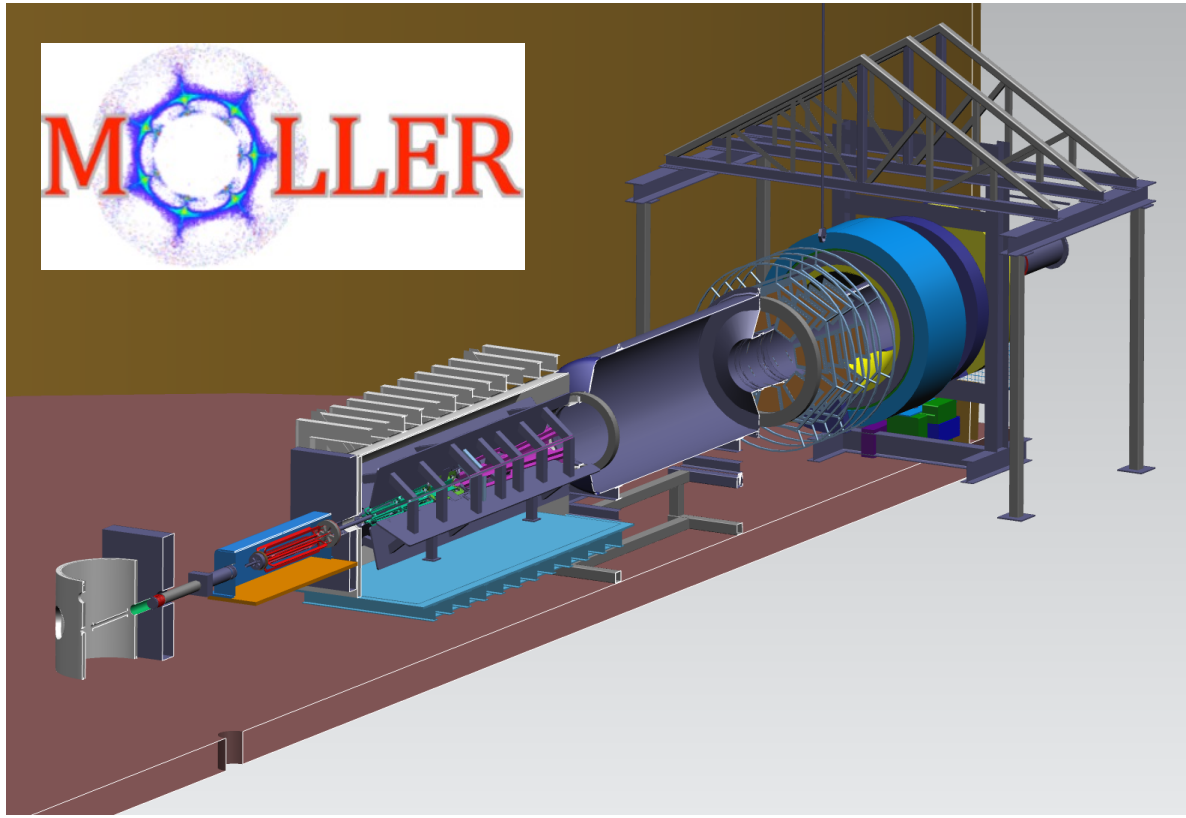
MOLLER MIE Project Update

MOLLER Collaboration Meeting

June 2022



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Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

JSA

MOLLER – a DOE Major Item of Equipment (MIE)

