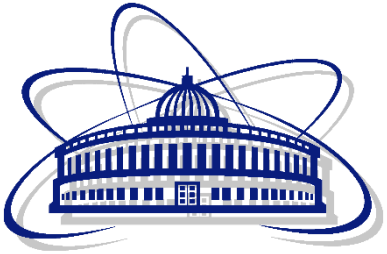
Drell-Yan measurements with SPD. Feasibilities and asymmetries

Artem Ivanov

on behalf of the SPD Drell-Yan team

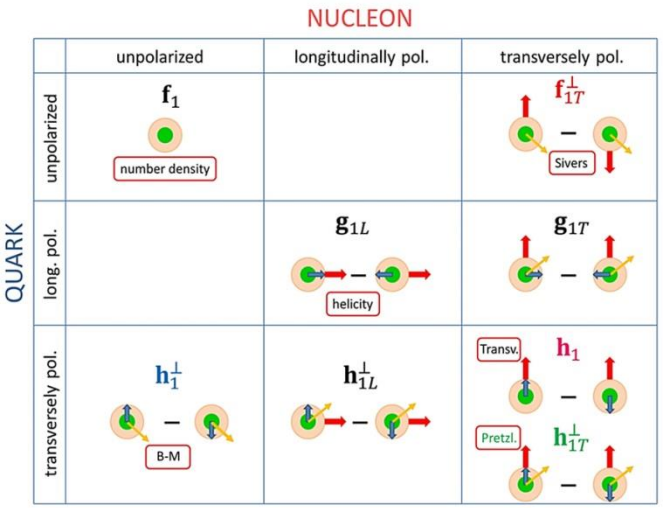


Joint Institute for Nuclear Research (Dubna, Russia)

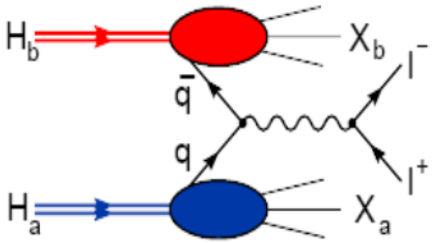
NICA-SPD

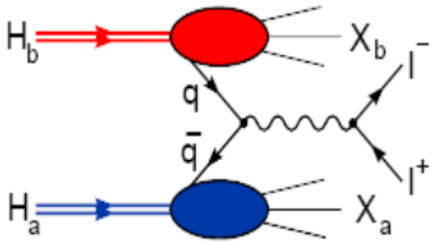
Dubna, Russia, June 6, 2019

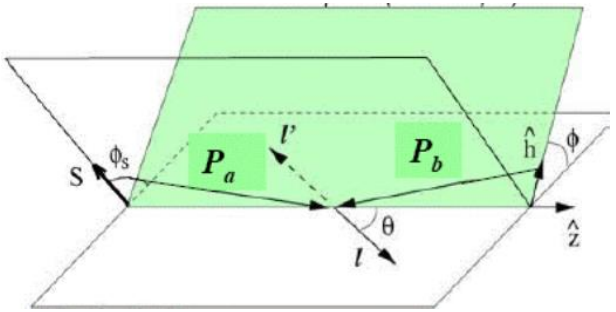
Leading Order (TMD) PDFs



1. Transversity: $A_{UT}^{\sin(\phi+\phi_S)}$, represents the number distribution of transversely polarized quarks in a transversely polarized nucleon;
2. Sivers: $A_{UT}^{\sin(\phi-\phi_S)}$, represents the distribution over the transverse momentum of non-polarized quarks in a transversely polarized nucleon;
3. Pretzelosity: $A_{UT}^{\sin(3\phi-\phi_S)}$, represents the distribution over the transverse momentum of transversely polarized quarks in a transversely polarized nucleon;
4. Boer-Mulders: $A_{UU}^{\cos(2\phi_h)}$, represents the distribution over the transverse momentum of transversely polarized quarks in a non-polarized nucleon;
5. Worm-Gears: $A_{UL}^{\cos(2\phi_h)}$, represents the distribution over the transverse momentum of longitudinally polarized quarks in a longitudinally polarized nucleon.

