

# Silicon Vertex Tracker Health Status

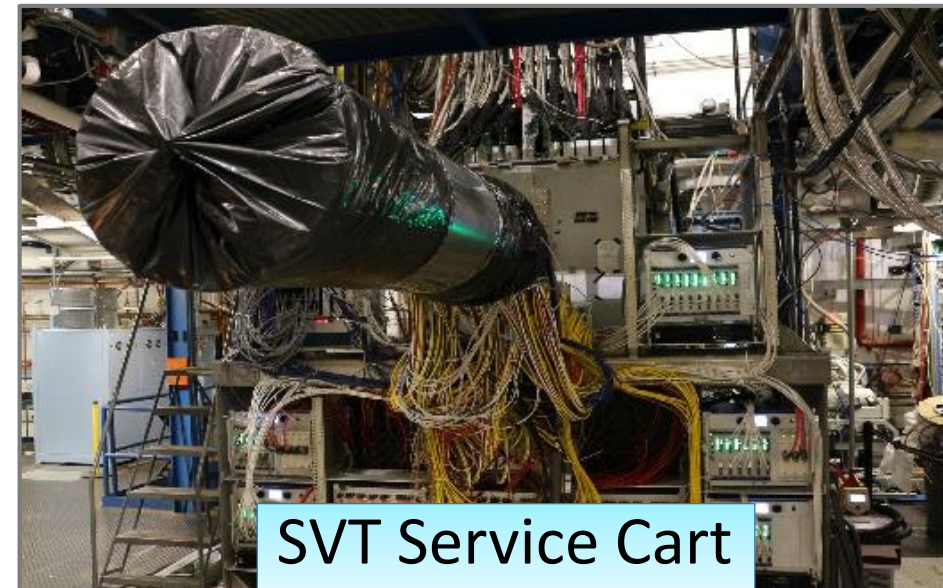
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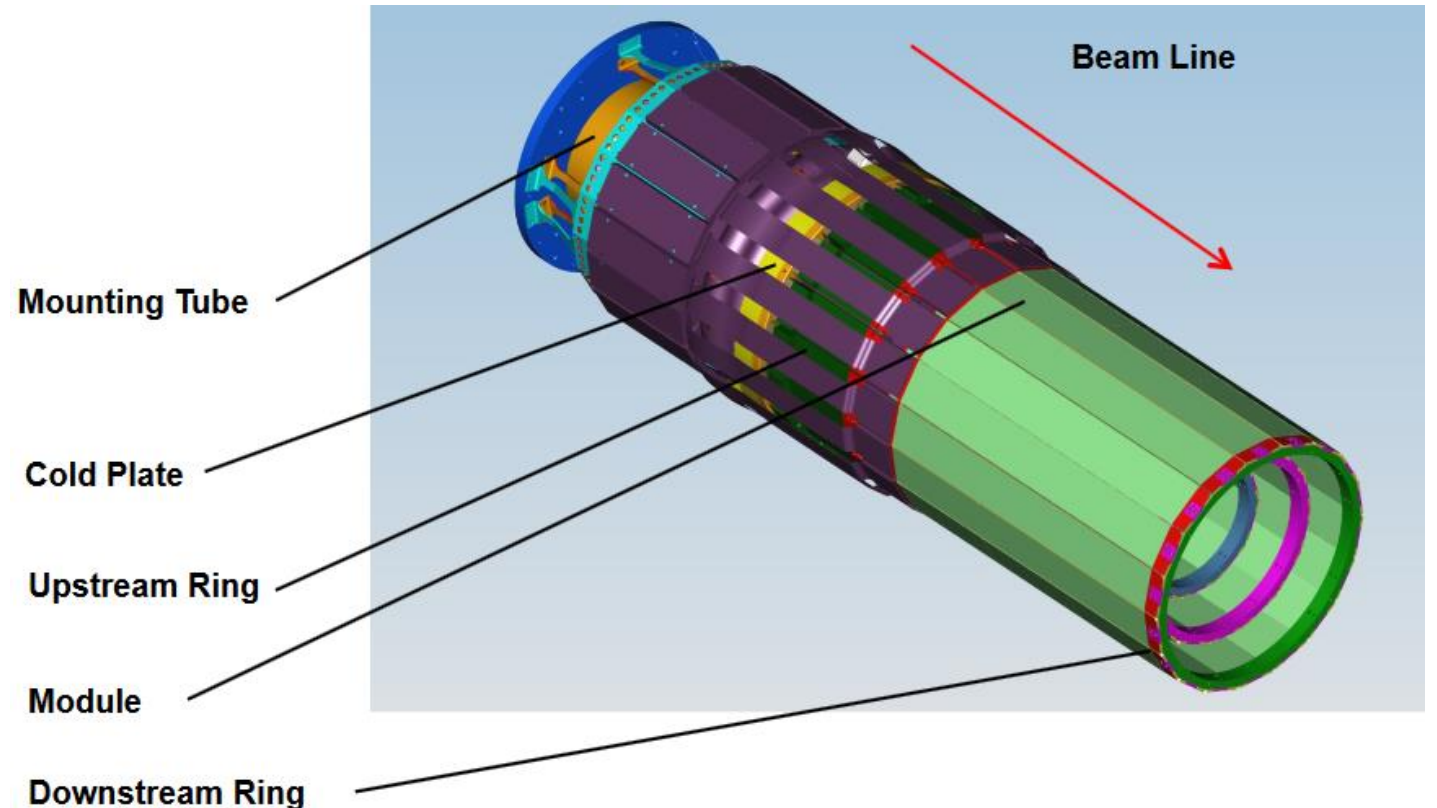
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- Hardware interlocks
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- Cooling
- Leak detection
- Processor replacement
- Conclusion



