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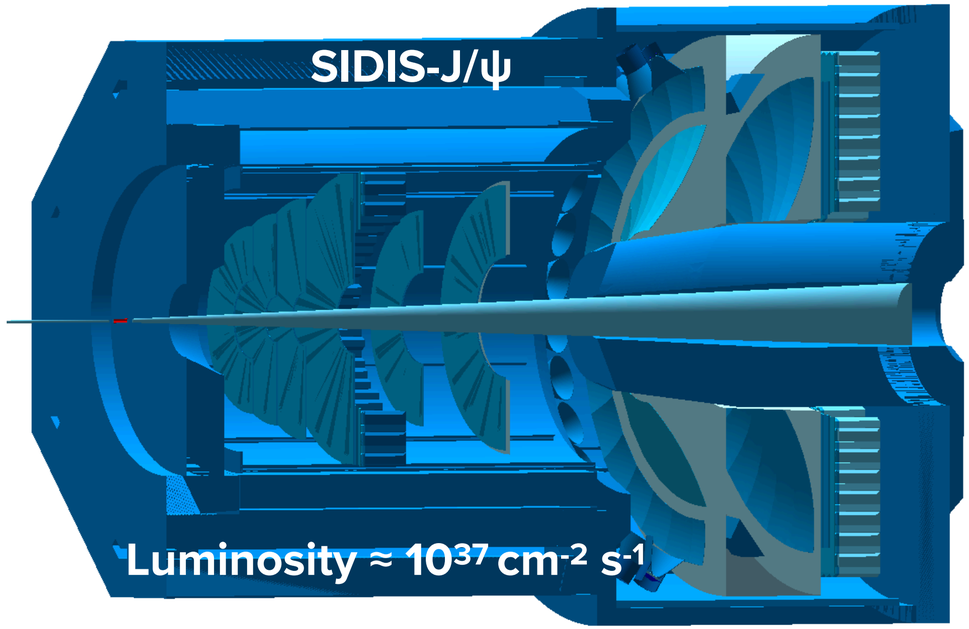
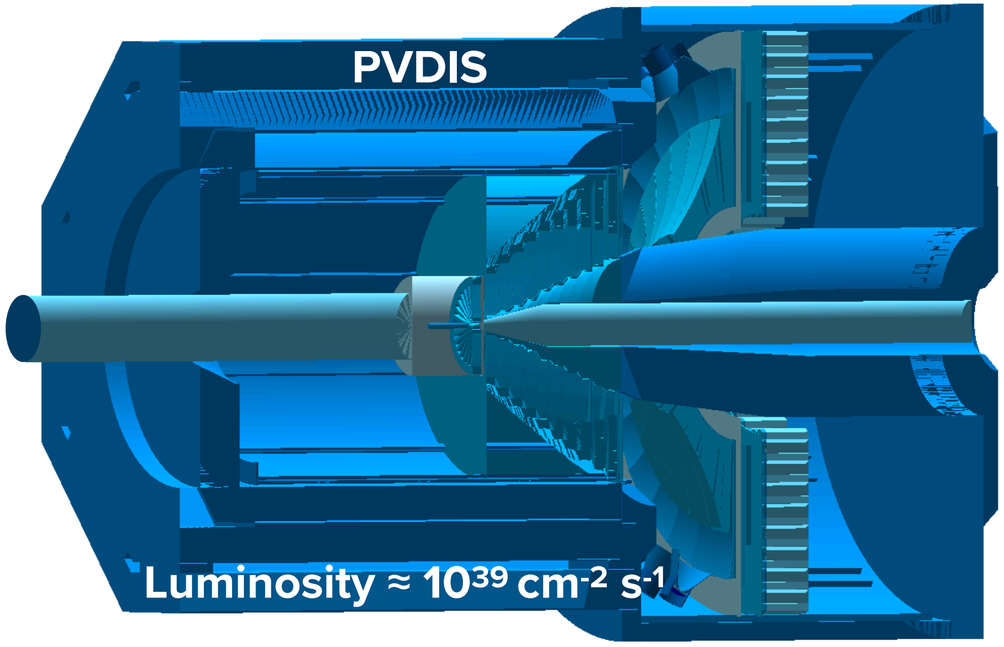
TECHNICAL RISKS AND PRE-R&D

