Fermilab

Directorate

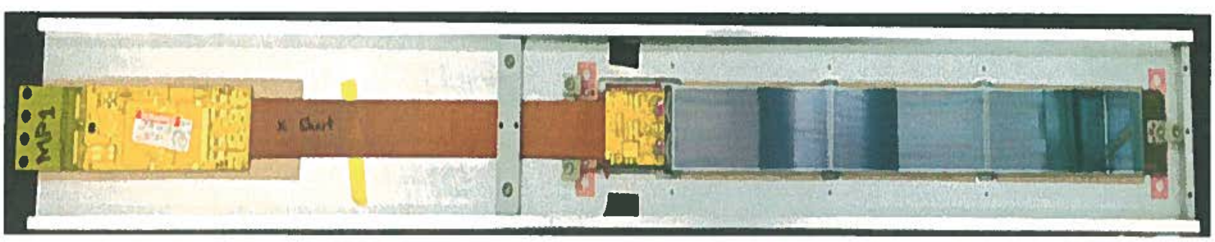
TECHNICAL SCOPE OF WORK

FOR THE 2014 FERMILAB TEST BEAM FACILITY PROGRAM

T-1047

CLAS12 Silicon Vertex Tracker Module Test

September 11, 2013



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INTRODUCTION

This is a technical scope of work (TSW) between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of CLAS12 collaboration who have committed to participate in beam tests to be carried out during the 2013-2014 Fermilab Test Beam Facility program.

The TSW is intended primarily for the purpose of recording expectations for budget estimates and work allocations for Fermilab, the funding agencies and the participating institutions. It reflects an arrangement that currently is satisfactory to the parties; however, it is recognized and anticipated that changing circumstances of the evolving research program will necessitate revisions. The parties agree to modify this scope of work to reflect such required adjustments. Actual contractual obligations will be set forth in separate documents.

This TSW fulfills Article 1 (facilities and scope of work) of the User Agreements signed (or still to be signed) by an authorized representative of each institution collaborating on this experiment.

Description of Detector and Tests:

The Continuous Electron Beam Accelerator Facility's (CEBAF) Large Acceptance Spectrometer (CLAS) 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 influence 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.
The central tracker consists of a solenoid, Central Time-Of-Flight system (CTOF), and Silicon Vertex Tracker (SVT). The SVT will be centered inside of the solenoid, which has 5 T magneticfield. Essential parts of the physics program, such as GPD's, require tracking of low momentum particles with few percent momentum and about one degree angle resolution at large angles. This is achieved by the SVT. Silicon detector technology makes an excellent match to the central tracking system in the CLAS12 configuration, small space and high luminosity operation that is needed for accurate measurements of exclusive processes at high momentum transfer. Barrel Silicon Tracker (BST) comprises 33792 channels of silicon strip sensors in eight layers (four concentric polygonal regions that have 10, 14, 18, and 24 double sided modules mounted back to back). There are three daisy-chained sensors per layer (six per module). Each layer has 256 strips with linearly varying angles. Double sided SVT module hosts three single sided daisy-chained microstrip sensors fabricated by Hamamatsu on each side.

