Drell-Yan Di-Muon Production in PANDA

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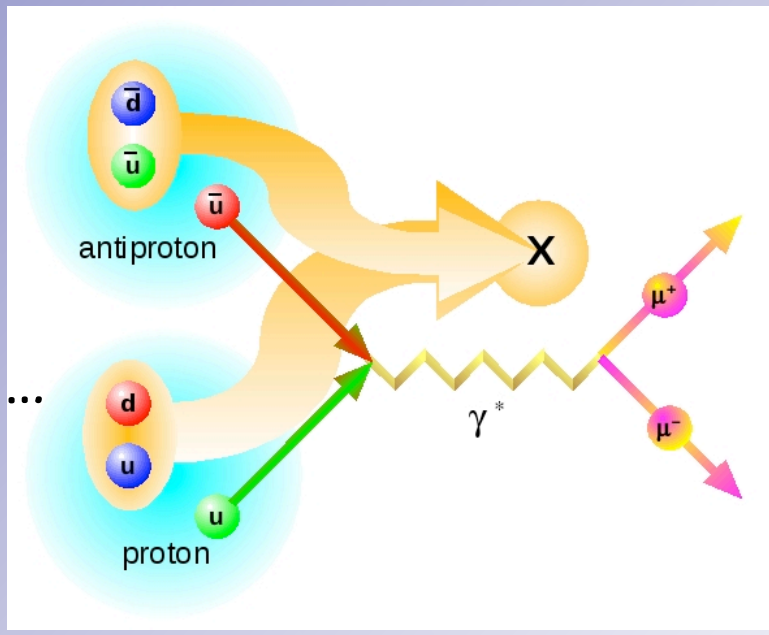
Overview

- Motivation
- Drell-Yan process and background
  - A. Bianconi Drell-Yan generator
  - Cut studies
- Investigation of Drell-Yan asymmetries
- Summary

Drell-Yan Process and Background

- Drell-Yan: $\bar{p}p \rightarrow \mu^+\mu^- X$

  cross section $\sigma \sim 1$ nb @ $s = 30\ GeV^2$



- Background: $pp \rightarrow \pi^+\pi^- X$, $2\pi^+2\pi^- X$,.....

  cross section $\sigma \sim$ 20-30 mb

  $m_\mu = 105\ MeV/c^2$; m_π 140 MeV/c^2

  average primary pion pairs: ~ 1.5

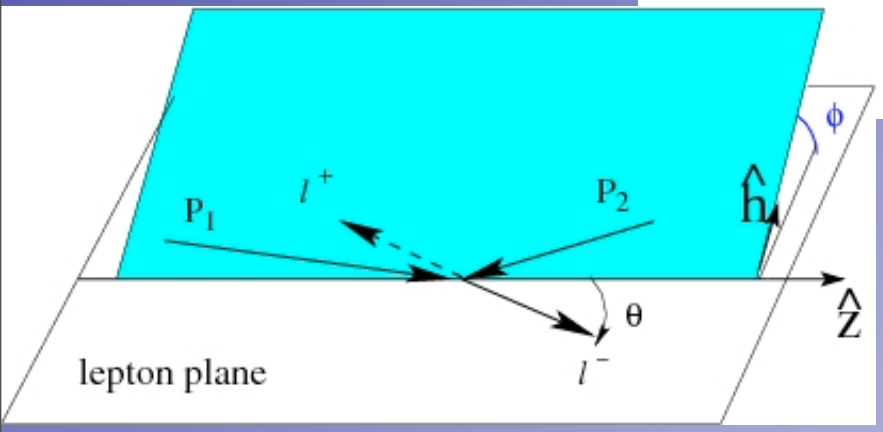
- Background studies: needed rejection factor of 10^7

Drell-Yan Asymmetries

UNPOLARISED

Collins-Soper frame

$$\frac{d\sigma^o}{d\Omega dx_1 dx_2 d\mathbf{q}_T} = \frac{\alpha^2}{12Q^2}\sum_f e_f^2 \left\{ (1+\cos^2\theta)\,\mathcal{F}\left[\bar{f}_1^f\, f_1^f\right] + f\,\sin^2\theta\,\cos 2\phi\,\mathcal{F}\left[\left(2\hat{\mathbf{h}}\cdot\mathbf{p}_{1_T}\,\hat{\mathbf{h}}\cdot\mathbf{p}_{2_T} - \mathbf{p}_{1_T}\cdot\mathbf{p}_{2_T}\right)\frac{\bar{h}_1^{\perp f}\, h_1^{\perp f}}{M_1 M_2}\right]\right\}$$



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$$\frac{d\sigma}{d\Omega dx_1 dx_2 d\boldsymbol{q}_T} = \frac{d\sigma^o}{d\Omega dx_1 dx_2 d\boldsymbol{q}_T} + \frac{d\Delta\sigma^{\uparrow}}{d\Omega dx_1 dx_2 d\boldsymbol{q}_T}$$

$$\frac{d\Delta\sigma^{\uparrow}}{d\Omega dx_1 dx_2 d\mathbf{q}_T} = \frac{\alpha^2}{12sQ^2}\sum_f e_f^2\,|\mathbf{S}_{2_T}|\left\{ (1+\cos^2\theta)\,\sin(\phi-\phi_{S_2})\,\mathcal{F}\left[\hat{\mathbf{h}}\cdot\mathbf{p}_{2_T}\,\frac{\bar{f}_1^f\, f_{1T}^{\perp f}}{M_2}\right] - \sin^2\theta\,\sin(\phi+\phi_{S_2})\,\mathcal{F}\left[\hat{\mathbf{h}}\cdot\mathbf{p}_{1_T}\,\frac{\bar{h}_1^{\perp f}\, h_{1T}^{f}}{M_1}\right] - \sin^2\theta\,\sin(3\phi-\phi_{S_2})\,\mathcal{F}\left[\left(4\hat{\mathbf{h}}\cdot\mathbf{p}_{1_T}\,(\hat{\mathbf{h}}\cdot\mathbf{p}_{2_T})^2 - 2\hat{\mathbf{h}}\cdot\mathbf{p}_{2_T}\,\mathbf{p}_{1_T}\cdot\mathbf{p}_{2_T} - \hat{\mathbf{h}}\cdot\mathbf{p}_{1_T}\,\mathbf{p}_{2_T}^2\right)\frac{\bar{h}_1^{\perp f}\, h_{1T}^{\perp f}}{2M_1 M_2^2}\right]\right\}$$