SoLID Collaboration Meeting
October 8th, 2020

SOLID LUMINOSITY AND RATES

- High luminosity and 2π coverage means high rate!
  - DAQ:
    - SoLID trigger-rate expected to be 85 to 100kHz with data rates up to 4.0 Gb/s.
    - GEM hit-rates may be as high as 500 kHz/cm2
      - 187,000 readout channels
  - LGC and HGC
    - 750 total MaPMTS
      - LGC: 270 MaPMTs (in trigger!)
      - HGC: 480 MaPMTs
    - Background rates are expected at 1 to 4 MHz per PMT (raw)





TIDBITS FROM THE LAST DIRECTOR'S REVIEW

Selected comments from SoLID director's review report (September 2019)

- Recommendations:
  - Make a pre-R&D plan, including a notional schedule, that resolves all significant technical questions if implemented....
- Comments - Technical:
  - The project team should put a modest additional effort into re-evaluating alternative approaches. These could include trade-offs such as
    - 1) ... use of MCPPMTs on the LGC and HGC.
    - 2) instrumenting all GEM sensors with VMM chips or on-board fADC chips vs re-use of APV 25
    - 7) additional robustness (and physics?) using multi-anode readout of the MAPMTs on the Cherenkov detectors versus summed readout.
  - The alternate GEM readout integrated circuit will have to be prototyped and tested at JLAB to integrate into the CODA DAQ framework for testing with the overall experiment software.
  - The GEM readout system is large ~100K channels instrumented with APV25 ASIC. The overall DAQ rate was listed at 100 kHz but this is a limitation from the APV25.... Considerations for a new ASIC [VMM3] to readout the GEM detectors were presented and these are promising. There is clear need for further R&D before final designs can be put into production.

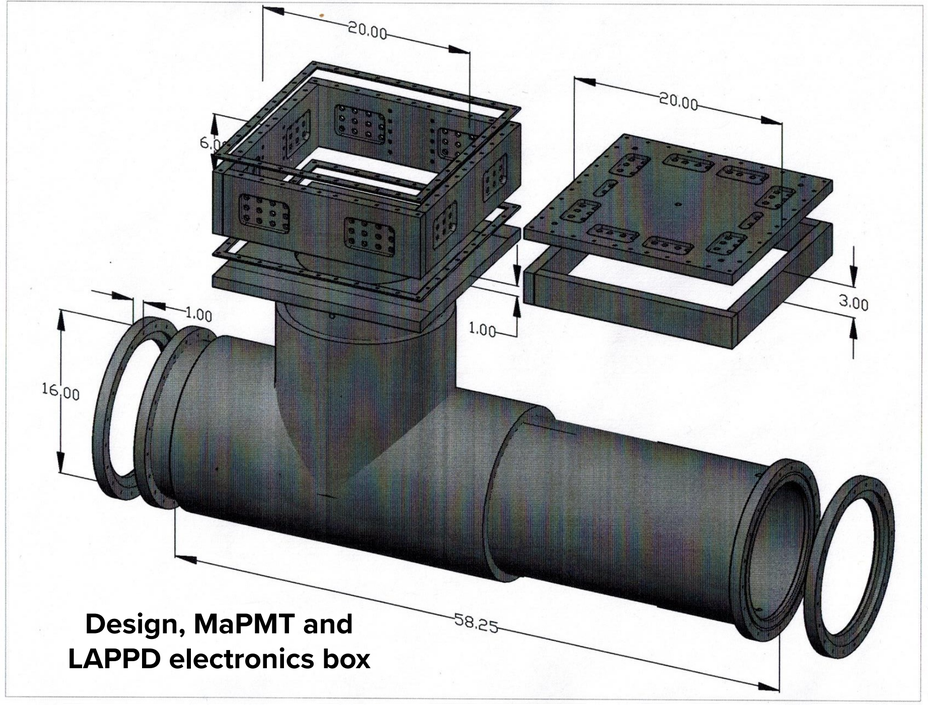
PRE-R&D: RISK AND CONTINGENCY

- Prior to commissioning, better understanding the capabilities and response of existing technologies when applied to the SoLID detector can optimize efficiency and reduce cost.
  - NOTE: All electronic components, individually, are fully within "specs" of handling the rate and through-put expected in SoLID. No "show-stoppers", regardless of pre-R&D activities.
  - The Pre-R&D can help steer design, and better define contingency within the program.
  - DAQ Pre-R&D:
    - GEM specific:
      - Test capabilities of VMM3 in direct readout mode
      - Test applicability of SBS style readout: APV25 chip + MPD
    - DAQ specific:
      - Test VXS FADC readout
      - Profile high resolution TDC readout
      - Prototype trigger configurations and optimize live-time.
      - Support for high-rate Cherenkov prototype DAQ.
  - Cherenkov Pre-R&D:
    - Profile response of integrated front-end electronics systems:
      - Array of MaPMTs with detector-group designed signal integration board.
      - Array of MaPMTs with extended CLAS12-RICH MAROC electronics integration.
      - LAPPD photodetector.
    - Optimize sub-system triggering configurations with realistic signals
    - Baseline simulation response and bring SoLID simulation better inline with reality.

