WBS 1.3 RICH Detector Installation Plan

By

M. Artuso, H. Cease and J.C. Wang

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INTRODUCTION

The RICH detector will be installed in two stages:

1. Stage 1 encompasses the assembly, installation and testing of the RICH vessel superstructure with the gas radiator RICH fully instrumented and ready to take data in the first stage of operation of BTeV (2009). The top PMT array and liquid radiator vessel will be mounted as well to satisfy the geometrical constraints posed by the whole detector structure. This stage has two phases that will be described below.
2. Stage 2 [installation expected during the 2010 shut-down] will involve the mounting of the 3 remaining PMT planes and the completion of the liquid radiator RICH.

Stage I of the RICH Installation

Phase I: Work in the assembly hall

The following steps must be performed before rolling the tank into the collision hall:

1. Shipping the tank frame segments to C-Zero;
2. Assembling the tank frame by welding the walls together;
3. Attaching the liquid radiator vessel to the tank;
4. Mounting the front window to the frame;
5. Installing the mirrors and mirror support structure;
6. Inserting a temporary (Al) beam pipe into the tank;
7. Making the beam pipe to window seals;
8. Mounting Top PMT enclosures completely instrumented;
9. Pre-aligning the mirror tiles;
10. Initial gas leak check of the tank frame, window seals, and instrument enclosures.

Tank frame segments –

Weight ~15,000 lbs
Assembled Size ~ 6 meters X, 5 meters Y, 3.5 meters Z
Large steel plates and structural beams are shipped to the C0 assembly building. The pieces need to be small enough to fit through the C-Zero exterior entrance door. The entrance door is approximately 12 feet wide and 13 feet tall. The frame segments are large and require a rigging crew, a technician crew, and a welder to assemble. Survey points can be the standard ¼" hole for a fiducial holder.
Duration: 2.5 months
Technician man time and rigging time to assemble the tank: 400 hrs
Welder man time to assemble the tank: 400 hrs
Engineering Support: 160 hrs
Survey time: 5 shifts of 3-man survey crew

Liquid Radiator Vessel –

Two Pieces, a lower half and an upper half
Empty Weight ~ 180 lbs total
Assembled Size ~ 2.48 meters X, 2.48 meters Y, 1.6 cm Z
Requires plumbing for 4 chambers.
Liquid Volume,
60 liters in the Vessel, additional
10 liters in the plumbing.
80 liters in the reservoir.
The liquid radiator vessel is inserted and mounted to the tank frame as a pre-assembled unit. Plumbing lines from the radiator vessel to the exterior of the tank are connected. Fiducials located on the radiator vessel are transferred to the tank frame prior to the windows being installed on the tank frame.
Technician man time to mount the liquid radiator: 1 man week
Engineering Support: 8 hours
Survey time: 1 shift of 3-man survey crew

Front Window

Front Window Weight ~40 lbs carbon fiber
Size ~ 2.54 meter X, 2.54 meter Y, 1.3 mm Z
The front RICH tank wall has a carbon fiber window to minimize the material on the path of the charged particles. In order to make the window replaceable, the window is mounted with flanges and o-ring seals.

Technician time to mount and leak check the front window: 120 hours
Engineering Support: 8 hours
Calendar time: 5 days

Mirrors and Support Structure

Mirror tiles weight ~17 lbs per tile without mounts,
Mirror tile size, 1 meter square, total of 16 tiles, 8 tiles per array
Single Mirror Array Size ~ 2 meter X, 4 meter Y, 0.6 meters Z due to curvature
Support Panel Weight including rear window, ~800 lbs
Support Panel Size ~4.4 meters X, 4.4 meters Y, 0.6 meters Z

The mirror support panel is a single panel that acts as the support structure for the individual mirror tiles and acts as the rear window for the tank. The mirror tiles are mounted to the mirror support panel using three point mounts. As part of the mirror panel assembly, individual mirror tiles are calibrated and adjusted to each other prior to the mirror panel installation. The assembled structure is then mounted to the back of the RICH tank using a gasket type seal. Fiducial marks are located on the inside surfaces of the support structure so that the panel can be aligned with respect to the MAPMT enclosures. A second set of fiducial marks is located on the outside of the structure so that it can be position with respect to the tank and the interaction point. An initial leak check of the gasket seal must take place prior to installing the tank into the collision hall. The interface between the mirror array and the rest of the tank should be covered with a temporary gas tight barrier. The purpose of the barrier is to provide dust protection for the mirrors while the PMT and MAPMT arrays are being installed in the collision hall.

