

Migrating to Phoebus

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Motivation



Great at the time:

- Build Setup
- Module System
- Preferences
- Extensibility
- Graphics... but there are now (better) alternatives

But...

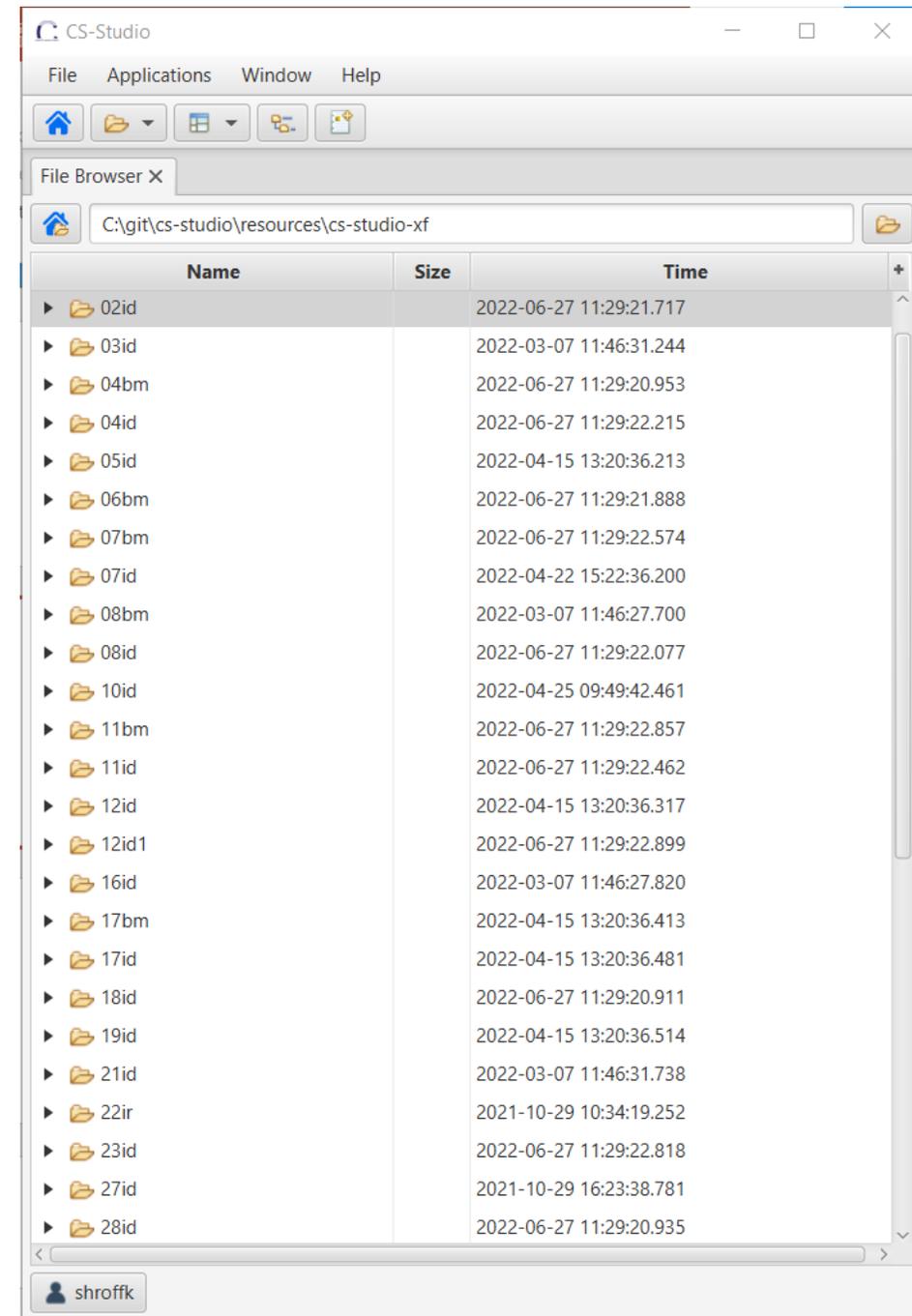
- Awkward layout constraints for control system user interface
- “Workspace” that’s different from the file system
- Odd menu entries that we don’t need
- Performance and Reliability Issues

Phoebus

- Better look and feel
- Better performance
- Lesser code
- JavaFX greatly facilitates the MVC design pattern

CS-Studio & Phoebus at NSLS2

- Different products packaged for different use cases
CS-Studio (for accl) → phoebus-accl
CS-Studio (for beamlines) → phoebus-beamlines
- Both CS-Studio and Phoebus are installed on all workstations
>> *run-css*
>> *run-phoebus*
- OPI screens are organized into 2 repo
cs-studio-accl (~10k .opi & .plt)
cs-studio-xf (~20k .opi & .plt)



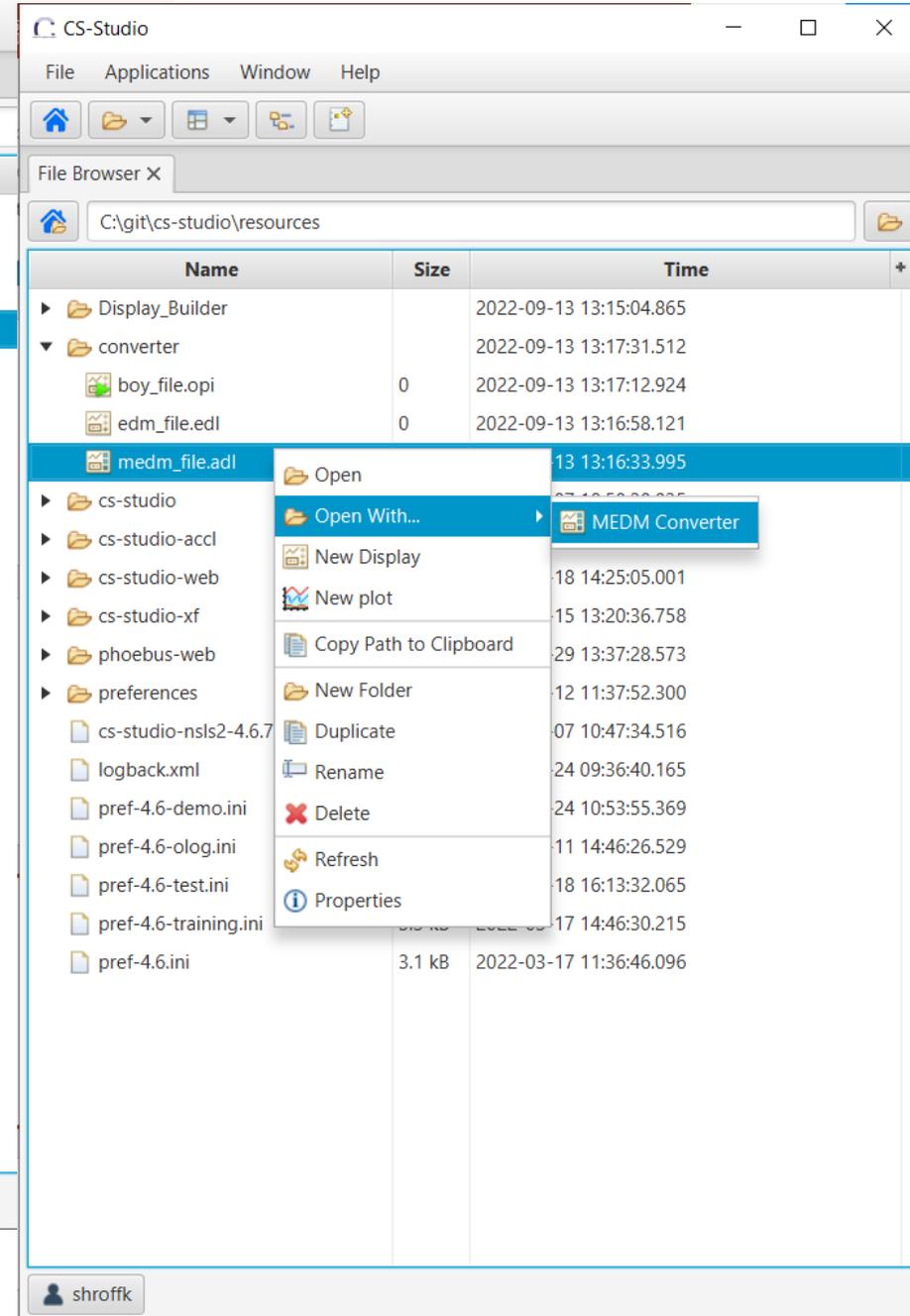
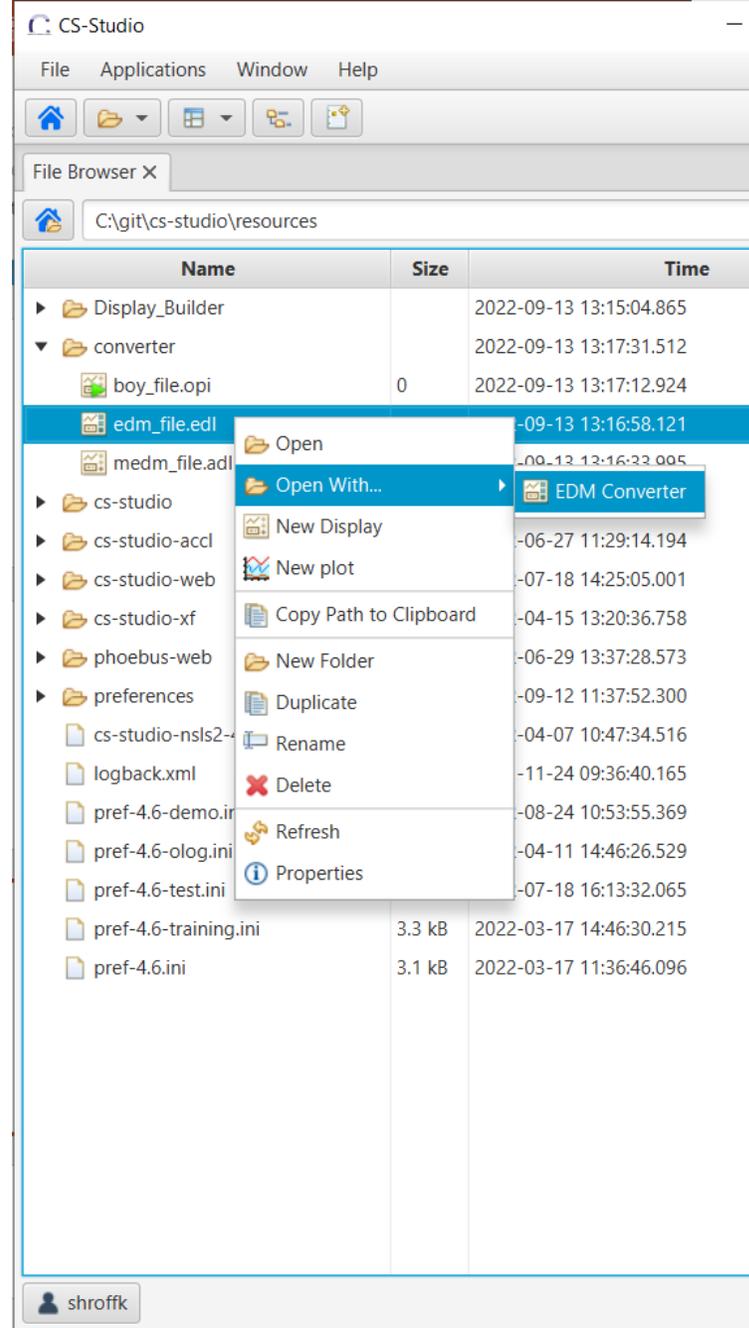
Auto converters

