Precision Photon Flux Determination for the Jefferson Lab PrimEx Experiment

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Photon Flux for PrimEx

- To achieve desired precision of ~1.4% in measurement of π^0 lifetime PrimEx needs to measure the flux of tagged photons on the target with precision of 1%.

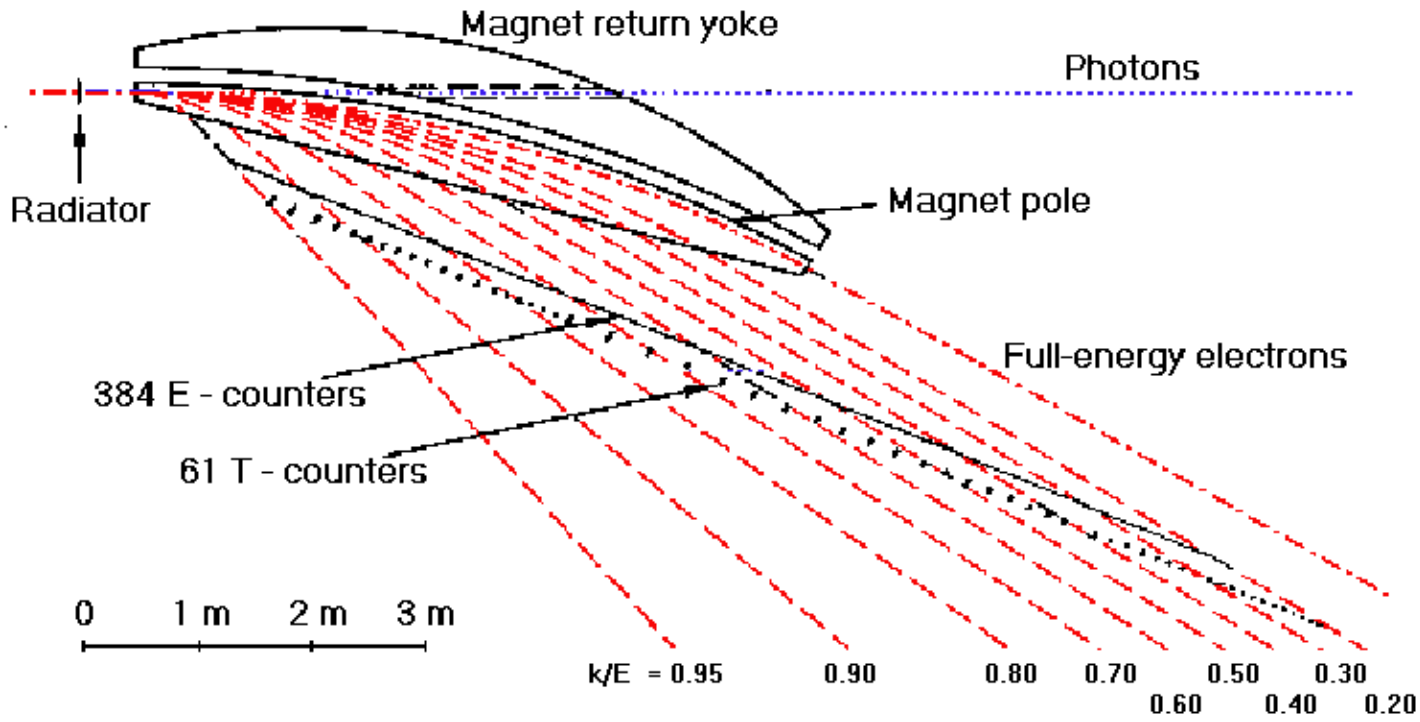
$$\frac{d\sigma}{d\Omega} = \frac{\pi^0_{tagged_yield}}{N_\gamma^{tagged}} \times 1/t \times 1/\Omega$$

$$N_\gamma^{tagged} = N_e \times R_{abs}$$

N_e – number of electrons, R_{abs} – absolute tagging ratio.

