Energy Recover from PileUp Events in Silicon Detectors

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Hellenic Institute of Nuclear Physics 2nd Workshop (HINPw2)
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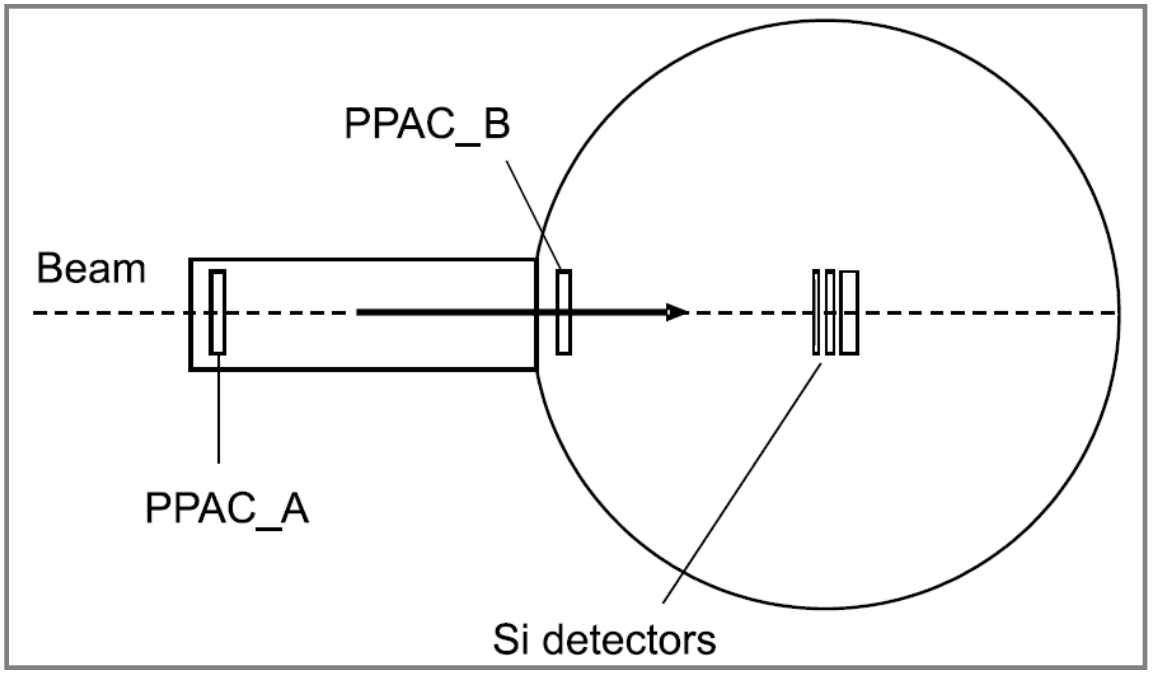
Physics Department, Aristotle University of Thessaloniki

Outline

- Experimental Setup - Data Acquisition System
- Pulse Shape Digitization
- Pulse Shape Analysis Techniques for Energy Calculations
- Identification of PileUp Events
- Energy Recovery
- Concluding Remarks

Experimental Setup – DAQ System



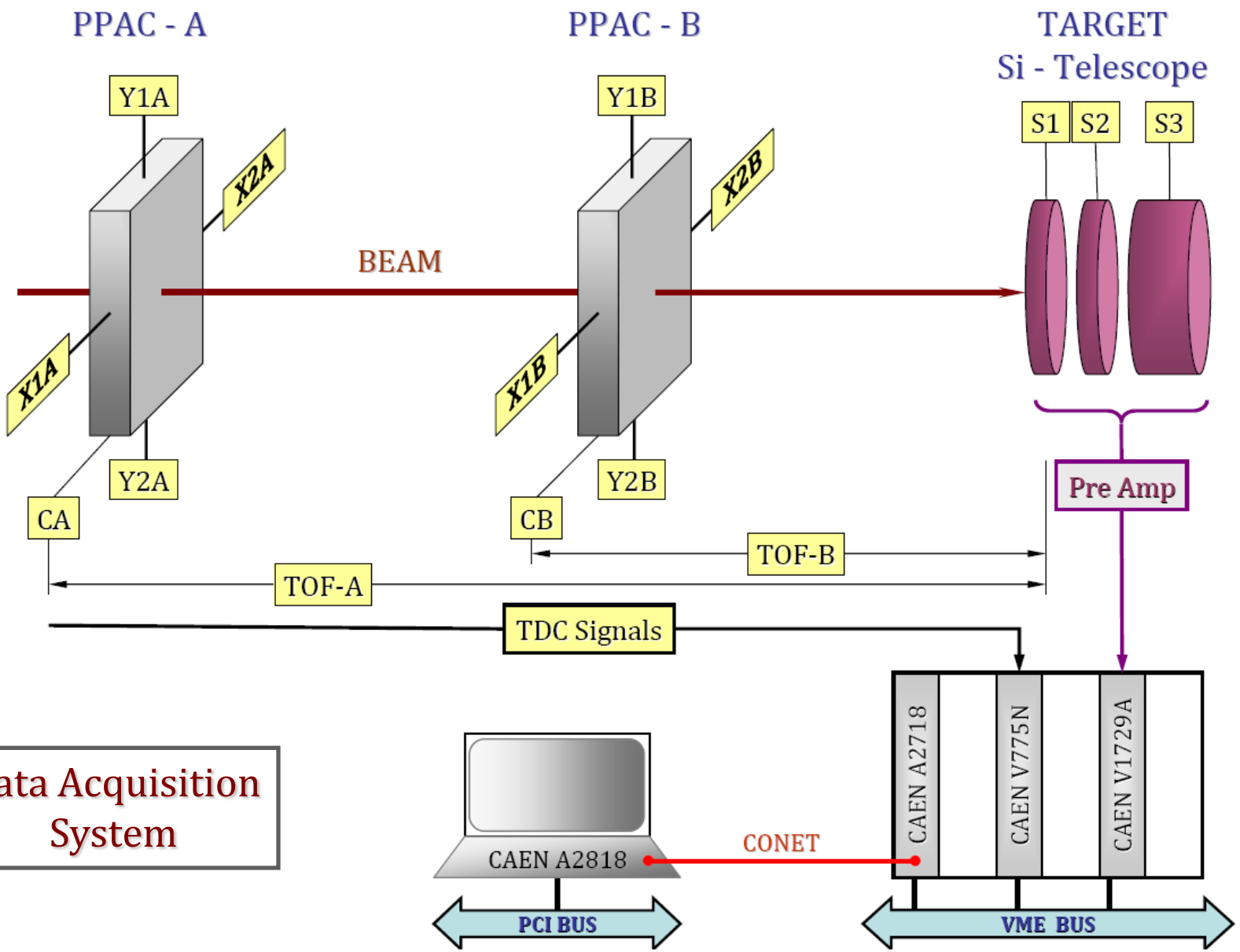
• Experiment: Measurement of the $^{8}B+^{28}Si$ total reaction cross section at energies near the Coulomb barrier at the INFN EXOTIC Beam Facility (Legnaro, Italy).

• Incident ^{8}B Beam Energy: 25 MeV–40 MeV with non-filtered ^{7}Be and ^{6}Li contaminants (parasitic beams).

• Target: A 3-stage Si target, acting as ΔE-E detector telescope. Energy signals are digitized by the CAEN V1729A flash ADC.

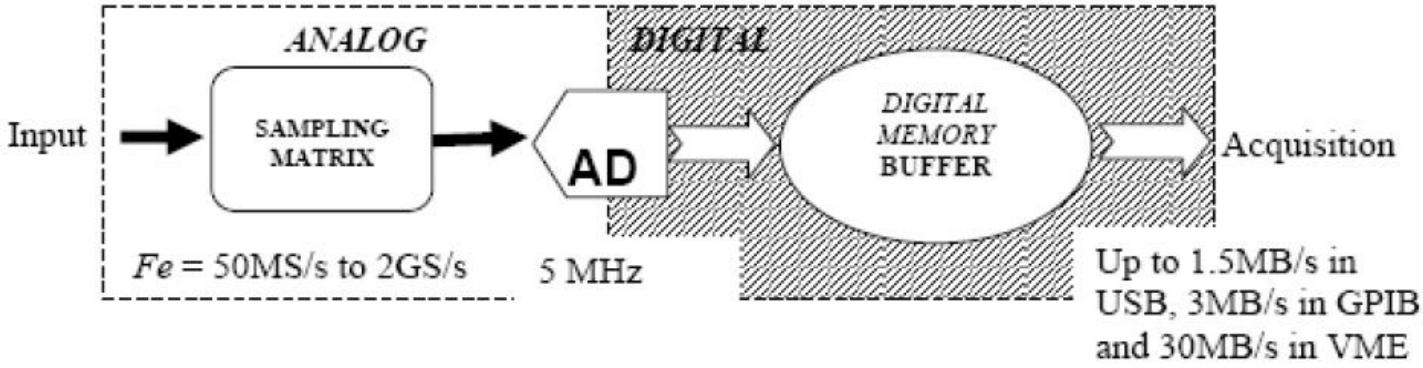
A. Pakou *et al.*, PRC 87 (2013) 014619

Experimental Setup – DAQ System

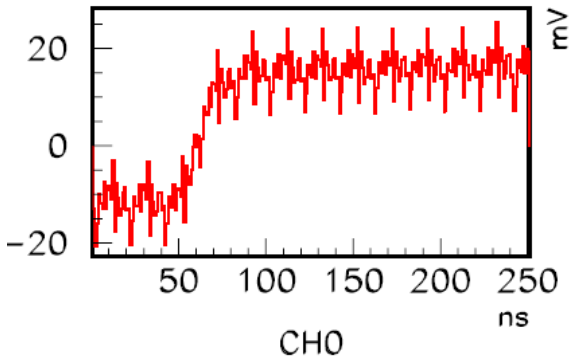


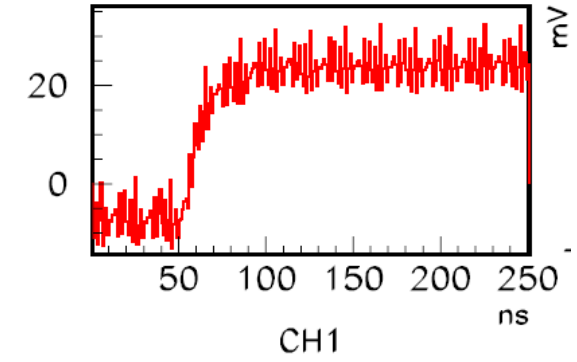
Experimental Setup – DAQ System

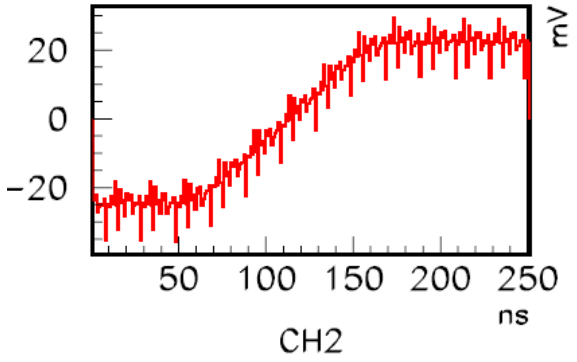
CAEN V1729A Digitizer	
Channels	4
Sampling Freq.	2GS max
Resolution	14 bits
Full Scale Range	±1 Volt
LSB	125 µV
Sample Points	2520 p/ch
Internal Clock	50 or 100MHz



