SNS Operations Tools and Automation
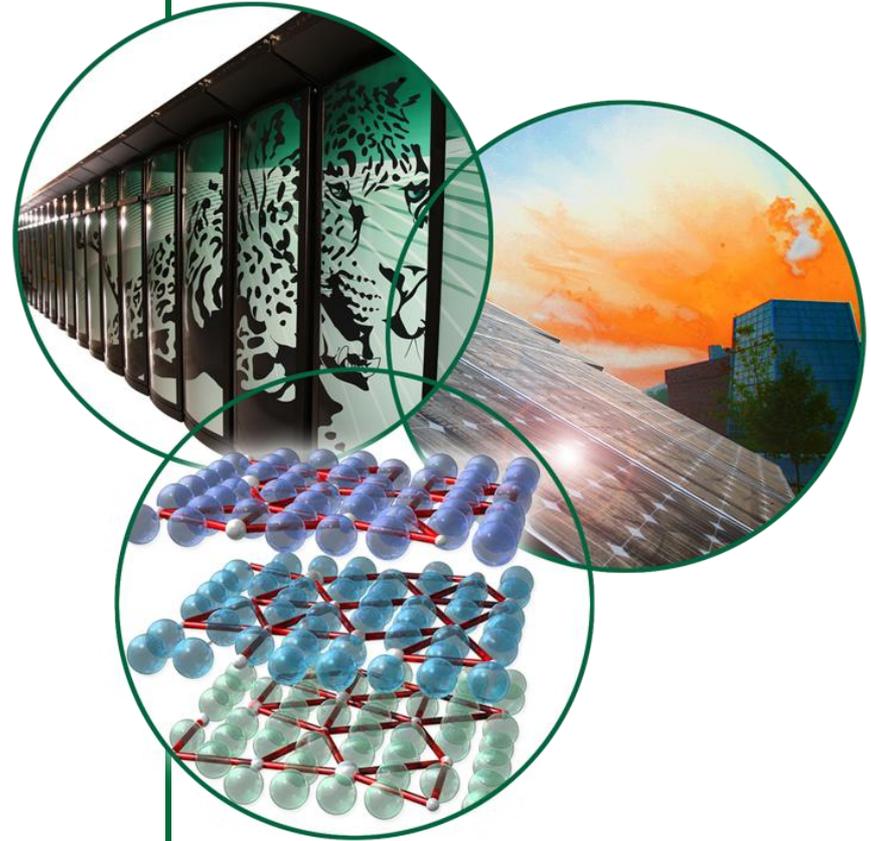
The 7th International Workshop on Accelerator Operations – Automation and Tools

