Towards a Measurement of Weak Magnetism in ^{6}He Decay

Xueying Huyan (huyan@nscl.msu.edu)

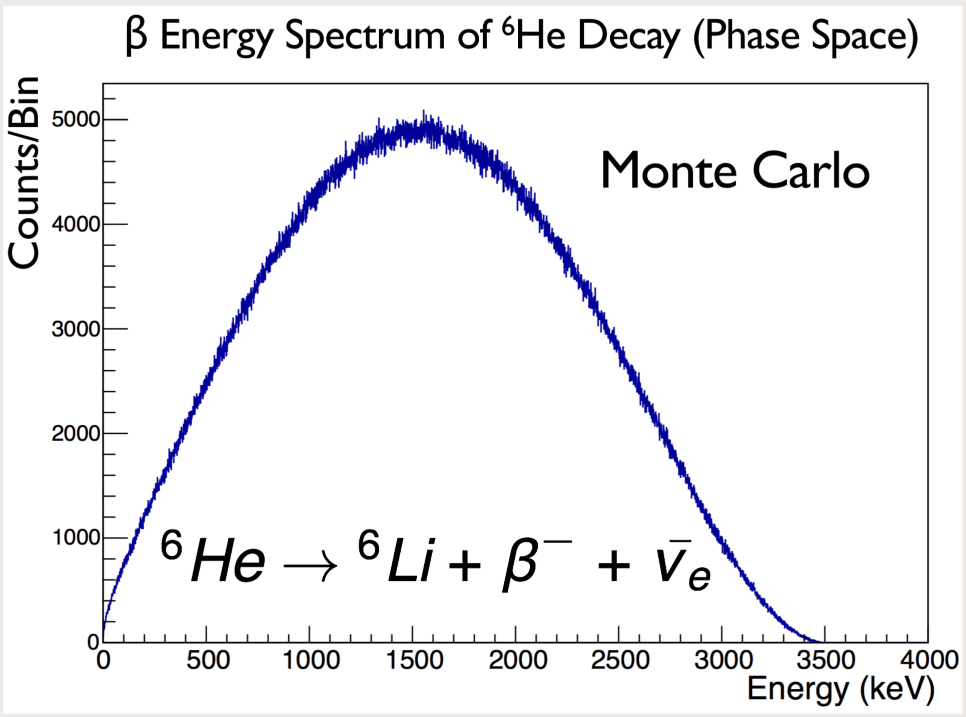
National Superconducting Cyclotron Laboratory/Michigan State University

Collaborators: D. Bazin[1], A. Gade[1], **M. Hughes**[1], S. Liddik[1], K. Minamisono[1], **O. Naviliat-Cuncic**[1], S. Noji[1], **S. Paulauskas**[1], A. Simon[1], **P. Voytas**[2], D. Weisshaar[1]

[1] *NSCL/Michigan State University MI, USA,* [2] *Wittenberg University OH, USA*

1. Motivation

This experiment focuses on a precision measurement of the β energy spectrum in ^{6}He decay to search for tensor type contributions to the weak interactions.



The shape of β energy spectrum:

$$N(W) = pW(W_0 - W)^2\left(1 + \frac{m}{W}b\right)S(W)$$

Total Energy; Phase Space

Beyond the Standard Model
Fierz interference term: b

Our first goal:
Shape Factor

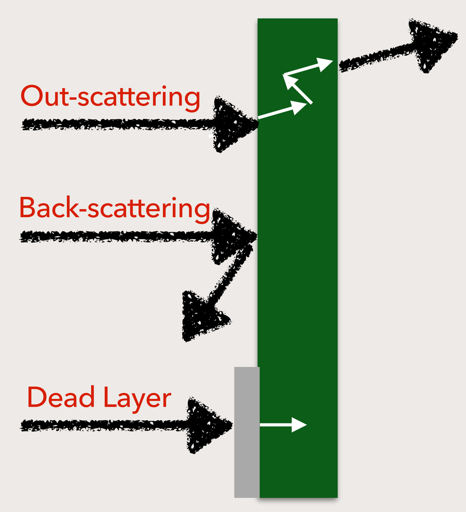
$$S(W) = (1 + C_0 + C_1 W + C_{-1}/W)$$

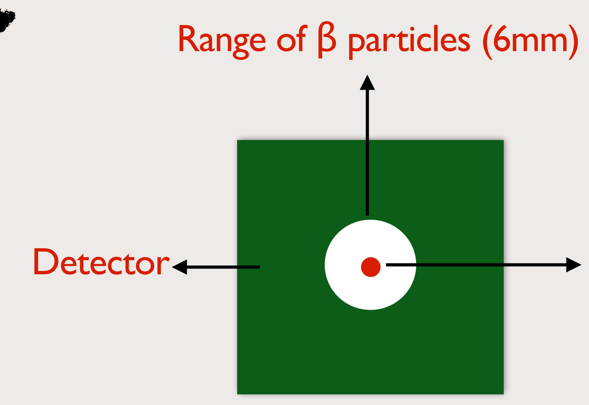
Related to weak magnetism form factor
Dominant term C_1 ~0.65%/MeV

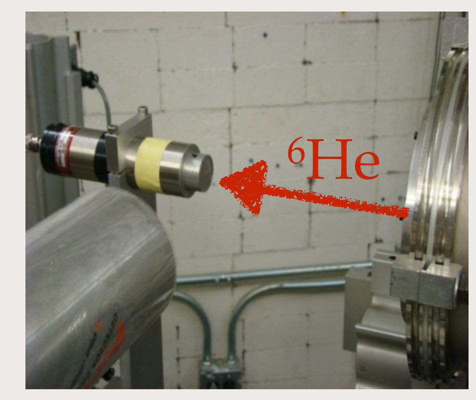
2. Experiment

Implant a ^{6}He beam into a CsI(Na) or a Na(I) scintillating detector. The detector fully encloses the radioactive source so that no β particles can escape.

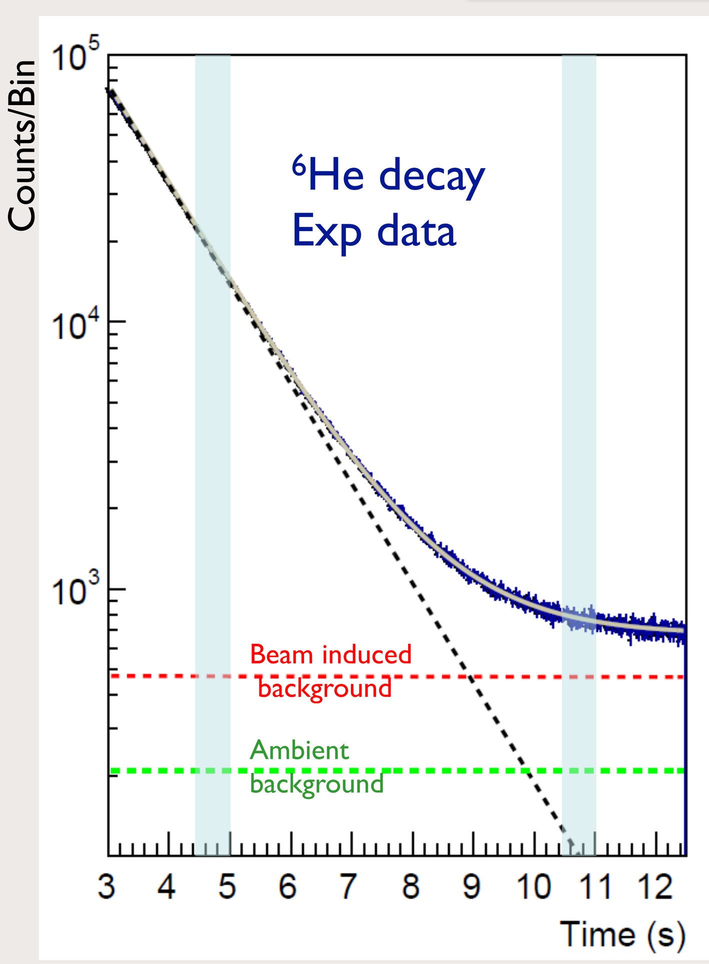
Instrumental Challenges | **Solution** | **Setup**





