Fermilab

Directorate

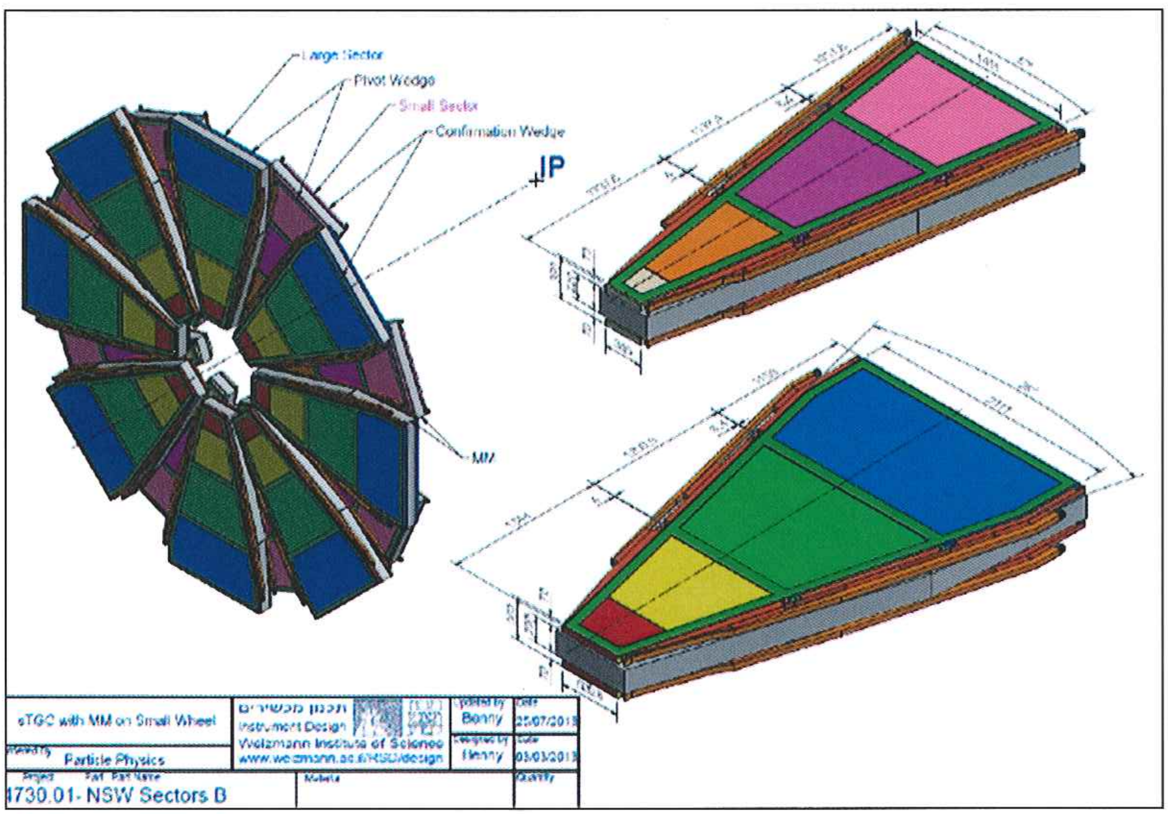
TECHNICAL SCOPE OF WORK

FOR THE 2014 FERMILAB TEST BEAM FACILITY PROGRAM

T-1049

ATLAS large scale Thin Gap Chambers

April 29, 2014



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Introduction

This is a technical scope of work (TSW) between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of the ATLAS sTGC New Small Wheel collaboration who have committed to participate in beam tests to be carried out during the FY2014 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 main motivation for the luminosity upgrade of the LHC (sLHC) is to accurately study the Higgs boson branching ratios as well as to extend the sensitivity to new physics (like Super-Symmetric Particles) to the multi TeV region. In order to achieve these goals one will have to trigger on moderate momentum leptons under background conditions (low energy photons and neutrons) much harder than those currently at the LHC. For the Muon Spectrometer (MS), such requirements necessitate the replacement of the forward muon-tracking region with new detectors capable of tracking and triggering simultaneously. This will enable ATLAS to reduce the fake trigger rate as shown in Figure 1. Thin Gap Chambers (sTGC) have been selected as one

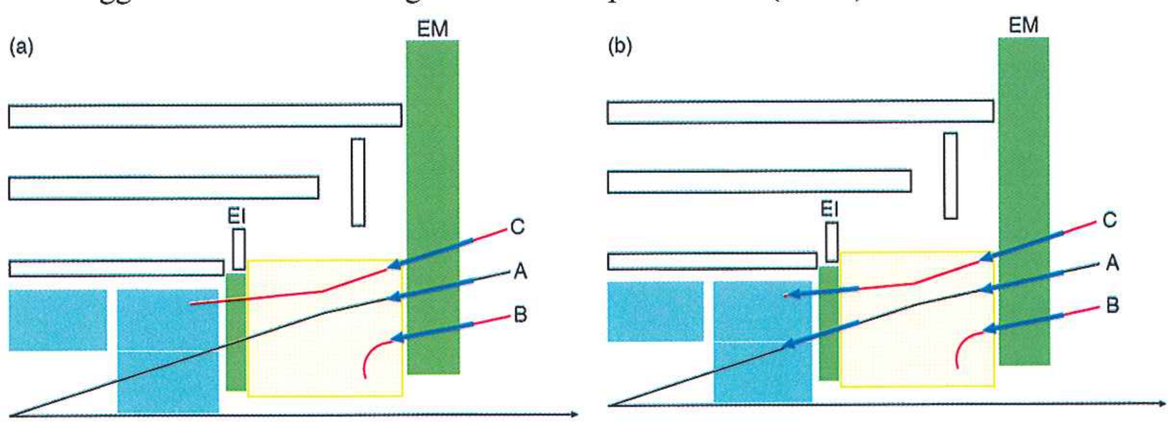


Figure 1: Left: The current ATLAS forward muon level-1 trigger is provided by the large muon wheel (EM). Background particles (B and C) can appear as if they are coming from the Interaction point resulting in fake triggers. Right: the addition of track segments at level 1 from a New Small Wheel (vertical green bar in center) reduces false triggers reducing the fake trigger rate.

of the two technologies that will be used for this upgrade. Figure 2 shows the presently foreseen layout for this upgrade. A large collaboration has been established to construct these devises, composed of members from Canada, Chile, China, Italy, Israel and the USA. A full size quadruplet of one of the modules will be constructed using the final tools by April 2014 in one of the experienced production sites (Israel), while a smaller quadruplet will be produced in one of the new production sites (Canada).