The display builder can read existing BOY .opi displays

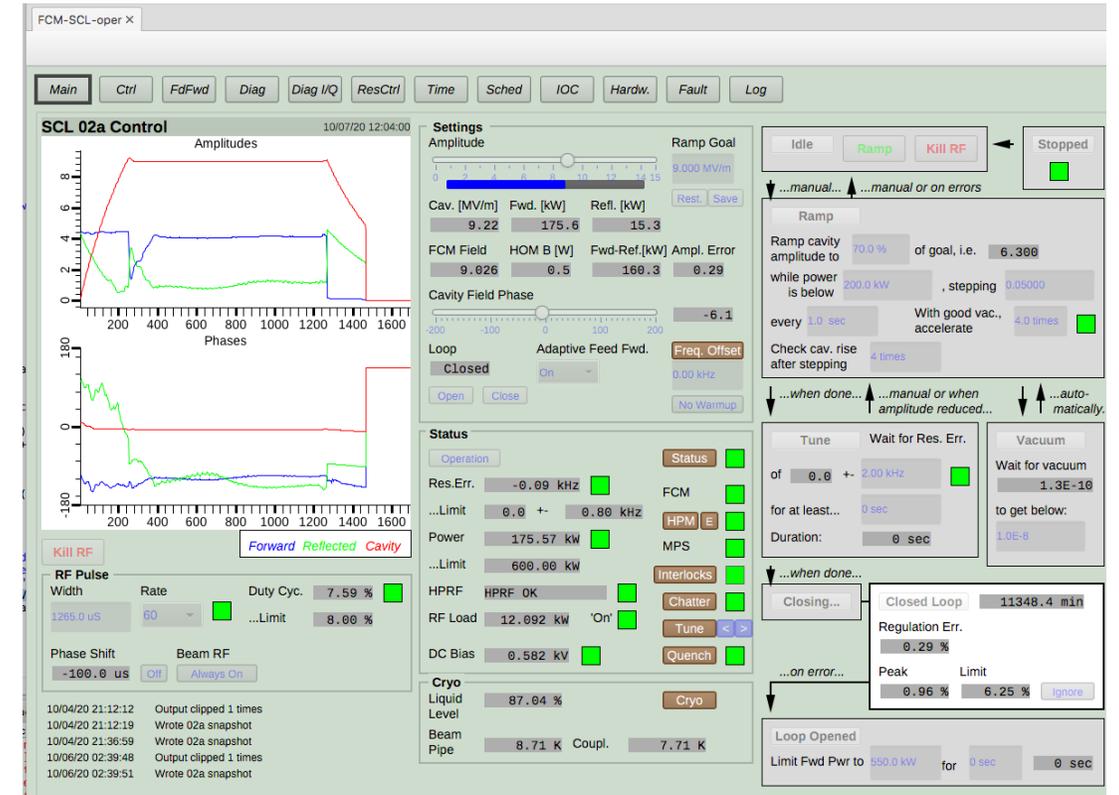
The display builder also supports converters for

MEDM: .adl → .bob

EDM: .edl → .bob



EDM screens converted on runtime



BOY screens converted at runtime

The screenshot shows the NSLS-II Main Launch Screen in a CS-Studio window. The interface is organized into several sections:

- Header:** NSLS-II NATIONAL SYNCHROTRON LIGHT SOURCE II logo.
- Main Title:** Main Launch Screen.
- Operations Section (Green Header):**
 - Buttons: Launch Apps, Remote Access (Permitted, Permitted), Emergency Off (Red).
 - Grid of sub-systems: Linac (LN-OP, Linac Status, Startup/Shutdown), LTB (LTB-OP, LTB Status, Top-Off, Launcher), Booster (BR-OP, Booster Status, Startup/Shutdown), BTS (BTS-OP, BTS Status, BR Operation), Storage Ring (SR-OP, SR Status, Op Status mini, 12-hr SR History), Global (Operations Tools, TV Displays, Op Center(s), Plot Launcher).
- Sub-Systems Section (Green Header):**
 - Environmental: 1 Wire System, Smoke Alarms, Building Utilities, Magnet 1 Wire.
 - Machine Timing: Timing.
 - Beam Diagnostics: diag checkout, BPM, Diag Status, Cell Controller.
 - Vacuum: Vacuum System, All Accel Vacuum, Ring Press. Display.
 - Magnets: Booster PS, Injector PS, Storage Ring PS, PS Viewer.
 - Insertion Devices: ID Launcher, ID&FE Main, Active Interlock.
 - RF: Summary, Frequency, LLRF, HLRF, E Source.
 - Controls: IOC Status, VME Crates, APC PDU, cPCI crates, UPS Detail List.
 - PPS: Area Monitoring, PPS, TOSS.
 - EPS: Gun Trig Permit, PS_Interlock, BR EPS, Magnet Lights, SR EPS.
 - Water Skids: Water Overview, Injector Skids, Injector Skid Plots, SR-RF Skid, SR-AI Skids.
 - Beamlines/Frontends: Beamlines, FE Slits/BPMs, Shutter Status.

