XXXIX International Symposium on Multiparticle Dynamics

Difference in multiplicity distributions in proton-proton and proton-antiproton collisions at high energies

N.V. Radchenko
Novgorod State University
Russia

Outline

1) Low constituents number model

2) Fitting of total cross sections

3) Three types of inelastic processes in pp and $p\bar{p}$ collisions and multiplicity distributions in these processes

4) Fitting of non single diffraction cross sections and weights of distributions

5) Examples of fitted charged multiplicity distributions

6) Difference between pp and $p\bar{p}$ interactions for energy 900 GeV

7) Predictions for energy 14 TeV

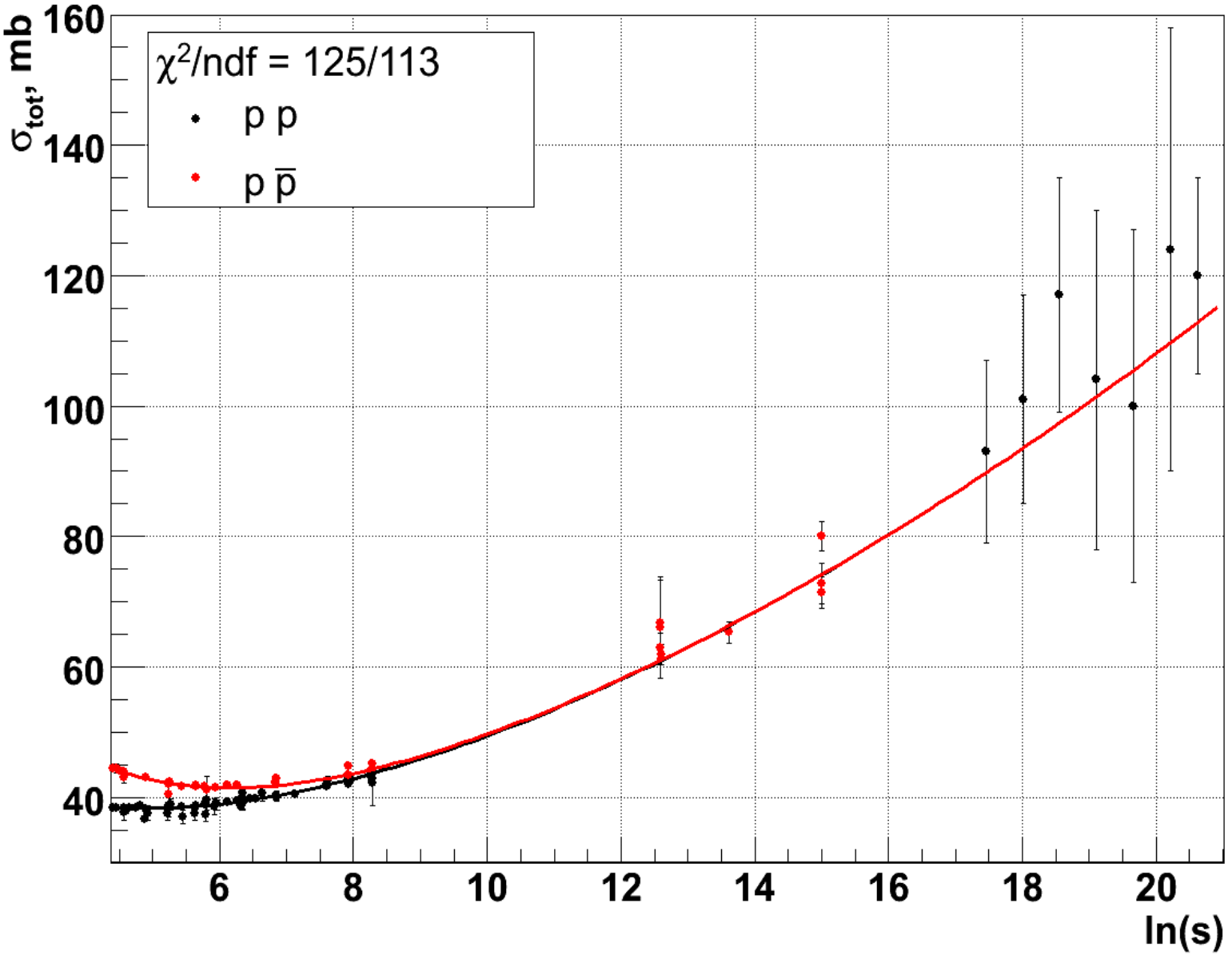
Low constituents number model

1) On the first step before the collision there is small number of constituents in hadrons. They are valent quarks and few gluons which fill in the whole spectrum in rapidity space.

2) On the second step the hadrons interaction is carried out by gluon exchange between the valent quarks and initial gluons and the hadrons gain the color charge.

3) On the third step after interaction the colored hadrons move apart and when the distance between them becomes larger than the confinement radius, the lines of color electric field gather into the string. This string breaks out into secondary hadrons.

$$\sigma_{tot}^{p(\bar{p})p} = 63.52 s^{-0.358} \mp 35.43 s^{-0.56} + \sigma_0^{pp} + \sigma_1^{pp} \ln s + \sigma_2^{pp} (\ln s)^2$$



$$\sigma_0^{pp} = 20.08 \pm 0.42$$

$$\sigma_1^{pp} = 1.14 \pm 0.13$$

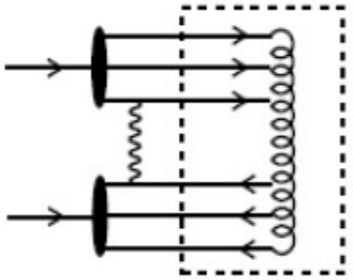
$$\sigma_2^{pp} = 0.16 \pm 0.01$$

only two gluons in initial state!

