Incoherent π^0 photoproduction from ^{12}C: Improvements of the cascade model

Tulio E. Rodrigues

University of São Paulo

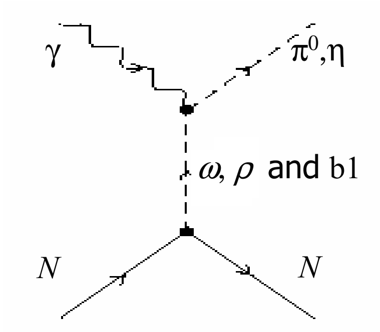
tulio@if.usp.br

Outline:

- The elementary π^0 photoproduction cross section (not changed)
- Shadowing effects for high energy photo-nucleus interactions (implemented)
- π^0 – nucleus Final State Interactions (improved)
- Effects of the Pauli principle in secondary scatterings
- π^0 photoproduction cross section for ^{12}C (single and double differential)

➢The elementary π^0 photoproduction cross section

Cross sections calculated in terms of *t*-channel helicity amplitudes (F_i)



$$\gamma(k) + N(p_1) \to P(p) + N(p_2)$$

$$s = (k + p_1)^2$$

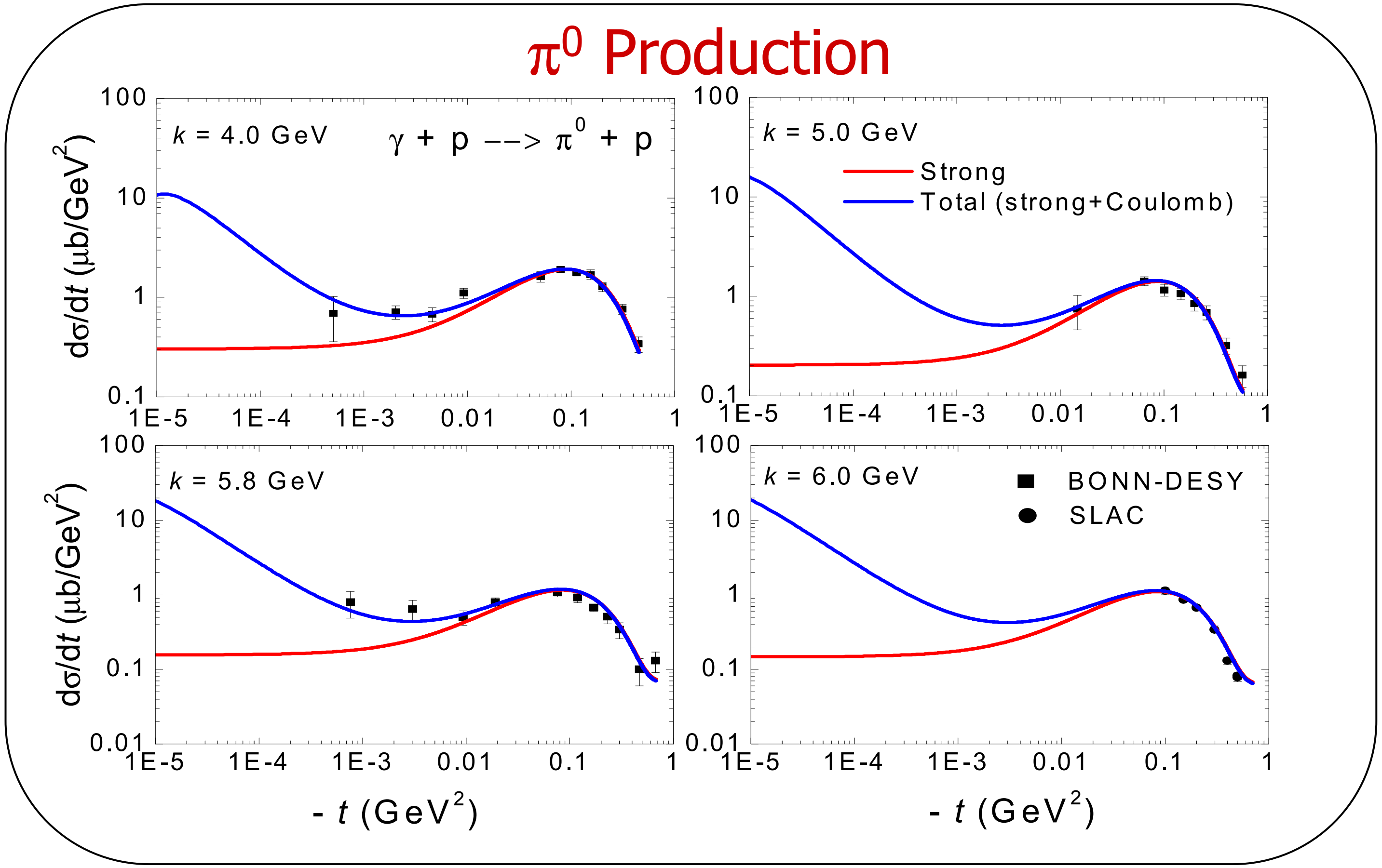
$$t = (k - p)^2$$

$$\frac{d\sigma_N}{dt} \cong \frac{1}{32\pi}\left\{ F_2^2 + \frac{F_3^2}{4m_N^2} - \left[t + \left(\frac{\mu^2}{2k}\right)^2\right]\left(F_4^2 + \frac{F_1^2}{4m_N^2} + \frac{F_3^2}{16m_N^4} + \frac{F_1F_3}{2m_N p\sqrt{s}}\right) - \frac{\left[t + \left(\frac{\mu^2}{2k}\right)^2\right]}{p\sqrt{s}}\left(F_2 - \frac{F_3}{2m_N}\right)\left(\frac{F_1}{2} - \frac{\sqrt{s}}{24p}F_2 + \frac{4p - 5\sqrt{s}}{16m_N p}F_3\right) \right\} \quad (*)$$

(*) A. Gasparian and S. Gevorkyan, *Theoretical part of PrimEx*, 2004

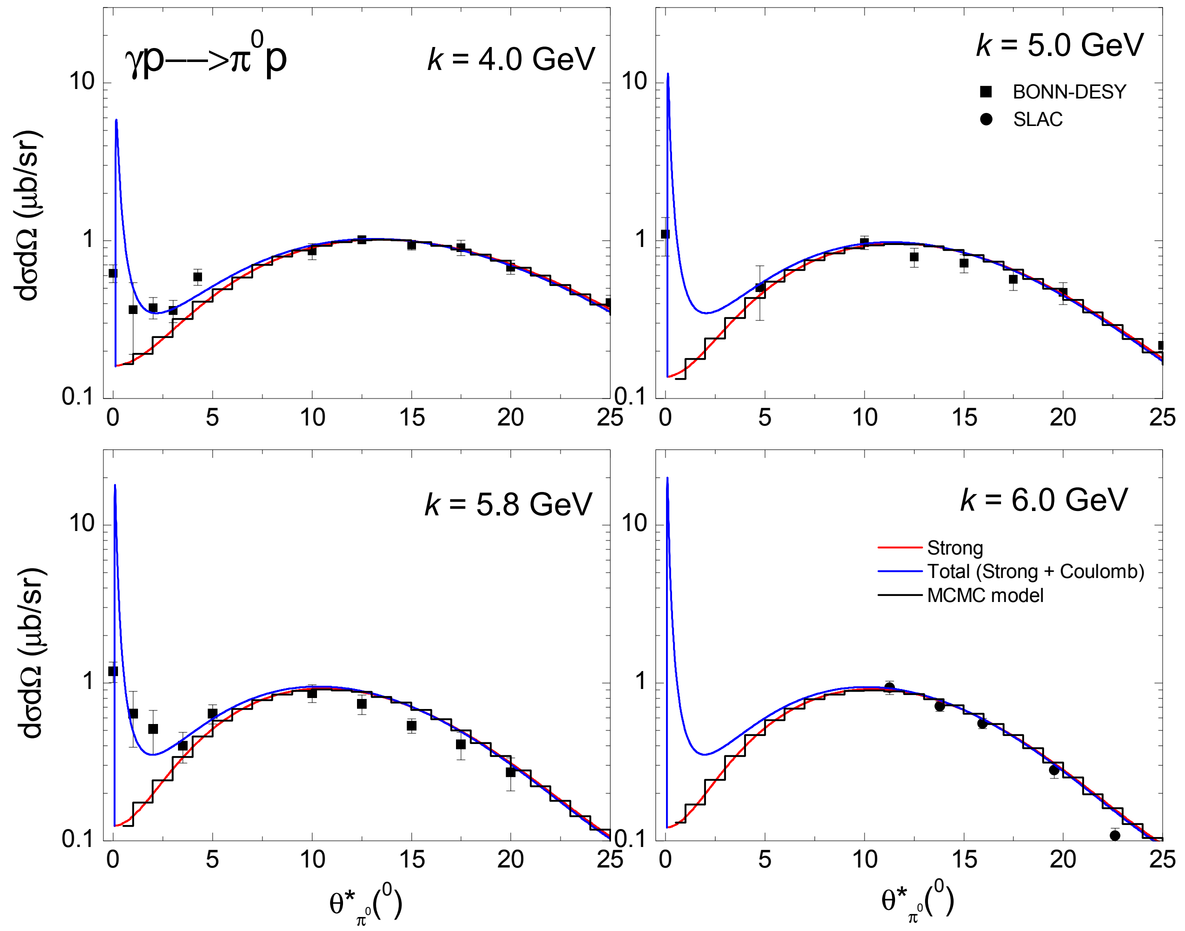
➢The elementary π^0 photoproduction cross section

