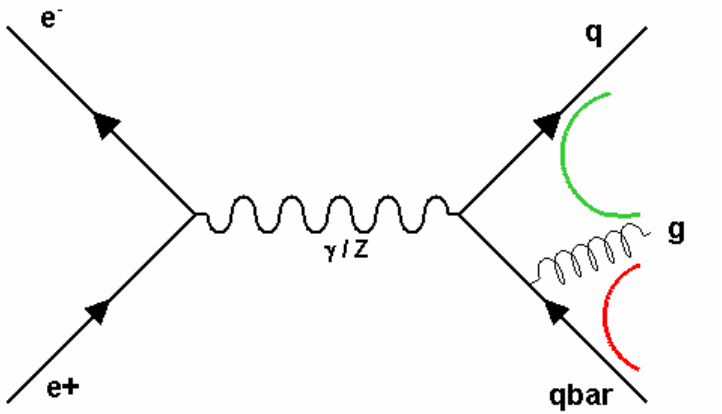
Can HERA tell us about long range particle correlations at LHC?

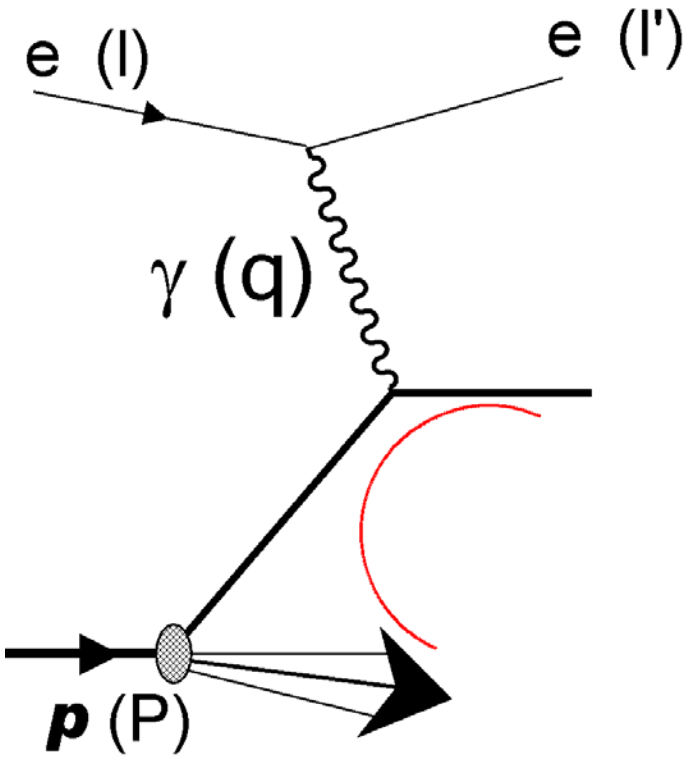
