Report on the session “Possible new developments” at the New Opportunities on the Physics Landscape at CERN.

Convenor: Michalangelo Mangano

The session received contributions on a few rather different topics, going from the search of new hypothetical particles or studies of QCD in various regimes, to studies of plasma physics in the LHC beam dumps or R&D on new acceleration techniques. We organize the review in terms of three categories: (1) experiments that make use of the existing beams, and whose running does not directly impact the standard LHC operations (2) experiments that directly impact the default LHC running operations, or require new infrastructure for the beam line and/or experimental halls (3) new accelerator technologies.

1. New, dedicated experiments, using existing accelerator infrastructure:

"Solving the neutrino mass and baryon asymmetry puzzles with experiments at the PS and SPS" (M.Shaposhnikov et al)

A simple extension of the SM with one light singlet fermion per family could provide all the necessary ingredients to explain neutrino masses, the baryon asymmetry of the Universe (BAU) and dark matter (DM). The lightest of these neutral fermions (N1) is stable on the scale of the Universe lifetime, and provides a DM candidate. Fitting its properties to the required behaviour of DM, and imposing that the model predicts the BAU, allows to constrain the model parameters, and to restrict the possible range of masses and couplings for the other two states (N2, N3). This mass range extends up to about 30 GeV. Meson decays like K->mu N2, D->mu N2 and B->mu N2, followed by the downstream decay of N2->mu+mu– nu, provide experimental signatures that allow to probe the N2 mass up to a few GeV. Previous experiments (CHARM, BEPC, NuTeV, etc) have set limits on such decays. A new generation of experiments, with statistics of the order of 1E20 POTs, will allow to improve by a factor of 10 the reach in the square of the mixing angle between N2 and the usual muon neutrino.

Comments: the proposal is scientifically motivated. The use of the SPS beam allows the exploration of a mass range larger than what achievable at any other planned facility (e.g. Project-X). The overall evaluation of the proposal reqires however a more explicit discussion of the experimental and detector aspects. As in the case of the previous experiments that set the current limits on this class of models, the search for heavy neutral leptons is only one of many other physics topics that can be addressed, and therefore it is reasonable to expect that the proposed experiment details a broader physics programme.

"Proposed Application of the LHC and SPS to Study High Energy Density Matter and Plasma Physics" (N.Tahir et al)

Monte Carlo simulations of the effects of beam absorbtion in a beam-dump target, and of their time evolution, have been studied for the SPS and LHC beams. The naive static modeling of the targets fails to describe the features observed in more complete, Fluka based, simulations. The validation of this modeling can enrich the study of solids in a very-high-density, or plasma-like, phase, with possible applications to the study of targets for high-power beams.

Comments: Direct measurements can be achieved by installing the appropriate probes on the beam-dumps, and monitoring standard SPS and LHC operations.

2. Experiments using modified configurations of the LHC beams

"Mono-energetic electron and gamma-ray beams at CERN" (M. Krasny)

A monoenergetic electron beam can be obtained by attaching electrons to heavy nuclei. This could allow ep and eA collisions. In the ep case, the CM energy is 205 GeV and a luminosity of about 1E29 can be achieved. This can be extended to a mono-energetic, high-intensity, and highly-collimated gamma-ray beam at CERN - with higher efficiency than the present inverse-Compton-scattering gamma-ray sources. These can be used both for a gamma-p high-energy programme (ECM(gamma-p)~60 GeV), and for many new possibilities for basic research and applications, including photo-transmutation of nuclear isotopes, gamma-ray transmission radiography, cancer therapy and positron beam production.

Comments: the ep programme would not extend significantly the knowledge acquired from HERA, but eA collisions at these energies would be a novelty, and unique. It is clear that operations in these modes would subtract luminosity to the normal LHC programme, and their interest would have to be properly motivated.

"Fixed target charmonium production with proton and lead beams at the LHC" (N.Topilskaya et al)

The proposal envisages the deployment of a ribbon target around the main orbit of the LHC beam, near the interaction point of the ALICE detector, to trigger fixed-target-like interactions induced by the beam halo. The physics goal is to achieve pA and AA collisions at energies in the range of approximately 100 GeV. The production properties of J/ψ and ψ' could then be studied in a domain in between the SPS and RHIC energies, to help clarify the onset and dynamics of a possible QGP phase.

Comments: energy scans over the proposed energy range can be easily done at RHIC, and are indeed part of the planning. There is no obvious advantage of using the LHC in a fixed-target mode.

"Measurement of magnetic moments of charmed baryons using an extracted beam at LHC" (S.Paul et al)

LHC beams could be extracted and directed towards a fixed target, to produce highly boosted charmed baryons, whose magnetic moments are measurable using crystal channeling. Baryon momenta of the order of a TeV are required, due to the short lifetime of these states. LHC beams on a fixed target are therefore a unique setup for such measurements.

Comments: infrastructure work appears necessary to allow for the beam extraction, and to host the spectrometers. No details on the actual needs and on the impact on LHC operations are however available at this time.

3. New ideas in beam acceleration

"Proton Driven Plasma Wakefield Acceleration (PDPWA)" (G.Xia et al)
It is proposed to use existing high-energy proton bunches to drive a plasma wakefield. The strong plasma field then accelerates a trailing electron bunch to high energies. Simulations show that a proton bunch with particle energy of 1 TeV, a bunch length of 100 µm, and 10^11 protons can accelerate an electron bunch to beyond 500 GeV in a single plasma channel. A key element in realizing PDPWA is the production of a very short proton bunch. A proof-of-principle experiment based on PDPWA is then proposed for consideration as a future CERN project. A proton bunch extracted from the PS or SPS would first be compressed through conventional magnetic compression and then enter into the plasma channel to exciting the plasma wakefield. In a first stage, the properties of the plasma wave could be studied without an electron bunch. Upon success of this stage, an electron bunch could be injected in the plasma and acceleration gradients demonstrated. Properties of the electron bunch would be studied in detail. A general facility for plasma wakefield studies could be envisaged.
Comments: The prospects that could be opened by these new ideas are very exciting, even if practical applications for HEP experiments are not guaranteed and anyway lie beyond forseeable timescales. The current CERN accelerator complex provides a unique facility to pursue this challenging R&D. A more complete proposal for the proof-of-principle experiment, detailing the required resources, should be encouraged.