

# Photon Tagging Measurements at MAX-lab

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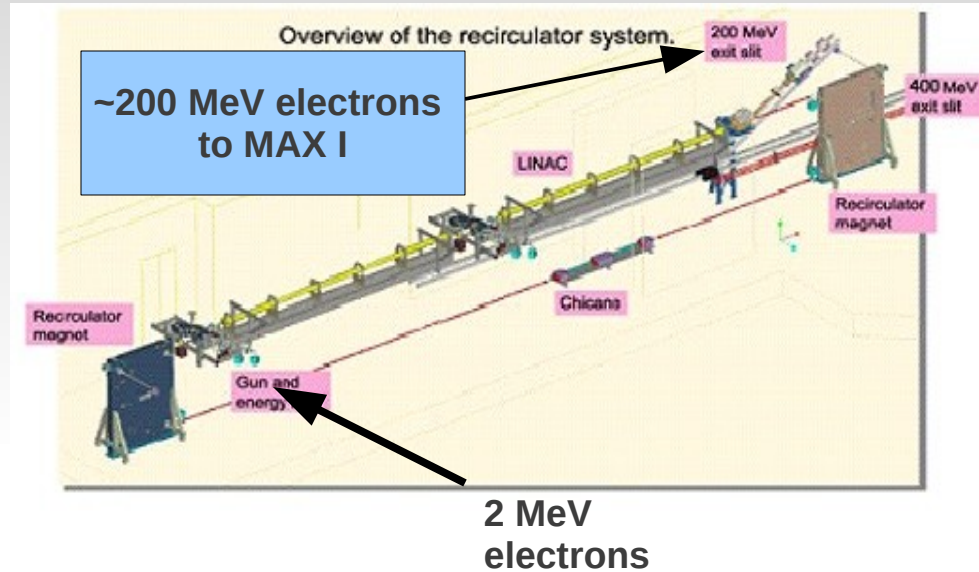
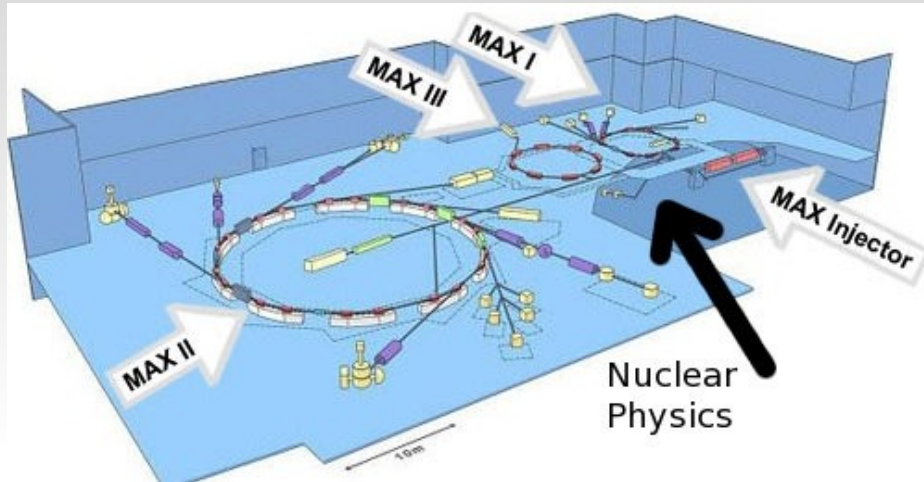
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# Outline

- The Electron and the Photon beams
  - Focal Plane Array
  - The Photon Beam (bremsstrahlung)
  - Pb glass detector
- Measurement of Tagging Efficiency
  - FP OR & Pb-glass Triggers
  - QDC
  - TiP & Tagging Efficiency
  - Tagging Efficiency Comparison
- Results

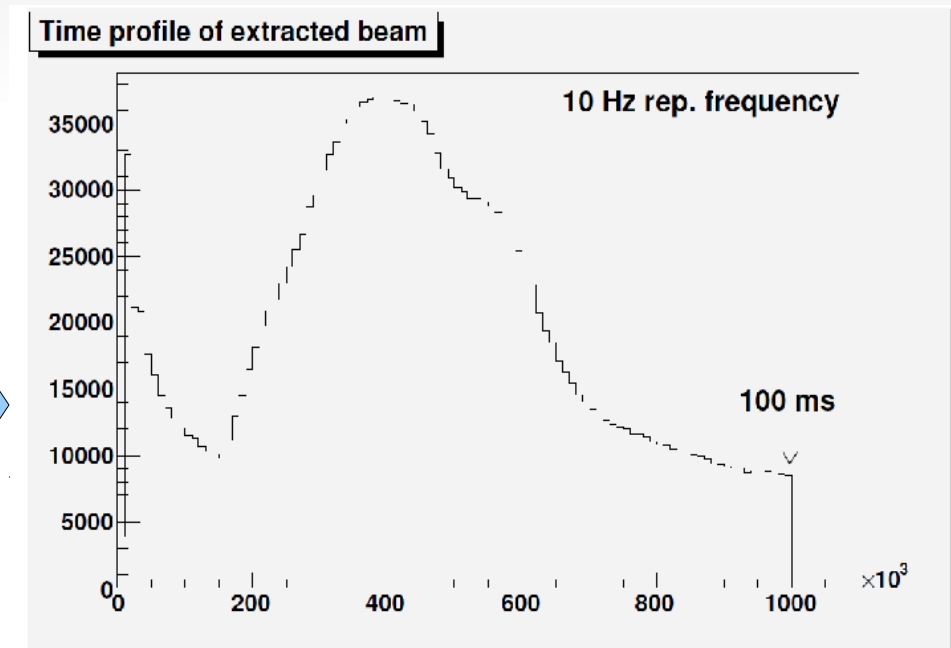
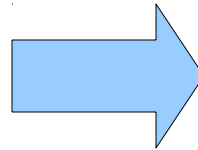
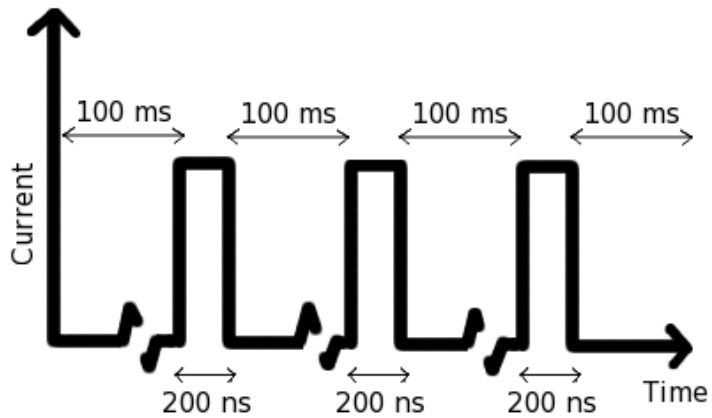
# Introduction



- Injector → MAX I → Tagged-photon Facility
- Electrons accelerated to 200 MeV
- MAX I, pulse stretcher ring
- Study of nuclei with photons (bremsstrahlung)