Achim Geiser, DESY Hamburg

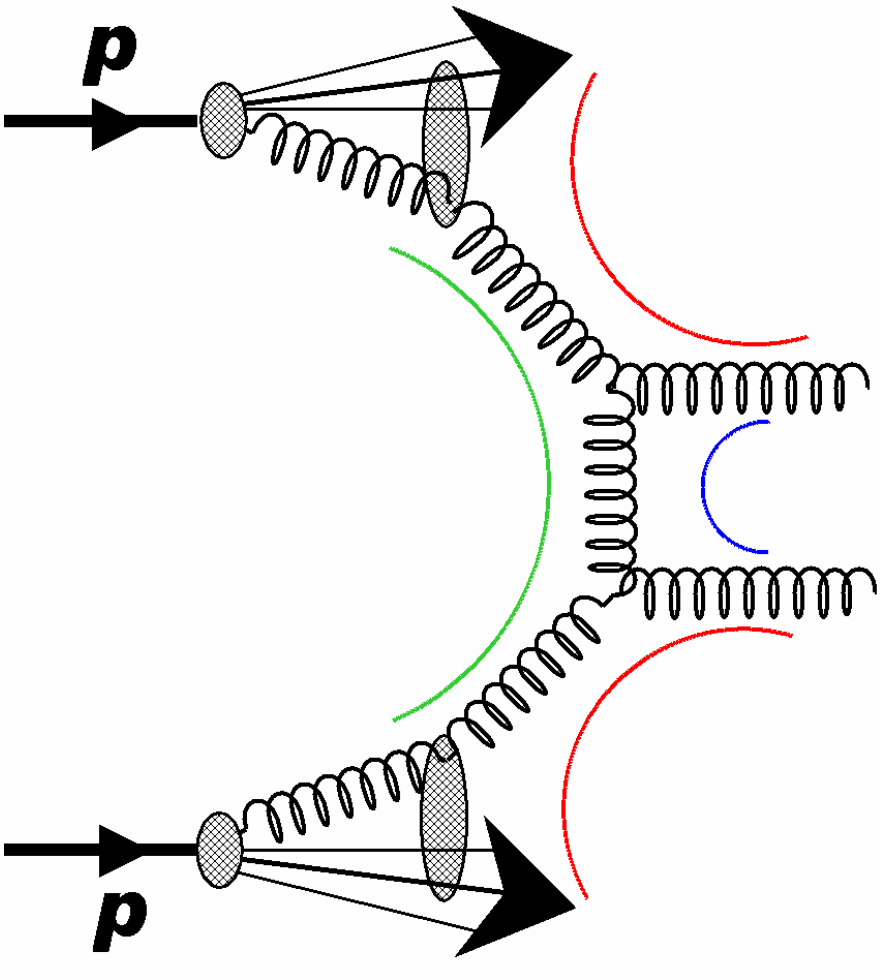
long range correlations meeting
DESY, Hamburg, November 1, 2010

