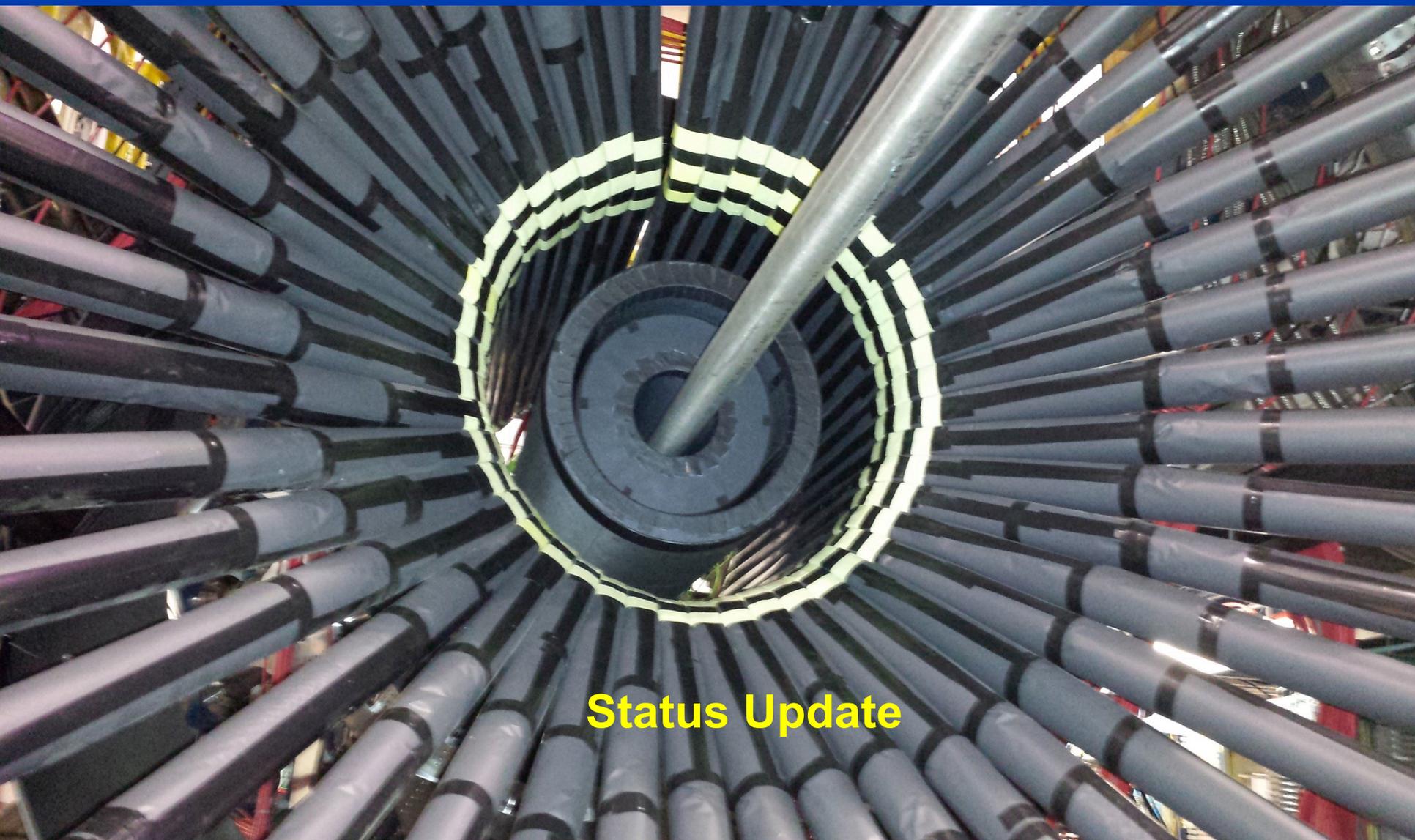


CLAS12 Silicon Vertex Tracker



Status Update

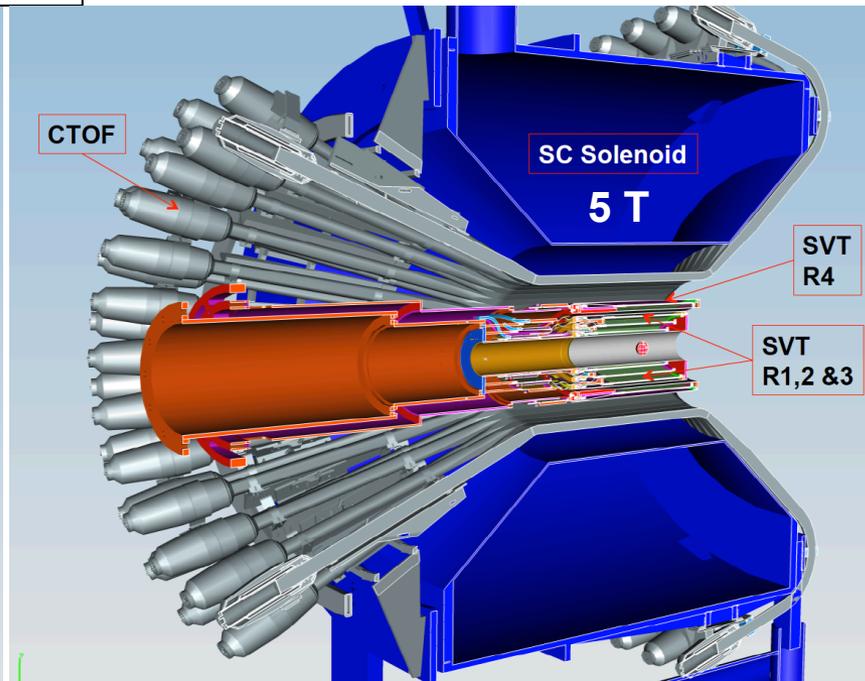
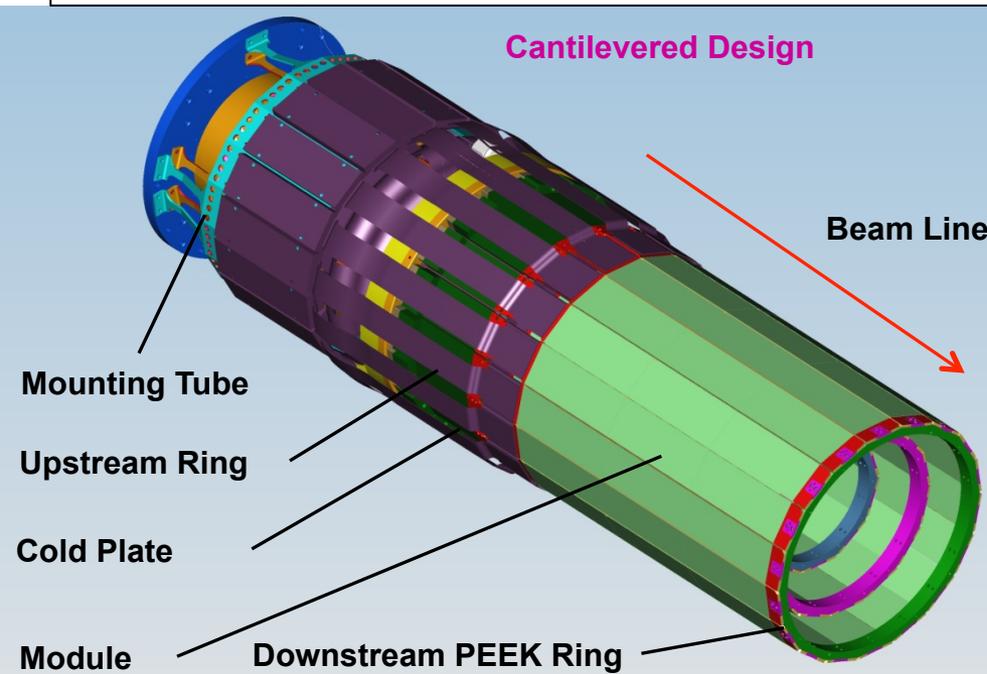
Outline

- ❑ **System Overview**
- ❑ **DAQ Status**
- ❑ **Slow Controls**
- ❑ **Operation and Safety**
- ❑ **Documentation**
- ❑ **Geometry Validation**
- ❑ **Alignment Status**
- ❑ **Calibration**
- ❑ **Detector Monitoring**
- ❑ **Detector Commissioning with Cosmics**
- ❑ **Performance in KPP**
- ❑ **CVT Integration**
- ❑ **Summary and Outlook**

System Overview

- Four regions (radii 65, 93, 120, 161 mm)
- 1% of radiation length per region
- 66 sectors/modules (10, 14, 18, 24)
- Two concentric barrels (MicroMegas upgrade)

- Silicon area $\sim 1.5 \text{ m}^2$
- Channels: $\sim 34,000$
- Bonds: $\sim 200,000$



- Cantilevered cylinders with support rings
- Double sided modules with 3 daisy chained sensors
- Single sided sensors with graded pitch
- Rigi-flex hybrid with extended L1 disconnect

DAQ Status

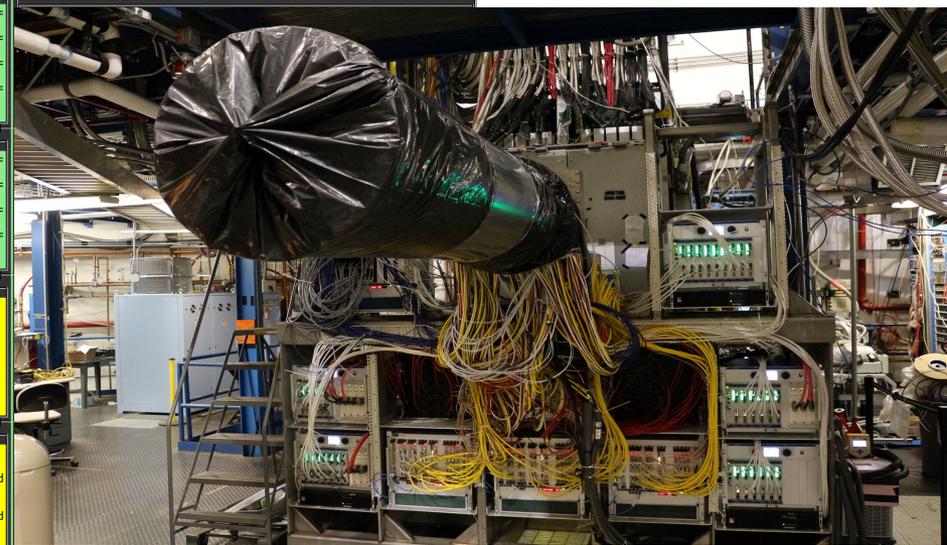
- Running stable, tested with week long runs
- Tested with SVT standalone (SD) and CLAS triggers
- High trigger rate test (80 kHz) with simplified configuration done
 - Will complete the test in normal operating conditions

The screenshot displays the RunControl software interface with several panels:

- Control Panel:** Includes buttons for Cancel, Reset, Disconnect, End Run, and Pause.
- Static parameters:** Shows Database (classvt), Session (classvt257), Configuration (svt123_er), and rcServer (svtsystem1.jlab.org).
- Session status:** Data file name is /home.local/clasrun/data/svt123. Config file name is /usr/clas12/release/1.3.0/parms/trigger/clasrun.cnf.
- Run status:** Run number 144, Run status active, Start time May 19 18:28:27. Limits: Events 0, KBytes 0.
- Run progress:** Events this run: 921571. Read From: ER11. Rates table:

Rates	Events/S	Rate (KB/S)
Integrated	9.0634	4.4020
Differential	10.0000	5.3320
- Process Monitors:** Multiple windows showing process statistics for svt1, svt2, svt3, and EB11 on svtsystem1, including waiting and processing times.
- Log Console:** Shows system messages and warnings, such as "CODA_write_event: WARN: ER is backed up! This may be causing system dead time".

Sergey Boiarinov
Ben Raydo



Slow Controls

Nathan Baltzell
Wesley Moore
Ken Livingstone



Page Experts

JMenu

Detectors

CTOF

DC

ECAL

FTOF

HTCC

LTCC

CVT

FT

CND

RICH

Slow Control and Monitoring System transferred to CS-Studio

- summary status records and overview screen
- soft IOCs running on CLAS machines
- all screens converted from EDM, tested in CS-Studio, with improvements
- alarms converted to **BEAST**
- moved soft interlocks from AIH into IOCs
- remote access to the system with VDI and VNC
- stable running on a clon pc
- autosave / restore to IOCs
- SVT ON/OFF GUI, HV control script

Future improvements:

- authentication
- ANOVA chiller control



<https://hallbopi.jlab.org>

Web OPI

SVT Overview

Region Status: ON/OFF

Region	ALARM	HV ON/OFF	LV ON/OFF
Region 1	OK	ALL ON	ALL ON
Region 2	OK	ALL ON	ALL ON
Region 3	OK	ALL ON	ALL ON

Soft Interlocks: ALL ON

Hard Interlocks: HV/LV Inhibit

Chiller: Status ON

IOCs: R1, R2, R3, Chille, Intlks, VME, cRio

Expert Humidity Interlock OK

Humidity SB	Sensor 1	Sensor 2	Value	Status
Humidity SB1	25.7	OK	OK	
Humidity SB2	27.5	OK	OK	
Humidity SB3	31.3	OK	OK	
Humidity SB4	24.2	OK	OK	
Humidity SB5	25.6	OK	OK	
Humidity SB6	27.6	OK	OK	
Humidity SB7	44.6	OK	OK	
Humidity SB8	39.2	OK	OK	
Humidity SB9	44.5	OK	OK	
Humidity SB10	46.9	OK	OK	
Ex Humidity SB1	47.3	OK	OK	
Ex Humidity SB2	46.8	OK	OK	

Expert Dewpoint Interlock OK

DewTempDiff SB	Sensor 1	Sensor 2	Value	Status
DewTempDiff SB1	14.9	OK	OK	
DewTempDiff SB2	14.5	OK	OK	
DewTempDiff SB3	13.7	OK	OK	
DewTempDiff SB4	15.2	OK	OK	
DewTempDiff SB5	14.9	OK	OK	
DewTempDiff SB6	14.5	OK	OK	
DewTempDiff SB7	11.1	OK	OK	
DewTempDiff SB8	12.2	OK	OK	
DewTempDiff SB9	11.1	OK	OK	
DewTempDiff SB10	10.7	OK	OK	
Ex DewTempDiff SB1	10.5	OK	OK	
Ex DewTempDiff SB2	10.6	OK	OK	

Expert Ambient Temp Intlk OK

Temp SB	Sensor 1	Sensor 2	Value	Status
Temp SB1	14.8	OK	OK	
Temp SB2	13.6	OK	OK	
Temp SB3	12.2	OK	OK	
Temp SB4	15.8	OK	OK	
Temp SB5	14.9	OK	OK	
Temp SB6	13.6	OK	OK	
Temp SB7	13.2	OK	OK	
Temp SB8	13.4	OK	OK	
Temp SB9	13.6	OK	OK	
Temp SB10	13.3	OK	OK	
Ex Temp SB11	20.3	OK	OK	
Ex Temp SB12	20.9	OK	OK	

Expert Coolant Flow Interlock

Parameter	Value	Status
Inlet Flow	-0.00 LPM	OK
Outlet Flow	1.99 LPM	OK
Inlet Temp	7.17 deg C	OK
R4 Outlet Flow	2.03 LPM	OK
Inlet Pressure	6.84 PSI	OK

Web OPI

Region Status: ON/OFF

Region	ALARM	HV ON/OFF	LV ON/OFF
Region 1	OK	ALL ON	ALL ON
Region 2	OK	ALL ON	ALL ON
Region 3	OK	ALL ON	ALL ON

Soft Interlocks: ALL ON

Hard Interlocks: HV/LV Inhibit

Chiller: Status ON

IOCs: R1, R2, R3, Chille, Intlks, VME, cRio

Slow Controls (Expert Level)

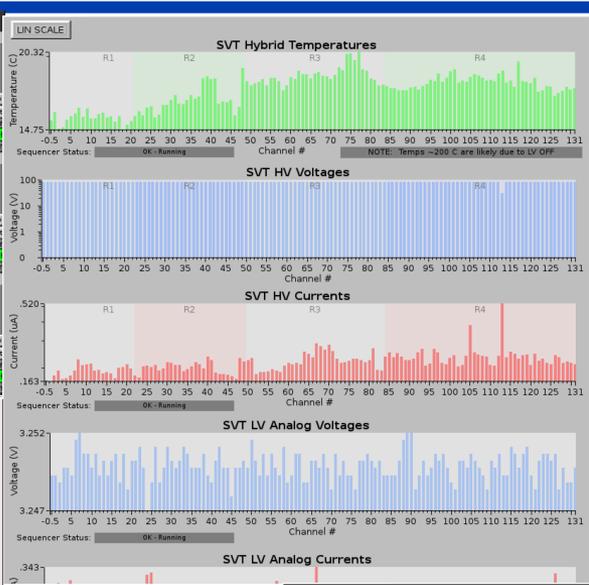
SVT

- Overview
- Crate Monitoring & Control
- Mpod Module Status
- Highland V450 Modules
- Chiller Control
- Gas System
- Interlocks
- IOCs
- Save/Restore
- Old Alarm Handler

SVT Region 3

Crate #3 Off

Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
A Top LV: On, D Top LV: On, Top HV: On	A Top LV: On, D Top LV: On, Top HV: On	A Top LV: On, D Top LV: On, Top HV: On	A Top LV: On, D Top LV: On, Top HV: On	A Top LV: On, D Top LV: On, Top HV: On	A Top LV: On, D Top LV: On, Top HV: On
LV Bat On: On, LV Bat Off: On, HV Top On: On, HV Top Off: On	LV Bat On: On, LV Bat Off: On, HV Top On: On, HV Top Off: On	LV Bat On: On, LV Bat Off: On, HV Top On: On, HV Top Off: On	LV Bat On: On, LV Bat Off: On, HV Top On: On, HV Top Off: On	LV Bat On: On, LV Bat Off: On, HV Top On: On, HV Top Off: On	LV Bat On: On, LV Bat Off: On, HV Top On: On, HV Top Off: On
LV Alarm: LV OK, LV Alarm: Temp Alarm, HV Alarm: LV OK, HV Alarm: Temp Alarm	LV Alarm: LV OK, LV Alarm: Temp Alarm, HV Alarm: LV OK, HV Alarm: Temp Alarm	LV Alarm: LV OK, LV Alarm: Temp Alarm, HV Alarm: LV OK, HV Alarm: Temp Alarm	LV Alarm: LV OK, LV Alarm: Temp Alarm, HV Alarm: LV OK, HV Alarm: Temp Alarm	LV Alarm: LV OK, LV Alarm: Temp Alarm, HV Alarm: LV OK, HV Alarm: Temp Alarm	LV Alarm: LV OK, LV Alarm: Temp Alarm, HV Alarm: LV OK, HV Alarm: Temp Alarm



SVT Chiller Controls

CHILLER ON | CHILLER OFF | COOLING OFF | COOLING ON | COOLING AUTO

CHILLER ON | COOLING AUTO

PUMP LEVEL 5 | LEVEL 5

Temp Setpoint: 7.0 | 7.0

External Temp: 6.980

Controlled Temp: 6.980

Temp Hi Limit: 23.0 | 23.0

Temp Low Limit: 4.0 | 4.0

OverTemp Trip: 40

Coolant Inlet Flow: -0.00 LPM

Coolant Outlet Flow: 1.99 LPM

Coolant Inlet Temp: 7.17 deg C

Coolant Inlet Pressure: 6.80 PSI

R4 Outlet Flow: 2.03 LPM

Status: Error, Alarm, Warning, WARM

SVT Region 1

WIENER MPD (4787066, MPD 2.1.3156.0)

SVT R1:LV:HV R2:HV

EPICS PV Name	MPD NAME	VOLTAGE (V)	CURRENT (I)	SET VOLTAGE	SET CURRENT	SWITCH	TEMP
LV_B_SVT_LV_VA_R1S1T_Slot1	U0	3.24902	0.31055	3.25000	0.50000	On	30
LV_B_SVT_LV_VD_R1S1T_Slot1	U1	3.24951	0.18091	3.25000	0.50000	On	30
LV_B_SVT_LV_VA_R1S1B_Slot1	U2	3.24902	0.31763	3.25000	0.50000	On	30
LV_B_SVT_LV_VD_R1S1B_Slot1	U3	3.24805	0.15771	3.25000	0.50000	On	29
LV_B_SVT_LV_VA_R1S2T_Slot1	U4	3.24854	0.32764	3.25000	0.50000	On	29
LV_B_SVT_LV_VD_R1S2T_Slot1	U5	3.25049	0.17017	3.25000	0.50000	On	28
LV_B_SVT_HV_R1S1T_Slot7	U600	85.00122	0.16346	85.00000	4.00000	On	28
LV_B_SVT_HV_R1S1B_Slot7	U601	85.00085	0.16552	85.00000	4.00000	On	28
LV_B_SVT_HV_R1S2T_Slot7	U602	84.99991	0.17824	85.00000	4.00000	On	28
LV_B_SVT_HV_R1S2B_Slot7	U603	85.00220	0.19275	85.00000	4.00000	On	28
LV_B_SVT_HV_R1S3T_Slot7	U604	84.99994	0.17144	85.00000	4.00000	On	28
LV_B_SVT_HV_R1S3B_Slot7	U605	85.00136	0.16693	85.00000	4.00000	On	28

SVT Hybrid Temps

R1511T	15.34	R451T	17.97
R1511B	15.89	R451B	17.52
R1512T	14.81	R452T	17.51
R1512B	14.89	R452B	17.77
R1513T	15.37	R453T	17.96
R1513B	15.40	R453B	17.73
R154T	17.51	R454T	17.51
R154B	16.78	R454B	17.62
R155T	15.55	R455T	17.46
R155B	16.40	R455B	17.64
R156T	15.48	R456T	17.80
R156B	15.48	R456B	18.13
R157T	15.75	R457T	18.02
R157B	15.85	R457B	18.66
R158T	15.52	R458T	17.97
R158B	15.62	R458B	18.29
R159T	15.23	R459T	18.77
R159B	15.41	R459B	18.91
R1510T	14.71	R4510T	17.78
R1510B	15.48	R4510B	17.07
R1511T	15.28	R4511T	17.96
R1511B	15.62	R4511B	18.31
R1512T	15.41	R4512T	18.64
R1512B	15.44	R4512B	18.44
R1513T	15.64	R4513T	18.26
R1513B	15.69	R4513B	18.64
R1514T	15.51	R4514T	18.12
R1514B	15.51	R4514B	18.48
R1515T	15.61	R4515T	18.61
R1515B	16.31	R4515B	18.82
R1516T	15.47	R4516T	17.91
R1516B	15.46	R4516B	18.27
R1517T	15.81	R4517T	17.62
R1517B	16.41	R4517B	19.53
R1518T	15.94	R4518T	18.01
R1518B	16.29	R4518B	18.91
R1519T	15.29	R4519T	17.66
R1519B	15.94	R4519B	18.27
R1520T	15.79	R4520T	17.76
R1520B	15.89	R4520B	17.93
R1521T	15.18	R4521T	17.67
R1521B	15.18	R4521B	17.93
R1522T	15.82	R4522T	17.28
R1522B	15.55	R4522B	16.95
R1523T	16.58	R4523T	17.28
R1523B	16.58	R4523B	17.93

SVT - Gas System

N2 Supply Flow: 0.45 | 0.45 lpm

cRio Heartbeat: ●

Main Switch: 1 | On | ON | OFF

System Hardware Reset: RST

Output No: 0 | P

Groups No: 0 | P

Power Supply Up Time: 94176360

Power Supply Serial No: P

Dynamic IP Addr: P

Static IP Addr: P

MAC Address: P

icccssvtr1 stats

icccssvtr1 stats

System Description: WIENER MPD (4787066, MPD 2.1.3156.0)

