Investigation of Limitations on the Photon Tagging Technique

Author: Marianna Gabrielyan
Supervisor: Dr. Daniel Dale

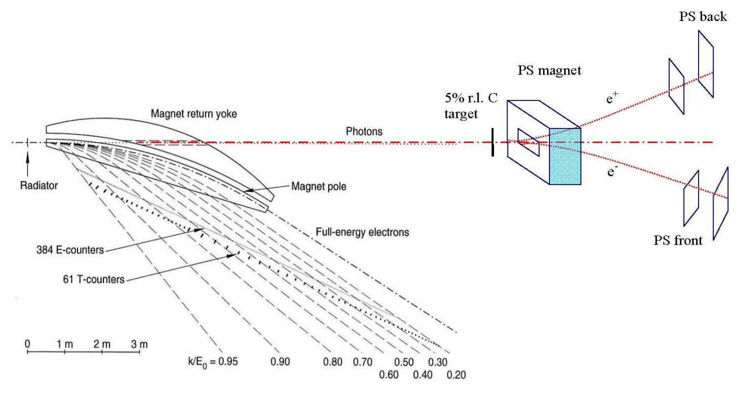
Department of Physics and Astronomy
University of Kentucky

Collaboration Meeting
June 23-24, 2006

Outline

Investigation of Limits on Tagging Technique
Experimental Setup

Experimental data from PRIMEX Fall 2004 run are compared with GEANT simulation of the experimental setup.



Investigation of Limits on Tagging Technique

The main assumption of the conventional tagging technique is that the photons are produced in a **Coherent** process, so that $E_\gamma = E_{e^-} - E'_{e^-}$ according to energy conservation relation.

Tagger Effects

- Radiative Møller Scattering $(e^- + e^- \to e^- + e^- + \gamma)$
- Incoherent Bremsstrahlung $(e^- + A \to e^- + \gamma + X)$
  The nucleus may be left in some excited state OR undergo a nucleon knock-out.
- Double Bremsstrahlung $(e^- + A \to e^- + \gamma + \gamma + A)$

Due to these effects occuring in the bremsstrahlung radiator, the Tagger indicates E_γ higher than it really is.

Investigation of Limits on Tagging Technique

The main assumption of the conventional tagging technique is that the photons are produced in a **Coherent** process, so that $E_\gamma = E_{e^-} - E'_{e^-}$ according to energy conservation relation.

Tagger Effects

- Radiative Møller Scattering $(e^- + e^- \rightarrow e^- + e^- + \gamma)$
- Incoherent Bremsstrahlung $(e^- + A \rightarrow e^- + \gamma + X)$
  The nucleus may be left in some excited state OR undergo a nucleon knock-out.
- Double Bremsstrahlung $(e^- + A \rightarrow e^- + \gamma + \gamma + A)$

Due to these effects occuring in the bremsstrahlung radiator, the Tagger indicates E_γ higher than it really is.

Investigation of Limits on Tagging Technique

PRIMEX is a High Precision experiment, measuring π^0 lifetime with a precision of 1.5%.
The π^0 decay cross-section is extracted from the tagged yield of the π^0's.

$$Yield = \frac{d\sigma}{d\Omega} \times d\Omega \times t \times \epsilon \times \Phi$$

where **t** is the target thickness,
ϵ is the π^0 detection efficiency,
Φ is the incident photon flux.
Determination of the photon flux strongly depends on knowing the number of tagged photons in each energy bin.

Investigation of Limits on Tagging Technique

The main assumption of the conventional tagging technique is that the photons are produced in a **Coherent** process, so that $E_\gamma = E_{e^-} - E'_{e^-}$ according to energy conservation relation.

Tagger Effects

- Radiative Møller Scattering $(e^- + e^- \rightarrow e^- + e^- + \gamma)$
- Incoherent Bremsstrahlung $(e^- + A \rightarrow e^- + \gamma + X)$
  The nucleus may be left in some excited state OR undergo a nucleon knock-out.
- Double Bremsstrahlung $(e^- + A \rightarrow e^- + \gamma + \gamma + A)$

Due to these effects occuring in the bremsstrahlung radiator, the Tagger indicates E_γ higher than it really is.

Investigation of Limits on Tagging Technique

- The photon energy can be determined **both** by tagger and by pair spectrometer. The idea is **to compare E_γ as determined by tagger with E_γ determined by the Pair Spectrometer.**
- Photon energy determination with high resolution is also complicated by *the Pair Spectrometer effects* occuring in the target
  - Pair production followed by bremsstrahlung
  - Multiple scattering

Investigation of Limits on Tagging Technique

- The photon energy can be determined **both** by tagger and by pair spectrometer. The idea is **to compare E_γ as determined by tagger with E_γ determined by the Pair Spectrometer.**

- Photon energy determination with high resolution is also complicated by *the Pair Spectrometer effects* occuring in the target
  - Pair production followed by bremsstrahlung
  - Multiple scattering

Analysis Results

- The SAME conditions are used for simulation as for the experiment.
  Simulation gives the *Perfect Tagger* case (i.e. no Radiative Moller, no Incoherent or Double bremsstrahlung).
- The difference between data and simulation is accredited to Tagger effects.
- The pair spectrometer effects are subtracted off.

