PROSPECTS AND STATUS OF ZEUS AT HERA II

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Selected physics topics of the HERA II program are briefly reviewed. An outlook for data taking as of October 2003 and estimated luminosity requirements for some physics topics are given.

1. Physics of HERA II

Some physics topics of HERA II were covered by the previous speaker[1]. Here I briefly outline some of the remaining topics.

1.1. *Structure Functions*

The HERA Collider experiments H1 and ZEUS have made measurements[2] of the proton lstructure function F_2 spanning five orders of magnitude in both the Bjorken variable x and the virtuality of the photon Q^2, from the data taken in the period 1992-2000. Below Q^2 of 500 GeV^2, these measurements have a 2-3% precision, which is dominated by systematic effects. In this kinematic region, these measurements will most likely be the most precise for the foreseeable future.

For higher Q^2, and so for high x ($x > 0.1$), the statistical uncertainties dominate the current F_2 measurements. Studies[3] have shown that with an integrated luminosity of 1 fb^{-1} planned at HERA II, the precision measurements at high x will be such that, for example, the strong coupling constant $\alpha_s(M_Z)$ can be constrained to 0.002, in experimental uncertainties, and the gluon to 3% when these data are used in a QCD fit.

1.2. *Electroweak Studies*

The sensitivity of polarized Neutral Current (NC) and Charged Current (CC) DIS cross-sections to electroweak parameters means that there will

be a rich spectrum of Electroweak results from HERA II. Again most of these are discussed in detail elsewhere[4].

An example of such a result is the determination of the NC couplings of the light quarks[5]. Depending on the polarization and integrated luminosity achieved, these can be determined to approximately 10%, and provide a result complementary to the heavy quark couplings at LEP.

Another example is the use of measured electron-proton cross-sections, both NC and CC, to determine the consistency of the electroweak description[6]. The results can be expressed in terms of the W mass and the top mass. A precise measurement of the top mass at the Tevatron or the LHC at the 5 GeV level would enable the HERA W mass to be constrained at the 50 MeV level. This would be a stringent test of the electroweak sector.

1.3. *Exotics and Anomalies*

There are intriguing anomalies observed in HERA I. H1 has observed excess of isolated electrons(and positrons) and muons accompanied by missing P_T; also an excess of di- and tri-electrons at high masses was seen[7]. While ZEUS does not see these excesses[8], it observes more than the expected number of isolated τ leptons accompanied by missing P_T, not associated with the τ decay[9]. All of these anomalies are at a level where more data are needed to study these effects. Since the HERA I data are based on an integrated luminosity of about 100 pb^{-1}, we would need something in the same order of magnitude in luminosity to start to make progress.

Also, there are new-physics channels, including R-parity violating SUSY and leptoquarks where HERA II remains competitive with the Tevatron[10]. In any case, the sign of the lepton beam and polarization are important for understanding any new physics that may emerge.

2. Prospects for data

2.1. *HERA performance*

Through 2002, the HERA machine has demonstrated its readiness for the high luminosity operation. The specific luminosity goal for HERA II of $1.8 \times 10^{30} cm^{-2} s^{-1} mA^{-2}$ has already been reached in November 2001. After a period of improvements to background conditions due to synchrotron radiation and aperture limitations, a HERA record luminosity of $2.7 \times 10^{31} cm^{-2} s^{-1}$ was reached in February 2003. This is to be compared

to the design goal of $7.0 \times 10^{31} cm^{-2} s^{-1}$. Polarization of 50% during luminosity runs was also achieved in February 2003. However, the maximum beam current storable in HERA was limited by the severe backgrounds encountered at H1 and ZEUS; this has severely limited the luminosity at which the machine could be operated practically.

2.2. *Background*

Throughout 2002 and early 2003, H1 and ZEUS could not effectively take data due to the background rates. To a very good approximation, they can be equated with the current being drawn in the central tracking detector, which is too high so that it cannot be operated safely. Many measures against the background were taken during the HERA shutdown of 2003 in time for beam operation in September 2003.

There are three components to the background:

- Backscattered synchrotron radiation. This background, up to early 2003, was worse in ZEUS than in H1. This was reduced with improved synchrotron masks at the experiments. At ZEUS, the reduction is estimated to amount to a factor of ten.
- Lepton-beam-related particle background. This was reduced by reducing the thickness of some collimators and making provisions for better vacuum such as additional pumps or improvement in existing pumps. A reduction of a factor of two in this background is expected.
- Proton-beam-related particle background. This is the dominant background after the improvements above. This is also the background that is the least understood quantitatively. The vacuum improvements, better vacuum conditioning and collimators redesigned to reduce higher-order-mode heating will certainly reduce this background. The aimed-for reduction for this background is a factor of two.

As of the date of this report, only sizable positron together with small proton currents hadve been stored in HERA. However, studies at ZEUS of the synchrotron background showed that the improvement was as expected. Also the positron background showed steady improvement over several days.

Since no significant proton currents have been stored, the situation with

respect to the proton background was not known[a].

3. Luminosity requirements and constraints

An estimate of the integrated luminosity required for the main physics topics for HERA II is shown in Figure 1. It is clear that the expected integrated luminosity for HERA II of 1 fb^{-1} is enough to cover a large portion, but not all, of the topics listed. The default plan of 250 pb^{-1} appears to be a relatively good compromise. Obviously, the actual operation of the machine and developing physics interests as the run progresses will determine the character of the data actually taken.

	Required Luminosity (pb^{-1})					
Physics	e^+_L	e^+_R	e^-_L	e^-_R	Total	E_P<920GeV
EW: EW parameters	250	250	250	250		
δM_W ~50 MeV			1000			
Large-x:F_2 for x>0.7					1000	
or						100
xF_3		500	250			
d_V from CC		500				
Med-x:F_2^b					500	
strange quark		250	250			
Small-x:High Q^2 VM					500	
Extend W coverage						50
F_L						30
Exo: rule out anomalies		200				
study anomalies	250	250	250	250		

Figure 1. A table of estimated integrated luminosities needed for HERA II physics topics.

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[a]As of January 2004, the background had been reduced to such an extent that it no longer limited the performance of the machine.

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