XAL – An Application Programming Framework *(Java based!)*

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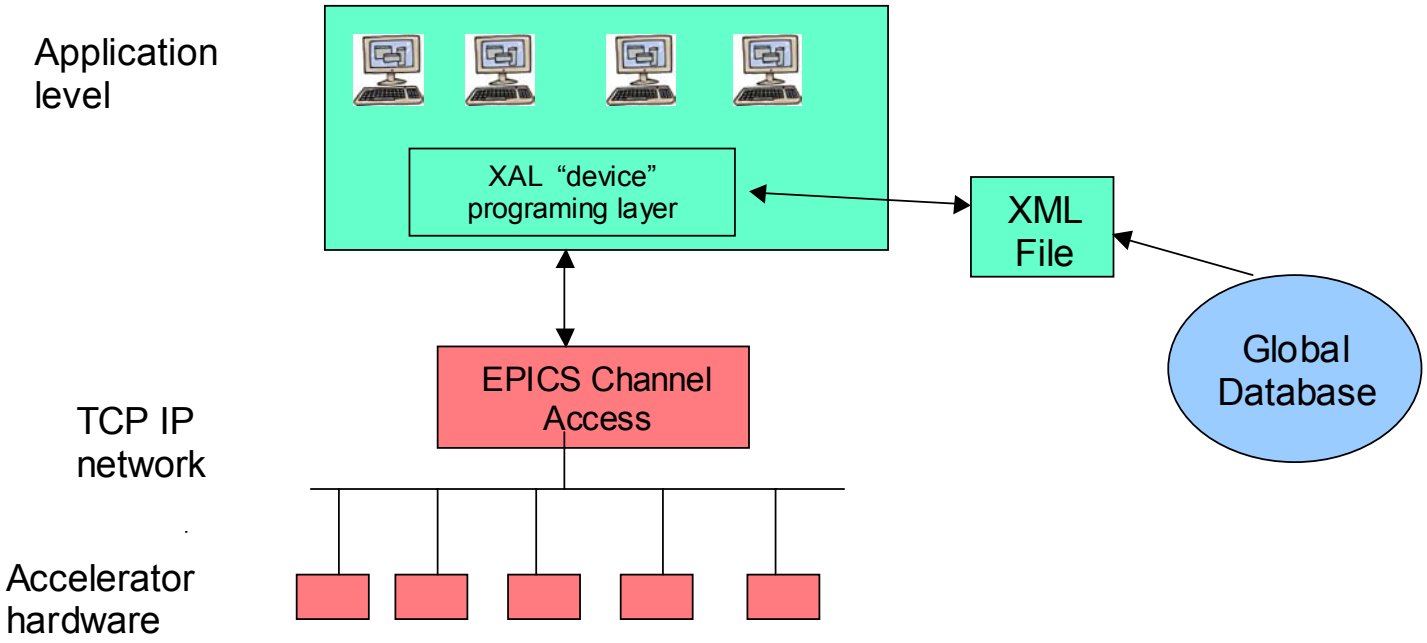
J. Galambos, C., M. Chu, W. D. Klotz, T. Pelaia, A. Shishlo (SNS, ORNL), C. K. Allen, C. McChesney (LANL), I. Kriznar, M. Plesko, A. Pucelj (Cosylab)

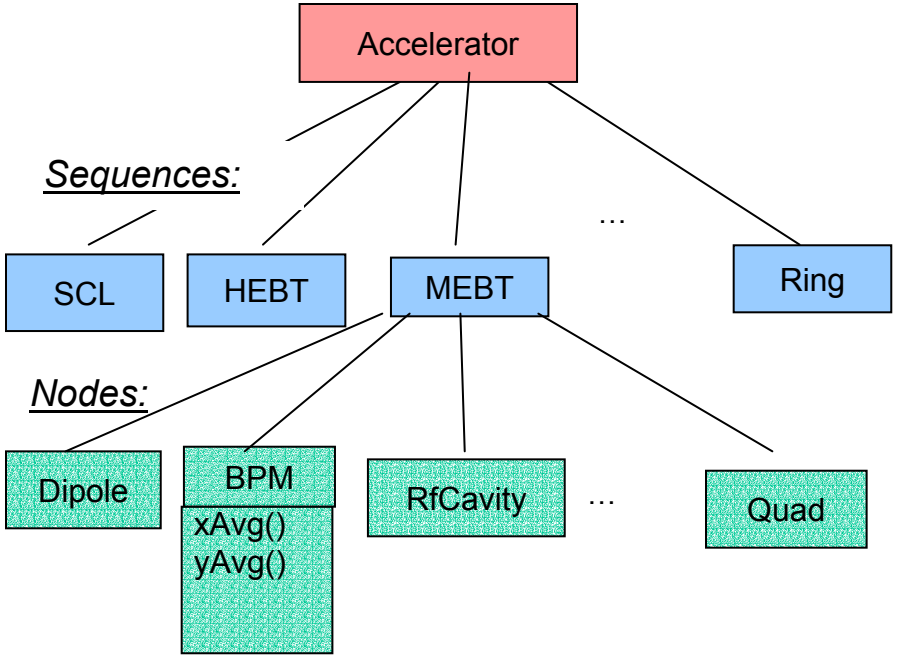
D. Attavio (BNL)

Outline

- XAL
  - Accelerator hierarchy
  - Tools
- Connections
  - EPICS Control System
  - Database
- Applications

