

Analysis of gluon polarisation for single production with high- p_T hadrons in the low Q^2

*Hiroki Matsuda, Takahiro Iwata , Shigeru Ishimoto¹ , Hajime Suzuki² ,
Norihiro Doshita , Genki Nukazuka , Naoaki Horikawa² , Tatsuro Matsuda³ ,
Kaori Kondo , Yoshiyuki Miyachi
on the behalf of COMPASS collaboration

Yamagata Univ., ¹KEK, ²Chubu Univ., ³Miyazaki Univ.

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Introduction

Glueon polarisation

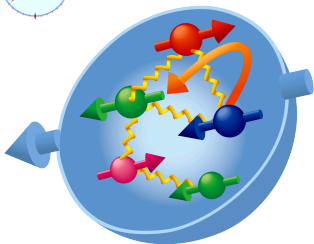
Summary



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Summary



$$S_N = \frac{1}{2} = \frac{1}{2} \Delta\Sigma + \Delta G + L_q + L_g$$

Quarks

Well known

$$\Delta\Sigma = 0.30 \pm 0.01 \pm 0.02$$

PLB 647 (2007) 8

Gluons

Poorly known

$$\Delta G = 0?, \neq 0?, > 0?, < 0?$$

COMPASS, HERMES, CLAS,
STAR, PHENIX give hints.

Orbital Angular Moment

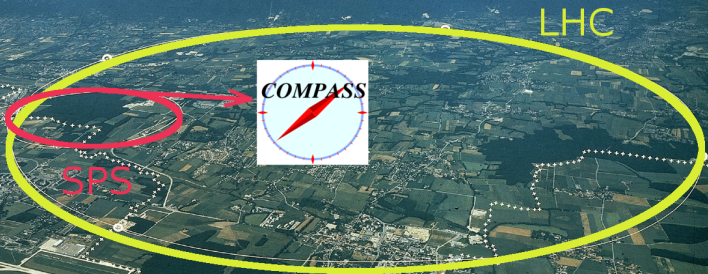
unknown

Future GPDs measurements
give hints.



COMPASS

COmmon Muon Proton Apparatus for Structure and Spectroscopy

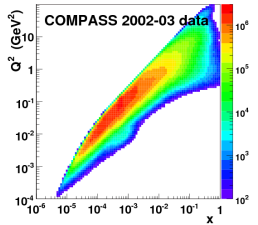
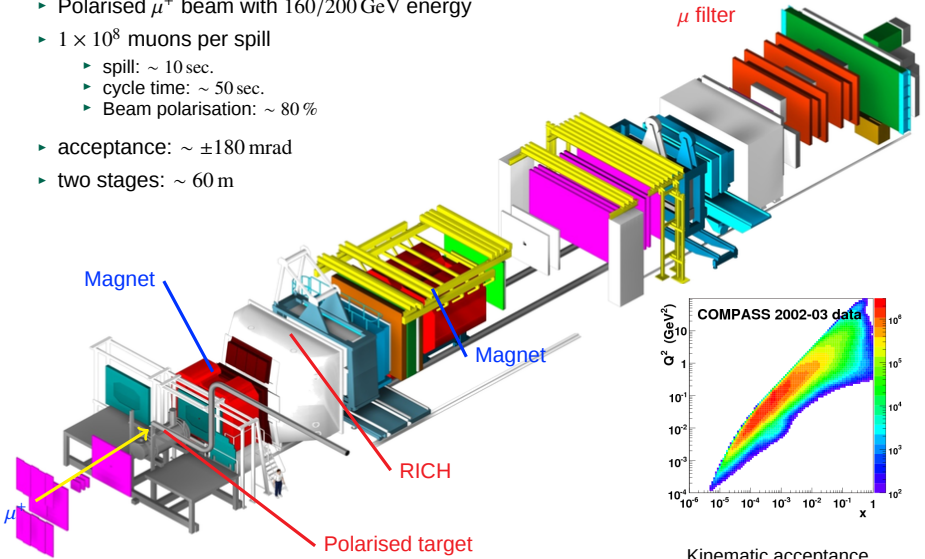