Checking the Regge Model with the best fit parameters



➢The elementary π^0 photoproduction cross section

The cascade input for the NI cross section includes only the strong part (red line)



- Shadowing effects for high energy photo-nucleus interactions

Physical interpretation: The direct coupling of photons to vector mesons leads to an attenuation of the total nuclear cross section due to the shadowing of the vector mesons deep in the nuclei. This attenuation can be accounted for in terms of a reduction in the total number of nucleons that effectively participate to the photoproduction.

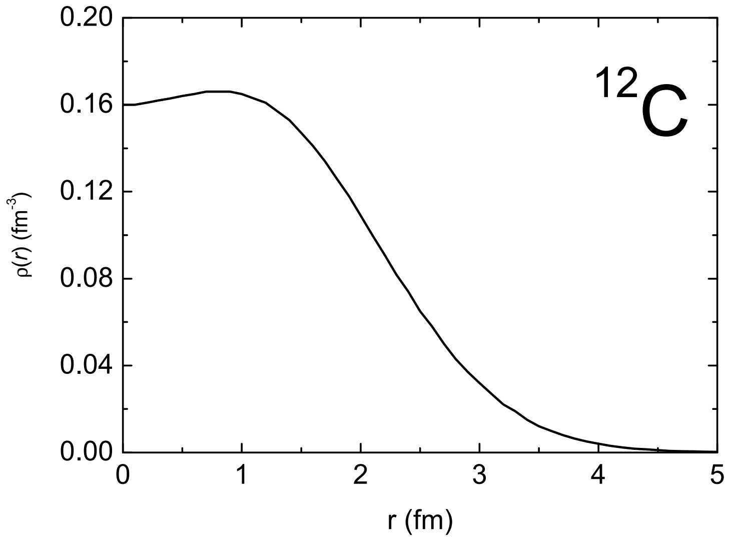
Strategy: Take advantage of the Monte Carlo cascade for the evaluation of the nuclear transparency, since it is a well known fact that $A_{\mathrm{shad}} = \mathrm{T}A$, where T is the nuclear transparency to vector mesons and A the nucleus mass.

➢ Shadowing effects for high energy photo-nucleus interactions

Calculation of the nuclear transparency

Nuclear density for ^{12}C based on a shell-model distribution (*):

$$\rho(r) = \frac{4}{\left(a_0\sqrt{\pi}\right)^3}\left(1+\frac{\delta r^2}{a_0^2}\right)\exp\left(\frac{-r^2}{a_0^2}\right) \quad \begin{cases} a_0 = 1.65\ \text{fm} \\ \delta = \frac{1}{6}(A-4) \end{cases}$$