The screenshot shows the NSLS-II Main Launch Screen in a CS-Studio window (Phoebus). The interface is organized into several sections:

- Header:** NSLS-II NATIONAL SYNCHROTRON LIGHT SOURCE II logo.
- Main Title:** Main Launch Screen.
- Operations Section (Green Header):**
 - Buttons: Launch Apps (dropdown), Remote Access (Permitted, Permitted), Emergency Off (Red).
 - Grid of sub-systems: Linac (LN-OP, Linac Status, Startup/Shutdown), LTB (LTB-OP, LTB Status, Top-Off, Launcher), Booster (BR-OP, Booster Status, Startup/Shutdown), BTS (BTS-OP, BTS Status, BR Operation), Storage Ring (SR-OP, SR Status, Op Status mini, 12-hr SR History), Global (Operations Tools, TV Displays, Op Center(s), Plot Launcher).
- Sub-Systems Section (Green Header):**
 - Environmental: 1 Wire System, Smoke Alarms, Building Utilities, Magnet 1 Wire.
 - Machine Timing: Timing (dropdown).
 - Beam Diagnostics: diag checkout, BPM (dropdown), Diag Status (dropdown), Cell Controller.
 - Vacuum: Vacuum System, All Accel Vacuum, Ring Press.
 - Magnets: Booster PS (dropdown), Injector PS (dropdown), Storage Ring PS, PS Viewer.
 - Insertion Devices: ID Launcher, ID&FE Main, Active Interlock.
 - RF: Summary (dropdown), Frequency (dropdown), LLRF (dropdown), HLRF (dropdown).
 - Controls: IOC Status (dropdown), VME Crates, APC PDU (dropdown), cPCI crates.
 - PPS: Area Monitoring, PPS (dropdown), TOSS (dropdown).
 - EPS: Gun Trig Permit, PS_Interlock (dropdown), BR EPS (dropdown), Magnet Lights.
 - Water Skids: Water Overview, Injector Skids, Injector Skid Plots, SR-RF Skid.
 - Beamlines/Frontends: Beamlines, FE Slits/BPMs, Shutter Status.

6BM Main 06BM utilities 08-BM PPS 06bm_mirrors.opi

100%

nsls-II
NATIONAL SYNCHROTRON LIGHT SOURCE II

06BM ES: Mirrors

Mirror 2 (TFM) MC04

Mir:M2 - JACK 1, YL	-5.8583 mm	-5.8586 mm	<	0.0000 mm	>	STOP	More	Disconnected
Mir:M2 - JACK 2, YL	-2.6382 mm	-2.6382 mm	<	0.0000 mm	>	STOP	More	
Mir:M2 - JACK 3, YL	-2.6384 mm	-2.6384 mm	<	0.0000 mm	>	STOP	More	
Mir:M2 - LATERAL 1	0.0017 mm	0.0005 mm	<	0.0000 mm	>	STOP	More	
Mir:M2 - LATERAL 2	-0.0001 mm	-0.0005 mm	<	0.0000 mm	>	STOP	More	
Mir:M2 - Bender, Be	212225.0 step	212225.0 step	<		>			

Mirror 3 (HRM) MC05

Mir:M3 - JACK 1, YL	-9.3333 mm	-9.3334 mm	<		>		
Mir:M3 - JACK 2, YL	-11.6676 mm	-11.6676 mm	<		>		
Mir:M3 - JACK 3, YL	-11.6680 mm	-11.6680 mm	<		>		
Mir:M3 - LATERAL 1	-8.0000 mm	-8.0001 mm	<		>		
Mir:M3 - LATERAL 2	-8.0000 mm	-8.0001 mm	<		>		

6BM Main /opt/css/opi/production/cs-studio-xf/06bm/es/06bm_mirrors.opi

100%

nsls-II
NATIONAL SYNCHROTRON LIGHT SOURCE II

06BM ES: Mirrors

Mirror 2 (TFM) MC04

Mir:M2 - JACK 1, Y	-5.8583 mm	-5.8586 mm	<	0.0000 mm	>	STOP	More	Kill all motors
Mir:M2 - JACK 2, Y	-2.6382 mm	-2.6382 mm	<	0.0000 mm	>	STOP	More	
Mir:M2 - JACK 3, Y	-2.6384 mm	-2.6384 mm	<	0.0000 mm	>	STOP	More	
Mir:M2 - LATERAL	0.0017 mm	0.0005 mm	<	0.0000 mm	>	STOP	More	
Mir:M2 - LATERAL	-0.0001 mm	-0.0005 mm	<	0.0000 mm	>	STOP	More	
Mir:M2 - Bender, B	212225.0 step	212225.0 step	<	0.0 step	>	STOP	More	

Mirror 3 (HRM) MC05

Mir:M3 - JACK 1, Y	-9.3333 mm	-9.3334 mm	<	0.0000 mm	>	STOP	More	Kill all motors
Mir:M3 - JACK 2, Y	-11.6676 mm	-11.6676 mm	<	0.0000 mm	>	STOP	More	
Mir:M3 - JACK 3, Y	-11.6680 mm	-11.6680 mm	<	0.0000 mm	>	STOP	More	
Mir:M3 - LATERAL	-8.0000 mm	-8.0001 mm	<	0.0000 mm	>	STOP	More	
Mir:M3 - LATERAL	-8.0000 mm	-8.0001 mm	<	0.0000 mm	>	STOP	More	

shroffk

Converted
BOY
screens

XAS Stages MC07 & MC08

Sample X	40.6490 mm	40.6489 mm	1.0000 mm	STOP	More
Sample Y	110.8752 mm	110.8751 mm	1.0000 mm	STOP	More
xafs_lins	16.8668 mm	16.8668 mm	1.0000 mm	STOP	More
Reference	21.1127 mm	21.1126 mm	1.0000 mm	STOP	More
Roll	-0.3000 deg	-0.3000 deg	0.1000 deg	STOP	More
Pitch	0.3098 deg	0.3098 deg	1.0000 deg	STOP	More
Sample wheel	419.9996 deg	419.9996 deg	15.0000 deg	STOP	More
xafs_ref	-75.4977 deg				
xafs_roth	0.0000 deg				
xafs_rots	-4.9999 deg				
xafs_mtr8	19.9999 mm				

XAS Table MC07

xafs_tbl_yu	126.0220 mm	
xafs_tbl_ydo	123.3780 mm	
xafs_tbl_ydi	123.3780 mm	
xafs_tbl_xu	-4.6000 mm	
xafs_tbl_xd	29.3721 mm	

XF:06BMA-BI{XAFS-Ax:LinX}Mtr

Status

Sample X Mtr. Type asynMotor

Units mm Status NO_ALARM

Drive

	USER	DIAL	RAW
High Limit	126.1000 mm	79.4045 mm	
Readback	40.6489 mm	40.7556 mm	128364
Move Abs.	40.6490 mm	40.7555 mm	128364
Low Limit	2.0000 mm	-44.6955 mm	

Move Rel. < 0.0000 mm > STOP

Tweak < 1.0000 mm > KILL

Calibration

Use Variable 81.4045 mm Neg

Dynamics

	Normal	Backlash	Jog
Max Speed	4.0000 mm/sec		
Speed	4.0000 mm/sec	4.0000 mm/sec	4.0000 mm/sec
Base Speed	0.0050 mm/sec		
Accel.	0.10 sec	0.20 sec	10.00 mm/s/s
Backlash Distance		0.0000 mm	
Move Fraction		1.0000	

CS-Studio

XAS Stages MC07 & MC08

Sample X	40.6490 mm	40.6489 mm	1.0000 mm	STOP	More
Sample Y	110.8752 mm	110.8751 mm	1.0000 mm	STOP	More
xafs_lins	16.8668 mm	16.8668 mm	1.0000 mm	STOP	More
Reference	21.1127 mm	21.1126 mm	1.0000 mm	STOP	More
Roll	-0.3000 deg	-0.3000 deg	0.1000 deg	STOP	More
Pitch	0.3098 deg	0.3098 deg	1.0000 deg	STOP	More
Sample wheel	359.9997 deg				
xafs_ref	-75.4977 deg				
xafs_roth	0.0000 deg				
xafs_rots	-4.9999 deg				
xafs_mtr8	19.9999 mm				

XAS Table MC07

xafs_tbl_yu	126.0220 mm	
xafs_tbl_ydo	123.3780 mm	
xafs_tbl_ydi	123.3780 mm	
xafs_tbl_xu	-4.6000 mm	

XF:06BMA-BI{XAFS-Ax:LinX}Mtr

Status

Sample X Mtr. Type asynMotor

Units mm Status NO_ALARM

Drive

	USER	DIAL	RAW
High Limit	126.1000 mm	79.4045 mm	
Readback	40.6489 mm	40.7556 mm	128364
Move Abs.	40.6490 mm	40.7555 mm	128364
Low Limit	2.0000 mm	-44.6955 mm	

Move Rel. < 0.0000 mm > STOP

Tweak < 1.0000 mm > KILL

Calibration

Use Variable 81.4045 mm Neg

Dynamics

	Normal	Backlash	Jog
Max Speed	4.0000 mm/sec		
Speed	4.0000 mm/sec	4.0000 mm/sec	4.0000 mm/sec
Base Speed	0.0050 mm/sec		
Accel.	0.10 sec	0.20 sec	10.00 mm/s/s
Backlash Distance		0.0000 mm	
Move Fraction		1.0000	

Phoebus

Converted
BOY
screens

BOY screens converted (not perfectly)

(on xf06bm-ws1.nsls2.bnl.local)

ADBase

100%

Area Detector Control - XF:06BM-ES{UVC-Cam:1}cam1:

