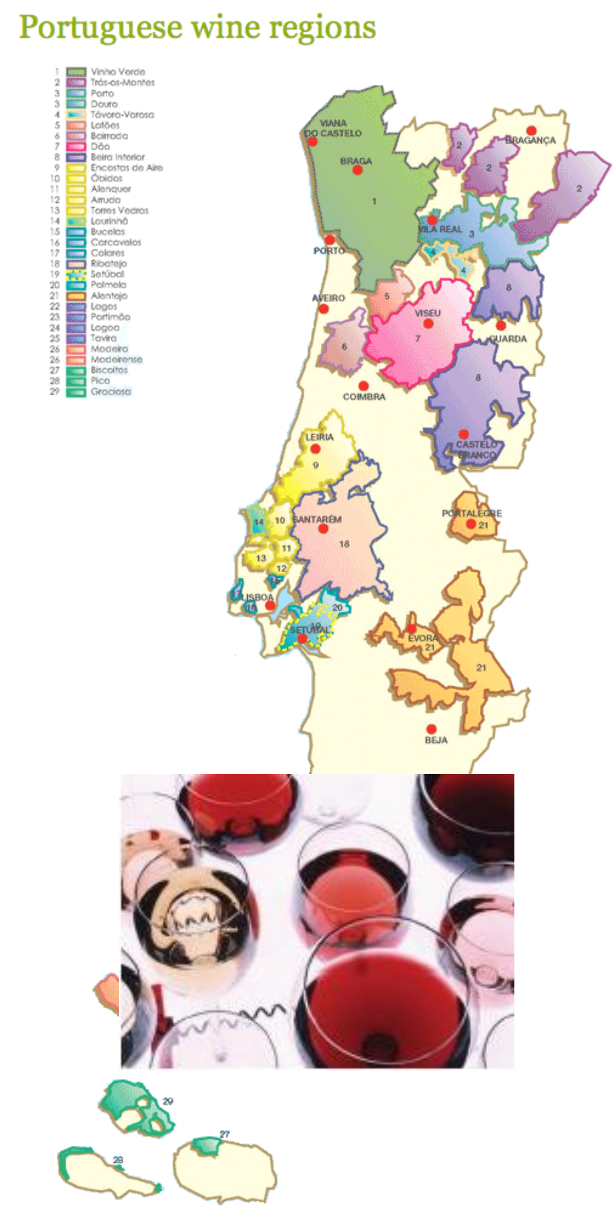
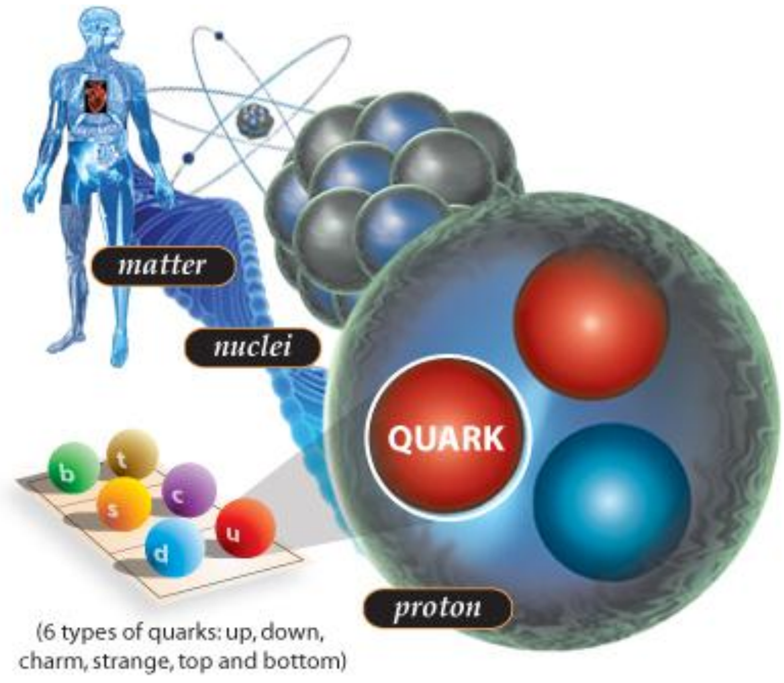
Workshop Highlights

G. Mallot/CERN

Uncontroversial Highlights



Structure & Spectroscopy



Vogelsang

25 years since the "proton spin crisis"

Talks & Topics

- Excellent, balanced scientific programme

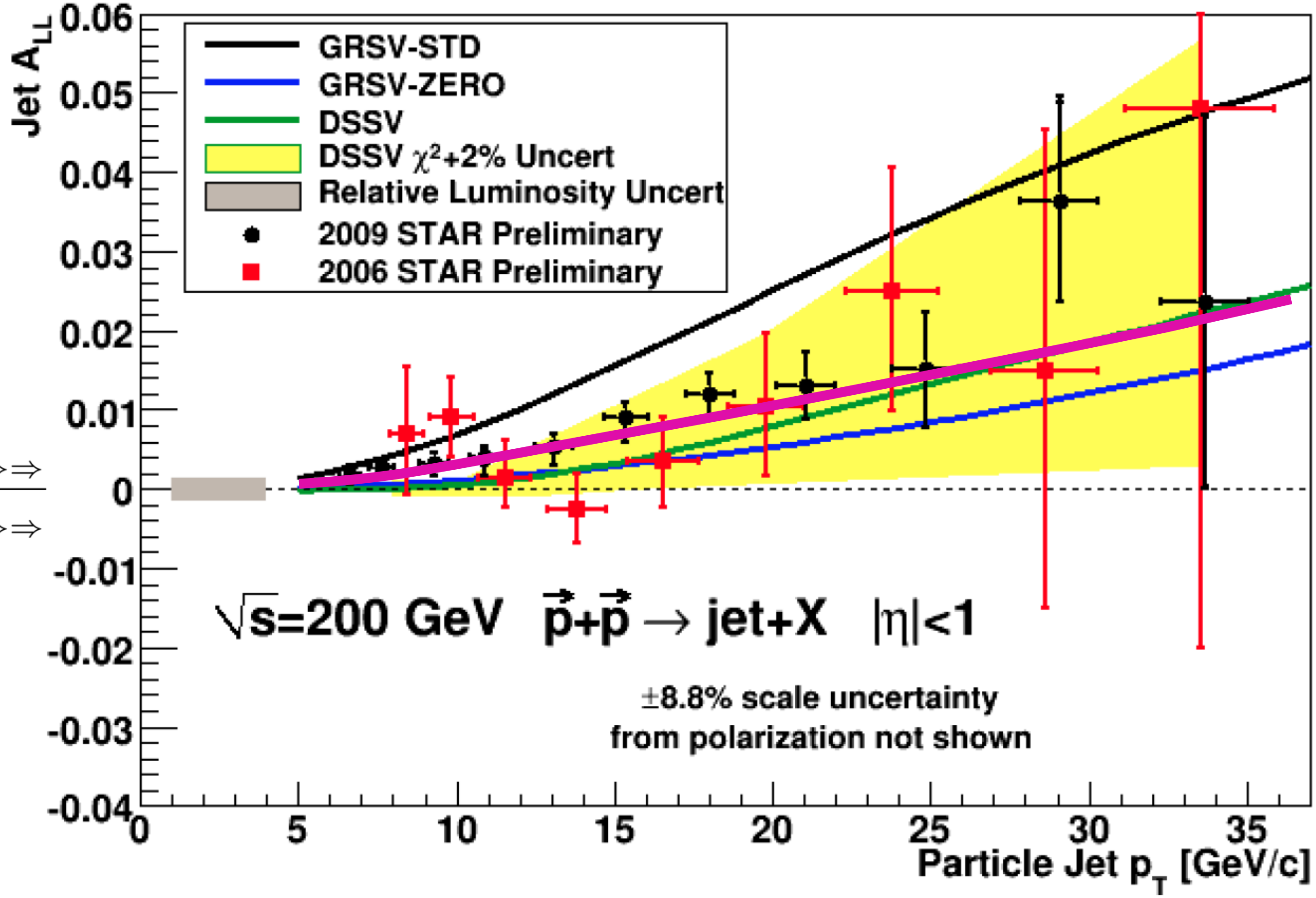
Topic	exp	theo	total
Longitudinal spin	1	3	4
GPDs	2	2	4
TMDs & transverse spin	3	3	6
Spectroscopy & χPT	4	3	7
Total	**10**	**11**	**21**

Longitudinal spin

- gluon polarisation
- strangeness
- spin decomposition
- lattice

New devlopments on Δg :

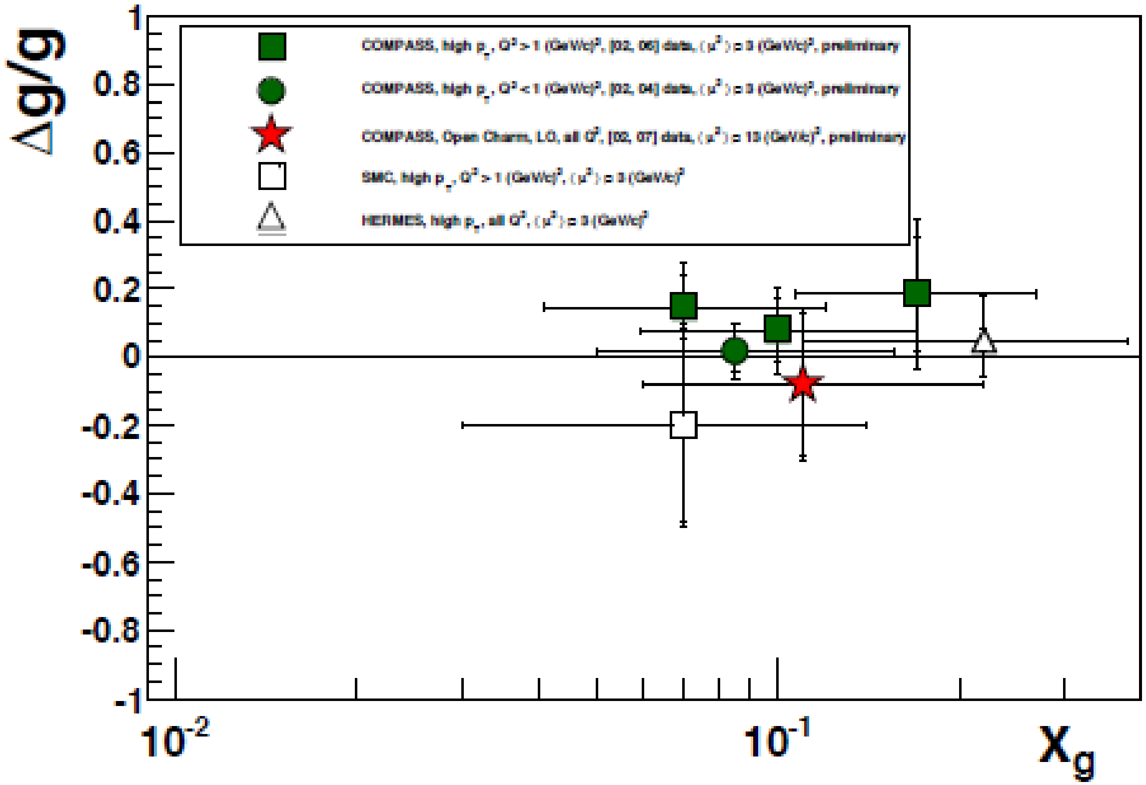
$$A_{LL} = \frac{\sigma_{\Rightarrow\Leftarrow} - \sigma_{\Rightarrow\Rightarrow}}{\sigma_{\Rightarrow\Leftarrow} + \sigma_{\Rightarrow\Rightarrow}}$$



- gives gluon with $\int_{0.05}^{0.2} dx\, \Delta g \approx 0.1$

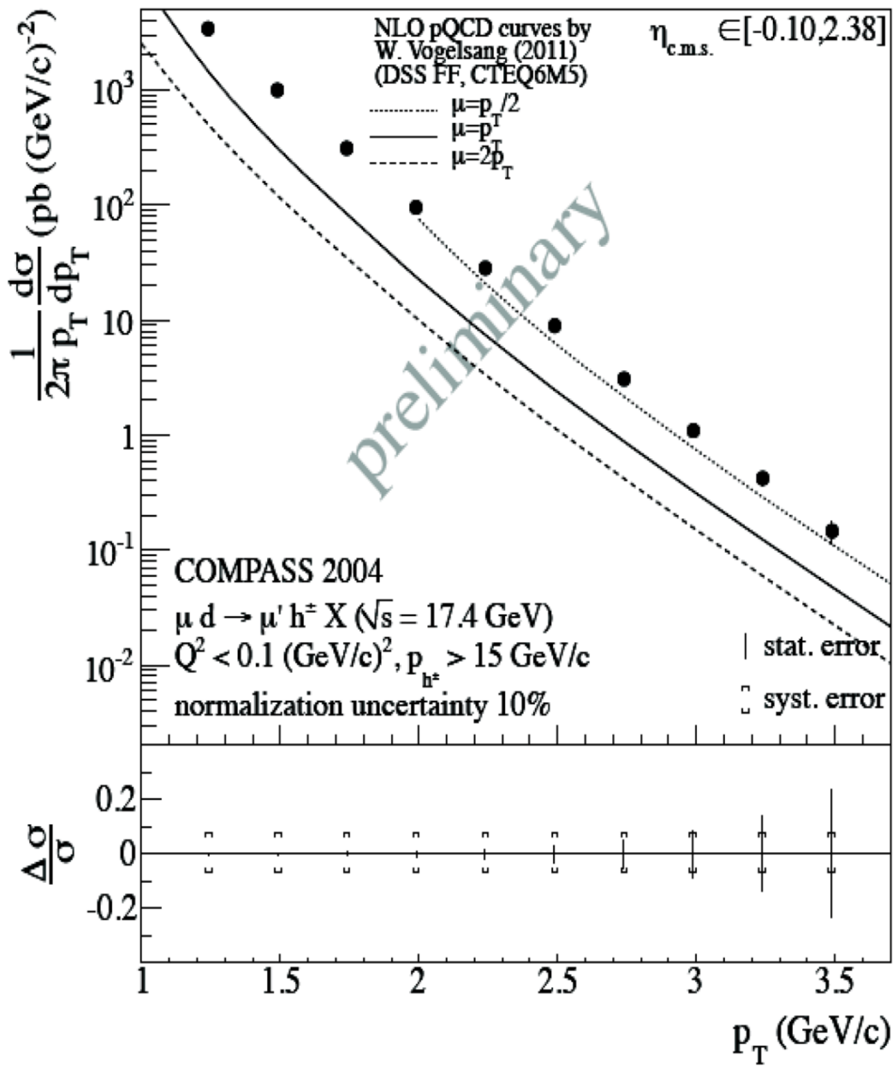
Vogelsang
Stolarski

LO Gluon polarisation from hadron production in DIS

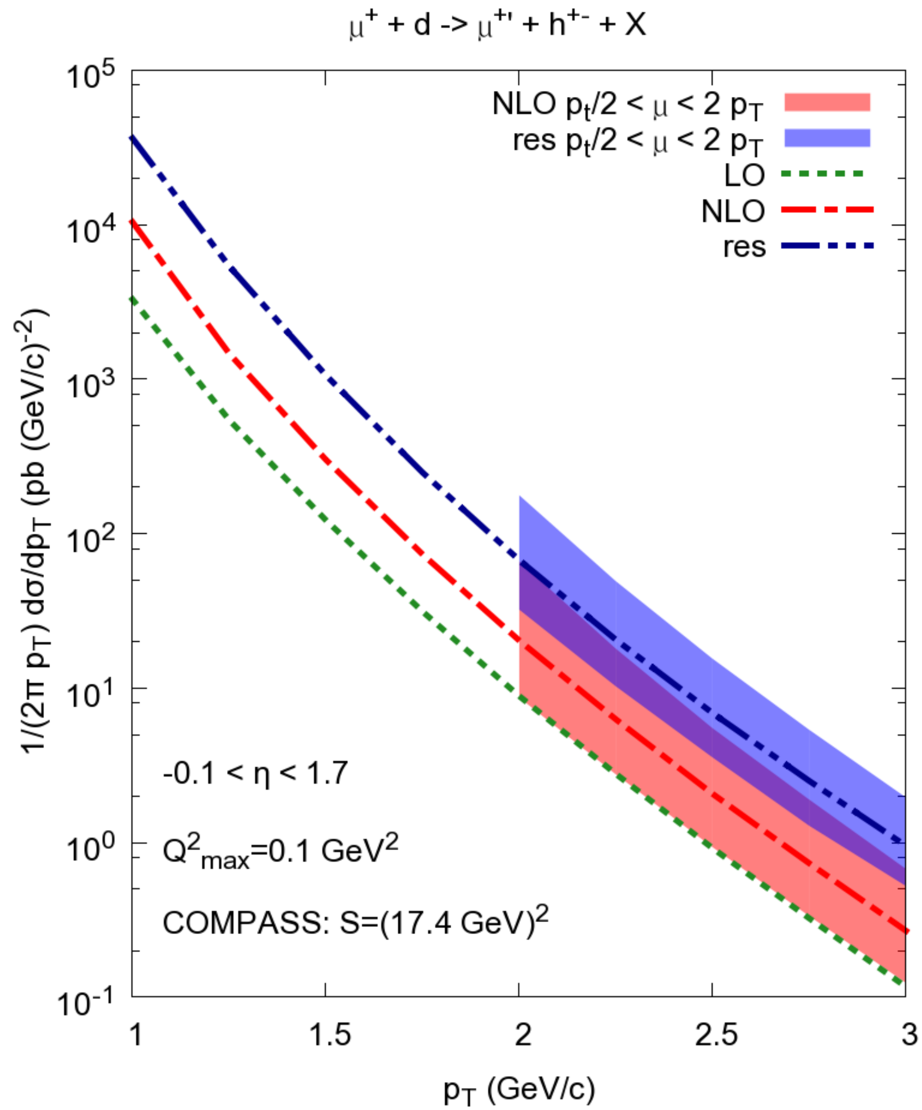


Vogelsang
Stolarski

From single hadrons in DIS? Resummed calculation!



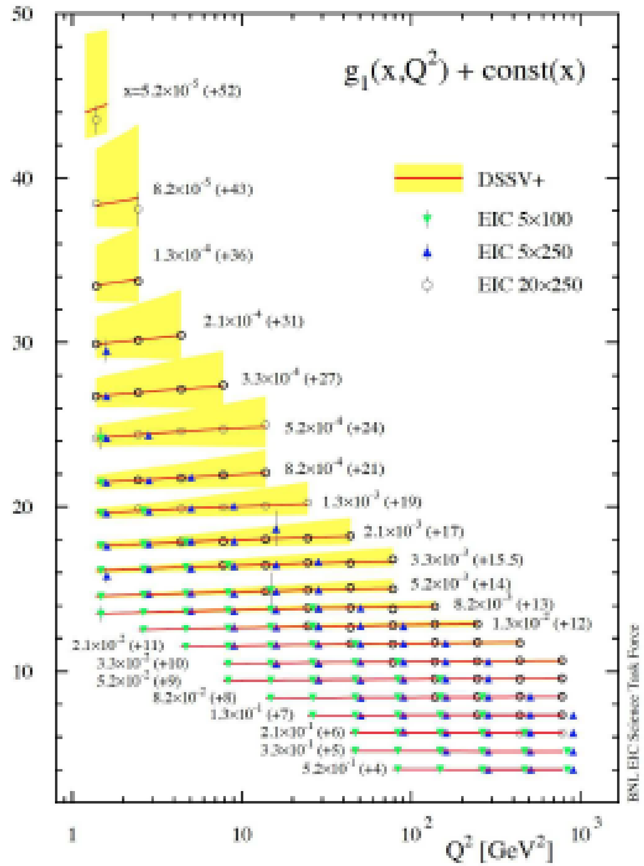
Vogelsang



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

Electron Ion Collider and g_1^p

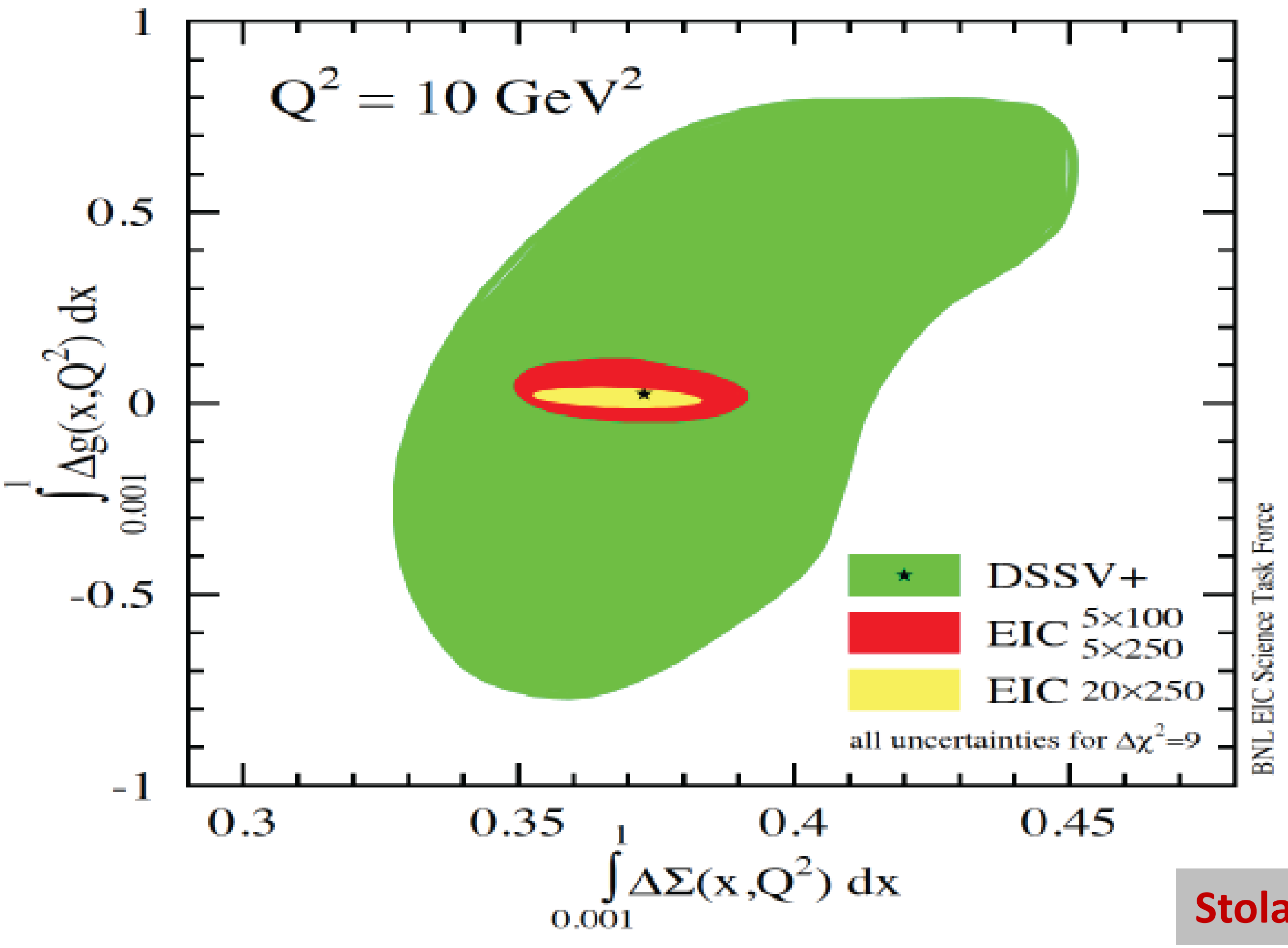
- large increase of phase space where g1p will be measured
- observe it will be possible to extract Δg from inclusive measurement!
- $\frac{dg1(x,Q^2)}{dlog(Q^2)} \sim -\Delta g(x, Q^2)$



Stolarski

Electron Ion Collider cont.

