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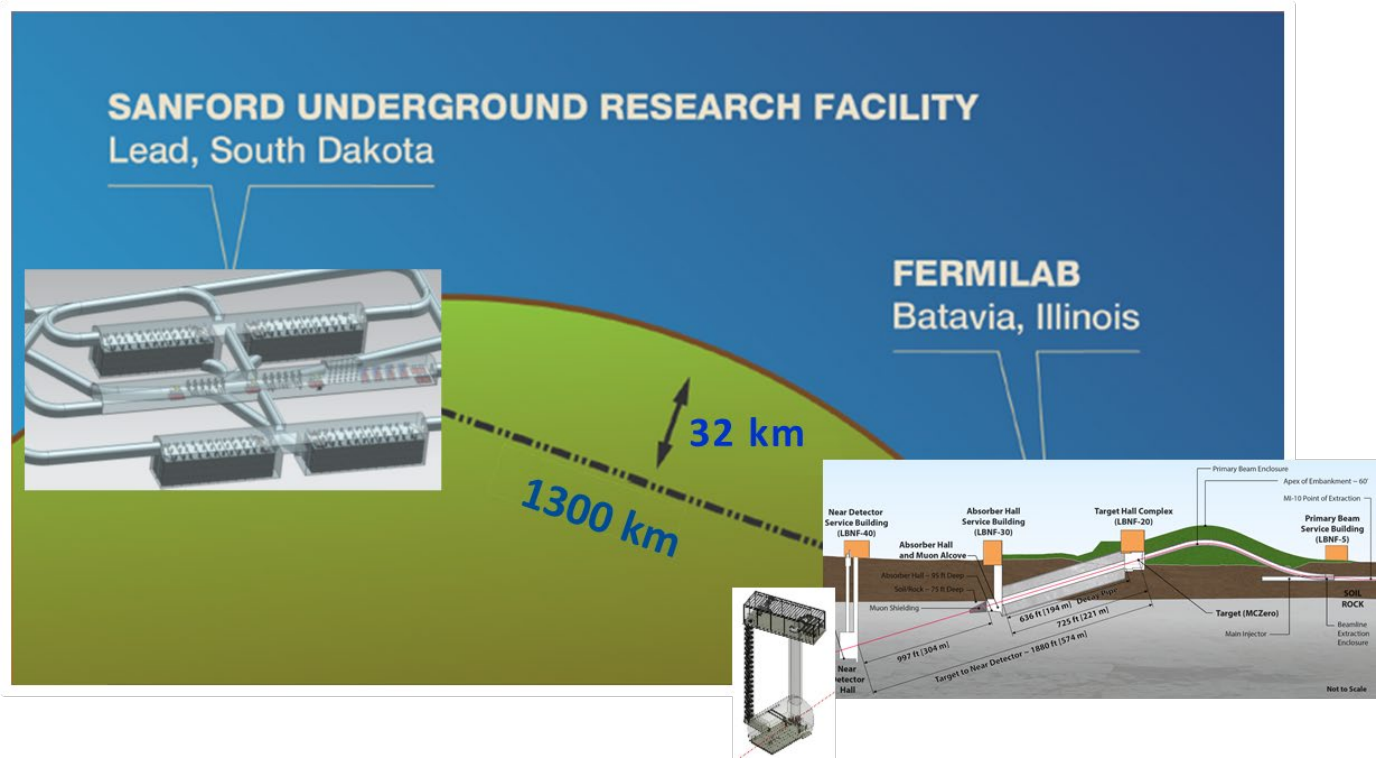
LBNC Closeout: DUNE

LBNC

14 Jun 2016



State of DUNE [Rubbia]

