DIS 2010

XVIII International Workshop on Deep-Inelastic Scattering and Related Subjects

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Future COMPASS Drell-Yan experiment

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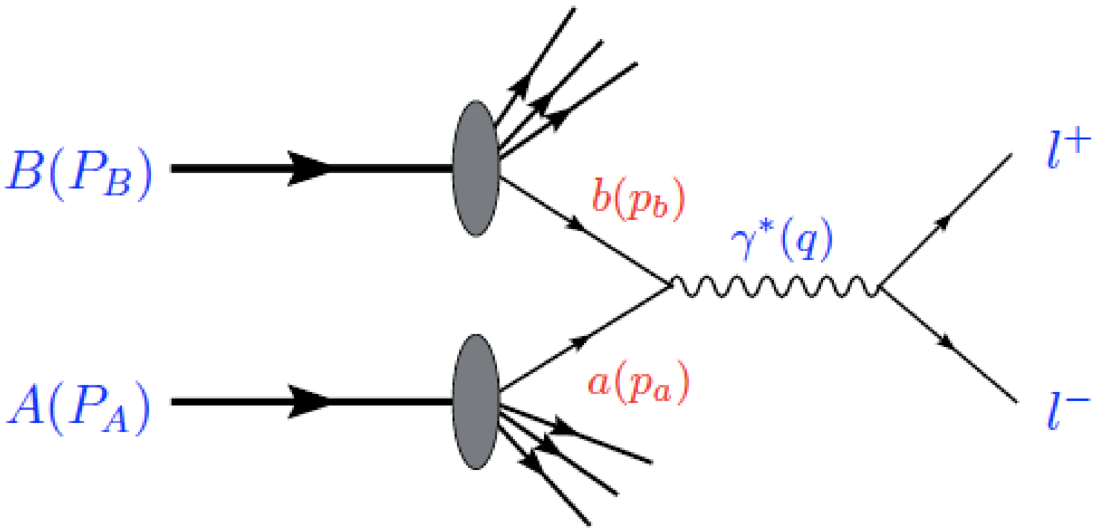
Outline

- Drell-Yan@COMPASS – physics case
  - TMDs universality test SIDIS ←→DY
  - TMD PDF sign change SIDIS ←→DY
  - Polarised J/Psi production and J/Psi ←→ DY duality
- DY@COMPASS - kinematic range
  - Valence quark contribution is dominant
  - 'Pure' u-ubar channel
  - $<P_T>$ ~ 1GeV – TMDs induced effects expected to be dominant
- DY@COMPASS – set-up
- DY@COMPASS - feasibility
- Projections
- Conclusions

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



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

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

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

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

▻ 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:

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

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

Drell-Yan Kinematics (transverse motion)

- If we consider the transverse motion of partons then:

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

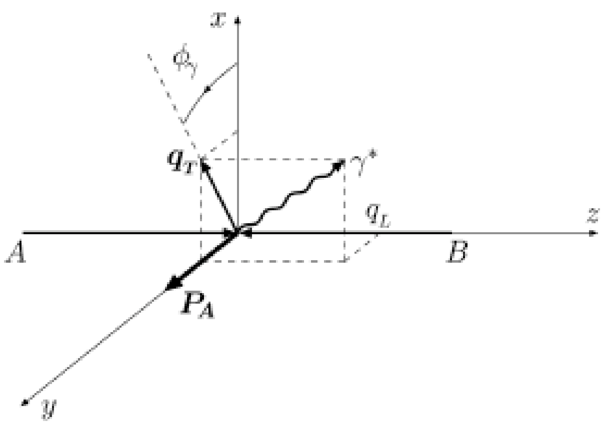
$$p_b = \frac{\sqrt{s}}{2} x_b \left(1 - \frac{k_{\perp b}^2}{x_b^2 s}, \frac{2\boldsymbol{k}_{\perp b}}{x_b\sqrt{s}}, -1 + \frac{k_{\perp b}^2}{x_b^2 s}\right)$$

- ... 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



In other words is dominated by the contribution from TMD PDFs

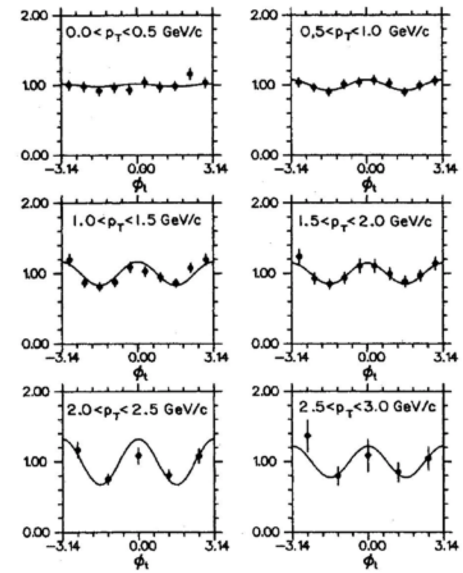
Unpolarised Drell-Yan angular distributions: NA10(CERN) and E615 (Fermilab) – Lam-Tung sum rule violation

FIRST TMD INDUCED EFFECT OBSERVATION

Boer-Mulders function (cos(2ϕ) modulations)

- A model indipendent expression for the angular distribution of the unpolarized Drell-Yan in terms of the parameters λ, μ, ν:

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



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

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

- 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 $1-\lambda = 2\nu$

DY mechanism is very sensitive to k_T -induced effects

DY cross-section: Leading order QCD parton model, TMD PDFs universality

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

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

Thus the measurement of 4 asymmetries (modulations in the DY cross-section):

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

TMDS UNIVERSALITY TO DE PROVEN

Single polarised Drell-Yan: SSA

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

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

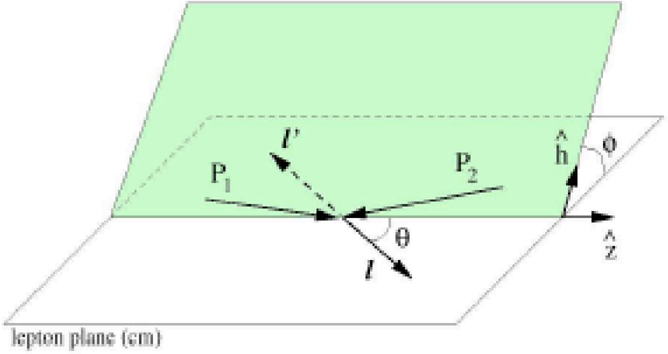
D. Boer, *Phys. Rev.* D60, 014012

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

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

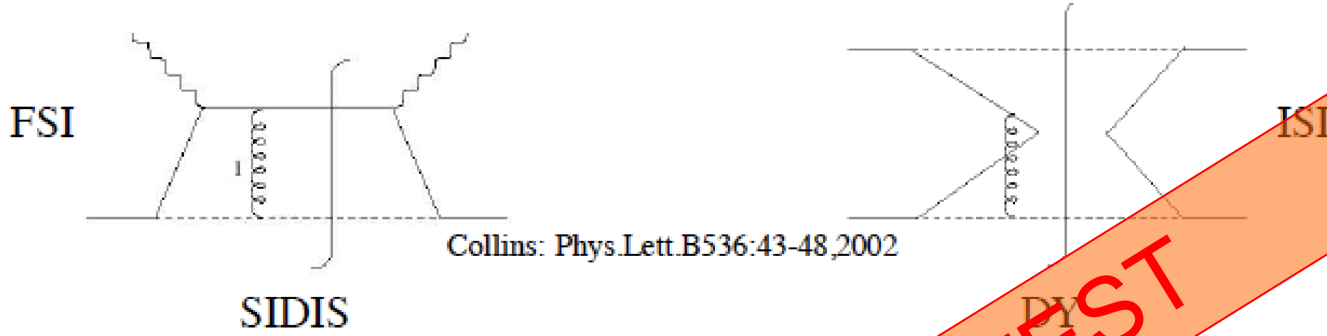
- θ and ϕ in the dilepton rest frame
- ϕ_{S_1} in the dilepton rest frame!

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



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

Sivers, Boer-Mulders functions SIDIS ←→ DY



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

FUNDAMENTAL QCD TEST

- 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

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

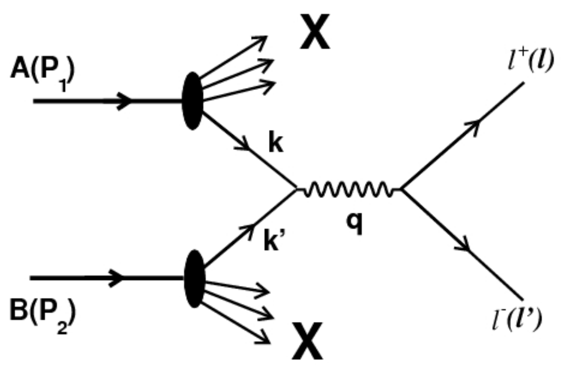
$$f_{1T}^{\perp}(x, \mathbf{k}_T)\Big|_{SIDIS} = -f_{1T}^{\perp}(x, \mathbf{k}_T)\Big|_{DY}$$

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

J. Collins, talk at LIGHT CONE 2008

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



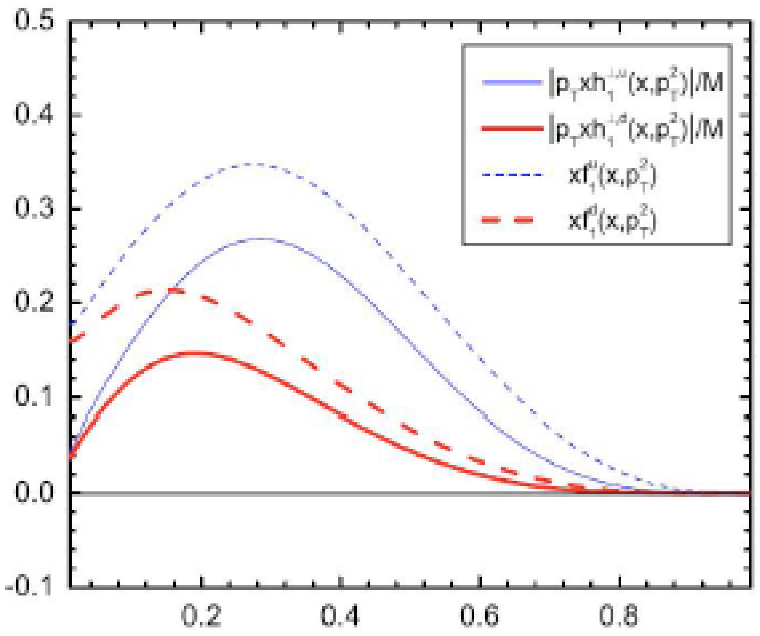
$$\sigma_{q\bar{q}} = \frac{4\pi\alpha^2}{3M_{\mu\mu}^2}e_q^2$$

