

STATUS OF THE OPERA LONG BASELINE EXPERIMENT*

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OPERA (Oscillation Project with Emulsion tRacking Apparatus) is an international collaboration (Europe–Asia) aiming to give the first direct proof of ν_τ appearance in a pure ν_μ beam, in order to validate the $\nu_\mu \rightarrow \nu_\tau$ atmospheric oscillation hypothesis. OPERA has already obtained good results with electronic detectors during the first CNGS run in August 2006, and neutrino interactions have been observed in OPERA-like target with the PEANUT test beam at Fermilab in 2005.

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1. Beam and detector status

The neutrino beam, CERN Neutrino to Gran Sasso (CNGS), is produced at CERN with 400 GeV protons extracted from the SPS and sent on a graphite target at 4.5×10^{19} protons on target (pot) per year. The resulting ν_μ are sent in the direction of the Gran Sasso underground National Laboratory (LNGS or GS), located in Italy 730 km away from CERN, with a mean energy of 17 GeV making an angle with the Earth surface of 3.2 degrees. The CNGS is totally instrumented since 2006 [1], and the first beam has been sent to GS in August 2006. From FLUKA simulations predicting the different neutrino fluxes, we expect about 3000 ν_μ charged current (CC) interactions per year and per kt of target at GS. Assuming a $\Delta m_{23}^2 = 2.5 \times 10^{-3} \text{ eV}^2$, the number of ν_τ CC interactions from oscillated ν_μ is of the order of 16 events per year and kt. The ν_τ appearance signature will be the detection of the τ particle, that will be reconstructed through its 4 main decay channels: electron (17.8%), muon (17.4%), one hadron (49.5%), or three hadrons (14.5%). The OPERA performances for all channels after 5 years running with the design target mass of 1.8 kt¹, would allow the detection of 12.8 signal events (with $\Delta m_{23}^2 = 2.5 \times 10^{-3} \text{ eV}^2$) for only 1 background event.

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¹ The final target mass should be 25% less than the original design, leading to 1.35 kt.

The OPERA detector is composed of 2 super-modules, each made of a muon spectrometer (that gives a muon momentum resolution of 20% below 50 GeV), and a target part. The target is composed of 31 passive lead-emulsions ECC [2] brick walls, interleaved with active plastic scintillator strips (TT), that have a trigger efficiency of 99% and a brick finding efficiency of the order of 70%–90%, which depends on the event type and topology. The OPERA bricks are made of 57 photographic emulsion sheets 300 μm wide, interleaved with 56 lead plates of 1 mm. This technology allows a micrometric spatial resolution, and a 3D reconstruction of particle tracks, necessary for τ detection. In total, 154750 bricks will be inserted, and about 20 candidate bricks per day will be extracted, developed, and sent to scanning laboratories for analysis.

2. First results

First CNGS run in August 2006 gave good electronic detector results with 0.084×10^{19} integrated pot: more than 300 events correlated in time with beam were registered with neutrino interactions inside the rock, and the TT and spectrometers of the detector (the target section was not filled) [3].

In addition, neutrino events have been observed in OPERA-like bricks from the PEANUT test-beam which took place in 2005 at Fermilab, using the NUMI beam running in Low Energy configuration: 9 muon neutrino events have been located and reconstructed, the analysis is still going on.

3. Conclusion

OPERA is the first experiment for ν_τ appearance in a ν_μ beam. It uses an hybrid detector with passive lead-emulsions target and active electronic detectors. Electronic parts are fully instrumented and tested. In June 2007, 27000 bricks were inserted in the detector, and the full target is expected for summer 2008. The OPERA electronic detectors gave good results during the CNGS beam run in August 2006. The next CNGS run is expected for Autumn 2007 with 60000–70000 bricks and a beam intensity of 0.43×10^{19} integrated pot; 180 neutrino interaction events in bricks are then expected.

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