HEAVY FLAVOR PRODUCTION IN P-P COLLISIONS AND INTRINSIC QUARK COMPONENTS IN PROTON

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OUTLINE

1. Intrinsic flavour in proton

2. PDF including intrinsic heavy quark components

3. Hard parton-parton collisions

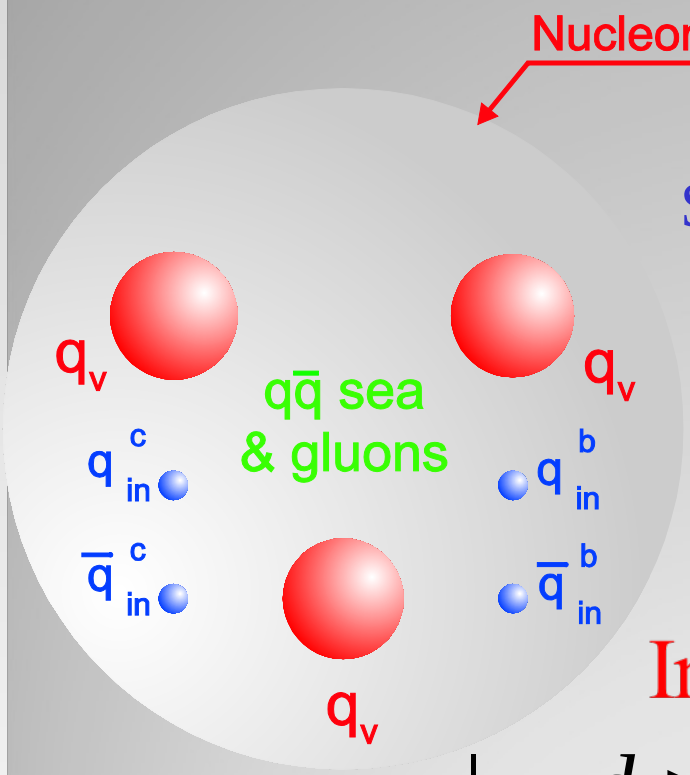
4. Intrinsic charm in proton and D-meson production in p-p at LHC

5. IC signal in the γ +c-jet and γ^*/Z^0 production in p-p

6. Intrinsic strangeness (IS) in proton

7. IS signal in NA61,CBM, HADES and NICA

8. Summary



BHPS model

S.J. Brodsky,P. Hoyer, C. Peterson and N. Sakai, Phys.Lett. B93 (1980) 451;
S.J. Brodsky, S.J. Peterson and N. Sakai, Phys.Rev. D23 (1981) 2745.

Intrinsic $Q\bar{Q}$ in proton

$$|uud>, |uudg>, |uudQ\bar{Q}>$$

$Q\bar{Q}$ is $u\bar{u}, d\bar{d}, s\bar{s}, c\bar{c}, b\bar{b}, t\bar{t}$

J.Pumplin, H.L. Lai and W.K.Tung, Phys.Rev.D75 (2007) 054029

INTRINSIC HEAVY QUARK STATES

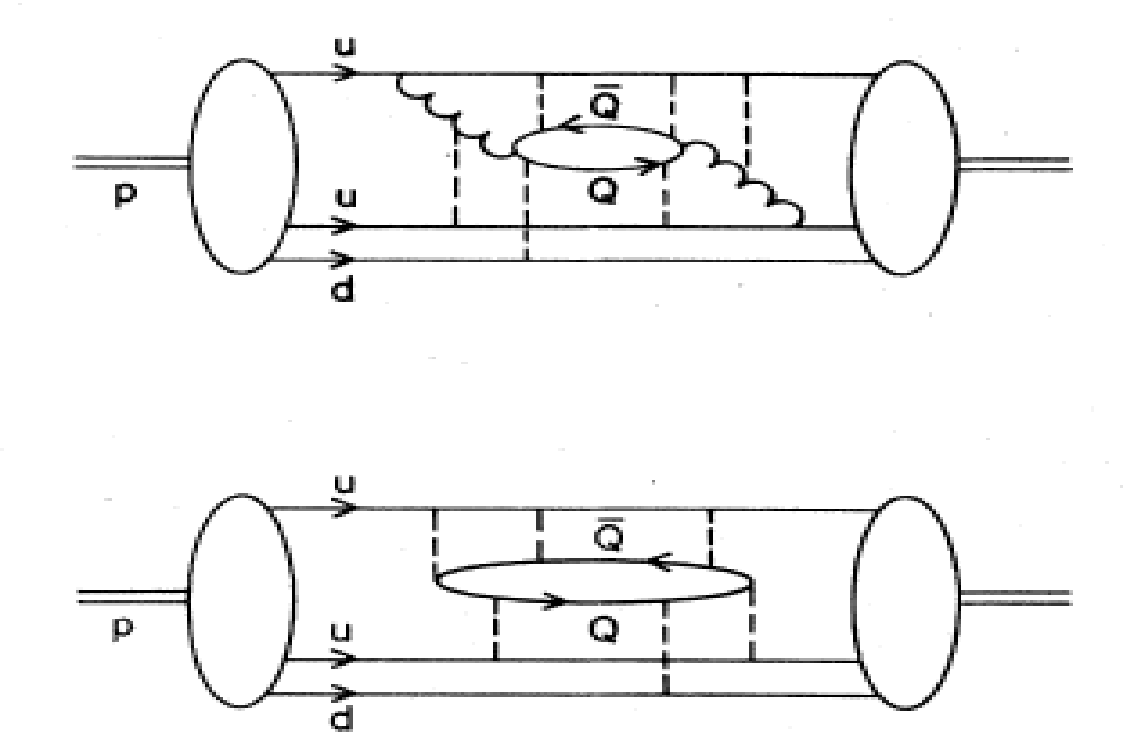
Two types of parton contributions

The extrinsic quarks and gluons are generated on a short time scale in association with a large transverse-momentum reaction.

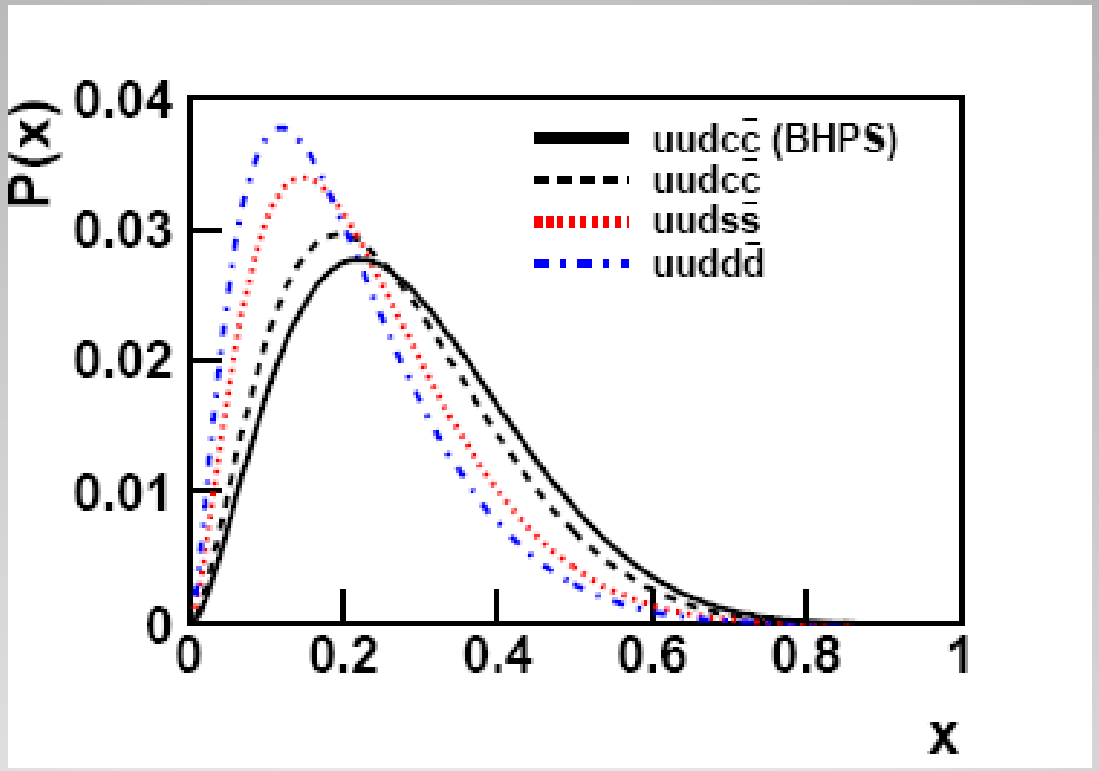
The intrinsic quarks and gluons exist over a time scale independent of any probe momentum, they are associated with the bound state hadron dynamics.

$$P(x_1,...,x_5) = N_5\,\delta\left(1-\sum_{i=1}^{5} x_i\right)\left[M_p^2-\sum_{i=1}^{5}\frac{m_i^2}{x_i}\right]^{-2}$$