Flash ADC V1729A Digitization & Noise Removal







3-Stage Silicon Detector

ΔE1 (45μ) → S1 → Ch0
ΔE2 (45μ) → S2 → Ch1
E3 (2000μ) → S3 → Ch2

Digitized at 1GHz (1ns)

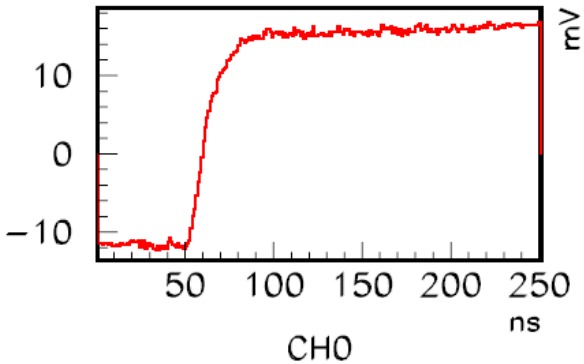
Noise Removal

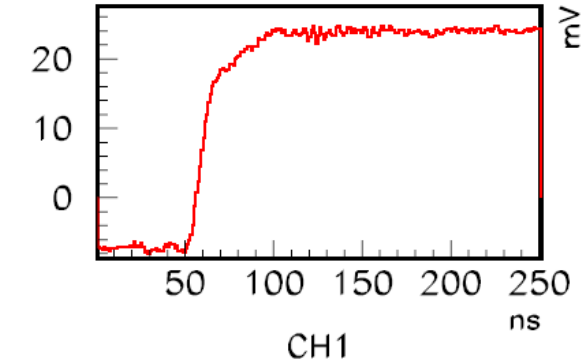
$$\bar{S} = \frac{\sum_{i=N1}^{N2} S(t_i)}{N2 - N1}$$

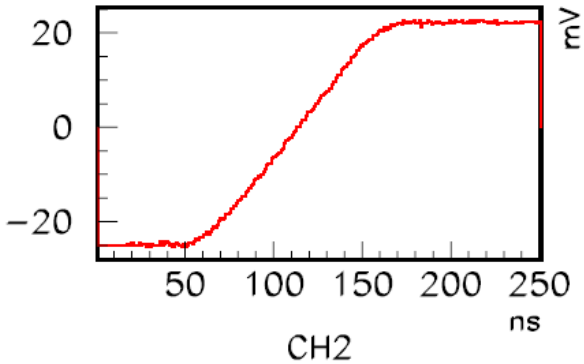
$$N2 - N1 = No\,(multiple\,of)\,T_{noise}$$