Since the requirements on precision for such devices are very hard to achieve (40μm RMS between the 4 detector planes and 80μm RMS in the position of each plane, perpendicular to the direction of the particles) a test-beam is needed to qualify the assembly procedure, in order to ensure that one can proceed to the production of the final devices. The proposed test beam at Fermilab will allow for a scan of these pre-series detectors to confirm that required relative and absolute precision has been achieved. This will be done by comparing the extrapolated beam particle incidence point using a pixel telescope with that measured in each of the 4 sTGC planes. The test period will be used to certify the newly developed front-end electronics by comparing the position resolution with the results achieved with the first prototypes of this electronics. The test beam will also investigate the alignment of strips between the sTGC planes.

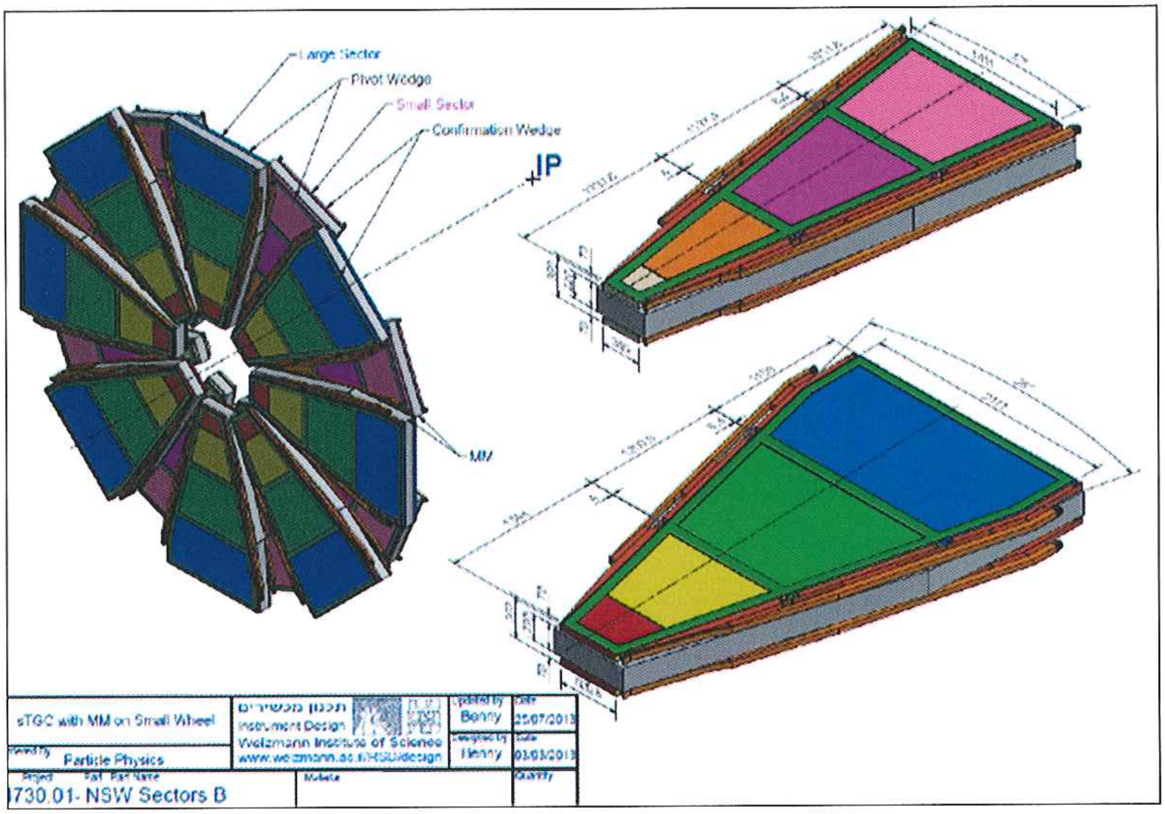


Figure 2: Layout of the ATLAS New Small Wheel detector and arrangement of a large and a small sector. Each colored panel corresponds to an sTGC quadruplet. One full sized quadruplet will be produced in Israel by April 2014 while a smaller prototype quadruplet will be produced in one of the new production sites (Canada).

PERSONNEL AND INSTITUTIONS:

Co-Spokesperson: George Mikenberg

Co-Spokesperson: Bernd Stelzer

Lead Experimenter in charge of beam tests: Alain Bellerive

Fermilab Experiment Liaison Officer: Aria Soha

The group members at present are:

	Institution	Country	Collaborator	Rank/Position	Other Commitments
1.1	Weizmann Institute	Israel	George Mikenberg Meir Shoa Vladimir Smakhtin	Professor Detector specialist Detector specialist	ATLAS ATLAS ATLAS
1.2	Tel Aviv University	Israel	Yan Benhammou Hadar Cohen Merlin Davies	Research Scientist Research Associate Research Associate	ATLAS ATLAS ATLAS
1.3	Carleton University	Canada	Alain Bellerive Gerald Oakham Thomas Koffas James Botte Stephen Weber Sebastian Rettie	Professor Professor Asst Professor DAQ specialist Graduate student Ugrad student	ATLAS, ILC ATLAS ATLAS ATLAS ATLAS
1.4	McGill University	Canada	Brigitte Vachon Benoit Lefebvre Camille Belanger-Champagne	Assoc Professor Student Research Associate	ATLAS ATLAS ATLAS
1.5	Universite de Montreal	Canada	Jean Francois Arguin Lea Gauthier	Asst Professor Research Associate	ATLAS ATLAS
1.6	Simon Fraser University	Canada	Bernd Stelzer Heberth Torres Daniel Mori	Asst Professor Research Associate Graduate student	ATLAS ATLAS ATLAS
1.7	TRIUMF	Canada	Oliver Stelzer-Chilton Simon Viel Doug Schouten Estel Perez Codina	Research Scientist Graduate student Research Associate Research Associate	ATLAS ATLAS ATLAS ATLAS
1.9	National ResearchKurchatov Institute	Russia	Alexander Khodinov	Research Associate	ATLAS
1.10	Technion – Israel Institute of Technology	Israel	Aledsander Vdovin Nachman Lupu	Detector specialist Detector specialist	ATLAS ATLAS

2. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS:

2.1 LOCATION

2.1.1 The beam test(s) will take place in MT6.2B. The experiment will require a motion table to mount the sTGC quadruplet (approximate dimensions are 2m x 1.5m). The pixel telescope will rest on the floor and will surround the sTGC.

