2020 Pre-CD-1 Director's Review of MOLLER

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Executive Summary

The Measurement of Lepton-Lepton Electroweak Reactions (MOLLER) experiment at Thomas Jefferson National Accelerator Facility (JLab) proposes to measure the weak mixing angle, $\sin^2\theta_W$, to unprecedented precision at low energy, thus improving our understanding of the running of this fundamental constant and providing a sensitive probe of new physics. The purely leptonic scattering channel is complementary to current efforts and future proposals to measure A_{PV} from e-p scattering, and is particularly relevant in an era where a number of other anomalies have emerged in the lepton sector. The theoretical uncertainty on Q^e_W is currently at 1.4% with an expected reduction to <0.5% after the full 2-loop treatment is complete, which compares favorably to the expected experimental uncertainty of 2.4%. The MOLLER experiment represents a unique opportunity for JLab that leverages the large investment made in the 12 GeV upgrade. The experiment is a compelling opportunity for the US Department of Energy Nuclear Physics (DOE-NP) program and represents a 5-fold improvement over the last measurement made in E158. Mission need was recognized in 2016 and the science motivation for MOLLER remains strong.

The MOLLER experiment was approved by the JLab PAC in 2009. There was a successful Science Review convened by DOE-NP in 2014. A Director's Review was held in 2016 to assess the conceptual design and provide advice on pre-project planning and development. MOLLER received DOE Critical Decision-0 (CD-0) "Approve Mission Need" in December 2016, which was followed by a pause due to lack of funding. In anticipation of a project restart, a Director's Review was held in both 2019 and early 2020 to assess the progress of MOLLER towards CD-1. In August of 2020 JLab Management convened a Director's Review and charged the review committee with evaluating the preparedness of the MOLLER Project team for an upcoming CD-1 review.

The committee found that the MOLLER Project Team has made impressive progress since the last Director's review in January 2020. Both the documentation provided to the committee and the presentations made at the review were consistent with what one would expect at a successful CD-1 review conducted by DOE OPA. While certain improvements in documentation and presentations are possible, as described in the Appendix of this report, overall the committee concluded that the MOLLER team was ready for the upcoming CD-1 review. The MOLLER Project should proceed to the CD-1 review.

Answers to Charge Questions

1. Science Basis: Is the MOLLER conceptual design capable of achieving the scientific goals of the experiment? **Yes**

2. Conceptual Design: Is the MOLLER conceptual design sound, achievable and sufficiently defined to meet the specified technical requirements? Are technical risks properly identified and are appropriate mitigation strategies in place? **Yes, Yes**

3. KPP: Are the proposed Key Performance Parameters (KPP) appropriate for determination of successful project completion? **Yes, assuming that the remaining "TBD" in the KPP table found in the draft preliminary Project Execution Plan (pPEP) is resolved prior to the CD-1 review.**

4. Cost and Schedule: Are the cost and schedule estimates credible for this stage of the project and mature enough to establish the cost range for the project? Do they include adequate scope, cost and schedule contingency? **Yes, although there is some concern regarding the cost range and schedule contingency. See the comments in the review report.**

5. Management: Is the Project being properly managed at this stage? Is there a capable team in place to effectively manage risks and develop a robust baseline in the next phase? **Yes, Yes however an addition to the Project team could benefit the project. See comments in the SC-1 section of the review report**.