- Falls under DOE-O-413.3B Change 5

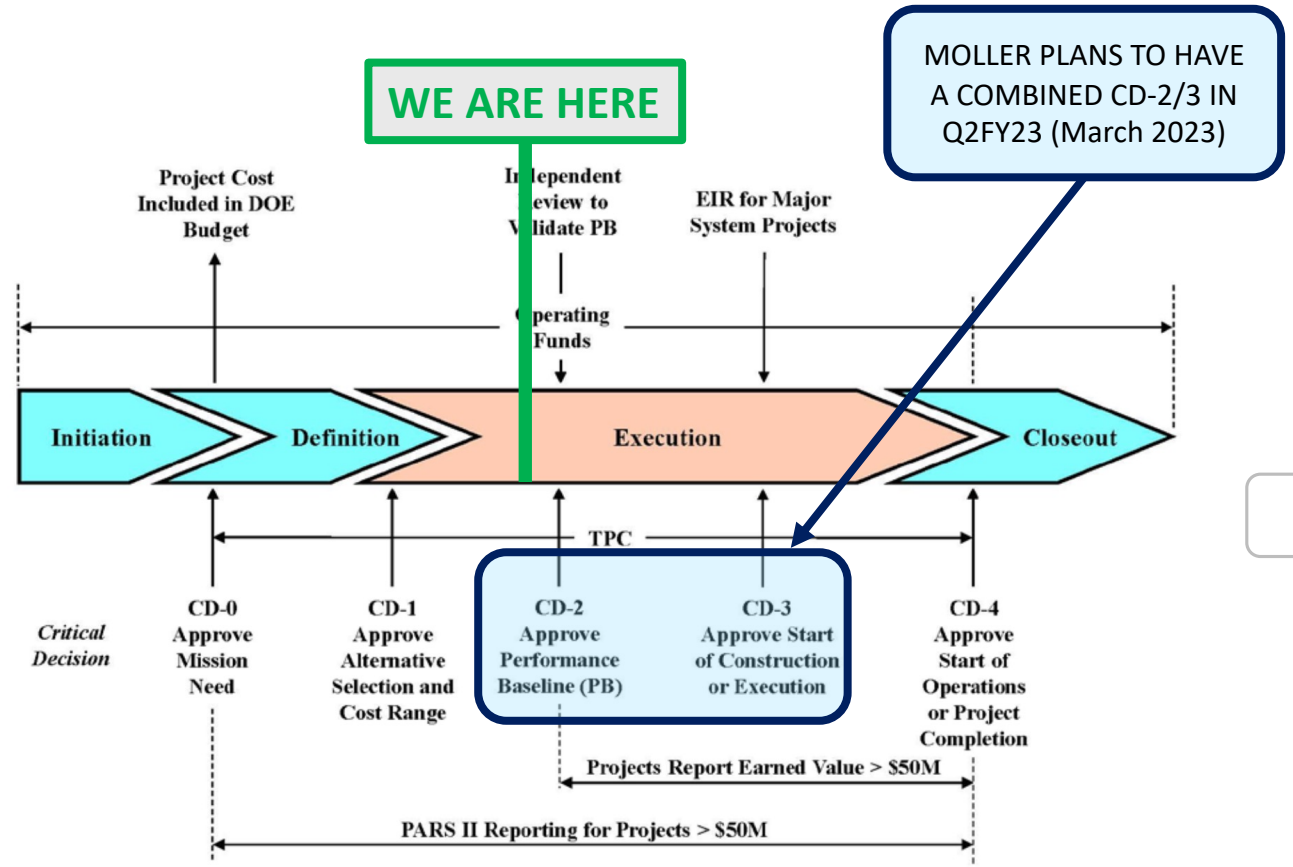
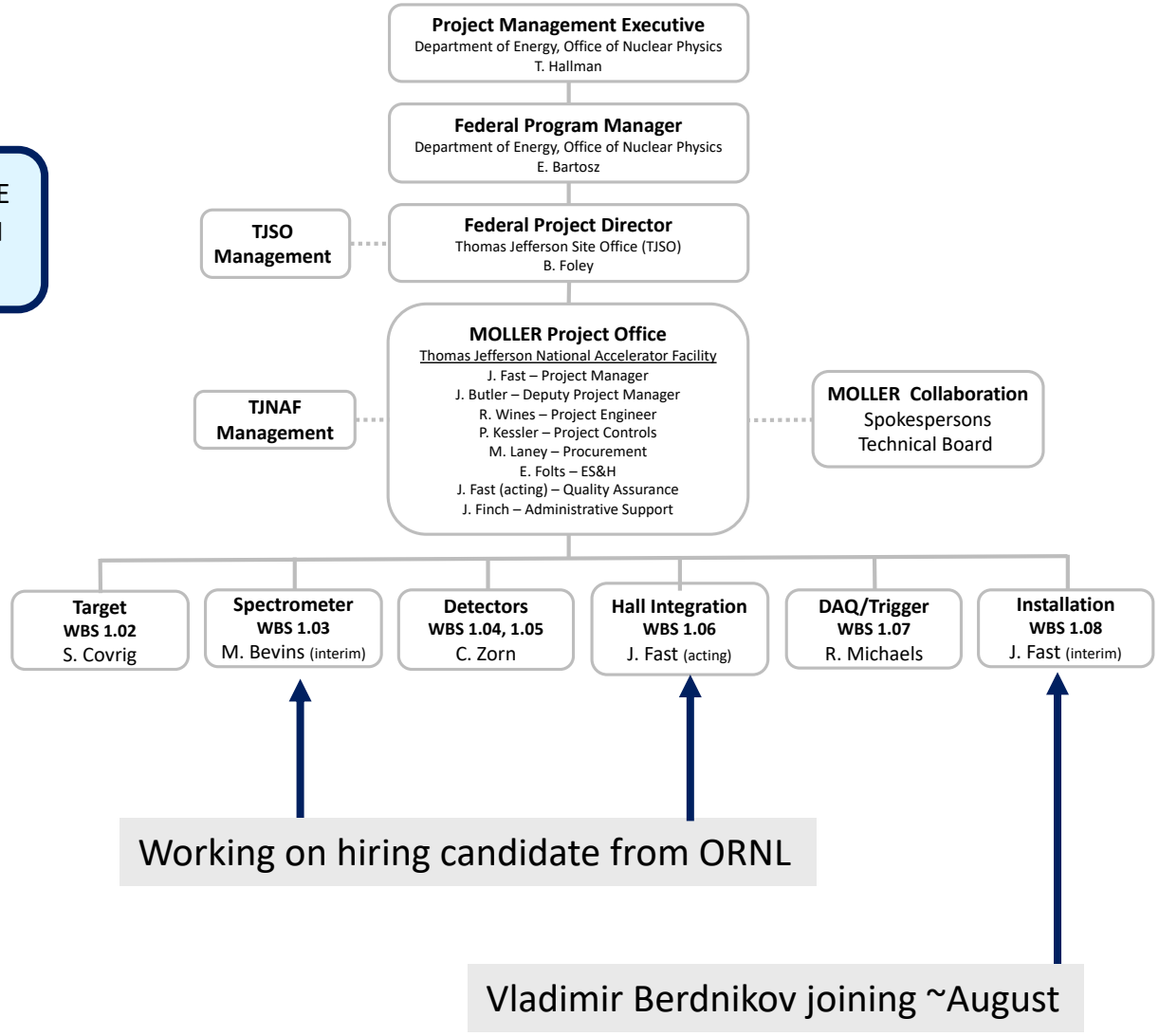


