Extraction of pPDFs from pDIS/pSIDIS at NLO

Rodolfo Sassot

Universidad de Buenos Aires

DIS05, Madison April 27, 2005

In collaboration with D. de Florian and G. Navarro,

based on hep-ph/0504155 and references therein.

Outline:

- role of pDIS and pSIDIS in the extraction of pPDFs.

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- results from a NLO combined global analysis

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- uncertainties in future/ongoing measurements

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- pSIDIS as a way out:

SMC @ CERN:	first steps; encouraging
HERMES @ DESY:	from consistency checks to constraints
COMPASS @ CERN:	…..
E04-113 @ JLAB:	…..

pDIS/pSIDIS I

$$A_1^N(x,Q^2) = \frac{g_1^N(x,Q^2)}{F_1^N(x,Q^2)}$$

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$$g_1^N(x_{Bj},Q^2) = \frac{1}{2}\Sigma e_q^2 \left\{ \Delta q + \frac{\alpha_s}{2\pi}\left[C_q \otimes \Delta q + C_g \otimes \Delta g \right] \right\}$$

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$$g_1^{p,n} = \left[\pm \frac{1}{12}\Delta q_3 + \frac{1}{36}\Delta q_8 + \frac{1}{9}\Delta\Sigma\right] \otimes \left(1 + \frac{\alpha_s}{2\pi} C_q\right) + \Sigma\, e_q^2\, \frac{\alpha_s}{2\pi}\, C_g \otimes \Delta g$$

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$$\Delta\Sigma = (\Delta u + \Delta\bar{u}) + \left(\Delta d + \Delta\bar{d}\right) + (\Delta s + \Delta\bar{s})$$
$$\Delta q_3 = (\Delta u + \Delta\bar{u}) - \left(\Delta d + \Delta\bar{d}\right)$$
$$\Delta q_8 = (\Delta u + \Delta\bar{u}) + \left(\Delta d + \Delta\bar{d}\right) - 2\,(\Delta s + \Delta\bar{s})$$

pDIS/pSIDIS II

$$A_1^{Nh}(x,Q^2)\,|_Z \simeq \frac{\int_Z\, dz\, g_1^{Nh}(x,z,Q^2)}{\int_Z\, dz\, F_1^{Nh}(x,z,Q^2)},$$

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D. de Florian et al. Nuc.Phys.B470 (1996) 195
M. Stratmann W.Vogelsang Phys.Rev.D64 (2001) 114007

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$$2\,g_1^{p\,\pi^{+(-)}} \sim \frac{4}{9}(\Delta u+\Delta\overline{u})\,D^{\pi}_{1(2)} + \frac{1}{9}\left(\Delta d+\Delta\overline{d}\right) D^{\pi}_{2(1)} + \frac{1}{9}\left(\Delta\overline{d}-4\Delta\overline{u}\right)\left(D^{\pi}_{1(2)}-D^{\pi}_{2(1)}\right) + \frac{1}{9}(\Delta s+\Delta\overline{s})\,D^{\pi}_{s}$$

$$D_u^{\pi^+} = D_d^{\pi^-} \equiv D_1^{\pi}$$
$$D_d^{\pi^+} = D_u^{\pi^-} \equiv D_2^{\pi}$$

NLO combined analysis: parameterizations

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pDIS can probe:

$$x(\Delta q + \Delta \bar{q}) = N_q \frac{x^{\alpha_q}(1-x)^{\beta_q}(1+\gamma_q\, x^{\delta_q})}{B(\alpha_q+1,\beta_q+1)+\gamma_q\, B(\alpha_q+\delta_q+1,\beta_q+1)}, \quad q = u, d$$

$$x(\Delta s + \Delta \bar{s}) = 2N_s \frac{x^{\alpha_s}(1-x)^{\beta_s}}{B(\alpha_s+1,\beta_s+1)},$$

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$Q_0^2 = 0.5\,\mathrm{GeV}^2$

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$$N_u + N_d - 4N_s = (3F-D)(1+\epsilon_{SU(3)})$$

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positivity relative to MRST02: $|\Delta q| \leq q$

A.D. Maritn et al. Eur.Phys.J.C28 (2002) 455

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➡ 20 parameters

positivity relative to MRST02: $|\Delta q| \le q$

A.D. Maritn et al. Eur.Phys.J.C28 (2002) 455

NLO combined analysis: data

Collaboration	Target	Final state	# points
EMC	proton	inclusive	10
SMC	proton,deuteron	inclusive	12, 12
E-143	proton,deuteron	inclusive	82, 82
E-155	proton,deuteron	inclusive	24, 24
Hermes	proton,deuteron,helium	inclusive	9, 9, 9
E-142	helium	inclusive	8
E-154	helium	inclusive	17
Hall A	helium	inclusive	3
COMPASS	deuteron	inclusive	12
SMC	proton,deuteron	h^+, h^-	24, 24
Hermes	proton,deuteron,helium	h^+, h^-, π^+, π^-, K^+, K^-, K^T	36,63,18
Total			478

$Q^2 > 1\text{GeV}^2$

Fragmentation functions input:

KRE: S. Kretzer Phys.Rev.D62 054001 (2000)

KKP: B. A. Kniehl, G. Kramer, B. Potter, Nucl.Phys.B582 514 (2000)

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flavor separation:

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Results:

set		χ^2	χ^2_{pDIS}	χ^2_{pSIDIS}
NLO	KRE	430.91	206.01	224.90
	KKP	436.17	205.66	230.51