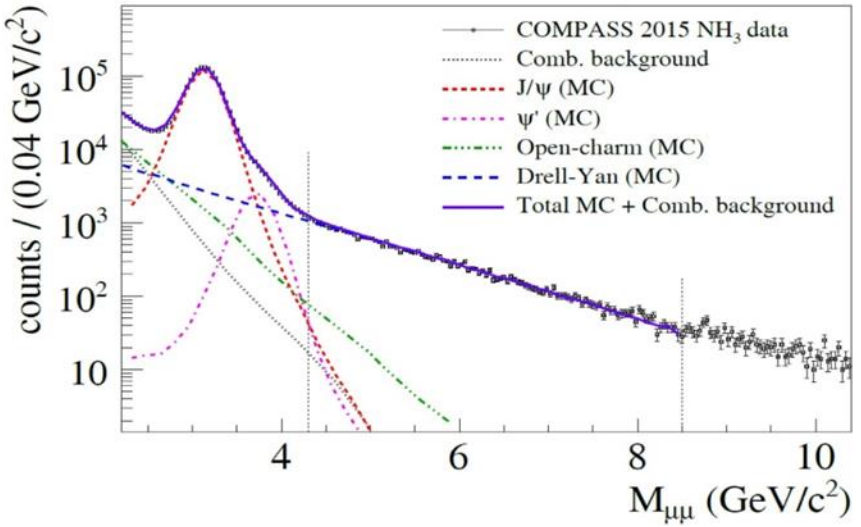






- 4π geometry
- Collider mode– no dilution factor as in case of fixed target solid state PT experiments (factor ~5 in statistical error)
- Double spin asymmetries
- Right kinematic range

- no absorber, huge background ⟶ Next talks by Ruslan Akhunzyanov
  Anna Skachkova



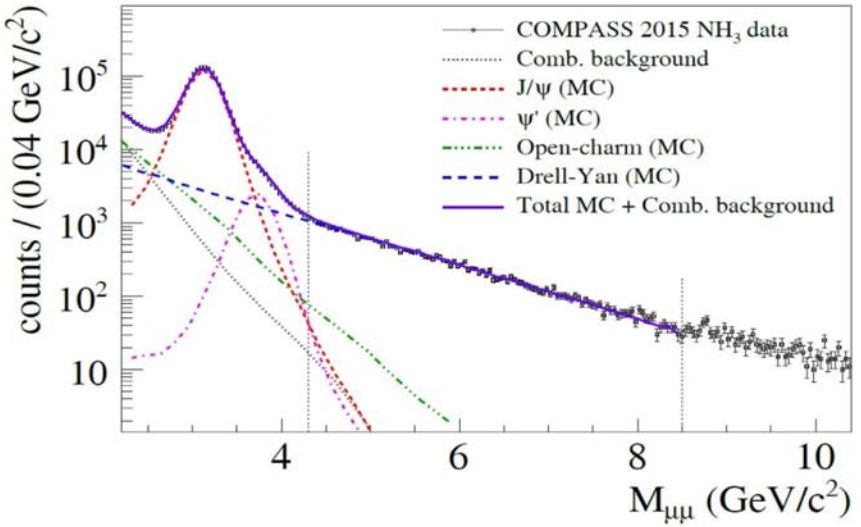
Estimation of DY pairs production rates in Pythia6.4

pp, DY via $\mu^+\mu^-, \sqrt{s} = 26\ GeV$

Some settings:

MSEL=0	turn OFF global process selection
MSUB(1)=1	turn ON q+qb -> gamma*/Z0 -> mu+mu- (Drell-Yan process)
MSTP(43)=1	only gamma* included (Drell-Yan)
MDME(184,1)=1	Z0 -> mu+mu- turned ON

