Recent results from COMPASS

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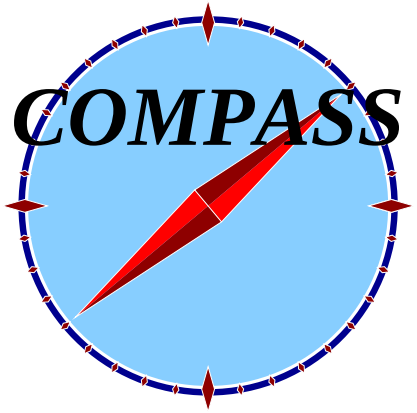
September 19, 2012

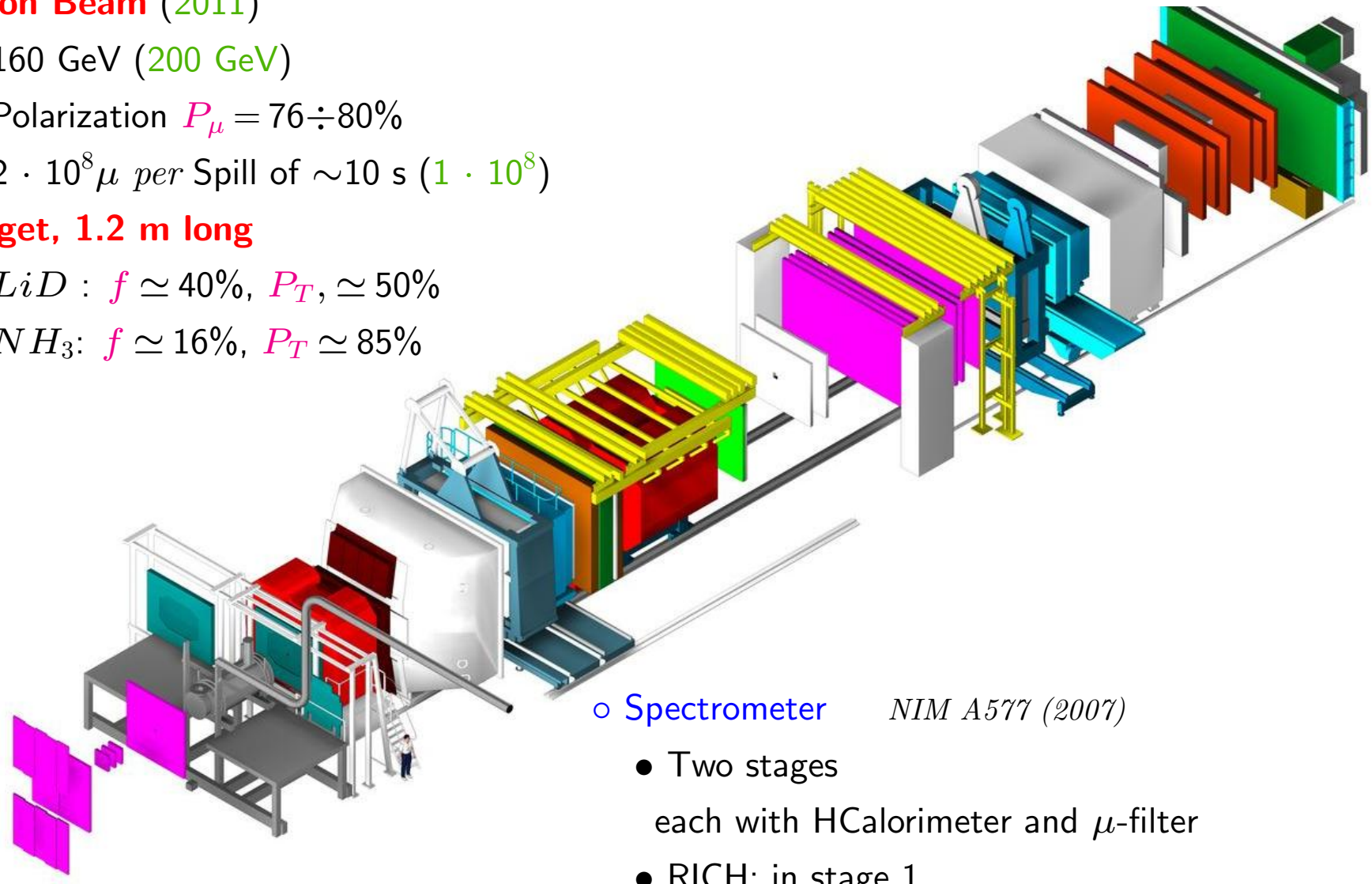


Outline

- **The COMPASS experiment**
- **Longitudinal Spin: 2011 data**
- $\boldsymbol{\Delta G}$
- **Transverse Spin and k_T dependent processes: Collins, $H_1^{\sphericalangle}$, TMDs**
- **GPD**: Deeply virtual $\boldsymbol{\rho}$ production
- **Fragmentation Functions**: Hadron Multiplicities
- $\boldsymbol{\Lambda}$: Contribution of heavy hyperons

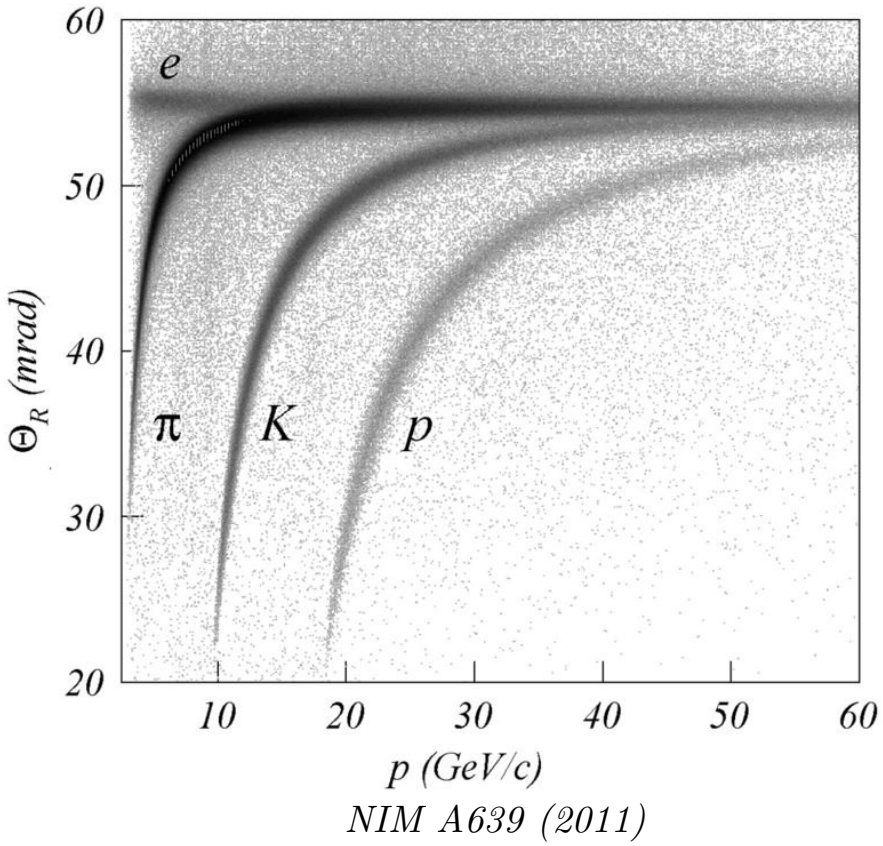
COMPASS: Spectrometer

- **Muon Beam** (2011)
  - 160 GeV (200 GeV)
  - Polarization $P_\mu = 76 \div 80\%$
  - $2 \cdot 10^8 \mu$ *per* Spill of $\sim$10 s ($1 \cdot 10^8$)
- **Target, 1.2 m long**
  - LiD : $f \simeq 40\%$, P_T, $\simeq 50\%$
  - NH_3: $f \simeq 16\%$, $P_T \simeq 85\%$



- Spectrometer *NIM A577 (2007)*
  - Two stages
    each with HCalorimeter and μ-filter
  - RICH: in stage 1
  - ECalorimeters(1&2): not yet in Spin analyses

COMPASS: RICH



NIM A639 (2011)

- Used to. . .

. . . ID final state hadrons in SIDIS
. . . Veto electrons in open charm production

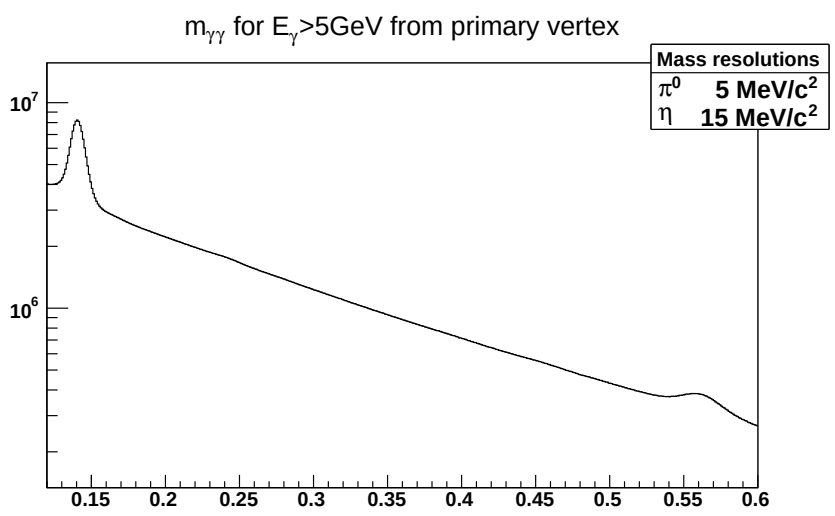
- **K range: 10 $\lesssim P \lesssim$ 50 GeV**

- No K/p resolution below $\sim$10 GeV

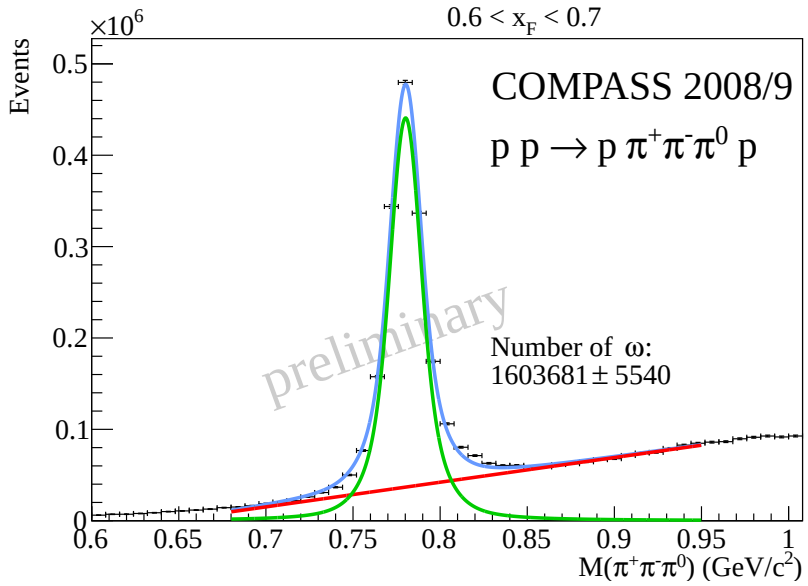
COMPASS: ECalorimeters

- No reconstruction of neutrals yet in any Spin physics analyses
  (Energy deposits in ECals still in Semi-Inclusive triggers)

