Double parton interactions in $\gamma + 3$ jets events in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV in CDF

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Outline

1. Introduction and DPI theory
2. Kinematics of γ + 3 jets events
3. Discriminating variables
4. Data results
5. Montecarlo simulations
6. Summary

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Introduction

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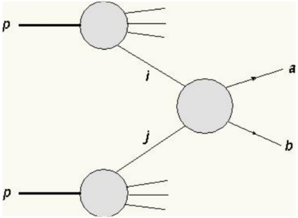
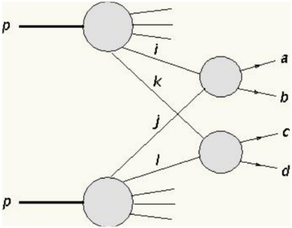
Single Parton Collision

One partonic scattering in one proton-antiproton collision



Double Parton Collision

Two indipendent partonic scatterings in one proton-antiproton collision



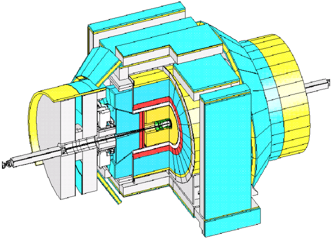
Final state of DPI: γ+jet and dijet

The first analysed was performed by UA2 in 1991

Introduction

How?

- γ + 3 jets events
- $\int L\, dt = 9.5$ fb^{-1}
- $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV



Why?

- to determine the fraction of the DPI in a single $p\bar{p}$ collision
- to make accurate estimation of background for many rare new physics processes
- QCD studies

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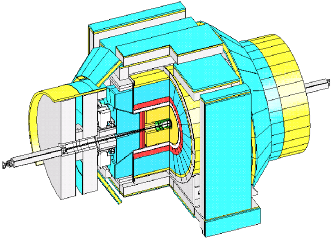

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Kinematics

Kinematics of γ + jets events: Multiplicities

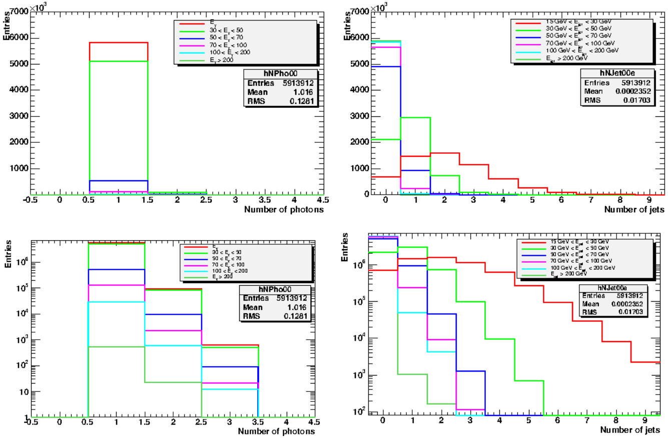


Figure: Multiplicities of photons and jets depending on their energy, in linear and log scale

Kinematics of γ + jets events: angular distributions

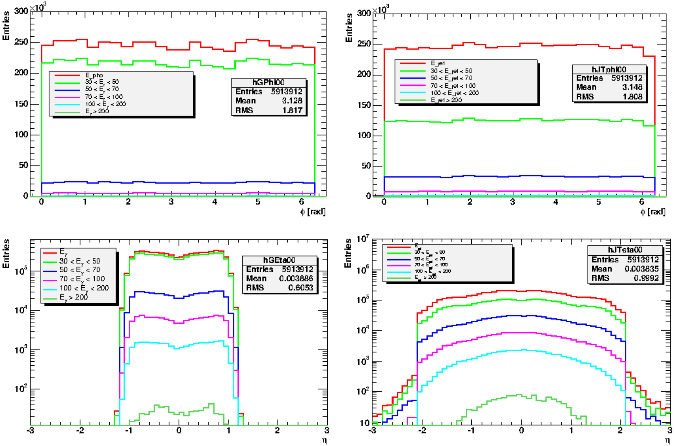


Figure: Azimuthal angle and pseudorapidity distributions for the γ and for the leading jet, as a function of their energy

