WbLS Proton Light Yield

Ed Callaghan

for J. Brown, B. Goldblum, T. Laplace J. Manfredi, G. D. Orebi Gann

November 11, 2019

Outline

- Introduction
- Experimental overview
- Analysis methodology
- Current status
- Future measurements

Introduction

Reconstructing proton recoils useful in low-background experiments

- np scattering for fast neutron background
- νp scattering for all-flavor supernova ν energy spectrum

Can detect scintillation light from proton recoils

- Interesting in characterizing in WbLS
- 2 g/L LABPPO as a reference

Experimental overview

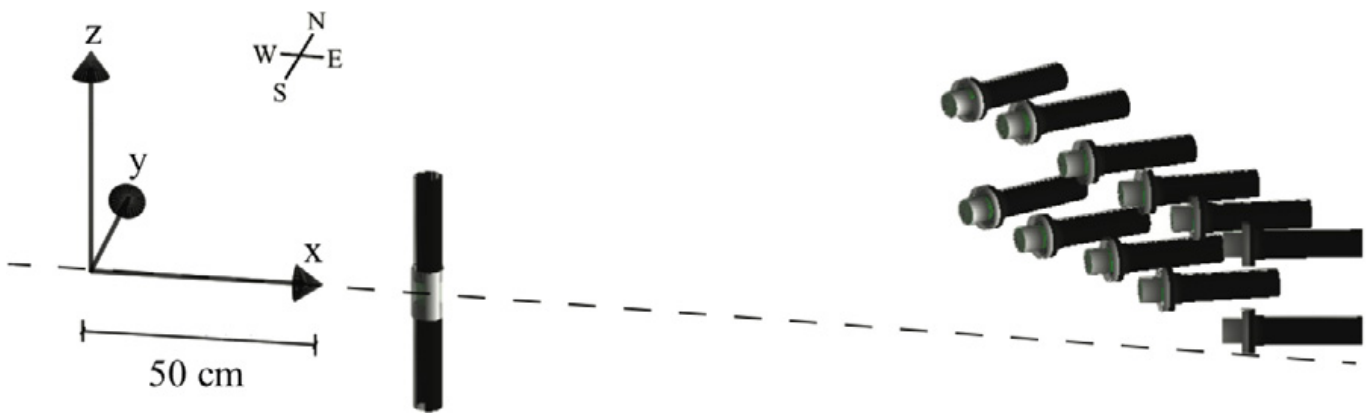
33 MeV deuteron beam delivered from 88-Inch cyclotron at LBNL

