Figure 1 Installation of RGA in Storage Ring Cell

EPICS Interface and Control of NSLS-II Residual Gas Analyzer System

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U.S. DEPARTMENT OF ENERGY | Office of Science

MOPPC122

ABSTRACT

Residual Gas Analyzers (RGAs) have been widely used in accelerator vacuum systems for monitoring and vacuum diagnostics. The National Synchrotron Light Source II (NSLS-II) vacuum system adopts Hiden RC-100 RGA which supports remote electronics, thus allowing real-time diagnostics with beam operation as well as data archiving and off-line analysis. This paper describes the interface and operation of these RGAs with the EPICS based control system.

INTRODUCTION

The NSLS-II under construction at Brookhaven National Laboratory is designed to provide an average vacuum pressure of $< 1 \times 10^{-9}$ Torr across the storage ring and front ends during operation. Quadrupole-type RGAs are installed to measure the partial pressure of residual gas species at selected locations in the booster ring, storage ring, front ends, and user beamlines. Their use will help to identify sources of residual gases, including photoelectron stimulated-desorbed gas from chamber walls, absorbers, air leaks, cooling water leaks, gases back-streamed from the beamlines, and other contaminants. The partial pressure can be measured down to 10^{-13} Torr range using the electron multiplier option.

NSLS-II RGA SYSTEM

The NSLS-II RGA system comprises the RGA heads distributed around NSLS-II accelerator complex, the RF boxes, the RGA controllers and the interconnecting cables.

Hiden RC-100 RGA

RGAs used on NSLS-II are Hiden RC-100 RGA, which contains an RC Interface Unit (IU), a Radio Frequency (RF) box, and a Probe.

NSLS-II RGA Installation and Distribution

The remote electronics units of RGAs are located at the vacuum control racks in the NSLS-II mezzanine, to allow easy access for online analysis and maintenance. These units are connected to the RF Head using a multi-conductor and high voltage cable with customized length of up to 45 meters. The RF Head is attached to the Probe, which is mounted on vacuum chambers. The RF box is ~ 50 cm off the mid plane thus minimizing the radiation dosage from the copious synchrotron radiation.
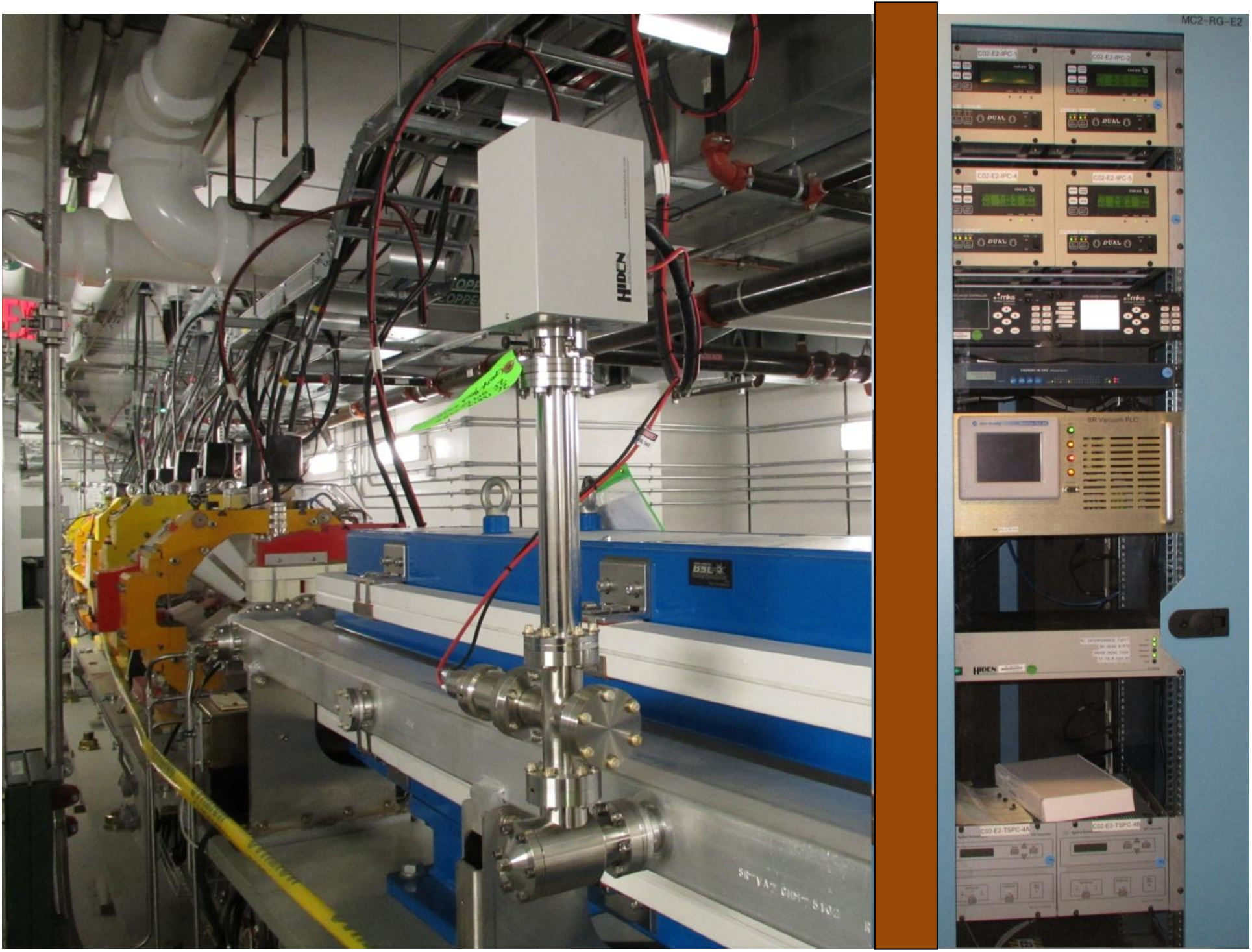

