Report on the session "SPS Rare K-decays and CNGS" at the New Opportunities on the Physics Landscape at CERN.

Convener: Christos Touramanis

Executive summary

The session consisted of one contribution on Rare K-decays (charged K to pi-nu-nubar) by experiment NA62 at the SPS, where a measurement with precision around 10% of the SM prediction will be sensitive to loop effects coming from new physics at higher energy scales, and four contributions on the lepton sector, of which three combine frontline neutrino physics measurements with advancements in large Liquid Argon TPC technology.
Two contributions addressed one of the key objectives of the next generation of long baseline neutrino experiments, namely the search for CP violation in the lepton sector. With both T2K and DoubleChooz taking data in months from now, if the yet unobserved 1-3 neutrino oscillation is not more than one order of magnitude below the current (0.14) upper limit (i.e. if $\sin^2(2\theta_{13})>0.01$) both experiments will observe evidence for non-zero theta_13 in the next few years and it can be anticipated that construction of experiments aiming to search for CP violation in neutrino oscillations could start by the middle of the next decade. The known CP violation in the quark sector, arising from the established and well-measured CKM mechanism, is by far inadequate to satisfy the corresponding Sakharov condition for the development of our matter-dominated, suitable for life Universe. Although CP violation in light neutrinos is not necessarily directly linked to CP violation in the corresponding heavy sector which is relevant in leptogennesis scenarios, a discovery would significantly strengthen the viability of such models. Hence the proposed activities in this direction, both based on large liquid Argon detectors, are timely and important if Europe is to play a leading role in this future discovery program, even in the case that the actual experiments will not take place in Europe.
The session was lively and well-attended and an excellent precursor to the dedicated event next October on the wider neutrino physics scene, opportunities, and horizons.

NA62: Opportunities in Rare Kaon Decays, Augusto Ceccucci (ID 8)

Speaking on behalf of the NA62 collaboration (26 institutes from Europe and America) Augusto started with the case for a combination of precision measurements in theoretically clean channels in the quark flavour sector which on one hand use SM-dominated transitions to pin down the CKM parameters, and rare transitions where weak SM loop amplitudes may compete with New Physics contributions from the presence of yet-unknown high mass particles in loops.
K to pi-nu-nubar is a prime example of the second category, where the SM predicts decay rates of few times 10^{-11} with 8% precision for the charged mode and 15% for the neutral one. NA62 is preparing to measure the charged mode, while E14 at J-PARC propose to measure the neutral one.
Using a modified NA48 detector and an unseparated 800MHz, 75GeV/c SPS beam NA62 aims to observe 55 signal evens in one typical year (as per NA48 experience) with backgrounds expected around or below 13%. The experiment is based on K-decays in flight and uses precision timing and the new "Gigatracker" to associate individual incoming Kaons to their decay products. New photon vetos are being

constructed using OPAL leadglass crystals and PID will be provided by a combination of upgraded CEDAR Cerenkov counters and fast RICH.
The experiment claims that with 2(+1) years of running with SPS duty cycle of 0.3 and a proton rate of 1.1×10^{12}/s they can achieve a precision of 10% on pi-nu-nubar and also extract improved measurements on a number of other rare K decays.

DOUBLE-LAr: sterile neutrinos at the CERN-PS, Calro Rubbia (ID 24)

Carlo started with the LSND result where an excess of nu_e in a nu_mu beam would require, if confirmed, new physics beyond the SM 3 neutrino picture. He mentioned the wide range of theoretical hypotheses which can reconcile the LSND result with the rest of the neutrino oscillation data, many of which require the presence of additional, sterile neutrinos. He then made the case that MiniBooNE has not conclusively resolved the issue, and moreover has come up with the well-known low-E excess which is unexplained at this point in time.
This area will be explored by CNGS2 (ICARUS) which will be able to cover most of the LSND region in the Δm^2-$\sin^2$_2theta plane, with lower Δm^2 regions remaining uncovered, and that is where this proposal comes in. MicroBooNE at FNAL is a proposed 70-tonne LAr (ICARUS-like) experiment that will address the same issue, possibly taking data as early as 2012, although there is a question if this size of detector will be sufficient, while another experiment is being proposed at ONRL.
After a quick review of the advantages of LAr TPCs (full event reconstruction with vertexing, PID and energy measurement allowing powerful background rejection) Carlo proposed to revive the PS neutrino beam and use two identical in terms of design LAr detectors at 127m and 550m from the target, both inside CERN. The detectors are based on ICARUS with significant improvements and simplifications from the lessons learned from it, offering 10 and 500 tonnes of fiducial mass respectively, with an estimated cost of €7.85M. With 2.5×10^{20} POTs of neutrino and the same of antineutrino running the experiment will have thousands of fully reconstructed neutrino events and will address conclusively the LSND issue.

