

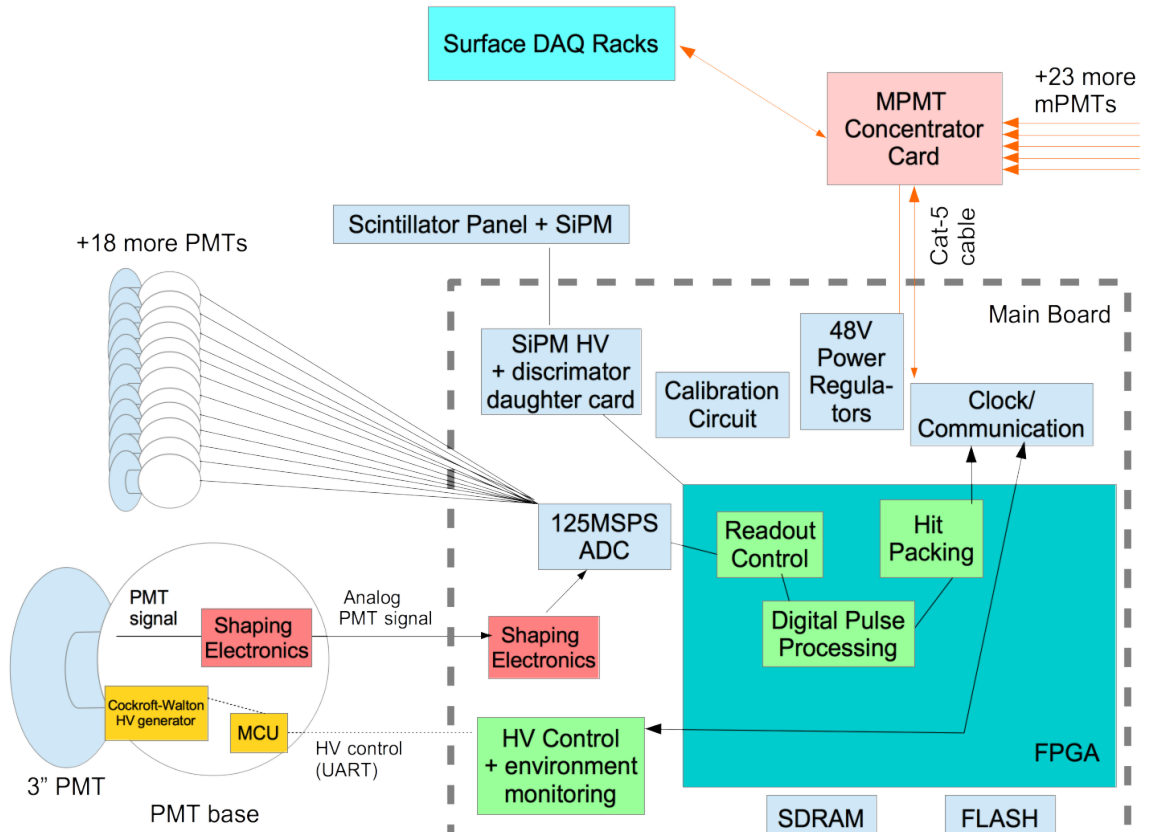
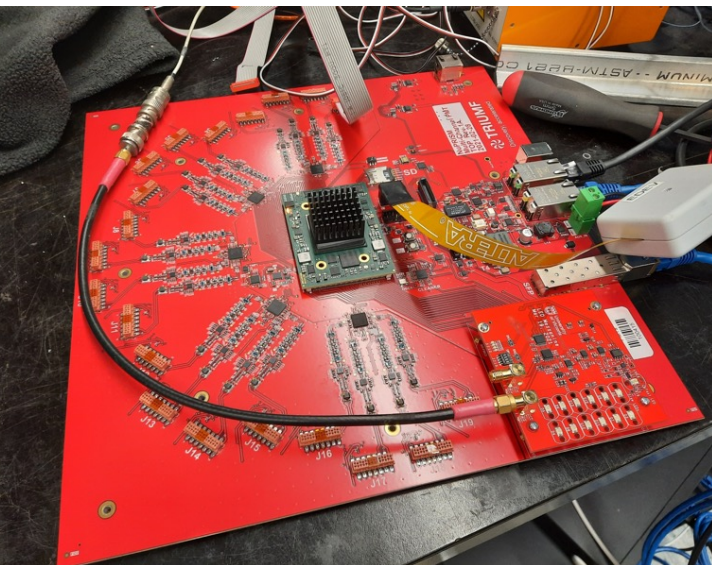
mPMT Electronics Status And Schedule

