22nd International Spin Symposium
September 25-20, 2016 at UIUC

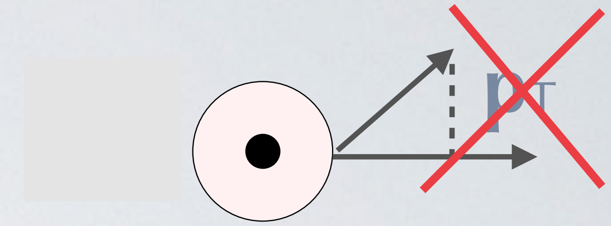
Di-hadron production in p-p collisions and the universality of transversity

Marco Radici
INFN - Pavia

in collaboration with
- A. Bacchetta (Univ. Pavia)
- A. Courtoy (Univ. Guanajuato - Mexico)
- A. Mukherjee (IITB - Mumbai - India)

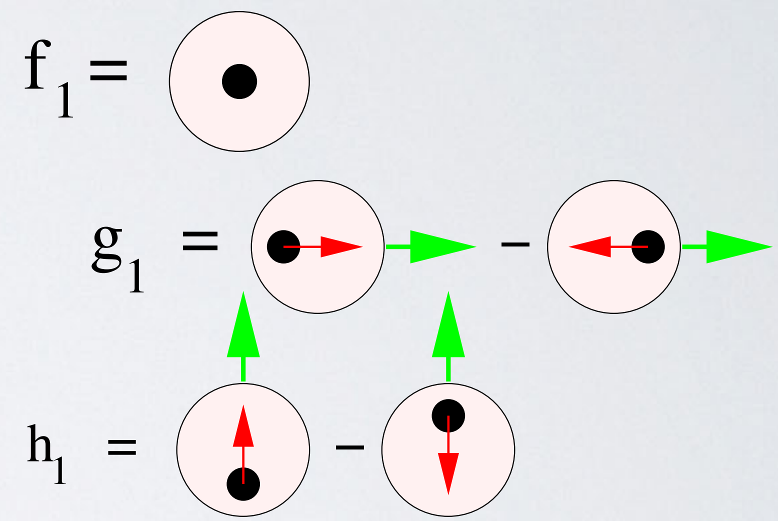
based on Master th. of
A.M. Ricci (Univ. Pavia)

leading-twist TMD map → PDF map



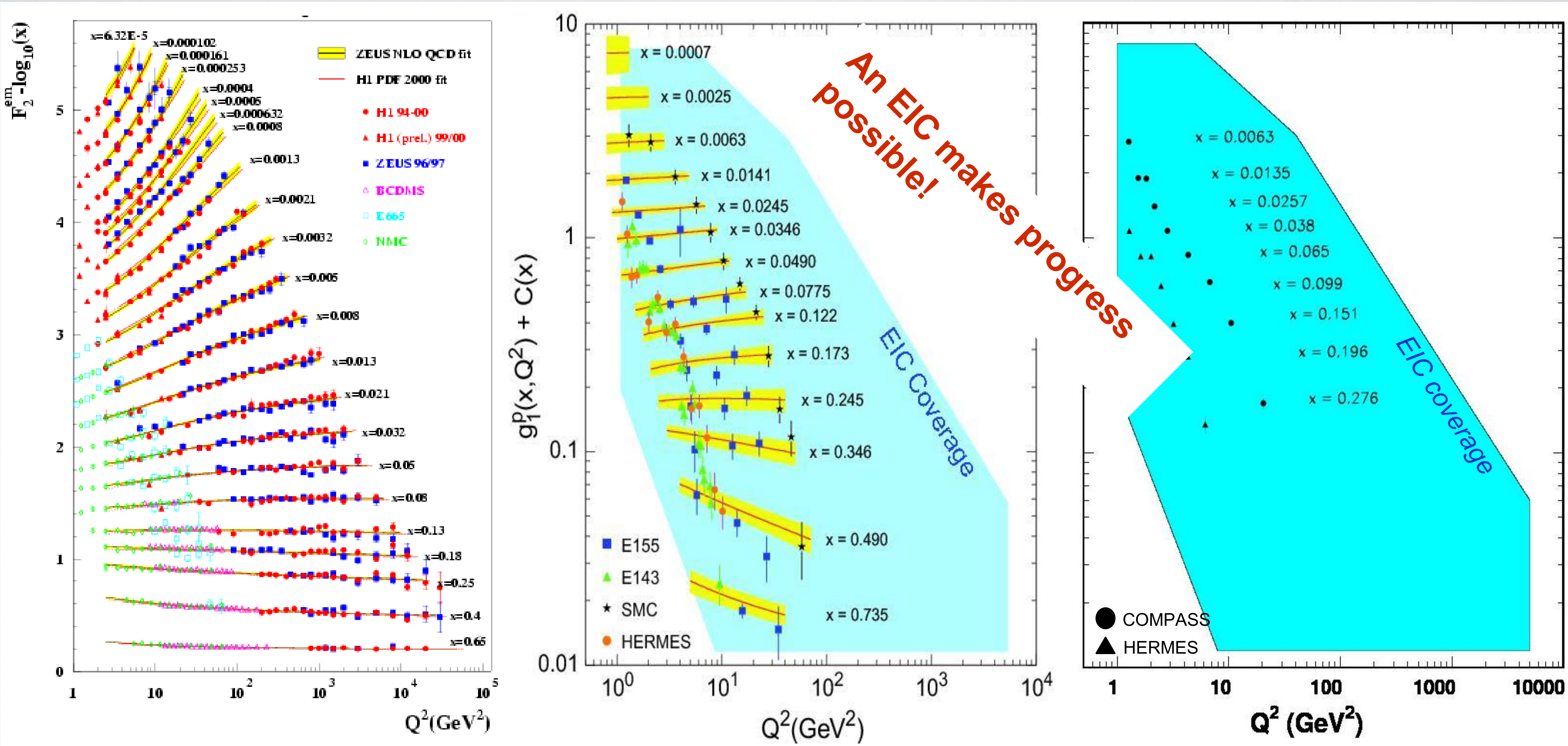
quark polarization

nucleon polarization	U	L	T
U	f_1		$h_1^\perp$
L		g_{1L}	$h_{1L}^\perp$
T	$f_{1T}^\perp$	g_{1T}	h_1 $h_{1T}^\perp$



h_1 transversity distribution

Transversity poorly known, but how much ?



World data for F_2^p
f_1 from fits of
thousands data

World data for g_1^p
g_1 from fits of
hundreds data

World data for **h_1**
from fits of **tens** data

slide from H.Montgomery, QCD Evolution 2016

Tensor Charge

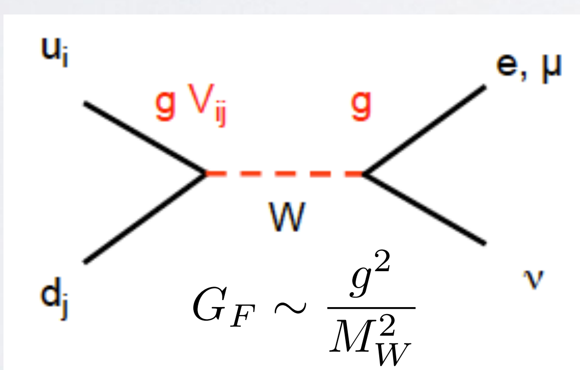
- 1st Mellin moment of transversity $\Rightarrow$ tensor "charge"

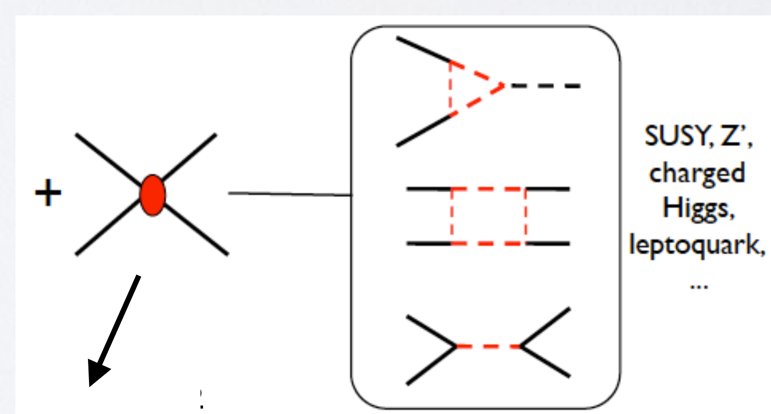
$$\delta q \equiv g_T^q = \int_0^1 dx \; \left[h_1^q(x, Q^2) - h_1^{\bar{q}}(x, Q^2) \right]$$

tensor charge not directly accessible in $\mathcal{L}_{SM}$
low-energy footprint of new physics at higher scales ?

Example: neutron β–decay $n \rightarrow p\, e^- \bar{\nu}_e$

SM





BSM

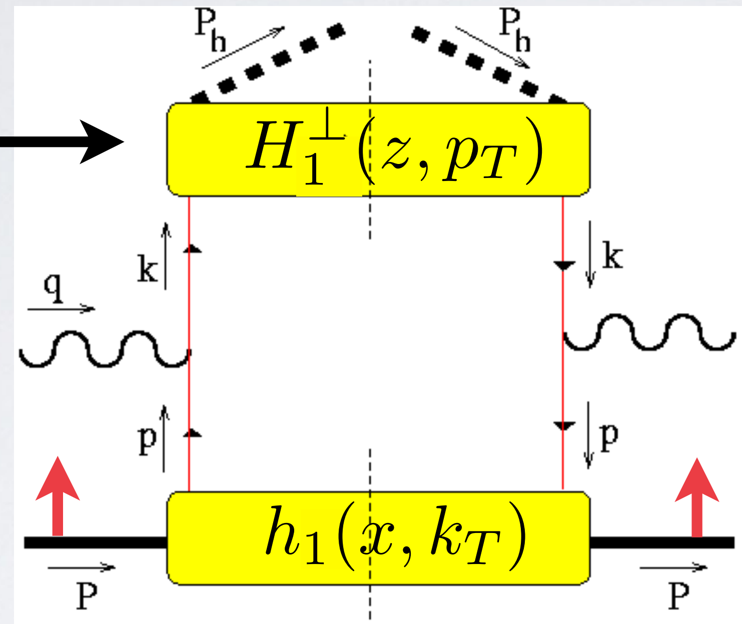
$$\varepsilon_T \, g_T \approx M_W^2 / M_{BSM}^2$$

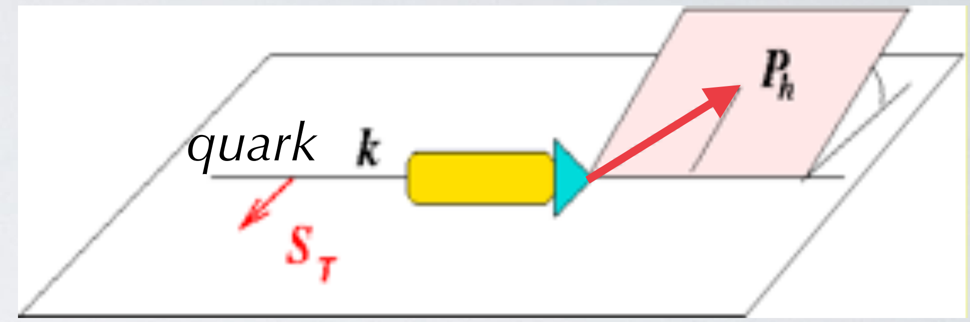
precision of 0.1% $\Rightarrow$ [3-5] TeV bound for BSM scale

First extractions of transversity: the Collins effect

one-hadron SIDIS

Collins function →





correlation $\mathbf{S}_T$ and $\mathbf{P}_{hT}$

→ azimuthal asymmetry

TMD factorization

$$A_{\text{SIDIS}}^{\sin(\phi_h+\phi_S)}(x, z, P_T^2) \sim \frac{\sum_q e_q^2 \; h_1^q(x, \boldsymbol{k}_\perp^2) \otimes H_{1,q}^\perp(z, \boldsymbol{p}_\perp^2)}{\sum_q e_q^2 \; f_1^q(x, \boldsymbol{k}_\perp^2) \otimes D_{1,q}(z, \boldsymbol{p}_\perp^2)}$$

h_1 "considered" as a TMD

..... *Anselmino et al., P.R. D**87** (13) 094019*
*[Anselmino et al., P.R. D**92** (15) 114023]*

← very compatible →

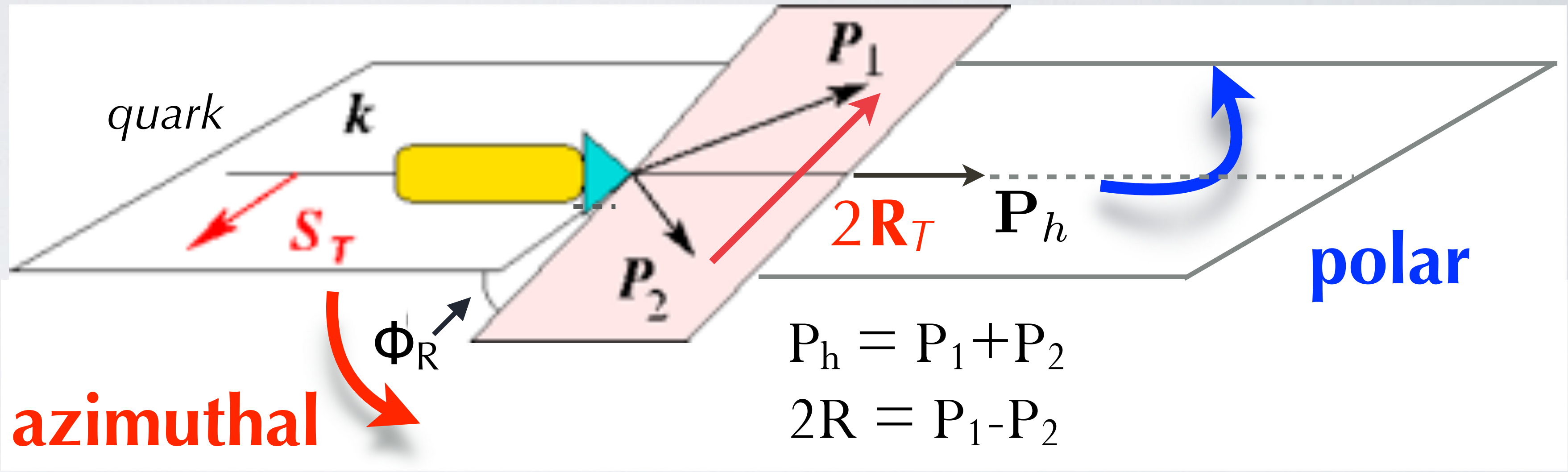
*Kang et al., P.R. D**93** (16) 014009*

also "quasi-transversity" on lattice (LaMET) *Chen et al., arXiv:1603.06664*

forward limit of chiral-odd GPD H_T *Goldstein, Gonzalez and Liuti, P.R. D**91** (15) 114013*

di-hadron fragmentation (DiFF)

Collins, Heppelman, Ladinsky, *N.P.* ***B420*** *(94)*



correlation between quark pol. $\mathbf{S}_T$ and $2\mathbf{R}_T$

→ azimuthal asymmetry

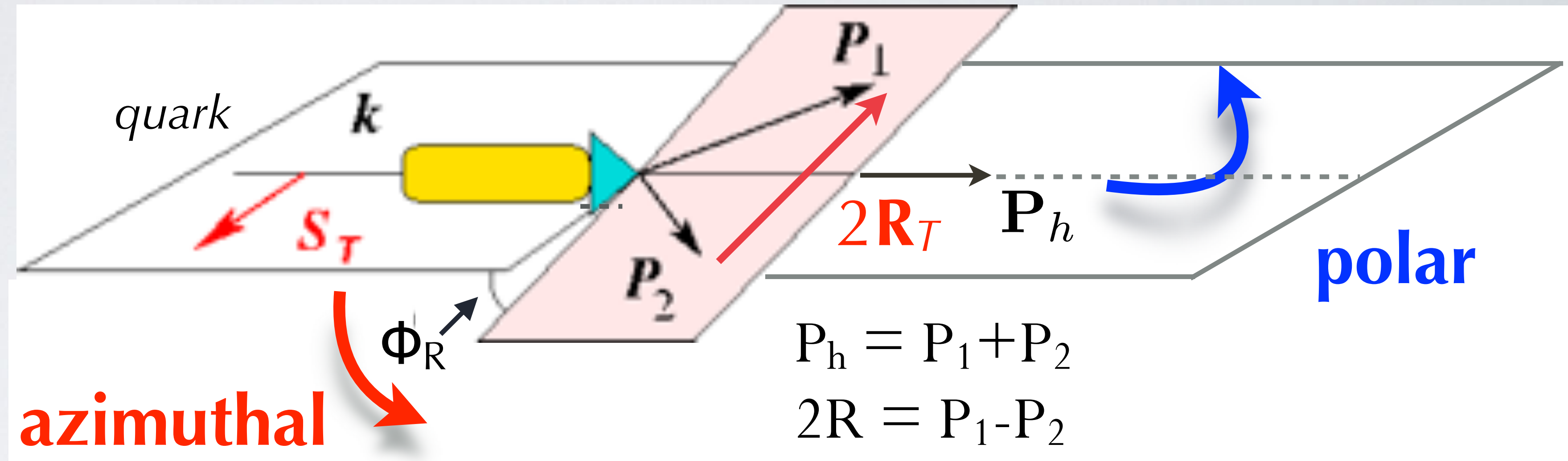
survives even if polar symmetry ($\int d\mathbf{P}_{hT}$)

equivalent to take $\mathbf{P}_h \| \mathbf{k}$ → no $\mathbf{k}_T$

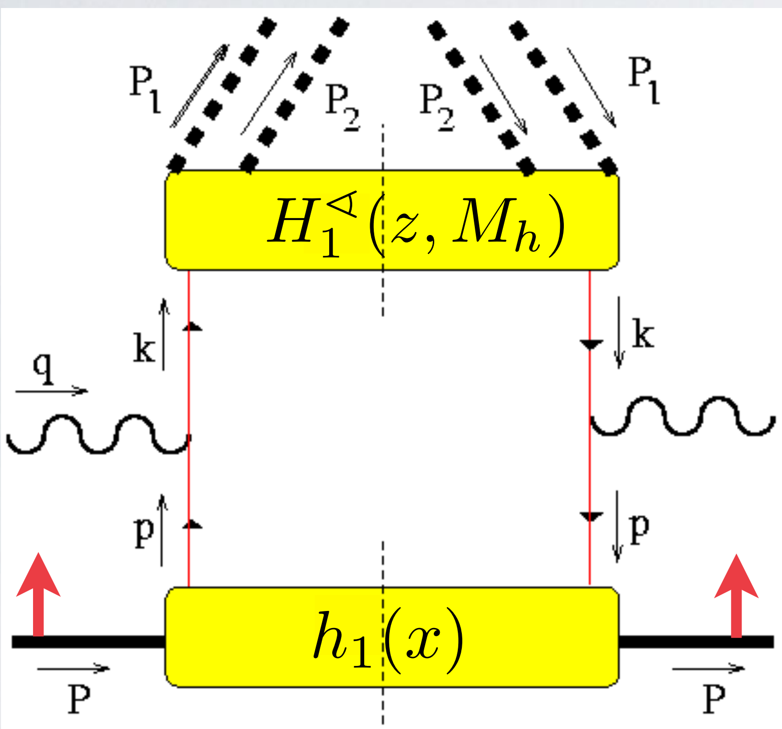
collinear factorization

di-hadron fragmentation (DiFF)

Collins, Heppelman, Ladinsky, N.P. ***B420*** *(94)*



two-hadron SIDIS



*Radici, Jakob, Bianconi, P.R.D****65*** *(02) 074031*

correlation between quark pol. S_T and $2R_T$

→ azimuthal asymmetry

survives even if polar symmetry ($\int dP_{hT}$)

equivalent to take $P_h \| k$ → no k_T

collinear factorization

$$A_{\rm SIDIS}^{\sin(\phi_R+\phi_S)}(x, z, M_h^2) \sim -\frac{\sum_q e_q^2\; h_1^q(x)\; \frac{|\boldsymbol{R}_T|}{M_h}\, H_{1,q}^{\sphericalangle}(z, M_h^2)}{\sum_q e_q^2\; f_1^q(x)\; D_{1,q}(z, M_h^2)}$$

