# Measurements of $\Delta G/G$ from high transverse momentum hadrons pairs in COMPASS

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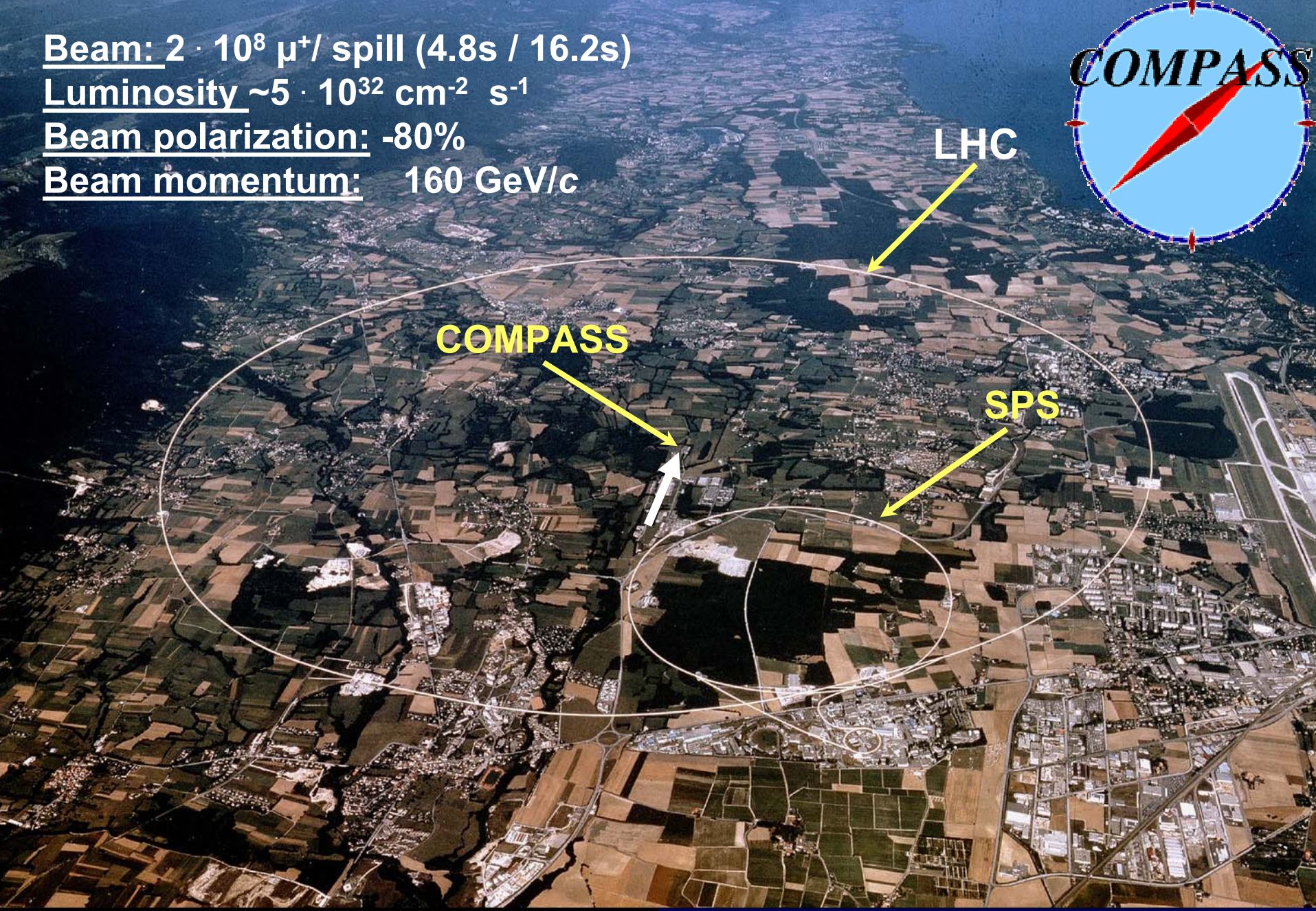
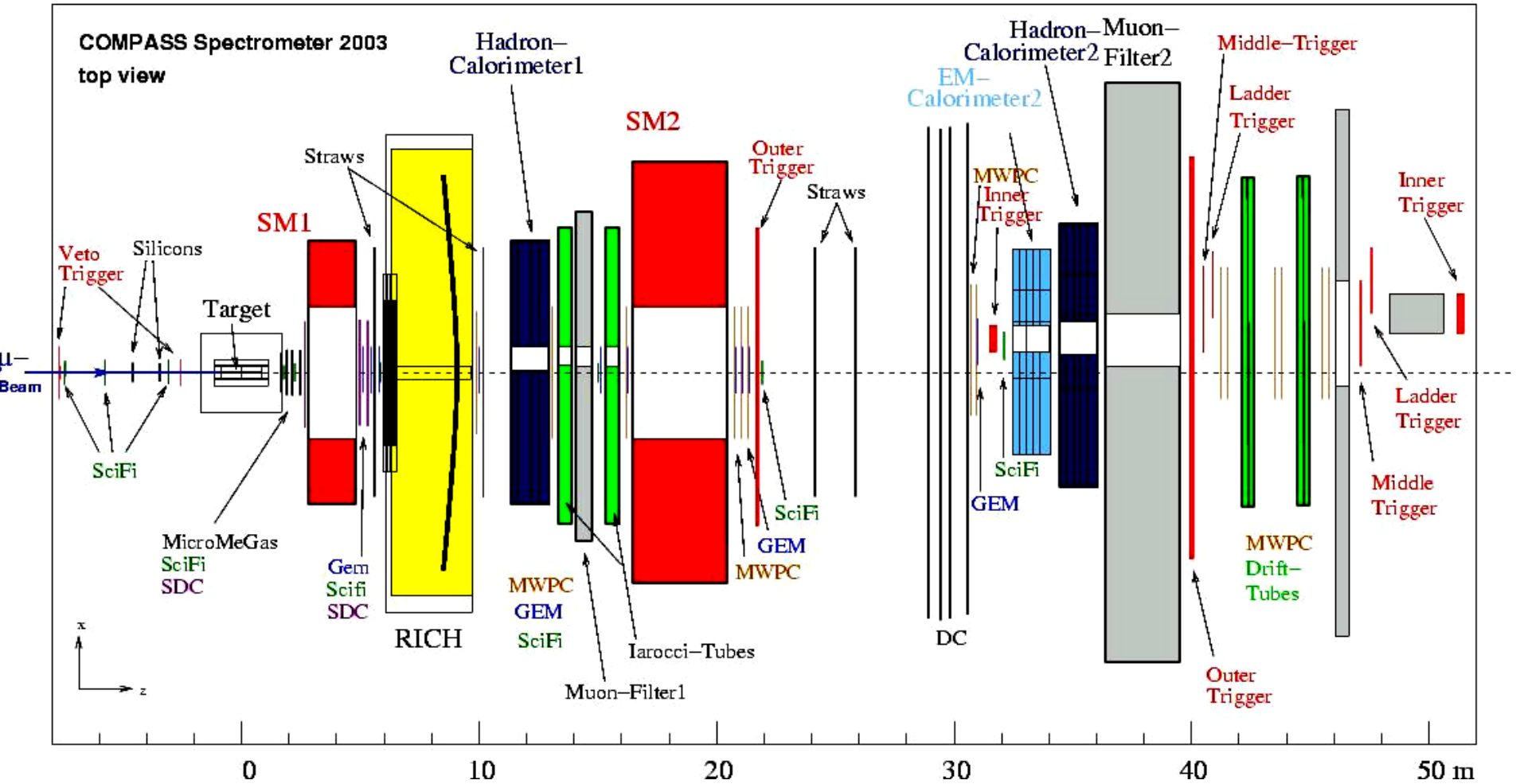
CERN
On behalf of the COMPASS Collaboration