Gluon-exchange & vacuum-polarization graphs

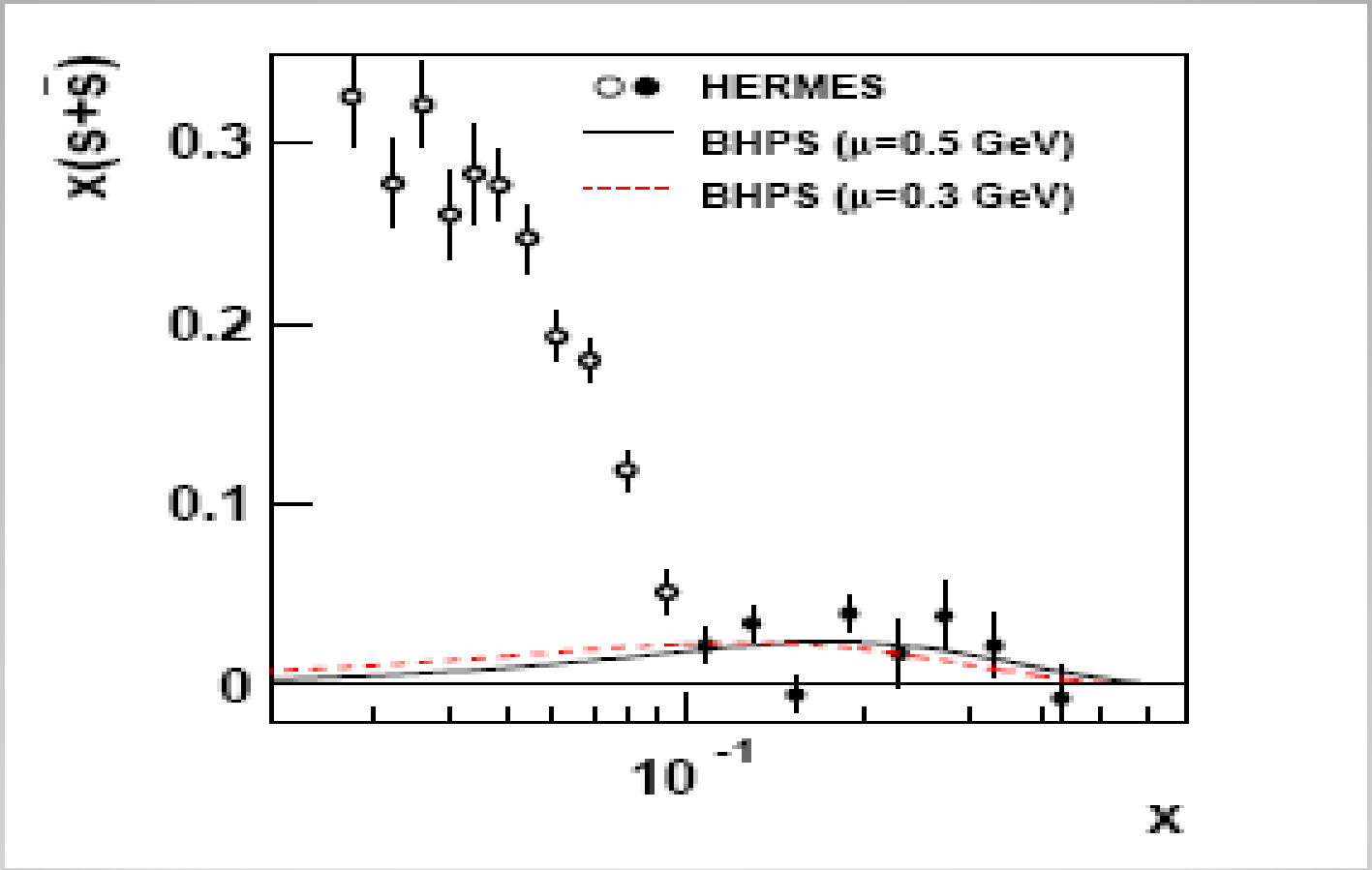


Diagrams which give rise to the intrinsic heavy quarks $(Q\bar{Q})$ within the proton. Curly and dashed lines represent transverse and longitudinal-scalar (instantons) gluons, respectively.
(S.J.Brodsky, C.Peterson, N.Sakai, Phys.Rev. D23 (1981) 2745.)

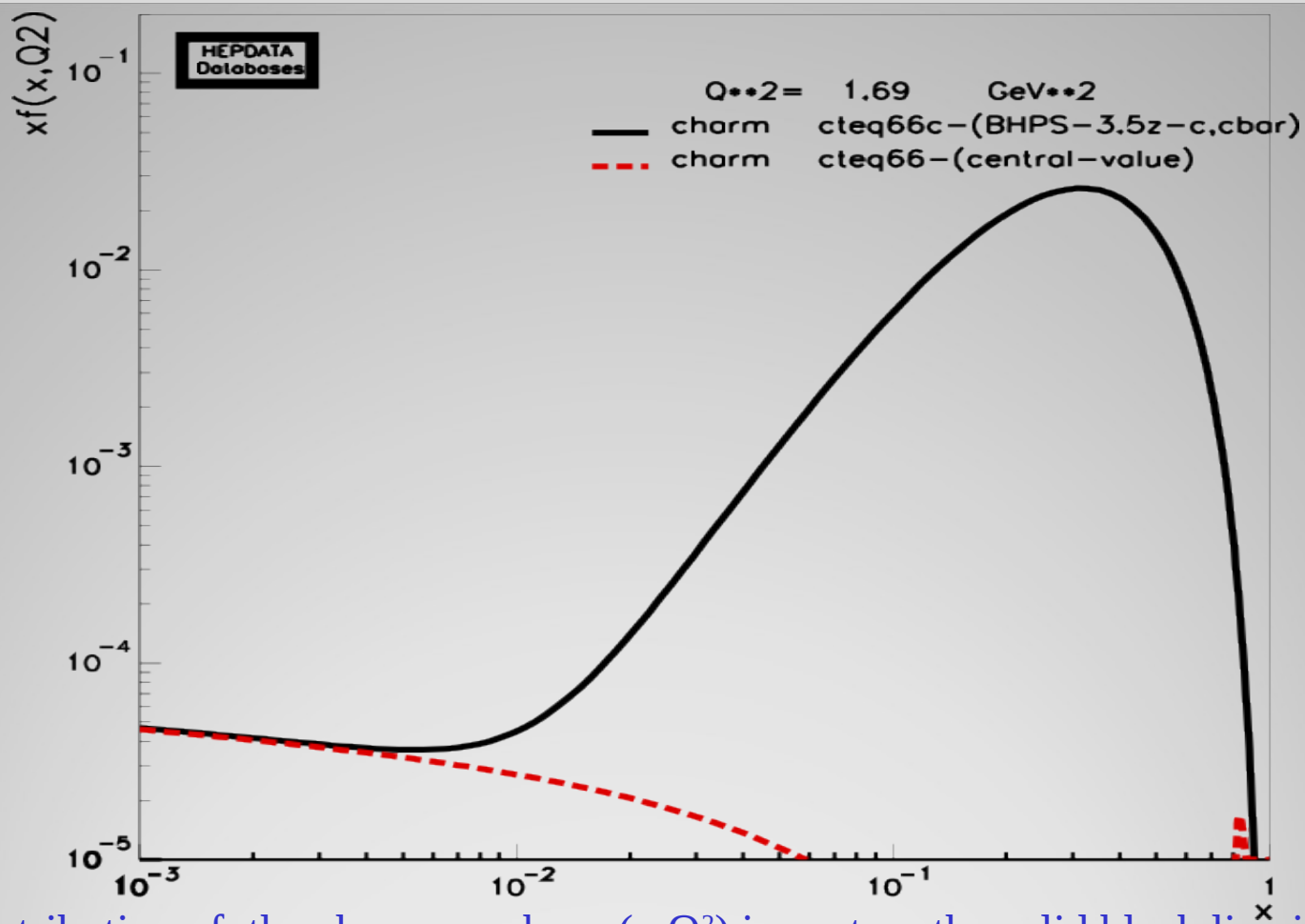


The x-distribution of the intrinsic Q in the $|uudQ\bar{Q}>$ configuration of the BHPS.