Main Switch: On | ON | OFF | Clear Events All Modules: Clear

Main On: On

Main Inhibit: no inhibit

Local Control Only: nonlocal control allowed

Input Failure: no failure

Output Failure: no failure

Fantray Failure: no failure

Sensor Failure: no failure

Vme System Failure: no failure

Power Supply Up Time: 35699582

Power Supply Serial No: P

Dynamic IP Addr: P

Static IP Addr: P

MAC Address: P

icccssvtr1 stats

SVT R1:LV:HV R2:HV

Nathan Baltzell, Wesley Moore, Ken Livingstone

System Operation and Safety

- **OSPs** – Hazards and mitigations (*subject matter experts*)
 - **EPICS based Detector Control and Safety System**
 - **BEAST Alarm Handler** (*slow controls, cooling and gas purging*)
 - **Hardware interlocks and hardware parameter limits**
 - **LV, HV, currents, temperature, humidity, dew point, and flow software parameter limits**
 - **EPICS monitoring/time histories in MYA database for the past 2 years**
 - **Cables (UL CL-2 rating – signal and power), QA travelers**
 - **Grounding (reviewed by Fast Electronics Group and external reviewers)**
 - **Electronics (UL/TUV approved)**
 - **Quality Assurance procedures and safety reviews, assembly travelers**
- **Operations Manuals** – *details for shift workers and system experts*
- **Data Quality Monitoring, Validation and Calibration suites**
- **Engineering FEA calculations**
- **ANSYS thermal analysis**
- **ANSYS quench analysis of the cold plate**
- **Magnetic fields for the crates in the service cart**
- **Electronic logbooks for the past 3 years**

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Org: PHALLB		Saved: 7/25/2016 2:49:48 PM	
		Submitted: 7/25/2016 2:49:49 PM	
Jefferson Lab <small>Thomas Jefferson National Accelerator Facility</small>		Operational Safety Procedure Review and Approval Form # 61740 <small>(See 2.8.6.3 Manual Chapter 3.11.1 Appendix 1, Operational Safety Procedure LOSTP and Temporary LOSTP Procedures for Instructions)</small>	
Type:	OSP	Click for OSP/TOSP Procedure Form Click for LOSTP Procedure Form	
Serial Number:	ENP-16-61740-OSP		
Issue Date:	8/1/2016		
Expiration Date:	8/1/2017		
Title:	Silicon Vertex Tracker Commissioning for installation in CLAS12		
Location: <small>(where work is being performed)</small>	Experimental Equipment Lab (EEL) - 12A	Location Detail: <small>(Specify about where in the subarea the work is being performed)</small>	EEL12A clean room, Hall B, Level 1
Business Travel Pass			
Risk Classification: <small>(See JLAB Manual Chapter 3.10 Appendix 23 Risk Class Assessment)</small>	Without mitigation measures (3 of 4):		I
Reason:	This document is written to mitigate hazard issues that are: <i>Not applicable</i>		
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Procedure: 331011Form_SVT.pdf			
TIA: 321011Form_SVT.pdf			

Detector Safety Control and Monitoring: Alarm Handler / IOC

- Alarm handler in BEAST
- Interlocks (hardware, software)
- IOC Health
- Crate Inhibits
- Color coded screens

IOC Health - SVT

softIOCs

IOC Name	Hostname	Up Time	Heartbeat	Expert	Soft Reboot	Last Reboot	Console	Hard Reboot
iocsoftsvtR1	clonioc1.jlab.org	8 days, 08:41:03	722462			05/12/2017 14:05:26		
iocsoftsvtR2	clonioc1.jlab.org	1 day, 04:22:09	102128			05/19/2017 18:24:20		
iocsoftsvtR3	clonioc1.jlab.org	8 days, 08:41:03	722461			05/12/2017 14:05:27		
iocsoftsvtR4	clonioc1.jlab.org	8 days, 08:41:02	722460			05/12/2017 14:05:28		
iocsoftsvtChiller	clonioc1.jlab.org	2 days, 12:59:54	219594			05/18/2017 09:46:34		
iocsoftsvtIntk	clonioc1.jlab.org	8 days, 08:40:19	722419			05/12/2017 14:06:09		

VME IOCs

IOC Name	Hostname	Up Time	Heartbeat	Expert	Soft Reboot	Last Reboot	Hard Reboot
iocvmesvt	classcsvt	1 day, 05:06:47	104807			05/19/2017 16:39:41	

cRIO

cRio Name	Up Time	CPU Load
B_HW_CRIO_SVT	207602 s	13.2 %

CS-Studio (on clonioc2.jlab.org)

SVT Status R3

LV R3 On	HV R3 ...	LV R3 Off	SVT Region 3	Crate #3 Off

Alarm Area Panel

Beamline	Solenoid	Torus
CND	CTOF	FTOF
DC	ECAL	PCAL
FT	HTCC	LTCC
RICH	SVT	MVT
Weather	DAQ	COMMS

Alarm Tree

HallB

- Area: SVT
 - System: Gas
 - System: SLOW_CONTROLS_VT
 - System: MPOD_CRATE_#1
 - System: MPOD_CRATE_#2
 - System: MPOD_CRATE_#3
 - System: MPOD_CRATE_#4
 - System: MPOD_CRATE_#5
 - System: IOC_WATCHDOGS
 - System: R1
 - System: HV
 - System: TOP
 - System: BOTTOM
 - System: LV_VA
 - System: LV_VD
 - System: TEMP
 - System: S2
 - System: S3

SVT LV/HV Power Supply Inhibits

Crate #	Crate Inhibits		Clear
	Main Inhibit	Input Fail	
1	no inhibit	no failure	
2	no inhibit	no failure	
3	no inhibit	no failure	
4	no inhibit	no failure	
5	no inhibit	no failure	

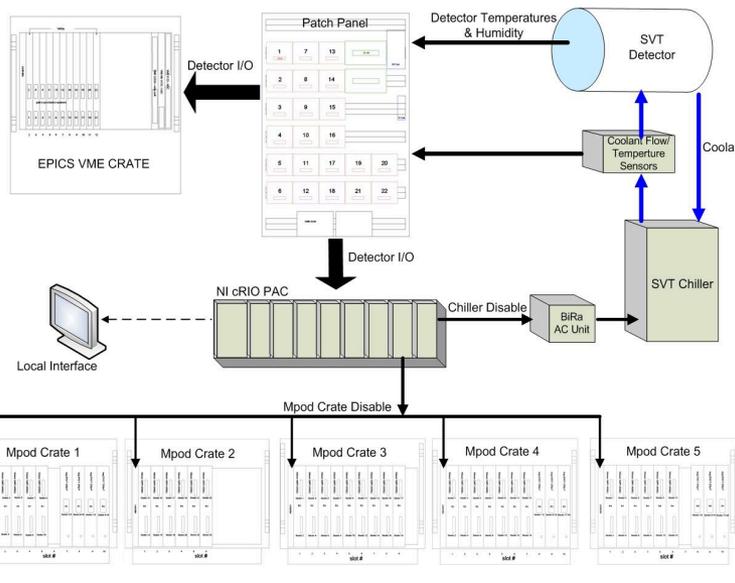
HV Channel Output Inhibits

Region #	Inhibit	(Crate #)
1	0	(Crate #1)
2	0	(Crate #1)
3	0	(Crate #4)
4	0	(Crate #5)

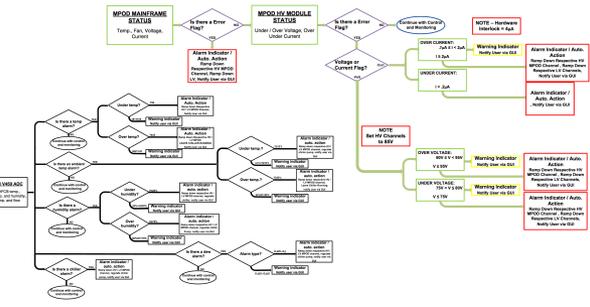
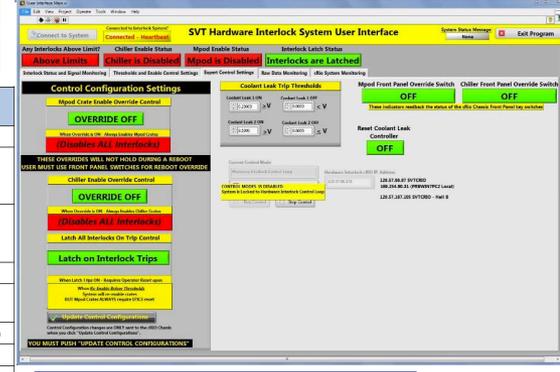
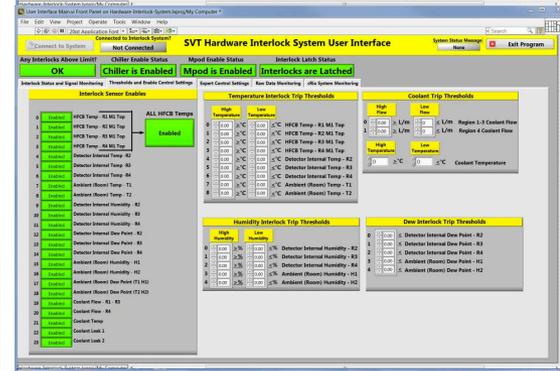
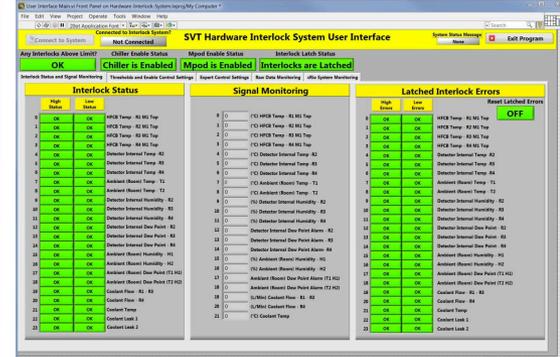
Clear All Inhibits

Detector Safety Control and Monitoring: Hardware Interlock

- Fault charts
- Color coded screens
- HW interlock to EPICS / CSS
 - ETA July 2017



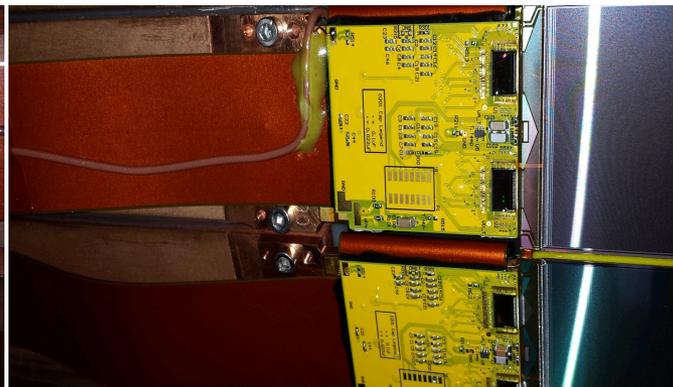
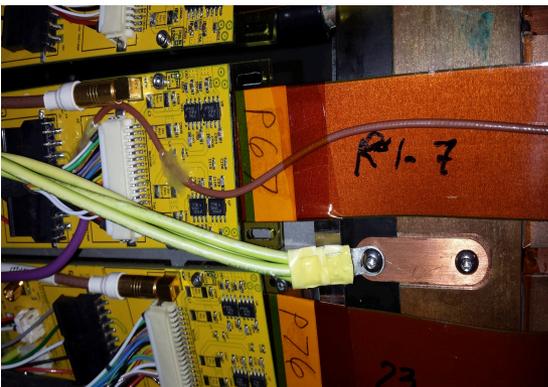
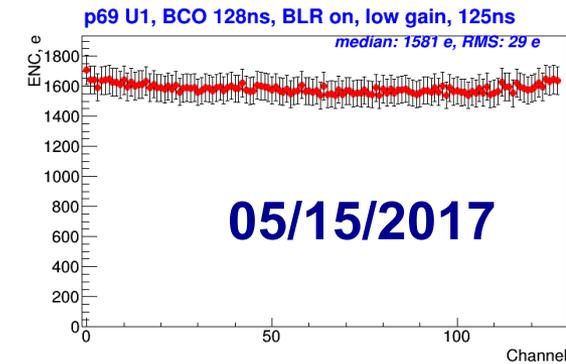
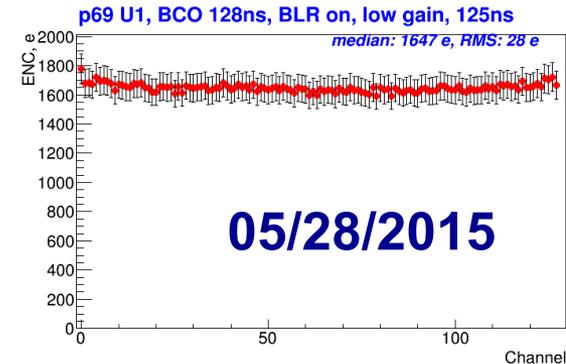
Category	Part	Part Number	Manufacturer	Notes
MPOD CRATE 1	1	9100-00-0000	NI	NI-9402 Analog Input Module
	2	9100-00-0000	NI	NI-9402 Analog Input Module
	3	9100-00-0000	NI	NI-9402 Analog Input Module
	4	9100-00-0000	NI	NI-9402 Analog Input Module
	5	9100-00-0000	NI	NI-9402 Analog Input Module
	6	9100-00-0000	NI	NI-9402 Analog Input Module
	7	9100-00-0000	NI	NI-9402 Analog Input Module
	8	9100-00-0000	NI	NI-9402 Analog Input Module
	9	9100-00-0000	NI	NI-9402 Analog Input Module
	10	9100-00-0000	NI	NI-9402 Analog Input Module
MPOD CRATE 2	1	9100-00-0000	NI	NI-9402 Analog Input Module
	2	9100-00-0000	NI	NI-9402 Analog Input Module
	3	9100-00-0000	NI	NI-9402 Analog Input Module
	4	9100-00-0000	NI	NI-9402 Analog Input Module
	5	9100-00-0000	NI	NI-9402 Analog Input Module
	6	9100-00-0000	NI	NI-9402 Analog Input Module
	7	9100-00-0000	NI	NI-9402 Analog Input Module
	8	9100-00-0000	NI	NI-9402 Analog Input Module
	9	9100-00-0000	NI	NI-9402 Analog Input Module
	10	9100-00-0000	NI	NI-9402 Analog Input Module



Signal Name	Number of Channels	Input / Output	Description
HFCB Temperature	4	Analog Inputs	Monitors top side of a subset of modules in R1, R2, R3, R4 RTD's are mounted in the support rings. The Hardware Interlock System will use the backup sensors (to be disconnected in EPICS).
Detector Internal Temperature	3	RTD Inputs	Humidity sensors are mounted in the support rings. The Hardware Interlock System will use the backup sensors (to be disconnected in EPICS).
Detector Internal Humidity / Dew Point	3	Analog Inputs	Humidity sensors are mounted in the support rings. The Hardware Interlock System will use the backup sensors (to be disconnected in EPICS).
Ambient Temperature	2	RTD Inputs	RTD's are mounted externally to the detector.
Ambient Humidity / Dew Point	2	Analog Inputs	Humidity sensors are mounted externally to the detector.
Coolant Flow	2	Analog Inputs	Measures coolant flow (external from chiller) (R1-3) + (R4)
Coolant Temperature	1	Analog Input	Measures coolant temperature (external from chiller)
Coolant Leak Detection	1	Analog Input	Checks for coolant leaks via sensor mounted in drip pan.
Chiller Disable	1	Analog Output	Signal to BiRa AC Unit - Removes 120VAC from Chiller.
Mpod HV/LV Crate Disable	5	TTL Outputs	Signals to Mpod crate controllers to ramp down LV & HV

Operational Stability

- Detector operating stable since integration time
- Channel calibration data in elog for past 3 years
- Slow controls data in MYA for past 2 years
- 8 modules with hybrid leakage kludged
 - Stable leakage currents
- Stability test operational (8 modules on the bench)
 - 24/7 monitoring for over 6 months
- Large cosmic data sample collected
- No new bad channels
- **Outstanding issue:**
 - **R1S2B high leakage current in the HFCB**



Documentation

Technical Design Report



Geometry Document



Commissioning Document



Reconstruction Algorithms



Manufacturing Drawings and Schematics



Assembly/Service Procedures



Production, Assembly, and Survey Databases and Travelers



Operations Manual and Safety Procedures



Bench Testing Results



Electronic Logbooks



SVT presentations



CLAS Notes and Conference Reports



Photographic History



Wiki pages



Archival webpage



Fermilab

Process Document Database

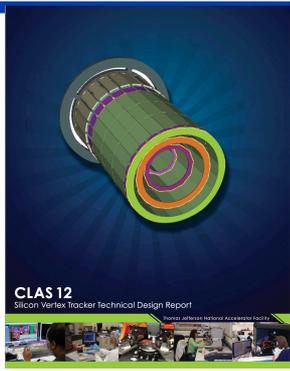
Document List by Topic

This document is in the Lab Silicon Vertex Tracker Project and sub-projects available:

Project/Doc #	Title	Author(s)	Topic(s)	Last Updated
2255-57	Production Models, CDRs, CDRs, CDRs	Suzuki, Mikami	Assembly, QC, Draw	31 May 2014
2255-64	Production, Backing, Stripping, CDRs, CDRs, File	Suzuki, Mikami	Assembly, QC, Draw	23 May 2014
1833-12	Flange - Top Side, Service Installation	Greg DeLo	Assembly, Drawing	20 May 2014
2211-09	Blank Transfer Frame for Module & FSSR	Greg DeLo	Module, Backing, Stripping, FSSR, Card	22 Apr 2014
2866-11	Flange measurement of rev. 3, AB, 8mm	Greg DeLo	Sketch	31 Mar 2014
2212-18	CDR, Draw File - Module, Service Alignment	Greg DeLo	Assembly, QC, Draw	17 Mar 2014
2865-07	CDR, Production, Draw - Backing, Stripping	Greg DeLo	Backlog, Stripping	14 Mar 2014
2213-09	Production for Module, Assembly	Greg DeLo	Module	13 Mar 2014
2865-12	Inspection Results - Incoming, copper & FSSR, 8mm	Greg DeLo	Assembly, QC, Draw	12 Feb 2014
2865-11	LAB/PSA, Module, production, for SVT	Project, Management	09 Feb 2014
2865-11	LAB/PSA, Summary of Work, SVT	Project, Management	09 Feb 2014
2252-12	Alignment check of silicon detector in the new service installation, 8mm	Greg DeLo	Assembly, Drawing	25 Nov 2013
2262-17	Flange - Bottom Side, Service Installation	Greg DeLo	Assembly, Drawing	13 Nov 2013
2213-11	Module Transfer, Service, Copper	Assembly, QC, Draw	21 Oct 2013
1833-13	Flange Design, Service, List	Greg DeLo	Assembly, Drawing	07 Aug 2013
1833-15	Backlog, Stripping, Site, Lamination, Layout	Greg DeLo	Backlog, Stripping	07 Aug 2013
2865-11	Flange - Module, Yielding, Report	Greg DeLo	Assembly, Drawing	05 Aug 2013
1761-12	Module, Mechanical, Drawing	Suzuki, Mikami	Module, Backing, Stripping	05 Aug 2013
1833-12	Flange - Backing, Stripping, Mold	Greg DeLo	Assembly, Drawing	02 Aug 2013
2262-11	Fast, Skids - Lab, Production, Readout	Richard D. Zorf	Readout	22 Jul 2013
2865-11	Draw, Skids - Quality, Inspection	Yuri Gotra	Readout	22 Jul 2013
2865-11	Draw, Skids - Lab, Production, Readout, Montage	Greg DeLo	Readout	21 Jul 2013
2262-18	Flange - Module, Storage, Box	Greg DeLo	Module	22 May 2013

Click to open

- Photographic History
- Operation and Safety
- Wiki Pages
- Detector Description
- SVT Presentations
- Technical Documents
- Electronic Logbook
- Publications
- Databases



CLAS12 Silicon Vertex Tracker Technical Design Report

Performance of the CLAS12 Silicon Vertex Tracker modules

M. A. Aronson¹, S. Binneman¹, P. Brossmer¹, L. Ehrhardt^{1,2}, H. Eng¹, V. Geor¹, F. Korfmann¹, M. Leifert¹, S. Meindl¹, M. Mikolajewicz¹, M. Michel¹, M. Riegler¹, W. Trautsky¹, G. Trautsky¹, G. Ungerer¹, A. Zupancic¹, V. Zupancic¹

¹Thomas Jefferson National Accelerator Facility, Newport News, VA, USA
²Department of Physics, Brock University, St. Catharines, Ontario, Canada

Abstract

For the 12 GeV upgrade, the CLAS12 experiment has designed a Silicon Vertex Tracker (SVT) using single sided microstrip sensors fabricated by Hamamatsu. The sensors have graded-gate design to minimize dead areas and a readout pitch of 156 μm with interconnect strip. Double sided SVT modules have three daisy-chained sensors on each side with full strip length of 33 cm. There are 512 channels per module read out by four Fermilab Silicon Strip Reader (FSSR) modules. The SVT modules are assembled on a rigid-flex hybrid. Modules are assembled on the barrel using unique cantilevered geometry to minimize amount of material in the tracking volume. Design and performance of the SVT modules are presented, focusing on results of electrical measurements.

Keywords: Tracking and position-sensitive detectors, Solid state detectors, Hybrid integrated circuits

1. Introduction

The Continuous Electron Beam Accelerator Facility's (CEBAF) Large Acceptance Spectrometer (CLAS12) is being upgraded for the 12 GeV electron beam to conduct spectroscopic studies of excited baryons and of polarized and unpolarized quark distributions. Investigations of the spin structure of nuclear matter on propagating quarks, and measurements of Generalized Parton Distributions (GPDs). Deep exclusive reactions, in which an electron scattering results in a meson baryon final state, provide stringent requirements for the CLAS12 tracking system (see Fig. 1). The central tracker consists of a central, Central Time-of-Flight system (CTOF) and Silicon Vertex Tracker (SVT). The SVT will be centered inside of the CTOF, which has 17 segments fields.

2. SVT Physics requirements

Essential parts of the physics program, such as GPDs, require tracking of low momentum particles with low geometrical uncertainties and about one degree angular resolution at large angles [1]. This is achieved by the SVT. Silicon detector technology offers an excellent match to the central tracking system in the CLAS12 configuration, small size and high luminosity operation that is needed for accurate measurements of exclusive processes at high momentum transfer. SVT provides excellent tracking capabilities in the central detector region:

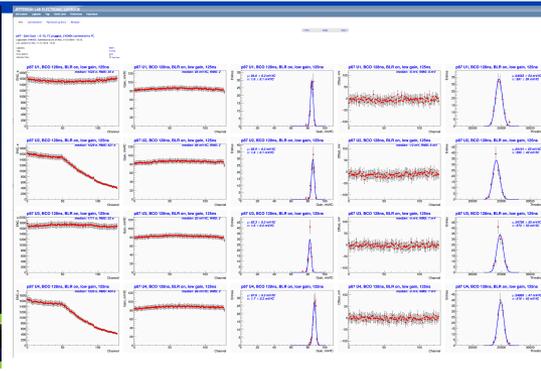
- Measure small baryons and large angle pions, kaons
- Full angle (φ) coverage: 20°–120°
- Azimuthal angle (φ) coverage: ± 90% of 2π
- Momentum resolution: Δp/p ≤ 5%
- Angle resolution: Δθ ≤ 10–20 mrad, Δθ ≤ 5 mrad
- Tracking efficiency: > 90%
- Match up tracks with hits in the CTOF for pions, mesons and kaons (particle ID)
- Reconstructing dihadron vertices, e.g. K_s⁰ → π⁺π⁻, Δ → π⁺π⁻π⁰, etc. for efficient experimental program in strangeness physics
- Stable operation at 10³⁰ cm⁻² s⁻¹ TeV magnetic field at instantaneous luminosities L = 10³⁰ cm⁻² s⁻¹

Expected integrated luminosity per year 500 fb⁻¹. Radiation dose for forward sensors (barrel) targets 1.25 Mrad.