γ → J/Ψ substitution

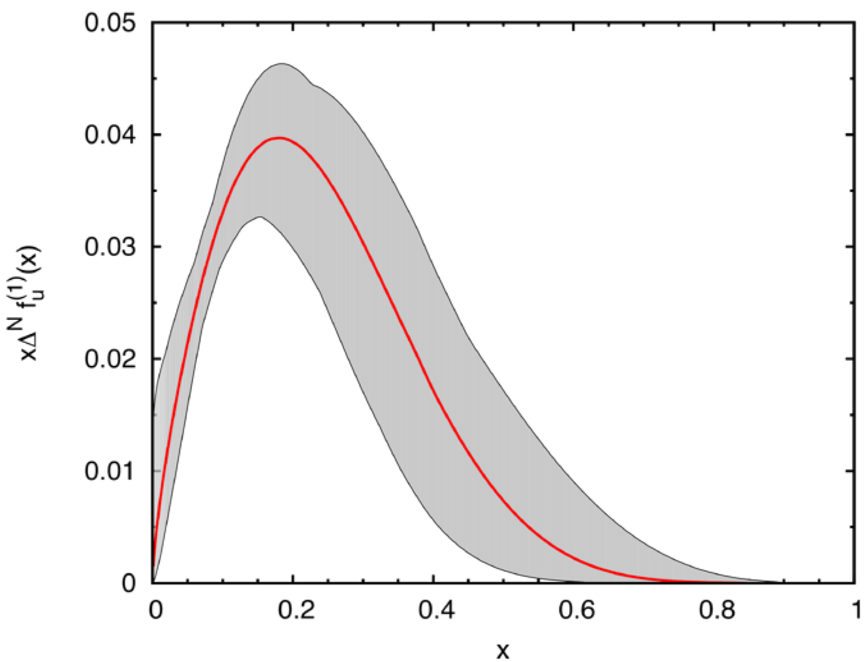
$$16\pi^2\alpha^2e_q^2 \longrightarrow (g_q^{J/\psi})^2\,(g_\ell^{J/\psi})^2, \qquad \frac{1}{M^4} \longrightarrow \frac{1}{(M^2 - M_{J/\psi}^2)^2 + M_{J/\psi}^2\Gamma_{J/\psi}^2},$$

DY@COMPASS kinematics - Indication

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]

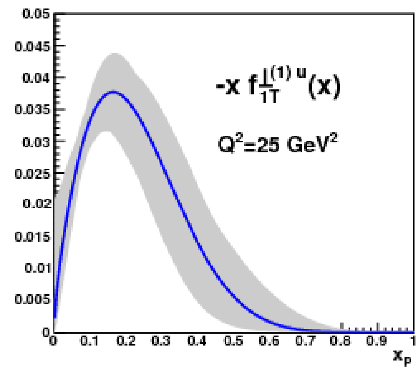


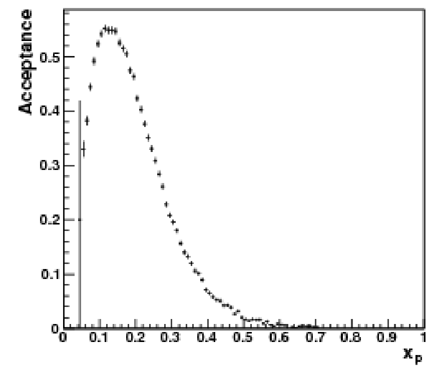
Sivers effect in Drell-Yan processes. M. Anselmino, M. Boglione U. D'Alesio, S. Melis, F. Murgia, A. Prokudin Published in Phys.Rev.D79:054010, 2009

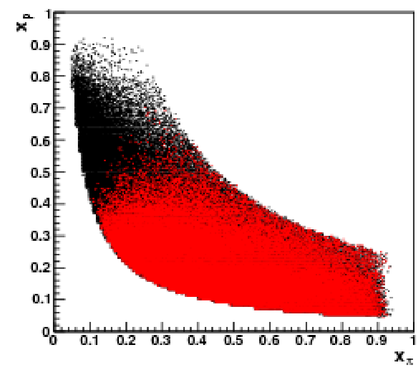
DY@COMPASS – kinematics - valence quark range

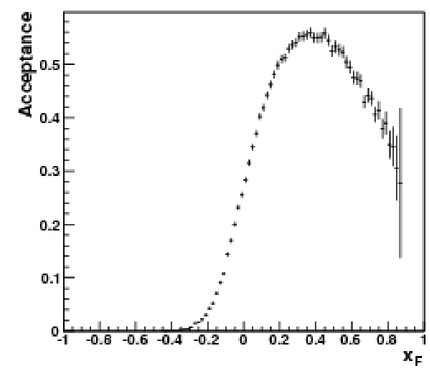
$\pi^- p \rightarrow \mu^- \mu X$

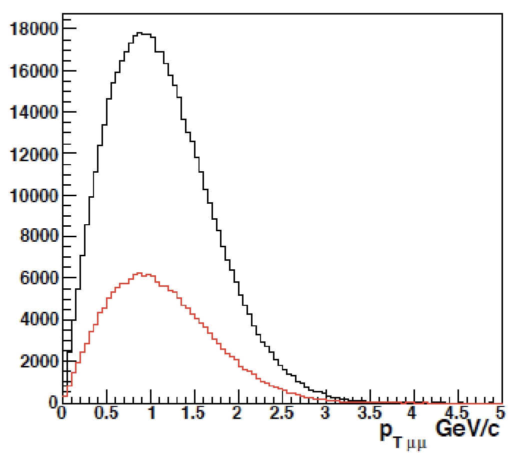
- In our case ($\pi^- p \rightarrow \mu^- \mu X$) contribution from valence quarks is dominant
- In COMPASS kinematics u-ubar dominance
- $<P_T>$ ~ 1GeV – TMDs induced effects expected to be dominant with respect to the higher QCD corrections





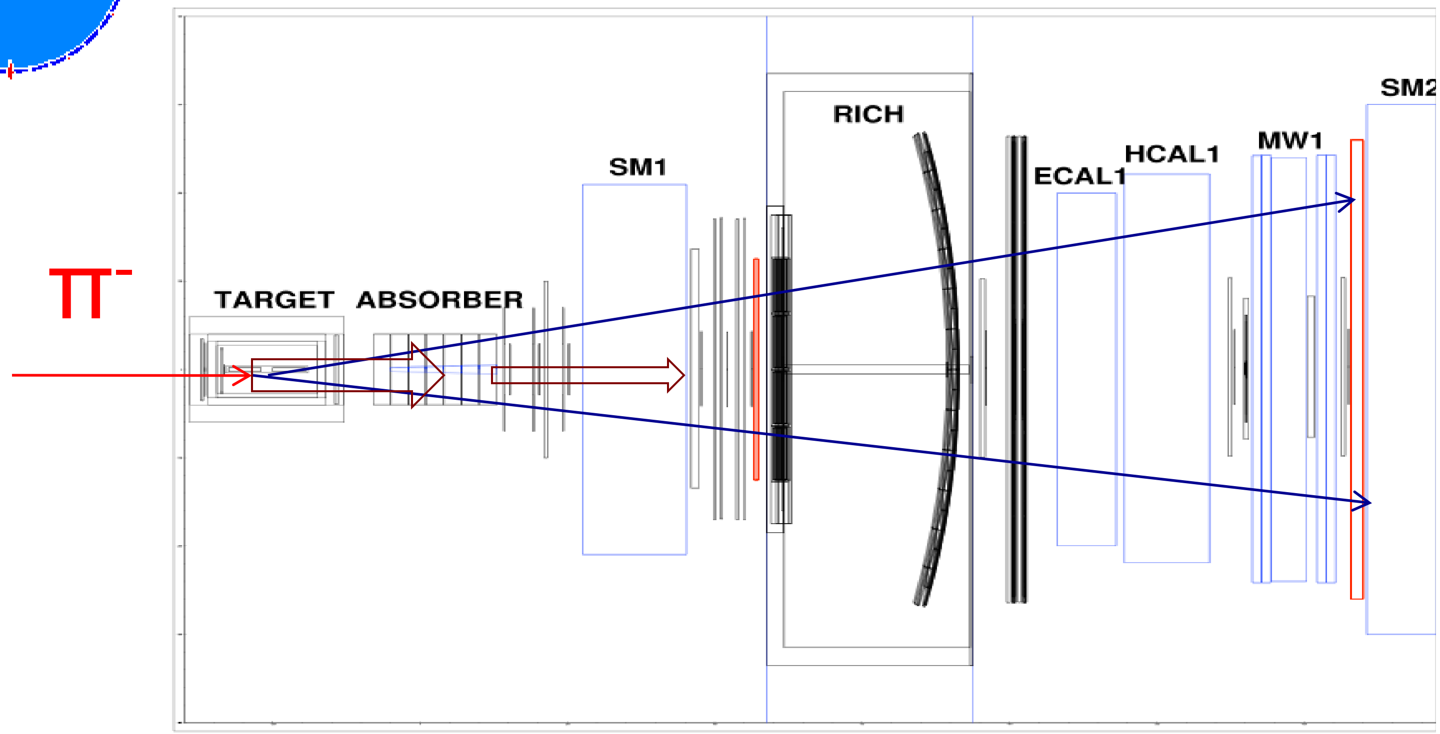






DY@COMPASS - set-up

$\pi^- p \rightarrow \mu^- \mu X$



Key elements:

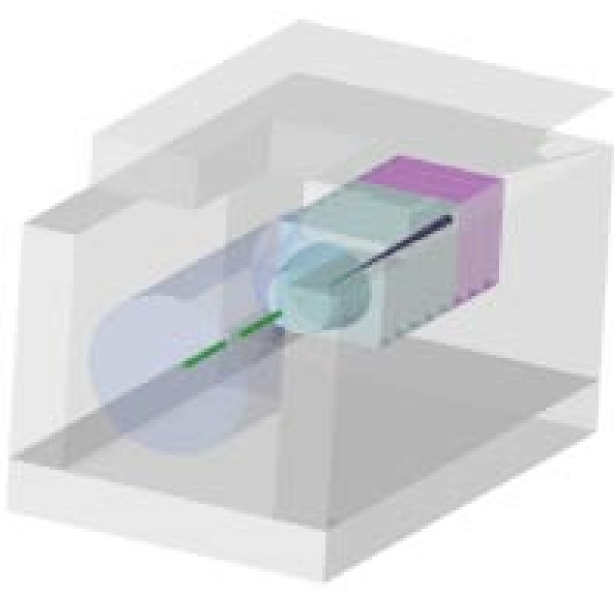
1. COMPASS PT
2. Tracking system (both LAS abs SAS) and beam telescope in front of PT
3. Muon trigger (in LAS is of particular importance - 60% of the DY acceptance)
4. RICH1, Calorimetry – also important to reduce the background (the hadron flux downstream of the hadron absorber ~ 10 higher then muon flux)

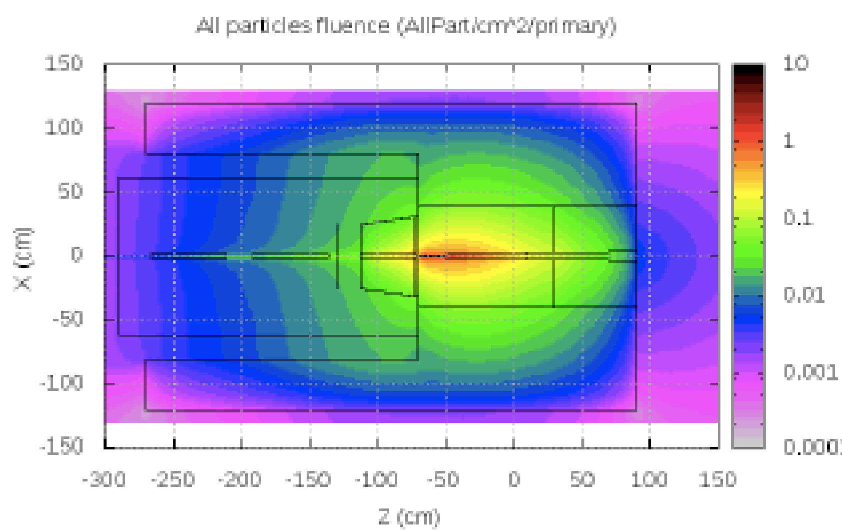
DY@COMPASS - feasibility

- Small cross section - High luminosity experiment
- Polarised target is the key instrument of the program
- Radioprotection issue – experiment similar to NA3
- Detector occupancies
- Trigger rates
- DY event rate (J/Psi as a monitoring signal)
- Physics background study:
  - D-Dbar semi-leptonic decays
  - Combinatorial background from π and K
- COMPASS spectrometer kinematic range

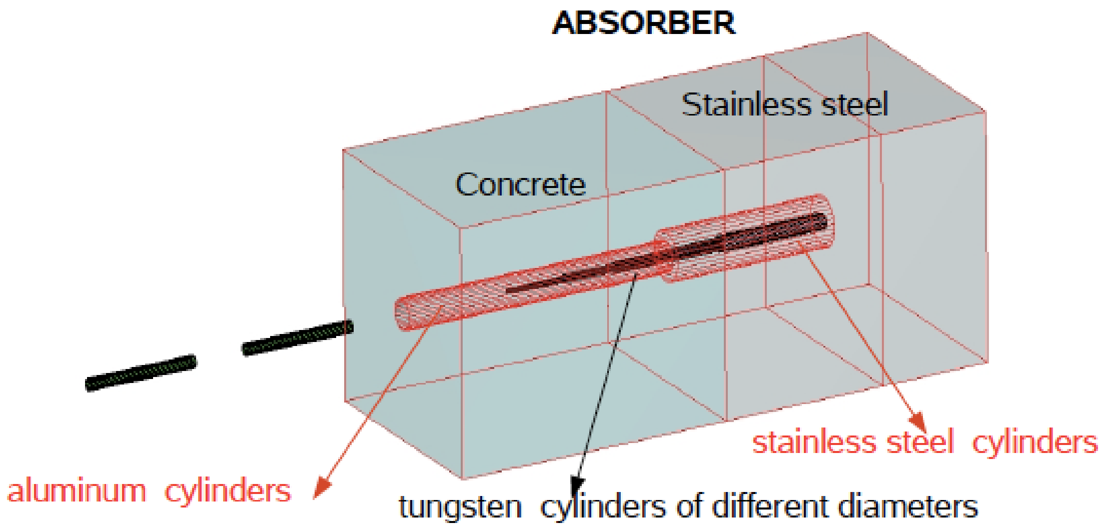
DY@COMPASS - feasibility - PT

- Beam of the intensity up to 10^8 s^{-1} normally not a problem
- Expected heat input ~ 2 mW will not affect relaxation time, refrigerator cooling power is sufficient (~ 5 mW)
- Beam spot has to stay large (~ 1 cm HWHM) – implemented in MC
- The radiation dose is simulated with FLUKA (cross-checked with Radio-Protection group) – the results are communicated to PT group





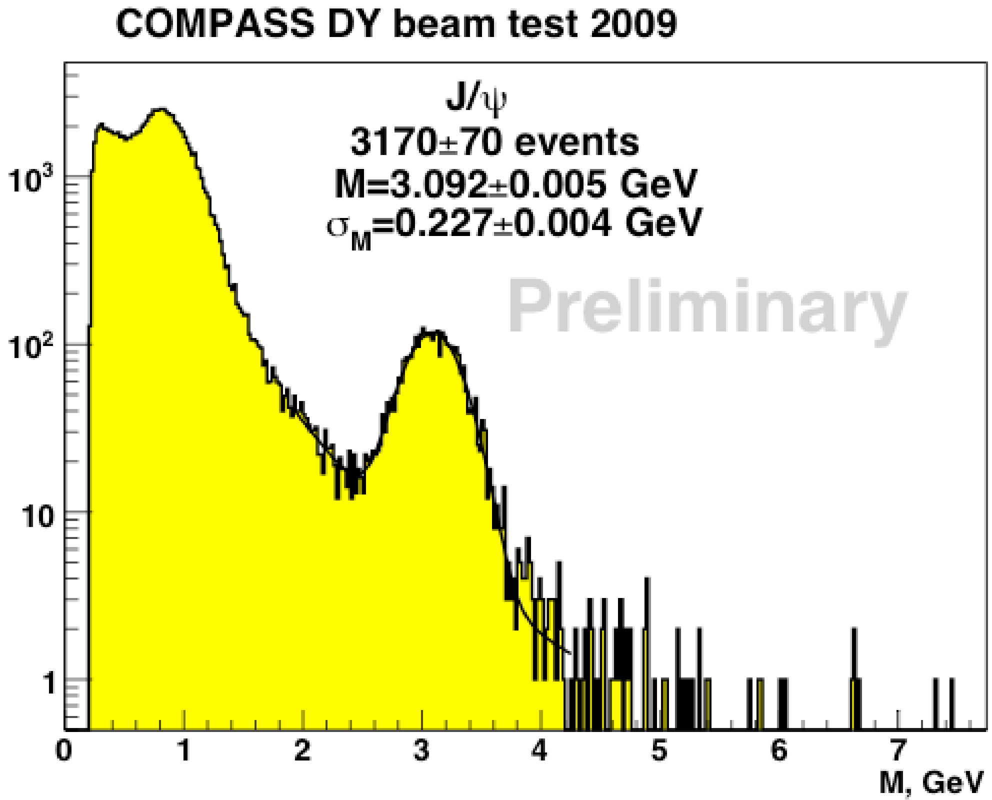
DY Feasibility@COMPASS
Beam Test 2009 – very important results



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

DY@COMPASS - feasibility - Signal

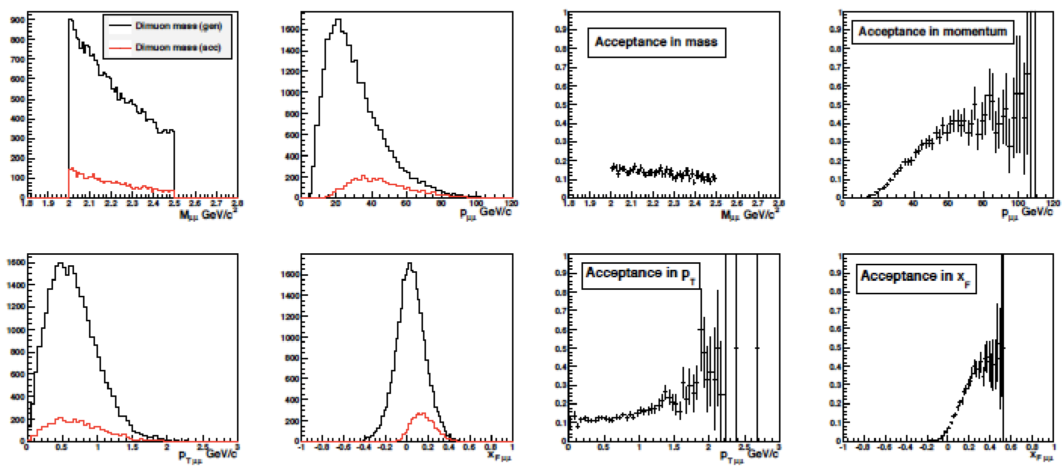
- Expected according to the proposal J/Psi and Drell-Yan yields: 3600±600 and 110±23 (normalized to 2009 beam flux ~3.7 x 10^{11})
- Measured in 2009 beam test J/Psi yield is 3170±70, and DY yield is 84