Jefferson Lab Hall-B Tagger

- 384 E-counters provide energy resolution ~$10^{-3}xE_0$ (E_0 - electron beam energy)
- 61 T-counters provide timing resolution of 0.18ns.
- Can tag photons in the energy range of 0.2 - 0.95 E_0.



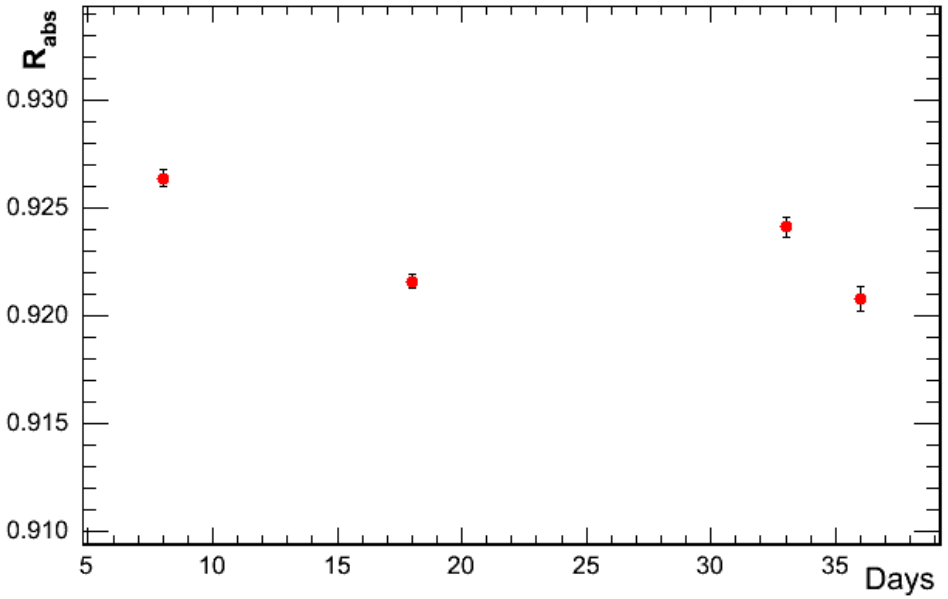
Absolute Tagging Ratio - R_{abs}

$$R_{abs} = \frac{N_{\gamma}^{tagged}}{N_e}$$

Mitigating effects:

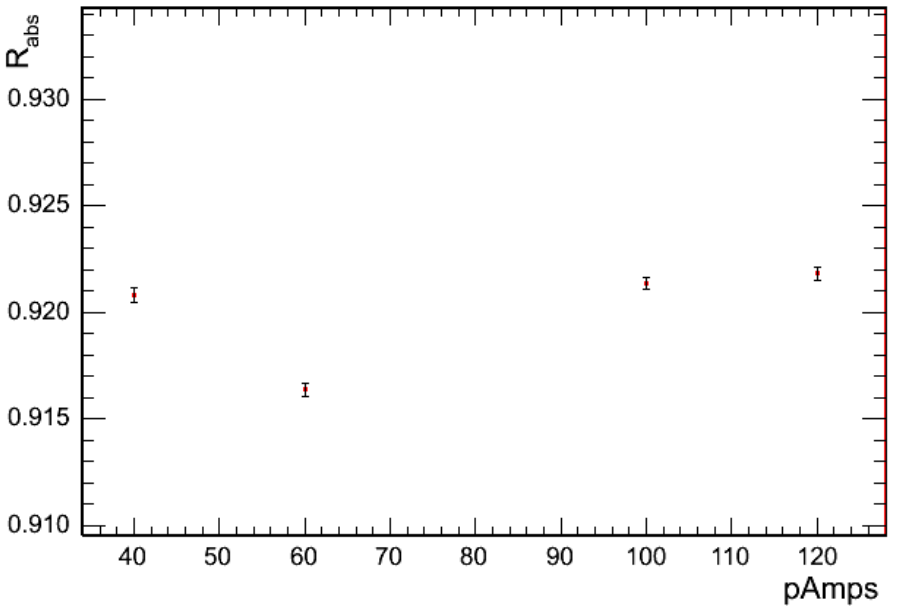
- Photon is lost before reaching the target.
- Moller scattering in the bremsstrahlung radiator.
- Extra electrons in the tagger due to the room background.