Beam: 2 · 10^8 μ+/ spill (4.8s / 16.2s)
Luminosity ~5 · 10^32 cm^-2 s^-1
Beam polarization: -80%
Beam momentum: 160 GeV/c
COMPASS
LHC
COMPASS
SPS

# COMPASS


COMPASS Spectrometer 2003
top view
Hadron–
Calorimeter1
SM2
Hadron–Muon–
Calorimeter2
Filter2
EM–
Calorimeter2
Middle–Trigger
Ladder
Trigger
Straws
Outer
Trigger
Straws
MWPC
Inner
Trigger
Inner
Trigger
SM1
Veto
Trigger
Silicons
Target
μ–
Beam
SciFi
MicroMeGas
SciFi
SDC
Gem
Scifi
SDC
RICH
MWPC
GEM
SciFi
Iarocci–Tubes
Muon–Filter1
SciFi
GEM
MWPC
SciFi
GEM
DC
Ladder
Trigger
Middle
Trigger
MWPC
Drift–
Tubes
Outer
Trigger
x
z
0
10
20
30
40
50 m

# Contents

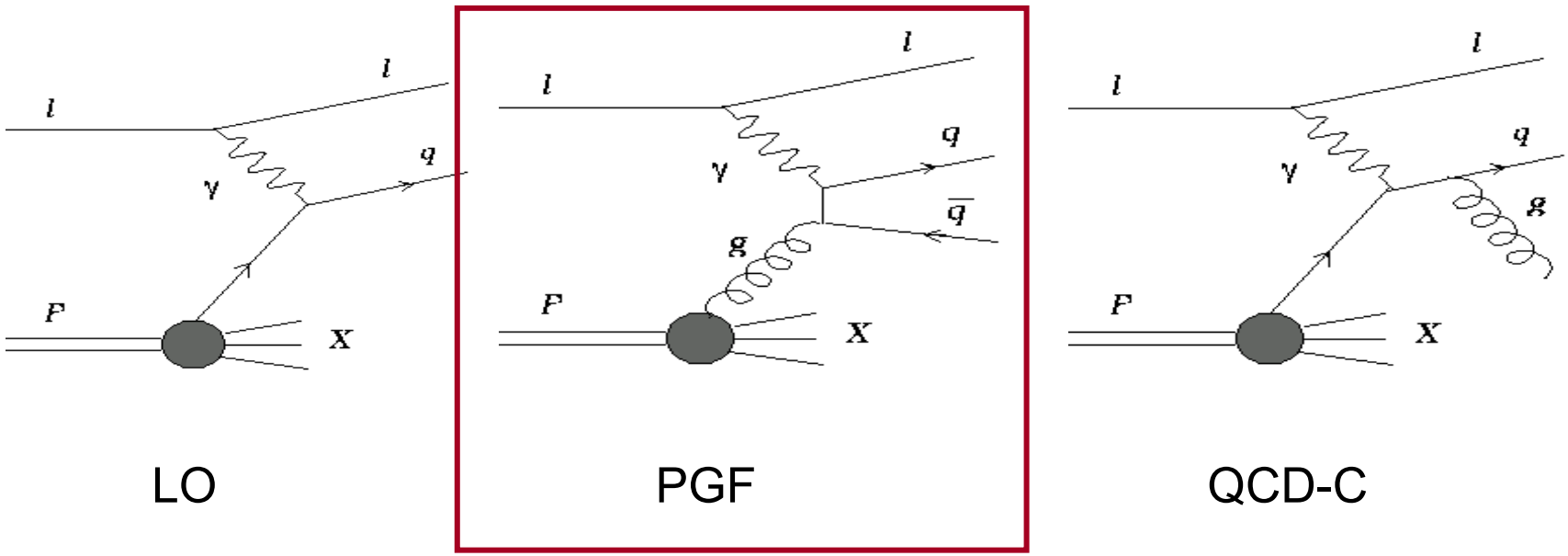
New results from $Q^2 > 1(GeV/c)^2$ analysis

- Determination of the gluon polarization
- Data selection
- Neural Network (NN) approach
- Data and MC comparison
- Systematics studies and results

$Q^2 < 1\ (GeV/c)^2$ analysis

- Methods and results

# Determination of the gluon polarization from high-$p_T$ hadron pairs

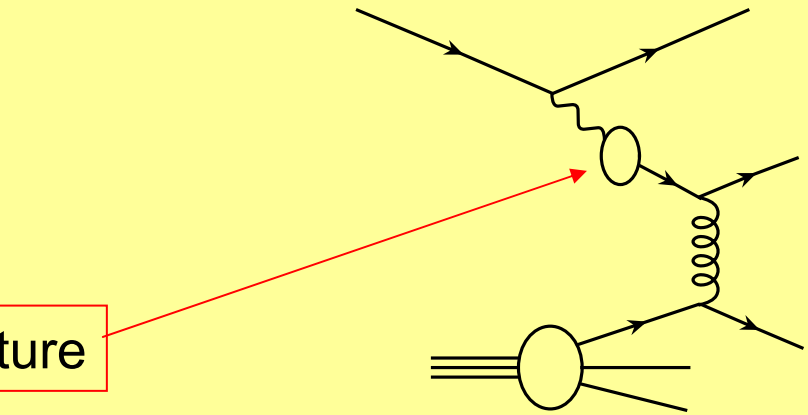



$$A_{LL}^{2h}(x_{Bj}) \approx \frac{\Delta G}{G}(x_G)\hat{a}_{LL}^{PGF} R_{PGF} + A_1^{LO}(x_C)\hat{a}_{LL}^{C} R_C + A_1^{LO}(x_{Bj}) D R_L$$

$$A_1^{LO} \equiv \frac{\sum_i e_i^2 \Delta q_i}{\sum_i e_i^2 q_i}$$

# Determination of the gluon polarization from high-$p_T$ hadron pairs

Low $Q^2$ analysis:
In addition large contribution
from so-called resolved photon:



Photon structure

$$A_{LL}^{2h}(x_{Bj}) \qquad \frac{\sum_i e_i^2 \Delta q_i}{\sum_i e_i^2 q_i}$$

$$A_{LL}^{2h}(x_{Bj}) \approx \frac{\Delta G}{G}(x_G)\hat{a}_{LL}^{PGF} R_{PGF} + A_1^{LO}(x_C)\hat{a}_{LL}^{C} R_C + A_1^{LO}(x_{Bj}) D R_L \qquad A_1^{LO} \equiv \frac{\sum_i e_i^2 \Delta q_i}{\sum_i e_i^2 q_i}$$