Figure 1: Installation of RGA in storage ring cell.

Due to the high cost, RGAs are installed at selective vacuum sections during the initial phase of NSLS-II operation.

Table 1: Numbers of RGAs for BR, SR, FE

Booster Ring (BR)	2
Storage Ring (SR)	38
Front End (FE)	6

MASsoft User Interface

A Windows based software called MASsoft is provided by the manufacturer to use together with the RC RGA system. The MASsoft application provides complete control and tuning of the instrument; also data acquisition, storage, recall and analysis within Microsoft Windows interface. Communication between MASsoft and RGA is done via both RS-232 serial link and Ethernet link.
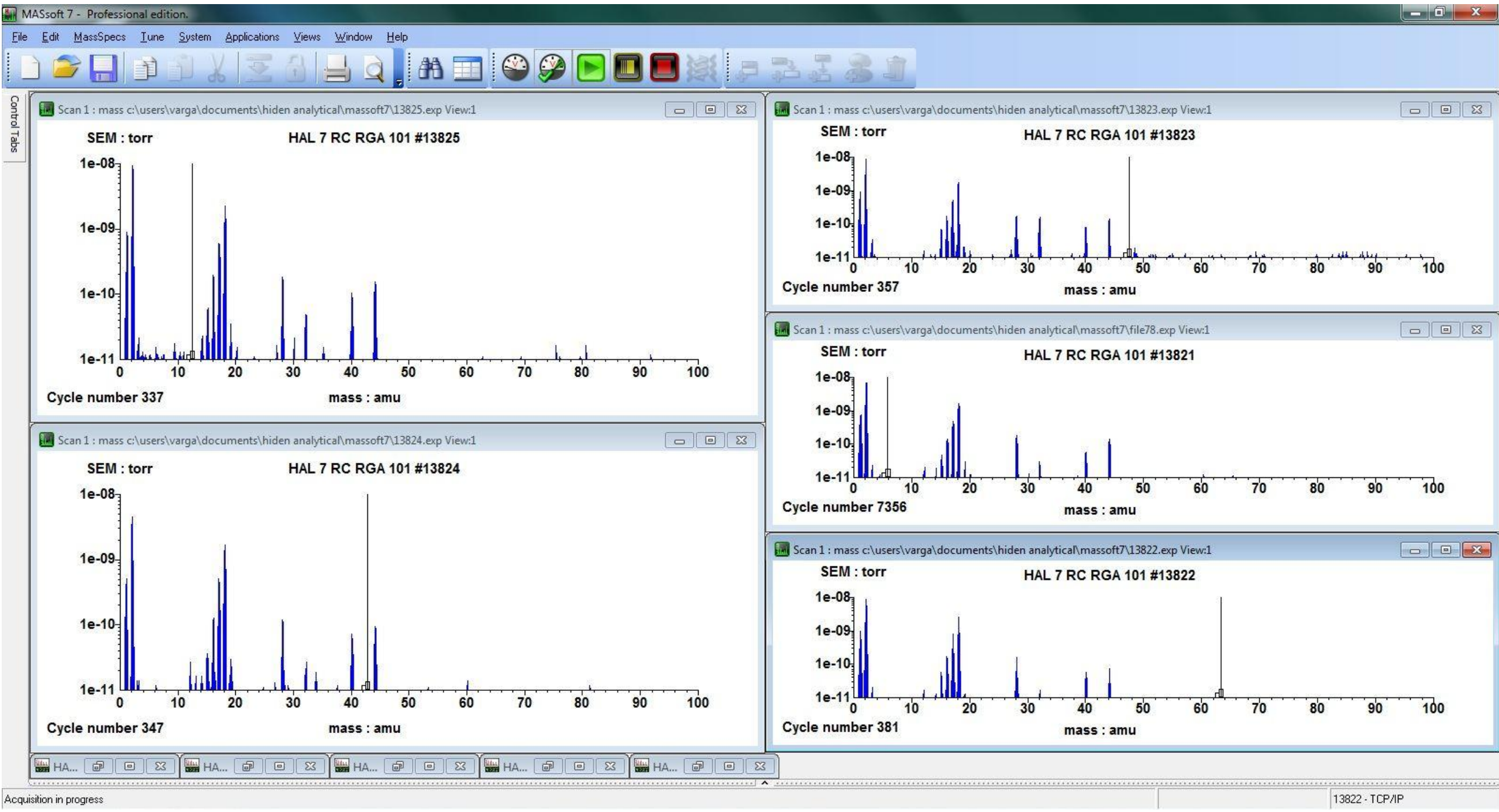

Figure 2: MASsoft RGA scans running 5 units.

EPICS INTERFACE TO NSLS-II RGA SYSTEM

The NSLS-II RGA system will be monitored and controlled by EPICS based control system during commissioning.

RGA's Control PC

The Input/Output Controller (IOC) works as the RGA's control PC. The Hiden RC RGAs supports both RS-232 serial link and Ethernet LAN connection for communication between RC Interface and the PC. NSLS-II uses Ethernet link to communicate between IOCs which running on PC/Linux and RGAs. All the vacuum IOCs and RGAs will be assigned the IP addresses in the same subnet.

The NSLS-II vacuum control system has 6 physical IOCs in total, one for each pentant in storage ring and one for the injector. The EPICS based RGA programs run on the IOCs and up to 12 RGAs will be controlled by each of these IOCs.

EPICS Support for Hiden RC RGA

The RGA is a complex device and thousand of command sets are used to fulfil all of its functions. The Hiden RGA EPICS support was developed based on the vacuum group's requirements incorporating basic and commonly used functions.

StreamDevice is adopted to develop the EPICS support for Hiden RGA. This support provides the same scan operation as MASsoft. It gives the option to choose one of the three scan modes, the BAR mode which displays a histogram of peak intensities across a range of masses, the PROFILE mode which displays the shape of peaks across a range of masses, and the MID (Multiple Ion Detection) mode which measures selected individual masses. Besides StreamDevice, the State Notation Language (SNL) is used to perform degas function. Similar to MASsoft, user can select filament, set degas time and start or stop degas operation.