April 13, 2010
KAERI, Daejeon, Korea

C.C. Peters, Accelerator Machine Specialist

On behalf of:
N.P. Luciano, T.B. Southern, and many others
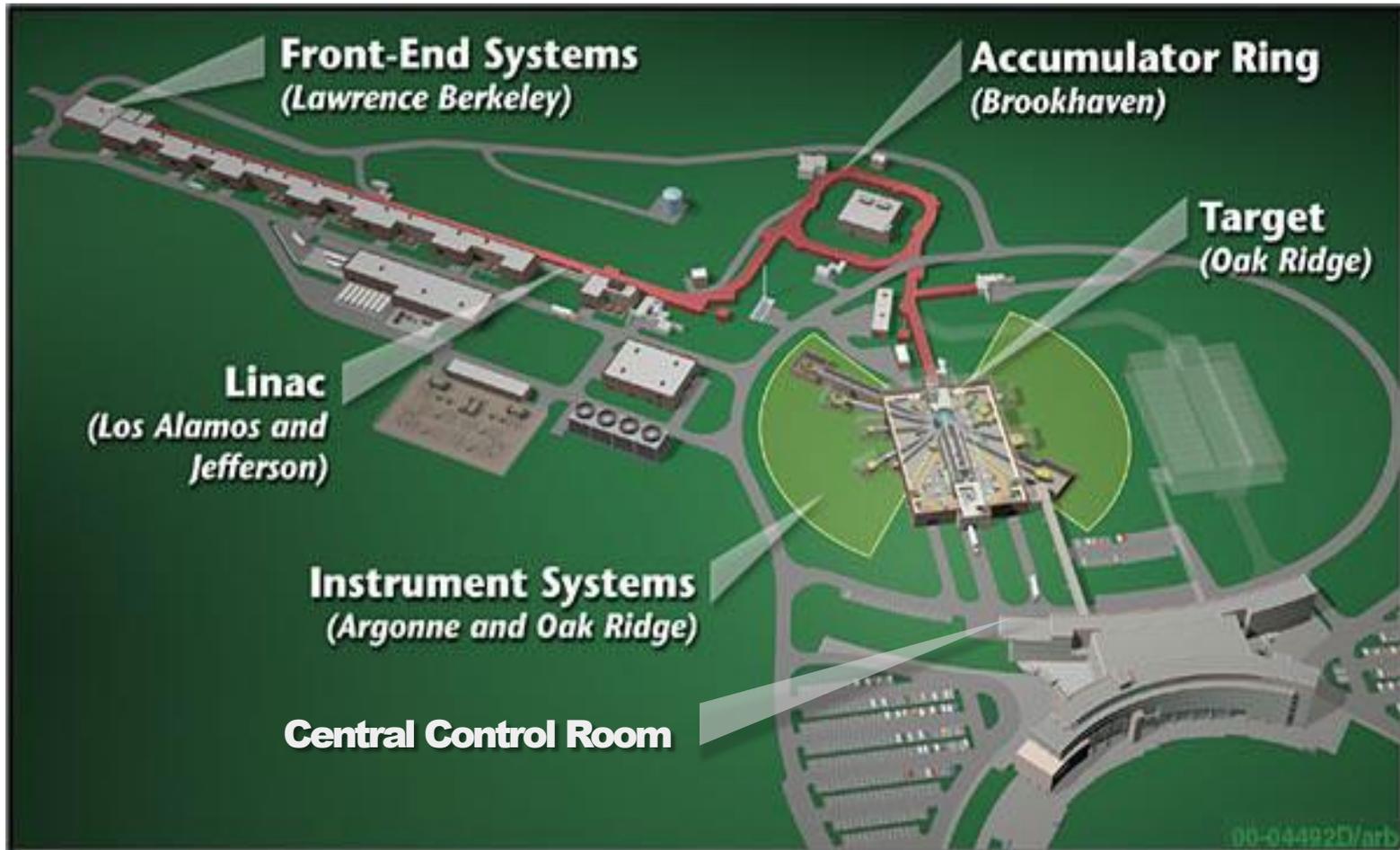
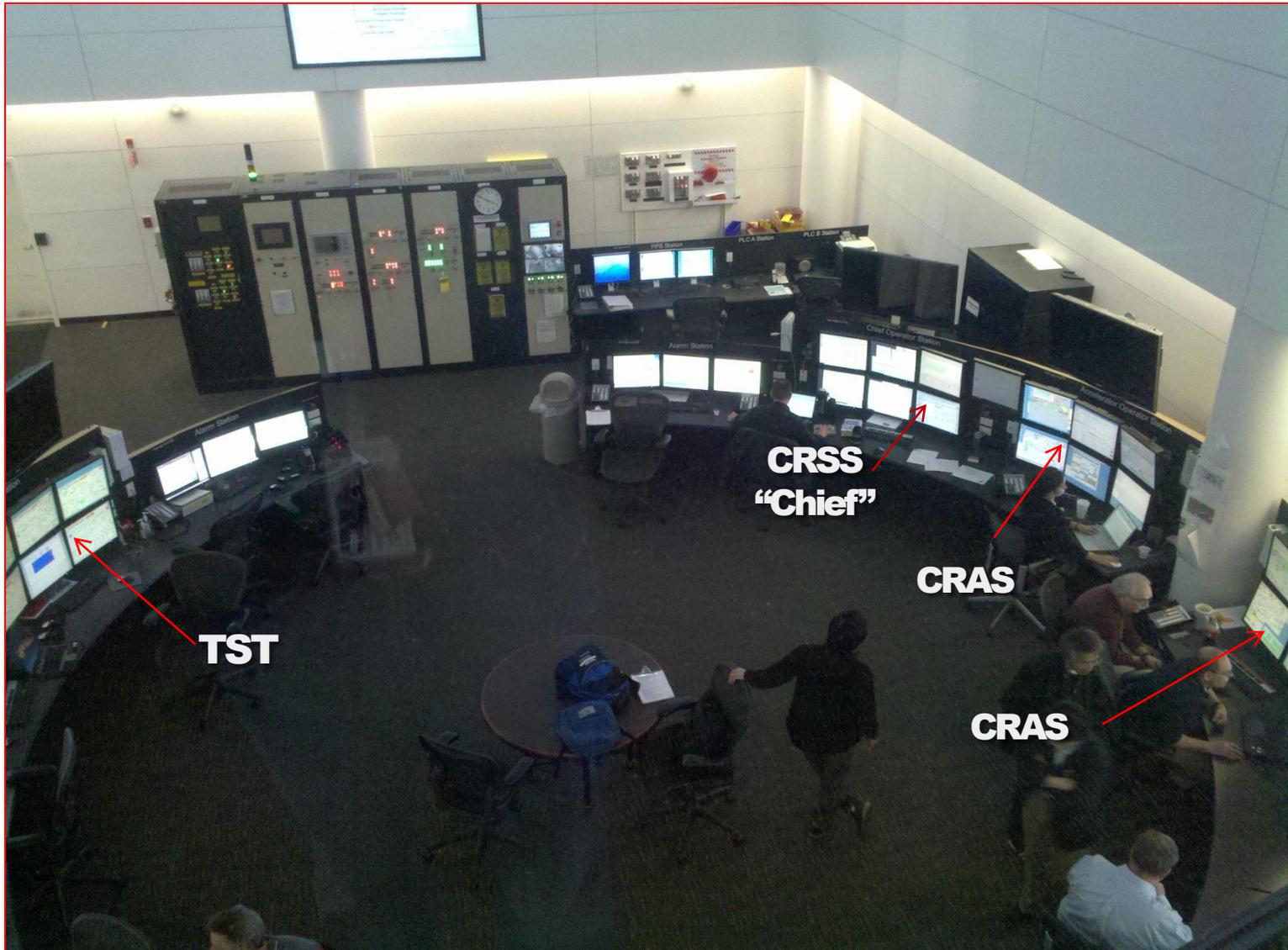Presented by: George Dodson