# The extraction formula for the gluon polarization

$$\frac{\Delta G}{G}(x_G^{av}) = \frac{A_{LL}^{2h}(x_{Bj}) + A^{corr}}{\beta}$$

$$\beta = a_{LL}^{PGF} R_{PGF} - a_{LL}^{PGF,incl} R_{PGF}^{incl} \left(\frac{R_L}{R_L^{incl}} + \frac{R_C}{R_L^{incl}} \frac{a_{LL}^{C}}{D}\right)$$

$$A^{corr} = -A_1(x_{Bj}) D \frac{R_L}{R_L^{incl}} - A_1(x_C)\beta_1 + A_1(x'_C)\beta_2$$

$$\beta_1 = \frac{1}{R_L^{incl}}\left(a_{LL}^{C} R_C - a_{LL}^{C,incl} R_C^{incl} \frac{R_L}{R_L^{incl}}\right) \qquad \beta_2 = a_{LL}^{C,incl} \frac{R_C R_C^{incl}}{(R_L^{incl})^2} \frac{a_{LL}^{C}}{D}$$

Rs - fractions of the sub-processes (LO,PGF, QCDC)
$a_{LL}$s – analysing powers for LO,PGF and QCDC

# Data selection for $Q^2 > 1 (GeV/c)^2$

- Cuts on inclusive variables:
  $Q^2 > 1$ (GeV/c)$^2$ (Scale of the process)
  $0.1 < y < 0.9$
- Cuts on hadronic variables:
  $p_{T1} > 0.7$ GeV/c and $p_{T2} > 0.7$ GeV/c
  $x_{F1,2} > 0$, $z_{1,2} > 0$, $z_1 + z_2 < 0.95$
  inv. mass of two hadrons > 1.5 (GeV/c)$^2$

Total number of events in the selected sample: ~500 k

# Weighted method for ΔG/G extraction

The following factors we need to know on the event by event basis:

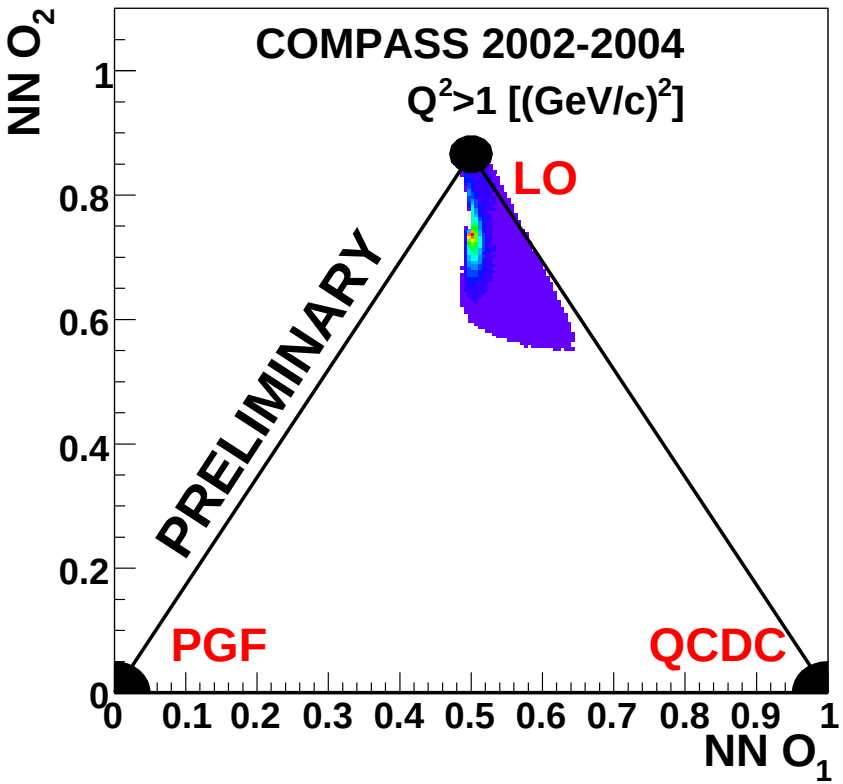
$$R_{PGF}, R_C, R_L, R_{PGF}^{incl}, R_C^{incl}, R_L^{incl},$$
$$a_{LL}^{PGF}, a_{LL}^{PGF,incl}, a_{LL}^{C}, a_{LL}^{C,incl},$$
$$x_C, x_G, \; f, D, P_b$$

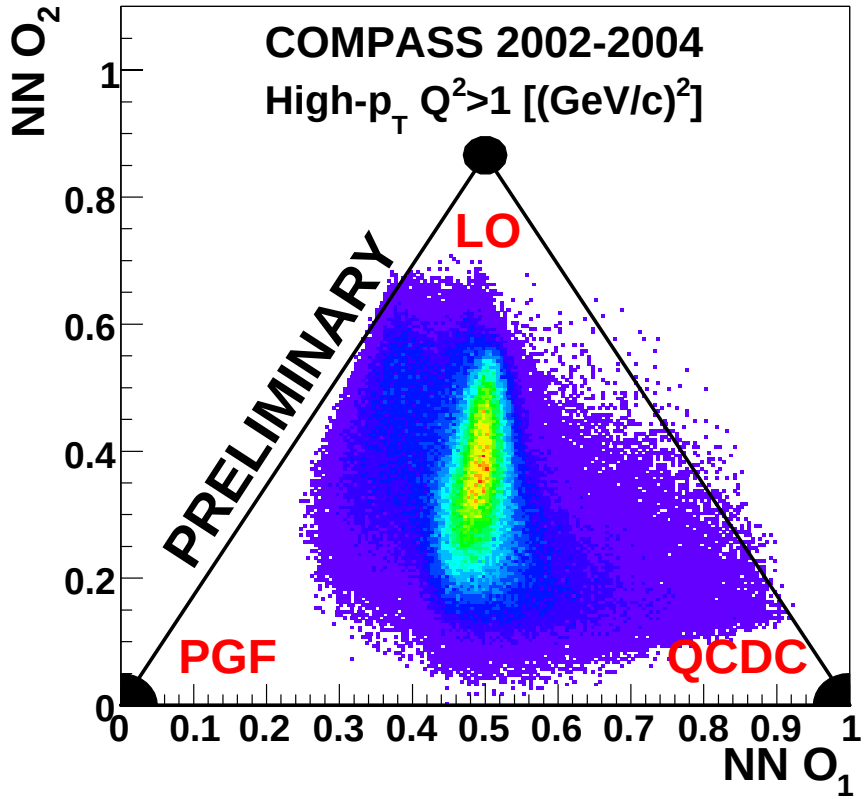
- $f, D, P_b$ can be directly obtained from data
- Remainning factors have to be obtained from MC
- NN trained on MC samples is used for parameterization of these quantities

  Input variables for NN:
  - inclusive case: $x_{Bj}$ and $Q^2$
  - high-$p_T$: $x_{Bj}$ ,$Q^2$,$p_{L1,2}$,$p_{T1,2}$
- Weight used: $fDP_b\beta$
- Good data description with MC is a „key point” of the analysis