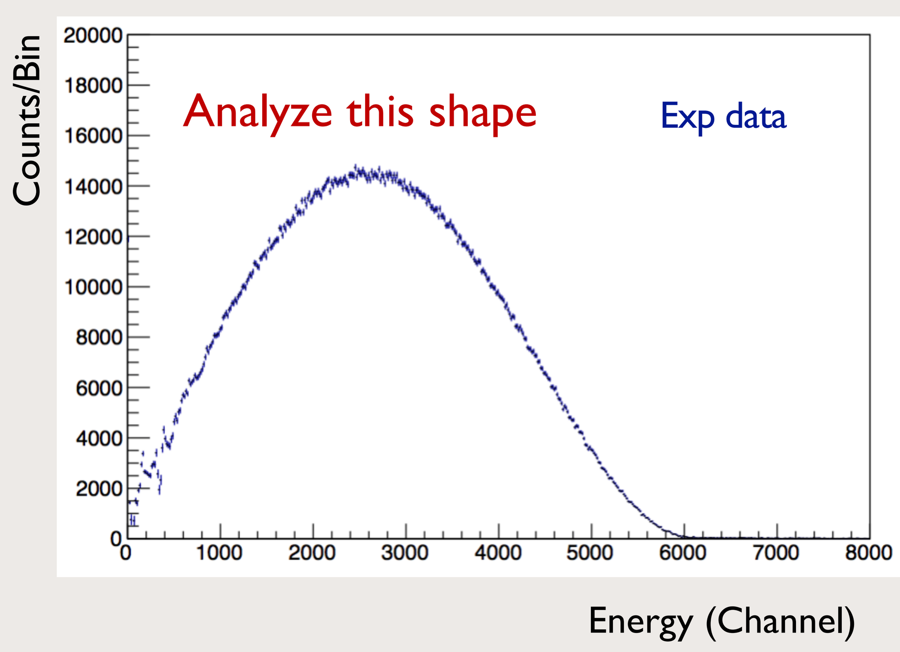


3. Measured β Spectra



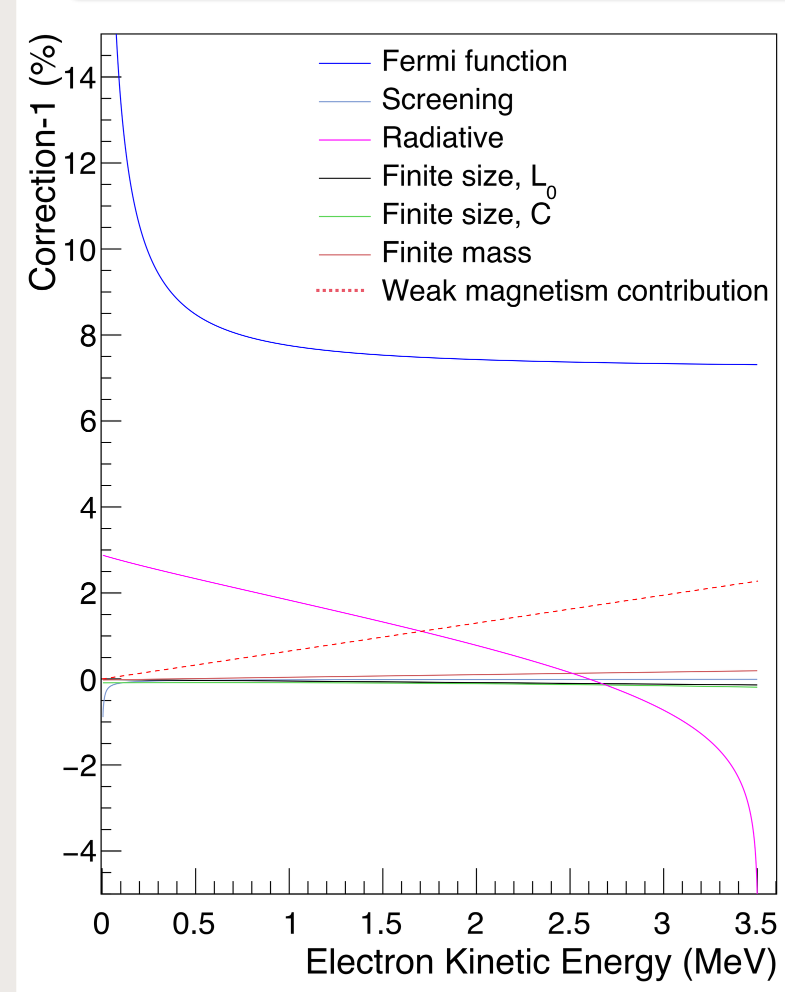
No traces of "short lived" beam induced background

