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UNIVERSITY of the WESTERN CAPE

Comparison of neutron fluence energy distributions measured with NE213 proton recoil spectrometer and NE230 deuteron recoil spectrometer at the iThemba LABS time-of-flight facility

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Overview

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Motivation

- Neutron fluence energy distributions measurements required in nuclear applications such as
  - Neutron detector calibration
  - Neutron radiotherapy
  - Radiation protection in nuclear research facilities

Motivation

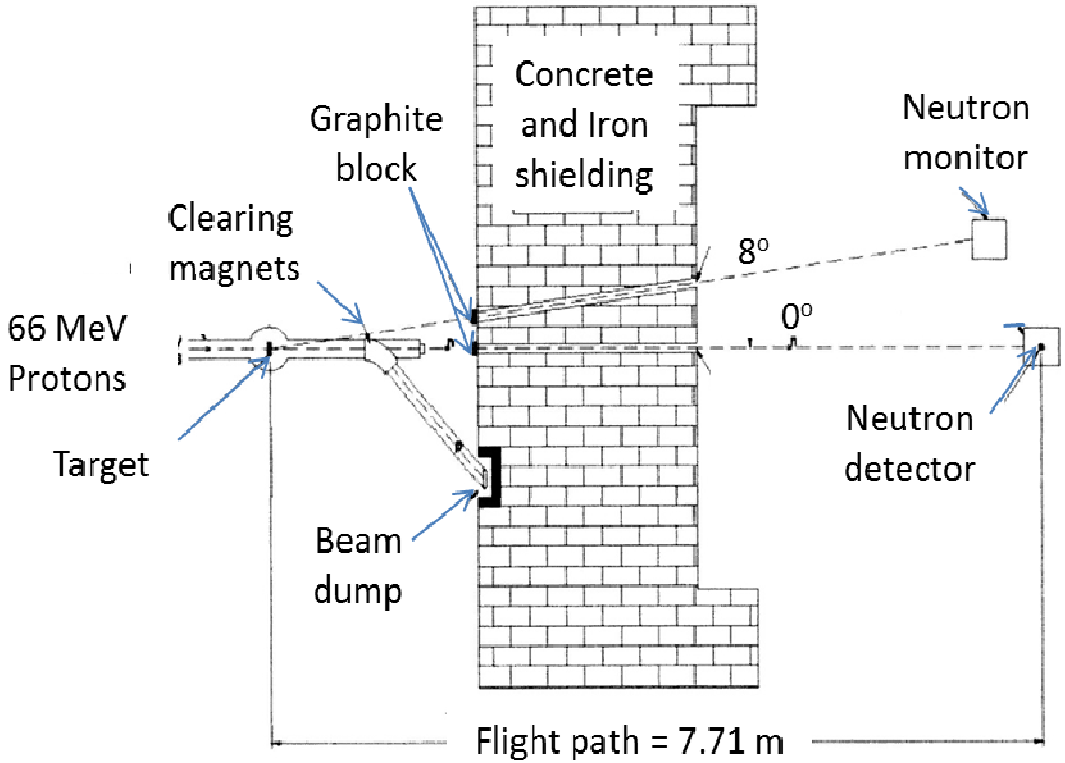
- NE230 deuteron recoil spectrometer more suitable than NE213 proton recoil spectrometer for measurements in water (simulate the human tissue)
  - In order to discriminate against backgrounds that can arise from n-p scattering in the water.
  - Better spatial resolution because of stopping power

Objectives

- Measure neutron fluence energy distributions with NE213 and NE230 using the time-of-flight technique
- Compare measured neutron fluence energy distributions