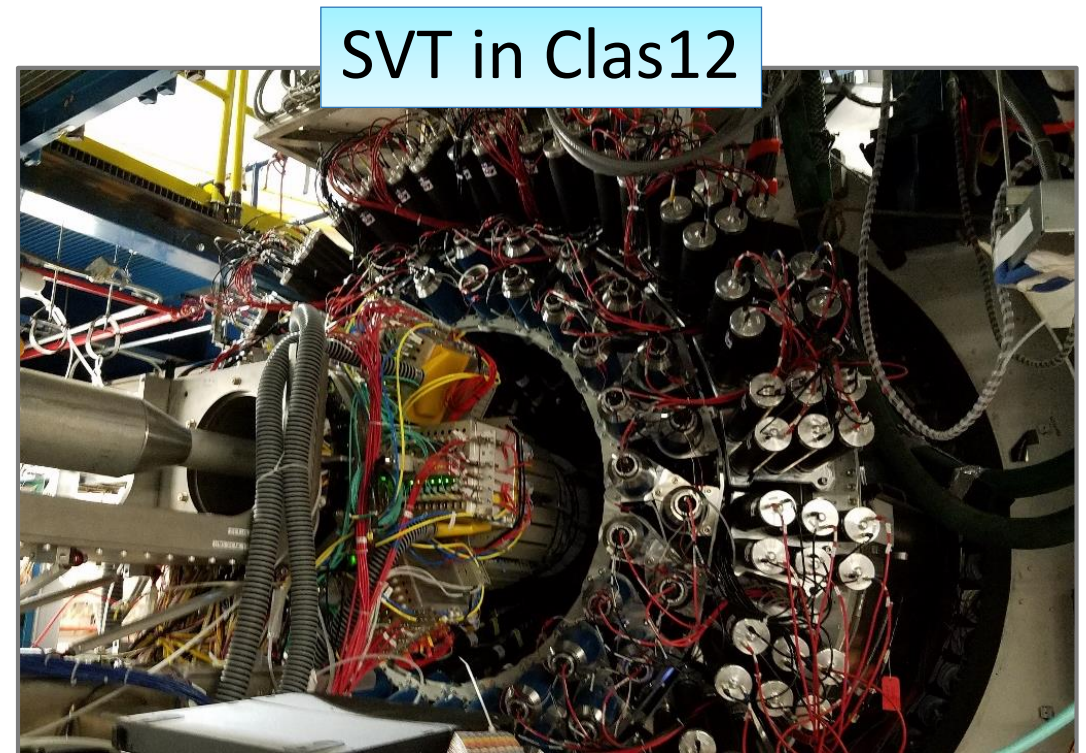
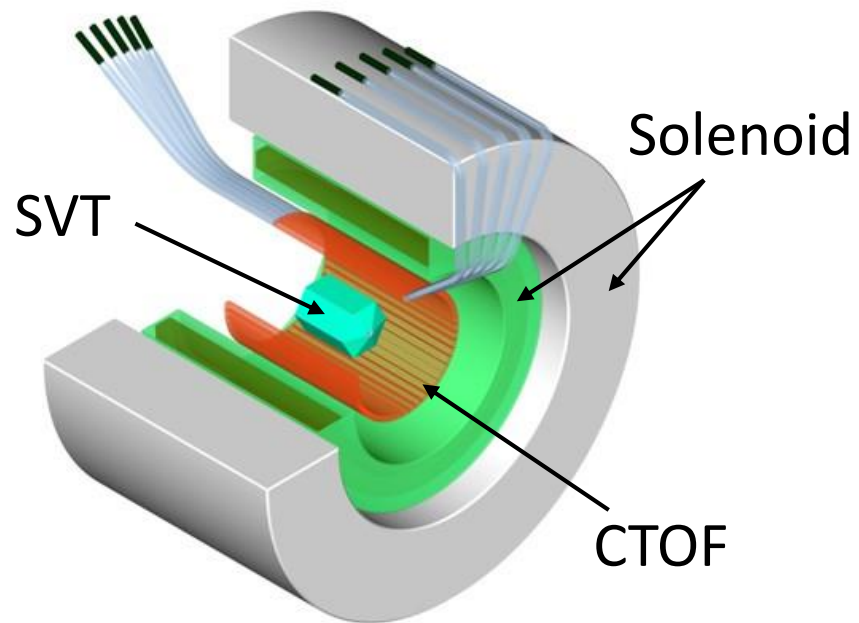
# Detector Overview

