OAG Tools for General Users

A Contribution to the "Getting Started with EPICS" Lecture Series

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Brief Introduction to OAG

- Group of accelerator physicists and programmers formed in 1995 to "apply the lessons of commissioning to accelerator operation."
- We write high-level applications for physicists, engineers, and operators, e.g.,
  - Automated startup and shutdown
  - Orbit correction and steering
  - Accelerator experiments
- We manage the accelerator data logging systems and configuration control systems.
- Much of the software we write is generic and can be used in any EPICS context.

Outline

- Brief introduction to Operations Analysis Group
- Intended audience
- What you'll learn
- How to access the software
- General features of OAG applications
- Accessing the accelerator data logs
- Performing data analysis
- Controlling things through EPICS
- Summary

Intended Audience

- We cater to a range of users
  - Programmers in a variety of languages
  - Those who want commandline tools
  - Those who want an easy-to-use graphical user interface (GUI)
- Today, we'll concentrate the last type.
- Underlying software is the same.
- Two later talks will concentrate on the details.

A Few Details

- We build our applications out of two components
  - Tcl/Tk: a scripting language that allows easily making graphical user interfaces (GUIs).
  - SDDS: a type of general data file and a toolkit of C programs that work with such files.
- Almost all the screen-shots in this presentation are Tcl/Tk GUIs.
- The data processing is done by SDDS tools hidden under the Tcl/Tk layer
  - SDDS Toolkit for data processing and display
  - SDDS/EPICS Toolkit for EPICS-specific functions

What You Can Learn from this Talk

- Types of applications that are available from OAG
- Features and usage of specific applications
  - Detailed click-by-click guidance,
  - Review of the interface, or
  - Listing of major features.
- Important concepts for using OAG applications
  - SDDS files and "meta-applications"
  - Reusing data and programs
- How you can do even more with SDDS Toolkits
- How OAG software differs from similar EPICS clients

Accessing the Software

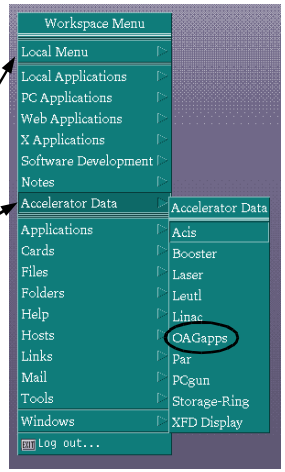
- For AOD, ASD, and XFD staff with access to a Sun workstation, access is via your workspace menu

  Right-click on the background to bring up the workspace menu

  Click on "Accelerator Data"

  Click on "OAGapps"

- Others can download from our website: http://www.aps.anl.gov/asd/oag/oaghome.shtml

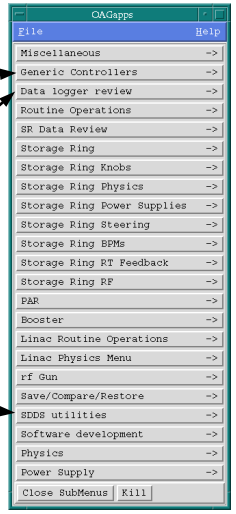


OAGapps Main Menu

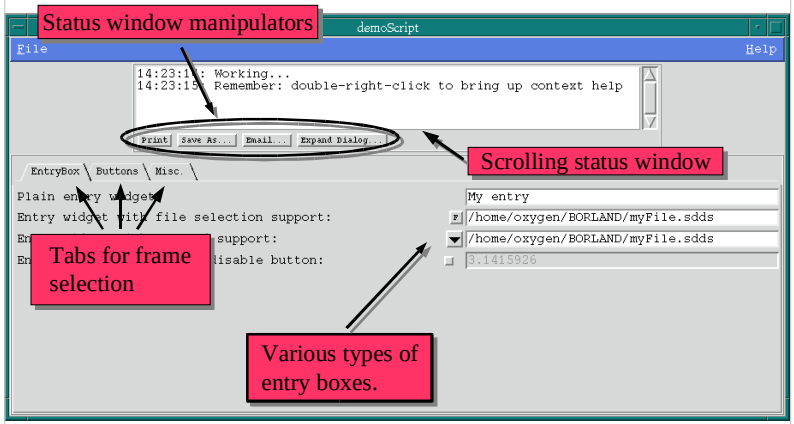
Generic applications for controlling things in EPICS

Applications for accessing the accelerator data logs

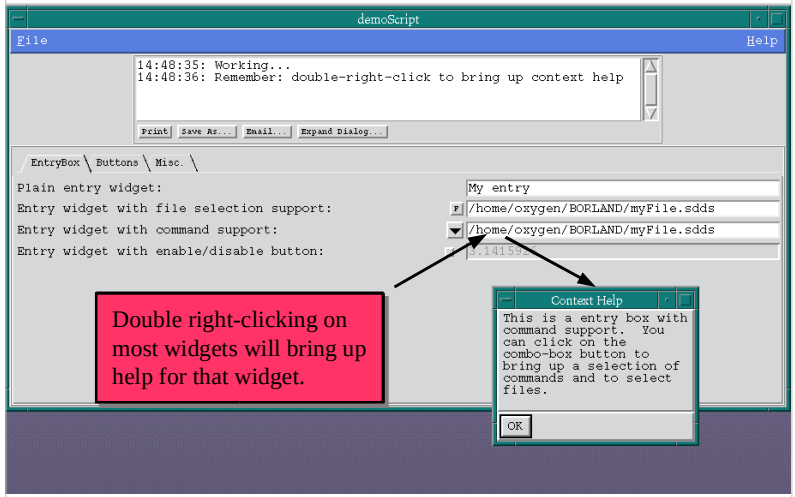
Data collection, review, and analysis utilities

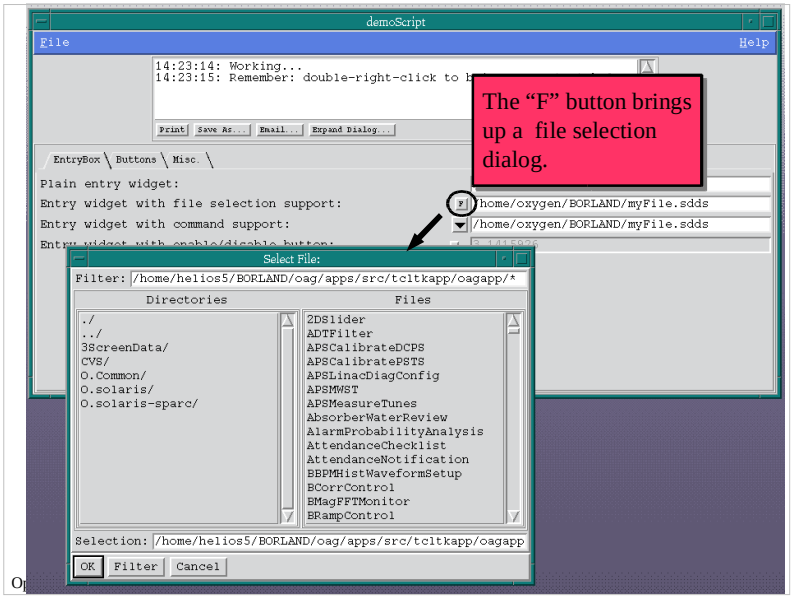


A Typical OAG-Style Application

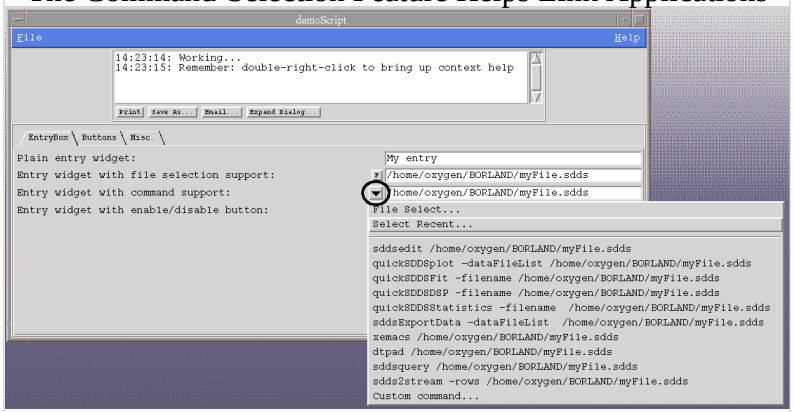


Context-Help Feature





The Command-Selection Feature Helps Link Applications

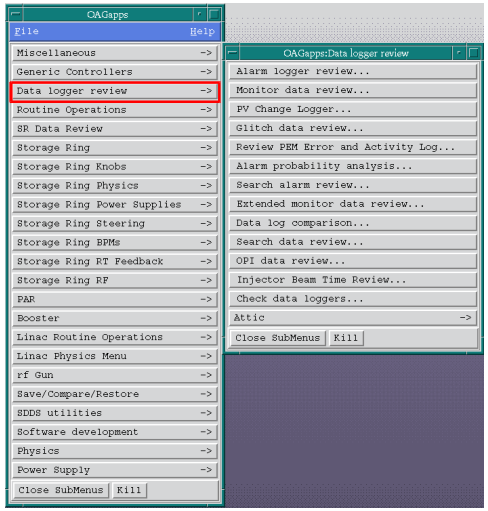


- Select file
- Select recently-used file
- Launch another application using given file

Why All the Files?