3. Detector design and simulation

The current design of the Barrel Silicon Vertex Tracker (BST) comprises 33792 channels of silicon strip sensors in eight layers.

March 10, 2013



Proceedings of Science

Silicon Vertex Tracker for CLAS12 experiment

Yuri Gotra on behalf of the CLAS Collaboration
 Thomas Jefferson National Accelerator Facility, Newport News, VA, USA
 E-mail: gotra@jlab.org

The Silicon Vertex Tracker is a central tracker built for the CLAS12 experiment aiming at measuring the momentum and reconstructing the vertices of charged particles emerging from the target. The system is designed to operate at a luminosity of 10³⁰ cm⁻² s⁻¹ and to have a momentum resolution of 5% for 1 GeV tracks. The tracker is centered inside ST solenoid magnet and has 33792 channels of Hamamatsu silicon microstrip sensors. To lower the amount of material in the tracking volume modules are assembled on the barrel using unique cantilevered geometry. The sensors have graded angle design to minimize dead areas and a readout pitch of 156 μm. Double sided module hosts three daisy-chained sensors on each side with total strip length of 33 cm. There are 512 channels per module read out by four Fermilab Silicon Strip Reader (FSSR) chips featuring data driven architecture, mounted on a rigid-flex hybrid. We describe the detector and present performance results from tracker commissioning with cosmic muons.

Previous topic

<https://www.jlab.org/Hall-B/cvt/svt/>

CLAS12 Detectors 1.0 documentation »

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SVT Detector Description

- Quick Overview
- Introduction
- SVT Physics requirements
- Detector design and simulation
- SVT Module
- Readout system
- Calibration of the readout chain
- Results of the Full Chain Test
- Calibration Software

SVT Detector Description

Quick Overview

For the 12 GeV upgrade, the CLAS12 Hamamatsu. The sensors have graded-gate design to minimize dead areas and a readout pitch of 156 μm. Double sided module hosts three daisy-chained sensor Silicon Strip Reader (FSSR) chips featuring data driven architecture, mounted on a rigid-flex hybrid. We describe the detector and present performance results from tracker commissioning with cosmic muons.

Introduction

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SVT Detector Description

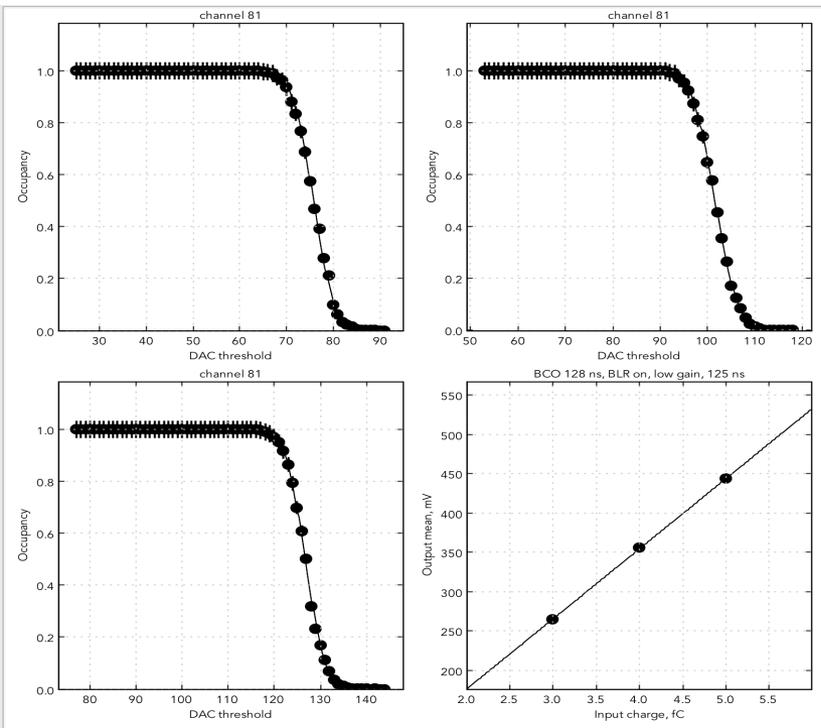
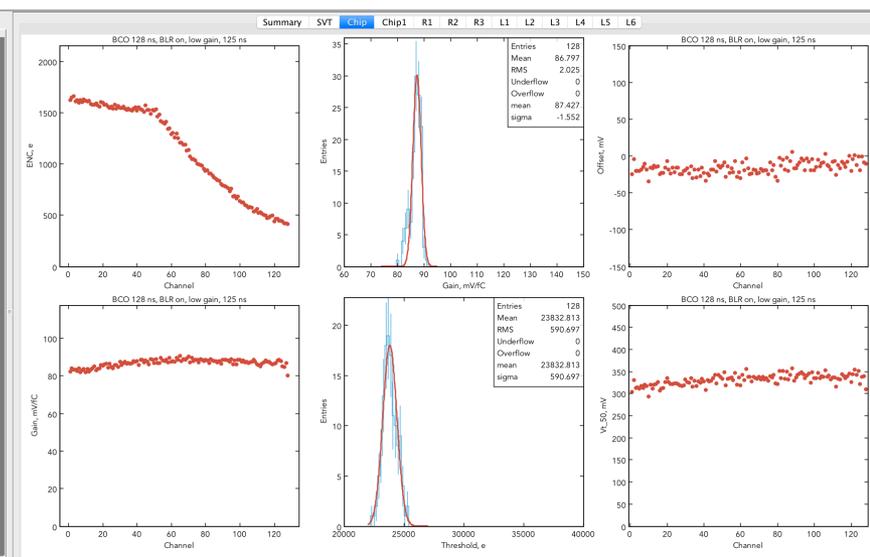
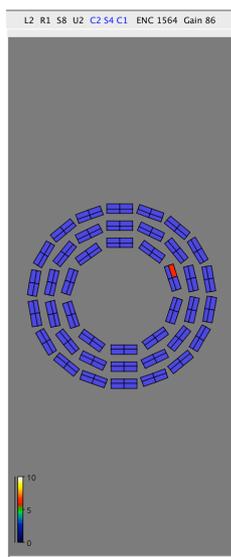
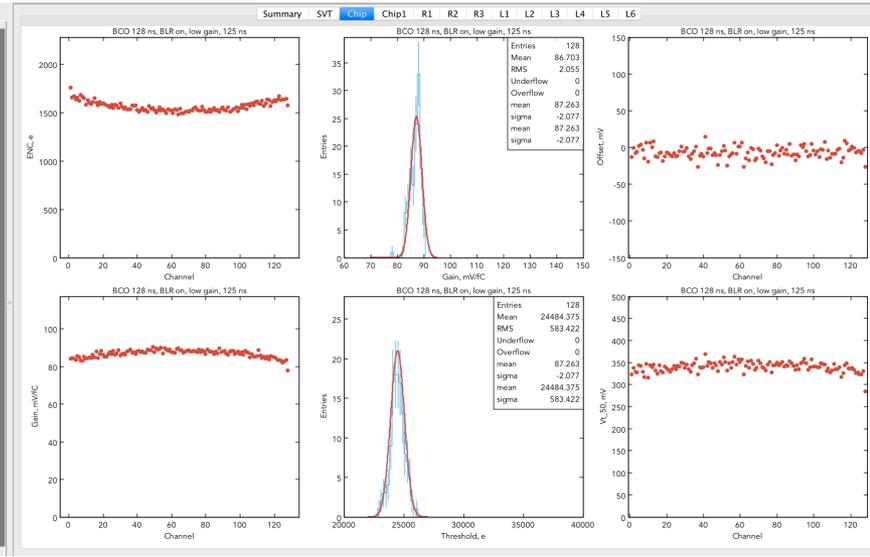
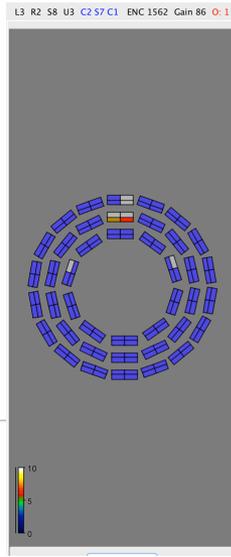
Quick Overview

For the 12 GeV upgrade, the CLAS12 Hamamatsu. The sensors have graded-gate design to minimize dead areas and a readout pitch of 156 μm. Double sided module hosts three daisy-chained sensor Silicon Strip Reader (FSSR) chips featuring data driven architecture, mounted on a rigid-flex hybrid. We describe the detector and present performance results from tracker commissioning with cosmic muons.

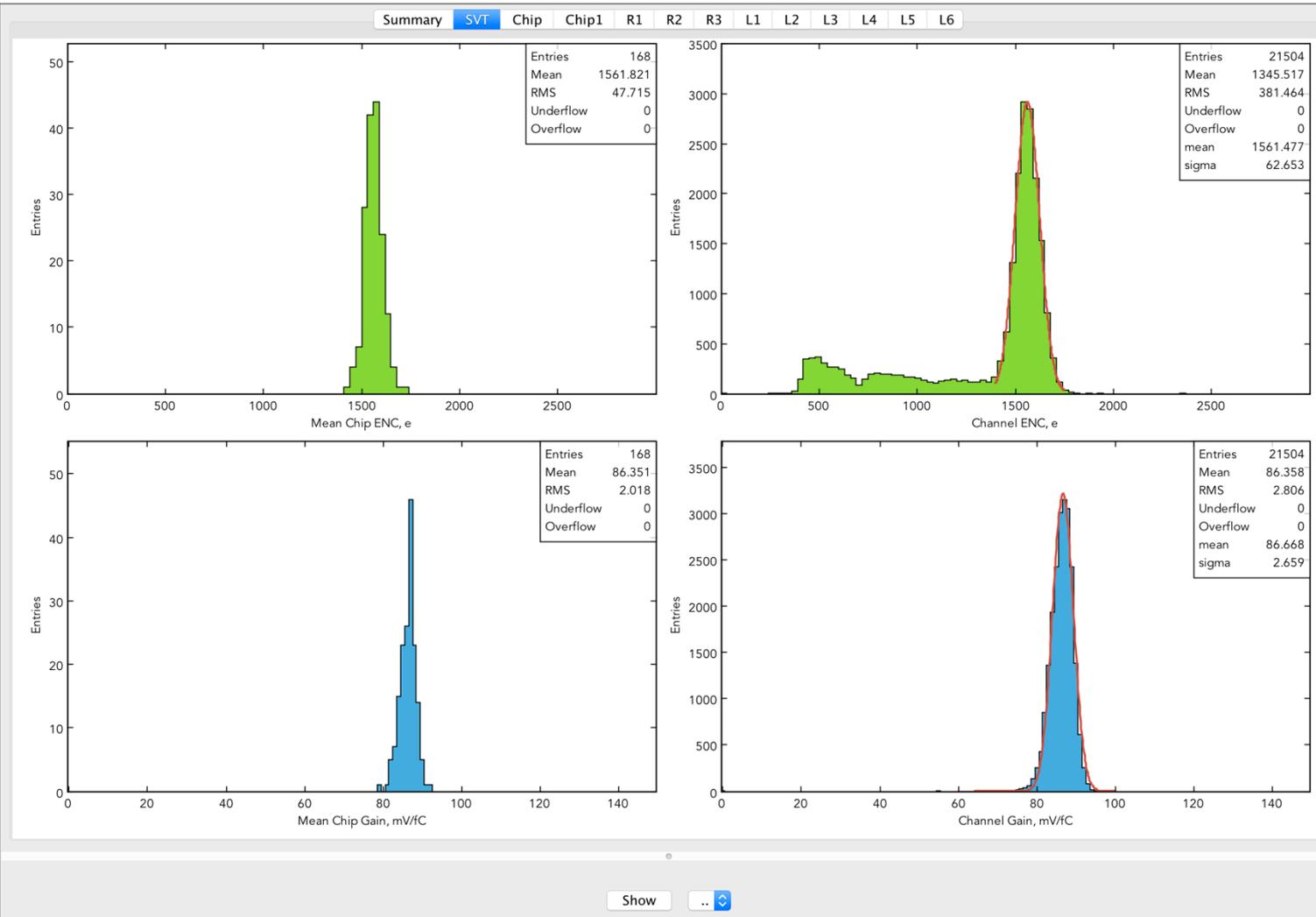
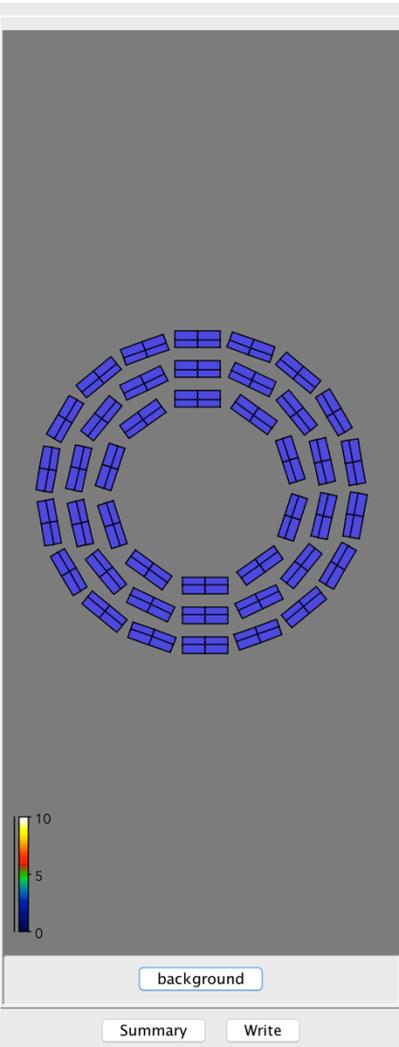
Introduction

Calibration Suite

- Regular calibration scans
- Calibration data in elog
<https://logbooks.jlab.org/book/hbsvt>
- Mean S.N.R. = 15
- Calibration constants stable
- No new bad channels



Detector Calibration



Detector Calibration

Summary

L6 R3 S2 U2 N97 ENC 2362 N
 L6 R3 S18 U1 N113 ENC 0 D
 L6 R3 S2 U1 N2 ENC 356 O
 L4 R2 S7 U2 N56 ENC 286 O
 L3 R2 S8 U4 N14 ENC 290 O
 L6 R3 S9 U1 N4 ENC 368 O
 L6 R3 S11 U1 N17 ENC 348 O
 L5 R3 S14 U3 N25 ENC 437 O

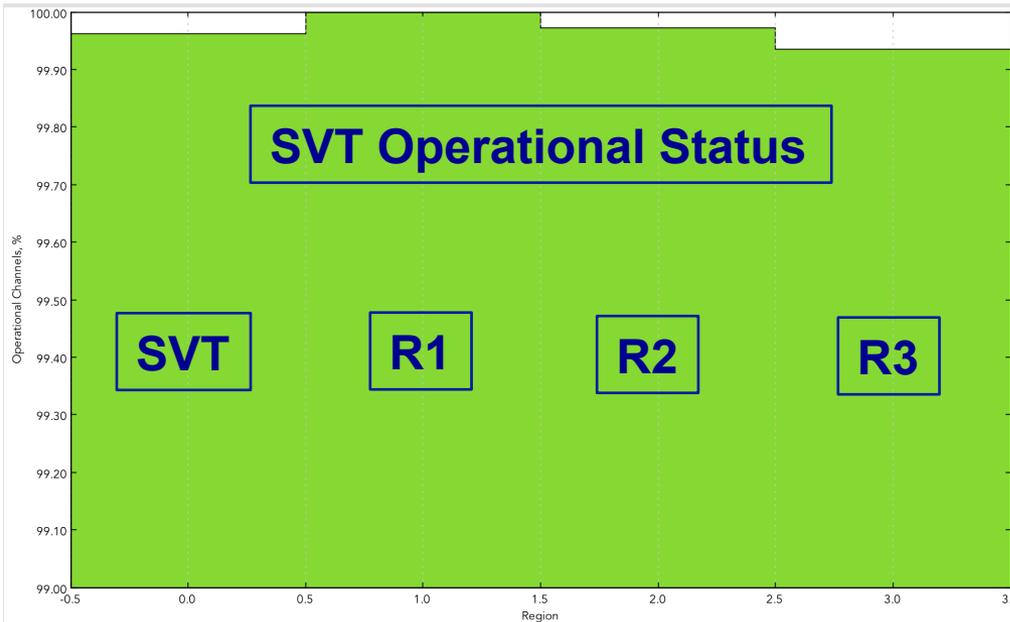
==== Region 1 =====
 Operational: 100.00%
 Mean Chip ENC: 1564
 Mean Chip Gain: 85

==== Region 2 =====
 2 bad channels: 2 open
 Operational: 99.97%
 Mean Chip ENC: 1557
 Mean Chip Gain: 86

==== Region 3 =====
 6 bad channels: 1 noisy 1 dead 4 open
 Operational: 99.93%
 Mean Chip ENC: 1563
 Mean Chip Gain: 86

==== SVT =====
 8 bad channels: 1 noisy 1 dead 6 open
 Operational: 99.96%
 Mean Chip ENC: 1561
 Mean Chip Gain: 86

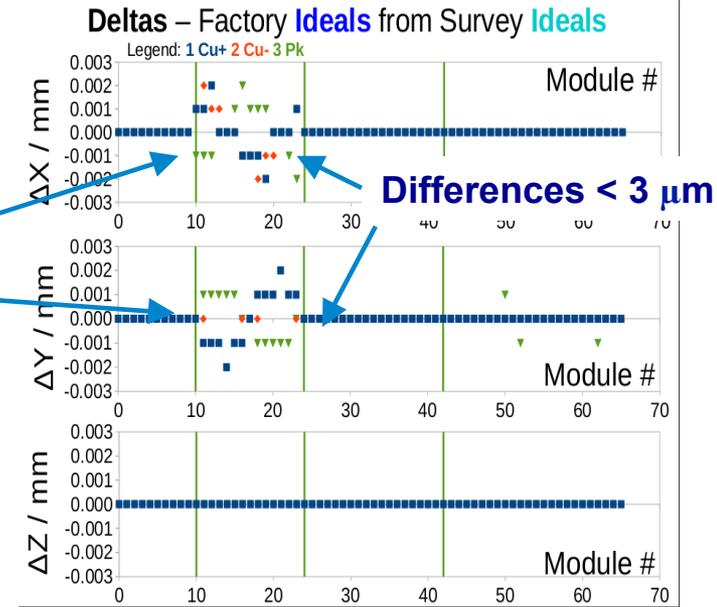
Chips processed: 168



1	2	1	6	0	1645	85	-2	338	24817
1	2	1	7	0	1657	86	-13	331	23990
1	2	1	8	0	1648	85	-24	317	23209
1	2	1	9	0	1669	84	-7	329	24422
1	2	1	10	0	1628	86	-12	332	24083
1	2	1	11	0	1668	85	-33	307	22506
1	2	1	12	0	1649	86	-18	326	23608
1	2	1	13	0	1645	84	-28	310	22886
1	2	1	14	0	1618	85	-18	323	23640
1	2	1	15	0	1621	85	-19	323	23551
1	2	1	16	0	1605	83	-26	306	22938
1	2	1	17	0	1606	86	-16	327	23769
1	2	1	18	0	1617	86	-14	330	23957
1	2	1	19	0	1596	86	-21	323	23411
1	2	1	20	0	1609	88	-33	319	22614
1	2	1	21	0	1592	86	-16	328	23759
1	2	1	22	0	1623	86	-27	319	23009
1	2	1	23	0	1611	87	-9	340	24309
1	2	1	24	0	1581	88	-27	325	23052
1	2	1	25	0	1570	86	-31	314	22683
1	2	1	26	0	1578	86	-18	328	23655
1	2	1	27	0	1589	86	-31	313	22656
1	2	1	28	0	1596	86	-16	329	23759
1	2	1	29	0	1551	88	-28	323	22937
1	2	1	30	0	1595	88	-8	344	24463
1	2	1	31	0	1571	88	-32	319	22671
1	2	1	32	0	1570	86	-18	328	23644

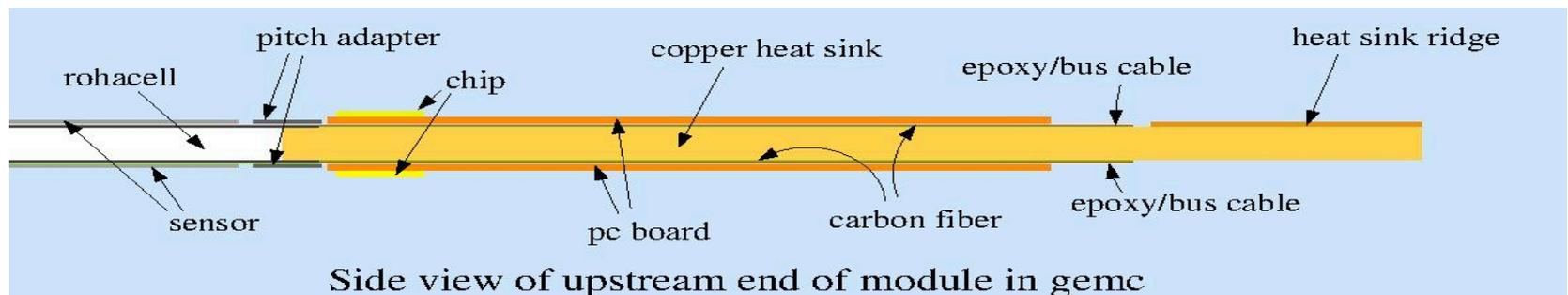
SVT Geometry Database

- **Ideal Geometry Validation and Testing**
 - Calculate ideal fiducial location on each module.
 - Observed significant difference with engineering drawings - up to 100 μm . Now reduced to $< 3 \mu\text{m}$
 - Ideal geometry now well defined with parameters from engineering drawings.
 - Used by simulation and reconstruction codes.



- **Geometry package is being validated**
 - Common Java utility in JCSG
 - Shifts from ideal geometry to measured fiducials.
 - Full inventory of material in SVT for gemc.
 - **Charles Platt, new Surrey masters student.**
 - **Sereres Johnston – ANL postdoc.**

Jerry Gilfoyle, Peter Davies



SVT Geometry Validation

- Master thesis of Peter Davies
- Poster by Peter Davies
- CLAS Note near completion

Geometry Calibration of the SVT in the CLAS12 Detector

Peter E. J. Davies and Gerard P. Gilfoyle
University of Surrey and University of Richmond
March – October 2016



UNIVERSITY OF SURREY



Jefferson Lab
Thomas Jefferson National Accelerator Facility

Introduction

The Continuous Electron Beam Accelerator Facility's (CEBAF) Large Acceptance Spectrometer (CLAS) at Jefferson Lab is being upgraded for the 12 GeV electron beam. It is effectively a very large microscope that will be used to probe nucleons and nuclei to learn how the quarks and gluons are distributed inside. [Fig. 1]

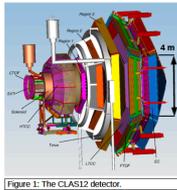


Figure 1: The CLAS12 detector.

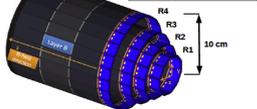
The Silicon Vertex Tracker (SVT) is one of the subsystems designed to measure the trajectory of charged particles as they are emitted from the target at large angles (35°-125°) in a 5 T solenoid magnetic field. The information gathered is used to reconstruct the path of an identified particle and calculate its 4-momentum at the target position.

The SVT is the smallest detector in CLAS12, boasting 33,792 readout channels at 512 channels per module. It is designed for a beam luminosity of 1.0 cm⁻² s⁻¹.

