Direct photon cross section from POWHEG + PYTHIA 8

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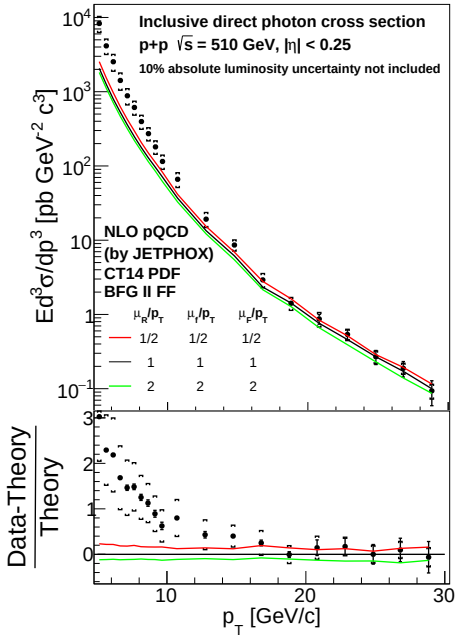
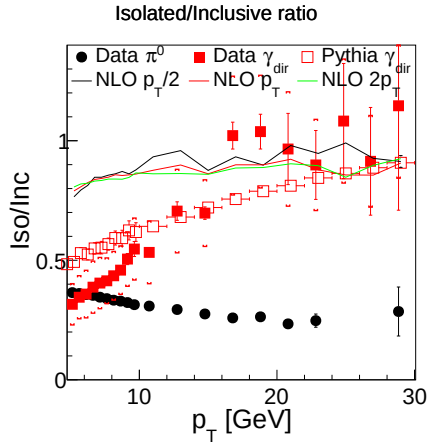
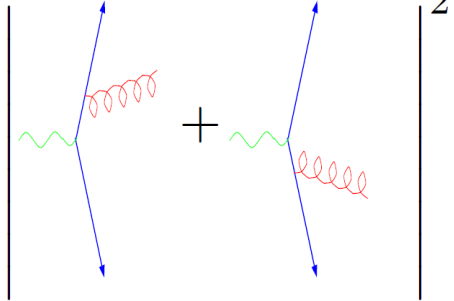

Inclusive direct photon cross section
p+p √s = 510 GeV, |η| < 0.25
10% absolute luminosity uncertainty not included
Ed³σ/dp³ [pb GeV⁻² c³]
NLO pQCD
(by JETPHOX)
CT14 PDF
BFG II FF
μR/pT μf/pT μF/pT
1/2 1/2 1/2
1 1 1
2 2 2
Data-Theory / Theory
pT [GeV/c]


Isolated/Inclusive ratio
Data π0
Data γdir
Pythia γdir
NLO pT/2
NLO pT
NLO 2pT
Iso/Inc
pT [GeV]

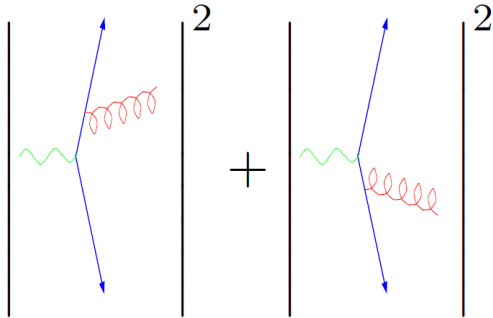
Problems and possible reasons

- The inclusive direct photon cross section is $\sim$ 2–3 times larger than JETPHOX prediction at pT $\sim$ 5–10 GeV.
- The PYTHIA 6 with LO+PS+MPI overestimated the isolated over inclusive direct photon ratio at pT $\sim$ 5–10 GeV.
- POWHEG authors studied PHENIX run 6 data and attributed these discrepancies as underlying event activity or quark fragmentation contributions [JHEP 11 (2016) 033].
- POWHEG + PYTHIA 8 gives NLO+PS+MPI corrections with correct treatment of matching and merging matrix elements and parton showers.
- NLO with real radiations gives correlated emissions, which are lacked in traditional PYTHIA parton showers.
- POWHEG + PYTHIA 8 gives good predictions for both inclusive and isolated direct photon cross sections.
- PYTHIA 8 uses $\sigma_{ND} = 32.65$ mb for MPI, as a comparison PHENIX has $\sigma_{BBC} = 32.51$ mb.
- PYTHIA includes only perturbative fragmentation to photon, the nonperturbative VMD is not included yet.