2.1.2 The alignment of the beam with the pixel telescope will require the usage of the laser system in MT6-2.

2.1.3 A crane will be required to position the sTGC support structure (80 - 100 kg) onto the motion table.

2.1.4 Additional space outside the beam line enclosure (about 5m x 3.5m to setup the telescope) will be needed for initial setup (between May 2-5, 2014).

2.1.5 Workspace will be required in the control room (~3 tables) to be used for computing and general monitoring of the experiment. Access to a conference room and small work rooms will also be needed.

2.1.6 Space (0.5m x 0.5m) in the gas distribution area is requested for a portable gas system (bubbler) from TRIUMF to mix a gas mixture of 55% CO_2 + 45% n-pentane for the sTGC quadruplet. The sTGC chamber and gas distribution must be in an environment where the temperature of the gas mixture must remain at above ~20-degree Celsius (68° F) to avoid condensation of the n-pentane.

2.2 BEAM

2.2.1 BEAM TYPES AND INTENSITIES

Energy of beam: 20 – 60 GeV
Particles: Pions
Intensity: ~10k particles/spill
Beam spot size: about 1 cm^2

The experimenters require high-energy pions (> 20 GeV) to mitigate the effect of multiple scattering. This will allow for intrinsic position resolution measurement of the sTGC chambers. Electron contamination should be eliminated.

2.2.2 BEAM SHARING

The main goal of the experiment is to determine the position resolution of the sTGC chambers to qualify the design parameters. Any multiple scattering upstream of the experiment should be avoided. Since a long alignment run is required every time the apparatus set-up will be moved, it is preferred that the full pixel telescope and sTGC assembly stays in the beam for the full duration of the beam test.

Radiation length of all the material in the beam is estimated around 11% X_o

2.2.3 Running Time

The experimenters would like to maximize running time and have sufficient person power to operate round the clock, if such an operation mode becomes available. Data taking that requires more frequent accesses is planned to be done during the day, when technicians are available.

2.3 Experimental Conditions

2.3.1 Area Infrastructure

The main experimental setup components are shown in Figure 3. The Device Under Test (DUT) is a full-sized (~ 1.5m × 2m laterally) Thin Gap Chamber (sTGC) quadruplet. It consists of four narrow drift gaps ~3 mm wide separated from each other by ~5mm honeycomb spacers for a total thickness of ~70mm once the enclosing frame is included. A 2.9 kV voltage is applied across the gap. The gap planes serve as the cathodes and are made of FR-4 boards whose interior surface is coated with graphite while the exterior one has either precisely machined copper strips with 3.2 mm pitch or a pattern of etched copper pads. Sandwiched in the middle of the two cathode boards at a distance of 1.4 mm from either is the anode plane made of 50 μm tungsten wires at 1.8 mm pitch. The signals from the pads, strips and wires are read out and they are used for reconstructing charged-particle track patterns along the quadruplet both for online triggering and for precision position readout.

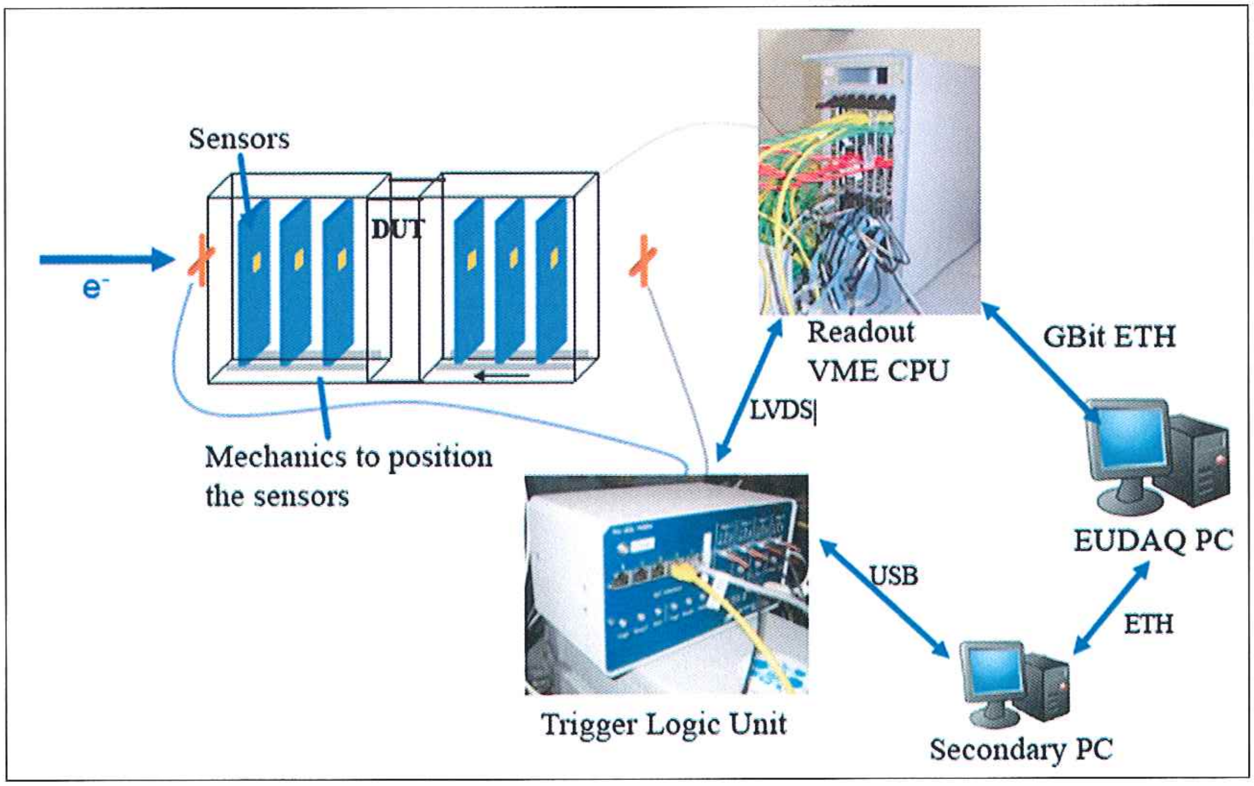


Figure 3: Main components of pixel telescope experimental setup and data acquisition.

