Future Prospects

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Abstract

A summary of the many topics presented at the parallele session on Future Prospects is given. The topics cover prospects of polarised and unpolarised targets, of proton and heavy targets and of fixed target and collider mode experiments.

Résumé

Un aperçu sur les nombreux exposés présentés à la session parallèle sur les perspectives de la physique de la diffusion profondément inélastique est donné. Les exposés couvrent aussi bien les perspectives sur cible polarisée que non polarisée, les cibles légères que les cibles lourdes, les expériences de cible fixe que celles en mode collisionneur.

1. Introduction

In the years 1991 and 1992 when data taking was brought to an end in the lepton nucleon fixed targets experiments at CERN and FNAL it was commonly believed that deep inelastic scattering (DIS), in particular the measurement of the structure of the nucleon, had reached a stable level of maturity, waiting for the final analysis of the data and for a renewal of the field with the advent of the first electron-proton collider HERA. Such a rejuvenation has indeed occurred with the spectacular results at low x. However, HERA so far has just started his physics programme. There is more than one order of magnitude of luminosity per year which can be gained. At FNAL a new high statistics neutrino scattering experiments is still foreseen. The most ambitious future experiment in DIS being collisions between electrons of LEP and protons of LHC.

Furthermore, the field of polarised electrons or muons scattering upon stationary polarised targets to study spin dependent asymmetries is of growing importance. More and more experiments are projected. An attractive future prospect would be to study collisions of high energy polarised electrons and protons at HERA.

It is also worth to mention in this review that lepton-nuclei scattering experiments, at present at CEBAF and possibly later at ELFE, are moving from a description of nuclei in terms of mesons and baryons to a more fundamental approach in terms of quarks and gluons, thus completing our understanding of the structure of the nucleon.

Herafter in this summary, we just illustrate with a few numbers the many aspects of the future prospects in lepton-nucleon DIS. To get more details the reader is advised to read the written proceedings of our rich parallel session.

2. DIS Physics

The short and long range prospects in deep inelastic scattering of leptons on unpolarised targets are based on the upgrade programme of HERA, the new neutrino experiment at FNAL and possibly the e-p option for

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LHC.

2.1. HERA

Currently the experiments H1 and ZEUS have each collected in 1993 and 1994 a total luminosity of about 3.5 pb^{-1}. There are some prospects that the machine could deliver up to 170 pb^{-1}, thus providing a recorded luminosity of more than 100 pb^{-1} per year and per experiment [1]. It would require to modify the optics close to the interaction point, to change the kickers in PETRA and to improve the preaccelerators. An integrated luminosity of several hundred inverse picobarns would allow very unique searches for extensions of the standard model together with studies of the structure of the charged and neutral currents of the electroweak interaction and of QCD at high transverse momenta and very high Q^2 [2].

2.2. FNAL

A three-year fixed target running period is scheduled for 1996-1998 while the Main Injector is being constructed. A new neutrino experiment, Fermilab E815 (NuTeV), will start in 1996 [3]. The new experiment uses the upgraded CCFR detector. Hadron and muon calibration beam will run into the detector at the same time as the neutrino beam. Energy scale uncertainties should be reduced from 1% to 0.3% and statistics improved by a factor 4. This should result in greater precision for structure functions and determination of fundamental parameters as the Weinberg angle or the QCD running coupling constant α_s. The post Main Injector collider run will start in 1999 and accumulate about 1000 pb^{-1} for CDF and D0 experiments. Although the main physics programme will be devoted to studies of the top quark, other physics quantities such as the W charge asymmetry should drastically benefit of the anticipated huge luminosity. The present error on the quark distribution ratio $d(x)/u(x)$ at $x \sim 0.1$ should be reduced by almost a factor 10 [3].

2.3. LHC $\otimes$ LEP

As the LHC design choices are evolving the e-p option for LHC is perodically revisited. In the last review (SPC, March 1995) it has been concluded that unpolarised e-p collisions at proton energy of 7000 GeV, electron energy up to 60 GeV and luminosity L $\geq 10^{32} cm^{-2} s^{-1}$ are feasible under present LEP parameters. Polarised electrons need a beam energy of about 45.6 GeV. The physics motivations will most likely depend on what we will have learnt from HERA. The e-p option at LHC could extend the Q^2 and $\frac{1}{x}$ kinematic range of HERA by a factor 30 (see figure 1).

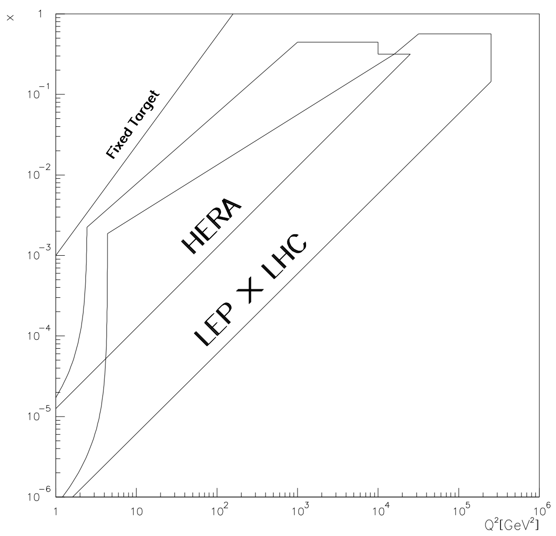

Figure 1. *(Q^2,x) range accessible to fixed target lepton nucleon experiments, to e-p collisions at HERA and e-p collisions at LEP*LHC*

It could also provide an energy in the electron-quark centre of mass up to 1.3 TeV.