- Findings:
  - DUNE Collaboration has continued to grow, with 856 collaborators from 149 institutions and 29 countries
  - The present level of effort from the collaboration is estimated to be 240 FTEs
  - DUNE provided responses to LBNC recommendations from the January 2016 meeting
  - DUNE has developed a draft strategy document describing the goals, milestones and steps needed in preparation for CD-2
  - Collaboration management has been stable since the January 2016 meeting, with the addition of Kam-Biu Luk to the ND WG
  - A set of bottom-up priorities have been laid out for 2016, including advancing protoDUNE-SP and –DP, WG & TF progress, and resource development

State of DUNE [Rubbia]

- Findings (continued)
  - The organizational structure of the Software & Computing WG has been clarified to include interfaces to Physics, protoDUNE, and DUNE-wide support
  - The two main goals for protoDUNE were stated as:
    - Engineering demonstration: mitigation of design risks, establishment of construction facilities, early detection of potential construction or performance issues
    - Calibration of detector response

State of DUNE [Rubbia]

- Comments
  - DUNE management needs to be actively identifying and resolving critical technical and performance issues, e.g. with protoDUNE-SP cold electronics
  - Presentations would be more useful if they include a identification of current problems, risks, and mitigating strategies or actions taken to solve problems, e.g., the protoDUNE-SP cold electronics
- Recommendations:
  - Develop a full assessment of risks and corresponding mitigation strategies for protoDUNE-SP and -DP
  - Keep the LBNC informed of progress in dealing with critical issues
  - Use the engagement of the Fermilab Director and Fermilab as host lab to maximum advantage in resolving critical issues

DUNE Strategy for CD-2 [Thomson]

- Findings
  - High-level goals for DUNE are delivering protoDUNE-SP and -DP (2018), a DUNE TDR for CD-2 (2019), 20-kt FD commissioning in 2024, and ND operation by first beam
  - A Strategy and Implementation plan has been approved by the DUNE EC (DUNE-docDB-1050)
  - The strategy includes: assumptions and schedule, key goals and milestones, plans for prototypes, development of construction-phase resource matrix, neutrino beam design, development of a TDR, and enlarging the collaboration
  - A set of major milestones have been identified
  - DUNE will follow the LHC detector strategy of organizing consortia of institutions to construct major detector sub-systems through a process of soliciting EOIs in 2017

DUNE Strategy for CD-2 [Thomson]

- Findings (continued)
  - Preliminary design of the first 10-kt module is assumed in Q4 2017 and a design decision of the second 10-kt module in 2018
  - A conceptual design choice for the ND is targeted for 2017, based on scientific arguments, technical readiness, institutional interest, and funding availability
  - A path for development of the TDR is laid out, starting with establishing an editorial team in 2018
  - Active steps to enlarge the collaboration were taken with a Latin America meeting (April 27-28) at Fermilab and a European meeting at CERN (April 7-8)
  - The plan includes provision for LBNC review of the TDR in Q4/2019

DUNE Strategy for CD-2 [Thomson]

- Comments
  - The strategy appears to capture the main goals and lays out a plausible pathway to a TDR and IPR in Q4/2019
  - The call for DUNE FD construction EOIs in Q2/2017 overlaps the construction of protoDUNE-SP and –DP which may be a challenge
  - The Collaboration currently sees a variety of factors in the technology choice for the second FD module, and does not want to lay out definitive criteria and a process at this time
  - Development of the strategy document is responsive to the LBNC recommendation from Jan 2016 and will serve as an effective communication vehicle for the collaboration as a whole
  - One of the more challenging elements of the plan is the development of a full funding matrix on the timescale of the TDR

DUNE Strategy for CD-2 [Thomson]

- Recommendations
  - Expand on this excellent start to incorporate alternatives planning, *e.g.,* if protoDUNE-SP does not demonstrate the required engineering performance

Far Detector Task Force Update [Whitehead]

- Findings
  - Both nucleon decay and atmospheric neutrinos samples have now been simulated and reconstructed with LArSoft, along with background samples
  - Supernova events have been generated, but standard reconstruction does not work for energies below 50 MeV
  - A Long-baseline Oscillation Analysis Fitter (LOAF) has been developed
  - Detector optimization studies have begun by looking at wire spacing and pitch
  - Photon detection system studies have been added to the scope of the TF
  - Event selection studies have begun for long-baseline oscillation analyses using multivariate techniques

