Proton Detector Activity Hazard Document

FRIB-S10300-RA-001193-R002

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6/13/2019

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Revision History

Revision	Issued	Changes
R001	9 October 2018	Original issue
R002	13 June 2019	Added three Qualified Operators. Updated Signatories.

Authorizing Document

Activity Hazard Document Procedure (FRIB-S10300-PR-000241) [1]

Authorized Documents

None.

Authorized Committees and Boards

None.

1 Activity Description

This AHD is in effect after it has been reviewed and approved. It must be reviewed annually and revised following system modifications or operational changes.

The Proton Detector (Figure 1) is a 7.7 L cyclindrical volume that is operated as a radiation detector. It is filled with P10 gas (10% methane, 90% Ar) or a mixture of 5% isobutane with 95% Ar, typically at 800 Torr. A Kapton window separates the gas volume from air and allows a rare-isotope beam to enter the detector. A gas-handling system (Figure 2) is used to flow gas through the volume at a typical rate of 1 L/hr (~16 sccm) and the gas is pumped outside through a vent line. An electric field is applied inside the gas volume through an HV feedthrough. The Proton Detector can be operated in stand-alone mode using radioactive sources in Room 1039 or in conjunction with the Segmented Germanium Array (SeGA) at the end of a rare-isotope beam line in the S2 Vault (Figure 3). The latter configuration is known at the Gaseous Detector with Germanium Tagging (GADGET).