The Experiment

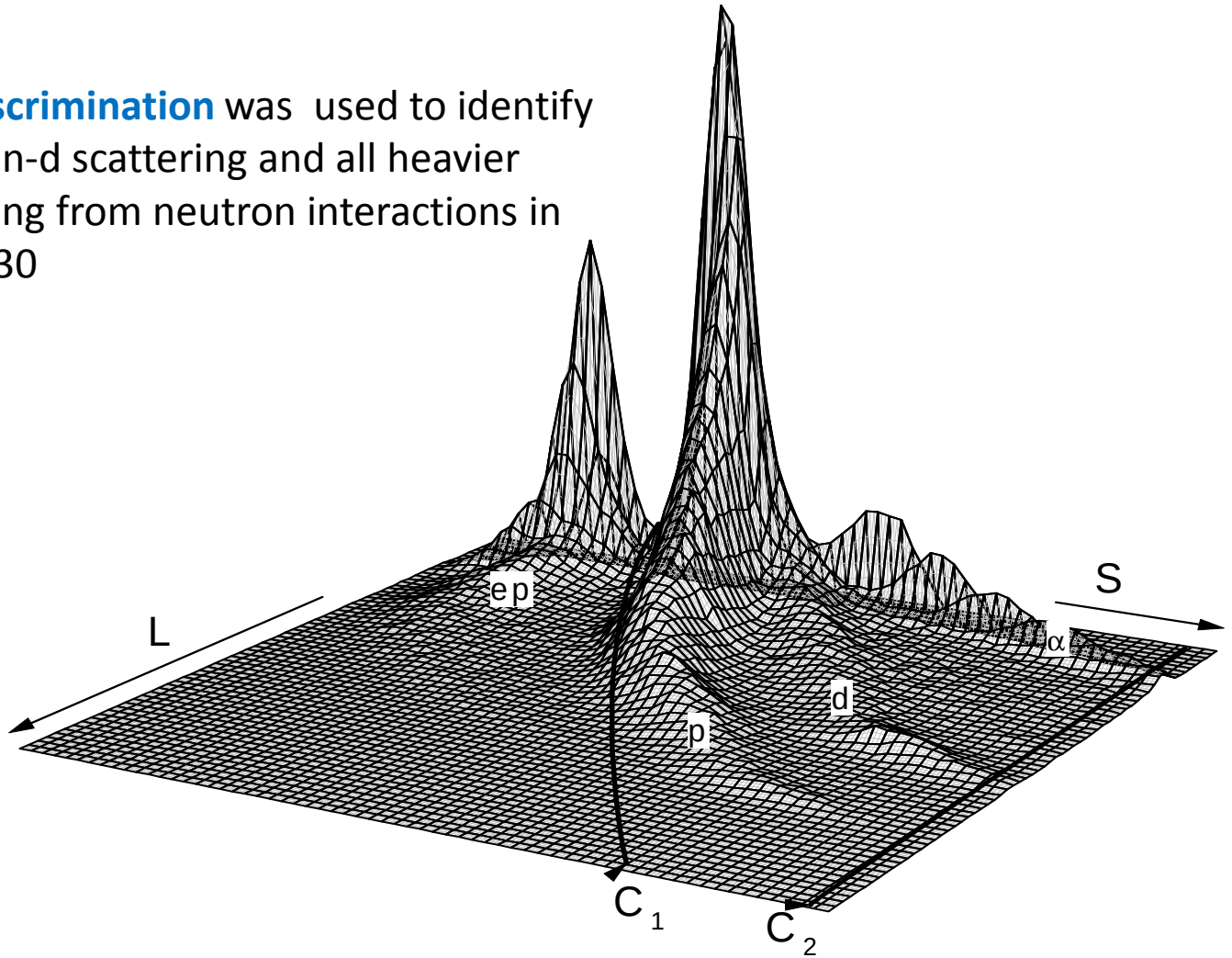
- **Experiments** were conducted at the neutron time-of-flight facility at the iThemba LABS.
- **Targets used**
  Li (1 mm) metal target ,
  Be (10 mm) metal target and
  Graphite (10 mm) target .
- Both the NE213 and NE230 was equipped with a **LINK pulse shape discriminator**
- **Dimensions** of detectors
  NE213 (50 mm diameter x50 mm)
  Ne230 (25 mm diameterx25 mm)