Breakup on Be + copper target, ~ 8 m baseline to target material

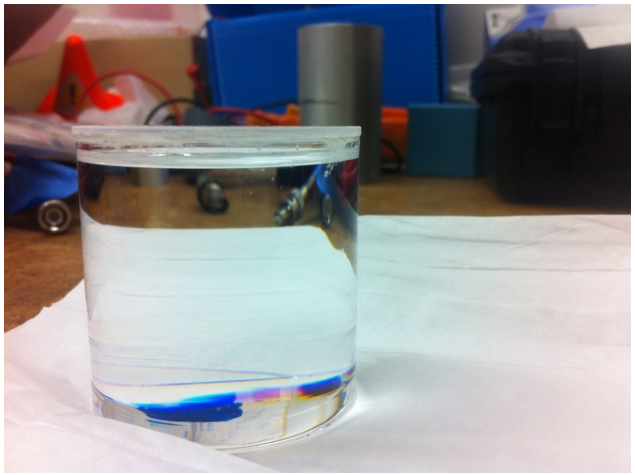
- Broad-spectrum *n* flux

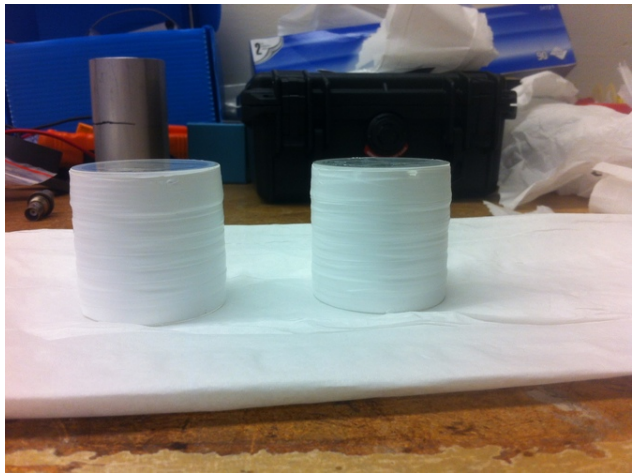
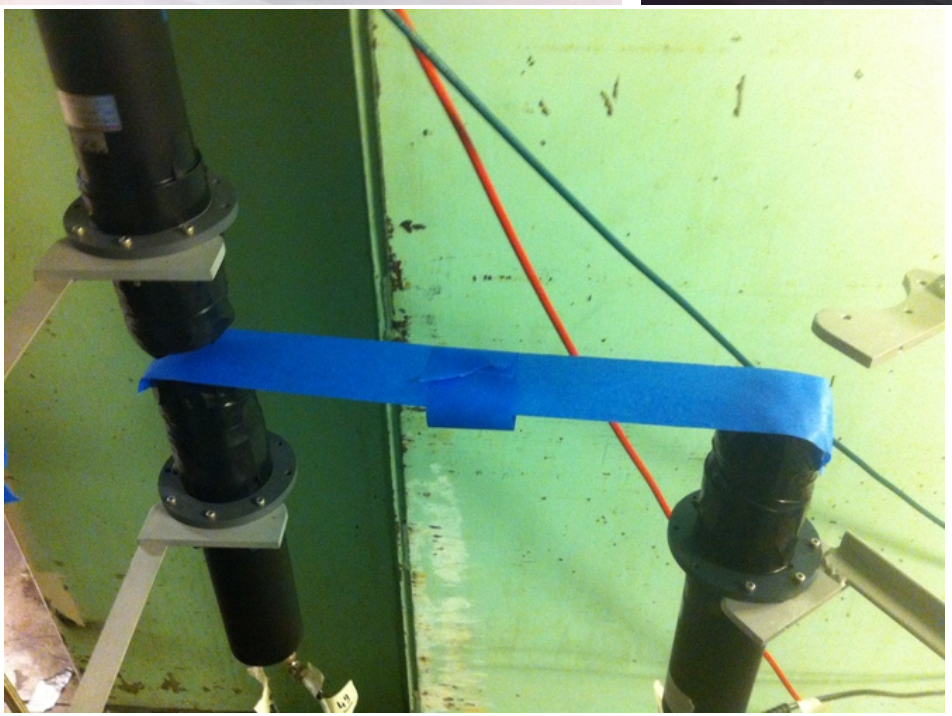
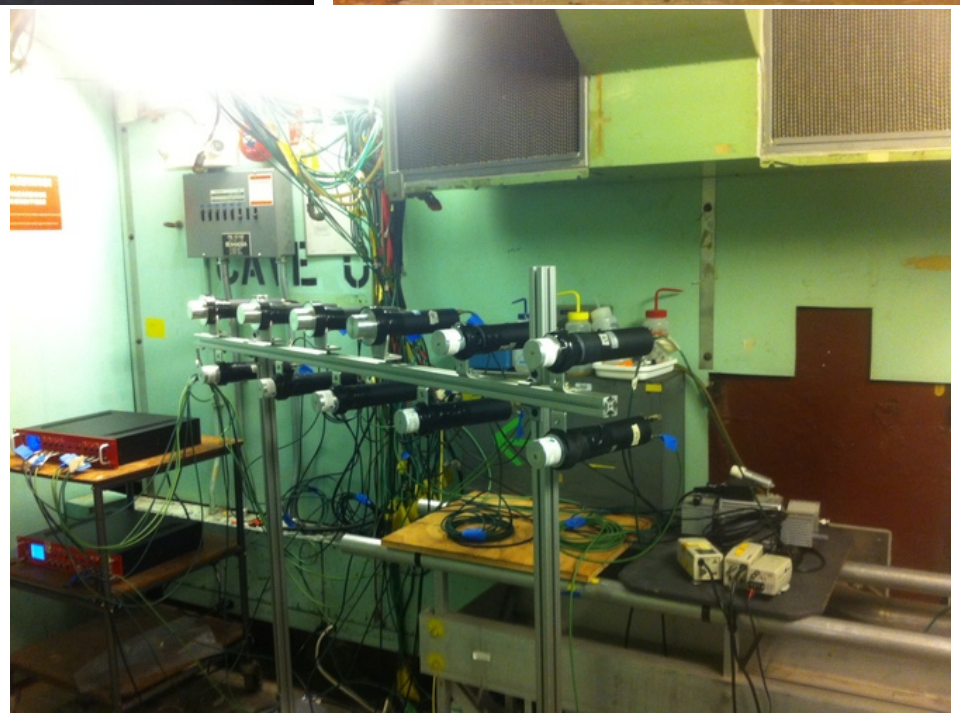
Also Detect two *np* scatters in different detectors

- PSD in scatter cells
- "Double time-of-flight"



Experimental overview



Analysis methodology

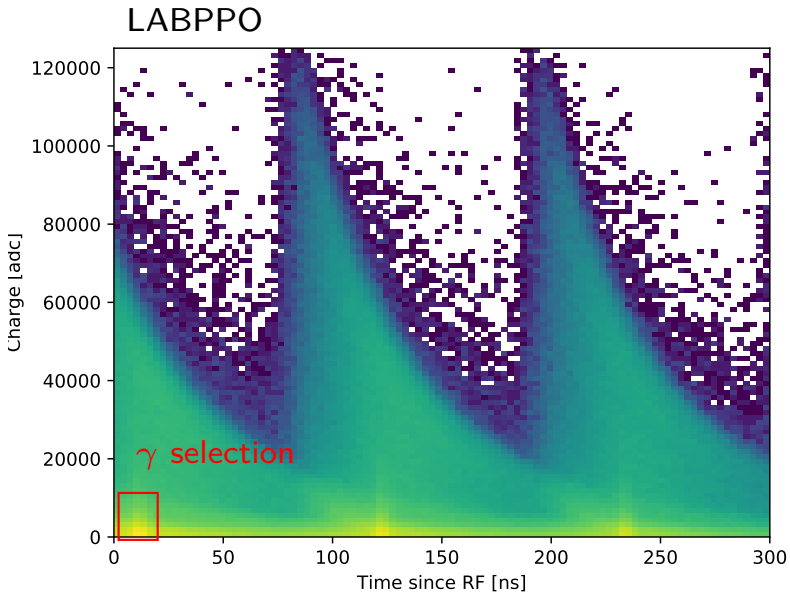
Trigger on generous coincidence between "target" and "scatter" cells, assume all target/scatter pairs are legitimate events

