P.I.D. in SK as function of the lepton momentum for 20% and 40% coverage

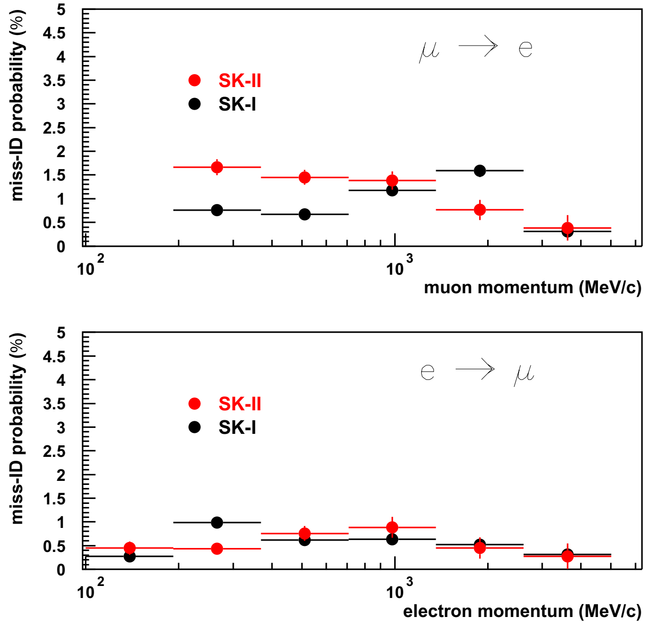


Figure 11.9: The mis-ID probability of particle type as a function of momentum. The horizontal axis is momentum in log scale. The upper figure shows the fraction of the events classified as muon-like while electrons are generated, and the lower one shows vice versa. Black points represent SK-I, and red ones represent SK-II.

