DAQ Proton Trigger Efficiency in Nab

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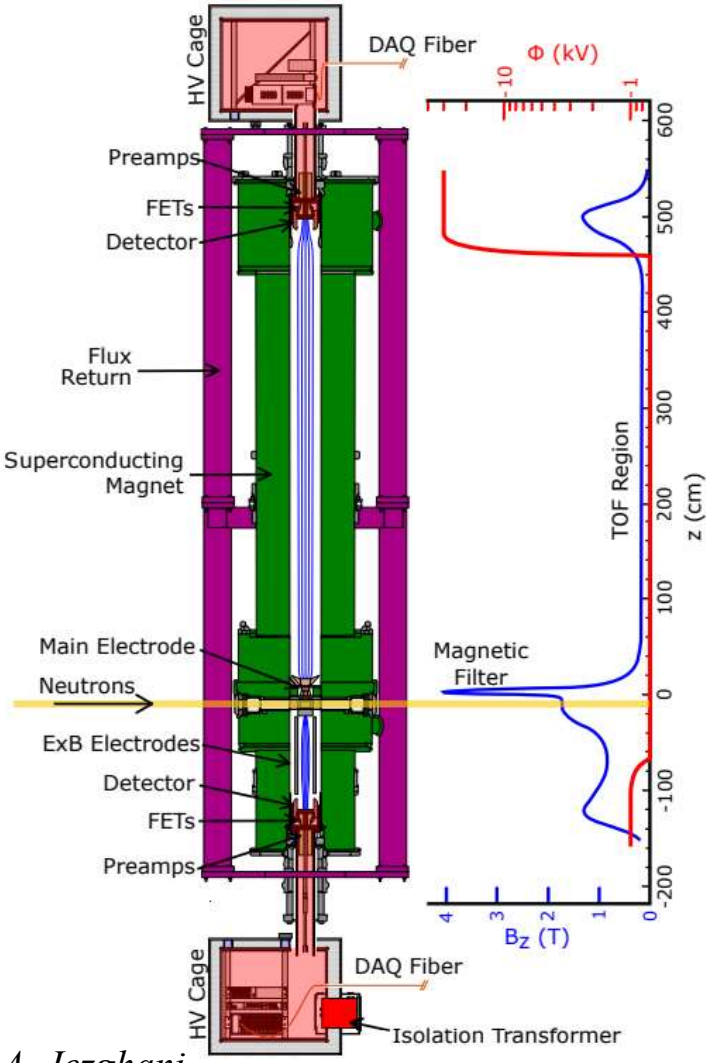
University of Kentucky

Outline

- Determine how proton signal amplitude affects Data Acquisition System (DAQ) proton trigger efficiency
- DAQ coincidences are proton anchored, missed proton triggers not saved by the DAQ
- Synthetic proton model: proton shape template + real noise
- Synthetic protons as input for DAQ emulated trigger logic → efficiency curves as a function of proton signal amplitude



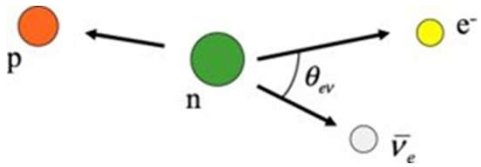
A. Jezghani

- Protons leave decay vertex with some initial momentum and pitch angle v_p, θ_o and have a time of flight to detector t_p