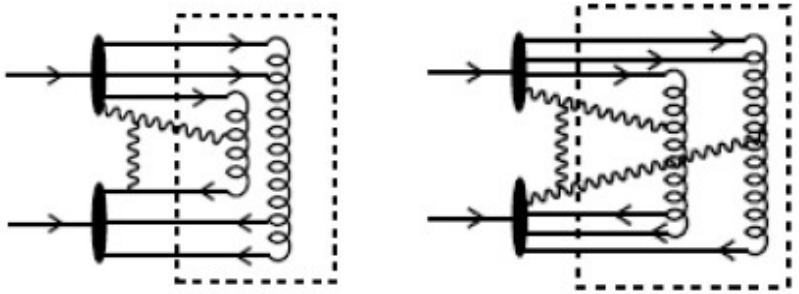
Types of inelastic processes in *pp* and $p\bar{p}$ collisions

proton-antiproton

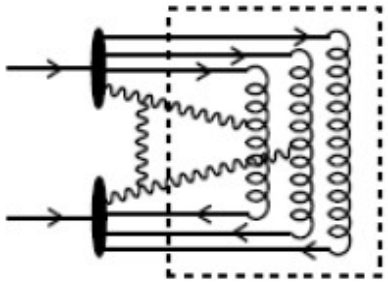
1)



2)

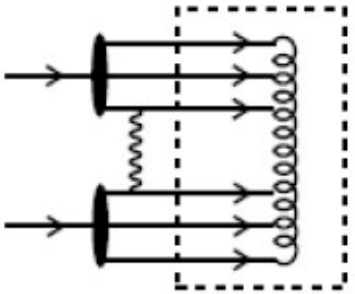


3)

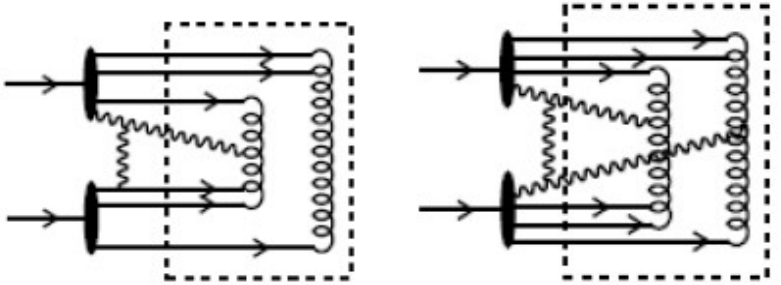


proton-proton

1)

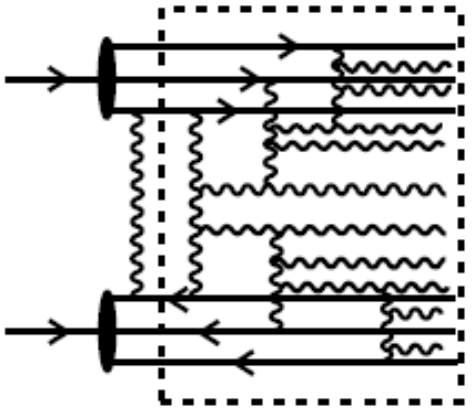


2)



Multiplicity distributions in different processes

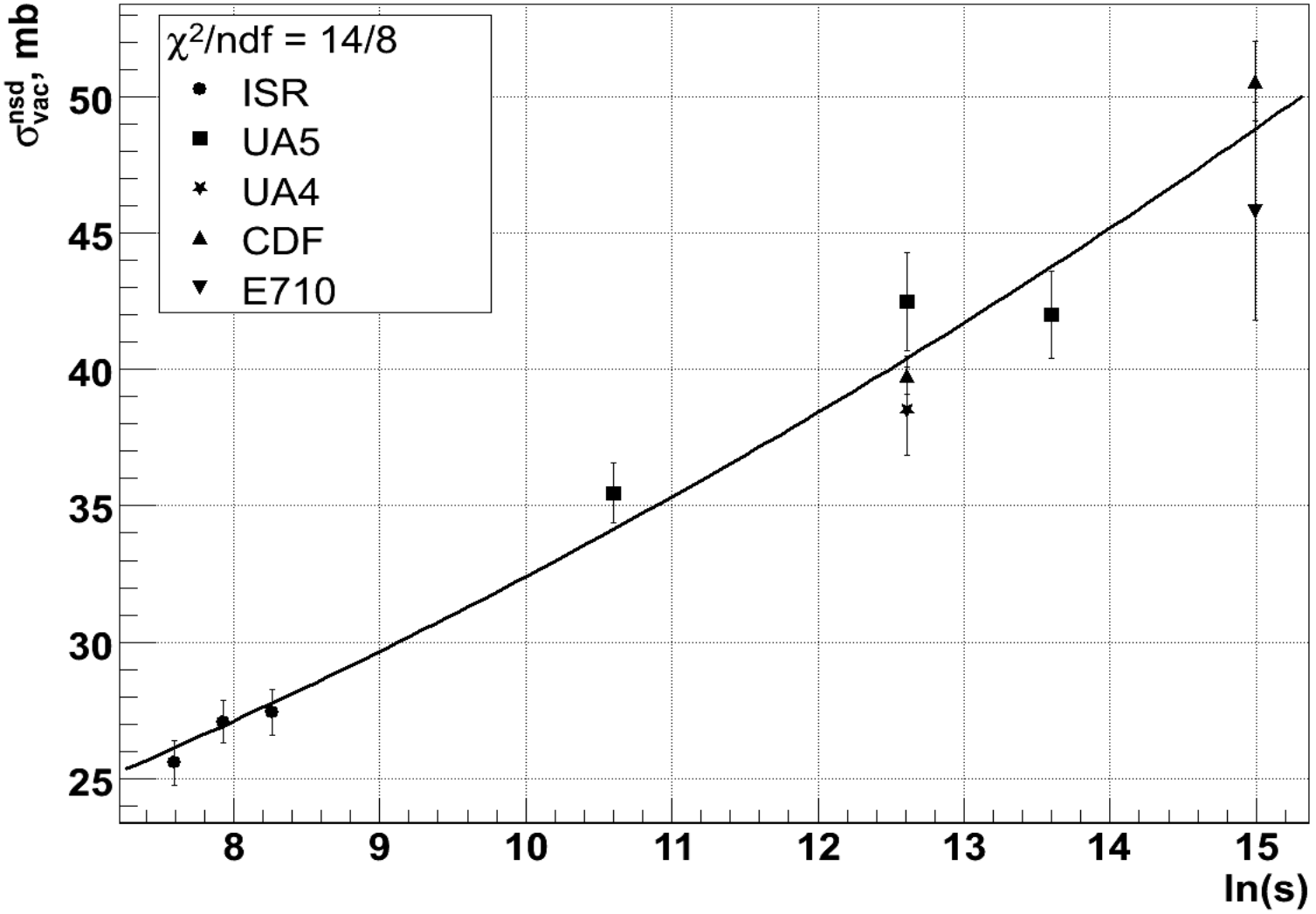
Multiplicity distribution of secondary hadrons produced from gluon string decay is normal distribution.