Lepton momentum resolution for 20% and 40% coverage

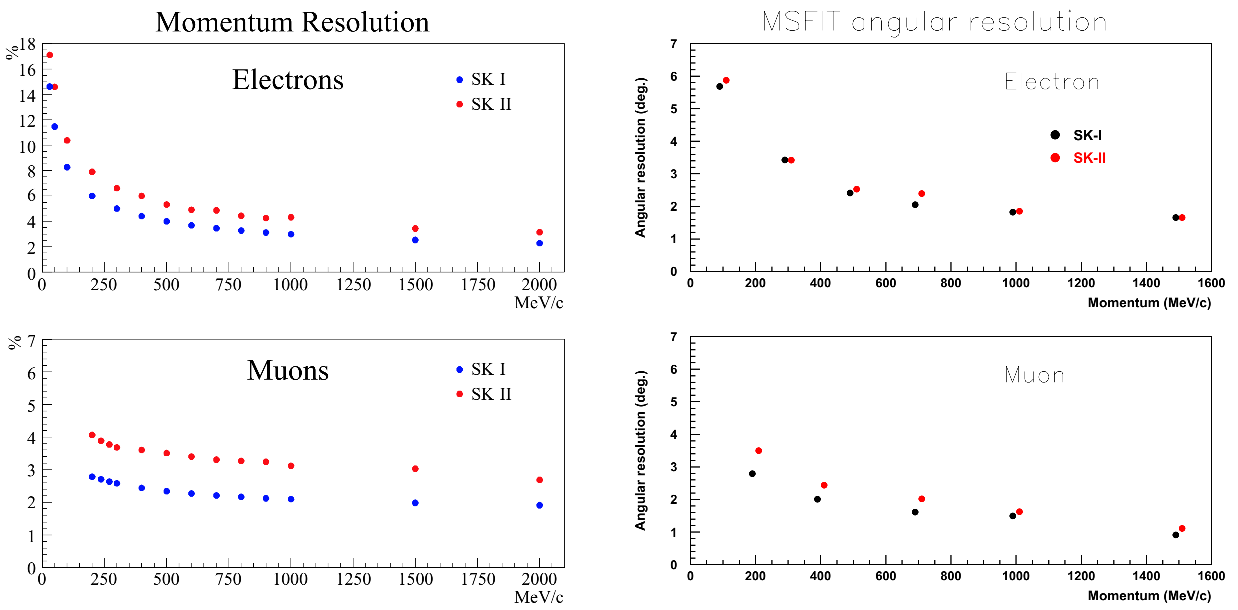
