EDIT 2018 Photodetection: XELDA

Energy calibration and particle identification in a liquid xenon time-projection chamber

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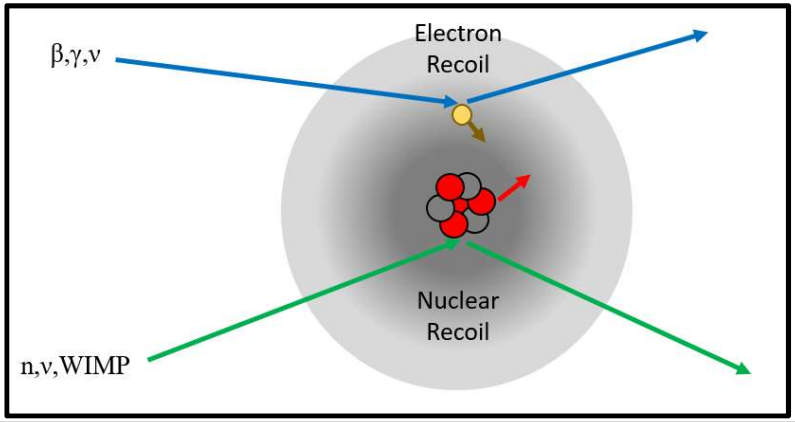
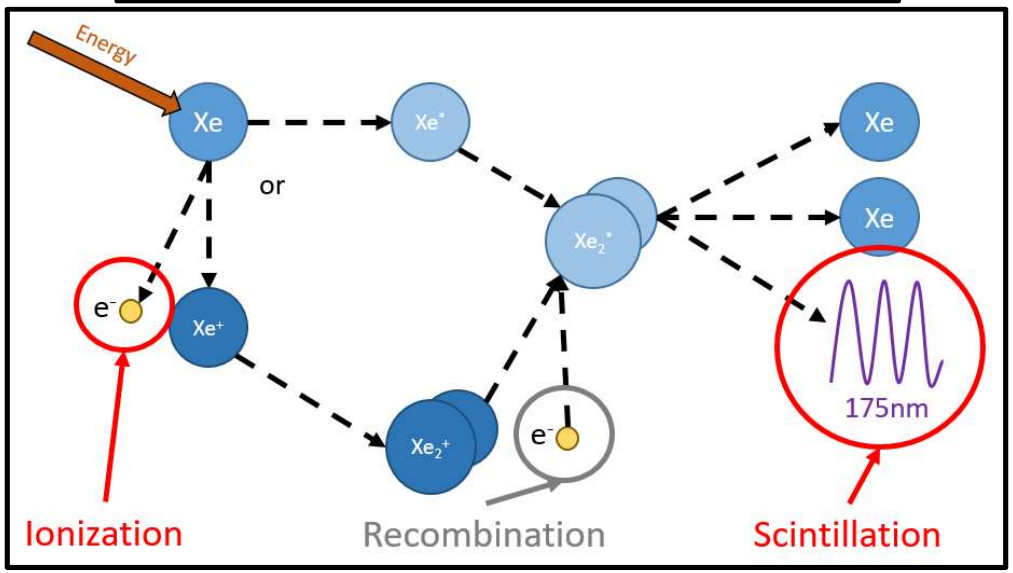
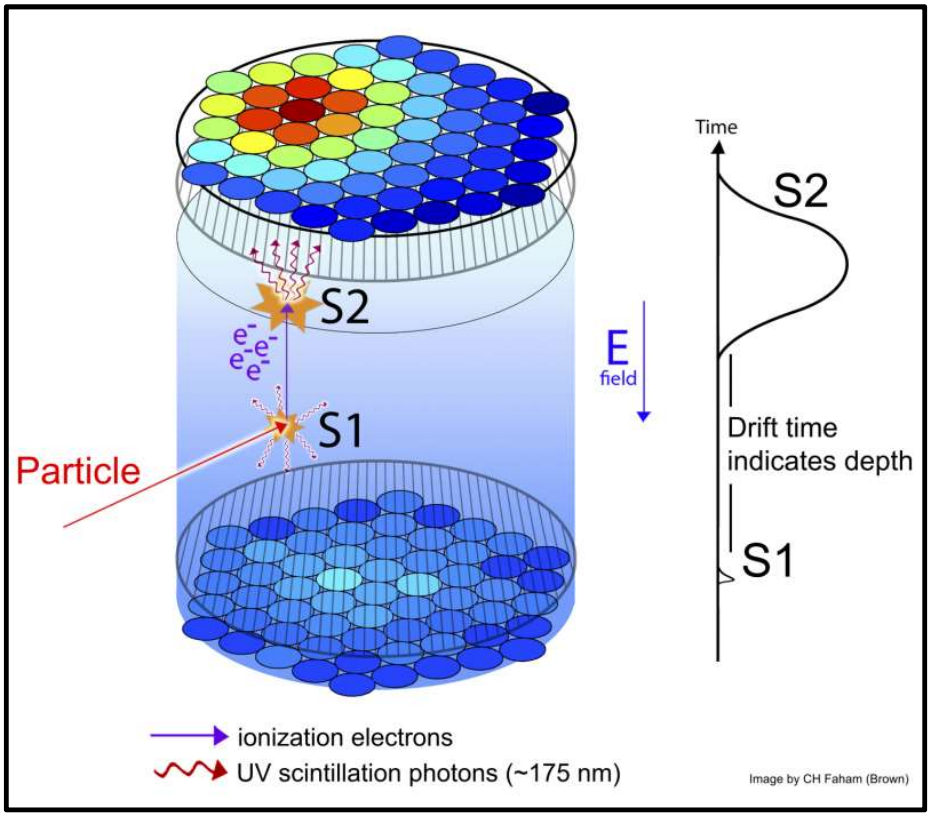
Two-phase xenon time-projection chambers