At the moment, most RGAs installed in NSLS-II are running at PROFILE mode of 1-100 amu with a 0.13 step size under EPICS. Important parameters affecting the operation of the RGA are constantly monitored, such as filament emission status, and over pressure trip. The global and local environment parameters are allowed to make modification.

Operator Interface

The monitor and control panels are similar to those of MASsoft to make it convenient and consistent for operators. These panels are created with software tools in Control System Studio (CSS), which is an Eclipse-based collection of tools to monitor and operate large scale control systems.

The main RGA entry provides the real-time monitoring of the filament, emission status, as well as the current scan trend. The operators have the ability to stop, pause, or continue current scan operation, change the environment and scan parameters. A simple graphical view of scan tree is also provided in the secondary panel. Multi variables are listed and can be changed by operator.
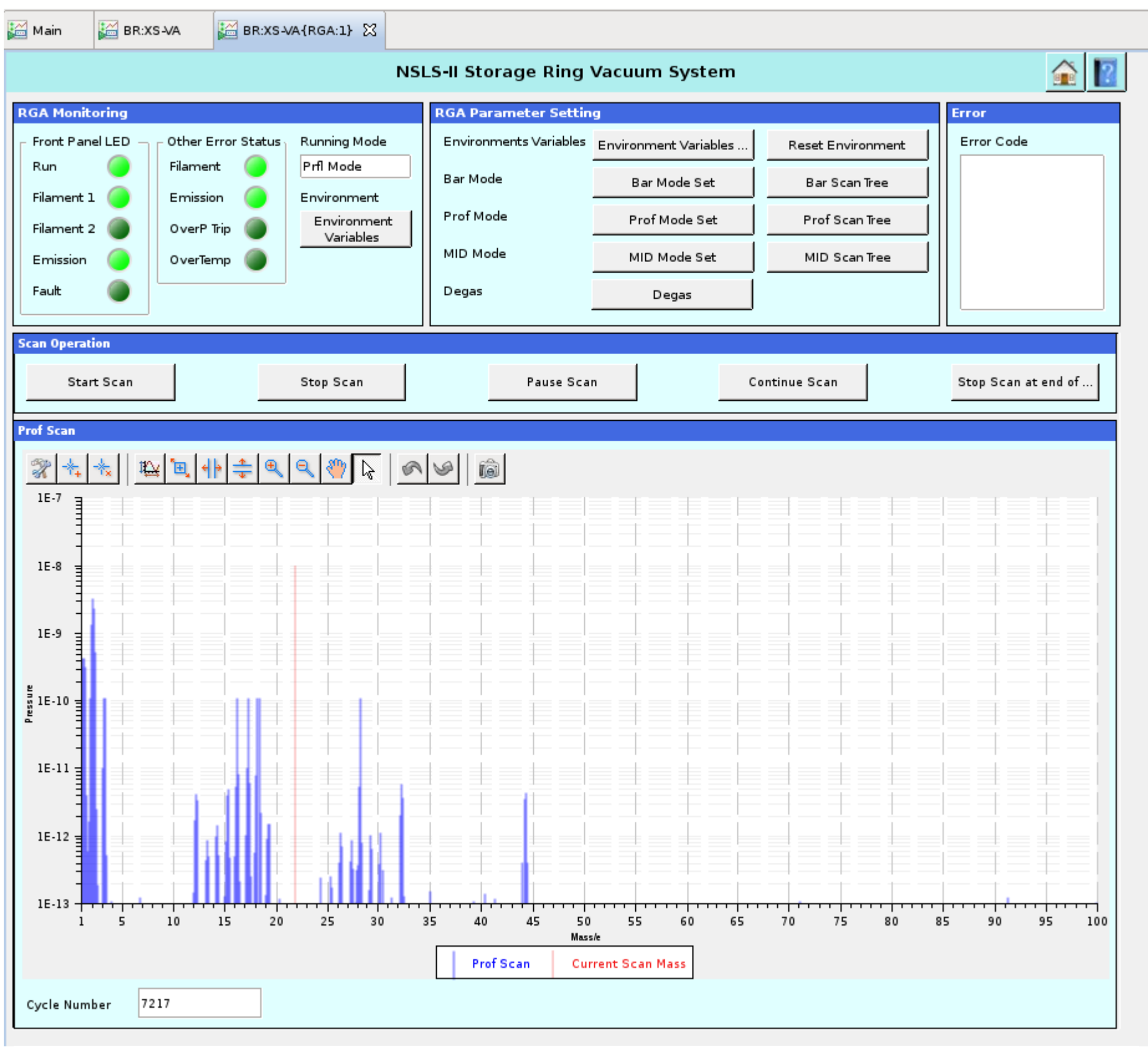