# NN parameterization of Rs

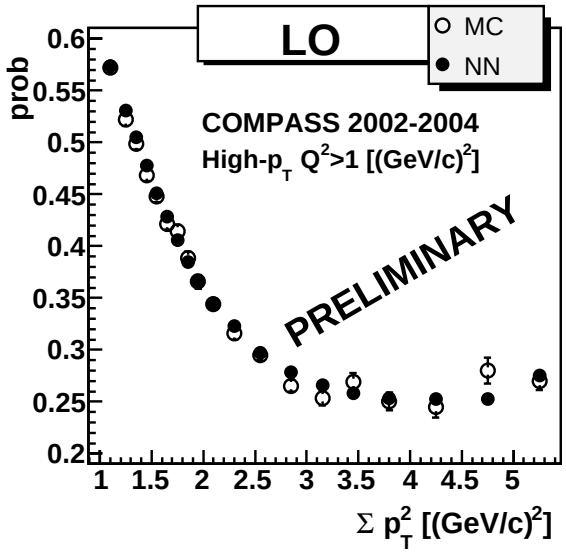
2 variables $o_1$ and $o_2$ are used (Rs sum up to 1)

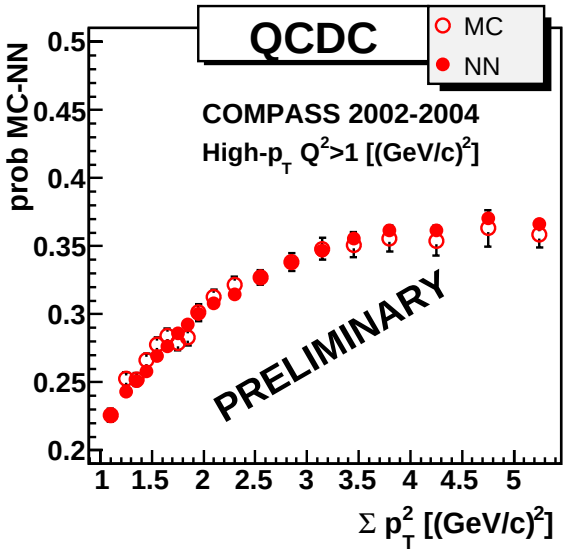


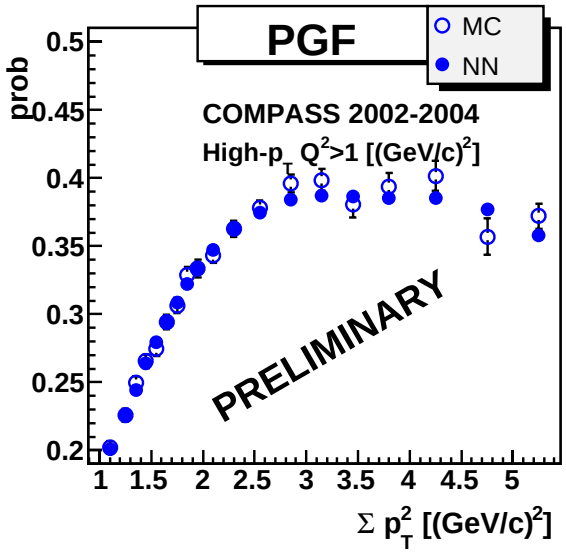



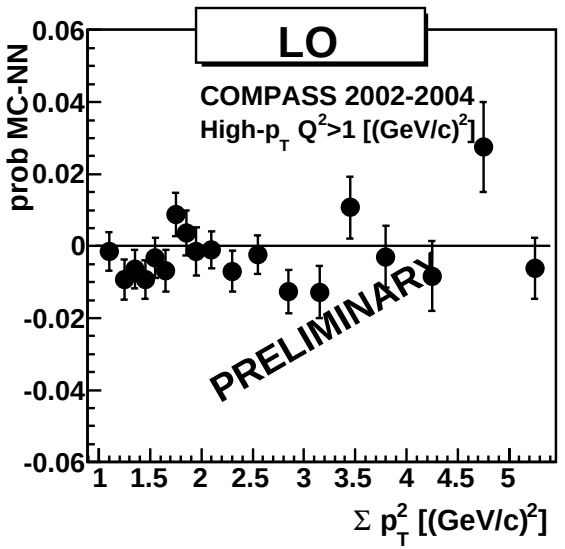

$$R_{PGF} = 1 - o_1 - \frac{1}{\sqrt{3}} o_2 \qquad R_C = o_1 - \frac{1}{\sqrt{3}} o_2 \qquad R_L = \frac{2}{\sqrt{3}} o_2$$