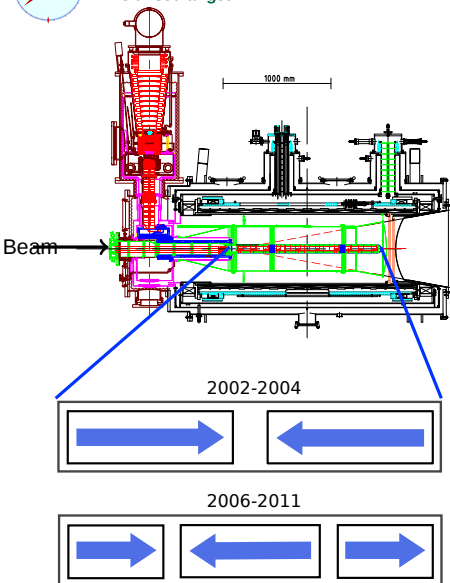
COMPASS Setup



- ▶ Polarised μ^+ beam with 160/200 GeV energy
- ▶ 1×10^8 muons per spill
 - ▶ spill: ~ 10 sec.
 - ▶ cycle time: ~ 50 sec.
 - ▶ Beam polarisation: $\sim 80\%$
- ▶ acceptance: $\sim \pm 180$ mrad
- ▶ two stages: ~ 60 m



Kinematic acceptance



- ▶ Target cell
 - ▶ -2004: 2 cells
 - ▶ 2006-: 3 cells
- ▶ Target material
 - ▶ -2006: ${}^6\text{LiD}$ for deuteron
 - ▶ 2007-: NH_3 for proton
- ▶ Polarisation
 - ▶ ${}^6\text{LiD} \sim 50\%$
 - ▶ $\text{NH}_3 \sim 90\%$
- ▶ Magnetic field
 - ▶ 2.5 T
- ▶ Change spin direction by rotating magnetic field to cancel acceptance difference
- ▶ Reverse microwave once in a while to cancel correlations

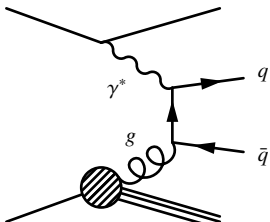


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Photon Gluon Fusion



$$A_{PGF} = \frac{N_{PGF}^{\leftarrow} - N_{PGF}^{\rightarrow}}{N_{PGF}^{\leftarrow} + N_{PGF}^{\rightarrow}}$$

$$\Rightarrow \Delta G/G$$

N_{PGF} : the number of PGF events

\leftarrow, \rightarrow : the spin helicity of lepton and nucleon

Methods

- ▶ High- p_T hadron pair ($Q^2 > 1$ and $Q^2 < 1$)

$$\gamma^* g \rightarrow q\bar{q} \Rightarrow h^+ h^- \text{ or } 2 \text{ jets}$$

☺ High statistics

☹ large physical backgrounds, strong MC dependence

- ▶ Open charm meson

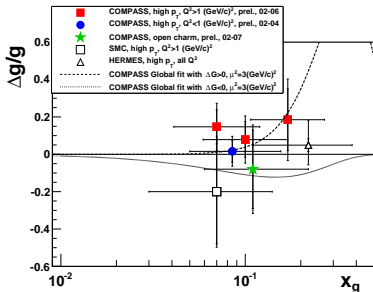
$$\gamma^* g \rightarrow c\bar{c} \Rightarrow D^0 \text{ meson}$$