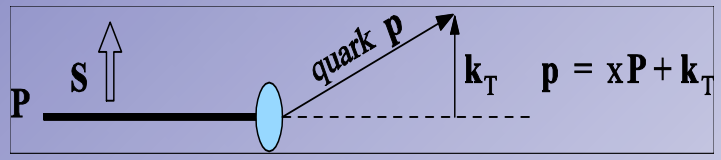
U = N(cos2 ϕ >0)

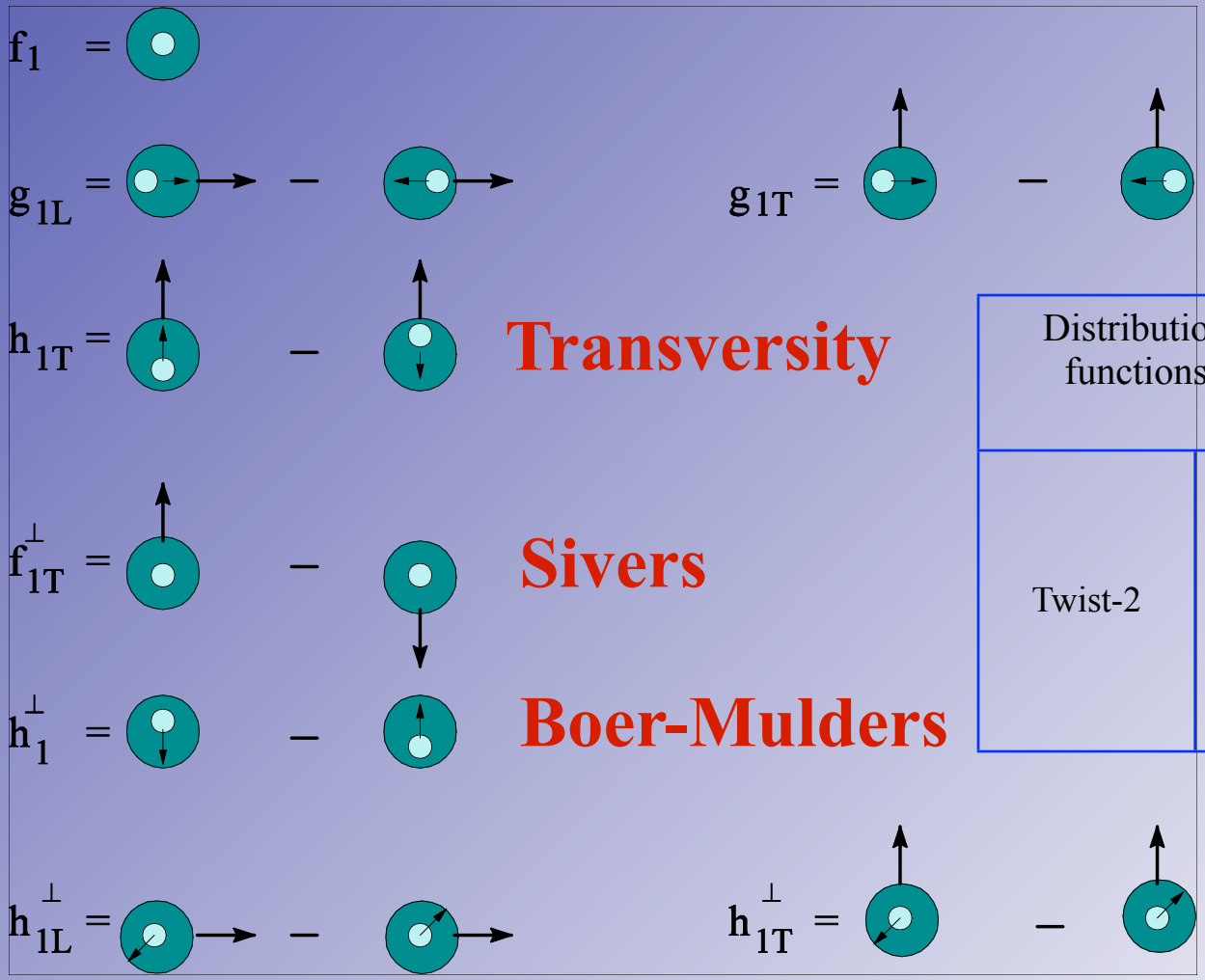
D = N(cos2 ϕ <0)

