Beamline EPS Acceptance Testing

Rev Date: 09/16/2015
Author: Barrett Clay
Approved: 09/16/2015

Title	Name	Approval Date
Controls Infrastructure Group Leader	Ruslan Kadyrov	09/16/2015
ES&H Operations Manager	Lori Stiegler	09/16/2015
Quality Assurance Engineer	Joseph Zipper	09/16/2015

Serial No	Part No	Part Rev	ECN	Rev	ECN	Rev
	Beamline: 21-ID ESM					
Deviation & Waiver: _____						

OP	Description	Name/Life #	Date	DR
10	Follow the ES&H and Personal Protective Equipment Requirements for the area.	RKadyrov 25392	06/03/16	
20	Verify measuring and test equipment used for this procedure contains a valid calibration label in accordance with NSLS-II Calibration Procedure PS-QAP-0901, where applicable. The technician is responsible for notifying the technical supervisor and/or the cognizant engineer of any discrepancies occurring during the performance of this procedure. All discrepancies shall be identified and reported in accordance with NSLS-II Discrepancy Reporting Procedure PS-QAP-0002.	R Kadyrov 25392	06/06/16	
30	BEAMLINE INFORMATION - This step shall be performed by the cognizant EPS Engineer. A) Record the relevant Beamline name on this sheet, in the box for "Part No". B) Review this entire traveler and write in the relevant drawing, software, and procedure numbers where required	M Bilello 24738	06/16/16	
40	INSTALLATION VERIFICATION A) List the relevant drawing(s): Drawing No.: LT-EL-BL-ET-EPS-1210_90 Rev. No.: A Drawing No.: _____ Rev. No.: _____ B) Verify the following items are acceptable: ✓ System layout configured per drawing(s) ✓ System Labeled / Tagged	M Bilello 24738	06/16/16	

OP	Description	Name/Life #	Date	DR
50	SOFTWARE CONFIGURATION A) Download PLC software to controller and verify it was accepted by the controller. B) Record the software part number: Part No.: LT-EL-BL-ES-EPS-1210-70 Rev. No.: A	M Bilello 24738	6/17/16	
60	ACCEPTANCE TESTING A) List relevant testing procedure Procedure No.: PS-R_XFD_EPS_CHK_001 Rev. No.: 1 B) Verify acceptable completion of test procedure C) Attach test report to this traveler	M Bilello 24738	6/17/16	
65	WATER LEAK DETECTION SYSTEM TEST Verify water leak detection system, as designed for this beamline, functions correctly.	R. Kadyrov 25392	6/24/16	
70	Verify All Traveler Operations Complete	R Kadyrov 25392	06/17/16	
80	REVISION HISTORY (This step is informational and does not require signoff) Rev - Description - Date A First Release 8/27/2014 B OP#65 added 9/16/15 Joe Delong removed as approver Ruslan Kadyrov added as approver			

Beam Line: 21-ID ESM

Test Date: 6/24/16

EPS Engineer: Michael Bilello

BL Group Leader: Elio Vescovo

Beam Line master spreadsheet: LT-R-XFD-CO-DR-ESM-002

The Beam Line Master Spreadsheet contains a comprehensive list of all EPS related signals. As this test plan is executed note the results in the "test results" column of this spreadsheet.

Test Set 1: Vacuum

Vacuum Section:

Starting conditions: pressure at or below acceptable limits, GVs open.

Simulate pressure rise (toward poor vacuum) by disabling the vacuum gauge controller channel. Ensure EPICS PVs enter proper alarm states, photon shutter closes[1] and vacuum section is isolated. Two local gate valves or more, if it is required to isolate upstream section, e.g. section branching, upstream gate valve close. Record results for the following:

EPICS PV Alarm

EPS fault

Photon Shutter closes

GVx closes

GVy closes

GVz closes

Attempt to open the front end shutter and gate valves through EPICS.

Photon shutter and gate valves cannot be opened through EPICS (1)

Enable vacuum gauge controller and ensure EPICS alarms clear. Open gate valves and photon shutter through EPICS.

