Fundamental problem:

- **RMMs spontaneously trip off:**
  - RMMØ and RMM1
    - August testing: trip off after ~20 minutes of operation
  - RMM2
    - Also tripped off during further testing during T2K meeting

- Without these RMMs, we cannot take data with 50% of the PØD:
  - Upstream ECAL SuperPØDule
  - Upstream water target SuperPØDule

- In this state, we cannot take useful PØD data.

--> The goal of the repair is to have working RMMs
Why are the RMMs tripping?

One hypothesis: failure of RMM FPGA cooling

- Clear relationship observed between trips and temperature (measured nearby on TFB - not direct FPGA temperature)
- Concerns were previously raised about FPGA cooling blocks

However:

- Visual inspection of the cooling blocks via boroscope:
  As best we can tell, cooling blocks are still in the right place (Note: this inspection was only done AFTER the decision was made to open the magnet, as it required a hole in the dry air containment)

There are many other possibilities!

- RMMs compromised by exposure to humidity?
  - Debris due to condensation?
  - Oxide growth causing resistive shorts in fine-pitch FPGA connections?
  - Something wrong with on-board voltage regulators?
- Some other mechanical issue in which thermal expansion causes a short?
- Something else?
How should we fix the RMMs?

Option 1: Keep RMMs in current location
- The approach presented at collaboration meeting
- Add improved cooling
- Replace bad RMMs

Option 2: Relocate RMMs outside the magnet
- Started to consider and evaluate this approach on site during the meeting
- More robust solution:
  -> With the RMMs in an accessible location, we can fix the problem regardless of the underlying cause
PØD Repair Option 1

Option 1 (presented at the collaboration meeting):

- Visual inspection of RMMØ, RMM1, **RMM2**
  (RMM2 also tripped - testing during the meeting)

- Replace problem RMMs with spare RMMs
  -> Recommended by UK electronics group

- Replace RMM cooling with water-cooled heat sink
  -> This approach is used by the ECAL RMMs
  -> Dave Warner would design a new heat sink;
      needed for proper water flow

- Get water by extending the cooling loop on each
  PØD electronics ladder

- Add RMM temperature sensor read out through U.Washington system
  -> allows readout with electronics off

- Add humidity sensors in dry air volume (UW system readout)
PØD Repair Option 2

Option 2: Move the RMMs below the magnet

- Location identified on the curtain wall below the PØD (picture next slide)
- Power/ground will be run down from the same distribution points now used, to maintain the grounding scheme
  - Voltage drop in RMM power cables will be kept below 0.2V
- RMM cooling using water-cooled heat sinks (same approach as the ECAL)
  - Water source still under discussion
  - Several options, including branching off of existing PØD cooling loop(s)
  - Issues to consider: flow impedance of cooling blocks, not affecting cooling of any other part of ND280
- Plan has been discussed in detail with the UK electronics group.
  - They agree that this plan is good.
  - We are working with them to coordinate the details
- Visual inspections; temperature and humidity sensors as in Option 1.
Proposed RMM location

- On the curtain wall below the magnet
- Between the optical junction box and the PØD LI box
- Warner has a design to fit 6 RMMs into this location
- Available cable tray space to run all TFB-RMM cables, power and ground (cable slot currently used only for RMM optical fibers)
- Tangle of dry air, water cooling lines easy to move out to the way
Option 1 Schedule

Compressed relative to schedule shown at the collaboration meeting

- Two shifts/day, work on Saturdays
- 2.5 weeks total

(Schedule assumes no mechanical issues found with PØD)
Option 2 Schedule

Shorter magnet-open schedule - 2 weeks

- Work with the magnet open is simpler
- Prep work below the magnet can be done before the magnet opening

(Specific schedule to be determined)
Discussion

Moving the RMMs is our preferred option on technical grounds

- Both approaches fix any cooling problems
  (though we no longer consider this explanation the most likely)
- If the problem is more insidious,
  moving the RMMs removes them from this environment
  (e.g. humidity: PØD water bags are not hermetically sealed)
- Moving the RMMs outside the magnet makes them accessible
  if there are any further problem
- All other subdetectors have RMMs mounted outside the magnet
- Minimizes the time needed with the magnet open

→ Relocating the RMMs is a more robust solution with lower risk

Disadvantages of moving the RMMs:
- More expensive: new cables, new RMM mounting hardware, infrastructure
- Full funding not yet secured (~$22K difference)