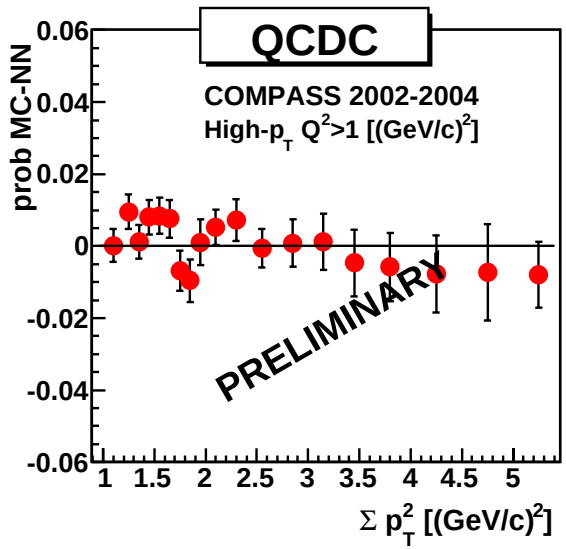
# NN stability

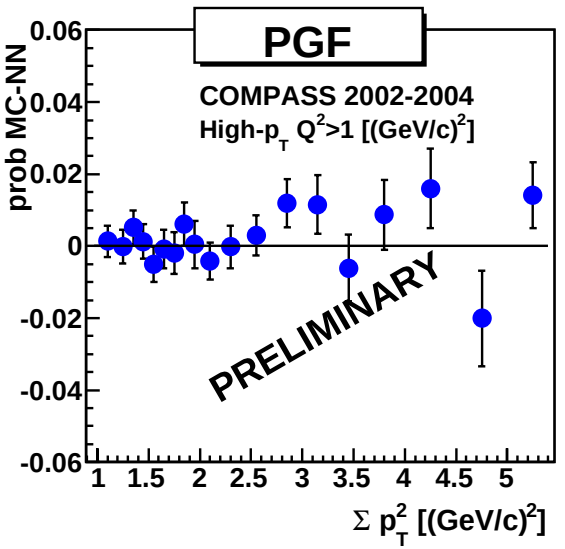


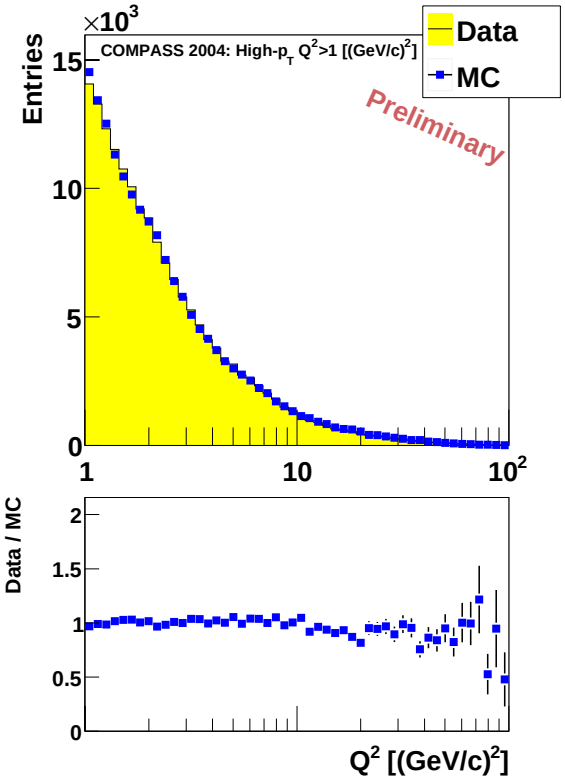
# MC simulations

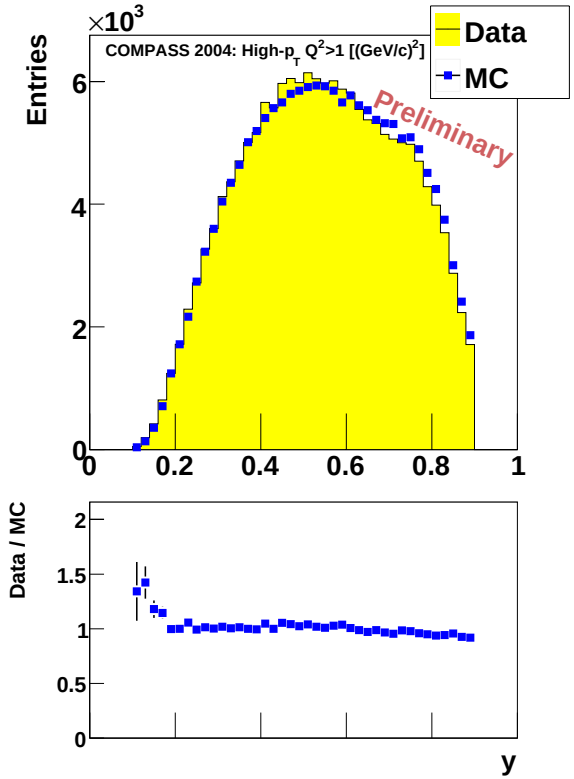
- 2 MC samples were used in the analysis: high-$p_T$ and inclusive
- Input: LEPTO generator and full simulation of the detector
  PDFs: MRST2004LO
- Gluon radiations in final and initial states – simulation of the part of NLO corrections:
  - Parton Shower on were used for $\Delta G/G$ extraction (means NN training)
  - Parton Shower off were tested and included in the systematics
- To improve data/MC agreement - LEPTO was tuned ($k_T$ and parameters of fragmentation)
- Default MC parameters were used in systematics studies

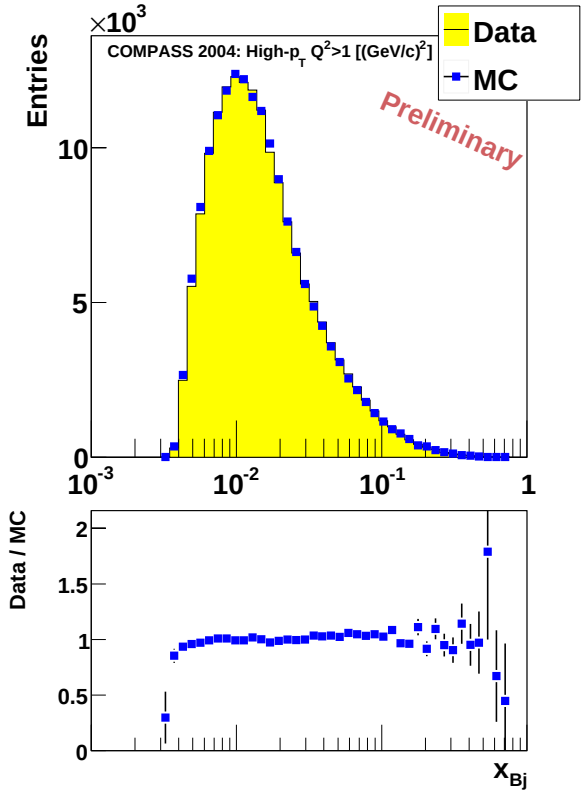
| | PARJ21 | PARJ23 | PARJ214 | PARJ41 | PARJ42 |
|---|---|---|---|---|---|
| Default | 0.36 | 0.01 | 2.0 | 0 .3 | 0.58 |
| Compass | 0.3 | 0.02 | 3.5 | 0.6 | 0.1 |

| | Final MC |
|---|---|
| $\langle a^{LO} \rangle$ | 0.63 |
| $\langle a^{C} \rangle$ | 0.50 |
| $\langle a^{PGF} \rangle$ | -0.36 |
| $R_L$ | 0.40 |
| $R_C$ | 0.29 |
| $R_{PGF}$ | 0.31 |