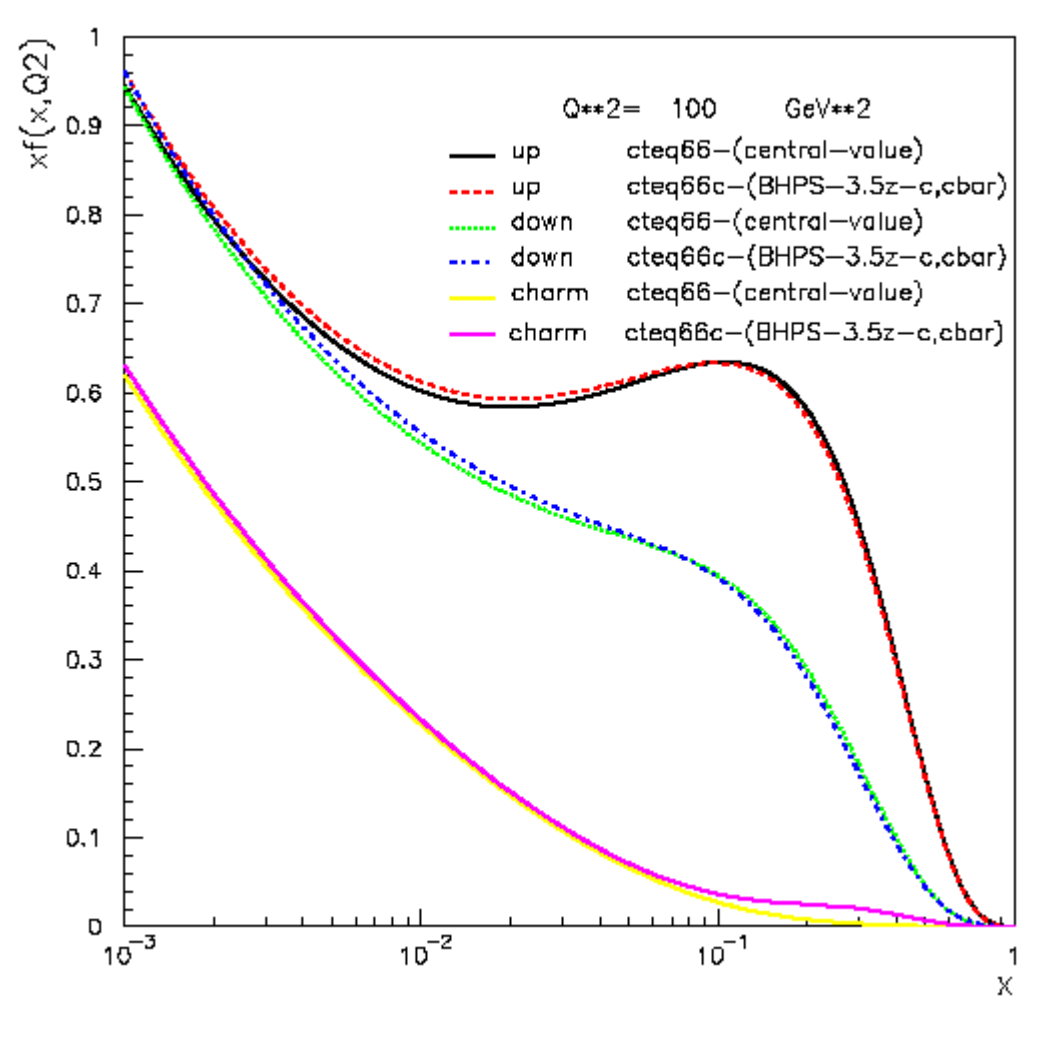
Jen-Chieh Peng & We-Chen Chang, hep-ph/1207.2193.



Comparison of the HERMES data with calculation within the BHPS at Q^2 about 2.5 Gev^2, μ is the QCD scale. A.Airapetian, et al., Phys.Lett.B666 (2008) 446; J.Peng, W.Cheng, hep-ph/1207.2193.

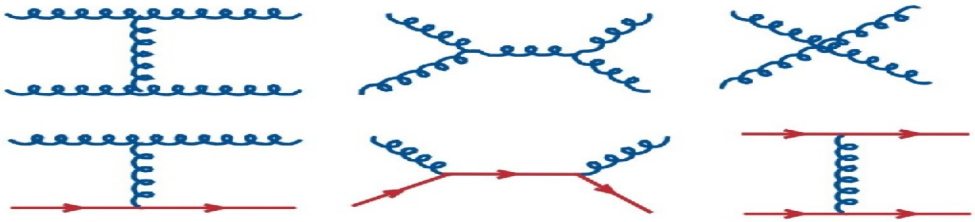


The x-distribution of the charm quarks $xc(x,Q^2)$ in proton; the solid black line is the IC contribution with its probability about 3.5 %, the dash green curve is the see charm quark contribution $xc_{sea}(x,Q^2)$ at $Q^2=1.69$ GeV^2. There is enhancement at $x>0.1$.


Q**2= 100 GeV**2
up cteq66-(central-value)
up cteq66c-(BHPS-3.5z-c,cbar)
down cteq66-(central-value)
down cteq66c-(BHPS-3.5z-c,cbar)
charm cteq66-(central-value)
charm cteq66c-(BHPS-3.5z-c,cbar)
xf(x,Q2)
x
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
10^-3
10^-2
10^-1
1

Hard processes

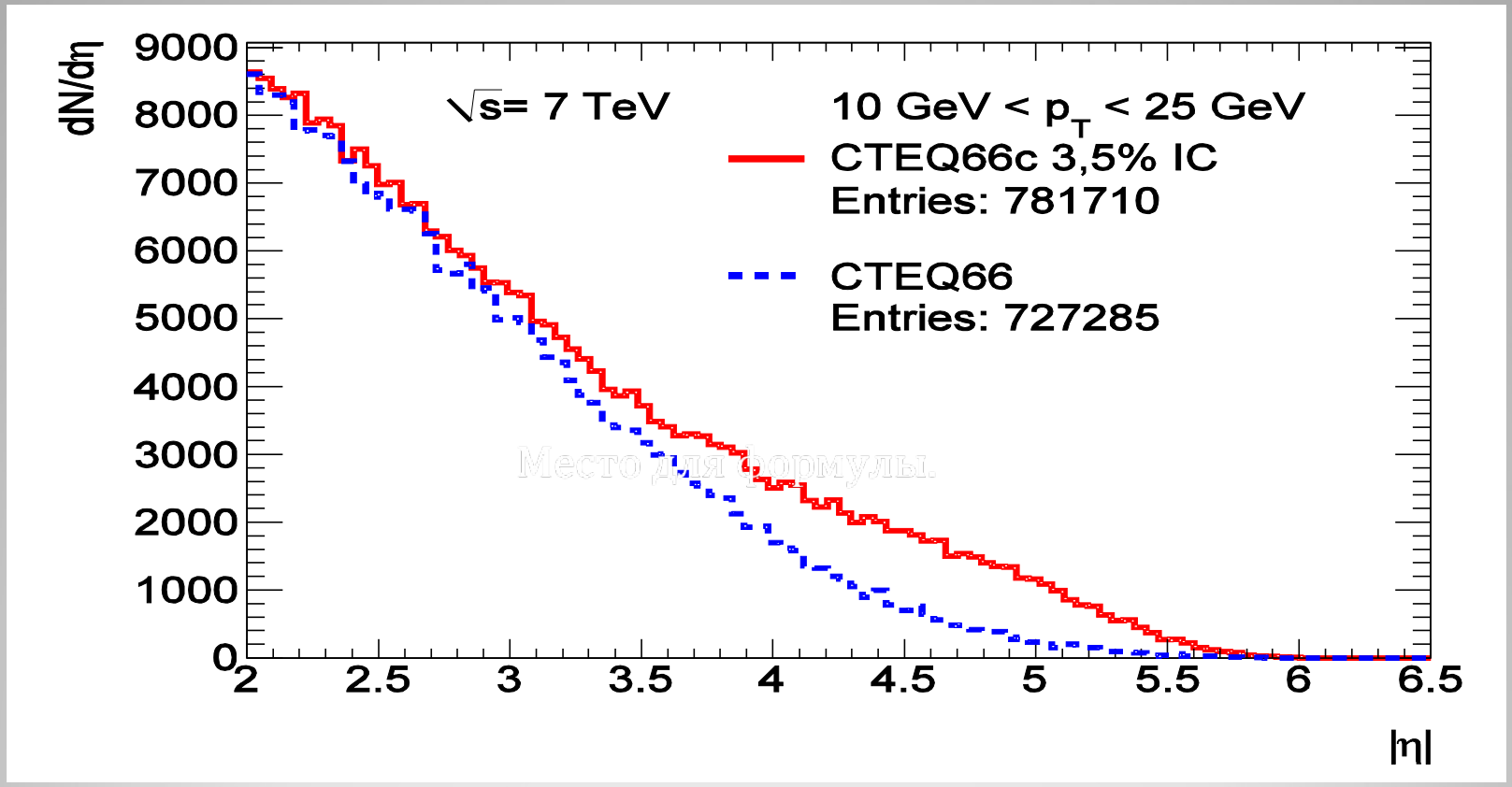
For example, leading order QCD.