- impact of EIC data for the $\Delta\Sigma$ and ΔG



Stolarski

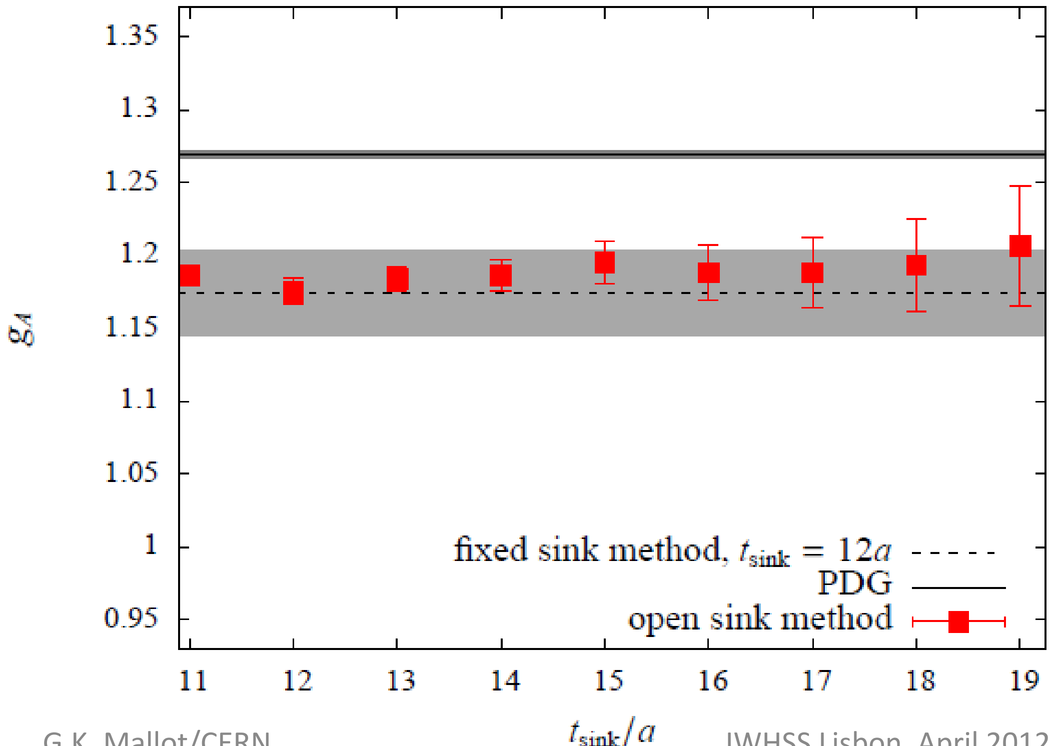
Lattice

Alexandrou

Study of excited state contributions

$N_F = 2 + 1 + 1$ with $m_\pi \sim 380$ MeV and $a = 0.08$ fm

Vary source- sink separation:

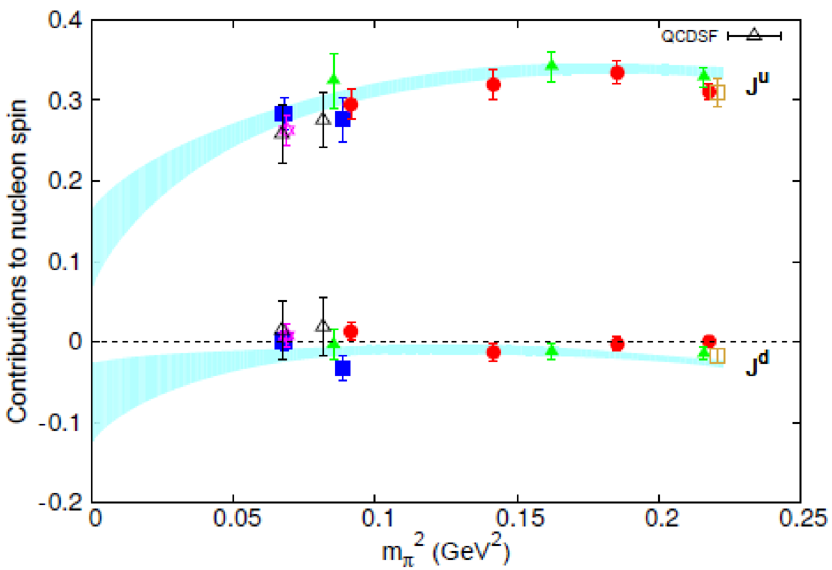


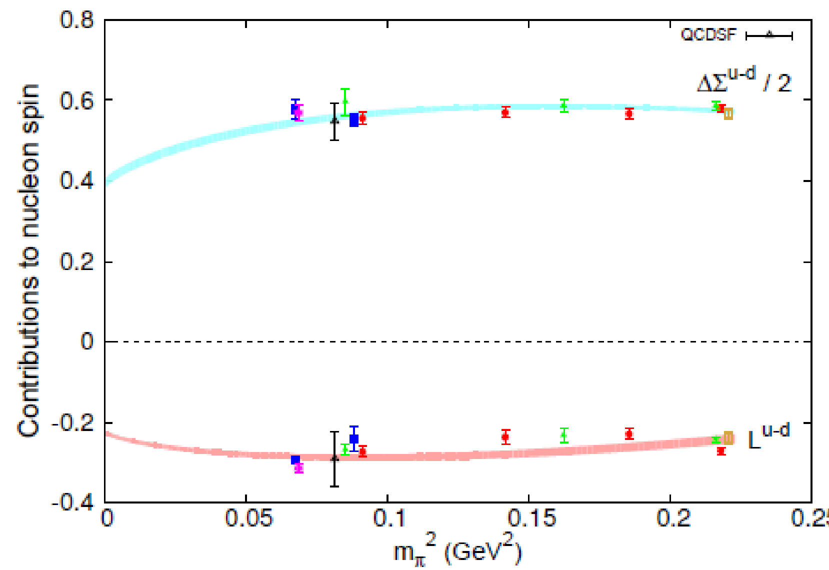
S. Dinter, C.A., M. Constantinou, V. Drach, K. Jansen and D. Renner, arXiv: 1108.1076

Alexandrou

Lattice results on the nucleon spin

$J_q = \frac{1}{2}[A_{20}(0) + B_{20}(0)] = \frac{1}{2}\Delta\Sigma_q + L_q$
$\Delta\Sigma_q = \tilde{A}_{10}$
Only connected contribution
Results using $N_F = 2$ TMF for 270 MeV $< m_\pi <$ 500 MeV, C. Alexandrou *et al.* (ETMC), arXiv:1104.1600
In agreement with A. Sternbeck *et al.* (QCDSF) arXiv:1203.6579
In qualitative agreement with J. D. Bratt *et al.* (LHPC), PRD82 (2010) 094502





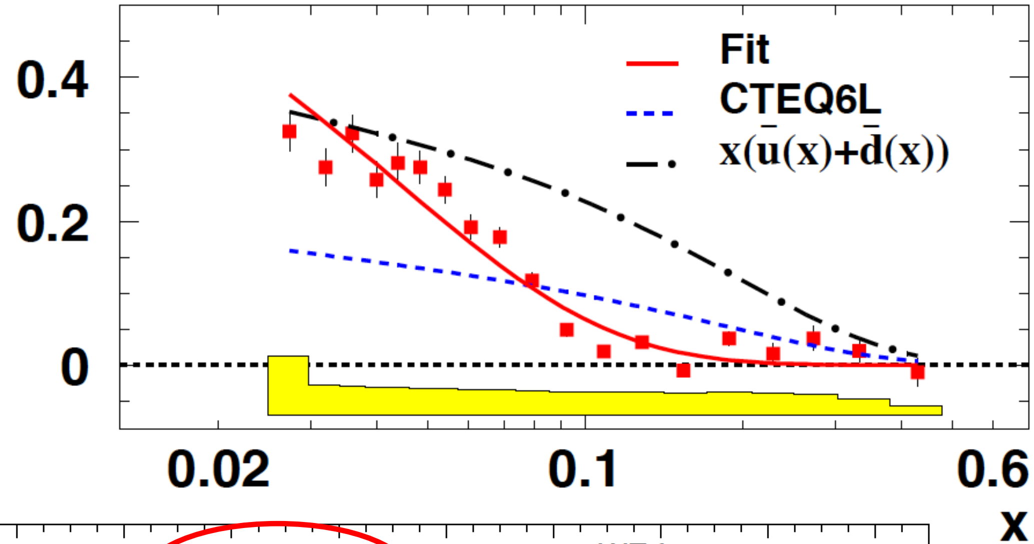
$\Longrightarrow$ Good agreement also for $\Delta\Sigma^{u-d}$ and ΔL^{u-d}

- still have a lot to learn about strangeness:

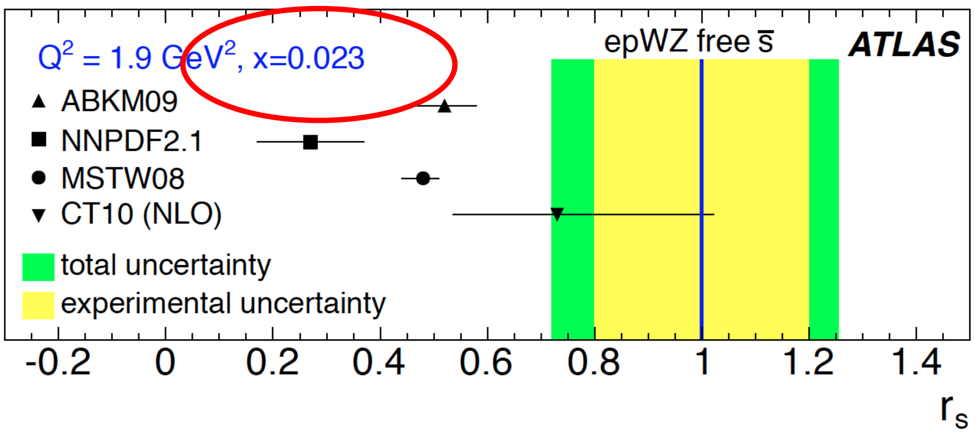
Vogelsang

and FF!

$x(s+\bar{s})$



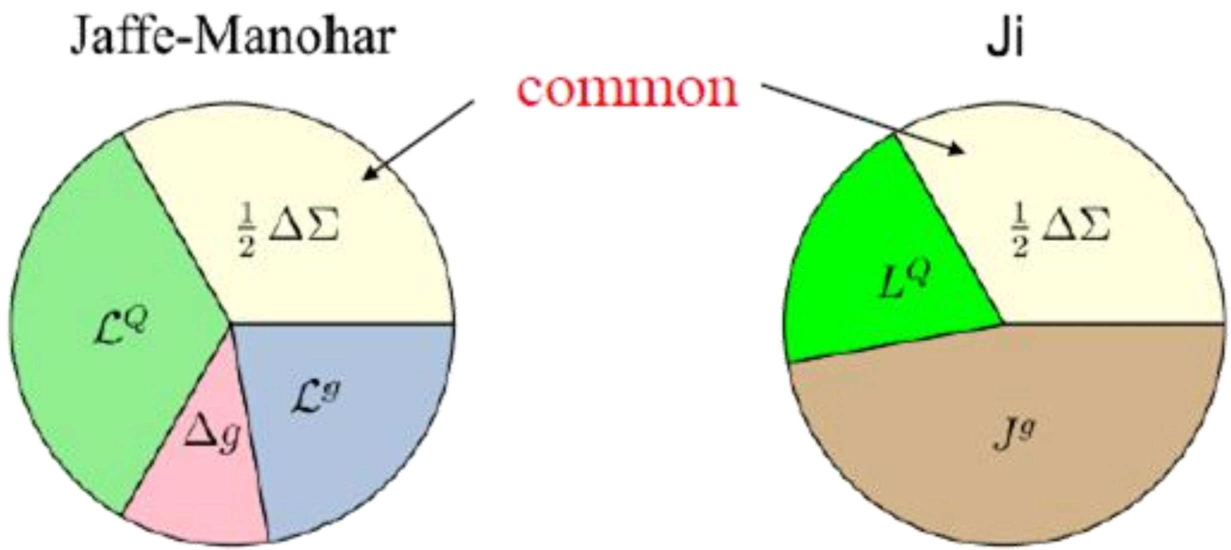
HERMES



ATLAS

$$r_s = 0.5\,\frac{s+\bar{s}}{\bar{d}}$$

Longitudinal spin decomposition



Wakamatsu, Lorcé

$L_Q(\mathrm{JM}) \sim \psi^\dagger \boldsymbol{x} \times \boldsymbol{p}\, \psi$

$L_Q(\mathrm{Ji}) \sim \psi^\dagger \boldsymbol{x} \times (\boldsymbol{p} - g\, \boldsymbol{A})\, \psi$

canonical OAM

dynamical OAM

not gauge invariant !

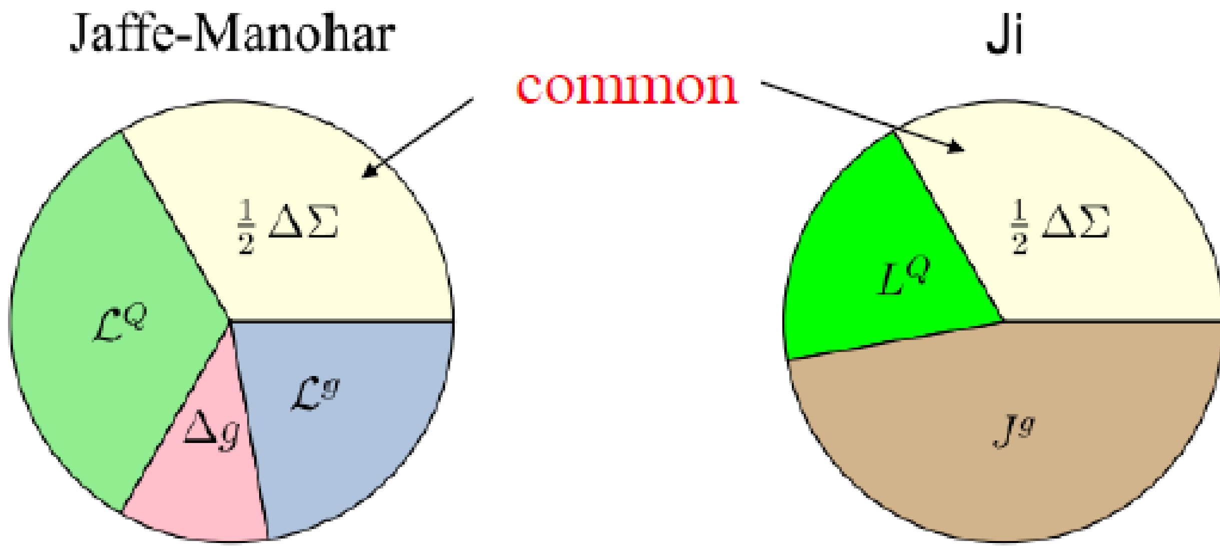
gauge invariant !

J_g

Each term is not separately gauge-invariant !

No further decomposition !

Wakamatsu



Decomposition (II)	Decomposition (I)
gauge-invariant decomposition containing **Jaffe-Manohar's decomp**. as gauge-fixed form	extension of **Ji's decomp**. including gluon part
"canonical" OAMs	**dynamical (mechanical) OAMs**

Hatta's recent work opened up a possibility that the canonical OAM may also be related to observables.

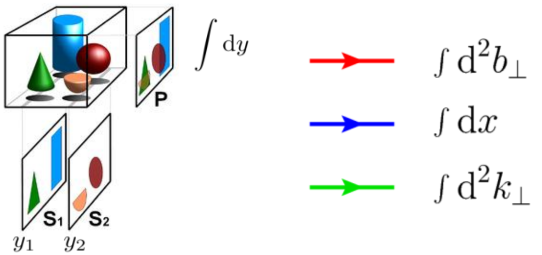
The dynamical OAMs of quarks and gluons can in principle be extracted model-independently from GPD and polarized DIS measurements.

At least one satisfactory solution ☑

GPDs (and TMDs)

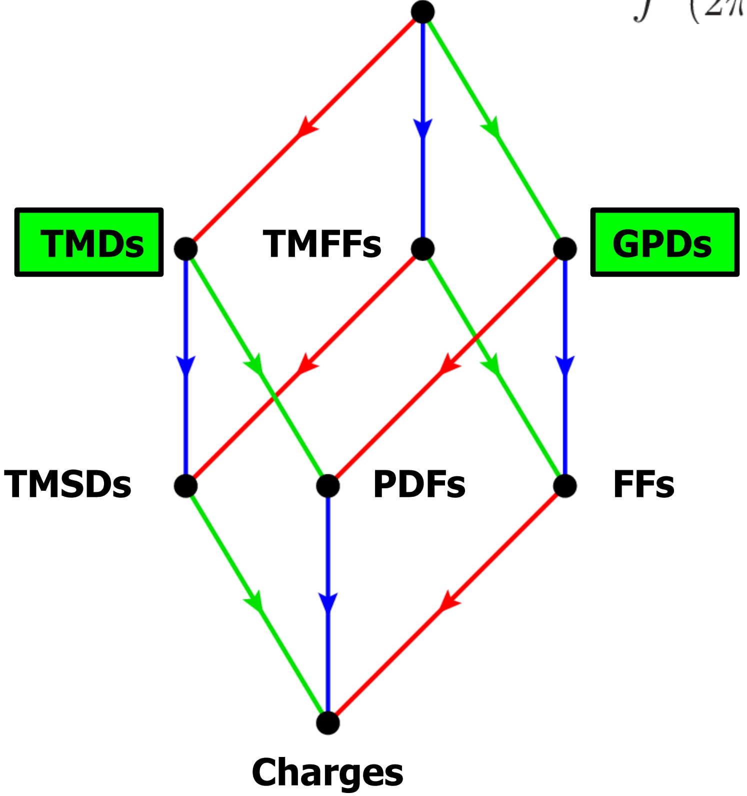
- GPDs and TMDs, OAM
- lattice
- new data
- future

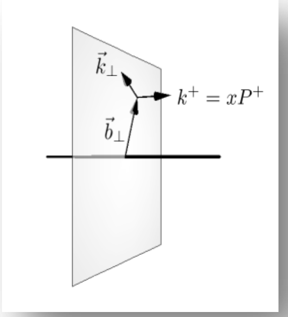
Complete picture



GTMDs and Wigner distributions

$$\text{GTMDs}\,\big|_{\xi=0} \sim \int \frac{\mathrm{d}^2 b_\perp}{(2\pi)^2}\, e^{i\vec{\Delta}_\perp\cdot\vec{b}_\perp}$$





5D imaging

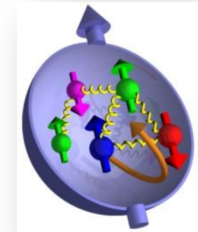
Wigner distribution

Lorcé, Pasquini

[C.L., Pasquini, Vanderhaeghen (2011)]
[C.L., Pasquini (2011)]

Quark spin and OAM

Lorcé



GPDs

Quark spin $S_z^q = \frac{1}{2}\int \mathrm{d}x\,\tilde{H}^q(x,0,0)$

Ji sum rule [Ji (1997)]

$$L_z^q + S_z^q = \frac{1}{2}\int \mathrm{d}x\,x\,[H^q(x,0,0) + E^q(x,0,0)]$$

Twist-3

$$L_z^q + 2S_z^q = -\int \mathrm{d}x\,x\,\tilde{E}_{2T}^q(x,0,0)$$

$$\tilde{E}_{2T}^q = -(G_2^q + H^q + E^q) + 2(G_4^q + \xi\,G_3^q)$$

$$\int \mathrm{d}x\,x\,G_{3,4}^q = 0$$

PPSS sum rule

$$L_z^q = -\int \mathrm{d}x\,x\,G_2^q(x,0,0)$$

← Pure twist-3!

