ProtoDUNE-II Integration Meeting Minutes

Meeting Notes (4/21/21):

Dimitar showed his updated models of the laser periscopes situated within the selected penetrations (2.5 and 2.7). He did not observe any interferences, even in the worst-case positioning of the periscopes within the penetrations.

The CALCI consortium presented a concept for how the laser boxes could be positioned on the top of the cryostat to service the periscopes in penetrations 2.5 and 2.7. The proposed location of the box serving penetration 2.5 would cover penetration 18.2, which was used for cameras in ProtoDUNE-II. It was noted that this particular penetration is not currently planned to be used in ProtoDUNE-II and that penetration would be accessible if needed in any case. The group therefore agreed that the proposed laser box locations were preferable to avoid potential interferences with the walkway going around the top of the cryostat. Jan promised to develop a model of a stand for the laser boxes that could be supported from the beams of the cryostat roof and pass this to Dimitar for validation.

It was mentioned that it might be useful at some point to perform a test to see if a single laser box could service multiple penetrations. However, performing such a test would likely require placing a laser box on the walkway. Proposed DUNE FD laser locations that could be serviced by a single laser are also significantly closer to one another than the proposed ProtoDUNE-II laser penetrations, and it’s not clear that beam alignment and stability can be maintained over such a long distance. Therefore, the default plan is to stick with having separate laser boxes for each periscope. A test could potentially be performed later if determined to be useful.

Dimitar showed the updated models of the ProtoDUNE-II supports for both the right-side up and upside-down APAs including also the trolleys used during installation. No interferences are observed (final connections to the DSS beams are required to be in place before the trolleys are removed).

Dimitar noted that because the position of the TPC within the cryostat is being modified to be more DUNE-like, new holes would need to be drilled in the DSS beams to support the APAs and the Cathode Planes. A total of 32 additional slotted holes will be required based on the current detector position. Dimitar suggested it would be possible to drill new holes in place without having to remove the DSS beams from the cryostat. He promised to investigate further as to exactly what would be necessary.

It may be possible to reduce the number of additional holes that need to be drilled by changing the position of the TPC within the cryostat. Current configuration has 1.84m and 1.89 spacing between end-wall field cages and the front/back walls of the cryostat, respectively. This mimics 1816mm spacing between end-wall field cages and both ends of DUNE FD cryostat.

Model for upside-down APA still needs to be modified to eliminate interferences at the bottom of the cold box. [Post-meeting Update: Kyle sent Dimitar an updated model incorporating new ProtoDUNE-II cable tray, flat head screws at bottom of the APA, and APA yoke moved 8mm toward the adapter piece (no change to trolley). Changes result in a 7mm clearance at the bottom of the Cold Box (confirmed by Dimitar).]

Meeting Notes (4/14/21):

Based on the information provided by Dimitar, the CALCI consortium concluded that potential inclinations in the laser periscopes originating from cryostat deformations that occur during the cool-down process and from normal pressure variations are not problematic in terms of being able to operate the system.

However, due to the close proximity of a DSS runway beam to the proposed laser periscope in penetration 2.8 (the beam slightly protrudes into the space under the penetration), the CALCI consortium prefers to use penetrations 2.5 and 2.7 (as opposed to 2.6 and 2.8). Studies were completed by the CALCI consortium demonstrating that the overall performance of the system is not degraded by having the end-wall periscope located at a distance of roughly 1m from the end-wall field cage (penetration 2.5) as opposed to on the order of 40cm (penetration 2.8) that more closely mimics the situation in the FD.

The group agreed to lock in the choice of penetrations 2.5 and 2.7 for the laser periscopes in lieu of any additional issues being raised. This choice means that the APA signal penetrations are now locked into penetrations 2.2 and 2.6. Cold Electronics consortium will now work to finalize cable routing from APAs to the penetrations (and understand what to do with excess cable coming from upside-down APAs).