DY@COMPASS - feasibility – Background – D-Dbar

- Calculated by MC
- Negligible in both HM and IM ranges (~15% contribution in IM)

Acceptance for open-charm 2.0 - 2.5 GeV/c^2

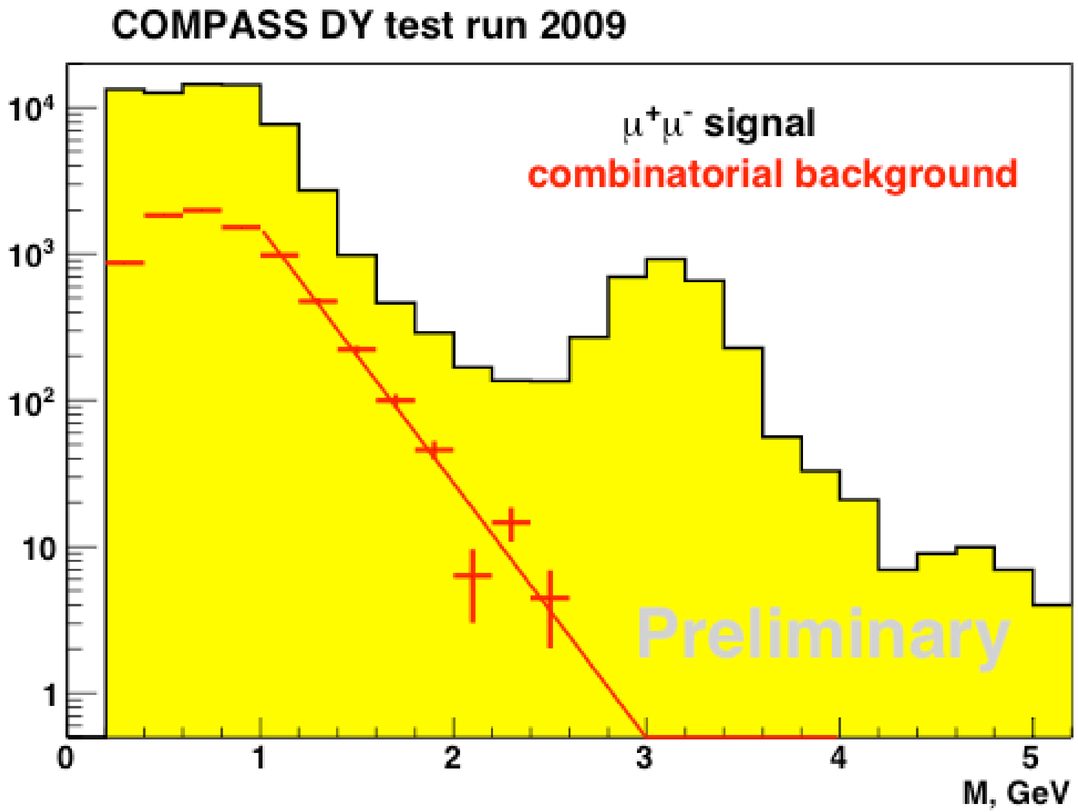


As in the IMR the acceptances are 14% for open-charm and 43% for DY, the ratio of observable events in the dimuon mass spectra will be

$N_{DD}/N_{DY} = (5.47 \times 0.14)/(12.46 \times 0.43) = 0.14$.

DY@COMPASS - feasibility – Background – Combinatorial

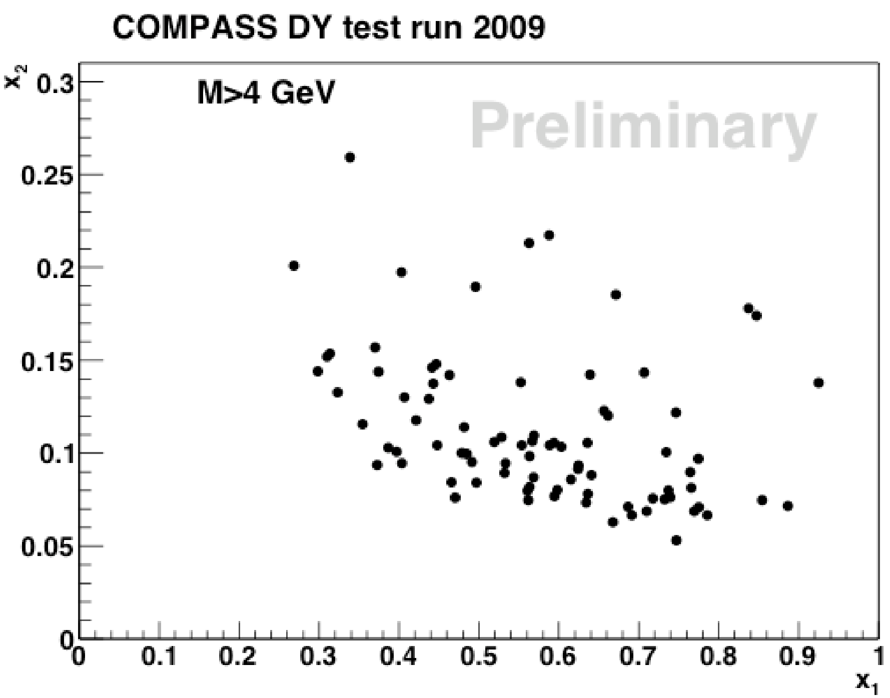
- 2009 beam test id very important
- Combinatorial background suppressed by ~10 at 2.0 GeV/c dimuon invariant mass

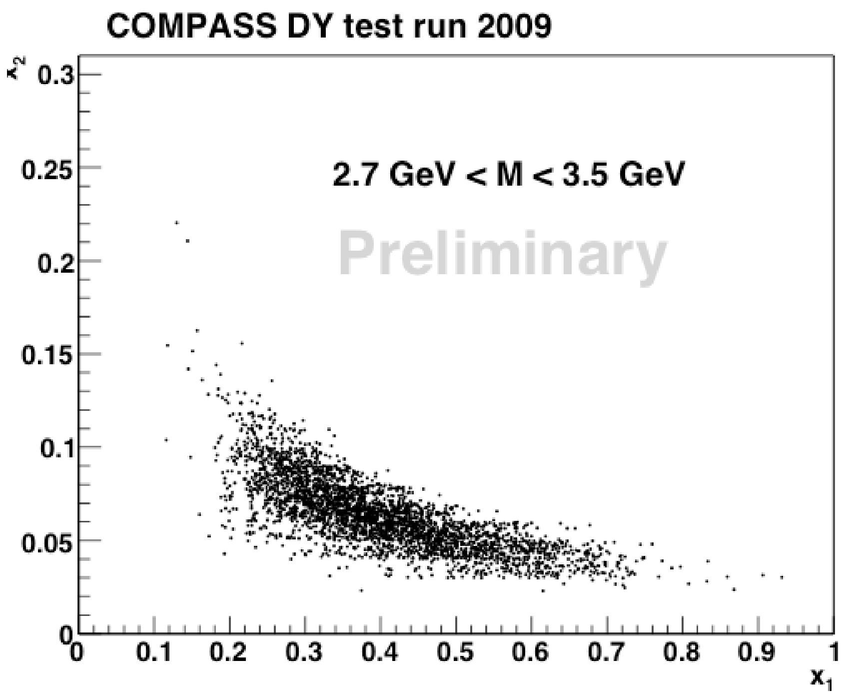


DY@COMPASS - feasibility – Kinematics I

- Valence quark range for both J/Psi and DY

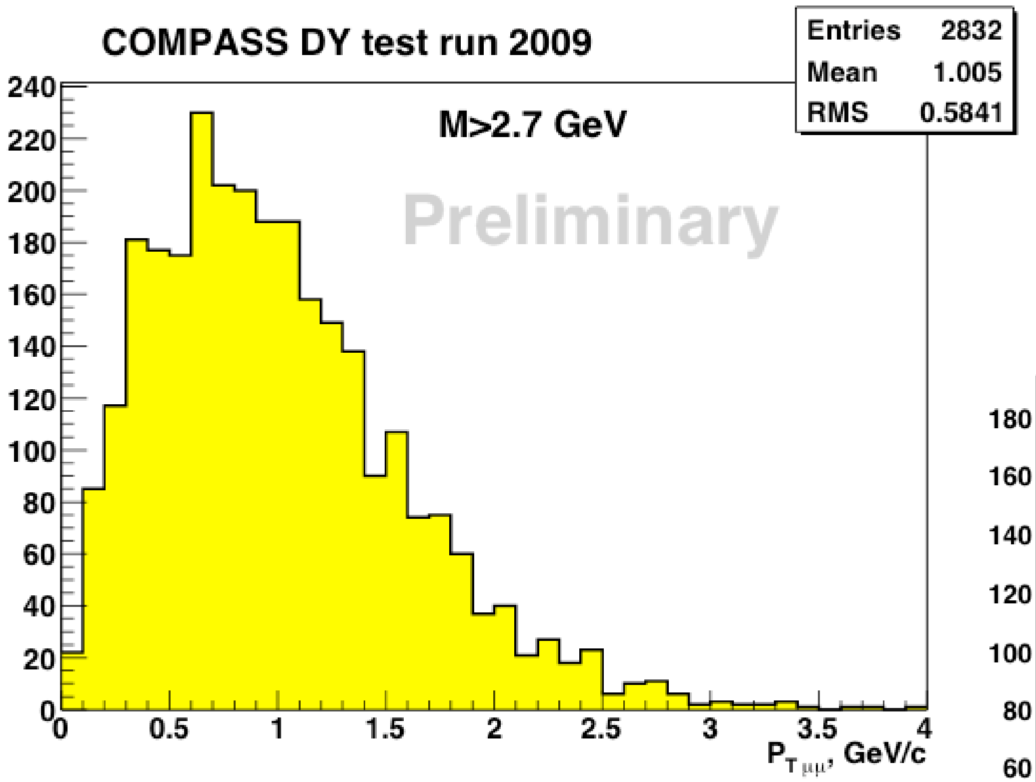
$$x_1 = \frac{Q^2}{P_1 q},$$
$$x_2 = \frac{Q^2}{P_2 q},$$
$$x_f = x_1 - x_2,$$