- OAG applications require input and output filenames as part of data processing
- Some feel this is inconvenient or even bad software design
- However, using files
  - Lets user name and identify data and results
  - Creates open-ended “meta-applications” out of many small, simple applications
  - Lets anyone add to the application suite
  - Avoids getting trapped by software that doesn't do what you want

Data Logger Review SubMenu



Access archives of accelerator-related data

- Review alarm history
- Review signal values
- Review history of setpoint changes
- Review glitches
- Find process variables in the data loggers

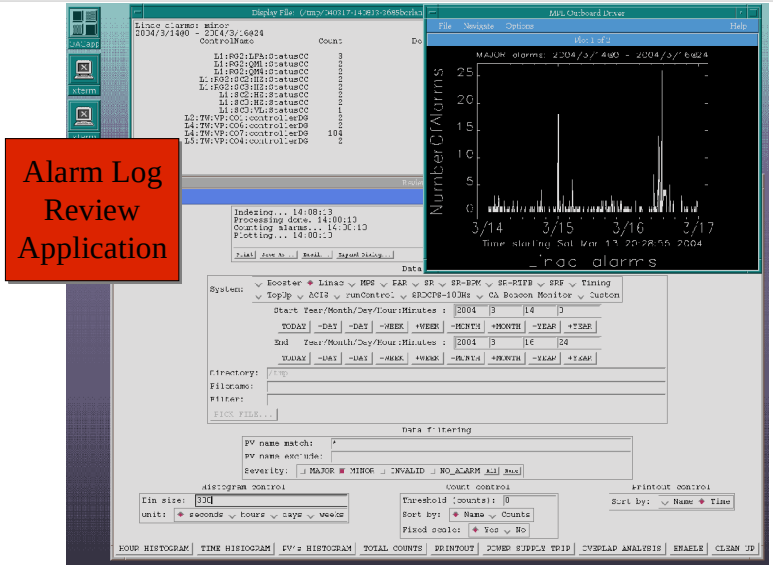
Alarm Logger Review

- The alarm logger review utility allows
  - Reviewing alarms by subsystem and time period
  - Finding alarm times, severity, and status
  - Viewing related information (e.g., status bits)
  - Histogramming alarm density
  - Look for overlapping alarms
- We monitor alarms on 14k process variables
- Private alarm logs also supported

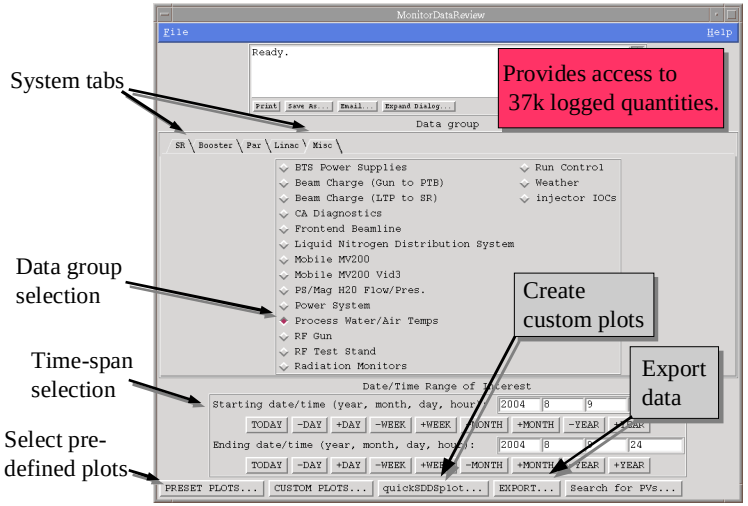
Alarm Logging or ALH?

- ALH (ALarm Handler) is a GUI for alerting operators to alarms
- ALH logs data, but
  - Must have GUI open
  - Not space efficient
  - No analysis tools
- `sddsalarmlog` provides
  - Background logging
  - Space-efficient format
  - Sophisticated analysis and review tools

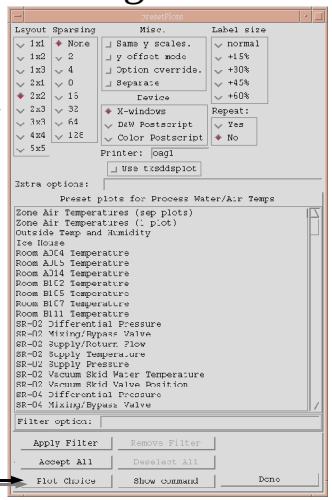
You need both!



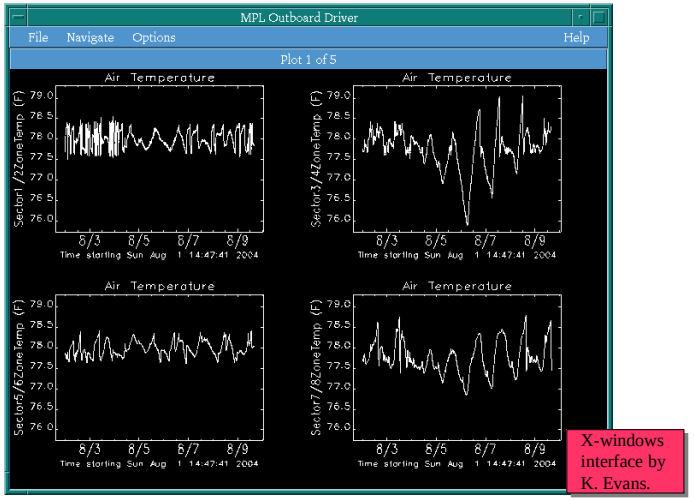
"Monitor Data Review" Application

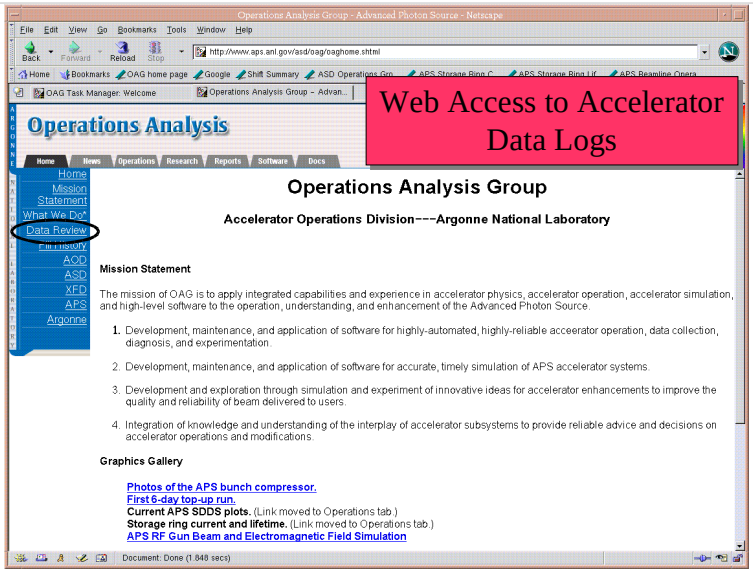


Preset Plots Dialog

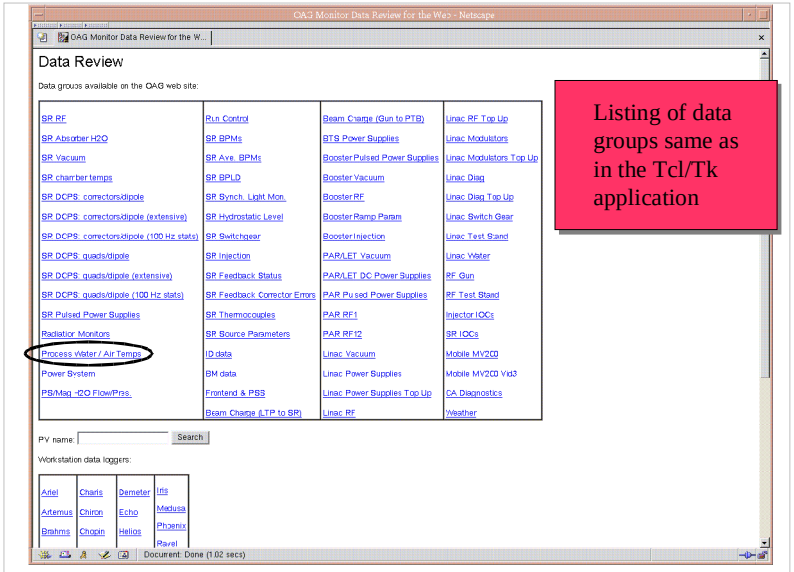


A Typical "SDDS Plot"

