What Is the Proton Spin Problem All About,

Stefano Forte
Università di Milano

WHAT IS THE PROTON SPIN PROBLEM ALL ABOUT,

AND WHEN ARE WE GOING TO SORT IT OUT?

STEFANO FORTE
UNIVERSITÀ DI MILANO

SUMMARY

- WHERE DO WE COME FROM?: THE NUCLEON SPIN PROBLEM
  - POLARIZED STRANGENESS IN THE NUCLEON: Δs
  - THE AXIAL ANOMALY AND POLARIZED GLUE: Δg
  - THE QCD VACUUM AND INSTANTONS
  - WHAT WE'D LIKE TO KNOW
- WHERE DO WE STAND NOW?: UNPOL. EXPERIENCE VS POL. RESULTS
  - THE GLUON: SCALING VIOLATIONS
  - STRANGENESS: NEUTRINO DATA
  - POLARIZED TROUBLE AND SEMI-INCLUSIVE DATA
  - POLARIZED GLOBAL FITS
- WHERE ARE WE GOING?: HADRONIC PROCESSES AND GLOBAL FITS
  - THE ROLE OF HADRONIC DATA IN UNPOLARIZED FITS
  - HADRONIC DATA: POLARIZED EXPECTATIONS
  - CAN WE TRUST PARTON FITS?
  - NEW IDEAS: NEURAL NETWORKS

PAST

THE NUCLEON SPIN: WHAT IS THE PROBLEM?

AXIAL CHARGES (for flavor i): $\langle N;\, p, s | J^{\mu}_{5,\, i} | N;\, p, s \rangle = a_i M_N s^{\mu}$

SINGLET AXIAL CHARGE $\Longrightarrow$ QUARK SPIN FRACTION (??)

$$a_0 \equiv \sum_{i=1}^{n_f} a_i = \int_0^1 dx \sum_{i=1}^{n_f} (\Delta q_i + \Delta \bar{q}_i) + O(\alpha_s)$$

MEASURED TO BE SMALL: $a_0 = 0.18\,^{+0.17}_{-0.11}$ $(Q^2 = 10)$ GeV^2

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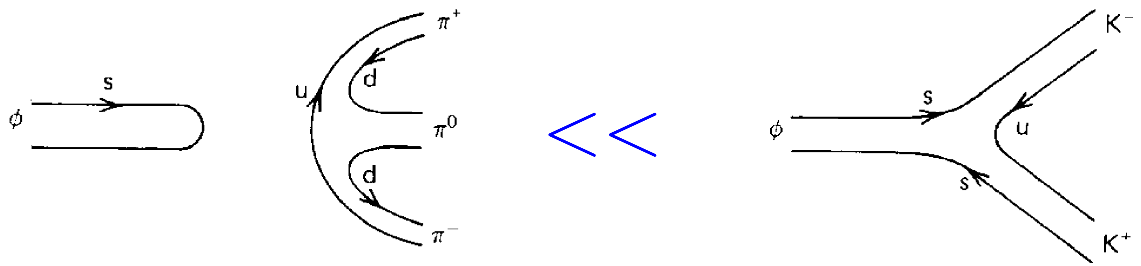
OZI VIOLATION!

OZI RULE:



EXPECT $a_0 \equiv \Delta u + \Delta d + \Delta s \;\approx a_8 \equiv \Delta u + \Delta d - 2\Delta s$ (OZI $\rightarrow$ Ellis-Jaffe S. R.)

GET $a_8 = 0.58 \pm 0.03 >> a_0 = 0.18^{+0.17}_{-0.11}$

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SOLUTIONS

- THE OCTET AXIAL CHANNEL IS SPECIAL BECAUSE OF

  SU(3) SPIN STRUCTURE $\Rightarrow$ POLARIZED STRANGENESS Δs

  (SEA POLARIZATION, SKYRMIONS,. . .)

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- THE SINGLET AXIAL CHANNEL IS SPECIAL BECAUSE OF THE
  ANOMALY $\Rightarrow$ POLARIZED GLUONS Δg
  (SCHEME AND SCALE DEPENDENCE, INSTANTONS,. . .)

STRANGENESS IN THE NUCLEON

INDICATIONS OF SIZABLE NUCLEON STRANGENESS:

- THE SIGMA TERM:
  $2\frac{\langle p|\bar{s}s|p\rangle}{\langle p|\bar{u}u+\bar{d}d\rangle} \sim 0.5$ BUT LARGE UNCERTAINTY (100%?)
- UNPOLARIZED PDFS MOMENTUM FRACTIONS $M_i \equiv \int_0^1 xq_i(x)dx$:
  $\frac{M_s+M_{\bar{s}}}{M_{\bar{u}}+M_{\bar{d}}} \sim 0.5$ BUT $\frac{M_s+M_{\bar{s}}}{M_u+M_d+M_{\bar{u}}+M_{\bar{d}}} \sim 0.03$

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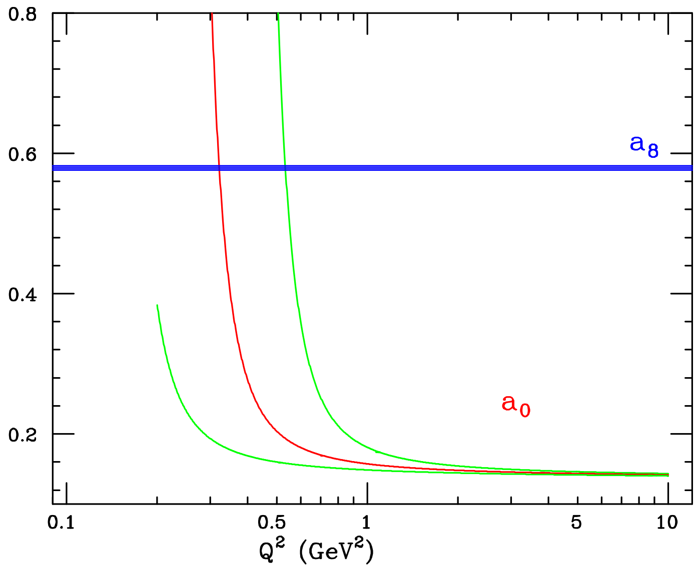
MODELS OF THE NUCLEON

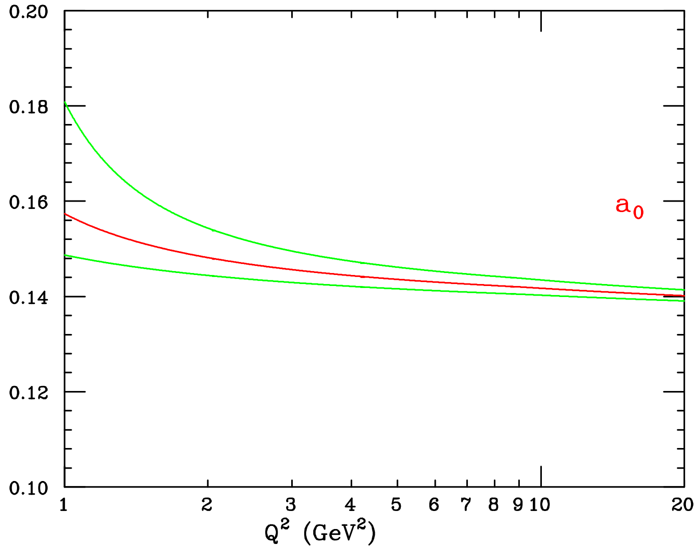
- LARGE INTRINSIC STRANGENESS FROM MESON CLOUDS
  $\Leftrightarrow$ OZI EVASION $p\bar{p} \to \gamma\phi$
- SKYRME MODEL: NUCLEON FROM MESON OCTET (π, K, η_8) BUT NO COUPLING TO $\eta_0 \Leftrightarrow \Delta s = -(\Delta u = \Delta d)$
  (Brodsky, Ellis, Karliner, 1988)

THE AXIAL ANOMALY

SCALE DEPENDENCE OF THE AXIAL CHARGE

THE SINGLET a_0, UNLIKE THE OCTET a_8, IS SCALE DEPENDENT





SCALE DEPENDENCE OF a_0 $\Leftrightarrow$ NON–CONSERVATION OF j_5^μ (Axial Anomaly)

$$\partial_\mu j_5^\mu = n_f \frac{\alpha_s}{2\pi} \epsilon^{\mu\nu\rho\sigma} \,\mathrm{tr}\, F_{\mu\nu} F_{\rho\sigma}$$

PERTURBATIVE RESULTS

SCALE DEPENDENCE OF $a_0 \Rightarrow$ SCALE DEPENDENCE OF $\int_0^1 dx\, \Delta g$

$$\frac{d}{d\ln Q^2} a_0(Q^2) = \frac{d}{d\ln Q^2}\left(-2n_f \frac{\alpha_s}{2\pi}\int_0^1 dx\, \Delta g\right)$$
$$= \gamma(\alpha_s) a_0(Q^2); \qquad \gamma(\alpha_s) = \gamma^{(2)}\alpha_s^2 + \gamma^{(3)}\alpha_s^3 + \dots$$

- $\int_0^1 dx\, \Delta g \sim \frac{1}{\alpha_s} \Leftrightarrow$ THE GLUON DOES NOT DECOUPLE AS $Q^2 \to \infty$
- CAN DEFINE A SCALE-INDEPENDENT QUARK (choice of factn. scheme)

$$a_0 = \int_0^1 dx \sum_{i=1}^{n_f} (\Delta q_i + \Delta \bar{q}_i) - \frac{\alpha_s}{2\pi}\int_0^1 dx\, \Delta g$$

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IF Δg IS LARGE $\frac{\alpha_s}{2\pi}\int_0^1 dx\,\Delta g \sim 0.5$

- SCHEME DEPENDENCE OF Δq AS LARGE AS OZI VIOLATION
- NO OZI VIOLATION IN SCHEME WHERE ALL QUARKS $\int_0^1 (\Delta q_i + \Delta\bar{q}_i)$ SCALE INDEP. (Altarelli and Ross, 1988)

INSTANTONS?

- QCD VACUUM CAN CONTRIBUTE TO $\langle j_5^\mu \rangle$ DUE TO ANOMALY
  $\langle j_5^\mu \rangle = \frac{\alpha}{\pi}\epsilon^{\mu\nu\rho\sigma}\mathrm{tr}\int d^3x \, (A_\nu(\vec{x})\partial_\rho A_\sigma(\vec{x}) + A_\mu(\vec{x})A_\nu(\vec{x})A_\rho(\vec{x})) + \mathrm{index}$
  nonlocal index term required for gauge invariance

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- IN $n_f = 1$, $m_q = 0$ CASE
  FULL SCREENING OF QUARK AXIAL CHARGE IN INSTANTON VACUUM

$$\langle q | j_5^\mu | q \rangle = 0$$

(S.F., 1989, S.F. and Shuryak 1991)

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IF SO, Δg SMALL, a_0 SMALL (ZERO?), $\Delta s = \Delta \bar{s}$

can view instanton contribution as polarized quark sea

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- Is the strangeness "valencelike"?
  If not, no skyrmions
  $\Rightarrow$ need measurement of $\Delta s - \Delta \bar{s}$

PRESENT

UNPOLARIZED EXPERIENCE

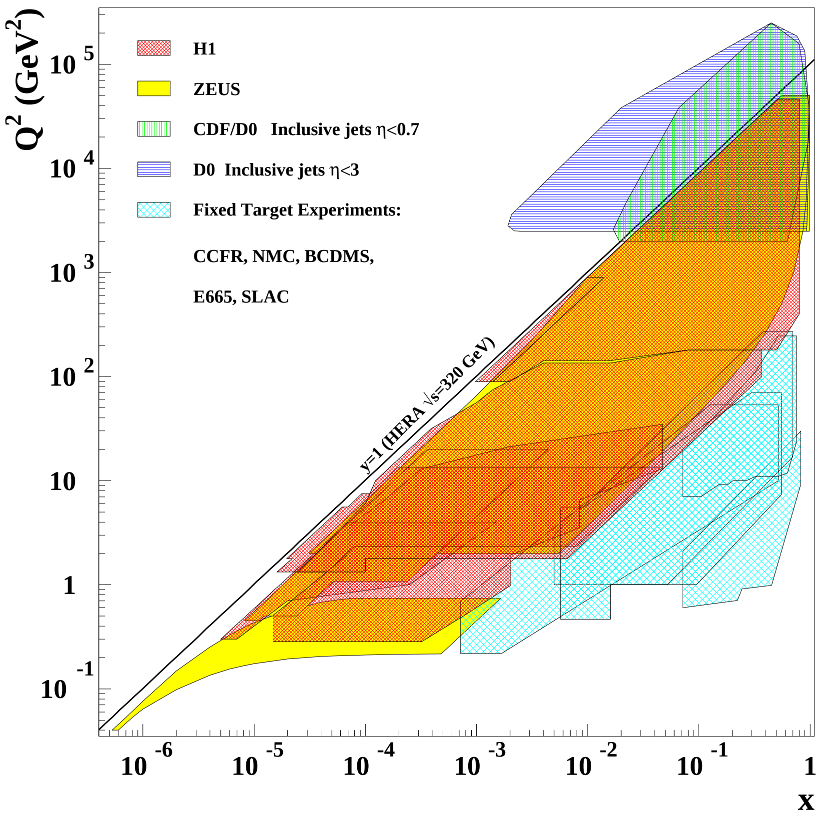
HOW ARE PDFS DETERMINED?

GLOBAL FITS

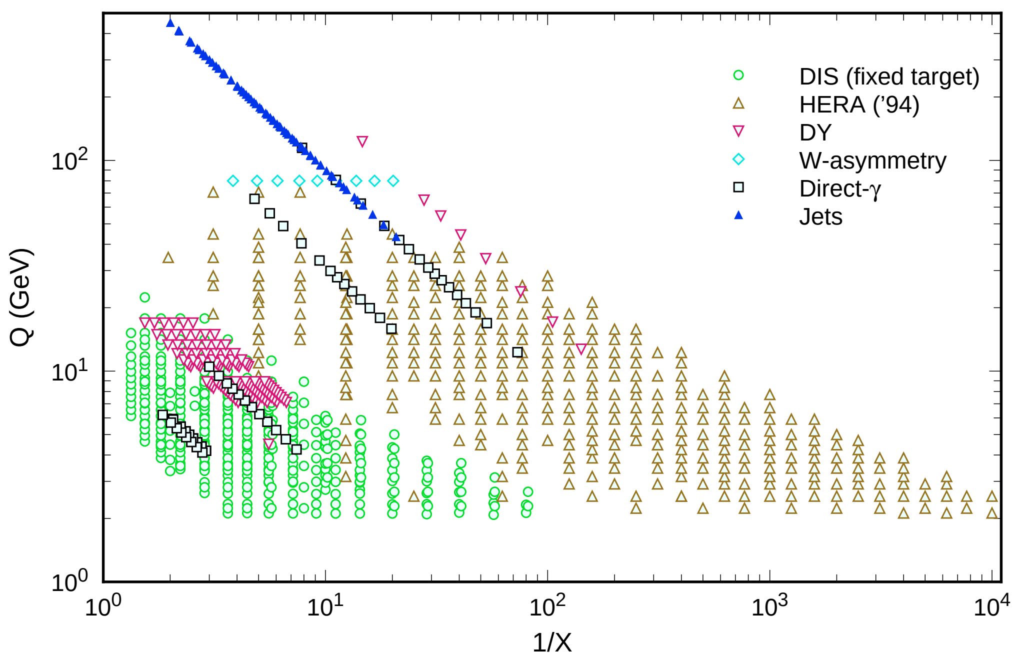
KINEMATIC COVERAGE

OF UNPOLARIZED EXPERIMENTS

ν, μ FIXED TARG.; $e^{\pm}p$ COLL.