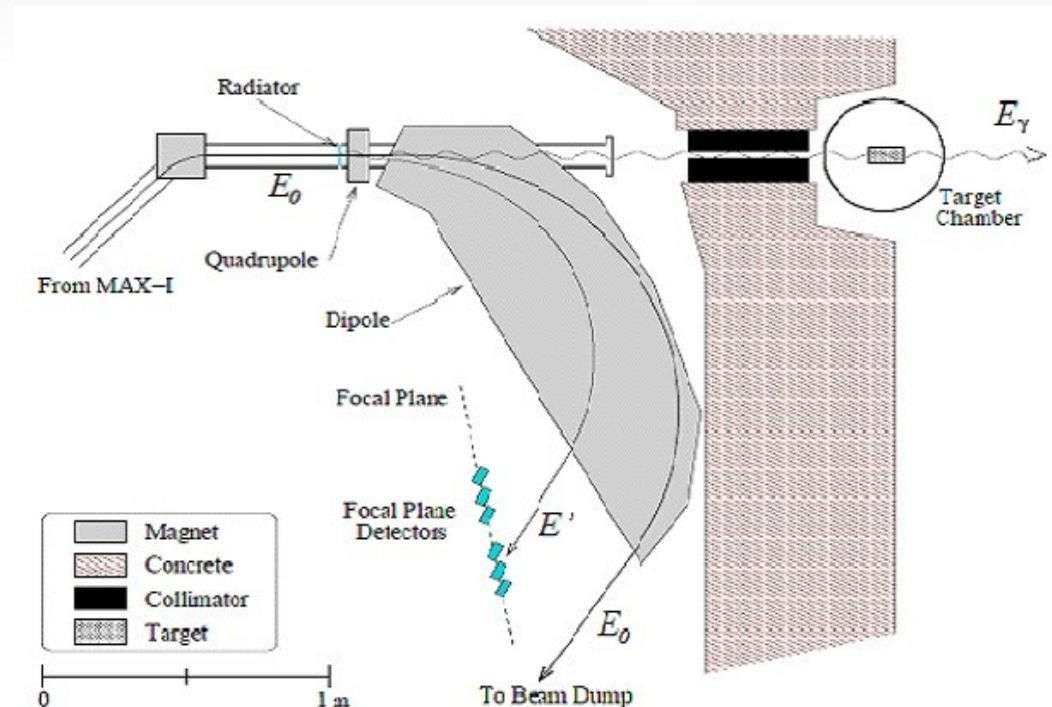
# MAX-I

- Electron-pulses are stretched through MAX-I
- 200 ns (from LINACs)  $\rightarrow$  100 ms (from MAX-I)



# The Photon Tagger

- Radiator: 300  $\mu\text{m}$  Al foil
- Some ( $<0.01\%$ ) of the electrons radiate photons
- Recoiling electrons pass through magnetic dipole
- Lorentz force:  $\vec{F} = e^- \cdot \vec{v} \times \vec{B}$
- Focal plane



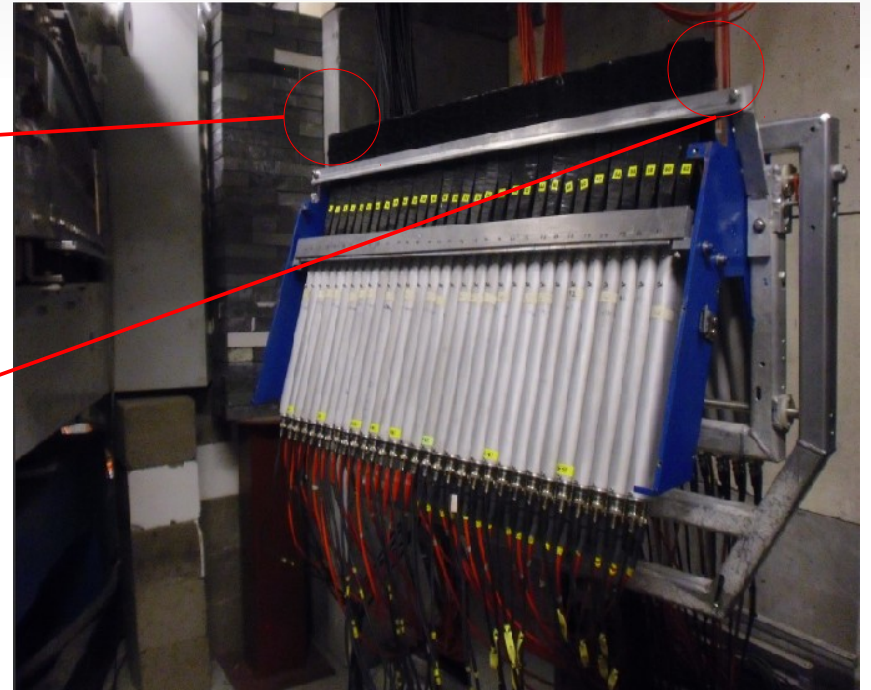
# Focal Plane Array

- Array of scintillator detectors at the exit of the tagger magnet
- Divided into 31 channels, each corresponding to different recoiling electron energy

Min. electron-energy  
Max. photon-energy

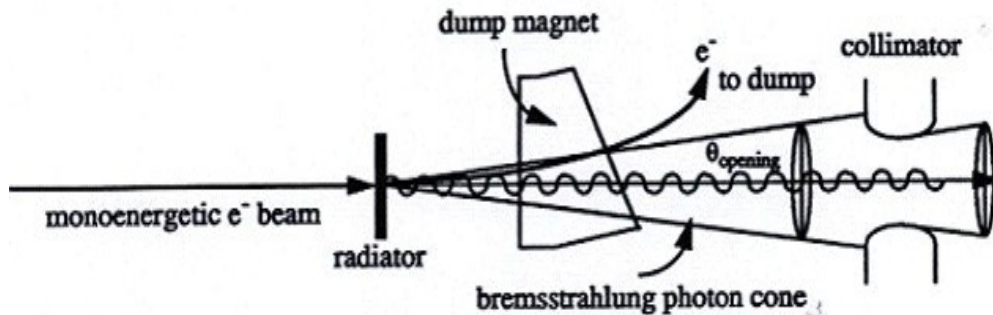
Max. electron-energy  
Min. photon-energy

$$E_{\gamma} = E_0 - E'$$

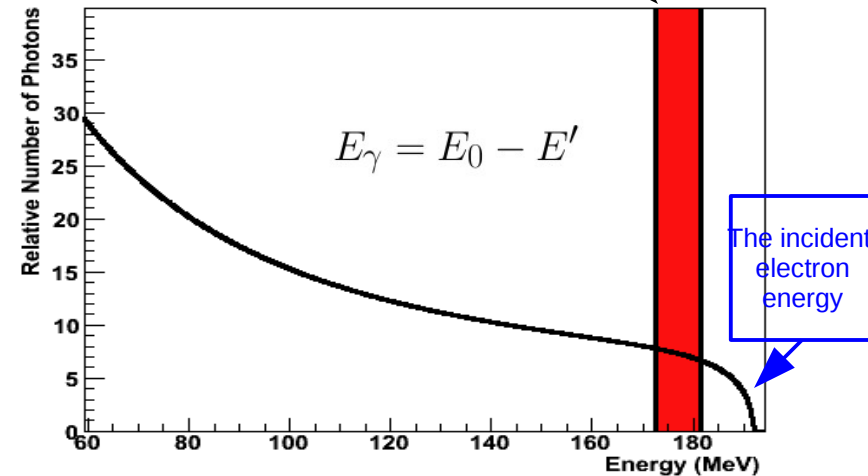


# The Photon Beam (bremsstrahlung)

- Electrons hit the thin foil
- Bremsstrahlung is produced, ranging up to the incident electron energy
- Conical distribution with an opening angle  $\theta_{\text{opening}} \approx \frac{1}{\gamma} = \frac{1}{\frac{E_0}{m_e c^2}}$
- Collimator ensures that photons strike the target

