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**Date:** March 5, 2018

**Re:** Meeting Minutes, IPM Development Status (revision A)

**Meeting Time: 10:00 am to 11:00 am**

**Meeting Location: TGC The Loft**

**Attendees:**

Craig Drennan, Department Head, AD/Instrumentation

Kyle Hazelwood, Physicist, AD/Main Injector

Carl Lundberg, Senior Operations Specialist, AD/ Instrumentation

Denton Morris, Physicist, AD/Main Injector

Troy Petersen, Electrical Engineer, AD/Instrumentation

Aleksey Semenov, Senior Electrical Engineer, AD/Instrumentation

David Slimmer, App. Development & Systems Analyst, AD/Instrumentation

Randy Thurman-Keup, Applications Physicist, AD/Instrumentation

James Zagel, Principal Electrical Engineer, AD/Instrumentation

**Request for Feedback:**

Please send any additions, corrections, rephrasing and/or comments to Craig Drennan. There has been liberal use of paraphrasing in recalling what others have said in the meeting. There may also be some editorializing and introduction of new thoughts that could use some review. Thank You.

**Minutes:**

The meeting was called to review issues surrounding the implementation and development of the Ion Profile Monitors (IPMs). Much of the details discussed were for the IPM at **R4H**, which has its power supplies located the furthest from the IPM. That is the cables from the power supplies to the IPM are the longest (~250 ft.). Jim Zagel confirmed that this is the worst-case and is an appropriate place to consider.

The Need for a Rad-Hard High Voltage Switch

Troy Petersen described how long it currently takes to get stable data from the IPMs, from the time that power supplies are turned on.

* The first supply is the Micro Channel Plate (MCP) bias voltage. It takes **1.5 seconds** for the supply currents to stabilize, after which the MCPs are ready to provide reliable signals.
* The IPM’s use a clearing field voltage of -10 kV. This voltage is on a plane on the opposite side of the IPM from the micro channel plates and accelerates the electrons produced in the chamber towards the MCPs. The electric field is evenly distributed through divider resistors and bus bars evenly spaced between the top plate and the ground plane.
* A control grid, a metal screen, is mounted a centimeter above the MCP. It is believed that by using the control grid to block the flow of electrons from reaching the MCPs that the lifetimes of the MCPs can be increased. With the MCP bias voltage and clearing field voltage left on, the -10 kV voltage is removed from the control grid to allow the flow of electrons to the MCPs and hence act as a switch.
* A 10 kV switch was implemented on the far end of the 250 ft. control grid power cable at location R4H. Because of the cable capacitance, this implementation was not able to switch the voltage off quickly enough. Troy was reporting that it took 75-100 turns, around 1 ms, to get a stable reading from the IPM after switching the control grid voltage off. Troy would like to make more of these measurements to get a clearer picture.
* It is desired to have the 10 kV switch much nearer, or even at the IPM. This however, requires a switch that can tolerate the radiation in the enclosure. Chris Jensen in AD/EE Support has been approached for support in designing such a switch.

Jim Zagel pointed to a plot of IPM data that showed an indication of data after “a couple turns”, but it was Troy’s observation that the data was not stable for some time after. Troy said he would like to repeat the measurement.

Jim stated that ideally, we would be able to turn the control grid on or off within 100 ns.

Need for Research into Refurbishing MCPs

By gating of the flow of electrons through the MCPs when not making a measurement is an important step in conserving the lifetime of the MCPs and making the IPMs less expensive to use. Another effort to make the IPMs more affordable is to be able to refurbish the MCPs. This may be able to be done at a lower cost than buying new ones. Rick Tesarek, physicist in the Neutrino Division here at Fermilab, has some connection with people at Argonne Labs that have been looking into this possible refurbishment.

A test stand is being setup, with help from Carl Lundberg, to use a UV arc lamp to test the gain of the micro channel plates. This would provide more data on the deterioration of the MCP response and the effectiveness of refurbishing efforts.

Whether the test stand is ready or not, Jim Zagel said he would like to get in contact with Rich Tesarek and take Troy Petersen and some plates over to Argonne to make introductions and see what can be done with the plates.

Two Types of MCPs in Use

Besides the standard MCPs there are extended dynamic range MCPs. The extended dynamic range plates have a lower impedance. Jim stated that we are currently using a dual chevron arrangement of a standard plate and an extended dynamic range MCP in Main Injector / Recycler. We are using a single extended dynamic range plate in the Booster IPMs to achieve extra gain. We could try to use the standard MCP in Booster and see if we can still get a good signal.

The extended dynamic range MCPs have an impedance of approximately 1.5 Mohm.