- Provides tracking for angles of  $35^\circ$ - $125^\circ$  from beam axis.
- ~34,000 channels for all 4 regions.
- Currently has 3 Regions
  - 4<sup>th</sup> region removed for MVT
- Sectors:
  - 10 for Region 1
  - 14 for Region 2
  - 18 for Region 3



# Detector Overview

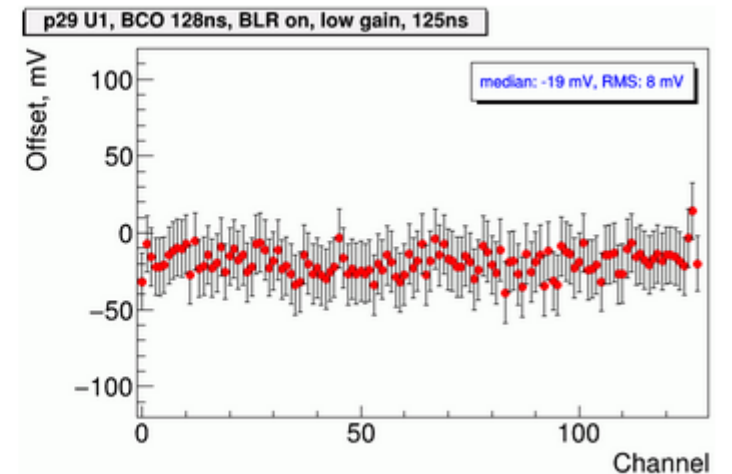
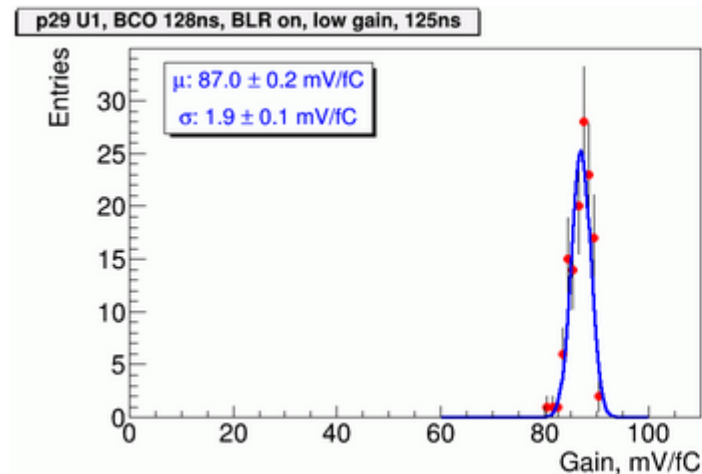
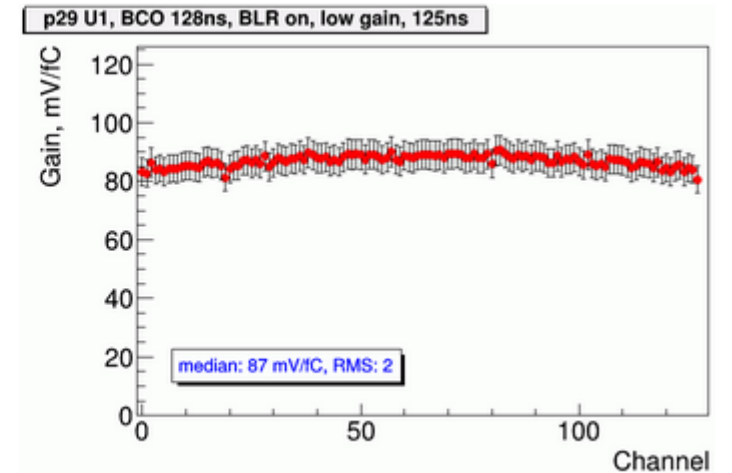
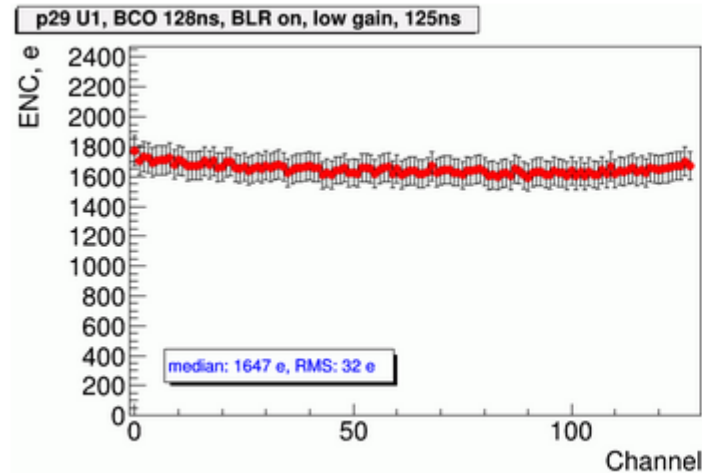
- Installed in Clas12
- Located inside CTOF and solenoid magnet.