← chiral-odd DiFF

$z = z_1+z_2$

price to pay: dependence on ($\pi\pi$) invariant mass M_h

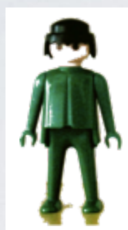
x-dep. of SSA given by PDFs only

the Pavia fit

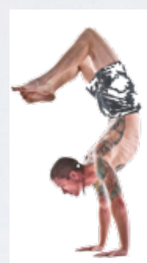
- parametrization at $Q_0^2 = 1\ \mathrm{GeV}^2$

$$x h_1^{q_v}(x) = \tanh\left[\sqrt{x}\left(A_q + B_q x + C_q x^2 + D_q x^3\right)\right]\ \left[x\,\mathrm{SB}_q(x) + x\,\overline{\mathrm{SB}}_{\bar{q}}(x)\right]$$

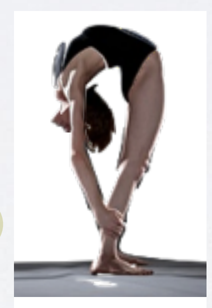
rigid



flexible



extra-flexible



satisfies **S**offer **B**ound at any Q^2

$$2|h_1^q(x,Q^2)| \leq 2\,\mathrm{SB}_q(x) = |f_1^q(x) + g_1^q(x)|$$

- SIDIS data from hermes and COMPASS

*Airapetian et al., JHEP **0806** (08) 017*

*Adolph et al., P.L. **B713** (12)*

*Braun et al., E.P.J. Web Conf. **85** (15) 02018*

history of upgrading fits

*Bacchetta, Courtoy, Radici, P.R.L. **107** (11) 012001*

*Bacchetta, Courtoy, Radici, JHEP **1303** (13) 119*

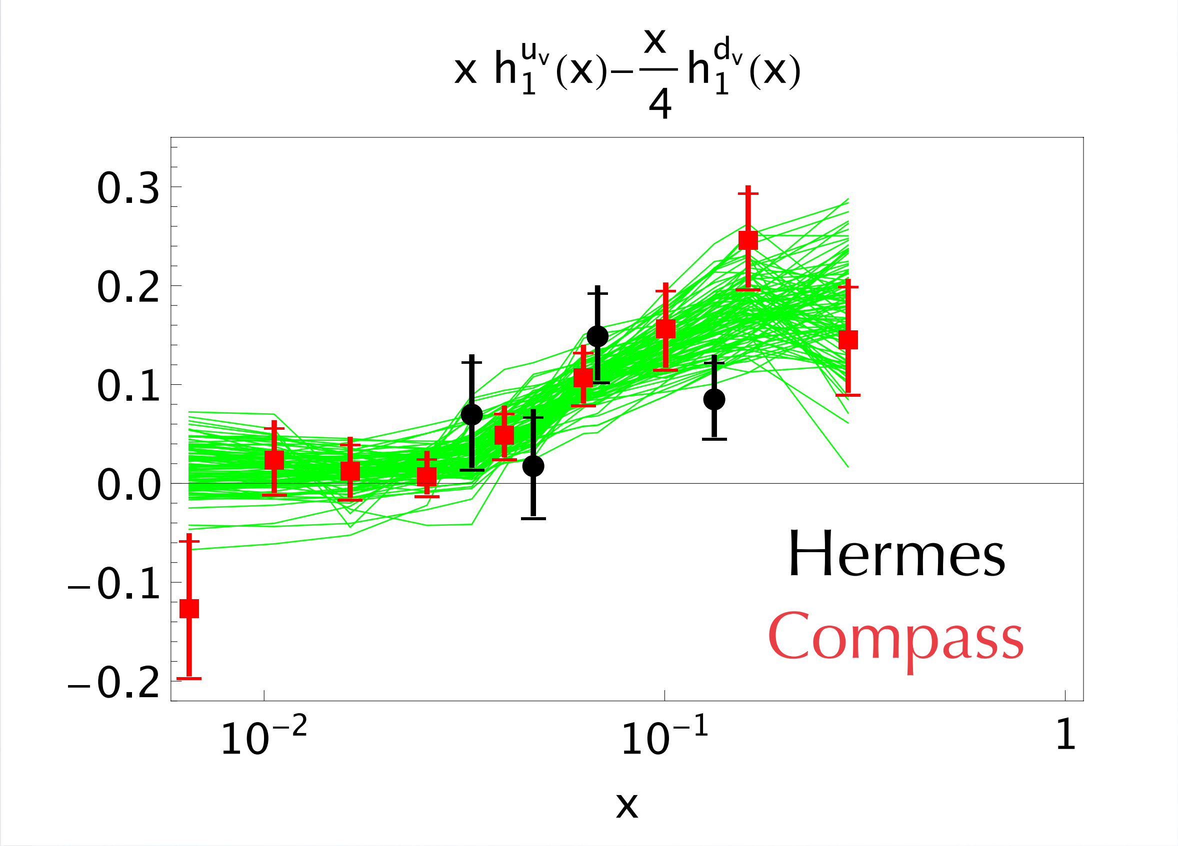
*Radici et al., JHEP **1505** (15) 123*

error analysis : the replica method

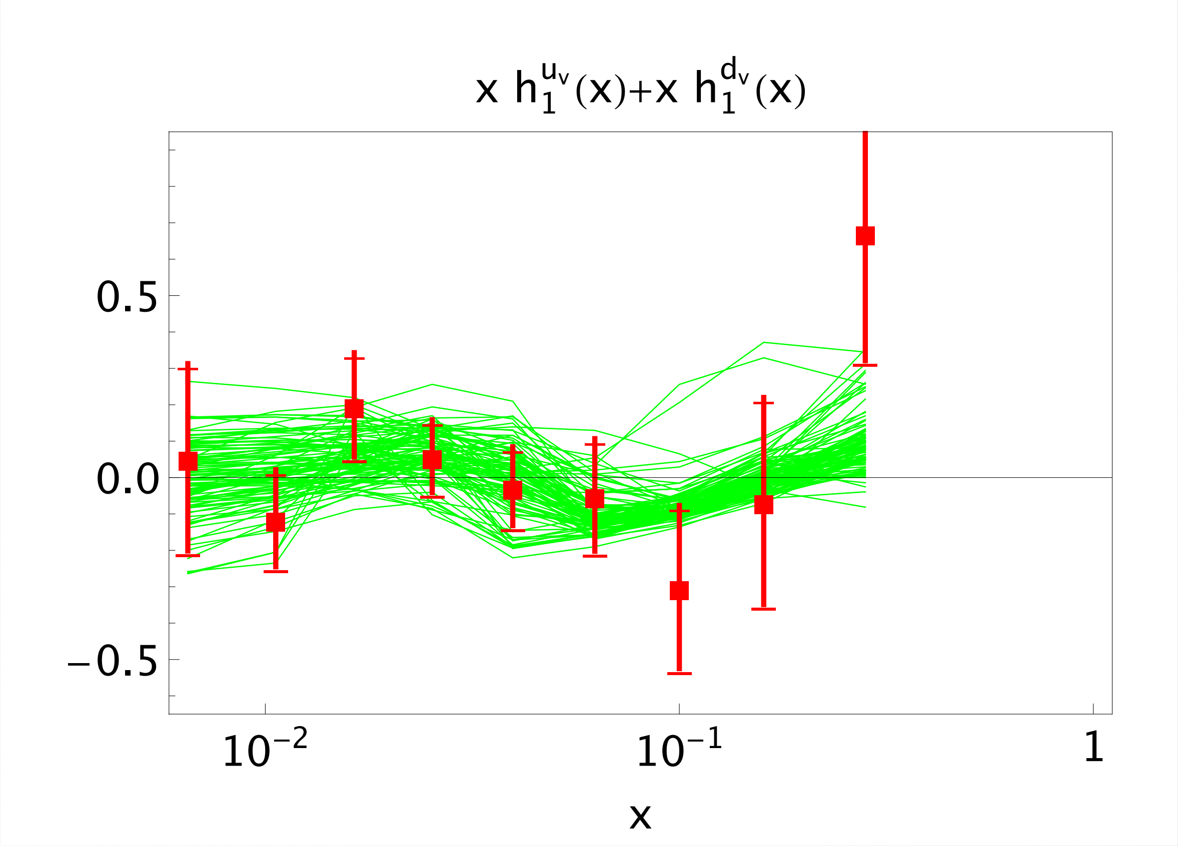
alter data with random noise and fit them