The sensors of the SVT consist of long, narrow strips of p-type silicon with aluminium electrodes on an n-type, bulk silicon substrate. There are 256 strips in a sensor, with a readout pitch of 156 μm, and a stereo angle of 0-3 degrees. [Fig. 2]

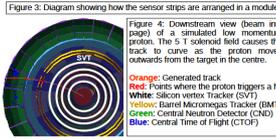
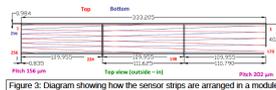
The location of the sensor strips must be known to a precision of a few microns in order to accurately reconstruct particle tracks with the required position resolution of 60 μm.

Figure 2: Screenshot of the simulator showing the coordinate system sensor modules in black, and backing structure.



Ideal Geometry

Two sensors are paired with opposite stereo-angle orientation in a module. [Fig. 3] The pairs of sensors are arranged into sectors in four circular regions, centred on the target. [Fig. 2, 4]



The first step toward calibrating the geometry was to compare an early version of simulated geometry to the technical design drawings. [Fig. 5] Several inconsistencies were discovered. The location of the sensor layers was not the same for the simulation and the reconstruction, and the backing structure did not match.

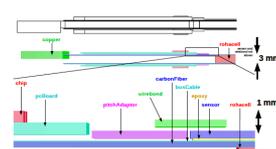
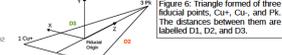


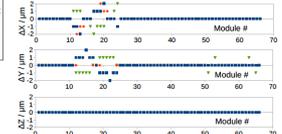
Figure 5: Top: Technical drawing showing side view of the copper support and Hybrid Flex Circuit Board (p-Board) components of a sector module. Middle: Early version of the simulated geometry showing inconsistencies. Bottom: Close-up of the readout components. Below: A photograph of the same area on a test module.

Geometry Validation Results

There were three fiducial points on each sector module for surveying purposes, two on the upstream copper support (Cu+ and Cu-), and one on the downstream peek support (Pk). [Fig. 6]



One set of fiducial points was computed from the core parameters that describe the SVT, such as the radius and position along the beam of the regions. Another set of fiducial points were read from a Computer Aided Design (CAD) model based on the technical drawings. The latter was used to verify the former, and the ideal geometry is now well defined within 2 μm resolution of the design specification. [Fig. 7]



Module #	Region	Sector
1-10	1	1-10
11-24	2	1-14
25-42	3	1-18
43-66	4	1-24

Alignment Shifts

Software was developed to apply alignment shifts to the ideal geometry from two sources:

- Survey of fiducial points on the structure that supports each pair of sensor modules.
- Analysis of reconstructed cosmic tracks using linear least-squares fitting with many parameters.

The fiducial points were used to form plane vectors that represented the data. The raw points from the survey were fit to three circles for each region to minimise the overall shift of each module.

References

1. M.A. Antonoli et al. "Performance of the CLAS12 Silicon Vertex Tracker modules". Nucl. Inst. and Meth., A752 (2015) 99-102.
2. V. Blobel "Millepede: Linear Least Squares Fits with a Large Number of Parameters". DESY. https://www.wiki.lerascas.de/index.php/Millepede_II (2014).

Calibration Results

Computer code was written in Java using CLAS12 Common Tools (COAT.JAVA) to calibrate and align the SVT.

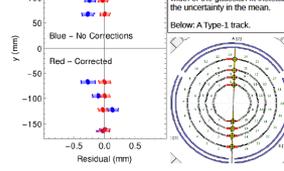
• A Geometry package generates the ideal geometry in formats suitable for the simulation and reconstruction software.

• A general Alignment package uses matrix algebra to compute the translation and rotation shifts between two given sets of plane vectors, and apply a given shift to a set of points or volumes.

The code was validated by generating track-based alignment shifts from the analysis of real (not simulated) Type-1 cosmic tracks. Type-1 tracks were selected for the analysis because they pass through all 8 horizontal layers.

A program called Millepede used a least squares approach to simultaneously fit straight lines to the cosmic ray tracks and shifts in the module positions. It used the partial derivatives of the distance of closest approach (DOCA) taken with respect to the track parameters and the SVT geometry. This approach accounts for correlated shifts among the geometry parameters.

Misalignments as large as 250 μm before alignment have been reduced to ~20 μm. The resolution of individual strips has been improved from an average of 93 μm to 80 μm. [Fig. 8]



Conclusion

- Geometry has been well defined according to the design specification.
- Aligned the SVT using real cosmic data.
- The simulation and reconstruction software now receive the same geometry from one source.

- Future work:
- Further alignment studies using non-Type-1 tracks.
 - Processing the fitted fiducial survey data into alignment shifts.
 - Testing the common geometry.

Geometry and Alignment Software for the CLAS12 Detector

P. Davies¹, V. Ziegler², M. Ungaro², Y. Gotra², A. Kim³, and G.P. Gilfoyle⁴

- ¹ University of Surrey, Guilford, UK
- ² Jefferson Lab, Newport News, VA
- ³ University of Connecticut, Storrs, CT
- ⁴ University of Richmond, Richmond, VA

May 1, 2017

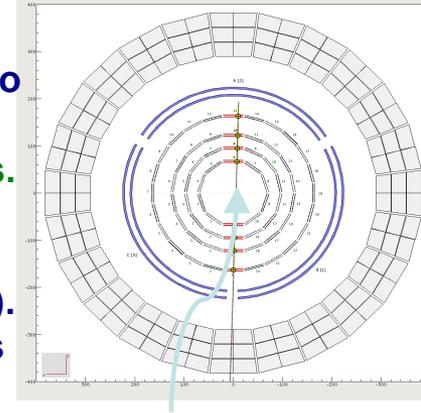
Abstract

The CLAS12 detector is currently under construction in Hall B as part of the CEBAF 12 GeV Upgrade. The Silicon Vertex Tracker (SVT) is a position sensitive detector subsystem in CLAS12, and is the closest one to the target. This document is designed to be a comprehensive guide to the geometry of the SVT, and the software used to model it for simulation and reconstruction. The sensors of the SVT consist of long, narrow strips of p-type silicon with aluminium electrodes on an n-type, bulk silicon substrate. There are 256 strips in a sensor, with a readout pitch at the upstream end of 156 μm, and a stereo angle of 0 – 3°. The location of the sensor strips must be known to a precision of a few microns in order to accurately reconstruct particle tracks with the required position resolution of 60 μm specified in the CLAS12 design. The geometry of the SVT has been well defined according to the design specification after consultation with the design team, and software was developed to align the sectors using real cosmic data. The simulation and reconstruction software now receive the same geometry from one source.

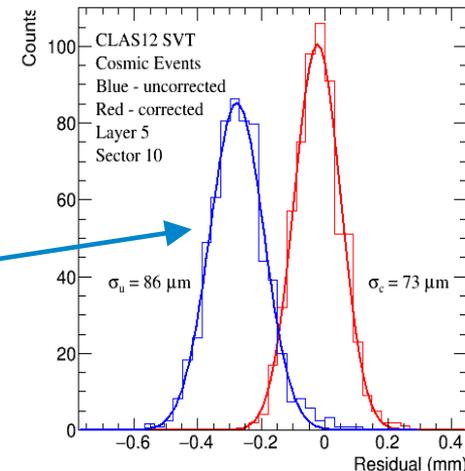
Jerry Gilfoyle, Peter Davies

Alignment Status

Jerry Gilfoyle



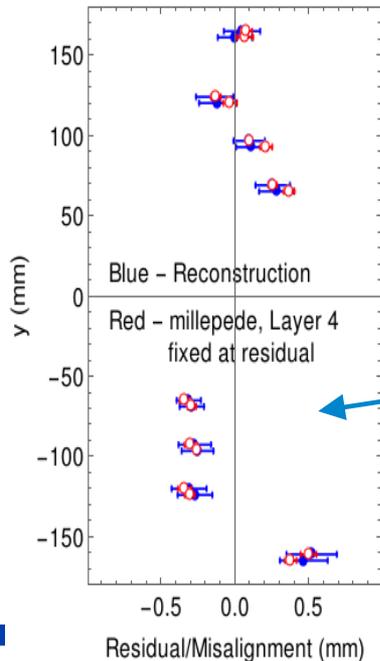
Type 1 tracks – sensors are horizontal.



- Track-based alignment of SVT requires fitting many parameters:

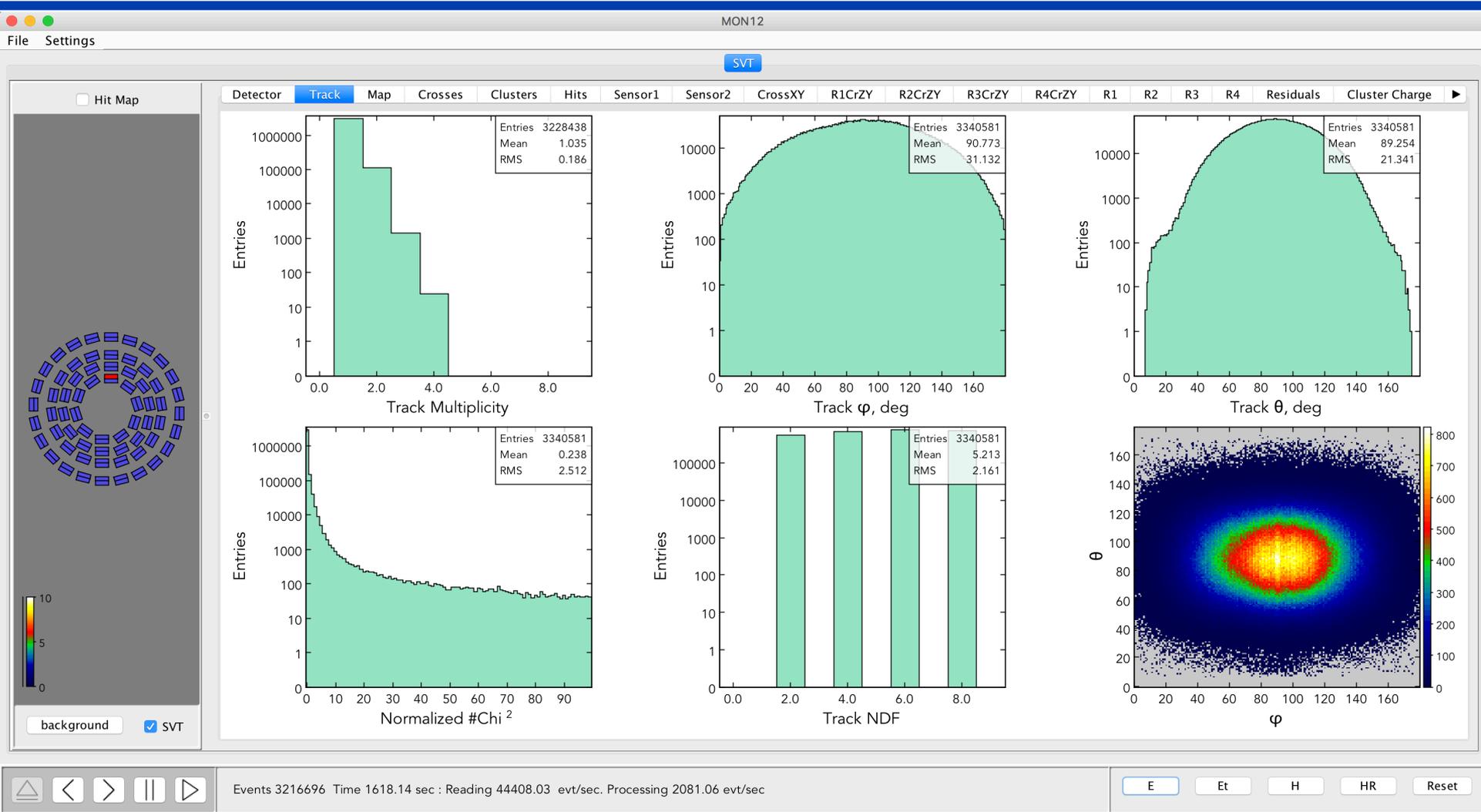
$$N_{\text{sectors}} \times N_{\text{layers}} \times N_{\text{trans}} \times N_{\text{rot}} = 66 \times 2 \times 3 \times 2 = 792$$
- Program millepede does linear least squares with many parameters.
 - Uses matrix form of least squares method and divide the elements into two classes.
 - Global parameters – the geometry misalignments. **Same in all events.**
 - Local – individual track fit parameters. **Change event-to-event.**
 - Calculate first partial derivatives of the fit residuals with respect to the local (i.e. fit) parameters and global parameters (geometry misalignments).
 - Manipulate the linear least squares matrix to isolate the global parameters (geometry) and invert the results to obtain the solution.

Type 1, May 11-18

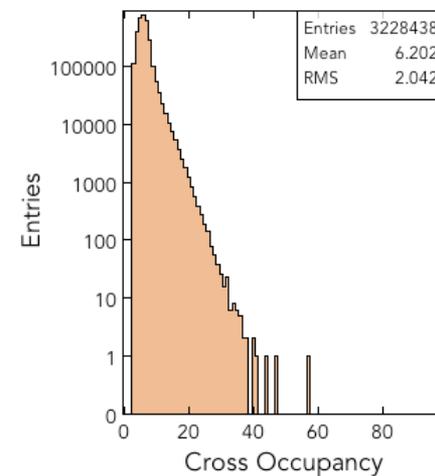
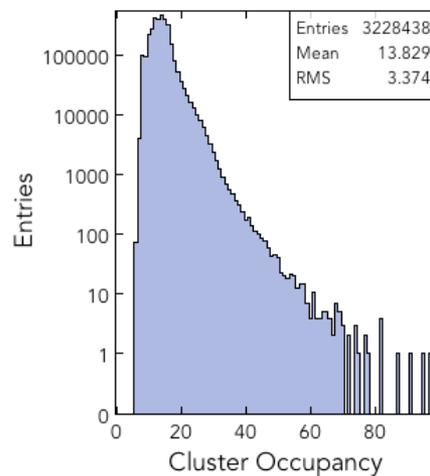
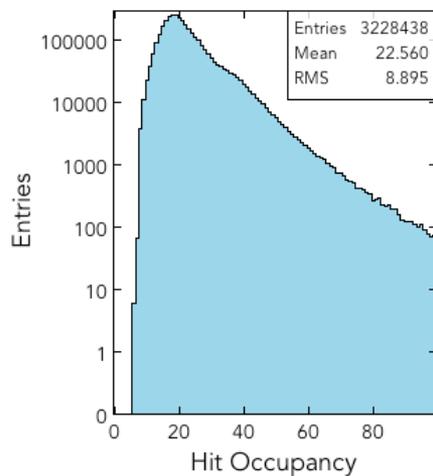
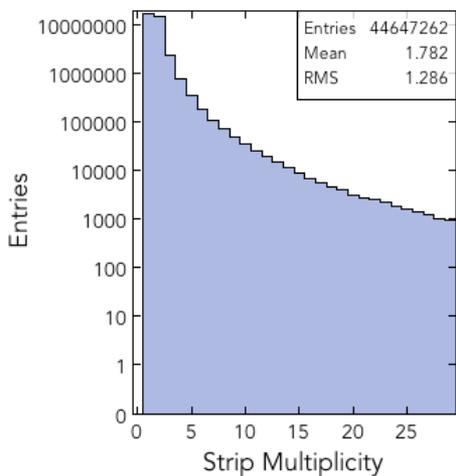
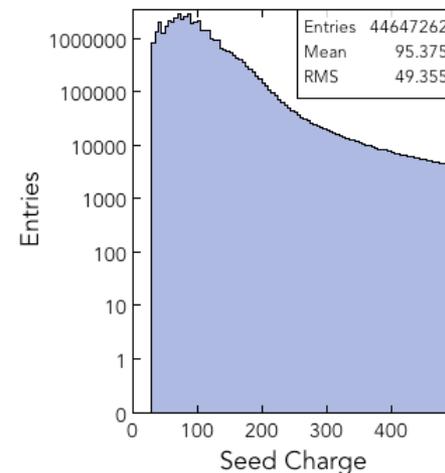
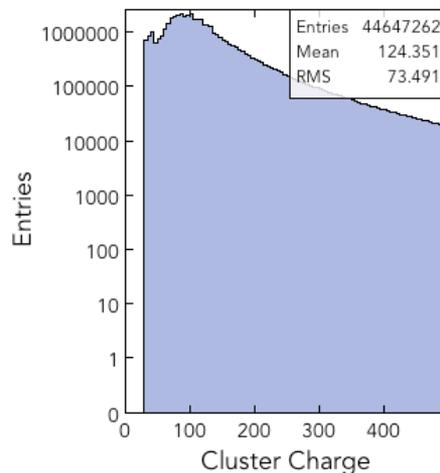
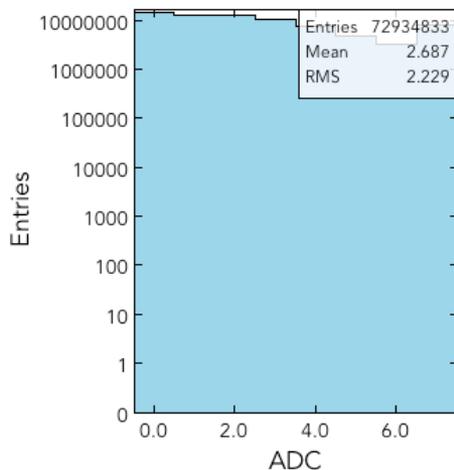
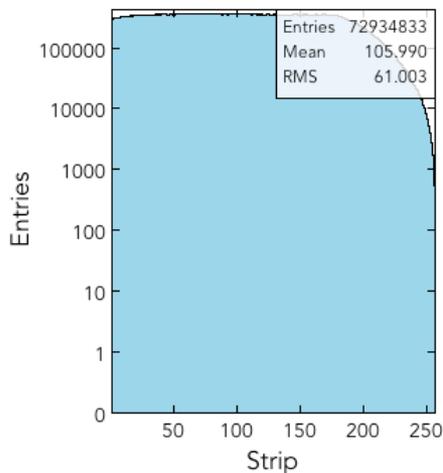


- Apply to a 'simple' example – Type 1 tracks.
 - Use gemc cosmics for testing and validation.
 - Shift layers 1-2 (Region 1) by 2-500 μm in x .
 - millepede reproduces all shifts.
- Apply to Type-1 cosmic ray sample from SVT.
 - Fixed layer 4 in millepede fit to SVT residual.
 - Good agreement between millepede misalignment and residuals.
 - Fit residual and resolution improve.
- Analysis chain for full set of events complete.
 - First millepede fits obtained.
 - Testing on Type 1 events now.

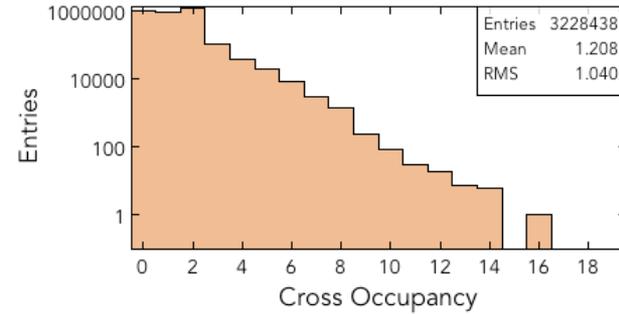
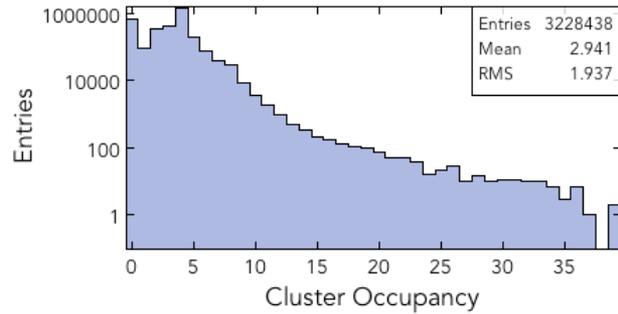
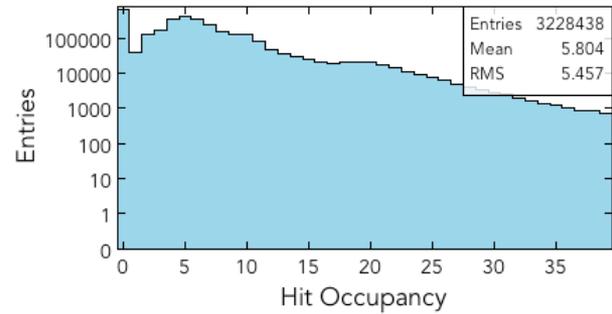
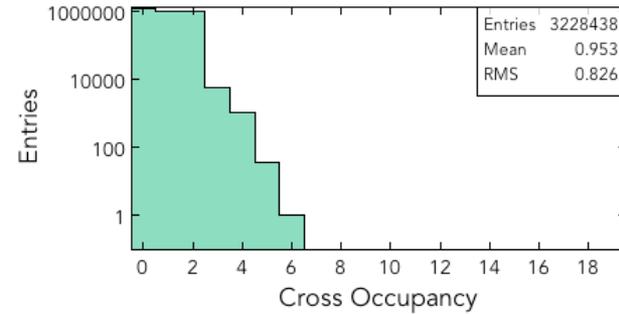
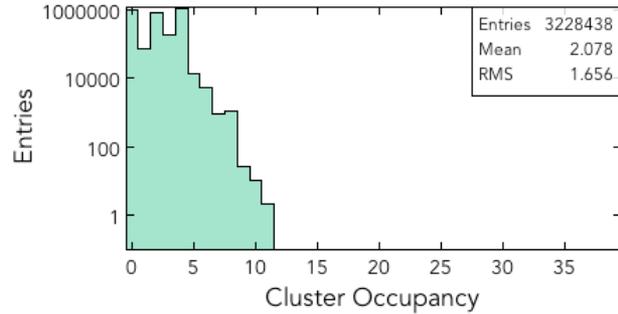
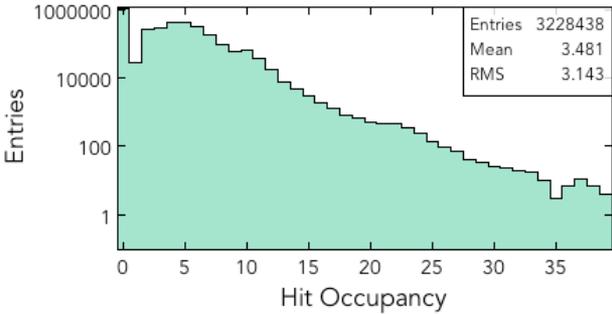
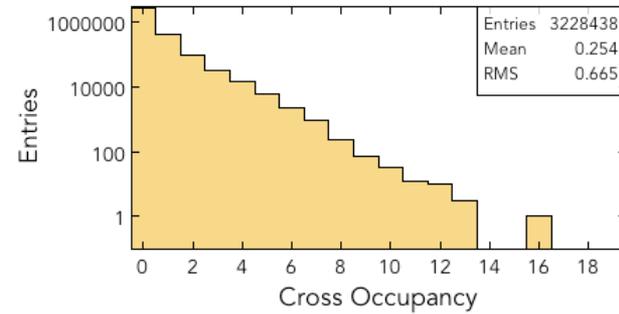
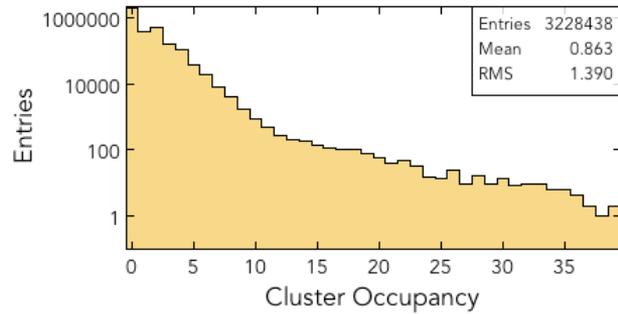
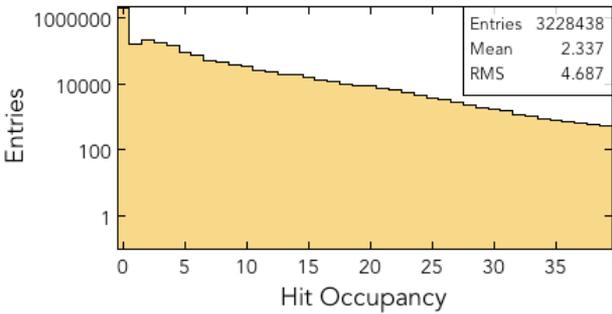
Detector Monitoring Suite: Tracking