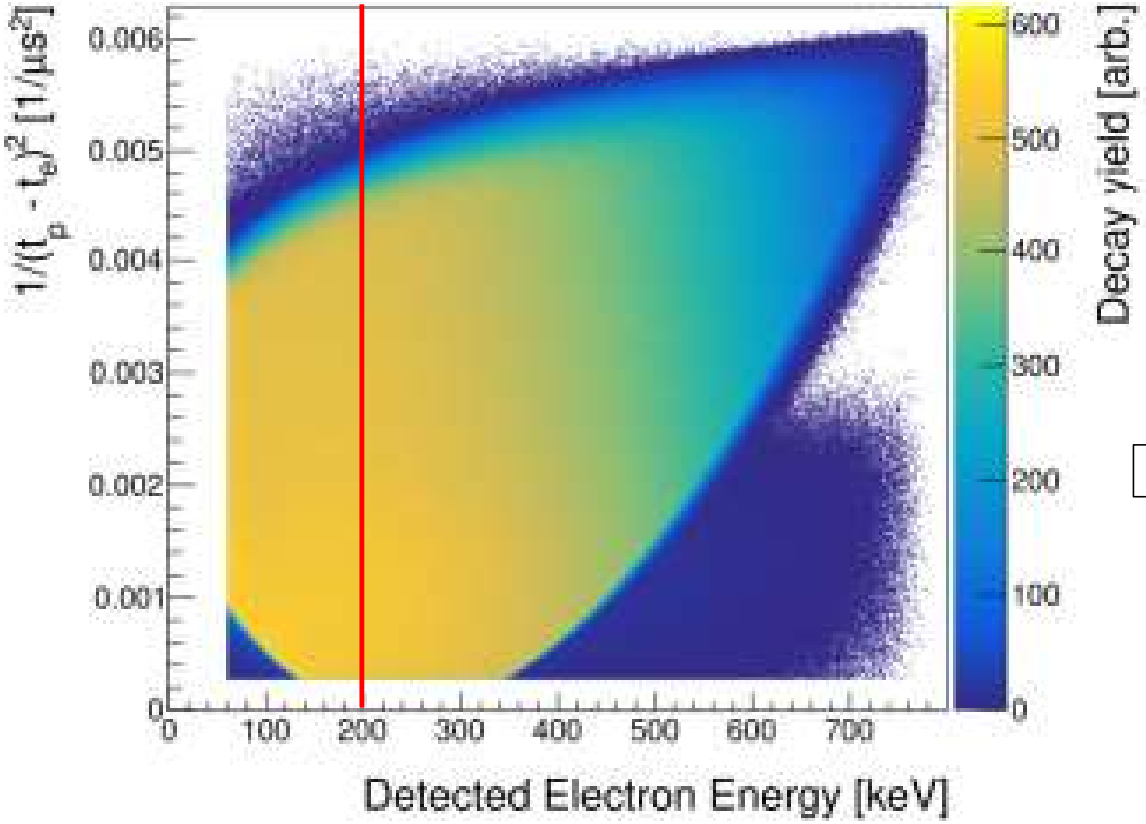
- Measure $t_p \rightarrow v_p(t_p)$
- Measure electron energy, E_e

- correlation between θ_o and t_p reduced through magnetic field filtering

$$t_p = \frac{m_p}{p_p} \int_{z_0}^{l} \frac{dz}{\sqrt{1 - \frac{B(z)}{B_0} \sin^2 \theta_0 + \frac{q}{E_0}(V(z) - V_0)}}$$



https://arxiv.org/abs/1811.10047



J. Choi

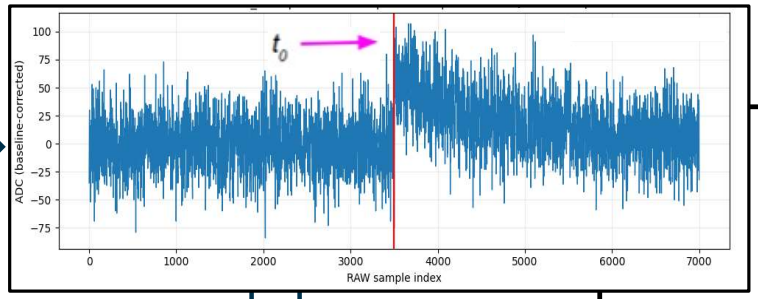
- Construct "Tear Drop" plot from measured $t_p \rightarrow \frac{1}{(t_p - t_e)^2}$ and detector electron energy E_e
- The *measured* TOF, E_e distribution is the true distribution weighted by the proton trigger efficiency ϵ_p