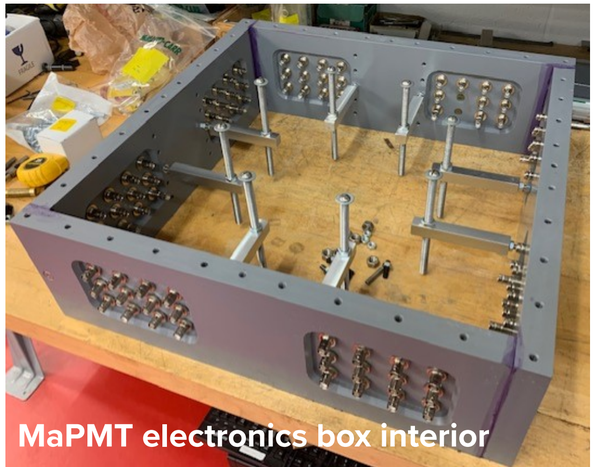
STATUS AND TIMELINE: TCD

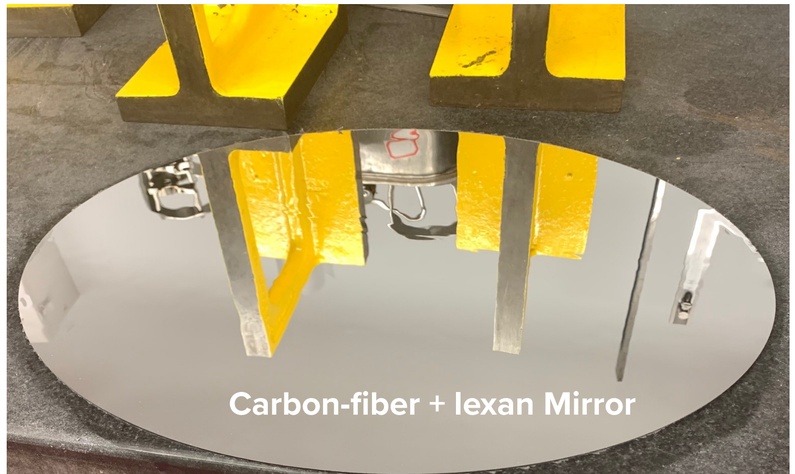
Collaborative effort from ANL, Duke, JLab, and Temple.

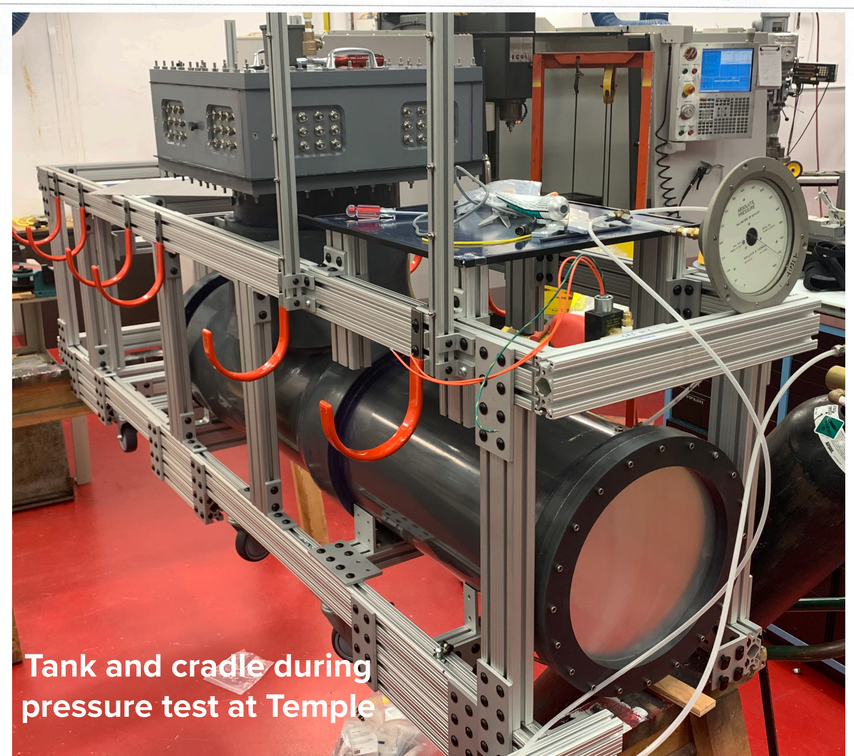
- Project was given a "soft" go-ahead in late 2019.
  - A telescopic cherenkov device (TCD) was designed that can can collect light over a 4 by 4 array of Hamamatsu H12700 MaPMTs.
    - Tank and cradle designed and built at Temple University
    - Approximately the same amount of radiator gas expected in LGC-PVDIS and HGC, same array of photo-sensors proposed for use in HGC.
    - MaPMTs and LAPPD WLS coated (p-Terphenyl)
    - Single flat-mirror design, removable electronics box, and 80/20 cradle that supports tank plus scintillator arrays and calorimeter blocks.
    - Pressure tested at Temple University before transport to JLab.