6. ES&H: Is ES&H being properly addressed given the project's current stage of development? **Yes**

7. CD-1 Requirements: Has the project met all the prerequisite requirements for CD-1 approval? **Yes, although improvements can be made in the documentation prior to the CD-1 Review. See the Appendix, *Suggestions to Improve Presentations and Documentation in Preparation for the CD-1 Review.***

8. Previous reviews: Has the project team responded appropriately to recommendations from prior Reviews? **Yes**

SC-1 Management, Cost & Schedule, ESH&Q

Committee Members: Xiaofeng Guo, Ed O'Brien, David Radford, Bob May

Management, Cost & Schedule

Findings

- The MOLLER project will build an experiment designed to operate in Hall A of the CEBAF accelerator complex at JLab.
- MOLLER received CD-0 approval in December 2016. It is scheduled for a CD-1 review by the DOE Office of Project Assessment (DOE OPA) in September 2020.
- The MOLLER project scope includes a hydrogen target, a toroid spectrometer magnet in a vacuum enclosure, detectors with electronics, infrastructure and integration, DAQ/Trigger/Online computing, beam diagnostics and monitoring, beam polarimetry and project management.
- The project team contains a Project Manager, Deputy Project Manager, Project Engineer, and Safety Lead. The JLab Project Management Office provides project Controls. JLab Procurement is an overhead function.
- The MOLLER org chart has the Project Office report through the JLab DOE Site Office (TJSO) to the DOE-Nuclear Physics Program Office (DOE-NP). MOLLER has five Control Account Managers (CAMs) covering 6 Level-2 areas. One L2 CAM is responsible for two L2 WBS elements.
- In the presentation, the Project team Org Chart shows 6 Level-2 Managers. The Org Chart does not show Level 3 managers. Below each L2 box, L2 CAMs are linked to Experiment Contacts (EC). These are shown as external links to the project organization.
- The point estimate for the TPC is 49.5M AY$ with 35% contingency. The CD-1 cost range is proposed to be -5% to +15% of the point estimate, or 47.0M to 56.9M AY$.
- The contingency was estimated using a table of Estimate Uncertainties based on the Estimate Type along with a risk-based Monte Carlo.
- The MOLLER risk register has 65 risks of which 4 are rated high. There are two large opportunities. One for National Science Foundation (NSF) funding and another for Canadian Foundation for Innovation (CFI) funding.
- The project team has defined threshold and objective Key Performance Parameters (KPPs) and Ultimate Performance Parameters (UPPs). Discussion of the KPPs and UPPs with DOE-NP and TJSO is ongoing
- The external dependencies to the MOLLER project include:
    - Hall A electrical power and Low Conductivity Water (LCW) upgrades
    - The addition of End Station Refrigerator2
    - Polarimeter upgrades
    - Beam line and injector improvements

    - Software, computing, networking, tapes
    - Completion of the SBS physics program
- The Federal Project Director (FPD) and Federal Program Manager (FPM) for MOLLER have been identified
- The current baseline schedule shows a CD-1 review in September 2020, and CD-2/3 review in the 4th quarter of CY2022, with 5 months schedule contingency for CD-2/3.
- The project critical path (CP) runs through the hydrogen target up to CD-2/3. After that the CP proceeds through Gas Electron Multiplier (GEM) procurement and fabrication, Hall A prep and spectrometer installation. The fabrication of the spectrometer toroids is close to the critical path.
- The schedule contingency is 21 months from the early completion date to CD-4.
- The project has a resource-loaded P6 schedule. It includes over 1700 activities of which 200 are procurement tasks.
- A quantitative analysis predicts that the 80% likelihood project completion date has 7 months of float to CD-4.
- MOLLER has a new Project Manager as of January 2020.
- Preparation for Earned Value Management System (EVMS) reporting has begun using JLab standard CAM handbooks and CAM training
- University scope on MOLLER will be managed by (i) Cooperative Research and Development Agreements (iCRADAs), regardless of funding source.
- MOLLER is using a Recommendation Tracker.
- Resource leveling of the resource-loaded schedule is not complete.
- The COVID-19 impact to the project schedule is estimated to be minimal.