# Gain Scans

## Module 29

- Electron Count
  - Median: 1647 e
  - RMS: 32 e
- Gain
  - Median: 87 mV/fC
  - RMS: 2 mV/fC
- Offset
  - Median: -19 mV
  - RMS: 8 mV



# Hardware Interlock System

- Interlock Summary
- Monitors status of:
  - Temperature
  - Humidity
  - Dew Point
  - Coolant
    - Flow
    - Temperature
    - Leak Status

The screenshot displays the 'SVT Hardware Interlock System User Interface'. At the top, a yellow header reads 'SVT Hardware Interlock System User Interface'. Below this, a dark purple bar contains the title 'Interlock Status'. The main interface is divided into several sections:

- Interlock Status Summary:** A row of five green 'OK' buttons with labels: 'Any Interlocks Above Limit?', 'Chiller Enable Status' (Chiller Enabled), 'Mpod LV/HV Enable Status' (LV/HV Enabled), 'Mpod Override' (OK), and 'Chiller Override' (OK).
- System Health:** A small green 'SVT cRIO Heartbeat' indicator and a '6 cRio CPU Usage' display.
- Navigation Tabs:** 'Summary of Interlocks', 'Interlock Status and Signal Monitoring' (active), '(EXPERT) Thresholds and Enable Control Settings', and 'LV/HV Power Supply Inhibits'.
- SVT Sensor Status:** A list of seven sensors, each with a green 'OK' button: Temperature Status, Humidity Status, Dew Point Status, Outlet Coolant Flow Status, Inlet Coolant Flow Status, Coolant Temperature Status, and Coolant Leak Status.
- SVT Latched Errors:** A list of seven latched error states, each with a green 'OK' button: Temperature Latched Error, Humidity Latched Error, Dew Point Latched Error, Outlet Coolant Flow Latched Error, Inlet Coolant Flow Latched Error, Coolant Temperature Latched Error, and Coolant Leak Latched Error.

# Hardware Interlock System

- Interlock status and signal monitoring

**SVT Hardware Interlock System User Interface**

**Interlock Status**

Any Interlocks Above Limit?

OK

Chiller Enable Status

Chiller Enabled

Mpod LV/HV Enable Status

LV/HV Enabled

Mpod Override

OK

Chiller Override

OK

■ SVT cRIO Heartbeat    10 cRio CPU Usage

Summary of Interlocks
Interlock Status and Signal Monitoring
(EXPERT) Thresholds and Enable Control Settings
LV/HV Power Supply Inhibits

**Interlock Status**

**Signal Monitoring**

**Latched Interlock Errors**

High Status	Low Status	
DISABLED	DISABLED	HFCB Temp - R1 M1 Top
DISABLED	DISABLED	HFCB Temp - R2 M1 Top
DISABLED	DISABLED	HFCB Temp - R3 M1 Top
OK	OK	Detector Internal Temp - R2
OK	OK	Detector Internal Temp - R3
OK	OK	Ambient (Room) Temp - T1
OK	OK	Ambient (Room) Temp - T2
OK	OK	Detector Internal Humidity - R2
OK	OK	Detector Internal Humidity - R3
OK	OK	Detector Internal Dew Point - R2
OK	OK	Detector Internal Dew Point - R3
OK	OK	Ambient (Room) Humidity - H1
OK	OK	Ambient (Room) Humidity - H2
OK	OK	Ambient Dew Point - (T1 H1)
OK	OK	Ambient Dew Point - (T2 H2)
OK	OK	Outlet Coolant Flow
OK	OK	Inlet Coolant Flow
OK	OK	Coolant Temp
OK	OK	Coolant Leak