Each of the four gaps in the quadruplet is filled with a 55% + 45% mixture of CO_2 + n-pentane that provides the ionization signal. To create and maintain the proper mixture of gases a dedicated gas handling system will be provided. This is a portable system that will be shipped to Fermilab. The experiment requests that Fermilab provide 1 cylinder of CO_2. The experiment will ship the n-pentane directly to Fermilab from the supplier. A photo of the gas system is shown in Figure 4. The overall weight of a sTGC quadruplet is ~80 kg. The sTGC quadruplet will be mounted into a mechanical structure that will need to be securely fixed to the motion table 2B. A schematic is shown in Figure 5. It is foreseen that the sTGC quadruplet

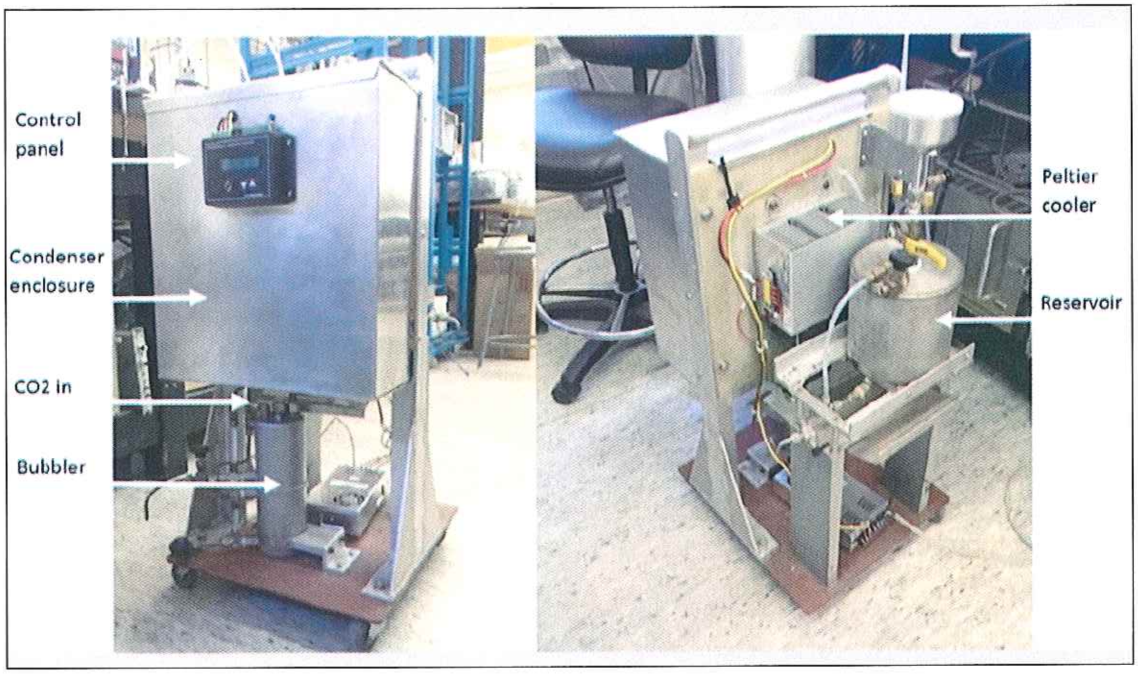


Figure 4: Portable gas system (bubbler) at TRIUMF to mix the required gas for the sTGC (55% CO_2 + 45% n-pentane). The reservoir tank allows the system to be refilled with n-pentane without disturbing the test or requiring the system to be purged. A Peltier cooler and thermistor are used to keep the condenser at the required 17°C for gas mixing.

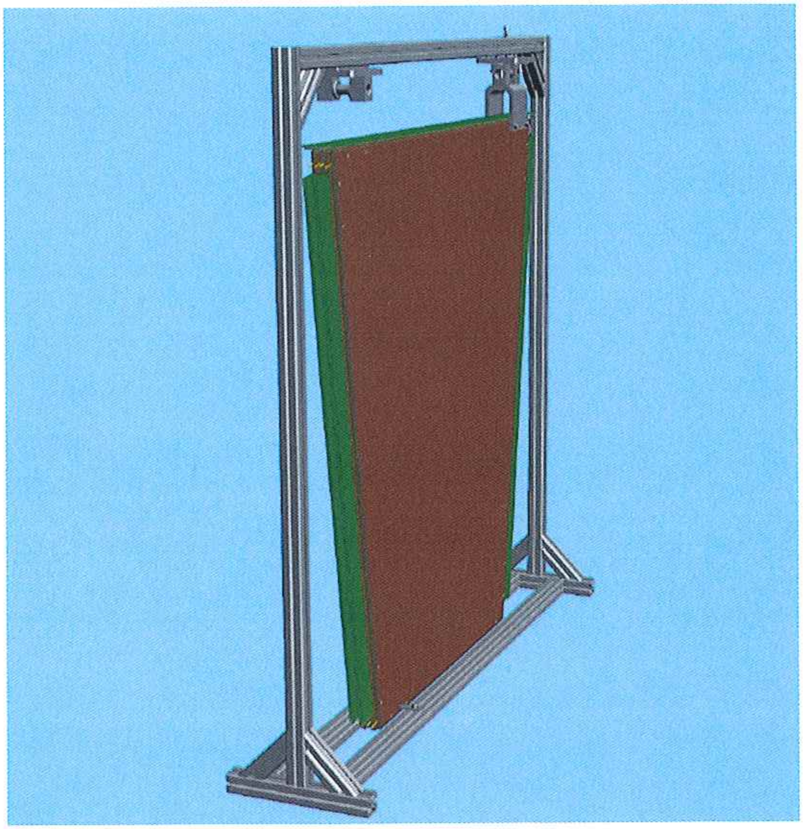


Figure 5: Mechanical aluminum structure to mount the sTGC quadruplet.