Comments

- MOLLER Project Management has done a very good job preparing the project team for CD-1. There has been great progress since the January 2020 review. Overall, the project documentation and presentations, including BoE documents and cost summaries have improved very significantly since the last review.
- The Risk Register is useful, comprehensive and detailed.
- The Recommendation Tracker is detailed and complete.
- The CD-1 focus is on the approval of alternative selection and cost range, in addition to the approval of the overall framework for project management. The MOLLER experiment overview presentation by the spokesman laid out a very good case for the Analysis of Alternatives and the selected alternative for meeting the mission need. Consider documenting the Analysis of Alternatives as a separate supporting document for CD-1.
- It will be beneficial to show a flow down of science goals to technical requirements in both review documentation and presentations.
- The project should clearly identify the interface milestones, including milestones for external dependencies, and internal dependencies between different L2 and L3 elements. This is necessary to show good interface management and for easy identification of schedule impact of these dependencies.
- Evaluate whether the Objective KPP for the target power test is correct.

- The MOLLER design is in an early phase. There is little scope contingency in the project. Much of the cost estimate is based on engineering or JLab experience (77%) with less than 20% based on a combination of vendor quotes, vendor estimates, and catalog prices. The project should evaluate whether 35% contingency is adequate for a project of this level of maturity.
- The CD-1 Cost range is -5%, +15% around the TPC point estimate of $49.5M. The top of the range may not give the project sufficient flexibility at the time MOLLER sets its baseline at CD-2. The bottom of the cost range does not take into account the significant risk opportunities associated with pending proposals to NSF and CFI. Other issues that might impact the cost range are that MOLLER contains very little scope contingency and the potential impacts of the identified high risks.
- Consideration should be given to expanding the CD-1 cost range on both the high and low ends, and amending the preliminary PEP accordingly.
- Many aspects of MOLLER are technically challenging, and the technical performances and specifications of the project deliverables must be met in order for MOLLER to obtain its science objectives. The project could consider adding a person to the Project team with the responsibility of delivering the technical performance of the complete project scope.
- Consider adding schedule contingency to the five months between the early completion L1 milestone date for CD-2/3 approval and the baseline date for this milestone.

Recommendations

- The Project should proceed to the OPA CD-1 Review.

Environment, Safety, Health & Quality

Findings

- National Environmental Policy Act (NEPA) Categorical Exclusion (CX) determination is complete
- The Integrated Safety Management (ISM) Plan used for the project is the JLab ISM Plan
- The Preliminary Hazard Analysis Report (PHAR) is complete and has a July 1, 2020 signature date by the MOLLER Project Manager and a July 2, 2020 signature date for the MOLLER Environment, Safety and Health (ES&H) Lead and JLab ES&H Director. It has a change log.
- The preliminary Project Execution Plan (pPEP) is complete and the organizational charts appear to be up to date.
- The scope of the project has been defined and risks are being captured and managed as part of the Risk Registry (RR).
- The JLab ISM plan is identified as a key feature in the following MOLLER documents:

- Quality Assurance Plan (QAP), Criterion 5 Performance/Work Processes
- Risk Management Plan (RMP) Section 1.2 Risk Management Plan Overview
- Preliminary Project Execution Plan, Section 8.8 ES&H,

is mentioned in the pHAR once in Section 1, Introduction.

Comments

- The mention of ISM Plan in the QAP, RMP in the pPEP anchors the project in JLab ISM programs and processes. However, the lack of detail on the application of ISM with specific project features may give an outside reviewer the impression that ISM is included as boilerplate. The project should identify features that are representative of ISM in the QAP, RMP in the pPEP, and plan on incorporating ISM features in the Hazard Analysis Report (HAR) required for CD-2 by parsing hazards using the Table 2 Risk Matrix to prioritize high-hazard mitigation strategies early enough for substitution or engineering solutions (according to the hierarchy of controls) while it is still cost effective to make this change.
- MOLLER will likely generate considerable activated materials. Life cycle costs of radioactive waste disposal associated with both preconstruction preparation and post project rip out and disposal of radioactive material should be captured in future operations planning.
- The project should consider incorporating salient features of ISM Core Function 5: Provide Feedback and Continuous Improvement into the QAP as part of the project planning, development, and execution.