[Penttinen, Polyakov, Shuvaev, Strikman (2000)]

Genuine sum rule

$$\int \mathrm{d}x\left[x\left(H^q + E^q + 2\tilde{E}_{2T}^q\right) + \tilde{H}^q\right] = 0$$

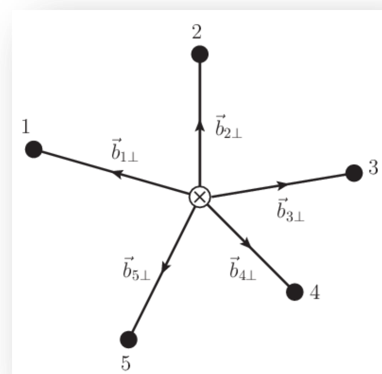
TMDs

Quark spin $S_z^q = \frac{1}{2}\int \mathrm{d}x\,\mathrm{d}^2k_\perp\,g_{1L}^q(x,\vec{k}_\perp)$

Pretzelosity

$$\mathcal{L}_z^q(x,\vec{k}_\perp) = -\frac{\vec{k}_\perp^2}{2M^2}\,h_{1T}^{\perp q}(x,\vec{k}_\perp^2)$$

[Burkardt (2007)]
[Efremov, Schweitzer, Teryaev, Zavada (2008,2010)]
[She, Zhu, Ma (2009)]
[Avakian, Efremov, Schweitzer, Yuan (2010)]
[C.L., Pasquini (2011)]



- **Model-dependent**
- **Not intrinsic OAM**

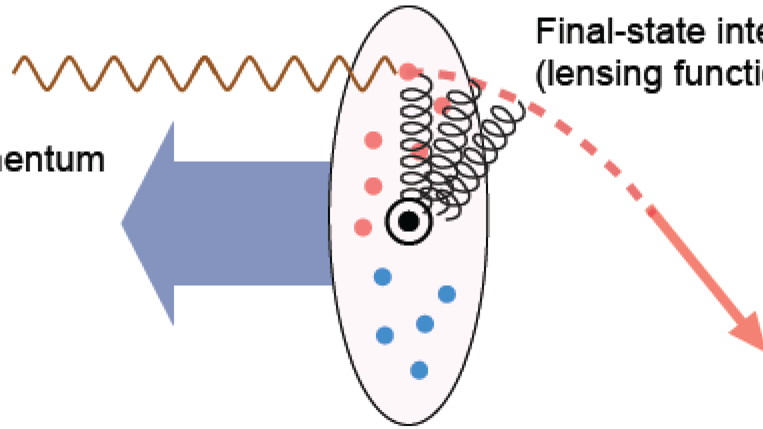
TMDs $\mathcal{L}_{iz} = \vec{r}_{i\perp} \times \vec{k}_{i\perp}$

GTMDs $\ell_{iz}^{\text{int}} = \vec{b}_{i\perp} \times \vec{k}_{i\perp}$

Constraining quark OAM with Sivers function

Pasquini

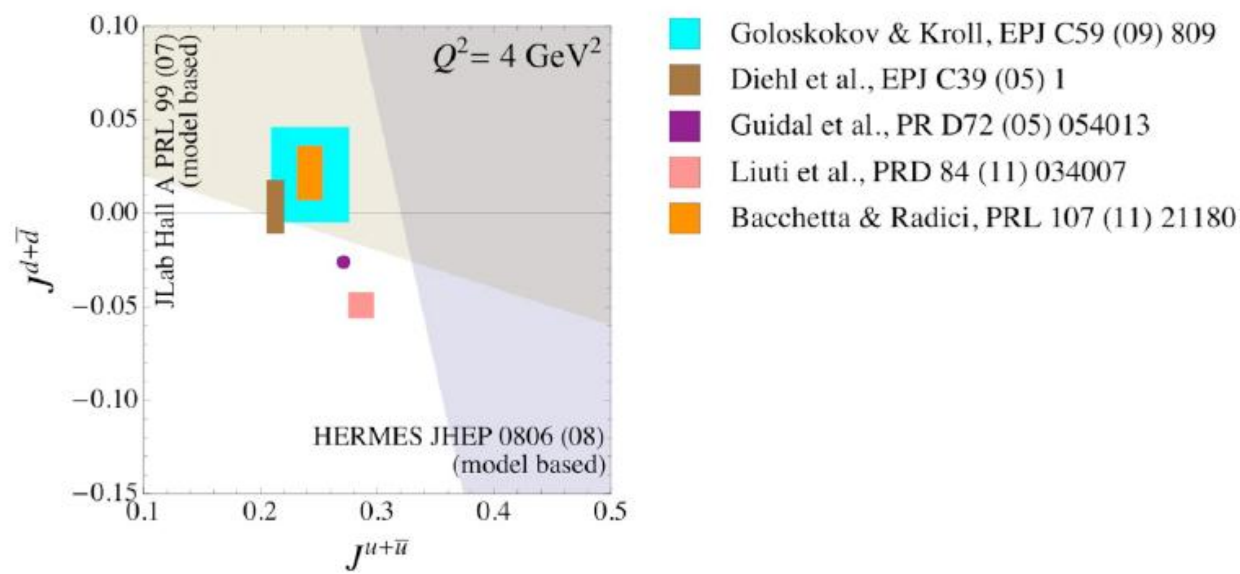
unpolarized quark in transversely pol. nucleon

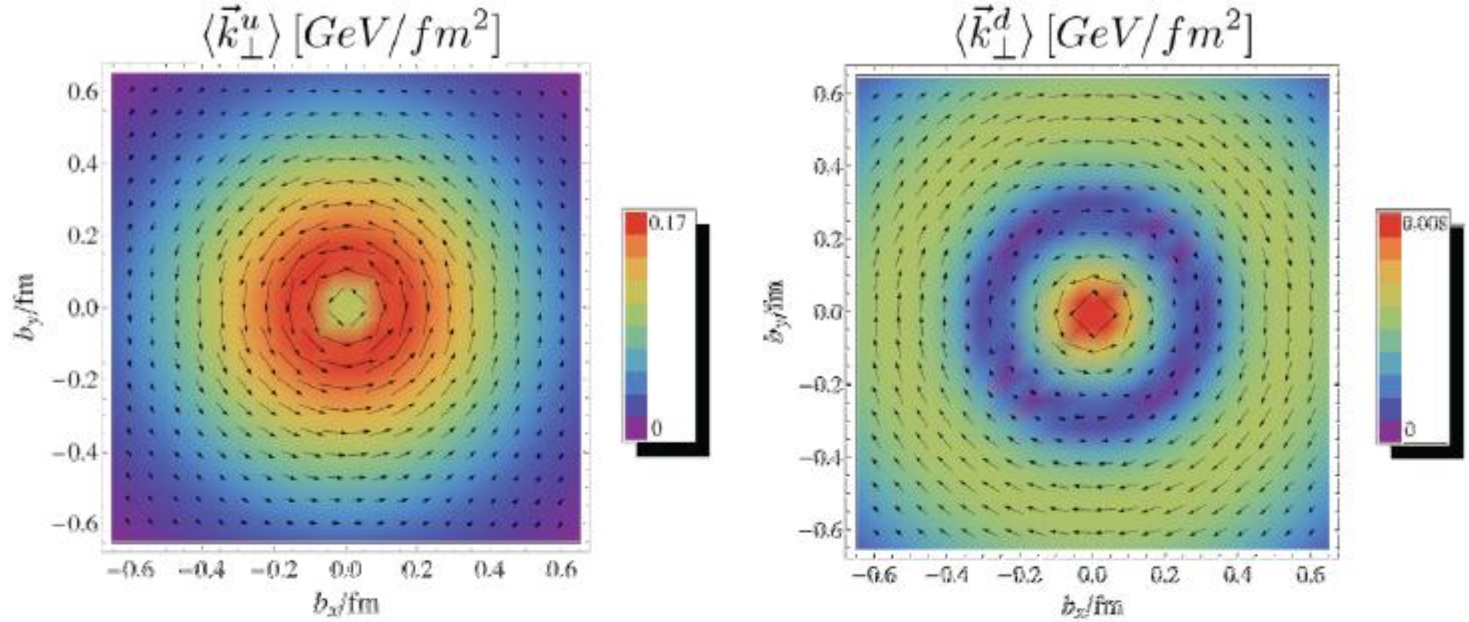


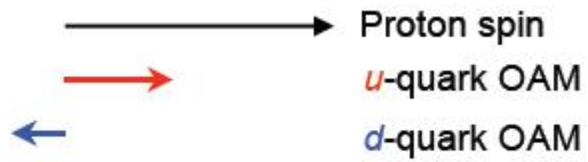
Burkardt, PRD66 (02)

A. Bacchetta, DIS2012

Bacchetta, Radici, PRL107(2011)



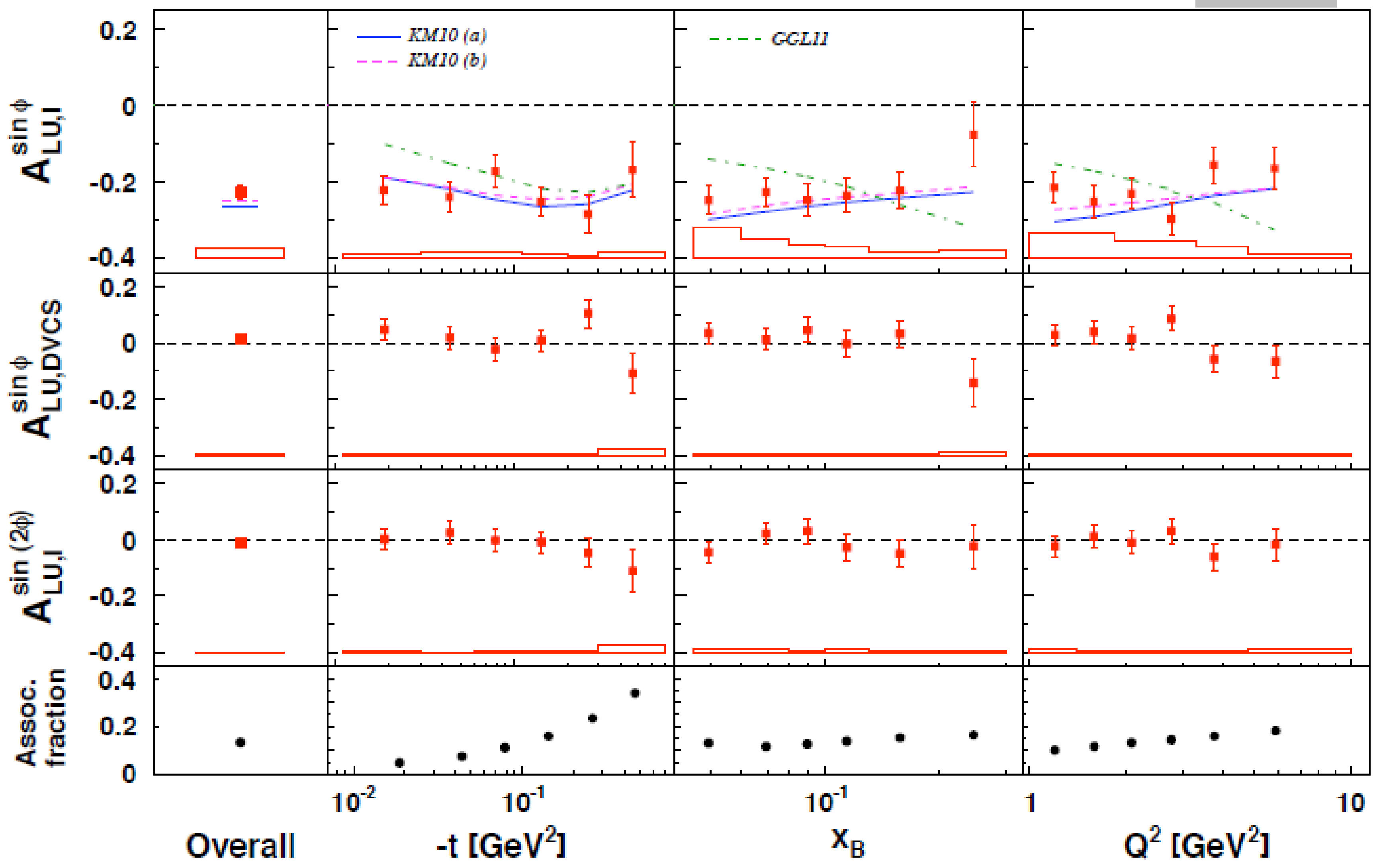




Results in a light-cone constituent quark model:
Lorce', BP, Xiong, Yuan, arXiv:1111.4827 [hep-ph]

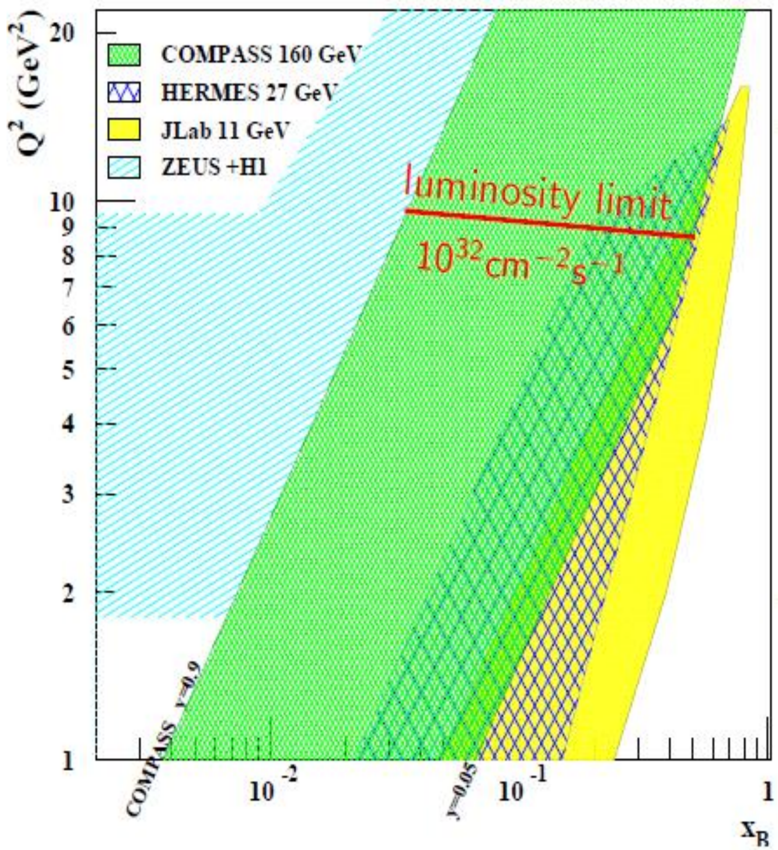
New HERMES results: combined DVCS BSA

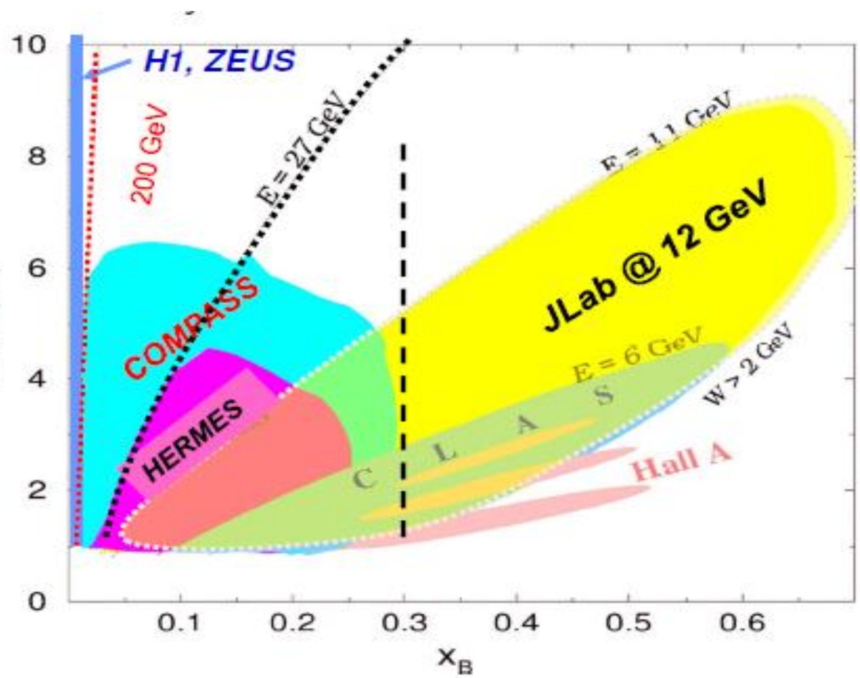
Muñoz



arXiv:1203.6287

Kinematic range (DVCS)

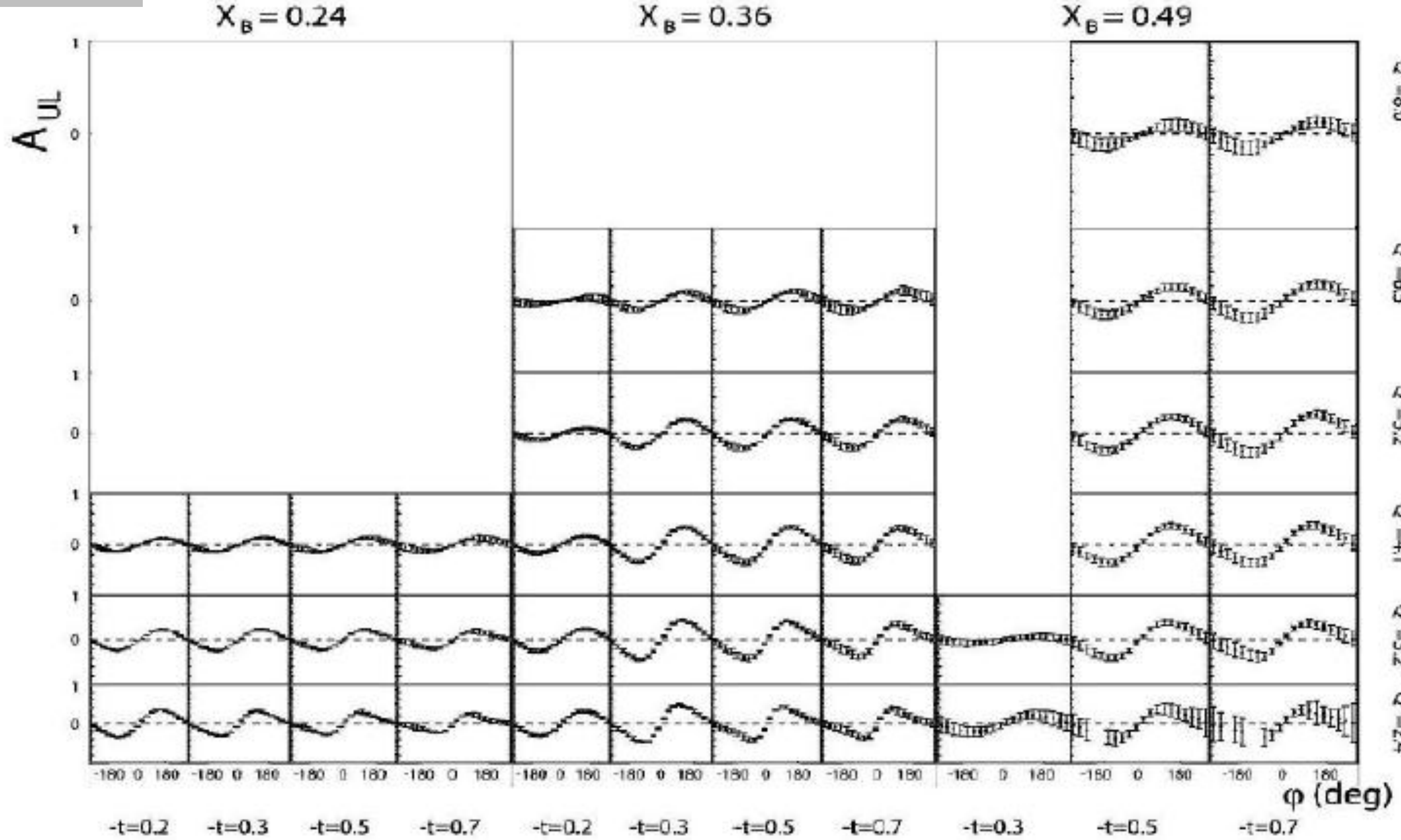




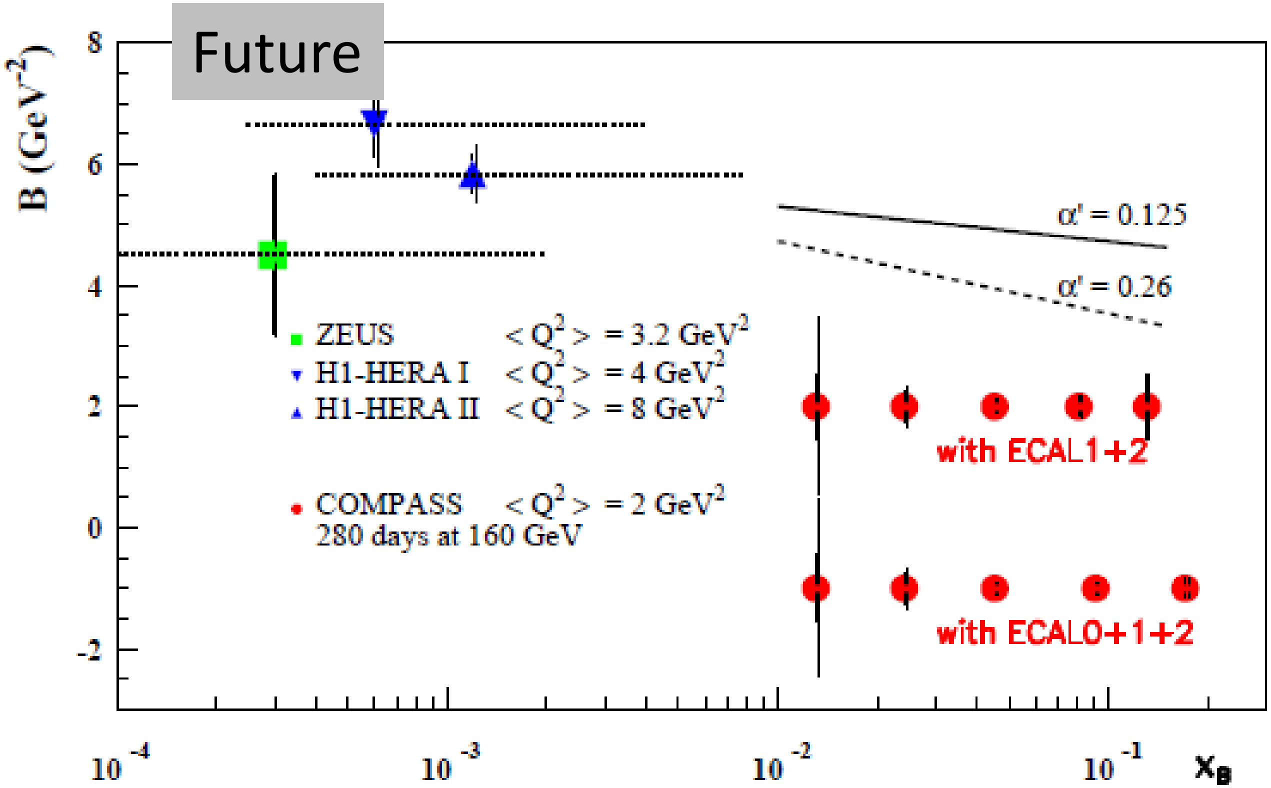
E12-06-119: DVCS on the proton with CLAS12

