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Tagging Efficiency Measurements at the Nuclear Physics Beam Line at MAX-lab

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Overview

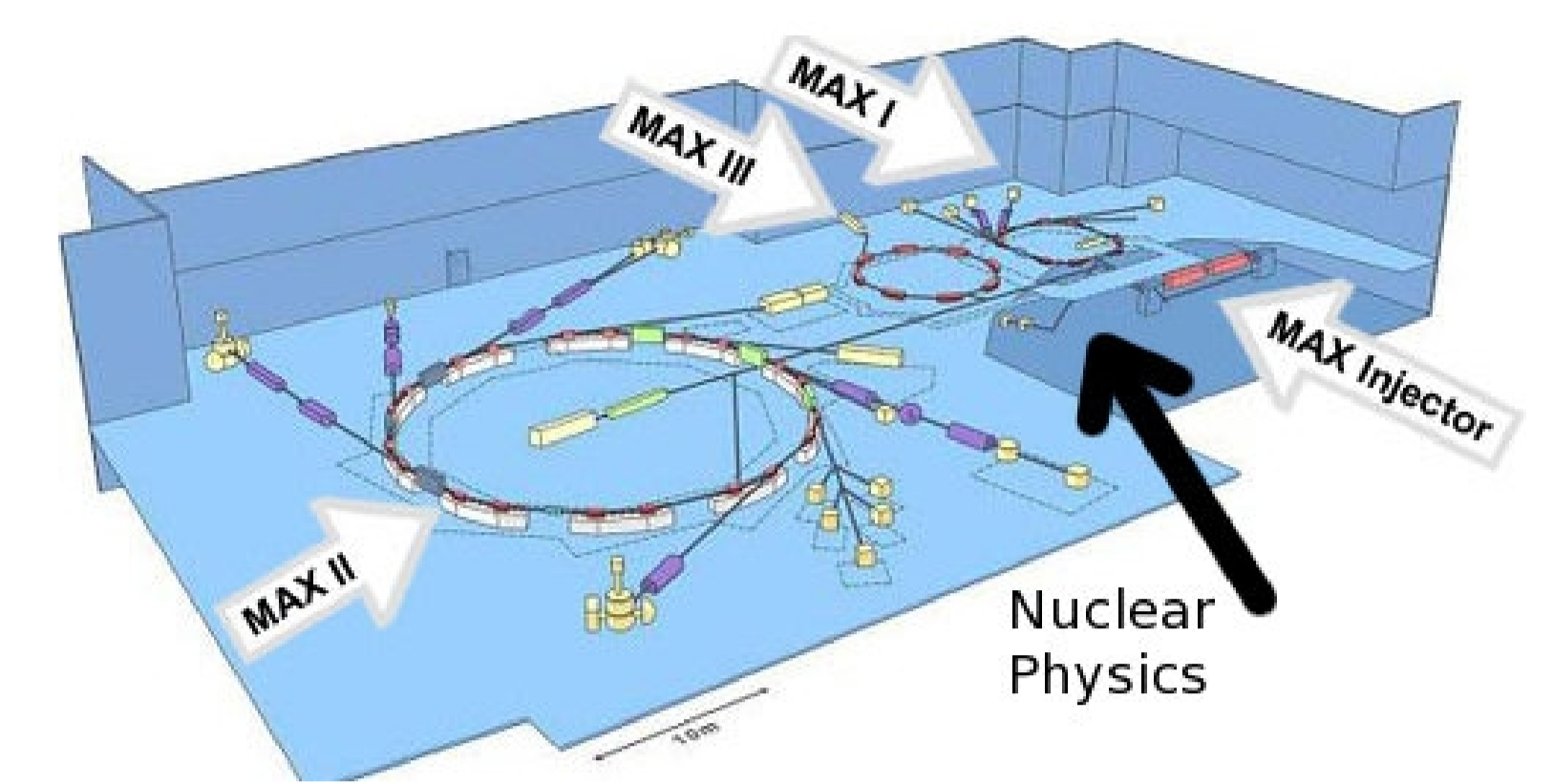
- Series of nuclear physics experiments using high-energy photons are currently underway at the Tagged-Photon Facility at MAX-lab, located at Lund University in Lund, Sweden
- Photon beam produced via bremsstrahlung radiation from 200 MeV electron beam
- Tagging efficiency is a measure of the number of photons striking the experimental target
- Tagging efficiency is eventually used to normalize the results of pion photo-production data