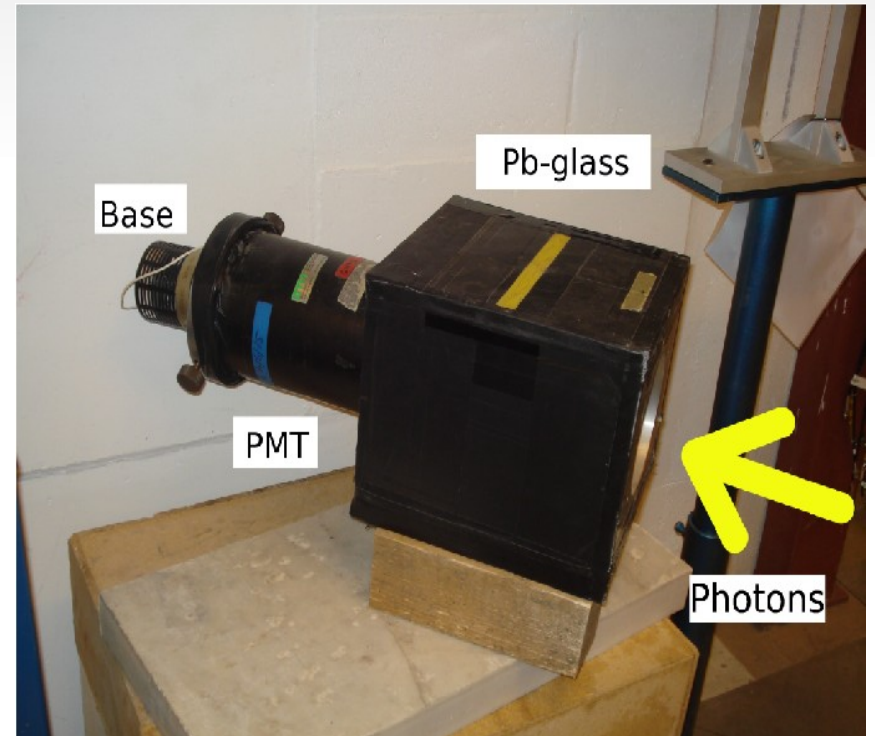


Bremsstrahlung Distribution



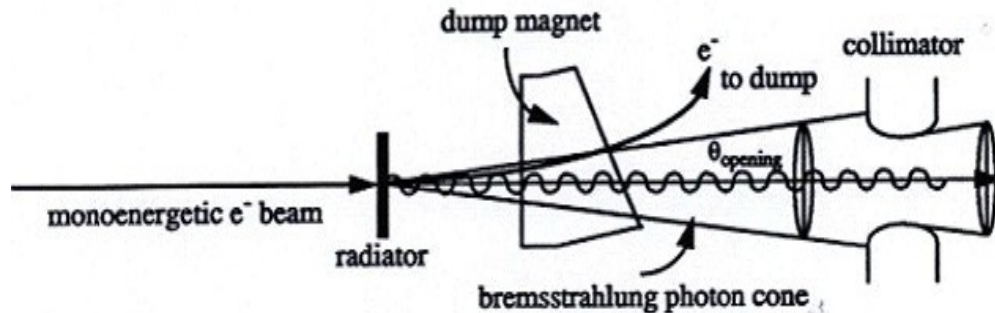
# Pb-glass detector

- Detects photons passing through the collimator
- Scintillator detector; Pb is used as photo-absorber
- Used for measuring tagging efficiency
- 100% efficient photon-detector at low rates
- Intensity reduced to eliminate the pile-up



# Tagging Efficiency

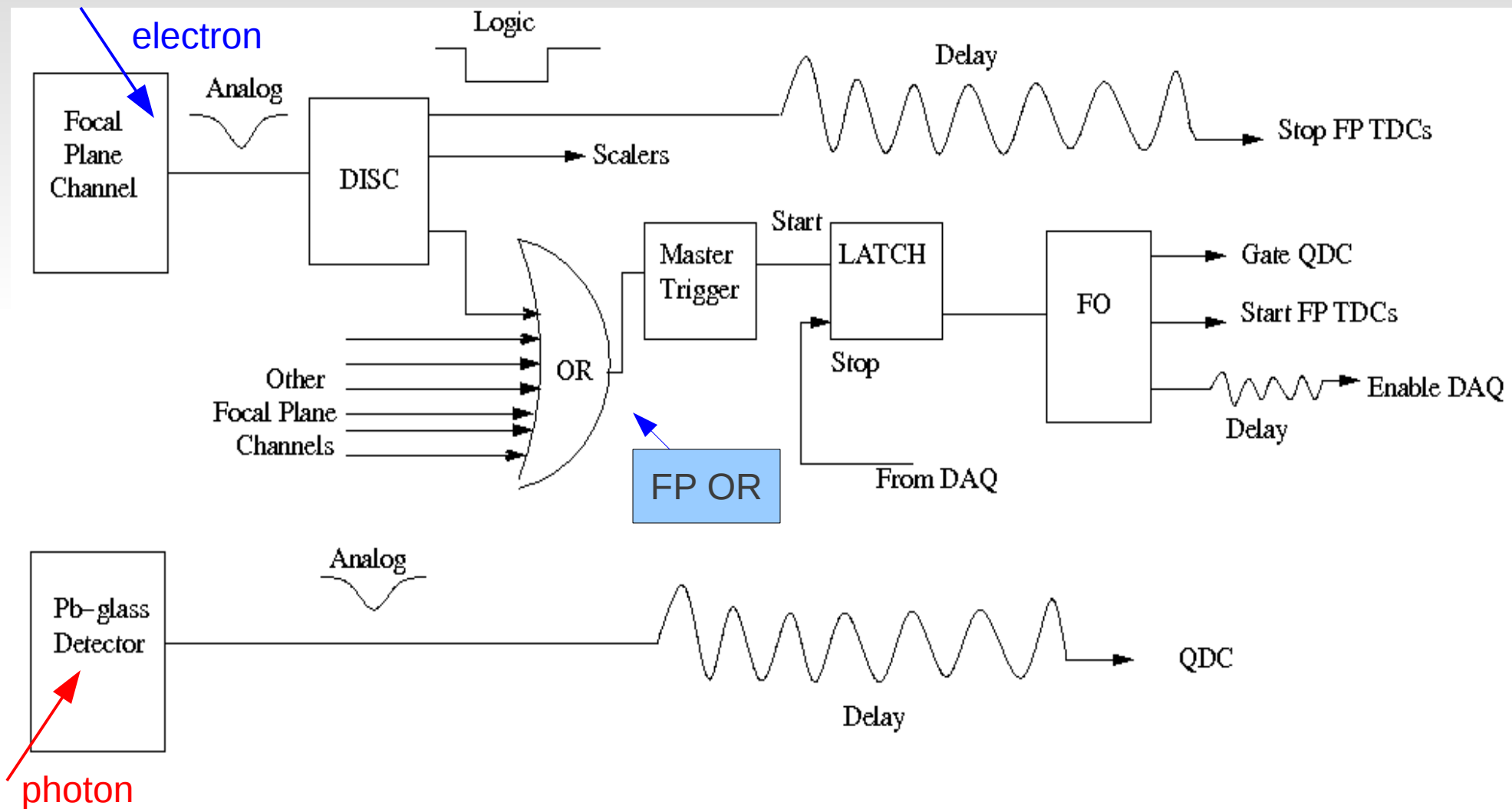
- Ratio of photons passing through the collimator to the electrons in the focal plane
- Values are background-corrected for the activation photons in the facility
- Investigation of this factor for FP OR and Pb-glass Trigger