100 replicas

proton

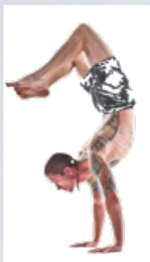


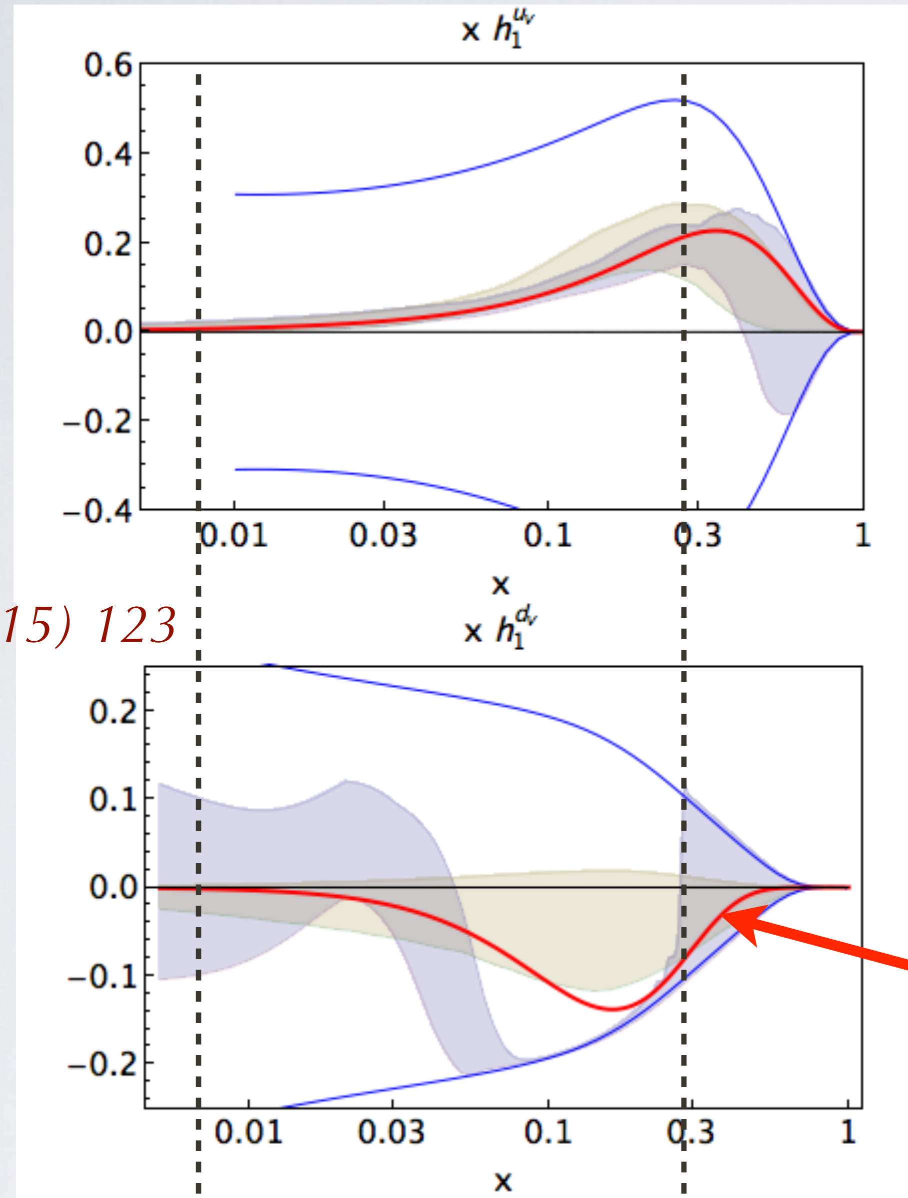
deuteron



comparison with Collins effect

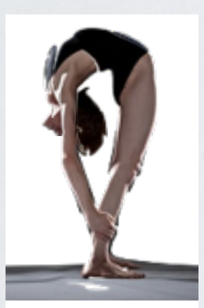
up





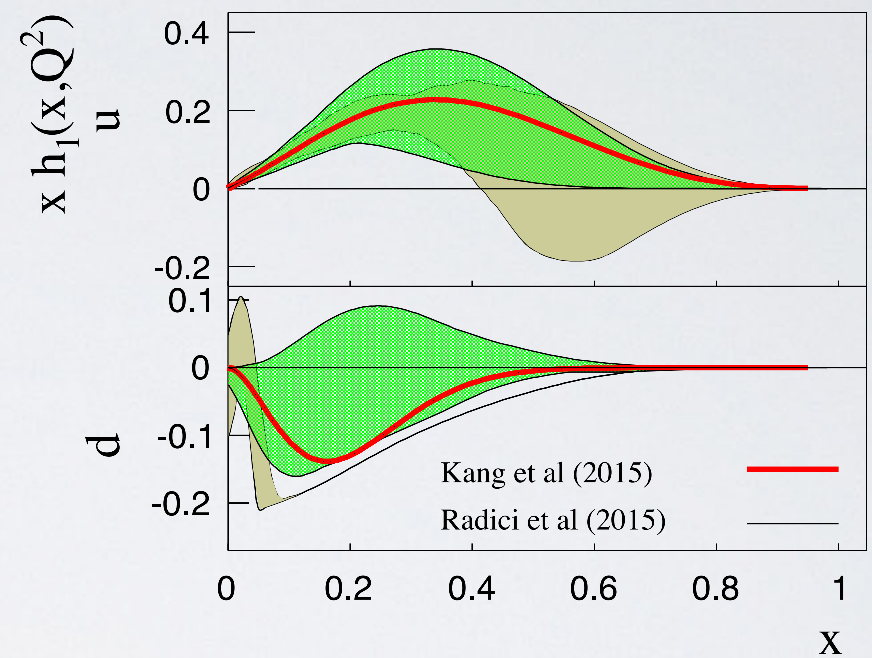
*Radici et al., JHEP **1505** (15) 123*

down



data

Kang et al. 2016 <-> Pavia 2015



Q^2=2.4 GeV^2

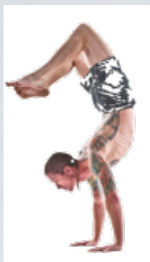
linear scale

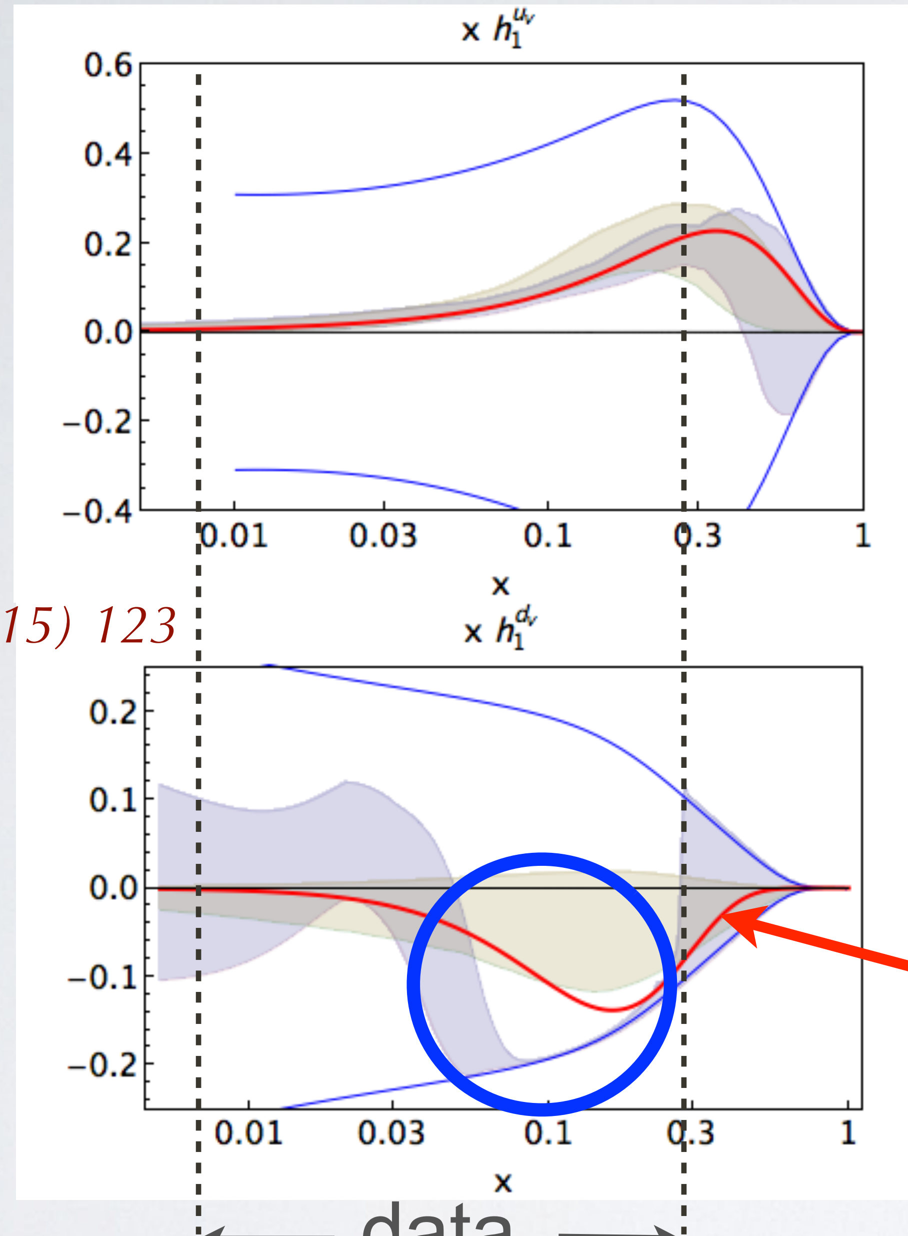
*Anselmino et al., **2013***

*Kang et al., **2015***

comparison with Collins effect

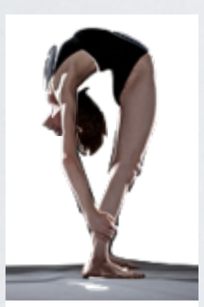
up



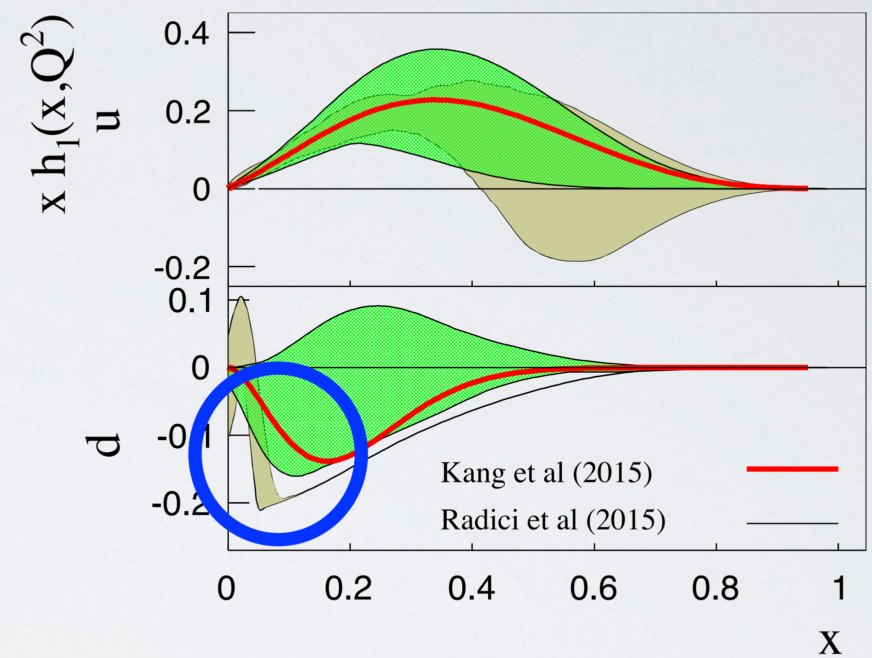


Radici et al.,
JHEP ***1505*** *(15) 123*

down



Kang et al. 2015 <-> Pavia 2015



Q^2=2.4 GeV^2

linear scale

Anselmino et al., ***2013***

Kang et al., ***2015***

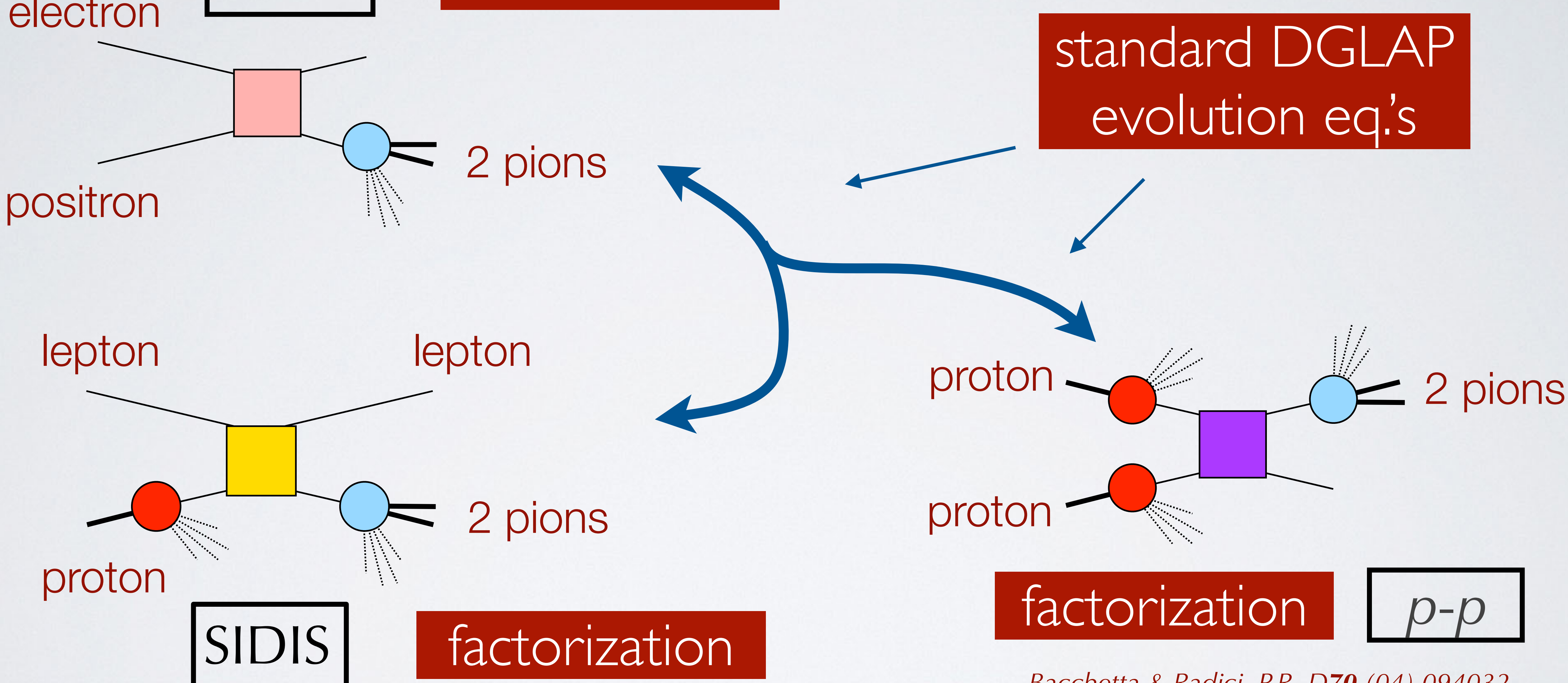
unusual saturation of Soffer bound for down

collinear factorization in hard processes

Artru & Collins, Z.Phys. ***C69*** *(96) 277*
*Boer, Jakob, Radici, P.R.D**67*** *(03) 094003*

*DeFlorian & Vanni, P.L.**B578*** *(04) 139*
*Ceccopieri, Radici, Bacchetta, P.L.**B650*** *(07) 81*
(see also
Zhou and Metz, P.R.L. ***106*** *(11) 172001*
for M_h—evolution of DiFFs)

e^+e^- factorization



*Bacchetta & Radici, P.R. D**70*** *(04) 094032*

*Jaffe, Jin, Tang, P.R.L.**80*** *(98) 1166*
*Radici, Jakob, Bianconi, P.R.D**65*** *(02) 074031*
*Bacchetta & Radici, P.R. D**67*** *(03) 094002*

collinear factorization in hard processes

Artru & Collins, Z.Phys. ***C69*** *(96) 277*
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(see also
Zhou and Metz, P.R.L. ***106*** *(11) 172001*
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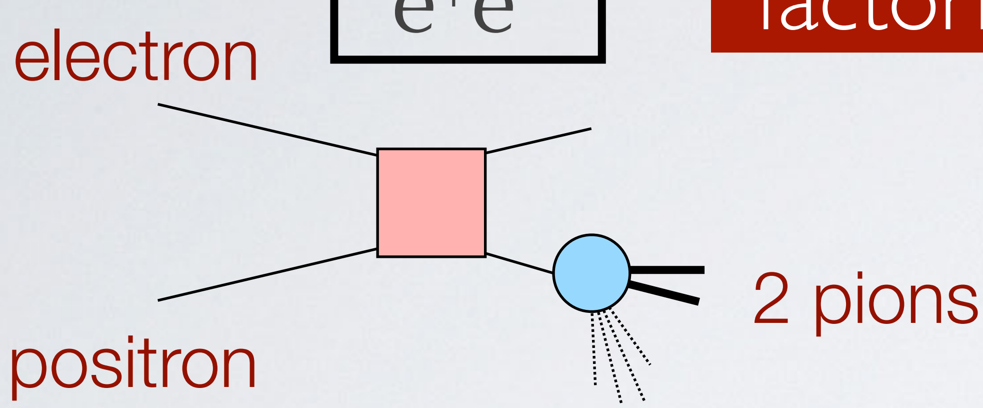
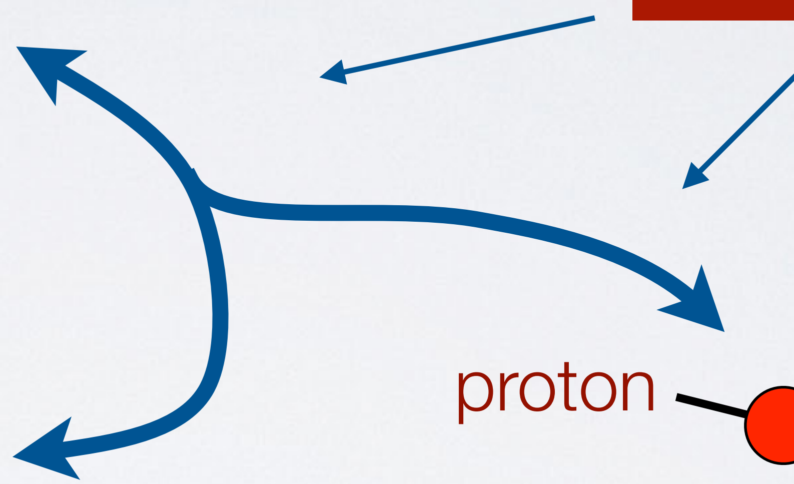
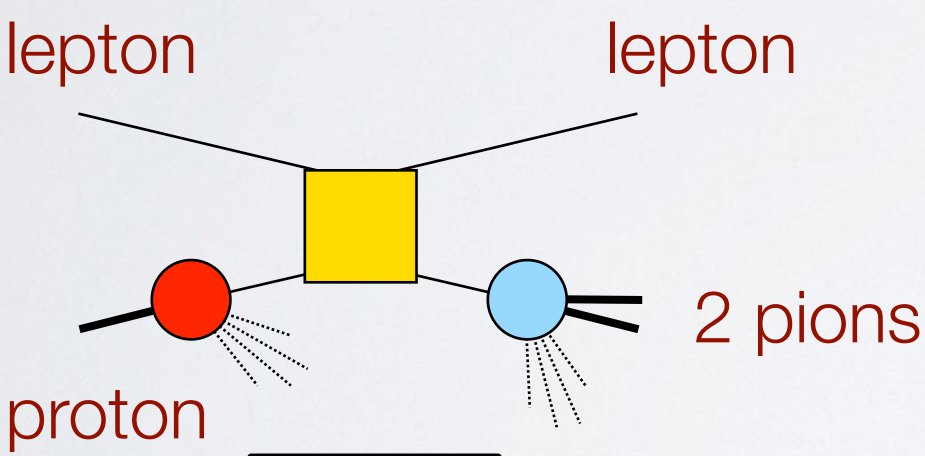
e^+e^- — **factorization**

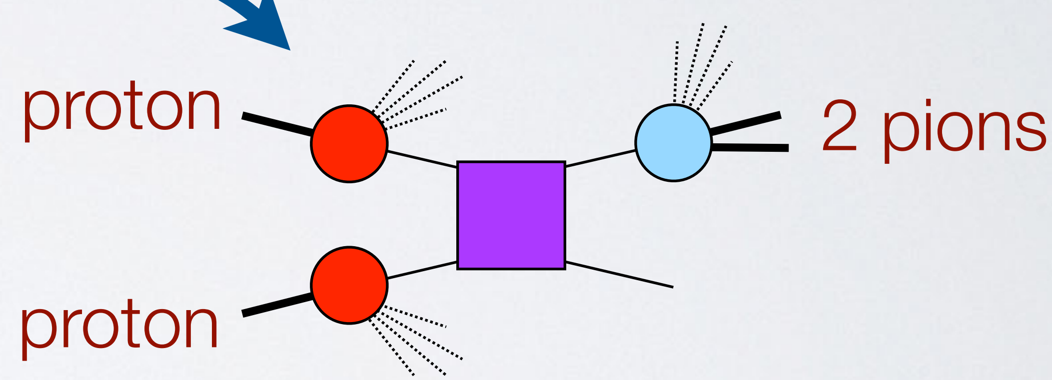


standard DGLAP evolution eq.'s





SIDIS — **factorization**



factorization — *p-p*

*Bacchetta & Radici, P.R. D****70*** *(04) 094032*

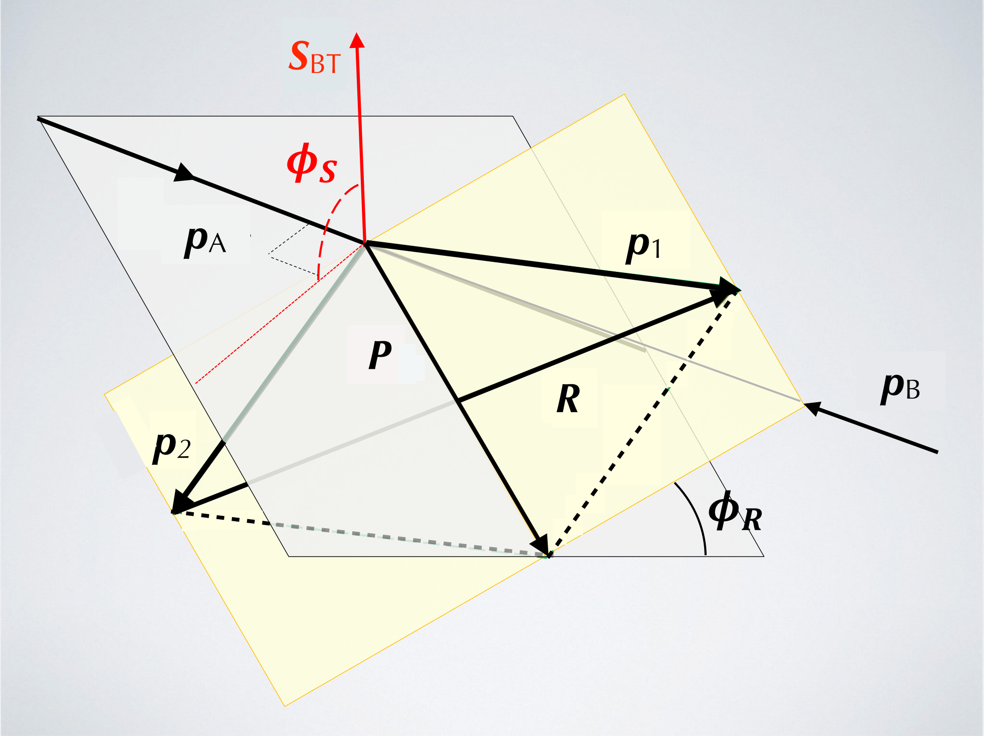
*Jaffe, Jin, Tang, P.R.L.****80*** *(98) 1166*
*Radici, Jakob, Bianconi, P.R.D****65*** *(02) 074031*
*Bacchetta & Radici, P.R. D****67*** *(03) 094002*

Rogers & Mulders,
*P.R. D****81*** *(10) 094006*

not possible in $p+p \to \pi+\pi+X$

the process $p + p^{\uparrow} \to (\pi\ \pi) + X$

*Bacchetta & Radici, P.R. D**70** (04) 094032*



B beam polarized

forward
polarized particles
at η < 0

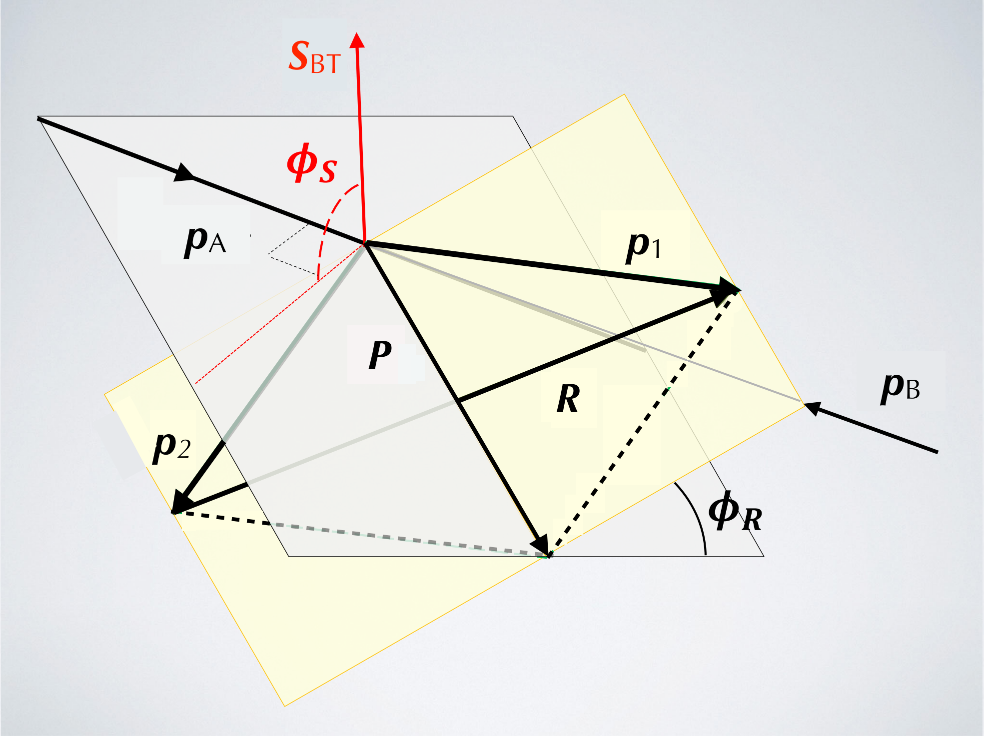
$$d\sigma \sim d\sigma^0 + \sin(\Phi_S - \Phi_R)\, d\sigma_{UT}$$

$$\hat{t} = t\, x_a/\bar{z}$$

$$\frac{d\sigma^0}{d\eta\, d|\boldsymbol{P}_T|\, dM} = 2\,|\boldsymbol{P}_T| \sum_{a,b,c,d} \int \frac{dx_a\, dx_b}{8\pi^2 \bar{z}}\, f_1^a(x_a)\, f_1^b(x_b)\, \frac{d\hat{\sigma}_{ab\to cd}}{d\hat{t}}\, D_1^c(\bar{z}, M)$$

the process $p + p^{\uparrow} \to (\pi\,\pi) + X$

Bacchetta & Radici,
*P.R. D**70** (04) 094032*



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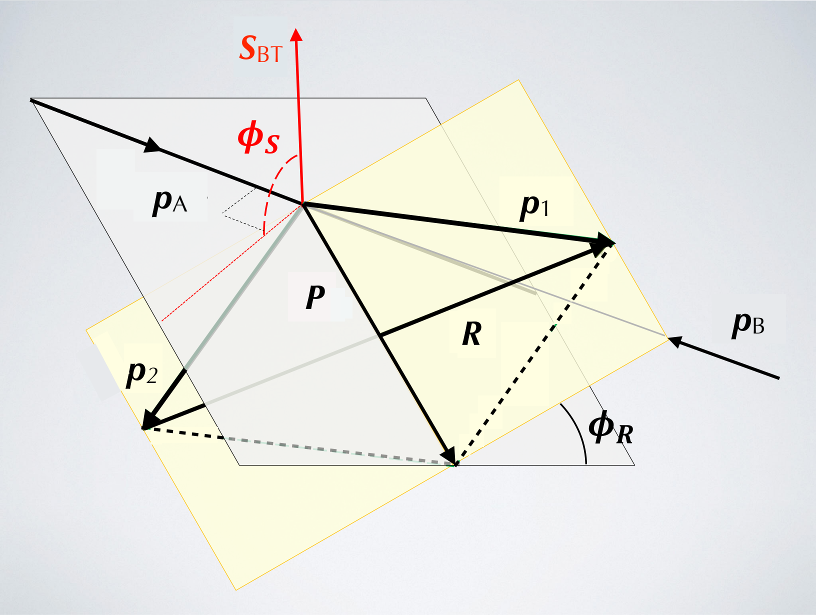
$$\frac{d\sigma_{UT}}{d\eta\, d|\boldsymbol{P}_T|\, dM} = |\boldsymbol{S}_{BT}|\, 2\,|\boldsymbol{P}_T|\, \frac{|\boldsymbol{R}|}{M}\, \sin\theta \sum_{a,b,c,d} \int \frac{dx_a\, dx_b}{8\pi^2 \bar{z}}\, f_1^a(x_a)\, h_1^b(x_b)\, \frac{d\Delta\hat{\sigma}_{ab^{\uparrow}\to c^{\uparrow}d}}{d\hat{t}}\, H_1^{\sphericalangle c}(\bar{z}, M)$$

Our prediction: asymmetry given by same mechanism active in SIDIS

the process p + p$^{\uparrow}$ → (π π) + X



*Bacchetta & Radici, P.R. D**70** (04) 094032*

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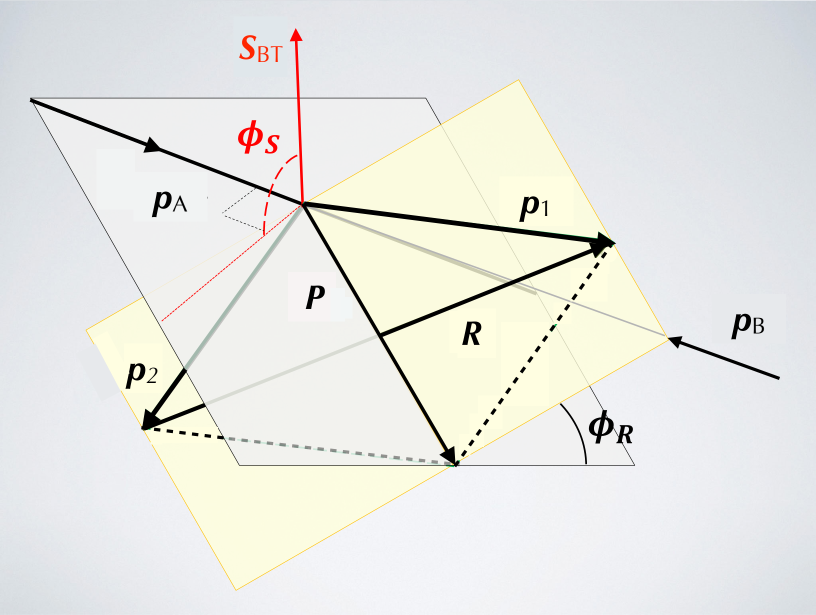
$$\frac{|\boldsymbol{R}|}{M} = \frac{1}{2}\sqrt{1 - 4\frac{m_\pi^2}{M^2}}$$