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

Front-End Systems (Lawrence Berkeley)

Accumulator Ring (Brookhaven)

Target (Oak Ridge)

Linac (Los Alamos and Jefferson)

Instrument Systems (Argonne and Oak Ridge)

Central Control Room

00-04492D/arb

WAO 2010

OAK RIDGE National Laboratory

Central Control Room

WAO 2010

SNS Operations

- **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**

**RAD Accelerator Operations
Personnel Staff List**

Accelerator Operations Manager:
George Dodson — dodsong@sns.gov

Deputy Operations Manager:
TBD

Operations Coordinator:
Larry Longcoy — Longcoyla@sns.gov

Machine Specialist:
Charles Peters — peterscc@sns.gov

Operability Coordinator:
Shane Passmore — spazmore@sns.gov

Control Room Shift Supervisors (CRSSs):
David Brown	browndl1@sns.gov
Andy Arvin	arvina@sns.gov
Bill Krapf	krapfwa@sns.gov
Louis Rupp	rupplv@sns.gov
Nick Luciano	lucianonp@sns.gov
Saul Matovu	matovuss@sns.gov
Elisa Rodriguez	rodriguezej@sns.gov
Geoff Milanovich	milanovichgw@sns.gov
Tim Southern	southerntb@sns.gov

Control Room Accelerator Specialists:
Vaughn Patania	pataniavp@sns.gov
Roger Housman	housmanrw@sns.gov
Heidi Arvin	lesserh@sns.gov
Michael Spaar	spaarmt@sns.gov
David Dunthorn	dunthorndc@sns.gov
Thomas Hanlon	hanlonte@sns.gov

OAK RIDGE
National Laboratory

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.**

OAK RIDGE National Laboratory

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**

WAO 2010

OAK RIDGE
National Laboratory

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)**

OAK RIDGE
National Laboratory

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!**

OAK RIDGE
National Laboratory

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
Edit — 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 De

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: Ion Source   * SubGroup1: Ion Source Antenna   * SubGroup2
SubGroup3   SubGroup4   SubGroup5
* Beam Loss Downtime Amount (ie 1.2) 7   Beam Downtime Max 12   Non Beam Downtime Amount
* Continuing from Previous Shift ○ Yes ● No   Datastream WO Number
* Notes: Ion source antenna failure

```
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

OAK RIDGE National Laboratory

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)**
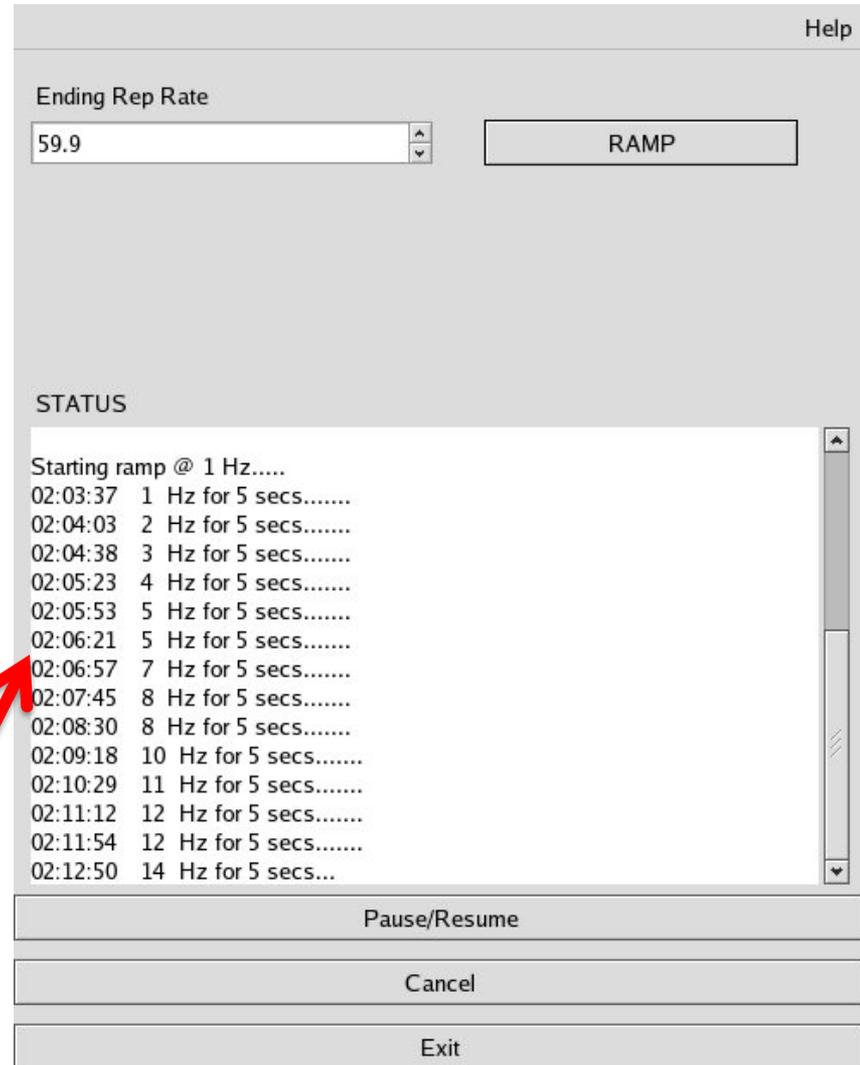 - **In process Machine Protection System mode change (EDM sequencer)**

OAK RIDGE
National Laboratory

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!**

Help

Ending Rep Rate

| 59.9 | | RAMP |

STATUS