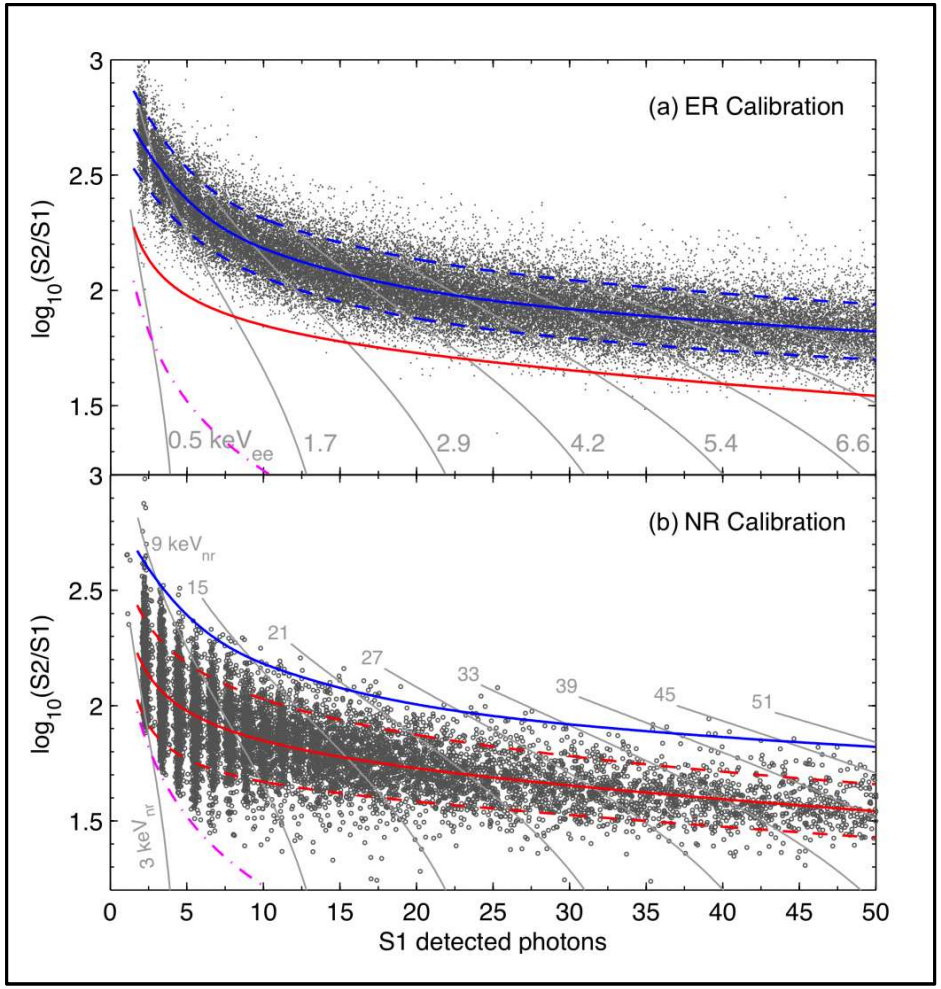


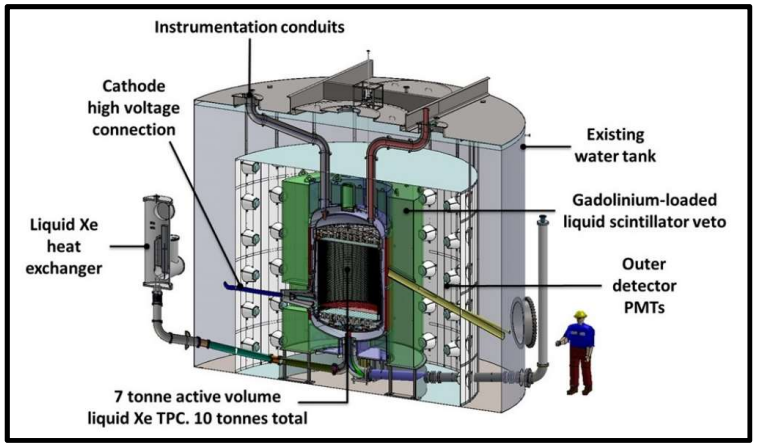


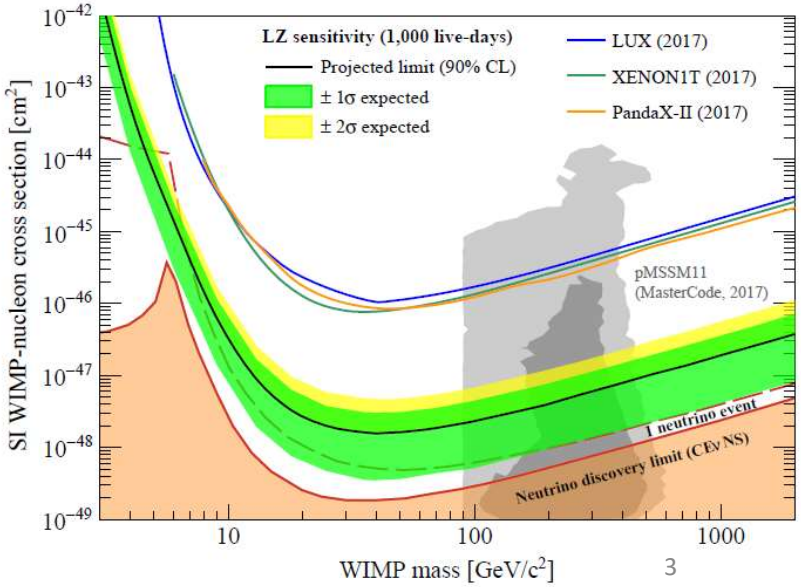
$$E = W(n_\gamma + n_e)$$

W = 13.7 eV (Xe)

