ω photoproduction in PrimEx

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Objective: To calculate the $\omega \rightarrow \pi^0\gamma$ contribution in PrimEx due to ω photoproduction (coherent, incoherent and incoherent with isobar excitation) on Carbon and Lead.

Outline:

1. Omega photoproduction in nuclei (overview)
2. Elementary omega photoproduction ($d\sigma/dt$) versus photon energy
3. $d\sigma/dt$ for Carbon (theory versus Rochester data)
4. Forward angle cross section $(d\sigma/dt)_{\theta=0}$ versus photon energy
5. A_{eff} versus photon energy
6. Results for omega photoproduction
7. Results for π^0 background
8. Adding the omega background to the NI mechanism (“total” π^0 background due to inelastic processes)
9. Conclusions and final remarks

1. Omega photoproduction in nuclei (overview)

Mechanisms included in the analysis:

1. Coherent omega photoproduction. Diffractive production of omega mesons from nuclei (VMD model). The nucleus remains in the GS and the recoil (relativistic kinematics) is taken into account. The slope and forward cross sections are taken from previous experiments on nuclei.
2. Incoherent omega photoproduction. Includes the diffractive scattering of the vector mesons on a single nucleon (natural parity exchange) and meson exchange processes (π and f_2; unnatural parity exchange). Both mechanisms have the same kinematics and are not distinguishable by the PrimEx apparatus. The total cross section from the nucleon is to be interpreted as the sum of these processes and is taken into account for the NI omega photoproduction via the impulse approximation (IA)
3. Incoherent omega photoproduction with isobar excitation. The process is not Pauli-blocked but have a significant energy constraint that affects very drastically the background if we impose elasticity cuts on pion energy. The energy carried out by the isobar is taken into account sampling the isobar rest mass with a Lorentzian shape.

Mechanisms neglected in the analysis:

1. Omega photoproduction in secondary scatterings. These second order mechanisms are empirically taken into account (without kinematical analysis) since the normalization of the results are constrained by real data from nuclei.

1. Omega photoproduction in nuclei (overview)

$$\left(\frac{d\sigma}{dt}\right)_{\omega A} = \left(\frac{d\sigma}{dt}\right)_{\omega A}^{Diff.} + A_{eff}\left[\left(\frac{d\sigma}{dt}\right)_{\omega N^*} + G(t)\left(\frac{d\sigma}{dt}\right)_{\omega N}\right]$$

Coherent photoproduction

Incoherent photoproduction

$$\left(\frac{d\sigma}{dt}\right)_{\omega A}^{Diff.} = \left(\frac{d\sigma}{dt}\right)_{\theta=0} \times e^{-b|t|};$$

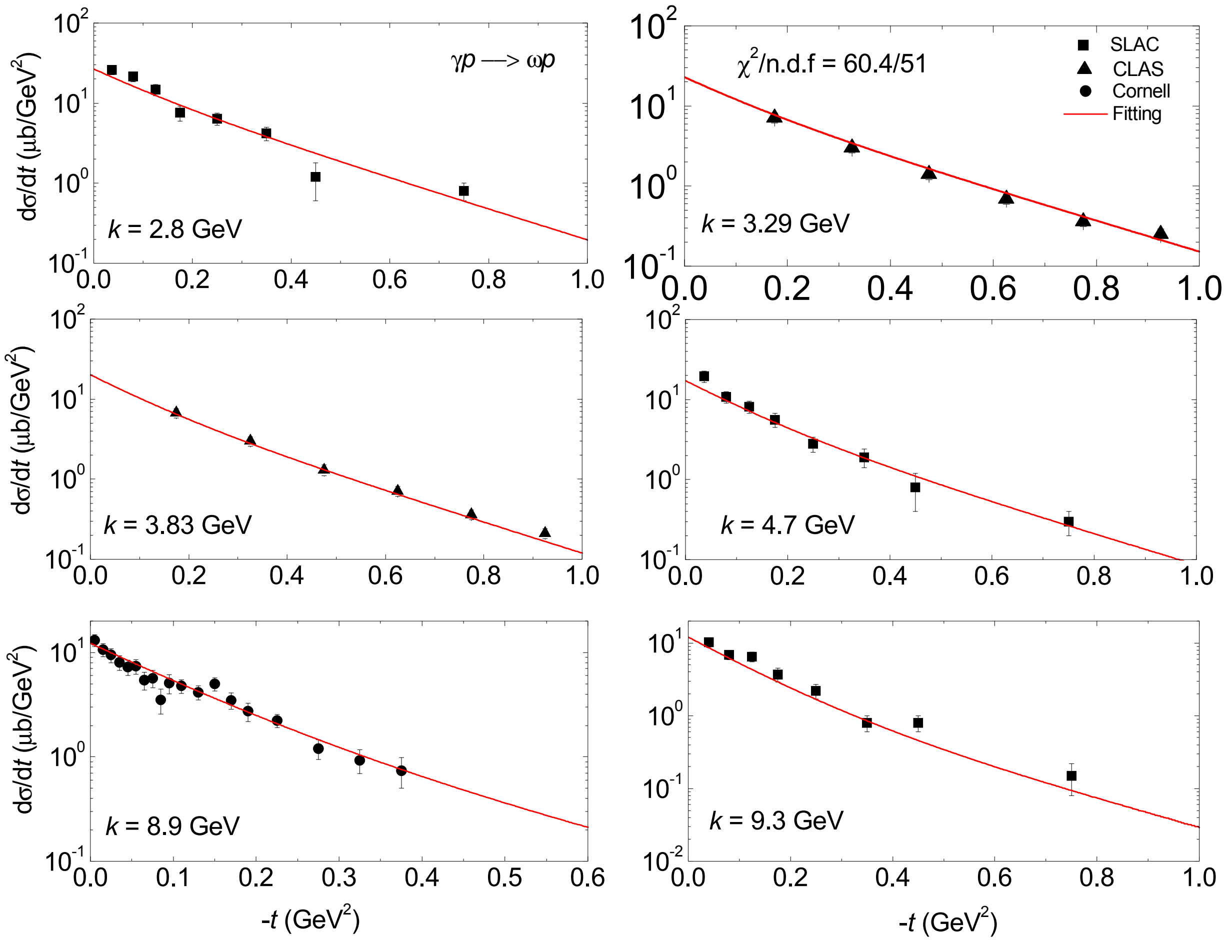
$$\left(\frac{d\sigma}{dt}\right)_{\theta=0}, b, A_{eff} \rightarrow$$ Fitting parameters

$$\left(\frac{d\sigma}{dt}\right)_{\omega N^*,N} \rightarrow$$ Elementary photoproduction (proton data)

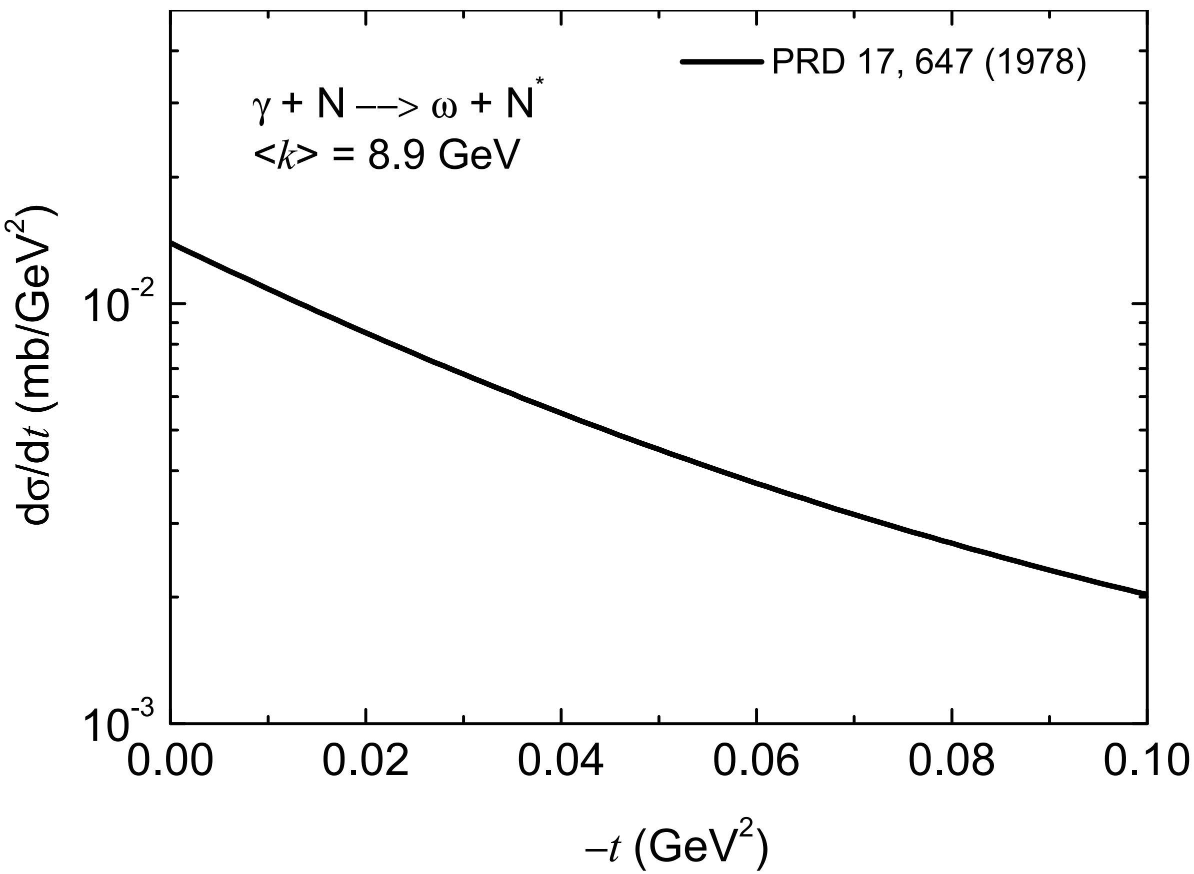
$G(t) \rightarrow$ Pauli-blocking (MCMC cascade)