```
Starting ramp @ 1 Hz.....
02:03:37   1  Hz for 5 secs.......
02:04:03   2  Hz for 5 secs.......
02:04:38   3  Hz for 5 secs.......
02:05:23   4  Hz for 5 secs.......
02:05:53   5  Hz for 5 secs.......
02:06:21   5  Hz for 5 secs.......
02:06:57   7  Hz for 5 secs.......
02:07:45   8  Hz for 5 secs.......
02:08:30   8  Hz for 5 secs.......
02:09:18   10 Hz for 5 secs.......
02:10:29   11 Hz for 5 secs.......
02:11:12   12 Hz for 5 secs.......
02:11:54   12 Hz for 5 secs.......
02:12:50   14 Hz for 5 secs...
```

Pause/Resume

Cancel

Exit

OAK RIDGE National Laboratory

LLRF EDM Sequencer

- ## LLRF detail EDM
  - ### Idle
  - ### Ramp
  - ### Tune
  - ### Closed loop
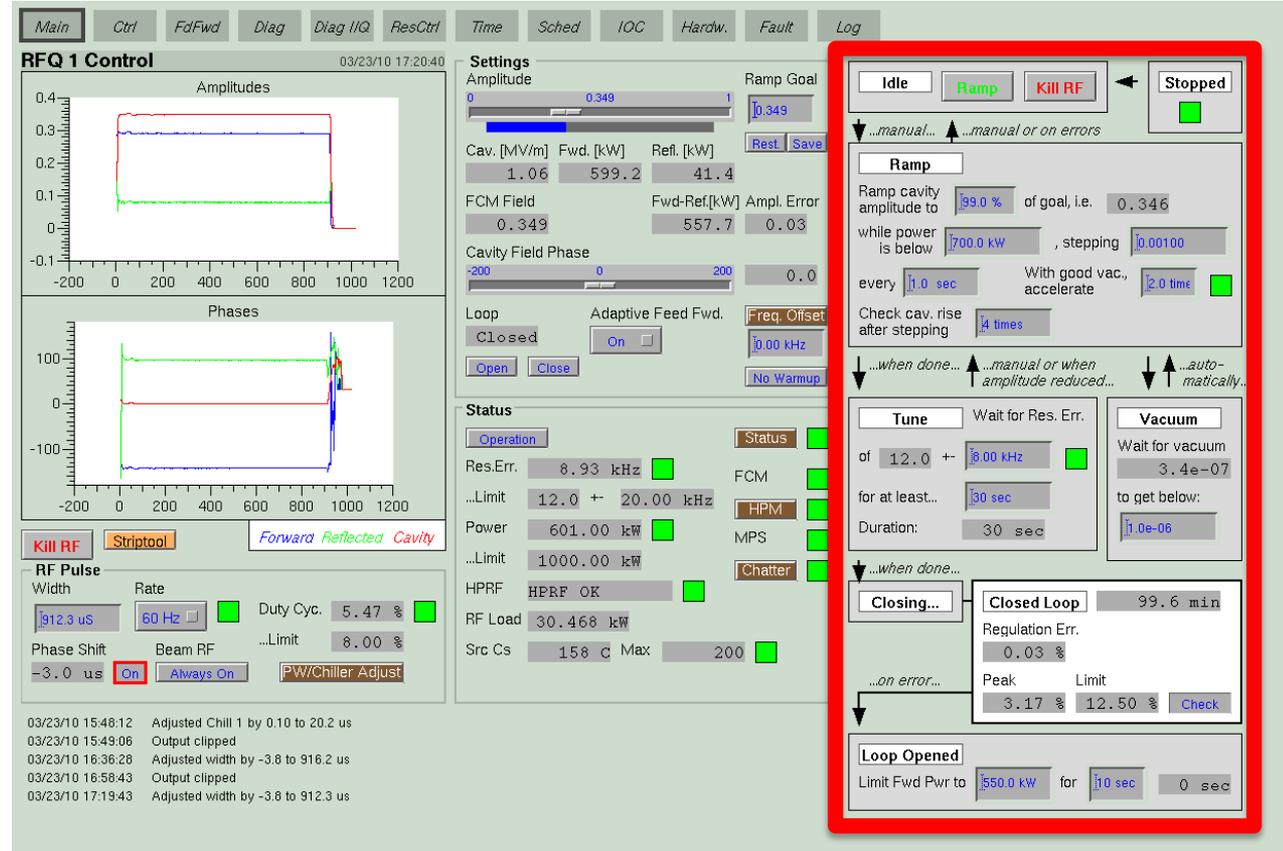
- **Operator suggested using the same state sequencer for ramping the beam power on target**