Electron-Gun and LINAC



- Electron pulses are produced using an electron gun, operating on thermionic emission principles
- 10 Hz pulses, each 200 ns long
- Electron pulses enter consecutive pair of 5.2 m, 100 MeV linear accelerators (LINAC), producing electron pulses with ~ 200 MeV of energy

MAX I Pulse-Stretcher Ring



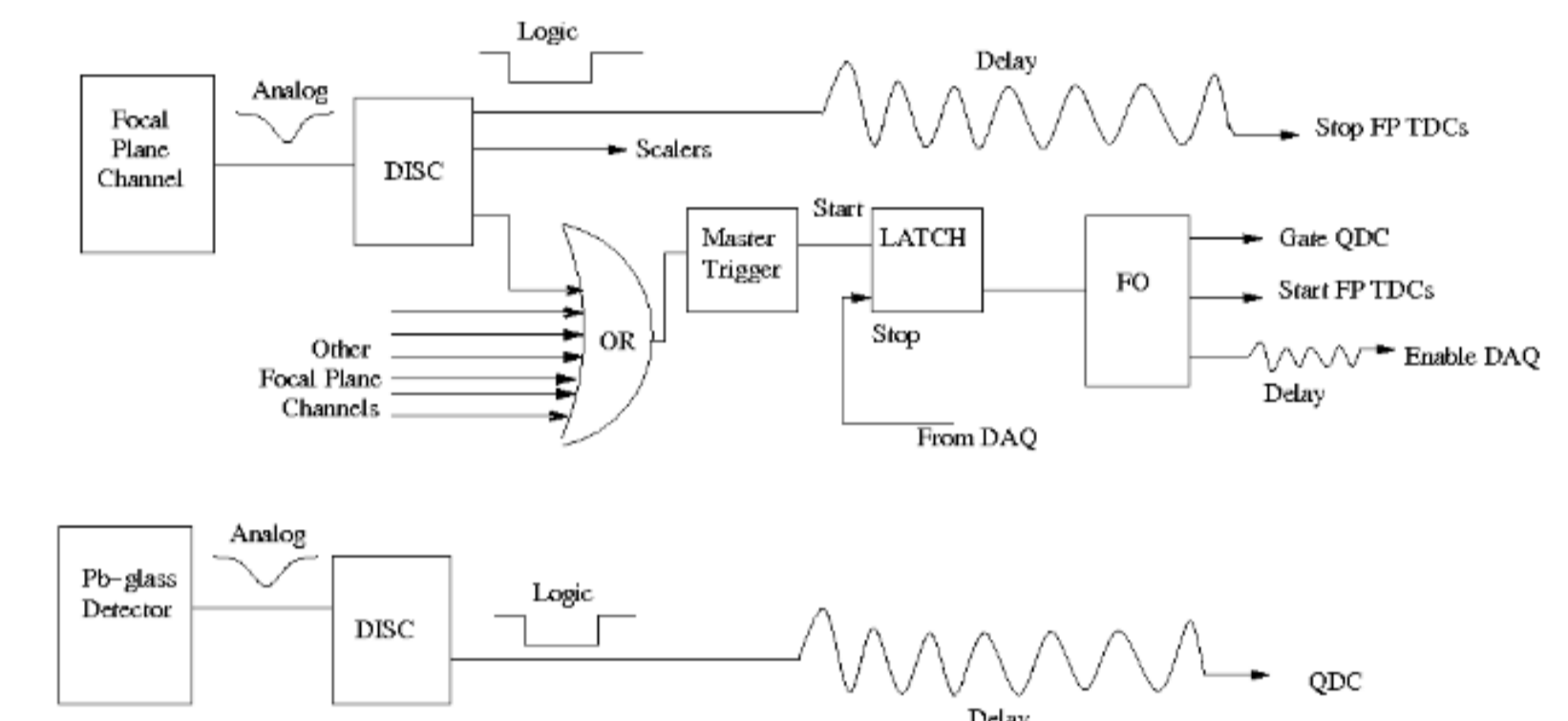
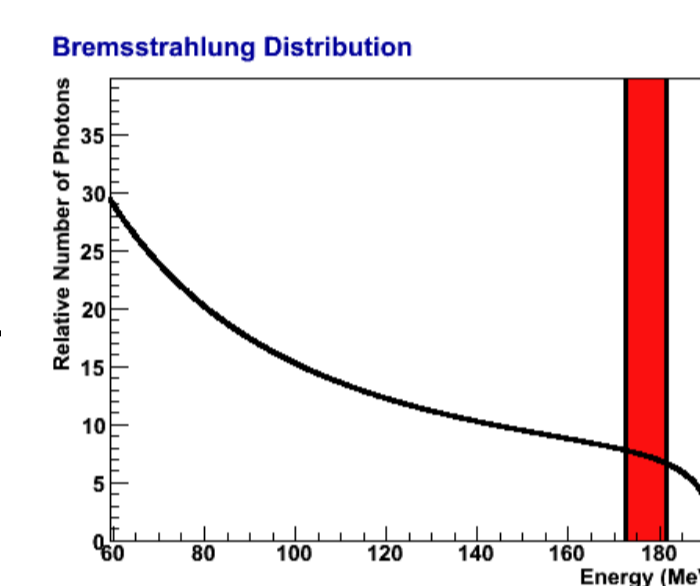
- Electron pulses enter 32.4 m circumference MAX I Pulse-Stretcher Ring (PSR)
- Electrons in MAX I PSR can be extracted slowly, effectively creating a continuous-wave beam
- Continuous beam is suitable for experiment

