

MEASUREMENT OF THE DIFFERENTIAL CROSS
SECTIONS OF THE PROCESSES WITH
A DIRECT PHOTON AND ASSOCIATED HADRONIC JET
IN $p\bar{p}$ COLLISIONS AT $\sqrt{s} = 1.96$ TeV

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on behalf of the DØ collaboration

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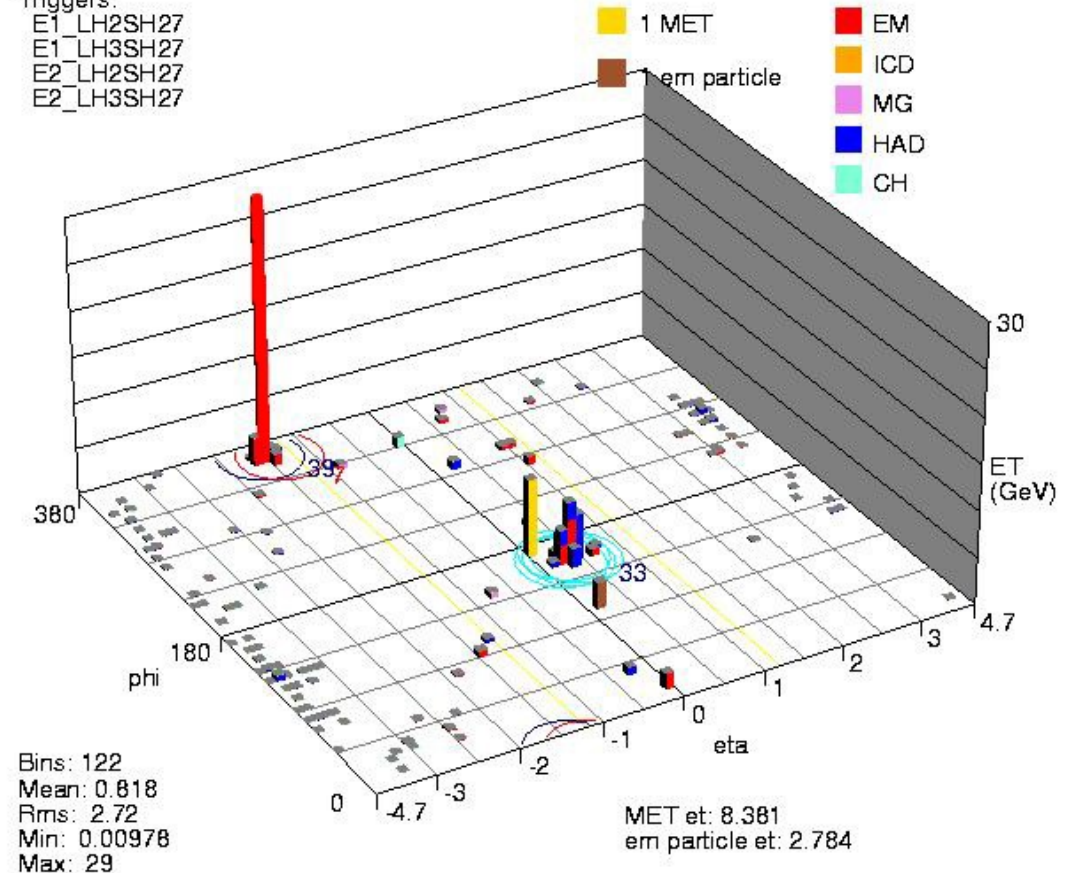
XXII IBSHEPP, Dubna
19 September 2014

Outline

- Motivation
- Data Sample and Selection
- Cross Section Calculations
- Results
- Comparison with Theory
- Summary

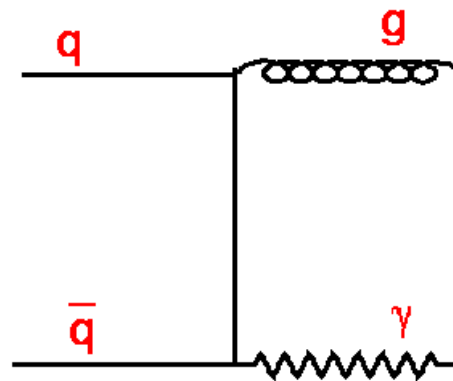
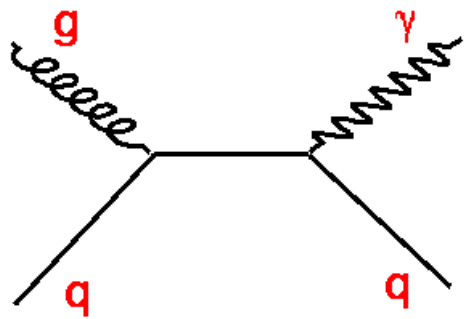
Run 267794 Evt 38299488 Sat Dec 25 08:40:11 2010

Triggers:
E1_LH2SH27
E1_LH3SH27
E2_LH2SH27
E2_LH3SH27

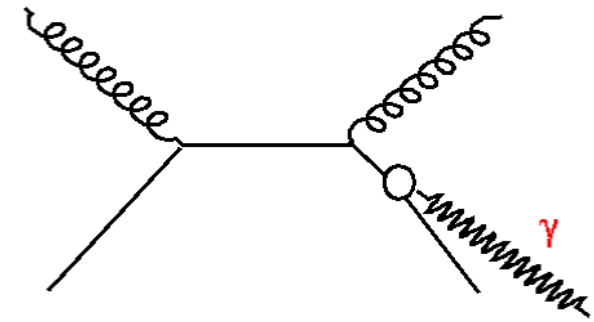


Motivation

- Inclusive production of prompt isolated photons in high energy hadronic collisions is known as one of the most **important test in QCD**.
- The physics prospects here are mostly based on the usage of associated production process of direct photon with jet in the final state.



Compton-like scattering and annihilation subprocesses (2 main sources of direct photons)



fragmentation (can be suppressed)

- Direct photons are one of substantial backgrounds to many physical processes.
- Extension of previous 1 fb^{-1} measurement.

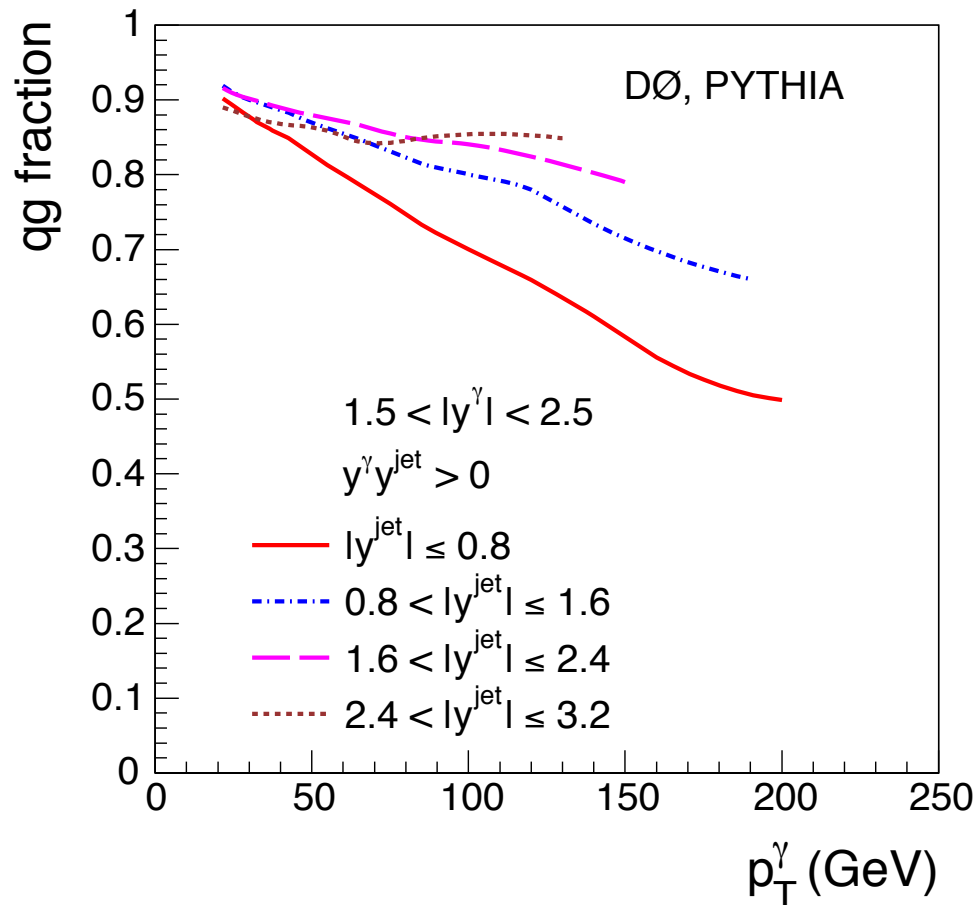
Phys. Lett. B 666, 435 (2008)



Motivation (cont'd)

16 rapidity regions: Photon: $|y| < 1.0$ (CC, central), $1.5 < |y| < 2.5$ (EC, forward);
Jet: $|y| < 0.8$, $0.8 < |y| < 1.6$, $1.6 < |y| < 2.4$, $2.4 < |y| < 3.2$;
Product of same (opposite) rapidities $y^\gamma \times y^{jet} > 0$, $y^\gamma \times y^{jet} \leq 0$

