Injection System Controls and Software

- ***Booster Ramp Control Hardware and Software***

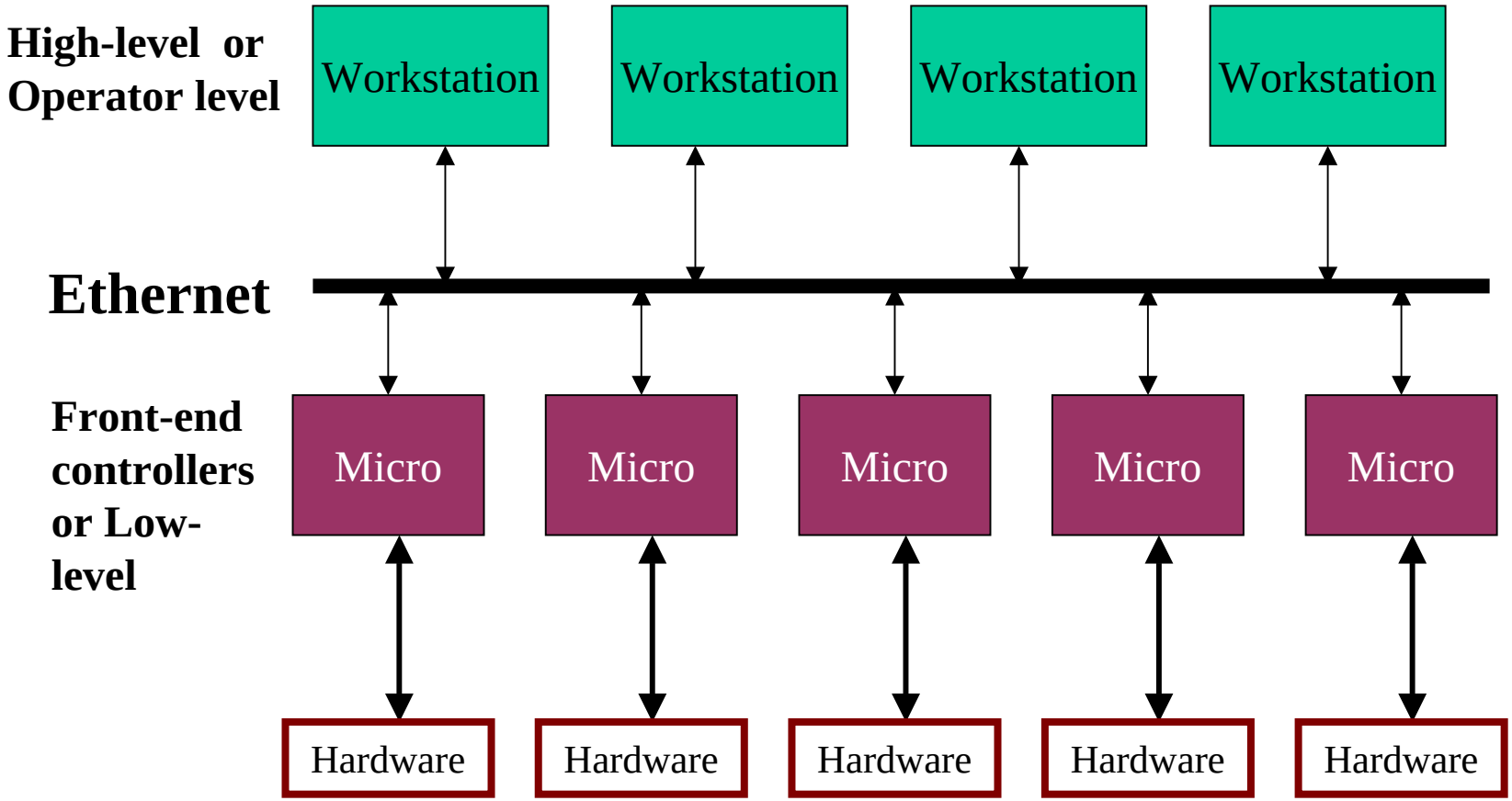
  Susila Ramamoorthy
- **Booster Ramp: High Level Software**

  Pauline Pearson

Booster Ramp Control Hardware and Software

Susila Ramamoorthy

NSLS Control System Architecture: Hardware



1. Two-level architecture.
2. MICRO is the name used for the Front-end-controller at NSLS
3. Micros interface with the machine hardware (Ex. Power supplies, timing system vacuum controller and gauges etc.
4. Programs running on any workstation can communicate with any micro on the network. Any micro can communicate with any other micro.

Hardware

Workstation:

HP workstations and PCs with Xterm emulator.

Micro:

The Micros are VME-based systems.

The minimum required boards are: a single board computer (CPU), a General Purpose Light Source board (GPLS) and a battery-backed-up memory.

Additional boards depend on the machine hardware interfaced with the micro.

ADC, DAC, Bit-Input and Bit-output cards, Ramp cards.

Boards to handle GPIB and RS-232 communications.

Camac controllers, boards with Timers and Counters, PLCs etc.

VME Micro System

Software Objectives

The **complexity and diversity** of various hardware used in a facility like NSLS make **each micro unique** at the control level. However, the main objective is to **present a standard interface** to the high-level programs.

1. **Hide all hardware details from the high-level programs.**
2. **Programs use a standard set of control and data acquisition commands for the same function.**

To achieve these objectives, the control system uses the Device Concept.

Device Concept

All hardware input and output signals are viewed as named devices.

Examples: xrf1rfcavpwr, lbish, buish

Computed machine parameters as well as software variables used for controls are also treated as devices.

Examples: xrlifetime, uvtune, x25undgap

A device can also represent an array of data.

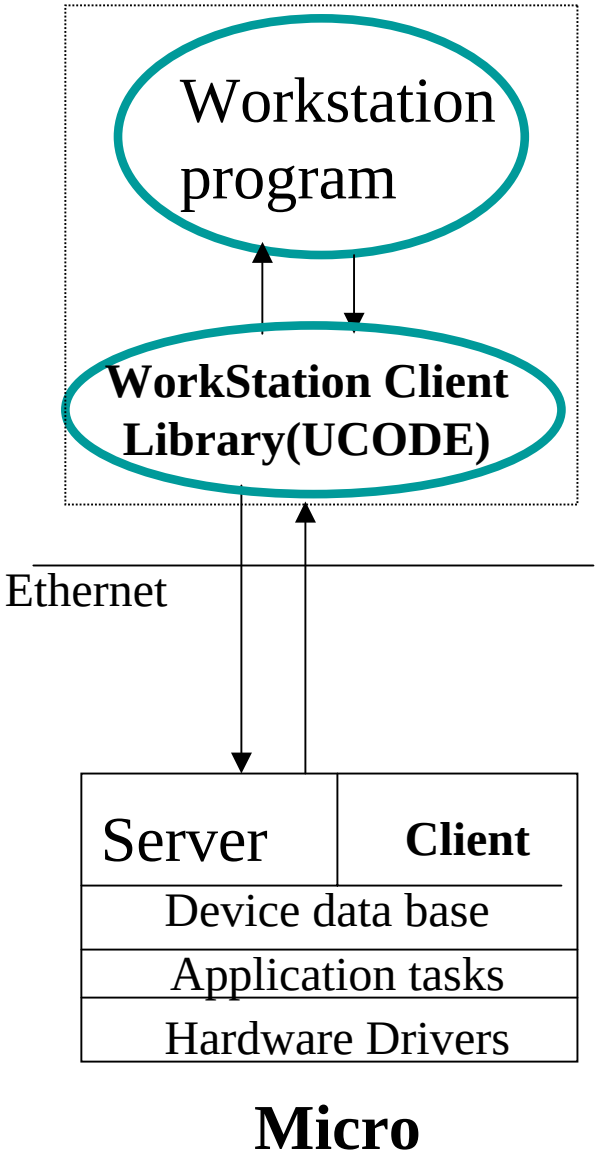
Example: ramp data file, messages displayed on the TVscreen, read-backs from power supplies while ramping.