Photon Tagging

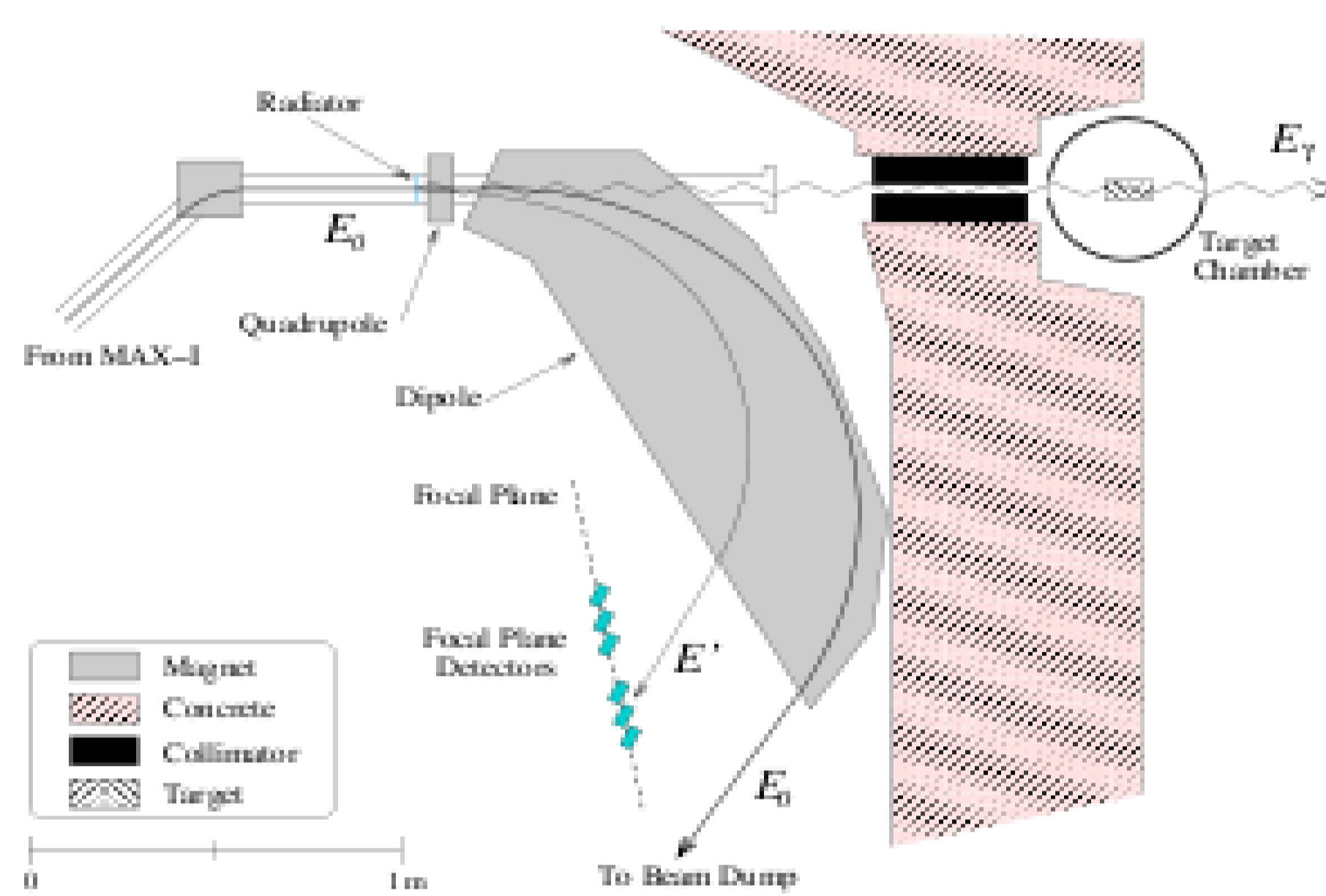
- Electron beam is directed towards 300 μm aluminum foil, inducing bremsstrahlung
- Energy of photon E_γ found using pre- and post-bremsstrahlung electron-energies (E_0 and E , respectively):

