DUNE Risk Registry

ID	Title	Category	Explanation	Risk Level	Mitigation
1	Experience with protoDUNE shows that design improvements are needed.	All		M	Allocate enough engineering/scientific resources to understand the cause of the problem. Improve QA/QC procedures and/or design.
2	Detector performance is impaired by external electrical noise	SPCE, SPPD, DPCE, DPPD, DAQ Technical	This experiment will have channels of electronics with intrinsic noise levels. The detector utilizes low-noise electronics. Noise from external sources can introduce interference. The TPC has a requirement to distinguish a minimum ionizing particle from noise with a signal to noise ratio of 9:1. If external noise affects the TPC readout it will be more difficult to discern the event signals. Grounding, shielding and power distribution are critical to the success of the experiment. Excess noise may also increase the cost of DAQ.	M	Having a well-defined and isolated detector ground, the use of double shielded transformers for detector power, using proper shielding techniques on all conductive cables, validation of the noise performance of all equipment (e.g., variable frequency drives) and careful review and oversight of the installation process. Continual monitoring of noise performance once the first detector elements are installed and appropriate modifications to any aggressor system if and as problems are discovered.
3	Required Far Detector R&D is not completed on time	SPPD, SPCE, CRP, DPPD, HV, DAQ, CISC Technical	If R&D is required and is not being performed by other groups or collaborations then DUNE may need to perform this work. Depending on detector validation studies and physics analysis work further test beam measurements may be needed.	L	Follow closely the activities by ProtoDUNE and other experiments (SBND for example) that are closely related to the design of DUNE. Add support for those activities if necessary for achieving the goals of DUNE.
4	Far Detector Technical interfaces not adequately defined	all	Incompatibilities between various components of the Far Detector can go undetected until the integration of different components, tests at the integration site, or even later until the installation inside the cryostat and the corresponding tests. Incompatibilities between different subsystem will result in rework, redesign, and delays.	L	Perform regular reviews of the interface documents and ensure that vertical slice tests (including the most recent design iteration of each component) are done prior to launching the full production. These vertical slice tests should include integrating different detector components together and then testing them simultaneously, in addition to trial installations. Production readiness reviews should include a review of all interfaces and a demonstration that all issues stemming from integration and simultaneous operation have been addressed.
5	Number of nonworking channels is higher than expected.	SPCE, DPCE, SPPD, DPPD, APA, CRP, Technical	We are planning for a channel failure percentage of less than 1% with a goal of less than 0.5%. ProtoDUNE results may point to a larger failure rate.	M	Allocate enough engineering/scientific resources to understand the cause of the problem. Improve QA/QC procedures and possibly some aspects of the design.
6	Average component lifetime is less than expected, leading to a larger than expected number of dead channels.	SPCE, DPCE, SPPD, DPPD, APA, CRP, HV, DAQ, CISC Technical	The design is greatly different than existing devices built by the engineering team. The mean time between failure for the detector components may be shorter than expected. If this risk is realized the detector will degrade over time and channels may die or become noisy to the extent that it is best to ignore them. Loss of channels impacts the ability to identify, reconstruct, and measured neutrino scatters and other events on physics interest. Missing channels will correspond to dead argon volume. Events that originate or pass through the volume that is viewed by these channels may have to be removed from physics analyses.	L	Work toward identifying weak spots in the design, and perform studies of the possible failures of the detector. Redesign components that are highly critical, if they could endanger a lot of contiguous channels. Implement redundancy in components of the design if this can help achieving the goals of mean time between failures. Introduce new QA/QC procedures and try to learn from other experiments / fields that have similar or more stringent reliability requirements.
7	Winder modifications do not provide enough reduction in time for APA assembly.	APA Schedule	It is not possible to substantially reduce the manufacturing time of an APA (presently about 3 months) by middle of 2019 because of limited engineering resources, complexity of the winding problems, tight manufacturing tolerances.	M	Allocate enough engineering resources asap to address modifications to the winder. Plan for enough assembly lines to produce the total number of APAs within the required time.
8	SiPMs windows fail due to multiple cold cycles/extended cryogen exposure	SPPD Technical	QA testing prior to ProtoDUNE has revealed that the conformal front SiPM windows can fail due to repeated cryogenic dunking.	M	Develop alternate vendors and require performance certification from vendors. Continue testing of candidate SiPMs to insure acceptable performance. Develop QC procedures to catch failed devices prior FD installation
9	SiPM active ganging required to minimize electronics costs	SPPD Technical	Revised PD module designs may require active ganging of SiPMs to meet performance requirements	M	Continue development of active ganging circuits and investigate in Tallbo and other non-ProtoDUNE test beds.