Each device has a unique name in the entire control system.

The list of devices, their location (the micro and its IP address), its polarity etc. are in the device database (DDR: Device Data Records) on the HP workstation.

The high-level programs use the device names to control and monitor the ring hardware and parameters. To implement a high-level program, only the list of the device names and the control commands that operate them are needed.

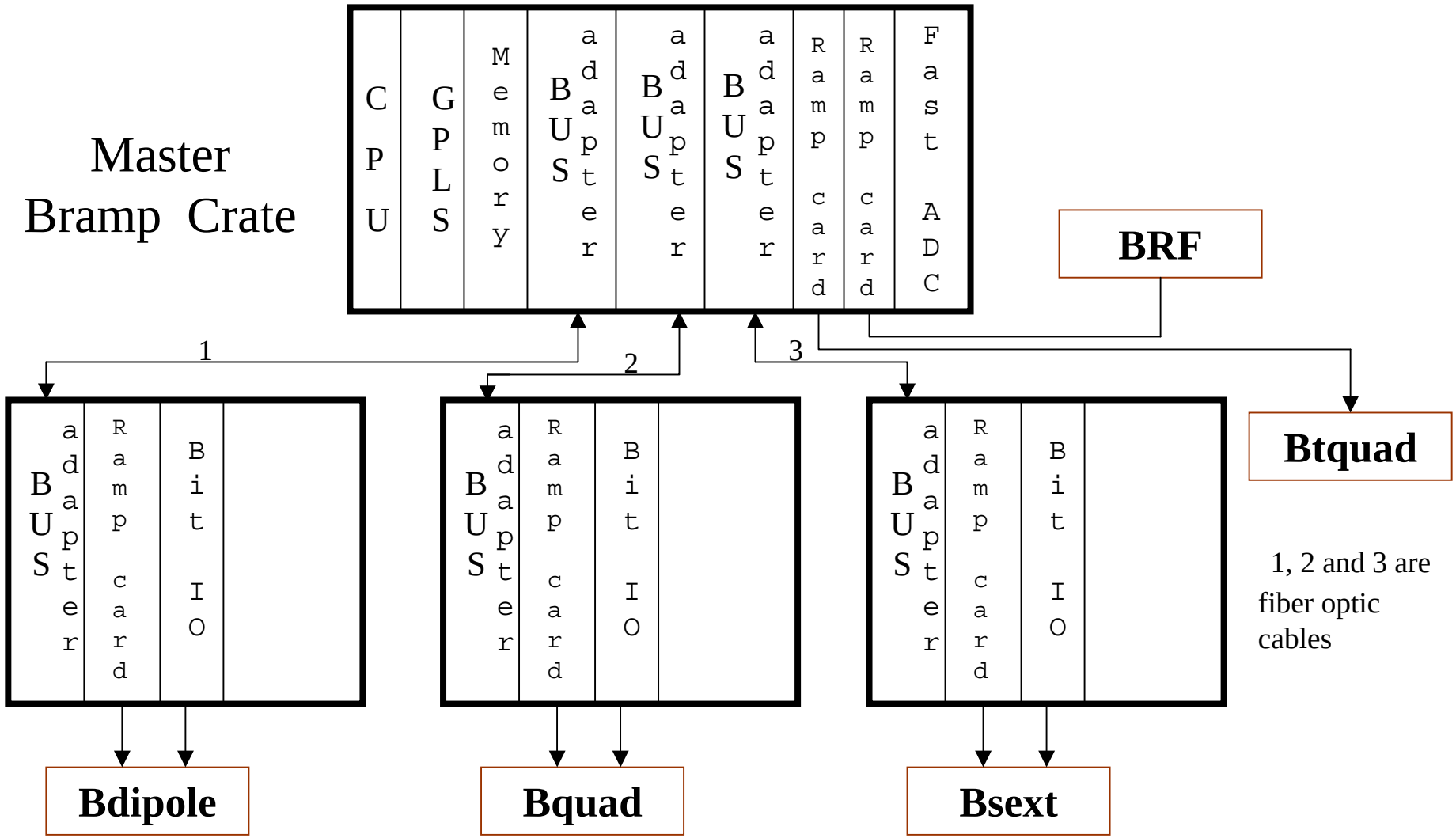
Software



- The operator programs are called clients.
- Send control commands to the micro.
- Send requests to get device data and status.

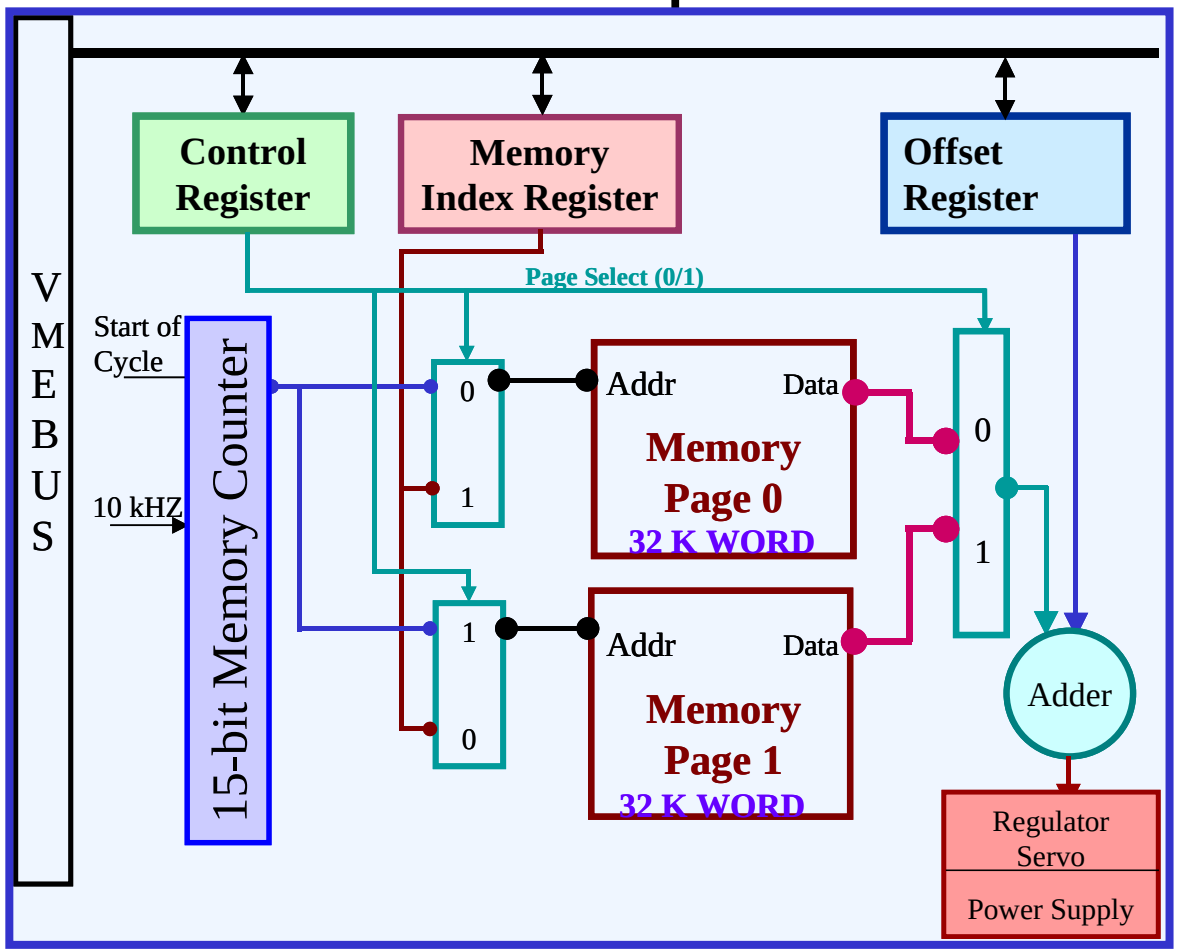
- Server software receives and decodes the messages.
- If it is a control command, the appropriate driver is invoked to execute the function on the hardware.
- If it is a read request, it sends the requested data for the device (or devices) from the device database.
- The micro continuously monitors the hardware and updates the database. The monitoring rate can be 1 to 10 KHz depending on the hardware.
- The micro uses its client module to send messages to other micros.

