KEK theory center workshop
on
High-energy hadron physics
with hadron beams

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Tsukuba, Japan

Future Drell-Yan program of the COMPASS collaboration

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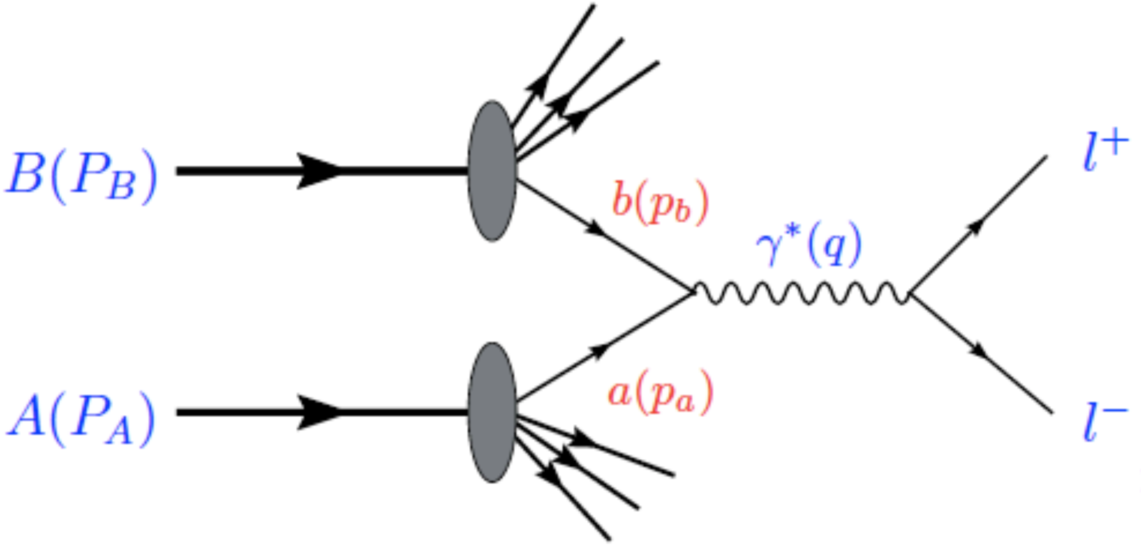
CERN and INFN sez. di Torino
06.01.2010

Outline

- Drell-Yan – physics case
  - Drell-Yan kinematics
  - Unpolarised Drell-Yan
  - Single (Transverse) polarised Drell-Yan
  - Double polarised Drell-Yan
  - J/Psi production and J/Psi <-> DY duality
  - Access to GPDs?
- Some indications to the future Drell-Yan experiments
- Drell-Yan @ COMPASS:
  - What we are going to do
  - How we are going to do it
- Conclusions

Drell-Yan Kinematics (collinear case)

$$A + B \longrightarrow l^+ + l^- + X$$



$P_A = \frac{\sqrt{s}}{2}(1,0,1)$

$P_B = \frac{\sqrt{s}}{2}(1,0,-1)$

$p_a = \frac{\sqrt{s}}{2}x_a(1,0,1)$

$p_b = \frac{\sqrt{s}}{2}x_b(1,0,-1)$

- Collinear virtual photon:

  $q = p_a + p_b = (q_0, 0, q_L)$

- Observing the dilepton we can "observe" the γ^* and directly have information on partons:

• $M^2 \equiv q^2 = (p_a + p_b)^2$ • $y \equiv \frac{1}{2}\ln(\frac{q_0+q_L}{q_0-q_L}) = \frac{1}{2}\ln(\frac{x_a}{x_b})$ • $\tau = x_a x_b = M^2/s$

$$x_{a/b} = \frac{M}{\sqrt{s}}e^{\pm y} = \frac{q_0 \pm q_L}{\sqrt{s}}$$

Drell-Yan Kinematics (transverse motion)

- If we consider the transverse motion of partons then:

$$p_a = \frac{\sqrt{s}}{2} x_a \left(1 + \frac{k_{\perp a}^2}{x_a^2 s}, \frac{2\boldsymbol{k}_{\perp a}}{x_a \sqrt{s}}, 1 + \frac{k_{\perp a}^2}{x_a^2 s}\right)$$

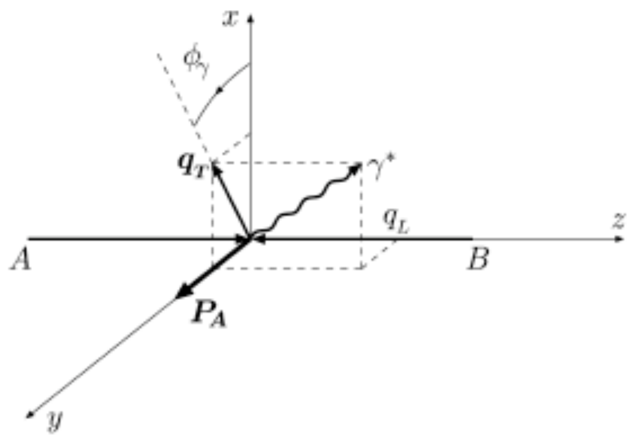
$$p_b = \frac{\sqrt{s}}{2} x_b \left(1 - \frac{k_{\perp b}^2}{x_b^2 s}, \frac{2\boldsymbol{k}_{\perp b}}{x_b \sqrt{s}}, -1 + \frac{k_{\perp b}^2}{x_b^2 s}\right)$$

- ... and the γ^* (dilepton) momentum has a transverse component in the h.c.m. frame

$$q = p_a + p_b = (q_0, \boldsymbol{q}_T, q_L)$$

$$\boldsymbol{q}_T = \boldsymbol{k}_{\perp a} + \boldsymbol{k}_{\perp b}$$

Only low q_T ($q_T^2 \ll q^2$) have a non-perturbative origins



Unpolarised Drell-Yan angular distributions (Collins-Soper frame)

- A model indipendent expression for the angular distribution of the unpolarized Drell-Yan can be written by means of the so called helicity structure functions :

$$\frac{dN}{d\Omega} = \frac{3}{8\pi}\frac{W_T(1+\cos^2\theta) + W_L(1-\cos^2\theta) + W_\Delta \sin 2\theta \cos\phi + W_{\Delta\Delta}\sin^2\theta\cos 2\phi}{2W_T + W_L}$$

or in terms of the parameters λ, μ, ν:

$$\frac{dN}{d\Omega} = \frac{3}{4\pi(\lambda+3)}\left[1 + \lambda\cos^2\theta + \mu\sin 2\theta\cos\phi + (\nu/2)\sin^2\theta\cos 2\phi\right]$$

$$\lambda = \frac{W_T - W_L}{W_T + W_L}$$
$$\mu = \frac{W_\Delta}{W_T + W_L}$$
$$\nu = \frac{2W_{\Delta\Delta}}{W_T + W_L}$$

- Lam-Tung sum rule:

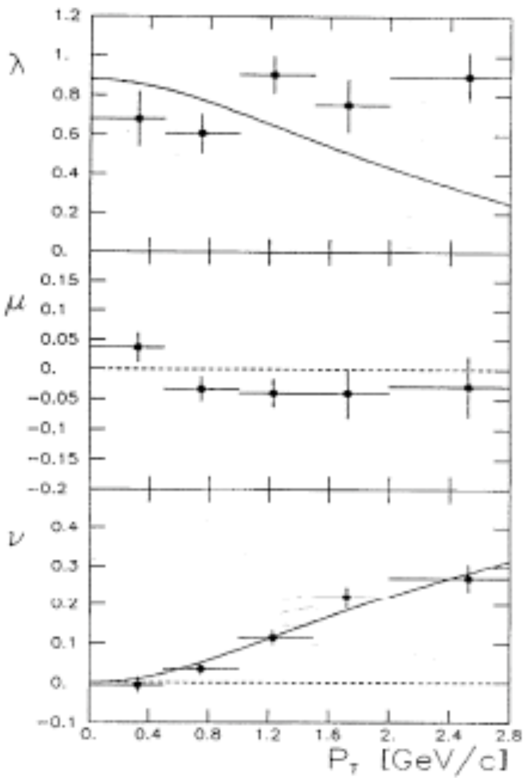
$$1 - \lambda = 2\nu \quad \text{or} \quad W_L = 2W_{\Delta\Delta}$$

  - ◇ Parton model: $\lambda = 1\,,\ \ \nu = 0\,;$
  - ◇ α_s QCD corrections: $\lambda \neq 1\,,\ \ \nu \neq 0\,;$ but still $1 - \lambda = 2\nu$

- J.C. Collins and D.E. Soper, Phys. Rev. D 16,2219; C.S. Lam and W. Tung, Phys. Rev. D 18,2447

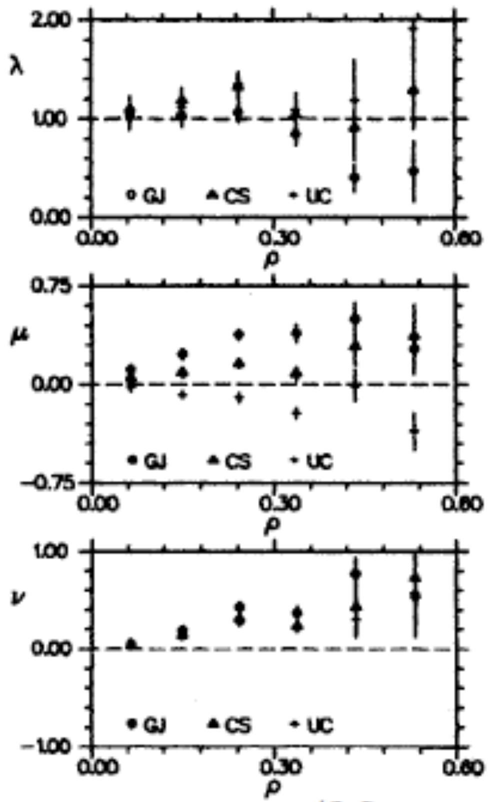
Unpolarised Drell-Yan angular distributions:
Lam-Tung sum rule violation

- NA10: $\pi^-(194\text{GeV}/c)W \to \mu^+\mu^-$
- E615: $\pi^-(252\text{GeV}/c)W \to \mu^+\mu^-$



(Collins Soper frame)

Falciano *et al*, Z.Phy. C 31, 513(1986)



$\rho = q_T/M$

Conway *et al*, Phys. Rev. D 39, 92(1989)

Unpolarised Drell-Yan angular distributions:
Boer-Mulders function (cos(2ϕ) modulations)

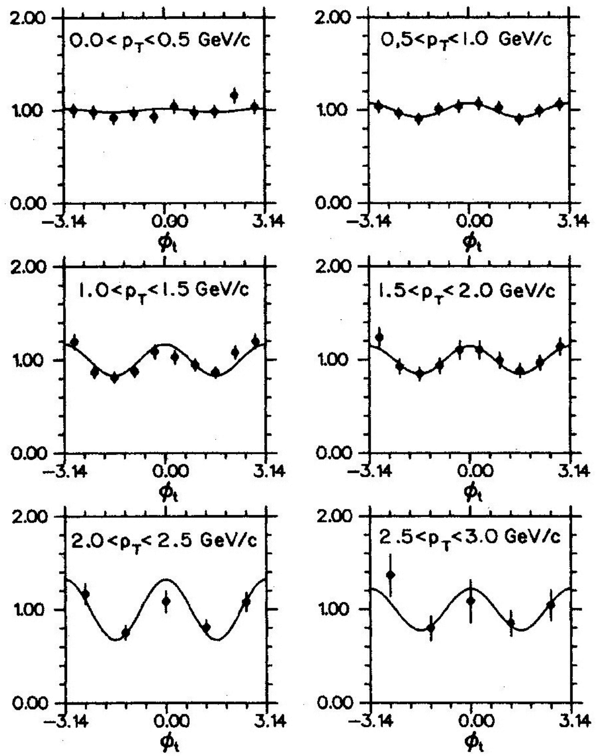
► Non perturbative effect: intrinsic transverse motion+Boer-Mulders function

$$\frac{d\sigma}{d^4q d\Omega} = \frac{\alpha^2}{6M^2 s} \sum_{a,\bar{a}} e_a^2 \Big\{ \underbrace{(1+\cos^2\theta)\mathcal{F}[f_1 \bar{f}_1]}_{\lambda \text{ term}} + \underbrace{\sin^2\theta \cos 2\phi \mathcal{F}\big[(2\hat{h}\cdot k_{\perp 1}\, \hat{h}\cdot k_{\perp 2})\frac{h_1^\perp \bar{h}_1^\perp}{M_1 M_2}\big]}_{\nu \text{ term}} \Big\}$$

where: $\mathcal{F}[f\bar{f}] = \int d^2k_{\perp 1} d^2k_{\perp 2} \delta^2(k_{\perp 1} + k_{\perp 2} - q_T) f^a(x_1, k_{\perp 1}^2) \bar{f}^a(x_2, k_{\perp 2}^2)$

◇ $$\nu = \frac{2\sum_{a,\bar{a}} e_a^2 \mathcal{F}\left[(2\hat{h}\cdot k_{\perp 1}\, \hat{h}\cdot k_{\perp 2})\frac{h_1^\perp \bar{h}_1^\perp}{M_1 M_2}\right]}{\sum_{a,\bar{a}} e_a^2 \mathcal{F}[f_1 \bar{f}_1]}$$

DY mechanism is sensitive to k_T -induced effects



Drell-Yan cross section (general form)

Recent paper by Arnold, Metz and Schlegel arXiv:0809.2262 –
For the first time the general expression for the DY cross-section is derived

$$
\begin{aligned}
\frac{d\sigma}{d^4q\,d\Omega} &= \frac{\alpha_{em}^2}{F\,q^2}\Big\{\Big(\big(1+\cos^2\theta\big)\,F_U^1 + \big(1-\cos^2\theta\big)\,F_U^2 \\
&+ \sin 2\theta\, F_U^{\cos\phi}\cos\phi + \sin^2\theta\, F_U^{\cos 2\phi}\cos 2\phi\Big) \\
&+ S_L\Big(\sin 2\theta\, F_L^{\sin\phi}\sin\phi + \sin^2\theta\, F_L^{\sin 2\phi}\sin 2\phi\Big) \\
&+ |\vec{S}_T|\Big[\Big(F_T^{\sin\phi_S} + \cos^2\theta\,\tilde{F}_T^{\sin\phi_S}\Big)\sin\phi_S \\
&+ \sin 2\theta\Big(F_T^{\sin(\phi+\phi_S)}\sin(\phi+\phi_S) + F_T^{\sin(\phi-\phi_S)}\sin(\phi-\phi_S)\Big) \\
&+ \sin^2\theta\Big(F_T^{\sin(2\phi+\phi_S)}\sin(2\phi+\phi_S) + F_T^{\sin(2\phi-\phi_S)}\sin(2\phi-\phi_S)\Big)\Big]\Big\},
\end{aligned}
$$

DY cross-section: Leading order QCD parton model

At LO the general expression of the DY cross-section simplifies to:

$$\begin{aligned}
\frac{d\sigma^{LO}}{d^4q\,d\Omega} &= \frac{\alpha_{em}^2}{F\,q^2}\hat{\sigma}_U^{LO}\Big\{\Big(1 + D^{LO}_{[\sin^2\theta]}\,A_U^{\cos 2\phi}\cos 2\phi\Big) \\
&+ S_L D^{LO}_{[\sin^2\theta]}\,A_L^{\sin 2\phi}\sin 2\phi \\
&+ |\vec{S}_T|\Big[A_T^{\sin\phi_S}\,\sin\phi_S + D^{LO}_{[\sin^2\theta]}\Big(A_T^{\sin(2\phi+\phi_S)}\sin(2\phi+\phi_S) \\
&+ \qquad A_T^{\sin(2\phi-\phi_S)}\sin(2\phi-\phi_S)\Big)\Big]\Big\},
\end{aligned}$$

Thus the measurement of 5 asymmetries (modulations in the DY cross-section):

- $A_U^{\cos 2\phi}$ gives access to Boer-Mulders functions of incoming hadrons,
- $A_L^{\sin 2\phi}$ – to Boer-Mulders functions of beam hadron and $h_{1L}^{\perp}$ function of the target nucleon,
- $A_T^{\sin\phi_S}$ – to Sivers function of the target nucleon,
- $A_T^{\sin(2\phi+\phi_S)}$ – to Boer-Mulders functions of beam hadron and $h_{1T}^{\perp}$ (pretzelosity) function of the target nucleon,
- $A_T^{\sin(2\phi-\phi_S)}$ – to Boer-Mulders functions of beam hadron and h_1 (transversity) function of the target nucleon.

Single polarised Drell-Yan: SSA

$$\frac{d\sigma^{A^\uparrow B} - d\sigma^{A^\downarrow B}}{d\Omega dx_1 dx_2 d^2\boldsymbol{q}_T} = \frac{\alpha_{em}^2}{6M^2}\sum_{a,\bar{a}} e_a^2 \times$$

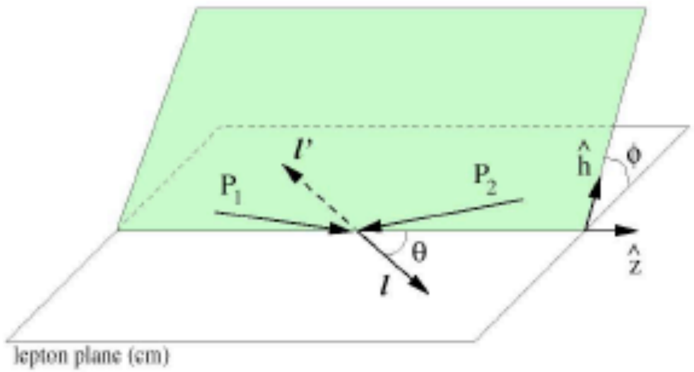
$$\Big\{|\boldsymbol{S}_{1T}|(1+\cos^2\theta)\sin(\phi-\phi_{S_1})\mathcal{F}\Big[\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_{\perp 1}\frac{f_{1T}\bar{f}_1}{M_1}\Big]$$

$$-\sin^2\theta\,\sin(\phi+\phi_{S_1})\mathcal{F}\Big[\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_{\perp 2}\frac{h_1\bar{h}_1^\perp}{M_2}\Big]$$

$$-\sin^2\theta\,\sin(3\phi-\phi_{S_1})\mathcal{F}\Big[\Big(4\,\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_{\perp 2}(\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_{\perp 1})^2 - 2\,\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_{\perp 1}(\boldsymbol{k}_{\perp 1}\cdot\boldsymbol{k}_{\perp 2}) - \hat{\boldsymbol{h}}\cdot\boldsymbol{k}_{\perp 2}\boldsymbol{k}_{\perp 1}\Big)\frac{h_{1T}^\perp\bar{h}_1^\perp}{M_2}\Big]\Big\}$$

D. Boer, *Phys. Rev.* D60, 014012

- θ and ϕ in the dilepton rest frame
- ϕ_{S_1} in the dilepton rest frame!

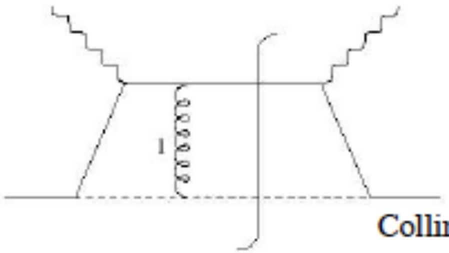


N.B.: ϕ_{S1} angle in D.Boer, Phys.Rev. D60, 014012 is not exactly equivalent to ϕ_S used by us so far (Arnold, Metz and Schlegel arXiv:0809.2262) but similar

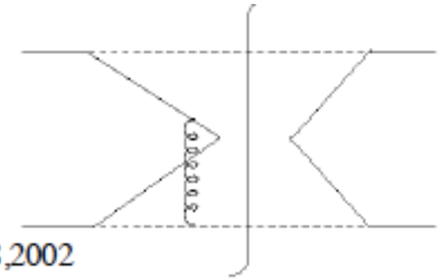
$$A_{h(f)} = \frac{\int d\Omega d\phi_S \sin(\phi \pm \phi_S)[d\sigma(\phi_S) - d\sigma(-\phi_S)]}{\int d\Omega d\phi_S [d\sigma(\phi_S) + d\sigma(-\phi_S]}$$

TMD PDF effect SIDIS <->DY

FSI



ISI

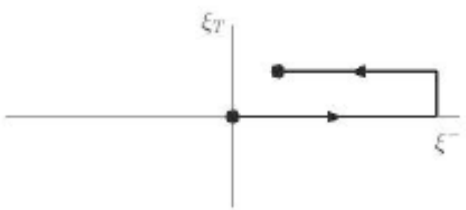


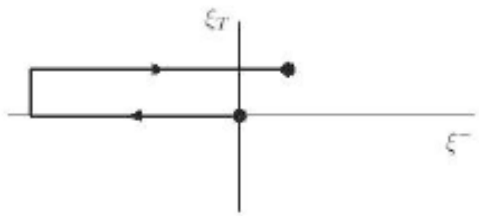
Collins: Phys.Lett.B536:43-48,2002

SIDIS

DY

A. Schafer – Mainz'09





- The sign of the gauge link is related to time direction of the Wilson line. For a T-odd function, it implies that the function changes sign for a past/future pointing Wilson line

$$h_1^{\perp}(x, \mathbf{k}_T)\Big|_{SIDIS} = -h_1^{\perp}(x, \mathbf{k}_T)\Big|_{DY}$$

$$f_{1T}^{\perp}(x, \mathbf{k}_T)\Big|_{SIDIS} = -f_{1T}^{\perp}(x, \mathbf{k}_T)\Big|_{DY}$$

J.C. Collins, Phys. Lett. B536 (2002) 43

J. Collins, talk at LIGHT CONE 2008

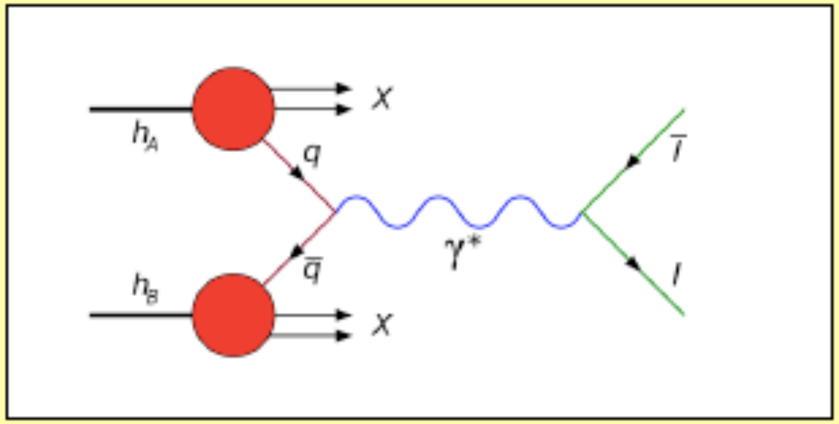
Double polarised Drell-Yan: direct access to Transversity

directly accessible uniquely via the double transverse spin asymmetry A_{TT} in the Drell-Yan production of lepton pairs

$$A_{TT} \equiv \frac{d\sigma^{\uparrow\uparrow} - d\sigma^{\uparrow\downarrow}}{d\sigma^{\uparrow\uparrow} + d\sigma^{\uparrow\downarrow}} = \hat{a}_{TT} \frac{\sum_q e_q^2 h_1^q(x_1, M^2) h_1^{\bar{q}}(x_2, M^2)}{\sum_q e_q^2 q(x_1, M^2) \bar{q}(x_2, M^2)} \quad q = u, \bar{u}, d, \bar{d}, \ldots$$

$$\hat{a}_{TT} = \frac{\sin^2\vartheta}{1+\cos^2\vartheta}\cos 2\varphi$$

Spin asymmetry of the QED elementary process



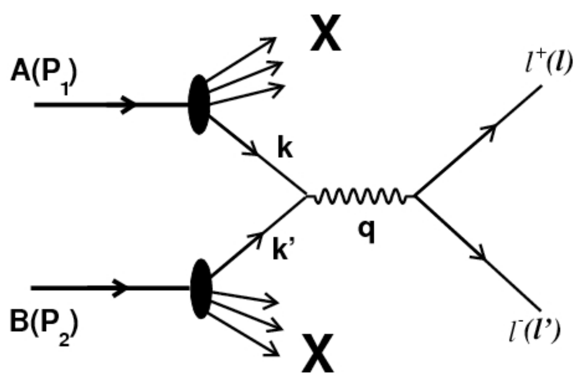
definitive observation of $h_1^q(x,Q^2)$ of the proton for the valence quarks (A_{TT} in Drell-Yan >0.2)

M.Nekipelov -> PAX

Feasibility study is underway, polarised antiprotons(>20%) - not a trivial issue

J/Ψ – Drell-Yan duality

- J/Ψ – DY duality → close analogy between Drell-Yan and J/Ψ production mechanism:
  - Occurs when the gluon-gluon fusion mechanism of the J/Ψ production is dominated by the quark-quark fusion mechanism
  - We can expect that the duality is valid in the COMPASS kinematic range
- Key issue for the applicability of the J/Ψ signal for the study of hadron spin structure
- J/Ψ production mechanism by itself is an important issue



$$\sigma_{q\bar{q}} = \frac{4\pi\alpha^2}{3M_{\mu\mu}^2} e_q^2$$

γ → J/Ψ substitution

$$16\pi^2\alpha^2 e_q^2 \rightarrow (g_q^{J/\psi})^2 (g_\ell^{J/\psi})^2, \quad \frac{1}{M^4} \rightarrow \frac{1}{(M^2 - M_{J/\psi}^2)^2 + M_{J/\psi}^2 \Gamma_{J/\psi}^2},$$

Drell-Yan processes and access to GPDs

Very preliminary – feasibility is under discussion now, some indications:

- O.Teryaev: Drell-Yan pair production in the pion-nucleon collisions for large x_F (the region whose exploration is favourable in COMPASS kinematics) is sensitive to such an important and hot ingredient of pion structure as its light-cone distribution (DA). In other words in this kinematic range pion participate in the interaction coherently (as pion) rather then by only one of its quark.

References:

A.P.Bakulev, S.V.Mikhailov and N.G.Stefanis, Phys.Lett.B 508, 279 (2001)
A.Brandenburg, S.J.Brodsky, V.V.Khoze and D.Mueller, Phys.Rev.Lett. 73, 939 (1994)
A.Brandenburg, D.Mueller and O.V.Teryaev, Phys.Rev.D 53, 6180 (1996)

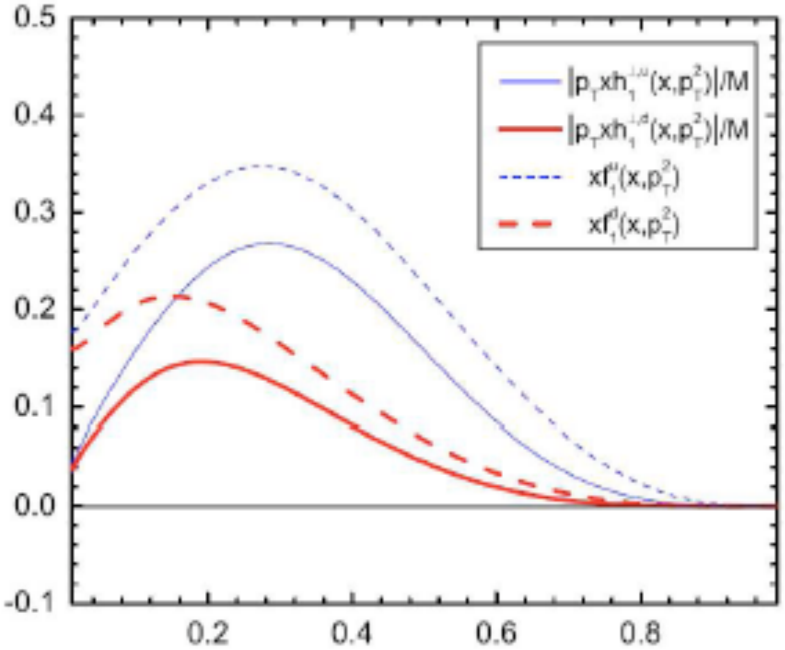
- B.Pire, O.Teryaev: Semiexclusive DY – crucial test of the GPDs universality (time-like process contrary to the Deep Inelastic scattering)

Reference:

B.Pire, L. Szymanowski, arXiv:0905.1258v1 [hep-ph] 8 May 2009

Some indications for the future Drell-Yan experiments

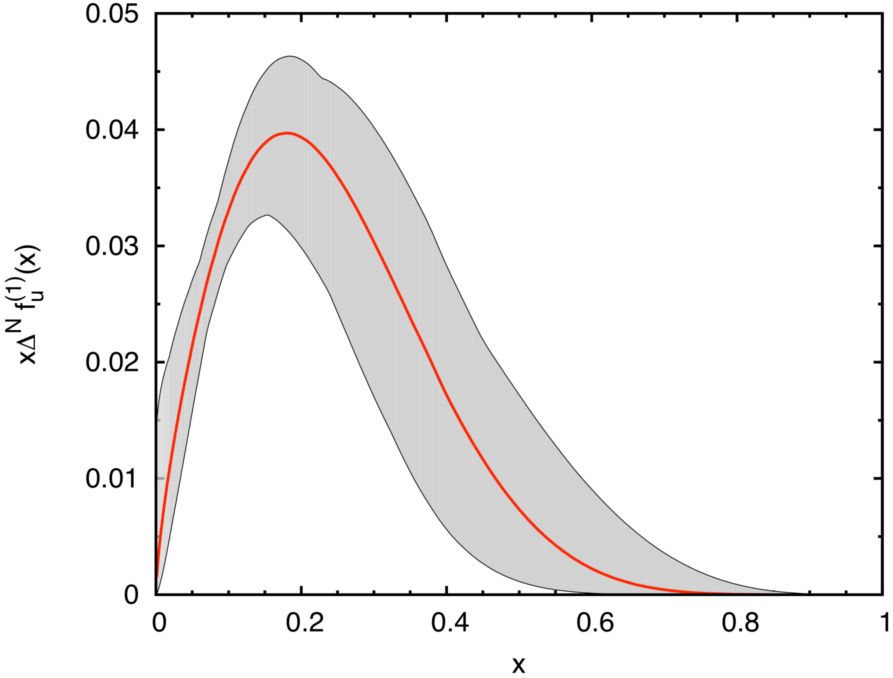
TMD PDFs – ALL are sizable in the valence quark region



► Boer-Mulder function for u and d quarks

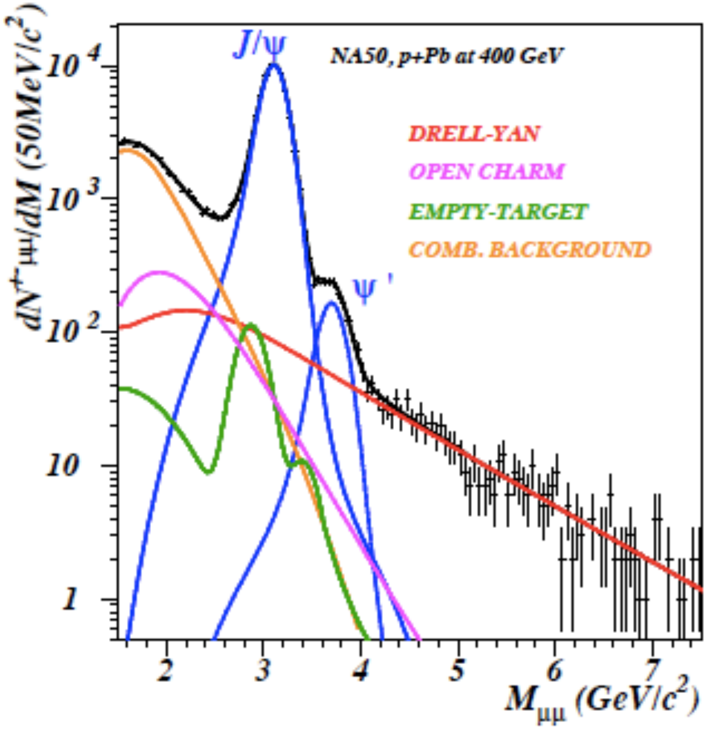
as extracted from $p + D$ data

from Zhang *et al Phys. Rev.* D77,0504011]



Sivers effect in Drell-Yan processes.
M. Anselmino, M. Boglione U. D'Alesio,
S. Melis, F. Murgia, A. Prokudin
Published in Phys.Rev.D79:054010, 2009

Safe region: 4. < M < 9. Gev/c^2



In the dimuon mass spectrum, 2 background sources must be considered:

- physics background:
  D and $\bar{D}$ decays to $\mu^{\pm}X$;
  J/ψ and ψ', also a subject of research.
- Combinatorial background
  π and K decaying to $\mu\nu$

The cleanest region to study Drell-Yan is $4. < M < 9.$ GeV/c^2

In the region $2.0 < M < 2.5$ GeV/c^2 there is important contribution from background sources.

Polarized Drell-Yan measurements in COMPASS C. Quintans -

$$\delta A = \frac{1}{P_b f} \frac{1}{\sqrt{N_{sig}}} \sqrt{1 + \frac{N_{sig}}{N_{backg}}}$$

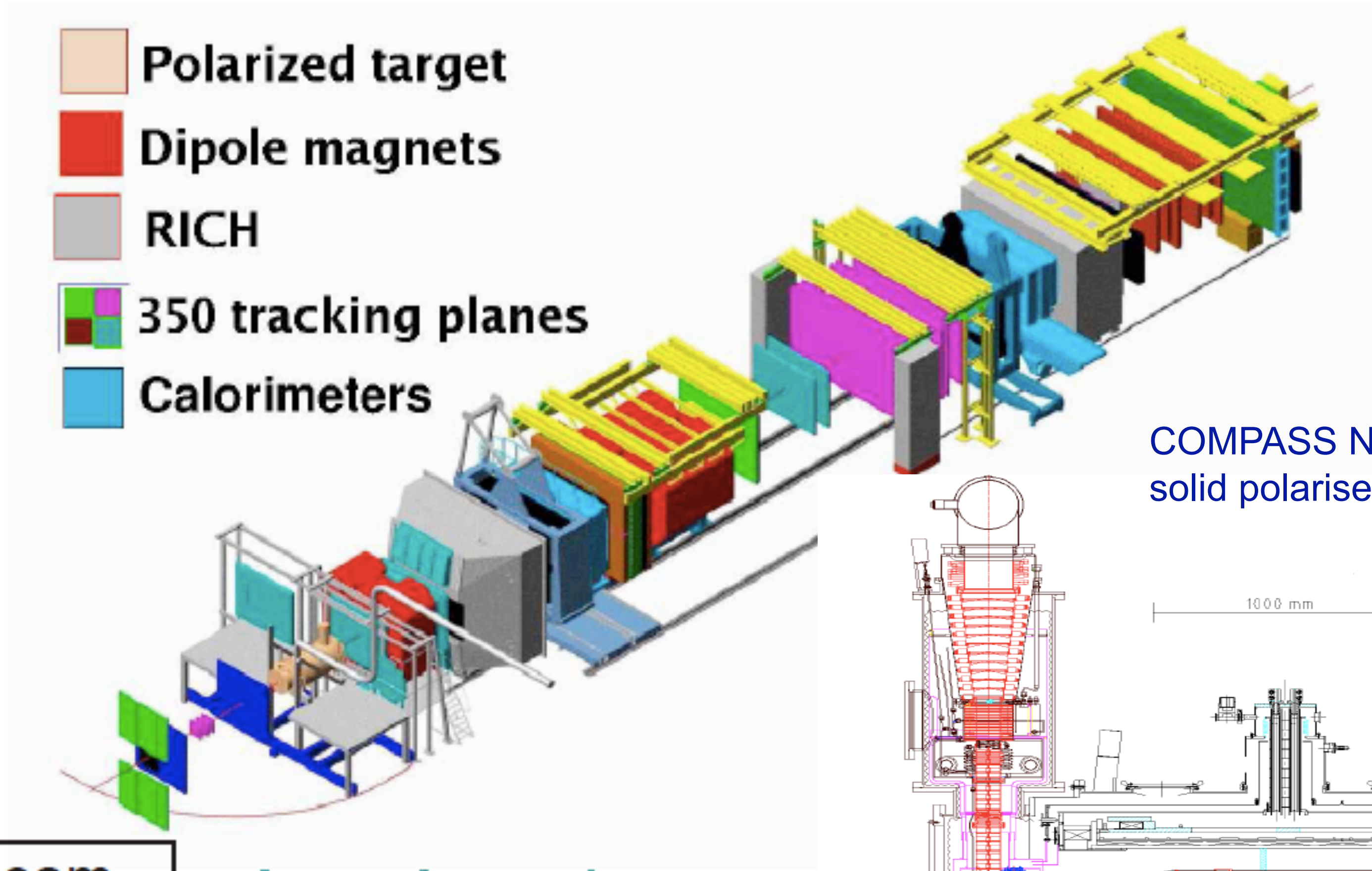
$$\tau = x_a x_b = M^2/s$$

1. Drell-Yan experiments:
   - High luminosity (DY Cross Section is a fractions of nanobarns) and large angular acceptance, better pion or antiproton beams (valence anti-quark)
   - Sufficiently high energy to access 'safe' of background free M_{ll} range (4 GeV/c < M_{ll} < 9 GeV/c)
   - Good acceptance in the valence quark range $x_B > 0.05$ and kinematic range: $\tau = x_A x_B = M^2/s > 0.1$
2. Polarised Drell-Yan:
   - Good factor of merit (FoM), which can be represented as a product of the luminosity, target polarisation (dilution factor *f*) and beam polarisation P_{beam} (if any): FoM ~ $L \times f^2 \times P^2_{beam}$

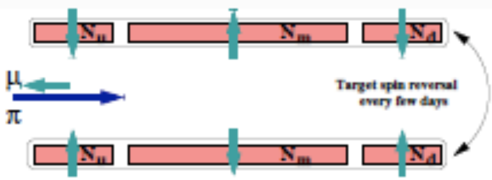
Future Drell-Yan experiment

- Fixed target experiments (COMPASS, E906, J-Park) characterised by:
  - Very high luminosity (>10^{33} $cm^{-2}s^{-1}$)
  - Only muon in the final state (hadron absorber has to be used because of the 'all forward' geometry and high luminosity)
  - Light unpolarised targets (liquid hydrogen and deuterium) and solid state polirased targets (NH_3, ^6LD)
  - Pion, proton and (probably) antiproton (COMPASS) beams
- Collider experiments (RHIC, NICA SPD, PAX)
  - Moderate luminosity
  - High universality (not only TMD PDFs, J/Psi and related aspect but also formfactors, various hard processes – not a topic of this talk)

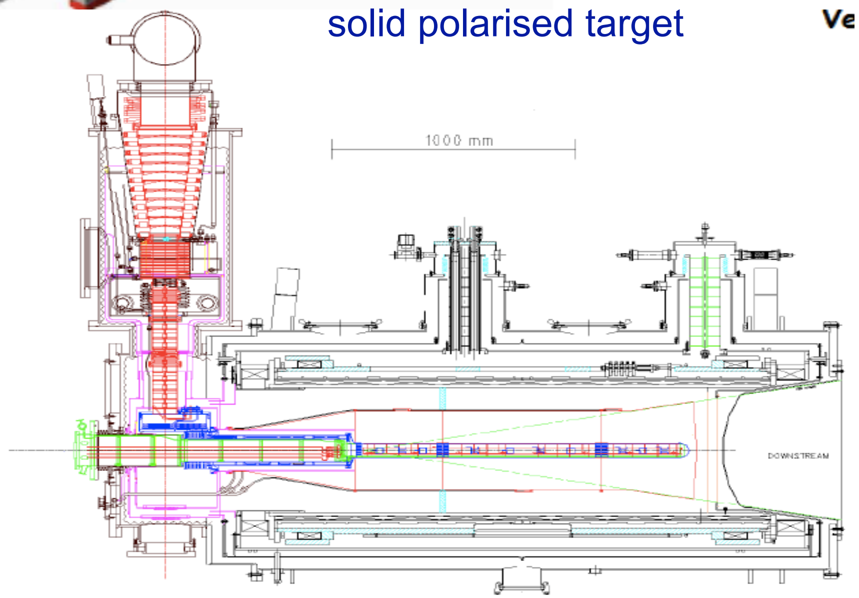
COMPASS experiment at CERN



μ or π beam



COMPASS NH_3 or ^{6}LiD solid polarised target



Why Drell-Yan @ COMPASS

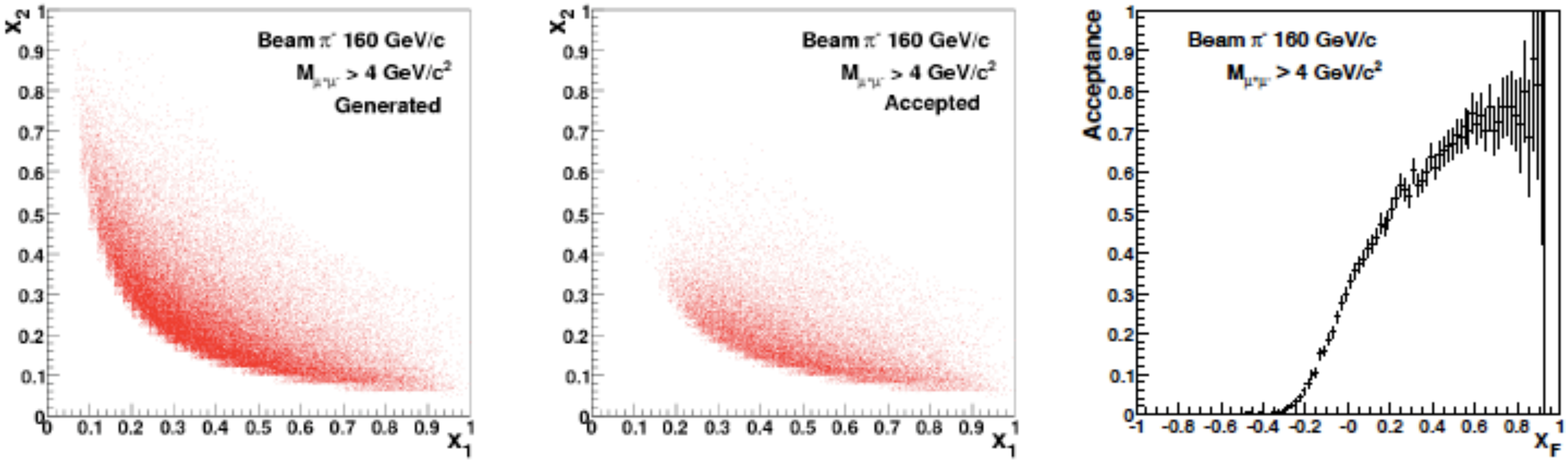
1. Large angular acceptance spectrometer
2. SPS M2 secondary beams with the intensity up to $6x10^7$ particles per second
3. Large acceptance COMPASS Superconducting Solenoid Magnet
4. Solid state polarized target working in frozen spin mode with long relaxation time;
5. a detection system designed to stand relatively high particle fluxes;
6. a Data Acquisition System (DAQ) that can handle large amounts of data at large trigger rates;
7. The dedicated muon trigger system

For the moment we consider two step DY program:

- The program with high intensity pion beam
- The program with Radio Frequency separated antiproton beam

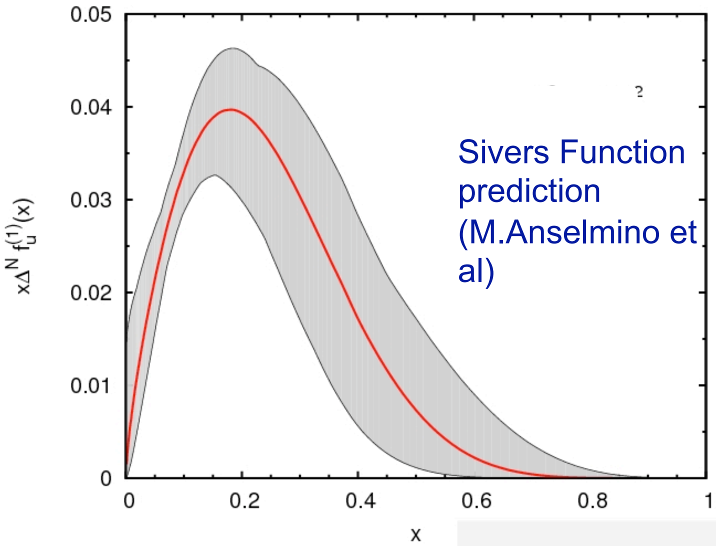
DY cross section and acceptance @ COMPASS

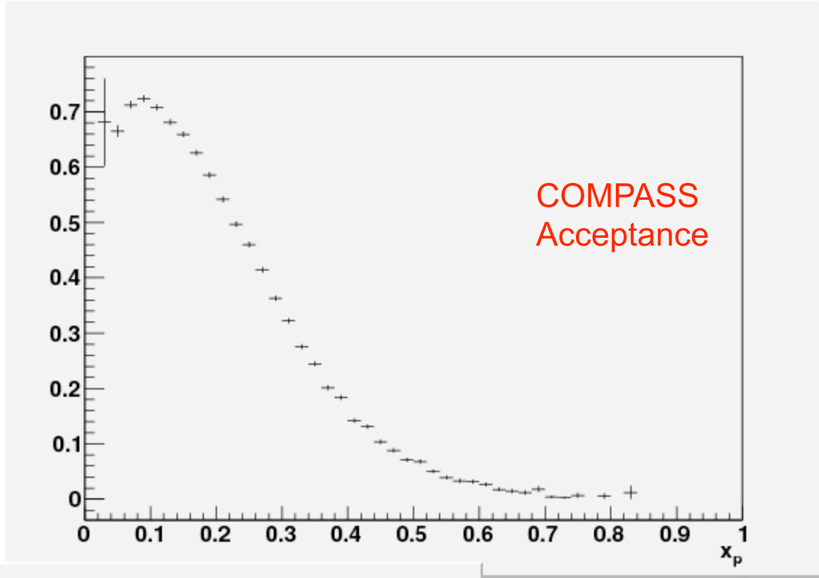
σ^{DY} (nb)	$2.0 < M_{\mu\mu} < 2.5$ (GeV/c^2)	$4. < M_{\mu\mu} < 9.$ (GeV/c^2)
s=200 GeV^2, p_π=106 GeV/c	1.2	0.10
s=300 GeV^2, p_π=160 GeV/c	1.4	0.17
s=400 GeV^2, p_π=213 GeV/c	1.6	0.24

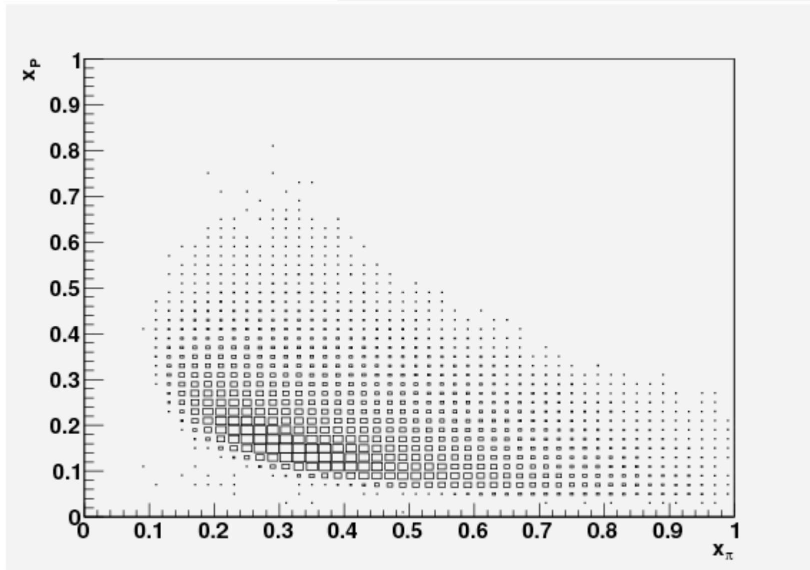


COMPASS acceptance is in the valence quarks region ($x > 0.1$). This is also the best region to measure the spin asymmetries, as expected from theory predictions.

DY acceptance @ COMPASS







Prediction for Sivers function as a function of x, COMPASS acceptance in x_p and acceptance coverage x_π.vs.x_p

Access to the TMD PDFs @ COMPASS

Near future: $(\pi^-, p^\uparrow)$

π^-: $(\bar{u}d)$ p: (uud)

In the valence region: $$\sigma^{DY} \propto f_{(\bar{u}|\pi^-)} \otimes f_{(u|p)}$$

where $f = h_1^\perp, f_1, f_{1T}^\perp, h_1, h_{1T}^\perp$

The following topics can be studied:

- Sivers function u_v quarks-dominance;
- Model dependent extraction of transversity and Boer-Mulders functions.

Longer term future: $(\bar{p}, p^\uparrow)$

$\bar{p}$: $(\bar{u}\bar{u}\bar{d})$ p: (uud)

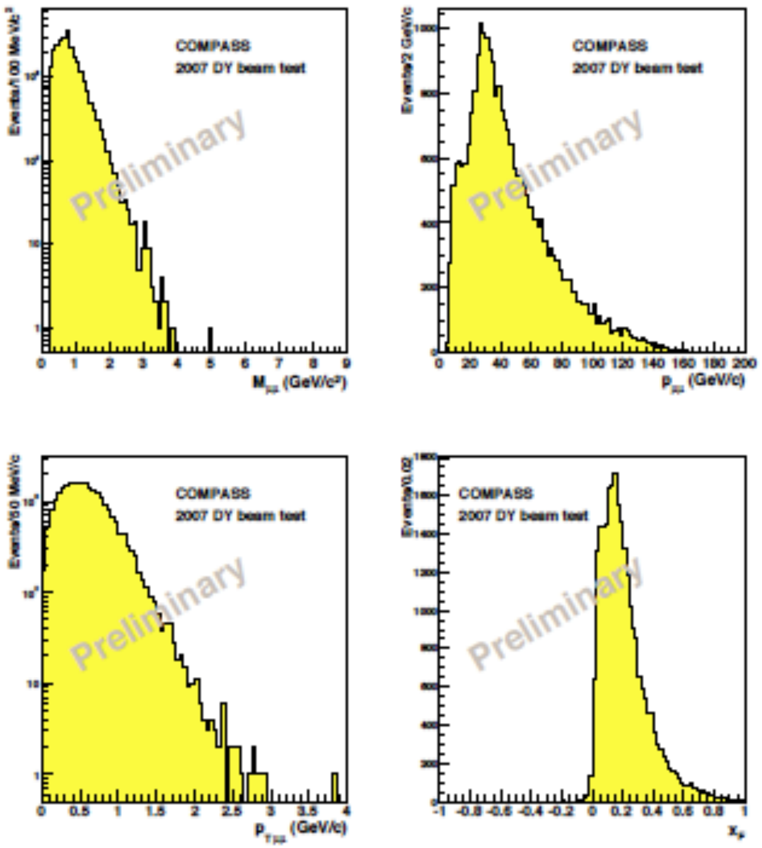
In this case, $f_{(\bar{u}|\bar{p})} = f_{(u|p)}$, thus

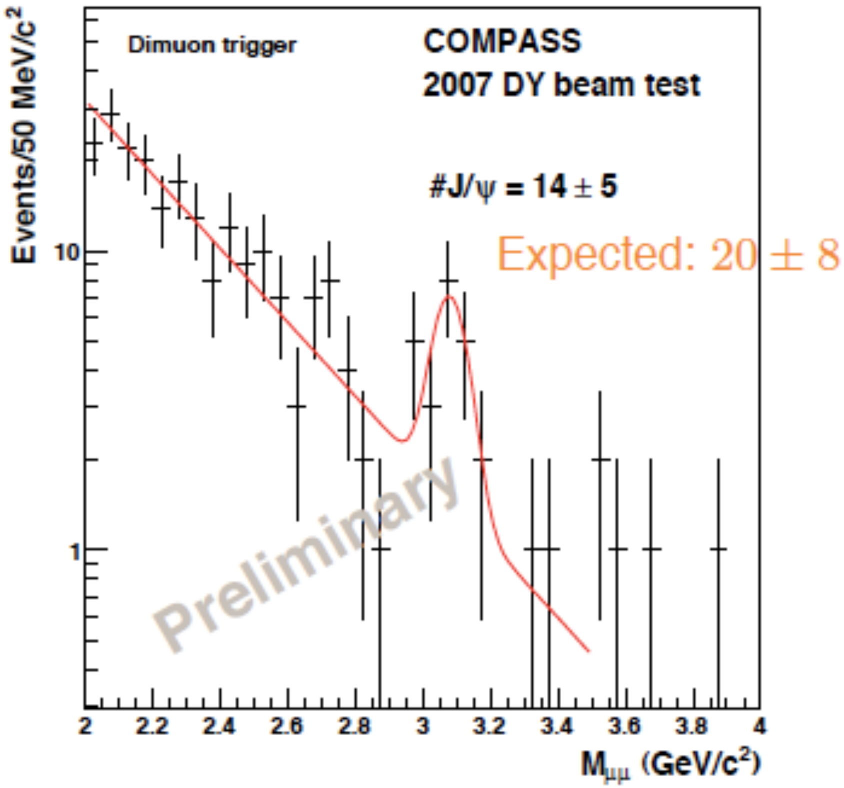
$$\sigma^{DY} \propto f_{(u|p)} \otimes f_{(u|p)}$$

- Model independent extraction of Sivers and transversity functions.

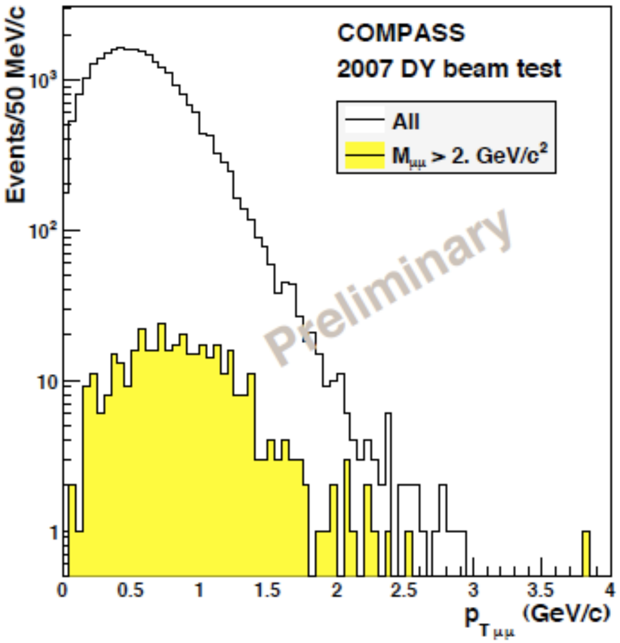
DY Feasibility@COMPASS
Beam Test 2007 (no hadron absorber)

In 2007, with a π^- beam of 160 GeV/c on a NH_3 target, and without hadrons absorber: ≈ 90000 dimuon events (< 12 hours data-taking).



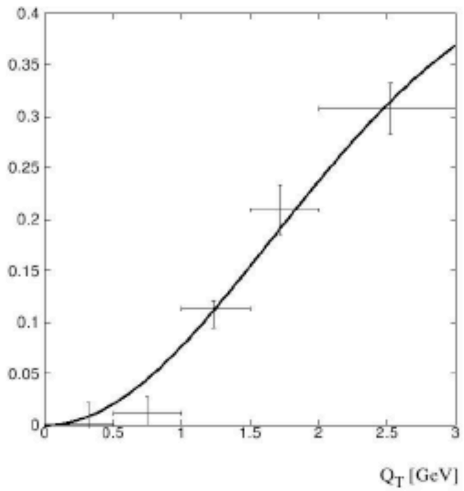


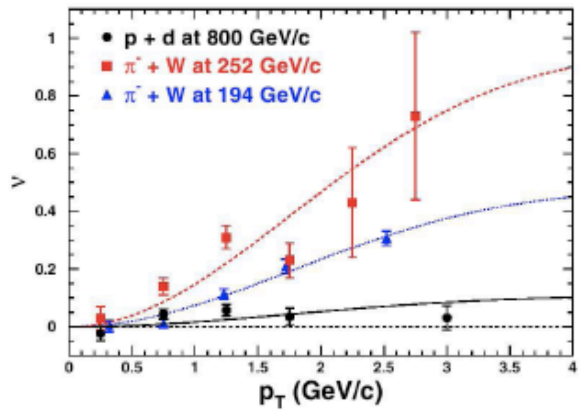
Pt range covered by COMPASS



COMPASS Pt coverage (Pt ~ 1 GeV what makes COMPASS sensitive to the contribution from the TMD PDFs but not from higher twists – see slide 4)

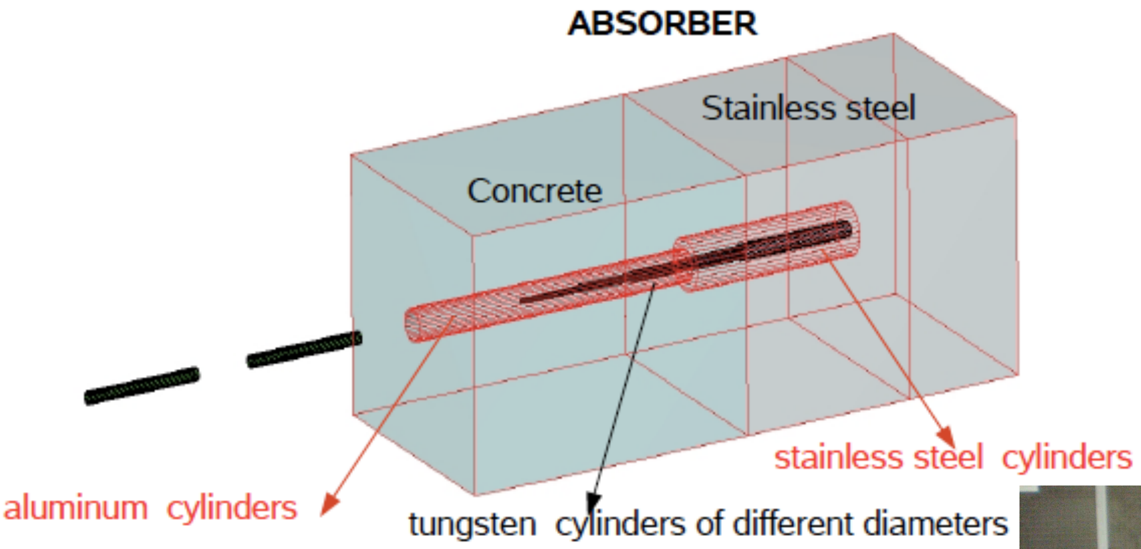
Previous experiments:



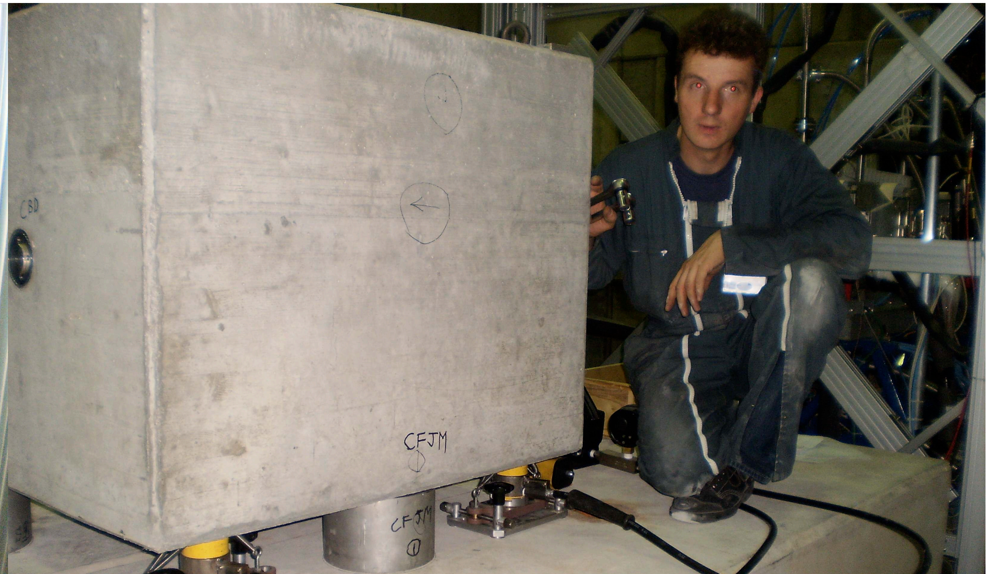


- ν NA10 data at 194 Gev/c as function of Q_T fitted by means of a diquark model of the BM function [D.Boer, *Phys. Rev.* D60,014012.]
- Same model applied to $p + D$ data at FERMILAB. [Zhu et *al*, *Phys. Rev. Lett.* 99, 082301]

DY Feasibility@COMPASS
Beam Test 2009 (with hadron absorber I)



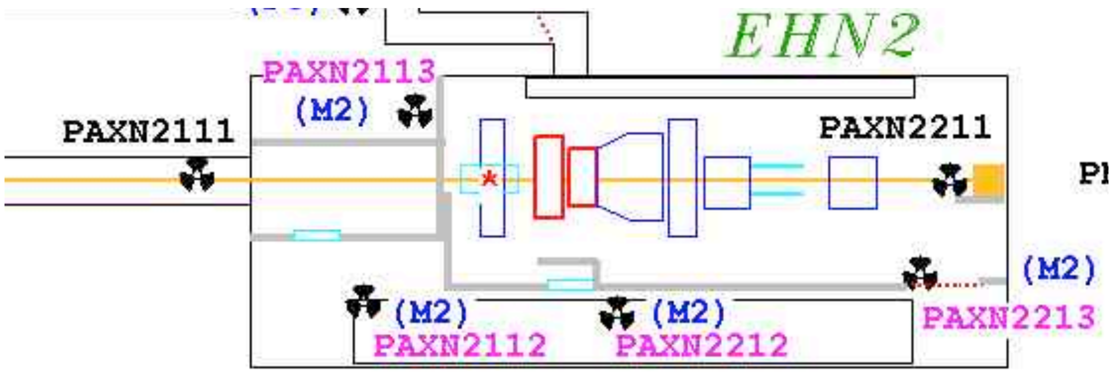
DY Feasibility@COMPASS
Beam Test 2009 (with hadron absorber II)

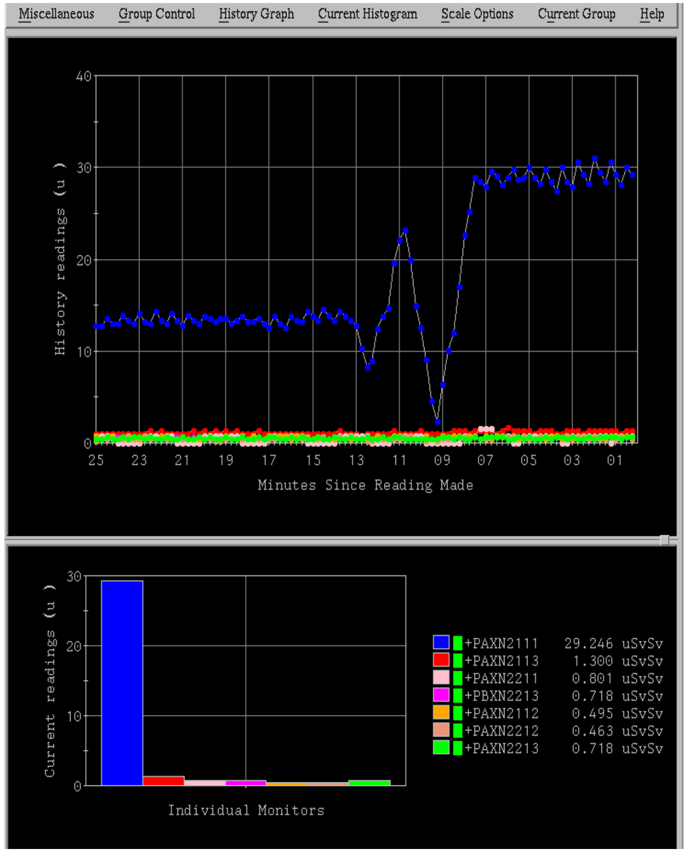


DY Feasibility@COMPASS
Beam Test 2009 (with hadron absorber III)

Some results of 2009 DY beam test: radio-protection issues and tracking detectors occupancies

- RP - the detected radiation level is factor 6 lower than allowed one (3 uSv), in a good agreement with simulations done by COMPASS and CERN RP (pion beam intensity ~8x10^7 pions per spill (10 seconds))
- The tracking detectors occupancy downstream of hadron absorber is factor 10 lower compare to the normal muon running conditions





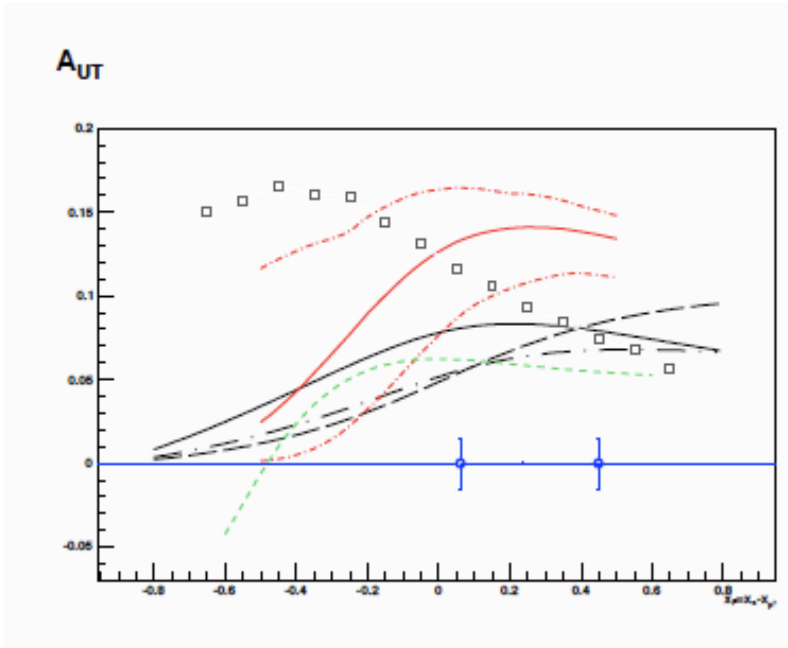
Sivers and expected statistical error @ COMPASS

With a beam intensity $I_{beam} = 6 \times 10^7$ particles/second,
a luminosity of $L = 1.7 \times 10^{33}\ cm^{-2}s^{-1}$ can be obtained.

$\hookrightarrow$ Assuming 2 years of data-taking, one can collect > 200000 DY events in the region $4 < M_{\mu\mu} < 9.$ GeV/c^2.

Predictions for the Sivers asymmetry in the COMPASS phase-space, for the mass region $4. < M < 9.$ GeV/c^2, compared to the expected statistical errors of the measurement:

- solid and dashed: Efremov et al, PLB612(2005)233;
- dot-dashed: Collins et al, PRD73(2006)014021;
- solid, dot-dashed: Anselmino et al, PRD79(2009)054010;
- boxes: Bianconi et al, PRD73(2006)114002;
- short-dashed: Bacchetta et al, PRD78(2008)074010.



COMPASS: Summary

- Pion and, later, antiproton beams (50-200 GeV), Drell-Yan process dominated by the contribution from the valence quarks (both beam and target), $\tau = x_1 x_2 = Q^2/s \cong 0.05 \div 0.3$
- Solid state polarised targets, NH_3 and ^6LiD, in case of hydrogen target – pure u-dominance
- Statistical error on single spin asymmetries is on the level 1÷2% in two years of data taking
- LoI already submitted to CERN SPSC (January 2009)
- Proposal will be submitted to the SPSC at the beginning of 2010
- First Drell-Yan data taking >2012

Conclusions

- Next decade looks very promising for the new Drell-Yan experiments – a lot of activity in the field
- The new generation of the polarised Drell-Yan programs will contribute in decisive way into our understanding of the hadron structure
- Access to the valence quarks contributions as well as high luminosity are important prerequisits to the successful Drell-Yan experiment

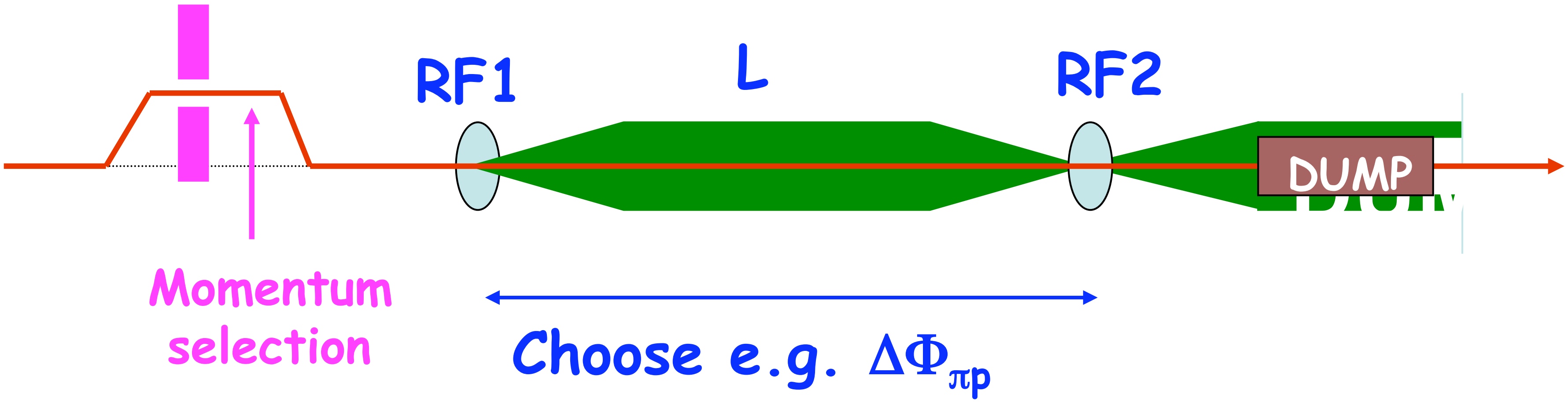
- Spares

WHAT ABOUT A RF SEPARATED pbar BEAM ???

First and very preliminary thoughts, guided by

- recent studies for P326
- CKM studies by J.Doornbos/TRIUMF, e.g. http://trshare.triumf.ca/~trjd/rfbeam.ps.gz

E.g. a system with two cavities:



$$\Delta\Phi = 2\pi\,(L\,f\,/\,c)\,(\beta_1^{-1} - \beta_2^{-1}) \text{ with } \beta_1^{-1} - \beta_2^{-1} = (m_1^2 - m_2^2)/2p^2$$