Parton - parton interactions within LO QCD,
the wavy line is the gluon, the solid line is the quark.

$$\frac{d\sigma_{ij}}{d\hat{t}} = \frac{8\pi}{\hat{s}} A_1 \alpha_s^2 \frac{d\sigma_{ij}}{d\Phi_2}; \alpha_s(Q^2) = \frac{12\pi}{(33 - 2n_f)\ln(Q^2/\Lambda^2)};$$

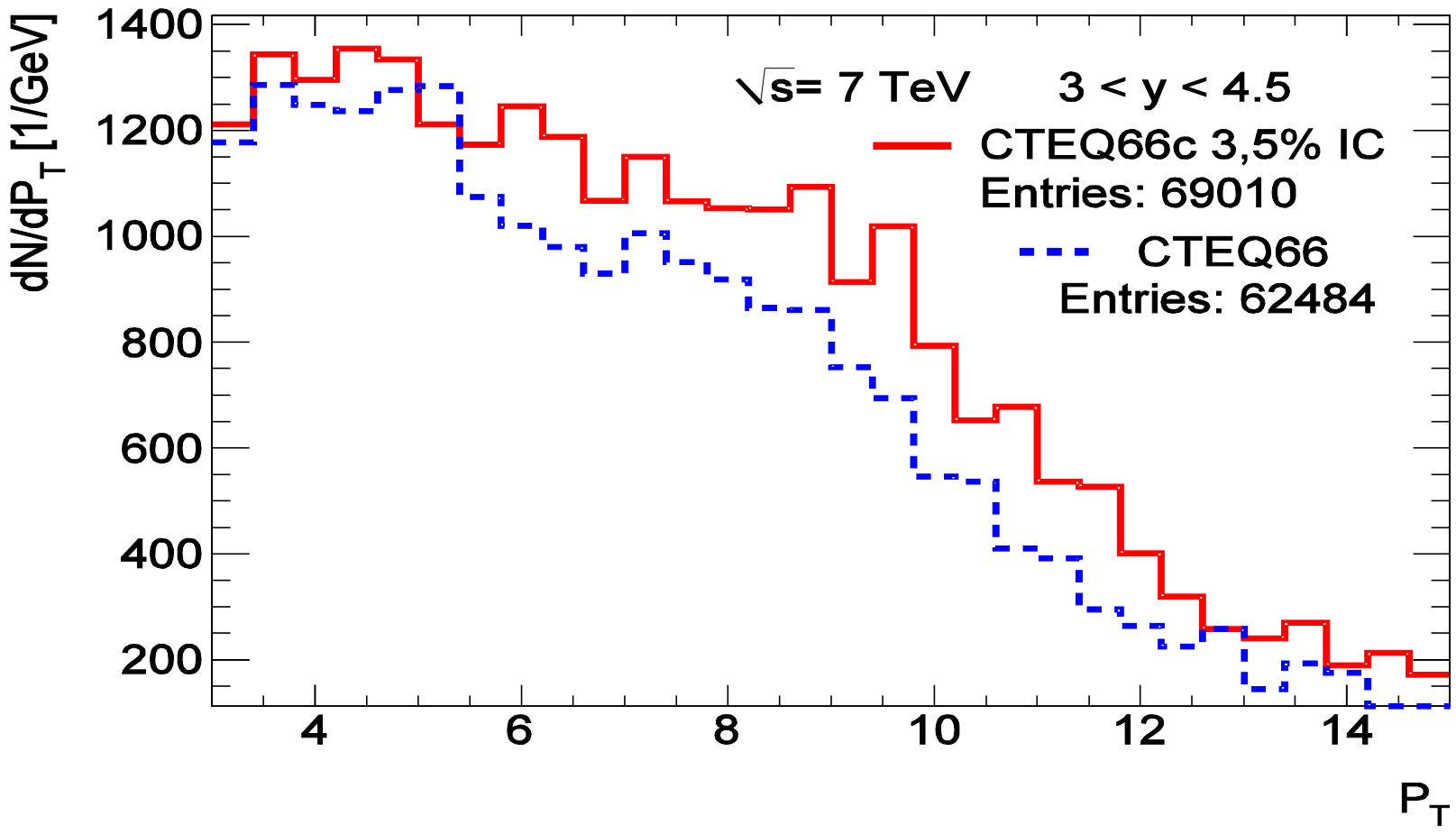
Process	$\frac{d\hat{\sigma}}{d\Phi_2}$	Process	$\frac{d\hat{\sigma}}{d\Phi_2}$
$qq' \to qq'$	$\frac{1}{2\hat{s}}\frac{4}{9}\frac{\hat{s}^2+\hat{u}^2}{\hat{t}^2}$	$q\bar{q} \to gg$	$\frac{1}{2}\frac{1}{2\hat{s}}\left[\frac{32}{27}\frac{\hat{t}^2+\hat{u}^2}{\hat{t}\hat{u}} - \frac{8}{3}\frac{\hat{t}^2+\hat{u}^2}{\hat{s}^2}\right]$
$qq \to qq$	$\frac{1}{2}\frac{1}{2\hat{s}}\left[\frac{4}{9}\left(\frac{\hat{s}^2+\hat{u}^2}{\hat{t}^2}+\frac{\hat{s}^2+\hat{t}^2}{\hat{u}^2}\right) - \frac{8}{27}\frac{\hat{s}^2}{\hat{u}\hat{t}}\right]$	$gg \to q\bar{q}$	$\frac{1}{2\hat{s}}\left[\frac{1}{6}\frac{\hat{t}^2+\hat{u}^2}{\hat{t}\hat{u}} - \frac{3}{8}\frac{\hat{t}^2+\hat{u}^2}{\hat{s}^2}\right]$
$q\bar{q} \to q'\bar{q}'$	$\frac{1}{2\hat{s}}\frac{4}{9}\frac{\hat{t}^2+\hat{u}^2}{\hat{s}^2}$	$gq \to gq$	$\frac{1}{2\hat{s}}\left[-\frac{4}{9}\frac{\hat{s}^2+\hat{u}^2}{\hat{s}\hat{u}} + \frac{\hat{u}^2+\hat{s}^2}{\hat{t}^2}\right]$
$q\bar{q} \to q\bar{q}$	$\frac{1}{2\hat{s}}\left[\frac{4}{9}\left(\frac{\hat{s}^2+\hat{u}^2}{\hat{t}^2}+\frac{\hat{t}^2+\hat{u}^2}{\hat{s}^2}\right) - \frac{8}{27}\frac{\hat{u}^2}{\hat{s}\hat{t}}\right]$	$gg \to gg$	$\frac{1}{2}\frac{1}{2\hat{s}}\frac{9}{2}\left(3 - \frac{\hat{t}\hat{u}}{\hat{s}^2} - \frac{\hat{s}\hat{u}}{\hat{t}^2} - \frac{\hat{s}\hat{t}}{\hat{u}^2}\right)$



Single D^0 production in p-p at $\sqrt{s} = 7\text{TeV}$.

$x_F = \frac{2p_t}{\sqrt{s}} \sinh(\eta) = x_t sinh(\eta)$; IC signal, when $x_F > 0.1$

G.L., V.A.Bednyakov, A.F.Pikelner, N.P.Zimin, Eur.Phys.Lett. 96 (2012)21002;



Double D^0 production in p-p at $\sqrt{s} = 7$ TeV.