Configuration of Booster Ramp Micro



5 Ramp cards, 3 Bit/IO to turn supplies On/Off and to monitor their status and fault conditions and a fast ADC board

Booster Ramp Card



- 2 - 32K word memory pages
- Access via control, memory index and offset registers.
- active page is 0 or 1
- active page controls the ramping of the power supply.
- new data is loaded into the inactive page.

The counter has 2 input signals: Start of pulse and 10 KHz. When the counter receives start of cycle pulse, it resets to 0. The memory location will point to 0. To initiate the ramp cycle, CPU has to turn the ramp control bit ON via the control register. The counter will increment at 10 KHz. The number in the counter is the address of the memory from which the data is output. As the counter increments, the data from successive locations are output. This combined with the offset data is sent to the power supply.

Devices in the Booster Ramp Micro

1. Array devices to hold the ramp data files.

   bdpdatar, bqdatar, bsxdatar, btqdatar, brfdatar

2. Devices to set the Offset registers.

   bdpoffst, bqoffst, bsxoffst, btqoffst, brfoffst

3. Devices to turn On/Off the ramp cycle.

   bdprmpctl, bqrmpctl, bsxrmpctl, btqrmpctl, brfrmpctl

4. Devices to read the number of samples in the last cycle, error status current active page number (used for diagnostic purposes).

5. Devices to hold the read-backs from the magnet regulator servo and the power supplies. These are array type devices and hold the data for the last ramp cycle. There are 16 signals from the hardware.

6. Devices to turn ON/OFF the Booster diploe, quadrupole and sextupole power supplies.

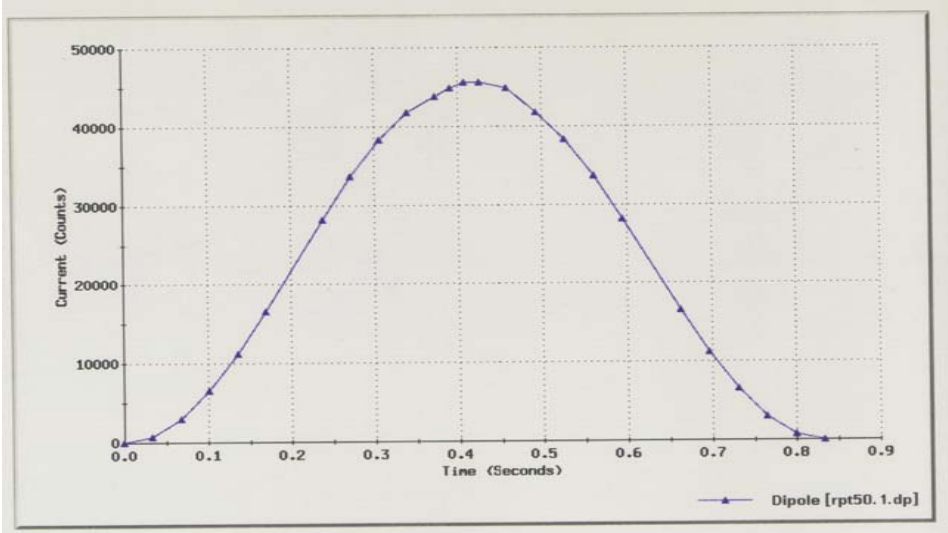
   bdippower, bquadpower, bsextpower

Functions of the Micro

- Turns On/Off or Reset the booster dipole, quadrupole and sextupole power supplies when operator sends the commands.
- Set-points for the offset devices are written to offset registers.
- For On/Off commands to the ramp control devices, appropriate bit in the control register is set/reset.
- When ramp files are downloaded into the data array devices, the micro processes the arrays and loads the data into the respective ramp cards.

Processing of Ramp file

The ramp data files downloaded by the operator are received by the data array devices in the micro.The figure shows a typical ramp file.

