

Diffraction Studies with the RAPGAP MC Generator

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BNL

Outline

- Datasets Generated
 - ➔ x - Q^2 space for each energy configuration
- Differentiating between inclusive DIS and Diffractive events
 - ➔ Large Rapidity Gap method
- Simulations for the EIC
 - ➔ LRG method - how well does it work
 - ▶ Purity vs Efficiency
 - ➔ The importance of acceptance (detector coverage)
- Reproducing HERA plots

Datasets Generated (e+p)

- Generated 10^6 inclusive DIS and 10^6 diffractive events for the EIC energies:

➔ 2 + 100 GeV

➔ 5 + 100 GeV

➔ 10 + 100 GeV

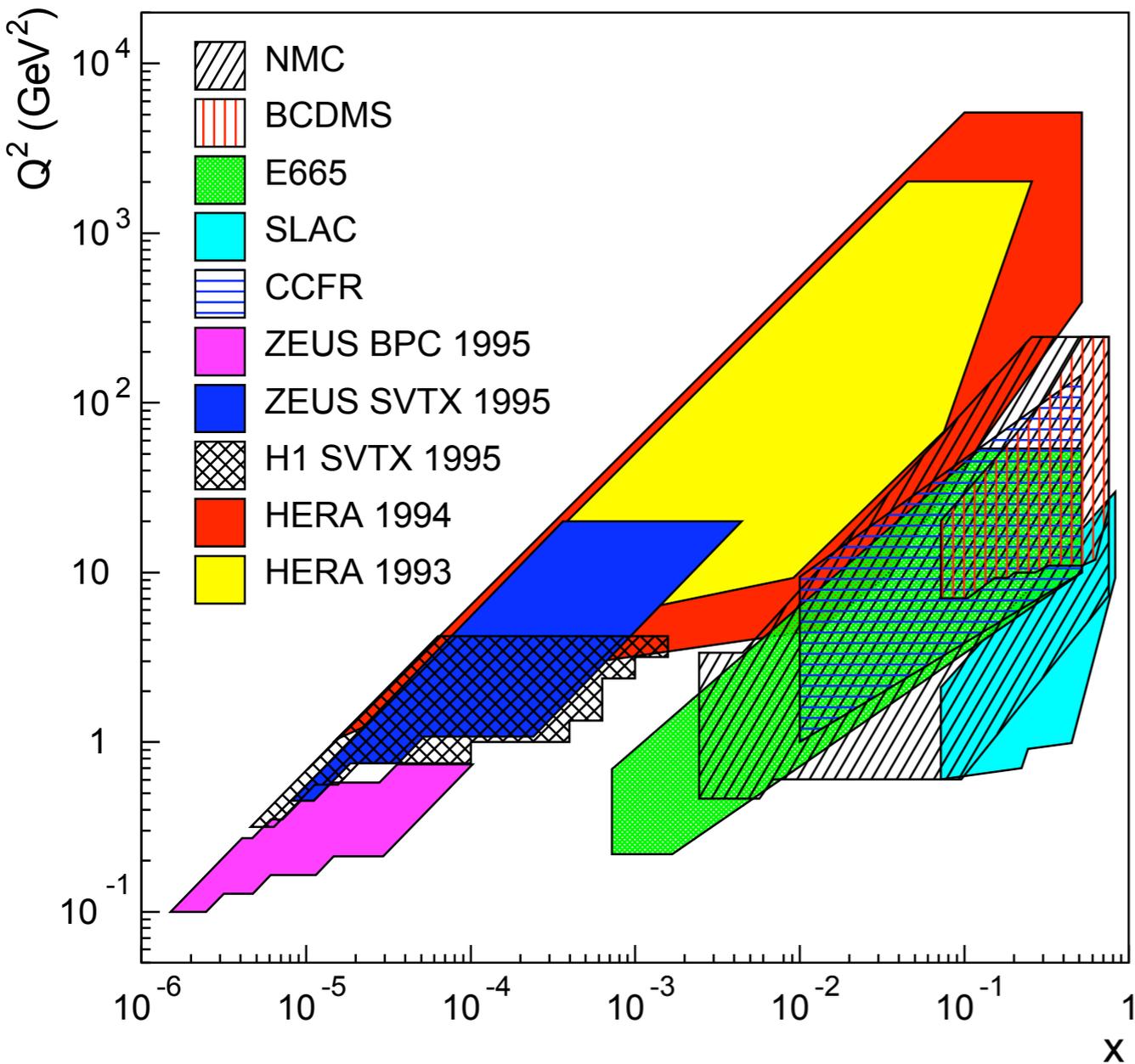
➔ 20 + 100 GeV

➔ 30 + 100 GeV

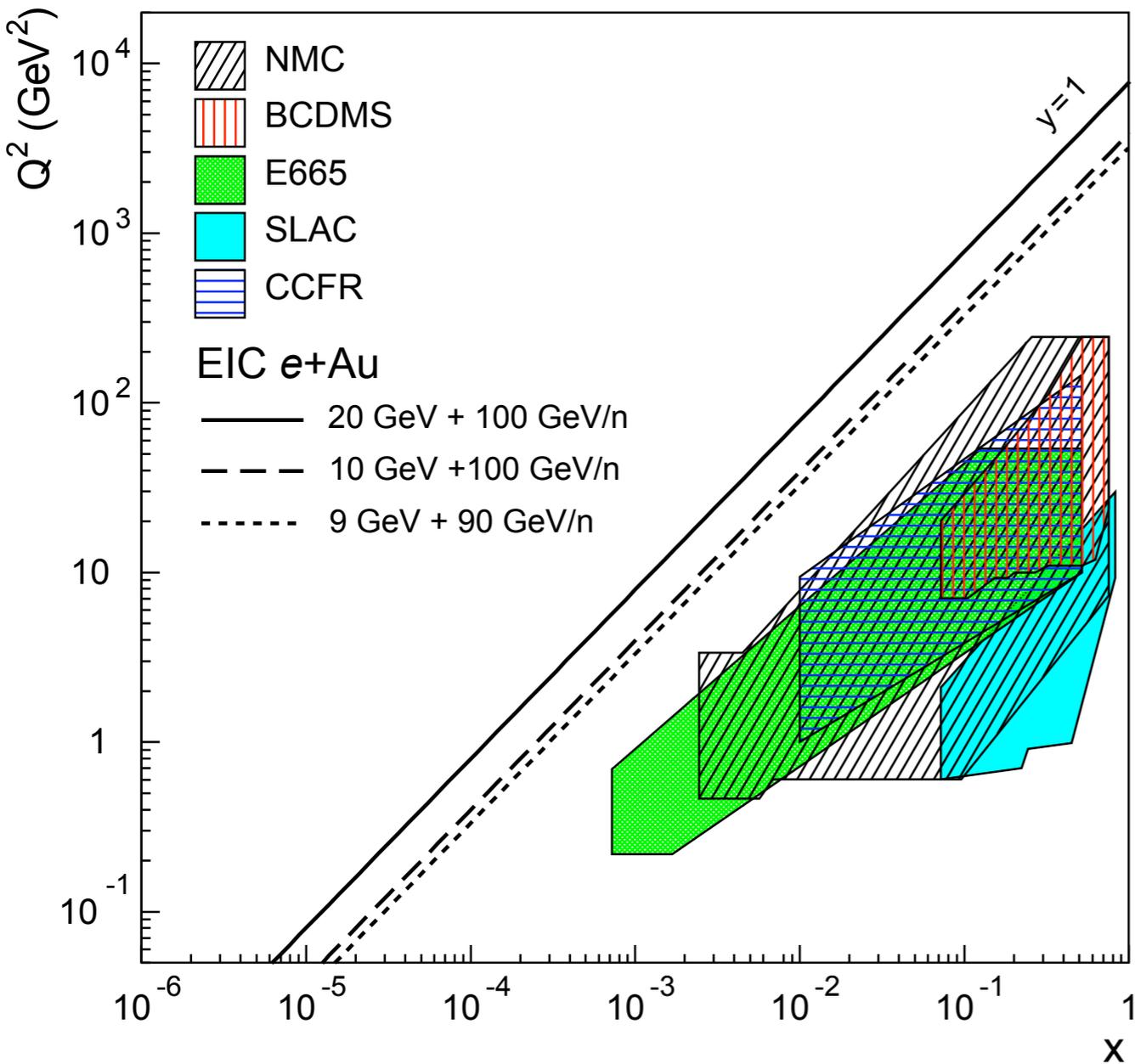
- For cross-reference with HERA:

➔ 30 + 820 GeV

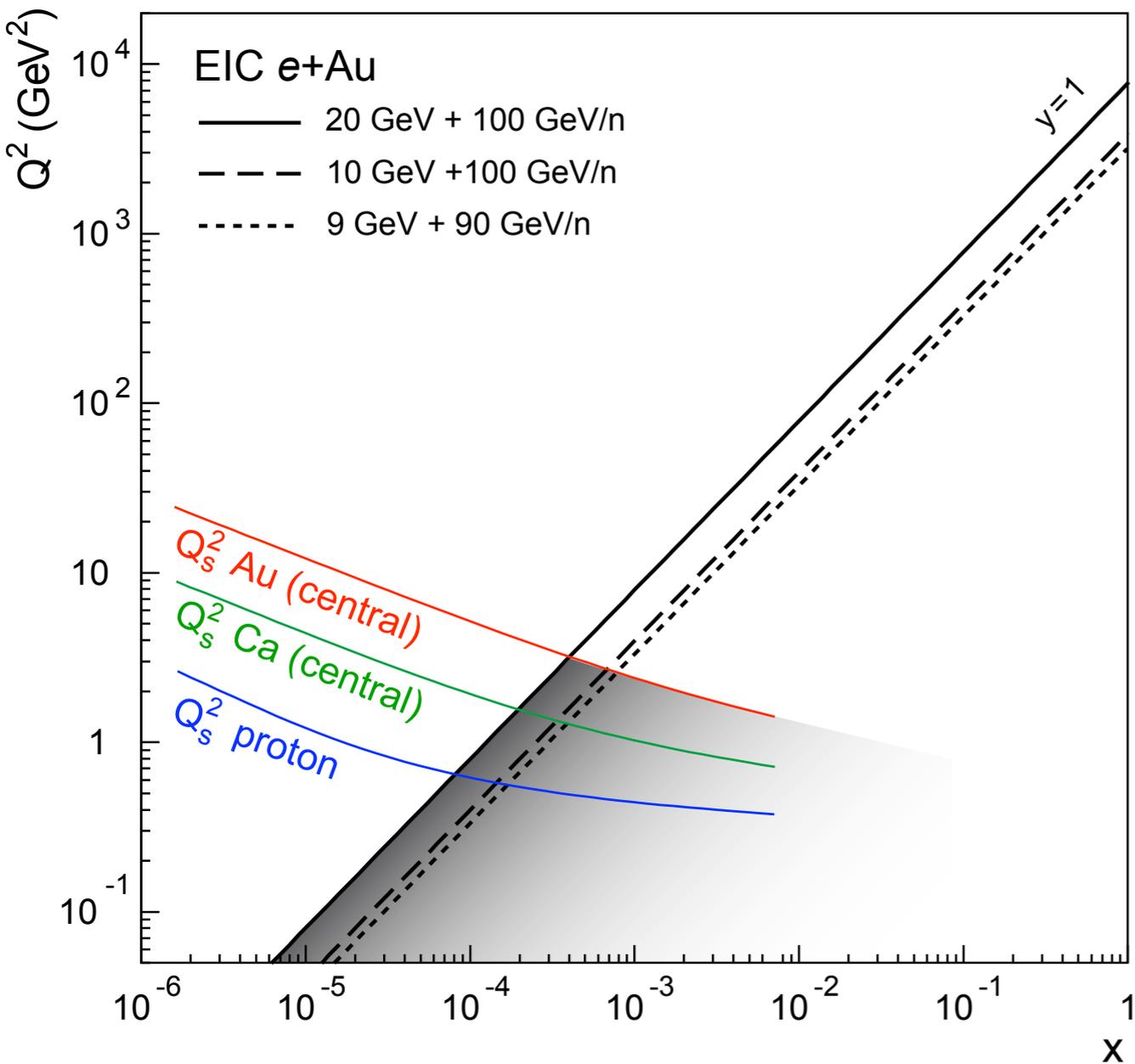
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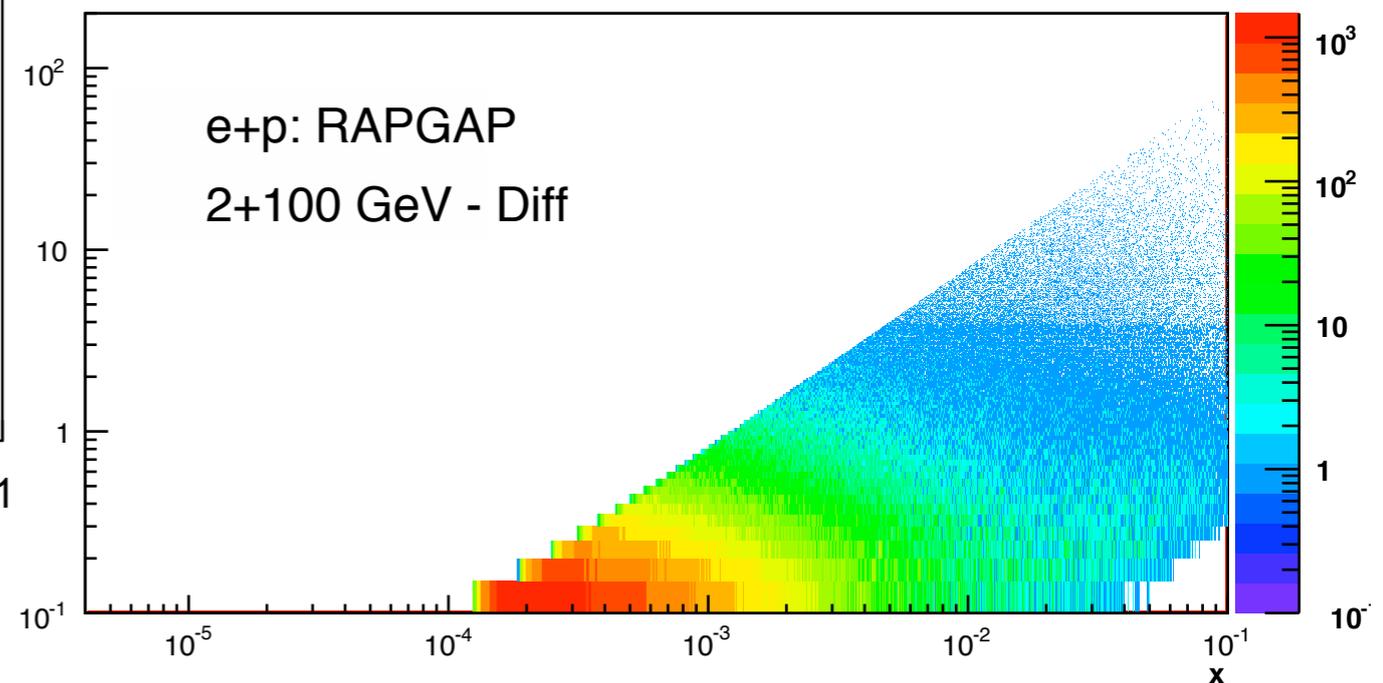
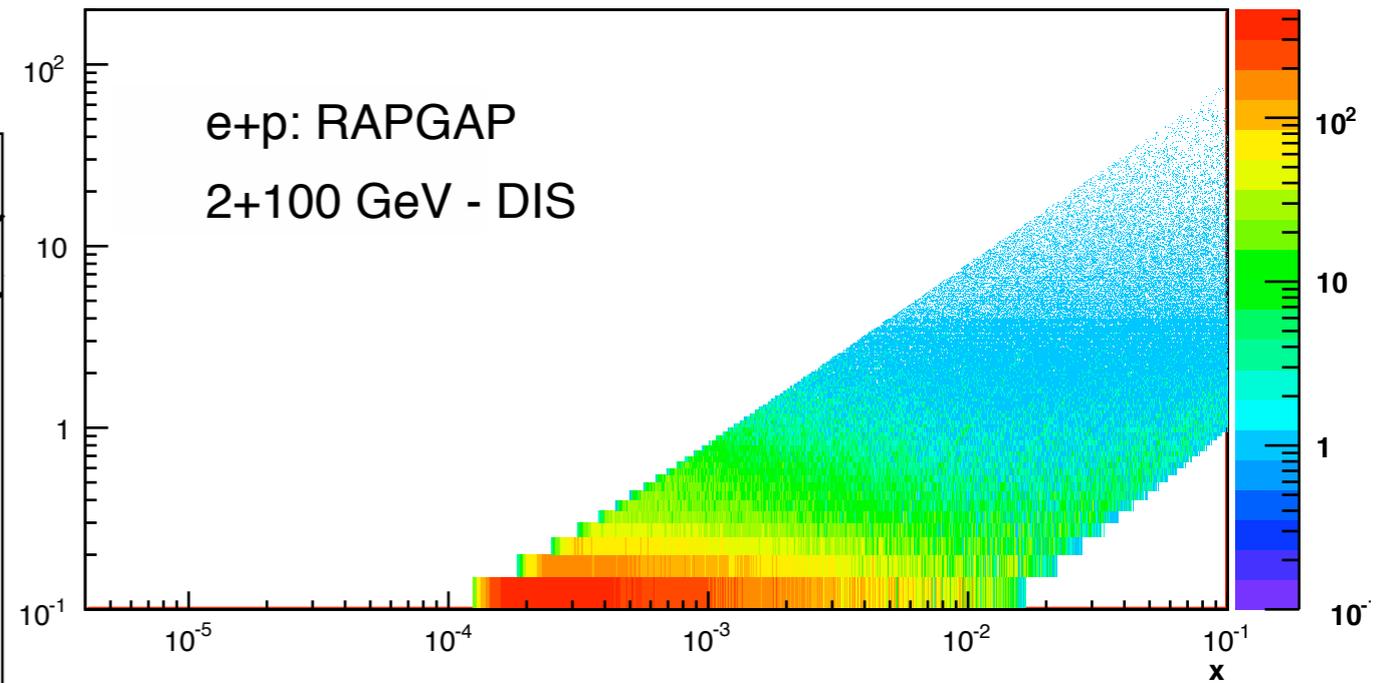
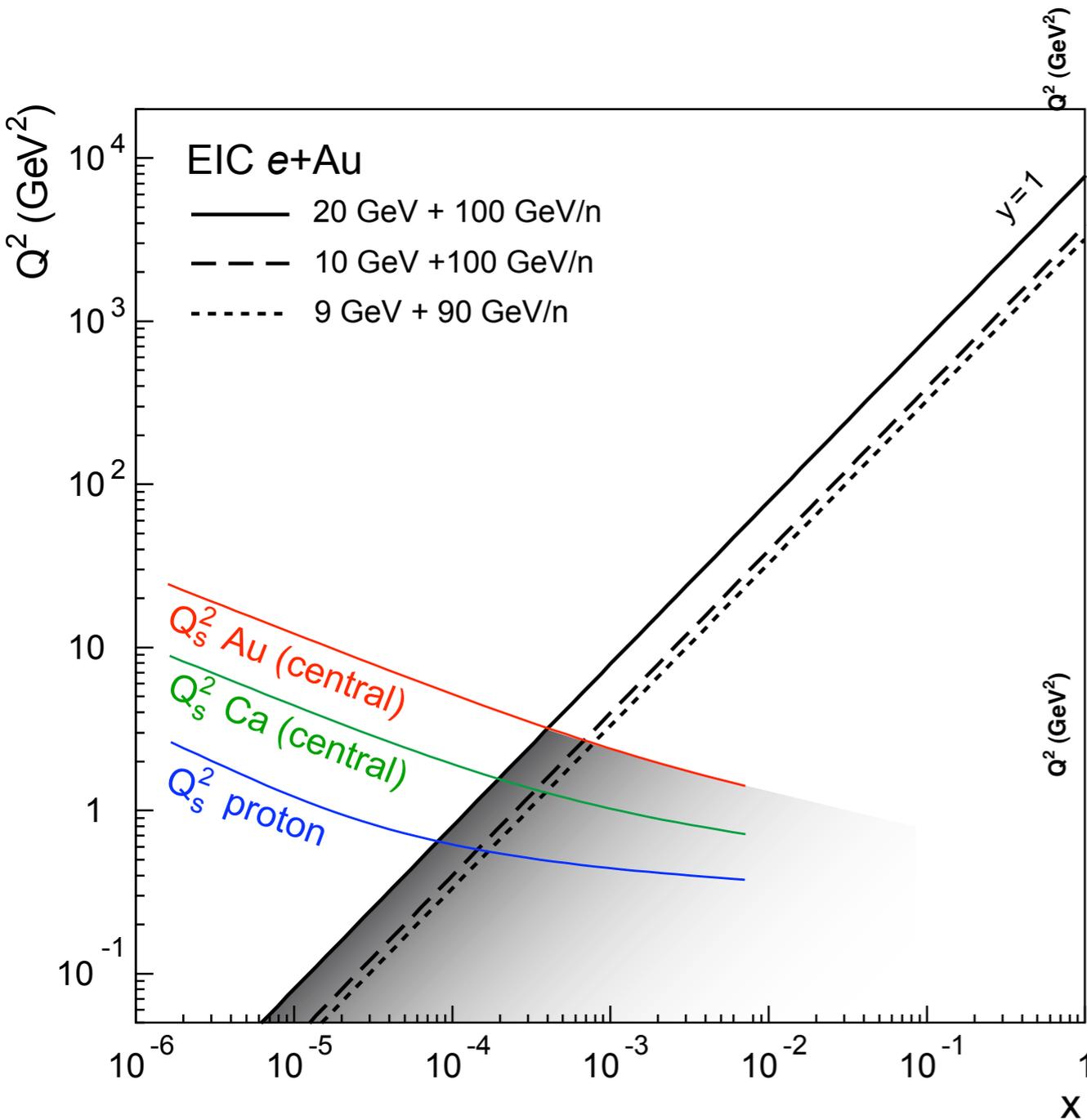
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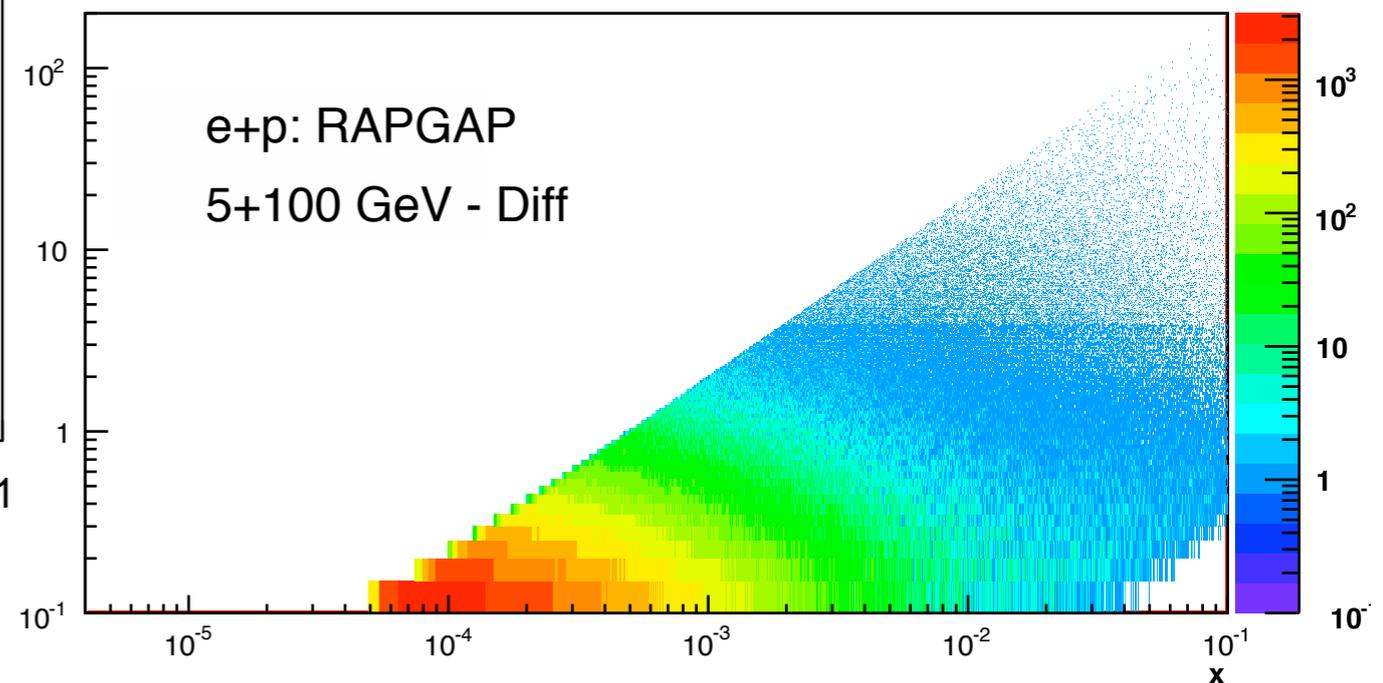
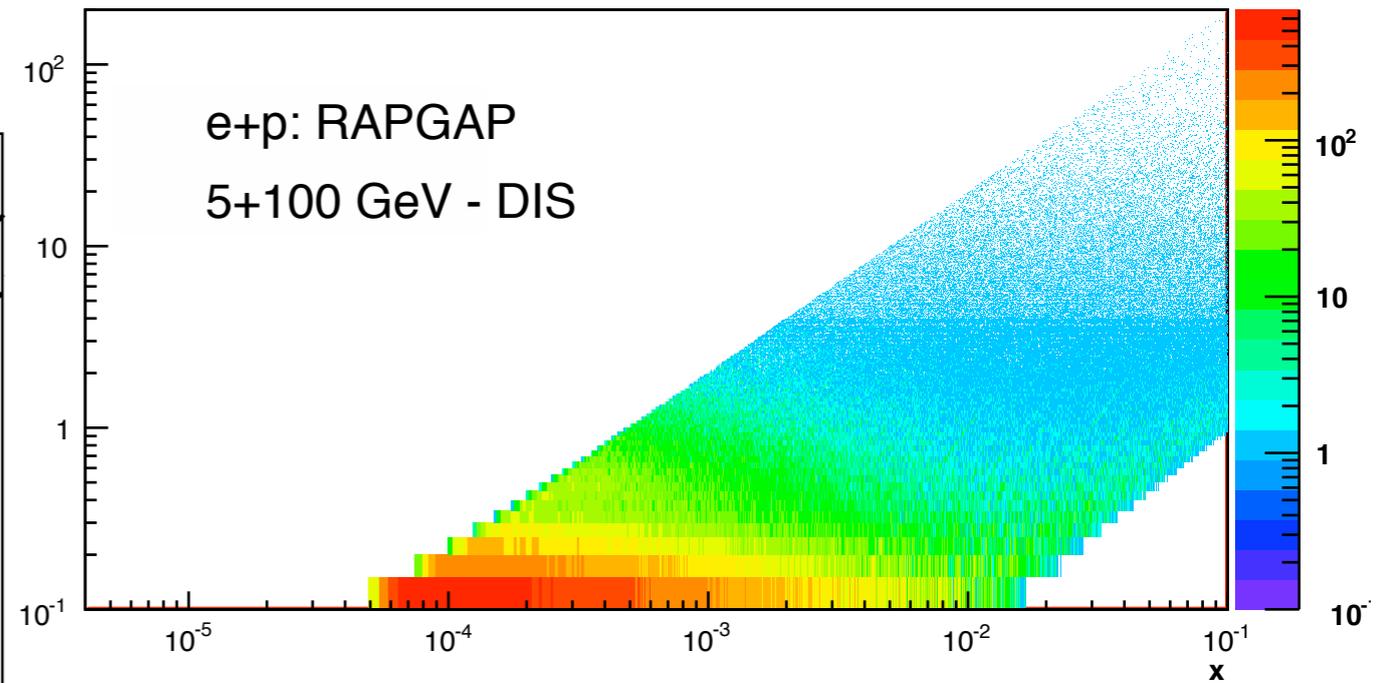
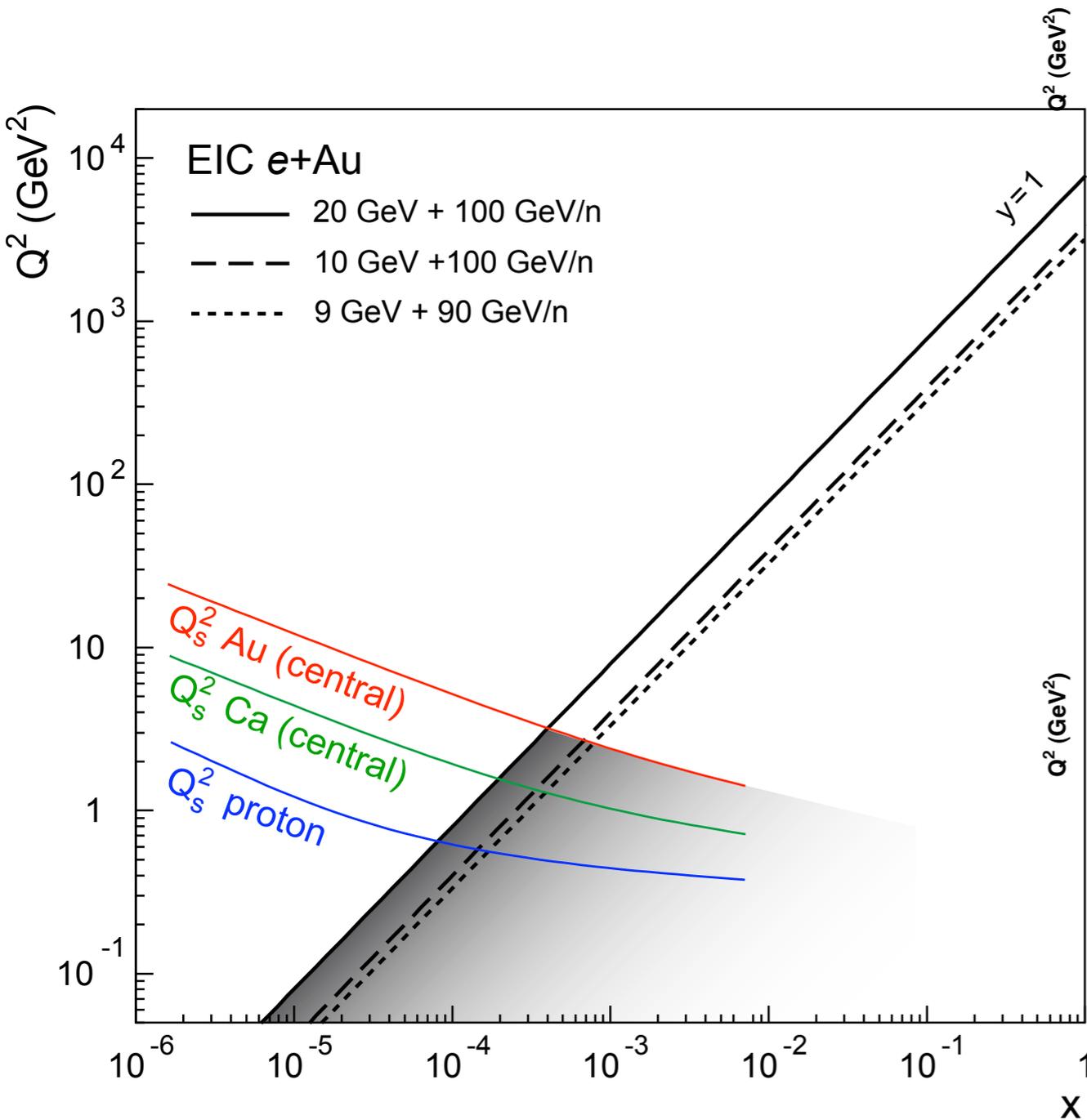
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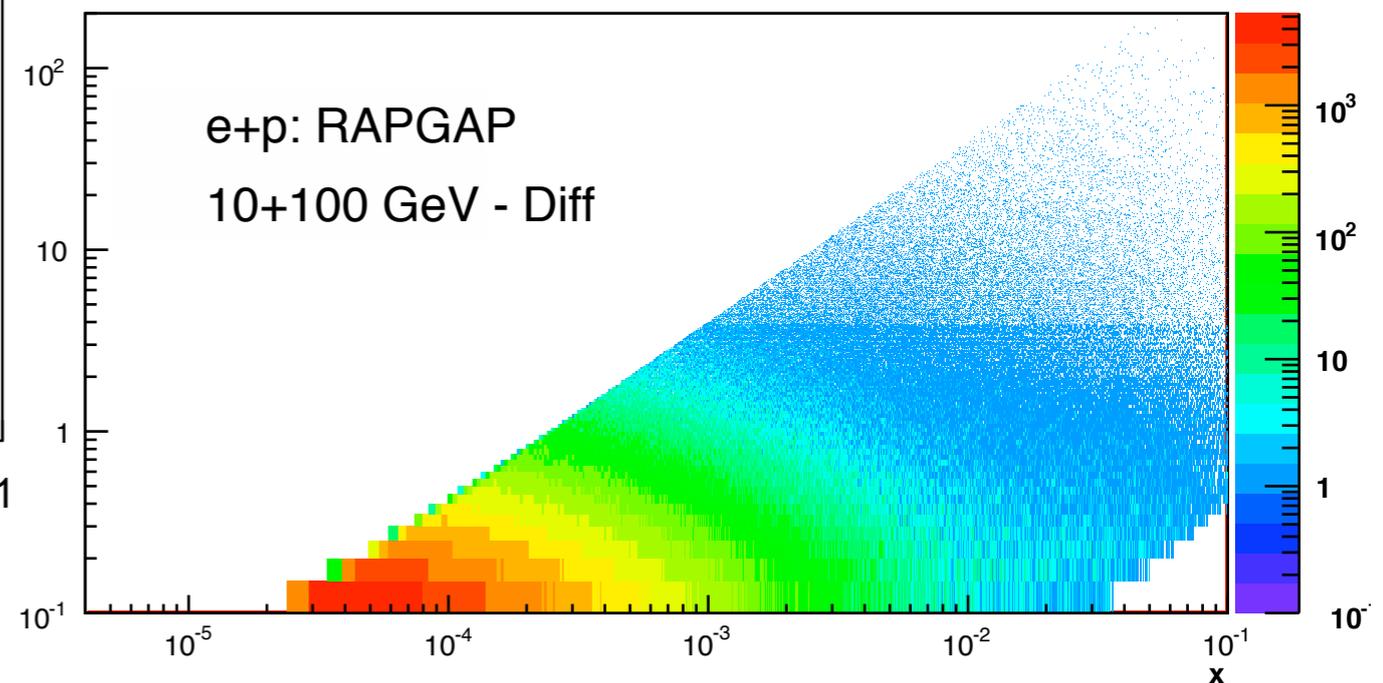
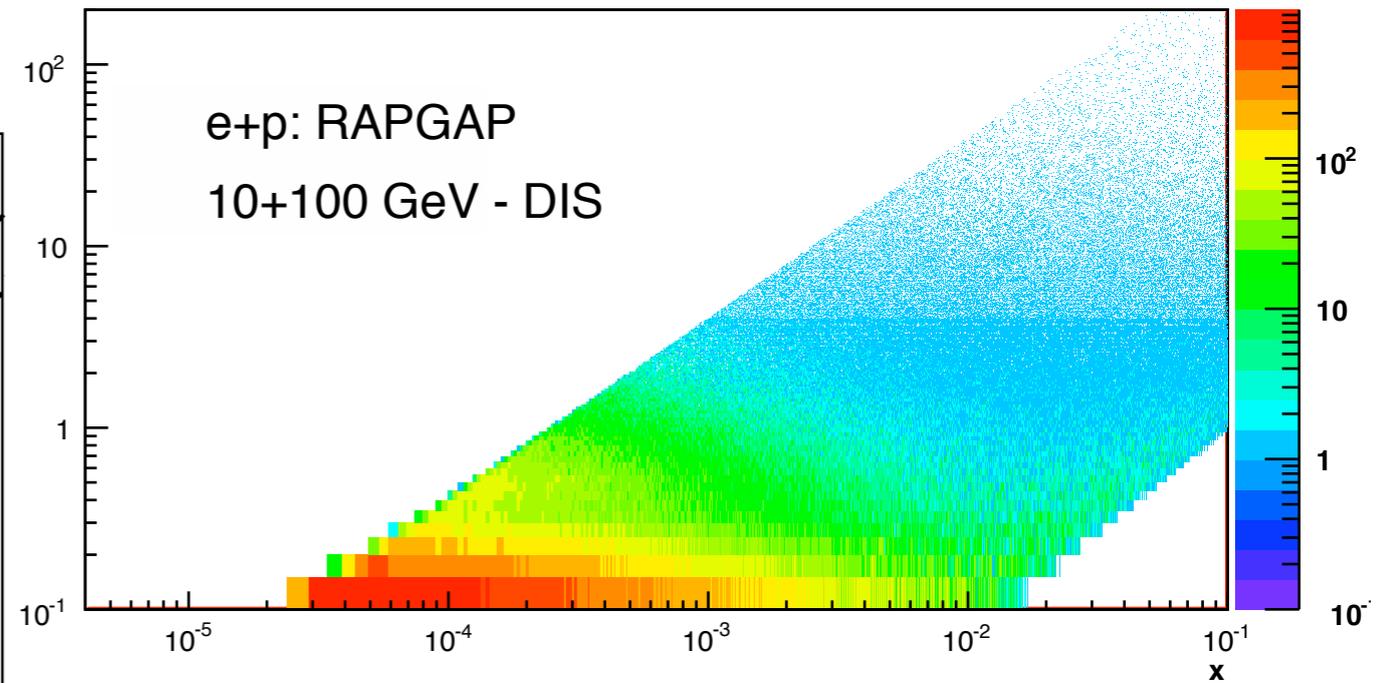
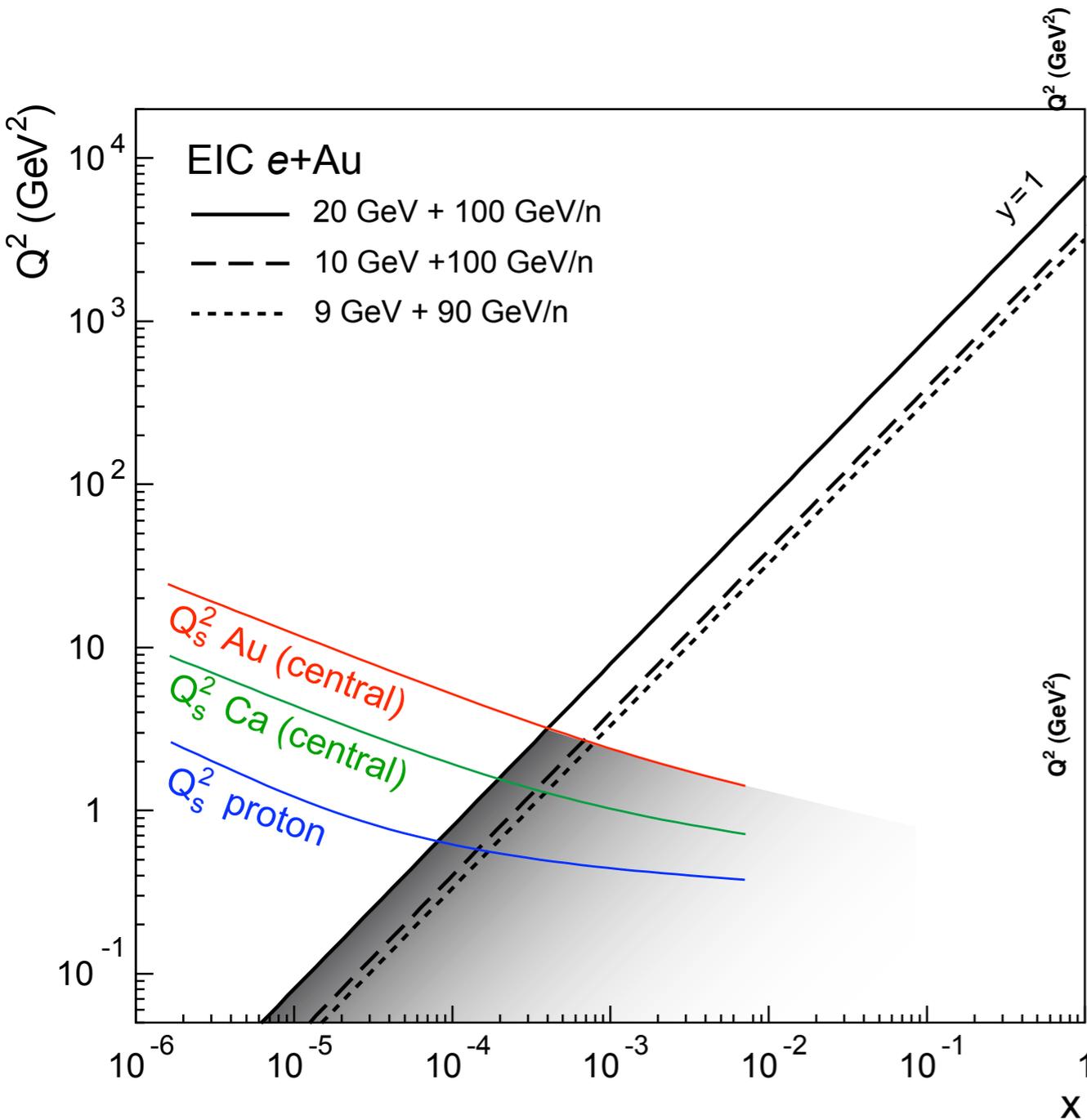
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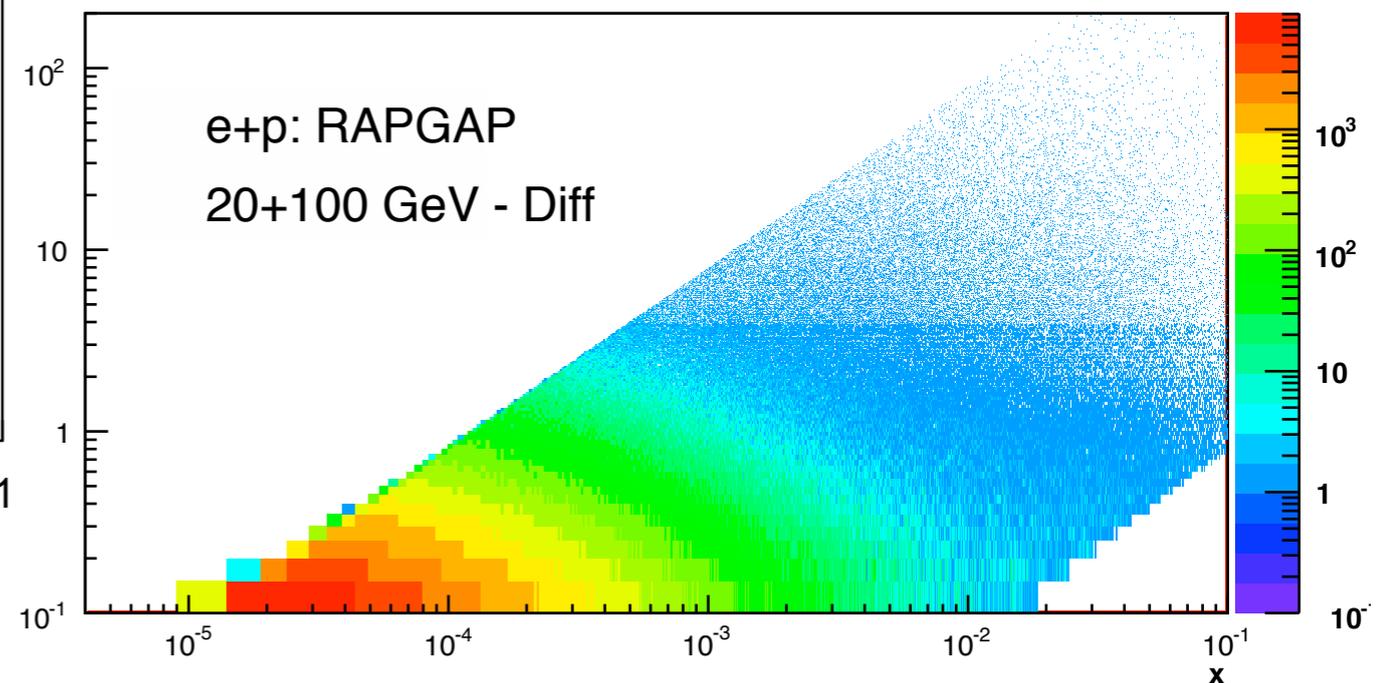
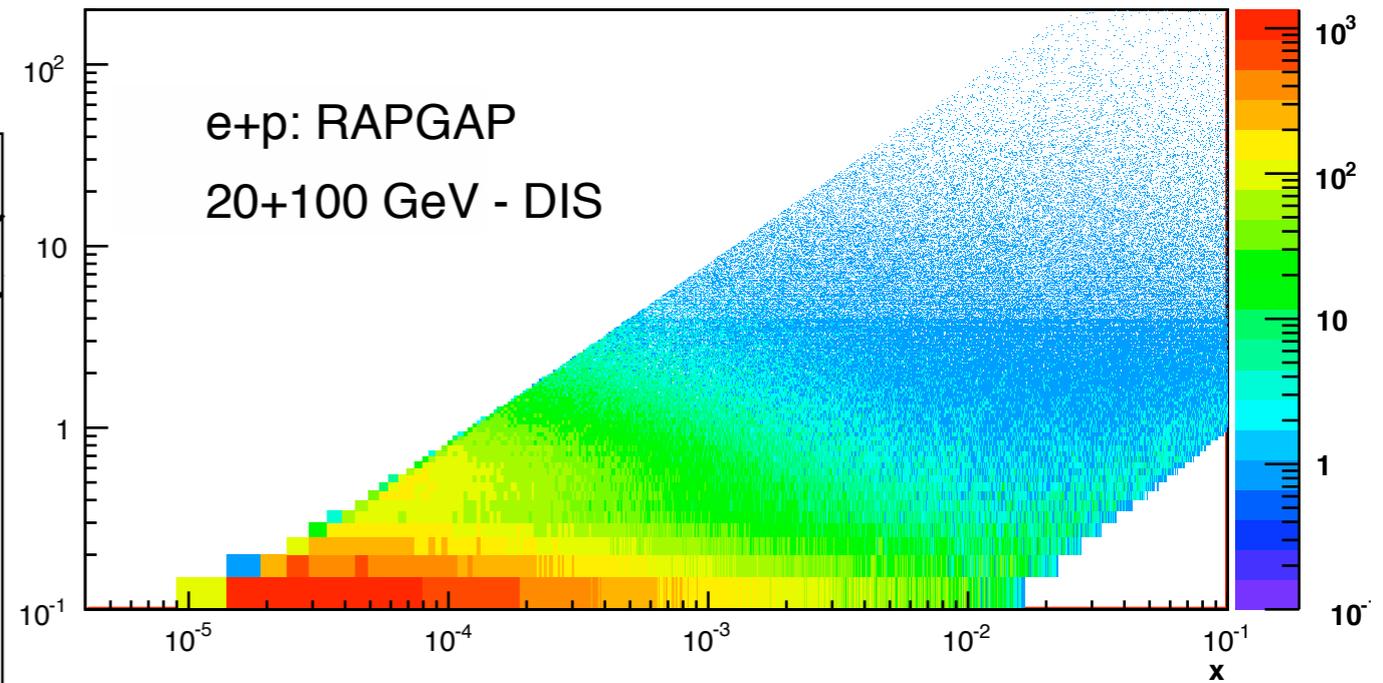
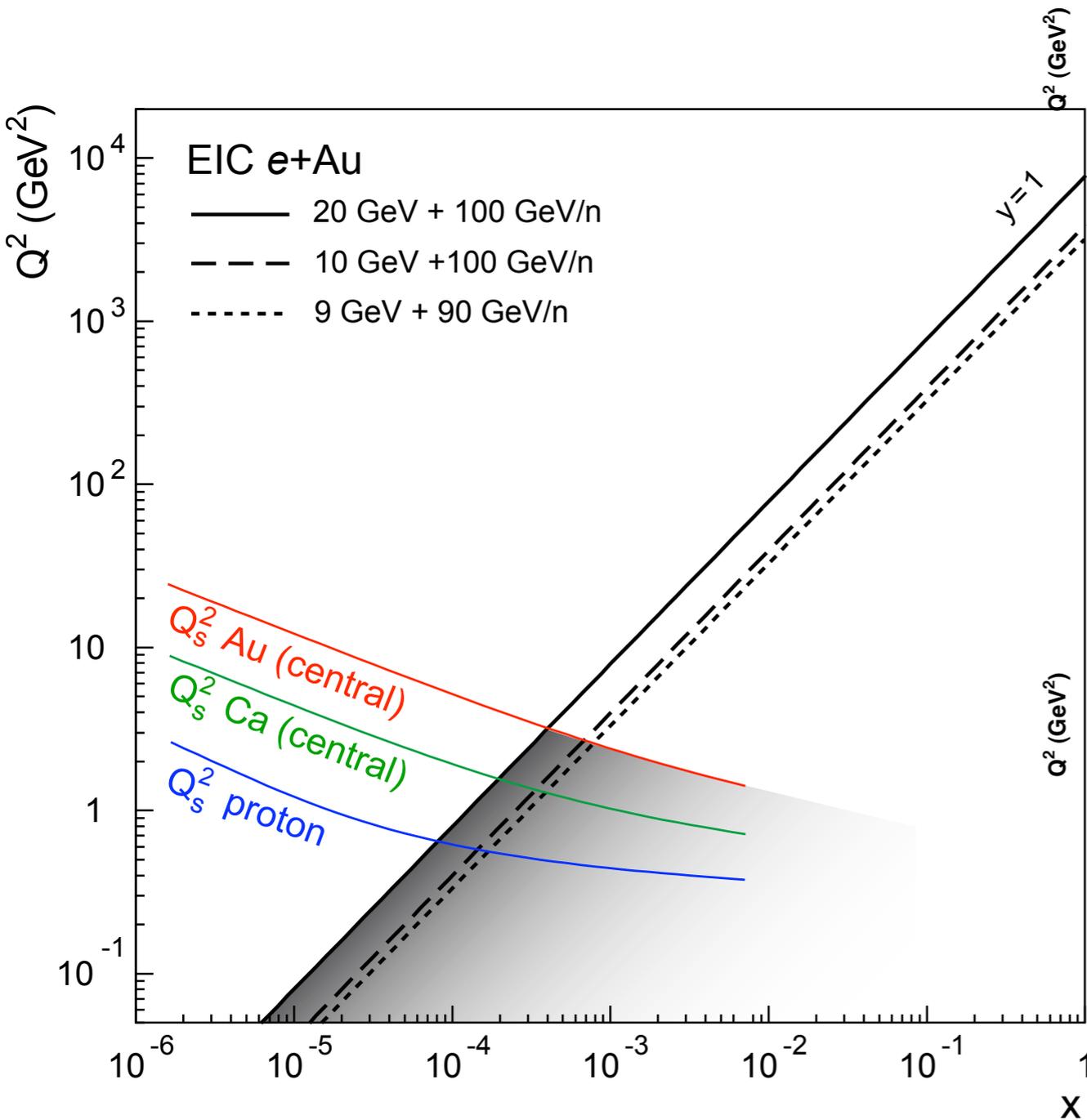
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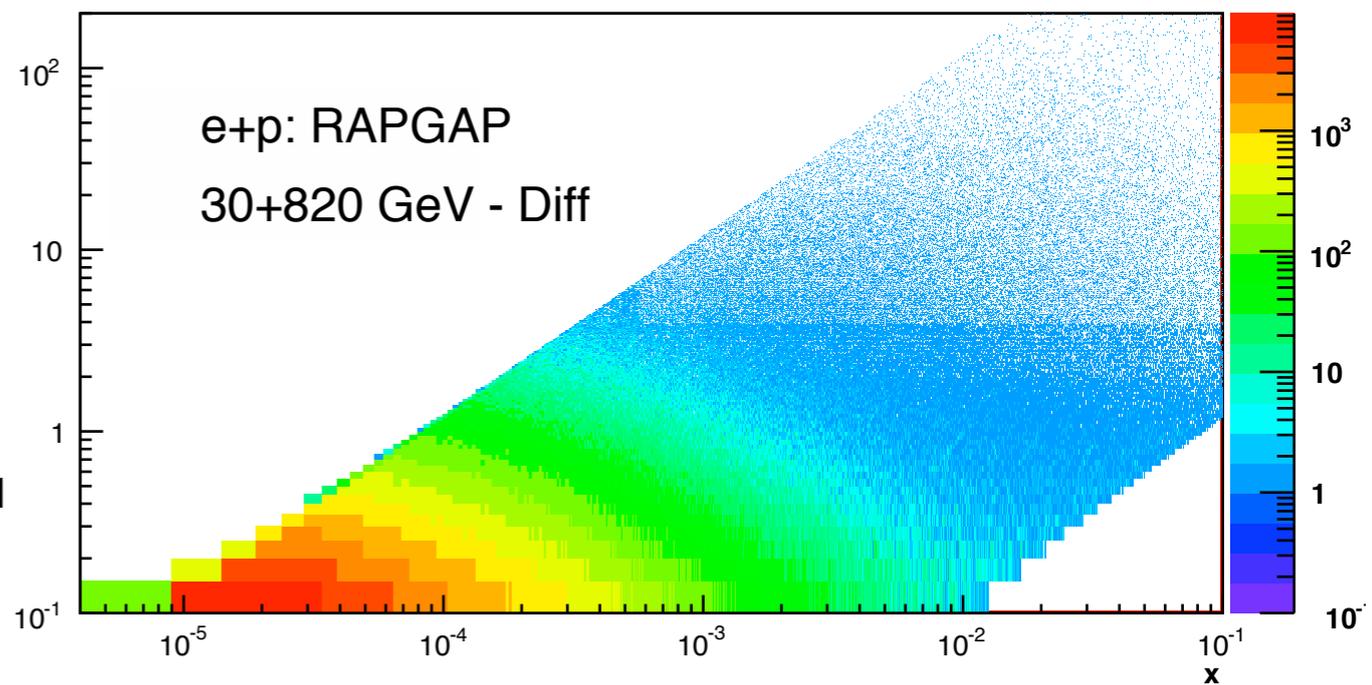
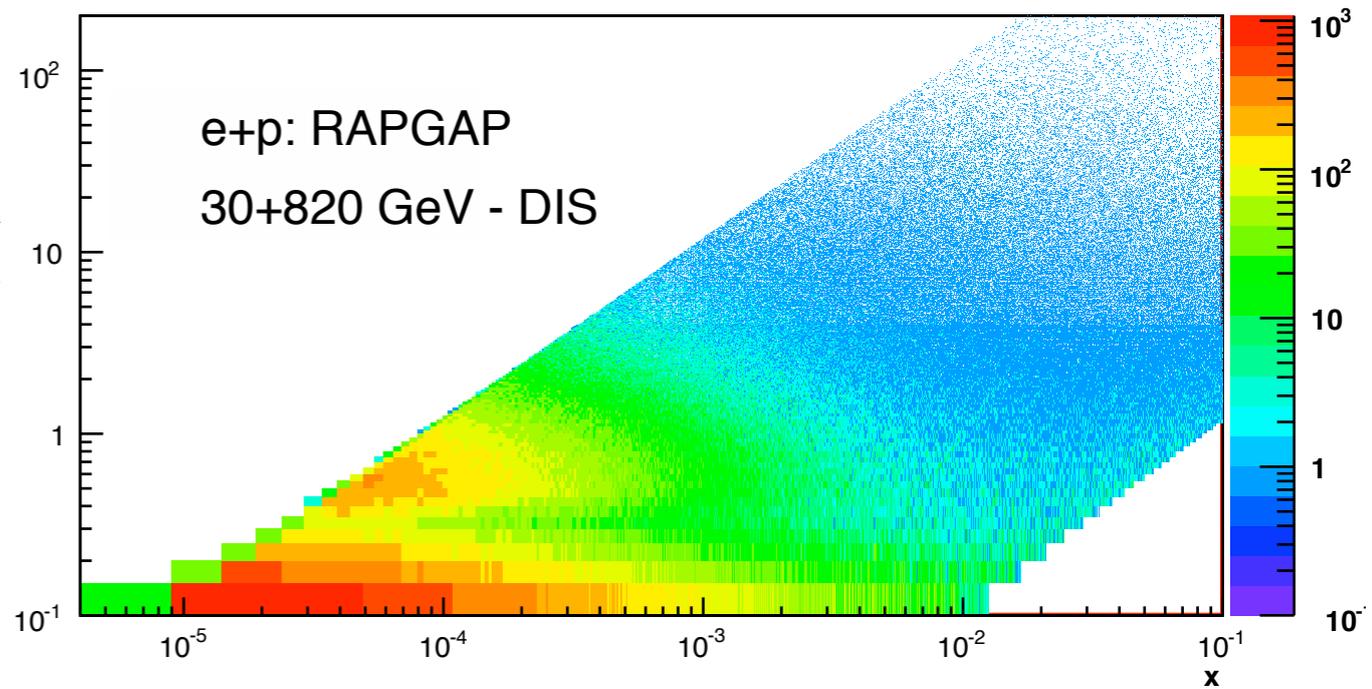
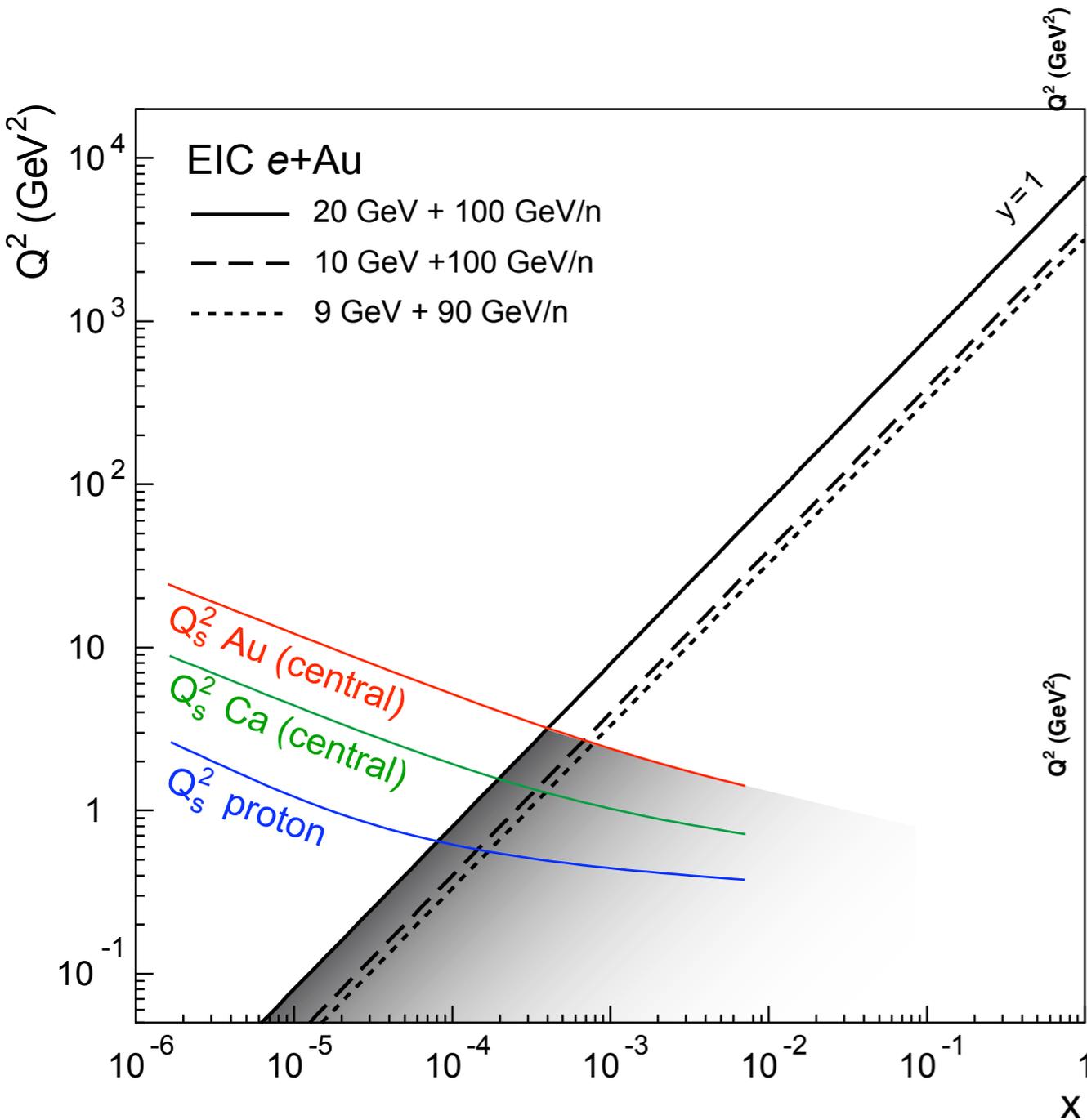
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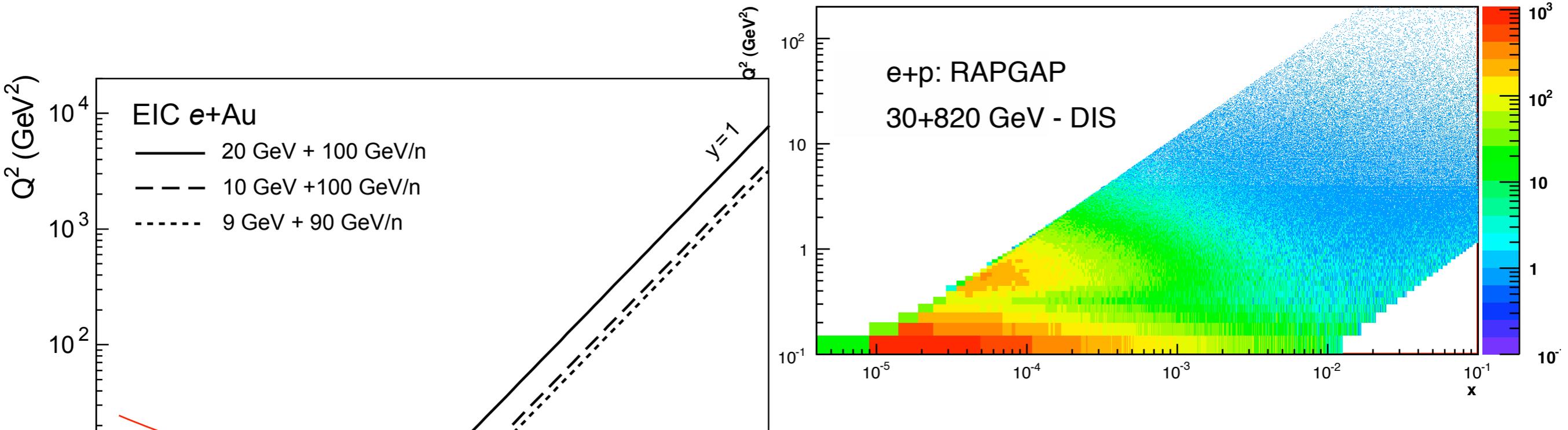
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Textfiles (HEP Event format) and **ROOT TTrees** exist on the eic /afs/ space at BNL:

[/afs/rhic.bnl.gov/eic/DATA/MCGenerators/RAPGAP](https://afslab.bnl.gov/eic/DATA/MCGenerators/RAPGAP)

If you want access and don't currently have it, let me know !!

Differentiating between DIS and Diff

- In order to be able to extract the gluon density - we need to be able to differentiate between DIS and Diffractive events.
- Large Rapidity Gap (LRG) method
 - ➔ requires an interval in rapidity with no measured particles
 - ▶ No information on t
 - ▶ sensitive to hadronization models
 - ▶ lots of statistics

Differentiating between DIS and Diff

ZEUS:

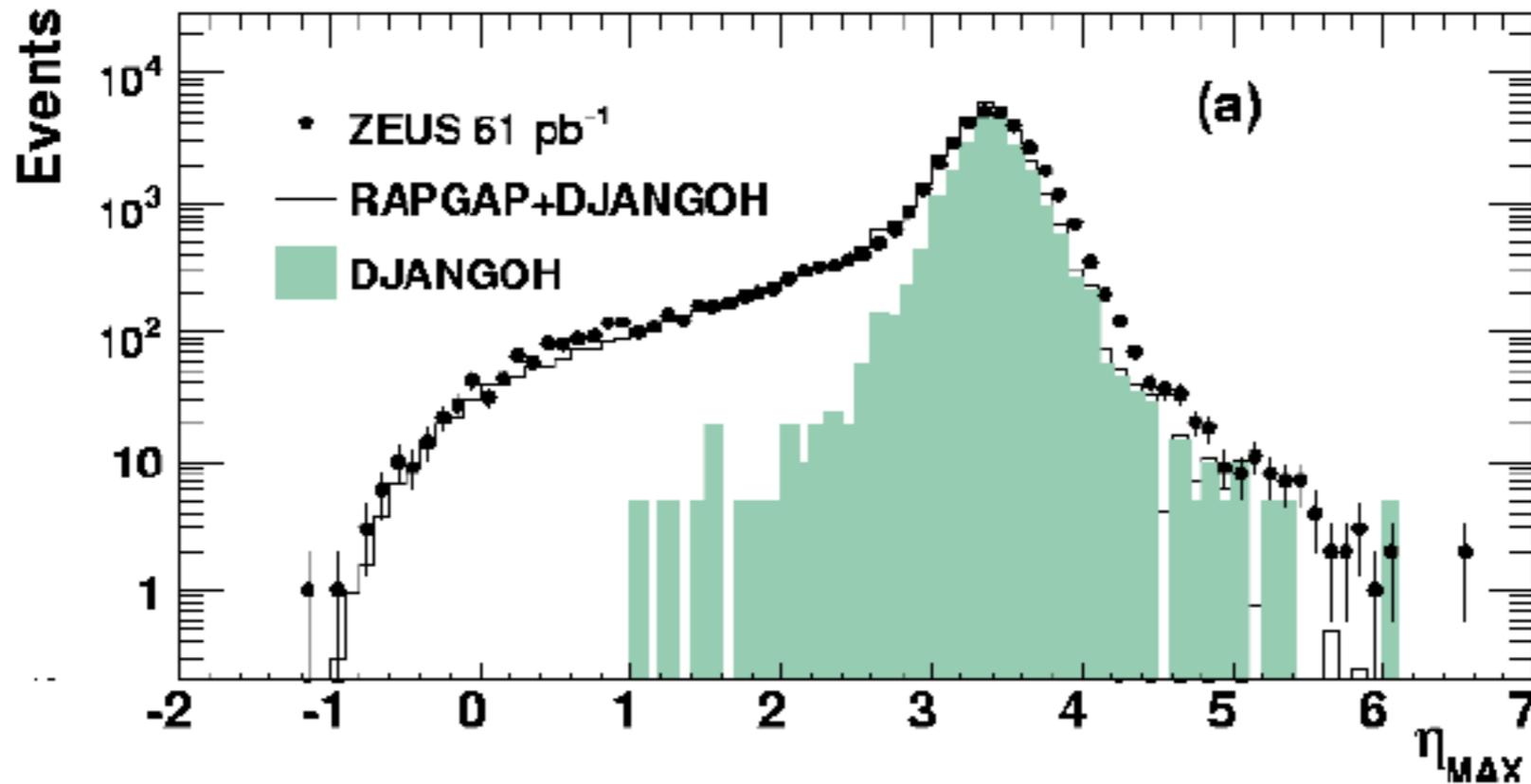


Figure 2.25: The η_{MAX} distribution as measured by the ZEUS collaboration. The points with the error bars show the data. The Monte Carlo predictions for the diffractive and non-diffractive contributions are shown as histograms. The diffractive signal gives the tail at low η_{MAX} (from [78]).

Differentiating between DLS and Diff

ZEUS:

Diffraction
signal

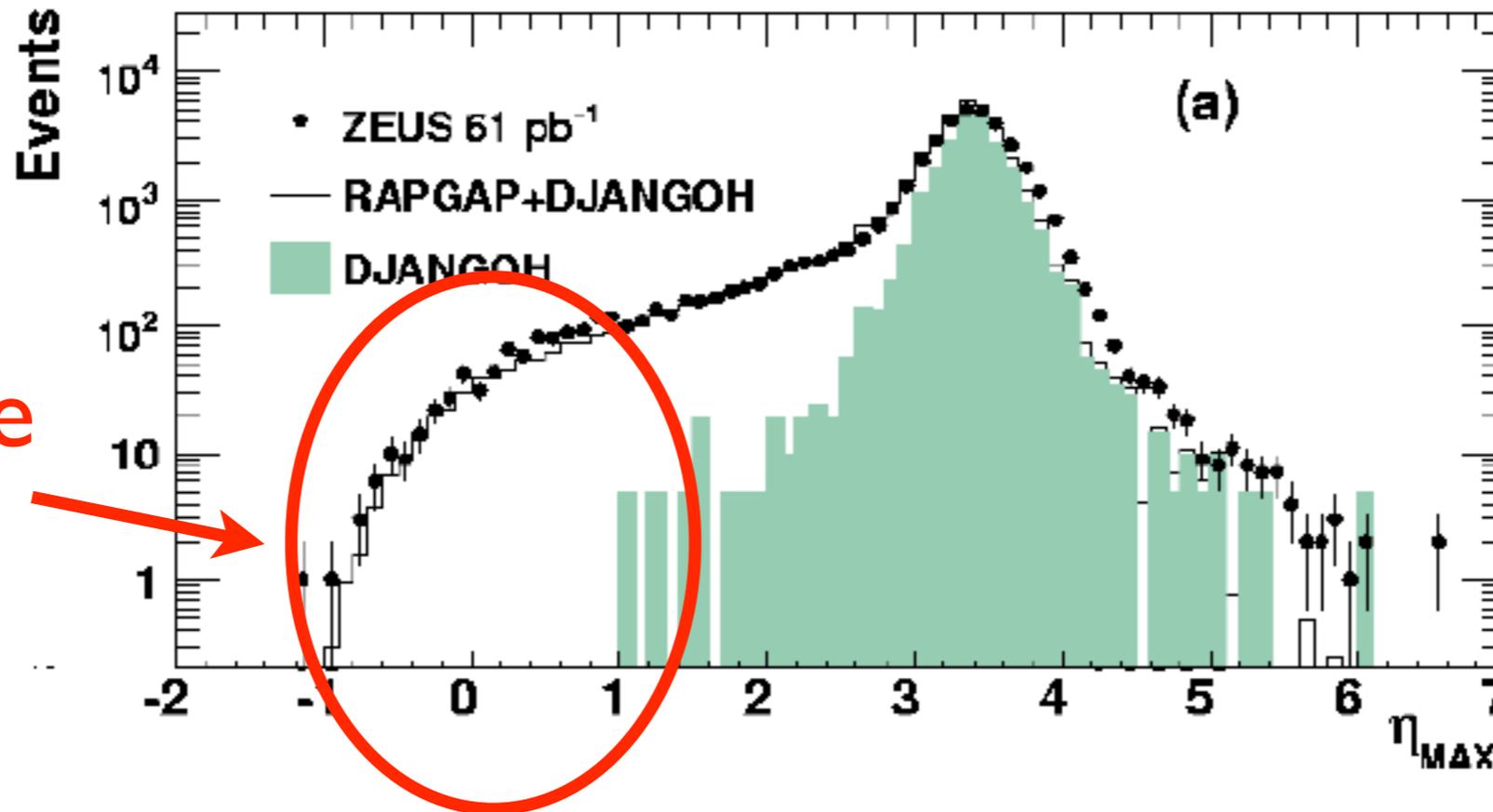


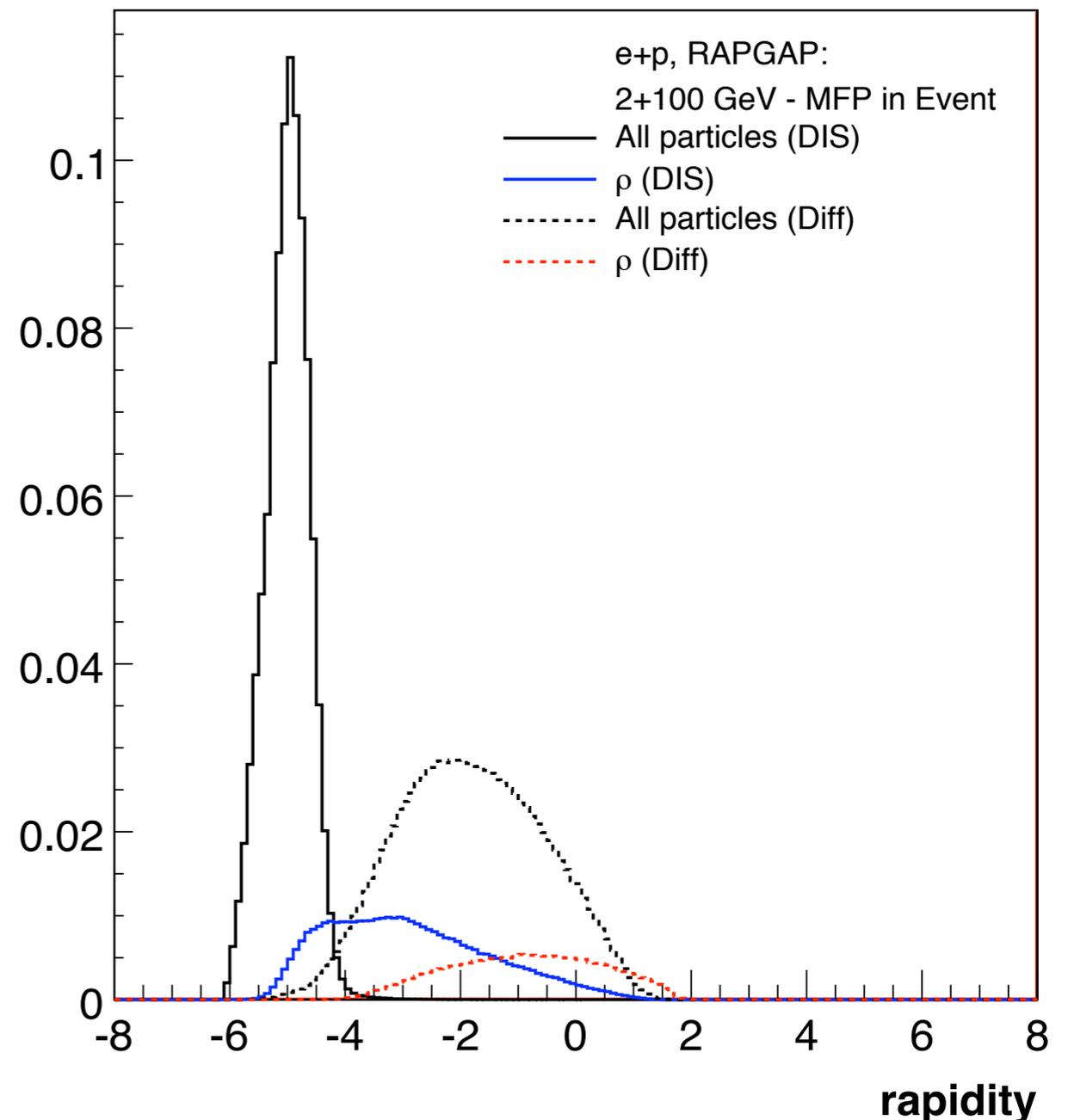
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Most Forward Particle (MFP) in Event

- So, in order to differentiate between the two methods, need to be able to distinguish events based on the MFP

DIS: MFP distribution doesn't change with energy, ρ gets slightly wider

Diff: MFP and ρ distributions widen with energy

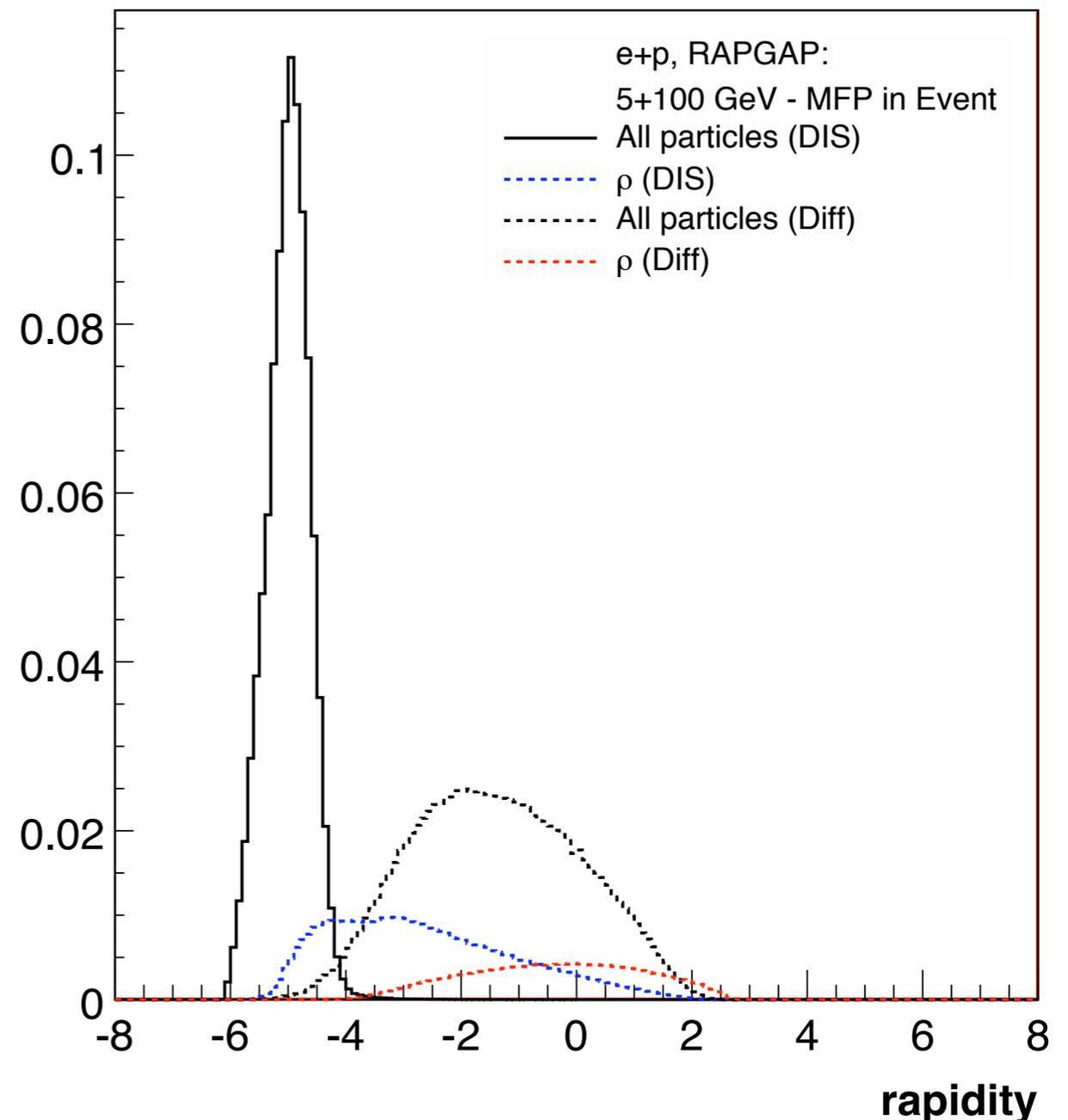


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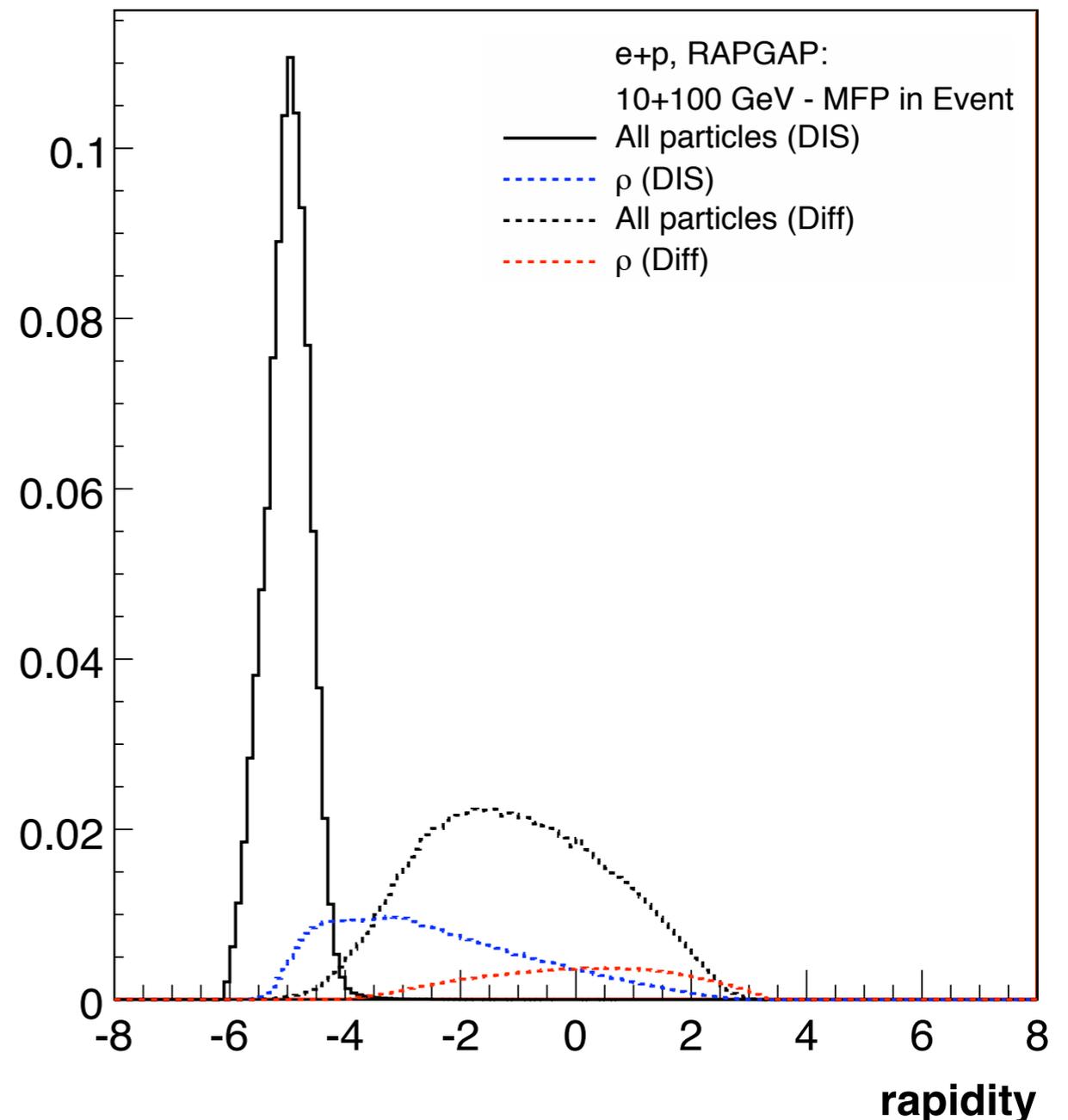


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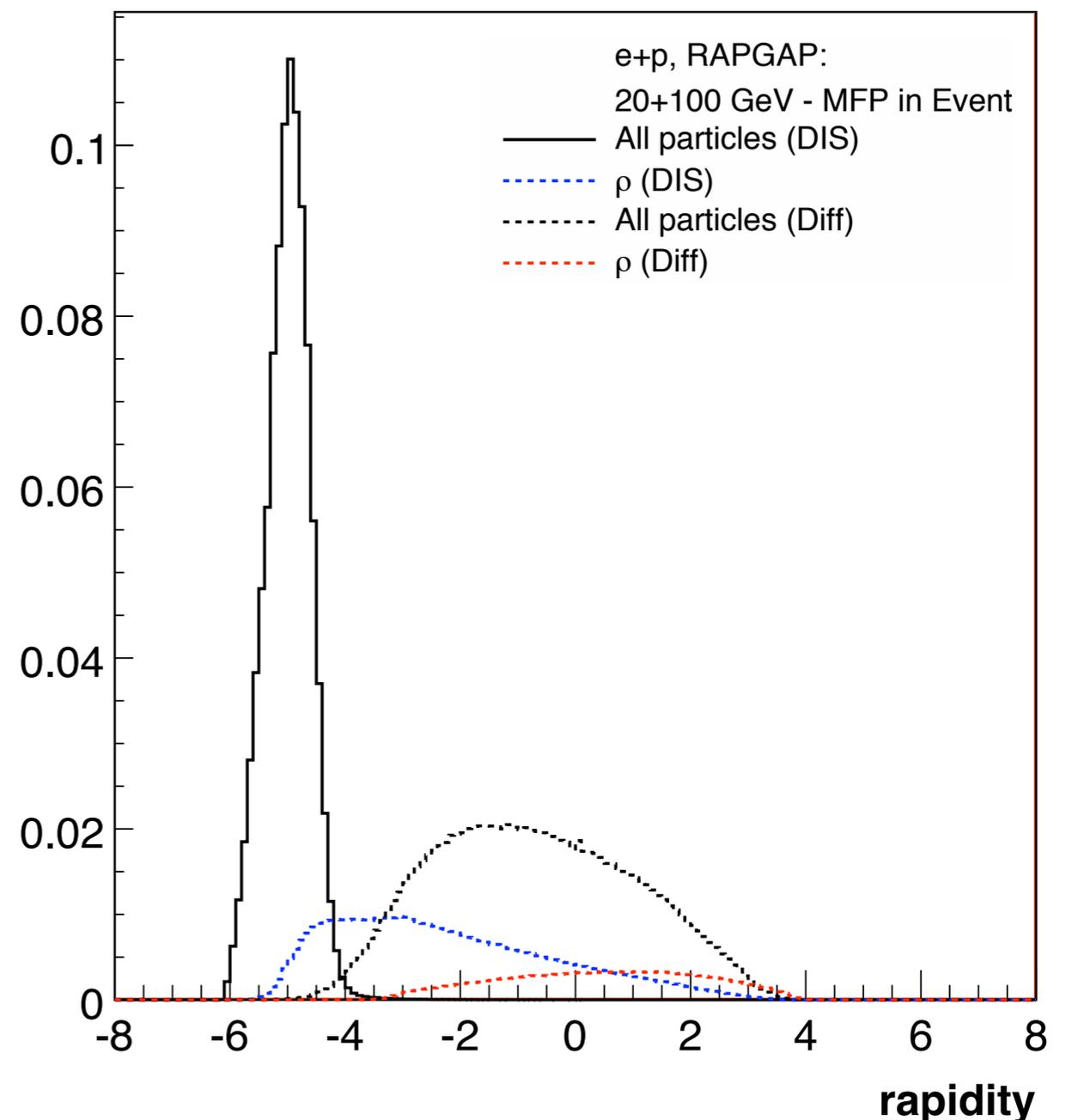


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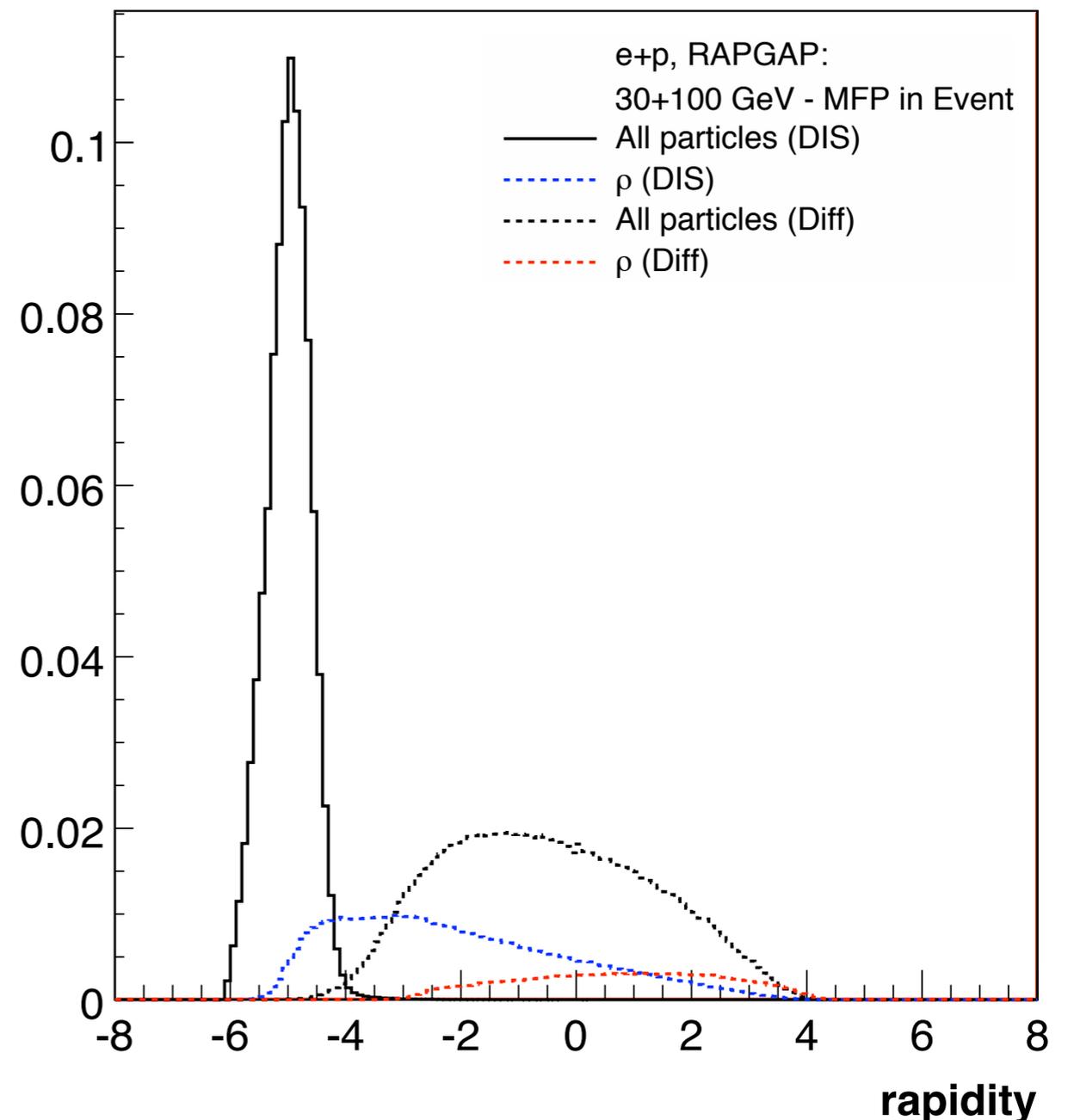


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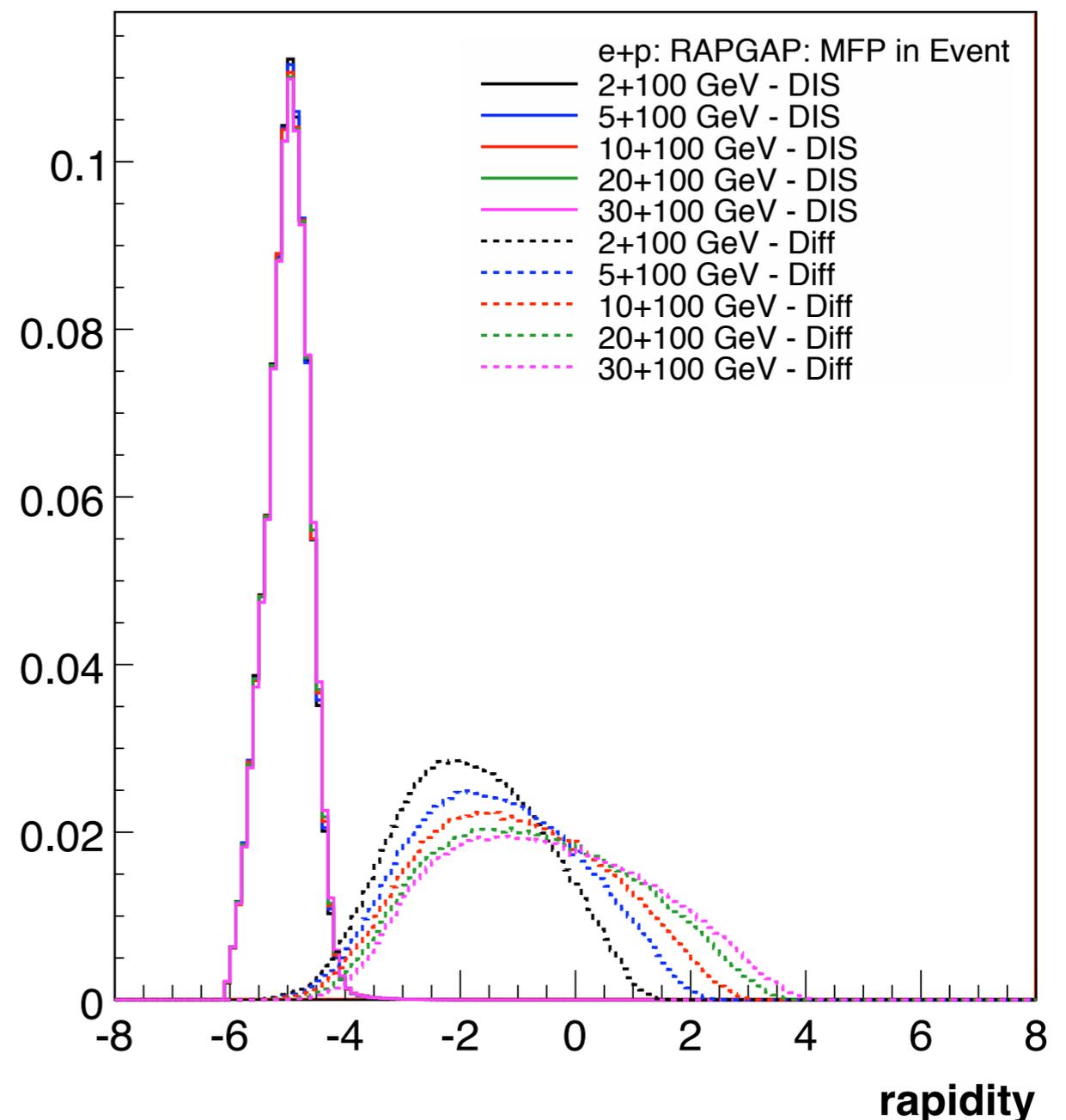


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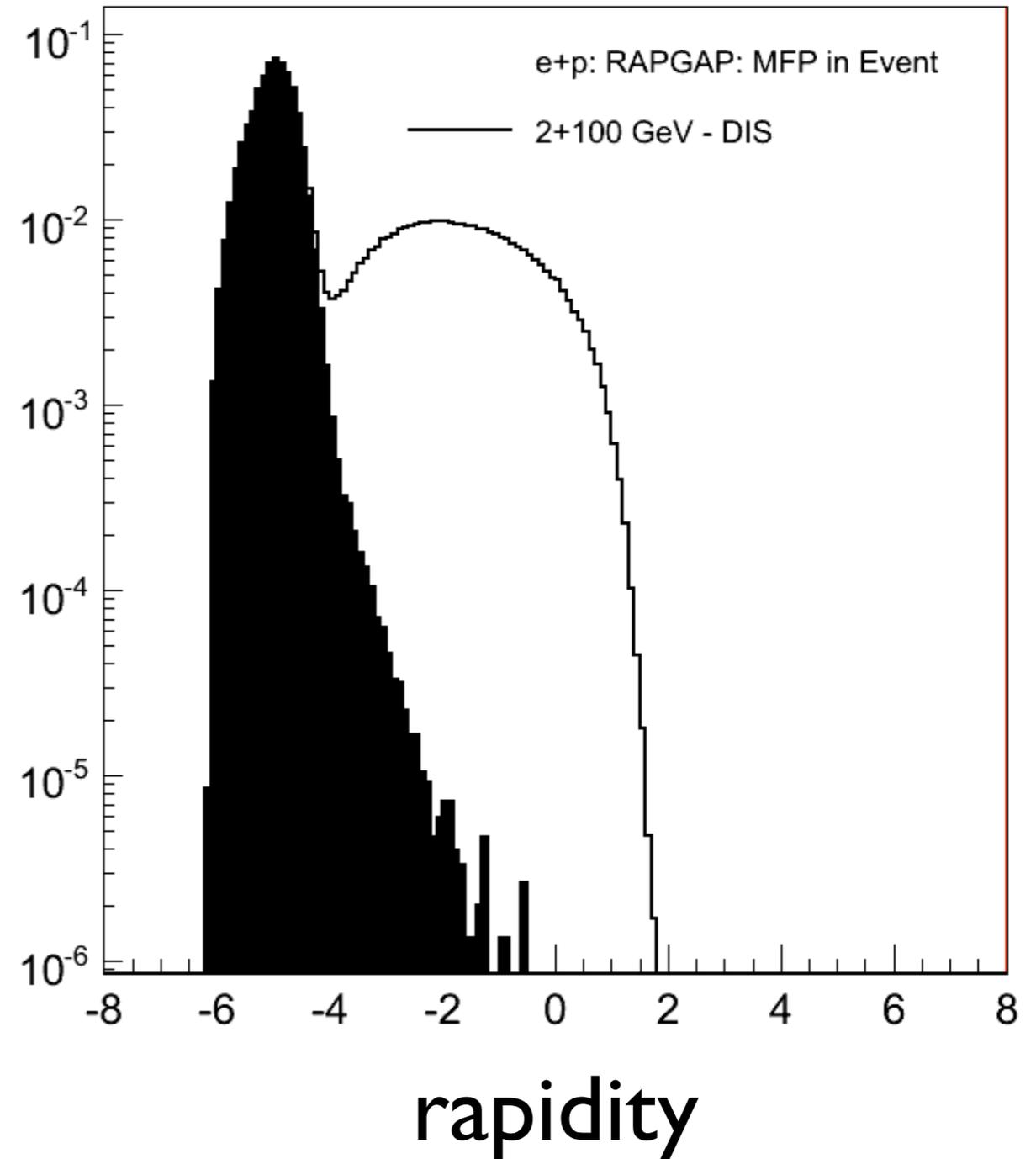
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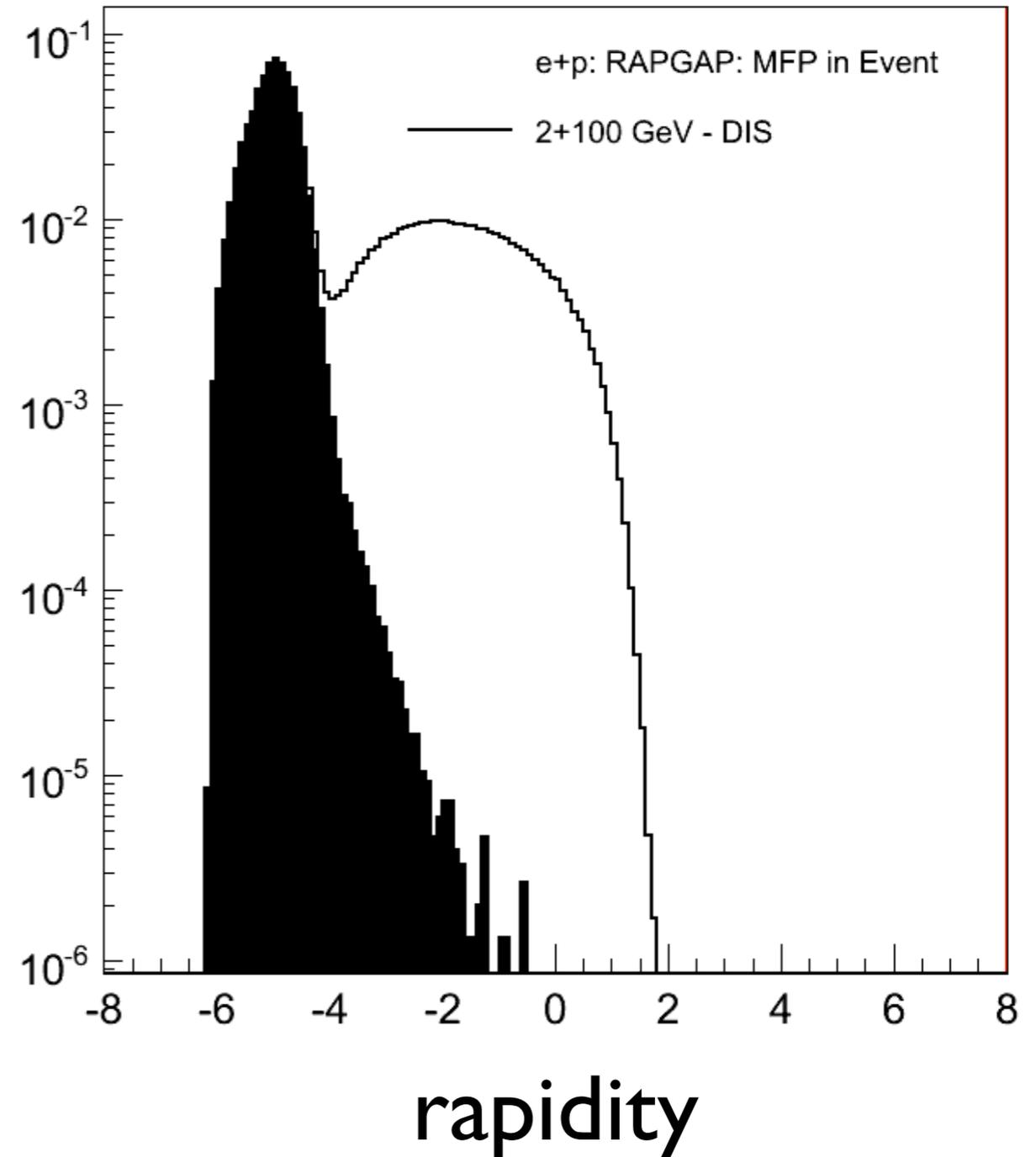


Can we reproduce the HERA plot?



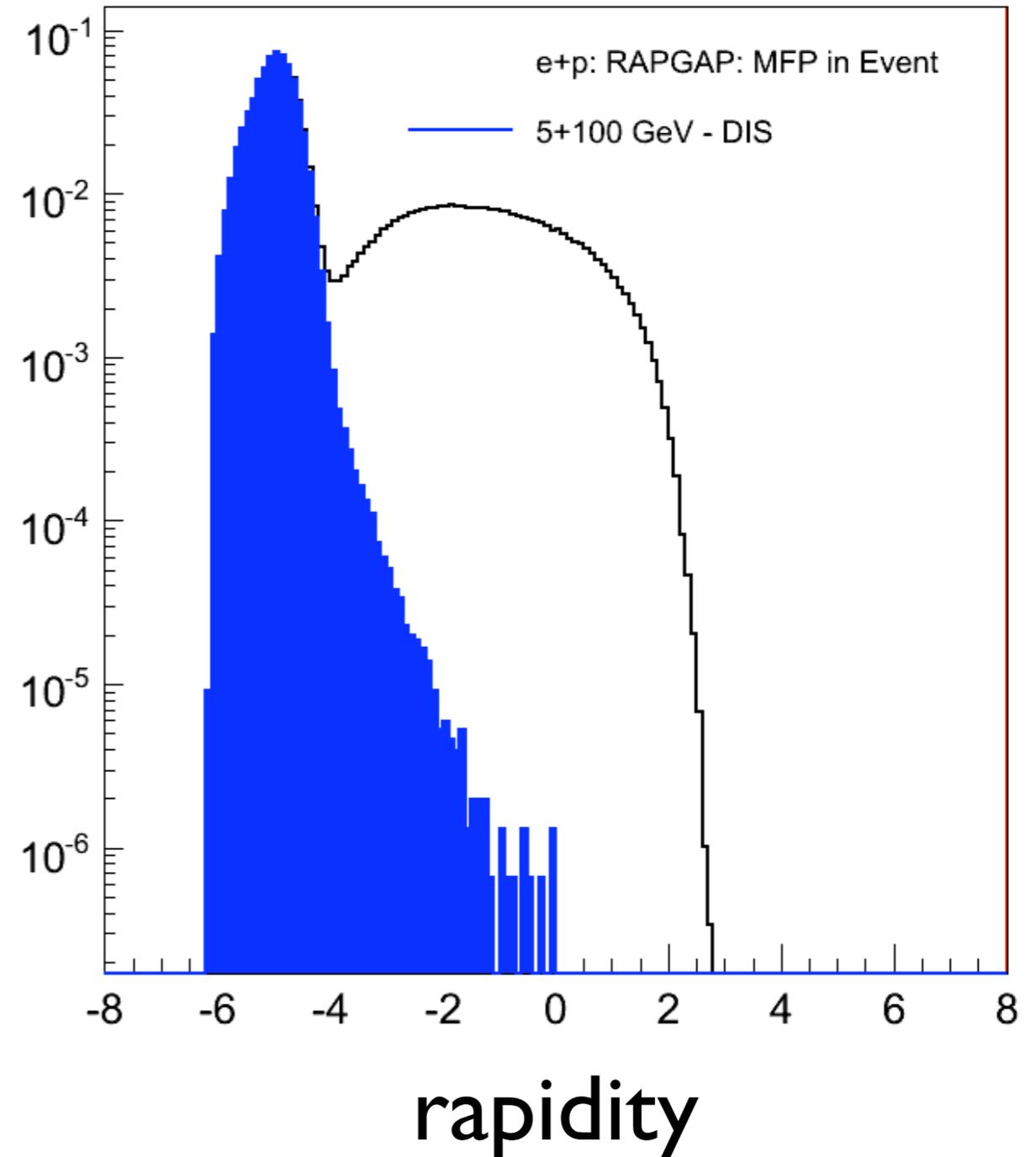
Can we reproduce the HERA plot?

- To begin with, we don't know the Diff/DIS components of the total cross-section.
- First guess:
 - ➔ DIS - 66%, Diff - 34%



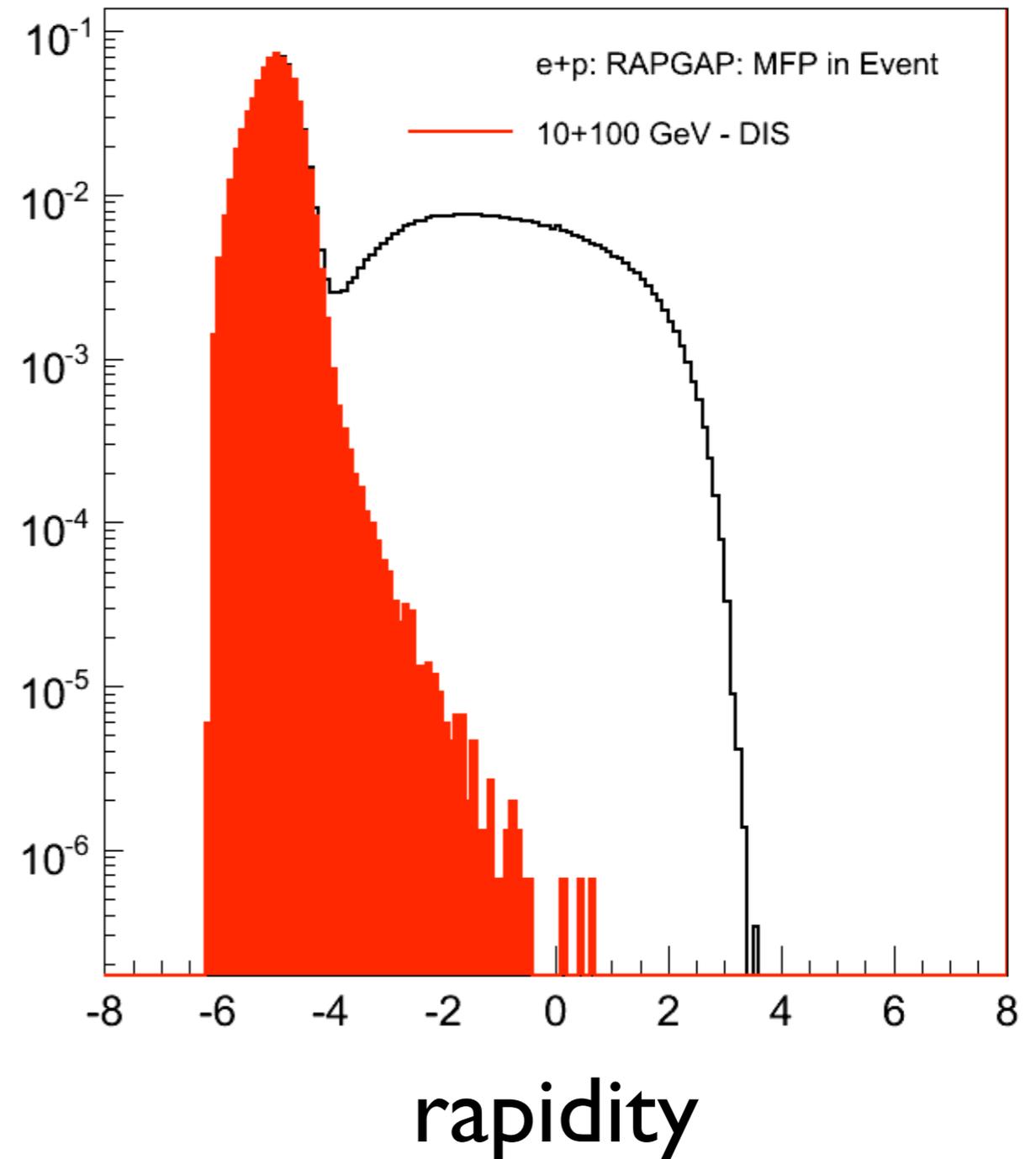
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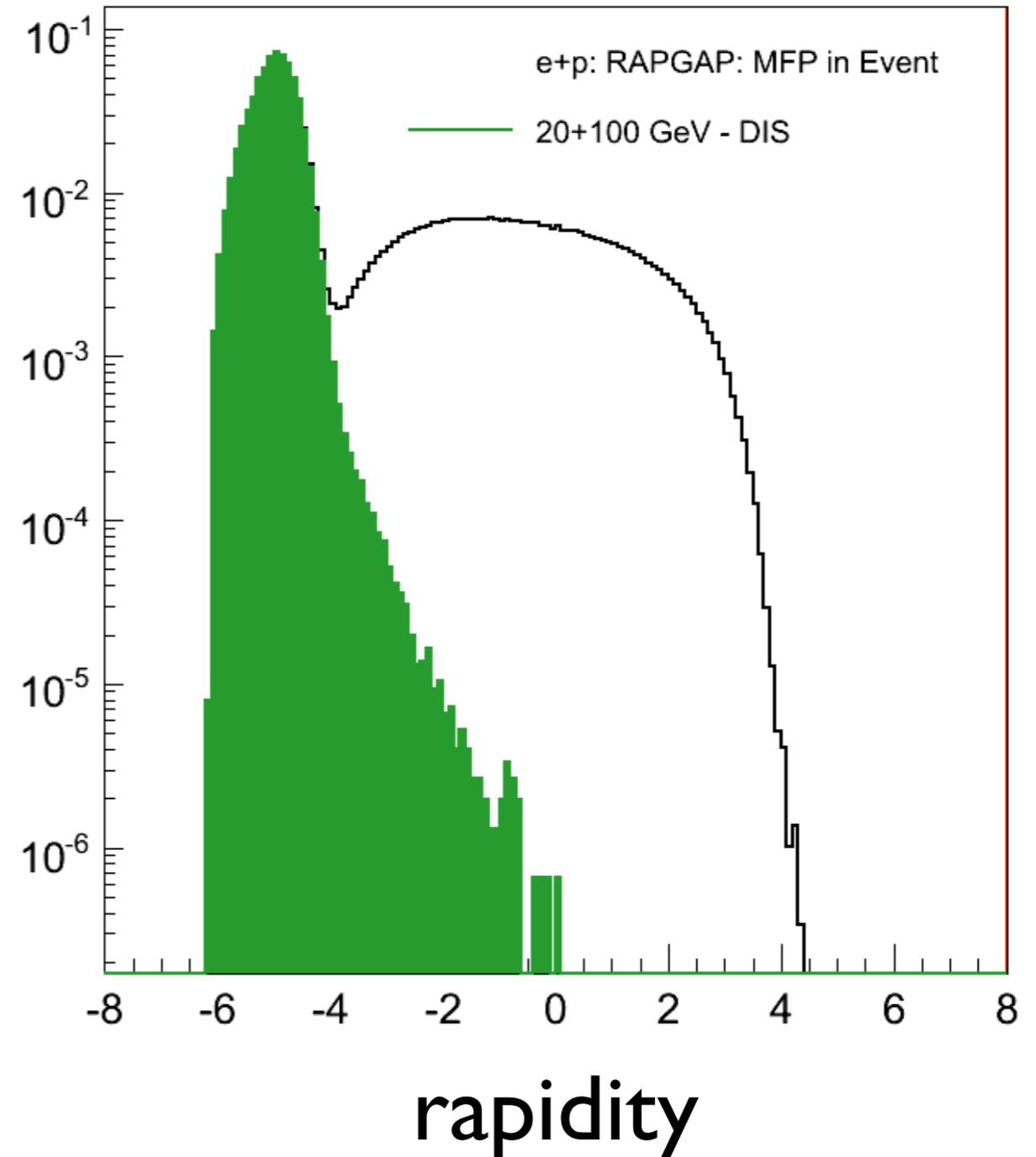
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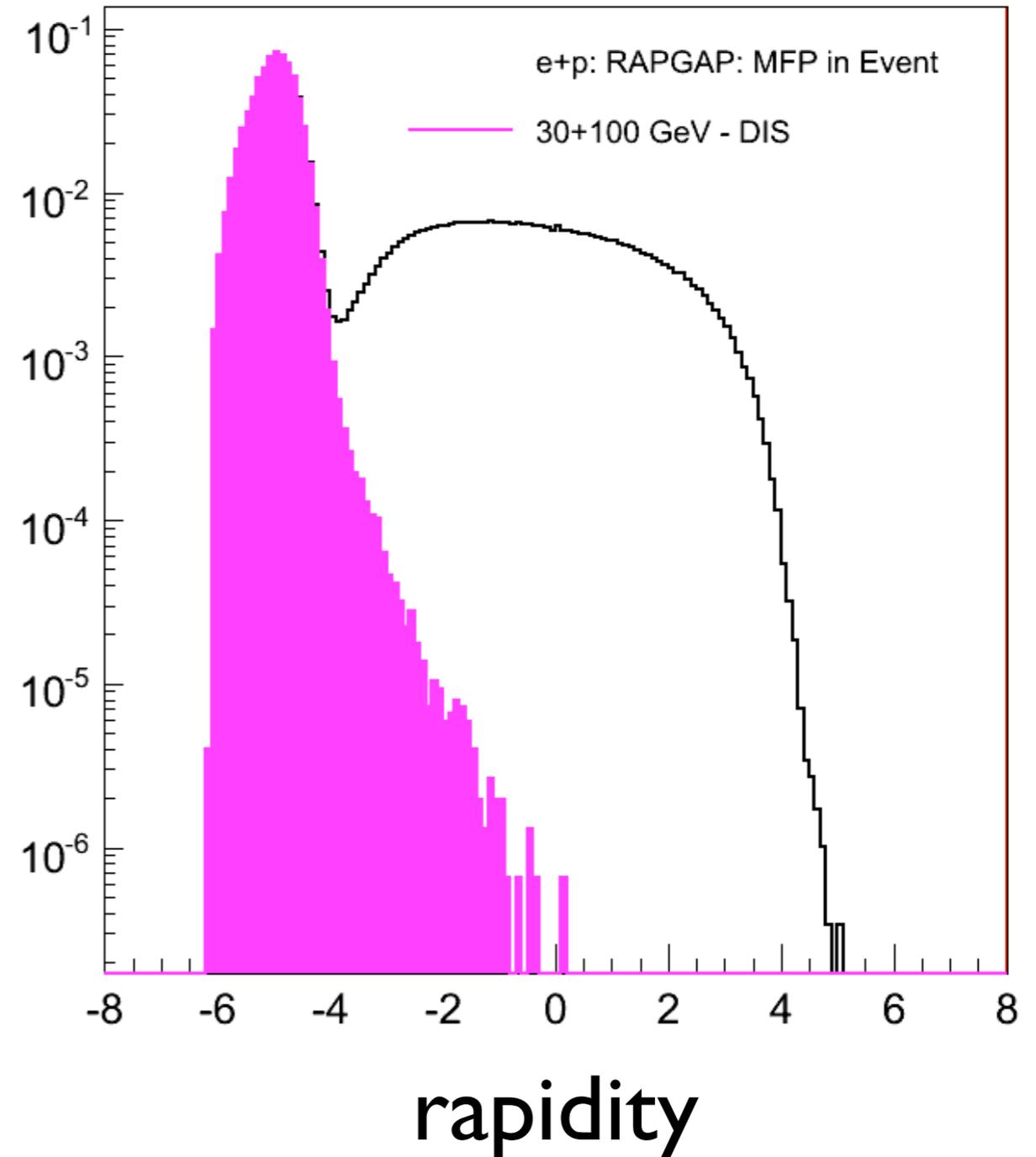
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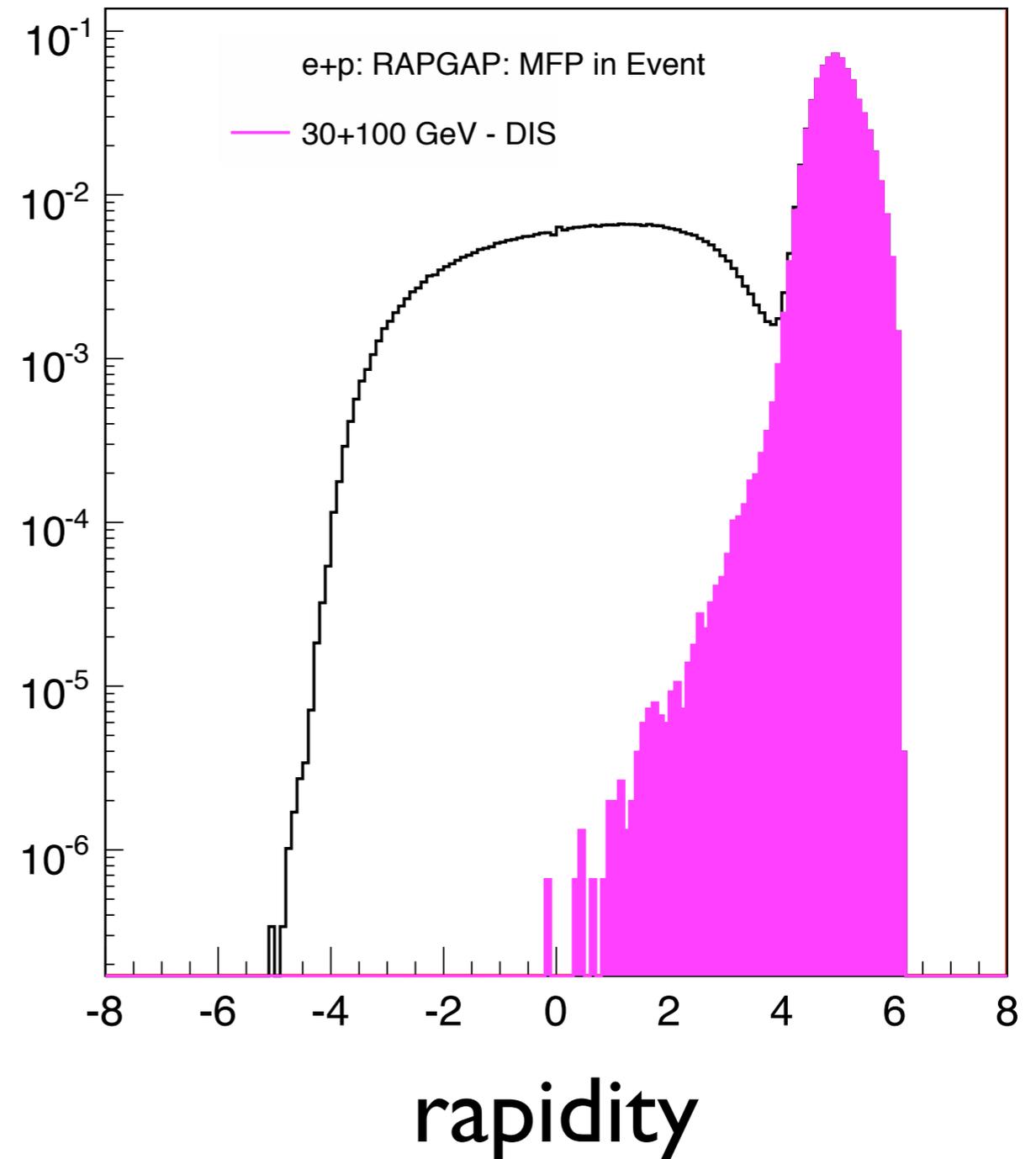
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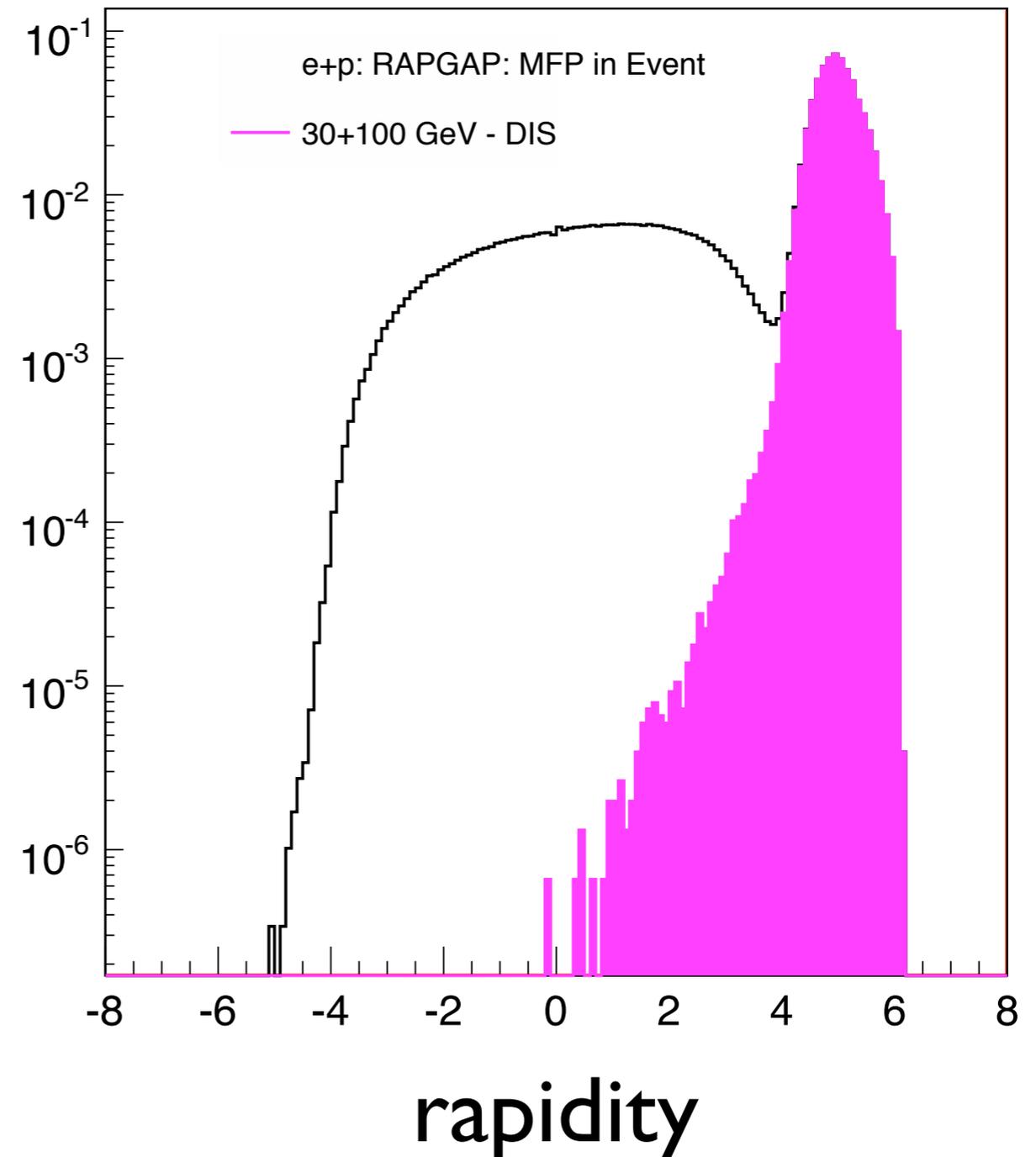
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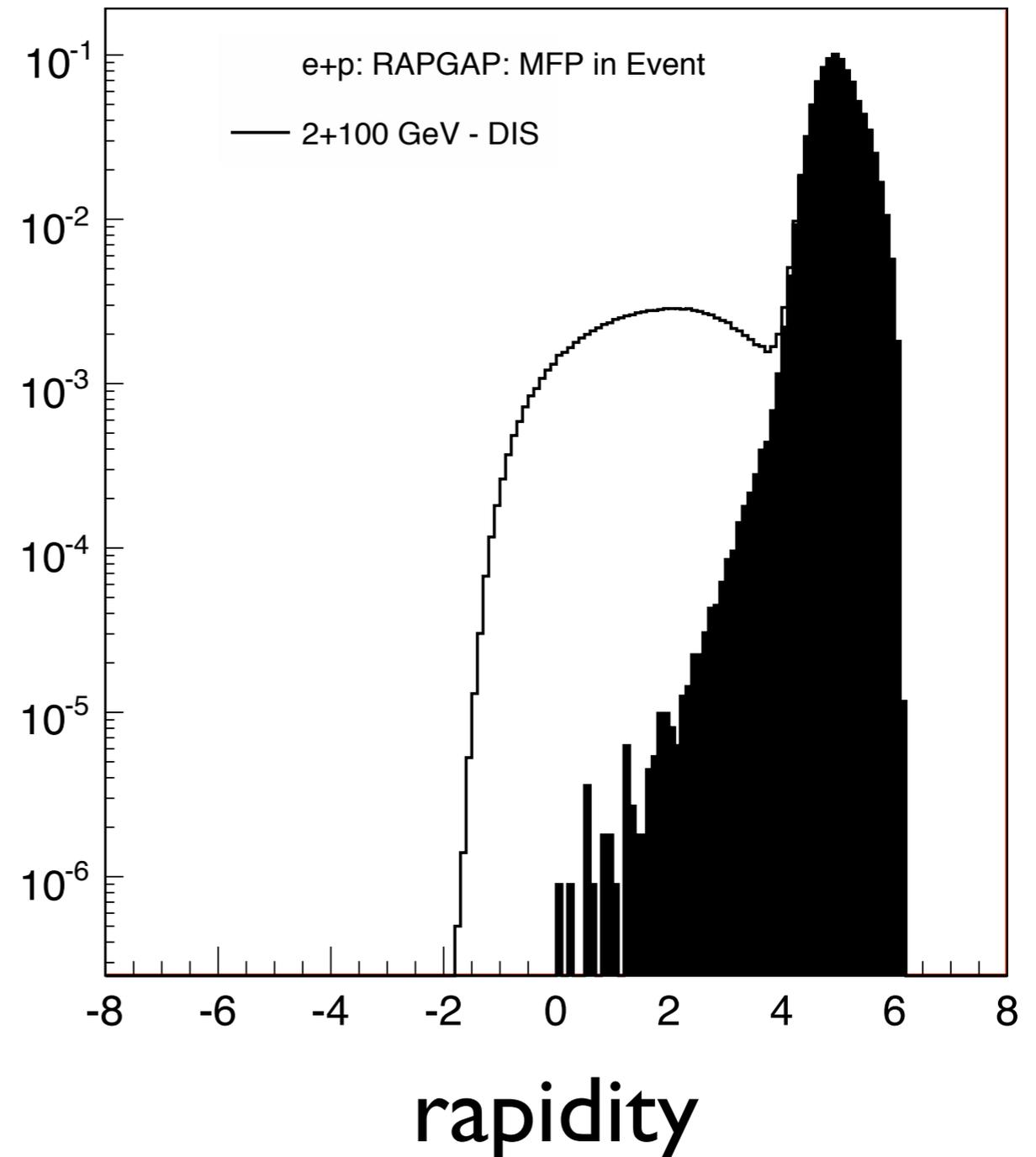
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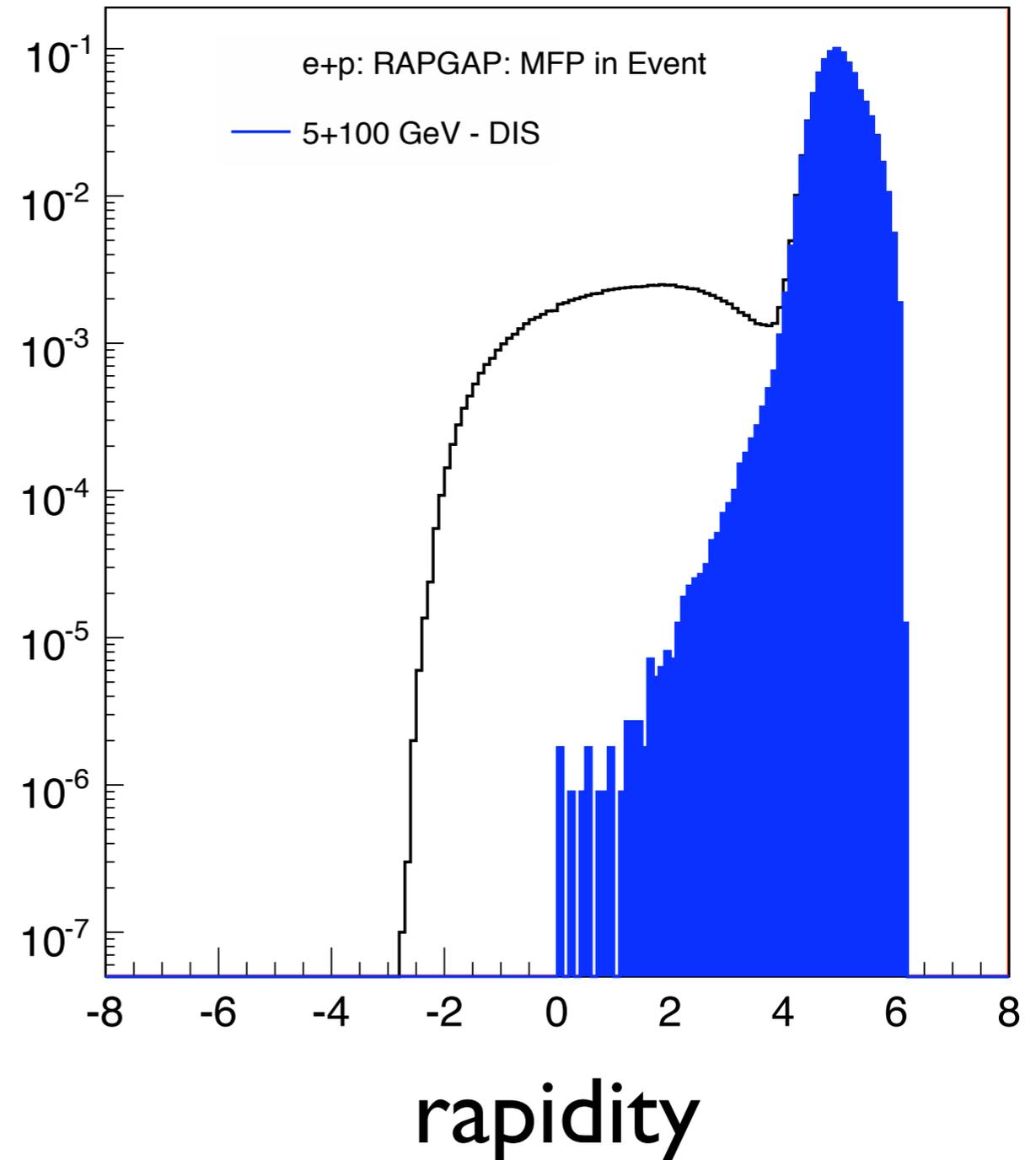
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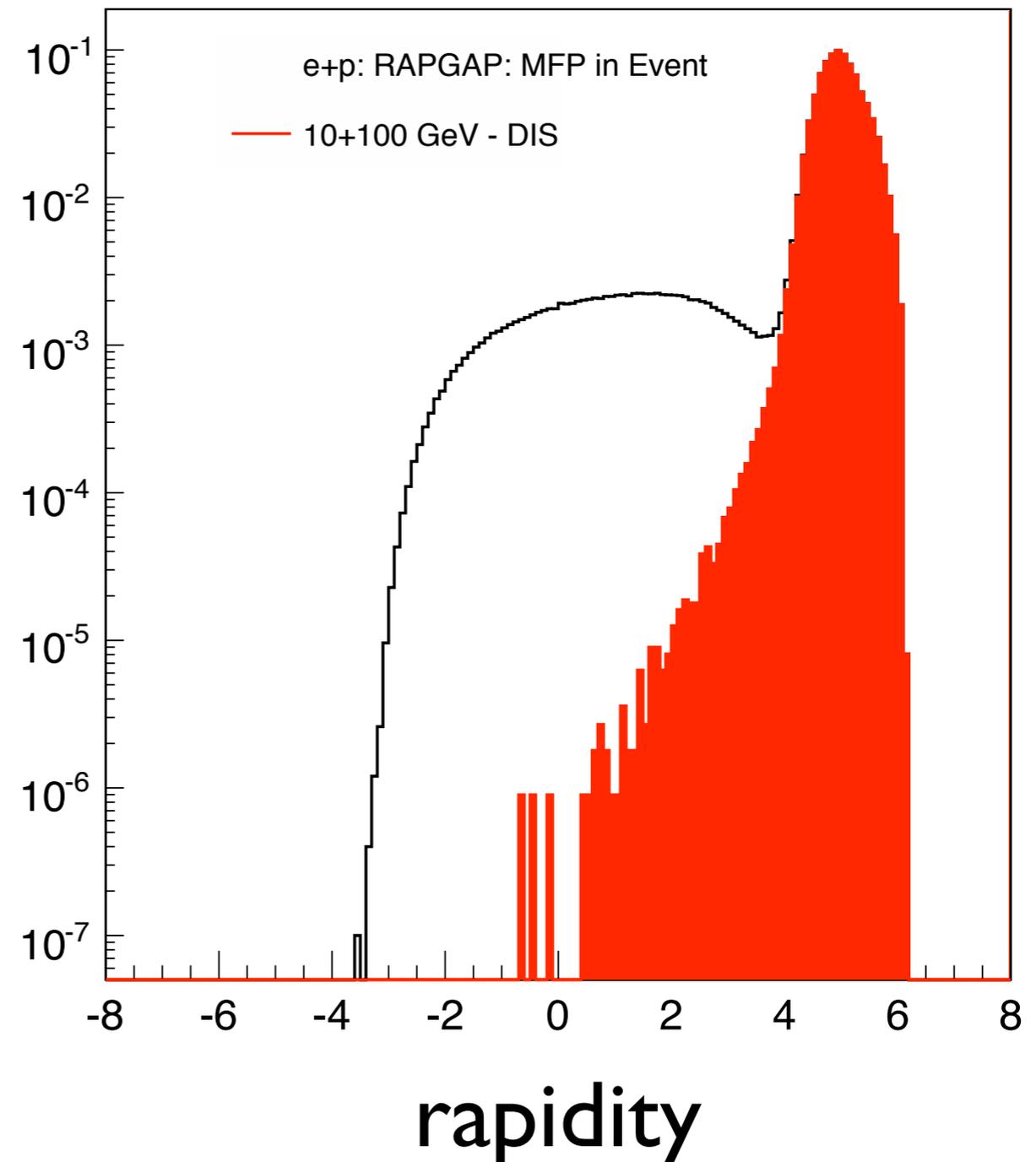
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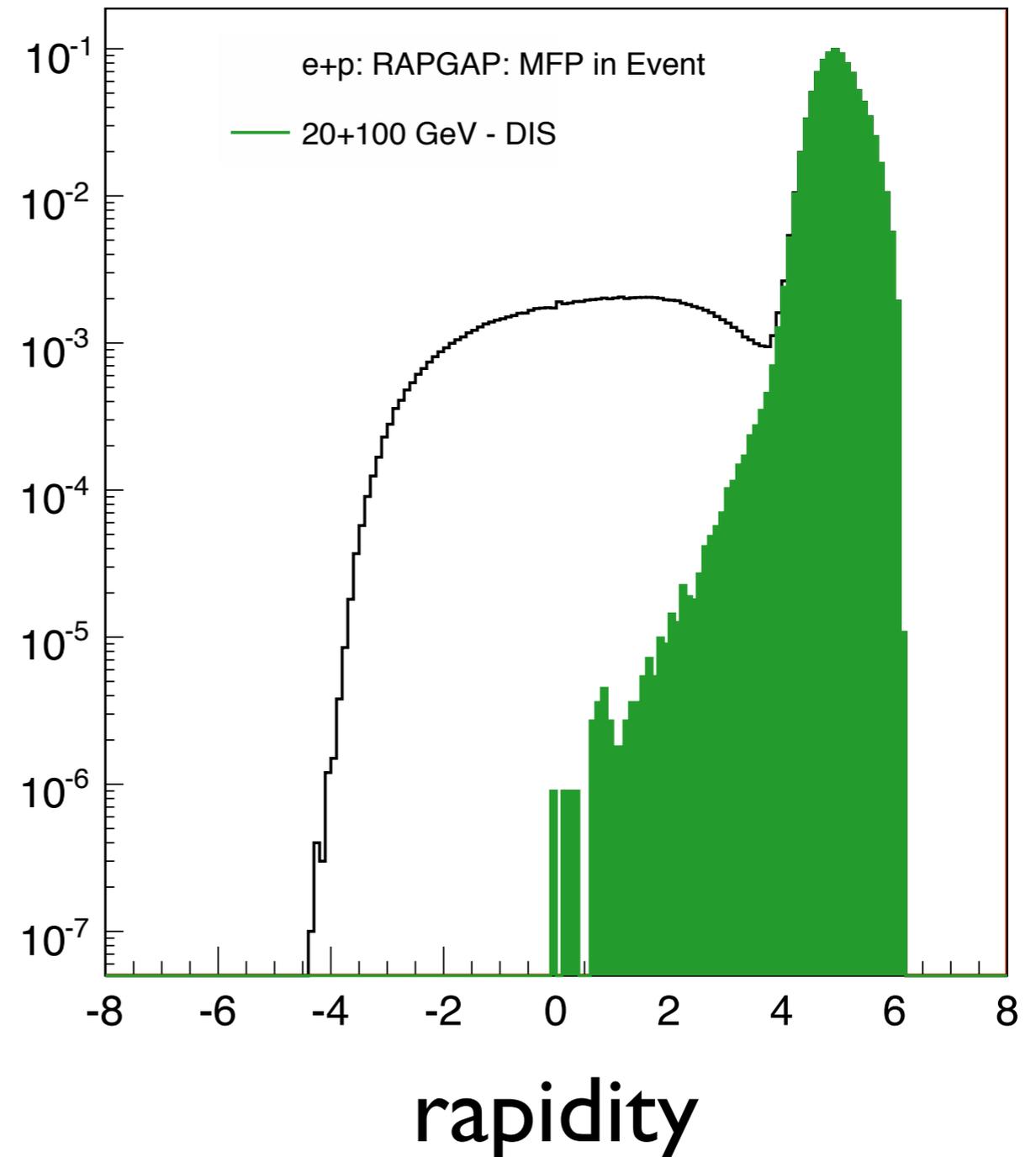
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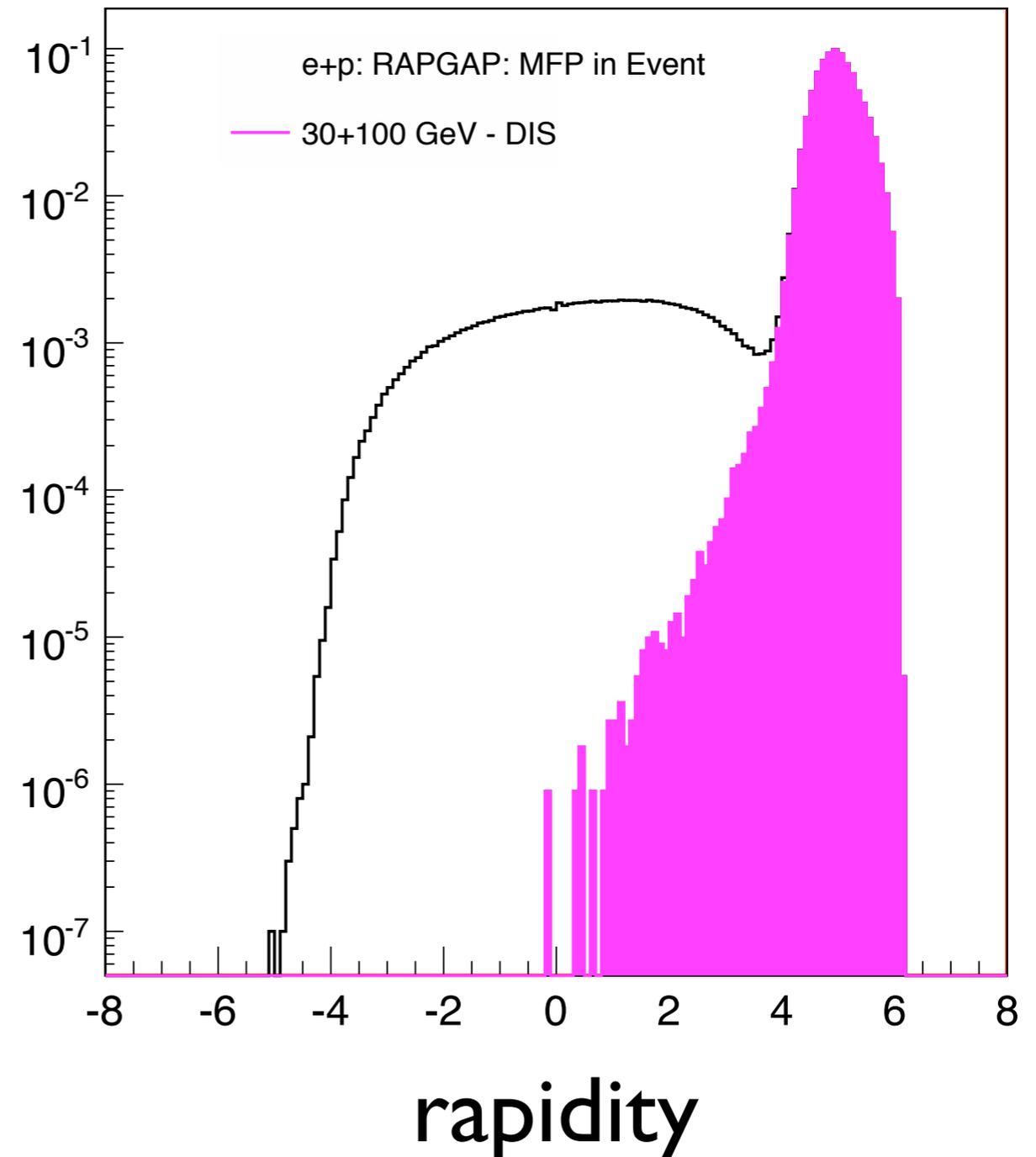
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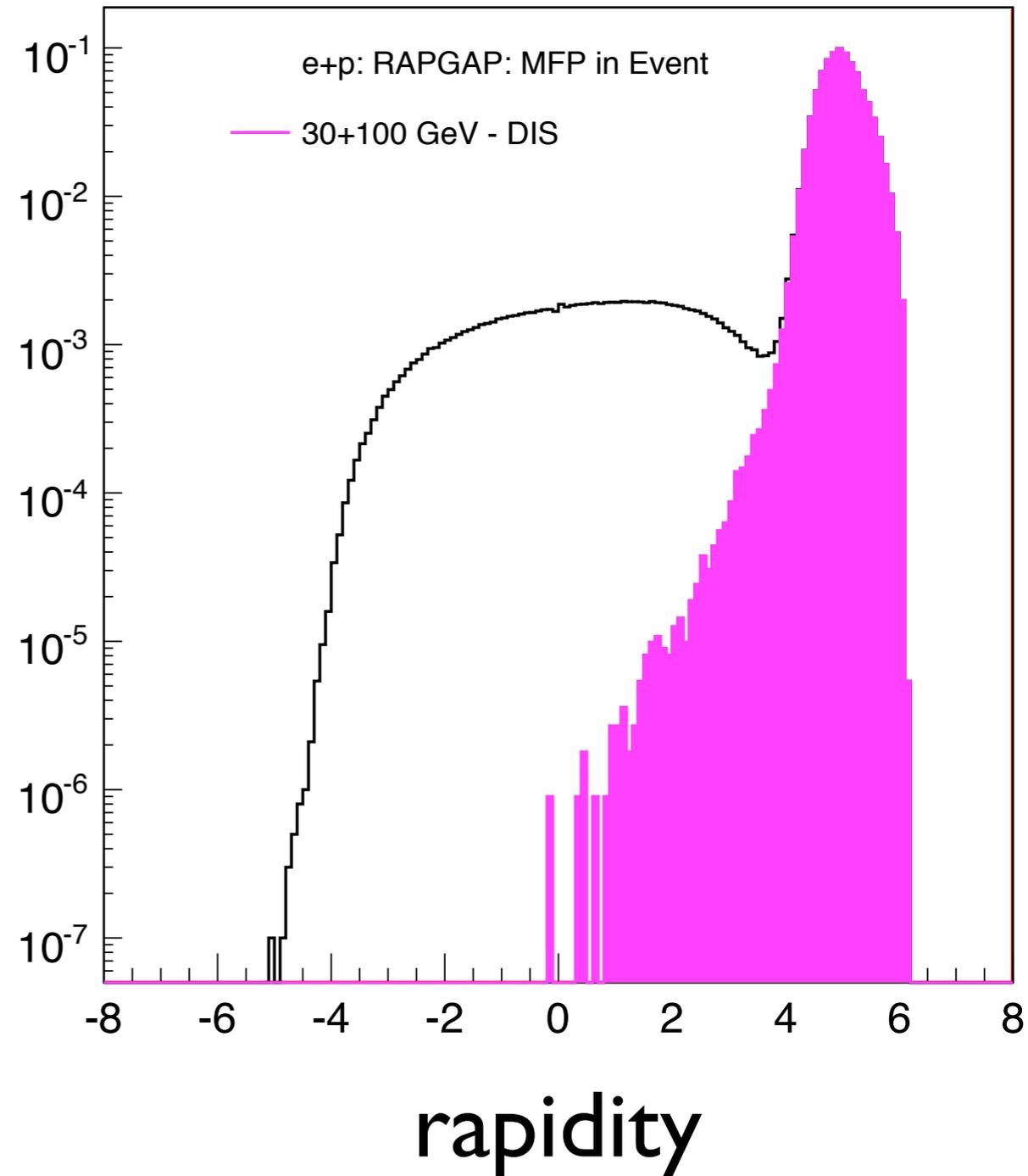
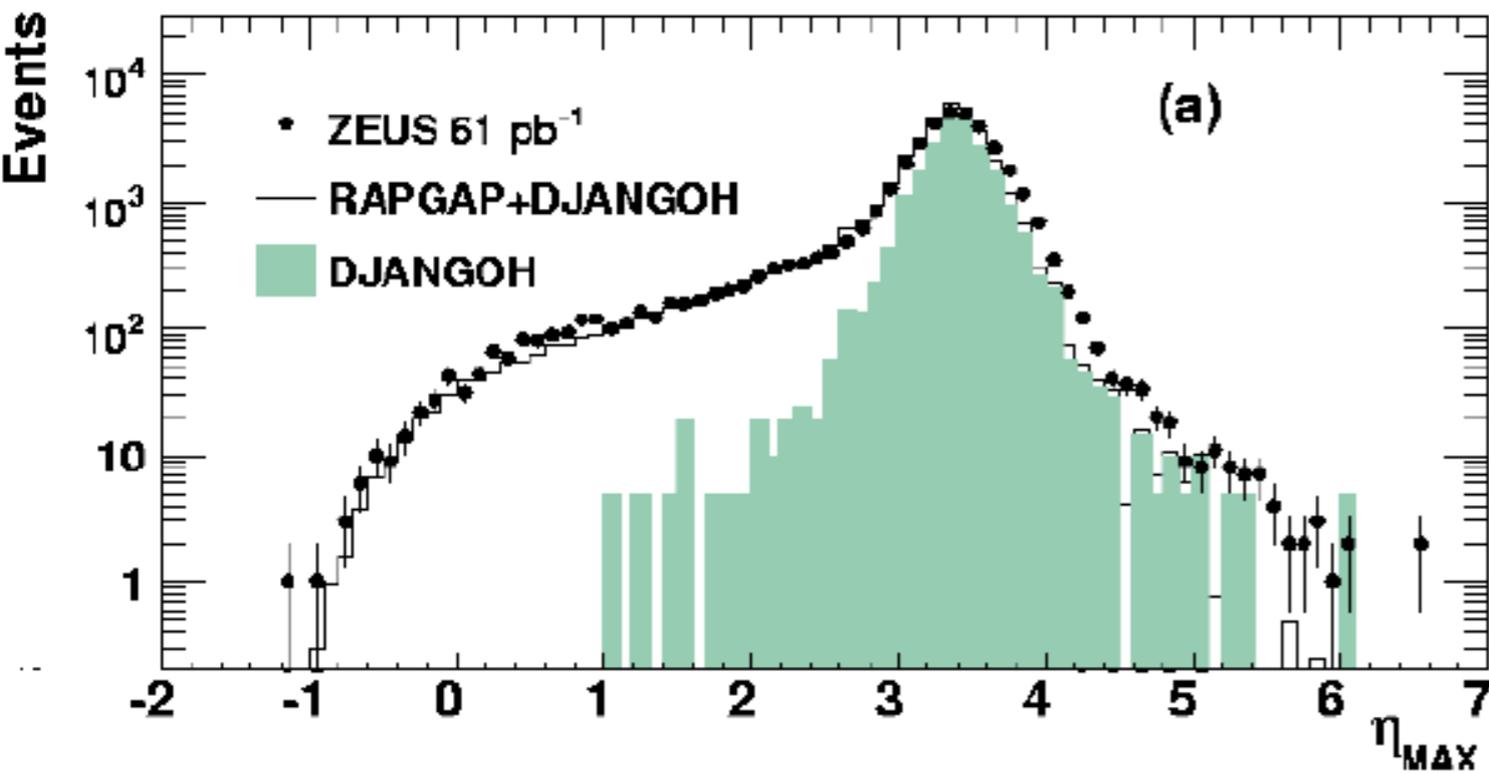
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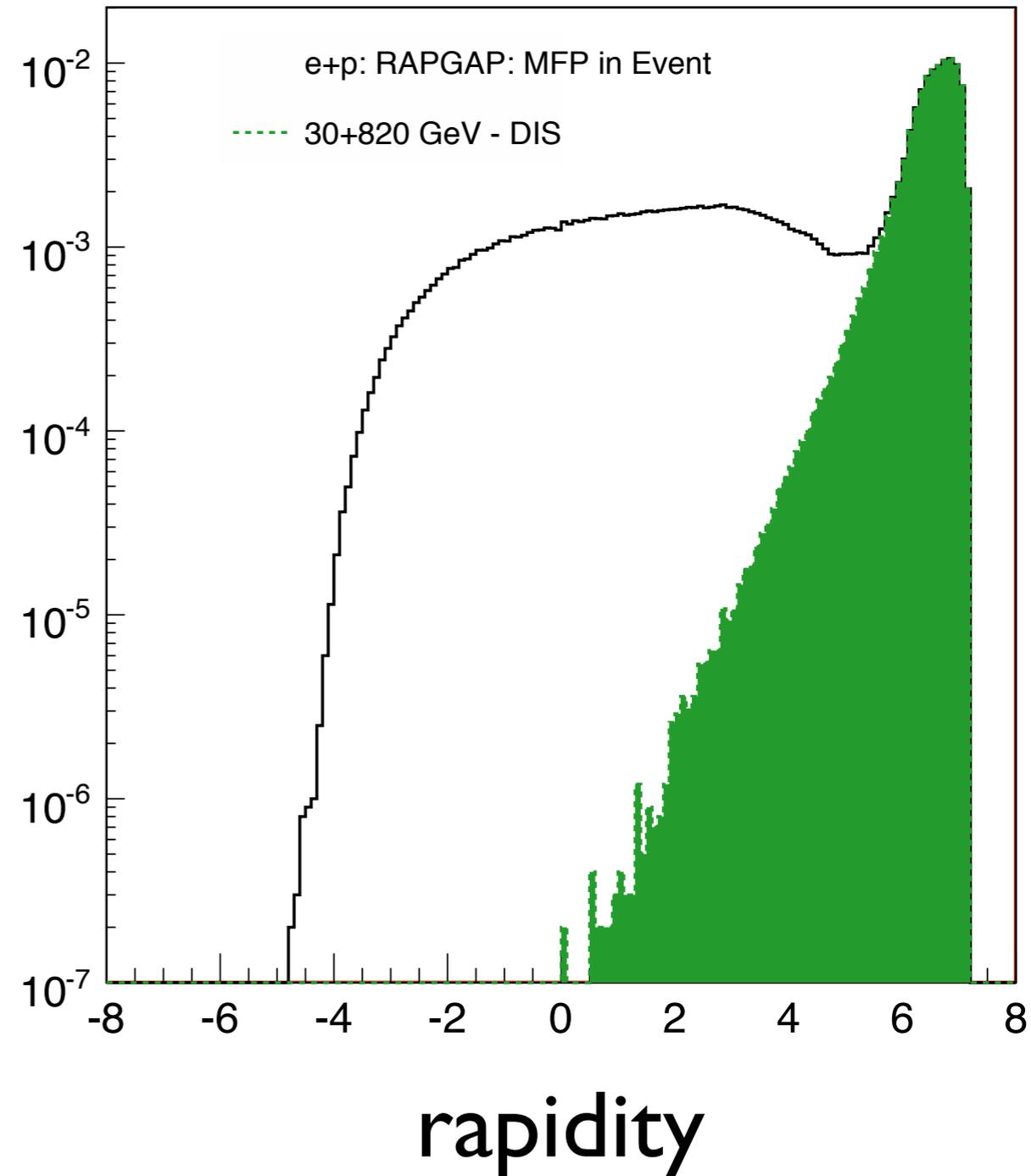
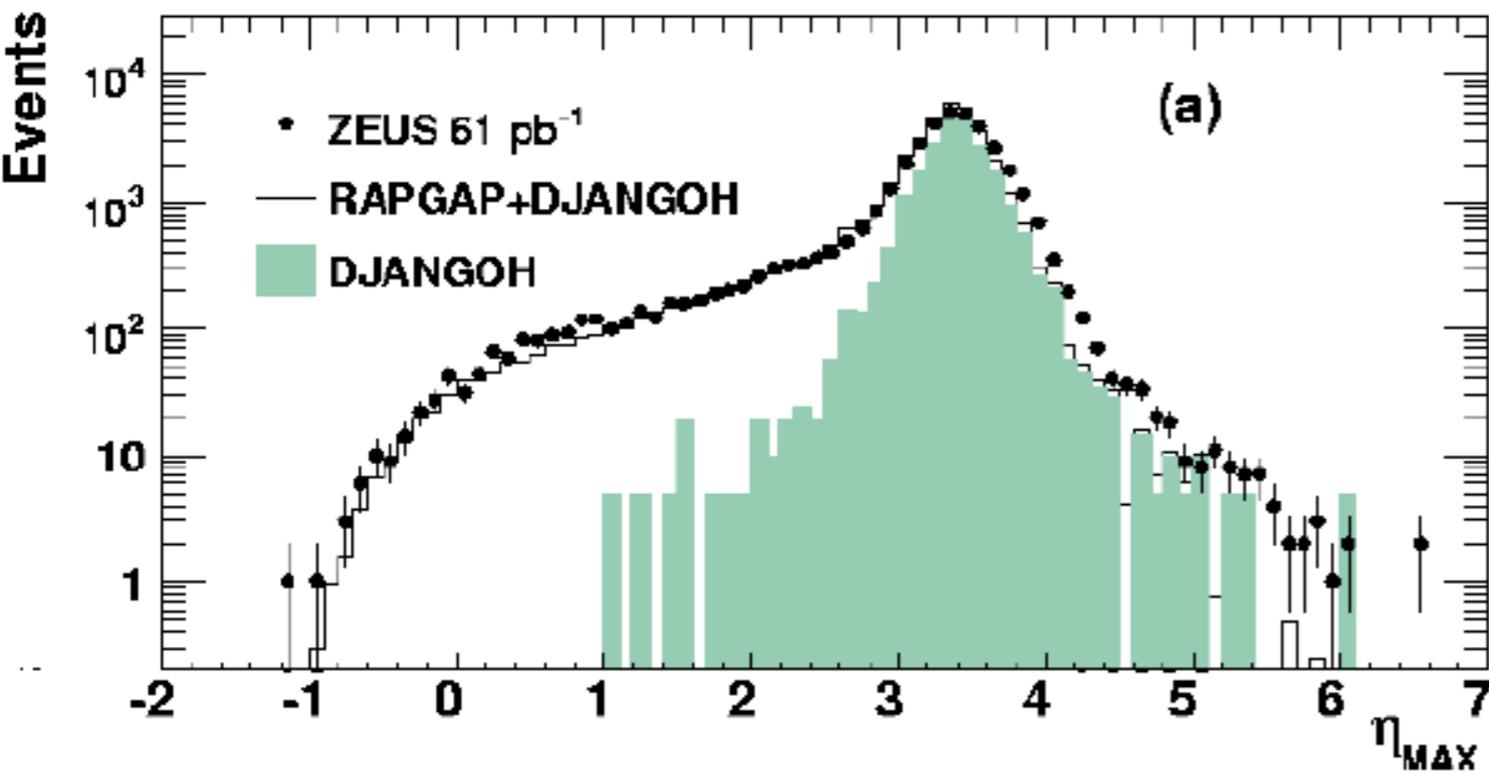
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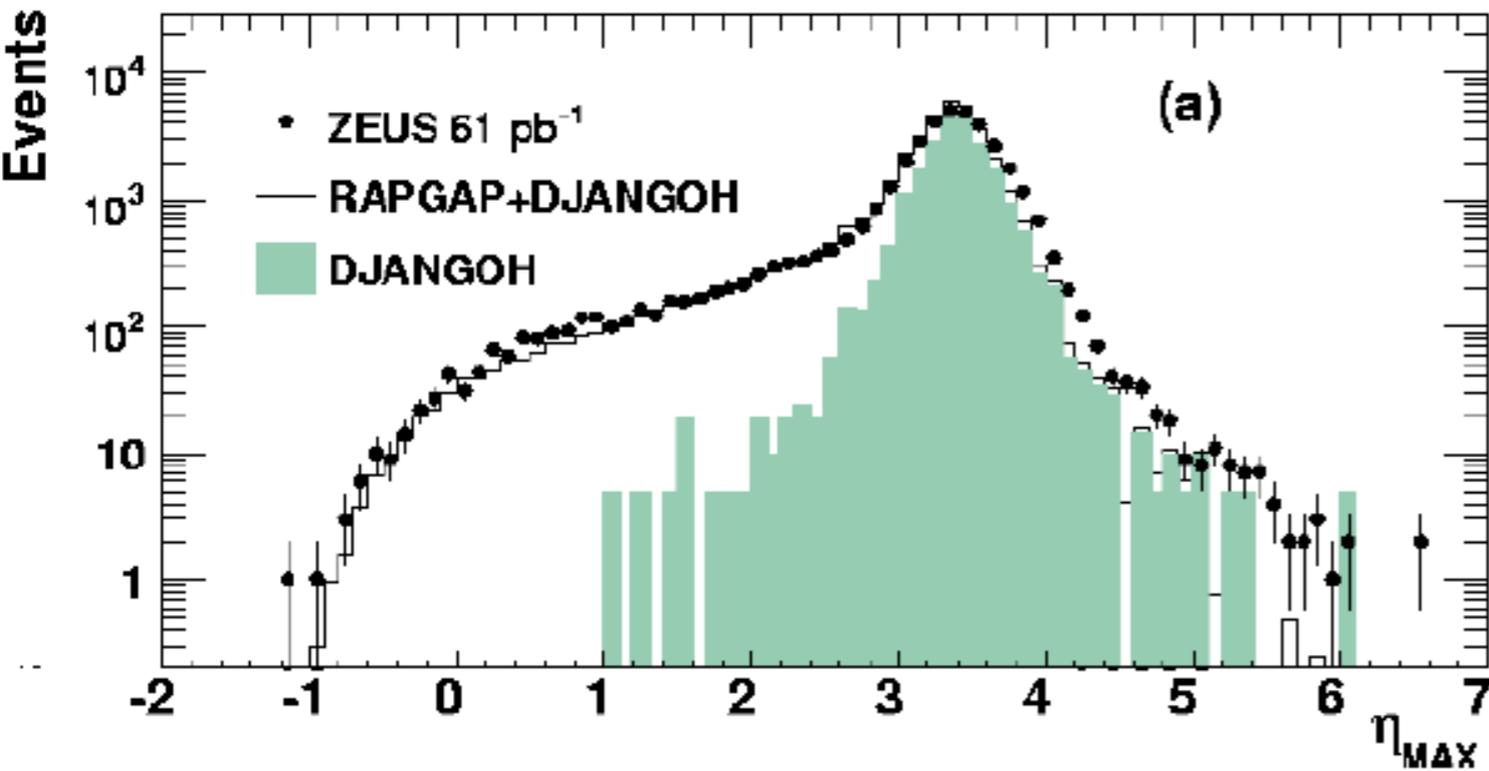
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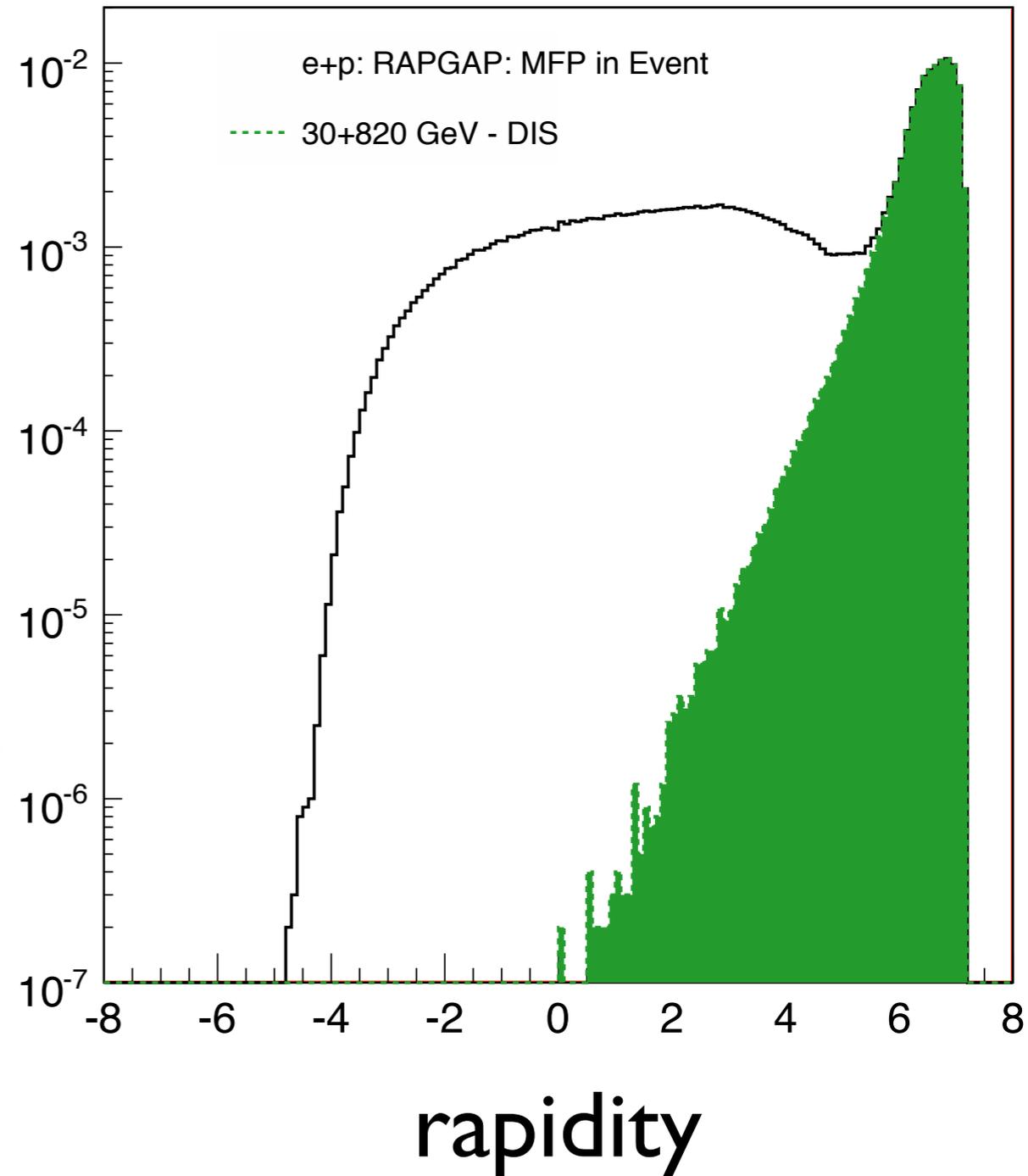
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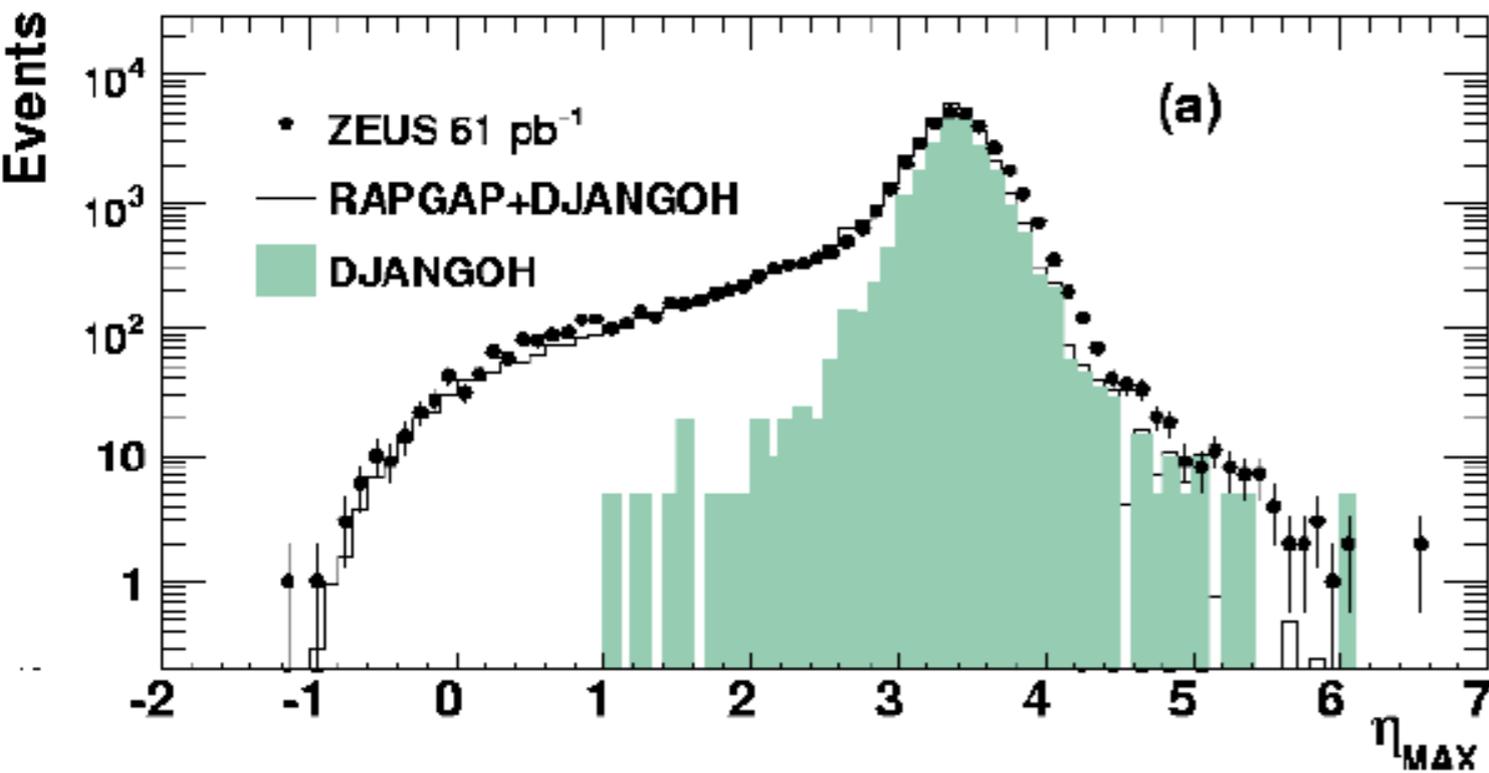
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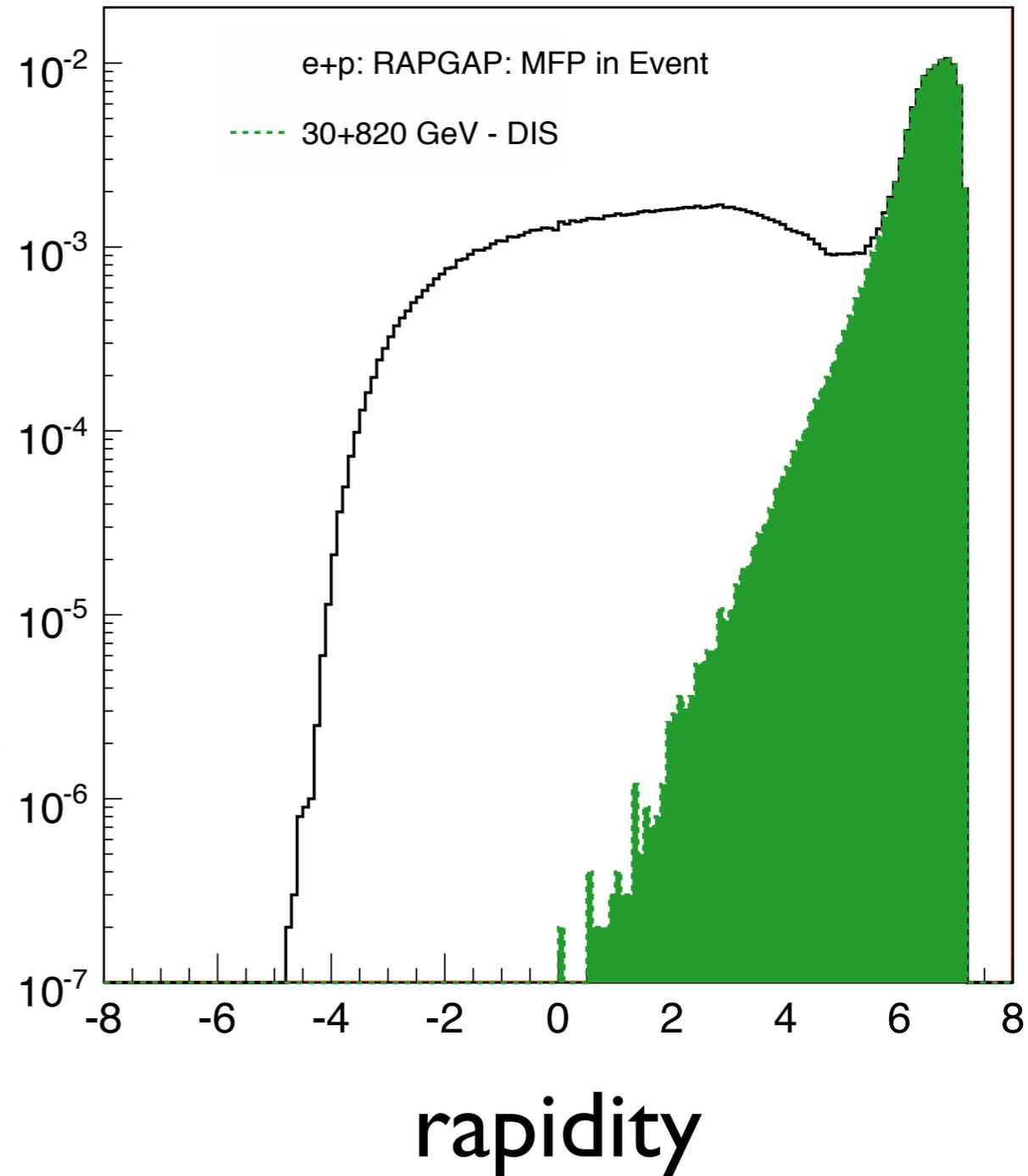


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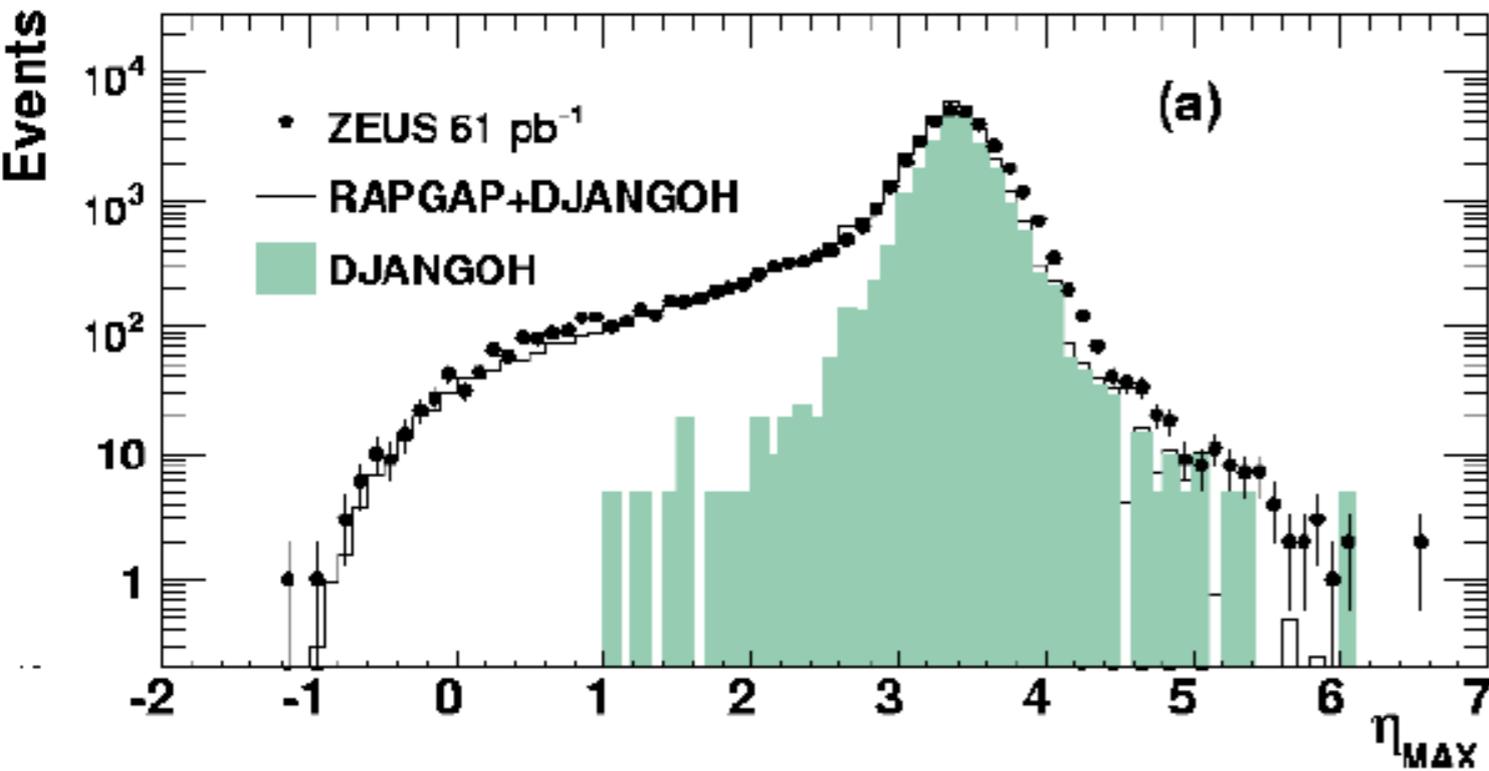


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rapidity vs pseudo-rapidity?



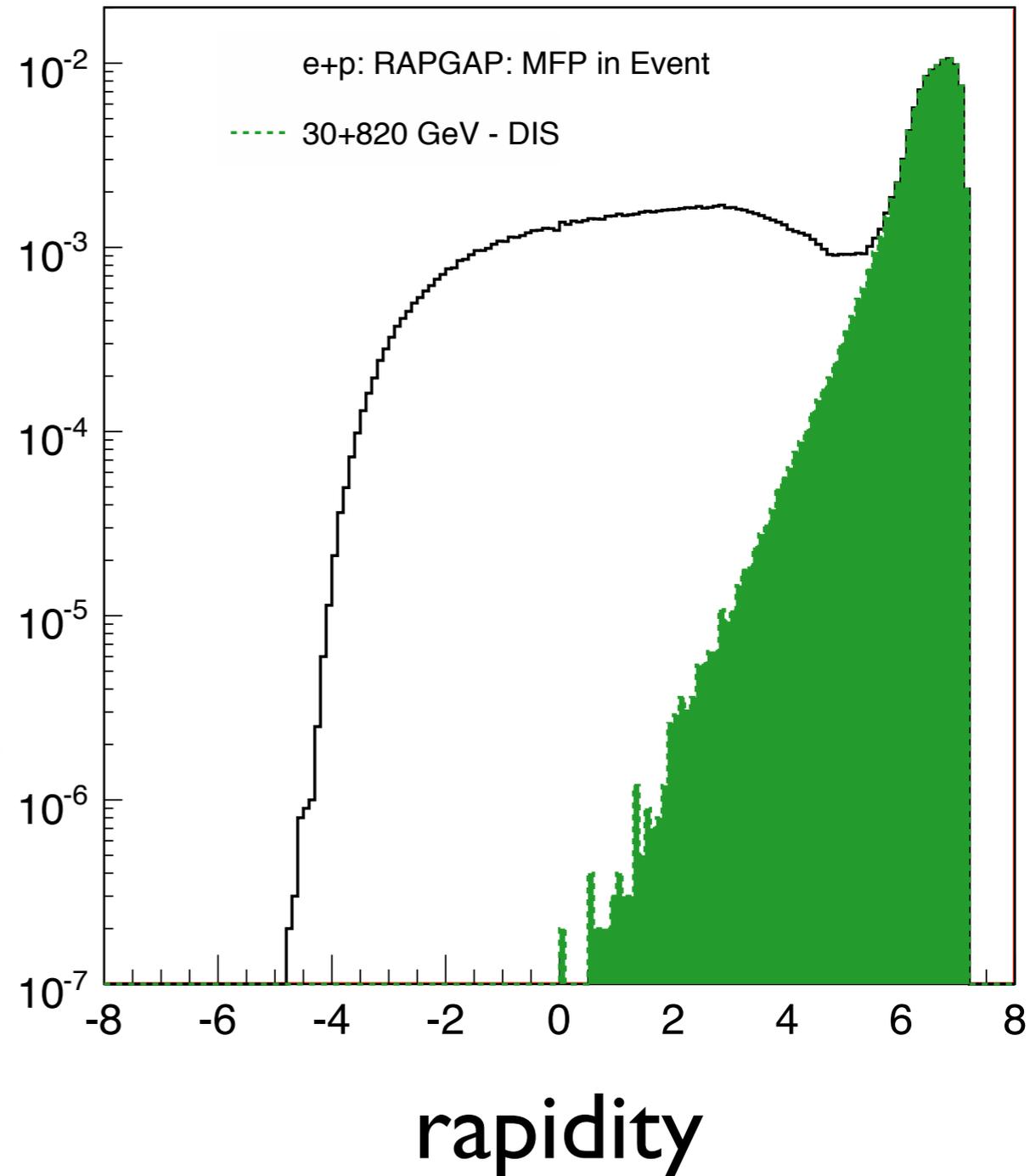
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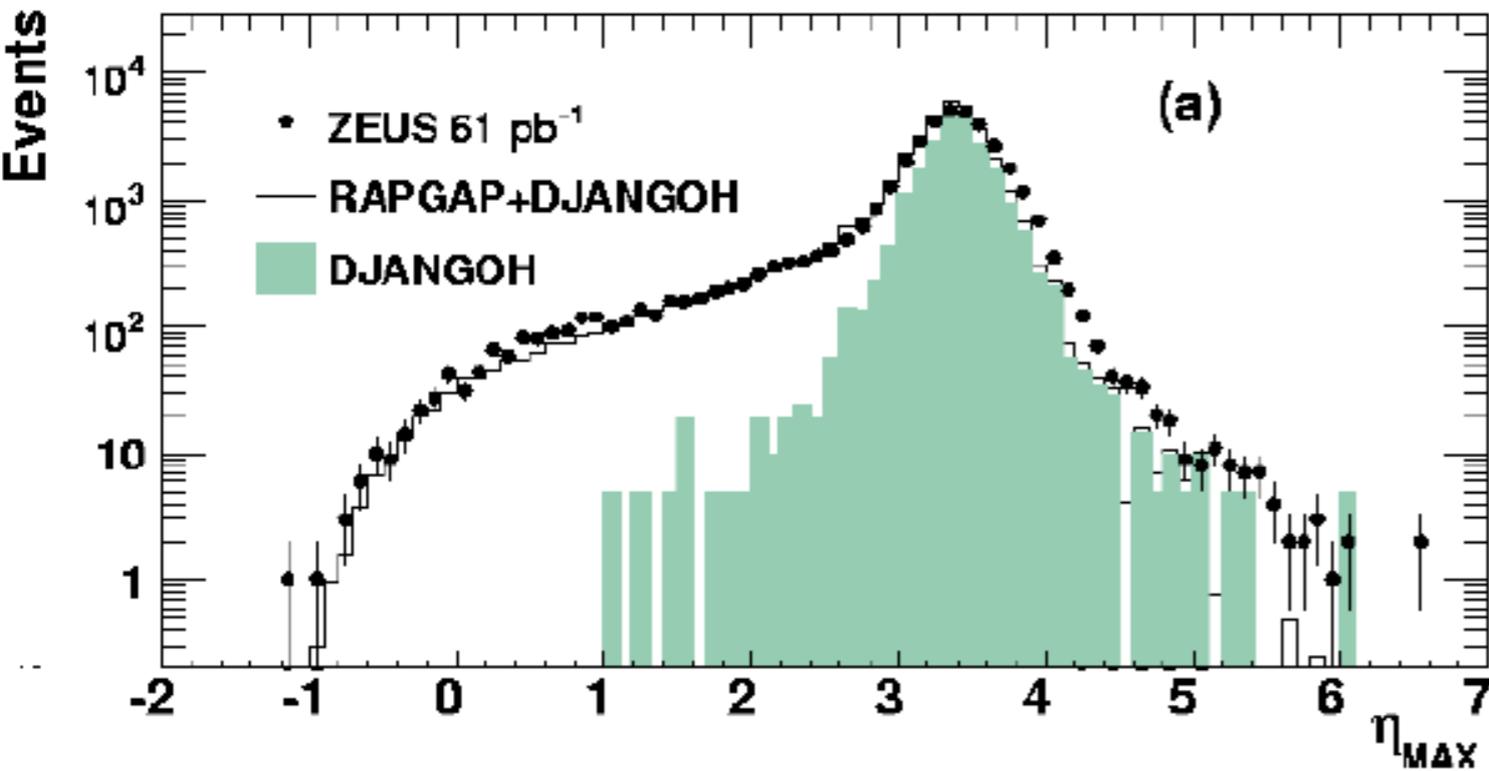
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RAPGAP vs DJANGO description of inclusive DIS events



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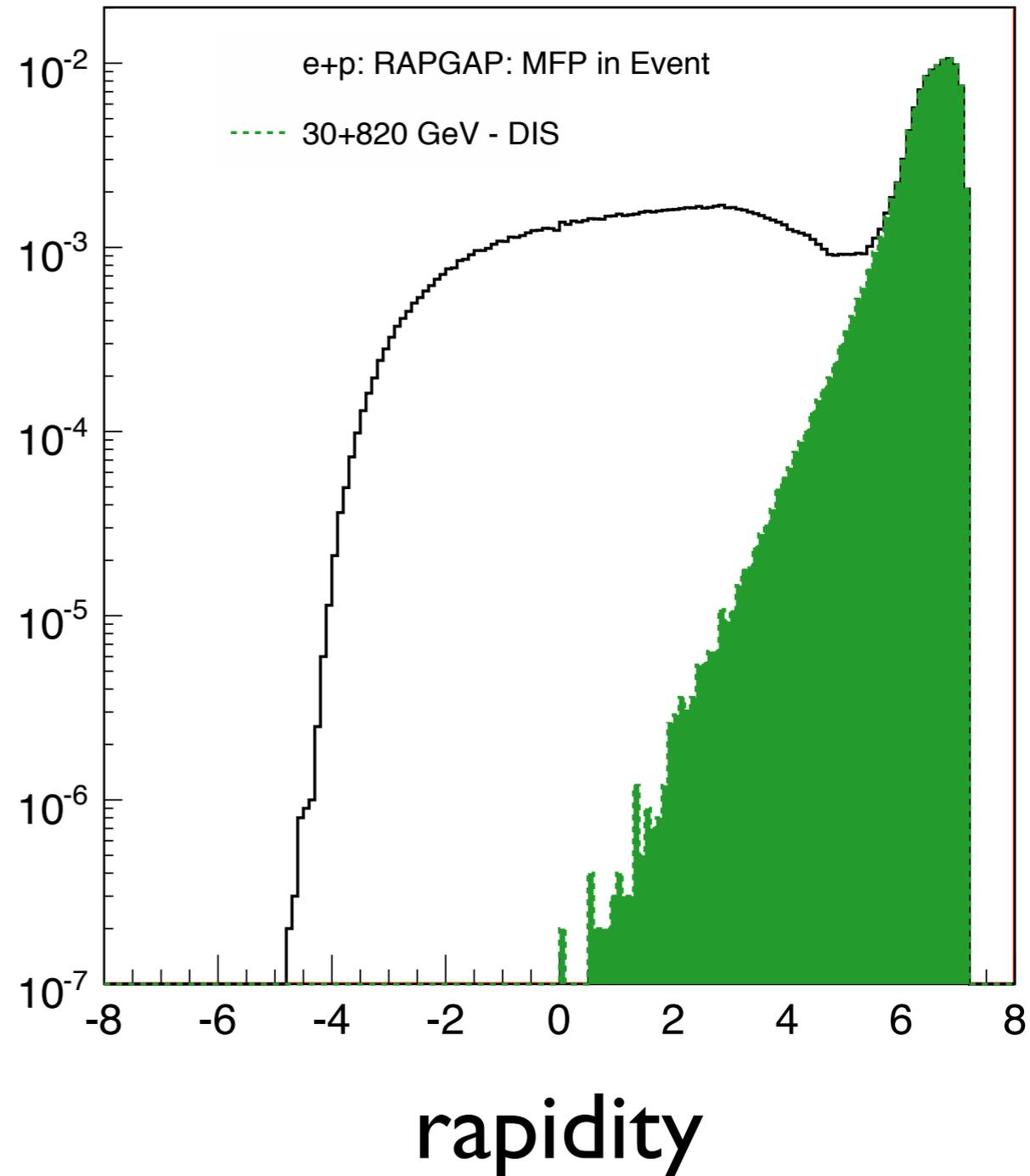


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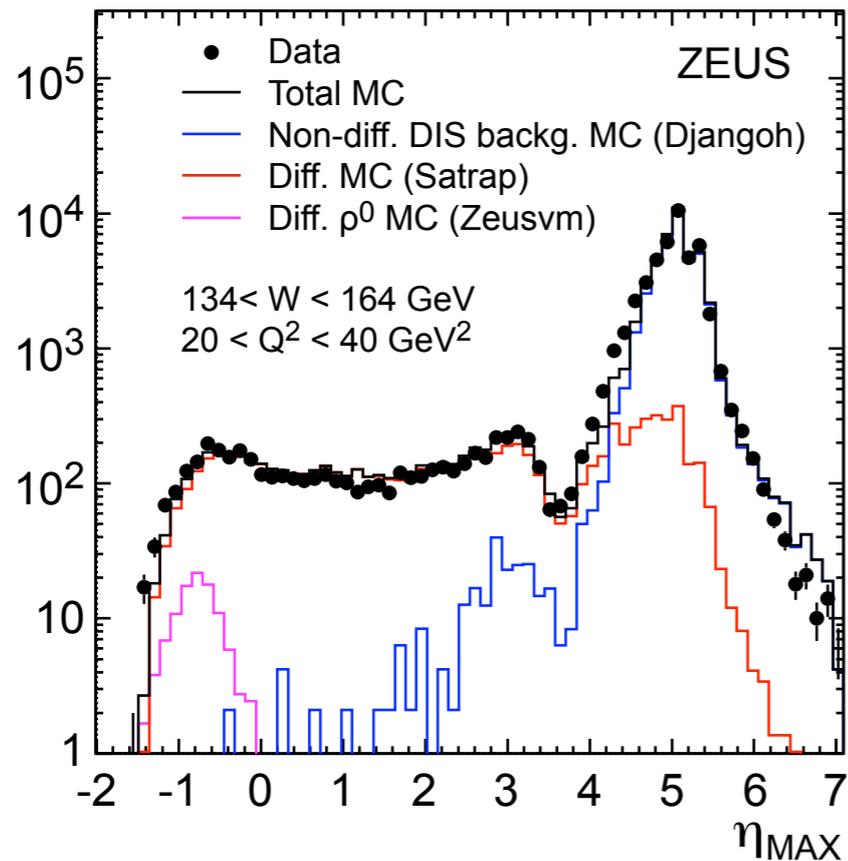
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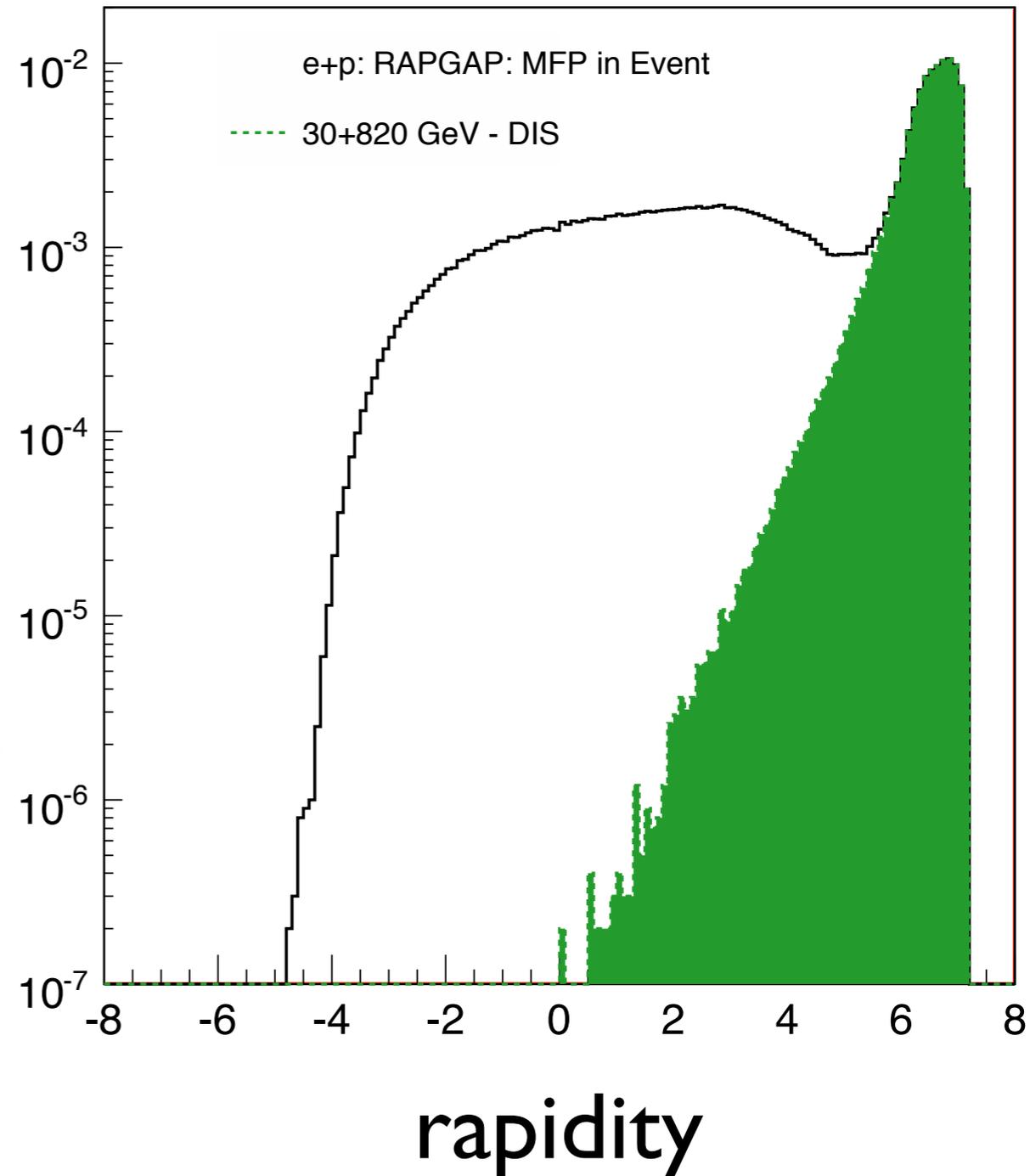


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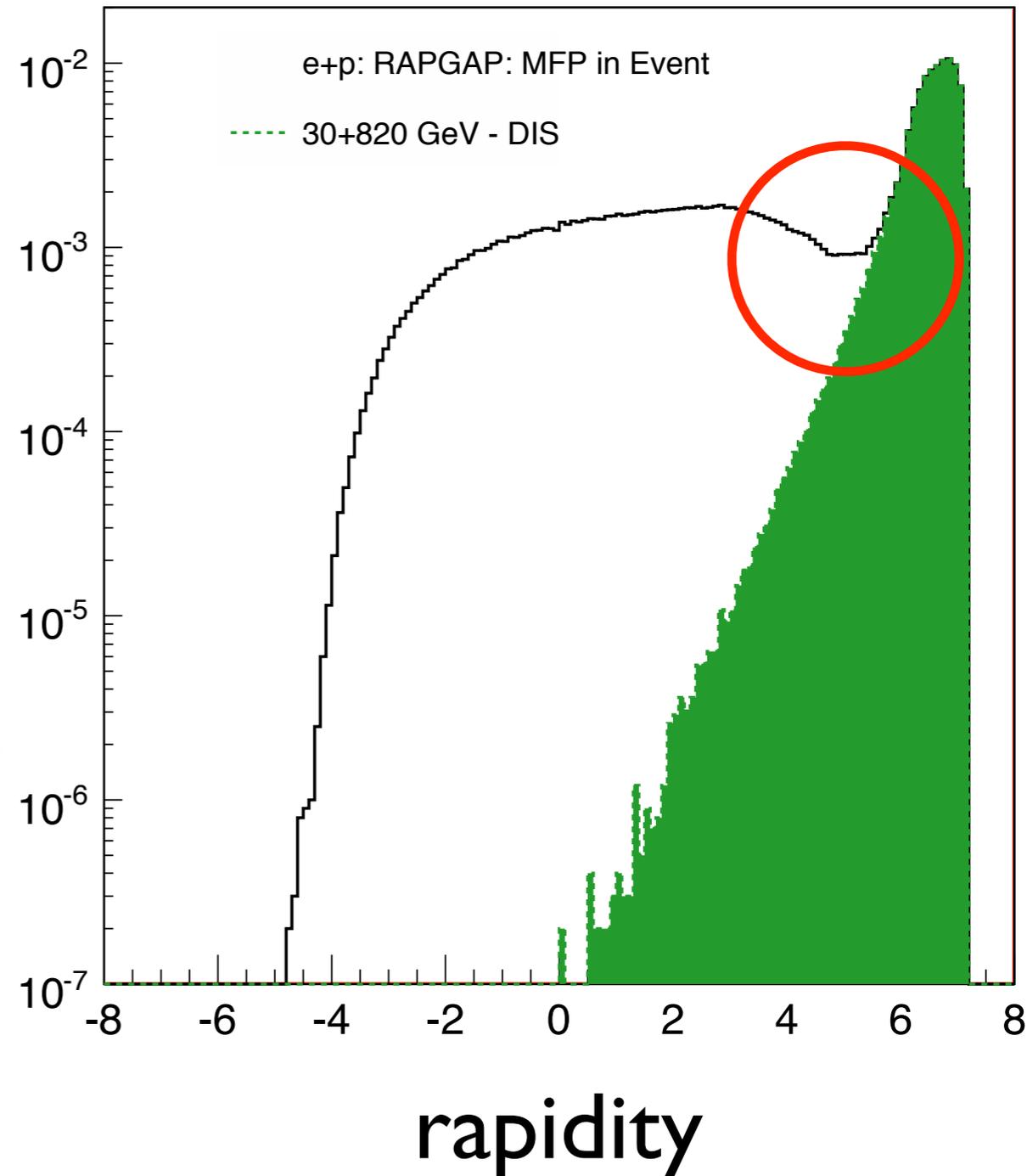
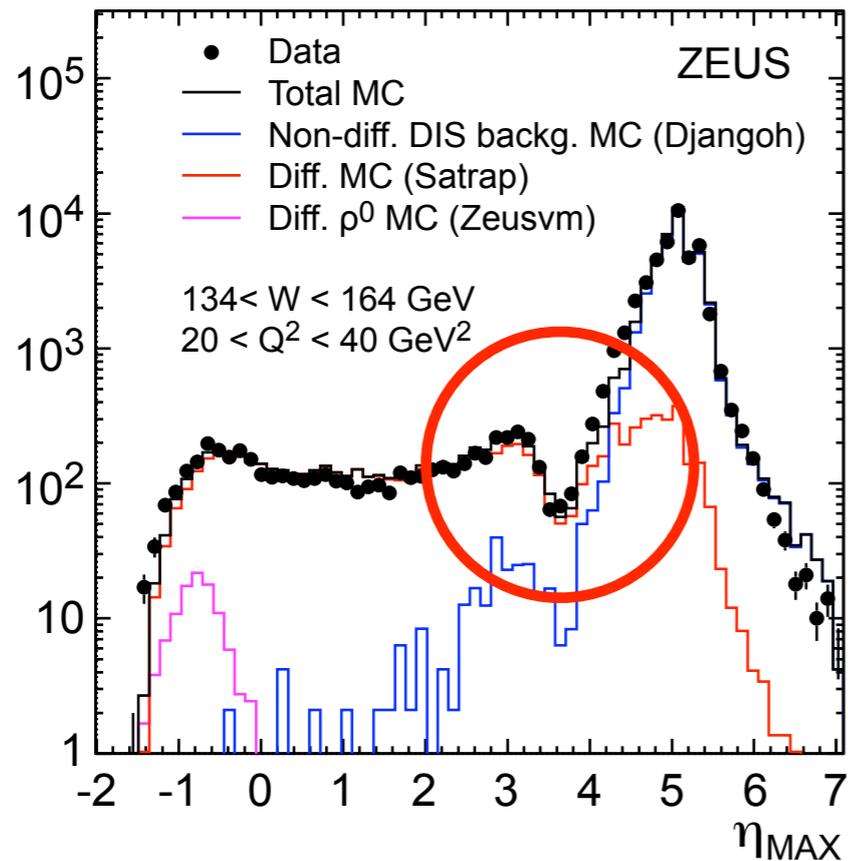
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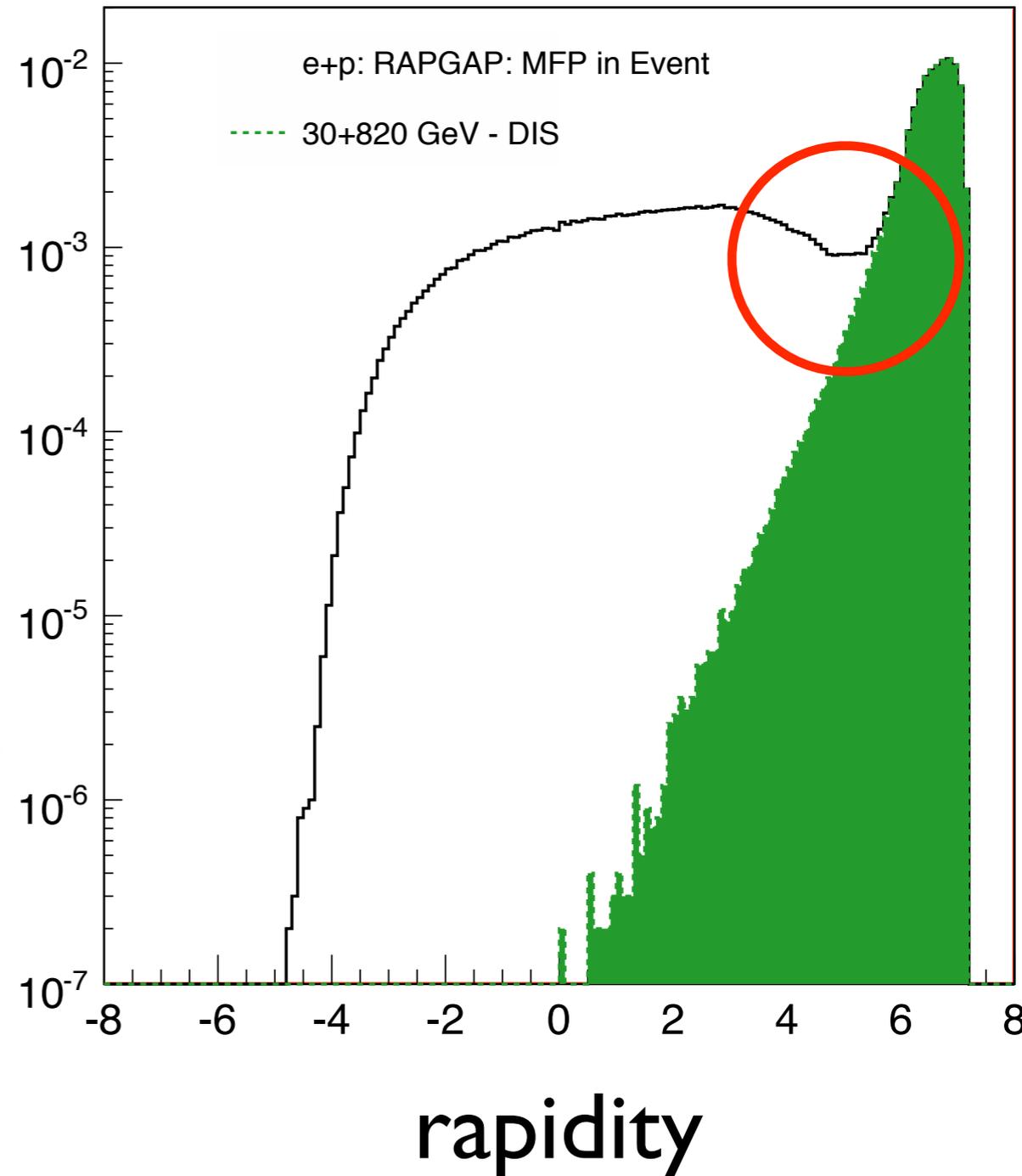
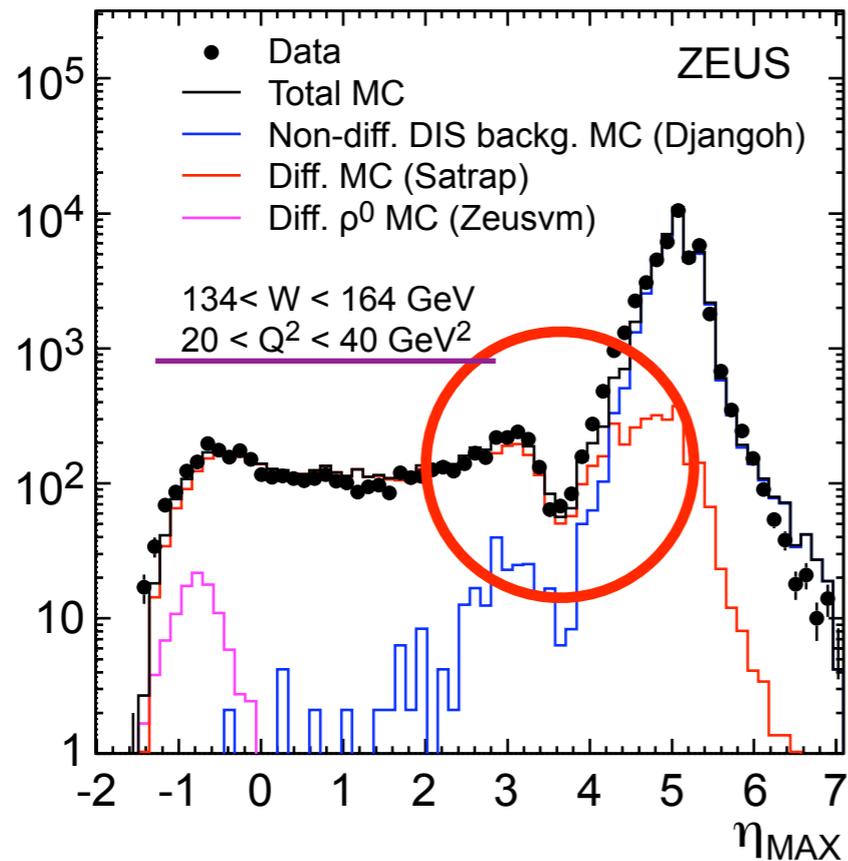
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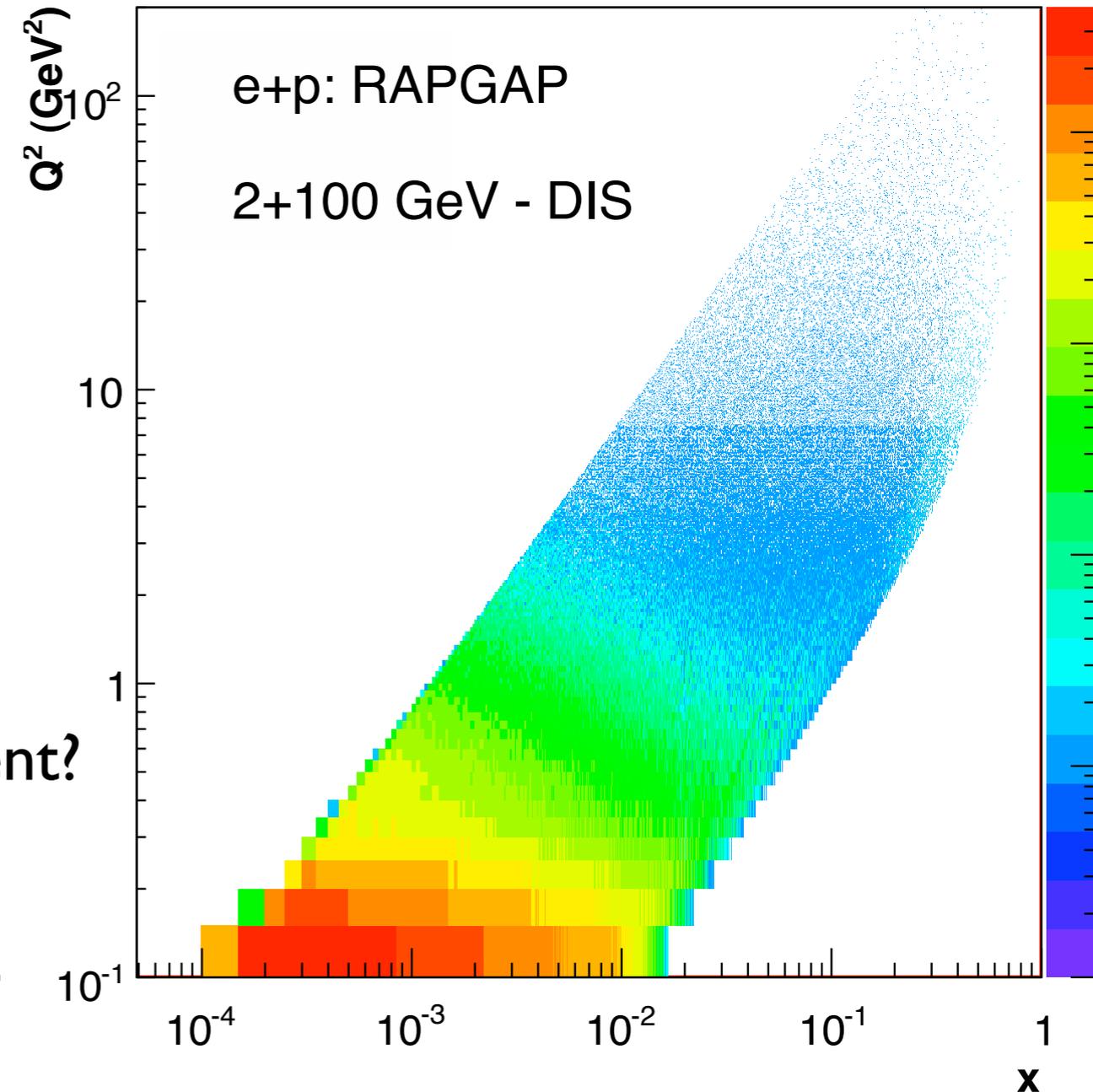
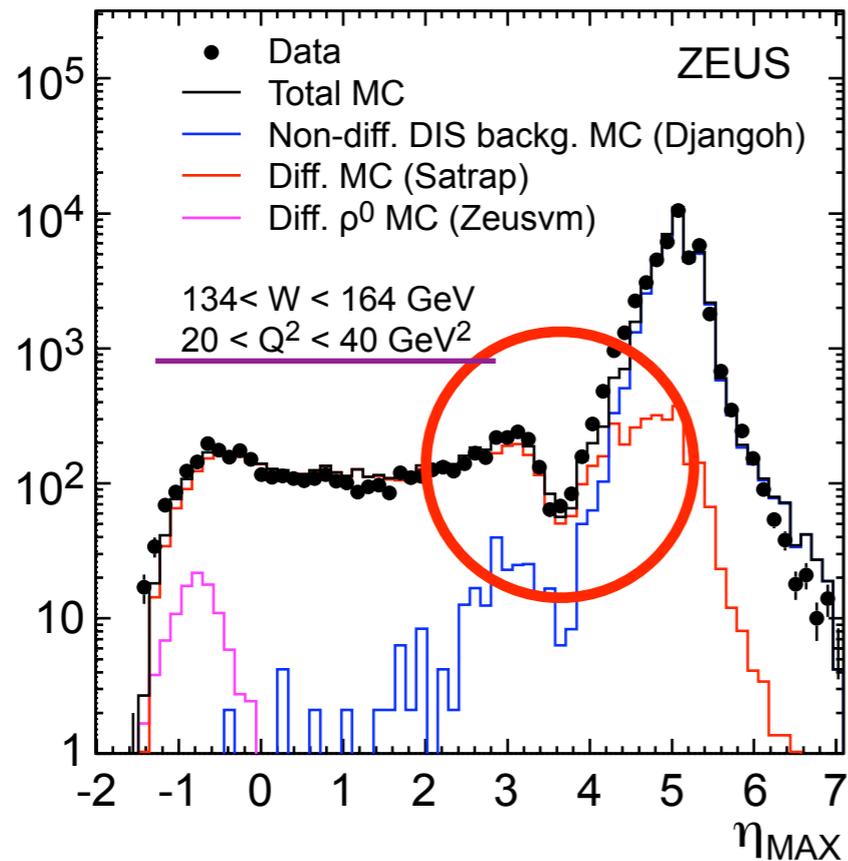
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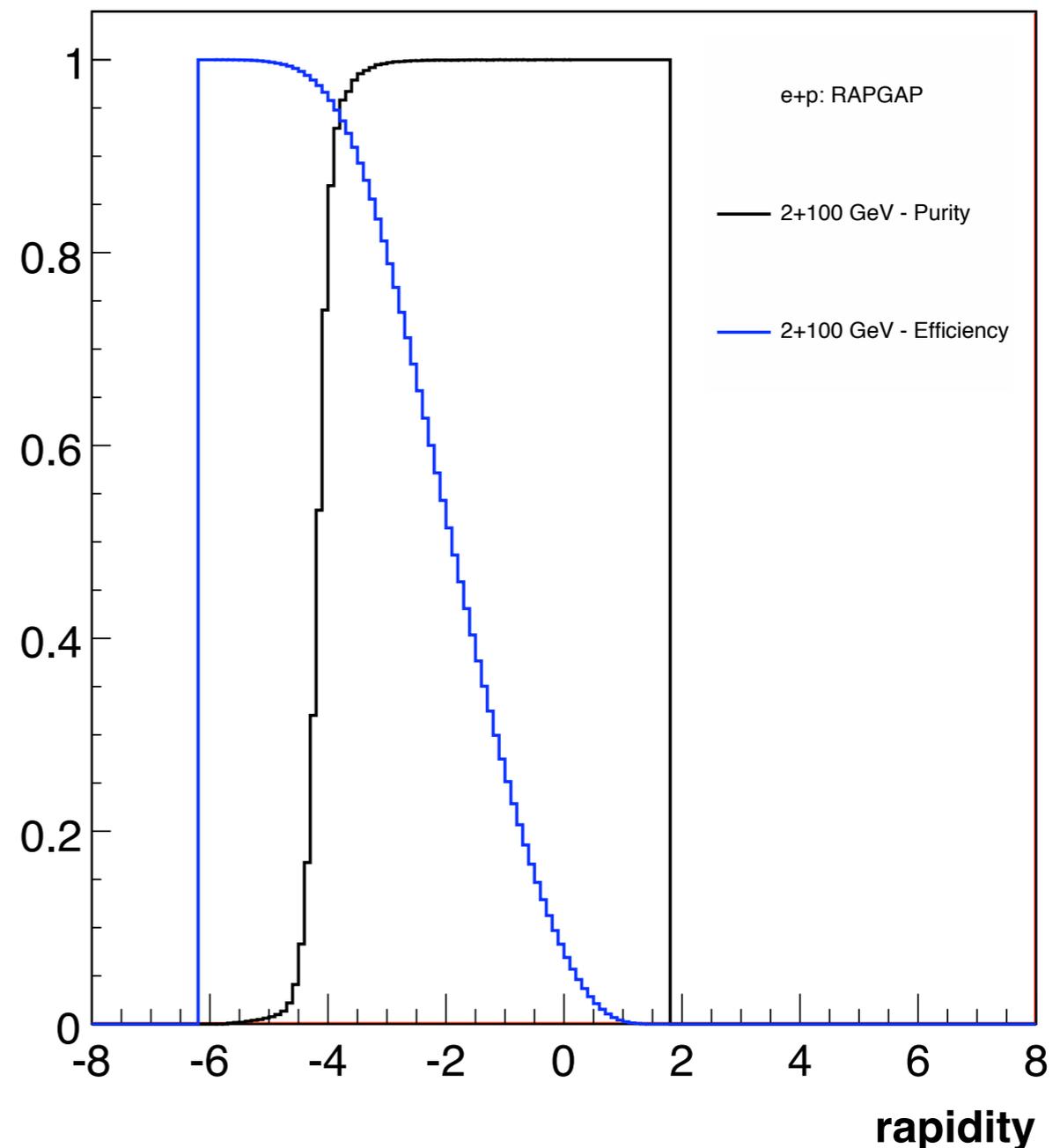
Efficiency vs Purity

- Although the separation of the rapidities looks good, this is best quantified by plotting the efficiency vs purity - a high efficiency and purity is most desirable

Efficiency: fraction of all
Diff events measured

Purity: fraction of Diff
events measured out of all
measured events (Diff
+DIS)

Integrated Distributions !!!!



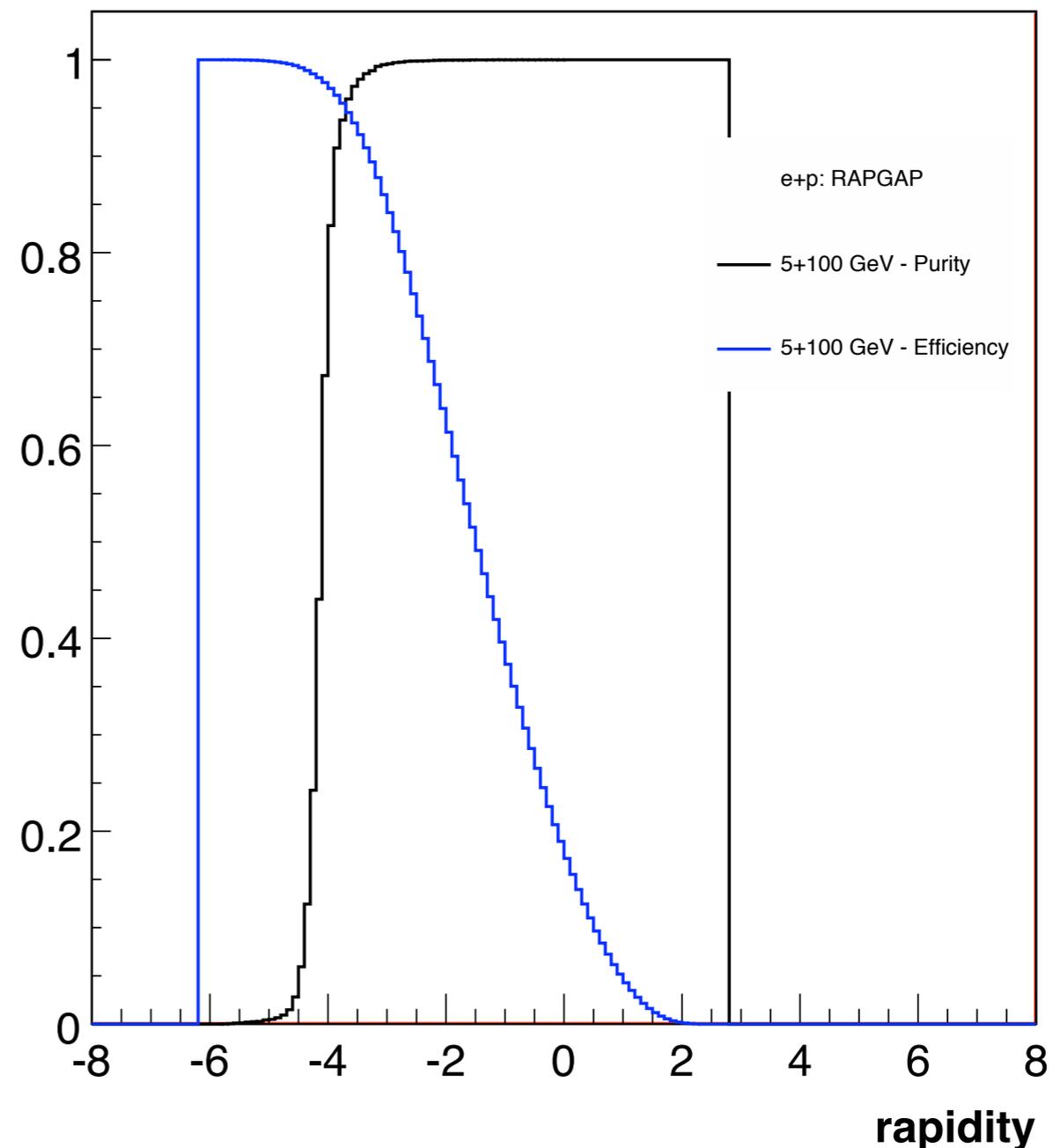
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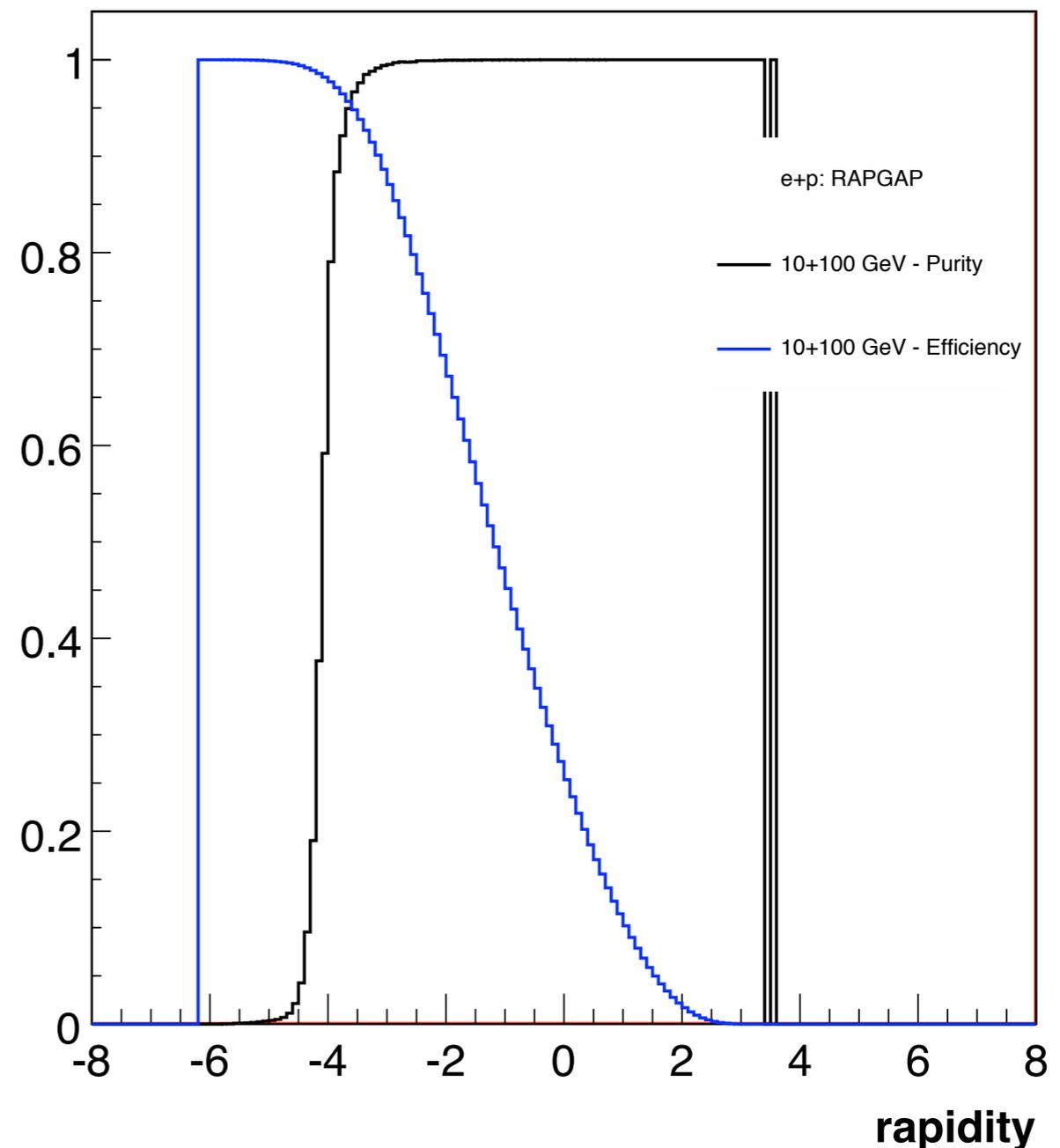
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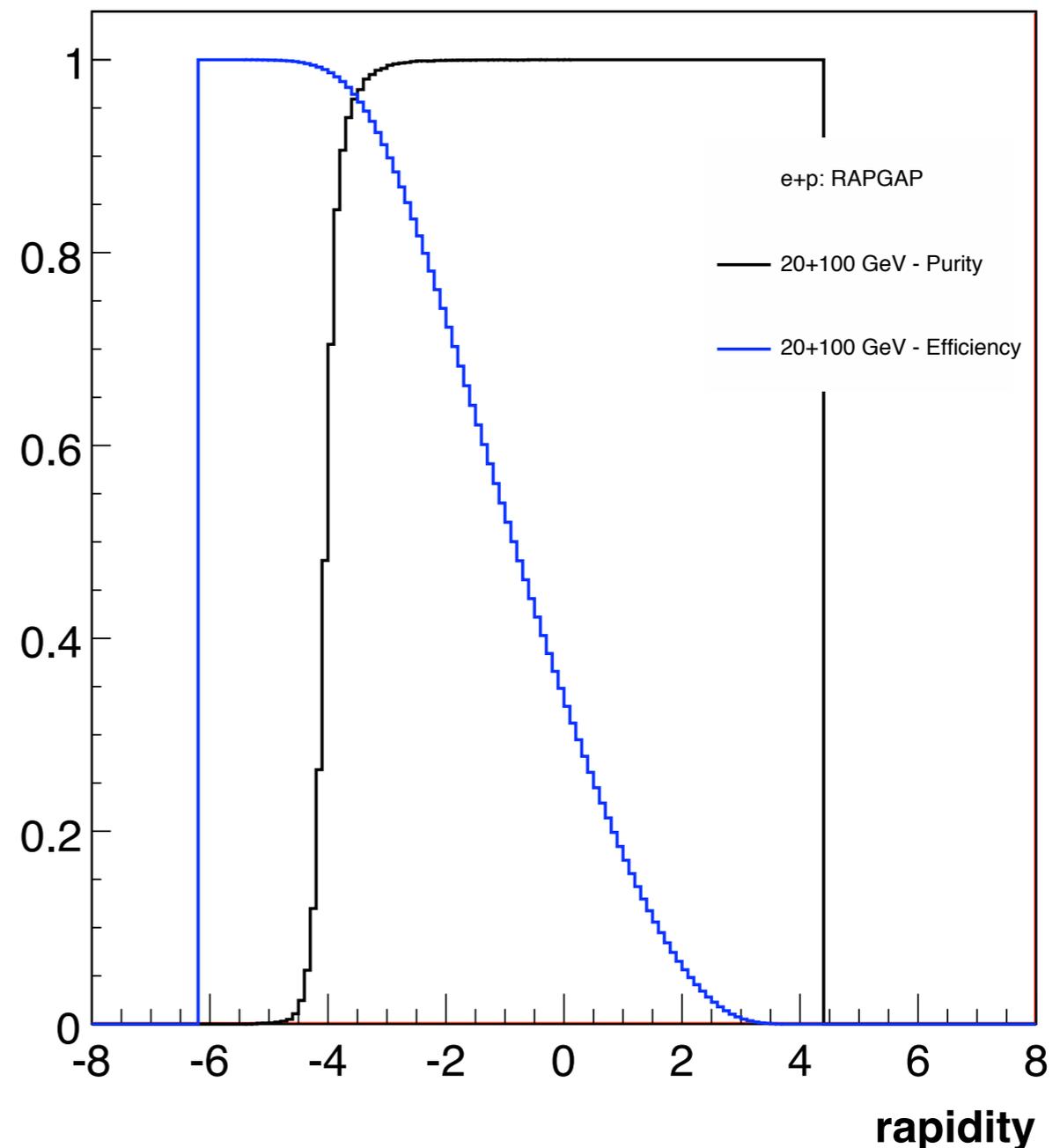
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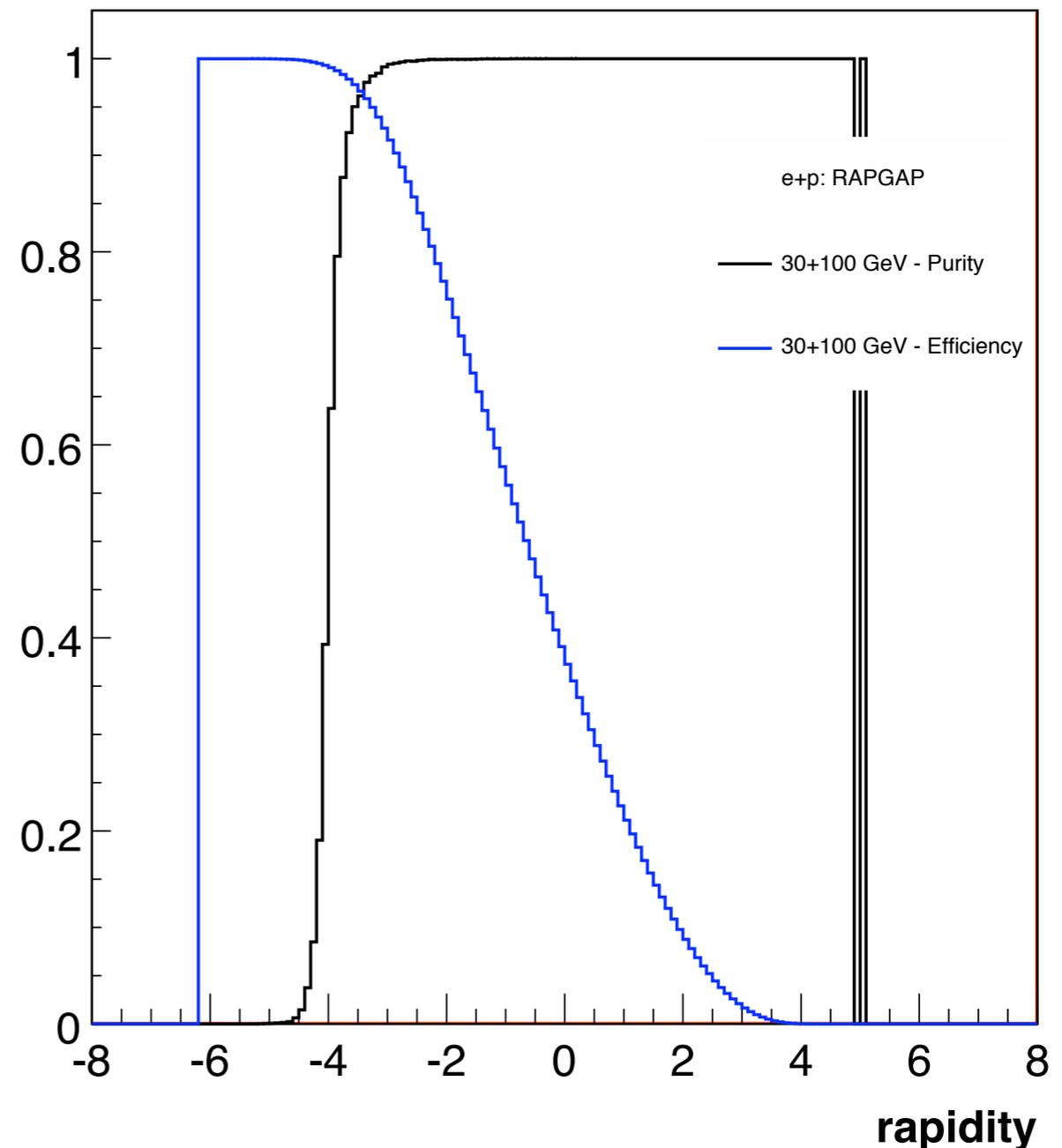
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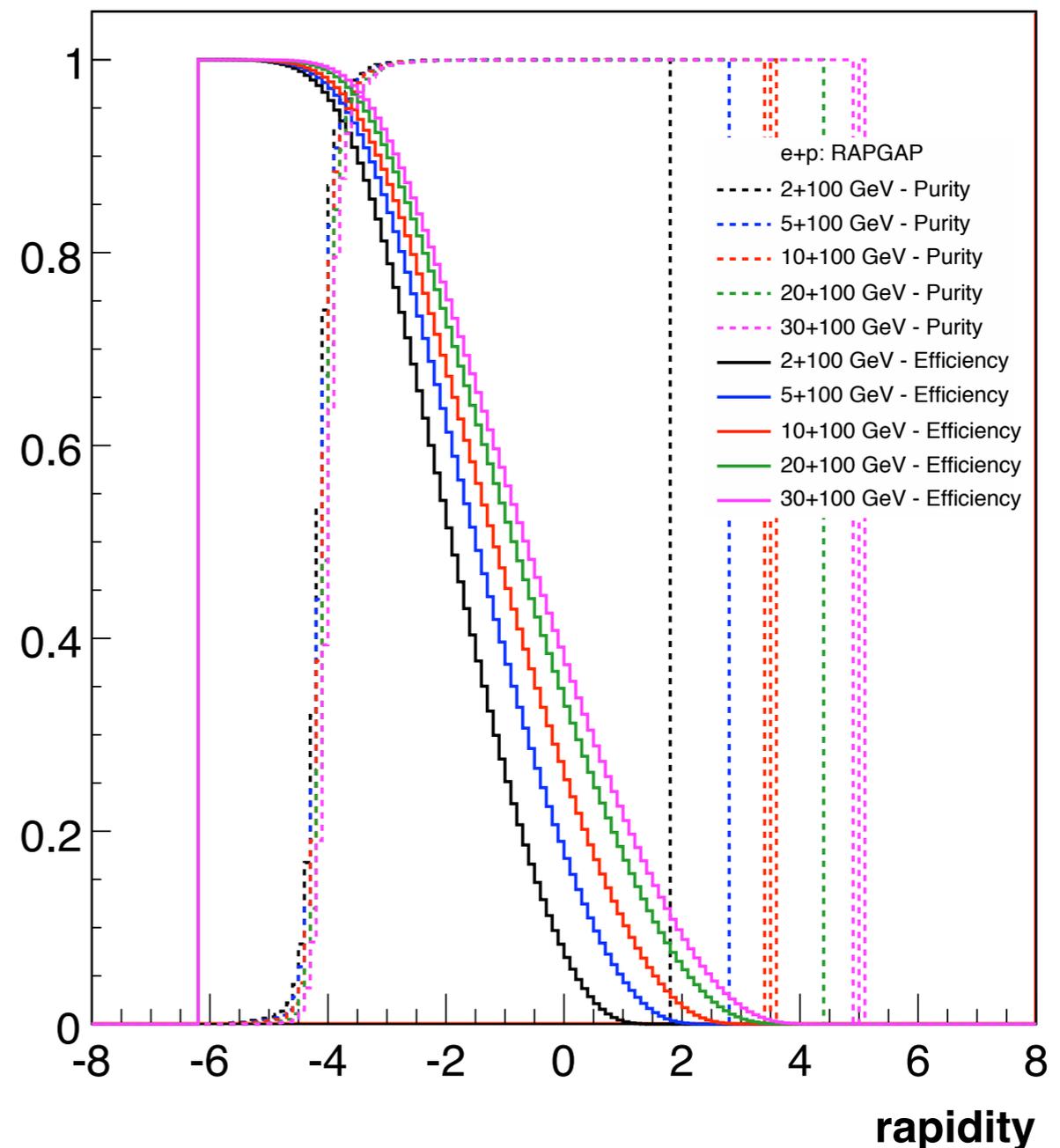
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Integrated Distributions !!!!



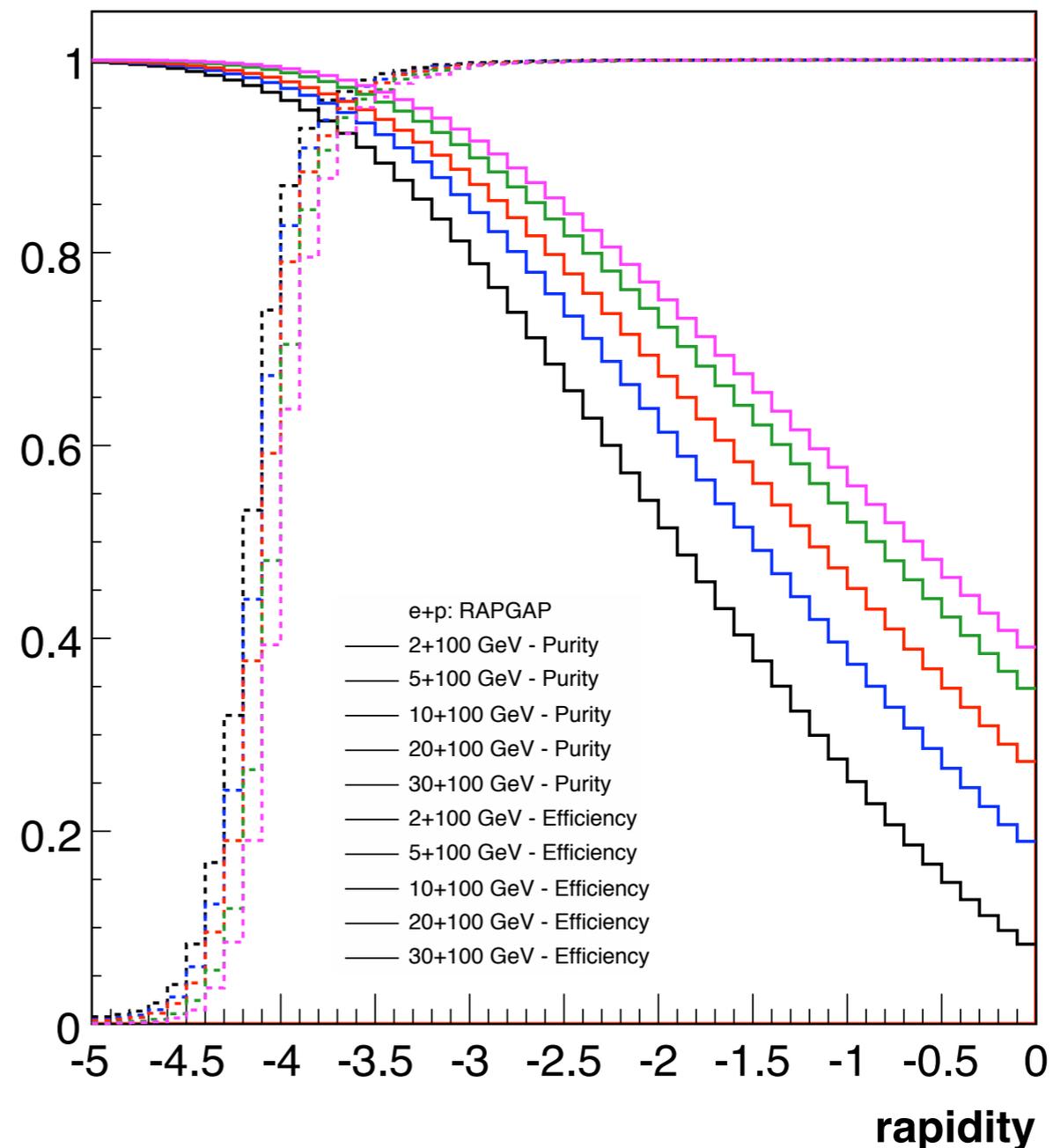
Efficiency vs Purity

- Although the separation of the rapidities looks good, this is best quantified by plotting the efficiency vs purity - a high efficiency and purity is most desirable

Efficiency: fraction of all
Diff events measured

Purity: fraction of Diff
events measured out of all
measured events (Diff
+DIS)

Integrated Distributions !!!!



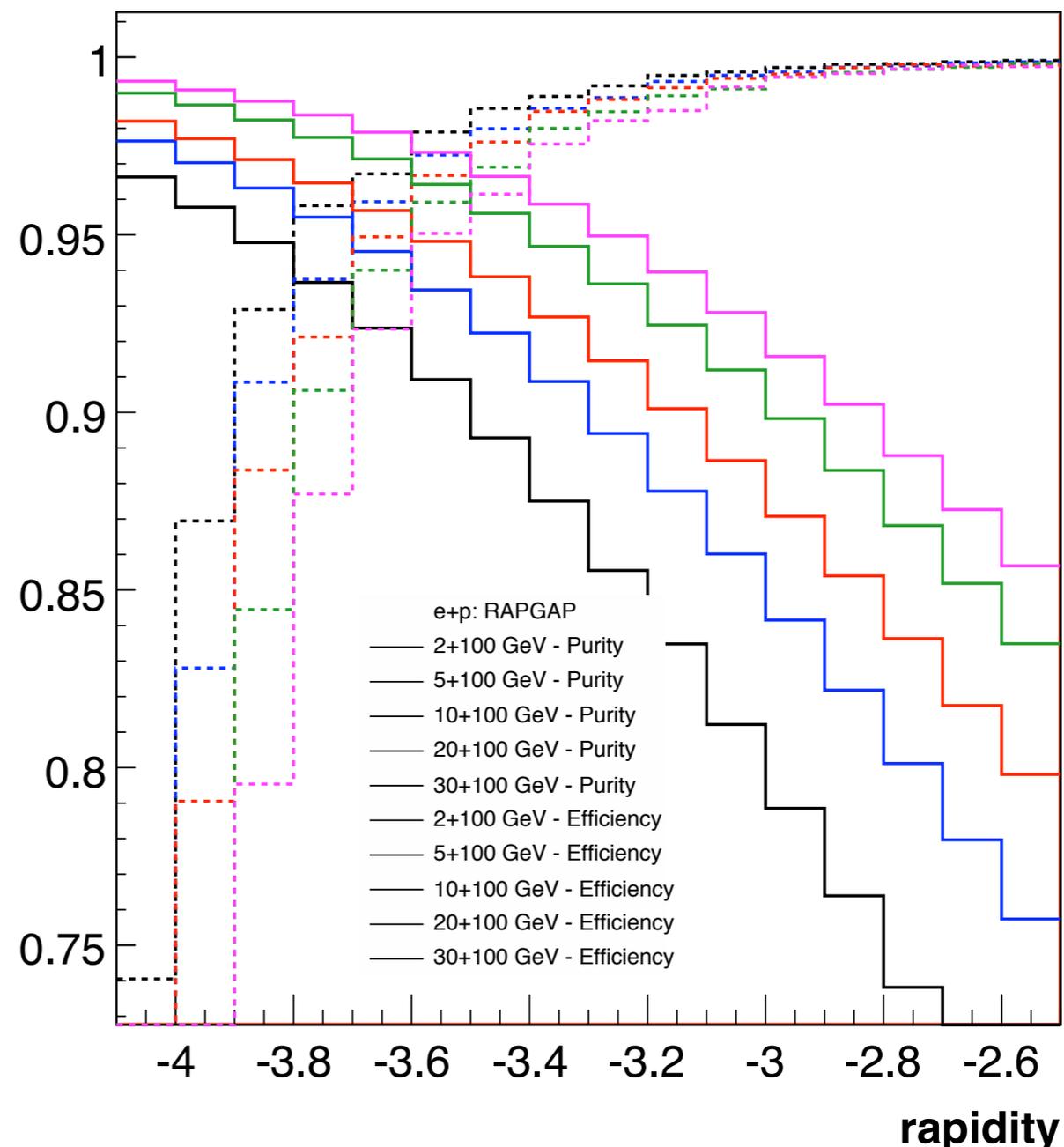
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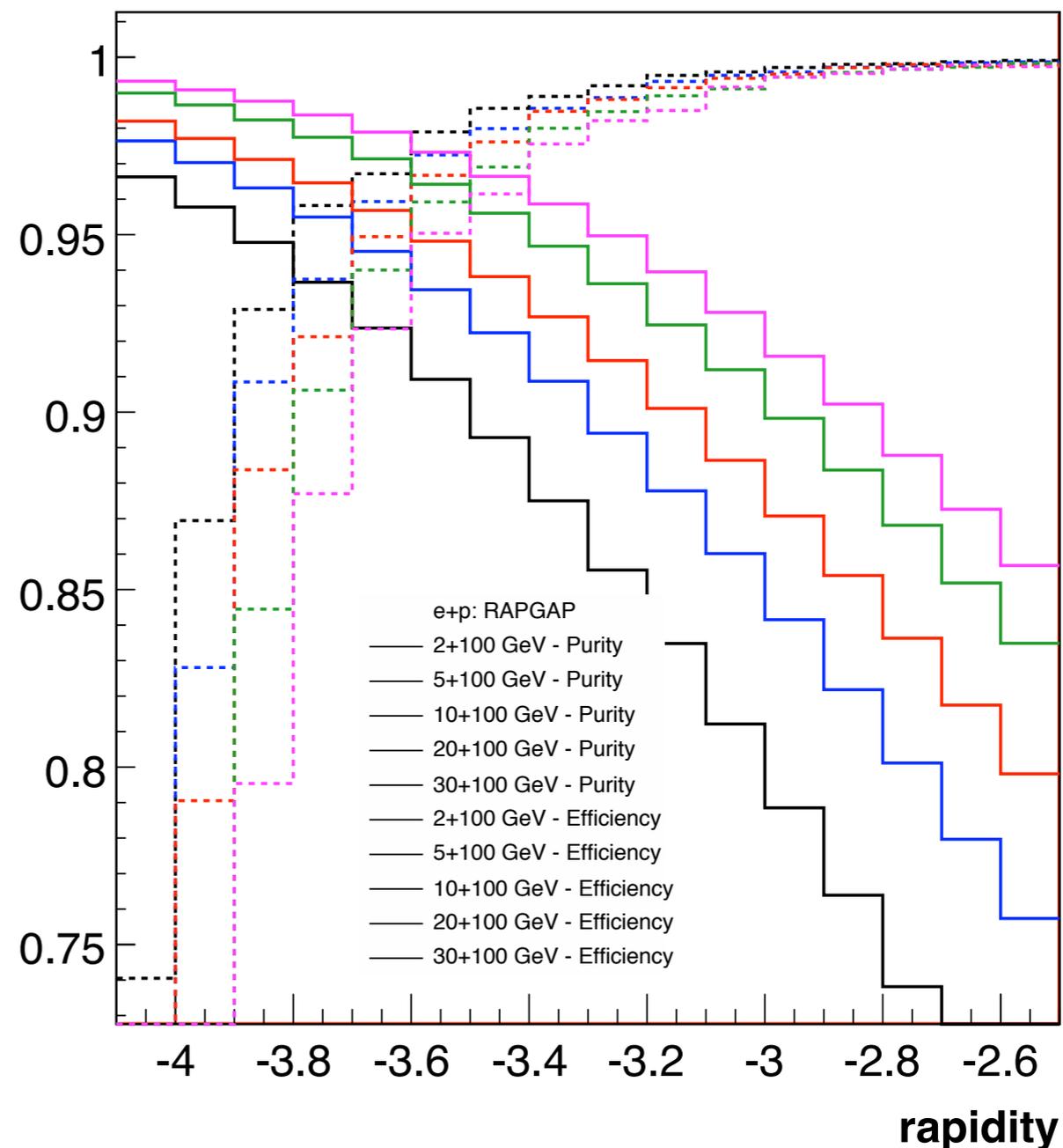
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events measured out of all
measured events (Diff
+DIS)

As expected from earlier
plots, the efficiency and
purity get better with
increasing energy

Integrated Distributions !!!!



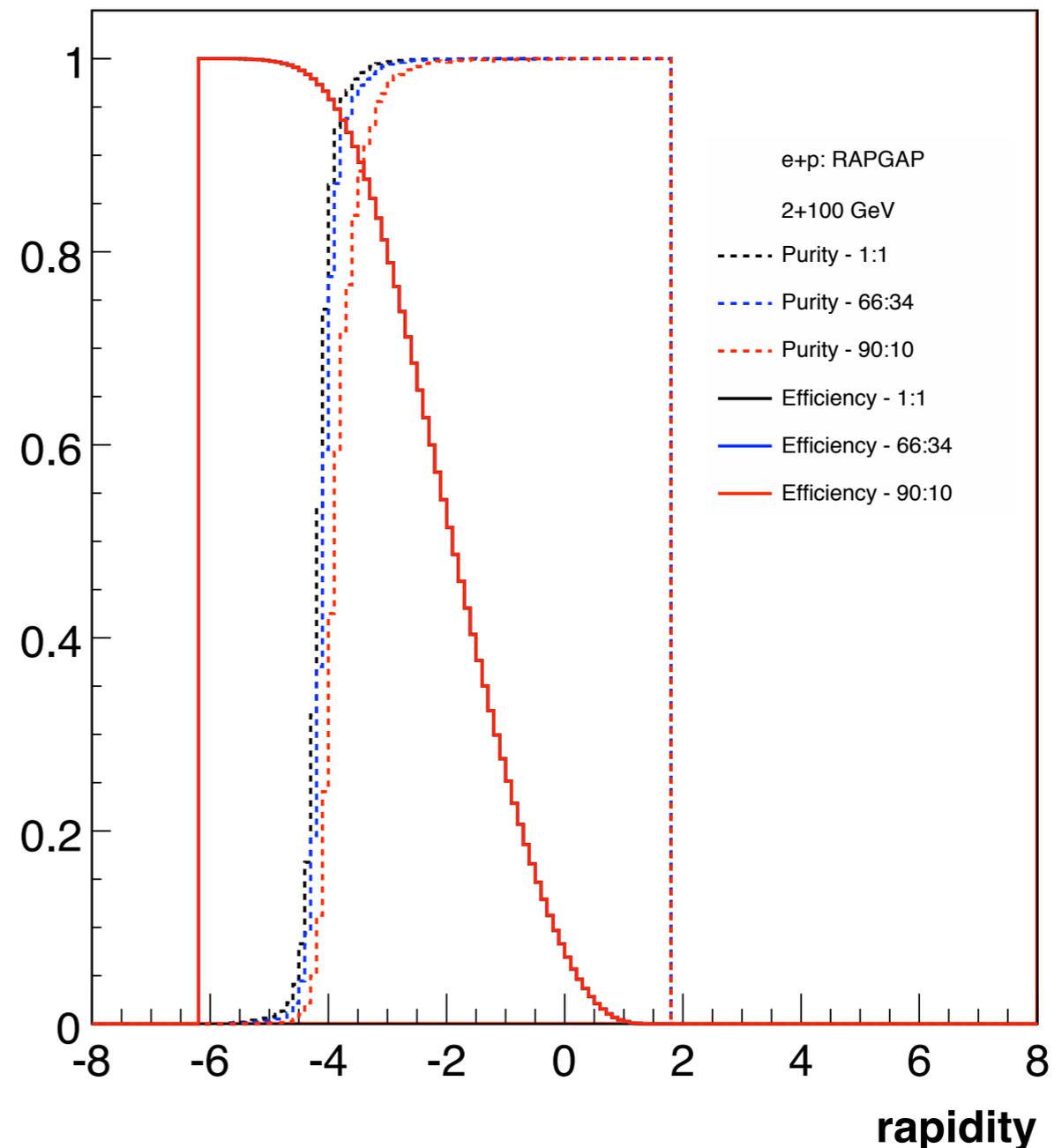
Efficiency vs Purity

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Integrated Distributions !!!!



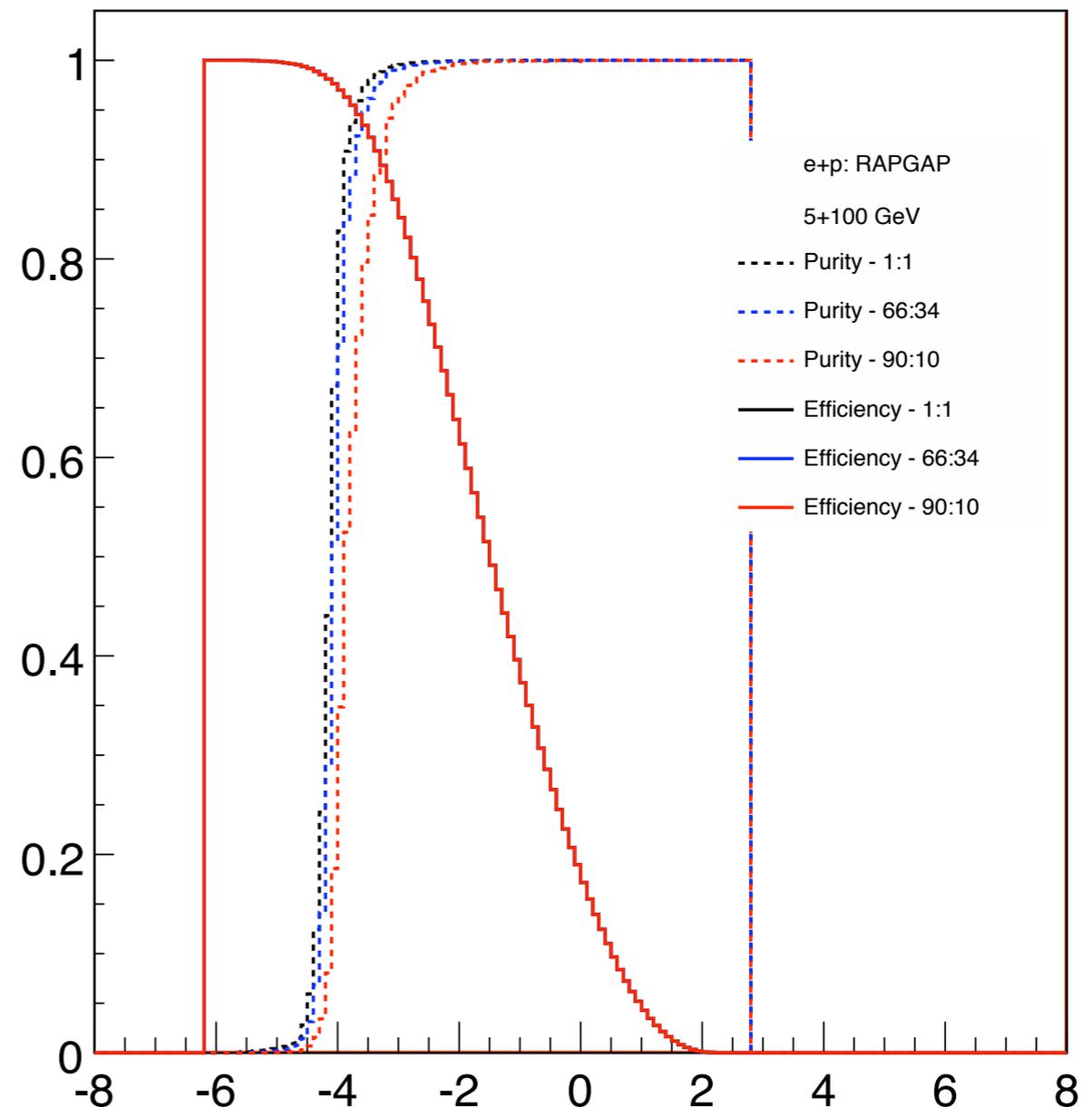
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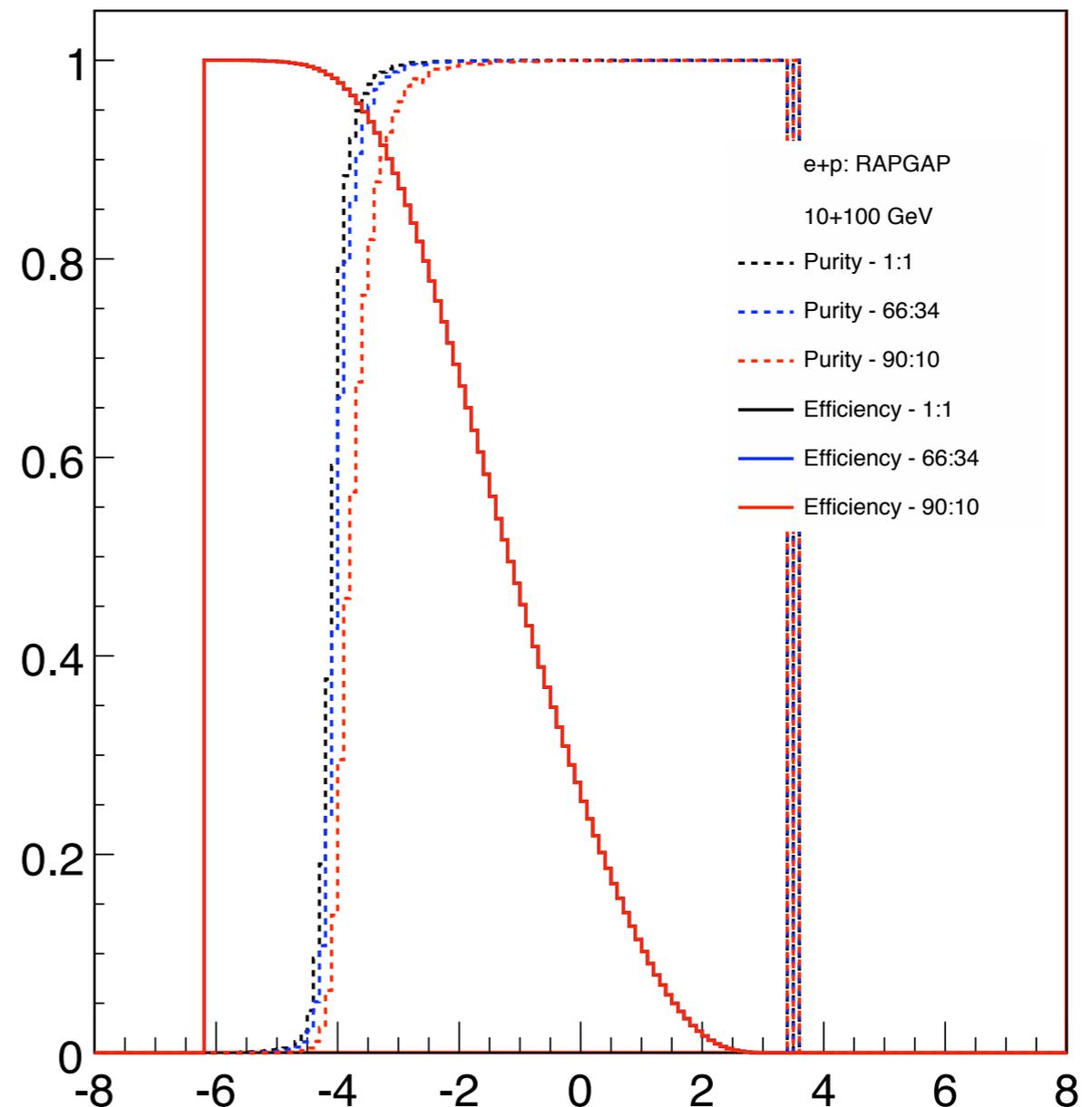
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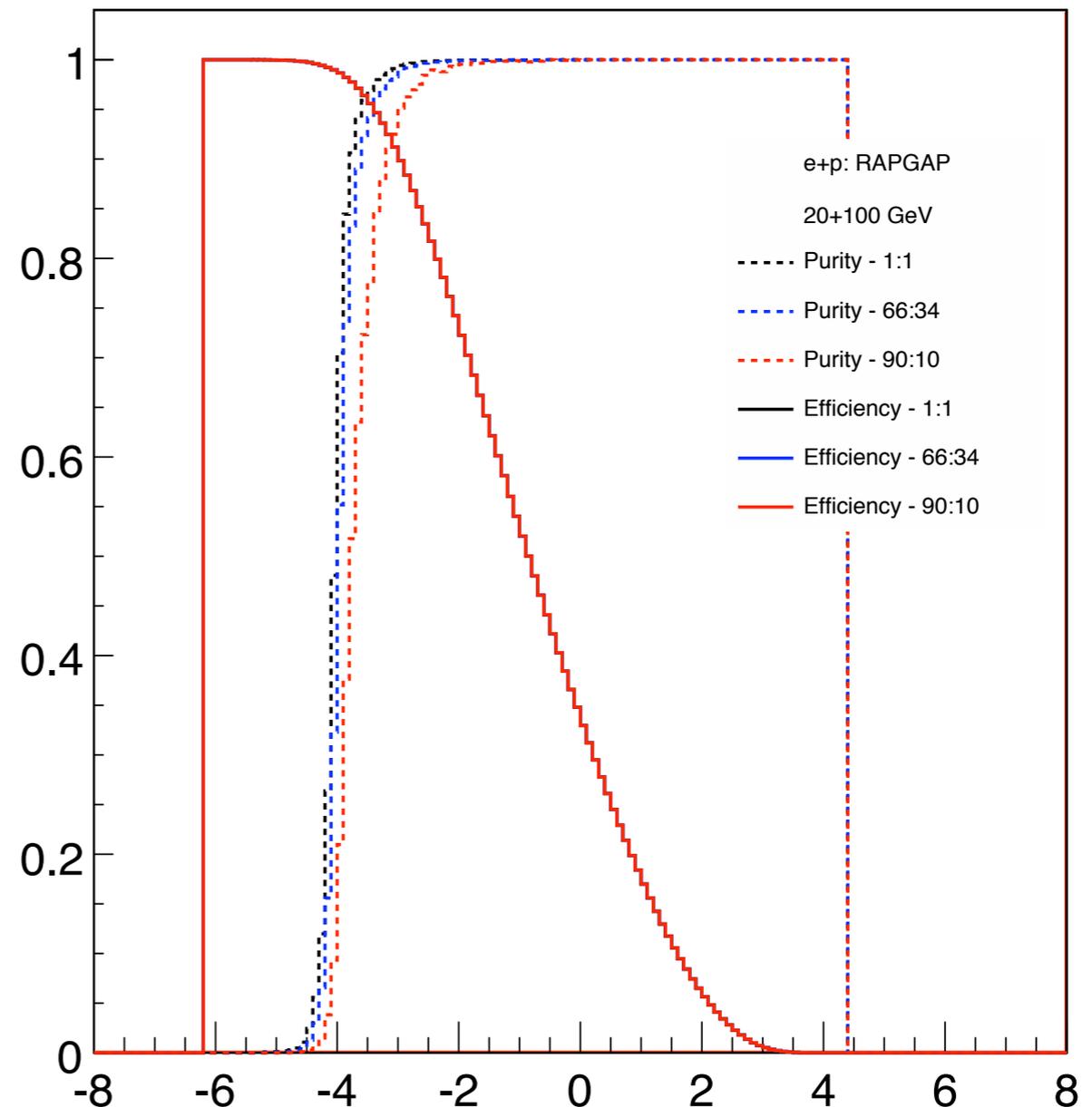
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Integrated Distributions !!!!



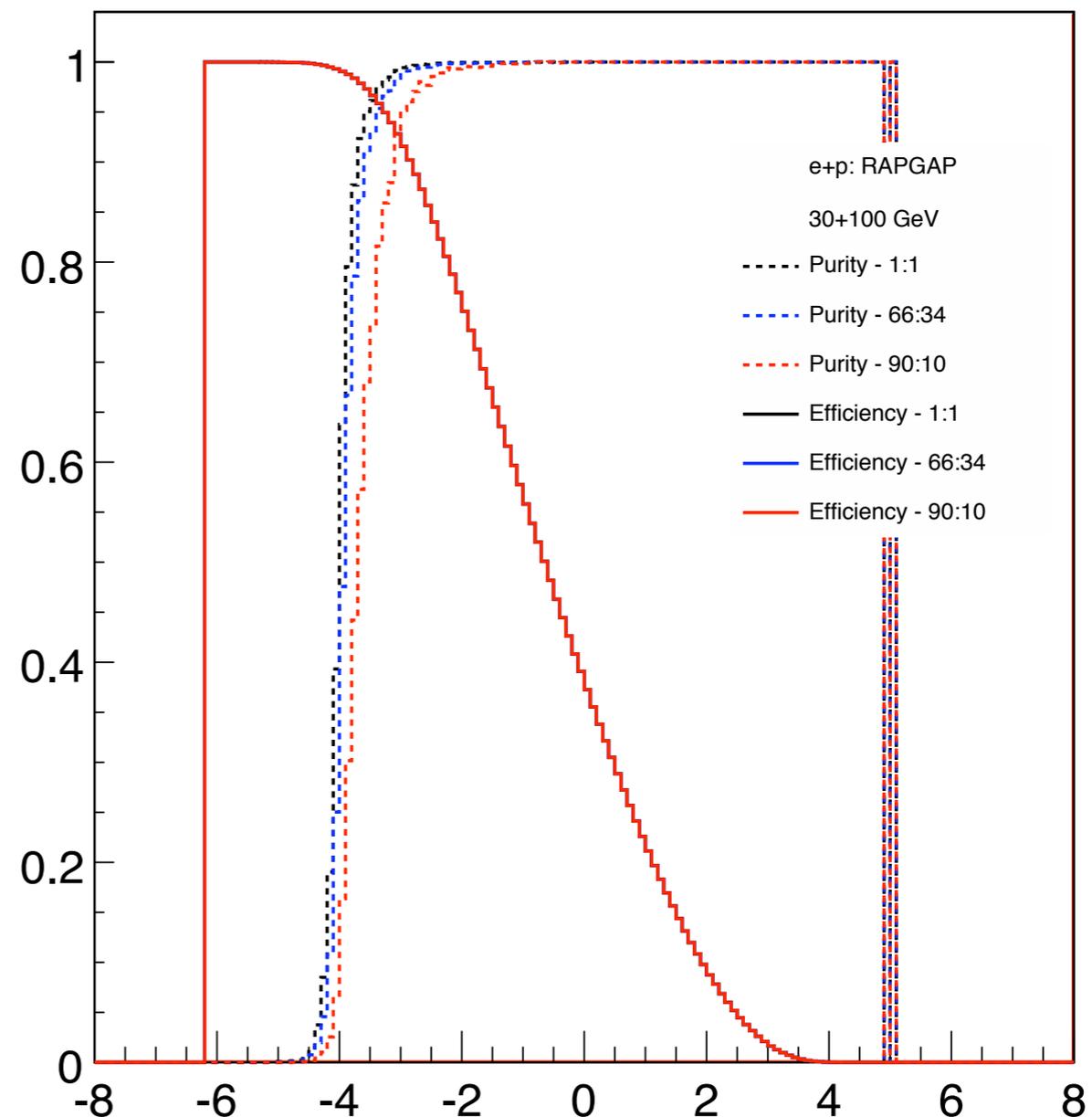
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Integrated Distributions !!!!



Efficiency vs Purity

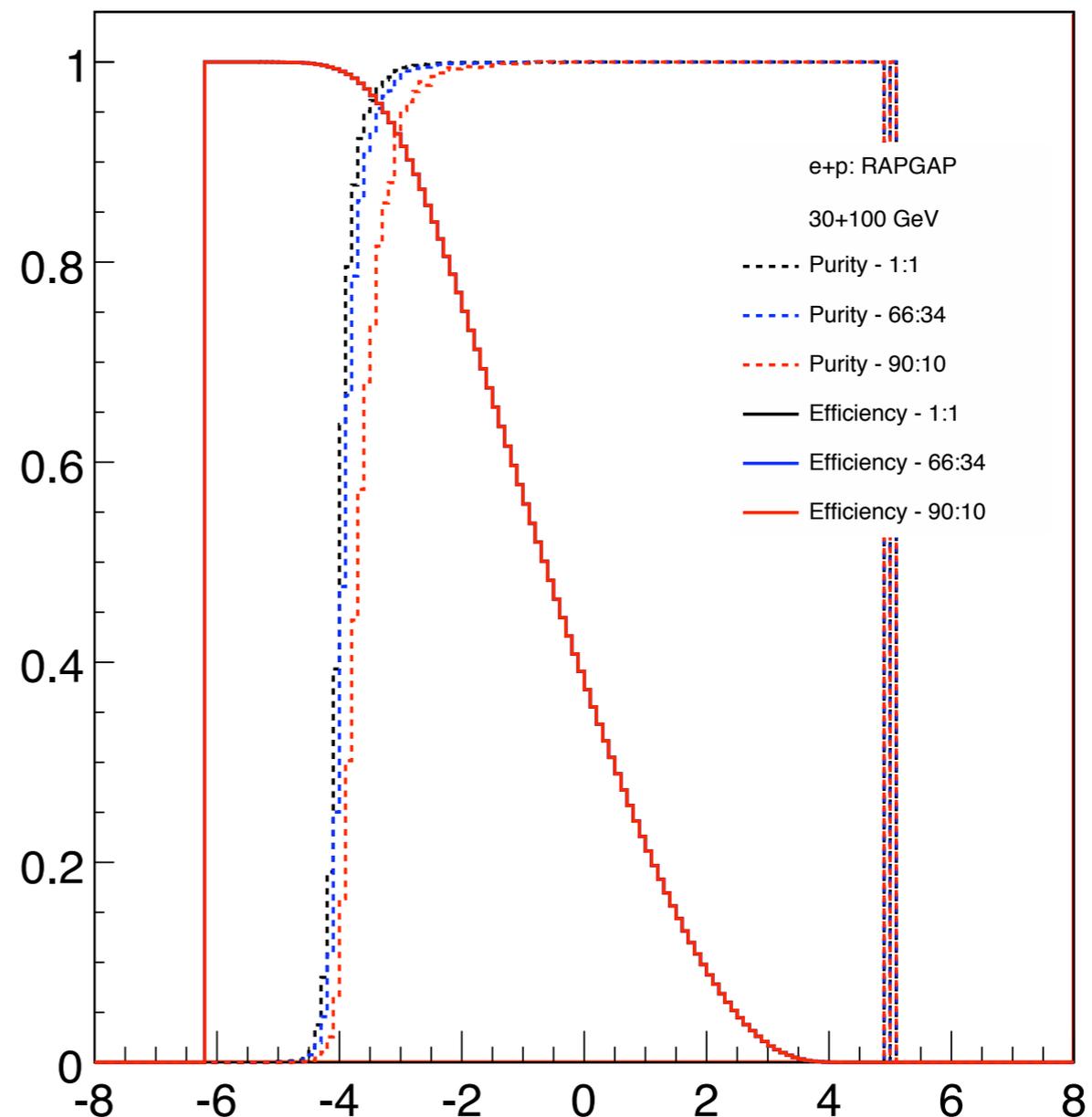
- However, these plots are assuming that the ratio of inclusive DIS to Diffractive events is 1:1. If we again change this ratio, we get the following distributions:

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Diff events measured

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measured events (Diff
+DIS)

As expected, the efficiency
and purity depend strongly
on the ratio, but it is still
acceptable

Integrated Distributions !!!!



The need for a large acceptance

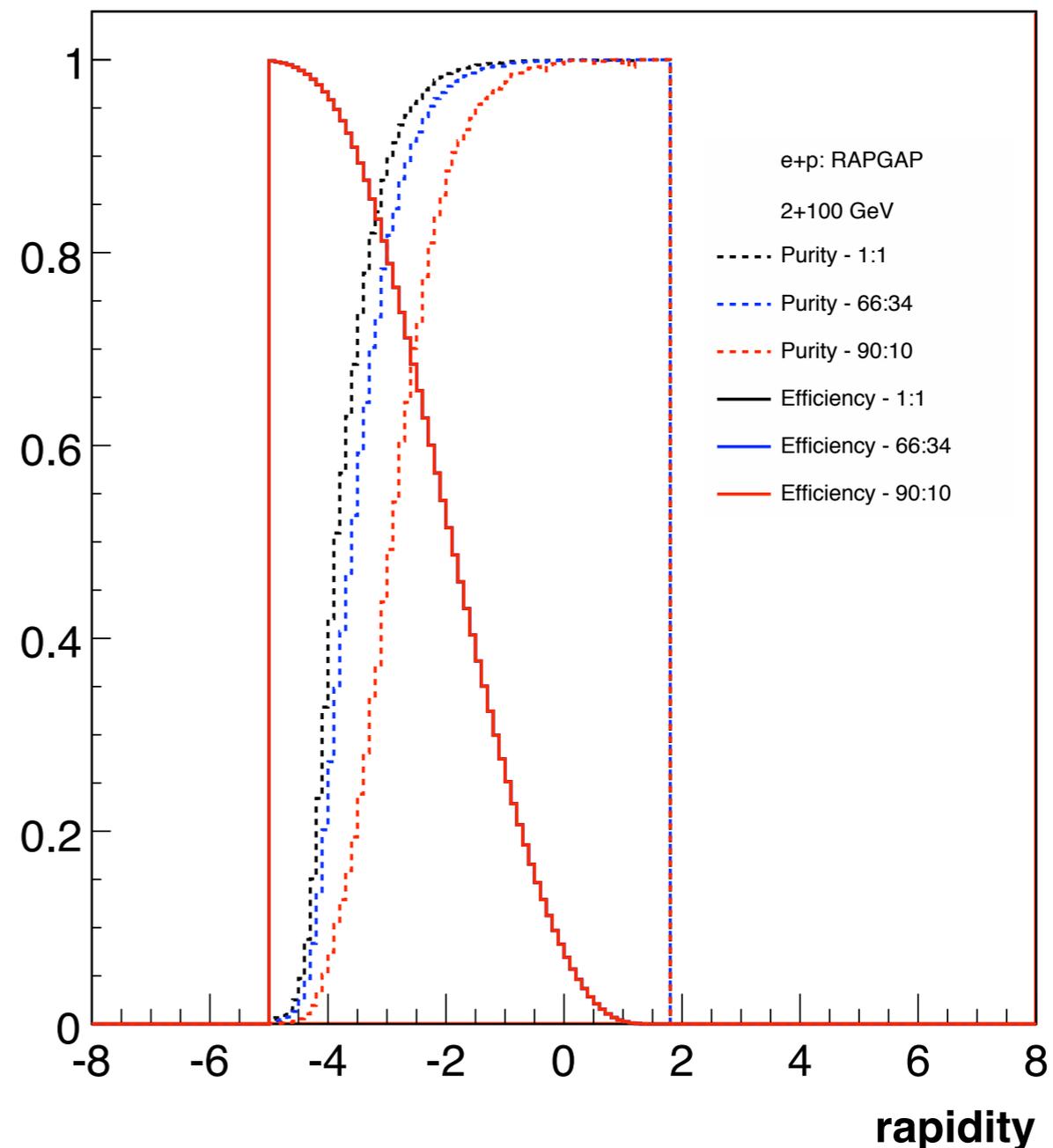
- These plots are assuming that we have full acceptance coverage in our detector. Things change rapidly if we even have a small amount of missing acceptance.

Efficiency: fraction of all ~ 1.2 units of rapidity acceptance missing

Diff events measured

Purity: fraction of Diff events measured out of all measured events (Diff + DIS)

Even with a small amount of rapidity missing, the Purity:Efficiency ratio falls off dramatically !!!!



The need for a large acceptance

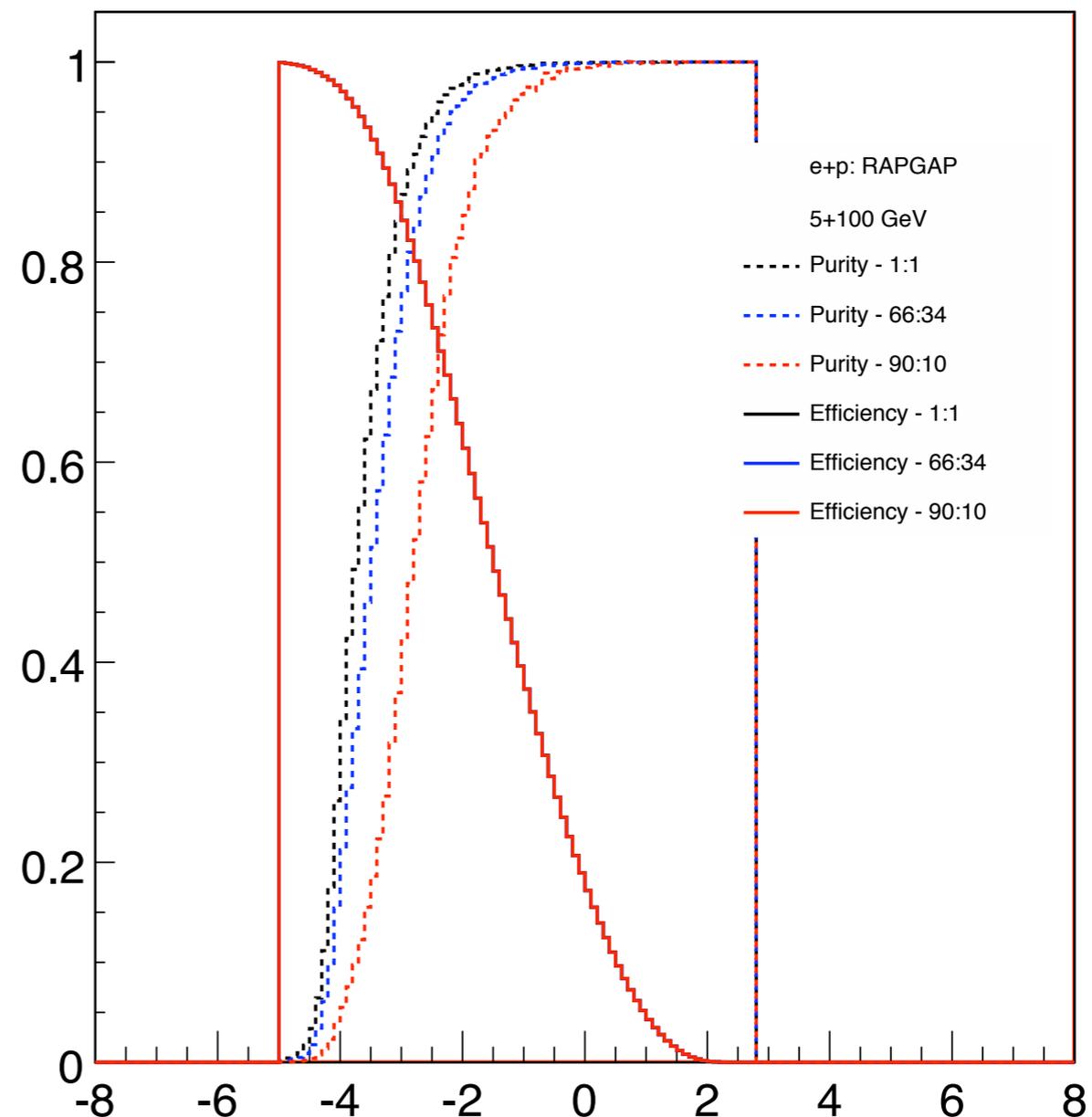
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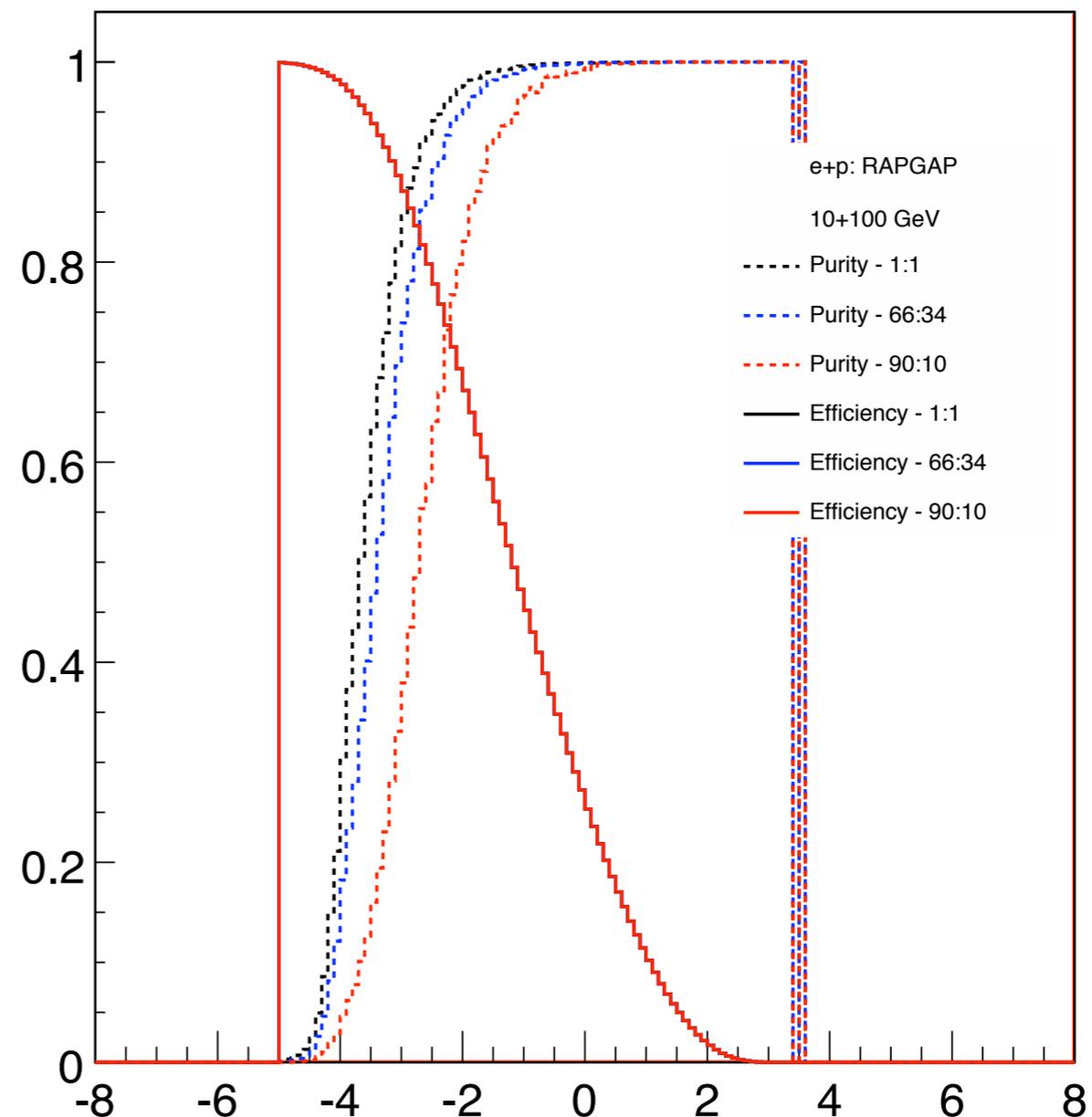
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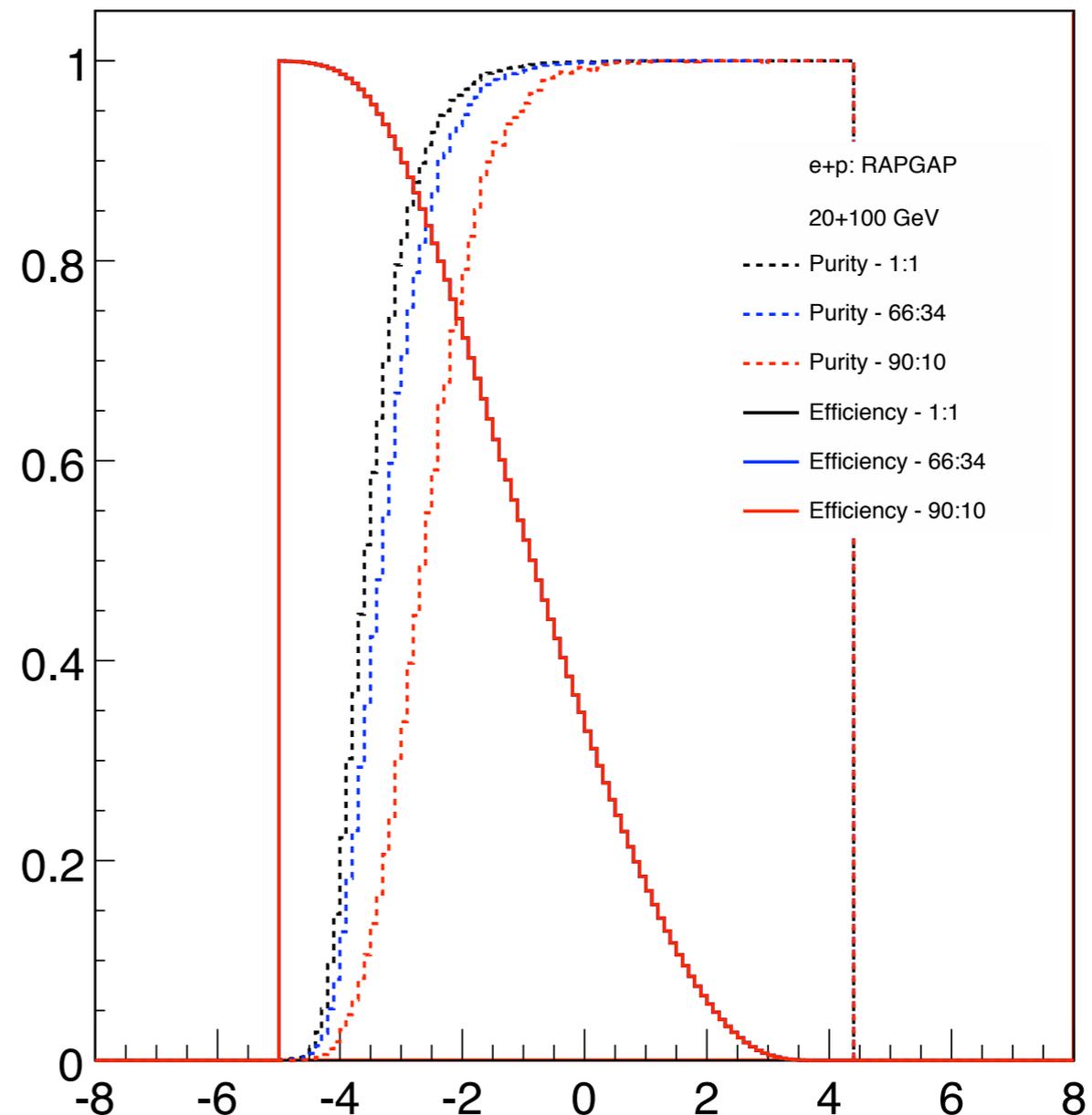
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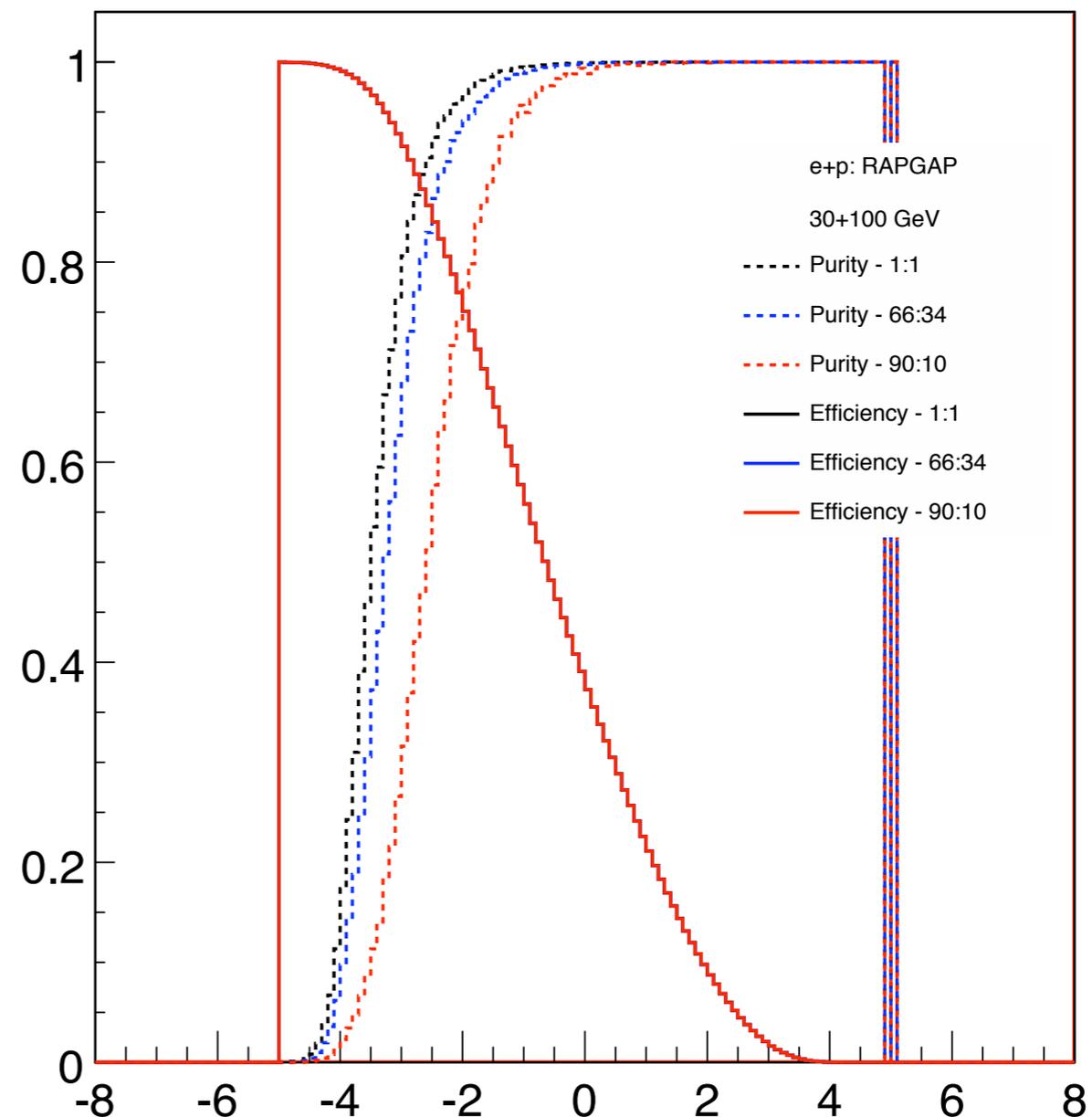
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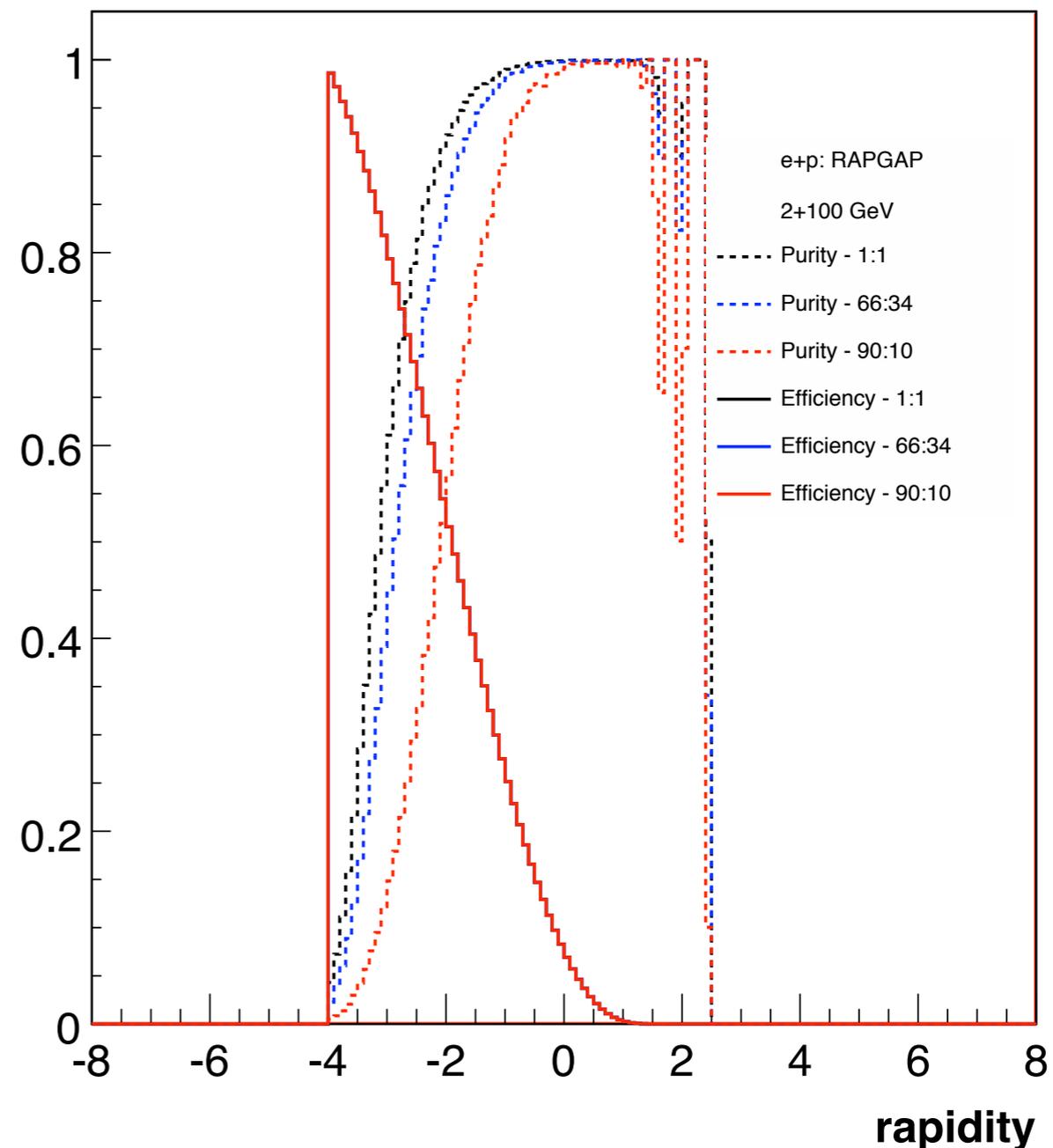
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Efficiency: fraction of all ~ 2.2 units of rapidity acceptance missing

Diff events measured

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The need for a large acceptance