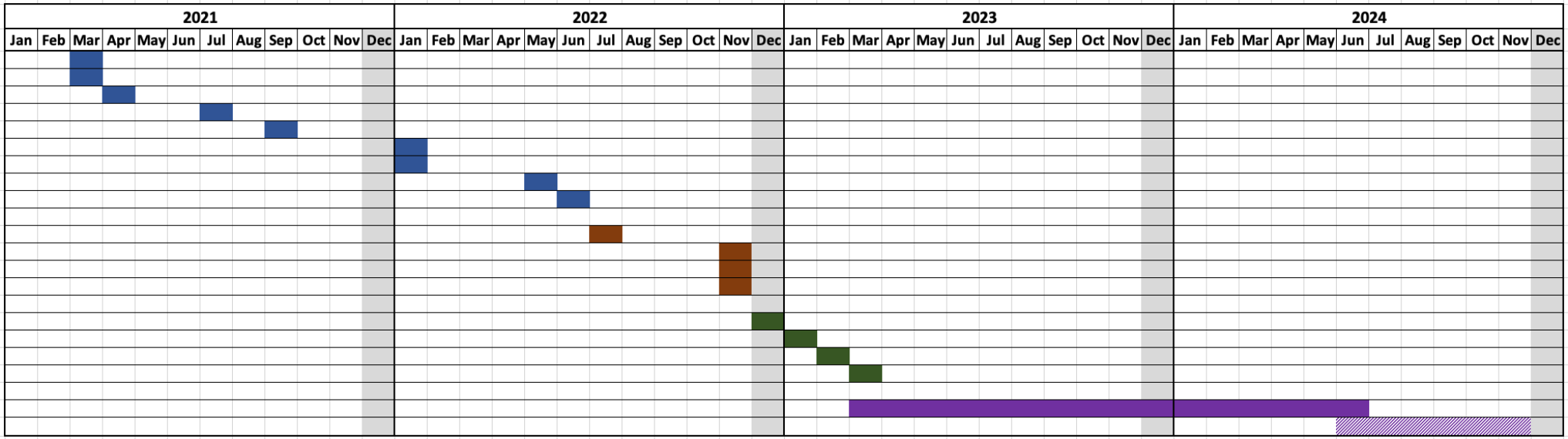
Figure 2. Typical DOE Acquisition Management System for Other Capital Asset Projects (i.e., Major Items of Equipment and Operating Expense Projects)



