SMC analysis of high-p_T events

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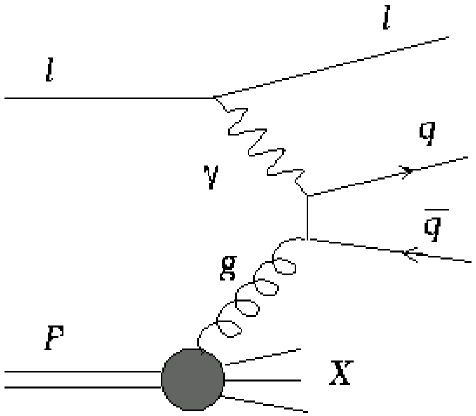
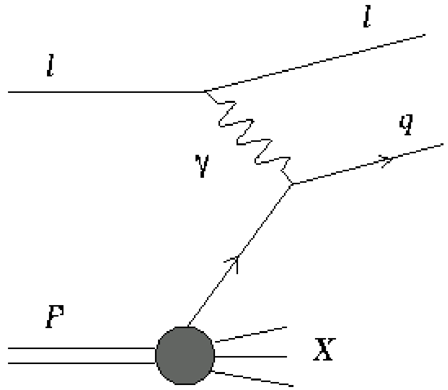
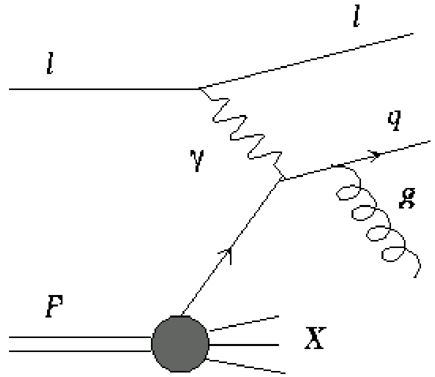
DIS 2004, 14-18/04/04 Štrbskė Pleso, Slovakia

PGF with high-p_T hadrons







Photon Gluon Fusion (PGF) $\propto \frac{\Delta G}{G}$

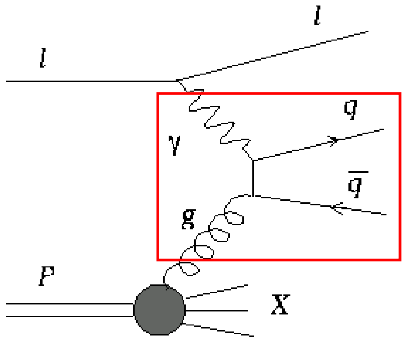
Leading Process (LP)

QCD Compton (QCD-C)

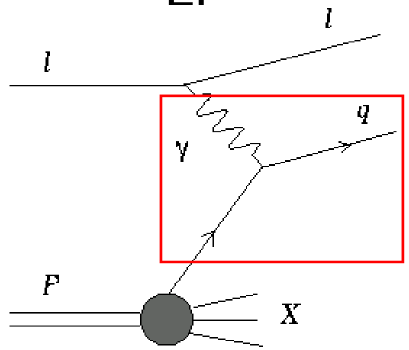
Pairs of high-p_T hadrons more likely in QCD-C and PGF

$\Delta G/G$ from measured asymmetry $A^{lN\to lhhX}$

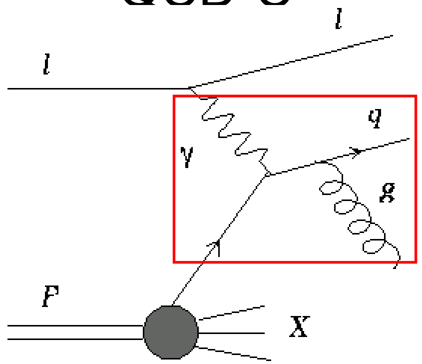
PGF



LP



QCD-C



$$A^{lN\to lhhX} = \frac{\Delta G}{G}\langle \hat{a}\rangle_{LL}^{PGF} R^{PGF} + \frac{\Delta q}{q}\left(\langle \hat{a}\rangle_{LL}^{LP} R^{LP} + \langle \hat{a}\rangle_{LL}^{QCD\text{-}C} R^{QCD\text{-}C} \right)$$

$\frac{\Delta q}{q}$ taken from inclusive DIS measurements

$\langle \hat{a}\rangle_{LL}$ the asymmetry for hard sub-process

R the fraction of events

(the asymmetry and the fraction of events:) Provided by MonteCarlo

$\Delta G/G$ determination for production of pairs of hadrons with high-p_T

- Idea proposed by R.D.Carlitz, J.C.Collins and A.H.Mueller, Phys.Lett.B 214, 229 (1988)

- Revisited by A.Bravar,D.von Harrach and A.Kotzinian, Phys.Lett.B 421, 349 (1998)

- Method used in HERMES for photoproduction
HERMES, A.Airapetian et al., Phys.Rev.Lett.84, 2584 (2000)

$$\frac{\Delta G}{G} = 0.41 \pm 0.18(\text{stat}) \pm 0.03(\text{sys}) \qquad x_g=0.17$$