Design, MaPMT and LAPPD electronics box


MaPMT electronics box interior


Carbon-fiber + lexan Mirror


Tank and cradle during pressure test at Temple

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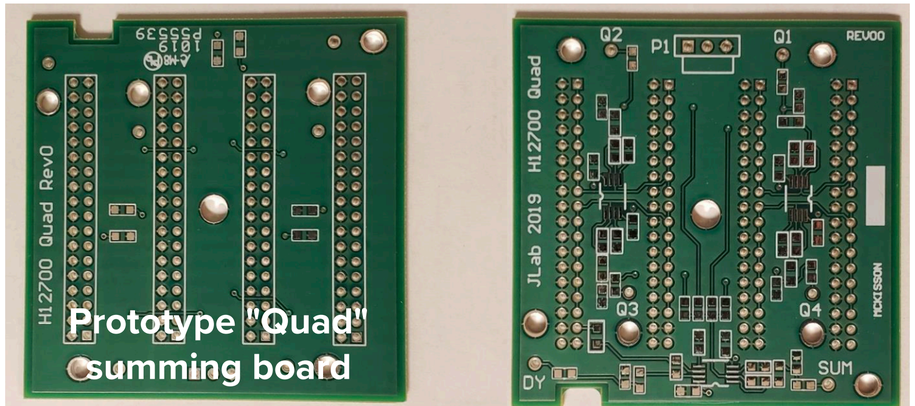
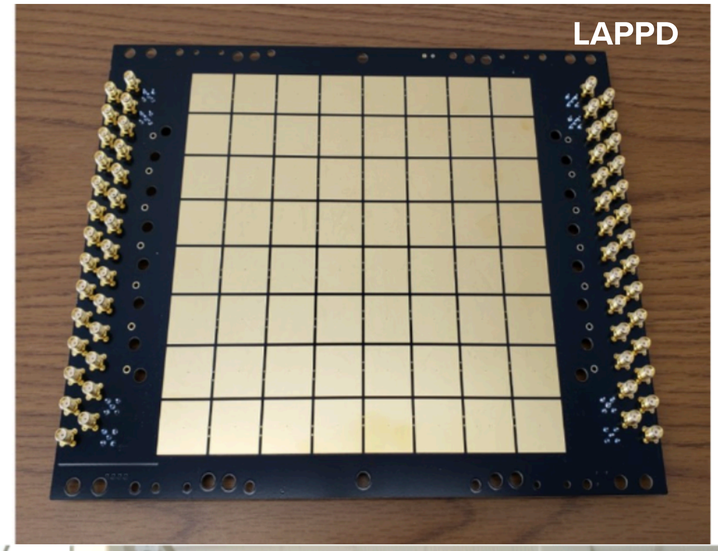
Collaborative effort from ANL, Duke, JLab, and Temple.

