Fermilab

Directorate

MEMORANDUM OF UNDERSTANDING
FOR THE 2012 FERMILAB TEST BEAM FACILITY PROGRAM

T-1018

UCLA Spacordion Tungsten Powder Calorimeter

November 16, 2011

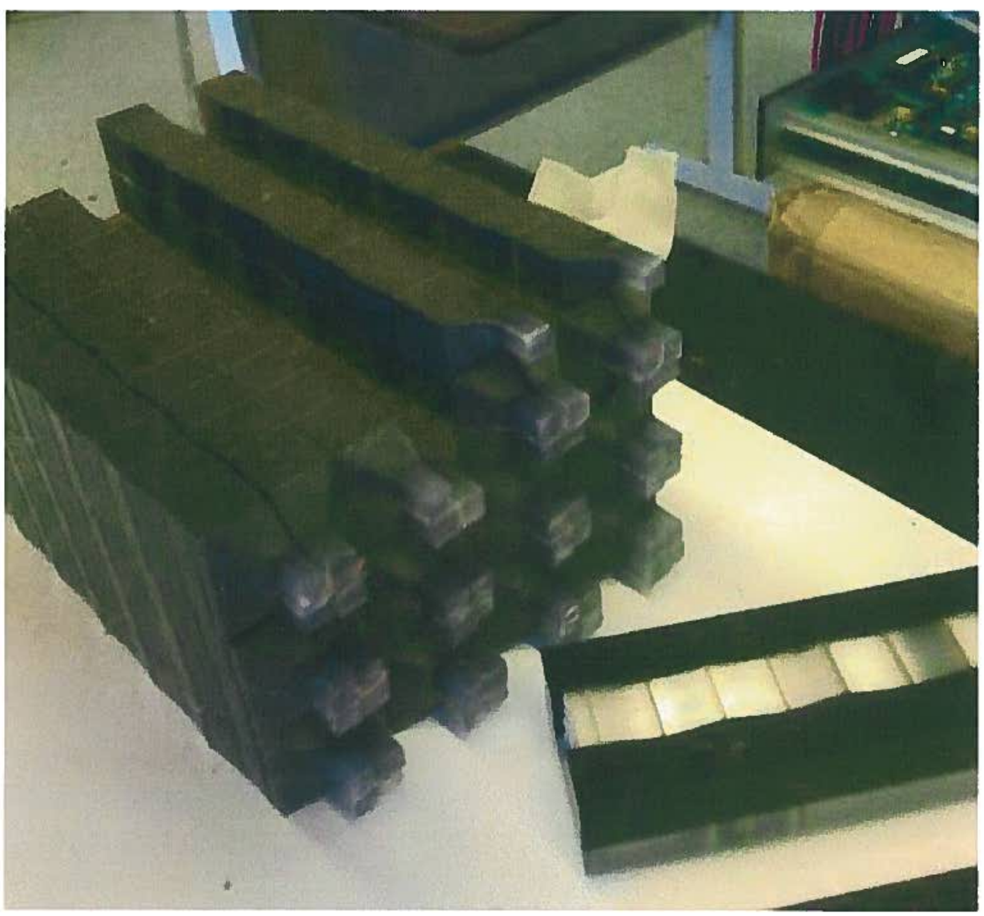


TABLE OF CONTENTS

INTRODUCTION

This is a memorandum of understanding between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of the University of California at Los Angeles (UCLA), Pennsylvania State University (PSU), and Texas A&M University (TAMU) who have committed to participate in beam tests to be carried out during the 2012 Fermilab Test Beam Facility program.

The memorandum 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 memorandum to reflect such required adjustments. Actual contractual obligations will be set forth in separate documents.

Description of Detector and Tests:

The present experiments at the BNL-RHIC facility are evolving towards physics goals which require the detection of medium energy electromagnetic particles (photons, electrons, neutral pions, eta mesons, etc.), especially at forward angles. New detectors will place increasing demands on energy resolution, hadron rejection and two-photon resolution and will require large area, high performance electromagnetic calorimeters in a variety of geometries. In the immediate future, either RHIC or JLAB will propose a facility upgrade (Electron-Ion Collider, or EIC) with physics goals such as electron-heavy ion collisions (or p-A collisions) with a wide range of calorimeter requirements. An R&D program based at Brookhaven National Laboratory has awarded our group funding of approximately $110,000 to develop new types of calorimeters for EIC experiments.