# Data and MC comparison

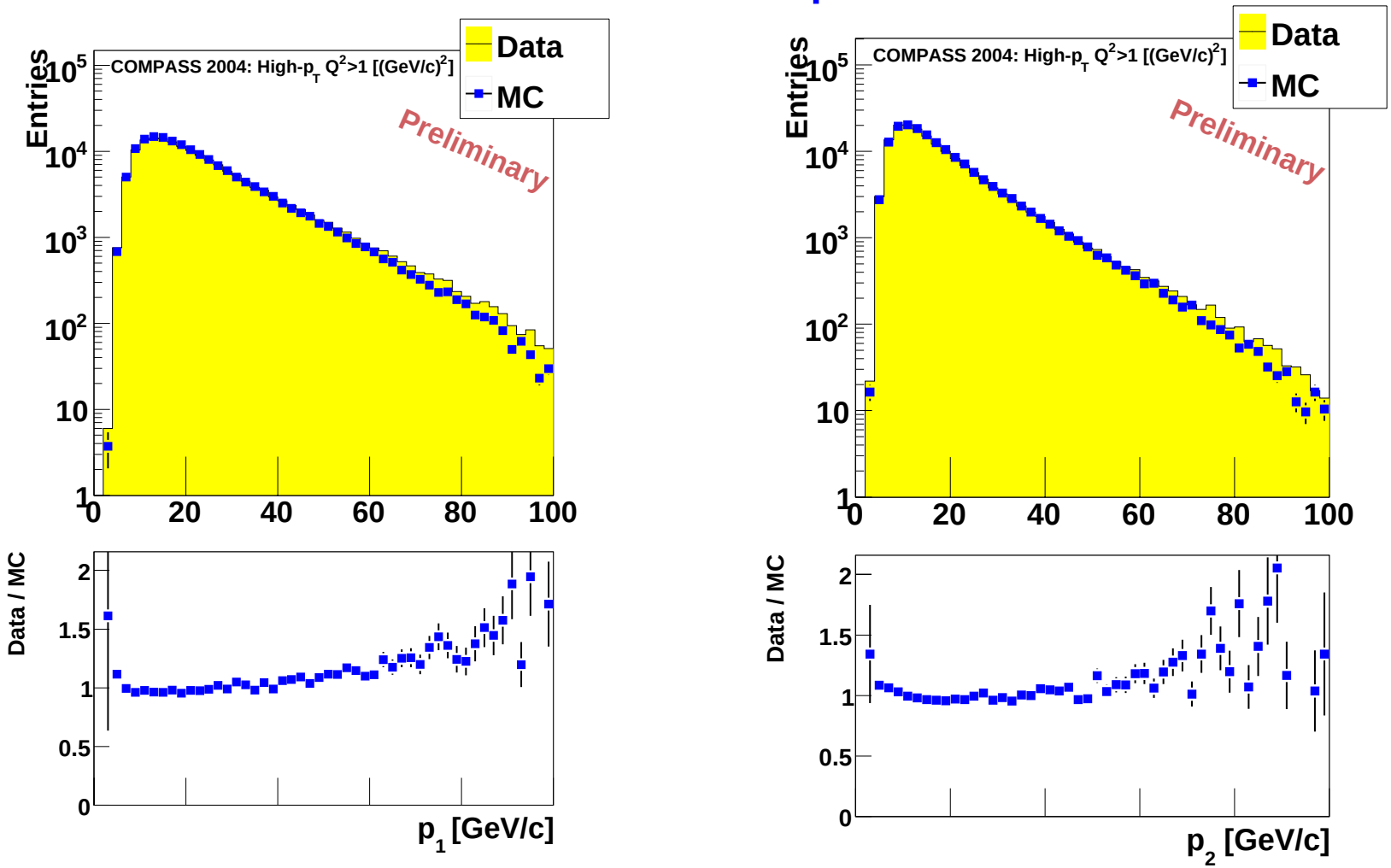


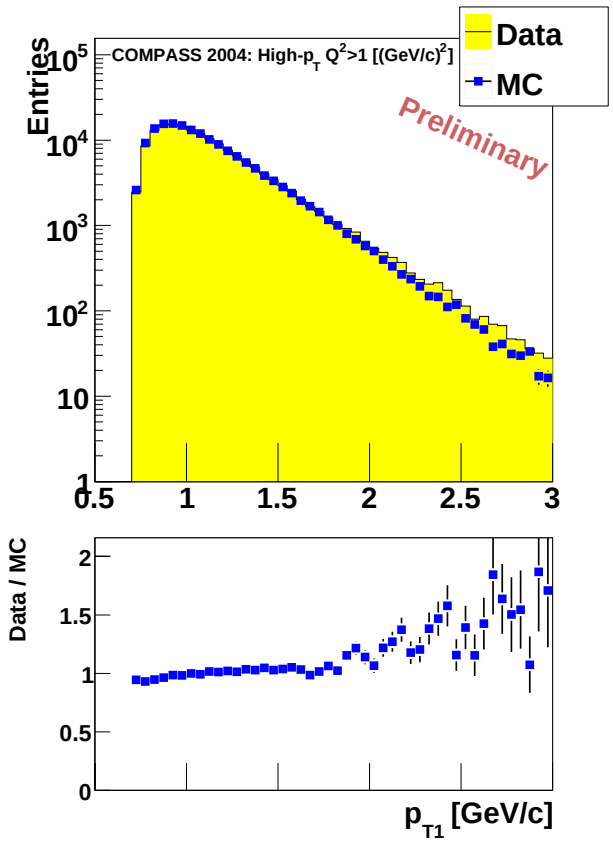

Comparison: MC/data for high $p_T$ sample; x,y and $Q^2$

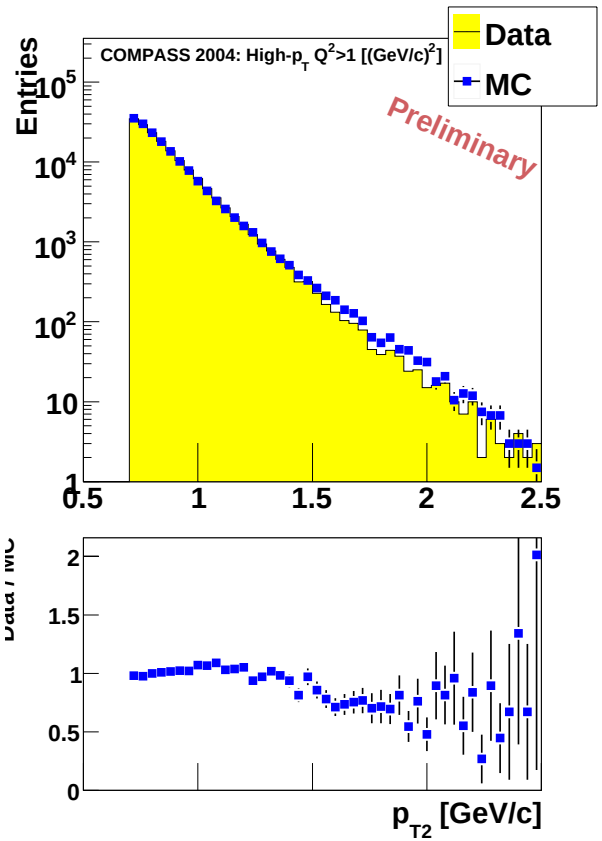
# Data and MC comparison

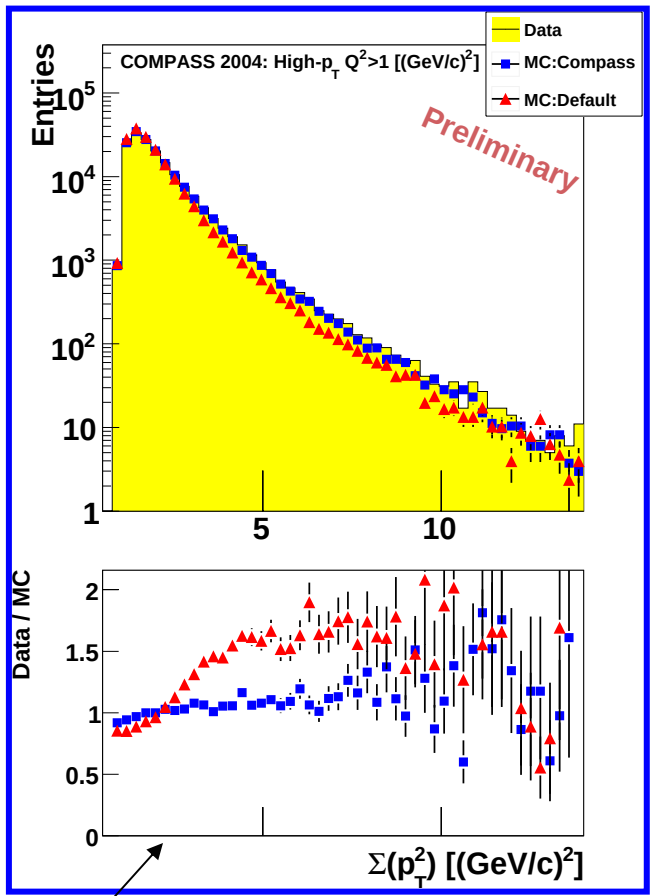



Comparison: MC/data for high $p_T$ sample;
momenta of leading and sub-leading hadrons.