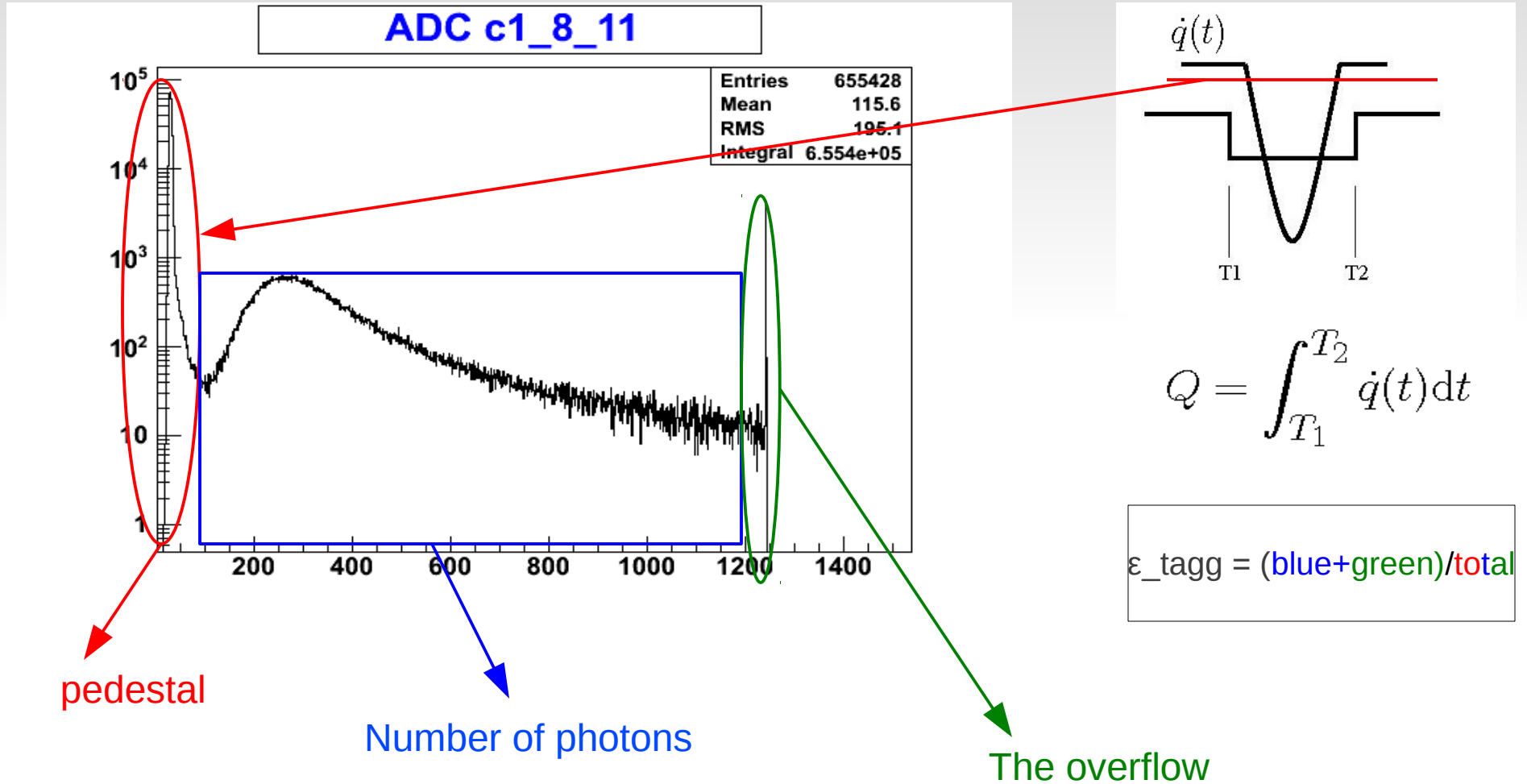
$$\epsilon_{\text{tag}} |i = \frac{N_{\gamma}}{N_0} |i = \frac{N_{\gamma}}{N_e} |i$$