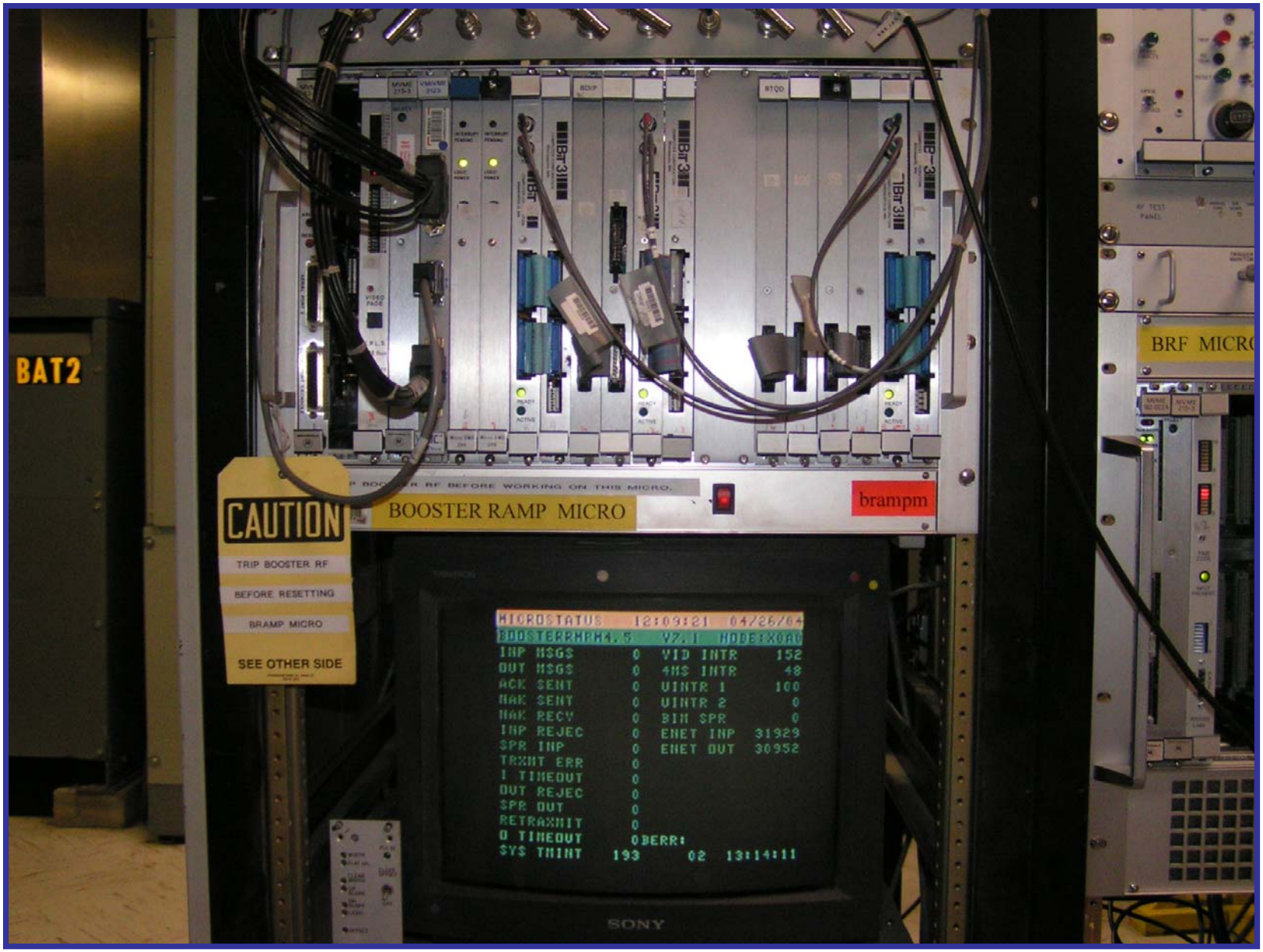


- Each ramp file can have up to 100 points. The first point is always for time 0 (corresponds to the start of ramp cycle). The last point is the end of ramp cycle.
- Since the ramp memory is 32k word and the ramp clock rate is 10 KHz, the maximum ramp cycle (32k * 100Usec) should be less than 3.2 67 seconds.
- Start of ramp cycle signal is derived from TBRAMP from the timing system. The cycle is 830msec. (which is the frequency of the TREP signal).
- The ramp data is linearly interpolated between 2 consecutive points. The time interval between the interpolated points is 100 microsec. Interplated data is loaded into the inactive memory page of the ramp card.
- To activate the new ramp, the operator has to issue an ON command. The next start of cycle pulse will output the new ramp data to the magnet supplies. RF ramp controls the RF level.

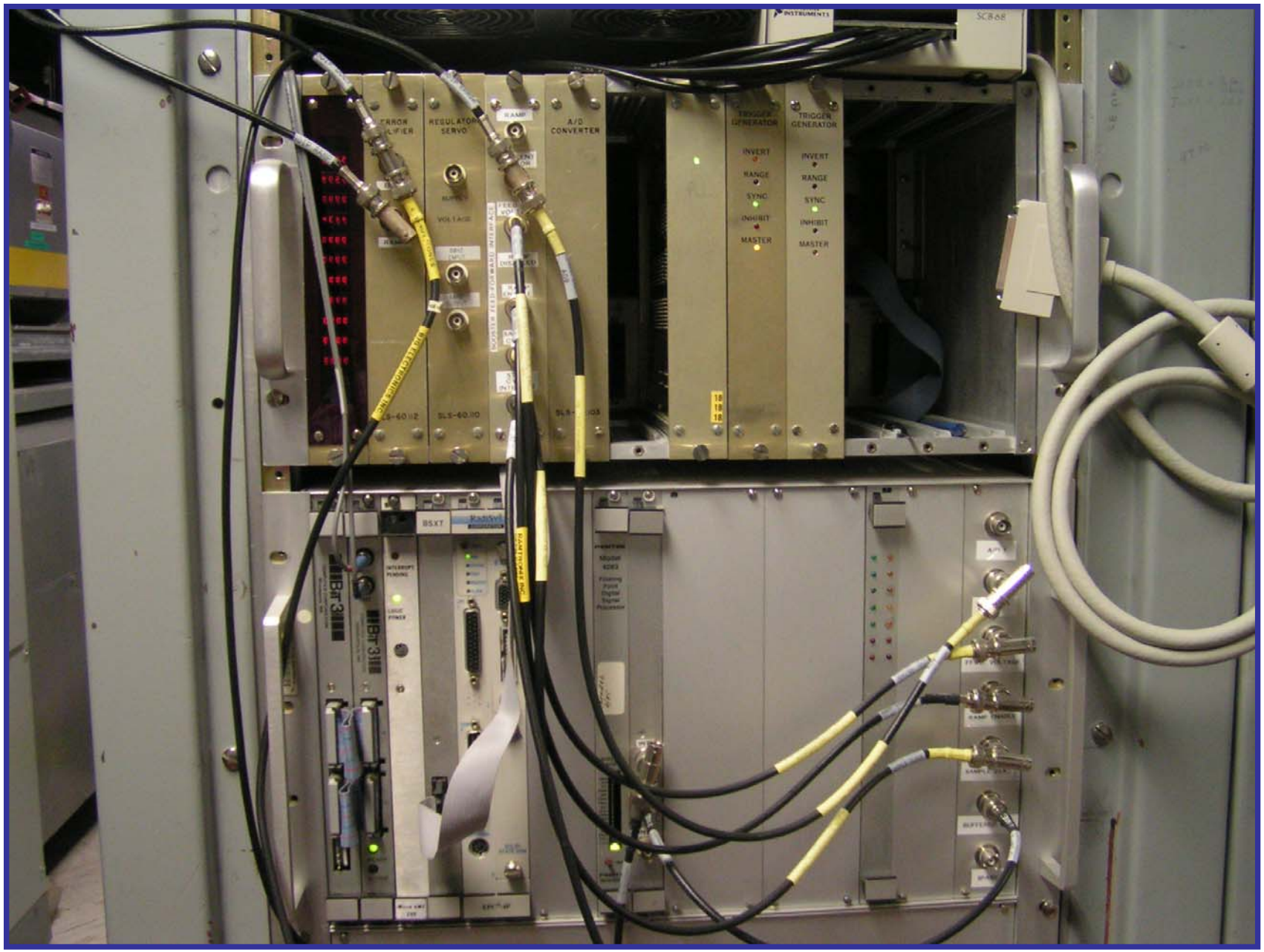
Functions of the Micro (contd).