Asymmetry $A = \dfrac{U-D}{U+D}$

TMD: K_T-dependent Parton Distributions

Twist-2 PDFs $f_1(x) = \int d^2k_T f_1(x,k_T)$

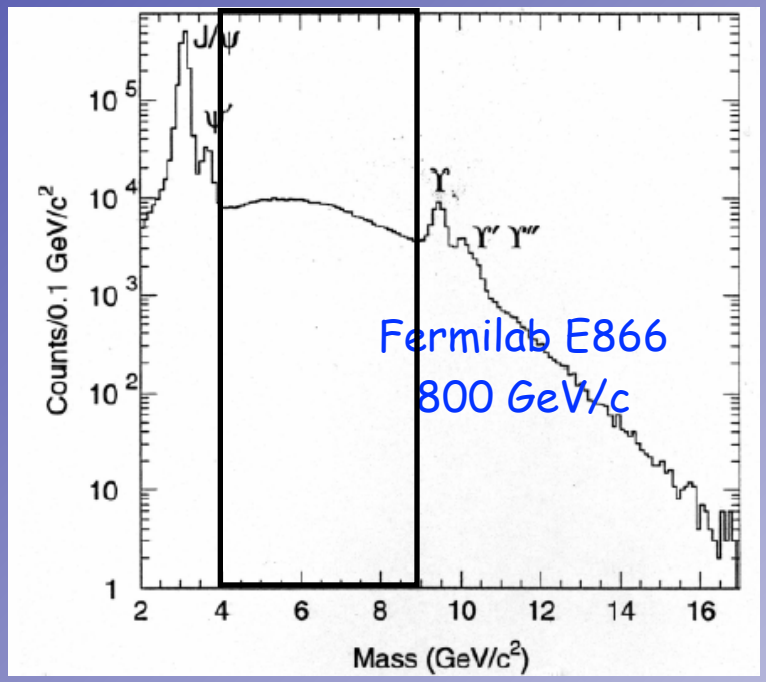


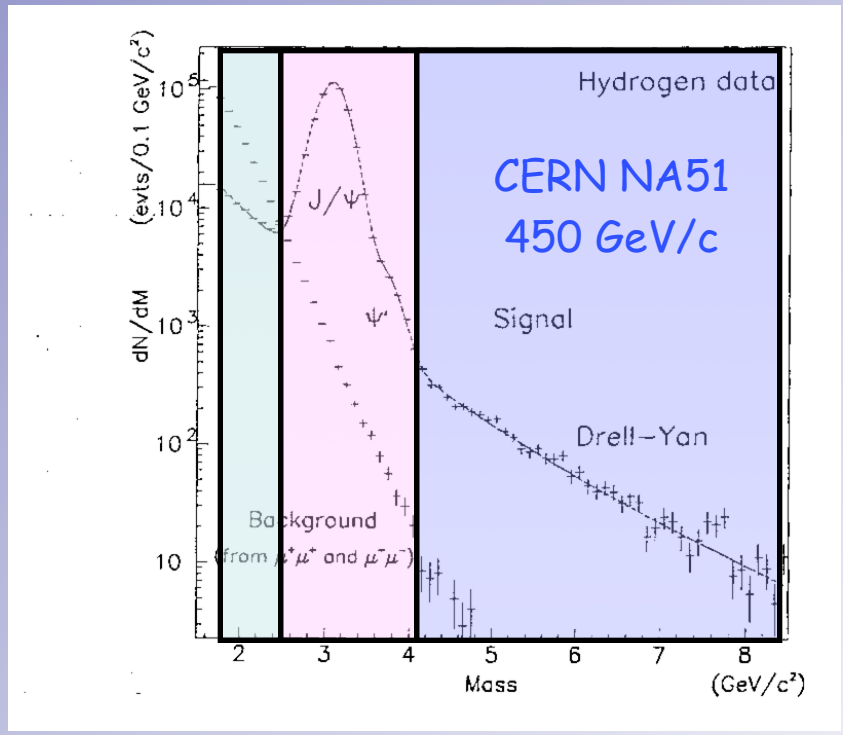


Distribution functions		Chirality even	Chirality odd
Twist-2	U	f_1	$h_1^{\perp}$
	L	g_1	$h_{1L}^{\perp}$
	T	$f_{1T}^{\perp}, g_{1T}$	h_1, $h_{1T}^{\perp}$