- Different compositions of subprocesses



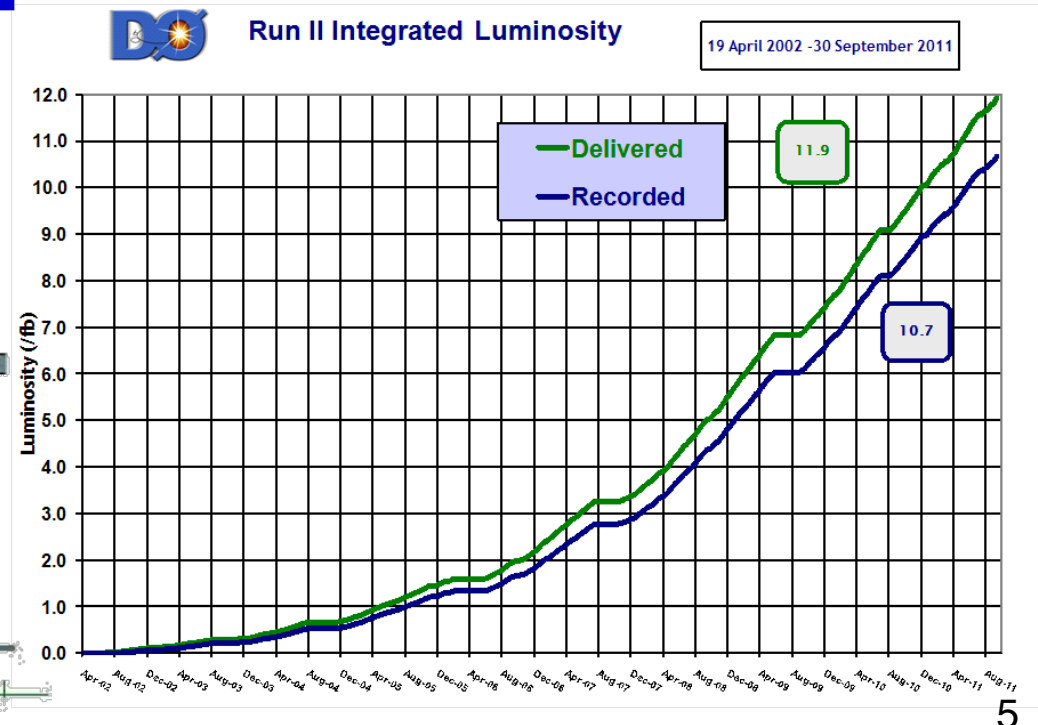
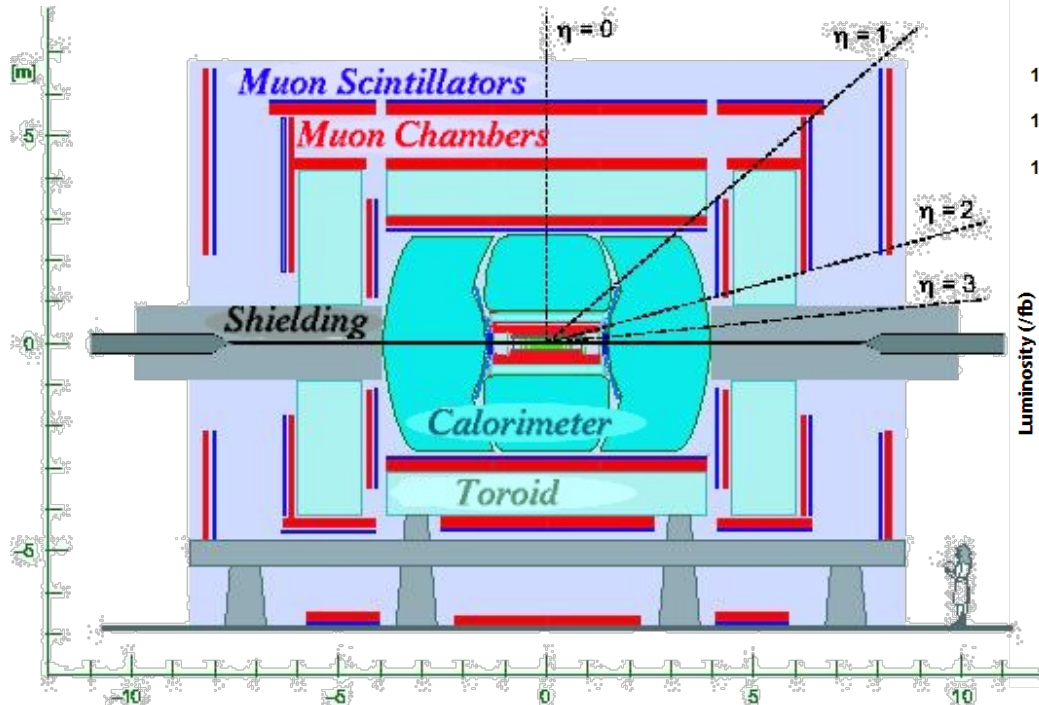
The production of cross section may give us an opportunity for extracting/tuning a form of the gluon distribution that still has noticeable uncertainties.



DØ detector



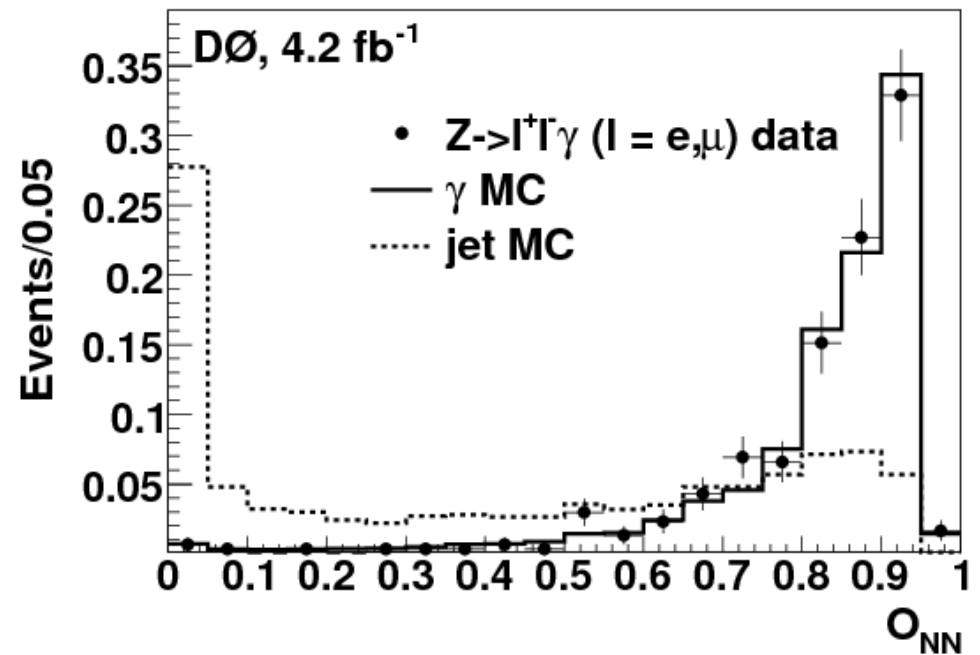
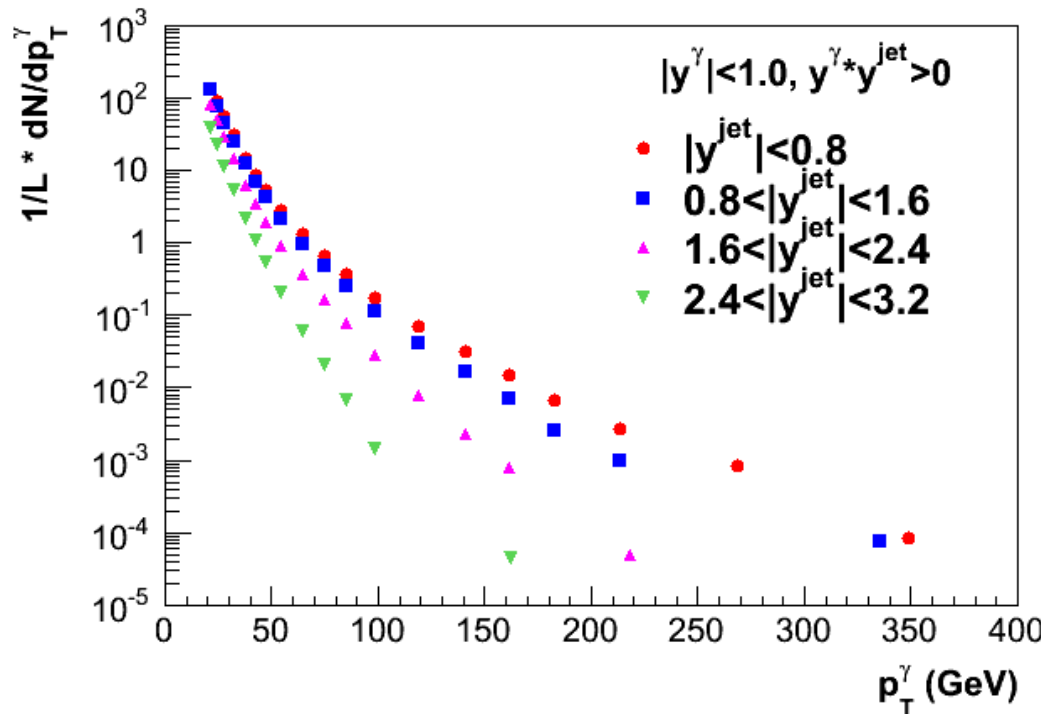
- DØ is a multipurpose detector with
- a silicon vertex detector,
 - central fiber tracker,
 - liquid Argon and Uranium calorimeter,
 - a muon tracking system with large acceptance.



Data Sample and Event Selection

The analysis corresponds the RunIIb DØ data set ($\sim 8.7 \text{ fb}^{-1}$).

