Automated Shifting in SNO+

M.Ward on behalf of the DWG

SNOLAB Users meeting June 26-27th 2024



What you know (hopefully)

- SNO+ is a 780 tonne Liquid scintillator Detector.
- The scintillator is held in a 12 meter diameter acrylic sphere, surrounded by a PMT support structure (PSUP) emersed in 7000 tones of ultra pure water.
- It is instrumented with ~9400 8 inch PMTs to observe light produce by interactions.
- The DAQ is composed of original SNO electronics from the 90s (with a few upgrades)
- The Detector Working Group's Mission :
 - Maximum detector uptime
 - High quality physics data
 - Entropy control



"The History of every major Galactic Civilization tends to pass through three distinct and recognizable phases, those of Survival, Inquiry and Sophistication, otherwise known as the How, Why, and Where phases."

Douglas Adams



The Journey

- How do we do shifts?
- Why do things go wrong when we are on shift?
- Where can we do better?





How do we do shifts?

- We monitor the SNO+ detector using several sources of information
 - DAQ and Builder logs
 - XSNOED (Event Display)
 - AlarmGUI
- We produce shift reports, noting events of interest or interactions with SNOLAB, hourly updates of general detector health stats.
- Respond to upset, or alarm states
- Contact the DAQ Expert team when things go wrong...
- Shifts are typically 8 hours in length, the detector does not sleep



Why do things go wrong when we are on shift?

- SNO+ is built on the shoulders of the original SNO hardware
- In many cases we are pushing the hardware into new and exciting territory.
- Sometimes there be dragons in these unmapped regions.

- Higher trigger rates and more stringent thresholds
 - There is a limit at which we can trigger and keep the detector in sync
 - Extra heat stress pushes some components outside of specification
- Some components are genuinely reaching end of life.
 - Passive components going out of spec causes many of our issues



Where can we do better?

- Entropy control is a constant battle
- There are cases when we see new and interesting issues, HOWEVER we are truly into the stage were the DAQ Experts group has very good knowledge in diagnosing and fixing issues with the detector.
- We have spent a lot of energy in hardware robustness in the last few years
- So what else can we do better?

- Automation!
 - Shifting is a time consuming and labor intensive task
 - Much like we use online monitoring tools to perform data quality tasks, the question becomes... Can we create a tool to automate the tasks a shifter would do?
 - Do we gain anything else through automation?



Why Automate?

- Less people required to operate the detector
- Taking control away from the shifter frees up people to do other tasks
- A computer can respond to issues in a programmed manner
 - (No disrespect) but not all shifters are good at it.
 - A bad shifter can cause uptime loss, some examples :
 - Not seeing that a crate tripped and we haven't been seeing data from it for about 2 hours.
 - Not noticing the DAQ and builder are extremely unhappy and the detector is totally out of sync... for 4 hours
 - Waiting for a a few hours because they 'didn't want to wake the expert at 2am'
- Realistically not many people enjoy listening to TUBII sing a white-noise waltz over night. (We have shifters listen to triggers)



Shifting Stats!

- Shifts are taken by members of the collaboration across all seniority!
- It has however become difficult to keep all shift slots filled
- Anti-social hours are obviously the hardest to fill.
- Typically it runs down to about 15 shifts per person per year...



- Less people are taking shifts year on year...
- (Tongue in cheek) we will be out of shifters by 2032



How do we approach automation?

- For very good reasons we operate SNO+ with caution.
- It is important that the collaboration trusts what we are unleashing, the collaboration's DAQ experts are a big part of defining what is safe for SNO+
- Our approach has 3 important starting blocks
 - 1. Look at how shifters actually do shifts
 - Analyze the data for when SNO+ does go wrong, are there any trends? Can we exploit it?
 - 3. Use the existing tools as much as possible
- Figure out what it means to automate and what we
- 9 want from it!







1 – How do shifters shift

- We have already spoken of the responsibilities in slide 4
- What is important to note is what are the problematic behaviors, can we fix these or not have automation recreate these issues.

- Main issues of note
 - Inconsistent note taking in shift reports
 - Inconsistent completion of shift reports
 - Inconsistent response time to Alarms
 - Long training period to identify what counts as a problem and what is a warning
 - Kinda like compiling code in C++, sometimes you can ignore warnings, other times not.



1 – How do shifters shift : The stories....

- 3am Shifter lets an alarm go unanswered because they don't want to wake up an expert.
- Shifter lets an alarm go unanswered likely because they silenced their speakers and just didn't notice all of the signs of issues... (asleep?)
- Shifter constantly resyncs the detector because of DAQ warnings, potentially wasting run time.
- Shifter doesn't notice a HV supply tripped off and a crate has been dark for 3 hours.

Take home message for Automation : Being attentive to the detector, constantly, is difficult for some.
 A Tool than can't fall foul of being inconsistent or somehow complacent will be great.
 We do also do not have the luxury of a huge collaboration and pool of people to do shifting!

Disclaimer : There are more good shifters than bad! Don't hate me!



2 – Alarms – When things go wrong



Shifter, initially startled by the alarmgui, takes a few moments to look at what is going on.

- Fix themselves? Nope gonna need help
- > Call an expert

Expert : Don't worry about a thing, I got this

Expert : Yeah... so... let me tell you a story in 3 parts for the shift report.



