A Simple Event Display for the DarkSide-50 TPC

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INTRODUCTION

The DarkSide-50 Liquid Argon Time Projection Chamber (LAr TPC) is designed to detect nuclear recoils caused by dark matter particles. This detector sits inside a cylindrical cryostat, with arrays of photomultiplier tubes (PMTs) along the upper and lower faces. Liquid argon fills the entire cryostat, with the exception of a small argon gas pocket below the upper PMTs. Copper rings located along the outside of the cylinder produce a uniform electric field between the PMT arrays. (See Figure 1 below.)

When a particle interacts with the liquid argon, it immediately causes an electron or nuclear recoil, resulting in ionization and a scintillation signal, S1. Electrons escaping recombination are then drifted upward by the electric field. Upon reaching the surface of the liquid argon, a stronger electric field accelerates them into the gas layer. This acceleration excites the gaseous argon, producing a secondary scintillation signal, S2. Both signals are detected by the PMTs and recorded by 250 MHz waveform digitizers. Because S2 occurs near the top of the cryostat, the distribution of the light gives the transverse location of an event. Meanwhile, the time between S1 and S2 gives the event's vertical location.

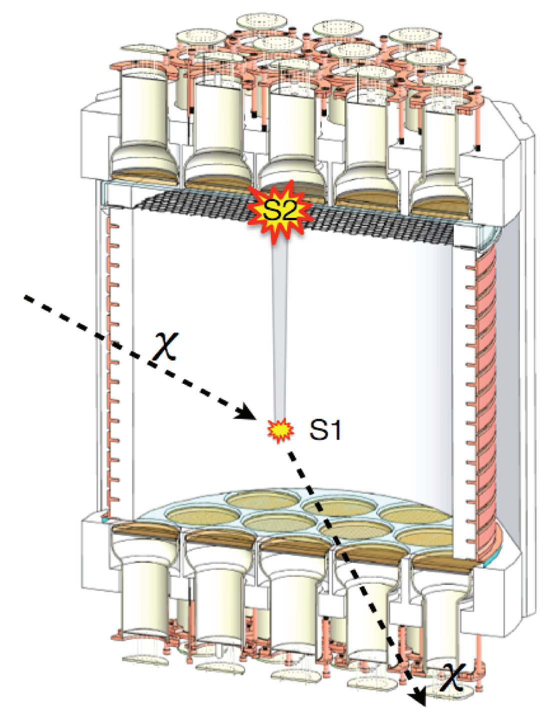

Figure 1
A sketch of the DS-50 LAr TPC.

The dark matter search depends on a deep understanding of all the events in the detector. However, the DarkSide-50 analysis lacks a simple means of viewing these events. This poster reports the development of a simple event display, which allows users to quickly obtain and display event data.

CHALLENGES

Obtaining Event Data
The DarkSide-50 analysis stores approximately 550 TB of data corresponding to millions of events.

Displaying Events
Approximately 10 MB of data is recorded for each event; a clean display must show only the most important information.

METHOD

The event display is comprised of two main components: the event selector, which obtains relevant event data from a remote computer, and the main display, which outputs that data to a window. Figure 2 below shows how these components work together.

Event Selector
To use the selector, the user inputs a text file listing the run, sub-run and event numbers of each relevant event. The selector then utilizes art — software used by a number of Fermilab experiments — to extract data from raw data files, apply reconstruction algorithms, and output a single tree.

Main Display
Using the selector's output tree, the main display produces a list of requested events and allows users to switch between them. When the user selects an event, that event's waveform is displayed, as are color-coded diagrams of the PMT arrays, which show the size of the signal from each PMT during the first pulse. The user can then switch between pulses using a secondary list. (For clarity, a green box on the waveform highlights the selected pulse.)