☺ Pure PGF events, weak MC dependence

☹ Low statistics

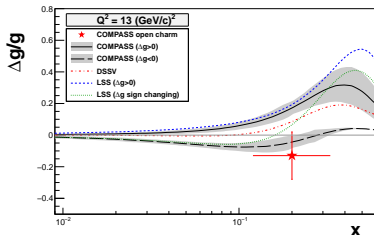


LO @ high- p_T hadron pair



PLB 718 (2013) 922

NLO @ open charm



PRD 87 (2013) 052018

$\Delta G/G$ @ COMPASS

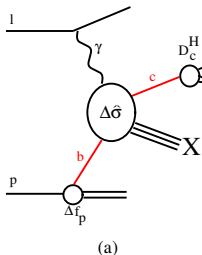
- ▶ $+0.02 \pm 0.09 \pm 0.06$ @ $x_g = \langle 0.01 \rangle$ LO, high- p_T pair, $Q^2 < 1$, PLB 633 (2006) 25
- ▶ $+0.13 \pm 0.06 \pm 0.06$ @ $x_g = \langle 0.09 \rangle$ LO, high- p_T pair, $Q^2 > 1$, PLB 718 (2013) 922
- ▶ $-0.06 \pm 0.21 \pm 0.08$ @ $x_g = \langle 0.20 \rangle$ LO, open charm, PRD 87 (2013) 052018
- ▶ $-0.13 \pm 0.15 \pm 0.15$ @ $x_g = \langle 0.11 \rangle$ NLO, open charm, PRD 87 (2013) 052018



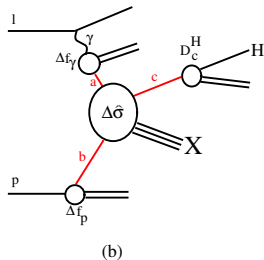
- ▶ based on JSV framework (EPJ C44 (2005) 533)
- ▶ collinear pQCD analysis at NLO
- ▶ photoproduction of single inclusive hadrons: $l + N \rightarrow l' + H + X$
 $Q^2 < 1 \text{ (GeV/c)}^2$

Direct γ -contribution

Resolved γ -contribution

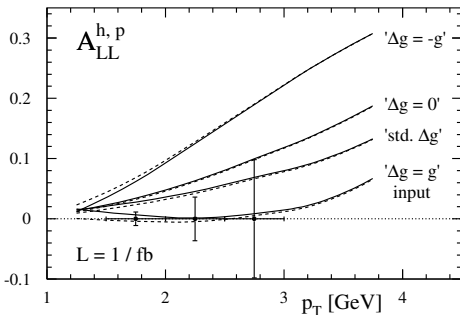
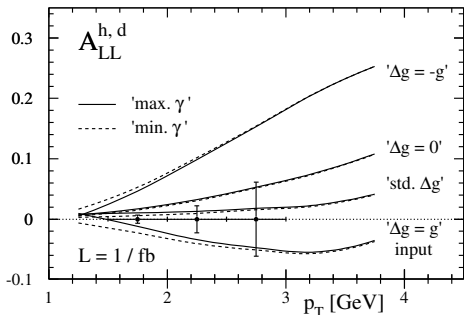


Δf_γ : Photon's parton density
 Δf_p : Nucleon p 's parton density
 $\Delta \hat{\sigma}$: spin-dependent partonic hard scattering cross section
 $a, b, c = q, \bar{q}, g$
 D_c^H : fragmentation function





Ref: EPJC 44 (2005) 533, Fig. 7



▶ $A_{LL} \equiv \frac{d\Delta\sigma}{d\sigma}$

▶ Small impact of resolved photon PDF uncertainty at low- p_T

▶ Luminosity is estimated as 4 fb^{-1}
 ⇒ error bars becomes half



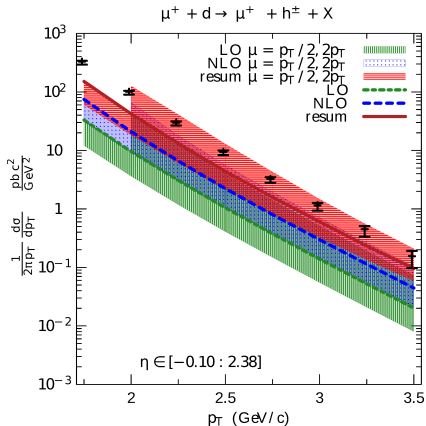
COMPASS data in 2004

- ▶ C. Adolph, *et. al.*, PRD 88 (2013) 091101
- ▶ $l + N \rightarrow l' + H + X$ cross section at $Q^2 < 0.1 \text{ (GeV/c)}^2$