Absolute Tagging Ratio - R_{abs}

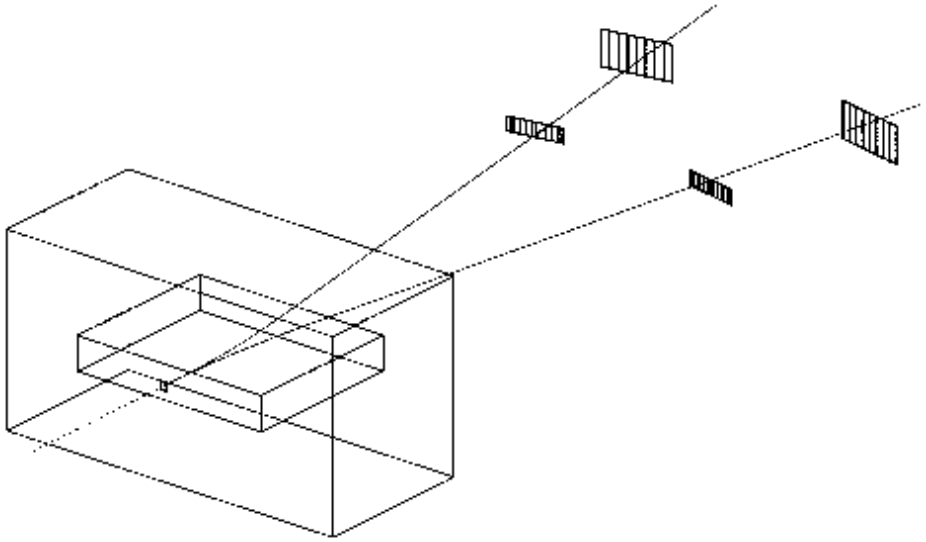


$$R_{abs} = \frac{N_{\gamma}^{tagged}}{N_e}$$

- Can be measured only at low beam intensities.
- Normalization is a destructive measurement.
- Has to be known and be stable within 1% when in production mode.



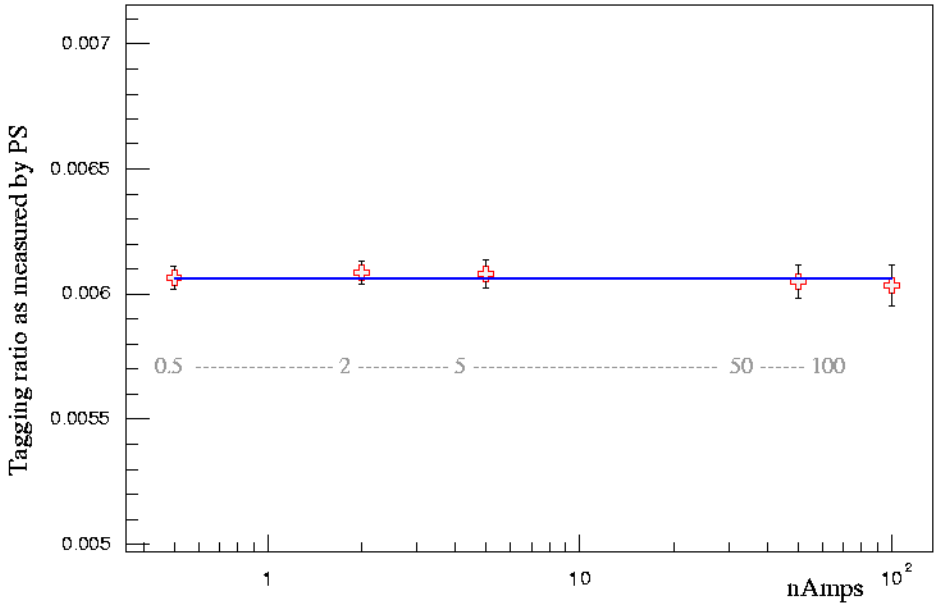
PrimEx Pair Spectrometer / Relative Tagging Ratio - R_{rel}