A schematic representation of the experimental setup

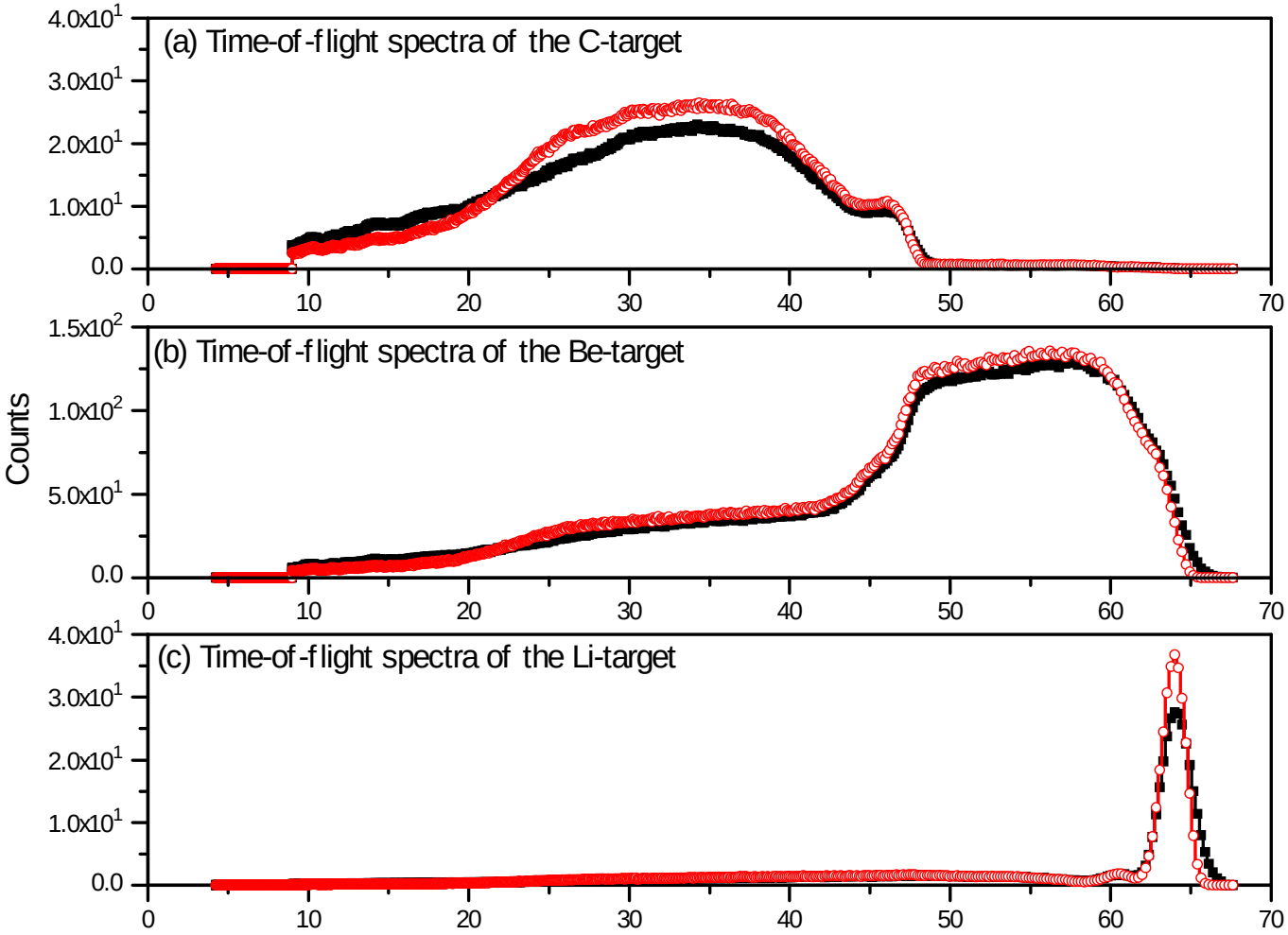
Data Reduction

Pulse shape discrimination was used to identify the n-p elastic, n-d scattering and all heavier particles resulting from neutron interactions in NE213 and N230