Muñoz

Future



DVCS: Transverse Size of the Nucleon



Wollny

Input for projections:

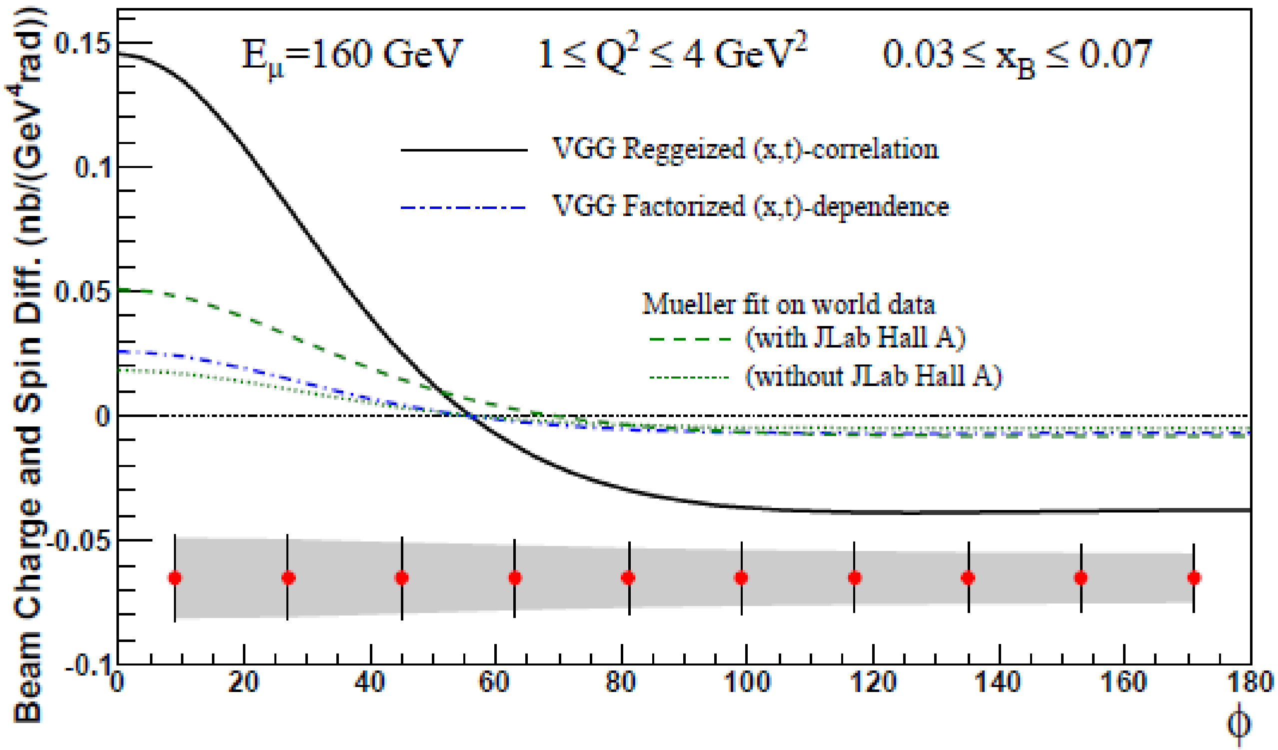
- L=1222 pb^{-1}
  2 years of data
- 160 GeV/c muon beam
- $4.6 \times 10^8 \mu^+$ / per spill
  (9.6 s every 48 s)
- 2.5 m LH_2 target
- $\epsilon_{global} = 10\,\%$

In 2012 we can determine one mean value of B:

1 week of data taking with 2.5 m LH_2 target and 4 m RPD

$\rightsquigarrow$ 1/40 of the complete statistics

DVCS: Beam Charge and Spin Difference



Input for projections:

- L=1222 pb^{-1}
  2 years of data
- 160 GeV/c muon beam
- 4.6×10^8 μ^+ / per spill
  (9.6 s every 48 s)
- 2.5 m LH_2 target
- ECAL0 + 1 + 2
- $\epsilon_{global} = 10\,\%$

- Systematic error assumes 3% charge dependent effect between μ^+ and μ^-
- Statistics permit 2 dimensional analysis:
  e.g. 6 bins in x_B and 6 in t

Wollny

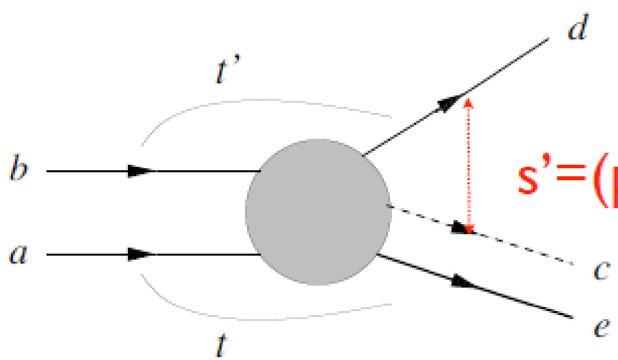
Future

GPDs and CT

Strikman

- New type of hard hadronic processes - *branching exclusive processes* of large c.m. angle scattering off a “a color singlet cluster” in a target/projectile (MS94)

to study both color transparency (CT) (suppression of absorption) in $2 \to 2$
& hadron generalized parton distributions (GPDs)



$s' = (p_d + p_c)^2$

Limit:

$-t' >$ few GeV^2, $-t'/s' \sim 1/2$

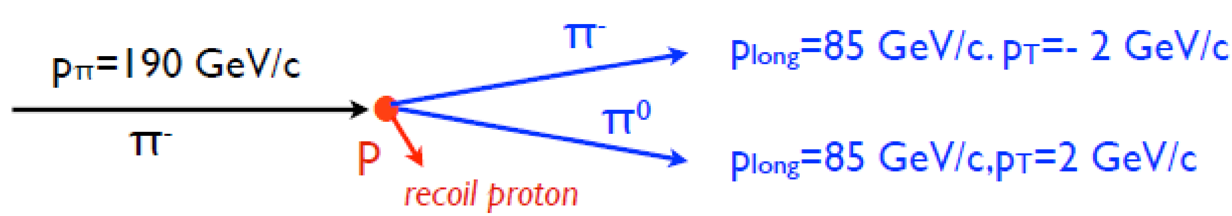
$-t = const \sim 0$

⇒ $s'/s = y \ll 1$,

$t_{min} = [m_a^2 - m_b^2/(1-y)]y$

Two recent papers: Kumano, MS, and Sudoh PRD 09;
Kumano &MS Phys.Lett. 2010

COMPASS can observe for example:
$\pi^- + p \to \pi^- + \pi^0 + p$



Conclusions

Strikman

At the very least, analysis of the collected COMPASS data would allow

To measure for the first time cross sections of large angle pion - pion scattering

Resolve long standing puzzle of sizes involved in large angle scattering

If CT is observed, COMPASS will be able

to measure several nucleon quark GPDs.

to measure quark GPDs of other hadrons and photon (tagged photons in DIS?)

to use beams of lower energies to map space time evolution of small wave packets at distances $1 < z < 6$ fm.

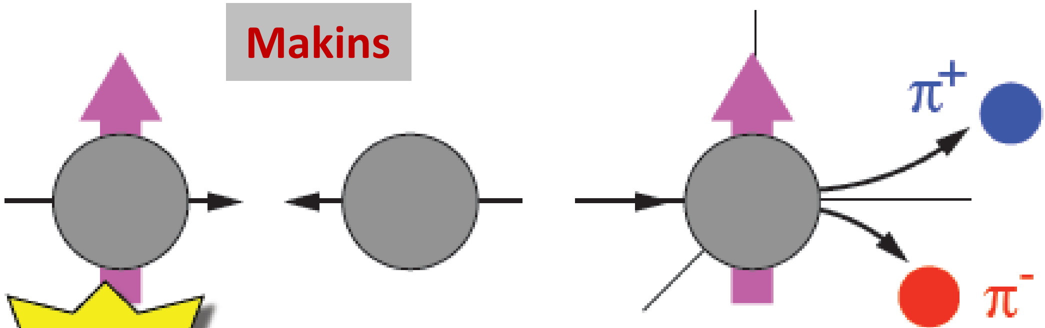
26

transversity & TMDs

- new data PDF & FF
- TMD evolution
- Drell-Yan

Single-spin asymmetries in $p^{\uparrow}p \rightarrow \pi X$

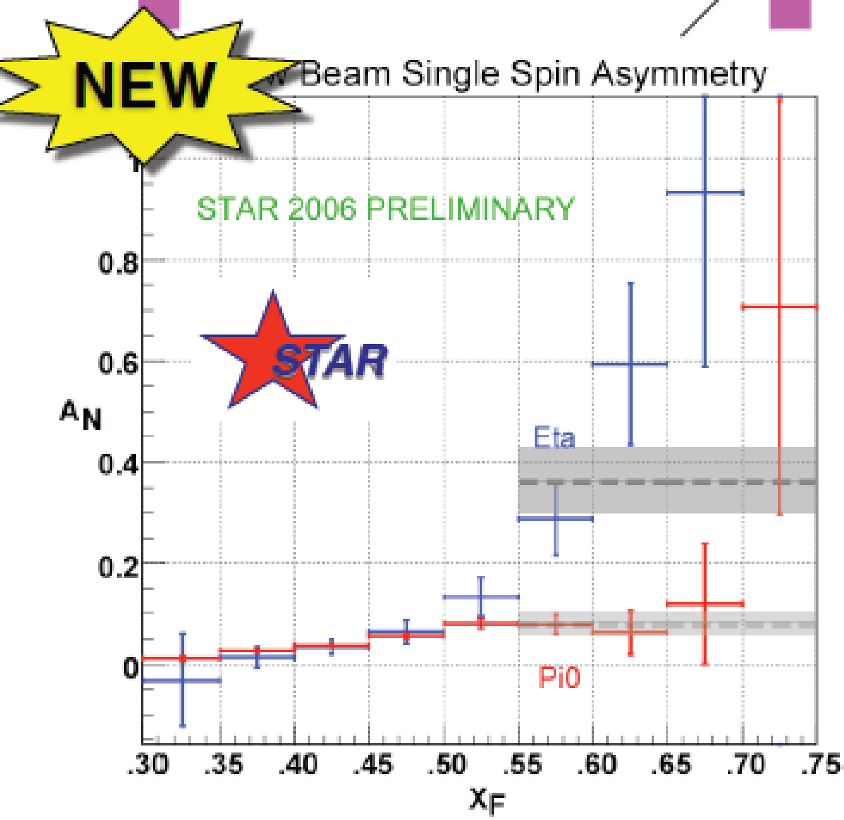
Makins

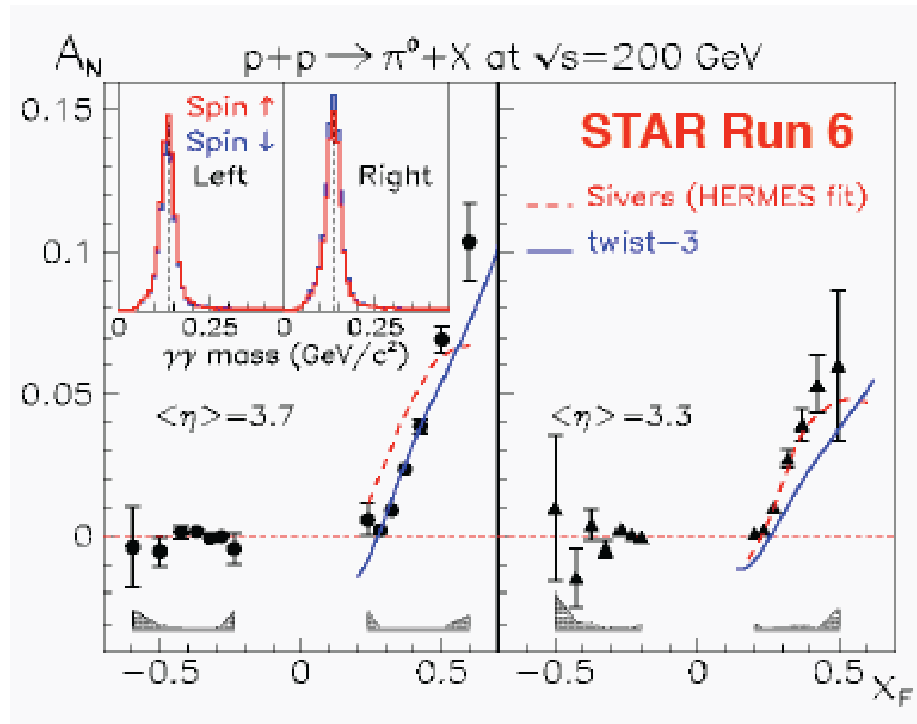


Analyzing Power

$$A_N = \frac{1}{P_{beam}} \frac{N^{\pi}_{left} - N^{\pi}_{right}}{N^{\pi}_{left} + N^{\pi}_{right}}$$

Huge ***single-spin asymmetry***
for ***forward*** meson production

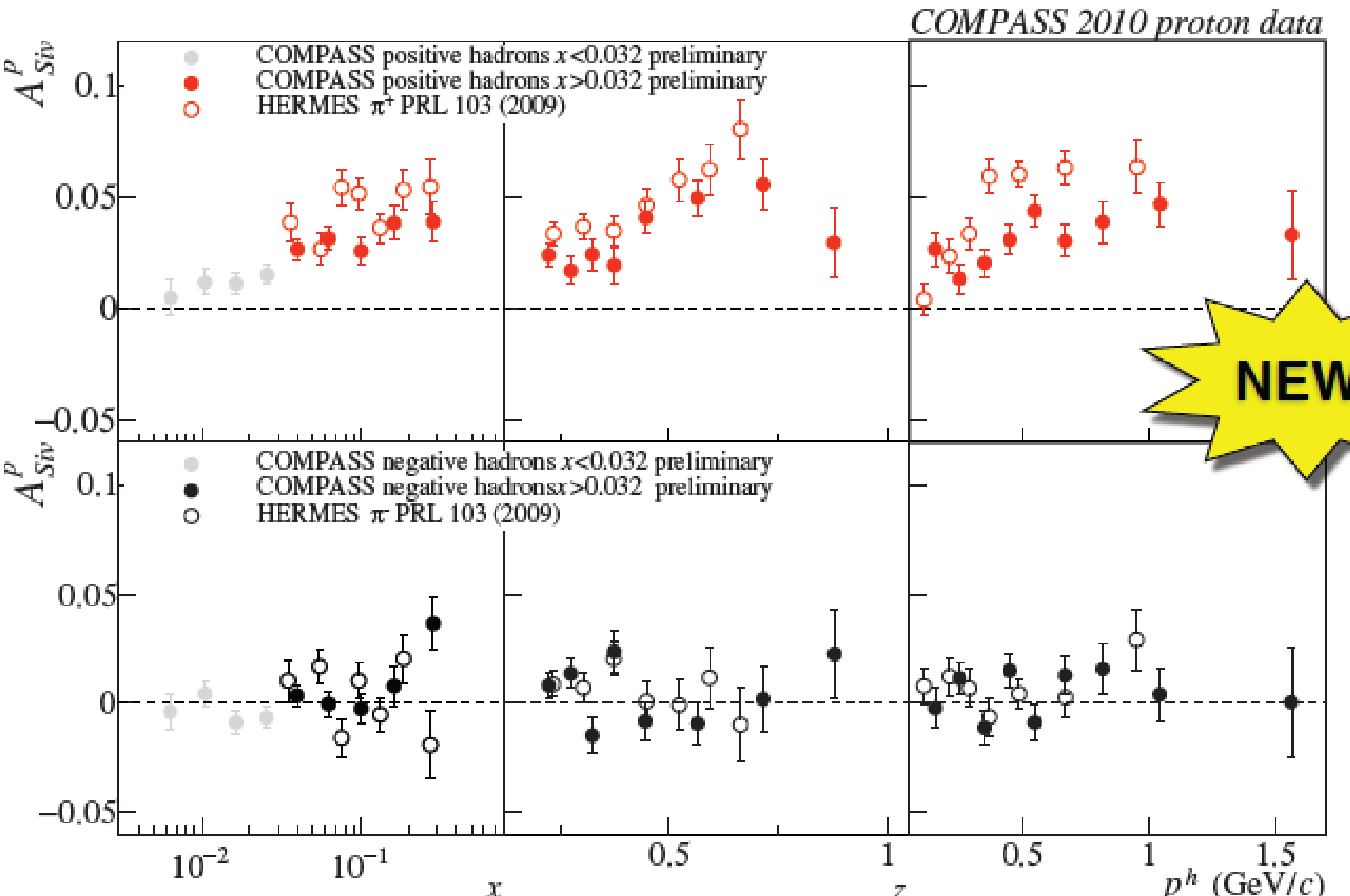




Observable $\vec{S}_{beam} \cdot (\vec{p}_{beam} \times \vec{p}_{\pi})$ ***odd*** *under naive* ***Time-Reversal***

COMPASS proton data: confirmation!

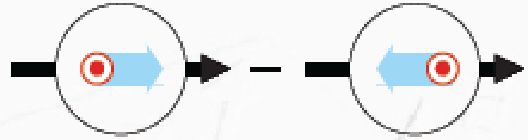
○ HERMES $H^{\uparrow} \rightarrow \pi^{\pm}$ ●● COMPASS 2010 $H^{\uparrow} \rightarrow h^{\pm}$



Makins

<u>New COMPASS data from H target</u>: high-precision confirmation of non-zero Sivers effect in SIDIS

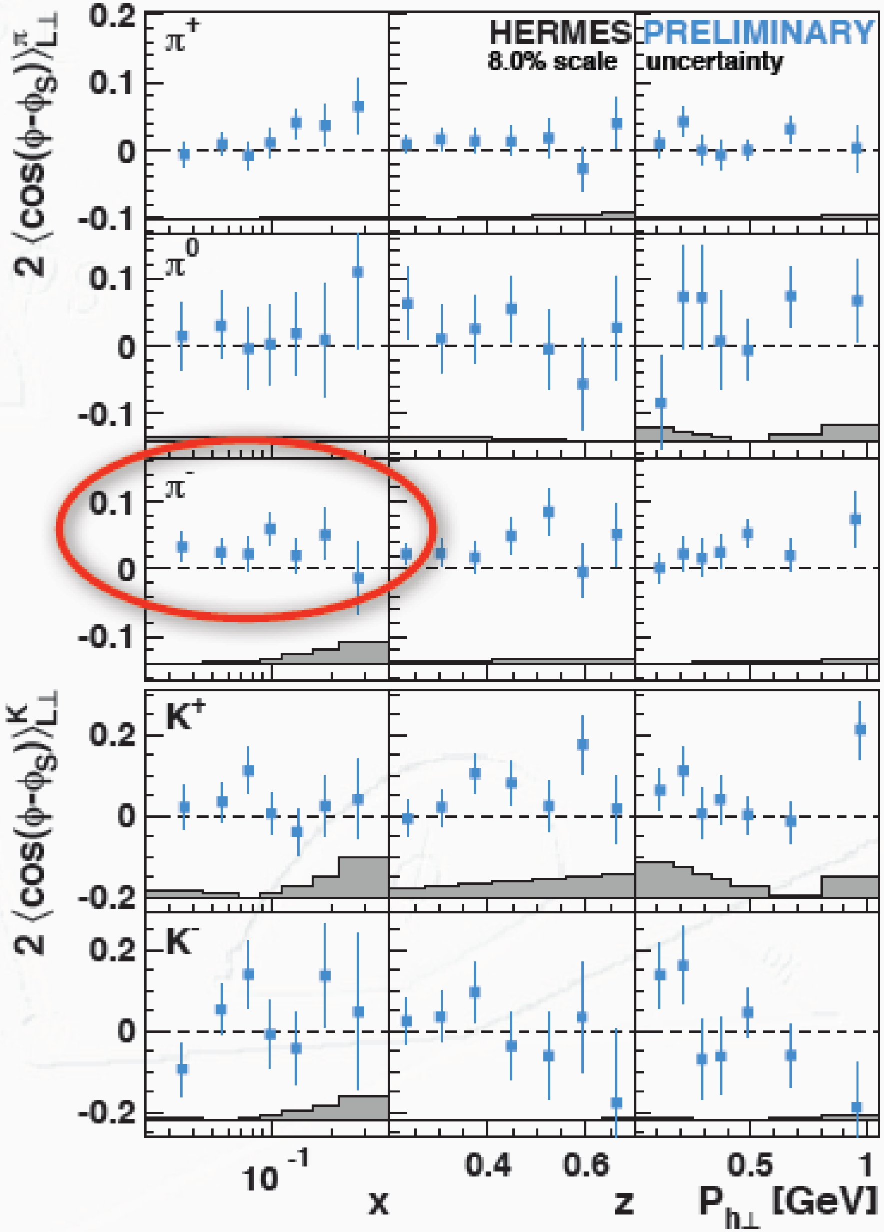
	U	L	T
U	f_1		$h_1^\perp$
L		g_{1L}	$h_{1L}^\perp$
T	$f_{1T}^\perp$	g_{1T}	h_1, $h_{1T}^\perp$



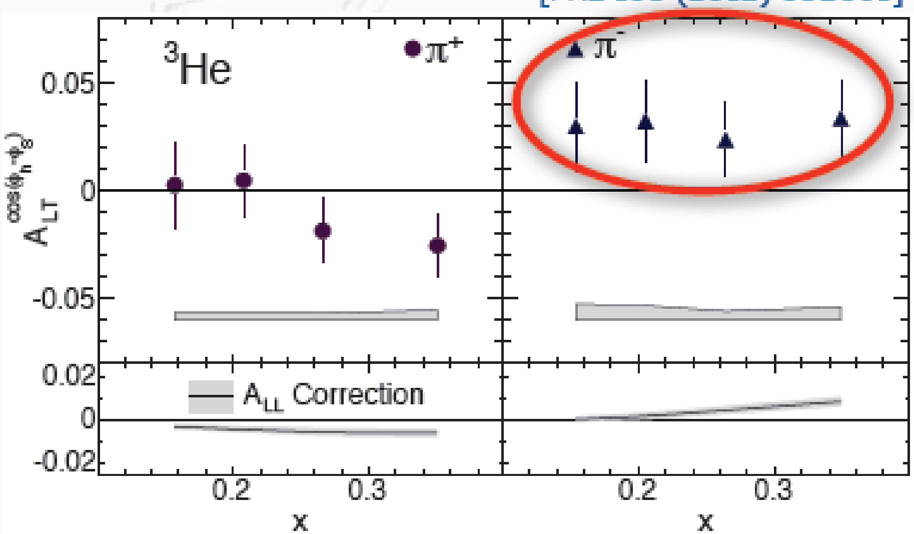
Worm-Gear II

Makins

- chiral even
- first direct evidence for worm-gear g_{1T} on
  - ^{3}He target at JLab
  - H target at HERMES



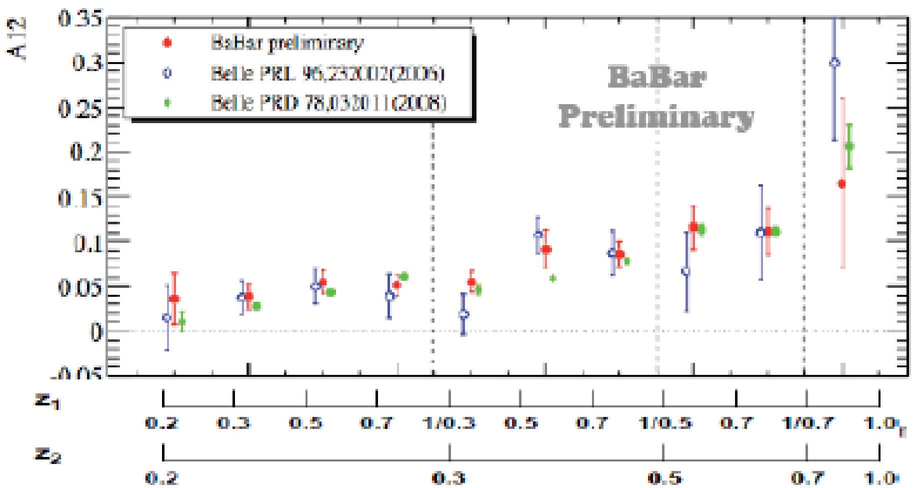
[PRL 108 (2012) 052001]



Collins effect in e^+e^- annihilation

Sozzi

2005: Belle measured sizeable asymmetries : Independent proof that Collins FF are different from zero



Belle: 547 fb-1 data set, small statistical uncertainties;
Measured asymmetries rising with z.