Photon shutter and gate valves can be opened through EPICS (2)

[1] if the intensity of the beam in the section cannot cause damage to its valves, poor vacuum doesn't have to cause shutter close

Gauge Name	EPS fault:				(1)	(2)
	Shutter:	d/s GV:	u/s GV:	D u/s:		
XF:21IDA-VA{BC:1-CCG:1_0}	SH FE	✓*	✓*	n/a	✓	✓
XF:21IDA-VA{BC:1-TCG:1_0}	—	—	—	n/a	✓	✓
XF:21IDA-VA{BC:1-CCG:2_1}	SH FE	✓*	✓*	n/a	✓	✓
XF:21IDA-VA{BC:1-TCG:2_1}	—	—	—	n/a	✓	✓
XF:21IDA-VA{Diag:1-CCG:3_1}	SH FE	✓*	✓*	✓*	✓	✓
XF:21IDA-VA{Diag:1-TCG:3_1}	—	—	—	—	✓	✓
XF:21IDA-VA{Mir:1-CCG:4_1}	SH FE	✓*	✓*	✓*	✓	✓
XF:21IDA-VA{Mir:1-TCG:4_1}	—	—	—	—	✓	✓
XF:21IDA-VA{BT:5-CCG:5_1}	SH FE, PSH1	✓*	✓*	✓*	✓	✓
XF:21IDA-VA{BT:5-TCG:5_1}	—	—	—	—	✓	✓
XF:21IDB-VA{BT:6-CCG:6_1}	SH FE PSH1	✓*	✓*	✓*	✓	✓
XF:21IDB-VA{BT:6-TCG:6_1}	—	✓*	✓*	—	✓	✓
XF:21IDB-VA{BT:7-CCG:7_1}	PSH1	✓*	✓*	✓*	✓	✓
XF:21IDB-VA{BT:7-TCG:7_1}	—	—	—	—	✓	✓
XF:21IDB-VA{Mono:1-CCG:8_1}	PSH1	✓	✓	✓*	✓	✓
XF:21IDB-VA{Mono:1-TCG:8_1}	—	—	—	—	✓	✓
XF:21IDB-VA{BT:9-CCG:9_1}	PSH1	✓	✓	✓	✓	✓
XF:21IDB-VA{BT:9-TCG:9_1}	—	—	—	—	✓	✓
XF:21IDB-VA{BT:9-CCG:9_2}	PSH1	✓	✓	✓	✓	✓
XF:21IDB-VA{BT:9-TCG:9_2}	—	—	—	—	✓	✓
XF:21IDB-VA{BT:10-CCG:10_1}	—	✓	✓	✓	✓	✓
XF:21IDB-VA{BT:10-TCG:10_1}	—	—	—	—	✓	✓

SH FE – Front End Shutter
PSH1 – Hutch A Shutter
* – tested with simulator
"—" – no action as expected

Gauge Name	EPS fault:				(1)	(2)
	Shutter:	d/s GV:	u/s GV:	D u/s:		
XF:21IDB-VA{BT:10-CCG:10_2}	—	✓	✓	✓	✓	✓
XF:21IDB-VA{BT:10-TCG:10_2}	—	—	—	—	✓	✓
XF:21IDB-VA{Mir:3-CCG:11_1}	—	✓	✓	✓	✓	✓
XF:21IDB-VA{Mir:3-TCG:11_1}	—	—	—	—	✓	✓
XF:21IDC-VA{Slt:1A-CCG:A1_1}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{Slt:1A-TCG:A1_1}	—	—	—	—	✓	✓
XF:21IDC-VA{BT:A2-CCG:A2_1}	—	✓	✓	—	✓	✓
XF:21IDC-VA{BT:A2-TCG:A2_1}	—	—	—	—	✓	✓
XF:21IDC-VA{BT:A3-CCG:A3_1}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{BT:A3-TCG:A3_1}	—	—	—	—	✓	✓
XF:21IDC-VA{Mir:4A-CCG:A4_1}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{Mir:4A-TCG:A4_1}	—	—	—	—	✓	✓
XF:21IDC-VA{Slt:1B-CCG:B1_1}	—	✓	✓	—	✓	✓
XF:21IDC-VA{Slt:1B-TCG:B1_1}	—	—	—	—	✓	✓
XF:21IDC-VA{BT:B2-CCG:B2_1}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{BT:B2-TCG:B2_1}	—	—	—	—	✓	✓
XF:21IDC-VA{BT:B3-CCG:B3_1}	—	✓ *	✓	✓	✓	✓
XF:21IDC-VA{BT:B3-TCG:B3_1}	—	— *	—	—	✓	✓
XF:21IDC-VA{Mir:4B-CCG:B4_1}	—	✓ *	✓ *	✓	✓	✓
XF:21IDC-VA{Mir:4B-TCG:B4_1}	—	— *	— *	—	✓	✓
XF:21IDC-VA{BT:B5-CCG:B5_1}	~~n/a~~ (2K)	n/a	✓ *	✓	✓	✓
XF:21IDC-VA{BT:B5-TCG:B5_1}	—	n/a	— *	—	✓	✓