# Data and MC comparison




Comparison: MC/data for high $p_T$ sample; transverse momenta of leading and sub-leading hadrons

Impact of MC tuning

# Systematics studies

What has been checked:

- False asymmetries
- NN stability
- systematic errors due to MC
- $\delta P_b$ ,$\delta P_t$ ,$\delta f$
- Radiative corrections
- Simplification of the formula for $\Delta G/G$

| | |
|---|---|
| $\delta(\Delta G/G)_{NN}$ | 0.006 |
| $\delta(\Delta G/G)_{MC}$ | 0.040 |
| $\delta(\Delta G/G)_{f,Pb,Pt}$ | 0.006 |
| $\delta(\Delta G/G)_{false}$ | 0.011 |
| $\delta(\Delta G/G)_{A1}$ | 0.008 |
| $\delta(\Delta G/G)_{formula}$ | 0.013 |
| Total | 0.045 |

# Systematic errors due to MC

4 different MC's have been used:
- COMPASS tuning PS on
- COMPASS tuning PS off
- standard tuning PS on
- standard tuning PS off

For every MC samples 3 different analysis have been performed to extract $\Delta G/G$:

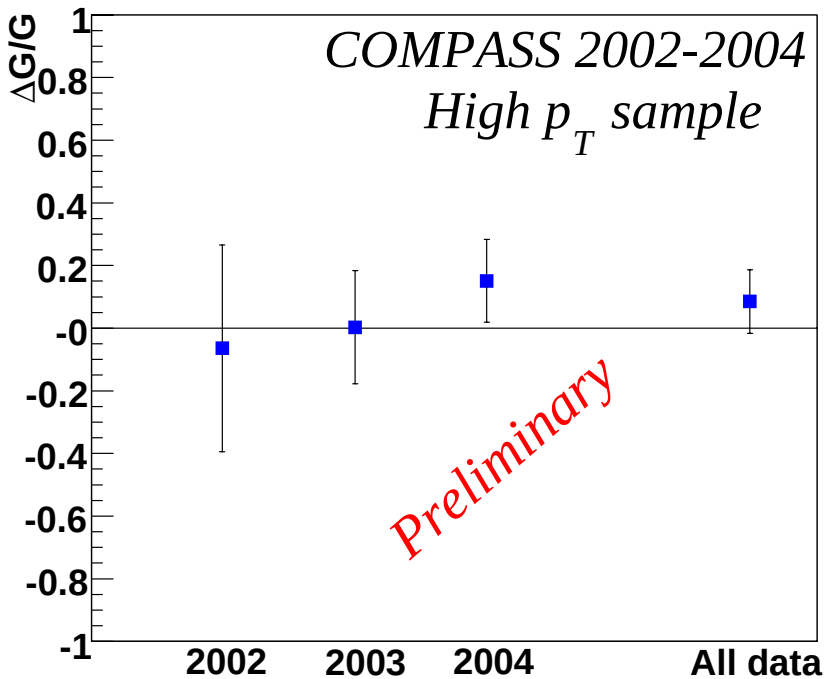
1. Standard MC events are used and $\Delta G/G$ is extracted
2. Limited sample is used for $\Delta G/G$ extraction
   (events with good data/MC agreement)
3. MC events re-weighted to obtain the ratio of data/MC =1

Final result for the error: 0.04

# Preliminary result for gluon polarization for $Q^2 > 1\ (GeV/c)^2$

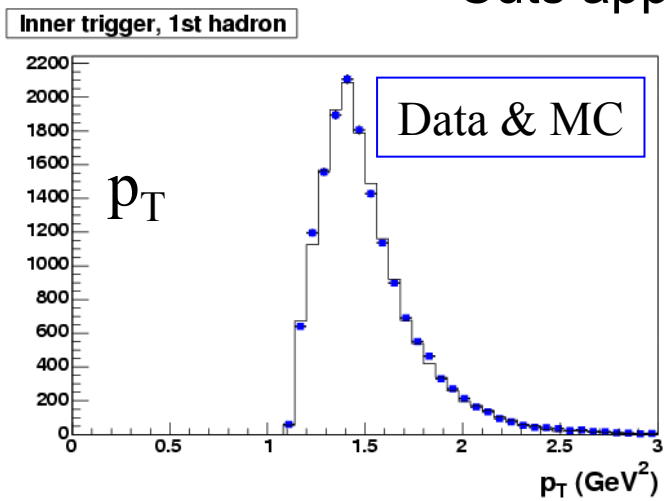
$$\frac{\Delta G}{G} = 0.08 \pm 0.10 \pm 0.05$$

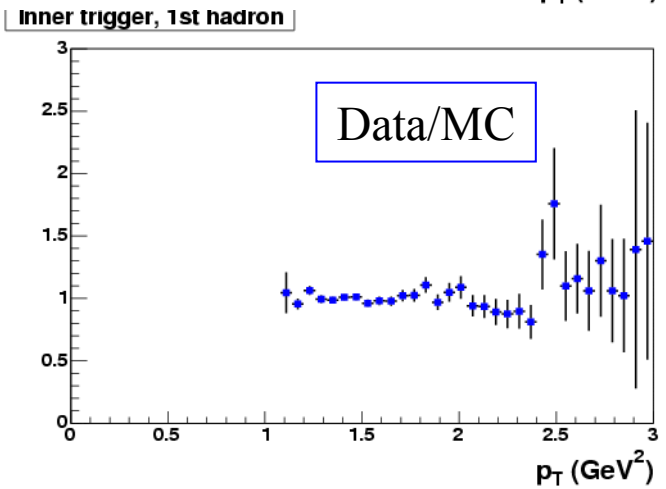
$$x_G = 0.082^{+0.041}_{-0.027} @ \mu^2 \approx 3(GeV/c)^2$$



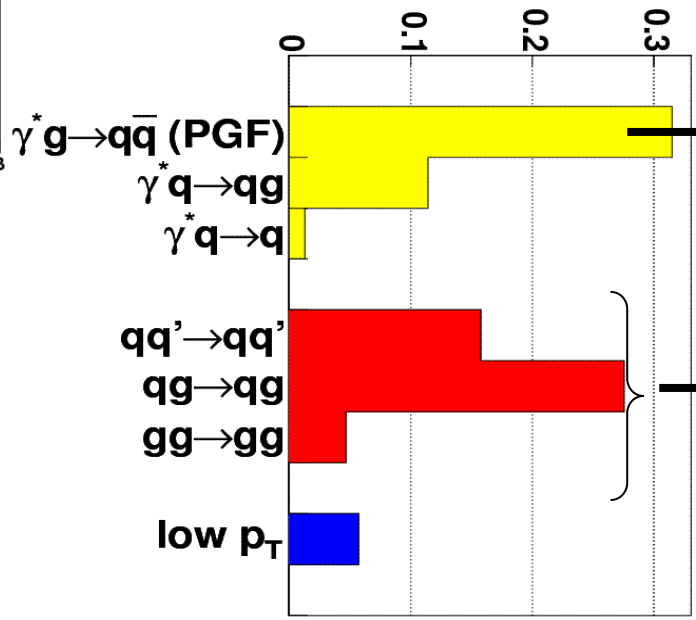
# Low $Q^2$ analysis ($Q^2$ <1 $(GeV/c)^2$)