MOLLER schedule from 10,000 meters

- Wrapped up all Preliminary Design Reviews last week
  - PDRs generally went well
  - Detectors and Upstream Toroid fell a little short of “60% design complete”
  - However, designs mature enough to continue to Final Design without further review
- Working on completing final designs
  - Need to complete Technical Design Report over this summer
- Targeting Final Design Review(s) in late CY2022 to support spring 2023 CD-2/3 approval
  - This is the DOE authorization to start construction; should be ready for installation about 18 months later

MOLLER Schedule		
Review	Start	End
PDR - Downsteam Toroid	3/29/21	3/29/21
PDR - Trigger and DAQ	3/18/21	3/18/21
PDR - Magnet Power Supplies, Leads, Jumpers	4/30/21	4/30/21
PDR - Beam Pipes, Bellows and Windows	7/12/21	7/12/21
PDR - GEM Modules	9/14/21	9/14/21
PDR - Detector Systems (except GEMs)	1/12/22	1/14/22
PDR - Hydrogen Target	1/20/22	1/20/22
PDR - Spectrometers	5/23/22	5/24/22
PDR - Shielding and Utilties	6/1/22	6/1/22
FDR - Trigger and DAQ; Cables, LV, HV Supplies	7/11/22	7/15/22
FDR - Hydrogen Target and Shielding	11/17/22	11/21/22
FDR - Spectrometers and Infrastructure	11/17/22	11/21/22
FDR - Detectors and Beam Pipes	11/17/22	11/21/22
Independent Final Design Review	12/12/22	12/16/22
CD-2/3 Directors Review	1/16/23	1/20/23
CD-2/3 Independent Project Review	2/13/23	2/17/23
CD-2/3 ESAAB	3/16/23	3/16/23
Construction	3/17/23	6/17/24
Installation	6/18/24	12/15/25



Funding outlook

- FY20 funding was $2M (TEC)
  - All carried over to FY21 – awaiting CD-1 approval for spending this flavor of funding
- FY21 funding was $5M
  - $3.2M carried over to FY22
- FY22 funding President's Budget Request was $7M
  - Actual appropriation was only $5M
  - **Still ample to get the project through CD-2/3**
- Challenge is going to be FY23 where we requested ~$14M
  - We need ~$8M to stay on schedule
    - Any less and we will have to slip the schedule one year
  - President's Budget Request supports only $4M [worst case scenario]
    - Estimate is that we will have >$2.5M in carryover to help us through FY23
    - We can maintain the team and get through this lean year, but funding will be very tight
  - Congressional marks are not available yet
    - **Congress funds science very well**
    - We are awaiting news on House and Senate marks (typically come out during the summer)

Fallback plans if DOE is not ready to baseline MOLLER in spring 2023

- DOE has hinted that they may not be ready to baseline (approve CD-2) MOLLER in the spring due to funding uncertainty on their end
  - Driven by bad experience with the GRETA project where they were unable to fund according to the funding plan in the baseline, which is causing some administrative issues now
- If that is the case, we will request a CD-3A "authorization for long lead procurements" to ensure that all of the key procurement activities for FY 23 can proceed
  - What exactly we would proceed with depends on the FY23 funding level
  - Priorities include:
    - Funding to keep staff engaged at SBU, MIT-Bates, Ohio
    - Following through with prototyping activities for spectrometer, target and beam line
    - Keeping magnet power supply and coil vendors engaged (excercising some options on contracts)
    - Doing our best to stay in synch with NSF/CFI (e.g. trigger scintillators)
    - Electrical utility work in Hall A (electrical panel/switchgear is 36 weeks ARO)