$$E_\gamma = E_0 - E$$

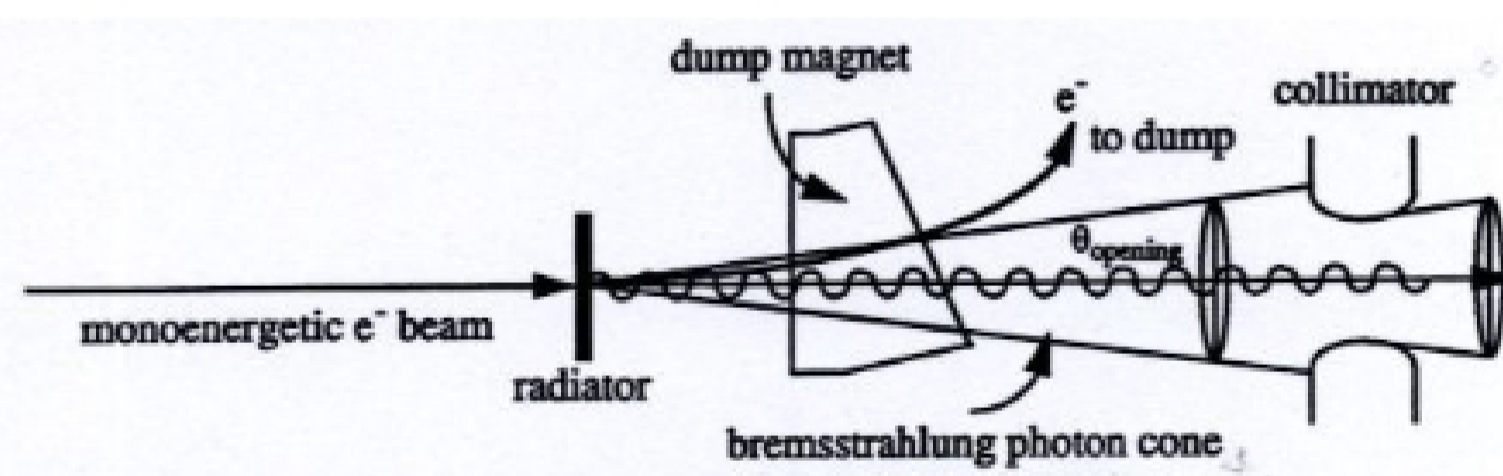
- E_0 known from electron beam energy
- E is found using tagger apparatus
- Post-bremsstrahlung photons exit foil and enter magnetic dipole
- Energy of electrons is proportional to radius of curvature of path



- Plastic scintillators are installed at exit of dipole in order to detect electrons
- 60 scintillators form a focal plane of detectors, allowing E to be determined based on which detectors electrons pass through



Photon-Beam Collimator



- Photons leaving foil are radiated in forward cone
- Size of uncollimated photon cone is large enough that many photons would miss the target
- Photon cone passes through 19 mm collimator
- Uniform photon beam exits collimator