2 - Alarms

- The alarm system is operated from a database,
 - Any system can be programed to issue an alarm!
 - We track 587 different alarms with 3 levels of severity!
 - We can add more if we want... is it Tuesday? ALARM!
- Safety systems are already tied to several level 3 alarms
 - We can issue hardware level emergency shutdown based on alarms alone.
- A system will issue a SQL post to the DB with the alarmID (one of the 587 IDs)
- DB will create an active alarm with a timestamp.
 - Alarms can be acknowledged by a user
 - They can clear based on user action, OR hardware changes
 - Not all alarms require expert intervention!

























We can draw one very important conclusion from this data



SNO+ is a teenager (in its 20s)

- Doesn't like it when people are nearby
- Doesn't like daytime hours
- Sometimes craves attention
- Needs reminding how to do basic tasks
- Can't count... sometimes



• In reality... likely there is a grounding issue causing this.



2 – Alarms – The serious version of the last slide

Take home for automation

- We trust in our Alarm system to trigger when something is wrong
- We know SNO+ is most stable outside times of lab occupancy
 - If we are to unleash an automated system, THIS would be the target times
- The Expert group is extremely well versed in items we can safely ignore and ones that need response.
- The Expert group knows how things behave when there are alarms and what can be done (if any) to remedy things in a safe manner.



3 – Existing tools

- Lots of our tools and utilities are written in Python
 - Fairly quick to develop, we have produced many very stable scripts that we know work and trust, edge cases ironed out.
- We already have mechanisms that watch for specific alarms and perform actions for detector safety
 - Detect communication loss between UG and Surface > Power off after 30 minutes
 - We monitor rack power supplies for issues, and automatically shut down racks in the case of alarms
- Orca software we use to control the detector
 - Has a communication protocol already that had not been implemented
- Take Home We don't need to invent anything significantly different



Minimum specifications for automation

Required:

- Simple Logical program to perform basic case like tasks
- 2. Start, Stop, Restart and Resync runs
- 3. Change runtype (into our maintenance config)
- 4. Communicate with Experts when things go wrong
- 5. Produce a log that can be used by run-selection

Stretch goals

- Produce shift reports like a shifter would
- Multiple lines of communication with Experts
- Slack integration via a bot



Initial Planning – Lily de Loe, Mark (advice)

- Quickly we identify that the AlarmGUI already in use provides a good starting point.
 - It already pools the AlarmDB for active alarms.
- We track alarms for basically EVERYTHING
- Our Expert group has dealt with a huge number of issues, we know what things can be fixed by a shifter vs an Expert.
- Develop response philosophy.
- Identified a route by which we can talk with Orca

- Result
 - Decided that actions should be based on the alarm, NOT the level
 - Pooled our experts for default actions, created a list of actions.
 - Produced a modified AlarmGUI with prototype functions as a possible replacement for the GUI
 - Understand that Orca will require some modification for us to interact with it.



Production – David Drobner (Co-op), Anita Masuskapoe, Mark (Advice)

- Turned expert feedback into an extra column in our Alarm Table, action to take per alarm.
- Reworked lots of code to produce a program we renamed Roboshifter.
- Communication between Roboshifter and Orca is demonstrated,
 - Orca updated to allow for remote run start, stop, runtype changes, HV readback and control.
- Basic interaction with Shift report pages
- Able to pull DAQ log and builder log information
- Able to send SMS messages

			alarmGUI v.beta		_ = ×
Alarm Cent	ter Alarm Log Rob	oshifter Settings			
Operator Mode				ENABLE ROBOSHIFTER CONTROL	Go to observer mode
				Incorrect Alarm	level 3
-	anthur stress	·		Perform	Select level
Current	active alarms	(newest on top)	order by time order by level	Action	₩ L1
9880	07/21-11:34:03	level 2 XL3	crate 18: Bus error reading FEC ram level	1	₩ L2
9879	07/21 - 11:33:56	level 2 FEC	FIFO high in crate 16		₩ L3
9878 9877	07/21 - 11:33:50 07/21 - 11:33:42	level 3 XL3 level 3 OR0	crate 2 disconnected A Crate 10 HV Monitor Heartbeat		Acknowledge
9876	07/21 - 11:33:36	level 3 Cra	e 7 Supply B - Current near zero		selected alarm
9875	07/21 - 11:33:29	level 3 Cra level 3 Cov	e 11 Supply A - Setpoint changed during pl er gas bag positions		Color legend
9873	07/21 - 11:33:10	level 3 Ger	eric ORCA alarm		Color legend
9872	07/21 - 11:33:03	level 3 Net	work monitoring stopped		acknowledged
9871	07/21 - 11:32:54	level 2 XL3	error in crate 0		cleared
9870	07/21 - 11:32:47	level 3 Cra	e 2 Supply B - Current near zero		selected
9869	07/21 - 11:32:40	level 1 CAE	N event too big		Cileman surrough
9868	07/17 - 14:55:34	level 3 Log	server heartbeat missing		alarms for Smin
			I		
			I	Des	scribe Incorrect Alarm Prompt
			I		
			I		
			I		
			I		
			I		
			I		
			I		
<u> </u>				ž	
What to	do for selected al	arm:			
If it recov	ers immediately, n	ote the crate and sl	ot in the shift report. If it occurs rt.		
Propose	d action for robo	-shifter:	-		
Resynce	with the same runt	pe			
Te	stautio	Close GUI	Report GUI hun on GitHub	Database tim	a: hulu 21 2022 - 11-24-21



Process

- ▶ 1. Alarm occurs, regular alarmgui / webgui do what they usually do. User alerted via regular means.
 - 2. Pull the desired action matching the alarm id from the database
 - 3. Grab the DAQ log and builder log, put this in the Shift Report
 - 4. Alert the shift channel of the alarm with the DAQ and builder messages, send SMS and Email to shifter
 - 5. Perform desired action, for most alarms it will try a resync of the detector,
 - 6. Start a shutdown timer.
 - 7. If timer reaches 30 minutes, ramp down PMTs...
- 8. Timer is cleared upon alarm acknowledgement or clearing due to action



Testing during Davids Co-op term

- Testing
 - Roboshifter was tested disconnected with Orca in a development environment to catch crashes and edge cases
 - Runtype change and run start, stop, resync tested in a development environment but not connected to the detector.
 - Slack functionality works
 - SMS works

- Issues
 - Orca communication is a little flaky
 - Alarm floods can cause crashes
 - Random crashes
 - Grabbing builder and DAQ logs can hang or just take an excessive amount of time.