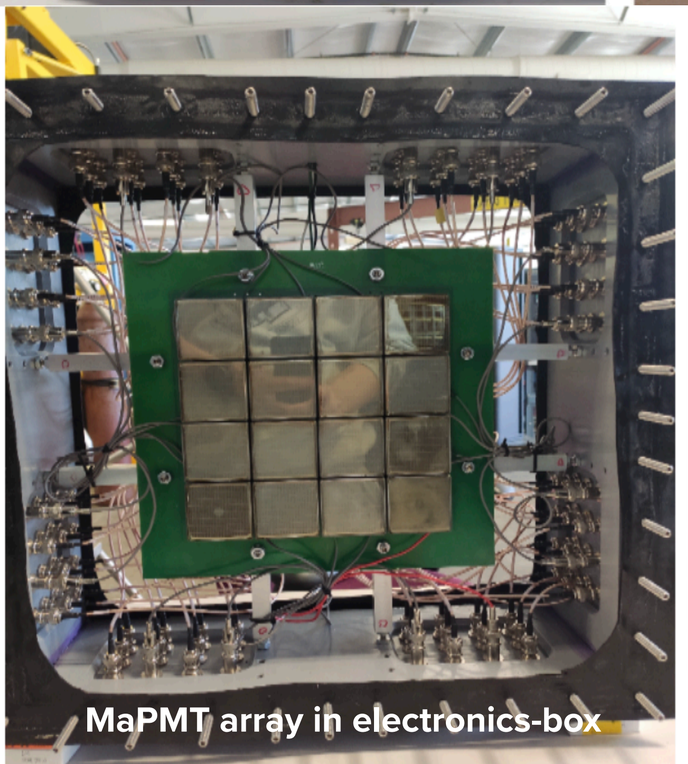
- A "simple-summing" electronics board was developed by the JLab detector group.
- MaPMTs and simple-summing board was bench tested and baselined by Duke group.
- MAROC design comes from modified CLAS12 RICH electronics
- MAROC electronics box designed and built by Duke University
- C4F8 Heavy gas provided by Duke University.
- LAPPD provided by ANL through INCOM.