0.00	(°C) HFCB Temp - R1 M1 Top
0.00	(°C) HFCB Temp - R2 M1 Top
0.00	(°C) HFCB Temp - R3 M1 Top
-5.40	(°C) Detector Internal Temp - R2
-7.92	(°C) Detector Internal Temp - R3
26.89	(°C) Ambient (Room) Temp - T1
26.83	(°C) Ambient (Room) Temp - T2
0.15	(%) Detector Internal Humidity - R2
0.4	(%) Detector Internal Humidity - R3
63.9	Detector Internal Dew Point - R2
54.3	Detector Internal Dew Point - R3
32.44	(%) Ambient (Room) Humidity - H1
32.23	(%) Ambient (Room) Humidity - H2
17.90	Ambient Dew Point - (T1 H1)
17.98	Ambient Dew Point - (T2 H2)
1.72	(L/Min) Outlet Coolant Flow
1.60	(L/Min) Inlet Coolant Flow
-22.90	(°C) Coolant Temp

**Reset Latched Errors**  

OFF

High Errors	Low Errors	
OK	OK	HFCB Temp - R1 M1 Top
OK	OK	HFCB Temp - R2 M1 Top
OK	OK	HFCB Temp - R3 M1 Top
OK	OK	Detector Internal Temp - R2
OK	OK	Detector Internal Temp - R3
OK	OK	Ambient (Room) Temp - T1
OK	OK	Ambient (Room) Temp - T2
OK	OK	Detector Internal Humidity - R2
OK	OK	Detector Internal Humidity - R3
OK	OK	Detector Internal Dew Point - R2
OK	OK	Detector Internal Dew Point - R3
OK	OK	Ambient (Room) Humidity - H1
OK	OK	Ambient (Room) Humidity - H2
OK	OK	Ambient Dew Point - (T1 H1)
OK	OK	Ambient Dew Point - (T2 H2)
OK	OK	Outlet Coolant Flow
OK	OK	Inlet Coolant Flow
OK	OK	Coolant Temp
OK	OK	Coolant Leak

# Hardware Interlock System

## Average values:

- Internal temperature: -7 °C
- Ambient temperature: 26 °C
- Internal humidity: 0.3%
- Ambient humidity: 28%
- Internal dew point: -57 °C
- Ambient dew point: 19 °C
- Outlet coolant flow: 1.9 L/m
- Inlet coolant flow: 1.9 L/m
- Coolant temp: -23 °C



# Hardware Interlock System

- Thresholds and enable control settings
  - Enable/Disable settings
  - Trip threshold levels

## SVT Hardware Interlock System User Interface

### Interlock Status

Any Interlocks Above Limit?	Chiller Enable Status	Mpod LV/HV Enable Status	Mpod Override	Chiller Override
OK	Chiller Enabled	LV/HV Enabled	OK	OK

SVT cRIO Heartbeat    7    cRio CPU Usage

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Summary of Interlocks   
 Interlock Status and Signal Monitoring   
 (EXPERT) Thresholds and Enable Control Settings   
 LV/HV Power Supply Inhibits

EPICS Controlled Thresholds    Threshold Control Status

Interlock Sensor Enables	
Disabled	HFCB Temp - R1 M1 Top
Disabled	HFCB Temp - R2 M1 Top
Disabled	HFCB Temp - R3 M1 Top
Enabled	Detector Internal Temp - R2
Enabled	Detector Internal Temp - R3
Enabled	Ambient (Room) Temp - T1
Enabled	Ambient (Room) Temp - T2
Enabled	Detector Internal Humidity - R2
Enabled	Detector Internal Humidity - R3
Enabled	Detector Internal Dew Point - R2
Enabled	Detector Internal Dew Point - R3
Enabled	Ambient (Room) Humidity - H1
Enabled	Ambient (Room) Humidity - H2
Enabled	Ambient Dew Point - (T1 H1)
Enabled	Ambient Dew Point - (T2 H2)
Enabled	Outlet Coolant Flow
Enabled	Inlet Coolant Flow
Enabled	Coolant Temp
Enabled	Coolant Leak