478-20=458 d.o.f
313 pDIS
165 pSIDIS

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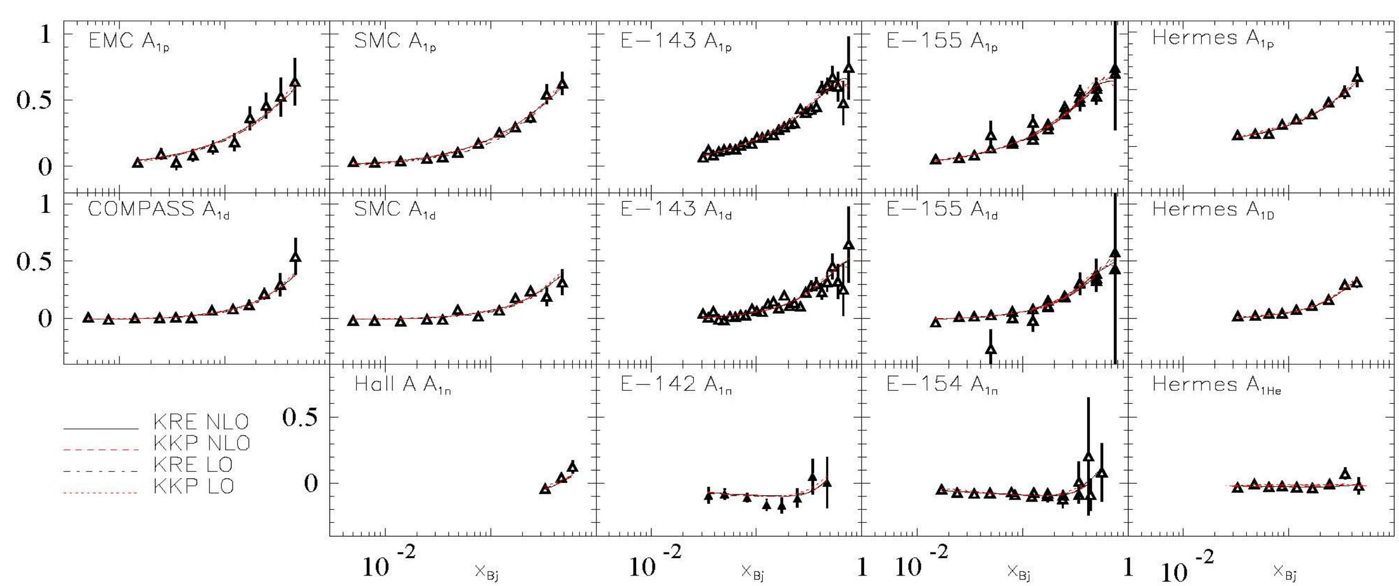

