

# Update on aMCfast

Valerio Bertone  
CERN



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In collaboration with: Rikkert Frederix, Stefano Frixione, Andreas Papaefstathiou, Juan Rojo and Paolo Torrielli

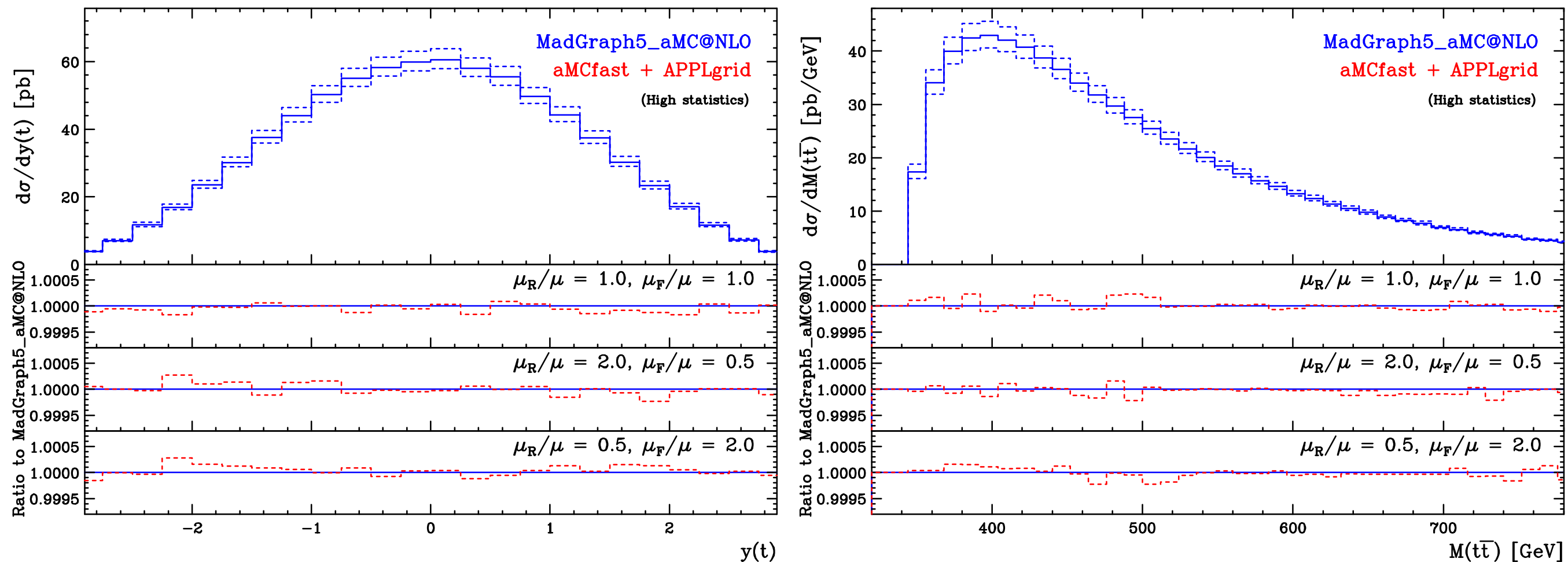
# Brief Recap on aMCfast

- aMCfast is an **automated interface** that bridges:
  - **MadGraph5\_aMC@NLO**
    - that provides all the ingredients relevant to the computation of LO and NLO cross sections, with or without matching to parton showers.
  - **APPLgrid**
    - a framework that implements a strategy for the fast computation of cross sections based on the polynomial interpolation of PDFs (and  $\alpha_s$ ) on the  $(x, Q^2)$ -plane.
- The result is a set of ROOT interpolation grids (one for each observable defined in the analysis) in the APPLgrid format **independent from PDFs**:
  - such grids can be convoluted *a posteriori* with any PDF set,
  - the convolution takes a few milliseconds  $\Rightarrow$  suitable for PDF fits (?).
  - *Caveat*: the independence of the interpolation grids from PDFs is strictly true in the fixed-order case.

# aMCfast 1.2.0

## *The Fixed-Order Case*

- The code is already public since last year.
- No conceptual problem in this case.



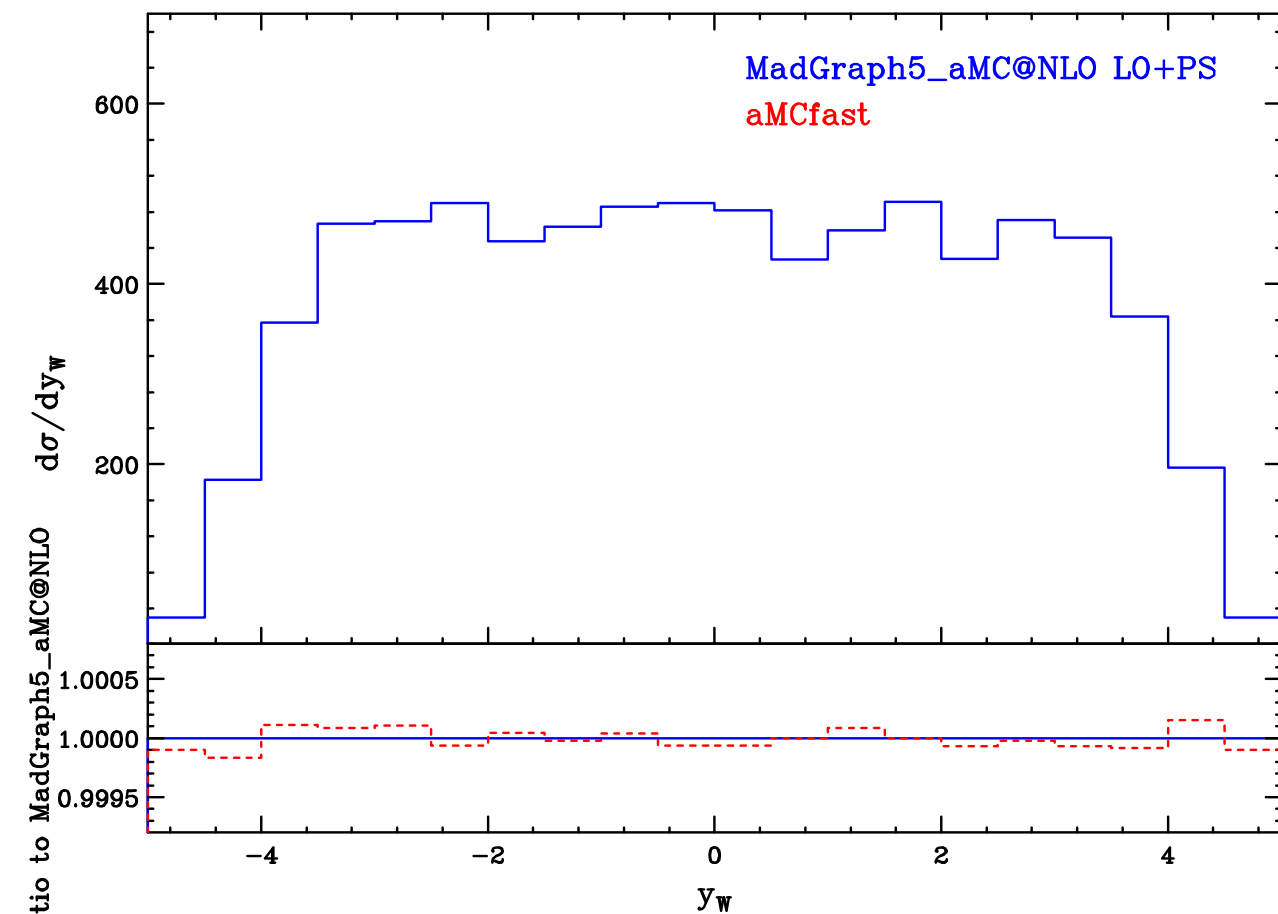
- The convolution of the interpolation grid is in very good agreement with the original distributions also when considering scale variations

# aMCfast 2.0.0

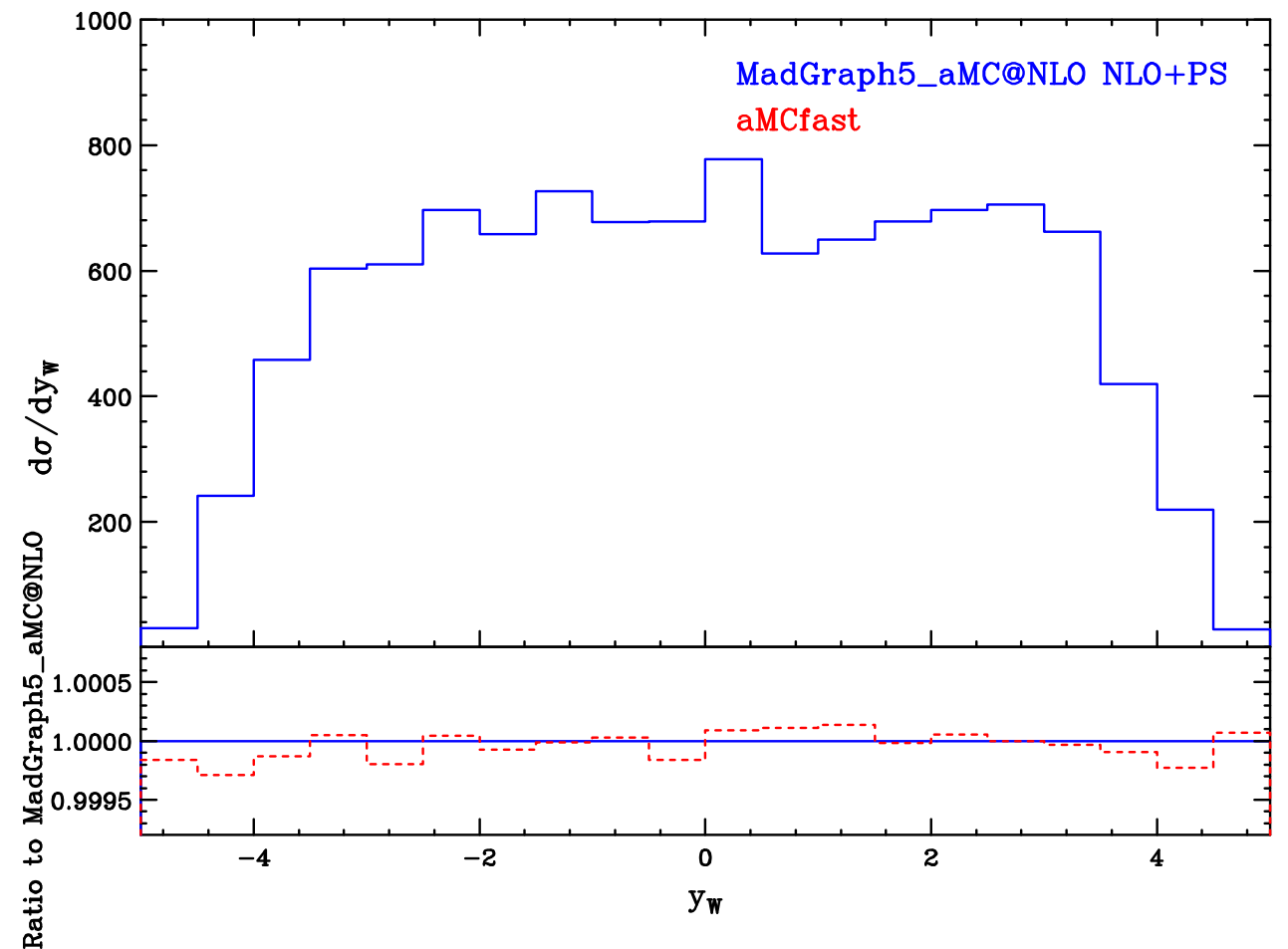
## *The NLO + PS Case*

- The code is up working also for the NLO + PS case but not public yet.
- aMCfast is now interfaced to all parton showers in MG5\_aMC@NLO (*i.e.* HERWIG6, PYTHIA6, HERWIG++ and PYTHIA8):

MadGraph5\_aMC@NLO vs. aMCfast (LO+PS)



MadGraph5\_aMC@NLO vs. aMCfast (NLO+PS)



- Very good agreement between reference and reconstructed histograms also in the low statistics regime, as in the fixed-order case.

# aMCfast 2.0.0

## *The NLO + PS Case*

- The production of interpolation grids in the presence of PS poses more **conceptual questions** as compared to the fixed-order case.
- There are **two main issues**:
  - 1) **Dependence on PDFs** of the **PS evolution** as a results of different kinematic configurations at the **matrix element** (ME) level when the latter is computed with different PDF sets cannot be removed.
  - 2) **Dependence on PDFs** of the **backward PS evolution** cannot be disentangled:
    - expected to be small as it appears as a ratio of PDFs at the same  $x$  but different  $Q^2$ .
- Need to explicitly check that interpolation grids including PS do not have a (strong) dependence on the PDFs used for the production.

# aMCfast 2.0.0

## *The NLO + PS Case: Checking Point 1)*

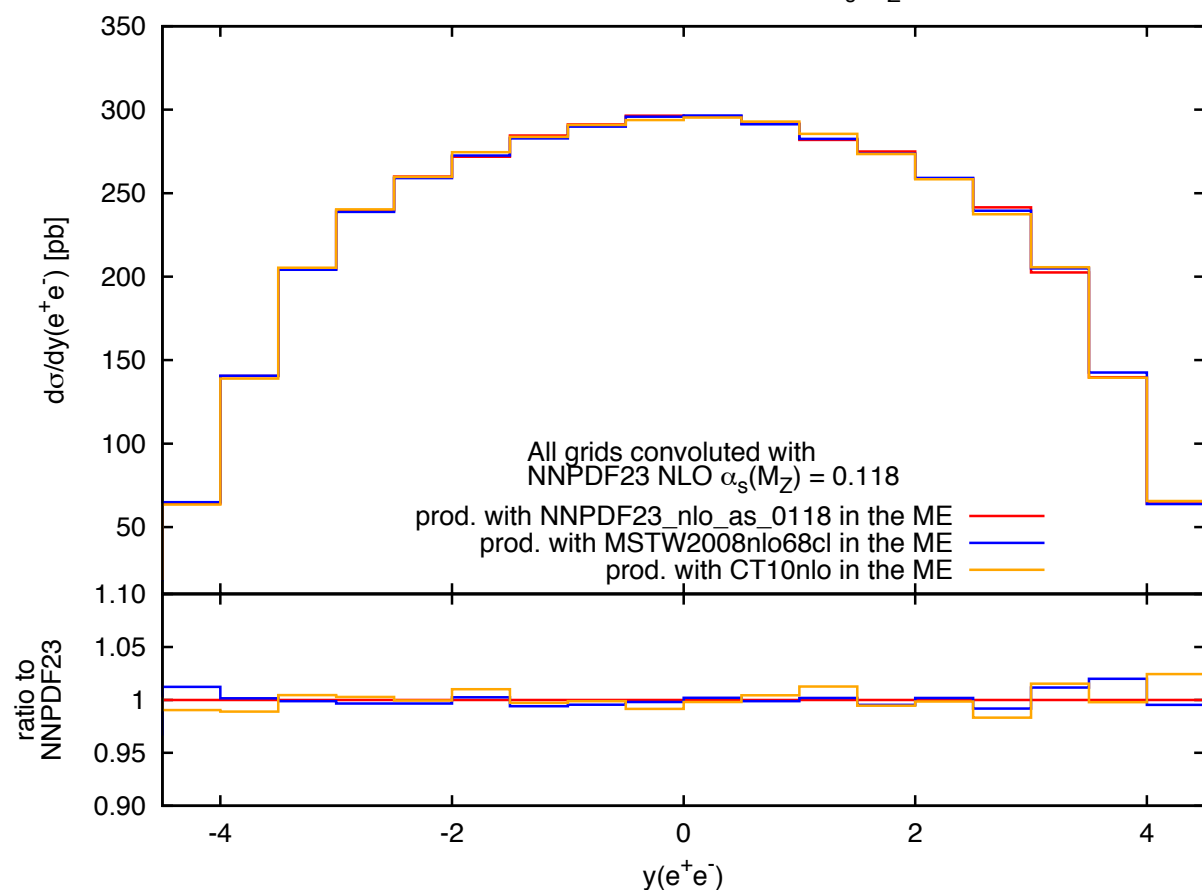
- Take a couple of observables at NLO+PS for the processes:

$$\begin{aligned} p p > e^+ e^- \text{ [QCD]} \\ p p > t \bar{t} \text{ [QCD]} \end{aligned}$$

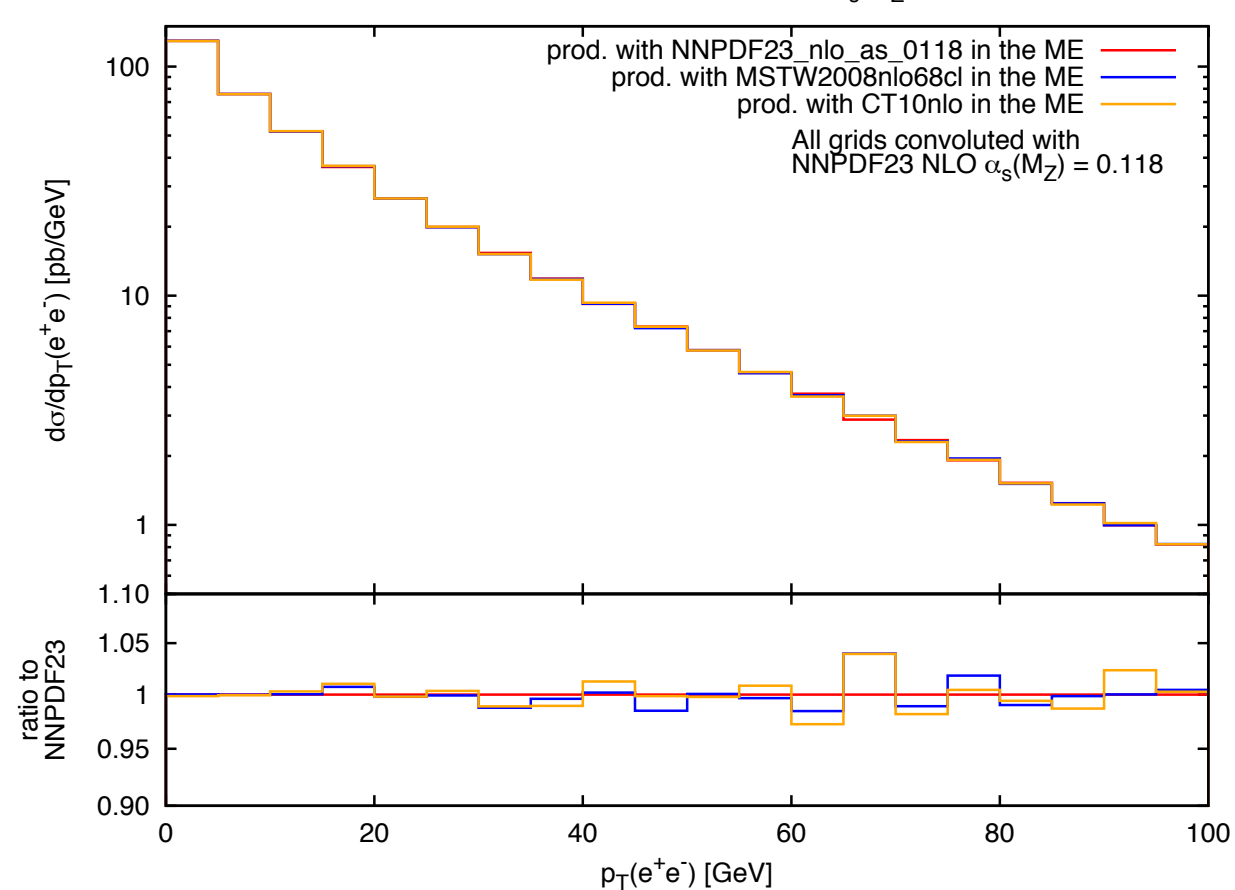
- Shower them with HERWIG6, PYTHIA8 and HERWIG++ using always NNPDF23\_nlo\_as\_0118 in the PS.
- Produce interpolation grids using in the ME:
  - 1) NNPDF23\_nlo\_as\_0118
  - 2) MSTW2008nlo68cl
  - 3) CT10nlo
- Convolute the resulting grids with NNPDF23\_nlo\_as\_0118.
- If the results are in good agreement, the dependence on PDFs of the PS evolution as a results of different kinematic configurations at the ME level when the latter is computed with different PDF sets is mild.

# HERWIG6

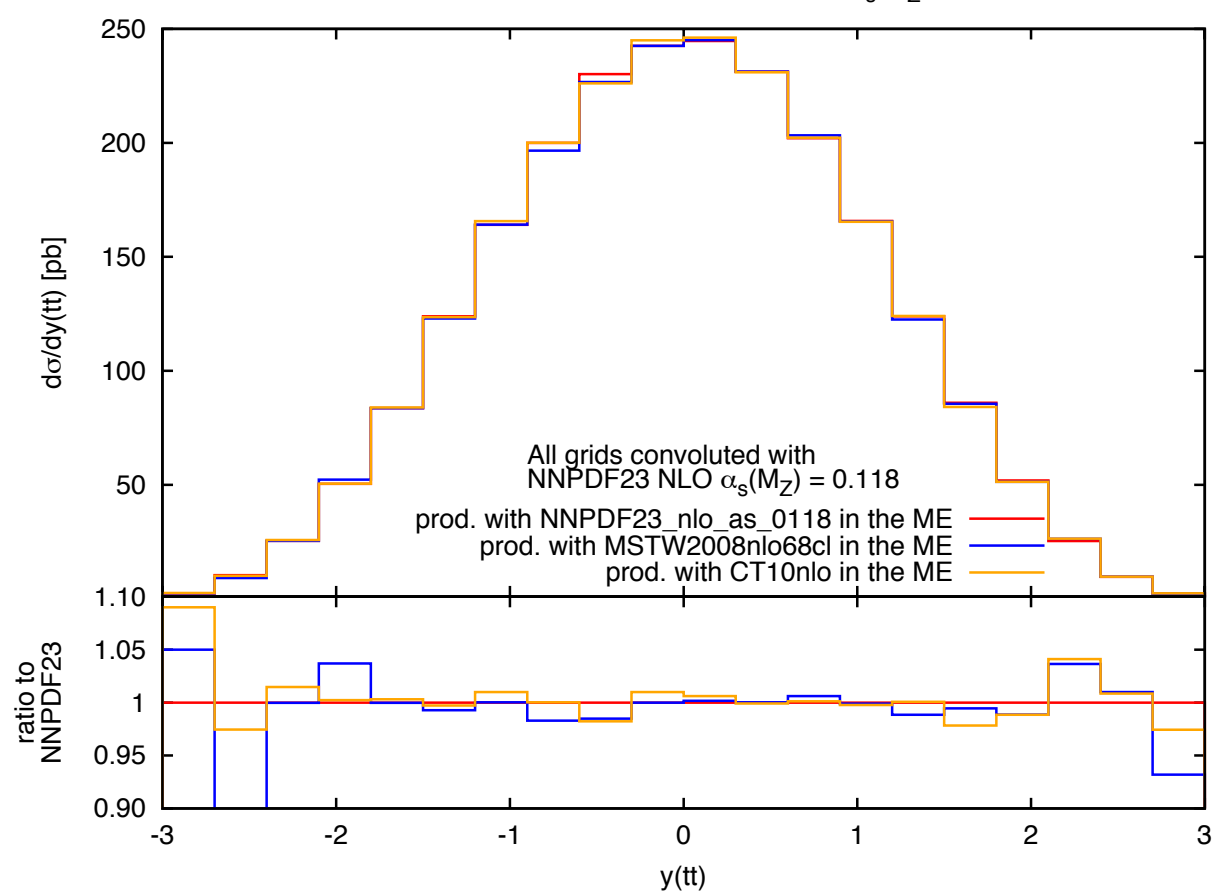
$e^+e^-$  at NLO+PS with HERWIG6, NNPDF23 NLO  $\alpha_s(M_Z) = 0.118$  in the PS



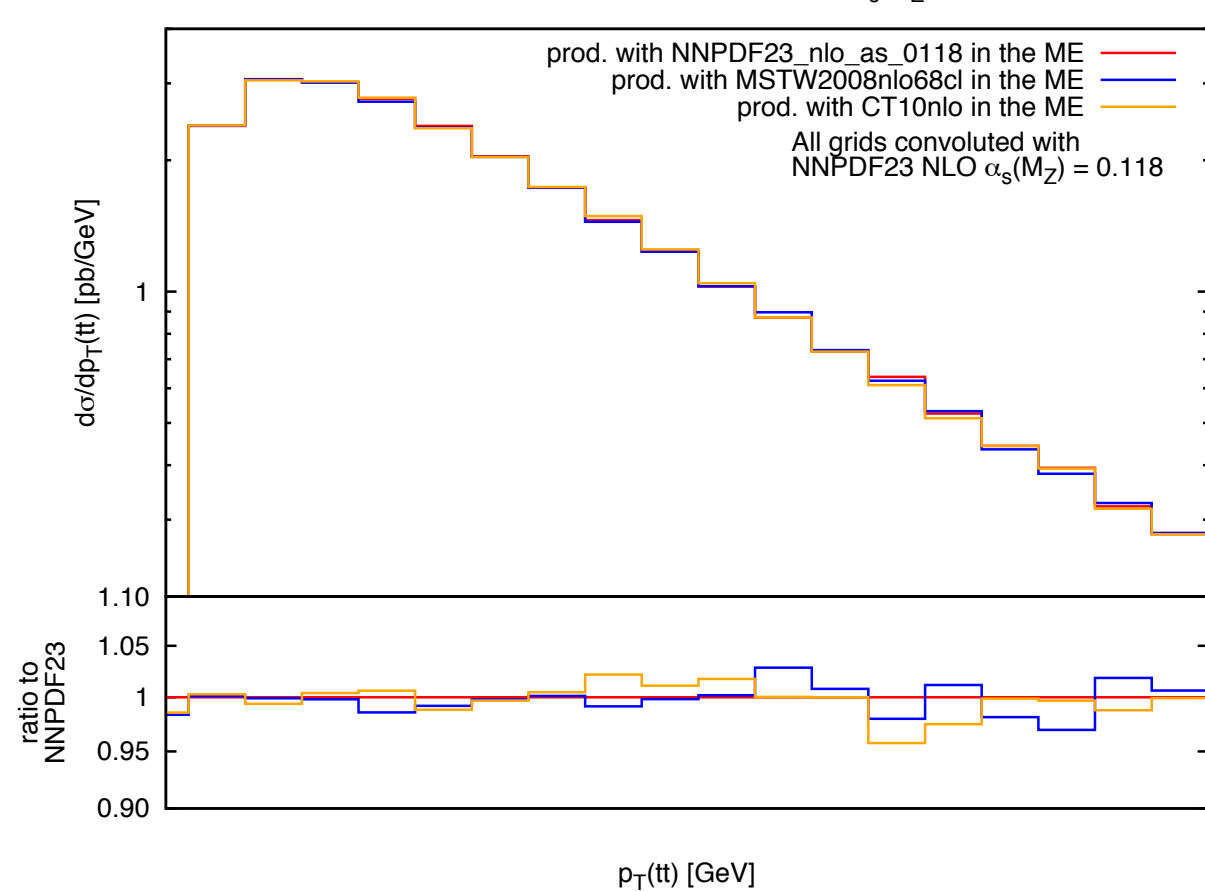
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top pair at NLO+PS with HERWIG6, NNPDF23 NLO  $\alpha_s(M_Z) = 0.118$  in the PS



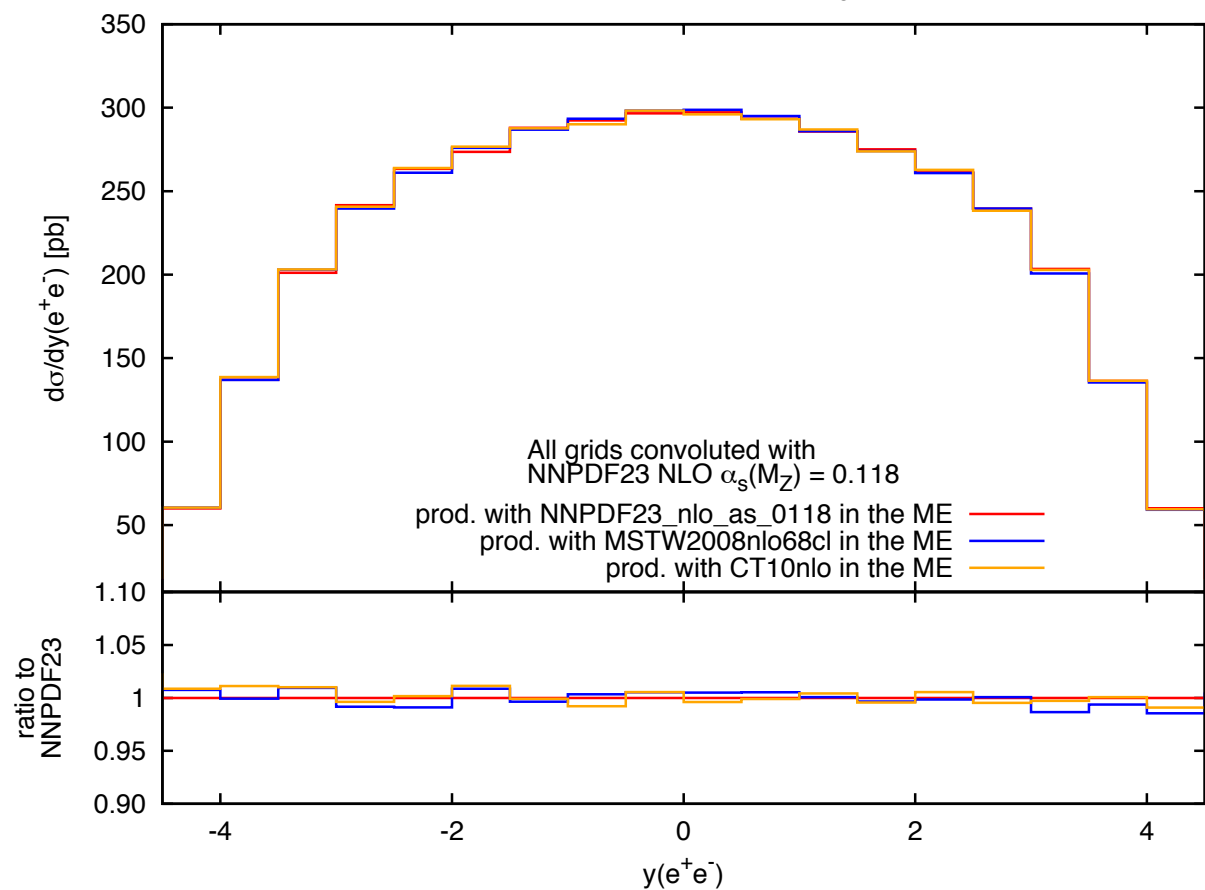
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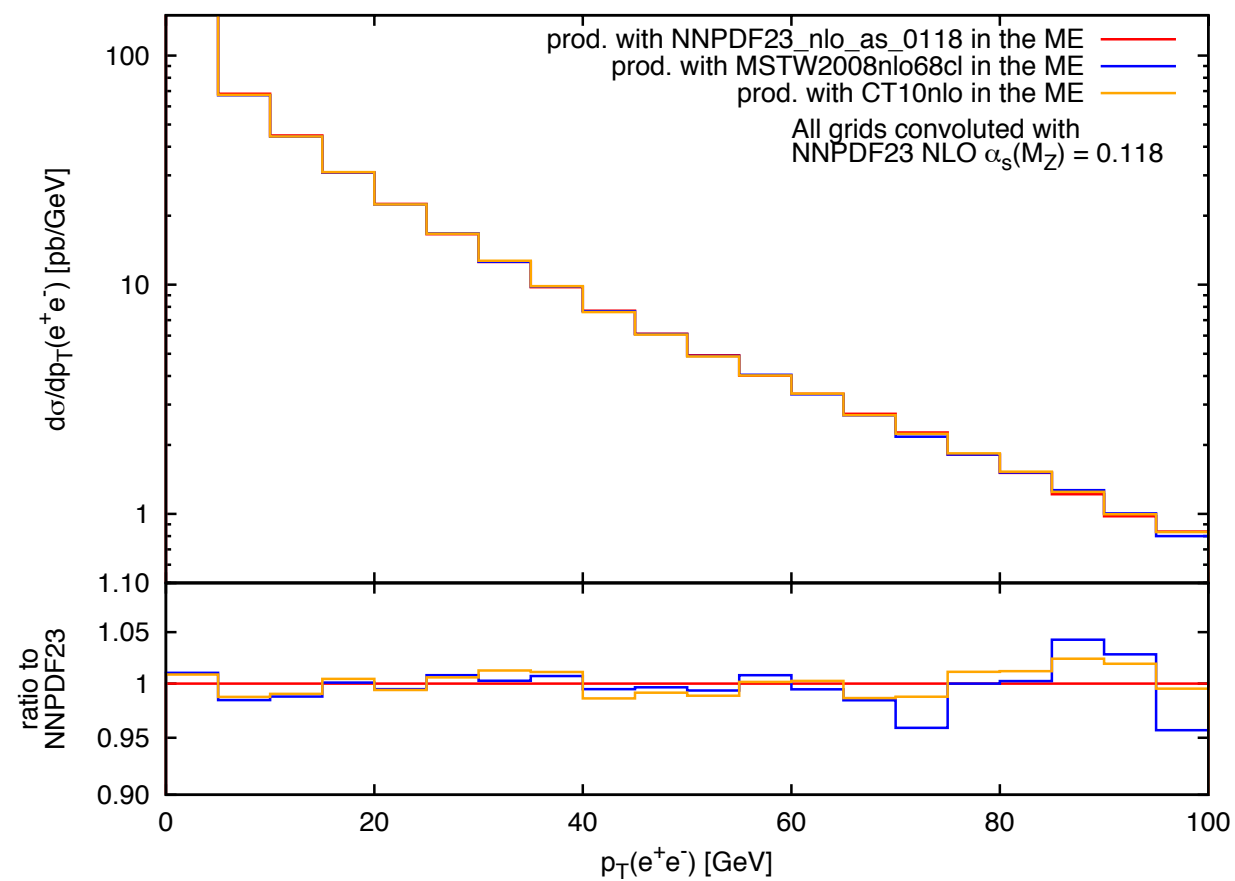


# PYTHIA8

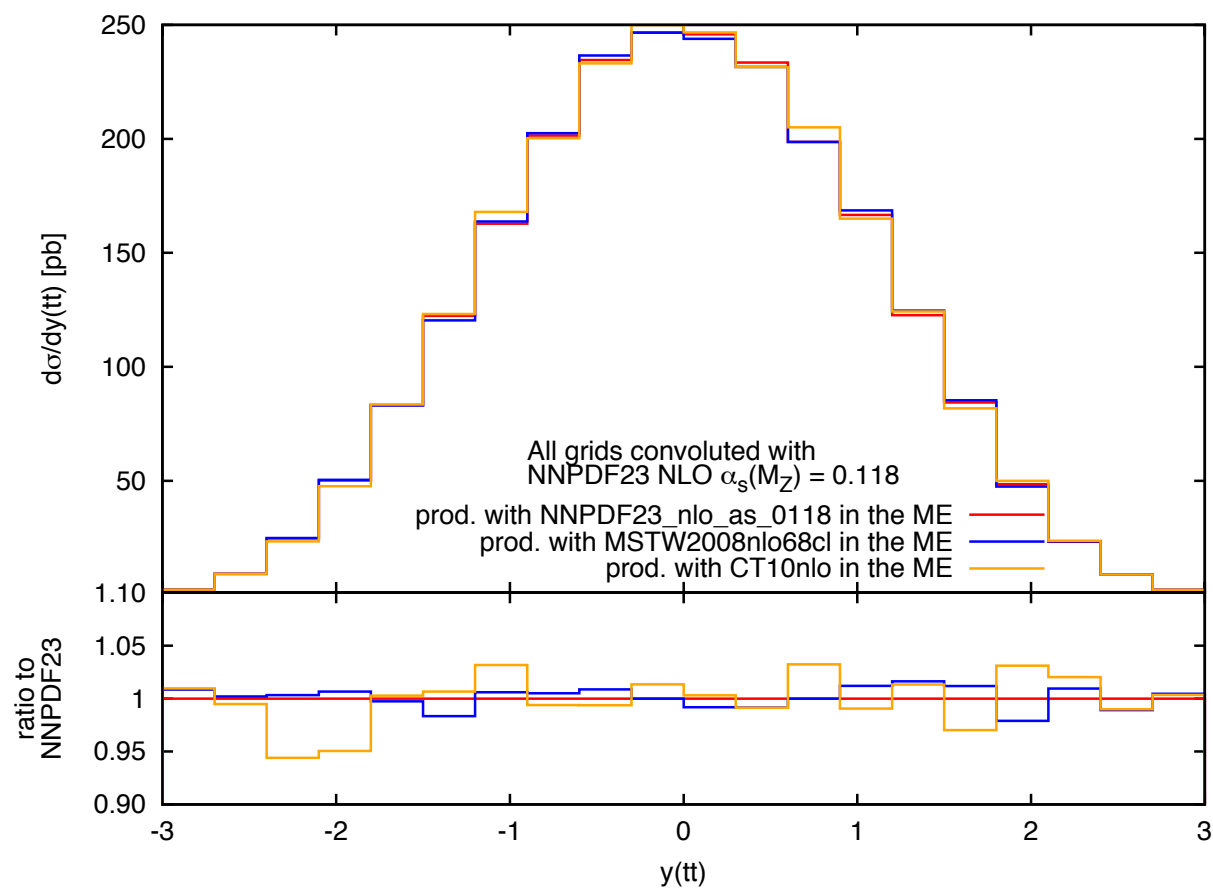
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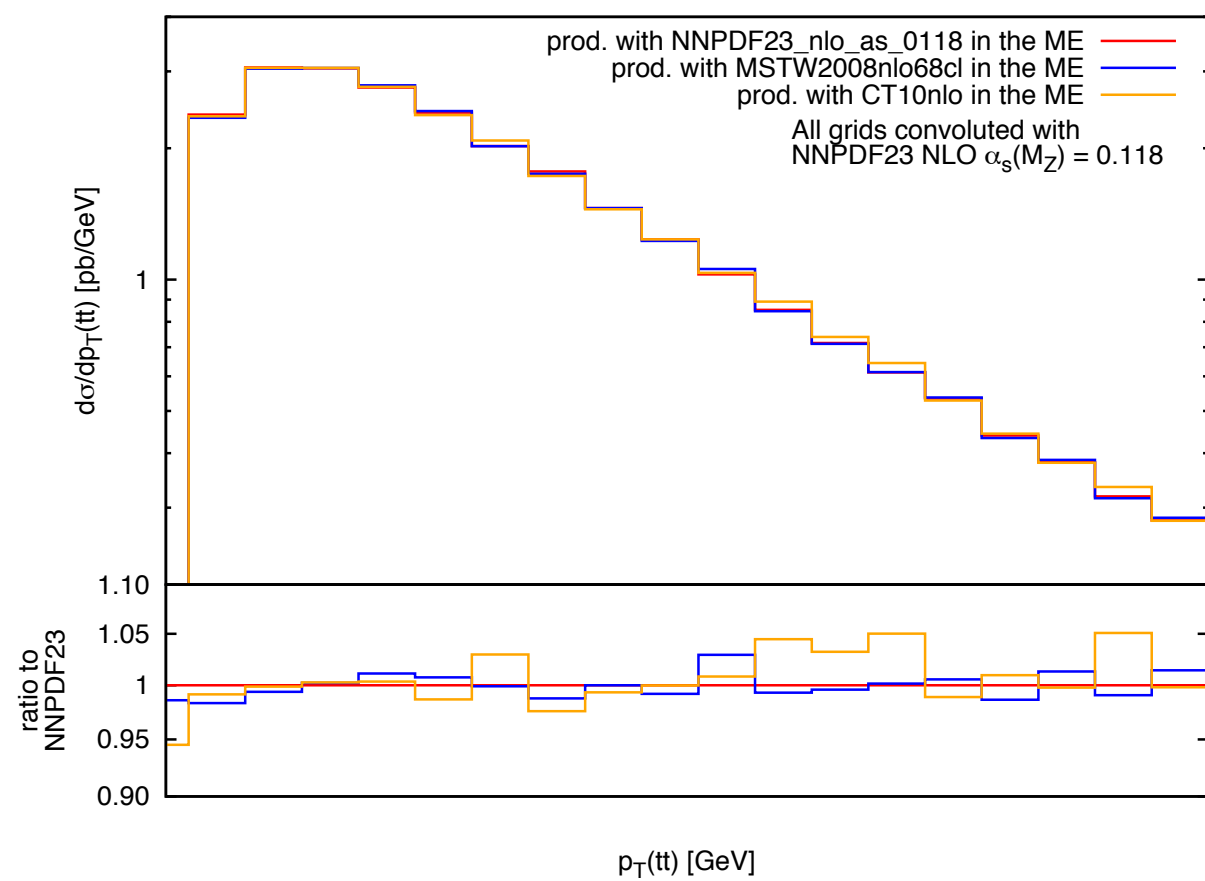
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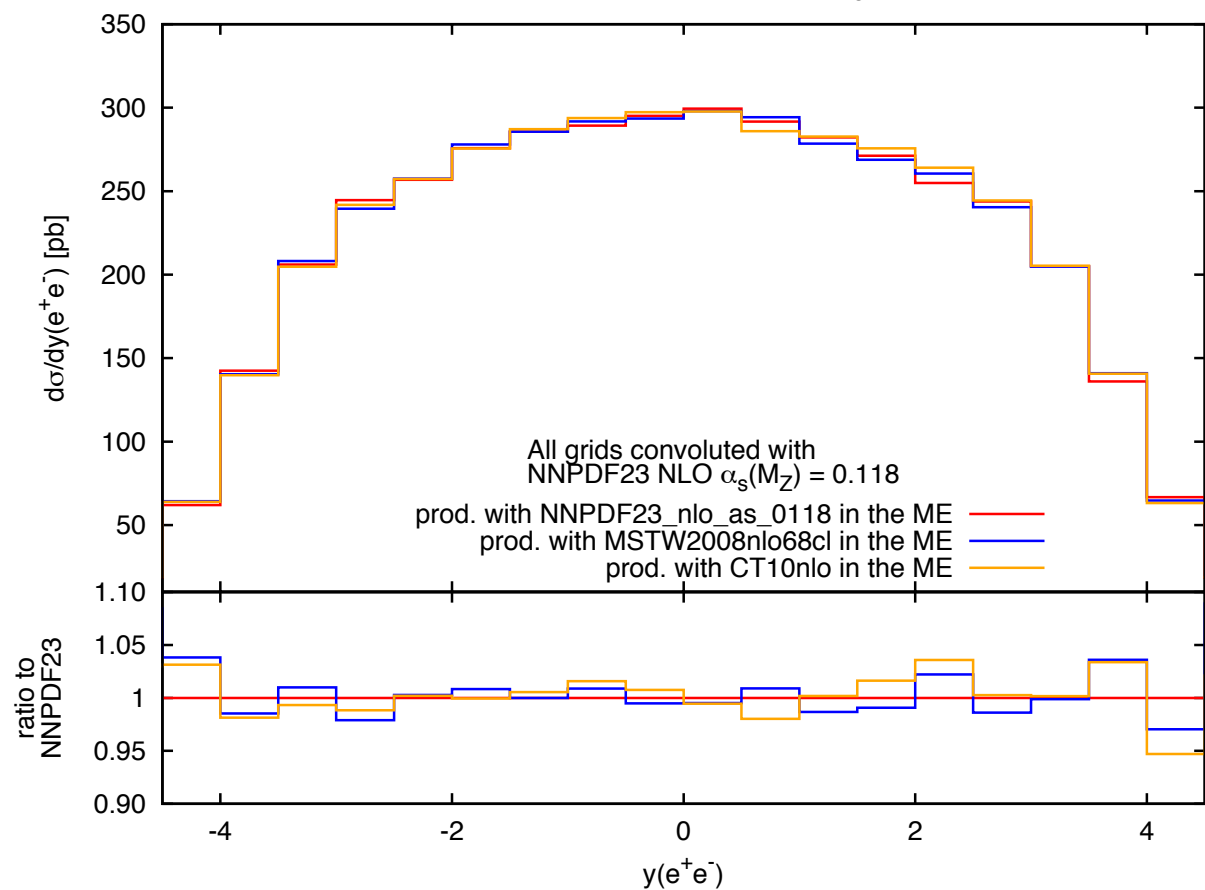
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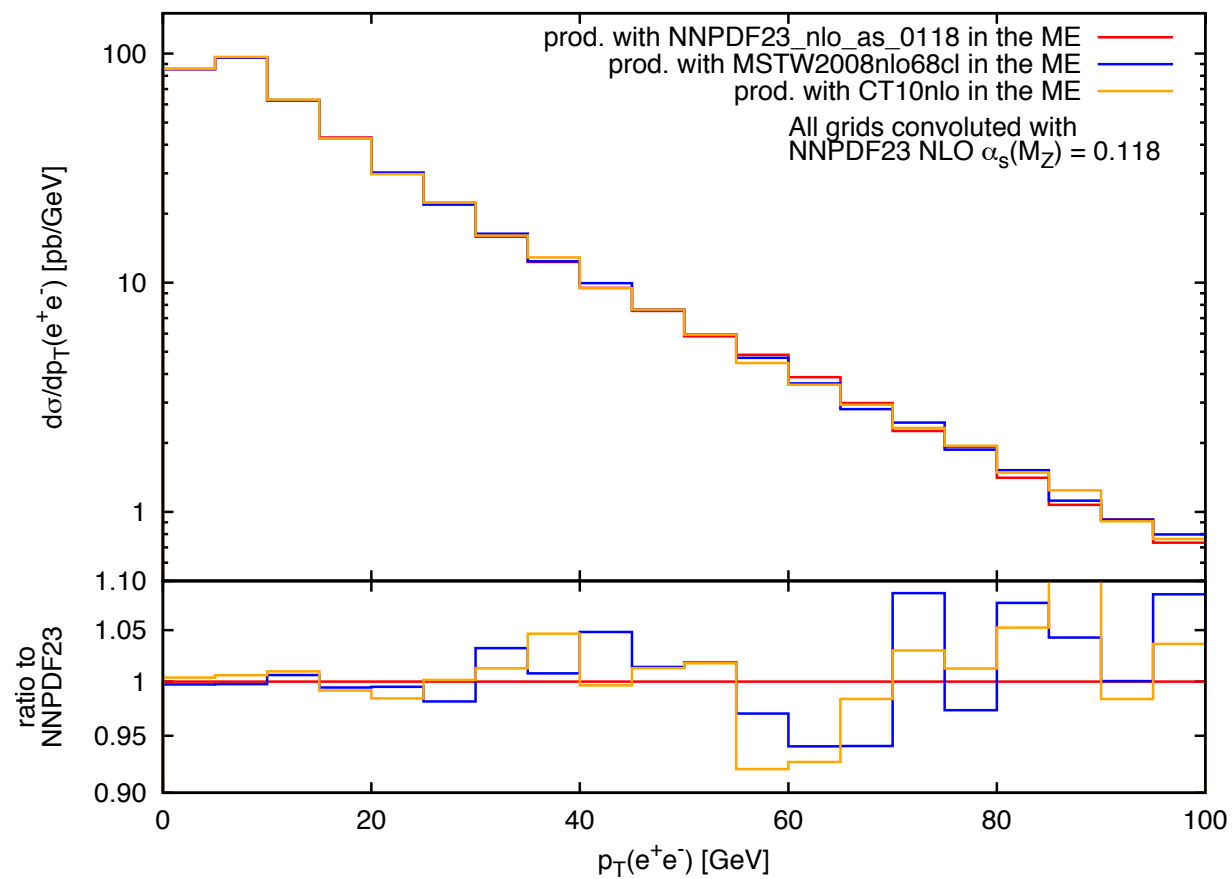


# HERWIG++

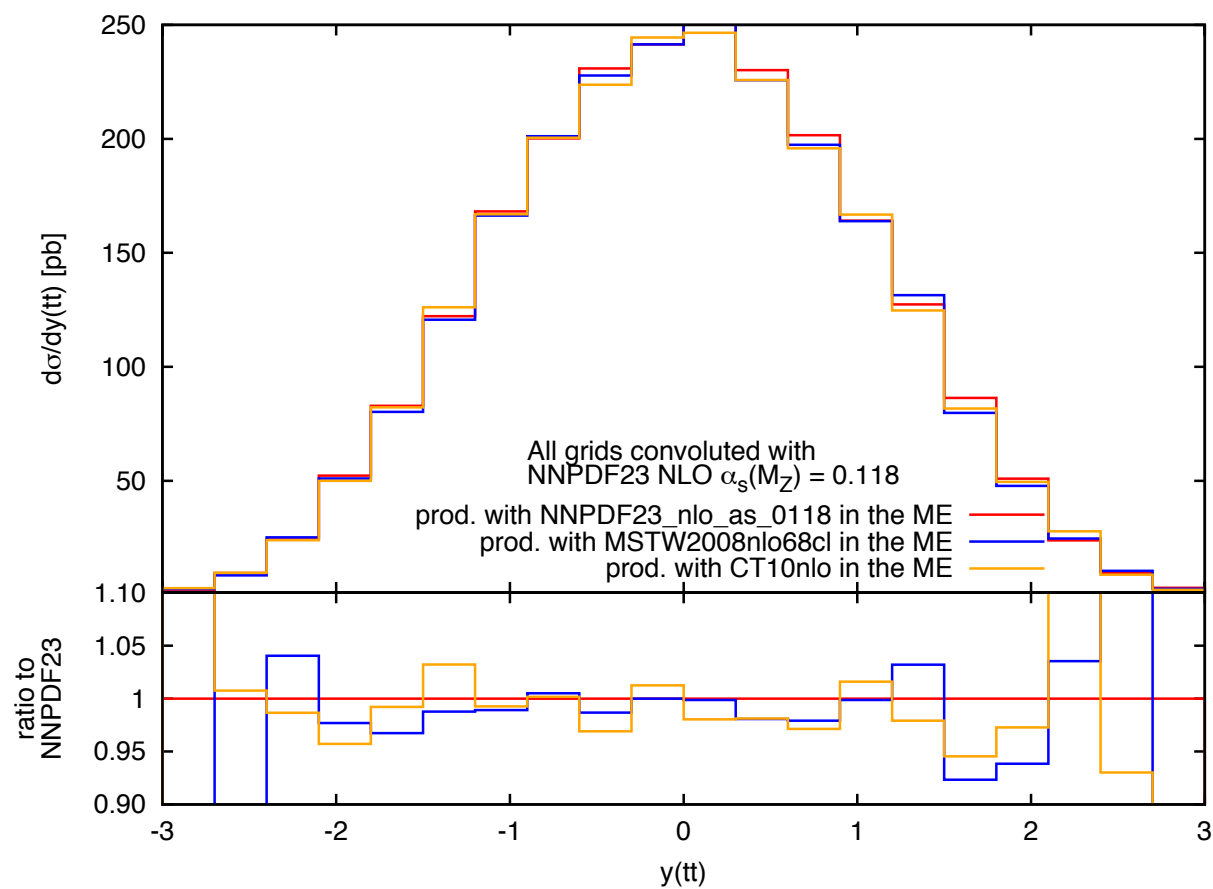
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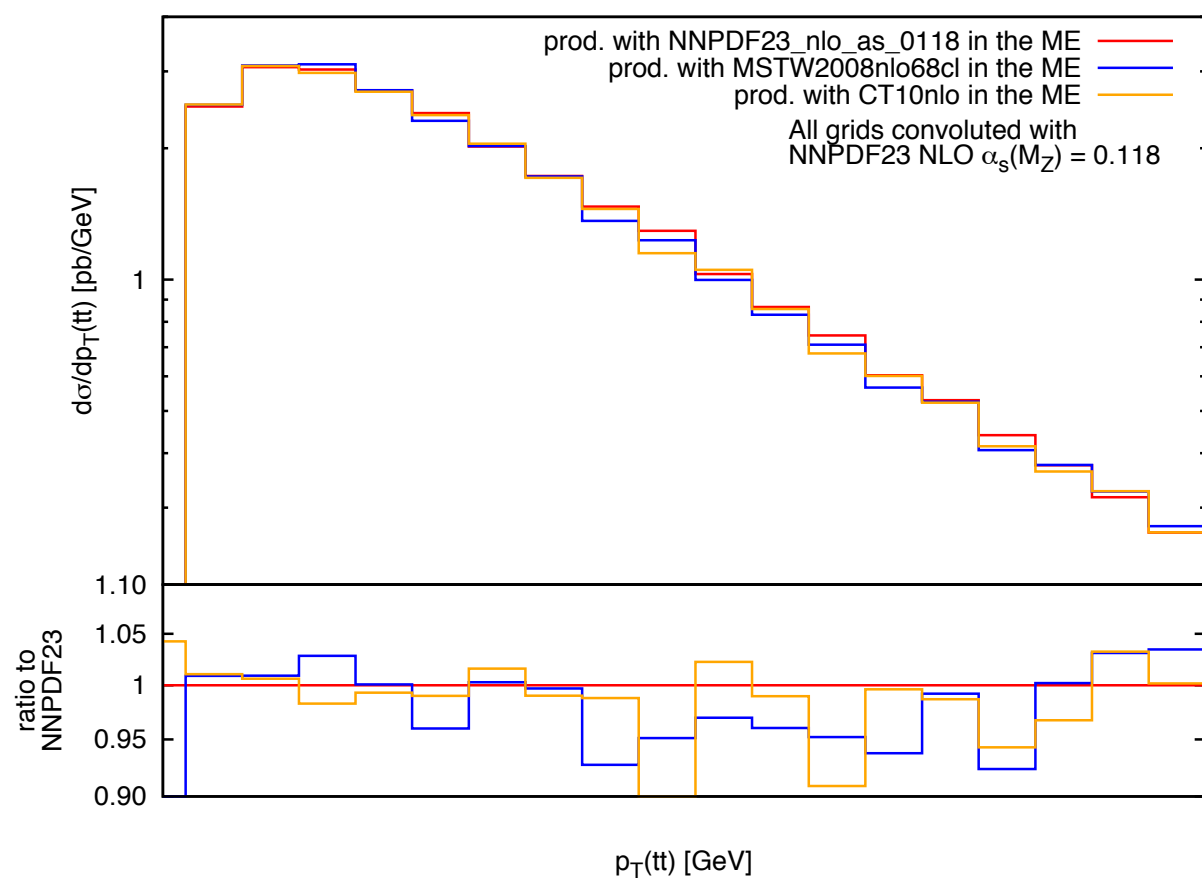
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# aMCfast 2.0.0

## *The NLO + PS Case: Checking Point 2)*

- Take a couple of observables at LO+PS and NLO+PS for the processes:

$p p \rightarrow e^+ e^-$  [QCD]

$p p \rightarrow t \bar{t}$  [QCD]

$p p \rightarrow e^+ \nu_e c^{\sim}$  [QCD]

- Shower them with HERWIG6, PYTHIA8 and HERWIG++ using always NNPDF23\_nlo\_as\_0118 in the ME.

- Produce interpolation grids using in the PS:

1) NNPDF23\_nlo\_as\_0118

2) MSTW2008nlo68cl

3) CT10nlo

4) amb11\_5n\_nlo

5) NNPDF21\_lo\_as\_0119\_100

6) cteq6l

- Convolute the resulting grids with NNPDF23\_nlo\_as\_0118.

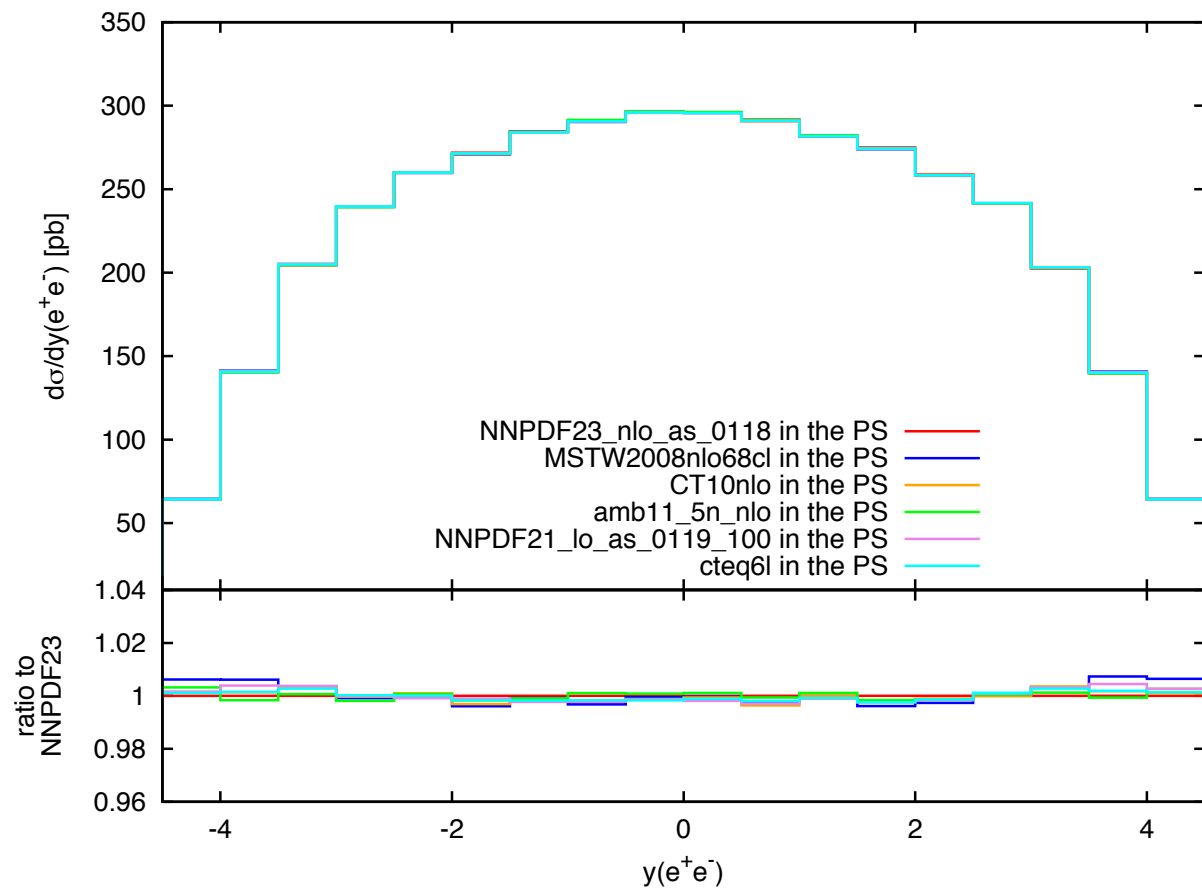
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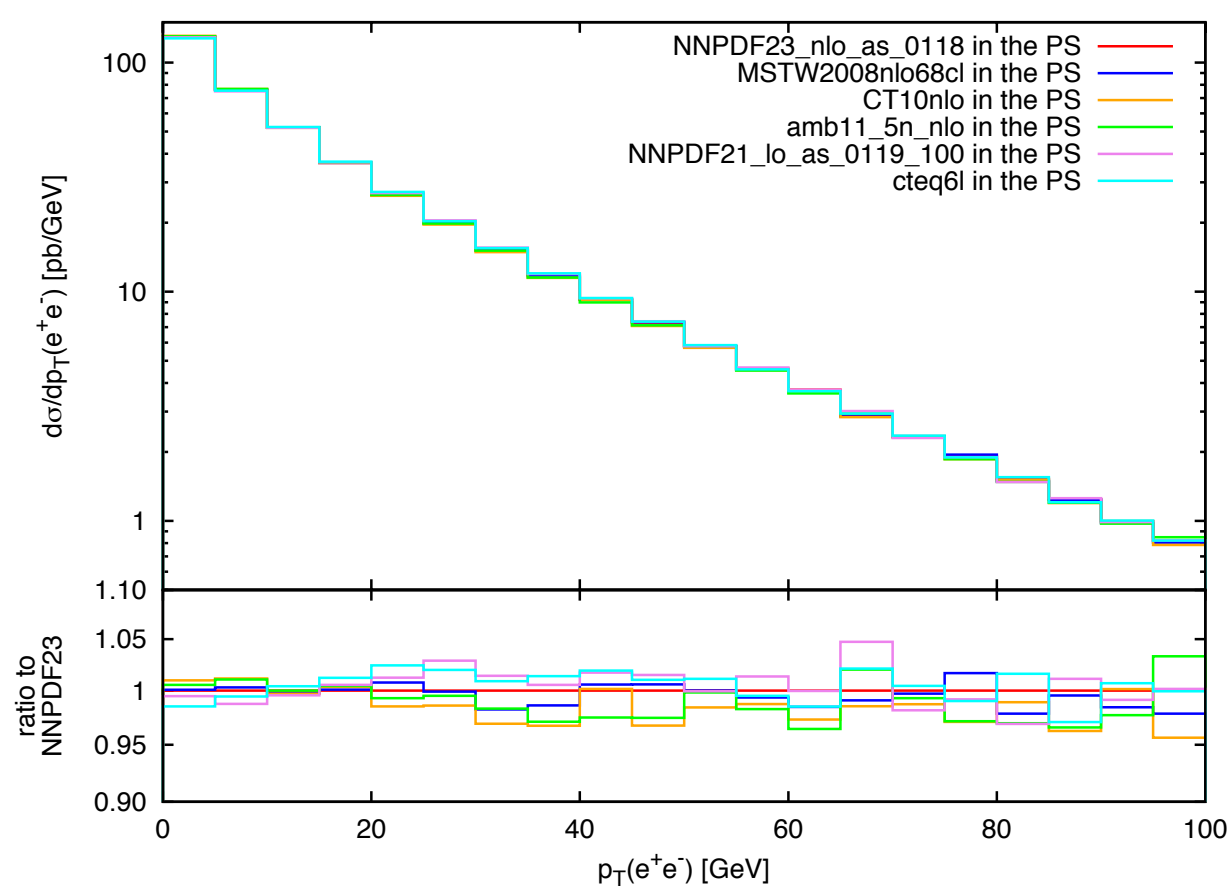
- If the results are in good agreement, the dependence on PDFs of the backward PS evolution is mild:
  - results are expected to be PS dependent.

# HERWIG6 $e^+e^-$

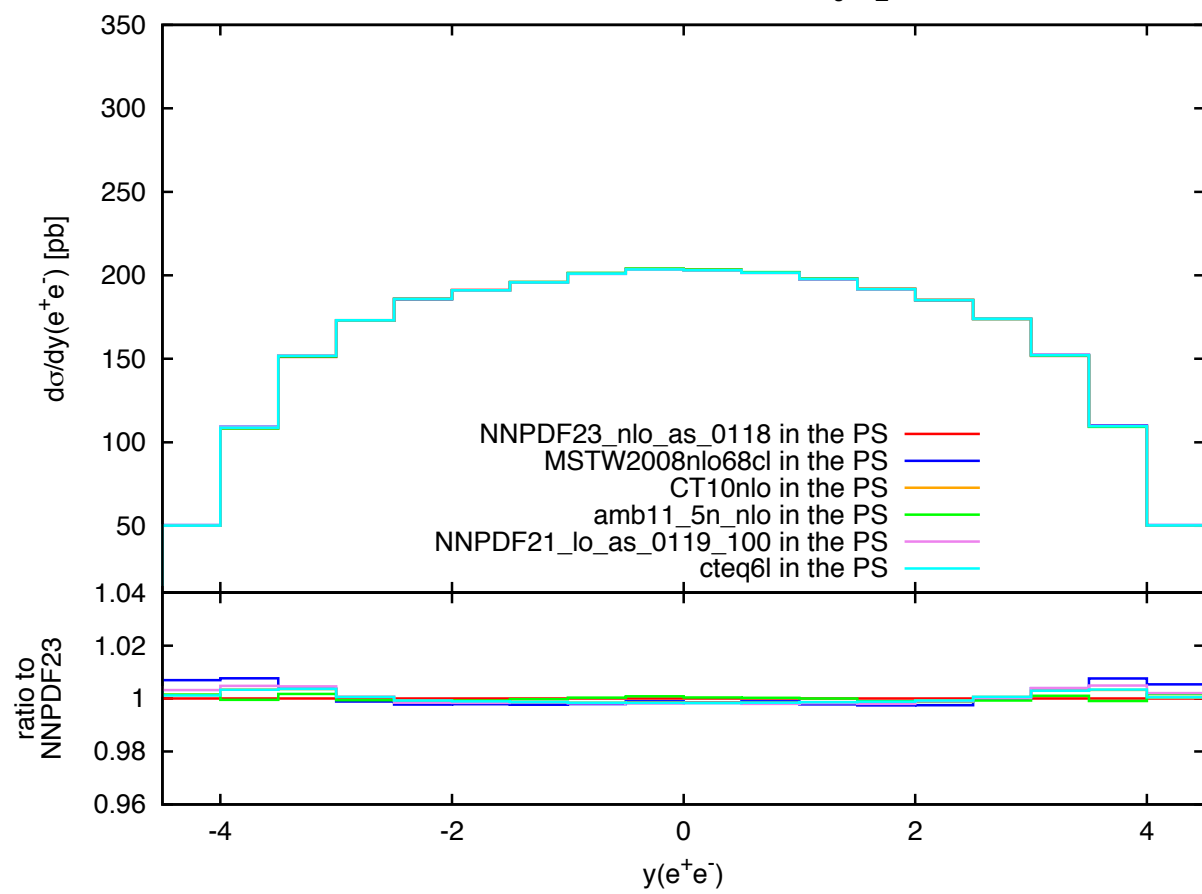
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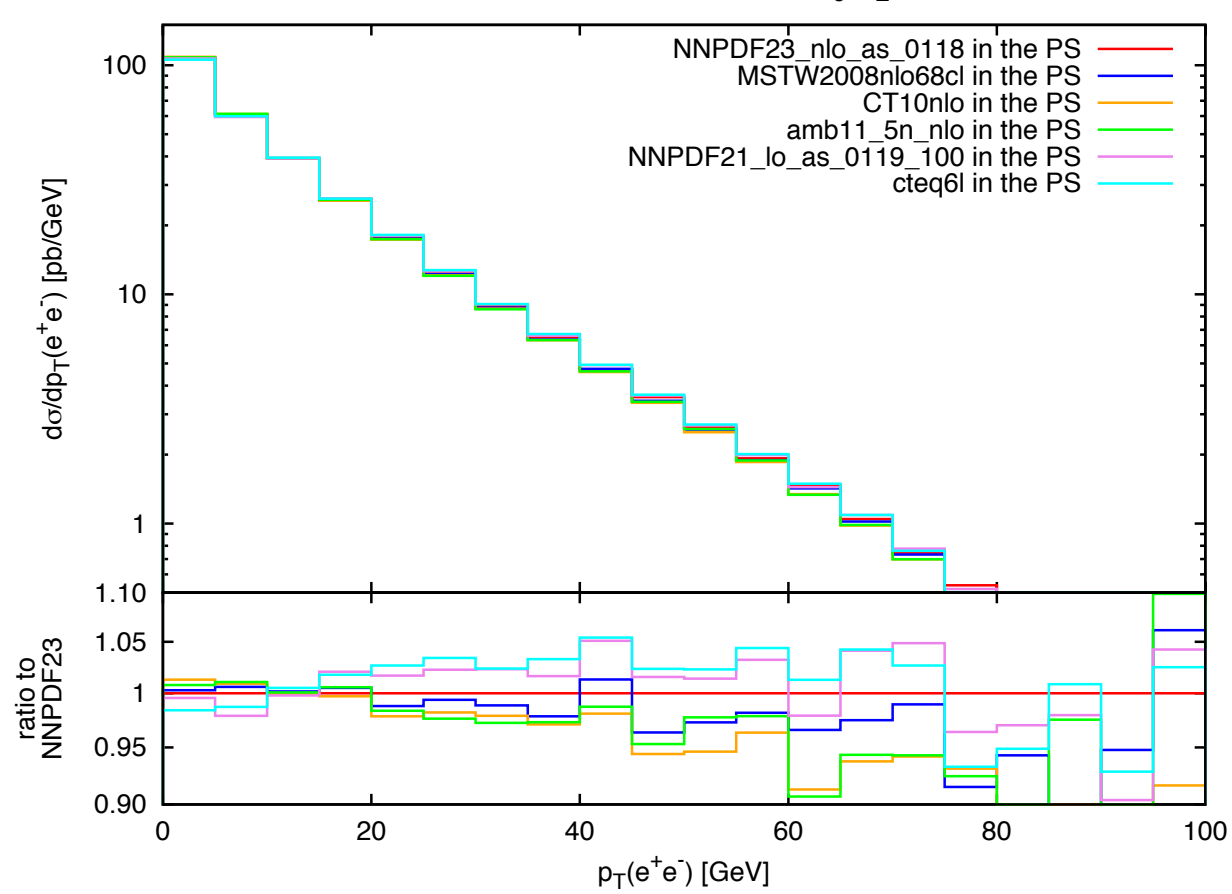
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$e^+e^-$  at LO+PS with HERWIG6, NNPDF23 NLO  $\alpha_s(M_Z) = 0.118$  in the ME

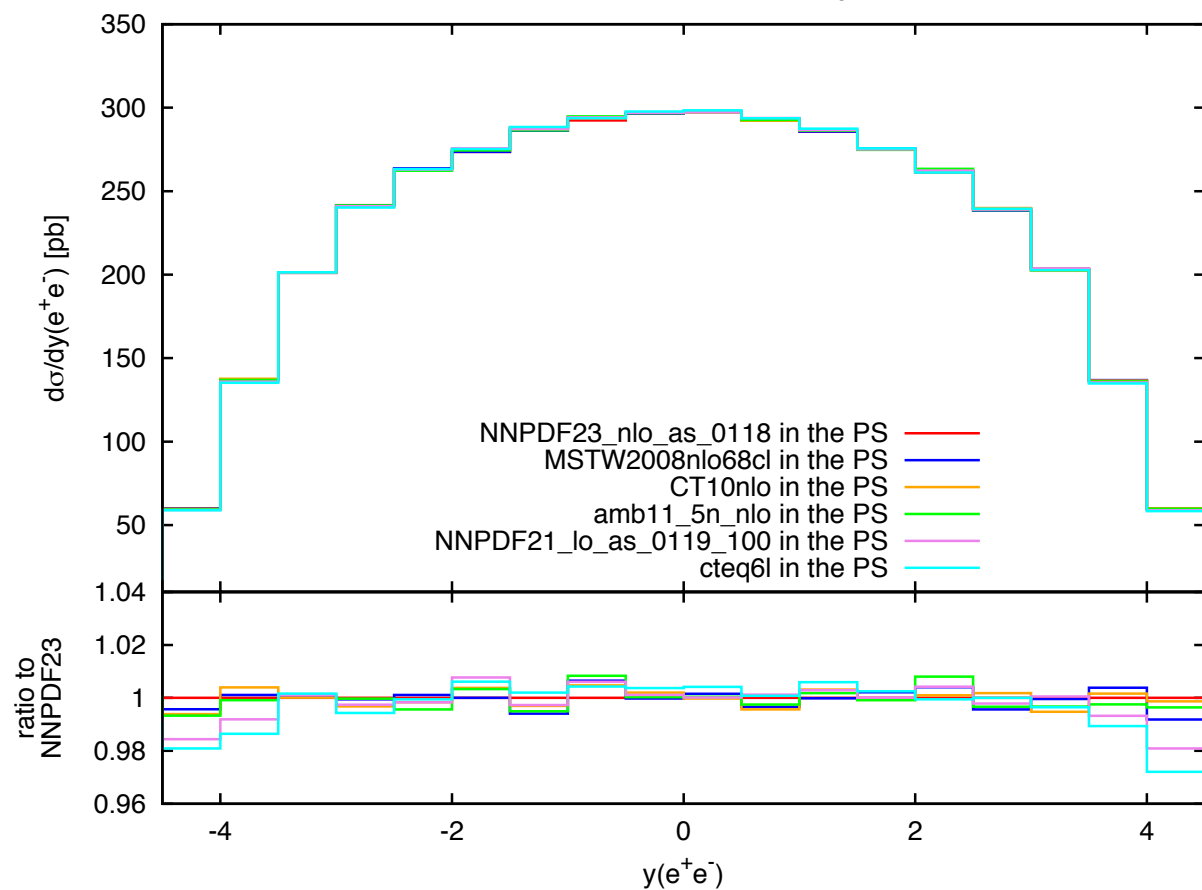


$e^+e^-$  at LO+PS with HERWIG6, NNPDF23 NLO  $\alpha_s(M_Z) = 0.118$  in the ME

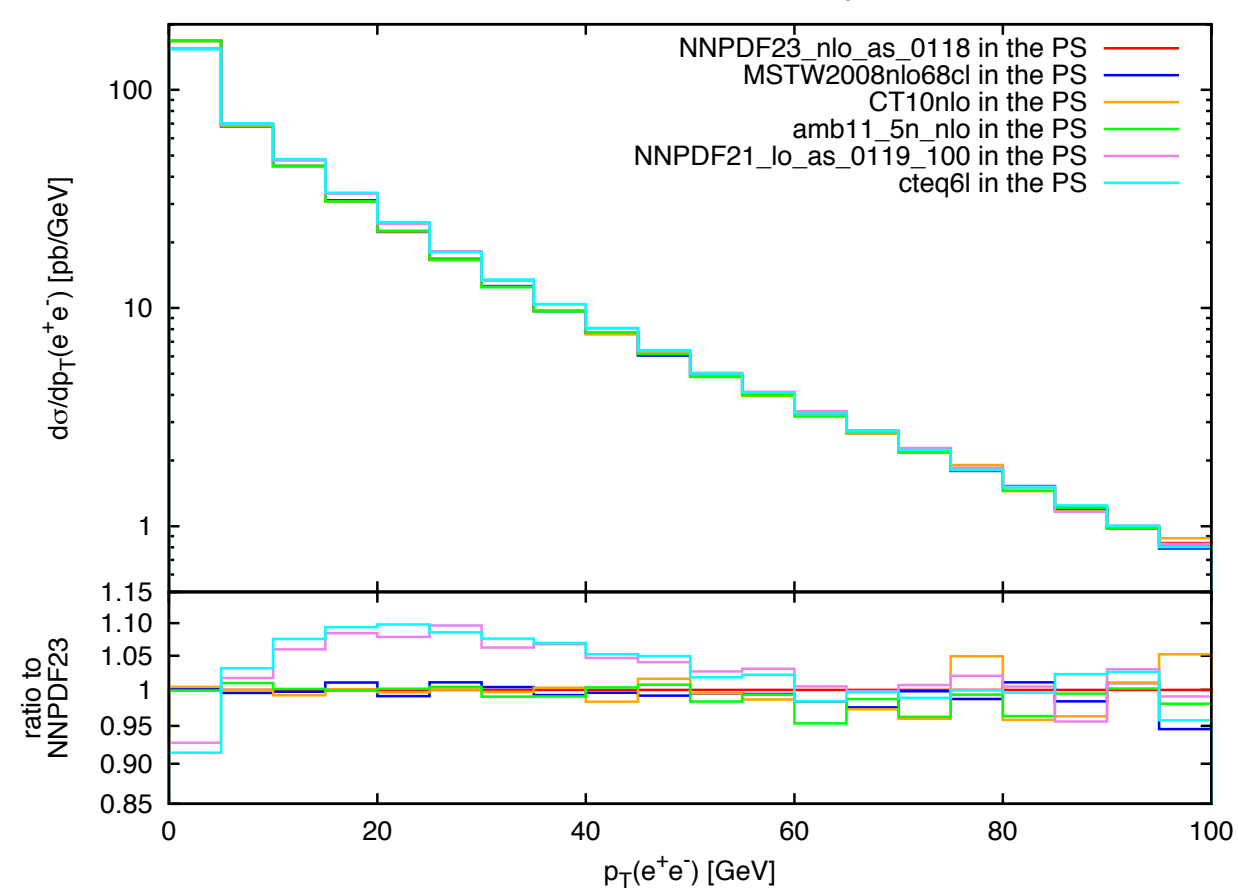


# PYTHIA8 $e^+e^-$

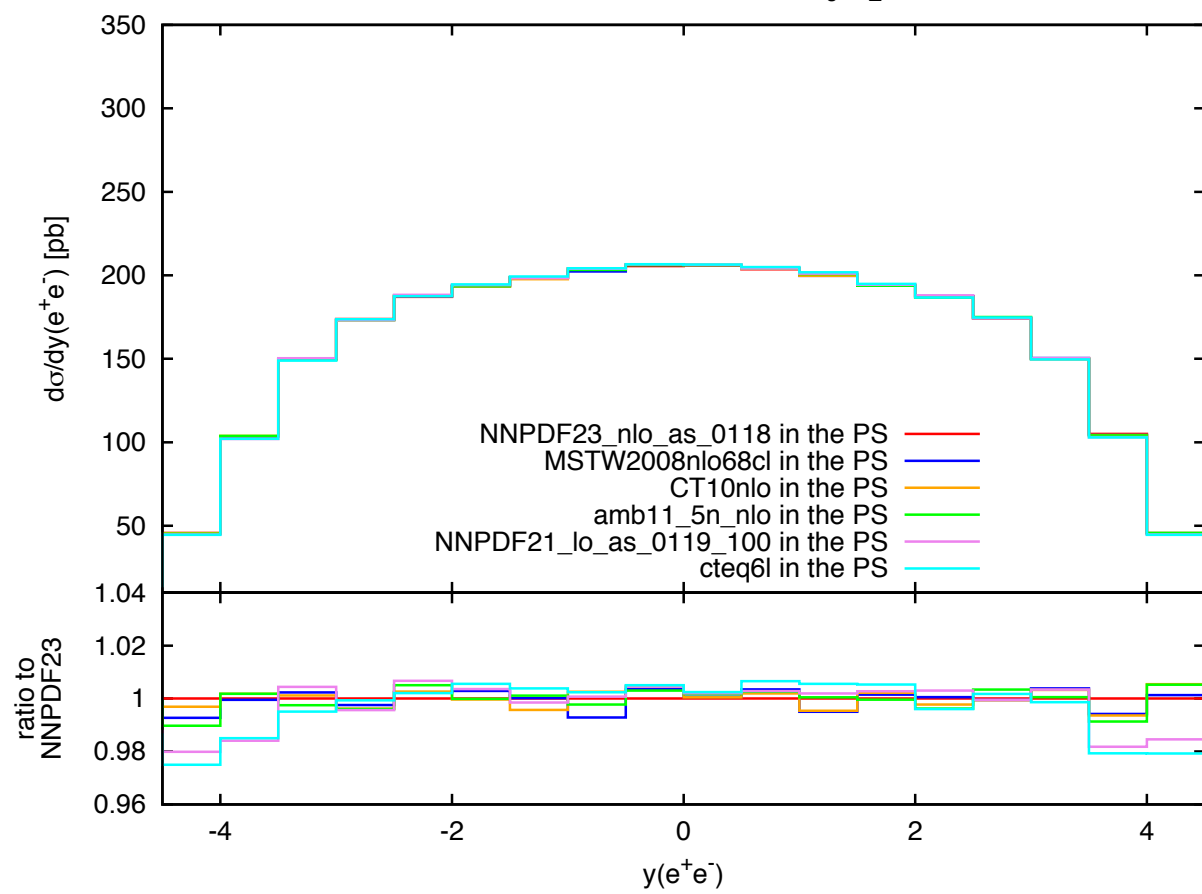
$e^+e^-$  at NLO+PS with PYTHIA8, NNPDF23 NLO  $\alpha_s(M_Z) = 0.118$  in the ME



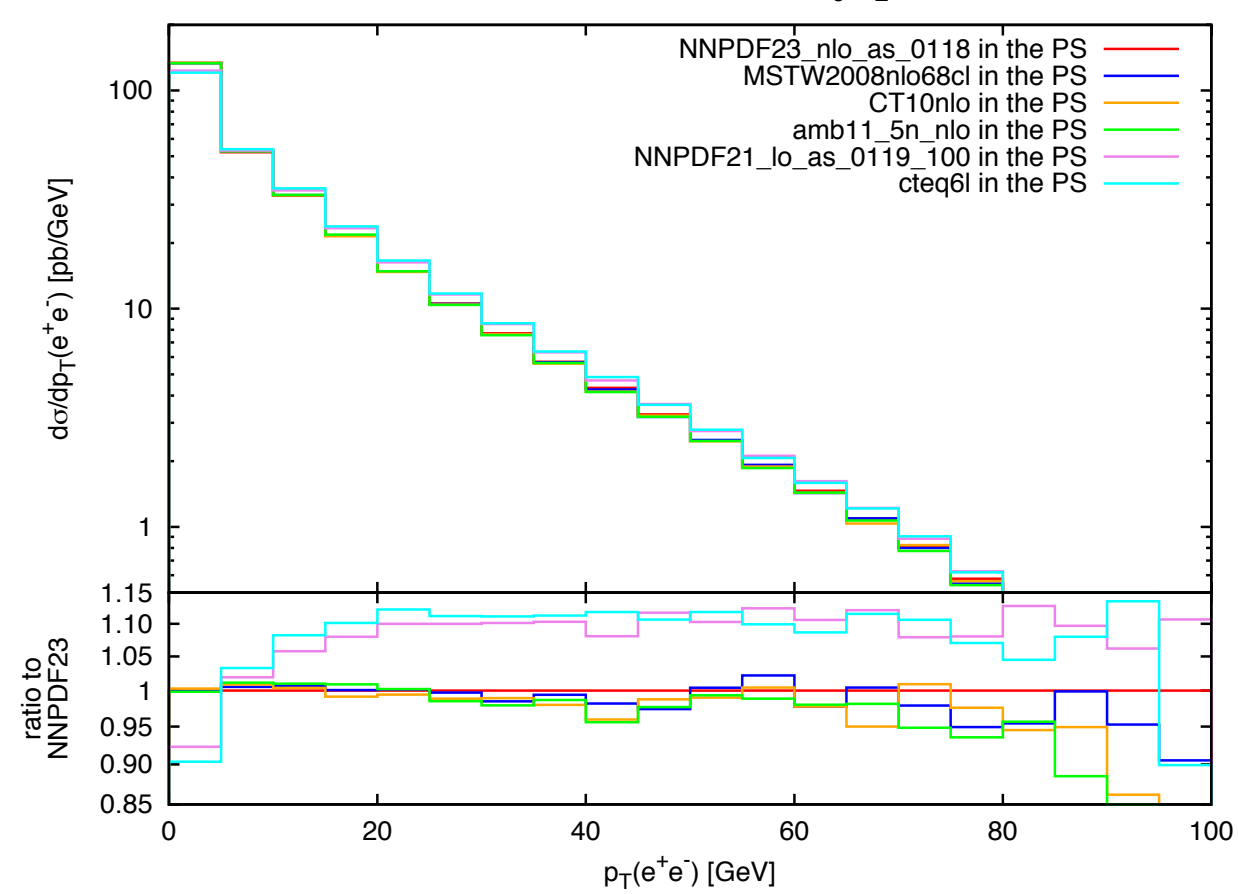
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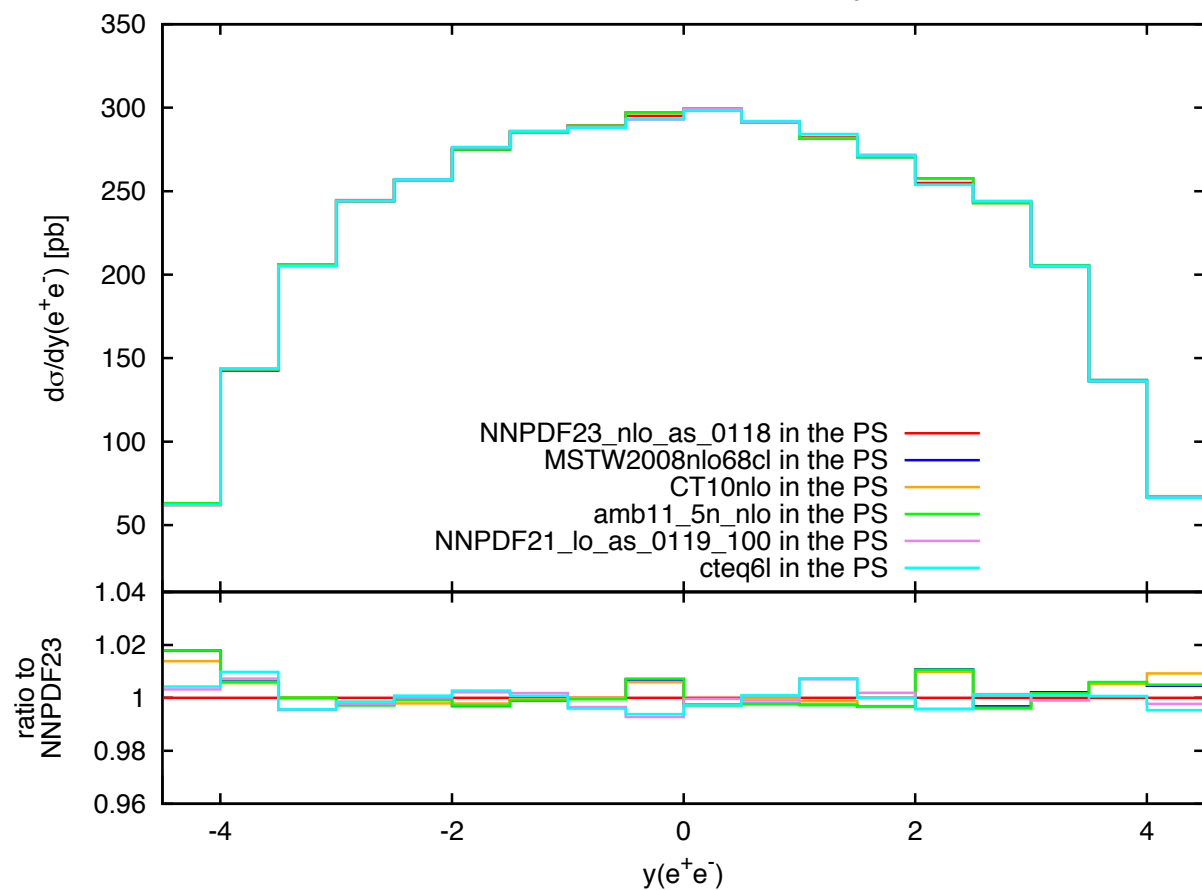


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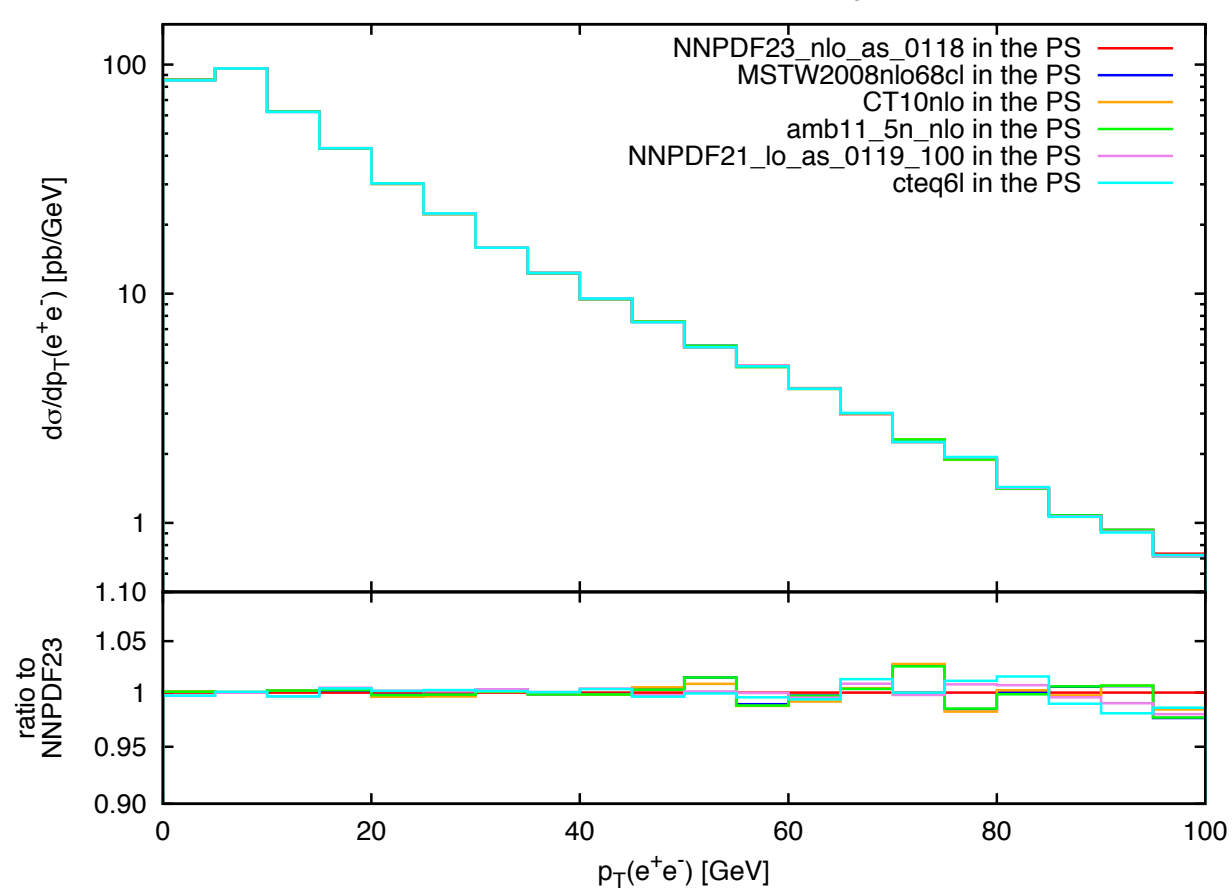


# HERWIG++ $e^+e^-$

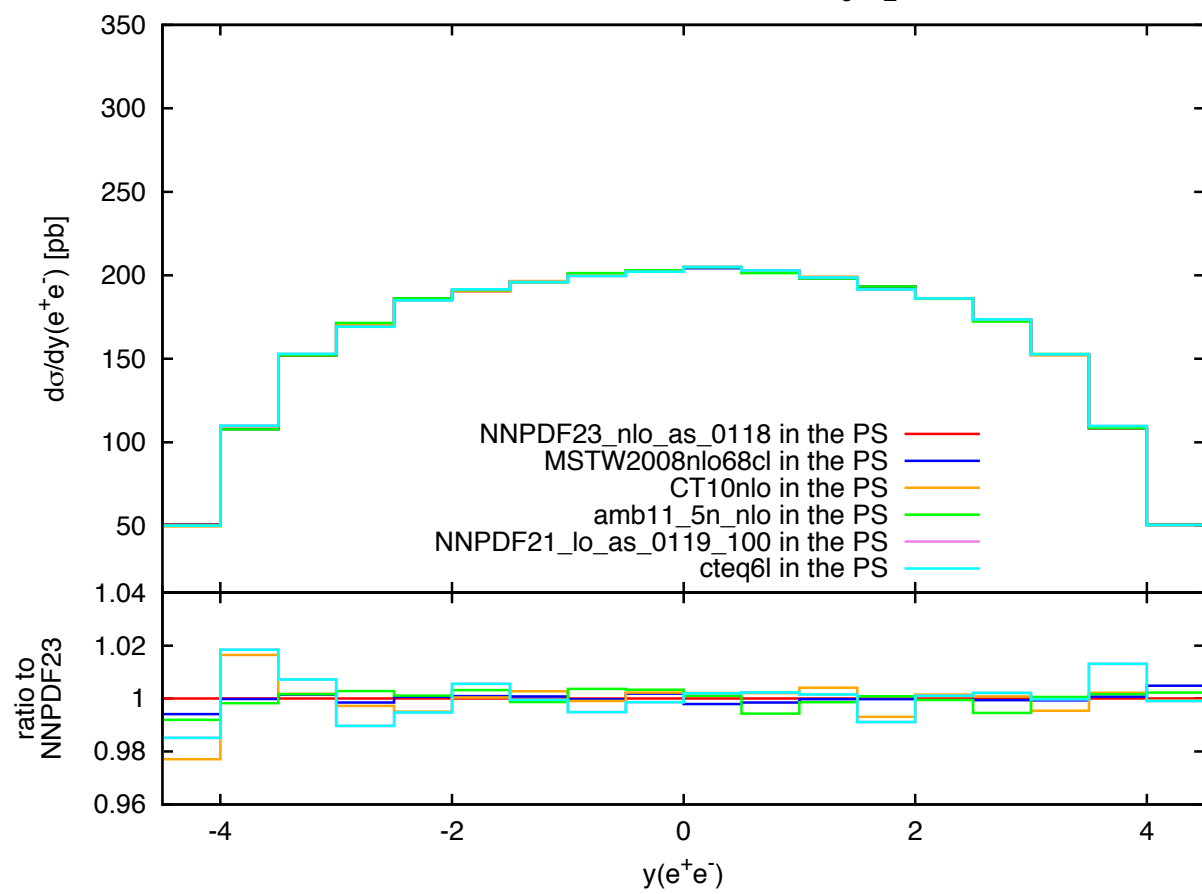
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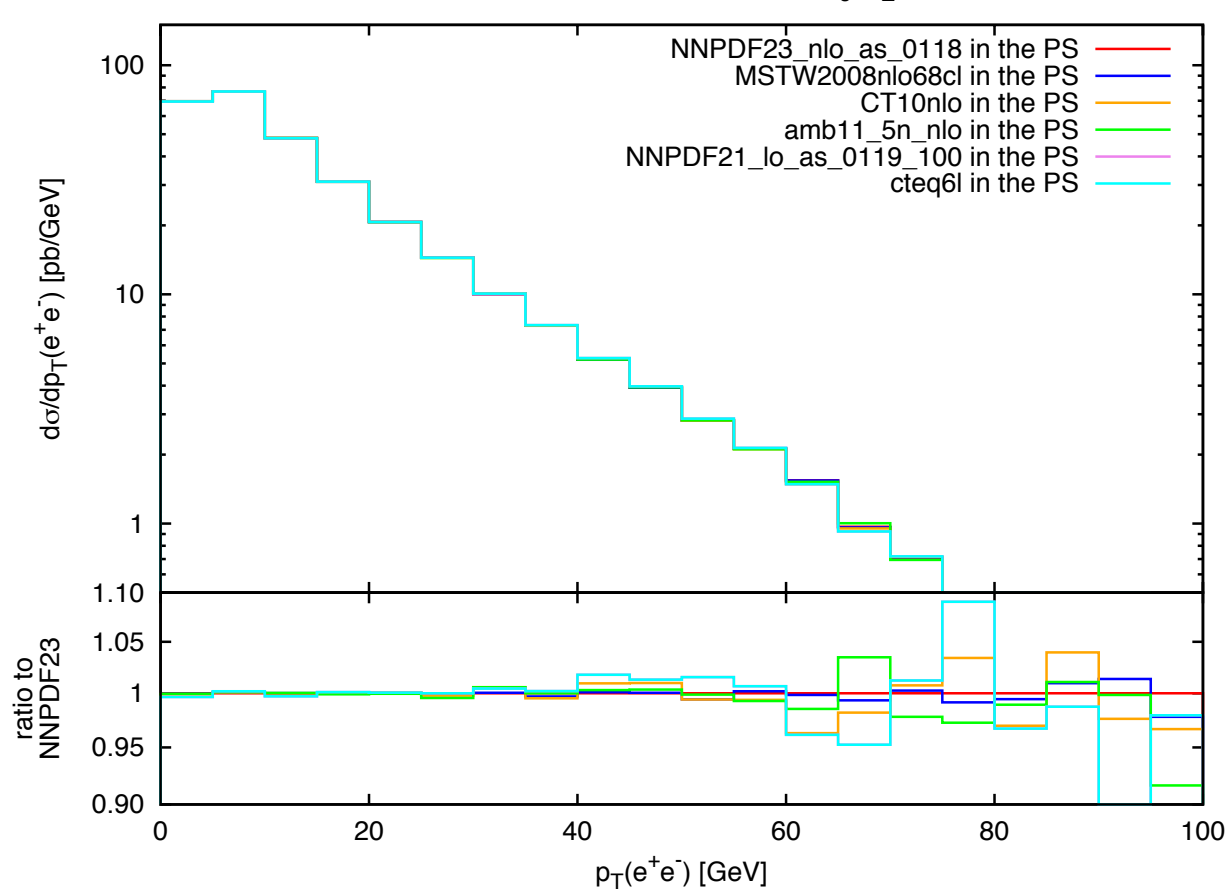
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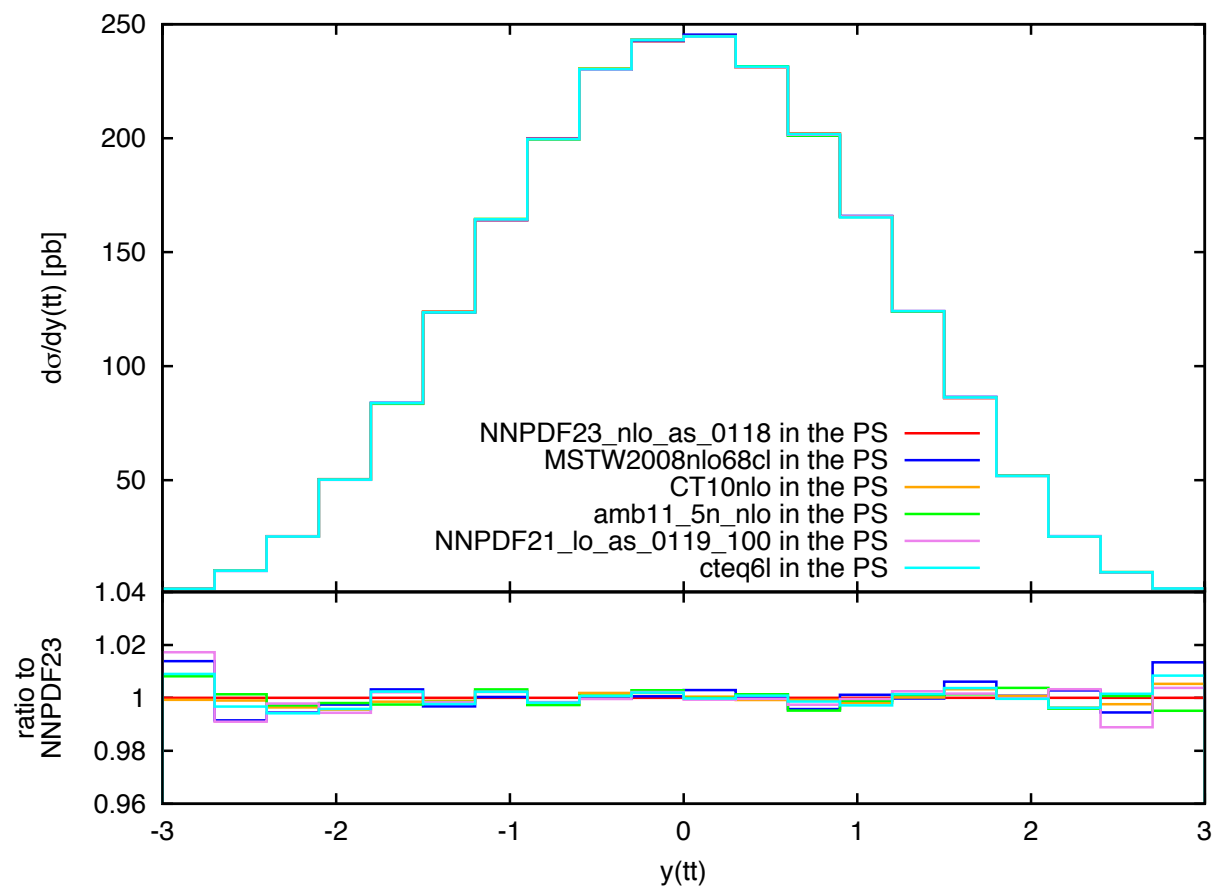


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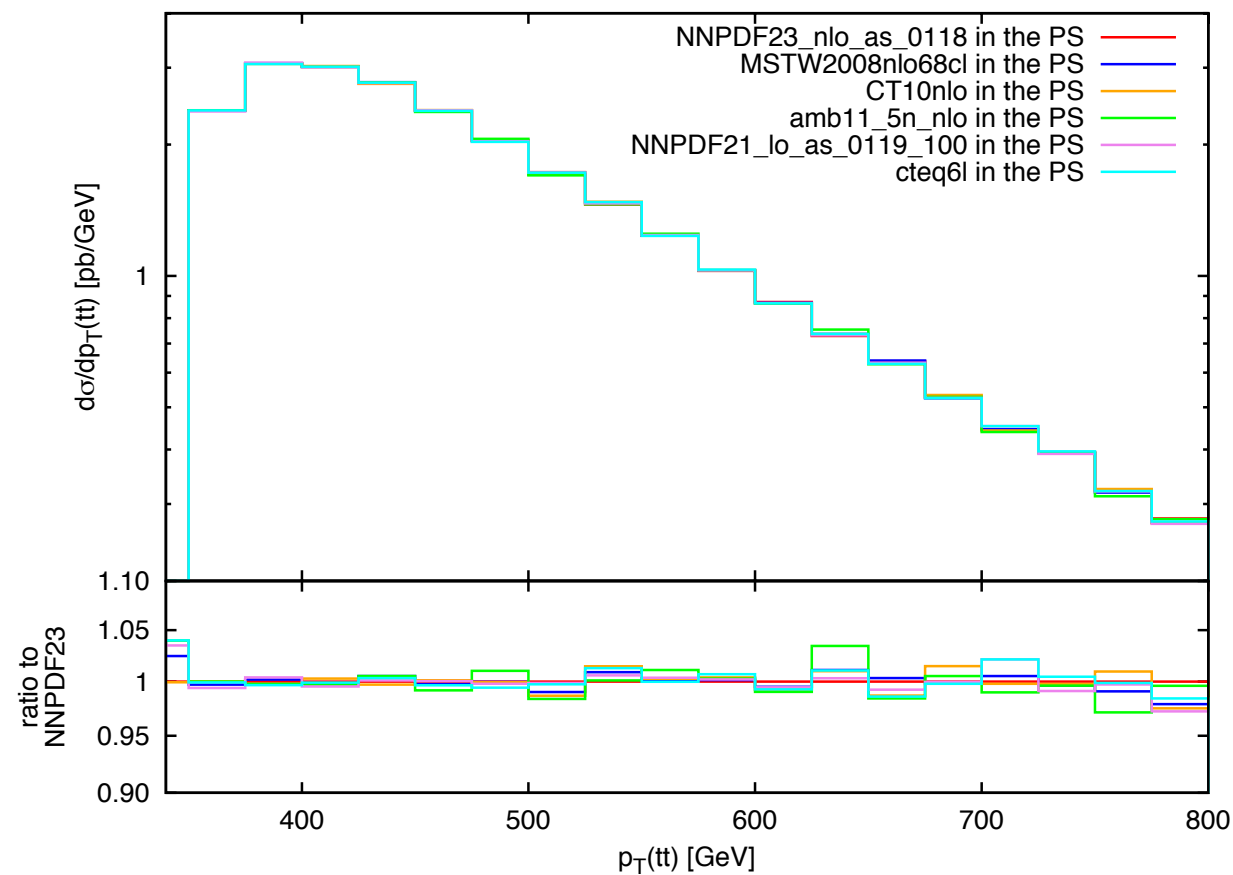


# HERWIG6 top pair

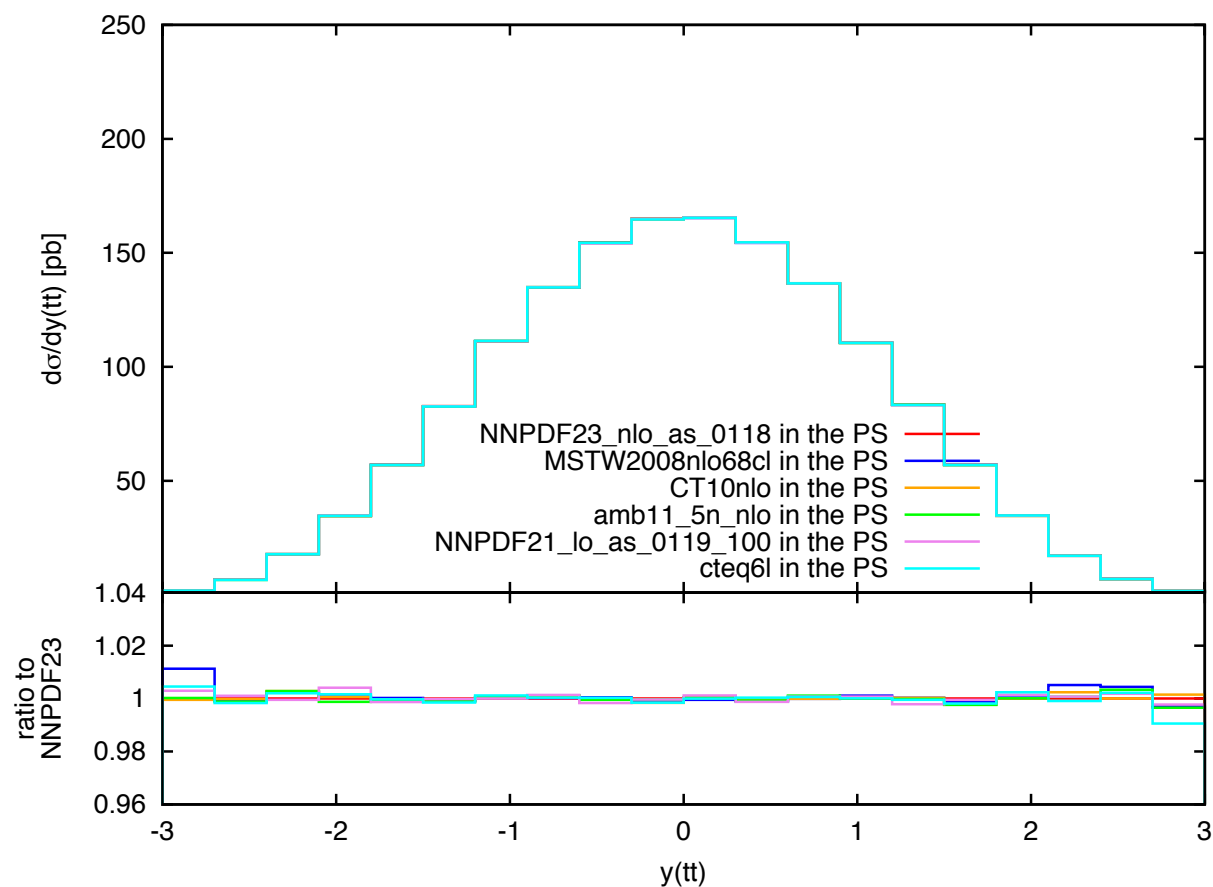
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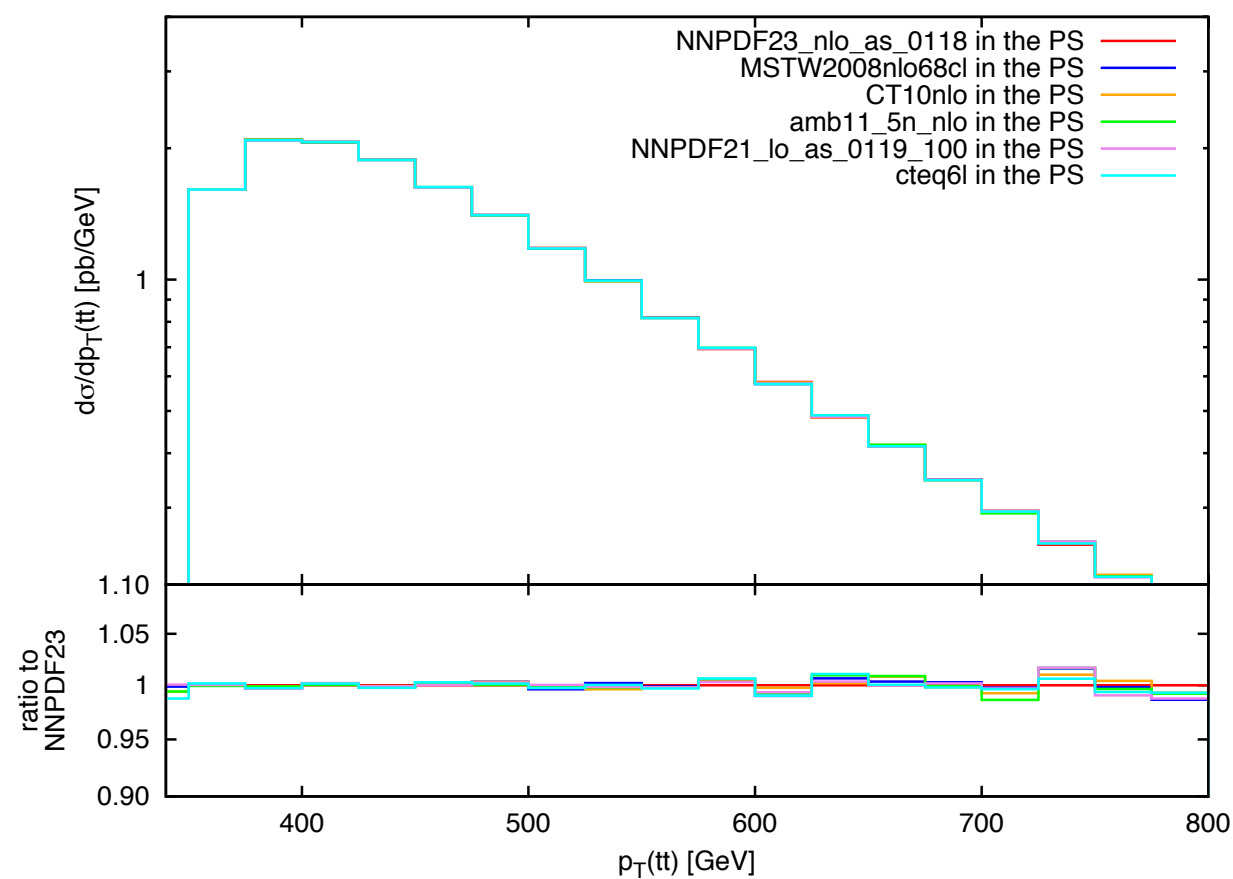
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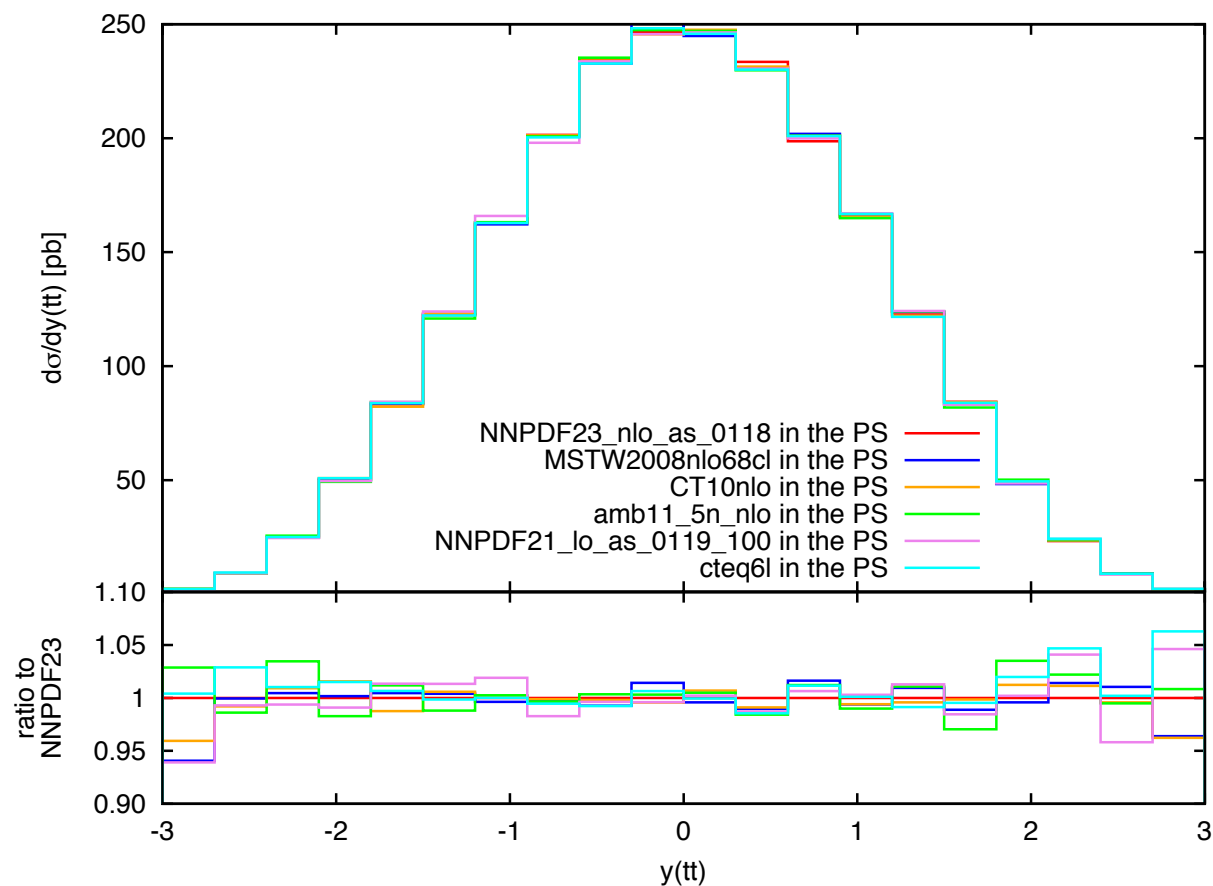
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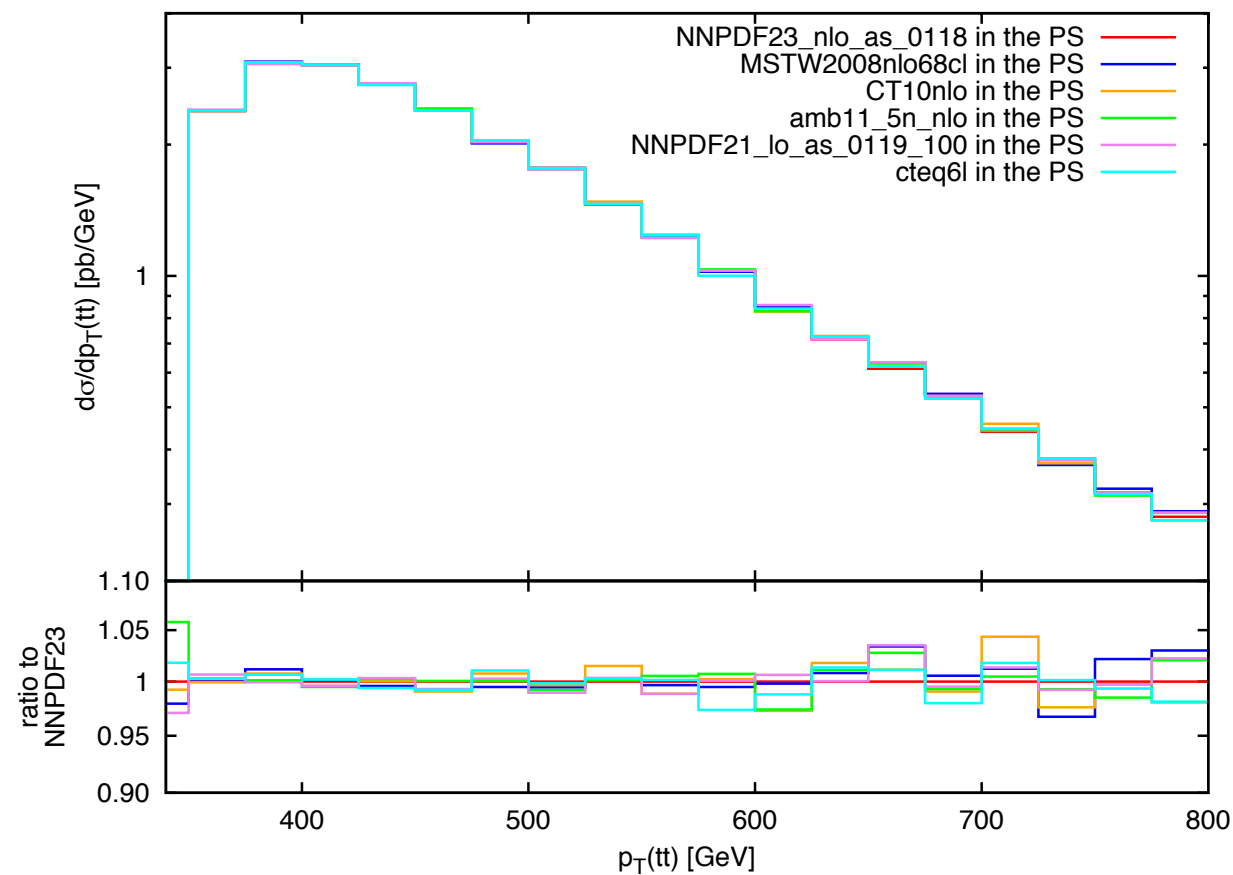


# PYTHIA8 top pair

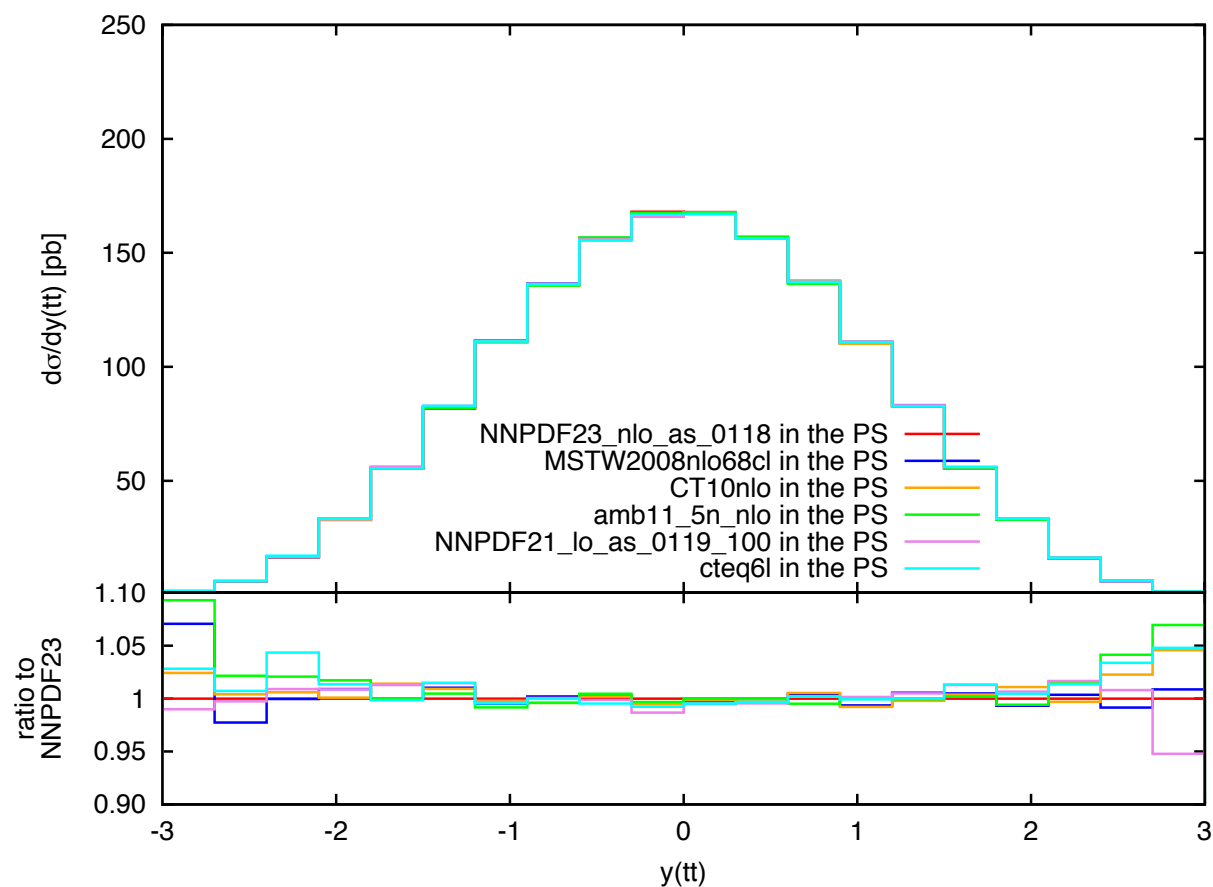
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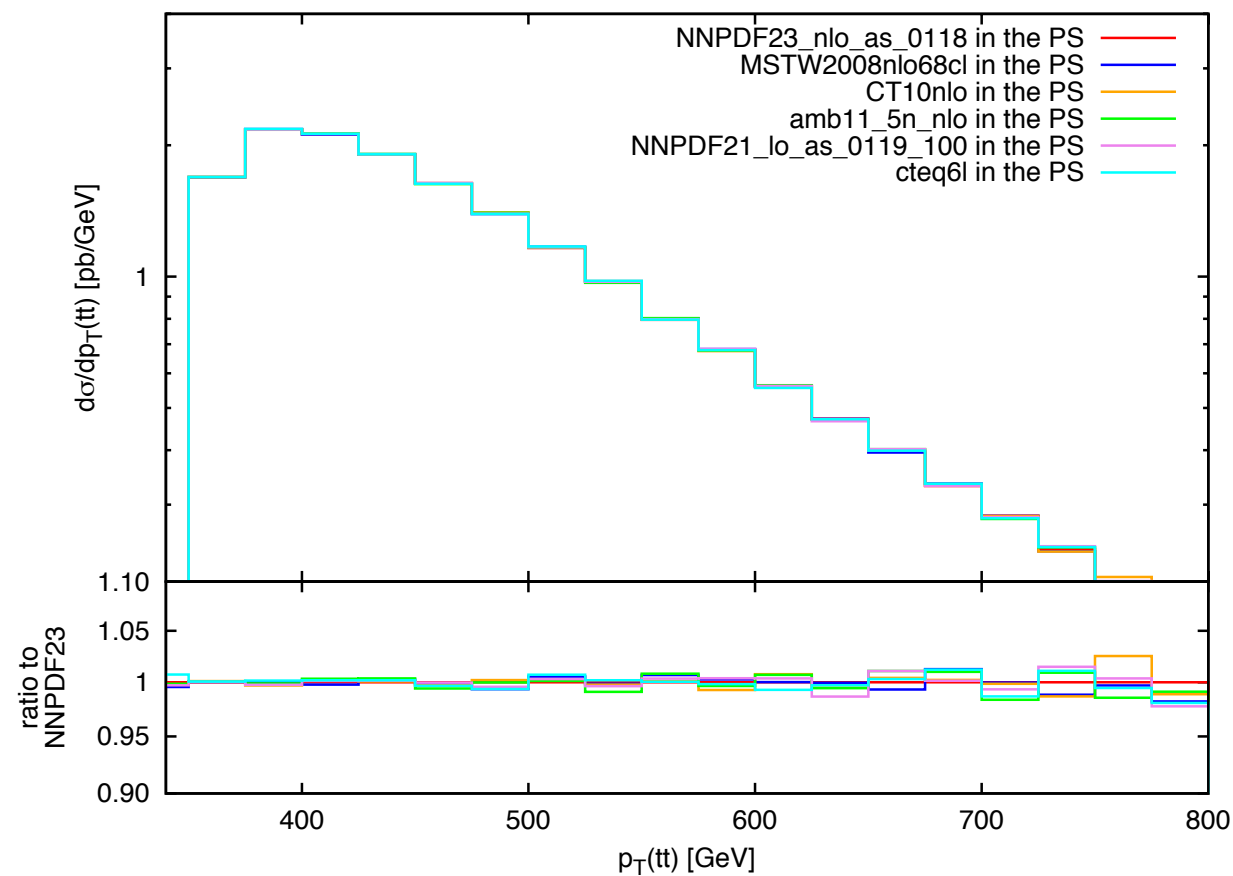
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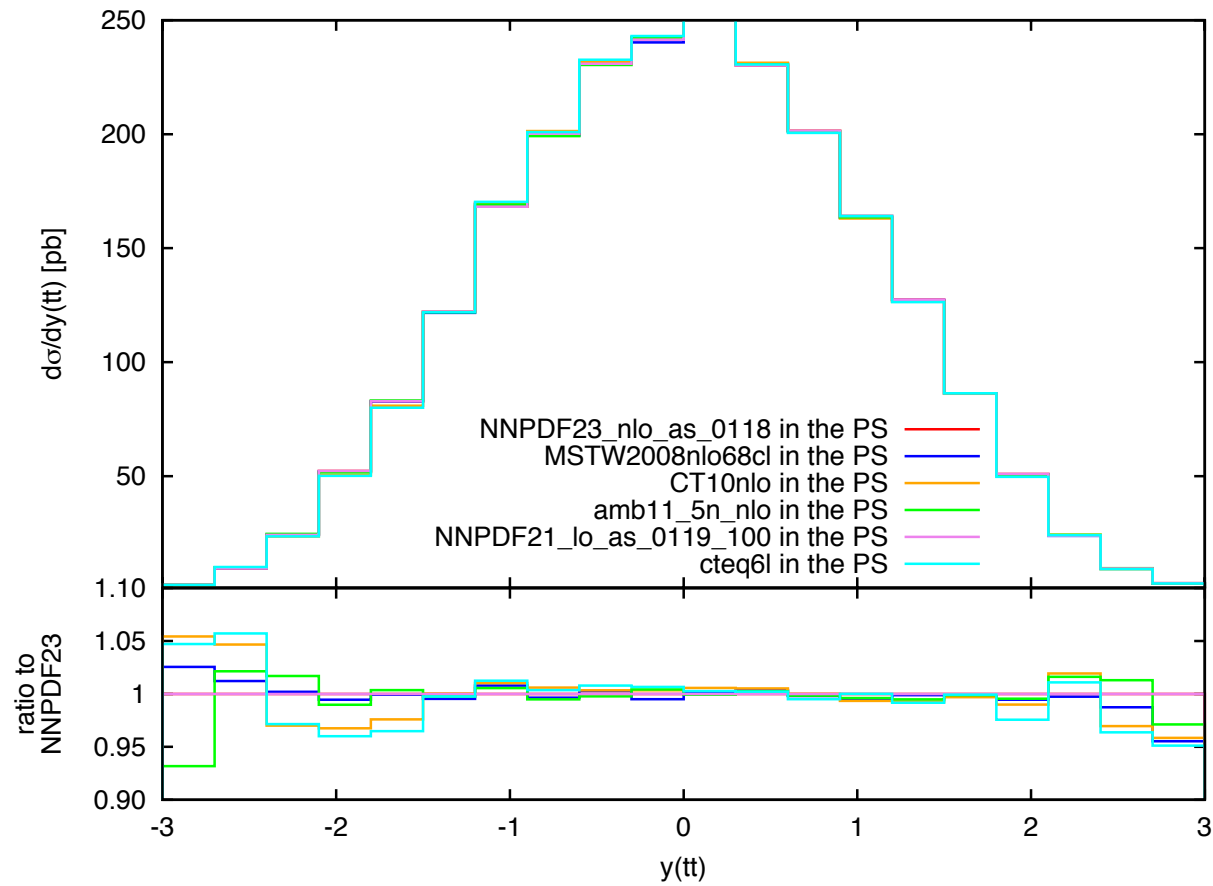


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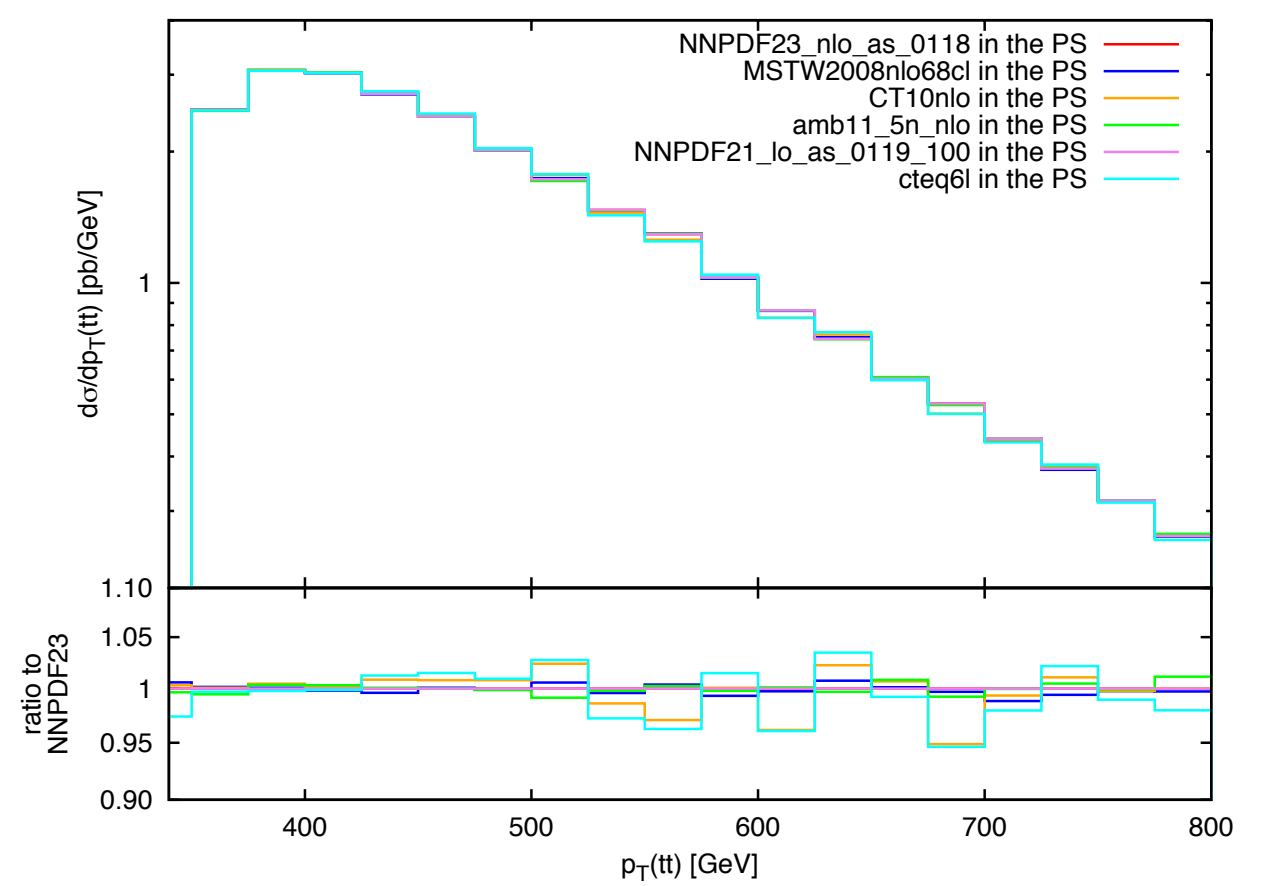


# HERWIG++ top pair

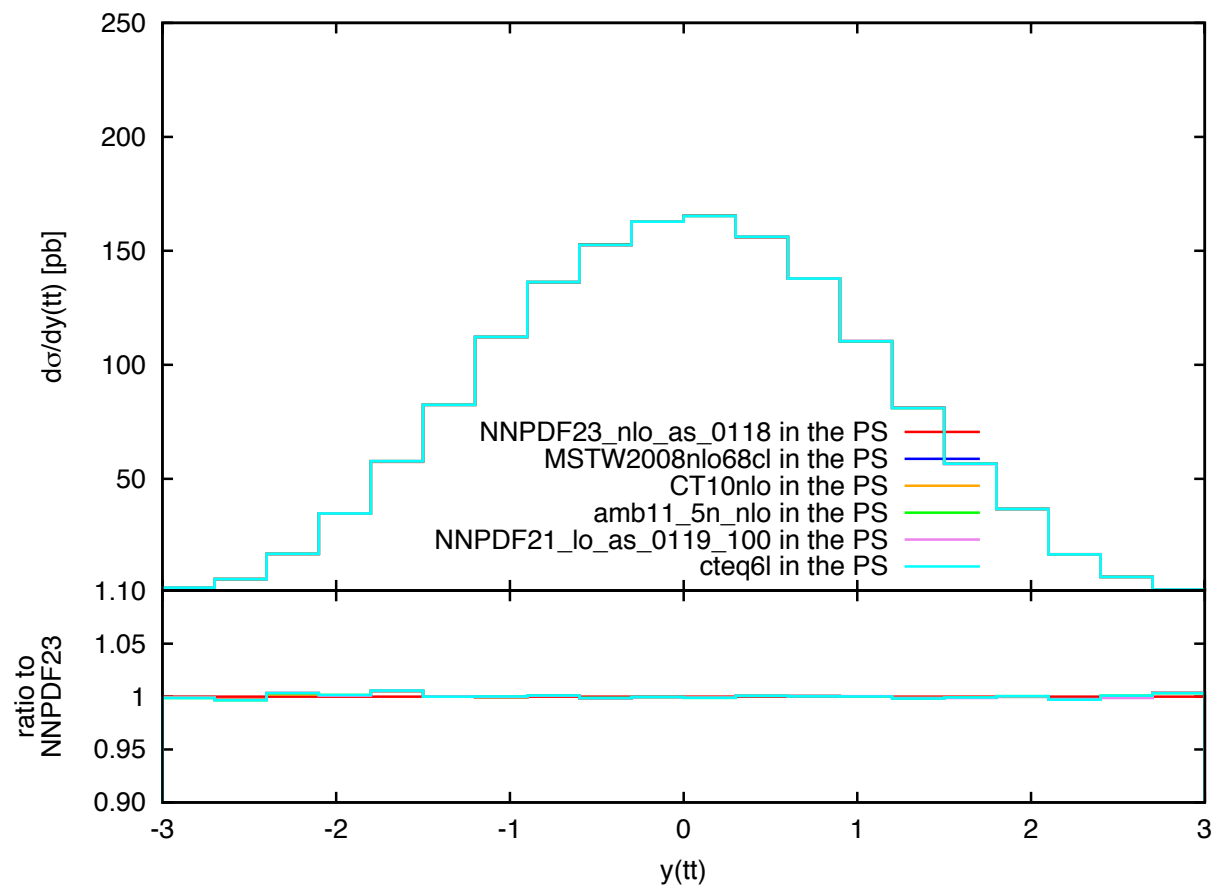
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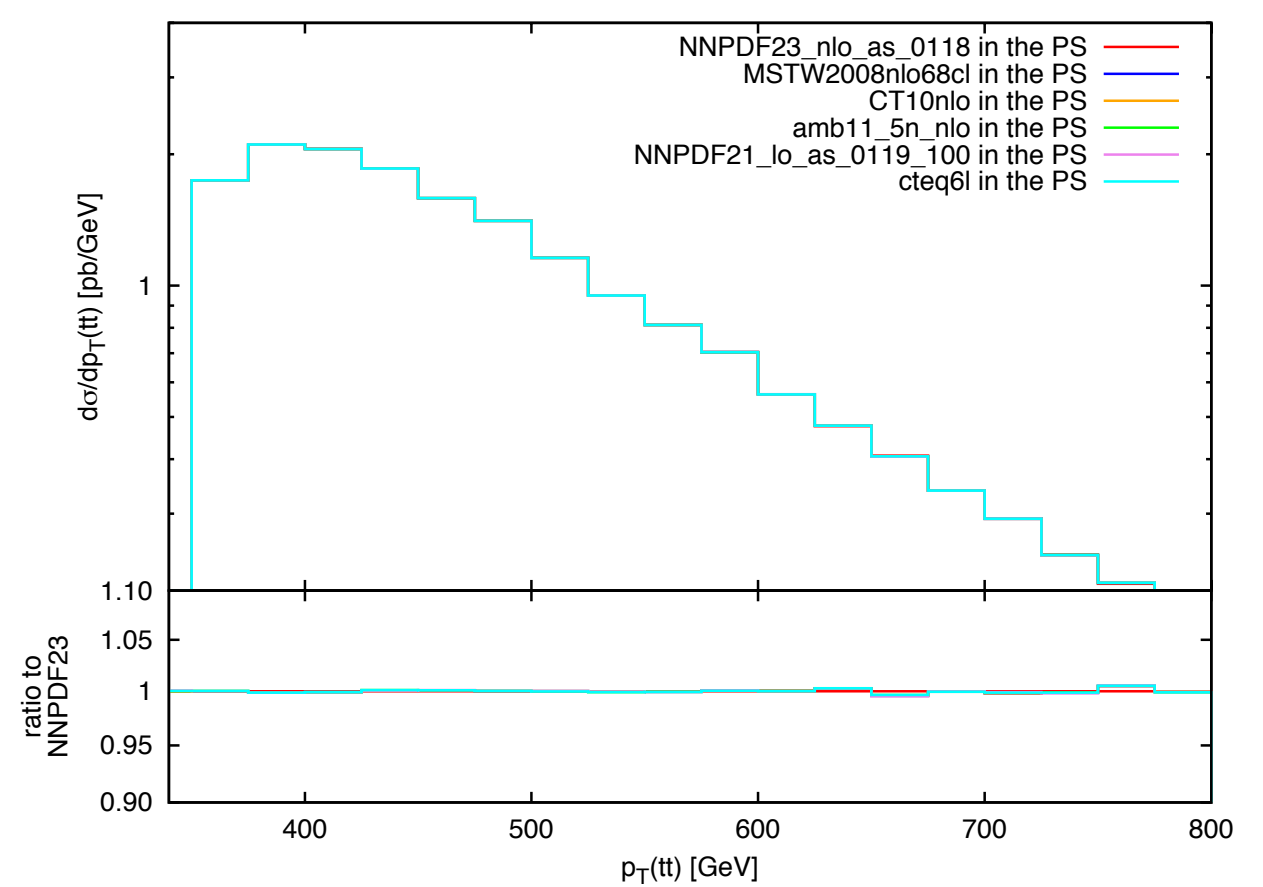
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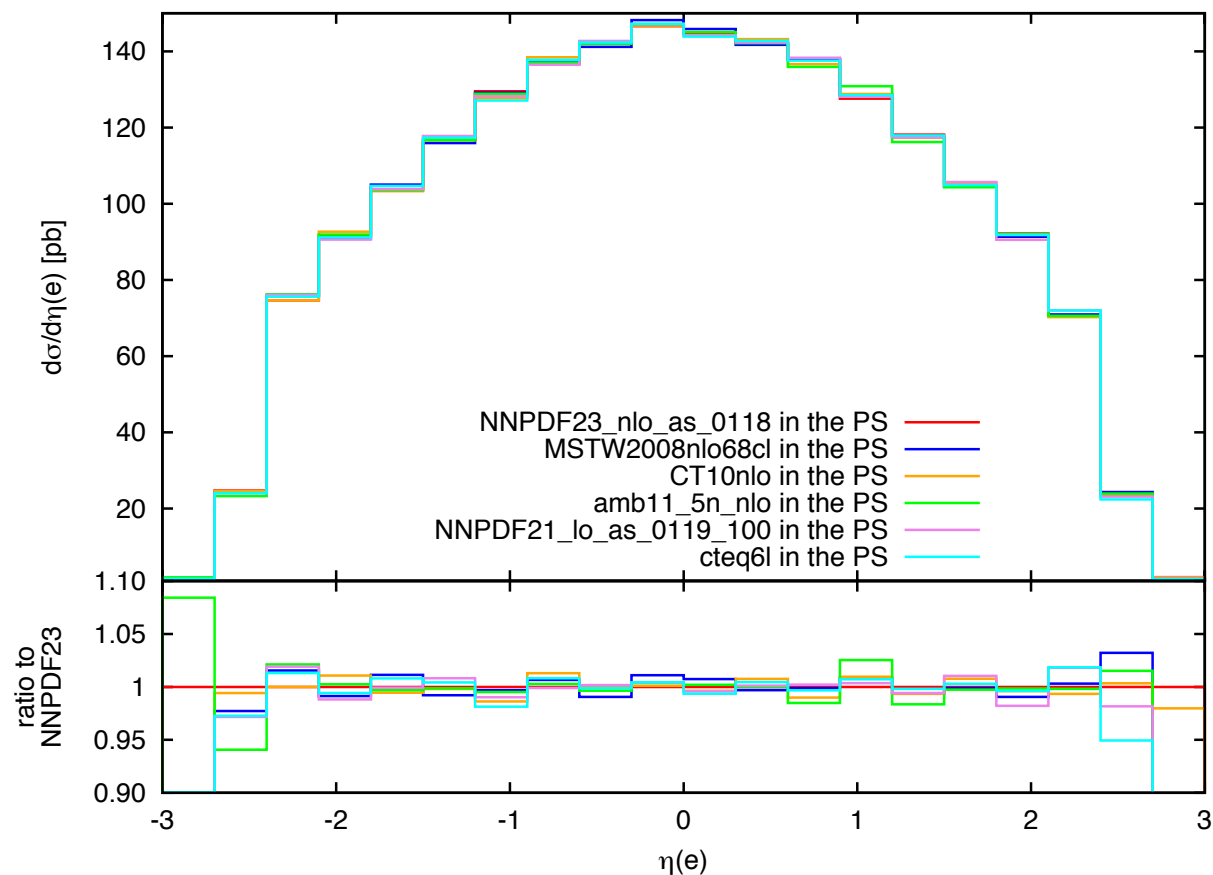


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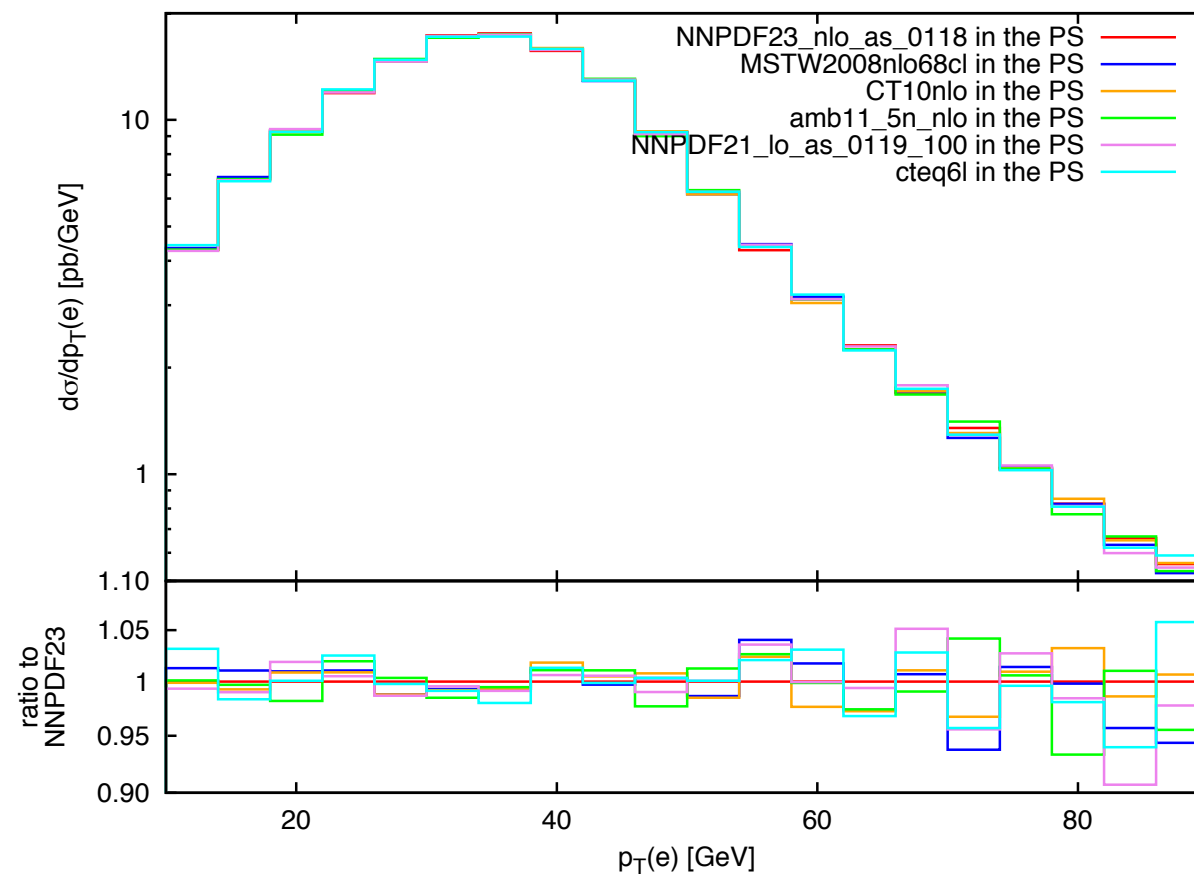


# HERWIG6 $W + c$

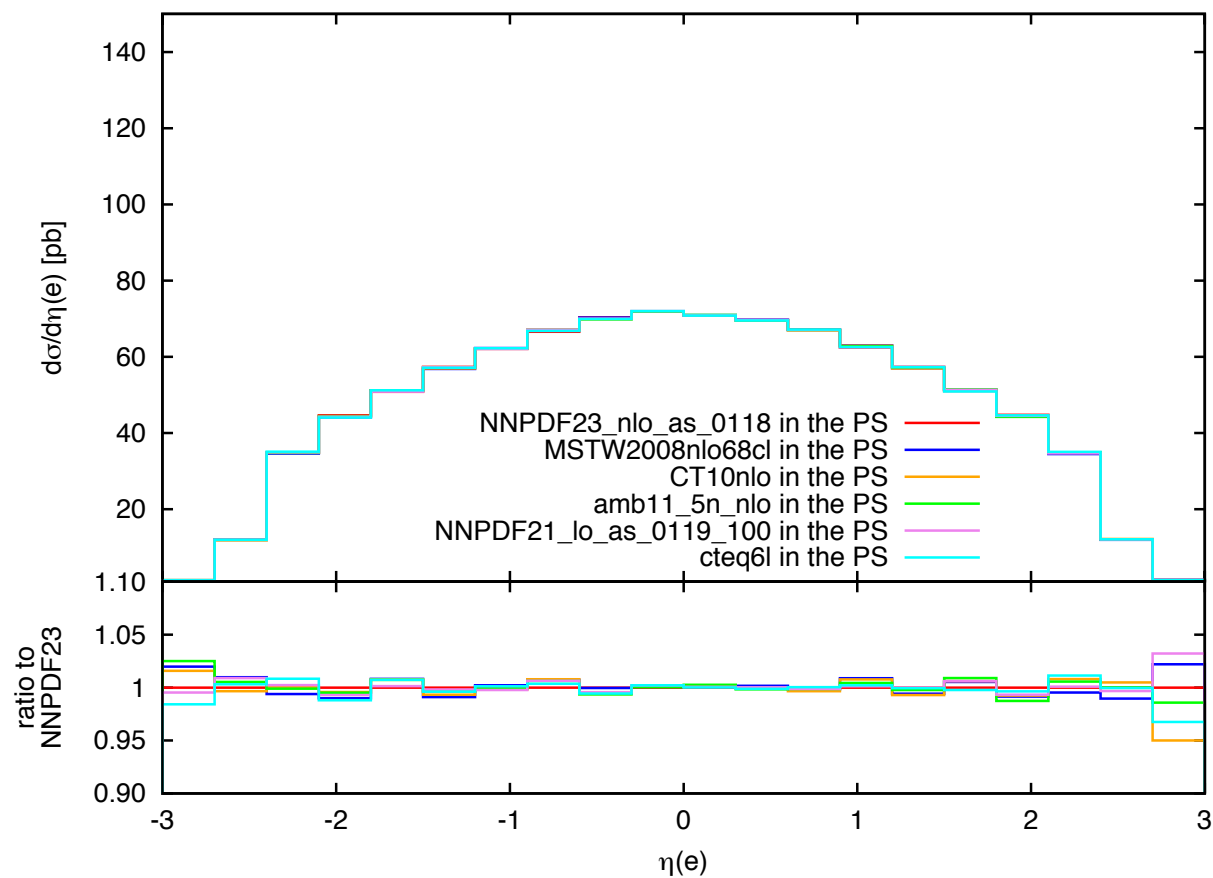
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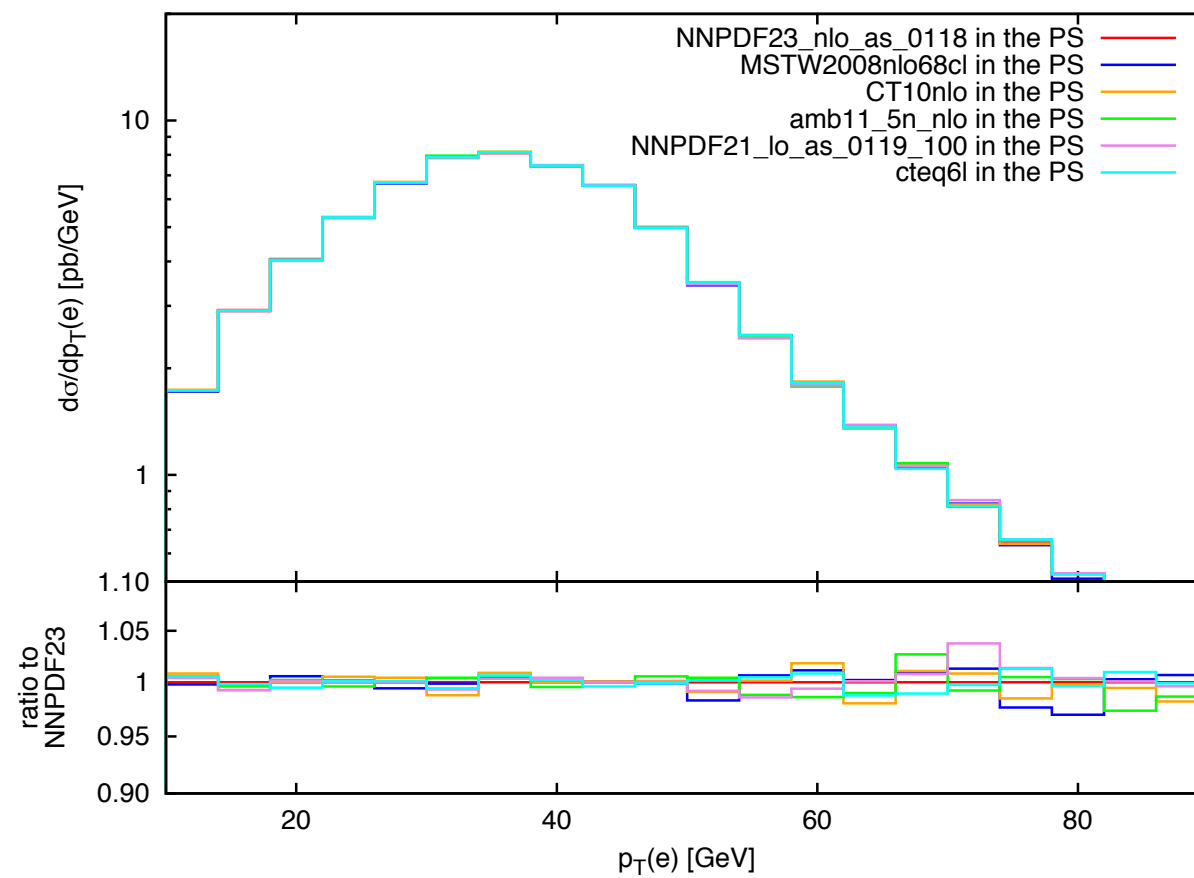
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$e^+v_e c$  at LO+PS with HERWIG6, NNPDF23 NLO  $\alpha_s(M_Z) = 0.118$  in the ME

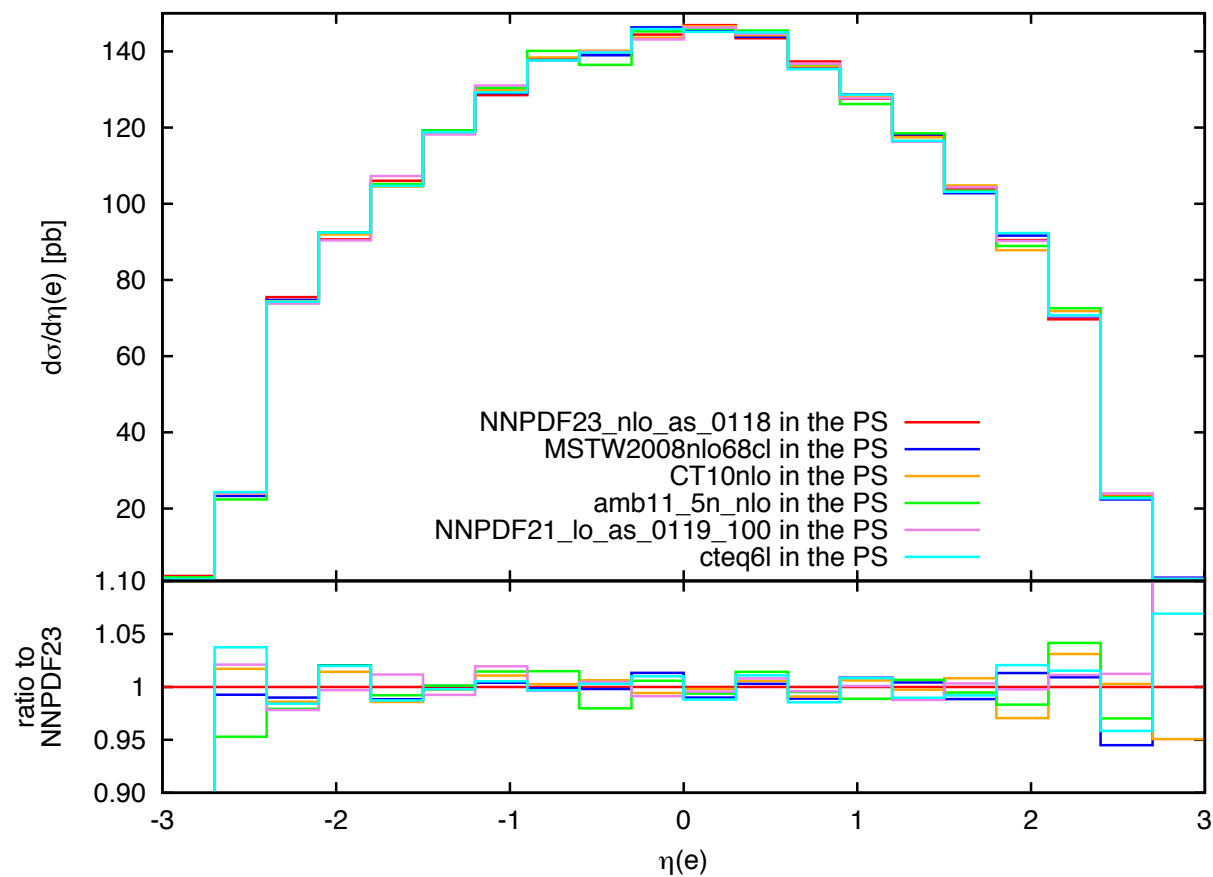


$e^+v_e c$  at LO+PS with HERWIG6, NNPDF23 NLO  $\alpha_s(M_Z) = 0.118$  in the ME

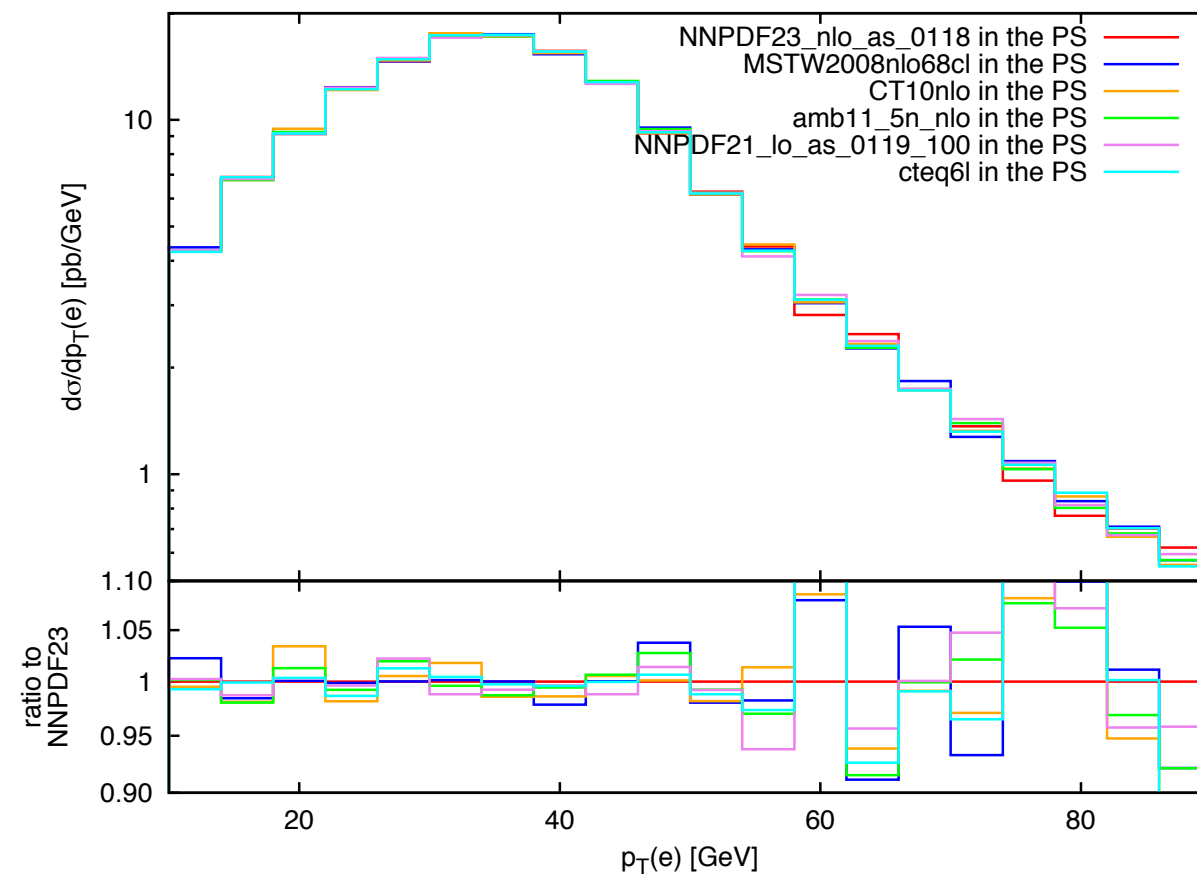


# PYTHIA8 $W + c$

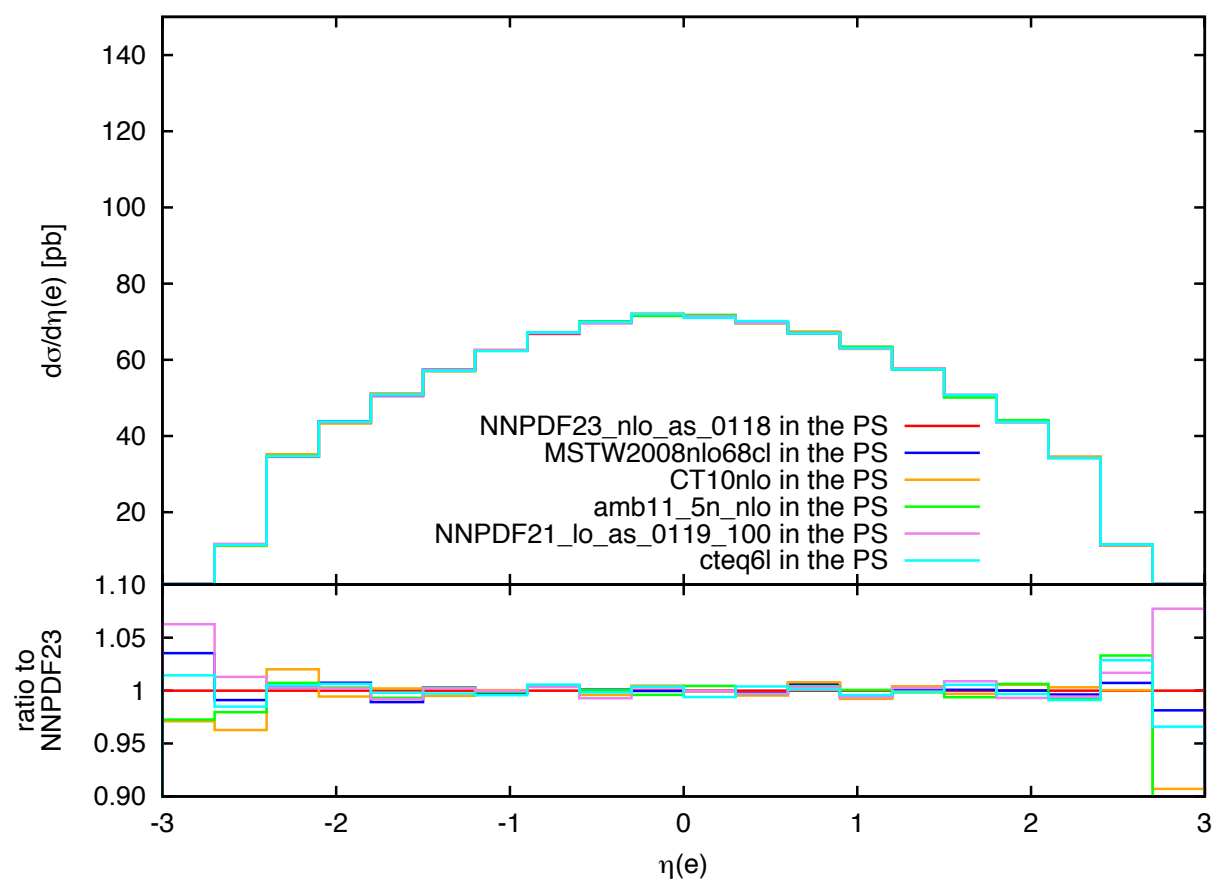
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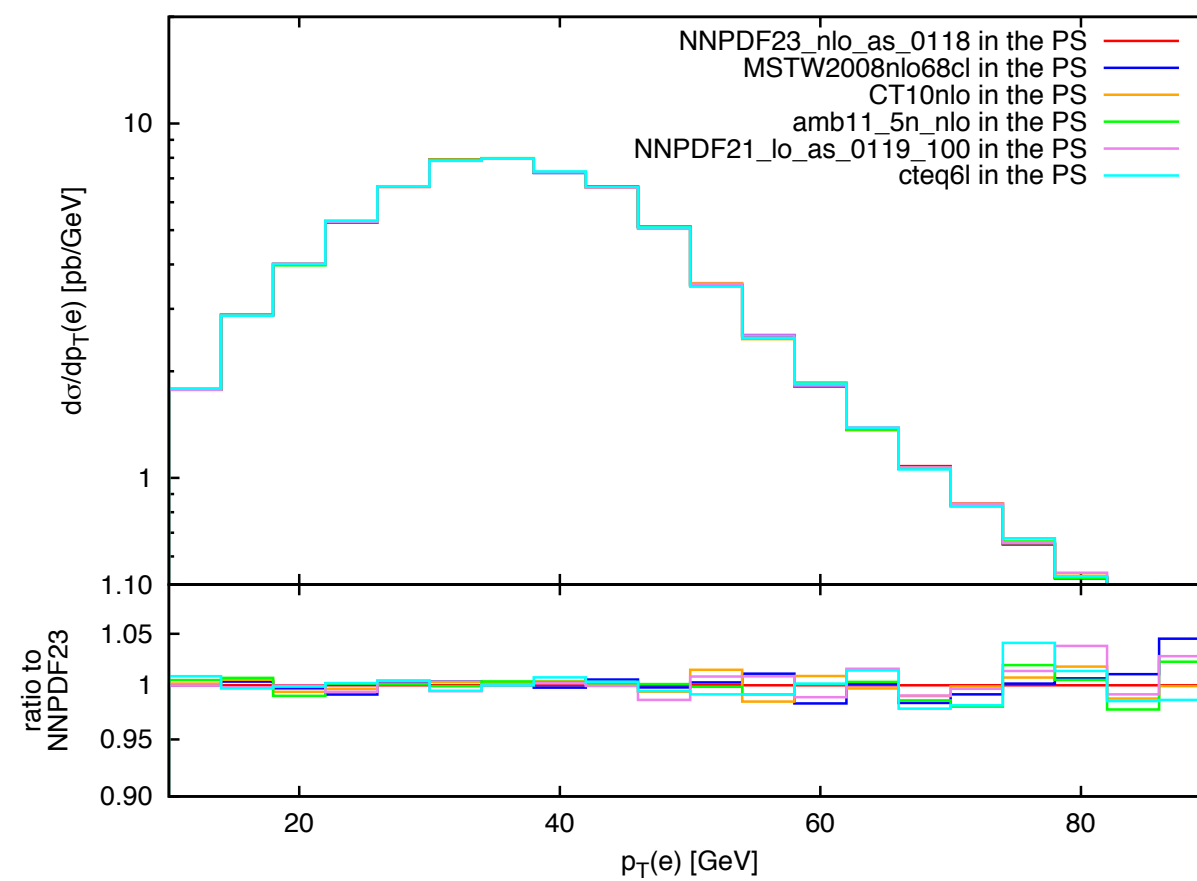
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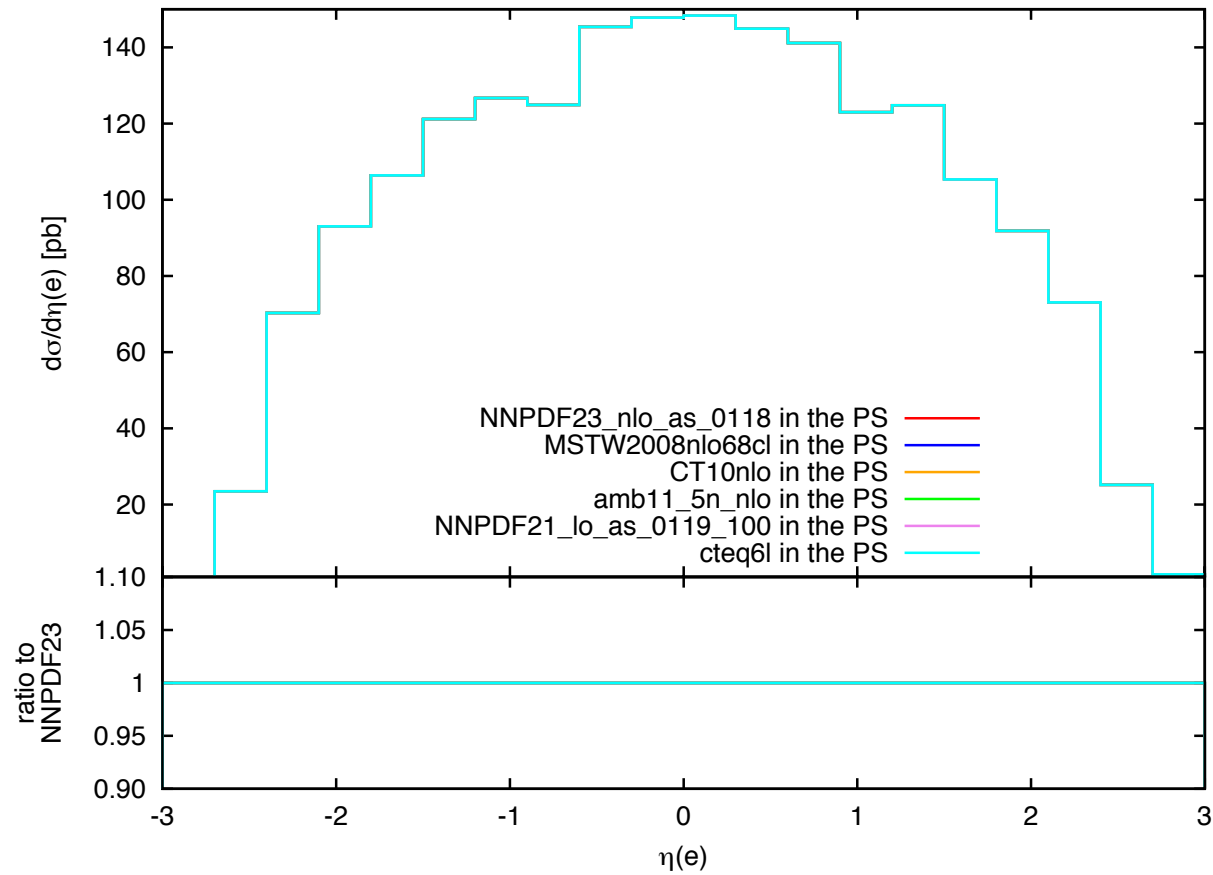
# Conclusions

- The aMCfast interface is now **complete**:
  - fixed-order case operative and public,
  - NLO + PS case operative but not yet public.
- The production of interpolation grid in the presence of PS requires some care:
  - impossibility to completely remove the PDF dependence from the interpolation grids,
  - however the residual PDF dependence seems to be moderate.
- The FxFx merging leads to an impressive stability of predictions when considering different PSs (see Paolo's talk):
  - this is a very desirable feature that would make the use of interpolation grids with PS “possible” in a PDF fit.
  - more detailed study needed.

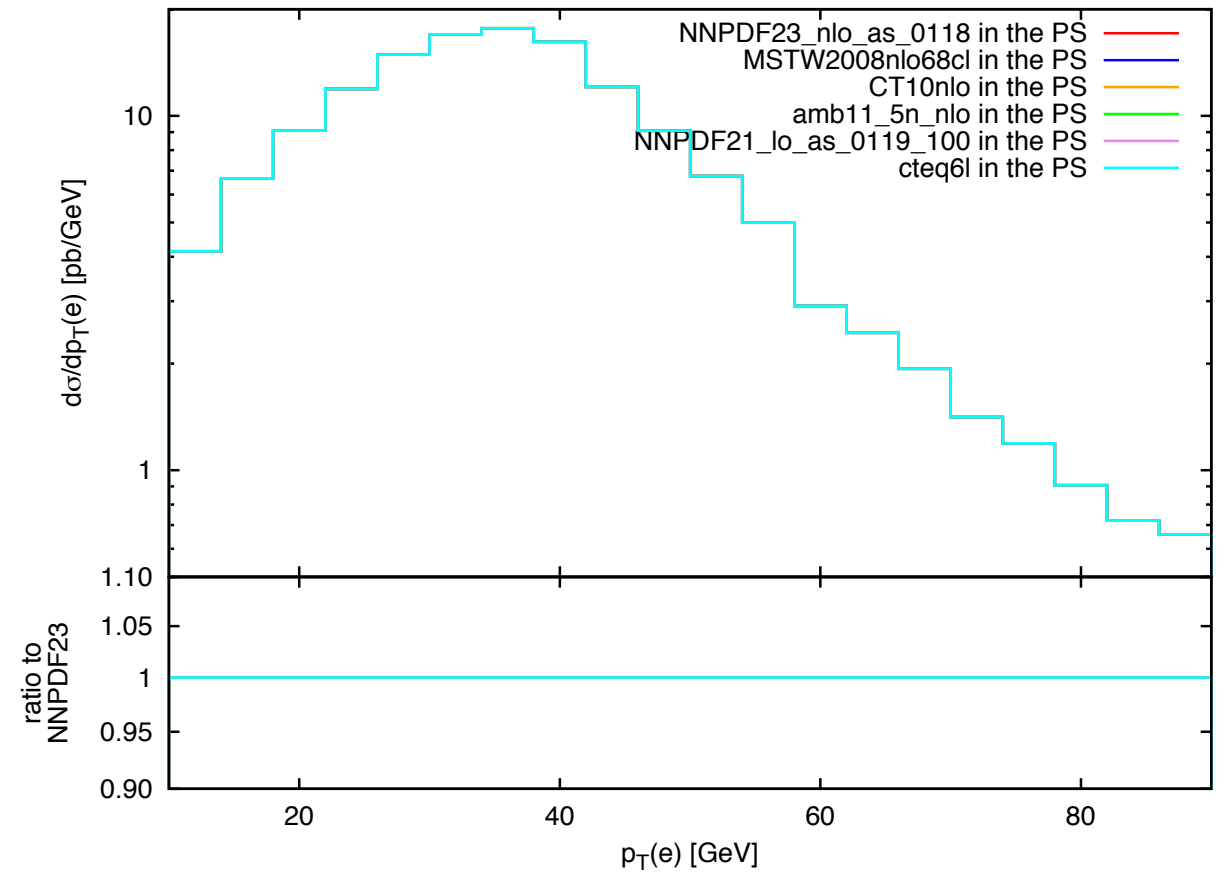
# **Backup Slides**

# HERWIG++ $W + c$

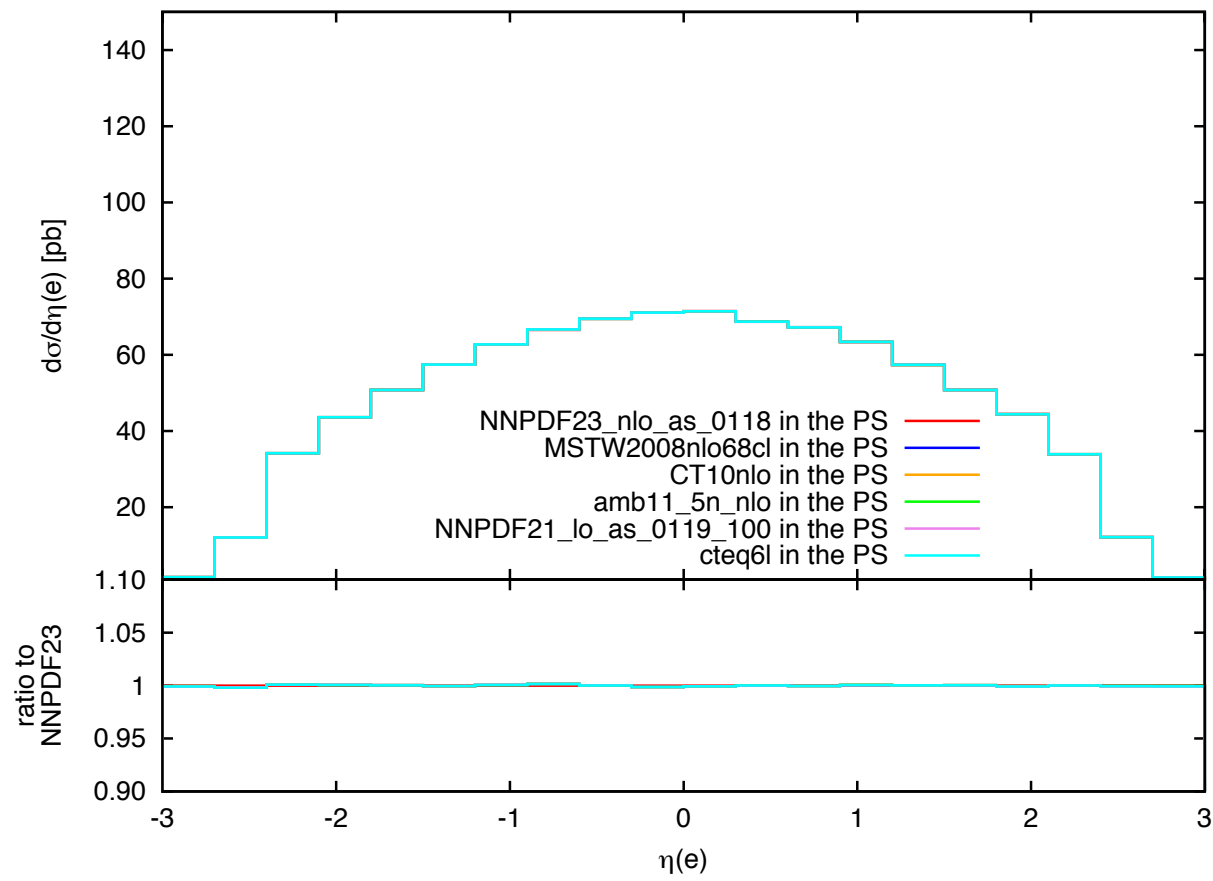
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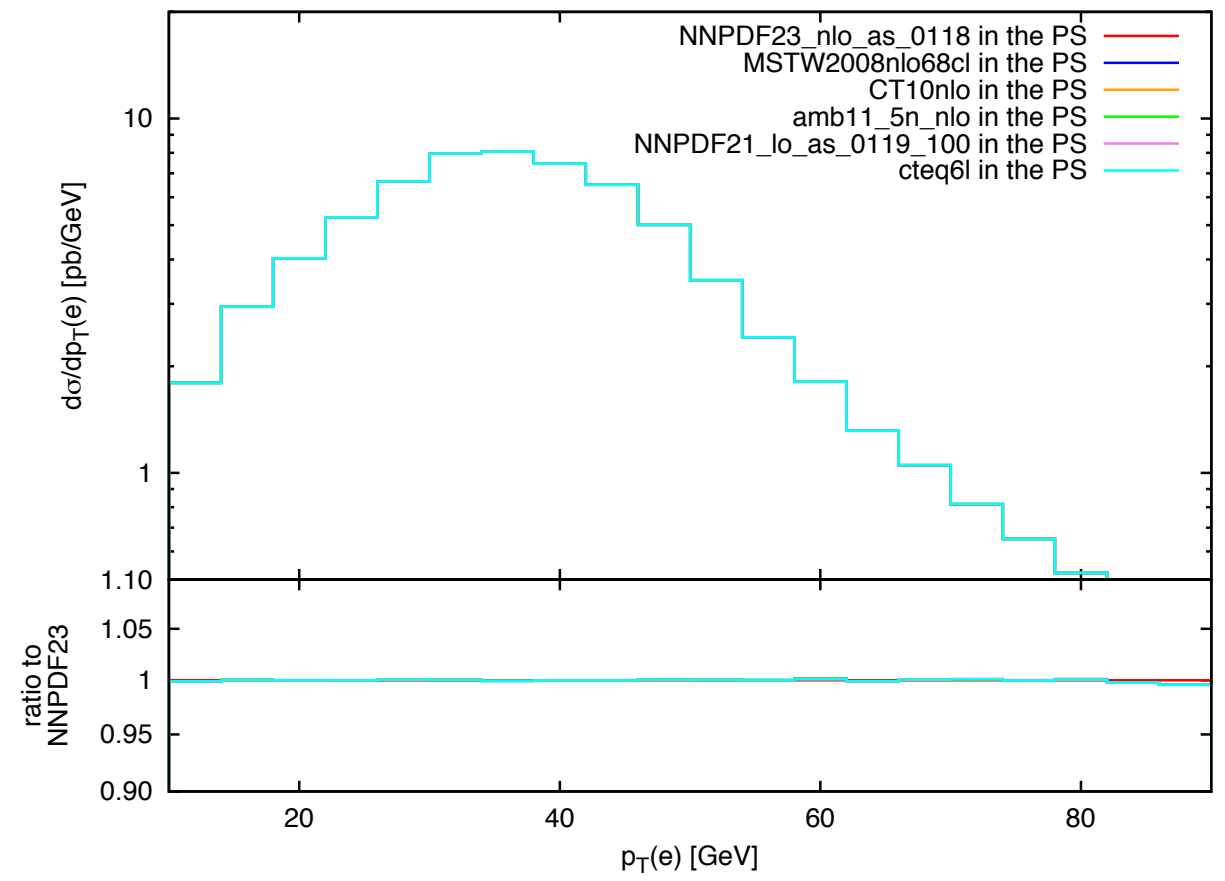
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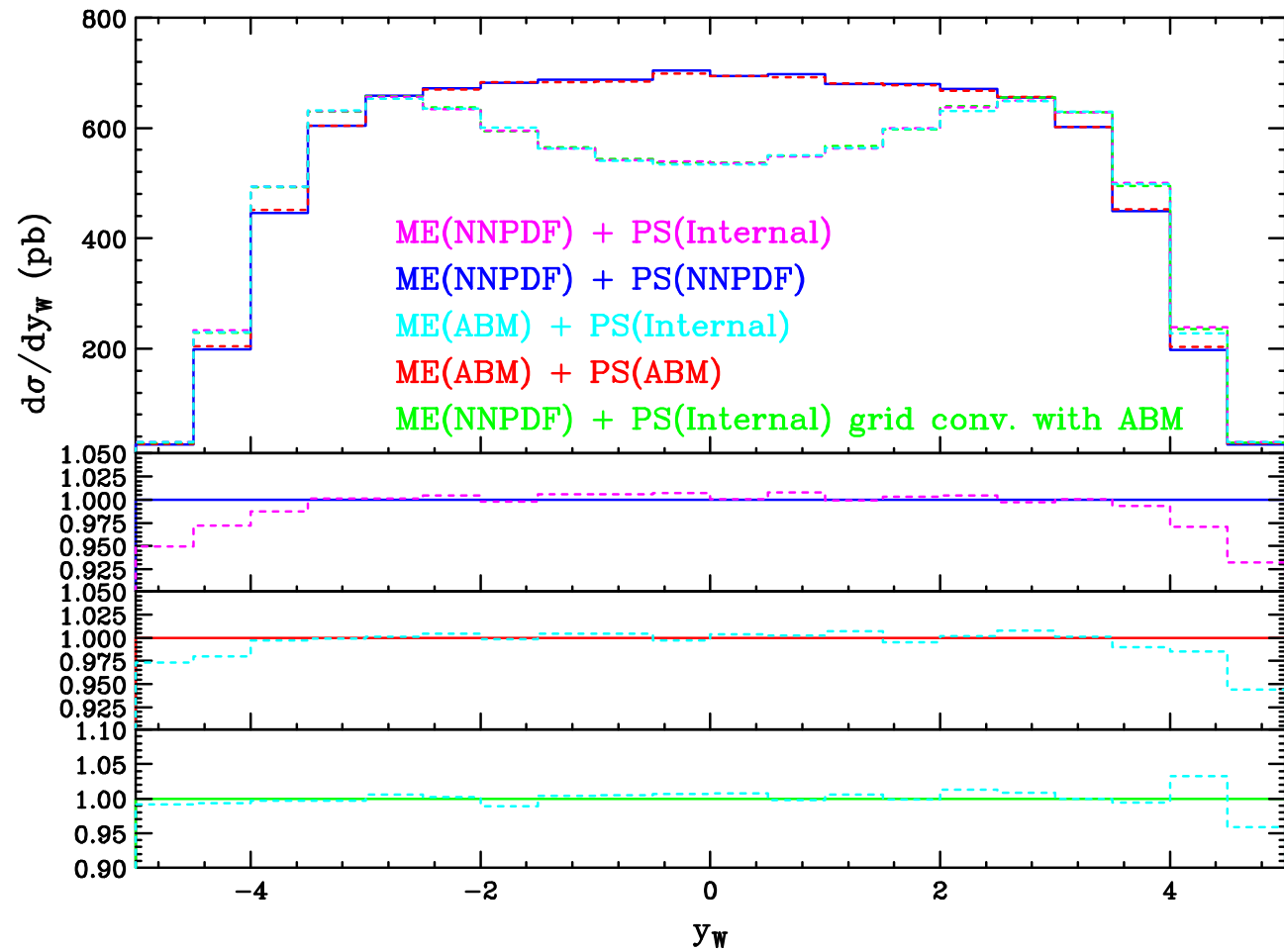
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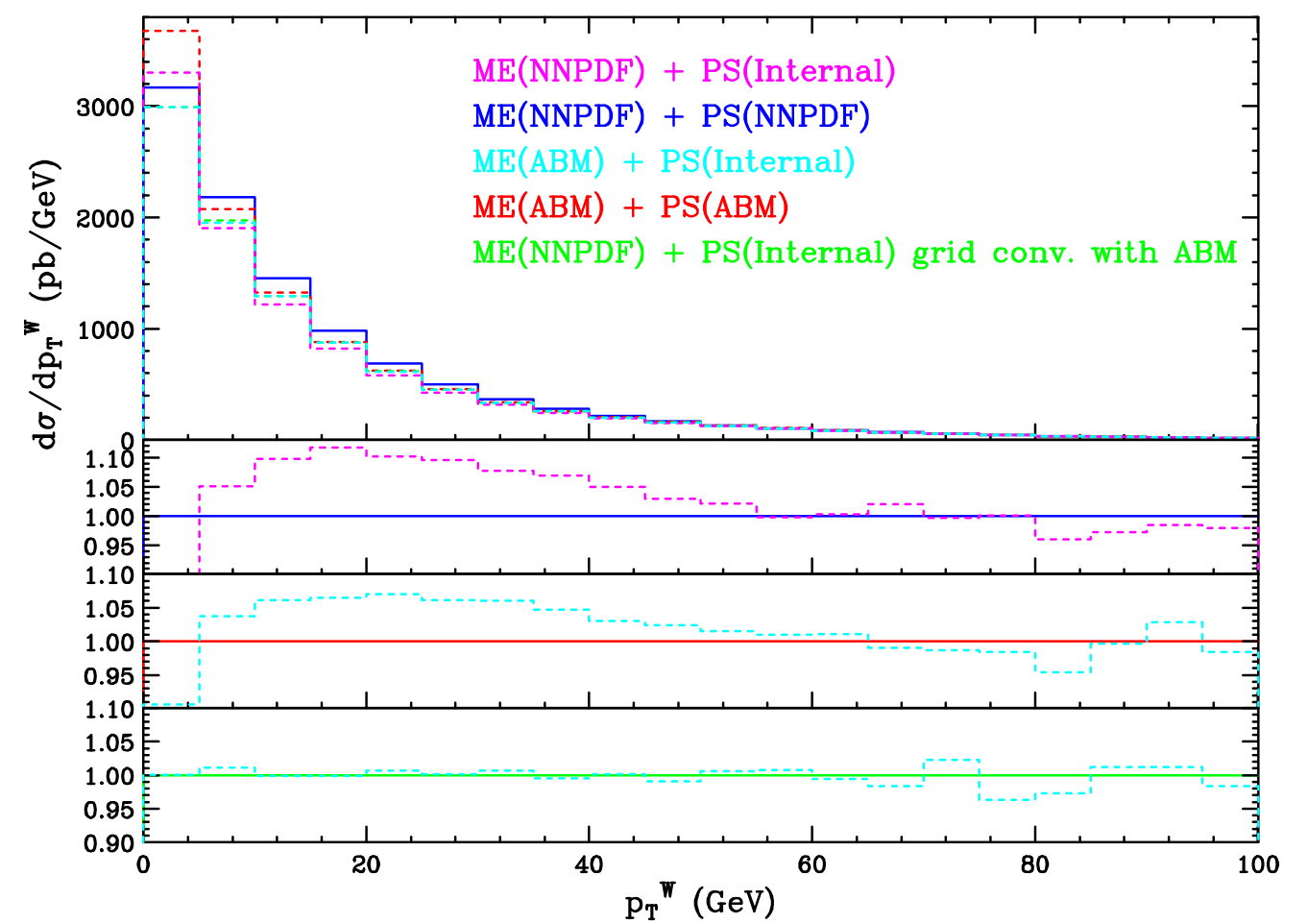


# PYTHIA8 $e^+e^-$

Prediction for  $e^+\nu$  production (PYTHIA8)



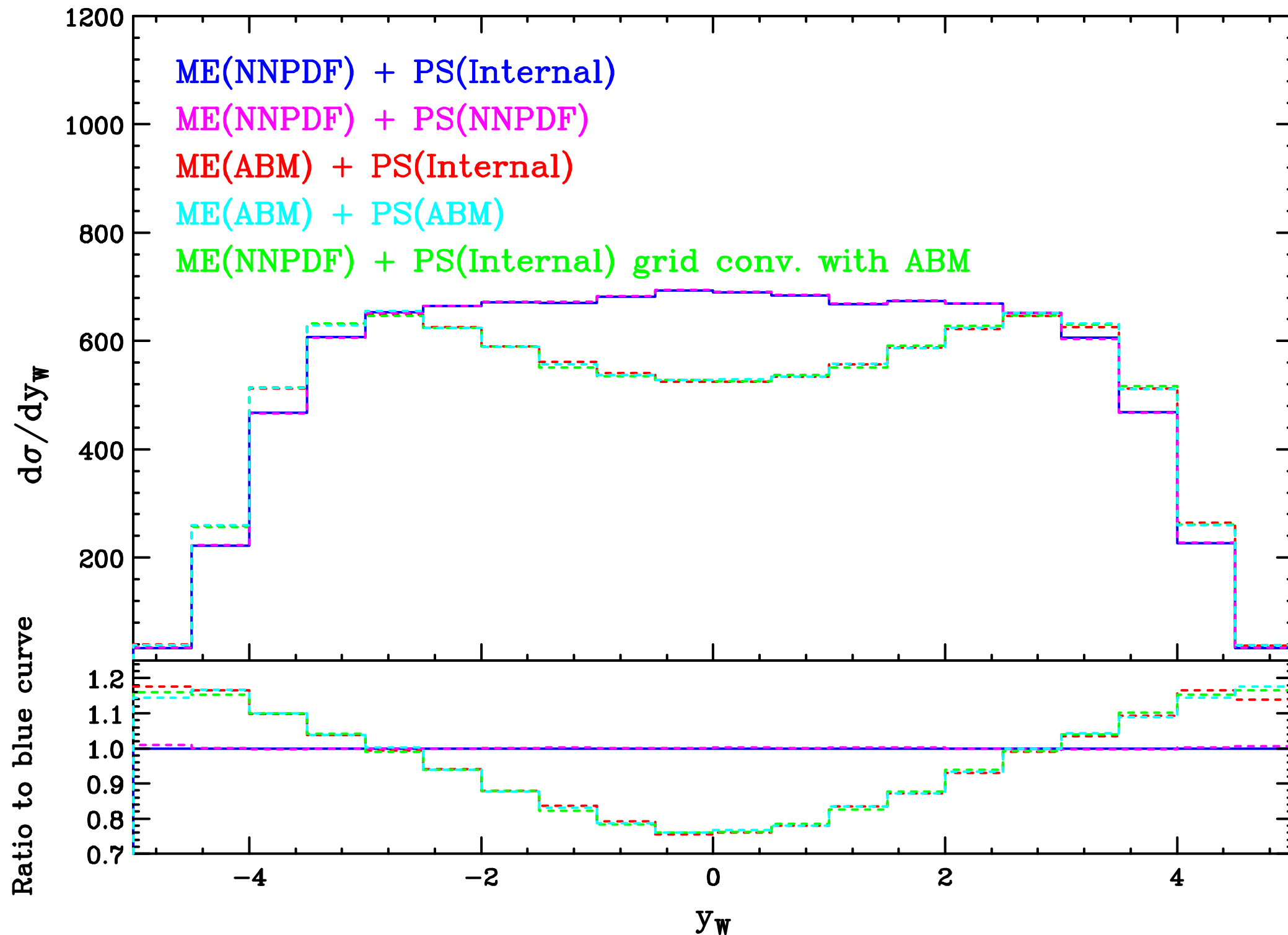
Prediction for  $e^+\nu$  production (PYTHIA8)



# The aMCfast Interface

*The NLO + PS Case: Preliminary Results*

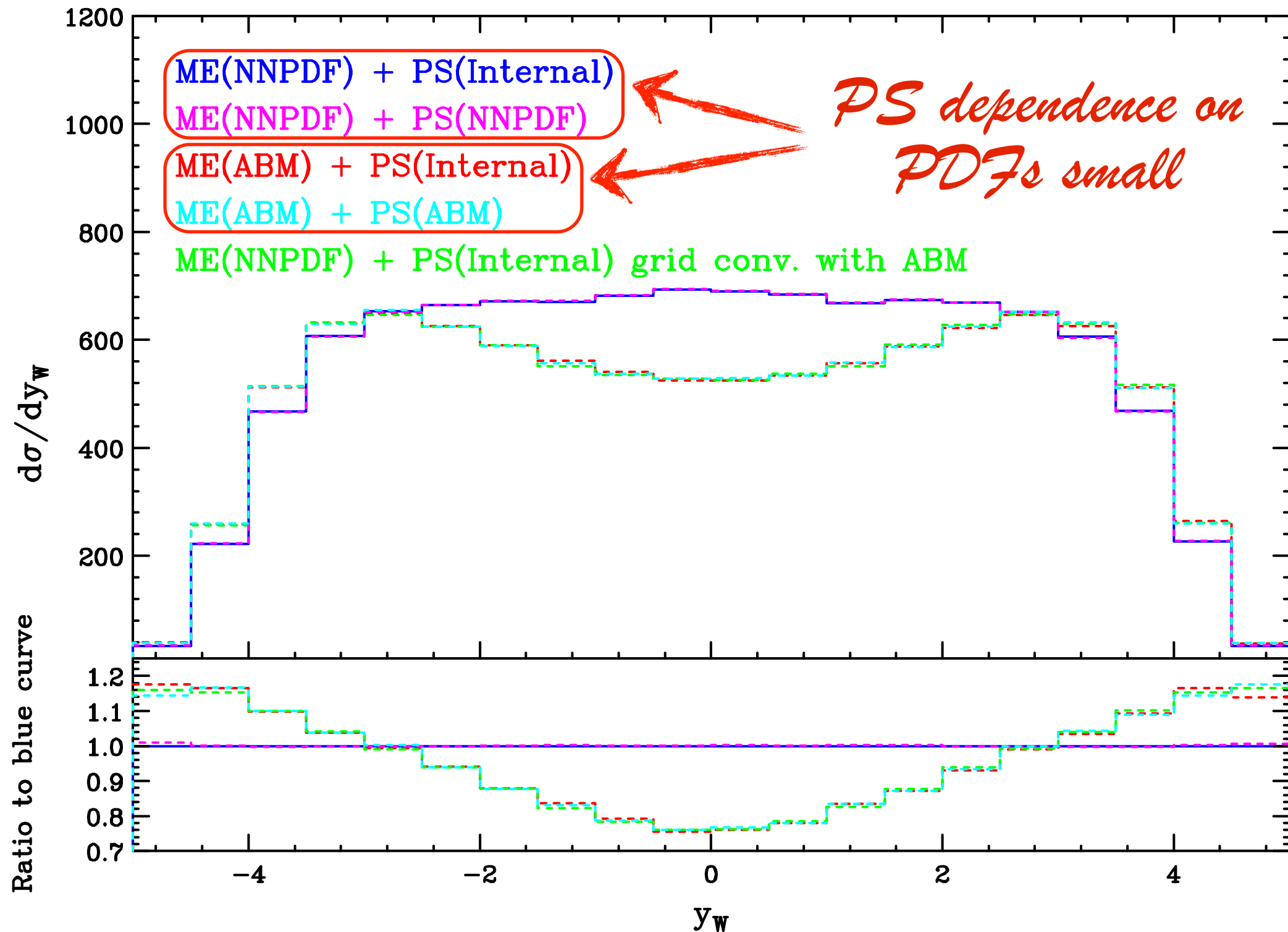
Prediction for  $e^+ \nu$  production



# The aMCfast Interface

*The NLO + PS Case: Preliminary Results*

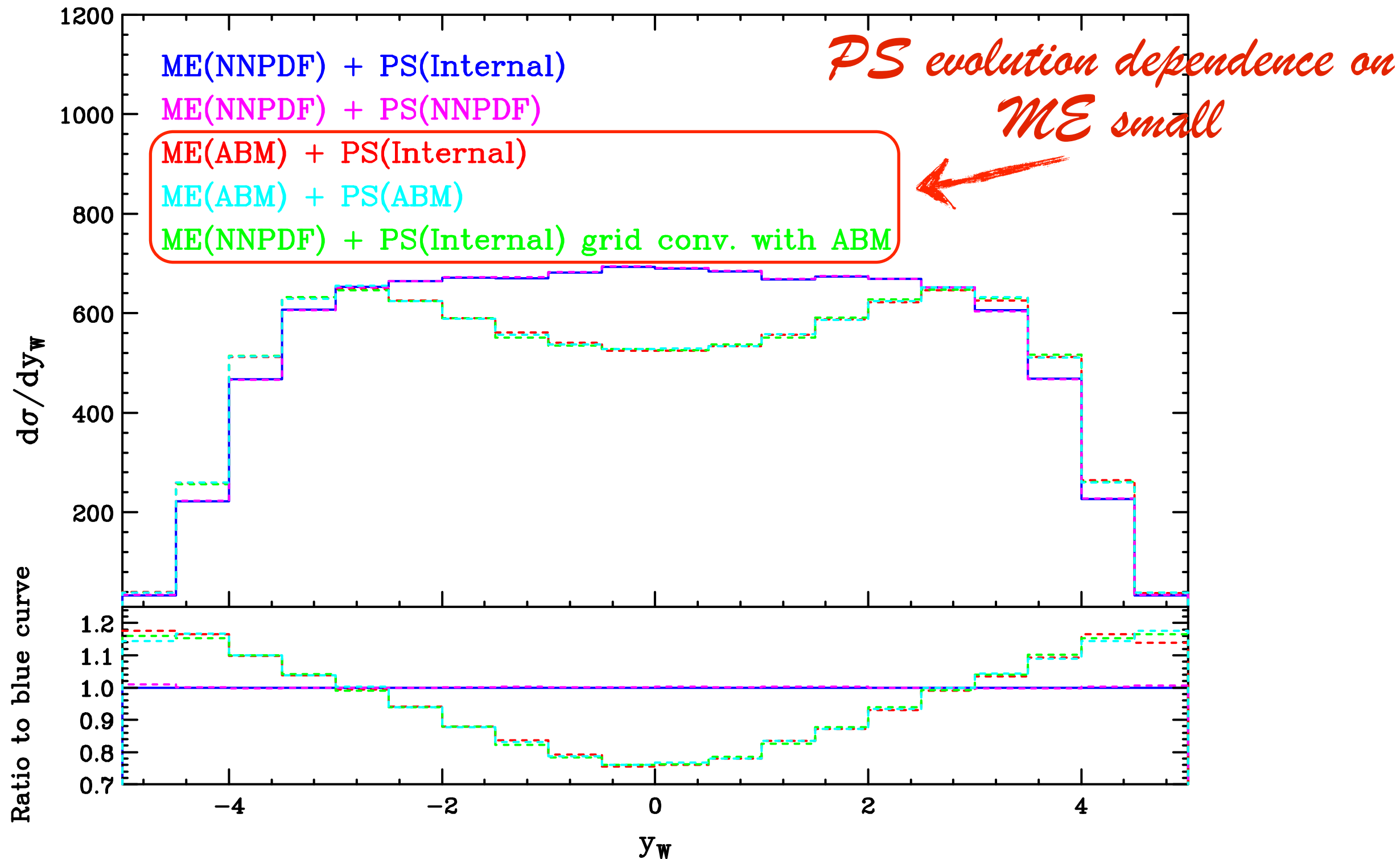
Prediction for  $e^+ \nu$  production



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