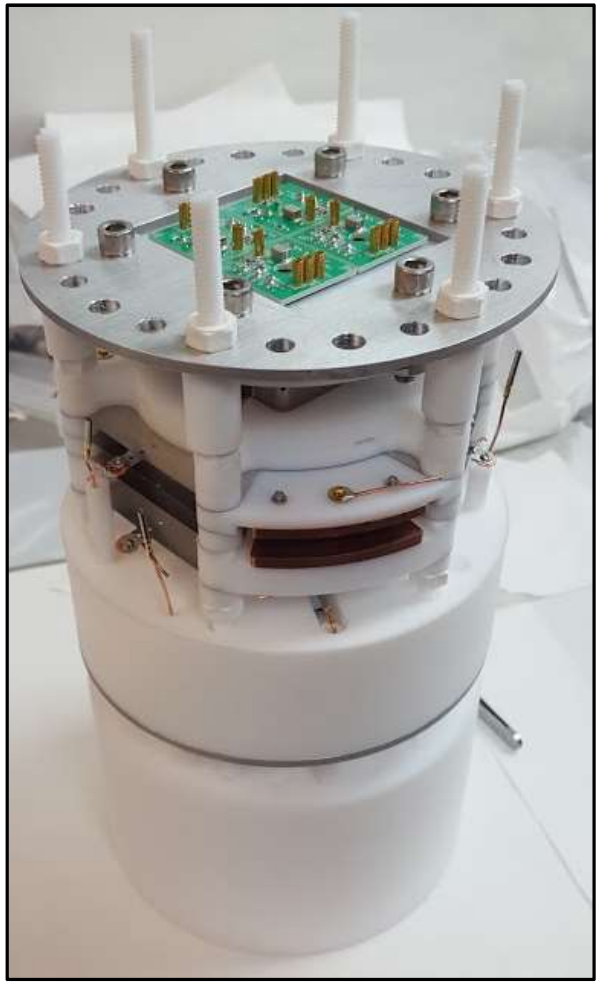
LXe-TPCs as dark matter detectors



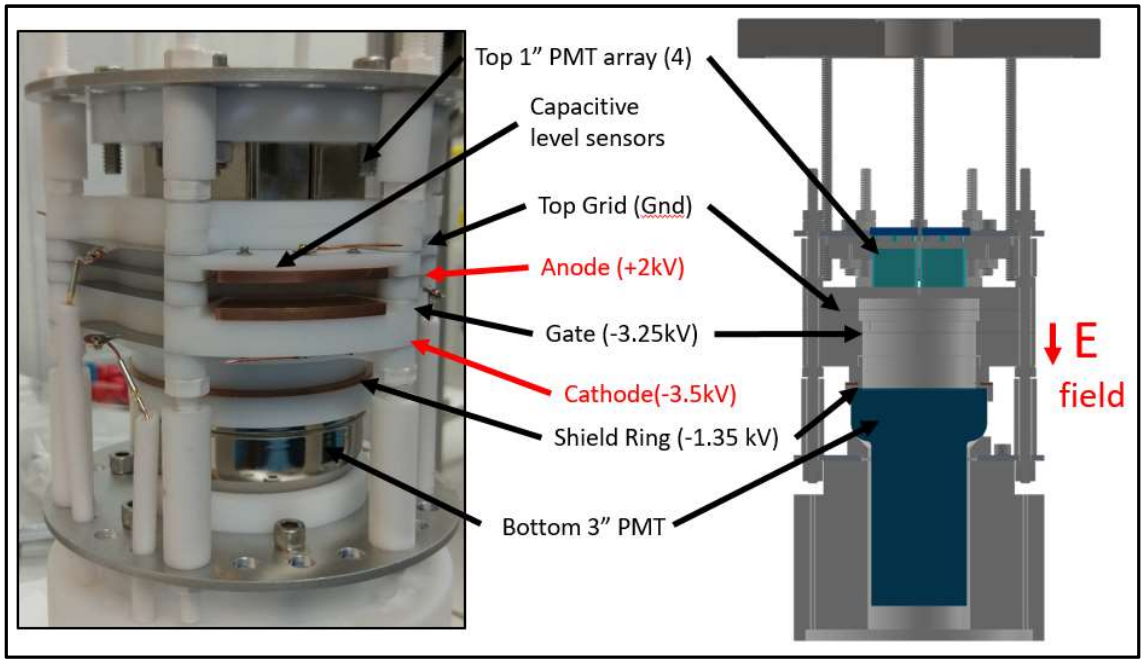




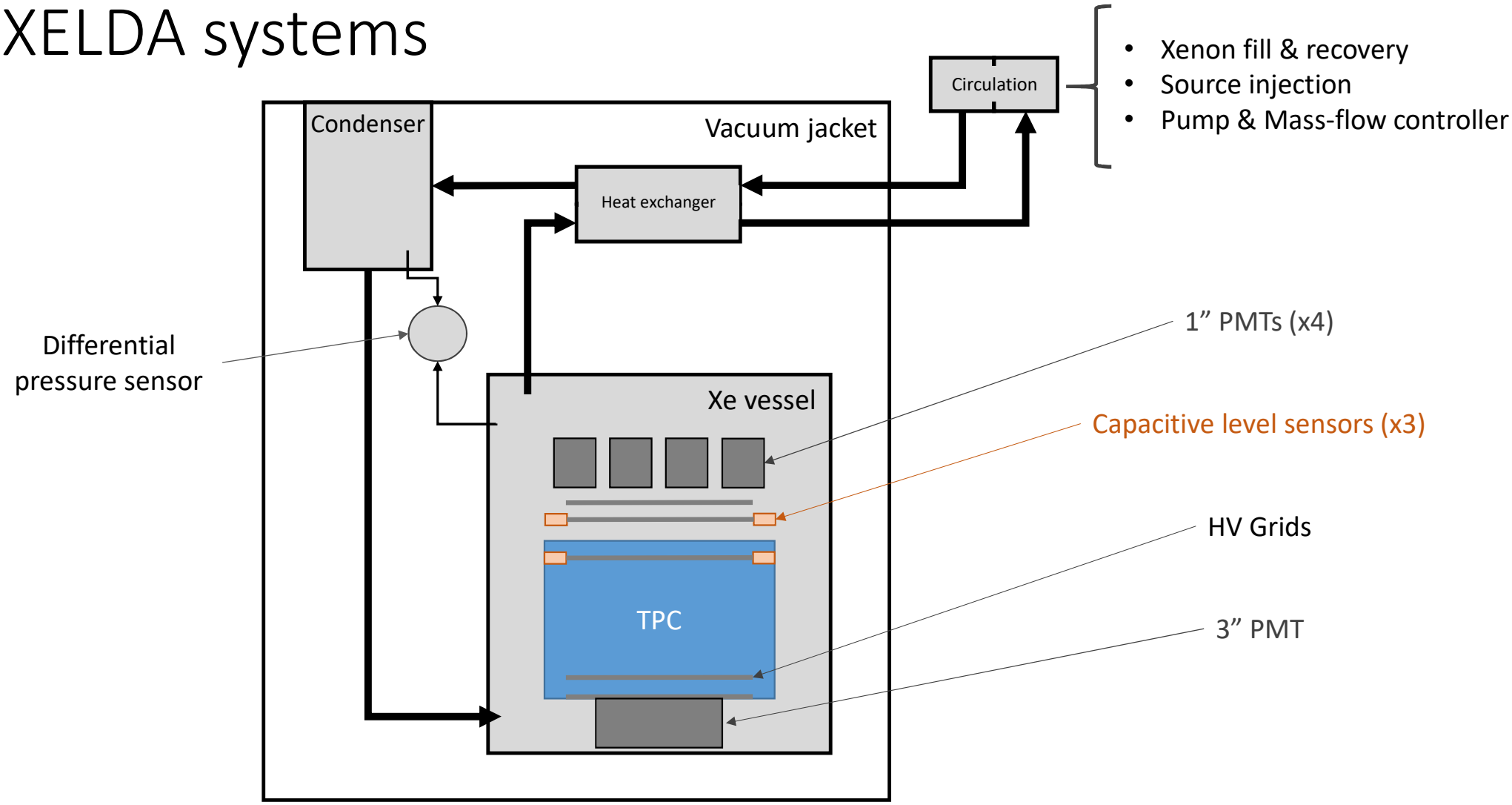
The XELDA detector



Drift field	300	V/cm
Extraction field	10,000	V/cm
Maximum drift length	0.5	in.
LXe volume in TPC	40	mL