- Here application for DIS region, SMC data with Q^2 >1GeV^2
SMC, B.Adeva et al.., submitted to Phys.Rev.D, **hep-ex/0402010**

Beam:

μ+ 190 GeV

Pμ= -0.78±0.03

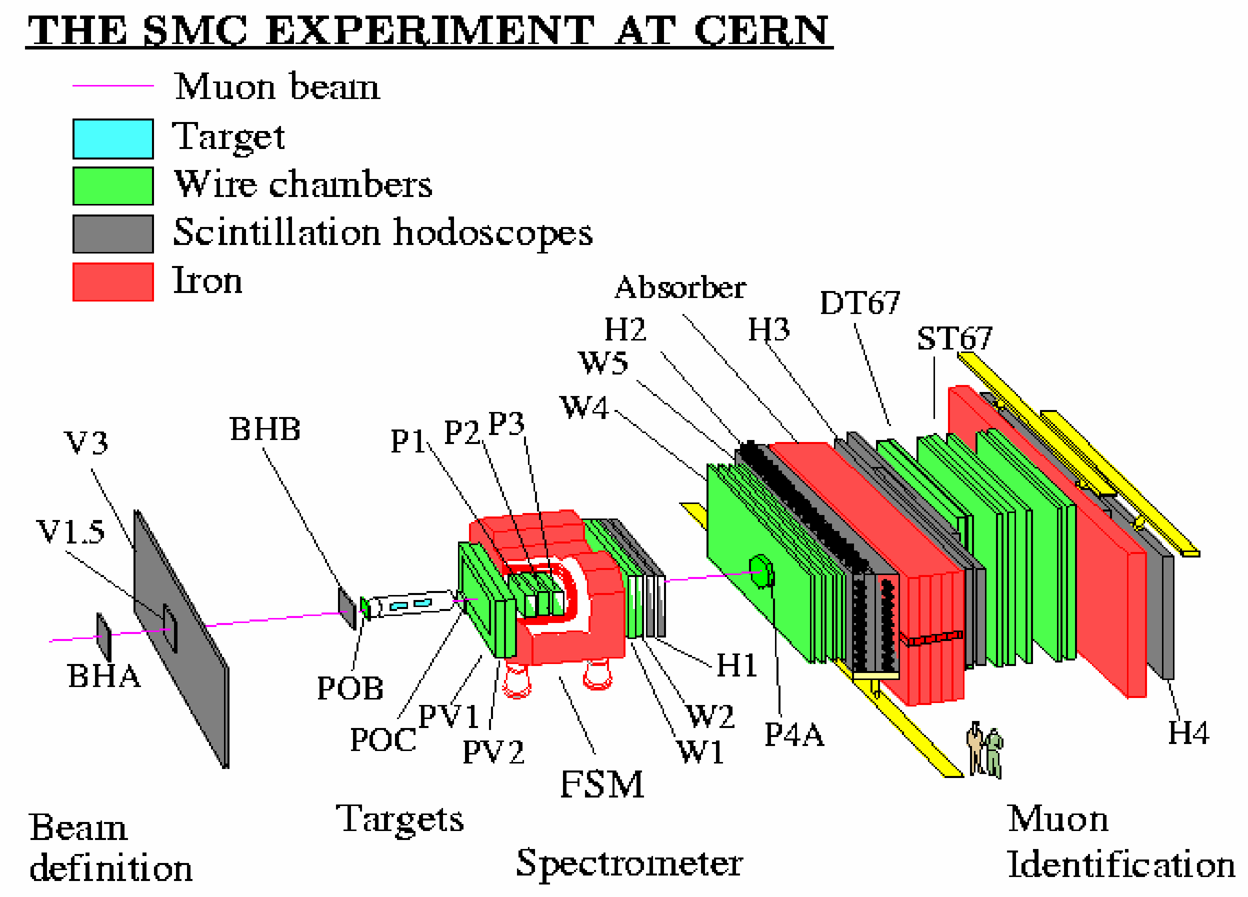
Target:

butanol, ammonia } Proton

d-butanol Deuteron

P_{Tp} ~ 0.89

P_{Td} ~ 0.50



$$A^{lN\to lhhX} = -\frac{1}{2}\frac{1}{\langle P_\mu P_T f\rangle}\left(\frac{N_u - N_d}{N_u + N_d} + \frac{N_{u'} - N_{d'}}{N_{u'} + N_{d'}}\right)$$