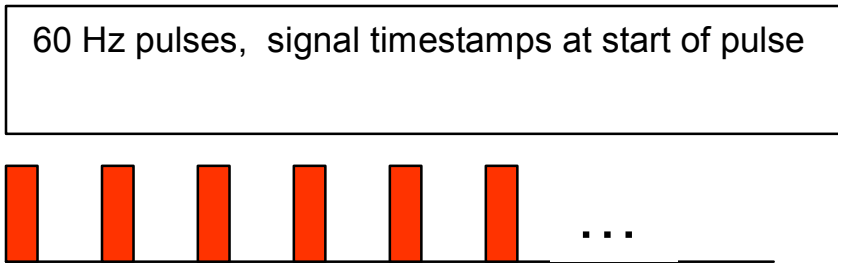


XAL Accelerator Hierarchy



- XAL is Java based
- Includes a class hierarchy describing the accelerator structure
- Methods exist to directly work with accelerator devices

Tools

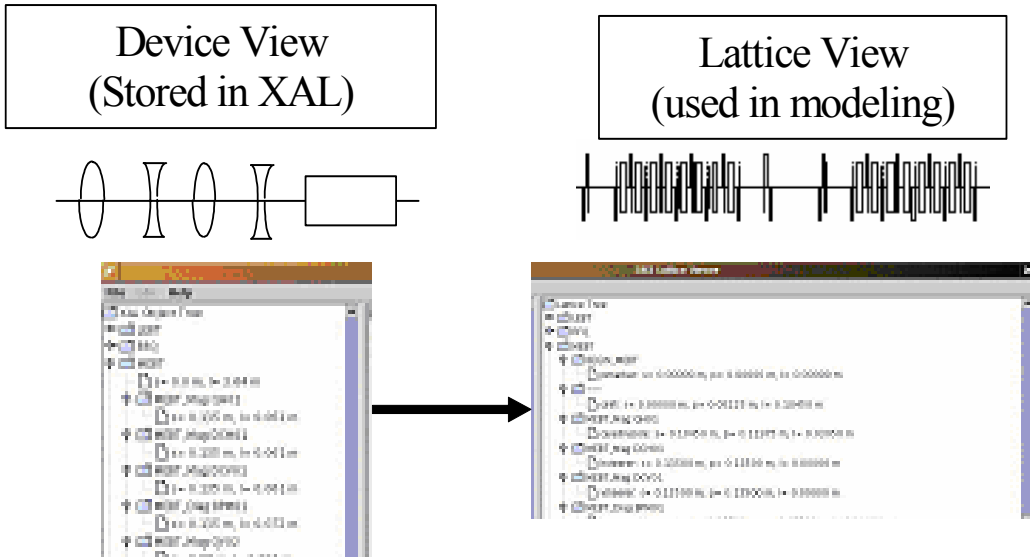


- Channel Correlator
  - SNS is a pulsed device
  - Correlator gathers sets of signals from the same pulse
  - Different modes: stream correlation sets to listeners or periodic posting
  - Can use filters (triggered data acquisition)

- DataTable
  - Provides database like functionality with easy interface
- XML DataAdaptor
  - Easy file i.o. in XML format, for any hierarchy

The Online Model (WE116: A Novel Online Simulator for High-Level Control Applications Requiring A Model Reference, C.K. Allen, et. al.)

- Calculate beam parameters based on machine settings in real time
- A lattice view of the machine is constructed from the “device” structure (via a set of rules
  - Drifts are added, elements are split
- Lattice element values can be updated from the machine, user defined values or design values
- Mostly use an envelope model for linac tracking at present



- Single entry per element

- Only physical devices

- Elements may be split

-Includes drifts

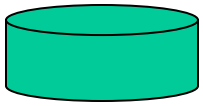
The Control System Connection

- Channel Class
  - An abstract class that provides an interface to the control system
- JcaChannel
  - A concrete class that uses the JCA interface to EPICS channel access protocol.
- Transformations: allows modification of the value of the signal coming from the control system
  - Can map one signal to > one “Channel” object, with and without the transformation
  - Facilitates quick fixes, changes to signals
    - Magnetic field calculated from current
    - BPM polarity fixes

The Database Connection (WE113: "Initial Experience with SNS Database Application", D. Purcell et. al.)

- XAL uses "Beamline Device" tables in the global SNS database
- Creates the accelerator hierarchy
- Serves as a common configuration file for all applications
- Provides the "map" from the flat list of EPICS signals to the accelerator hierarchy
- Use an intermediate XML file for XAL initialization

Database ⟶ XML configuration files



```
<node type="QH" id="MEBT_Mag:QH01" pos="0.135" len="0.061">
  <attributes>
    <align x="10000" y="2000.046" z="19546.440844" pitch="0" yaw="0" …/>
  </attributes>-
  <channelsuite name="magnetsuite">
    <channel handle="fieldSet" signal="MEBT_Mag:QH01:fieldSet" …/>
  </channelsuite>
</node>
```

•On-the-fly editing for quick across the board fixes

http://ntser3.cad.ornl.gov/mis/EnterpriseModel/modell.htm

Scripting Interface to XAL

- Scripting interfaces are available with Jython (www.jython.org) and Matlab
  - No glue code, or extra compile steps etc needed!!! Mix XAL java classes seamlessly with scripting language
- Have written simple applications, but the main use is in providing simple code examples
- http://www.sns.gov/APGroup/appProg/xal/scripts/jythonScripts.html