Setup

asyn port UVC1
EPICS name XF:06BM-ES{UVC-Cam} Manufacturer e-con systems Model See3CAM_CU55 Serial number 1CD90500 Firmware version Unknown SDK version 0.0.6 Driver version 1.5.0 ADCore version 3.10.0

Connected
Connection **Connect** **Disconnect**
Debugging

Plugins

All File ROI
Stats Other #1 Other #2

Readout

	X	Y
Sensor size	2592	1944
Binning	1	1
	0	0

Shutter

Shutter mode None
Status: Det. Closed EPICS Closed
Open/Close **Open** **Close**
Delay: Open 0.000 Close 0.000
EPICS shutter setup

Collect

Exposure time 1.000 1.000
Acquire period 0.000 0.000
Images 1 1
Images complete 25518622
Exp./image 1 1
Image mode Continuous Continuous
Trigger mode Internal Internal

Collecting
Acquire **Start** **Stop**
Queued arrays 1
Wait for plugins No
Acquire busy
Detector state 1
Status Started acquisition
Time remaining 0.000

CS-Studio (Phoebus) (on xf06bm-ws1.nsls2.bnl.local)

ADBase

100%

Area Detector Control - XF:06BM-ES{UVC-Cam:1}cam1:

Setup

asyn port UVC1
EPICS name XF:06BM-ES{UVC-Cam:1}ca Manufacturer e-con systems Model See3CAM_CU55 Serial number 1CD90500 Firmware version Unknown SDK version 0.0.6 Driver version 1.5.0 ADCore version 3.10.0

Connected
Connection **Connect** **Disconnect**
Debugging

Plugins

All File ROI
Stats Other #1 Other #2

Readout

	X	Y
Sensor size	2592	1944
Binning	1	1
	0	0

Shutter

Shutter mode None
Status: Det. Closed EPICS Closed
Open/Close **Open** **Close**
Delay: Open 0.000 Close 0.000
EPICS shutter setup

Collect

Exposure time 1.000 1.000
Acquire period 0.000 0.000
Images 1 1
Images complete 25516341
Exp./image 1 1
Image mode Continuous Continuous
Trigger mode Internal Internal

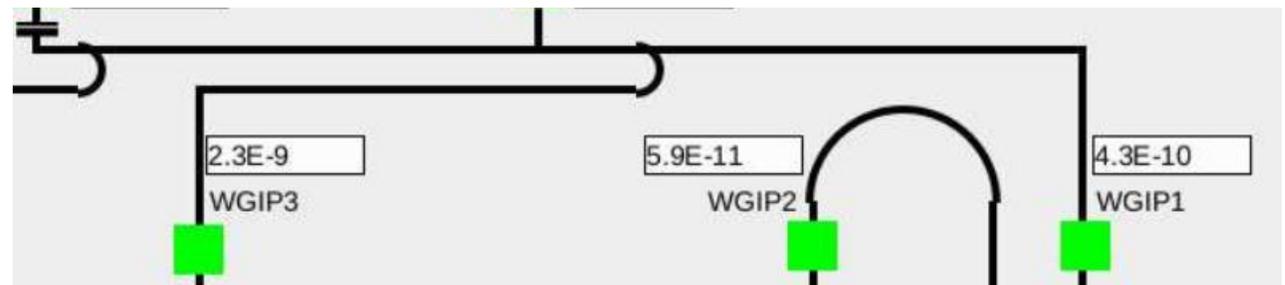
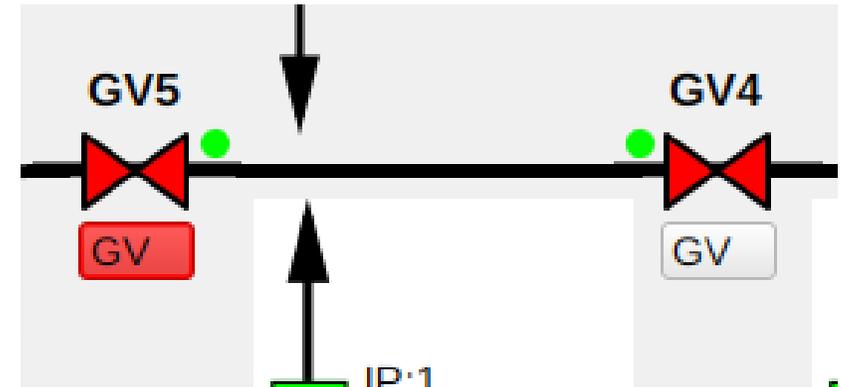
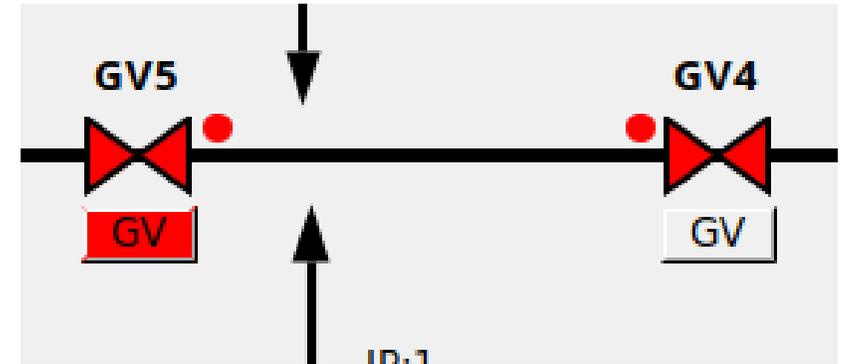
Collecting
Acquire **Start** **Stop**
Queued arrays 0
Wait for plugins No
Acquire busy Acquiring
Detector state 1
Status Started acquisition
Time remaining 0.000

BOY screens converted (not perfectly)

Case 1a:

The auto converted screens are completely functional but have aesthetic issues

- The most common of these has been alignment of widgets inside auto resized containers
- Changes are made to the original .opi file to avoid use of auto resize

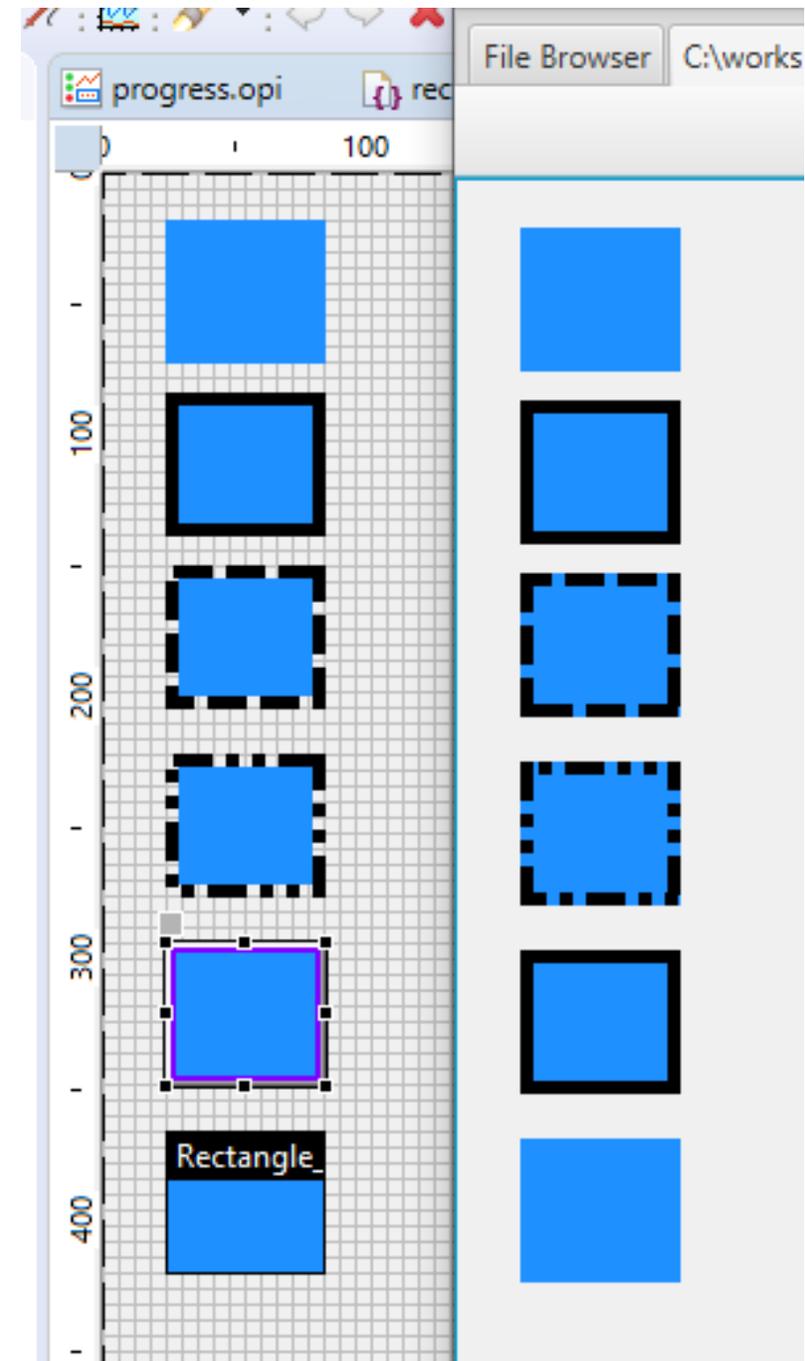


BOY screens converted (not perfectly)

Case 1b:

The auto converter is not converting some widget properties correctly.

