# Hazard Overview of pRad Experiments in Area C at LANSCE

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# HAZARD OVERVIEW of pRad EXPERIMENTS in AREA C at LANSCE

## Introduction

Experimental Area C houses the Proton Radiography (PRAD) facility. The primary purpose of the facility is to take radiographic images of static (stationary) as well as dynamically exploding systems in a containment vessel using the 800 MeV beam from the Los Alamos Neutron Science Center (LANSCE) accelerator. The area consists of beam lines under vacuum, electromagnets, vacuum pumps, beam diagnostic instrumentation, cameras, high current cables, high voltage and signal cables, fiber optic cables for data and laser light transmission, etc. Several of these components pose potential hazards to workers and visitors. The purpose of this document is to familiarize individuals to the area and alert them to the potential hazards associated with working in Area C. In addition, area C is a radiological controlled area.

A schematic layout of the area is shown in Figure 1 (page 9). Please take a few minutes to study this figure as the text also makes repeated references to it when there is need to indicate local areas of concern. Figure 2 is a picture of the beam line and, together with Figure 1, can be used to identify some of the components discussed in the text. In the event of evacuations due to hazardous conditions, the designated muster area is the parking lot outside SECTOR P. Figure 3 is a picture of the area.

## Requirements for working in Area C

Individuals requiring unescorted access to Area C must do the following:

1. Complete and follow RADWORKER training
2. Complete and follow TA-53 Site specific training
3. Follow other entry requirements as posted by HSR-1, including radiation work permits
4. Read and acknowledge this document.

If the area is running under secure conditions for classified experiments, additional requirements are:

5. Must have an active Q-clearance.
6. Complete and follow LANL security training.
7. Complete and follow PRAD security training.
8. Have documented need-to-know from their supervisor.

## Facility Exits and Entries

There are three exit and entry points serving Area C. They are labeled D1A, D1B and D2 (Door2) in fig 1.

a) D1A: This small metal door, inside the ninety ton concrete shield door (labeled D1B in figure 1), is the primary access into and out of Area C. It is normally closed with Personnel Access Control System (PACS) keys from the outside but can be opened from the inside to allow exit of personnel at all times and regardless of the status of the facility. This door is blocked off when D1B is open.

b) D1B: This is a heavy concrete radiation-shielding doorway, which is closed during proton beam and high explosive operations. When this door is open it becomes the primary access and exit point for the area since D1A (which is structurally connected to D1B) is not usable. Note that D1A and D1B can never be open at the same time.
During beam delivery into the area, access is controlled by LANSCE operations. In the presence of high explosives outside the containment vessel, access is controlled by the DX3 firing leader. Under both of these circumstances, you must have the permission of the Experimenter in Charge (EIC) to enter the area.
All doors are closed and secured prior to beam delivery into the area.

c) D2: This gate connects line C to Line B. While this door is seldom used to access Area C, it can be used as an emergency exit. It serves the same purpose for workers in Line B.

### Removal of Objects from Area C

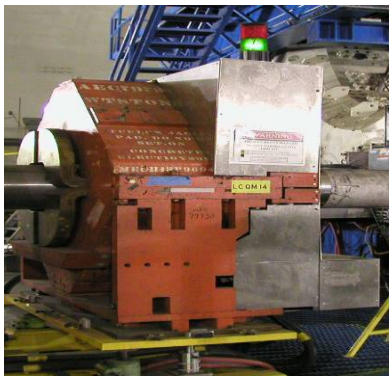
Objects that were in Area C when beam was delivered must be monitored and tagged by a Radiological Control Technicians (RCT) before removing from the area. When there is need to remove an object from Area C please contact HSR-1 personnel at 7-7069. If the object is classified, it must be properly marked and packaged.

## Radiation hazards from Direct Proton Beams

Before beam delivery into the area, qualified HSR and LANSCE operations personnel will make sure that all other personnel have left the area by performing a standard sweep. Prior to the sweep, announcements are made over the intercom that the area is being swept and all personnel are to leave the area. Also, the status of the area is displayed in the Personnel Access Control System (PACS) status indicators located at several locations inside the dome and above the bank of PACS keys in the hallway outside the dome. The labels on the indicator lights are self-explanatory and the reader is encouraged to spend a few minutes studying these signs.