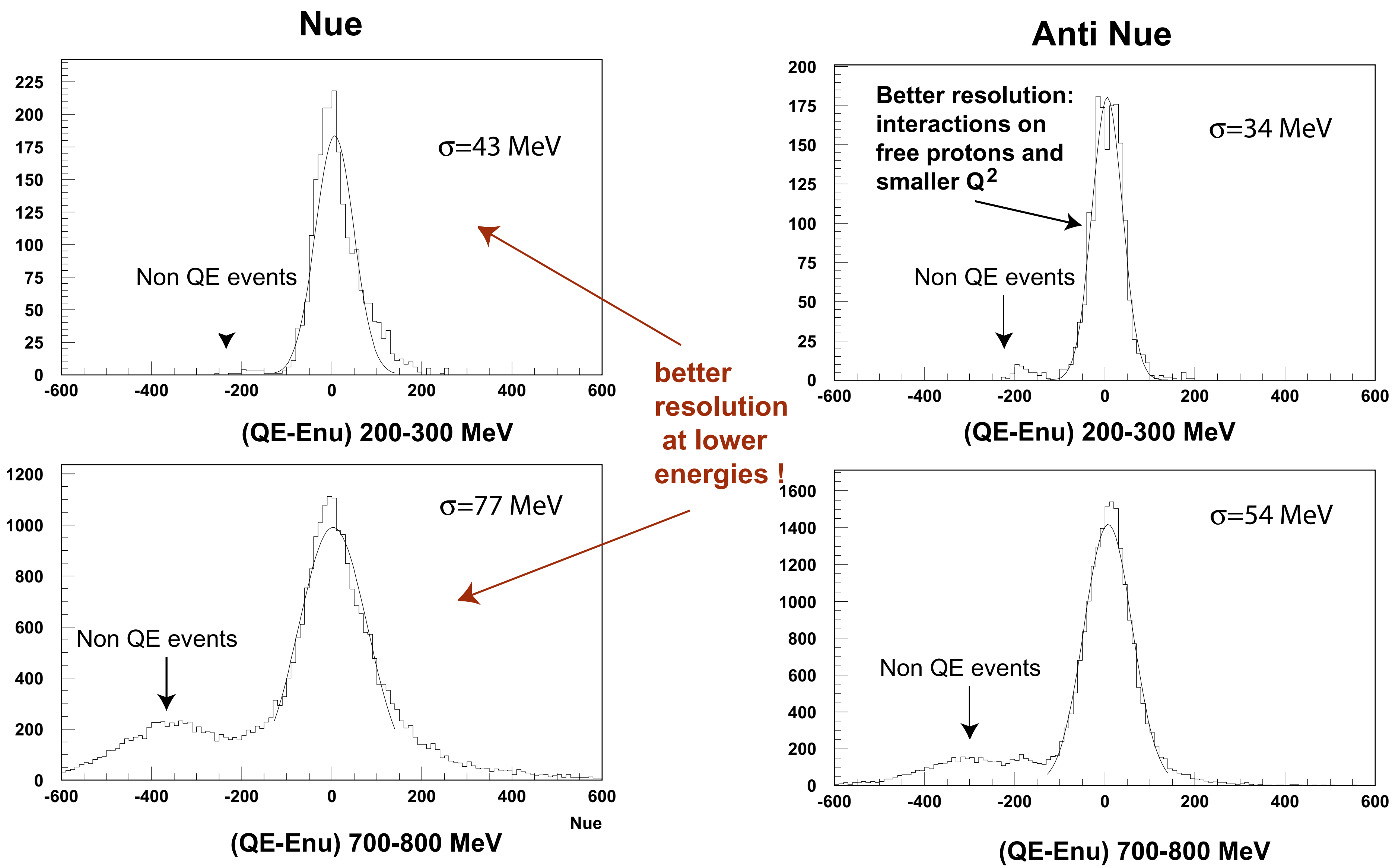
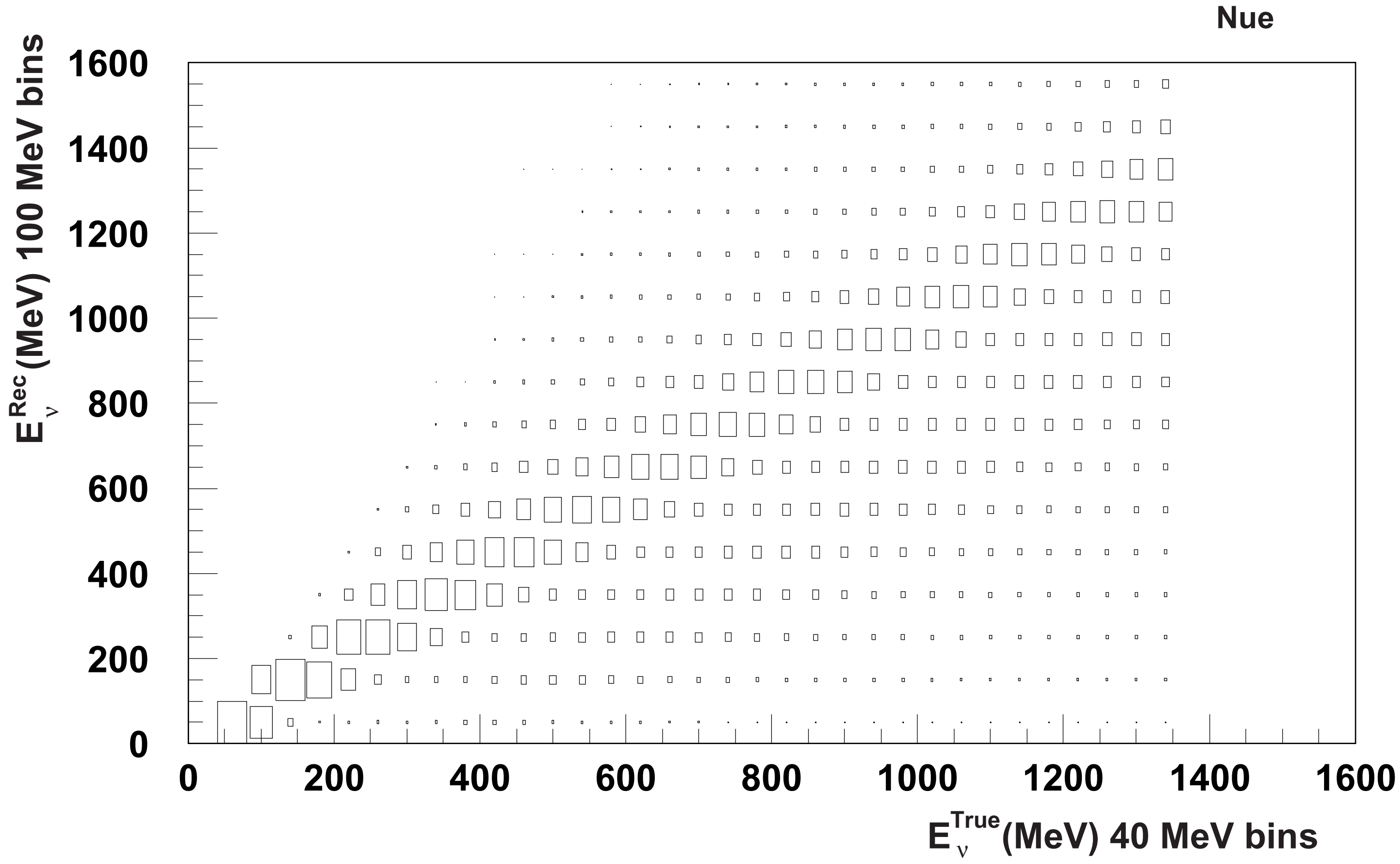