MODULAr: A new, very massive modular Liquid Argon Imaging Chamber to detect low energy off-axis neutrinos from the CNGS beam, Alberto Guglielmi (ID 25)

Based on ICARUS but with improvements form the lessons learned, MODULAr will be based on individual modules of 5kt each (cf 0.3kt for the current ICARUS modules), with the initial configuration envisaged to be 20kt. The new detector will be located in an off-axis position with respect to the existing CNGS beam. This can be achieved either in a new underground location 10km from the existing lab, or on surface, submerged in a water pool inside the external lab, 7km off-axis. An underground location will also allow to search for proton decay and cosmic neutrinos, but is not required for the oscillation / CP program.
The new modules will be similar to ICARUS, with 4m drift length, 6mm wire pitch, and 30m long wires. Each module will have 50,000 readout channels. The beam requirement would be 512 kW at 400 GeV delivering 1.2×10^{20} pot/y. This is expected to match the nominal planned NOvA sensitivity. By using ICARUS in its current on axis position and combining the measurements from the two detectors beam related systematics can be adequately controlled.

As soon as successful operation of ICARUS has been demonstrated the collaboration will seek to expand with new groups in order to be able to raise the appropriate resources.

Opportunities for European neutrino oscillation physics building on the T2K experience, Andre Rubbia (ID 81)

Europeans from 7 countries make up one third of the T2K neutrino oscillation experiment which will start collecting data in late 2009 using the new neutrino facility at J-PARC, Super-Kamiokande, and a purpose-built near detector. After a non-zero theta_13 is established, planned improvements in beam power to above 1MW and a new very large far detector (Mt water Cerenkov or 100kt LAr TPC) would be required to extend the programme to search for CP violation. While the LAr option does not require a deep underground site, this would allow to also search for proton decay and cosmic neutrinos.

Andre, on behalf of a number of European groups from Switzerland, the UK, Poland, and France presented the GLACIER concept for a large double phase, single volume, fully active detector based on commercial LNG storage tank technology, with charge readout by large area LEMs (2.5×10^6 channels) and light readout with large PMTs and wavelength shifter.

Ongoing engineering studies and results from the operation of LEMs in small prototypes with custom preamplifiers and commercial digital FEs were presented. The proposed approach of step-by-step R&D currently has so far demonstrated all principles in small prototypes in a number of labs. The 1t ArDM device in operation at CERN and the 5m long DriftTube will demonstrate scalability, and as the next step it was proposed to build a 3t device to be tested extensively with charged particles in the North Area to demonstrate the full system including reconstruction and to evaluate LAr performance with high statistics.

Physics reach estimates were shown for such a detector of 100kt located at different baselines and off axis angles related to the J-PARC neutrino beam. It was noted that the same detector would provide similar sensitivity if located off-axis to the CNGS beam (similar to the MODULAr case above) but would require an increase of beam power by a factor between 3 and 10 times the current CNGS beam, probable requiring major interventions in the beamline itself.

Search for heavy neutral leptons, Francois Vannucci (ID 0)

Francois revisited the searches for heavy sterile neutrinos (N) which have been the object of a dedicated search 25 years ago (PS191). Recently the case for the existence of heavy sterile neutrinos was postulated again, in the vMSM model where three sterile N are assumed with masses in the keV-GeV region. It is assumed that N is produced mixed with the known neutrinos (e.g. K to e N) and then decays weakly giving a 2-prong vertex in a decay volume. Thus he proposes to use a vacuum tank as decay volume followed by a fine grained calorimeter to detect the decays. Using the higher proton fluxes available today to accumulate 10^{21} POT of 19GeV protons, one could improve the limits for N with $m<450$MeV by a factor of up to 20 compared to PS191. Using a TeV energy proton beam from a new source (SPS+) one could do a beam dump experiment extending the N mass range up to the B mass.

Convenor's comments

CERN has a long and successful track record in rare kaon decays and currently one of the frontline experiments under preparations and clearly this is a very exciting programme at the international frontline, and as such merits continued support.

In the area of neutrino experiments with accelerator-made beams CERN has an equally long track record and the community also has the leading position internationally in developments in large LAr TPCs which is a very promising technology for neutrino detection and also proton decay searches. The proposals at the workshop are all interesting, ambitious, and at the same time realistic. They offer ways for CERN to retain its leadership and to support the European neutrino physics community to position themselves so that they can be key players in the field in the medium and far term future through focused detector R&D and valuable physics measurements.