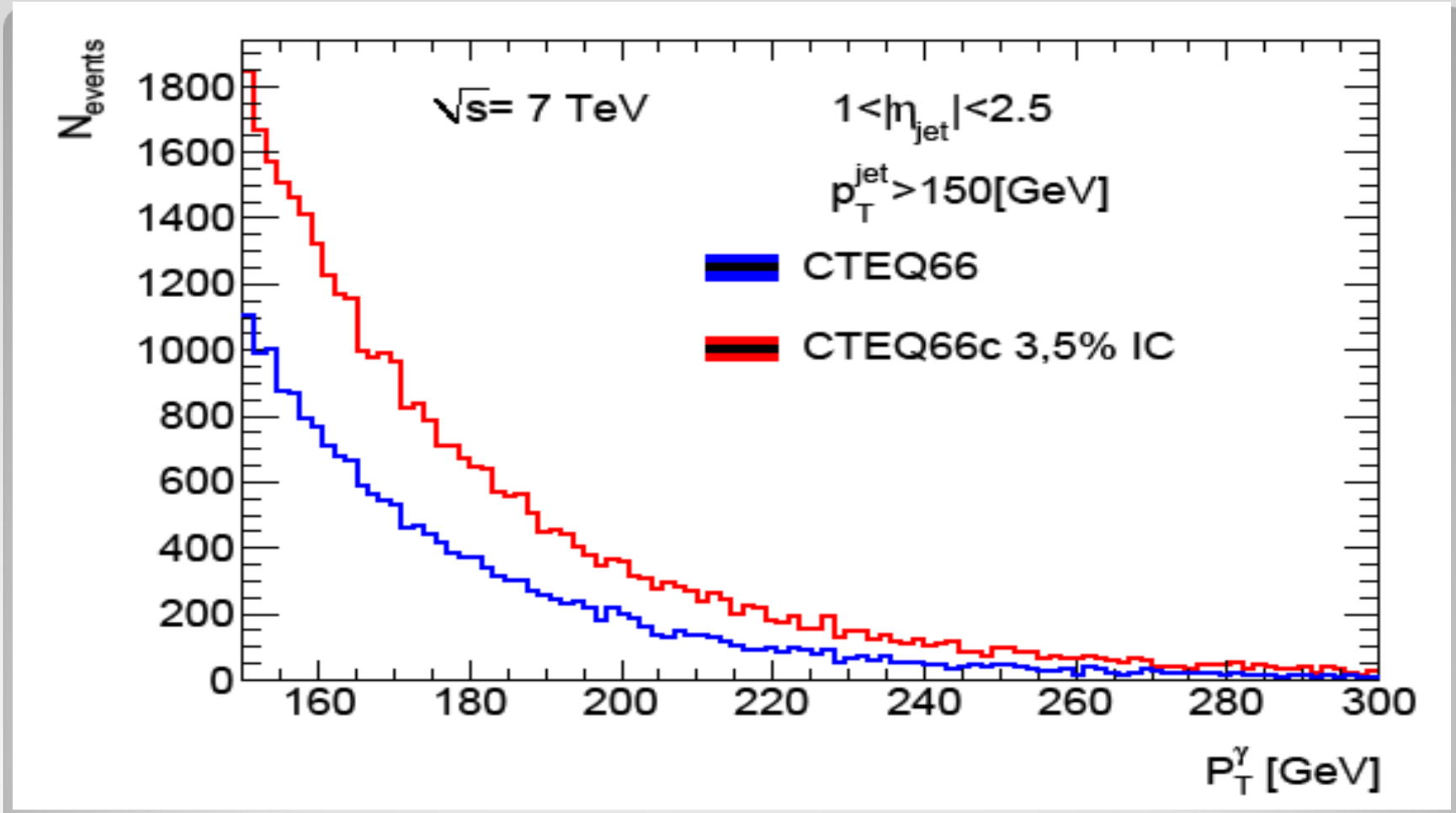
G.L., V.A.Bednyakov, A.F.Pikelner, N.P.Zimin, Eur.Phys.Lett. 96 (2012) 21002

XX1 ISHEP, Dubna, September 10-15 , 2012

PROMPT PHOTON PRODUCTION IN P-P TOGETHER C-JET

$$p + \bar{p} -> \gamma + c(jet) + X$$

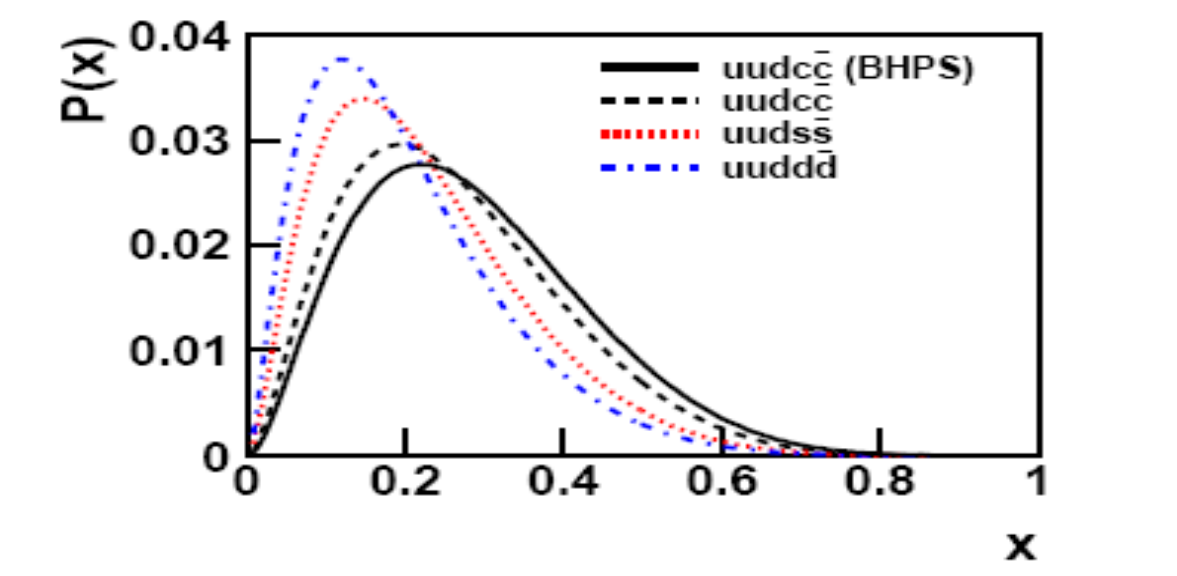
Some enhancement in the p_t - spectrum of photons produced in this reaction was observed at the Tevatron (D0-experiment) that can be related to the IC signal. (V.M.Abazov, et al., Phys.Rev.Lett., 102 (2009) 192002).



Contribution of the hard process $g + c -> \gamma + c$ in

$p + p -> \gamma + c - jet + X$ at $\sqrt{s} = 7$ TeV. $p + p \to \gamma^* / Z^0 + c - jet \to l^+ l^- + c - jet$

INTRINSIC STRANGENESS IN PROTON



There is an enhancement at x>0.1

Strange hadron production in p-p collisons

$$x_F = \frac{2p_t}{\sqrt{s}}\sinh(\eta)$$

SEARCH FOR INTRINSIC STRANGENESS IN P-P

$$pp \longrightarrow K^{+,-,0} X$$

At $x_F = \frac{2p_t}{\sqrt{s}} \sinh(\eta)$

there can be an enhancement due to the **IS.**

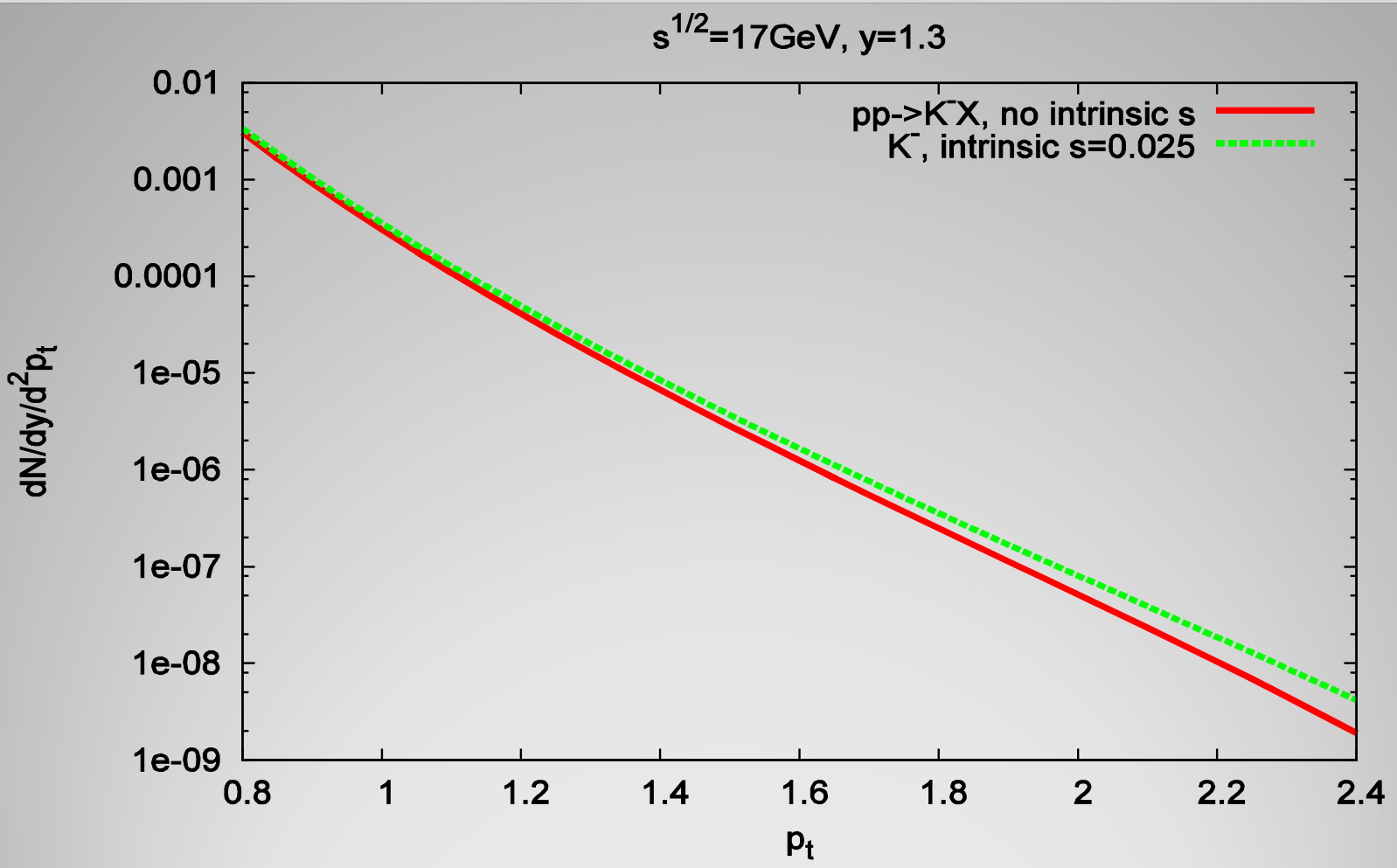
It means that the possible IS signal depend on $p_t / \sqrt{s}$

and does not depend on $\sqrt{s}$

$K^+(u\bar{s}); K^-(\bar{u}s)$ Therefore, it make some sense to measure K^- mesons in p-p collisions at

