RPC1 detector Q&A

Contents

1 RPC1 detector

1.1 Resistive Plate Chambers

A Phenix RPC gap (see figure 1) is made of 2 parallel high resistivity material (Bakelite) plates, with a 2 mm gap between them, filled with a mixture of Freon (95%) - Isobutane (4.5%)- SF6 (0.5%). The gas gap is closed at the edges with strips (2 mm); to keep the distance between plates constant, a number of spacer disks are glued between the plates. The outer side of the chamber is coated with graphite to distribute the high voltage on one side, and the ground on the other. To isolate it from the ouside readout plane, the chamber is covered by PET or Mylar, a high resistive film.

A RPC module includes, in an aluminum support frame, a double-gap structure, and a readout plane (made of copper strips) sandwiched between them. When operating, a high potential (9.5 KV) is maintained between the bakelite plates; the passage of a charged particle originates electron-ion clusters in the gas: the generated electrons start moving towards the cathode thanks to the electric field, and their charge is eventually collected by the readout plane via capacitive coupling.

There are 4 stations of RPC detector at Phenix. The RPC3, already installed and working, is located downstream of the MuID, both on the North and on the South side, as shown in figure 2. The Station 1, located closer to the interaction region, upstream of the MuTr station (see figure 2), is the one we will work on this summer, and it is supposed to be installed at the end of July (North Station 1) and at the end of September (South Station 1). For this reason we will first concentrate on the North Side modules. For Station 1, we have 4 types of gaps, with slightly different sizes:

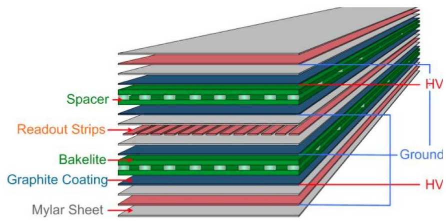

Figure 1: Structure of a RPC gap.

- N1A1, N1A2, to be installed in the North Phenix Side
- S1A1, S1A2, to be installed in the South Phenix Side

. These gaps are stored in a dedicated area, which is humidified, to prevent the bakelite to become dry. Despite the 4 different gap types, we have only 1 aluminum box type and one readout plane type.

2 RPC Factory

The production and assembly of the RPC1 modules will be done in the RPC Factory (building 912), The name of racks and tables we will be using are listed in figure 3. In the factory long pants and closed shoes are mandatory, long sleeves suggested. Please note that to work in the Factory the following courses are mandatory:
- Collider User Training (AD-CA_COLLIDER_USER)
- Hazard Communication (HP-IND200)
- Cyber Security (GE-CYBERSEC)
- PHENIX Awareness Training (RC-PAT).

3 Production scheme

The Q&A for RPC1 consists of a number of tests to make sure each module we are building satisfies a few basic requirements. Before assembly the modules, some preparation work on the gaps and on the readout planes is needed. In particular the gaps must be tested for leak, and we also have to make sure the spacers of the gap are well attached to the top and bottom bakelite layers (Pop test): both tests are described in sec. 4.1. In addition, we need to check what level of dark current are generated when the gaps are connected to High Voltage: the Burning test is described in sec 4.2.

For the readout planes, the coax signal cables must be soldered to the readout strips, while their grounds must be soldered on copper strips. The other side of the cables must be soldered on transition cards. The soldering procedure is described in sec. 5.2.

After the gaps passed these tests, and the readout planes are ready, we can proceed with the assembly of a complete module. Once assembled, this module has to be checked

