Inclusive rates for electron and pion productions in the (ep) scattering at 11.5 GeV

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Contents

1 Introduction

One of PID problems for the upgraded CLAS at 11 GeV electron beam energy will be a separation of the scattered electron and pions, both π^+ and π^-, at the trigger level, and the separation of an electron and π^- in the analysis. This is due the fact that more pions will be produced in the kinematical regions where electrons are detected. This problem can be solved by adding a high threshold Cherenkov counter in the forward region, that can be used in the trigger as well in the data analysis.

In this note we present estimates for the electron and pion rates at 11 GeV. We use projected acceptance functions for the upgraded CLAS (FastMC). Contribution of e^-s from π^0 decay is presented as well.

2 Cross sections

To calculate rates of electrons computer code developed by M. Sargsyan [1] is used. It uses parameterization of the inclusive electron scattering cross section, and allows to calculate radiative effects. This code was tested with raw (radiatively uncorrected) experimental data and showed excellent agreement. For inclusive pion electroproduction rate we use results of SLAC measurements from the internal note [2] by M. Mestayer. and pions

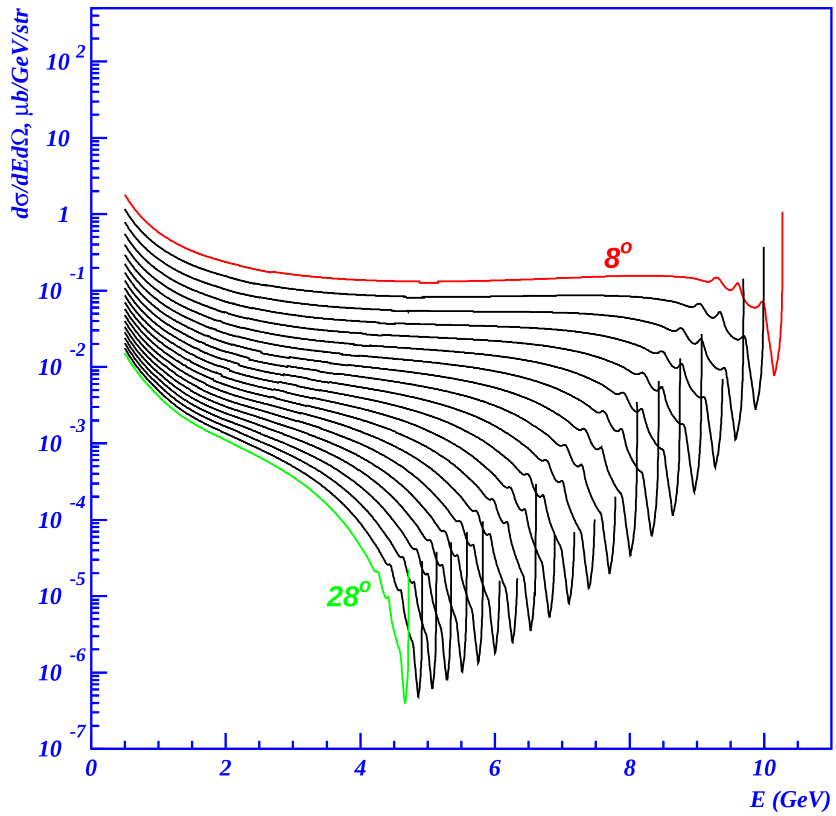

Figure 1: Cross section of the reaction $ep \rightarrow eX$ at 11.5 GeV as a function of scattered electron energy, for scattered angles from 8° to 28°. Calculations done using code [1].

2.1 Reaction $ep \rightarrow eX$

For inclusive electron scattering cross section is calculated based on the Bodek parameterization, then radiative effects are added on. Final cross section consists of 3 pieces: radiated elastic, radiative tail of the elastic, and radiated inelastic. Program allows to set beam energy target thickness, scattered electron kinematics, and chose the output, like radiative or non-radiative cross sections. Results of simulations were tested against measured raw cross sections, it it showed good agreement. In Figure 1 radiated cross section of the process $ep \rightarrow e'X$ as a function of scattered electron energy is shown for several values of scattered electron angles, from 8^o to 28^o degree. In this calculation beam energy was 11.5 GeV

2.2 Reaction $ep \rightarrow \pi^- X$

Cross section of the π^- production in the reaction $ep \rightarrow \pi^- X$ was studied in the reference [2]. The purpose this study was the same as in our case, estimate of the pion contamination in the electron sample for deep inelastic electron scattering reactions. In [2] cross section is parametrized as a function of $p_\perp$, with scaling variable that includes possible maximum momentum of pion from final state $ep \rightarrow \Delta^{++}\pi^-$.