M = invariant mass of (π π)

the process $p + p^{\uparrow} \rightarrow (\pi\,\pi) + X$



*Bacchetta & Radici, P.R. D**70** (04) 094032*

$$d\sigma \sim d\sigma^0 + \sin(\Phi_S - \Phi_R)\, d\sigma_{UT}$$

B beam polarized

⬇

forward
polarized particles
at $\eta < 0$

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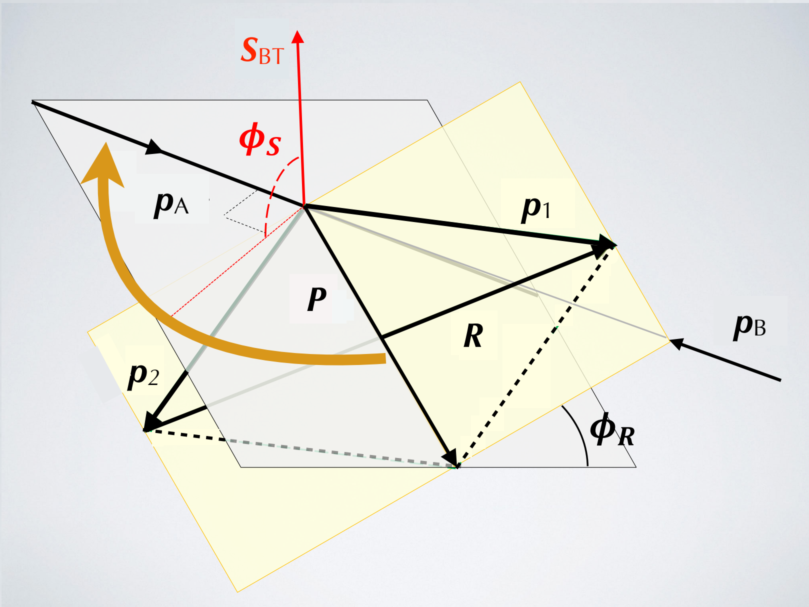
η = pseudorapidity

conservation of momenta in $ab \rightarrow cd$

$\Rightarrow$ $(\pi\pi)$ fract. energy fixed to

$$\bar{z} = \frac{|\boldsymbol{P}_T|}{\sqrt{s}}\, \frac{x_a e^{-\eta} + x_b e^{\eta}}{x_a x_b}$$

the process p + p$^{\uparrow}$ → (π π) + X



*Bacchetta & Radici, P.R. D**70** (04) 094032*

$$d\sigma \sim d\sigma^0 + \sin(\Phi_S - \Phi_R)\, d\sigma_{UT}$$

B beam polarized

forward
polarized particles
at $\eta < 0$

$$\frac{d\sigma^0}{d\eta\, d|\boldsymbol{P}_T|\, dM} = 2|\boldsymbol{P}_T| \sum_{a,b,c,d} \int \frac{dx_a\, dx_b}{8\pi^2 \bar{z}}\, f_1^a(x_a)\, f_1^b(x_b)\, \frac{d\hat{\sigma}_{ab\to cd}}{d\hat{t}}\, D_1^c(\bar{z}, M)$$

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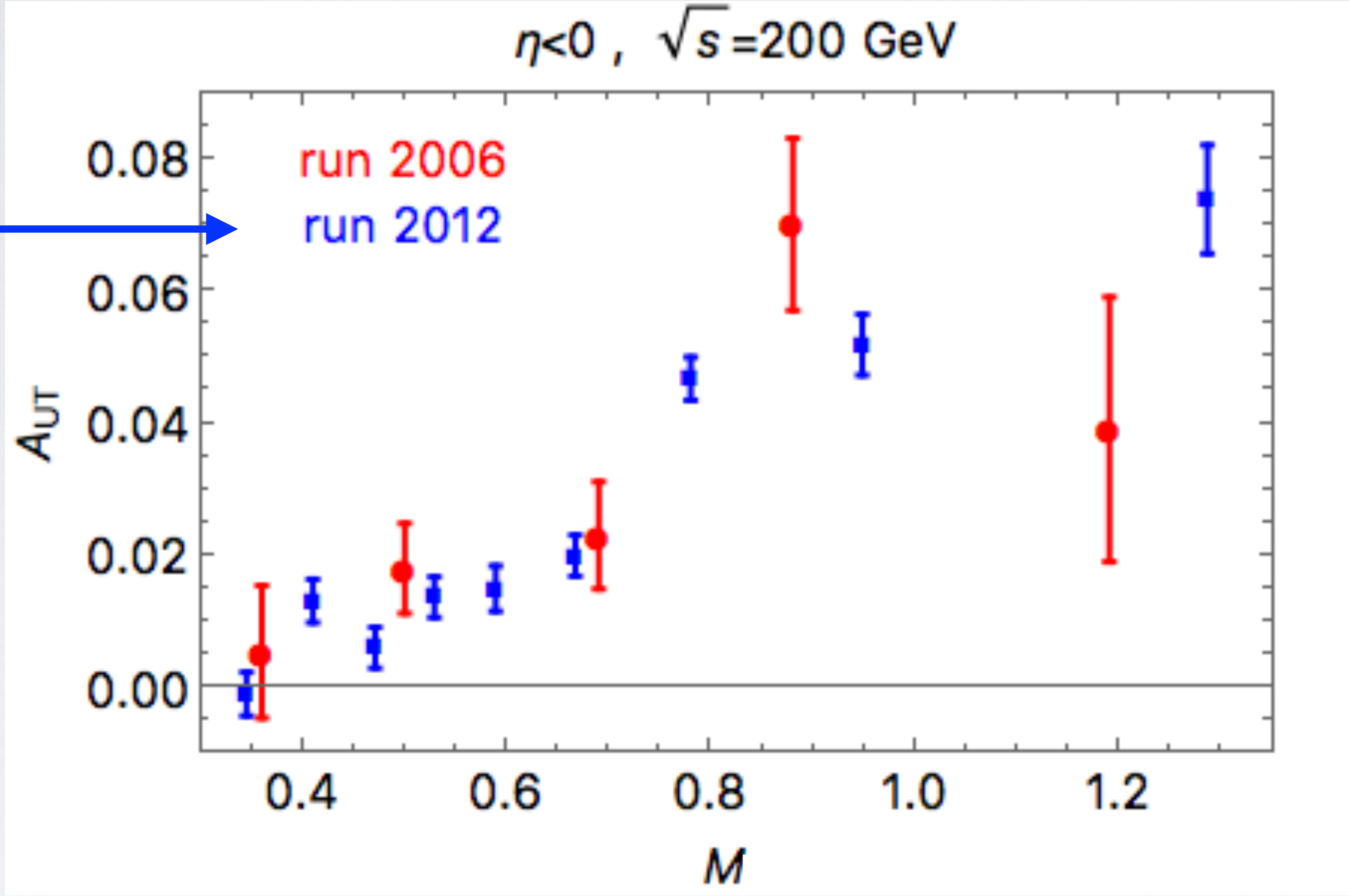
$|P_T|$ = transverse component of pair total momentum with respect to *A* beam

hard scale $|P_T| \gg M, M_A, M_B$

forward $A_{UT}(M)$: STAR data

PRELIMINARY



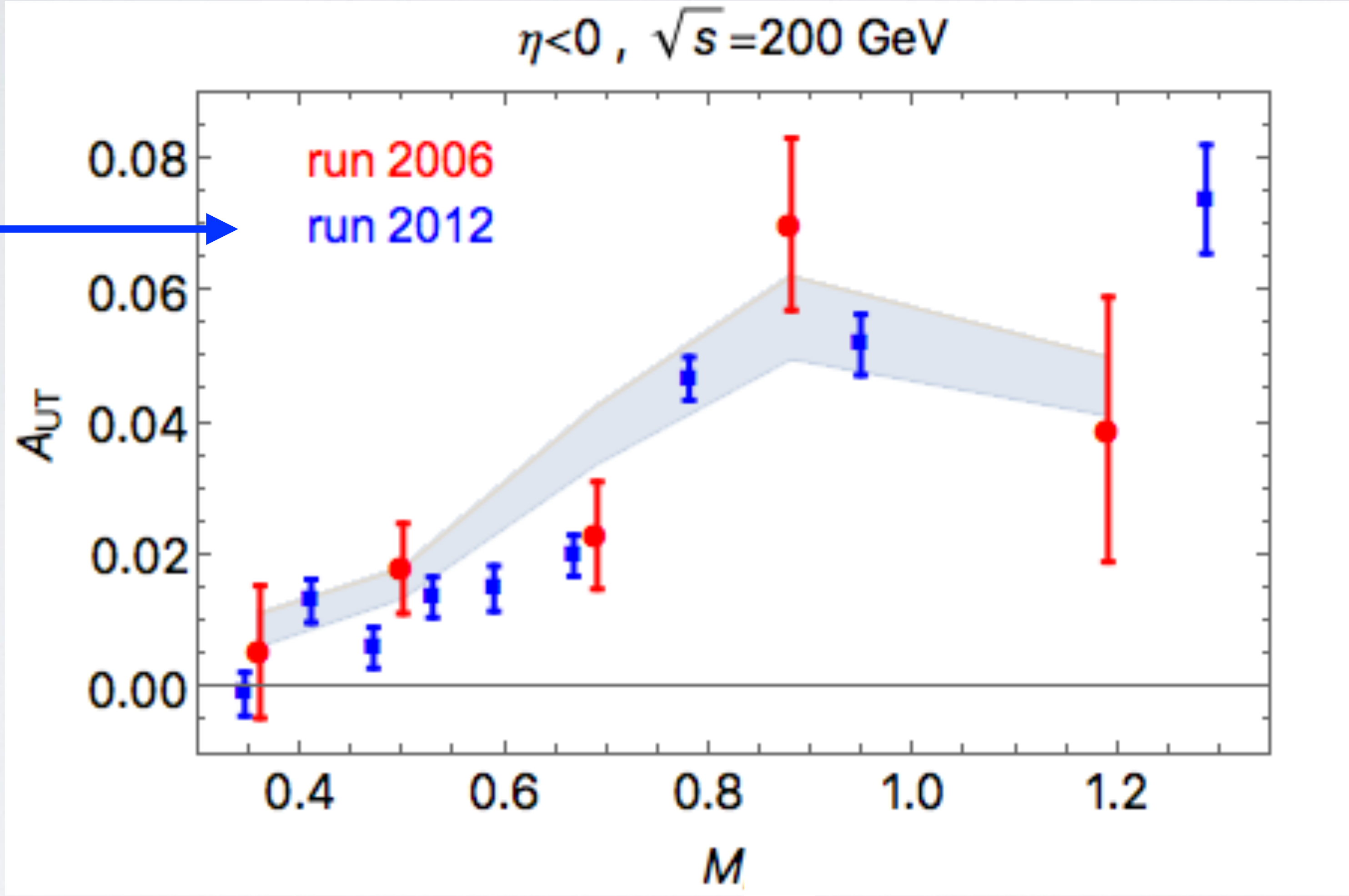
run 2006 *Adamczyk et al. (STAR), P.R.L.* ***115*** *(2015) 242501*

run 2012 *K. Landry, talk at APS 2015*

forward $A_{UT}(M)$: our prediction vs. STAR data

*Radici et al., P.R. D**94** (16) 034012*

PRELIMINARY



band = prediction using central 68% of replicas from SIDIS fit

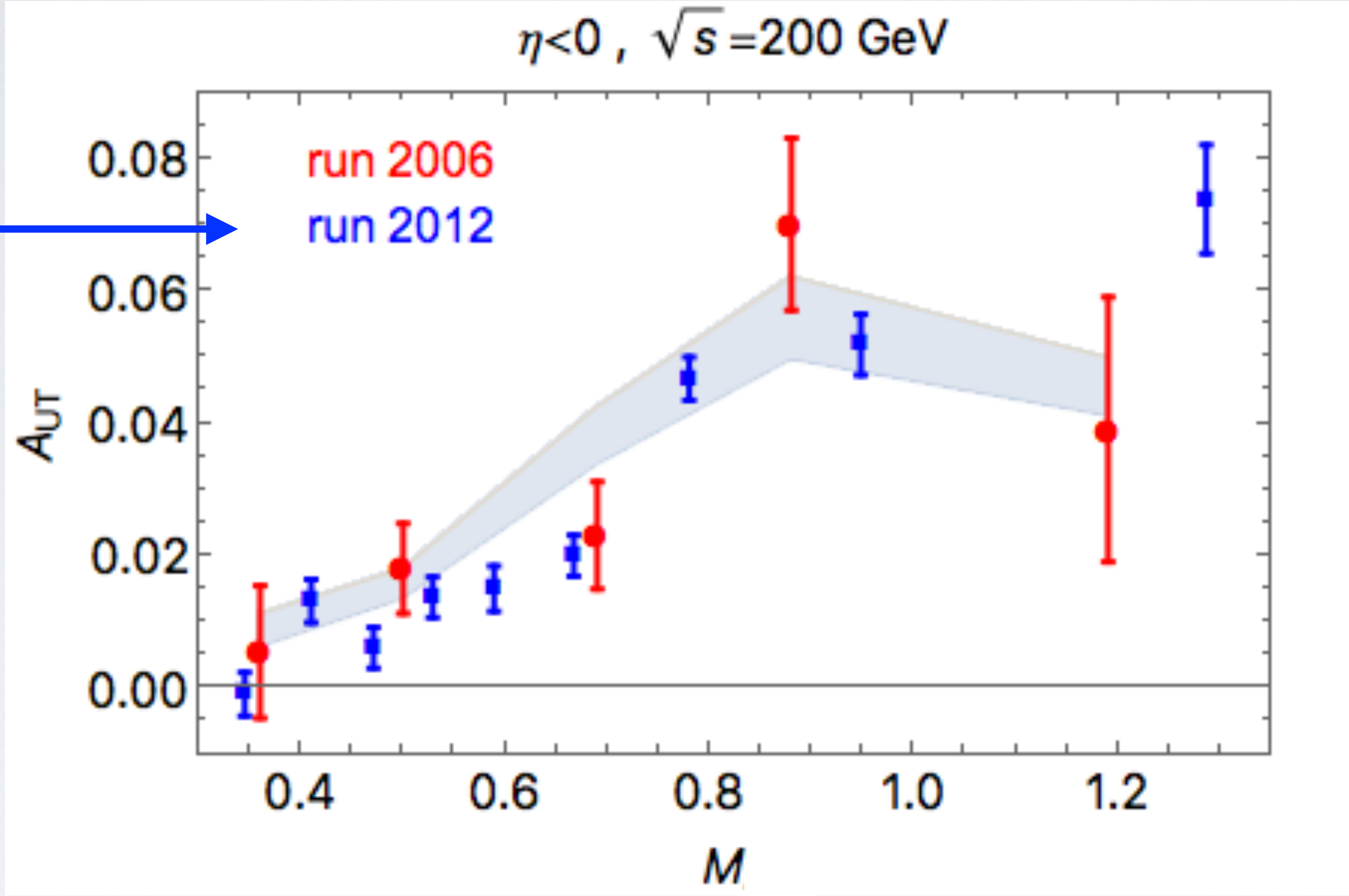
run 2006 *Adamczyk et al. (STAR), P.R.L. **115** (2015) 242501*

run 2012 *K. Landry, talk at APS 2015*

forward $A_{UT}(M)$: our prediction vs. STAR data

*Radici et al., P.R. D**94** (16) 034012*

PRELIMINARY



band = prediction using central 68% of replicas from SIDIS fit

same mechanism produces asymmetries in SIDIS and pp collisions
⇒ likely to be universal

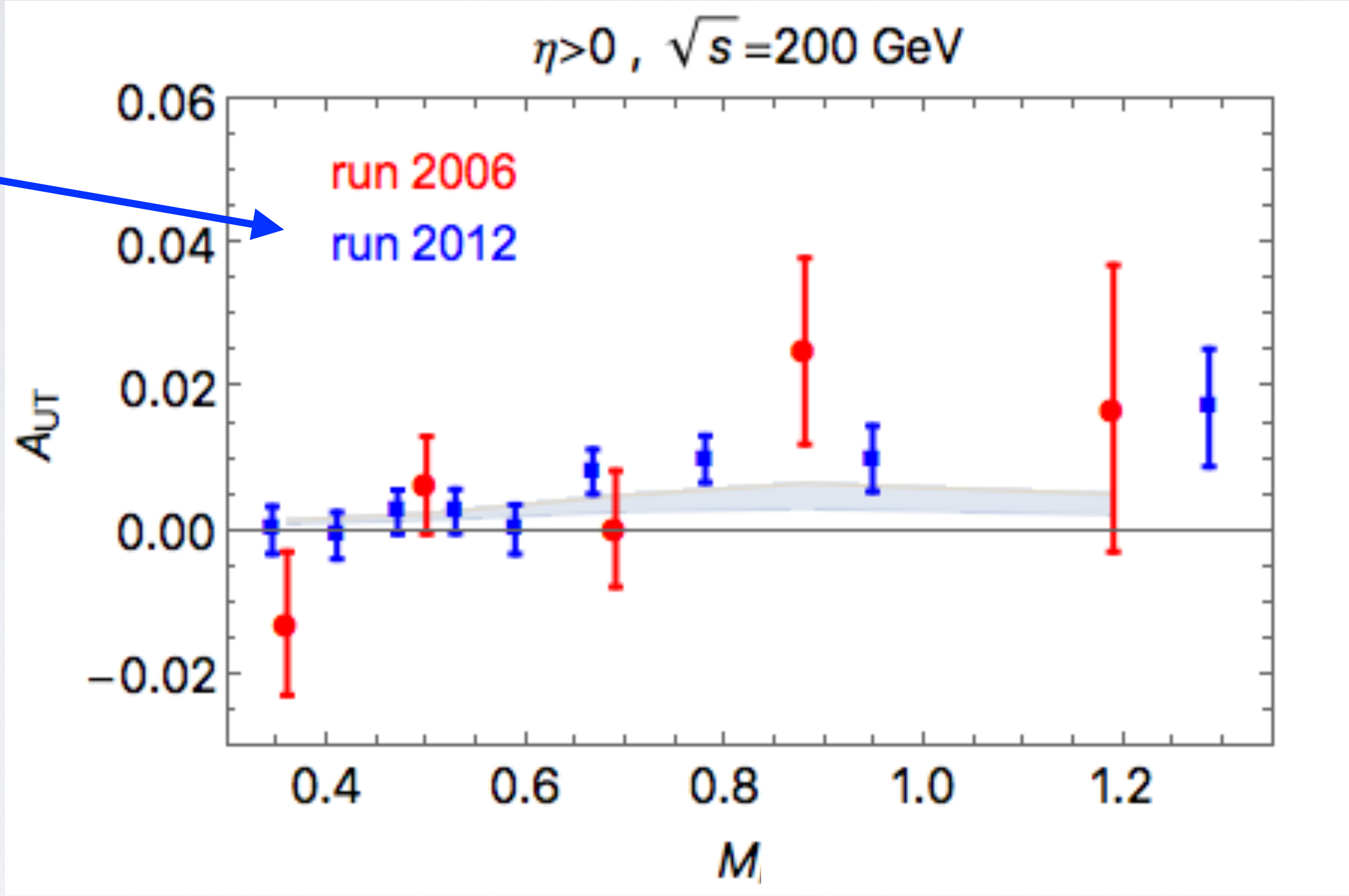
run 2006 *Adamczyk et al. (STAR), P.R.L.* ***115*** *(2015) 242501*

run 2012 *K. Landry, talk at APS 2015*

backward $A_{UT}(M)$

*Radici et al., P.R. D**94** (16) 034012*

PRELIMINARY



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run 2006 *Adamczyk et al. (STAR), P.R.L. **115** (2015) 242501*