Tagging Efficiency

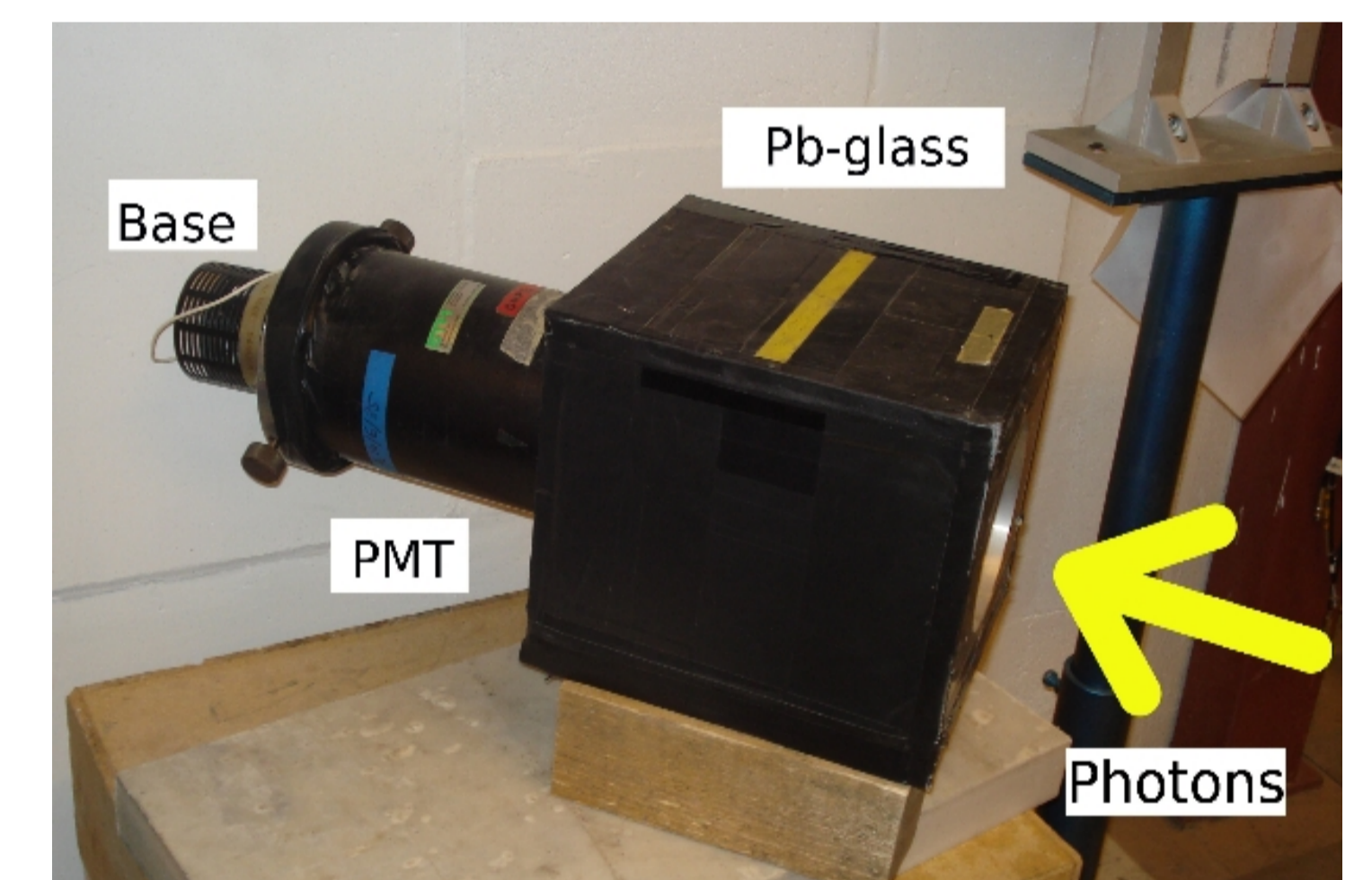
- Many photons are lost during collimation process
- Tagging efficiency is the ratio of photons passing through the collimator, N_γ , to total number of initial photons, N_0 :