Technician time to complete the mirror assembly procedure: 240 hours
Survey time:
Engineering Support: 40 hours
Total calendar time: 21days

Beam Pipe

Installation of the beam pipe involves inserting a temporary Al beam pipe section into the tank frame, later to be replaced by a Be beam pipe. The beam pipe is supported by the tank frame. After inserting the beam pipe into the tank, the window to beam pipe seal is made. The continuity of the Tevatron beam pipe must be restored to a vacuum below 10^{-7} torr. Inserting the beam pipe into the tank frame and making the seals is estimated to take 1 week calendar time.

Technician time to install the beam pipe: 24 hours
Engineering Support: 8 hours
Total Calendar time: 5 days

Beam Pipe to Window Seals

A gas seal is required between the beam pipe and the RICH windows. This is done by gluing mounting rings to the beam pipe and the rich windows, and mounting a light/gas tight bellows between the two mounting rings.
Technician time to install the bellows: 30 hours
Engineering Support: 20 hours
Calendar time: 8 days

PMT Enclosure Installation

The next step in the installation procedure is the assembly of the PMT enclosures that provide mechanical support and magnetic shielding for the PMT arrays.
Technician time to install PMT Enclosures: 128 hours
Mechanical Engineering support: 20 hours
Syracuse Oversight: physicist 180 hours
Duration: 12 days

Top PMT Array Installation

~1100 pmt tubes,
Beehive Weight ~ 3,000 lbs of mu-metal tubes
Enclosure Weight ~several hundred lbs
Size ~ 4 meter X, 0.2 meter Y, 3 meter Z
The PMT array is fully instrumented and includes the mu-metal beehive, PMT modules and associated electronics and cooling. The array will be delivered at C0 after having been fully assembled and tested at Syracuse. Upon arrival, it will be tested in the assembly hall prior to be mounted on the top of the RICH superstructure. All cabling to the feed-thru board is already completed. The array is installed using the overhead crane in the assembly hall. Once installed, the PMT array will be surveyed and adjusted to its correct location with respect to the RICH tank and the liquid radiator vessel. All necessary electronic cooling and electronic readout connects are made. The back panel to the enclosure is then placed onto the enclosure and leak checked. It is estimated that installation requires 1/2 week per array and surveying requires 1 week of calendar time.
Array testing in the assembly hall: 80 hours of physicist time and 160 hours of graduate student time
Technician time to install, cable and leak check the array: 120 hours
Engineering Support: 16 hours
Syracuse Oversight: 16 hours
PMT array survey: 3shifts of 3-man survey crew

Pre-alignment of the Mirror Tiles

Once the tank is nearly complete, a pre-alignment of the mirror arrays can take place. The pre-alignment is performed by viewing by eye an image at the focal point of the mirror array.

Syracuse PostDoc: 160 hours
Syracuse Physicist: 40 hours
Engineering Support: 16 hours
Duration: 20 days

Install expansion volume

This step involves the installation of the bellow system that allows the gas to change its volume according to the variations of atmospheric pressure. This system is located at the very top of the tank and has multiple connections to the vessel superstructure.
Technician time to mount the expansion volume: 120 hours
Engineering Support: 10 hours
Duration: 10 days

Initial Leak Check of the Tank System

Prior to rolling the tank into the collision hall, the entire tank is leak checked. The instrument array enclosures should be gas tight and the liquid radiator vessel and plumbing should be liquid tight.
Technician time to leak check the tank: 120 hours
Postdoc time to oversee tank check: 80 hours
Engineering Support: 10 hours
Duration: 20 days

Phase II: The tanks rolls into the collision hall

At this point the tank is ready for installation and is expected to roll into the collision hall during the shut-down of 2008. The only task envisaged upon this transfer is a survey of the tank, followed by the mirror alignment procedure, with the same technique used in the assembly hall. This procedure can be performed any time prior to the MAPMT installation.

1 shift of 3-man rigging crew to transfer the tank
Syracuse Postdoc:
Survey time: 2 shifts of 3-man survey crew

The next step to complete stage I of the RICH installation is the mounting of the MAPMT arrays. They are pre-assembled in their enclosures at Syracuse, where they are tested extensively. Upon arrival at C0, they are expected to undergo a basic performance check, to insure integrity.

Postdoc time to test each array: 80 hours
Undergraduate student time to test each array: 120 hours
Test duration for each array: 15 day

Prior to installation of the West MAPMT array, the infrastructure that needs to be ready in the collision hall includes the population of the local crates, including low voltage power supplies, monitoring electronics (electronics calibration, light pulser, alignment system) and connections for the gas system. The installation of this array involves the

mounting of the plane on the vessel superstructure, the power and signal cable connection to the corresponding racks and the assembly of the cooling system.