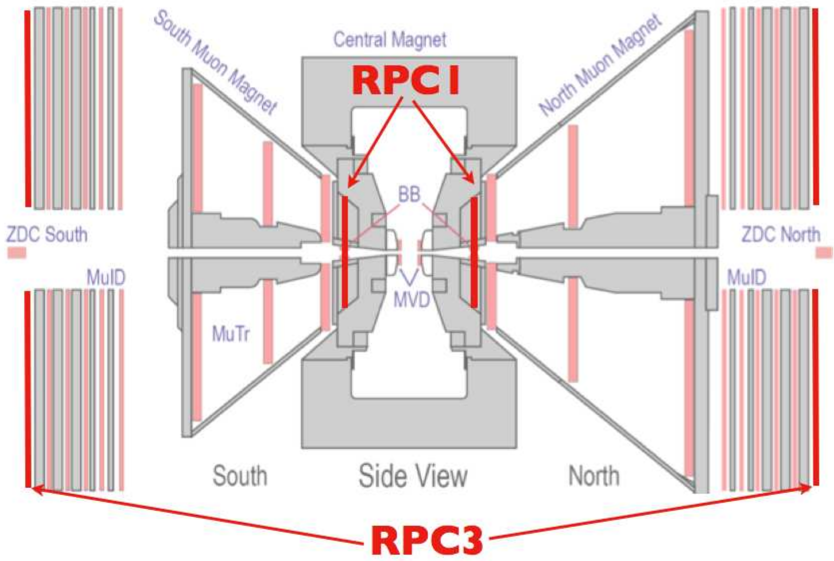

Figure 2: Phenix spectrometer: location of RPC Station 1 & 3.

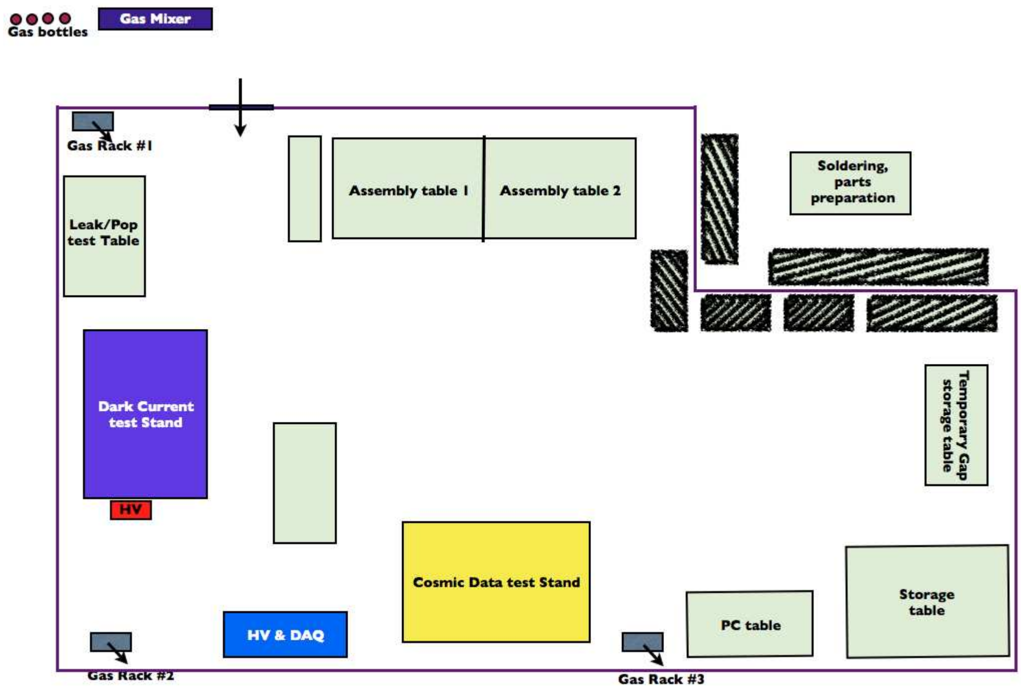

Figure 3: Factory layout.

for noise and dead channels (noise rate check); only after that we can proceed taking some cosmic data, to determine the module's efficiency.

4 Gap's tests

4.1 Leak and Pop tests

For this test use	Leak-Test table
	Gas rack #1

This test can be done for 1 gap at a time. Before assembly the modules, the gaps should be tested for leak (Leak test); we also have to make sure the spacers of the gap are well attached to the top and bottom bakelite layers (Pop test).

Leak test

For the gap to pass the Leak test, there should not be a drop of more than 1 increment each 10 minutes.

- Put the gap on the Leak-test table
- Open Argon bottle
- Connect the gap to the input and output line, close the other inlet of the gaps.
- Open the first valve
- Make sure the flowmeter is close
- Open valve 2
- Slowly open the flowmeter to fill the gap
- Close valve 2 when the pressure reaches 8.2 water inches.
- Wait for a couple of minutes to let the gas settle within the gap.
- Report in the Leak/Pop test check-list the time and the loss of pressure
- Wait 10 min and write down again time and the loss of pressure
- Without disconnecting the gap, go to Pop test

Pop test

To pass the test, there should not be more than 2 broken spacer in a gap.

