

# Pythia 6-8 comparison update

MCEG validation for EIC

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# Comparison between PYTHIA 6 and PYTHIA 8

| Process                                       | PYTHIA6 (mb) | PYTHIA8(mb) |
|-----------------------------------------------|--------------|-------------|
| $f + f' \rightarrow f + f'$ (QCD)             | 3.098E-04    | 3.757E-04   |
| $f + fbar \rightarrow f' + fbar'$             | 5.698E-06    | 6.111E-06   |
| $f + fbar \rightarrow g + g$                  | 7.085E-06    | 8.387E-06   |
| $f + g \rightarrow f + g$                     | 1.229E-03    | 1.824E-03   |
| $g + g \rightarrow f + fbar$                  | 1.823E-05    | 3.447E-05   |
| $g + g \rightarrow g + g$                     | 6.887E-04    | 1.456E-03   |
| Elastic scattering                            | 2.982E-03    | 4.084E-03   |
| Single diffractive (XB)                       | 2.127E-03    | 2.310E-03   |
| Single diffractive (AX)                       | 1.741E-03    | 2.676E-03   |
| Double diffractive                            | 1.192E-03    | 1.483E-03   |
| Low-pT scattering                             | 8.855E-03    |             |
| Non-diffraction                               |              | 2.819E-02   |
| $q + gamma^* \rightarrow q$ ( $0 < Q^2 < 2$ ) | 1.717E-02    |             |
| $q + gamma^* \rightarrow q$ ( $Q^2 > 10$ )    | 6.919E-05    | 6.495E-05   |
| $f + gamma^*_T \rightarrow f + g$             | 1.338E-04    | 2*1.618E-04 |
| $f + gamma^*_L \rightarrow f + g$             | 1.696E-07    |             |
| $g + gamma^*_T \rightarrow f + fbar$          | 4.043E-04    | 2*3.859E-04 |
| $g + gamma^*_L \rightarrow f + fbar$          | 4.725E-06    |             |

- Reasonable agreement for the different cross section with matching phase-space cuts
- Still need to check with equal PDFs

Table by Z. Zhang

# HERA dijet photoproduction data

## ZEUS dijet measurement

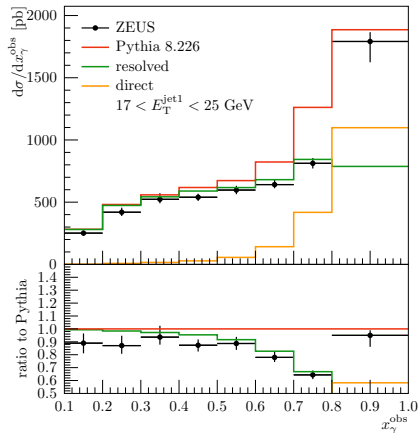
- $Q^2 < 1.0 \text{ GeV}^2$
- $134 < W_{\gamma p} < 277 \text{ GeV}$
- $E_T^{\text{jet1}} > 14 \text{ GeV}, E_T^{\text{jet2}} > 11 \text{ GeV}$
- $-1 < \eta^{\text{jet1,2}} < 2.4$

## Two contributions

- Momentum fraction of partons in photon

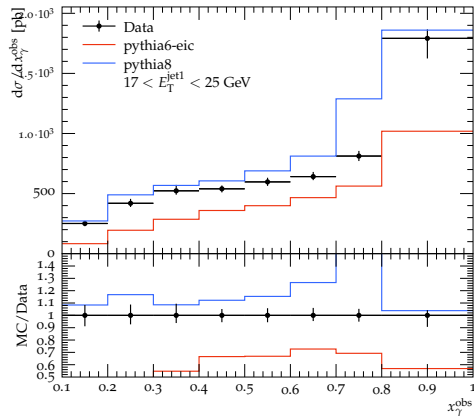
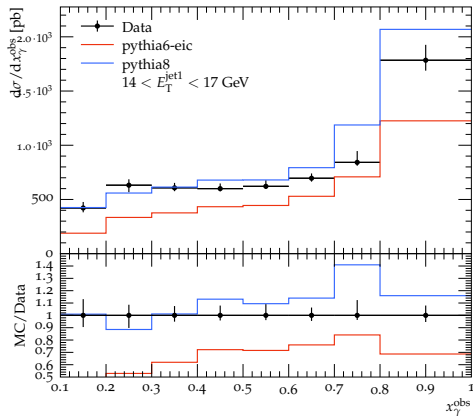
$$x_\gamma^{\text{obs}} = \frac{E_T^{\text{jet1}} e^{\eta^{\text{jet1}}} + E_T^{\text{jet2}} e^{\eta^{\text{jet2}}}}{2yE_e} \approx x_\gamma$$

- Sensitivity to process type
- At high- $x_\gamma^{\text{obs}}$  direct processes dominate