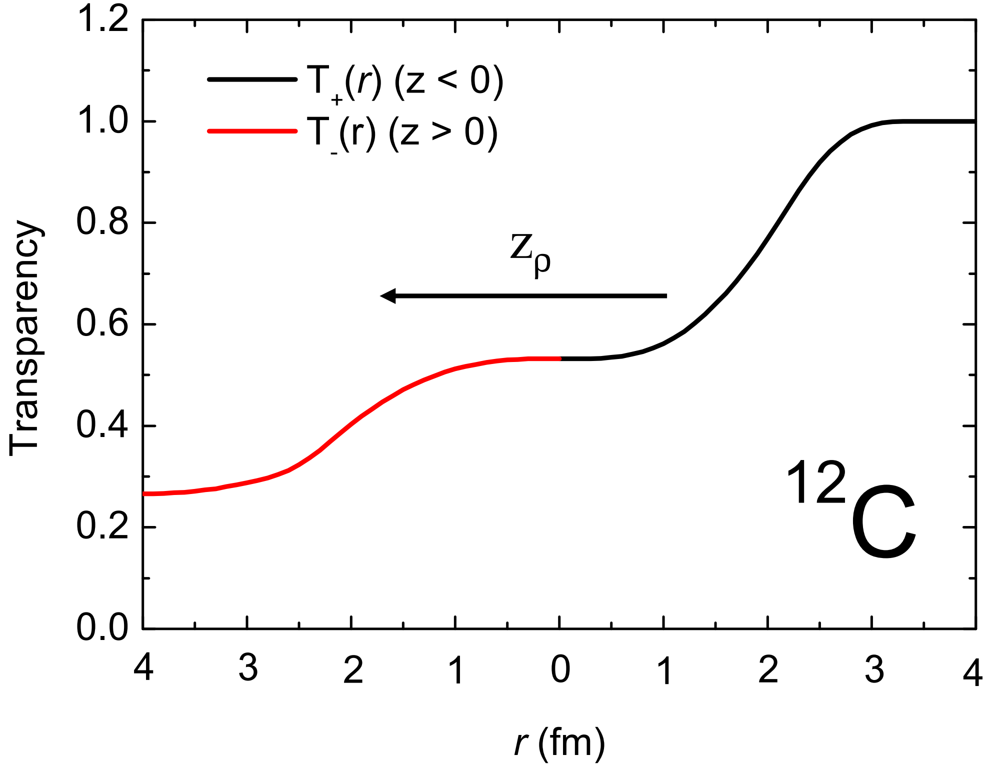


(*) PRL 28, 1344 (1972)

➢Shadowing effects for high energy photo-nucleus interactions

Calculation of the nuclear transparency and A_{shad}

The nuclear transparency is calculated as a function of *r* using the MCMC model and a total ρ*N* cross section of 27 mb.



T independent of r:

$$A_{\text{shad}} = \mathrm{T}A$$

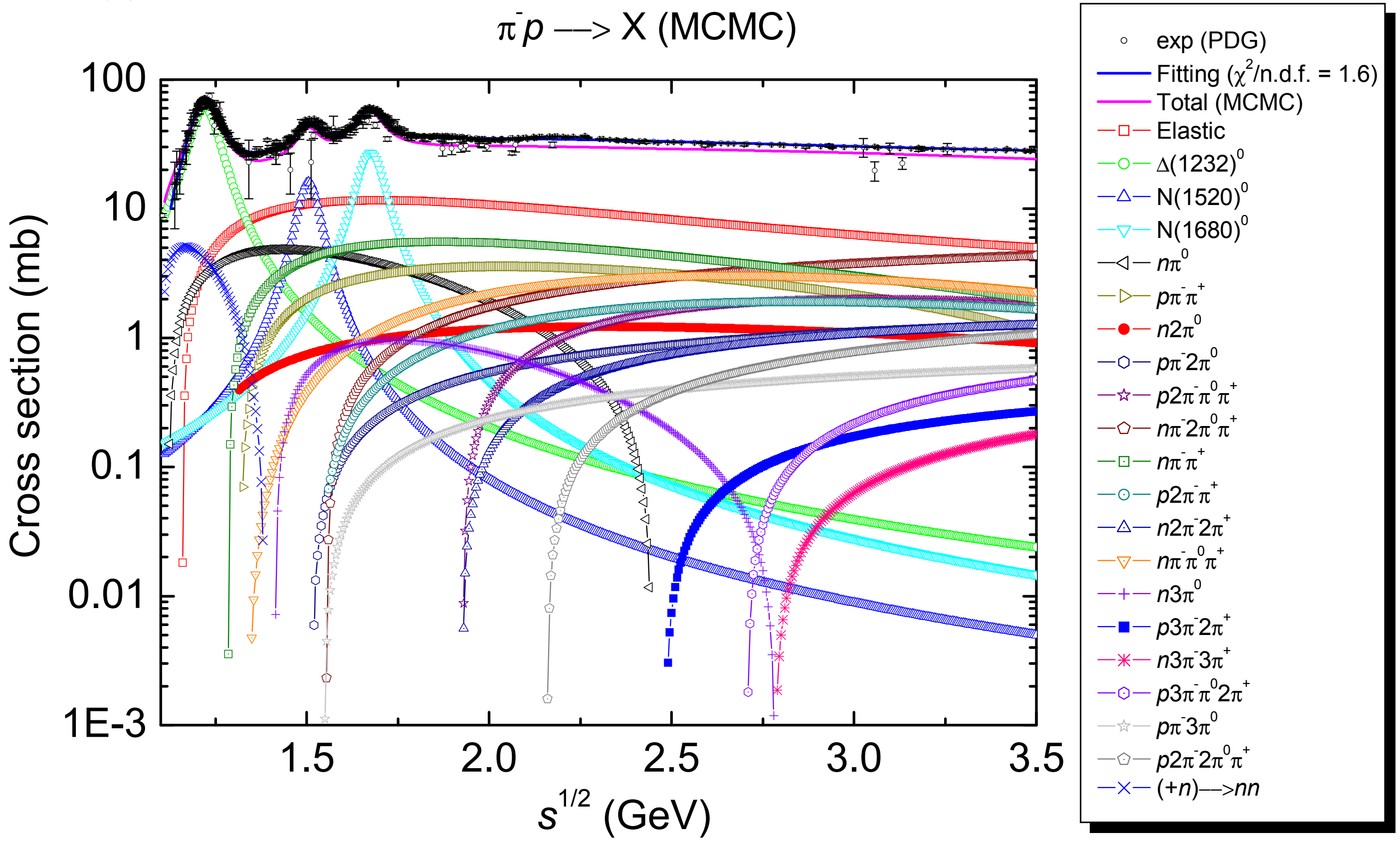
T dependent of r:

$$A_{\text{shad}} = 4\pi\int_0^\infty \left(\frac{\mathrm{T}_+(r)+\mathrm{T}_-(r)}{2}\right)\rho(r)r^2dr$$

$$= 7.163 \therefore \frac{A_{\text{shad}}}{A} = 0.597$$

➢π^0-nucleus Final State Interactions

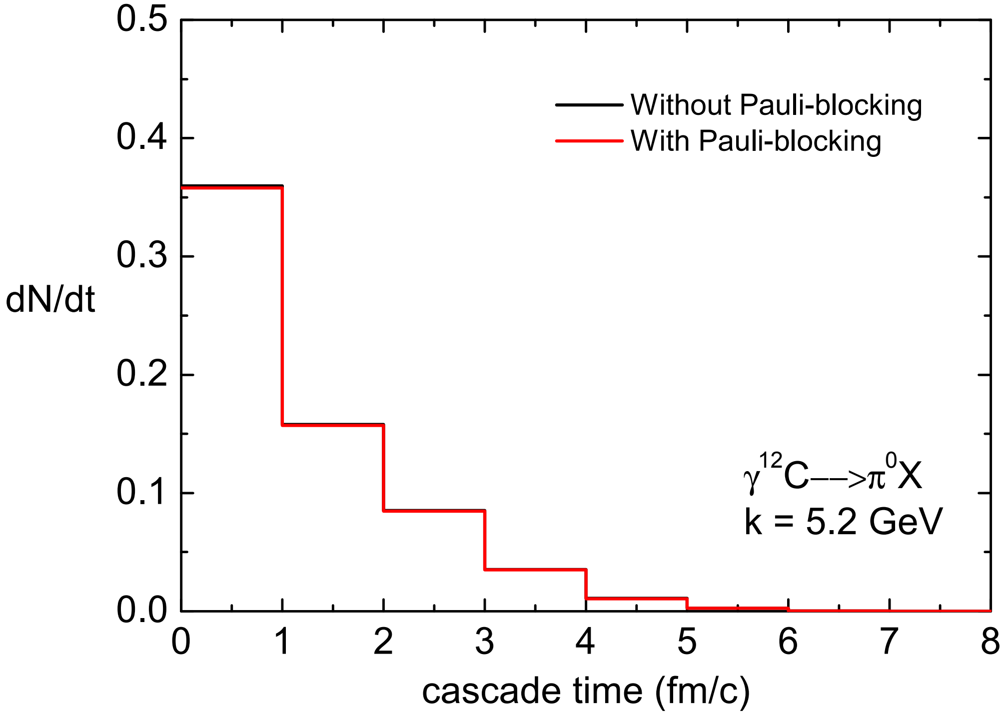
Typical πN channels included in the MCMC cascade (*)