Preliminary results from BaBar, 45 fb^{-1}

Asymmetries in good agreement

BaBar preliminary: $\mathcal{L}\approx 45$ fb^{-1}

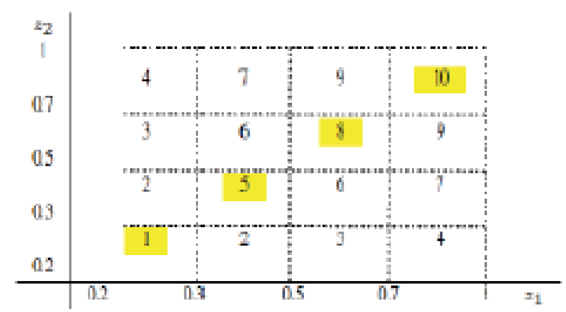
Belle Off-peak: $\mathcal{L}\approx 29$ fb^{-1}

Belle full statistics (supersede previous results) $\mathcal{L}\approx 547$ fb^{-1}

BaBar

I. Garzia, Transversity2011

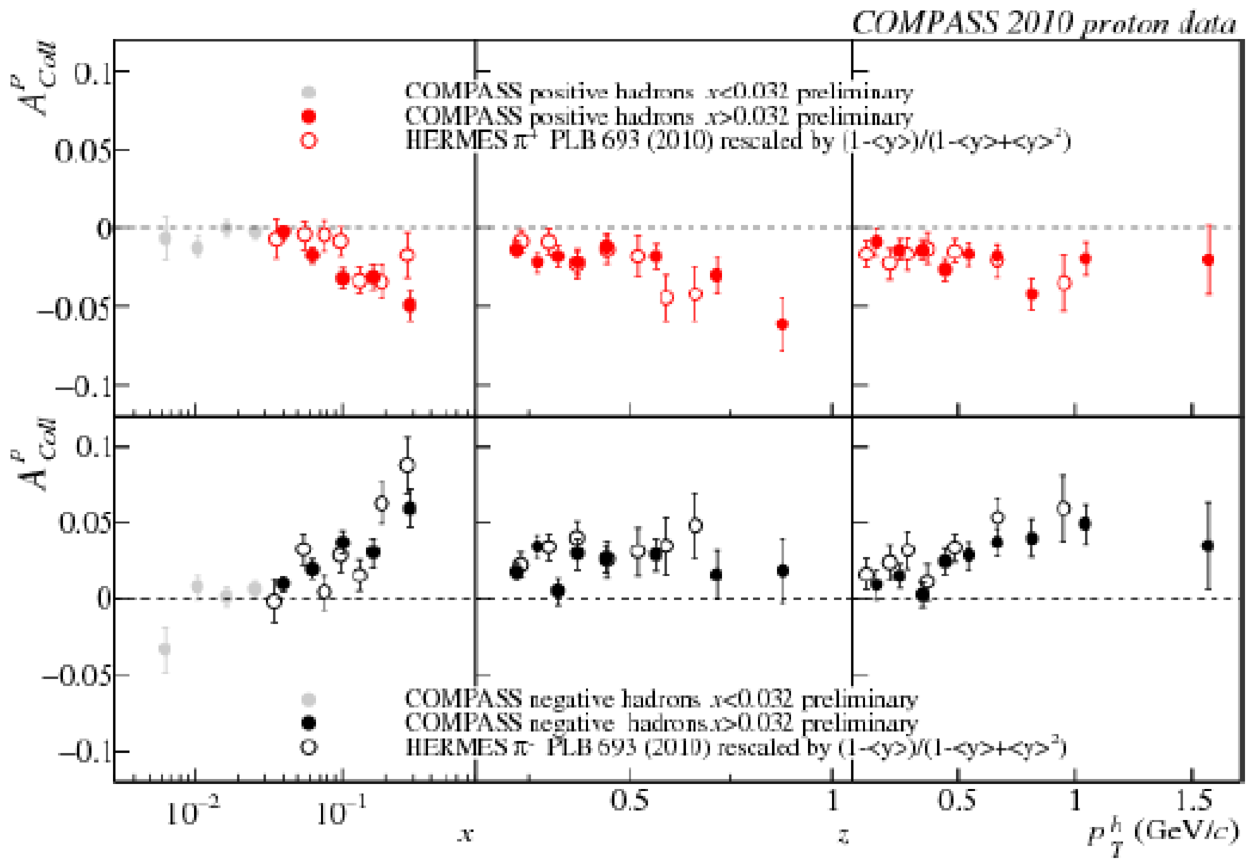
BELLE



Collins asymmetries, results on proton

Sozzi

- Comparison between HERMES and COMPASS, taking into account the different conventions (sign, D_{nn})
- and limiting COMPASS range to the x>0.032 region, overlap with HERMES

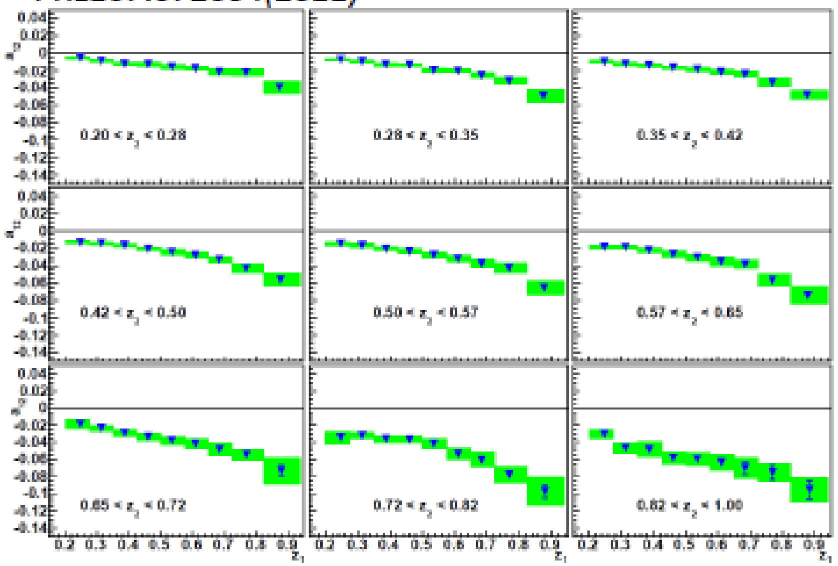


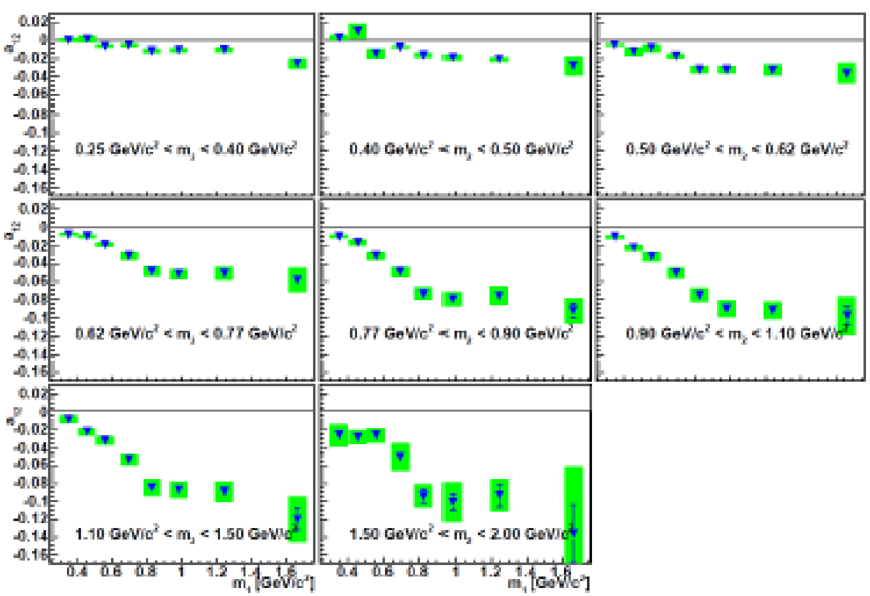
Good agreement :
- Non trivial result:

Q^2 COMPASS larger of HERMES's of a factor 2-3 in the last x bins
→weak Q^2 dependence of the Collins effect

Two hadron asymmetries in e$^+$e$^-$ annihilation

PRL107:072004(2011)





672fb^{-1}

Large asymmetries increasing with z

and

with invariant mass

Sozzi

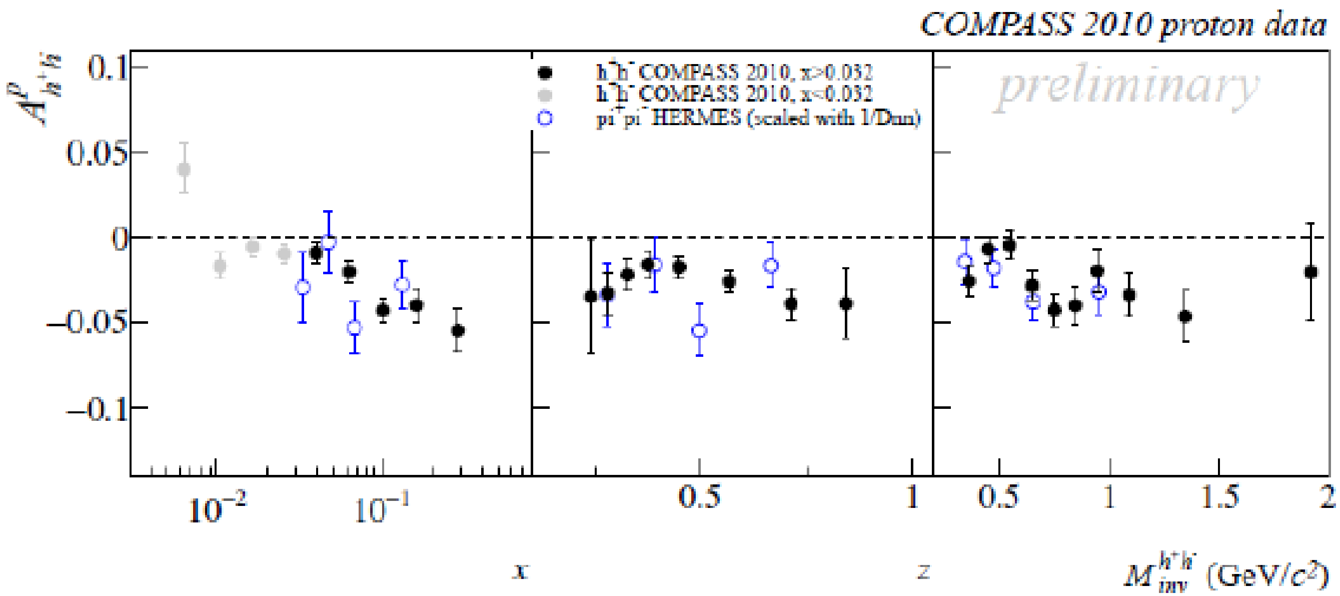
Two hadron asymmetries, proton

Sozzi

Results from 2010 run COMPASS available, here compared with HERMES

- Comparison between HERMES and COMPASS taking into account the different conventions (sign, D_{nn})
- and limiting COMPASS range to the x>0.032 region, overlap with HERMES

This selection makes the M_{inv} dependence more visible

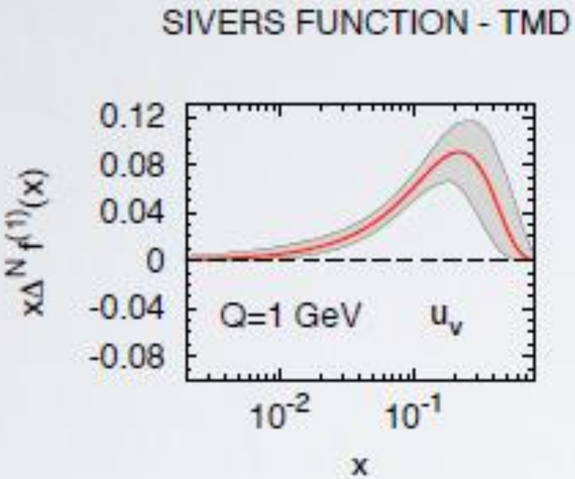


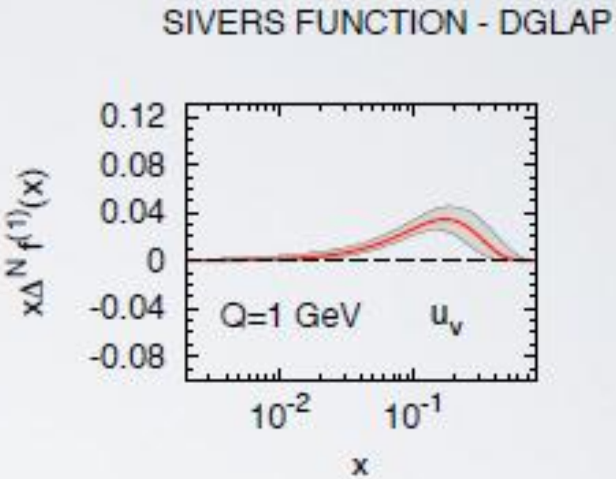
Good agreement

Broader range for COMPASS data in invariant mass

Bacchetta

Effects of TMD evolution





Sivers becomes BIGGER at low Q

Is it similar for Collins?

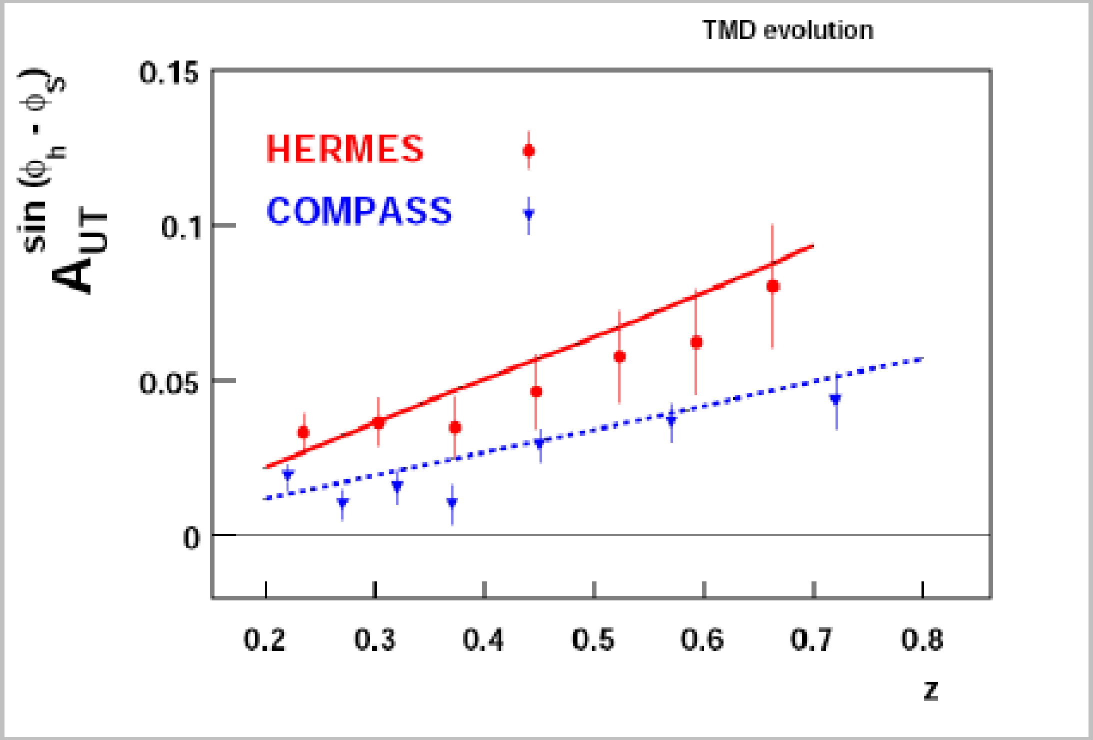
Anselmino, Boglione, Melis, arXiv:1204.1239

see Alexei Prokudin's talk

TMD evolution

Can we explain the experimental data?

Full TMD evolution is needed!