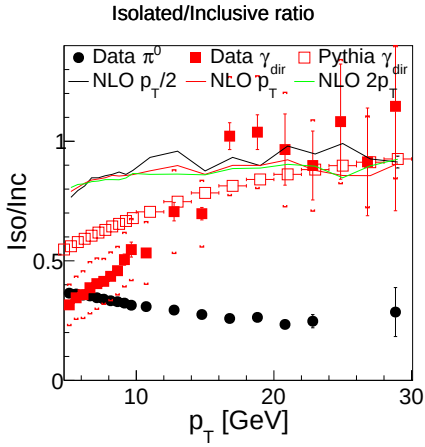
$$\frac{d\sigma_{\mathrm{ME}}}{dx_1 dx_2} \sim$$



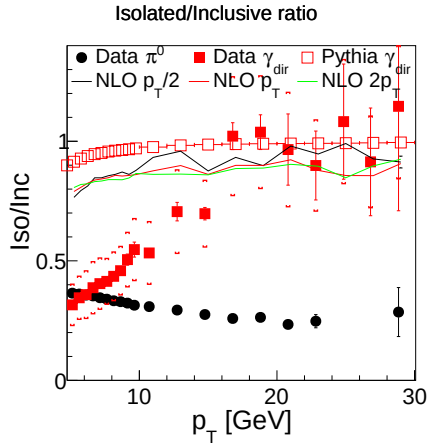
$$\frac{d\sigma_{\mathrm{PS}}}{dx_1 dx_2} \sim$$