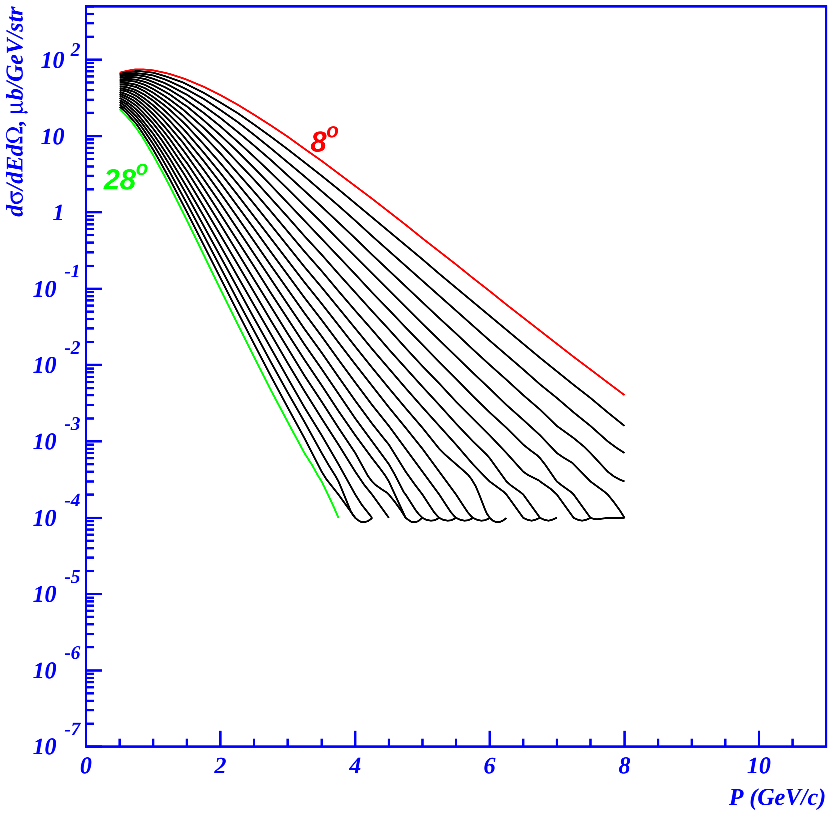

Figure 2: Cross section of the reaction $ep \rightarrow \pi^- X$ at 11.5 GeV as function of pion momentum, for pion angles from 8° to 28°. Calculations done according to [2].

Therefore this parameterization has beam energy in it (data points were obtained at different electron beam energies). Parameterization give in [2] was used to calculate cross section of π^- production. Obtained results are shown in Figure 2. In the figure pion production cross section is shown as a function of the pion momentum for several production angles from 8^o to 28^o. Calculations are done for the

2.3 Cross section ratios

Ratio of cross sections for reactions $ep \rightarrow \pi^- X$ and $ep \rightarrow eX$ as a function of electron (pion) momentum for several different values of scattered angle is presented in Figure 3. As one can see for momenta bellow 3-4 GeV/c pion cross section is two-tree orders of magnitude higher than electron cross section. This implies that for data analysis e/π rejection system should be able to suppress π^- with more than three-four orders of magnitude at these momentum range.