- Introduction
- Long range correlations at HERA (mainly ZEUS)
- Conclusions

Colour strings in e+e-, ep, and pp

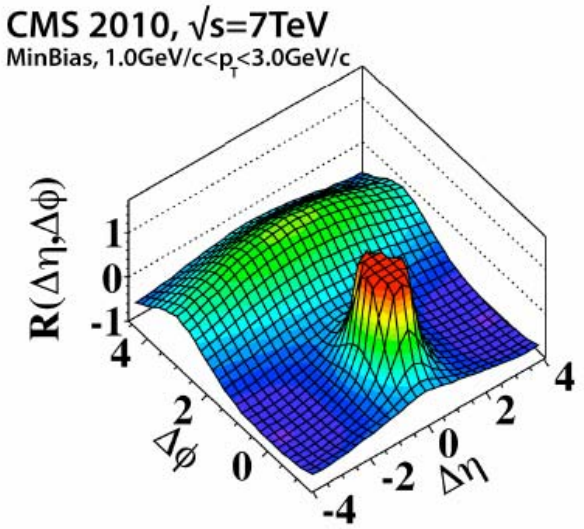


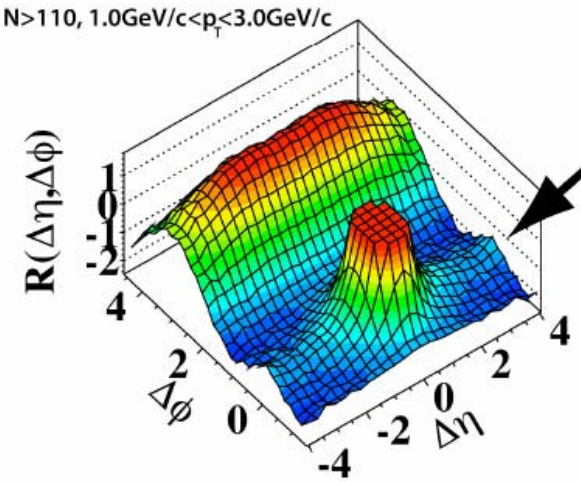


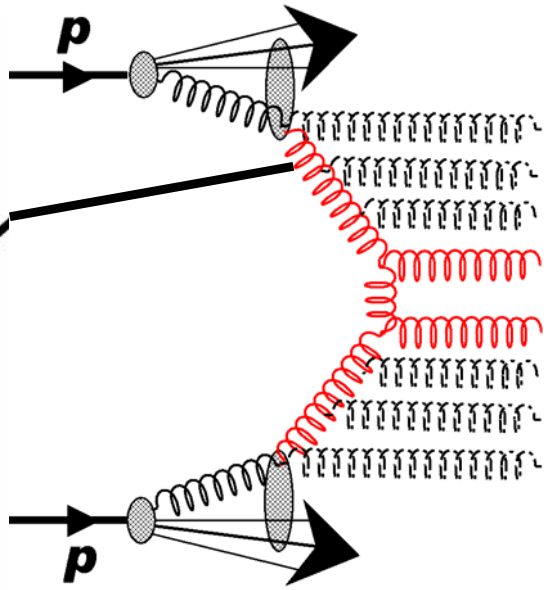


Long range two-particle correlations in CMS

arXiv:1009.4122 [hep-ex]

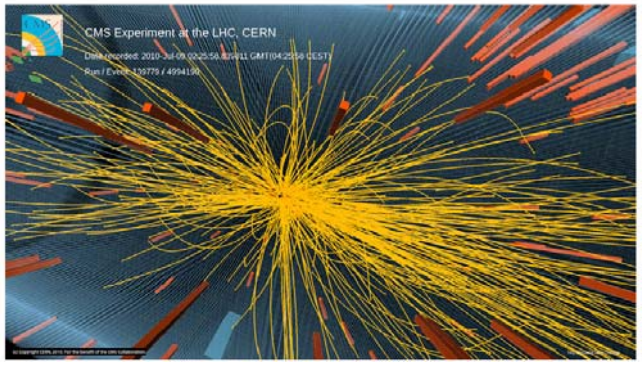






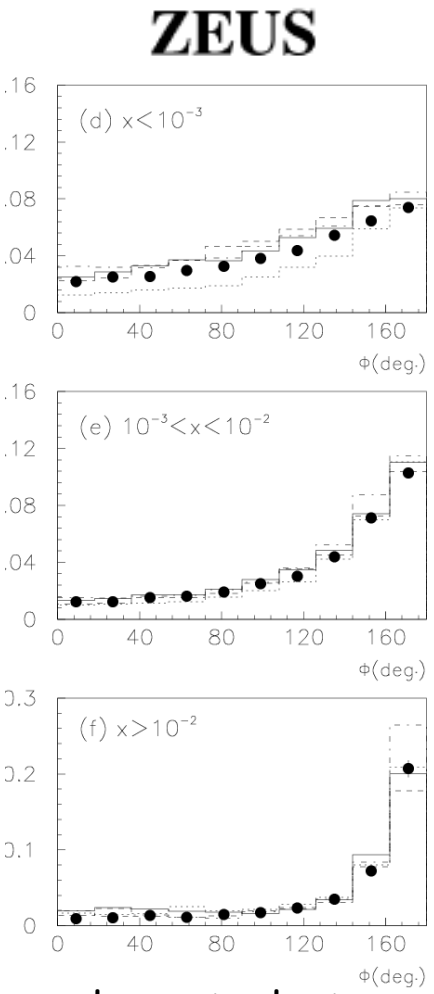
?

could it simply be a rediscovery of colour strings/dipoles as a source of gluon radiation between (semi-)hard partons and proton remnant ?