- Put on top of the gap the proper template to determine the position of the spacers
- Press each spacer position and observe the oscillation of the pressure
- If the spacer is fine, the pressure will oscillate very little
- If the spacer is broken you will observe a larger oscillation

After passing the tests, you need to attach a label (tape) saying “L/P tests OK”. Write also if 1-2 spacer were broken. If one of the tests was not passed, write in the label: “BAD Leak” or “BAD pop”.

Change the gap, and start over!

When stopping the test (for instance at the end of the day) be sure you close both valves and you also close the Argon bottle.

4.2 Burning test

For this test use	Dark Current Test Stand
	Gas rack #2

Once the gaps passed the Leak and Pop tests, they can be tested for dark current. The dark current test can be done for a maximum of 4 gaps per time. Position the four gaps into different shelves and connect them to the gas inlet (red cable) and gas outlet (yellow cable). Connect the gap’s high voltages to the HV boxes, be sure you are using the right number of channel for each shelf. Close the HV boxes and press the red button until you see the “HV on” led becoming red.

Purging

Before the test, we have to purge the gaps to flow out air and humidity.
For this purpose we will use Argon gas:

- Open the Argon bottle;
- Open the valve in the gas rack #2 to flow the Argon in the gaps, with a rate of 40 cc/min for 40 minutes (we let in roughly 2 times the volume of the larger gap);
- Close the valve in gas rack #2 ;
- Close Argon bottle.

Burning

After purging with Argon, we need to flush the mixed gas (Freon-Isobutane-SF6) into the gaps:

- Increase the percentages in the gas-mixer to 13/13/13 (channels 1, 2, and 3). Be careful when the mixed gas is used by rack #2 and #3 simultaneously, the pressure in one rack will affect the pressure in the other. If you are starting using the mixed gas, make sure people working at rack #3 knows it.
- Turn the valve of rack #2 so that the mixed gas is now flowing, and set the rate to 10 cc /min. While you change the pressure, monitor the changes in rack #3, and the pressure of the gas mixer.
- Let the mixed gas flow for 12 h
- Switch on the HV to 1 KV (telnet 192.168.12.99 1527, from phenix-rpc machine)
- Each half hour, increase the HV of 1 KV, until you reach 5KV.
  Write down in the Burning check-list the dark current before and after changing the Voltage
- From 5KV to 8KV, increase the HV of 1 KV each hour.
  Write down in the Burning check-list the dark current before and after changing the Voltage
- Run 1 day with 8KV then increase to 9KV.
  Write down in the Burning check-list the dark current before and after changing the Voltage

- Run 1 day with 9 KV then increase to 9.5 KV.
  Write down in the Burning check-list the dark current before and after changing the Voltage
- Run 3 days with 9.5 KV.
  Write down in the Burning check-list the dark current once per day.
- Rampp down the HV
- Close the valve in gas rack #2 ;
- Reduce the percentages in the gas-mixer back to 10/10/10 (channels 1, 2, and 3). (Notify people in rack #3)

Purging (again...)

We don't want to open immediately the gaps after burning, as they are filled with the mixed gas. Altough the gaps are small and so is the amount of gas, we don't want this gas to enter the building, as it can fire the gas alarm. For this reason we flush again Argon, so that the mixed gas is flushed outside of the building:

- Open the Argon bottle;
- Open the valve in the gas rack #2 to flow the Argon in the gaps, with a rate of 40 cc/min for 20 minutes (we let in roughly 1 times the volume of the larger gap);
- Close the valve in gas rack #2 ;
- Close Argon bottle;
- Disconnect the gaps from the gas tubes;
- Disconnect the gap HV cables from the HV boxes;
- Close the inlet/outlet of the gaps.

We are ready to start over with other gaps!

5 Assembly

Once a set of 3 gaps pass the leak, pop, and dark current tests, we can proceed with the assembly of a module, but some preparation works is needed, that are listed in this section

5.1 Additional preparation works

- Gaps:
  - Be sure you are using tested gaps: there shoud be a label saying "L/P test ok", and the inlet/outlet should be closed as after the Burning test.
  - Eliminate the plastic layer from the top and bottom side of the gap
  - Clean the gap with Alcool
  - Strenghten and protect the gaps: add a strip of Kapton tape on the gap border on the HV side, and on the gap inlets/outlets.
  - Connect the gap to gas tubes, and secure them together with tape
  - Cut the HV cables to the proper length and connect them to CPE cables.
- Readout planes:
  - solder the lemo cables to the transition card (see sec. 5.2)
  - solder the lemo cable signal wires to the readout strips (see sec. 5.2)
  - solder the lemo cable grounds to copper strips (see sec. 5.2)
  - clean the readout planes with alcool to remove residual flux or dirt

5.2 Solder the Lemo cables

For this test use	Soldering, parts preparation table

The lemo cables need to be cut to the proper lenght, then one end must be soldered on the transition cards, while on the other end the signal cables must be soldered on the readout planes, and their grounds must be soldered on copper strips.