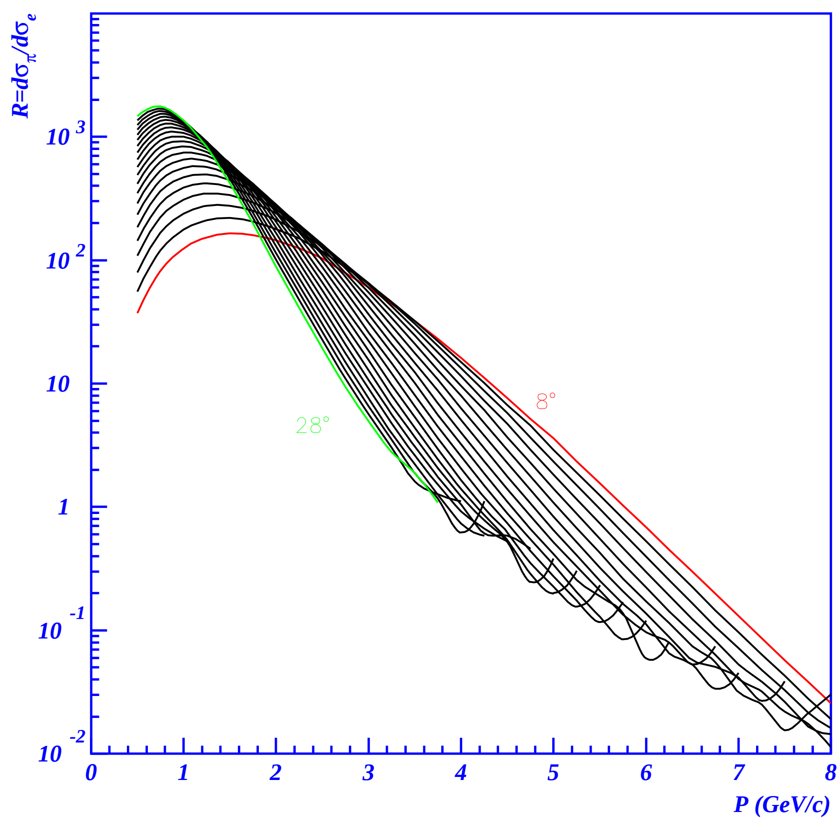

Figure 3: Ratio of cross sections of reactions $ep \rightarrow \pi^- X$ and $ep \rightarrow eX$ at 11.5 GeV as a function of particle momenta. Scattering angles are from 8° to 28°.

3 Trigger rates with upgraded CLAS

$CLAS^{++}$ will be design to run at luminosities up to 10^{35} cm^{-2} sec^{-1}. Trigger system should be able to effectively trigger on scattered electrons in the electron scattering experiments. Unlike in previous case, in the trigger will be impossible to separate charge, so to the pion rate not only π^-s will contribute but also π^+. Estimated ratio of π^+:π^- is about $4:1$. Taking all these into account, and the cross sections from above estimates, expected electron trigger rate and the rate pions, contributing into the trigger is studied.

In this studies pion suppression factor for the forward calorimeter was taken using cut on the energy deposited in the calorimeter. Studied showed that if cut at 0.7 GeV then suppression factor will be less than 0.1 for pions with energy bellow 3 GeV, and will be around 0.2 for pions with energy above 3 GeV. For the existing Cherenkov counter pion suppression above 3 GeV was taken 0.05. No additional detector for π/e separation is considered.

3.1 Electron rates

Number of electrons scattered at given angle as a function of electron momentum in the 10 MeV/c momentum bins is shown in Figure 4. Luminosity is 10^{35} cm^{-2} sec^{-1}. Angular range is the same as in the case of cross section calculations, from 8^o to 28^o in 1^o steps. These rates are calculated using $CLAS^{++}$ acceptance function.

For the triggering purposes of course important number is the integrated rates. Integrated rates for this angular range is shown in Figure 5. Rates are shown as a function of possible trigger threshold in the calorimeter (the same as scattered electron energy).

Useful range for triggering is bellow 2 GeV. In Figure 6 the ration of number of electrons as a function of Q^2 is shown. Although this ration stays constant in the wide range of Q^2, it is incomplete since one should also look the effect of the trigger threshold on x or W.