- A 16 kGausd×m Magnet
- 8 front and 8 back scintillating paddles in each arm

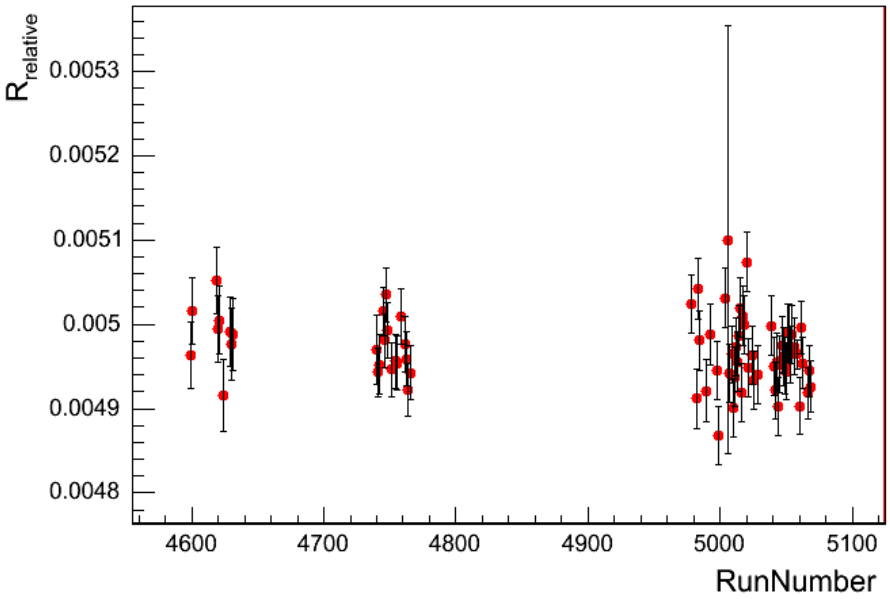
$$R_{rel} = \frac{N_{e^+e^-}^{tagged}}{N_e}$$