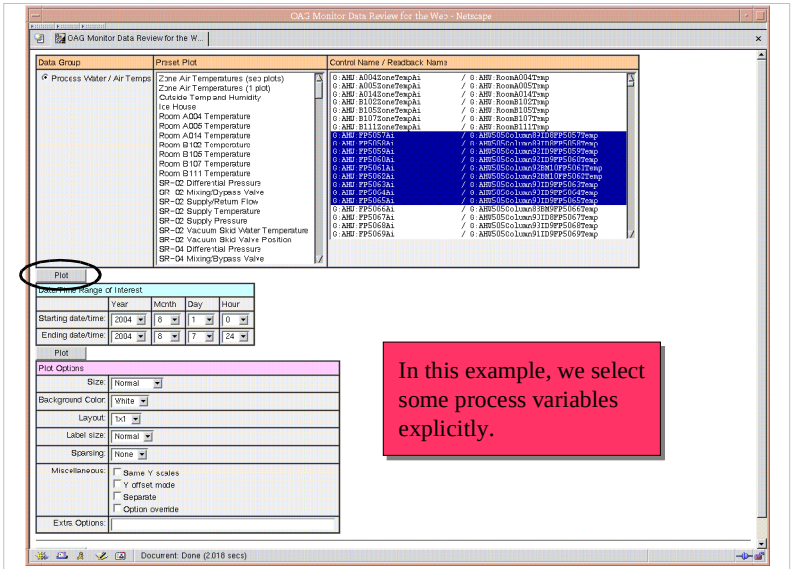




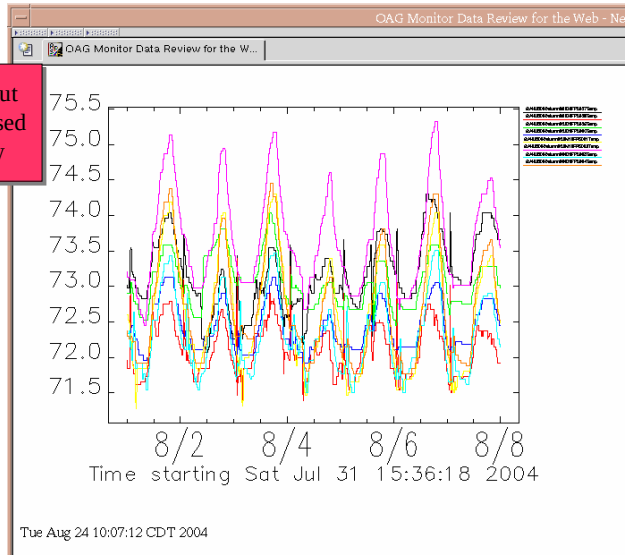
Web Access to Accelerator Data Logs



Listing of data groups same as in the Tcl/Tk application



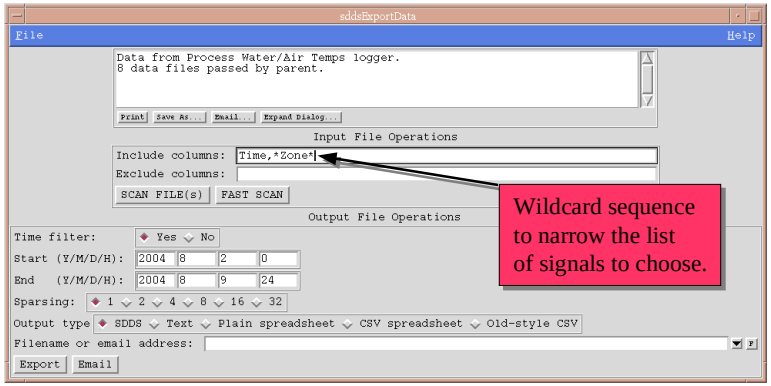
In this example, we select some process variables explicitly.



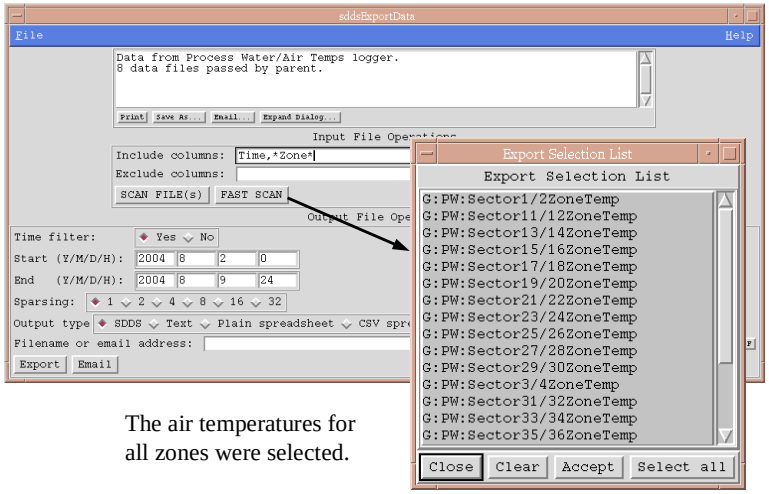
Sample output from web-based data review

Exporting Data

In this case, “sddsExportData” is launched from the data review application to allow exporting the selected data.

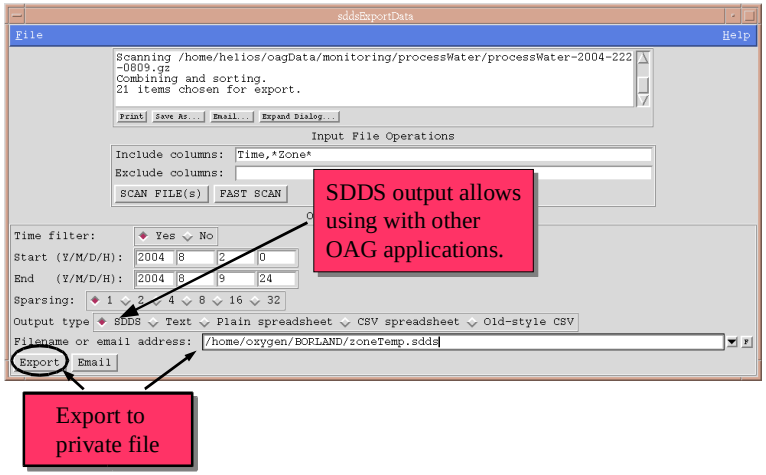


Exporting Data

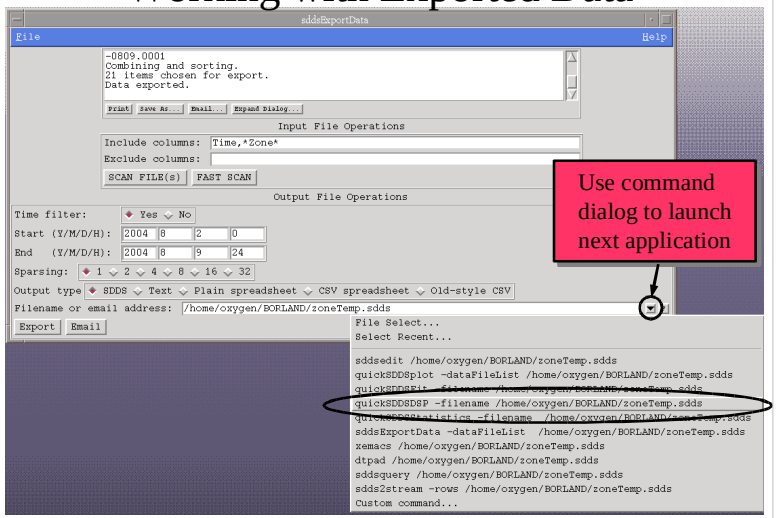


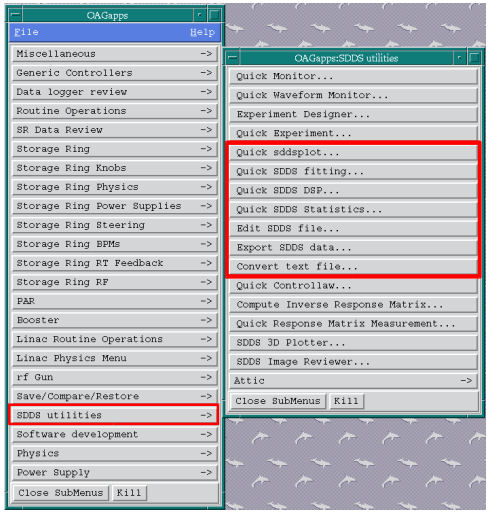
The air temperatures for all zones were selected.

Exporting Data



Working with Exported Data





SDDS Utilities SubMenu

"Quick" interfaces to basic SDDS capabilities

- Graphics
- Fitting
- Digital signal processing
- Statistical analyses
- Edit
- Export/import

"quick SDDS DSP": Digital Signal Processing

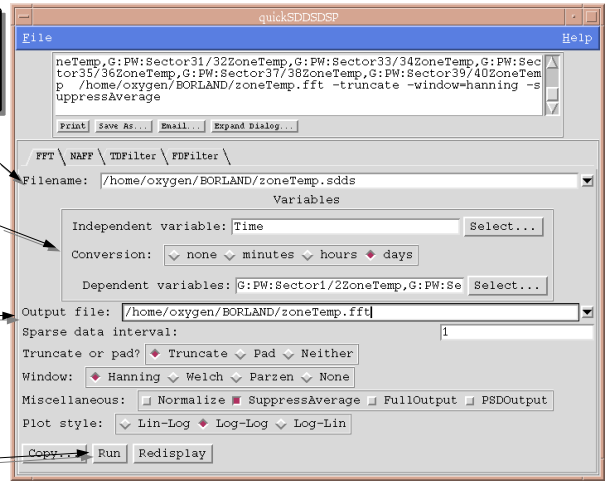
Fast Fourier Transforms

Input file preset by export application

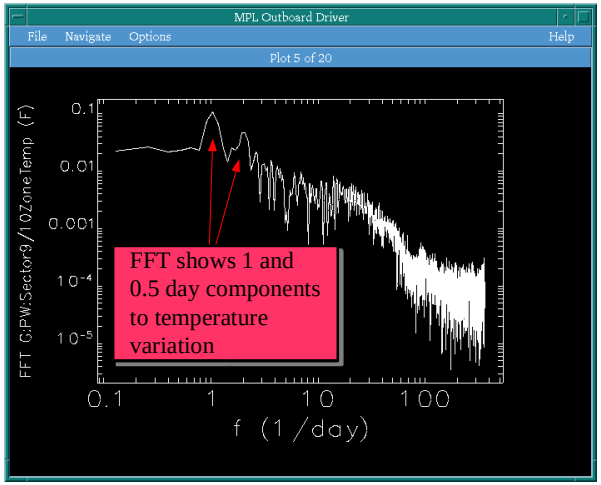
Select independent and dependent variables

Specify output file and processing parameters

Do the analysis and display results



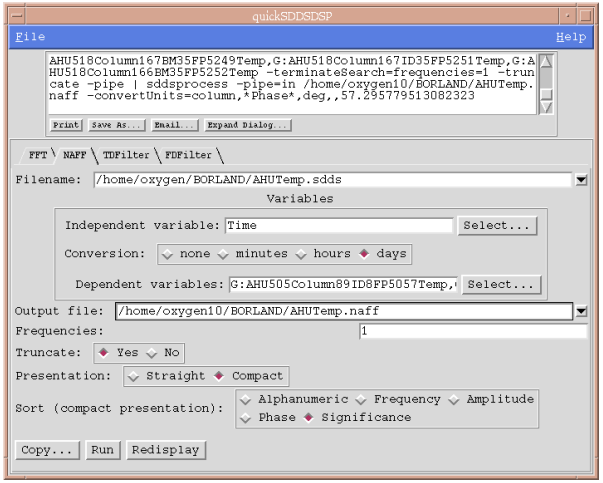
Example of FFT Results



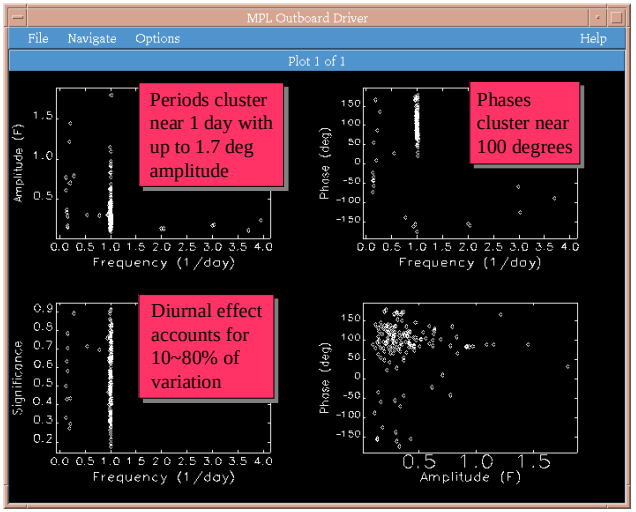
More DSP: NAFF

Numerical Analysis of Fundamental Frequencies

To make it more interesting, look at all 172 AHU temperatures for the experimental hall.