$$yield_{measured}(t_p, E_e) = \epsilon_p \, yield_{true}(t_p, E_e)$$

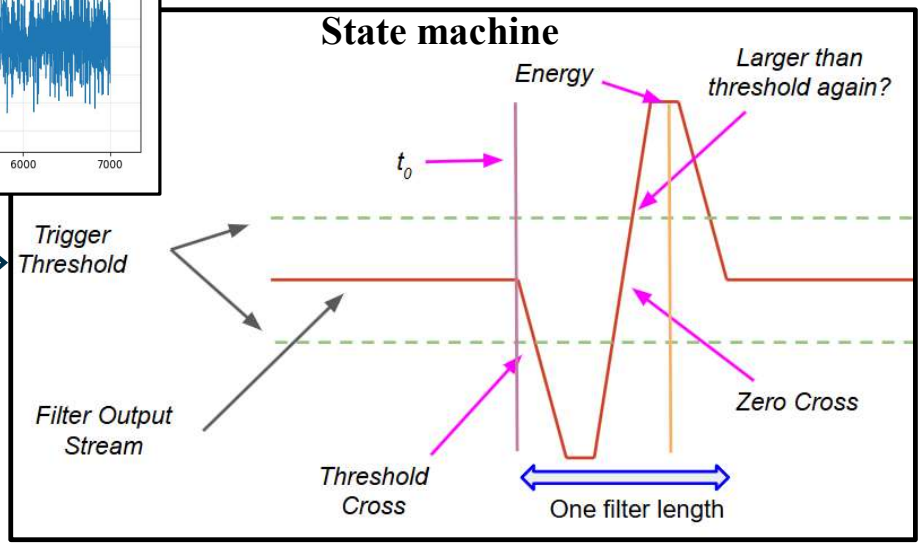
$$\epsilon_p(E_p) = P(event\ selected\ |E_p)$$

- Extract little *a* from slope of fixed electron energy cross sections of "Tear Drop" plot

Identify proton candidate



Double Trap Filter



Trigger?

Yes

Energy in proton range?

Yes

Proton Candidate

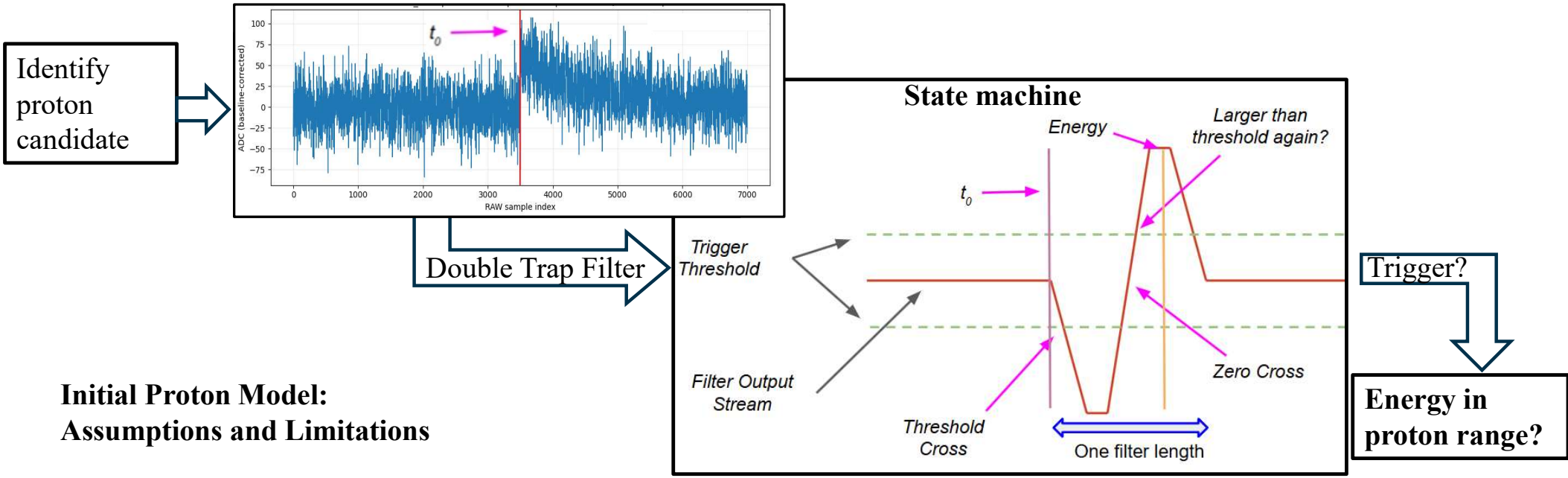
electron candidate found in time range?