Further development – Parmesh Ravi, Anita Masuskapoe, Matt Depatie, Mark Ward

- Further orca communication
 - HV and Current feedback
 - Set Runtype word
 - Save Orca status
- User communication reworked
 - Slack messages are less spammy, and more targeted
 - SMS system more robust
 - Email system more robust
 - Voice calls!
 - Able to call experts rather than just shifter
 - Interaction with SNOPLUS shift whiteboard.

- UI changes
 - New interface, extra tabs
 - Visible mode changes, so we know who/what is in control
 - Visible feedback on who is on call along with overrides
- Able to make full shift reports!!!
 - Able to complete shift reports at a level a shifter should be able to!
 - Able to track and alert a shifter to changes in PMT Current readback.
- Lots of under the hood robustness fixes





Status Log Alarm Log Errors Log Book Run Control Status Log Alarm Log Errors Log Book Run Control Status Log Alarm Log Control Restant Resync Stop Control Roboshifter Nonlocing Scattings Control Control Control Roboshifter Shifter Information Restant Resync Status Log Alarm Log Environ Control	Standard Runs HV Master Der Standard Run control Refresh Standard Runs Run Name: PHYSICS Roboshifter Settings Set Values	etector State Calibrations Nhit Monitor Load Standard Run rite Standard Run ent settings in HV DB value 0 0x0 0x0 0x7F 0x1000000 0x10000000	r Settings Run Type W Current Maintena Tranaition Physics Deployed External S ECA Diagnostii	
Voltage Triggers Read Nominal Tolerance 0021 151845 Ster Ped Mask: 00000 0/1 0N 0N 2052 V 100 V 10221 151845 Ster Ped Mask: 00000 0/1 0N 0N 2052 V 100 V 10221 151845 Ster Ped Mask: 00000 0/1 0N 0N 2052 V 100 V 10221 151845 Ster Ped Mask: 00000 0/1 0N 0N 2052 V 100 V 10221 151845 Ster Ped Mask: 00000 0/1 0N 0N 2052 V 100 V 10221 151845 Ster Ped Mask: 00000 0/1 0N 0N 2052 V 100 V 10221 151845 Ster Ped Mask: 00000 0/1 0N 0N 2052 V 100 V 10221 151845 Ster Ped Mask: 00000 0/1 0N 0N 2052 V 100 V 10221 151845 Ster Ped Mask: 00000 0/1 0N 0N 2052 V 100 V 10221 151845 Ster Ped Mask: 00000 0/1 0N 0N	Standard Run control Refresh Standard Runs Run Name: PHYSICS Roboshifter Settings	Load Standard Run Load Standard Run rent settings in HV DB value 0	Run Type W Current Maintena N Physics Deployed External 3 ECA Diagnosti	
Orde21 End Start RESTART RESYNC STOP 0-021 518.144 Warning, Run Started Roboshifter Roboshifter Stop 0-021 518.144 Qpering dataFile: -D. Roboshifter Shifter Information Expert Information Monitoring Settings 1 0-021 1518.44 Run 360/021 started(s) Currents Voltages Currents 0-021 1518.44 Run 360/021 started(s) Currents Voltages Currents 0-021 1518.45 Set Ped Mask: 00000 Refresh Refresh Nominal Tolerance 0-021 1518.45 Set Ped Mask: 00000 0/1 ON ON 2050 V 1 100 V 0-021 1518.45 Set Ped Mask: 00000 0/1 ON ON 2050 V 1 100 V 0-021 1518.45 Set Ped Mask: 00000 0/1 ON ON 2050 V 1 100 V 0-021 1518.45 Set Ped Mask: 00000 0/1 ON ON </th <th>Refresh Standard Runs Run Name: PHYSICS Roboshifter Settings Set Values</th> <th>Load Standard Run rite Standard Run rent settings in HV DB value 0</th> <th>Current Maintena V Physics Deployee External ECA Diagnost</th>	Refresh Standard Runs Run Name: PHYSICS Roboshifter Settings Set Values	Load Standard Run rite Standard Run rent settings in HV DB value 0	Current Maintena V Physics Deployee External ECA Diagnost	
Violation Reduction Respective 000000000000000000000000000000000000	Roboshifter Settings Set Values	DB value 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Mainten Transitio ✓ Physics Deploye External ECA Diagnos	