Far Detector Task Force Update [Whitehead]

- Findings (continued)
  - A dual phase simulation and reconstruction capability has been developed in LArSoft, although implementation of the light collection system remains to be done
  - A preliminary TF report to be provided in September will include studies of lower level e/g separation and tracking efficiency but not optimization results based on sensitivity
- Comments
  - While there is good overall progress being made by the TF, many important milestones have shifted from spring to summer
  - Implementation of DP simulation and reconstruction is going well but not too surprisingly is delayed until fall
  - It is not clear how effective the feedback loop is between reconstruction development and higher-level analysis efforts

Far Detector Task Force Update [Whitehead]

- Comments (continued)
  - Ultimately detector design optimization will also need to weigh factors such as relative cost and technical risk vs TF physics performance results
- Recommendations
  - Define a plan to address reconstruction below 50 MeV
  - Review whether there is sufficient manpower to conduct the full range of physics studies laid out in the TF charge
  - Review whether feedback from physics studies to reconstruction algorithm development is working effectively
  - Update the LBNC with the status of actual versus planned manpower across the TF at the fall meeting

ND Task Force [Brice]

- Findings
  - Points of contact have been identified for all components of the TF effort, but additional manpower is needed for the three simulation efforts (FGT, LAr, GAr)
  - Progress is being made relative to the plan of the TF, with a schedule that is tied to Collaboration meetings and incremental improvements
  - A strategy of “cheating”, *i.e.,* informed guesses about reconstruction performance, will be used
  - Currently there are technical issues with the VALOR fitting framework manifested by unrealistically small output uncertainties
  - Cross section uncertainties are being implemented in a less model-dependent manner

ND Task Force [Brice]

- Findings (continued)
  - Optimized beam from the BOTF and non-beam backgrounds will be used for next development run
  - Interactions between the TF and the ND Physics WG are occasional, although there will be upcoming consultation on cheating models for the three simulation efforts
  - An initial TF report will be provided in September and a final report in March 2017
  - A technology decision is not in the remit of the TF

ND Task Force [Brice]

- Comments
  - Neutral particles are not accounted for in detail, *i.e.,* no specific detector treatment with resulting uncertainties in energy response, is implemented
    - Recent literature indicates that this can be a serious problem
  - A valuable outcome from the TF, instead of just a comparison of ND technologies, could be a set of overall ND requirements independent of technology
  - “Cheating” appears to be a response to the lack of manpower to develop suitable event reconstruction and the details of the assumptions made here may have significant impact on the reliability of the final result

ND Task Force [Brice]

- Comments (continued)
  - The attempt at including model-independent cross section errors is very valuable and can be easily extended to include uncertainties associated with neutral particles (see recent literature)
  - Lessons learned from existing software solutions should be used to address current or future related technical problems VALOR may be trying to resolve

ND Task Force [Brice]

- Recommendations
  - Clearly document “cheating” strategies and investigate sensitivity of results on those assumptions
  - Properly include energy response uncertainties from neutral particles (“missing energy”)
  - Investigate alternatives to the current framework if technical difficulties were to persist
  - Consider extending the TF scope to deliver requirements for a near detector independent of any specific design
  - Update the LBNC with the status of actual versus planned manpower across the TF at the fall meeting

Beamline Optimization Task Force [Weber]

- Findings
  - An interim report was produced examining optimized designs for four system based on three 3-m long horns and a long target
  - All options perform substantially better than the CDR conceptual design
  - The recommended system uses a carbon fin target, but further work since the interim report suggests that using a beryllium sphere array target may be a better option
  - Engineering analysis work has started based on a mechanical design for an idealized three-horn system
  - This suggests that conductor and endcap thicknesses may be important factors in optimization
  - A conceptual design for an optimized beamline is anticipated in August 2017 & planning for engineering resources is underway