Yes

Recorded as **coincidence**

No

Single



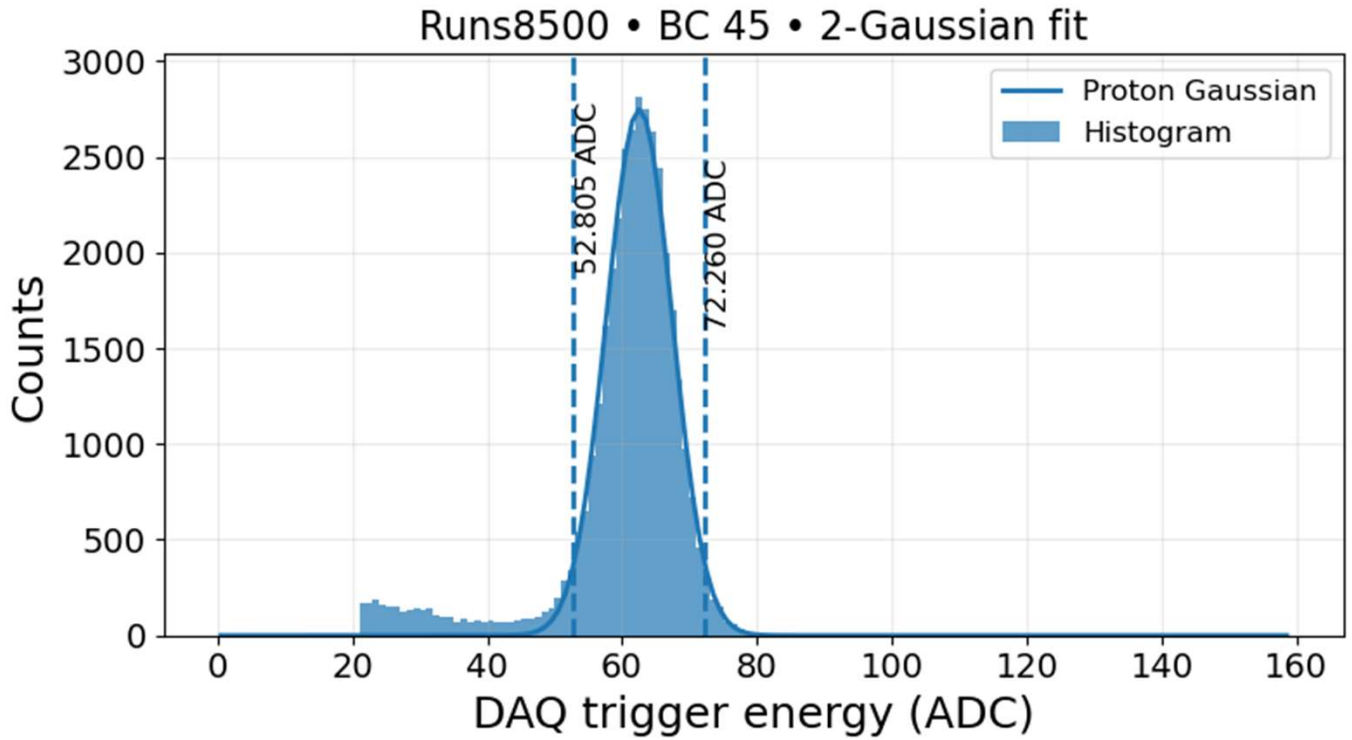
Initial Proton Model: Assumptions and Limitations

- **template + noise**
- Template representative of only DAQ classified protons
- Noise snippets from detector noise with no pulses

The DAQ only sees amplitude to determining proton candidates. How does the DAQ's proton trigger efficiency depend on the amplitude of the proton?