NAFF Reveals a Wealth of Information

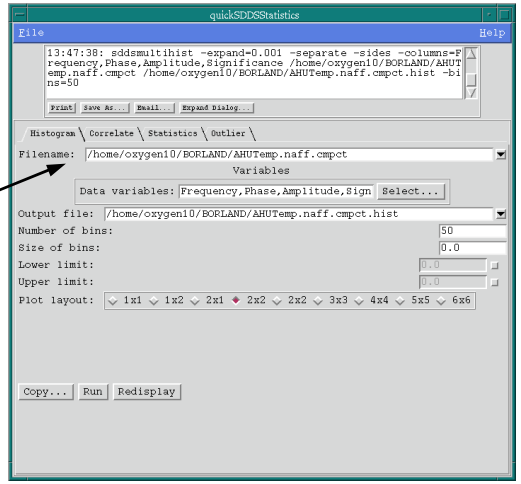


"quick SDDS Statistics"

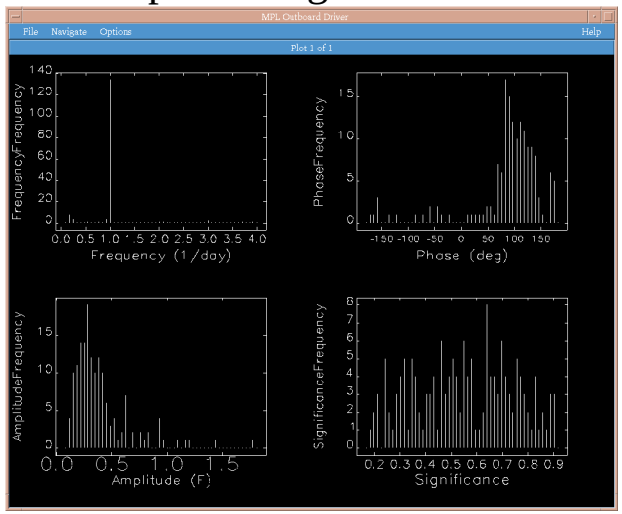
- Histograms
- Statistics computation
- Outlier analysis
- Correlation analysis

Input for histogram is the output from NAFF analysis.

The idea of using one program's output as another program's input is central to SDDS.

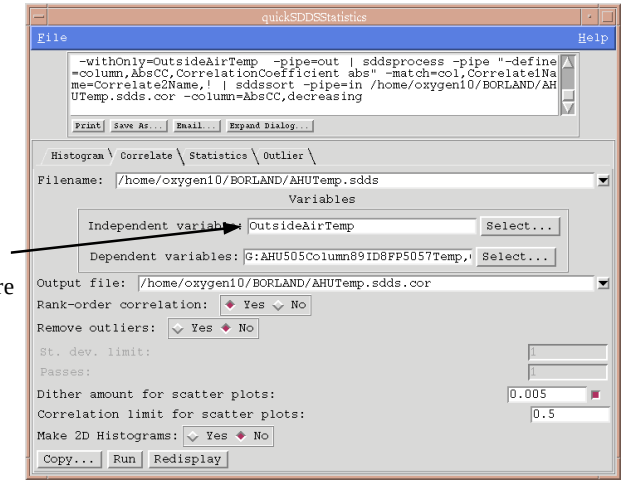


Sample Histogram Results



Searching for Correlations

Search for correlations with outside air temperature



Correlation Analysis: Experimental Hall Temps. with Outside Air Temp.

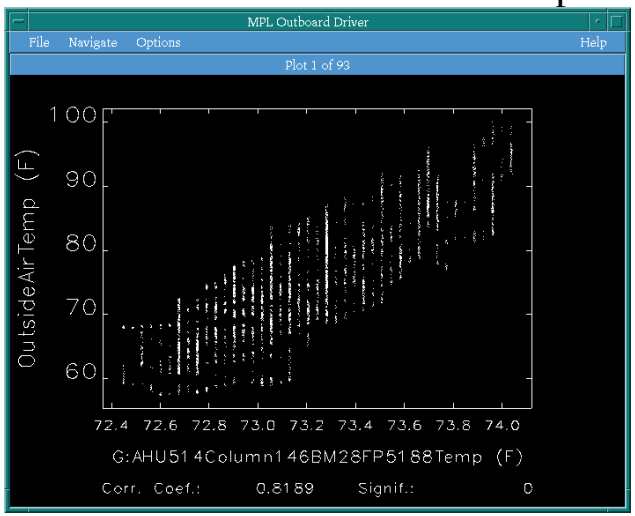
Display File: (/tmp/040811-115348-29914borland5)

Printout for SDDS file /home/oxygen10/BORLAND/AHUTemp.sdds.cor

Corr.Coef.	Corr.Signif.	CorrelatePair
0.819	0.000	G:AHU514Column146BM28FP5188Temp.OutsideAirTemp
0.805	0.000	G:AHU517Column160ID32FP5234Temp.OutsideAirTemp
0.805	0.000	G:AHU513Column139BM26FP5174Temp.OutsideAirTemp
0.795	0.000	G:AHU507Column102ID13FP5092Temp.OutsideAirTemp
0.791	0.000	G:AHU514Column142ID26FP5192Temp.OutsideAirTemp
0.777	0.000	G:AHU509Column116ID18FP5117Temp.OutsideAirTemp
0.761	0.000	G:AHU508Column110BM16FP5104Temp.OutsideAirTemp
0.761	0.000	G:AHU513Column141ID25FP5180Temp.OutsideAirTemp
0.754	0.000	G:AHU511Column128ID22FP5146Temp.OutsideAirTemp
0.752	0.000	G:AHU508Column110BM16FP5103Temp.OutsideAirTemp
0.750	0.000	G:AHU515Column152BM30FP5202Temp.OutsideAirTemp
0.745	0.000	G:AHU516Column156ID31FP5218Temp.OutsideAirTemp
0.737	0.000	G:AHU513Column140ID25FP5172Temp.OutsideAirTemp
0.735	0.000	G:AHU513Column139ID25FP5175Temp.OutsideAirTemp
0.719	0.000	G:AHU513Column140ID25FP5171Temp.OutsideAirTemp
0.717	0.000	G:AHU513Column138ID25FP5176Temp.OutsideAirTemp
0.716	0.000	G:AHU515Column152BM30FP5201Temp.OutsideAirTemp
0.714	0.000	G:AHU514Column143BM27FP5196Temp.OutsideAirTemp
0.709	0.000	G:AHU517Column160BM33FP5233Temp.OutsideAirTemp
0.705	0.000	G:AHU513Column140ID26FP5173Temp.OutsideAirTemp
0.702	0.000	G:AHU510Column119BM19FP5135Temp.OutsideAirTemp
0.702	0.000	G:AHU511Column125BM21FP5154Temp.OutsideAirTemp
0.701	0.000	G:AHU508Column106ID14FP5108Temp.OutsideAirTemp
0.693	0.000	G:AHU514Column144ID27FP5190Temp.OutsideAirTemp
0.693	0.000	G:AHU509Column113BM17FP5121Temp.OutsideAirTemp
0.691	0.000	G:AHU514Column143ID26FP5184Temp.OutsideAirTemp
0.691	0.000	G:AHU514Column144ID26FP5193Temp.OutsideAirTemp
0.687	0.000	G:AHU513Column139ID25FP5181Temp.OutsideAirTemp
0.684	0.000	G:AHU506Column98BM12FP5076Temp.OutsideAirTemp
0.682	0.000	G:AHU509Column113BM17FP5126Temp.OutsideAirTemp
0.680	0.000	G:AHU515Column150ID29FP5203Temp.OutsideAirTemp
0.676	0.000	G:AHU514Column145ID27FP5195Temp.OutsideAirTemp
0.673	0.000	G:AHU511Column128ID21FP5143Temp.OutsideAirTemp
0.658	0.000	G:AHU516Column156ID31FP5217Temp.OutsideAirTemp
0.657	0.000	G:AHU506Column96ID11FP5077Temp.OutsideAirTemp

Close | Print | Print... | Export text... | Email... | Export SDDS...

Correlation Scatter Plot Example



Statistics Computation

Example of computing a variety of statistics for AHU temperatures

quickSDDSStatistics

File Help

```
rameter,OriginalPage | sddscollect -nowarning -pipe -collect=suff
ix=Mean -collect=suffix=Median -collect=suffix=StDev -collect=suf
fix=DRange | sddssort -pipe=in /home/oxygen10/BORLAND/AHUTemp.sdd
s.stat -column=Rootname,decreasing
```

Print | Save As... | Email... | Expand Dialog...

Histogram \ Correlate \ Statistics \ Outlier \

Filename: /home/oxygen10/BORLAND/AHUTemp.sdds

Variables

Data variables: G:AHU505Column89ID8FP5057Temp, Select...