Analysis Results

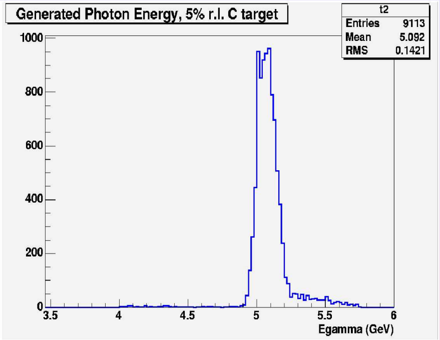
- The SAME conditions are used for simulation as for the experiment.
  Simulation gives the *Perfect Tagger* case (i.e. no Radiative Moller, no Incoherent or Double bremsstrahlung).
- The difference between data and simulation is accredited to Tagger effects.
- The pair spectrometer effects are subtracted off.

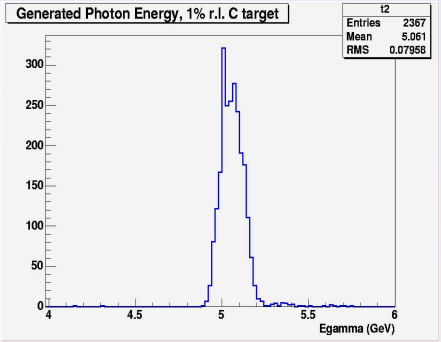
Analysis Results

- The SAME conditions are used for simulation as for the experiment.
  Simulation gives the *Perfect Tagger* case (i.e. no Radiative Moller, no Incoherent or Double bremsstrahlung).
- The difference between data and simulation is accredited to Tagger effects.
- The pair spectrometer effects are subtracted off.

Analysis Results

Simulations with 1% r.l. and 5 % r.l. C targets

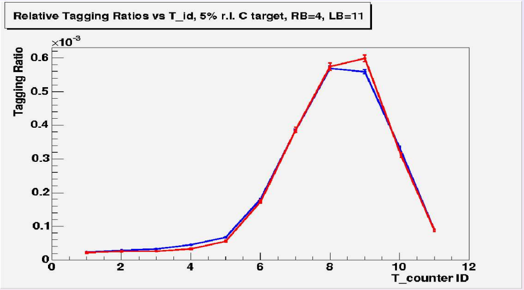


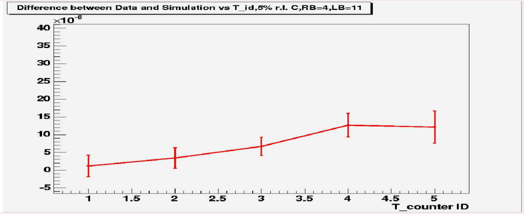


Thicker Target (5% r.l.) $\Longleftrightarrow$ Pair Spectrometer effects are larger then for 1% r.l. target.

Thinner Target (1% r.l.) $\Longleftrightarrow$ the Pair Spectrometer effects are minimized.

Analysis Results





Low T-ID $\Longleftrightarrow$ High E_γ

RED = Simulation

BLUE = Data

Data:

Relative tagging ratio$=\frac{N_{e^+e^-\cdot e_i^-}}{N_{\gamma_i}}$

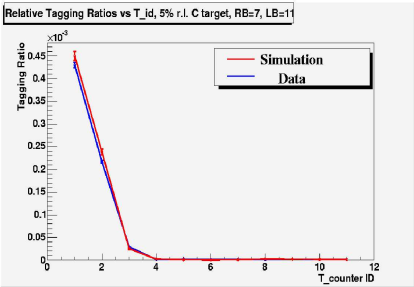
where $N_{\gamma_i} = N_{e_i} \times R_i^{TAC}$

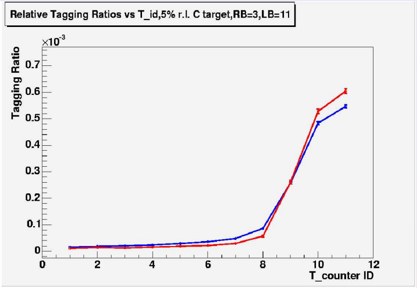
Simulation:

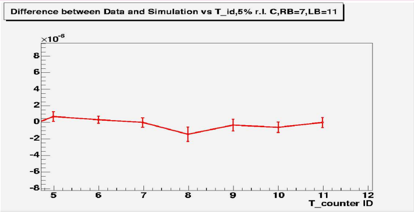
Relative tagging ratio$=\frac{N_{e^+e^-\cdot\gamma_{\Delta E_i}}}{N_{\gamma_{\Delta E_i}}}$

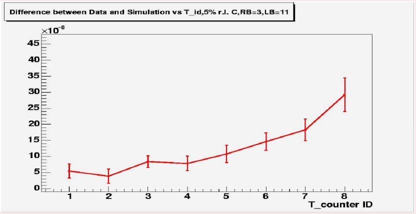
where ΔE_i is the energy range covered by T_i.

Analysis Results









Summary

- Radiative Møller, incoherent bremsstrahlung and double bremsstrahlung can impose inherent limitations on high resolution photon energy determination using the tagging technique.
- By comparing E_γ as determined by the tagger with that as determined by the pair spectrometer **we see this effect.**
- We are presently quantifying the impact of limitation effects on high resolution photon energy determination for PRIMEX experiment.
- More (parasitic) data collection is needed in future runs.

Summary

- Radiative Møller, incoherent bremsstrahlung and double bremsstrahlung can impose inherent limitations on high resolution photon energy determination using the tagging technique.
- By comparing E_γ as determined by the tagger with that as determined by the pair spectrometer **we see this effect**.
- We are presently quantifying the impact of limitation effects on high resolution photon energy determination for PRIMEX experiment.
- More (parasitic) data collection is needed in future runs.