* – tested with simulator

"—" – no EPS action as expected

Simulate pressure rise (toward poor vacuum) by disabling the vacuum pump controller channel. Ensure EPICS PVs enter proper alarm states, photon shutter closes[2] and vacuum section is isolated. Two local gate valves and one upstream (or more, if it is required to isolate upstream section, e.g. section branching) gate valve close. Record results for the following:

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GVz closes

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Photon shutter and gate valves can be opened through EPICS (2)

[2] if the intensity of the beam in the section cannot cause damage to its valves, poor vacuum doesn't have to cause shutter close

Pump name:	EPS fault:				(1)	(2)
	Shutter:	d/s GV:	u/s GV:	D u/s:		
XF:21IDA-VA{BC:1-IP:1_0}	Sh FE	✓ *	✓ *	n/a	✓	✓
XF:21IDA-VA{BC:1-IP:2_1}	Sh FE	✓ *	✓ *	n/a	✓	✓
XF:21IDA-VA{Diag:1-IP:3_1}	Sh FE	✓ *	✓ *	✓ *	✓	✓
XF:21IDA-VA{Mir:1-IP:4_1}	Sh FE	✓ *	✓ *	✓ *	✓	✓
XF:21IDA-VA{BT:5-IP:5_1}	Sh FE, PSH1	✓ *	✓ *	✓ *	✓	✓
XF:21IDA-VA{BT:5-IP:5_2}	Sh FE, PSH1	✓ *	✓ *	✓ *	✓	✓
XF:21IDB-VA{BT:6-IP:6_1}	Sh FE, PSH1	✓ *	✓ *	✓ *	✓	✓
XF:21IDB-VA{BT:7-IP:7_1}	PSH1	✓	✓ *	✓ *	✓	✓
XF:21IDB-VA{Mono:1-IP:8_1}	PSH1	✓	✓	✓ *	✓	✓
XF:21IDB-VA{BT:9-IP:9_1}	PSH1	✓	✓	✓	✓	✓
XF:21IDB-VA{BT:9-IP:9_2}	PSH1	✓	✓	✓	✓	✓
XF:21IDB-VA{BT:9-IP:9_3}	PSH1	✓	✓	✓	✓	✓
XF:21IDB-VA{BT:10-IP:10_1}	—	✓	✓	✓	✓	✓
XF:21IDB-VA{BT:10-IP:10_2}	—	✓	✓	✓	✓	✓
XF:21IDB-VA{Mir:3-IP:11_1}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{Slt:1A-IP:A1_1}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{Slt:1A-IP:A1_2}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{BT:A2-IP:A2_1}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{BT:A3-IP:A3_1}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{Mir:4A-IP:A4_1}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{Slt:1B-IP:B1_1}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{Slt:1B-IP:B1_2}	—	✓	✓	✓	✓	✓

Sh FE - Front End Shutter
PSH1 - A hutch shutter
"_" - no action as expected
"*" - tested with the simulator

Pump name:	EPS fault: Shutter:	d/s GV:	u/s GV:	D u/s:	(1)	(2)
XF:21IDC-VA{BT:B2-IP:B2_1}	—	✓	✓	✓	✓	✓
XF:21IDC-VA{BT:B3-IP:B3_1}	—	✓ ‡	✓	✓	✓	✓
XF:21IDC-VA{BT:B3-IP:B3_2}	—	✓ ‡	✓	✓	✓	✓
XF:21IDC-VA{Mir:4B-IP:B4_1}	—	✓ *	✓ ‡	✓	✓	✓
XF:21IDC-VA{BT:B5-IP:B5_1}	—	n/a	✓ *	✓ *	✓	✓

‡ - tested with simulator

Repeat for each vacuum section on beam line. For the sections adjacent to Front end and End Station, also simulate poor vacuum signal from remote systems.