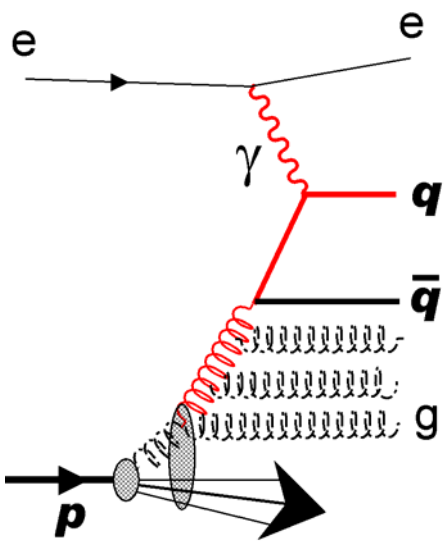


Observation of colour strings/dipoles

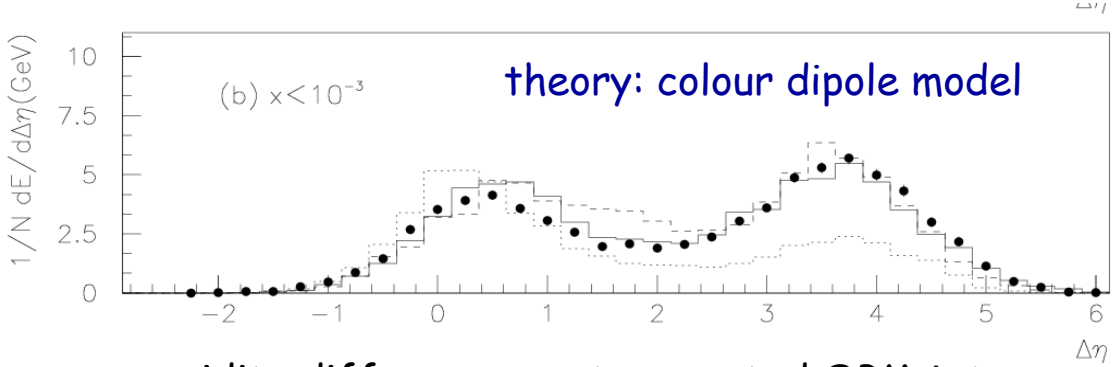
in hadronic energy flow in DIS at HERA: Z. Phys. C59 (1993) 231



angle w.r.t. electron



"In the low x region, the peak in the hadronic energy flow in the direction of the current jet is shifted […] towards the proton remnant with most of the energy appearing between the position of the expected jet peak and that of the proton remnant."



rapidity difference w.r.t. expected QPM jet

see also H1, DESY-94-033

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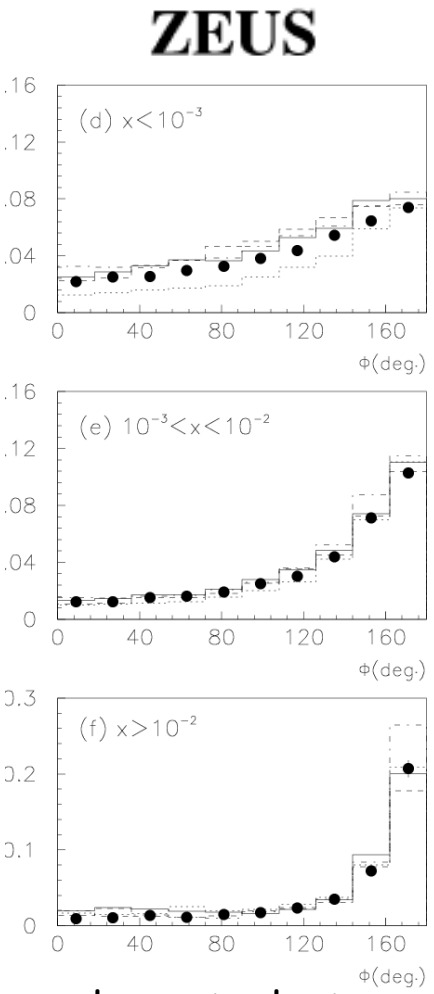

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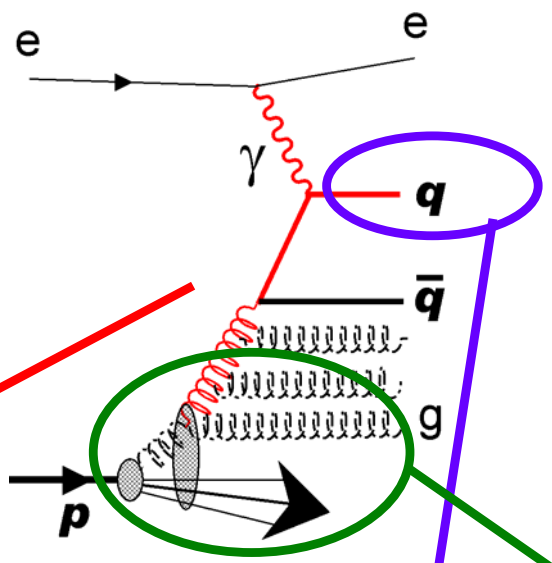