will be moved in the x,y directions in order to probe different areas of the module and test/verify its uniformity in reconstructing track segments (both position resolution and efficiency). The sTGC quadruplet (DUT) will be positioned between the two arms of the Carleton EUDET silicon telescope. The telescope consists of six silicon pixel sensor planes that have a 2 cm^2 active area, with three sensor planes in each arm and each arm separated by about 0.5m. The EUDET telescope will provide the position resolution reference for the sTGC. It has been measured to be better than 10 μm using a 4 GeV electron test beam at DESY. The overall length and width of the telescope including the sTGC quadruplet in the middle will be ~2m. The telescope width is about 2m and it will surround the motion table. A great effort has been taking by our draftsman to insure a secure fit of the telescope and sTGC structure in the MT6-2 area. To maintain the pixel sensors at a constant temperature of ~17 ^{0}C a cooling system that uses regular de-ionized water will be provided with the pixel telescope from Carleton University. The telescope is equipped with two scintillators read by PMTs on each end that will provide the basic trigger signal to the Trigger Logic Unit (TLU).

The electronics and the DAQ system are described in detail in the following section. Figure 6 shows a picture of the telescope together with all the necessary peripherals (power supplies, DAQ system, cooling system).

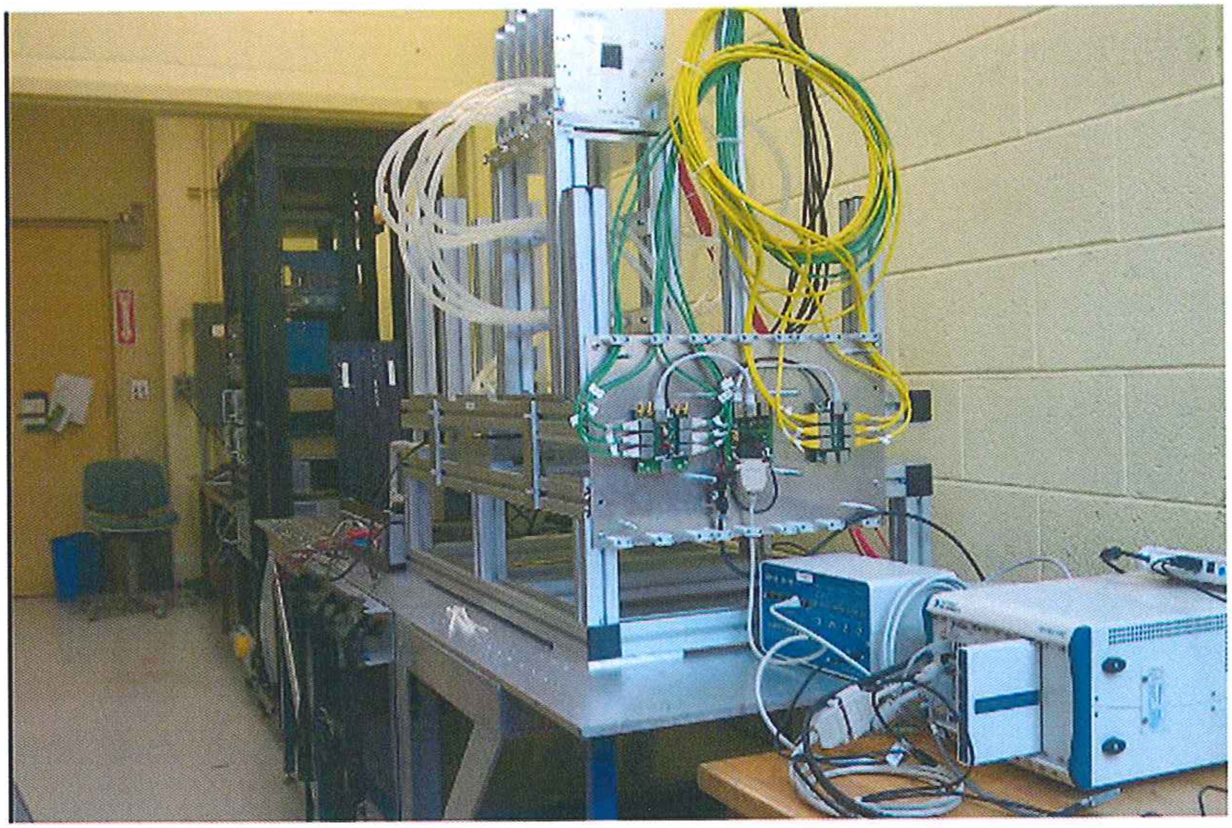


Figure 6: EUDET telescope at Carleton University, together with all the necessary peripherals, power supplies, DAQ system and cooling system.

2.3.2 Electronics Needs

During test beam operation, data from the pixel telescope and the DUT will be acquired. The pixel telescope consists of six pixel sensors (MIMOSA-26), the DUT consists of four sTGC (quadruplet) chambers. Data from a group of 64 channels on each planes of the sTGC quadruplet will be collected.

Readout:

The readout of the pixel telescope is performed using a FPGA embedded into a PXI crate. As shown in Figure 7. The pixel telescope is configured through a controller embedded in the PXI crate.