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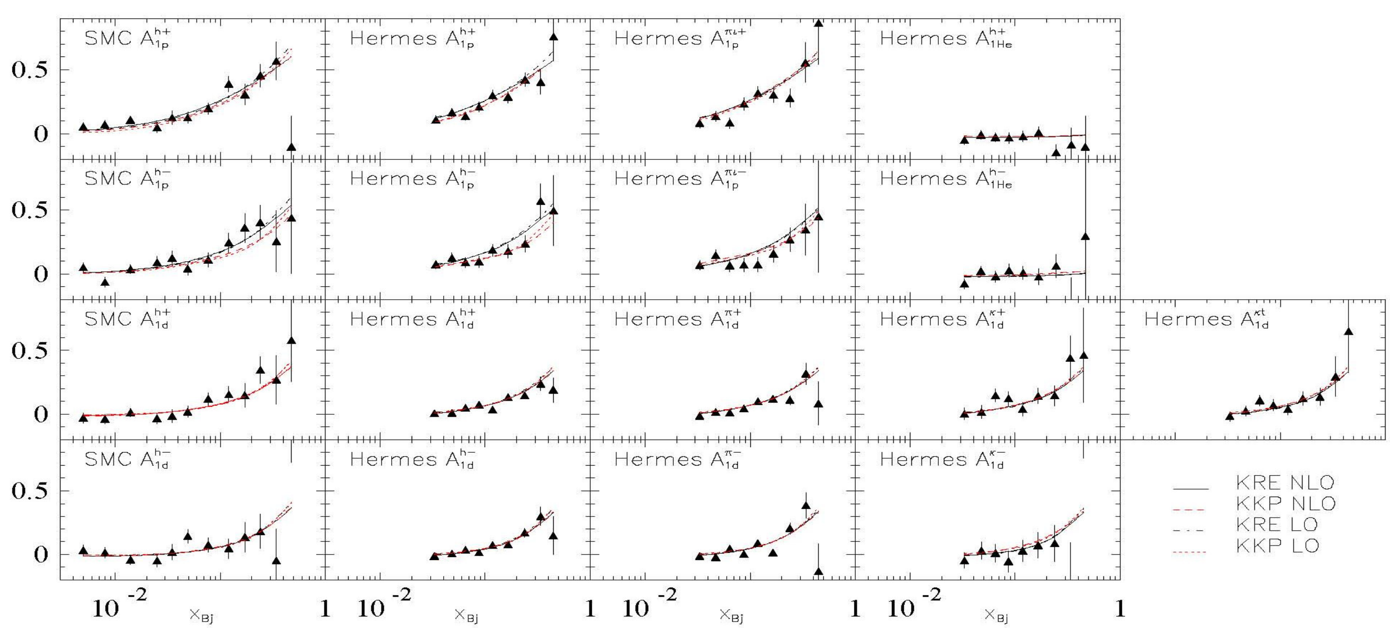
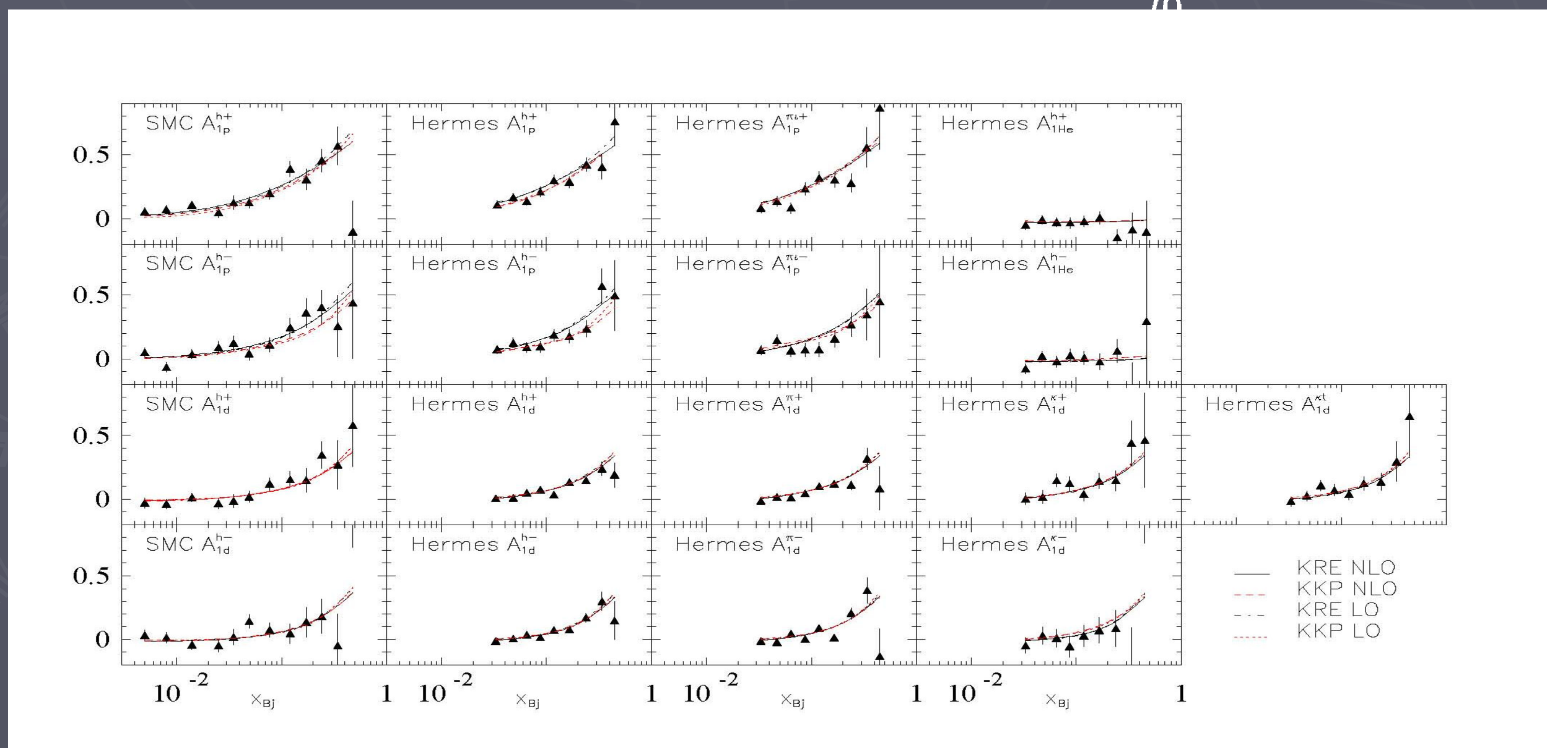


Results:

set		χ^2	χ^2_{pDIS}	χ^2_{pSIDIS}	δu_v	δd_v	$\delta\bar{u}$	$\delta\bar{d}$	$\delta\bar{s}$	δg	$\delta\Sigma$
NLO	KRE	430.91	206.01	224.90	0.936	-0.344	-0.0487	-0.0545	-0.0508	0.680	0.284
	KKP	436.17	205.66	230.51	0.700	-0.255	0.0866	-0.107	-0.0454	0.574	0.311
LO	KRE	457.54	213.48	244.06	0.697	-0.248	-0.0136	-0.0432	-0.0415	0.121	0.252
	KKP	448.71	219.72	228.99	0.555	-0.188	0.0497	-0.0608	-0.0365	0.187	0.271

