

## DYNAMIC VISUALIZATION OF SNS\* DIAGNOSTICS SUMMARY REPORT AND SYSTEM STATUS

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### Abstract

The Spallation Neutron Source (SNS) accelerator systems will deliver a 1.0 GeV, 1.4 MW proton beam to a liquid mercury target for neutron scattering research. The accelerator complex consists of a 1 GeV linear accelerator, an accumulator ring and associated transport lines. The majority of the SNS diagnostics platform is PC-based and runs Embedded Windows XP and LabVIEW. The diagnostics instruments communicate with the control system using the Channel Access (CA) protocol of the Experimental Physics and Industrial Control System (EPICS). This paper describes the Diagnostics Group's approach to collecting data from the instruments and presenting live in a summarized way over the web. This data mining resulted in the "Diagnostics Status Page" that summarizes the insertable devices, transport efficiencies, and the mode of the accelerator in a compact webpage. The displays on the webpage change automatically to show the latest and/or most interesting instruments in use.

### INTRODUCTION

Even though only the warm section of the SNS accelerator of up to 159 MeV is commissioned, there are already many operational instruments and control systems. While the status of these systems can be seen from the multiple EPICS Enhanced Display Manager (EDM) console screens, there was no quick one-stop overview screen from home or work. To be able to create a concise overview screen, we cannot just display data but must evaluate the current state of the accelerator and then decide what to display. Thus, in effect, we need to perform smart data mining.

### DESIGN

To provide access to a status page from internal and external networks, we decided that a web browser would be best in terms of availability and quick display. But because there are already many instruments in the warm linac, e.g. 19 wire scanners and 8 beam current monitors, not all data can be displayed all the time on one screen. On top of that, often one wants to see more than just a summary parameter, e.g. a sigma, but also view plots representing the transverse or longitudinal profile. To support this, we need an area on the screen that displays only recent measurements and has a priority scheme to

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decide what measurement to show in the limited space available. Other areas on the overview screen can be used for permanent displays that should be shown all the time.

### IMPLEMENTATION

The main programming development for our instruments is LabVIEW and it has built-in functions to produce excellent displays or images thereof and is thus the choice for our development environment again.

#### Program Structure

The program has two main parts, one to schedule the dynamically displayed instruments and one to display both the permanent and dynamic displays, see Figure 1.

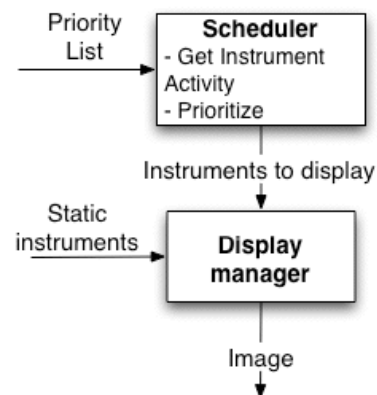


Figure 1. The structure of the Status Page program.

To schedule an instrument for display, the instrument must be active and have the highest or second highest priority as there are currently two dynamic display areas.

Priorities per instrument are declared in a list. The list assigns higher priorities the further downstream the beam line instrument is, if of the same kind. Otherwise, in general, instruments that are active less and thus more interesting when in use, have a higher priority.

For each instrument type there is a module that decides whether the instrument is active. For instruments that are always ready to measure, such as a beam current monitor, the decision is based on the actual measurement data. If no beam pulse is detected the instrument is regarded as inactive. The module for a Faraday cup checks first to see if the actuator is inserted and then checks to see if there was a beam pulse measured. The wire scanner module checks for a returning actuator as the measurement is only then complete when the actuator returns home. This module also uses a time-out to prolong the "active" time.