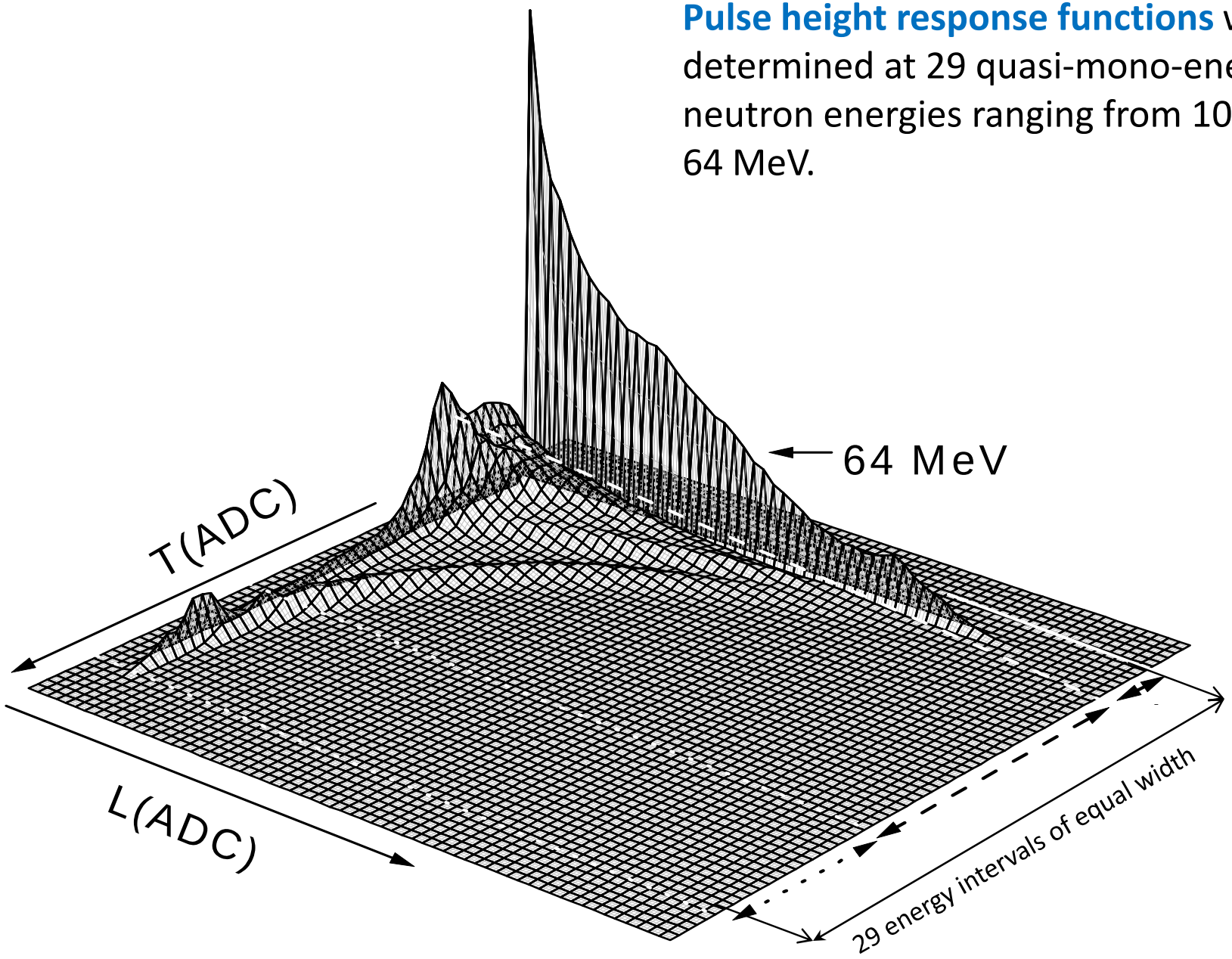
Perspective view of counts (vertical axis) as a function pulse height, *L* and pulse shape, *S* for charged particles events detected by NE230 when exposed to neutrons produced by 66 MeV protons incident on the 1 mm thick Li-target.

