Tritium Mitigation for the LBNE Beamline

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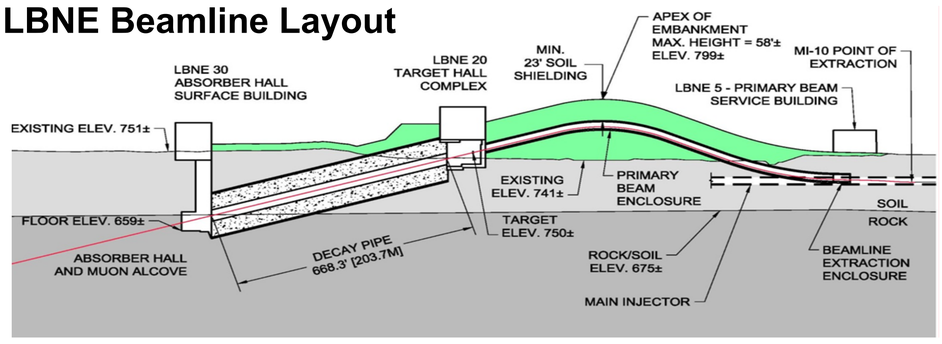
Introduction

- The proposed Long Baseline Neutrino Experiment (LBNE) beamline is planned to deliver high intensity neutrino beam to a detector approximately 1300 km away in South Dakota.
- The use of high intensity beams will generate significant quantities of tritium in the beamline complex.
- Tritium is highly mobile making it a challenge to contain and to inventory.
- To mitigate the amount of tritium which may impact the environment, the LBNE project must either contain the tritium in a fail-safe manner in areas where tritium production is high and reduce the amounts of tritium produced in regions where the tritium cannot be contained.

LBNE Beamline Layout

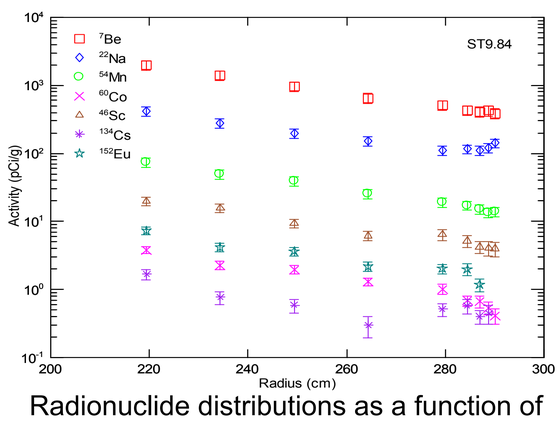


Side view of the LBNE beamline. The LBNE beamline is angled down by 102 mrad to deliver neutrinos to the LBNE far detector in South Dakota. Doing this requires that the decay pipe and absorber hall penetrate the bedrock and hence may expose the aquifer to tritium.

Shielding

- As the decay pipe and absorber hall penetrate the bedrock, this provides a potential pathway for tritium to enter the groundwater system.
- To protect the environment from radionuclide production outside of LBNE complex, sufficient shielding in the decay pipe and absorber hall will be in place to maintain the radionuclide production below detection limits.
- Tritium concentrations less than 1 pCi/cm are considered to be undetectable by regulatory standards.

Estimating Tritium Production



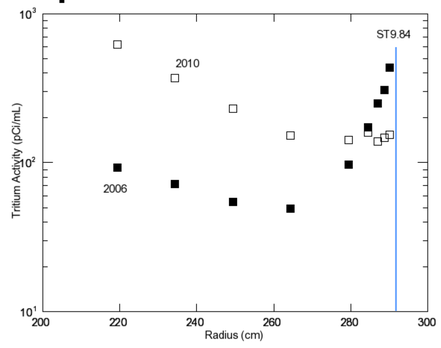
Radionuclide distributions as a function of radius in the NuMI decay pipe.

- Can use radiological simulations to predict tritium production in shielding.
- Use non-tritium radionuclides generated in shielding to benchmark codes.
- MARS prediction of tritium activity in the NuMI decay pipe indicates that only 41% of the tritium is collected from the samples taken from the decay pipe shield.