It is too early to tell how FY23 will play out; standing by for Congressional action on budget

In the mean time, we are staying the course to complete final designs to allow NSF/CFI to proceed to construction

Final Design Reviews

- Final Design Reviews
  - Expectation is that design is at 90-100% complete
  - Full drawing package completed
  - Pre-production prototypes constructed and tested to validate designs
  - Demonstration that all requirements and interfaces are satisfied by design
  - Present plan to validate requirements during production
  - Evaluation of risk and risk mitigation strategy for production
  - ***Integrated reviews will be held to assure integration of systems***
    - E.g. target and shielding bunker; beampipes and detectors
  - ***Completion of all internal project FDRs is required to proceed to CD-2/3***
- Considering holding select “manufacturing” design reviews between PDR and FDR
  - Another opportunity to look in on designs prior to making final drawings and specifications packages
  - Particularly relevant for complex components (Target, Spectrometer, Detectors)

Preliminary Design Review Recommendations

- Downstream coils
  - Risk registry does not include schedule risk. Review schedule, specifically the timeframe for fabricating pre-prototype coil set, verify possibly through RFI. Review plan to procure conductor.
- Power supplies, leads, jumpers
  - The physics requirements and constraints need to be defined prior to final design review of the power supplies and magnet connections.
  - Interfaces with the Hall utilities and experiment space allocation needs to be confirmed and agreed upon prior to the final design review of the power supplies and leads. Specifically the use of water cooled aluminum leads is to be compatible with the Hall LCW system, the shielded space for the power supplies is defined, power requirements are compatible with the Hall power and the routing of leads is optimized with other experiment space requirements. The interface control document should define these parameters and be complete prior to the final design review. Data acquisition plan and integration into data acquisition is to be confirmed.
- Beampipes, bellows, windows
  - Continue analysis of components and as a pressure system. Review buckling analysis and load cases, providing conclusions on resultant directional and shape factors to be considered in design. Evaluate and document pressure relief system. Analyses to be complete to achieve 90% design status.
  - Fabricate and test a test piece exemplifying the detector pipe window design prior to procuring the actual detector pipe window to verify the design and the fabrication procedures.
  - Continue failure mode analysis for components and as a complete pressure system. Failure mode analysis to include safety mitigations and constraints in phases of process including fabrication, installation and operation. Document failure conditions of materials, such as gaskets.

Preliminary Design Review Recommendations

- Spectrometer
  - Define the interface between the bottom of the Upstream Spectrometer Vacuum Chamber being designed by MIT and the support structure to be designed by JLab. Release the ICD with all interfaces defined well before the FDR.
  - Make explicit the procurement and assembly responsibilities for the components of the upstream spectrometer (coils, internal supports, vacuum chambers, collimators, etc.), including inspection of the components and the assembly.
  - Pursue the BCR to add a prototype bellows contract with an option for the production units.
  - Pursue a BCR to add prototypes of Collimator 1-2 with an option for production units.
  - Make it a top priority to hire additional designers to complete the required level of design and drawings for the FDR. In addition, the engineering level that MIT plans for completion appears to be under estimated. MIT should come up with a detailed plan to complete their portion.
- Target
  - Complete vibration/modal analysis for all components to insure target cell and target positioning are not affected as well as fatigue of components.
  - Time-dependent simulations for both cell and HPH are not done yet. Complete CFD studies prior to final design review to prevent redesign.