Channel number

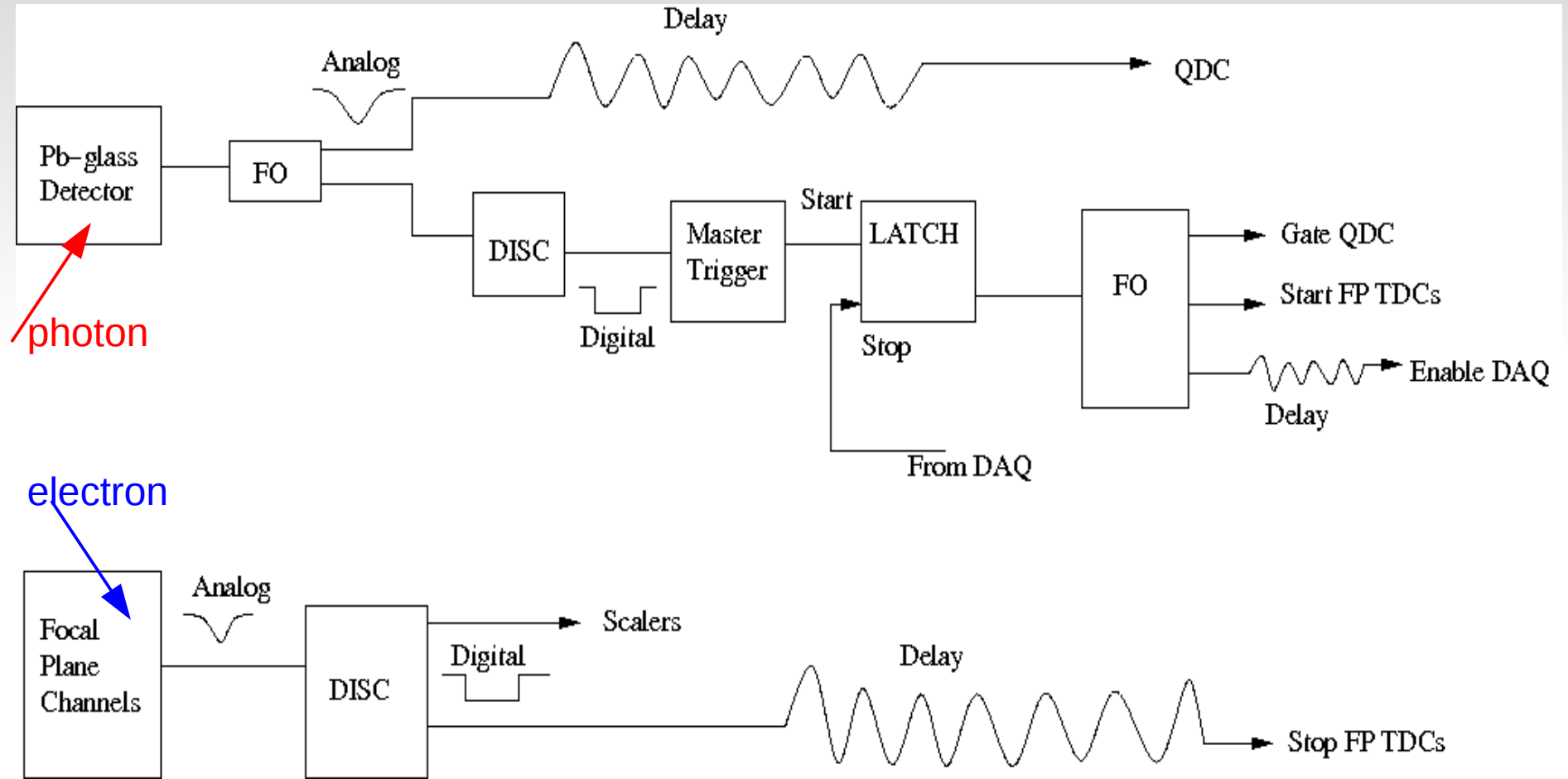
# FP OR Trigger



# QDC & tagging efficiency determination

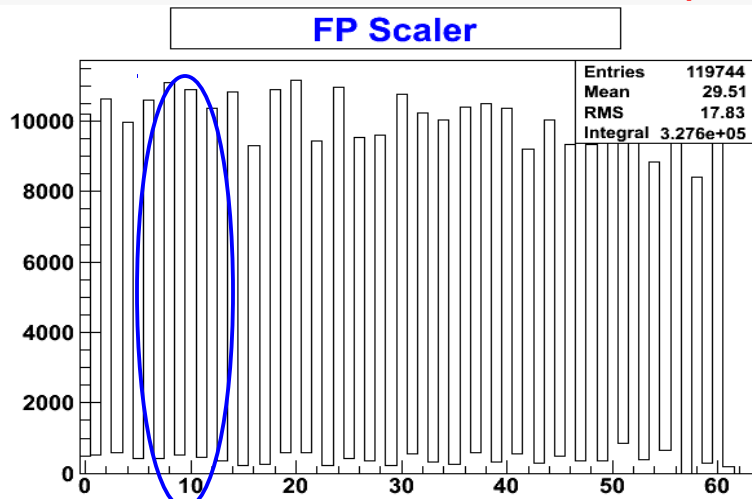


# Pb-glass Trigger



# Tagging efficiency determination

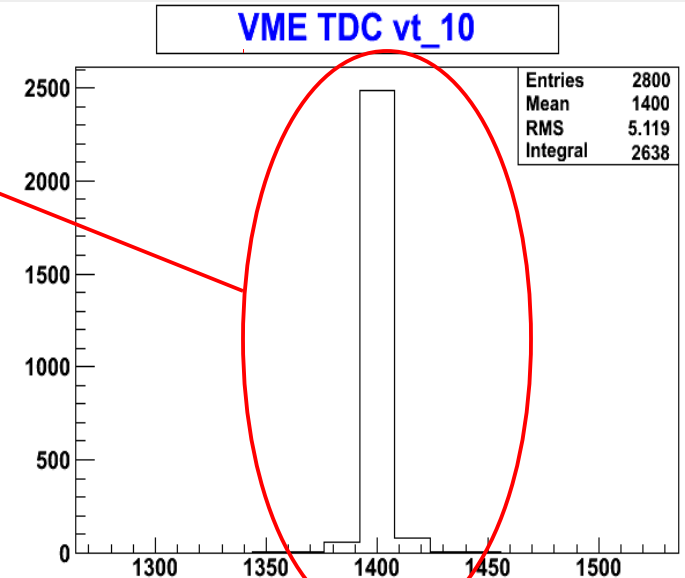
- No pedestal, every photon produces a trigger, cannot use FP OR method



Number of electrons

Number of photons

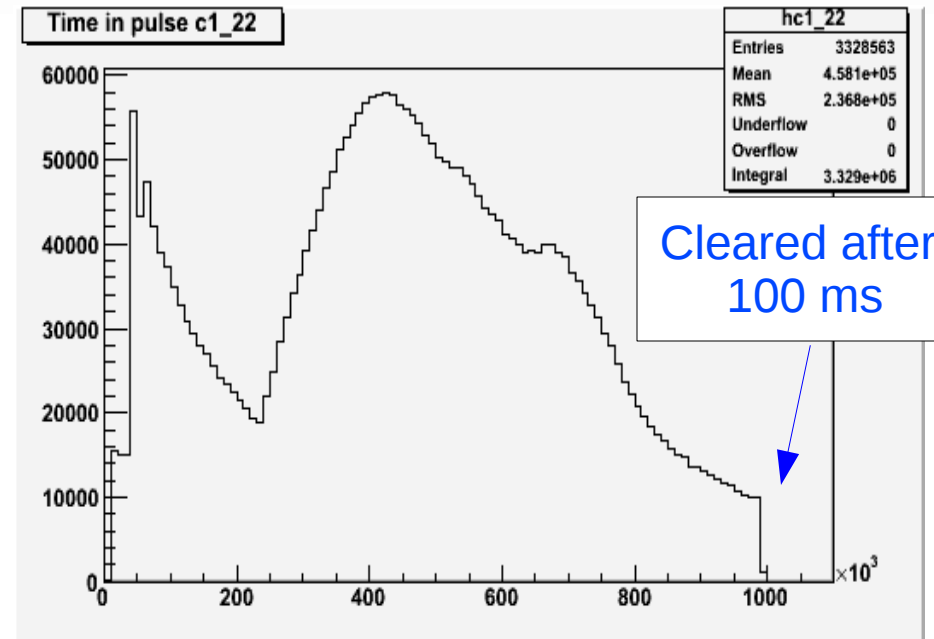
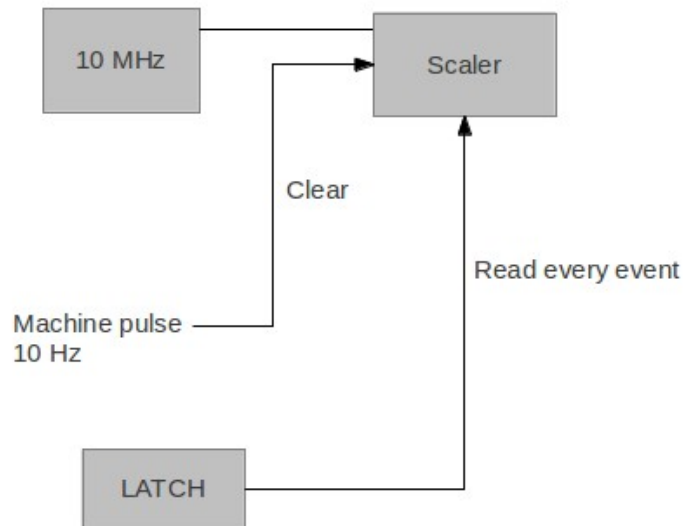
$$\epsilon_{\text{tagg}} = \text{red}/\text{blue}$$



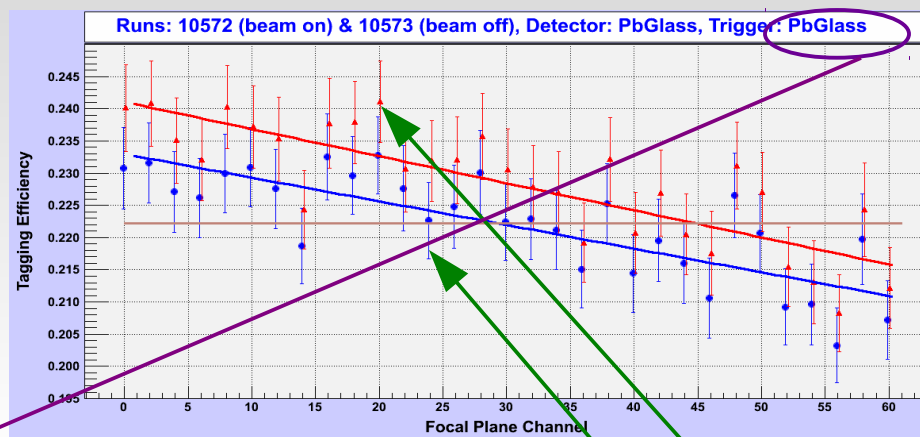
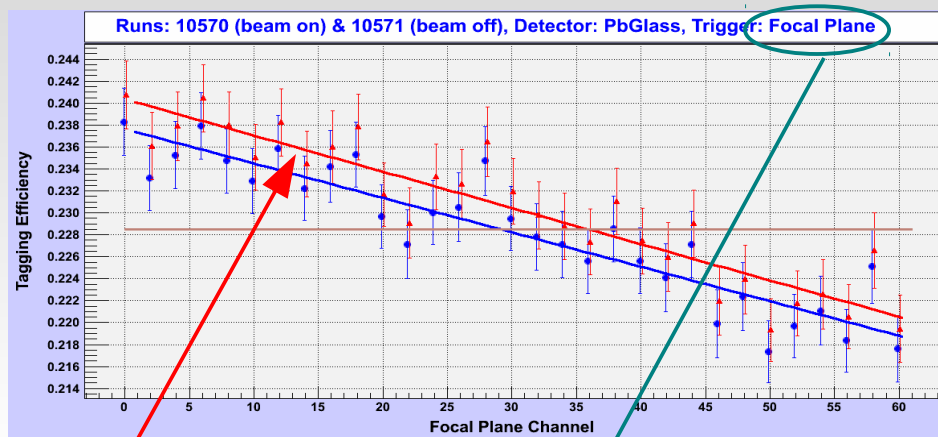
Focal plane TDC