Jython

```
# read the accelerator
#acc_xml = "file:/home/jdg/xaldev/xal_xmls/sns.xml"
acc_xml = "file:./sns.xml"
acc = XmlDataSource.parseUrlAt(acc_xml, 0)

# get the some primary sequences from the accelerator

mebt = acc.getSequence("MEBT")
dtl1 = acc.getSequence("DTL1")
dtl2 = acc.getSequence("DTL2")

print " There are ", mebt.getAllNodes().size(), "nodes in the
sequence", mebt.getId()
```

MatLab

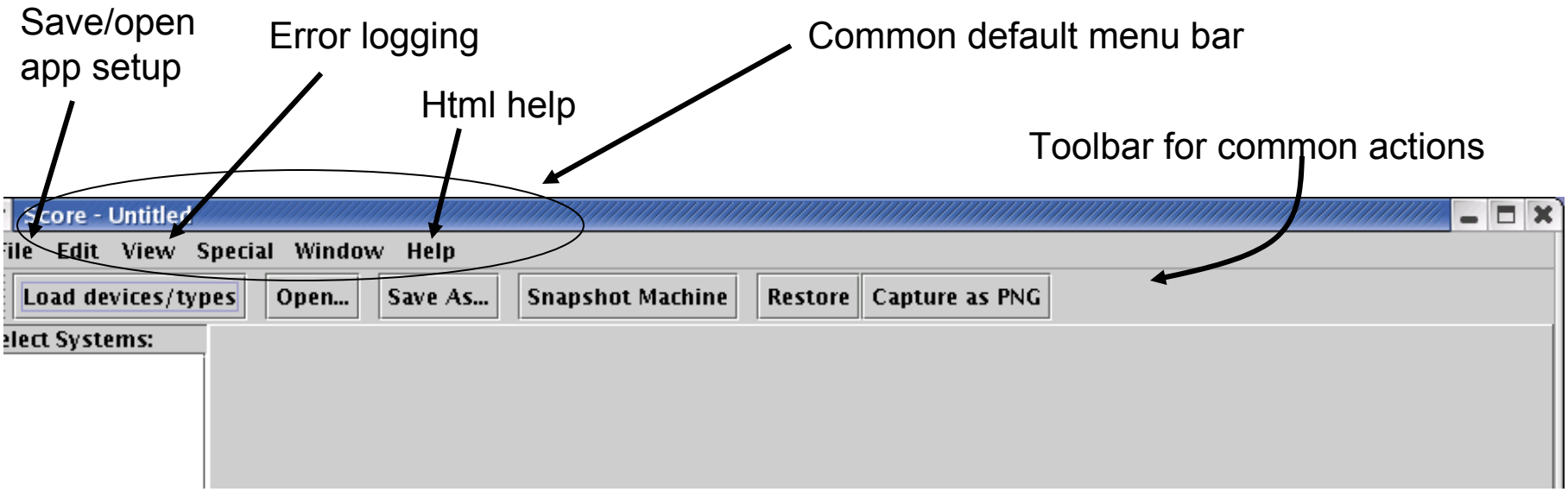
```
%  scan the first quad
% monitor beam positions in the last MEBT BPM

for i =1:10
      fld(i) = field;
            quad.setField(field);
            va_chan.putVal(1); %  for virtual accelerator
            pause(1); %  for virtual accelerator
            xpos(i) = bpm.getXAvg;
            ypos(i) = bpm.getYAvg;
            field = field * 1.015; % increment field value
end

% Plot results
plot(fld, ypos)
```

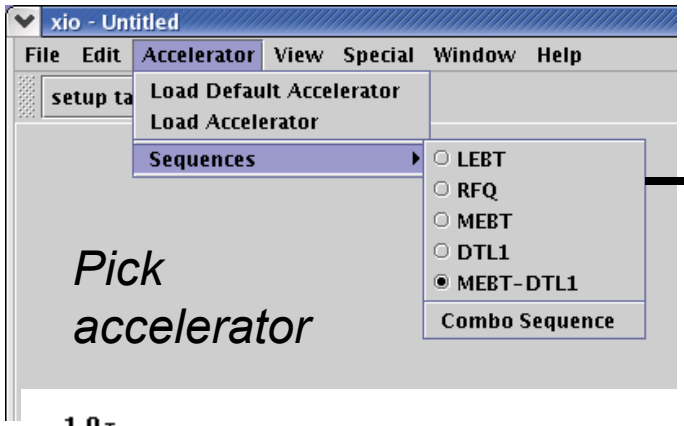
Application Programming Framework

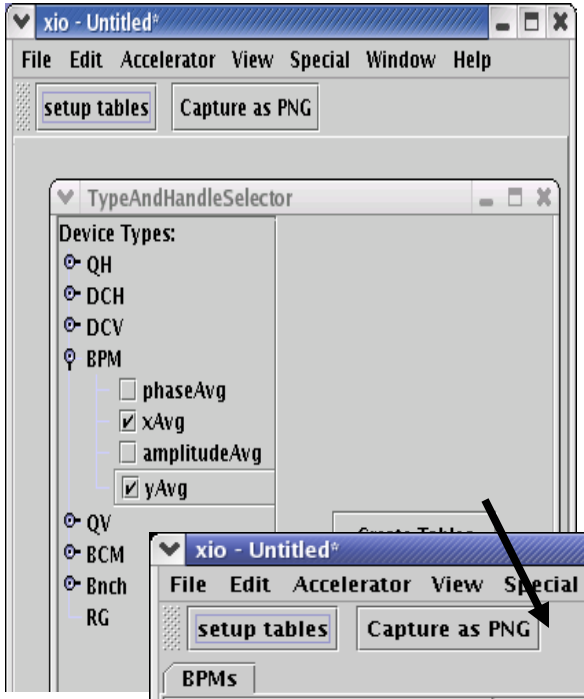
- An Application Framework is developed and used as a common starting point for application programs
  - Provides a common look feel for all apps
  - Quick jump-start for application development
  - Easy retro-fixes across many apps
  - Use familiar “windows” app look & feel
  - Uses a document paradigm