HADES, CBM & NICA

to observe a possible intrinsic strangeness in the proton



Inclusive spectrum of K^- produced in pp at $\sqrt{s} = 17$ GeV

SUMMARY

1. The forward production of heavy flavors at LHC can give us the information on the intrinsic quark components in proton.
2. The signal for intrinsic charm in proton can be studied in the single and double D-meson production in p-p at the LHCb.
3. Some enhancement due to the intrinsic charm can be seen in the inclusive spectrum over y or p_t at y>3 and p_t > 6 GeV/c.

It is about by factor 2 in comparison to the case without the IC.

4. The measurements of the inclusive spectra of photons or dilepton pairs and c(b)-jets in the reaction of type $p+p->\gamma+c(b)-jet+X$ $p+p->\gamma^*/Z^0+c(b)-jet+X$

or in

at LHC can give a new information on the intrinsic charm in proton.

5. At **HADES, CBM, NICA, NA61** experiments can be studied

THANK YOU VERY MUCH FOR YOUR ATTENTION !

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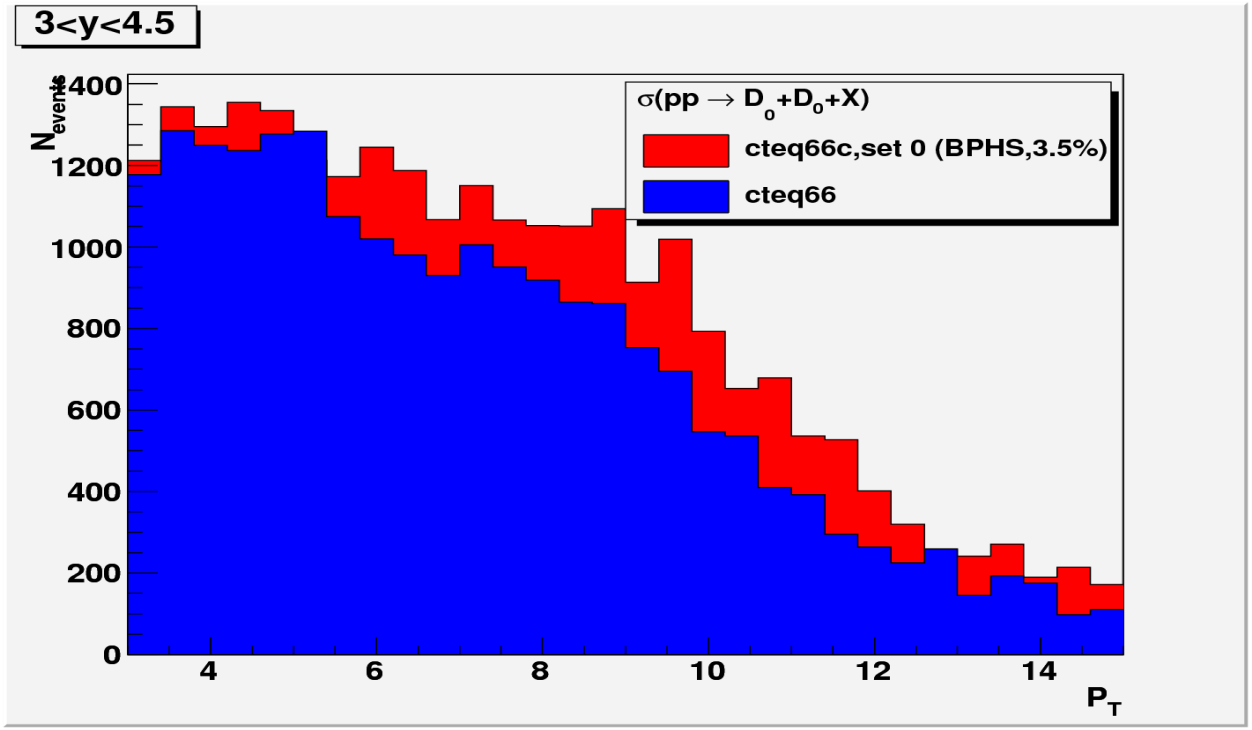
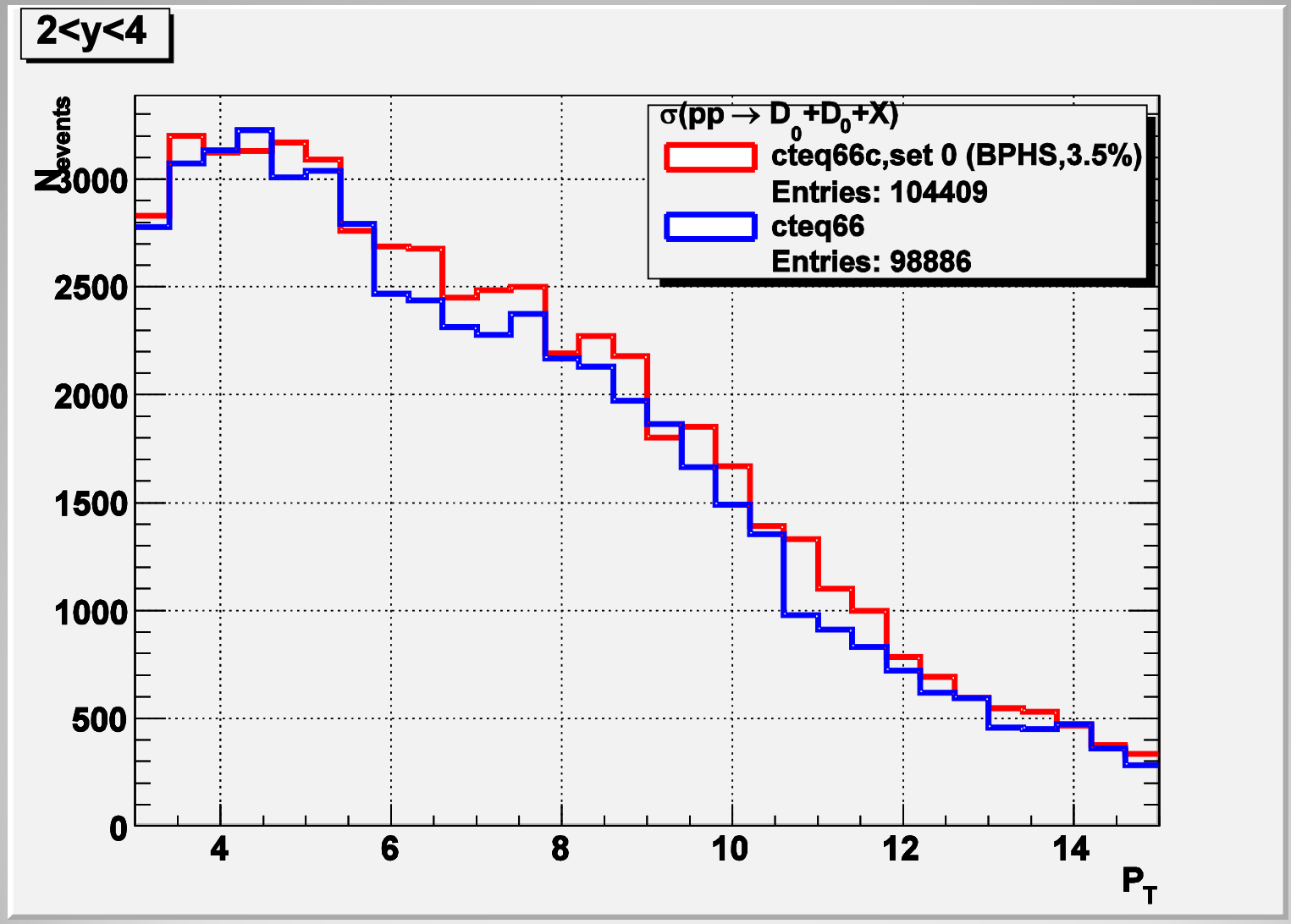
Double D^0 production in pp at $\sqrt{s} = 7TeV$