DATA IN CTEQ5 PARTON FIT



THE GLUON

DETERMINED BY SINGLET SCALING VIOLATIONS

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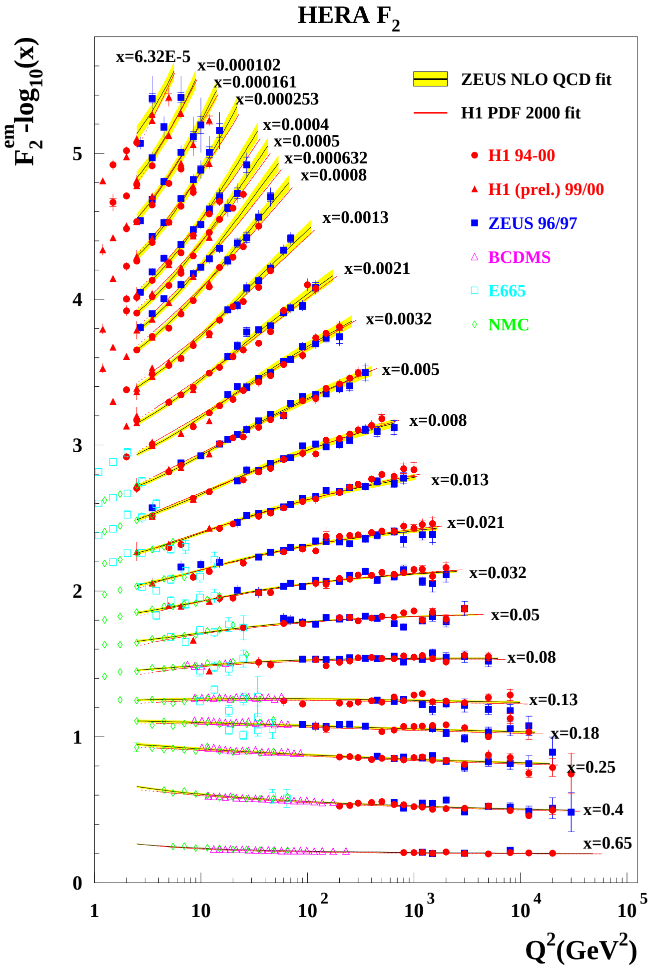
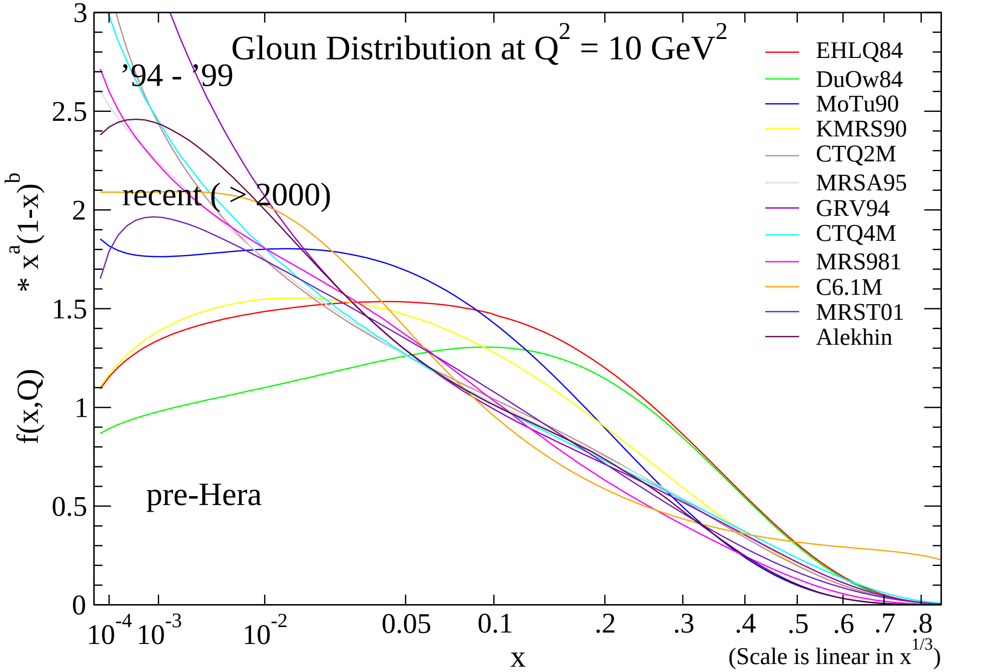
NEED LARGE LEVER ARM ⇒ ONLY REALLY KNOWN AFTER HERA





W.K. Tung, 2004

STRANGENESS

γ^* SCATTERING VS. $W^\pm$ SCATTERING:

IN NC, CHARGED LEPTON DIS, ONLY MEASURE COMBINATION $\sum_i e_i^2 \left(q_i + \bar{q}_i\right)$

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IN NEUTRINO DIS, CAN DISENTANGLE INDIVIDUAL PDFS BY LINEAR COMBINATION: AT LO

$$\frac{1}{2}\left(F_1^{W^-} + \frac{1}{2}F_3^{W^-}\right) = u + c; \qquad \frac{1}{2}\left(F_1^{W^+} - \frac{1}{2}F_3^{W^+}\right) = \bar{u} + \bar{c}$$

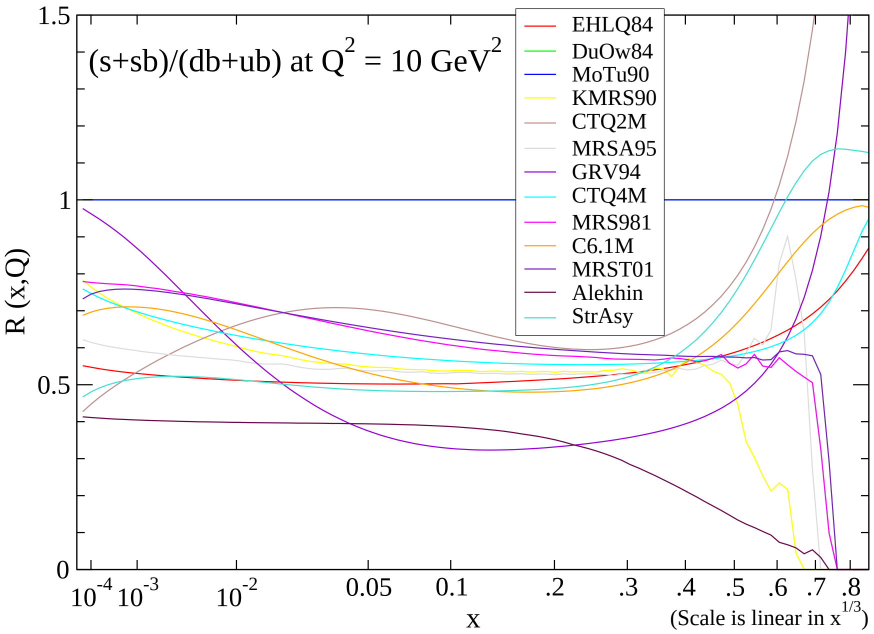
$$\frac{1}{2}\left(F_1^{W^+} + \frac{1}{2}F_3^{W^+}\right) = d + s; \qquad \frac{1}{2}\left(F_1^{W^-} - \frac{1}{2}F_3^{W^-}\right) = \bar{d} + \bar{s}$$

c, $\bar{c}$, s, $\bar{s}$ only present above charm threshold

STRANGENESS: TOTAL

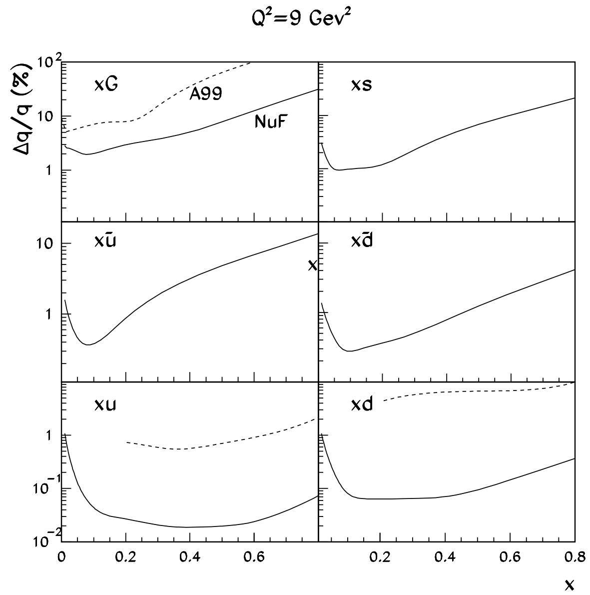
NEUTRINO DATA

PRESENT: ONLY $\frac{M_s+M_{\bar{s}}}{M_{\bar{u}}+M_{\bar{d}}} \sim 0.5$ REALLY KNOWN



FUTURE: UNCERTAINTIES AT A NEUTRINO FACTORY

(50 GeV MUONS)



STRANGENESS: VALENCE
COMBINING INCLUSIVE AND EXCLUSIVE INFORMATION

STRANGENESS TAGGED FROM CHARM PRODUCTION: $W^+ + s \to c$
easily tagged through dimuon signal, 2nd muon from subsequent c decay

$W^\pm$ ASYMMETRY $\Leftrightarrow$ $s - \bar{s}$ ASYMMETRY RELEVANT FOR NuTeV ANOMALY

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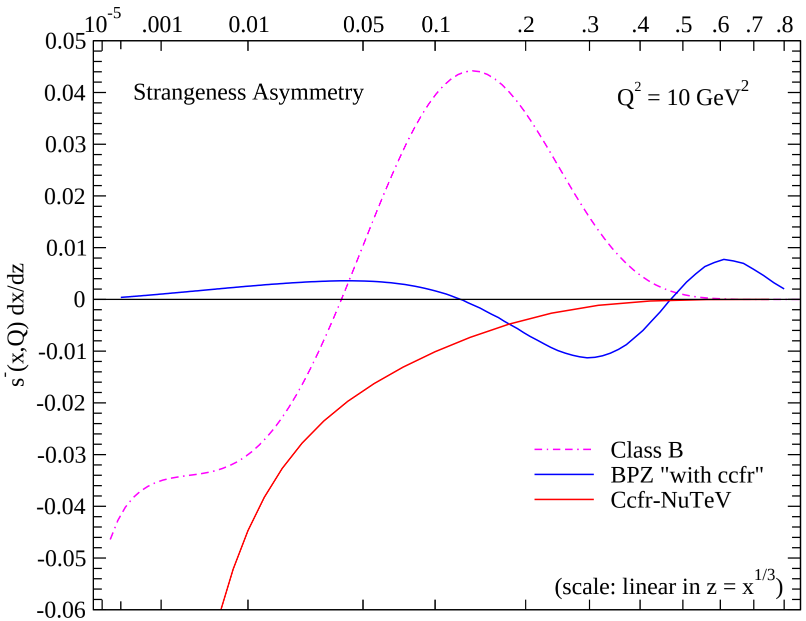
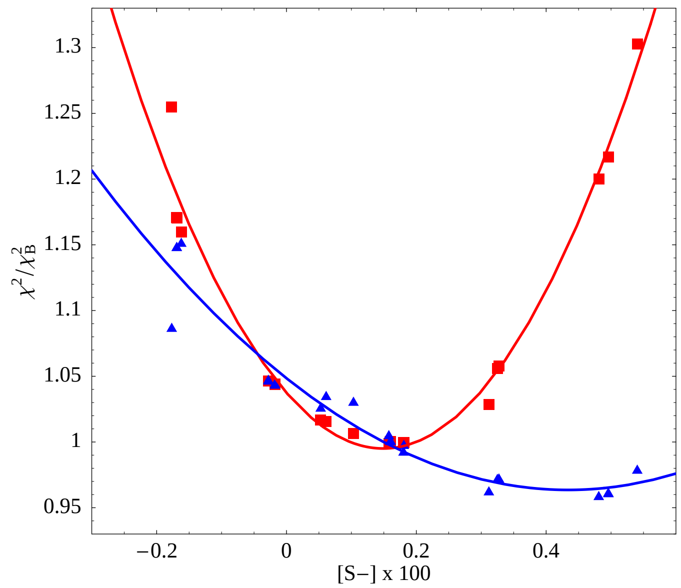
- $\int_0^1 (s(x) - \bar{s}(x))dx = 0$ IN PROTON
  $\Rightarrow$ EITHER $s(x) - \bar{s}(x)$ ZERO, OR MUST CHANGE SIGN
- DIMUON DATA $\Rightarrow [s(x) - \bar{s}(x)] < 0$ FOR $x \lesssim 0.05$
- POSITIVE MOM. FRACTION $s - \bar{s} \approx 0.02$ (CTEQ 2004)

strangeness asymmetry



χ^2 dimuon vs. inclusive



POLARIZED GLUE?
PROBLEMS:

- NO POLARIZED COLLIDER! LIMITED KINEMATIC COVERAGE IN Q^2

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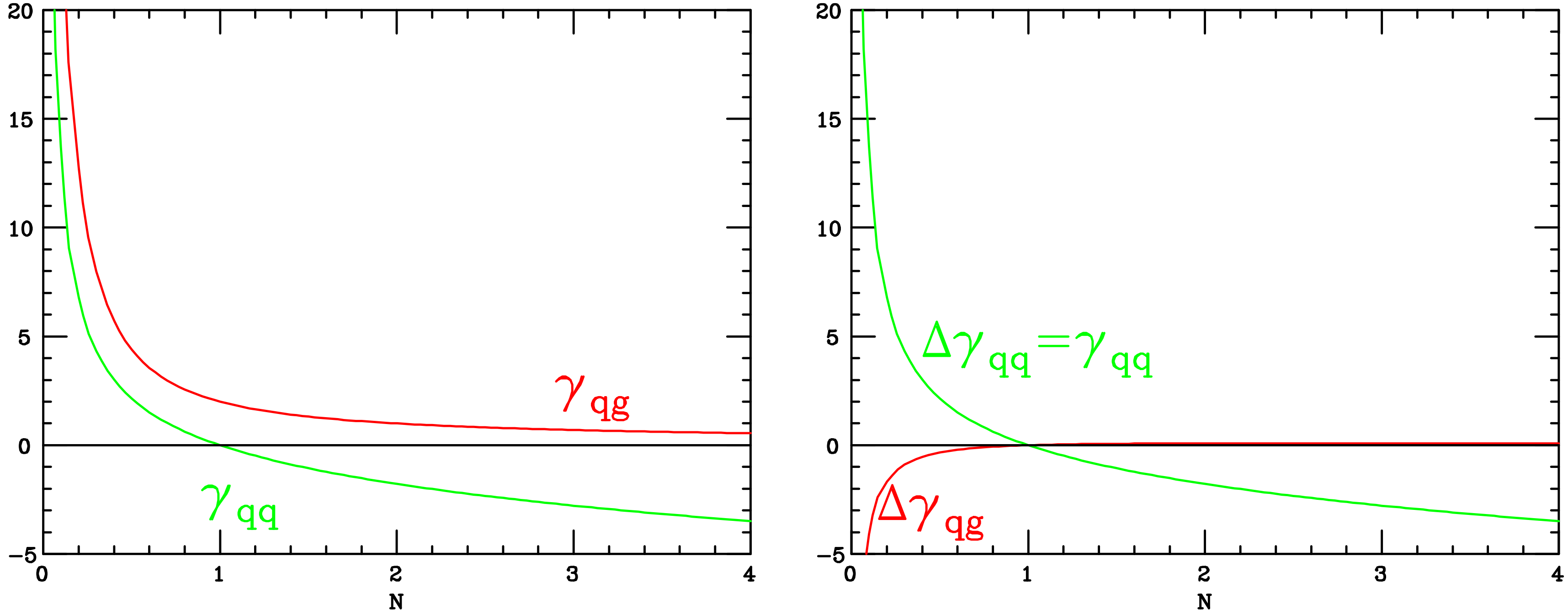
- NO POLARIZED COLLIDER! LIMITED KINEMATIC COVERAGE IN Q^2
- GLUON DRIVES SCALING VIOLATIONS ONLY AT LOW x! WHERE THERE ARE NO DATA…