Output file: /home/oxygen10/BORLAND/AHUTemp.sdds.stat

Compute: Mean Median Standard Deviation Sigma Quartile Range Decile Range

Sort by: Name Mean Median Standard Deviation Sigma Quartile Range Decile Range

Copy... | Run | Redisplay

Statistics Results

Display File: Statistics for /home/oxygen10/BORLAND/AHUTemp.sdds (/tmp/040811-122550-409borland1)

Printout for SDDS file /home/oxygen10/BORLAND/AHUTemp.sdds.stat

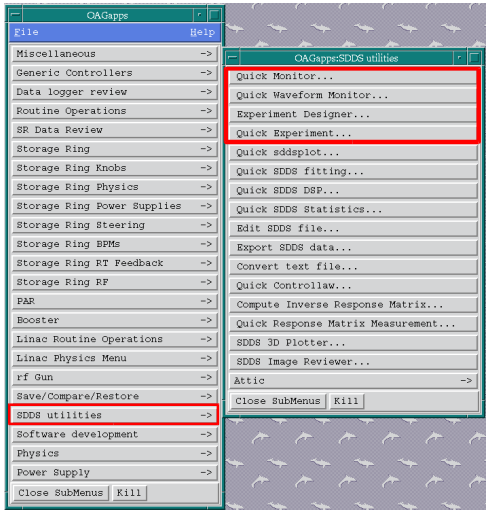
Data	Mean F	Median F	StDev F	QRange F	Units
OutsideAirTemp	74.6002	73.6877	8.66182	12.3464	F
G:AHU513Column138ID24FP5170Temp	149.361	149.083	3.15517	2.45618	F
G:AHU513Column138ID24FP5169Temp	136.968	137.142	1.87958	1.92712	F
G:AHU511Column129ID21FP5152Temp	81.1791	80.9899	1.12983	1.62488	F
G:AHU513Column140ID25FP5171Temp	71.18	71.0896	1.10392	0.642395	F
G:AHU510Column119BM19FP5140Temp	76.0424	76.3799	0.994822	1.66266	F
G:AHU510Column122ID19FP5130Temp	77.2784	77.3624	0.956028	0.869141	F
G:AHU506Column94BM11FP5080Temp	72.8692	72.6389	0.843321	1.20923	F
G:AHU506Column99ID12FP5075Temp	71.3853	71.5431	0.837735	0.982483	F
G:AHU506Column96ID10FP5081Temp	72.9772	72.7523	0.799526	1.54932	F
G:AHU505Column90ID9FP5064Temp	72.7389	72.5255	0.766343	1.05798	F
G:AHU506Column95BM11FP5079Temp	72.7368	72.6011	0.760342	1.20911	F
G:AHU505Column90ID9FP5065Temp	73.4221	73.2057	0.760193	1.09583	F
G:AHU505Column92BM10FP5061Temp	72.6179	72.4878	0.755631	1.17133	F
G:AHU513Column140ID26FP5173Temp	72.5121	72.2988	0.724488	1.02026	F
G:AHU513Column139BM26FP5174Temp	73.3495	73.3569	0.720899	1.05804	F
G:AHU507Column104BM14FP5089Temp	72.8949	72.8279	0.720211	1.02032	F
G:AHU508Column110ID15FP5102Temp	73.4295	73.2812	0.709764	1.05804	F
G:AHU505Column92BM10FP5062Temp	73.719	73.5458	0.70514	1.05811	F
G:AHU513Column140ID26FP5173Temp	72.3504	72.3744	0.704499	0.755737	F
G:AHU511Column125ID20FP5141Temp	71.4532	71.203	0.702095	0.944702	F
G:AHU511Column126ID20FP5142Temp	73.2692	73.2057	0.693935	1.20923	F
G:AHU511Column125BM21FP5149Temp	72.6193	72.5255	0.673863	0.944641	F
G:AHU514Column142ID26FP5192Temp	72.7267	72.6767	0.615539	1.13361	F
G:AHU506Column96ID11FP5078Temp	73.7232	73.5836	0.613883	0.982544	F
G:AHU509Column115BM18FP5118Temp	73.5204	73.4325	0.601155	[illegible]	[illegible]
G:AHU505Column90ID9FP5063Temp	72.3857	72.2988	0.580747	[illegible]	[illegible]
G:AHU518Column168ID35FP5244Temp	73.7625	73.5836	0.575005	[illegible]	[illegible]
G:AHU513Column138ID25FP5176Temp	72.2851	72.2988	0.56553	[illegible]	[illegible]
G:AHU513Column139ID25FP5175Temp	73.0856	73.1301	0.563497	[illegible]	[illegible]
G:AHU511Column124BM21FP5150Temp	71.9982	71.8454	0.559164	[illegible]	[illegible]
G:AHU506Column98BM12FP5076Temp	72.7235	72.6389	0.558715	[illegible]	[illegible]
G:AHU513Column140ID25FP5172Temp	71.8758	71.8076	0.55239	[illegible]	[illegible]
G:AHU513Column137BM25FP5177Temp	72.8068	72.79	0.534591	[illegible]	[illegible]
G:AHU505Column89ID8FP5057Temp	73.2572	73.1679	0.534436	[illegible]	[illegible]
G:AHU508Column108ID15FP5106Temp	72.4288	72.2988	0.52788	[illegible]	[illegible]
G:AHU513Column139ID24FP5179Temp	71.7383	71.6943	0.526587	[illegible]	[illegible]
G:AHU507Column102ID13FP5091Temp	72.9825	73.0546	0.526466	[illegible]	[illegible]
G:AHU509Column114ID17FP5119Temp	72.4345	72.3744	0.523983	[illegible]	[illegible]
G:AHU507Column102ID13FP5092Temp	71.803	71.7698	0.521031	[illegible]	[illegible]
G:AHU508Column110BM16FP5104Temp	72.9612	72.979	0.510259	0.793457	F

Context Help

Shows statistical analysis for /home/oxygen10/BORLAND/AHUTemp.sdds. The "sigma" value is the error bar for the mean. The "QRange" and "DRange" are, respectively, the quartile and decile ranges, which contain, respectively, the middle 50% and 80% of the data.

OK

Close | Print | Print... | Export text... | Email... | Export SDDS...



SDDS Utilities SubMenu (again)

"Quick" interfaces to basic SDDS capabilities

- Data collection
- Experiment execution

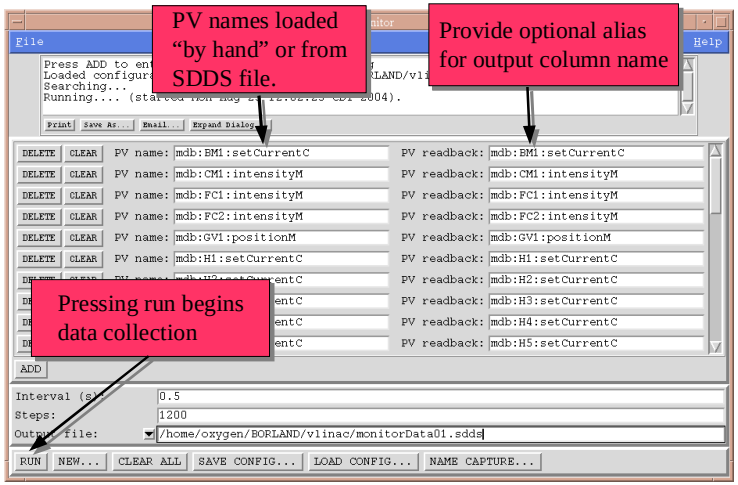
Data Collection

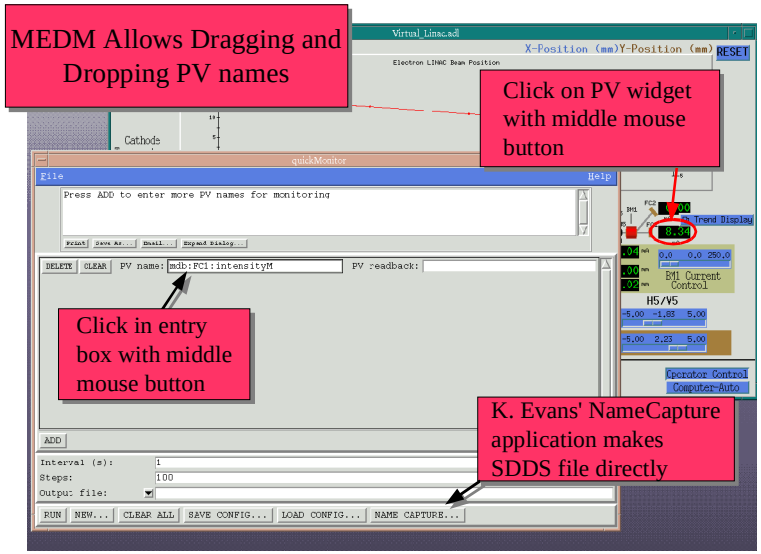
- quickMonitor
  - Interface to basic features of the program `sddsmonitor`
  - Time-interval-based data collection
- quickWaveformMonitor
  - Interface to basic features of the program `sddswmonitor`
  - Time-interval-based collection of waveforms and scalar values
- For more sophisticated applications, one can use commandline SDDS tools...

SDDS Data Collection Capabilities

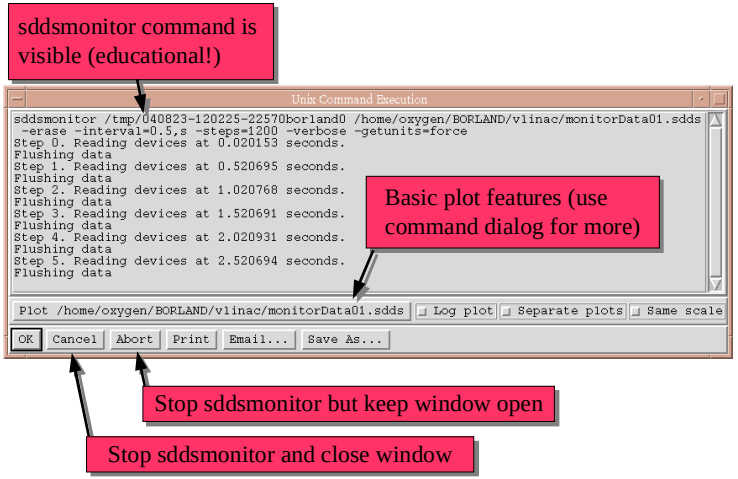
- Capabilities include
  - Time series logging of values and statistics
  - Glitch-, alarm-, or trigger-initiated logging with pre- and post-event samples
  - Synchronous and quasi-synchronous logging
  - Logging of changes to values
  - Alarm logging with related data capture
- Input files for these programs are largely identical
- All APS accelerator data logging uses these tools
- See our web site or later talks for more...

quickMonitor





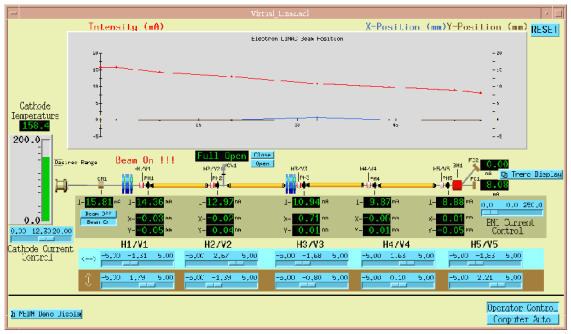
quickMonitor Run Dialog



quickMonitor or StripTool?