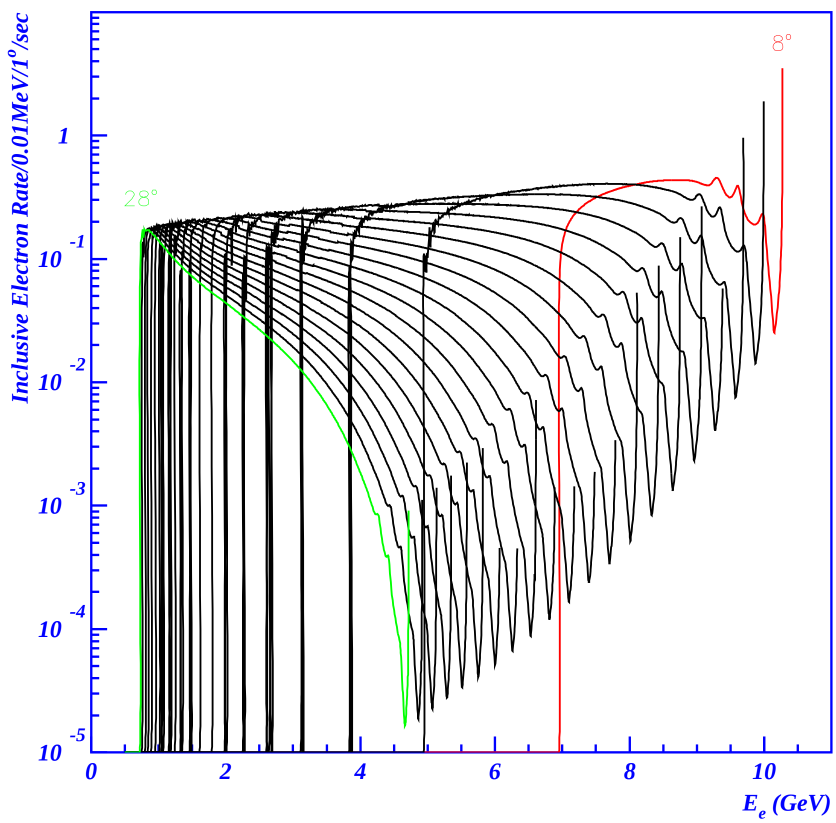

Figure 4: Rates of electrons scattered at 8° to 28°, as a function of scattered electron energy in the 10 MeV energy bin. Beam energy 11.5 GeV, luminosity 10^{35} cm^{-2} sec^{-1}. Upgraded CLAS acceptance is applied.

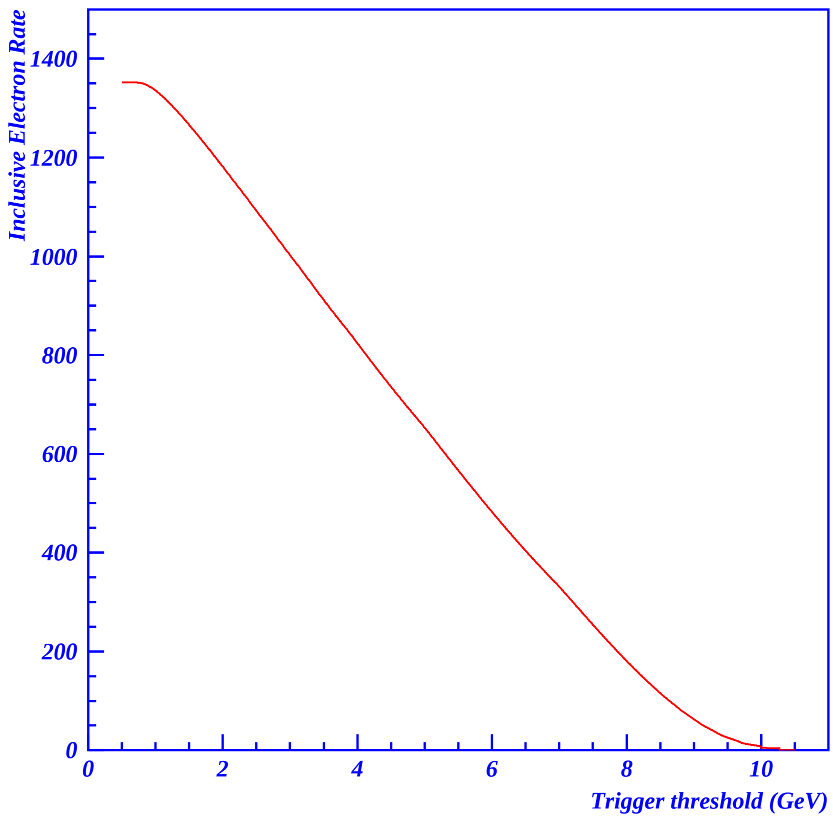

Figure 5: Rates from Figure 4 integrated over scattering angle as a function of minimum energy (trigger threshold).