[ZEUS: Eur.Phys.J. C23 (2002) 615-631]

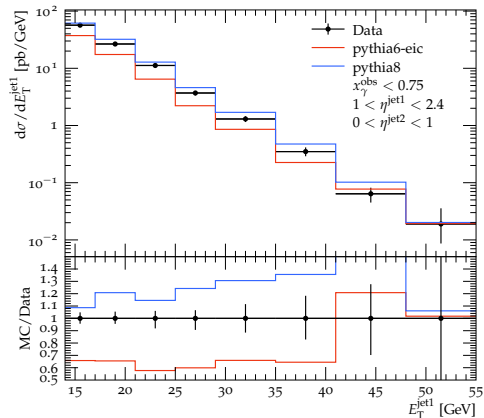
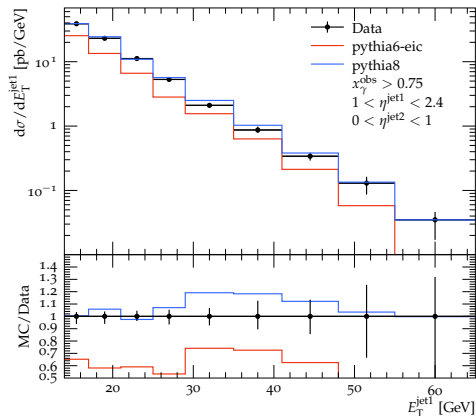
# Comparison between PYTHIA 6 and PYTHIA 8



[ZEUS: Eur.Phys.J. C23 (2002) 615-631]

- PYTHIA 8 slightly above dijet data, PYTHIA 6 clearly below

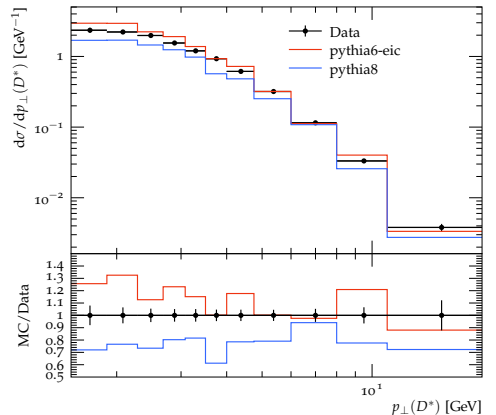
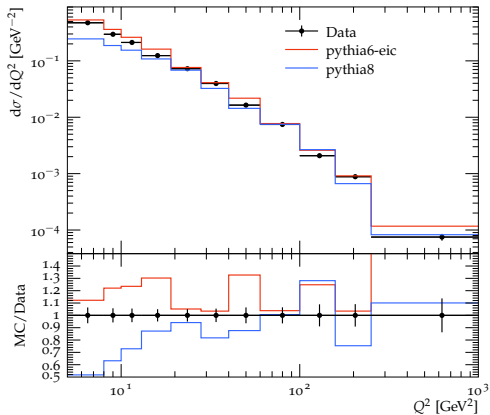
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[ZEUS: Eur.Phys.J. C23 (2002) 615-631]

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# $D^*$ production in DIS



[HERA: JHEP 1509 (2015) 149]

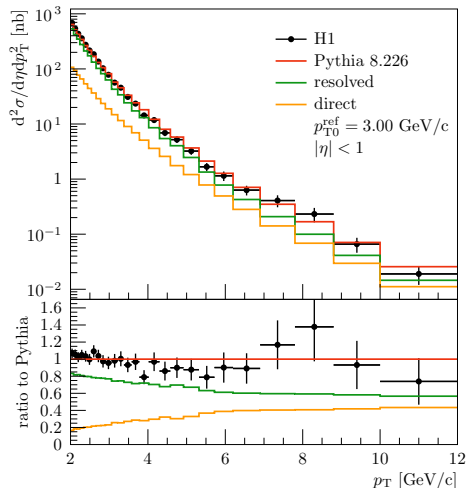
- PYTHIA 8 below data at small  $Q^2$ , PYTHIA 6 doing well

## Discussion items

- We have discussed not to include PYTHIA 6 results for data comparisons
  - Should we still have some in section 3?
- Should we invest more time on PYTHIA 6 and HERA comparisons?