Background subtracted energy spectrum obtained with the CsI(Na) detector:

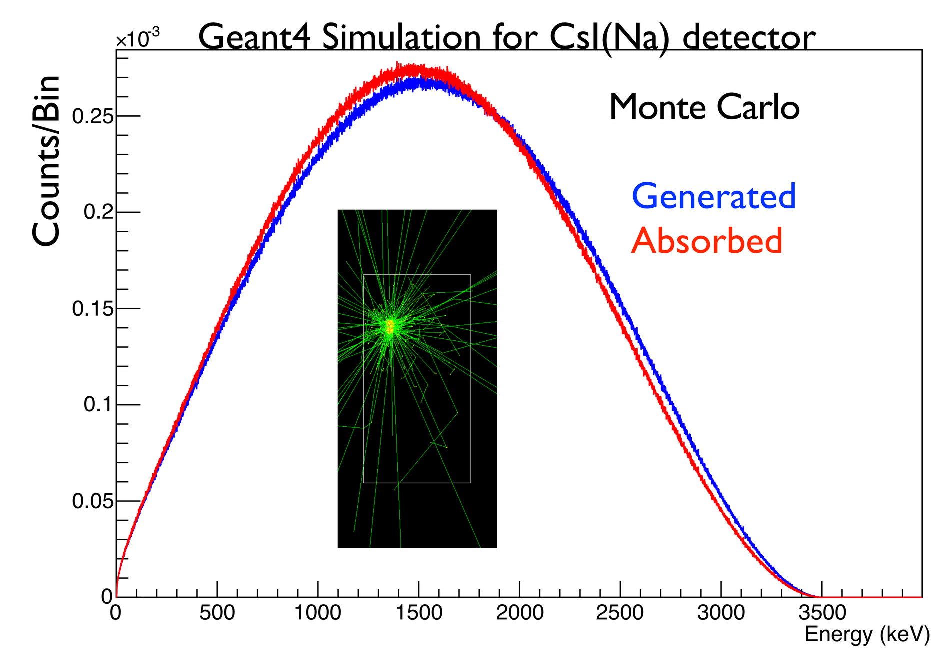


- Define 6-7 slices between 3 and 6 s, with about 10^6 events in each spectrum.
- We collected typically 10^7 events in 1 h run.

4. Theoretical Corrections and Geant4 Simulations



- β particles lose energy in the detector by collision and radiation.
- Some Bremsstrahlung radiation escapes the detector and produces a distortion in the spectrum shape.



Theoretical Corrections are dominated by Fermi function and radiative corrections.