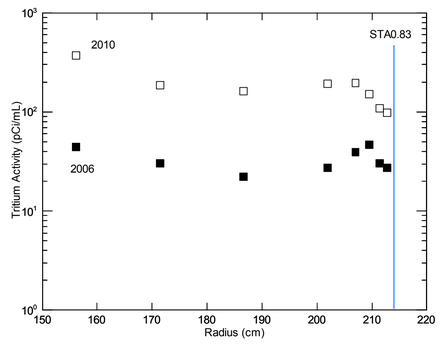
Tritium Mobility

- Tritium in its elemental form or as part of water (HTO) is highly mobile.
- In its elemental form it can permeate many substances including steel.
- Can spread as HTO in either gaseous or liquid forms in porous substances like concrete.
- Any transmission of water into or out of an area which has tritium can move tritium elsewhere.

Upstream Z=93m



Downstream Z=683m

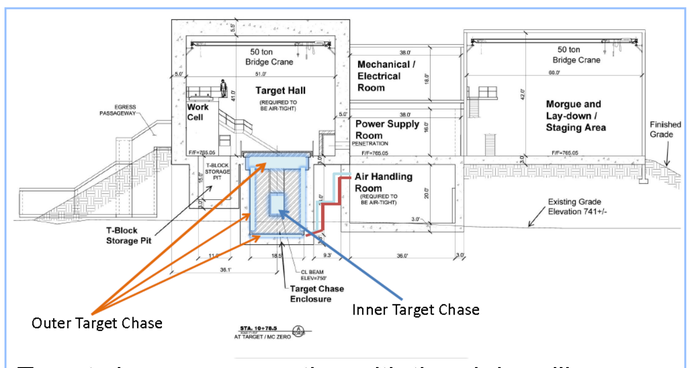


Tritium activity in the NuMI decay pipe shield as a function of radius at 93 m and 683 m distance from the target. The samples were taken in the years 2006 (solid squares) and 2010 (open squares) after at least 30 days of beam off. The blue line denotes the location of the outer surface of the decay pipe shield. Dehumidifiers were installed in the target hall (upstream) between 2006 and 2010 but not in the absorber hall (downstream) until after 2010.

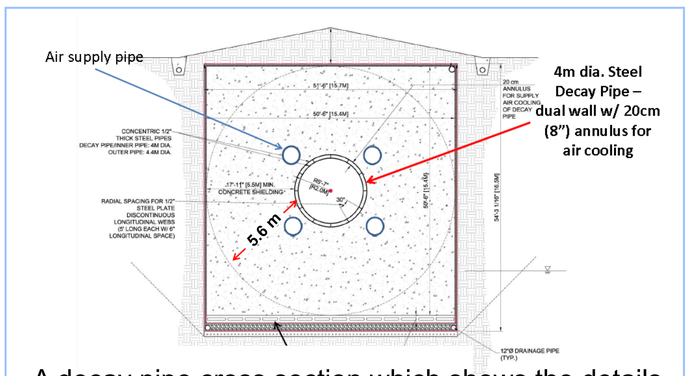
- Whether tritium in the form of HTO enters of leaves a concrete shield at a surface exposed to air depends on the humidity in the air.
- Conditions with high humidity will see tritium in the air infiltrating the shield resulting in a build up of tritium near the shield's surface.
- Low humidity will result in tritium leaving the shield resulting in depletion in tritium activity near the surface.

Dehumidification

- Experience with NuMI saw a decrease in tritium in the sump water after dehumidifiers were installed.
- The target chase and decay pipe will be air cooled with a single air handler which also dehumidifies the air.
- Air is supplied through the outer chase and returns through the inner chase.
- In a separate circuit for the decay pipe, the air is supplied through four cooling pipes embedded in the shield and returned through the annulus.
- Dehumidifying the cooling air will collect any airborne HTO.