1. At least one photon with $p_T^\gamma > 20 \text{ GeV}$;
2. At least 1 jet with $p_T^{\text{jet}} > 15 \text{ GeV}$;
3. Photon and Jet are isolated from each other by $dR > 0.9$ in η - ϕ space;
4. Missing Energy $< 0.7 p_T^\gamma$



Cross Section Calculation

$$\frac{d^3\sigma}{dp_T^\gamma dy^\gamma dy^{jet}} = \frac{NP}{L_{\text{int}} \Delta p_T^\gamma \Delta y^\gamma \Delta y^{jet} A \epsilon_{tr} \epsilon_s^\gamma \epsilon_s^{jet} \epsilon_s^{evt}}$$

N – the number of gamjet candidates in the selected samples;

P – the signal event purity;

L – the integrated luminosity;

A – the geometric and kinematic acceptance;

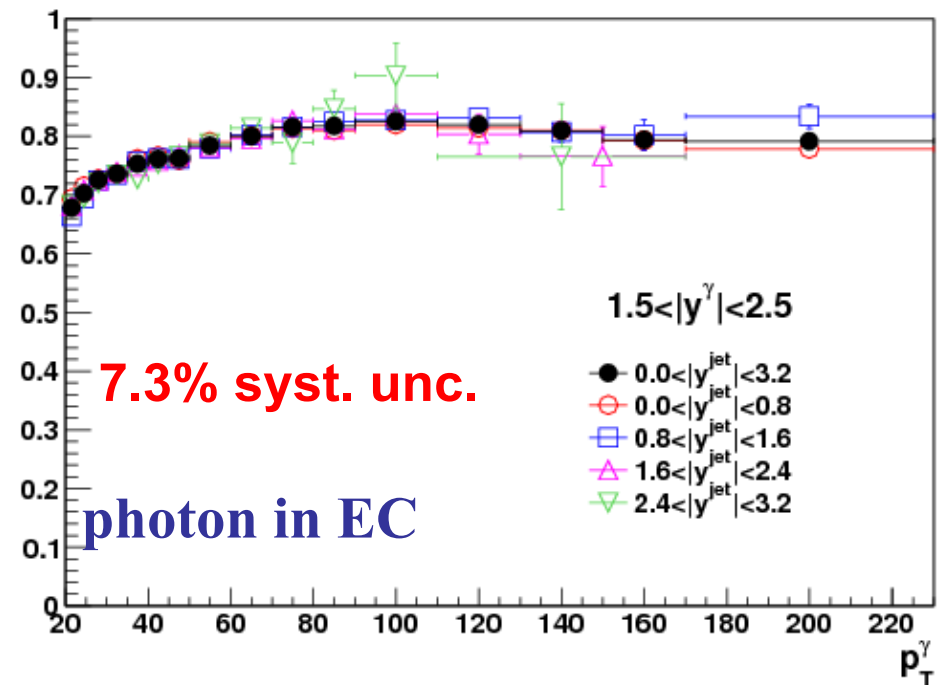
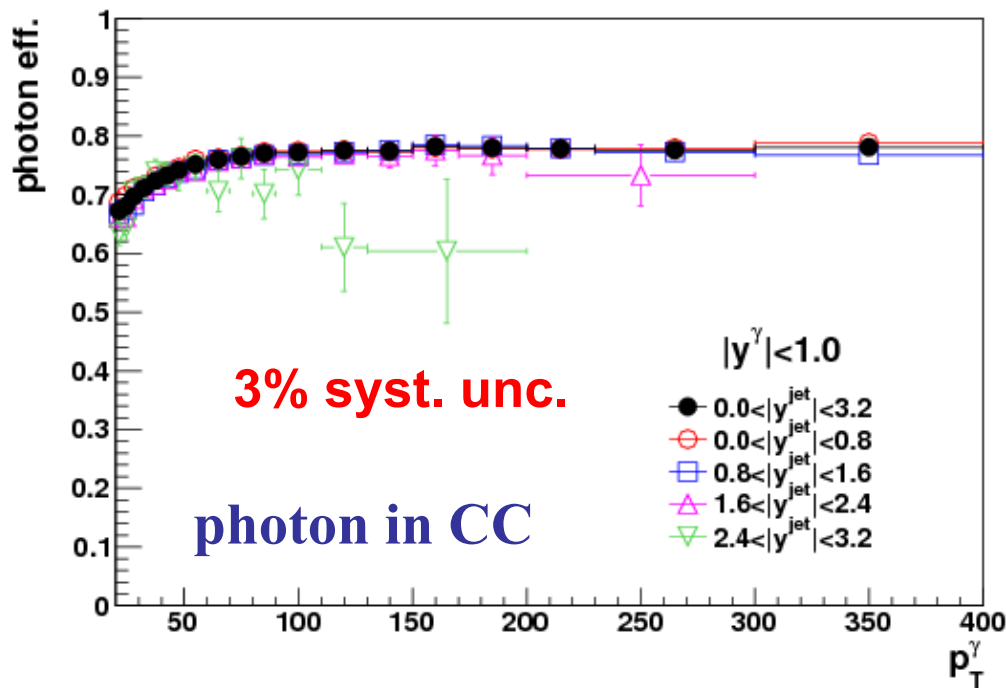
$\Delta p_T^\gamma \Delta y^\gamma \Delta y^{jet}$ - are bin sizes in photon transverse momentum, photon and jet rapidities;

$\epsilon_{tr} \epsilon_s^\gamma \epsilon_s^{jet} \epsilon_s^{evt}$ - are trigger efficiency and efficiencies of the photon and jet selection criteria, and event selection efficiency.



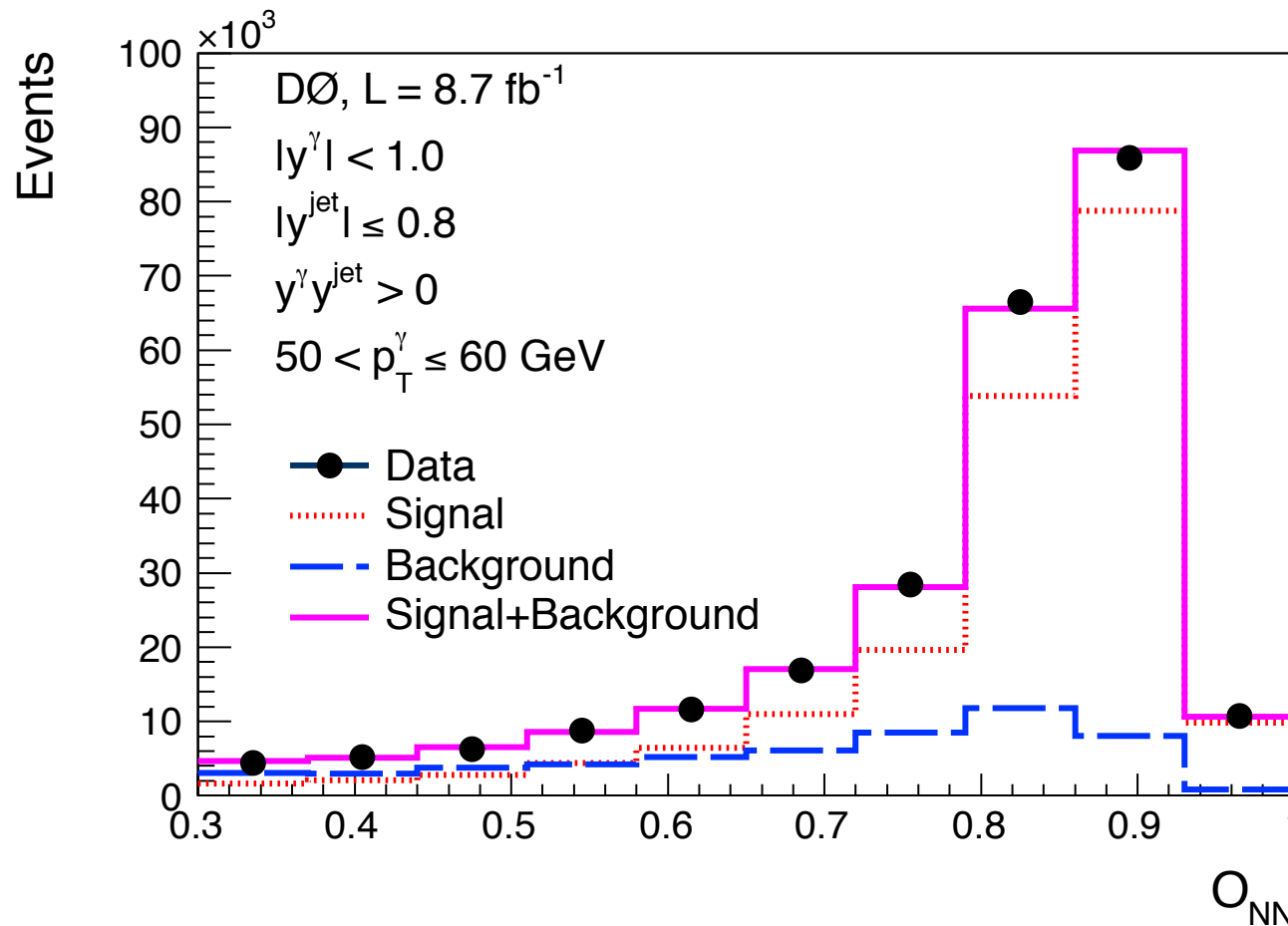
Selection:

- at least 96% of the energy should be deposited in EM layers of calorimeter
- isolation fraction in region $0.2 \leq R \leq 0.4$ of less than 0.07
- track isolation in region $0.05 \leq R \leq 0.4$ less than 1.5 GeV
- no association between EM cluster and track in the central tracking system
- NN Output > 0.3 to retain 97% of photons and reject 15-40% of jets.