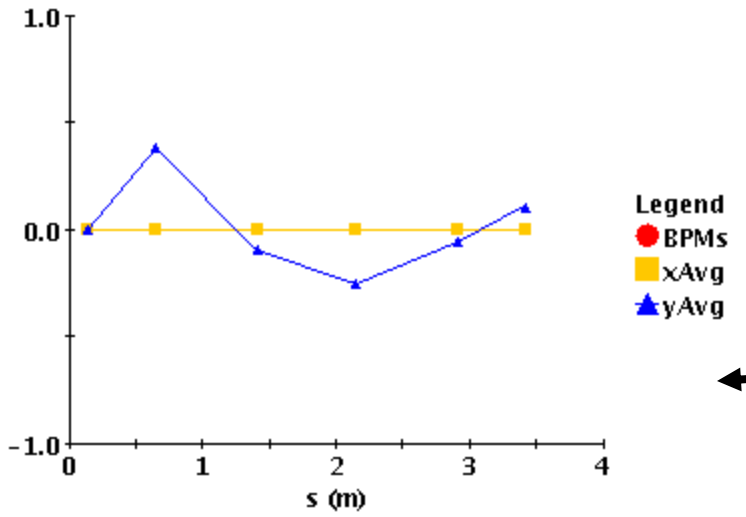
Xio Application

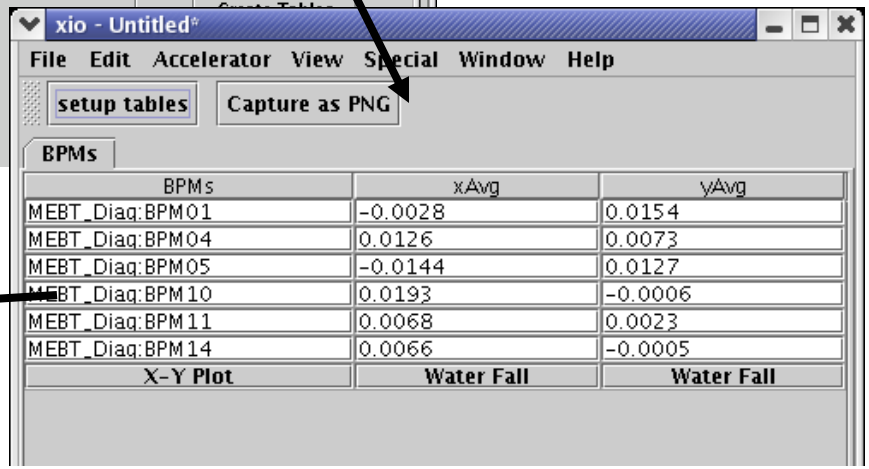
- General purpose value displayer (tables, and or plots)
- Browser the accelerator hierarchy to select what you are interested in