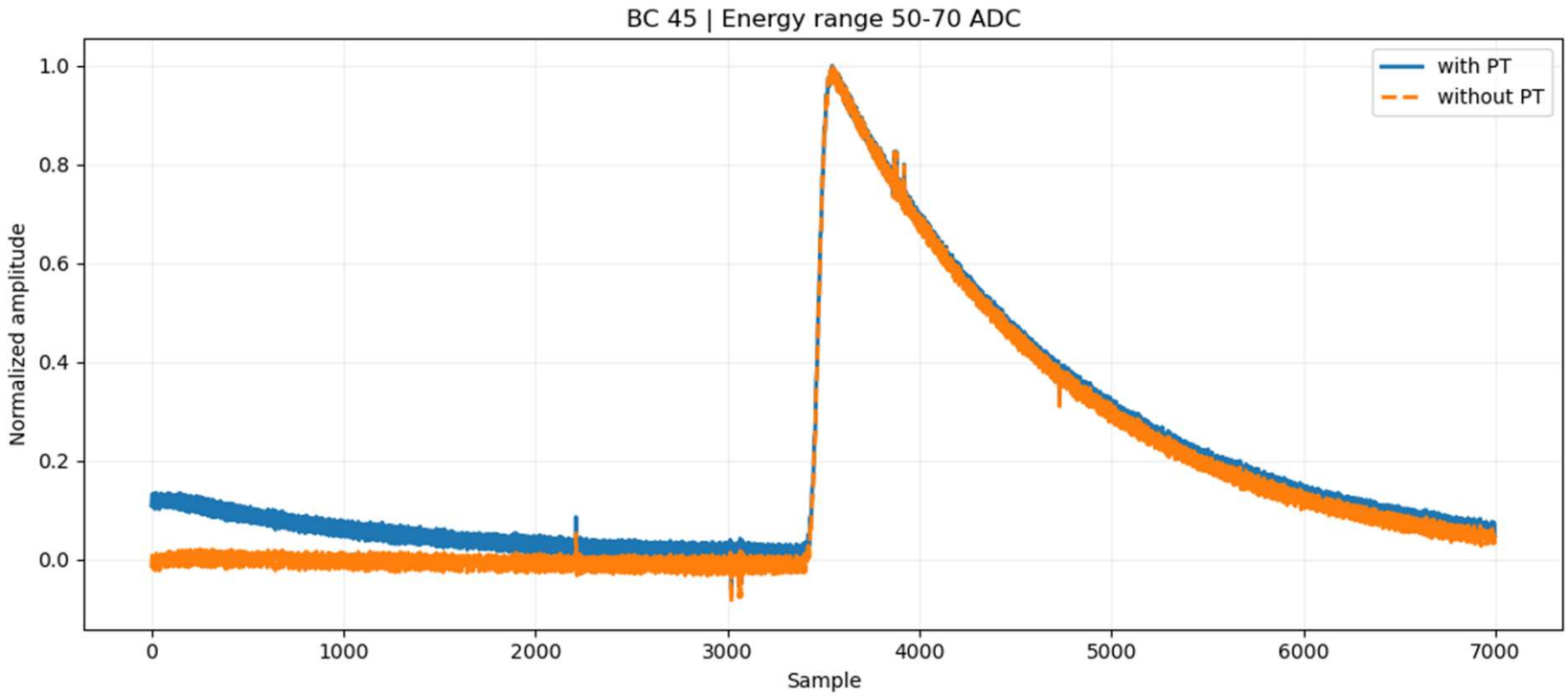
Template Energy Cuts

- 2 sigma cut on DAQ triggered energy used to determine which data gets used into template