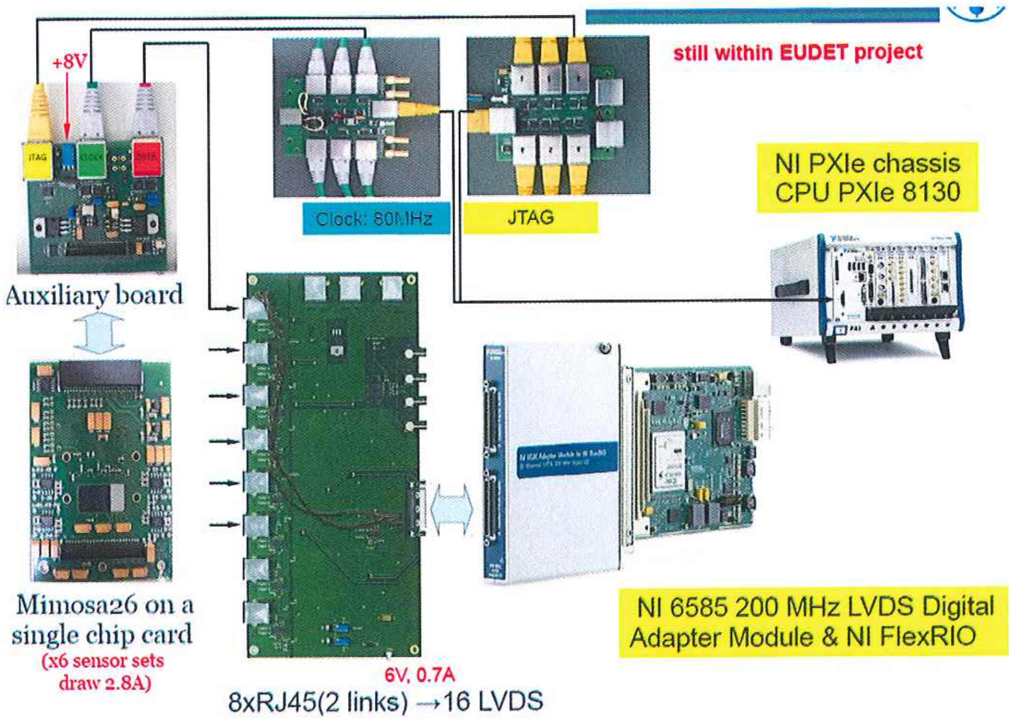


Figure 7: DAQ infrastructure system for the pixel telescope (MIMOSA-26 sensor).

The sTGC chambers are read using the VMM1 front-end chip. This chip is read and configured by a set of 3 cards as shown in Figure 8. The data are sent via Ethernet using the UDP protocol.

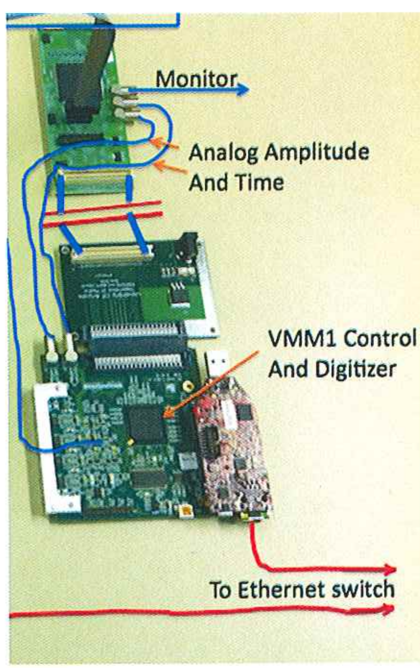


Figure 8: Schematic of the DAQ system for the sTGC chambers.

Trigger:

Scintillators read by photomultiplier tubes (PMTs) provide the trigger signal of the majority of the tests. Some tests anticipated use the self-triggering capability of the sTGC based on the cathode pad readout.

Synchronization:

In order to synchronize the pixel telescope and the sTGC quadruplet, the experimenters will use a Logic Unit Module (TLU) developed by the EUDET community. The trigger PMTs are connected to the TLU.

1. TLU generates the TRIGGER signal when PMT coincidence is detected, the TRIGGER signal is latched and is used to immediately generate the BUSY signal back to the TLU

2. The TRIGGER signal from the TLU also generates a 200-250ns pulse which is sent to all VMM1 DAQs and the LabView-based wrapper control system

3. The LabView system toggles the TRIGGER_CLOCK line to the TLU while reading the TRIGGER line from the TLU (which sends the Trigger Counter's lowest 15 bits, one at at time on the TRIGGER signal line, see below). Since the TRIGGER line changes in the readout mode, it is isolated from the VMM1 DAQ and LabView-based wrapper control system trigger inputs

4. LabView system waits for UDP packets from all the VMM1 DAQs in the system (fixed timeout)

5. The VMM1 DAQ UDP data and TLU Trigger Counter value are combined and sent to EUDAQ VMM Producer (UDP/IP over Ethernet, exact data format to be determined)

6. The TRIGGER and BUSY signal latches are then cleared by the LabView system

7. The system is then ready to accept the next event (no TRIGGERS will be generated while the BUSY signal line is asserted by the wrapper electonics' BUSY latch, allowing explicit synchronization of the VMM1 DAQs and the EUDET Telescope data using the TLU Trigger Counter value)

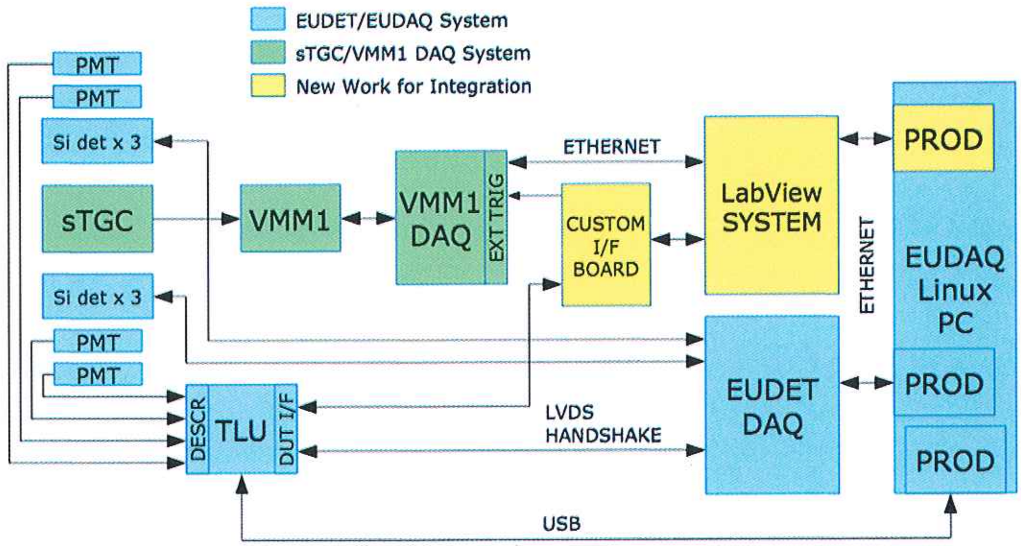


Figure 9: Block diagram showing the synchronization of the EUDET and sTGC DAQ systems.