- But used in our "hadron" programme (exotics search, χPT tests)



- Inclusive π^0,η from π beam on 40 cm LH_2



- Exclusive ω (40 cm LH_2)

- *Caveat: Thickness of polarised targets along beam axis* $\simeq 1 \times X_0$.
  and probability for photon conversion is high

COMPASS: Asymmetry Measurement

- **Simultaneous** recording of the two spin states in oppositely polarised target cells
  - Reversal by field rotation only to cancel acceptance diff

. . . 2 cells: $1/2 \uparrow 1/2 \downarrow \quad \Longleftarrow \; 8\,hours \; \Longrightarrow \quad 1/2 \downarrow 1/2 \uparrow$

. . . 3 cells: $1/4 \uparrow 2/4 \downarrow 1/4 \uparrow \quad \Longleftarrow \; 24\,hours \; \Longrightarrow \quad 1/4 \downarrow 2/4 \uparrow 1/4 \downarrow$

$$\frac{A^{\parallel}}{D} = \frac{1}{|P_\mu P_T| f D} \frac{1}{2} \left(\frac{N^{\Uparrow\downarrow} - N^{\Uparrow\uparrow}}{N^{\Uparrow\downarrow} + N^{\Uparrow\uparrow}} + \frac{N^{\Uparrow\downarrow} - N^{\Uparrow\uparrow}}{N^{\Uparrow\downarrow} + N^{\Uparrow\uparrow}} \right) \qquad D = Depolarisation\ factor$$

LiD: $P_\mu \times D \times P_T \times f \simeq 80\% \times 60\% \times 50\% \times 40\% \simeq 10\%$ *(typical values)*

NH_3: . . . $P_T \times f \simeq$ . . . $85\% \times 16\% \simeq 6\%$

- Reversal *via* micro-wave once per year of data taking to cancel field/acceptance correlation

COMPASS: Data Taking

- [2002,2004], 2006: 160 GeV
  - $Deuteron$ target
  - Mostly longitudinal, ∼20% in tranverse mode
  - Longitudinal luminosity

	2002	2003	2004	2006
Integrated Luminosity (fb^{-1})	0.43	0.58	0.92	0.85

- 2007: $Proton$ target. 1/2 longitudinal, 1/2 transverse. 160 GeV
- 2008,2009: Hadron physics
- **2010**: **Transverse** $proton$ **160 GeV**
- **2011**: **Longitudinal** $proton$ **200 GeV**
- 2012: Hadron physics ($Primakoff$)

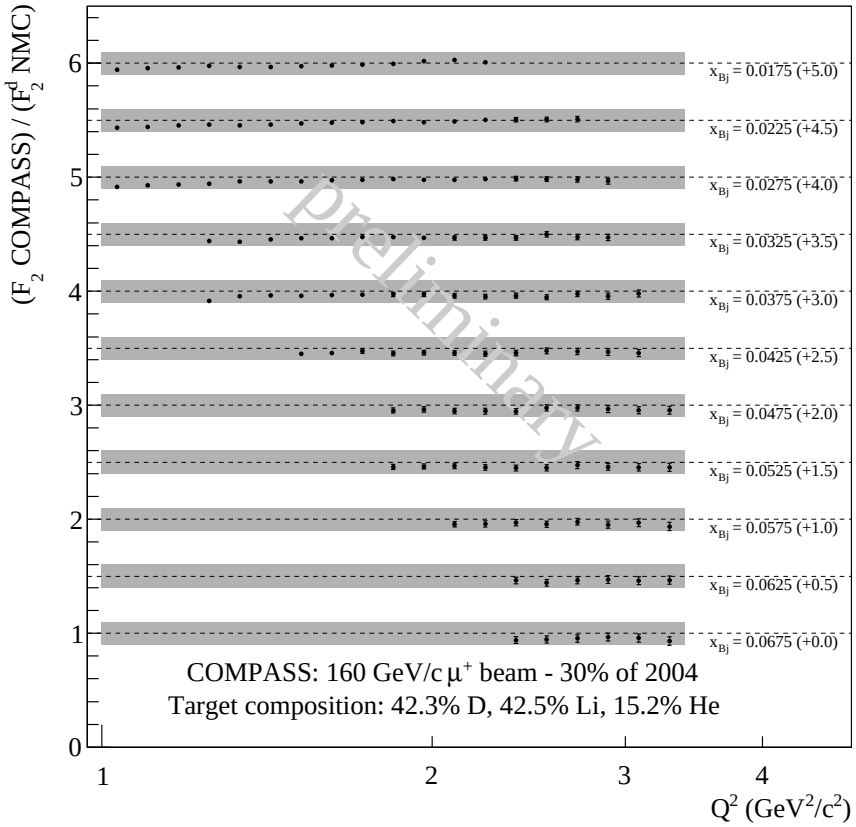
  + muon beam on $LH2$ target: DVCS test run and SIDIS

COMPASS: Luminosity Measurement

- **Precise luminosity plays an important role in part of our programme**

  . . . in our future DVCS measurement

  . . . in our measurement of hadron photo-production X-section *vs.* p_T



arXiv:1104.2926 [hep-ex]

- As an evaluation exercise: F2 X-check

- **Systematics (=10%)**
  most likely pessimistic.

Longitudinal Spin: Motivations for 2011 data taking

- More statistics @ low x for longitudinally polarized protons

- Only longitudinal protons @ COMPASS so far $= 1/2$ of 2007

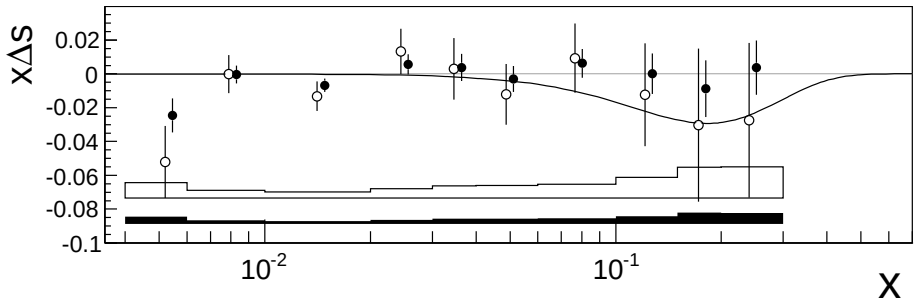
  $\Rightarrow$ Unbalance p w.r.t. d affecting particularly the analyses mixing both

  - Bjorken sum rule:

    projected precision: $\int_{0.003}^{0.7} g_1^{NS}(x)dx : \pm 0.006(stat.) \pm 0.011(syst.)$

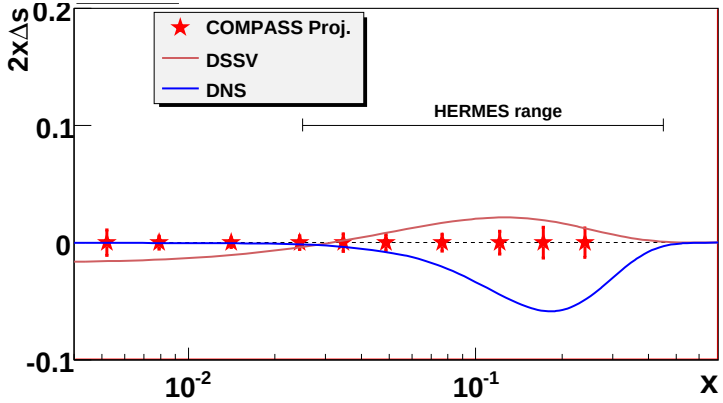
  - Flavor separation:

    E.g. **ΔS puzzle: SIDIS != Inclusive DIS + SU(3)**



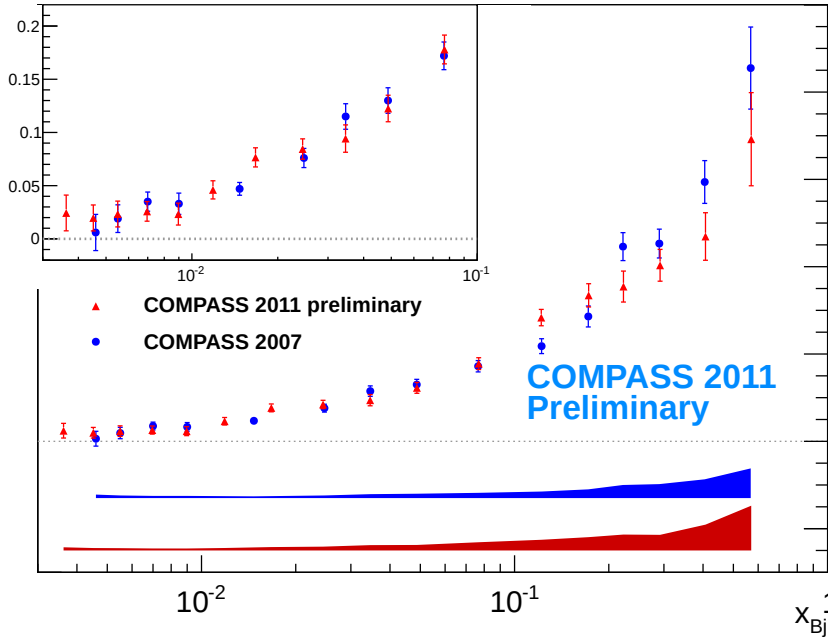
LO analysis using DSS (●) or EMC (○) FFs compared to DNS global fit of Incl. DIS

Phys. Lett. B **693** *(2010)* *arXiv:1007.4061 [hep-ex]*



Projection including 2011 data ($DSS\ FF$)

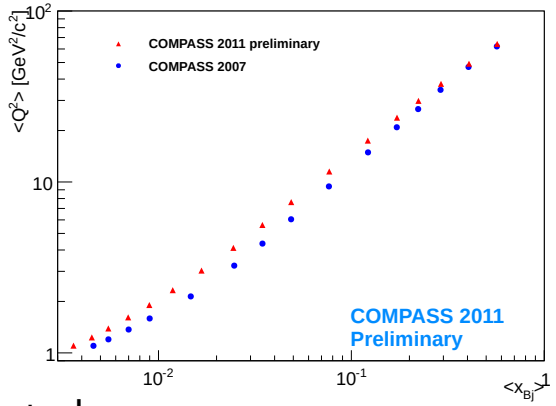
Longitudinal Spin: 2011 preliminary results



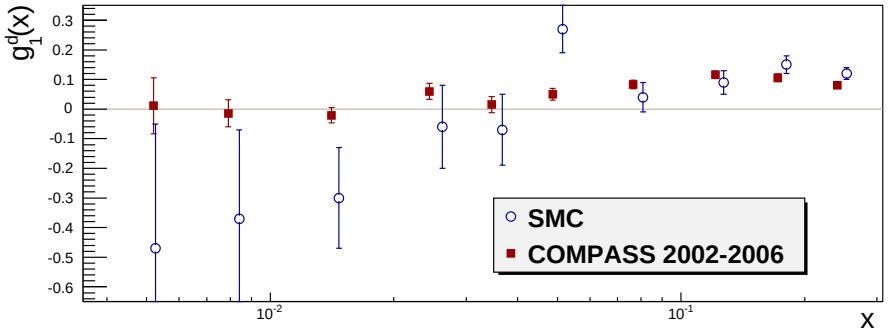
- $A_1^p(x)$

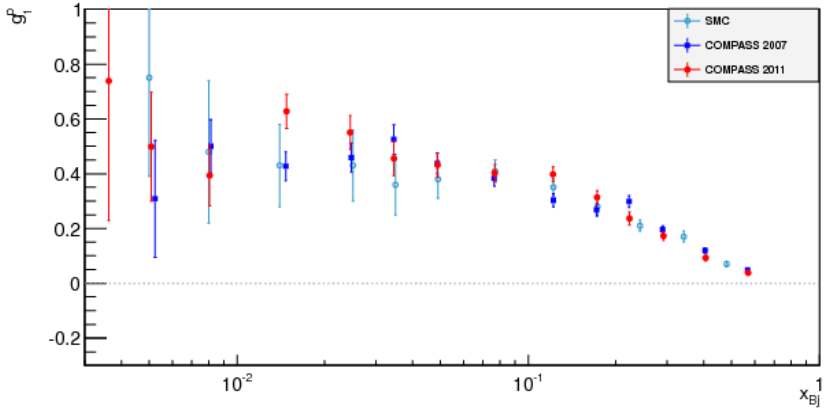
  $\simeq \frac{A^{\parallel}}{D}$ to good precision in COMPASS