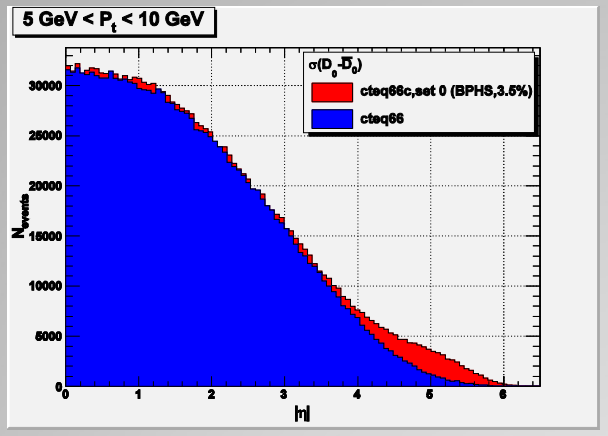


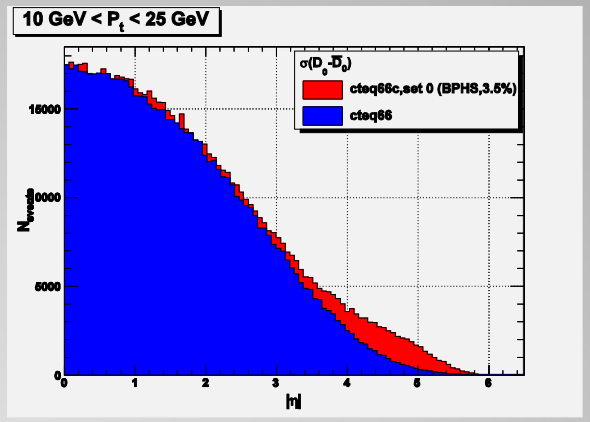
The number of D^0D^0 events in p-p as a function of the transverse momentum including the intrinsic charm in proton (red histogram) with the probability about 3.5%.

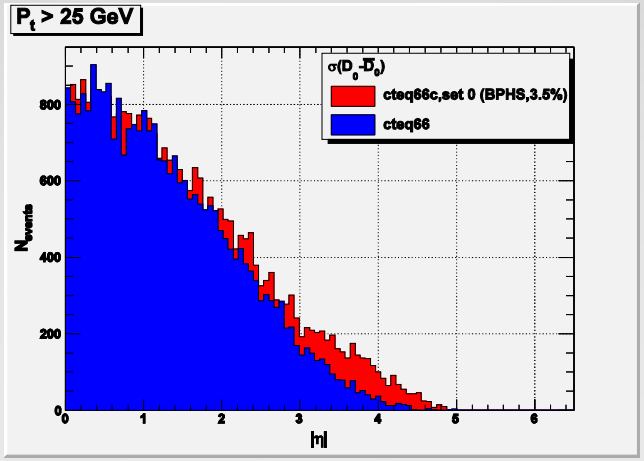
$\sigma^{theor}_{2D^0} \cong 700nb$ including IC and $\sigma^{theor}_{2D^0} \cong 630nb$ without IC. $\sigma^{exp}_{2D^0} \cong 687 \pm 86nb$


2<y<4
σ(pp → D0+D0+X)
cteq66c,set 0 (BPHS,3.5%)
Entries: 104409
cteq66
Entries: 98886
N events
3000
2500
2000
1500
1000
500
0
4
6
8
10
12
14
PT