Relative Tagging Ratio - R_{rel}



$$R_{rel} = \frac{N_{e^+e^-}^{tagged}}{N_e}$$

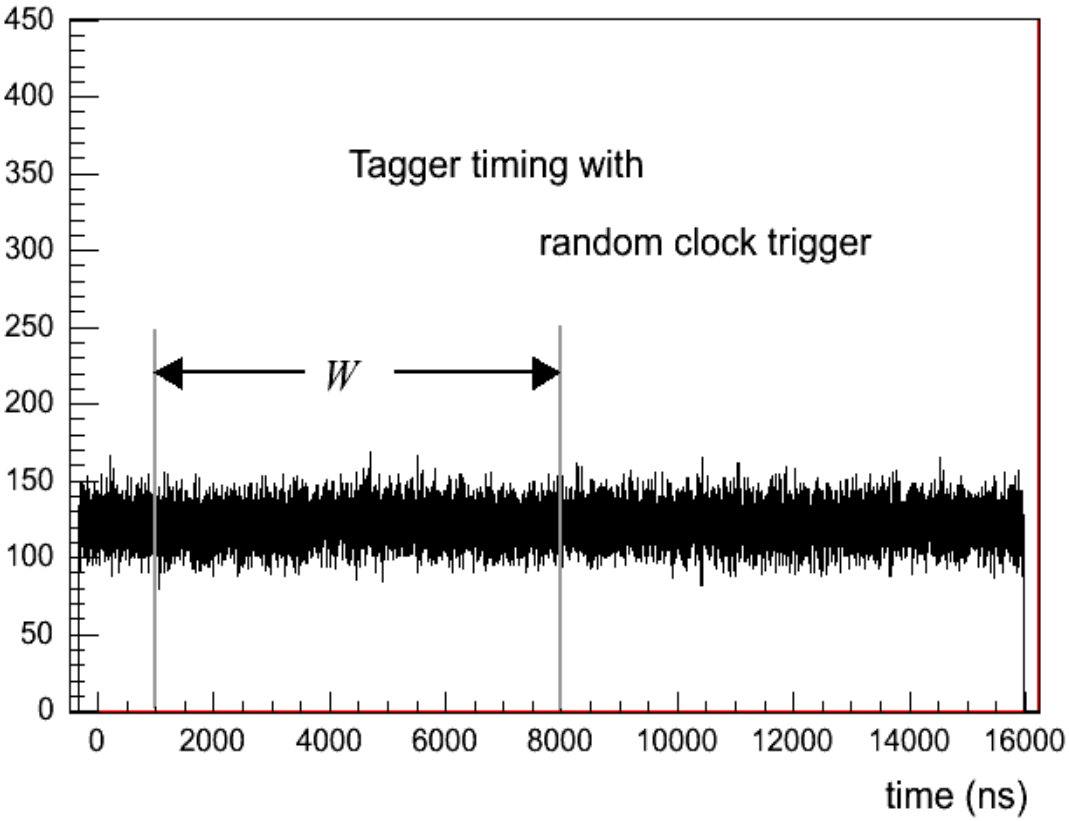
- Can be measured at low as well as at high beam intensities.
- Monitoring is a non-destructive measurement.
- Has to be stable within 1%.



Electron Counting

- **It is impractical to trigger on post-bremsstrahlung electrons due to high rates.**
- **Traditionally hardware scalers are used.**
- **For PrimEx we have chosen to use multi-hit TDCs to determine the rates in Tagger.**

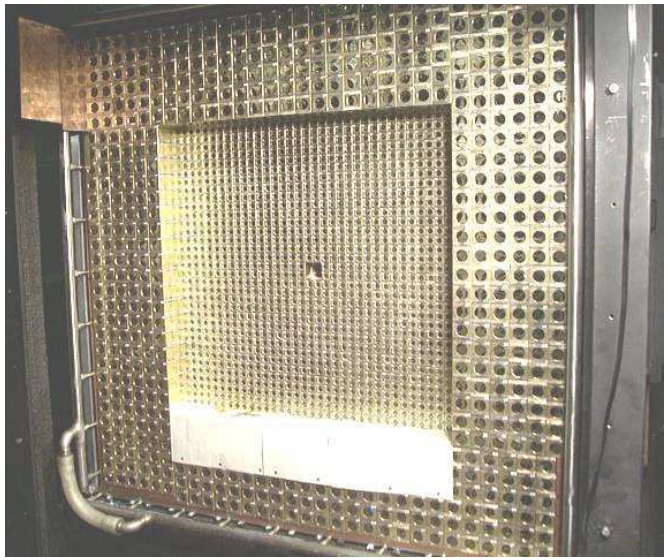
Electron Counting - Integral Method



$$N_e = \frac{n_{integral}}{w \times n_{samples}} \times T_{live}$$

- It is preferable to use *a Random Clock Trigger*.
- Automatically includes the same TDC deadtime effects, which necessarily exist in π^0 yield measurement.

Summary

To ensure achievement of 1% level precision in absolute photon flux determination we:

- Measure the absolute tagging ratio R_{abs} with a total absorption counter.
- Monitor the relative tagging ratio R_{rel}, measured by Pair Spectrometer, during the run.
- Utilize the ability of multi-hit TDCs to take snapshots of data to determine the number of electrons N_e in the run.
- And last but not least the PrimEx experimental setup has the ability to verify the photon flux normalization by measuring cross-sections for well known electromagnetic processes such as pair production and the Compton effect.