Dimitar showed that there was still a potential clearance issue of a few milli-meters between upside-down APAs and the bottom of the cold box. Kyle and Manhong promised to explore if we could recover a few additional milli-meters by using flat-head screws for attaching the bottom APA cable shield and raising the APA yoke towards the trolley.

Dimitar also showed an updated design for the support used for connecting APAs to the DSS beams with the additional, requested spherical washer. As in the case of the APA trolley, the design mimics that of the one for the DUNE FD as closely as possible. Dimitar indicated that currently he did not observe any issues with the updated design.

Meeting Notes (4/13/21):

Discussed plans for how we would handle the ProtoDUNE-II APAs. Noted that at least first (right-side up) APA would arrive in “old” ProtoDUNE-I shipping frame. Later APAs including up-side down APAs would arrive in new shipping frames.

New APAs arriving in old shipping frame require updated structural analysis due to increased APA mass. Dan pointed out that lifting fixture requires longer bars to increase the separation between the fixture and the APA. PSL will fabricate the modified lifting fixture in time for the Ash River installation tests this summer and update the structural analysis.

The APA trolleys used in ProtoDUNE-II will follow the new design targeting the DUNE FD. The ProtoDUNE-II trolley widths will be smaller than those for the DUNE FD due to the widths of the DSS beams. Bill has the final trolley drawings and is in the process of fabricating a few of these for the planned Ash River tests this summer. Dimitar is responsible for performing the required structural analysis.

In addition, load tests of the new APA trolleys will be needed. The ProtoDUNE-I trolleys were subjected to a load test at liquid nitrogen temperatures, and it’s expected that the new trolleys will need to undergo an equivalent test. We need to coordinate with Olga and the CERN safety team to ensure that load testing meets CERN requirements such that the tests will not need to be repeated later on.

Once the new trolleys are validated, we will also need to re-analyze the ProtoDUNE-II load cases (e.g. placement on the rails, insertion into the cold box, and movement into the cryostat) for the new, heavier APAs. In ProtoDUNE-I, a special clamp was used for attaching the APA to the beam in the cold box to prevent the APA from falling in the event that one of the trolleys failed structurally in the cold. It’s expected that this will remain a requirement in ProtoDUNE-II.

In the case of the APAs that will arrive later in the new shipping frames, it’s expected that these will be handled equivalently to DUNE FD APAs, and therefore the load cases currently being incorporated within the DUNE FD structural analysis of the new APA shipping frame should be sufficient for ProtoDUNE-II as well.

Meeting Notes (4/7/21):

Dimitar reported that the maximum inclination of cryostat roof during the filling in the area of the laser penetrations is estimated to be 0.1 degree. Maximum inclinations expected from pressure differences in the ullage is expected to be +/- 0.02 degrees.

CALCI consortium showed that the full range of movement of the end-wall periscope situated in penetration 2.8 results in a 10mm clearance with the runway beam the partially overlapping runway beam. The additional clearance needed to accommodate the maximum expected roof inclination (0.1 degrees) is 4.5mm, which nominally fits but is potentially uncomfortably tight. In this configuration, software controls would likely be necessary to restrict the full range of motion of the periscope.

Based on these facts, the CALCI consortium asked to re-visit whether penetrations 2.5 and 2.7 might be better locations for the laser periscopes. Penetration 2.5 sits further away from the end-wall (over 1m) compared to Penetration 2.8, which sits roughly 40cm from the opposite end-wall (close to the nominal DUNE distance). Sitting further away from the end-wall is not necessarily problematic from the standpoint of the calibration itself as the motion of the periscope can compensate for the smaller observed angular opening between the field-cage profiles resulting from the laser being placed at a greater distance from the end-wall. The CALCI consortium agreed to study the issue further and make a recommendation at the next meeting.

Dimitar showed some initial pictures of an updated mount to be used for connecting APAs to the DSS beams incorporating the proposed, additional spherical washer. Currently, there are some clearance issues that Dimitar thought it would be possible to solve but still needed to be worked through.