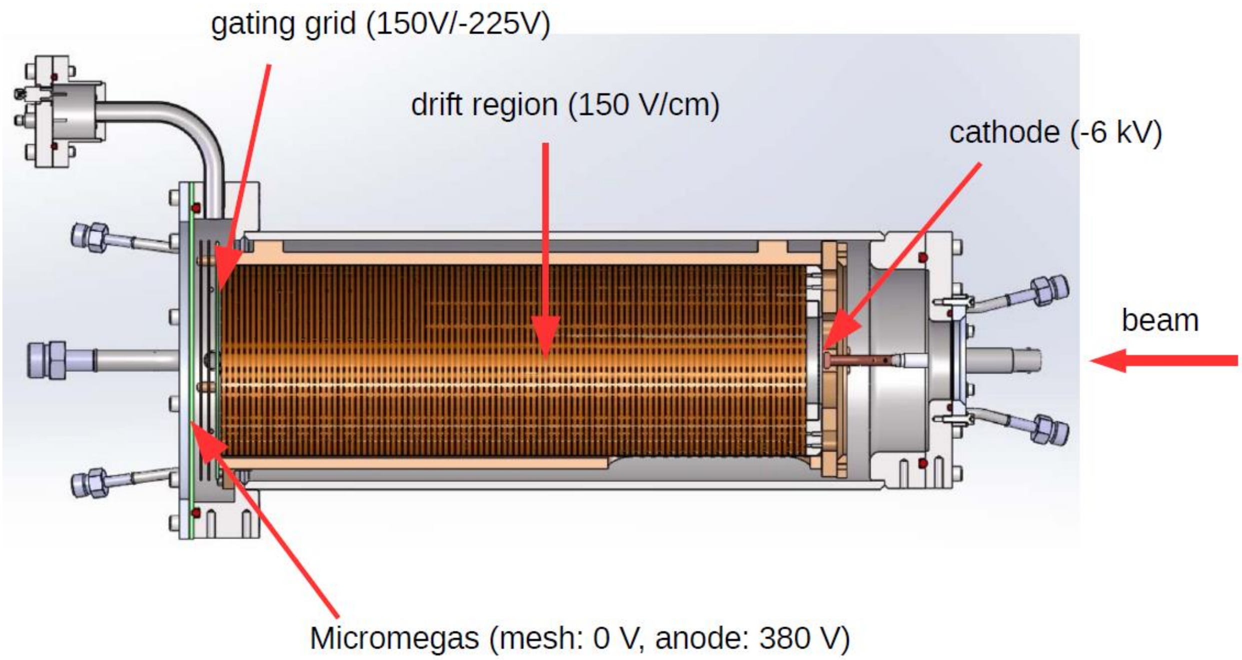

Figure 1: Mechanical design drawing of Proton Detector

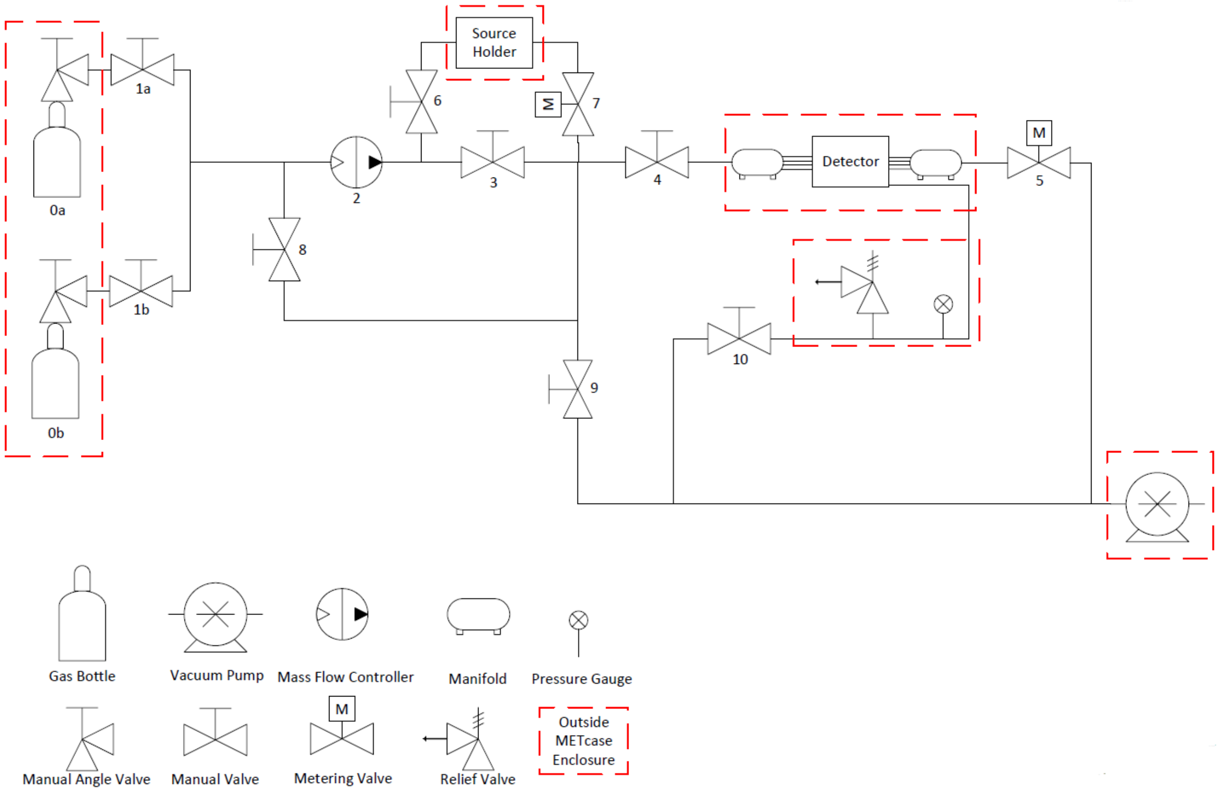

Figure 2: Schematic of Proton Detector Gas Handling System

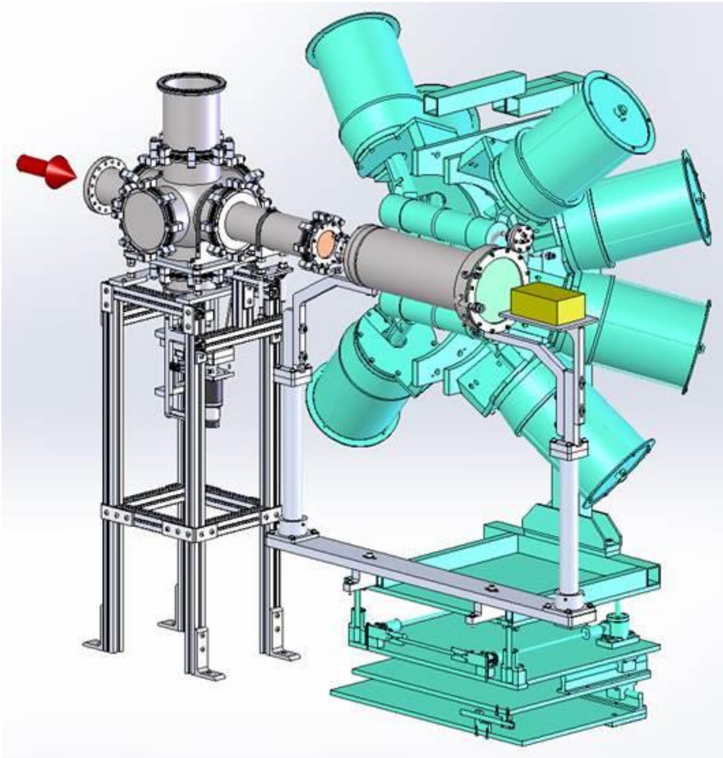

Figure 3: Mechanical design drawing of Proton Detector inside SeGA (cutaway, blue) in S2 Vault

2 Hazard Identificaiton

Table 1: Hazard identification.

Hazards Present		Yes	No
	MECHANICAL HAZARDS		
ESH-101	Portable Ladder Use (Larger than 10 ft)		X
ESH-104	Elevated Work (Above 4ft, requiring fall protection)		X
ESH-105	Handheld Non-Powered Tool Use (New, never used/evaluated)	X	
ESH-106	Handheld Power Tool Use (New, never used/evaluated)	X	
ESH-110	Mechanical Material Handling (Mechanical Lifting Equipment)		X
ESH-111	Manual Material Handling (Greater than 20lbs/each or greater than 10 pieces)	X	
ESH-117	Scaffolds		X
ESH-118	Scissor Lift		X
ESH-119	Abrasive Blasting		X
ESH-121	Slip, Trips and Falls (Obstruction of any egress or walking path)	X	
ESH-124	Ergonomics (Repetitive Tasks/Non-Standard Working Positions)	X	
ESH-133	Articulating Boom Lift		X
	CHEMICAL HAZARDS		

ESH-102	Chemical Use		X
ESH-130	Modifying Painted or Coated Surfaces or Handling Elemental Lead		X
ESH-135	Reactive Chemicals		X
	ENERGY HAZARDS		