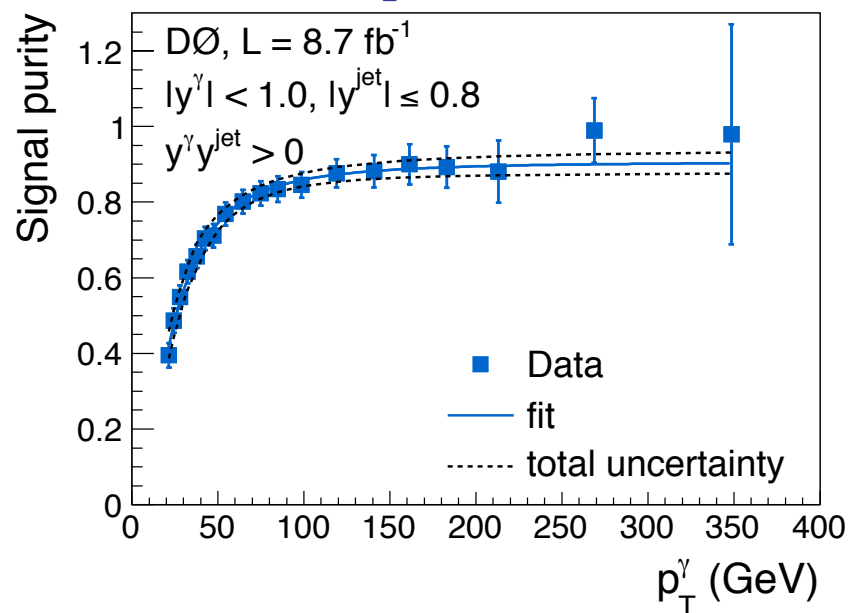
Purity

1. Obtain photon NN output distributions for each p_T^γ bin for Data, Signal, Background.
2. Fit Data distributions by MC using maximum likelihood fit and extract purity as fraction of Signal MC.

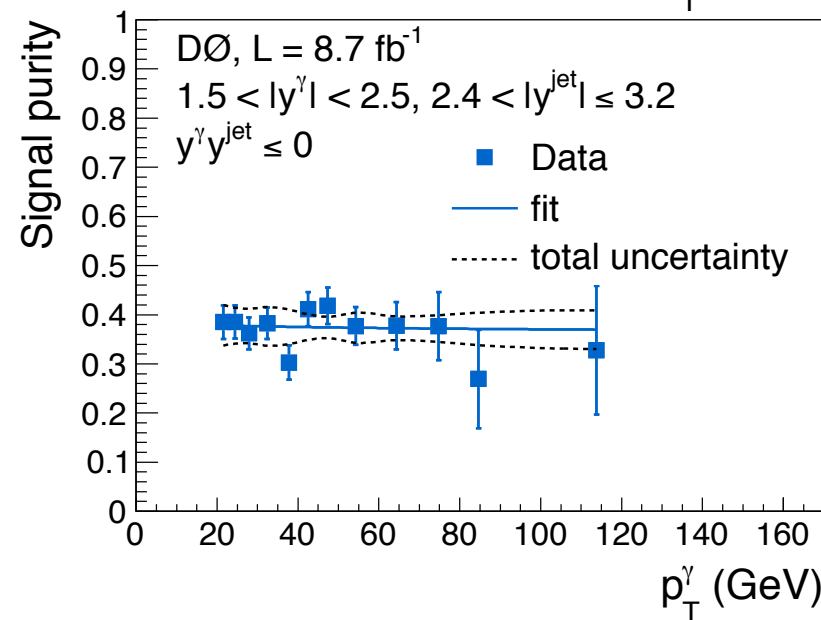
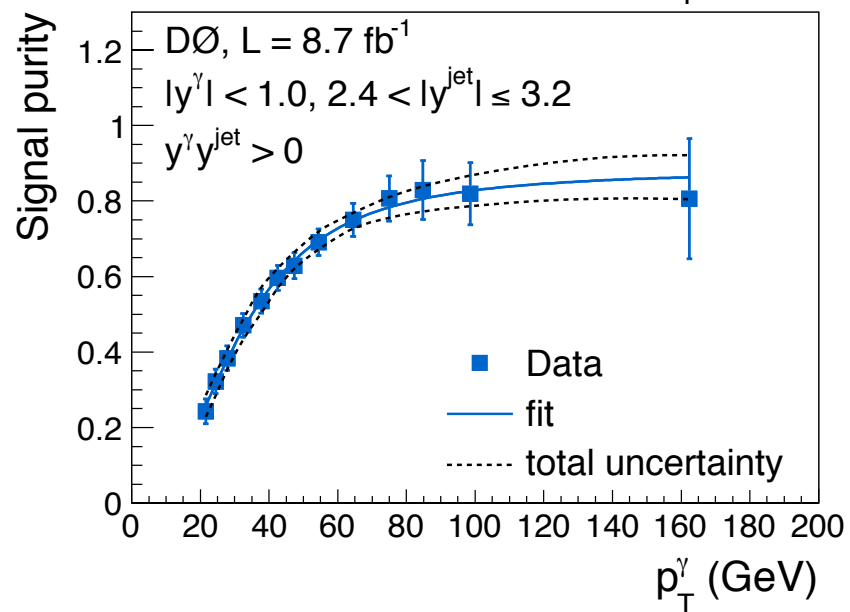
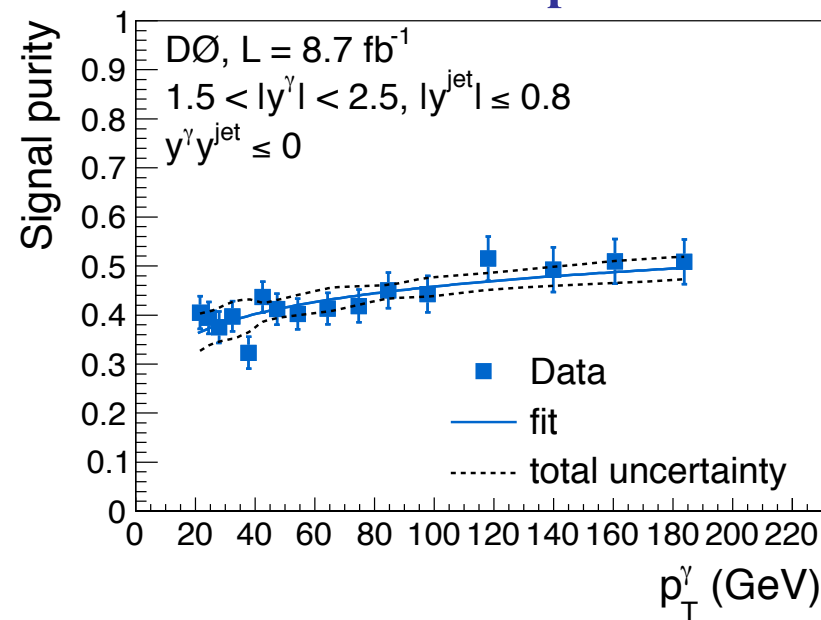


Purity (cont'd)

Central photon



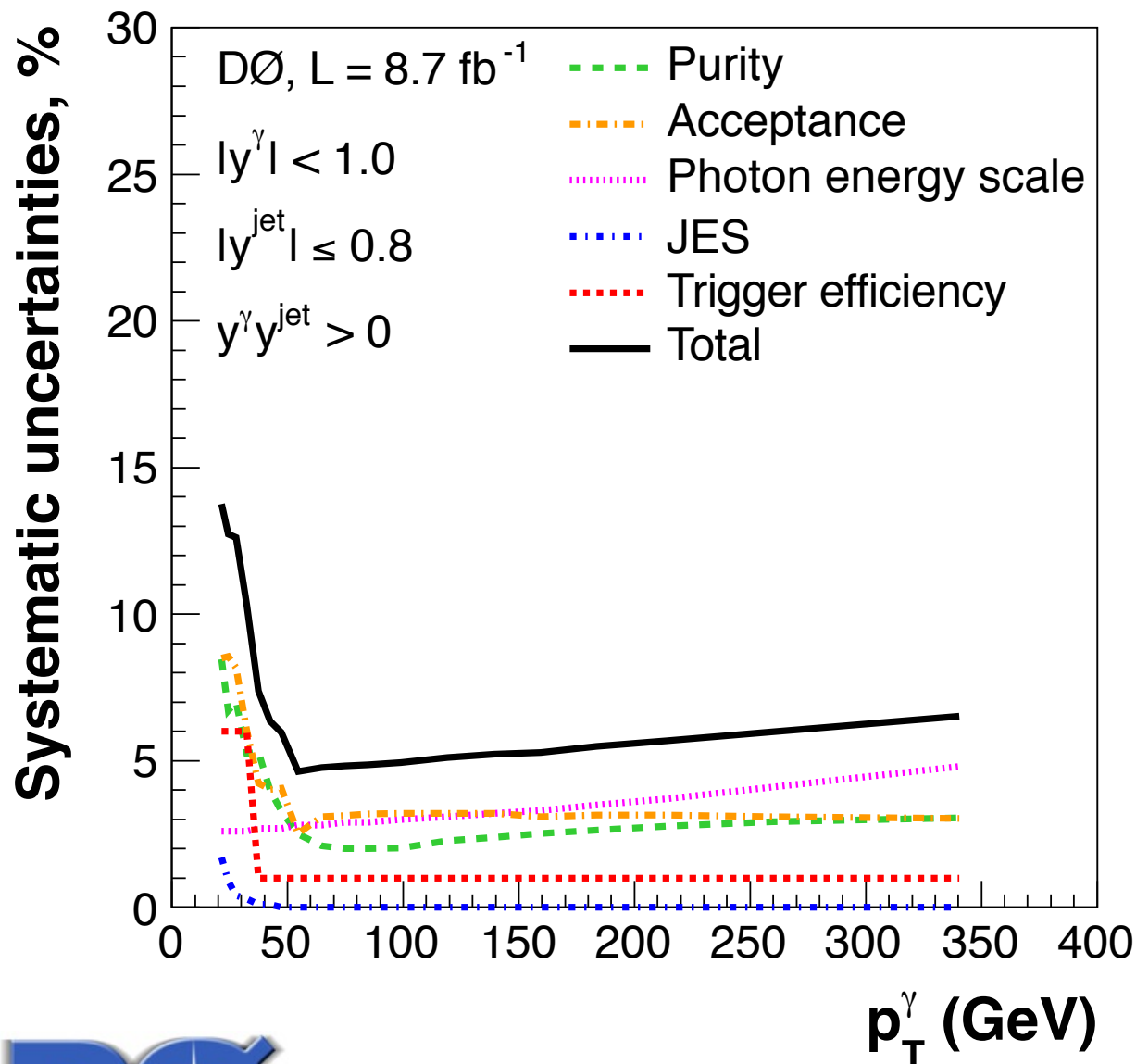
Forward photon



Purity does depend on the product of rapidities, jet rapidity and p_T^γ .