Preliminary Design Review Recommendations

- GEMs (launched prototyping effort)
  - Review and clarify all specifications for the GEM project and run a simulation to determine whether it fulfills those specs. In particular, the current four GEM layers have a total thickness of 3.2%, while the specification sheet indicated a need for less than 2%.
  - Continue to develop the integrated schedule for the MOLLER project including inputs from the project team, DOE/NSF and the Canadian Foundation for Innovation (CFI) in order to have a common understanding of deliverables and milestone dates.
- Detectors
  - A detailed design for the mechanical support of the quartz radiators needs to be completed and documented
  - In advance of the pre-CD2/3 review develop/optimize production schedule, acceptance testing, and installation procedure, including labor and engineering support requirements
  - Qualification of 3D printed materials for use in the expected environment and in proximity to the quartz radiators should be completed as soon as possible
  - Finish design criteria for trigger scintillators before starting light guide optimization.
  - Stiffening the rings is likely to be an easier solution to excess deflection than adding a redundant support at the top of the assembly.
  - There should be diagonal bracing or a shear plate between the vertical legs and the horizontal members of the base. This will stiffen the structure reducing both deflections and stress. With sufficient connections between the legs and base it may be possible to use aluminum instead of stainless.
  - The bearing assembly has bearings with parallel sides riding in a groove. Using a bearing with angled sides (for example Bishop Wisecarver) could reduce the tendency of the assembly to bind. Another alternative would be to guide on both the inside and the outside of the rings with a flanged bearing eliminating the need for machining a groove in a large ring.
  - A mechanism to provide a positive hold down of the rings (prevent the rings from lifting up) would be a good safety measure.

Preliminary Design Review Recommendations

- Detectors (continued)
  - The cable tray system presented has the cable exit the GEM vertically upward, make a tight loop, and then go downward to the aluminum ring. If the cables can exit to the side (in the plane of the ring) the movement could be accommodated as two large radius bends.
  - More engineering oversight on a weekly basis is highly recommended.
  - Add the third [polarimeter] GEM plane. It will take advantage of the high coordinate precision of the GEM chamber in selection of the correct tracks.
  - Prepare clear documentation of assembly/disassembly procedures (for polarimeter GEMs)
  - The access to the LAMs for maintenance and repair needs to be improved.
  - For SAM quartz, revisit rate estimates and perhaps test to damage; or at least make a spares/planned replacement baseline
  - For LAM glue, test for realistic environment
  - [main detectors] Perform a thermal study to consider the effects of heat loads and temperatures on alignment and loads as well as limited construction accuracy. Some items identified to consider:
    - Quantify the thermal effects of the heat load of the PMTs and determine if anything is over-constrained (for example, axial length change of the segment constrained by stiff axial bars between rings).
    - Consider expected hall temperature profile and check for alignment changes during normal range and mechanical interference during extremes
    - Determine if additional temperature monitoring would be useful to correlate effects with analysis or trigger alarms.
    - Determine requirements (supply temperature, and flow) for cooling systems for PMTs and also examine if provisions are needed to deal with potential condensation.

Preliminary Design Review Recommendations

- Detectors (continued)
  - Re-evaluate the required resources for the quartz detector to achieve readiness in the desired 6-month period
  - Develop an assembly and alignment plan that includes
    - A storyboard of the assembly process
    - Lists components and subassemblies being installed and estimated weights.
    - A detailed ordered list of assembly steps and who is responsible for them o Identify handling and alignment features that are needed on each piece
    - Consider lines of sight needed for alignment
    - Consider personnel access requirements to install hardware and observe interfaces during assembly.
  - Consider an alternative to Robot aided installation of the segments. One possible idea using a gantry and rotation of the lower segment frames is outlined in Appendix B.
  - **Proceed towards final design**