478-20=458 d.o.f
313 pDIS
165 pSIDIS

$$\delta q \equiv \int_0^1 dx\, \Delta q \quad @\,10\,\text{GeV}^2$$

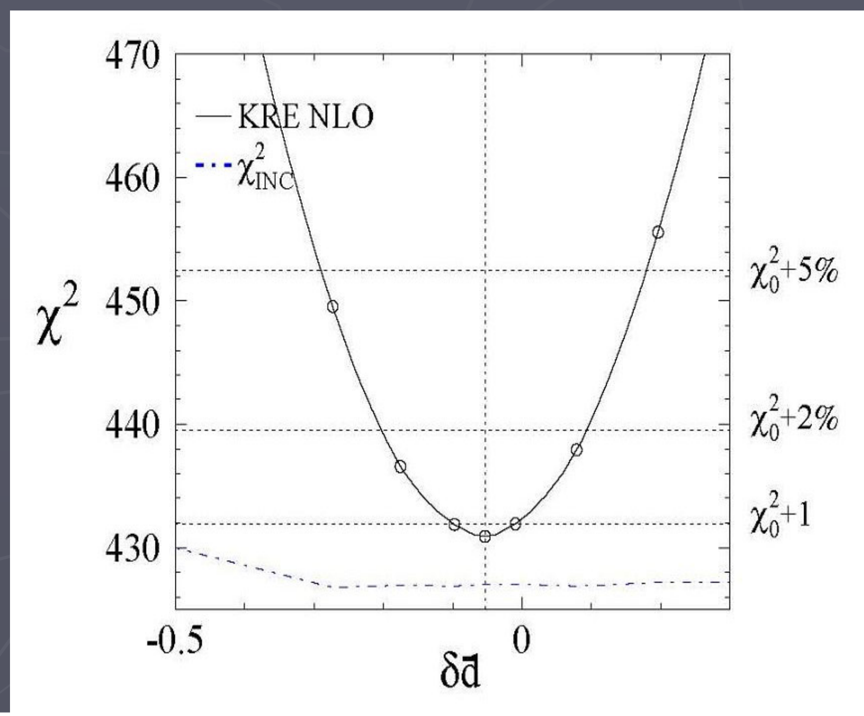


Uncertainties:

$$\Phi(\lambda_i, a_j) = \chi^2(a_j) + \sum_i \lambda_i O_i(a_j)$$

J. Pumplin et al. Phys.Rev.D65 014011 (2002)

$$\Phi(\lambda_q, a_j) = \chi^2(a_j) + \lambda_q \delta q(a_j) \qquad q = u, \overline{u}, d, \overline{d}, s, g$$



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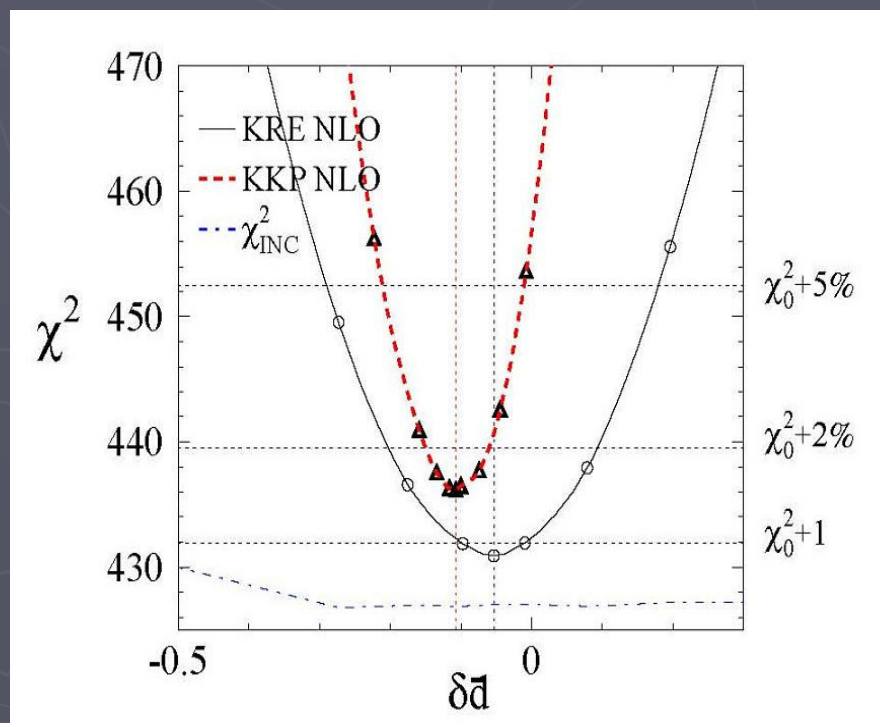

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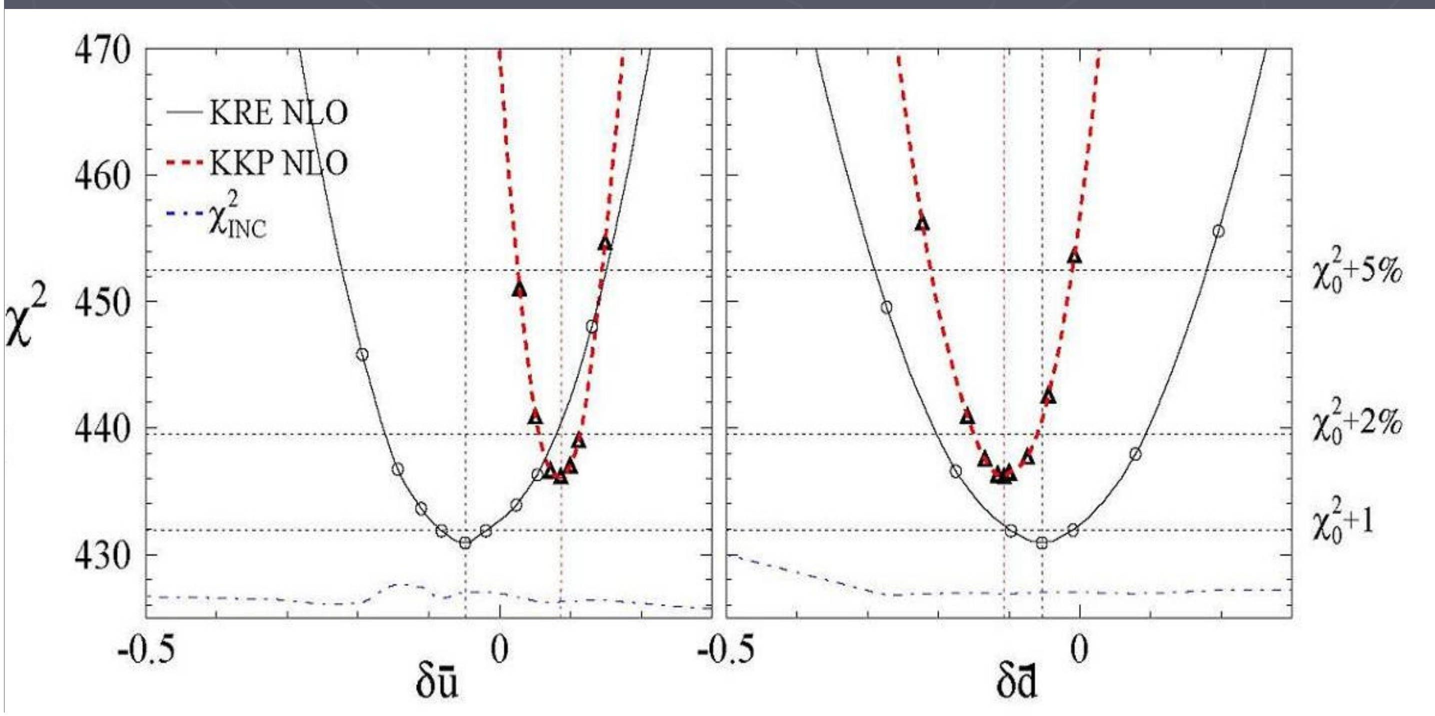