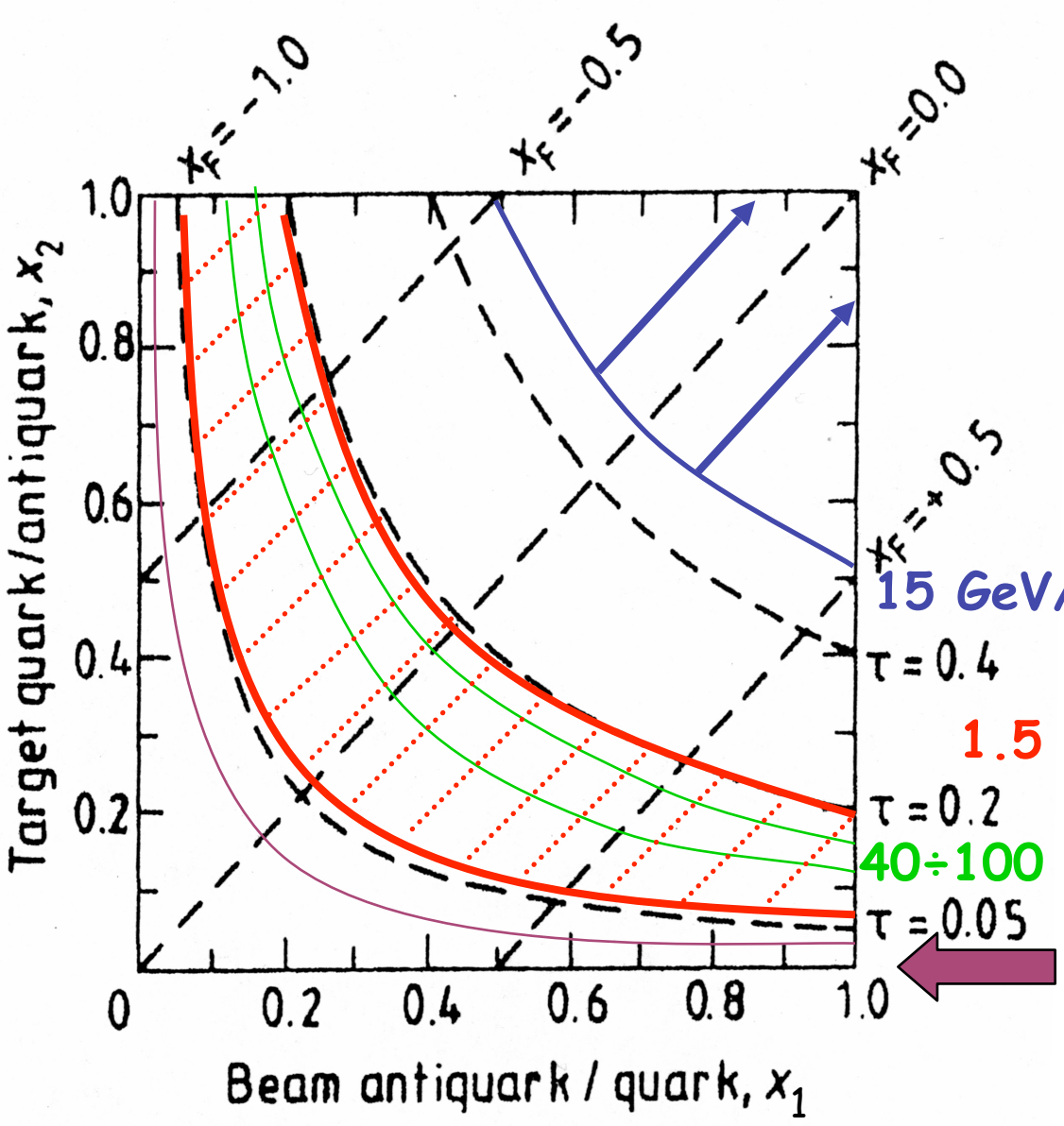
Di-Lepton Production

$\bar{p}p \rightarrow \ell^+\ell^- X$





Phase space for Drell-Yan processes



$x_{1,2}$ = mom fraction of parton$_{1,2}$

$\tau = x_1 \cdot x_2$

$x_F = x_1 - x_2$

τ = const: hyperbolae

x_F = const: diagonal

15 GeV/c ⟵ PANDA/PAXfix

$1.5\ \mathrm{GeV/c^2} \le M_{\mu\mu} \le 2.5\ \mathrm{GeV/c^2}$

40÷100 GeV/c ⟵ PAX @ HESR

symmetric HESR collider

A. Bianconi Drell-Yan Generator for $\bar{p}p$

- Antiproton beam
- Polarized/Unpolarized beam and target
- Drell-Yan cross section from experimental data
- Selects event depending on the variables:

$$x_1, x_2, P_T, \vartheta, \varphi, \varphi_S$$

from a flat distribution

$$\frac{d\sigma}{dx_1 dx_2 dP_T d\Omega} = \frac{K}{S} \times S(x_1, x_2) \times S'(P_T) \times A(\vartheta, \varphi, \varphi_S)$$

- Cross section:

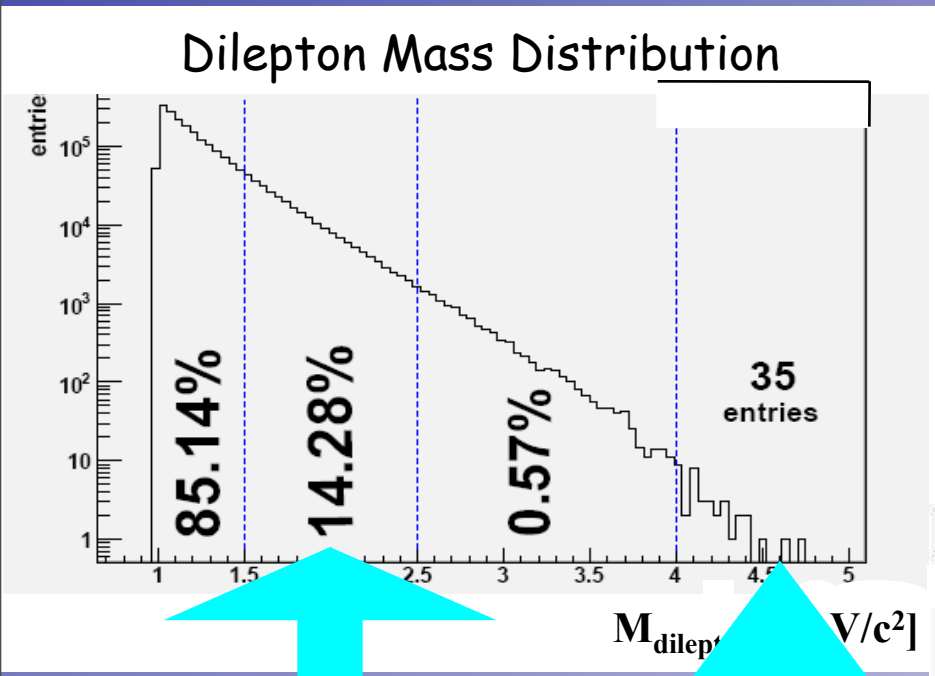
A. Bianconi, Monte Carlo Event Generator DY_AB4 for Drell-Yan Events with Dimuon Production in Antiproton and Negative Pion Collisions with Molecular Targets, internal note (PANDA collaboration)