Meeting Notes (3/31/21):

Dimitar had received current models for the laser periscopes and boxes and integrated them into his global model using penetrations 2.6 and 2.8. Penetration 2.8 is partially blocked from below by one of the runway beams, but the global model shows that there is enough room for the periscope, particularly if the periscope is offset from the center of the penetration (towards the middle of the detector).

Dimitar also showed that there does appear to be enough space available to mount the laser boxes on the top of the cryostat. The idea is that the laser boxes will be mounted high enough such that the beams will be run above any potential interferences on the top of the cryostat and be directed downwards into the periscopes (allowing room for the periscope to be placed in either its retracted or extended positions). For safety reasons, enclosed piping will be used to contain the beam as it traverses the top of the cryostat.

An issue was raised about the deformation of the top of the cryostat during the filling process and whether misalignments of the periscope laser coming from the inclination of the cryostat roof could be self-corrected. It was reported that the laser penetration on top of the field cage did have such a mechanism, but that this mechanism was not currently incorporated into the design of the end-wall periscope. This mechanism could be included in the end-wall design if necessary.

Dimitar showed a model of the upside-down APA entering the TCO with a potential clearance issue. Kyle noted that there are two models for the upside-down APA (for the APA in its raised and lowered positions). The APA is moved only into its lowered position once it is sitting in its final location within the cryostat. Conversely, the upside-down APAs are located in their raised position when entering the cryostat through the TCO and into the Cold Box.

Kyle noted that the model for the upside-down APA had not yet been updated to include the new cabling arrangement at the bottom of the upside-down APA, which allows the protective shield to be raised by 2cm. Kyle promised to send Dimitar the updated model so that he can confirm that this modification provides sufficient clearance for the upside-down APAs to enter the Cold Box. (Post-Meeting Note: Kyle delivered updated models to Dimitar on April 7th).

Re-affirmed the plan to use a modified version of the new DUNE APA trolleys (single trolley as opposed to two trolleys used in ProtoDUNE-I). Also, re-affirmed desire for additional spherical washer at permanent connection between APA and DSS beam. Kyle noted that the current model showed an interference at the point where the APA connects to the DSS. Dimitar will have a look and make an assessment.

Meeting Notes (3/29/21):

Smaller group discussion on how to initially configure TPC in the warm so that it winds up in the optimal position after cool-down and filling. Agreement on the following:

Want the TPC drift distance to be 3574 mm after cryostat filling. This implies that DSS beams are placed 3583 mm apart in warm. This would also be the length of the stainless-steel ground plane supports that run between (and are connected to) the DSS beams.

Top field cage modules would be built to a length of 3580mm. A preference was expressed for not relying on friction-based sliding motion of the field cage module relative to their latches during the cooling process to account for the different CTEs of the stainless-steel beams and the FRP field-cage supports. The proposed plan for the top and bottom field cage modules would therefore be to provide only a 2mm tolerance in the diameter of holes used to attach the latches (consistent with the tolerances of the drill holes and bolts used to connect the DSS beams to the runaway beams), the effect of which would be to essentially fix the positions of the field cage supports and stainless-steel beams and cause them to not line up vertically in the warm state.

To accommodate this difference in the warm, spherical joints would need to be employed at the connections of the APA mount with both the DSS beam and at the APA itself. These spherical joints would allow for a small inclination of the APA mount while the TPC is in its warm state. After filling, the APA mount would nominally return to hanging in the vertical direction.

Meeting Notes (3/17/21):

Dimitar highlighted some of the features of the just-released updated ProtoDUNE-II integration model. Drift distances match the nominal DUNE value of 3574mm, with the consequence that the beams supporting the APAs do not lie directly underneath the DSS supports. The position of the detector along the direction of the beam is chosen so that the front (back) face of the end-wall field cage assemblies is 1.84m (1.89m) from the cryostat membrane (consistent with plans for the DUNE detector).