$M_{\mu\mu}$ GeV	σ_{tot} nb
>2	1.23
>3	0.27
>4	0.07

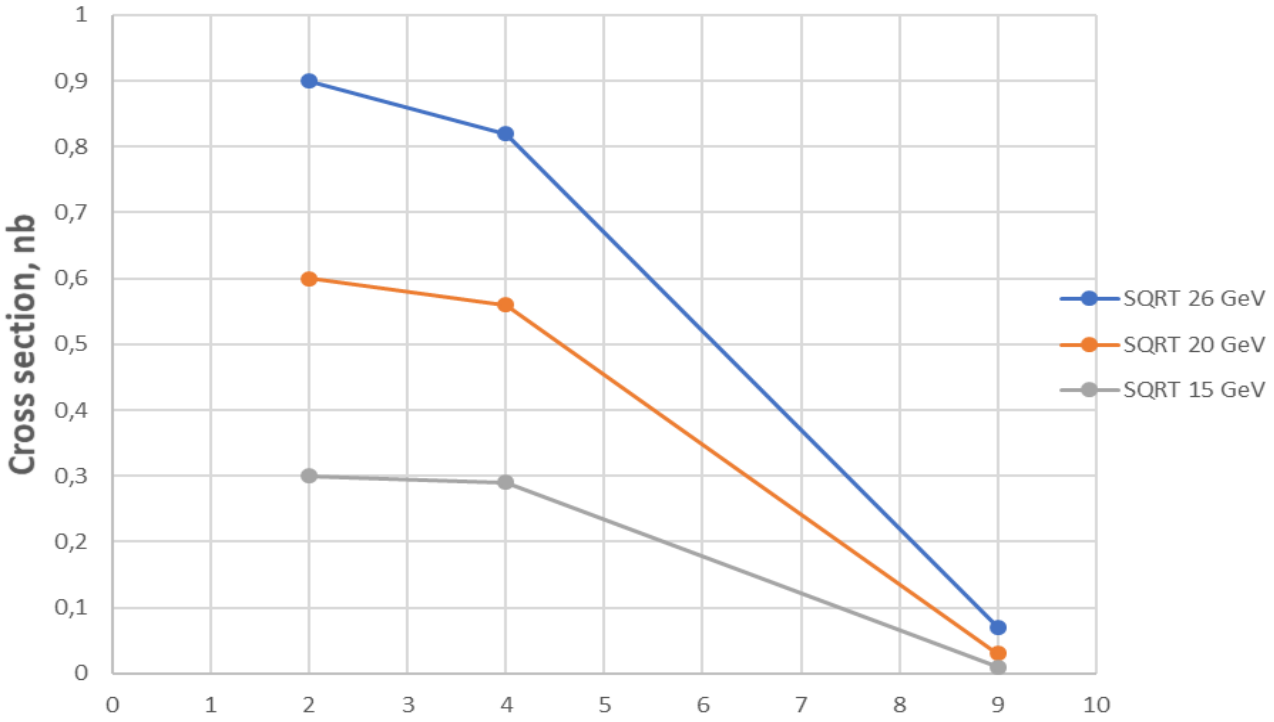


Cross sections and statistics: various invariant mass ranges

$$\sigma_{range} = (\sigma_{tot} \times N_{events\ in\ range})/N_{events}$$

$P_\mu > 1\ GeV$

$\sqrt{s}$ GeV	$M_{\mu\mu}$ [2-11] GeV	$M_{\mu\mu}$ [2-4] GeV	$M_{\mu\mu}$ [4-9] GeV	$M_{\mu\mu}$ [9-11] GeV
26	0.9	0.82	0.07	<0.01
20	0.6	0.56	0.03	<0.01
15	0.3	0.29	0.009	<0.01