3. Spin Physics

After the pioneering experiments at SLAC with polarised electrons (1983,E80/E130) and at CERN with polarised muons (1988,EMC), since 1993 a second generation of experiments at SLAC (E142/E143) and at CERN (SMC) have produced extensive data on spin-dependent structure functions of proton, neutron and deuteron since 1993 [4]. Data taking in SMC will be carried on up to 1996. A third generation of experiments is being prepared or has just started at DESY (HERMES), SLAC (E152,E154) and possibly at CERN (HMC). On longer range an important extension would be to get collisions of high energy polarised protons and electrons at HERA.

3.1. HERMES

The HERMES experiment studies collisions of the polarised electron or positron beam of HERA with polarised gas jet targets. It should not only provide new precise determinations of the spin dependent structure functions but also exploit semi-inclusive reactions to get separately the valence and the sea quarks spin distributions. The data taking has just started in 1995 and should continue up to about the year 2000 [5]. On longer ranges various options are considered. Collision of the polarised proton beam of HERA with gas jet targets in HERMES ? Upgrade of the detector to study collisions of electrons and protons of HERA in the collider mode [6] ?.

3.2. *SLAC*

An upgrade of the electron beam line is being prepared, it will provide beam energies up to 51 GeV. Two new experiments are approved [7]. E154 experiment is an extension of E142 to measure the neutron spin structure function using a polarised ^3He target. E154 is scheduled to run in late 1995. E155 experiment is an extension of E143 to measure proton and deuteron spin structure function using ammonia targets. E155 is scheduled to run in late 1996. Further extensions are not excluded, for example rotating the spectrometer to access larger Q^2 or production of a polarised real photons to measure asymmetries in J/ψ photoproduction [7].

3.3. *HMC*

HMC, from Hadron and Muon Colaboration, is a new experiment recently proposed at CERN to measure hadron asymmetries in semi-inclusive scattering of polarised muons off a polarised solid target [8]. The main goal is to measure the polarised glue ΔG from the production of D mesons by photon-gluon fusion. It requires a major upgrade of the SMC detector and could start in 1998.

3.4. *HERA*

At present the principal conclusions from polarised lepton-nucleon scattering are obtained which sum rules which necessitate to extrapolate the data to $x = 0$. The extrapolation is strongly model dependent and casts a doubt on all present interpretations [4, 9]. Additional data from a polarised proton collider experiment at HERA, at two order of magnitude lower x values than in fixed target experiments, could make extrapolation uncertainties negligible. It is moreover not possible to extract the contribution of polarised gluons to the nucleon from the sum rules. This outstanding question may be resolved by direct gluon measurement at HERA or combining HERA data with fixed target data [9].
To get a polarised proton beam is a challenging problem in accelerators physics at HERA. An active strategy of studies has been developped. The prospects are optimistic. The time scale could be of at least 5 years [1].

4. Heavy Nuclei

It has been a long tradition to probe nuclei with electron beams. There is an irresistible tendency to increase energy and luminosity of the beams, thus reaching the quark and gluon structure of the heavy nuclei. The most recent facilty is CEBAF, for Continuous Electron Beam Accelerator Facility, which will start its operation at the end of 1995 in the United States. A new facilty, ELFE, for an Electron Laboratory For Europe, is being proposed. It has also been suggested to accelerate heavy ions at HERA.

4.1. *CEBAF*

At Newport News (Virginia) the electron beam has now reached its nominal energy of 4 GeV. A polarised electron source can provide beams with a polarisation higher than 50%. The experimental programme is focused on exclusive and semi-inclusive electron scattering to study heavy nuclei in terms of mesons and nucleons but also to understand the transition to a more fundamental description in terms of partons [11]. The nuclear physics community has started to consider extensions at energies up to about 10 GeV.

4.2. *ELFE*

The Nuclear Physics European Collaboration Committee (NuPECC) has recently recommended the construction of a 15-30 GeV high intensity continuous beam electron accelerator. The main goal would be to elucidate how do colour forces build up hadrons from quarks and gluons [10]. The proposed design in 1992 consists of a 1 km superconducting 5 GeV LINAC with three recirculations. Different design are also being considered, for example a test linac of 30 GeV for the future e^+e^- collider TESLA.

4.3. *HERA*

For completeness, let us mention that running HERA with heavy ions is also being investigated. To accelerate deuterons does not look to be a problem. The luminosity would be probably two times lower than with protons. Accelerating heavier ions would bring a stronger reduction to the luminosity [1].

5. Conclusion

In summary, lepton-nucleon deep inelastic scattering is one of the most active fields in high energy physics. Many facilities are being upgraded and numerous new projects are under preparation or have been recently commissioned in the United States and Europe. Several projects are related to upgrade of the electron proton collider HERA. After the present DIS workshop at Paris in may 1995, a new workshop called 'Future Physics at HERA' has been set up to work out and review prospects for future physics at HERA in collider and fixed target modes. It should start in september 1995.

Aknowledgements

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