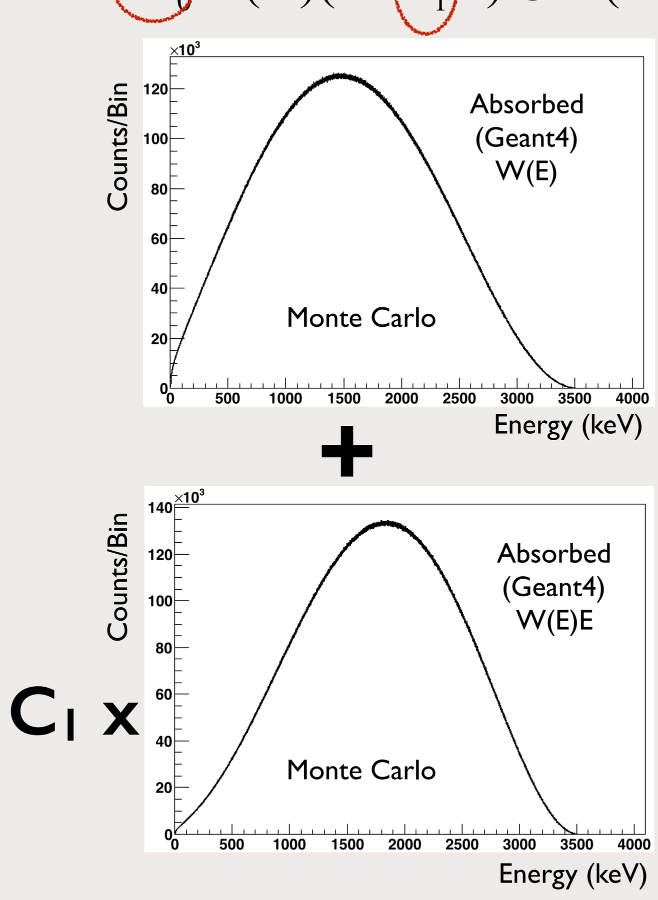
5. Fit Procedure

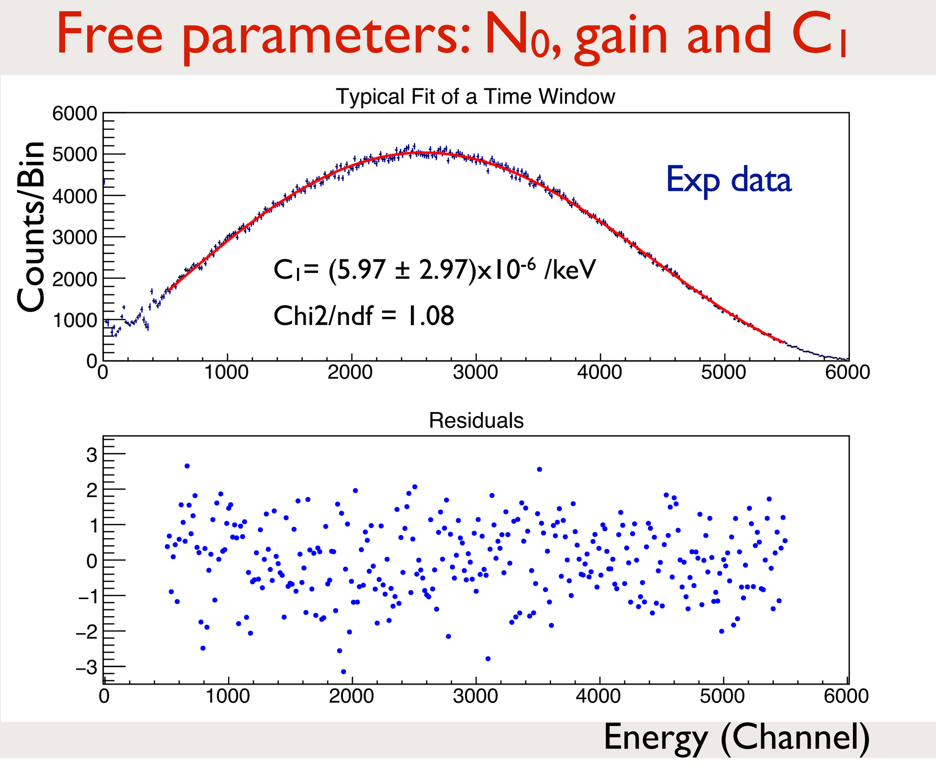
Approximation with dominant term C_1

$$N_0 W(E)(1 + C_1 E) \otimes F(E) \rightarrow N_0\left[f_0(C) + C_1 f_1(C)\right] \quad \text{C: channel}$$

