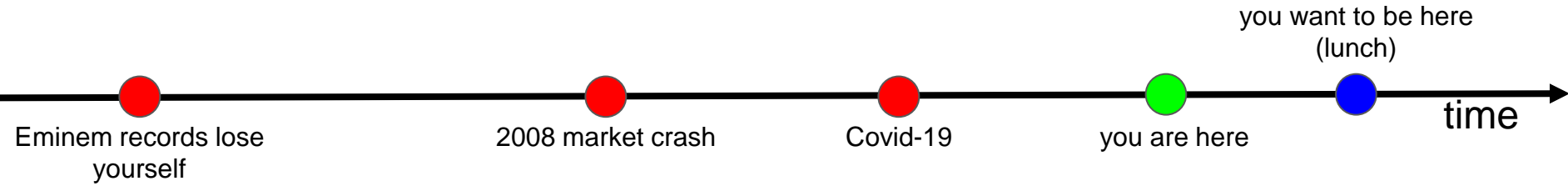


SiPM Characterization for use in HAICU

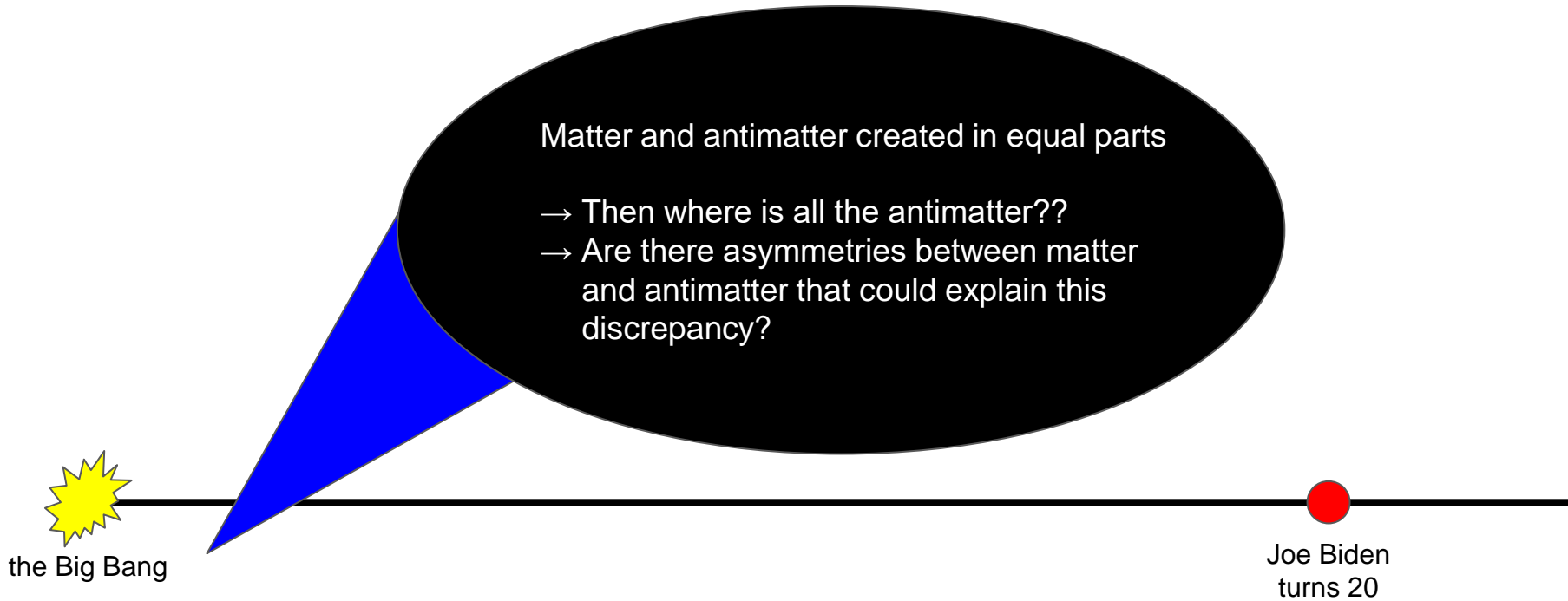
Zach Charlesworth
CERN Summer Student Program

A brief history of the universe:





Invention of
sliced bread



Matter and antimatter created in equal parts

→ Then where is all the antimatter??