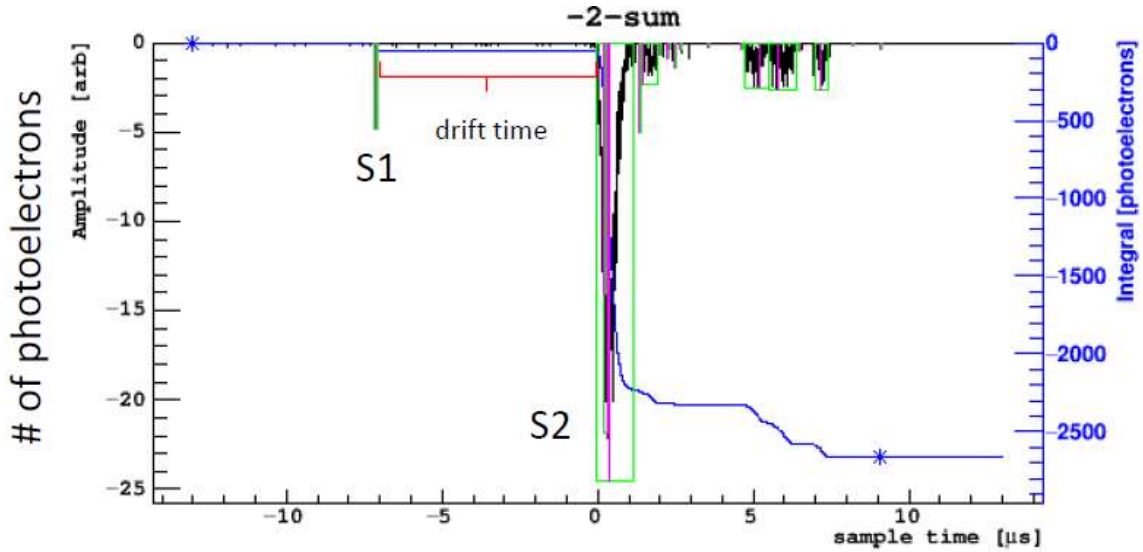


XELDA systems



- Xenon fill & recovery
- Source injection
- Pump & Mass-flow controller

XELDA waveforms and data analysis



$$E = W(n_\gamma + n_e)$$

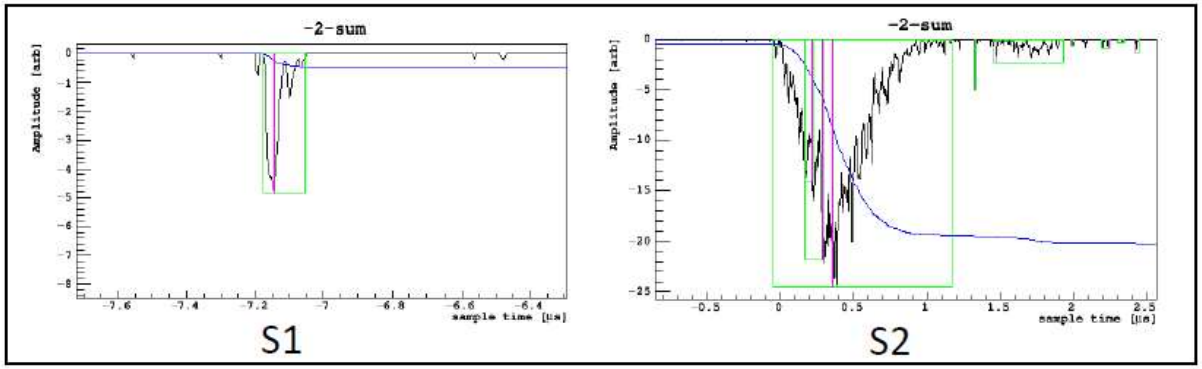
$$n_e = S2/g_2$$

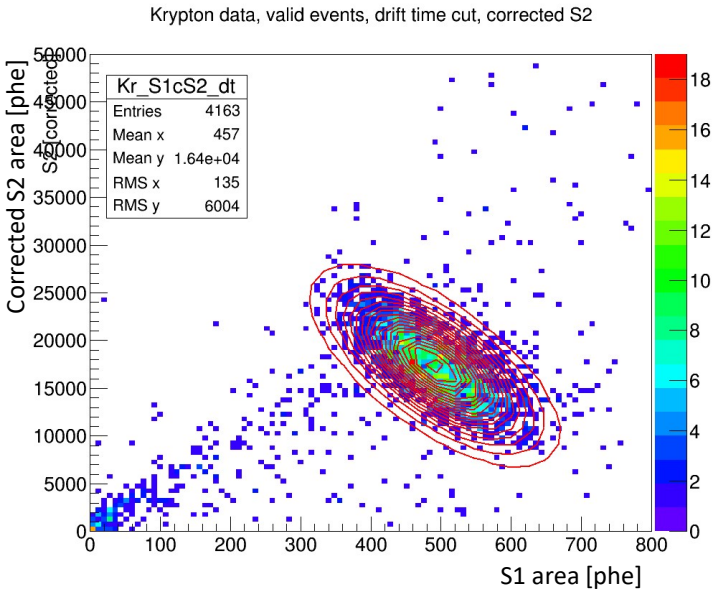
$$n_\gamma = S1/g_1$$

Determined by field strength and energy of calibration source

g1 = 0.226 +/- 0.0009
g2 = 20.25 +/- 0.141

g1: photons detected per photon emitted
g2: photons detected per electron emitted