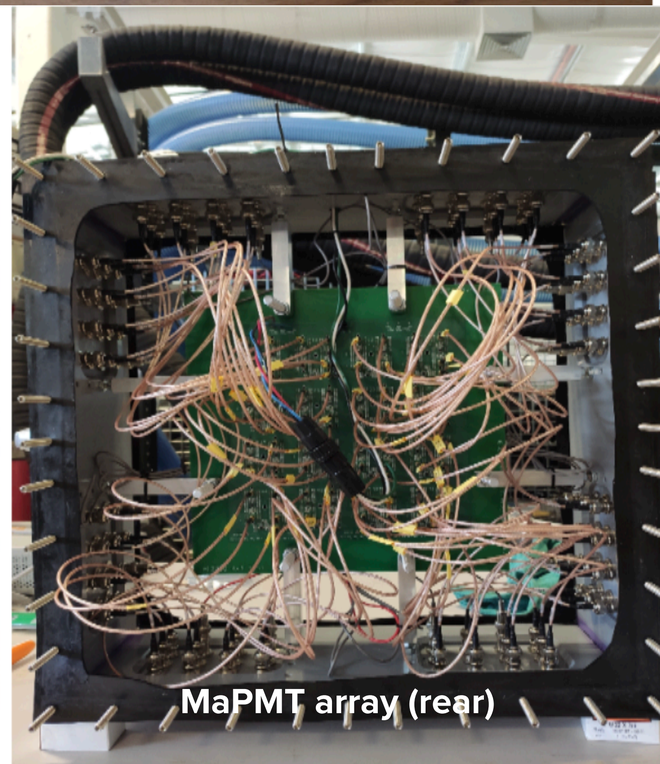


Prototype "Quad" summing board


LAPPD electronics box interior

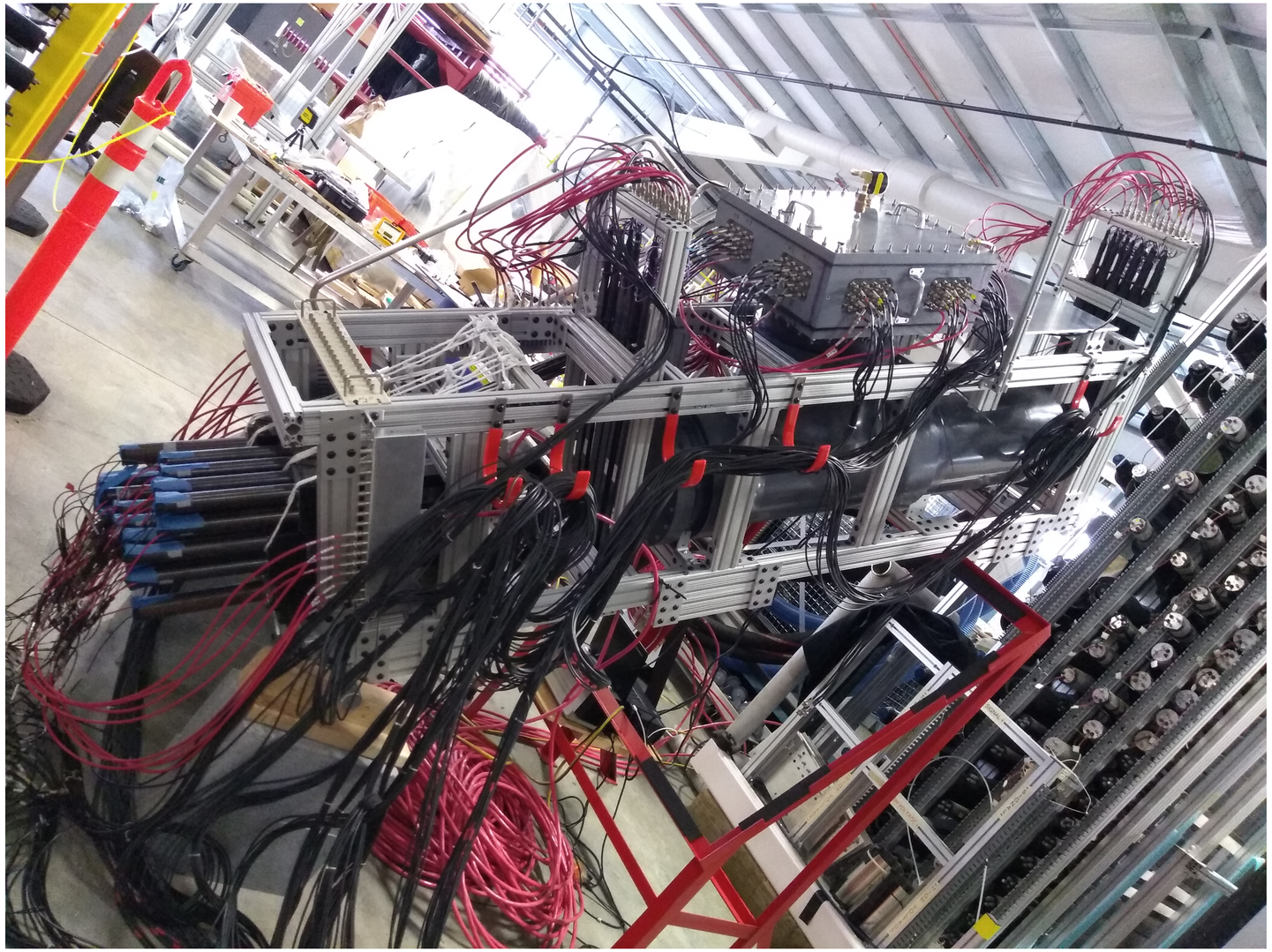

LAPPD

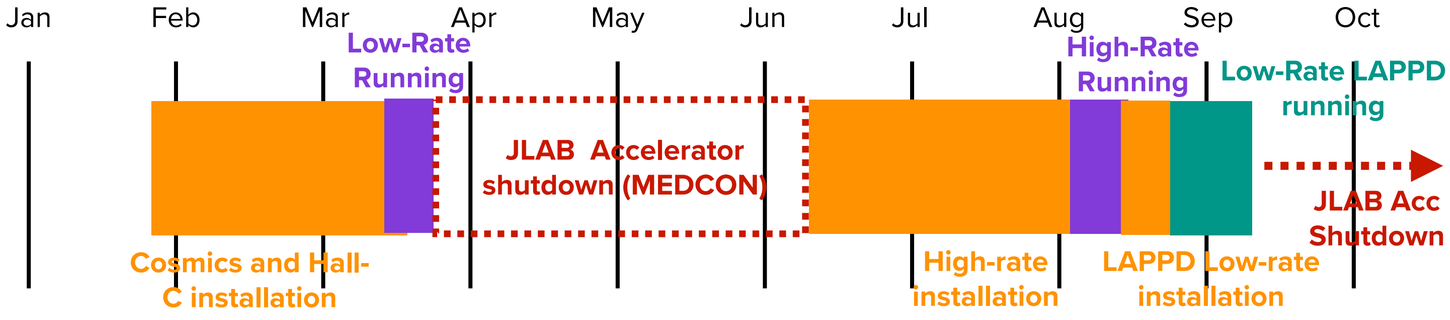

MaPMT array in electronics-box


MaPMT array (rear)

STATUS AND TIMELINE: TCD

- Transported to JLAB ESB in January 2020.
  - Scintillator planes, calorimeter blocks, and DAQ were added and the the entire device was cosmic tested (see Simona's talk).
- TCD set-up in Hall-C to collect parasitic data during "d2n" experimental running in March.
  - Low-rate data collected for MaPMT "simple" summing board.
- JLAB goes into shutdown end of March, testing postponed
  - TCD set-up for high rate testing.
- JLAB resumes operations in August, available parasitic opportunity is truncated.
  - High rate data collected for MaPMTs
  - Additional low-rate data collected for LAPPDs with CO2 and then C4F8 gas.