- The Phoebus auto converter is updated to handle the conversion issue
- e.g. [Issue #1564](#) & [Issue #1771](#)
For certain shapes the “border” property from the .opi files was being ignored

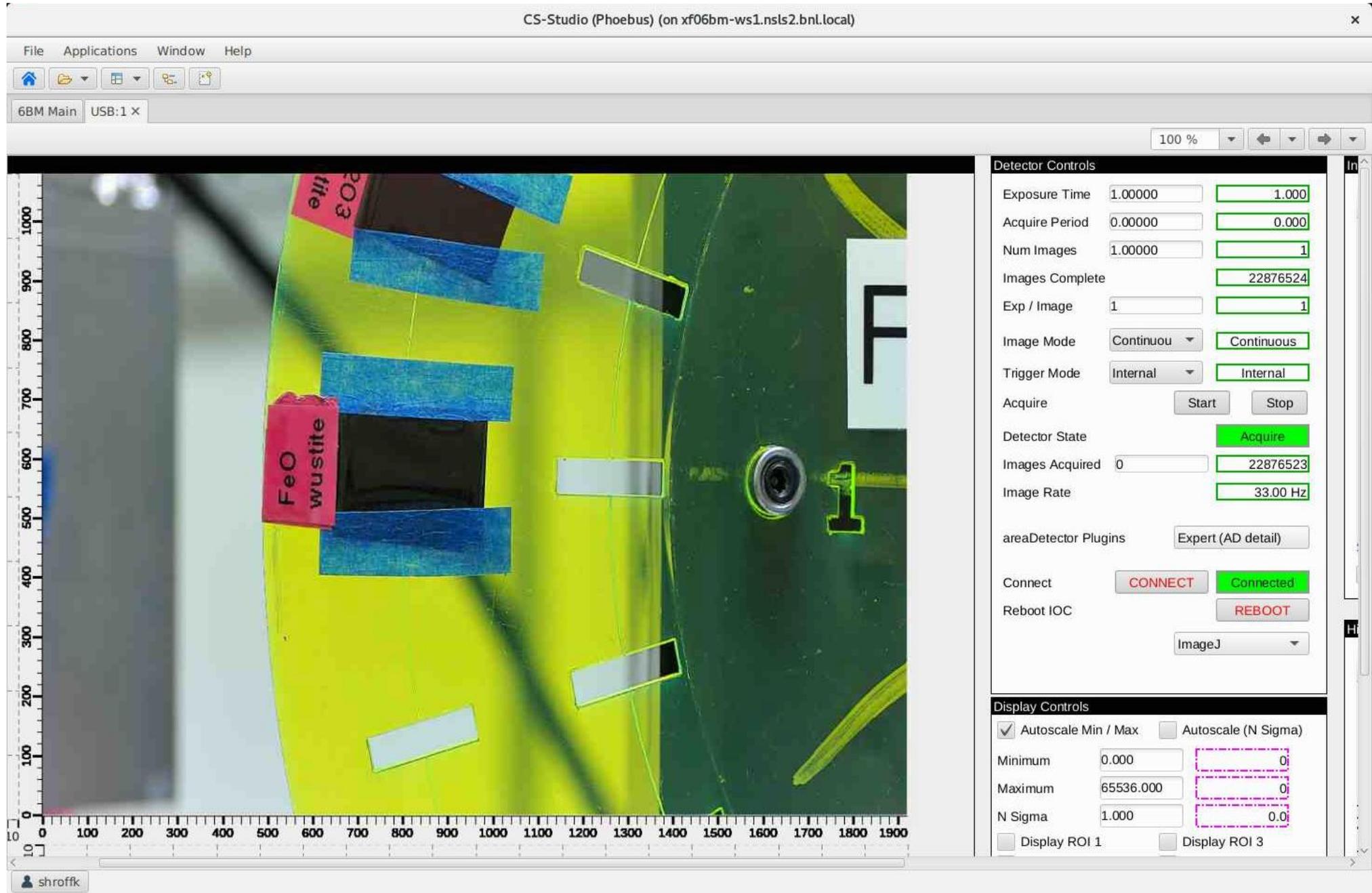


BOY screens converted (not perfectly)

BMM USB camera

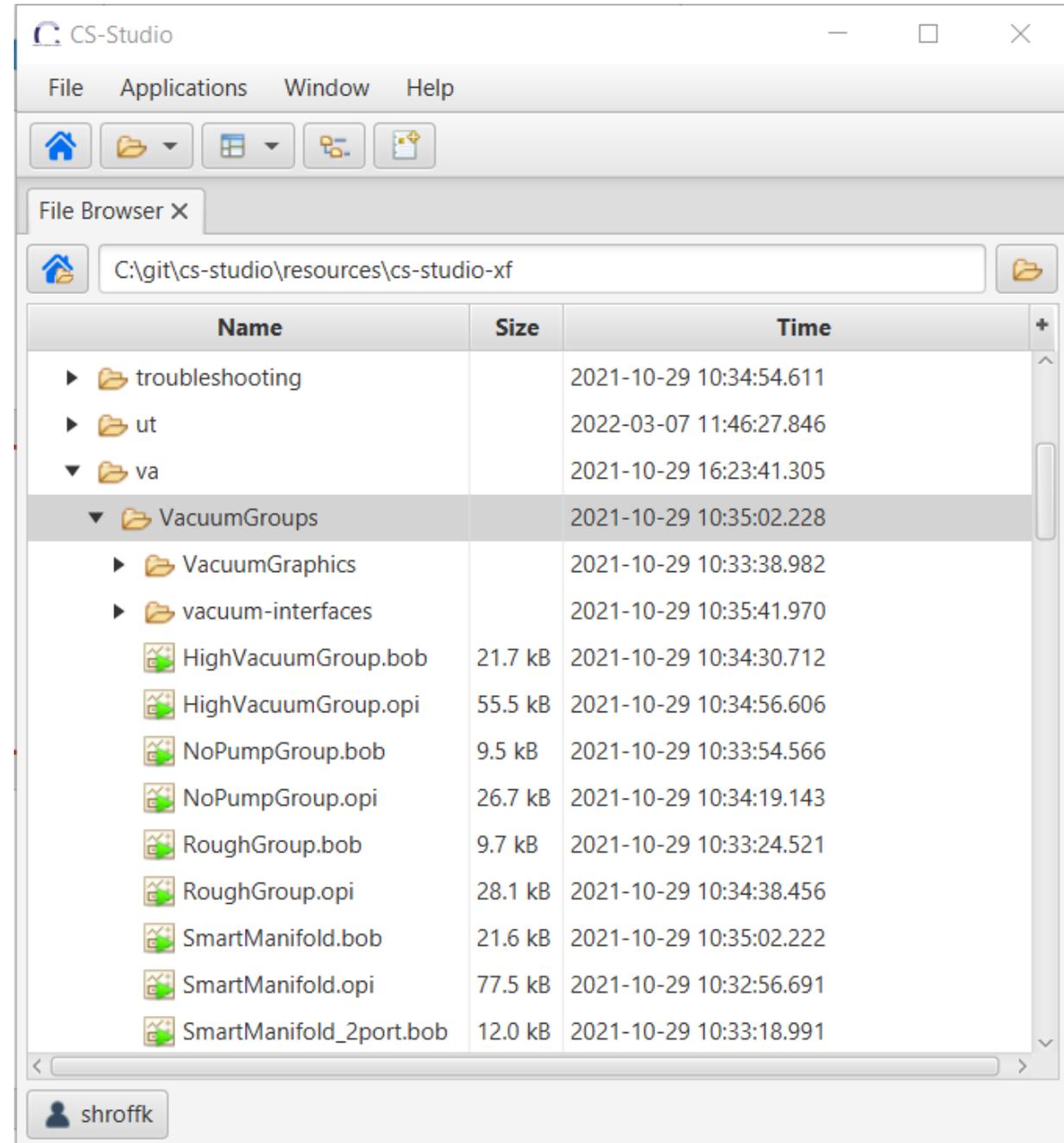
PVA Images handled automatically

Dozens of rules needed to properly render the image are no longer needed



Good Neighbours

- Once a converted file is modified it is stored as a .bob file
- The Display Builder runtime will first check for a .bob file, if found it will open it otherwise fall back on the .opi file
- No impact on existing use of CS-Studio



Redesign Screens in Phoebus (more efficient)

- Some screens which are converted perfectly can still benefit from a redesign

The screenshot displays the Phoebus software interface. At the top, there are two tabs: "SR-PS-Status.opi" and "_MG_Qstatus_Odd.opi". Below the tabs is a grid-based workspace with a horizontal axis labeled from 100 to 600. A row of green circular indicators is visible, with the first one highlighted by a dashed box. To the right of the workspace is a "Properties" panel with a "Basic" section.