A. Bianconi, M. Radici, Phys. Rev. **D71**, 074014 (2005) & **D72**, 074013 (2005)

A. Bianconi, arXiv:hep-ex/0806.0946v1

DY @ 15 GeV/c — $\bar{p}p \to \mu^+\mu^- X$

$\sqrt{s} = 5.5$ GeV



A. Bianconi Drell-Yan Generator [1]

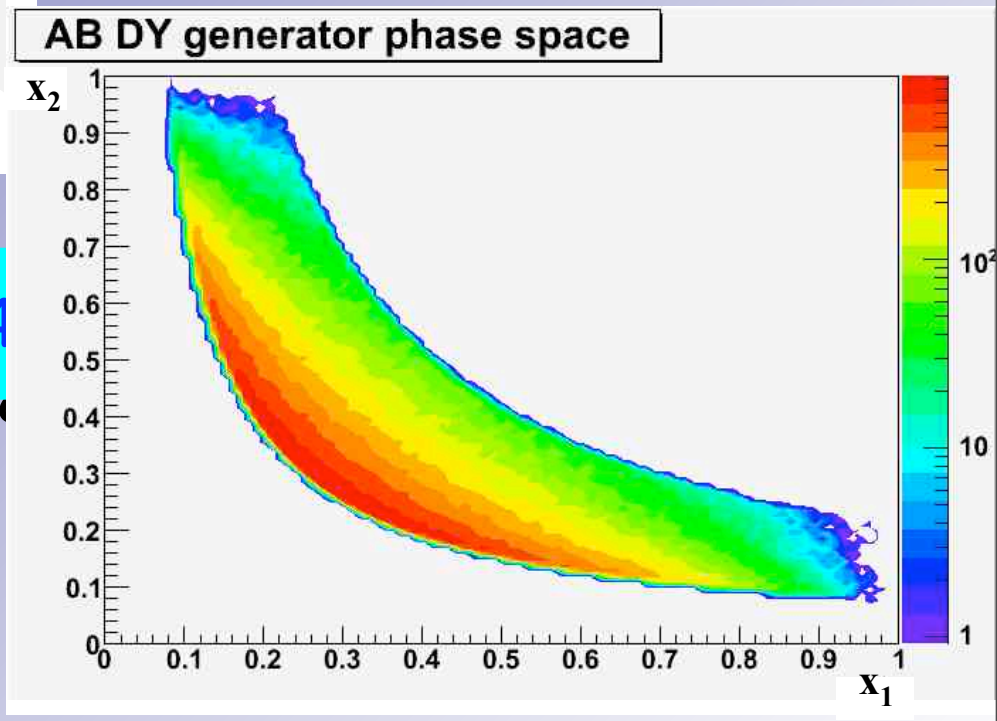
- layout studies for muon id with ABDYG (1.5 MEv)