Aybat, AP, Rogers 2011

COMPASS dashed line

$$\langle Q^2 \rangle \simeq 3.6 \; (GeV^2)$$

HERMES solid line

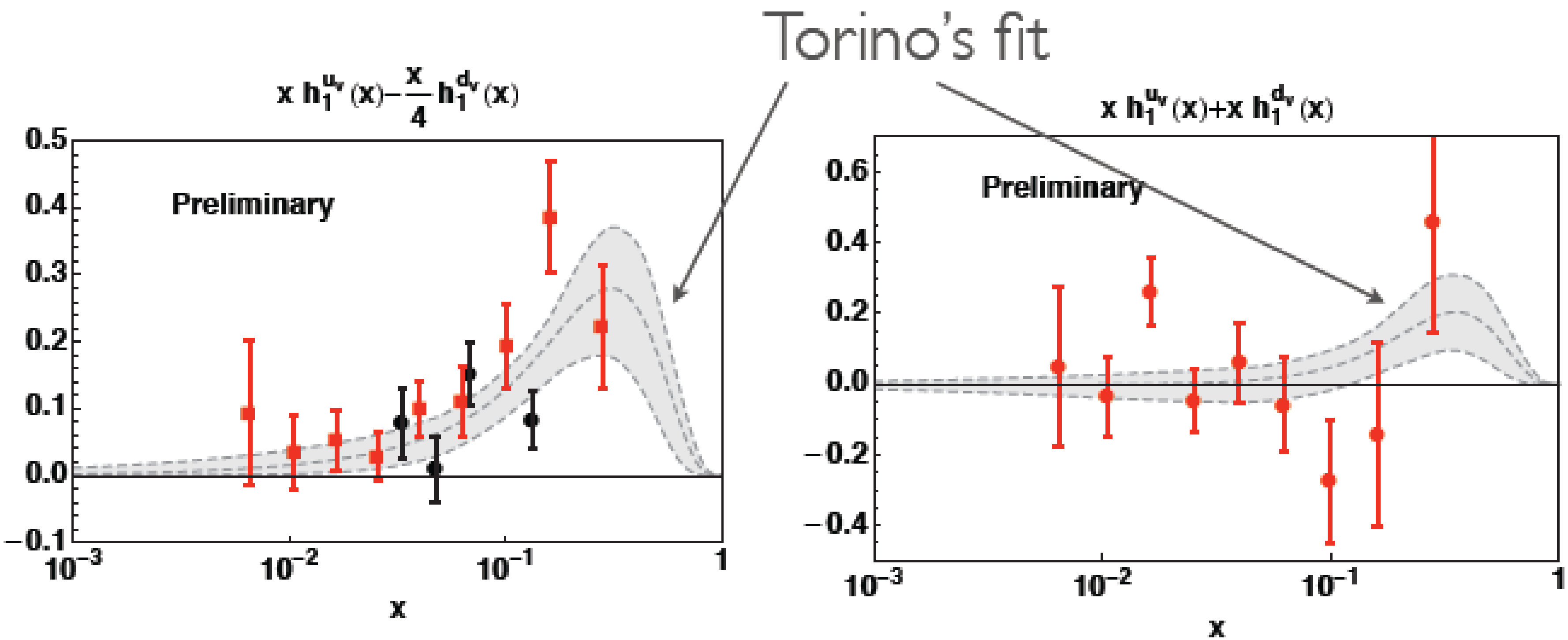
$$\langle Q^2 \rangle \simeq 2.4 \; (GeV^2)$$

Prokudin

Bacchetta, Prokudin

NEW extraction

COMPASS

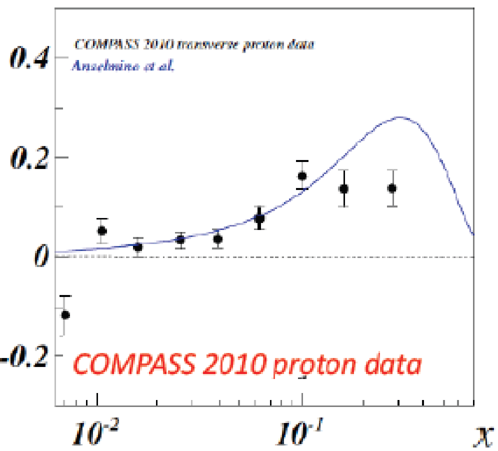


Transversity

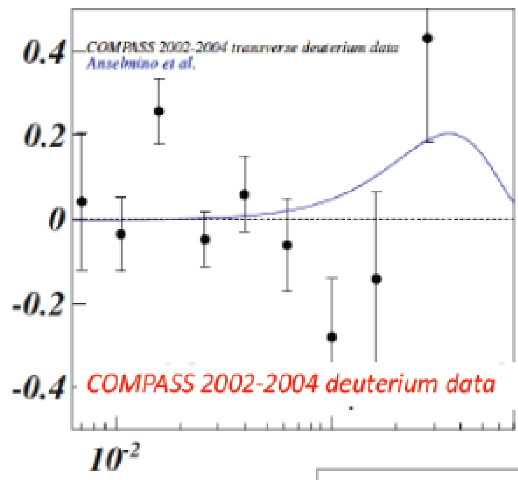
Sozzi

deuterium and 2010 proton data

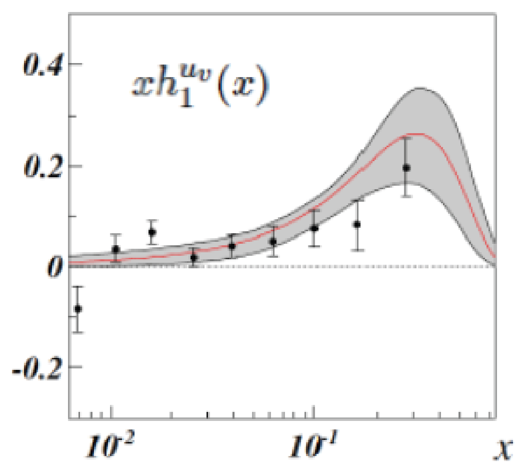
$xh_1^{u_v}(x) - \frac{1}{4}xh_1^{d_v}(x)$

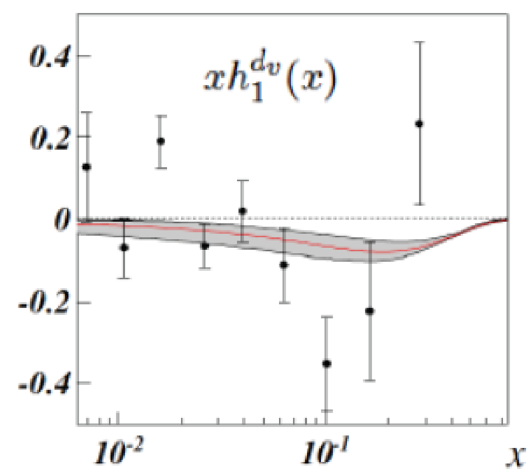


$xh_1^{u_v}(x) + xh_1^{d_v}(x)$



C.Elia PhD thesis,
Trieste
December 2011





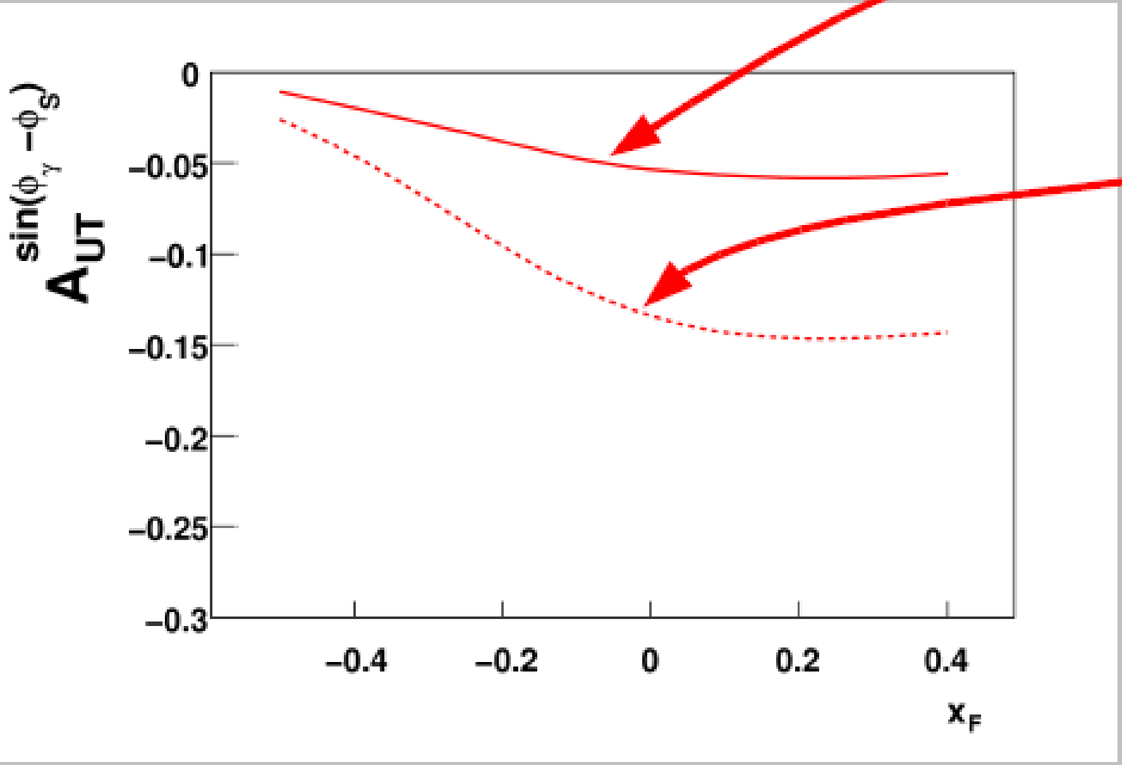
Drell Yan

$$A_N = \frac{\sum_q f_{1T}^{\perp q}(x_2, p_T) \otimes f_1^{\bar{q}}(x_1, p_T)\sigma_{q\bar{q}}}{\sum_q f_1^q(x_2, p_T) \otimes f_1^{\bar{q}}(x_1, p_T)\sigma_{q\bar{q}}}$$

Analysis in hadronic cm frame

With TMD evolution

No TMD evolution

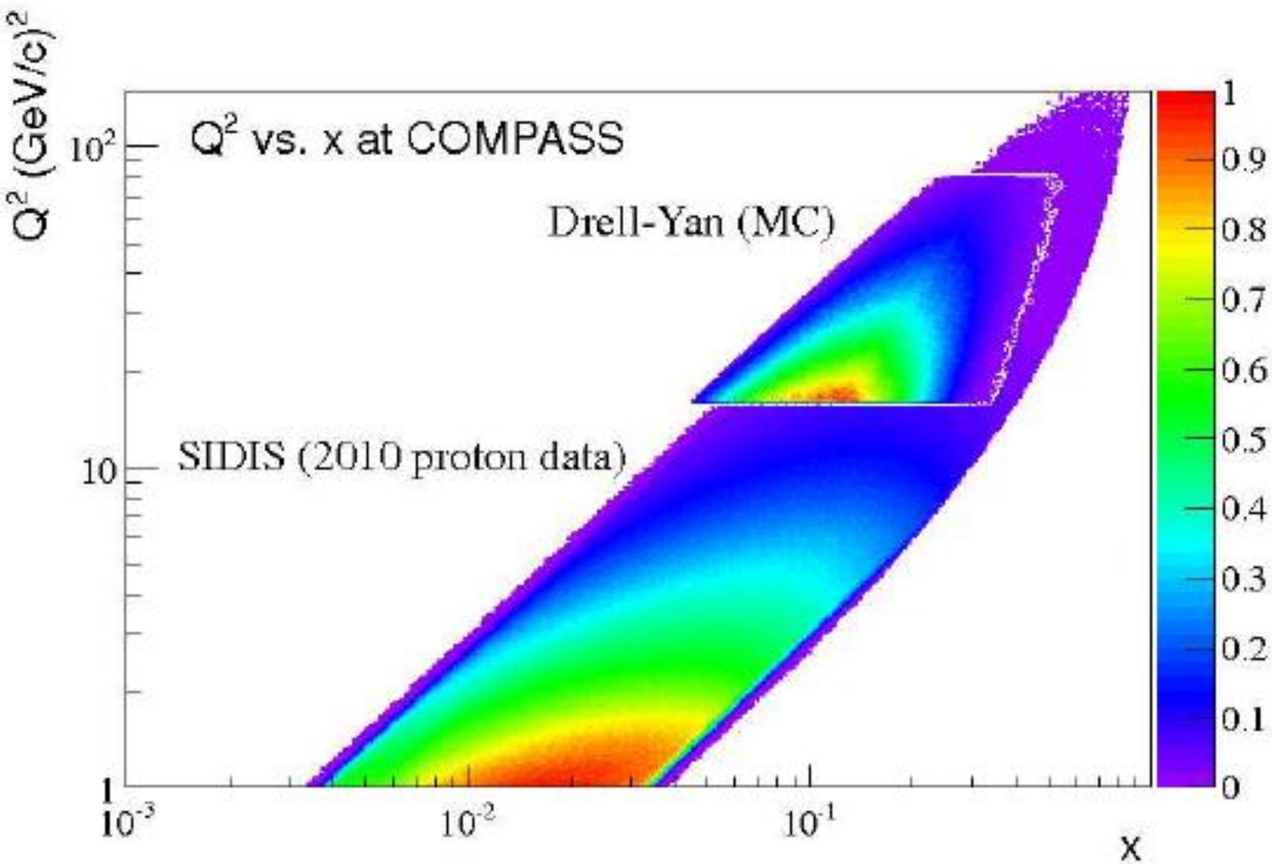


Prokudin

Asymmetry is suppesed with respect to LO analysis

DY versus SIDIS in COMPASS

Quintans



The 2 experimental measurements have an overlapping region.

Comparing with theory predictions

Quintans

...but: Q^2 evolution not properly accounted for in the predictions...

DY: $4 < M_{\mu\mu} < 9$ GeV/c^2

Sivers

Anselmino et al, PRD79(2009)054010

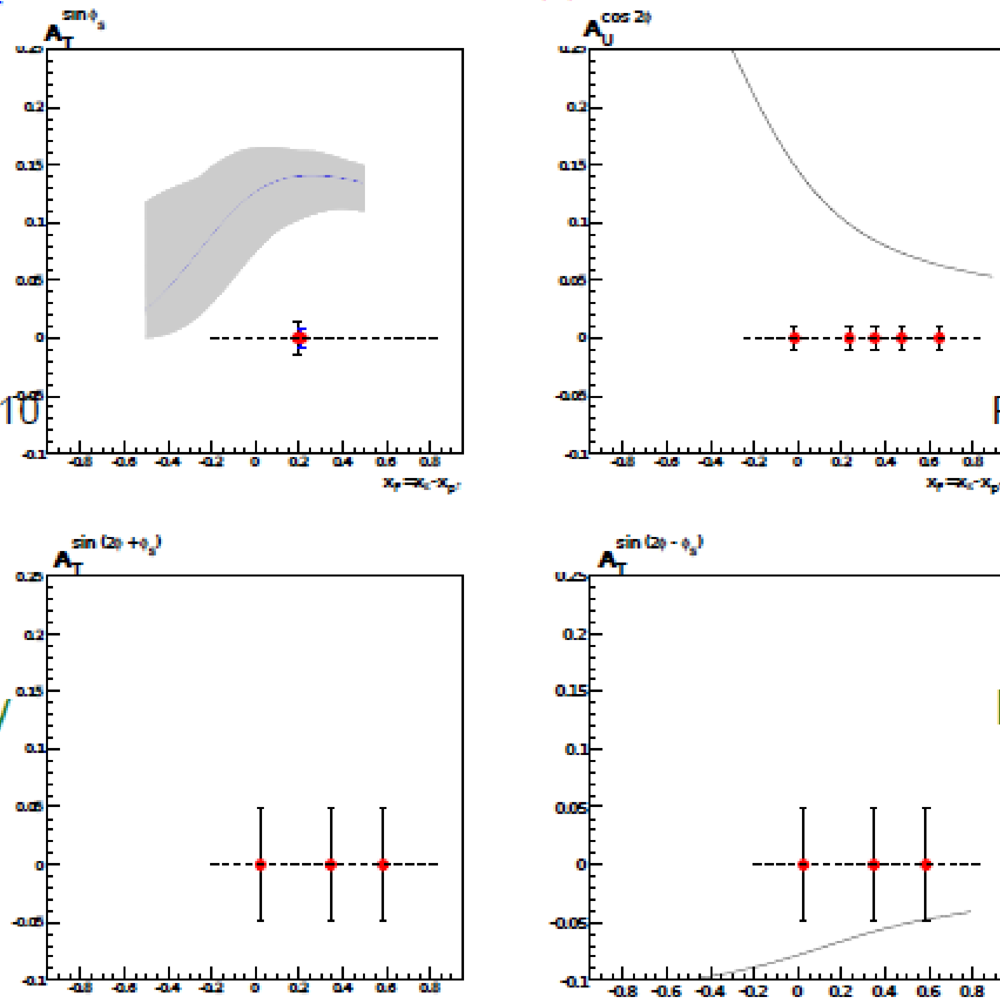
Boer-Mulders

B. Zhang et al, PRD77(2008)054011

BM $\otimes$ pretzelosity

BM$\otimes$transversity

A.N. Sissakian et al, Phys.Part.Nucl.41: 64-100,2010



Status of transversity studies

Bacchetta

Spectroscopy & χPT

- lattice, flux tube
- new data: “bottomonium”
- new data: light mesons
- test of χPT

The myths about lattice spectroscopy

Myths: lattice QCD can …

… only study hadronic ground-states

… not study states with high spin

… not study isoscalar meson with precision

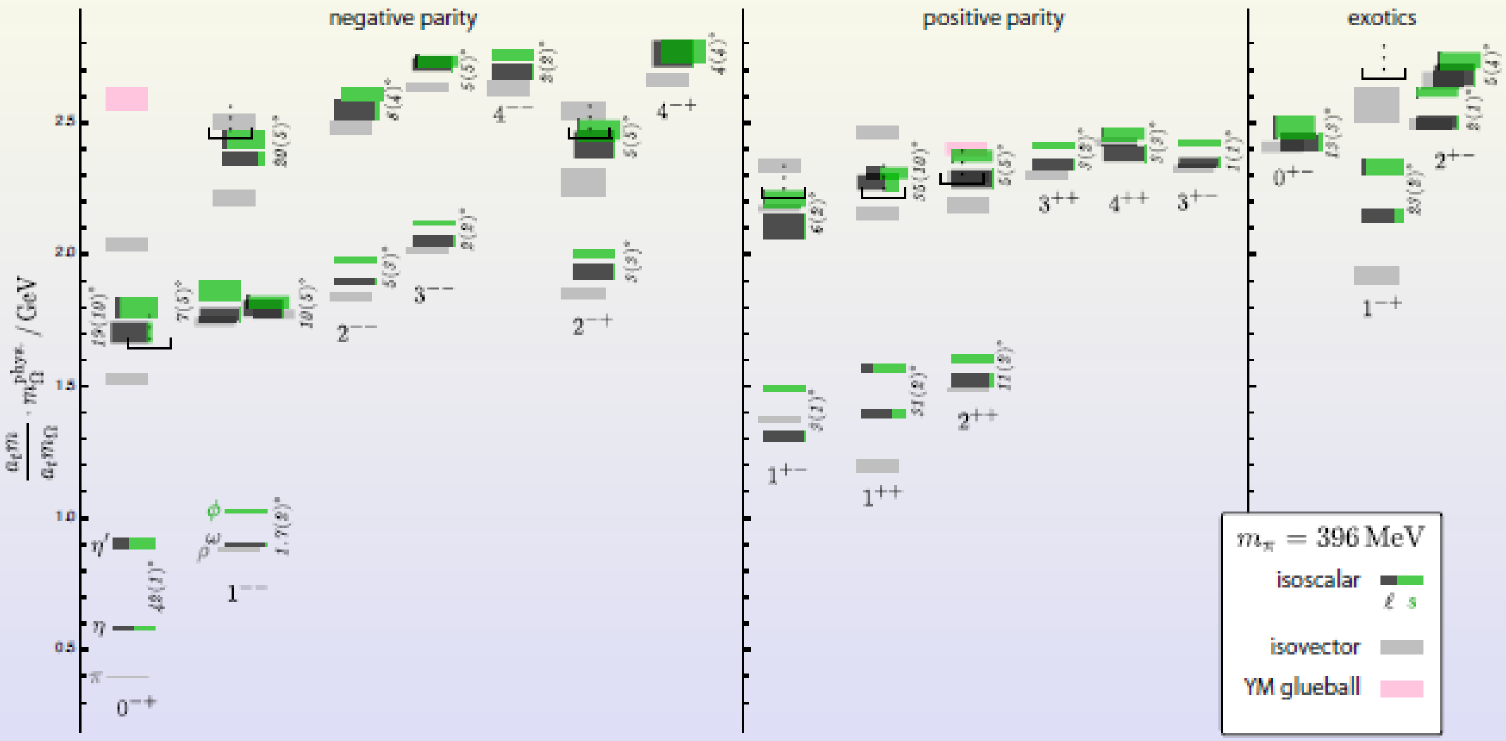
… not deal with resonances or compute scattering properties

- Where do these myths come from?
- How close to solving these problems are we?
- New results: most of these myths need to be re-examined

Peardon

Example:

Isoscalar mesons

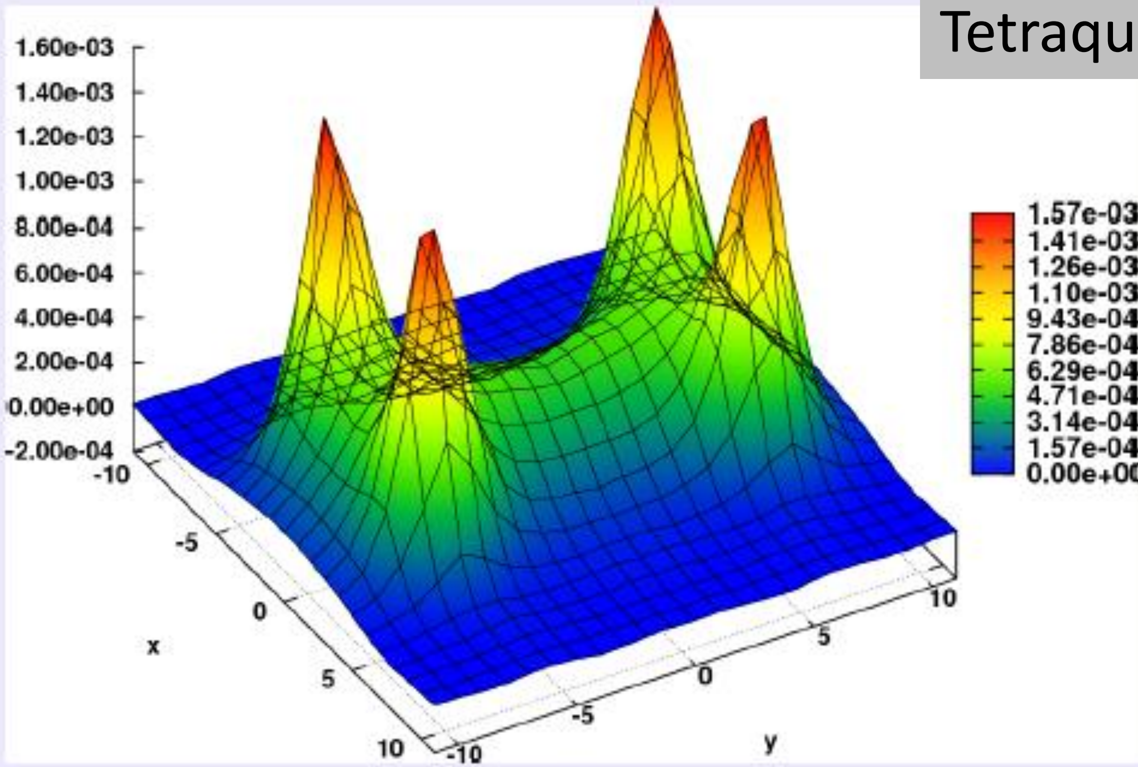


[Dudek et.al. Phys.Rev.D83:111502,2011]

- These developments have been enabled by **extending the toolkit** for measuring quark propagation on the lattice

Peardon

Tetraquark flux tube

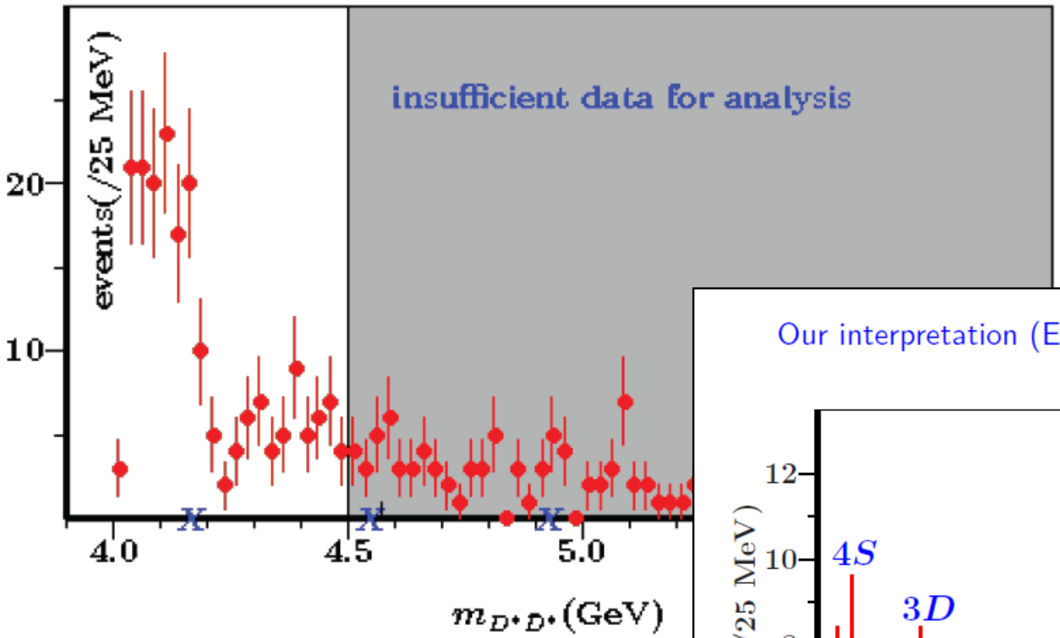


(a)

Figure 11: In the tetraquark flux tube (or string) model, the elementary flux tubes meet in two Fermat points, at an angle of $\alpha = 120°$ to form a double-Y flux tube, except when this is impossible and the flux tube is X-shaped. Lagrangian density 3D plot for $r_1 = 8$, $r_2 = 14$. Here we show our results are presented in lattice spacing units .