A person exposed to the primary proton beam can receive potentially lethal dose of radiation. In the unlikely event that the sweep team fails to evacuate the area completely, and a person finds himself inside the facility with the area ready for beam, there are several red-lit SCRAM SWITCHES which, when pressed, would interrupt beam delivery into the area. The approximate locations of all SCRAM switches in Area C are indicated in figure 1. It is strongly recommended that workers and visiting staff take note of SCRAM SWITCH locations inside the Area C dome.

### Quadrupole (four pole) Electromagnets:



Quadrupole electro-magnets are used as lenses to guide pulses of proton beams on to targets and image planes. Lights on top of the magnets indicate the state of the magnet. These lights are only indicator lights and in no way should be taken as definitive indicators for whether a particular magnet is on or off[1]. Some of the most obvious hazards associated with these magnets are:

1. Energized magnets can accelerate nearby ferrous objects and turn them into dangerous projectiles. Keep ferrous objects at least 3 ft away from energized magnets.
2. DC power supplies through high current cables typically carrying currents ranging from tens of Amps to over 1000 Amps power all

[1] These lights were originally meant to indicate whether a magnet is on or off. While a RED light indicates a magnet in the ON state, a GREEN light can mean any of the following: a) the magnet is OFF b) the light is disconnected and the magnet can be ON or OFF.

magnets. The leads connecting these cables to the coils in the magnet are typically located at the bottom of the magnets. In some cases these leads are not insulated but are located at normally inaccessible positions such as underneath the magnets. Only qualified (trained) and authorized personnel are allowed to perform electrical work on these magnets. All other personnel shall refrain from accessing the vicinity of any exposed electrical conductors.

3. The quadrupole magnets are water-cooled. If there are visible water leaks emanating from any of the magnets, refrain from stepping in the puddles or otherwise coming into contact with the water. Such leaks can pose radiological and electrical hazards. If you notice such leaks notify any of the PRAD crew available.

## Containment Vessel

The containment vessel, which can be located in Figure 2, is classified as a confined space. Individuals without special training should not put their heads, hands or any part of their body in the vessel.

## Lead Bricks

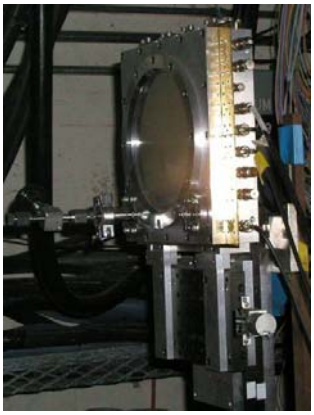
Lead bricks are stored in the area. Only qualified and authorized personnel are allowed to handle lead bricks.

Designated Storage of lead bricks

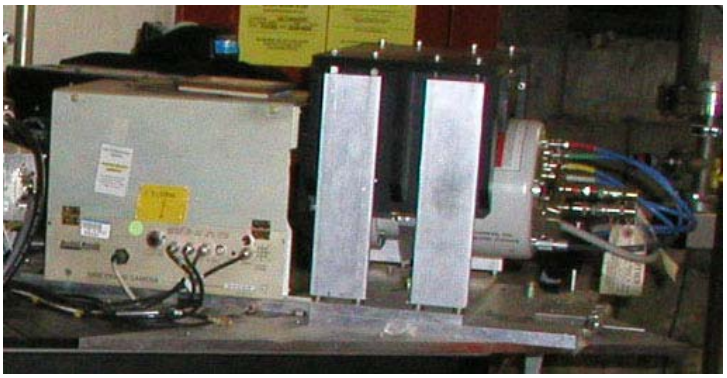
## Flammable Gases

There are two locations containing small quantities of flammable gases where open flames/ignition sources are strictly prohibited.

1. A hydrogen ion chamber used as the beam position monitor located at IL0 (fig. 1) containing a small amount of hydrogen gas.
2. Two camera units in IL2 (see fig. 1) that use flammable hydrocarbons for cooling purposes.