ESH-107	Electrical Hazards to an Unqualified Electrical Worker (Exposed to >50 V)		X
ESH-108	Electrical Hazards to a Qualified Electrical Worker		X
ESH-107/ ESH-108	Use of Equipment That is Not UL or NRTL Rated	X	
ESH-122	Laser Use		X
ESH-123	Magnetic Field Exposure (Greater than 5 Gauss)		X
ESH-126	Working on or Near Equipment Where Unexpected Movement, Release of Stored Energy, Energizing Electrical Systems, Flow of Gases, or Fluids Could Endanger People	X	
	PHYSICAL HAZARDS		
ESH-103	Compressed Gas Cylinder Use	X	
ESH-109	Fire Hazards	X	
ESH-112	Noise Hazards (Greater than 85db)		X
ESH-113	Working with/around Cryogenics		X
ESH-114	Potential Explosive Atmosphere	X	
ESH-115	Compressed Air	X	
ESH-116	Confined Space	X	
ESH-120	Radiation Hazards	X	
ESH-125	Pressure/Vacuum Vessels	X	
ESH-127	Microwave Exposure (Entering an Area With High Microwave Exposure > 10 mW/cm2)		X
ESH-128	Hot Work (Welding, Brazing, Cutting, Grinding, Torch Soldering)		X
ESH-129	Oxygen Deficiency Hazards	X	
ESH-134	Dispersible Radioactive Materials		X
	ENVIRONMENTAL HAZARDS		
ESH-131	Reduction of Natural Resources (Using large quantities of natural resources)		X
ESH-132	Degradation of Air, Soil and Water Quality (Generating large quantities of waste)		X
ESH-136	Other		

