SEARCH FOR QCD INSTANTON-INDUCED PROCESSES IN DEEP-INELASTIC SCATTERING AT HERA

S. MIKOCKI,
FOR H1 COLLABORATION
Institute of Nuclear Physics, Cracow, Poland

Preliminary H1 results on dedicated searches for QCD instanton induced processes in DIS are presented. The investigations are based on the expected characteristics of their hadronic final state. Searches were performed in the kinematical region $x > 10^{-3}$, $0.1 < y < 0.6$ and $\theta_{el} > 156^o$.

1 Introduction

Instantons [1], non-perturbative fluctuations of non-abelian gauge fields, induce anomalous processes which violate classical conservation laws like baryon plus lepton number in the case of the electroweak interactions and chirality in the case of QCD. Deep-inealstic scattering at HERA offers the unique possibility [2] to discover processes induced by QCD-instantons. The theory [3] and phenomenology [2,4] have been worked out by A. Ringwald and F. Schrempp. The expected event topology can be simulated with the QCDINS [5] Monte Carlo program. The predicted cross section [6] is $\sigma_{ins} \approx 30$ - 100 pb for $0.1 < y < 0.9$ and $x > 10^{-3}$.[a] We can therefore expect sizeable number of such events. The background, however, is three orders of magnitude higher.

2 Data Selection

The analysis is based on data taken in 1997 with the H1 detector corresponding to an integrated luminosity of $\mathcal{L} = 15.78$ pb^{-1}. The analysis is performed in the following phase space: $0.1 < y_{el} < 0.6$, $x_{el} > 10^{-3}$ and $\theta_{el} > 156°$. The charged particles are reconstructed in the acceptance region of the Central Track Chambers $20° < \theta < 155°$ with the transverse momentum $p_T > 0.15$ GeV. A combination of tracks and energy depositions in the calorimeter is used to measure the energy flow. [7] The total DIS sample contains ~ 280000 events.

3 Observables and Search Strategy

The instanton-induced hadronic final state is expected to have the following signature (see Fig. 1): a densely populated narrow band in pseudorapidity

[a] We use QCDINS2.0 with the default values. We do not apply the $Q^2 > 100$ GeV^2 cut to suppress non-planar diagrams as recently recommended by the authors.

Table 1: Measured numbers of events and expected background for three cut scenarios. The errors are dominated by systematic errors.

(A) DATA: 3000		(B) DATA: 1332		(C) DATA: 549	
CDM	MEPS	CDM	MEPS	CDM	MEPS
2469^{+242}_{-238}	2572^{+237}_{-222}	1005^{+82}_{-70}	1084^{+75}_{-46}	363^{+22}_{-26}	435^{+36}_{-22}

which is homogeneously distributed in azimuth (isotropic 'fireball'-like final state), a large total transverse energy, a large particle multiplicity including all kinds of flavours e.g. the strange particles. The high background from normal DIS events requires the best possible discrimination.

The following observables[b] have been used to discriminate I-induced processes from normal DIS events: (1) Et_{jet}, the jet with highest E_T (cone algorithm with radius $R = 0.5$). We associate this jet with the 'current' quark (q") in Fig. 1. (2) The virtuality of the quark entering the I-process $Q'^2 = -(q - q")^2$ where the photon (q) is reconstructed by the scattered electron. (3) The number of charged particles n_B in the instanton band.[c] (4) The sphericity SPH calculated in the rest system of the particles not associated with the current jet. (5) Et_b the total transverse energy in the instanton band calculated as the scalar sum of the transverse energies and (6) Δ_b,[d] a quantity measuring the E_T weighted Φ event isotropy.

To find the optimal cut scenario the following cut values have been applied: $n_B > 5, 6, 7, 8, 9$; $SPH > 0.4, 0.5, 0.55, 0.6, 0.65$ and $95, 100, 105, 110, 115 < Q'^2 < 200$ GeV^2 (see Fig. 1). From 125 cut combinations three scenarios are chosen according to the following criteria: (A) The highest instanton efficiency ($\epsilon_{ins} \approx 30\%$), (B) High ϵ_{ins} at reasonable background reduction and (C) Highest background reduction ($\epsilon_{dis} \approx 0.13 - 0.16\%$) at $\epsilon_{ins} \approx 10\%$.

[b] All observables are calculated in hadronic CMS ($\vec{q} + \vec{P} = \vec{0}$) except the sphericity.

[c] The particles belonging to the jet q" are removed from the final state and the E_T-weighted mean pseudorapidity $\bar{\eta}$ is recalculated with the remaining ones. The instanton band is defined as $\bar{\eta} \pm 1.1$.

[d] Δ_b is defined as $\Delta_b = \frac{E_{in} - E_{out}}{E_{in}}$ where E_{in} (E_{out}) is the maximal (minimal) value of the sum of the projections on all possible axis $\vec{i}$ of all energies depositions in the band (i.e. $E_{in} = max \sum_n |\vec{p_n}\vec{i}|$). For isotropic events Δ_b is expected to be small while for jet-like events it should be large.