The installation of the east array involves the mounting of the plane on the vessel superstructure, the power and signal cable connection to the corresponding racks and the assembly of the cooling system.

Fermilab Manpower: 1 shift of 3-man rigging crew
Syracuse Manpower (cabling and inspection)
Graduate Students: 80 hours
Postdoc: 80 hours
Technician: 80 hours
Physicist: 24 Hours

After this step we fill the tank with radiator gas and we do a final survey of the instrumented gas RICH. The system is thus ready for commissioning for the first phase of the BTeV data taking.

The remaining 3 PMT planes are installed in the shut-down of FY10: the installation procedure follows the same approach as the MAPMT installation, with the arrays delivered instrumented and tested at C0, ready to be mounted on the detector after a brief testing procedure upon arrival. Syracuse University is responsible for providing the majority of the needed manpower, with Fermilab providing some support.

ROLLING THE TANK INTO THE COLLISION HALL AND FINAL INSTALLATION STEPS (Summer 2008 Shutdown)

The RICH tank installation involves the following steps:

1. The shielding door is opened at the start of a Tevatron shutdown period.
2. The RICH tank assembly is rolled into the collision hall by riggers utilizing rollers at C0 and temporary steel plates on the floor.
3. It may be necessary to remove additional sections of beam pipe to allow the tank to roll into position.
4. The RICH tank assembly will be surveyed and adjusted to its correct location with respect to the Tevatron.

It is estimated that installation requires 1 month and surveying requires 1 week of calendar time.

Technician time to install: 3 man tech crew, 2 days
Engineering Support: 1 man week
Survey time: 3 man tech crew, 2 days

INSTALLATION STEPS IN THE COLLISION HALL 2009 SHUTDOWN

The following steps, not time ordered, are required once the tank has been installed into the collision hall.

1. MAPMT Array Installation;
2. PMT Array Installation is completed in the assembly hall
3. Install the Electronic Cooling plumbing system;
4. Install the Electronic Cooling Slow Control System;
5. Install Liquid Radiator Plumbing system;
6. Install Liquid Radiator Slow Control System for the Liquid;
7. Install Gas Radiator Plumbing system;
8. Install Gas Radiator Passive Expansion Volume;
9. Install Gas Radiator Slow Control System for the Gas;
10. Install the Mirror In-Situ Alignment System;
11. Fill the Liquid Radiator Vessel;
12. Fill the Tank with radiator Gas;

HPD ARRAY INSTALLATION (OPTIONAL)

472 tubes per array, 2 arrays

HPD 32 pack Weight ~50 lbs, 32 HPD tubes, electronic cards, support frame
Beehive Weight ~ 700 lbs, 472 mu-metal tubes
Enclosure ~1500 lbs of steel framing per enclosure (2.1 m x 1.5 m x0.025 M)
Size ~ 2.1 meters X, 1.5 meters Y, 0 .6 meters Z
~15 packs per enclosure
Cables per feedthru
- *Internet data cable 6 per row, max 25 per row*
- *4 red high voltage cables per row*
- *3 low voltage cables per row*
- *Thermistors for slow control*
- *2 coolant lines in/out*

Cables per enclosure (15 feed-thru boards per enclosure)
- *~70 internet cables*
- *60 red high voltage cables*
- *45 low voltage cables*
- *Thermistors for slow control*
- *30 coolant lines in/out*

The HPD array installation is performed after the straw tube installation is complete. The HPD array includes the mu-metal beehive, HPD enclosure, exterior magnetic shielding (500 lbs), HPD 32 packs, and associated electronic cooling and electronic cables. The HPD packs are independent to the assembly structure and can be installed into the array when received. Installation of the assembly involves the following steps:

1. The Straw Tube installation is complete.

2. The shielding door is opened at the start of a Tevatron shutdown period.
3. The HPD Enclosure is rolled into the collision hall as a completely instrumented unit by riggers utilizing rollers at C0 and temporary steel plates on the floor.
4. The HPD complete enclosure will be surveyed and adjusted to its correct location with respect to the Tevatron, the RICH tank, and Mirror array.
5. All necessary electronic cooling, electronic readout, and gas connections are made.
6. Leak check enclosure.

Repair of an individual HPD requires the removal the exterior magnetic shielding on the HPD enclosure, opening the enclosure, removing the HPD row from the structure, removing the necessary electronic and cooling connections, then closing the enclosure and replacing the exterior magnetic shielding. Repairing of one HPD would require 1 day of calendar time.

