



**POLYTECH**

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# SPbPU results based on State assignment

SPbPU working group:

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- Comparative analysis of prompt photon production in  $d + d$  collisions, generated using nuclear modified PDFs and in  $d + d$  collisions generated using free nucleon PDFs at NICA energies
- Development of a generator of polarized proton interactions with prompt photon production based on generative adversarial neural networks (GAN)
- Development and testing of technical solutions for synchronization system elements based on White Rabbit technology  
(Report «Current status of TSS development. White Rabbit precision and accuracy» by O. Mamutova)



- **Simulation of prompt photon production in  $d + d$  collisions at  $\sqrt{s} = 13.5$  GeV and  $\sqrt{s} = 27$  GeV**  
(ICPPA-2024, Shapaev D.S., Berdnikov Ya.A. The creation of prompt photons during interactions of deuterium nuclei at energies of 13.5 GeV and 27.0 GeV // SPbPU J. Phys. and Math. 2024. V. 17. № 4)
- **Application of generative adversarial neural networks (GAN) to compute prompt photon  $A_{LL}$  in longitudinally polarized  $p+p$  collisions at  $\sqrt{s} = 27$  GeV**  
(ICPPA-2024, Lobanov A.A., Berdnikov Ya.A. Direct photons asymmetries in longitudinally polarized proton-proton collisions at energy  $\sqrt{s_{NN}} = 27$  GeV // SPbPU J. Phys. and Math. V. 18. № 1.)
- **Identified charged hadrons measurements in the PHENIX experiment as a prototype for SPD studies**  
(Larionova D. PhD thesis)

# Simulation of prompt photon production in $d + d$ collisions

Shapaev D.S., Berdnikov Ya.A.

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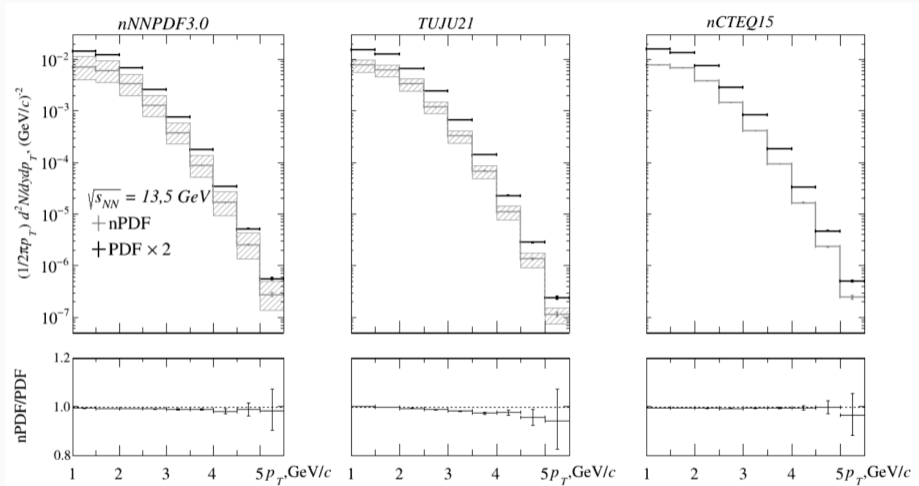
Prompt photon invariant spectra and nuclear modification factors in  $d + d$  collisions at  $\sqrt{s_{NN}} = 13.5$  and 27.0 GeV/nucleon are obtained.

## Two methods:

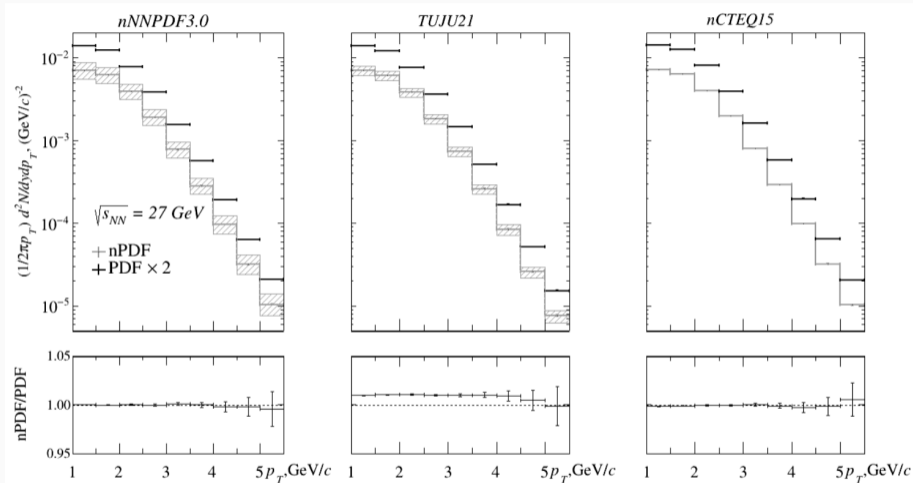
1. **Free nucleon PDFs are used** and  $d + d = \frac{1}{4}(pp + pn + np + nn)$ .  
The neutron PDFs are obtained via proton PDFs using isospin symmetry, for example,  $u^p = d^n u^n = d^p$
2. **Nuclear-modified PDFs are used for simulation of  $d + d$  collisions** (include nuclear effects: shading, EMC effect, Fermi motion, etc.).

