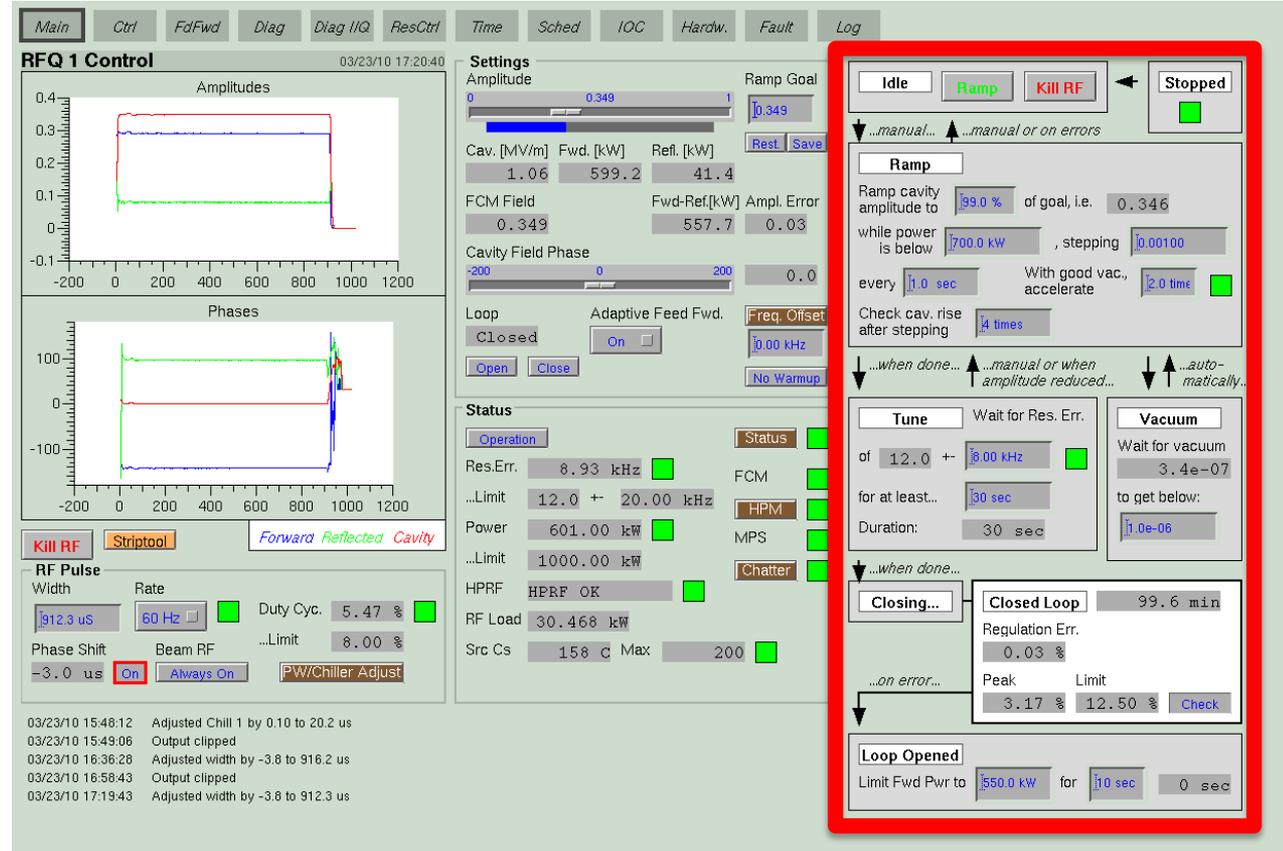
**Supposed to be 5 seconds!  
And missing beam repetition rates!**



# LLRF EDM Sequencer

- LLRF detail EDM

- Idle
- Ramp
- Tune
- Closed loop



- Operator suggested using the same state sequencer for ramping the beam power on target

- Plus we can use the same code

# Repetitive Tasks

- Beam Power Ramp up Sequencer
  - Ready = Idle
  - Ramp = Ramp
  - Goal = Closed Loop
- Great addition
  - Recovery
    - Added initially because of ring injection foil failures
    - When beam trips for any reason, power will recover quickly and automatically using beam repetition rate and LEPT chopper Pulse Width modulation.