TCD GOALS AND ACCOMPLISHMENTS

- Primary:
  - Understand the exact response of Hamamatsu H12700 MaPMTs, aligned in a square array, under high rate conditions to:
    - Best understand the realistic response of our proposed electronics
    - Determine the most efficient high-rate electron trigger configuration for in SoLID
    - Better match true response to Monte Carlo.
- Secondary:
  - Test alternate technologies:
    - WLS coated LAPPD
    - MAROC summing electronics (pixel+quad+sum readout)
  - Test components of Cherenkov detectors
    - Simple summing board design
    - Mirror fabrication (reflective lexan film + carbon fiber blanks)
    - C4F8 gas response and interaction with electronics under realistic conditions.
    - WLS coated MaPMT response with pixel/quadrant/sum logic.

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These goals are either completed, or we collected the data and analysis is underway!

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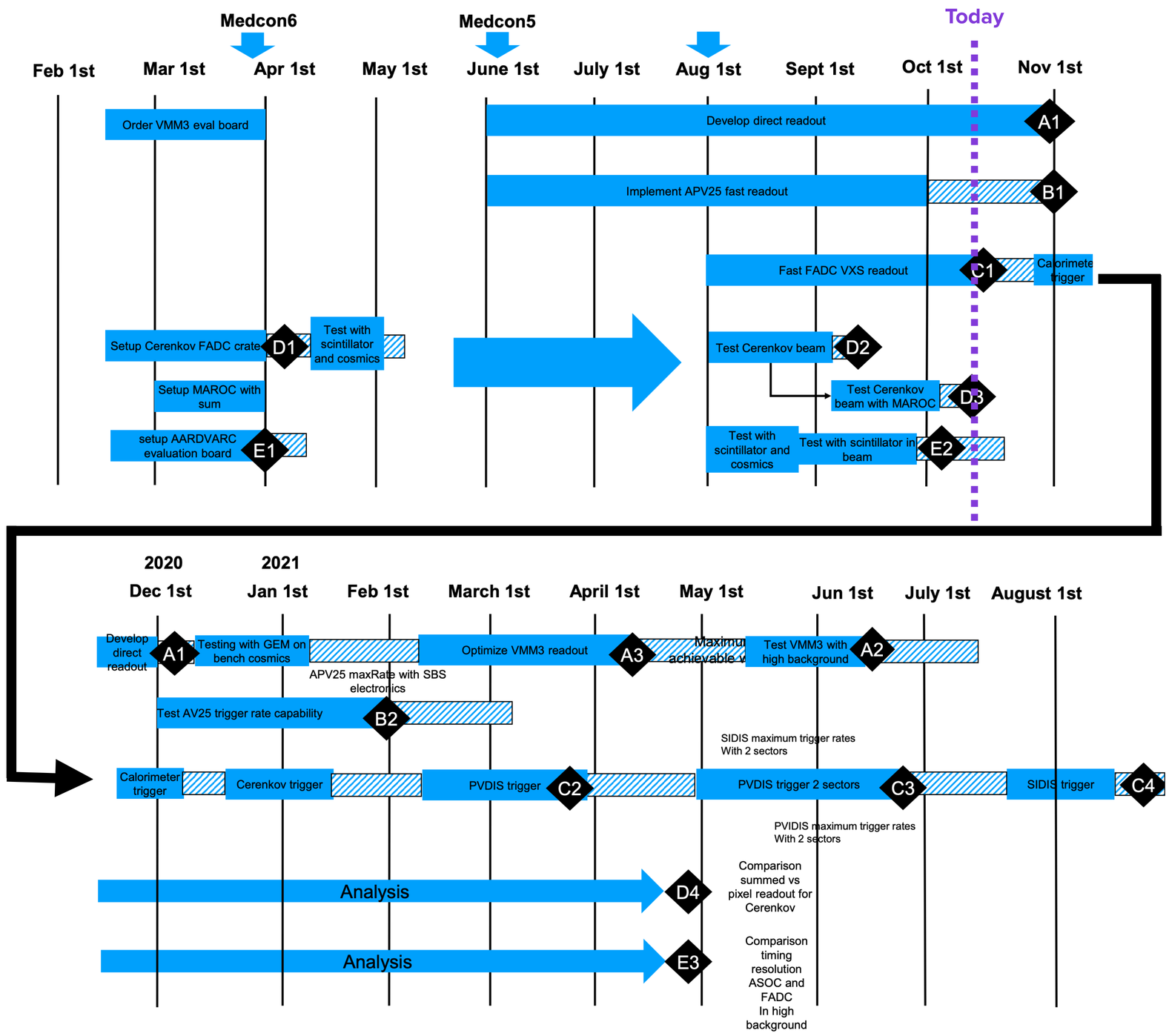
Testing planned on the bench (or possibly using the UITF at JLab)