Dimitar showed two potential top ground plane configurations, where the ground planes are installed in either a parallel or perpendicular orientation with respect to the upper field cage assemblies. The perpendicular orientation may have an advantage in that it could make it easier to cover the region directly over the CPA modules. Dimitar will continue to explore the two options with the HV consortium.

Extended discussion with CALCI consortium representatives regarding the best penetrations for the proposed laser systems. Preference of CALCI consortium is penetrations 2.6 and 2.8. These choices are based on desire to cover drift volume penetrated by beam; space the penetrations as far apart as possible from one another; and have the penetration for the laser outside the TPC at roughly the same distance from the end-wall field cage assemblies as what would be expected for DUNE.

It was noted that penetration 2.8 is at least partially covered by one of the three upper runway beams. Dimitar’s initial check indicated that the overlap between the outer diameter of the penetration and the beam was 24mm (out of 250mm). The diameter of the laser periscope was quoted as 180mm. In principal, there should not be interference with the runway beam even in the case where the laser periscope is centered within the penetration. Additional clearance can be gained by translating the periscope in the direction opposite to the beam. CALCI promised to look at this in closer detail utilizing the updated CAD model.

Based on a first look at the model, the cold electronics consortium indicated that they believed it would be possible for them to move their signal flange from penetration 2.6 to 2.7. There could be a need to change the orientation of or move one of the warm electronics racks, which Filippo did not believe would be a big issue. Cold electronics consortium needs to study their cable routing in more detail to ensure that there are no issues.

Position of penetration 2.6 relative to the top field-cage assembly looked good in the sense that it did not overlap the assembly support beams. HV consortium expressed confidence that they could modify design of this specific field cage assembly to allow for penetration of the laser periscope into the TPC. Did note that at least one of the resistor-divider chains would need to be re-located, but HV consortium did not consider this to be a big issue.

CISC consortium engineering team showed a conceptual design for a single laser box feeding both penetrations supported from a platform hanging off one side of the cryostat. The group consensus is that this probably not the correct approach as it would be difficult to transmit the beam across the entire top of the cryostat both in terms of preserving the beam alignment and intensity and having to navigate other infrastructure on the top of the cryostat. Recommended that engineering team should consider placement of two laser tables closer to the individual penetrations. CISC engineering team should develop a proposal based on the just-released integrated ProtoDUNE-II CAD model. Full integration of the CISC components into the full CAD model would need to be done by Dimitar once a conceptual approach is agreed upon.

Meeting Notes (3/10/21):

Dimitar showed updated pictures of the DUNE-style signal flanges (crosses) attached to penetrations 2.2 and 2.6 with the flanges attached directly to the top of the penetrations. No obvious interferences were noted. Discussion ensued regarding which cryostat penetrations would be needed to host the proposed laser calibration systems. Eric promised to invite CALCI consortium representatives to the next meeting to further explore this issue.

Dimitar also showed an updated model of the detector assembly based on the models received from Kyle. The updated model also incorporated initial conceptual designs for the bottom ground plane supports and beam plug supports. Feedback was positive and Dimitar indicated that he planned to continue to advance these designs over the next week along with the design for the top ground plane supports.

Dimitar promised to release the updated ProtoDUNE-II CAD model in EDMS before the next meeting. [Post-meeting Update: Dimitar released the updated ProtoDUNE-II CAD model in EDMS on 3/16/21. See <https://edms.cern.ch/project/CERN-0000209067>.]