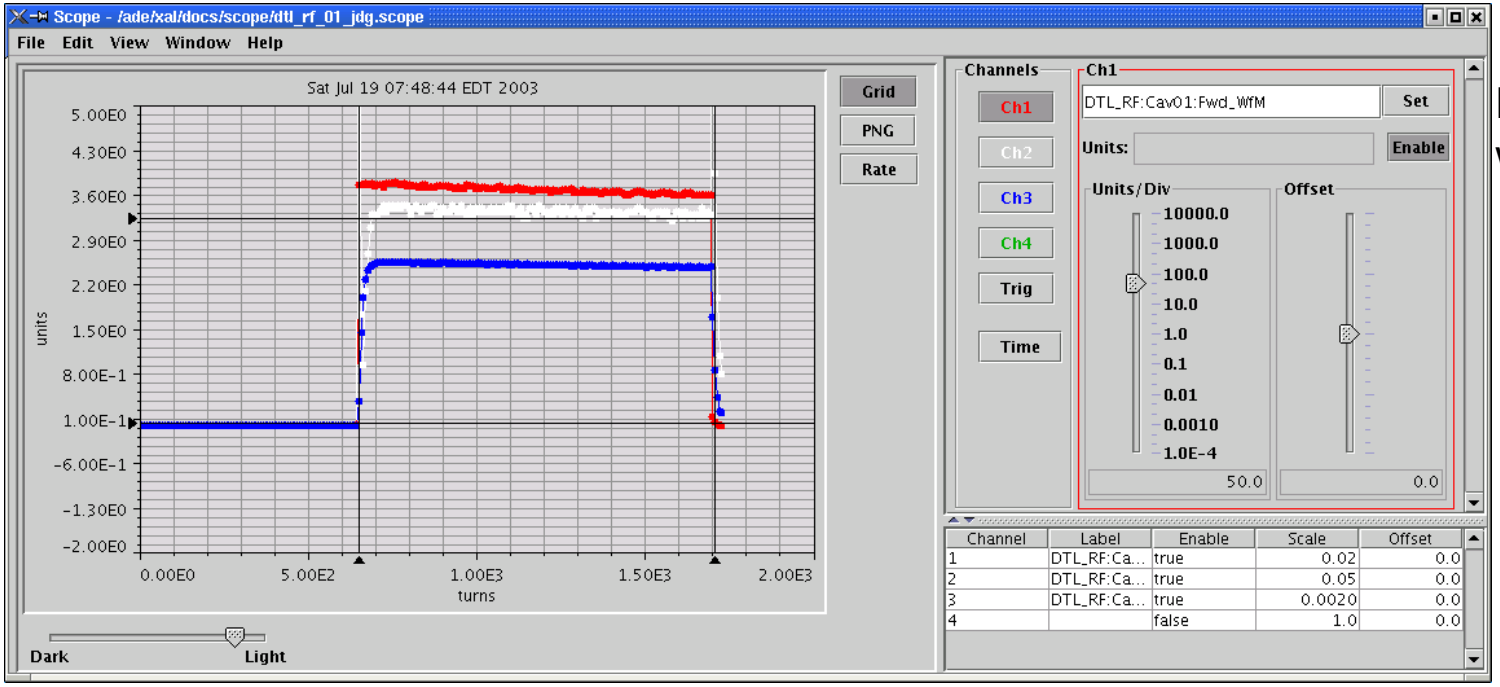
Pick device + signal types





Scope Application

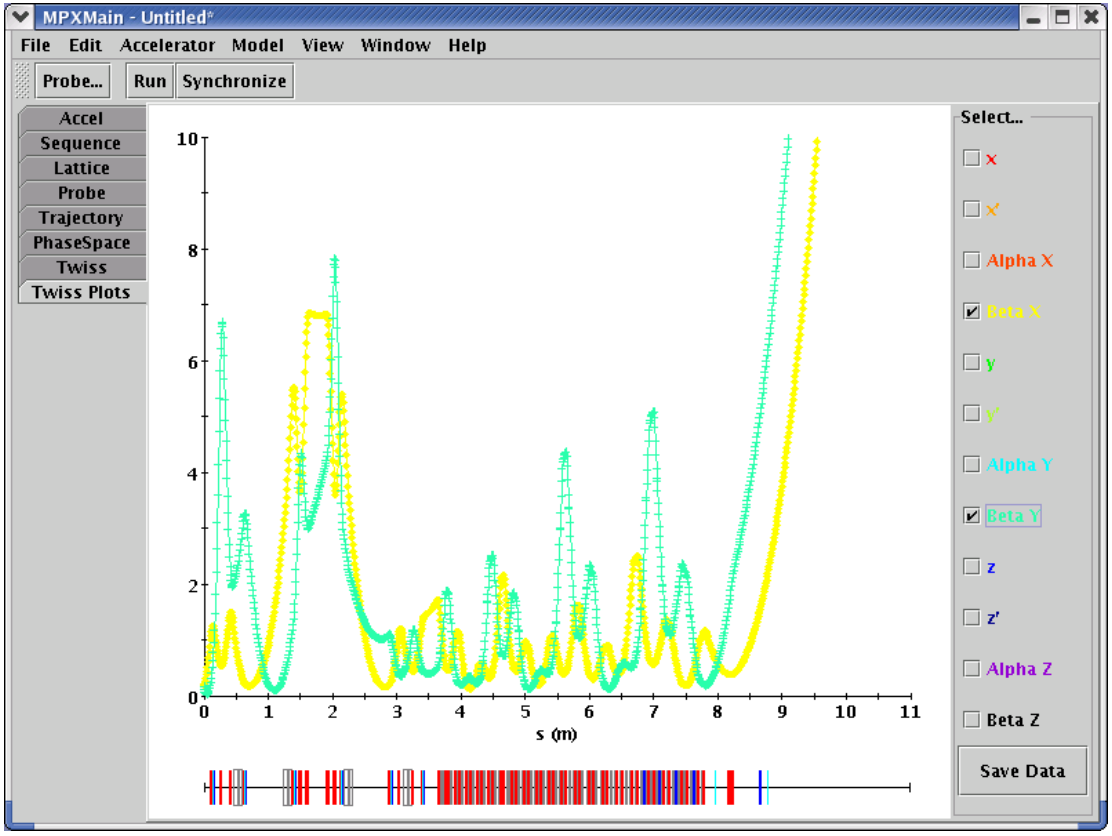
- A Digital Oscilloscope – with a similar user interface as analog scopes
- Displays array waveforms vs. time (NOT vs arbitrary units)
- Uses the time correlator, has built-in math capability, triggered data acquisition+ many other features
- Will use this for comparing waveforms from RF, diagnostics, etc.
- Requires input from signal providers describing how the array information is packaged, and offset from the cycle start



DTL1 RF waveforms

Online Model

- An online model is now available within the XAL framework
- Online model can be run for 1) live values, 2) design values and 3) user defined what-if changes
- Can display or dump beam Twiss output