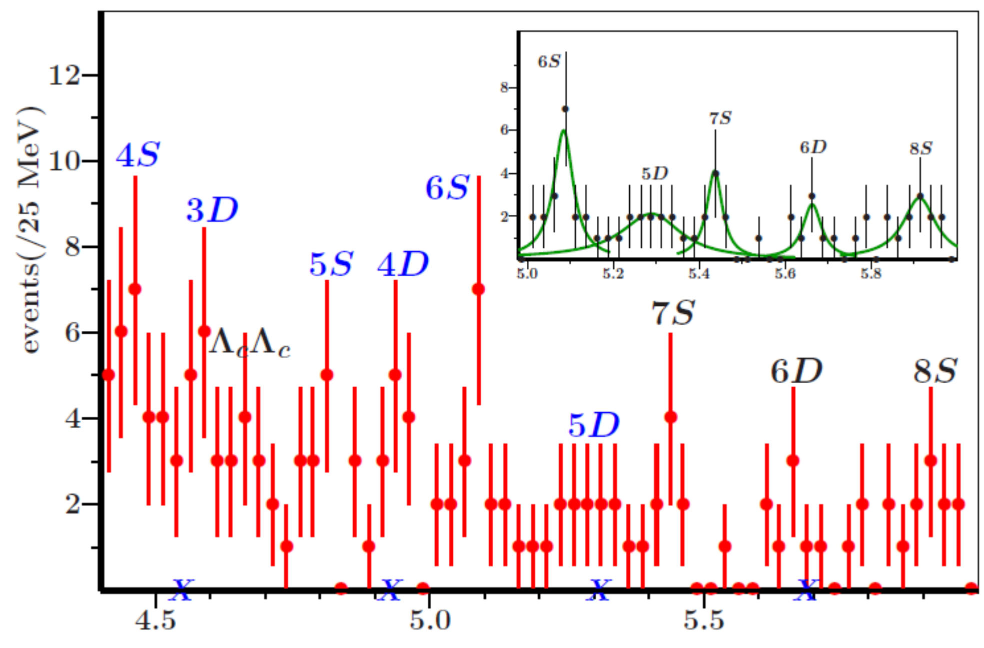
Bicudo

2009 $D^*\bar{D}^*$ BABAR data on vector charmonium:



Rupp

Our interpretation (EvB & GR, Chin. Phys. C **35** (2011) 1):



Rupp

V. Conclusions

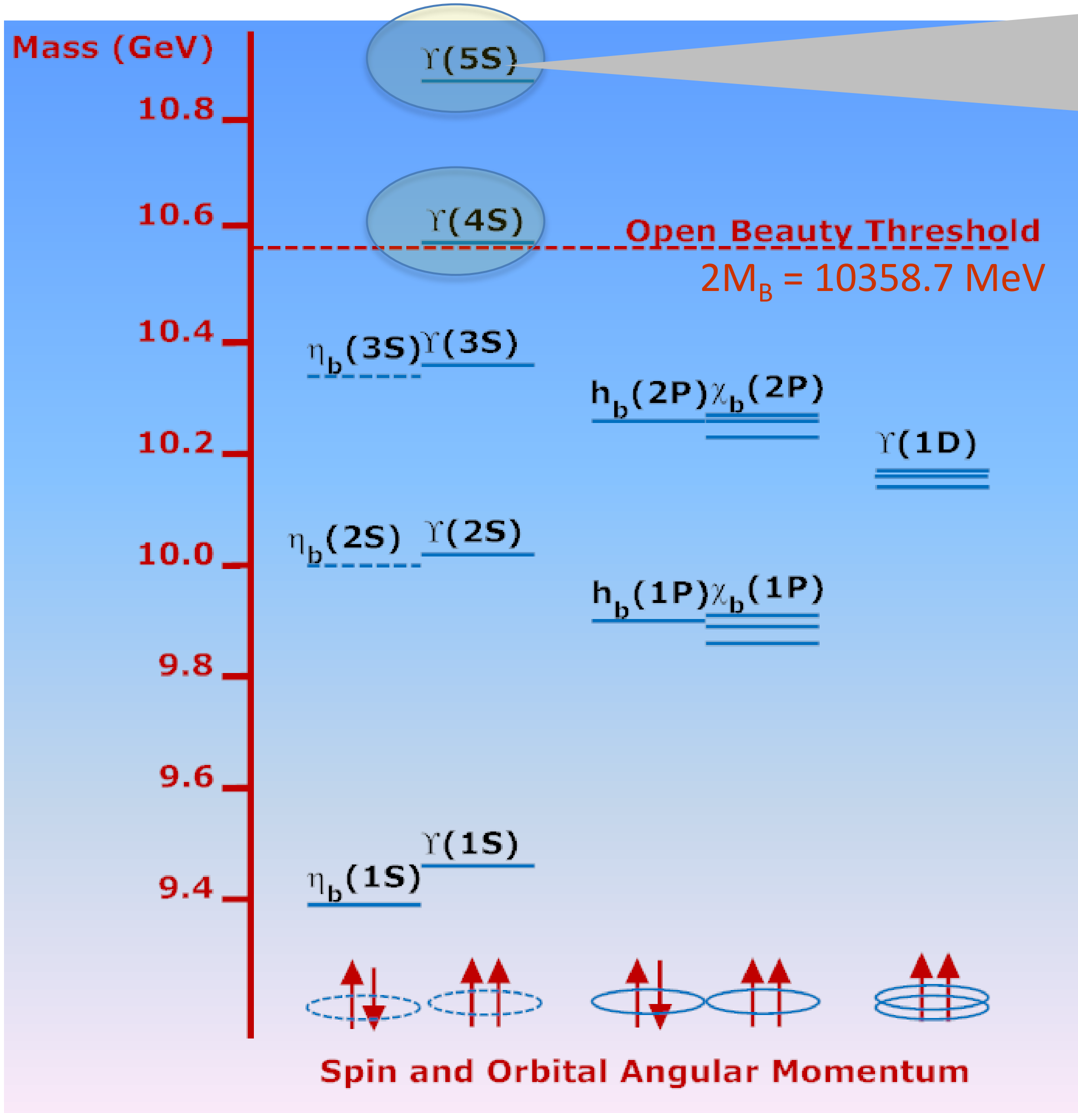
⇒ Meson spectroscopy is in a globally bad shape:

- Many states predicted by the quark model are missing, especially in the charmed, bottom, charmonium, and bottomonium sectors.
- In the light-quark sector, there are very serious discrepancies between several excited states and the Godfrey-Isgur model.

..

- Dedicated spectroscopy experiments are needed in the 1–2 GeV region, with reliable partial-wave analyses, and no PDG bias. COMPASS might play a significant role here.

Υ(4&5S) "bottomonium" $\bar{b}b$ mesons



"Υ(5S)" is very different from other Υ states

100xΓ wrt

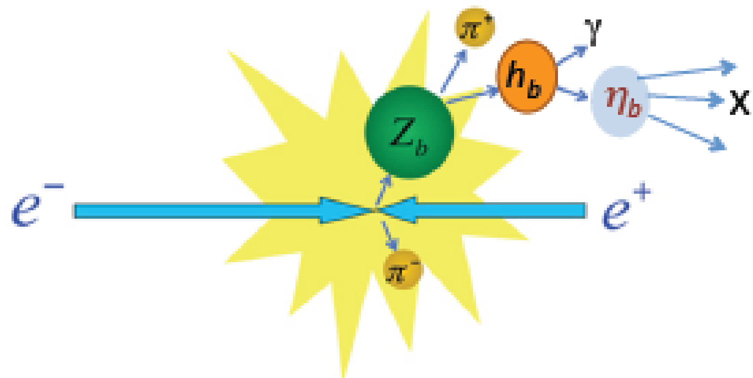
Υ(2,3,4S)$\rightarrow$ Υ(1S) $\pi\pi$

Olsen

Belle PRL100,112001(2008)

1^{st} observation of the $\eta_b(2S)$

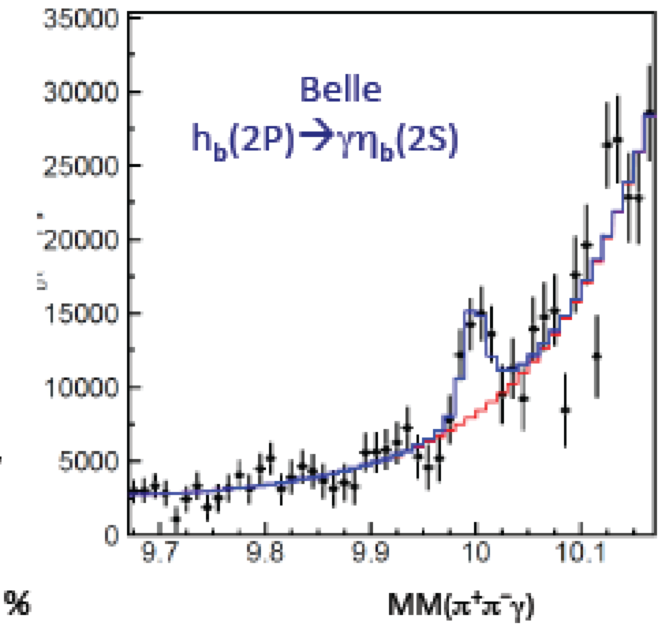
$h_b(2P) \to \gamma\eta_b(2S)$ is expected to be the dominant decay mode (20%~50%)



measure $h_b(2P)$ yields in bins of $MM(\pi^+\pi^-\gamma)$
(require $10.59 < MM(\pi) < 10{,}67$ GeV, *i.e.* $= M_{Z_{b1,2}}$)

Final state: $\pi^+\pi^-\gamma$ X

New!!!



$\Delta M_{hfs}(2S) = 24.3 \pm 3.5^{+2.8}_{-1.9}$ MeV

$M[\eta_b(2S)] = 9999.0 \pm 3.5^{+2.8}_{-1.9}$ MeV

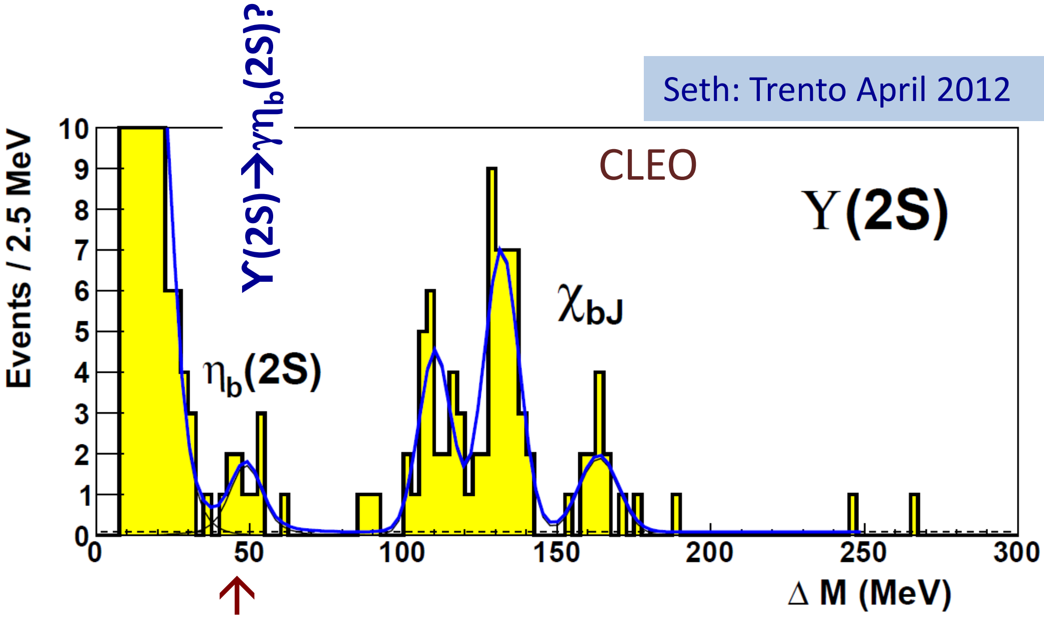
$Bf[h_b(2P) \to \gamma\eta_b(2S)] = 47.5 \pm 10.5^{+6.6}_{-7.7}$ %

preliminary

BELLE

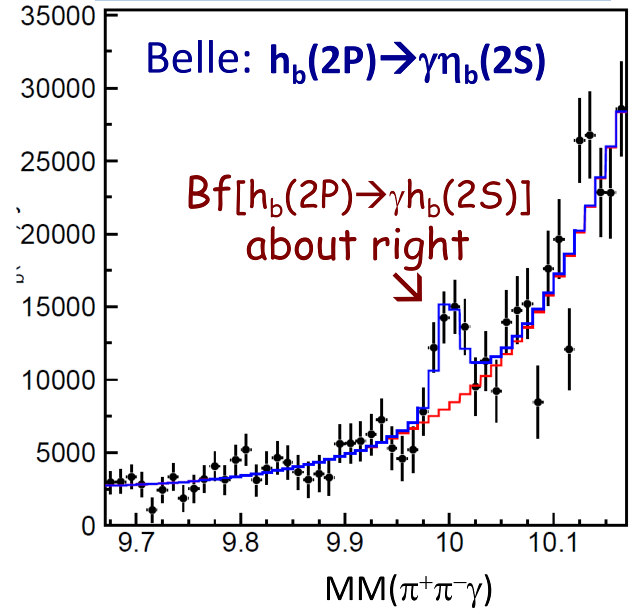
Comparison: $\eta_b(2S)$ "signals"

Seth: Trento April 2012



↑ anomalously large production rate ($\sim 0.2\times\chi_{b1}$ rate)

Belle: IWHSS'12 April, 2012



Expt	ΔM_{hfs} (2S) (MeV)
CLEO	48.7±2.7
Belle	24.3±4.3

← strong disagreement with theory (CLEO)

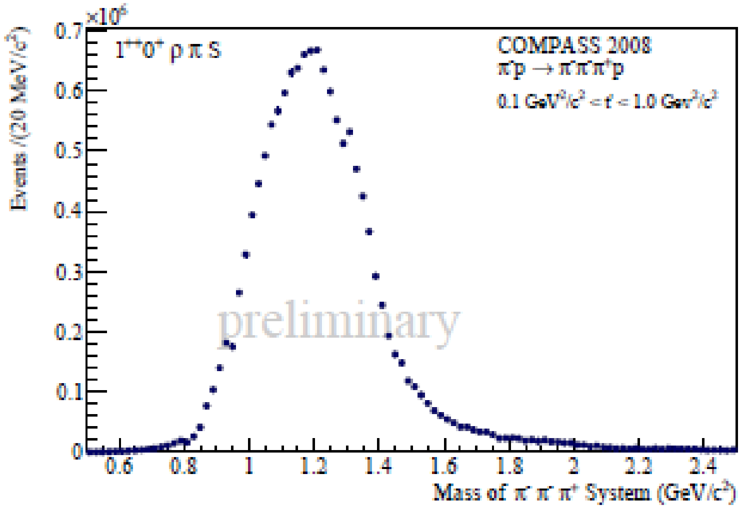
← agrees with theory (Belle)

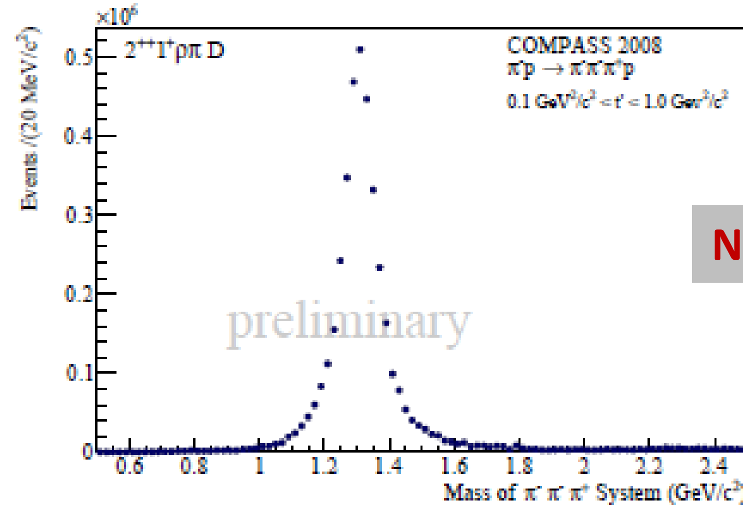
≈5σ discrepancy

Olsen

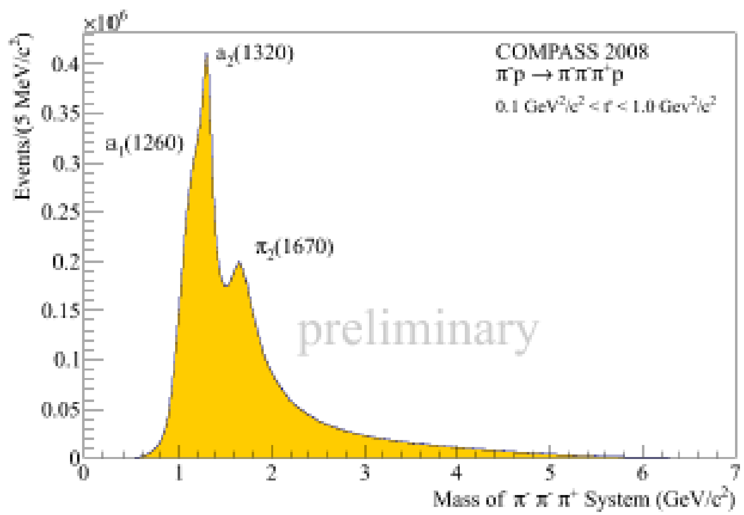
Intensities of dominant J^{PC} states

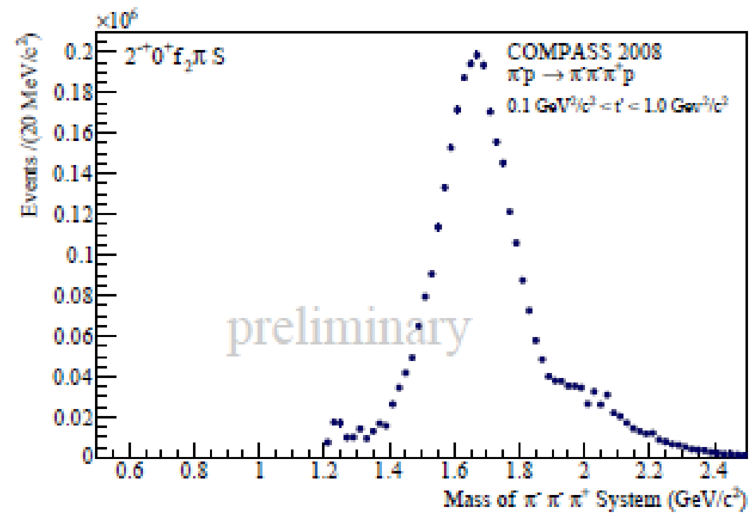
First results from mass independent PWA (2008)





Neubert





Spin Density Matrix (Subset)