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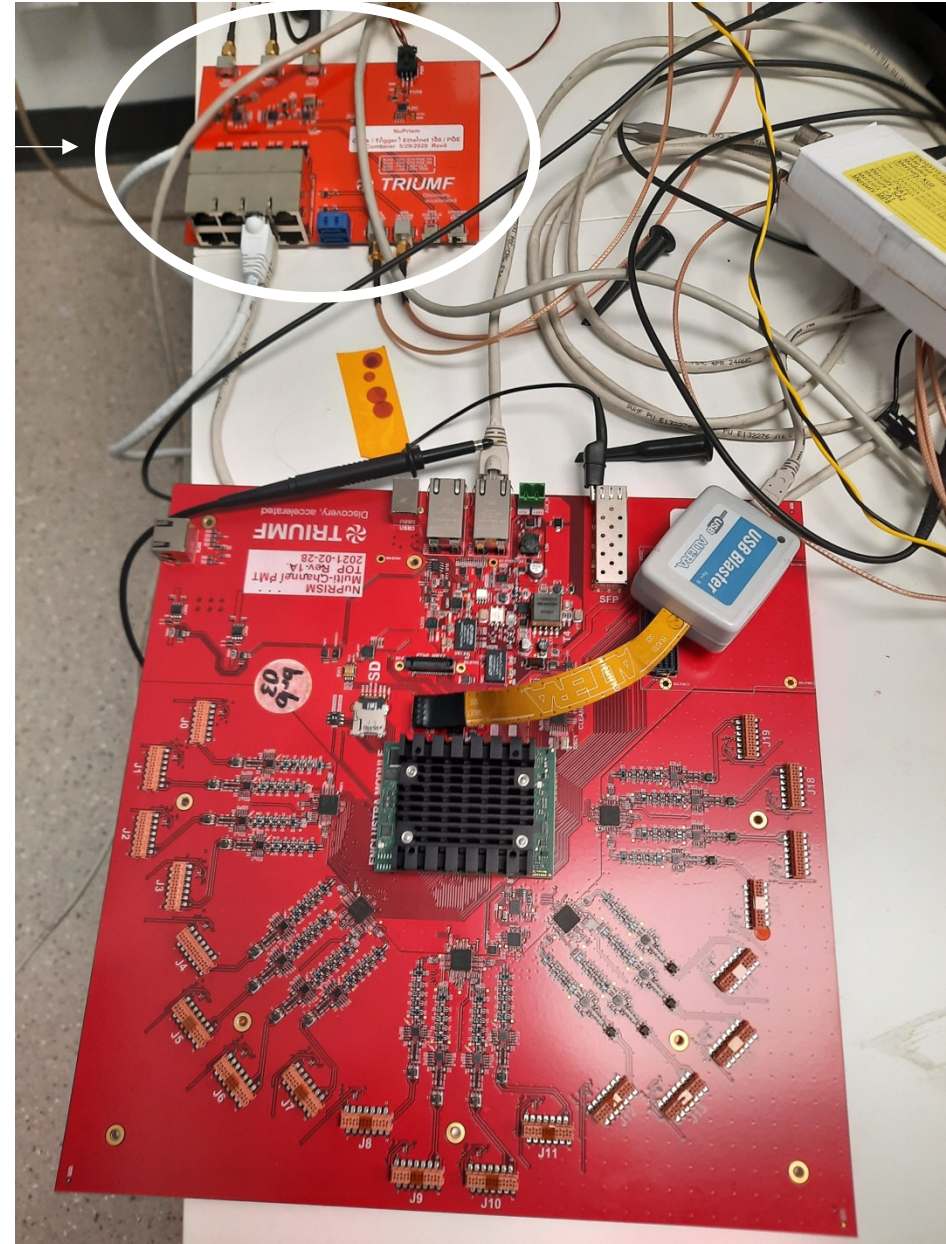
- Status of mPMT electronics projects
- PMT tests and ordering
- Key remaining R&D work and technical choices
- Schedule and Challenges for WCTE mainboard production

- HV generated on PMT base
- 125MSPS ADC digitization of PMT signal
 - Pulse finding and feature extraction in FPGA
- Design and testing from Poland and Canada (with INFN design for PMT base)