- Only one is kinematically consistent with beam-dump

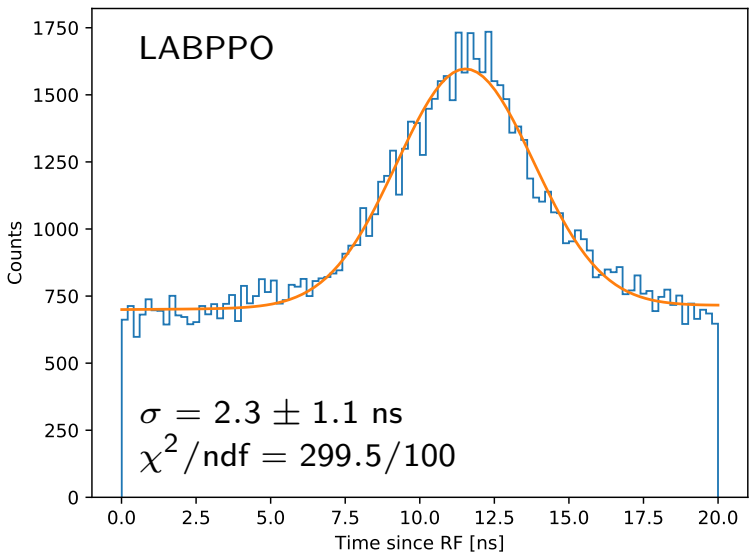
Measured charge and time differences yield relative LY and neutron energy

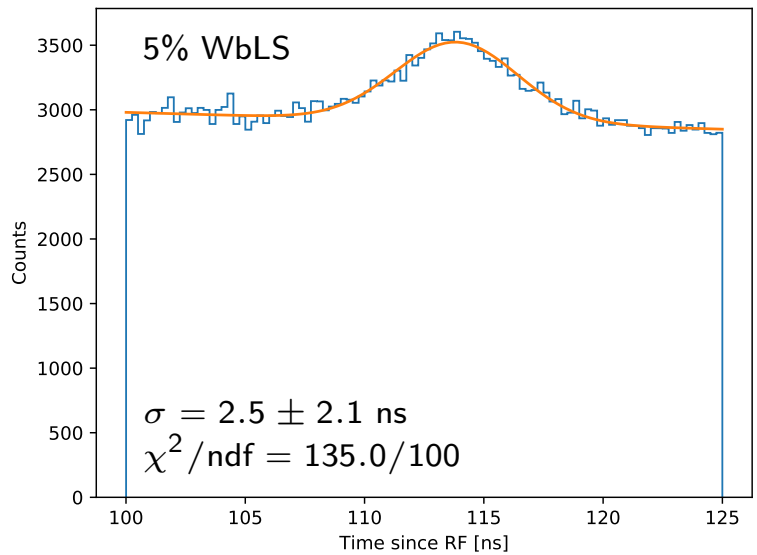
- Also know scattering angle
  - 3 measures of p energy
- System is kinematically overconstrained
- Further reduction in background

Analysis methodology



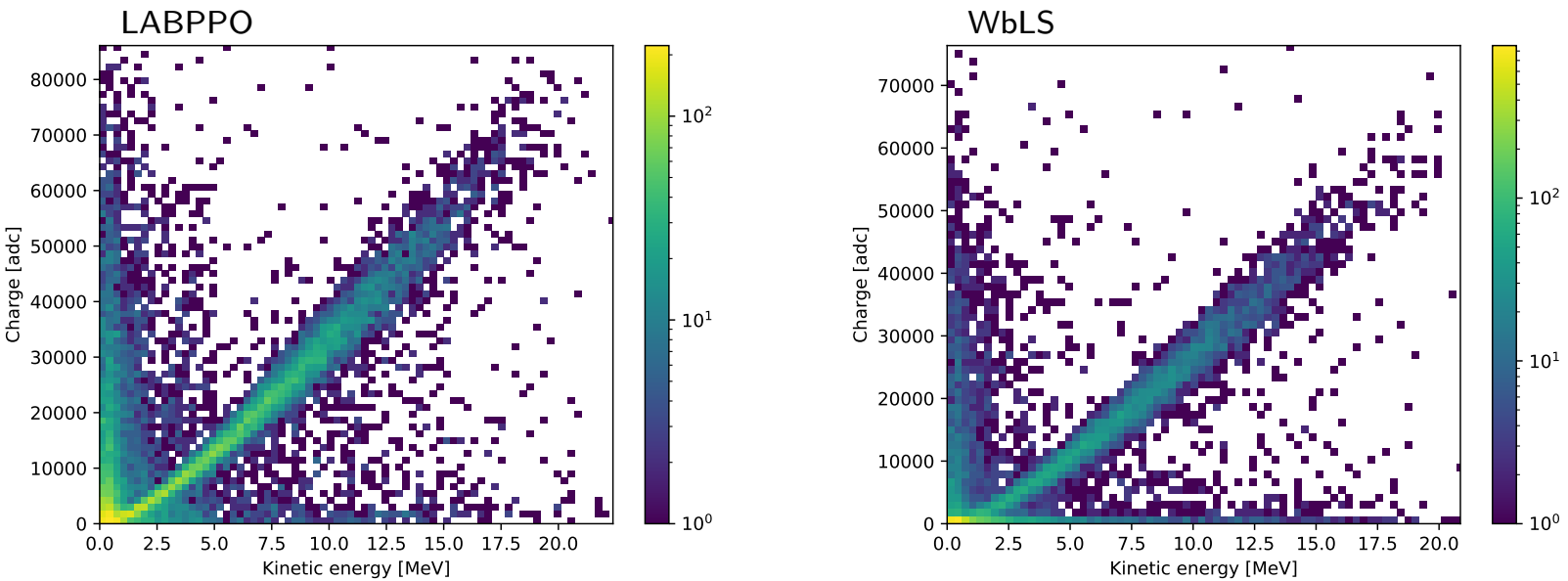
Fit to timing of γ sample yields gross time-of-flight calibration and beam profile