2. Elementary omega photoproduction $(\gamma + N \longrightarrow \omega + N)$

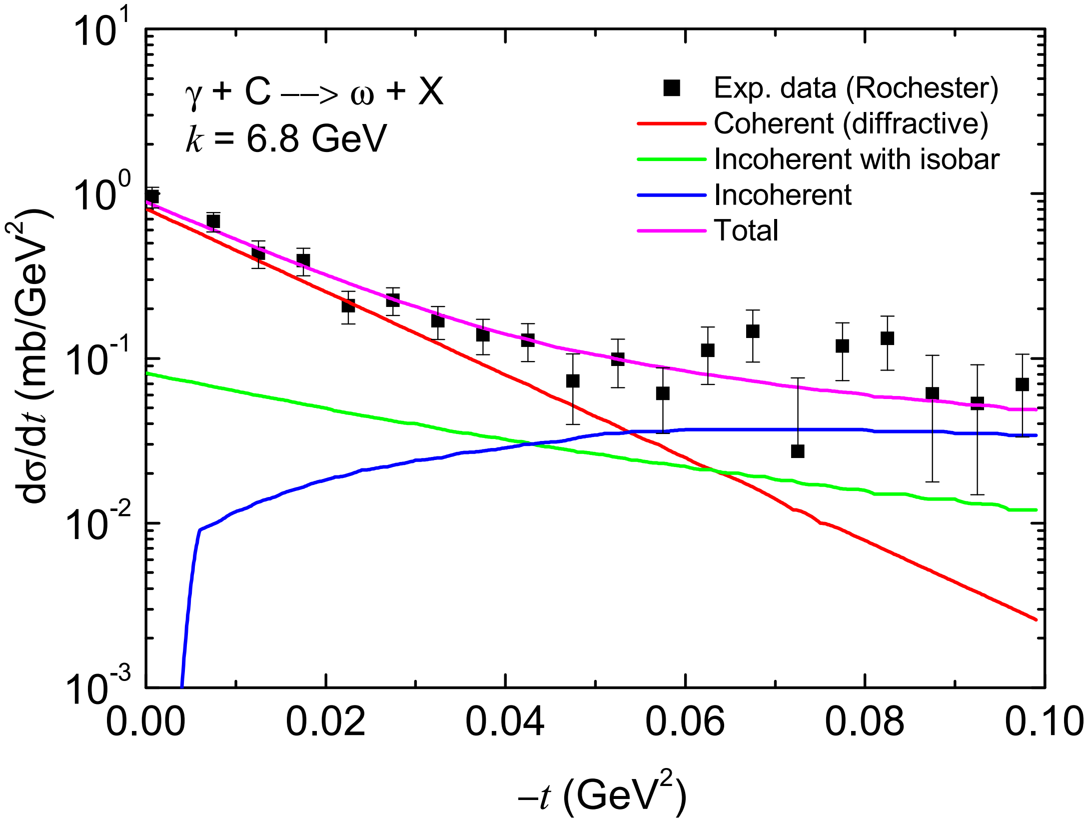
$$\left(\frac{d\sigma}{dt}\right)_{\omega N}(k,t) = C_1 k^{-1.6} e^{-b_1|t|} + C_2 k^{-0.08} e^{-b_2|t|},\ k \text{ in GeV} \quad \begin{cases} C_1 = 83.219\,\mu b / GeV^{0.4} \\ C_2 = 11.617\,\mu b / GeV^{1.92} \\ b_1 = 4.406\,GeV^{-2} \\ b_2 = 9.509\,GeV^{-2} \end{cases}$$



2. Elementary omega photoproduction ($\gamma + N \dashrightarrow \omega + N^*$)



3. dσ/d*t* for Carbon (theory versus Rochester data)



$$\left(\frac{d\sigma}{dt}\right)_{\theta=0} = 0.808 \pm 0.082 \left(\frac{\text{mb}}{\text{GeV}^2}\right)$$

$$b = 58\ \text{GeV}^{-2}$$

$$A_{eff} = 5.8 \pm 1.2$$

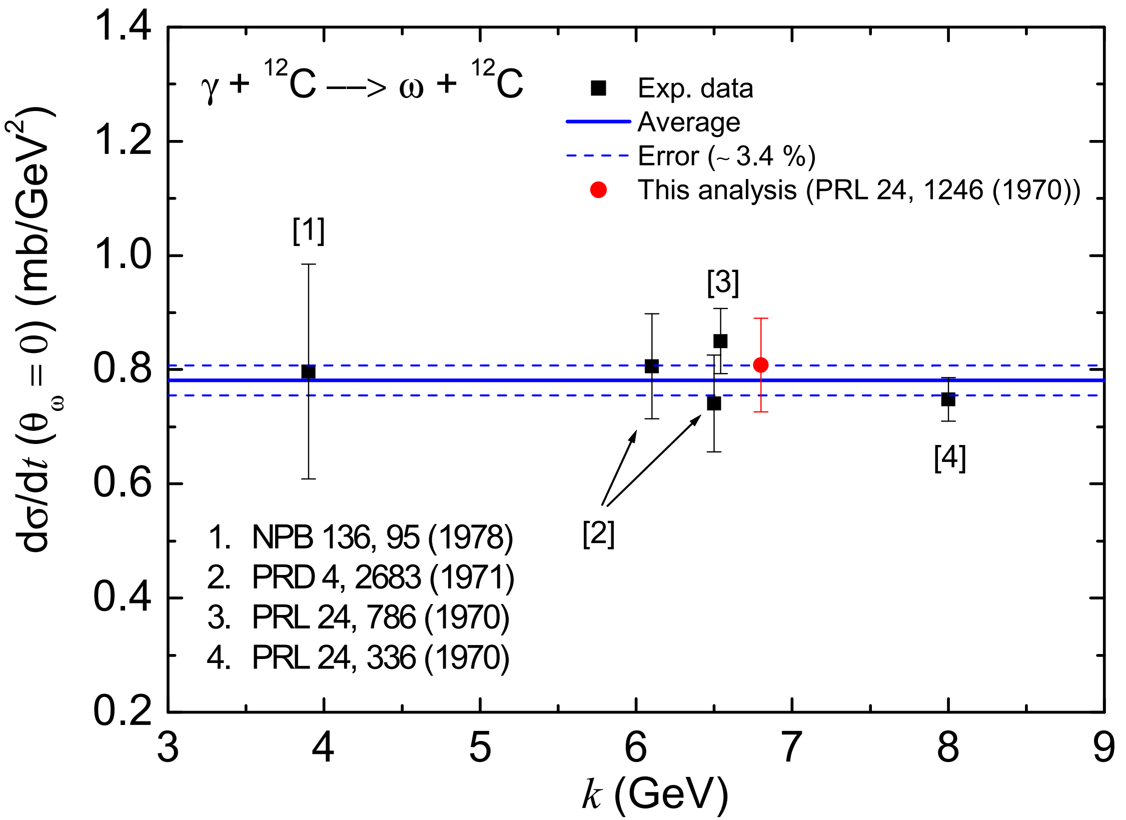
$$\frac{\chi^2}{n.d.f.} = 0.82$$

Exp. Data: H. –J. Behrend et al., Phys. Rev. Lett. 24, 1246 (1970)
(dσ/dt was not published)

4. Forward angle cross section $(d\sigma/dt)_{\theta=0}$

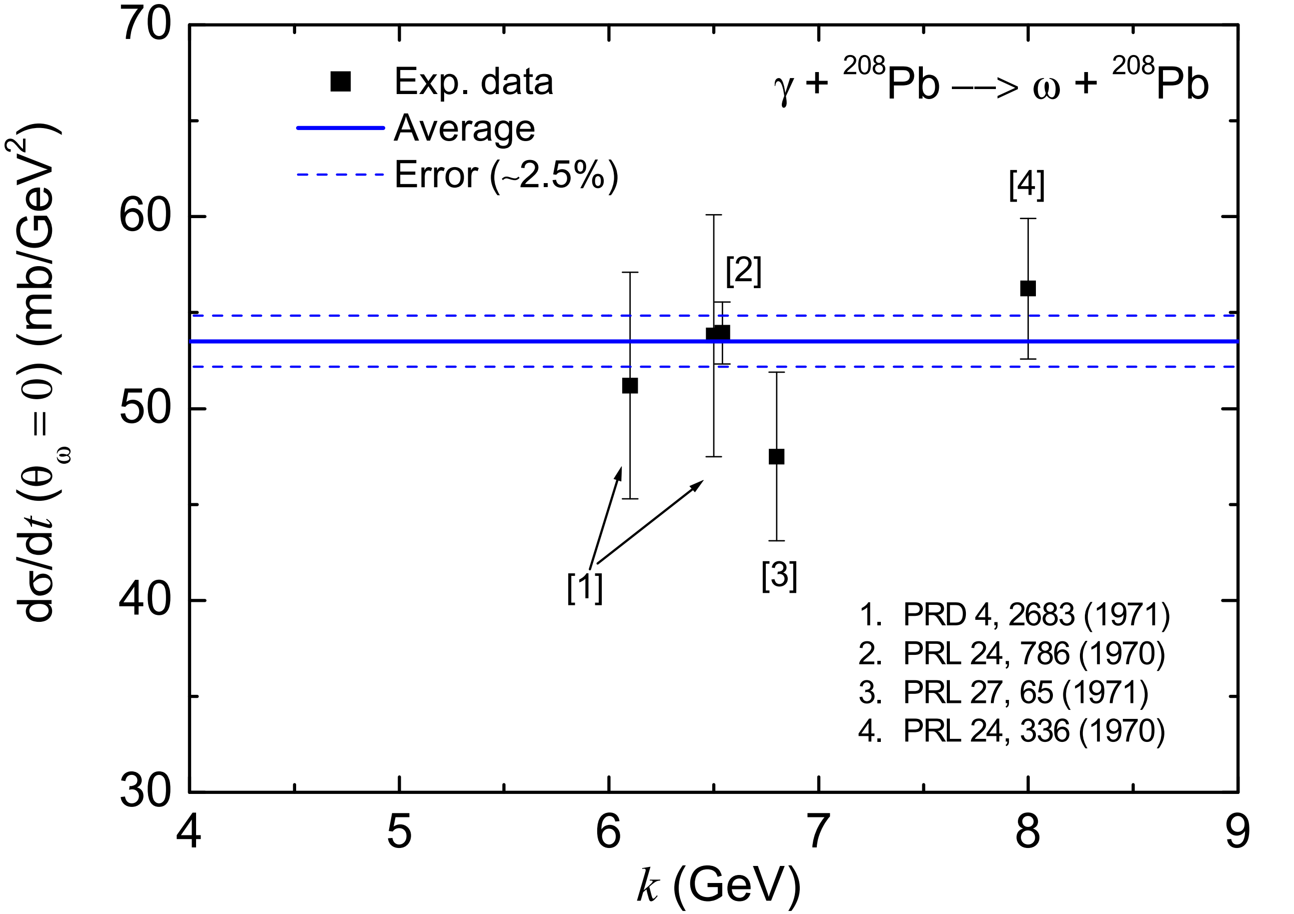
Combining omega and rho results:

$$\left(\frac{d\sigma}{dt}\right)_{\omega A}^{Diff.} = \frac{\gamma_\omega^2}{\gamma_\rho^2}\left(\frac{d\sigma}{dt}\right)_{\rho A}^{Diff.}, \quad \frac{\gamma_\rho^2}{\gamma_\omega^2} = 11.8 \pm 1.3 \ \textbf{(PRL 24, 1246 (1970))}$$