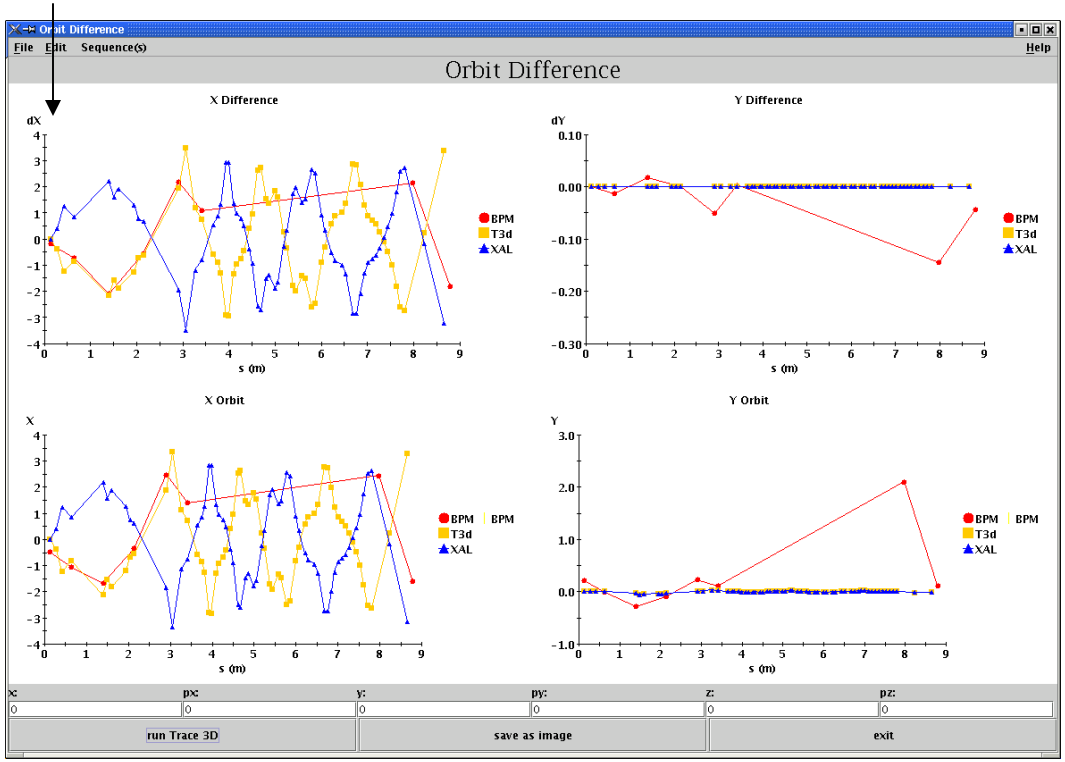


•Vertical and horizontal beta functions through the MEBT, DTL + D-plate for design values

OrbitDifference Application

- Compares differences in beam orbits, for both BPMs and calculated
- Online model is also used in the Orbit Difference Application, in addition to running Trace 3D (external fortran code)

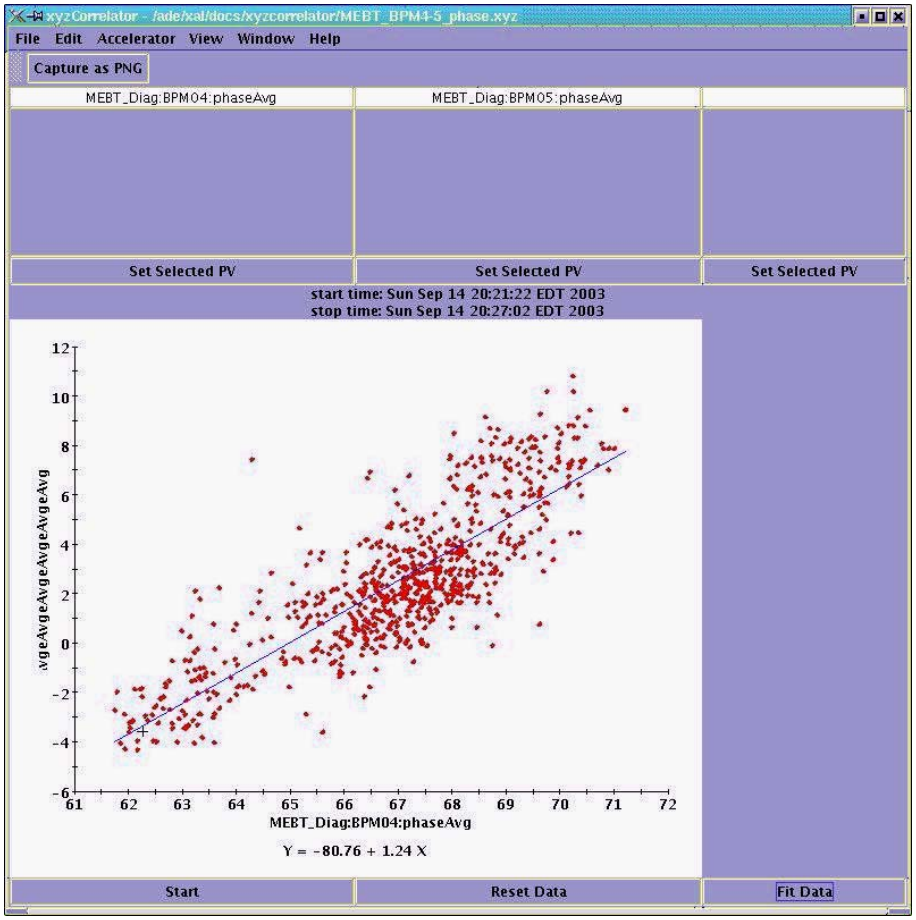
Kick applied here



- Orbit difference example using the online model
- Used to observe orbit difference in the horizontal direction
- Helped resolve sign issue in BPMs

XYZ Correlator Application

- Pick 2 (or three) signals and monitor them together
- Uses the time correlator to ensure signals are from the same pulse
- Can export or fit the acquired data