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Systematic Uncertainty (Central Photon)

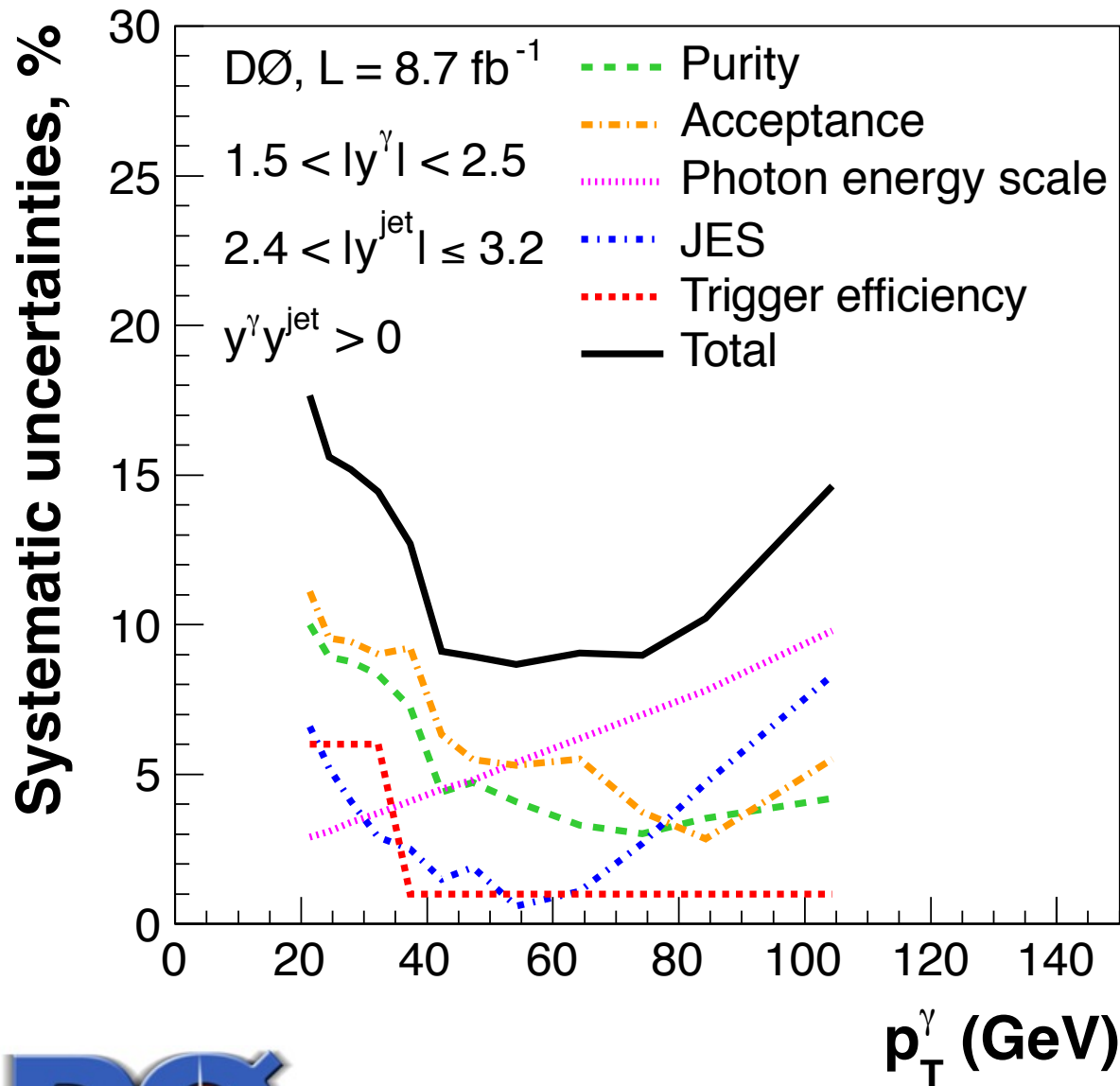


Trigger eff.	1.0 – 6.0%
Acceptance	2.0 – 8.0%
Purity	1.0 – 8.0 %

Overall correlated systematic $\sim 7\%$
 due to luminosity and photon selection



Systematic Uncertainty (Forward Photon)



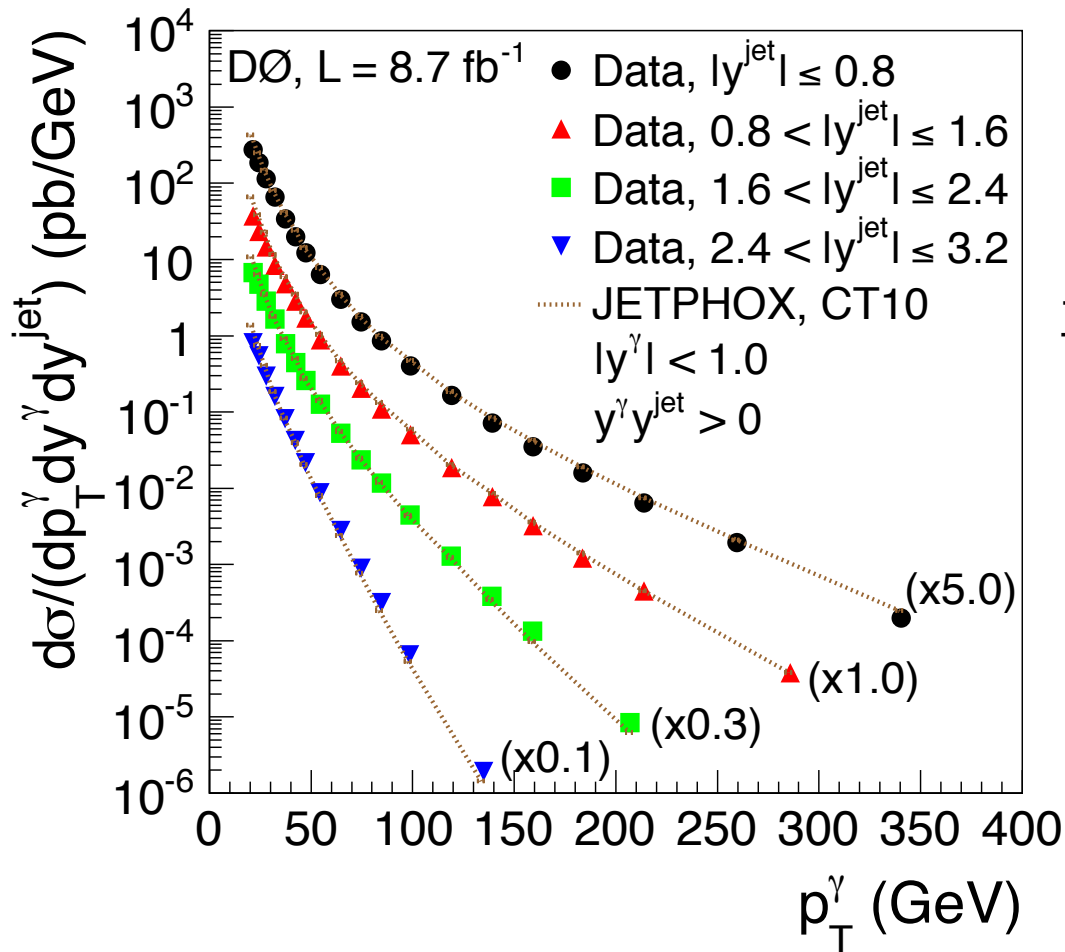
Trigger eff.	1.0 – 6.0%
Purity	3.0 – 10.0 %
Acceptance	2.0 – 11.0%
JES	2.0 – 7.0%