STATUS AND TIMELINE: DAQ

- Recently adjusted to account for CoVID and JLAB MEDCON-6 shutdown.
  - Long lead-time electronics have been ordered.
    - VXS crates
    - VTP trigger module
    - VMM3 evaluation board
    - VMM3 chips for prototype
  - Support for TCD Hall-C tests is completed and successful.
  - Many items in-progress or soon to be started.

Received

- More details in Alexandre's talk on Friday.



DAQ GOALS AND ACCOMPLISHMENTS

- VMM high rate test
  - Procure evaluation board and test direct readout (delayed: expected November 2020)
  - Develop prototype determine maximum trigger rate (expected December 2020)
  - Study behavior in high background (expected June 2021)
- APV rate capability
  - Develop Fast Readout (delayed: after FADC VXS readout, expected December 2020)
  - Demonstrate 100 KHz rate (delayed: expected February 2021)
- FADC development
  - Fast VXS readout (ongoing)
  - Calorimeter trigger (delayed: expected December 2020)
  - PVDIS trigger and test (expected April 2021)
  - PVDIS trigger and test 2 sectors (expected June 2021)
  - SIDIS trigger and test (expected September 2021)
- TCD Support
  - Readout for TCD MaPMTS and low rate data collection.
  - Collection of high rate TCD data
  - MAROC data with high background
  - Evaluation improvement with MAROC pixel readout
- NALU ASOC Time of flight chip
  - Install evaluation board
  - Sample high background data (delayed: expected October 15th 2020)
  - Timing resolution analysis (expected April 15th 2021)

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Completed or currently ongoing

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Delayed due to CoVID, but "on-schedule" after adjustments.

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Dependant on MAROC tests done by TCD group

DOE MANDATED REVIEW OF PRE-R&D

- A review of the pre-R&D program was conducted on August 7th, 2020.
- The overall response from the committee was positive:
  - Summary comments:
    - "The committee finds that the pre-R&D plan is adequately formulated to address the technical risks for the DAQ system and the Cherenkov detectors."
    - "The committee is impressed with the progress that the pre-R&D team has already made in the current challenging environment, the quality of the presentations, and the quality of the data acquired to date."
    - "The committee encourages that the pre-R&D plan be seen through to completion."

- TCD specific:
  - "The committee is impressed that the pre-R&D collaboration has acquired data already with the Cherenkov test setup at large and small angles, and that the data-analysis as well simulations are proceeding well."
  - The committee agreed with the prioritization of tasks with limited parasitic opportunity.
  - Recommendation: "... pursue the simulation(s) to satisfactory agreement with the acquired data as a means towards future design."

- DAQ specific:
  - The committee feels that an intermediate step with 3 VTP cards, given the large anticipated rate, could be beneficial.
  - Pursue opportunities for testing with the SBS collaboration.
  - Clearly delineate DAQ tests that can be done on the bench and those that (absolutely) need beam.
  - Advance the determination of he maximum rate capability of the VMM3 chip.

SUMMARY

- Technical risks were identified concerning the SoLID cherenkov electronics and the overall SoLID DAQ.
  - These risks affect contingency and design, but are NOT "show-stoppers" for the SoLID project.
  - A pre-R&D plan was developed to address these issues.
- A prototype telescopic cherenkov device (TCD) was designed and built and collected data parasitically in Hall-C earlier this year.
  - Final tests of MAROC electronics will need an alternative testing procedure (combination of bench tests, cosmic tests, and possibly UITF tests).
- So far, the pre-R&D has been very successful, in spite of delays due to the CoVID pandemic.
  - Many proposed milestones have been adjusted (about 2 months delayed), but after this shift, all projects are "on-schedule".
  - Completion of all studies are expected by summer 2021.