Data sample for asymmetry calculation

Full SMC statistics with longitudinal target polarization was used

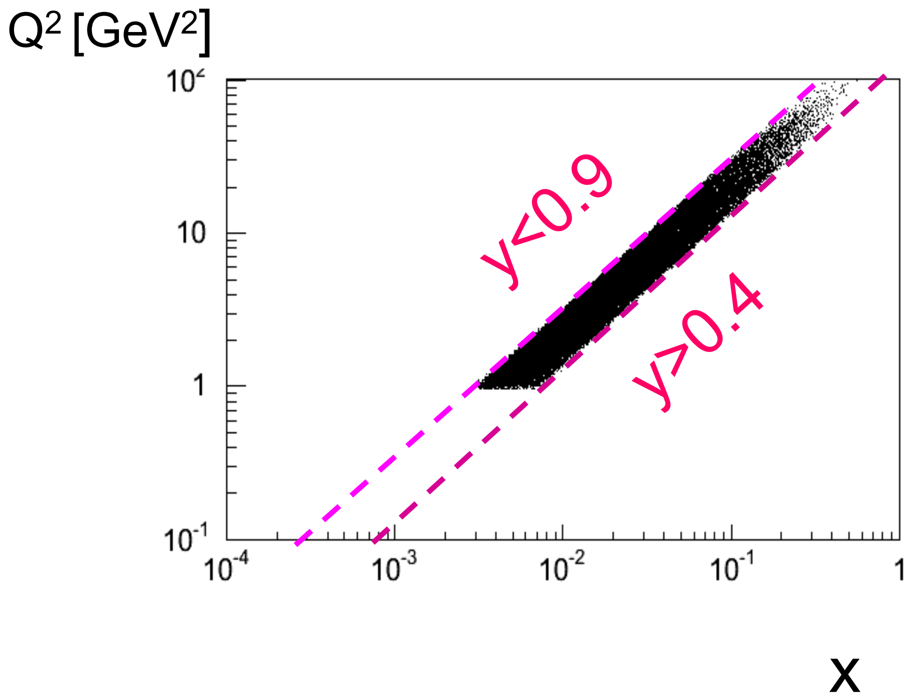
- $\mu\ \mu'$ and at least 2 hadrons at primary vertex
- Kinematic cuts :

  $Q^2 > 1\,GeV^2$ pQCD region

  $y > 0.4$ $y < 0.9$

- for both hadrons with $p_T > 0.7 GeV$:

  $x_F > 0.1$, $z > 0.1$



Statistics after selection: proton ~81 K , deuteron ~75 K

below 0.5% of the inclusive sample

Monte Carlo studies

→ studies for DIS μN interactions for E_B=190 GeV

→ LEPTO simulations, $Q^2 > 1$ GeV^2

→ detector and reconstruction effects

- simulations of trigger conditions
- geometrical acceptance for hadrons,muons
- looses in reconstruction (chamber efficiencies)
- smearing for scattered μ and hadrons (1/p, angles)
- secondary interaction in target for hadrons