Multiplicity distribution of secondary hadrons produced from quark string decay is negative binomial distribution (NBD).

If there are two (three) quark strings than multiplicity distribution is convolution of two (three) NBD.

The experimental multiplicity distributions are normalized by non single diffraction cross sections $\sigma_{nsd} = \sigma_{tot} - \sigma_{el} - \sigma_{sd}$.
Pomeron contributions are the same as for total cross sections
$\sigma_{vac}^{nsd} = \sigma_0^{nsd}(1 + \delta_1^{nsd} \ln s + \delta_2^{nsd} \ln^2 s)$.



$\sigma_0^{nsd} \simeq 13.3$

$\delta_1^{nsd} = 0.075 \pm 0.011$

$\delta_2^{nsd} = 0.007 \pm 0.001$

Weights of distributions

proton-antiproton

Normal distribution

$$\frac{1}{1+\delta_1^{nsd}\ln s+\delta_2^{nsd}(\ln s)^2}$$

Double NBD

$$\frac{\delta_1^{nsd}\ln s+(1-c)\,\delta_2^{nsd}(\ln s)^2}{1+\delta_1^{nsd}\ln s+\delta_2^{nsd}(\ln s)^2}$$

Triple NBD

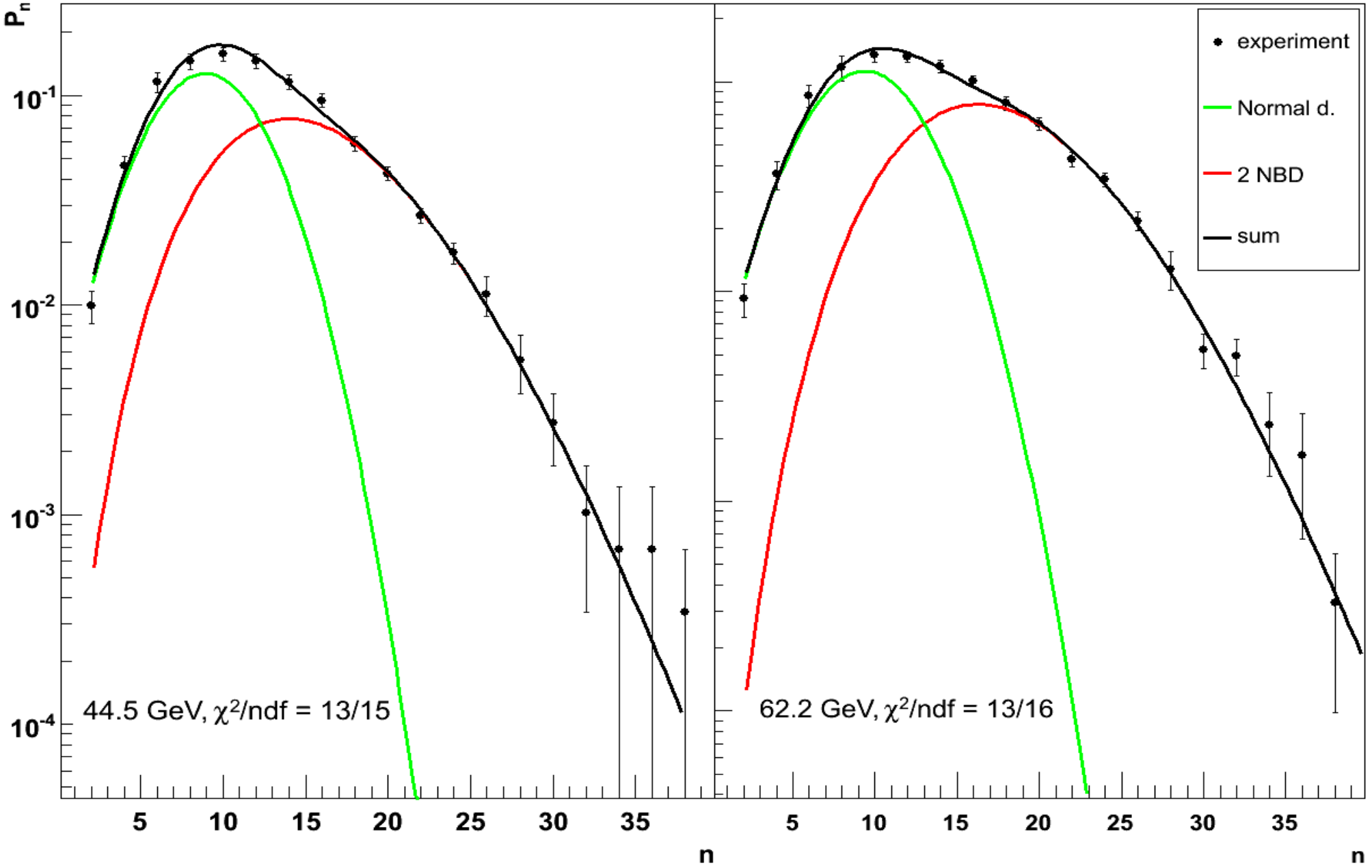
$$\frac{c\,\delta_2^{nsd}(\ln s)^2}{1+\delta_1^{nsd}\ln s+\delta_2^{nsd}(\ln s)^2}$$