Analysis methodology - extracting the LY scaling

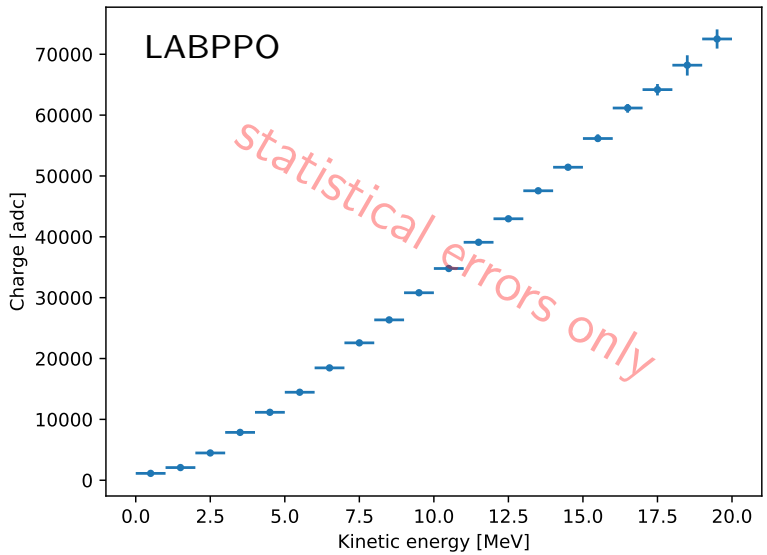
Impose kinematic consistency requirements

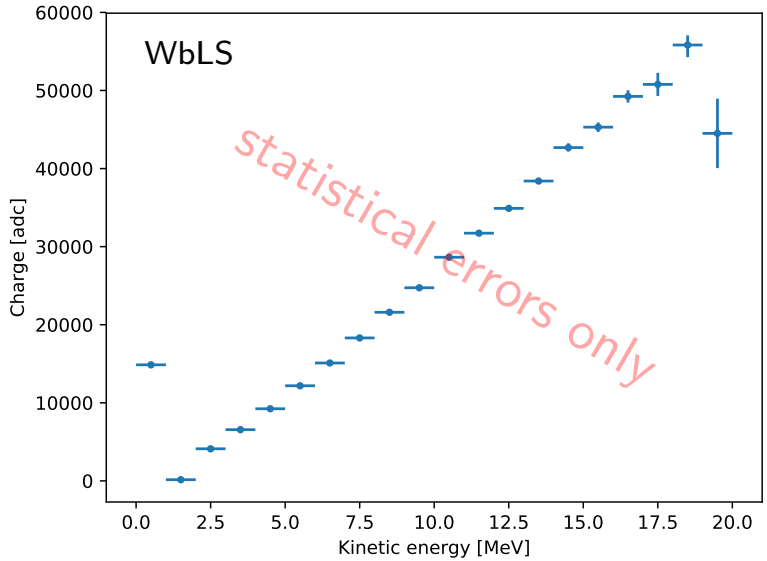


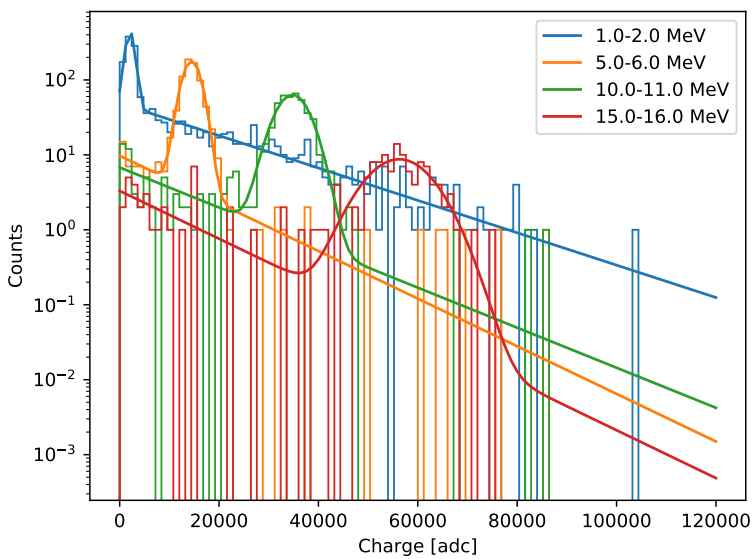
Bin in neutron energy and fit with Gaussian + exponential

