PØD Repairs

Summary version:

• The new PØD RMMs are mounted in the new location under the magnet and are operational

• Continued tests are going on this week
Checks on old RMMs

Before removing the old RMMs we did several inspections and checks

• Ran the system with one RMM (RMM0) to try to reproduce the problem
  -> No failure after over 1.5 hours of running
  vs. ~20 minutes with the magnet closed
  -> Note that the environment was very different:
    • magnet open, dry air covers off
    • temperatures ~3 C lower

• Inspected RMM FPGA cooling blocks
  -> Cooling blocks mounted correctly and in correct alignment with the FPGAs
  -> Cooling block temperatures measured with thermocouple: 18 C
  -> Tried to measure FPGA temperature with thermocouple just after running the RMM. Measured 23 C.
    Note: Difficult measurement, required positioning the tip of a thermocouple mostly by feel
  -> Cooling blocks appeared to be in good thermal contact with all FPGAs, had to break adhesion to remove the RMMs
  -> No evidence of FPGA cooling failure
Disconnections

- All 6 RMMs old removed
- Cooling blocks removed
- RMM power looms removed for reuse (more on this later)
- All TFB-to-RMM cables removed
  -> Had thought to abandon them in place
  -> On y-layers (side of the PØD), the cable runs are very tight, and the space was needed to run the new TFB-to-RMM cables
  -> On x-layers (top of the PØD), cables were easy to remove safely, and were just in the way otherwise
New RMM Mounting

Prep work before Thanksgiving

• RMM mounting frame installed on curtain wall below the magnet (shown with dummy RMMs)

• All low-voltage power lines installed
  Connect distribution points at top corner of PØD to terminal blocks in RMM mounting frame
New TFB-to-RMM Cables

- New cables are all 50 ft (15 m), based on anticipated longest cable run
- Tried several different cable path configurations with test cables to keep the cabling organized and within allowed clearances
- Final paths:
  -> y-layers (south side of PØD) - cables run up and across the top
  -> x-layers (top of PØD) - cables run across the top the north side
  -> over to either the upstream or downstream edge
  -> down the north side
  -> in to the curtain wall
  -> along the north side of the curtain wall
  -> through a gap in the curtain wall
  -> down the curtain wall cable tray through the magnet
  -> any slack dressed on the back (north) side of the curtain wall below the magnet
  -> through the curtain wall to the RMM box
New TFB-to-RMM Cables

- y-layer cabling (side of PØD)
- x-layer cabling (top of PØD)
- Back (north) side of curtain wall
- Front (south) side of curtain wall behind water target fill/drain lines into single cable tray through magnet
New TFB-to-RMM Cables

All 174 cables in one cable tray through the magnet

All cables dressed into the RMM box and strain relieved
New FPGA Cooling

Custom cooling blocks installed on new RMMs prior to RMM installation
- Same ID as main cooling lines
- Cooling flow in series through all 6
  - on the return line from the upstream ECAL cooling loop
- System went together beautifully
- No bubbles at all - easy to see through clear internal cooling lines
New RMM Power Looms

• Original plan was to reuse the same power “looms” to connect the RMM power terminal blocks to the RMM power connector (as shown in this picture of the first connected RMM)

• Matt Thorpe inspected the looms carefully and found that in some cases the wires were not well-connected to the connector --> in one case a ground wire was loose

• Not clear if the damage happened during removal of the looms or earlier

• Speculation: could poor power connections have caused the RMM trips in August and September?

• Better, more flexible looms provided by electronics group and installed --> better suited to snake around inside RMM box
System Testing

RMMs were cabled up tested as we installed them
  -> RMMs mounted in layers, harder to access back RMMs
  -> Basic pedestal runs to test communication
  -> Short runs with air cooling only,
      as water cooling was installed only after all 6 RMMs were in

12/4: All 6 RMMs connected with water cooling in place
  -> Took overnight pedestal run, system ran stably

12/5: Did HV tuning, made connections necessary for PØD-triggered cosmics
  -> Took overnight PØD triggered-cosmics run, system ran stably

12/6: PØD Light Injection testing, LI working well
  -> Took overnight run in interspill mode,
      mix of pedestal, LI, and cosmic triggers
  -> System ran stably

Continued tests this week.
  -> Primary goal is to verify system stability
  -> Also check that pedestal, LI, and cosmic track responses are as expected
Minor issues

RMMs were tested as we installed them

Problems uncovered:
• Cat5E cables not fully connected (3x) - fixed by reconnecting
  -> Lesson learned: a TFB cable can be connected well enough to initialize
      the TFB but not well enough it to receive triggers!
• One bad Cat5E cable - abandoned in place, replacement cable run
• Bad power connection for one TFB
  -> On a power point previously shared with an RMM;
  taking off the RMM lugs make the connection loose
  -> Systematically rechecked all TFB power connections,
     tightened several connections and replaced one lug
• Bad power connection for one RMM terminal block
  -> 3.1 V cable came loose from terminal block during nearby cabling work,
     all screw connections checked and spade lugs replaced by ring lugs
Bad Channels

Results of initial bad channel checks:
~30 dead channels (pedestal only)
~20 unusual response (low gain or noisy)

-> Had ~20 bad channels total before
-> Total is still less than 0.5%

A few bad channels due to visibly disconnected MPPC microcoax cables at the TFB, but in areas where this connection is blocked by the basket

In these areas the TFB-to-RMM cables also run through a tight space close to the MPPC cables. Even though we were careful to avoid the MPPC microcoax cables, it is likely that the MPPC cables were accidentally affected during the cabling work.
Humidity?

- In August, the major noise problems observed in June and August were attributed to humidity in the PØD electronics volume (likely at the MPPC)
- Problem resolved by increasing the dry air flow back to nominal
- The dry air volume around the electronics was inspected soon after the magnet was opened
- Seals were found to be dislodged (see photos)
- Even after restoring seals, no noticeable bulging of plastic sheets...
- During PØD work, no signs of condensation or residue observed in the dry air volume area
- (Clear residue in the drip pan below the PØD, from the leak that led to draining the PØD target water in February, but that is not in the electronics dry air volume)
Thank You!

Many thanks to a lot of people who helped out!

• PØD group prep work in November:
  Vittorio Paolone, Scott Davis, Karin Gilje, Jay Jo

• At CSU: Bob Adame, Jay Jablonski, Thomas Campbell, Walter Toki

• PØD during primary installation and testing:
  David Warner, Istvan Danko, Tomasz Wachala, Scott Davis, Jay Jo,
  BEB, Dan Ruterbories (consultant)

• UK electronics and DAQ support:
  Mohammed Siyad, Weiming Qian, Matt Thorpe, Carl Metelko (by phone)

• FGD triggers: Nick Hastings, Sujeewa Kumaratunga
Summary

The new PØD RMMs are fully installed and running in the new configuration.

Testing will continue all of this week.

No problems found with previous PØD RMM FPGA cooling scheme.  
-> It now seems unlikely that the FPGA cooling was the cause of  
   the RMM trips that we experienced in August and September tests.