Overall correlated systematic $\sim 11\%$
due to luminosity and photon
selection

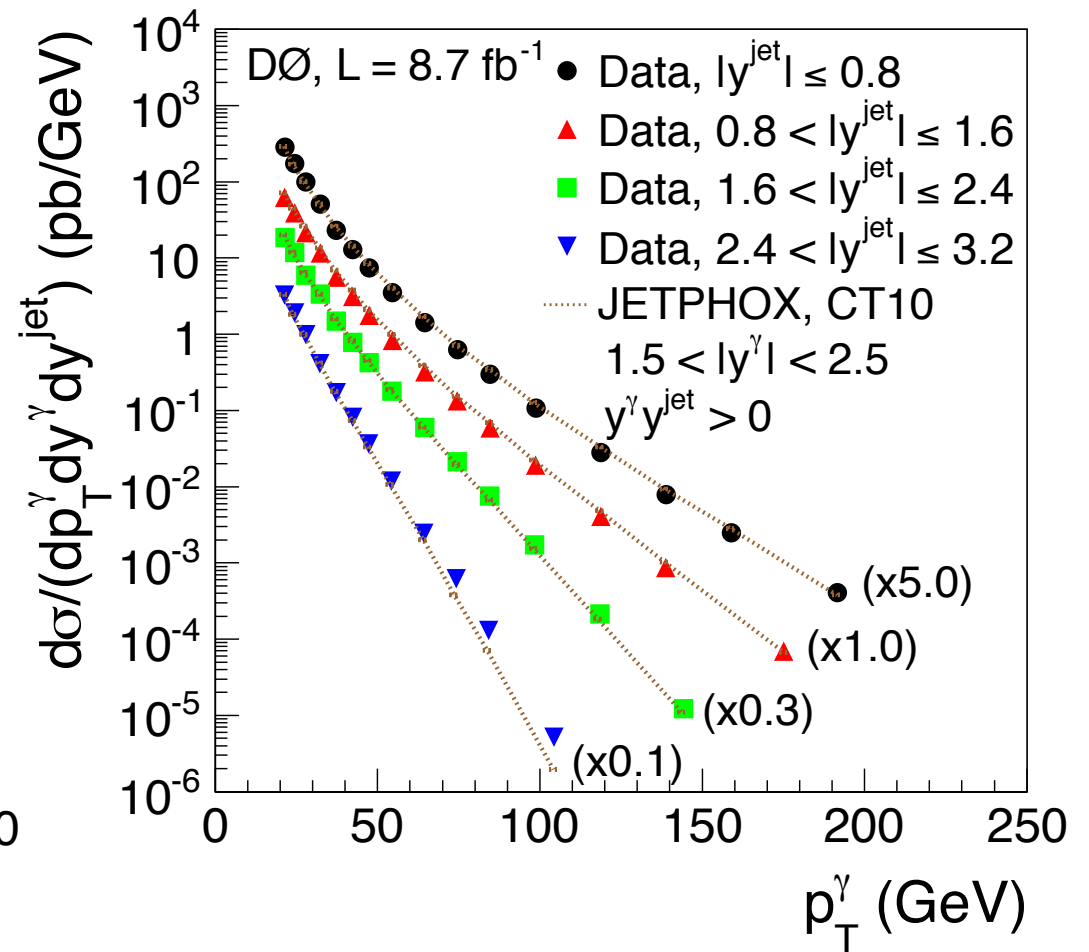


Cross Section

Central photon

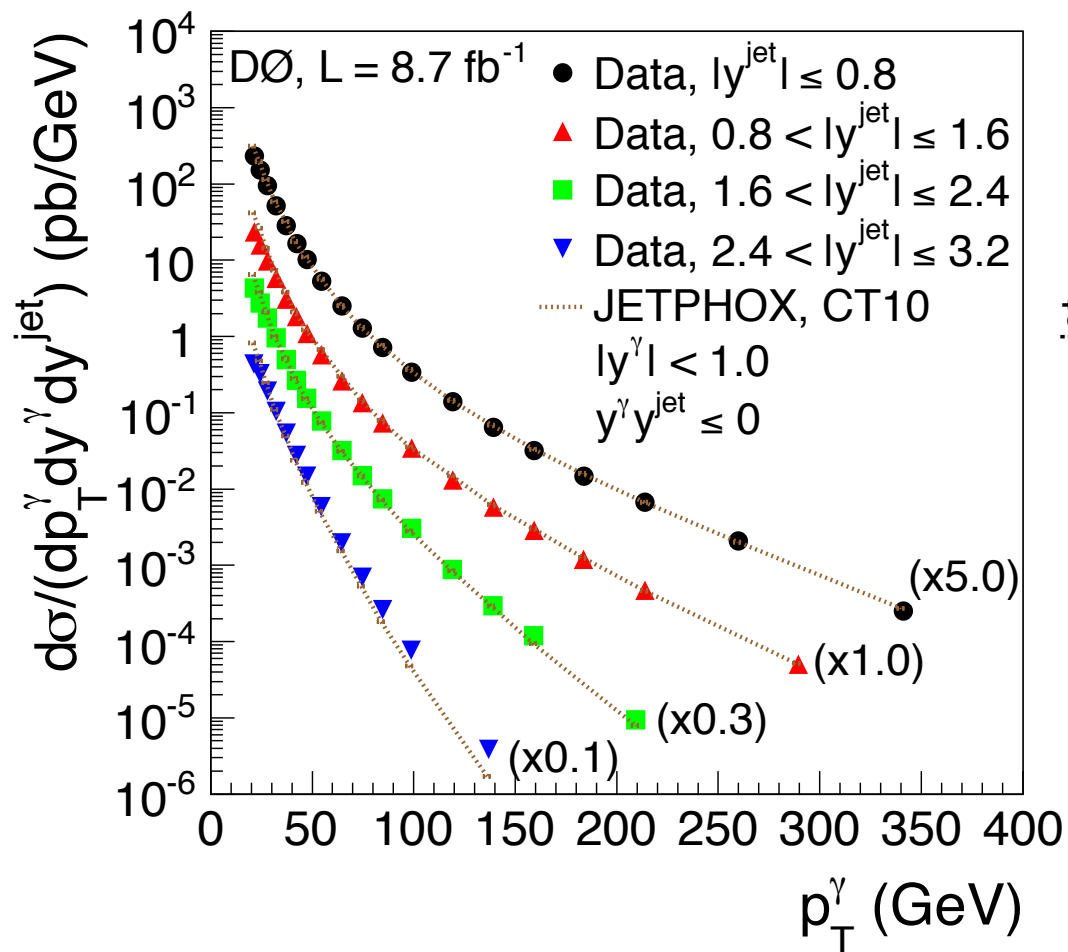


Forward photon

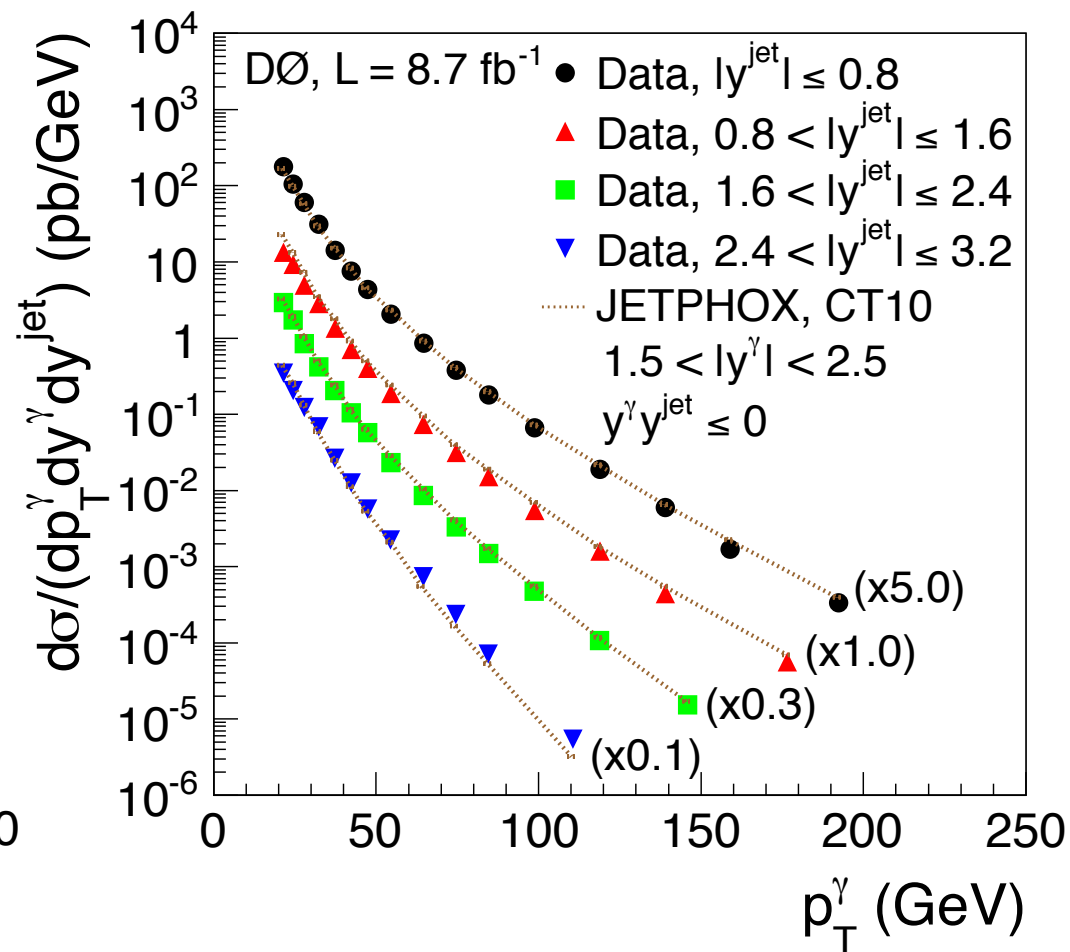


Cross Section (cont'd)