- Continuously monitors the On/Off status and fault conditions of the power supplies at 5 Hz rate. If faults (Ex. DC over-current, temperature fault, SCR fault) are detected, they are notified to the central alarm handler.
- Generates a video display for the faults.
- Reads the current sample numbers for the previous cycle for all the ramp cards and stores in the sample count devices. Zero sample count for any device indicates loss of 10 kHz or start pulse for that card.
- Monitors 16 signals from the magnet servo and power supplies at 10 KHz using a fast ADC. The same 10 KHz signal used for ramping is used as the sampling clock. The micro gets interrupt at the start of ramp cycle. The ADC operation is initiated at the interrupt level. The micro uses a double buffer to store the data. At the end of each cycle the buffer is switched.
- When the operator requests data, the micro returns the data of the previous cycle.
- The 16 signals that are monitored are:
- DAC voltage, current and error signals for the dipole, quadrupole and sextupole.(9)
- Trim quad controls two power supplies. Each gives three signals (DAC , voltage and current).(6)
- RF cavity power signal from Booster RF micro.(1)

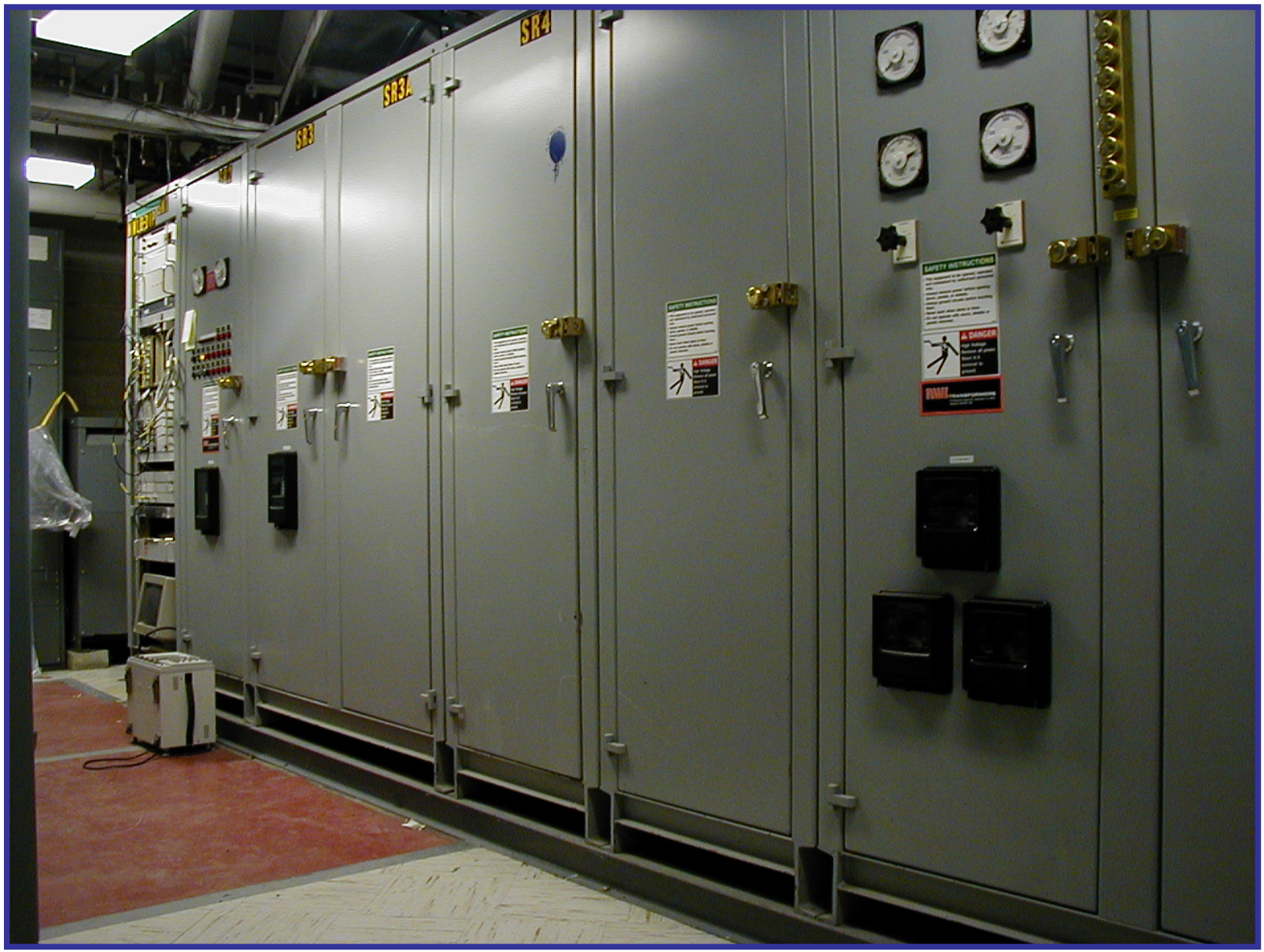
Booster Ramp Micro



Booster Dipole Slave Crate



Booster Dipole Magnet Supply



Thanks

Dabrowski

Fulkerson

Johnson

Kushner

Michta

Rambo

Shaftan

Zitvogel

Zuhoski

Booster Ramp: High Level Software

Pauline Pearson

NSLS Application Software

Languages/Tools

C / C++ Programming Language
X11 Windows Graphics (Version 6)
Motif Widgets (Version 2.1)
XRT/Plotter (Version 4)
UIMX Graphics Interface

Libraries

User Interface Library (UIF): Library of functions used by the Application Programs. The library provides a uniform user interface for most of the applications.

Ucode Library: Library of functions used by the Application Programs to read/write data to Micro devices.

Util Library: Library of utility routines used by all Application Programs.

FILE RegFile PlotFile Group Controls Offset Diagnose HELP

Booster Ramp Control [Apr 27, 2004 Version]

	SUPPLY	RAMP	OFFSET
DIPOLE	ON	OFF	1531
QUADRUPOLE	ON	OFF	5934
SEXTUPOLE	ON	OFF	2391
TRIM QUADS	LOCAL	OFF	13391
RF	ON	OFF	319