Cross sections and statistics: rate vs luminosity

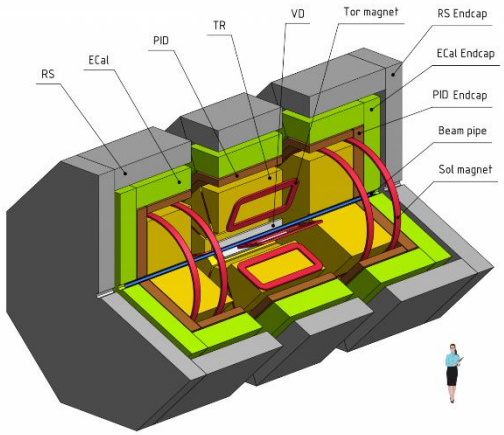
$\sqrt{s}$ = 26 GeV

$$R = L \times \sigma \times month \times efficiency$$

L $cm^{-2}s^{-1}$	$M_{\mu\mu}$ [2-9] GeV			$M_{\mu\mu}$ [2-4] GeV			$M_{\mu\mu}$ [4-9] GeV		
	Eff. 100%	Eff. 80%	Eff. 60%	Eff. 100%	Eff. 80%	Eff. 60%	Eff. 100%	Eff. 80%	Eff. 60%
	$R, 10^3$			$R, 10^3$			$R, 10^3$		
1×10^{31}	23	19	14	21	17	13	1.8	1.4	1
5×10^{31}	162	93	70	103	82	61	9	7.2	1.4
1×10^{32}	233	169	139	207	165	124	18	14	10
2×10^{32}	466	338	278	415	332	250	36	29	21

Drell-Yan asymmetry in SPD

Pythia6.4 + *SpdRoot*



	%
PV	100
RS	96.7
RS-BB	27.3
RS-EE	16.2
RS-BEEB	53.2

B-*barrel*, E-*endcap*

N_{DY} generated events = 1×10^6 [4.0 ->]

- **N muon pairs [4-9] GeV = (PV) - 100%**
- **N muon pairs [4-9] GeV = (RS) - 96 %**

Boer-Mulders

- $4.0\ GeV/c^2 < M_{\mu\mu} < 9.0\ GeV/c^2$
- $\langle P_b \rangle = 1.0$

$$weight = \sigma_0 + kP\cos 2\varphi_{CS}$$

$$\sigma_0 = 1.0$$
$$k = 0.5$$
$$P = \pm 1$$

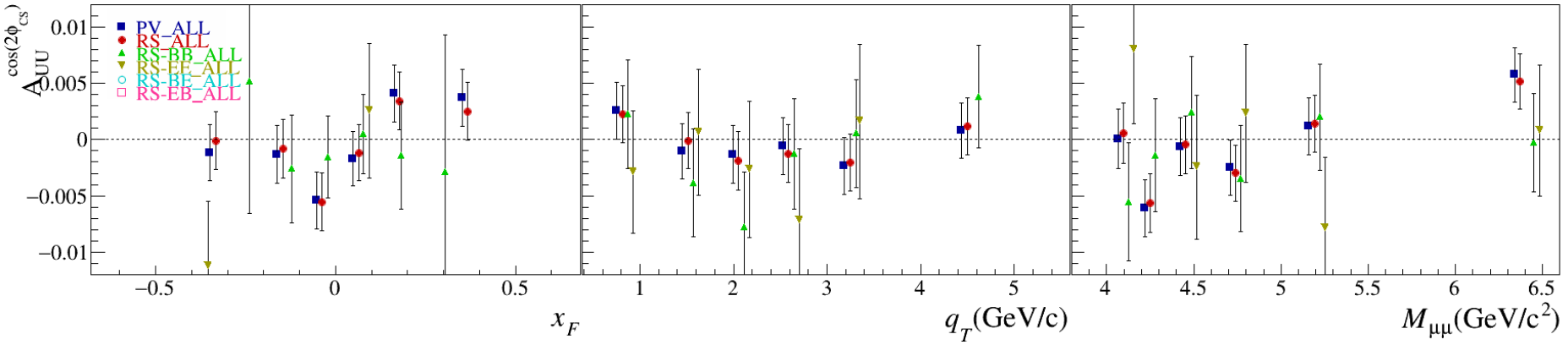
$$A = \frac{N_{w,2} - N_{w,1}}{N_{w,2} + N_{w,1}}$$