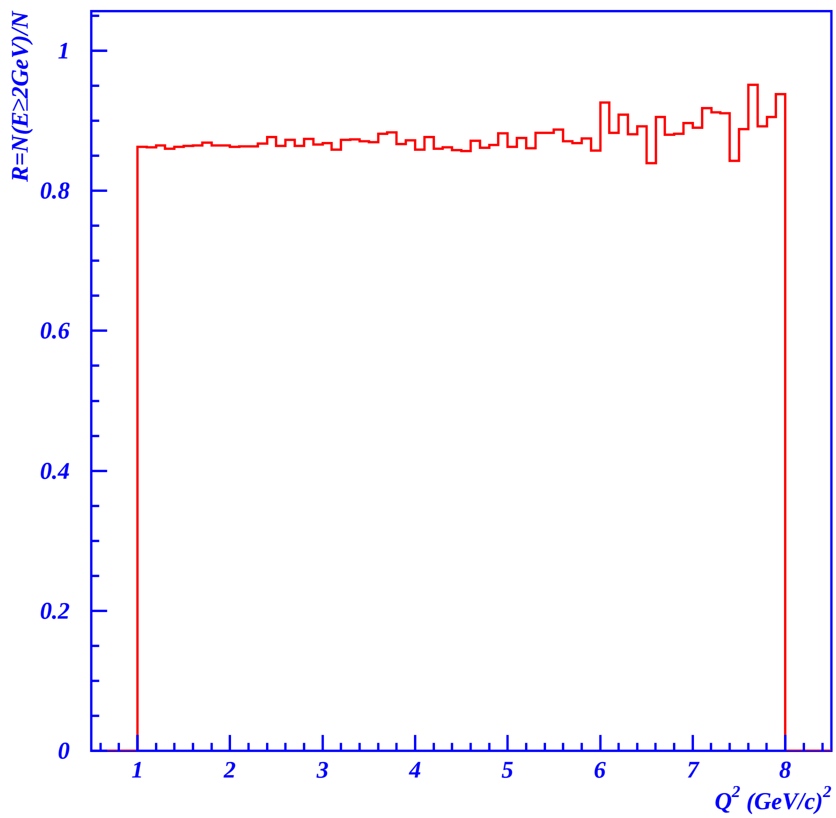

Figure 6: Ratio of the number of electrons with E>2 GeV over the number of electrons with E>0.5 GeV as a function of Q^2.