Simulation – Pythia8

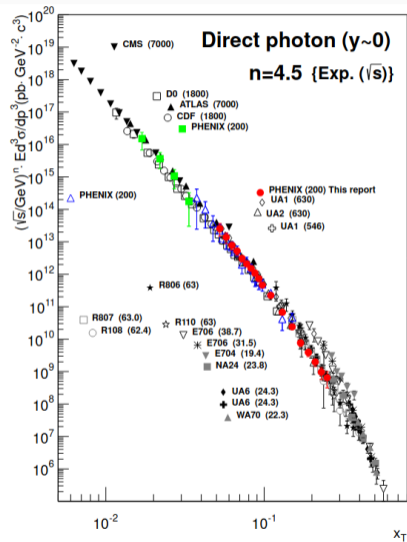
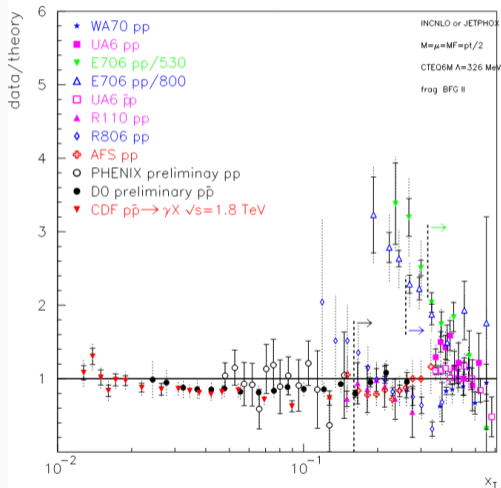
PDF sets – nNNPDF, TUJU, nCTEQ15



Invariant  $p_T$  spectra obtained by different methods coincide within uncertainties.



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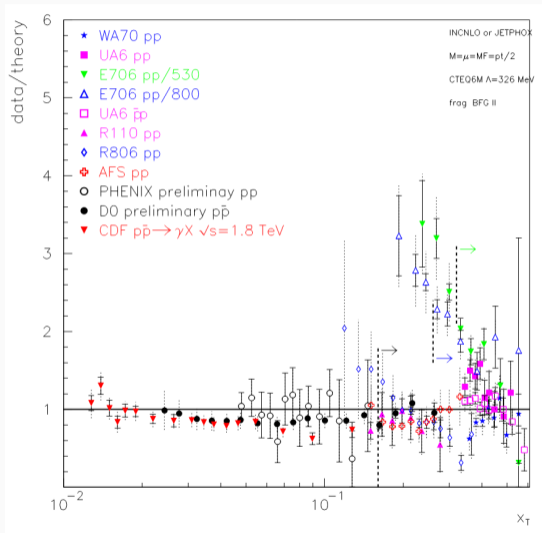


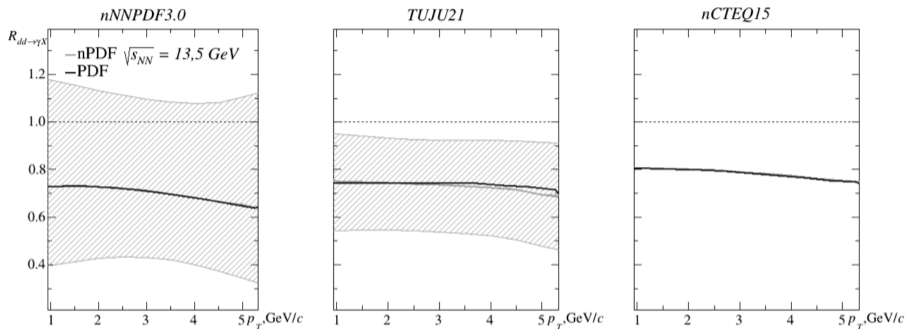
✗ E706

✓ UA6 (24.3 GeV)

✓ WA70 (22.3 GeV)