Ion Profile Monitor Use in the Main Injector

Denton Morris and Kyle Hazelwood described how the IPMs contribute to the operation of the Main Injector / Recycler.

Kyle stated that they have made peace with the operational aspects of having a Labview front-end. However, there are a sequence of things that need to be toggled in order to make a measurement. He would like, essentially, a front door to be able to toggle all this stuff and know the proper sequence and generate a periodic read of the IPM and save the data. Dave Slimmer has created a periodic function in the actual front-end, itself, but in a previous meeting they discussed outsourcing this function to another node that could be configured to do this kind of stuff. Kyle is expecting to get an email from Elliott McCrory telling Kyle how to toggle the necessary parameters. Kyles long term plan is to do periodic reads, so many times a day, so they can track how the emittance coming into the machine is changing and hopefully link this to other conditions in the machine.

Jim Zagel stated that it should not be hard to give Main Injector what it needs to make these periodic measurements. We will have Elliott get in touch with Kyle.

Denton Morris stated that the IPMs are the only mechanism in Main Injector / Recycler to measure the beam emittance. Kyle said that they have wires in place in the 8 GeV line that they can actively monitor the emittances with. They can’t do this in the circulating beam path in MI/ Recycler. These IPMs are literally the only way they are ever going to be able to do that. And they would love to know, from the 8 GeV line to the Recycler, what’s happening.

Carl asked how many times a day they would be making a measurement. Kyle replied four times a day per beam event, perhaps more. There are seven operational events now. Not all of them are going out at once, but three or four are operationally going out, so sixteen reads a day.

Craig asked whether they needed a fast control grid switch. They replied yes, that we do in order to save the lifetime of the micro channel plates. Denton explained that when he wants to measure the emittance on a NuMI cycle, it triggers on the E3 for Recycler and that micro channel plate current starts coming up and beam comes blasting through, illuminating the micro channel plate, but no data is taken. A second later the micro channel plate is up to full voltage and then another full injection comes through and you get blasted again, and this time you probably get data. So, you are effectively exposing the MCP twice every time you take data. That is how it has been historically, that you expose the MCP on multiple cycles before you get the one you want to read.

Jim Zagel mentioned that we already have the other three power supplies out at MI-10, that have not been installed, that could be implemented. Troy Petersen has two of the controller boards but intends to make more of them. He had waited to see that the first two worked correctly and order the rest. All the IPMs in place in MI / RR have the control grid. The other charging supplies for the clearing field are sitting out in the service building.

Denton further explained that with the current configuration, if they wanted to take data on a unique event like Switchyard once a super-cycle he would trigger on the E2. If everything is not up to voltage he would miss the first one and everything would sit there at low voltage and see a ton of beam. Sometimes, things time out properly and sometimes they do not, and you can go until the next super-cycle with it all on without taking any data. So, it is like collecting a month’s worth of wear, for just one sample.

Kyle stated that just gating with the control grid, as it is now will be a big gain, and once we can gate on an individual batch, things will improve another order of magnitude.

*It was noted after the meeting that before last summer’s shutdown, Denton gave Jim a list of items that he did not believe worked correctly on the IPM systems. One of the items was that one could not manually terminate a spec by issuing a command to abort the current activated spec from the Acnet console page. This problem was identified in the front-end code and corrected. Denton may have been recalling this problem, and incorrectly identifying it as a spec timeout problem. In any case, I don’t believe there is a problem with the timeout period that is specified in each measurement spec.*

Issue of Obsolescence of VME-MXI Interface

The IPMs use a National Instruments VME to PCI interface to transfer data from the VME crate digitizers to the PC front-end. The board in the VME crate is part number VME-MXI-2 and the board at the PC end of the cable is part number PCI-MXI-2. National Instruments no longer sells or supports these boards. It was believed that spares or replacements would be very expensive. Therefore, a proposal was made to develop and interface of our own using the ethernet capability of the VME digitizer module we support in house. This is an option that could work.

Craig Drennan was against the proposal for the following reasons. Using the VME digitizers as an interface would take some development time, where purchasing new MXI interface boards and continuing with the current method would not. After some looking we found that the spare MXI interface boards can be purchased for less than the cost of a VME digitizer. We should only need to buy two more spare sets of MXI boards to add to the spare set we have in our test stand.

Beyond using the MXI boards, a new interface between the VME crate and the PC front-end employing ethernet should use VME front-end cards that we use throughout the lab, for which we have programming infrastructure for (people, compilers). Though a VME digitizer type of front-end board would cost half the price of a standard Slot 0 processor, using the digitizer in this way would add another platform for which we would need long term support.

In applications for VME digitizers with Ethernet that can be applied without an expensive VME crate, as well as front-end processor, the savings may justify the implementation.

Another meeting has not been scheduled at this time.