The screenshot displays a control interface for the Beam Power Ramp up Sequencer, organized into three main task stages and a status section.

**Stage 1: Ready** (Step 1)

- Rep Rate: 59.9 Hz
- Beam: Disabled
- Cycle: Continuous
- Run: Trigger
- Buttons: Hold 1 Hz, Enabled, Single-Shot, Restart

**Stage 2: Ramp** (Step 2)

- Ramp Goal: 59.9 Hz
- Step By: 1.0 Hz
- Every: 5.0 s
- Over: 200000 Watts
- Wait: 30 s
- Button: Wait Done

**Stage 3: Goal** (Step 3)

- Power: 003004 Watts
- Status: Unlimited Power

**Status and Timing**

- State: Complete
- Timing: 37 %
- IOC Load: 37 %
- PW On: 37 Ticks
- To: 37 ticks

**Recovery Parameters**

- Recover Step By: 2.0 Hz
- Every: 1 s
- After: 60 s
- Set PW\_On To: 32 ticks
- Step By: 1 ticks
- Every: 2 s

**Messages**

- Goal

**STOP SEQUENCER**

**Buttons:** Help, Ramp Times, Save/Restore

# The SNS Downtime – Operator Error

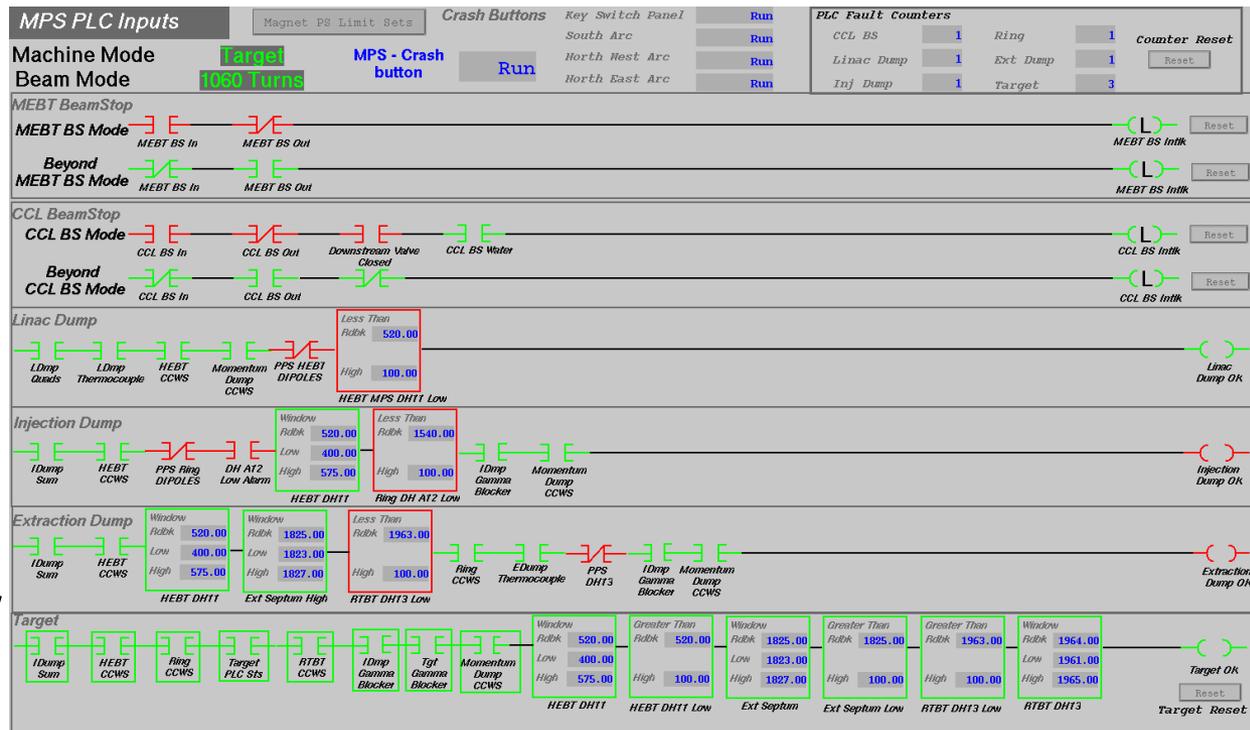
- MPS PLC trips in “Changing Machine Mode” are the largest component of operator caused downtime
- Simple in principal;

- Turn on power supplies, put in beamstops, close vacuum valves in the correct sequence.