Caveat: 2007 and 2011 at (slightly) different $Q2$



- **COMPASS boost in precision at low x** now completed

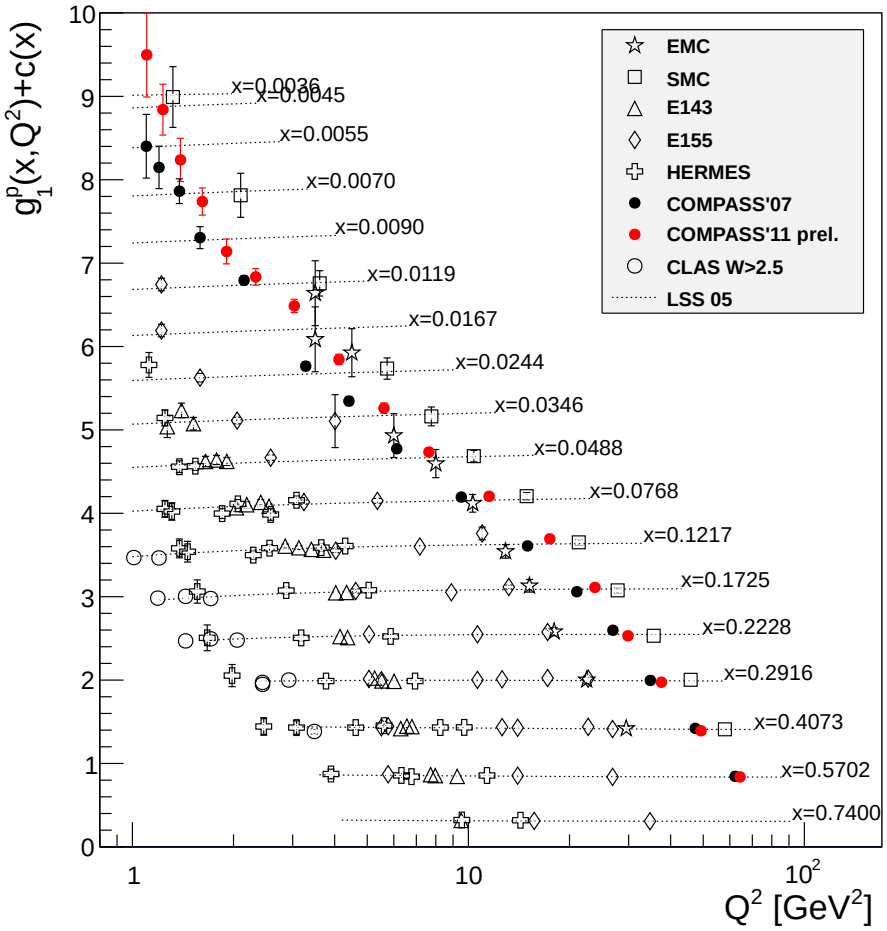


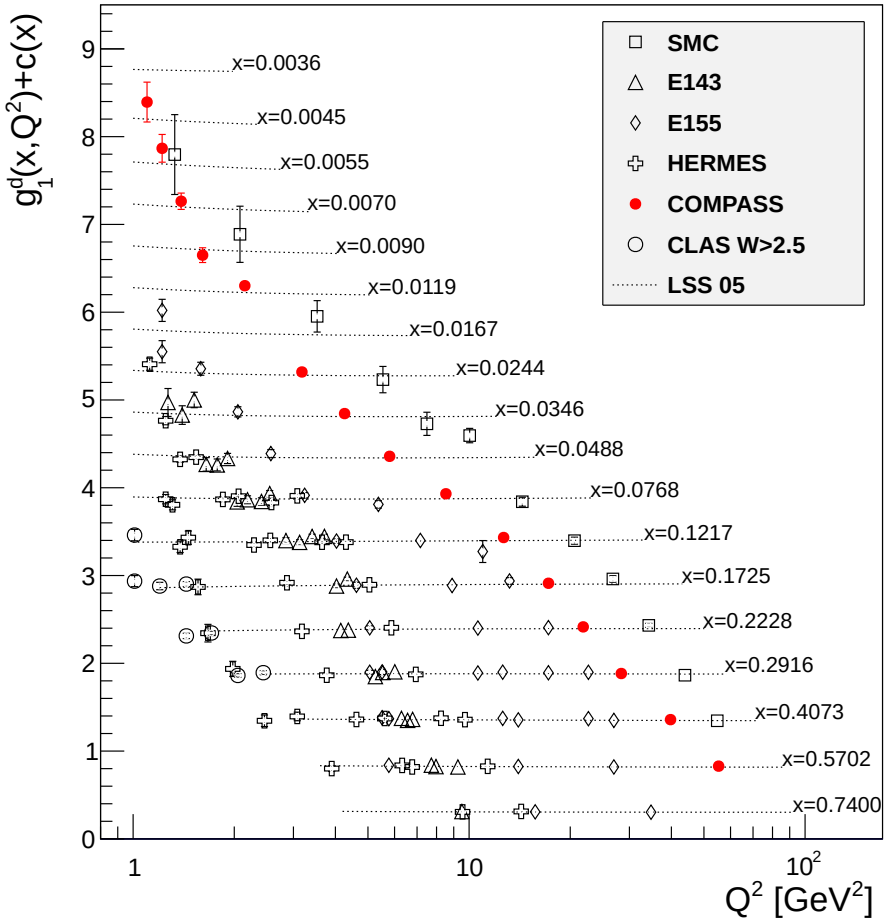


Cf. presentation by E. Zemlyanichkina

Longitudinal Spin: Status of polarised inclusiveDIS

- World polarised DIS data: $g_1(Q^2) + c(x)$





$\Rightarrow$ Little sensitivity to ΔG from inclusive DIS

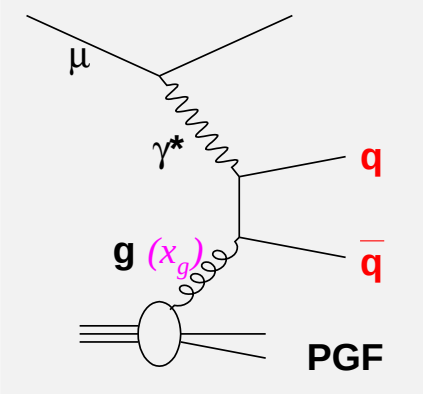
ΔG: Two approaches: Direct extraction *vs.* Fit

- **Direct** *vs.* **Fit**, differing in:
  - Folding partonic level pQCD calculations with. . .
  . . . the soft fragmentation process,
  - Handling of the quark contributions

1. **Fit** (*Used at RHIC, see Bernd Surrow's talk*)
   - pQCD calculations w/. . .
   . . . Independent collinear fragmentation
   - Quark contributions: imported pPDFs or global $(q + g)$ fit
   - In COMPASS: Photo-production of charge hadrons at high p_T
   - **New**: validation of the framework in unpolarized case

2. **Direct** extraction
   - Based on MC generator
   $\Rightarrow$ Lund Fragmentation
   - Quark contributions autochthonous
   . . . (*except in the high pT low* Q^2 *case*)
   - COMPASS main approach: open-charm and high p_T
   - **New**: NLO corrections to open charm

ΔG: Two channels: Open charm *vs.* high p_T



- **q = c**: **Open Charm** production
  - PGF enters alone at LO
  - Resolved γ small (high x_γ)

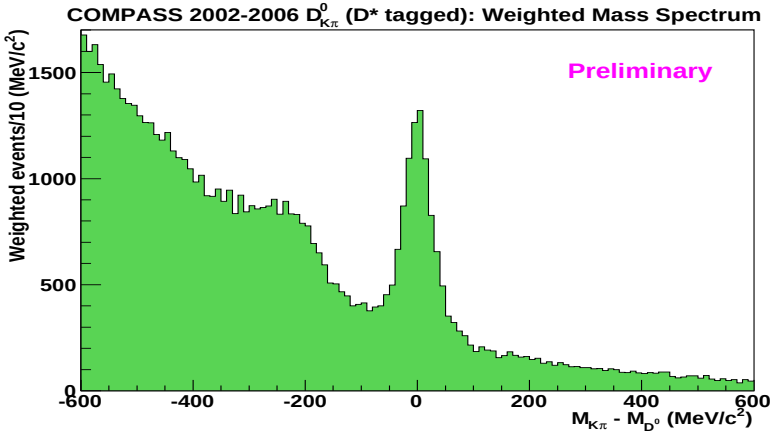
  $\Rightarrow$ COMPASS Golden Channel
  - Experimentally difficult
  - pQCD scale set by $\hat{s} > 4m_c^2$

- **q = u,d,s,c**: **High-p_T** Hadrons
  - Competing LO-DIS, QCD-Compton
  - At low Q^2: Competing resolved γ processes.
  - Experimentally: Higher statistics
  - pQCD scale set by p_T or Q^2

ΔG: Open charm

- Open charm selection.

$$E.g.\ D^* \to D^o\pi \to K\pi\pi$$



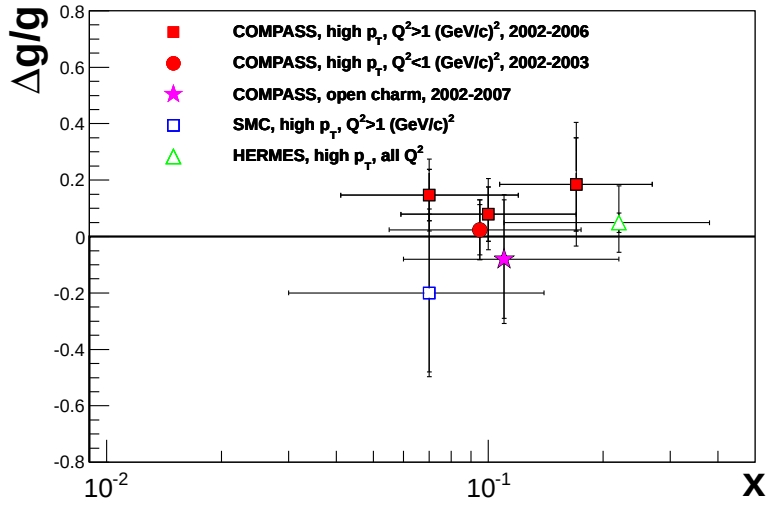
- LO interpretation $(2002\text{-}2007\ data)$

$$\Delta G/G = -0.08 \pm 0.21(stat.) \pm 0.11(syst.) \qquad x_G = 0.11^{+0.11}_{-0.05};\ \ \mu^2 \approx 13 GeV^2$$