$$F_{noise}(t_i) = S(t_i) - \bar{S}$$

$$S_{corr}(t_i) = S(t_i) - F_{noise}(t_{mod(i,No)})$$

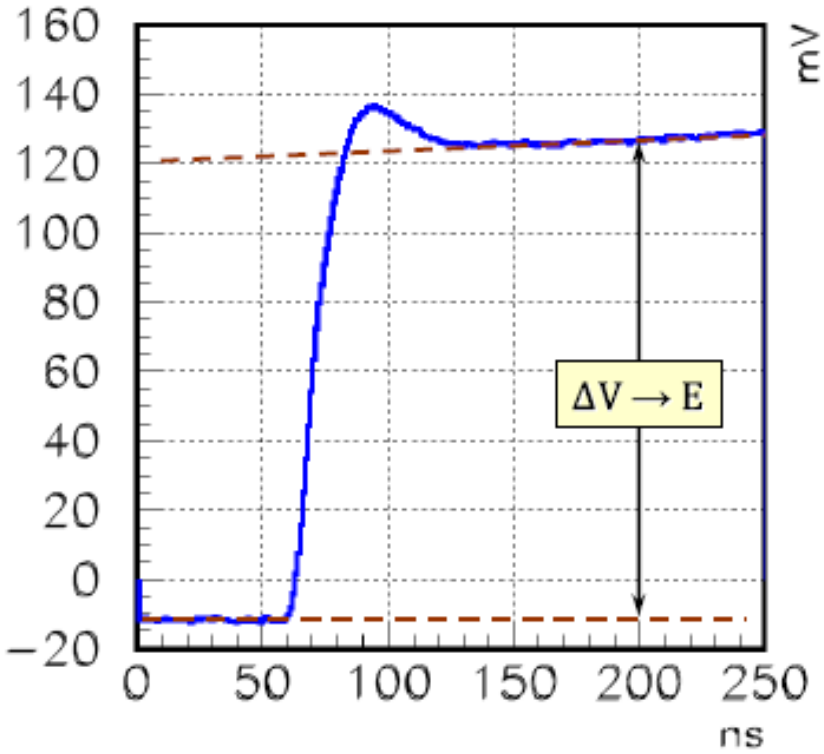




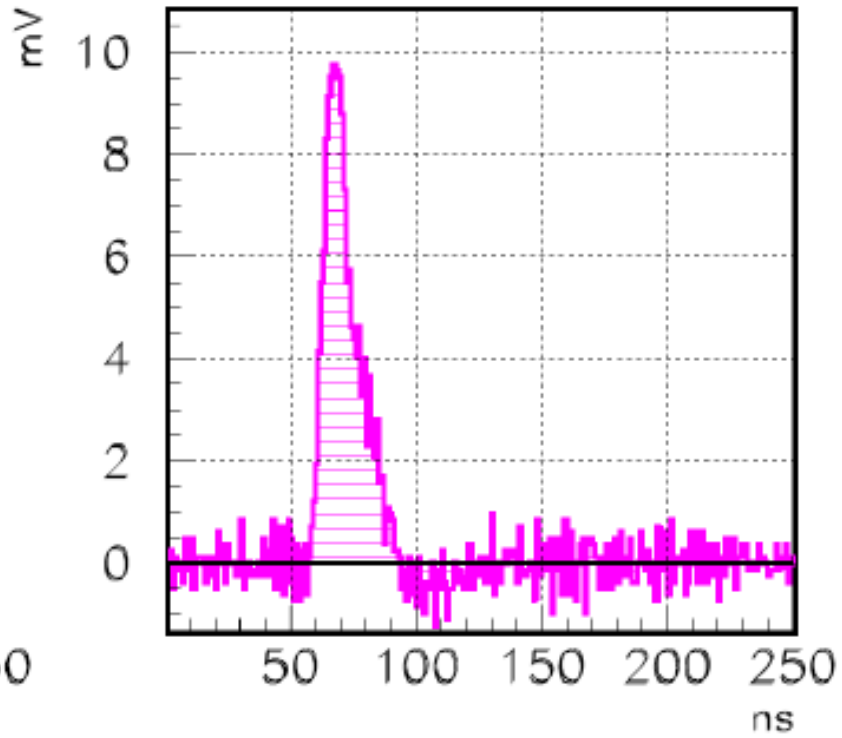


Run: b8_run4_1 Evt: 152890

Pulse Shape Analysis



from Base Line Fit

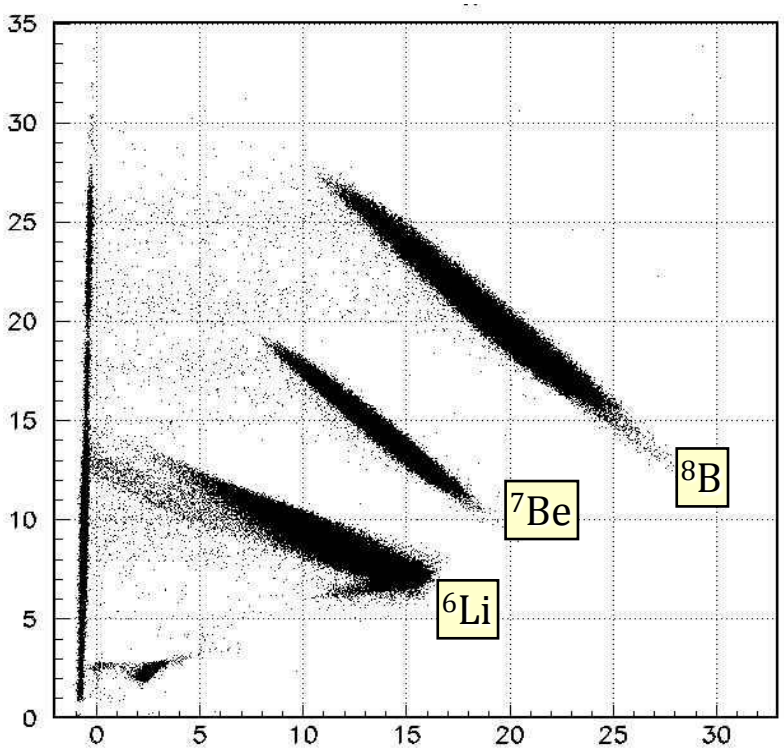


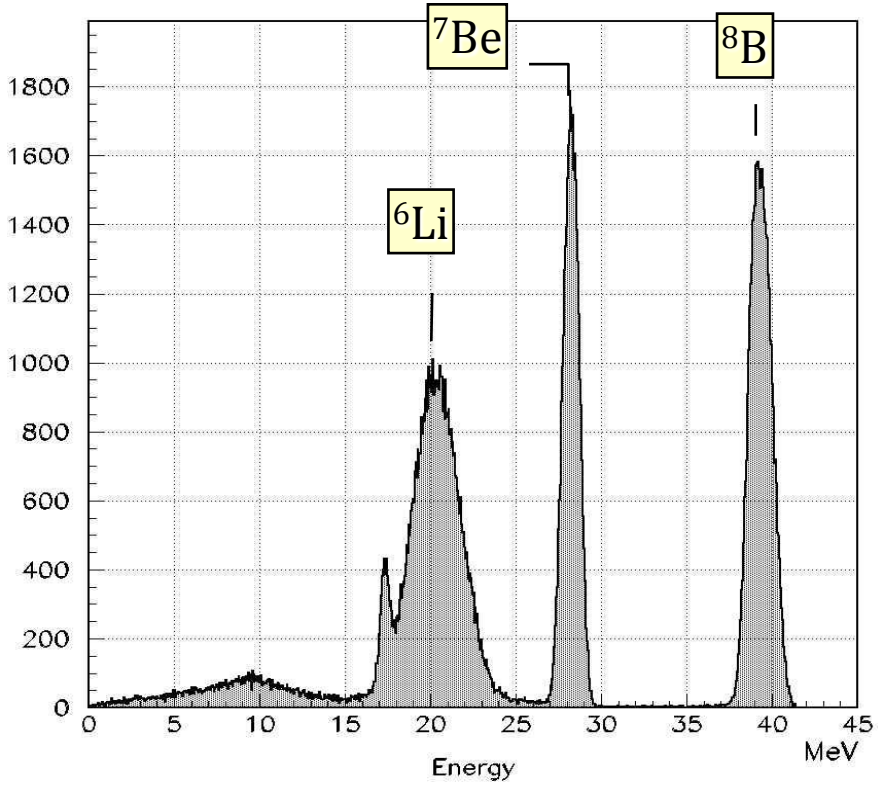
from the Differentiated Signal

$$E = \Delta V = S_2 - S_1$$

$$E = \int \frac{dS}{dt} dt$$

Si-Detector Energy Calibration

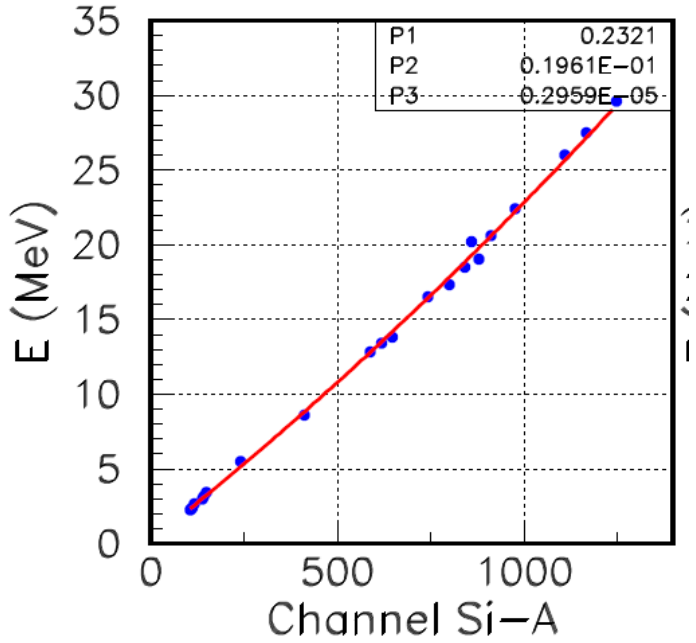


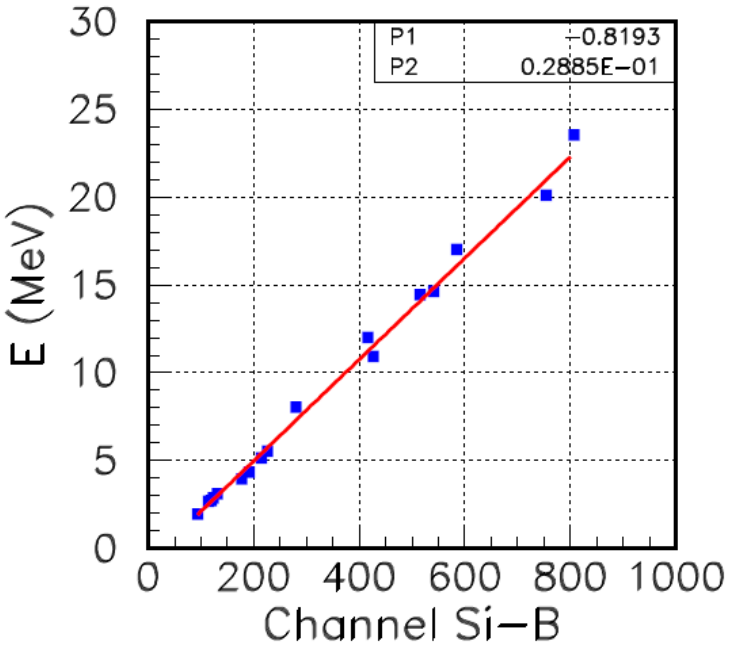


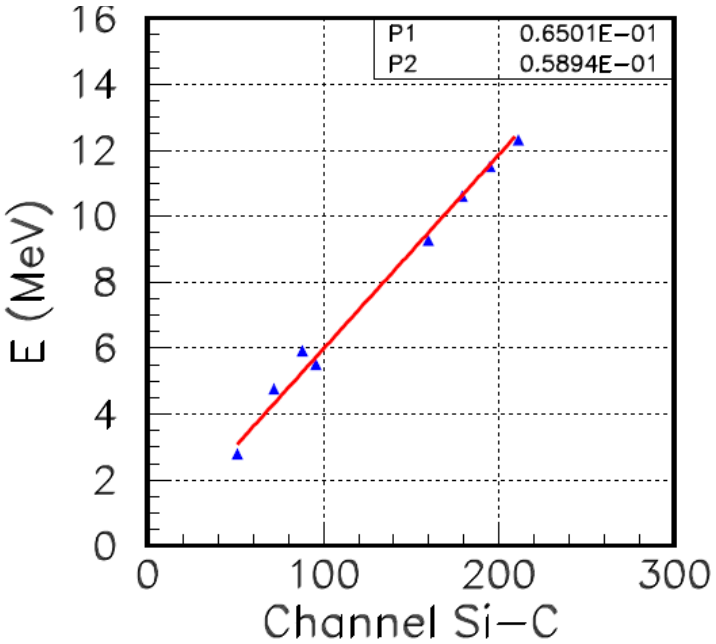
Left: Identification Plot (ΔE1 vs ΔE2+E3) from the calibrated fADC signals.

Right: Total Energy (ΔE1+ΔE2+E3) spectrum from the calibrated fADC signals. The strongly appearing isotopes correspond to the incident 8B beam and the non-filtered parasitic ^{7}Be and ^{6}Li beams.

Si-Detector Energy Calibration

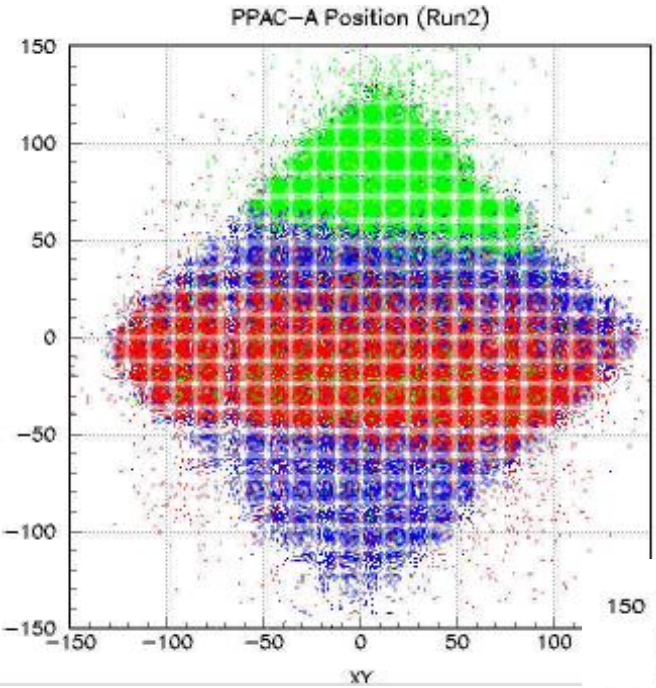






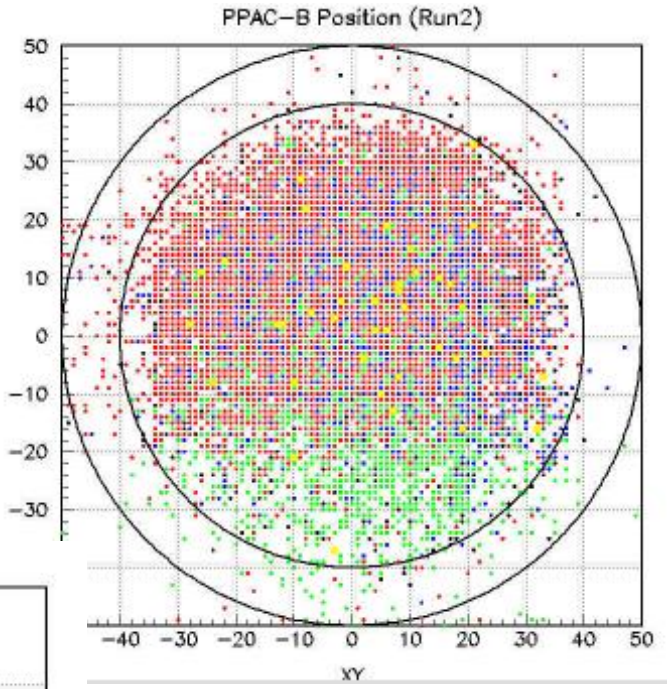
Energy calibration curves for each stage of the Si telescope. The first Si detector (45μm) is fitted with a second order polynomial, the other two parts (45μm and 2000μm) with a linear function.