EPS fault:	Front end:	End station:
Photon Shutter closes	✓	n/a
GVx closes GV2	✓	n/a
GVy closes	n/a	n/a
GVz closes	n/a	n/a
Shutter and GVs cannot be opened	✓	n/a

Test Set 2: Water flow

Record initial flow through section with all valves fully open.

Slowly close supply valve and record the LOW and LOW LOW PV Alarm levels.

If the channel is associated with an EPS action, also register the flow at which the EPS fault occurs. Ensure cable disconnection results in EPS action. Repeat for each water circuit on beam line.

Sensor name:	Nominal flow: GPM	LOW: GPM	LOLO: GPM	EPS:
XF:21IDA-OP{Diag:1}F:3_2	2.67	1.4	1.2	FE SH
XF:21IDA-OP{SPARE:1}F:3_3	2.74	1.4	1.2	—
XF:21IDA-OP{Mir:1)F:4_5	1.4	1.5	1.3	FE SH
XF:21IDA-OP{Mir:1-Slt:4_D_1}F:6	2.69	0.85	0.75	FE SH
XF:21IDA-OP{SPARE:1}F:8	2.63	1.4	1.2	—
XF:21IDA-OP{Main:1}F:9	20.9	—	—	—
XF:21IDA-OP{Mono:1-Mir:8_1}F:11	1.37	1.9	1.7	PSH 1
XF:21IDA-OP{Mono:1-Grt:8_1}F:12	0.6	0.75	0.5	PSH 1
XF:21IDA-OP{Mono:1-Slt:8_D_1}F:13	0.94	0.75	0.5	PSH 1

FE SH - Front End shutter
"—" no action registered as expected
PSH 1 - FOE Shutter

Test Set 3: Thermal

For each temperature transducer ensure the temperature measurement reports expected value.

Attach an appropriate adaptor and transducer simulator to the temperature input of the EPS system (remote IO chassis or Armor Block). Raise the temperature above each of the HI and HIHI PV alarm limits and ensure the alarm is reported. If the transducer is associated with an EPS interlock, continue to raise the temperature until the EPS trip level is exceeded. Ensure the appropriate EPS mitigation process occurs. Ensure channel cable disconnection results in EPS action.

Sensor name:	EPICS PV:	Temperature: °C	HI: °C	HIHI: °C	EPS:
White beam aperture Bottom	XF:21IDA-OP{Msk:1}T:1_B1	28.6	60	80	FE SH
White beam aperture Top	XF:21IDA-OP{Msk:1}T:1_T1	28.8	60	80	FE SH
Diagon Bottom 1	XF:21IDA-OP{Diag:1}T:3_B1	28.6	60	80	FE SH
Diagon Bottom 2	XF:21IDA-OP{Diag:1}T:3_B2	28.6	60	80	FE SH
Diagon Bottom 3	XF:21IDA-OP{Diag:1}T:3_B3	28.7	60	80	FE SH
Diagon Outboard 1	XF:21IDA-OP{Diag:1}T:3_O1	28.4	60	80	FE SH
Diagon Outboard 2	XF:21IDA-OP{Diag:1}T:3_O2	28.4	60	80	FE SH
Diagon Outboard 3	XF:21IDA-OP{Diag:1}T:3_O3	28.5	60	80	FE SH
Entrance Mask 1	XF:21IDA-OP{Mir:1-Msk:4_U_1}T:1	24.0	60	80	FE SH
Entrance Mask 2	XF:21IDA-OP{Mir:1-Msk:4_U_1}T:2	24.0	60	80	FE SH
Exit Mask 1	XF:21IDA-OP{Mir:1-Msk:4_D_1}T:1	24.0	60	80	FE SH
Exit Mask 2	XF:21IDA-OP{Mir:1-Msk:4_D_1}T:2	24.0	60	80	FE SH
Beam Stop 1	XF:21IDA-OP{Mir:1-BS:4_1}T:1	24.0	60	80	FE SH
Beam Stop 2	XF:21IDA-OP{Mir:1-BS:4_1}T:2	24.0	60	80	FE SH