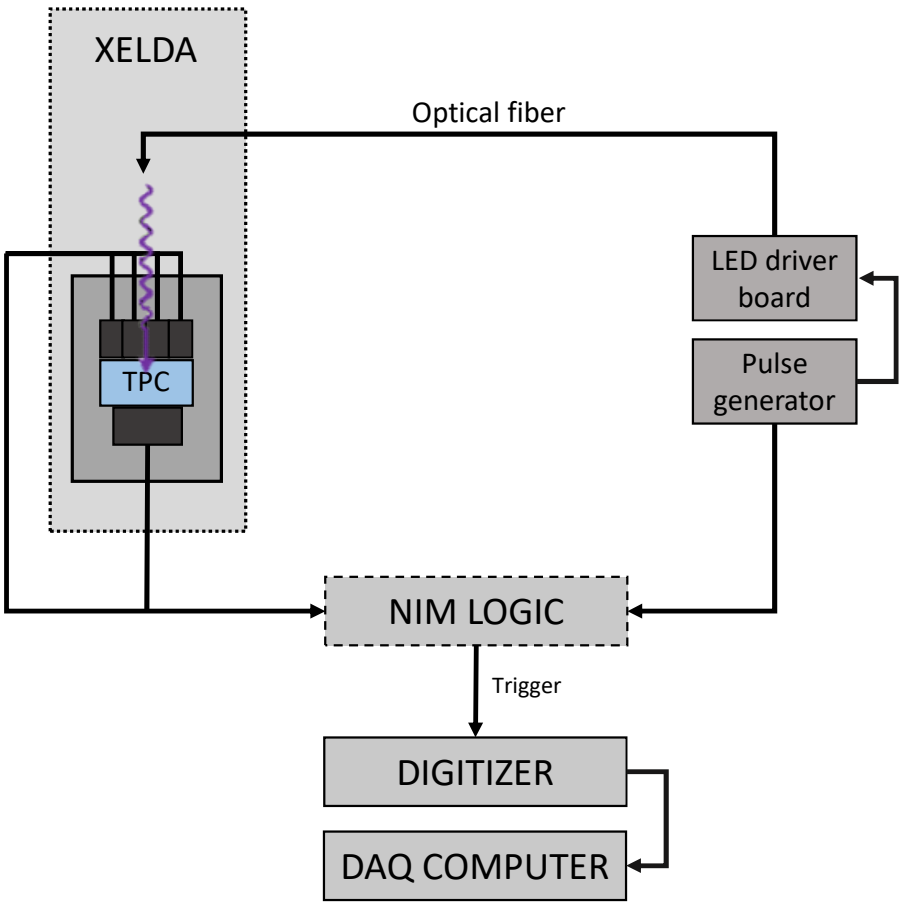




Schedule

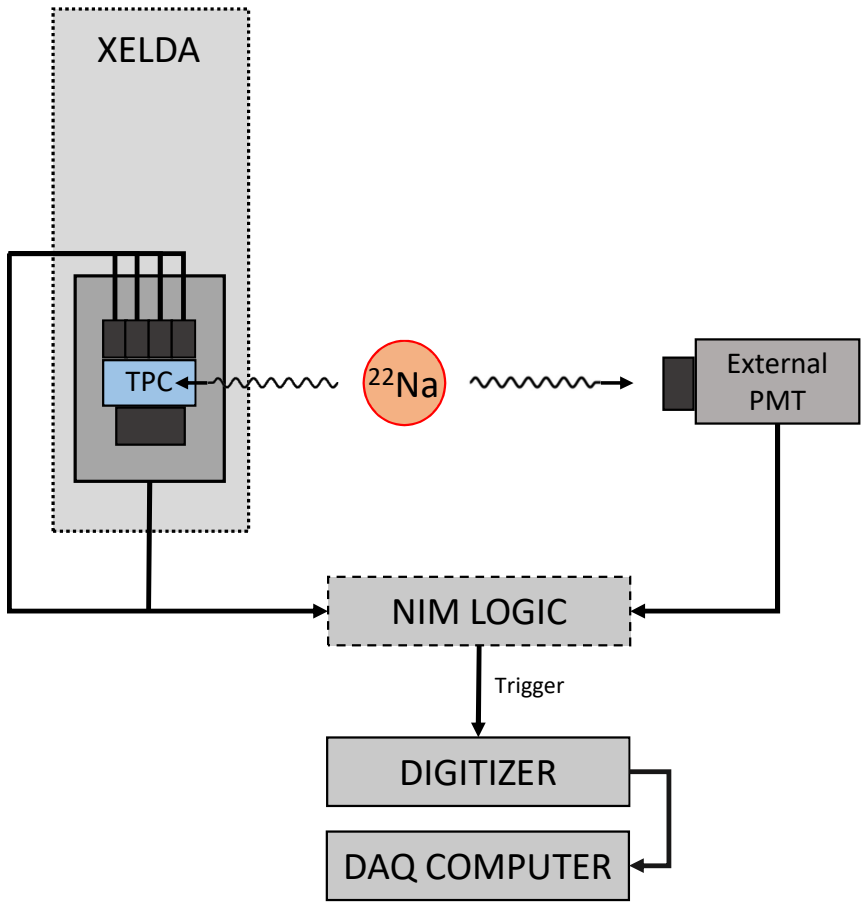
- XELDA system overview & LED calibration
- Bias grids and set up ^{22}Na source and external PMT (time permitting)
- Lunch
- Electron recoil calibration using ^{22}Na γ source
- Nuclear recoil calibration using AmBe neutron source
- Event hand scanning
- Analysis demonstration