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$$\frac{d}{d\ln Q^2}g_1^s(N,Q^2) = \frac{\alpha_s(Q^2)}{2\pi}\left[\Delta\gamma_{qq}(N)g_1^s + 2\,n_f\Delta\gamma_{qg}(N)\Delta g(N,Q^2)\right]+O(\alpha_s^2)$$

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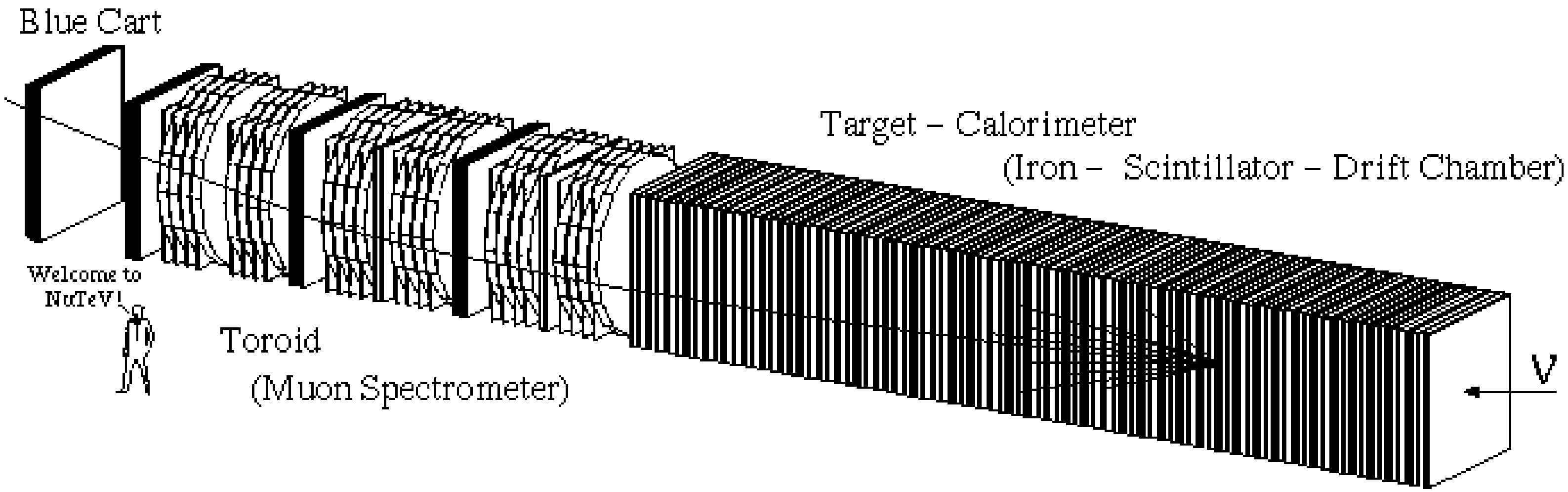

The NUTEV target/spectrometer

CAN'T FIT TARGET INTO MAGNET!

SEMI-INCLUSIVE CHANNELS?

CAN DETERMINE PARTON CONTENT BY TAGGING FINAL STATE HADRONS

E.G. IN SIDIS: $\gamma^* p \longrightarrow \pi^\pm + X \Rightarrow u/d,\ \bar{d}/\bar{u}$; $\gamma^* p \longrightarrow K^\pm + X \Rightarrow \bar{s}/s$, ETC.

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PROBLEMS:

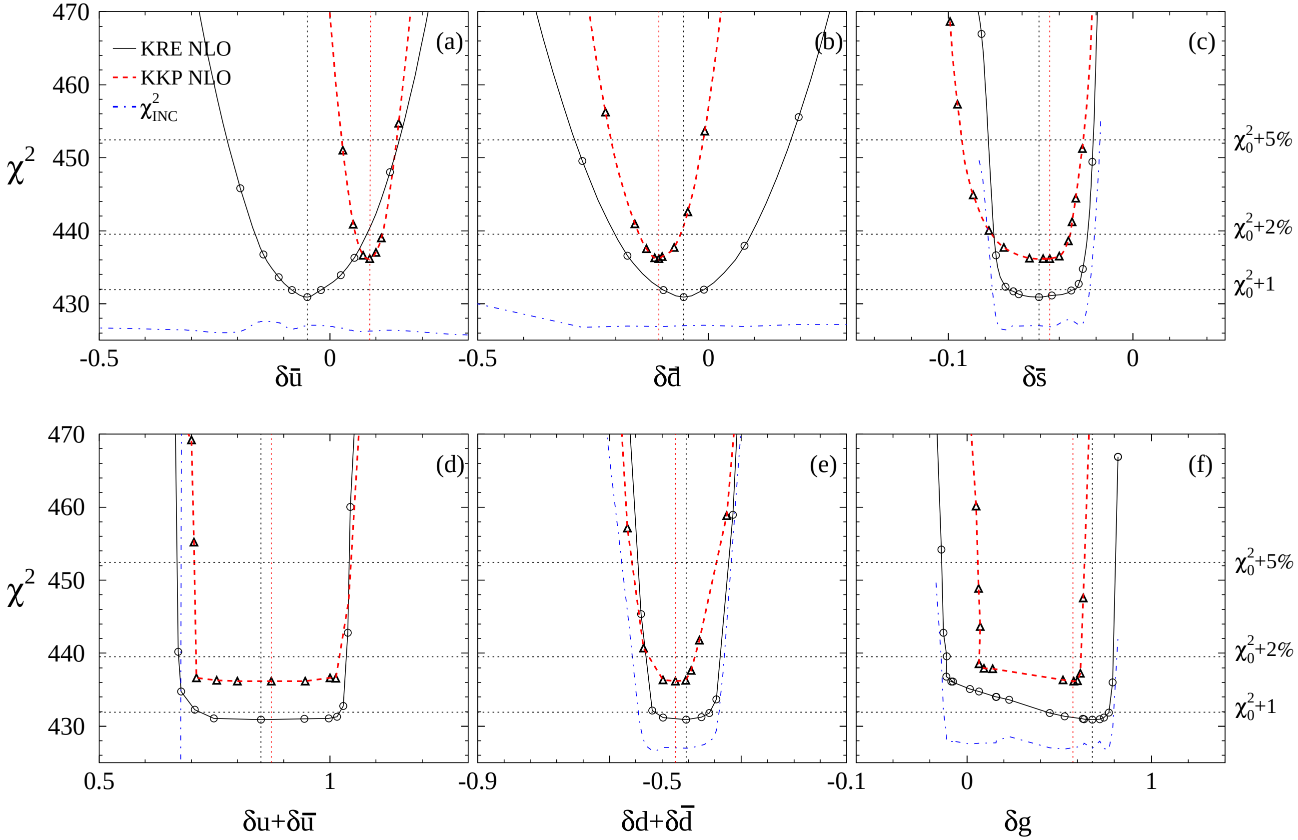
set		χ^2	χ^2_{DIS}	χ^2_{SIDIS}	δu_v	δd_v	$\delta\overline{u}$	$\delta\overline{d}$	$\delta\overline{s}$	δg	$\delta\Sigma$
NLO	KRE	430.91	206.01	224.90	0.936	-0.344	-0.0487	-0.0545	-0.0508	0.680	0.284
	KKP	436.17	205.66	230.51	0.700	-0.255	0.0866	-0.107	-0.0454	0.574	0.311
LO	KRE	457.54	213.48	244.06	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

(De Florian, Navarro, Sassot, 2005)

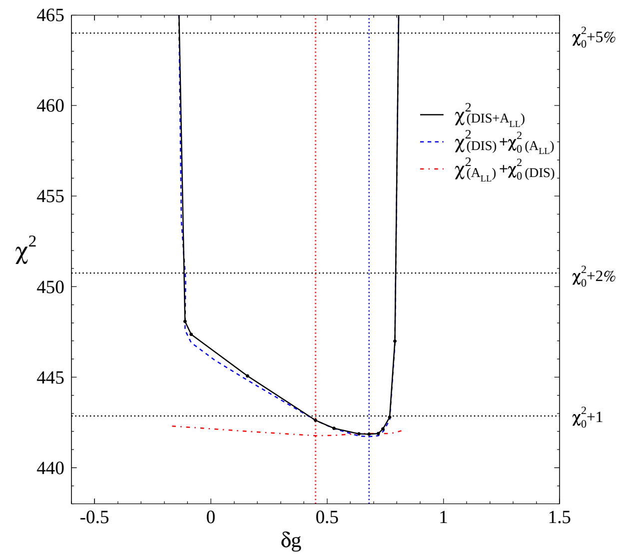
- SENSITIVITY TO POORLY KNOWN FRAGMENTATION FCTN
  $\Delta\bar{u}$ CHANGES SIGN WITH DIFFERENT FRAGMENTATION
- LARGE NLO CORRECTIONS
  $\Delta\bar{u}$ CHANGES BY FACTOR TWO FROM LO TO NLO

THE POLARIZED CASE: ARE WE THERE YET?

GLOBAL FIT WITH SIDIS DATA (De Florian, Navarro, Sassot 2005)



THE IMPACT OF THE PHENIX $A_{LL}^{\pi^0}$ (Navarro, Sassot 2006)



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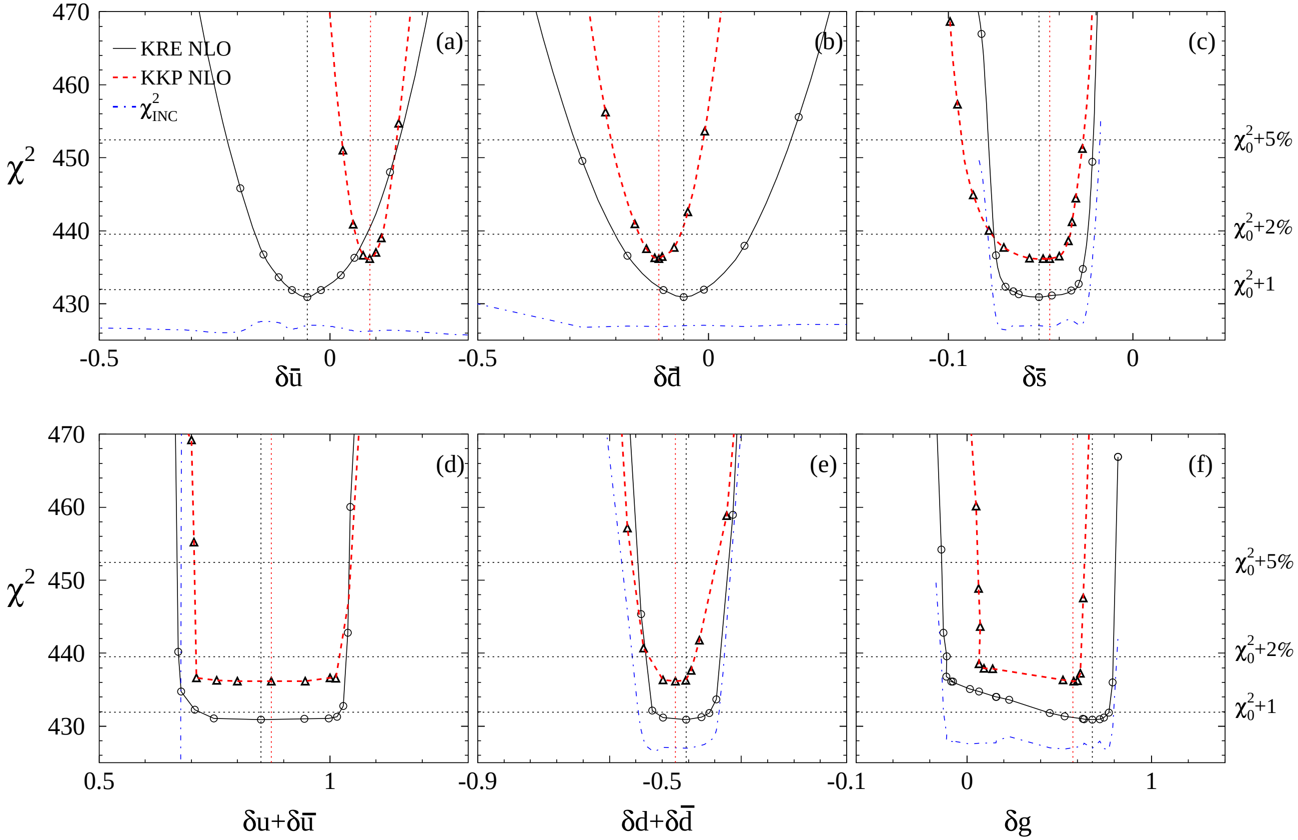

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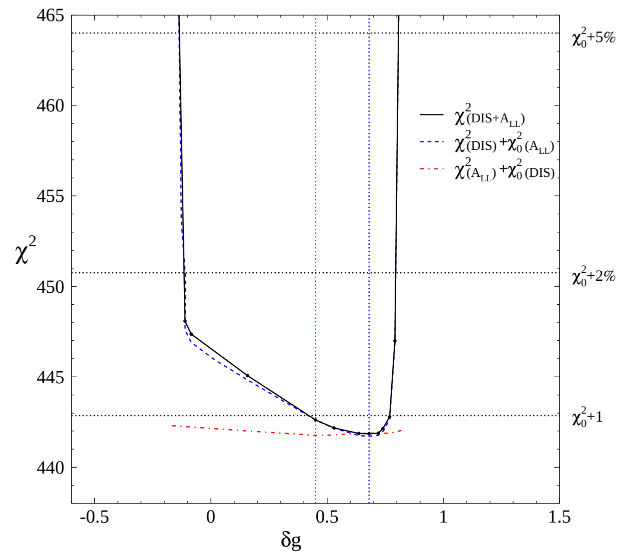

- LARGE TH. UNCERTAINTIES (FRAGMENTATION)
- UNKNOWN PARAMETRIZATION BIAS (E.G. POSITIVITY)
- ERRORS NOT PARABOLIC $\Rightarrow$ ONE SIGMA ERROR BANDS FROM $\Delta\chi^2 \sim 20$

THE NUCLEON SPIN
WHAT HAVE WE LEARNT FROM GLOBAL FITS?