$$\text{Tagging Efficiency} = N_\gamma / N_0$$

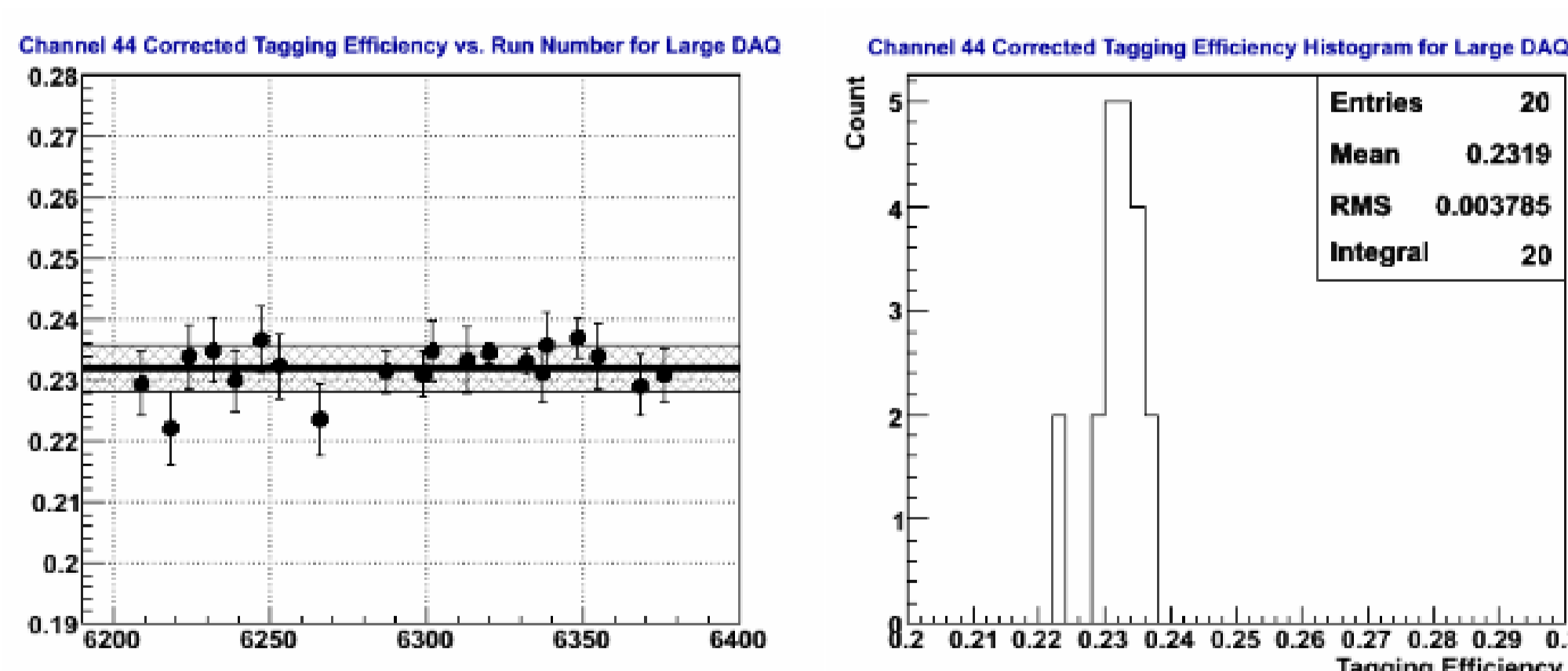
- Alternatively, using total number of bremsstrahlung electrons, N_e , ratio is stated as:

$$\text{Tagging Efficiency} = N_e / N_0$$

- Collimated number of photons detected by periodically using a Pb-glass detector
- Pb-glass detector is 100 % efficient at detecting photons
- Tagging efficiency measured daily during 4 week experiment in May 2009