In the foreground, an "Edit Rule" dialog box is open, titled "Edit Rule (on box64-4.nsls2.bnl.gov)". The dialog contains the following fields and sections:

- Rule Name:** A text input field containing "Rule".
- Property:** A dropdown menu showing "Off Color (off_color)".
- Output Expression**
- Expressions:** A table with two columns: "Boolean Expression" and "Output Value".

Boolean Expression	Output Value
pv0==0 & pv1==0	Minor
pv0==0 & pv1==1	On
pv0==1	Major
- Input PVs:** A table with three columns: "#", "PV Name", and "Trigger".

#	PV Name	Trigger
0	\$(Pri):\$(Sec)-MG{PS:QL1A}Sum1-Sts	<input checked="" type="checkbox"/> yes
1	\$(Pri):\$(Sec)-MG{PS:QL1A}PsOnOff-Sel	<input checked="" type="checkbox"/> yes
- See Generated Script:** A button.
- Script:** A text area containing the following code:

```
importPackage(Packages.org.csstudio.opibuilder.scriptUtil);
var pv0 = PVUtil.getDouble(pvs[0]);
```

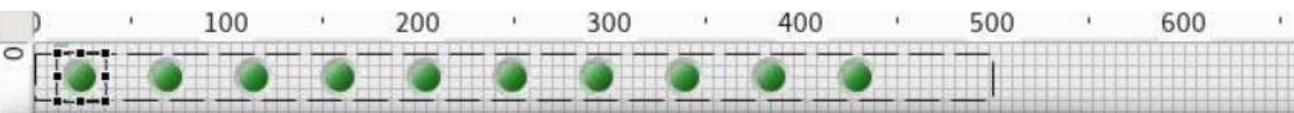
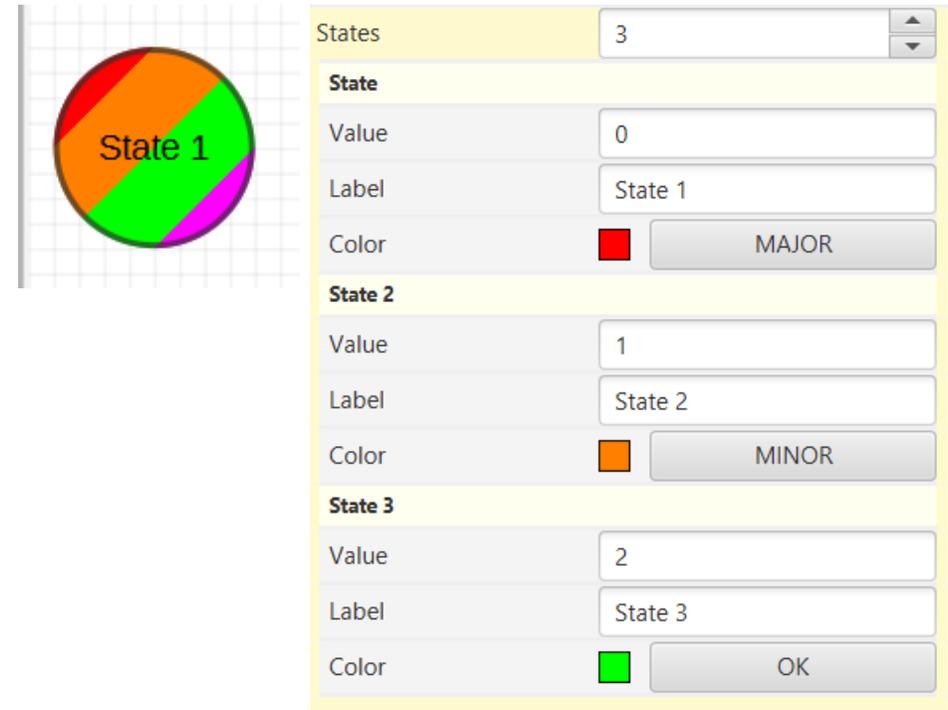
Redesign Screens in Phoebus (more efficient)

- 1800 rules to create multi state LED's



Redesign Screens in Phoebus (more efficient)

- The same functionality can be accomplished using multistate LEDs + Formula functions
- Faster loading of .bob files
- Less load on the UI thread since formulas are processed off the UI thread



Boolean Expression	Output Value
<code>pv0==0 & pv1==0</code>	Minor
<code>pv0==0 & pv1==1</code>	On
<code>pv0==1</code>	Major

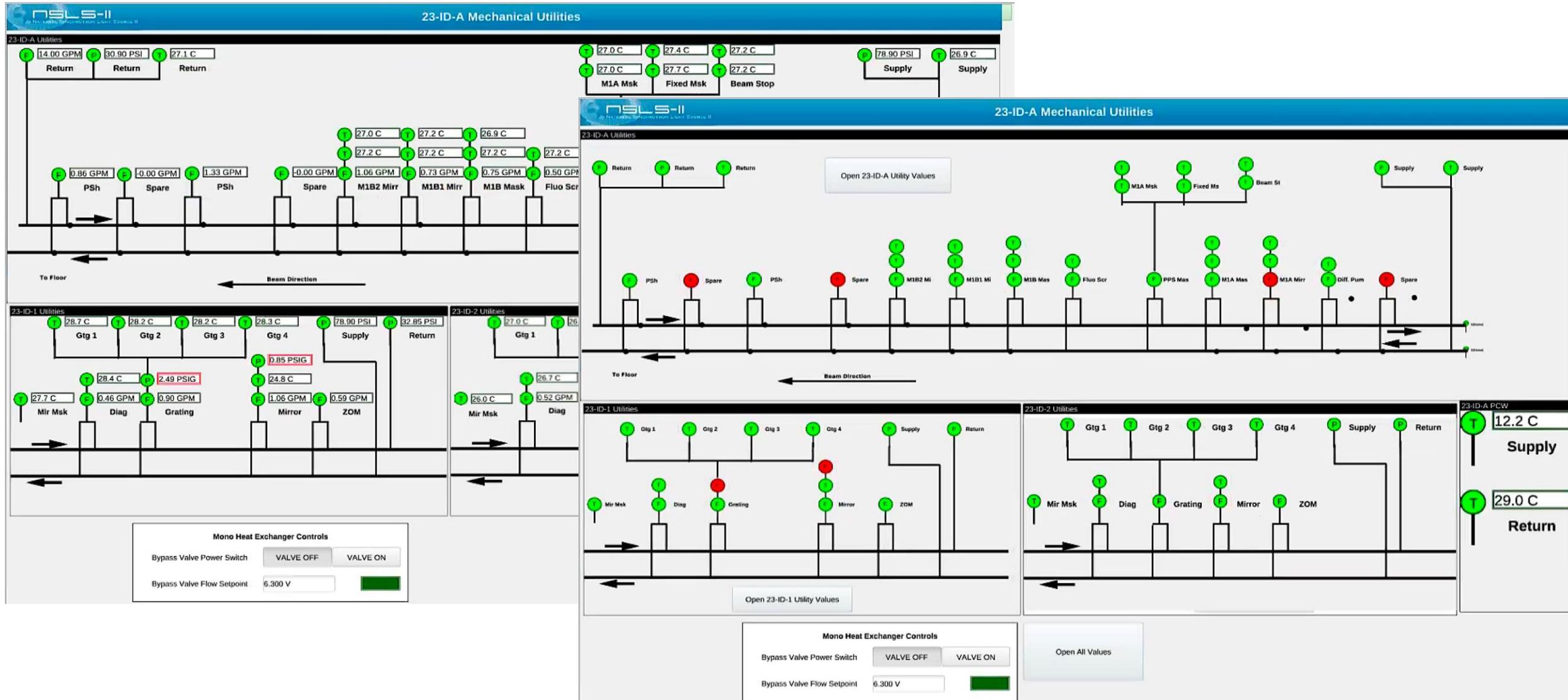
#	PV Name	Trigger
0	<code>\$(Pri):\$(Sec)-MG(PS:QL1A)Sum1-Sts</code>	<input checked="" type="checkbox"/> yes
1	<code>\$(Pri):\$(Sec)-MG(PS:QL1A)PsOnOff-Sel</code>	<input checked="" type="checkbox"/> yes