- COMPASS open charm at LO ($\star$)
  and other direct measurements (@ 3 GeV^2)

$\Rightarrow$ **$\Delta G/G$ small**
Axial anomaly scenario definitely excluded

- LO $\Rightarrow$ not into global fits



ΔG: NLO corrections to open charm

- *Bojak and Stratmann, Nucl. Phys. B* **540** *(1999)* *arXiv:hep-ph/9807405*

  Collinear fragmentation: Charm quark is "measured" by D meson
  $\gamma + N \rightarrow c[\bar{c}] + X$ @ $Q^2 = 0$ w/ Mandelstam invariants U_1 and T_1
  $d^2\hat{\sigma}/dU_1dT_1$ and $d^2\Delta\hat{\sigma}/dU_1dT_1$ including virtual + soft and real gluon corrections

- *K. Kurek, J. Phys. Conf. Ser.* **295** *(2011)*

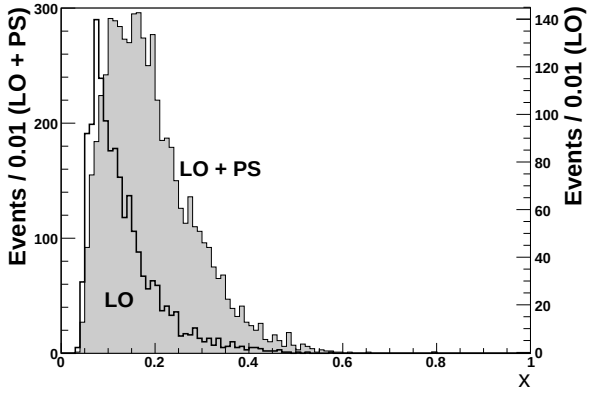
  Analytical integration over U_1.
  Integration over x using MC (AROMA) w/ Parton Shower
  $\Rightarrow$ $\langle a_{LL}\rangle(p_T)$

- Asymmetries binned along p_T

  $\langle a_{LL}\rangle(p_T)\, A^{\gamma N}(p_T) = \langle a^g_{LL}\rangle(p_T)\Delta G/G + \langle a^q_{LL}\rangle(p_T) A_1$

  $\Rightarrow$ $\Delta G/G = -0.13 \pm 0.15(stat.) \pm 0.15(syst.)$ $x_G = 0.20^{+0.13}_{-0.08}$ $\mu^2 \approx 13 GeV^2$

- **Significant impact on x_g**

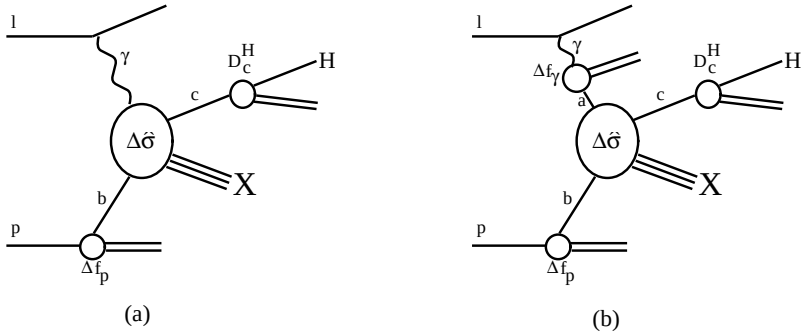


ΔG: High p_T Hadron Photo-production

- Theory: NLO pQCD for

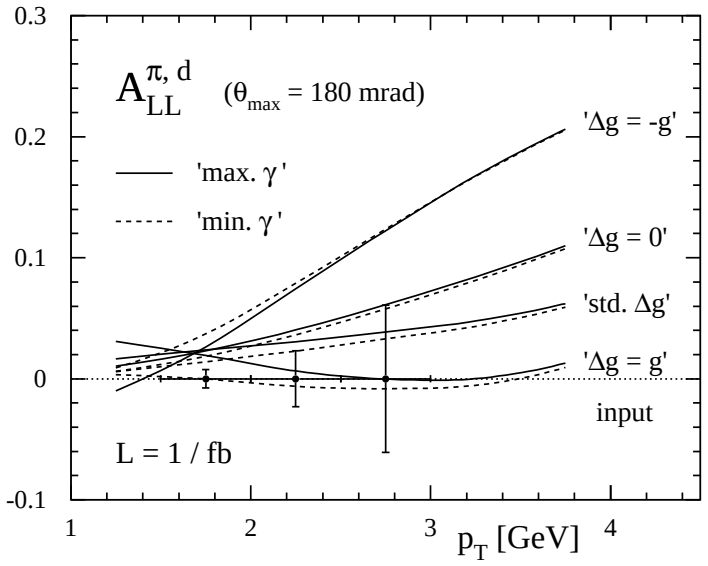
  [Polarised] Photoproduction of Inclusive Hadrons

  Jäger, Stratmann, Vogelsang EPJ C44 (2005) [arXiv:hep-ph/0505157]



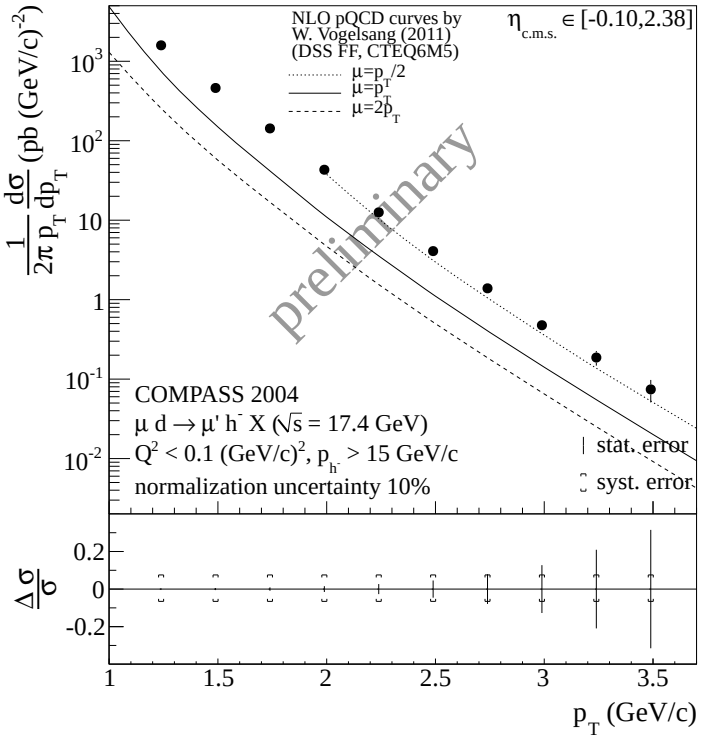
- Projections ($\mathbf{1\ fb^{-1}}$) compared to GRSV options

  Polarised photon structure explored based on extreme scenarios: limited impact



- Total COMPASS integrated luminosity: $\sim\mathbf{4\ fb^{-1}}$

ΔG: Hadron Photo-production X-section *vs.* p_T

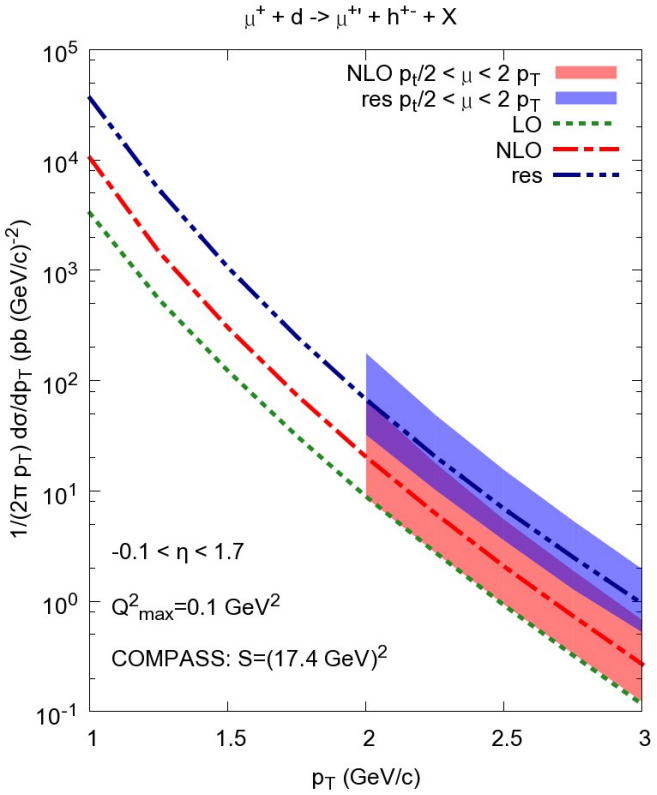


Measured X-section (*compared to old calculation*)

To be submitted to Phys. Lett. B

arXiv:1207.2022 [hep-ex]

Cf. presentation by S. Platchkov



New calculation (*compared to old*)

including resummation of leading logarithms

de Florian, Pfeuffer, Schäfer, Vogelsang (prel.)

Transverse Spin and k_T-dependent Functions

- **2010 entirely** dedicated to **transversely** polarised data taking
  - Improved triggering efficiency @ high x
  - Very stable data taking

  $\Rightarrow$ **Gain in both statistics and systematics** w.r.t. previous (2007): **factor 2**

- **Collins** and **Sivers**: **Complete** analysis including
  - π, K ID
  - Combined analysis of 2007 and 2011
  - *First* publications submitted to PLB: *arXiv:1205.5121 [hep-ex]* and *arXiv:1205.5122 [hep-ex]*

- 6 extra **TSAs** and $\boldsymbol{H}_1^{\sphericalangle}$: First 2010 results

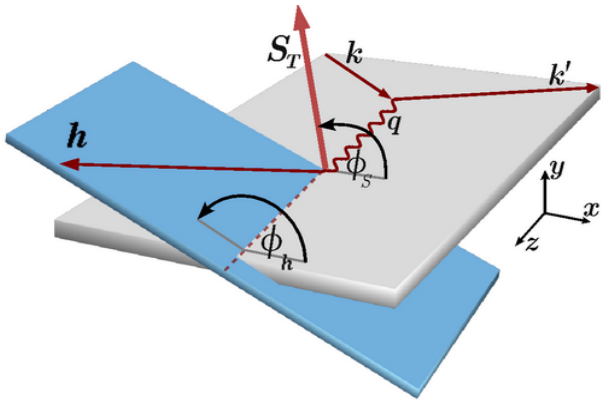
k_T dependent processes: Collins

- Transversely polarised q fragmenting into unpolarized h

  $\Delta^N D_q^h(z, p_\perp^2)$

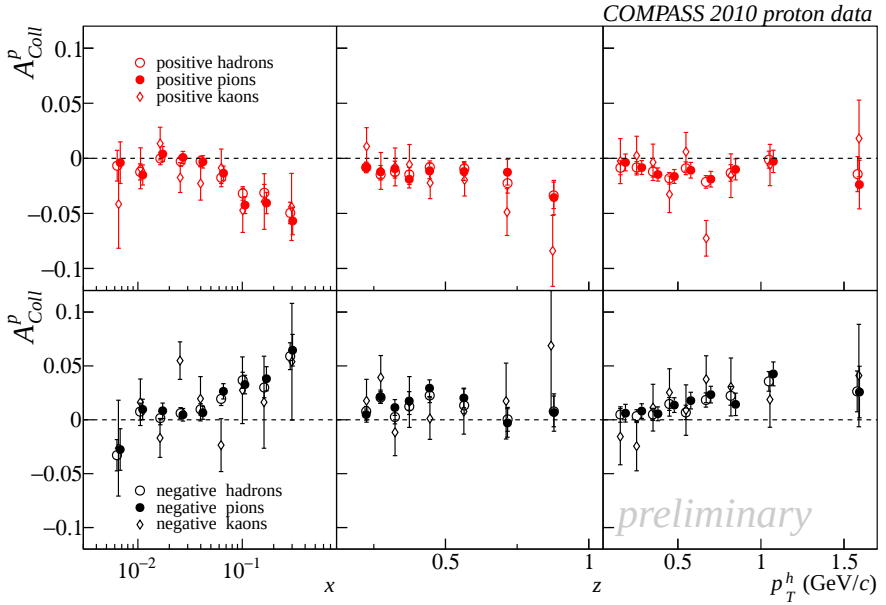
  convoluted with transversity $\Delta_T q(x, k_T^2)$

$$A_{UT}^{h,sin(\phi_h+\phi_S)} \propto \sum e_q^2 \, \Delta_T q(x, k_T^2) \otimes \Delta^N D_q^h(z, p_\perp^2)$$



- Actually: 8 azimuthal modulation fit, independently for h^+, h^-, π^+,. . .