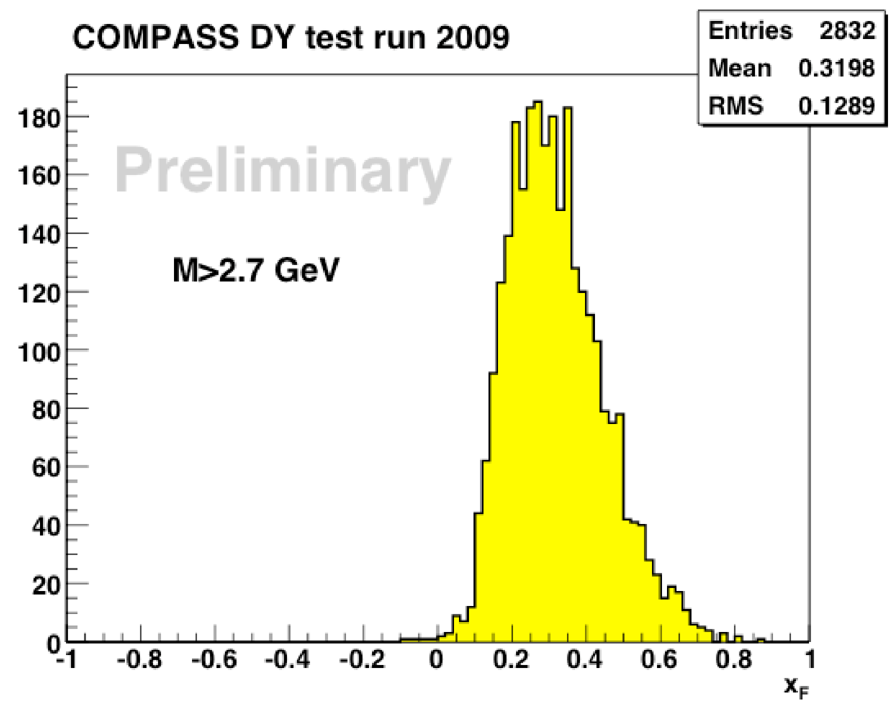




DY@COMPASS - feasibility – Kinematics II

- x_F and q_T ranges





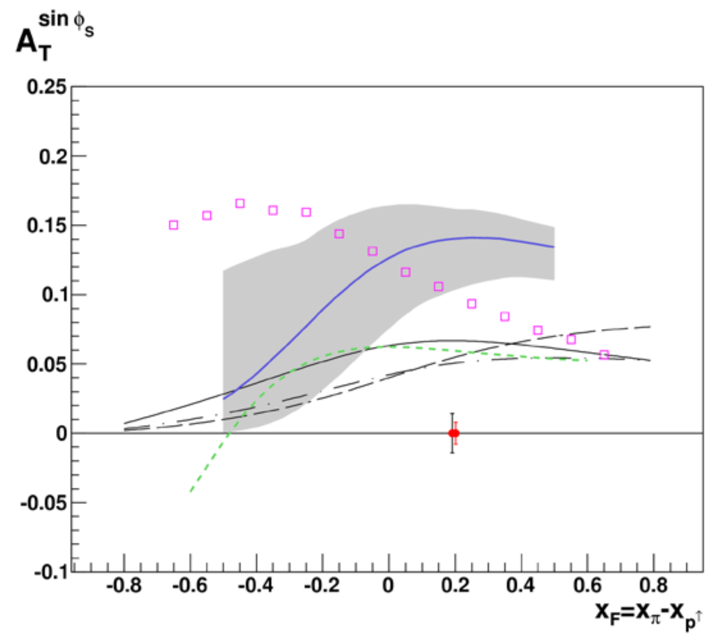
DY@COMPASS projections I

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.

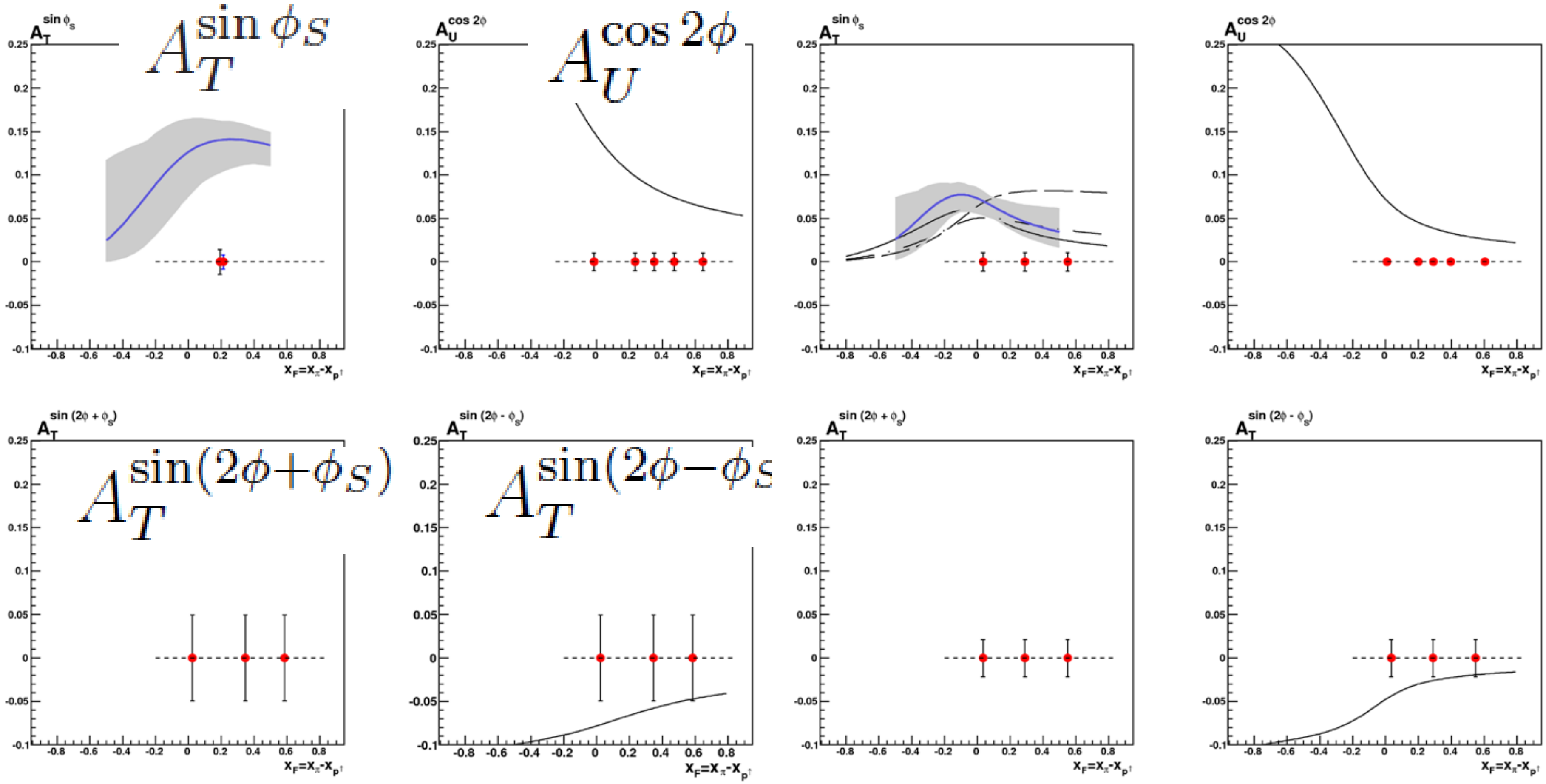
↪ Assuming 2 years of data-taking, one can collect > 200000 DY events in the region $4 < M_{\mu\mu} < 9.$ GeV/c^2.

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.