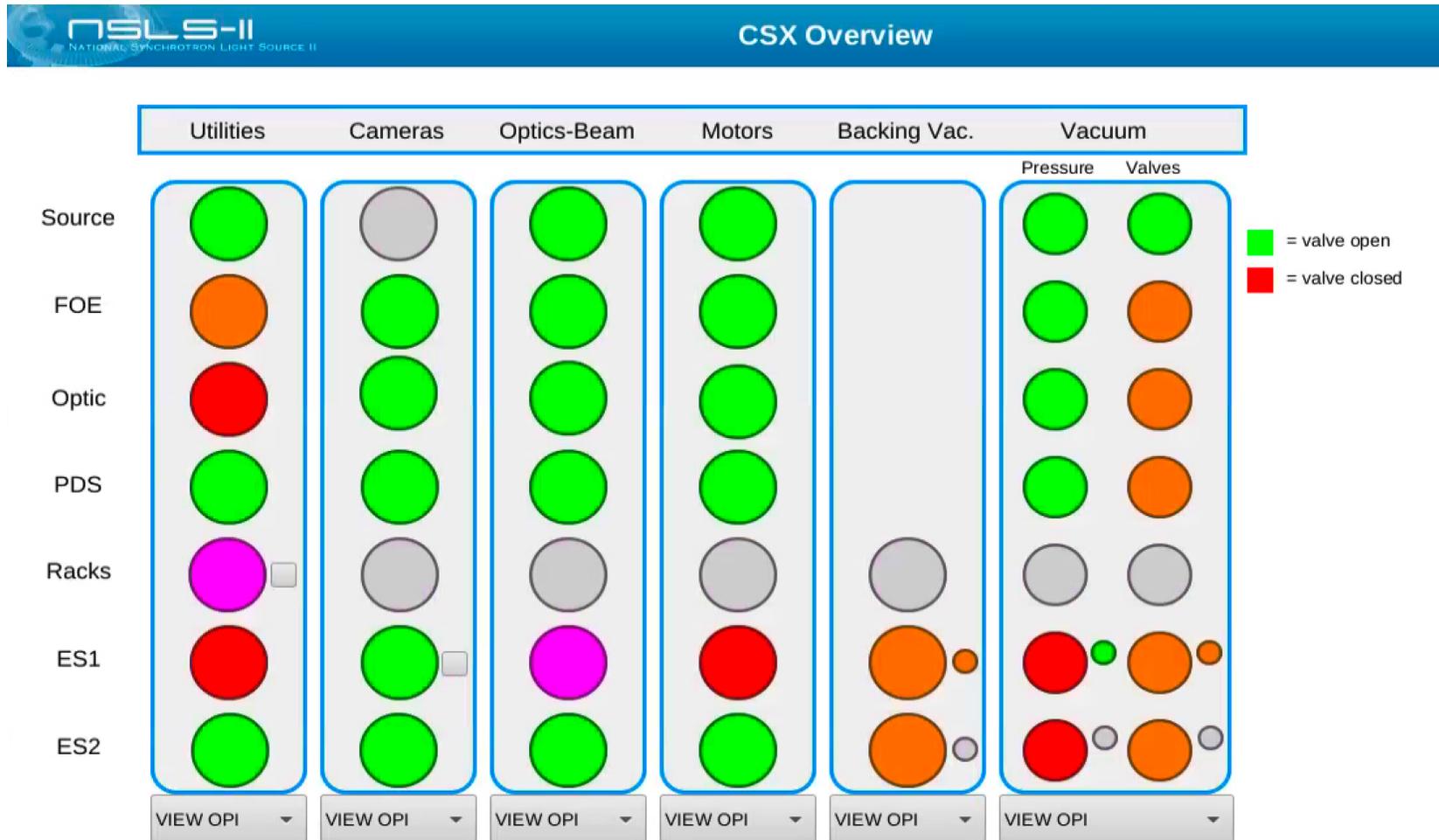
`=(pv0==1? Major : pv1 ==0 ? Minor : OK)`

(Major, Minor, OK are 3 states)

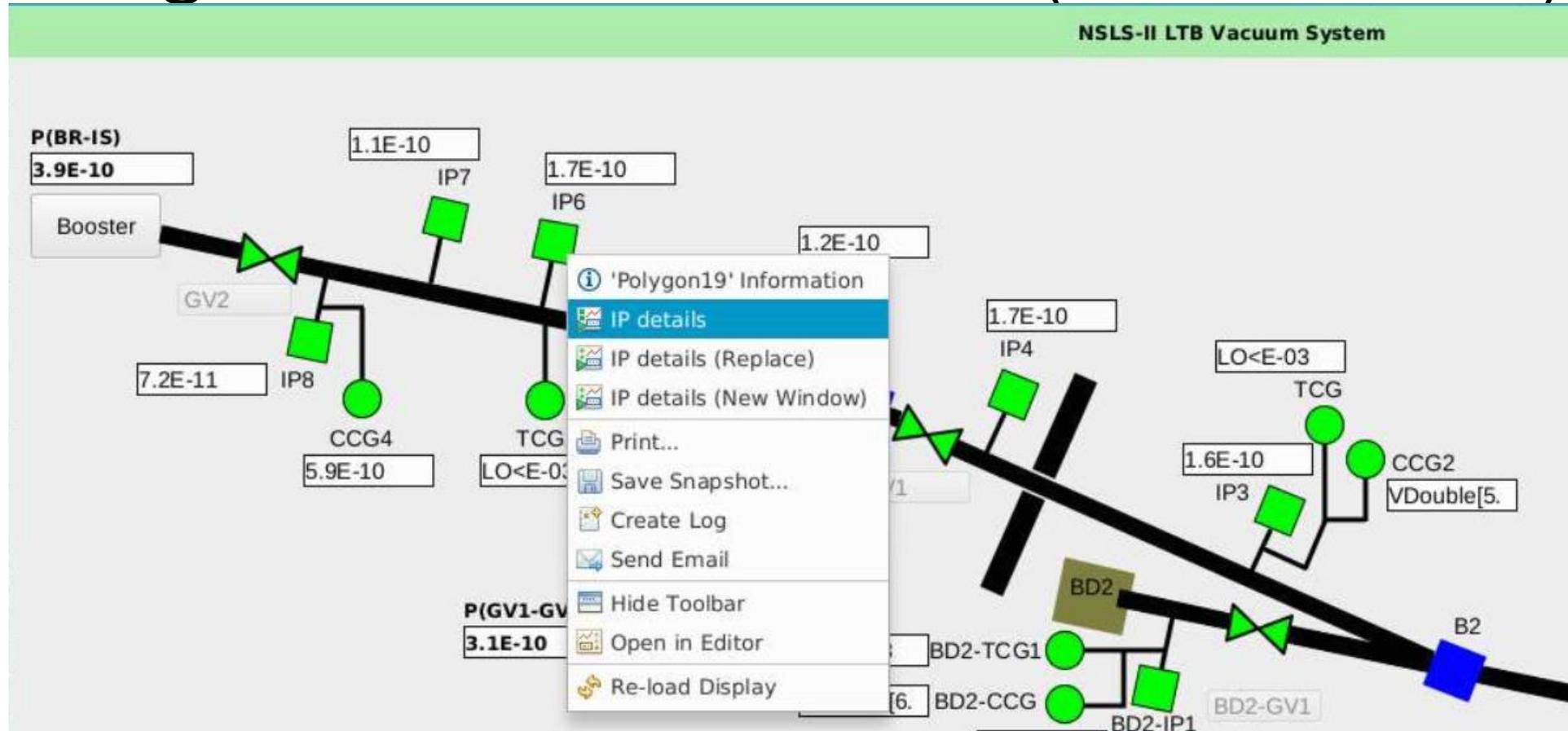
Redesign Screens in Phoebus (more usable)



Redesign Screens in Phoebus (more usable)