Theoretical calculations

- ▶ D. Florian, *et. al.*, PRD 88 (2013) 014024
- ▶ Higher-order QCD corrections to the cross section
- ▶ Large logarithmic “threshold” corrections → improved the agreement between data and theory

⇒ Valid within theoretical uncertainty





Year	Target	E_{beam} [GeV]	Detail
2002	${}^6\text{LiD}$	160	Longitudinal mode(~20 % transverse mode)
2003	${}^6\text{LiD}$	160	Longitudinal mode(~20 % transverse mode)
2004	${}^6\text{LiD}$	160	Longitudinal mode(~20 % transverse mode)
2005			Shutdown & upgrade
2006	${}^6\text{LiD}$	160	New setup, longitudinal mode
2007	NH_3	160	1/2 longitudinal, 1/2 transverse
2008			Hadron physics
2009			Hadron physics
2010	NH_3	160	Transverse
2011	NH_3	200	Longitudinal
2012	LH_2		Hadron physics(Primakoff) + DVCS test run and SIDIS
2013			Shutdown & upgrade
2014	NH_3		Drell-Yan
2015	NH_3		Drell-Yan
2016	LH_2		DVCS
2017	LH_2		DVCS

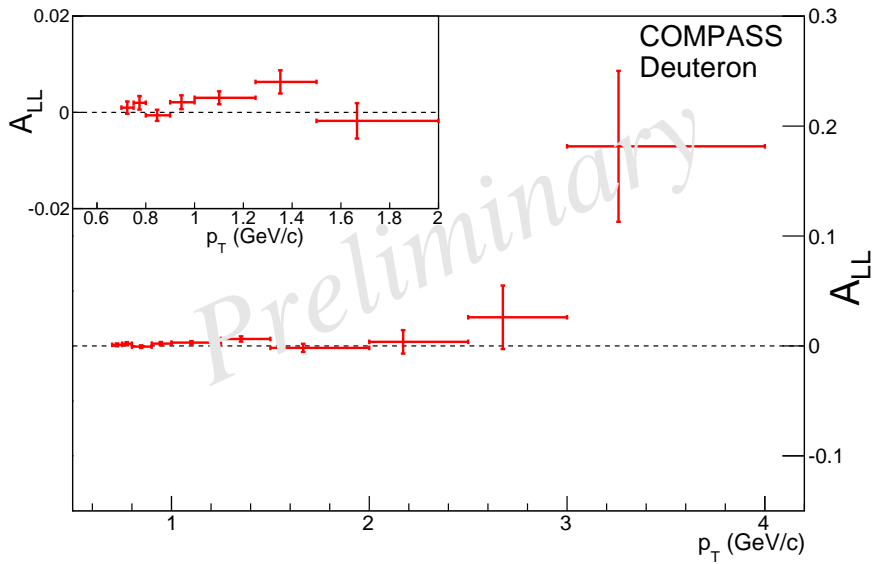