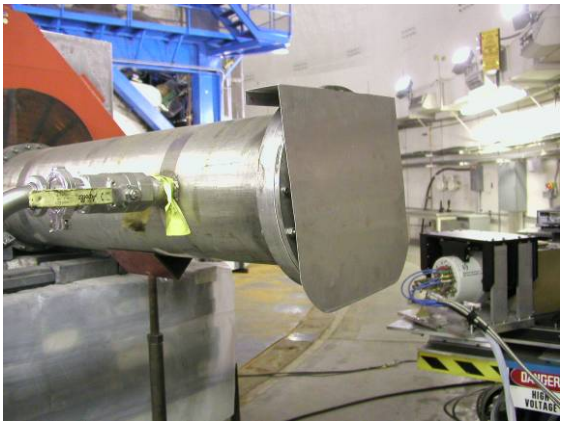


Beam Position Monitor (contains $H_2$ gas)



Framing Camera (uses flammable hydrocarbon for cooling)

## High Pressure (Vacuum) Hazards




Thin window on beam pipe covered with Al protector

The beam-line in AREA C consists of breaks in the line where the beam-pipes are capped off using thin Al or steel windows. The locations of these windows are shown in figure 1. These fragile windows can be damaged by falling objects or by careless handling of tools. A suddenly breaking window is followed by the release of ~50KJ energy which can easily result in hearing loss for a person in the immediate vicinity. The picture shows a beam window protector in place. When working near such windows, please ensure these protectors are in place. (See figures 1 and 2)

## High Voltage Hazards

Camera Table: Note High Voltage Warning posted

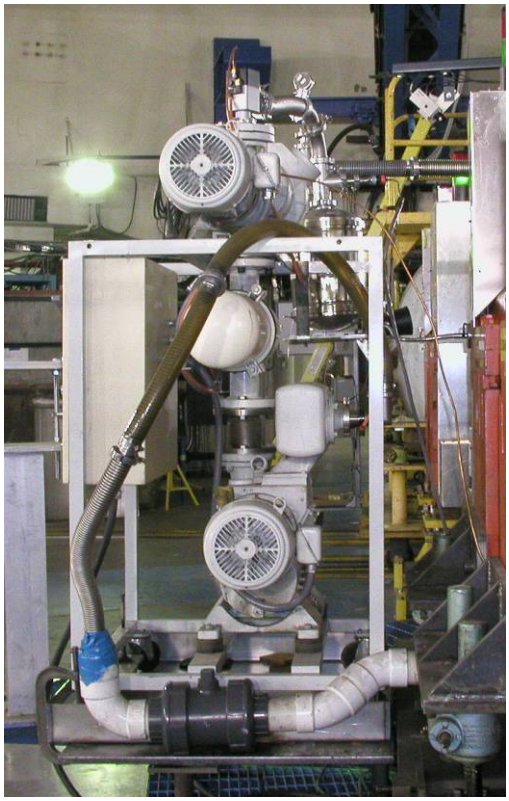
The camera tables at IL1 and IL2 contain sources of high voltage. Only qualified and authorized personnel shall perform work on these camera tables. Please note the high voltage warnings posted on these tables and, individuals not familiar with the camera equipment should refrain from working in close proximity to these locations.

### CRYOGENS in Line B

Low oxygen alarm

Area B, which lies to the east of Area C, makes use of large volume liquid helium (He) dewars. It has been recognized that a catastrophic failure of these cryogenic containers could possibly displace oxygen from both the Line B tunnel and Area C. There are three “Low Oxygen Alarms” in Area C consisting of audible alarms and flashing red lights (see Fig. 1). If any of these alarms go off, personnel must leave the area immediately. In this case the choice of exit is through the primary exit D1A or D1B. Avoid exit through D2 toward Line B: this route may draw one closer to the most likely source of oxygen displacement.

## Vacuum Pumps



Roughing Pump

There are three roughing pumps in Area C and their locations are indicated in fig. 1. There exist remote possibilities that oil can leak out of these devices. In addition to being hazardous to the environment, such spills can also be radiological hazards. If a spill is noticed, avoid any contact and notify PRAD personnel immediately.

## Cranes

Both gantry and jib cranes are used in the area and are shown below. When the crane is supporting a load, all personnel involved in the lift must be authorized as per the IWD for crane operations in Area C. Personnel not participating in the lift must stay out of the cone of danger[2].

Gantry Crane

Jib Crane

[2] According to the TA-53 Site Specific Training, "the distance you maintain from a suspended load should be equal to or greater than the height of the load." The "cone of danger" is then a 45-degree cone with its apex at the suspended object.

**LASER**

A VISAR using a Class IV laser is part of the PRAD diagnostic system. The light is produced in the VISAR room (see fig. 1) and transported into the Area C dome through optical fibers. There are three LASER status indicators in the area on the outside of the VISAR room door, at the entrance to the dome near D1A, and inside the dome (locations are shown in figure 1). Each status light is well labeled and individuals working in the area are expected to read these labels and follow the procedures indicated on the labels.