- **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 LEBT chopper Pulse Width modulation.

WAO 2010

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**
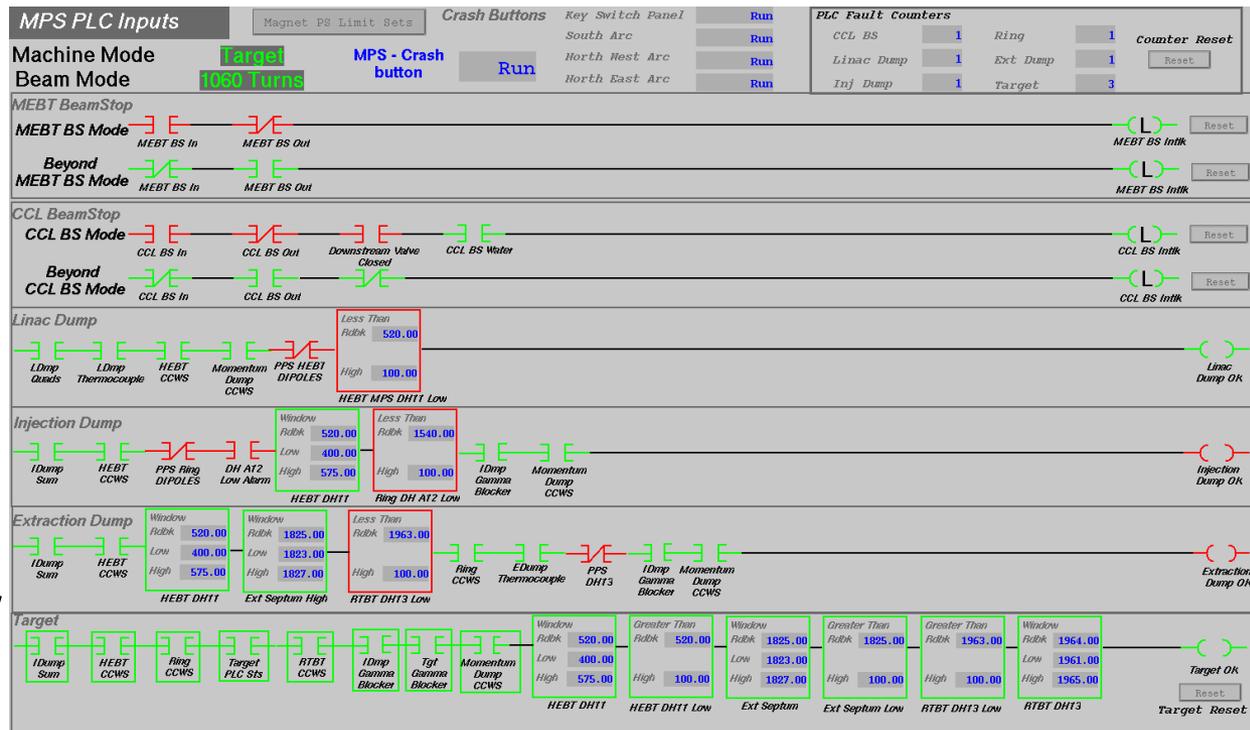
EDM SEQUENCER TO THE RESCUE!

The SNS Downtime – Operator Error

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

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**

Managed by UT-Battelle
for the U.S. Department of Energy

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

WAO 2010

Communication

- **Wiki links from EDM**

  - **Fast links to page specific wiki**

  - **Anyone can update including the system experts**

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**
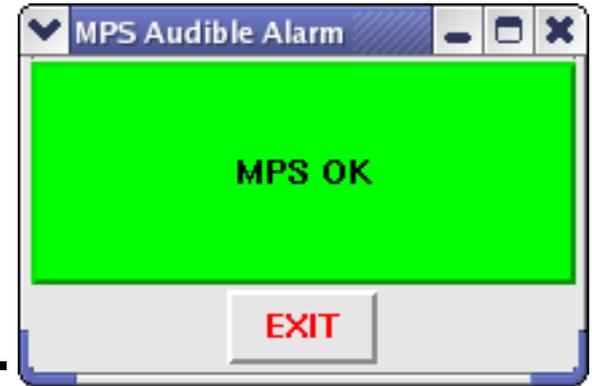
Ion Source Alarms

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