- Collins for h, π and K



Cf. presentation by A. Martin

k_T dependent processes: Collins

- Transversely polarised q fragmenting into unpolarized h

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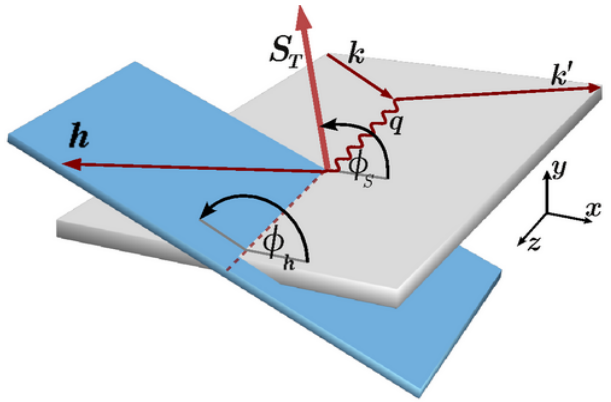
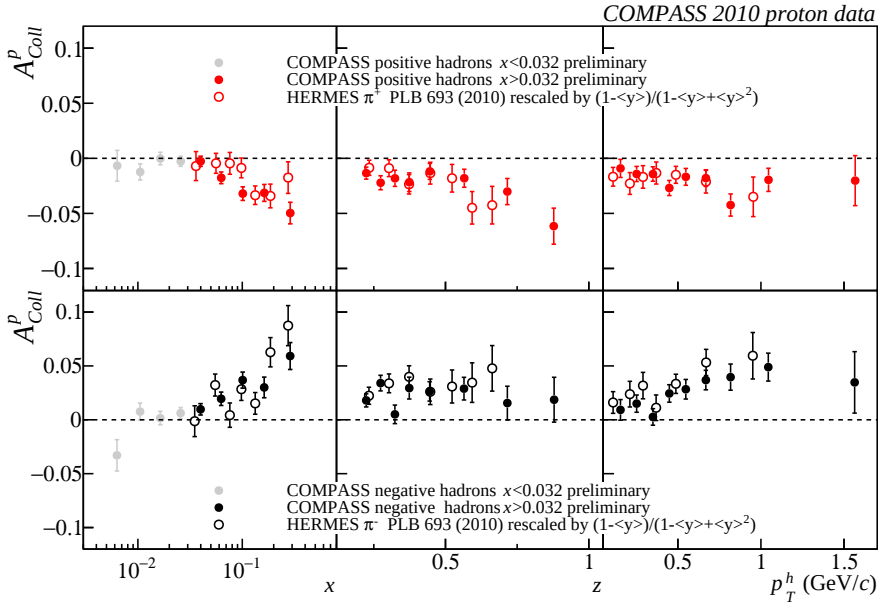


- Actually: 8 azimuthal modulation fit,
  independently for h^+, h^-, π^+,. . .

- Trends observed by **HERMES confirmed**
  w/ **improved precision**
- At **lower** x: $\Delta_T q(x)$ **compatible w/ 0**

- **Weak Q^2 dependence**, as seen
  comparing w/ HERMES (Q^2 3÷4 lower)
  or binning in y (*not shown*)



Cf. presentation by A. Martin

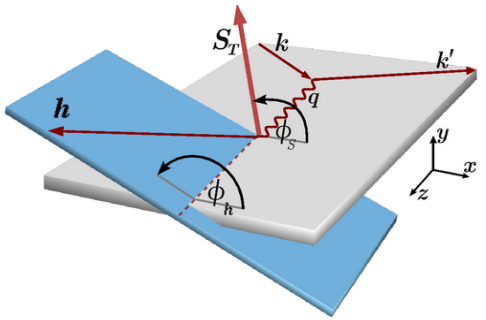
k_T dependent processes: Sivers

- Correlation of nucleon transverse spin w/ k_T of unpolarized q

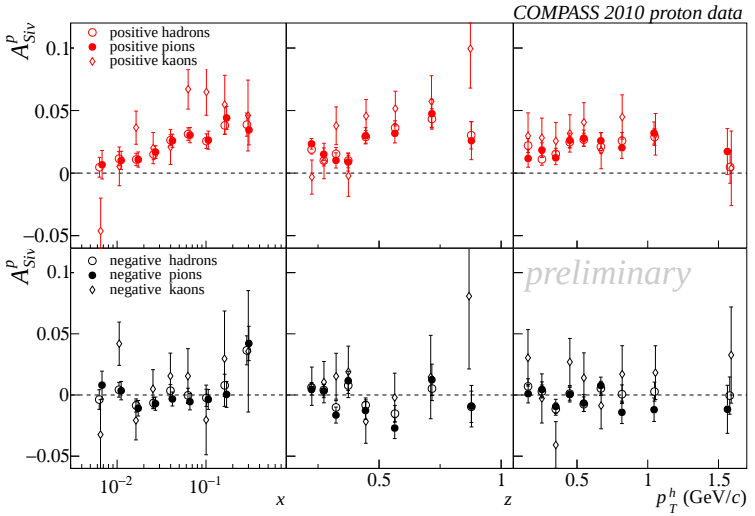
$$\Delta^N f_q(x, k_T^2)$$

convoluted with Fragmentation $D_q^h(z, k_T^2)$

$$A_{UT}^{h,sin(\phi_h - \phi_S)} \propto \sum e_q^2 \, \Delta^N f_q(x, k_T^2) \otimes D_q^h(z, p_\perp^2)$$



- Sivers for h, π and K



Cf. presentation by A. Martin

k_T dependent processes: Sivers

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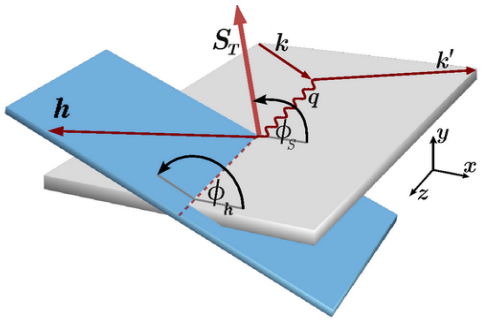
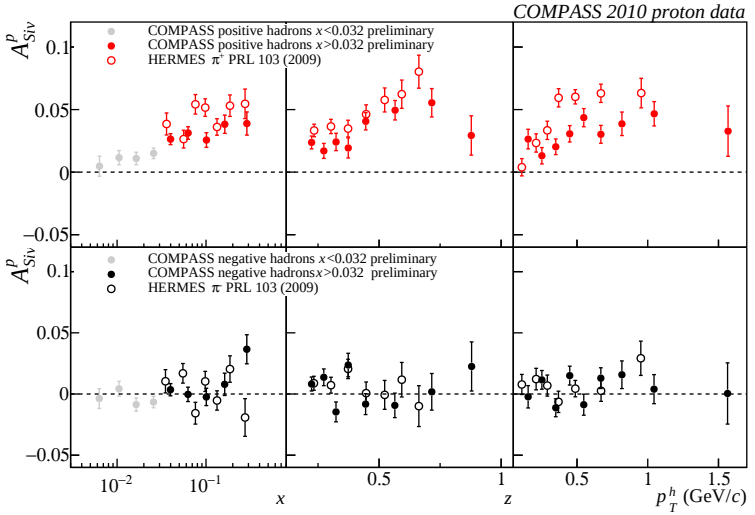


- Trends observed by **HERMES confirmed**
  over a **wider x range**
  down to 10^{-2}, asymmetry for h^+ **stays finite**

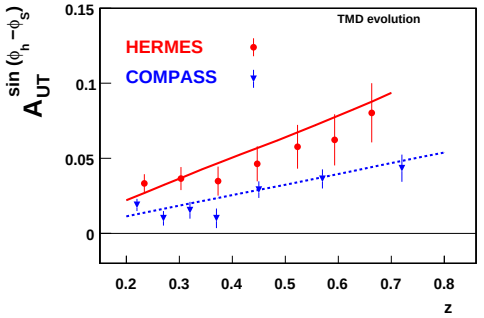
- **Strong Q^2 dependence** (*for* h^+), as seen
  comparing w/ HERMES (Q^2 3÷4 lower)
  or binning in y (*not shown*)



- Consistent w/ **suppression prescribed by TMD evolution**

  Aybat, Prokudin and Rogers, Phys. Rev. Lett. **108** *(2012)*

  arXiv:1112.4423 [hep-ph]



Cf. presentation by A. Martin

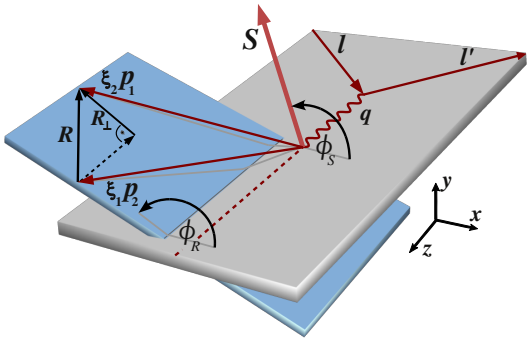
Interference Fragmentation $H_1^{\sphericalangle}$

- Transversely polarised q fragmenting into 2 unpolarized h

  $H_1^{\sphericalangle}(z, M^2_{h^+h^-})$

  Convolution w/ transversity: k_T integrated out

$$A_{UT}^{h,sin(\phi_R+\phi_S)} \propto sin\theta \sum e_q^2 \Delta^T q(x) H_1^{\sphericalangle}(z, M^2_{h^+h^-})$$

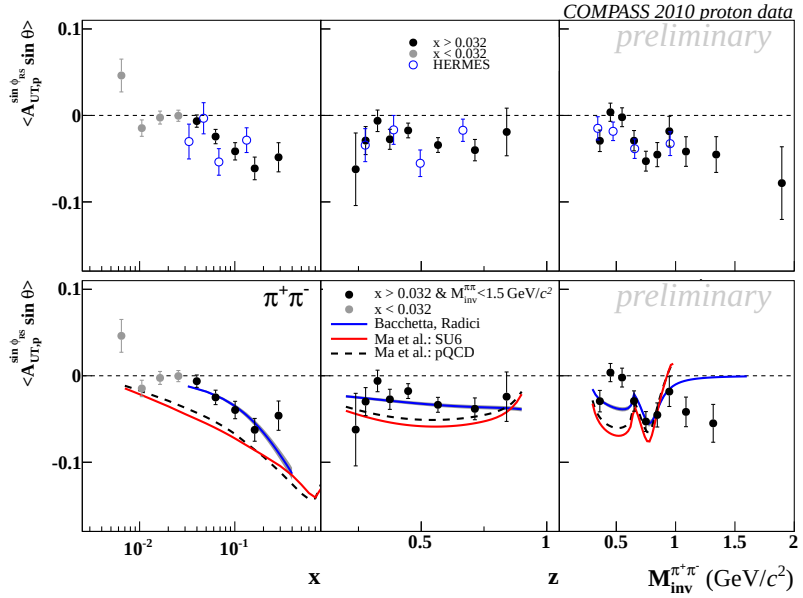


$\Rightarrow$ Alternative access to transversity
w/ easier evolution from e^+e^- measurements (of $H_1^{\sphericalangle}$) to fixed target SIDIS

- ID'd hadrons: $\pi^+\pi^-$, π^+K^-,. . .