(*) **T. E. Rodrigues *et al.*, Phys. Rev. C 71, 051603 (R) (2005).**

➢Effects of the Pauli principle in secondary scatterings

Time derivative of the average number of πN interactions:
Bug of Pauli-blocking was corrected in the routine

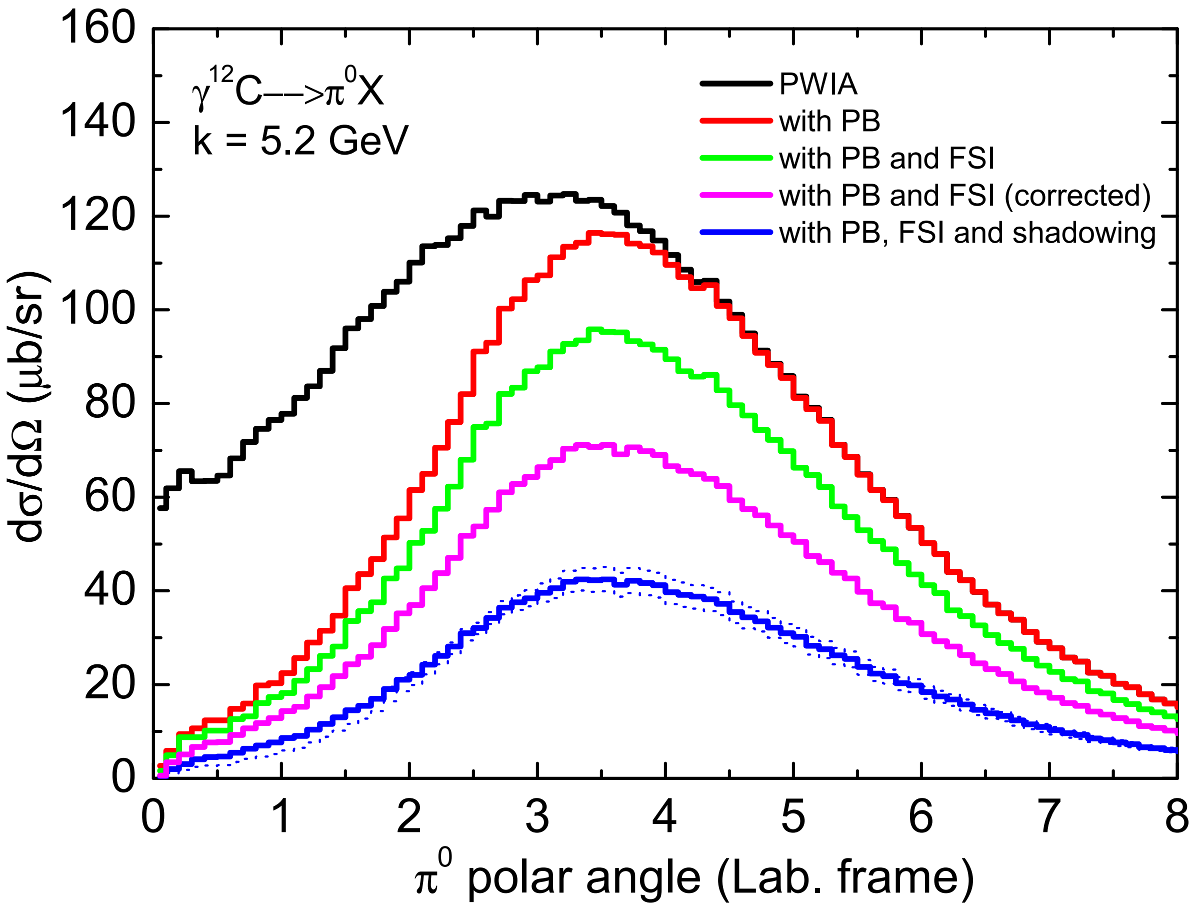


$$\frac{\int_t \left(\frac{dN}{dt}\right)_{\text{w.o. Pauli}} dt}{\int_t \left(\frac{dN}{dt}\right)_{\text{w. Pauli}} dt} = \frac{0.65167}{0.64839} = 1.005$$

Conclusion: this is a less than 1% effect!