Important consistency between data and Monte Carlo

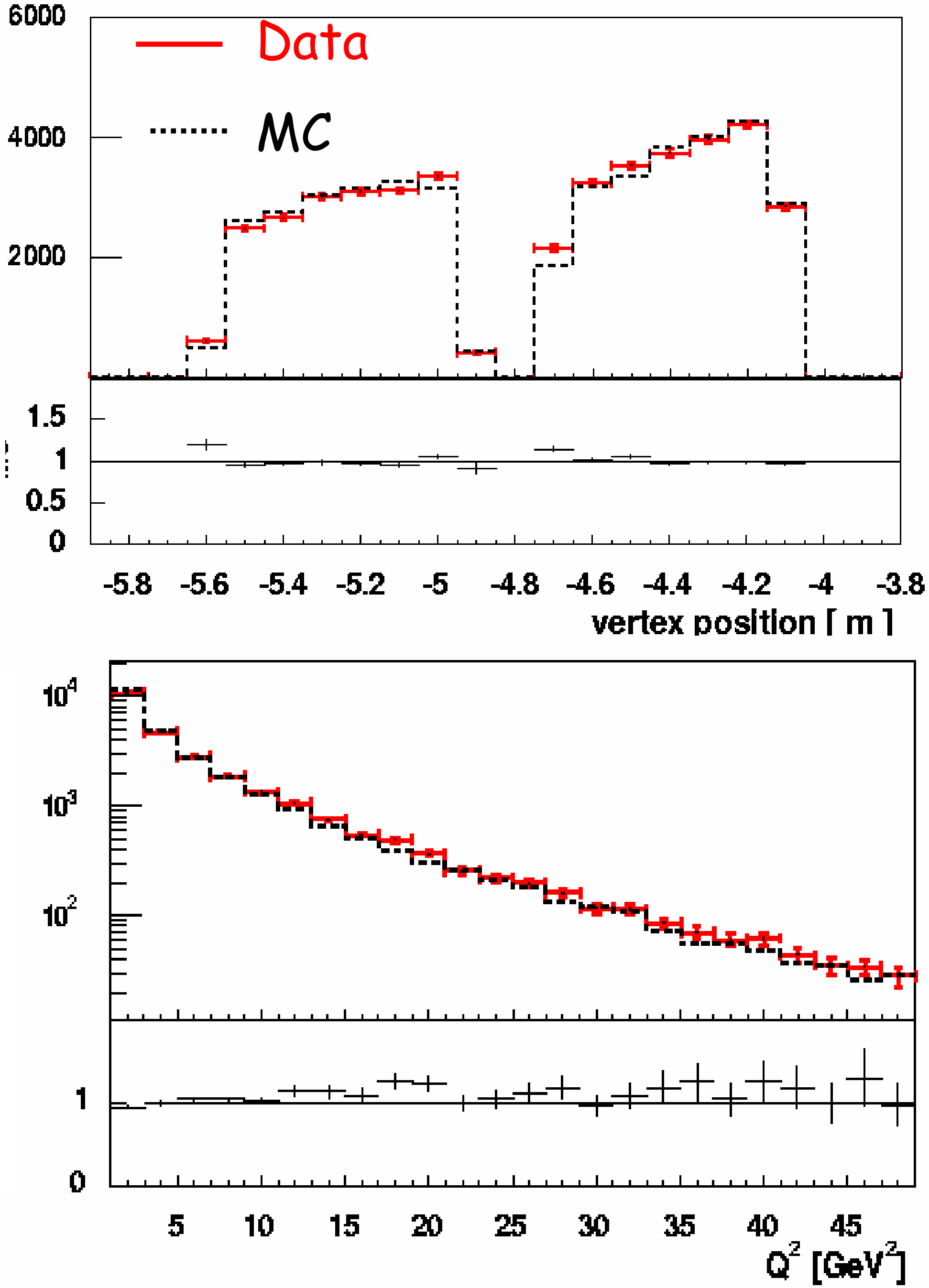
Kinematic variables

Number of events

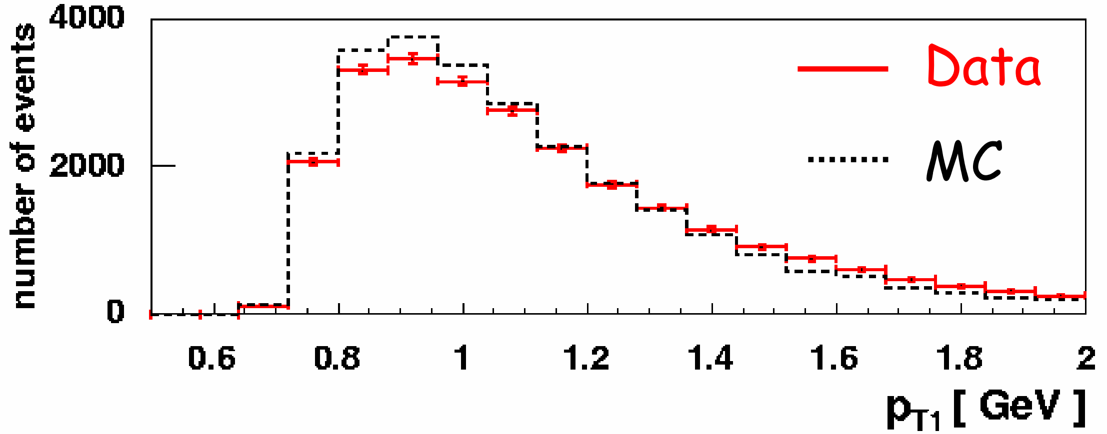
Data/MC

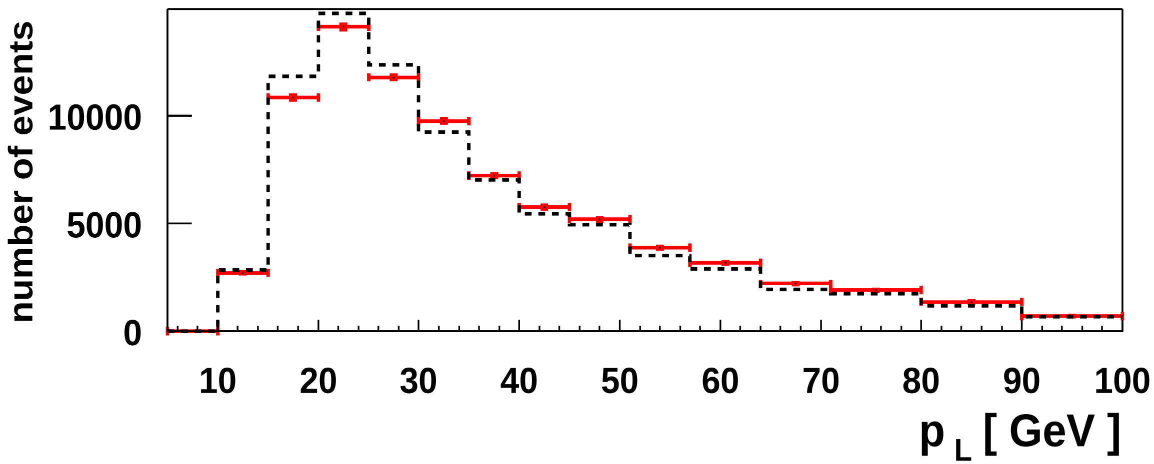
Number of events

Data/MC



Hadron variables





Data and Monte Carlo agree at the level of 10-25%

To be used for selections of PGF and ΔG evaluation

Contribution of PGF process

- generated sample LP=73% QCD-C=19% PGF= 8%
- 2 hadrons with p_T>0.7GeV LP=40% QCD-C=35% PGF=25%

Two methods to enhance PGF contribution used

cut selections and neural network classificattion (NN)