Beamline Optimization Task Force [Weber]

- Comments
  - BOTF is on track to meet its goals by March 2017
- Recommendations
  - Complete assessment of the recent narrow-band beam option by mid July

Software & Computing Working Group [Junk]

- Findings
  - An organizational structure with interfaces to Physics WGs and the protoDUNE effort has been developed
  - A summary of computing resources required to support the 35Ton effort was provided
  - An overview of event samples produced for FD/ProtoDUNE SP/35ton as part of Monte Carlo Challenge 6.0 was provided
  - An analysis of computing resource requirements for ProtoDUNEs was presented, based on:
    - Initial event sample and measurement program
    - protoDUNE-SP trigger/DAQ requirements and data handling estimates
  - A summary of personnel currently involved in software and computing was provided

Software & Computing Working Group [Junk]

- Comments
  - MC Challenge 6.0 demonstrated the capability for producing large simulation samples with available resources
  - No analysis of whether identified manpower is adequate to address high-priority S&C tasks was presented
  - It is unclear how well experience from analysis of MC samples are fed back to the S&C group
  - It is not clear how well ProtoDUNE-DP is integrated in the C&S WG

Software & Computing Working Group [Junk]

- Recommendations
  - Provide an overview of high level computing infrastructure including how requests are made to the group and how feedback from the working groups is incorporated into software development planning
  - Engage physics WGs in analysis of simulation samples and in providing feedback to the S&C WG
  - Ensuring adequate support for protoDUNE(s) at CERN is high priority, including defining the Fermilab role
  - Provide an update on ProtoDUNE-DP software integration and MCC production
  - Provide an overview of strategy for addressing the different software release timelines and goals (*e.g.,* when the next software release is due and when the next MCC7 is planned)

Update on reconstruction development [Xin Qian]

- Findings
  - Progress in automated reconstruction was reported in several areas: TPC SP signal processing, field response, pattern recognition and particle flow algorithms.
  - Substantial progress in shower reconstruction was reported, including a 50% improvement in π^0 reconstruction efficiency
  - Progress on the wire-cell reconstruction was reported
- Comments
  - Impressive progress in event reconstruction since the last LBNC meeting
  - It is not clear what is ready enough to be deployed in production and what is still under development

Update on reconstruction development [Xin Qian]

- Recommendations
  - Provide an overview of reconstruction development tasks, with priorities in importance and schedule, along with personnel associated with each of these tasks
  - Provide ongoing updates on the integration of dual phase software into LArSoft and status of reconstruction
  - Track progress in terms of high level performance metrics

Physics Working Group [Urheim]

- Findings
  - Continued progress has been made in organizing physics efforts with increased participation from collaboration members
  - A BSM working group has been established and is very active
  - Configuration information used for the CDR has been released publicly
  - There still only limited manpower for atmospheric neutrinos
  - Many analyses now include actual simulation of full events in the detector and reconstruction (as available)
  - Progress in simulation and reconstruction of low-energy SN events is being made
  - A successful VT SN workshop was held
  - There is a plan for developing a Physics TDR prior to CD-2

Physics Working Group [Urheim]

- Comments
  - Many of the BSM topic appear to be at the intersection between ND physics and the BSM group
  - The SN workshops are a model that could be emulated in other areas
  - Release of the CDR will serve well to engage the broader community
  - The BSM working group has gotten off to a very good start and impressive progress is being made
  - The participation of theorists in bi-weekly phone calls is commendable
  - Despite good success in attracting more collaborators, manpower remains an issue in several areas and needs continued attention, especially in view of the planned TDR

Physics Working Group [Urheim]