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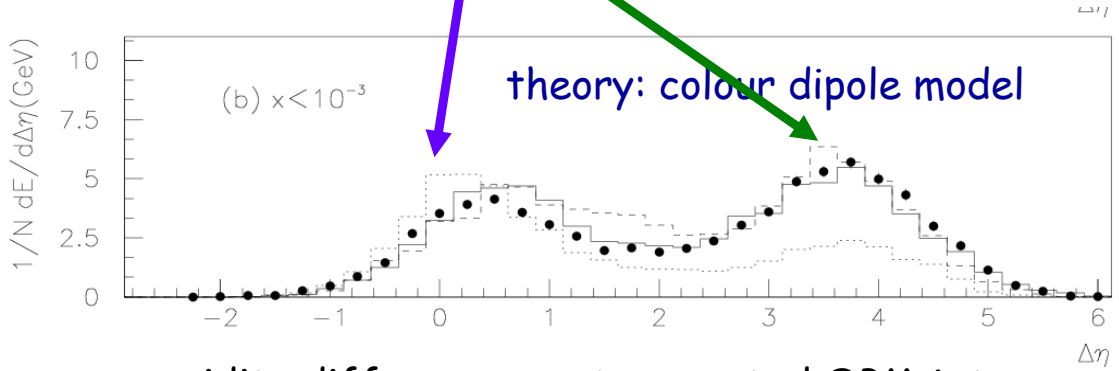

rapidity difference w.r.t. expected QPM jet

see also H1, DESY-94-033

Also studied in momentum flow;
thesis C. Catterall, UCL 1995

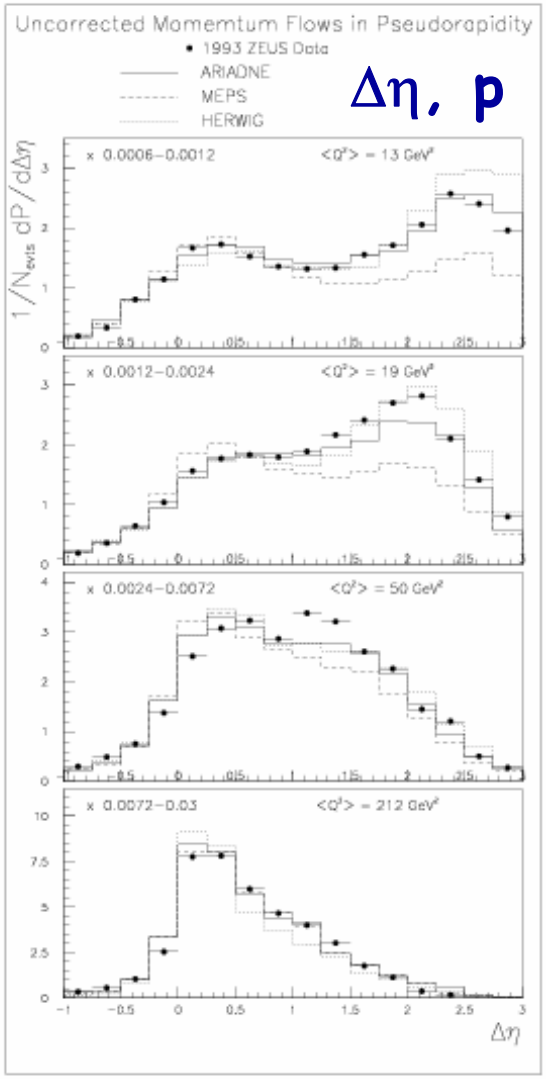

Figure 7.8: *Momentum flow versus $\Delta\eta$ showing 1993 ZEUS data and the Monte Carlo predictions of three theoretical models.*