Time-of-flight spectra

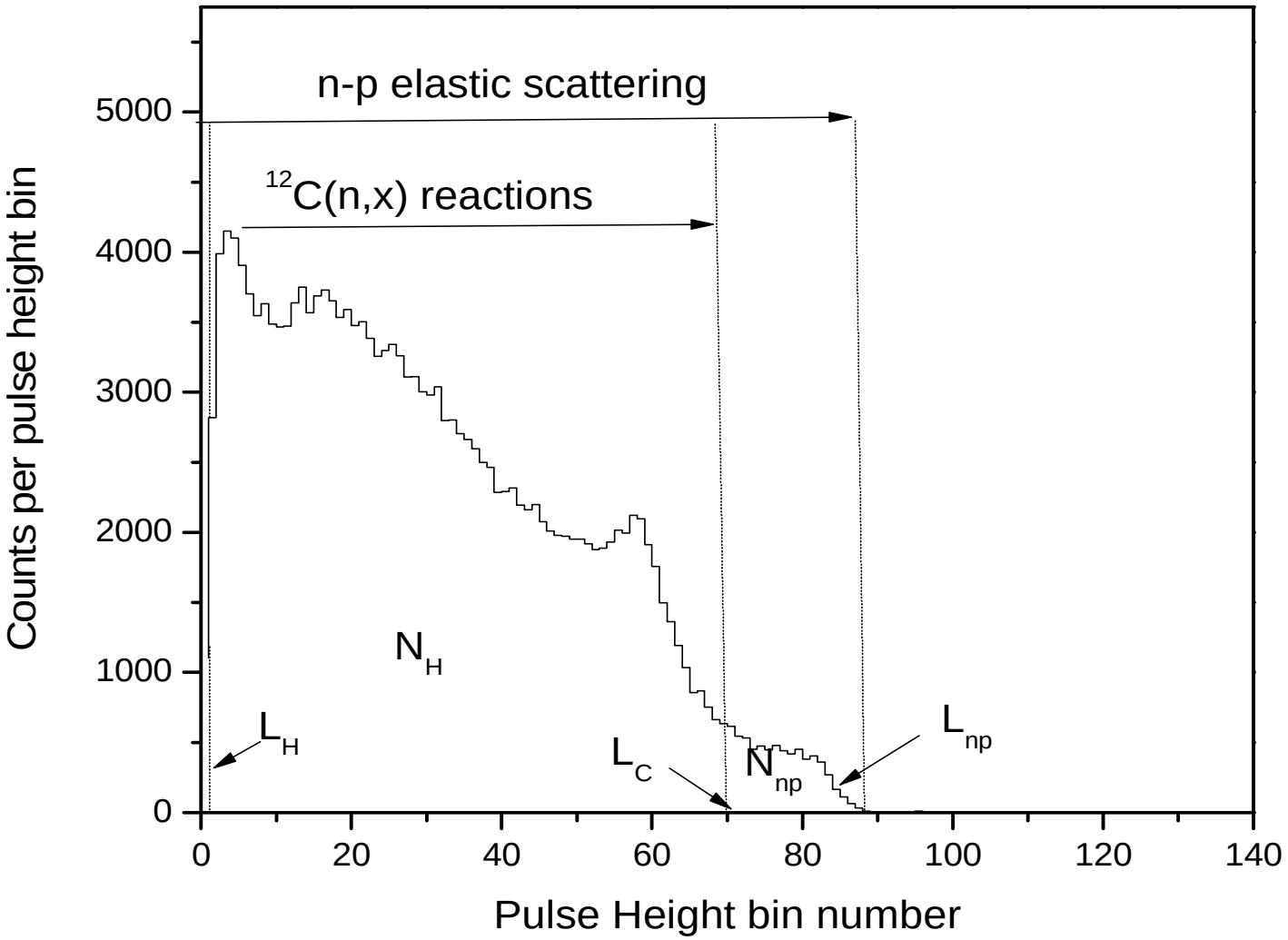


NE213 measured time-of-flight spectra (solid black squares histogram) compared with NE230 measured time-of-flight spectra (open red circles histogram)

Pulse height response functions were determined at 29 quasi-mono-energetic neutron energies ranging from 10 to 64 MeV.