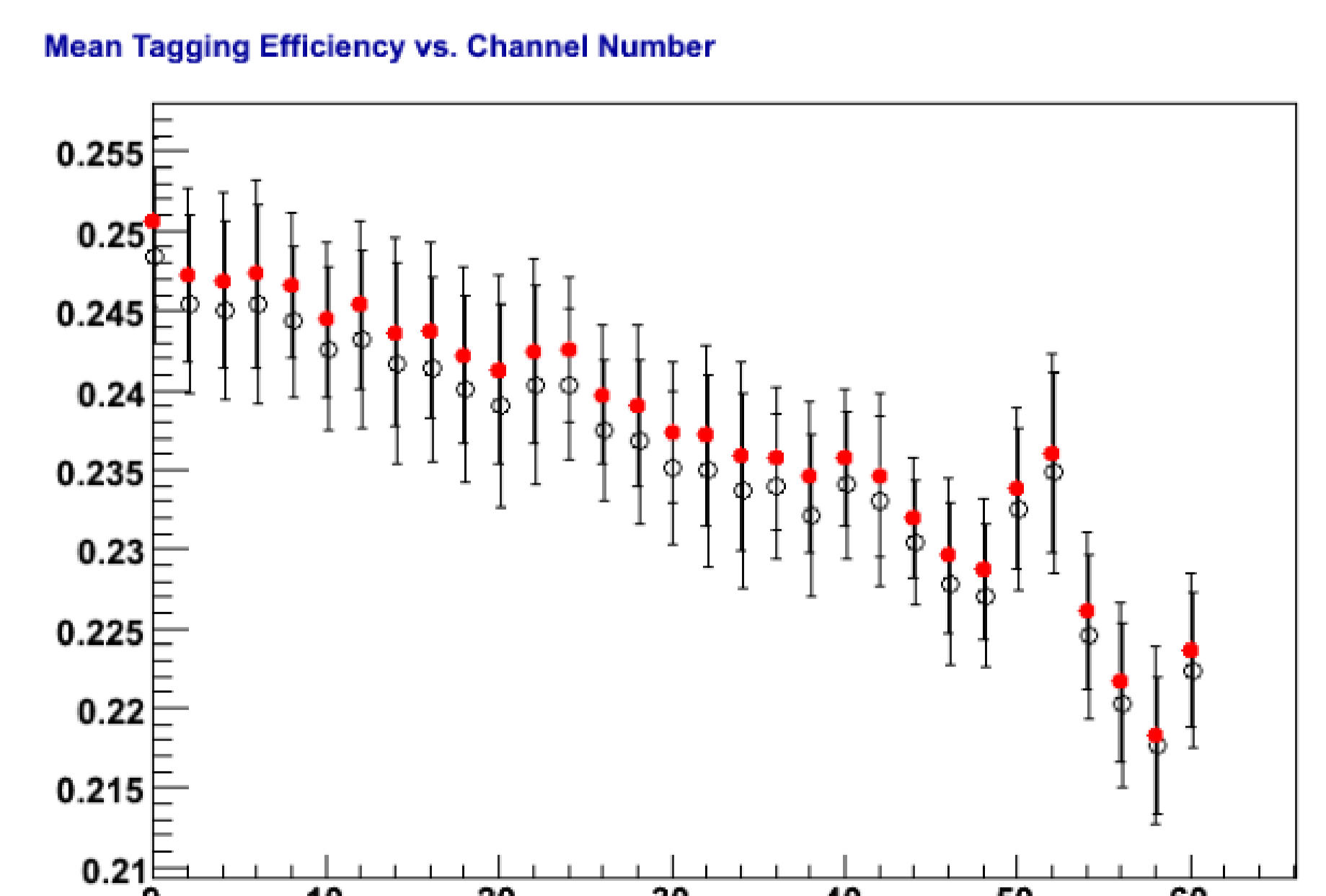


Results

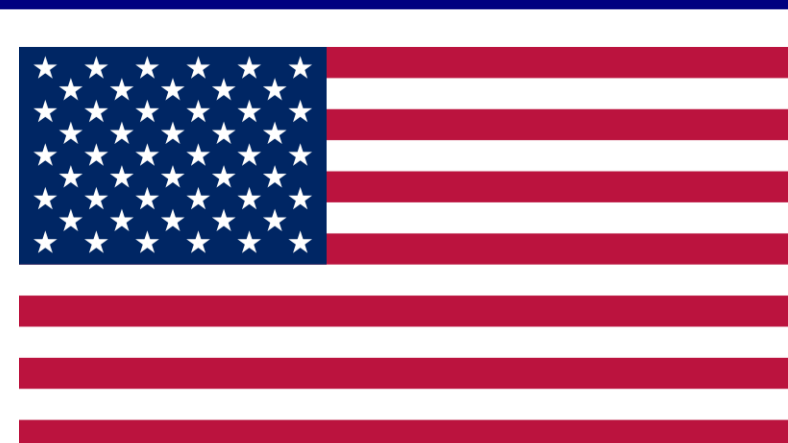


- Focal plane divided into channels based on combinations of scintillators that are hit consecutively
- Tagging efficiency calculated for each channel
- Tagging efficiency analyzed for time evolution, showing change in tagging efficiency as the experiment progressed
- Tagging efficiency analyzed with counting histogram, showing the distribution of tagging efficiency values with time

Results



- Background analysis also performed for tagging efficiencies
- Background electrons result in inflated counts for electron numbers
- Data collected with electron beam off to measure background
- Removal of background results in generally higher tagging efficiencies



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Acknowledgments