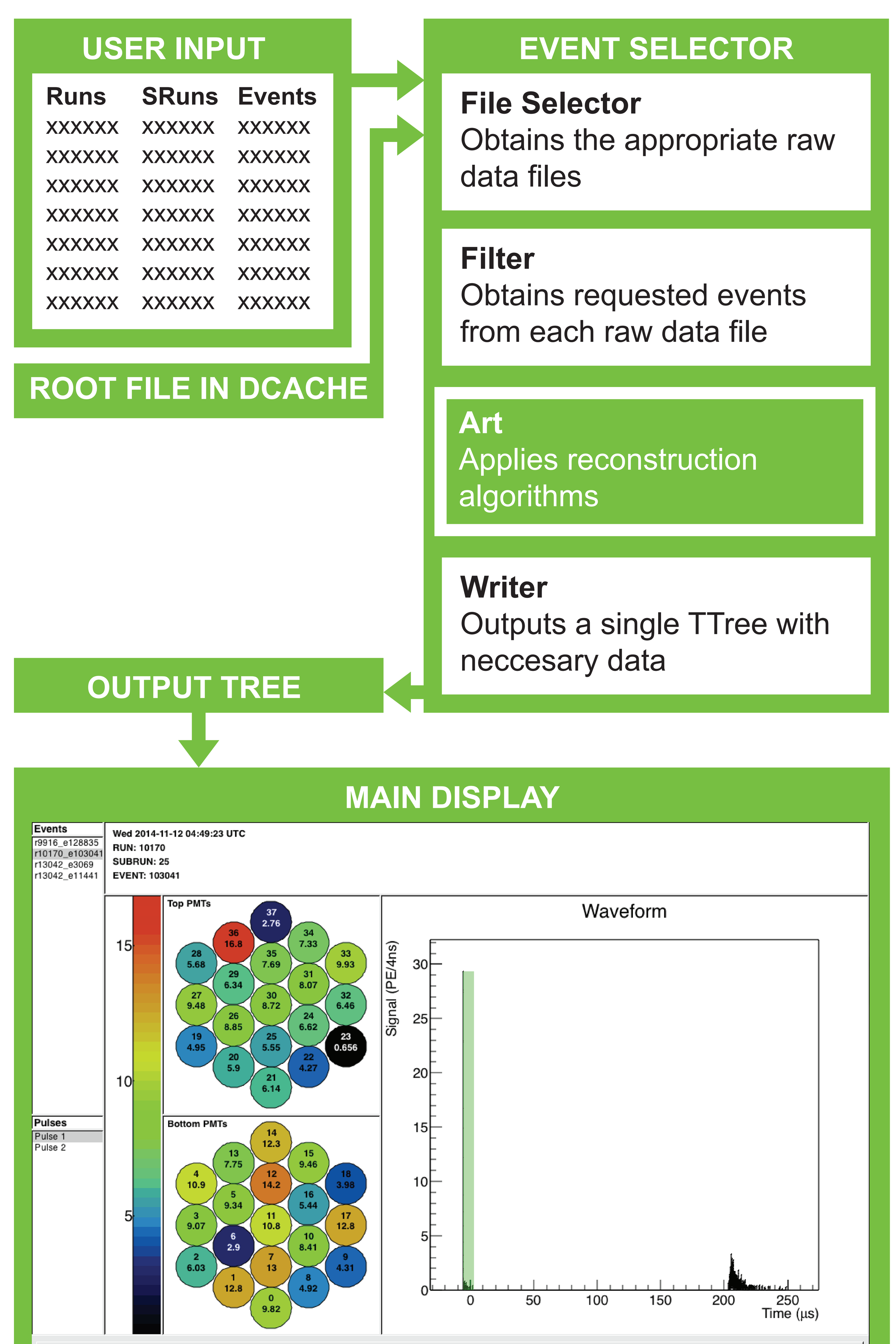

Figure 2
A schematic of the event display program. The event displayed above depicts a typical nuclear recoil.

RESULTS & DISCUSSION

The current version of the event display allows users to view key event data with ease. The figures below show the displays for a few different types of events. Note that, by simple examination of the waveforms, the type of event can be identified.