Recommendations

- None

SC-2 Target and Infrastructure (Detector Integration & Shielding)

Committee Members: Chris Polly and Kelly Dixon

Findings

Target

- 2 kW applied to the target is the threshold power and is a KPP requirement. 3 kW is the minimum required to do physics. Initially, this experiment can run at the lower power but eventually will need a functional ESR2 to achieve the higher power. This will be the highest power hydrogen target at JLab.
- The target is on the critical path at the start of the project.
- The existing HX used for Q_{weak} has not been tested to the 3 kW level but calculations indicate that it should easily handle a 4 kW load.

- There will be gaseous H_2 in the enclosed area between the shaft and the temperature compensating bellows. This is required since the motor was moved away from the pump outside of the vacuum chamber.
- The E158 pump, having similar operating flow conditions also has the extended shaft with a warm motor and has been proven to be a reliable, low vibration design.
- Model 2 of the target cell design, eliminates the need for end caps, has a low-density loss within the beam volume, and is chosen to be the conceptual design for this target. With the new design the overall density decrease due to boiling is now within the <1% specification, and the local density fluctuation due to boiling at the upstream beam window has been reduced from 35% to 7%.
- Another Computational Fluid Dynamics (CFD) analysis will be necessary to evaluate the 125 cm target design as it has been reduced from 150 cm, saving an estimated $1M mostly due to re-purposing Q_{weak} equipment. The expectation is that the results will improve due to the 4.5 kW to 3.2 kW power reduction.
- The negative impact of the shorter target on the physics program is small since the reduction in flux is largely offset by a corresponding decrease in ep scattering backgrounds.
- There is a 28% cost contingency for this project.

Infrastructure

- All dependencies, except for power and LCW upgrades, are not necessary to meet the KPP's but are needed to meet the UPP's. The power and LCW upgrades are expected to be completed by January 2021.
- The main detector length is not yet optimized.
- An estimate of high gamma ray fluxes have led to the need of lead and concrete shielding in the clam-shelled section of the rear detector (post April 2020 design).
- An engineering concept has been developed to integrate the detectors with the new tapered beam pipe. The main integrating detector is now envisioned to come together as two clamshells to facilitate installation and later maintenance. The downstream pion and small angle detectors have been suspended from a frame from above to reduce interference with the beam dump.
- An engineer from JLab Physics Division has started laying out the installation sequence. Another Mechanical Engineer will join this effort this month along with a couple of designers.
- There will possibly be a $200K increase if a 16 channel floating power supply isn't viable for the Low Voltage cables and will need to be replaced by individual power supplies.
- MOLLER uses essentially the same readout chain that Q_{weak} used.
- Particle shielding is 40% of the Hall A Infrastructure and Integration budget yet has a high level of cost uncertainty due to the early stage of its design. The shielding cost could be up to $700k higher than the cost estimate used in MOLLER project planning.

- According to the latest models of the radiation levels emitted, the neutron and EM radiation should be several orders of magnitude below damage thresholds.
- There is a 30% cost contingency on the concrete portion of the shielding. The volume of the shielding is currently known but the specific shapes that are needed are not and depend upon the design of the equipment that is being shielded.
- The approach is to install the shielding as close to radiation sources as possible.
- Backwards scattering upstream of the target should not produce significant radiation levels, even considering the thermal neutrons that are produced.

Comments

- The ANSYS Computational Fluid Dynamics (CFD) model with a smaller, simplified target geometry demonstrated the value in quantifying the density fluctuations in the target. An updated analysis with the full 125 cm scale target and new geometry will be valuable in informing the final design.

Recommendations

- Prioritize the completion of the design of the shielding due to its significant cost risk.