Roboshifter Roboshifter Roboshifter Roboshifter Roboshifter Roboshifter Roboshifter Shifter Information Expert Information Monitoring Settings Voltage Currents Voltage Thresholds Crate/Rack Status Voltage Thresholds Crate/Rack Status O O O O O O Carte/Rack Status Tolerance O O O Crate/Rack Status Tolerance O Crate/Rack Status Tolerance O O O Crate/Rack Status Tolerance <th colspan<="" td=""><td>Roboshifter Settings Set Values</td><td>Cent settings in HV DB value 0 0x0 0x0 0x7 0x7 0x70 0x70 0x70 0x70</td><td>W Transitio V Physics Deploye External ECA Diagnos</td></th>	<td>Roboshifter Settings Set Values</td> <td>Cent settings in HV DB value 0 0x0 0x0 0x7 0x7 0x70 0x70 0x70 0x70</td> <td>W Transitio V Physics Deploye External ECA Diagnos</td>	Roboshifter Settings Set Values	Cent settings in HV DB value 0 0x0 0x0 0x7 0x7 0x70 0x70 0x70 0x70	W Transitio V Physics Deploye External ECA Diagnos
Nome Operating Operating Nominal Monitoring Sattings I 00221151844 Run 3800211 stated or Referesh Voltages Currents Voltages Currents 00221151844 State Pack State Pack Nominal Voltages Currents 00221151844 State Pack State Pack Nominal Referesh 00221151845 State Pack Nominal Tolerance 011 ON NN 2050 V 2052 V 100 V 02211518	Roboshifter Settings Set Values	DB value 0 0x0 0x0 0x7 0x7 0x700000 0x7000000	 Physics Deploye External ECA Diagnos 	
06-21 15:18:44 Run 380021 started(c) Voltage Currents 06-21 15:18:44 mic carse delay 250 Currents 06-21 15:18:44 Set Ped Mask: 0x0000 Carset Refresh 06-21 15:18:44 Set Ped Mask: 0x0000 Refresh Refresh 06-21 15:18:44 Set Ped Mask: 0x0000 Crate/Rack Status Triggers Read Nominal Tolerance 06-21 15:18:45 Set Ped Mask: 0x0000 0/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:45 Set Ped Mask: 0x0000 0/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:45 Set Ped Mask: 0x0000 0/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:45 Set Ped Mask: 0x0000 0/1 ON ON 2028 V : 2043 V ± 100 V 06:21 15:18:45 Set Ped Mask: 0x0000 3/2 ON ON 2028 V : 2043 V	Set Values	DB value 0 0x0 0x0 0x7 0x7 0x700000 0x1000000	External ECA Diagnos	
Voltage Voltages Currents 0621 15/16/4 Mit: the delay Ops 0621 Currents 0621 15/16/4 Set Ped Mask: 0x0000 0621 Nominal Currents 0621 15/16/4 Set Ped Mask: 0x0000 0621 Nominal Tolerance 0621 15/16/4 Set Ped Mask: 0x0000 0621 Crate/Rack Status Triggers Read Nominal Tolerance 0621 15/16/4 Set Ped Mask: 0x0000 06/21 0/1 ON ON 2050 V 1 2052 V ± 100 V 06/21 15/16/4 Set Ped Mask: 0x0000 0/1 ON ON 2050 V 1 2052 V ± 100 V 06/21 15/16/4 Set Ped Mask: 0x0000 0/1 ON ON 2050 V 1 2043 V ± 100 V 06/21 15/16/4 Set Ped Mask: 0x0000 0/1 ON ON 2028 V 100 V 1 100 V 06/21 15/16/4 Set Ped Mask: 0x0000 0/1 3/2 ON ON 2019 V 120	Set Values	0 0x0 0x0 0x7 0x7 0x700000 0x1000000	ECA Diagnos	
0-2-1 15:18:44 Set Ped Mask: 0x0000 0-20:1 15:18:44 Set Ped Mask: 0x0000 0-20:1 15:18:45 Set Ped Mask: 0x0000 0-21:15:18:45 Set Ped Mask: 0x0000 0-21:15:18:47 Set Ped Mask: 0x0000 0-21:15:18:49 Set Ped Mask: 0x0000 0-21:15:	Set Values	0x3 0x6 0x7 0x7000000 0x1000000	Diagnos	
Voitage Thresholds Refresh 0621 151844 Set Ped Mask: 0x0000 0621 151845 Set Ped Mask: 0x0000 071 Crate/Rack Status Triggers Read Nominal Tolerance 0621 151845 Set Ped Mask: 0x0000 0621 151845 Set Ped Mask: 0x0000 0621 151847 Set Ped Mask: 0x0000 071 ON ON 2050 V : 2052 V ± 100 V 0621 151845 Set Ped Mask: 0x0000 071 ON ON 2194 V : 100 V 0621 151847 Set Ped Mask: 0x0000 071 ON ON 2194 V : 100 V 0621 151847 Set Ped Mask: 0x0000 072 2/2 ON ON 2028 V : 2043 V ± 100 V 0621 151847 Set Ped Mask: 0x0000 0621 151847 Set Ped Mask: 0x0000 0621 151848 Set Ped Mask: 0x0000 0621 151849 Set Ped Mask: 0x0000 0621	Set Values	0xF 0x7F 0x1000000 0x1000000	Example and the	
0-8-21 15:18:44 Set Ped Mask: 0x0000 Voltage Thresholds Refresh 0-8-21 15:18:45 Set Ped Mask: 0x0000 0-821 15:18:45 Set Ped Mask: 0x0000 Refresh 0-8-21 15:18:45 Set Ped Mask: 0x0000 0-821 15:18:45 Set Ped Mask: 0x0000 Tolerance 0-8-21 15:18:45 Set Ped Mask: 0x0000 0-71 1 0 N Non 2050 V : 2052 V ± 100 V 0-8-21 15:18:46 Set Ped Mask: 0x0000 0/1 0 N Non 2050 V : 2052 V ± 100 V 0-8-21 15:18:46 Set Ped Mask: 0x0000 0/1 0 N Non 2050 V : 2052 V ± 100 V 0-8-21 15:18:46 Set Ped Mask: 0x0000 0/1 0 N NoN 2194 V : 100 V 0-8-21 15:18:47 Set Ped Mask: 0x0000 1/1 0 N N 2028 V : 2043 V ± 100 V 0-8-21 15:18:47 Set Ped Mask: 0x0000 3/2 0 N N 2019 V : 2121 V ± 100 V 0-8-21 15:18:48 Set Ped Mask: 0x0000 3/2 0 N N 2018 V ± 100 V 0-8-21 15:18:48 Set Ped Mask: 0x00004 5/4 0 N	Set Values	0x1000000 0x1000000	Superno	