The VISAR stand in the Area C dome is shown in the picture. When the indicator light is yellow, the fibers may or may not carry laser light and, in the latter case the light is confined to the fibers. An accidental break of the fibers may precipitate a light leak, which can cause serious eye damage only to personnel that are close to the fiber break point. Under these or other scenarios that can result in inadvertent escape of laser light, the emergency switch on the stand (shown in the picture) should be used to shut off laser light transmission to the optical fibers. When the indicator light is red, qualified personnel must escort individuals accessing the Area C dome. Green lights indicate that the area is free of laser light.

The Status indicator on the VISAR room door is meant to indicate the status inside the VISAR room. Note that there are redundant lights on all status indicators. If any of these lights are burned out or otherwise indicate conflicting or confusing laser status, contact any of the PRAD operations personnel before proceeding into the area.

## Forklift Operations

Forklifts are used to move heavy equipment into and out of Line C. Personnel in the area should be cognizant of forklift operations and fumes produced by the operation of the forklift. Operation of forklifts is restricted to qualified and authorized personnel.

## Ladders and Falling Hazards

Individuals shall not climb on ladders without having received ladder safety training at LANL. Some experimental configurations require raised platforms and the introduction of tripping hazards. The configurations in Area C change regularly. Be aware of newly introduced bumping and tripping hazards.

## Powder Launcher/Gun

The picture shows a containment system known as a powder launcher and sometimes referred to as the "powder gun". This system has not yet been deployed and there are no hazards associated with it as yet.

## Neutron Detector (ALBATROSS) Alarm

A neutron detector (ALBATROSS) is located in the hallway outside the Area C dome to monitor the neutron radiation in the normally occupied areas. Only unusual beam spills can lead to a neutron radiation higher than background. The detector alarm consists of flashing lights and a loud high frequency alarm. Under these circumstances, all personnel are to vacate the hallways, VISAR room and the counting house immediately, and assemble in the muster area indicated in figure 3.

## High Explosives

During dynamic "shot" operations, high explosives are in Area C. When high explosives are in the area, access shall be restricted to authorized and qualified personnel. No ignition sources shall be present within Area C.

### Typical PRAD Shot Day Sequence of Operations

1. In preparation for the shot day, the experimental area is left ready to accept the proton beam. This means the beam line vacuum is established and the area is swept of personnel and left locked up.
2. Tune the proton beam into and through the beam line. For this operation and all beam operations, the experimental area must be "PACS Secure"; that is, swept of personnel and locked up.
3. For classified shots, the temporary physical security area is established.
4. Turn on and test the camera and data acquisition systems. For this operation, the area must be opened for access.
5. Prepare the containment vessel and shot stand for the delivery of High Explosives (HE).
6. HE is delivered in DOT-approved shipping container. While the HE is in the delivery truck or in the process of being unloading, please refrain form smoking within a distance of 50 ft.
7. A pre-job briefing is conducted to familiarize the workers with the particular tasks and hazards associated with this day's shot.
8. A High Explosive Exclusion Area is formed in the experimental area. The number of workers allowed in the area simultaneously is limited. A door guard is responsible for controlling access to the HE area.
9. The shot is removed from the DOT container and mounted on its stand in the containment vessel.
10. When the shot is mounted and the vacuum has been established in the containment vessel, the High Explosive Exclusion Area is disestablished.
11. Calibration radiographs of the undetonated (static) object are acquired.
12. Final preparations for detonation are completed, such as turning on the monitor microphone.

13. The shot is detonated.
14. The experimental area is reentered and the shot residual gasses pumped and flushed from the vessel by trained workers.
15. Post-shot calibration radiographs are acquired, including beam profile measurements, fiducial calibration pictures, and camera dark current pictures.
16. The camera and data acquisition systems are shut down and the data backed up.
17. For classified shots, the temporary physical security area is disestablished.
18. The experimental area is left open ready for maintenance or preparation for the next shot.
19. Typically on a later day, shot debris is removed from the containment vessel and the beam line prepared for future shots.

## Classified Operations

During classified operations, Area C, the Line C counting house, and Line B are converted to a temporary limited security area. Access is limited to Q-cleared personnel or escorted uncleared persons. The security responsible line manager must first approve entry by any escorted, uncleared persons. Normally, this is done to allow L-cleared persons to perform a PAC sweep. These people are allowed only in the hallway and dome, not the counting house. Persons approved to use the classified computers may only perform classified computing in the counting house. Classified operations, conversations, etc., should be limited only to matters relating to PRAD operations.