Carbon

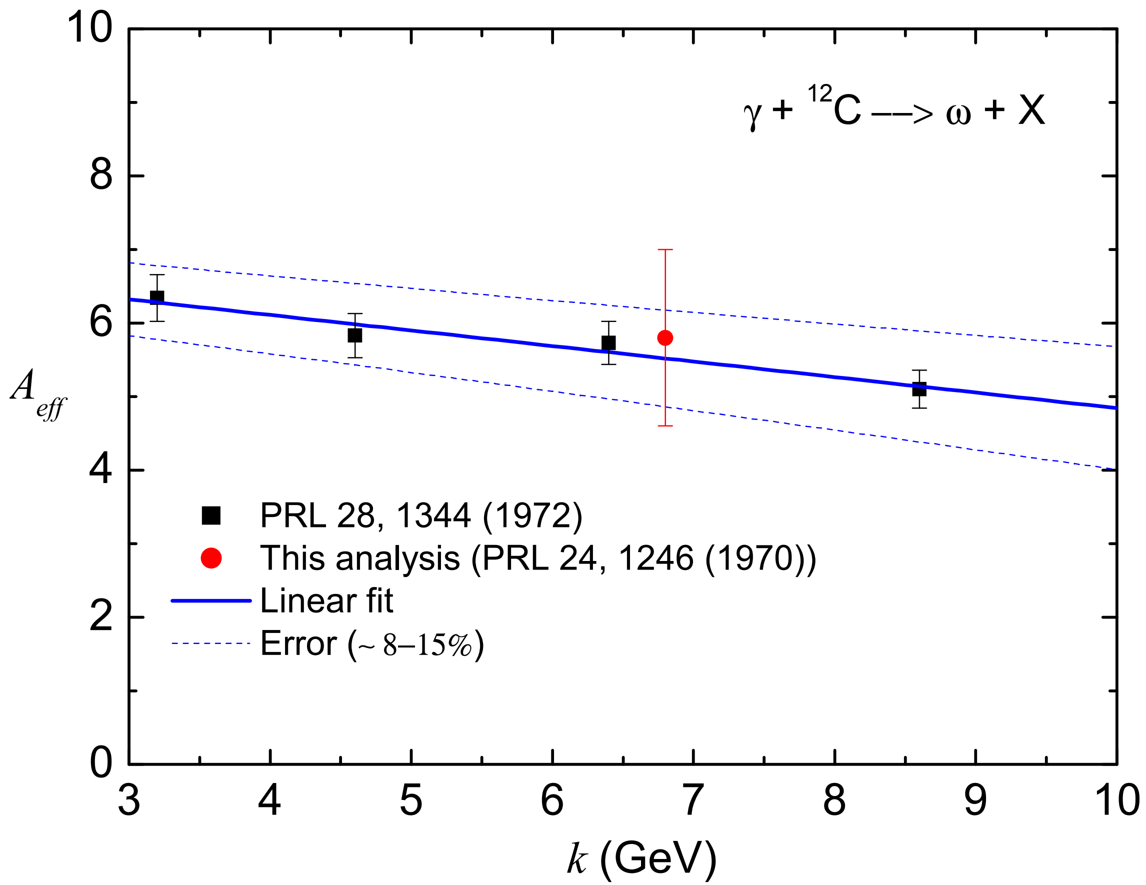
4. Forward angle cross section $(d\sigma/dt)_{\theta=0}$



Lead

5. A_{eff} versus photon energy

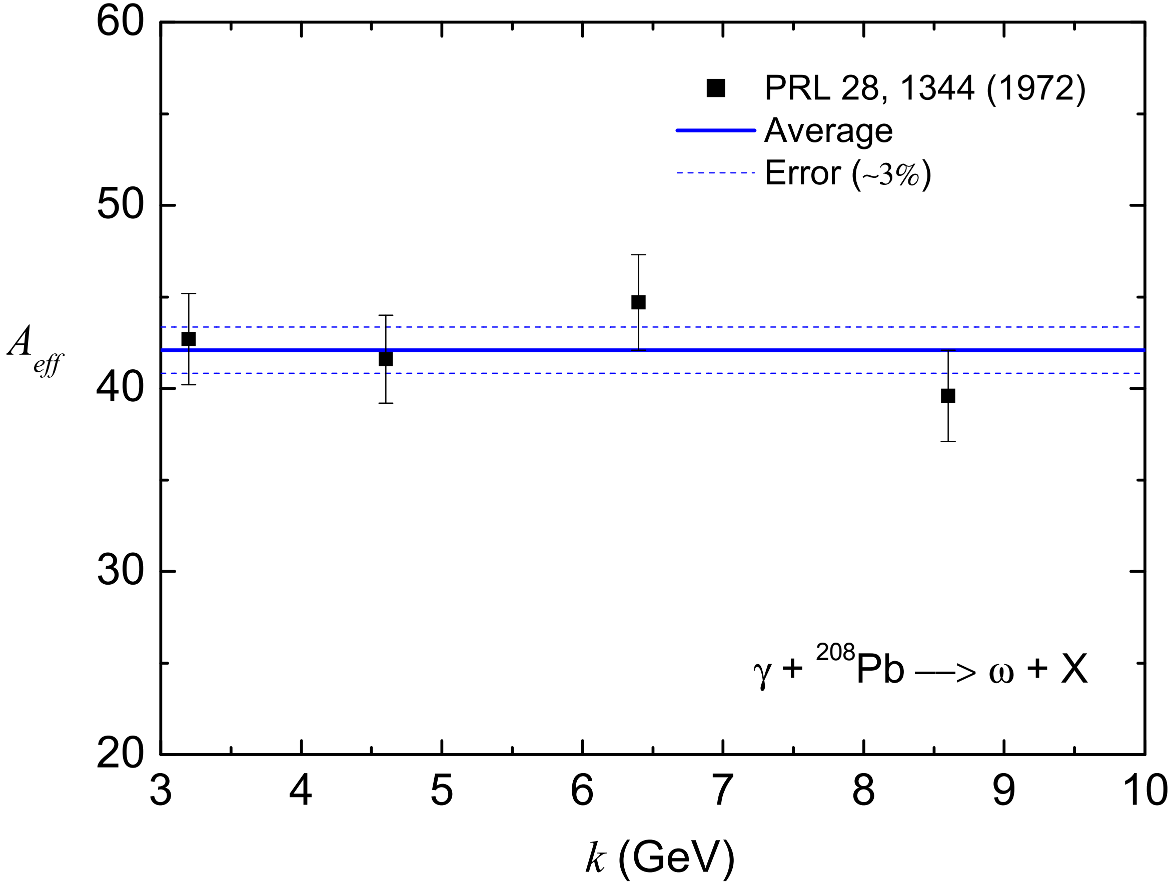
Using π^0 photoproduction results and the omega result (red point).
The A_{eff} factors are quite similar for π^0 and omega (VMD model).



Carbon

5. A_{eff} versus photon energy

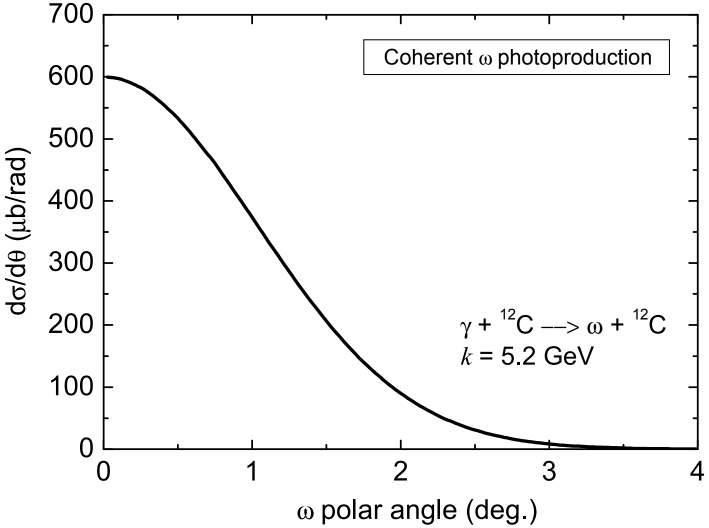
A_{eff} factors based only on π^0 measurements