Single D^0 production in p-p





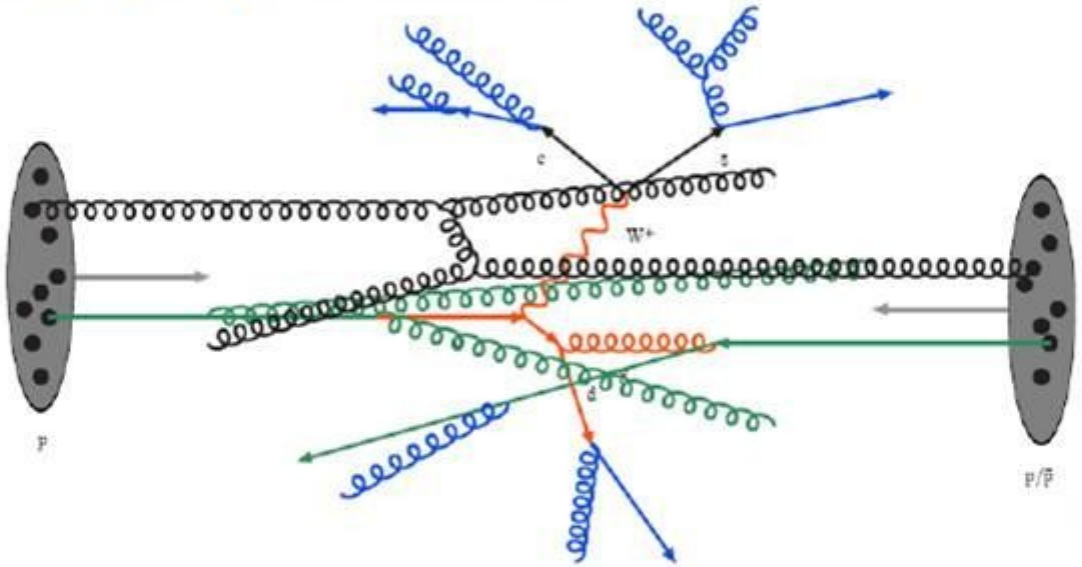


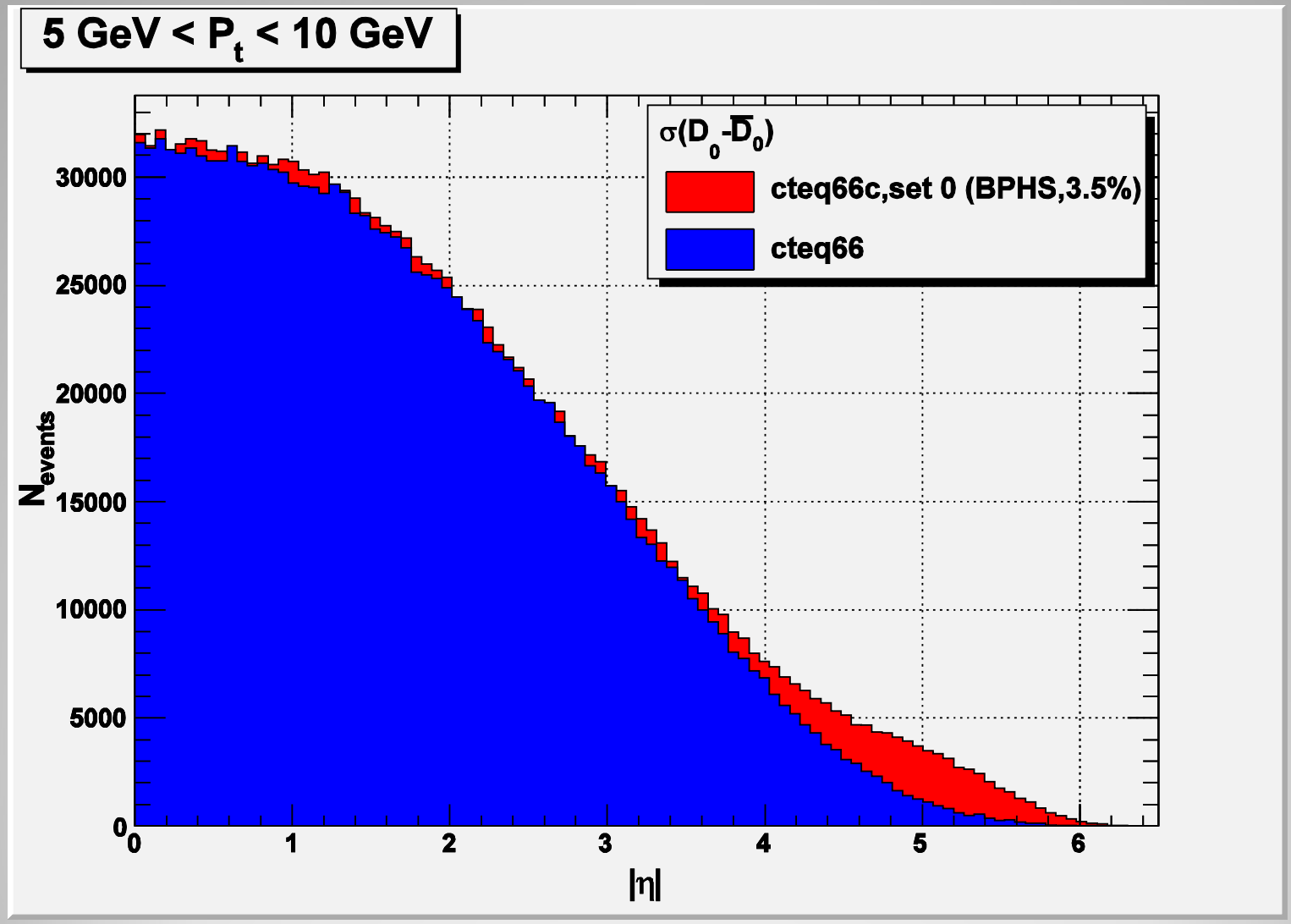
$$\sqrt{s} = 7TeV$$

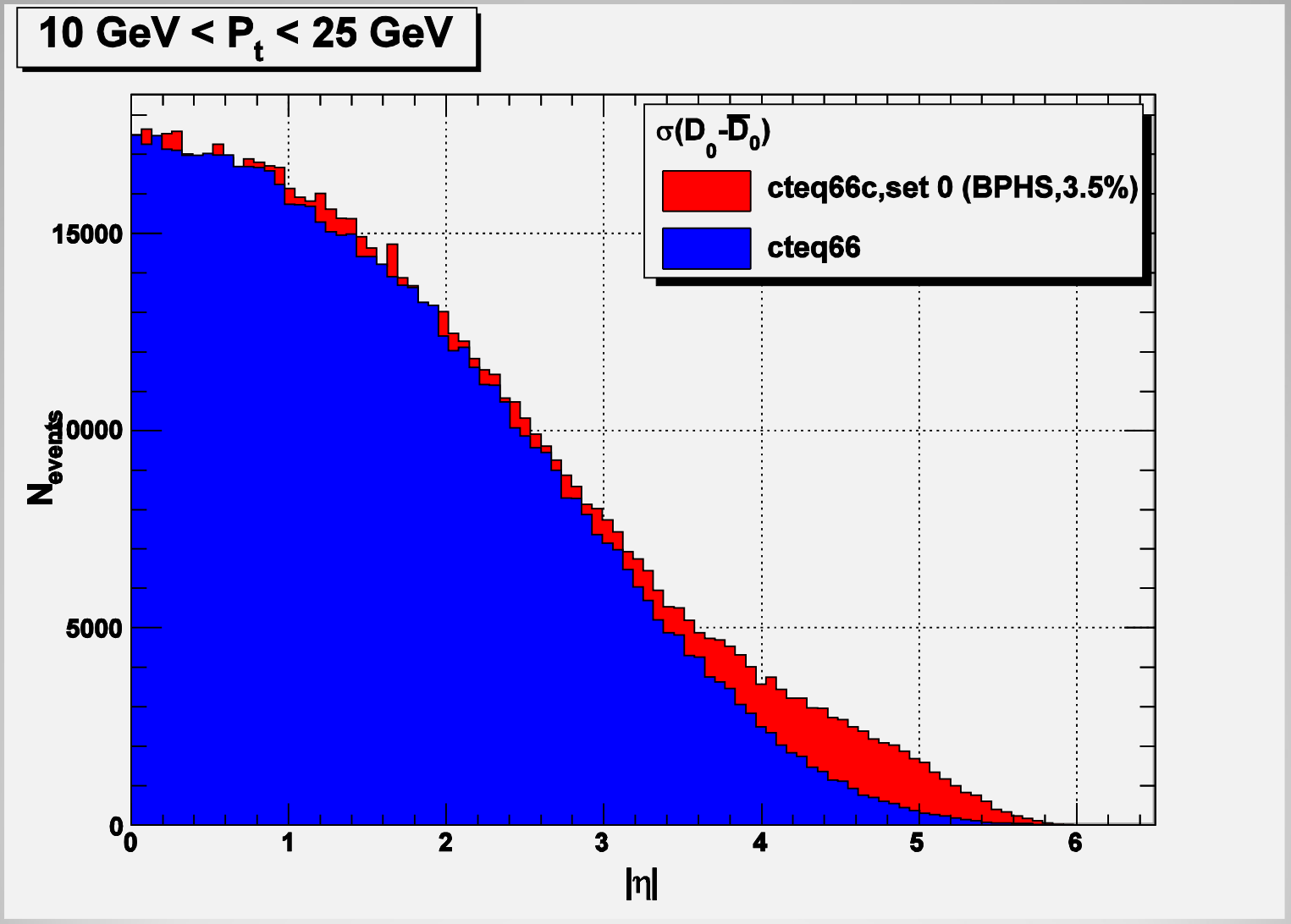
Pseudo-rapidity η distribution of $D^0 + \overline{D}^0$ produced in p-p

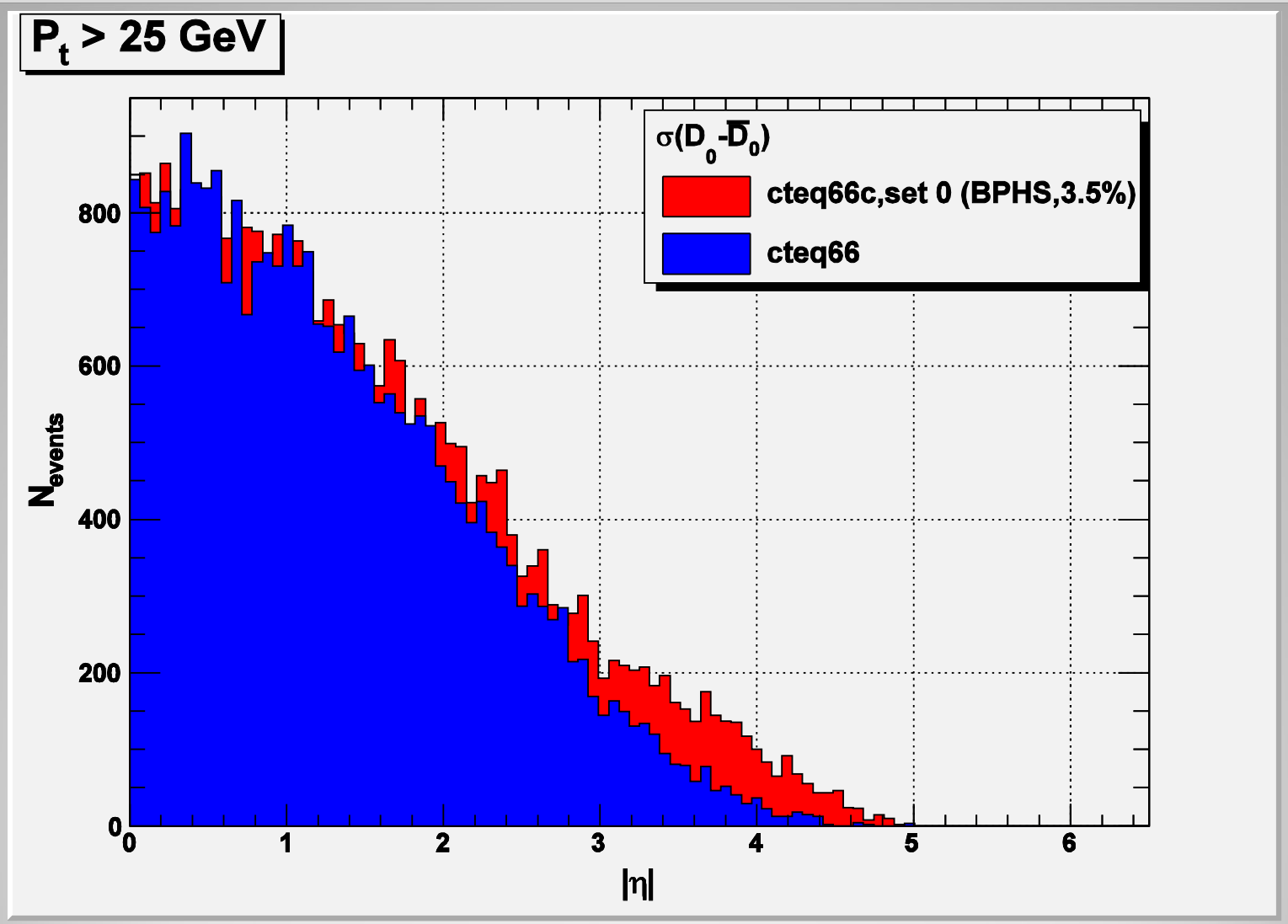
Structure of an event

- Multiple parton-parton interactions




5 GeV < P_t < 10 GeV
σ(D_0-D̄_0)
cteq66c,set 0 (BPHS,3.5%)
cteq66
N_events
|η|
0
5000
10000
15000
20000
25000
30000
0
1
2
3
4
5
6


10 GeV < P_t < 25 GeV
σ(D_0-D̄_0)
cteq66c,set 0 (BPHS,3.5%)
cteq66
N_events
15000
10000
5000
0
0
1
2
3
4
5
6
|η|


P_t > 25 GeV
$\sigma(D_0-\bar{D}_0)$
cteq66c,set 0 (BPHS,3.5%)
cteq66
N_{events}
|η|
0
200
400
600
800
0
1
2
3
4
5
6