## Useful Contact Phone Numbers

1. Emergency ---------- 911
2. CCR ---------- 7-5729
3. HSR-1 ---------- 7-7069
4. Safety RLM (Martin Cooper, P-25 Group Leader) ----- 7-2929
5. Security RLM (Doug Fulton, P-23 Group Leader) ----- 7-5005
6. Line C Counting House and Line C Dome ---------- 7-3225
7. PRAD team leader (Frank Merrill) ---------- 5-6416

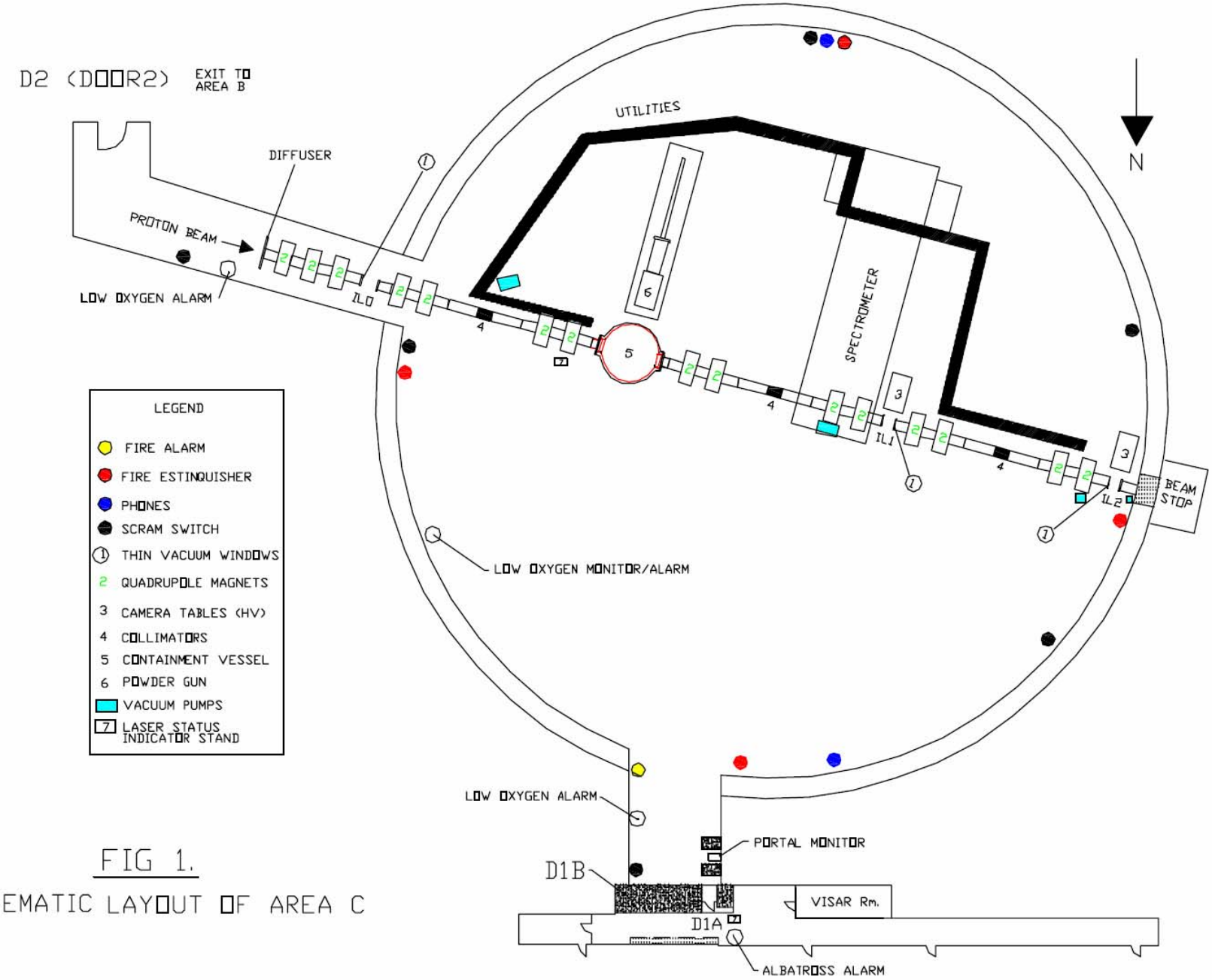



FIG 1.

