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FUTURE LEPTON HADRON COLLIDERS

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ABSTRACT

Main parameters of future lepton-hadron colliders are estimated. Namely, THERA and Linac*LHC based ep, γp, eA, γA and FELγA colliders are considered. The physics search potential of these machines are considered.

1 Introduction

It is known that lepton-hadron collisions have been playing a crucial role in exploration of deep inside of matter. Today, THERA (TESLA on HERA) and Linac*LHC can be considered as realistic candidates for future lepton-hadron and photon hadron colliders. We discuss the main parameters and physics search potential of the lepton-hadron colliders and draw the attention of the high energy and nuclear physics communities to future $ep, eA, \gamma p, \gamma A$ and FEL γA collider facilities.

2 TESLA*HERA Based Lepton-Hadron Colliders

It is known that the TESLA Collider will be a powerful tool for exploraiton of the multi-hundred GeV scale [1]. Taking into account the possible polarized proton and nucleus options for HERA will provide a number of additional opportunities to investigate lepton-hadron and photon hadron interactions at TeV scale. Recently, the

work on TESLA TDR has been finished, and TESLA⊗HERA based $ep, \gamma p, eA$ and γA colliders are included into TESLA project. Main parameters of TESLA⊗HERA based ep collider are given in [2]. It is seen that one has $L_{ep} = 4.1 \cdot 10^{30}\ cm^{-2}s^{-1}$ with $E_e = 250$ GeV and $E_p = 1\ TeV$. Also two additional versions ($E_e = E_p = 500\ GeV$ with $L_{ep} = 2.5 \cdot 10^{31}\ cm^{-2}s^{-1}$ and $E_e = E_p = 800\ GeV$ with $L_{ep} = 1.6 \cdot 10^{31}\ cm^{-2}s^{-1}$) have been mentioned in TESLA TDR. In principle, TESLA⊗ HERA based ep collider will extend the HERA kinematics region by an order in both Q^2 and x and, therefore, the parton saturation regime can be achieved. Main parameters and physics search potential of THERA based γp collider are given in [3, 4]. Main limitations for eA option comes from fast emittance growth of nucleus beam due to intra-beam scattering. In our opinion γA option is the most promising option of TESLA⊗HERA complex, because it will give unique opportunity to investigate small x_g region in nuclear medium. Colliding of TESLA FEL beam with nucleus bunches from HERA may give a unique possibility to investigate "old" nuclear phenomena in rather unusual conditions. The main idea is very simple [5]: ultra-relativistic ions will see laser photons with energy ω_o as a beam of photons with energy $2\gamma_A\omega_o$, where γ_A is the Lorentz factor of the ion beam. The region 0.1÷10 MeV, which is matter of interest for nuclear spectroscopy, corresponds to 0.1÷10 keV lasers, which coincide with the energy region of TESLA FEL.

3 Linac*LHC Based Lepton-Hadron Colliders

The center-of-mass energies which will be achieved at different options of this machine [6] are an order larger than those at HERA are and ∼3 times larger than the energy region of TESLA⊗HERA. Center-of-mass energy and luminosity for this option are $\sqrt{s} = 5.29$ TeV and $L_{ep} = 8 \cdot 10^{31}$ cm^{-2}s^{-1}. This machine, which will extend both the Q^2-range and x-range by more than two order of magnitude comparing to those explored by HERA, has a strong potential for both standard model and new physics research. Using γp option of this collider thousands di-jets with $p_t > 500$ GeV and hundreds thousands single W bosons will be produced, hundred millions of $\overline{b}b$- and $\overline{c}c$- pairs will give opportunity to explore the region of extremely small x_g etc. Details on main parameters and physics search potential of Linac*LHC based eA, γA and FEL γA coliders can be found in [4, 6]. The CLIC, an electron-positron collider with $\sqrt{s} = 3\ TeV$ and $L_{ee} = 10^{35}\ cm^{-2}s^{-1}$, is considered as one of the future options for post-LHC era at CERN. The work on CLIC*LHC based $ep, \gamma p, eA, \gamma A$ and FEL γA options is under progress.

4 Conclusions

It seems that neither HERA nor LHC⊗LEP will be the end points for lepton-hadron colliders. We see that TeV scale linac-ring type *ep* machines will give an opportunity to go far in this direction (see Table 1). In addition, more knowledge on the subject can be found in [7].

Table 1: *Future lepton-hadron colliders: a) First stage (2010-2015).*

	TESLA⊗HERA	LEP⊗LHC	e⊗RHIC
$\sqrt{s}$, TeV	1.0→1.6	1.37	0.1
E_l, TeV	0.25→0.8	0.0673	0.01
E_p, TeV	1	7	0.25
L, 10^{31} $cm^{-2}s^{-1}$	1-10	12	46
Additional options	$eA, \gamma p, \gamma A$, $FEL\gamma A$	eA	$eA, FEL\gamma A$

b) *Second stage (2015-2020).*

	Linac⊗LHC	CLIC based
$\sqrt{s}$, TeV	5.29	3
E_l, TeV	1	1.5
E_p, TeV	7	1.5
$L, 10^{31}$ $cm^{-2}s^{-1}$	10-100	10
Additional options	$eA, \gamma p, \gamma A$, $FEL\gamma A$	$eA, \gamma p, \gamma A$, $FEL\gamma A$

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