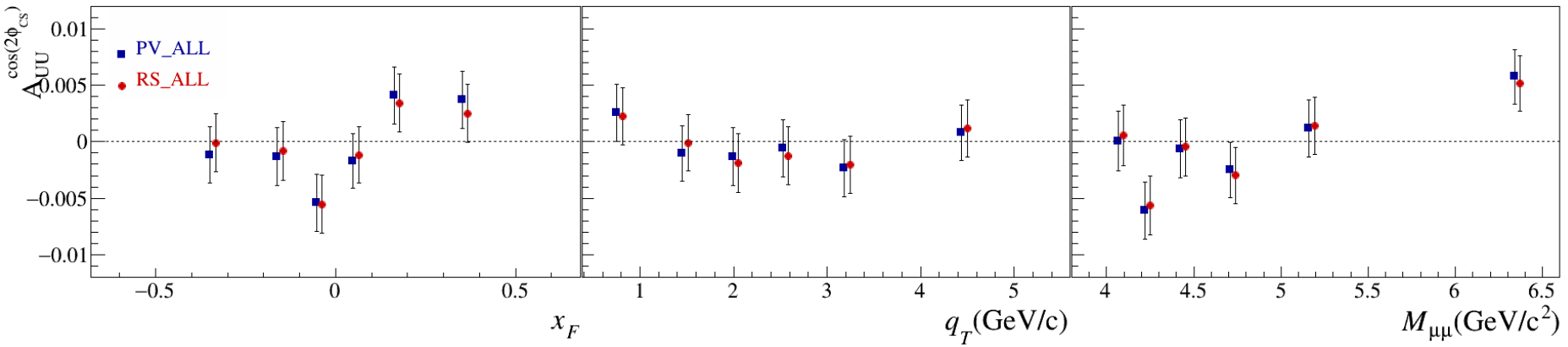
$$N_{w,1} = \sum_{1}^{N1} (\sigma_0 - k\cos 2\varphi_{CS})$$