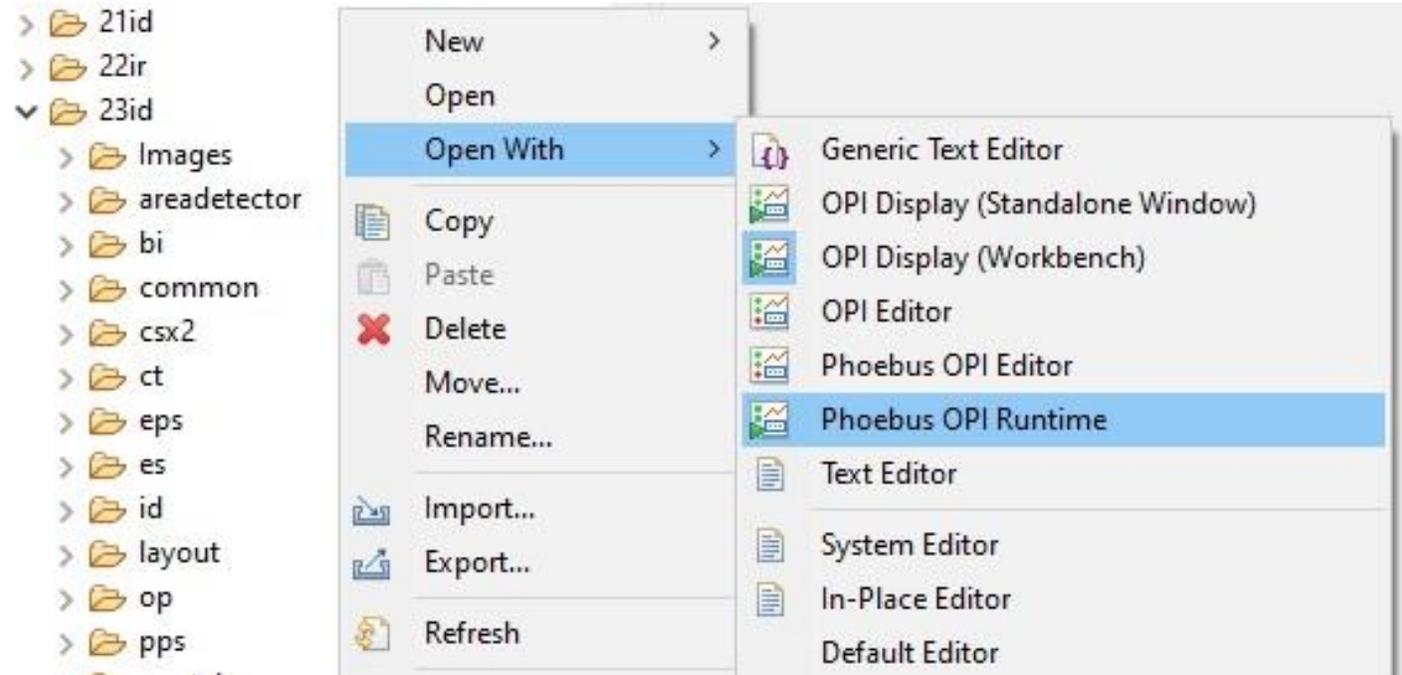
Redesign Screens in Phoebus (more usable)



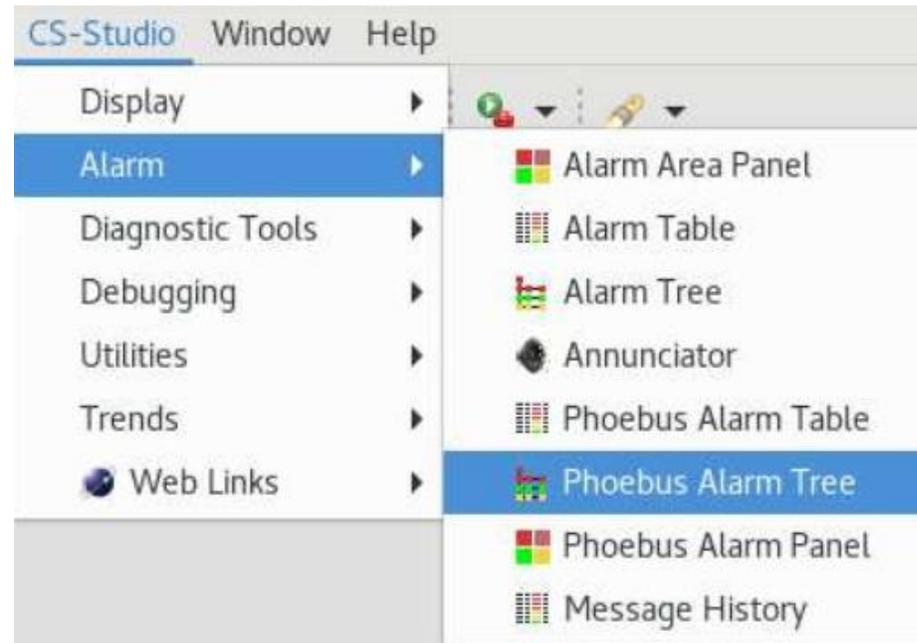
- Rethink the use of “on click actions”

Iterative migration

- Individual .opi files can be opened in the Phoebus editor or runtime



- Individual Phoebus apps can be launched



Integrating .bob files in existing .opi screen hierarchy

Action Buttons & Menu

Buttons can be configured to open .opi/.bob files in Phoebus

The screenshot illustrates the integration of .bob files into an existing .opi screen hierarchy within CS-Studio (Phoebus). The interface is divided into several key areas:

- Component Tree (Left):** A hierarchical view of the system components, including:
 - Vacuum subsystem:** FE Vacuum, 06BM Vacuum
 - Currents:** I400 1, I400 2, F450 1, F450 2
 - Controls:** DIODE, New Components
- PPS / EPS / FE Panel (Top Left):** A panel with buttons for PPS Interface and EPS Utilities. A red arrow points from the PPS Interface button to the main diagram area.
- Set Actions Dialog (Center):** A dialog box for configuring actions for a widget. The 'Actions' list includes:
 - Add Open OPI
 - Add Write PV
 - Add Execute Command
 - Add Execute Javascript
 - Add Execute Python Script
 - Add Play WAV File
 - Add Open File
 - Add Open Webpage
 - Add Open Phoebus** (highlighted)The 'Properties' section shows a table with columns for Property and Value:

Property	Value
File Path	{Parent on widget.
- Main Diagram Area (Right):** A schematic diagram of the NSLS-II FE:C06B-VA Vacuum System. It shows a central horizontal line representing a vacuum chamber with various components connected to it:
 - CCG1-CCG6 / TCG1-TCG6:** Six pairs of green circular gauges (CCG) and red circular gauges (TCG) are connected to the main line.
 - IP1-IP6:** Six green square gauges (IP) are connected to the main line.
 - GV1-GV3:** Three green square gauges (GV) are connected to the main line.
 - Other components:** Bmps, Mirror, IDPS, and XF06 are also shown.Pressure values are displayed below the gauges:
 - P(GV1-Window): 3.6E-9
 - P(Window-GV3): 1.0E-9
 - P(GV3-GV2): 4.3E-10
- Color Definition (Top Right):** A legend for the diagram's color coding:
 - Green circle: GV open/Vacuum good
 - Orange circle: GV closed/IP HV off/CCG TCG off/Vacuum warning
 - Red circle: GV error/TCG off/Vacuum alarm
 - Pink circle: Disconnected/Invalid read

Phoebus on the web

Help support remote operations by bringing OPI screens to the web

.bob files converted to web runtime OPI's

Brookhaven National Laboratory
National Synchrotron Light Source II

08/02/2022 13:38:19

ID & FrontEnd Status

SR RF

Brookhaven National Laboratory
National Synchrotron Light Source II

08/02/2022 13:39:09

Storage Ring RF Status

RF Cavity A

Amplitude	1200.0 kV
Voltage	1200.0 kV
Fwd Power	119.90 kW
Ramp Down	OFF
Fast Trip	OFF
Phase	36.4 deg
Pf Offset	343
Kp	0.080
Ki	0.004
Target State	RF
RF State	RF
1st Fault	OK
# Faults	0

Graphs for RF Cavity A: GHe Pressure, LHe SP, LHe, Tuner Position

RF Cavity C

Amplitude	1200.0 kV
Voltage	1199.7 kV
Fwd Power	139 kW
Ramp Down	OFF
Fast Trip	OFF
Phase	78.0 deg
Pf Offset	10
Kp	0.012
Ki	0.050
Target State	RF
RF State	RF
1st Fault	OK
# Faults	0

Graphs for RF Cavity C: GHe Pressure, LHe SP, LHe, Tuner Position

Beamline Shutter Status

Beamline Shutters ENABLED

GV1	Flag	Shutters	IDPS	FV	SSA	SSB	GV2&BL	Gap 1	Gap 2	Beamline Control
Open	Err	Enabled	Open	Open	Open	Open	Open	29.5		Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	5.92		Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	6.10		Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	7.11		Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	15.0	15.0	Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open			Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	7.73		Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	6.64		Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open		-0.0	Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	6.20		Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	6.04		Permitted
Open	Err	Err	Enabled	Open	Open	Open	Open	7.07	7.94	ResRes
Open	Err	Enabled	Open	Open	Open	Open	Open		0.0	Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	15.0	15.0	Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	6.40		Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open		220.0	Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	26.7	30.8	Permitted
Open	Err	Enabled	Open	Open	Open	Open	Open	15.0	15.0	Permitted

Future plan

- 2 beamlines have moved over completed to Phoebus and the new EPICS middle layer services and 4 more are in the process
- The accelerator is using Phoebus with the new alarm services and started testing some of the basic screens
- Training workshops on Phoebus to encourage conversion to be accompanied with adoption of new features and conventions

Useful links:

- <https://controlsystemstudio.org/>
- <http://phoebus.org>
- Fork us on github
<https://github.com/ControlSystemStudio>
- Documentation and Help
<https://control-system-studio.readthedocs.io/en/latest/>

Questions?