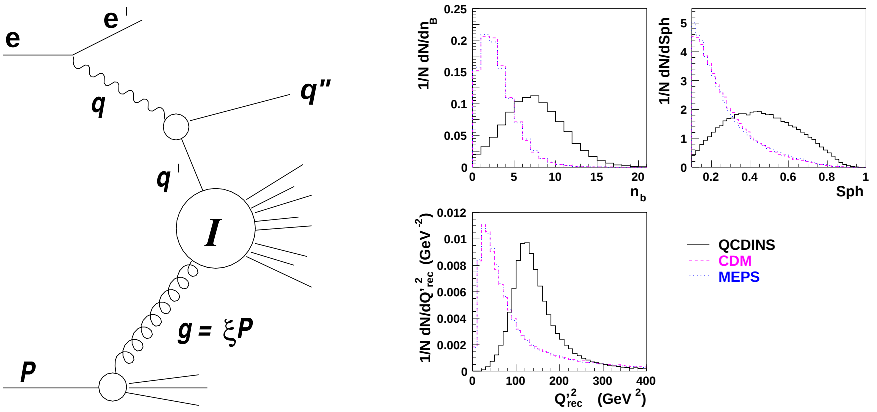

Figure 1: Left: Sketch of an instanton-induced process. Right: Shape normalised distributions of the observables used to discriminate I-processes from normal DIS.

4 Results and Conclusions

The results are presented in Fig. 2 and Table 1. In all scenarios more events are observed than expected by the standard QCD models CDM [8] and MEPS. [9] The shape of the excess in n_B, SPH and Q'^2 is qualitatively compatible with the expected instanton signal. However, the size of this signal is at the level of differences between the QCD models. The shapes of the other observables (not used in the cuts) are neither well reproduced by CDM nor by MEPS. The observed excess in Et_b and Δ_b is not particularly favoured by the QCDINS predictions.

QCDINS contributions cannot be excluded given the uncertainties in their calculation and modelling. [6] In addition, a better understanding of the DIS hadronic final state formation in the phase space relevant for instanton searches is required.

References

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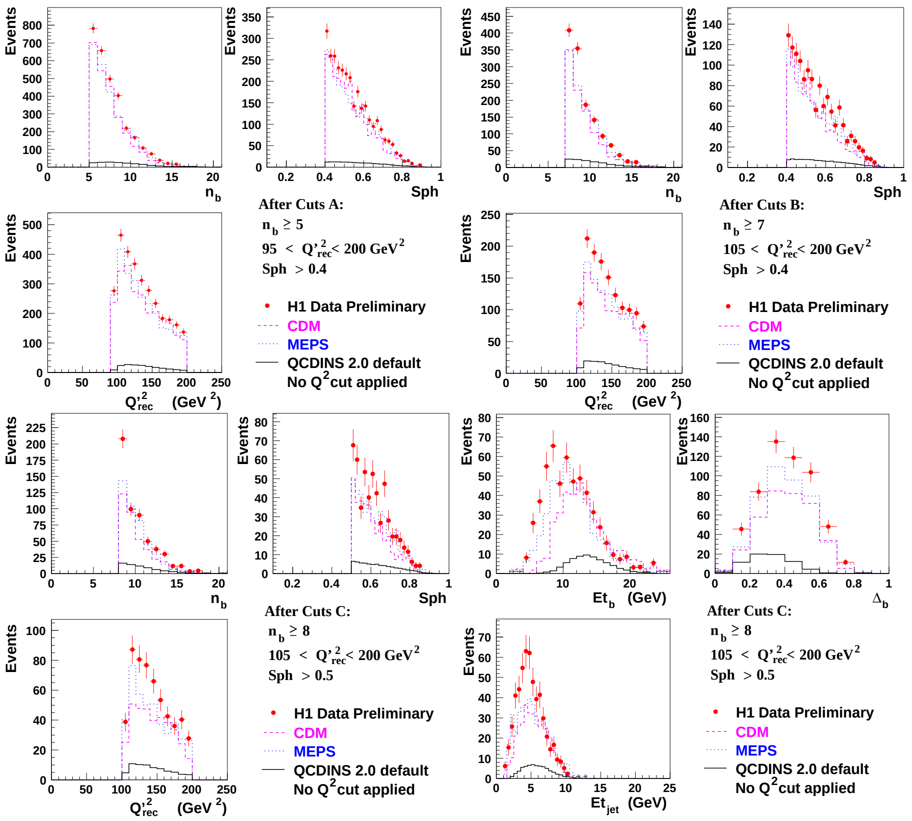

Figure 2: The distributions of the observables used in cuts for three cut scenarios and (lower right) the distributions of observables not used in cuts for scenario C.

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