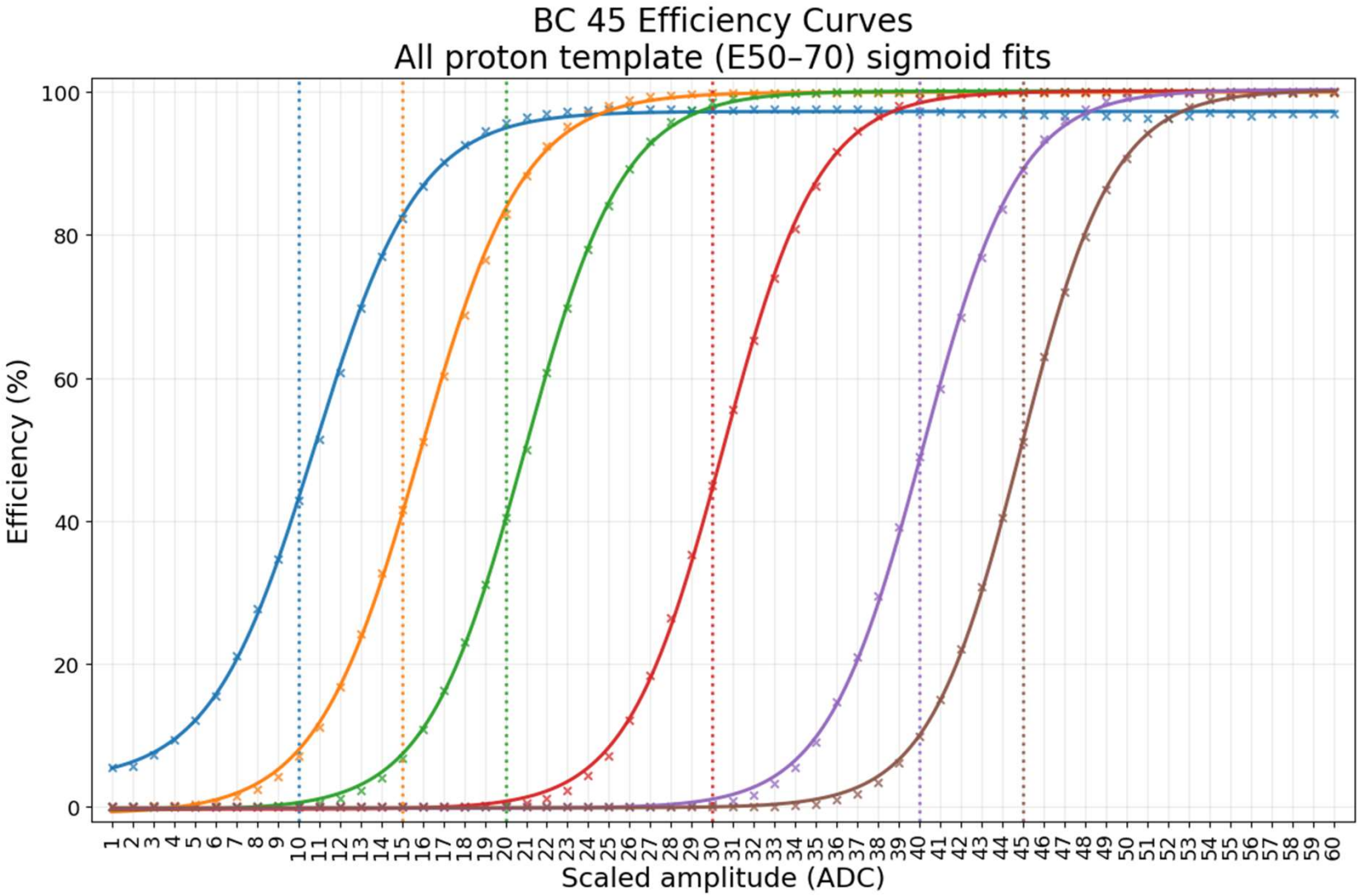


Protons in electron tail influence template

- Template including same channel pile up template excluding same channel pile up