LED calibration: single photoelectron pulse size



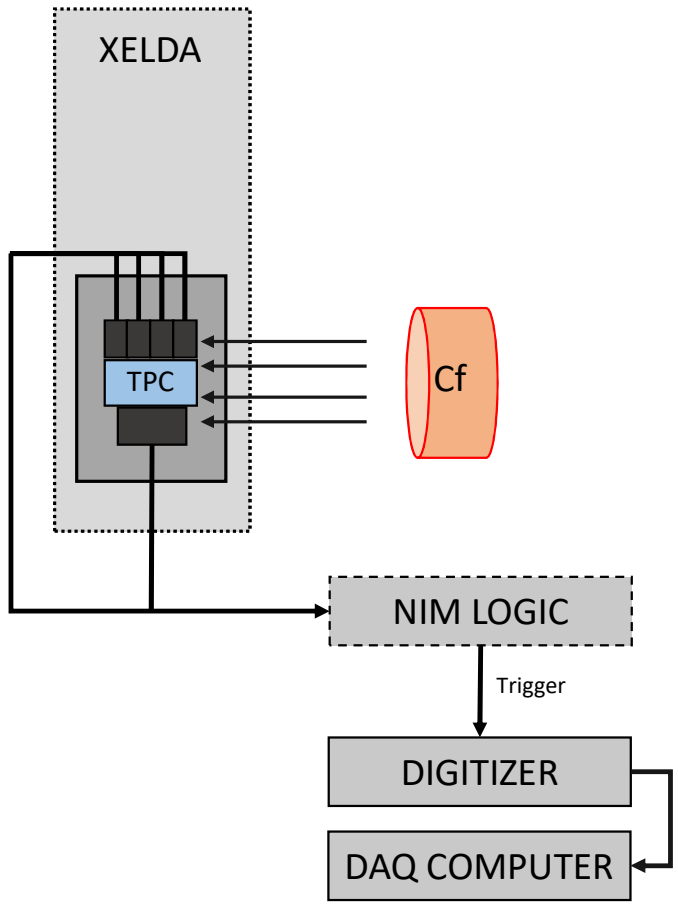
- Goal: determine normalize of integrated pulse area (V · T) to the average pulse size for one photoelectron - a measure of how many photons hit the photocathode.
- Procedure:
  - Set up LED output
  - Look at PMT traces on oscilloscope, triggered on pulse generator
  - Set up NIM logic to trigger on pulse generator
  - Take and process data, instructor will implement normalization over lunch

Electron recoil calibration



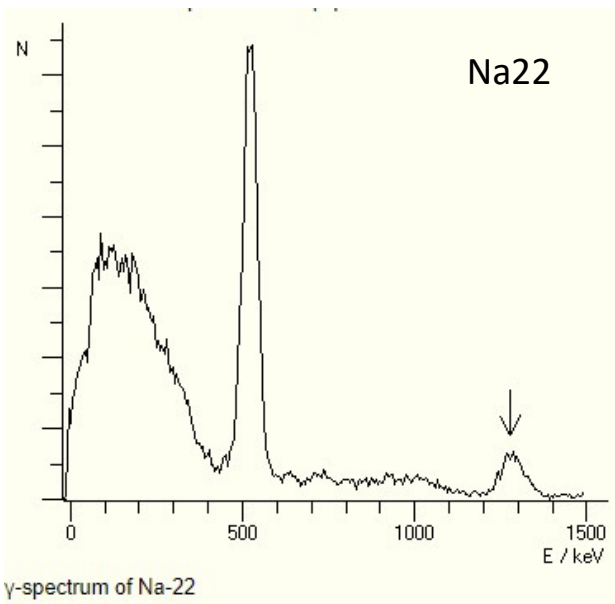
- ^{22}Na: 2 back-to-back 511 keV γs
- Tag ERs from ^{22}Na using external PMT
- Goal: obtain distribution of ERs in S1 – $\log_{10}$(S2/S1) space
- Procedure:
  - Bias grids & PMTs, look at traces on the oscilloscope
  - Set up external PMT, verify operation
  - Set up NIM logic for external trigger on external PMT
  - Look at traces on DAQ, identify S1 and S2 pulses
  - Take data, process waveform data into RQs