➢π^0 photoproduction cross section for ^{12}C

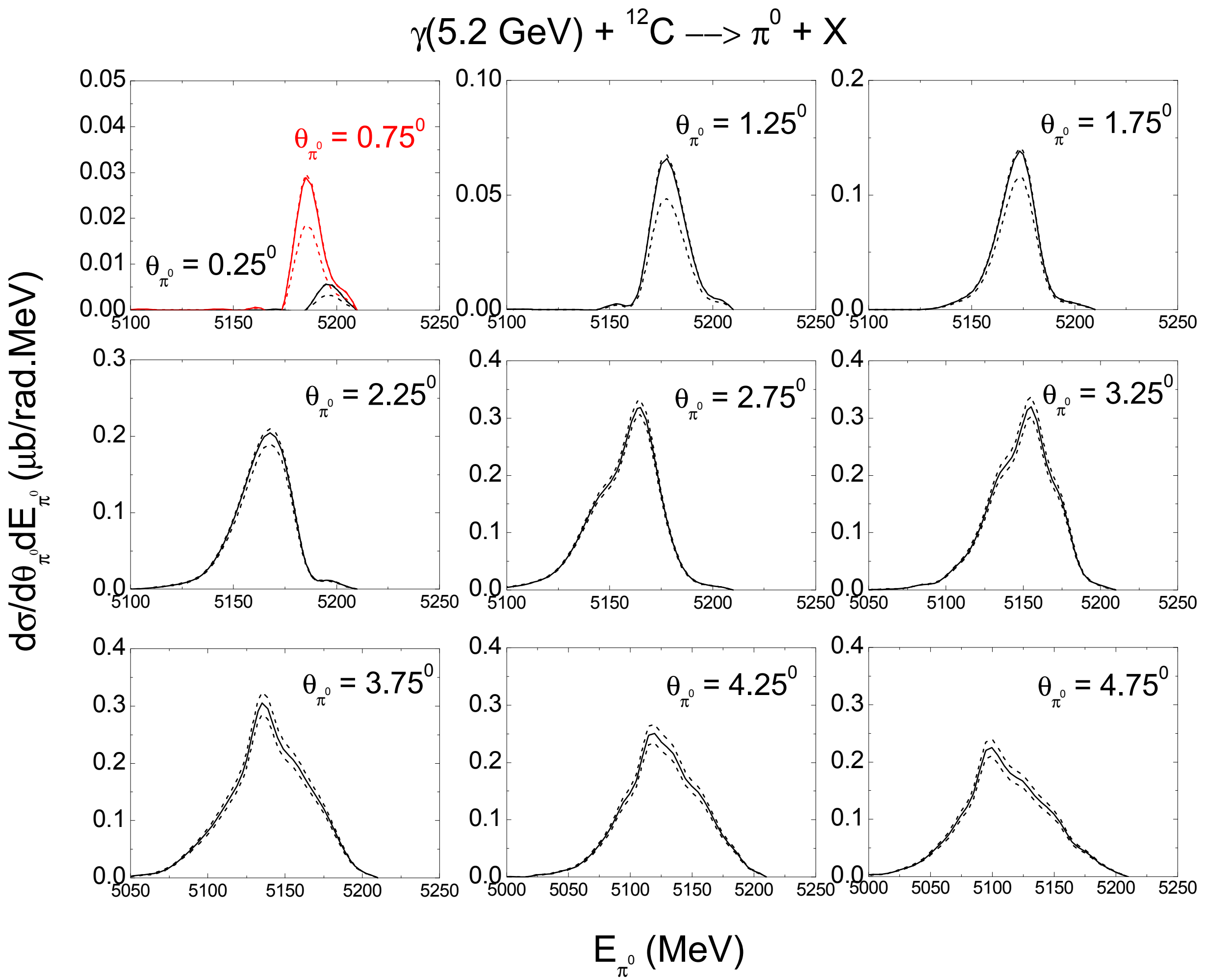
Single differential cross section



http://axpfep1.if.usp.br/~tulio/PrimEx/12C/new_results/Aug2007/5.2GeV/dsdW.txt

➢π^0 photoproduction cross section for ^{12}C

Double differential cross section



http://axpfep1.if.usp.br/~tulio/PrimEx/12C/new_results/Aug2007/5.2GeV/