Down Load | Start Ramp | Stop Ramp | Supplies On | Supplies Off

Dipole: rpt50.02-20-04.dp

Booster Ramp Control Program Functions

1: Create/Edit Ramp array

2: Plot 1/2 Ramp arrays

3: Create groups of ramps for download

4: Turn Ramps ON / OFF

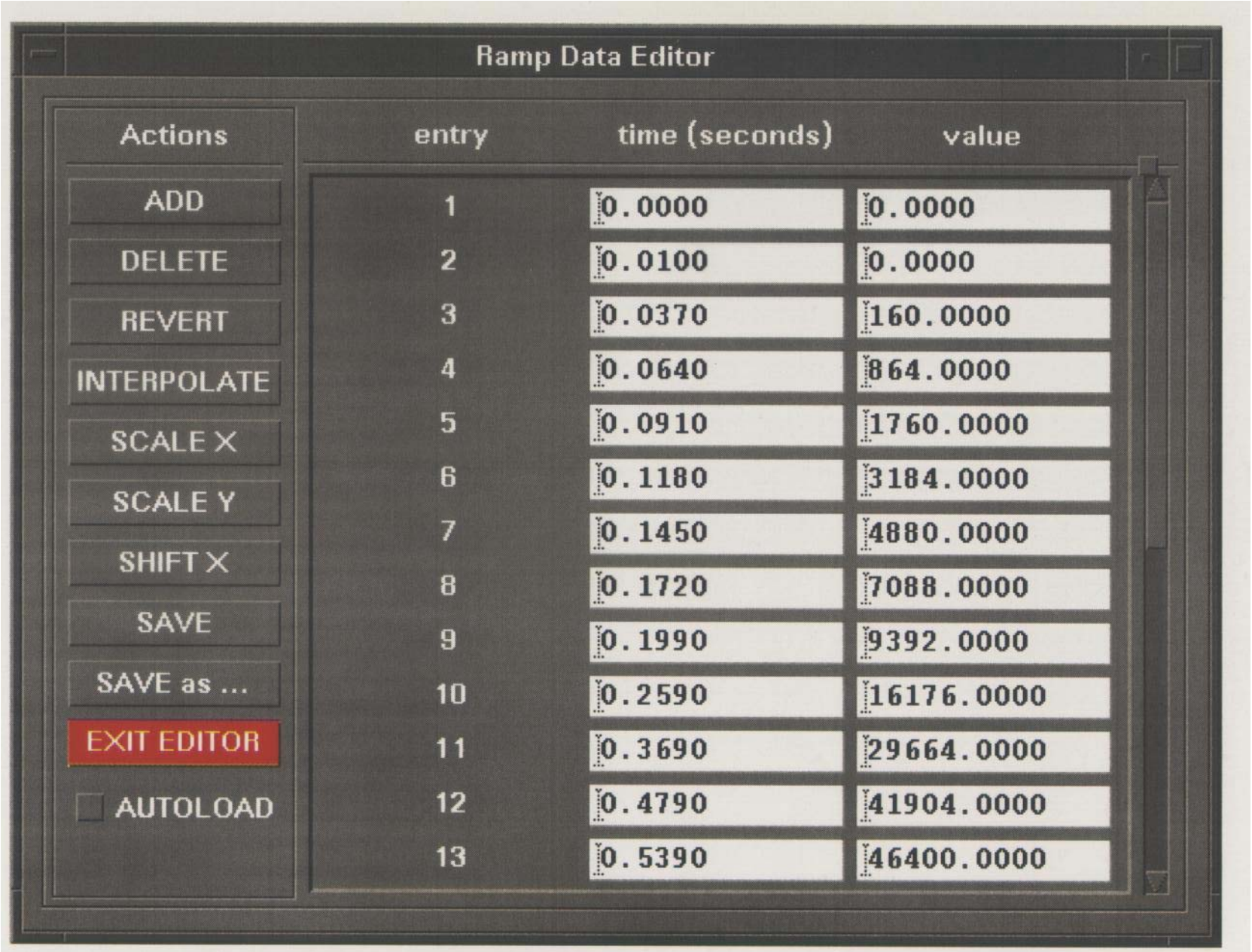
5: Turn Power ON / OFF / RESET

6: Offsets - Operator can enter new values

7: Download - Group of Ramp Arrays to Dipole, Quadrupole, Sextupole, TrimQuads and RFgenerator devices

Booster Ramp Control

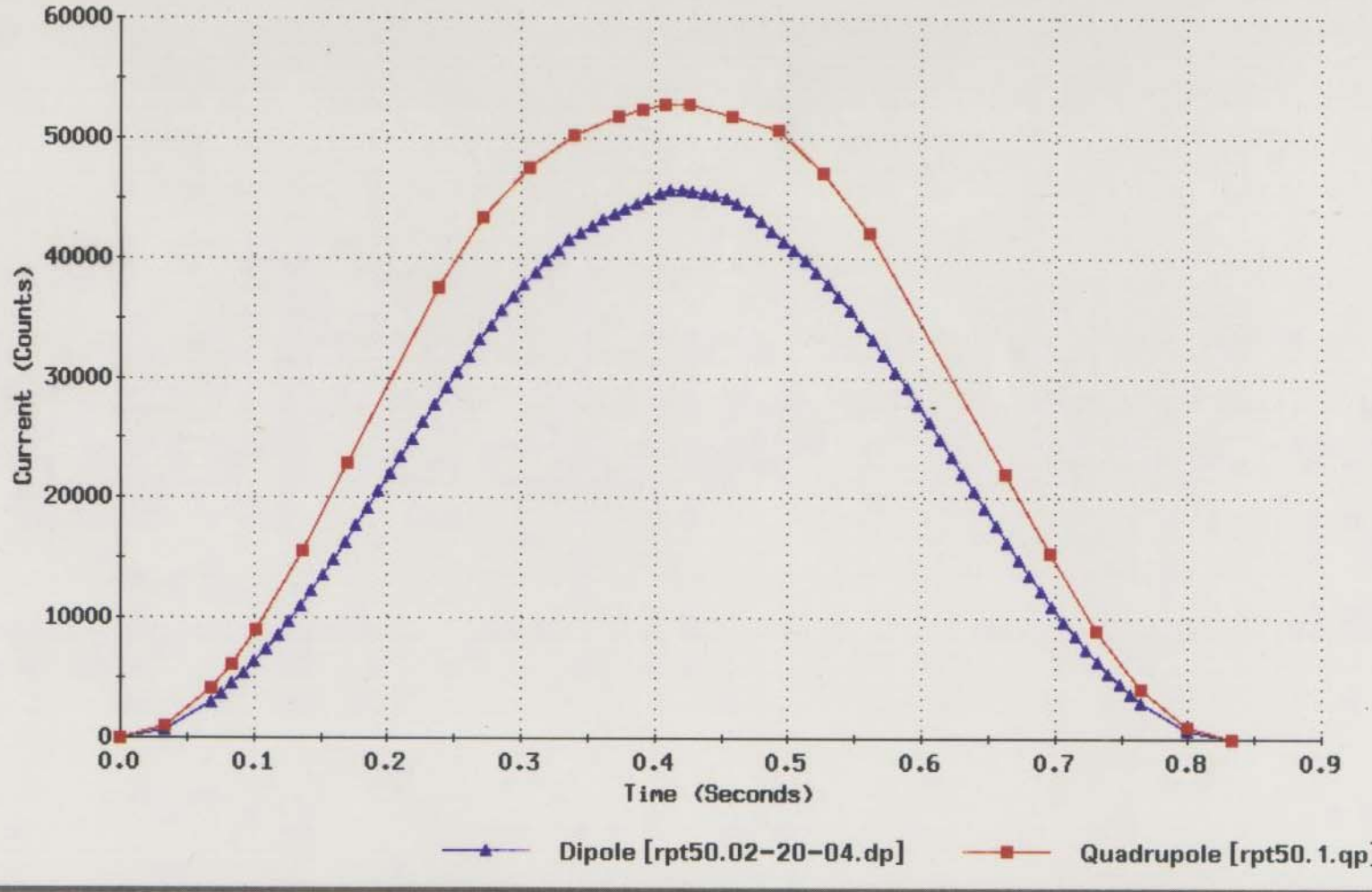
Create Ramp array:	Enter time, setpoint values and save to file. Read data from an ascii file.
Ramp Array Editor:	Use editor to scale data, add or delete points, or add points by interpolating between existing points. As values are changed the plot on screen will change interactively.
Groups of ramps:	Select a rampfile for each of Dipole, Quad, Sext, TrimQuad and RF, and store names in file for download.