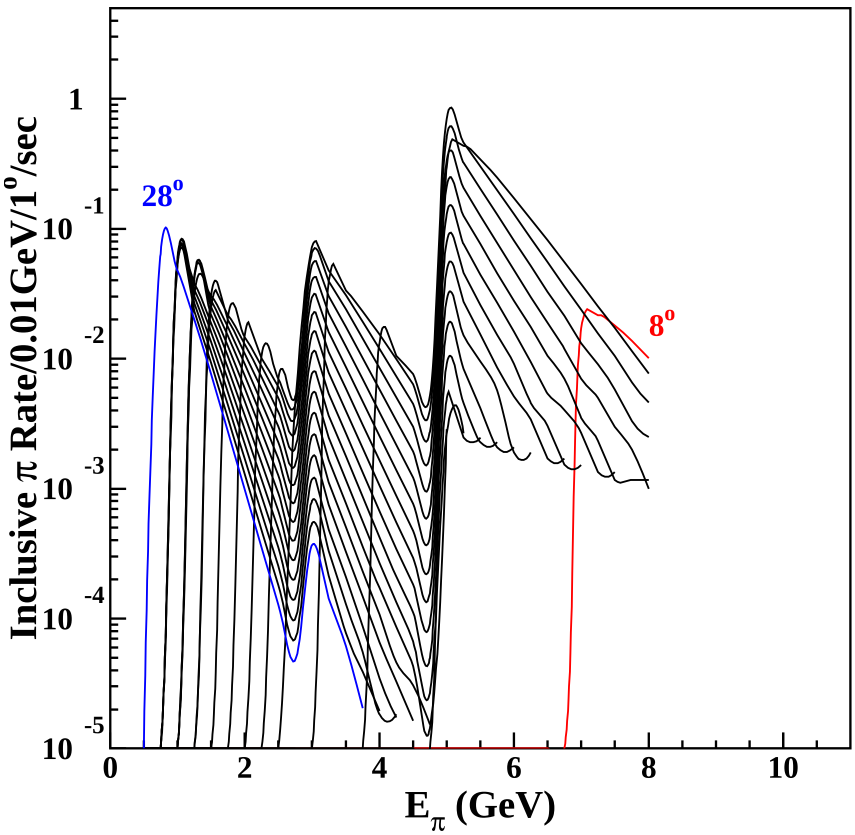

Figure 7: Rates of π^+ and π^- scattered at 8° to 28°, as a function of scattered electron energy in the 10 MeV energy bin. Beam energy 11.5 GeV, luminosity 10^{35} cm^{-2} sec^{-1}. Upgraded CLAS acceptance is applied. Rates for π^+ is taken as 4 times of π^- rate. Suppression factor for pions with $P_\pi < 5$ GeV is 0.001 (0.1 from EC energy cut at 0.7 GeV and 0.01 from high threshold CC), for pions < 3 GeV 5×10^{-5} with 0.05 from low threshold CC, and for pions $P_\pi > 5$ GeV 0.2 coming from EC energy cut only.

3.2 Contribution of π^-, π^+ and π^0

The same way as for electrons, $\pi-$ and π^+ rates were estimated assuming above mentioned π/e rejection factors for the forward calorimeter and the existing Cherenkov counter. It was estimated that π^+ rate will be 4 times higher than the rate of π^-. The dependence of charged pion rates on pion energy is shown in Figure 7 for luminosity 10^{35} cm^{-2}. CLAS^{++} acceptance is applied. Change of dependence at 3 GeV is due to Cherenkov with 3 GeV threshold and pion suppression factor of 0.05. For the energy range shown calorimeter pion rejection factor was assumed to be 0.1.

Integrated rates for charged pions and electrons as a function of scattered particle energy are shown in Figure 8. As one can see pion rate is much higher than electron rate bellow 4 GeV. In this region one will need to suppress pions at least an order of magnitude to have the same number of pions and electrons in the trigger. This can be done by raising calorimeter threshold, for example (see Figure 6 and discussions above).