Sensor name:	EPICS PV:	Temperature: °C	HI: °C	HIHI: °C	EPS:
Mir Internal Mechanics 1	XF:21IDA-OP{Mir:1-IM:4_1}T:1	24.0	60	80	FESH
Mir Internal Mechanics 2	XF:21IDA-OP{Mir:1-IM:4_1}T:2	24.0	60	80	FESH
Mir Slt Top 1	XF:21IDA-OP{Mir:1-Slt:4_D_1}T:T1	24.1	60	80	FESH
Mir Slt Top 2	XF:21IDA-OP{Mir:1-Slt:4_D_1}T:T2	24.0	60	80	FESH
Mir Slt Bottom 1	XF:21IDA-OP{Mir:1-Slt:4_D_1}T:B1	24.0	60	80	FESH
Mir Slt Bottom 2	XF:21IDA-OP{Mir:1-Slt:4_D_1}T:B2	24.0	60	80	FESH
Mir Slt Outboard 1	XF:21IDA-OP{Mir:1-Slt:4_D_1}T:O1	24.1	60	80	FESH
Mir Slt Outboard 2	XF:21IDA-OP{Mir:1-Slt:4_D_1}T:O2	24.1	60	80	FESH
Mir Slt Inboard 1	XF:21IDA-OP{Mir:1-Slt:4_D_1}T:I1	24.0	60	80	FESH
Mir Slt Inboard 2	XF:21IDA-OP{Mir:1-Slt:4_D_1}T:I2	24.0	60	80	FESH
Pink beam aperture #1 1	XF:21IDA-OP{Msk:2}T:5_1	28.4	60	80	FESH
Pink beam aperture #1 2	XF:21IDA-OP{Msk:2}T:5_2	28.4	60	80	FESH
Pink beam aperture #2 1	XF:21IDA-OP{Msk:3}T:5_1	28.7	60	80	FESH
Pink beam aperture #2 2	XF:21IDA-OP{Msk:3}T:5_2	28.5	60	80	FESH
Pink beam aperture #3 1	XF:21IDA-OP{Msk:4}T:5_1	21.0	60	80	FESH

IDB Thermocouple K-type:

Sensor name:	EPICS PV:	Temperature: °C	HI: °C	HIHI: °C	EPS:
Pink beam aperture #4 1	XF:21IDB-OP{Msk:5}T:6_1	25.9	60	80	FESH
Mono Top 1	XF:21IDB-OP{Mono:1-Slt:7_U_1}T:T1	24.0	60	80	FESH
Mono Bottom 1	XF:21IDB-OP{Mono:1-Slt:7_U_1}T:B1	24.0	60	80	FESH
Mono Outboard 1	XF:21IDB-OP{Mono:1-Slt:7_U_1}T:O1	24.1	60	80	FESH
Mono Inboard 1	XF:21IDB-OP{Mono:1-Slt:7_U_1}T:I1	24.0	60	80	FESH
Mono Grating 1	XF:21IDB-OP{Mono:1-Grt:8_1}T:1	24.0	60	80	FESH
Mono Grating 2	XF:21IDB-OP{Mono:1-Grt:8_2}T:1	24.0	60	80	FESH
Mono Grating 3	XF:21IDB-OP{Mono:1-Grt:8_3}T:1	24.1	60	80	FESH
Mono Grating 4	XF:21IDB-OP{Mono:1-Grt:8_4}T:1	24.0	60	80	FESH
Mono Mirror 1	XF:21IDB-OP{Mono:1-Mir:8_1}T:1	24.0	60	80	FESH
Mono Mirror 2	XF:21IDB-OP{Mono:1-Mir:8_1}T:2	24.1	60	80	FESH
Mono Mirror 3	XF:21IDB-OP{Mono:1-Mir:8_1}T:3	24.1	60	80	FESH
Mono Mask 1	XF:21IDB-OP{Mono:1-Msk:8_U_1}T:1	24.0	60	80	FESH
Mono Mask 2	XF:21IDB-OP{Mono:1-Msk:8_U_1}T:2	23.9	60	80	FESH
Mono Mask 1	XF:21IDB-OP{Mono:1-Msk:8_D_1}T:1	23.9	60	80	FESH
Mono Mask 2	XF:21IDB-OP{Mono:1-Msk:8_D_1}T:2	23.6	60	80	FESH