Ramp Data Editor
Actions
ADD
DELETE
REVERT
INTERPOLATE
SCALE X
SCALE Y
SHIFT X
SAVE
SAVE as ...
EXIT EDITOR
AUTOLOAD
entry
time (seconds)
value
1 0.0000 0.0000
2 0.0100 0.0000
3 0.0370 160.0000
4 0.0640 864.0000
5 0.0910 1760.0000
6 0.1180 3184.0000
7 0.1450 4880.0000
8 0.1720 7088.0000
9 0.1990 9392.0000
10 0.2590 16176.0000
11 0.3690 29664.0000
12 0.4790 41904.0000
13 0.5390 46400.0000

FILE RegFile PlotFile Group Controls Offset Diagnose HELP

Booster Ramp Control [Apr 27, 2004 Version]

Amplitude
Min Range
Max Range
Time
Min Time
Max Time
Actions
EDIT DATA
UNZOOM
Print Plot
Help
EXIT PLOT



Down Load | Start Ramp | Stop Ramp | Supplies On | Supplies Off

Dipole: rpt50.02-20-04.dp

Booster Ramp Control

Turn Ramps ON

Set Ramp Control Devices to ON

- Booster Dipole Ramp Control (bdrmpctl)
- Booster Quadrupole Ramp Control (bqrmpctl)
- Booster Sextupole Ramp Control (bsrmpctl)
- Booster TrimQuad Ramp Control (btrmpctl)
- Booster RF Ramp Control (brfrmpcl)

Turn Ramps OFF

Set Ramp Control Devices to OFF

- Booster Dipole Ramp Control (bdrmpctl)
- Booster Quadrupole Ramp Control (bqrmpctl)
- Booster Sextupole Ramp Control (bsrmpctl)
- Booster TrimQuad Ramp Control (btrmpctl)
- Booster RF Ramp Control (brfrmpcl)

Booster Ramp Control

Reset Power Supplies

- If any Ramps are ON turn them OFF

- Wait for 3 seconds

- Send RESET command to Booster Power Supply Devices

Dipole Power Supply	(bdippower)
Quadrupole Power Supply	(bquadpower)
Sextupole Power Supply	(bsextpower)

Power Supplies 'OFF' Sequence

Reset Power Supplies

Read Offset readback values:

Dipole Offset	(bdpoffst)
Quadrupole Offset	(bqdoffst)
Sextupole Offset	(bsxoffst)
TrimQuad Offset	(btqoffst)
RFgenerator Offset	(brfoffst)

Write these offset values to data file:

Set Offset Device setpoint to 0:

Dipole Offset	(bdpoffst)
Quadrupole Offset	(bqdoffst)
Sextupole Offset	(bsxoffst)

Wait for 1 second:

Turn Power supplies OFF:

Dipole Power Supply	(bdippower)
Quadrupole Power Supply	(bquadpower)
Sextupole Power Supply	(bsextpower)

Turn Ramps OFF

Power Supplies 'ON' Sequence:

Reset Power Supplies

Set Offset Device setpoint to 0

- Dipole Offset (bdpoffst)
- Quadrupole Offset (bqdoffst)
- Sextupole Offset (bsxoffst)

Turn Power supplies ON

- Dipole Power Supply (bdippower)
- Quadrupole Power Supply (bquadpower)
- Sextupole Power Supply (bsextpower)

Read offsets from data file

Set Offset Device to offset value

- TrimQuad Offset (btqoffst)
- RFgenerator Offset (brfoffst)

Ramp Up Offset Device Setpoints in 9 steps (intervals of 250 mS)

- Booster Dipole Offset (bdpoffst)
- Booster Quadrupole Offset (bqdoffst)
- Booster Sextupole Offset (bsxoffst)

Turn Ramps OFF

Download Sequence

Select a named group file: Contains the names of the 5 ramp files for the Dipole, Quadrupole, Sextupole, TrimQuad and RFgenerator

The program reads the ramp file data for each type:

 # points
time and setpoint data

The program builds/formats the ramp array: Maximum of 100 points

- Structure
Number of points
Time Setpoint
Time Setpoint
... ...
Filename (max 24 characters)

The array is downloaded to the Ramp Devices via ucode call:

Dipole	**bdpdatar**
Quadrupole	**bqddatar**
Sextupole	**bsxdatar**
TrimQuad	**btqdatar**
RFgenerator	**brfdata**

Booster Ramp Control

Offsets: Operator can enter new values

Range between 0 – 65535

Dipole	bdpoffst
Quadrupole	bqdoffst
Sextupole	bsxoffst
TrimQuads	btqoffst
RFgenerator	brfoffst

Booster Ramp Monitor

1: Reads array data from device for ‘Dipole+DAC’ , ‘Dipole+ERROR’ etc. and plots the data along with a reference array stored in a file, and the original ramp sent by the Booster Ramp Control program.

2: The plotted array data is updated once per second. The plot can be halted and then resumed.

3: The plot can be printed. (Halt plot first)

4: The array data can be stored as reference data for future plots.

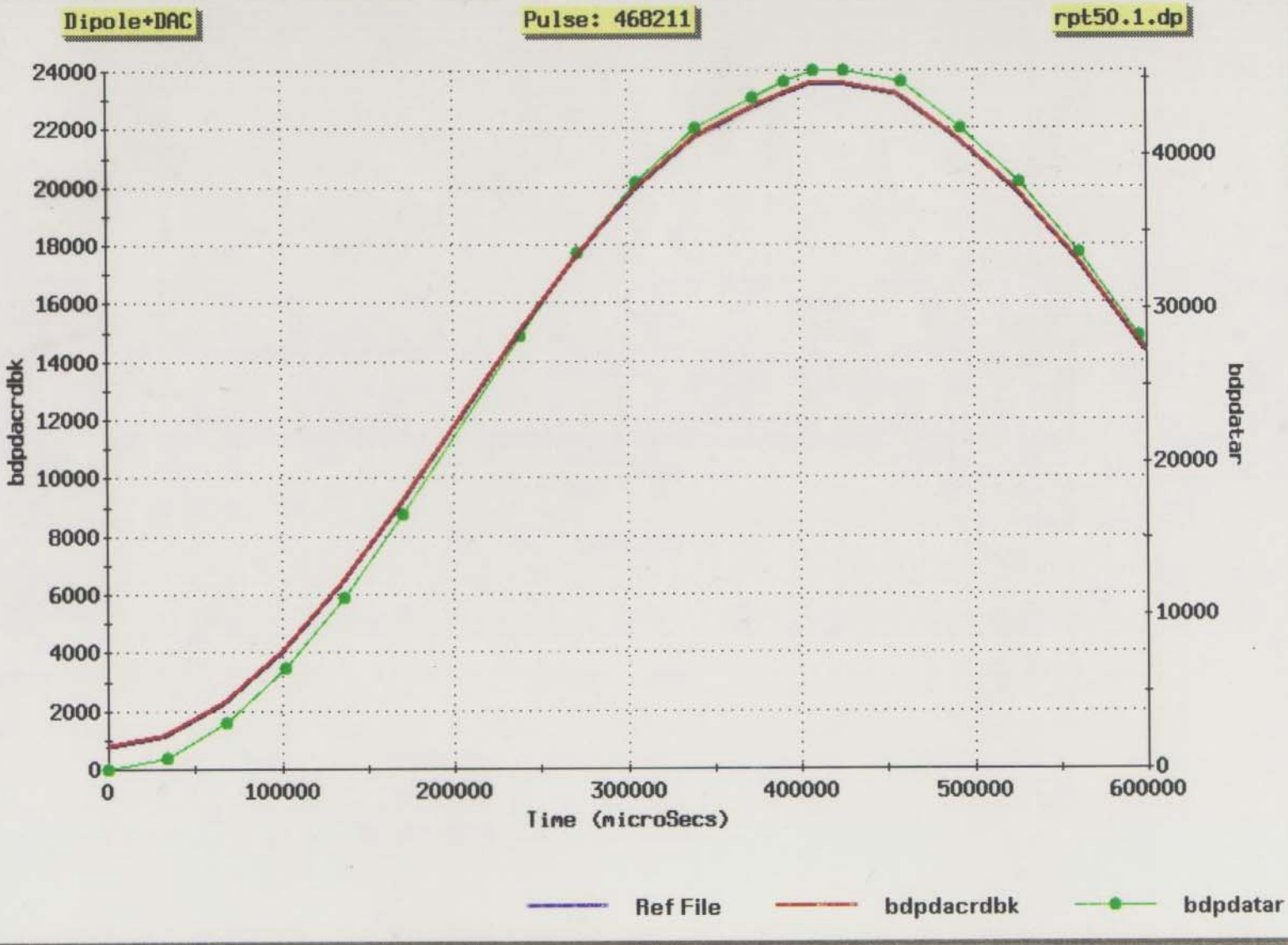
5: Zoom IN / Zoom OUT, Display point data.