The UCLA group is developing a method to manufacture very flexible and cost-effective, yet high quality calorimeters based on scintillating fibers and tungsten powder. The design and features of the calorimeter can be briefly stated as follows: an arbitrarily large number of small diameter fibers (<0.5mm) are assembled as a matrix and held rigidly in place by a set of precision screens inside an empty container. The container is then back-filled with tungsten powder, compacted on a vibrating table and infused with epoxy under vacuum. The container is then removed. The resulting sub-modules are extremely uniform and achieve roughly the density of pure Lead. The sub-modules are stacked together to achieve a final detector of the desired shape. There is no dead space between sub-modules and the fibers can be in an accordion geometry bent to prevent 'channeling' of the particles due to accidental alignment of their track with the module axis. This technology has the advantage of being modular and inexpensive to the point where the construction work may be divided among groups the size of typical university physics departments.

This test run is a proof-of-principle and will allow the experiment to improve the design and performance of the final detectors. The experimenters have constructed prototypes of three different designs in order to investigate the characteristics of practical devices such as uniformity, linearity, longitudinal and transverse shower shapes.

The first design is an array of 4x4 modules intended as a prototype for a practical device to be installed within two years in the STAR experimental hall. The modules are a combination of a spaghetti calorimeter and an accordion (hence "spacordion"). Each sub-module is 1.44cm x 1.44cm x15cm and constructed individually. The second design is a prototype of 4 sub-modules constructed in one step, using a different construction technique. The third design is a set of single sub-modules each intended to test variations of the tungsten powder/embedded fiber concept by enhancing the light output /density using liquid scintillator or heavy liquids.

PERSONNEL AND INSTITUTIONS:

Spokesperson and Physicist in charge of beam tests: Stephen Trentalange (UCLA)

Fermilab liaison: Aria Soha

The group members at present are:

	Institution	Collaborator	Rank/Position	Other Commitments
1.1	University of California, Los Angeles	Oleg Tsai	Research Scholar	STAR
		Stephen Trentalange	Researcher	STAR
		George Igo	Professor	STAR
		Huan Huang	Professor	STAR
		Yu Xi Pan	Graduate Student	STAR
		Jay Dunkelberger	Graduate Student	STAR
		Wen Qin Xu	Graduate Student	STAR
1.2	Pennsylvania State University	Steven Heppelmann	Professor	STAR
1.3	Texas A&M	Carl Gagliardi	Professor	STAR

II. Experimental Area, Beams and Schedule Considerations:

2.1 Location

2.1.1 The beam test(s) will take place in MT6.2B

2.1.2 The experimenters will require work space for 3-5 people in the MTest Control Room for laptops connected through Ethernet. All electronics, including the DAQ PC for the device, will be located in a single standard rack within 3 meters of the apparatus. The experimenters anticipate a single Ethernet connection from this rack to the control room PC.

2.2 Beam

2.2.1 Beam Types and Intensities

Energy of beam: 1, 2, 4, 8, 16, 32 GeV

Energy spread of beam: less than 1%
Type of Beam: electrons/pions
Intensity: 10k – 100k particles/ 4 sec spill
Beam spot size: about 1-10 cm^2

The expected resolution of the detector is about 10%/sqrt(E_beam), so the expected resolution would be ~2.5% at 16 GeV, which is about the intrinsic resolution of the beam. It is possible to 'deconvolute' the true resolution if the beam resolution is known. In any case, if the detector resolution is very large, then this will be seen at 16 and 32 GeV. The experiment accepts this resolution.

2.2.2 Beam Sharing

Tests will require many short runs at different energies and detector positions. This will be followed by periods of data analysis which may allow users downstream to piggy-back for periods ~ hours. The apparatus is less than 1 cubic meter and weighs approximately 100 kg, so it should be possible to move it out of the beam using a short access or a remote XY stage.

2.2.3 Running Time

The experimenters believe it will be most efficient to run 2 shifts of 8 hours per day. Data will be taken as many short runs at different detector positions and should only require beam energy changes or access infrequently (~1-2/day). See section 2.3.3 for total run time.

2.3 Experimental Conditions

2.3.1 Area Infrastructure

The apparatus is table-size, measuring about 20x20x50cm and weighs approximately 80 kg. It will be placed on facility motion table #1 which exceeds the requirements of a remote controlled XY staging platform, about 30x50 cm and able to move +/-10 cm in each direction with 1 mm reproducibility, and able to support a load of approximately 100 kg.

A single 19" rack of electronics plus a PC will operate inside the enclosure within 3 meters of the apparatus. The experimenters will control data-taking from another PC in the control room through a single Ethernet connection.

The experiment would make use of the FTBF Cerenkov detector to tag electrons, and one MWPC station for tracking.