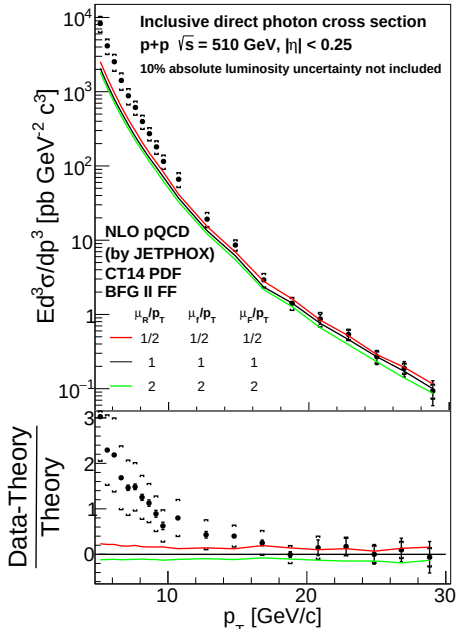
MPI influences



With MPI



Without MPI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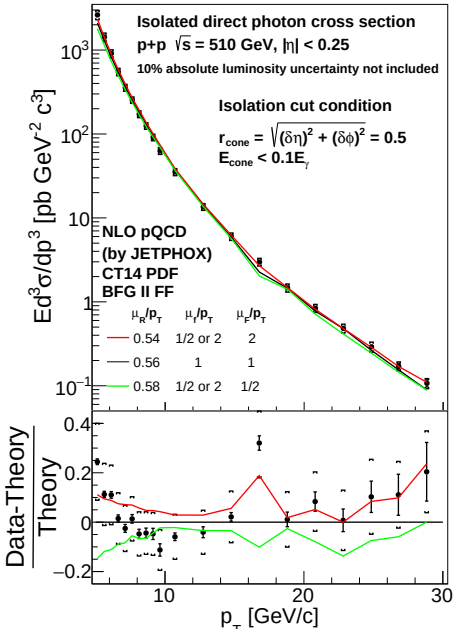
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E_cone < 0.1E_γ
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(by JETPHOX)
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BFG II FF
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0.54 1/2 or 2 2
0.56 1 1
0.58 1/2 or 2 1/2
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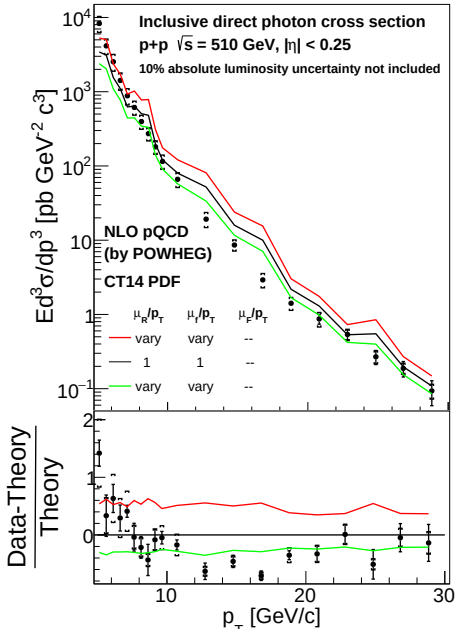
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vary vary --
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Data-Theory / Theory
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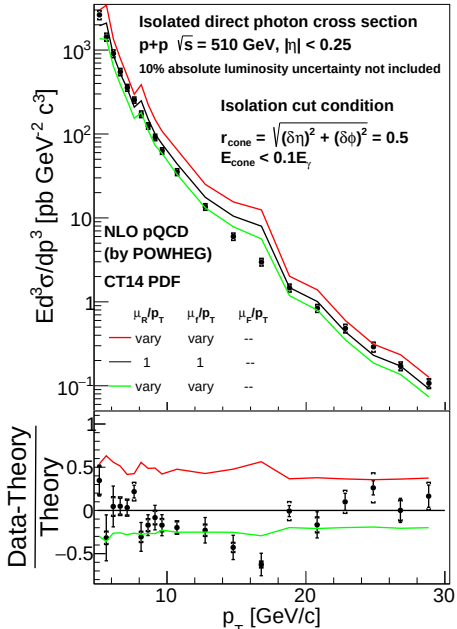
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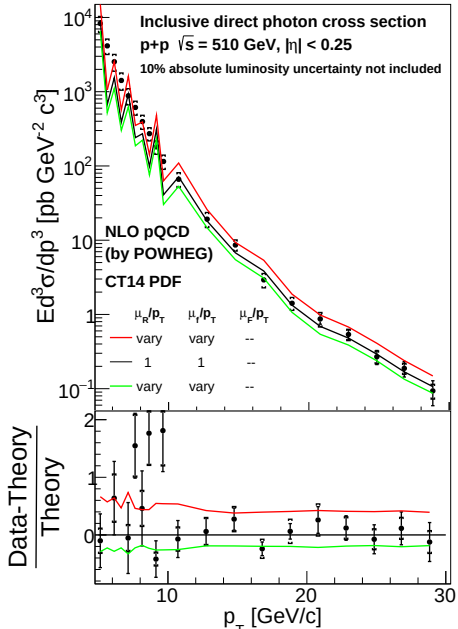
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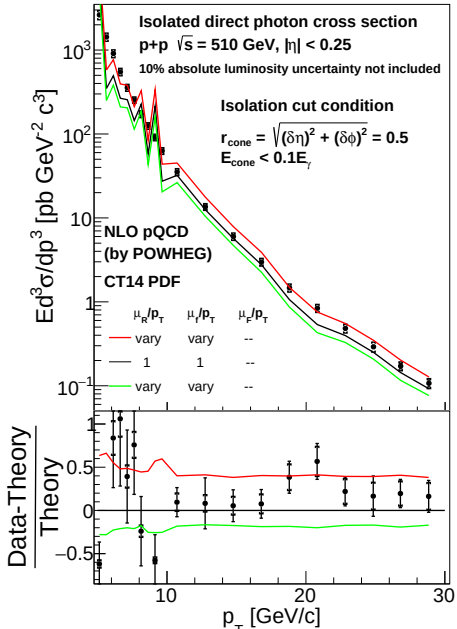
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1 1 --
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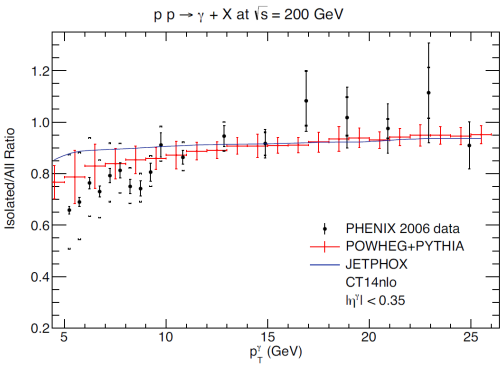
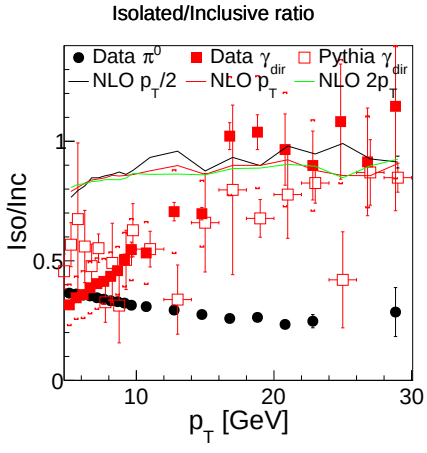
Data-Theory / Theory
pT [GeV/c]

Isolated over inclusive ratios



Run 6 with NLO+PS



Run 13 with NLO+PS+MPI

Conclustions and next steps

- The complicated structures of underlying event in p+p collisions have big influence to inclusive direct photon production.
- These effects are lacked in JETPHOX, but well simulated in PYTHIA.
- Run more statistics with POWHEG.
- Study discrepancy among spin patterns in ALL at pT $\sim$ 2–4 GeV.