HEMATIC LAYOUT OF AREA C

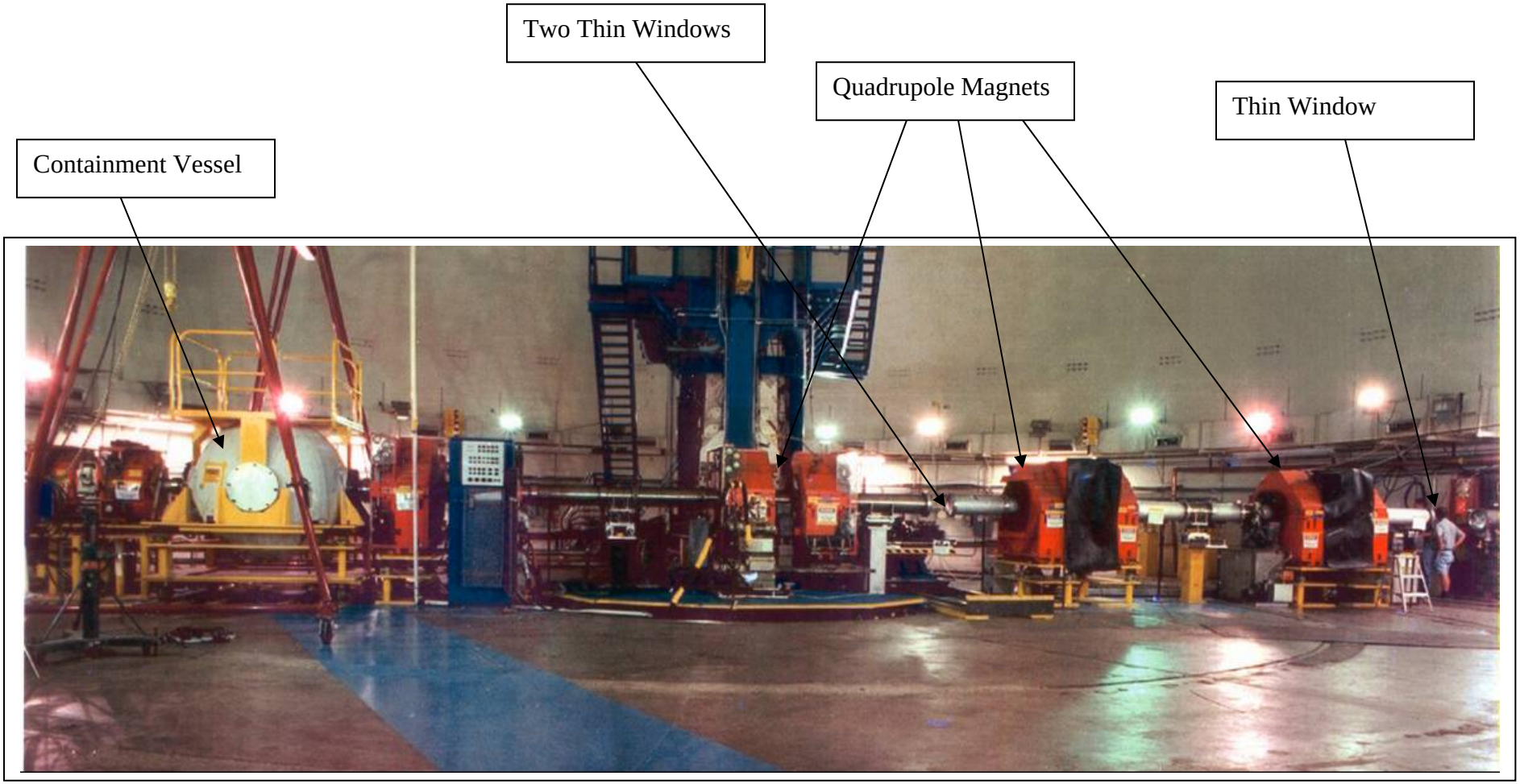



Figure 2. A section of the beam line in the Area C dome.

Figure 3. The PRAD facility in the LANSCE Sector P. The facility is under the dome of dirt behind the structure. The PRAD counting house (CCH), which contains a bank of data acquisition computers and experimental control modules, is also shown. The designated muster area is in the foreground.



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