# Time-in-Pulse for FP OR

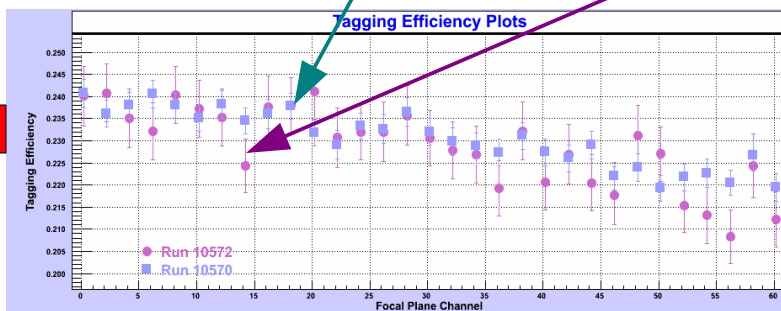
- Oscillator pulses are sent to a scaler
- Every 100 ms the scaler is cleared
- The scaler is read every time there is an event
- An event at a certain time corresponds to a count in the distribution



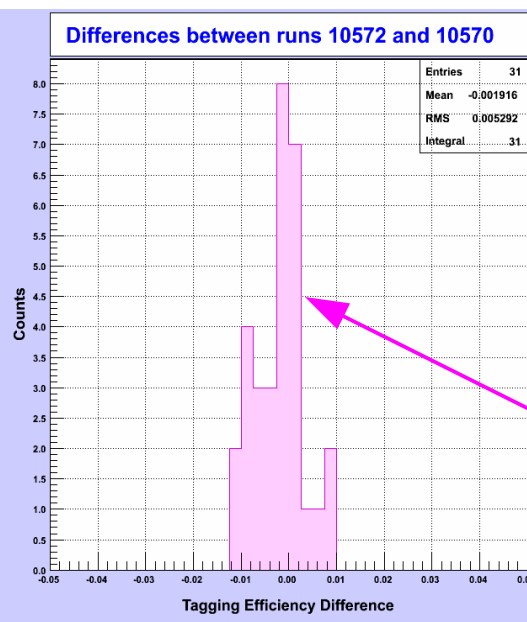
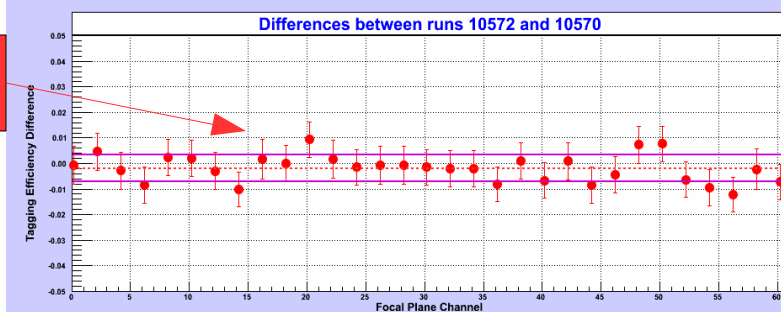
# Tagging Efficiency Comparison



After correction



The Difference

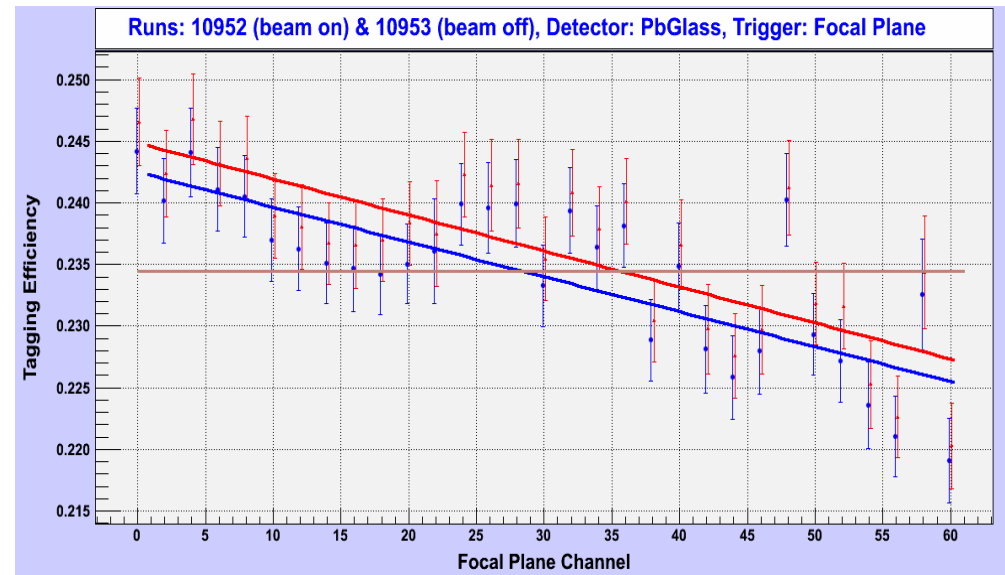
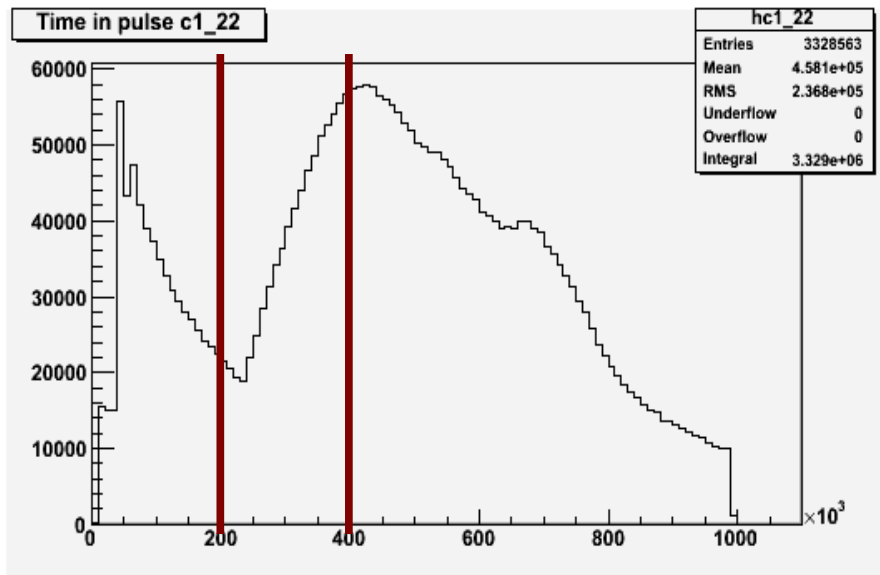


