The Emulsion Scanning System of the OPERA Experiment

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The emulsion scanning system

The emulsion scanning system has been developed in the framework of an R&D project for the OPERA neutrino experiment. It is able to scan nuclear emulsion films at a speed of up to 75 cm^2 emulsion surface per hour, one order of magnitude higher than past systems.

References:
http://operaweb.lngs.infn.it/
L. Arrabito et al., Nucl. Instr. and Meth. A 568 (2006) 578
N. Armenise et al., Nucl. Instr. and Meth. A 551 (2005) 261
T. Nakamura et al., Nucl. Instr. and Meth. A 556 (2006) 80

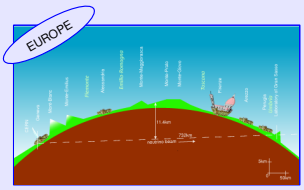
The OPERA experiment

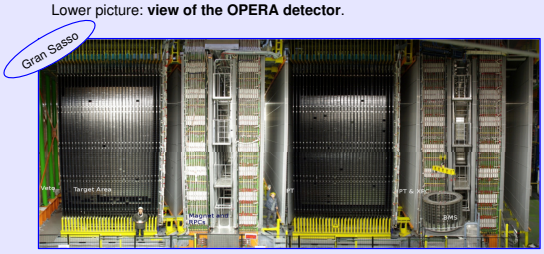
An oscillation neutrino experiment to prove the direct appearance of ν_τ

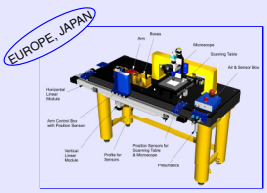
Right picture: **neutrinos from CERN to OPERA**.

- OPERA production run started in 2008.
- CNGS beam delivered 1.8*10E19 pot for 2008 run and 3.5*10E19 expected for 2009: ~ 2 expected tau events.

Lower picture: **view of the OPERA detector**.







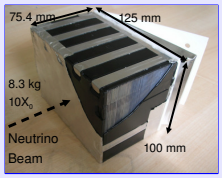
The european scanning microscope to read out the data of the OPERA brick.

The main detector unit

The OPERA brick

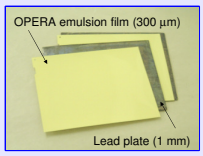
Lead + photographic emulsions:

- 57 layers, about 10X$_0$, 8.3 kg.
- 150000 bricks in the detector.
- Target mass 1.25 kton.



The OPERA emulsion

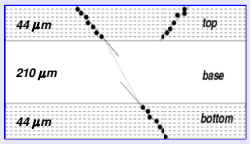
- The size of one emulsion film is 10 cm x 12.5 cm with a thickness of 300 µm.
- Readout by optical microscopes in Europe/Japan.
- Almost 10 Mio. emulsions in the detector (150000 m^2 of emulsion area)



Scanning the OPERA emulsion

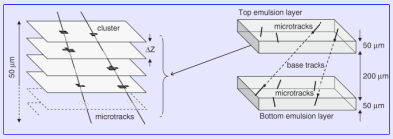
The OPERA emulsion specifications

- AgBr cristals with a size of 0.2 µm
- 10E13 channels in a film
- Intrinsic resolution of 0.06 µm
- Sensitivity of 33 grains / 100 µm (m.i.p.)
- 5-10 accidental grains / 1000 µm^3

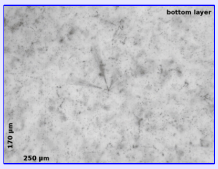


The OPERA scanning

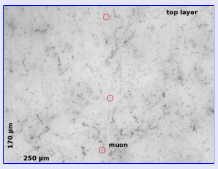
- A sequence of images every 2-3 µm provides a tomographic view of the emulsion layers.
- Tracks in one layer, called microtracks, can be connected to the corresponding microtrack on the other side of the emulsion base. The new track is called basetrack.
- Tracks are followed from emulsion to emulsion up to the interaction point.



The image grabbing is performed while the focal plane is moved along the vertical axis with a constant speed. The tomographic sequence of images is used to reconstruct 3D particle tracks.

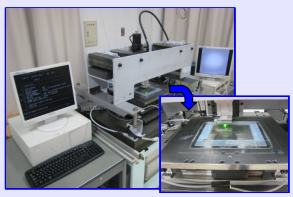


ν_μ CC interaction in the base of an emulsion. Back-scattering fragments (left) and three particles that leave the vertex (right).



Scanning

Japanese scanning system



- Scanning speed/system: up to 75 cm^2/h
- High speed CCD camera (3 kHz)
- Piezo-controlled objective lens
- FPGA Hard-coded algorithms

Nagoya: 4 systems (75 cm^2/h), 1 system (20 cm^2/h)
5 sub systems (1 cm^2/h)

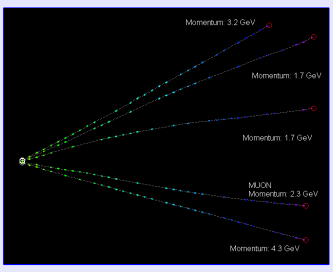
European scanning system

- Scanning speed/system: 20 cm^2/h
- Customized commercial optics and mechanics
- Asynchronous DAQ software

LNGS: 10 systems, Napoli: 5 systems,
Bern: 5 systems, Bari: 4 systems,
Salerno: 4 systems, Bologna: 4 systems,
Padova: 1 system, LNF: 1 system,
Rome: 1 system

ν_μ CC interaction

A ν_μ CC interaction from the 2008 run with 5 tracks reconstructed at the vertex. All the impact parameters are within 5 µm. The momenta are estimated with the multiple coulomb scattering method.



Literature

The OPERA experiment in the CERN to Gran Sasso neutrino beam, R Acquafredda et al. 2009 JINST 4 P04018
The detection of neutrino interactions in the emulsion/lead target of the OPERA experiment, arXiv-0903.2973v1