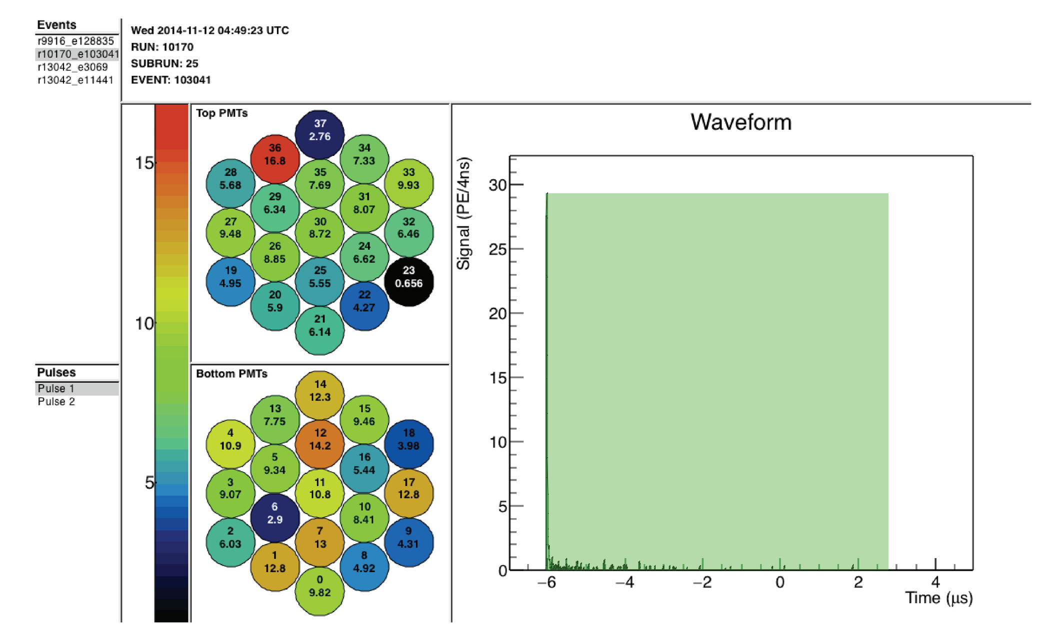

Figure 3
S1 from a typical nuclear recoil.

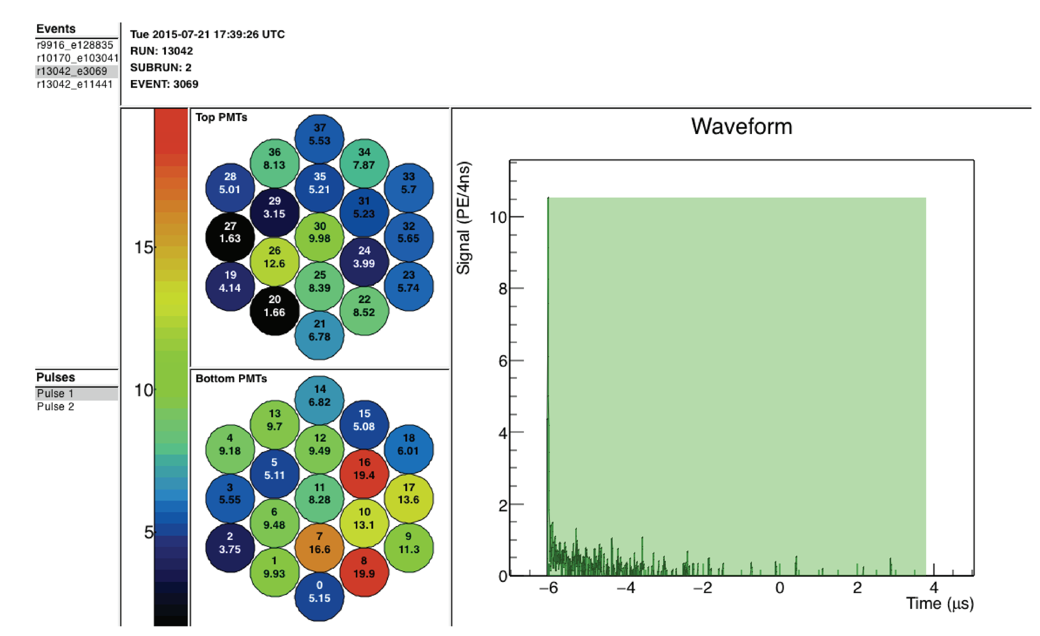

Figure 4
S1 from a typical electron recoil. Note that the pulse's tail is larger than that of the nuclear recoil (Figure 3). This pulse shape discrimination can be used to reject β/γ decays.