Statistical error

The projection

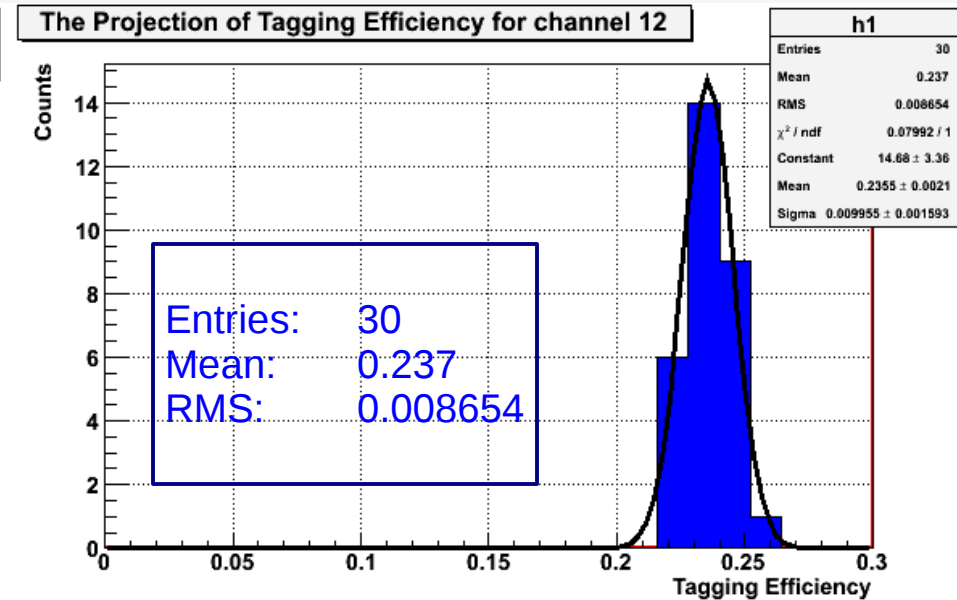
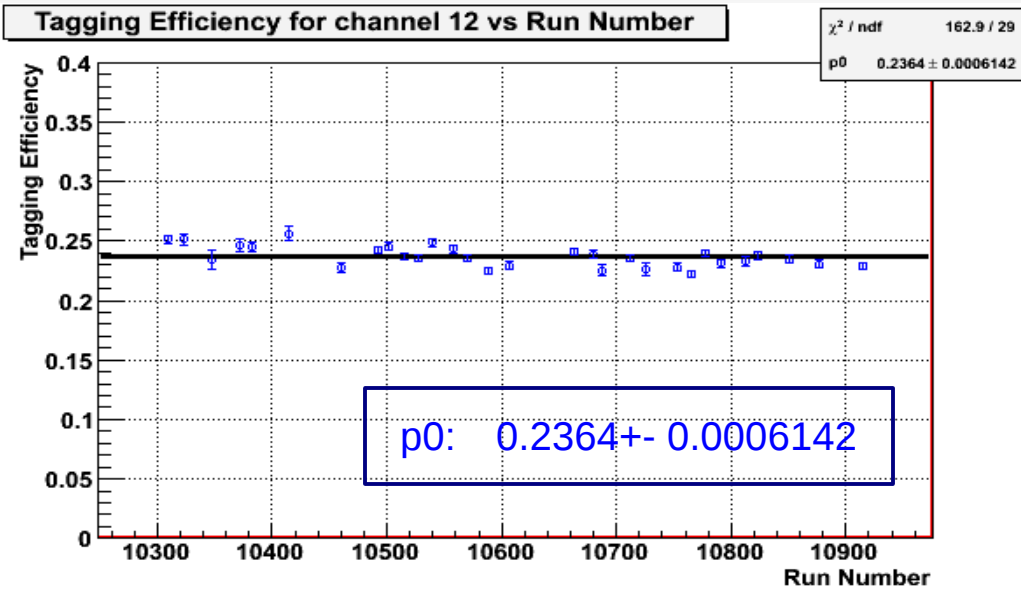
# TiP cutting and Tagging Efficiency

- Slice the TiP-distribution to look for changes in tagging efficiency
- Same analysis performed on these data subsets
- In this manner the relative timing of tagging efficiency has been studied.



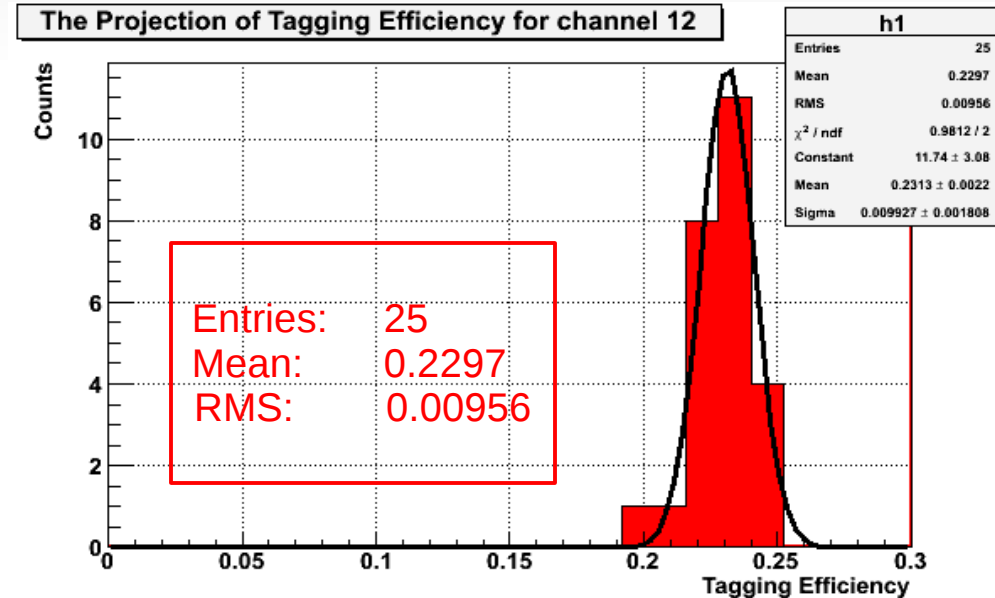
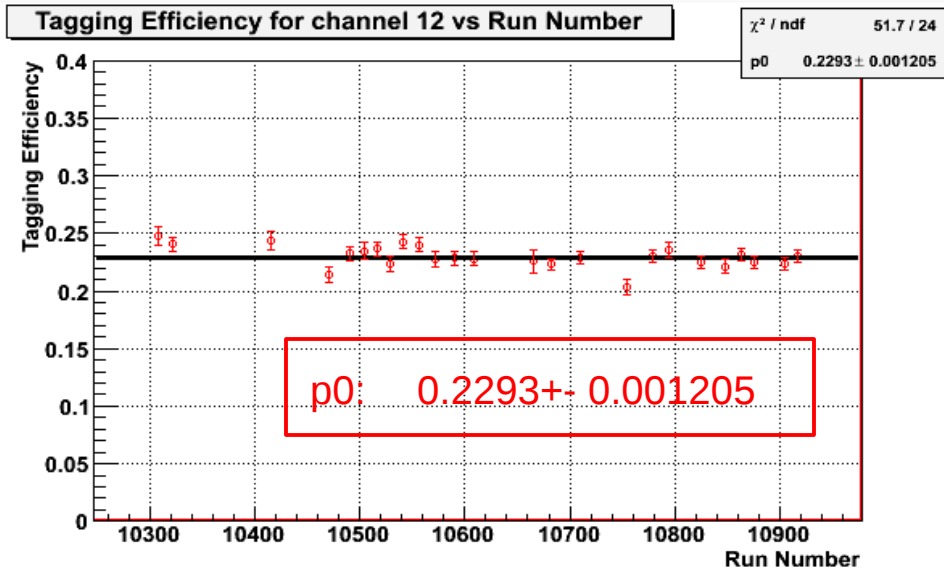
# Results from FP OR

- Statistical uncertainties
- Time evolution fitted
- The projection is fitted with the Gaussian