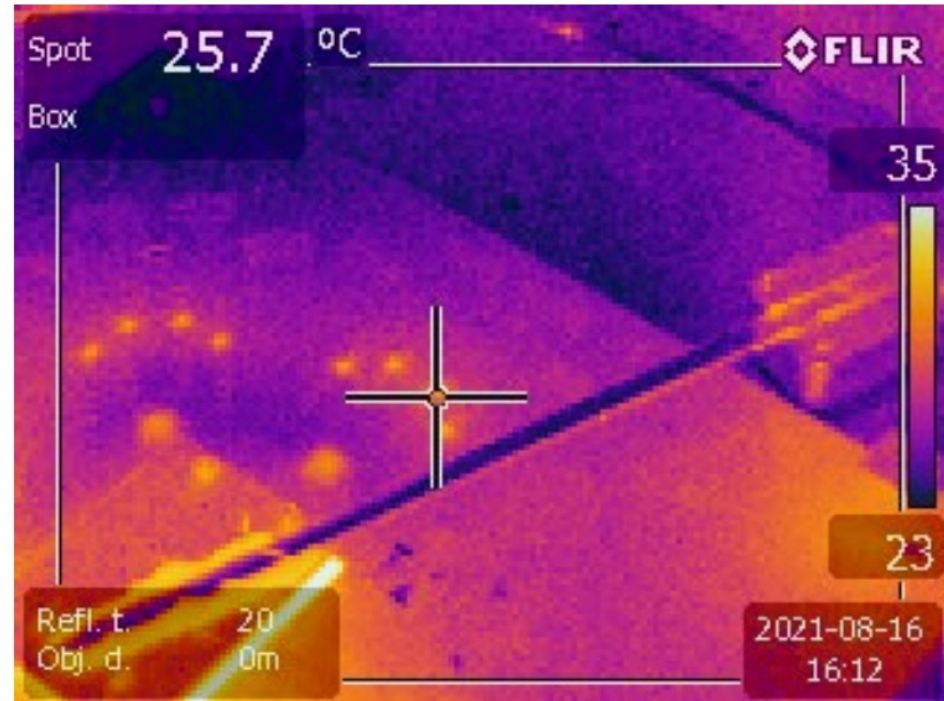
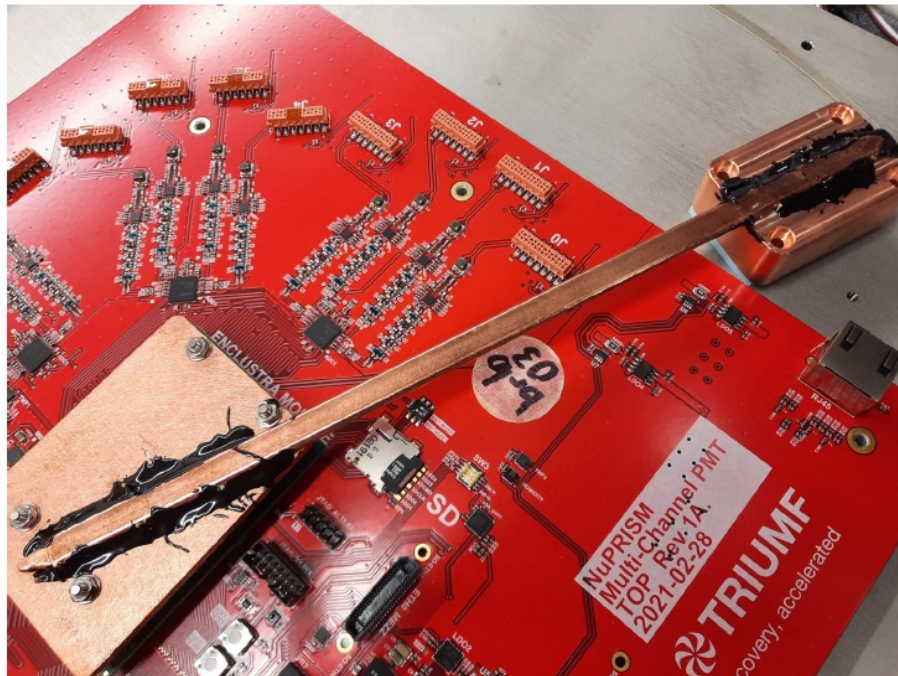
Rev-1 mPMT mainboard
(15 produced)



- TRIUMF engineers have finished debugging and testing combiner card.
- Combiner card puts together the following signals into a single cat-5 cable:
 - 100 Mbps ethernet and POE+ power (2 pairs)
 - 62.5MHz clock (1 pair)
 - Trigger (1 pair)
- Daryl and Yair developed complicated scheme to get trigger through AC coupled RJ45 connector.
 - Can now send external trigger to fully assembled mPMT module (including submerged module).
- Combiner card can be used to synchronize together clocks for four mPMTs. Plan to start testing synchronization soon.