- Recommendations
  - Close interaction with reconstruction efforts should continue to be encouraged and maintained
  - The low-energy reconstruction efforts should continue to be a priority given their importance for informing the detector design

protoDUNE-SP mini-review: management

- Findings
  - Major sub-system components for protoDUNE-SP will be delivered by hardware WGs within the FD WG (APAs, HV/FC/CP, Photon Detector, Cold Electronics)
  - FD WGs are also responsible for coordination with protoDUNE-SP management in identifying system experts for assembly, integration and commissioning at CERN
  - protoDUNE-SP management will form teams for DAQ, Installation, Calibration with large overlap with FD WG membership
  - A set of 5 joint SP/DP working groups are envisioned: beam configuration & instrumentation, detector monitoring & slow controls, cryogenic systems, muon tagging detectors, online computing & storage

protoDUNE-SP mini-review: management

- Findings (continued)
  - There will be a set of teams with interfaces to physics and computing (measurements WG, computing infrastructure, software development)
  - A physics workshop will be held later this month to better define the calibration and physics goals of the protoDUNE effort
  - A call for EOIs in participating in the protoDUNE efforts was made in January
  - DUNE WG leaders are responsible for bringing together interested institutes to facilitate formation of consortia; written proposals will be reviewed by the DUNE Technical Board
  - The goal for the review process is to assign final responsibilities by late June

protoDUNE-SP mini-review: management

- Findings (continued)
  - DUNE Technical Board will review conceptual designs for protoDUNE detector components, while the project will be responsible for design and production reviews
  - A schedule for design and production reviews has been laid out
  - A uniform set of milestones is planned to monitor the project, in addition to the resource loaded schedule for protoDUNE-SP
  - An initial risk table and mitigating strategies was prepared for this review
  - A lessons-learned document has been prepared for the 35 Ton and a review was held at Fermilab (Jun 2-3)
  - A task force is investigating grounding/shielding/noise problems with the 35 Ton

protoDUNE-SP mini-review: management

- Findings (continued)
  - A set of slice tests and integration tests are planned at Fermilab, CERN and other sites
  - The integration, installation and protoDUNE operation at CERN will require the build up of some 35 people on site
- Comments
  - The management for protoDUNE-SP has not responded in a decisive fashion or elevated the response appropriately to the serious risks from the cold electronics system
  - It is important to maintain engineering rigor in the design and production of components as planned
  - There does not appear to be a single individual who is responsible for delivery of the cold electronics as a working system

protoDUNE-SP mini-review: management

- Comments (continued)
  - Some basic design decisions are still subject to R&D, such as the field cage design
  - It does not appear that the process of forming consortia will converge before end of summer, and there will still be funding support questions at that point
  - protoDUNE-SP is a critical part of the CD-2 preparation plan and a very visible first major project undertaken by DUNE

protoDUNE-SP mini-review: management

- Recommendations
  - Put in place a single individual with appropriate expertise who is responsible for cold electronics (from wire signal to delivery of digital signals to DAQ) as a working system
  - Clarify roles and responsibilities of the major participants in the cold electronics system and potentially revisit roles in the process
  - Form a task force to devise a robust strategy for delivery of a cold electronics system for protoDUNE-SP
  - Complete the development of a risk matrix and corresponding mitigation strategies, particularly for the cold electronics
  - Take design decisions as early as possible, particularly in cases where choices will not impact significantly the overall goals of the protoDUNE effort

protoDUNE-SP mini-review: management

- Recommendations
  - Work with the funding agencies, including DOE, to make sure support for operations and the hiring of key personnel is realized in a timely fashion
  - Develop and monitor an agreed upon set of key milestones associated with the protoDUNE-SP project by September 1

protoDUNE-SP mini-review: TPC

- Findings
  - A stable APA design was presented
  - Work on the APA has focused on an automated winding machine, bolted frames and electrical isolation
  - The CPA design is for a solid G10 frame with G10 panels laminated with resistive Kapton foils
  - The field cage design uses open metal profiles, segmented into four electrically isolated parts
  - Outside ground planes are integrated into the design
  - Trial assembly will take place at Ash River

protoDUNE-SP mini-review: TPC

- Comments
  - The TPC team has presented an excellent summary of the construction plans
  - The schedule is very tight, with no hidden contingency
  - Potential human resources required to meet this schedule have in many places been identified, but many are not yet committed.
  - Given the tight schedule and personnel constraints, the focus needs to shift from R&D and optimization to production. The team continues to explore manufacturing options on items which, though valuable for DUNE, are not required for protoDUNE success
  - The design of the CPA is relatively mature, and the team should decide on a lamination process soon

protoDUNE-SP mini-review: TPC

- Comments (continued)
  - The team should develop a quantified failure mode analysis, including probability and impact of a broken wire in an APA.