Synthetic protons as input for DAQ emulated trigger logic



Summary

- Determine how proton signal amplitude affects DAQ proton trigger efficiency
- DAQ coincidences proton anchored, missed proton triggers not saved by the DAQ
- Synthetic proton model: proton energy cut template + real noise
- Synthetic protons as input for DAQ emulated trigger logic → efficiency curves as a function of proton signal amplitude

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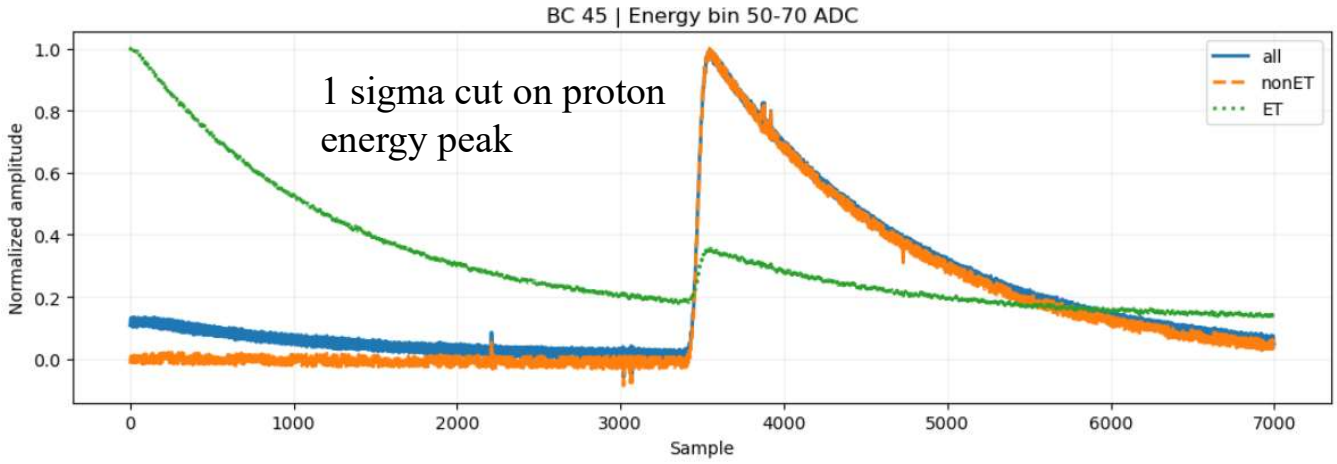
Conclusion/Future Work



Template + noise → Python DAQ emulation → Efficiency curves as a function of template amplitude for synthesized protons

$$Trigger\ Eff = \frac{\#\ of\ triggers}{\#\ of\ real\ signals}$$

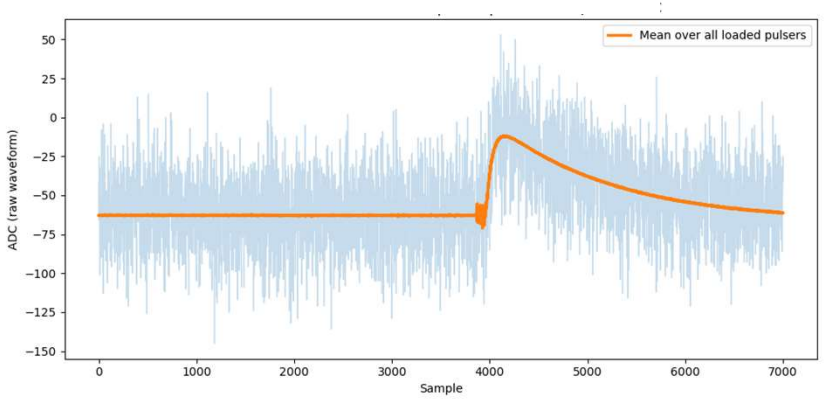
Pulsers are a test bench to validate synthesized protons

- Pulser data sets give us a clean denominator for efficiency
- Apply template + noise method to pulsers → show efficiencies match real pulser efficiencies within error band

Pulsers are NOT protons

- Differences in shape could affect the trigger efficiency

Pulsers



Protons