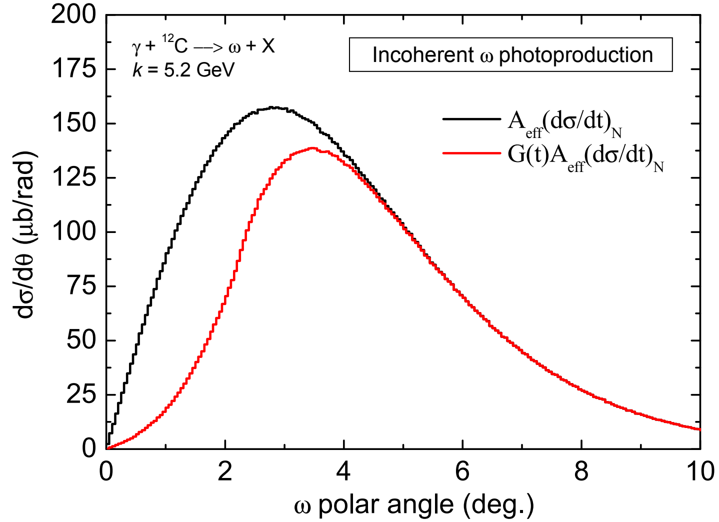


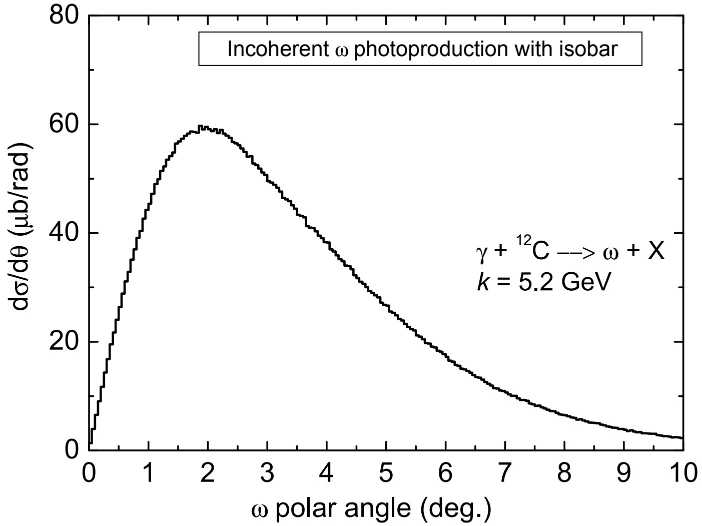
Lead

6. Results for omega photoproduction

Single differential cross section: dσ/dθ







Carbon

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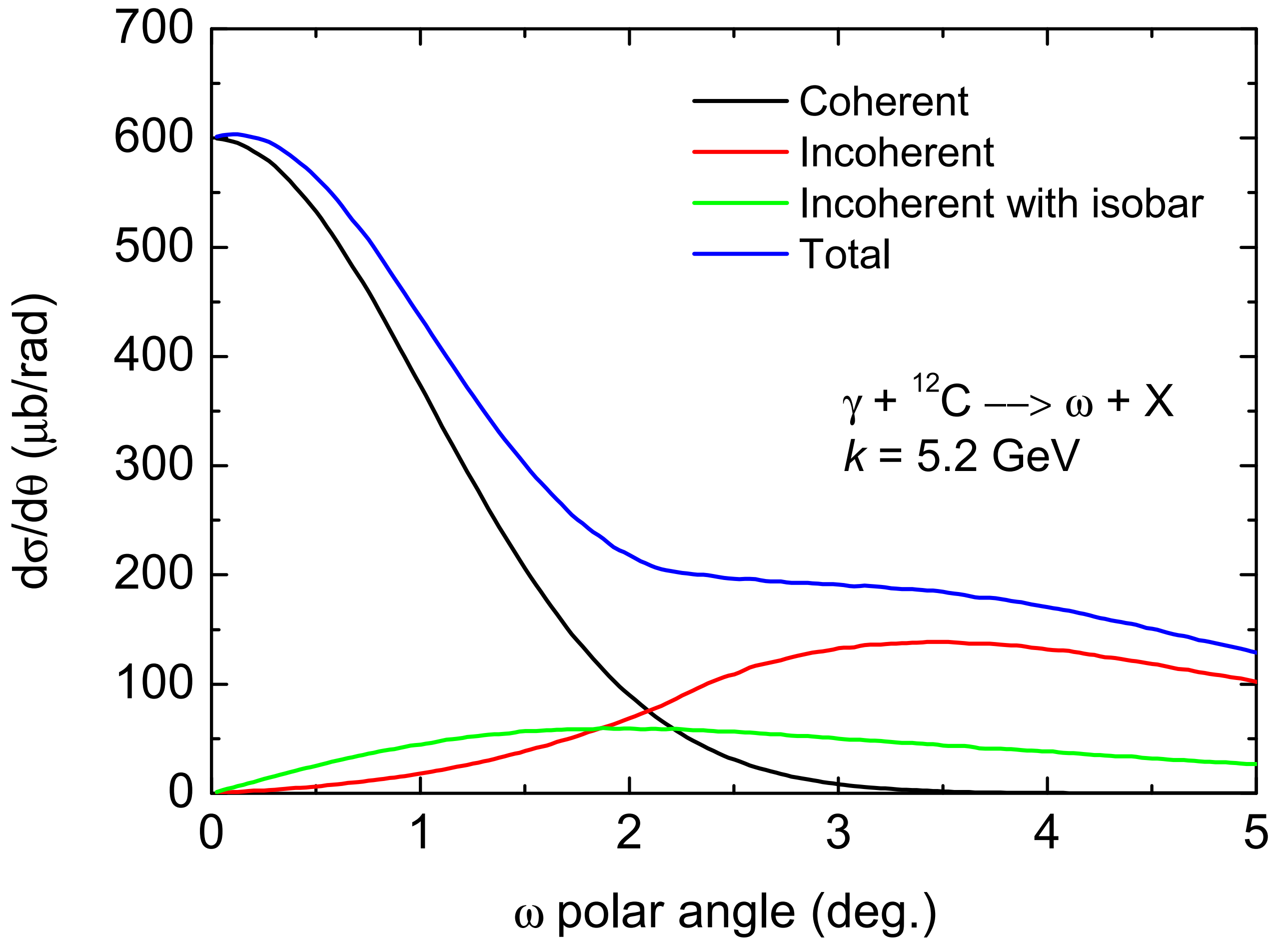
Single differential cross section: $d\sigma/d\theta$



Carbon

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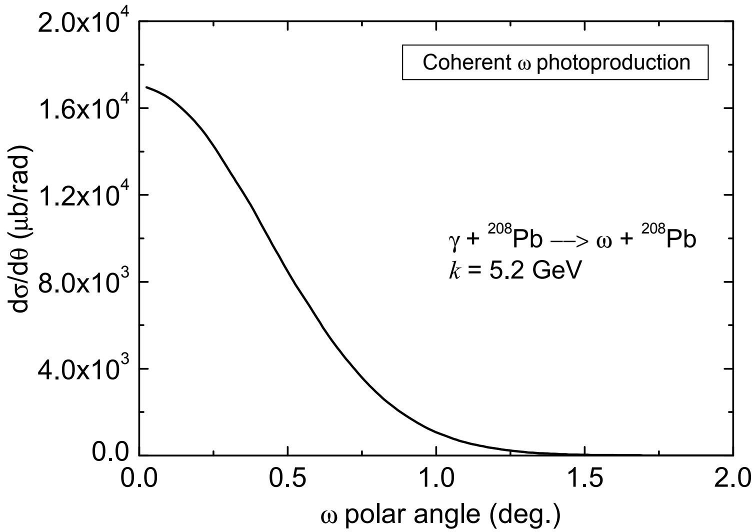