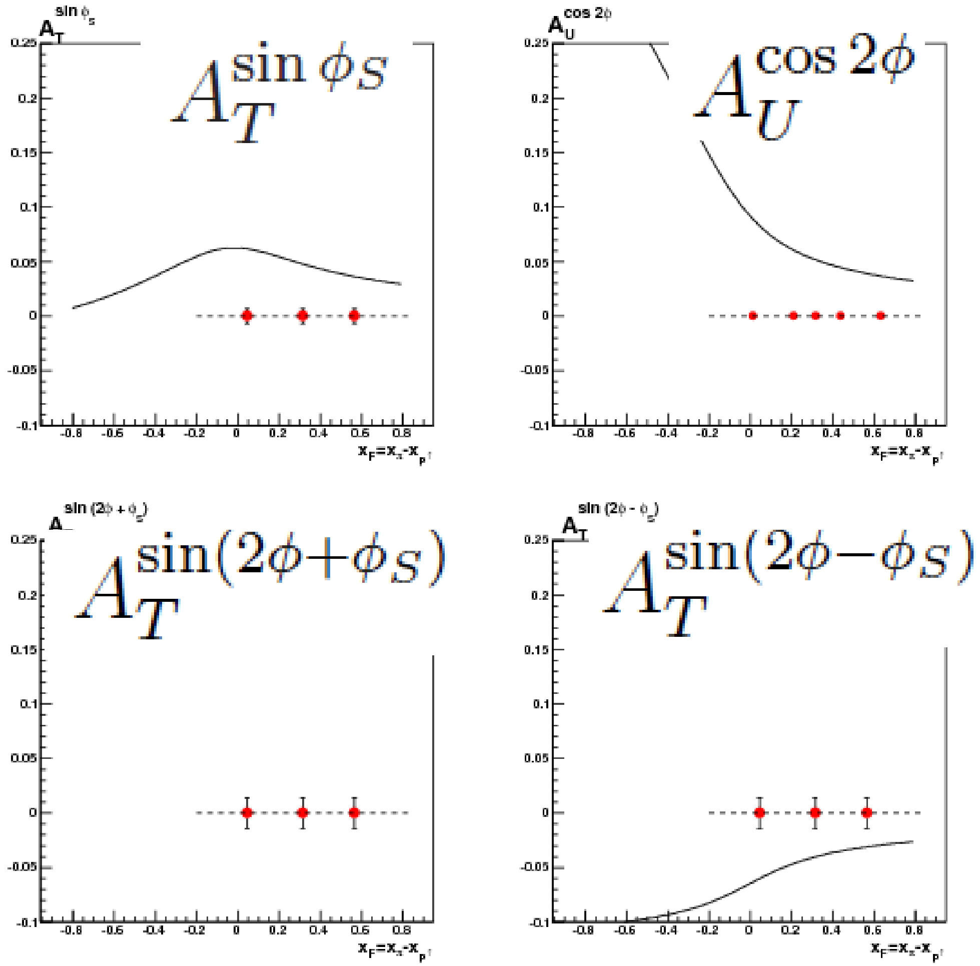


DY@COMPASS projections II



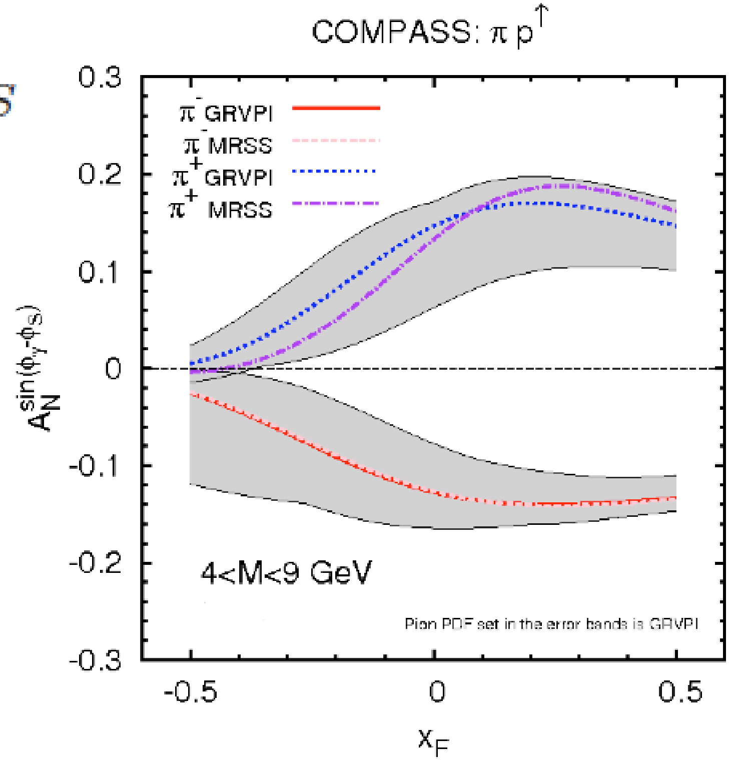
$$(\text{HMR}): 4. \leq M_{\mu\mu} \leq 9.\ \text{GeV}/c^2 \quad (\text{IMR}): 2.0 \leq M_{\mu\mu} \leq 2.5\ \text{GeV}/c^2$$

$$J/\psi \text{ region: } 2.9 \le M_{\mu\mu} \le 3.2\ \mathrm{GeV/c^2}$$



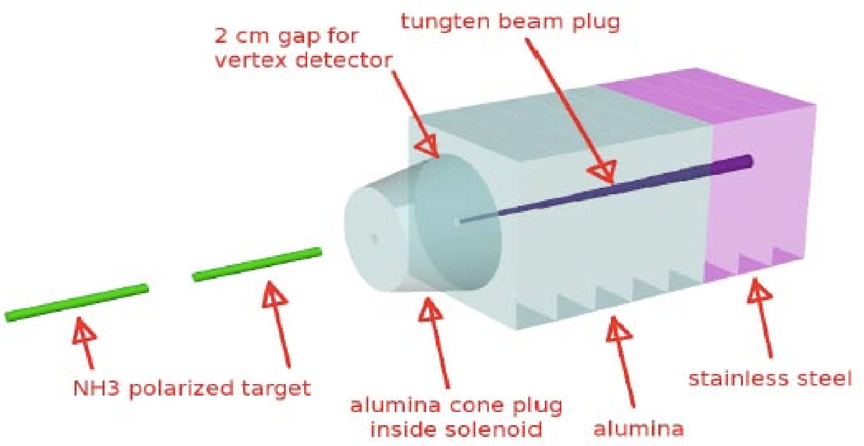
DY@COMPASS uncertainty coming from the pion PDFs

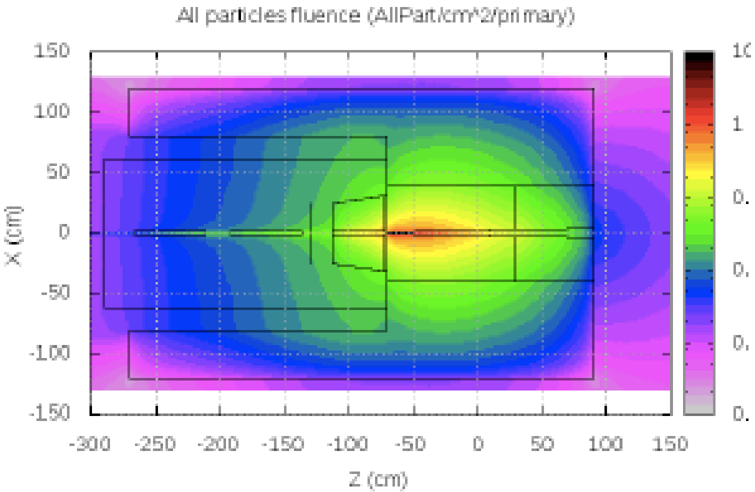
$A_T^{\sin \phi_S}$

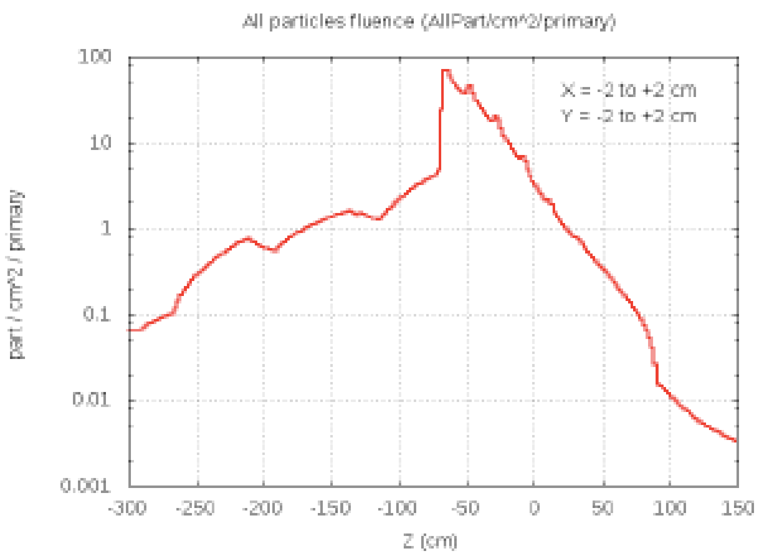


In case of $\pi^- p$ scattering the valence pion $\bar{u}$ unpolarised PDF is well known and there is no difference between two pdf sets. In case of $\pi^+ p$ scattering there is a little contamination coming from sea $\bar{u}$ of the pion, which annihilates with valence u quark of the proton, because the distribution functions are weighted in the cross section with e_q^2, and the $\bar{u}u$ contribution is multiplied by factor 4/9 while the $\bar{d}d$ by factor 1/9. Thus, the contribution from the sea $\bar{u}$ of the pion can not be neglected, it is less known with respect to valence PDFs and it explains the difference from one data set (GRVPI) to another (MRSS).

DY@COMPASS upgrades: Absorber







- The absorber geometry and composition is optimized taking into account the experience of past DY experiments
- The MC (FLUKA) simulation of the stopping power as well as particle fluxes downstream of the absorber is performed
- The recommendations on the RP shielding is worked out (cross-check by CERN RP group is in progress)

DT@COMPASS: Summary

- Can be first ever polarised Drell-Yan experiment, sensitive to TMD PDFs induced effects
- DY@COMPASS process dominated by the contribution from the valence quarks ($\tau = x_1x_2 = Q^2/s \cong 0.05 \div 0.3$), it is pure u-dominance channel because of the π^- beam
- Key measurement:
  - TMD PDF universality test SIDIS ←→ DY
  - Fundamental test of QCD - T-odd TMD (Sivers and Boer-Mulders) sign change from SIDIS to DY
- Now we can say (after series of beam tests) that the feasibility is proven
- Statistical error on single spin asymmetries is on the level $1 \div 2\%$ in two years of data taking (useful event yield is confirmed by the results of 2009 beam test)
- In case we successful the DY measurement with antiproton beam can be considered as a continuation of the program

- Spares

Drell-Yan Workshop at CERN, April 26-27

Studying the hadron structure in Drell-Yan reactions

26-27 April 2010 *CERN*

- **Overview**
- Programme
- Registration
  - Registration Form
- List of registrants
- Laptop and Wireless access
- Access Cards
- Accomodation
- How to get to CERN

Support

Since a long time the Drell-Yan (DY) process is considered to be a powerful tool to study hadron structure. In the past, several experiments were successfully carried out using unpolarised beams and targets. Nowadays, taking into account the much advanced understanding of the spin structure of the nucleon, we are discussing a new generation of DY measurements using polarised beams and/or targets.

The COMPASS collaboration is currently preparing a proposal for future studies of nucleon structure beyond 2011. One of the main aims is a first measurement of transverse-momentum-dependent parton distributions (TMDs) using the Drell-Yan process on a transversely polarised proton target hit by a pion beam. Among the distributions to be studied are Sivers, Boer-Mulders and pretzelosity TMDs as well as transversely polarised quark distributions.

The workshop will review ongoing theoretical and experimental efforts related to the Drell-Yan process. Detailed presentations and discussions of the theoretical aspects will be complemented by descriptions of planned fixed-target and collider experiments.