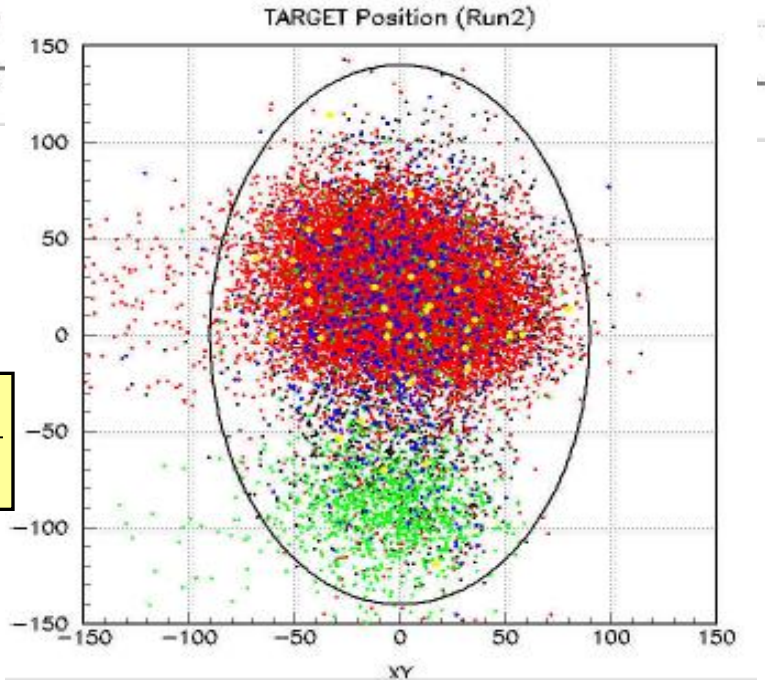
PPAC Signals – Position Reconstruction



PPAC-A Position

Reconstructed Position on Target

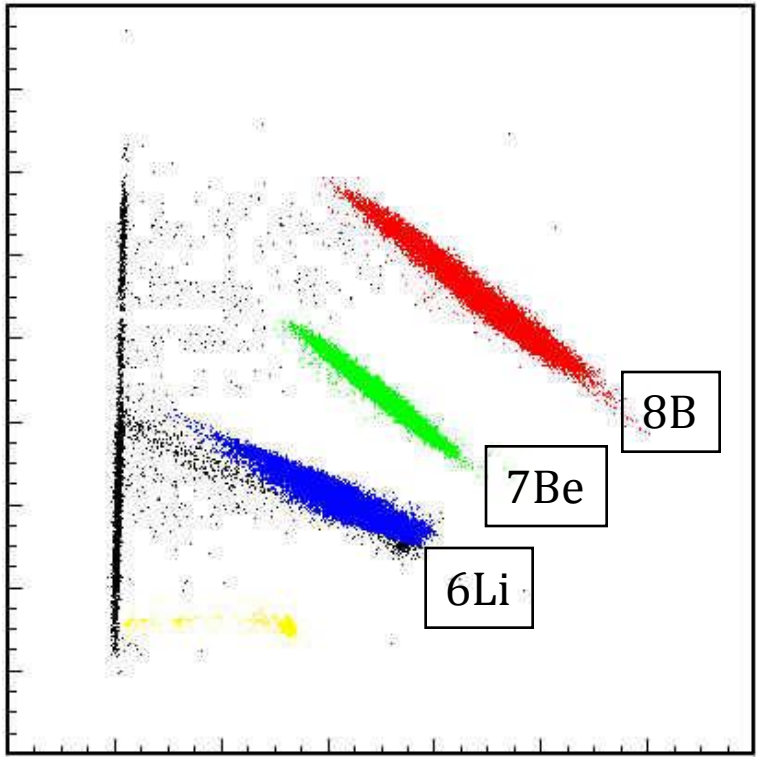




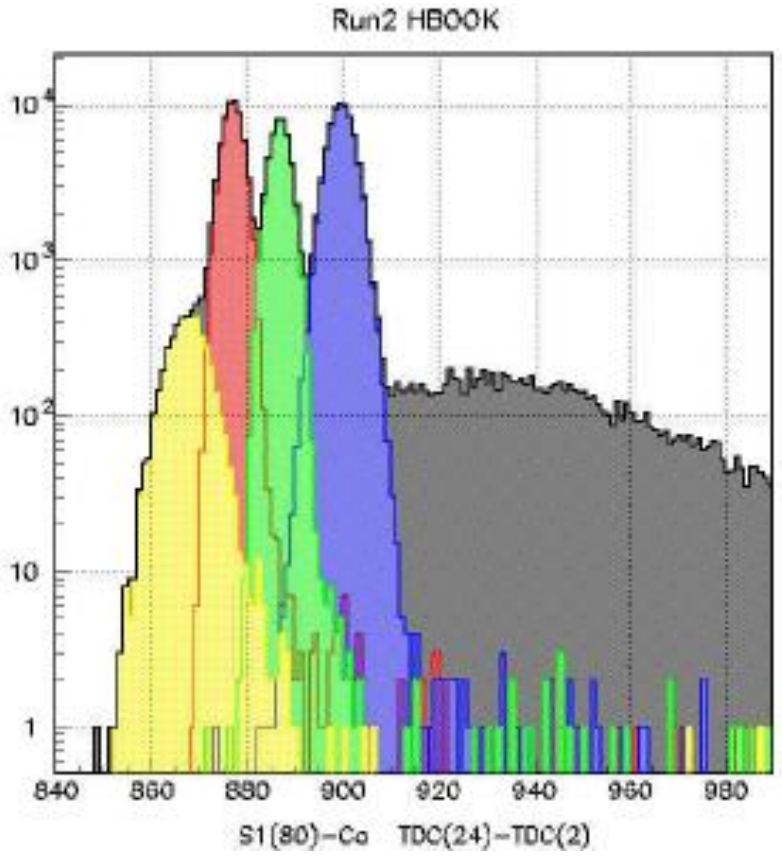
$$\frac{x-x_A}{x_B-x_A}=\frac{y-y_A}{y_B-y_A}=\frac{z-z_A}{z_B-z_A}$$