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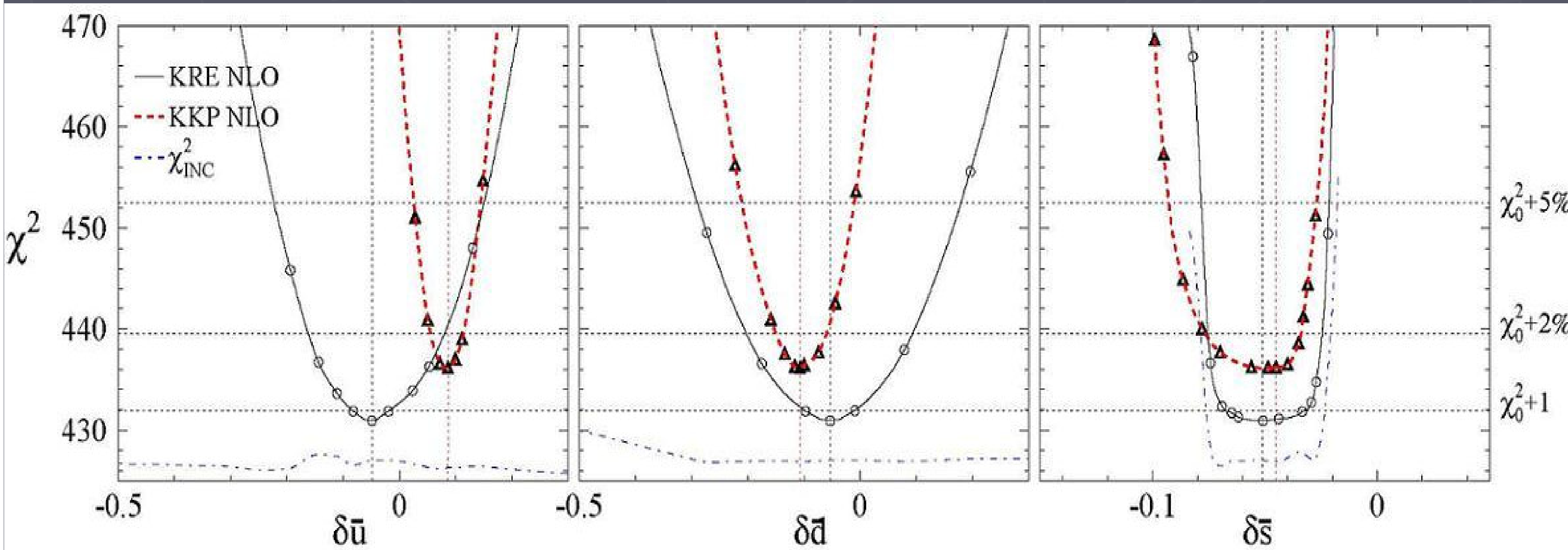