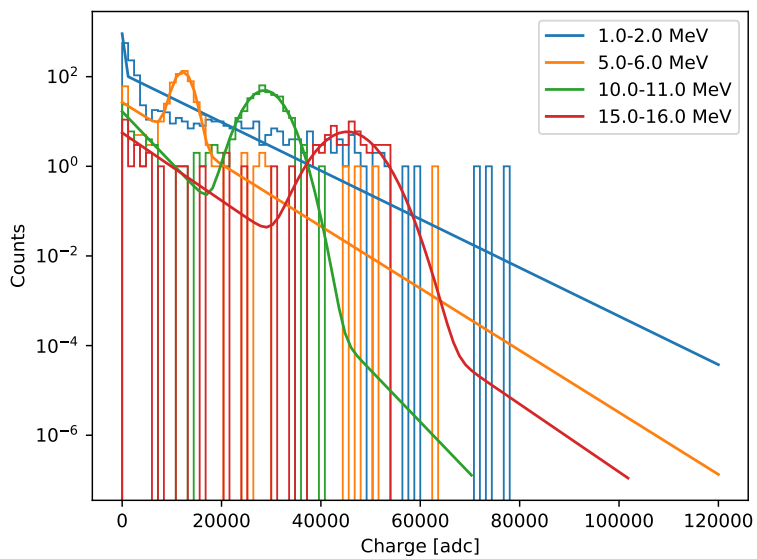
Systematics propagated by scrambling detector positions (correlated) and timing calibration

Analysis methodology - extracting the LY scaling









Analysis methodology - Calibrating to electron LY

Endpoint of button-source Compton spectrum used as normalizing scale

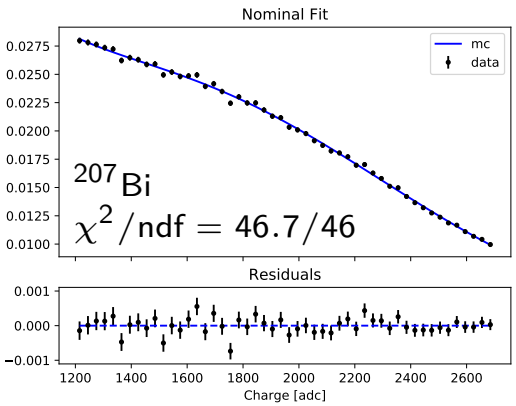
GEANT4 Monte Carlo to generate Compton spectrum

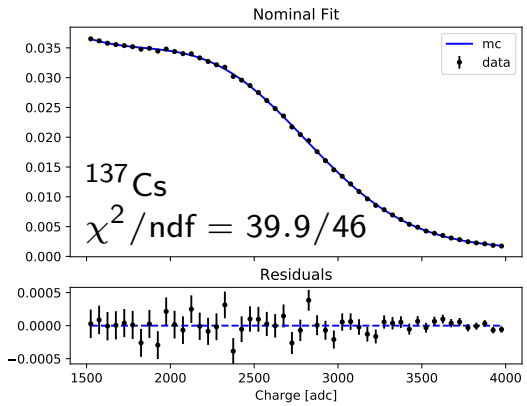
- Klein-Nishina + secondary scatters

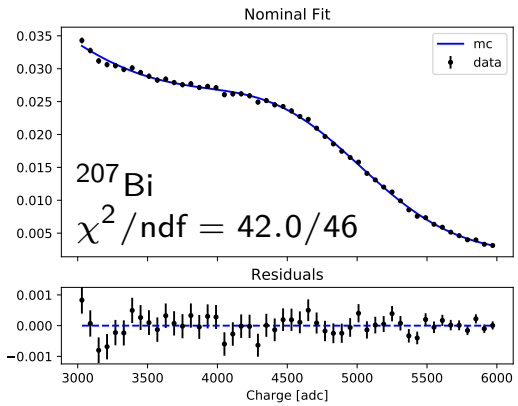
Fit to data:

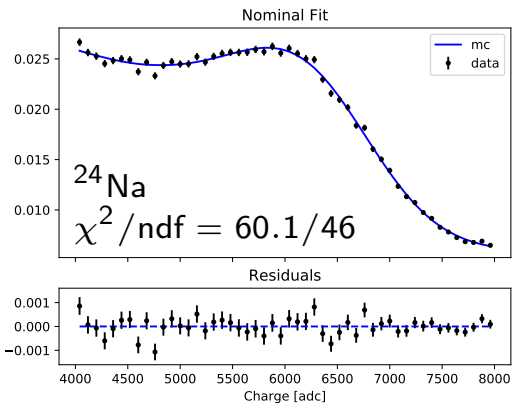
- Local linear charge-response $Q = \alpha\,(E - E_C) + Q_C$
- Local Gaussian (σ)
- Power-law background (Q^{-n}, A)