protoDUNE-SP mini-review: TPC

- Recommendations
  - Clearly identify the goals for the protoDUNE-SP TPC and focus resources where needed to achieve them
    - Understand and communicate the relative priorities of manufacturing process development, preproduction engineering for DUNE, and construction, installation, and commissioning of a TPC in time to validate operation and test calibration before the CERN long shutdown.
    - If the principle goal is for protoDUNE to be ready for beam in mid-2018
      - Refocus resources on R&D of direct relevance to protoDUNE
      - Have a clear de-scoping plan
  - Develop a more quantitative failure mode analysis
  - Develop and monitor an agreed upon set of key milestones associated with the TPC system by September 1

protoDUNE-SP mini-review: electronics

- Findings
  - The cold electronics system (CE) is composed of two custom ASICs, a front-end preamp and shaping amplifier, and a novel 12 bit ADC both realized as 16 channels per chip and a commercial low drop out linear regulator mounted on a custom front end printed circuit board (the FEMB) and a commercial FPGA mounted on a second custom circuit board mounted as a mezzanine above the FEMB.
  - The FEMBs connect to the TPC collection and induction wires through a “wire card” on the APA that provides DC bias to the TPC wires and HV decoupling before the FEMB.
  - Prototypes of the custom ASICs and FEMBs were used in the 35Ton run in the first half of 2016.

protoDUNE-SP mini-review: electronics

- Findings (continued)
  - The 35Ton detector was the first liquid argon TPC to operate with digital elements in the cold and the performance did not meet expectations.
  - Observed noise levels were very much worse than expected and the ADC showed “features” which kept it from producing anything close to 12 bit linearity.
  - The 35Ton CE used version 5 of the cryogenic ADC. Recently a revised, version 6, device has been measured to have somewhat improved performance but still demonstrates serious problems in achieving the desired linearity.

protoDUNE-SP mini-review: electronics

- Findings (continued)
  - At least some of the low frequency noise seen in the 35Ton test is reasonably well known to be caused by small variations in the DC voltage provided by the commercial low drop out regulator.
  - The CE group is expecting a revised version of the front end chip which includes a number of improvements approved in the review in January to be tested in the near future.
  - The revised ADC chip is still under design with simulations ongoing and with the expectation at the moment that a revision will be submitted by the end of June.
  - The slip in schedule by four months does not allow for another iteration of the ADC chip before production for protoDUNE-SP.

protoDUNE-SP mini-review: electronics

- Comments
  - Communication between the CE designers and the rest of the DUNE collaboration needs improvement
  - The recent involvement of MSU and Boston University is evidence of a new openness in collaboration
  - It is not clear that all of the interactions / connections between the APA structure and the CE system are well defined or well understood
  - Understanding of the “noise” problems observed in the 35Ton detector is only beginning and may never fully converge on the technical changes necessary to achieve acceptable performance in protoDUNE

protoDUNE-SP mini-review: electronics

- Recommendations
  - Develop a method to improve the communications between the CE team and the rest of the collaboration
  - Consider developing multiple mitigating strategies to ensure a working protoDUNE-SP electronics system:
    - Investigate the options (including the identification of possible design teams) for implementing the design of a cryogenic capable true 12 bit ADC using the same interface as the present CE ADC but based on a more traditional and well-understood ADC architecture
    - Investigate the options (including the identification of possible design teams) for implementing a cryogenic front-end design as a fully differential device (to improve the power supply rejection ratio) using the same interface as the present CE front-end chip