Dan Wenman raised two additional questions for the group to consider. The first is whether the modified APA trolleys are acceptable for supporting the weight of the APA in the cold box which was an issue originally identified for ProtoDUNE-I. The new trolleys utilize smaller wheels, which may not satisfy the 5x safety factor employed for ProtoDUNE-I to ensure that brittleness encountered in the cold could not lead to an APA falling from rail. Note that an additional clamp was also used in the cold box during ProtoDUNE-I to protect the APA from falling in the event of a structural failure of the trolley. The second question was about potential bending loads in the M20 rod that supports the APA from the DSS beams. Dan is concerned that the bending loads may lead to safety issues in the case where there is not a spherical joint in the connection between the beam and the APA to accommodate material differences between the DSS and TPC during the cool-down process. There was not enough time remaining in the meeting to discuss these questions in detail, so Eric agreed to include them in the list of questions to be addressed by the group.

Meeting Notes (2/24/21):

Dimitar showed CAD model images of DUNE-style signal flanges (crosses) attached to penetrations 2.2 and 2.6 of NP04 cryostat. No interferences noted, but it was pointed out that flanges should be attached directly to top of penetrations (not to the tops of old protoDUNE-style flanges). When lowered the crosses could have interferences with the warm interface crates, although this could be solved by rotating the crosses. Dimitar promised to produce new images with the old protoDUNE-style flanges removed.

Confirmed that the two upside-down APAs would be installed on the left side of the cryostat (viewing the cryostat from the direction of the incoming beam). The upside-down APAs sit lower in the cryostat and need to be on the left-side to avoid interferences with the cryogenic pipes at the bottom of the cryostat.

Discussed clearance of upside-down APA in cold box. In the raised position of the APA, the shield panel that protects the bottom cables interferes with the bottom layer of insulation in the Cold Box. Some insulation can be removed, but the panel also overlaps with the steel support structures of the box at the level of a few mm. Modifications to the steel structure are more involved.

Manhong showed the current situation with the routing of the readout cables at the bottom of the APA. It seems likely that smaller bend angles on the cables can be used allowing the bottom shields to be raised at least 1 cm higher (2cm looks more difficult). Manhong promised to use his test setup at BNL to study what would be possible and report back. In the meantime, engineers promised to re-look at the stack up and tolerances to ensure that the Cold Box will be able to accommodate the upside-down APA assuming that 1-2cm can be recovered from the space reserved at the bottom for the able plant.

[Post-meeting updates: Manhong confirmed on his test-setup that we can recover 2cm at the bottom of the APA by modifying the cable bend radius. Manhong will send an updated model to Kyle incorporating the thinner protective sheet advertised at the meeting. We still need to discuss whether this change will apply to just ProtoDUNE-II or to both ProtoDUNE-II and DUNE. In either case, Dan will produce an updated design for the stand-offs that hold the protective sheet (reducing their length by 2cm).]

Dimitar showed updated CAD models for HV system components received from Vic. Included were proposed changes to the end-wall connection to the DSS and proposed modifications for supporting the beam plug and upper ground planes. It was noted that the CAD model updates were not based on the most recent (and released) ProtoDUNE-II integration model. [Post-meeting updates: Vic sent the updated models of the HV components to Kyle who integrated them into the current ProtoDUNE-II detector model. Kyle then passed the updated models to Dimitar for integration into the global ProtoDUNE-II model. Dimitar conformed via email that everything looked ok.]

Meeting Notes (2/17/21):

Confirmed intent to use DUNE-style signal flanges (crosses) in cryostat penetrations closest to middle of side-by-side APA pairs. Still need to confirm that there are no interferences on top of cryostat. Jack agreed to send flange model to Dimitar so that these checks could be performed within the integrated model.

Confirmed intent to use DUNE-Style cable trays that are supported from separate trolleys during the installation process. The one difference with respect to DUNE is that the additional vertical cable tray, which supports the cables coming from the bottom APA in the doublet, is not needed. Once the APA is in its final position the cable trays are clamped directly to the DSS beams and the supporting trolleys are removed.