Kinematics of γ + jets events: energy distributions

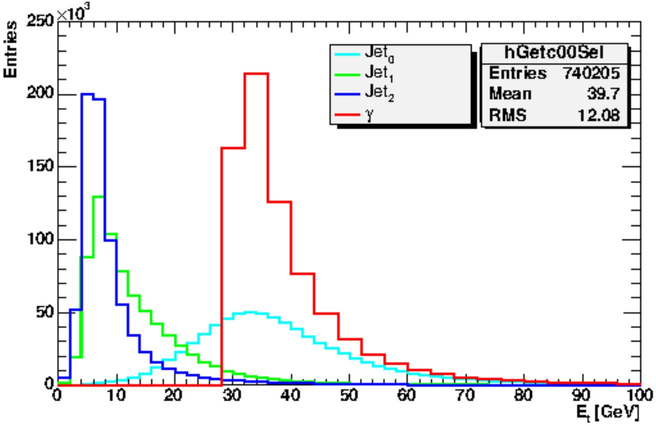


Figure: Energy distributions for the γ and for the leading jet

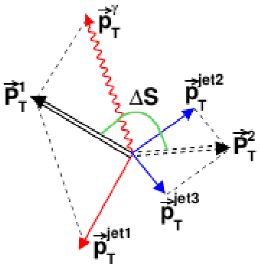
Discrimination beetween DPI and SPI

Discriminating DPI from SPI

Try to exploit the back-to-back nature of the objects coming from SPI events

$$\Delta S = \Delta\phi(\vec{p_T}(\gamma, i), \vec{p_T}(j, k)) \quad (1)$$

- In the $\gamma + 3$ jet analysis, the i, j and k objects are chosen such as to minimize the p_T imbalance
- In this way, it is possible to split the $\gamma + 3$ jet into $\gamma +$ jet and dijet pairs



Discriminating variables

The two object pairs are found by minimizing three other variables with respect to the jet index:

$$S_{p_T} = \frac{1}{\sqrt{2}}\sqrt{\left(\frac{\vec{p_T}(\gamma,i)}{\delta p_T(\gamma,i)}\right)^2 + \left(\frac{\vec{p_T}(j,k)}{\delta p_T(j,k)}\right)^2} \qquad (2)$$

$$S_{p'_T} = \frac{1}{\sqrt{2}}\sqrt{\left(\frac{\vec{p_T}(\gamma,i)}{|\vec{p_T^{\gamma}}| + |\vec{p_T^{i}}|}\right)^2 + \left(\frac{\vec{p_T}(j,k)}{|\vec{p_T^{j}}| + |\vec{p_T^{k}}|}\right)^2} \qquad (3)$$

$$S_{\phi} = \frac{1}{\sqrt{2}}\sqrt{\left(\frac{\Delta\phi(\gamma,i)}{\delta\phi(\gamma,i))}\right)^2 + \left(\frac{\Delta\phi(j,k)}{\delta\phi(j,k))}\right)^2} \qquad (4)$$

where $\Delta\phi(\gamma,i) = |\pi - \phi(\gamma,i)|$

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Discriminating variables

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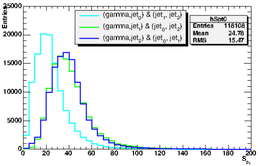
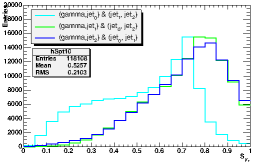
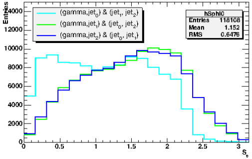


S_{p_T} distribution



$S_{p'_T}$ distribution



S_{p_ϕ} distribution

Observation

Good separation between the plots of the pair (γ, jet 0) and the remaining two.