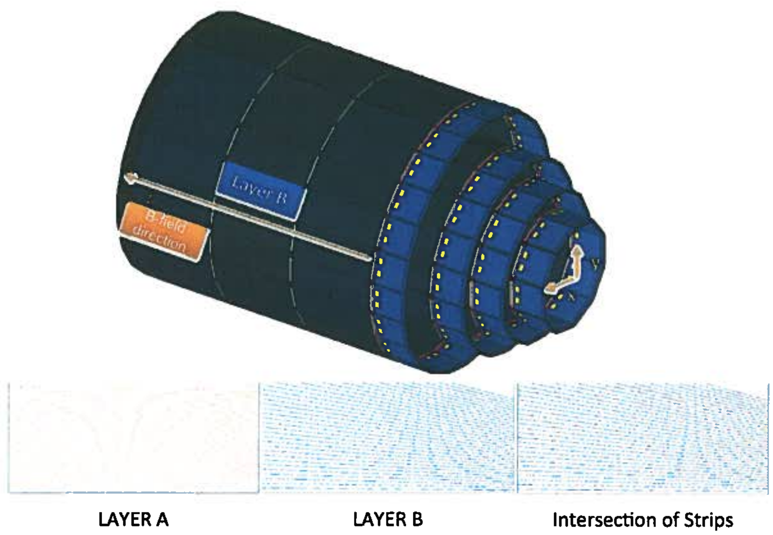


Figure 1. Barrel Silicon Tracker

SVT modules are fabricated by the Silicon Detector Facility (SiDet) at Fermilab. All modules have 3 types of sensors: Hybrid, Intermediate, and Far. Sensors are cut from 6 inch wafers, 2 sensors per wafer. All sensors have the same size, 112x42 mm. All SVT modules are identical. Sensors are mounted on a composite backing structure composed of Rohacell 71 core, bus cable, and carbon fiber. The carbon fiber skin is made from K13C2U fibers oriented in a quasi-isotropic (45/-45/0) pattern. It is co-cured with the bus cable, which is made from a Kapton sheet with 0.003-mm thick copper traces, which are 0.5 mm wide; traces on one side provide high voltage to the sensors, on the other side they form a 6x6 mm copper mesh over the entire area for grounding the carbon fiber. The Rohacell core under the hybrid board is replaced by a copper heat sink to remove ~2 W of heat generated by the ASICs. At the downstream end of the module, the Rohacell core is replaced by a polyether ether ketone (PEEK) core. Pitch adapter serves to match the 156 um sensor readout pitch to the 50 um FSSR2 bonding pad pitch. The pitch adapter is a glass plate with metal traces made of an alloy of aluminum and copper. The alloy improves electromigration hardness and bonding. The metal layer is sputter deposited. The passivation layer protects the aluminum traces from damage and is made from SiO_2.

Figure 2. SVT module

There are 512 channels per module read out by FSSR2 chips, mounted on a hybrid.
A readout system which instruments both sides of a module with a single rigid-flex Hybrid Flex Circuit Board (HFCB), has been developed by JLAB and fabricated by Compunetics Inc. The HFCB is located on the upstream end of the module.

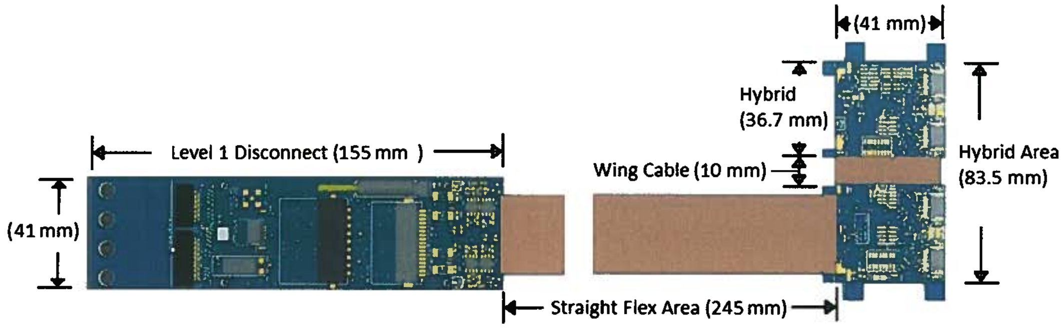


Figure 3. Hybrid Flex Circuit Board

There are 512 channels per module read out by four Fermilab Silicon Strip Readout (FSSR2) chips featuring data driven architecture, mounted on a rigid-flex hybrid, two on the top and two on the bottom side. The hybrid areas are connected by a 10~mm-long wing cable. Data is transferred from the hybrid via the flex cable to the level one connect (L1C) board. The L1C has two high density Nanonics connectors for data and control lines, Molex Micro-Fit 9-pin connector for high voltage (~85V) bias to the sensors, and AMP Mini CT 17 pin connector for low voltage (2.5V) power to the ASICs. There are 12 layers in rigid part and 6 layers in flex part. Control, data, and clock signals do not cross the ground plane splits. Clock signals are located on a separate layer. Guard traces are routed between output, clock, and power lines. Separate planes are provided for analog and digital power. To reduce noise on these planes, regulators and bypass capacitors are added. High voltage filter circuits and the bridging of high and low voltage return lines are located close to the ASICs. Decoupling capacitors for power transmission are placed at transitions between flex and rigid materials.
The FSSR2 ASIC has been developed at Fermilab for the BTeV experiment. It was fabricated by Taiwan Semiconductor Manufacturing Company in the 0.25-um CMOS process. The chip features a data-driven architecture (self-triggered, time-stamped). Each of the 128 input channels of the FSSR2 ASIC has a preamplifier, a shaper that can adjust the shaping time (50—125 ns), a baseline restorer (BLR), and a 3-bit ADC. The period of the clock called beam crossing oscillator (BCO) sets the data acquisition time. If a hit is detected in one of the channels, the core logic transmits pulse amplitude, channel number, and time stamp information to the data output interface. The data output interface accepts data transmitted by the core, serializes it, and transmits it to the data acquisition system. To send the 24-bit readout words one, two, four, or six Low Voltage Differential Signal (LVDS) serial data lines can be used. Both edges of the 70~MHz readout clock are used to clock data, resulting in a maximum output data rate of 840 Mb/s. The readout clock is independent of the acquisition clock. Power consumption is <4 mW per channel. The FSSR2 is radiation hard up to 5 Mrad.

Each of the four FSSR2 ASICs reads out 128 channels of analog signals, digitizes and transmits them to a VXS-Segment-Collector-Module (VSCM) card developed at Jefferson Lab. The event builder of the VSCM uses the BCO clock timestamp from the data word of each FSSR2 ASIC and matches it to the timestamp of the global system clock, given by the CLAS trigger. The event builder buffers data received from all FSSR2 ASICs for a programmable latency time up to ~16 us. The VSCM is set up to extract event data within a programmable look-back window of ~16 us relative to the received trigger. The trigger latency is expected to be ~8 us.