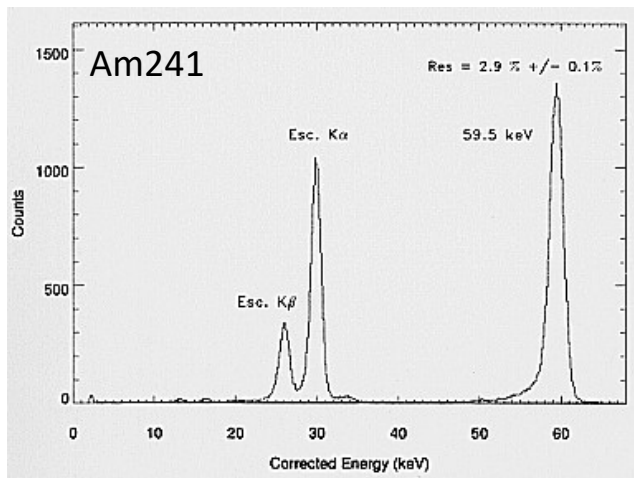
Nuclear recoil calibration



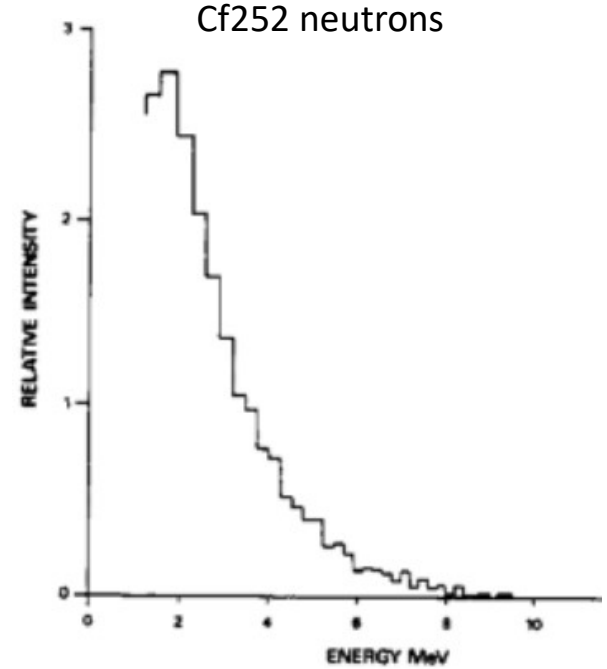
- ^{252}Cf spontaneous fission source, average energy 2 MeV (~10 MeV maximum)
- Data will contain NRs from neutrons as well as ERs from both background and the γs produced in the (α,n) reaction (4.44 MeV)
- Goal: populate NR band in S1 – $\log_{10}$(S2/S1) space
- Procedure:
  - Set up neutron source
  - Set up NIM logic to trigger on 3-fold coincidence of top PMTs
  - Take and process data

Spectra

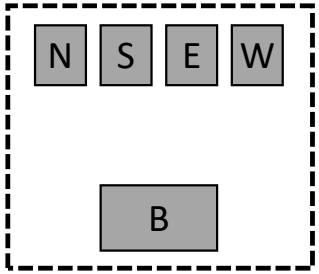


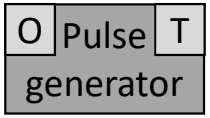


Cf252 neutrons

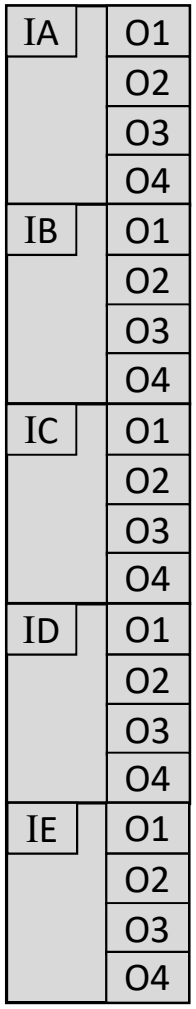


NIM Logic





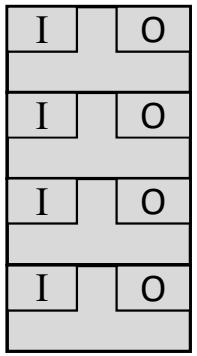
Fan-in fan-out



+3 more

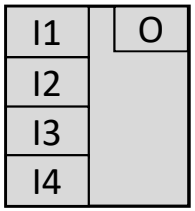
Each FIFO module has 4 inputs (1 shown) and 4 outputs. Each output of one module is the sum of all four inputs. We have 8 modules.

Discriminator

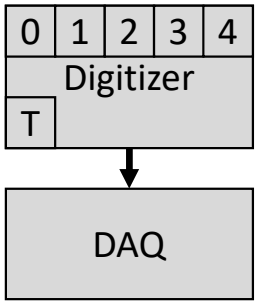


Each discriminator module takes an analog input and turns it into NIM signal. NIM transitions occur when the analog signal is below a set threshold. Both threshold and width are tunable.

Logic



The logic module will take multiple NIM inputs and output a logical AND NIM signal of N-fold coincidence.



The digitizer takes analog signal for a specified window before and after a NIM trigger pulse, and saves it to the DAQ computer.