Target Detector Status & Plans

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Objectives of target detector(s)

- Provide target mass for neutrino interaction
 - Especially important for Ve measurement
 - Water target necessary or not?
- Acceptance for large angle tracks
- Reconstruct tracks inside detector
- Background reduction/control for Ve measurement

Need to be quantitively defined in terms of physics requirements, with consideration of the detector design

Current FGD

- 0.96×0.96cm², planar geometry
 - Scintillator produced in TRIUMF based on Fermilab recipe







Reference design (based on WAGASCI structure)



3-mm thick plastic scintillator Grid + x/z layers

Two modules: water-in and empty.



Benjamin Quilain



Figure 31: Reconstruction efficiency for muons, pions and protons.

From Task Force Report

Other possibilities..?



Some ideas from Davide





More ideas exist

Electron neutrino measurement Fractional error on the number of expected events at SK

- Ve cross section uncertainty will be important for CP measurement in T2K-II era
- Need to consider how to suppress/control γ background
 - Current level sufficient?
 - Finer granularity helps? other idea?

| | $ u_{\mu} \text{ sample} $ 1R _µ FHC | v_{e} sample 1R _e FHC | $\overline{ u}_{\mu}$ sample 1R _µ RHC | $\overline{\nu}_{e}$ sample 1R _e RHC | 1R _e FHC/RHC |
|-----------------------------------------------------------------------------------------|------------------------------------------------|------------------------------------|--------------------------------------------------|-------------------------------------------------|----------------------------|
| ν flux+cross-section constrained by ND280 | 2,8% | 2,9% | 3,3% | 3,2% | 2,2% |
| $ u_{\rm e}/ u_{\mu} $ and $ \overline{ u}_{\rm e}/\overline{ u}_{\mu} $ cross-sections | 0,0% | 2,7% | 0,0% | 1,5% | 3,1% |
| ΝC γ | 0,0% | 1,4% | 0,0% | 3,0% | 1,5% |
| NC other | 0,8% | 0,2% | 0,8% | 0,3% | 0,2% |
| Final or secondary hadron int. | 1,5% | 2,5% | 2,1% | 2,5% | 3,6% |
| Super-K detector | 3,9% | 2,4% | 3,3% | 3,1% | 1,6% |
| Total | 5,0% | 5,4% | 5,2% | 6,2% | 5,8% |



ies

Low energy hadrons

- Efficiency study by Benjamin
- Low energy proton measurement (energy, direction) is difficult (resolution)
 - Maybe possible with much finer granularity?
 - Quantitative requirement?
- How important is Michel electron tagging?
 - Requirements for electronics (dead time, ..)

Sub-WorkPackages (preliminary)

- Definition of detector configuration [with simulation/physics]
 - Water target necessary? (alternative configuration?)
 - WAGASCI-like? FGD-like? Else?
- Plastic scintillator
- WLS fibers
- Photosensors (MPPC)
- Mechanical structure [with WPI]
- Water system (if necessary)
- Electronics (frontend, backend)
 - Independent system or identical to HTPC (like FGD-TPC)?
 - Interface to other system (DAQ, hardware)
- Monitoring system

Scintillators

- Lots of experience with Fermilab extrusion facility
 - Produced scintillators for MINOS/SciBar/INGRID/P0D/ ECAL/WAGASCI
 - May need to produce/test new die
 - Availability of facility for mass production to be checked
- Other suppliers?



Scintillator performance

Light yield measurement with WAGASCI scintillator (2014)



MPPC (Multi-Pixel Photon Counter)

- Semiconductor photosensor ("SiPM") by Hamamatsu
 - Compact, high photon detection efficiency, immunity to B-field
- T2K near detectors were first large scale application
 - >50,000 devices used
 - Excellently working since 2009







MPPC development

- Recent version has significantly improved performance compared to those used in T2K
- Will (re-)start communication with Hamamatsu about possible further development, including package



Preliminary Timeline

- 2017
 - Fix design
 - R&D and test of components
 - Scintillator, MPPC, electronics, mechanical component
- 2018
 - Test production of scintillator.
 - Beam test with small prototype?
 - Start mass production/procurement (fiber, MPPPC)
- 2019
 - Mass production, testing
- 2020
 - Construction of detectors

Groups currently interested

- Japan
 - Japanese universities
 - KEK
 - Postdoc opening for ND upgrade! (Deadline:Apr/17) <u>http://www.kek.jp/en/Jobs/e_researcher_T2Kexperiment.pdf</u>
 - Got grant for T2K upgrade, acc.+beam+ND (-2020)
 - Postdocs+test/prototype/construction
 - Little engineering resource in Japanese institutes
- LLR (France)?
 - Mechanical engineering? electronics??
- More groups are necessary! your contribution is welcome