Need to ensure that wheels of trolleys supporting cable trays have sufficient headroom to support the weight at the decreased temperatures that will be seen inside Cold Box. It was noted that the APA trolleys used in ProtoDUNE-I were rated for 5x higher loads than what was actually required. It was also noted that an additional clamping fixture was used during the ProtoDUNE-I installation process to provide a second attachment of the APA to supporting beam inside the Cold Box to ensure that the APA would not fall if the trolleys were to fail.

Kyle’s model did not yet include the DUNE-style cable trays. He promised to incorporate these and send the updated design to Dimitar so he could do final checks within the integrated model (and check for potential Cold Box interferences). [Post-meeting update: Kyle sent out an email on 12/19 pointing to the revised models]. It was felt that the current cable tray design would work for both the right-side up and up-side down APAs. This needs to be confirmed within the integrated model.

Confirmed that PSL considers the design of the hardware for supporting up-side down APAs (as well as raising and lowering them during the installation process) to be final. Structural analysis will be performed this spring in advance of planned prototyping tests at Ash River scheduled for this summer. Also confirmed that it would not be necessary to support up-side down APAs from the dual trolley system used in ProtoDUNE-I. Yoke used to support up-side down APAs will only accommodate new DUNE-Style APA trolley, although a slightly modified version of the design will be needed for ProtoDUNE-II due to the reduced width of the DSS beams.

Design leads to unavoidable interference at the bottom of the Cold Box of a few centi-meters. Dimitar expects that it will not be difficult to modify the Cold Box (removing a small amount of the bottom installation) to accommodate the current design. Kyle will pass the final design to Dimitri so he can confirm that the necessary modifications are manageable.

Cold electronics support hardware at bottom of up-side down APA will be the same as that planned for DUNE. Checks are needed to ensure that the new hardware does not interfere with the closing of the latches that connect to bottom field cages to the APAs.

Meeting Notes (2/10/21):

Bo showed three potential methods for supporting the end-walls from the DSS. There was consensus that his “simple” approach in which the end-walls are supported directly from the currently unused DSS beams was best. This will require drilling holes in the bottom of these beams for the final fixturing (end-walls could be supported via trolleys during the installation process to provide some movement flexibility).

End-wall installation is anticipated to be performed via pulleys attached to a temporary fixture supported from the DSS beams. It was pointed out that it would be ideal if this temporary fixture could be supported from the beams using a clamping mechanism rather than relying on additional new holes that would need to be drilled in the existing DSS beams at the top of the cryostat.

Additional permanent support beams orthogonal to the direction of the five primary DSS beams will be needed to support the upper ground plane modules. Bo did not think it would be possible to support these solely from the currently unused DSS beams as the center-of-gravity of the ground plane loads would not be located along the unused beam axes. Based on the assumption that the ground plane support beams need to be connected to more than one beam, shrinkage issues need to be taken into consideration (either using stainless steel to be consistent with current DSS or incorporate sliding mechanism on one end or the other if using FRP).

Bo showed a potential design for supporting the beam-plug without specifying how to attach the supports to the DSS. Concerns were raised about how to ensure that the beam plug will remain in the path of the incoming particle beam after cool-down and filling. General agreement that the approach looked reasonable pending the additional design issues to be worked through.

Agreement that it would be useful to install a piece of invar within the volume of the gas ullage to study aging and if it has any adverse effect on liquid argon purity. The installed piece should not have any structural role in supporting the detector.

Short discussion on how bottom ground plane modules could be supported from cryostat floor. It was noted that ProtoDUNE-I cameras showed pipes along cryostat floor moving during filling process and that we would need a mechanism to ensure that ground planes are safely secured in place to prevent possible detector damage.

Next Steps: Bo will provide additional conceptual design details to Dimitar. Dimitar will then examine the proposed design at a more detailed engineering level (expects to be able to report back in about two weeks). In the meantime, plan to use next week’s meeting to have an initial discussion about some of the APA-related issues on the attached list. Eric will work to re-engage the CALCI Integration Steering Group to discuss ProtoDUNE-II instrumentation needs.