Focus o one

1.5 MEv i .5 < $M_{\mu\mu}$ < 2.5 (GeV/

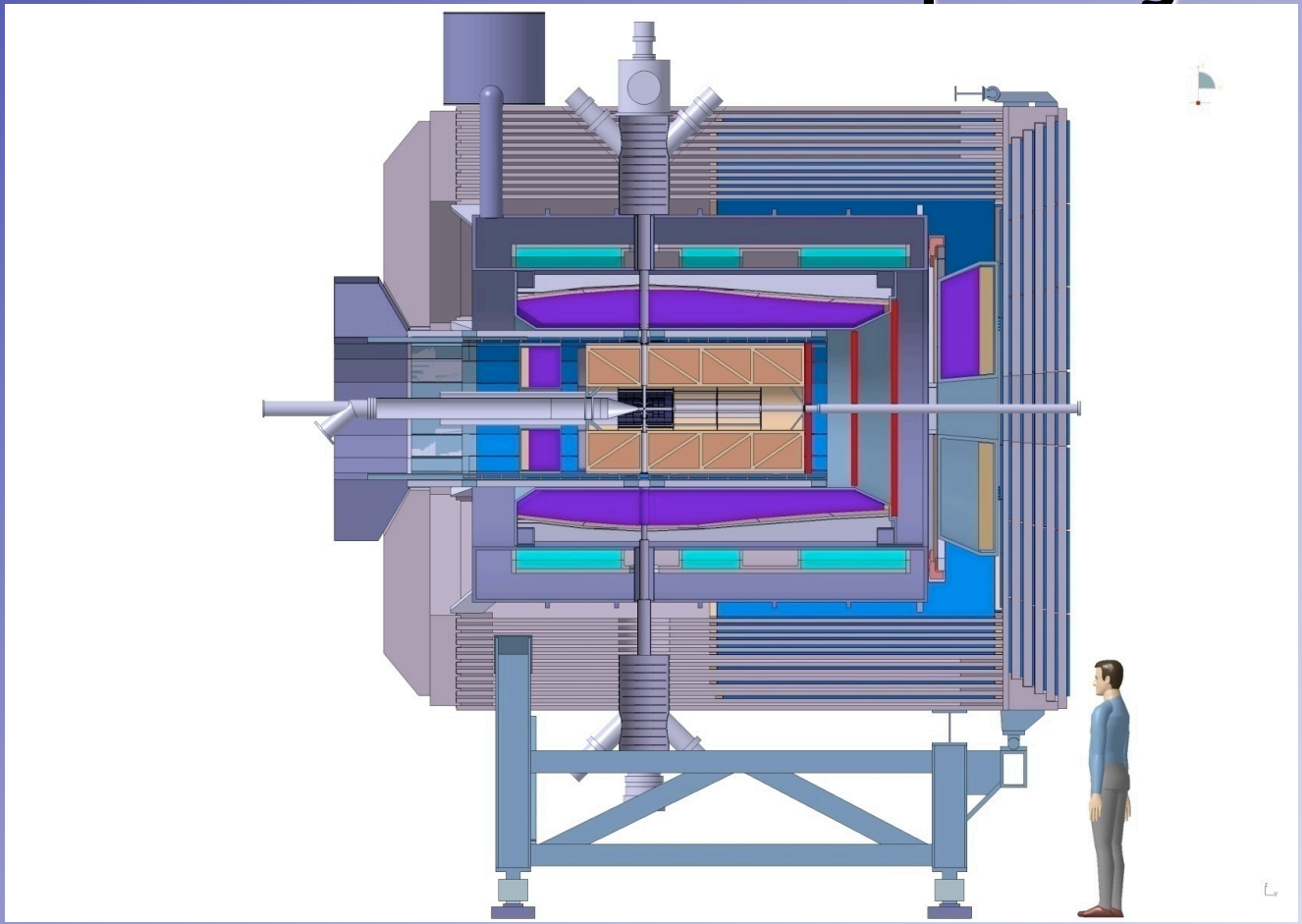
$\sigma^0_{4 \le M \le 9} \sim 0.4$

$\sigma^0_{1.5 \le M \le 2.5} \sim 0.8$ nb



[1] A. Bianconi and M. Radici, Phys. Rev. D71 (2005) 074014

PANDA Detector Setup Design



Signal: A. Bianconi Drell-Yan generator

Background: PYTHIA8 generator

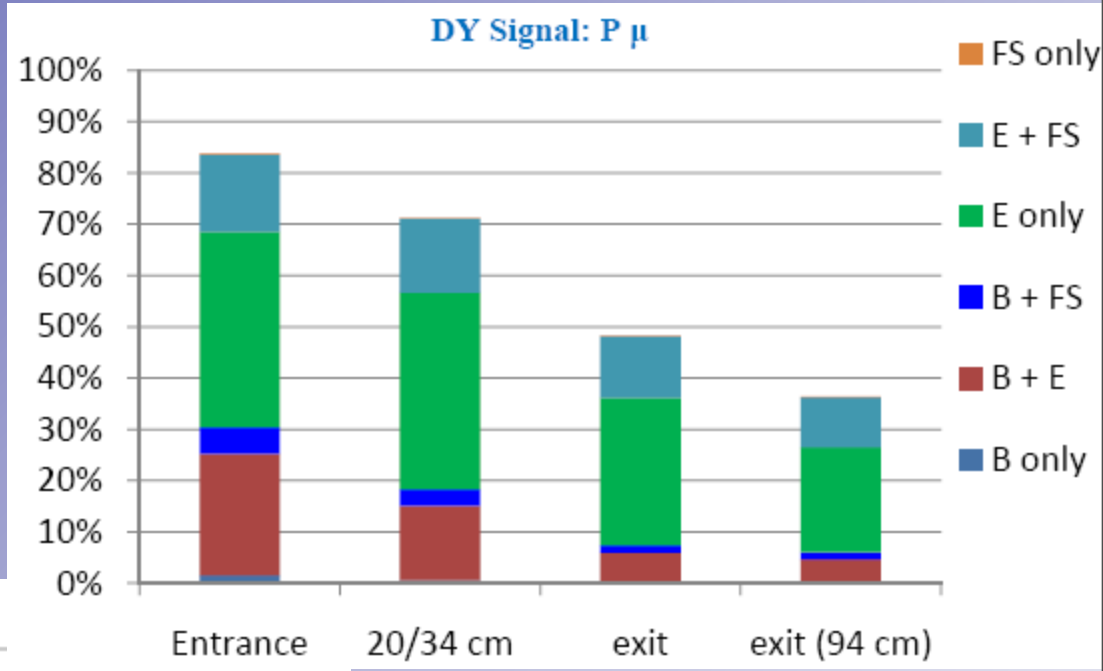
Framework: Muon Independent Simulation Software (MISS)

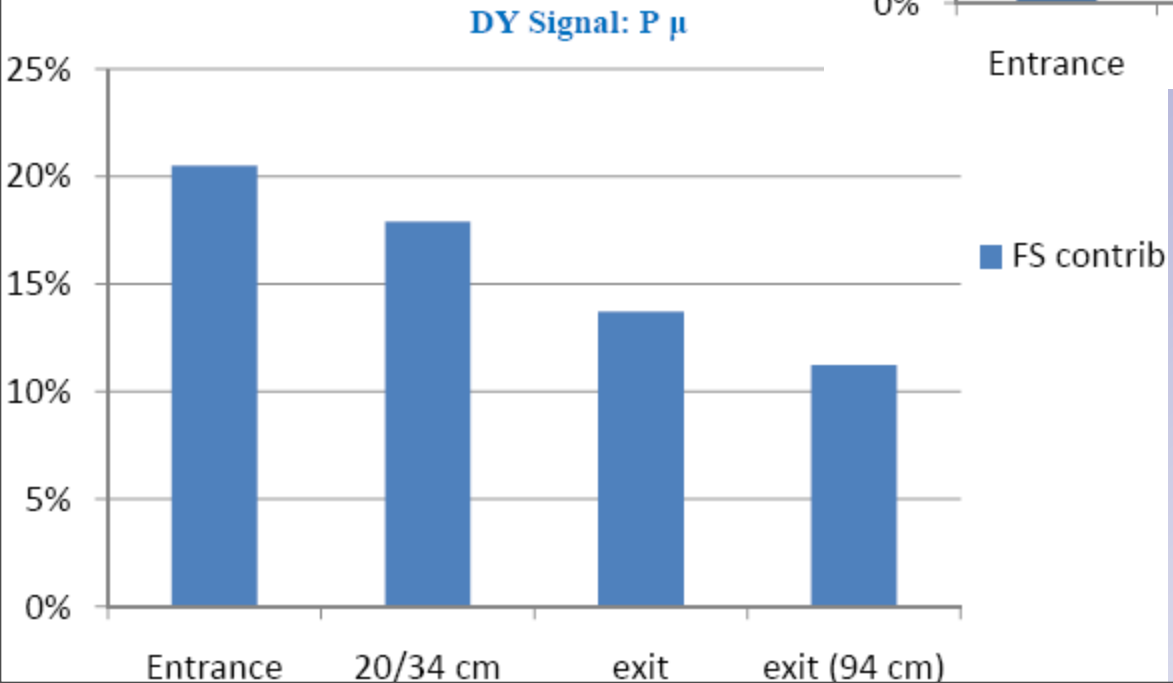
Next step: complete the work in PANDAROOT

ABDYG Signal Distribution

Most of the signal composed of two muons in the ENDCAP

Smaller contribution from B+E couples





Contributions from the FS region are not negligible

Background and Cuts

Sources of background

- Primary background: Primary π & Secondary μ from Primary π
- Secondary background: Secondary π & Secondary μ from Secondary π

Cuts and their effect on signal

Rejection factor of 10^7

	Iron	At least 1 hit in the first 2 layers	$q_T > 0.75$ GeV/c
Signal		% of	~ 35% of the signal is reconstructed
Primary Background	thickness	$\approx 10^3$	Rejection $\approx 10^4$
Secondary	Almost no effect	Rejection $\approx 10^4$	Rejection $>5 \cdot 10^6$