SC-3 Spectrometer, Collimators and Beam Pipes

Committee Members: David Harding, Steve Gourlay

Findings

- The elements of the spectrometer include two resistive toroidal magnets, collimators, beam blockers (for background studies) and the beamline. The spectrometer components are integrated with other parts of the experiment.
- Engineering requirements and associated scope have been developed that meet the goals for the scientific and technical needs of the experiment.
- Tolerances determined by single coil/single offset studies have been verified with "worst-case" multiple coil/multiple offsets within the specified tolerances.
- Two designs are still being considered for the downstream torus: A single, hybrid design is comprised of four interleaved coils and a segmented design using four separated coils. The pros and cons of the two coil designs are being evaluated.
- The project plans is to issue a Request for Proposal (RFP) for a prototype coil with an option for the seven production coils. If the prototype is satisfactory for use, it will become the spare.
- An opportunity for resource leveling has been identified.
- The team has converged on designs for the upstream and downstream vacuum vessels.
- A nominal testing program has been developed

- Preliminary designs for collimators, beam pipes and windows have been established.
- A hybrid version of one downstream torus coil has been successfully built and tested.
- Custom bellows will be required in some cases. Capable vendors have not yet been identified.
- Field mapping requirements are under development
- A high-level schedule and initial cost estimates have been produced.
- The labor profile that was shown has a 6-month dip followed by a rapid rise starting in the last half of FY23.
- A number of risks have been identified with one (delivery of power supplies) deemed high due to a long procurement lead-time.
- A KPP on installation and confirmation of alignment of collimators, beam pipes and shielding to beam line and spectrometer magnetic axis has been added as per a previous review recommendation.

Comments

- The conceptual design appears to meet physics goals and is at an appropriate level for this stage of the project.
- The collaboration and the project are working well together, with simulations informing design constraints and designs being tested with physics simulations – magnetic field modeling and particle tracking. This is intrinsically a slow process, but with a strong team in place there has been significant progress since the last review.
- Design issues have been systematically addressed, including maintaining the necessary aperture, minimizing scattering that would generate backgrounds, minimizing radiation exposure to the coil insulation, determining tolerances for fabrication and alignment errors. This work has led to tolerances that appear achievable with continued attention to a myriad of details.
- The successful fabrication of a hybrid downstream torus coil prototype that met some design requirements is an important step to retire risks to the experiment and gives confidence in some fundamental aspects of the design. While the measurements of the early prototype coil addressed electrical, water flow, and heating issues, the mechanical stability and tolerances remain to be demonstrated by a second prototype coil to be fabricated when the vendor is chosen.
- The torus coil procurement schedule is technically limited, with much engineering still to be done in concert with the detailed design of strongbacks, support frame, vacuum vessel, and the rest of the spectrometer. The down select on the downstream torus should be made as soon as reasonably possible.
- The coil procurement concept is sound. The schedule can be optimized by issuing the RFP for a prototype coil under CD-1 funding, with an option for the seven

production coils after CD-3. Against the possibility that the prototype is not usable, the project could include an option in the RFP for an eighth production coil.

- After an initial lag, the delivery of the production coils are expected at a rate of one per month. This mitigates the schedule risk on the coil delivery.
- The staggered delivery of downstream torus coils also offers the opportunity to advance the schedule. The current logic in P6 does not start assembly onto strongbacks until all coils are received, but that work could start as soon as the first coil is received and tested. This will also help level the demand for mechanical assembly technicians that shows a worrisome spike in FY24Q1-Q2.
- The magnetic field mapping requirements have not been established, but were plausibly described as very loose, mainly checking that the unwanted bending field seen by the unscattered beam is minimal.
- The final power supply specifications require a final magnet design. The highest current supply is forecast as a 12-month procurement of a single item, raising its profile as a schedule risk.
- After CD-1, consider ways to accelerate the power supply procurement to mitigate the identified schedule risk.
- There has been significant progress on the engineering design of the downstream torus support system
- The convergence of the vacuum vessel designs is a good example of productive joint work between the collaboration and JLab engineers.
- Key elements relative to the design of the spectrometer components have been identified, e.g. fabrication and alignment tolerances, possible effects of radiation, cooling, etc. There are many details left but the design is at the appropriate level for this stage of the project.
- The proposed resource leveling and correction of a logic error in the current schedule will put the spectrometer further from the possibility of falling onto the critical path.
- Having cost estimates from four vendors for the downstream torus coils (~50% of the total cost of the WBS element) adds plausibility.
- The CAM identified a few discrepancies between the P6 plan and the Basis of Estimate document, where the BoE had not been updated to reflect the current understanding.
- No mention was made by name of the KPPs in the talks, although two of the KPPs are about spectrometer performance.
- Assembly and installation work would be challenging under pandemic work guidelines, but that effort is three years away and JLab will have experience from at least one major experiment installation between now and then.