- FPGA temperature slightly reduced to 33C with heat-pipe cooling.
 - Though want to make a more precise measurement of FPGA using thermocouple
- FPGA temperature below 40C is acceptable, so this scheme seems to work.

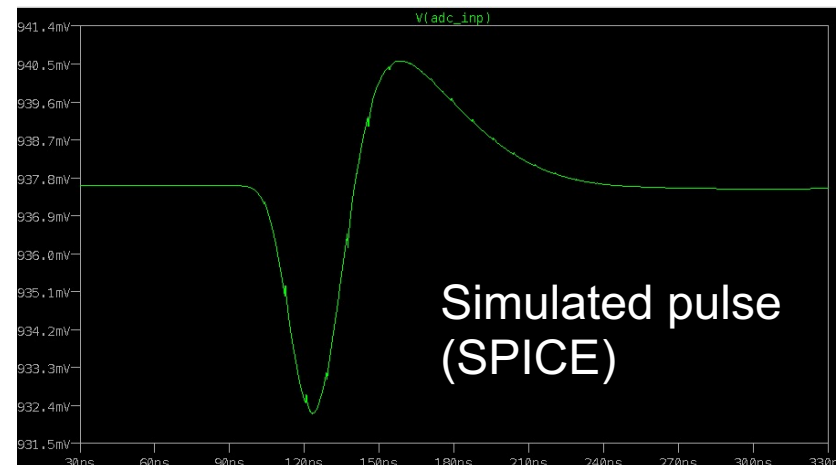
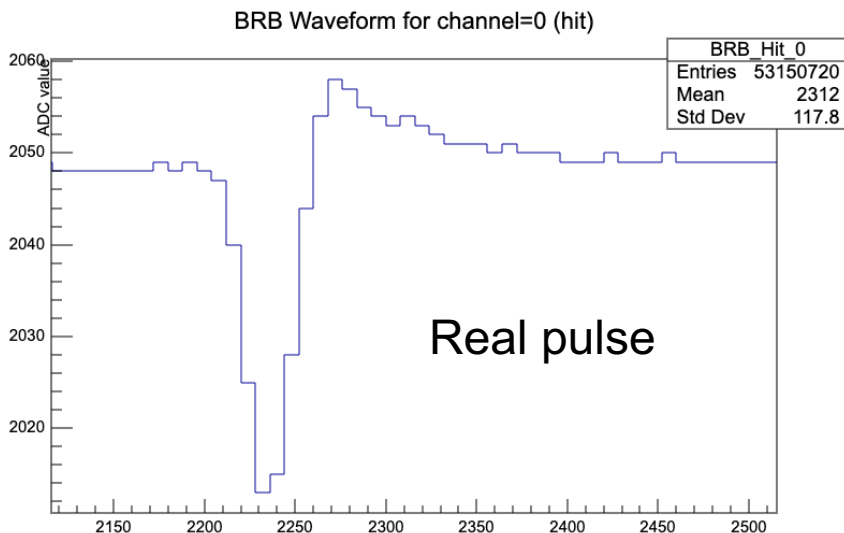


- Xilinx Firmware development mostly happening in Warsaw, with some support from TRIUMF.
- Got all the ADC channels functional
 - worked with MB length ADC samples
- Successfully tested with ADC test pattern and sine wave at input
- Once ADC readout working, need to start implementing digital pulse processing techniques in FPGA.

- HV status:
 - Investigating purchase method
 - tender vs standard order - will know answer this week
 - In contact with the company, already got feedback
 - One component reached end-of-life
 - Few components with lead times extending into 2023
 - Or can purchase at 5-8 times the standard price
 - In close contact with INFN (Luigi), already got revised BOM with replacements; sent to company, awaiting feedback
 - Need quote to prepare tender document; quotes valid for only few days;
 - Plan to either order or launch a tender next week
 - At the latest order at the week of Dec. 13th
- HV tester – parts purchased, student finalizing design
 - Need final check with Luigi (INFN) to incorporate changes suggested by INFN
- FE status
 - Need revision, working on it
 - Purchasing components that we know we will use
 - Microcontrollers available at Farnell, ordering now (delivery Jan 2022 if we manage to push order now).