Technician time to install, cable and leak check the instrumented array (both arrays): 4 man weeks
Survey time: 1 week
Engineering Support: 4 man days
Total Calendar time: 1 month

MAPMT ARRAY INSTALLATION (BASELINE)

Parts fabricated fall 2005 and assembled together
4508 tubes per array, 2 arrays
Module weight ~ 55lbs, 196 tubes ~ 23 modules per array
Gas Enclosure ~1500 lbs per enclosure (2.1 m x 1.5 m x0.025 M)
Size ~ 2.1 meters X, 1.5 meters Y, 0 .6 meters Z
Cables per enclosure (23 feed-thrus per enclosure) (there are 2 enclosures)
High-Voltage: 276 cables
Low Voltage: 92 cables
Data: 435 cables
2 Water connections to the on board manifold
46 Water Cooling, 2 tubes per module on the manifold.

The MAPMT array installation is performed after the straw tube installation is complete. The MAPMT array includes the MAPMT enclosure, exterior magnetic shielding, MAPMT modules and associated electronic cooling and electronic cables. The MAPMT arrays are independent to the assembly structure and can be installed when received. Installation of the assembly involves the following steps:

1. The Straw Tube installation is complete
2. The shielding door is opened at the start of a Tevatron shutdown period.
3. The MAPMT assembly is rolled into the collision hall by riggers utilizing rollers at C0 and temporary steel plates on the floor.
4. The MAPMT assembly will be surveyed and adjusted to its correct location with respect to the Tevatron and the RICH tank.

5. All necessary electronic cooling, electronic readout, and gas connections are made.
6. Leak check enclosure

Repair of an individual module requires the removal the exterior magnetic shielding (500lbs) on the MAPMT enclosure, opening the MAPMT enclosure, removing the Module from the structure, making the necessary electronic and cooling connections, then closing the MAPMT enclosure and replacing the exterior magnetic shielding. Repair of a module would require 1 day of calendar time.

Technician time to install, cable and leak check the instrumented array (both arrays): 4 man weeks
Engineering Support: 4 man days
Survey time: 1 week
Total Calendar time: 1 month

PMT ARRAY INSTALLATION
5000 total tubes, At least 4 arrays

Beehive Weight ~ 12,000 lbs, 5000 mu-metal tubes
Gas Enclosure ~ several hundred lbs per enclosure
Size ~ 4 X meters, 0 .3 Y meters, 3 Z meters
Electronic Cards
Bases
Front end boards
Data combiner boards
Cables per 256 tubes
64 channels for a hybrid board,
256 for a mult-iplexer 3"x 10", near middle of array
High-Voltage 312 cables
Low Voltage 16 cables
Data, 78 cables
Water Cooling each base and hybrid and multi-plexer

The PMT array installation is performed at a convenient time in the installation schedule and is not affected by the installation of other components. The most convenient time for this task is the 2009 shutdown. The PMT array includes the mu-metal beehive, PMT enclosure, exterior magnetic shielding, PMT modules and associated electronic cooling and electronic cables. The PMT modules are independent to the assembly structure and can be installed when received. Installation of the assembly involves the following steps:

1. The labyrinth door is opened at the start of a Tevatron shutdown period.
2. The PMT assembly is rolled into the collision hall by riggers utilizing rollers at C0 and temporary steel plates on the floor.

3. The PMT assembly will be surveyed and adjusted to its correct location with respect to the Tevatron, the RICH tank, and the liquid radiator vessel.
4. All necessary electronic cooling, electronic readout, and gas purge connections are made.
5. Leak check enclosure

It is estimated that installation requires 1 week per array and surveying requires 1 week of calendar time.

Technician time to install, cable and leak check the instrumented array (three remaining arrays): 4 man weeks
Engineering Support: 4 man days
Survey time: 1 week
Total Calendar time: 1 ½ months

ELECTRONIC COOLING SYSTEM

Installing the pre-assembled plumbing hardware and running cables for the instrumentations is expected to require:

Technician time to run cables: 3 man days
Technician time to install plumbing hardware: 8 man days
Engineering support time: 5 man days.

MIRROR IN-SITU CALIBRATION SYSTEM

The mirror calibration system consists of:

1. The LED arrays;
2. The monitoring system;
3. The control software including alarm function.

LIQUID RADIATOR SYSTEM

Installing the pre-assembled plumbing hardware and running cables for the instrumentations is expected to require:

Technician time to run cables: 3 man days
Technician time to install plumbing hardware: 8 man days
Engineering support time: 5 man days.