protoDUNE-SP mini-review: electronics

- Recommendations (continued)
  - Investigate the options (including the identification of possible design teams) for implementing a variant of the FEMB design
  - Fully document and understand the planned electrical connections (DC and AC) between the detecting elements and the CE system and the cryostat shell and verify that the design is as robust as possible
  - Develop and monitor an agreed upon set of key milestones associated with the CE and DAQ systems by September 1 and update if necessary

protoDUNE mini-review: cryogenics

- Findings
  - The cryogenic system scope that includes membrane cryostats and cryogenic system is managed by CERN/NP leadership.
  - The scope is managed internal to the CERN organization utilizing well established processes.
  - We were assured that NP/CERN will manage the cost and schedule risks internal to the organization.
  - The team includes four engineers and two designers from CERN, strong Fermilab collaboration, including an engineer from Fermilab stationed at CERN. Additionally, a new mechanical engineer with strong contract support experience has recently joined the team.
  - System requirements, interfaces, constraints, and specifications are well documented within CERN EDMS.

protoDUNE mini-review: cryogenics

- Findings (continued)
  - Cryogenic system engineering design is complete. A Functional Specification based contract is in process of being tendered by European industry.
  - The contract deliverables include engineering, design, factory testing, installation, and site acceptance testing at CERN and Fermilab of forty-two (42) cryogenic valve boxes and sixty-nine (69) cryogenic transfer lines
  - The tender for the cryogenic valve boxes and transfer lines was open at the end of May, 2016. Eight qualified vendors participated in the tendering conference at CERN.
  - The tender is scheduled to close at the end of July 2016.

protoDUNE mini-review: cryogenics

- Findings (continued)
  - Pending satisfactory outcome from the CERN finance committee, a contract will be executed in September 2016 for delivery in winter 2017, completion of installation by the end of 2017 and ready for cooldown in February 2018.
  - Fermilab will supply four (4) circulating LAr pumps manufactured by US or European industry.
  - The requisition for the pumps is being processed by LBNF procurement group. The anticipated award is in mid July, 2016.
  - The requested delivery of the pumps to CERN is 10 months ARO (late spring 2017).
  - An engineering contract for the Membrane Vessels with GTT for the complete design of the two membrane cryostats will be completed in September 2106.

protoDUNE mini-review: cryogenics

- Findings (continued)
  - The contract includes engineering and design of the two vessels (primary and secondary barrier)including penetrations, list of materials to be ordered (delivered end of March), detailed installation procedure (first version delivered this week), list of licenced assembly firms for the CERN tendering, structural analysis, and QA plan.
  - Addition of the beam ports and pump connection on the side of the cryostat requires a local modification of the insulation panels and primary membrane.
  - The project is working with experienced industrial vendors, GTT and Protego, to develop the appropriate design solutions for the membrane cryostat penetrations.

protoDUNE mini-review: cryogenics

- Findings (continued)
  - The tender for material has been written and is ready for placing (pending CERN Finance Committee (FC) approval); the material is to be delivered by October 2016.
  - The tender for assembly is scheduled for completion in July 2016, to be placed in September 2016 after the next CERN FC.
  - A contract for Warm Vessels has been let for the construction of the outer vessels that includes complete pre-assembly.
  - The material has already been delivered to the company.
  - First Warm Vessel delivery is scheduled in the beginning of August 2016; Second – beginning of October.
  - Warm Vessel assembly in EHN1 is scheduled to start in August 2016
  - Cold Vessel assembly is scheduled to start in October 2016

protoDUNE mini-review: cryogenics

- Comments
  - The senior management has a proven record for the successful delivery of complex projects.
  - There seem to be sufficient man power dedicated to the cryogenic systems work.
  - The cryostat and cryogenic system design leverages industrial expertize and experience with WA105.
  - Cryogenic operations in Building 182 in September will validate many design solutions.
  - Consideration for the cost and schedule risk mitigation solutions may include utilization of resources at CERN to assist vendors with project execution.