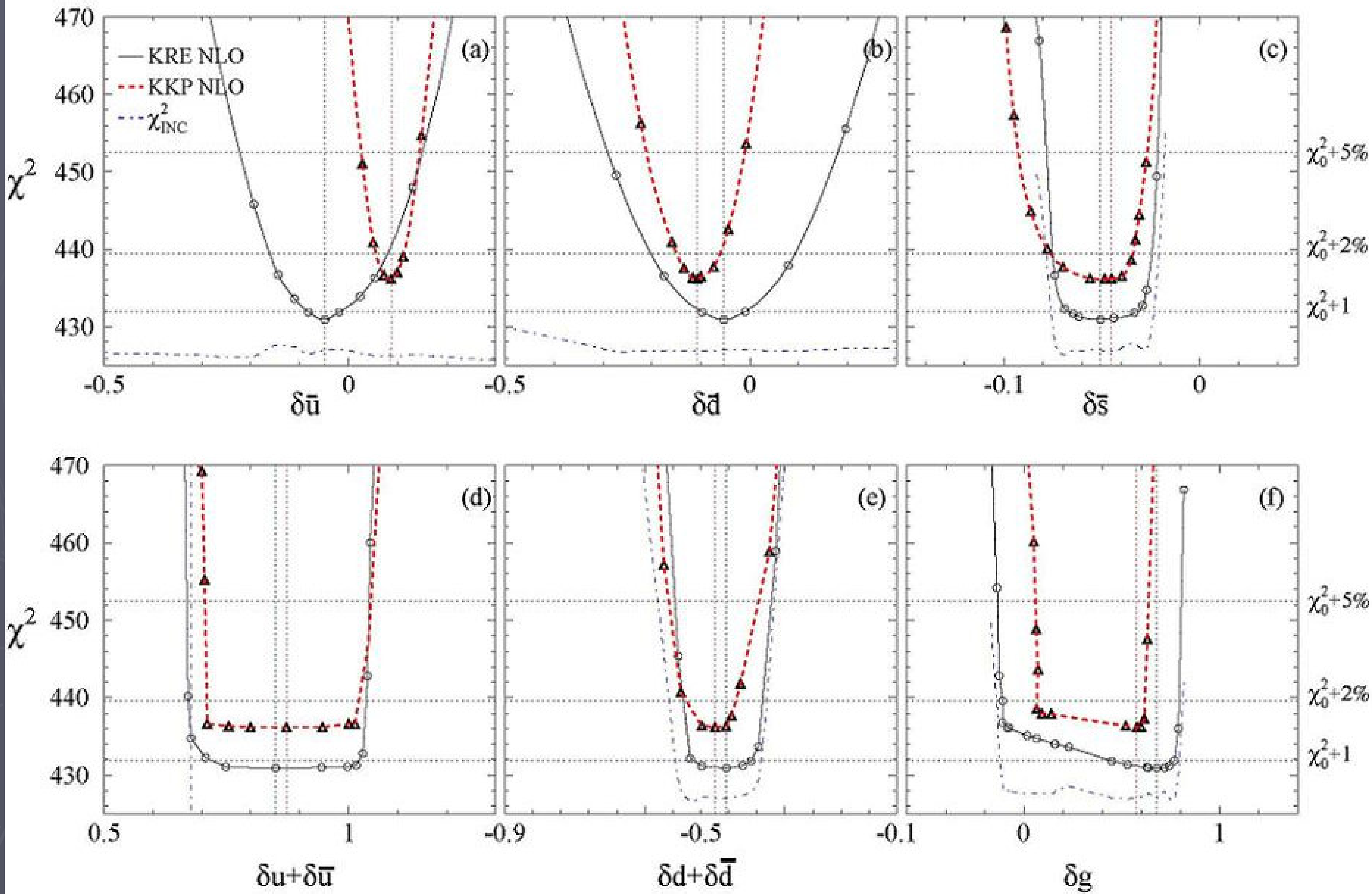
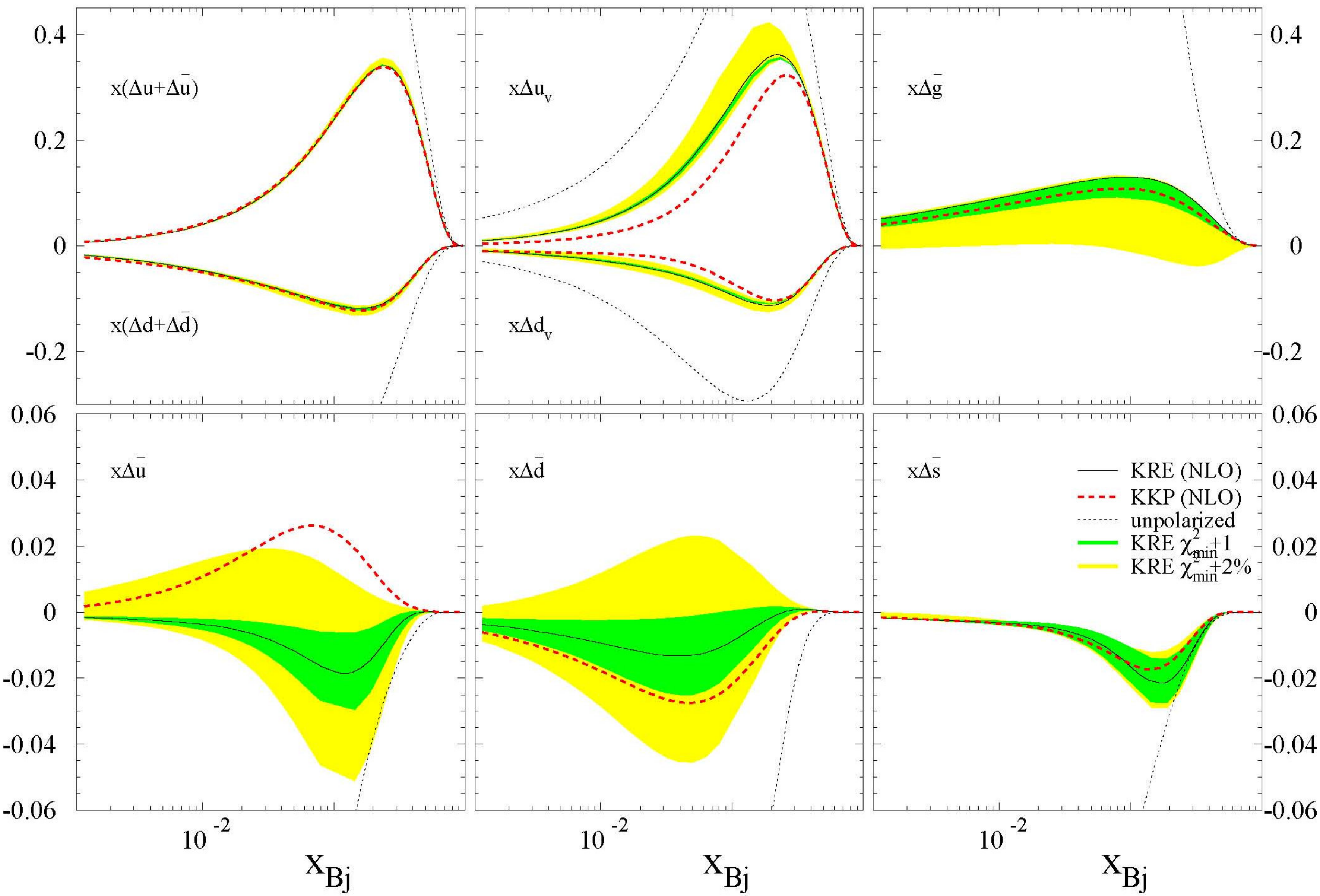