See Appendix II for summary of PREP equipment pool needs.

To connect the power supplies (HV and LV), standard 110V power is required.

2.3.3 Description of Tests

The sTGC prototype detectors, EUDET pixel telescope, electronics, DAQ system, gas system and HV will be shipped to Fermilab weeks prior to the beam test to ensure that the equipment clear custom and arrive in Batavia in time. The EUDET pixel telescope is already operational at Carleton. DAQ and readout electronics integration using an available smaller sTGC prototype chamber is being developed at Carleton such that the full system is operational when it arrives at Fermilab in 2014. The large sTGC prototype will be tested independently at the Weizmann Institute prior to shipping and when it arrives at Fermilab.

A team of at least two experimenters will arrive at Fermilab a few days before the scheduled beam time to setup the apparatus in a safe environment outside the beam area – this area (about 5m x 3.5m) will nevertheless be required to be close to the beam area such that the sTGC quadruplet and the EUDET telescope can easily be moved into the beam.

The first day of the test will require frequent access into the beam area because the primary goal of the first day is to perform diagnostic tests. Initially, the EUDET telescope will be operated on its own and make sure that all the sensors are performing as expected and that the 6 silicon planes are internally aligned based on a run with about 10,000 pion tracks. The experimenters will re-determine the voltage plateau of the sTGC to insure that the chamber run as expected. The second step is to perform a run to align the EUDET telescope with respect to the sTGC chambers. The acceptance of the EUDET telescope is 1 cm^2 so a good and stable location of the beam halo will be required. We will take advantage of the laser system in MT6-2 for this task. The experimenters expect one to two days for doing this operation (plateau, basic diagnostic test and alignment). Once the system is fully operational, the experimenters plan to perform 8-hour shifts around the clock. The experiment anticipates one access per shift.

The experimenters plan to ship the data via internet and the end of each day and also bring a few TB disks and store two copies of the data sets on these external drives.

The priority for this large-scale sTGC prototype is to establish uniformity of the sTGC quadruplet by measuring the spatial resolution and absolute position of strips along the vertical direction and different areas (e.g. center, edges and corners). Therefore, all tests primarily consist of high-statistics runs at several beam impact positions on the sTGC quadruplet.

Since not all the channels of the chambers will be instrumented with electronics, re-connection of the electronics and re-cabling will be required. Thus, access to the beam area will be required once or twice during every 8-hour shift to rotate the chamber and/or to re-instrument electronics channels. Some study might be repeated at different gain. The test will also allow the experimenters to study the pulse shapes, noise level, and timing of the sTGC as well as its self-triggering capability.

Since a long alignment run is required every time the apparatus set-up will be moved, it is preferred that the full pixel telescope and sTGC assembly stays in the beam for the full duration of the beam test.

All the power supplies and DAQ system of the pixel telescope will be hosted next to the sTGC inside the beam area.

2.4 SCHEDULE

A specific request has been made for the run period in May 2014. This particular time is bounded by prototype detector readiness and timeline of the full production of the project. The experimenters request a total of 2 weeks time, during the period May 7^{th} – 20^{th} with five days prior for setup and testing outside the MTest beam line. Shipment of all components for the test to Fermilab will be arranged. Assembly of the silicon telescope will start May 2, 2014.

III. RESPONSIBILITIES BY INSTITUTION – NON FERMILAB

3.1 WEIZMANN INSTITUTE:

- sTGC quadruplet module-1 construction (2x1.5m)
- Mechanical structure to mount sTGC quadruplet module-1
- Shifts / data analysis

3.2 TEL AVIV UNIVERSITY:

- VMM1 readout electronics integration / software
- Shifts / data analysis

3.3 CARLETON UNIVERSITY:

- Pixel telescope, sTGC/EUDET DAQ integration, cooling, power supplies
- sTGC quadruplet prototype construction (40x60cm) and its mechanical structure
- DAQ software and data formatting
- sTGC/EUDET integration mechanics
- Shifts / data analysis

3.4 MCGILL UNIVERSITY / UNIVERSITE DE MONTREAL:

- VMM1 readout electronics integration / software
- HV Power supplies
- Shifts / data analysis

3.5 TRIUMF/SFU/VICTORIA:

- sTGC cathode boards prototype construction (40x60cm)
- Gas system (bubbler)
- Shifts / data analysis

3.6 TECHION - ISRAEL INSTITUTE OF TECHNOLOGY:

- VMM1 readout electronics integration / online monitoring / software
- Shifts / data analysis

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). [0.5 FTE/weeks]
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. [6.5 FTE/week]
4.2.2 CO2 gas [$]
4.2.3 Use of the 2B motion table to mount the sTGC quadruplet
4.2.4 Crane support
4.2.5 Conduct a NEPA review of the experiment.
4.2.6 Provide day-to-day ESH&Q support/oversight/review of work and documents as necessary.
4.2.7 Provide safety training (May as necessary, with assistance from the ESH&Q Section.
4.2.8 Update/create ITNA's for users on the experiment.
4.2.9 Initiate the ESH&Q Operational Readiness Clearance Review and any other required safety reviews. [0.2 FTE]

4.3 Fermilab Scientific Computing Division

4.3.1 Internet access should be continuously available in the MTest control room.
4.3.2 See Appendix II for summary of PREP equipment pool needs.