Figure 11.10: Momentum and angular resolution of MS-fit as a function of momentum. The left figures show the momentum resolution, and the right ones show the angular resolution. Blue or black circles show SK-I, and red ones show SK-II. A single particle is generated by the MC simulation many times, and the standard deviation of the reconstructed value from the true value is plotted.

Neutrino energy reconstruction (QE kinematics)



Migration Matrix (4 matrixes for nue, numu and anti's)



Parameters	**UNO** (USA)	**HyperK** (Japan)	**MEMPHYS** (Europe)
Underground laboratory			
location	Henderson / Homestake	Tochibora	Fréjus
depth (m.e.w.)	4500/4800	1500	4800
Long Base Line (km)	$1480 \div 2760$ / $1280 \div 2530$	290	130
	FermiLab$\div$BNL	JAERI	CERN
Detector dimensions			
type	3 cubic compartments	2 twin tunnels	$3 \div 5$ shafts
		5 compartments	
dimensions	$3 \times (60 \times 60 \times 60)\mathrm{m}^3$	$2 \times 5 \times (\phi = 43\mathrm{m} \times L = 50\mathrm{m})$	$(3 \div 5) \times (\phi = 65\mathrm{m} \times H = 65\mathrm{m})$
fiducial mass (kt)	440	550	$440 \div 730$
Photodetectors			
type	20" PMT	13" H(A)PD	12" PMT
number (internal detector)	57,000	20,000 per compartment	81,000 per shaft
surface coverage	40% (1/3) & 10% (2/3)	40%	30%

Table 1: *Some basic parameters of the three Water Čerenkov detector baseline designs*

3.4 Photodetection

The baseline photodetector choice is photomultipliers (PMT) as they have successfuly equipped the previous generation of large water Čerenkov detectors and many other types of presently running detectors in HEP. The PMT density should be chosen to allow excellent sensitivity to a broad range of nucleon decays and neutrino physics while keeping the instrumentation costs under control.

Our goal for MEMPHYS is to reach in the whole detector the same energy threshold as Superkamiokande, that is 5 MeV, important for solar neutrino studies, for the proton decay into $K^+\nu$ using the 6 MeV tag from ^{15}N desexcitation, and also very useful for SN explosions, since the measurement of the ν_μ and ν_τ fluxes could be achieved using the neutral current excitation of Oxygen.

Our first approach was to consider 20" Hamamatsu tubes as used by Superkamioka, but the cost for 40% coverage becomes prohibitive, as these tubes are manually blown by specially trained people, which makes them very expensive. Following a suggestion presented at the NNN05 conference by Photonis company, we have considered the possibility of using instead 12" PMT's, which can be automatically manufactured and have better characteristics compared to 20" tubes: quantum efficiency (24% vs 20%), collection efficiency (70% vs 60%), risetime (5 ns vs 10 ns), jitter (2.4 ns vs 5.5 ns). Based on these numbers, 30% coverage with 12" PMT's would give the same number of photoelectrons per MeV as a 40% coverage with 20" tubes. Taking into account the ratio of photocathodes (615 cm^2 vs 1660 cm^2), this implies that going from 20" tubes to twice as many 12" tubes will give the same detected light, with a bonus on time resolution and on pixel locations, so that MEMPHYS performances should be at least as good as SuperKamiokande. A GEANT4 based Monte Carlo is under development to quantify the effective gain. Pricewise, each 20" PMT costing 2500 Euros is replaced by 2 12" PMT's costing 800 Euros each. The only caveat is to make sure that the savings on PMT's are not cancelled by the doubling of electronic channels. An R&D on electronics integration is presently underway (see Sec. 3.6).

3.5 Photomultiplier tests

A joint R&D program between Photonis company and French laboratories has been launched to test the quality of the 12" PMTs in the foreseen conditions of deep water depth, and to make a realistic market model for the production of about 250,000 PMTs that would be necessary to get the 30% geometrical coverage.

In parallel, studies on new photo-sensors have been launched. The aim is to reduce cost, while improving production rate and performance, as it is essential to achieve the long term stability and reliability which is proven for PMTs. Hybrid photosensors (HPD) could be a solution: the principle has been proven by ICRR and Hamamatsu with a 5" HPD prototype. Successful results from tests of an 13" prototype operated with 12 kV are now available, showing a $3 \cdot 10^4$ gain, good single photon sensitivity, 0.8 ns time resolution and a satisfactory gain and timing uniformity over the photo-cathode area. The development of HPD has also been initiated in Europe, in collaboration with Photonis.

5 Schedule

The following table presents an optimal schedule for the European project taking into account the key date of the completion of the new tunnel excavation around 2010. Soon after, CERN will have to decide its post-LHC strategy, while nuclear physicists will hopefully choose CERN as the host laboratory for the EURISOL project. We would also like to stress that the schedule of the neutrino beams from CERN is not constraining the start of the other non accelerator items of research.