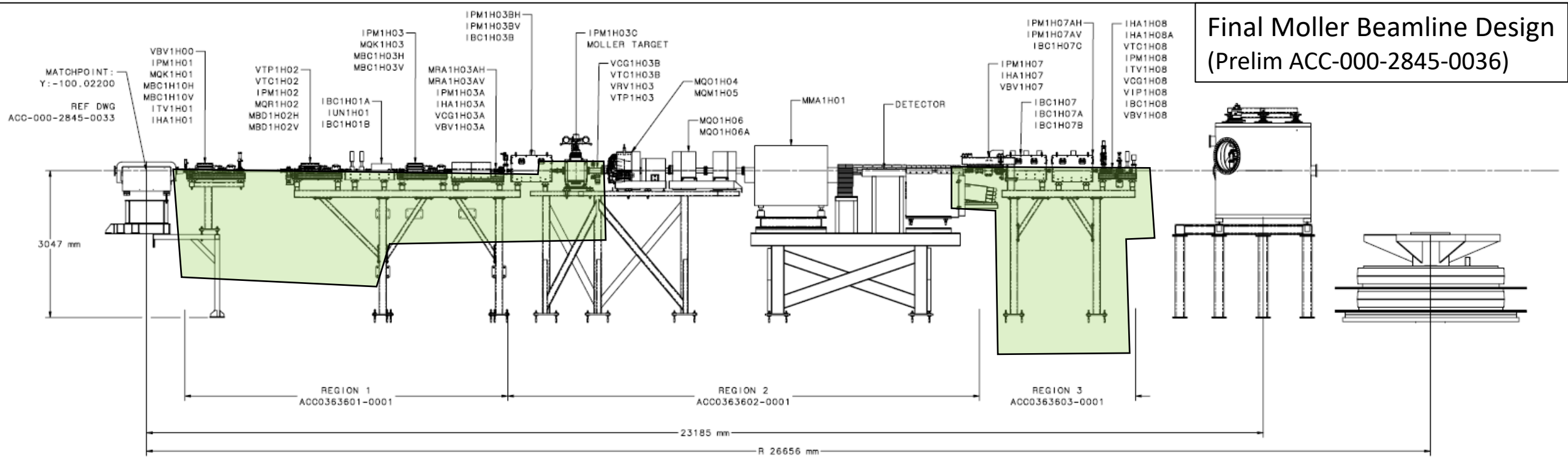
Preliminary Design Review Recommendations

- Trigger/DAQ
  - Continue plans for reviews of circuit board designs with Jefferson Lab staff before release of production versions.
  - Update/verify existing electrical/grounding system drawings for Hall A to include new equipment for MOLLER detector and magnet apparatus.
  - Carefully review the requirements for new fiber optic cables from the Injector Service Building (ISB) to the Hall A electronics bunker locations and create an installation plan.
  - Make progress on the prototyping of the Integration/readout board a priority. The more time it can be tested and integrated into the CODA framework the easier it will be to flush out all potential DAQ and timing issues.

Preliminary Design Review Recommendations

- Infrastructure
  - We recommend that JLAB management expedite the additional staff required (one engineer and one designer) so that the Moller project can meet the 90 % Infrastructure Design complete milestone by November 2022.
  - We recommend that the early installation and subsequent testing of the “prototype” Entrance Beamline be firmly scheduled about one year in advance of start of Moller installation in 2024 to facilitate actual testing under operating conditions prior to start of Moller Installation. Either SAD 23 or another down would seem appropriate.
  - We recommend that the upstream Torus services for DC power be designed to use robust radiation hard materials such as all metal buss bars and locomotive cables for DC power and that LCW be designed to use metal tubing with ceramic breaks or other similar materials.
  - It is further recommended that all Moller beam line vacuum connections in the Target Area and Upstream Torus area use metal seals. Generally, the use of metal seals, Aluminum, ceramic or other low density materials in the upstream beamline are highly desirable and recommended where these materials are practical.

Hall A Moller beamline – left-hand end is the “prototype” beamline effort



- Majority of New Design Scope is located in Regions 1 and 3
  - Existing Hall A Moller polarimeter Quads, Dipole and Detector box are unaffected and will remain in place
  - New Unser box (Unser-BCM-BCM) will use commercial “Unser”; has ½ the current noise of the Hall A unit
- Region 1 section being assembled and installed ahead of main MOLLER down as “prototype”
  - Improves beamline performance for SBS-era experiments
  - Gain operational experience with new beamline and instrumentation prior to MOLLER engineering run
  - Reduces work coordination issues in Hall A during the MOLLER installation down (i.e. shortens long down period)