FIRST MOMENTS

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- GLUON:
  $\Delta g(1\,\mathrm{GeV}^2) = 0.8 \pm 0.2 \pm 0.8$; [ABF]; $= 0.4\,^{+0.1}_{-0.5}$ [DNS];
- STRANGENESS:
  $\Delta s^{\overline{MS}}(1\,\mathrm{GeV}^2) = -0.13 \pm 0.02 \pm 0.09$; [ABF]; -0.10 ± 0.06 [DNS]

[ABF]: ALTARELLI, BALL, S.F., RIDOLFI 98-01:

- STAT. ERRORS OBTAINED FROM ONE-SIGMA CONTOURS
- MAIN SYSTEMATICS: SMALL x EXTRAP., FUNCTIONAL FORM
- SU(3) USED TO DETERMINE OCTET, 30% VIOLATION ALLOWED;

[DNS]: DE FLORIAN, NAVARRO, SASSOT 05

- ERRORS ESTIMATED FROM $\Delta\chi^2 = 0.02\chi^2_{min} \approx 20$
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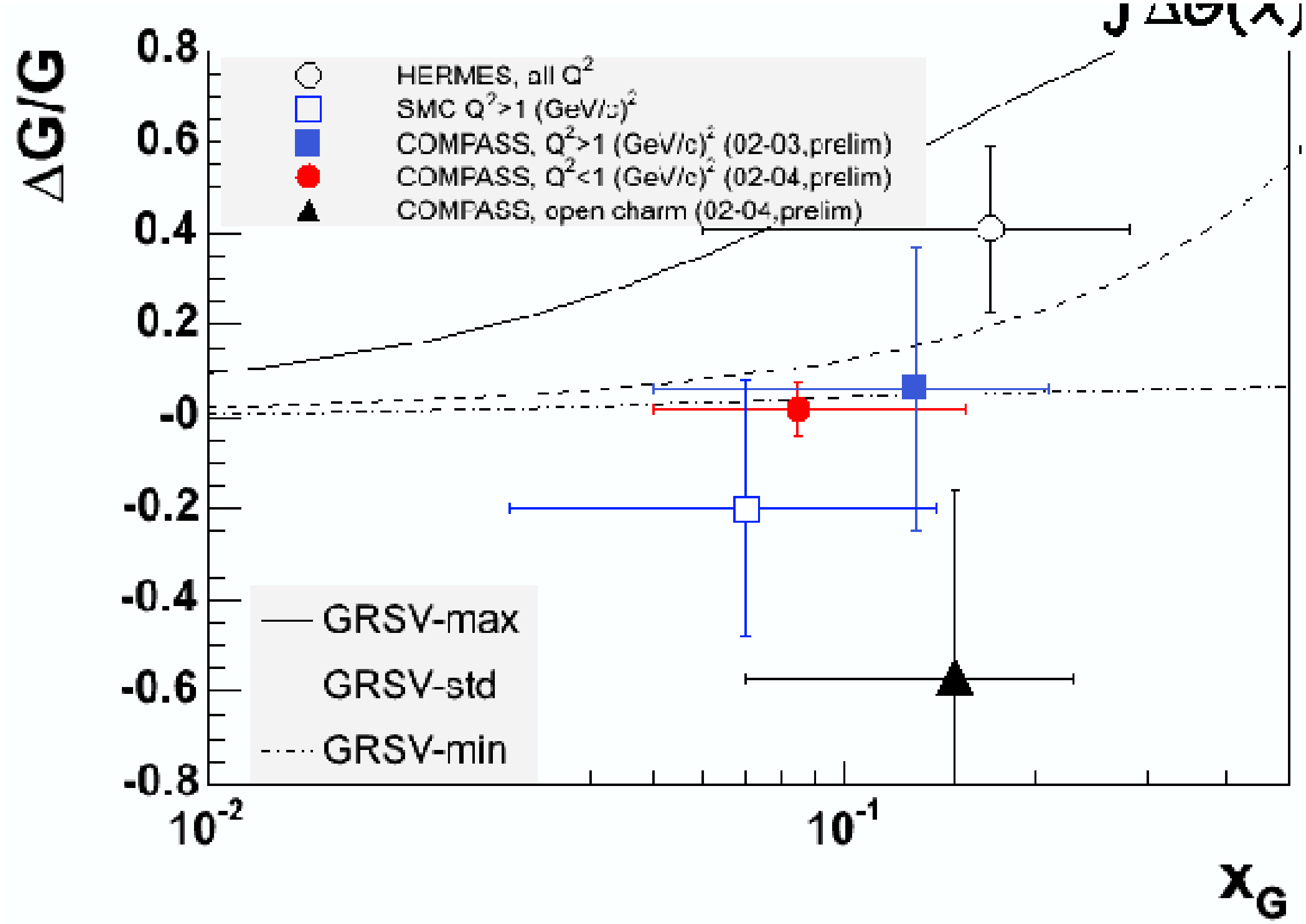
- THEORETICAL ERRORS DOMINATE
- SEMI-INCLUSIVE DATA HAVE MODERATE IMPACT ON Δg, Δs
- SU(3) NOT TESTED YET
- NO INFORMATION OF $\Delta s - \Delta\bar{s}$

INFORMATION FROM HIGH p_T HADRONS (AND CHARM)



- NLO calculations not available
- Dependence on Monte Carlo
- Deconvolution of gluon using mean values

(NO) CONCLUSION ON NUCLEON SPIN YET

EXISTING RESULTS VERY HARD TO COMPARE:

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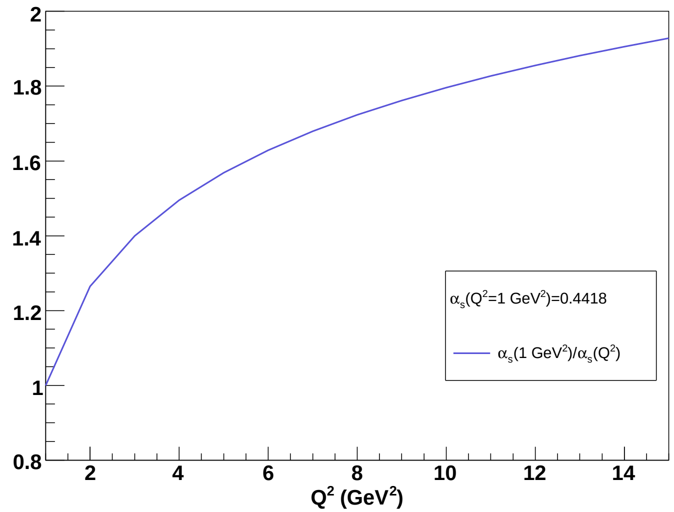

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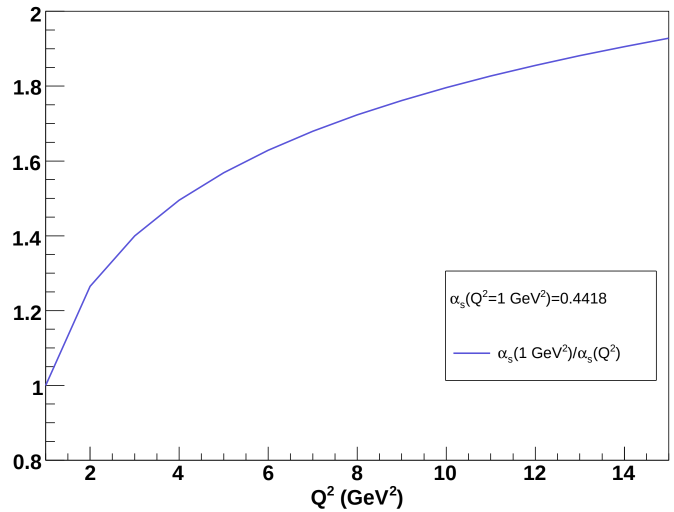

- UNCERTAINTIES DETERMINED WITH $\Delta\chi^2 = 1$ UP TO $\Delta\chi^2 = 12$
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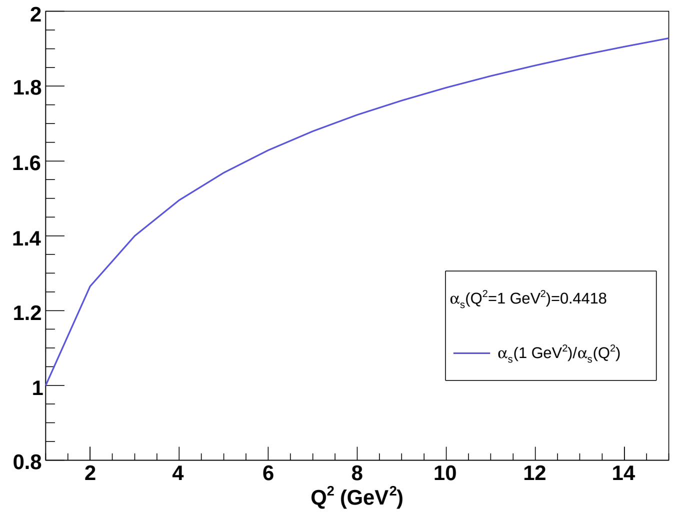

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ΔG PROBABLY POSITIVE BUT PERHAPS SMALL $\left(\frac{N_f}{2\pi}\right)\alpha_s(Q^2)\Delta G \lesssim \frac{1}{2}\Delta\Sigma$,
PERHAPS ZERO
Δs PROBABLY NEGATIVE, MAYBE SMALL

FUTURE

HADRONIC CHANNELS

HADRONIC CHANNELS

UNPOLARIZED GLOBAL FITS

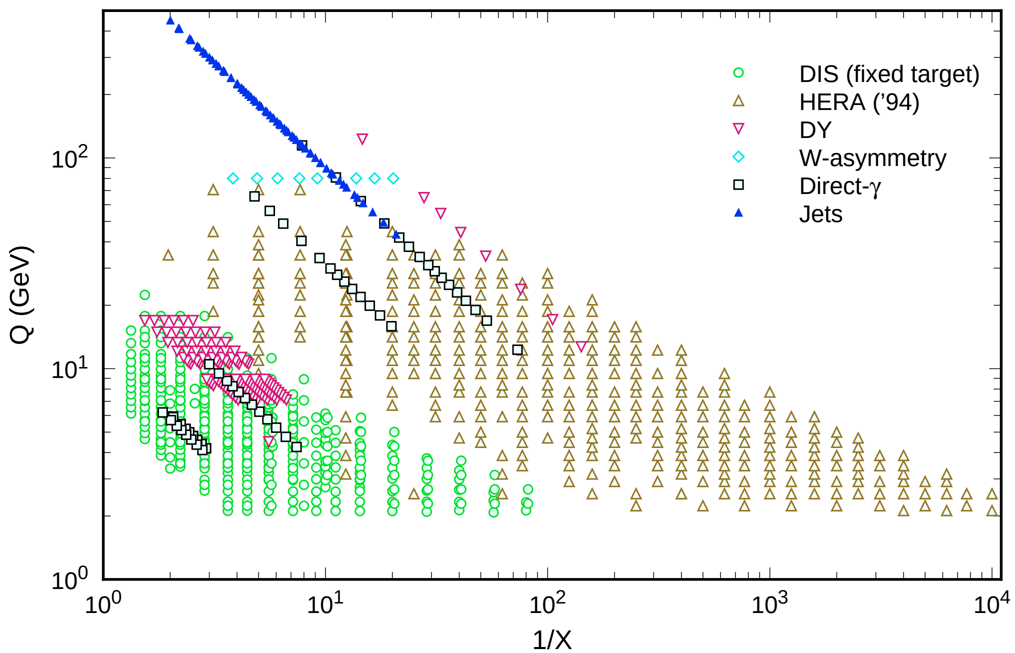
- DRELL-YAN
  $\Rightarrow \bar{u}/\bar{d}$ QUARK ASYMMETRY

- $W^{\pm}$ PRODUCTION
  $\Rightarrow u/d$ QUARK ASYMMETRY

- DIRECT $\gamma \Rightarrow$ GLUON
  (IMPACT NEGLIGIBLE W.R. TO DIS)

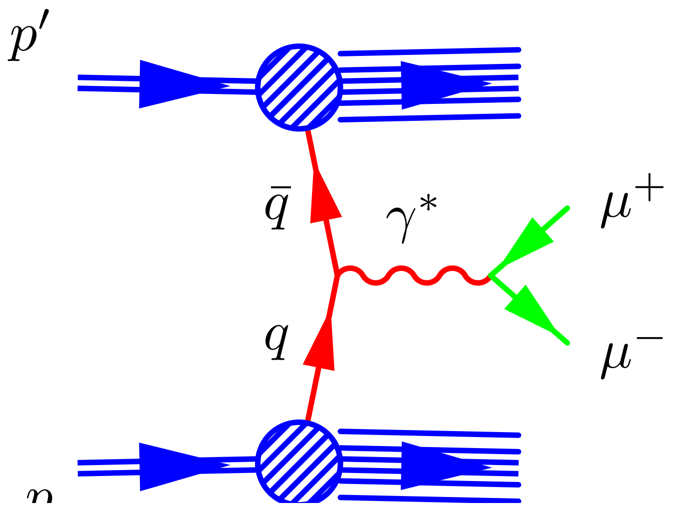
- LARGE E_T JETS
  $\Rightarrow$ LARGE x GLUON

DATA IN CTEQ5 PARTON FIT



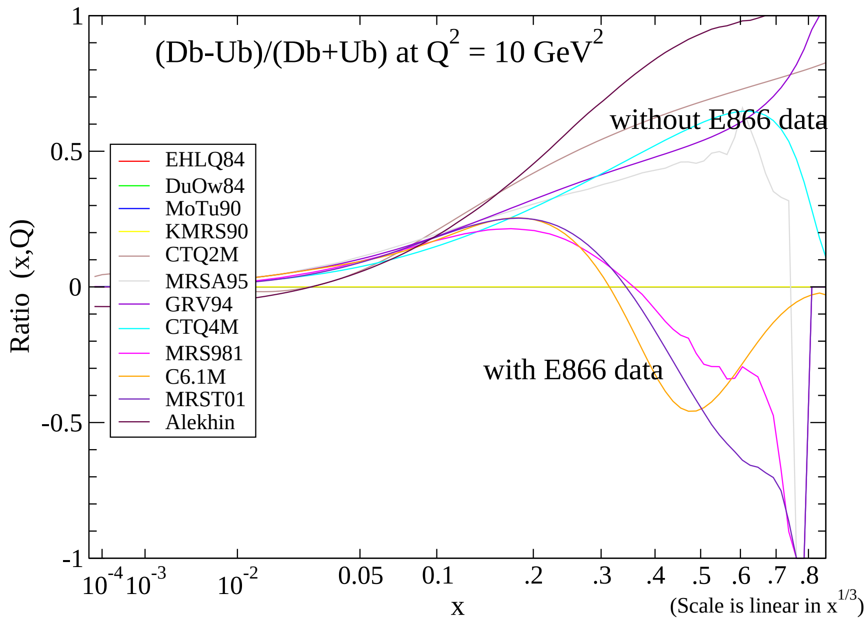
HOW WELL DOES IT WORK?