Temperature Interlock Trip Thresholds			
High Temperature	Low Temperature		
34 ≥ °C	-12 ≤ °C	↕	HFCB Temp - R1 M1 Top
34 ≥ °C	-12 ≤ °C	↕	HFCB Temp - R2 M1 Top
34 ≥ °C	-12 ≤ °C	↕	HFCB Temp - R3 M1 Top
26 ≥ °C	-20 ≤ °C	↕	Detector Internal Temp - R2
26 ≥ °C	-20 ≤ °C	↕	Detector Internal Temp - R3
36 ≥ °C	-12 ≤ °C	↕	Ambient (Room) Temp - T1
36 ≥ °C	-12 ≤ °C	↕	Ambient (Room) Temp - T2

Humidity Interlock Trip Thresholds			
High Humidity	Low Humidity		
25 ≥ %	-1 ≤ %	↕	Detector Internal Humidity - R2
25 ≥ %	-1 ≤ %	↕	Detector Internal Humidity - R3
71 ≥ %	-1 ≤ %	↕	Ambient (Room) Humidity - H1
71 ≥ %	-1 ≤ %	↕	Ambient (Room) Humidity - H2

Coolant Trip Thresholds			
High Flow	Low Flow		
11 ≥ L/Min	0.3 ≤ L/Min	↕	Outlet Coolant Flow
11 ≥ L/Min	0.15 ≤ L/Min	↕	Inlet Coolant Flow
High Temperature	Low Temperature		
20 ≥ °C	-28 ≤ °C	↕	Coolant Temp

Dew Point Trip Thresholds	
3 ≤	↕ Detector Internal Dew Point - R2
3 ≤	↕ Detector Internal Dew Point - R3
3 ≤	↕ Ambient Dew Point - (T1 H1)
3 ≤	↕ Ambient Dew Point - (T2 H2)

983.24    cRio Uptime (Hours)

# Hardware Interlock System

- LV/HV power supply inhibits
  - HV: 60 V
    - Voltage set lower for noisy modules.
      - R1S2B at 12.5 V
  - LV Analog: 2.4 V
  - LV Digital: 3.2 V

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- Interlock Status Summary:** A row of five status indicators, each in a green box:
  - Any Interlocks Above Limit?: OK
  - Chiller Enable Status: Chiller Enabled
  - Mpod LV/HV Enable Status: LV/HV Enabled
  - Mpod Override: OK
  - Chiller: (partially visible)
- Navigation Tabs:** Summary of Interlocks, Interlock Status and Signal Monitoring (selected), (EXPERT) Thresholds and Enable Control Settings, LV/HV Power Supply Inhibits.
- SVT LV/HV Power Supply Inhibits:** A detailed view of inhibits, including:
  - Crate Inhibits Table:**

Crate #	Main Inhibit	Input Fail	Output Fail	Action
1	no inhibit	no failure	no failure	Clear
3	no inhibit	no failure	no failure	Clear
4	no inhibit	no failure	no failure	Clear
  - HV Channel Output Inhibits Table:**

Region	Inhibits	Crate
1	0	1
2	0	3
3	0	4
  - Clear All Inhibits:** A button at the bottom of the inhibits section.

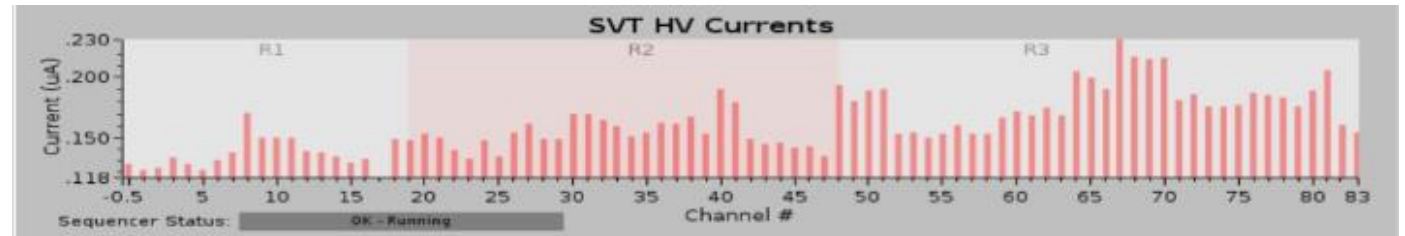
# Hardware Interlock System

- Hardware interlock signals added to MYA archiving.
  - 118 signals
- Signal averaging implemented in hardware interlocks.
  - Uses average value of set amount of signals to prevent occasional out-of-threshold values from tripping system.
    - 100 signals
- Trip delay option added to hardware interlocks.
  - Avoids signals tripping system that exist for less than specified timeframe.
  - Delay set for 3 seconds.
- Temperature fixed to allow for negative values.
  - Interlocks program read negative values as 999°C.