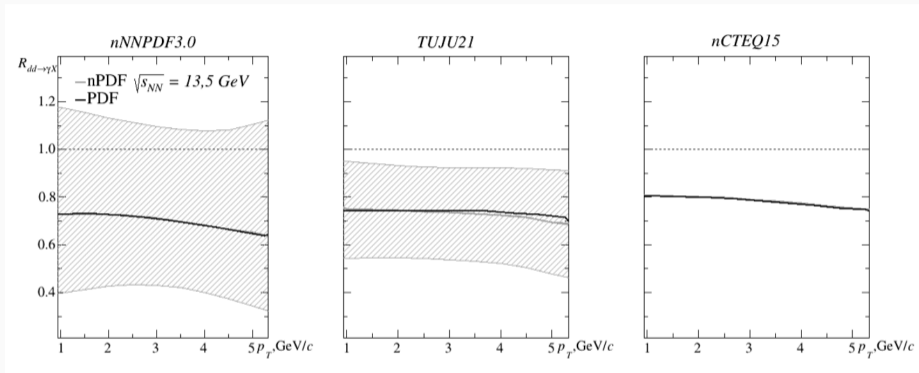
Pythia8 – LO calculations  
Presented work – is the  
first step of the analysis





$$R_{AA} = \frac{d^2 N_{dd}/p_T dp_T dy}{d^2 N_{pp}/p_T dp_T dy}$$

$R_{AA} = 1$  means absence of nuclear modification



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Prompt photon  $R_{AA} \approx 0.8$  at  $1 \text{ GeV}/c < p_T < 5 \text{ GeV}/c$

Isospin effects predominate over other nuclear modification effects



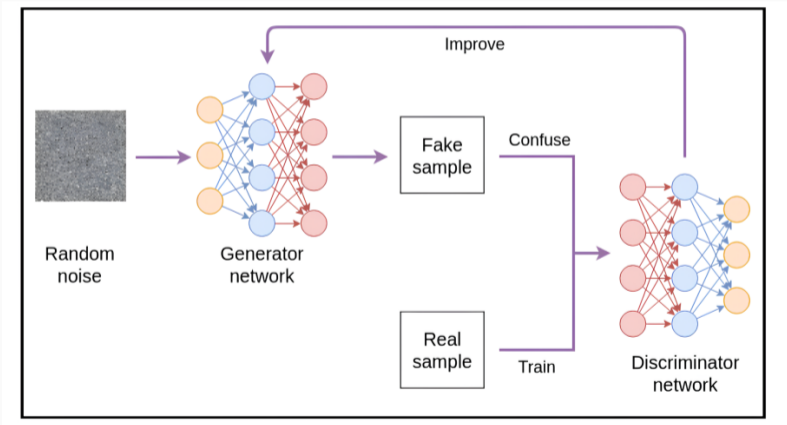
1. It is established that the consideration of nuclear-modified parton distribution functions weakly affects the predictions of the prompt photon invariant  $p_T$  spectra and nuclear modification factors measured in  $d + d$  collisions.
2. Prompt photon  $R_{AB} \approx 0.8$  at  $1 \text{ GeV} < p_T < 5 \text{ GeV}$
3. Isospin effects predominate over other nuclear modification effects

Application of GAN to simulation of  
longitudinally polarized  $p+p$   
collisions at  $\sqrt{s} = 27$  GeV

Lobanov A.A., Berdnikov Y.A.

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GAN – generative adversarial neural network with following architecture:





Pythia8 was used for modeling direct photons production in unpolarized/polarized  $p + p$  collision at energy  $\sqrt{s_{NN}} = 27$  GeV. Setting below was used:

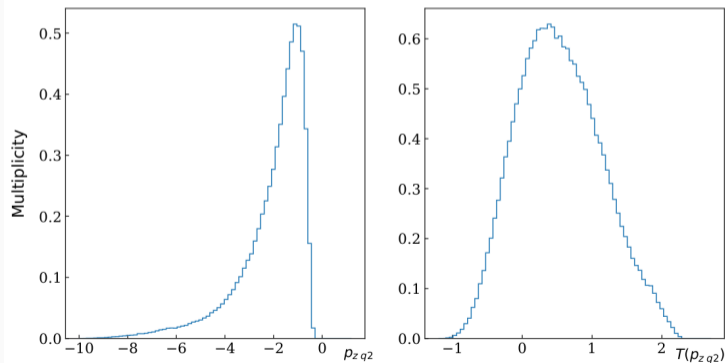
- Beam:eCM = 27;
- PromptPhoton: qg2qgamma = on;
- PromptPhoton: qqbar2ggamma = on;
- MultipartonInteraction: pT0Ref = 2.2;
- PDF:pSet = LHAPDF6:NNPDFpol11\_100 for polarized PDF;
- PDF:pSet = LHAPDF6:NNPDF31\_nlo\_as\_0118 for unpolarized PDF;

100'000 events for unpolarized and longitudinally polarized  $p + p$  collisions were generated.