Backup slides

# Charged particle $p_T$ spectra in ep collisions at HERA



[H1: Eur.Phys.J. C10 (1999) 363-372]

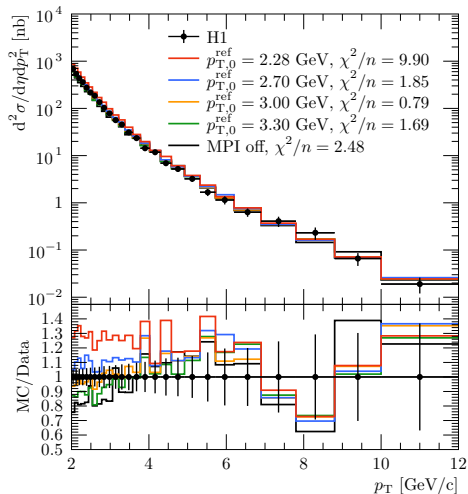
## H1 measurement

- $E_p = 820 \text{ GeV}$ ,  $E_e = 27.5 \text{ GeV}$
- $\langle W_{\gamma p} \rangle \approx 200 \text{ GeV}$
- $Q_\gamma^2 < 0.01 \text{ GeV}^2$

## Comparison to PYTHIA 8

- Resolved contribution dominates
  - Good agreement with the data using  $p_{T0}^{\text{ref}} = 3.00 \text{ GeV}/c$
- ⇒ MPI probability between pp and  $\gamma\gamma$

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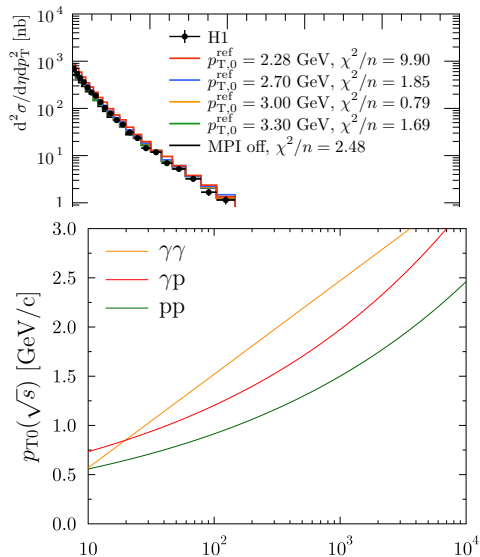
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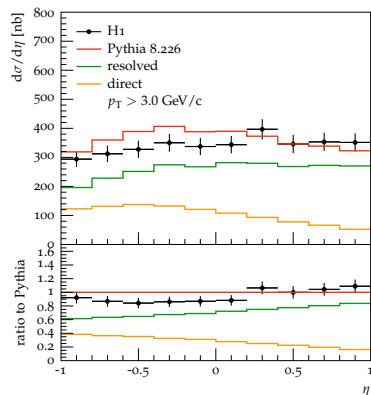
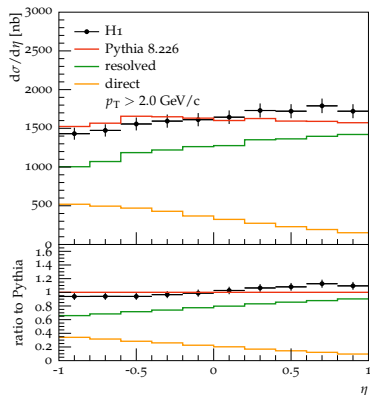
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## Comparison to PYTHIA 8

- Resolved contribution dominates
  - Good agreement with the data using  $p_{T0}^{\text{ref}} = 3.00$  GeV/c
- $\Rightarrow$  MPI probability between  $pp$  and  $\gamma\gamma$

# Charged-particle $\eta$ dependence

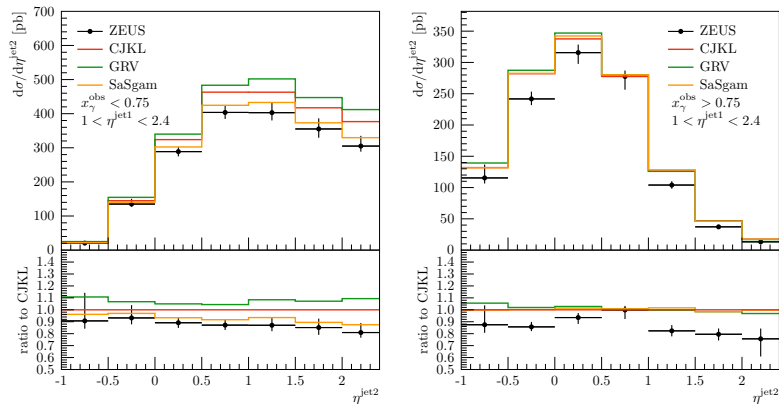


[H1: Eur.Phys.J. C10 (1999) 363-372]

- Good agreement also for charged-particle  $\eta$  dependence
- Resolved contribution dominates the cross section

## Pseudorapidity dependence of dijets

[Eur.Phys.J. C23 (2002) 615-631]



- Simulations tend to overshoot the dijet data by  $\sim 10\%$
- $\sim 10\%$  uncertainty from photon PDFs for  $x_\gamma^{\text{obs}} < 0.75$