FILE Devices PLOT Graph DataFile HELP

BOOSTER RAMP MONITOR

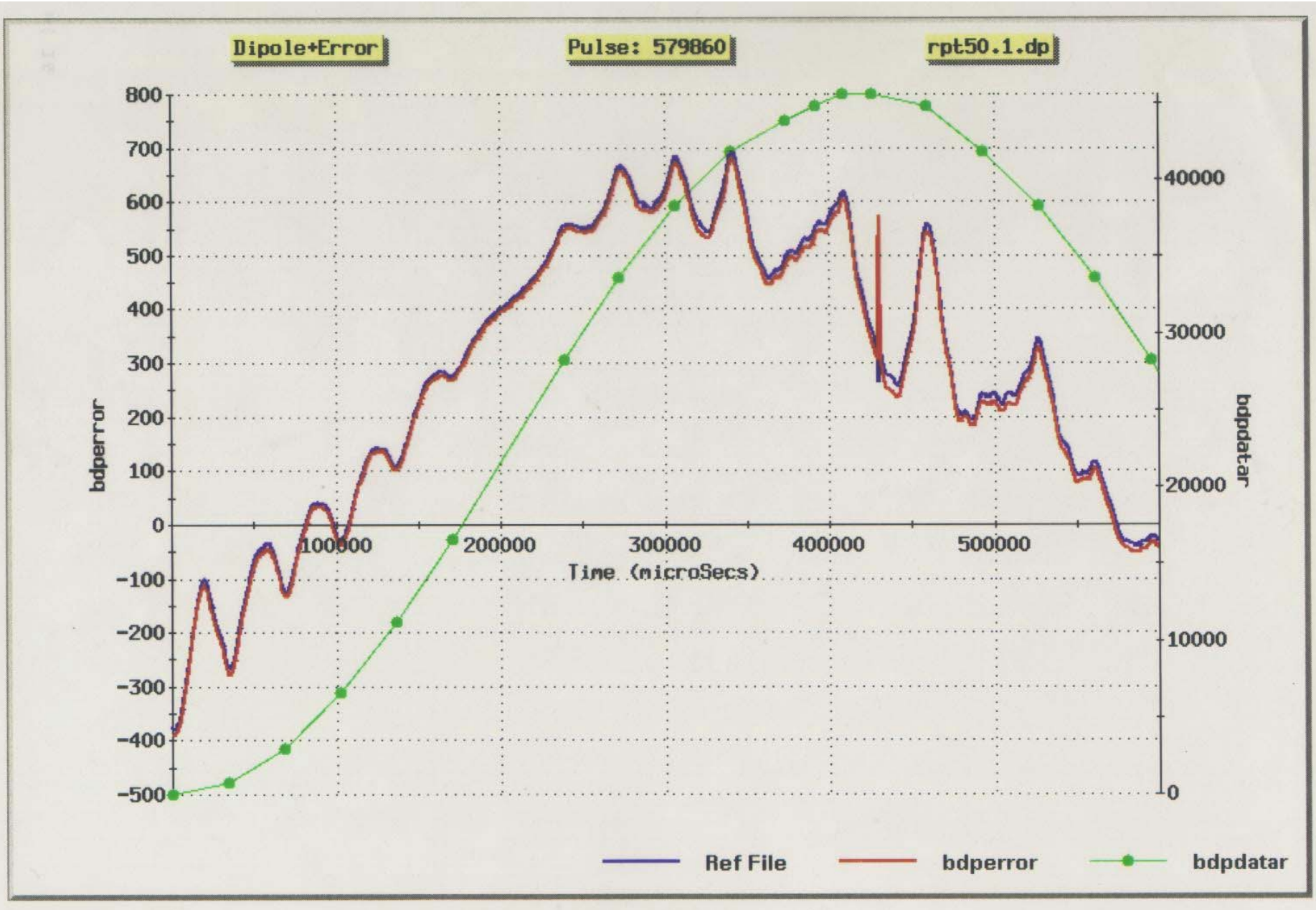
[Apr 27, 2004 Version]

Amplitude
Min Range
Max Range
Time
Min Time
Max Time
PLOT
Halt Plot
Continue
Print Plot
Actions
UNZOOM
Zoom Help



Booster Ramp Monitor

	Array Device	Ramp Device
Dipole+DAC	bdpdacrdbk	\
Dipole+ERROR	bdperror	| bdpdatar
Dipole+DCCT	bdpdcct	/
Quad+DAC	bqddacrdbk	\
Quad+ERROR	bqderror	| bqddatar
Quad+DCCT	bqddcct	/
Sext+DAC	bsxdacrdbk	\
Sext+ERROR	bsxerror	| bsxdatar
Sext+DCCT	bsxdcct	/
BTQ1+DAC	btq1dacrdbk	\
BTQ1+Voltage	btq1voltage	| btqdatar
BTQ1+Current	btq1current	/
BTQ2+DAC	btq2dacrdbk	\
BTQ2+Voltage	btq2voltage	| btqdatar
BTQ2+Current	btq2current	/
BRF+Field	brfdetfield	brfdatar


Dipole+Error
Pulse: 579860
rpt50.1.dp
bdperror
bdpdatar
Time (microSecs)
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
100000
200000
300000
400000
500000
40000
30000
20000
10000
0
Ref File
bdperror
bdpdatar


Dipole+DCCT
Pulse: 579850
rpt50.1.dp
0
100000
200000
300000
400000
500000
600000
0
-2000
-4000
-6000
-8000
-10000
-12000
-14000
-16000
-18000
-20000
-22000
-24000
-26000
bdpdcct
40000
30000
20000
10000
0
bdpdatar
Ref File
bdpdcct
bdpdatar

Booster Ramp Control / Booster Ramp Monitor

ZOOM OPTIONS

- DRAW a RECTANGLE around the AREA that you wish to VIEW.

  Position MOUSE POINTER at X / Y location.

  Press 'SHIFT' Keyboard Button AND Press 'LEFT' Mouse Button (1)

  AND Drag the Mouse(1) to form a rectangle THEN Release both Buttons.

- ZOOM in on an X/Y location: Graph magnifies with each click

  Position MOUSE POINTER at start X / Y location.

  Press 'MIDDLE' Mouse Button(2) AND Release Mouse Button (2) :

TO UNZOOM Press 'UNZOOM' Button on Side Panel.

POINT DATA To READ Data about an individual Point on a Graph:

Position MOUSE POINTER over a Point on the Graph AND Press 'RIGHT' Mouse Button (3) Down. A dialog box will appear giving Point Information.