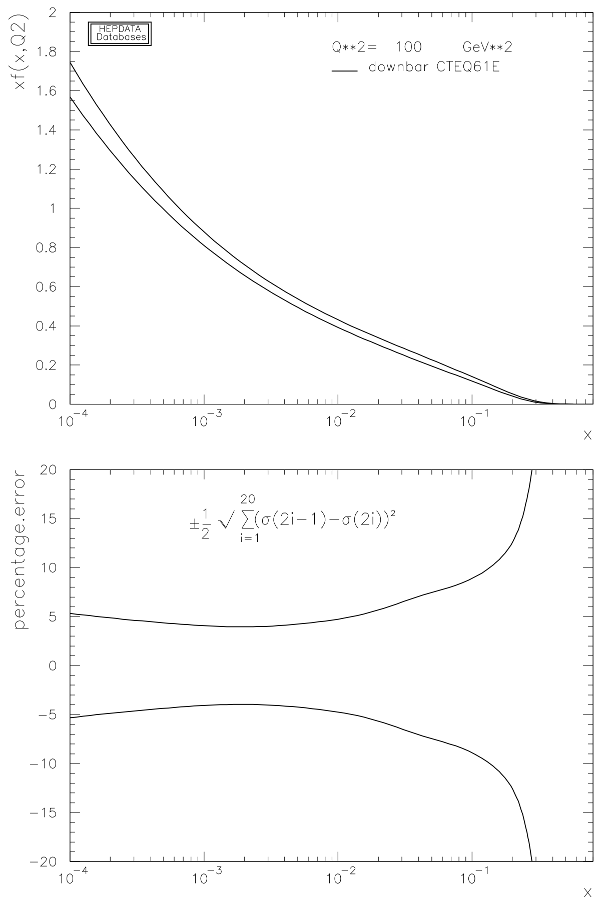
DRELL-YAN p/d ASYMMETRY



$$\left.\frac{\sigma^{pd}}{\sigma^{pp}}\right|_{x_1>>x_2} \approx \frac{1}{2}\left(1+\frac{\bar{d}(x_2)}{\bar{u}(x_2)}\right)$$

$5-10\%$ ACCURACY ON $\bar{u}$, $\bar{d}$





POLARIZED CASE
WHAT DO WE EXPECT?

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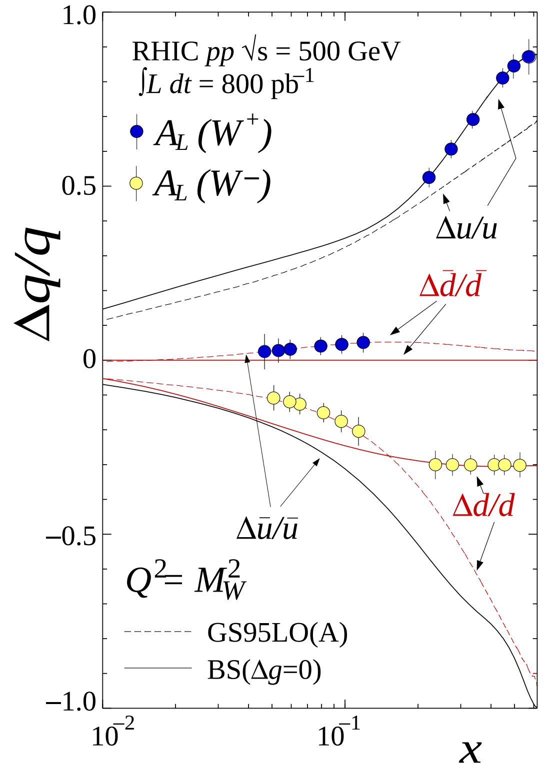

GOOD NEWS

- CAN DETERMINE Δu, Δd, $\Delta \bar{u}$, Δu
  TO A FEW PERCENT ACCURACY
  from $W^{\pm}$ production

RESULTS

- $\int (\Delta s + \Delta \bar{s})\, dx$
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- CAN DETERMINE Δg
  AT MANY INDIVIDUAL x VALUES
  from direct γ, jets, single inclusive hadrons

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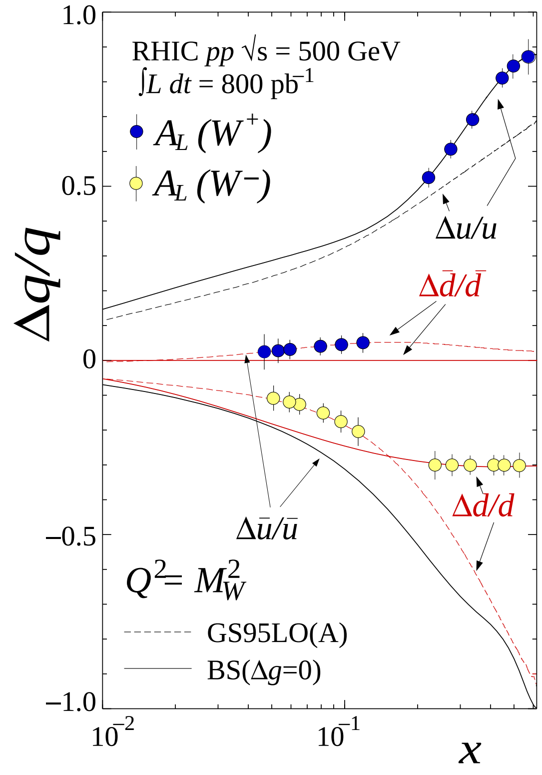

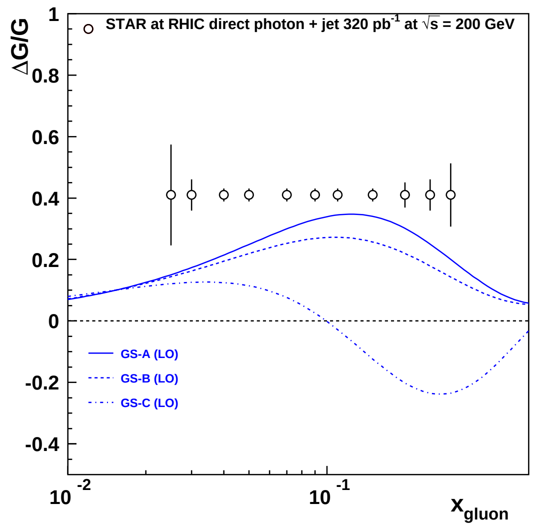

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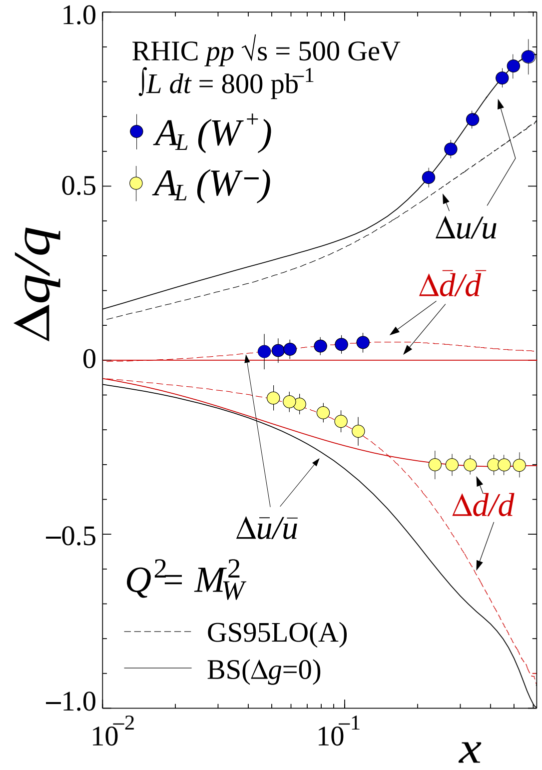

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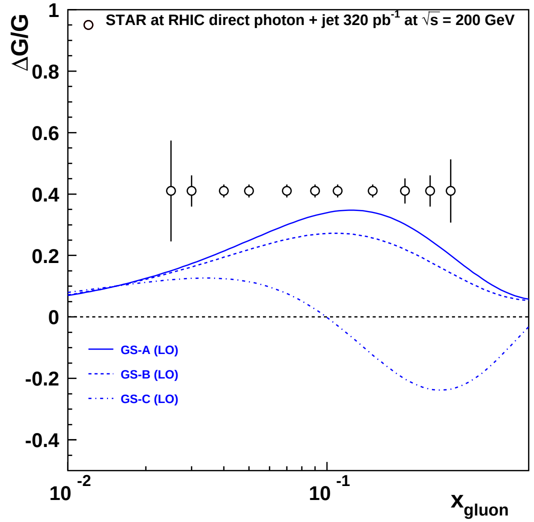

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BAD NEWS

- NO WAY TO DETERMINE $\Delta s - \Delta \bar{s}$
  WITHOUT NEUTRINO DIS
- NEED A GLOBAL FIT!

CAN WE TRUST GLOBAL FITS?

PARTON SETS DO NOT AGREE WITHIN RESPECTIVE ERRORS!

W PRODUCTION CROSS-SECTION
TEVATRON

PDF SET	XSEC [NB]	PDF UNCERTAINTY
ALEKHIN	2.73	± 0.05 (TOT)
MRST2002	2.59	± 0.03 (EXPT)
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THORNE 2003

- ALEKHIN VS. MRST/CTEQ → W PRODUCTION XSECT AT TEVATRON DO NOT AGREE WITHIN RESPECTIVE ERRORS

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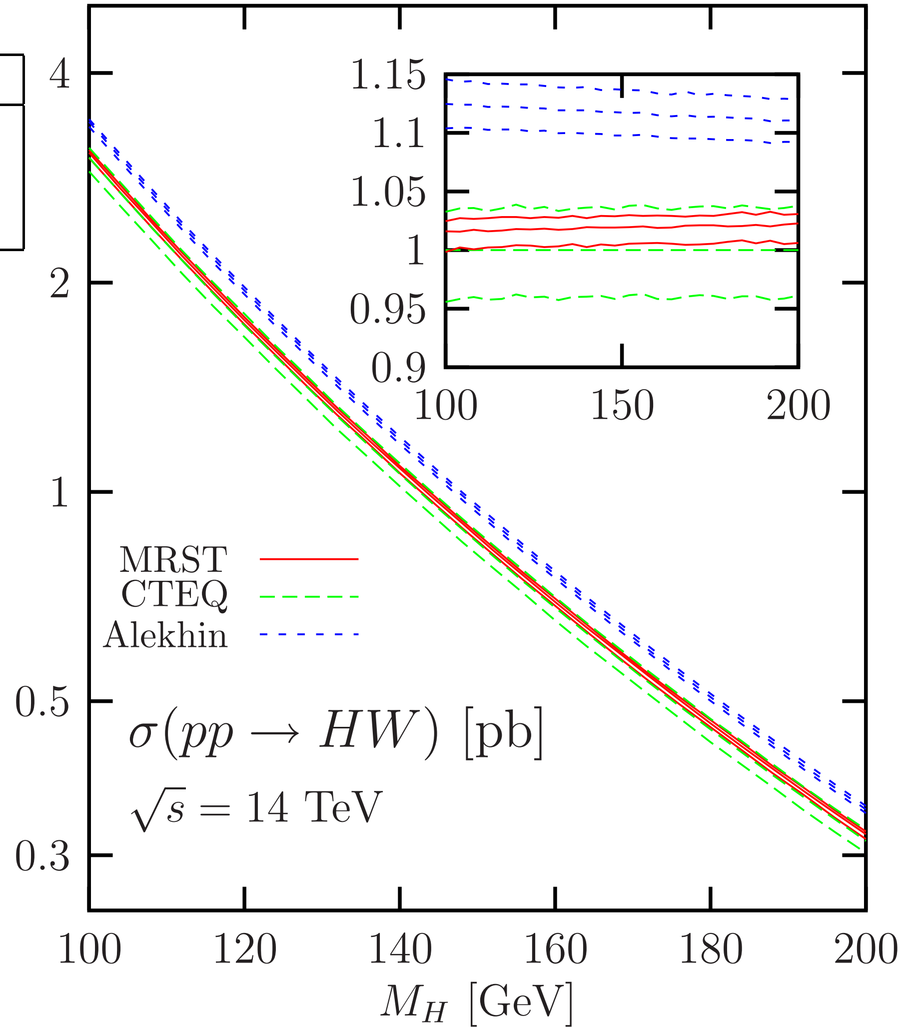
- ALEKHIN VS. MRST/CTEQ → PREDICTIONS FOR ASSOCIATE HIGGS W PRODUCTION LHC DO NOT AGREE WITHIN RESPECTIVE ERRORS

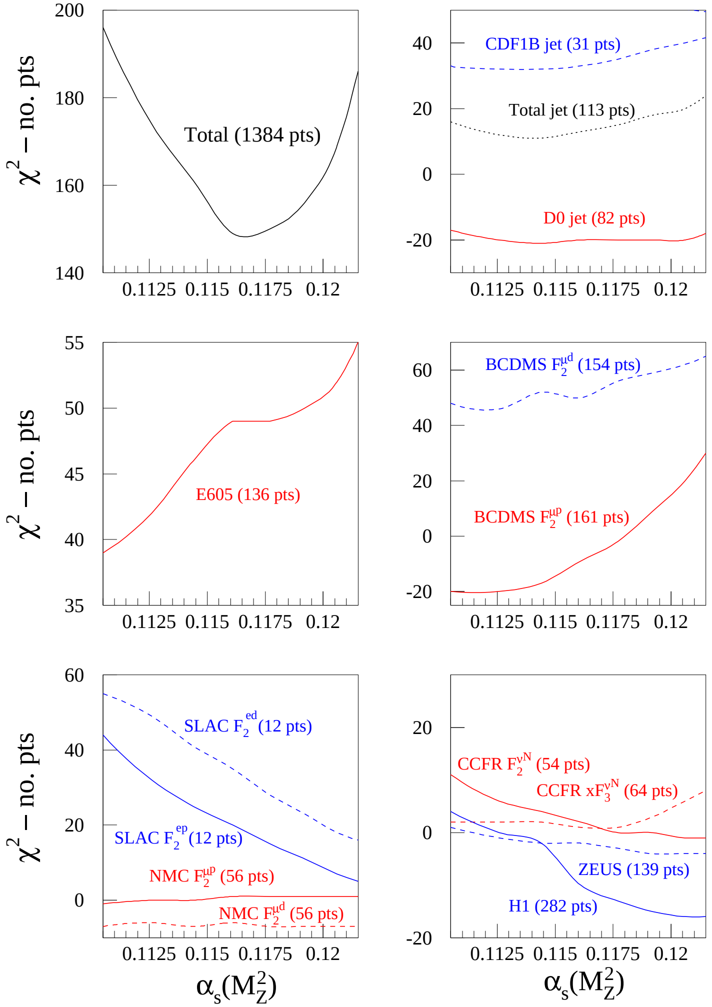
HIGGS PRODUCTION AT LHC



DJOUADI AND FERRAG, 2004

INCOMPATIBLE DATA?