proton-proton

$$\frac{1}{1+\delta_1^{nsd}\ln s+\delta_2^{nsd}(\ln s)^2}$$

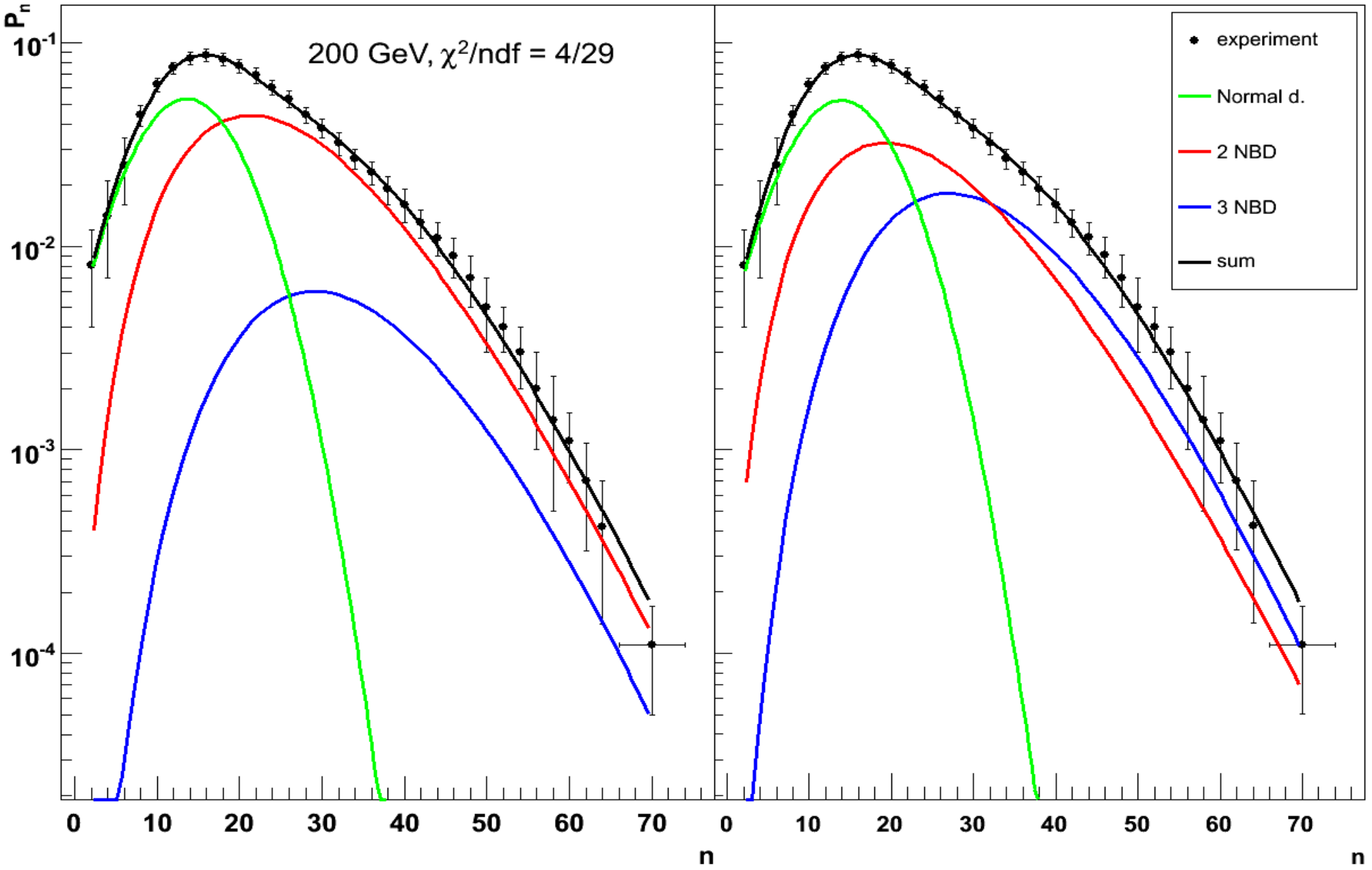
$$\frac{\delta_1^{nsd}\ln s+\delta_2^{nsd}(\ln s)^2}{1+\delta_1^{nsd}\ln s+\delta_2^{nsd}(\ln s)^2}$$

c = ?
c = 0.25
c = 0.75


P_n
10^{-1}
10^{-2}
10^{-3}
10^{-4}
experiment
Normal d.
2 NBD
sum
44.5 GeV, χ^2/ndf = 13/15
62.2 GeV, χ^2/ndf = 13/16
5
10
15
20
25
30
35
n