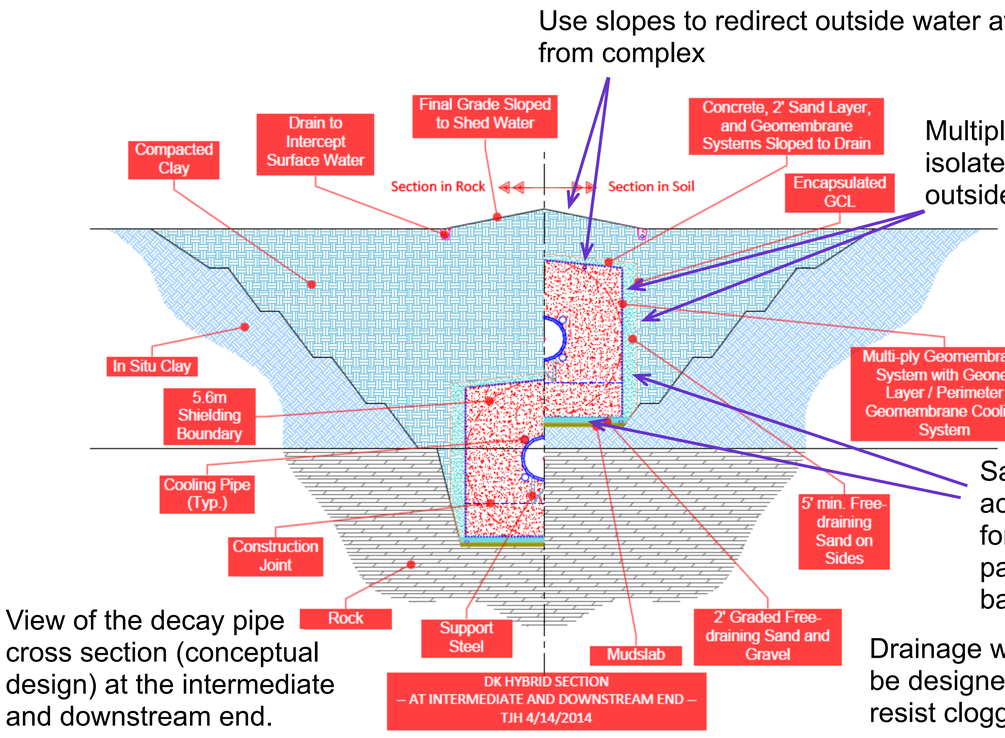
Target chase cross section with the air handling room



A decay pipe cross section which shows the details of the air cooling system.

Barrier and Drainage System

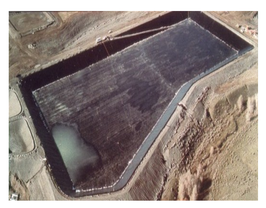
- A system of barriers and drains will be in place to prevent water from moving in and out of the complex.
- Excess water can generate more tritium so water must be prevented from entering the complex.
- Tritiated water inside the complex will be prevented from moving out.
- Any water in or near the complex will be collected in a series of drains.
- Multiple barriers separated by a large sand drainage region reduces the possibility of single point failures leaking tritium.



View of the decay pipe cross section (conceptual design) at the intermediate and downstream end.

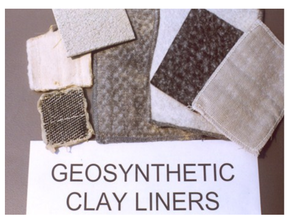
Drainage will be designed to resist clogging

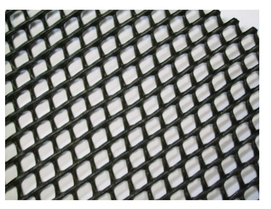
- The barrier system is planned to be comprised of layers of geomemberane, geonet and geosynthetic clay liner (GCL).



Geomembrane
- Water impermeable barrier
- 1 mm minimum thickness

Geosynthetic Clay Liner
- Acts as a hydraulic barrier
- ~6mm thick
- Equivalent to 0.3 - 0.6 m of clay





Geonet
- High capacity to convey fluids.
- Used as a drainage layer.