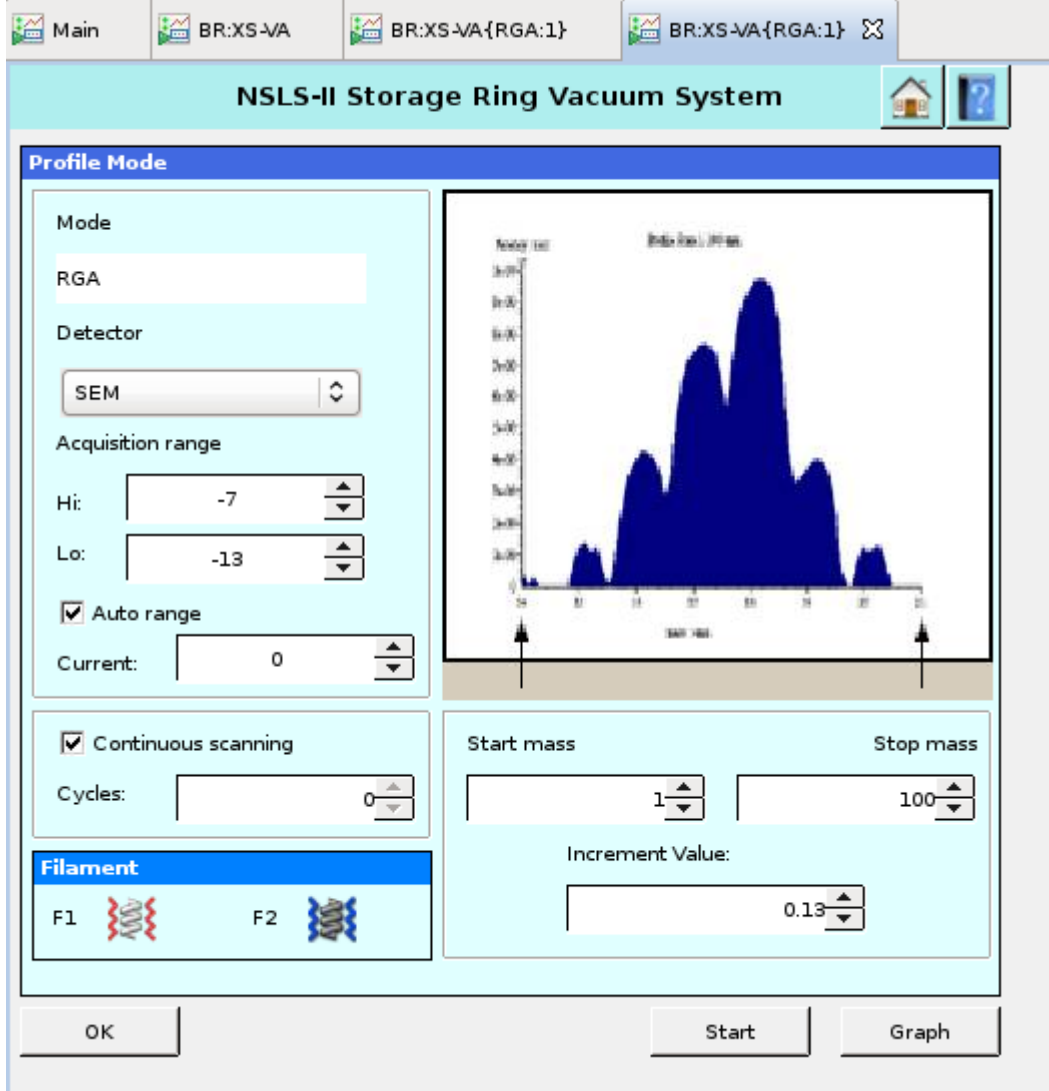Figure 3: NSLS-II individual RGA main display.
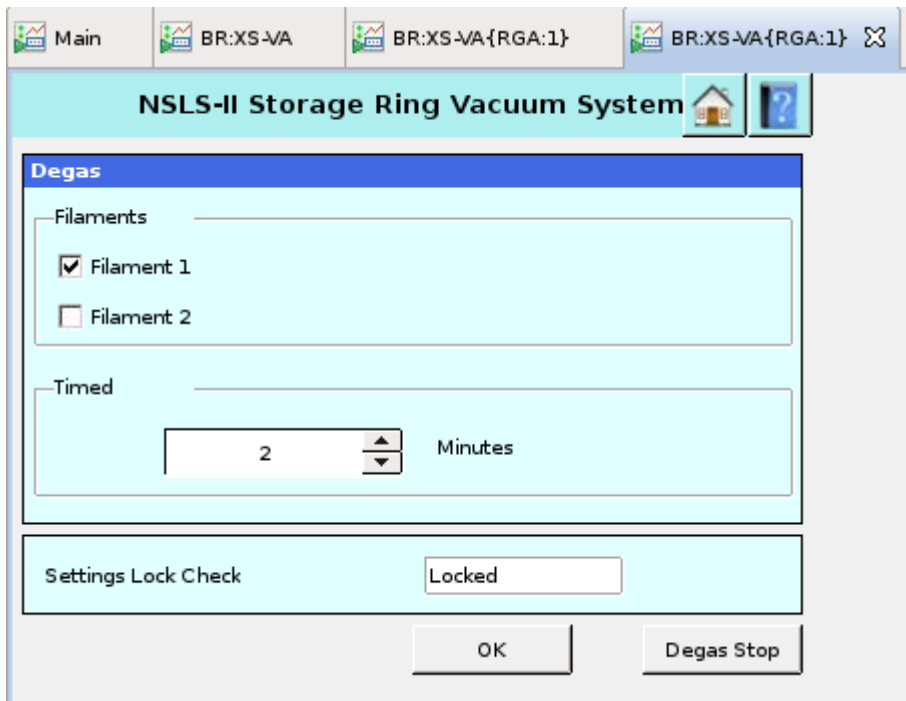

Figure 4: RGA profile mode set panel.

Figure 5: RGA degas control panel.

Data Archiving and Analysis

The filament status, emission status, and scan trend that are important to RGA system are constantly archived using Channel Archiver. A dedicated data server with several TB of disk space is used to store all archived data.

CSS provides a trending tool called Data Browser which can display live PVs as well as historic data in a strip chart type plot.

Many tools can be used for waveform data analysis, GNU Octave, Python, Matlab, and so on. GNU Octave is an easy-to-use application, which provides a convenient command-line interface for numerical computations. The Matlab and Python interface to EPICS Channel Access packages facilitate users familiar with these two languages to do array computation and analysis.

Limitation

For Hiden RGA, the EPICS program has limited support on nested scan which allowing a scan to call a scan logical device on the RGA instrument as an input or output device. It only supports simple, predefined nested scan and doesn't not support dynamic, complex nested scan.

SUMMARY

Till now, all RGAs required for NSLS-II initial operation have been installed. All the RGAs in Storage Ring Cell arc sections are operational and functioning properly. We're still learning from these RGAs and intend on improving system performance.