

Cost Estimates for the KPipe Experiment

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Abstract: We present estimates for the cost of the KPipe experiment. Excluding the cost of civil engineering, the total cost comes to 4.6 million USD. This report supports statements in arXiv article 1506.05811.

1 Introduction

In Ref. [1], we describe the design of an experiment to search for short-baseline muon-neutrino disappearance using neutrinos coming from a charged kaon decay-at-rest source. The experiment, dubbed "KPipe", would be run at the Material and Life-sciences Facility (MLF), which is part of the Japan Particle Accelerator Research Complex (J-PARC) located in Tokai, Japan. The detector envisioned for KPipe consists of a 120 m long by 3 m diameter cylindrical vessel that contains a little over 0.7 kilotons of liquid scintillator. The detector would be instrumented with 121,200 silicon photomultipliers (SiPMs). In the paper, we argue that KPipe will offer a decisive search for sterile neutrinos at high- Δm^2 at a competitive cost. While the physics reach was discussed in [1], in this document we describe our estimates for the cost of the KPipe detector components.

2 Vessel

Contech Engineered Solutions supplies a High-Density Polyethylene (HDPE) pipe that has been used for chemical storage underground. These pipes are also typically used for irrigation or drainage. It is reinforced radially with steel rods to maintain its circular shape, while flexible longitudinally for thermal expansion or flexibility in the event of an earthquake. We believe the HDPE will be compatible with various types of liquid scintillators. Due to the compatibility with liquid scintillator, ease of construction, and safety, we expect HDPE to be suitable for KPipe.

Based on the design outlined in Ref. [1], the 120 m, 2.995 m inner diameter HDPE pipe, including two bulkheads and two 30 risers for cabling, comes to approximately \$288,000. The full field, electro-fusion welding services to construct the vessel was quoted at approximately \$54,000, with an extra \$5,500 for leak testing the vessel. We also require an overflow tank capable of storing approximately 0.3% of the total LS volume. This adds an extra \$16,000 including bulkheads and a stub to connect a line to the main vessel.

3 Scintillator

We are currently considering using a mineral oil based liquid scintillator similar to that used in the NOvA experiment. Approximately 95% by mass is the mineral oil, which acts as a solvent, and the remaining 5% is mostly pseudocumene, which is the scintillator. Trace amounts of PPO and

bis-MSB are also added. These act to downshift the UV photons to longer wavelengths (~ 420 nm) where the quantum efficiencies of typical photodetectors are maximal. The cost of mineral oil and pseudocumene is strongly related to the market price of oil. This will be the largest uncertainty when determining when to acquire the liquid scintillator. KPipe requires a total of 732 tons of the NOvA scintillator mixture. Based on NOvA’s estimate as to the cost of their scintillator, \$1.53M/kiloton [2] [3], we expect the scintillator for KPipe to cost approximately \$1.1 M.

We have the ability to increase the light yield by changing the pseudocumene content or by using a different liquid scintillator, such as Linear Alkylbenzene (LAB). A higher light yield could allow us to reduce the number of SiPMs (which are the dominant cost driver). However, other scintillators will likely be more expensive than the mineral oil mixture.

4 Photon detectors and Readout Electronics

The light collection system is designed to have hoops of SiPMs, which are separated by 10 cm lengths along the axis of the detector (1200 hoops). These hoops are mounted on panels, which optically separate the fiducial region from the veto region. A single hoop contains 100 SiPMs and is read out on a single channel. Based on the reflective panels used in the MiniBooNE experiment, we expect the panels to cost approximately \$150/m². With this design, KPipe will require 120,000 SiPMs and 1200 readout channels for the fiducial volume. The design of the veto currently calls for an additional 1200 SiPMs – attached to 120 hoops – and a total of 12 readout channels. We have received quotes from two separate companies (Hammamatsu, SenSL) regarding the price of SiPMs and expect to be able to purchase them in bulk for \$15-20 per SiPM. Each channel, including cabling, data acquisition, and readout, will cost approximately \$300.

5 Facilities

In our cost estimates, we do not include the cost of civil construction for any on-site modifications to the MLF grounds. To install the detector, a 120 m trench dug out radially from the target station 5 m deep will need to be made. Burying KPipe has the benefits of introducing a slight overburden to help shield against cosmic rays and of insulating the detector from daily temperature fluctuations. If the detector is installed at the location specified in the paper, KPipe will require removing a 5 m section of the road, tree removal, and modifying the location of a storage tank located outside the western wall of the MLF. Once the HDPE components are electro-fusion welded in place, the trench can be filled and the road can be repaired. A small concrete storage building will have to be built to house the electronics and the expansion tank.

An alternative to burying the KPipe detector would be to house the pipe above ground in a long concrete structure whose internal air temperature is controlled. This avoids digging a trench and simplifies containment in case of a spill. However, it will require rerouting the road behind the MLF building.

6 Cost Summary for Detector

References

- [1] S. Axani, G. Collin, J. Conrad, M. Shaevitz, J. Spitz and T. Wongjirad, “A Decisive Disappearance Search at High- Δm^2 with Monoenergetic Muon Neutrinos,” arXiv:1506.05811

Component	Quantity	Unit price [\$M/unit]	Total [\$M]
Vessel Pipe	120 m	0.0024/m	0.288
Vessel Risers	2	0.00065/riser	0.0013
Pressure Tests	1	0.0055/test	0.0055
Expansion Tank	1	0.016/tank	0.016
SiPMs	132200	0.00002/SiPM	2.644
Readout Channels	1322	0.0003/channel	0.3966
Paneling	1056 m ²	0.00015/m ²	0.158
Scintillator	0.732 ktons	1.5/kton	1.1
Total			4.6

Table 1: Summary of component costs. The total estimated cost of the KPipe detector is \$4.6 million.

[physics.ins-det].

- [2] H. Nicholson, “Water Based Liquid Scintillator Workshop,” 2010, https://math.temple.edu/~cmartoff/scint_conf/Nicholson.pdf.
- [3] J. Cooper, “Cost and Schedule Status Risks and Mitigations”, http://www-nova.fnal.gov/reviews_summer_2012/FINAL%20Cost%20&%20Schedule%20Status%20and%20Risk%20&%20Mitigation%20Strategy%20for%2014Aug2012%20IPR%20mini-Review.pdf, IPR Mini-Review, 2012.