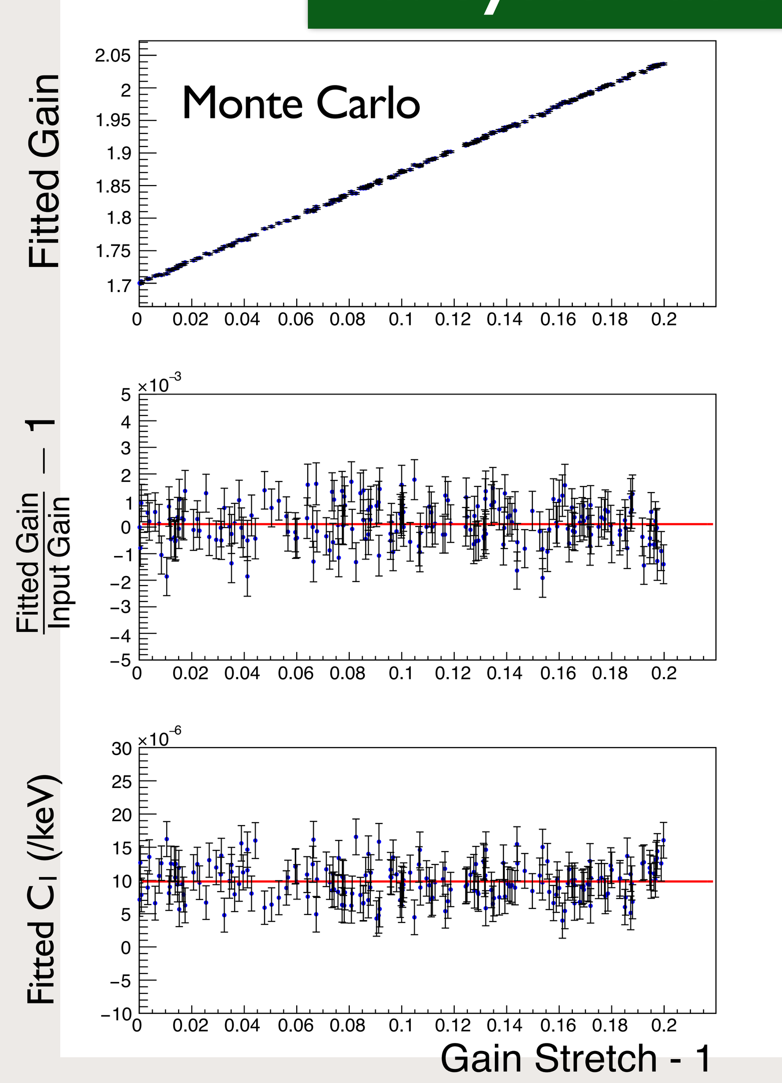
$$C = \text{gain} \times E + \text{offset}$$