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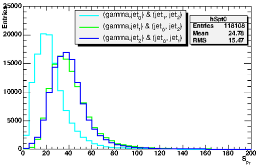

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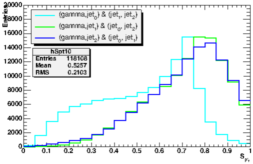

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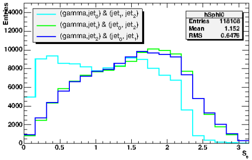

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Data results

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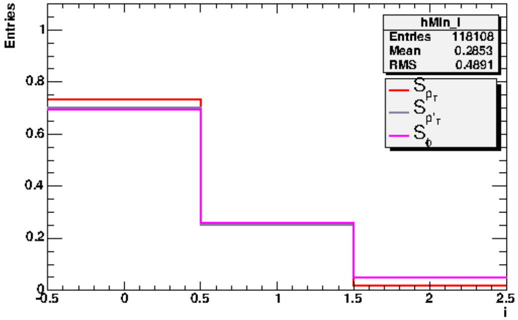

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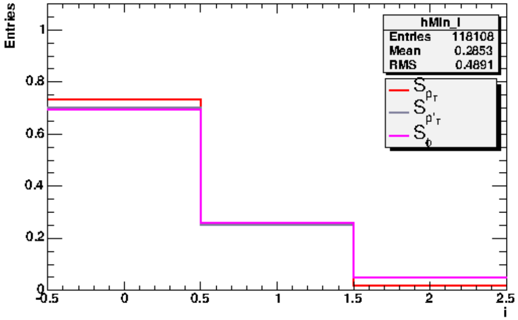

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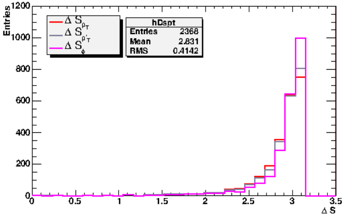
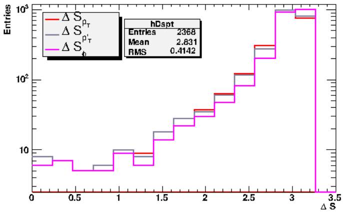
Data results

$$\Delta S = \Delta\phi(\vec{p_T}(\gamma, 0), \vec{p_T}(1, 2)) \quad (5)$$

with the pairs obtained based on the best pairwise balance





Result

The tail between 0 and 1.5 is relatively flat → Evidence for DPI

Data results

This is constistent with the theoretical hyphotesis:

SPI

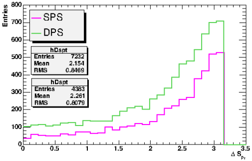
distribution ΔS should peak at π and should show a tail due to the radiation

DPI

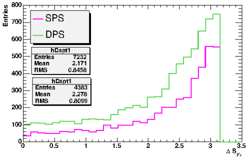
distribution ΔS alone should be relatively flat

Montecarlo

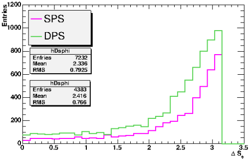
Montecarlo results



ΔS_{p_T} distribution



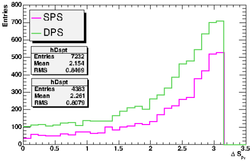
$\Delta S_{p'_T}$ distribution



ΔS_{p_ϕ} distribution

- evidence of the tail
  - relatively flat for DPS
  - with a light slope due to the radiation for SPS
- DPI samples bigger than SPI sample (SPS has no MPI)

Montecarlo results



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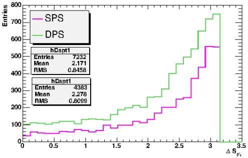

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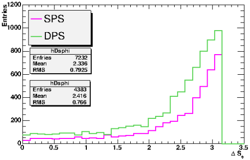

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- the best pair combination for the final state is $(\gamma, \text{jet } 0)$ and $(\text{jet } 1, \text{jet } 2)$
- evidence for DPI thanks to the low sided tail in the ΔS plot

What is next?

- found the fraction of DPI using both Montecarlo and data
- obtain the DPI cross section

To be continued...

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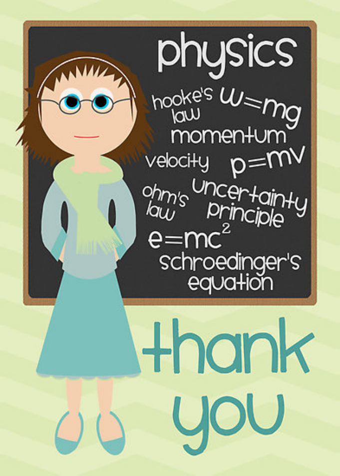

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