Ordel 15:18:45 Set Ped Mask: 0x0000 Voltage Thresholds Metresh 06:21 15:18:45 Set Ped Mask: 0x0000 Offication (Crate/Rack) Status Triggers) Read Nominal Tolerance 06:21 15:18:45 Set Ped Mask: 0x0000 O/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x0000 O/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x0000 1/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x0000 1/1 ON ON 2028 V : 2043 V ± 100 V 06:21 15:18:47 Set Ped Mask: 0x0000 3/2 ON ON 2019 V : 2121 V ± 100 V 06:21 15:18:48 Set Ped Mask: 0x0000 3/2 ON ON 2054 V : 2012 V ± 100 V 06:21 15:18:48 Set Ped Mask: 0x0000 4/3 ON ON 2018 V : 2012 V ± 100 V 06:21 15:18:48 Set Ped Mask: 0x0000 4/3 ON ON	Set values	Fot Now	Spare Spare	
Ofe-21 15:18:45 Set Ped Mask: 0x0000 Crate/Rack Status Triggers Read Nominal Tolerance 06:21 15:18:45 Set Ped Mask: 0x0000 0/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x0000 0/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x0000 1/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x0000 1/1 ON ON 2028 V : 2043 V ± 100 V 06:21 15:18:47 Set Ped Mask: 0x0000 3/2 ON ON 2028 V : 2043 V ± 100 V 06:21 15:18:47 Set Ped Mask: 0x0000 3/2 ON ON 2028 V : 2012 V ± 100 V 06:21 15:18:48 Set Ped Mask: 0x0000 4/3 ON ON 2054 V : 2012 V ± 100 V		4.998	Spare	
Obe 15:18:45 Set Ped Mask: 0x0000 Crate/Rack Status Triggers Read Nominal Tolerance 06:21 15:18:46 Set Ped Mask: 0x0000 0/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x0000 0/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x0000 0/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x0000 1/1 ON ON 2028 V : 2043 V ± 100 V 06:21 15:18:47 Set Ped Mask: 0x0000 3/2 ON ON 2028 V : 2043 V ± 100 V 06:21 15:18:48 Set Ped Mask: 0x0000 3/2 ON ON 2054 V : 2012 V ± 100 V 06:21 15:18:48 Set Ped Mask: 0x0004 5/4 ON<		130 340	SMELLI	
Ode-21 15:18:45 Set Ped Mask: 0x000C Crate/Rack Status Triggers Read Nominal Tolerance 06:21 15:18:46 Set Ped Mask: 0x000C 0/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x000C 0/1 ON ON 2050 V : 2052 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x000C 1/1 ON ON 2194 V : 2194 V ± 100 V 06:21 15:18:46 Set Ped Mask: 0x000C 3/2 ON ON 2028 V : 2043 V ± 100 V 06:21 15:18:47 Set Ped Mask: 0x000C 3/2 ON ON 2028 V : 2121 V ± 100 V 06:21 15:18:48 Set Ped Mask: 0x000C 3/2 ON ON 2054 V : 2111 V ± 100 V 06:21 15:18:48 Set Ped Mask: 0x000C 5/4		0x38	AMELLI	
06-21 15:18:46 Set Ped Mask: 0x000C 0/1 0N 0N 2050 V : 2052 V ± 100 V 06-21 15:18:46 Set Ped Mask: 0x000C 1/1 0N 0N 2194 V : 2194 V ± 100 V 06-21 15:18:46 Set Ped Mask: 0x000C 1/1 0N 0N 2028 V : 2194 V ± 100 V 06-21 15:18:47 Set Ped Mask: 0x000C 2/2 0N 0N 2028 V : 2043 V ± 100 V 06-21 15:18:47 Set Ped Mask: 0x000C 3/2 0N 0N 2109 V : 2121 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x000C 3/2 0N 0N 2054 V : 2012 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x000C 4/3 0N 0N 2054 V : 2012 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x000C 5/4 0N 0N 2108 V : 2132 V ± 100 V 06-21 15:18:49 mtc: 0x058 delay 340 6/4 0N 0N 2110 V : 2132 V ± 100 V <td< td=""><td>Mask Nominal</td><td>Tolerance</td><td>PCA</td></td<>	Mask Nominal	Tolerance	PCA	
06-21 15:18:46 Set Ped Mask: 0x0000 1/1 ON ON 2194 V : 2194 V ± 100 V 06-21 15:18:46 Set Ped Mask: 0x0000 2/2 ON ON 2028 V : 2043 V ± 100 V 06-21 15:18:47 Set Ped Mask: 0x0000 3/2 ON ON 2109 V : 2121 V ± 100 V 06-21 15:18:47 Set Ped Mask: 0x0000 3/2 ON ON 2109 V : 2121 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x0000 3/2 ON ON 2054 V : 2012 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x0000 4/3 ON ON 2054 V : 2012 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x0004 5/4 ON ON 2108 V : 2118 V ± 100 V 06-21 15:18:49 Bet Ped Mask: 0x0004 6/4 ON ON 2123 V : 2132 V ± 100 V 06-21 15:18:49 Bet Ped Mask: 0x004 6/4 ON ON 2110 V : 2132 V ± 100 V	✓ ~ 2052 V ± 10	100 C V	ECATSL	