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	0.5
Particle Physics Division	0.0	6.5
Scientific Computing Division	0	0
ESH&Q Section	0	0.2
Totals Fermilab	$0.0K	1.7
Totals Non-Fermilab	[$150K]	[75]

VI. General Considerations

6.1 The responsibilities of the Spokespersons 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 Spokespersons 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 Spokespersons 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 Spokespersons 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 Spokespersons 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 Spokespersons 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 listed in Appendix II. 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 Spokespersons 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 Spokespersons 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:

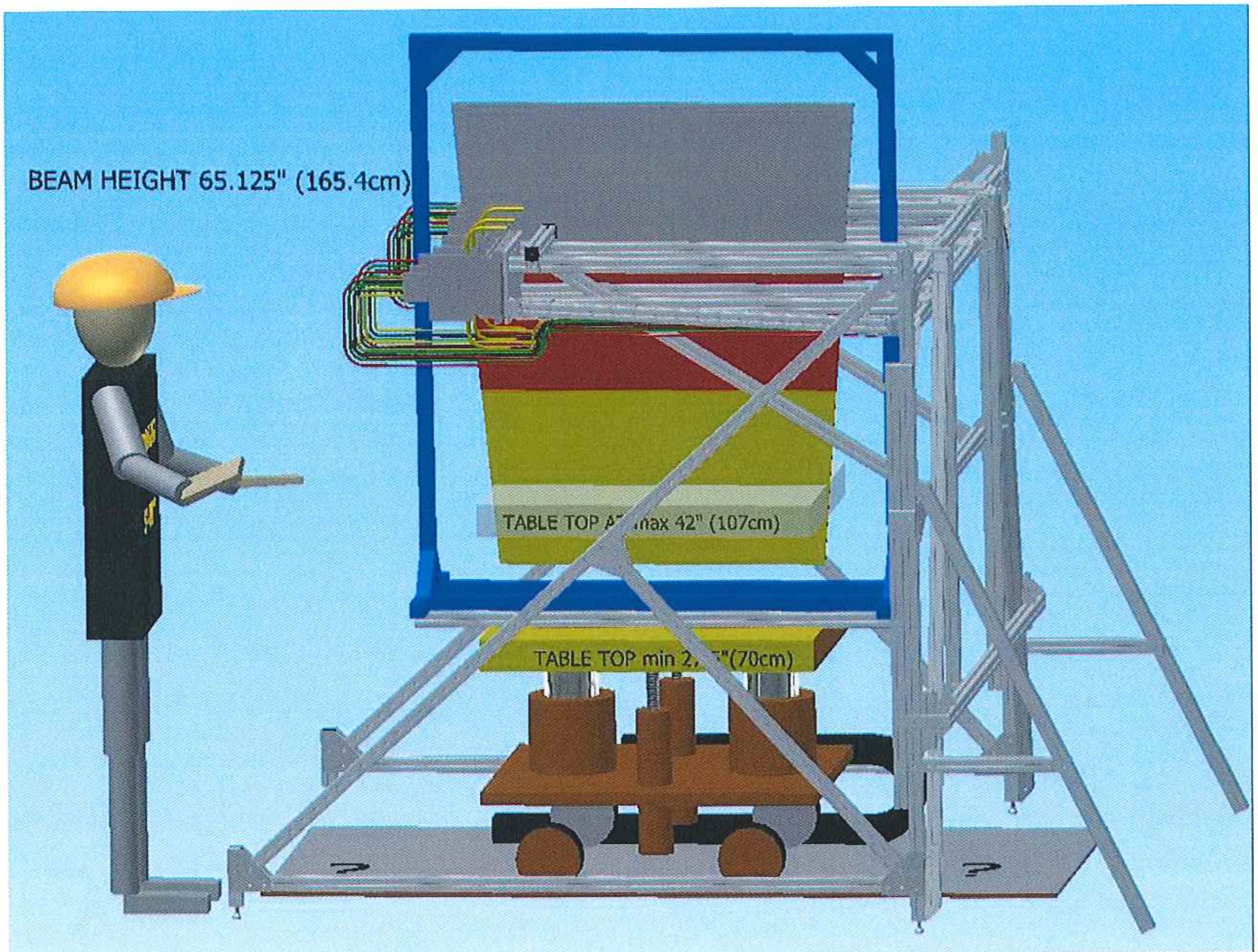
30/ April / 2014
George Mikenberg, Experiment Spokesperson

April/ 30 / 2014
Bernd Stelzer, Experiment Spokesperson

Appendix I: MT6 Area Layout

The beam test(s) for the ATLAS sTGC take place in MT6.2B

sTGC Setup on Motion Table 2B in MT6-2



APPENDIX II: EQUIPMENT NEEDS

Provided by experimenters:

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

PREP EQUIPMENT POOL:

Quantity	Description
3	NIM crates
2	NIM constant fraction discriminator modules
2	NIM logic unit modules
2	NIM pulse delay modules
1	Power Supplies for PMT (Model 1570 HV Power Supply 3 kV @ 40 mA)
1	NIM Fan Out near the motion Table 2B to sync with our telescope trigger logic

PPD FTBF:

Quantity	Description
1	Motion Table 2B (1mm precision)
1	small lift crane to mount sTGC on the motion table (80kg – 100kg)
1	FTBF Laser (to align the beam with our pixel telescope)
1	Cylinder of CO_2 gas
4	SHV cables to connect each sTGC gap to HV patch panel (cable certified 3 kV)
1	MT6SC3 Trigger Device (Direct connection)

APPENDIX III: - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need have been checked.

Flammable Gases or Liquids		Other Gas Emissions*		Hazardous Chemicals		Other Hazardous /Toxic Materials
Type:	n-pentane	Type:	CO2		Cyanide plating materials	List hazardous/toxic materials planned for use in a beam line or an experimental enclosure:
Flow rate:	50 cc/min	Flow rate:	61 cc/min		Hydrofluoric Acid	
Capacity:		Capacity:	1 cylinder		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	
		X	Non-commercial/Non-PREP	X	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	

The following people have read this TSW:

______________________________ 5 / 2 / 2014
Michael Lindgren, Particle Physics Division, Fermilab

______________________________ 5 / 5 / 2014
Sergei Nagaitsev, Accelerator Division, Fermilab

______________________________ 5 / 5 / 2014
Robert Roser, Scientific Computing Division, Fermilab

______________________________ 5 / 2 / 2014
Martha Michels, ESH&Q Section, Fermilab

______________________________ 5 / 5 /2014
Greg Bock, Associate Director for Research, Fermilab

______________________________ 5 / 5 /2014
Stuart Henderson, Associate Director for Accelerators, Fermilab