- But it is difficult to be correct every time with manual operations (HPI).

- The “Hurry Up!” factor

- MPS must be in “Standby” mode or the Front End is SCRAMed



**EDM SEQUENCER TO THE RESCUE!**

# The SNS Downtime – Operator Error

- MPS mode change sequencer
  - Code is written
  - Gui is built
  - Testing is needed

The screenshot displays the 'Machine Mode' interface. At the top, it shows the date and time 'MAR 25, 2010 12:45:26' and the title 'Machine Mode'. Below this are several control buttons: 'MEBT BeamStop', 'CCL BeamStop', 'Linac Dump', 'Injection Dump', 'Extraction Dump', and 'Target'. The 'Sequencer State' is shown as 'READY' in a dropdown menu. The 'Machine State' is 'MEBT Beamstop', with a message: 'MPS BeamMode must be in Standby & MPS MachineMode is set to destination for this sequencer to be enabled'. A 'MEBT Dump Screen' button is also present. The 'MPS Console Status' section shows 'Beam Mode' as '1 mSec' and 'Machine Mode' as 'Target'. The 'MEBT Beam Stop Status' section shows 'MEBT Beam Stop' as 'OUT', 'Downstream Valve MEBT\_Vac:XV' as 'OPEN', and 'MEBT MPS Intlk' as 'OK'. A list of instructions is provided on the right side of this section. At the bottom, a log window shows the following entries:

```
03/25/10 12:40:17 Sequencer Initialized
03/25/10 12:40:17 In Ready State
03/25/10 12:40:18 Not in Standby
03/25/10 12:44:44 In Ready State
03/25/10 12:45:01 Going to MEBT BS Mode
03/25/10 12:45:01 Configuring Machine to MEBT BS Mode
03/25/10 12:45:02 1. Inserting MEBT BS
03/25/10 12:45:02 2. Closing MEBT_Vac:XV
03/25/10 12:45:03 3. Resetting MPS PLC PVs
03/25/10 12:45:08 In Ready State
```

# Communication

- **How to communicate the ever changing machine, procedures, and daily activities.**
  - **Rotating crews make communication difficult**
    - **Elog**
      - A lot of entries and not all important for operations
      - Crews can't read every elog entry
    - **Email**
      - A lot of emails and not all important for operations
- **Want easier and faster way to convey information**

# Communication

- **Have a web-based tuning guide and wiki**
  - **Tuning guide lists “recipes” for tuning**
    - **Great for procedures that do not change often, but not fast because operators have to search**
  - **Wiki lists changing conditions**
    - **Great for daily updates, but again not fast because operators have to search**
- **Want an even easier and faster way to notify operators of changing conditions**
  - **Direct Wiki pushbutton link directly from EDM screens**
  - **EDM blogger attached to screens**

# Communication

- Wiki links from EDM
  - Fast links to page specific wiki
  - Anyone can update including the system experts

The screenshot shows a complex control interface for the Source/LEBT system. It features numerous control panels, including 'Vacuum', 'RFQ', 'IS OP Checklist', and 'Pumping Speed'. A red arrow points to a link labeled 'Ion Source Wiki' in the top right corner. The interface includes various numerical displays, buttons for 'Start', 'Off', 'Resume', and 'Stop', and a status bar at the bottom with options like 'Edit (Text)', 'Edit (GUI)', and 'Comments'.

## Ion Source Information

### Current

- Running ion source is #2.
- Scope 2 is having an issue. When channel 3 is set to 1 V/div the reflected power RMS calculation is not correct. So, try to keep this set to 2 V/div. This calculation is used in the plasma is out alarm.
  - Example:



### Tuning

- **Source dying or going out** - check out the [@movie](#) (click "Download" on the linked page) to see what it looks like when the source is starting to go out. If you see this happening it is time to make a change.
  - Increase the gas by 0.5 sccm. If this doesn't work then....
  - Lower the match by 0.5 turns. If this doesn't work then....
  - Contact Martin.