Criteria to judge the selection:

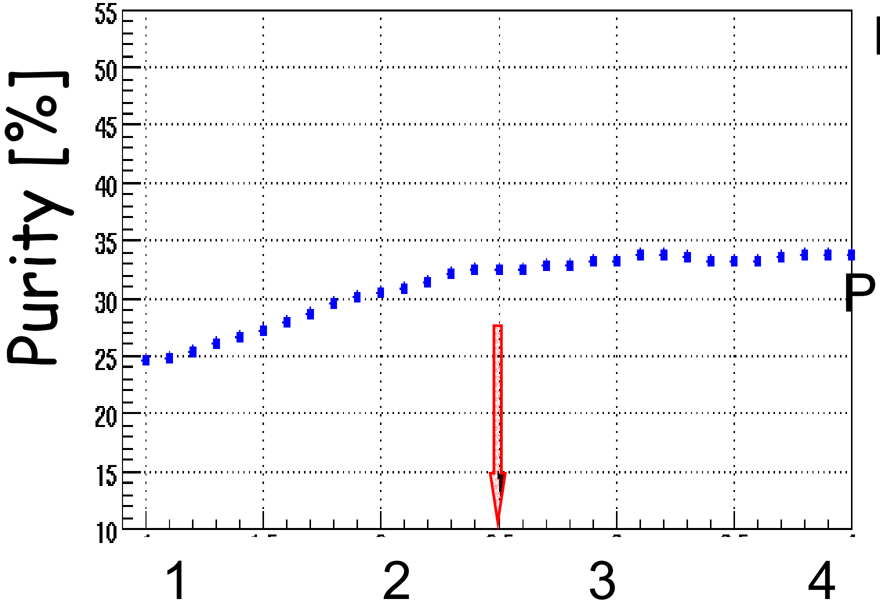
$$\text{Purity} = \frac{\text{PGF(out)}}{\text{LP(out)} + \text{QCDC(out)} + \text{PGF(out)}}$$

$$\text{Efficiency} = \frac{\text{PGF(out)}}{\text{PGF(in)}}$$

Several variables were considered to find the optimal selection:

- various cuts on p_T of both hadrons
- oppositely charge hadrons → 1% better purity but loss of statistics ~30%,
- invariant mass of the pairs of hadrons,
- difference between azimuthal angle of hadrons

} do not improve purity



For the analysis

$(p_{T1}^2 + p_{T2}^2) > 2.5\ \mathrm{GeV}^2$

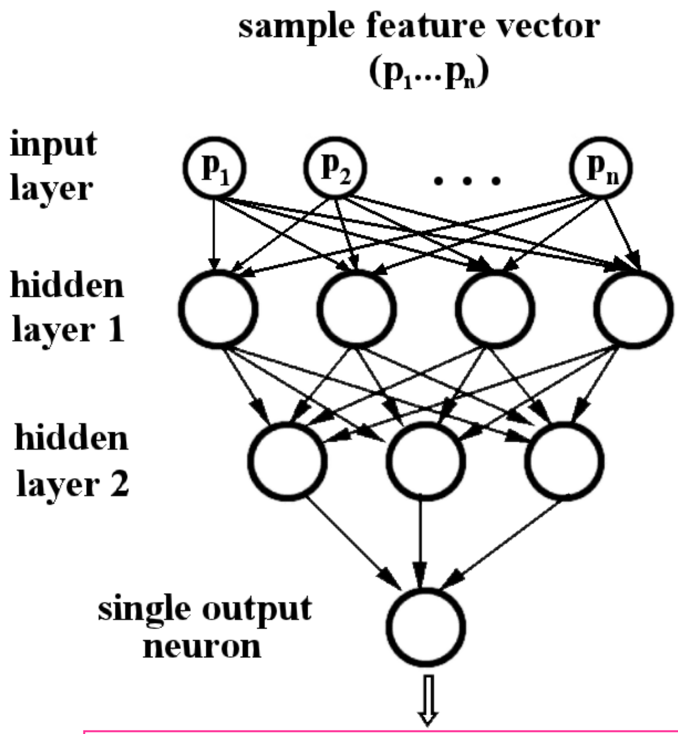
Purity ~31% at efficiency ~30%

Neural network

Motivation: optimal use of many correlated variables

The optimal set of input variables (input layer):

event kinematics (x, y, Q^2) and hadron variables ($E_{1,2}$, $p_{T1,2}$, charge, azimuthal angle between p_T of two selected hadrons)