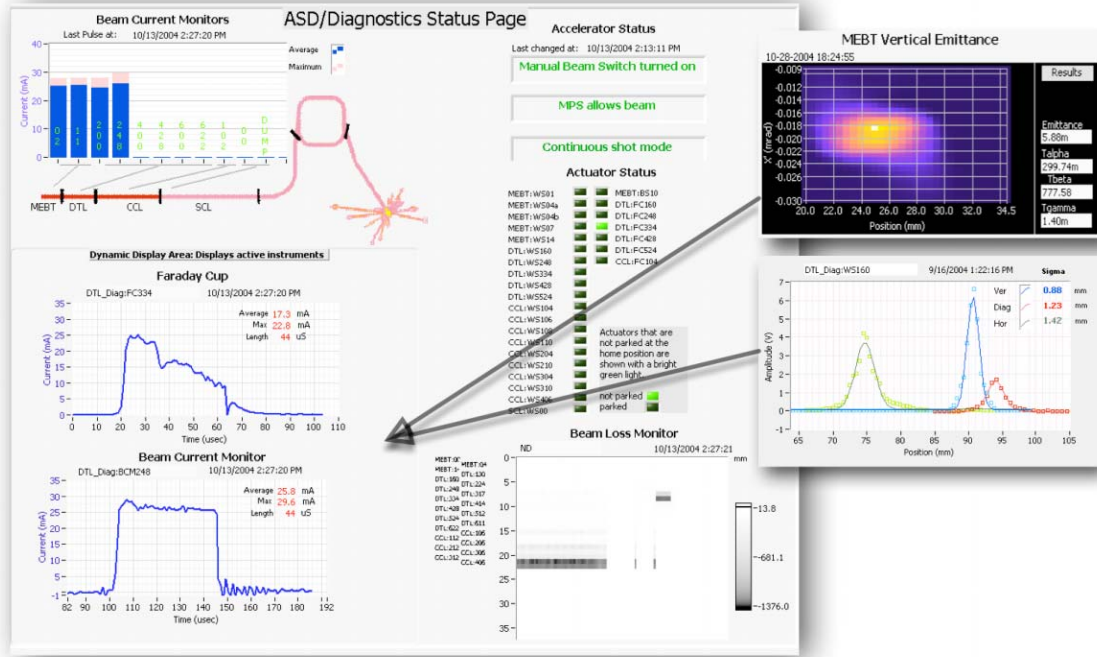


Figure 2. The Diagnostics Status Page shown during a beam loss study with inserted Faraday cup. The right side shows an emittance and wire scan display that would have been shown if the instruments had been active.

The display of different instruments is modularized to easily add or delete a display. For each instrument type there is a display module that handles the communication with the instrument and the display of the data. Each module opens, reads, and closes its own PVs and displays the data. The main program manages the display areas and attaches the module's display to a location on the main display. The display module can also be run by itself or be part of another program such as a console page. Currently available modules are:

- *Wire scanner*: Show profile and analysis results,
- *Emittance scanner*: Show 2-D result and analysis results,
- *No beam*: Tell a joke when there has been no beam for quite a while,
- *Faraday cup*: Beam current profile,
- *Beam loss*: 2-D intensity display of beam loss over time and location,
- *Beam current single*: Beam current versus time,
- *Beam current all*: Bar plot of average and maximum beam current for each monitor,
- *Actuator Status*: Listing of actuators, color coded to indicate in or out of beam,
- *RF Status*: List to show color coded status of RF stations,
- *Accelerator Message*: List of accelerator messages regarding installation, operations and other issues, and
- *Accelerator Mode*: Displays manual beam switch, single or multi-shot mode, and Machine Protect System (MPS) status.

### Dynamic Status Page

Figure 2 shows the page as it can be seen in a web browser. The data is taken during an energy scan and shows the inserted Faraday cup 334 and the nearest upstream beam current monitor (last one with a beam signal). To the right, the figure shows alternative display that could have been shown in the dynamic display area, if the emittance scanner or wire scanner had been used.

### Web Serving

To provide a status page to both the internal network and the external network there are two the same but separate Status Page computers, see Figure 3.

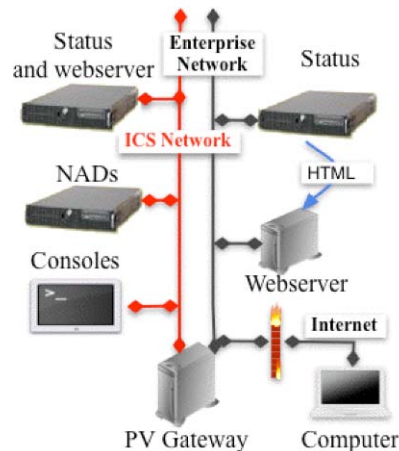


Figure 3. Publishing scheme.