Next Step:
Kinematic refit

DY Asymmetries @ Vertex

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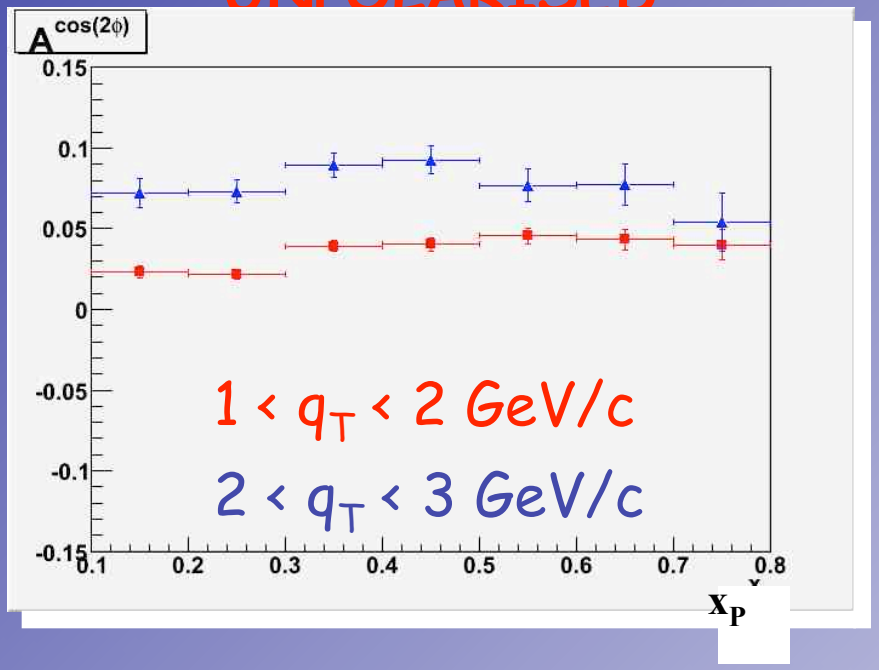

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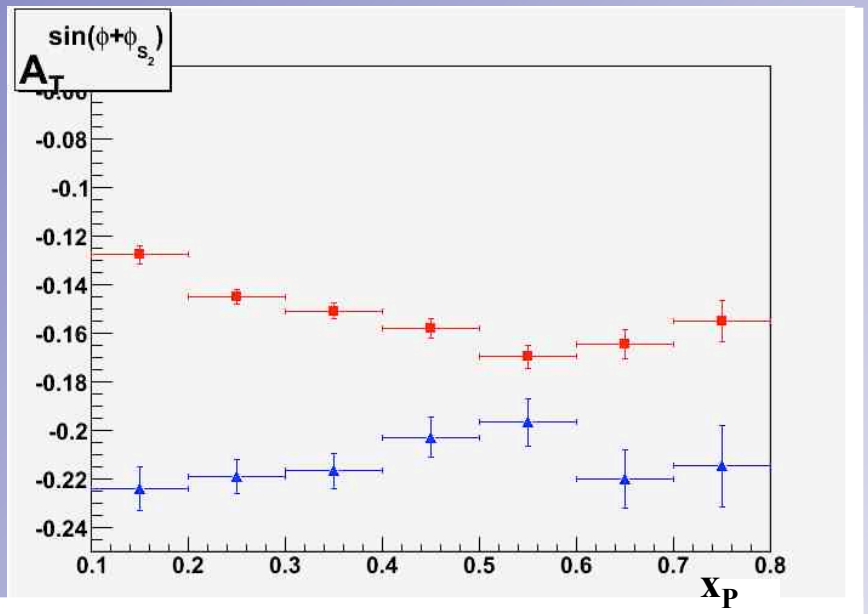
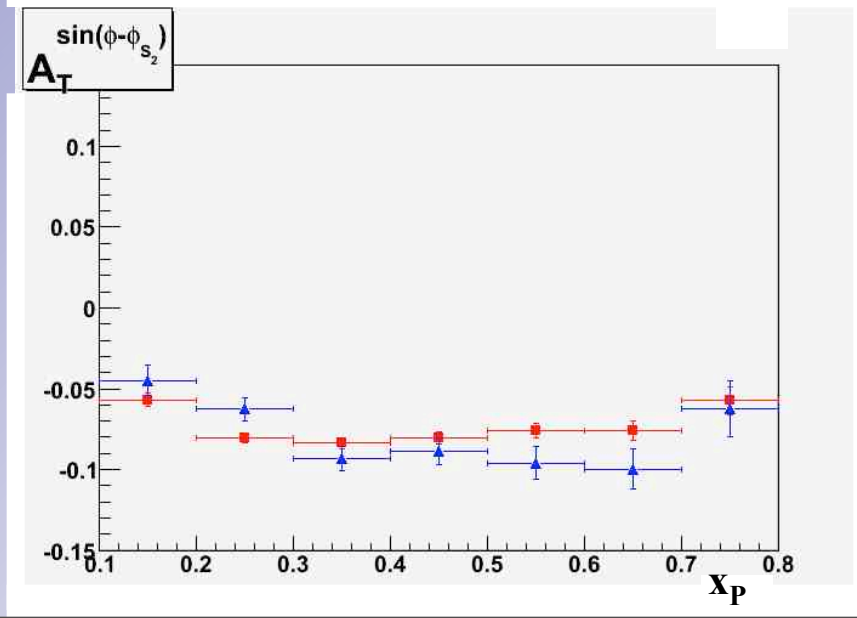
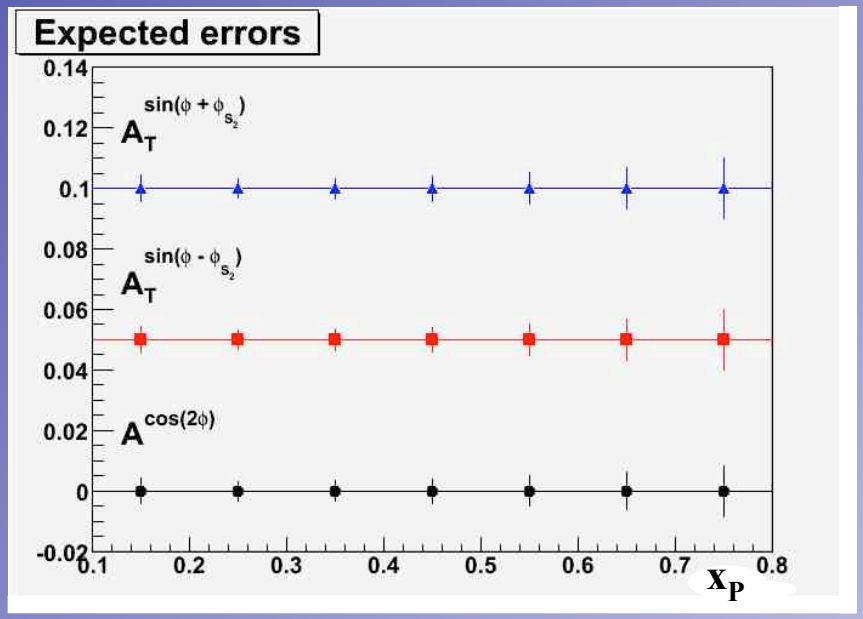