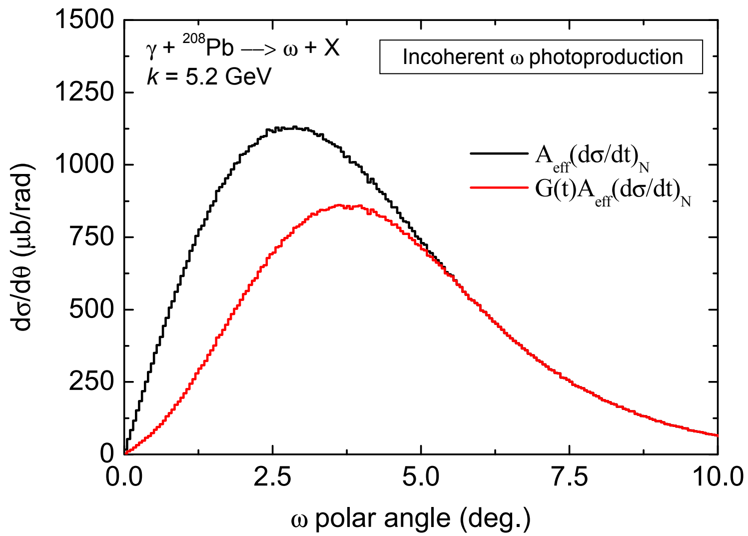

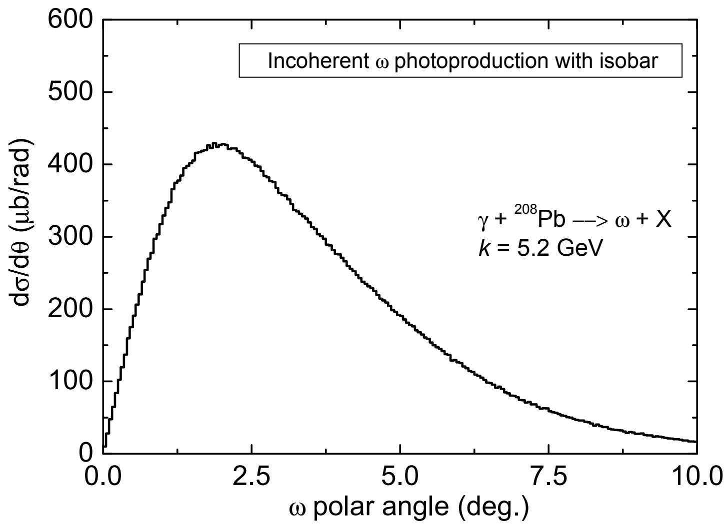

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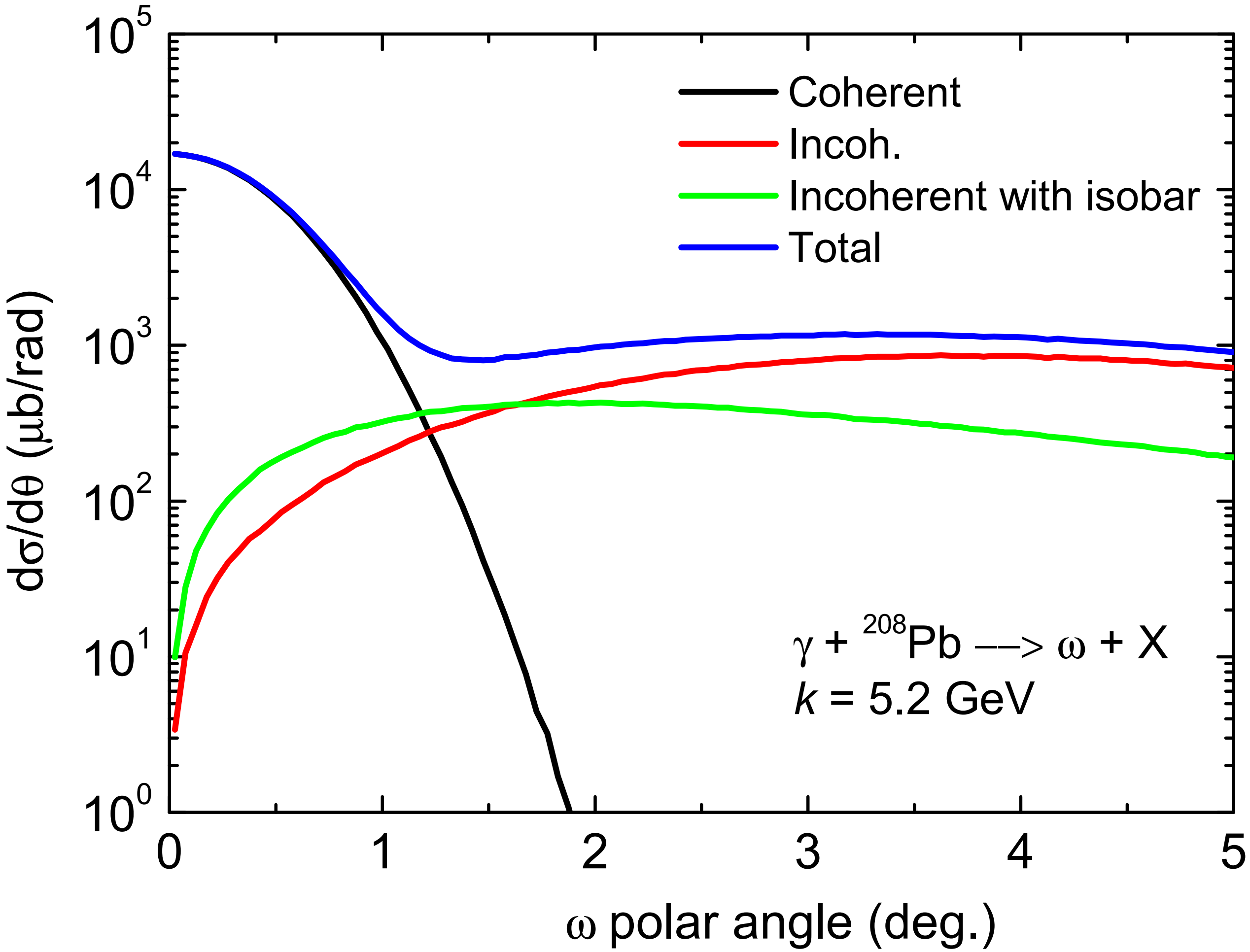
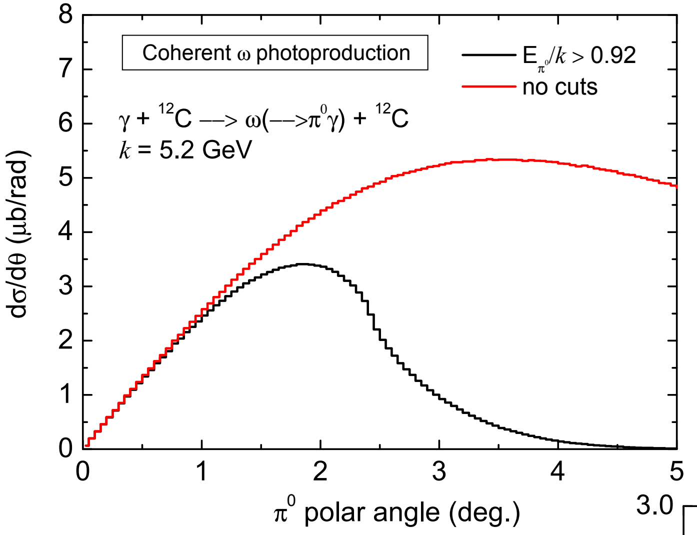


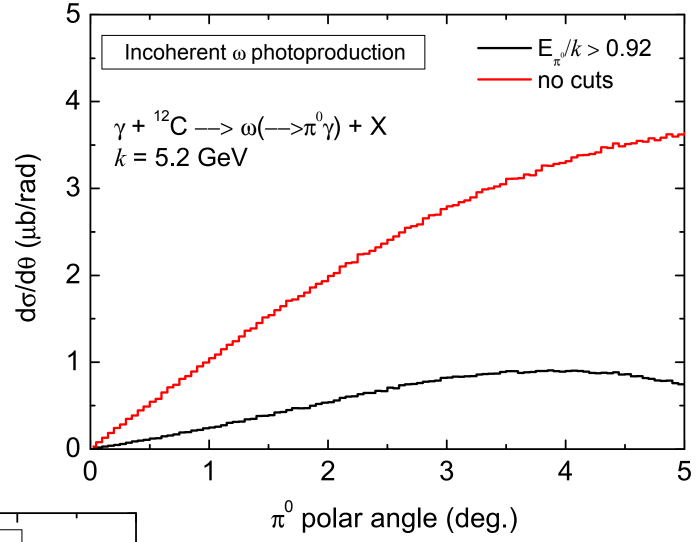
Lead

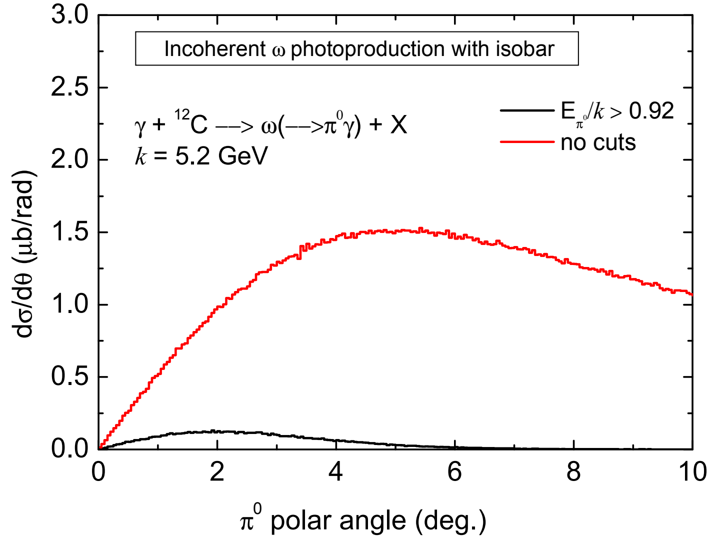
7. Results for π^0 background

Single differential cross section: $d\sigma/d\theta$

1. $\omega \longrightarrow \pi^0\gamma$ decay B.R. = 8.5 % (PDG)
2. Ang. Distr. ~ $1+\cos^2\theta$.







Carbon

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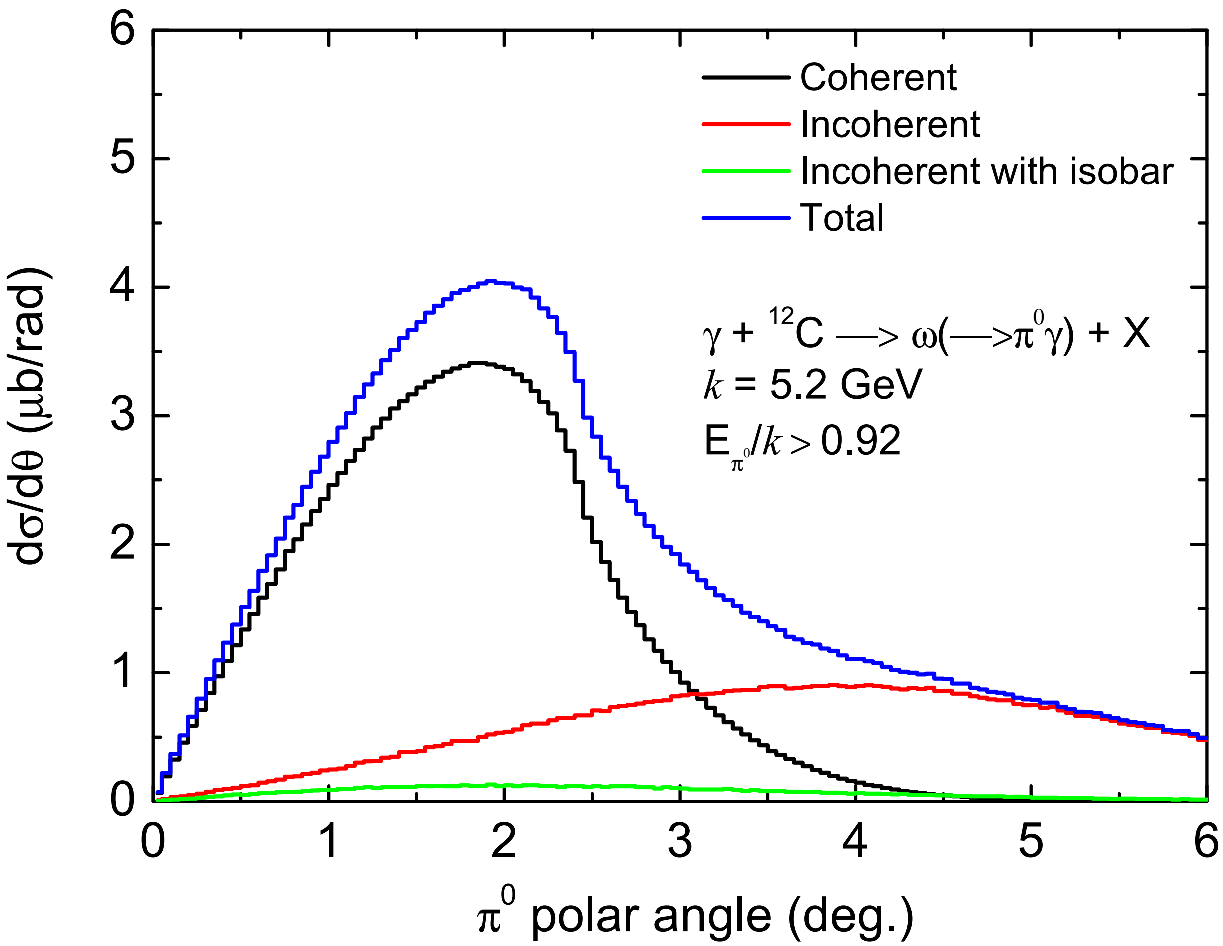