### Gotchas

- No beam seen on BCM02
  - MPS scope - all 4 signals should be displayed (and aligned) on the scope. If one or more are missing contact MPS personnel.
    - Example:



# Communication

- EDM blogger
  - Goal is to be able to communicate about a specific system on the system's EDM page
  - Should lead to faster operator response, and reduce error to changing conditions
  - BUT it is not easy to program into EDM, and is currently quite limited in EDM

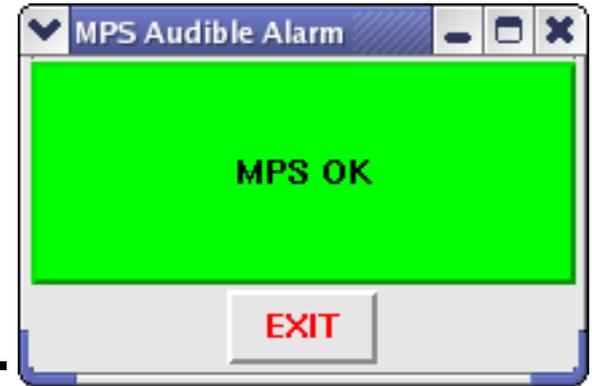


Ion Source Alarms		
Extinguished plasma	●	Mar 24 2010 17:52:59.016
H2 flow	●	Mar 24 2010 08:01:37.666
2 MHz	●	Mar 24 2010 08:02:02.881
13 MHz	●	Mar 24 2010 07:54:42.212
Cs collar heater	●	Mar 23 2010 07:04:23.575
65 kV	●	Mar 24 2010 12:18:51.972
E Dump	●	Mar 24 2010 07:54:42.579
Extractor	●	Mar 24 2010 07:54:42.445
Focus 1	●	Mar 24 2010 07:58:52.746
Focus 2	●	Mar 24 2010 07:58:33.115
Steerer A	●	Mar 24 2010 07:54:43.113
Steerer B	●	Mar 24 2010 07:54:43.113
Steerer C	●	Mar 24 2010 07:58:09.079
Steerer D	●	Mar 24 2010 07:54:43.113
LEBT chopper positive	●	Mar 24 2010 07:59:08.212
LEBT chopper negative	●	Mar 24 2010 07:54:42.147
Alarm Summary	●	Mar 24 2010 12:18:51.839
<b>EDM Blogger!</b>		
03/24/10 23:42:54 EDM Blogger!		

# Alarm Transitions

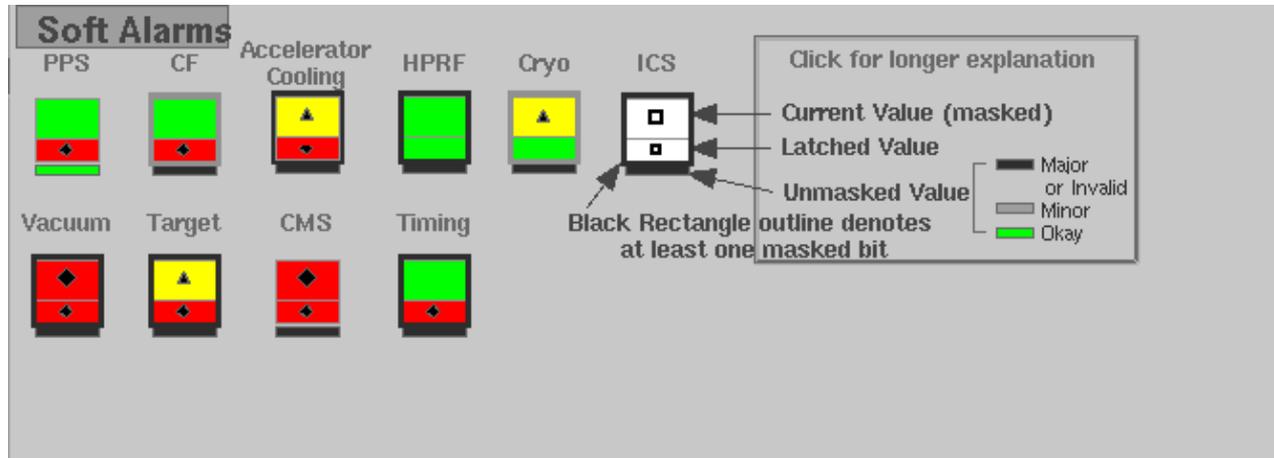
- MPS chirper

- Initially had no audible alert of beam trips.
- Using first BASH(Bourne Shell) and then python. Monitored MPS, and chirped.