GLOBAL χ^2 MINIMUM MAY NOT CORRESPOND TO LOCAL MINIMA



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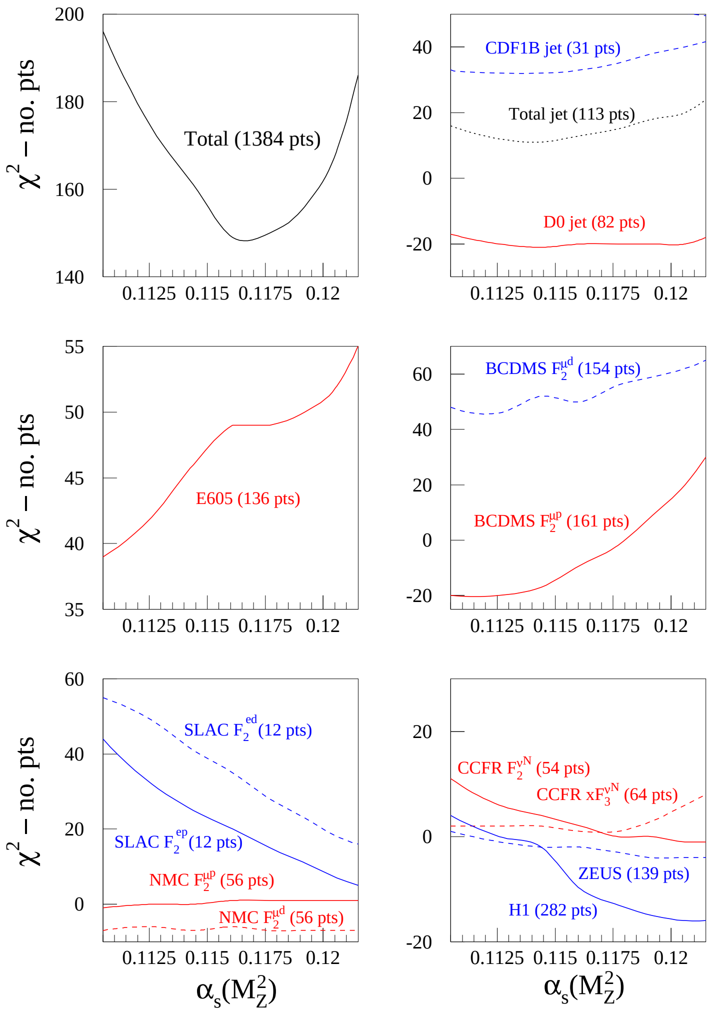
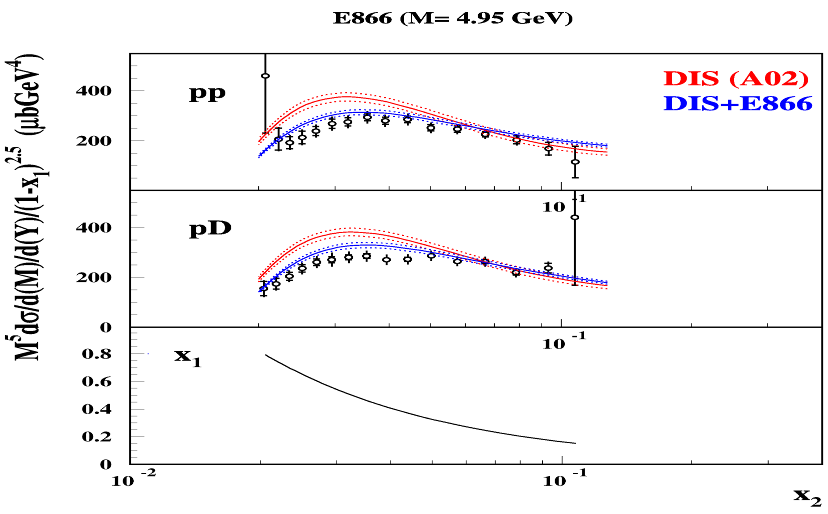


MRST 2003

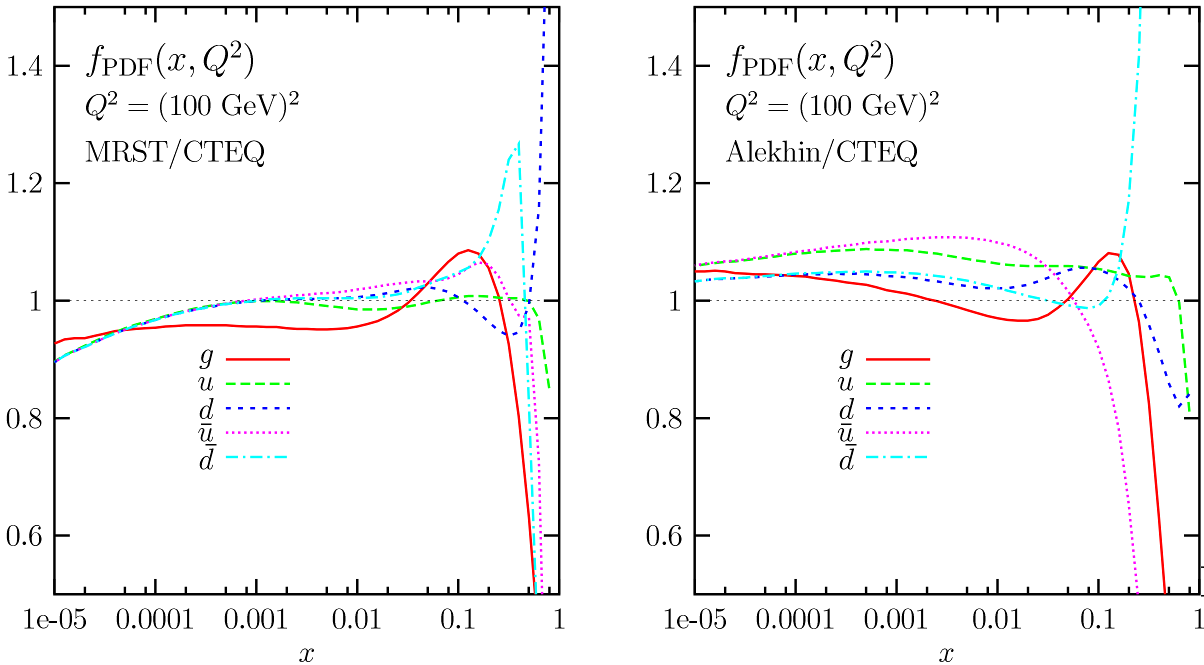
E866 DY DATA DISAGREE WITH DIS DATA:

$\sigma_{DY} \sim q(x_1)q(x_2)$ DISAGREES WITH DIS QUARK AT SAME x AND Q^2



ALEKHIN 2005

PARAMETRIZATION BIAS?



MRST & CTEQ
→ SIMILAR PARTONS

Djouadi and Ferrag 2003

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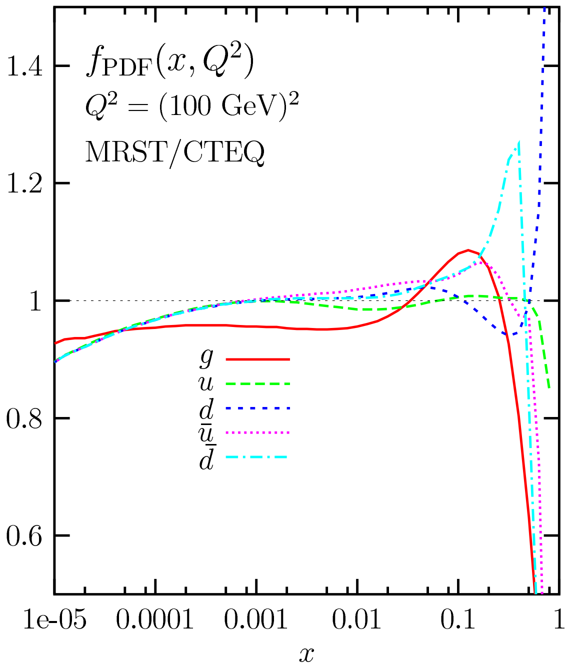

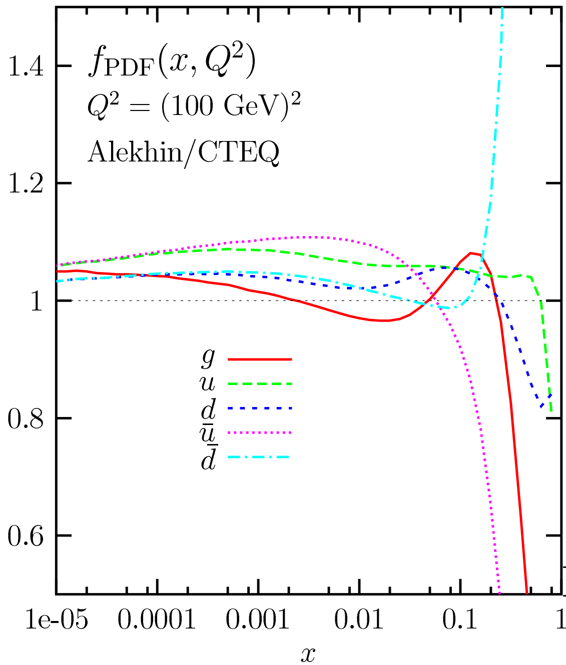

Djouadi and Ferrag 2003

MRST & CTEQ

$\longrightarrow$ SIMILAR PARTONS

SIMILAR PARTONS

$\Rightarrow$ SIMILAR RESULTS

THE W XSECT. AGAIN. . .

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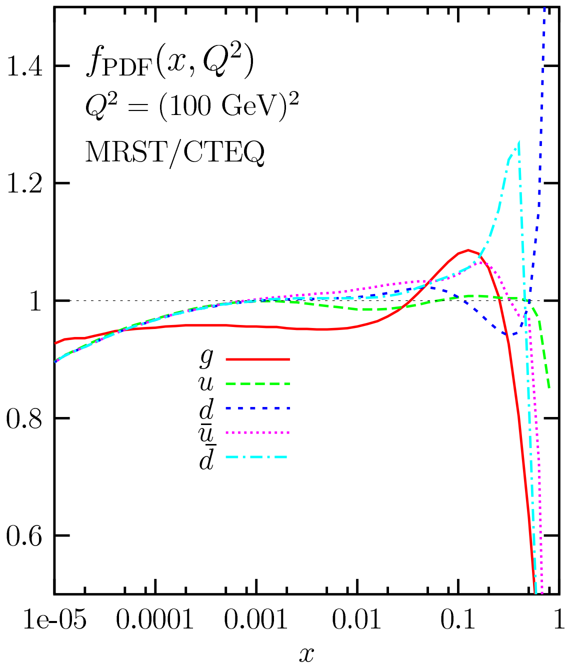

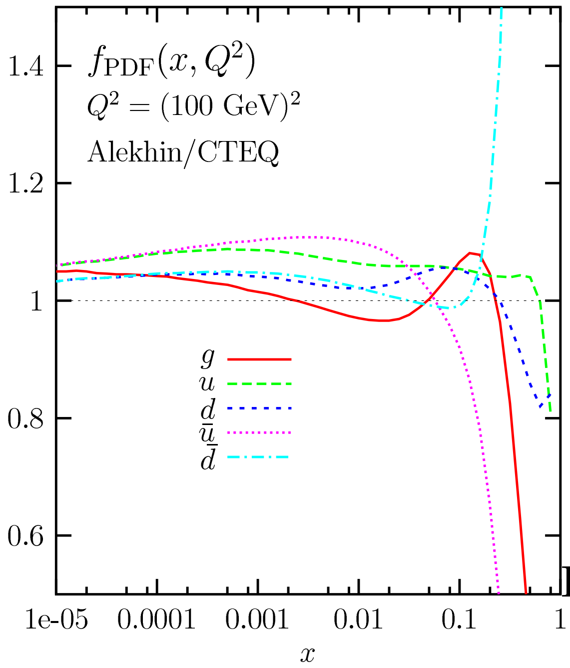

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SIMILAR PARTONS
$\Rightarrow$ SIMILAR RESULTS

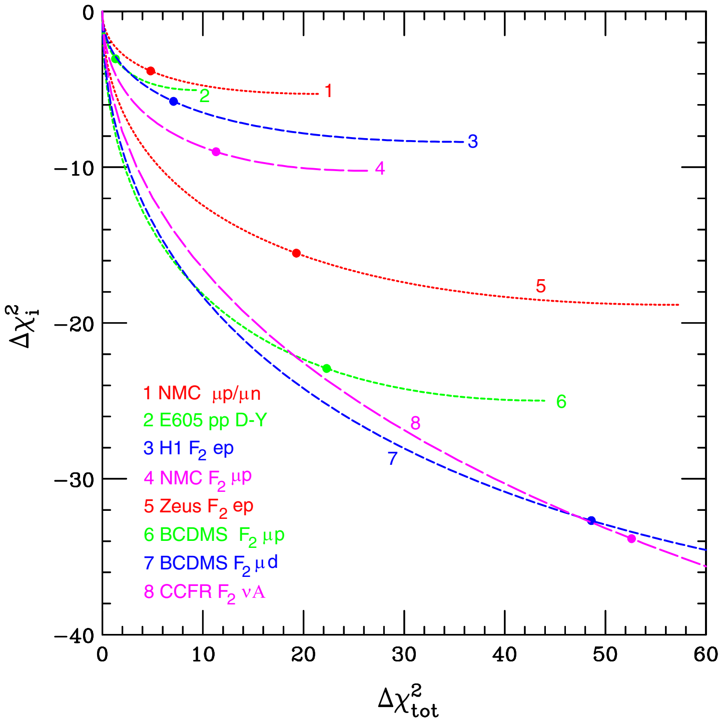
We do not seem to have the optimum parameterization for both finding the best fit and also investigating fluctuations about this best fit (...) This might then influence our error analysis...(MRST 2004)

SOLUTIONS: CTEQ TOLERANCE CRITERION

SINGLE OUT INCONSISTENT DATA

- HOW MANY PARAMETERS ARE SIGNIFICANTLY DETERMINED BY EACH DATASET?
- HOW CONSISTENT ARE THE DATA FROM ONE SET WITH THE REST?

STUDY MINIMUM ALLOWED χ_i^2
FOR i-TH EXP. AS
GLOBAL χ^2 ALLOWED TO INCREASE



Collins, Pumplin 2001

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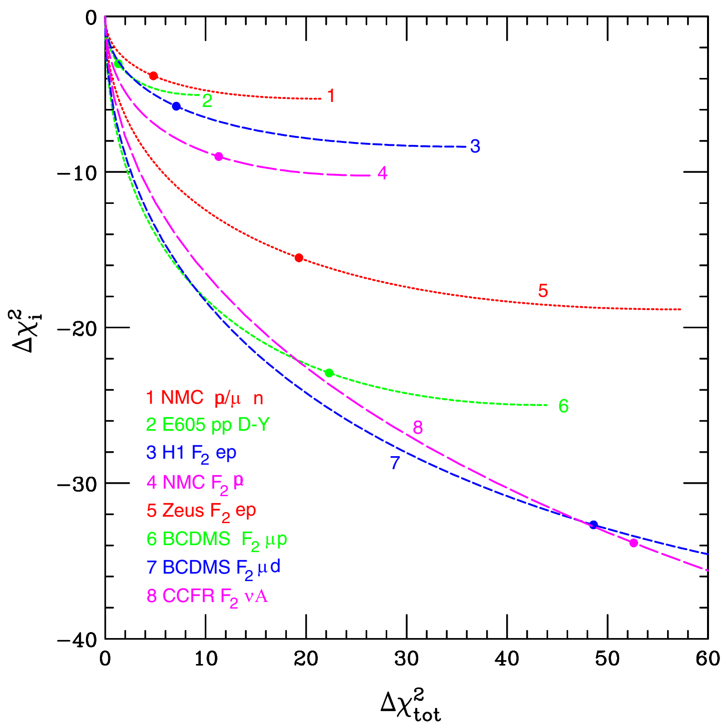

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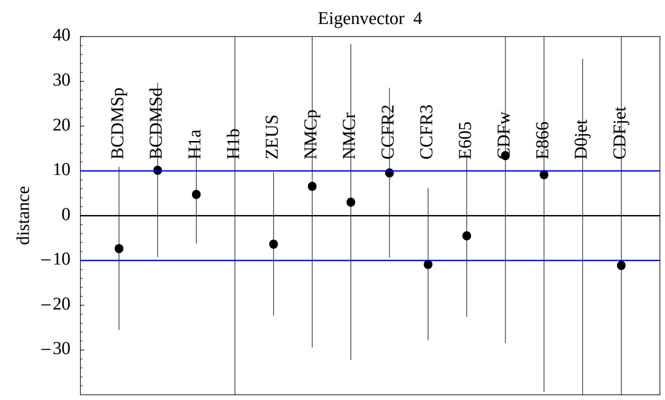
OPTIONS

- discard incompatible experiments
- reweight individual contributions
- INCORPORATE IN ERROR, TOLERATING FIXED MAX DEVIATION FOR EACH EXPERIMENT & EACH FIT PARAMETER