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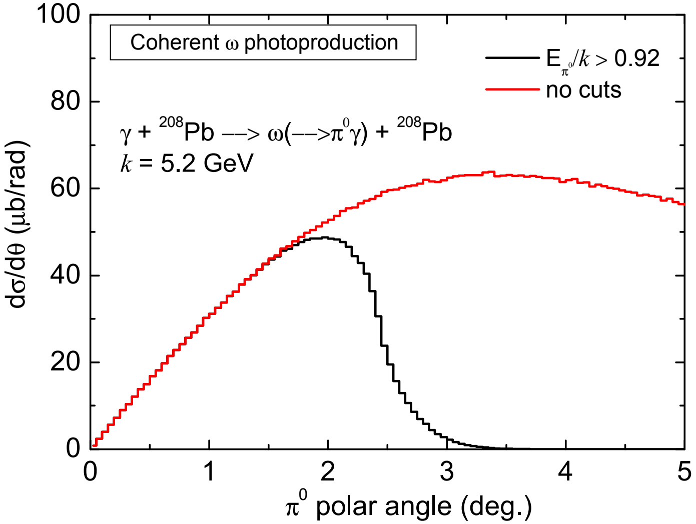

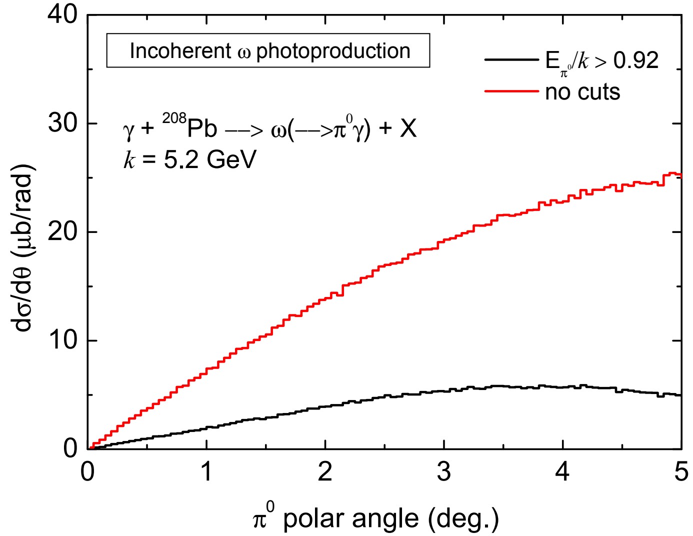

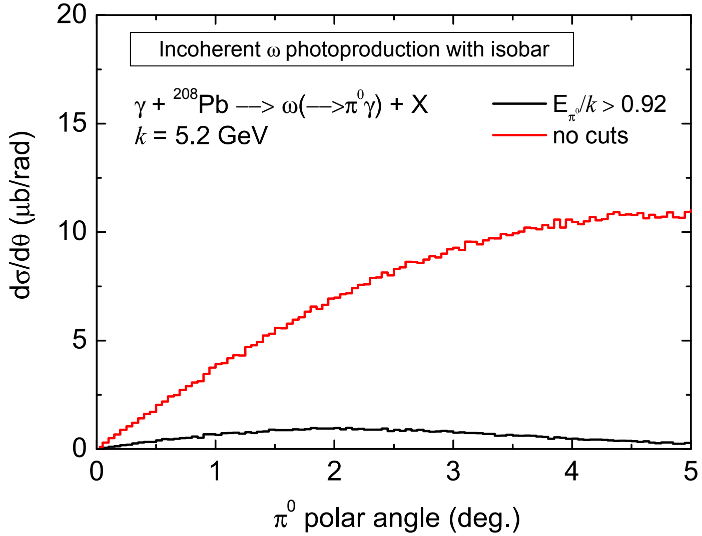

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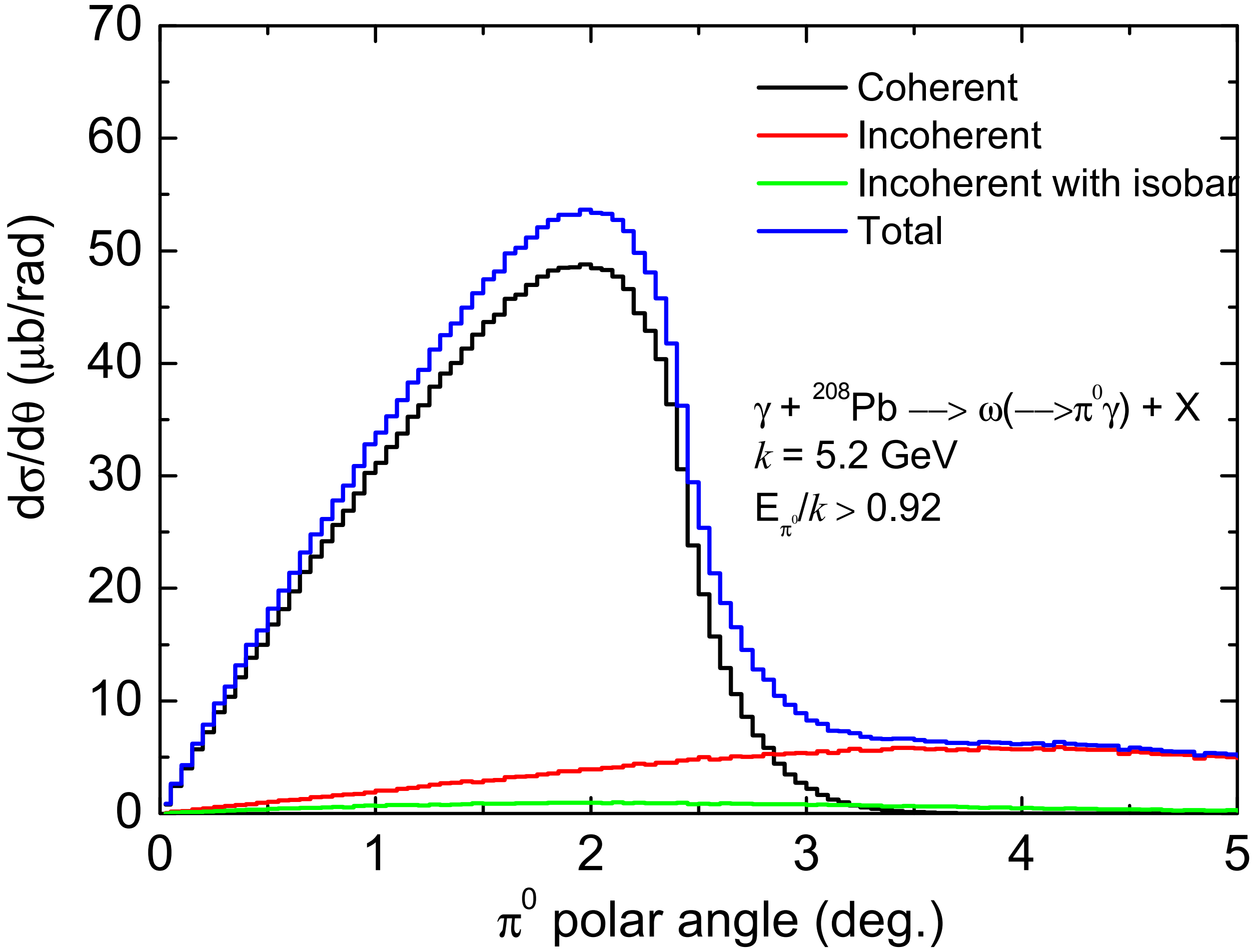
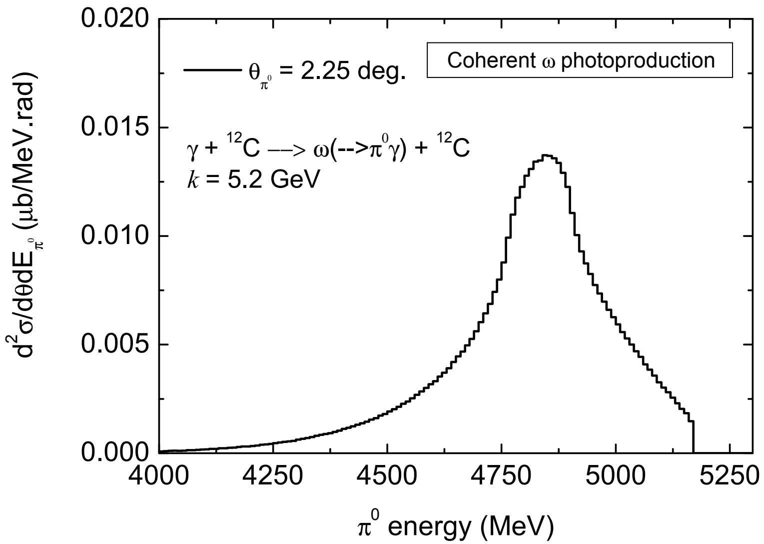
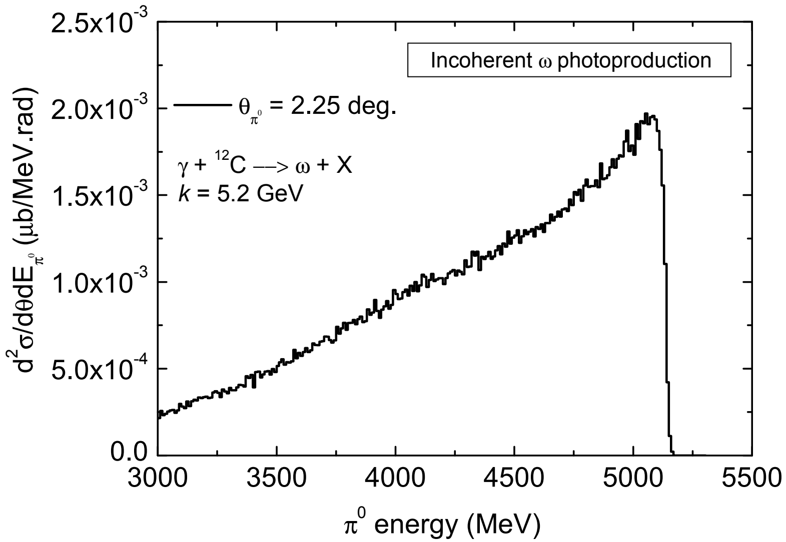