$$z=z_T \Rightarrow (x_T, y_T)$$

PPAC Signals – Time of Flight

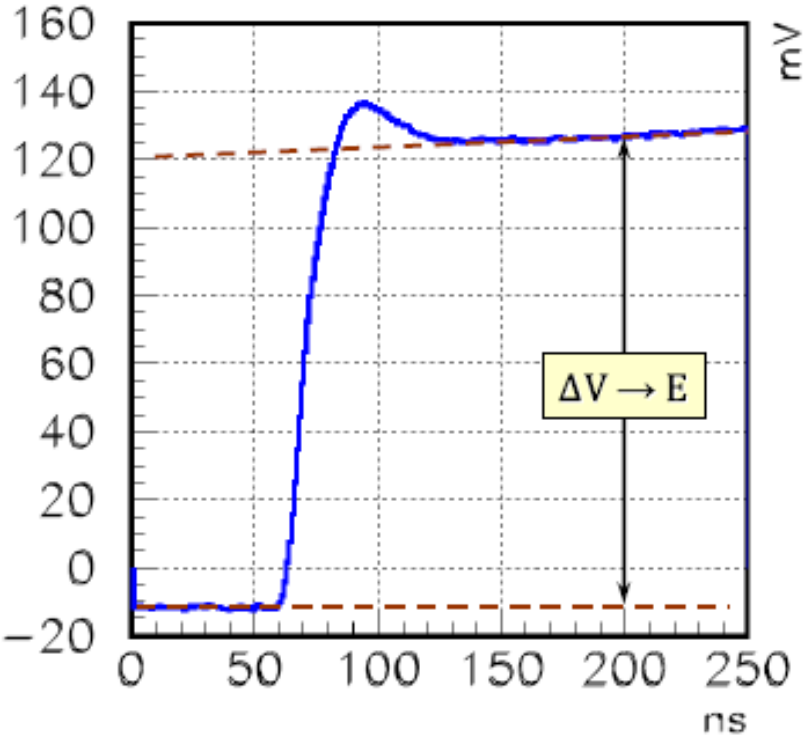


ΔE-E Identification Plot



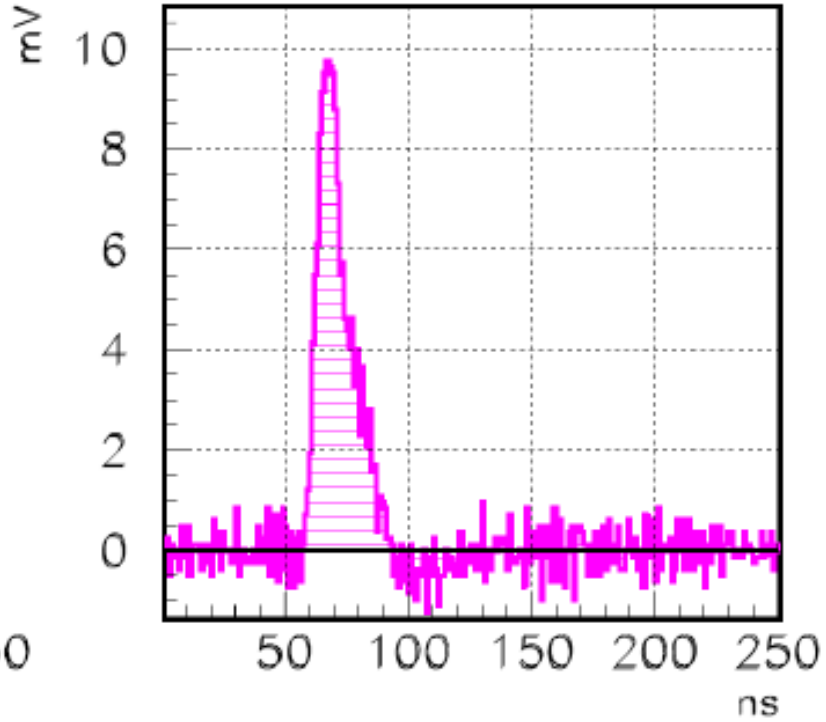
Time-of-Flight Spectrum

Pulse Shape Analysis



Energy Calculation
from Base Line Fit

$$E = \Delta V = S_2 - S_1$$

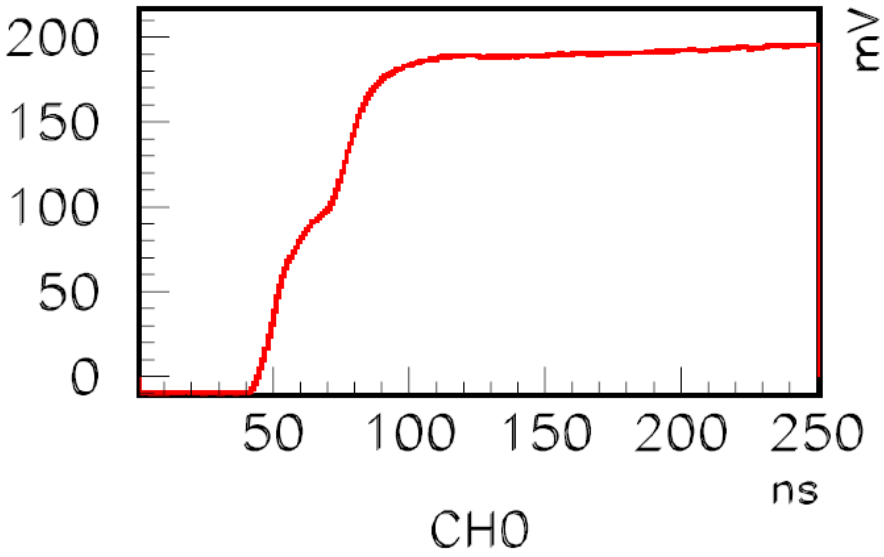


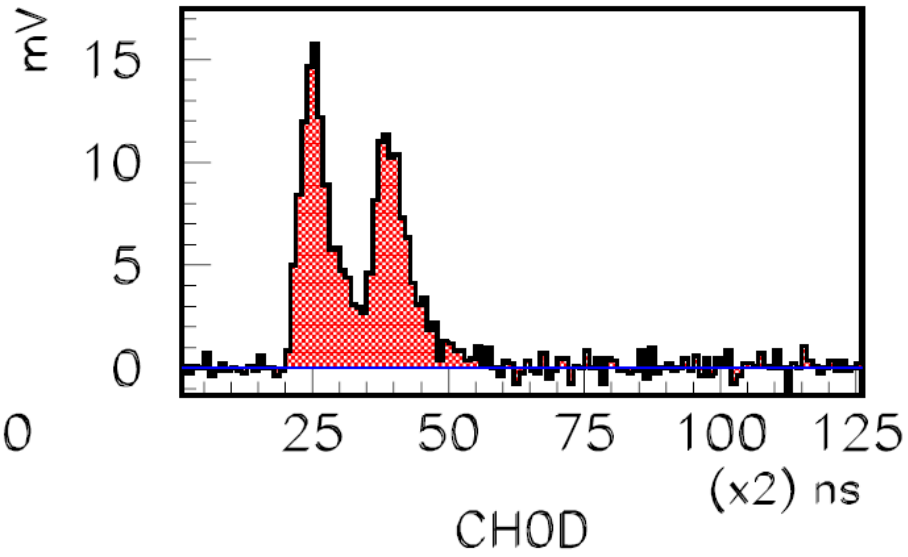
Energy Calculation
from the Differentiated Signal

$$E = \int \frac{dS}{dt}\, dt$$

Pulse Shape Analysis

PileUp Detection





$$\frac{dS}{dt} \rightarrow E = \int \frac{dS}{dt} dt$$

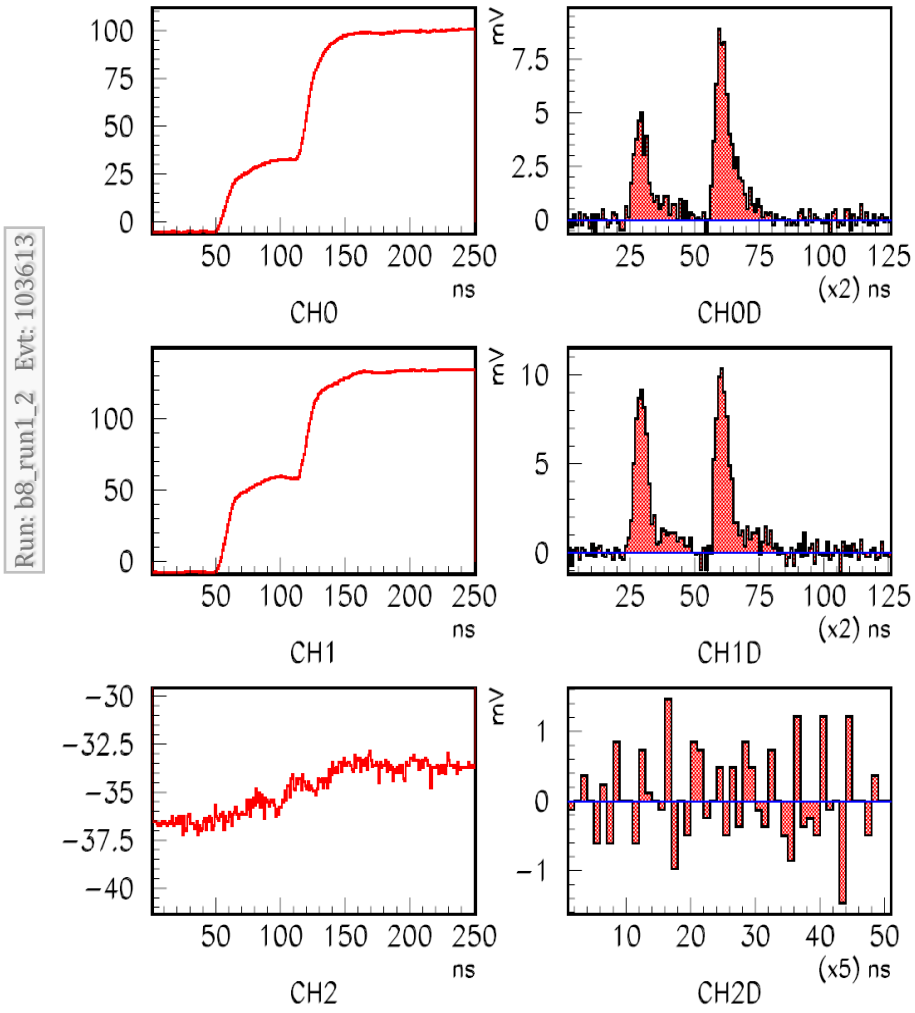
A two-peak structure in the derivative identifies a PileUp Event.
The energy information can be easily reconstructed by integrating each identified peak separately.