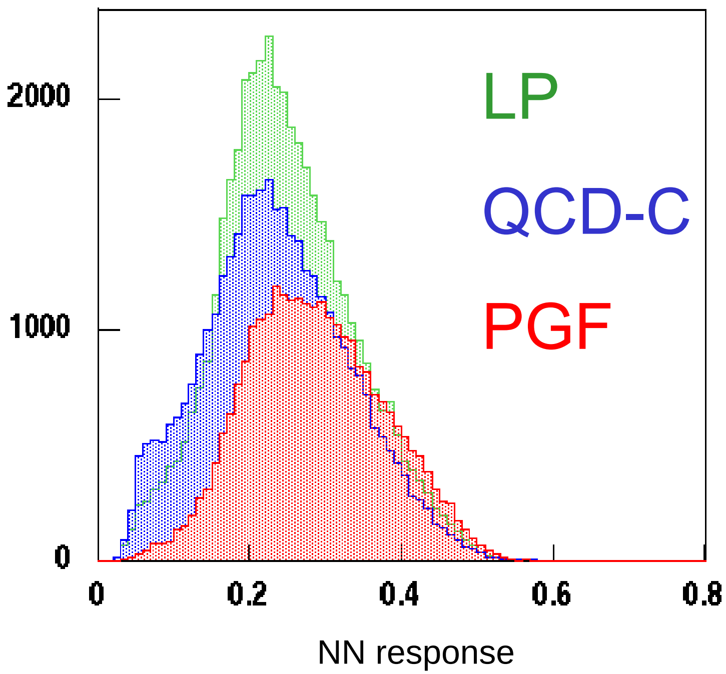


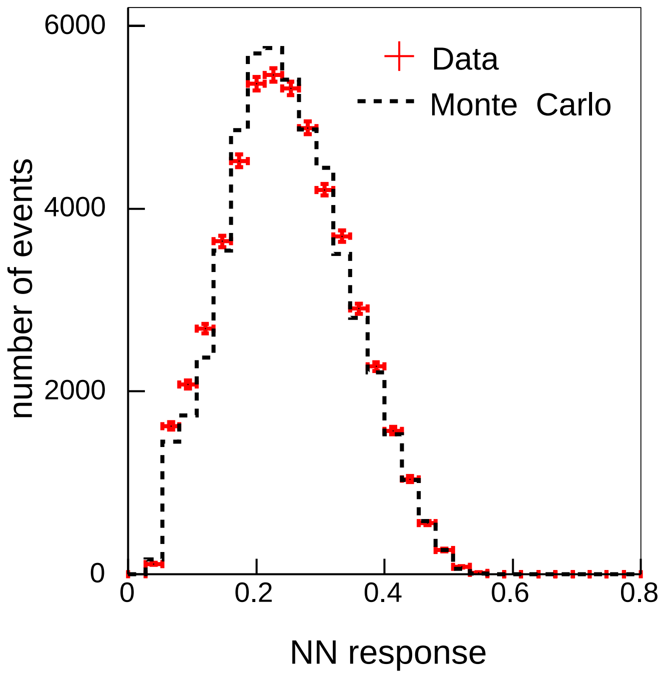
NN response

- output layer: single unit number within range (0,1)

  → interpretation in terms of background and signal contributions

Neural Network response

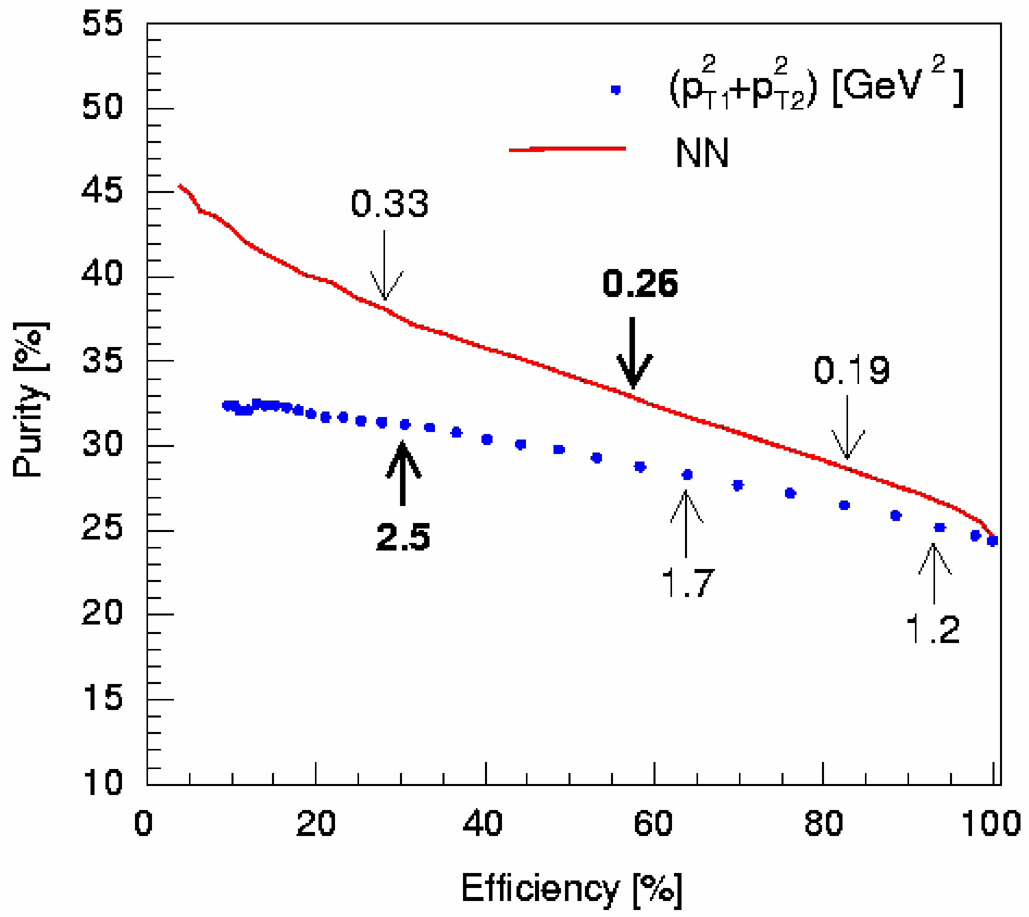




number within range <0,1.> events at high values of NN response are more likely to be PGF