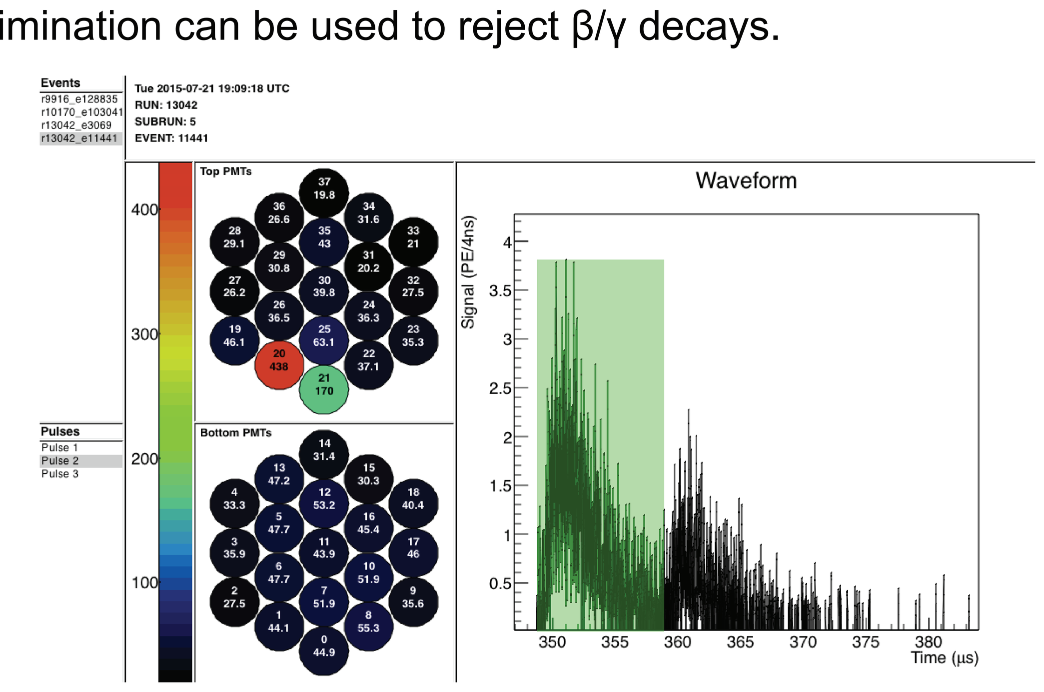

Figure 5
S2 from an electron recoil with multiple scatters, indicating that the recoil was caused by a γ.

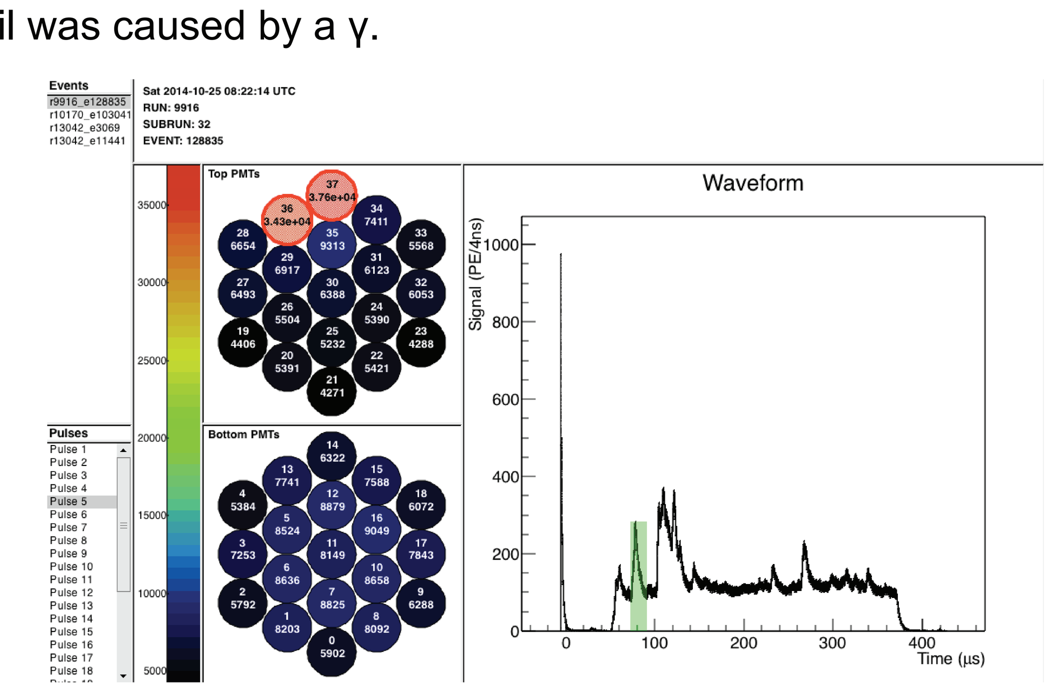

Figure 6
A typical muon event. Because muons deposit high energies throughout the TPC, the PMTs are saturated and the reconstruction algorithm fails to determine the correct number of pulses.

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