Organizers: Paula Bordalo (LIP-Lisbon and IST/UTL)
Oleg Denisov (CERN/INFN-Torino)
Eva-Maria Kabuss (Mainz)
Fabienne Kunne (CEA Saclay)
Alain Magnon (CEA Saclay)
Gerhard Mallot (CERN)
Anna Martin (Univ. Trieste and INFN-Trieste)
Wolf-Dieter Nowak (CERN)
Daniele Panzieri (Univ. Alessandria and INFN-Torino)

Dates: from 26 April 2010 09:00 to 27 April 2010 18:00

Location: *CERN*
Salle Andersson
Room: 40-S2-A01

Drell-Yan Workshop at CERN, April 26-27

Monday 26 April 2010

09:00 - 09:05	Welcome *05'* (CERN (40-2-A01)
09:05 - 09:35	Theory Overview *30'* Speakers: Daniel Boer
09:35 - 09:45	Discussion *10'*
09:45 - 10:15	Experiment overview *30'* Speakers: Paul Reimer
10:15 - 10:25	Discussion *10'*
10:25 - 10:55	QCD corrections for the DY process *30'* Speakers: Werner Vogelsang
10:55 - 11:10	Discussion *15'*
11:10 - 11:30	Coffee Break
11:30 - 12:00	General form of the DY cross-section *30'* Speakers: Marc Schlegel
12:00 - 12:15	Discussion *15'*
12:15 - 12:45	Single transversely polarised DY, observables, TMDs *30'* Speakers: Aram Kotzinian
12:45 - 13:00	Discussion *15'*
13:00 - 14:30	Lunch Break
14:30 - 15:00	TMD universality, factorization and sign change SIDIS-DY *30'* Speakers: Alessandro Bacchetta
15:00 - 15:15	Discussion *15'*
15:15 - 15:45	TMD phenomenology in SIDIS and DY *30'* Speakers: Stefano Melis
15:45 - 16:00	Discussion *15'*
16:00 - 16:30	Coffee Break
16:30 - 18:00	Theory - round table (topics: key issues in DY measurements, models, predictions,

Drell-Yan Workshop at CERN, April 26-27

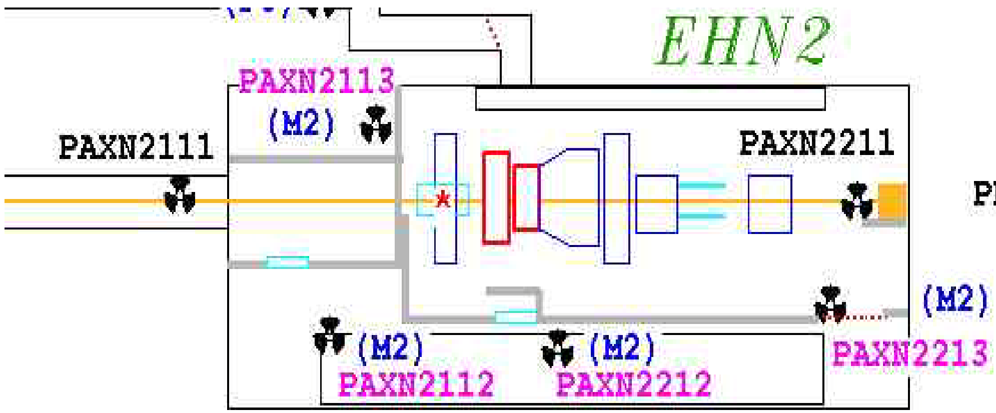
exclusive DY, GPDs) *1h30'*
Speakers: Oleg Teryaev, Marco Radici

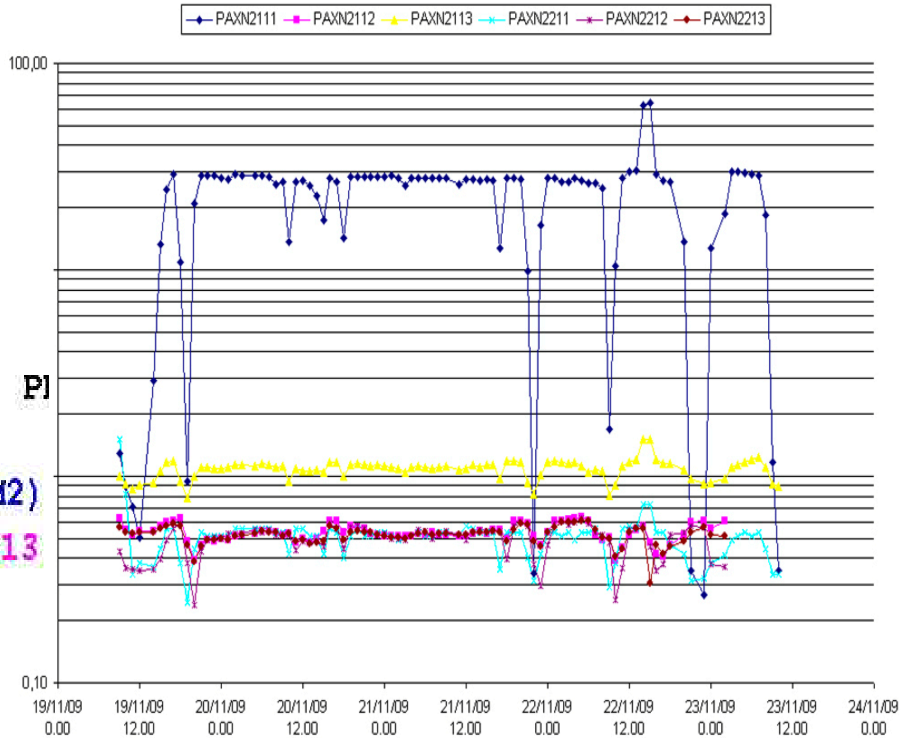
Tuesday 27 April 2010

09:00 - 09:20	Future Drell-Yan fixed target experiments at Fermilab *20'* Speakers: Wolfgang Lorenzon
09:20 - 09:30	Discussion *10'*
09:30 - 09:50	Future Drell-Yan collider experiments *20'* Speakers: Matthias Grosse Perdekamp
09:50 - 10:00	Discussion *10'*
10:00 - 10:20	Future Drell-Yan experiments at J-Parc and at RHIC (internal target) *20'* Speakers: Yuji Goto
10:20 - 10:30	Discussion *10'*
10:30 - 11:00	Coffee Break
11:00 - 11:20	Future Drell-Yan experiments at GSI *20'* Speakers: Paolo Lenisa
11:20 - 11:30	Discussion *10'*
11:30 - 11:50	Future Drell-Yan program at NICA *20'* Speakers: Alexander Nagaytsev
11:50 - 12:00	Discussion *10'*
12:00 - 12:20	Future COMPASS Drell-Yan experiment *20'* Speakers: N.N.
12:20 - 12:30	Discussion *10'*
12:30 - 13:00	Concluding remarks *30'* Speakers: Mauro Anselmino
13:00 - 14:30	Lunch break
14:30 - 17:00	Visit to the COMPASS experiment (optional) Location: COMPASS Experiment (Prevessin Site 888)

DY@COMPASS - feasibility - RP

- Very important 2009 beam test
- At 1.5x10[8] /spill stays below 0.5 uSv (allowed 3 uSv)
- Conclusion by CERN RP group – well under control

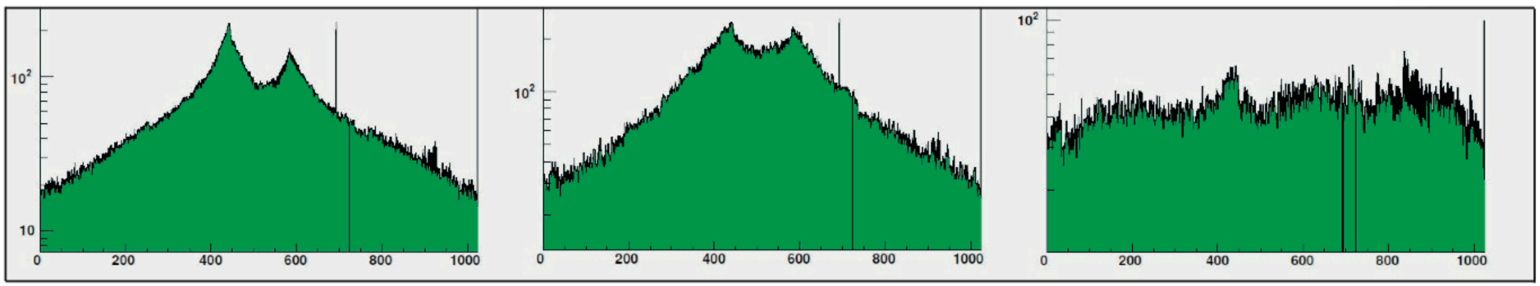




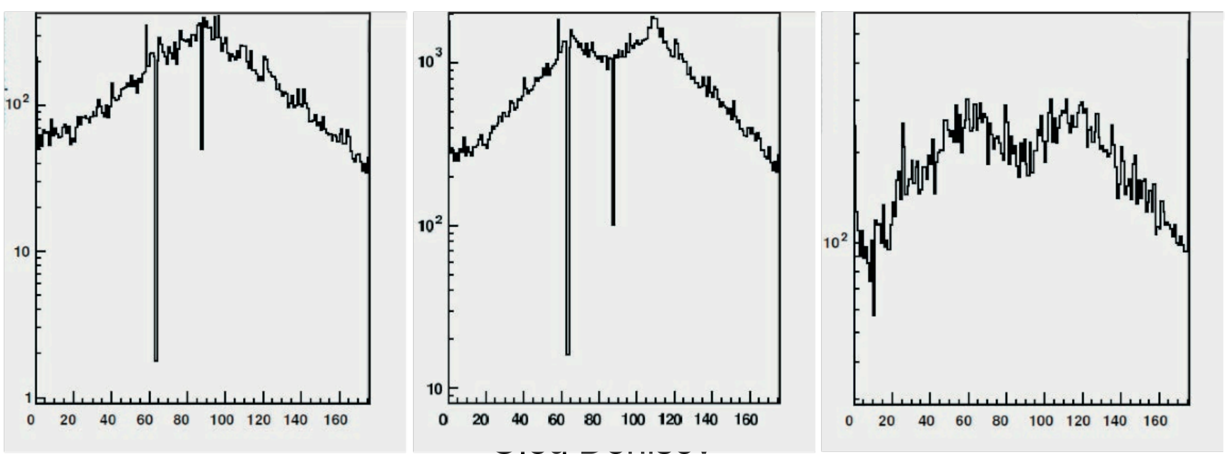
DY@COMPASS - feasibility - occupancies

- Very important 2009 beam test
- Occupancies are ~ factor 10 lower with respect to standard muon or hadron spectroscopy running

rates per channel (kHz)



rates per channel (kHz)