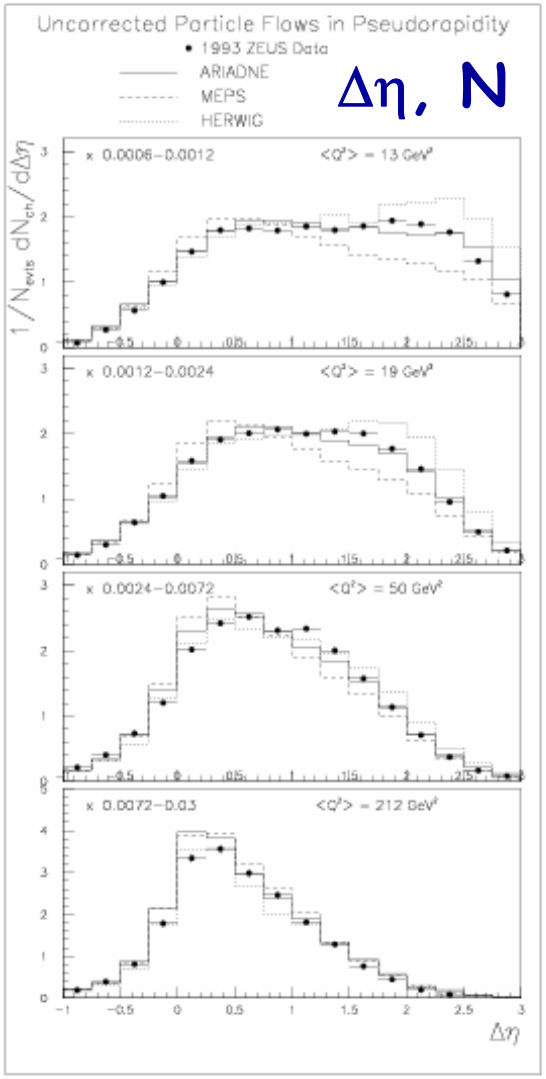

Figure 7.9: *Particle flow versus $\Delta\eta$, showing 1993 ZEUS data and the Monte Carlo predictions of three theoretical models.*

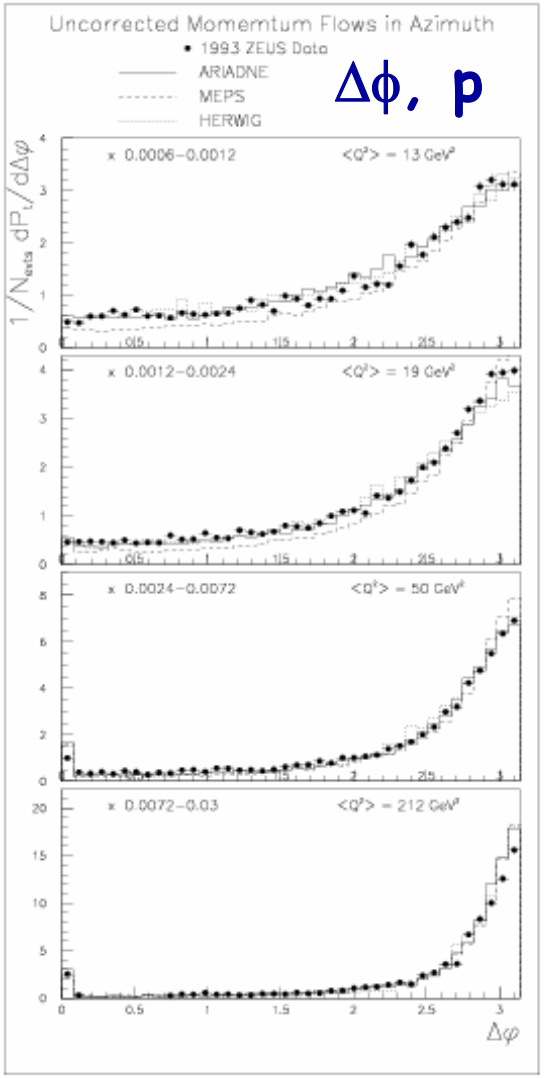

Figure 7.16: *Momentum flow versus $\Delta\phi$, (excluding matched electron tracks) showing 1993 ZEUS data and Monte Carlo predictions.*

C. Catterall

thesis 1995

also studied $\Delta\eta - \Delta\phi$ correlations:

A "ridge" in momentum, azimuthally correlated with the struck quark, extends in η between the current and target peaks, evidence of QCD "string" interactions.