Prepare the Lemo cables

To prepare the lemo cables for soldering:

- Cut the lemo cables to be 60 cm long; they must easily span the distance between the RPC octant and its respective preamplifiers.
- Strip one end of the lemo cable, approximately 2 cm.

- Unweave the ground wires, bring to one side, and twist together. The ground braid should be a branch off of the signal wire.
- Strip the end of the signal wire.
- Repeat on both ends of all the lemo cables.

After the lemo cables have been prepared, one end must be soldered on the transition cards, while the other end of the signal cables must be soldered on the readout planes with their grounds soldered to copper strips. We use a solder that has a Lead to Tin ratio of 63/37 for optimal tinning and wettability. The solder also contains rosin core flux.

CAUTION: The solder used to connect the lemo wires **contains lead**. Every person who solders must wash their hands after handling the solder.

- General Tips:
  - Wipe all surfaces to which cables will be soldered with alcohol.
  - Always keep the tip of the soldering iron coated with a thin layer of solder.
  - Place the solder between the soldering iron and the wire when soldering onto a surface.
  - Before joining a wire to a surface, tin both. (Coat a thin layer of solder on each.)
  - Apply additional flux to the wire or surface if the solder is not attaching properly.
  - Heat the solder thoroughly and connect the wires as quickly as possible to avoid cold solder joints. Cold solder joints are jagged or dull, and hint that the soldered connection is weak or contaminated. **Cold solder joints will cause noise in the signal and/or breakage over time.**
  - Use copper wick to soak up excess solder if too much has accumulated on the connection.

Solder the cables on transition cards

- Solder lemo cables to transition cards:
  - Identify the front of the transition card as the side with metallic tracks visible.

- Facing the front of the transition card, push the ground braid through the hole closest to the edge.
- Flip the transition card over to the back and cut the ground braid down as close to the surface of the card as possible. Be careful not to let the ground braid slip out of the hole.
- Solder the ground braid in place.
- Flip the transition card to the front again and check that the insulation on the signal wire has not been melted.
- Solder the grounds for the rest of the lemo cables on a single transition card.
- Twist the stripped signal wire of one of the attached lemo cables and bend it down towards the card at a right angle.
- Cut the signal wires short enough that they will not protrude from the transition card when they are pushed through the lead pins.
- Tin the end of the signal wire and push the signal wire into the lead pin.
- Solder the signal wire into place first on the back side and then on the front side. Check that the insulation has not melted.
- Repeat until the transition card is full.
- Use a multimeter to check for shorts in the wires. Put either lead on one of the ground braids and go down the line for each of the signal wires.
- Wipe the solder joints with alcohol to remove residual flux.
- With the aid of a fume hood, coat the wires on the top of the transition card with conformal coating.

Solder lemo cable signal wires to readout strips

- Tin soldering points on each row of the signal plane.
- Twist and tin the ends of the signal wires.
- Lay the tinned end of each signal wire flat onto the solder point and ensure that some of the wire's insulation is making contact with the plastic of the signal plane. (This helps strengthen the connections after the conformal coating is added.)
- Solder the wire in place. Ensure that the lemo cables are soldered in such a way that the transition cards will all face the same direction and that each cable on the readout strips corresponds to its order on the transition card.

– After soldering all of the signal wires for one octant, clean the solder joints with alcohol and coat the signal wire connections with conformal coating.

Solder lemo cable grounds to copper strips

– Tin soldering points on each row of the ground copper.
– Tin the ends of the ground braids.
– Lay the tinned end of the ground braids flat onto each solder point (with the aid of needle-nose pliers) and solder the grounds in place.
– After all the ground braids have been soldered, clean the connections with alcohol.

5.3 Assembly of a module

6 Assembled Module's tests

6.1 Noise rate check

6.2 Cosmic data taking