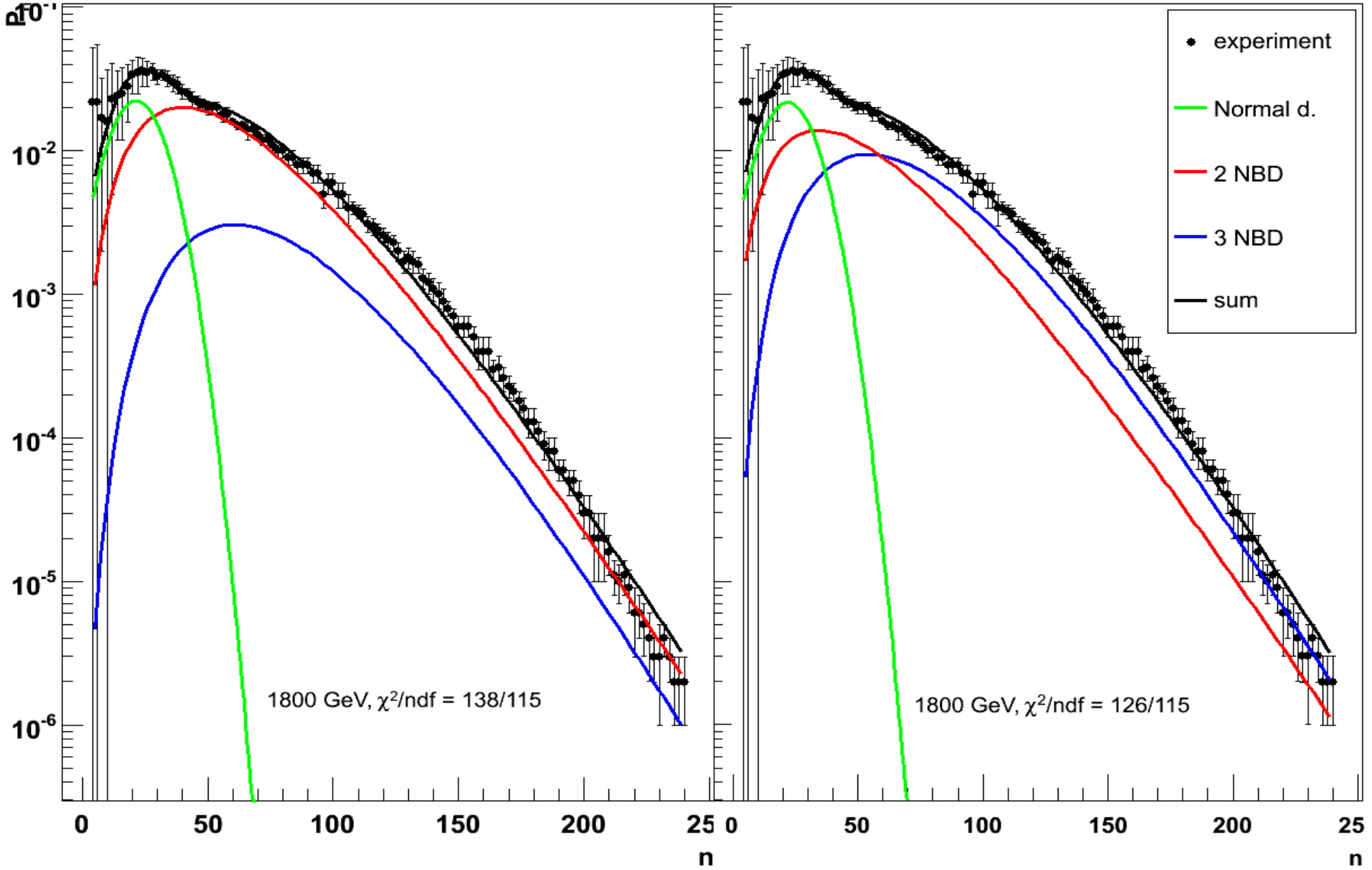
c=0.25

c=0.75


P_n
10^{-1}
10^{-2}
10^{-3}
10^{-4}
200 GeV, χ^2/ndf = 4/29
experiment
Normal d.
2 NBD
3 NBD
sum
0
10
20
30
40
50
60
70
n

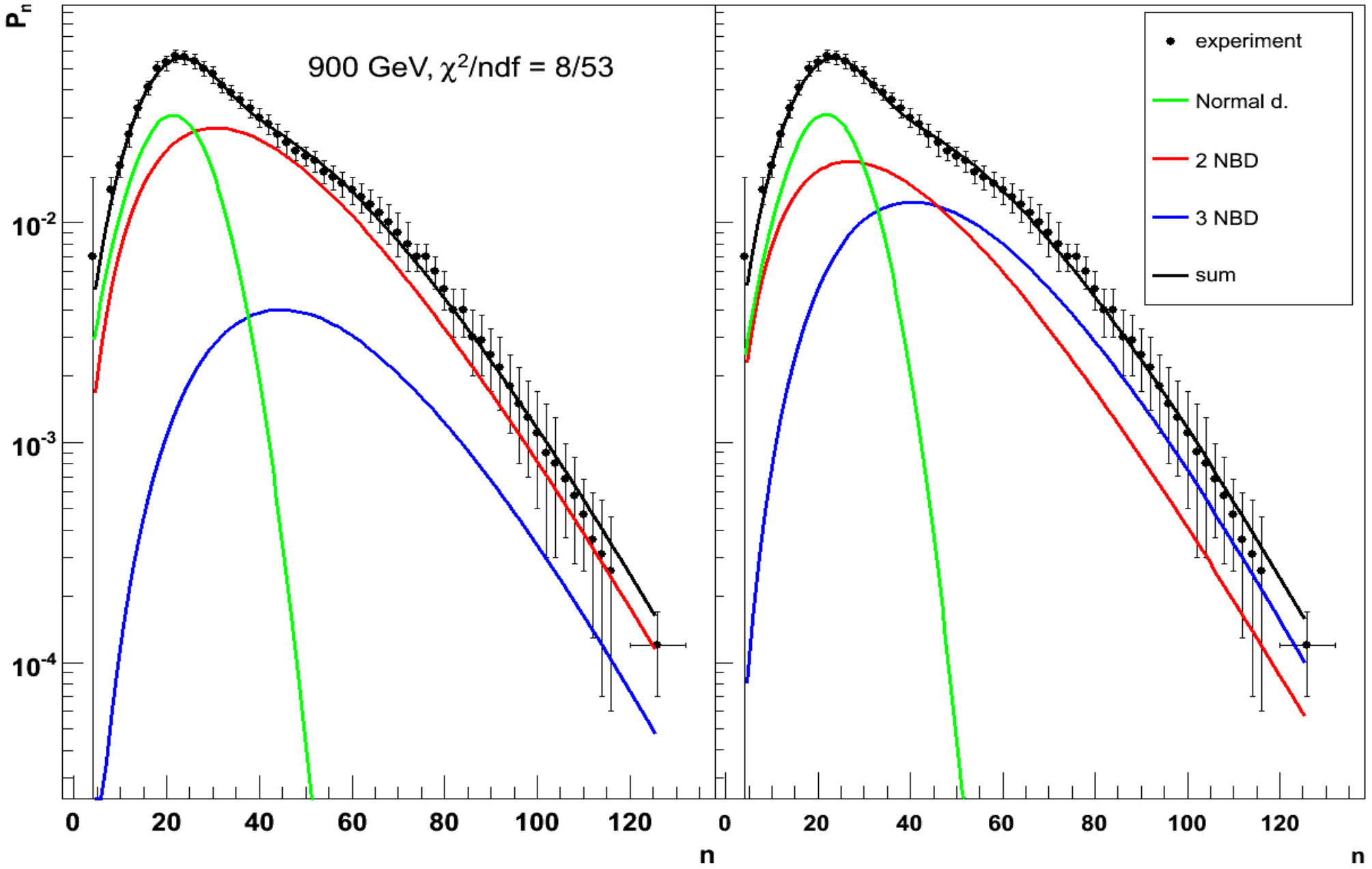
c=0.25

c=0.75


P
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0
50
100
150
200
25
n
1800 GeV, χ^2/ndf = 138/115
1800 GeV, χ^2/ndf = 126/115
experiment
Normal d.
2 NBD
3 NBD
sum

