Study of polarised gluon structure of proton via prompt photon production in the SPD experiment at the NICA collider.

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New Trends in High-Energy Physics

# NICA (Nuclotron based Ion Collider fAcility)





It consists of the 3 parts: 2 endcaps and central one. Each part has individual magnet system, the endcaps - solenoidal coils, central part toroidal.

 $\Box$  polarised (longitudinal and transverse) and non-polarised p –; d – collisions;

□ polarisation ~ 70%; □  $p \uparrow p \uparrow \sqrt{s} = 12 \div 27 \text{ GeV};$ □  $d \uparrow d \uparrow \sqrt{s} = 4 \div 13.8 \text{ GeV};$ □  $L_{average} \ge 10^{32} cm^{-2} s^{-1} (\text{at } \sqrt{s} = 27 \text{ GeV}).$ 

# SPD physics tasks Nucleon spin structure studies

- Drell-Yan pair production



- Nucleon PDFs by J/psi production

LO *cc* production diagram:



# Prompt photons

Photons produced in the hard scattering, named the **prompt photons**, provide information about gluon component of the proton.



 $d\sigma_{AB} = \sum_{a,b=q,\bar{q},g} \int dx_a dx_b f_a^A(x_a,\mu^2) f_b^B(x_b,\mu^2) d\sigma_{ab\to\gamma X}(x_a,x_b,\mu^2).$ 

One of the instrument to study gluon component of proton – prompt photons

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### Previous studies

Experiment	Beam and target	$\sqrt{s}$ , GeV	y range	$x_T$ range
E95 (1979)	p; Be	19.4, 23.75	-0.7 - 0.7	0.15 - 0.45
E629 (1983)	p, $\pi^+$ ; C	19.4	-0.75 - 0.2	0.22 - 0.52
NA3 (1986)	p, $\pi^+$ , $\pi^-$ ; C	19.4	-0.4 - 1.2	0.26 - 0.62
NA24 (1987)	p, $\pi^+$ , $\pi^-$ ; p	23.75	-0.65 - 0.52	0.23 - 0.59
WA70 (1988)	p, $\pi^+$ , $\pi^-$ ; p	22.96	-0.9 - 1.1	0.35 - 0.61
E706 (1993)	p, $\pi^-$ ; Be	30.63	-0.7 - 0.7	0.20 - 0.65
E704 (1995)	p; p	19.4	< 0.74	0.26 - 0.39
UA6 (1993,1998)	$\bar{p}; p$	24.3	-0.2 - 1.0	0.34 - 0.50



### Previous studies (data/theory)



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## TMD PDFs





#### **Gluon polarization**

3 PDFs are needed to describe nucleon structure in collinear approximation

8 PDFs are needed if we want to take into account intrinsic transverse momentum  $k_T$  of partons (LO) Transverse single spin asymmetry



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### Double longitudinal double spin asymmetry

Production of prompt photons at large transverse momentum with longitudinally polarised proton beams is a very promising method to measure gluon polarisation  $\Delta g$  from measurement of the Longitudinal double spin asymmetry  $A_{LL}$ , defined as:

$$A_{LL} = \frac{(\sigma_{++} + \sigma_{--}) - (\sigma_{+-} + \sigma_{-+})}{(\sigma_{++} + \sigma_{--}) + (\sigma_{+-} + \sigma_{-+})} \approx \int_{g(x_1)}^{\Delta g(x_1)} \times \left[ \frac{\sum_q e_q^2 [\Delta q(x_2) + \Delta \bar{q}(x_2)]}{\sum_q e_q^2 [q(x_2) + \bar{q}(x_2)]} \right] + (x_1 \leftrightarrow x_2)$$
  
Gluon polarization





#### From the theoretical point of view everything is simple



- Low  $p_T$  region is useless for any studies of prompt photons due to huge background
- At high  $p_T$  statistics is very limited
- A reasonable cut on transverse momentum (> 4 GeV/c) of photon has to be applied in order to maximize the accuracy of the planned measurements.

### Calorimeter







- Energy range from 50 MeV to 10 GeV
- Energy resolution of about  $5\% / \sqrt{E}(GeV)$
- Energy threshold below 100 MeV
- $12.5 X_0$

### **SPDROOT**

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### Prompt photons

Monte Carlo data using SPD root and Pythia 6 generator (29 process was generated).



# Main background sources



• π<sup>0</sup> decay

- η-meson decay
- double clusters
- neutral hadrons (n,K,Λ)
- charged particles

A reasonable cut on transverse momentum (> 4 GeV/c) of photon has to be applied in order to maximize the accuracy of the planned measurements.

### Expected accuracy

The main way to suppress the background is effective reconstruction of  $\pi^0$  decays and an accurate simulation of setup behaviour.



# Expected accuracy

- Data sample corresponds to  $10^7$  s of data taking (about 100 days) with average luminosity  $L = 10^{32} s^{-1} cm^{-2}$ .
- Errors from polarisation and luminosity measurements are not taken into account.





### Direct photons provide an information about polarased and non-polarised gluon component of the proton

SPD experiment at the NICA collider will provide new high precision results on asymmetries



### NICA (Nuclotron based Ion Collider fAcility)



#### More than 300 scientists from 70 institutes from 32 counties

- Detector MPD
- Detector SPD
- Detector BM@N