Cuts approach used – cut on $\Sigma p_T^2 > 2.5\ (GeV/c)^2$



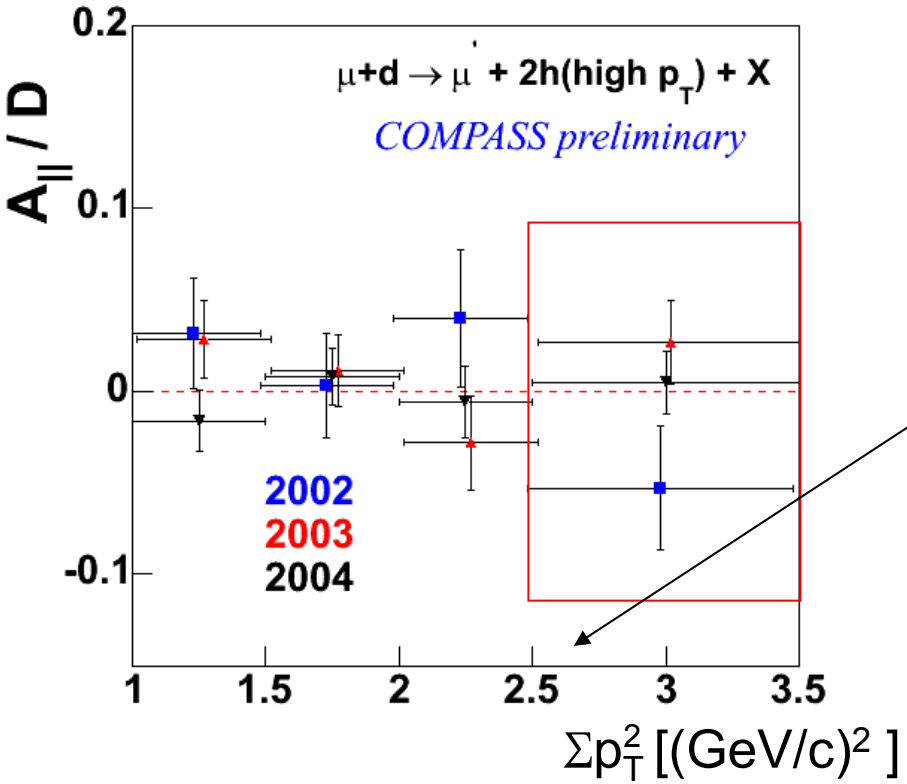

*PYTHIA* generator for low $Q^2$ + spectrometr simulation.




$R_{PGF} \approx 30\%$

$R_{Res.Phot} \approx 50\%$

# Low $Q^2$ results:

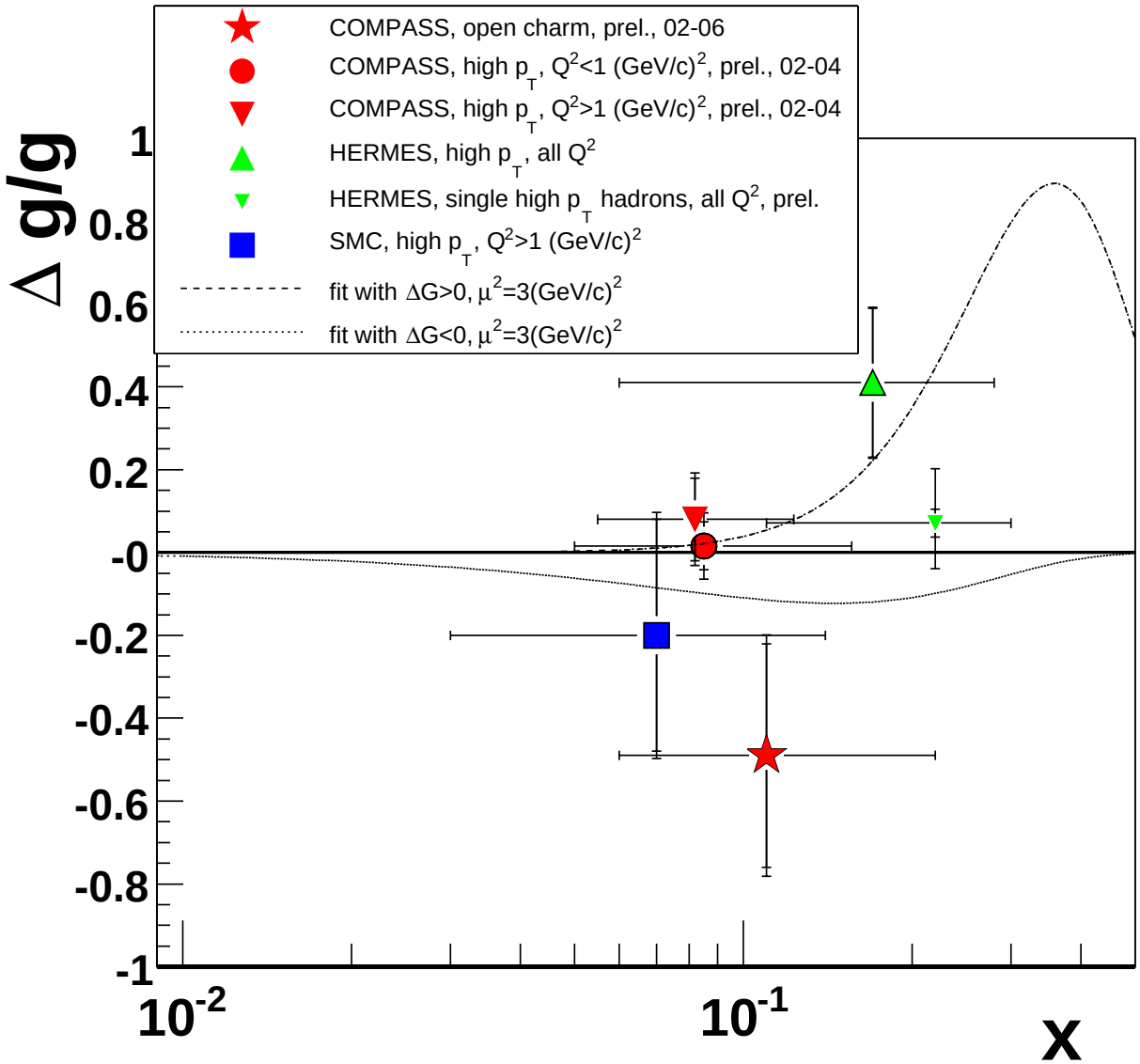



Cuts and asymmetry used for $\Delta G/G$ extraction

| Data | $(\Delta G/G)(x_g)$ | stat | exp.syst | MC.syst | resolved photon |
|---|---|---|---|---|---|
| 02-03 | 0.024 | 0.089 | 0.014 | 0.052 | 0.018 |
| 02-04 | 0.016 | 0.058 | 0.014 | 0.052 | 0.013 |

2002-2003 result published: PLB **633** (2006) 25-32

# Summary of ΔG/G results



# Conclusions and outlook

- New high-$p_T$ analysis has been performed for $Q^2 > 1$ $(GeV/c)^2$
- Preliminary result is:

  $\Delta G/G = 0.08 \pm 0.10 \pm 0.05$ @ $\langle x_G \rangle = 0.082$
- The new result is in a good agreement with the result from low $Q^2$ high-$p_T$ analysis

- 2006 data will be included soon
- 1 high-$p_T$ hadron analysis is planned