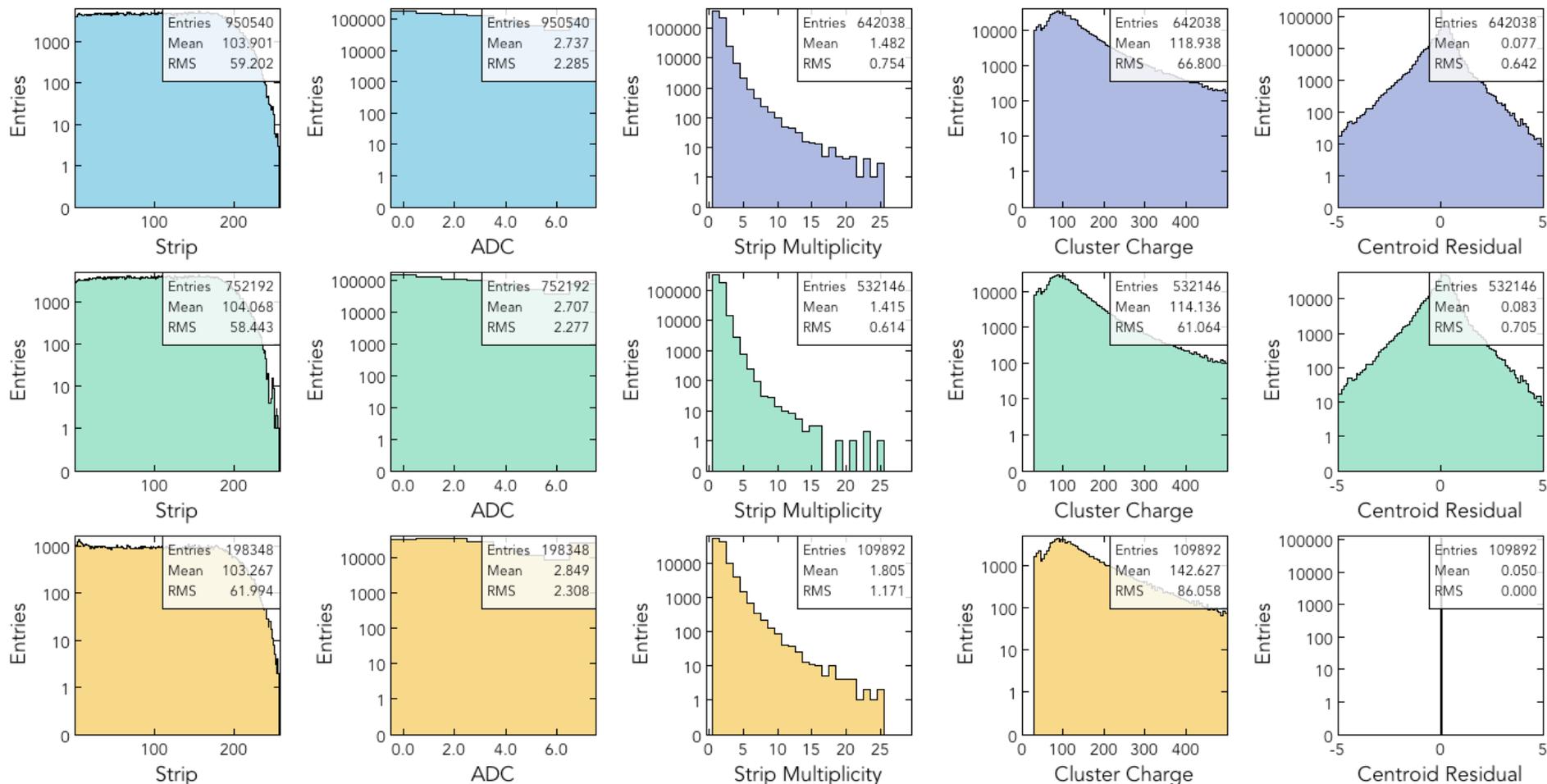
Detector Monitoring: Detector Level Histograms



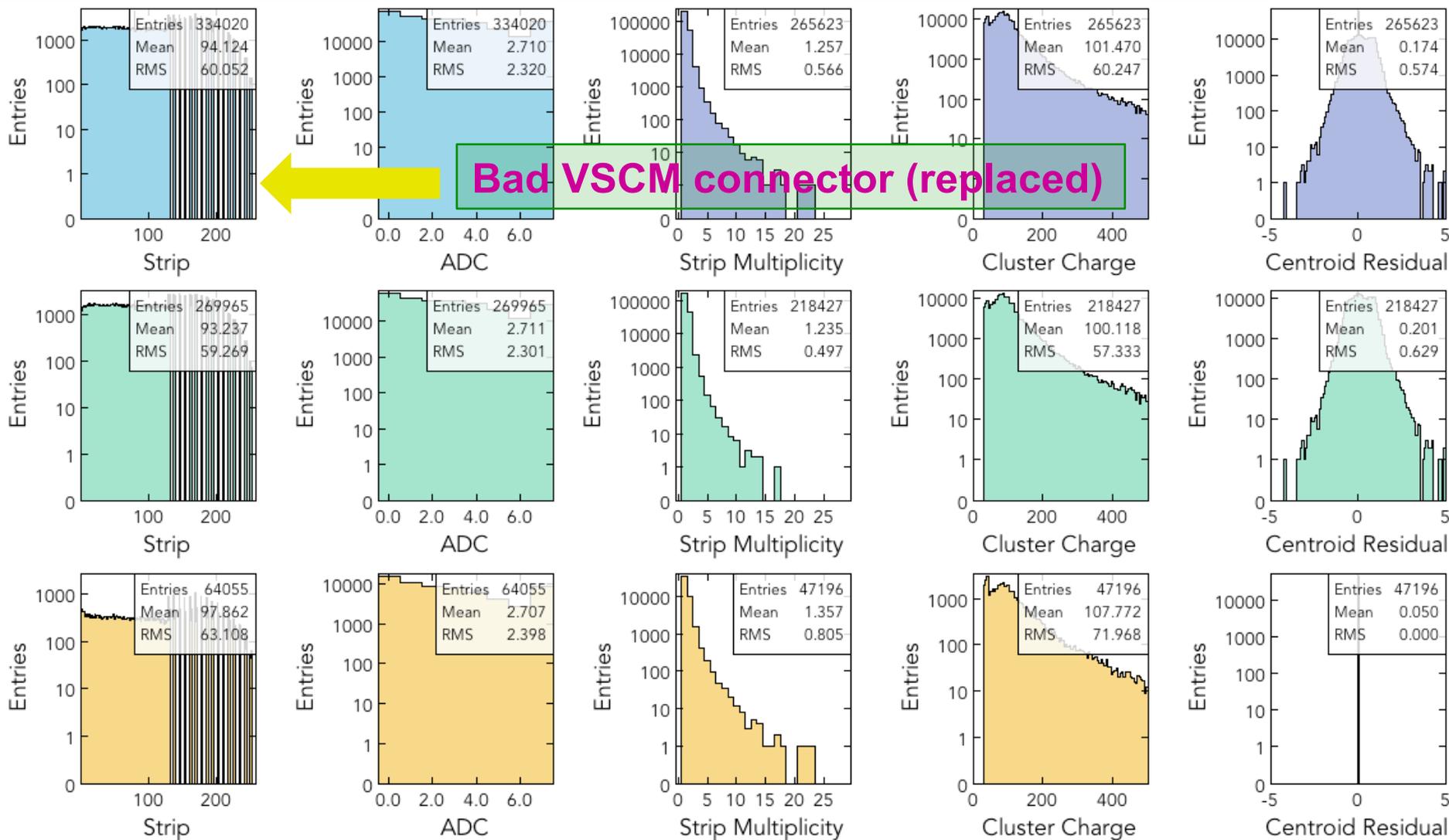
Detector Monitoring: Region Summaries



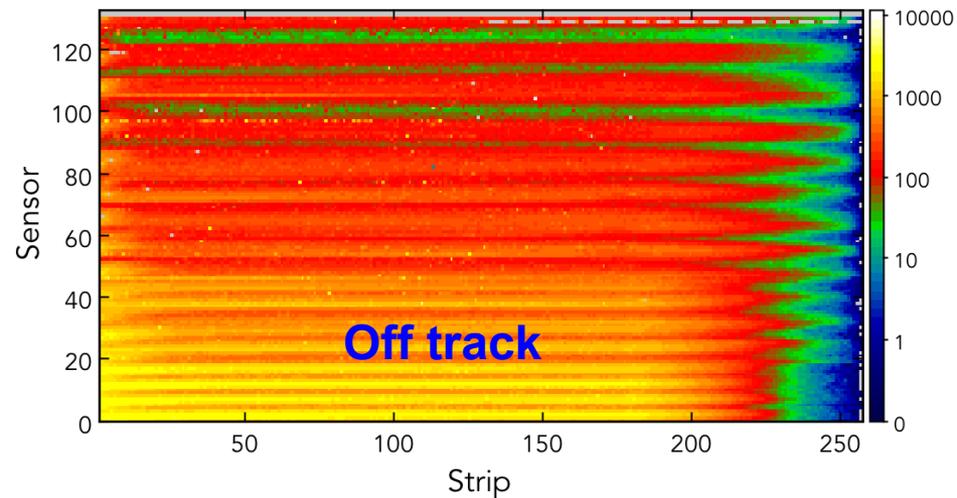
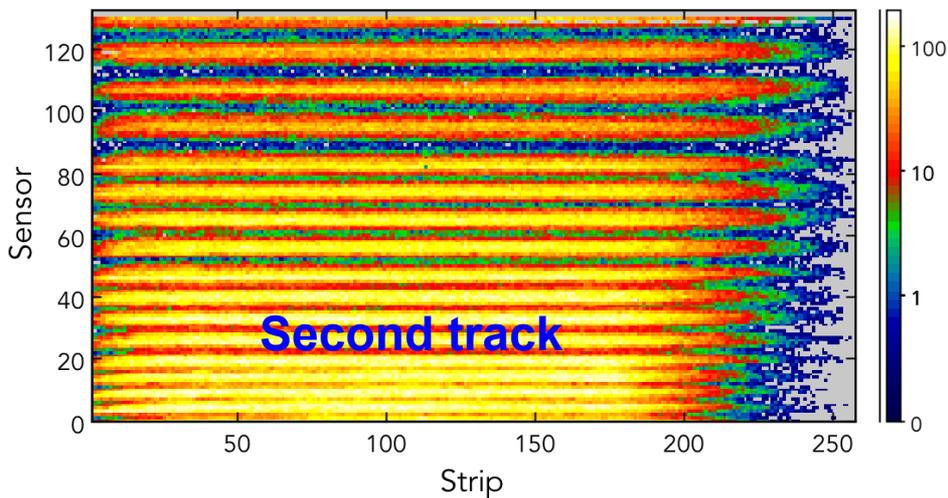
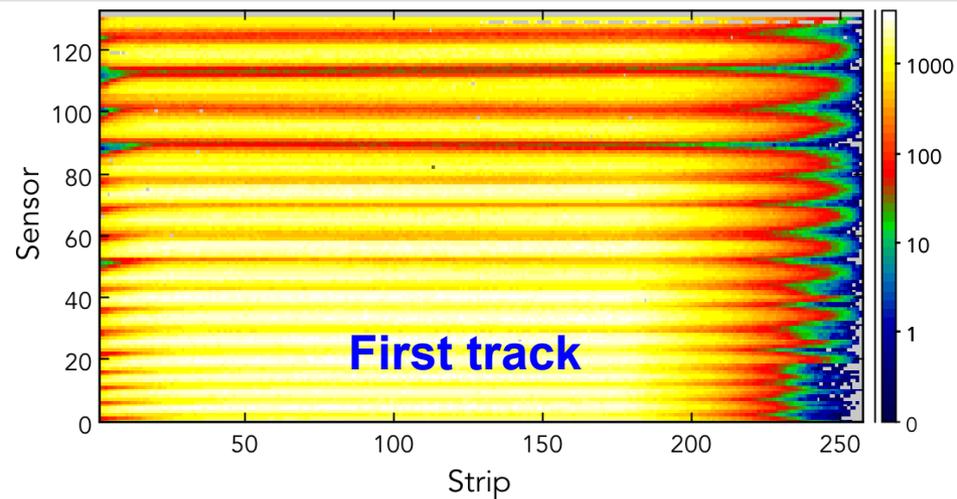
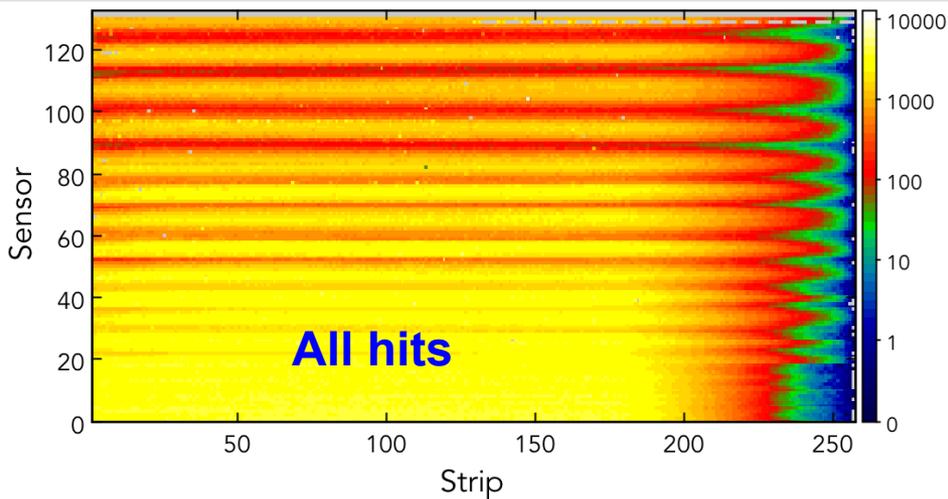
Detector Monitoring: Sensor Level Histograms



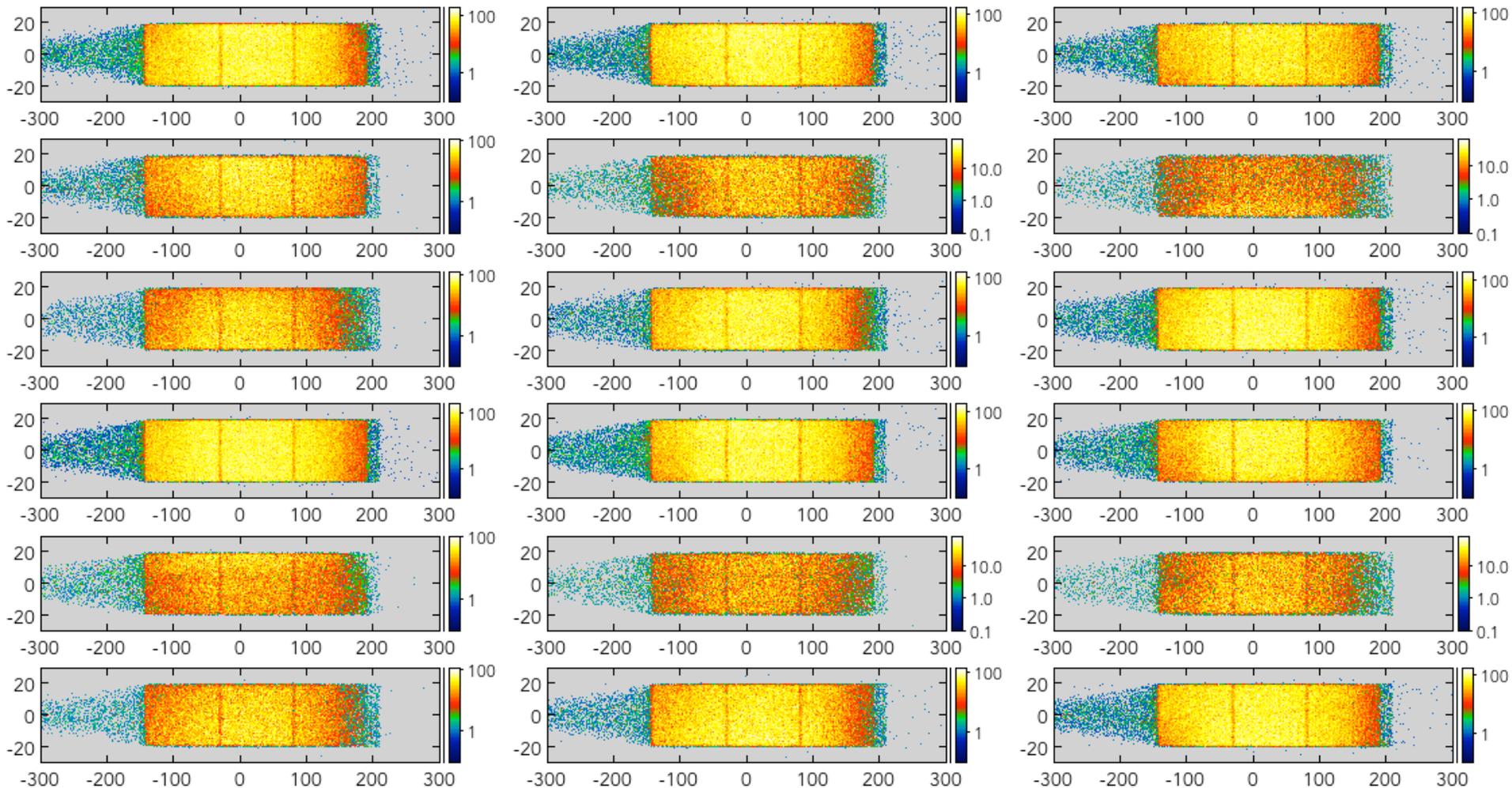
Detector Monitoring: Sensor Level Histograms



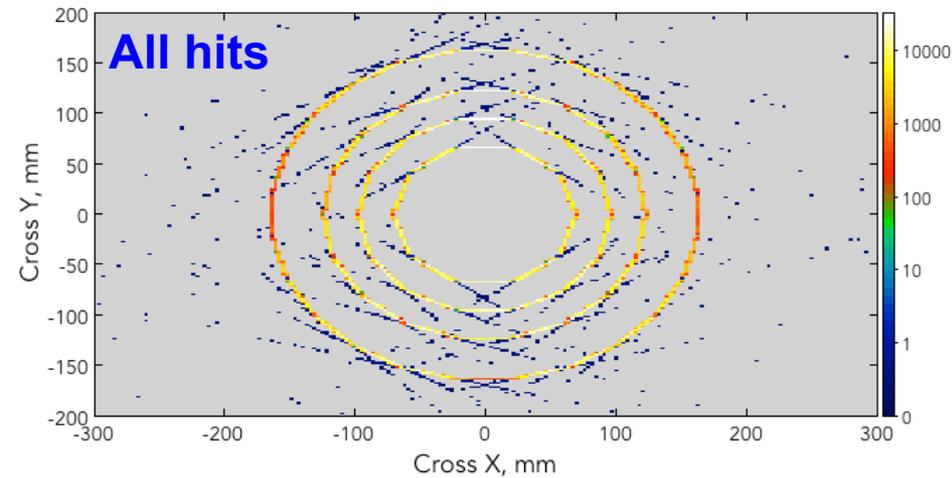
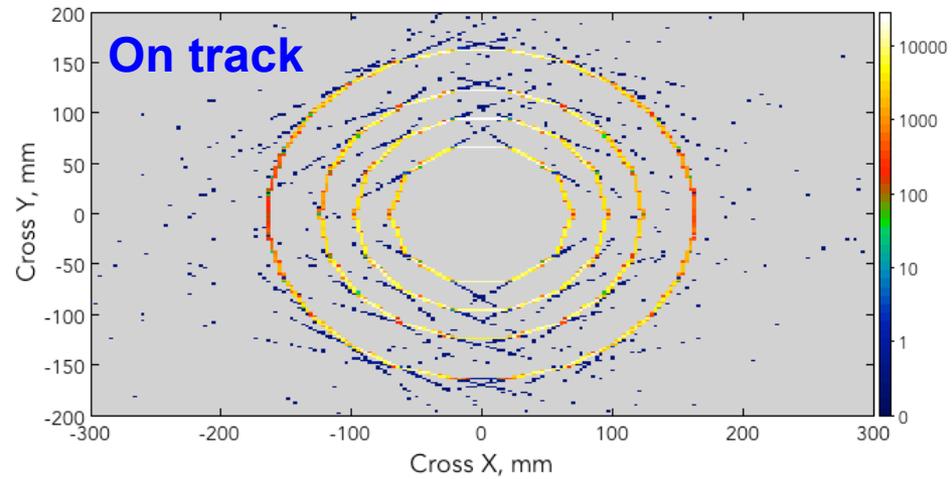
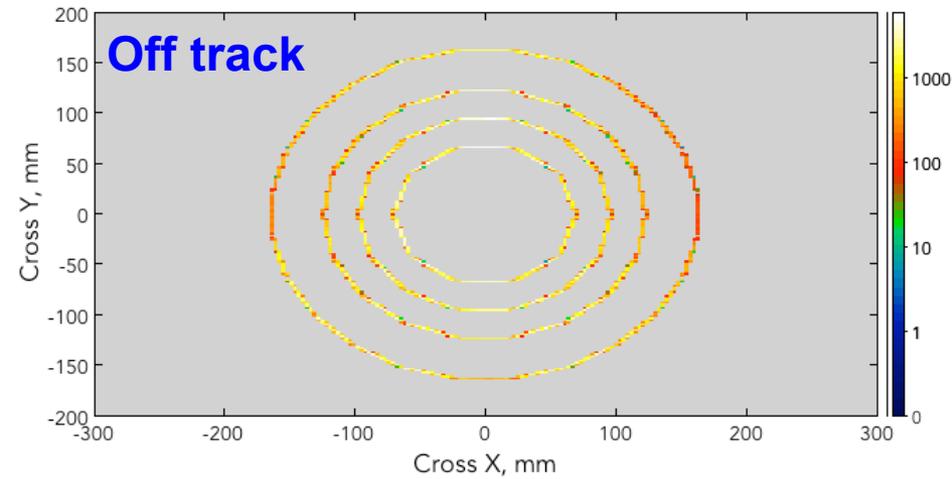
Commissioning with cosmic rays



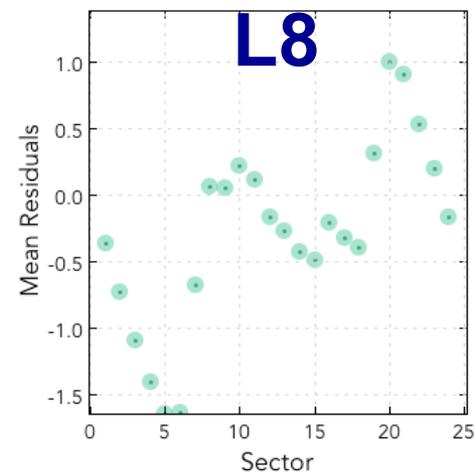
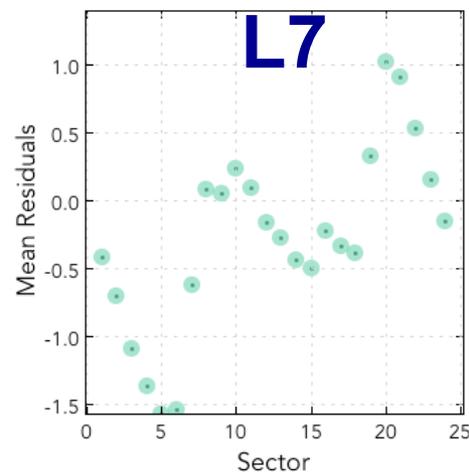
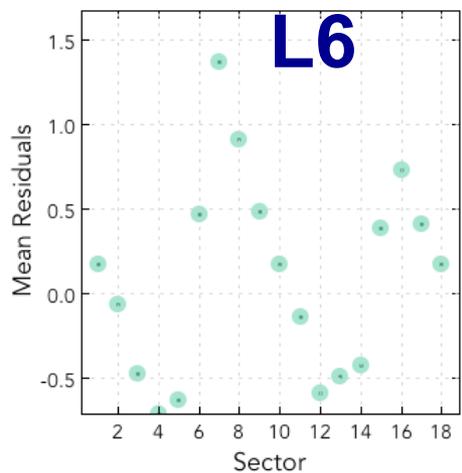
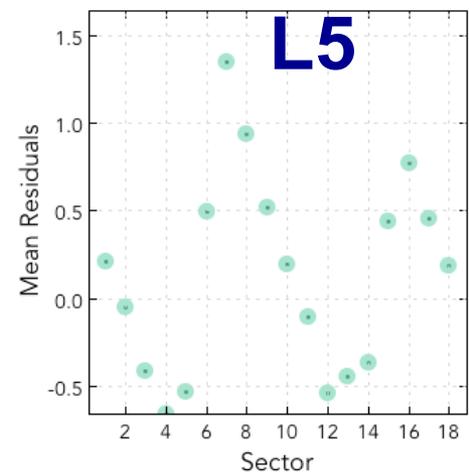
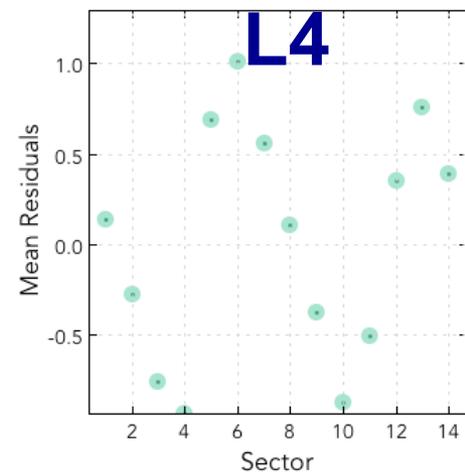
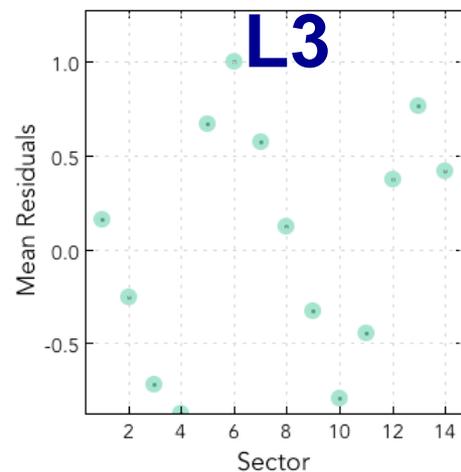
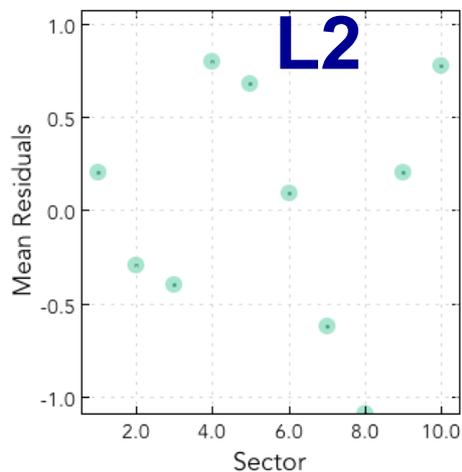
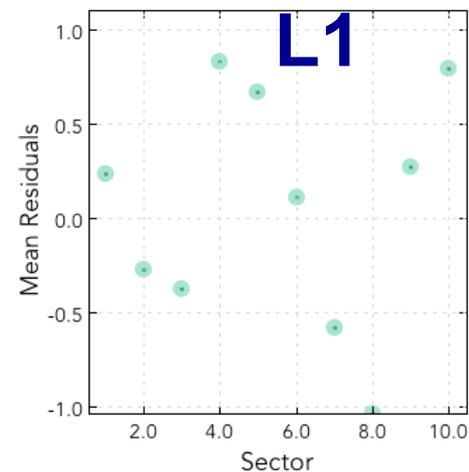
Reconstructed On-Track Crosses in Cosmic Run (March 2017)



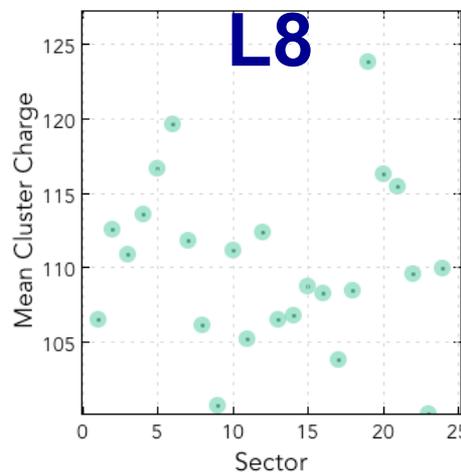
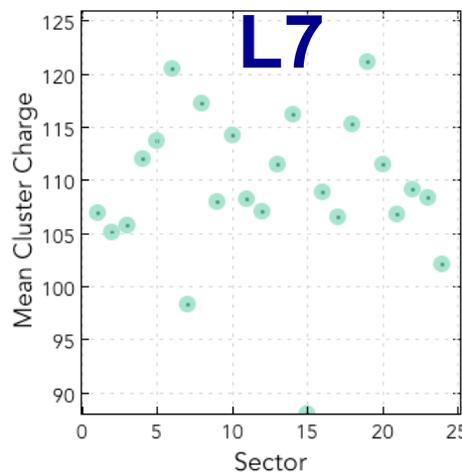
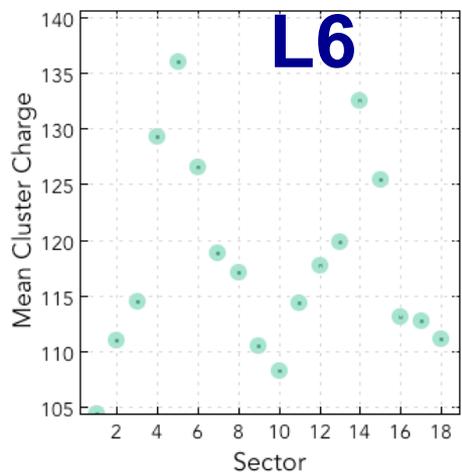
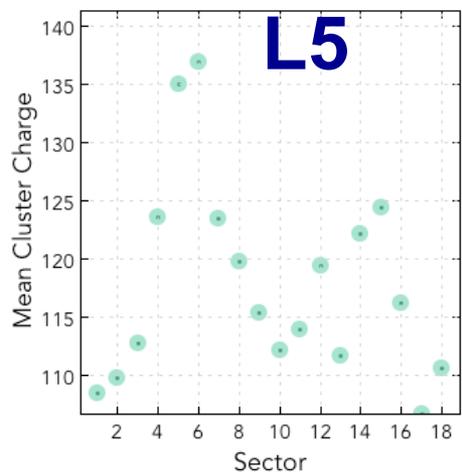
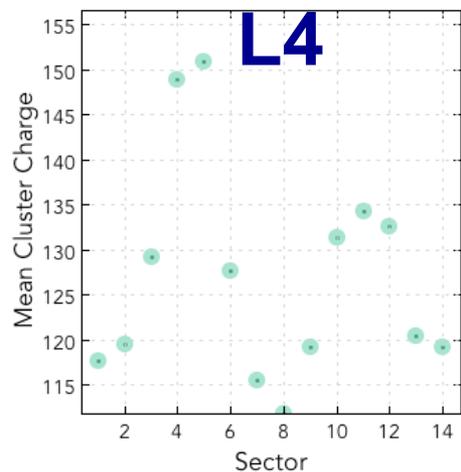
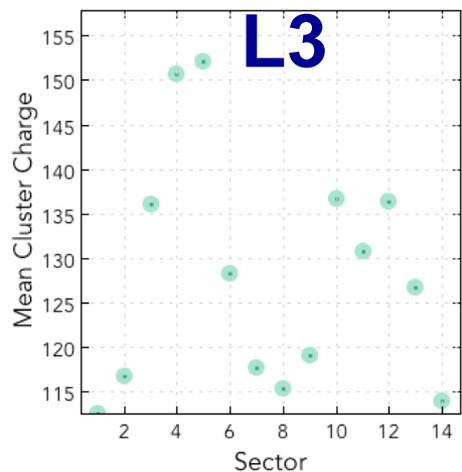
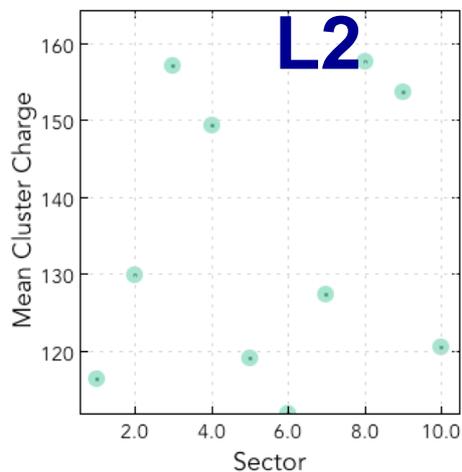
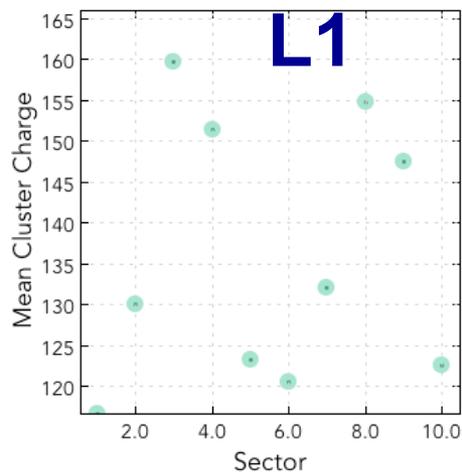
Cosmic run: reconstructed crosses (global track finder)



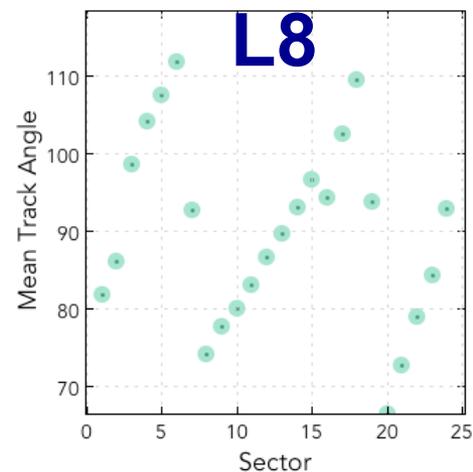
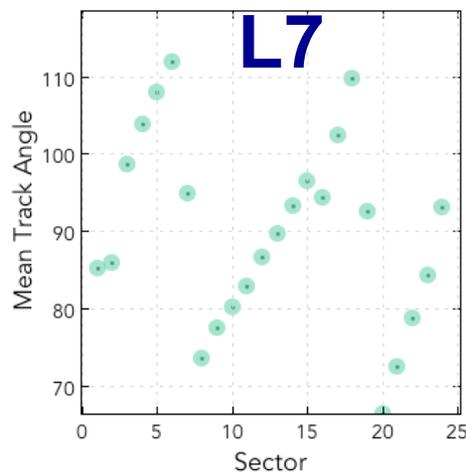
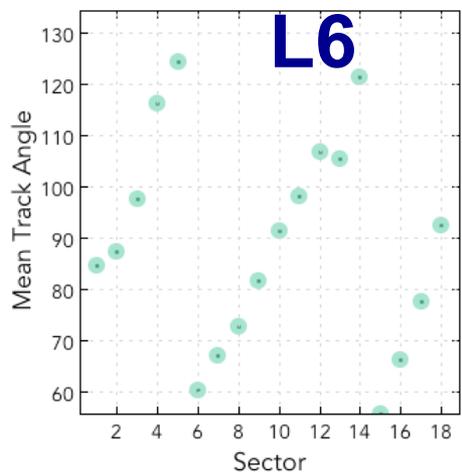
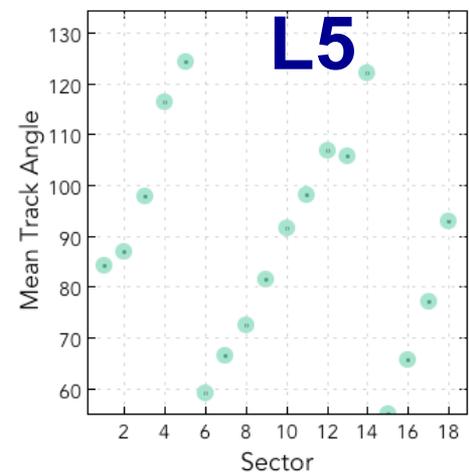
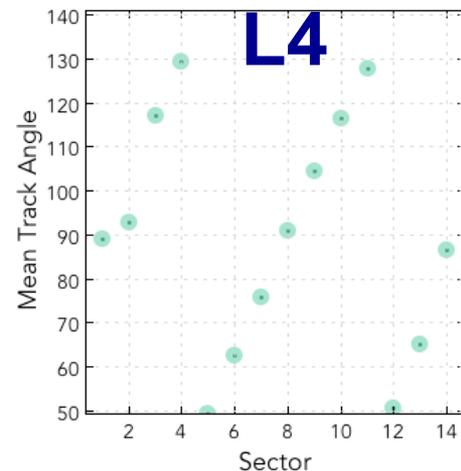
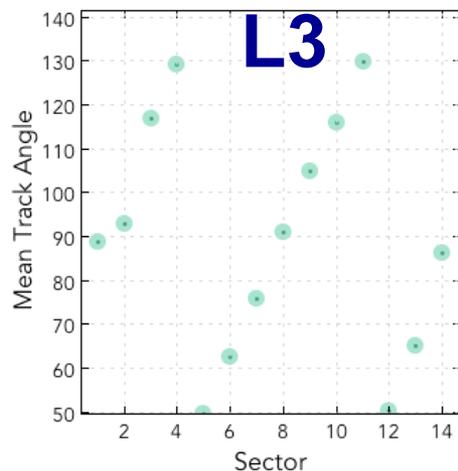
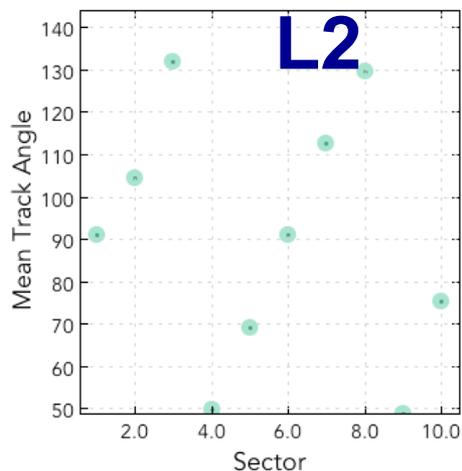
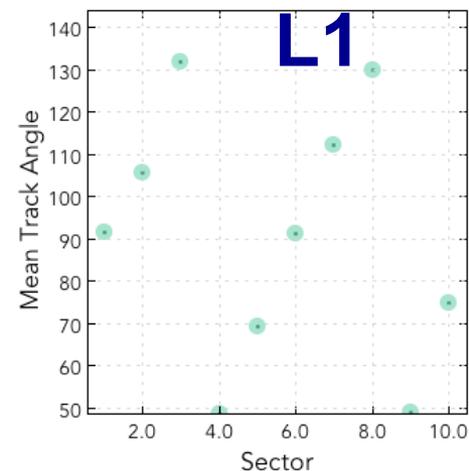
Detector Monitoring: Mean Residuals, mm



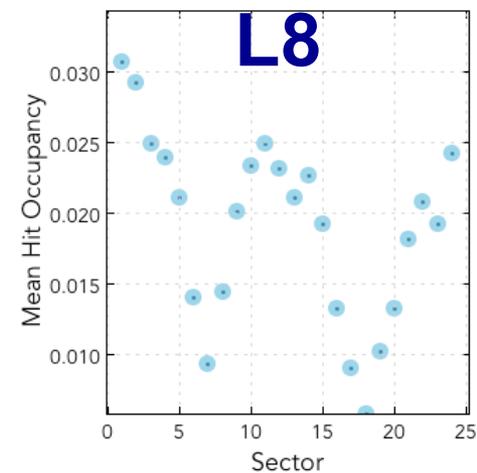
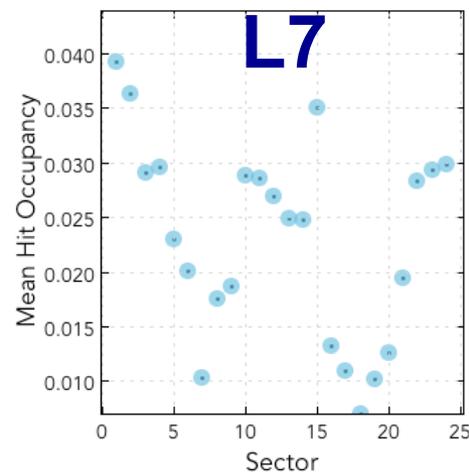
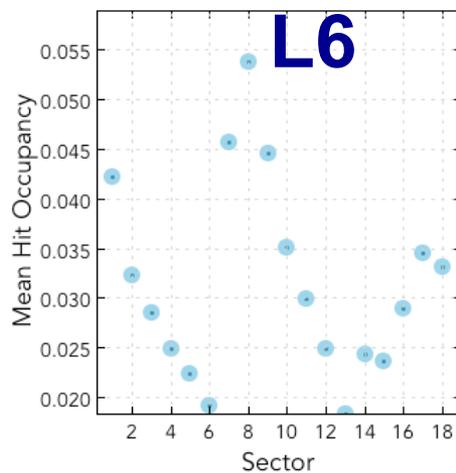
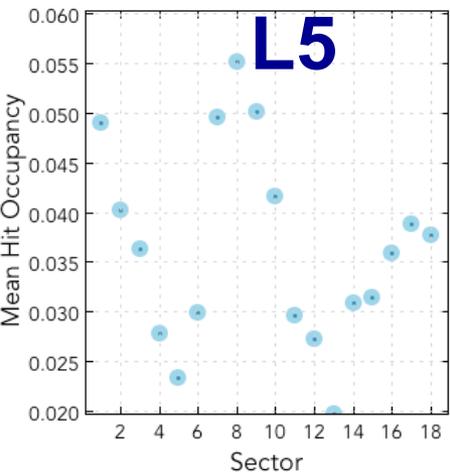
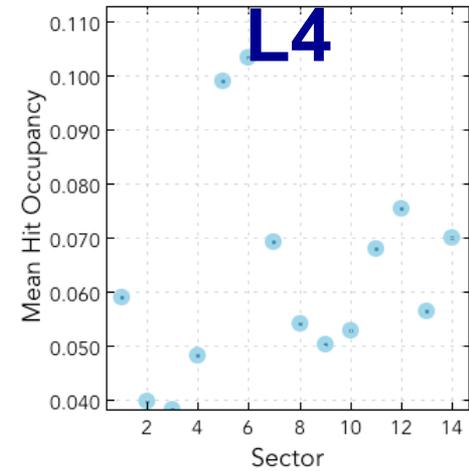
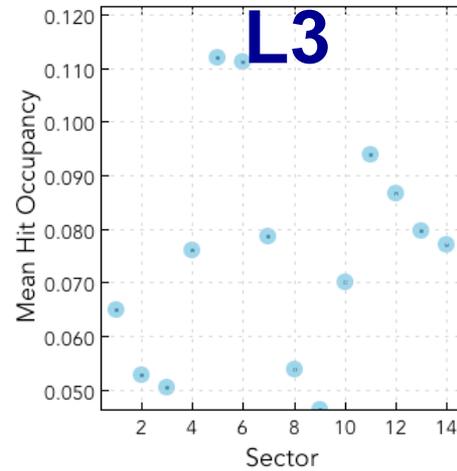
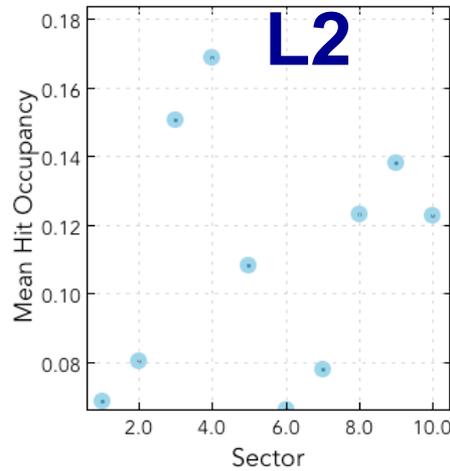
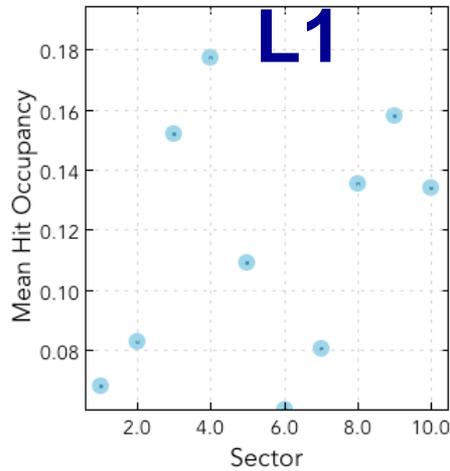
Detector Monitoring: Mean Cluster Charge



Detector Monitoring: Mean Track Angle



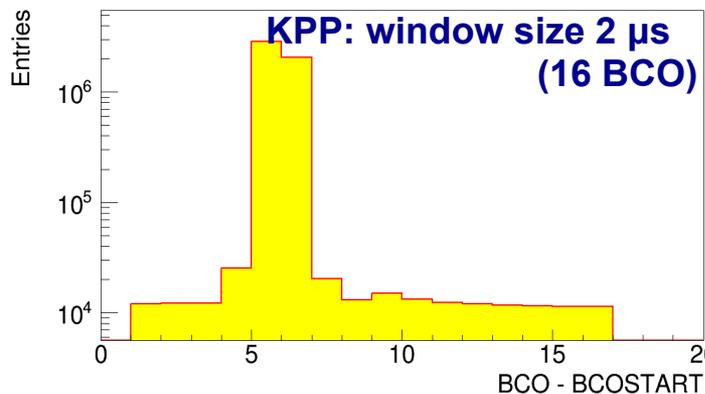
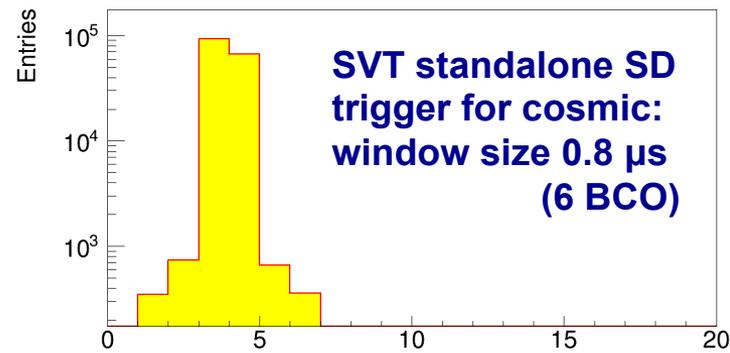
Detector Monitoring: Mean Hit Occupancy



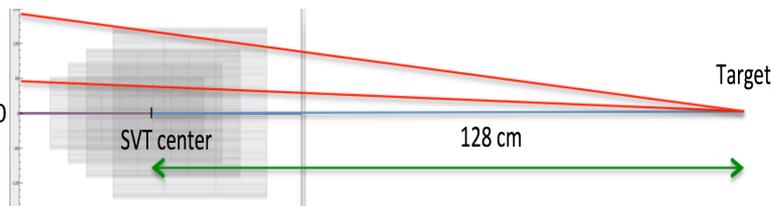
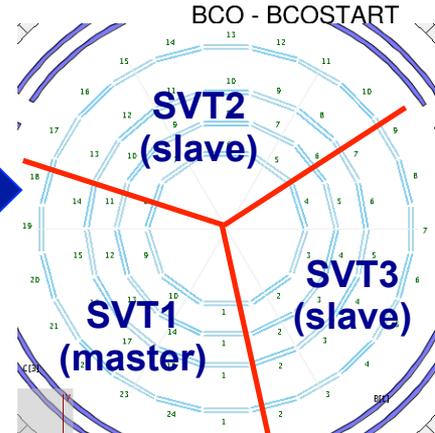
VSCM Trigger Window and Latency Setting (KPP and Cosmic Trigger)

```

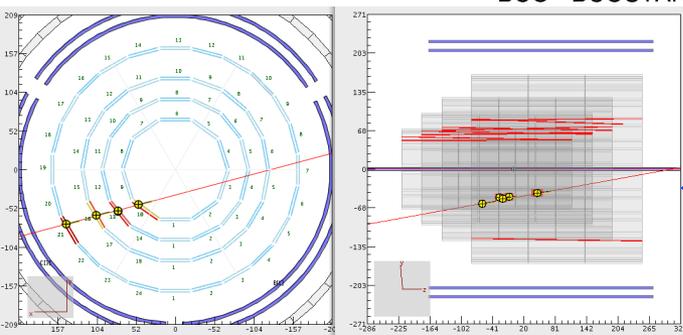
$CLON_PARMS/vscm/clasrun.cnf
# VSCM_BCO_FREQ      <freq>
#
# VSCM_TRIG_WINDOW  <windowSize> <windowLookback> <bcoFreq>
VSCM_CLOCK_EXTERNAL
# Set BCO frequency to 4 MHz
VSCM_BCO_FREQ      16
# Set Lookback parameters to 256=2 us window, 512=4 us lookback, 4 MHz BCO
# KPP: sync with CLAS trigger (added 6600 ns)
#VSCM_TRIG_WINDOW  256  1064  16
# cosmic trigger from SVT1's SD (96 * 8 ns = 768 ns = 6 * BCO, 1 BCO = 128 ns)
VSCM_TRIG_WINDOW  96   224   16
    
```



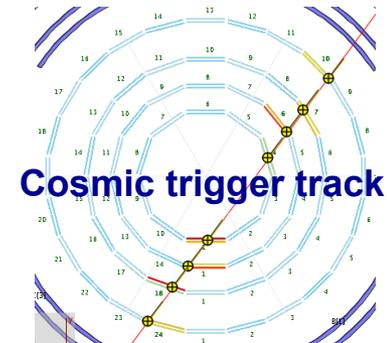
SVT SD based **standalone** cosmic trigger:
Double hit in 2 out of 3 crates
85% events have reconstructed track



KPP SVT location



CLAS trigger event with track
27 k tracks reconstructed in KPP runs 803, 809, 810



Singe Event Monitoring (SEM) Test during KPP run

- Radiation rates from LH₂ target are much less than what comes from the dump or carbon target
- Tests performed with yoke dump during KPP are sufficient to address the ERR recommendation
- Relatively minor SEUs were recorded in SVT readout electronics
- VSCM SEE Monitor recorded events are correlated with beam conditions in the experimental hall during the KPP
- No errors were recorded during 1 week SEE Monitor testing in EEL
- SVT readout and PS crates were operational during KPP, no rebooting required
- No readout or data corruption issues were observed
- SVT readout electronics and PS are operational after the KPP
- **Action items:**
 - review beam loss prevention and detector protection measures
 - install extra shielding of the SVT cart (polyethylene neutron shielding installed)
 - post a CLAS Note (done)
 - keep the SVT crates in OFF state during the beam tuning
 - move network switches to the SVT rack
 - add heart beat to SEM

Ben Raydo

CLAS-Note 2017-004

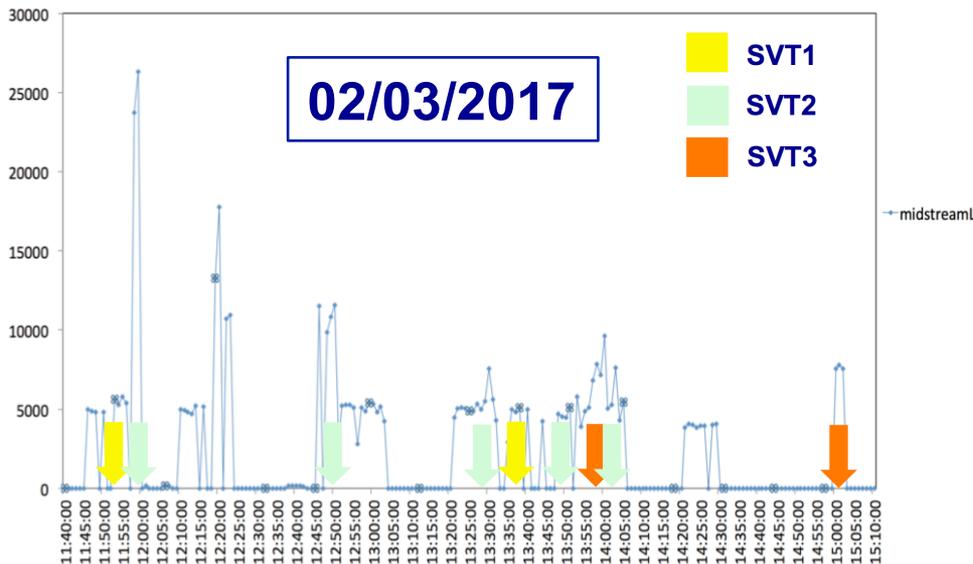
Single Event Effects Test of the Silicon Vertex Tracker Readout Boards

Yuri Gotra, Benjamin Raydo
Physics Division, Thomas Jefferson National Accelerator Facility, Newport News, VA 23606
May 4, 2017

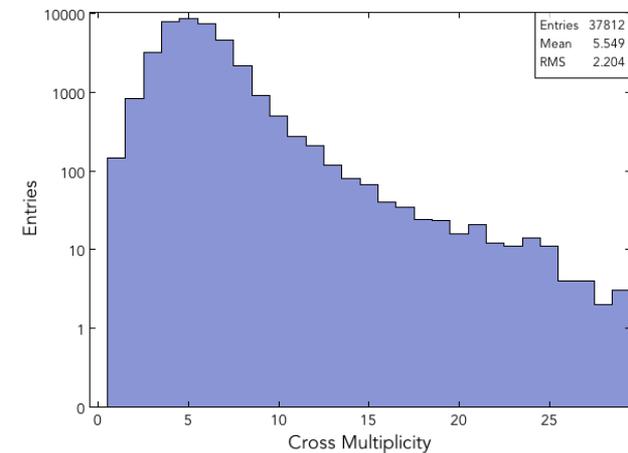
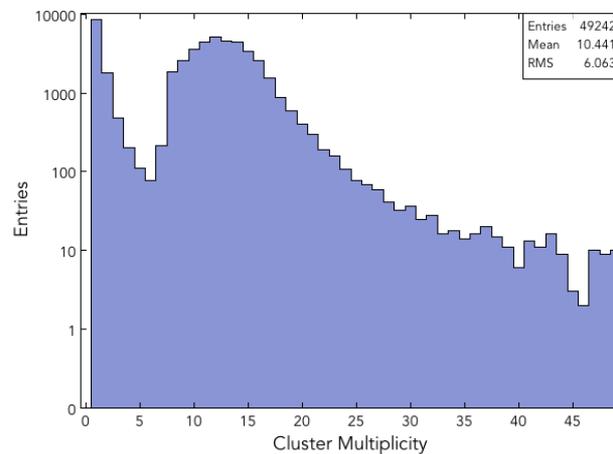
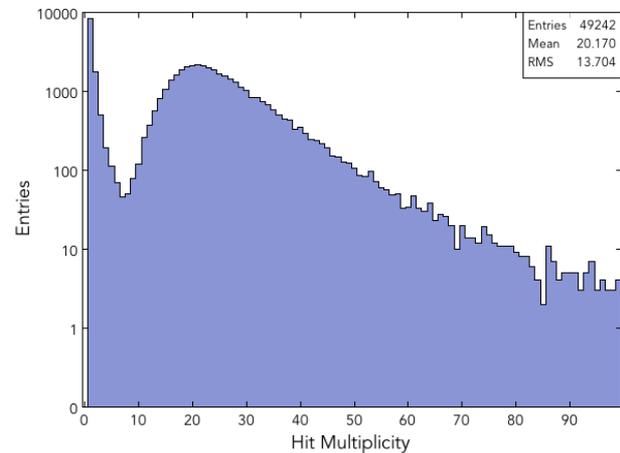
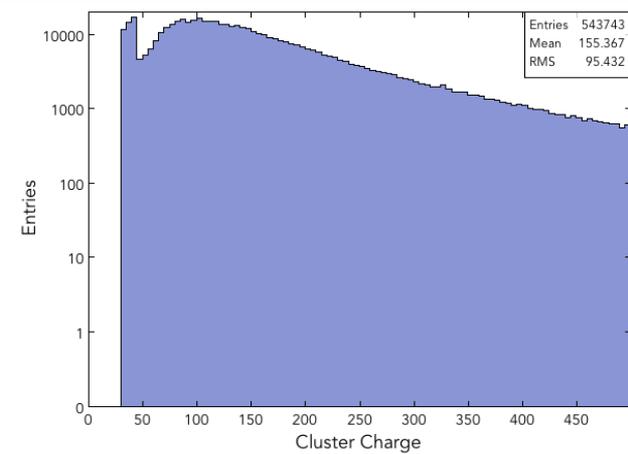
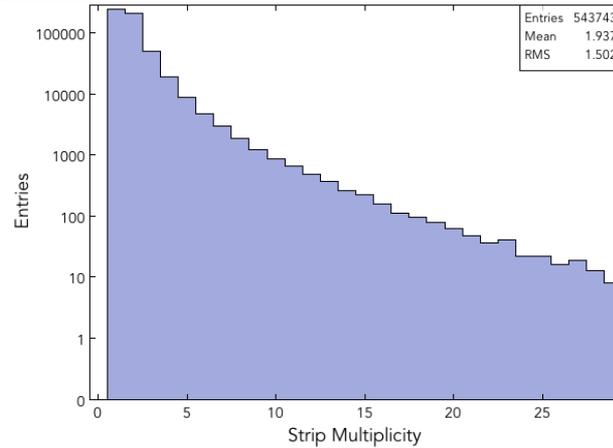
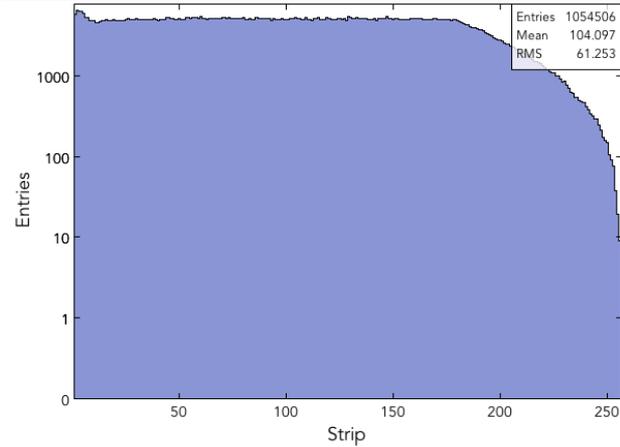
This note describes results of the Single Event Effects test performed during the Key Performance Parameter (KPP) run in February 2017.

In addition to chronic radiation damage, sensitive electronics may exhibit a change of state (bit flip, transistor state change etc.) due to passage of a single particle, collectively known as Single Event Effects (SEE). SEE could cause important operation consequences: single bit errors in the data due to a Single Event Upset (SEU), freezing the readout chain due to a Single Event Latch-up (SEL), or complete failure of a component due to a Single Event Burn-out (SEB). Single Event Effects have been a serious concern for the readout electronics operating in the high radiation conditions of nuclear physics experiments. SEE are experiment specific as the effects depend on the mixed radiation environment and the electronic components used in the system.

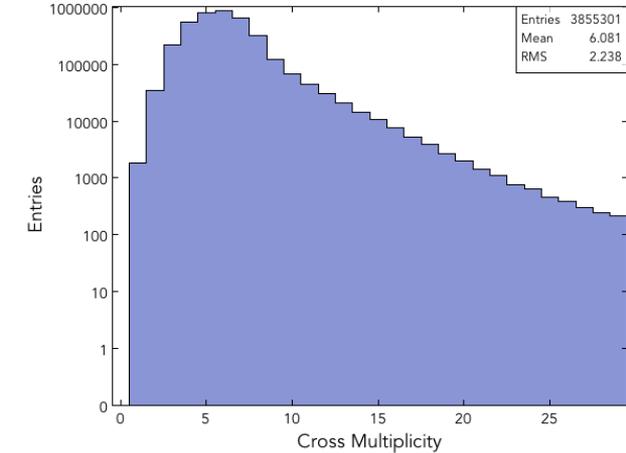
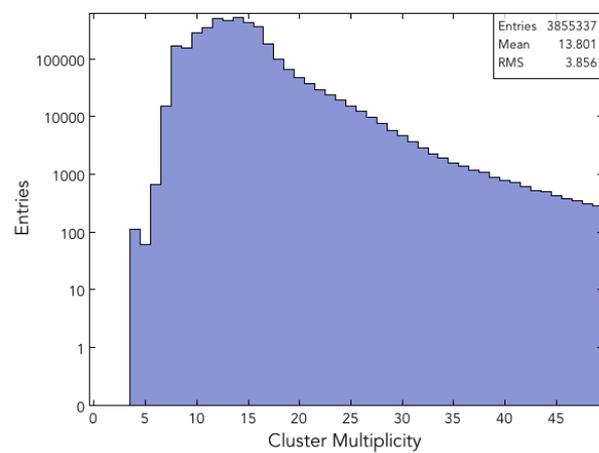
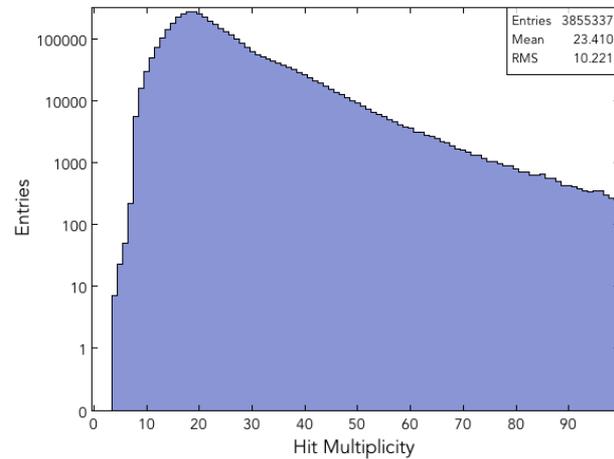
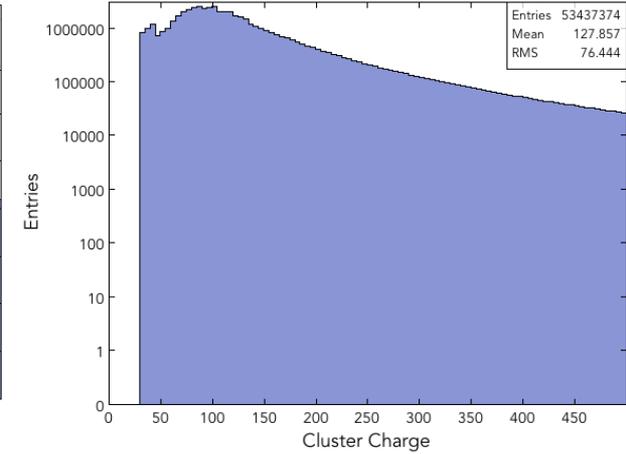
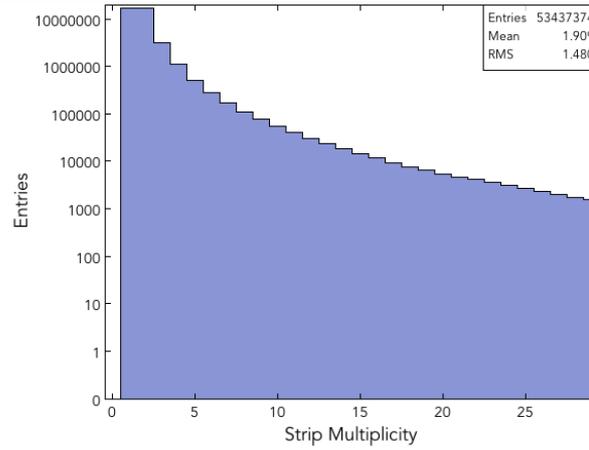
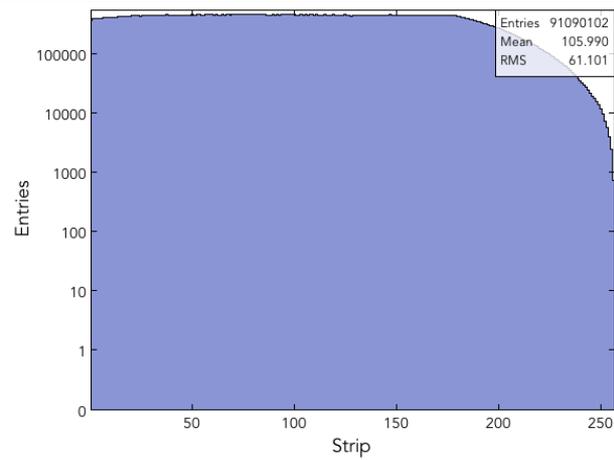
In the high luminosity environment of CLAS12 experiment SEE could become an important issue. Sensitivity to SEE could potentially lead to contamination of physics signals, data corruption, reduced reliability of the detector, or reduced detector lifetime. Although the effects of corruption of small fraction of the collected data are negligible, possibility of loosing control of the critical detector components should be addressed.



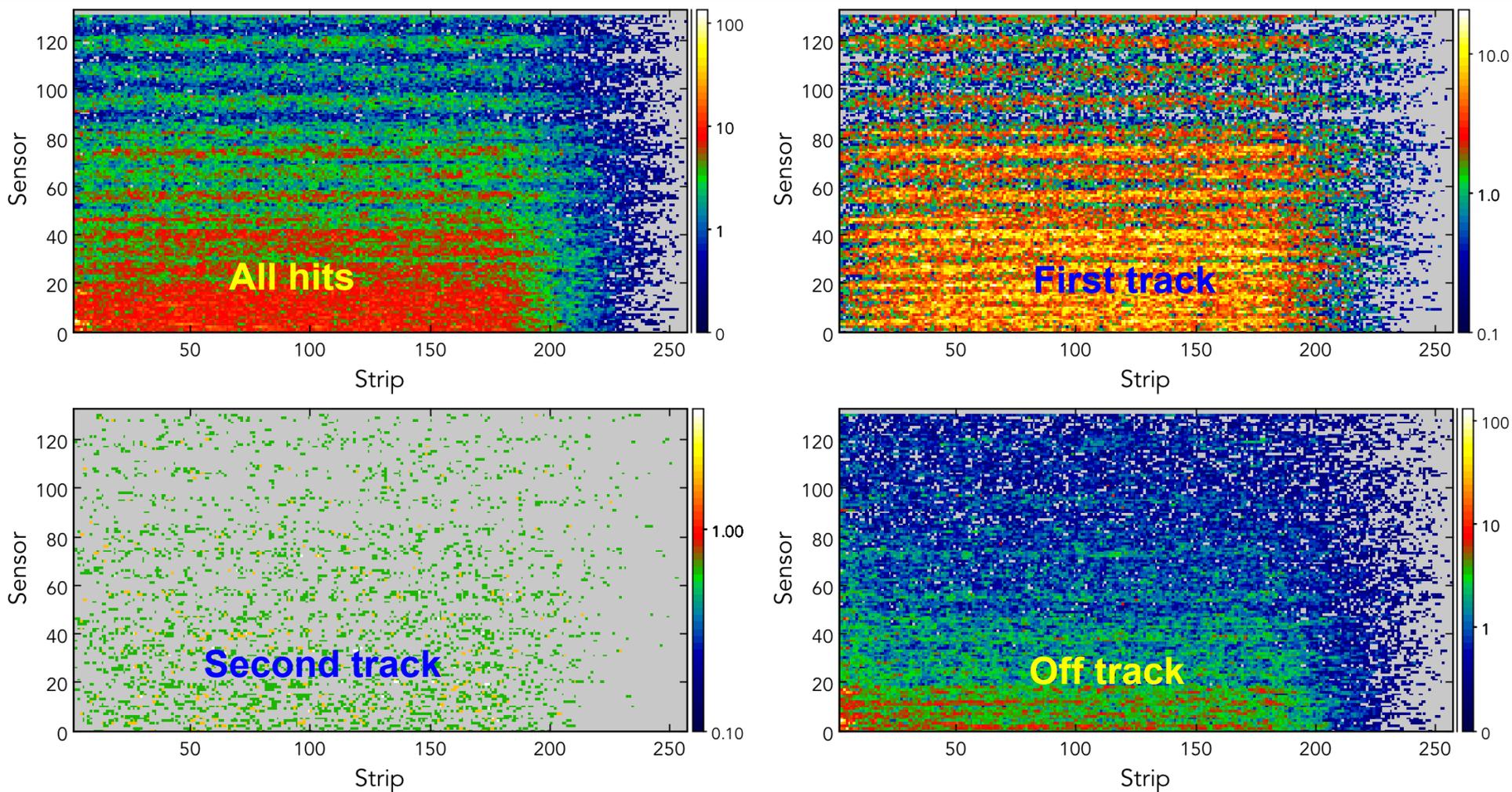
Local reconstruction (KPP runs 803, 809, 810, CLAS trigger)



Local reconstruction (cosmic trigger run 419)

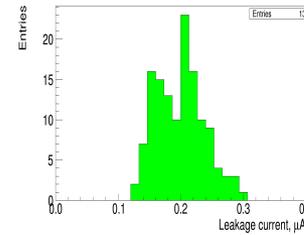
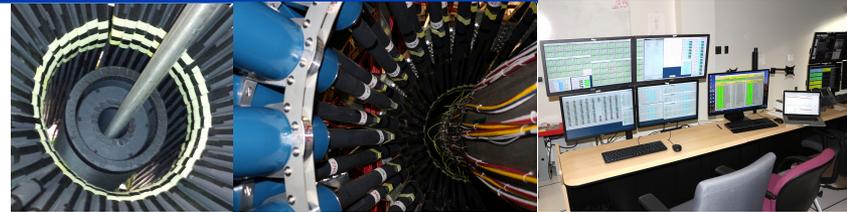


SVT Hit Occupancy (KPP run 799, SVT standalone trigger)

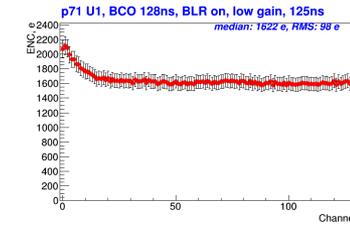


SVT Operation during KPP

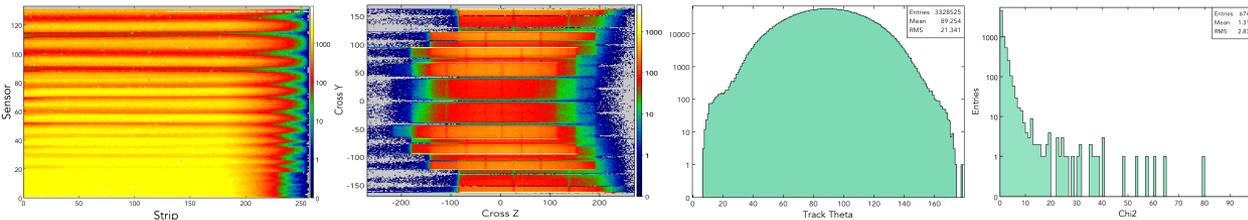
- SVT system installed, cabled, checkout complete in 4 days
- Great joint effort with DSG and Mechanical Engineering Group
- For cosmic data the standalone SVT SD based trigger was used
- Cosmic trigger rate was 6.5 Hz (compared to 9 Hz in EEL)
- 85% standalone SVT trigger events have reconstructed tracks
- All channels calibrated, no new bad channels observed
- In R1 U1/U3 chips have noise shoulders on the left side of ENC plots
- Disappeared when the beam pipe was removed
- Data taking and reco chain validated
- Confirmed signal and noise performance on KPP data
- 27 k tracks reconstructed in KPP runs 803, 809, 810
- Completed SEE monitoring test, no readout or data corruption
- Stable running with 99.9% channels operational



Leakage currents



R1 noise shoulder



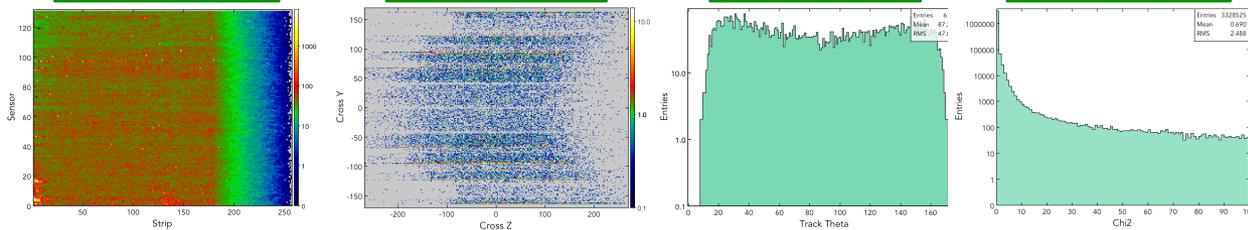
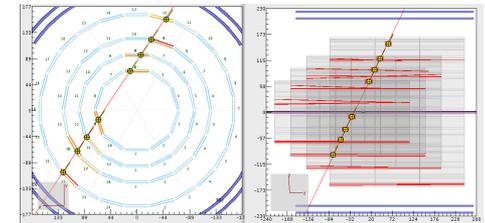
Hit occupancy

Track crosses

Track θ angle

Normalized χ^2

SVT Cosmic trigger data



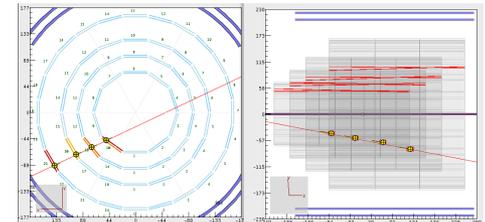
Hit occupancy

Track crosses

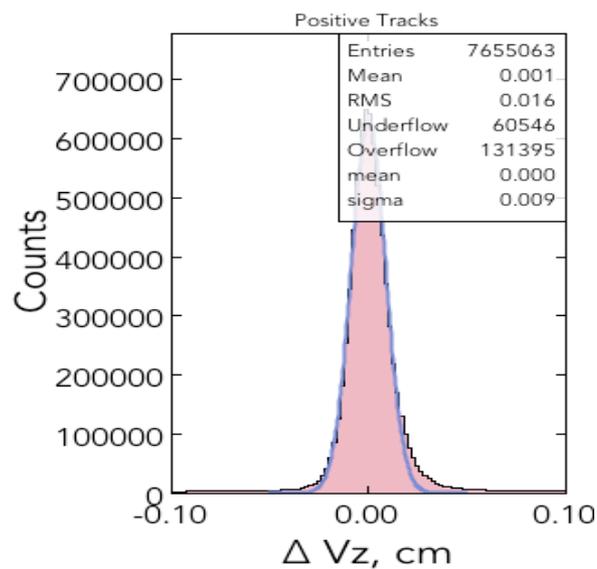
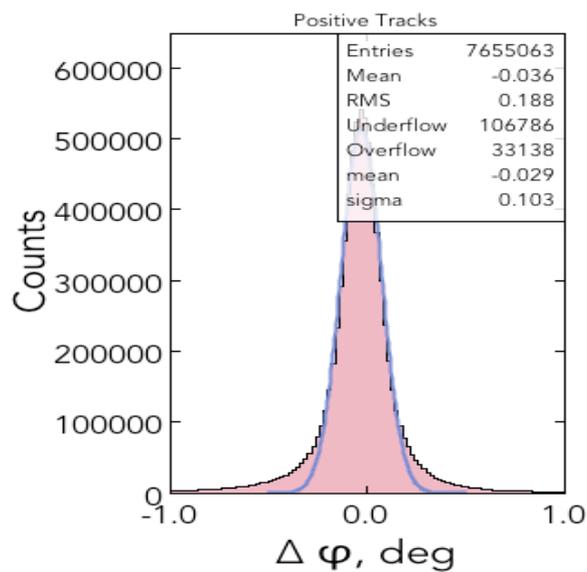
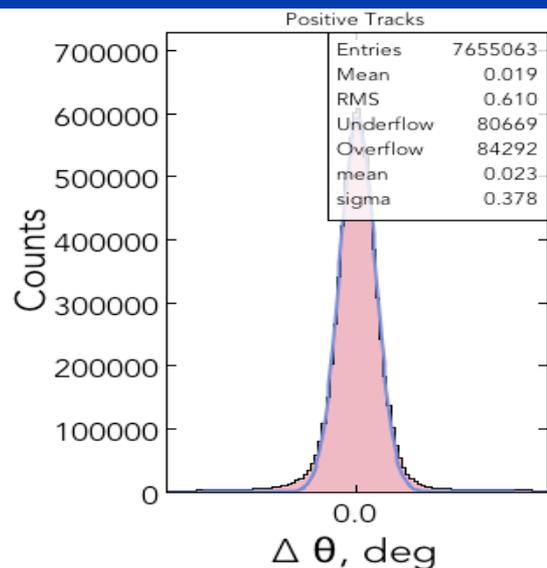
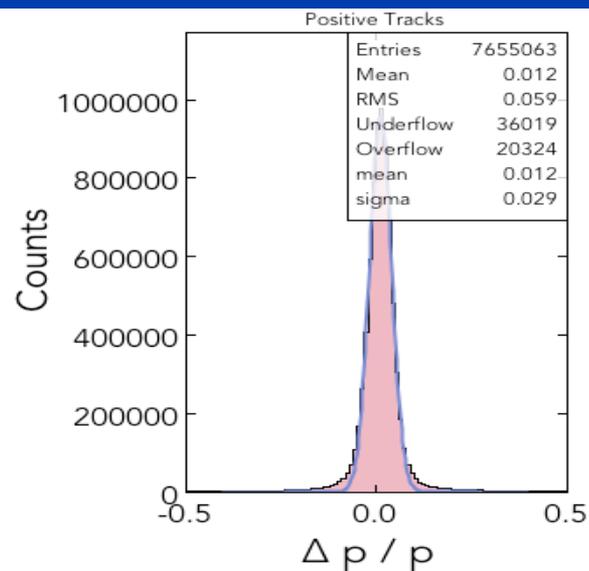
Track θ angle

Normalized χ^2

KPP CLAS trigger data



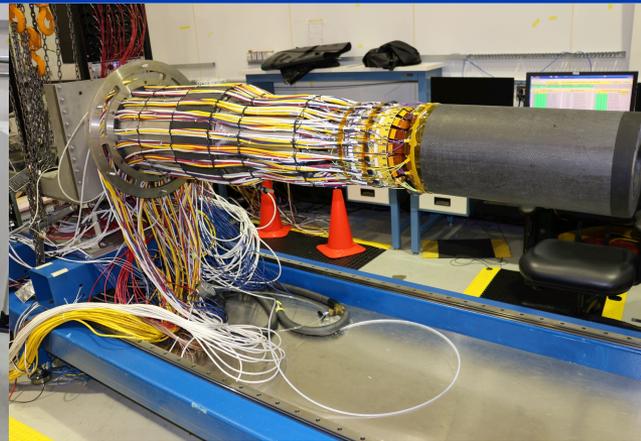
Resolution



CVT Integration



SVT Region 4 dismantled



SVT ready for integration



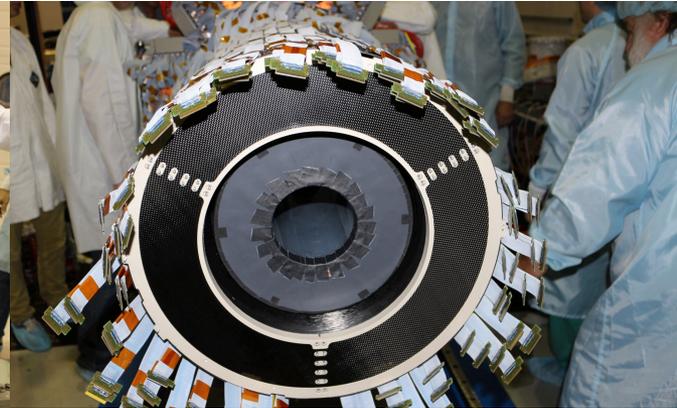
Mounting MVT on the support rods



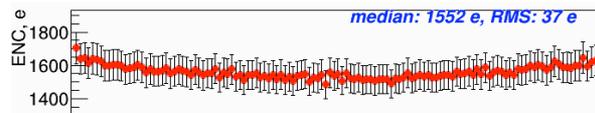
Survey of SVT and MVT
CVT alignment



CVT integration

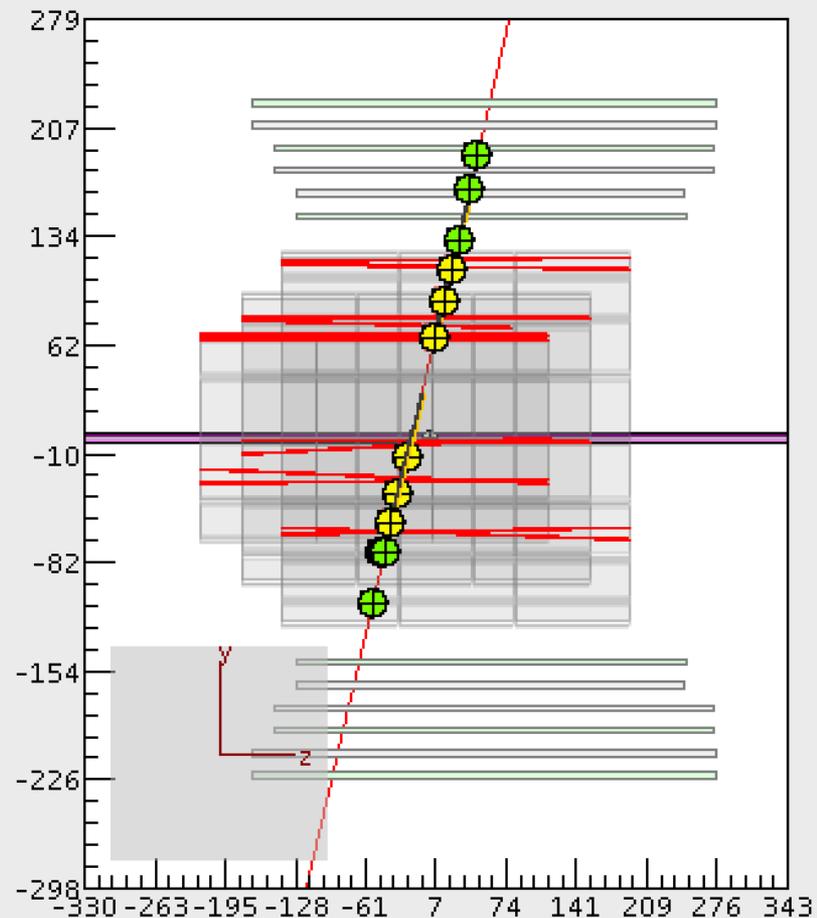
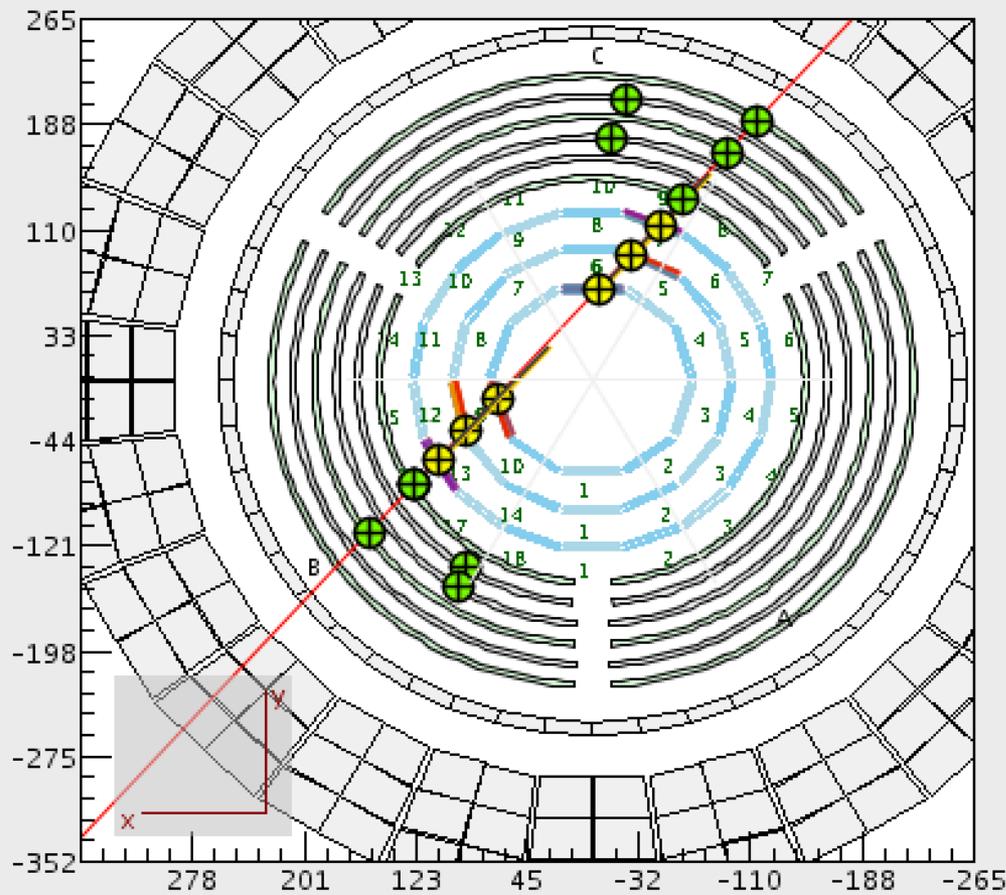


CVT integrated (SVT and BMT)

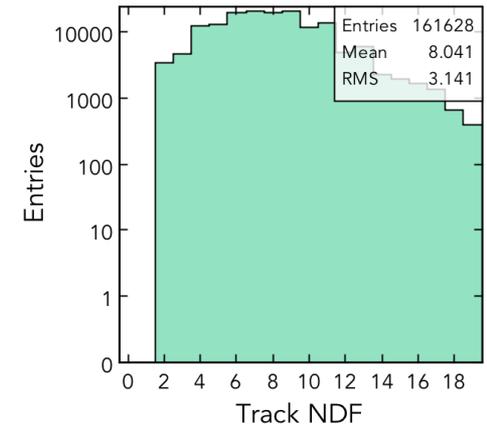
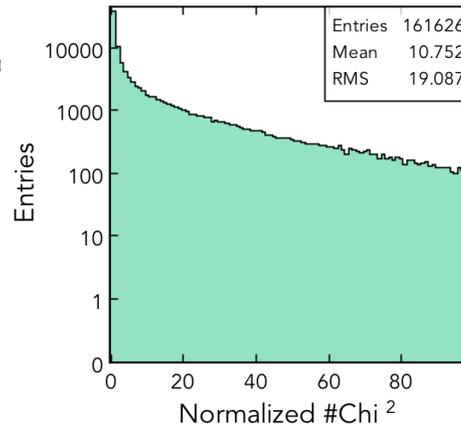
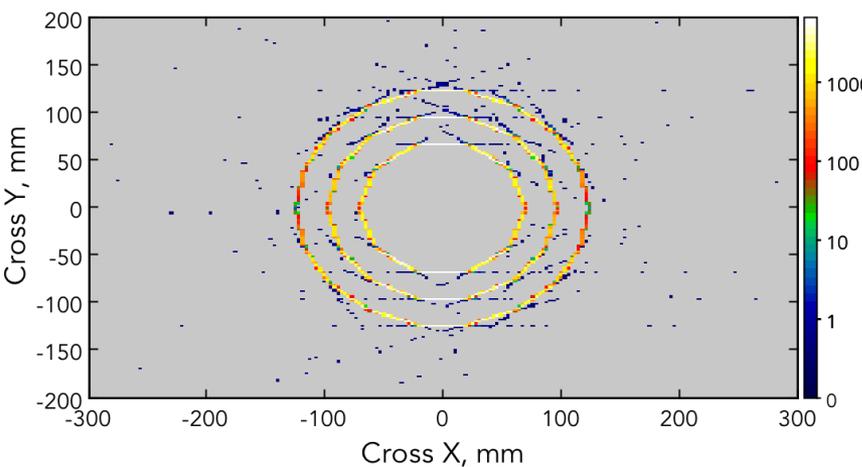
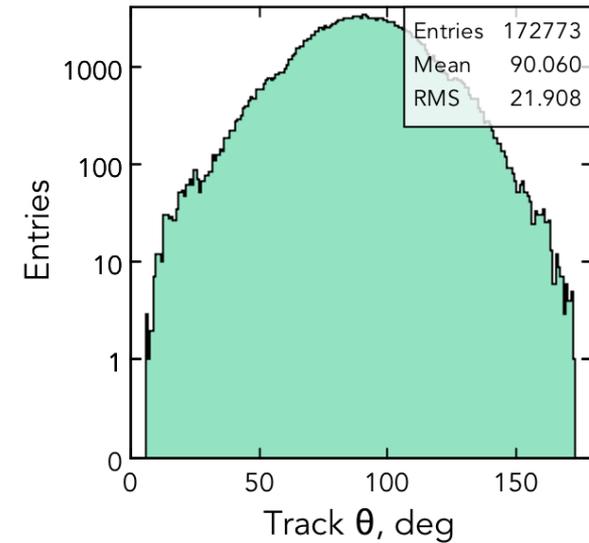
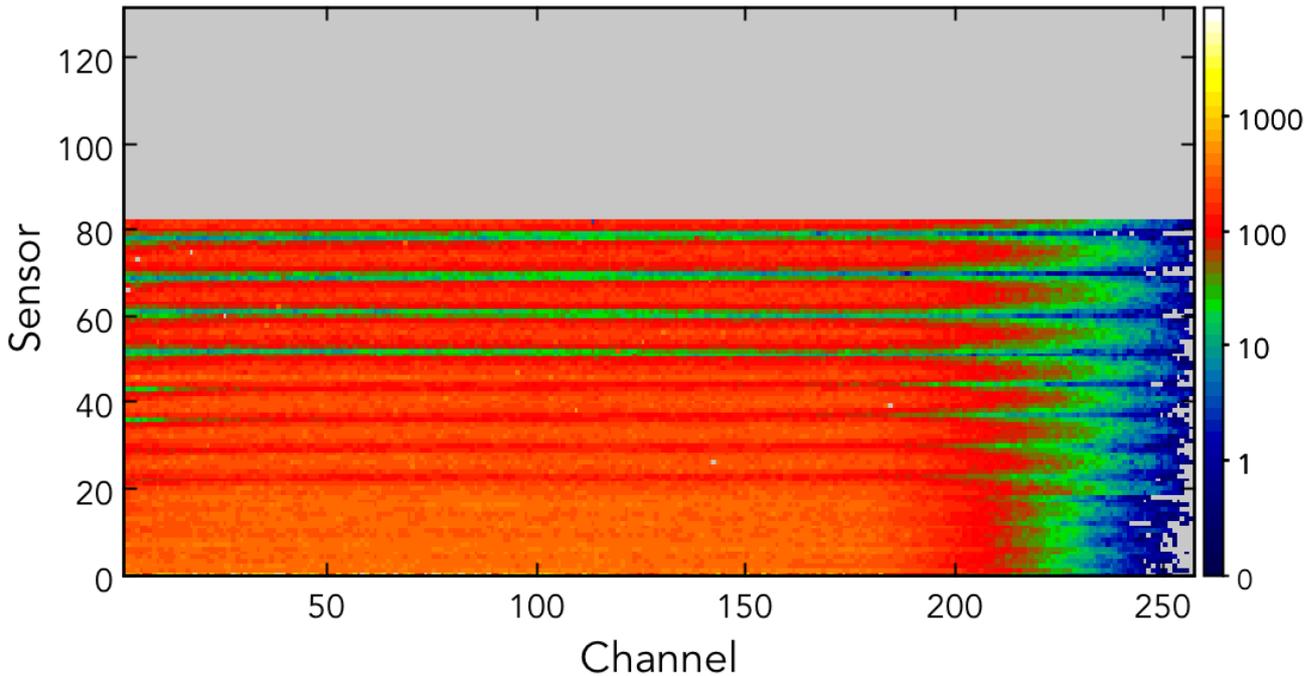


SVT noise the same after integration

CVT Reconstructed Cosmic Track (run 474)



CVT Cosmic Track Reconstruction (run 474)



CVT Commissioning Activities (summer 2017)

- **CVT Integration Complete**
- Geometry description and validation (June)
- Detector Control and Safety System (June)
- Detector functionality checks (June-July)
- Developing DQM suite (June - July)
- Validation of local and track reconstruction (June - July)
- Monte Carlo tuning on cosmic data (June - August)
- Installation Schedule and Manpower (July)
- CVT calibration (July)
- High trigger rate test (July)
- **Detector alignment is critical step in validating the tracker performance**
 - **Complete SVT survey DB validation by August**
 - **Complete SVT alignment by September**
 - **Complete CVT alignment by September**
 - **CVT alignment validation with MC and Cosmic data (July-September)**
- Long term stability test (ongoing activity)
- Detector optimization (July-August)
- Detector performance studies (July-August)
- Documentation (May-August)

Summary

- SVT is fully integrated, surveyed and calibrated
- Checkout of the detector services complete
- Checkout of detector safety system complete
- Checkout of DAQ and trigger complete
- Validation of data integrity and reconstruction chain complete
- No extra noise observed after integration
- Detector operation experience since 2015
- Stable running with 99.9% channels operational
- KPP installation and system checkout complete in 4 days
- Detector installation procedures and performance in the hall validated
- Confirmed signal and noise performance on KPP data
- 27 k tracks reconstructed in KPP runs 803, 809, 810
- Completed SEE monitoring test, no readout or data corruption
- 100 M tracks cosmic sample collected, alignment in progress
- Conversion of Slow Controls to CLAS CSS complete
- SVT calibration suite complete
- Expert level detector monitoring and validation suite complete
- Conference papers published in NIM, PoS, technical paper in the works
- Documentation of hardware and software available

BACKUP