protoDUNE mini-review: cryogenics

- Recommendations
  - Develop and monitor an agreed upon set of key milestones associated with the cryogenic system before the end of the calendar year and update if necessary

protoDUNE-DP

- Findings
  - The dual-phase TPC design was said to offer several advantages: two collection views with no ambiguities, a tunable gain in the gas phase, reduced number of readout channels with accessible FE and digital electronics, and no materials in the active volume
  - The original concept was pursued by a collaboration of 22 institutions from 10 countries (WA-105) before being integrated into DUNE planning as protoDUNE-DP
  - The design is based around a modular 3x3m Charged Readout Plane (CRP) that has been extensively developed for the 3x1x1m prototype being assembled at CERN
  - A mature design for the readout chain has been developed:
    - Cryogenic ASIC amplifiers on cards fixed to a plug-accessible from the outside

protoDUNE-DP

- Findings (continued)
  - Warm digital electronics using μTCA architecture and held in crates at the cryogenic tank upper deck
  - Fully engineered versions of many detector components exist, along with identified commercial vendors for components
  - Pre-production and most implementation steps for installation and ancillary services have been developed
  - All design, implementation, legal and contractual issues related to the construction of the membrane cryostat have been addressed in the implementation of the 3x1x1m prototype, to the benefit of both protoDUNEs
  - A detailed schedule for construction of components and assembly of protoDUNE has been developed, including scope and sources of manpower

protoDUNE-DP

- Findings (continued)
  - The design study for the 6x6x6m cryostat have been concluded with GTT, including definition of all penetrations and interfaces
  - Some aspects of the photodetection system (wavelength conversion plates) are still in R&D, with proposed implementation as transparent cathode plates with ITO coating
  - Options for the field cage are still in development (in common with protoDUNE-SP) with the aim of a design decision in July
  - Cold-FE electronics and DAQ have been in development since 2006
    - Full complement (700) cold ASIC amplifiers were produced at the end of 2015
    - Full complement of μTCA cards started at the end of 2015, and a pre-batch will be deployed on the 3x1x1m prototype

protoDUNE-DP

- Findings (continued)
  - A detailed installation plan has been developed including CRP pre-assembly at CERN (Building 185) and use of a clean room buffer near the 6x6x6 cryostat to stage installation
  - The schedule assumes Building 185 clean room is available in January 2017
  - A detailed beam time request was made to the SPSC encompassing 59 days of integrated beam delivery
  - The online processing and storage facility required to acquire and locally store test beam data has been designed
  - Offline computing plans include simulation production at CC-IN2P3 and analysis of a roughly 2.4 Pb dataset with QSCAN

protoDUNE-DP

- Comments
  - protoDUNE-DP has been developing an engineering design, with corresponding R&D, for several years and as a result the design is relatively mature
  - All aspects of the dual phase design appear to be well thought through, including details such as internal sensors
  - There are still aspects of the design in R&D: *e.g.,* cathode plates and field cage (in common with protoDUNE-SP)
  - The successful operation of the 3x1x1m prototype, as a large-scale demonstration of the dual phase technology, is crucial
  - There may not be enough schedule time for commissioning and initial operation of the 3x1x1m prototype before the start of procurements for the 6x6x6m TPC components

protoDUNE-DP

- Comments (continued)
  - The 6x6x6m assembly schedule appears plausible, based on previous experience with commercial vendors and assembly of the 3x1x1m prototype
  - There are critical dependences on CERN NP construction activities, starting with the availability of the Building 185 clean room in January 2017
- Recommendations
  - Complete the development of a risk matrix and corresponding mitigation strategies
  - Take design decisions as early as possible, particularly in cases where choices will not impact significantly the overall goals of the protoDUNE-DP effort
  - Develop and monitor an agreed upon set of key milestones associated with the protoDUNE-DP project by September 1