- Agreement w/ HERMES in common range
  Wider range in x, z and M^2

- Reasonable agreement withmodels ($H_1^{\sphericalangle}$, $\Delta^T q$):
  Bacchetta and Radici arXiv:hep-ph/0608037
  Ma et al. arXiv:0711.0817 [hep-ph]



Cf. presentation by C. Braun

k_T dependent processes: SIDIS X-section

$$\frac{d\sigma}{dx\,dy\,d\psi\,dz\,d\phi_h\,dP_{h\perp}^2} = \frac{\alpha^2}{xyQ^2}\frac{y^2}{2\,(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Big\{F_{UU,T} + \varepsilon F_{UU,L} + \sqrt{2\,\varepsilon(1+\varepsilon)}\,\boldsymbol{\cos\phi_h}\,F_{UU}^{\cos\phi_h}$$

$$+\varepsilon\boldsymbol{\cos(2\phi_h)}\,F_{UU}^{\cos 2\phi_h} + \lambda_e\sqrt{2\,\varepsilon(1-\varepsilon)}\,\boldsymbol{\sin\phi_h}\,F_{LU}^{\sin\phi_h}$$

$$+S_L\left[\sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin\phi_h\,F_{UL}^{\sin\phi_h} + \varepsilon\sin(2\phi_h)\,F_{UL}^{\sin 2\phi_h}\right] + S_L\lambda_e\left[\sqrt{1-\varepsilon^2}\,F_{LL} + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_h\,F_{LL}^{\cos\phi_h}\right]$$

$$+|\boldsymbol{S}_T|\Big[\boldsymbol{\sin(\phi_h-\phi_S)}\left(F_{UT,T}^{\sin(\phi_h-\phi_S)} + \varepsilon\,F_{UT,L}^{\sin(\phi_h-\phi_S)}\right) + \varepsilon\,\boldsymbol{\sin(\phi_h+\phi_S)}\,F_{UT}^{\sin(\phi_h+\phi_S)}$$

$$+\varepsilon\,\boldsymbol{\sin(3\phi_h-\phi_S)}\,F_{UT}^{\sin(3\phi_h-\phi_S)} + \sqrt{2\,\varepsilon(1+\varepsilon)}\,\boldsymbol{\sin\phi_S}\,F_{UT}^{\sin\phi_S} + \sqrt{2\,\varepsilon(1+\varepsilon)}\,\boldsymbol{\sin(2\phi_h-\phi_S)}\,F_{UT}^{\sin(2\phi_h-\phi_S)}\Big]$$

$$+|\boldsymbol{S}_T|\lambda_e\left[\sqrt{1-\varepsilon^2}\,\boldsymbol{\cos(\phi_h-\phi_S)}\,F_{LT}^{\cos(\phi_h-\phi_S)} + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\boldsymbol{\cos\phi_S}\,F_{LT}^{\cos\phi_S} + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\boldsymbol{\cos(2\phi_h-\phi_S)}\,F_{LT}^{\cos(2\phi_h-\phi_S)}\right]$$

Kotzinian, Nucl. Phys. B **441** *(1995)* *Bacchetta et al. JHEP* **0702** *(2007)*

⇒ 14 azimuthal modulations. All measured at COMPASS

⇒ **Collins**, **Sivers** and **6 extra** **Transverse Spin Asymmetries**. All determined on proton target

⇒ **2 ×UU + 1×LU azimuthal modulations** Extracted from unpolarized deuteron data

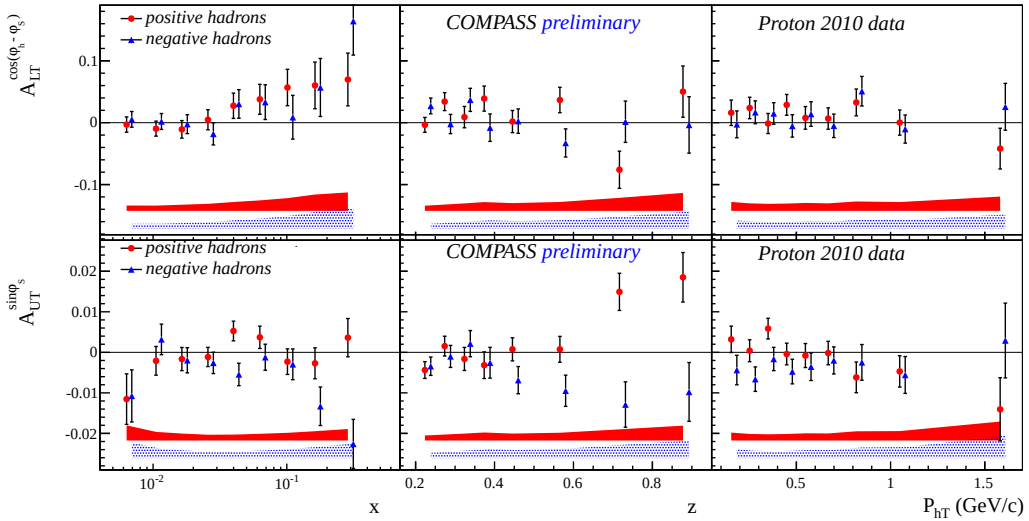
Longitudinal Spin Asymmetries: *Eur. Phys. J. C* **70** *(2010)* *arXiv:1007.1562 [hep-ex]]*

k_T dependent processes: 6 extra TSAs

- All 8 Transverse Spin modulations fitted at once

$\Rightarrow$ The 6 extra TSAs related to TMD DF $\otimes$ FF convolutions

- Clear signal seen on $A_{LT}^{cos(\phi_h - \phi_S)} \propto g_{1T}^q \otimes D_q^h$ $(worm\ gear)$
  and $A_{UT}^{sin\phi_S} \propto M/Q\ (h_1^q \otimes H_{1q}^{\perp h} + f_{1T}^{\perp q} \otimes D_q^h)$



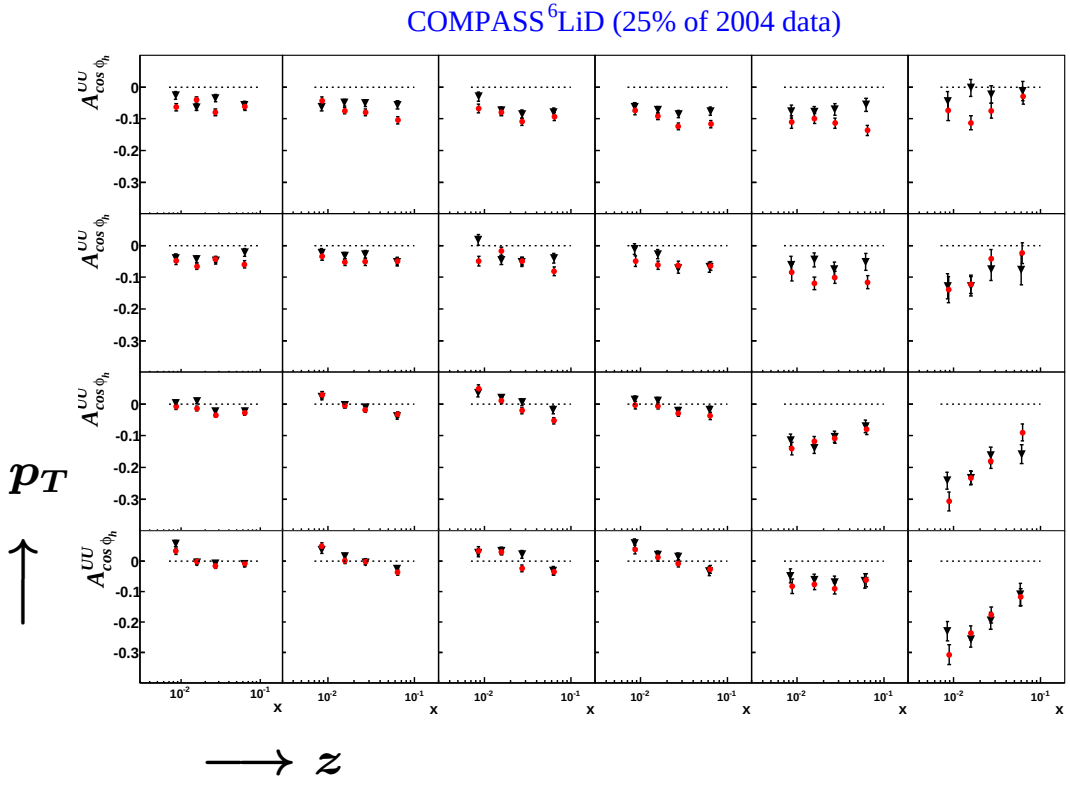
- All other 4 are compatible w/ 0
- Agreement w/ HERMES.
- Precision good enough to discriminate between models

Cf. presentation by B. Parsamyan

k_T dependent processes: Unpolarized azimuthal modulations

- $cos\phi_h$ and $cos2\phi_h$, related to combinations of **Cahn** effect and **Boer-Mulders** $h_1^\perp$ TMD
  - Large amplitudes, $h^+ \neq h^-$: shown at SPIN2010
  - Strong kinematical dependences, challenging theoretical models

- 3D analysis in x, z and p_T



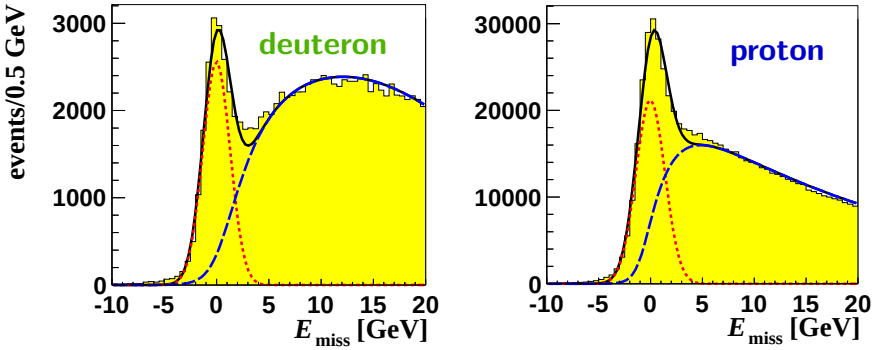
E.g. $A^{UU}_{cos\phi}$ *vs.* x in bins of z and p_T