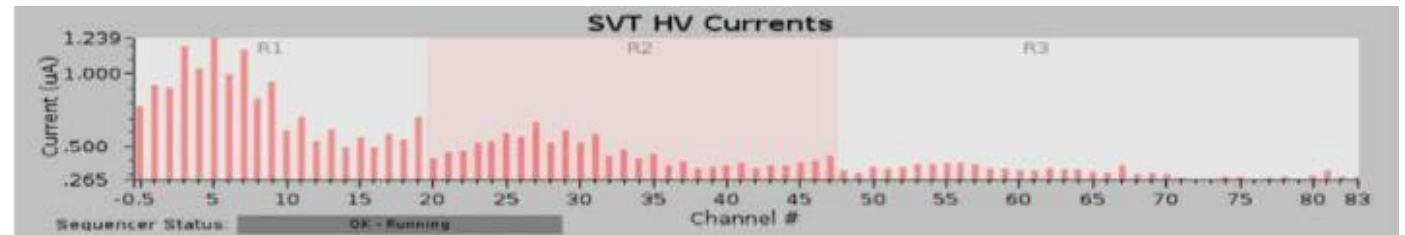
# Current Monitoring

- SVT Region 1 suffered radiation damage from beam.
  - Region 1 modules may be replaced with Region 4 modules (removed for MVT).
- R1 before radiation:
  - HV 60V
  - Hybrid Temp  $\sim 13\text{ }^{\circ}\text{C}$
  - Current Average  $\sim 0.135\text{ }\mu\text{A}$
- R1 after radiation:
  - HV 50V
  - Hybrid Temp  $\sim 13\text{ }^{\circ}\text{C}$
  - Current Average  $\sim 0.8\text{ }\mu\text{A}$