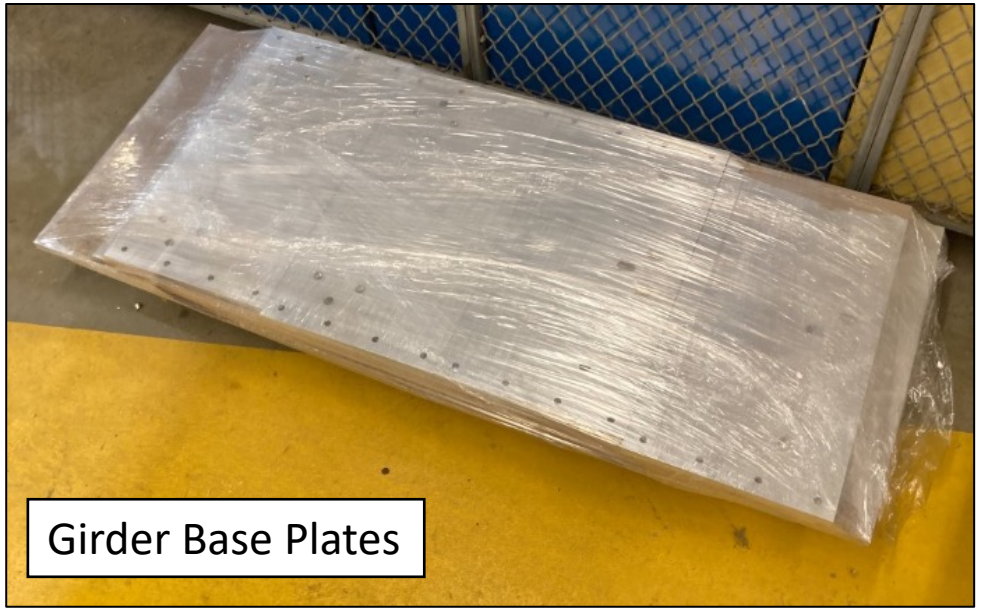
Hall A entrance beamline for MOLLER – prototype procurement progress

Pedestal, Stand Platform and Braces Stored in Test Lab High Bay

Girder/Vacuum Hardware

MCG Coils Currently being Fabricated at Technicoil, along with QR Coils to replace Spare QR that will be used for Moller Beamline.

MCG Magnet Steel Components



Girder Base Plates

Some lingering Project Review recommendations still need to get closed

- Several long-standing recommendations closed out since last collaboration meeting
- We will need to work to get the rest of these closed out in the next few months

Review	Subcommittee	Number	Identifier	Category	Subsystem	Recommendation	Owner
2021_11_IPR		1	2021_11_IPR	Engineering	Systems Engineering	Develop a process to track project documentation, specification, drawing progress by Q2FY22.	Robin Wines
2021_11_IPR		2	2021_11_IPR	Engineering	Systems Engineering	Finalize the SRDs and ICDs for Detectors, DAQ, and Infrastructure	Carl Zorn, Bob Michaels, Jim Fast
2021_11_IPR		4	2021_11_IPR	Management	Infrastructure	Infrastructure update their cost table	Jim Fast
2021_11_IPR		5	2021_11_IPR	Engineering	Detectors	Perform a "number of insertions" study on the barrel segment patch panel.	Dustin McNulty
2021_11_IPR		7	2021_11_IPR	Physics	Detectors	Report on number of spare APV chips and experience of radiation tolerance. The project should monitor exposure of the chips during SBS operations to ensure adequate lifetime margin for the MOLLER project.	Nilanga Liyanage, Carl Zorn
2021_09_DR	SC1	1	2021_09_DR_SC1_1	Management	Risk	In advance of the pre-CD2/3 review, the project should re-evaluate the risk registry, specifically with respect to COVID-19 direct and in-direct (supply chain) impacts.	Jessie Bultler
2021_09_DR		5	2021_09_DR_SC4_5	Physics	Systems Engineering	The project should finalize alignment tolerances and establish a QA program to ensure the tolerances are met throughout installation of the detectors and the highly-correlated spectrometer collimators and magnets.	Krishna Kumar
2020_10_IPR	SC3	4	2020_10_IPR_SC3_4	Management	PM	Add a Quality Assurance Professional to the project before CD-2/3.	Jim Fast

Summary

- We had a very successful set of Preliminary Design Reviews over the past several months
- Continue to be on track towards CD-2/3 Spring 2023
- FY22 allocated funding is sufficient for us remain on course to CD-2/3 with minimal impact on CD-4, but current President's Budget Request for FY23 would result in a 1 year delay
- **Next major effort for the collaboration is completion of the Technical Design Report this summer – this is a required document for CD-2**