- Complex structure

$\Rightarrow$ Interesting inputs for theory

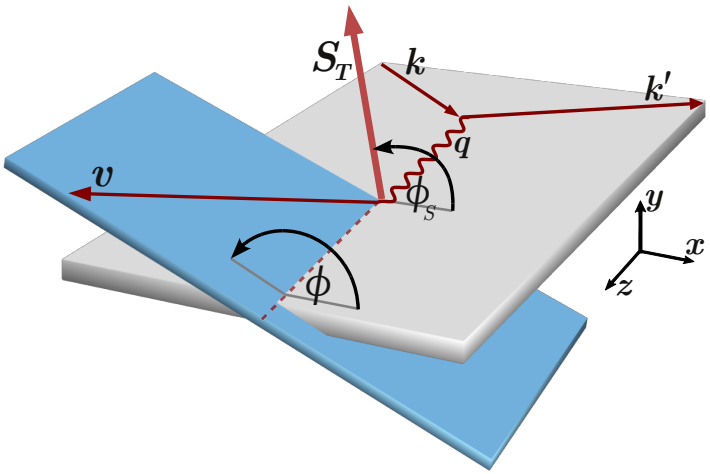
Cf. presentation by G. Sbrizzai

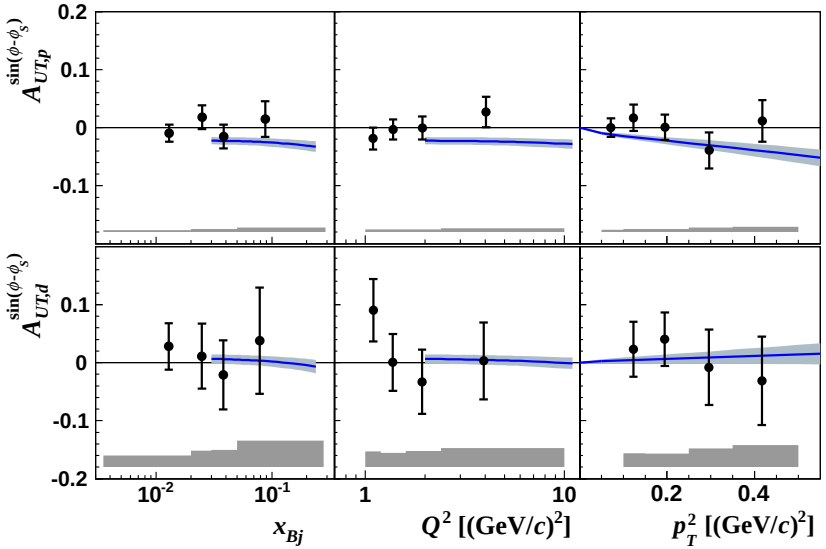
GPD: Deeply virtual exclusive ρ



- No Recoil detection $\Rightarrow$ High background, mainly from non-exclusive SIDIS. . .
- Subtracted based on LEPTO, rescaled by like-sign $h^{\pm}h^{\pm}$ pairs

- Analysis of deuteron and proton data: *Nucl. Phys. B* **865** *(2012) arXiv:1207.4301v1 [hep-ex]*
  - *Note: no separation longitudinal vs. transverse photon.*





- Comparison w/ *Goloskokov and Kroll, Eur. Phys. J. C* **59** *(2009) arXiv:0809.4126v1 [hep-ph]* gives access to combinations of GPDs E^u and E^d. . . w/ limited significance

Multiplicities: Single Hadron

- Single Hadron multiplicities for the purpose of measuring $D_q^h(z, Q^2)$
  - SIA in e^+e^- precise but sensitivity to flavour: weak, to charge: null
  - **COMPASS/SIDIS** offers

  . . . x and target dependence for **flavour/charge sensitivity**

  . . . **Extended scale coverage**, for evolution.

  . . . $\boldsymbol{K/\pi}$ **ID**

  . . . (*Disadvantage: possible non-perturbative corrections, nuclear* LiD *effects*)

- Global (e^+e^-,$p+p$,SIDIS) NLO framework: *DSS, Phys. Rev. D* **75** *(2007) arXiv:hep-ph/0703242*

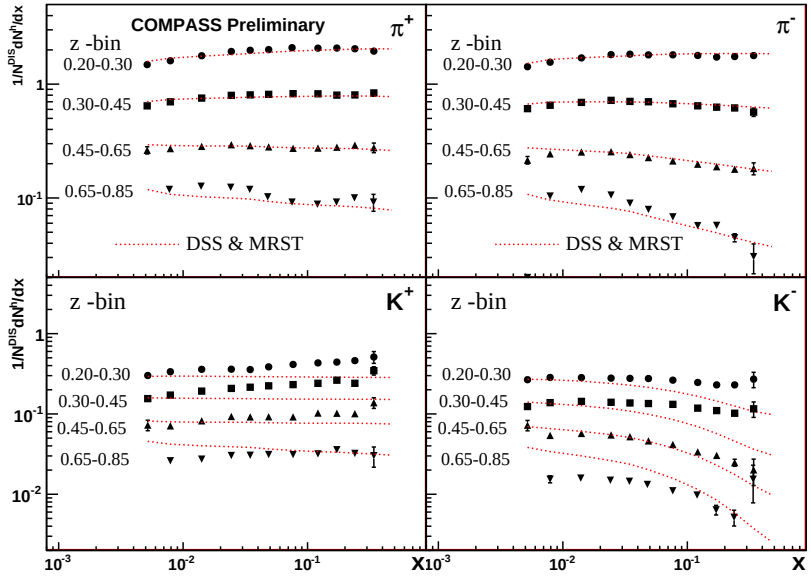
- **Multiplicities measured** on LiD

  Isoscalar target
  in $(\boldsymbol{x}, \boldsymbol{z})$ **bins**

- Presently trying to minimise systematics

  by confronting 2 experimental setups:
  2006 *vs.* 2004

  K^o also investigated



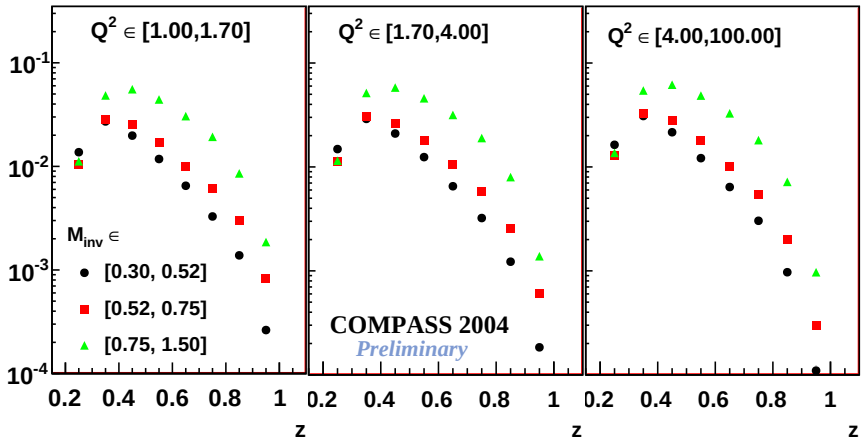
Multiplicities: Two hadrons

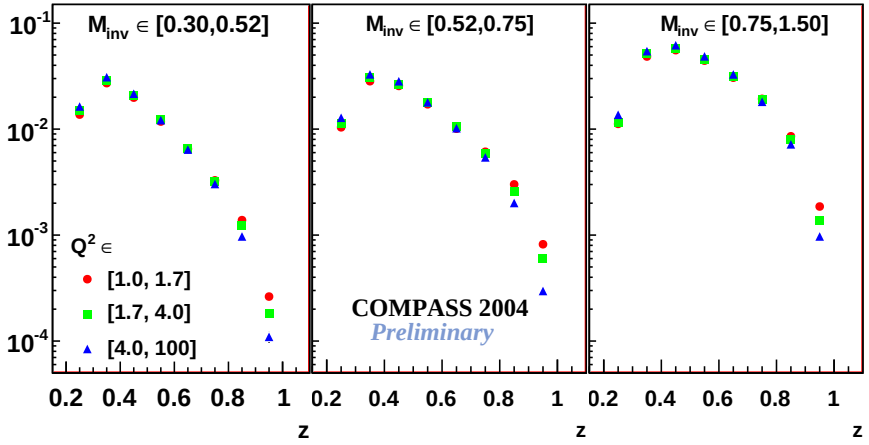
- For the purpose of measuring $D_q^{h^+,h^-}(z^+, z^-, Q^2) = D_q^h(z, M_h^2, Q^2)$
  not merely a trivial extension of the single hadron case

- In SIDIS: $A_{UT}^{sin(\phi_R+\phi_S)}(x, z, M_h^2) \propto \frac{\Sigma_q e_q^2 \Delta_T q(x) H_1^{\sphericalangle}(z,M_h^2)}{\Sigma_q e_q^2 q(x) D_q^h(z,M_h^2)}$

- Apart from SIDIS, useful to study in-medium effects in heavy-ion collisions

- **Measured** on LiD **(isoscalar)** in **3D bins** (z, M, Q^2)

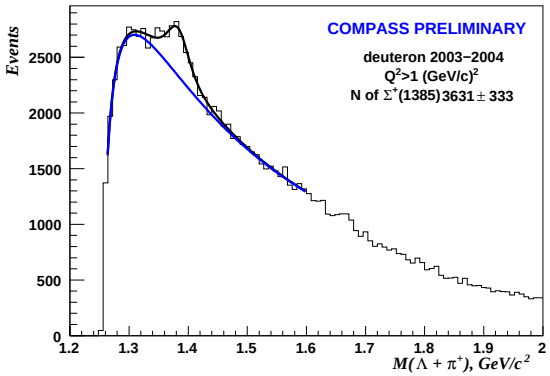




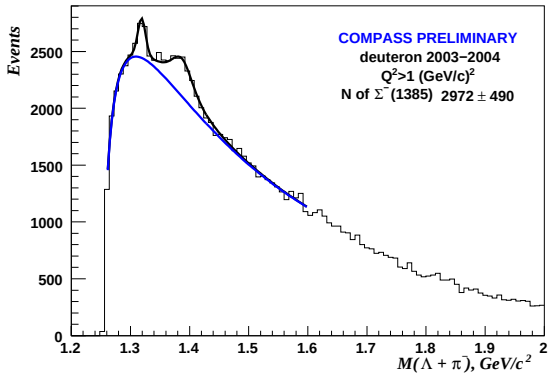
Cf. presentation by N. Makke

Λ

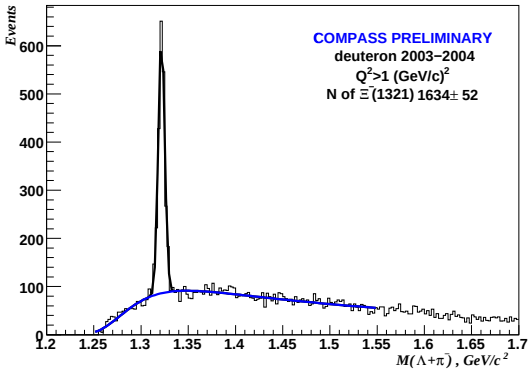
- **Measurement of hyperon ratios** H/Λ, $H = \Sigma^{*+}, \Sigma^{*-}, \Xi$ and cc $\bar{H}/\bar{\Lambda}$
- Tuning of JETSET to reproduce them
- MC evaluation of the **fraction of COMPASS Λ's** coming from hyperon decay (including Σ^0)



Σ^{*+}



Σ^{*-}



$[\Xi]$

Cf. presentation by N. Rossiyskaya

Conclusions

- Promising first results from 2011 Longitudinal data taking

- $\Delta G/G$ toward NLO accuracy

- Transverse spin and TMDs:

  - Confirmation of HERMES results w/ improved precision and over extended range
  - First evidence of the strong Q^2 evolution of TMDs.