$$N_{w,2} = \sum_{1}^{N2} (\sigma_0 + k\cos 2\varphi_{CS})$$

$$dA = \frac{1}{\sqrt{N_1 + N_2}}$$

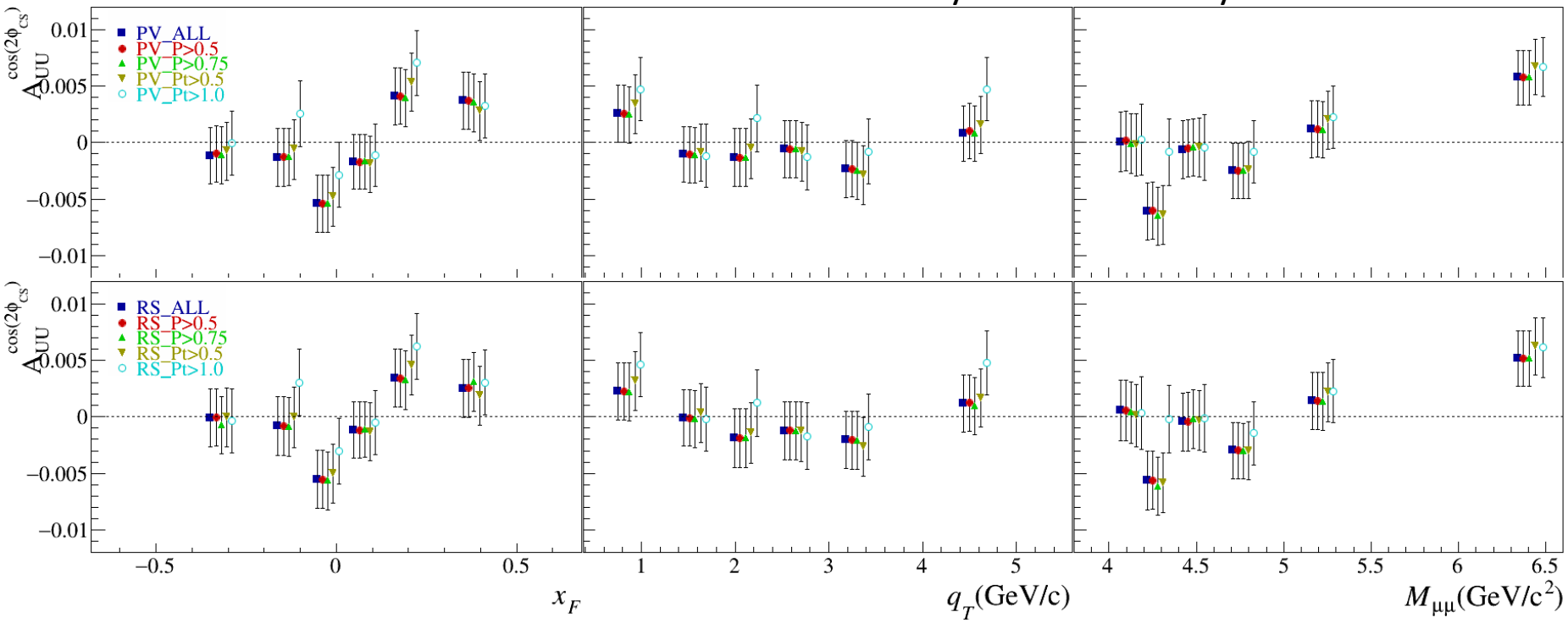
Drell-Yan asymmetry in SPD





Drell-Yan asymmetry in SPD

Next talk by Ruslan Akhunzyanov



	%
ALL	100
P>0.5	99.95
P>0.75	99.3
Pt>0.5	94.6
Pt>1.0	77.9

Comparison with COMPAS

PRL 119 (2017) 112002

COMPASS-2015 data

- $4.3\ \mathrm{GeV/c^2} < M_{\mu\mu} < 8.5\ \mathrm{GeV/c^2}$
- $q_T > 0.4\ \mathrm{GeV/c}$
- $\langle f \rangle \approx 0.18$
- $\langle P_{Target} \rangle \approx 0.73$

- $\langle x_F \rangle = 0.33$
- $\langle q_T \rangle = 1.2\ \mathrm{GeV/c}$
- $\langle M_{\mu\mu} \rangle = 5.3\ \mathrm{GeV/c^2}$

- $t \approx 1.08864 \times 10^7 s$ (18 weeks, 126 days)

$\boldsymbol{N_{DY} = 35 \times 10^3}$

SPD

- $4.0\ \mathrm{GeV/c^2} < M_{\mu\mu} < 9.0\ \mathrm{GeV/c^2}$
- $\langle P_{beam\ 1,2} \rangle \approx 0.6$

- $\langle x_F \rangle = 0.0$
- $\langle q_T \rangle = 2.4\ \mathrm{GeV/c}$
- $\langle M_{\mu\mu} \rangle = 4.8\ \mathrm{GeV/c^2}$

- $L = 10^{32}\ \mathrm{cm^{-2}s^{-1}}$ $(d = 0.1\ \mathrm{cm})$
- $t = 10^7 s$ (16.5 weeks)
- $\sigma_{DY[4-9]} = 0.074$ nb

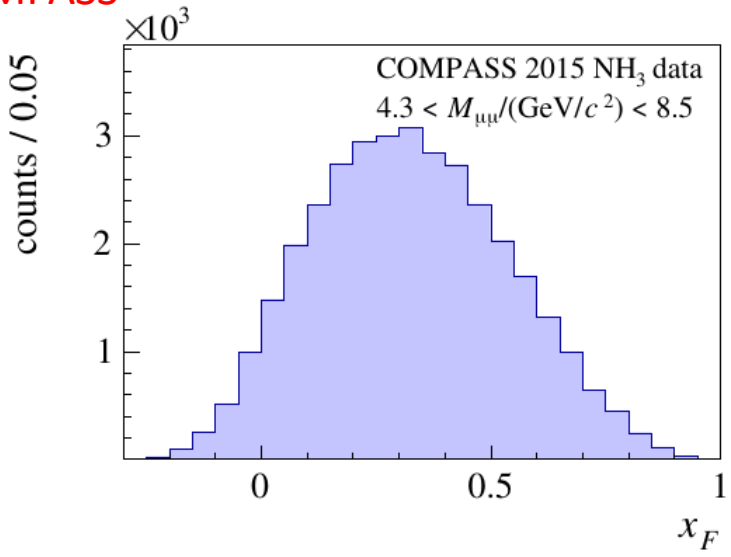
$N_{DY} = \sigma_{DY} \times L \times t$