Phase-I

Phase-II



Results: asymmetry

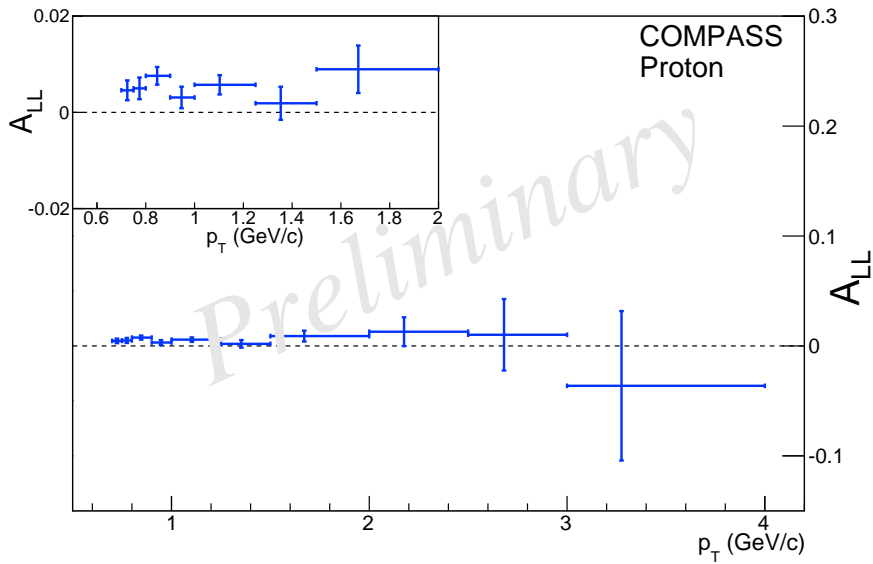
Deuteron

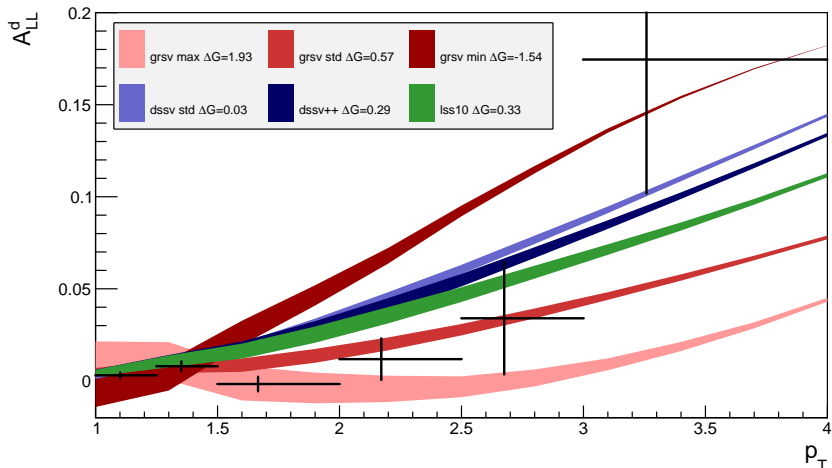




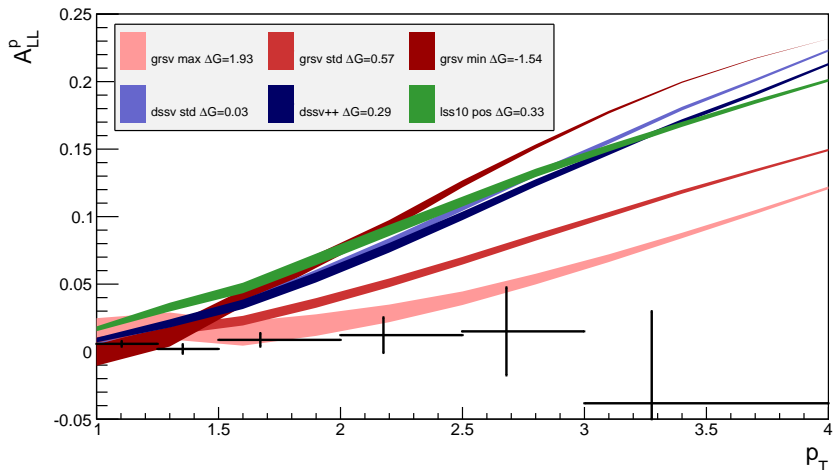
Results: asymmetry

Proton





- ▶ Calculations suggest a high positive ΔG
- ▶ No calculations drawn with gluon resummation
→ to be available in the very near future



- ▶ no PDF can yet explain A_{LL}^p at quite high ΔG
- ▶ No calculations drawn with gluon resummation
→ to be available in the very near future



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Gluon polarisation

- ▶ COMPASS has published results of gluon polarisation analysis
- ▶ Gluon polarisation extraction from A_{LL} for single hadron photoproduction at high- p_T on proton and deuteron targets
- ▶ Present NLO calculations do not agree simultaneously with deuteron and proton data
- ▶ Extraction of ΔG from A_{LL} done after the inclusion of soft gluon resummation