- StripTool is a popular EPICS client for time-series sampling
  - Convenient interface
  - Scrolling plots of the data
- Use StripTool when
  - ~5 channels or less
  - Primary interest is *seeing* the data
  - Note: StripTool can dump SDDS data
- Use quickMonitor when
  - More than ~5 channels
  - Primary interest is *analyzing* the data
  - quickSDDSplot can perform “movie” plots of updating data

Homework: Analyse the Vlinac* Simulation



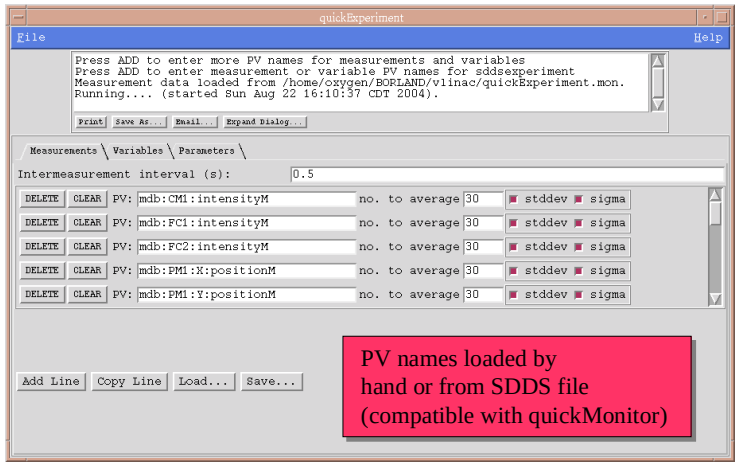
- Use quickMonitor to collect data on all PVs.
- Use quickSDDSplot to review signals: *Final current (FC1) varies with time.*
- Use quickSDDSStatistics to look for correlations with FC1: *Cathode temperature is highly correlated.*
- Use quickSDDSDSP to look for frequencies: *Clear 60s oscillations!*

*N. Arnold, ASD

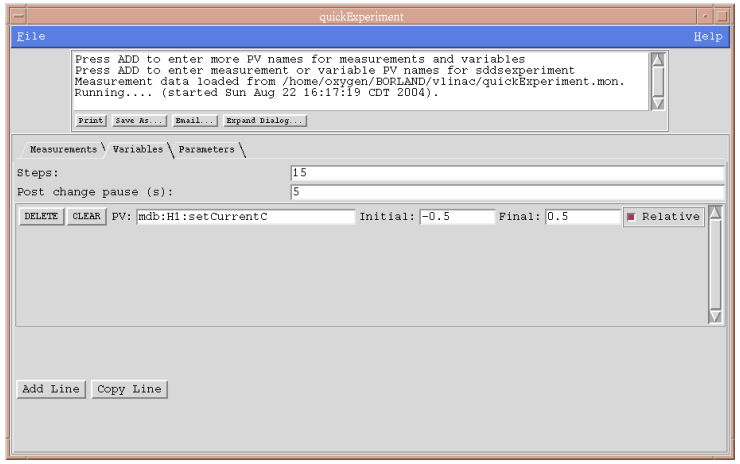
Experiment Execution: quickExperiment

- Limited interface to `sddsexperiment`
- Perform 1-D experiments with several (ganged) variables
- Measure any number of readbacks, with averaging and statistics
- `sddsexperiment` offers more
  - N-dimensional experiments
  - Verification of response of variables
  - Test limits to ensure data quality
  - Script execution

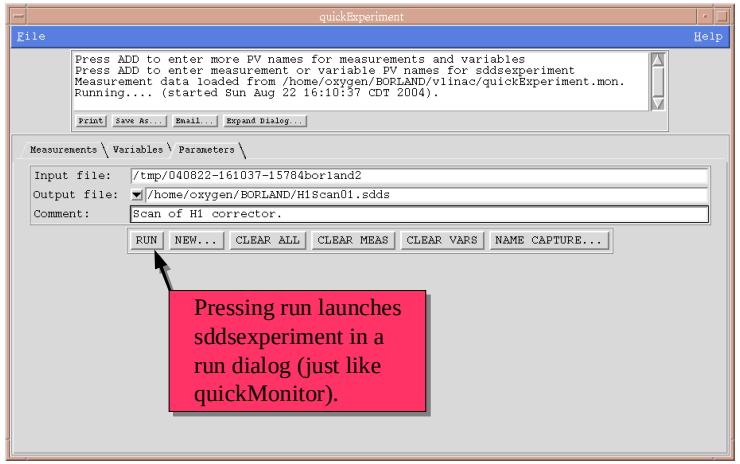
Example with Vlinac



Variables Tab

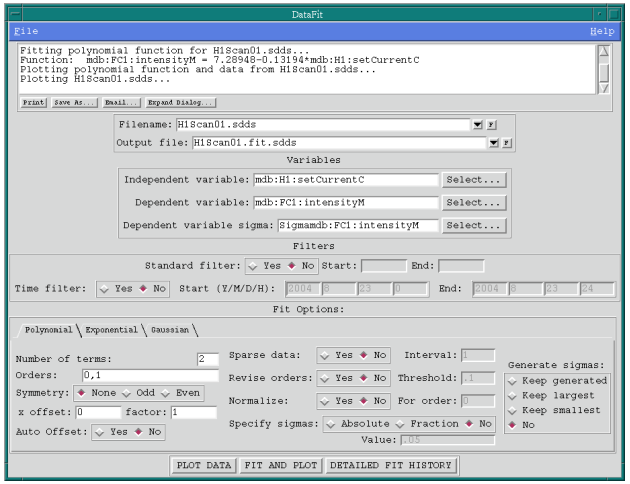


Parameters Tab

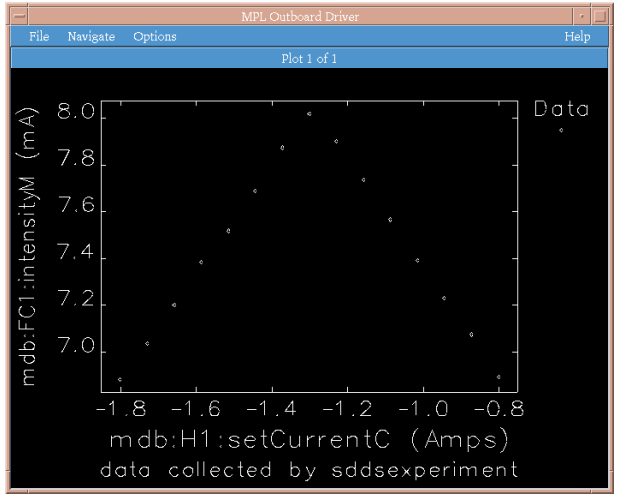


Use quickSDDSFit to Look at Results

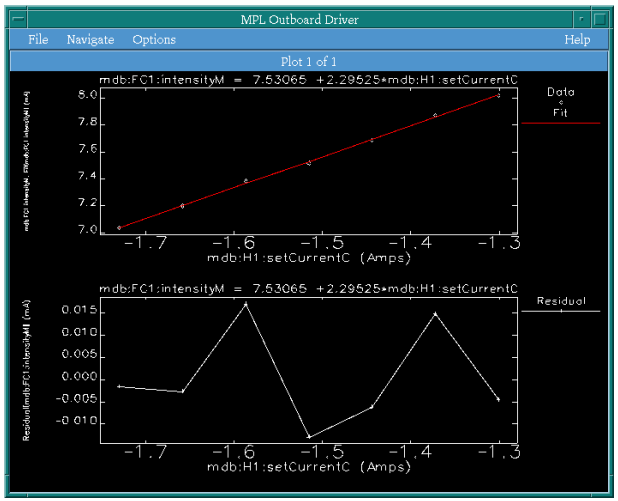
Provides polynomial, exponential, and gaussian fitting and display.