7-Resonance Fit

$0^{-+}\pi^- f_0(1500)\ S$

$0^{-+}\rho a_1(1260)\ S$

$1^{++}\pi^- f_0(1370)\ P$

$1^{++}\pi^- f_1(1285)\ P$

$1^{++}\rho\pi(1300)\ S$

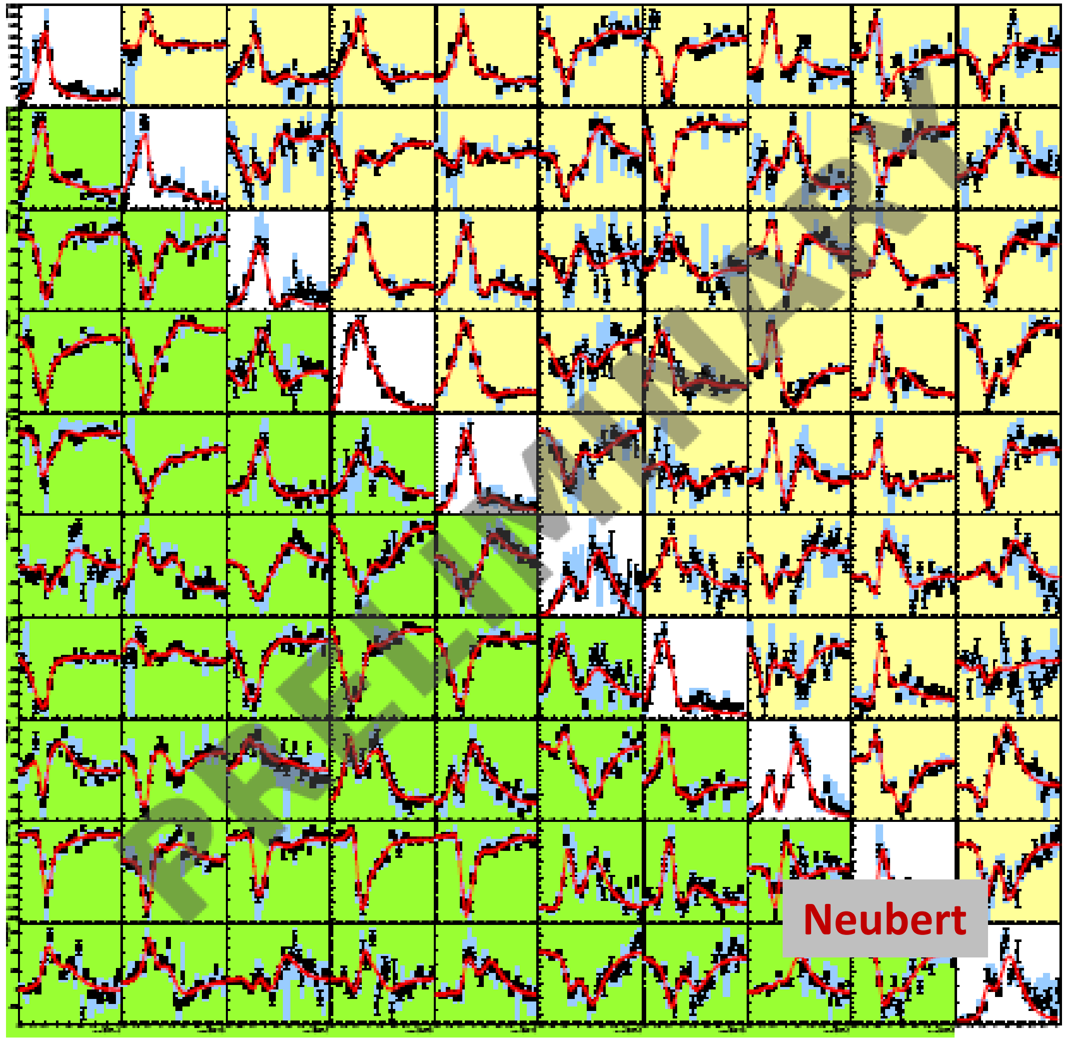
$1^{++}(\pi\pi)_S a_1\ D$

$2^{-+}\pi^- f_2(1270)\ S$

$2^{-+}\rho a_1(1260)\ S$

$2^{-+}\rho a_2(1320)\ S$

$2^{-+}\rho a_1(1260)\ D$

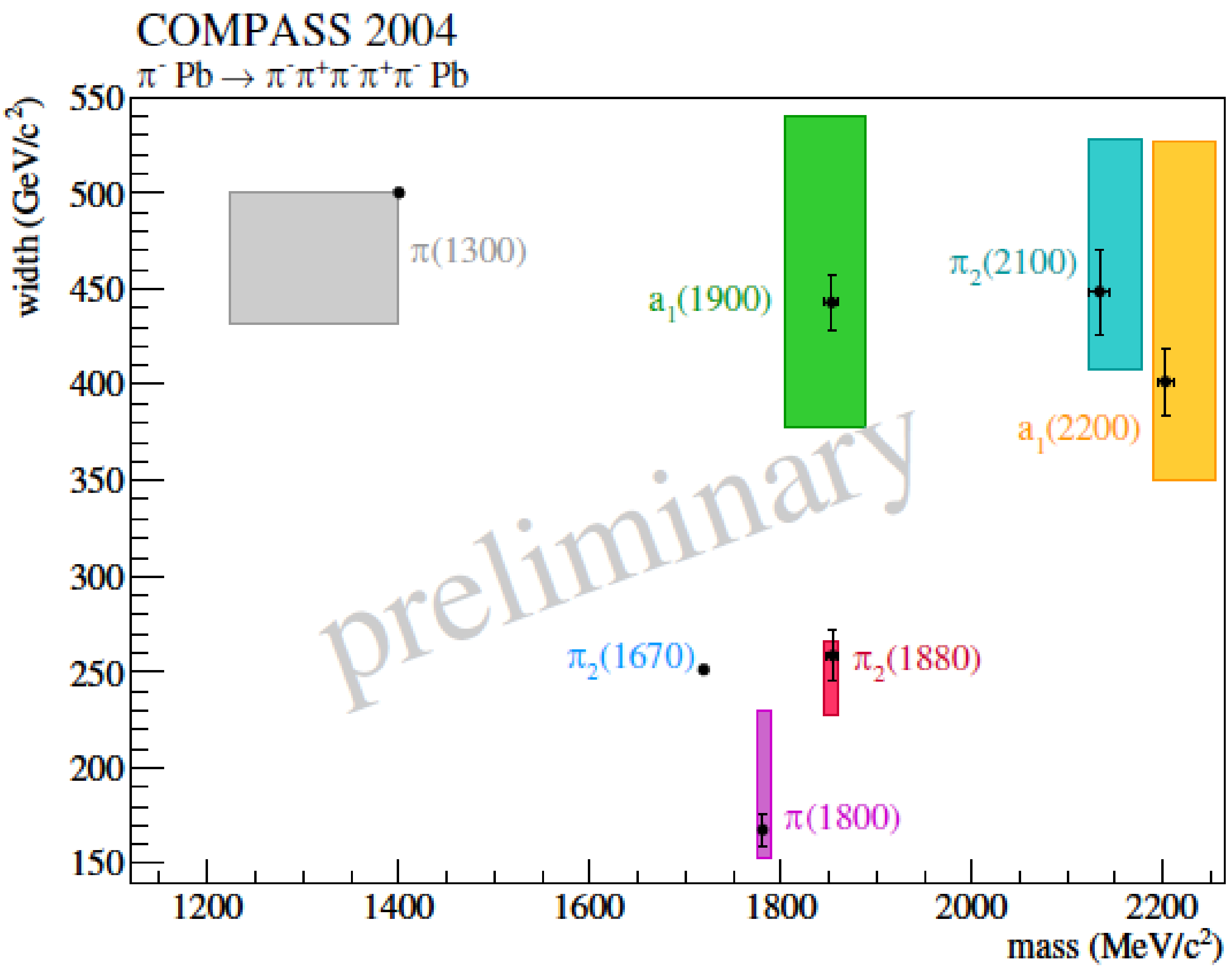


Neubert

5π Resonances — Extracted Parameters

Technische Universität München

Summary of Resonance Parameters



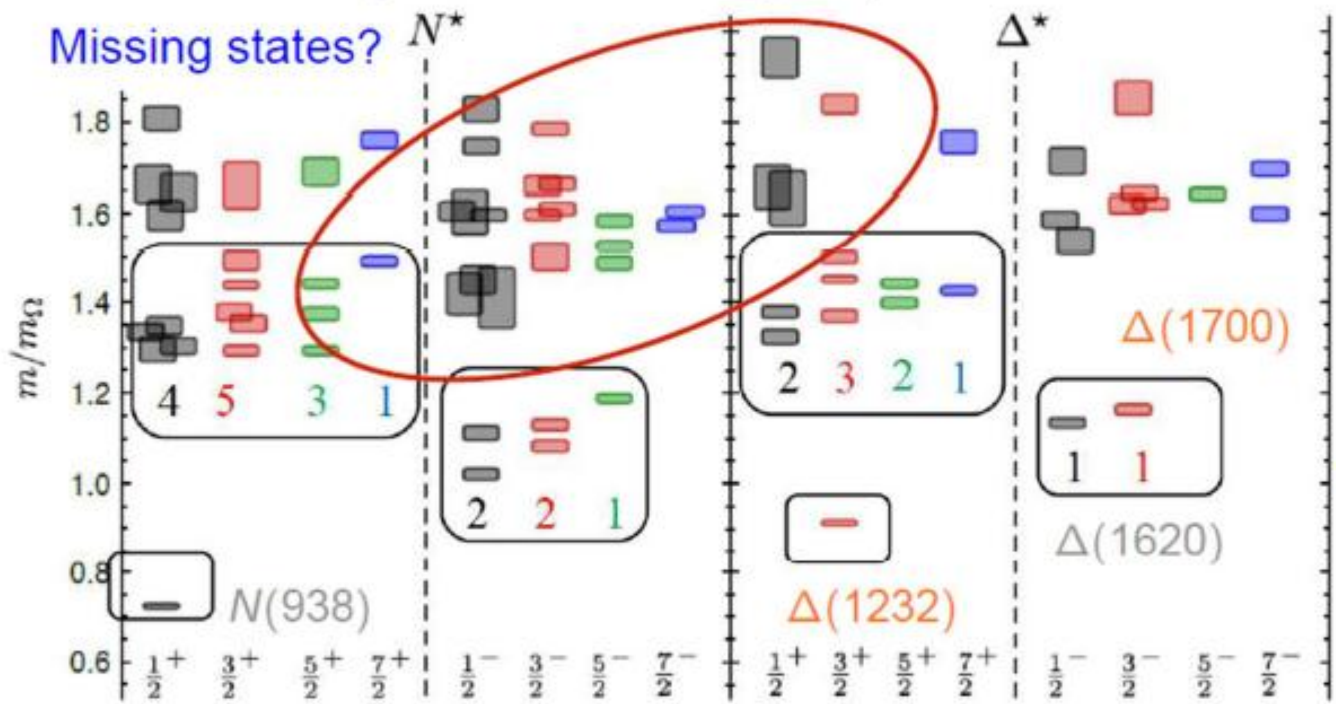
Neubert

Beck, Peardon

Introduction

talk yesterday by M. Peardon

R. Edwards *et al.*, Phys. Rev. D **84**, 074508 (2011)

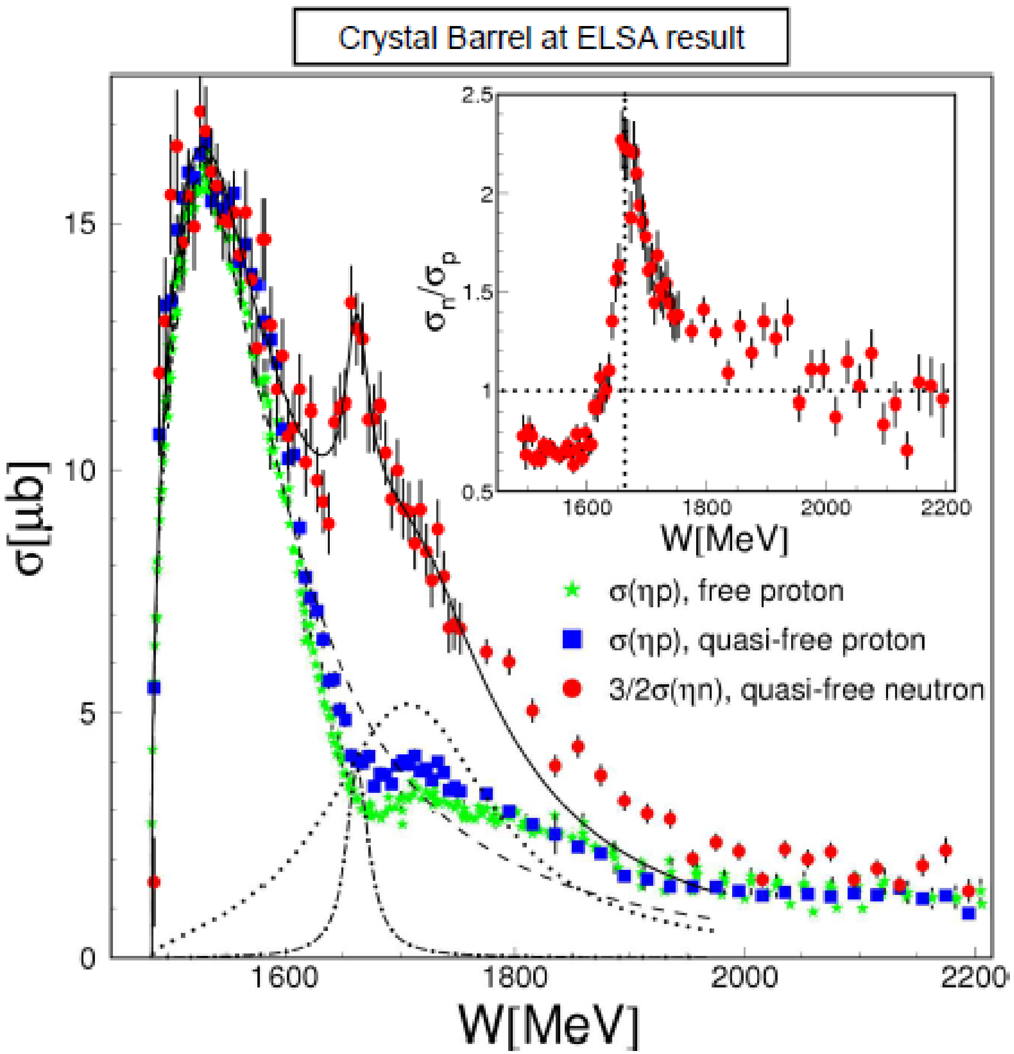


$m_\pi = 400$ MeV

Exhibits broad features expected of $SU(6) \otimes O(3)$ symmetry

➜ Counting of levels consistent with non-rel. quark model, no parity doubling

Electromagnetic excitation off the neutron



quasifree η photoprodruction:

$$\gamma + d \rightarrow n + p + \eta$$

Narrow structure in nη - final state

$$W \approx 1670 MeV$$

$$\sigma \approx 25 MeW \ (FWHM)$$

Beck

Publication:
I. Jaegle, B. Krusche, …
accepted by EPJA

Status on Meson Photoproduction Data Base

Beck

Crystal Barrel at ELSA

CLAS at JLAB

Crystal Ball at MAMI

	σ	Σ	T	P	E	F	G	H	T_x	T_z	L_x	L_z	O_x	O_z	C_x	C_z
Proton target																
$p\pi^0$	✔ (red)	✔ (green)	✔ (green)	✔ (black)	✔ (green)	✔ (green)	✔ (green)	✔ (green)								
$n\pi^+$	✔ (red)	✔ (green)	✔ (green)	✔ (black)	✔ (green)	✔ (green)	✔ (green)	✔ (green)								
$p\eta$	✔ (red)	✔ (green)	✔ (green)	✔ (black)	✔ (green)	✔ (green)	✔ (green)	✔ (green)								
$p\eta'$	✔ (red)	✔ (green)	✔ (green)	✔ (black)	✔ (green)	✔ (green)	✔ (green)	✔ (green)								
$p\omega$	✔ (red)	✔ (green)	✔ (green)	✔ (black)	✔ (green)	✔ (green)	✔ (green)	✔ (green)								
$K^+\Lambda$	✔ (red)	✔ (green)	✔ (green)	✔ (red)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (red)	✔ (red)
$K^+\Sigma^0$	✔ (red)	✔ (green)	✔ (green)	✔ (red)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (green)	✔ (red)	✔ (red)
$K^{0*}\Sigma^+$	✔ (red)	✔ (green)									✔ (green)	✔ (green)				
Neutron target																
$p\pi^-$	✔ (red)	✔ (green)	✔ (blue)		✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)								
$p\rho^-$	✔ (green)	✔ (green)	✔ (blue)		✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)								
$K^-\Sigma^+$	✔ (red)	✔ (green)	✔ (blue)		✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)								
$K^0\Lambda$	✔ (green)	✔ (green)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)
$K^0\Sigma^0$	✔ (green)	✔ (green)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)	✔ (blue)
$K^{0*}\Sigma^0$	✔ (green)	✔ (green)														

Nearly complete data base

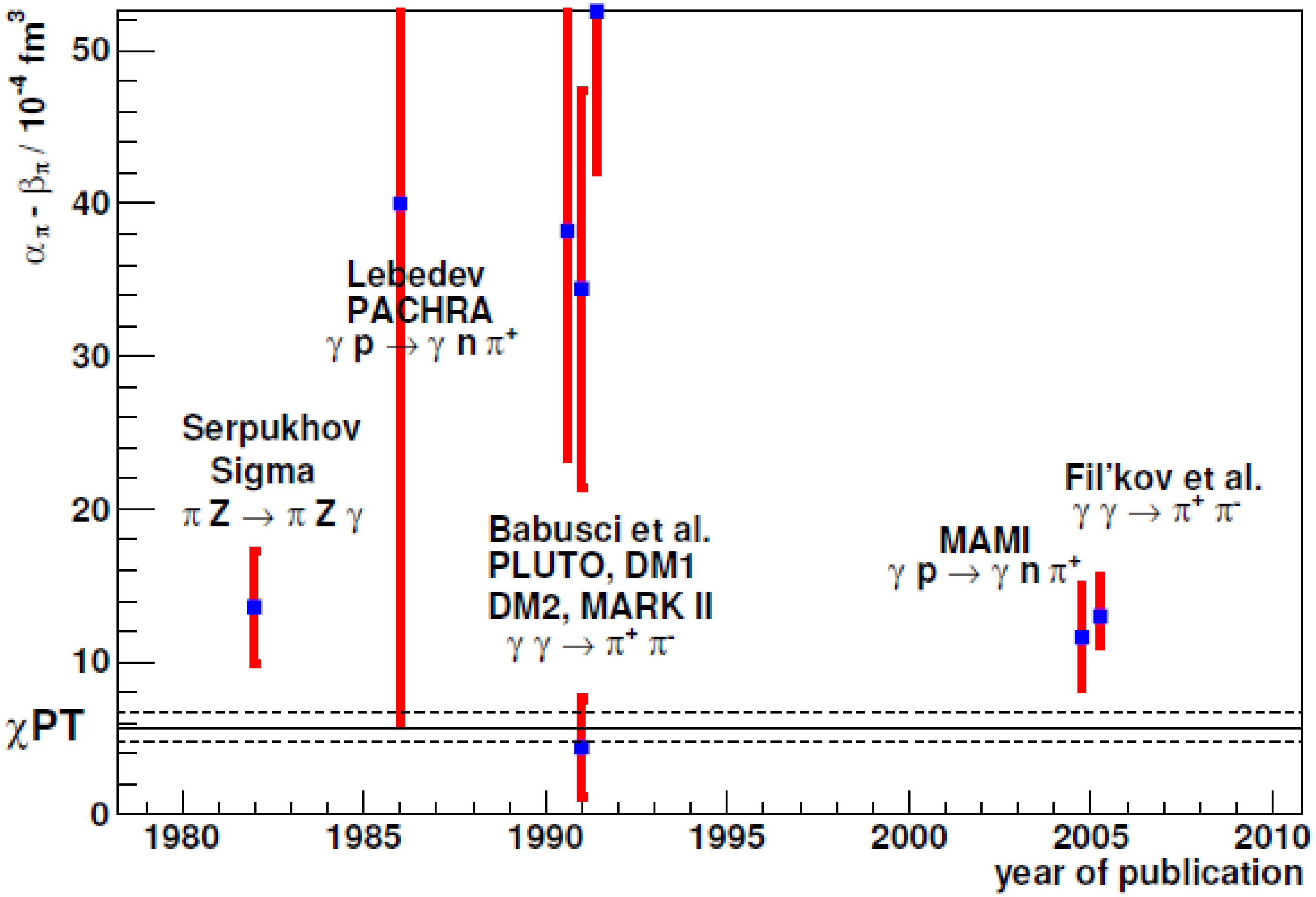
Complete data base

Only a few experiments

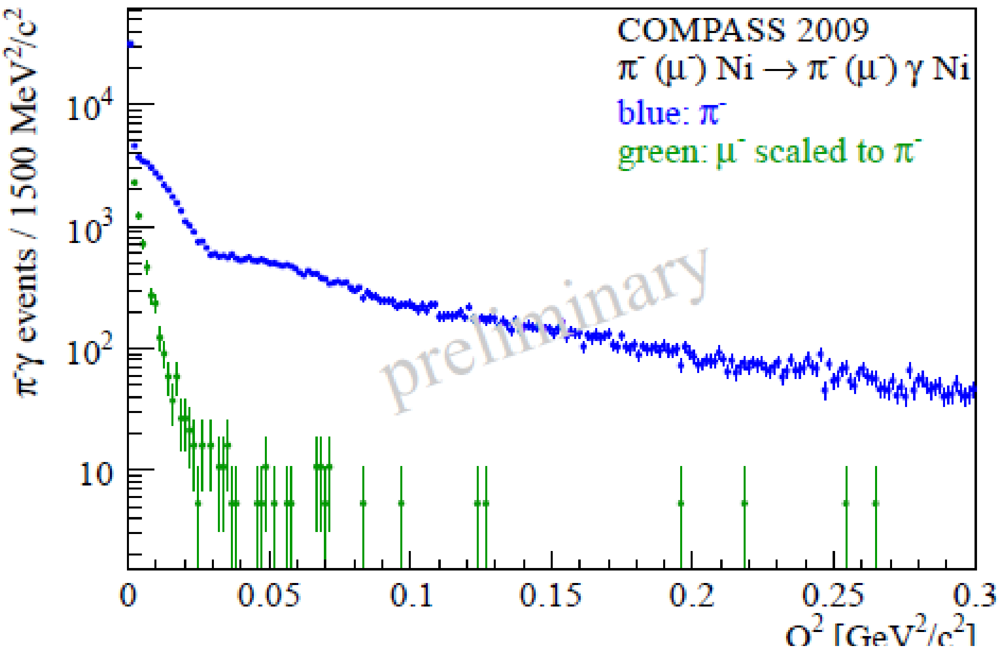
✔ (red) - published, ✔ (green) - acquired, ✔ (blue) - planned

Pion Polarisability: Experimental Situation

Friedrich



Primakoff peak



Friedrich

Days	π beam, days	μ beam, days	$\alpha_\pi - \beta_\pi$ σ_{tot}	$\alpha_\pi + \beta_\pi$ σ_{tot}	$\alpha_2 - \beta_2$ σ_{tot}
120	90	30	±0.27	fixed	fixed
			±0.26	±0.016	fixed
			±0.66	±0.025	±1.94
			ChPT prediction		
			5.70	0.16	4

Future

SUMMARY

YOU DID NOT REALLY EXPECT A SUMMARY, DID YOU?

INSTEAD

THANKS TO
Paula, Siocha and the local team
FOR THE WONDERFUL WORKSHOP