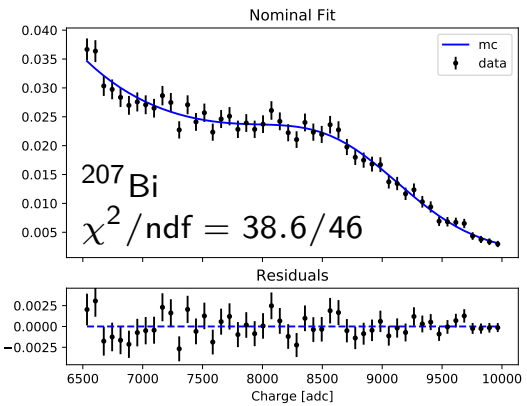
Analysis methodology - LABPPO calibration

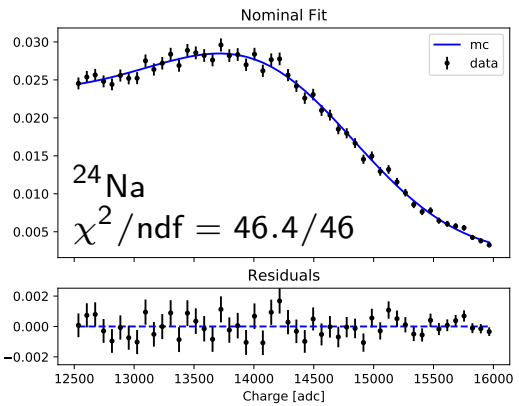




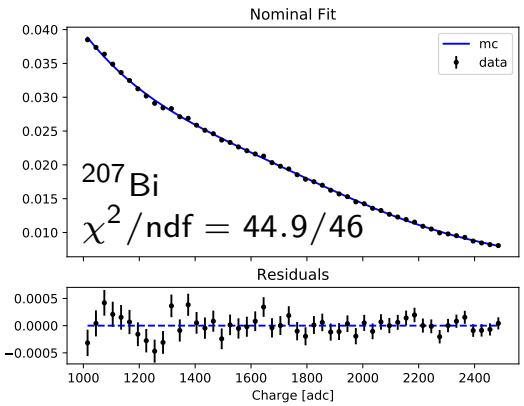


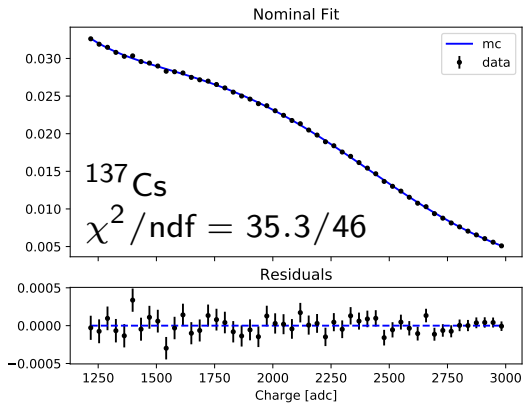


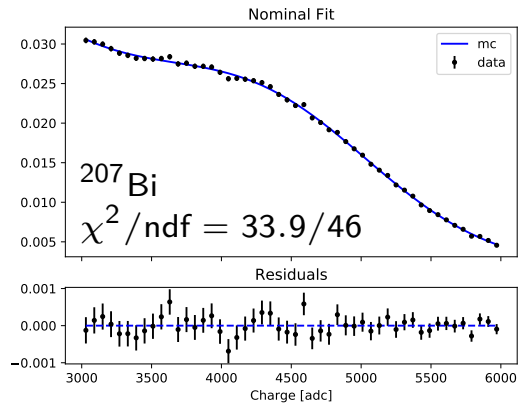


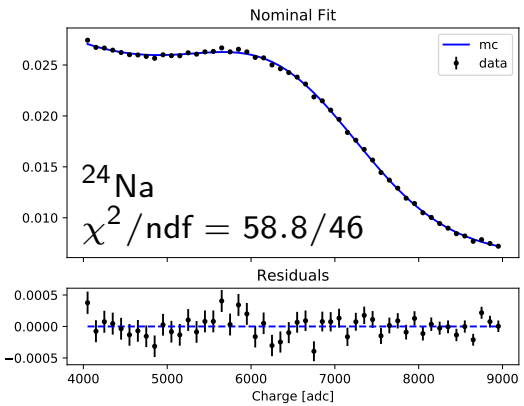


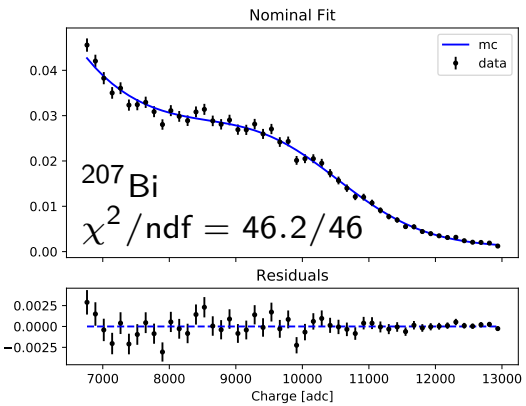
Analysis methodology - WbLS calibration

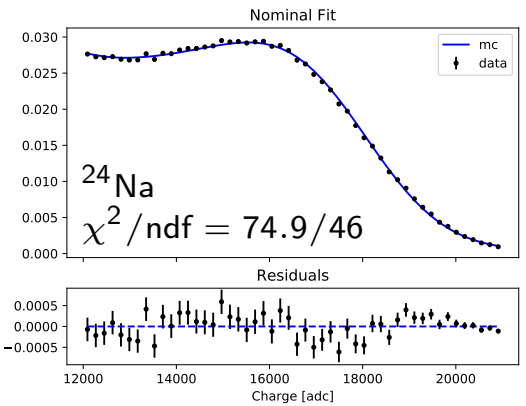












Current status

First iteration is complete and results are sensible

Current efforts:

- Optimize implementation and tune quality cuts
- Finalize uncertainties on charge calibration
- Correct for non-linearity in PMT response

Future measurements

Light yield as function of scintillator loading

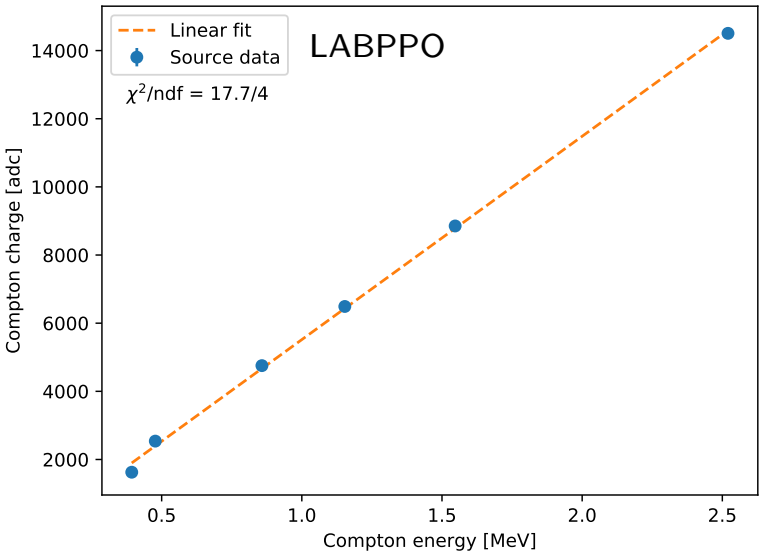
- Nominally 1% and 10% remaining

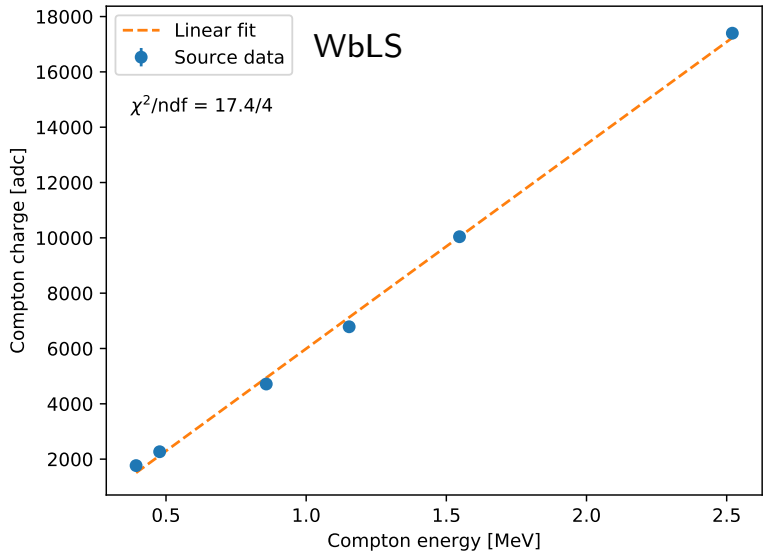
Effects of isotopic loading

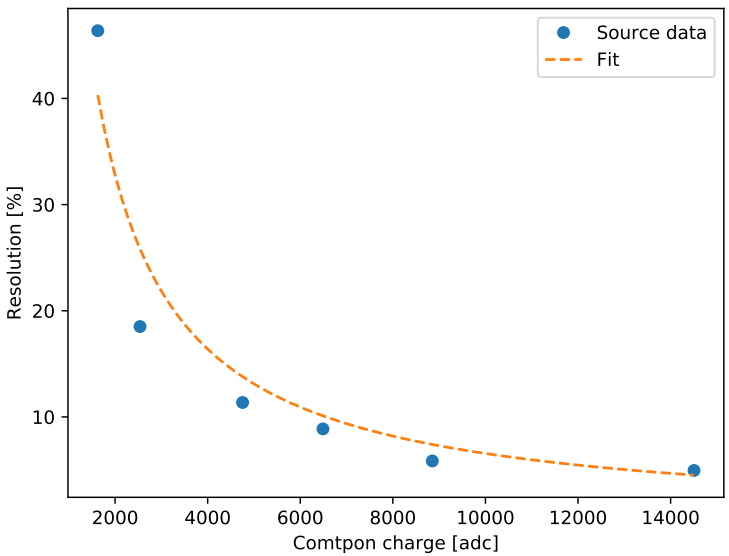
- Candidates for solar CC measurement
- Gadolinium