FESH – Front End Shutter

Sensor name:	EPICS PV:	Temperature: °C	HI: °C	HIHI: °C	EPS:
Mono Beamstop 1	XF:21IDB-OP{Mono:1-BS:8_1}T:1	24.0	60	80	FESH
Mono Beamstop 2	XF:21IDB-OP{Mono:1-BS:8_1}T:2	24.1	60	80	FESH
Mono Internal Mechanics 1	XF:21IDB-OP{Mono:1-IM:8_1}T:1	24.0	60	80	FESH
Mono Internal Mechanics 2	XF:21IDB-OP{Mono:1-IM:8_1}T:2	24.1	60	80	FESH
Mono Slt Top 1	XF:21IDB-OP{Mono:1-Slt:8_D_1}T:T1	23.8	60	80	FESH
Mono Slt Top 2	XF:21IDB-OP{Mono:1-Slt:8_D_1}T:T2	23.8	60	80	FESH
Mono Slt Bottom 1	XF:21IDB-OP{Mono:1-Slt:8_D_1}T:B1	23.9	60	80	FESH
Mono Slt Bottom 2	XF:21IDB-OP{Mono:1-Slt:8_D_1}T:B2	23.8	60	80	FESH
Mono Slt Outboard 1	XF:21IDB-OP{Mono:1-Slt:8_D_1}T:O1	24.0	60	80	FESH
Mono Slt Outboard 2	XF:21IDB-OP{Mono:1-Slt:8_D_1}T:O2	24.0	60	80	FESH
Mono Slt Inboard 1	XF:21IDB-OP{Mono:1-Slt:8_D_1}T:I1	24.0	60	80	FESH
Mono Slt Inboard 2	XF:21IDB-OP{Mono:1-Slt:8_D_1}T:I2	24.0	60	80	FESH
Mir 3 Internal Mechanics 1	XF:21IDB-OP{Mir:3-IM:12_1}T:1	24.0	60	80	FESH
Mir 3 Internal Mechanics 2	XF:21IDB-OP{Mir:3-IM:12_1}T:2	24.1	60	80	FESH
Slt 1A exit slit 1	XF:21IDC-OP{Slt:1A}T:A1_1	23.9	60	80	FESH
Slt 1A exit slit 2	XF:21IDC-OP{Slt:1A}T:A1_2	24.0	60	80	FESH

FESH - Front End Shutter

IDC B Branch Thermocouples K-type:

Sensor name:	EPICS PV:	Temperature: °C	HI: °C	HIHI: °C	EPS:
Slt 1B exit slit 1	XF:21IDC-OP{Slt:1B}T:B1_1	24.0	60	80	FE Sh
Slt 1B exit slit 2	XF:21IDC-OP{Slt:1B}T:B1_2	23.9	60	80	FE Sh
Slt B3 Top 1	XF:21IDC-OP{Mir:4B-Slt:B3_U_1}T:T1	23.9	60	80	FE Sh
Slt B3 Bottom 1	XF:21IDC-OP{Mir:4B-Slt:B3_U_1}T:B1	23.9	60	80	FE Sh
Slt B3 Outboard 1	XF:21IDC-OP{Mir:4B-Slt:B3_U_1}T:O1	26.1	60	80	FE Sh
Slt B3 Inboard 1	XF:21IDC-OP{Mir:4B-Slt:B3_U_1}T:I1	26.1	60	80	FE Sh

FE Sh - Front End shutter closes

Test Set 4: EPS/PPS interface

For the primary Photon Shutter:

Front End: If *FRONT END ENABLE STATUS* and *FOE PERMIT* and not *USER INTERLOCK* command the front end shutter to open. ✓

Front end opens and ***FRONT END OPEN STATUS*** = OPEN: ✓

Command the front end shutter to close.

Front end closes and ***FRONT END OPEN STATUS*** = CLOSED: ✓

With the front end open force a user interlock.

Front end closes and ***FRONT END OPEN STATUS*** = CLOSED: ✓

Attempt to open the front end shutter through EPICS while not all gate valves in white-beam region down to next secondary shutter are open.

Front end cannot be opened through EPICS: ✓

For the secondary photon shutter:

If PHOTON SHUTTER x ENABLE STATUS = 1 (ABILITY TO OPEN) and ESEE x PERMIT command the shutter to open.

Shutter opens and **PHOTON SHUTTER x *OPEN STATUS*** = OPEN ✓

Command the shutter to close.

Shutter closes and **PHOTON SHUTTER x *OPEN STATUS*** = CLOSED ✓

Attempt to open the shutter through EPICS while not all gate valves in white-beam region downstream the shutter are open.

Shutter cannot be opened through EPICS: ✓

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