PGF enriched sample selected by setting the threshold on the NN response

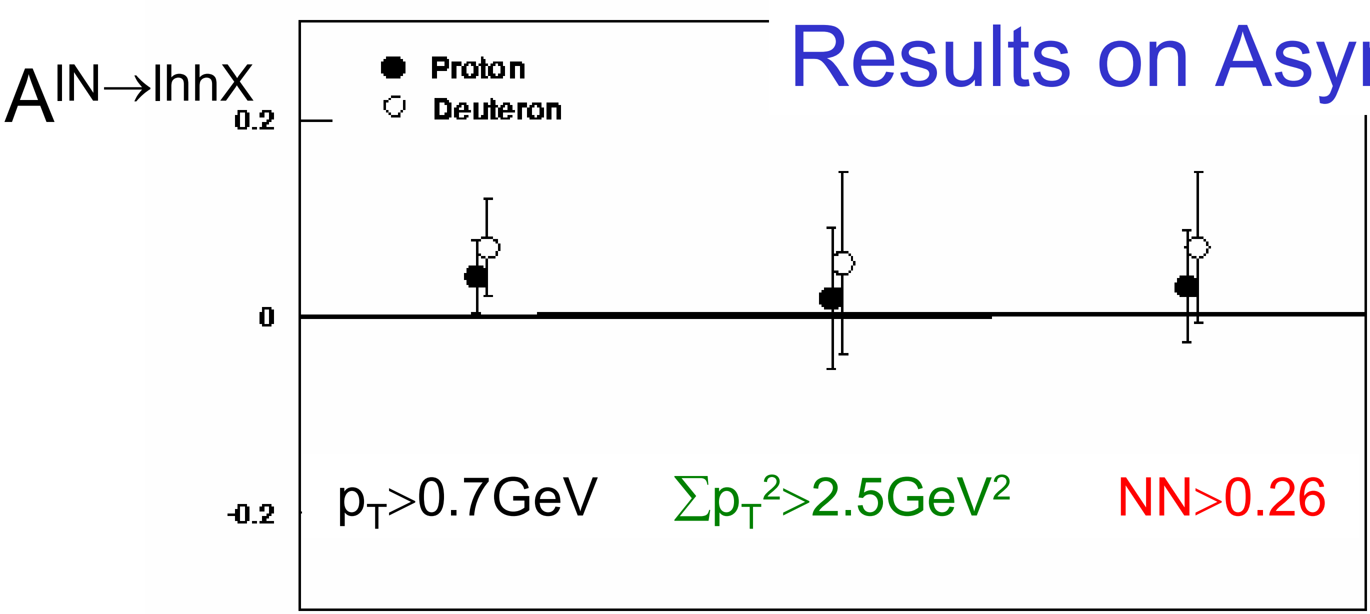
The result of cut selection based on $(p_{T1}^2 + p_{T2}^2)$ compared to NN



For NN purity is growing with efficiency in full range

→ NN response > 0.26 (purity ~33% at efficiency ~56%)

Results on Asymmetry



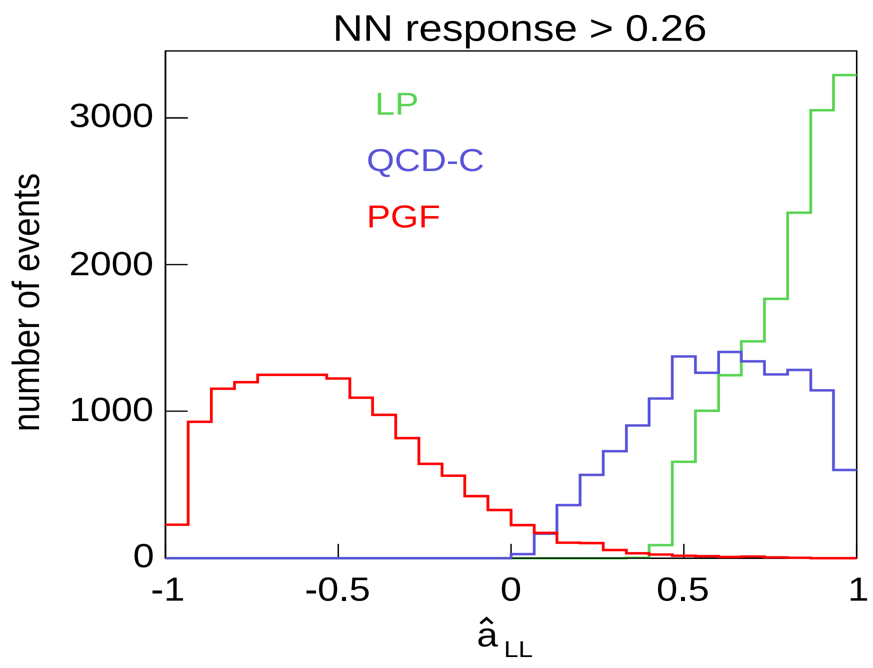
Selection	Proton $A^{lN\to lhhX}$	Proton $< Q^2>$	Deuteron $A^{lN\to lhhX}$	Deuteron $< Q^2>$
$\sum p_T^2$	0.018±0.071±0.010	7.1	0.054 ±0.093±0.008	7.9
NN	0.030±0.057±0.010	3.3	0.070 ±0.077±0.010	4.0