3 Hazard Specification & Mitigation

3.1 Mechanical Hazards

Description of Hazard: Transporting parts to/from the S2 Vault and manipulating the Proton Detector mechanically with tools may lead to cuts or scrapes, striking hand or arm against a surface, or strain injuries.

Controls (mitigation of hazards): Equipment weighing more than 20lbs will be transported using a wheeled cart. Personnel handling detector will use proper tools in good condition and exhibit correct use of tools, proper body positioning, and good housekeeping. Personnel performing tasks will take Hand and Power Tool and Back Safety and training and make ergonomic assessments.

3.2 Chemical Hazards

Not Applicable

3.3 Energy Hazards

3.3.1 Electrical Hazards

Description of Hazard: HV up to 6kV is applied to components inside detector chamber.

Controls (mitigation of hazards): Equipment that is not UL or NRTL certified has been inspected by Electrical Engineering department. All manipulative action will take place with the power off and the system grounded.

3.3.2 Radiological Hazards

Description of Hazard: Alpha particle sources of ^{228}Th and ^{232}U will be deployed in the source holder on the inlet line of the gas-handling system to introduce ^{220}Rn daughter to the detector volume at an alpha decay rate of a few Bq. X-ray source of ^{55}Fe will be deployed inside the detector volume using a source holder.

Controls (mitigation of hazards): Only sealed sources will be used with appropriate local controls. ALARA practices will be used when handling sources. When source is in use, signage to indicate the presence of the source will be in place, warning people to contact authorized users if work is to be done at or around the detector. The detector will not be moved with sources inside the holders. The source will be removed when the system is not in use and at vented. Sources will be secured when not in use. Weekly physical inventory for sources that are checked out to users will be carried out. Workers must take Require Access to Radiation Restricted Areas training and Radioactive Source User training.

3.4 Physical Hazards

3.4.1 Compressed Gas Use

Description of Hazard: Use of the gas handling system including compressed gas cylinders could lead to explosion, implosion, flying debris, or oxygen deficiency. A Kapton beam-entry window is used, which contains the gas.

Controls (mitigation of hazards): Design standards of gas-handling system and detector volume. Engineering controls (a mass-flow controller is used to set and maintain the pressure in the detector volume; in case the mass-flow controller fails, a pressure relief valve on the detector volume is set to activate at a differential pressure less than 1 atm, before the Kapton window breaks). An oxygen-deficiency monitor is employed in case the relief value is activated or the Kapton window breaks; standard procedures are followed in case the oxygen-deficiency monitor is activated (see Section 4). Personnel operating gas-handling system will take MSU EHS Compressed Gas Cylinder Safety training, Use a Four Gas Monitor to Evaluate Potentially Hazardous Atmospheres training, comply with NFPA and CGA, and exhibit proper use of cylinders, carts, regulators, and storage facilities.

3.4.2 Fire Hazard

Description of Hazard: Isobutane is flammable at concentrations of 1.8 to 8.4% in air. The HV in the detector could act as an ignition source if air were present. Isobutane has an autoignition temperature of 460^{o}C in air.