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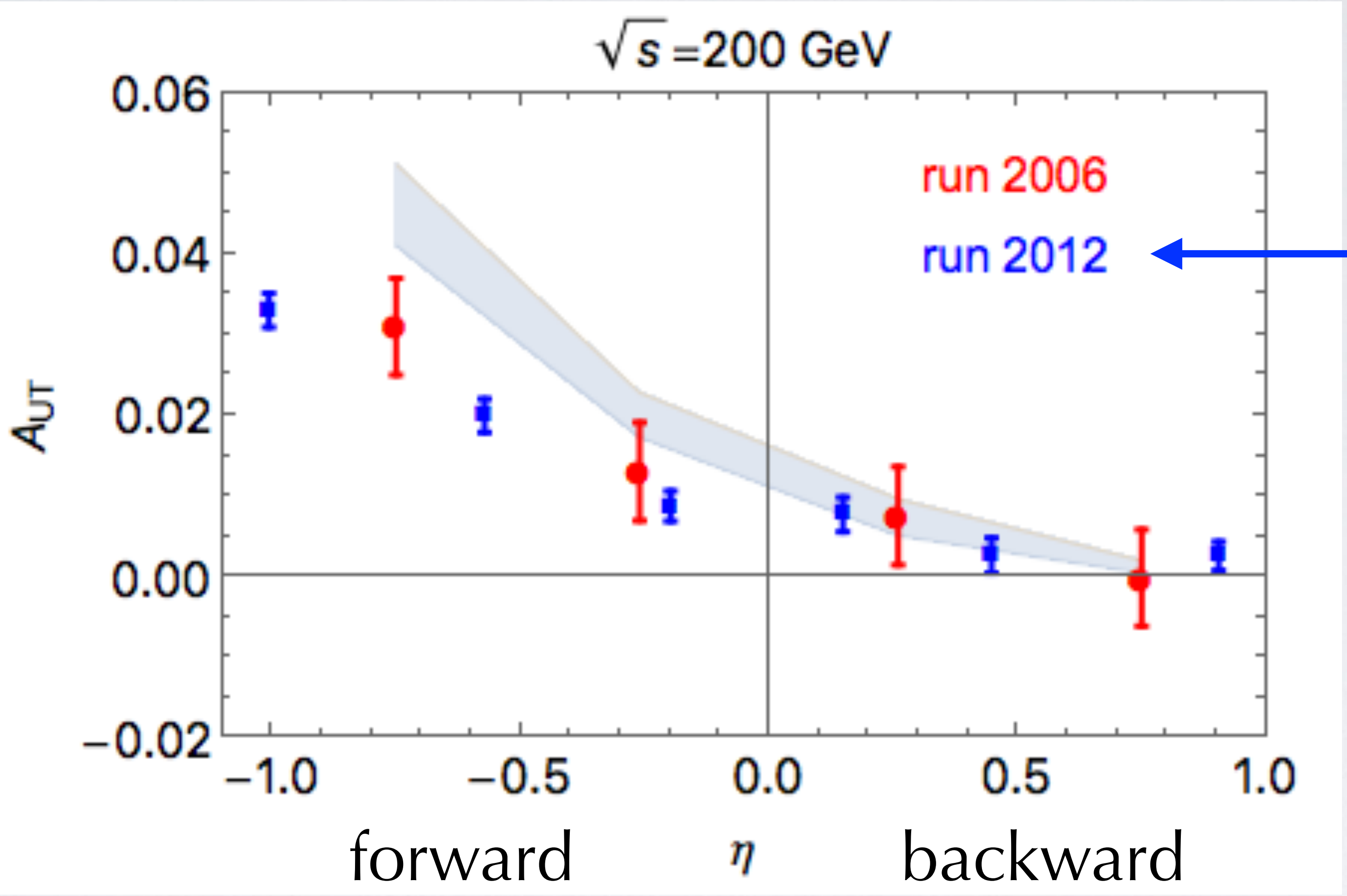
$A_{UT}(\eta)$

*Radici et al., P.R. D**94** (16) 034012*



PRELIMINARY

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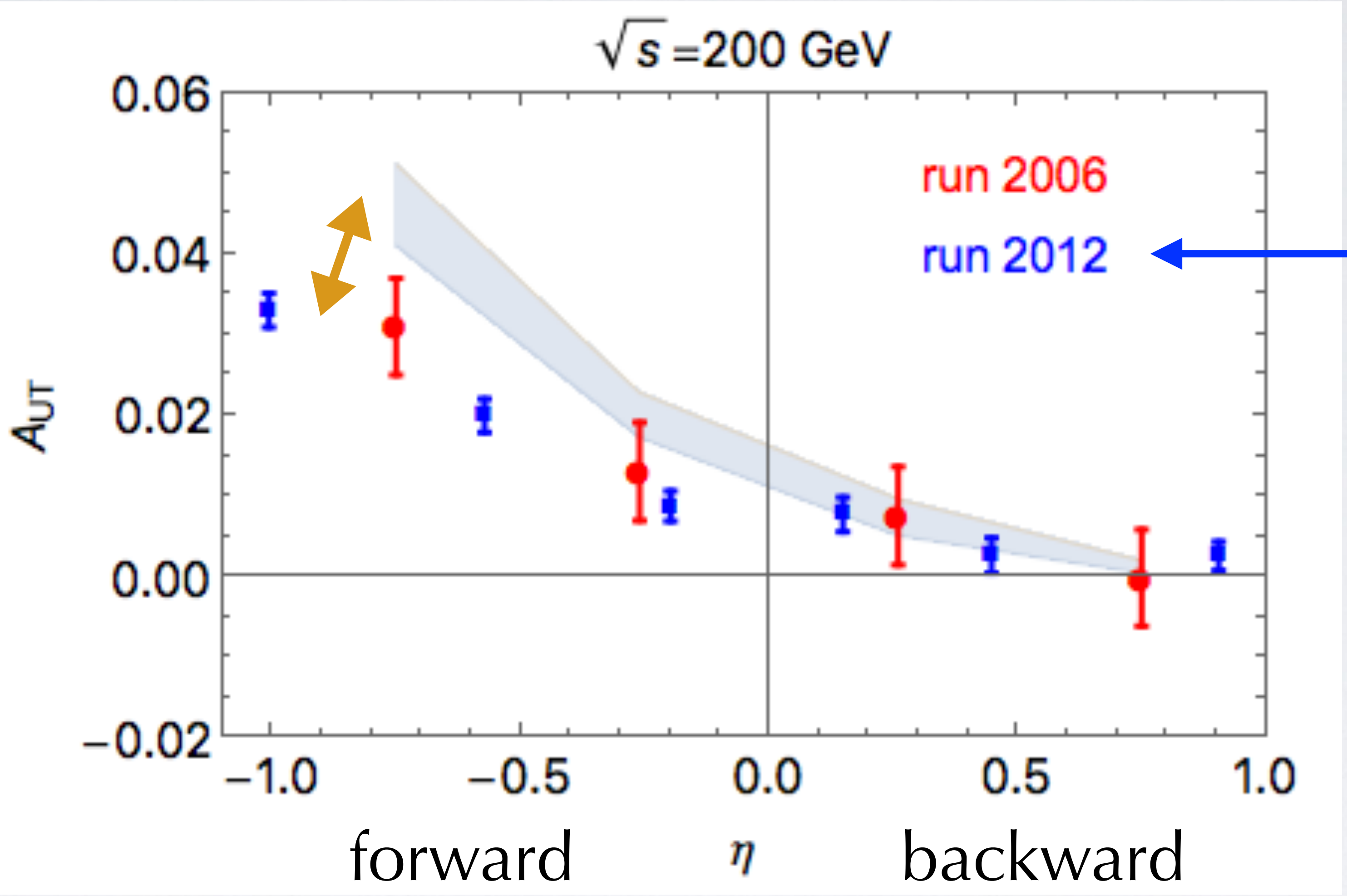
run 2006 *Adamczyk et al. (STAR), P.R.L. **115** (2015) 242501*

run 2012 *K. Landry, talk at APS 2015*

$A_{UT}(\eta)$

*Radici et al., P.R. D**94** (16) 034012*

problem ?



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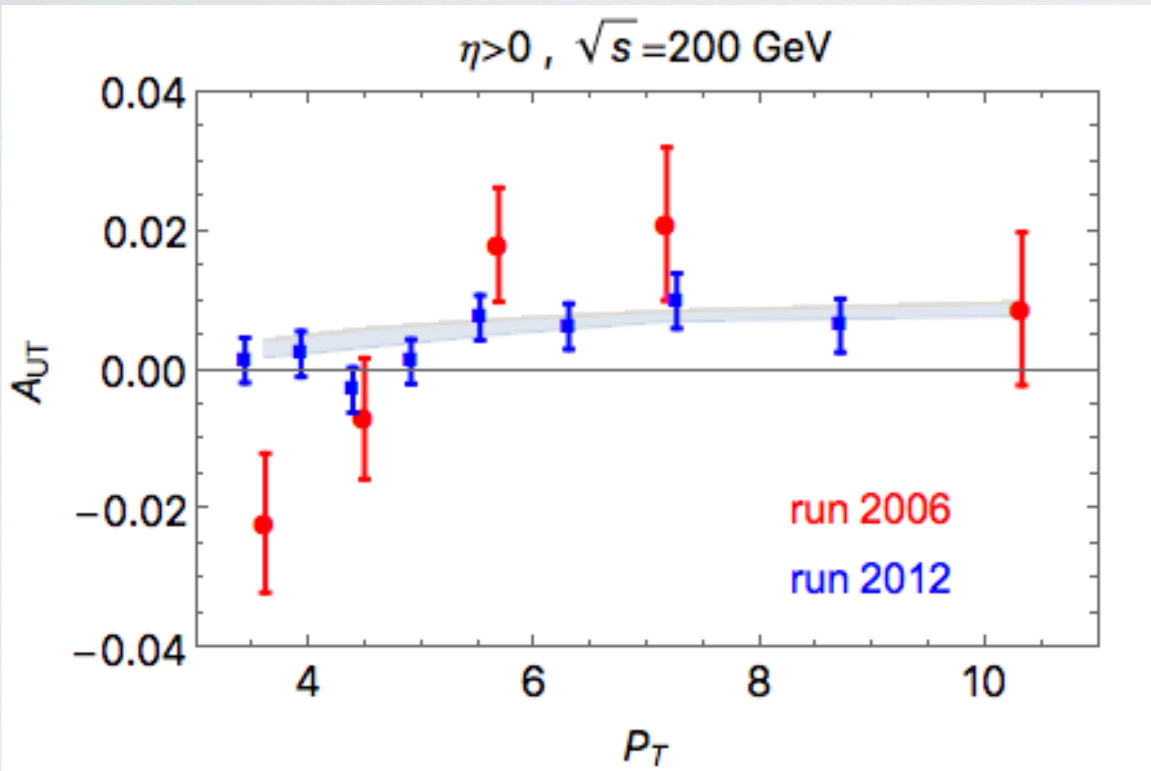
run 2006 *Adamczyk et al. (STAR), P.R.L. **115** (2015) 242501*

run 2012 *K. Landry, talk at APS 2015*

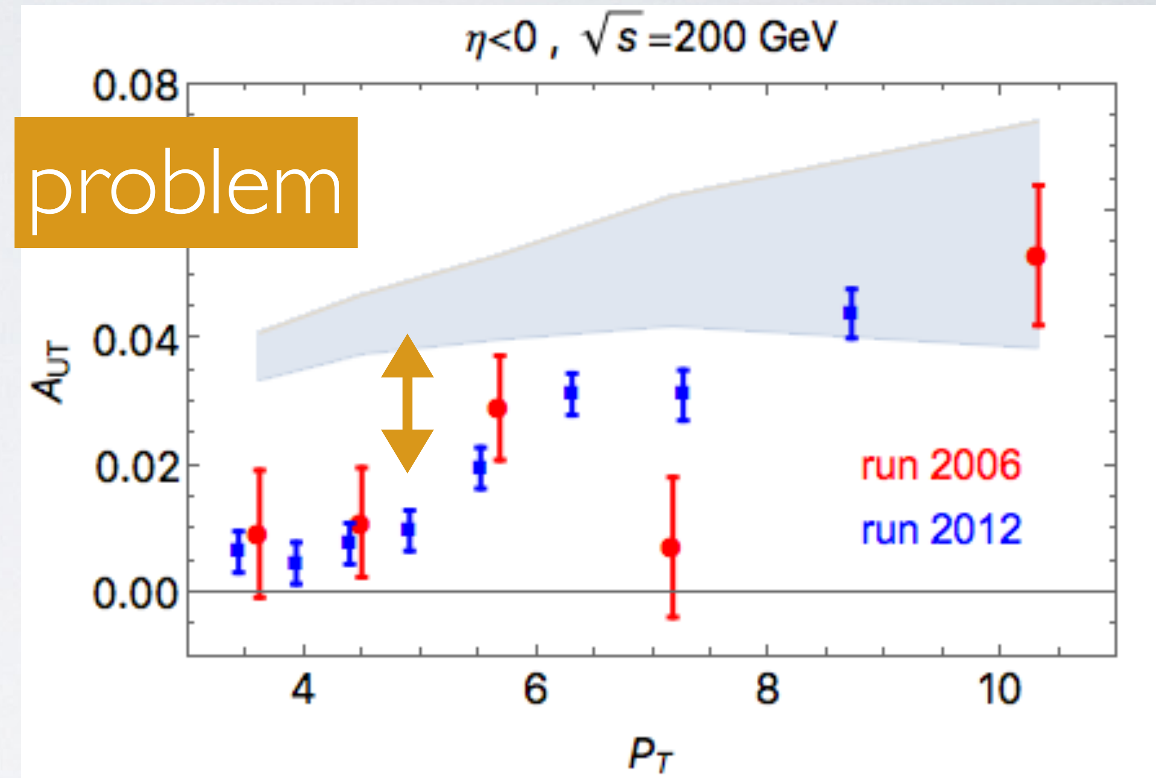
$A_{UT}(P_T)$

Radici et al.,
*P.R. D**94** (16) 034012*

backward



forward



band = prediction using central 68% of replicas from SIDIS fit

run 2006 *Adamczyk et al. (STAR), P.R.L.* ***115*** *(2015) 242501*

PRELIMINARY → **run 2012** *K. Landry, talk at APS 2015*

problem : K factor ?

$d\sigma \sim d\sigma^0 + \sin(\Phi_S\text{-}\Phi_R)\, d\sigma_{UT}$

no data yet for unpol. cross section
$d\sigma^0$: p+p → (ππ) X

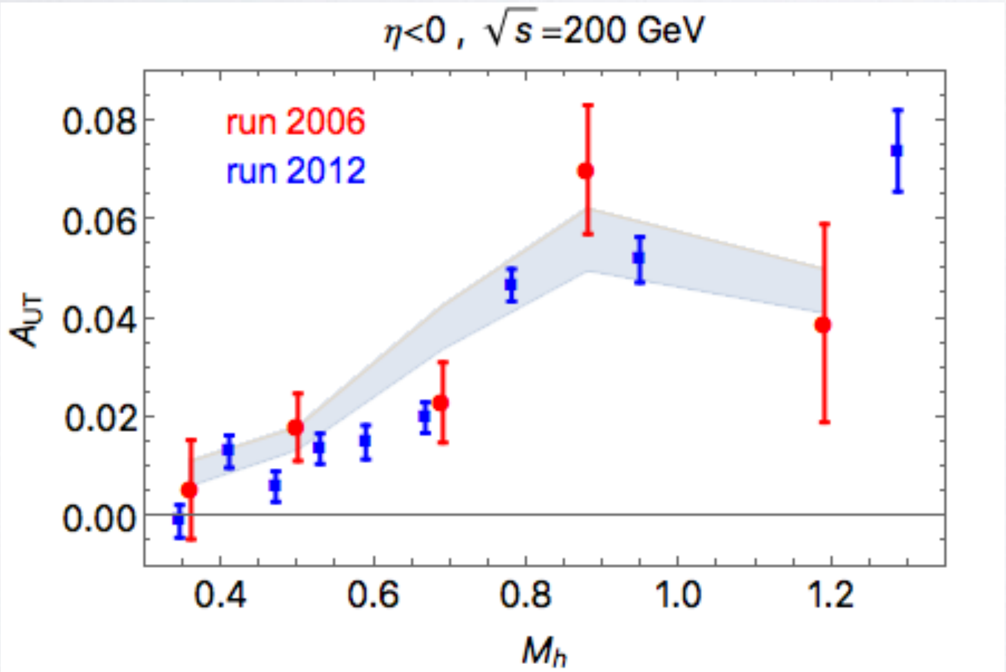
gluon channel unconstrained

only from DGLAP

$$\frac{d\sigma^0}{d\eta\, d|\boldsymbol{P}_T|\, dM} = 2\,|\boldsymbol{P}_T| \sum_{a,b,c,d} \int \frac{dx_a\, dx_b}{8\pi^2 \bar{z}}\, f_1^a(x_a)\, f_1^b(x_b)\, \frac{d\hat{\sigma}_{ab\to cd}}{d\hat{t}}\, D_1^c(\bar{z}, M)$$

possible large K factor in $d\sigma^0$
(but not in $d\sigma_{UT}$!)

uncertainty band
probably underestimated



*Radici et al., P.R. D**94** (16) 034012*

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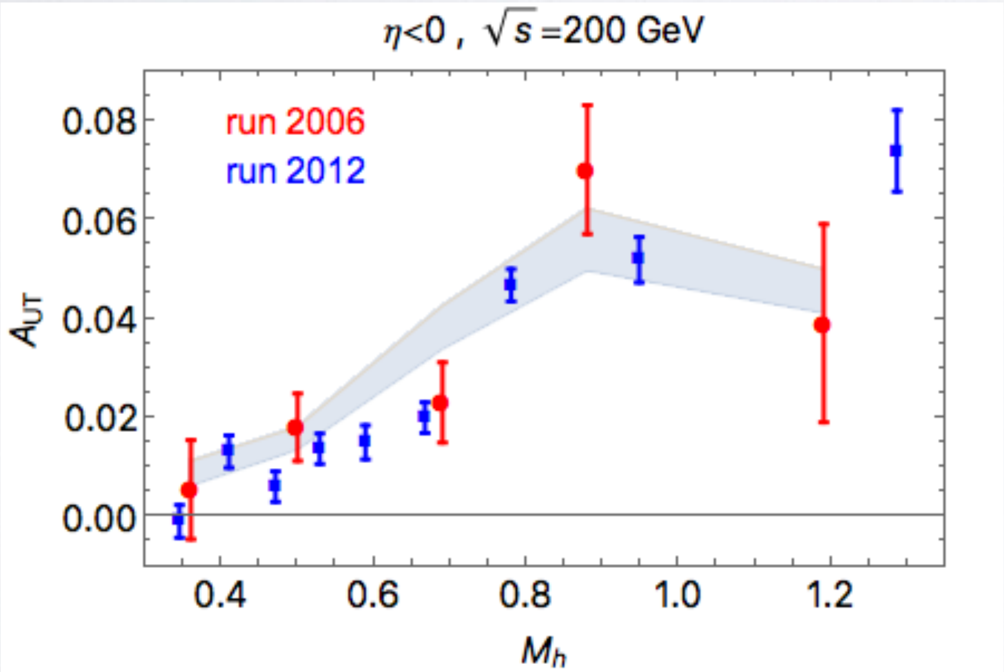
(but not in $d\sigma_{UT}$)



uncertainty band probably underestimated

but no K factor can change sign and trend of $A_{UT}(M)$

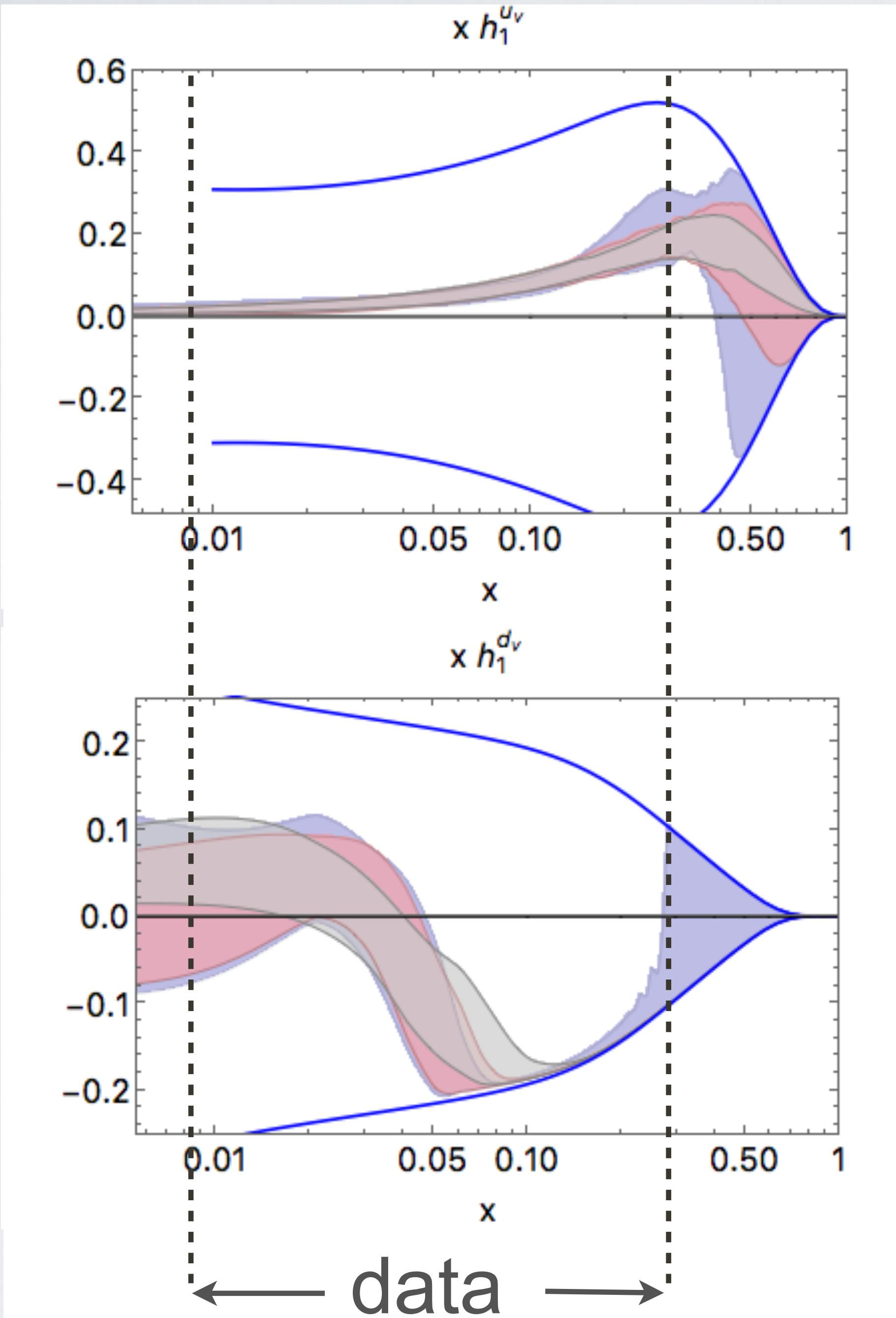
*Radici et al., P.R. D**94** (16) 034012*