06-21 15:16:47 Set Ped Mask: 0x000C 2/2 ON ON 2028 V : 2043 V ± 100 V 06-21 15:18:47 Set Ped Mask: 0x000C 3/2 ON ON 2109 V : 2121 V ± 100 V 06-21 15:18:47 Set Ped Mask: 0x000C 3/2 ON ON 2109 V : 2121 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x000C 3/2 ON ON 2054 V : 2012 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x000C 4/3 ON ON 2054 V : 2012 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x0004 5/4 ON ON 2108 V : 2118 V ± 100 V 06-21 15:18:49 bet Ped Mask: 0x004 6/4 ON ON 2123 V : 2132 V ± 100 V 06-21 15:18:49 bet Ped Mask: 0x01fff 6/4 ON ON 2110 V : 2118 V ± 100 V 06-21 15:18:49 bet Ped Mask: 0x01fff 6/4 ON ON 2099 V : 2022 V ± 100 V <t< td=""><td>✓ ~ 2194 V + 10</td><td>100 C V DB value</td><td>Spare Spare</td></t<>	✓ ~ 2194 V + 10	100 C V DB value	Spare Spare	
06-21 15:18:49 21/2 0N 0N 2109 V : 2121 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x000C 3/2 0N 0N 2109 V : 2121 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x000C 4/3 0N 0N 2054 V : 2012 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x000C 5/4 0N 0N 2108 V : 2118 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x000C 5/4 0N 0N 2108 V : 2118 V ± 100 V 06-21 15:18:49 Set Ped Mask: 0x000H 6/4 0N 0N 2123 V : 2132 V ± 100 V 06-21 15:18:49 Set Ped Mask: 0x00HH 6/4 0N 0N 2110 V : 2118 V ± 100 V 06-21 15:18:49 Set Ped Mask: 0x00HH 6/4 0N 0N 2110 V : 2118 V ± 100 V 06-21 15:18:49 Set Ped Mask: 0x00HH 5/5 0N 0N 2099 V	2043 V + 10	100 0x17	Embedd	
06-21 15:18:48 Set Ped Mask: 0x0000 5/2 0.N 0.N 2105 V : 2107 V 1 100 V 06-21 15:18:48 Set Ped Mask: 0x0000 4/3 0.N 0.N 2054 V : 2012 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x0004 5/4 0.N 0.N 2108 V : 2118 V ± 100 V 06-21 15:18:49 Set Ped Mask: 0x0004 5/4 0.N 0.N 2108 V : 2118 V ± 100 V 06-21 15:18:49 Set Ped Mask: 0x0004 6/4 0.N 0.N 2123 V : 2132 V ± 100 V 06-21 15:18:49 mtc: ine delay 0ps 7/5 0.N 0.N 2110 V : 2118 V ± 100 V 06-21 15:18:49 mtc: ine delay 0ps 7/5 0.N 0.N 2110 V : 2118 V ± 100 V 06-21 15:18:49 mtc: inglese rate set to 8/5 0.N 0.N 2099 V : 2022 V ± 100 V 06-21 15:18:49 mtc: pulser rate set to 8/5 0.N 0.N 2371 V : 2368 V ± 100 V <td></td> <td>-0.66 -0.62</td> <td>Spare</td>		-0.66 -0.62	Spare	
06-21 15:18:48 Set Ped Mask: 0x0004 5/4 ON ON 2108 V : 2118 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x0004 5/4 ON ON 2108 V : 2118 V ± 100 V 06-21 15:18:48 Set Ped Mask: 0x0004 6/4 ON ON 2123 V : 2132 V ± 100 V 06-21 15:18:49 mtc: coarse delay 340 6/4 ON ON 2110 V : 2118 V ± 100 V 06-21 15:18:49 mtc: coarse delay 340 6/4 ON ON 2110 V : 2118 V ± 100 V 06-21 15:18:49 mtc: coarse delay 340 6/4 ON ON 2110 V : 2118 V ± 100 V 06-21 15:18:49 mtc: pulser rate set to 8/5 ON ON 2099 V : 2022 V ± 100 V 06-21 15:18:49 mtc: pulser rate set to 8/5 ON ON 2371 V : 2368 V ± 100 V 06-21 15:18:49 mtc: pulser rate set to 10/6 ON ON 2252 V : 2192 V ± 100 V <td></td> <td>-0.6</td> <td>DCR Ac</td>		-0.6	DCR Ac	
06-21 15:18:49 Set Ped Mask: 0x0004 5/4 ON ON 2108 V : 2118 V ± 100 V 06-21 15:18:49 mtc: coarse delay 340 6/4 ON ON 2123 V : 2132 V ± 100 V 06-21 15:18:49 mtc: coarse delay 340 6/4 ON ON 2110 V : 2132 V ± 100 V 06-21 15:18:49 mtc: coarse delay 340 0 ON ON 2110 V : 2118 V ± 100 V 06-21 15:18:49 mtc: pulser rate set to 8/5 ON ON 2099 V : 2022 V ± 100 V 06-21 15:18:49 mtc: pulser rate set to 8/5 ON ON 2371 V : 2368 V ± 100 V 06-21 15:18:49 mtc: pulser rate set to 9/6 ON ON 2371 V : 2368 V ± 100 V 06-21 15:18:49 mtc: pulser rate set to 10/6 ON ON 2225 V : 2192 V ± 100 V			Comp. (
0.21 15:18:49 mtc: coarse delay 340 6/4 ON ON 2123 V : 2132 V ± 100 V 0.6-21 15:18:49 mtc: coarse delay 340 6/4 ON ON ON 2123 V : 2132 V ± 100 V 0.6-21 15:18:49 mtc: tine delay 0ps 7/5 ON ON 2110 V : 2118 V ± 100 V 0.6-21 15:18:49 mtc: pulser rate set to 8/5 ON ON 2099 V : 2022 V ± 100 V 0.6-21 15:18:49 mtc: pulser rate set to 8/5 ON ON 2371 V : 2368 V ± 100 V 0.6-21 15:18:49 mtc: pulser rate set to 10/6 ON ON 2227 V ± 100 V			Bubbler	