Intensity Data Is Bi-Linear



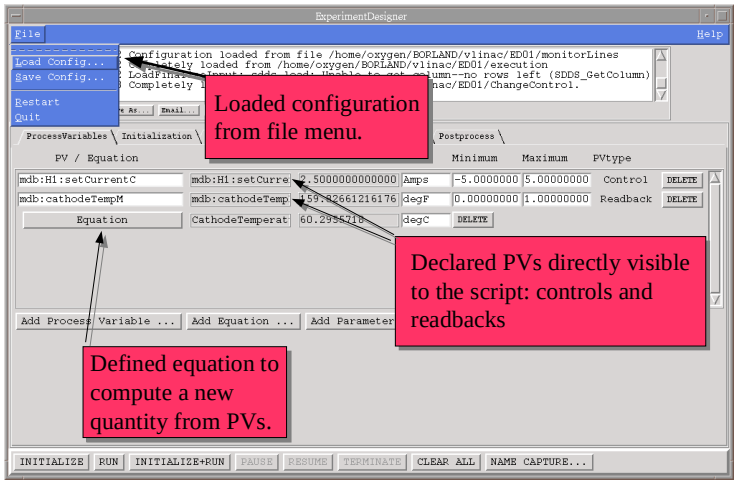
Linear Fit to One Side



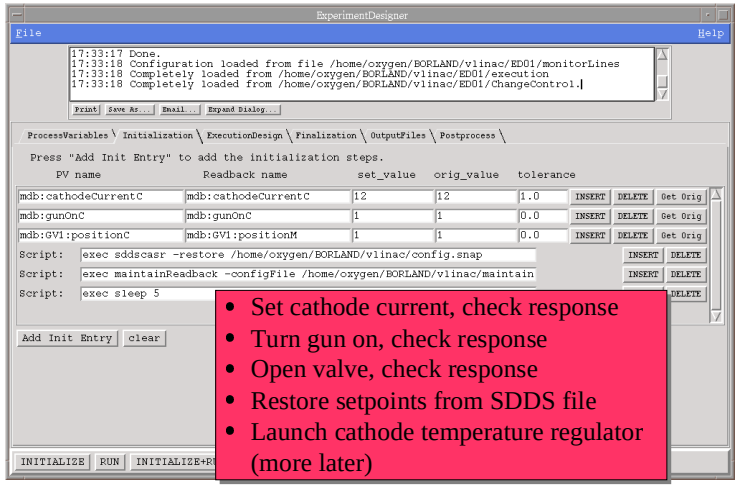
Experiment Execution: ExperimentDesigner

- Allows designing complex experiments that involve
  - Initialization
  - Execution sequence
    - User interaction
    - Coordination of external programs and scripts
  - Finalization
  - Postprocessing
- Configurations can be saved and executed as a script with no interface
  - Allows N-dimensional experiments

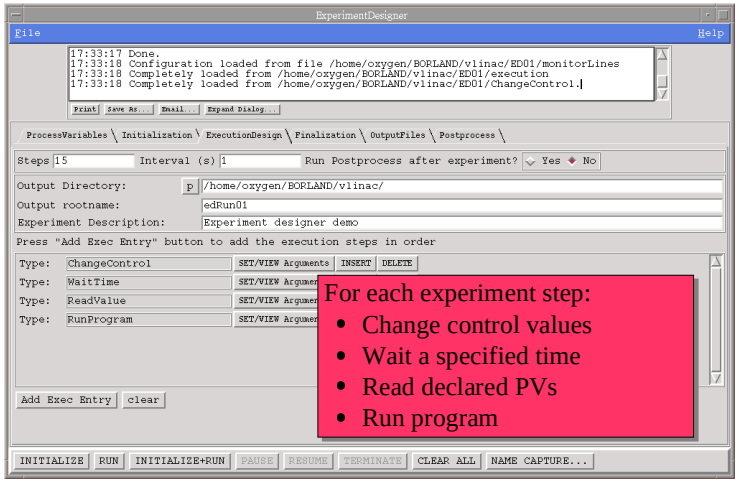
ExperimentDesigner: PV Panel



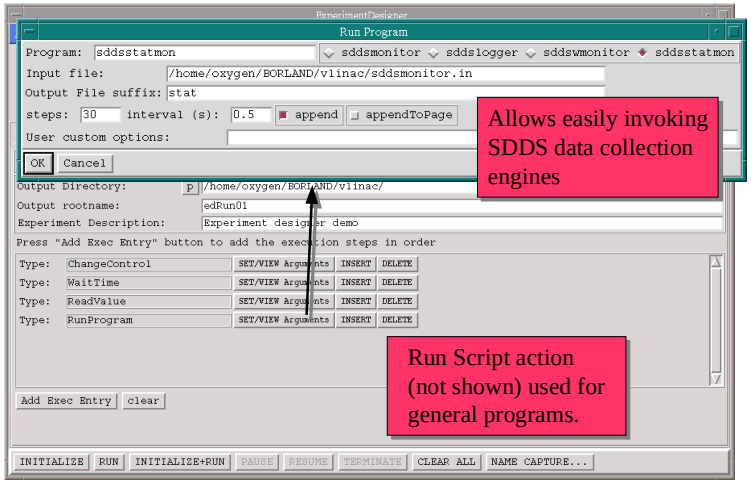
Experiment Designer: Initialization Design



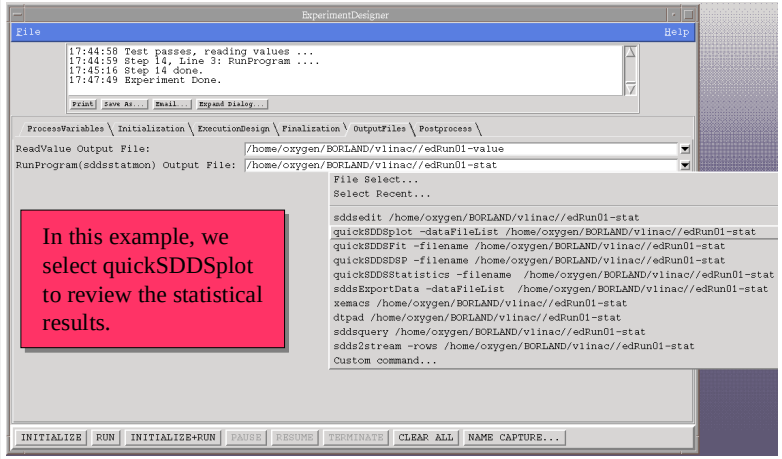
Experiment Designer: Execution Design



Experiment Designer: Run Program Dialog

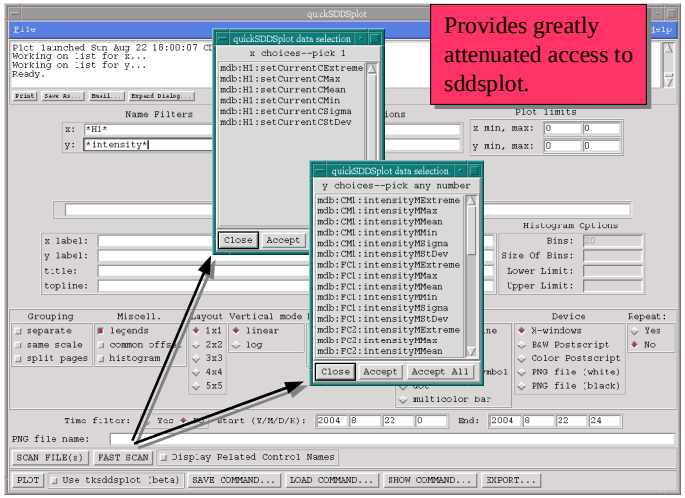


Experiment Designer: Output Files Tab



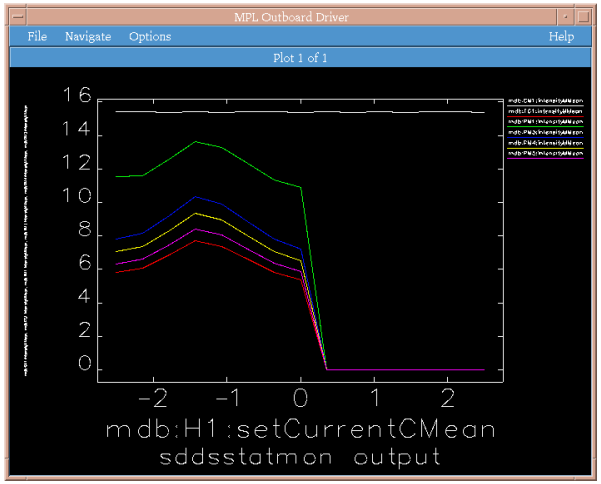
In this example, we select quickSDDSplot to review the statistical results.

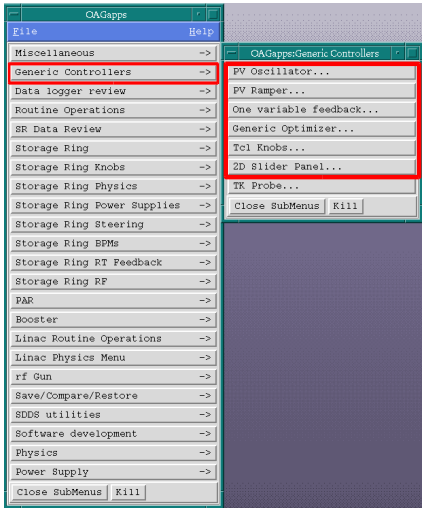
quickSDDSplot Interface



Provides greatly attenuated access to sddsplot.

quickSDDSplot Output Example





Generic Controllers SubMenu

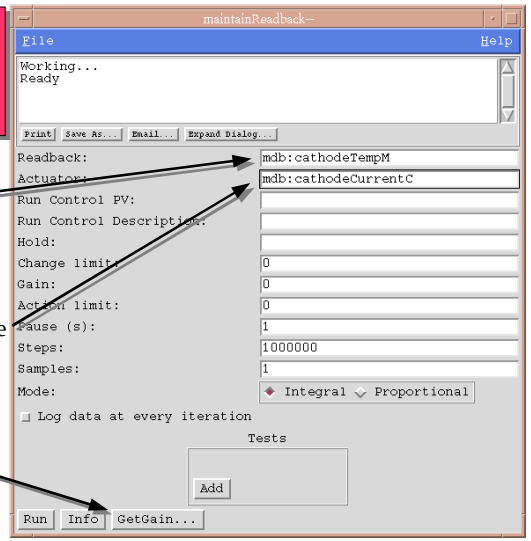
- Set up a one-readback, one-actuator feedback loop
- Set up and perform optimizations
- Change PVs in oscillatory or ramped fashion
- Set up knobs and 2D sliders