  New global fit of HERMES + BELLE + COMPASS welcome

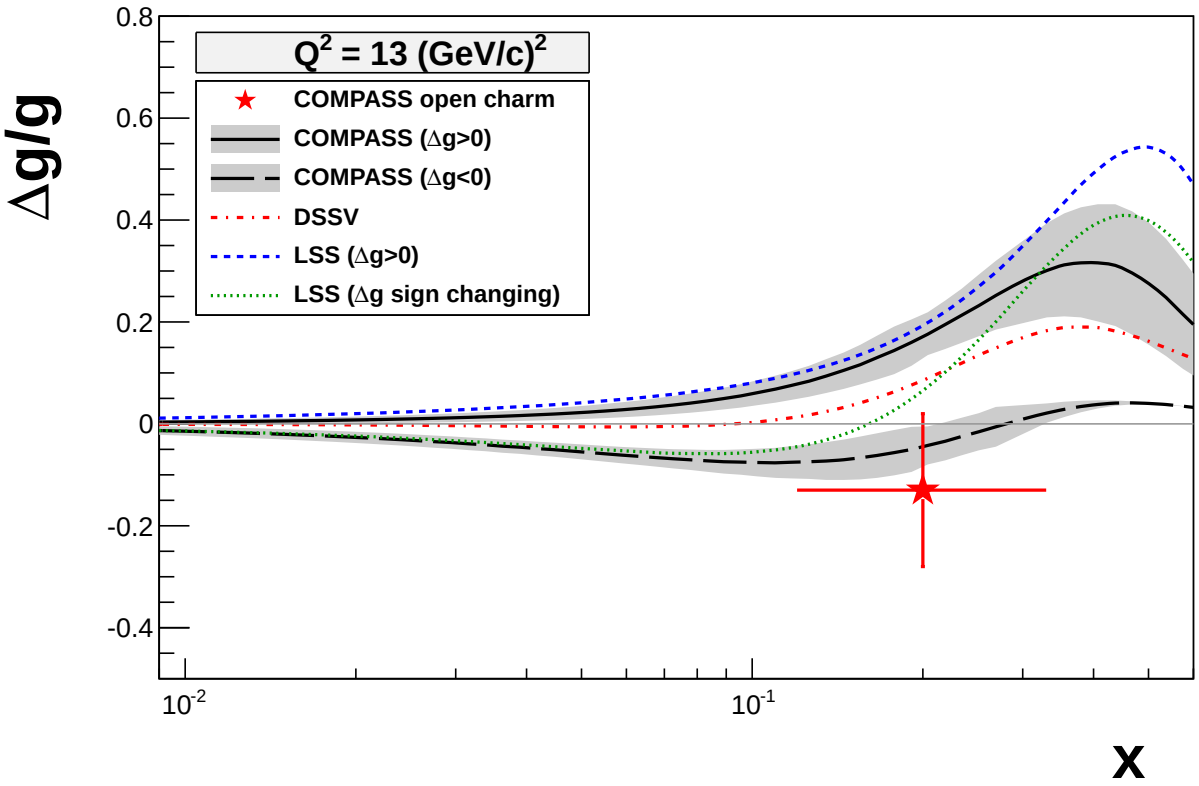
  Valuable inputs for our planned Drell-Yan run

- GPD: lack of statistical significance $\Rightarrow$ dedicated measurement

SPARES

ΔG: Global DIS + open charm NLO fit

- NLO corrected $\Delta G/G$ included in NLO QCD fit of polarised parton distributions



COMPASS: Asymmetry Measurement

- **Simultaneous** recording of the two spin states in oppositely polarised target cells. . .

. . . 2 cells: $1/2 \uparrow 1/2 \downarrow \Longleftarrow 8\,hours \Longrightarrow 1/2 \downarrow 1/2 \uparrow$

. . . 3 cells: $1/4 \uparrow 2/4 \downarrow 1/4 \uparrow \Longleftarrow 24\,hours \Longrightarrow 1/4 \downarrow 2/4 \uparrow 1/4 \downarrow$

  - Reversal by field rotation to cancel acceptance diff

$$\frac{A^{\parallel}}{D} = \frac{1}{|P_\mu P_T| f D} \frac{1}{2} \left(\frac{N^{\Uparrow\downarrow} - N^{\Uparrow\uparrow}}{N^{\Uparrow\downarrow} + N^{\Uparrow\uparrow}} + \frac{N^{\Uparrow\downarrow} - N^{\Uparrow\uparrow}}{N^{\Uparrow\downarrow} + N^{\Uparrow\uparrow}} \right) \qquad D = Depolarisation\ factor$$

LiD: $P_\mu \times D \times P_T \times f \simeq 80\% \times 60\% \times 50\% \times 40\% \simeq 10\%$ *(typical values)*

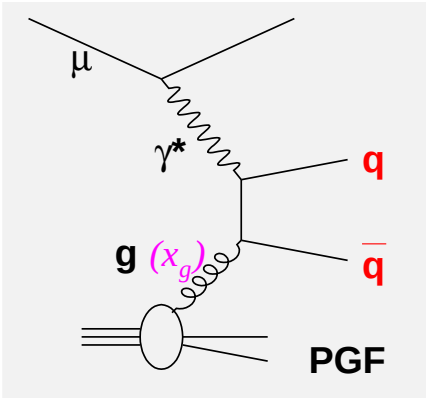
NH_3: . . . $P_T \times f \simeq$ . . . $85\% \times 16\% \simeq 6\%$

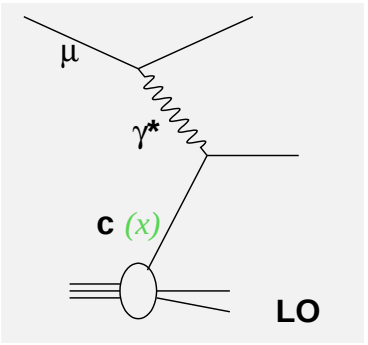
- Reversal *via* micro-wave once per year of data taking to cancel field/acceptance correlation
- Weighted asymmetry

$$\frac{A^{\parallel}}{D} = \frac{1}{P_T} \frac{1}{2} \left(\frac{\sum^{\Uparrow\downarrow} w \ - \sum^{\Uparrow\uparrow} w}{\sum^{\Uparrow\downarrow} w^2 + \sum^{\Uparrow\uparrow} w^2} + \frac{\sum^{\Uparrow\downarrow} w \ - \sum^{\Uparrow\uparrow} w}{\sum^{\Uparrow\downarrow} w^2 + \sum^{\Uparrow\uparrow} w^2} \right) \qquad w = P_\mu\, f\, D$$

$\Rightarrow$ Gain in precision $= \sqrt{\langle w^2 \rangle / \langle w \rangle^2}$

ΔG: Open charm *vs.* high p_T





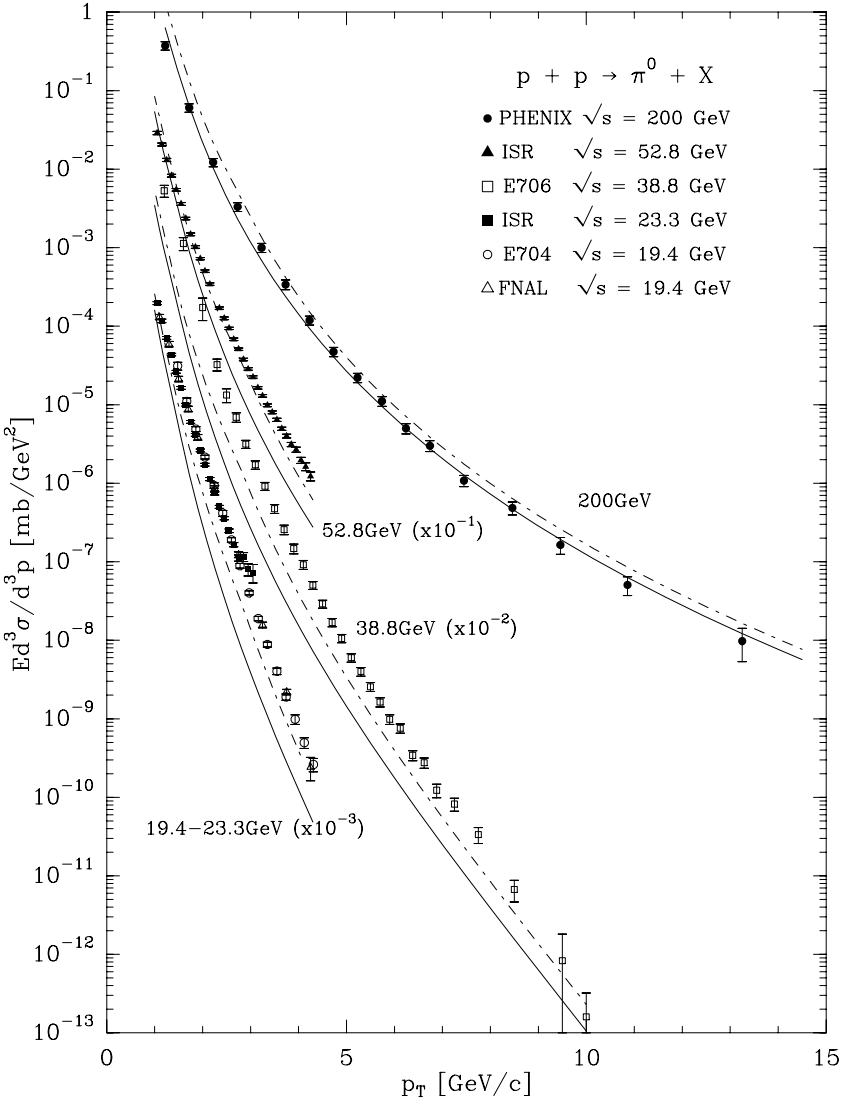
Intrinsic charm: Expected at large x
*(Brodsky et al., Phys.Lett. B**93** (1980))*
Probed here at $x = 10^{-4} \div 10^{-2} \ll x_g$
$\Rightarrow$ Neglect intrinsic charm

- **q = c**: **Open Charm** production
  - PGF enters alone at LO
  - Resolved γ small (high x_γ)

  $\Rightarrow$ COMPASS Golden Channel
  - Experimentally difficult
  - pQCD scale set by $\hat{s} > 4m_c^2$

- **q = u,d,s,c**: **High-p_T** Hadrons
  - Competing LO-DIS, QCD-Compton
  - At low Q^2: Competing resolved γ processes.
  - Experimentally: Higher statistics
  - pQCD scale set by p_T or Q^2

ΔG: High p_T Hadron $p+p$ production *vs.* $\sqrt{s}$



Bourrely and Soffer,
Eur. Phys. J. C **36** *(2004)*
[arXiv:hep-ph/0311110]

$\Rightarrow$ Need validate pQCD framework in COMPASS ($\sqrt{s} \simeq 17$ GeV) case