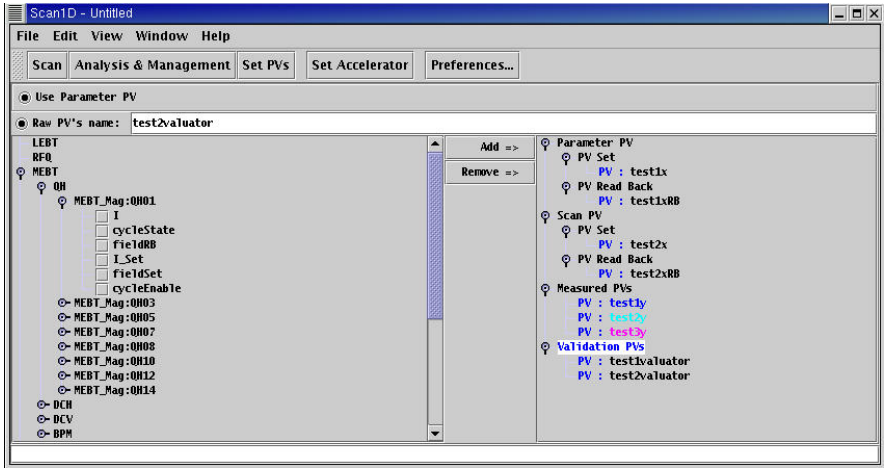


Correlation between phase measurements of 2 BPMs

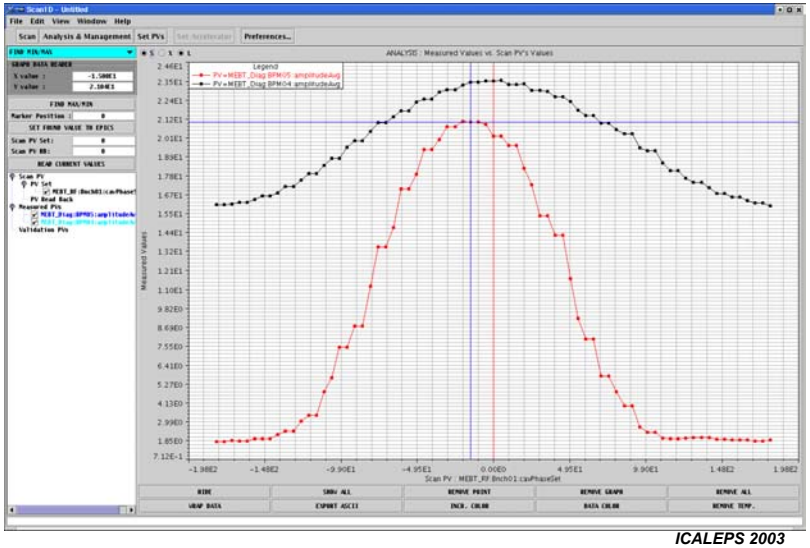
1-D Scan Application

- Provides an easy way to scan one quantity and monitor another
- Can average over pulses, scan multiple times, pause
- Analysis includes fitting, intersection finding, min/max, etc.
- Easy way to do a quick unanticipated experiment