stability and saturation of Soffer bound

Q^2=2.4 GeV^2

up

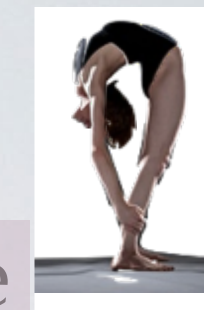
down



rigid

flexible

extra-flexible



stable results in range of SIDIS data

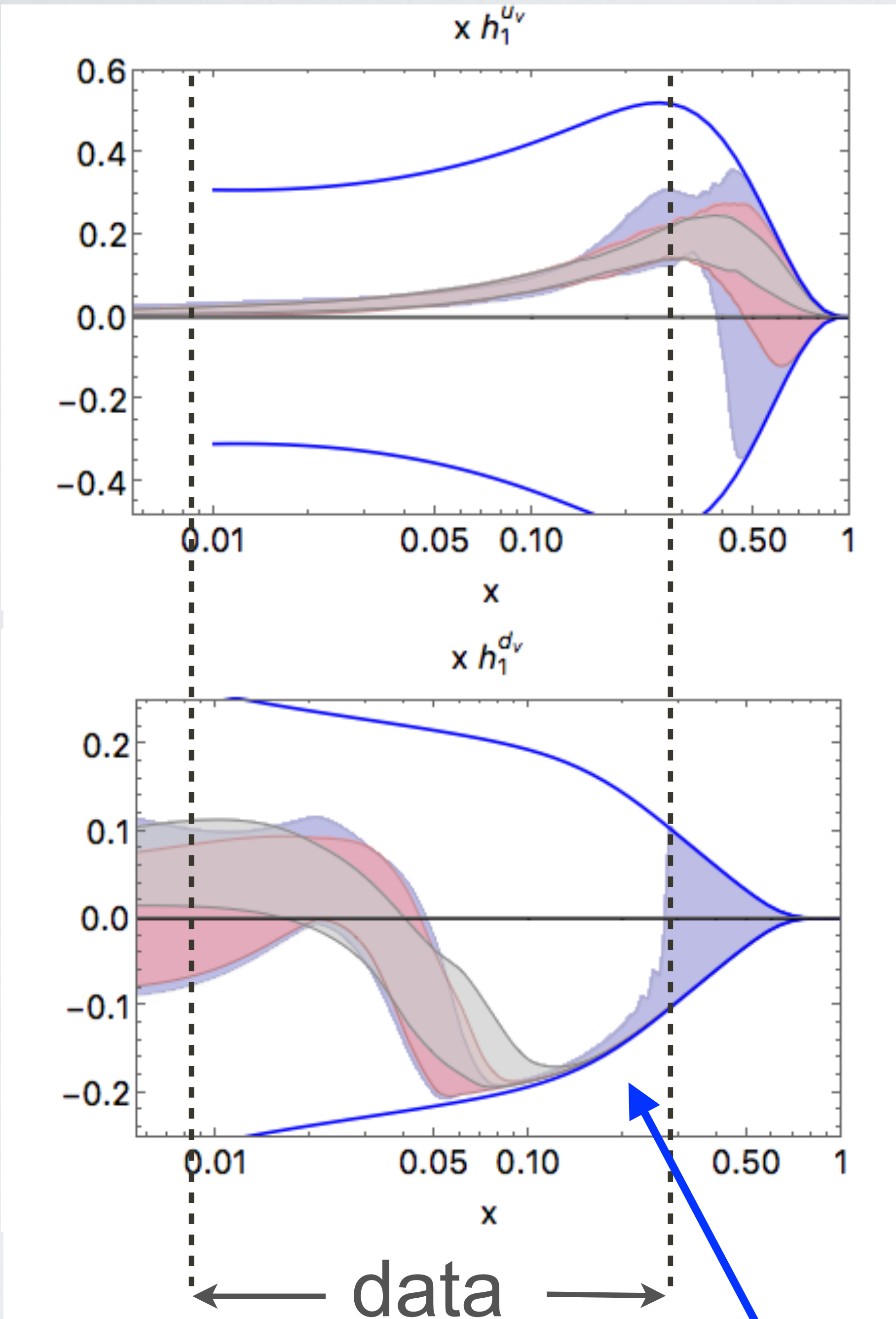
Radici et al.,
JHEP ***1505*** *(15) 123*

stability and saturation of Soffer bound

Q^2=2.4 GeV^2

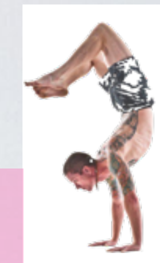
up

down



rigid

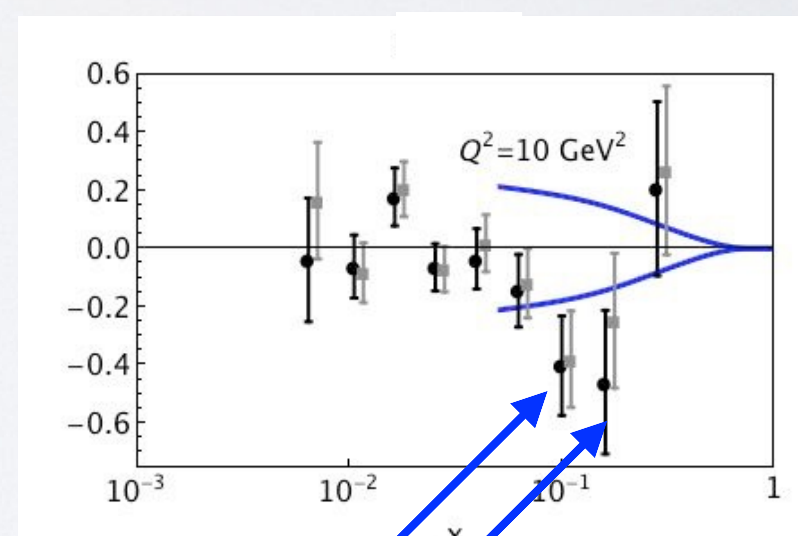
flexible



extra-flexible

stable results in range of SIDIS data

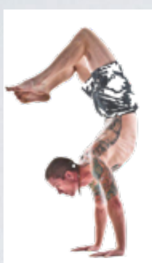
but **unusual saturation of Soffer bound** for down, due to 2 deuteron bins



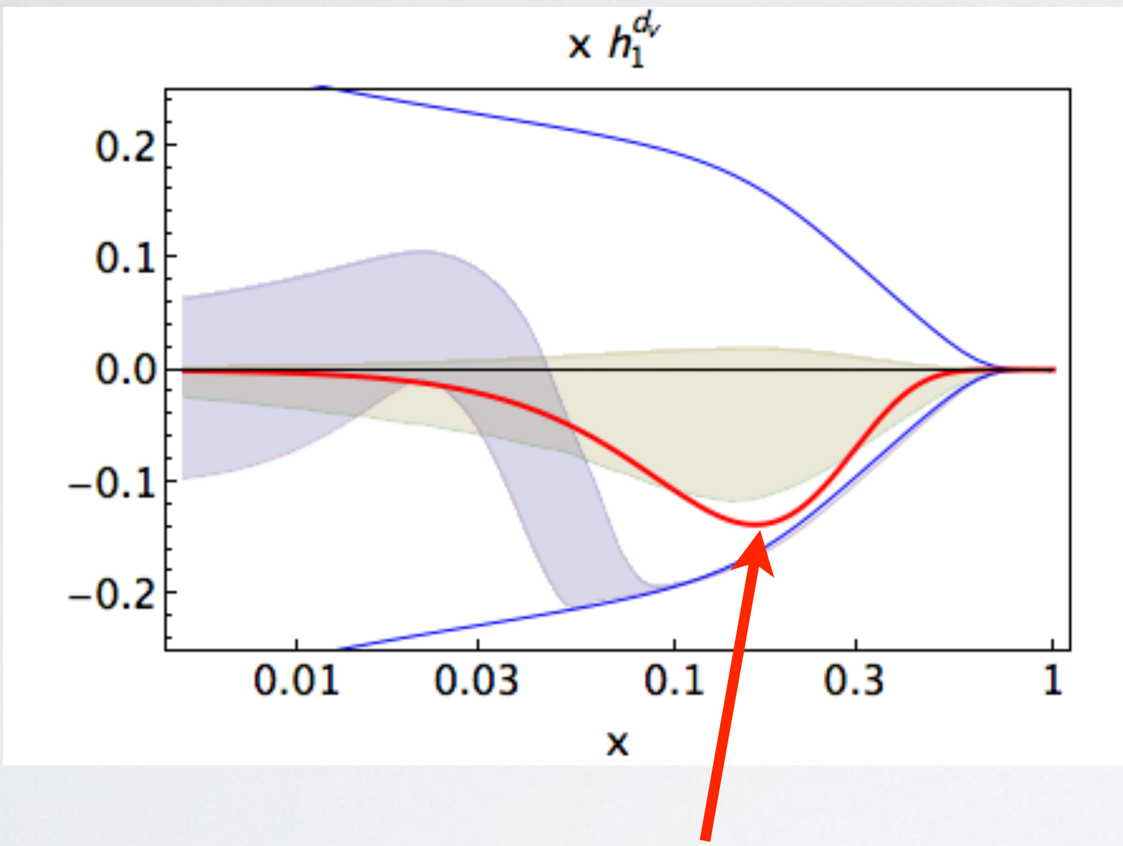
bins #7,8

Radici et al.,
JHEP ***1505*** *(15) 123*

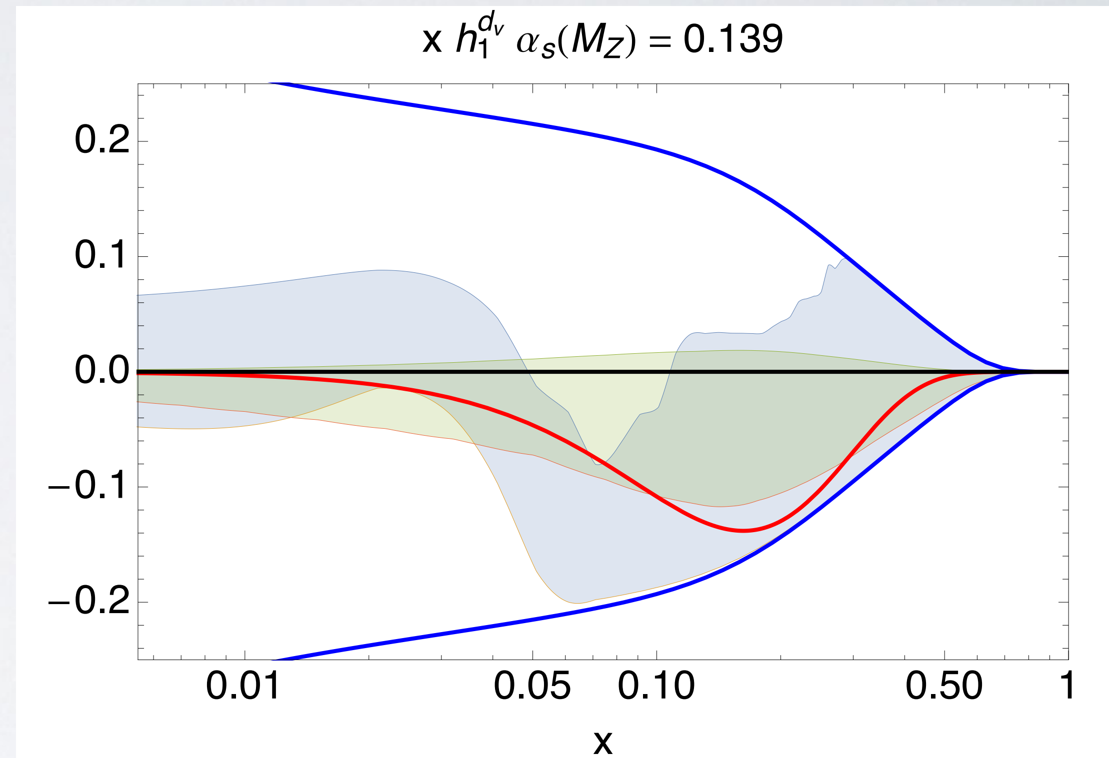
origin of saturation of Soffer bound



full SIDIS fit



"reduced" SIDIS fit :
no bins #7,8 with deuteron



Radici et al.,
*JHEP **1505** (15) 123*

Kang et al.,
*P.R. D**93** (16) 014009*

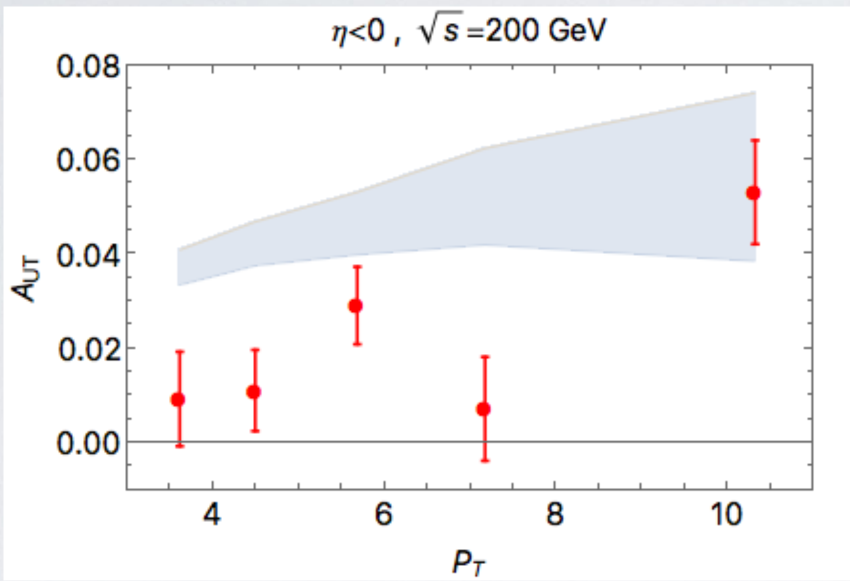
Anselmino et al.,
*P.R. D**87** (13) 094019*

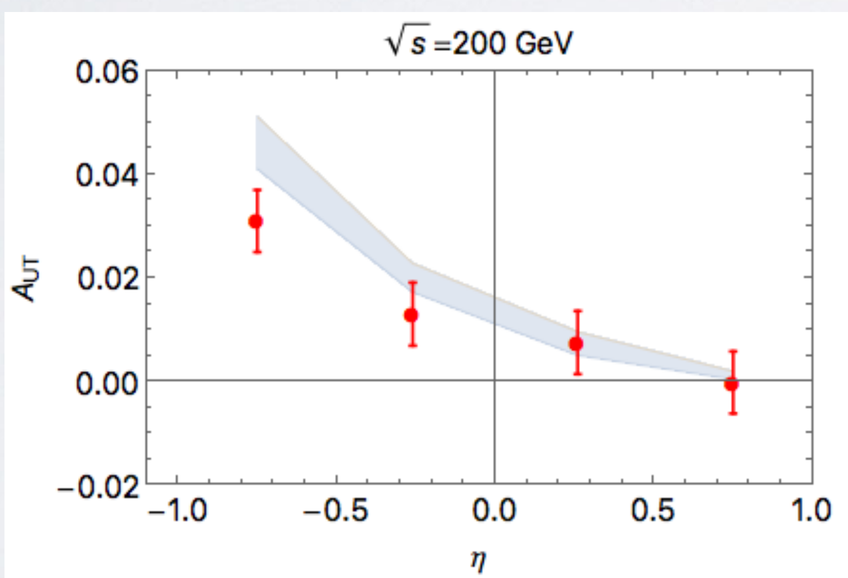
more flexibility
for down

no appreciable difference
for up

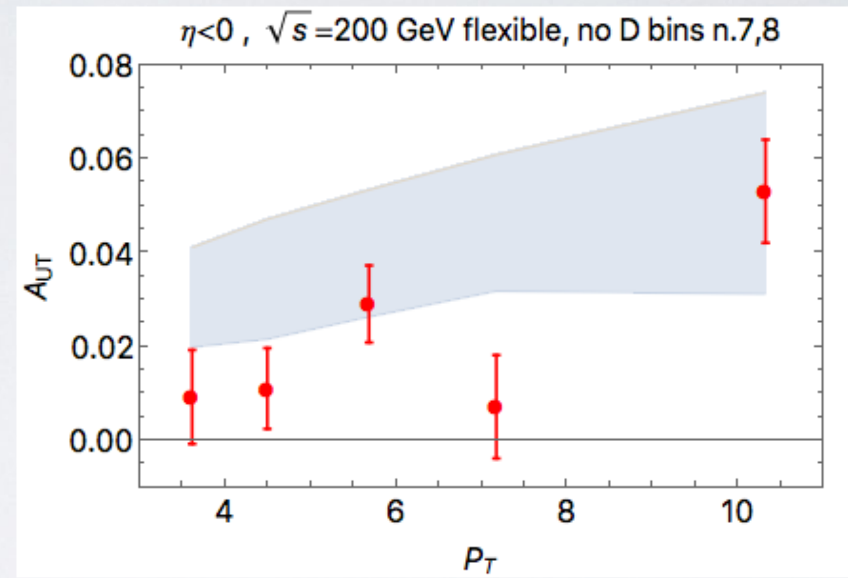
forward $A_{UT}(P_T)$ and $A_{UT}(\eta)$ with "reduced" fit