Controls (mitigation of hazards): The isobutane mixture is already diluted in Ar to only 5% and the detector volume and gas handling system are isolated from air. This makes it highly unlikely that a flammable mixture of isobutane with air could be created. The system will be leak checked before the isobutane mixture is used. This ensures that there are no small leaks that introduce small amounts of air into the system which accumulate over time. In case a large leak takes place (for example, if the pressure-relief value is activated or the Kapton window breaks), air will quickly dilute the isobutane to a non-flammable concentration in the S2 Vault due to the large volume of the room, even if the entire gas bottle is emptied into the room. The detector will not be operated with the isobutane mixture in Room 1039, due to the small volume of the room. Under normal operation, a pump suitable for isobutane gas will be used to flow gas slowly to an exhaust line, which removes any potential transient condition at the exit of the system. Communication with MSU EH&S on 4/18/2018 confirmed that, with these measures, the isobutane gas mixture can effectively be treated as non-flammable.

3.5 Environmental Hazards

Not Applicable

4 Special Emergency Response Procedures

In case the pressure-relief valve is activated or the Kapton window breaks and oxygen deficiency alarm sounds, leave the area immediately and contact the following people in order until someone answers:

1. Area Coordinator: 517-908-7337 (Elaine Kwan for S2 Vault); 517-908-7581 (Chris Wrede for Room 1039)
2. Area Manager: Associate Director for Operations 517-908-7321 (Dave Morrisey for S2 Vault) or Associate Director for Experimental Research 517-908-7473 (Remco Zegers for Room 1039)
3. ESH&Q Manager: 517-908-7473 (Peter Grivins)

If oxygen level is OK, close gas inlet valve and turn off HV.

Standard emergency response procedures apply to all other hazards described. Report all injuries. Call 911 for injuries requiring immediate medical attention.

Other numbers:

517-355-0153 (EHS office on the MSU campus)

517-908-7346 (Ashley Garrett)

or -7657 (Rebecca DeZess)

5 Adverse Conditions

Not Applicable

6 Operating Procedures

Attached as Appendix.

7 Qualified Operators

Employee Name	**User type**	**Tasks**	**Notes**
	Task specific/fully authorized		
Chris Wrede	Fully Authorized	Installation and operation of Proton Detector System including Gas Handling and HV; Check out radioactive sources	Activites will be performed in the S2 Vault and Room 1039 of NSCL
Moshe Friedman	Fully Authorized	Installation and operation of Proton Detector System including Gas Handling and HV; Check out radioactive sources	Activites will be performed in the S2 Vault and Room 1039 of NSCL
Tamas Budner	Fully authorized except for checking out radioactive sources	Installation and operation of Proton Detector System including Gas Handling and HV	Activites will be performed in the S2 Vault and Room 1039 of NSCL
Jason Surbook	Fully Authorized	Installation and operation of Proton Detector System including Gas Handling and HV; Check out radioactive sources	Activites will be performed in the S2 Vault and Room 1039 of NSCL
Lijie Sun	Fully Authorized	Installation and operation of Proton Detector System including Gas Handling and HV; Check out radioactive sources	Activites will be performed in the S2 Vault and Room 1039 of NSCL
Tyler Wheeler	Fully Authorized	Installation and operation of Proton Detector System including Gas Handling and HV; Check out radioactive sources	Activites will be performed in the S2 Vault and Room 1039 of NSCL

8 Safety Readiness Review Committee Members (proposed by project leader)

Peter Grivins	Chair
Thomas Russo	Electrical Subject Matter Expert
Jack Ottarson	Mechanical Subject Matter Expert
Peter Grivins	RSO
Daniel Bazin	Subject Matter Expert
Wolfgang Mittig	Subject Matter Expert

9 Training Requirements

Hazard	**Training**
General Hazards	Perform work that may require a hazard evaluation (JSA and/or AHD)
Radiation Hazards	Require Access to Radiation Restricted Areas; Use Radioactive Sources
General Hazards	Require Access to Nuclear Science Laboratory Spaces
Gas Handling System Operation	Work with Compressed Gas Cylinders; Use a Four Gas Monitor to Evaluate Potentially Hazardous Atmospheres; Work with Chemicals
HV Operation	General Electrical Safety
Handheld Non-Powered/Powered Tool Use	Use Manual and Powered Handheld Tools

10 References

[1] Activity Hazard Document Procedure (FRIB-S10300-PR-000241)