For security reasons, there are very few connections between the external (Enterprise) and internal (Internal Control System or ICS) network. One path is the EPICS CA PV Gateway, which allows the readout of internal network Process Variables (PVs) from the external network. LabVIEW uses the LabVIEW CA Library (see [1]) to obtain the data either directly (internal version) or

through the gateway (external version). The external version dumps the created pages to the SNS web server while the internal version uses the internal LabVIEW web server to serve up the created pages. Figure 4 shows that the Status Page is served up, as Ch13, together with the Accelerator Messages, Ch0.

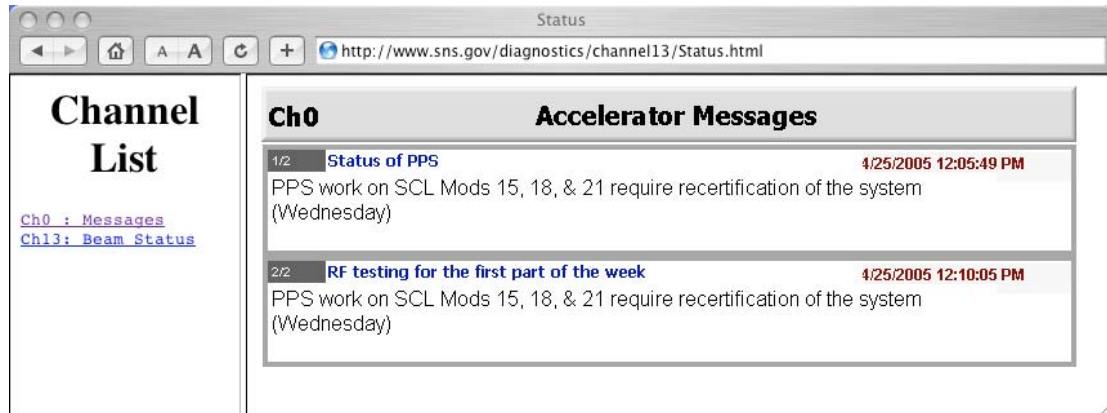


Figure 4. The main web link to Status Page and Accelerator Messages.

## PERFORMANCE

The displays are updated about every 30 seconds. With improvements to the PV gateway and how the display modules handle slow communication or turned off instruments, we have seen the system run reliably for several weeks. As for the author, the page has been already very useful in responding to control room calls and, after viewing the status page, tell the operators how to proceed without having to drive in. Many others have used the page to monitor progress of the accelerator commissioning and to decide if it was worthwhile to startup a console.

## FUTURE

More modules are under development for the Status Page system to add to Channel List. The program currently runs on Network Attached Devices (NADs) or the same platform as most of our instruments. We are in the process of adding watchdog timers to the NADs to further improve up-ties through automatic restarts and/or reboots. In addition, we are implementing a generic supervisory level where the programs will reside that continuously monitor the accelerator, like the Status Page system, but also provide new results based on analysis of data from many instruments. For example, beam losses can be correlated with beam positions, beam currents, and/or inserted devices. Such correlations will form the

basis of a daily or weekly beam loss report and can warn operators to immediately adjust operations. The supervisory level is being implemented on a computer cluster and when this is ready we will move the Status Page program from its dedicated computers to the cluster. Tools for data-acquisition and display that will be used to setup the supervisory level are described in [2].

## CONCLUSIONS

An extendable system to display the status of the diagnostics and other systems has been implemented. The system has proven to help out operations and is a first step towards a fully scalable supervisory level.

## ACKNOWLEDGEMENTS

Several of us Fermilab alumni thought SNS should have a Channel 13 page as well; you might recognize the interspersed Fermi nomenclature. Special thanks go to Saeed Assadi for jump-starting the project.

## REFERENCES

- [1] A. Liyu et al., "LabVIEW Library to EPICS Channel Access," PAC05 conference.
- [2] M. Sundaram et al., "SNS Diagnostics Tools For Data Acquisition And Display" PAC05 conference.