7.10 Correlations between $\Delta\eta$ and $\Delta\phi$

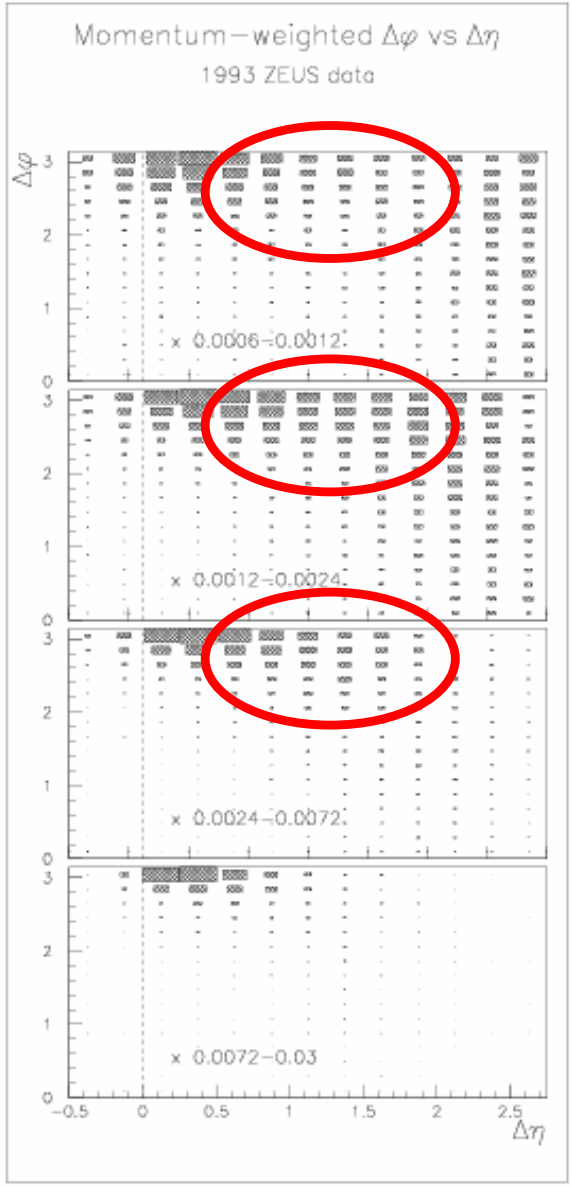

Figure 7.17: *Correlation between $\Delta\phi$ and $\Delta\eta$ in uncorrected ZEUS 1993 DIS data.*

Figure 7.17 shows the momentum flow in the $\Delta\phi$-$\Delta\eta$ plane, for 1993 ZEUS data which has not been corrected for detector effects. The most noticeable feature of these distributions is the correlation between $\Delta\eta$ and $\Delta\phi$ in the region of the current peak. Here, again, it is clear that the current peak is shifted forward from the QPM expectation of $\Delta\eta = 0$, but in azimuth occupies the expected region of $\Delta\phi = \pi$.

In the lower two bins of lower x, mometum flow associated with the remnant appears as a region of random azimuthal distribution at large $\Delta\eta$. For the higher x bins the remnant region is outside of the CTD acceptance.

It is interesting that a degree of correlation with $\Delta\phi = \pi$ extends forward well beyond the region of the current peak, and is discernable up to $\Delta\eta \approx 2$, which means that at two units of pseudorapidity forward from the nominal quark direction, the momentum flow is still affected in some way by the current.

This is perhaps the result of colour flow between the struck quark and the remnant, and of the forward pulling of the current peak, and is discussed further in the next chapter.

"ridge" in long range correlations at CMS

not only
at high
multiplicity!