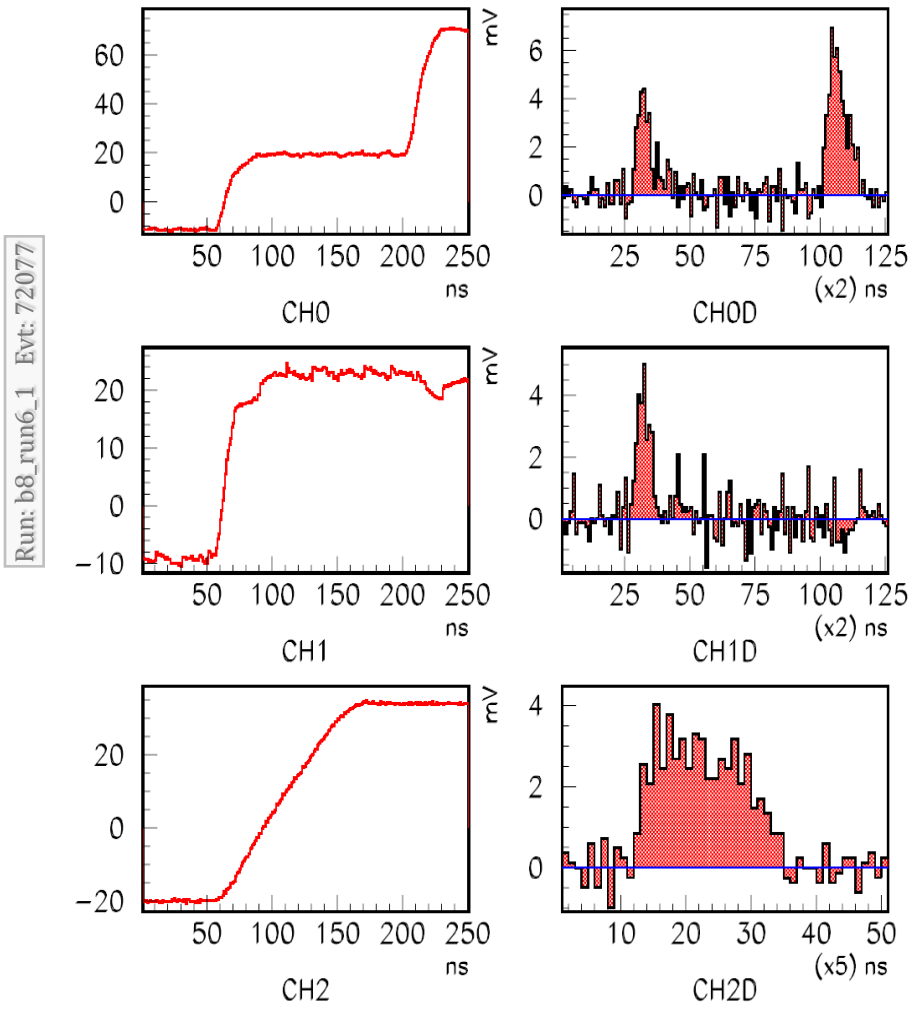
Pulse Shape Analysis

PileUp Detection

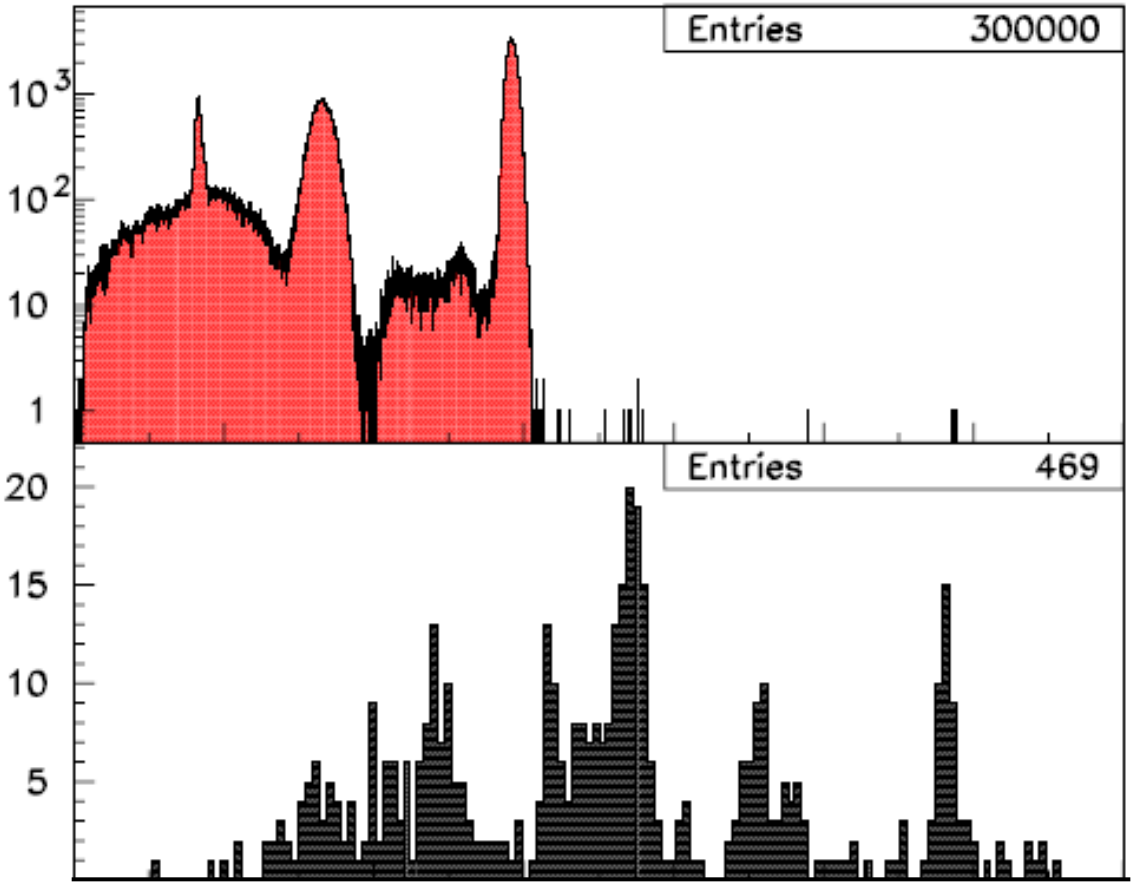
$$\frac{dS}{dt} \rightarrow E = \int \frac{dS}{dt} dt$$