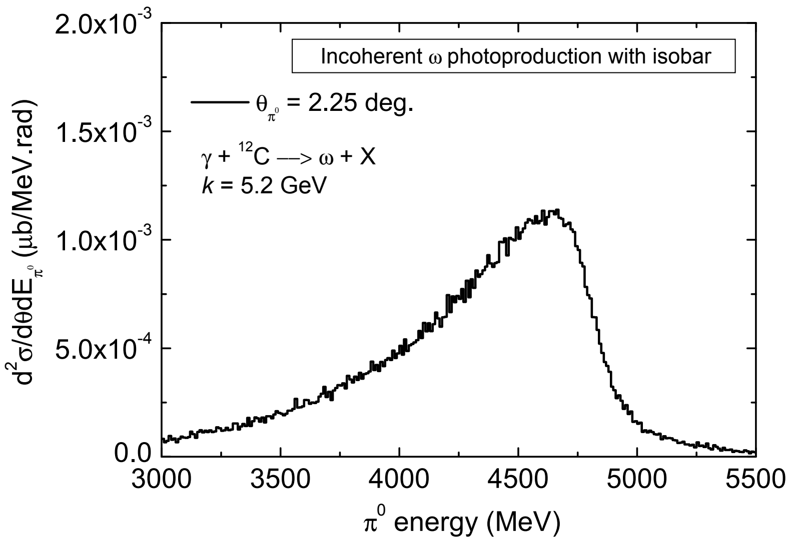
Lead

7. Results for π^0 background

Double differential cross section: $d^2\sigma/d\theta dE_{\pi 0}$







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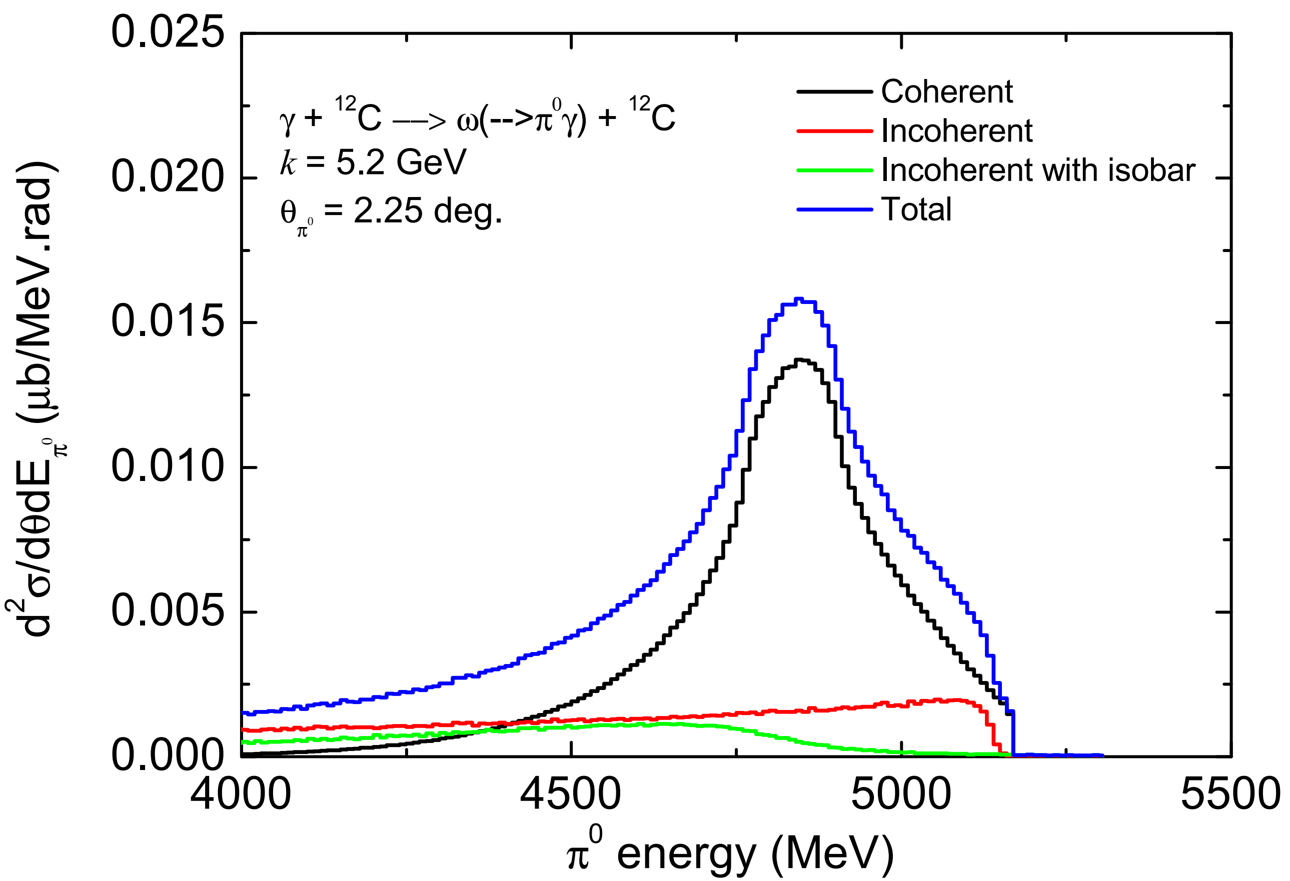

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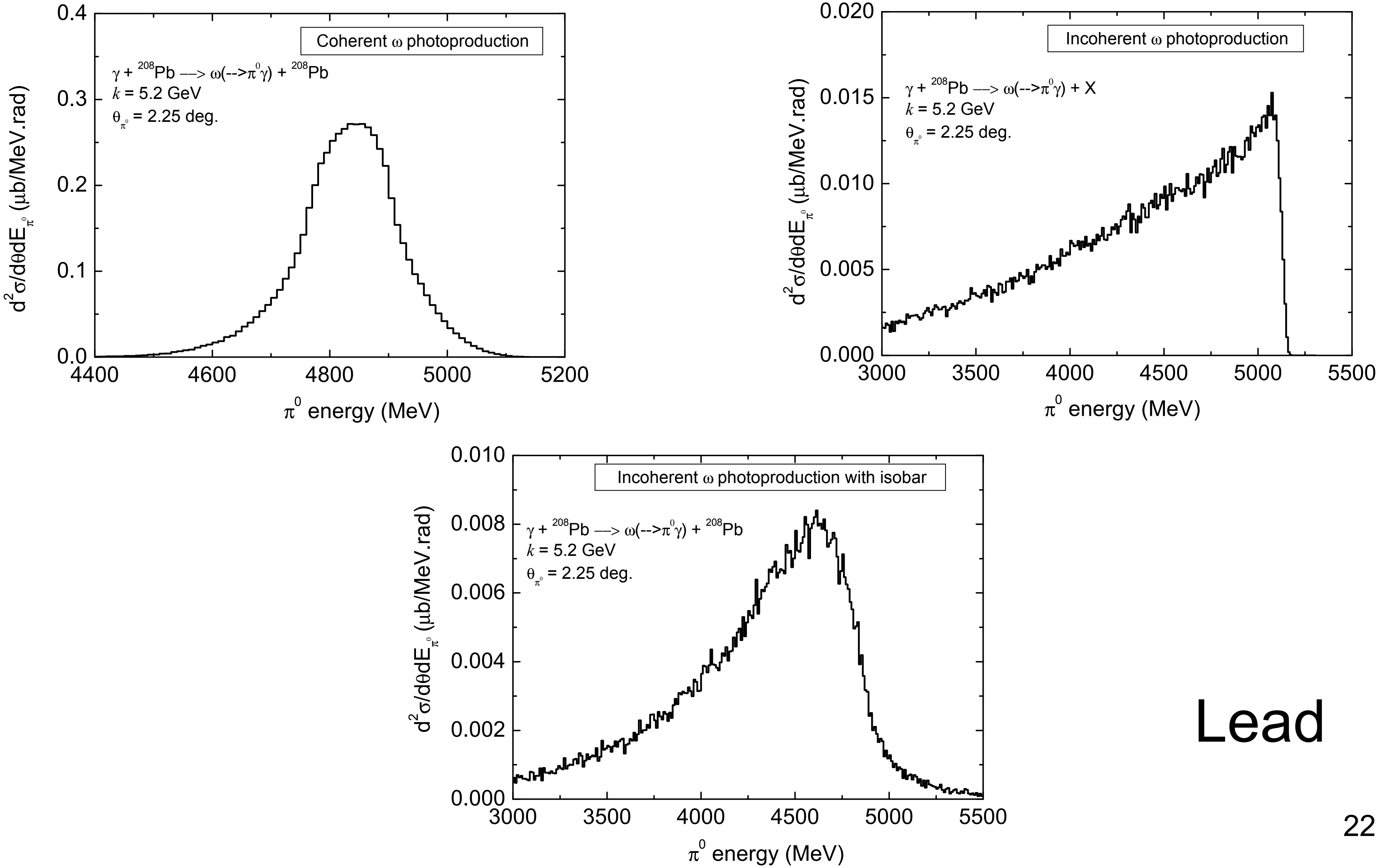