FILLING THE LIQUID RADIATOR VESSEL WITH C5F12 LIQUID

Filling the liquid radiator vessel requires that the following tasks are complete:

1. The vessel has been installed into the RICH tank;
2. The vessel has been leak checked;

3. The liquid radiator re-circulation system is complete and has been tested.

The process of filling the liquid radiator vessel and confirming the re-circulation system is operating properly is estimated at 1 month of calendar time.

GAS RADIATOR SYSTEM

Installing the pre-assembled plumbing hardware and running cables for the instrumentations is expected to require:
Technician time to run cables: 3 man days
Technician time to install plumbing hardware: 8 man days
Engineering support time: 5 man days.

GAS RADIATOR PASSIVE EXPANSION VOLUME

Expansion Volume Frame Weight ~1000 lbs for ten frames
Size ~ 4 meter X, 1 meter Y, 3 meter Z
The expansion volume is installed on top of the tank by lifting the expansion volume frame using the assembly hall overhead crane. The expansion volume plumbing is then connected to the tank gas system plumbing. The expansion volume has no survey requirements.
Technician time to install the expansion volume: 2 man weeks
Engineering Support: 2 man days
Rigging time to install the expansion volume: 1 man week
Total Calendar time: 2 weeks

FILLING THE RICH TANK WITH C_4F_8O GAS

Filling the RICH radiator tank requires that the following tasks are complete:

1. The tank has been installed in the collision hall;
2. The tank has been leak checked;
3. The temporary gas barrier for the mirrors has been removed;
4. All of the mirrors have been installed and are positioned with respect to each other, the MAPMT array, and the Tevatron;
5. The gas radiator re-circulation system is complete and has been tested.

The process of filling the RICH tank and confirming the re-circulation system will be performed carefully.

FABRICATION AND INSTALLATION OF UTILITY COMPONENTS (Starting 2005 up to the 2009 shutdown)

The following utilities are assembled in a general lab space so that the installation time in the Assembly Hall and the Collision Hall are minimized. Large pipe sections can be pre-assembled and utility process skids can be manufactured and de-bugged prior to installation. Approximately 20% of the Engineering and Technician time should be added for work in the collision hall.

1. Electronic Cooling System;
2. Mirror In-Situ Calibration System;
3. Liquid Radiator System;
4. Gas Radiator System.

ELECTRONIC COOLING SYSTEM

The electronic cooling system cools all of the electronic heat loads on the detector. The system is broken into two halves, one for the MAPMT system and one for the PMT system. The coolant supply is the building chilled water system. Each electronic enclosure has its own manifold system that supplies coolant to the electronic modules. Feed thru fittings are used to pass the coolant into the detector enclosures. The monitoring system includes the instrumentation that checks the temperatures and flow rates in each of the manifolds to ensure that the electronics are being adequately chilled. The electronic cooling system for each of the instrumented arrays consists of:

1. *The plumbing system and associated instrumentation;*
    a. *Engineering 96 hrs times*
    b. *Drafting 240 hrs*
    c. *Technician 1.5 man months*
2. *The monitoring system with control software including alarms;*
    a. *Engineering 48 hrs*
    b. *Drafting 20 hrs*
    c. *Technician 30 hrs*

MIRROR IN-SITU CALIBRATION SYSTEM

The mirror calibration system consists of:

1. The LED arrays;
2. The monitoring system;
3. The control software including alarm function.

LIQUID RADIATOR SYSTEM

The liquid radiator system slowly circulates the radiator fluid through the radiator vessel chambers. The system includes a process skid that maintains the fluid temperature and keeps the fluid purified.

1. The plumbing system and associated instrumentation;

a. Engineering 96 hrs times

b. Drafting 240 hrs

c. Technician 1.5 man months

2. The monitoring system with control software including alarms;

a. Engineering 48 hrs

b. Drafting 20 hrs

c. *Technician 30 hrs*

GAS RADIATOR SYSTEM

The gas radiator system slowly circulates the radiator gas through the large support tank. The system includes a process skid that maintains the gas volume and pressure and keeps the gas purified. The gas radiator plumbing system also includes the fabrication of the passive expansion volume.

1. *The plumbing system and associated instrumentation;*
    a. *Engineering 96 hrs times*
    b. *Drafting 240 hrs*
    c. *Technician 1.5 man months*
2. *The monitoring system with control software including alarms;*
    a. *Engineering 48 hrs*
    b. *Drafting 20 hrs*
    c. *Technician 30 hrs*