Response function



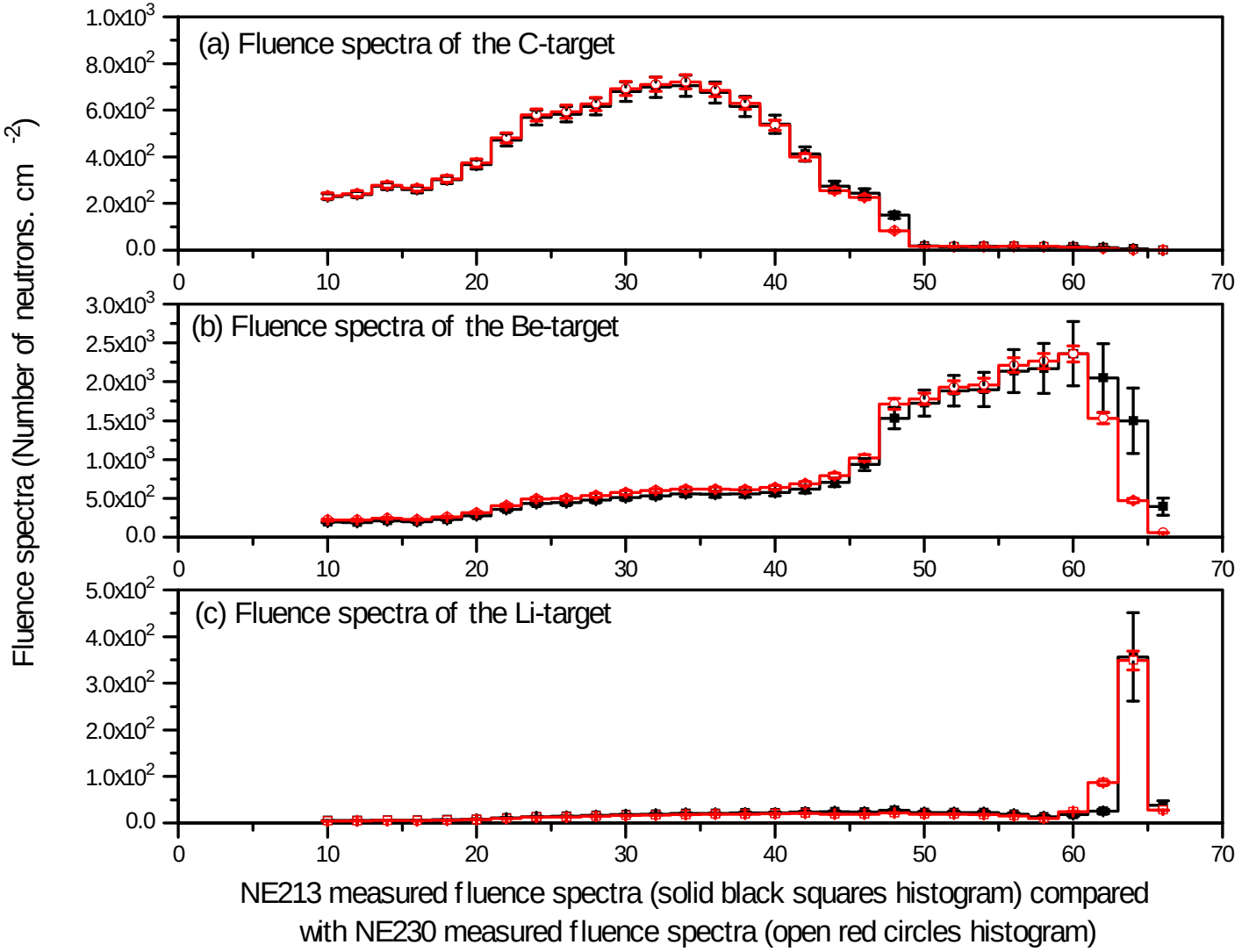
Pulse height spectrum measured with NE213 detector with incident neutrons of 64 MeV, with the PSD cut set to select proton and heavier charged particles

- **The neutron detection efficiency** of NE213 as a function of neutron energy was determined with reference to the n-p elastic scattering cross-section for each of the 29 incident neutron energies.

- Neutron fluence energy distribution, $\Phi(E)$ *for each incident neutron energy is then determined by* $\Phi(E) = N_{np}/\varepsilon(E)A$, A *is the cross-sectional area of the detector that is covered by the neutron beam.*

- **The neutron detection efficiency** of NE230 as a function of neutron energy was determined from the ratio of counts recorded (in the same with neutron beam) for each incident neutron energy by the NE213 and NE230 detectors , respectively. The efficiency of the detector is then given by the product of this and the efficiency of the NE213 detector determine with reference to n-p elastic scattering cross-section

Results


(a) Fluence spectra of the C-target
(b) Fluence spectra of the Be-target
(c) Fluence spectra of the Li-target
Fluence spectra (Number of neutrons. cm -2)
NE213 measured fluence spectra (solid black squares histogram) compared with NE230 measured fluence spectra (open red circles histogram)

Conclusions

- Spectra show expected trends (shape) and main features
- Spectra compare well with each other
- Differences might be due the escape of deuteron which was not corrected in NE230
- The measurement of neutron fluence energy distributions with NE230 using time-of-flight method is reliable in air

Future work

- Investigate the effect of escape effects on neutron fluence energy distributions measured with detectors NE213 and NE230 of the same size.
- A comparison of neutron fluence energy distributions with NE213 and NE230 detectors in water phantom