2.3.2 Electronics Needs

CAMAC crate (experimenter's controller)

Lecroy 1440 with 32 channels of negative HV up to -2.5 kV, see Appendix II for summary of PREP equipment pool needs.

If wire chamber information is available for beam particles, it may be possible to increase the efficiency of data-taking by incorporating this data stream into the DAQ system.

2.3.3 Description of Tests

PMT voltage adjustment and signal timing will be mostly accomplished prior to test beam using cosmic rays. The absolute calibration of all channels will be determined using single photoelectron signals.

The tests will begin by centering a beam of energy E~10 GeV on a reference tower. After checking timing and dynamic range, the gain of all 16 towers will be equalized. As the array is ~4 times the size of the beam, this will require ~20 short runs to cross-calibrate overlapping groups of towers.

Once all towers gains are equalized, the experimenters will re-center the array on the beam and take a series of long runs at beam energies from 1-32 GeV. Another energy scan will be made after rotating the device by 2 degrees. These tests will be repeated for the 3 other prototype designs. Several short accesses may be required between runs on each type of prototype.

Day 1-3: Setup

Day 4-6: Equalization of gains in all detector elements

Day 7-8: Check of rates/timings with beam E~5-10 GeV

Day 9-10: Prototype 4x4 supermodule: Runs at 1, 2, 4, 8, 16, 32 GeV

Day 11: Prototype Large Screen supermodule Runs at 1, 2, 4, 8, 32 GeV

Day 12: Prototype Two small modules: Runs at 1, 2, 4, 8, 32 GeV

Day 13-14: Pack up equipment

2.4 Schedule

The test beam run will occupy a single two-week period from January 18-January 31, 2012.

III. RESPONSIBILITIES BY INSTITUTION – NON-FERMILAB

3.1 UCLA:

UCLA will provide all detector elements and electronics for readout and control of apparatus, except for a CAMAC crate and HV system to be provided by the Fermilab PREP.

3.2 TAMU/PSU

Are to provide personnel for data-taking and analysis.

IV. RESPONSIBILITIES BY INSTITUTION – FERMILAB

4.1 FERMILAB ACCELERATOR DIVISION:

4.1.1 Use of MTest beam 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 signals should be made available in the counting house.
4.1.4 Reasonable access to the equipment in the MTest beamline.
4.1.5 Connection to beams control 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). [1 person-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 antiproton stacking rate and the neutrino flux by more than 5% globally, 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 MOU 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 MTest computers. [2.0 person weeks]
4.2.2 Setup and maintenance of Cerenkov particle ID system sufficient to tag particle species at DAQ or Trigger level. [0.2 person weeks]
4.2.3 Use of wire chamber as outlined in section 2.3.2 [0.2 person weeks]
4.2.4 Conduct a NEPA review of the experiment.
4.2.5 Provide day-to-day ES&H support/oversight/review of work and documents as necessary.
4.2.6 Update/create ITNA's for users on the experiment.
4.2.7 Provide safety training as necessary, with assistance from the ES&H Section.
4.2.8 Initiate the ES&H Operational Readiness Clearance Review and any other required safety reviews

4.3 FERMILAB COMPUTING SECTOR

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

4.4 FERMILAB ES&H SECTION

4.4.1 Assistance with safety reviews.

4.4.2 Provide safety training, with assistance from PPD, as necessary for experimenters. [0.25 person-weeks]

V. SUMMARY OF COSTS

Source of Funds [$K]	Materials & Services	Labor (person-weeks)
Particle Physics Division	0.0	2.4
Accelerator Division	0	1.0
Computing Sector	0	0
ES&H	0	0.25
Totals Fermilab	$0.0K	3.65
Totals Non-Fermilab	$100,000	16

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 (ES&H) 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 ES&H 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 Computing Sector 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 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 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 ES&H 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:

____ / / 2011
Stephen Trentalange, Experiment Spokesperson

____ 12 / 19 / 2011
Michael Lindgren, Particle Physics Division, Fermilab

____ 12 / 21 / 2011
Roger Dixon, Accelerator Division, Fermilab

____ 12 / 20 / 2011
Peter Cooper, Computing Sector, Fermilab

____ 2 / 21 / 2011
Nancy Grossman, ES&H Section, Fermilab

____ 12 23 /2011
Greg Bock, Associate Director for Research, Fermilab

____ 1 / 4 /2012
Stuart Henderson, Associate Director for Accelerators, Fermilab

SIGNATURES:

Stephen Trentalange ______________________________ 12 / 6 / 2011

Stephen Trentalange, Experiment Spokesperson

______________________________ / / 2011

Michael Lindgren, Particle Physics Division, Fermilab

______________________________ / / 2011

Roger Dixon, Accelerator Division, Fermilab

______________________________ / / 2011

Peter Cooper, Computing Sector, Fermilab

______________________________ / / 2011

Nancy Grossman, ES&H Section, Fermilab

______________________________ / /2011

Greg Bock, Associate Director for Research, Fermilab

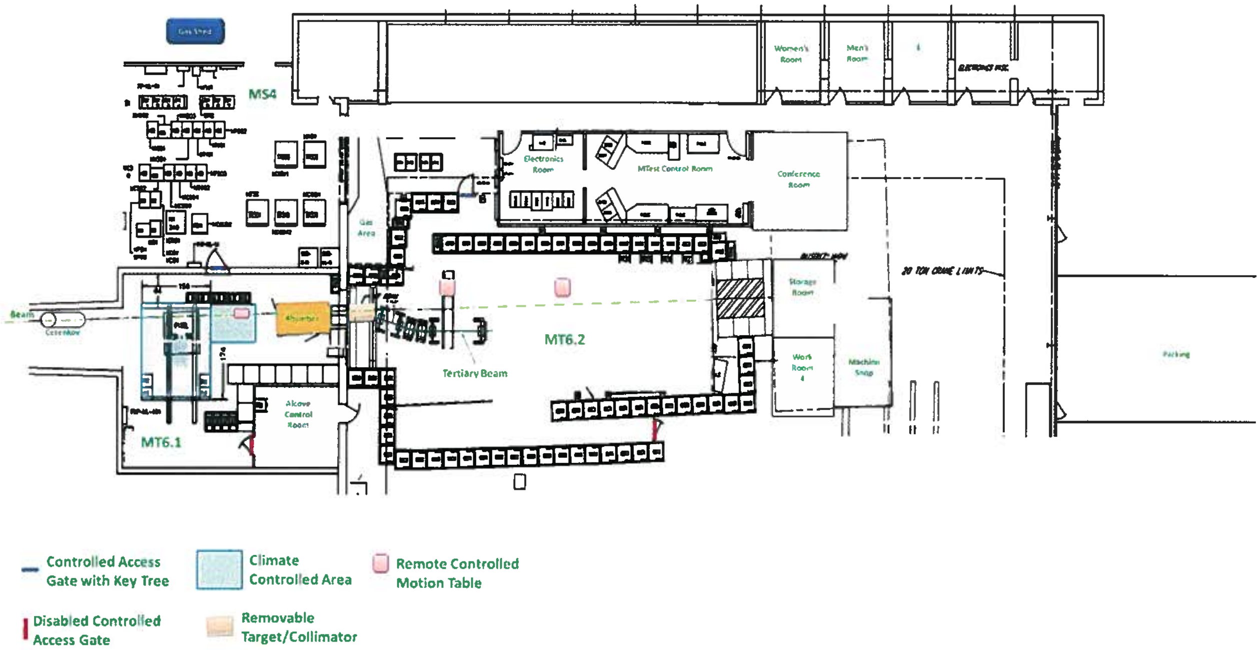
______________________________ / /2011

Stuart Henderson, Associate Director for Accelerators, Fermilab

APPENDIX I: MT6 AREA LAYOUT

The apparatus will be placed on a moveable XY stage in area MT6.2. An electronics rack containing a CAMAC crate, NIM Crate, Multichannel HV system and DAQ PC will be placed within 3 meters of this table. Connection to electronics room/control room should be via a single Ethernet connection. It is not anticipated to connect any signal or HV cables between the control room and the apparatus.

MTEST AREAS



APPENDIX II: EQUIPMENT NEEDS

Provided by experimenters:

UCLA/TAMU/PSU will provide:

- Detector elements (Calorimeters modules, Hodoscopes and PMTs)
- Trigger/Control Electronics (NIM crate, oscilloscopes, Signal/HV cables, NIM logic modules)
- DAQ System EXCEPT CAMAC Crate (Camac Modules, DAQ PC)

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

PREP EQUIPMENT POOL:

Quantity	Description	
1	CAMAC Crate	Bi Ra 6700P Power Supply
1	HV System	Lecroy 1450 HV System
4	HV System	Lecroy 1461 Negative HV cards for Lecroy 1450 System

PPD FTBF:

Quantity	Description
1	Beam Cerenkov Counter

APPENDIX III: - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need are checked. See next page for detailed descriptions of categories.

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		X	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	
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	

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.

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