Recommendations

- None

SC-4 Detectors and DAQ

Committee Members: Renee Fatemi, Haiyan Gao, Sergio Zimmermann, Will Jacobs

Findings

- Technical presentations were given in separate breakout sessions for the tracking detectors, the integrating detectors and for trigger and DAQ; details of budget and schedule were given in subsequent "CAM sessions". The assembled presentations reflected those elements expected to be the content of the upcoming CD-1 review.
- The collaboration has addressed a major GEM detector motion-related issue raised in the Jan 2020 Director's review. The current plan is for the GEM detectors together with the scintillators (attached to two GEM planes) to be moved in and out radially between the two data taking modes.
- Both the tracking and the main integrating detectors will be built based on proven technologies. There are no high-risk areas associated with the conceptual design of the detectors.
- The electronics system, with the exception of a new integrating ADC currently under development, will largely use existing modules or updates to existing electronics.
- There does not appear to be any significant COVID-19 related impact on the planned detector prototyping and beam test plans.
- The tracking system will be used at low beam currents to study a number of important aspects of the experiment such as the verification of the kinematic factor, spectrometer optics, event-rate map for background determination, etc.
- Two previous detector-related recommendations are still open and are being addressed.
- The MOLLER detector system operates in two modes: tracking mode and integrating mode. The photomultiplier tubes (PMTs) will be in place for these two modes, while the GEMs are used just in the tracking mode. The PMT base has a relay that routes the output to two different pieces of electronics. One is designed for tracking and the other for integrating.
- The PMT base is part of the PMT detector system. The proposal for grounding is to have the entire electronics chain grounded via the PMT HV and have separate voltage regulators on each component, supplied by ground isolated power supplies.
- The GEM detectors will use the same readout IC used in the SBS experiment.
- A list of required electronics for each operating mode (tracking or integrating) was presented.
- The project has identified a total of 8 risks associated with DAQ, Trigger and Monitoring. Seven risks are moderate risks and one is high.
- The collaboration is working on radiation estimates for the detector region. Those estimates are expected to be ready this month.
- Radiation damage is included in the Risk Registry.

- The groups responsible for various sub detectors in the collaboration are highly experienced and committed.
- The collaboration is actively seeking funding from the NSF mid-scale program, and also from the Canadian funding agency, and will find out whether these efforts are successful later this fall.