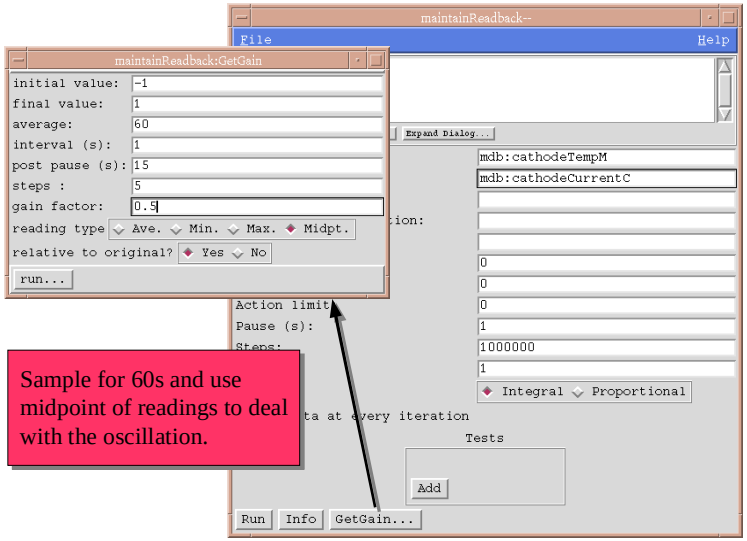
Can use the script "maintainReadback" to regulate Vlinac cathode temperature

The "readback" is the thing to be stabilized (cathode temperature)

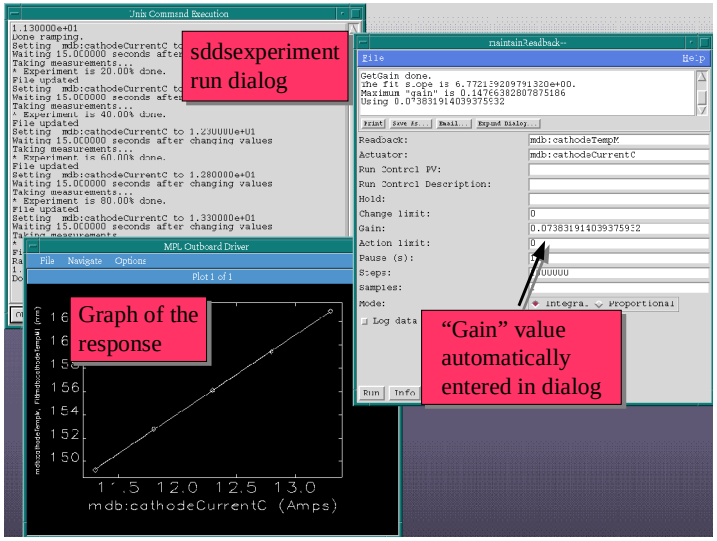
The "actuator" is the control used to stabilize the readback

Use "GetGain" button to measure response coefficient

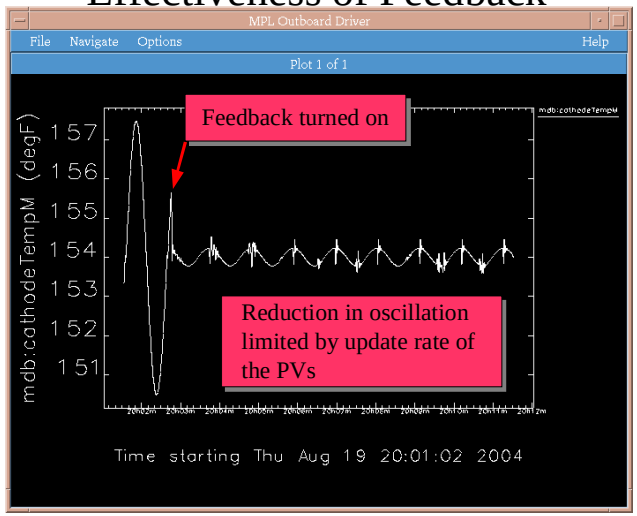




Sample for 60s and use midpoint of readings to deal with the oscillation.



Effectiveness of Feedback



Generic Optimizer*

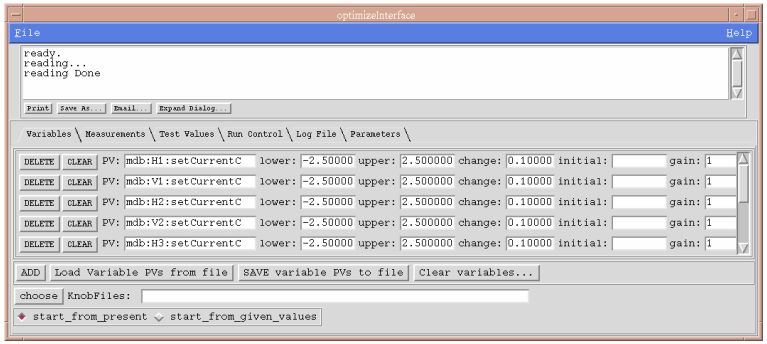
- A common requirement in control systems is optimization of some quantity
- Feedback requires quasi-linear responses measured around the desired point
- Automated optimization is useful when none of these conditions apply
  - Explores new territory
  - Has advantages over manual tweaking
  - It is relatively slow

*Inspired by J. Lewellen's “amoeba” script.

Example: Optimization of the Vlinac

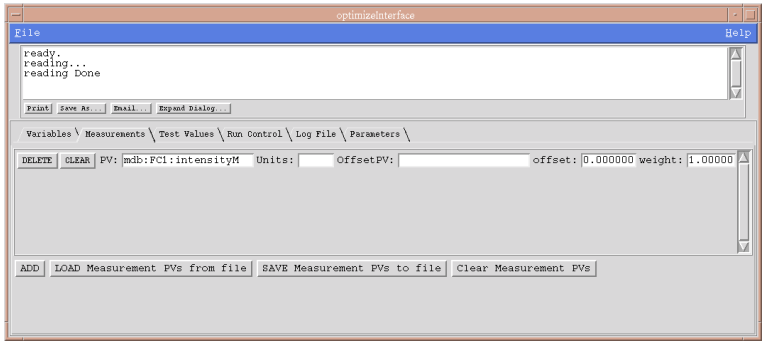
- Deliberately mis-set all the correctors in the Vlinac simulation
- Set up optimizer with
  - 10 variables: the setpoints for all the correctors
  - 1 readback: the final beam current
- Use Simplex method without initial 1D scans
- To reduce current ripple and noise effects:
  - Use maintainReadback to regulate cathode temperature
  - Average for 60 seconds

Optimizer Interface: Variables Tab



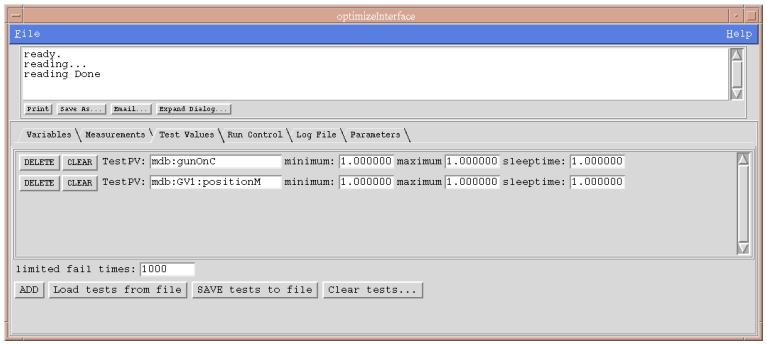
- Any number of actuators (“variables”)
- Enter limits and initial step sizes
- Provide composite knob definition files

Optimizer Interface: Measurement Tab



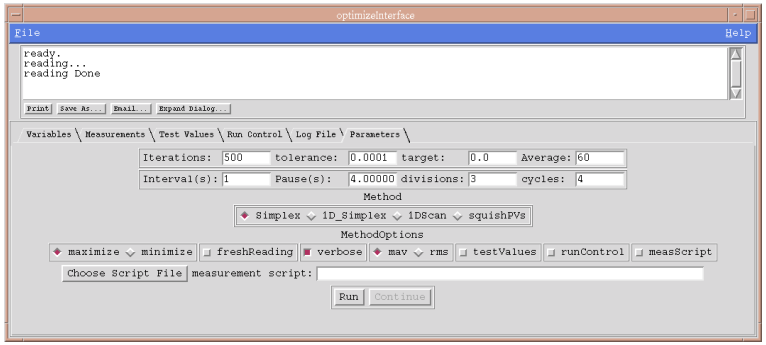
- Optimizes the mean-absolute-value (MAV) or RMS of any number of readbacks with optional offsets and weighting

Optimizer Interface: Tests Tab



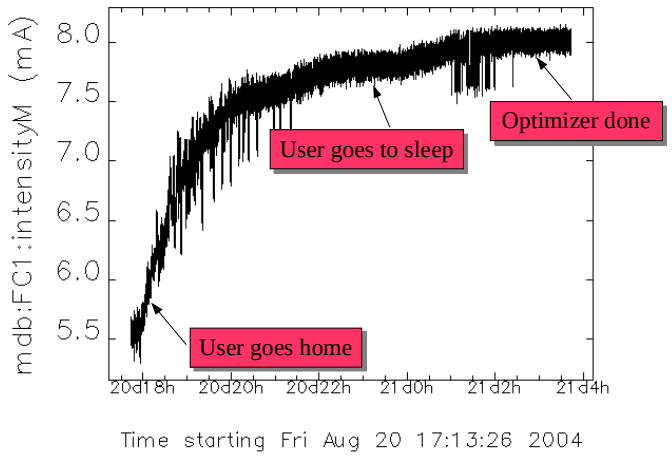
- Optional “test values” to prevent optimizer from running when conditions are not right (e.g., no beam)

Optimizer Interface: Parameters Tab



- Simplex or successive 1-D scan methods
- User-specified averaging and post-change pause
- Can optimize with user script to compute penalty function

Optimizer Result



Summary

- OAG provides a number of tools for the general EPICS user
  - Access to accelerator data logs
  - Perform data collection
  - Plot and analyze data
  - Design and execute experiments
  - Feedback and optimization
- These tools are interlinked by SDDS files
- Don't miss follow-up lectures
  - OAG Tcl/Tk (R. Soliday)
  - SDDS (M. Borland)

OAG Group Members

- Present:
  M. Borland, L. Emery, N. Sereno,
  H. Shang, R. Soliday
- Emeritus:
  D. Blachowicz, B. Dolin, K. Evans, C. Saunders