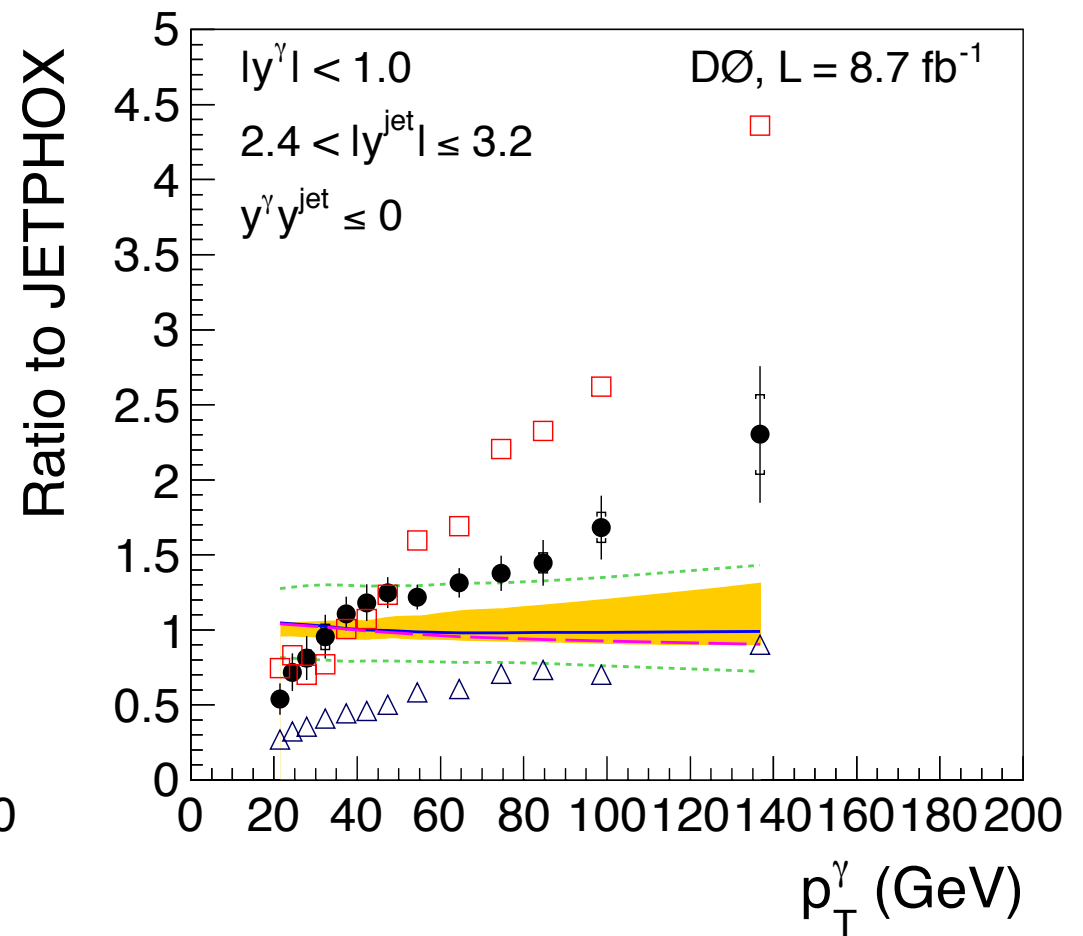
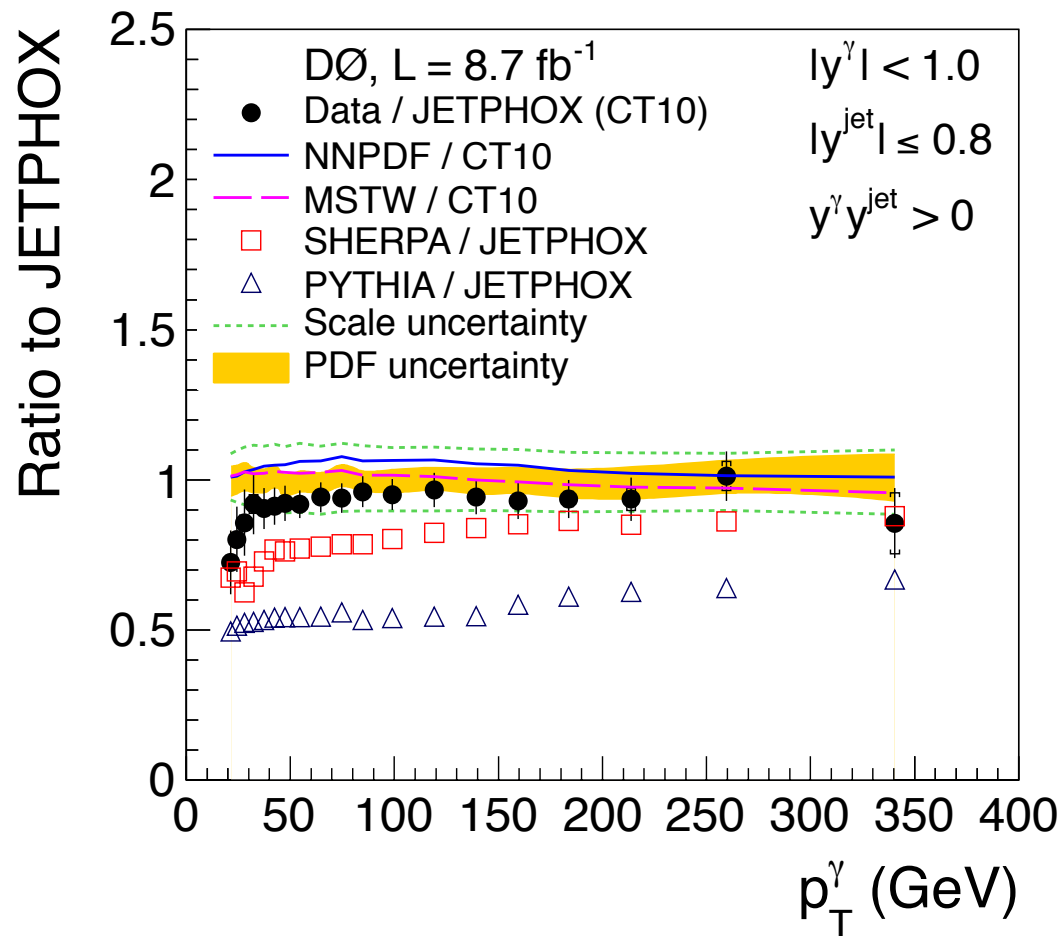
Central photon



Forward photon



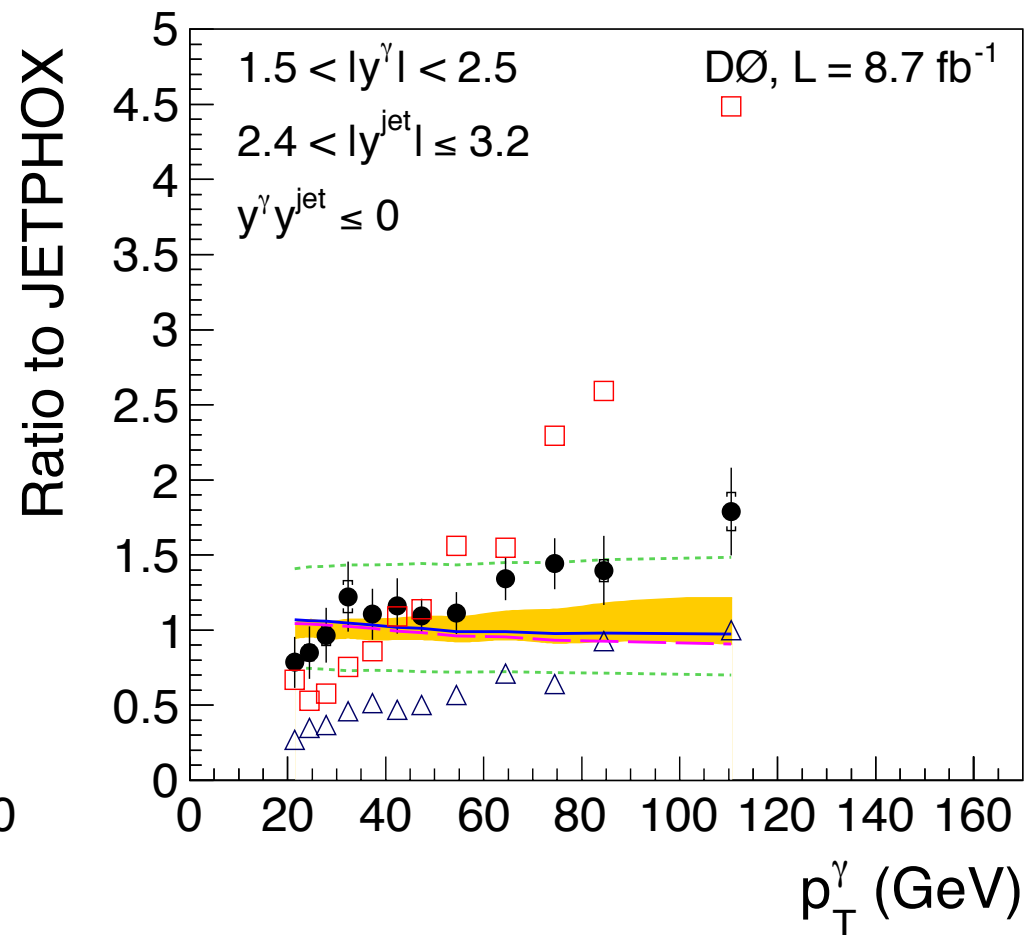
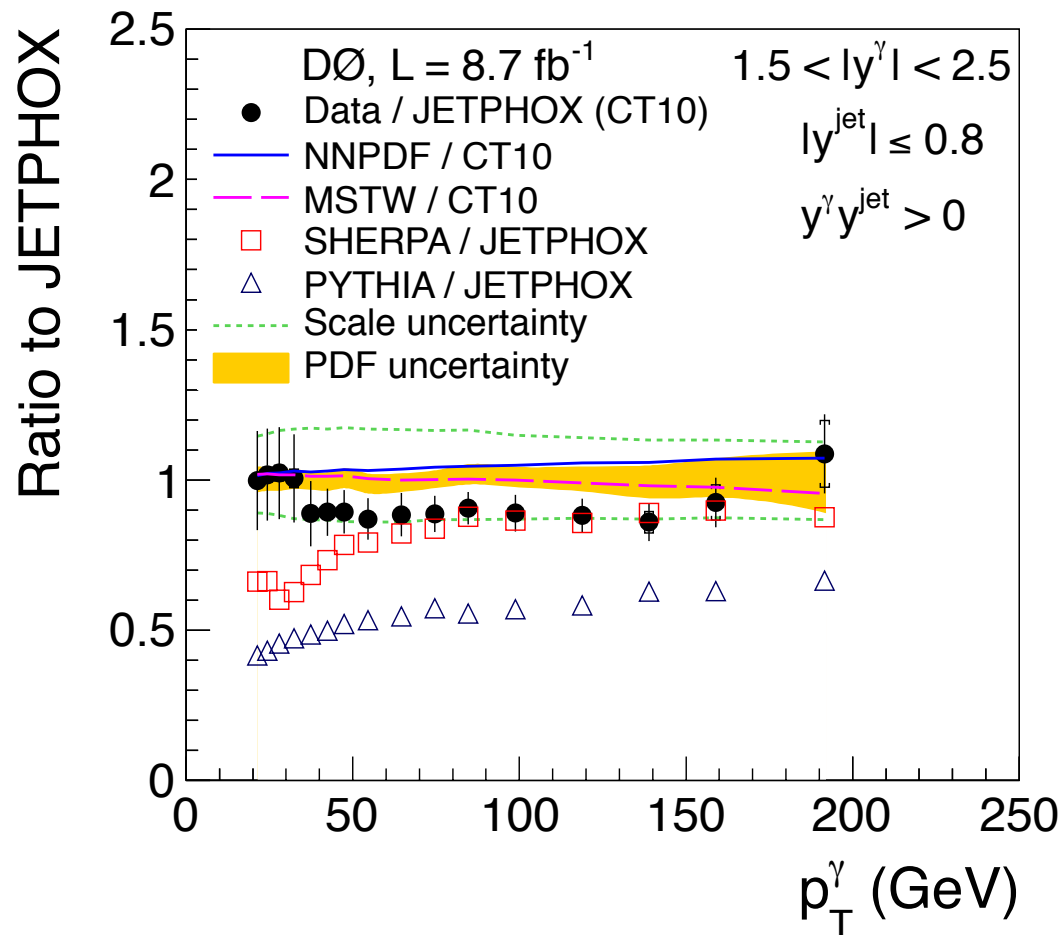
Data to Theory (Central Photon)