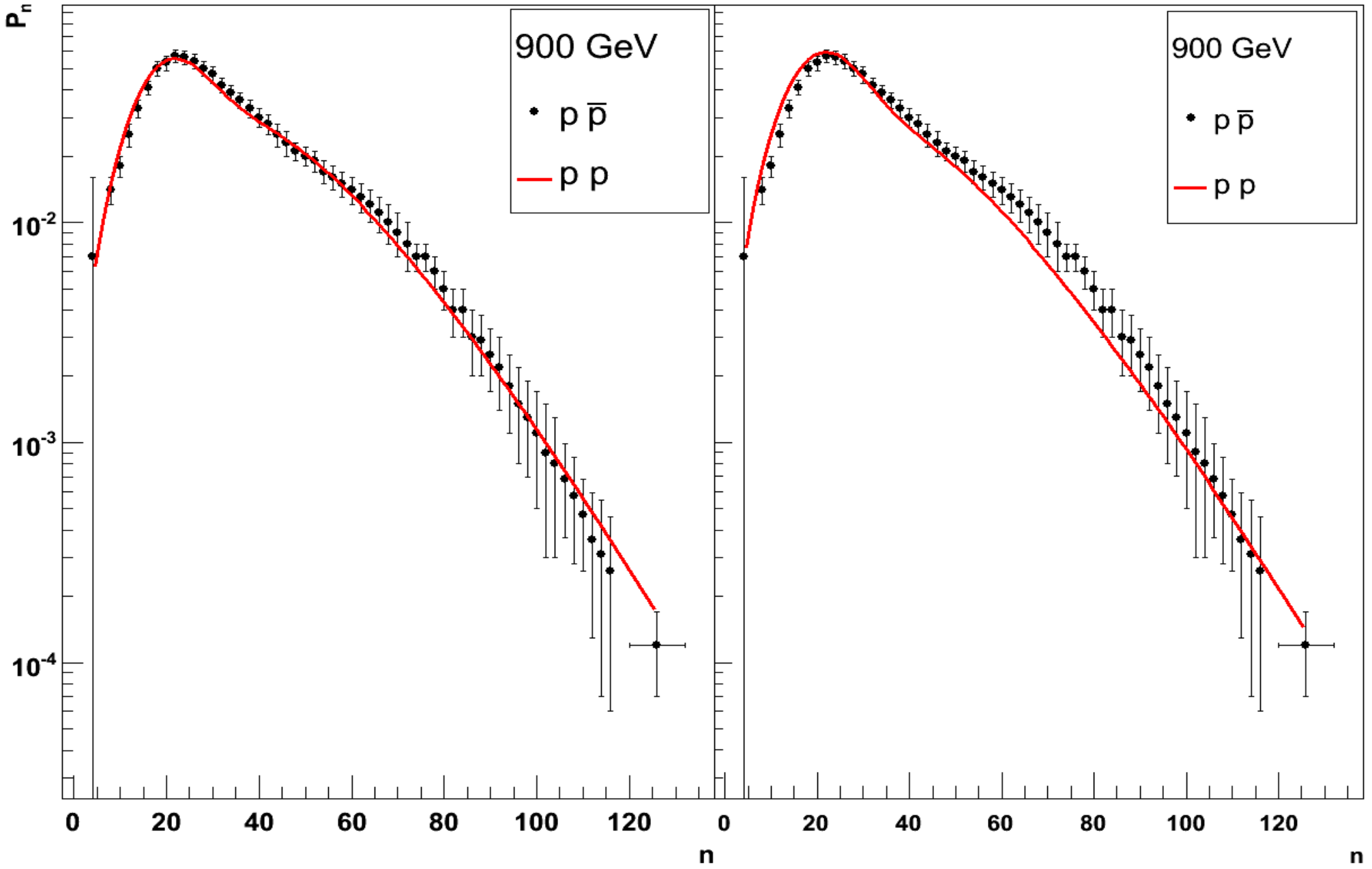
c=0.25

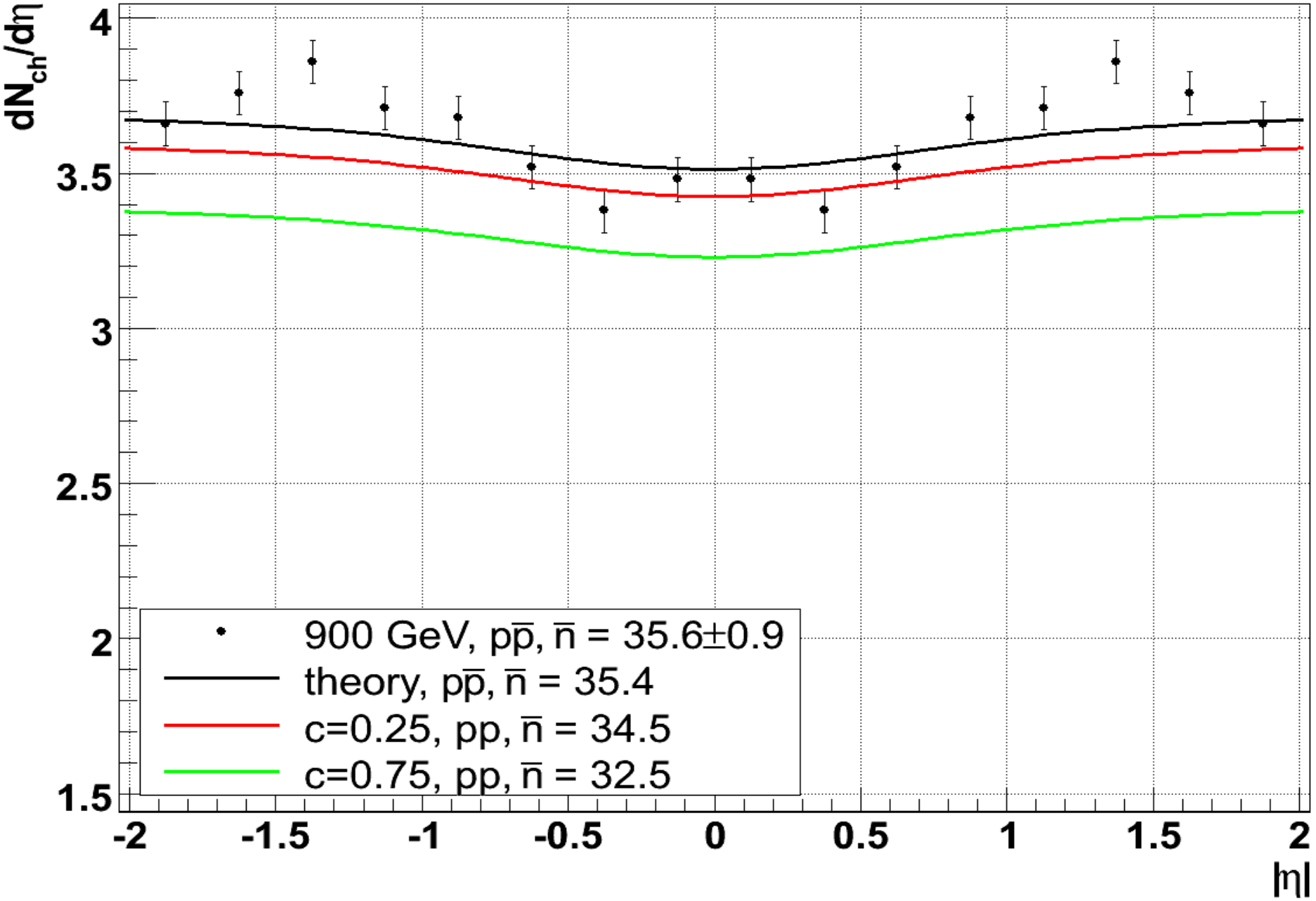
c=0.75

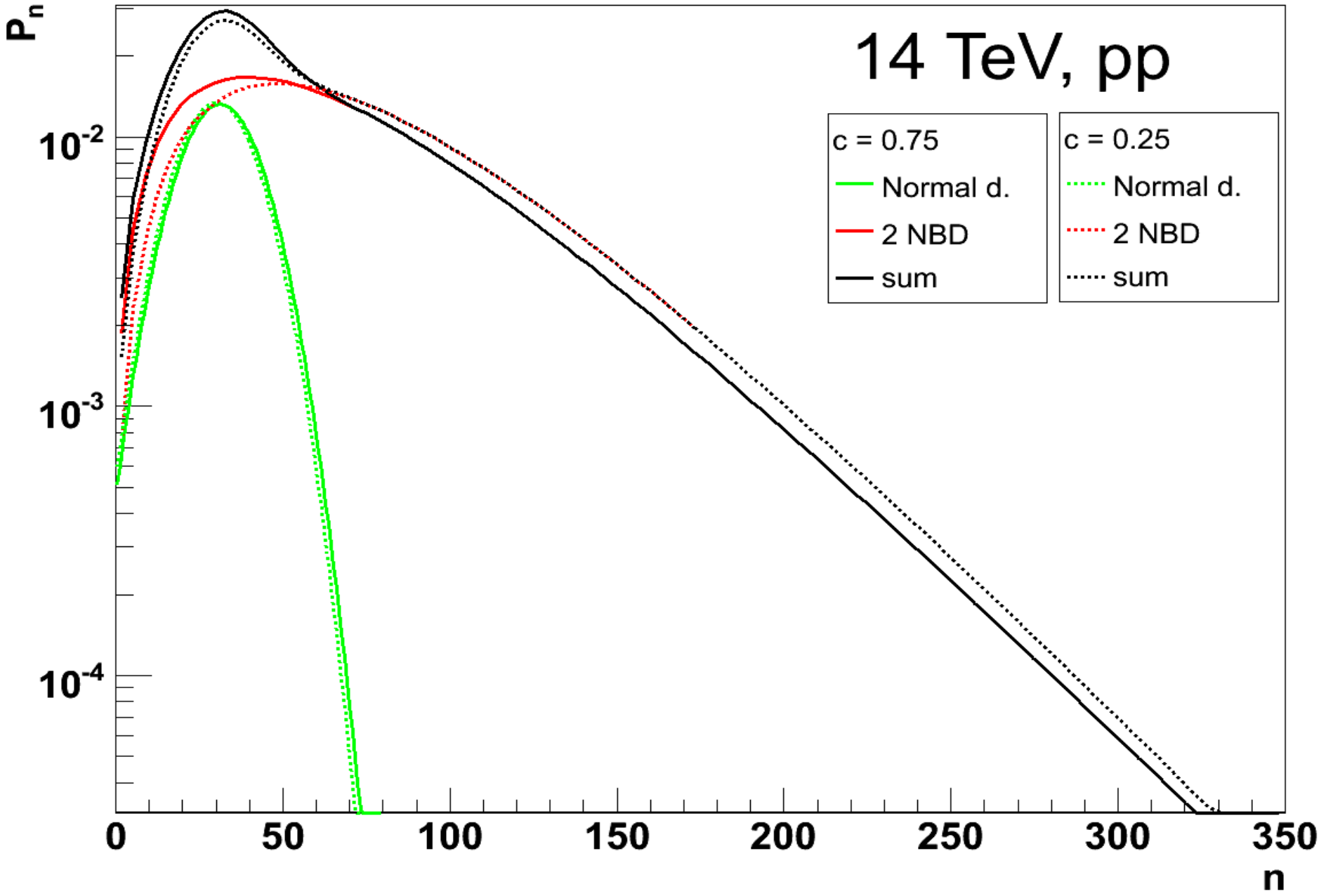

P_n
900 GeV, χ^2/ndf = 8/53
experiment
Normal d.
2 NBD
3 NBD
sum
10^{-2}
10^{-3}
10^{-4}
0
20
40
60
80
100
120
n