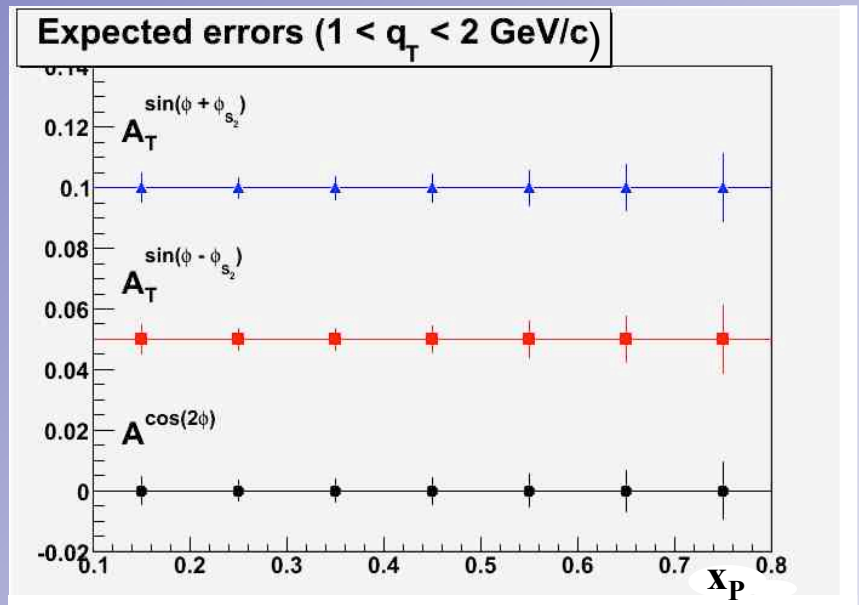


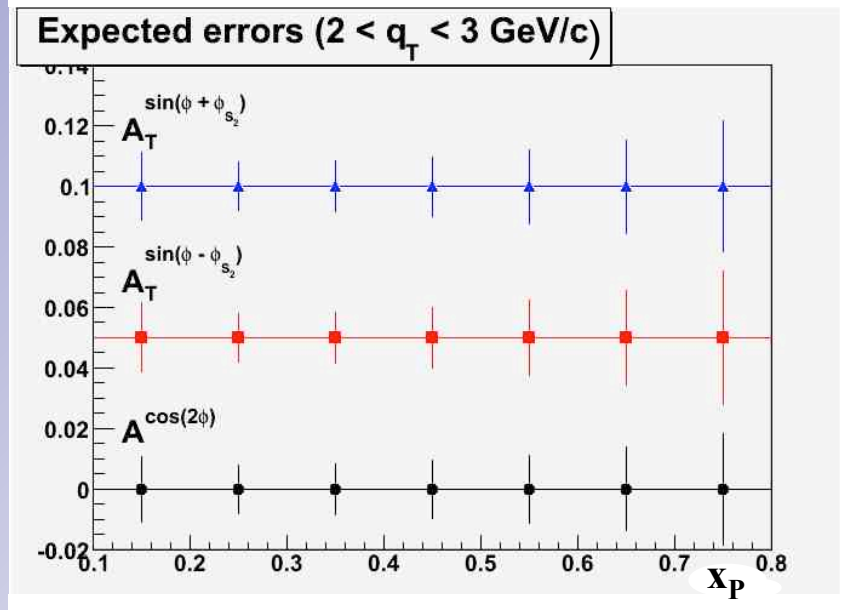
500KEv included in asymmetries

DY Asymmetries @ B(20cm)-E(34cm)

Statistical errors for 500KEv generated







$$R = L \cdot \sigma \cdot \varepsilon$$

$$= 2 \cdot 10^{32} cm^{-2} s^{-1} \times$$

$$\times 0.8 \cdot 10^{-33} cm^2 \times 0.33$$

$$= 0.05\ s^{-1} \sim 130\ Kev/month$$

Summary

- Interest on Drell-Yan studies
  - $1.5 < M_{\mu\mu} < 2.5$ GeV/c^2
  - Cuts for background rejection

  Rejection factor achieved for secondary background: > $5\ 10^6$

  Kinematically constrained refit still to be investigated
- Few months of data taking are enough to:

  ➢ evaluate unpolarised and single-spin asymmetries with good accuracy ⇒ investigate their dependence on $q_{T,\mu\mu}$
- Extensive simulations needed on the GRID (~10^8 Ev)

with PANDAROOT in order to: