ZEUS Diffractive Physics Group *29 November 2000*

DESY

The Pseudorapidity Approximation

- ☞ Rapidity
- ☞ Pseudorapidity
- ☞ The Difference
- ☞ Conclusions

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DESY

Lorentz Transformations (I)

(e.g. R.P.Feynman, Theory of Fundamental Processes)

Consider the Lorentz transformation

$$\begin{pmatrix} \gamma & -\gamma\beta & 0 & 0 \\ -\gamma\beta & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} ct \\ x \\ y \\ x \end{pmatrix} = \begin{pmatrix} \gamma(ct - \beta x) \\ -\gamma(\beta ct + x) \\ y \\ z \end{pmatrix} = \begin{pmatrix} ct' \\ x' \\ y' \\ x' \end{pmatrix}$$

It looks like some kind of rotation, maybe

Consider also

$$\begin{aligned} E^2 - p^2 &= m^2 \\ \gamma^2 - (\gamma\beta)^2 &= 1 \end{aligned}$$

Pythagorus slightly confused

Lorentz transfo's are rotations through an imaginary angle α

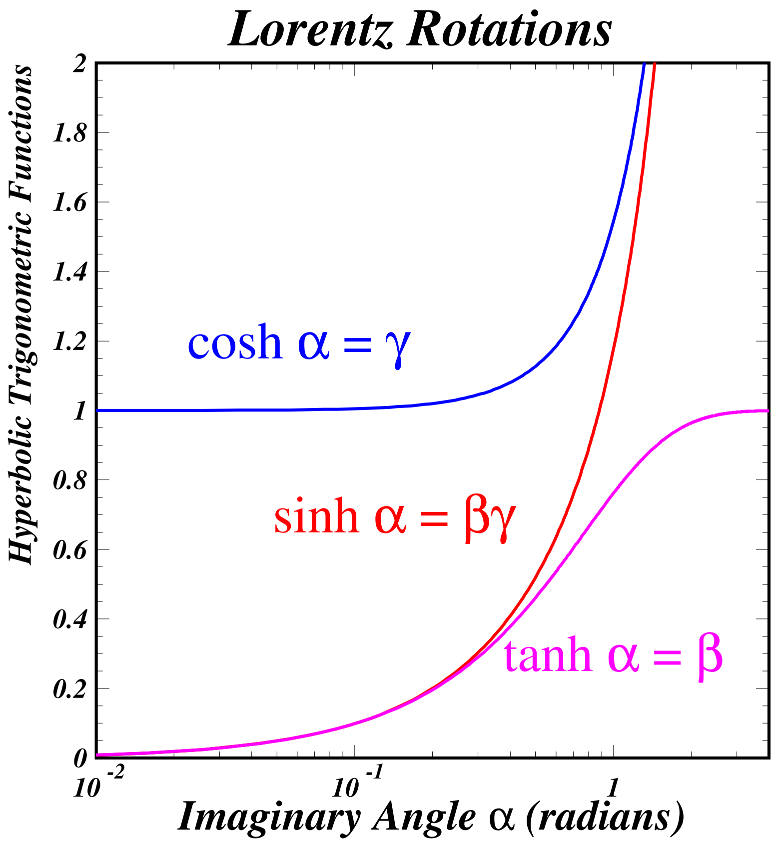
What is the meaning of α?

α is the rapidity

It is easy to show that

$$\alpha = \frac{1}{2} \ln \frac{1+\beta}{1-\beta}$$

Lorentz Transformations (II)



$$\begin{aligned}\cosh\alpha &= \tfrac{1}{2}\left(e^{\alpha}+e^{-\alpha}\right)\\ \sinh\alpha &= \tfrac{1}{2}\left(e^{\alpha}-e^{-\alpha}\right)\\ \tanh\alpha &= \frac{\sinh\alpha}{\cosh\alpha}\end{aligned}$$

$$\cosh^2\alpha - \sinh^2\alpha = 1$$

$$\begin{aligned}t' &= \frac{1}{\sqrt{\sinh^2\alpha+\cosh^2\alpha}}\left(\cosh\alpha\cdot t - \sinh\alpha\cdot x\right)\\ x' &= \frac{1}{\sqrt{\sinh^2\alpha+\cosh^2\alpha}}\left(-\sinh\alpha\cdot t + \cosh\alpha\cdot x\right)\\ y' &= y\\ z' &= z\end{aligned}$$

The Pseudorapidity Approximation

J. Collins
Light-cone Variables, Rapidity and All That
hep-ph/9705393

The pseudorapidity of a particle is defined as

$$\eta = -\ln(\tan(\Theta/2))$$

The relationship to rapidity is

$$\alpha = \ln\left(\frac{\sqrt{m^2 + p_T^2\cosh^2\eta} + p_T\sinh\eta}{\sqrt{m^2 + p_T^2}}\right)$$

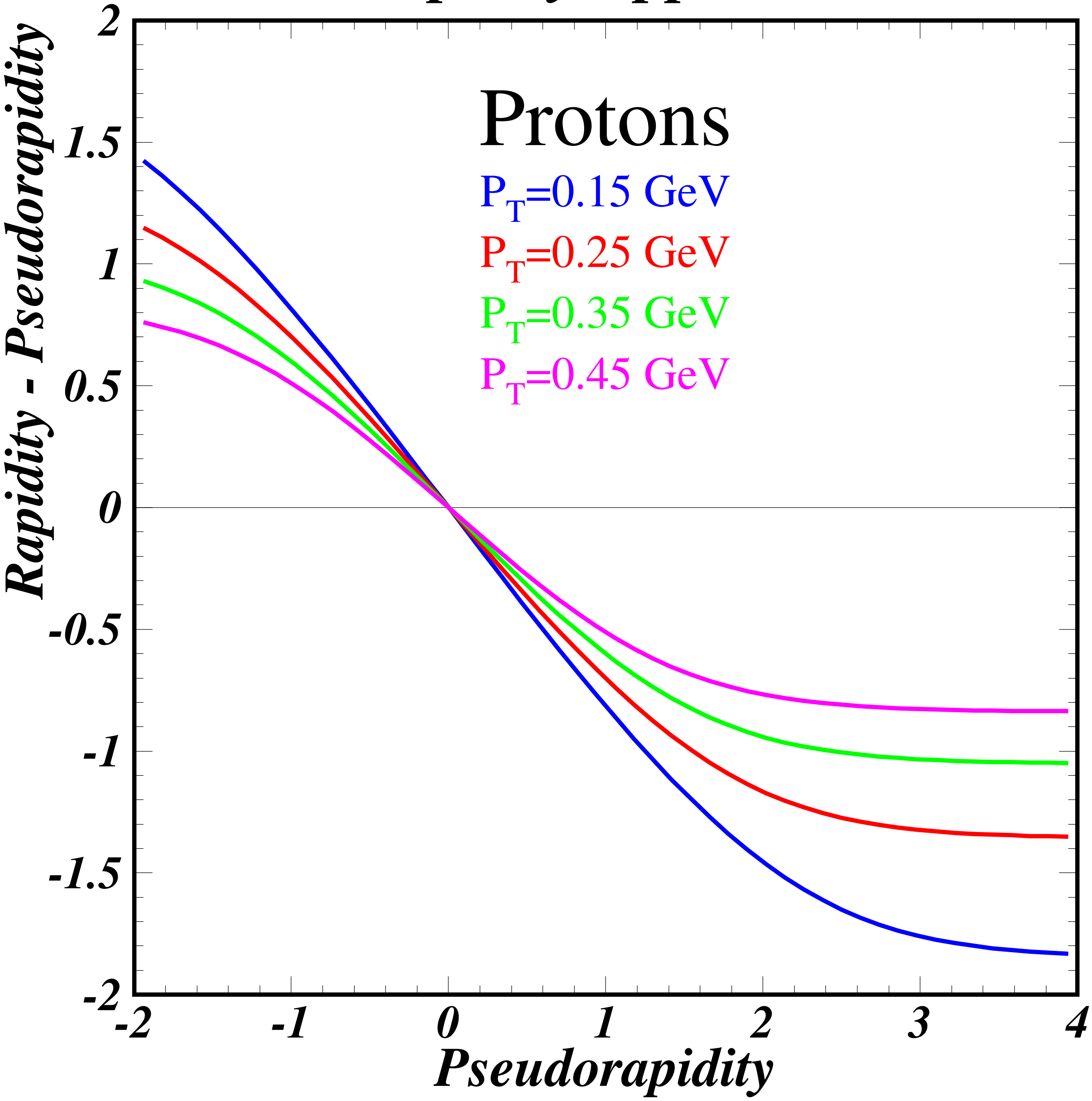
The two are similar when $m \ll p_T$.

(This is a poor approximation for our high-t J/ψ γp data)

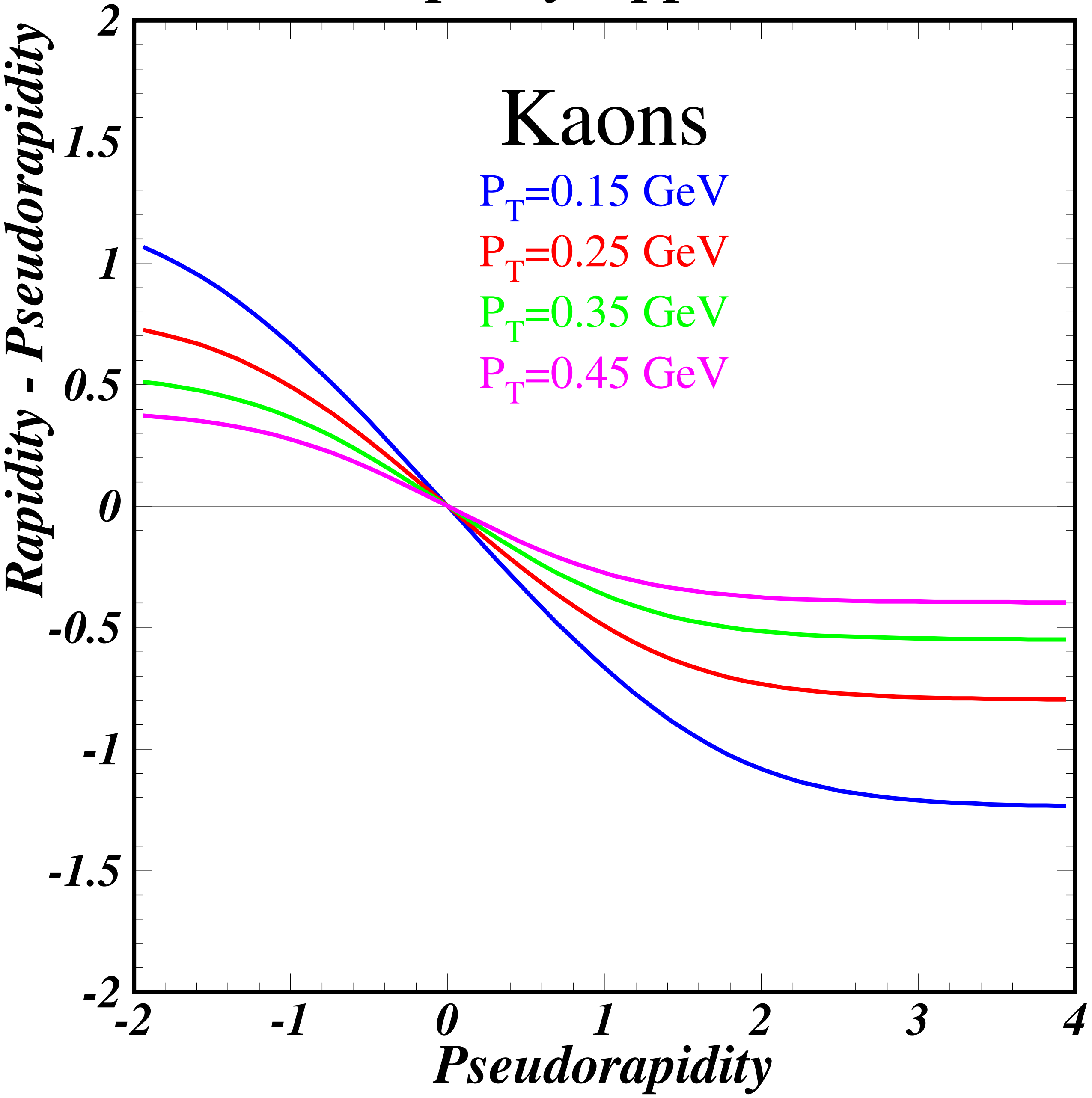
Note that $|\eta| \geq |\alpha|$

This means that ignoring the particle mass results in an overestimation of the size of backward-forward rapidity gaps

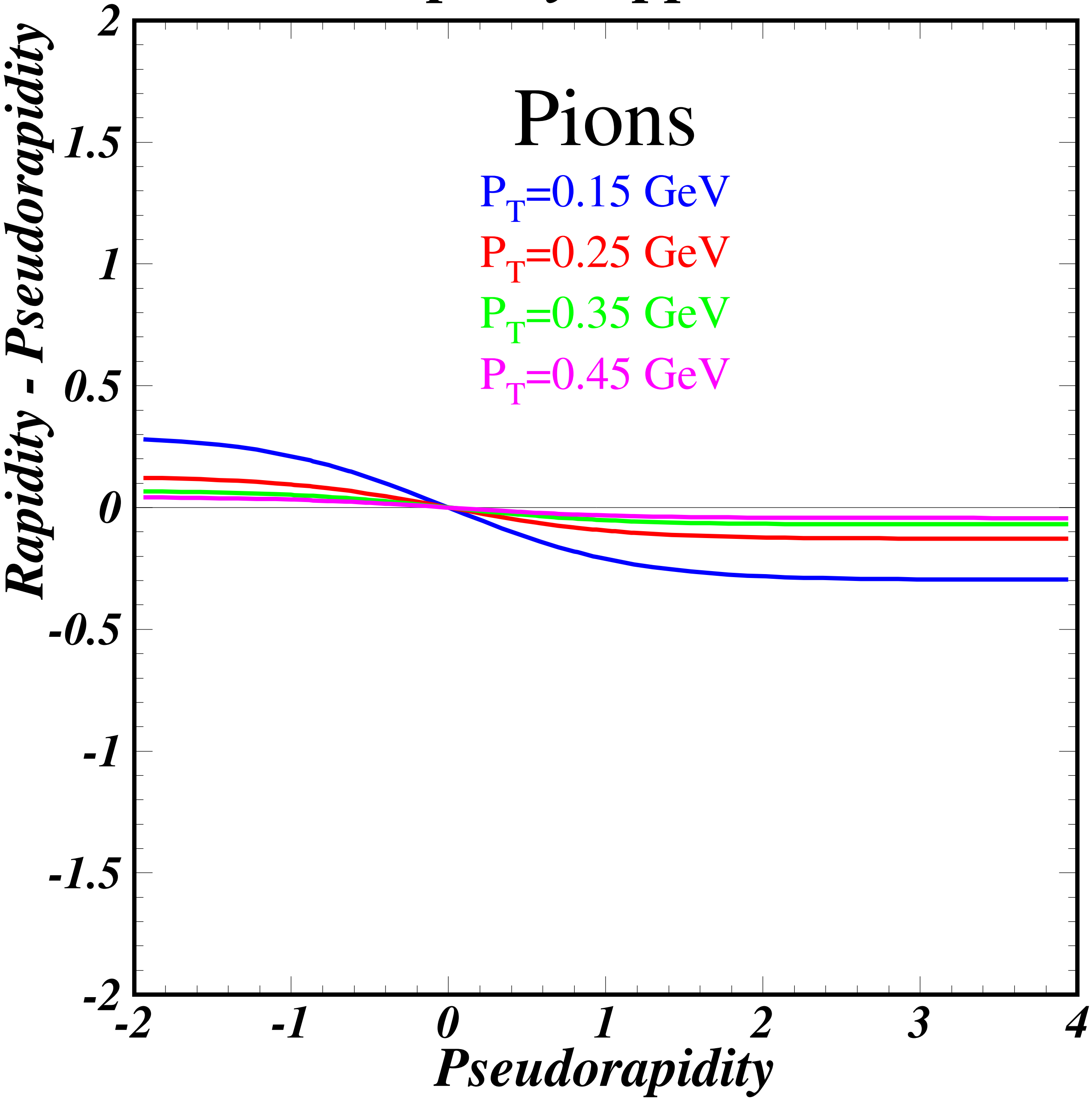
Pseudorapidity Approximation



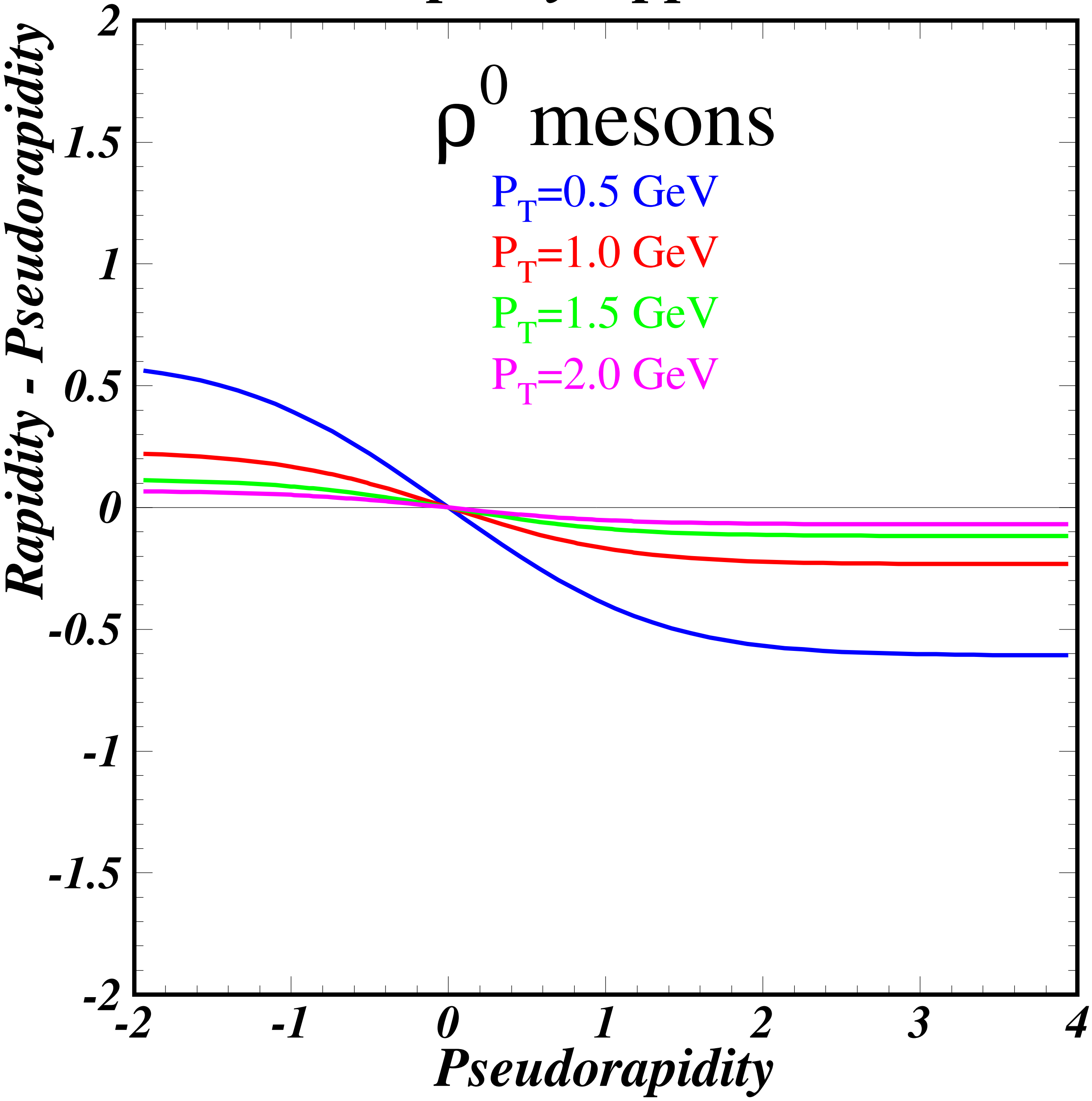
Pseudorapidity Approximation



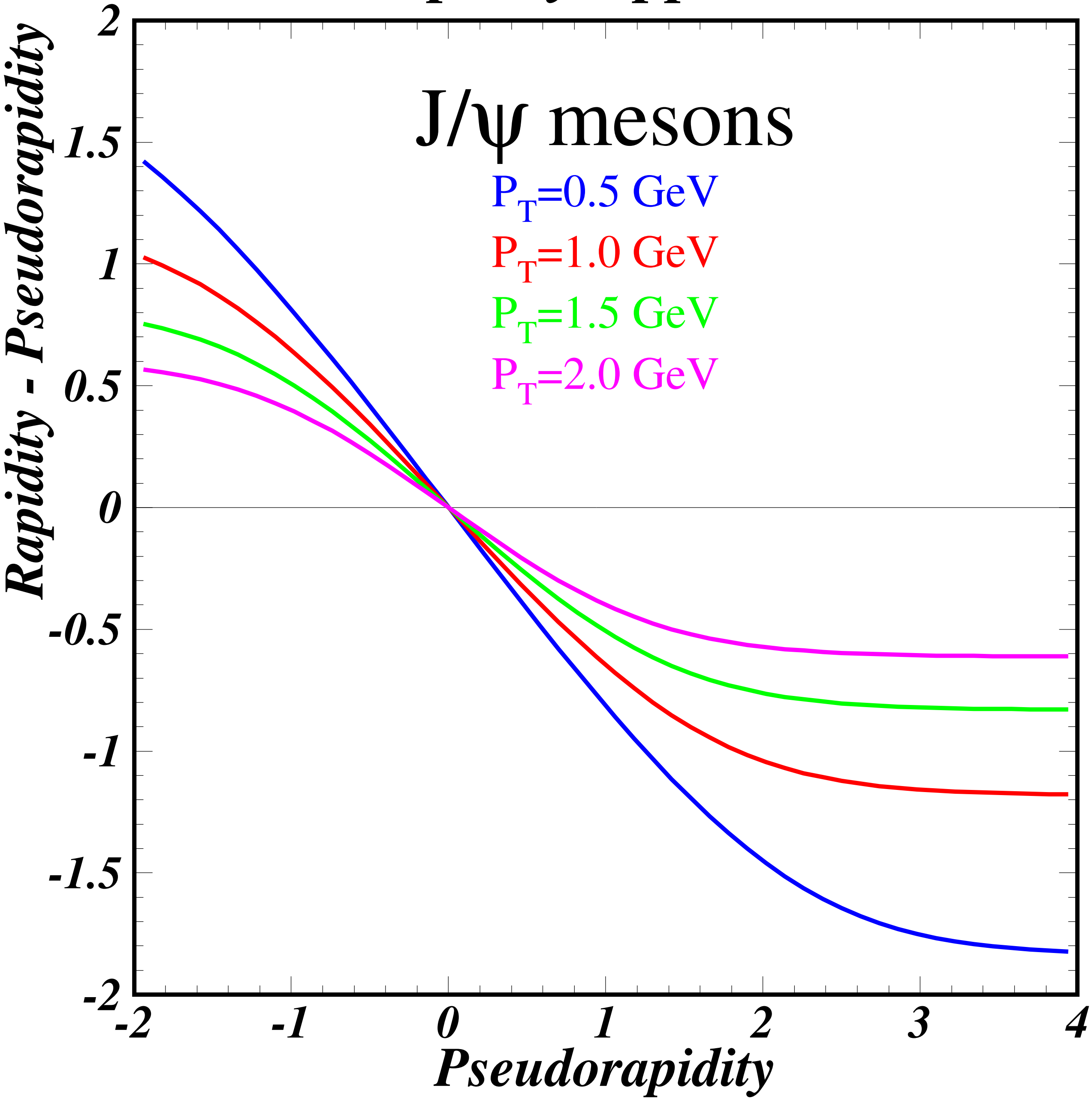
Pseudorapidity Approximation



Pseudorapidity Approximation



Pseudorapidity Approximation



Conclusions

For low-P_T pions, corrections are less than 0.3 units of rapidity

For low-P_T protons, corrections can reach 1.5 units of rapidity in the rear direction and 2 units of rapidity in the very forward region

For ρ^0 mesons at $|t| > 1$ GeV^2, corrections are less than 0.3 units of rapidity

For J/ψ mesons at $|t| > 1$ GeV^2, corrections are less than 1 unit of rapidity