Before



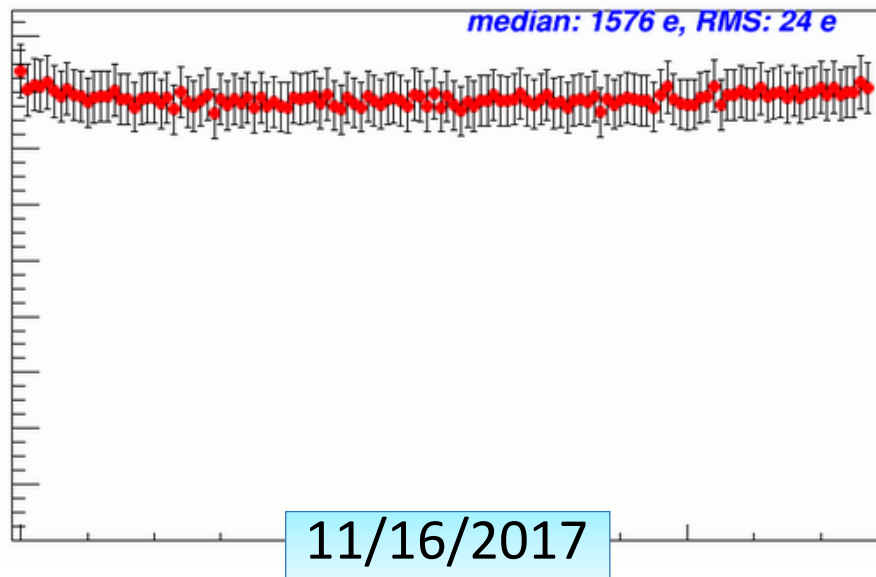
After



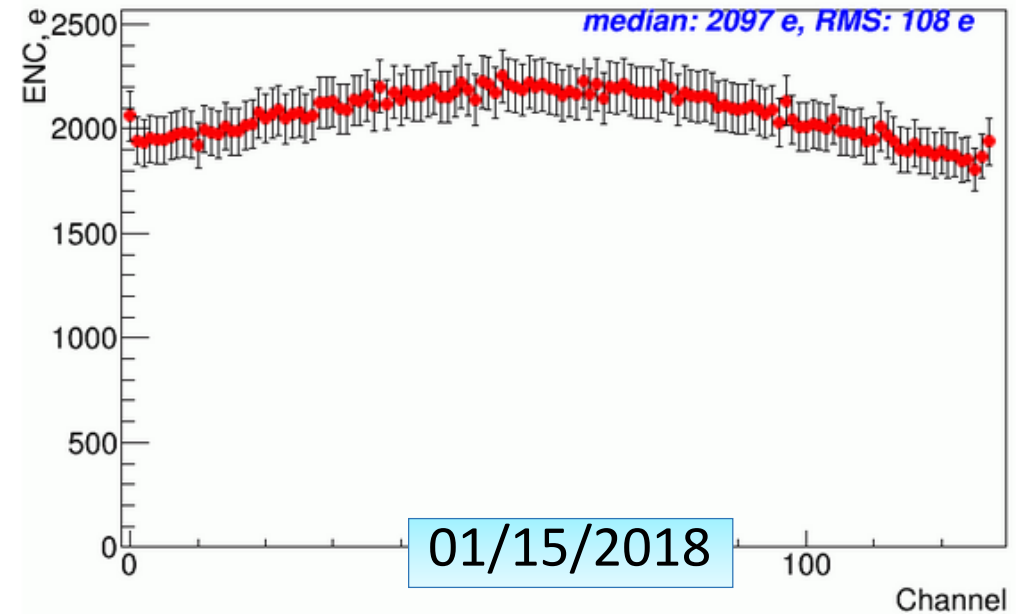
# Current Monitoring

- Module 26
  - Region 1, sector 5
  - 1576 e-count before radiation damage.
  - 2097 e-count after radiation damage.

p26 U1, BCO 128ns, BLR on, low gain, 125ns



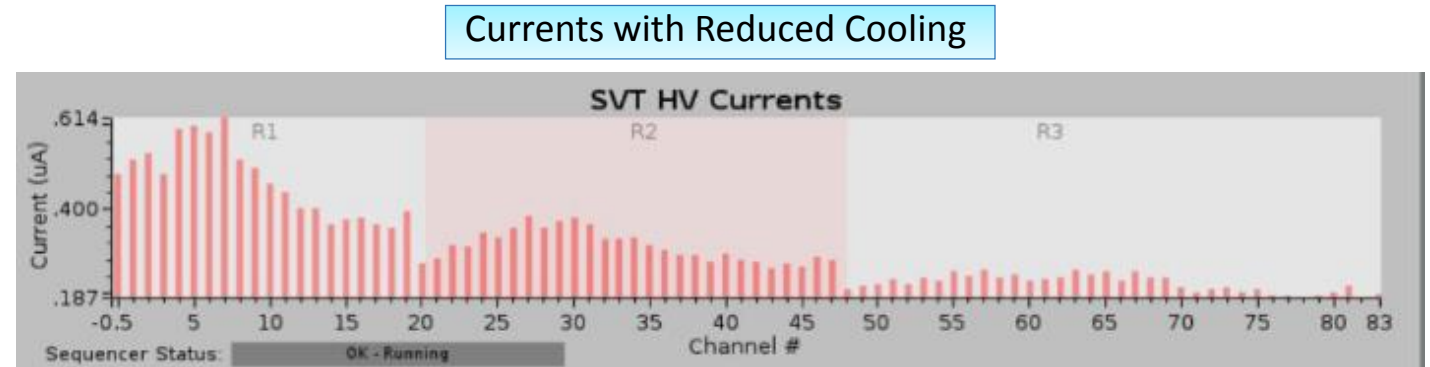
p26 U1, BCO 128ns, BLR on, low gain, 125ns



# Current Monitoring

- To reduce leakage current of Region 1 modules, cold plate chiller temperature and R1 voltages were reduced.

- R1 after cooling:
  - HV 50V average
  - Hybrid Temp  $\sim 1.5$  °C
  - Current Average  $\sim 0.46$   $\mu$ A



- Further radiation exposure will increase current with time.

# Cooling

- Anova A40 chiller would not function properly at negative temperatures.
  - Spare Lauda chiller connected in series with Anova.
    - Anova running at -31 °C.
    - Lauda running at -25 °C.
- Second relay box assembled and connected to hardware interlock to minimize down-time in case of chiller failure.
  - Relay box used to turn off chiller in case of loss of connection to interlock system.
  - Current relay box designed for 110 V outlet, whereas spare Lauda has 208 V plug.
- Four MFCs were installed for N<sub>2</sub> flow to prevent condensation and increase cooling.
  - Total flow rate 40 L/m

# Leak Detection

- Leak sensor installed on service cart.
- Implemented in hardware interlocks program.
- Sensor kept tripping interlocks.
  - Signal averaging implemented.
    - 100 signals





# Processor Replacement

- After power outage on 03/06/18, hardware interlocks cRIO processor failed to boot.
- Failed cRIO was NI-9067, a series which previously had processor failures.
  - Same series was used on Torus and Solenoid magnets.
    - Both failed.
- NI-9035 cRIO ordered to replace NI-9067.

# Conclusion

- Interlock system's hardware and software issues have been resolved.
- Radiation damaged R1 modules *will* have to be replaced.
- SVT's health is **“Good”**.