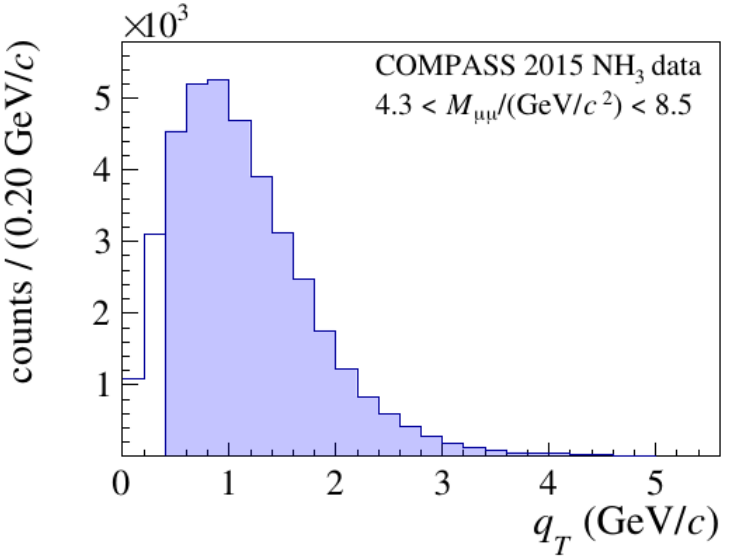
$\boldsymbol{N_{DY} = 88.8 \times 10^3}$