EDM Blogger!

03/24/10 23:42:54 EDM Blogger!

OAK RIDGE National Laboratory

Alarm Transitions

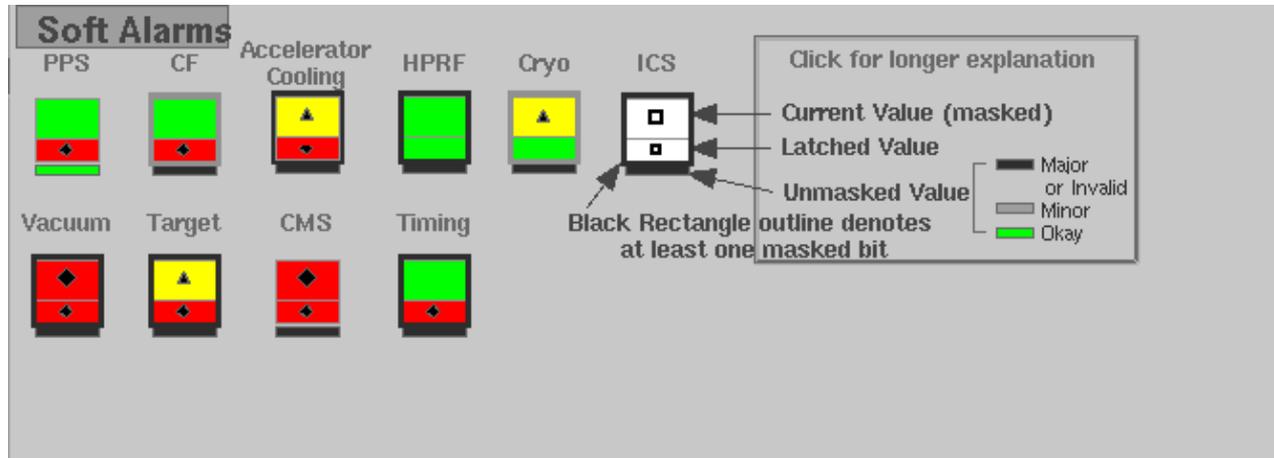MPS Audible Alarm — MPS OK — EXIT

- ## 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**

Soft Alarms — PPS, CF, Accelerator Cooling, HPRF, Cryo, ICS, Vacuum, Target, CMS, Timing. Click for longer explanation. Current Value (masked), Latched Value, Unmasked Value. Black Rectangle outline denotes at least one masked bit. Major or Invalid, Minor, Okay.

OAK RIDGE National Laboratory

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**

WAO 2010

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…**

WAO 2010

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**

WAO 2010

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