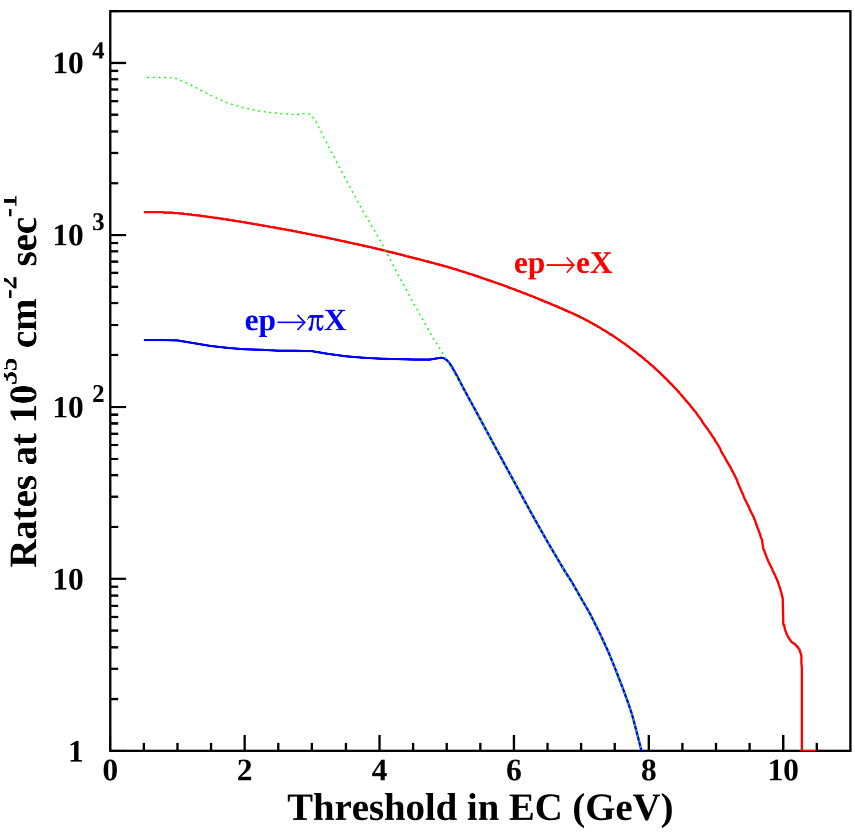

Figure 8: Rates from Figure 5 and Figure 7 integrated over scattering angle as a function of energy cut in the calorimeter. Green dotted line is the pion rate without high threshold Cherenkov counter.

The π^0 can contribute through Dalitz decay. In the upper plot of Figure 9 distributions of pi^0 and electrons from Dalitz decay of pion are shown as a function of particle momentum. In the lower plot ratio of these two distributions is presented as a function of particle momentum. Branching fraction 0.01 for $\pi^0 \to e^+e^-$ is not included. Therefore the increase of trigger rate due to π^0 Dalitz decay is negligible.

References

[1] M. Sargsyan, CLAS-NOTE 90-007 (1990).

[2] M. Mestayer, SLAC Eng.Note 72 (1977).

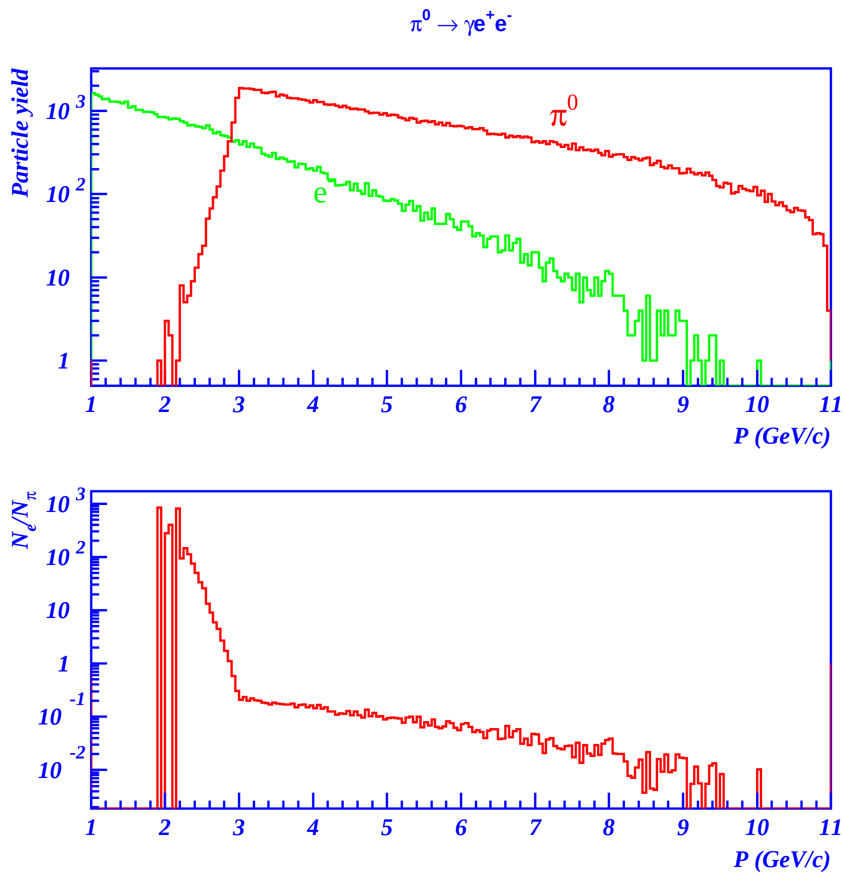

Figure 9: Upper plot: spectra of π^0s and electrons from $\pi^0 \to e^+e^-$ as a function of momentum. Lower plot the ratio of number of electrons and pions as function of momentum. Branching ratio of 0.01 for $\pi^0 \to e^+e^-$ is not included.