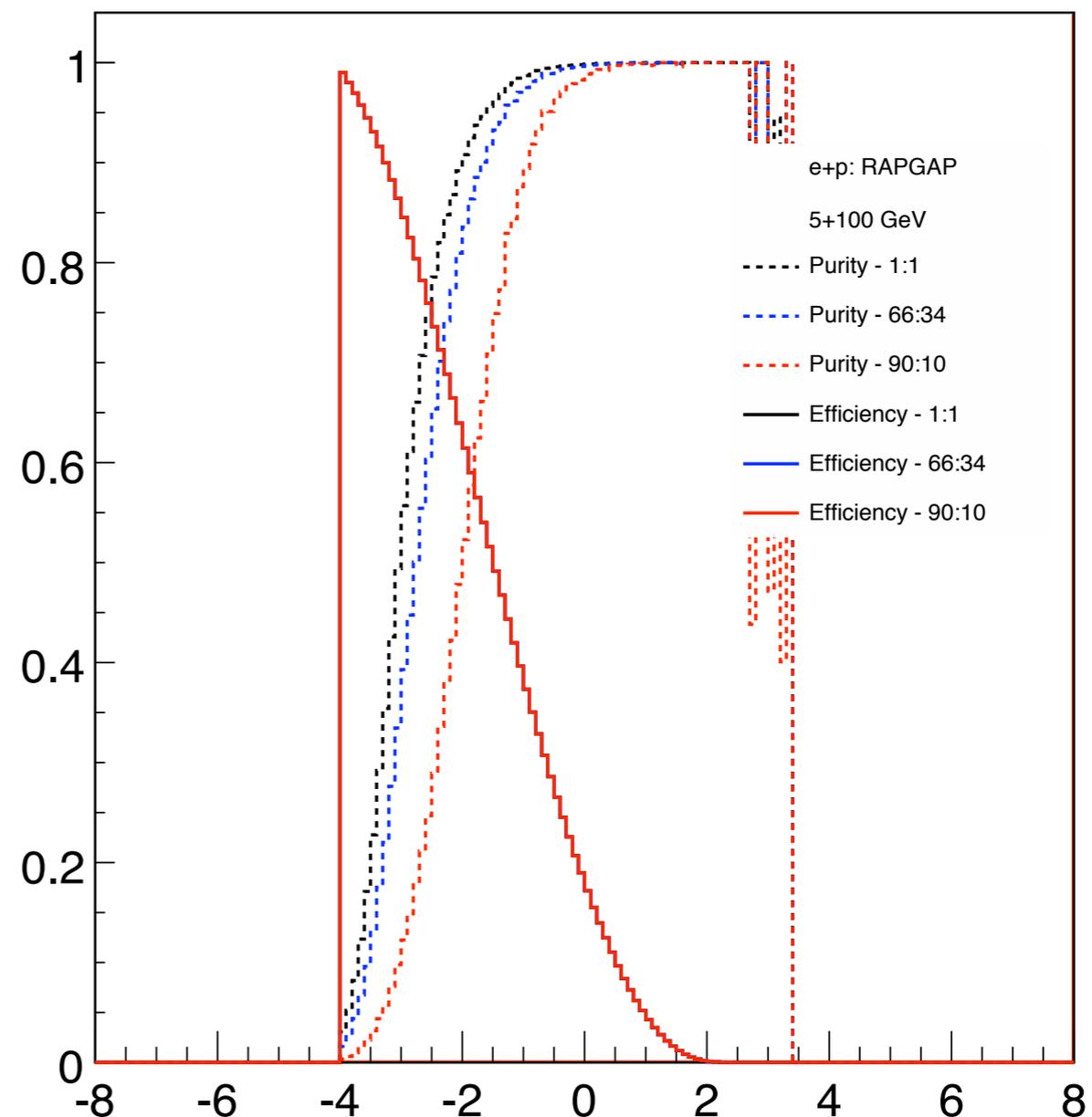
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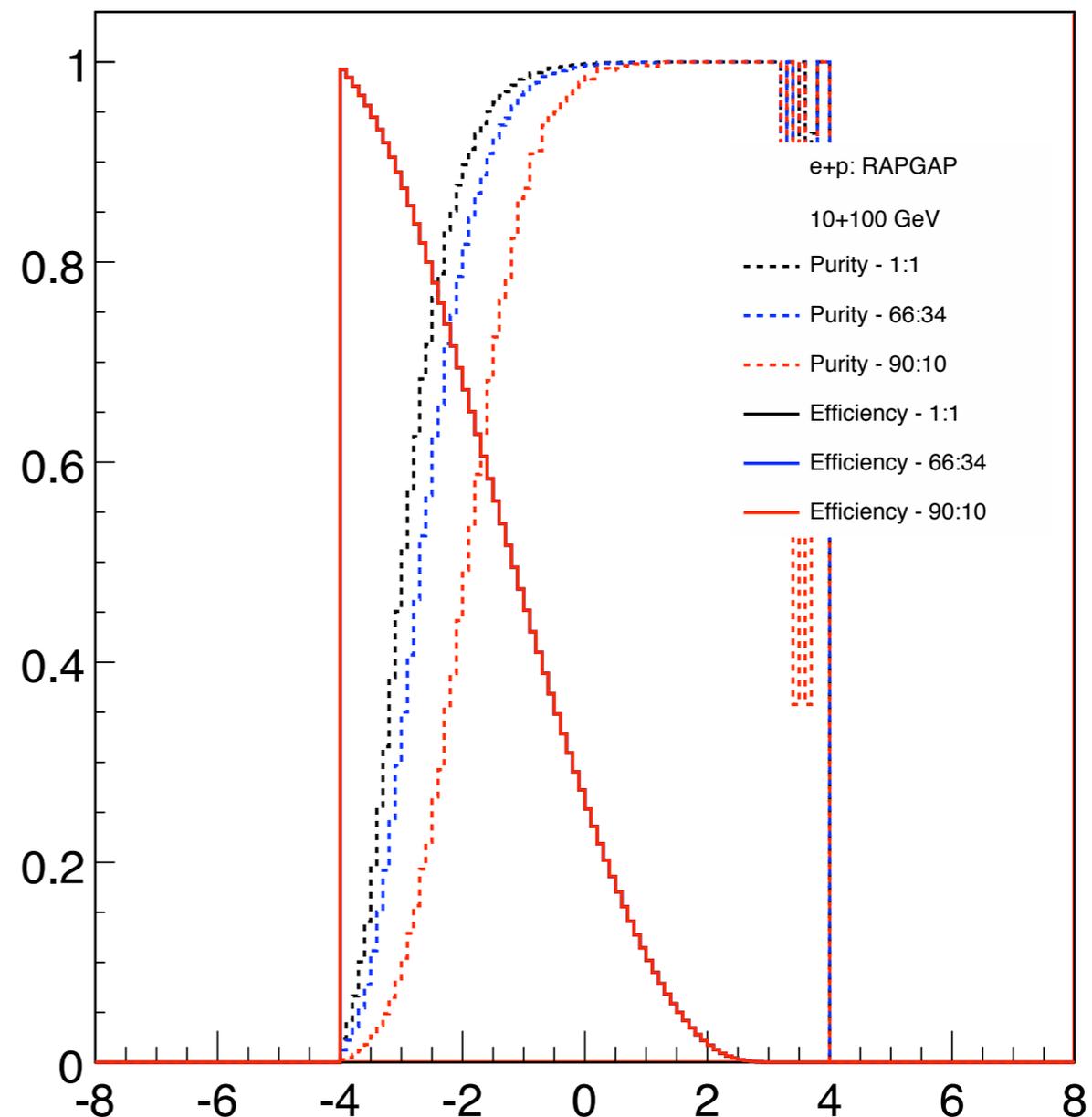
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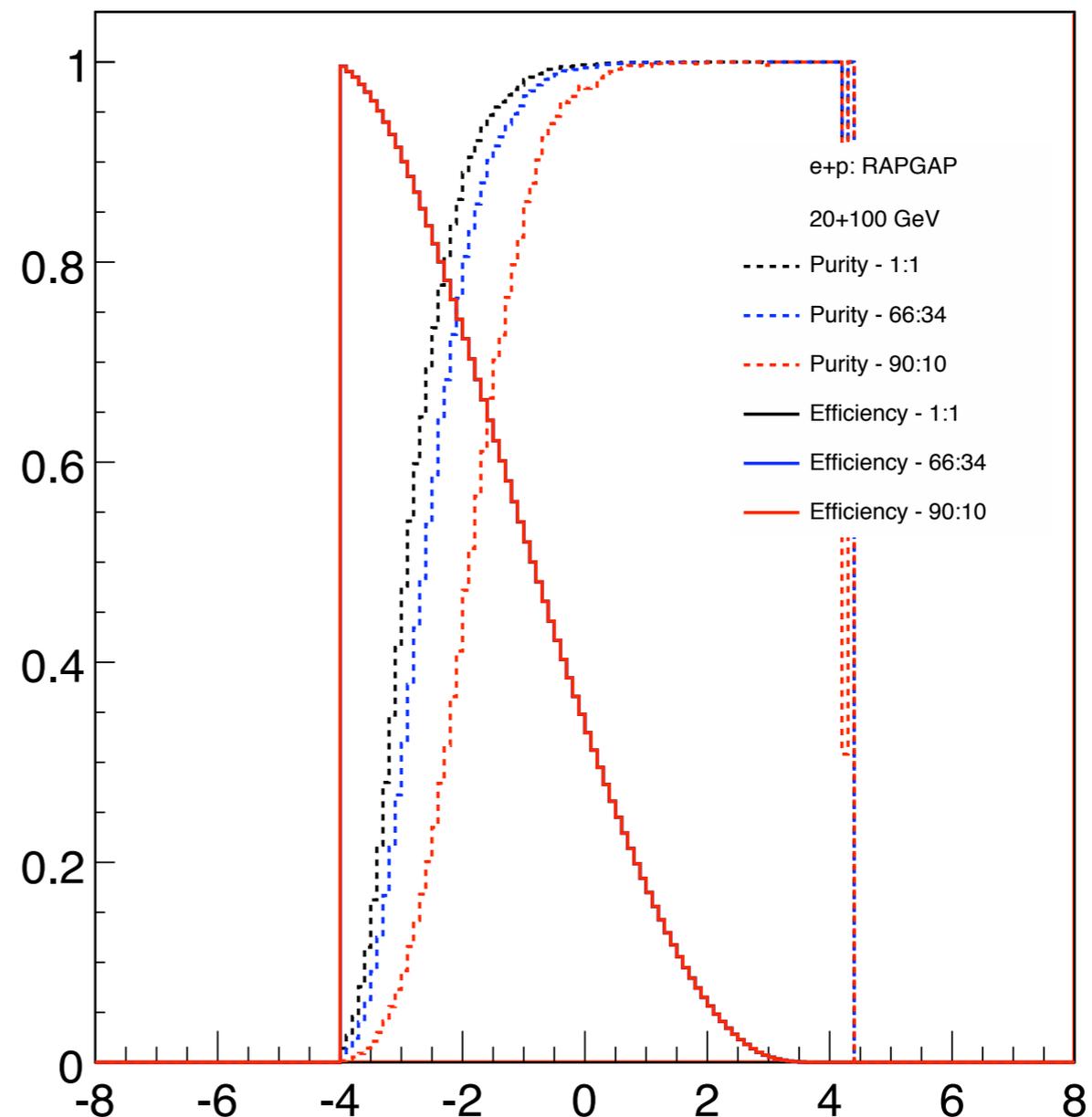
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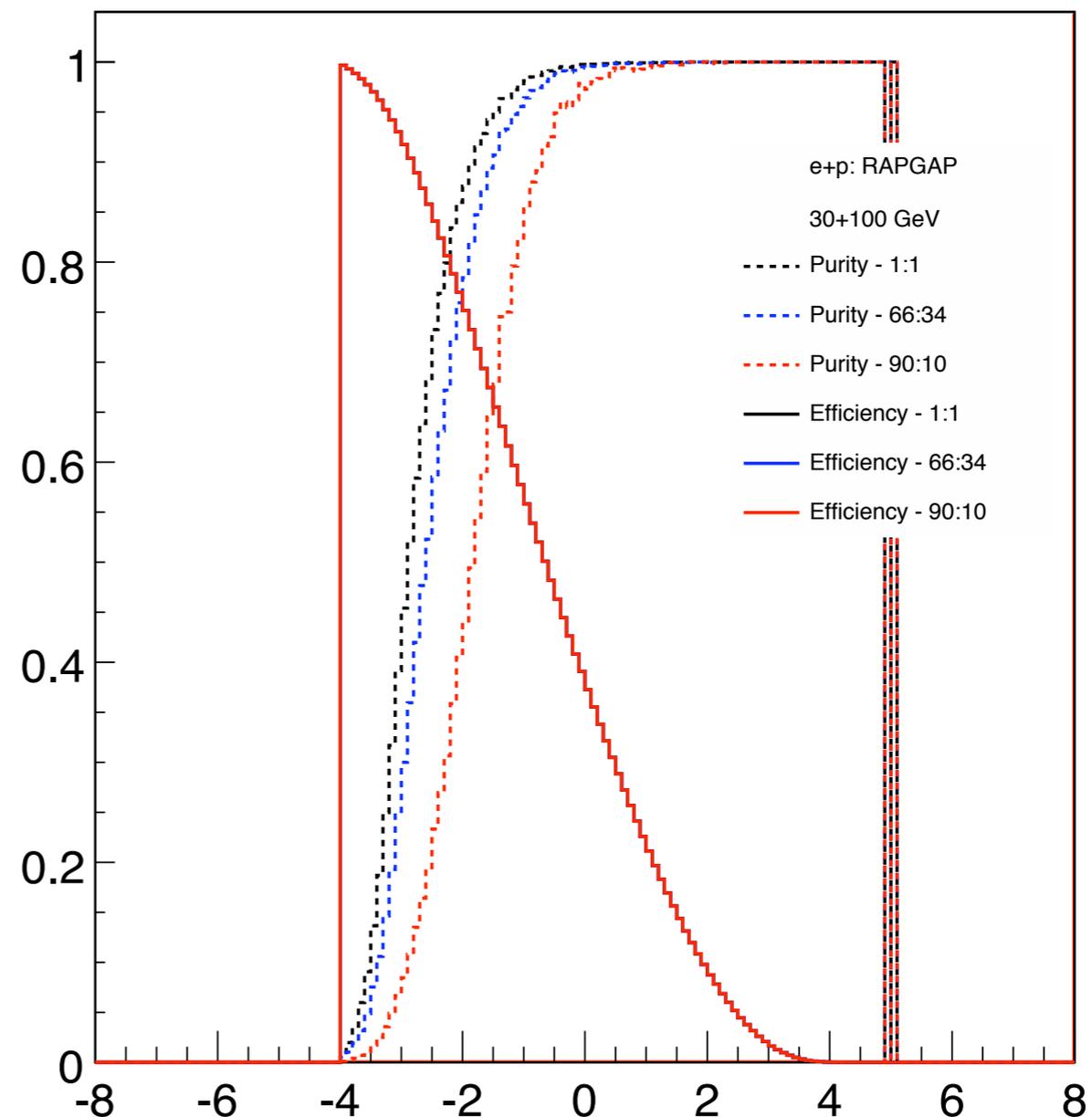
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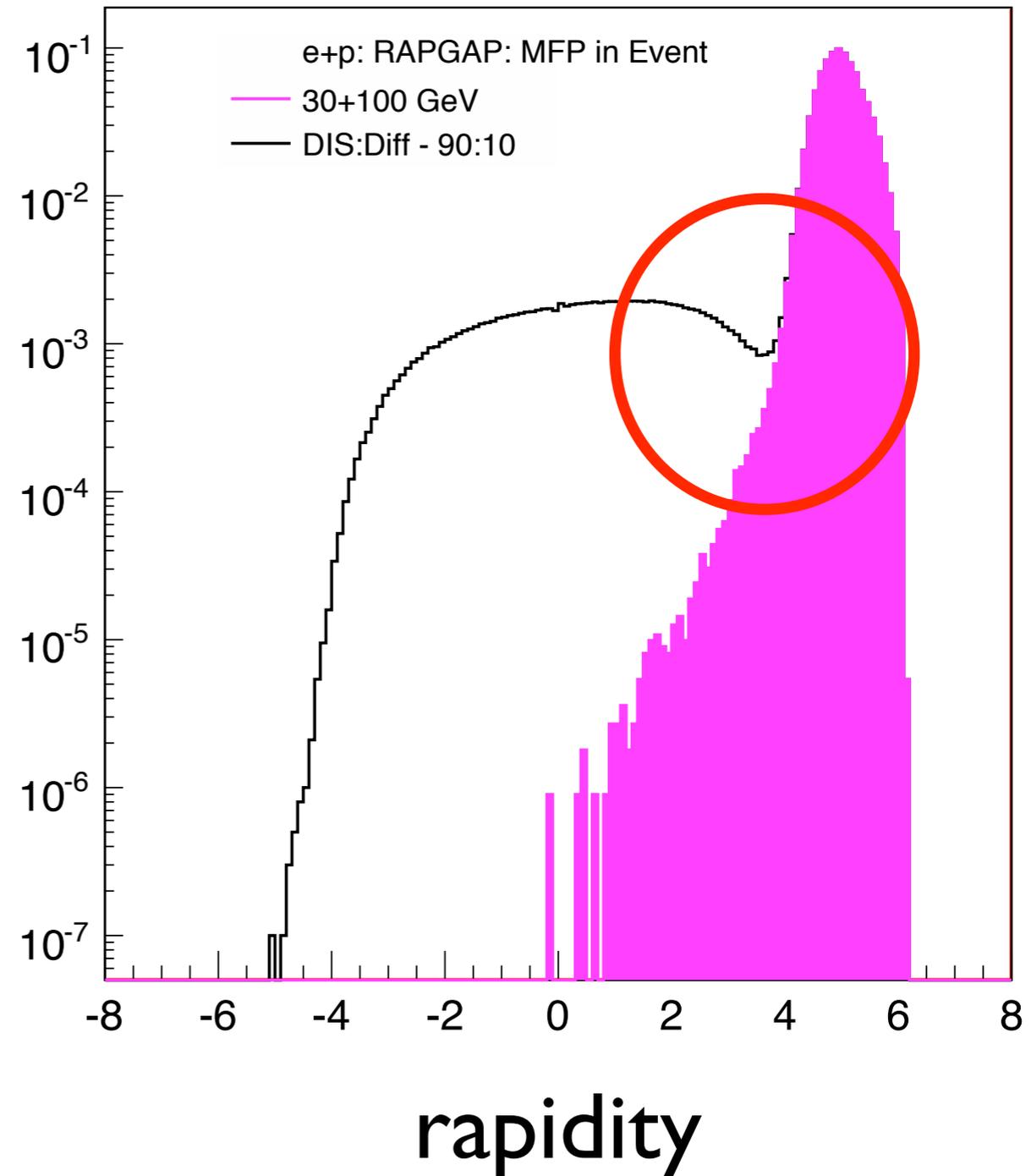
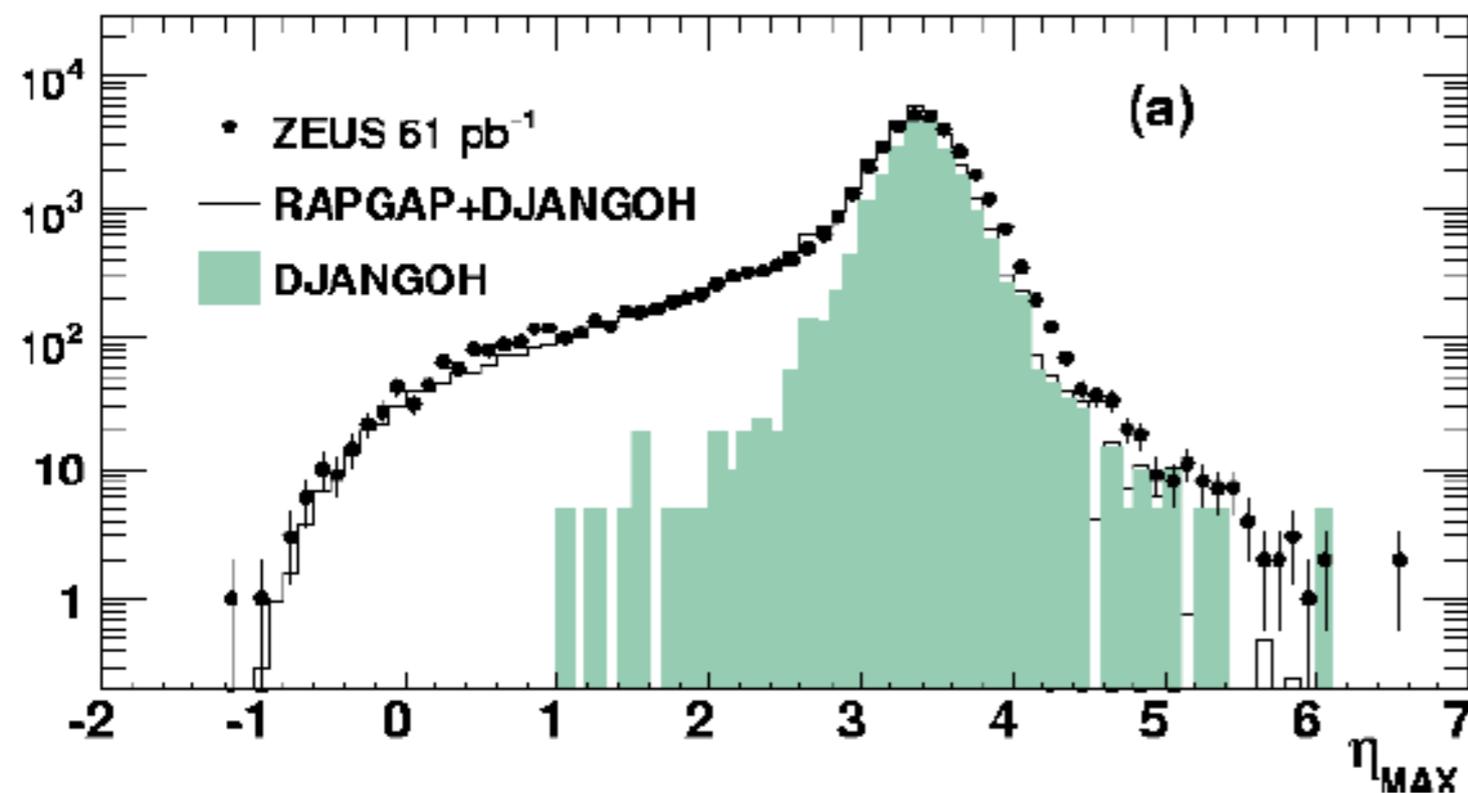


Can we reproduce the HERA plot?

- If we now apply the acceptance cuts to the HERA data, we get the following:

- Ratios:

➔ DIS - 90%, Diff - 10%

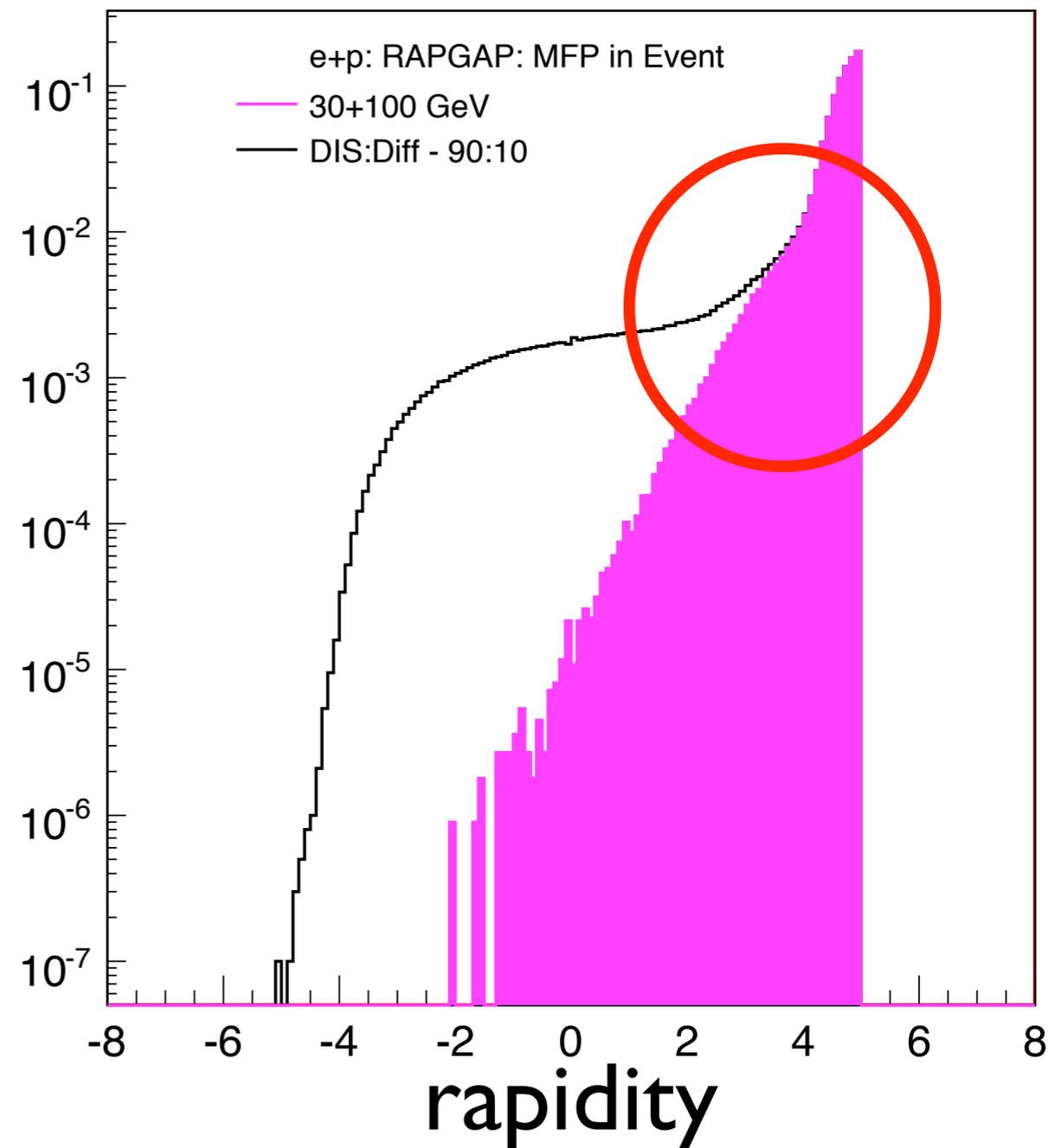
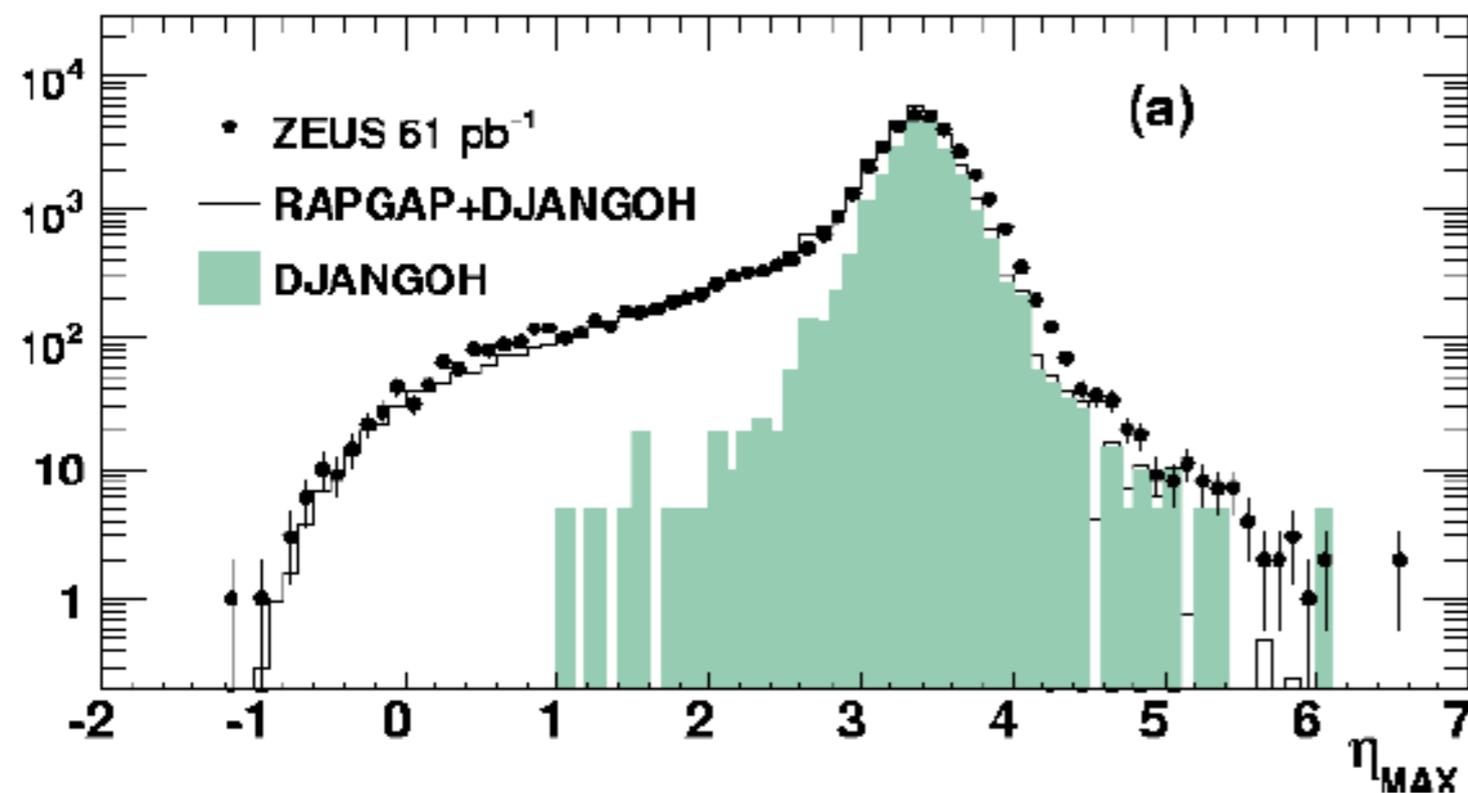


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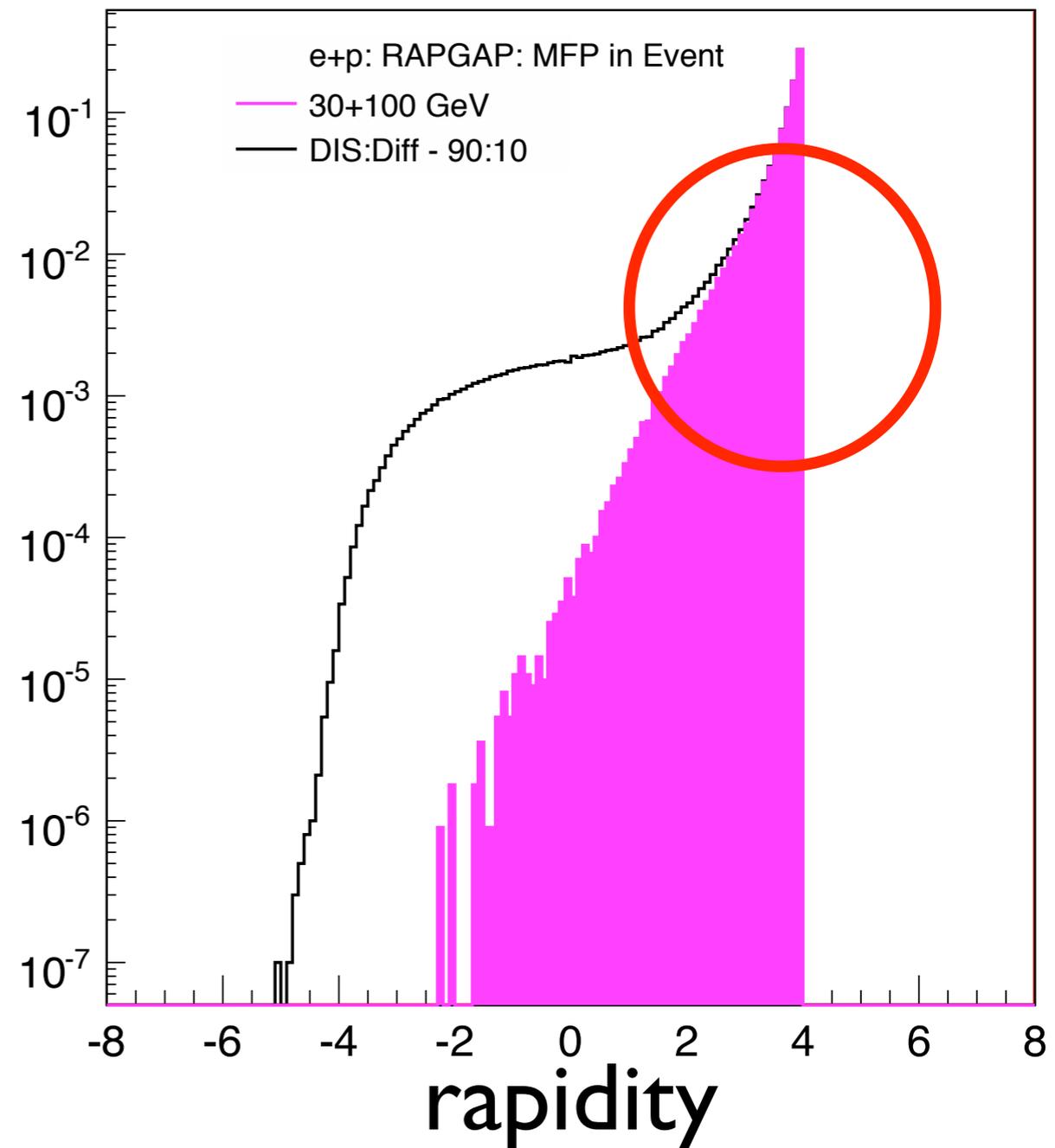
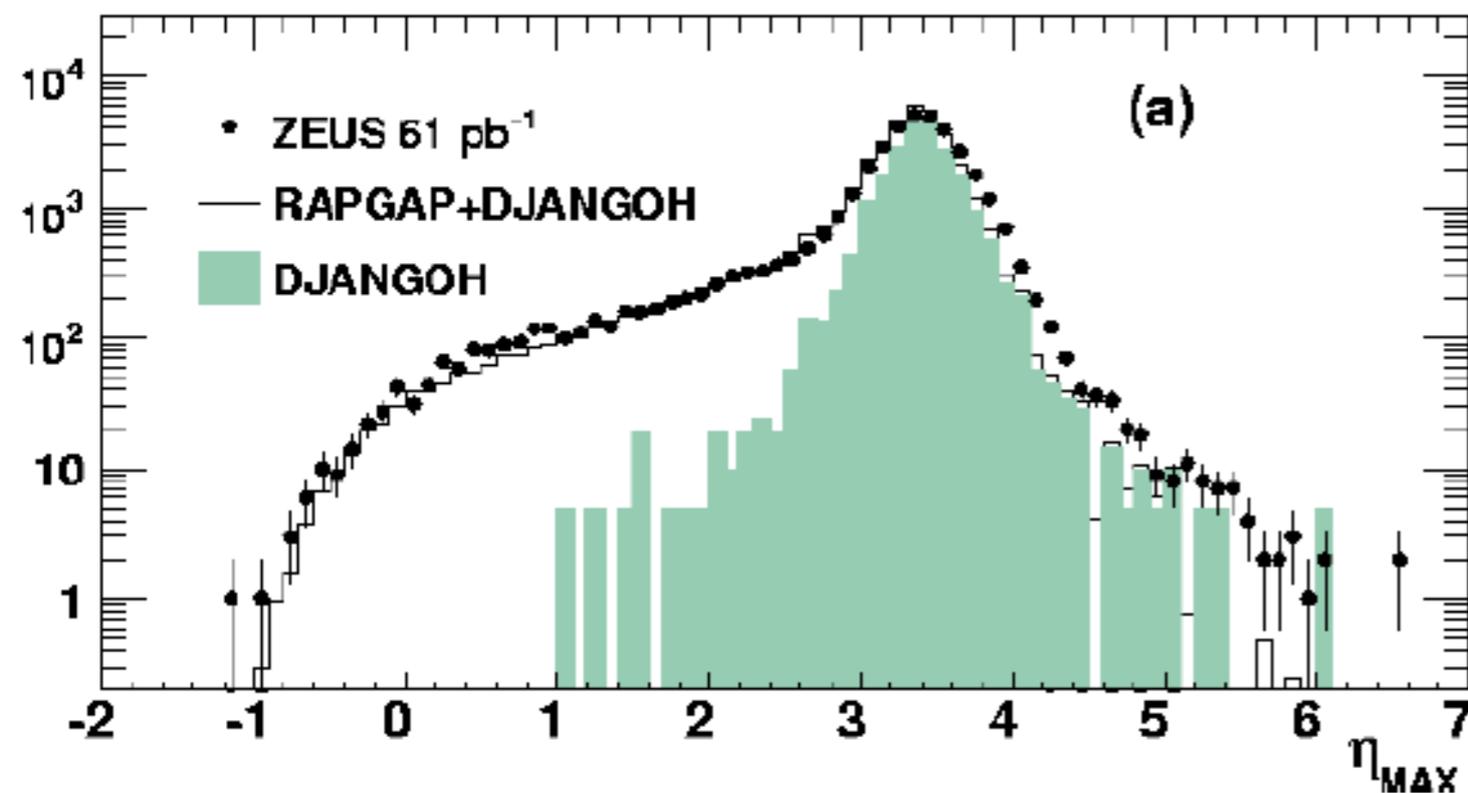


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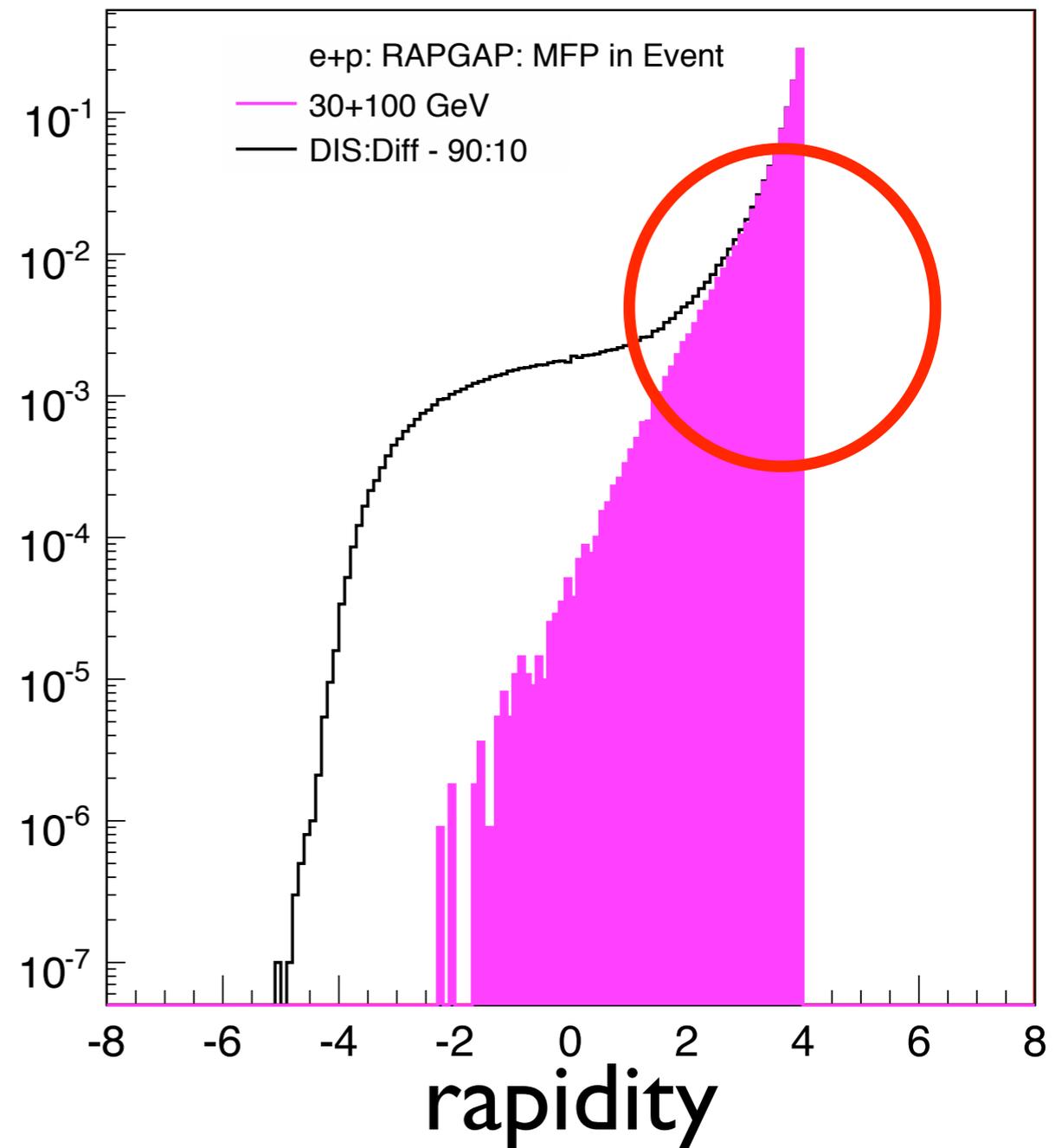
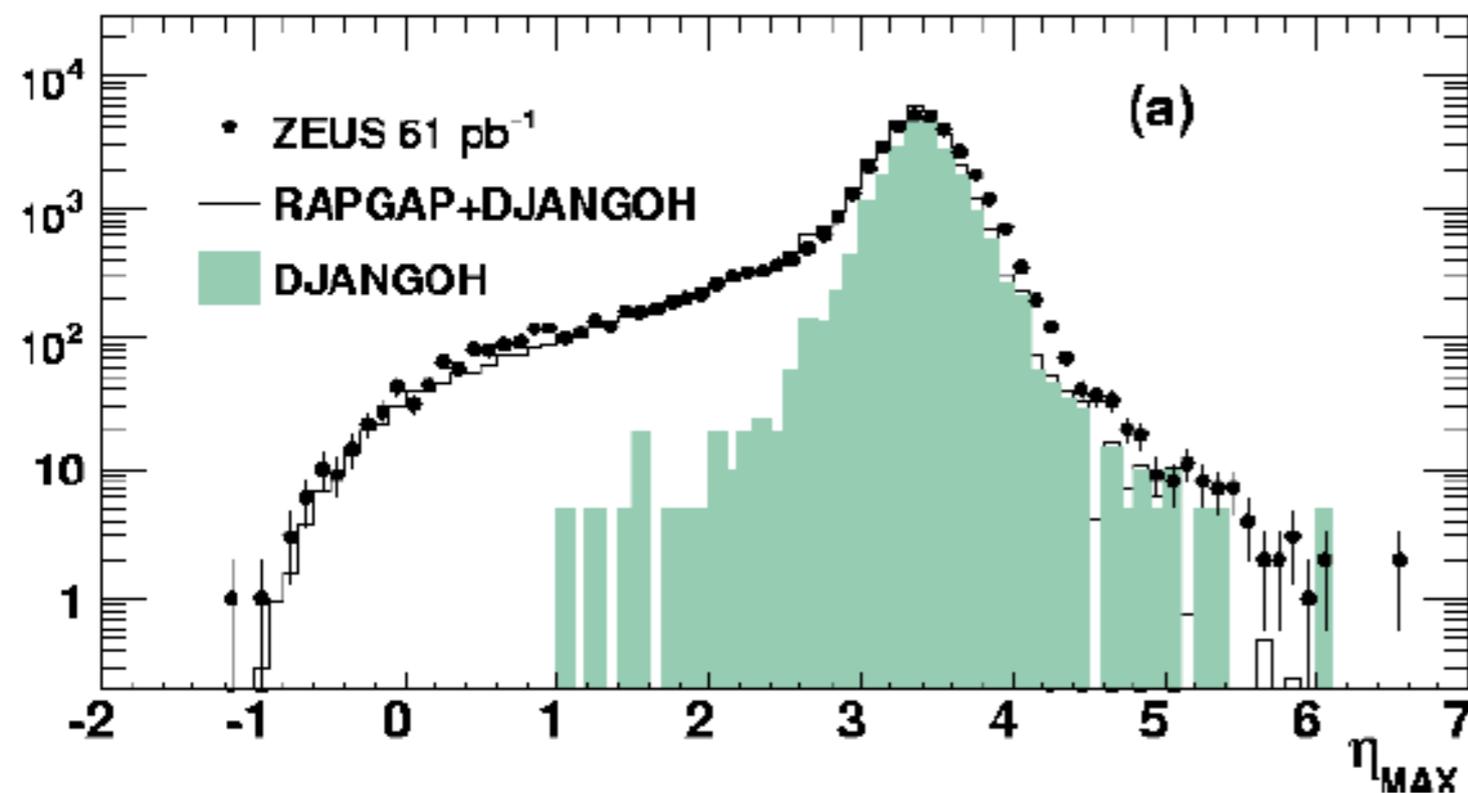
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Shape is just an artefact of the acceptance coverage of the different systems



Summary and Conclusions

- 10^6 events generated for a variety of energies
- Significant differences observed in DIS vs Diffractive events at all energies
- Plotted efficiency vs purity
 - ➔ Strongly dependent on acceptance
 - ▶ Full acceptance → efficiency & purity > 90% for all energies
 - ▶ This reduces dramatically with even a small drop in acceptance coverage
- DIS and Diffractive events can be disentangled, but need as much detector coverage as possible to make a clean measurement

What's next?

- All simulations so far for just $e+p$ collisions - no $e+A$ yet.
 - ➔ Work with Raju and Cyrille to implement this into a modified version of RAPGAP
- Investigate further the prospect of coherent diffraction measurements using a forward spectrometer
 - ➔ Not possible for large A (Au), but possible for light A (up to Si ?)