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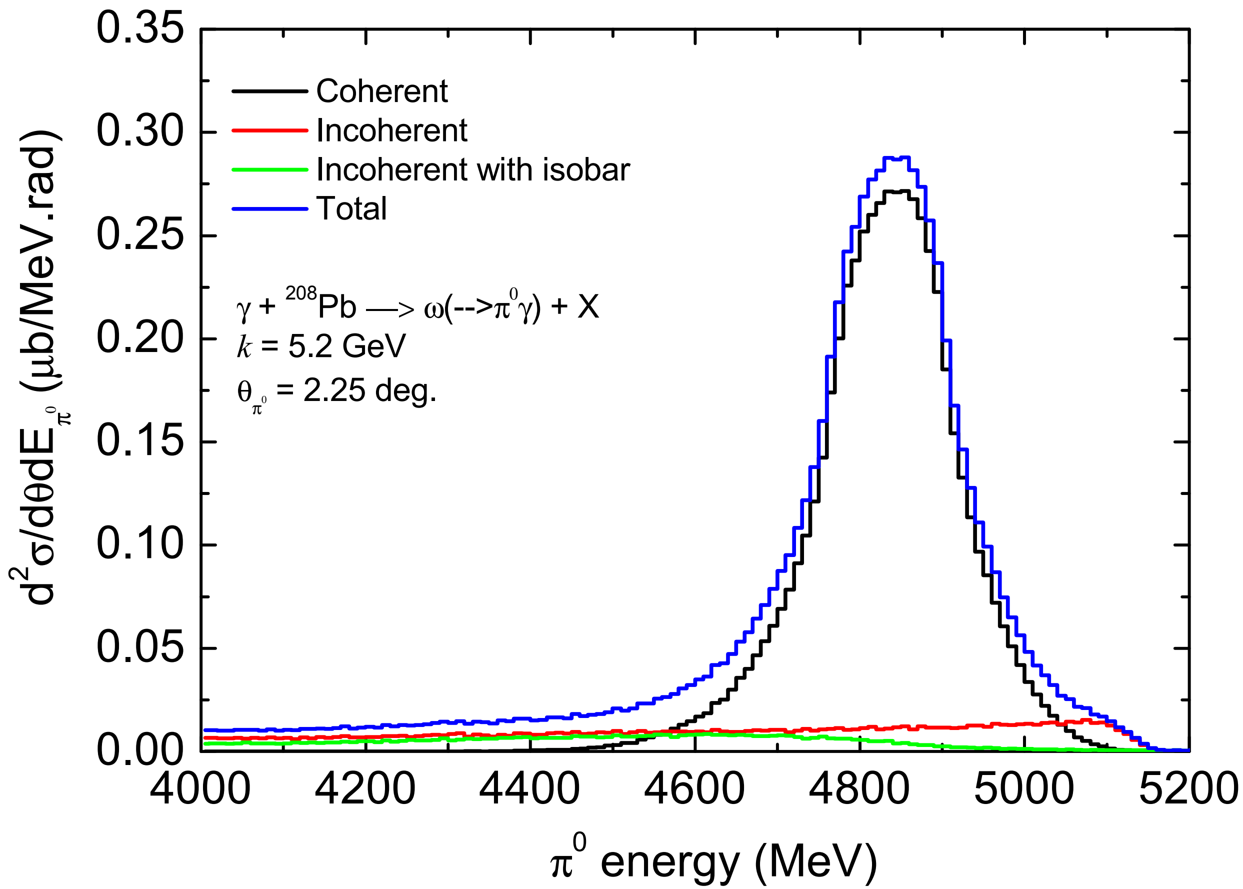
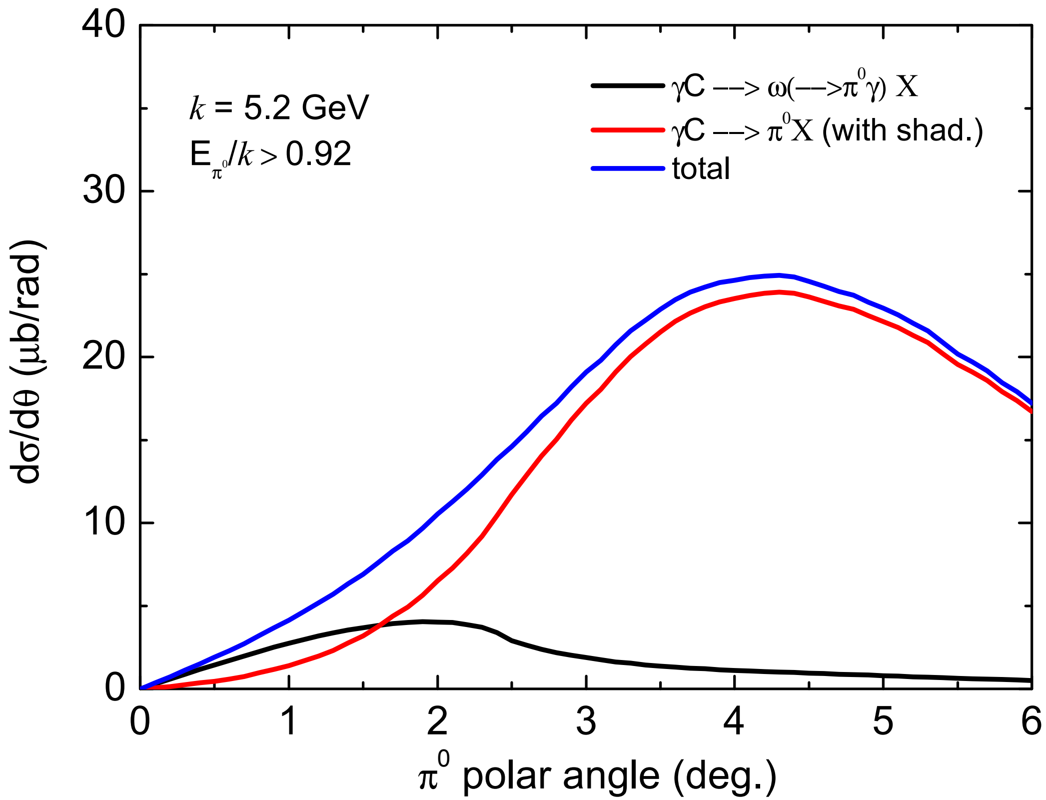


Lead

8. Adding the omega background to the NI mechanism

(“total” π^0 background due to inelastic processes)



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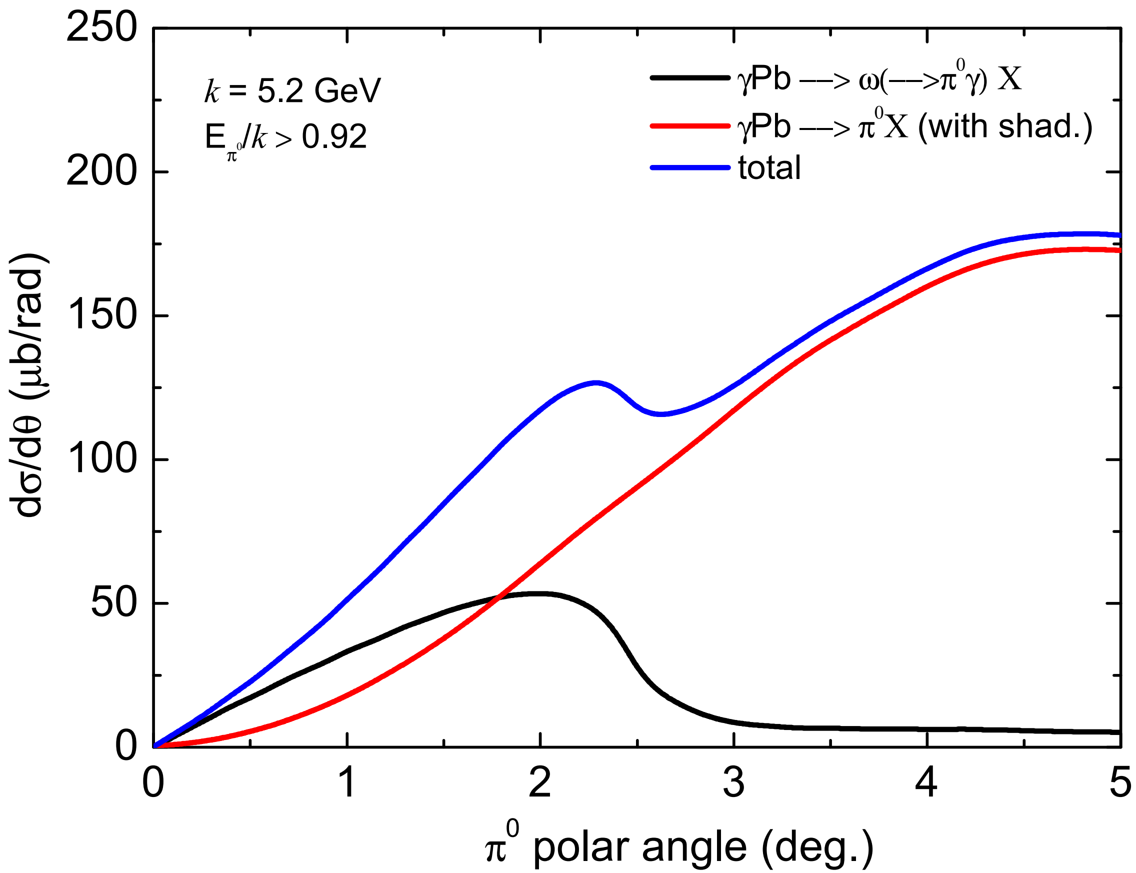

Lead

9. Conclusions and final remarks

1. All the relevant mechanisms for omega photoproduction in nuclei were included in the present analysis. The total cross section is largely dominated by coherent production (slides 13 and 15).
2. The forward angle cross sections and Aeff parameters were consistently determined in this analysis both for Carbon and Lead (slides 8 to 11). The Rochester omega photoproduction data for Carbon (unpublished) were described very accurately using G(t) from the MCMC model and the isobar contribution.
3. The π^0 background due to omega photoproduction with isobar is negligible when elasticity cuts of 0.92 are applied to the pion energy.
4. The double differential cross sections (slides 20 to 23) could be useful to investigate the influence of elasticity cuts to the angular distributions.
5. The inclusion of omega background to the previous NI π^0 background changes considerably the shapes of the angular distributions (slides 24 and 25). This procedure could be very important to extend the analysis to the Lead Glass.