10	Implosion of PMTs	DPPD Technical	A critical process could be the filling of the detector with LAr because a PMT could implode. If this happens, the detector must be emptied.	L	Special care must be taken during the filling of the detector with LAr.
11	Electric field uniformity is not adequate for muon momentum reconstruction	HV Technical	Cathode plane nonuniformities and space charge can distort the electric field. Momentum of non-contained muons is measured by estimating the multiple scattering rate for the observed track segments. Degraded resolution for non-contained muon momentum measurements. Affects numu disappearance analyses and the three-flavor fits. Can cause feed-down of high-energy neutrino backgrounds to low-energy reconstructed categories.	M	Addition of a laser calibration in case calibration with muons is inadequate.
12	Electric field is below specification during stable operations	HV Technical	SP+DP: Breakdown of high purity argon occurs at lower voltages causing a risk. Measurements need to be understood on this relationship. Experiments with high voltage in noble liquids have had to operate at lower voltages than design due to breakdowns. The calculated electric field gradient should be safely below the expected breakdown gradient. DP: unable to make a HV distributions system that reaches 600kV.	H	R&D in small tests and 6x6x6 operational experience to understand the results of the 35ton HV tests.

13	Energy stored in HV system is suddenly discharged.	HV Technical	In DP, PMTs are possibly at risk, membrane damage possible (kJ range stored energy)	M	SP - energy is normally drained through resistor chains and conducting cathode. DP - segmenting FC (similar to design developed for SP), Split cathodes into smaller tiles linked with inductive elements
14	Power / space requirements exceed CUC capacity	DAQ Technical			Leave provision for all data to be shipped to surface. Will require WDM on fibres – technically feasible, but expensive.
15	Insufficient throughput	DAQ Technical			plan to allow for expansion or upgrade of system components
16	CISC systems introduce noise in electronics	CISC Technical	Electric noise from the purity monitors is caused by the current surge in the discharging process of the main capacitor of the xenon light source when producing a flash	M	We will develop software for light source triggering mechanism to prevent the PrM flash lamp from flashing during photon detector data taking. In addition, we will make faraday cage to ground the light source. All CISC systems will be reviewed in regards the grounding & shielding plan
17	Not enough photons arriving at PMTs	DPPD, SPPD Technical	Due to the long drift distance and the position of the cathode on top of the PMTs, it could happen that not enough photons arriving to PMTs can be distinguished from noise.	L	In order to avoid this problem, the gain of the PMTs can be increased to be able to detect more photons. Otherwise, alternative light collection systems should be considered.
18	Air quality is very bad and affects the ventilation of the crates on top of the cryostat	DPCE, SPCE, DAQ Technical	Each uTCA crate, including the digitization cards inside, dissipates less than 300 W. The crates incorporate fan units for the cooling. The air should be reasonably clean in order not to obstruct the filters or the cooling units. This also impacts WIB crates, photon readout, power supplies and network switches.	L	The working conditions of any industrial environment or experimental hall at CERN/Fermilab are enough in order to guarantee the normal functioning of the fan units of the crates. There could be problems only in case of a very dusty environment. For instance if clouds of dust are liberated in the air due to the activity in the mine. Requirement to LBNF to have reasonable air conditions without over presence of dust, has to be set properly. This requirement should normally match also the one for health of the personnel operating around the experiment without the need of wearing masks.
19	Obsolescence of electronic components needed for maintenance during the long operation period of the experiment	DPCE, SPCE, SPPD, DAQ Technical	All electronics components will undergo obsolescence on the world market due to evolution of technology and market demand. In general electronic components are designed by industry for a lifetime much shorter than needed for DUNE. There is the risk that over 20 years period of operation time of DUNE some components will no longer be available for maintenance/repair. This is a general problem affecting all customized electronic components in DUNE (that are accessible) and a general DUNE policy should be established.	M	Allocate enough spares in order to be able to face this problem. It is preferable to have complete spares (e.g. complete spare cards) instead than spare components since also the technology in the industry to fix the cards may be evolving
20	LAr purity is less than expected or uniformity of the distribution of impurities is larger than expected	SPCE, DPCE, SPPD, SPCE Technical		M	
21	Insufficient LEM gain and stability	CRP	Experience with the 3x1x1 and with ProtoDUNE LEM production indicates that careful attention has to be paid to the LEM design and production techniques and to the HV distribution for the extraction, induction and LEM.	M	Continue to develop experience from 3x1x1 diagnosis and from ProtoDUNE-DP construction and operation
22	LAr surface flatness and stability is less than requires to allow efficient extraction and to keep the LEM dry.	CRP Technical		L	
23	Insufficient expert personnel	all			Avoid single points of failure. Plan resources to support experts to live at SURF during installation.
24	Insufficient calibration tools to extract DUNE detector performance and physics				