06-21 15:18:49 mtc: fine delay 0ps 7/5 ON ON 2110 V : 2118 V ± 100 V 06-21 15:18:49 mtc: pulser rate set to 8/5 ON ON 2099 V : 2022 V ± 100 V 06-21 15:18:49 mtc: pulser rate set to 8/5 ON ON 2099 V : 2022 V ± 100 V 06-21 15:18:49 mtc: pulser rate set to 9/6 ON ON 2371 V : 2368 V ± 100 V 0 snoperator - snc 10/6 ON ON 2225 V : 2192 V ± 100 V	✓ ~ 2132 V ± 10	100 V 0.8	✓ Cavity F	
No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No.	✓ ~ 2118 V ± 10	100 V 0x40000000	SLAssa	
OB-21 15 28:51 Saved Configuration: / 9/6 ON ON 2371 V : 2368 V ± 100 V Image: Strategy of the strategy of	✓ ~ 2022 V ± 10	100 C V 0 YES	AV Reci	
Image: Snoperator - snc 10/6 ON ON 2225 V : 2192 V ± 100 V	✓ ~ 2368 V ± 10	100 C V YES	Scint. F	
	✓ ~ 2192 V ± 10	100 C V 104	Spare	
Jun 16:00:01 gps * gps scrip 11/7 ON ON 2325 V : 2351 V ± 100 V	✓ ~ 2351 V ± 10	100 C V 24 0x10	- opene	
Jun 16:09:04 data * consumer 12/8 ON ON 2188 V : 2189 V ± 100 V	💟 ~ 2189 V ± 10	00 🗘 V 0		
Jun 16:91:00 gps * 10 MHz c1 13/8 ON ON 2237 V : 2221 V ± 100 V	✓ ~ 2221 V ± 10	100 C V		
Jun 16:01:04 gps * respricing Jun 16:01:04 gps * loading 1 14/9 ON ON 1908 V : 1928 V ± 100 V	✓ ~ 1928 V ± 10	100 Ç V		
Jun 16:91:94 gps * successfu 15/9 ON ON 1961 V : 1962 V ± 100 V	✓ ~ 1962 V ± 10	100 C V		
Jun 16:02:38 mtc + mtc: gtid Jun 16:02:38 mtc + mtc: gtid 16A/10 ON ON 2008 V : 2011 V ± 100 V	~ 2011 V ± 10	100 C V AEN 99%, disp	100%) GT=67c75	
Jun 16:02:49 check_rates * Po Jun 16:02:49 check_rates * Fo 16B/10 ON ON 2440 V : 2445 V ± 100 V	✓ ~ 2445 V ± 10	100 C V AEN 99%, disp	100%) GT=687d	
Jun 16:02:50 check_rates * Di 17/11 ON ON 1912 V : 1922 V + 100 V	✓ ~ 1922 V + 10	100 AEN 100%, disp) 100%) GT=68d7	
Jun 16:02:59 check_rates # Ig 10/1 0N 0N 1964 V : 1974 V + 100 V	✓ ~ 1979 V + 10	100 C V	40000 OT 1000	
Jun 16:02:52 check_rates + sk		AEN 99%, disp AEN 99%, disp	100%) GT=69321	
Jun 16:02:152 check_rates * sk Jun 16:02:152 check_rates * sk		AEN 99%, disp	100%) GT=69e5	
Jun 16:02:52 check_rates * sk		AEN 99%, disp	100%) GT=6a9a	
Jun 16:02:52 check_rates * sk		AEN 99%, disp	100%) GT=6af4	
Jun 16:02:52 check_rates * sk Jun 16:02:52 check_rates * sk		AEN 99%, disp	100%) GT=6ba7	
Jun 16:02:52 check_rates * skipping 1/4/25 because of bad poll 20240621 16:09:15 EB.1: 2333 evt/s NHIT=87.0 (4474 kB/	s, disk 11 days) 1778 queued (1779 wid) 23338 ou s, disk 11 days) 1602 queued (1602 wid) 23338 ou	ut, 0 orph, 23338 tubii (CAEN 99%, disp ut, 0 orph, 23338 tubii (CAEN 100%. disr	100%) GT=6c03 0 100%) GT=6c5	
Jun 16:02:53 check_rates * Total Screamer (100000 Hz) Count For all Channels: 5 Jun 16:02:56 check rates * High Rate PMTs with NHOP/N20 triggers enabled: 20240621 16:09:35 EB.1: 2251 evt/s NHIT=88.9 (4361 kB/	s, disk 12 days) 1699 queued (1699 wid) 22416 ou	ut, 0 orph, 22416 tubii (CAEN 99%, disp	100%) GT=6cb5	
Jun 16:02:56 check_rates * Low Rate PMTs with N100/N20 triggers enabled: 20240621 16:09:55 End; 2310 evt/s NH11=87.5 (4630 kB/	s, disk 12 days) 42/8 queued (4280 wid) 20541 ou s, disk 11 days) 1695 queued (1695 wid) 25510 ou	ut, 0 orph, 20541 tubii (CAEN 99%, disp ut, 0 orph, 25510 tubii (CAEN 100%, disp	100%) GT=6d0fa	
Jun 16:02:56 check_rates * None! 20246621 16:10:05 EB.1: 2208 evt/s NHIT=87.4 (44:12 kB/) Jun 16:02:56 check_rates * Pushing the data to the detector database.	s, disk 11 days) 1771 queued (1771 wid) 22905 ou	ut, 0 orph, 22905 tubii (CAEN 99%, disp	100%) GT=6dc31	
Jun 16:02:57 check_rates * No SWEBs identified. 20240621 16:10:15 EB.1: 2205 eVt/s NH1=87.9 (3925 kB/ 20240621 16:10:17 EB.0: FIXED MTC GT: was 6e0eb0, now	5, 015k 15 days; /110 queued (/11/ W1d; 1/308 ou 6e2eb0	ac, e orpn, 1/300 tubli (GAEN 99%, disp	100%) 01=0e1D	
Jun 16:10:17 mtc * mtc: gtid jumped from 0x6e2eaf to 0x6e0eb0	s, disk 10 days) 1757 queued (1757 wid) 28083 ou	ut, 0 orph, 28083 tubii (CAEN 100%, disp	100%) GT=6e7	
Jun 16:10:17 mtc * mtc: gtid jumped from 0x6e0eb0 to 0x6e2eb1	o, diek it days) 1/39 dueued (1/39 wid) 22903 ou	ac, e orph, 22903 tubii (CAEN 99%, disp	100%/ 01=0600	
🛃 👯 💋 🖂 🔊 🏶 💷 21 🕮 📒 🛛 🔃 🖓 N 🚣 🚱 É				