Interpretation of $A^{lN\to lhhX}$ in terms of $\Delta G/G$ requires additional information from MC simulation.

Inputs to ΔG/G calculations

From other measurements:

A_1 asymmetry taken from fit to da



From MC simulations:

- partonic asymmetries a_{LL}

$\langle a_{LL} \rangle^{LP} \approx 0.8$

$\langle a_{LL} \rangle^{QCD\text{-}C} \approx 0.6$

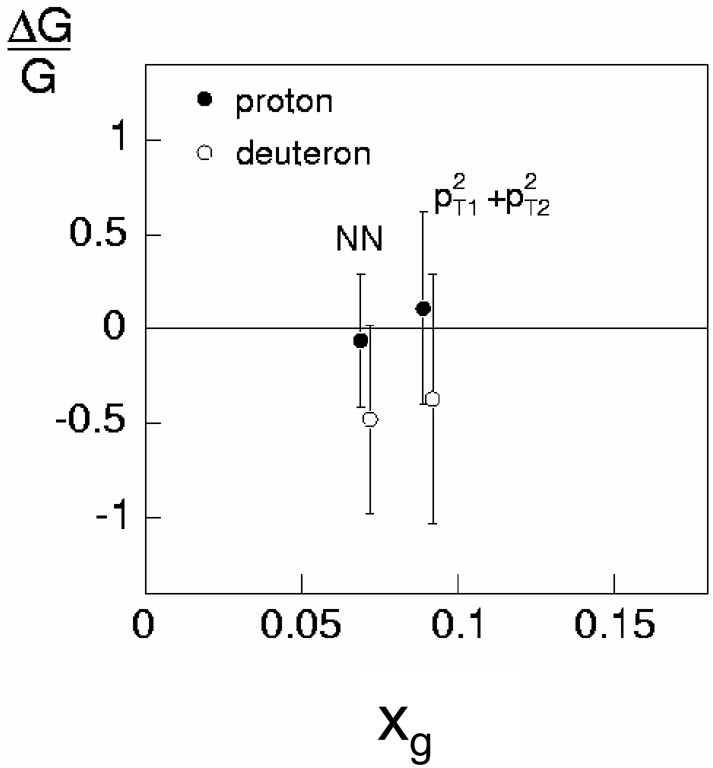
$\langle a_{LL} \rangle^{PGF} \approx -0.4$

- fractions of processes in the selected sample

Selection	R^{LP}	$R^{QCD\text{-}C}$	R^{PGF}
$\sum p_T^2 > 2.5 GeV^2$	26%	43%	31%
NN >0.26	37%	30%	33%

Gluon polarization

$\Delta G/G$ determined for a given fraction of nucleon momentum carried by gluons x_g



Averaged over proton and deuteron:

Selection	$\Delta G/G \pm \delta(\Delta G/G)_{stat}$	$<x_g>_{genPGF}$
$\sum p_T^2 > 2.5 GeV^2$	-0.07 ± 0.40	0.09
NN >0.26	-0.20 ± 0.28	0.07

Systematic uncertainty on $\Delta G/G$

Error source	uncertainty on $\Delta G/G$
Precision of A_1 fit	0.026
Scale change $Q^2/2$; $2Q^2$	0.010
Fragmentation function	0.034
Cutoffs in matrix elements	0.008
Syst.error from $A^{lN \to lhhX}$	0.062
Total	0.105

The maximum observed deviation of R or a_{LL}

+20%R / -20%R	0.067 / 0.100
+4% a_{LL} / -4% a_{LL}	0.015 / 0.017

Summary

- $\Delta G/G$ was evaluated from the measured asymmetry for events with high-p_T hadrons collected by SMC in DIS region
- Results obtained for cut selection and neural network

  $\Delta G/G \pm$stat. $\pm$sys.

  $-0.07 \pm 0.40 \pm 0.12$ cut $\sum p_T^2$

  $-0.20 \pm 0.28 \pm 0.10$ NN

  point to rather small value of the gluon polarization

  precision of $\Delta G/G$ limited by the statistical error

- Improvement on accuracy of $\Delta G/G$ in the future: COMPASS at CERN, RHIC at BNL