•Can select scan or readback signals from pull down Accelerator hierarchy

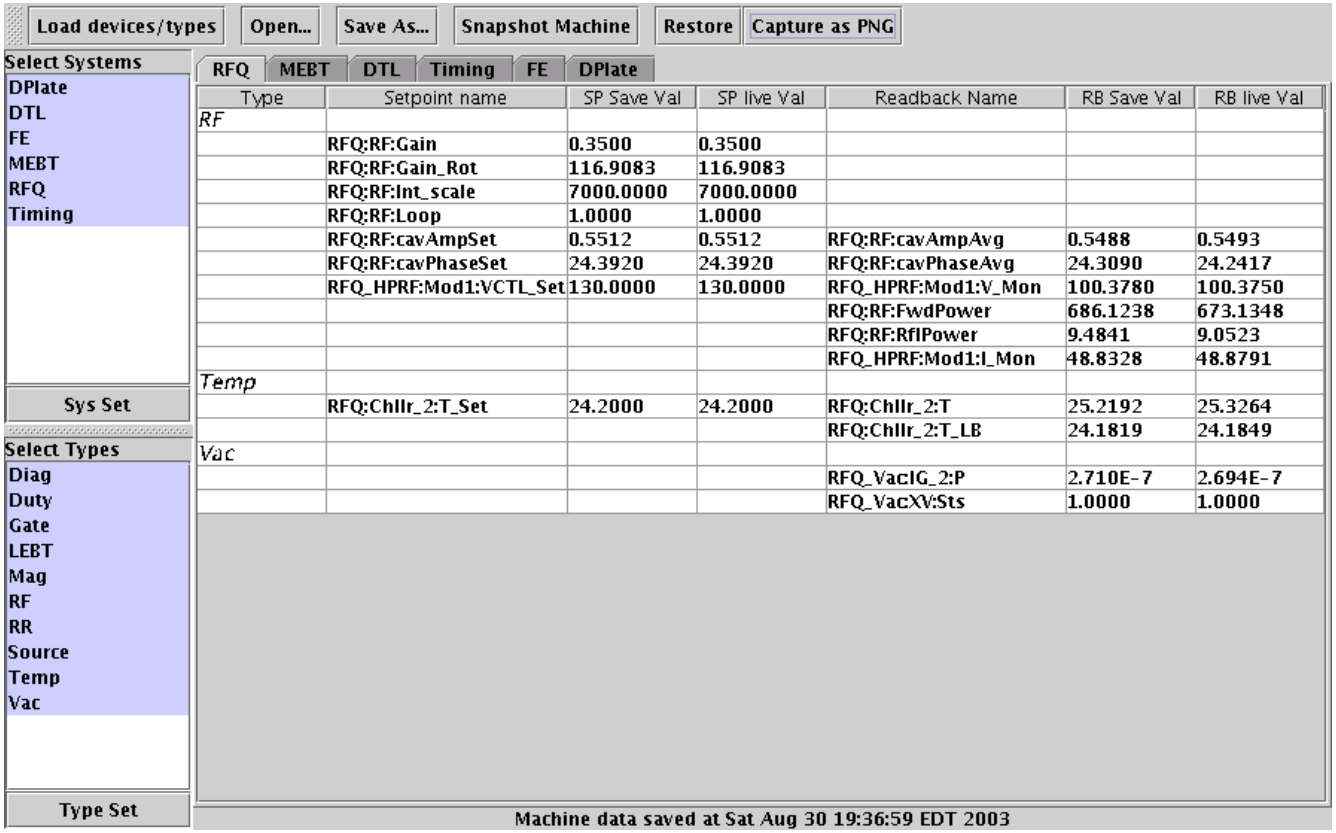


•BPM amplitude vs. MEBT RF phase setting



Save-Compare-Restore (Score) Application

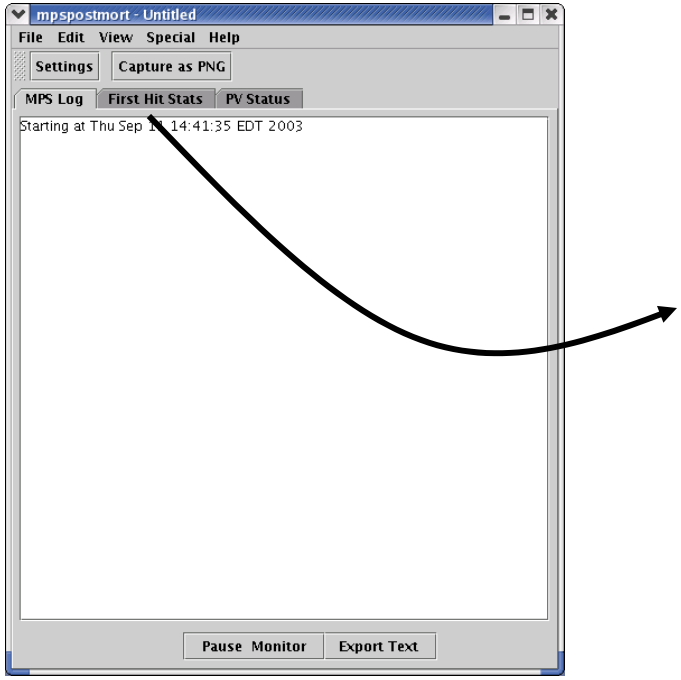
- Provides a means to capture machine setup, compare live values to a saved set, and to restore values to a saved set
  - Grabs settable + readback signals
- Can sort by system and device type
  - Uses DataTable classes for querying

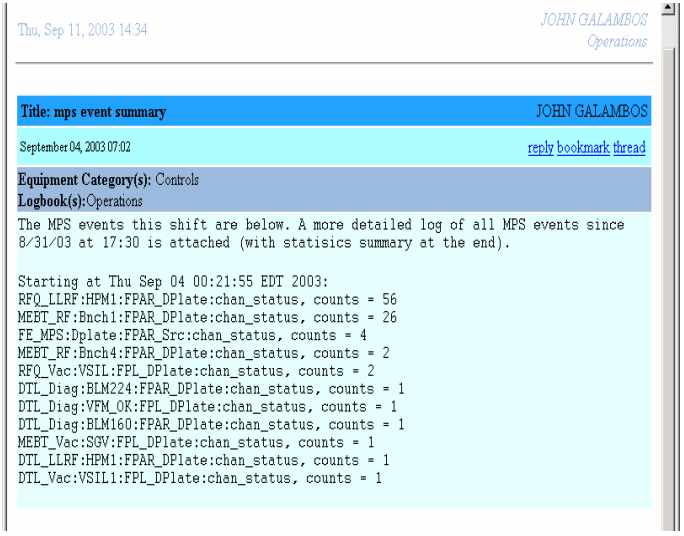


Type	Setpoint name	SP Save Val	SP live Val	Readback Name	RB Save Val	RB live Val
RF						
	RFQ:RF:Gain	0.3500	0.3500			
	RFQ:RF:Gain_Rot	116.9083	116.9083			
	RFQ:RF:Int_scale	7000.0000	7000.0000			
	RFQ:RF:Loop	1.0000	1.0000			
	RFQ:RF:cavAmpSet	0.5512	0.5512	RFQ:RF:cavAmpAvg	0.5488	0.5493
	RFQ:RF:cavPhaseSet	24.3920	24.3920	RFQ:RF:cavPhaseAvg	24.3090	24.2417
	RFQ_HPRF:Mod1:VCTL_Set	130.0000	130.0000	RFQ_HPRF:Mod1:V_Mon	100.3780	100.3750
				RFQ:RF:FwdPower	686.1238	673.1348
				RFQ:RF:RflPower	9.4841	9.0523
				RFQ_HPRF:Mod1:I_Mon	48.8328	48.8791
Temp						
	RFQ:Chllr_2:T_Set	24.2000	24.2000	RFQ:Chllr_2:T	25.2192	25.3264
				RFQ:Chllr_2:T_LB	24.1819	24.1849
Vac						
				RFQ_VacIG_2:P	2.710E-7	2.694E-7
				RFQ_VacXV:Sts	1.0000	1.0000

Machine Protection System (MPS) Post-mortem Application

- Captures MPS events, and sorts the signals in order of occurrence – i.e. determines the root cause of a trip (uses correlator)
- Logs mps events
- Provides statistics





Summary

- XAL is a Java based hierarchal framework SNS is using to write high level applications
- Uses a database to initialize the hierarchy
- Applications are written and being used in the initial SNS commissioning