NLO theory (with CT10 and NNPDFv2.1, MSTW) agree with data except low and high p_T^γ with very forward jets.



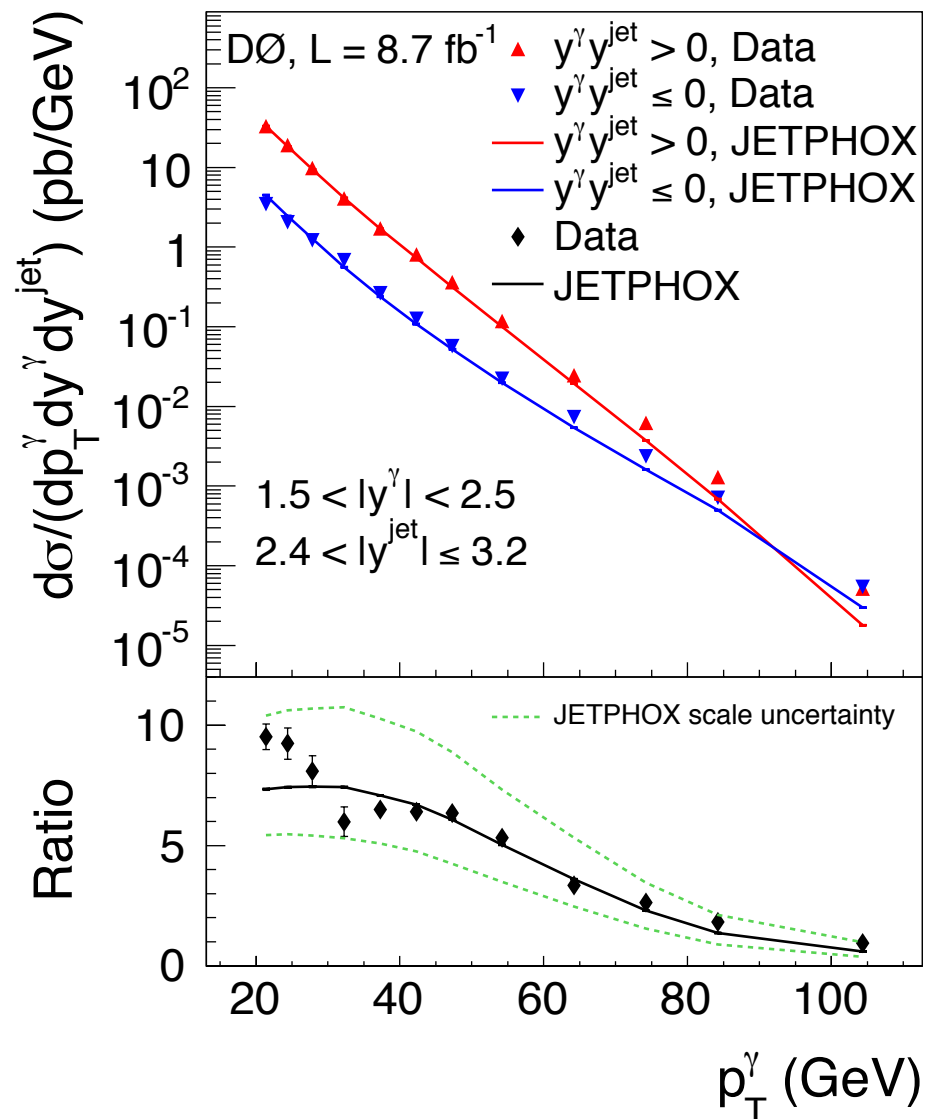
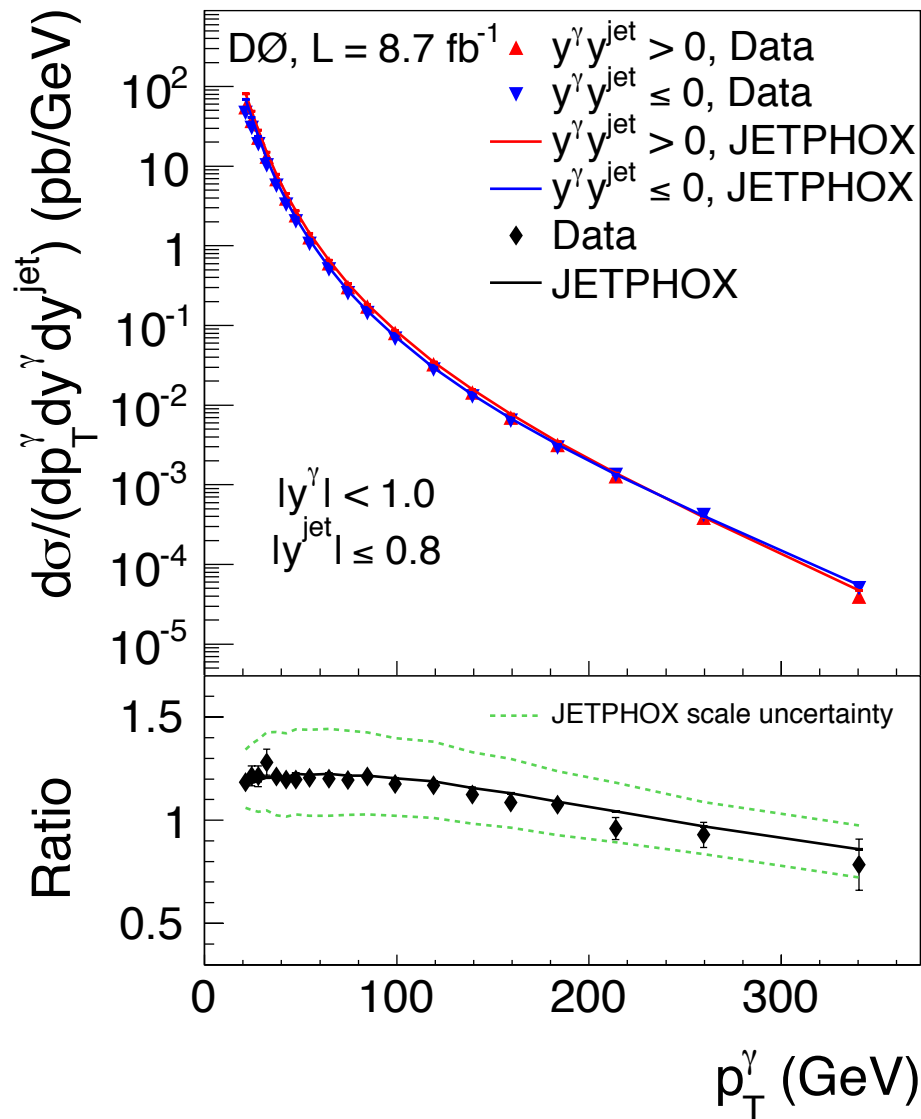
Data to Theory (Forward Photon)



NLO theory (with CT10 and NNPDFv2.1, MSTW) agree with data
 except high p_T^γ with very forward jets.



Positive and Negative Products Ratio



Different slopes for cross sections; the ratio of cross sections up to 10.



Summary

- Measured the triple differential cross section for production of photon+jet in the range $20 < p_T^\gamma < 400$ (230) GeV in 16 photon-jet rapidity regions.
- Compared with JETPHOX NLO MC (CT10, NNPDFv2, MSTW pdf data sets).
- Observed a disagreement with the theory for small (central photons) and high p_T^γ with very forward jets.
- Considered the ratios of cross sections between same-sign and opposite-sign of rapidities. The disagreement is especially noticeable for forward photons and very forward jets (up to 10).
- More details in [Phys. Rev. D 88, 072008 \(2013\)](#).



THANKS FOR YOUR ATTENTION