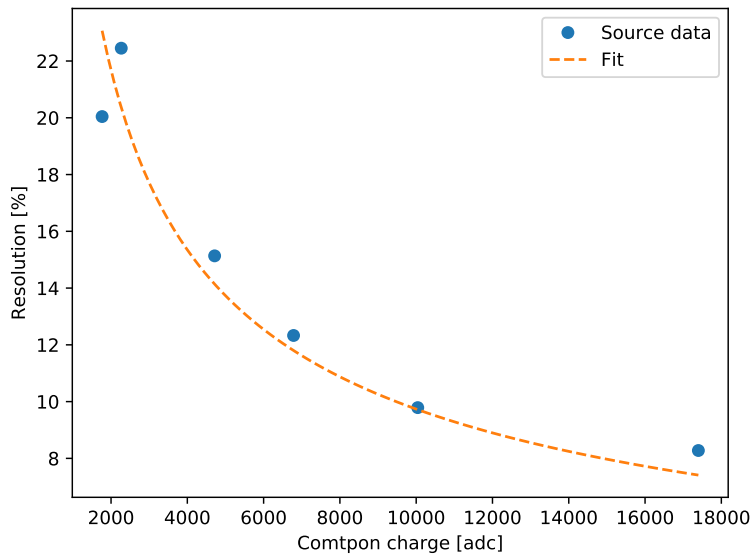
BACKUP

Electron LY calibration

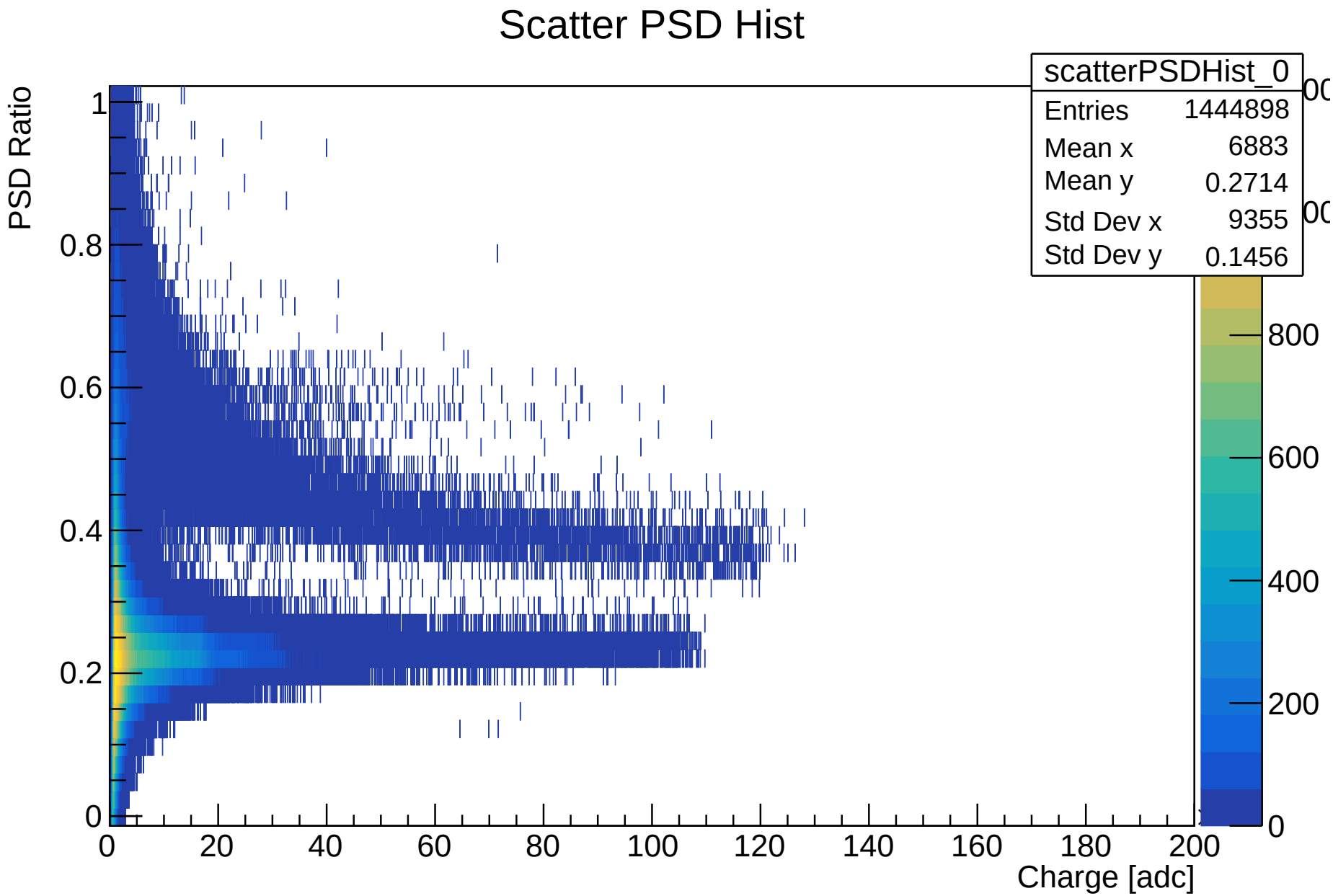








EJ309 PSD


Scatter PSD Hist
scatterPSDHist_0
Entries 1444898
Mean x 6883
Mean y 0.2714
Std Dev x 9355
Std Dev y 0.1456
PSD Ratio
Charge [adc]
0
0.2
0.4
0.6
0.8
1
0
20
40
60
80
100
120
140
160
180
200
0
200
400
600
800