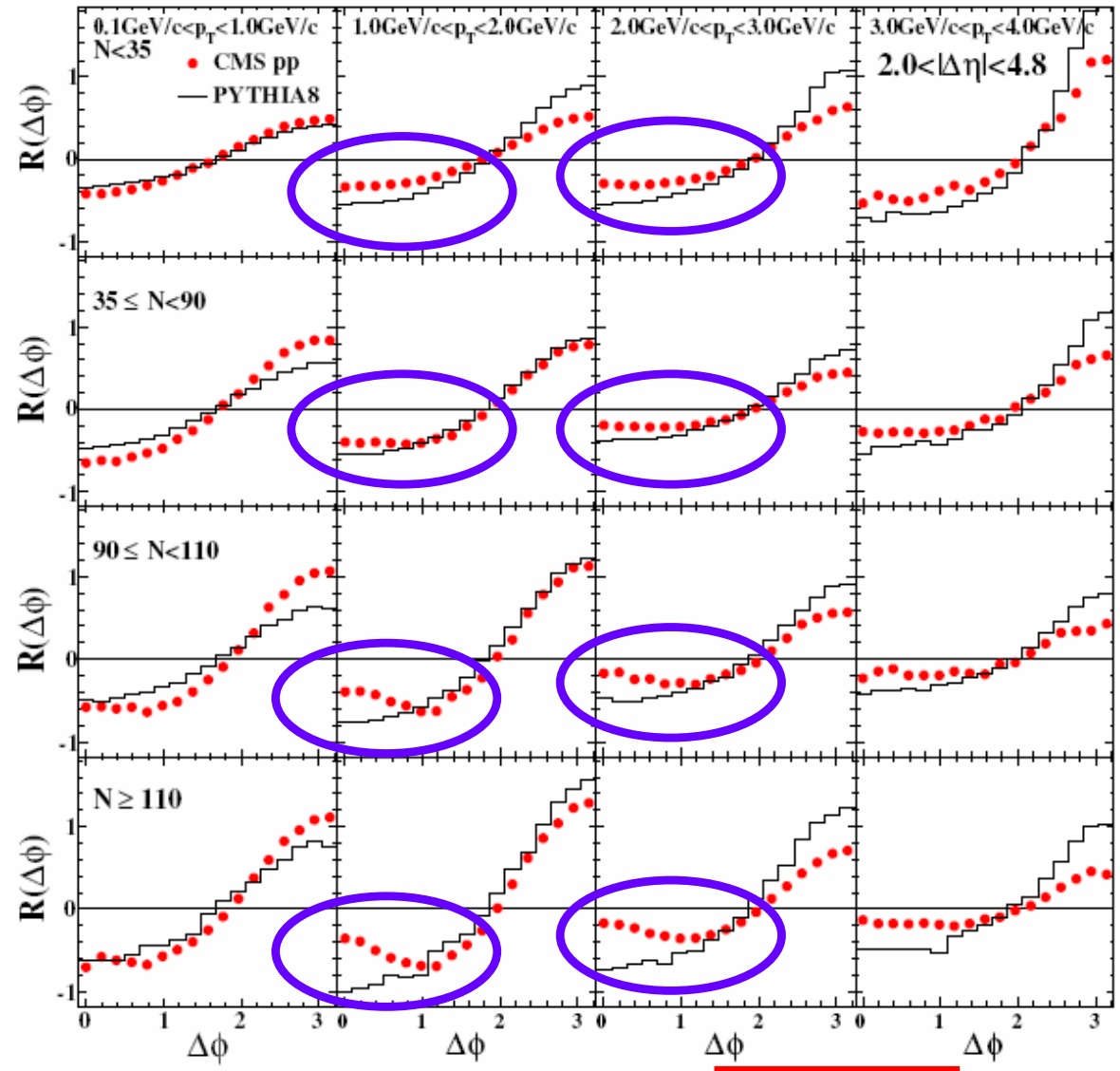

Figure 8: Projections of 2-D correlation functions onto $\Delta\phi$ for $2.0 < |\Delta\eta| < 4.8$ in different p_T and multiplicity bins for fully corrected 7 TeV pp data and reconstructed PYTHIA8 simulations. Error bars are smaller than the symbols.

Summary and conclusions

- **Enhanced hadronic activity due to coulour strings between final state partons and/or proton remnants has been observed:**

  in the early nineties at LEP (3-jet events): well known

  colour strings span between q and g jets

  -> more hadronic activity between q and g jets than between q and q jets

  in the mid-nineties at HERA (DIS events): this talk

  single colour string between outgoing struck quark and proton remnant

  -> enhanced hadronic activity between the two,

  -> "ridge" in long range azimuthal correlations

- **have colour strings/dipoles been rediscovered at LHC?**

  any reason why they shouldn't be there?