Appendix: Operating Procedures

Operating procedures:

Valve status summary (V - open, X - closed):

procedure	0	1	3	4	5	6	7	8	9	10
pump GHS	X	V	V	X	X	V	V	V	V	X
pump detector	X	V	V	V	V	V	V	V	V	V
flow gas	V	V	V	V	V	X	X	X	X	X
introduce Rn	V	V	X	V	V	V	V	X	X	X

Pump gas-handling system (GHS):

1. Check voltages off (cathode, gating grid and Micromegas).
2. Valves (0a,0b,4,5,9,10) closed, (1a,1b,3,6,7,8) open.
3. Turn off mass-flow controller or set to zero pressure.
4. Turn on pump.
5. Open valve 9.

Pump detector:

Note: always try to avoid situation of holding the detctor at lower pressure than the GHS while valve 4 is open.

1. Follow procedure to pump GHS.
2. Valves (0a,0b,4,5,10) should be closed, and valves (1a,1b,3,6,7,8,9) open.
3. Open Valve 5 for slow pumping.
4. When pressure in chamber goes below 200 Torr, open valves 4 and 10.

Flow gas through detector:

1. Follow instructions for pumping GHS and detector.
2. Close valves (0a,0b,1a,1b,5,6,7,8,9,10). Valves (3,4) should be open.
3. Re-check voltages off (cathode, gating grid and Micromegas).
4. Set mass-flow controller to the desired pressure.
5. Open valve 0a or 0b, then open valve 1a or 1b.
6. Adjust valve 5 to allow the desired flow rate.

Introduce ^{220}Rn to gas:

1. Follow instructions for flowing gas through detector.

2. Open valves 6 and 7.
3. Close valve 3.

Turn HV on:

1. Inspect system to verify:
   1.1. 20 KV SHV (red cable) is connected to the cathode, and the grounding SMA (white) is connected to the "cathode ground" electrical feedthrough. The other end of the red cable should be connected to the CAEN HV module.
   1.2. Two SMA (black cables) are connected to the "gg pos" and "gg neg" electrical feedthroughs. The other ends should be connected to the gating grid switch.
   1.3. Two or three cables connect the MHV-4 module to the switch, according to the relevant gating grid mode. Double check that the potential gradient direction is always obeyed. Connecting "POS" input at lower absolute potential relative to "NEG" in the same port will damage the switch.
   1.4. The preamp is connected to the Mesytec MHV-4 module.
   1.5. A grounding cable is connecting the electronics rack to the network ground. Make sure the inner frame of the electronics rack is connected to ground, not the outer blue frame.
   1.6. A grounding cable is connecting the rack to the detector.
   1.7. A grounding cable is connecting the preamp grounding screw to the Micromegas support ring.
2. Verify the pressure in the chamber. Note that while valve 4 is closed, the mass-flow controller does not measure the pressure in the chamber. Make sure that the HV that you are about to apply is appropriate for the pressure in the chamber.
3. Set interlocks for both HV modules. The interlocks should be no more than 20 μA for the MHV-4 module and 40 μA for the CAEN module.
4. If the chamber was exposed to air since the last time HV was applied, set ramping rate of 5 V/s in both modules.
5. Turn on the CAEN HV. Monitor the current as it is ramping. 3.75 μA/kV is normal. Wait until ramping is complete.
6. Turn on the gating grid high voltage. Here, again, make sure to obey the potential gradient direction while ramping the voltages. Monitor the current. Up to few μA is normal.
7. Turn on the Micromegas bias. A transient current should go up to 20 μA, but a zero current is expected at steady state.
8. As a general rule, avoid remote control of the HV if it is not necessary.
9. Before switching the CAEN HV module to "remote" mode, all the steps should be made as for turning it on.
10. When dealing with any of the HV cables during experiment, one must exit "remote" mode until the work is complete.

Turn HV off:

1. While turning off gating grid HV, make sure to obey the potential gradient direction.