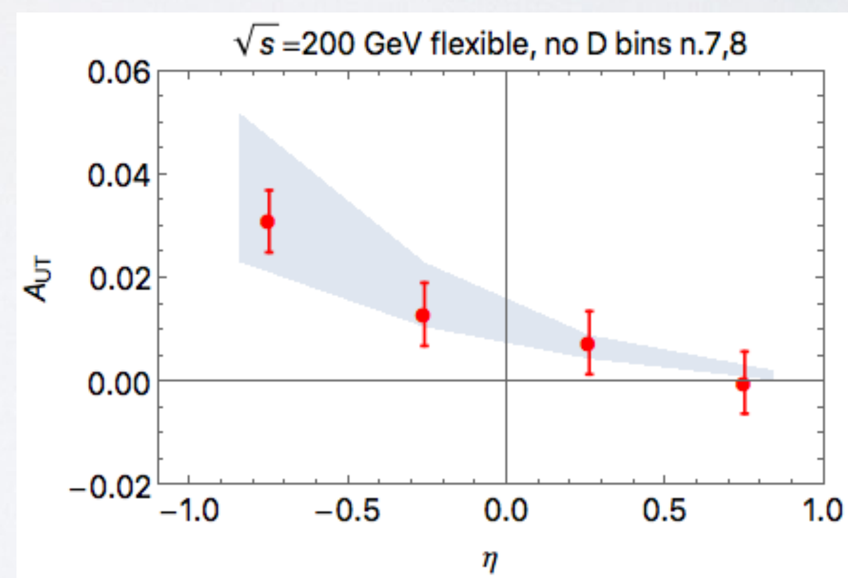
full SIDIS fit





"reduced" SIDIS fit



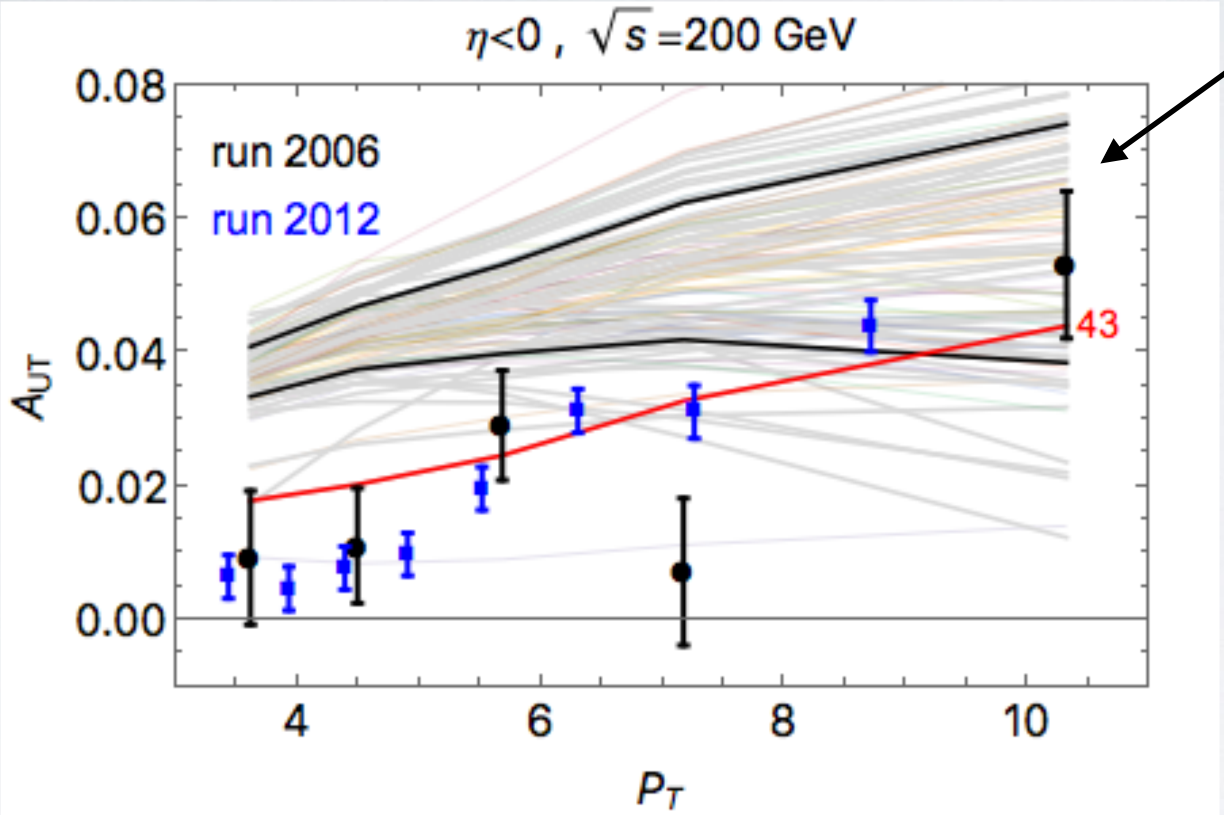


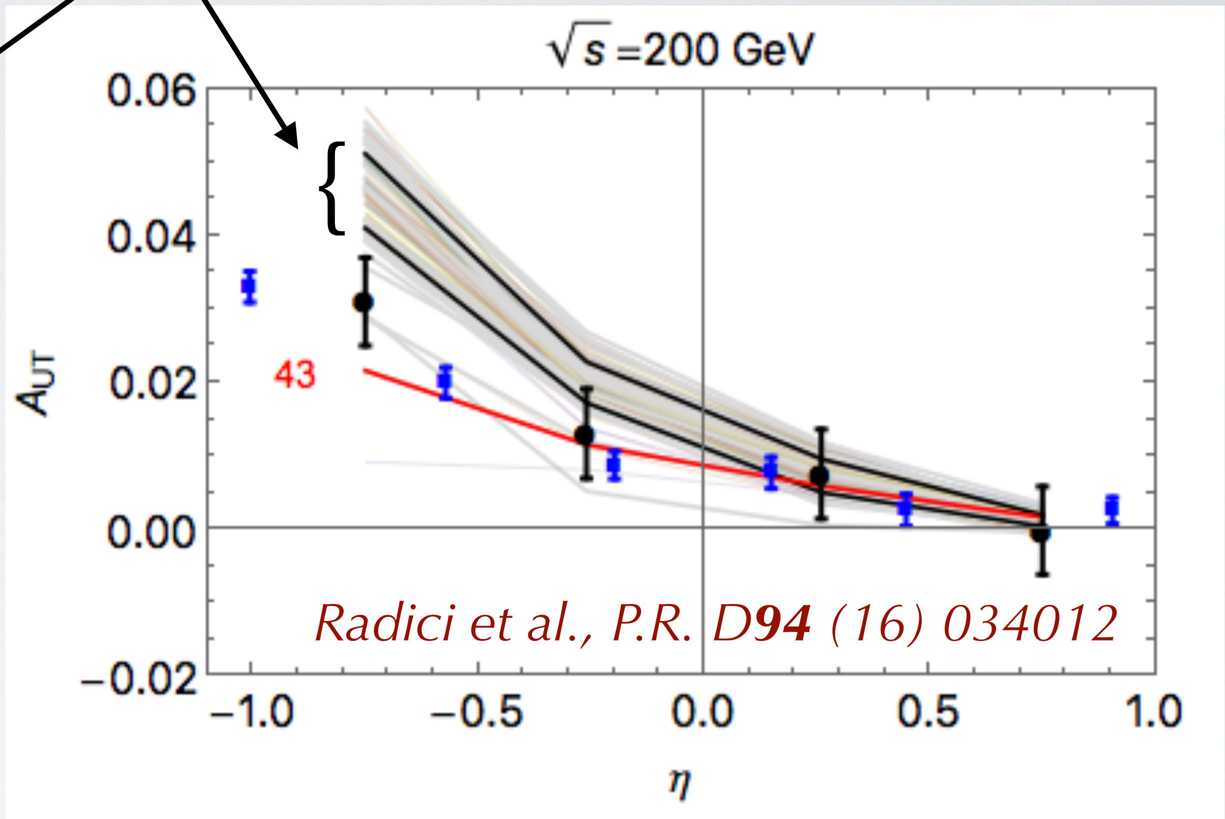
"reduced" fit : more flexibility ⇒ better compatibility

run 2006 *Adamczyk et al. (STAR), P.R.L.* ***115*** *(15) 242501*

reconsider problem in forward kin.

$A_{UT}(P_T)$ 68% **$A_{UT}(\eta)$**





some replicas outside the 68% band from SIDIS fit
show compatibility with p-p data in forward kin.

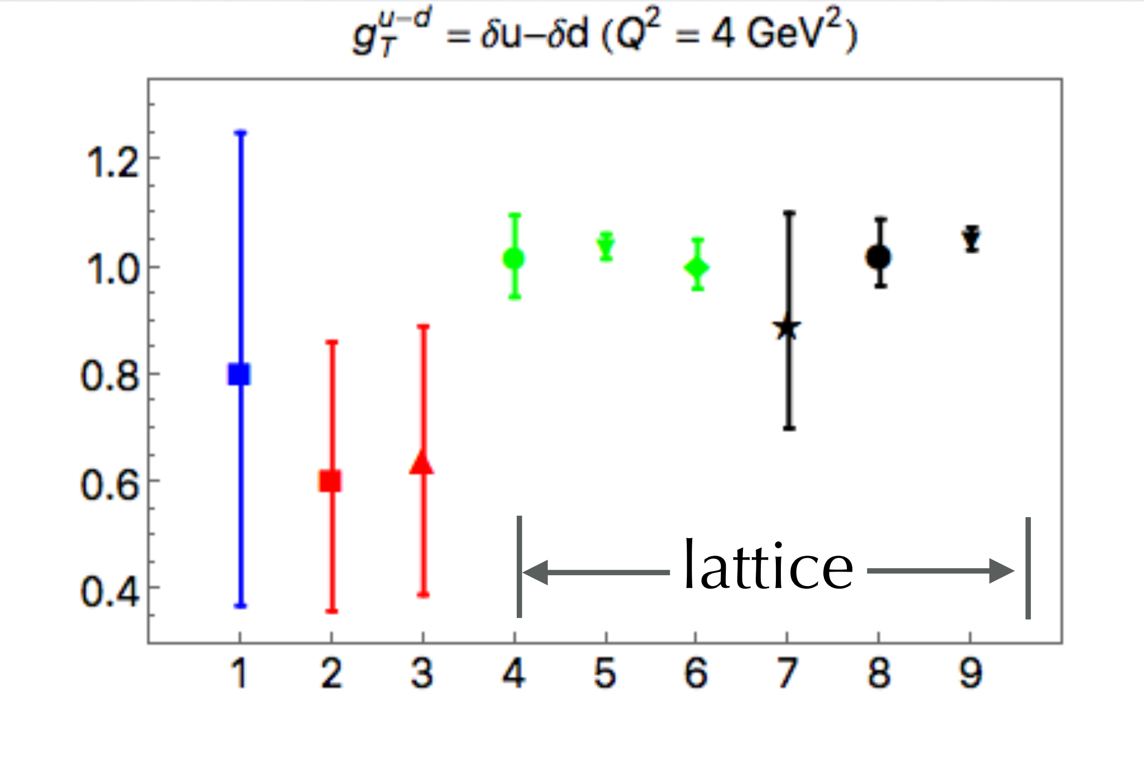
selectivity of p-p data on results from SIDIS fit → need global fit
work in progress

run 2006 *Adamczyk et al. (STAR), P.R.L. **115** (15) 242501*

PRELIMINARY → **run 2012** *K. Landry, talk at APS 2015*

neutron β-decay <—> isovector tensor charge

$g_T^{u\text{-}d}$ affects tensor coupling in β-decay



$Q^2 = 4 \text{ GeV}^2$

4) **PNDME '15** *Bhattacharya et al., P.R. D**92** (15)*

5) **LHPC '12** *Green et al., P.R. D**86** (12)*

6) **RQCD '14** *Bali et al., P.R. D**91** (15)*

7) RBC-UKQCD *Aoki et al., P.R. D82 (10)*

8) ETMC '15 *Abdel-Rehim et al., P.R.D**92** (15);*

9) ETMC '15 *E P.R.D**93** (16)*

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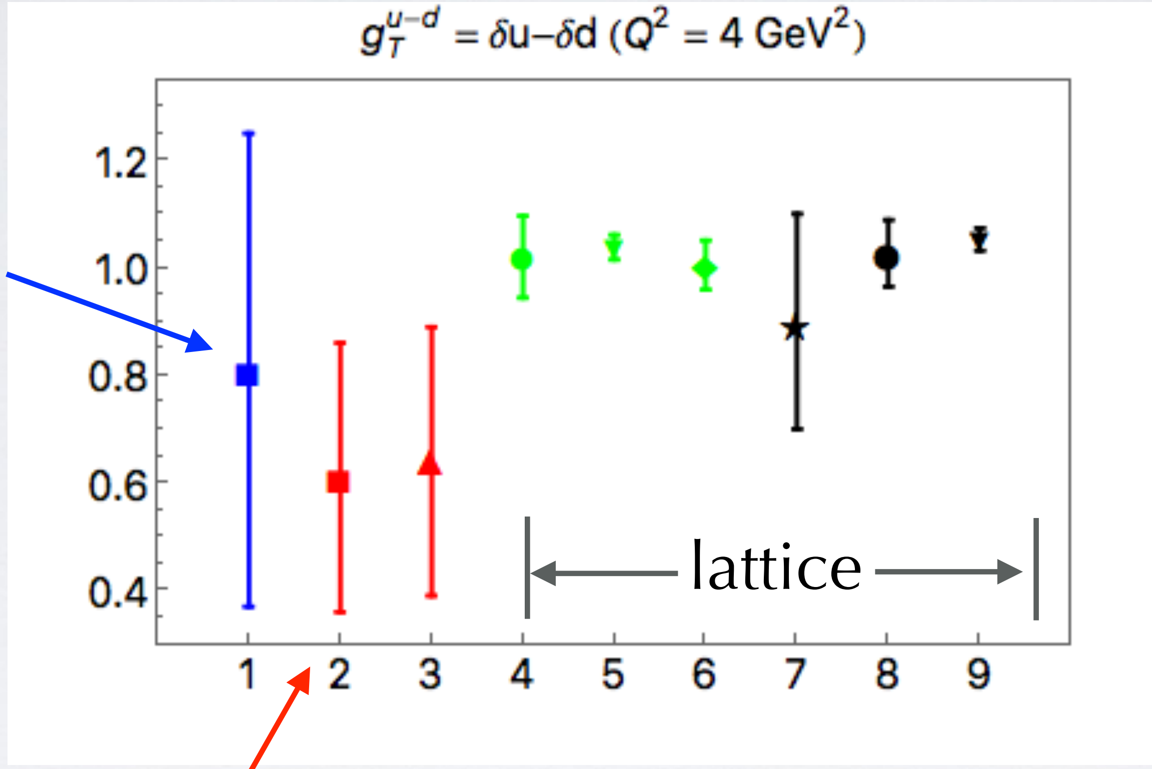
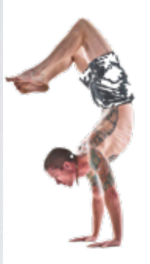
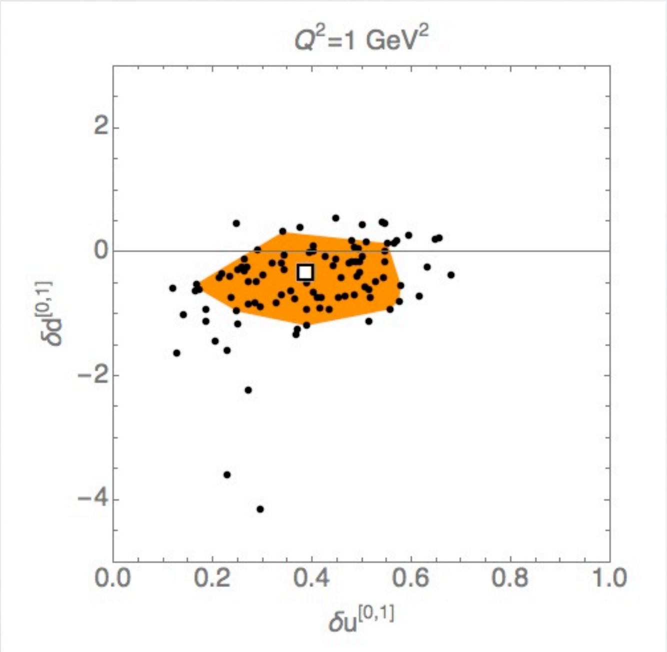


1) Radici et al. 2015

$Q^2 = 4$ GeV^2





2) Kang et al. 2016

$Q^2 = 10$

3) Anselmino et al. 2013

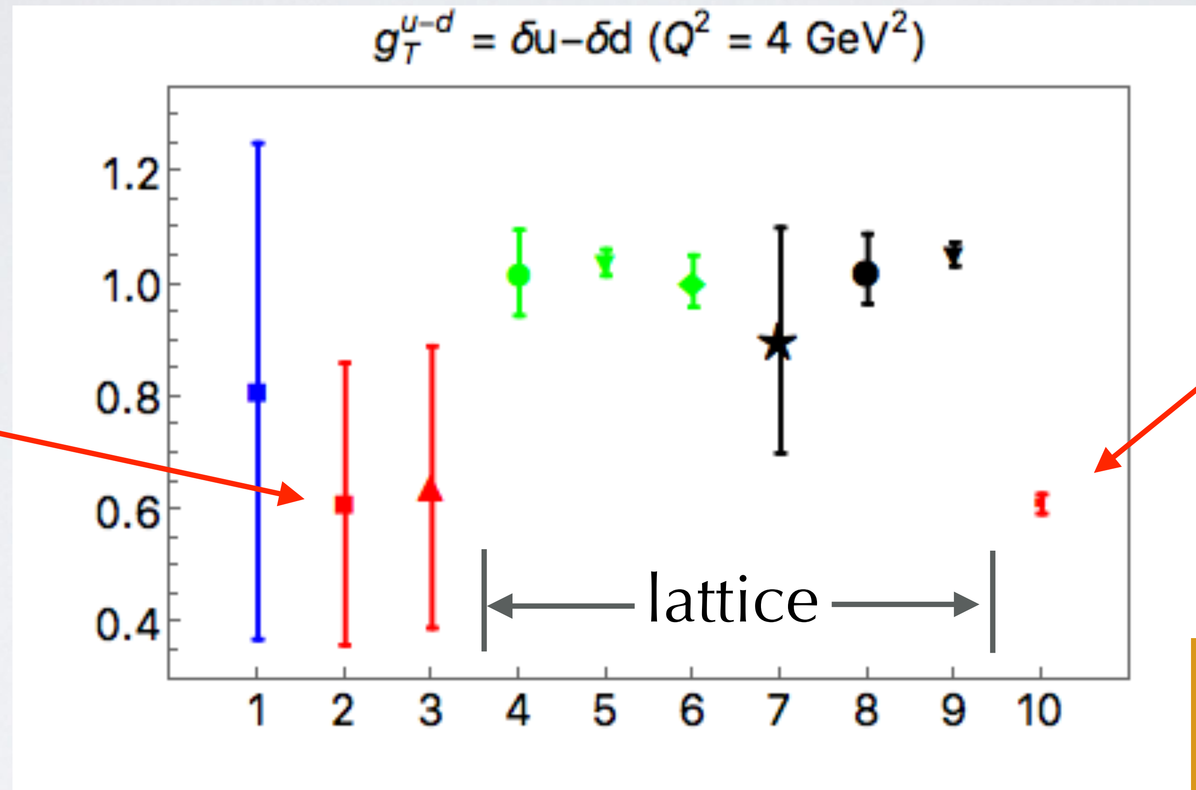
$Q^2 = 0.8$

neutron β-decay <—> isovector tensor charge

$g_T^{u\text{-}d}$ affects tensor coupling in β-decay

$Q^2 = 4\ \mathrm{GeV}^2$

2) Kang et al. 2016
$Q^2 = 10$



10) SoLID 2016
pseudo-data based on **2) Kang et al. 2016**
$Q^2 = 10$

Ye et al., arXiv:1609.02449

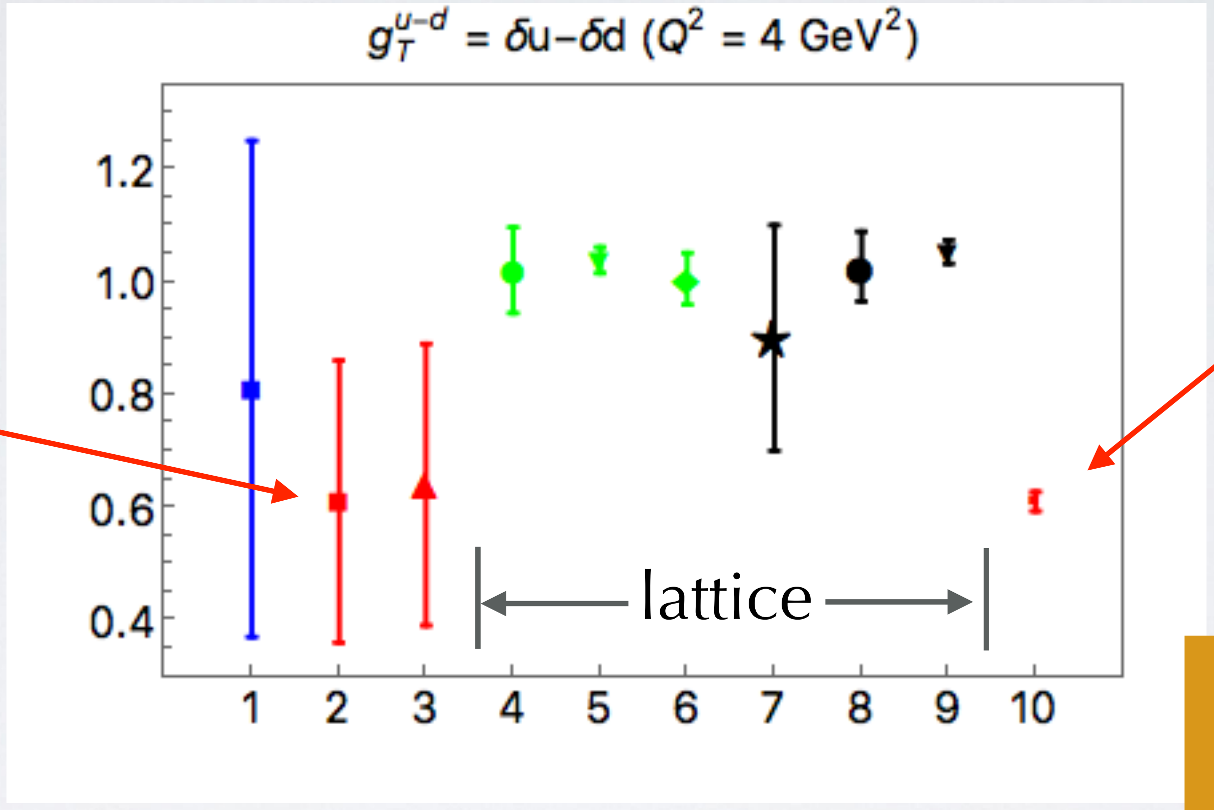
caveat:
SoLID acceptance
→ $x \in [0.05, 0.6]$

neutron β-decay <—> isovector tensor charge

g_T^{u-d} affects tensor coupling in β-decay

$Q^2 = 4$ GeV^2

2) Kang et al. 2016
$Q^2 = 10$



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$Q^2 = 10$

Ye et al., arXiv:1609.02449

caveat:
SoLID acceptance
→ $x \in [0.05, 0.6]$

current most stringent constraints on BSM tensor coupling from $\pi^+ \to e^+ \nu_e \gamma$ and neutron β-decay is