Comments

- The maturity of the design, implementation, schedule and budgetary details is impressive for this stage of a project that is now preparing for the OPA CD-1 review in the next month.
- We see no "show-stoppers" in any of the plans for the tracking and integrating detectors, or for trigger and DAQ. The designs of the tracking system and the main counting detector and the specifications will meet the requirements of the proposed science goals, and there are also ``redundancy/insurance'' built in the overall design to mitigate potential issues.
- The concept of the new motion mechanism for the GEMs (and scintillators attached) appears to be more practical and robust compared with the previous concept of flipping the detectors.
- Data taking in the counting mode at beam currents higher than the proposed 100 nA will relieve any ``unexpected'' beam current related systematic issues that may impact the Parity Violating (PV) asymmetry determination.
- More detailed simulations of the detector performance under realistic background environments will be important to close the remaining two detector-related recommendations from previous reviews. The timely down-selection of the downstream magnetic coil design will be helpful to the simulation effort.
- It is a good strategy to use, as much as reasonable, electronics already developed for other experiments or to implement minor/small modifications if needed. It reduces costs and risks, and allows for reuse of parts of firmware and software. While there is some risk of obsolescence of the older modules, this is not a big concern.
- The trigger will be built around the existing CODA system (CEBAF On-Line DAQ) already developed at JLab. The Integrator Board being designed at TRIUMF will be updated to include the interface with Trigger Supervisor (TS). The TS also synchronizes the DAQ system. It will be helpful to include more details of the trigger system during the presentation at the CD-1 review.
- The project would profit from an overall grounding and shielding strategy. It may not be practical or cost-effective to have the PMT electronics independently grounded on the detector side for every signal path as this requires ground isolation on every component (e.g., electronics input amplifier, ADCs, etc.)
- Early in the design phase the project must define its electronics grounding and shielding strategy.
- The Electronics team should use the estimation of the radiation type and dose to assess possible damage or single event upset on the front-end electronics. The team has to understand these effects and plan to mitigate them. Observe that a lot of information is available in the literature and from result of previous tests.

Recommendations

- None

2020 Pre-CD1 Director's Review of MOLLER Charge

The MOLLER experiment was approved by the Jefferson Lab PAC in 2009. There was a successful Science Review convened by DOE-NP in 2014. A Director's Review was held in 2016 to assess the conceptual design and provide advice on pre-project planning and development. MOLLER received DOE CD-0 "Approve Mission Need" in December 2016, which was followed by a pause due to lack of funding. In anticipation of a project restart, a Director's Review was held in 2019 to assess the progress of MOLLER towards CD-1. The project has made significant progress in anticipation of a DOE CD-1 review in September 2020. We would like this Director's Review to assess the readiness of the MOLLER project for the anticipated DOE CD-1 review.

In carrying out your review of the MOLLER Project, please evaluate whether the project is ready to move to the next stage of preliminary design towards CD-2. In so doing, please respond to the following questions:

1. Science Basis: Is the MOLLER conceptual design capable of achieving the scientific goals of the experiment?

2. Conceptual Design: Is the MOLLER conceptual design sound, achievable and sufficiently defined to meet the specified technical requirements? Are technical risks properly identified and are appropriate mitigation strategies in place?

3. KPP: Are the proposed Key Performance Parameters (KPP) appropriate for determination of successful project completion?

4. Cost and Schedule: Are the cost and schedule estimates credible for this stage of the project and mature enough to establish the cost range for the project? Do they include adequate scope, cost and schedule contingency?

5. Management: Is the Project being properly managed at this stage? Is there a capable team in place to effectively manage risks and develop a robust baseline in the next phase?

6. ES&H: Is ES&H being properly addressed given the project's current stage of development?

7. CD-1 Requirements: Has the project met all the prerequisite requirements for CD-1 approval?

8. Previous reviews: Has the project team responded appropriately to recommendations from prior Reviews?

MOLLER Director's Review Committee

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Appendix

Suggestions to Improve Presentations and Documentation in Preparation for the CD-1 Review