KRE NLO
KKP NLO
χ²INC
χ²
(a)
(b)
(c)
(d)
(e)
(f)
δū
δd̄
δs̄
δu+δū
δd+δd̄
δg
χ0²+5%
χ0²+2%
χ0²+1



x(Δu+Δū)
x(Δd+Δd̄)
xΔu_v
xΔd_v
xΔg
xΔū
xΔd̄
xΔs̄
KRE (NLO)
KKP (NLO)
unpolarized
KRE χ²_min+1
KRE χ²_min+2%
0.4
0.2
0
-0.2
0.06
0.04
0.02
-0.02
-0.04
-0.06
10^-2
x_Bj

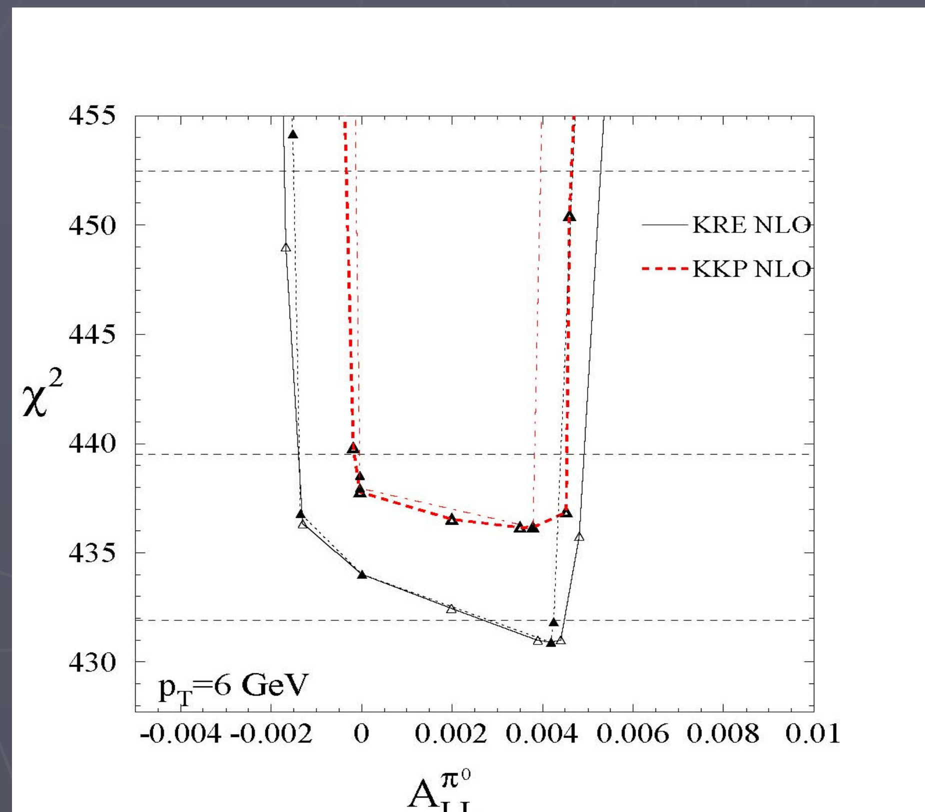
Future/ongoing measurements:

$$A_{LL}^{\pi^0} = \frac{d\Delta\sigma^{pp\to\pi^0 X}}{d\sigma^{pp\to\pi^0 X}}$$

PHENIX @ RHIC

Y. Fukao hep-ex/0501049

$$\Phi(\lambda, a_j) = \chi^2(a_j) + \lambda A_{LL}(a_j)$$



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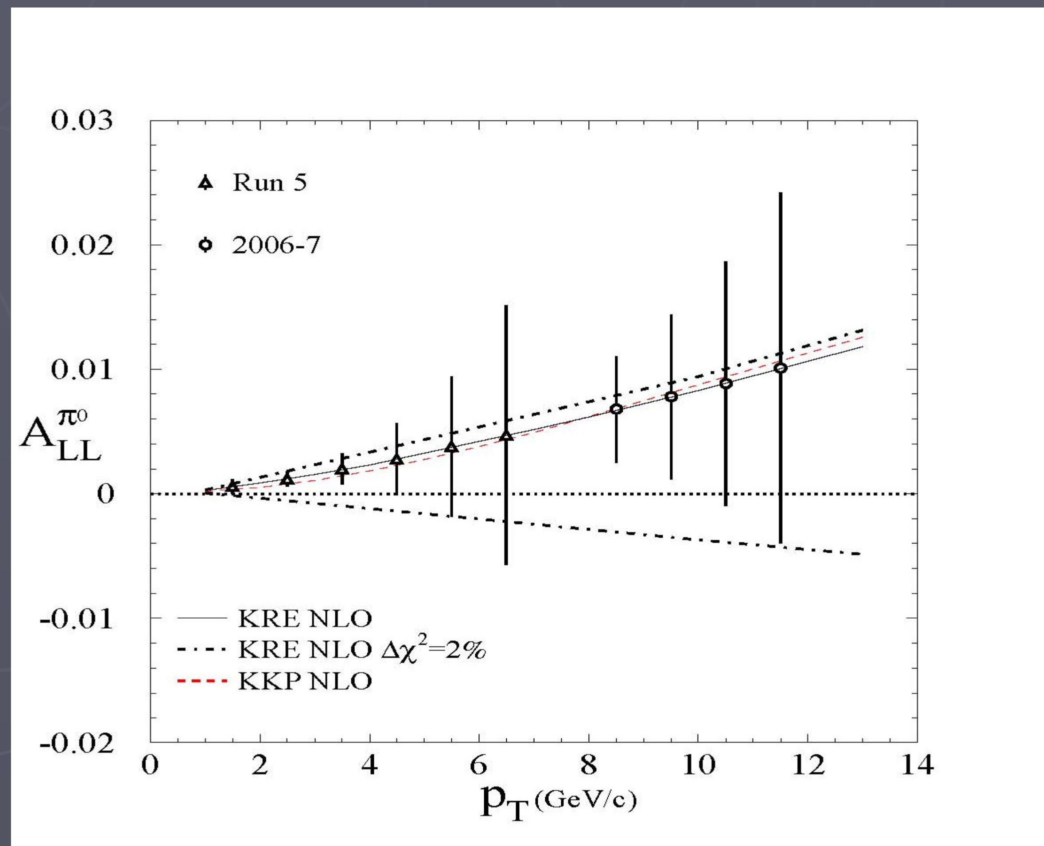
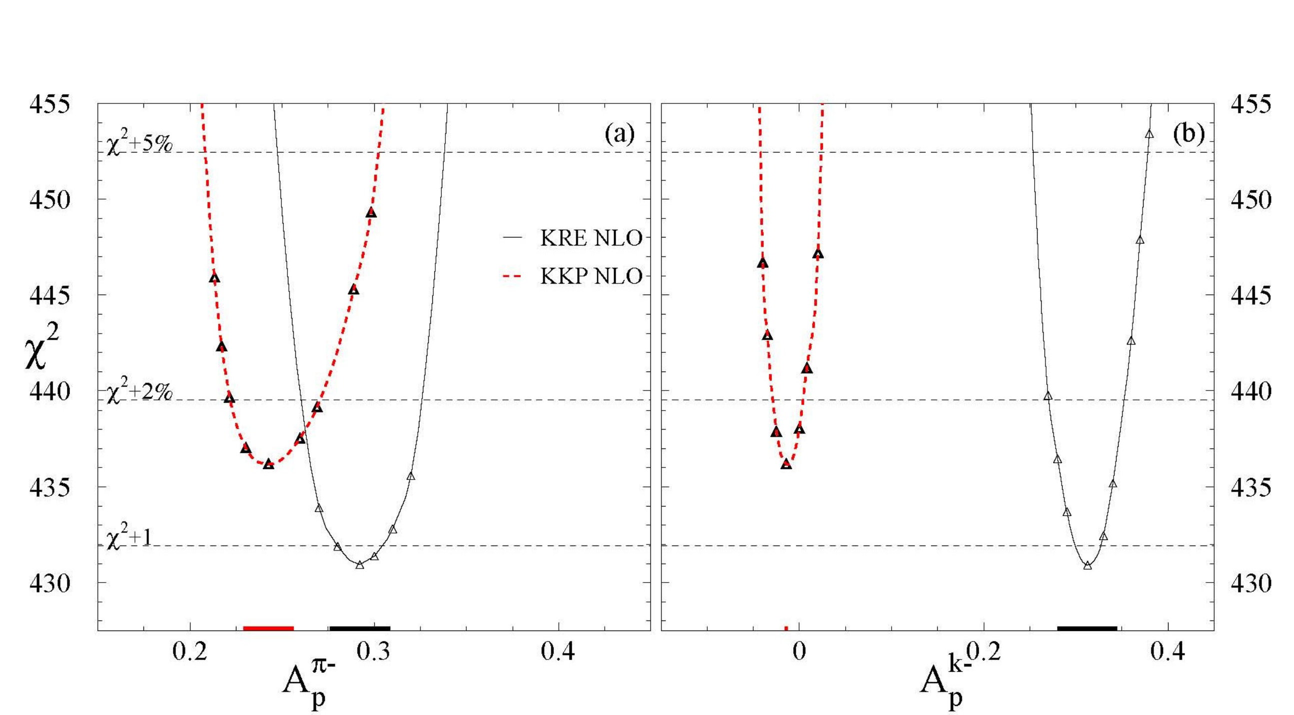


Future/ongoing measurements:

$A_p^{\pi}, A_p^{K}\, A_D^{\pi}\, A_D^{K}$ COMPASS @ CERN A. Bressan , hep-ex/0501040

E04-113 @ JLAB X. Jiang et al. , hep-ex/041203



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- future prospects: encouraging
  - PHENIX: Δg
  - COMPASS & E04-113 $\Delta \bar{q}$ and FFs