- Stoplights (example of the WRONG way!)

- EDM, lots of drilldowns, and not all annunciated



# Best Ever Alarm System (BEAST) Toolkit

- Running now
- BEAST
  - Running in CSS (DESY)
  - Alarms in list form (Current, Acknowledged, and Annunciated Alarms)
  - Alarms link to response instructions, wiki rationalization, and EDM pages
  - Using a lot of operations input

The screenshot displays the Control System Studio (CSS) interface. On the left is the Alarm Tree, listing various areas such as BeamPermit, CF, Diagnostics, HP\_Mod\_Smoke, HP\_Mod\_V\_Mon, HPRF\_PL\_Check, HPRF\_Rack\_Sts, ICS, MPS, PPS, Timing, Tunnels, Water\_Pump, IonSource, LEBT, RFQ, MEBT (OK, MAJOR, LOLO, ALARM), DTL, CCL, SCL, HEBT, RID, Ring (MINOR, MINOR, HIGH, ALARM), RTBT, Target, Test, Instrument Hall, CER, Vacuum, System: Pressures, System: Valves, System: Pumps, CHL, Operations, HVCM, and RF Transmitters. The main area shows three tables: Current Alarms, Acknowledged Alarms, and Annunciator. The Current Alarms table contains two entries: MEBT\_CHOP\_PS\_lik and CF\_RN\_DIWS\_PT4601S.P. The Annunciator table shows a list of events with columns for Time, Severity, and Message.

PV	Description	Time	Current Severt	Severity	Status	Value
MEBT_CHOP_PS_lik	mebbit chopper voltage differential interlock	2010/03/23 17:41:32	OK	MAJOR	LOLO_ALARM 0	
CF_RN_DIWS_PT4601S.P	Habbit ring RTBT DI water circulating loop supply pres	2010/03/23 15:28:28	MINOR	MINOR	HIGH_ALARM 20.0	

PV	Description	Time	Current Severt	Severity	Status	Value
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Time	Severity	Message
2010/03/23 17:05:52.910000000	MAJOR	SCL BLM trip
2010/03/23 17:03:52.309000000	MAJOR	SCL BLM trip
2010/03/23 17:03:52.073000000	MAJOR	SCL BLM trip
2010/03/23 17:02:56.185000000	MAJOR	SCL BLM trip
2010/03/23 17:02:20.332000000	MAJOR	CCL BLM trip
2010/03/23 17:02:18.339000000	MAJOR	SCL BLM trip
2010/03/23 17:02:16.507000000	MAJOR	CCL BLM trip
2010/03/23 17:02:15.237000000	MAJOR	SCL BLM trip

# Conclusions and Future

- **Goal is to reduce operator downtime**
  - **Thorough training program**
    - **Input from new, experienced operations staff**
  - **Measuring operator downtimes helps locate issues**
  - **Creative tools to automate repetitive tasks**
  - **Improved communication and decreased response time**
  - **Operator involvement has made huge improvements**
- **Into the future...**

# Future Plans 1 & 2

- **Real time downtime calculator**
  - Using the beam power ramp sequencer
  - Time outside of the “Goal” is downtime
  - Downtime timer will start automatically when outside of “Goal” state (e.g 80% nominal beam power for 0.1 Hr.)
- **Operator troubleshooting database using XAL**
  - Easily searchable database containing common problems
  - Faster than e-log, wiki, or tuning guide
  - Updated by operations

# Future Plans 3

- **XAL Sequencer (java)**
  - Want software so easy that anyone can easily create a sequence
    - Scripts and EDM sequences have learning curve.
  - Libraries of operations
  - Operations placed into sequences