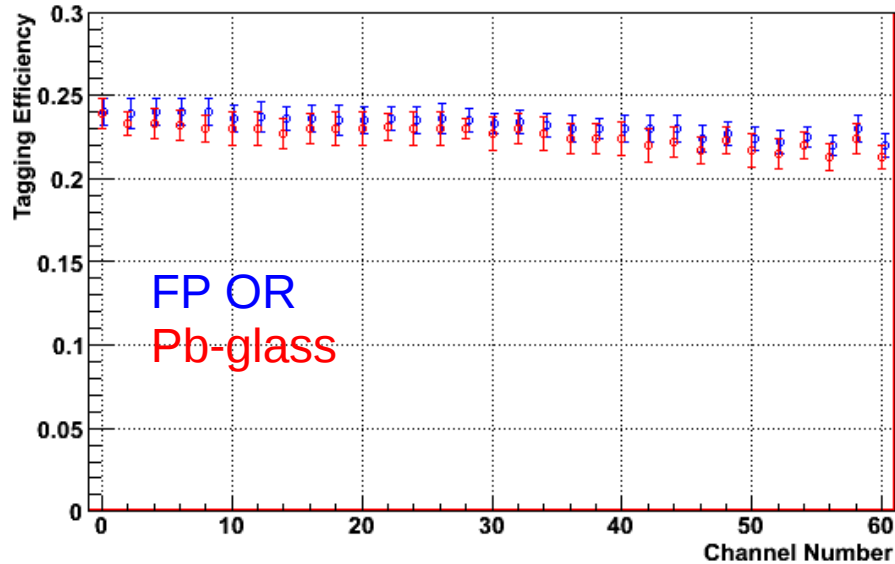
# Results from Pb-glass

- Statistical uncertainties
- Time evolution fitted
- The projection is fitted with the Gaussian

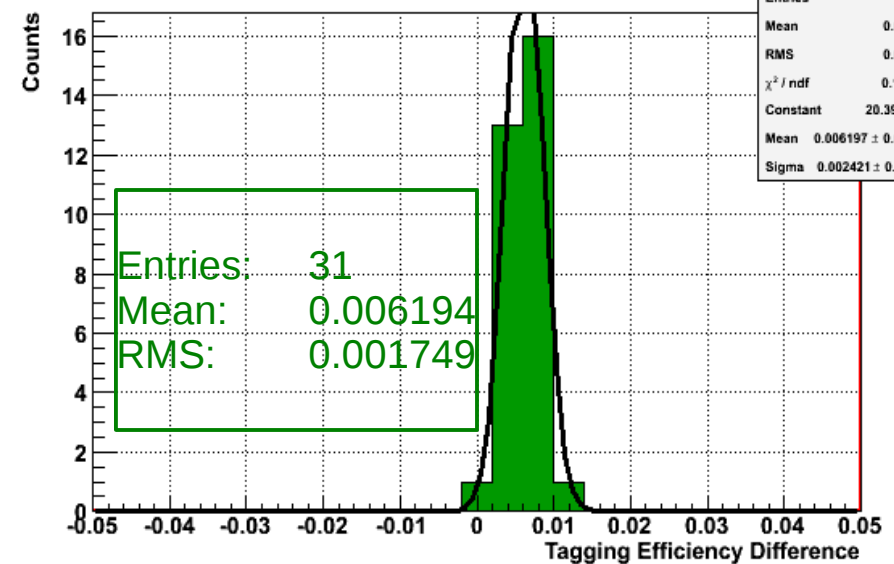


# Results

Final Tagging Efficiency per channel



Differences between FP OR and Pb-glass tagging efficiency



- Difference should be zero, it is not!!!
- Systematic error of  $\pm 0.6\%$
- The difference is shown with the **green** projection

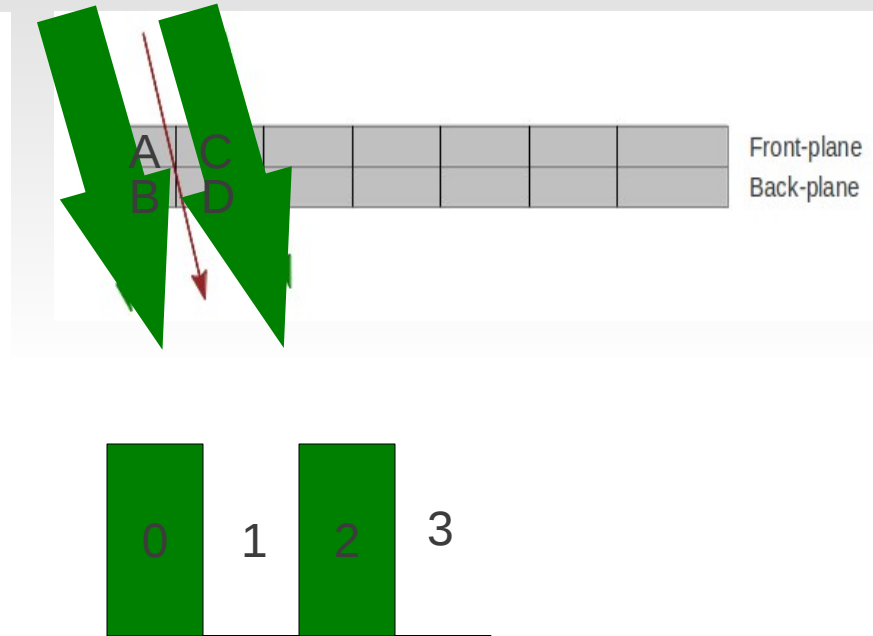
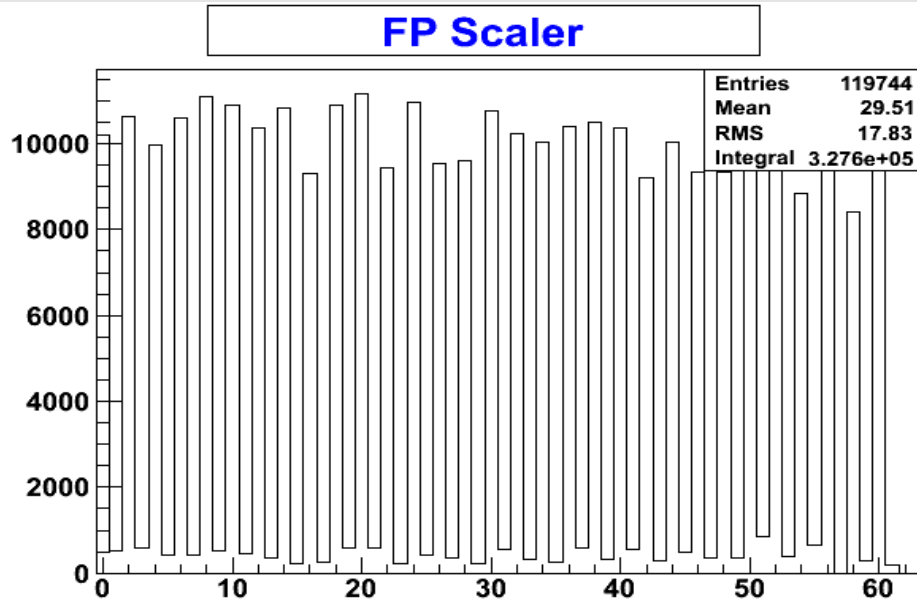
# Conclusions

- Tagging efficiency is **constant** as a function of run number
- Tagging efficiency is **constant** as a function of time in pulse
- Absolute value of the tagging efficiency is known to **+ - 0.6 %** systematic uncertainty

# Acknowledgments

- Dr. Kevin Fissum
- Dr. Jason Brudvik
- MAX-lab
- Nuclear Physics group
- IRES group

# FP Scaler



A and B in coincidence for many electrons  
A and D in coincidence for a few electrons  
C and D in coincidence for many electrons