- TRIUMF received two 3” R14374 PMTs from Hamamatsu with reduced after-pulse rate.
 - Initial results suggest lower after-pulse rate than standard PMTs
 - Similar results seen in Japan
 - Still need to do timing resolution measurements of the new PMTs
- Moving forward with purchase of first set of 3” PMTs for WCTE mPMTs.
 - Finalized the WCTE/IWCD 3” PMT requirements document and shared requirements with Hamamatsu.
 - Planning for initial purchase of ~600 PMTs between Poland and Canada in next month.
 - Purchase of rest of the PMTs waiting on award finalization in Canada.
 - For WCTE we will be purchasing the standard R14374 PMTs (not reduced afterpulse)

- Several concerns about analog shaping circuit:
 - Probably still running PMT at gain near to 3×10^7 still. Running at 1×10^7 might be too low signal to noise; might affect the timing resolution. Need to check and consider increase gain of amplifier.
 - Worried about the pulse shape not matching the SPICE simulation
 - Worried about the pulse shape having a very long overshoot, which is annoying in the analysis.
 - Still need to understand that pulse broadening and the pulse saturation
 - Are we happy with baseline or do we need to adjust it?
- Until we finalize the analog shaping we can't finalize that part of the BOM; won't know which supply chain issues we might have.



1. Need to develop a scheme for remote firmware updating.
2. Need to develop prototype mPMT Concentrator Card (MCC) module.
3. Need to decide on connection between MCC and mPMT
 - Currently using standard cat-5/cat-6 type cable with 100Mbps ethernet, clock and trigger (plus POE+ power)
 - Looking at alternate schemes based on single pair ethernet
4. Need to confirm what input clock will be coming into mPMT and MCC and what additional synchronization is needed for the system.
5. Start developing DAQ readout of mPMT

- Nominal plan:
 - Produce pre-production WCTE mainboard in Jan-Feb 2022.
 - But R&D not complete.
 - Start production of ~100 WCTE mainboards in April 2022.
 - Would allow to start full mPMT production in May 2022.
- There are many remaining R&D challenges that make this schedule difficult.
- But supply chain issues are probably an even bigger concern.

- Enclustra said they could only deliver preferred FPGA modules by ~November 2022.
- Needed to buy a more expensive module and pay expediting fee to purchase 100 modules and receive by April 2022.
 - Total cost ~115 keuro
- Splitting purchase between TRIUMF and Poland (50 modules each)
 - Purchase order completed in TRIUMF; bidding process ongoing in Poland.
- Enclustra last week threatened to raise prices further including on completed purchases.
 - Costs may increase by 5-15%.



- Initial checks of mainboard BOM suggests many components with long lead times.
 - 159 different items in mainboard BOM (1760 components in total)
- Decided to go ahead with purchases of mainboard components (for 102 mainboards), even though rev-2 mainboard design not finished.
 - Better to have as many components as possible in hand (even if we don't use some).
 - Allows us to figure out which components will be a problem.

- So far have tried to make purchases of most expensive 50 components.
 - Set deadline for component delivery of May 2022.
- Successfully purchased 40 of the components
 - Total cost so far ~\$100k CND
 - Latest delivery date April 2022; many components already delivered.
- 10 components with lead times later than May 2022.
 - delivery dates vary between July 2022 and March 2023.
 - Will start going through this list of components with engineers, look for replacement parts (that have shorter lead times).
 - Hopefully there are available replacements for all these components.
 - Will also consider whether we should purchase components with delivery dates between May – Aug 2022 as a hedge in case components can't be easily replaced.
- Will start working through list of passive components soon.
 - But many of the passives are in analog shaping circuit, which is likely to change.

- In principle it is still possible that we will receive all components by April 2022 and be able to produce rev-2 mainboards in May 2022.
- But this requires a lot of things to be possible:
 - Finish all R&D (particularly the analog shaping circuit) within next couple months, so we can finalize BOM.
 - Find available replacements for all long-lead time items
 - Somehow produce and quickly test a pre-production version of mainboard, so that we can test all the changes we made for rev-2.
- It is very likely that the electronics production will be delayed and hence delay start of mPMT production.

- Good progress on many aspects of electronics.
- However, many key technical decisions still need to be made.
- Supply chain issues makes electronics manufacture very difficult. Many important components have delivery dates into 2023.
- Having electronics ready for mPMT assembly in May 2022 seems very challenging.