$|\,\varepsilon_T\, g_T\,| \lesssim 5 \times 10^{-4}$

Bychkov et al. (PIBETA), P.R.L. ***103*** *(09) 051802*
Pattie et al., P.R. C88 (13) 048501

potential of SoLID can bring precision to level of modern lattice calculations and β-decay measurements

Conclusions

- transversity can be reliably extracted from data using semi-inclusive di-hadron production

- di-hadron method works in collinear factorization
  - cross-check of Collins effect in TMD factorization
  - extension to p-p collisions → check universality
  global fit in progress

Next: complete global fit of existing 2h-SIDIS & p-p data

- tensor charge useful for low-energy explorations of BSM new physics

need more data at (very) large and (very) small x
"short run": RHIC & JLAB12 "long run": EIC

Backup slides

reweighting the replicas

*NNPDF Collaboration, N.P. **B849** (11) 112; E **B854** (12) 926; E **B855** (12) 927; arXiv:1012.0836v4*

- each **replica h_k** (k=1,..,N) carries equal weight (important sampling)

- effect of set of new independent n data by assigning new weights w_k
  w_k ⇔ probability for each **replica h_k** to agree with **new n data** (χ_k^2)

$$w_k = \frac{(\chi_k^2)^{\frac{1}{2}(n-1)}\ e^{-\frac{1}{2}\chi_k^2}}{\frac{1}{N}\ \sum_{k=1}^N (\chi_k^2)^{\frac{1}{2}(n-1)}\ e^{-\frac{1}{2}\chi_k^2}}$$

- price to pay: replica k with **very low w_k** is statistically irrelevant
  loss of efficiency quantifiable through Shannon entropy

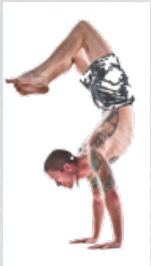
$$N_{\rm eff} = \exp\left\{ \frac{1}{N} \sum_{k=1}^N w_k \ln\left(\frac{N}{w_k}\right)\right\} \ \le\ N$$

- χ^2-profile of reweighted replicas

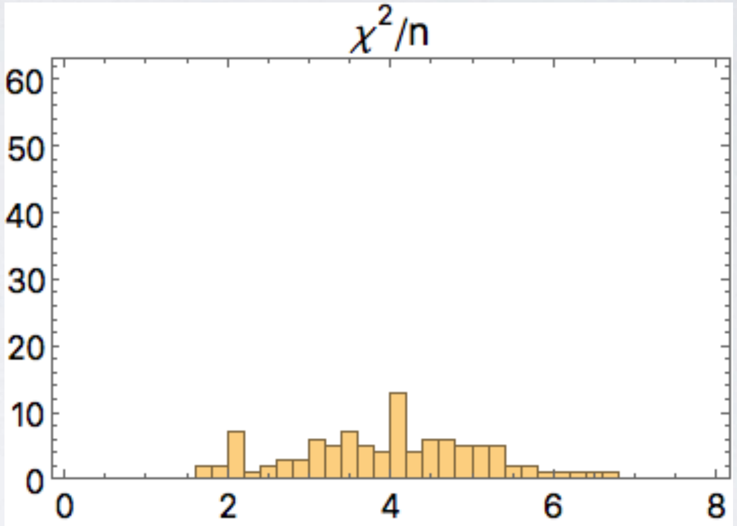
$$P\Big[A_\chi = \{\chi^2 \le \chi_k^2 < \chi^2 + d\chi^2\}\Big] = \sum_{k\in A_\chi} w_k$$

if $P[A_\chi]$ peaked at $\chi \sim O(1)$
new data bring new info
otherwise are inconsistent

χ^2-profile of reweighted replicas



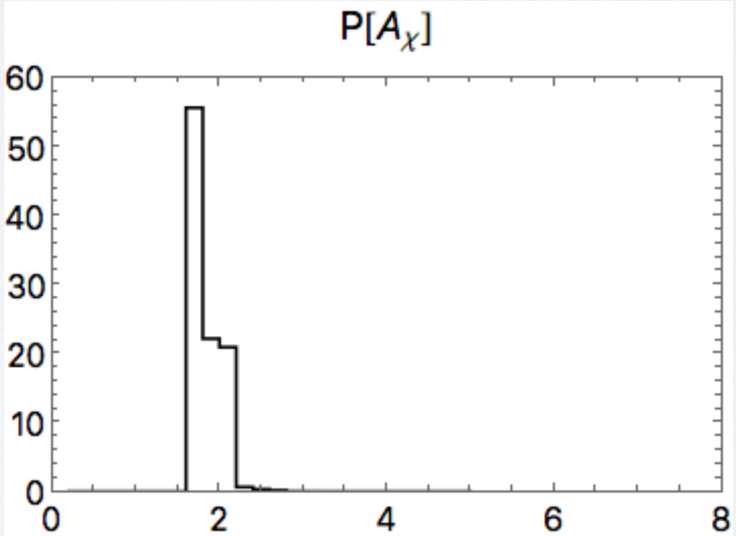
"reduced" SIDIS fit
flexible param.



N=100 replicas

χ^2-profile
n=24 RHIC data
from run 2006

Adamczyk et al. (STAR), P.R.L. ***115*** *(15) 242501*

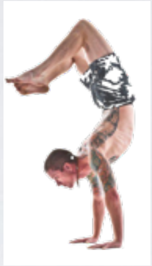


N_{eff} = 7

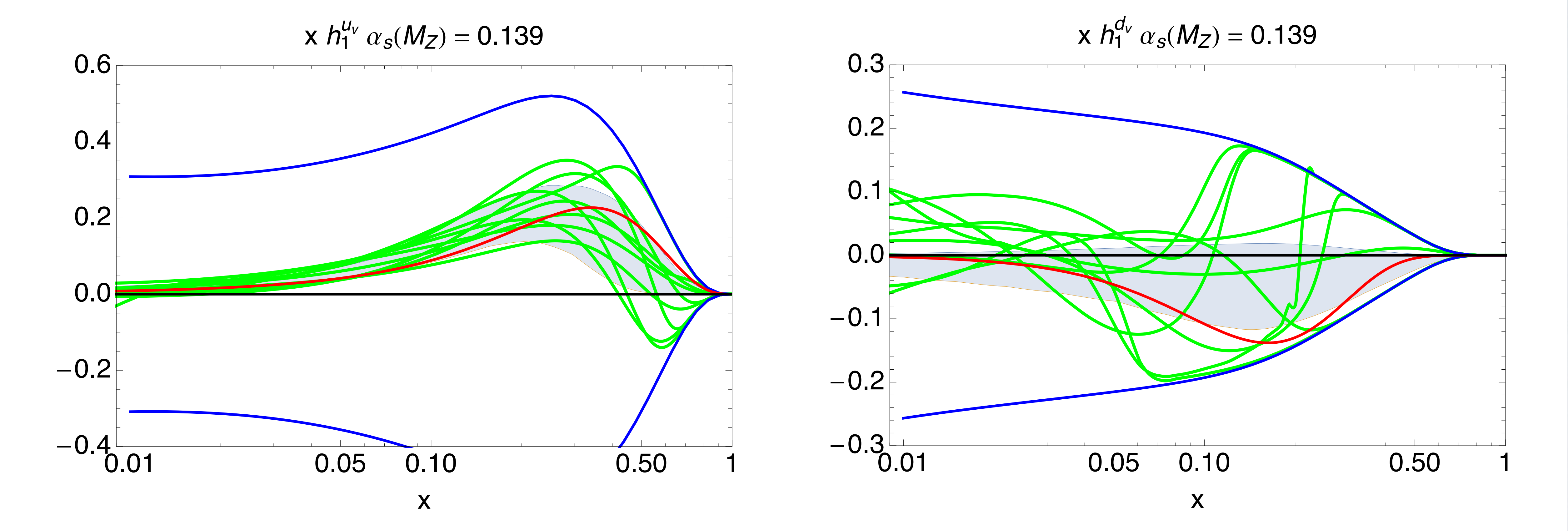
χ^2-profile
reweighted replicas

STAR data very selective on "reduced" SIDIS fit:
reduce the number of statistically relevant replicas by factor ≳10

statistically most relevant replicas



flexible param.



reweighted replicas

Kang et al.,
*P.R. D**93** (16) 014009*

Anselmino et al.,
*P.R. D**87** (13) 094019*

reweighting replicas on deuteron bins #7,8

- "reduced" SIDIS fit: **N=100** replicas with equal weights
- **reweighting** on STAR data (run 2006) → N_{eff} **=7** replicas with weights w_k

N_{eff} (=7) replicas with weights w_k	same probability distribution → (for $N' \to \infty$) **unweighting**	N′ (=100) replicas with equal weights

replica with large w_k → take it w'_k times

replica with small w_k → discard it

NNPDF Collaboration, N.P. ***B855*** *(12) 608; arXiv:1108.1758v2*

- reweighting **N′=100** replicas on bins #7,8 → N'_{eff} **=73** replicas

  but χ^2 profile of reweighted replicas not peaked at ~ $O(1)$

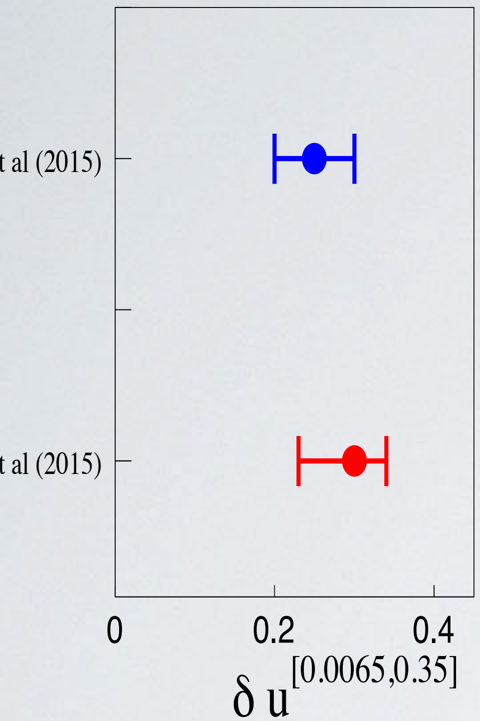
global fit of SIDIS and p-p data in progress…

back to tensor charge

$Q^2 = 10\ \text{GeV}^2$

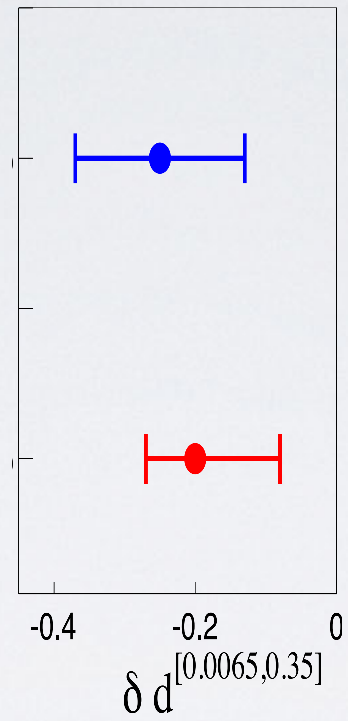
$$\delta q \equiv g_T^q = \int_0^1 dx\ \left[h_1^q(x,Q^2) - h_1^{\bar{q}}(x,Q^2)\right]$$

truncated to data range
$x \in [0.0065, 0.35]$



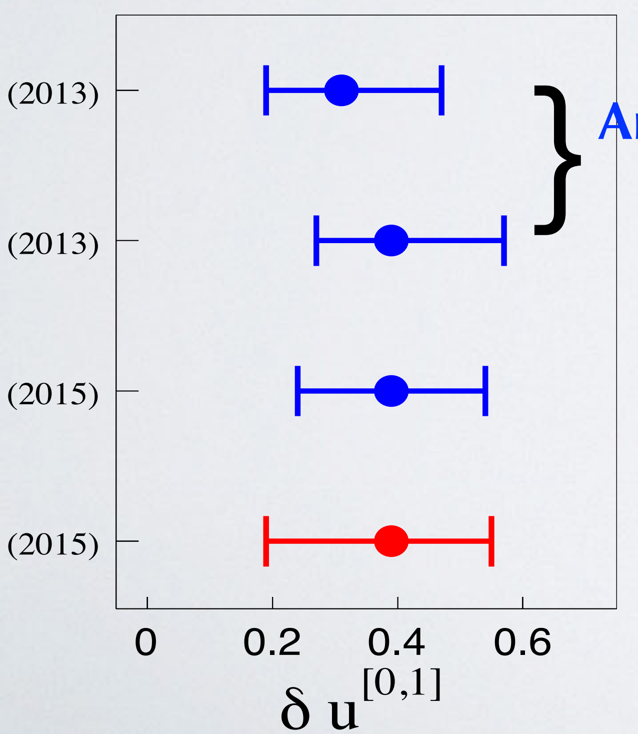
Radici et al. 2015

Kang et al. 2016



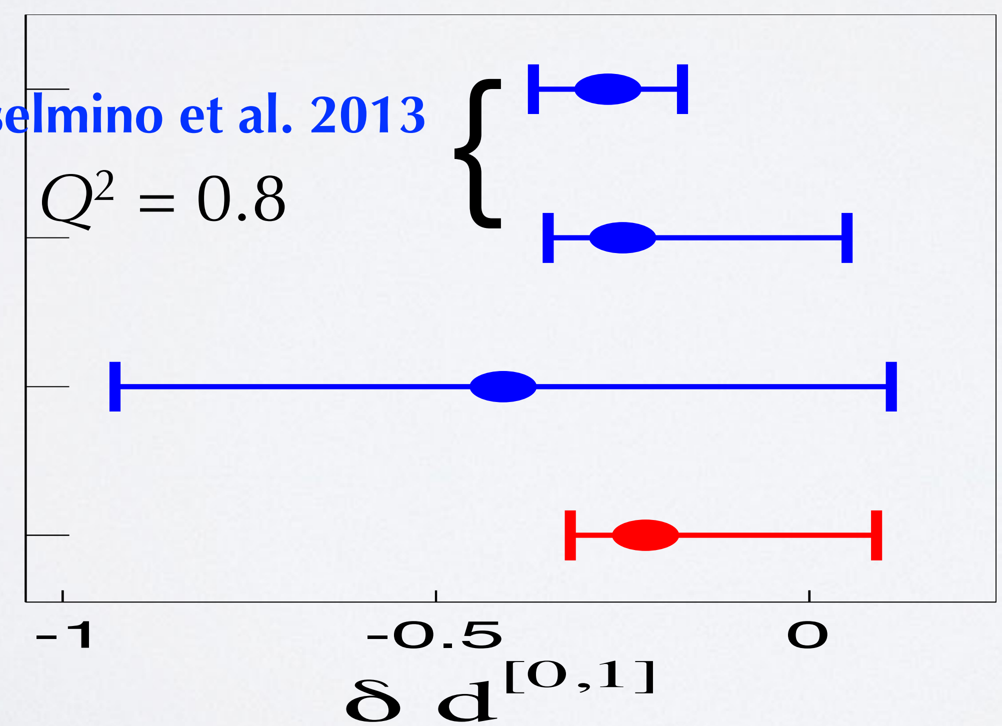
extrapolation to [0,1]

expect larger uncertainties



Anselmino et al. 2013

$Q^2 = 0.8$



Radici et al. 2015
$Q^2 = 1$

Kang et al. 2016
$Q^2 = 10$

- extrapolated tensor charges for TO2013: upper for standard param., lower for polynomial param.

precision of g_T^{u-d}

current most stringent constraints on BSM tensor coupling come from

- Dalitz-plot study of radiative pion decay $\pi^+ \to e^+ \nu_e \gamma$

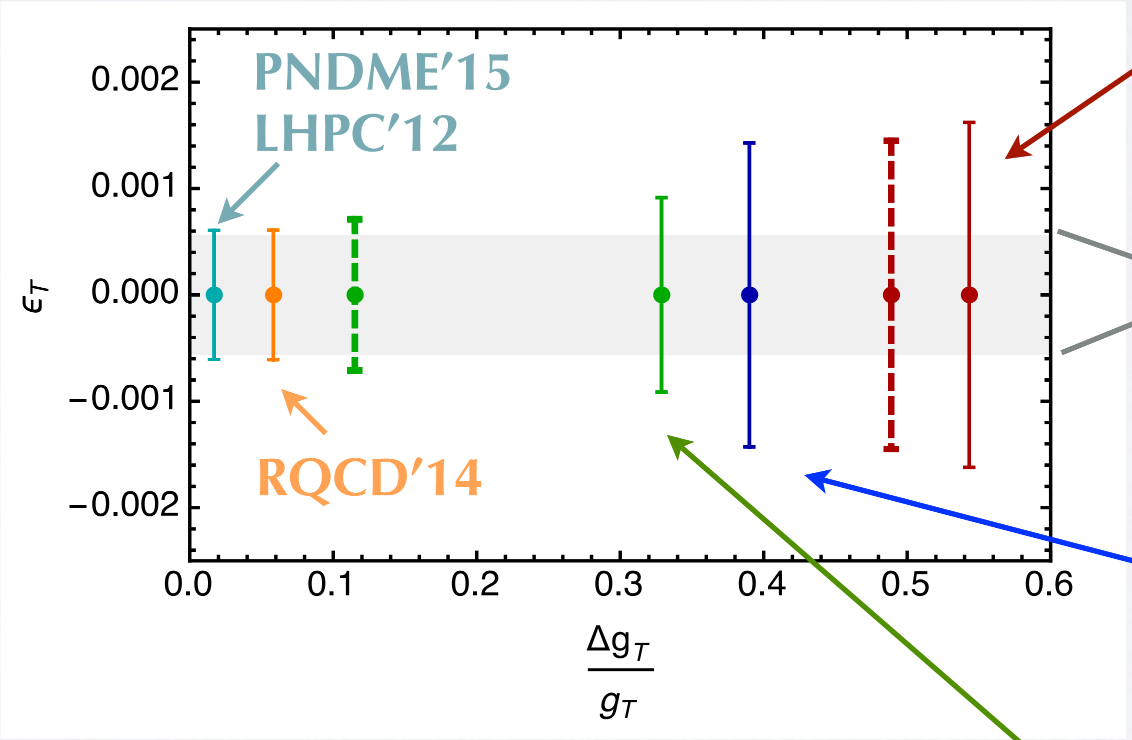
*Bychkov et al. (PIBETA), P.R.L. **103** (09) 051802*

- measurement of correlation parameters in neutron β-decay of various nuclei

Pattie et al., P.R. C88 (13) 048501

$| \varepsilon_T \, g_T | \lesssim 5 \times 10^{-4}$

need to adapt phenomenology to precision of measurements and lattice JLAB12 is good opportunity



$\Delta\varepsilon_T$ from **Radici et al. 2015**

(to be improved with RHIC data)

$\Delta\varepsilon_T$ assuming $\Delta g_T=0$

$\Delta\varepsilon_T$ from **Anselmino et al. 2013**

Goldstein et al., arXiv:1401.0438

*Courtoy et al., P.R.L. **115** (2015) 162001*