Staged deployment

- January March 2024
 - Roboshifter put in control over weekends
 - 38% of shifts
 - Successful! Iron out minor bugs
- March 2024 onward
 - Roboshifter put in control weekends and overnight.
 - 58% of shifts

- Stability is very good
 - Was able to keep SNO+ running during network outages!
- Shifters benefit greatly from Roboshifter,
 - More time to do other things
 - Roboshifter does lots of the book keeping tasks for the shifter during a regular shift.
 - User feedback has been positive.







Staged deployment

- January March 2024
 - Roboshifter put in control over weekends
 - 38% of shifts
 - Successful! Iron out minor bugs
- March 2024 onward
 - Roboshifter put in control weekends and overnight.
 - 58% of shifts

- Stability is very good
 - Was able to keep SNO+ running during network outages!
- Shifters benefit greatly from Roboshifter,
 - More time to do other things
 - Roboshifter does lots of the book keeping tasks for the shifter during a regular shift.
 - User feedback has been positive.







Staged deployment

- January March 2024
 - Roboshifter put in control over weekends
 - 38% of shifts
 - Successful! Iron out minor bugs
- March 2024 onward
 - Roboshifter put in control weekends and overnight.
 - 58% of shifts

- Stability is very good
 - Was able to keep SNO+ running during network outages!
- Shifters benefit greatly from Roboshifter,
 - More time to do other things
 - Roboshifter does lots of the book keeping tasks for the shifter during a regular shift.
 - User feedback has been positive.



Compare Stats for 6 months





Compare Stats for 6 months





Remarks

- Alarms are produced by the Detector... NOT the shifter
 - HOWEVER if a shifter responds slowly, we can generate multiple alarms for a single issue.
 - This could be the origin of the drop in alarm rates during evenings and weekends as automatic actions can fix issues before they cascade.
 - This would naturally impact weekend and night stats more.
- Reminder The goal of Automation was never to reduce alarms! So Use caution/common sense. There are scenarios though where we could get better uptime with its use.

There was a FEC FIFO alarm, but I already fixed it with a resync... you are welcome by the way... I still wanted to call you at 3am to tell you about it though, I'm fine to, not that anyone asks me. I sometimes skip my heartbeat to get attention

Marvin, SNO+'s pal who's fun to be with





Minimum specifications for automation - Revisited

Required:

- 1. Simple Logical program to perform basic case like tasks
- 2. Start, Stop, Restart and Resync runs
- 3. Change runtype (into our maintenance config)
- 4. Communicate with Experts when things go wrong
- 5. Produce a log that can be used by run-selection

Stretch goals

- Produce shift reports like a shifter would
- Multiple lines of communication with Experts
- Slack integration via a bot
- Current and HV tracking! A shifter can do this, but its extremely unlikely a shifter spots changes and alerts experts consistently
- Shown to work despite TERRIBLE outside world network connectivity



Summary

- Thanks to the work of the Expert group, as well as **talented students** and postdocs we have successfully produced an automated shifting tool for SNO+
- The tool can produce shift reports exactly as a human is expected to do.
- The tool can perform basic detector tasks which can aid in clearing of alarms and keeping data flowing.
- The tool acts as an aid to the human shifters, improving the consistency of shift reports and allowing accelerated responses to alarms.

Here I am, brain the size of a planet and they ask me to open a new shift report...

Marvin, SNO+'s pal who's fun to be with