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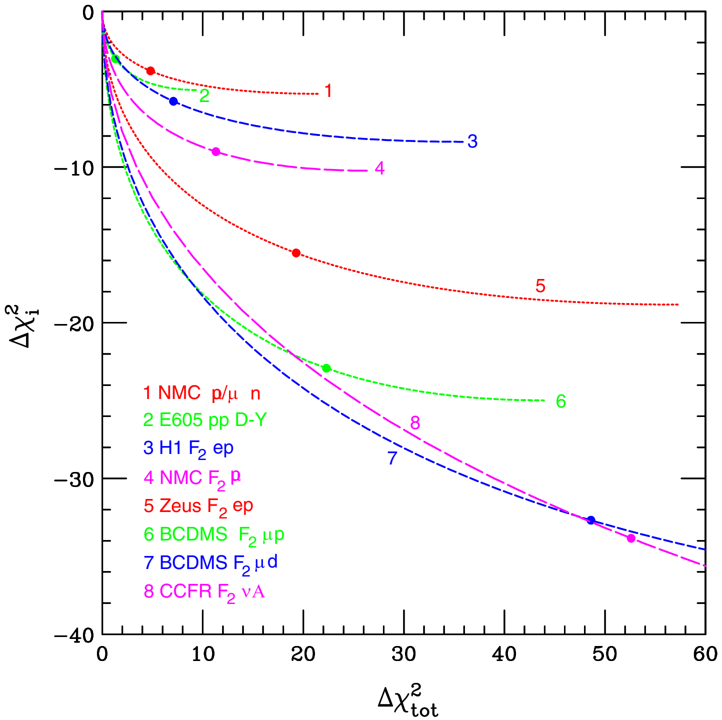

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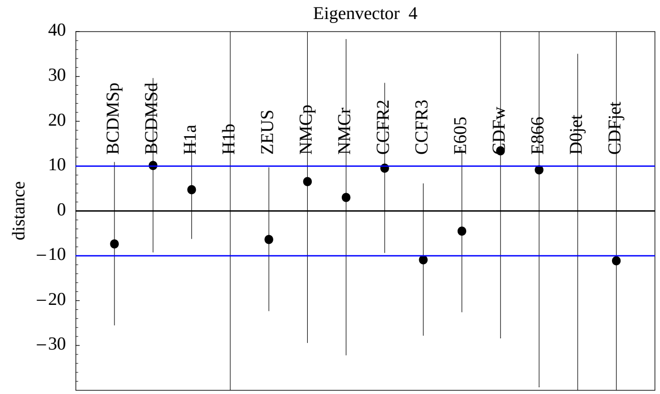
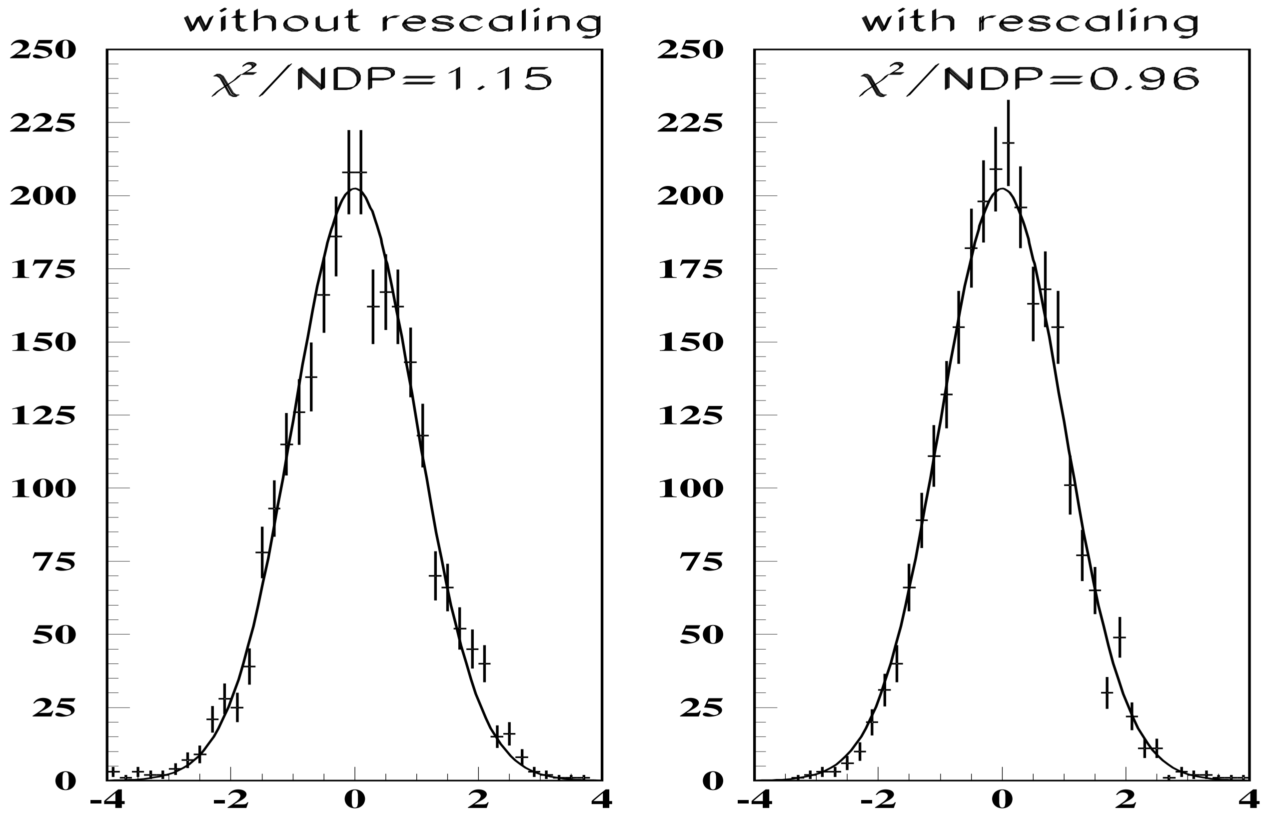


$$\Delta\chi^2 = 100$$ (CTEQ6)

SOLUTIONS: ERROR RESCALING

HOW CAN DATA FROM INCONSISTENT SETS BE INCLUDED?

ASSUME INCONSISTENCY DUE TO UNDERESTIMATED (SYST.) ERROR:



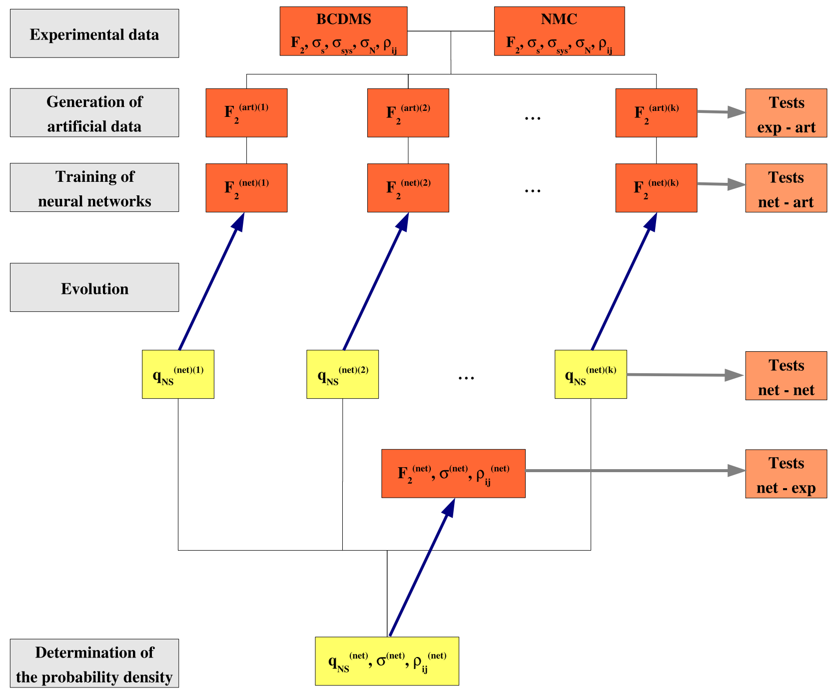
For the experiments with $\chi^2 > 1$ the statistical errors in data were rescaled in order to get $\chi^2 = 1$

ALEKHIN 2005 (PRELIM.)

THE FUTURE?

THE NEURAL MONTE CARLO APPROACH (S.F., GARRIDO, LATORRE, PICCIONE 2002)

BASIC IDEA: USE NEURAL NETWORKS AS UNIVERSAL UNBIASED INTERPOLANTS



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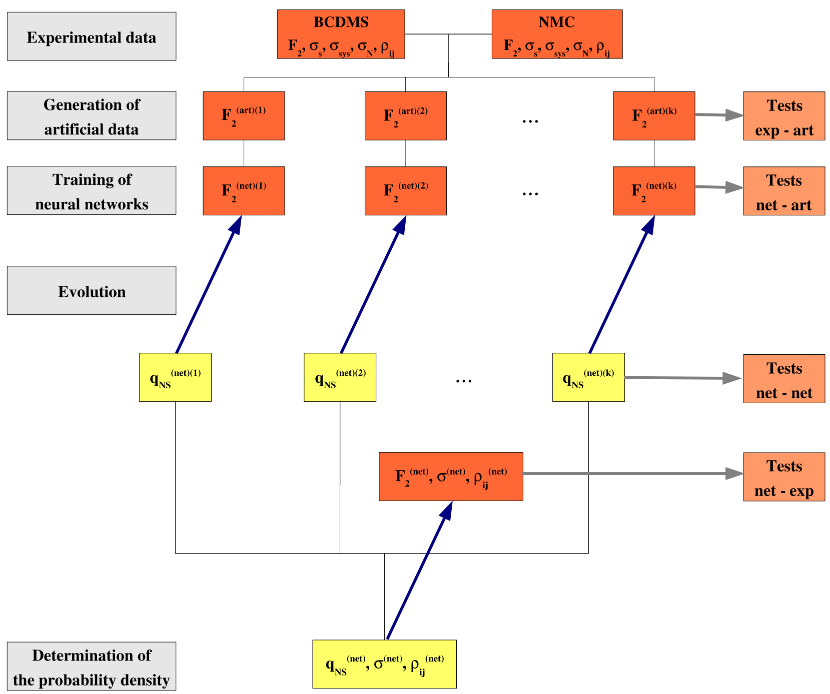
BASIC IDEA: USE NEURAL NETWORKS AS UNIVERSAL UNBIASED INTERPOLANTS

- GENERATE A SET OF MONTE CARLO REPLICAS $\sigma^{(k)}(p_i)$ OF THE ORIGINAL DATASET $\sigma^{(\mathrm{data})}(p_i)$
  $\Rightarrow$ REPRESENTATION OF $\mathcal{P}[\sigma(p_i)]$ AT DISCRETE SET OF POINTS p_i

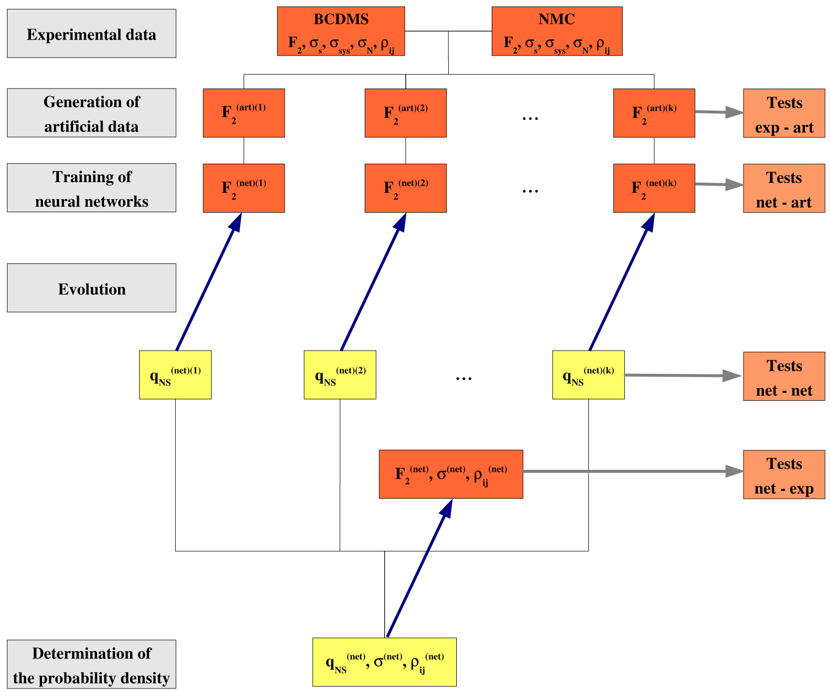


THE FUTURE?

The Neural Monte Carlo approach (S.F., Garrido, Latorre, Piccione 2002)

Basic Idea: use neural networks as universal unbiased interpolants

- generate a set of Monte Carlo replicas $\sigma^{(k)}(p_i)$ of the original dataset $\sigma^{(\mathrm{data})}(p_i)$
  $\Rightarrow$ representation of $\mathcal{P}[\sigma(p_i)]$ at discrete set of points p_i
- train a neural net for each PDF on each replica
  $\Rightarrow$ neural representation of the PDFs $f_i^{(net),(k)}$



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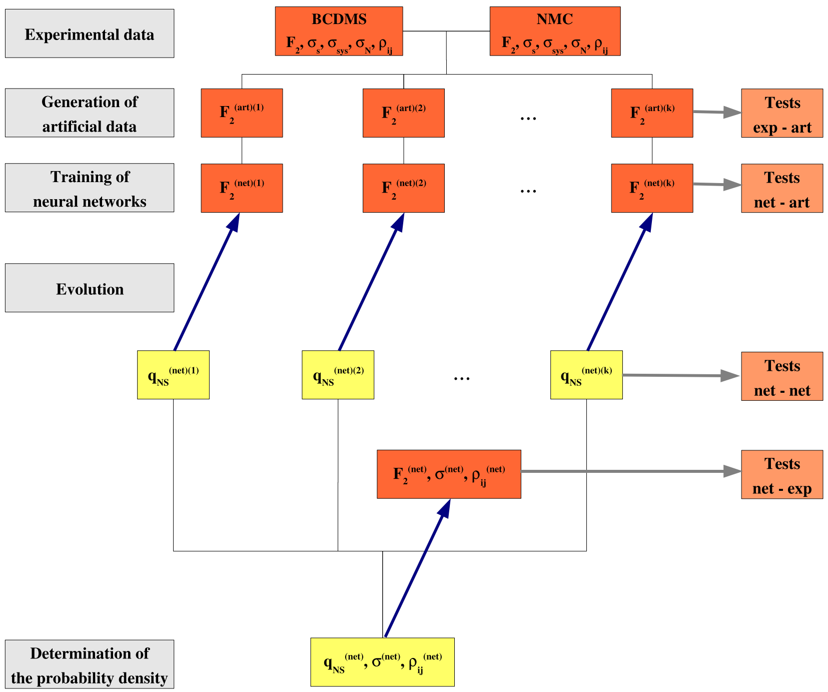
- TRAIN A NEURAL NET FOR EACH PDF ON EACH REPLICA
  $\Rightarrow$ NEURAL REPRESENTATION OF THE PDFS $f_i^{(net),(k)}$
- THE SET OF NEURAL NETS IS A REPRESENTATION OF THE PROBABILITY DENSITY