$$dA = \frac{1}{P_{b1} P_{b2}} \times \frac{1}{\sqrt{N}}$$

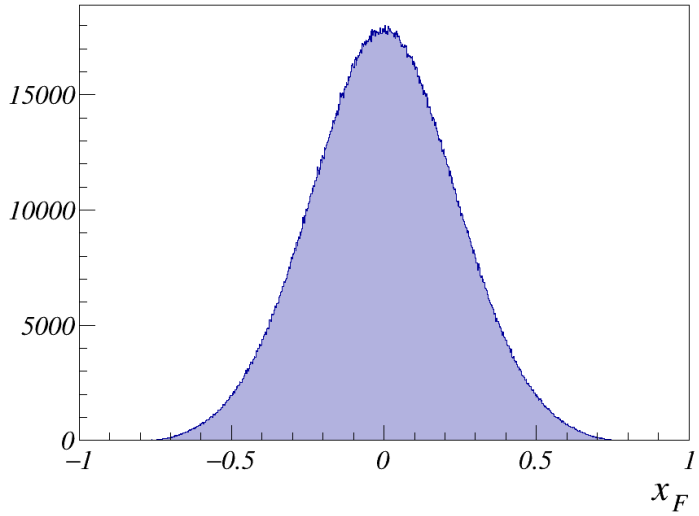
Comparison with COMPAS: **Kinematics**

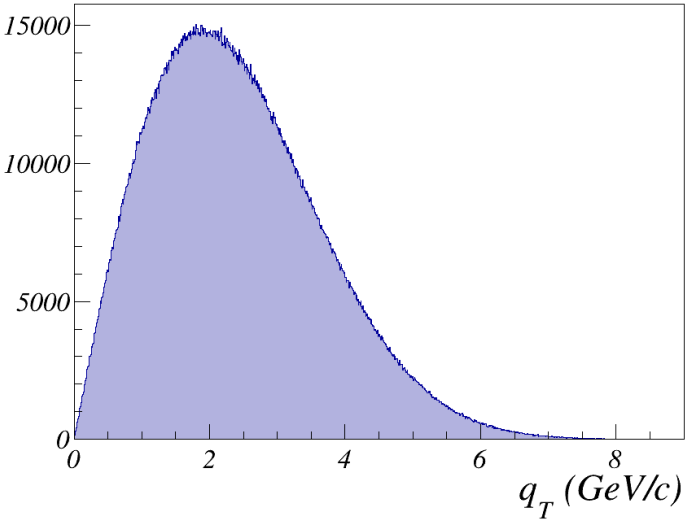
COMPASS



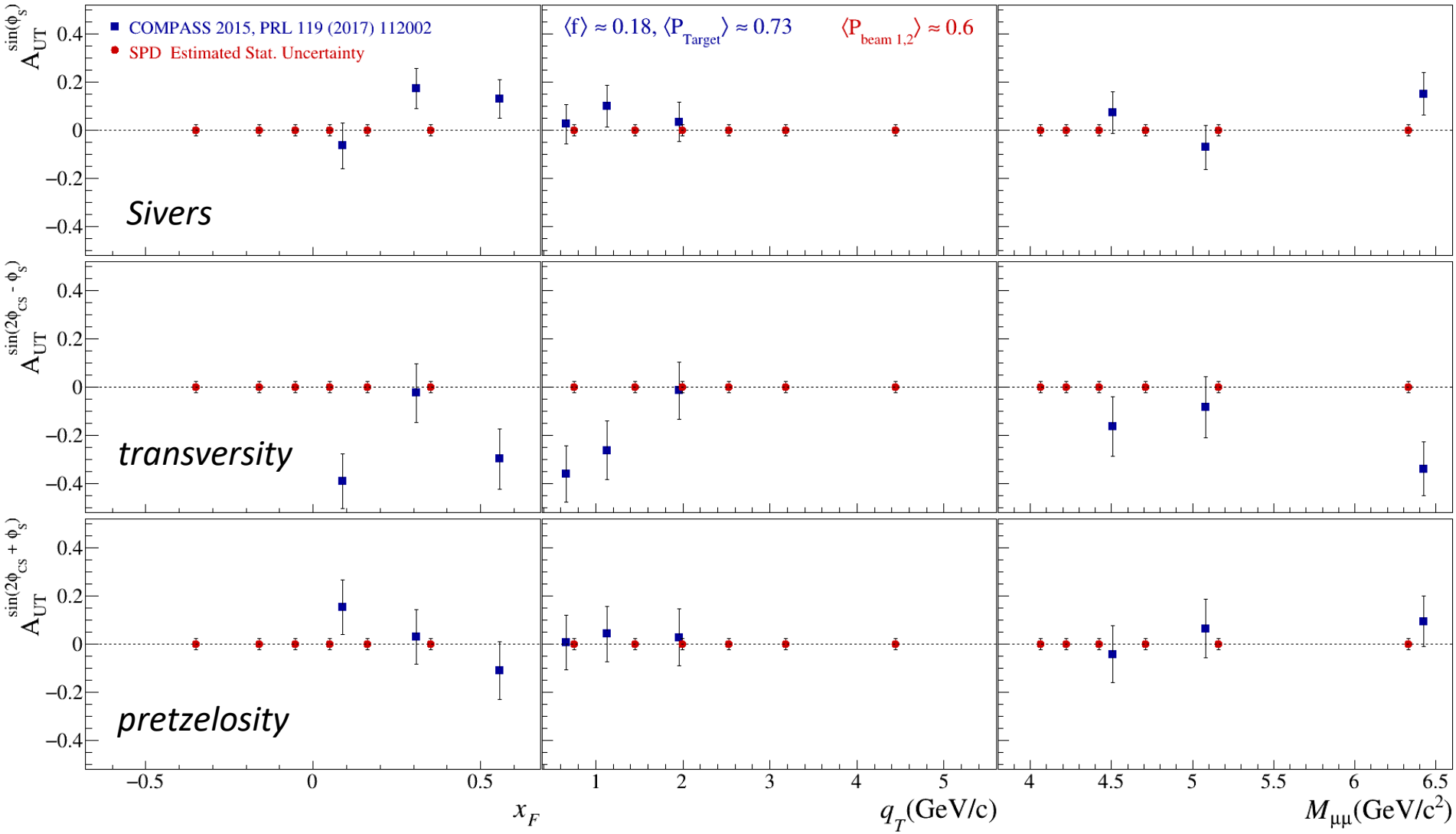


SPD





Comparison with COMPAS: **Asymmetry**



In 3 bins
COMPASS dA ≈ 0.1

In 6 bins
SPD dA ≈ 0.02

with $\langle P_{beam\ 1,2} \rangle = 1.0$ SPD dA ≈ 0.008

Proposals and plans

- MC asymmetry studies will be redone with reconstructed tracks (tracking is under preparation);
- These studies also will be done for Sivers and transversity asymmetries with modern theoretical predictions;
- MC generator with polarized DY events is planned to be used.

DY Team:

- Akhunzyanov Ruslan
- Gribowsky Alexandr
- Ivanov Artem
- Mescheryakov Gleb
- Nagaytsev Alexander
- Skachkova Anna

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welcome to join