DY@COMPASS - feasibility - trigger

- Very important 2009 beam test
- Sort of muon trigger was implemented in LAS based on HCal1
- Trigger rate < 50 kEvents/spill

Controller Status: okay ?

onSpill: 0 Spill: 6 Triggers: 248745

Prescaler Status: okay ?

num	name	div	attempts	triggers	MTi/attempts
0	LTi	1	41400	41400	1.77
1	MT+HCAL1m	1	328	328	222.87
2	LT+HCAL1m	1	608	608	120.23
3	OT+HCAL1m	1	175	175	417.73
4	HCAL2m	1	55187	55187	1.32
5	VetoInner	1000	1545636	1546	0.05
6	Halo	500	337107	675	0.22
7	BeamT	1000	52180988	52181	0.00
8	MTi	1	73102	73102	1.00
9	HCAL1m	10	697729	69773	0.10
10	OTi	1	1910	1910	38.27
11	TRand	100	307974	3080	0.24
deadtime not available				299965	----

Deadtime: 2_10_250 v plot

Controller Status: okay ?

onSpill: 0 Spill: 0 Triggers: 0

Prescaler Status: okay ?

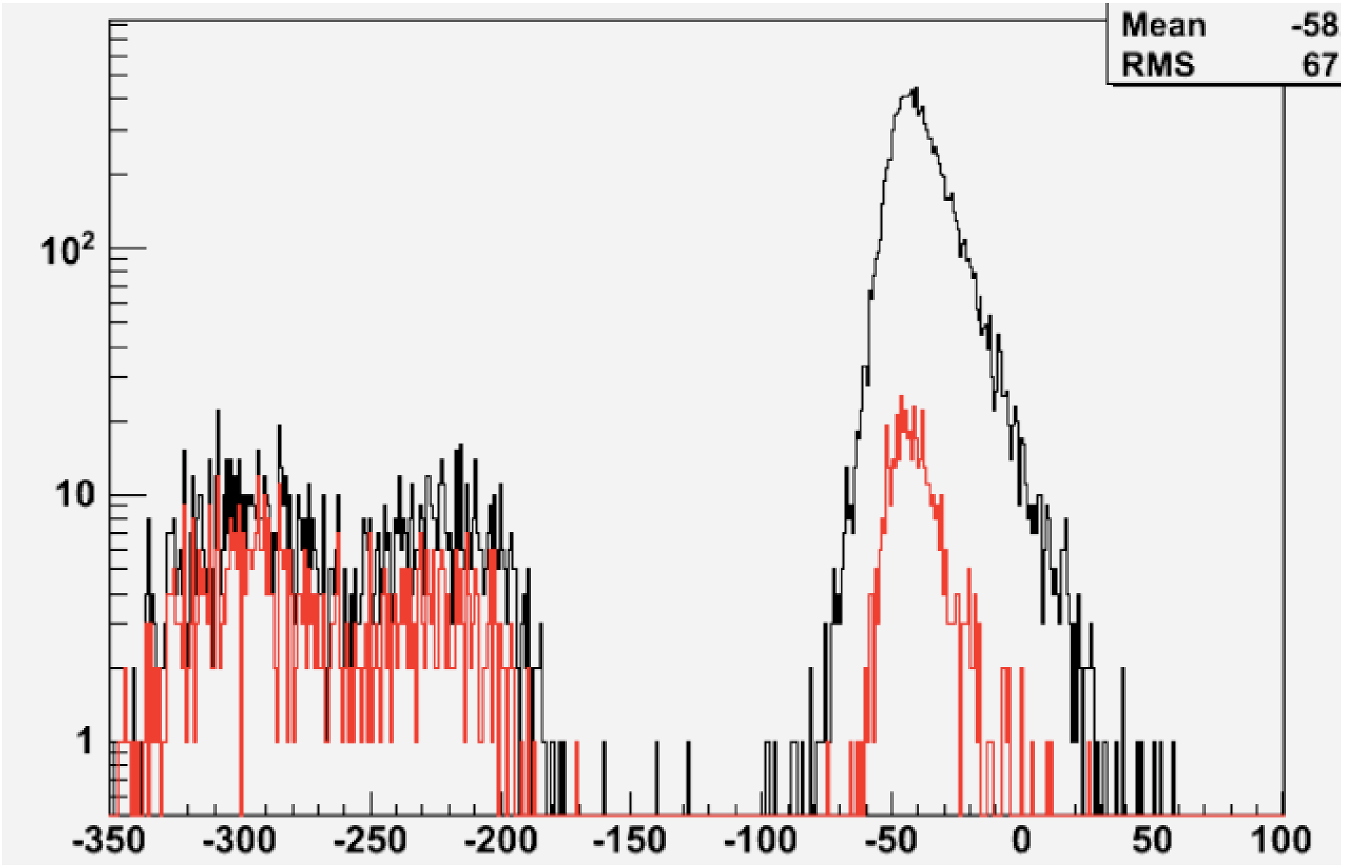
num	name	div	attempts	triggers	MTi/attempts
0	LTi	1	69885	69885	1.79
1	MT+HCAL1m	1	836	836	149.36
2	LT+HCAL1m	1	1333	1333	93.67
3	OT+HCAL1m	1	354	354	352.73
4	HCAL2m	1	98873	98873	1.26
5	VetoInner	1000	2806971	2807	0.04
6	Halo	500	663445	1327	0.19
7	BeamT	10000	71812665	7182	0.00
8	MTi	1	124867	124867	1.00
9	HCAL1m	100	1091782	10918	0.11
10	OTi	1	3398	3398	36.75
11	TRand	100	307851	3079	0.41
deadtime not available				324859	----

Deadtime: 2_10_250 v plot

UPGRADES:
DY@COMPASS upgrades: Trigger

Mass Range GeV	Global acceptance %	LAS	LAS+SAS	SAS
$4-9$	35	64	40	4
$2-2.5$	43	32	54	20

Table 2: Global and partial acceptance of the spectrometer for dimuons belonging to two mass ranges .



Competition and complementarity

Facility		Type		s (GeV^2)	Timeline
RHIC (STAR)	[134]	collider,	$p^{\Uparrow}p$	200^2	> 2013
E906 (Fermilab)	[135]	fixed target,	pp,	250	> 2011
J-PARC	[136]	fixed target,	$pp^{\Uparrow}$, $\pi p^{\Uparrow}$	$60 \div 100$	> 2015
GSI (PAX)	[137]	collider,	$\bar{p}^{\Uparrow}p^{\Uparrow}$	200	> 2017
GSI (Panda)	[138]	fixed target,	$\bar{p}p$	30	> 2016
NICA	[139]	collider,	$p^{\Uparrow}p^{\Uparrow}$, $d^{\Uparrow}d^{\Uparrow}$	676	> 2014
COMPASS	(this letter)	fixed target,	$\pi^- p^{\Uparrow}$	$300 \div 400$	> 2012

Table 10: Future Drell–Yan experiments.

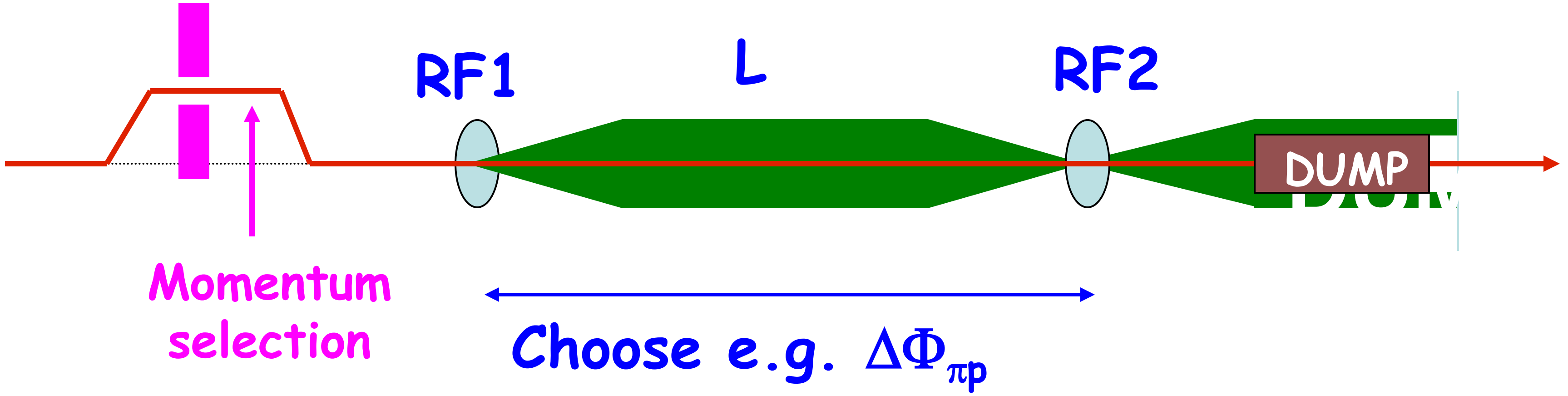
DY@COMPASS upgrades: beam telescope and additional tracking station downstream of PT

- Beam telescope upstream of the COMPASS PT
  - Radiation hardness (beam intensity ~ $6x10^7$ s^{-1}), 280 days in total
  - Good time resolution (~ few ns)
  - Moderate space resolution (50-100 um)
- Most probable, the additional tracking station will help to vertex resolution, further MC required. NA50 experience is not positive, but with ~ 10 higher intensity
- The issue will be discussed on one of the forthcoming TB meetings

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:



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