- Emphasize the Scope of the Project in the CD-1 Overview and CAM talks.
- Have a slide in the Overview talk that clearly defines the deliverables. Have a slide in each L2 talk that defines the L2-specific deliverables.
- The technical status of the MOLLER project should be reported in the overview talks of the CD-1 review including all design, R&D and prototyping work.
- The rational for the CD-1 cost range should be explained in the overview talk at the CD-1 review.
- A back up slide should be prepared explaining how the MIE scope would change if the NSF and/or CFI proposals were approved.
- Get buy-in from NP and TJSO for KPPs and UPPs prior to the CD-1 review.
- The pPEP doesn't include a description of the Project Team responsibilities. Consider adding that to the document.
- Consider writing a separate Analysis of Alternatives document in preparation for CD-1.
- There should be a dedicated Cost and Schedule talk in the plenary session of the review
- Consider promoting the ESH & Q talk to the plenary session of the CD-1 review to show the proper emphasis the project gives the safety and quality assurance issues.
- Each CAM should have an ESH&Q slides specific to their project responsibility.
- Consider promoting all the L2 CAM talks to the plenary session of the CD-1 review.
- All plenary talks should have a line on the summary slide that states "MOLLER ready for CD-1 approval" or something similar.
- All slides on all talks need to be up to date with consistent data, figures, numbers, dates, etc. There were inconsistencies in the presentations at this review.
- The discussion on COVID-19 impact can be made with better justification. It is a high level concern with DOE right now and should be given visibility in the review presentations.
- Consider writing a brief schedule-basis document to explain the dependencies and assumptions.
- The project has L3 managers as part of their project management team. It would be beneficial to show the WBS L3 management organization in an Overview slide.
- It is beneficial to show the project team as a well-integrated team of JLab CAMs and the collaboration technical leads. The Project team should consider ways to highlight this in the review presentations.
- Mention the existence of the Advanced Procurement Plan in the Overview talk and post it with the CD-1 support documents.
- Organize a rehearsal of the CD-1 Review talks prior to the CD-1 Review. Leave

time for a second rehearsal if necessary. Include an experienced reviewer in the group that sits in on the rehearsals.

- Practice drill downs with all of the CAMs prior to a CD-1 review.
- CAMs should be responsible for calculating their contingency and determining if it was adequate.
- The current cost summary document is only provided with a L2 breakdown. It will be useful to also have cost summary table for each L2 system with a L3 breakdown. This will be useful for the presentation.
- Consider adding “L2” or “L3” to each CAM designation to help clarify their roles for the review committee.
- Check and make sure the BoE and summary tables are consistent.
- Develop a uniform naming scheme for the CD-1 review presentation files that sorts into an order useful for a reviewer wanting to open a downloaded local copy during a talk.
- The Project Manager should make sure all speakers and subject matter experts adhere to a question and answer protocol during the plenary and parallel sessions. Generally the speaker should be the one answering the questions from the review committee.
- Attention should be paid to the associated text (bullets) to avoid confusion and add important details to the content and "take-away" message.
- Annotation on technical drawings and charts should be improved to facilitate orientation and more clearly indicate crucial aspects. CAD generated renditions may be faithful to detail, but difficult for the uninitiated to discern the pieces under discussion. Be aware that some of the details in large drawings are difficult to see on current slides.
- Minimize the use of JLab-centric acronyms without further definition on slides.
- For the technical talks, it is important to indicate the deeper investigation and consideration of the various purchasing or design decisions via mention/link to the "requirements" documentation or detailed technical note. For example, the detailed technical specifications/selection of the integrating detectors’ photomultiplier tube (PMT) -- an essential piece of the experiment-- could be collected in a short table for presentation/backup.
- CAM budgetary presentations should be more accessible. They should tell a story and flow logically from one topic to the next. Appropriate and consistent units that are readily explicable (e.g., burdened, fully burdened and escalated) should be used so that the committee can easily grasp the overall picture. Avoid using jargon as much as possible.
- A more systematic approach should be used when presenting budget and schedule information. Material prepared for "drill down" or different budgetary slice views should generally be relegated to backup. The main subgroup budgetary presentation should have a clear flow from item-specific costs to subsequent inclusion in WBS breakout, additional costs included, and then how it all sums to the final breakout pie chart pictured.

- Common presentation materials generated from the project management software (Primavera, "P6") should be optimized for individual CAM breakout section use so as to make schedule and effort use visuals more relevant and clear.