PileUp Detection



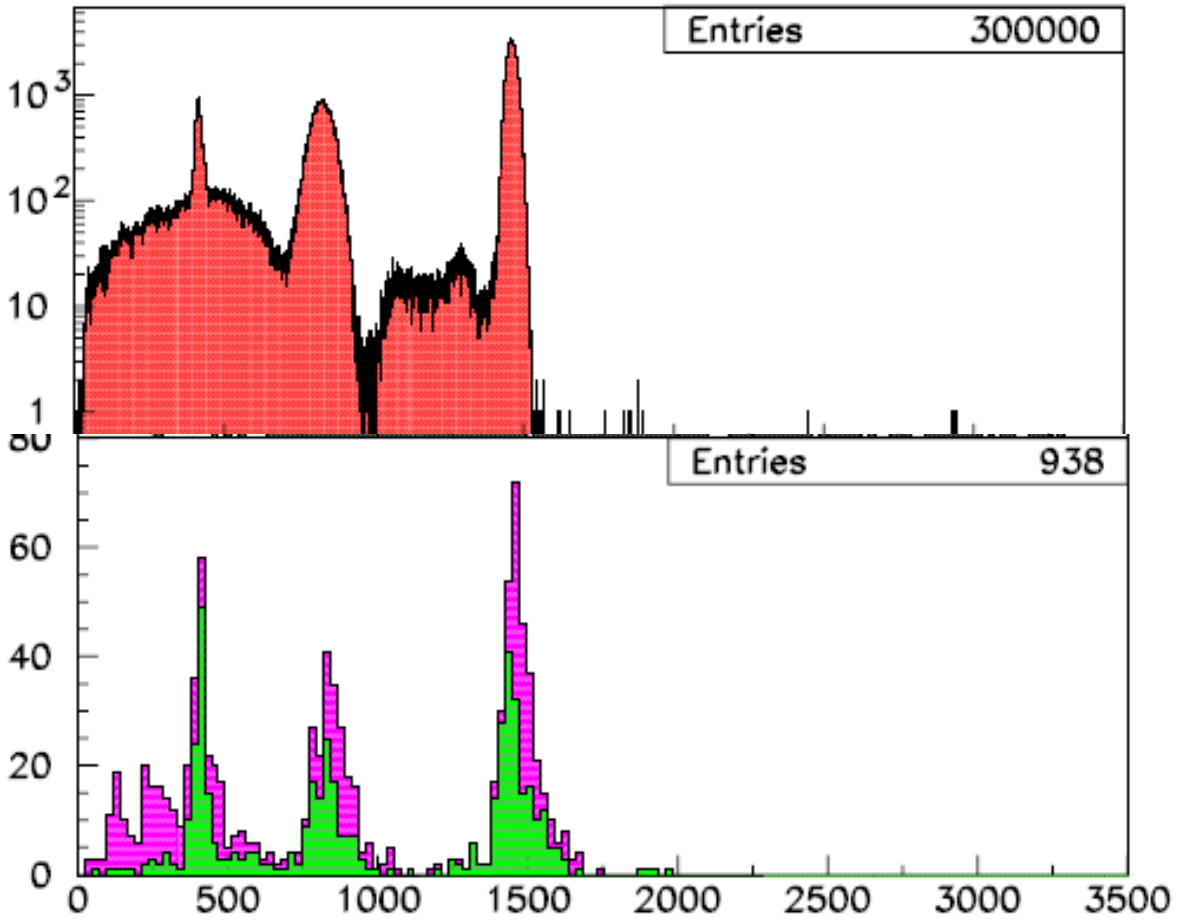


PileUp Signals – PSA Energy Recovery



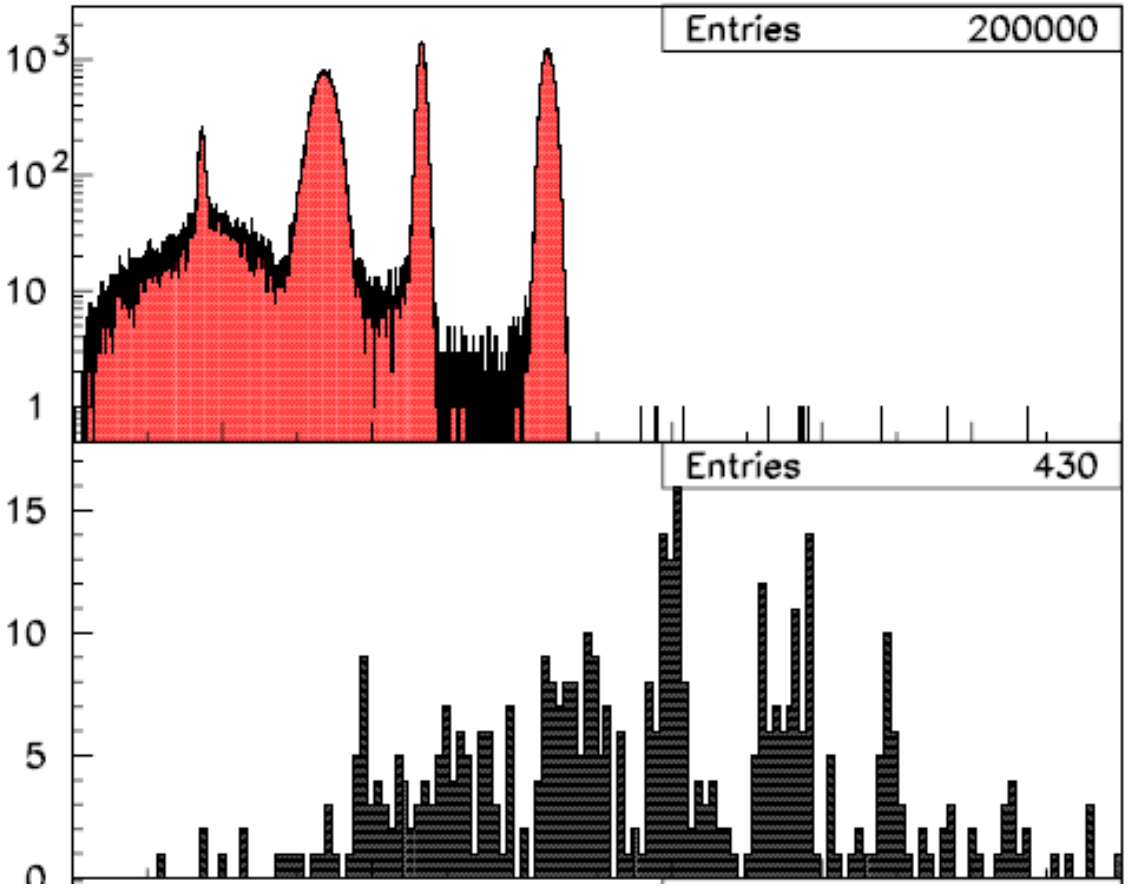
Identified PileUp Events

PileUp Signals – PSA Energy Recovery



Recovered Energy from PileUp Events

PileUp Signals – PSA Energy Recovery



Identified PileUp Events

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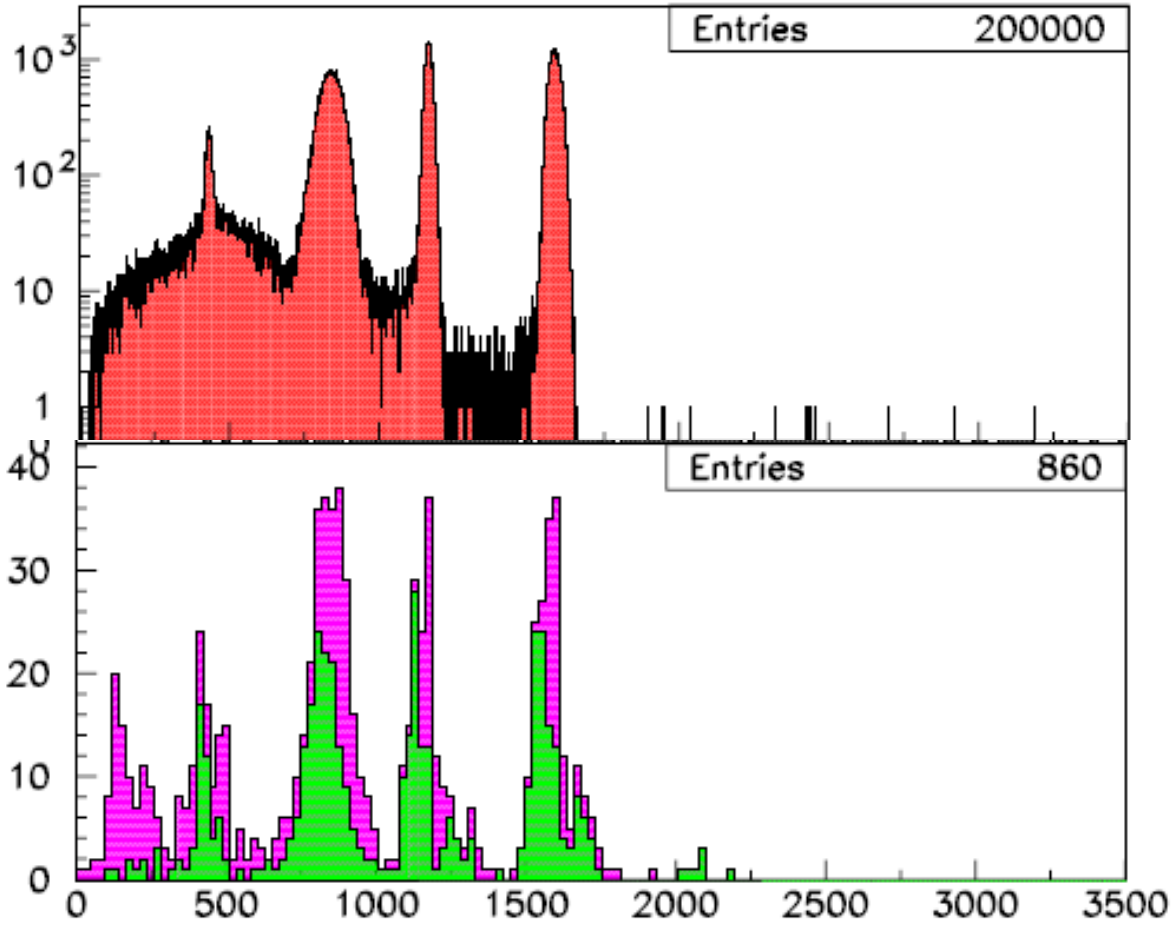
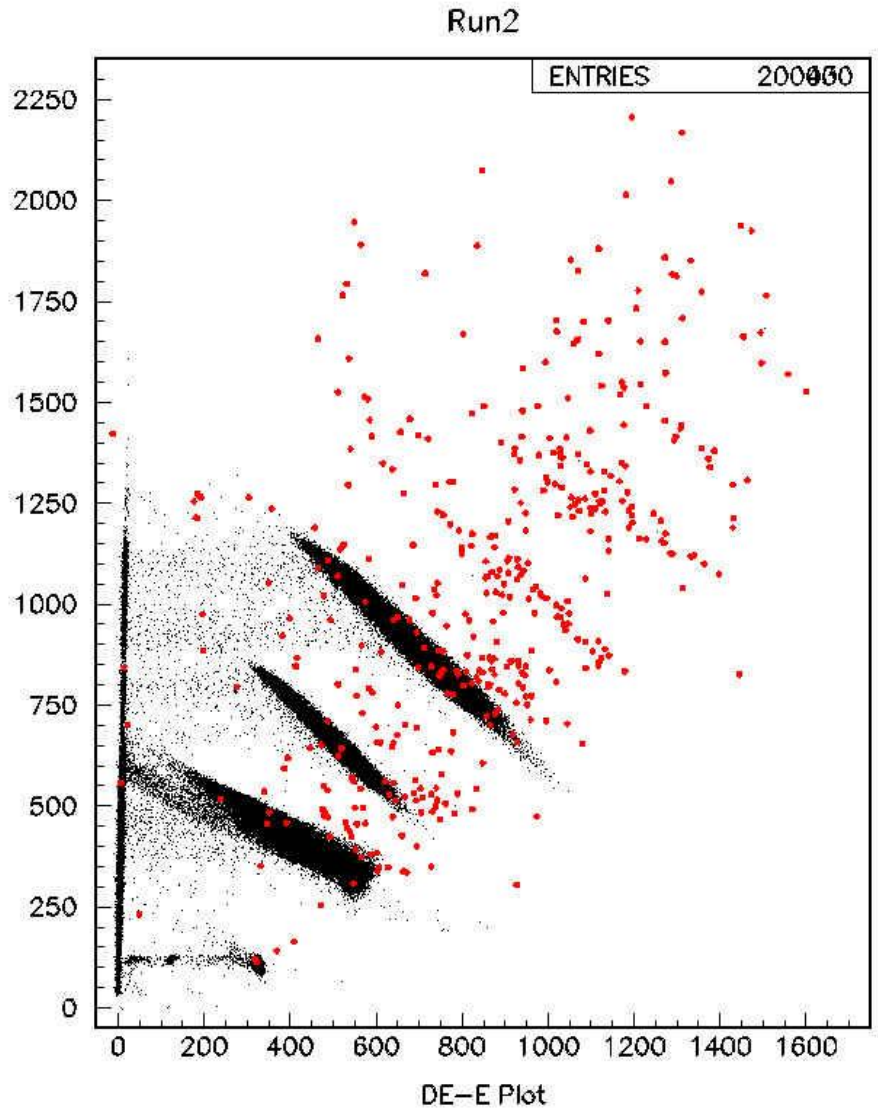
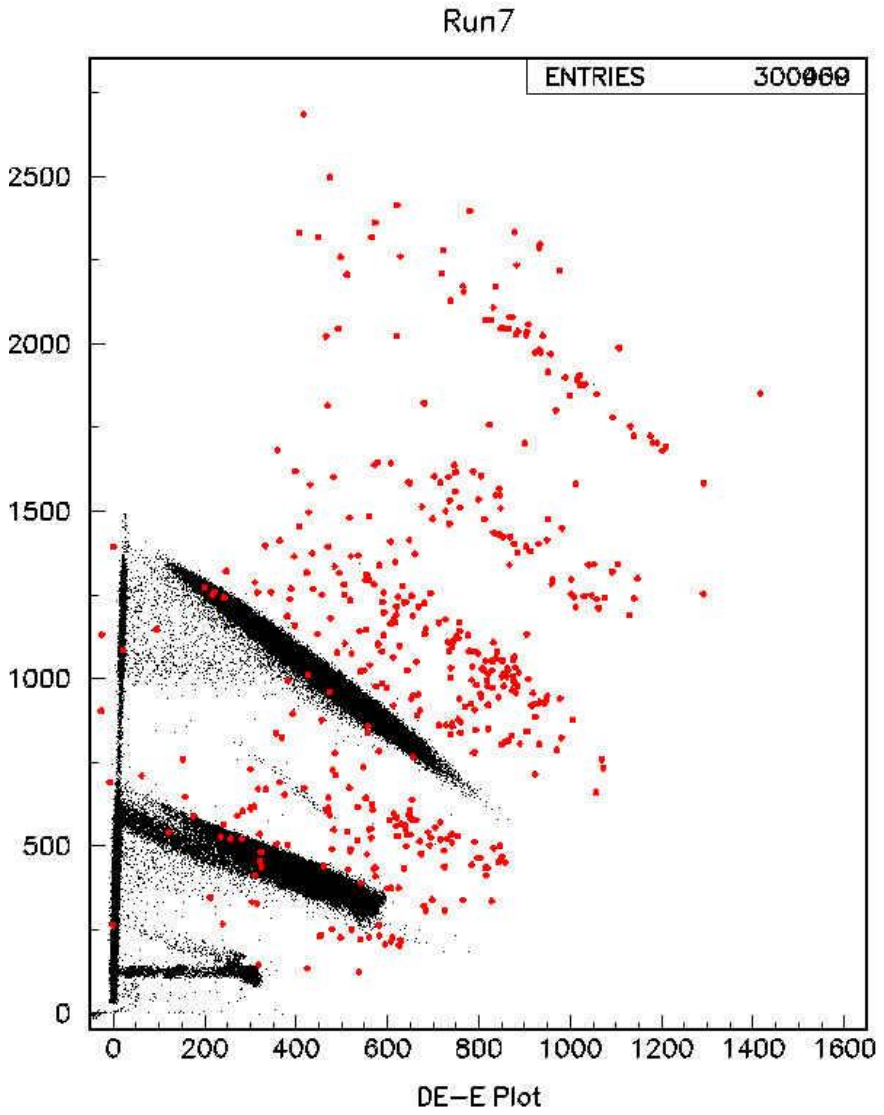