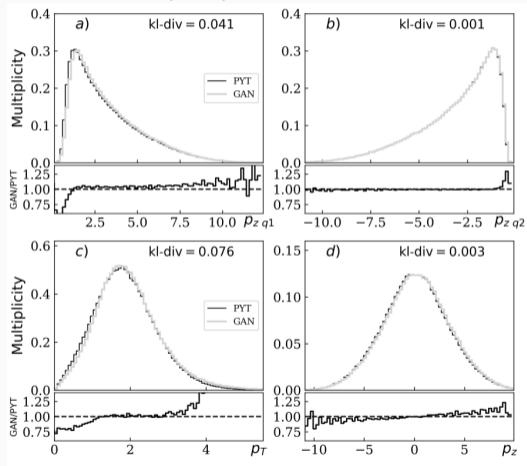
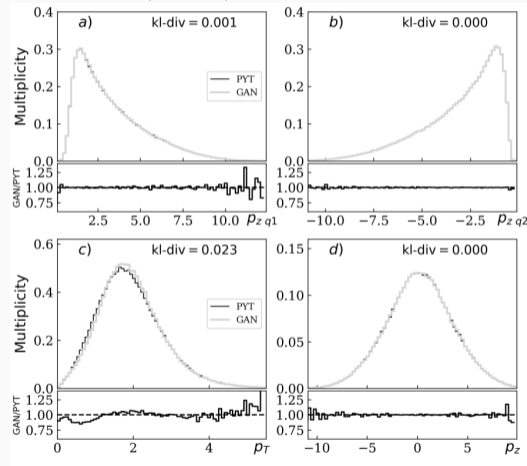
Features were chosen:

- For direct photons:  $p_x, p_y, p_z$
- For partons:  $p_{zq1}, p_{zq2}$

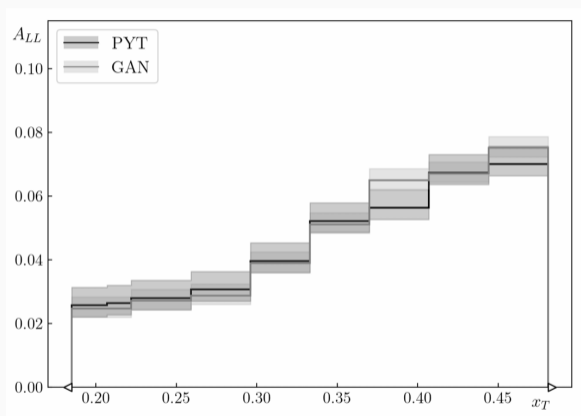
But for better work of GAN  $T(p_{zq1}) = \ln(p_{zq1})$  and  $T(p_{zq2}) = \ln(p_{zq2})$  were used.





$p + p$  collisions

 $p^{\rightarrow} + p^{\rightarrow}$  collisions


# Prompt photon $A_{LL}$ asymmetries obtained with the help of GAN and PYTHIA8



GAN reproduces prompt photon  $A_{LL}$  asymmetries and agrees with the PYTHIA8 results within uncertainties.



- Presented GAN allows to reproduce PYTHIA results with an accuracy of about 5%.
- Time to simulate  $10^6$  collisions using **PYTHIA** is  $\sim 5\text{m } 40\text{s}$
- Time to simulate  $10^6$  collisions using **trained GAN** is  $\sim 1\text{m } 12\text{s}$

✓ Thus, GAN allows to  $\sim 4$  times accelerate the process of simulation  $p + p$  collisions

✓ GAN can be trained on experimental data, obtained at available energies, and then used to estimate observables at intermediate energies.

Identified charged hadrons  
measurements in the PHENIX  
experiment as a prototype for SPD  
studies

Larionova D.M., Berdnikov Y.A.

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# Identified charged hadrons measurements in the PHENIX experiment as a prototype for SPD studies



The analysis of identified charged hadron production is more suitable for the **MPD experiment**

**However, the PHENIX experience may be useful for the SPD nuclei program:**

- Centrality identification
- $J/\psi$  measurements as a probe of possible phase transition
- Prompt photon measurements as a probe of possible phase transition (prompt photon production in  $d + d$  collisions is the first step)

**Studies of nuclei collisions have not been mentioned in state assignment for 2024 – future plans (next year?)**

# Thank you for attention!