SVT setup uses VME based readout using VXS-Silicon-Control-Module (VSCM) designed to interface the FSSR2 readout/controls section to the Hall B DAQ (figure 5). VSCM is a VXS Based Module, which allows reusing standard front-end crate configuration for triggering & readout. It supports two Hybrid Flex Circuit Board (HFCB) Interfaces per VSCM module, has 8 FSSR2 chips per VSCM (4 per HFCB), 6 readout lines per FSSR2 @ 70 MHz DDR for 840 Mbps operation, provides programmable BCO clock synchronized to CLAS global trigger clock, has FSSR2 slow control interface accessible through VME registers, Event Builder, 2 Mbyte multi-event buffer (storage for ~500,000 triggered strip hits), VME readout: 2eSST @ 200 MB/s, multi-event blocking supported, Programmable capture window (can span multiple BCO clocks).

Status words & hits not in defined trigger time window are suppressed from readout. There is a 32 bit scaler for every strip, and arbitrary pulser for each HFCB (synchronous to BCO clock). Continuous status & event word monitors are used for error checking & synchronization. VSCM buffering supports occupancies at 100% for several hundred sequential events before dead time occurs.

VSCM Event Structure (bracketed rows: Event Header through the second SVT Hit)

Structure Element	Size (bytes)	Element Information
Block Header	4	Block Number: 11bits VME Slot: 5bits EventsPerBlock: 11bits
Event Header	4	Event number: 27bits
Trigger Timestamp	8	Timestamp: 48bits (~13 day rollover)
SVT Hit	4	Pulse Height: 3bits BCO Number: 8bits Strip Number: 7bits Chip Identifier: 3bits Hit->Trigger Timestamp: 10bits
SVT Hit	4	
...		
SVT Hit	4	
...		
Event Header	4	
Trigger Timestamp	8	
SVT Hit	4	
Block Trailer	4	Block Word Count: 22bits VME Slot: 5bits

* Redundant information used for consistency checking

Figure 4. VSCM event structure.

Figure 5 shows global trigger system "CLK" and "SYNC" signals used by VSCM to phase align the BCO clocks and counters across all FSSR2 chips:

- When SYNC is asserted BCO clock is halted after a "smart reset" is issued to FSSR2
- When SYNC is released BCO clock is started with rising edge aligned to global trigger clock rising edge

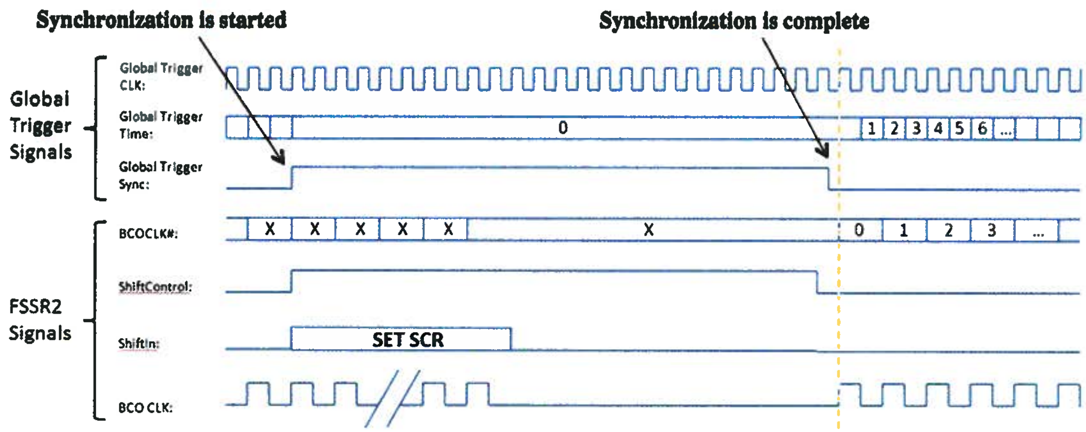
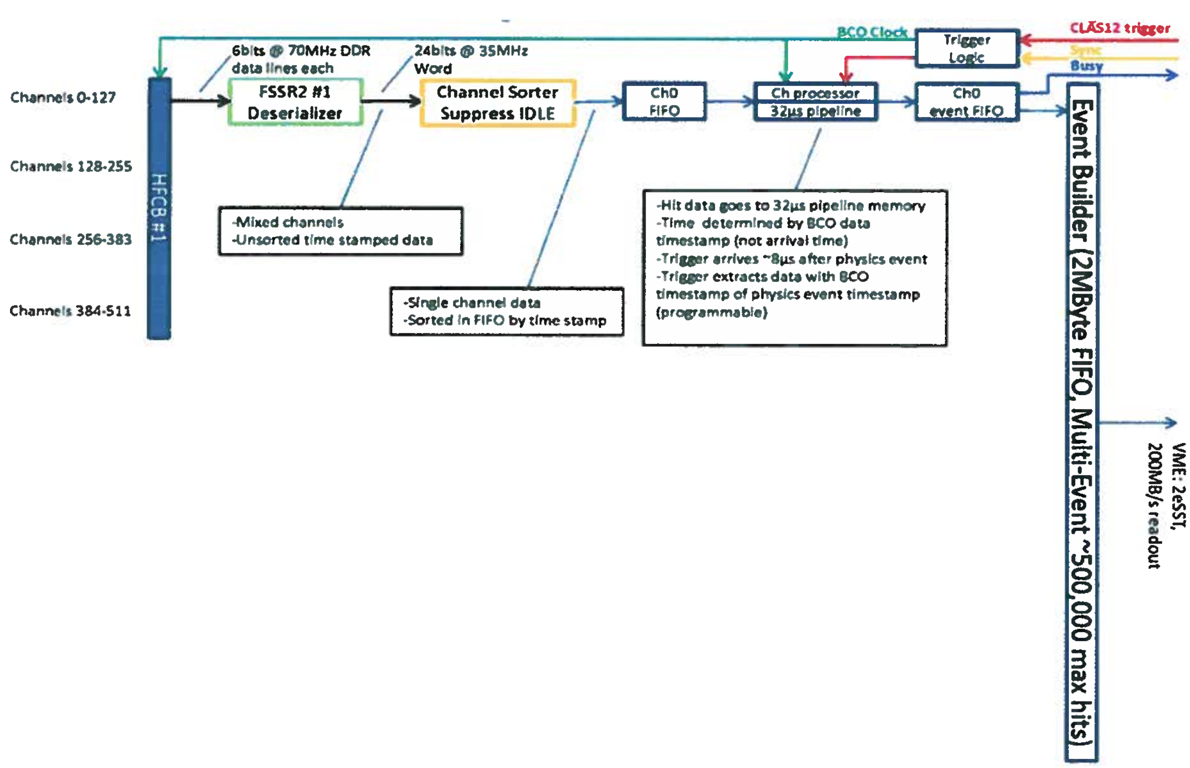


Figure 5. FSSR2 clock and timestamp synchronization.



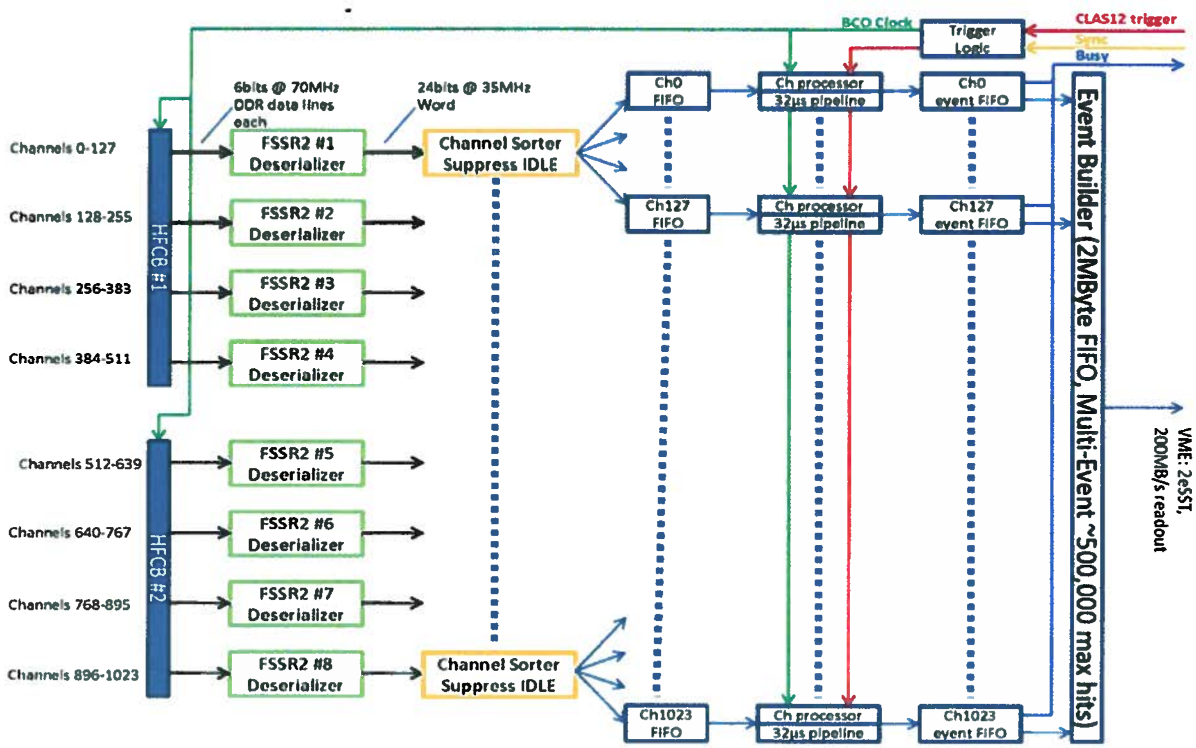


Figure 6. Event building in the VSCM for single and all strips

Each FSSR2 chip has its identification number specified by connecting external contact pads to corresponding potentials. This enables the separate operation of each IC. If synchronization of time stamps of separate chips is violated, this hinders reconstruction of data belonging to a single event. Information can be downloaded to one specific chip using the chip ID or all chips simultaneously using a wild chip ID address.

No time is allotted for transmitting stored information in the FSSR2 working cycle, i.e., the data arrives at the chip output directly after the signal is detected.

The signal reception units should be permanently ready for receiving data, since the data can arrive at any moment. Therefore, the chip can operate only as a part of the software–hardware complex with the external controller tuned for the data-waiting mode.

When the discriminator threshold is exceeded, the analog signal is converted into a digital signal, the time stamp is adhered to it, the channel number is added, and the information formed thereby is converted into a 2 bit word (3 bytes), which is transmitted with a high speed over differential lines to the VSCM board. If no events are detected, the chip transmits three service information bytes synchronously with the clock generator frequency. The Data Output Interface formats the information to be transmitted and adjusts the internal clocking frequencies so that all hit data in a single BCO are normally read out in about 1 BCO time interval. Number of readout lines of the

FSSR2 chip can be adjusted from 1 to 6 depending on the rate, 1 output is 24 bits, 6 outputs x 4 bits = 24 bits. ADC dynamic range is up to 2 MIPs.

SVT modules are powered by LV (2.5V) and HV (85 V) power supply modules located in the MPOD crate.

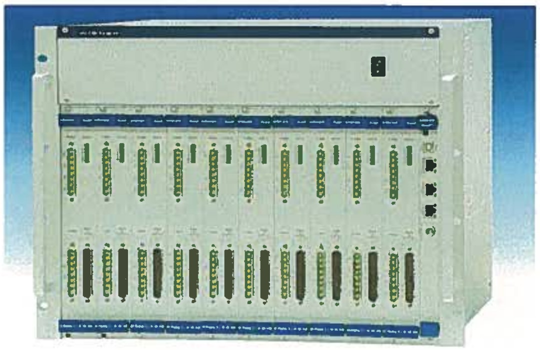


Figure 7. MPOD crate

SVT module test

SVT beam test will evaluate performance of the SVT module as a tracking device. Track position in the sensors is provided by the CMS pixel tracking telescope at the Fermilab Test Beam Facility. Production grade sensors and hybrid are used in the module under test which is powered by production grade power supplies and read out by production grade VME based DAQ.

The goals for the SVT beam test are:

- Validation of the SVT detector module
- DAQ testing
- Measurement of Signal-to-Noise Ratio (S.N.R.)
- Measurement of cross-talk between the two sides of a module
- Measurement of hit efficiency vs. threshold
- Measurement of channel inefficiency: study of defective (dead, noisy, broken bonds) channels and strips
- Measurement of capacitive coupling and strip multiplicity
- Testing cluster finding algorithms

I. PERSONNEL AND INSTITUTIONS:

Spokesperson: Yuri Gotra, Thomas Jefferson National Accelerator Facility

Lead Experimenter in charge of beam tests: Yuri Gotra

Fermilab liaison: Aria Soha

The group members at present are:

	Institution	Country	Collaborator	Rank/Position	Other Commitments
1.1	Thomas Jefferson National Accelerator Facility	USA	Brian Eng	Engineer	CLAS12
			Yuri Gotra	Scientist	
			Sergei Boiarinov	Scientist	

II. Experimental Area, Beams and Schedule Considerations:

2.1 Location

2.1.1 The beam test(s) will take place in MT6.1A, as shown in Appendix I.

2.2 Beam

2.2.1 Beam Types and Intensities

Energy of beam: 120 GeV
Particles: protons
Intensity: 10k – 100k particles/ 4 sec spill
Beam spot size: about $10cm^2$

2.2.2 Beam Sharing

The experiment will run parasitically downstream of the CMS Pixel Tracking Telescope.

The radiation length of the detector is $1\%X_0$.

2.2.3 Running Time

Experiment will run parasitically and no extra run time w.r.t. the run time allocated for the CMS Pixel Tracking telescope test beam program is needed.
It will take 2 hours to install before ORC Inspection/ requesting beam.

See section 2.3.3 for total run time and long-term schedule.

2.3 Experimental Conditions

2.3.1 Area Infrastructure

The experimental setup consists of three major components: the detector itself, the DAQ crate and the power supply crate. The detector is described in the Introduction. The DAQ crate, manufactured by W-IE-NE-R, is a VME/VXS enclosure for up to 21 6U cards along with a built-in fan tray (Dimensions: 19" (482mm) x 11U (489mm) x 480mm [whd], weight: ~40 kg). It has either a NEMA 5-20 or 5-15 plug for the AC power input. The power supply crate (MPOD), also manufactured by W-IE-NE-R, is a modular power supply mainframe (Dimensions: 19" (482mm) x 8U (356mm) x 460mm [whd], weight: ~20 kg) that can hold up to 10 of either Low Voltage (up to 8V) and High Voltage (up to 500V) cards. It uses a NEMA 5-15 plug for AC power input. There will be at least 1 Ethernet connection for the VME controller card and up to an additional two (VXS crate and MPOD crate) depending on available time to setup.

2.3.2 Electronics Needs

All power supply components are off the shelf commercial items. The VXS crate and controller are also standard commercial items. The VME cards are using commercial components; the manuals of which can be found online:

http://clasweb.jlab.org/instrumentation/SVT/Documents/Manuals/

No PREP electronics are requested.

2.3.3 Description of Tests

Tests are done with a single SVT module. No change of detectors is needed. No special needs and extra time is requested, running parasitically downstream of the setup T-992 (pixel telescope). Data will be collected with SVT DAQ using the trigger from the telescope during day shifts (8 am to 8 pm). No change in beam types requested.

2.4 Schedule

No extra beam requests are planned.

III. RESPONSIBILITIES BY INSTITUTION – NON FERMILAB

3.1 THOMAS JEFFERSON NATIONAL ACCELERATOR LABORATORY:

- Provides SVT module and DAQ
- Installs the hardware
- Provides shifters for data taking

IV. Responsibilities by Institution – Fermilab

4.1 Fermilab Accelerator Division:

4.1.1 Use of MTest beamline as outlined in Section II.
4.1.2 Maintenance of all existing standard beam line elements (SWICs, loss monitors, etc) instrumentation, controls, clock distribution, and power supplies.
4.1.3 Scalers and beam counter readouts will be made available via ACNET in the MTest control room.
4.1.4 Reasonable access to the equipment in the MTest beamline.
4.1.5 Connection to beams console and remote logging (ACNET) should be made available.
4.1.6 The test beam energy and beam line elements will be under the control of the AD Operations Department Main Control Room (MCR).
4.1.7 Position and focus of the beam on the experimental devices under test will be under control of MCR. Control of secondary devices that provide these functions may be delegated to the experimenters as long as it does not violate the Shielding Assessment or provide potential for significant equipment damage.
4.1.8 The integrated effect of running this and other SY120 beams will not reduce the neutrino flux by more than an amount set by the office of Program Planning, with the details of scheduling to be worked out between the experimenters and the Office of Program Planning.

4.2 Fermilab Particle Physics Division:

4.2.1 The test-beam efforts in this TSW will make use of the Fermilab Test Beam Facility. Requirements for the beam and user facilities are given in Section II. The Fermilab Particle Physics Division will be responsible for coordinating overall activities in the MTest beam-line, including use of the user beam-line controls, readout of the beam-line detectors, and FTBF computers.
4.2.2 Conduct a NEPA review of the experiment.
4.2.3 Provide day-to-day ESH&Q support/oversight/review of work and documents as necessary.
4.2.4 Provide safety training as necessary, with assistance from the ESH&Q Section.
4.2.5 Update/create ITNA's for users on the experiment.
4.2.6 Initiate the ESH&Q Operational Readiness Clearance Review and any other required safety reviews. [0.2 person-weeks]

4.3 Fermilab Scientific Computing Division

4.3.1 Internet access should be continuously available in the MTest control room.
4.3.2 Set up and maintenance of Si tracking system. [1.0 person weeks]

4.4 Fermilab ESH&Q Section

4.4.1 Assistance with safety reviews.
4.4.2 Provide safety training, with assistance from PPD, as necessary for experimenters. [0.2 person weeks]

V. SUMMARY OF COSTS

Source of Funds [$K]	**Materials & Services**	**Labor** (person-weeks)
Accelerator Division	0	0.0
Particle Physics Division	0.0	0.2
Scientific Computing Division	0	0
ESH&Q Section	0	0.2
Totals Fermilab	$0.0K	0.4
Totals Non-Fermilab	0.0	2.0

VI. GENERAL CONSIDERATIONS

6.1 The responsibilities of the Spokesperson and the procedures to be followed by experimenters are found in the Fermilab publication "Procedures for Researchers": (http://www.fnal.gov/directorate/PFX/PFX.pdf). The Spokesperson agrees to those responsibilities and to ensure that the experimenters all follow the described procedures.

6.2 To carry out the experiment a number of Environmental, Safety and Health (ESH&Q) reviews are necessary. This includes creating an Operational Readiness Clearance document in conjunction with the standing Particle Physics Division committee. The Spokesperson will follow those procedures in a timely manner, as well as any other requirements put forth by the Division's Safety Officer.

6.3 The Spokesperson will ensure at least one person is present at the Fermilab Test Beam Facility whenever beam is delivered and that this person is knowledgeable about the experiment's hazards.

6.4 All regulations concerning radioactive sources will be followed. No radioactive sources will be carried onto the site or moved without the approval of the Fermilab ESH&Q section.

6.5 All items in the Fermilab Policy on Computing will be followed by the experimenters. (http://computing.fnal.gov/cd/policy/cpolicy.pdf).

6.6 The Spokesperson will undertake to ensure that no PREP or computing equipment be transferred from the experiment to another use except with the approval of and through the mechanism provided by the Scientific Computing Division management. The Spokesperson also undertakes to ensure no modifications of PREP equipment take place without the knowledge and written consent of the Computing Sector management.

6.7 The experimenters will be responsible for maintaining both the electronics and the computing hardware supplied by them for the experiment. Fermilab will be responsible for repair and maintenance of the Fermilab-supplied electronics. Any items for which the experiment requests that Fermilab performs maintenance and repair should appear explicitly in this agreement.

At the completion of the experiment:

6.8 The Spokesperson is responsible for the return of all PREP equipment, computing equipment and non-PREP data acquisition electronics. If the return is not completed after a period of one year after the end of running the Spokesperson will be required to furnish, in writing, an explanation for any non-return.

6.9 The experimenters agree to remove their experimental equipment as the Laboratory requests them to. They agree to remove it expeditiously and in compliance with all ESH&Q requirements, including those related to transportation. All the expenses and personnel for the removal will be borne by the experimenters unless removal requires facilities and personnel not able to be supplied by them, such a rigging, crane operation, etc.

6.10 The experimenters will assist Fermilab with the disposition of any articles left in the offices they occupied.

6.11 An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters' Meeting.

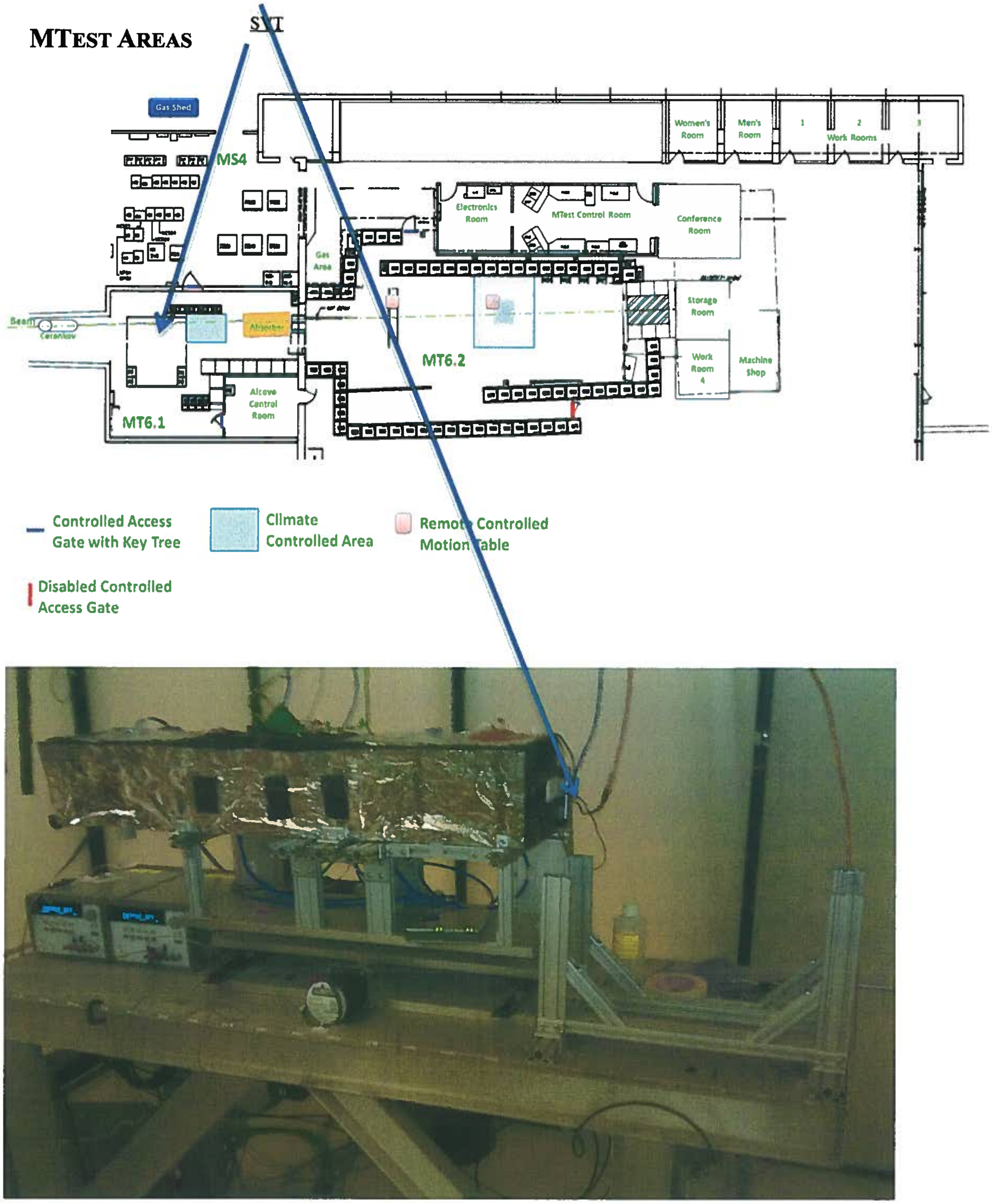
SIGNATURES:

________________________________ 09/10/ 2013

Yuri Gotra, CLAS12, JLAB, Experiment Spokesperson

Appendix I: MT6 Area Layout

MTest Areas



APPENDIX II: EQUIPMENT NEEDS

Provided by experimenters:

- SVT module
- VXS crate with controller and readout modules
- MPOD crate with LV and HV power supplies
- Cables to connect the SVT module with readout boards and PS

PPD items needed for Fermilab test beam, on the first day of setup.

PPD FTBF:

Quantity	Description
1	Si pixel tracking stations

APPENDIX III: - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need should be checked.
*See next page for detailed descriptions of categories.
There is NO need to list existing Facility infrastructure you might be using
(Do Not list FTBF Lasers or Motion Tables, unless you are bringing them)

Flammable Gases or Liquids		Other Gas Emissions*		Hazardous Chemicals		Other Hazardous /Toxic Materials
Type:		Type:			Cyanide plating materials	List hazardous/toxic materials planned for use in a beam line or an experimental enclosure:
Flow rate:		Flow rate:			Hydrofluoric Acid	
Capacity:		Capacity:			Methane	
Radioactive Sources		**Target Materials**			photographic developers	
	Permanent Installation		Beryllium (Be)		PolyChlorinatedBiphenyls	
	Temporary Use		Lithium (Li)		Scintillation Oil	
Type:			Mercury (Hg)		TEA	
Strength:			Lead (Pb)		TMAE	
Lasers			Tungsten (W)		Other: Activated Water?	
	Permanent installation		Uranium (U)			
	Temporary installation		Other:	**Nuclear Materials***		
	Calibration	**Electrical Equipment**		Name:		
	Alignment		Cryo/Electrical devices	Weight:		
Type:			Capacitor Banks	**Mechanical Structures**		
Wattage:		X	High Voltage (50V)		Lifting Devices	
MFR Class:			Exposed Equipment over 50 V		Motion Controllers	
			Non-commercial/Non-PREP		Scaffolding/ Elevated Platforms	
			Modified Commercial/PREP		Other:	
Vacuum Vessels		**Pressure Vessels**		**Cryogenics**		
Inside Diameter:		Inside Diameter:			Beam line magnets	
Operating Pressure:		Operating Pressure:			Analysis magnets	
Window Material:		Window Material:			Target	
Window Thickness:		Window Thickness:			Bubble chamber	

Other Gas Emission

Greenhouse Gasses (Need to be tracked and reported to DOE)

- ❑ Carbon Dioxide, including CO_2 mixes such as Ar/CO_2
- ❑ Methane
- ❑ Nitrous Oxide
- ❑ Sulfur Hexafluoride
- ❑ Hydro fluorocarbons
- ❑ Per fluorocarbons
- ❑ Nitrogen Trifluoride

Nuclear Materials

Reportable Elements and Isotopes / Weight Units / Rounding

Name of Material	MT Code	Reporting Weight Unit Report to Nearest Whole Unit	Element Weight	Isotope Weight	Isotope Weight %
Depleted Uranium	10	Whole Kg	Total U	U-235	U-235
Enriched Uranium	20	Whole Gm	Total U	U-235	U-235
Plutonium-242[1]	40	Whole Gm	Total Pu	Pu-242	Pu-242
Americium-241[2]	44	Whole Gm	Total Am	Am-241	–
Americium-243[2]	45	Whole Gm	Total Am	Am-243	–
Curium	46	Whole Gm	Total Cm	Cm-246	–
Californium	48	Whole Microgram	–	Cf-252	–
Plutonium	50	Whole Gm	Total Pu	Pu-239+Pu-241	Pu-240
Enriched Lithium	60	Whole Kg	Total Li	Li-6	Li-6
Uranium-233	70	Whole Gm	Total U	U-233	U-232 (ppm)
Normal Uranium	81	Whole Kg	Total U	–	–
Neptunium-237	82	Whole Gm	Total Np	–	–
Plutonium-238[3]	83	Gm to tenth	Total Pu	Pu-238	Pu-238
Deuterium[4]	86	Kg to tenth	D_2O	D_2	
Tritium[5]	87	Gm to hundredth	Total H-3	–	–
Thorium	88	Whole Kg	Total Th	–	–
Uranium in Cascades[6]	89	Whole Gm	Total U	U-235	U-235

[1] Report as Pu-242 if the contained Pu-242 is 20 percent or greater of total plutonium by weight; otherwise, report as Pu 239-241.

[2] Americium and Neptunium-237 contained in plutonium as part of the natural in-growth process are not required to be accounted for or reported until separated from the plutonium.

[3] Report as Pu-238 if the contained Pu-238 is 10 percent or greater of total plutonium by weight; otherwise, report as plutonium Pu 239-241.

[4] For deuterium in the form of heavy water, both the element and isotope weight fields should be used; otherwise, report isotope weight only.

[5] Tritium contained in water (H2O or D2O) used as a moderator in a nuclear reactor is not an accountable material.

[6] Uranium in cascades is treated as enriched uranium and should be reported as material type 89.

The following people have read this TSW:

______________________________ 9 / 13 / 2013
Michael Lindgren, Particle Physics Division, Fermilab

______________________________ 9 / 13 / 2013
Roger Dixon, Accelerator Division, Fermilab

______________________________ 9 / 13 / 2013
Robert Roser, Scientific Computing Division, Fermilab

FOR M M. ______________________________ 9 / 13 / 2013
Martha Michels, ESH&Q Section, Fermilab

______________________________ 9 / 14 / 2013
Greg Bock, Associate Director for Research, Fermilab

______________________________ 9 / 14 / 2013
Stuart Henderson, Associate Director for Accelerators, Fermilab