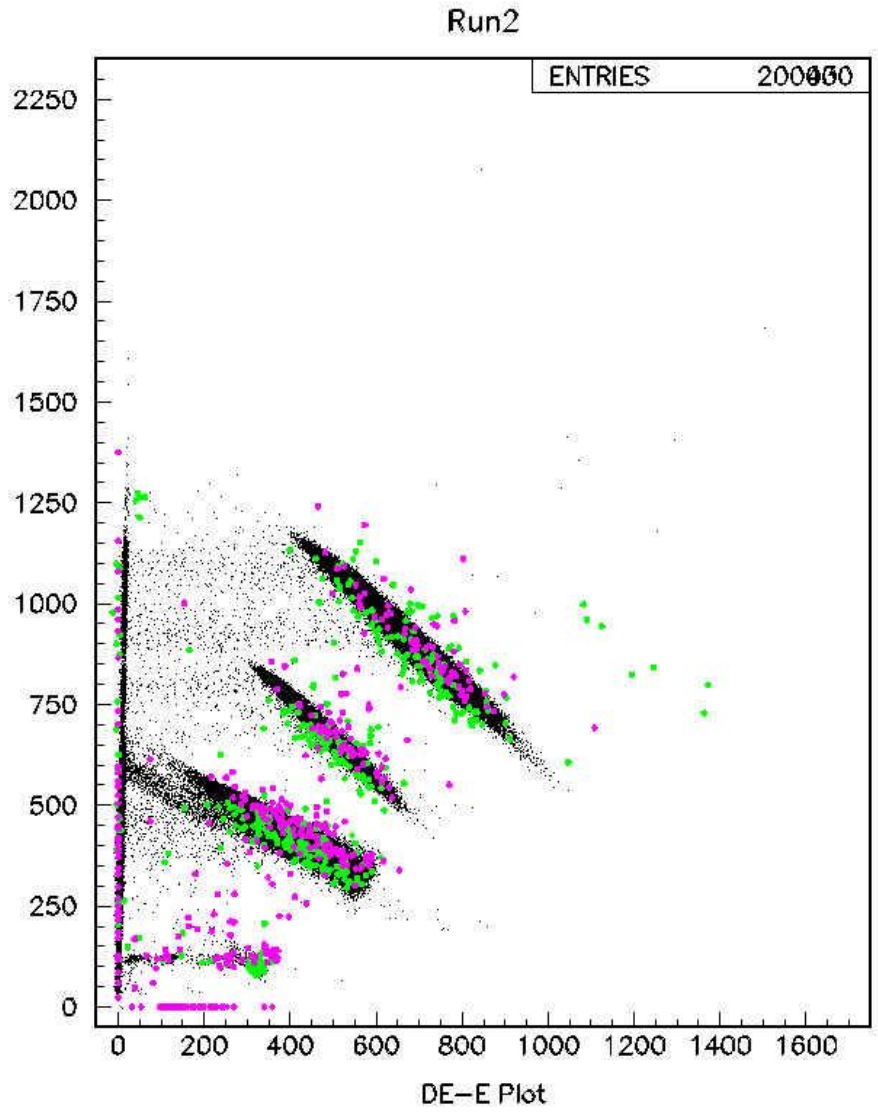
Recovered Energy from PileUp Events

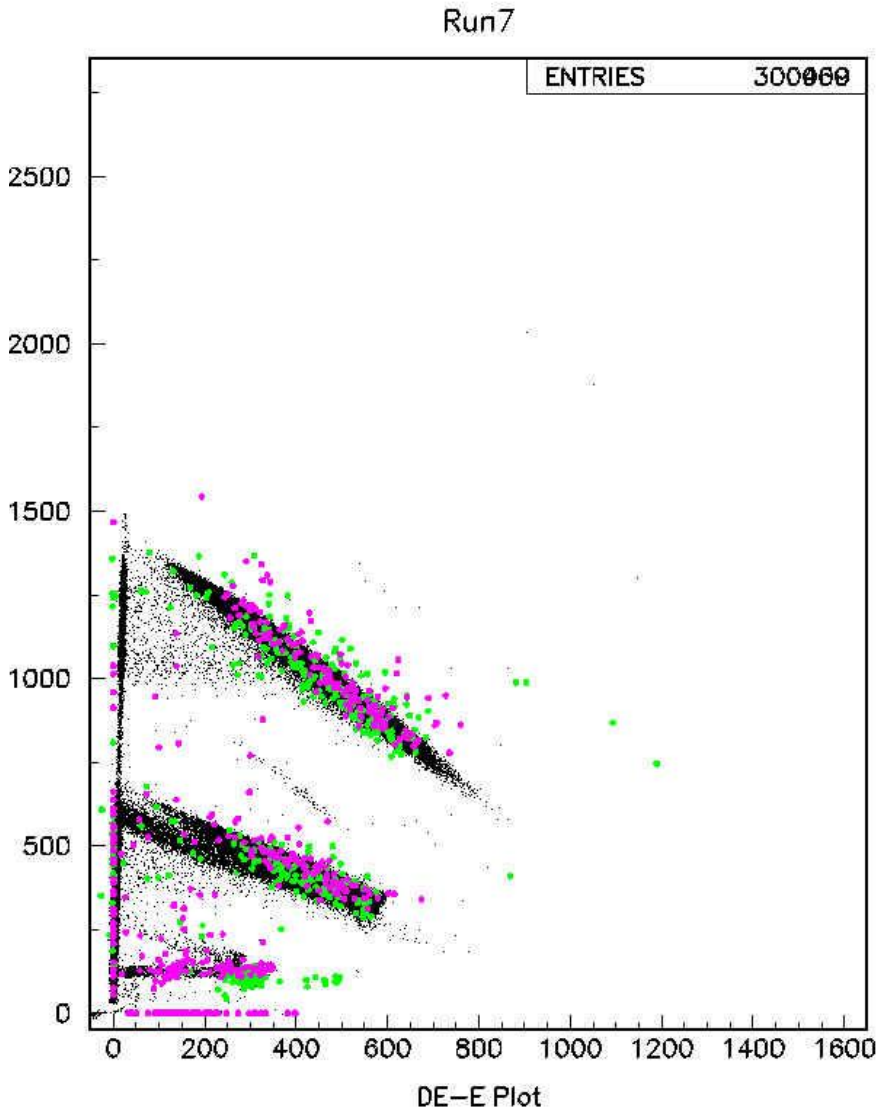
PileUp Signals – PSA Energy Recovery



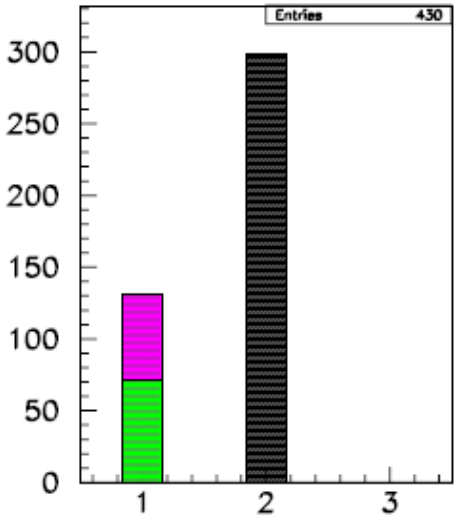


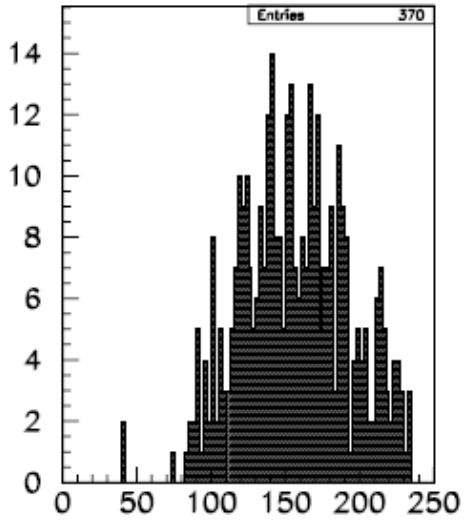
PileUp Signals – PSA Energy Recovery





PileUp Signals – PSA Energy Recovery

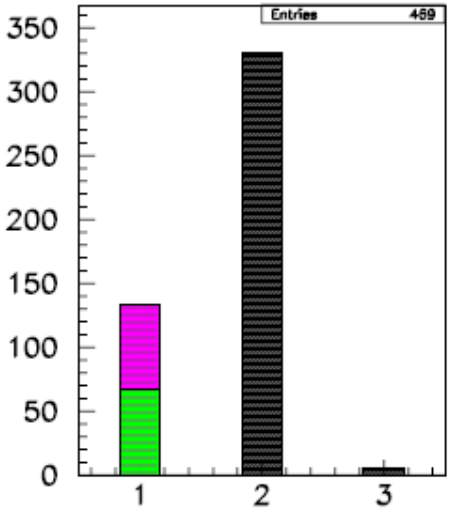


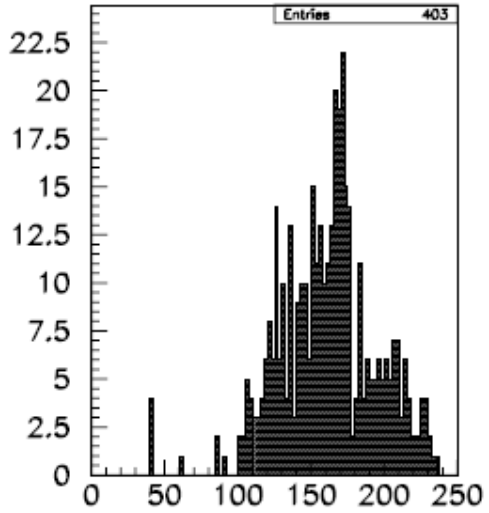


Statistics of PileUp Occurrence

Majority of the PileUp Event

1: Only on one Si-Detector
2: Only on two Si-Detectors
3: Occurrence on all three





Concluding Remarks

• An automatic search technique has been developed for the identification and the energy reconstruction of PileUp events in a Si telescope.

• The procedure is based on Pulse Shape Analysis techniques and utilizes the waveform information by time differentiating the digitized pulse signals.

• It has been successfully applied in a recent experiment studying the $^{8}B+^{28}Si$ reaction at beam energies near the Coulomb barrier to recover the energy information from PileUp Events.

• The method can be extended and generalized to other forms of PileUp signals.

A. Pakou[2], D. Pierroutsakou[3], M. Mazzocco[4], A. Boiano[3], C. Boiano[5], D. Filipescu[6], T. Glodariu[6], J. Grebosz[7], A. Guglielmetti[5], M. La Commara[8], C. Parascandolo[4], K. Rusek[9], A.M. Sanchez-Benitez[10], C. Signorini[4], O. Sgouros[2], F. Soramel[4], V. Soukeras[2], E. Strano[4], L. Stroe[6], N. Toniolo[11], D. Torresi[4] and K. Zerva[2]

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(5) Universtita degli Studi di Milano and INFN-Sezione di Milano (6) Horia Hulubei National Institute of Physics and Nuclear Engineering, Romania (7) IFJ-PAN, Krakow, Poland (8)Dipartimento di Scienze Fisiche and INFN – Sezione di Napoli
(9) Heavy Ion Laboratoty, University of Warsaw, Warsaw, Poland (10) Univesidad de Huelva, Huelva, Spain (11) INFN- Sezione di Padova

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Thank You!

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Back-Up Slides

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