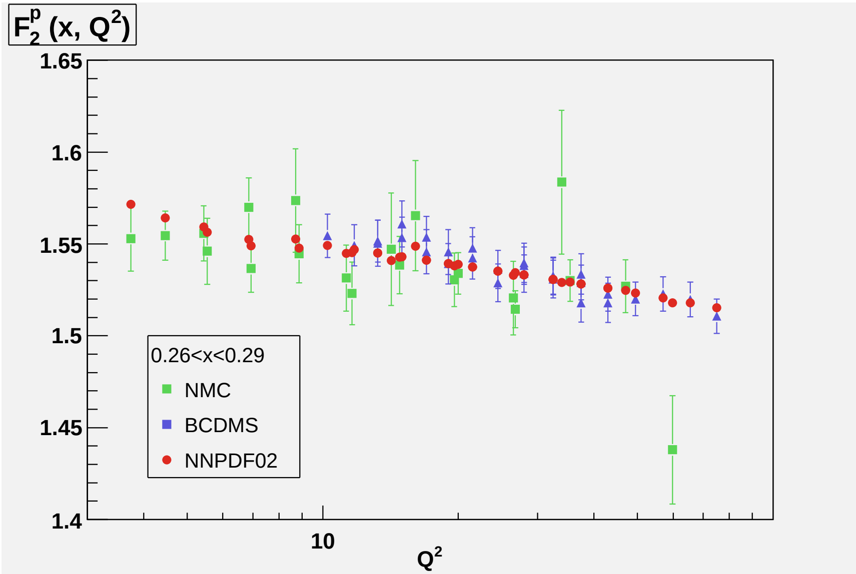


$$\left\langle \sigma\left[f_i\right] \right\rangle = \frac{1}{N_{rep}} \sum_{k=1}^{N_{rep}} \sigma\left[{f_i}^{(net)(k)} \right]$$

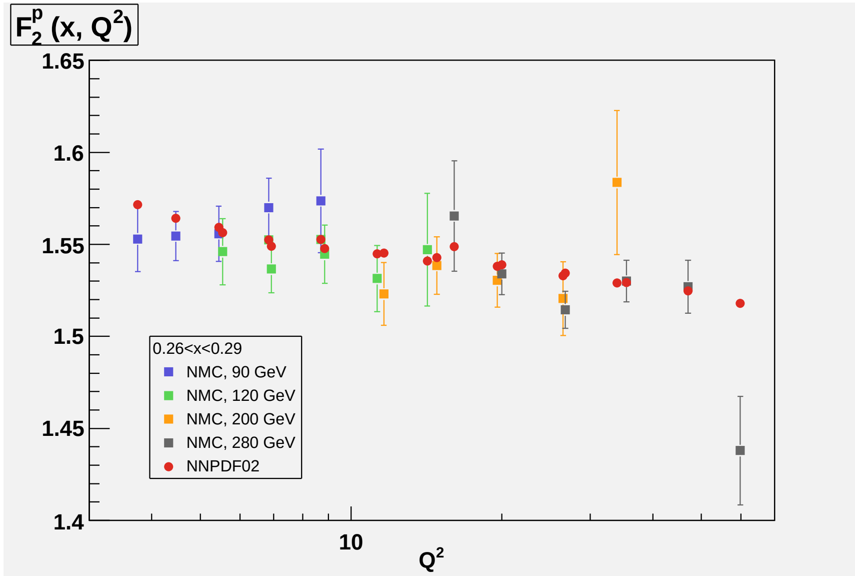
NEURAL HANDLING OF INCOMPATIBLE DATA

SOME NMC DATA ARE INCOMPATIBLE WITH OTHER DATA

Blow-up of proton data/nets



NMC proton data/nets



NEURAL NET DISCARDS INCONSISTENT DATA & PROVIDES GOOD FIT TO THE REST

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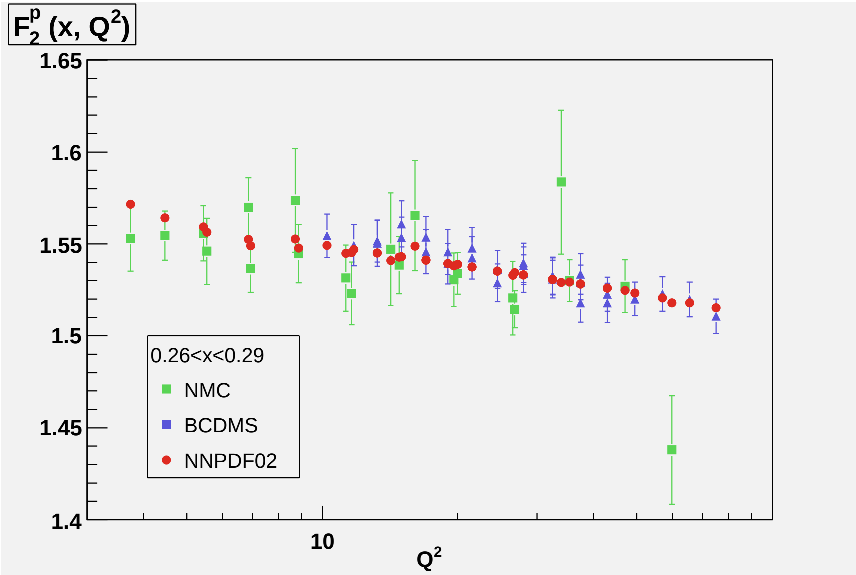
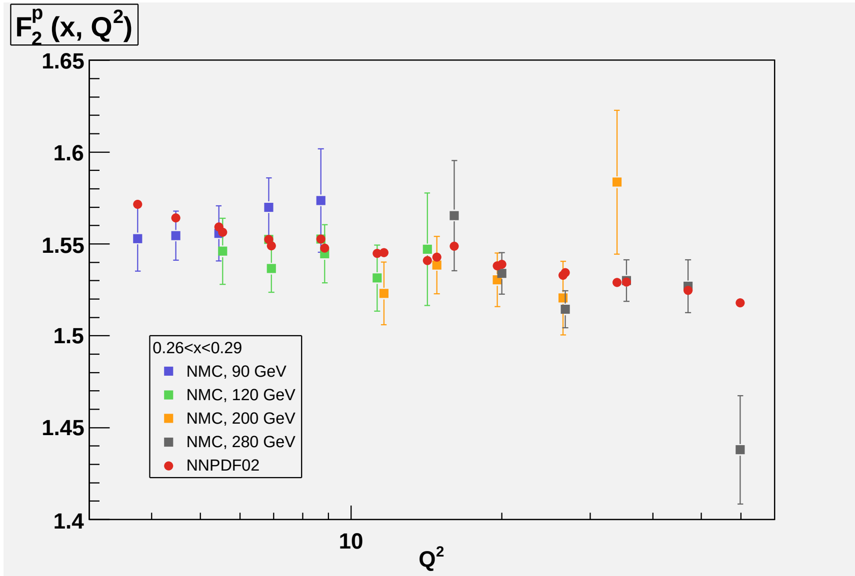
SOME NMC DATA ARE INCOMPATIBLE WITH OTHER DATA

Blow-up of proton data/nets



NMC proton data/nets



NEURAL NET DISCARDS INCONSISTENT DATA & PROVIDES GOOD FIT TO THE REST

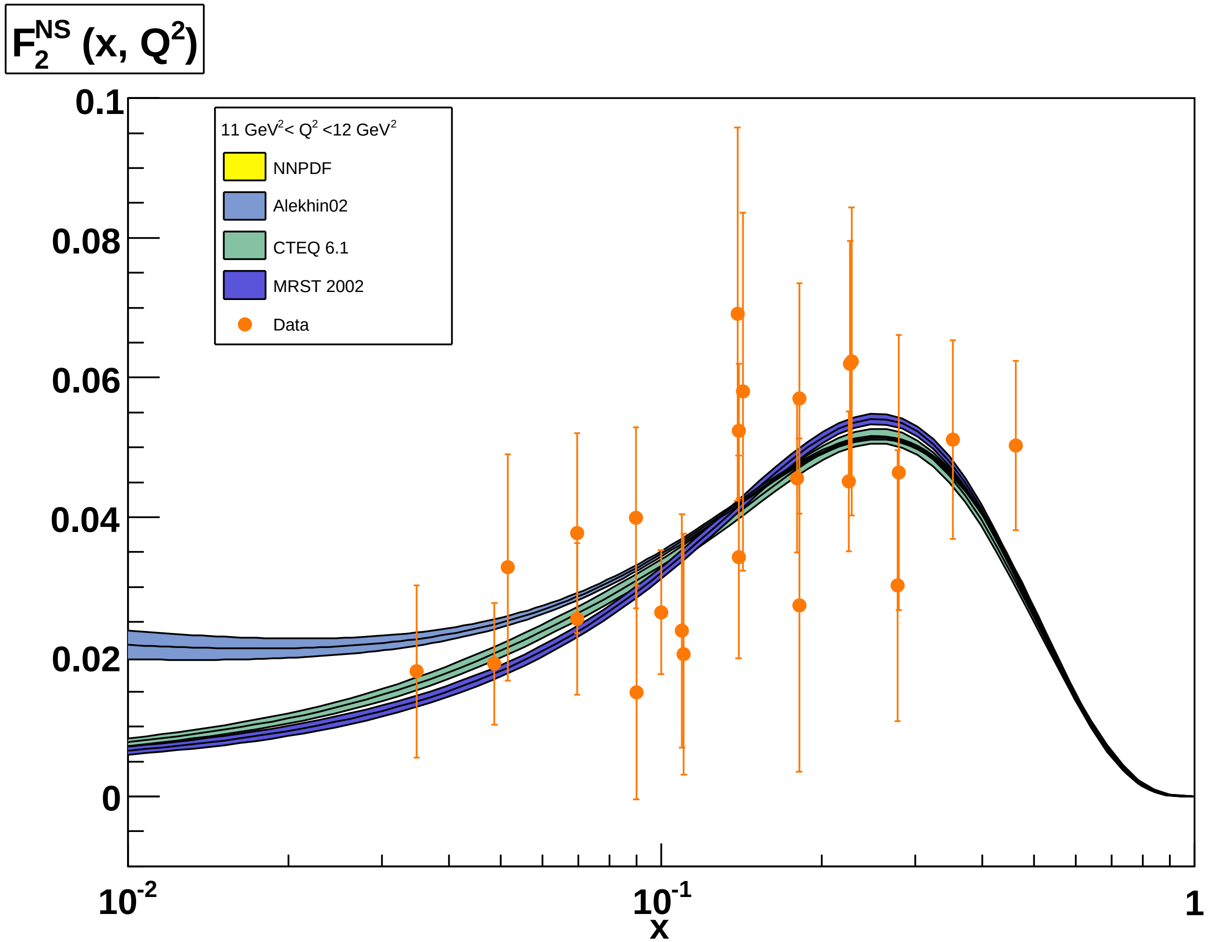
- NEURAL NET IS REDUNDANT
- SMOOTHNESS DECREASES DURING THE FIT
- STOPPING CRITERION: (NOT MINIMUM χ^2)
  DIVIDE DATA IN TWO SETS, USE ONE SET FOR FITTING, STOP FIT WHEN FIT TO OTHER SET STARTS DETERIORATING

NEURAL PARTONS:

THE NONSINGLET CASE

the NNPDF collaboration: L. Del Debbio, S.F. J. Latorre, A. Piccione, J. Rojo

FULL NLO, NNLO FITS TO ALL AVAILABLE DATA



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NEURAL PARTONS:

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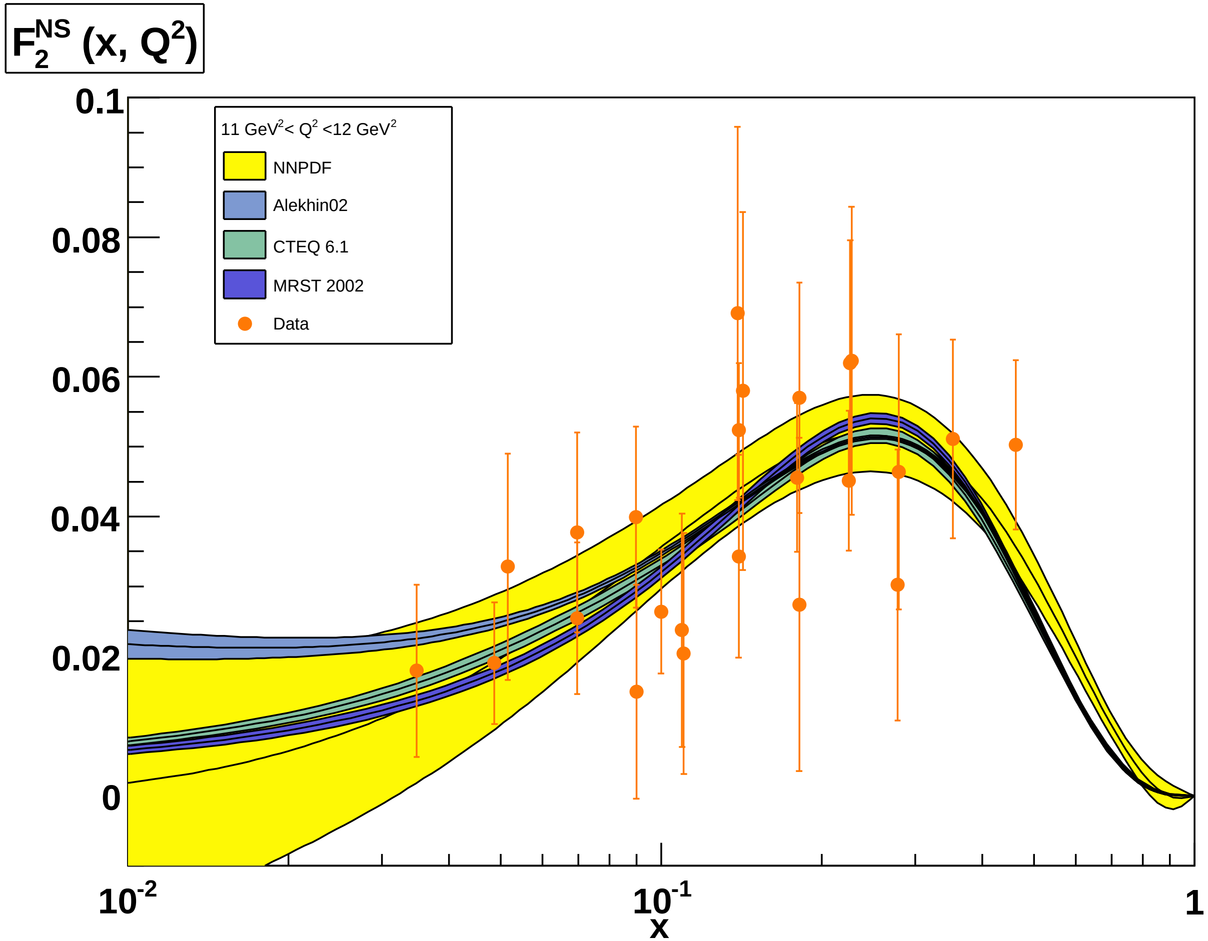
FULL NLO, NNLO FITS TO ALL AVAILABLE DATA



- FITS WITH FIXED FUNCTIONAL FORM SUBSTANTIALLY UNDERESTIMATE ERROR (ESPECIALLY ON EXTRAPOLATION)
- NO EVIDENCE FOR "WELL-KNOWN" SMALL x RISE OF NONSINGLET

CONCLUSION

IN SPIN PHYSICS,

ONE HAS TO BE VERY CLEVER

TO GET AN ANSWER