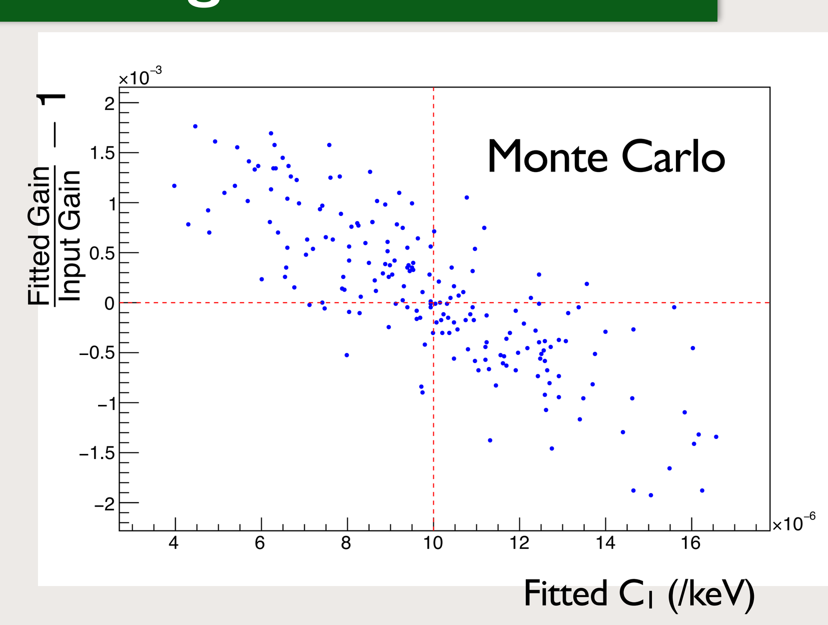
Free parameters: N_0, gain and C_1





6. Systematic effect: gain/calibration

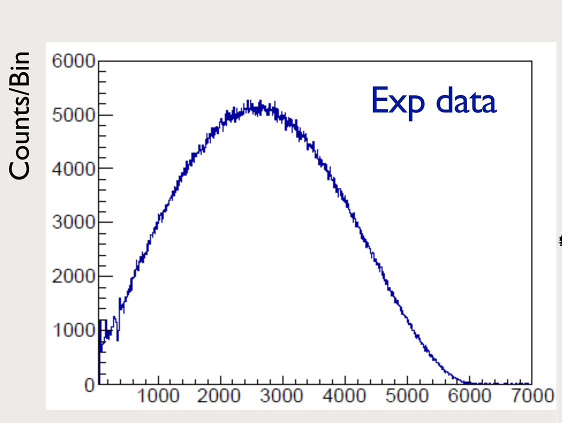




- There is no correlation between the **actual value of the system gain** and C_1.
- There is an anti-correlation between the **systematic error of the system gain** and C_1.
- Relative statistical uncertainty of the gain is 6×10^{-4} for a single spectrum with 10^6 events.

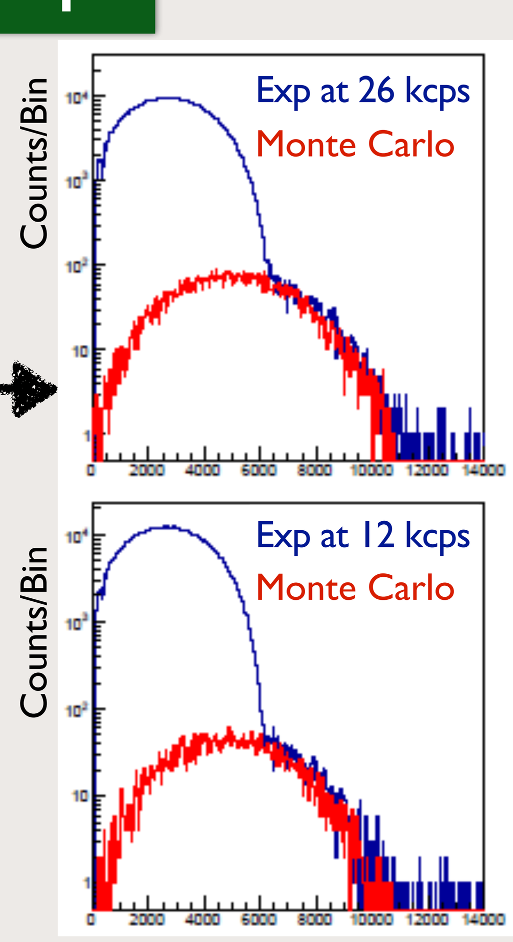
7. Systematic effect: pile-up

- Experiment
- Pile-up calculation



Modeling of Pixie-16 Digitizer

(Not a fit)



- The largest systematic effect
- About 10% relative variation on weak magnetism form factor

8. Status and Outlook

- Data analysis to extract weak magnetism is in progress. Collected statistics will enable to extract weak magnetism at ~5% relative statistical uncertainty.
- Weak magnetism should manifest on the way down to a precision measurement of the Fierz term.
- This provides a benchmark test to any experimental technique aiming to reach new levels of sensitivity.

Acknowledgement

Work supported by the National Science Foundation (US) under grant number PHY-11-02511.