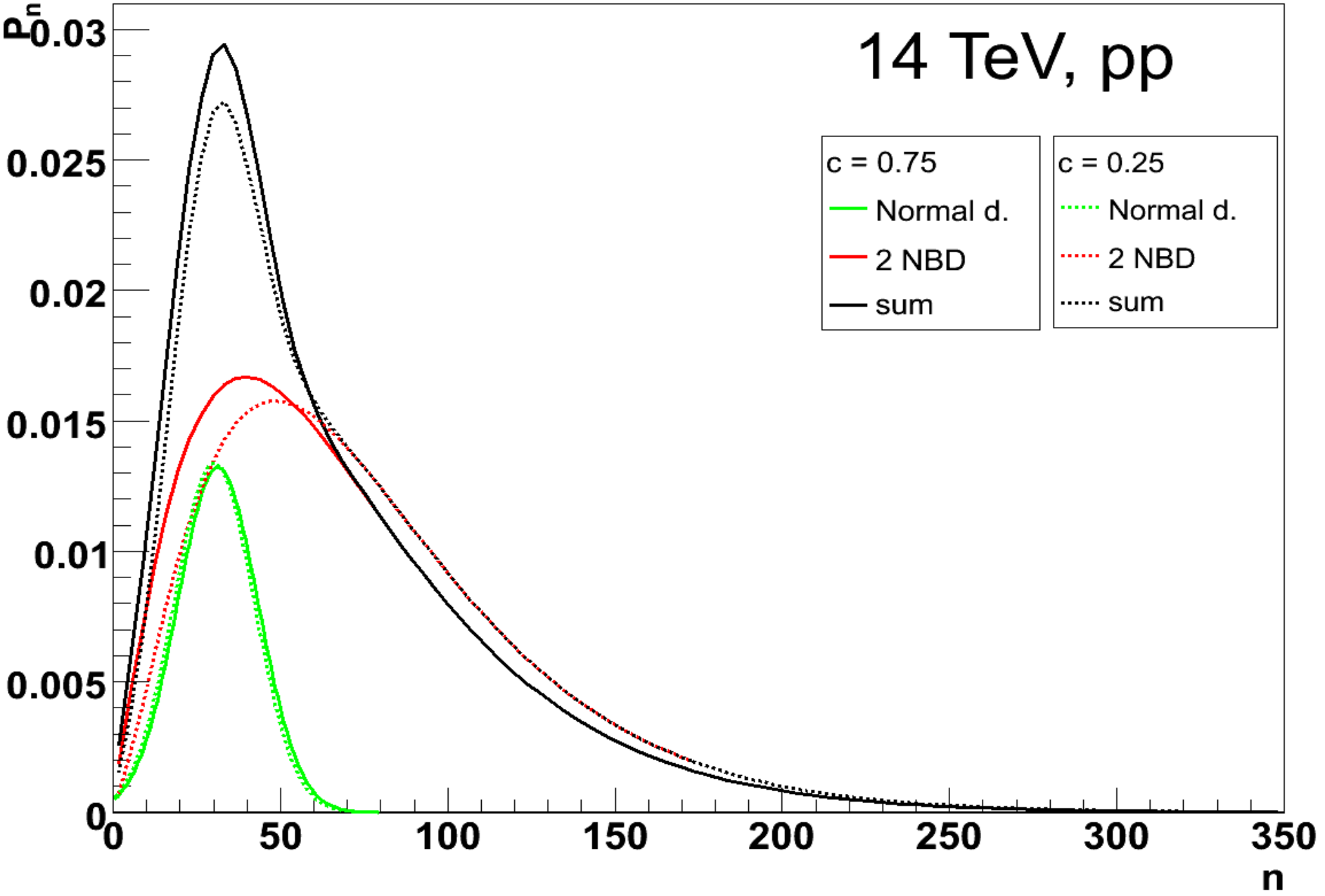
c=0.25

c=0.75


P_n
900 GeV
p $\bar{p}$
p p
10^{-2}
10^{-3}
10^{-4}
0
20
40
60
80
100
120
n
900 GeV
p $\bar{p}$
p p
0
20
40
60
80
100
120
n


$dN_{ch}/d\eta$
4
3.5
3
2.5
2
1.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
$|\eta|$
900 GeV, $p\bar{p}$, $\bar{n}$ = 35.6±0.9
theory, $p\bar{p}$, $\bar{n}$ = 35.4
c=0.25, pp, $\bar{n}$ = 34.5
c=0.75, pp, $\bar{n}$ = 32.5


14 TeV, pp
c = 0.75
Normal d.
2 NBD
sum
c = 0.25
Normal d.
2 NBD
sum
P_n
10^{-2}
10^{-3}
10^{-4}
0
50
100
150
200
250
300
350
n


14 TeV, pp
c = 0.75
Normal d.
2 NBD
sum
c = 0.25
Normal d.
2 NBD
sum
P_n
0.03
0.025
0.02
0.015
0.01
0.005
0
0
50
100
150
200
250
300
350
n

Predicted values for LHC energy 14 TeV

$$\sigma_{tot}^{pp} = 101.30 \pm 6.65 \text{ mb}$$

$$\bar{n}_{pp} = 68.59 \pm 4.47, \quad c = 0.25$$

$$\bar{n}_{pp} = 63.20 \pm 4.19, \quad c = 0.75$$