→ Are there asymmetries between matter and antimatter that could explain this discrepancy?



the Big Bang



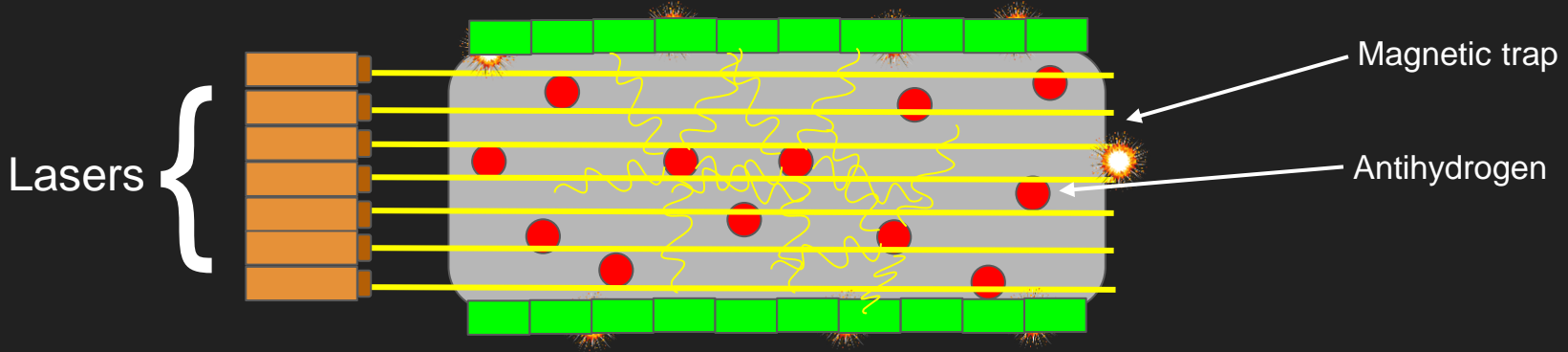
Joe Biden
turns 20

ALPHA2 and HAICU: Make precision measurements of hydrogen and antihydrogen energy levels using the same apparatus

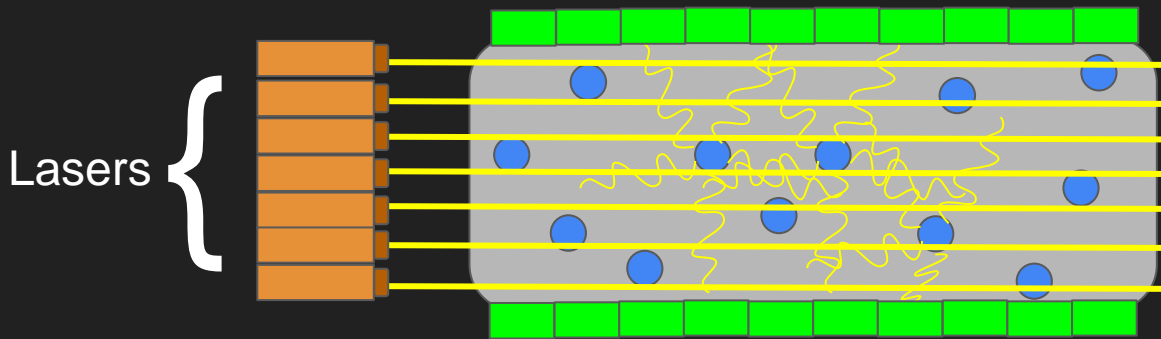
To have the same systematic errors

Current state of the Art:

ALPHA2: Spectroscopic measurements of antihydrogen energy levels in a magnetic trap

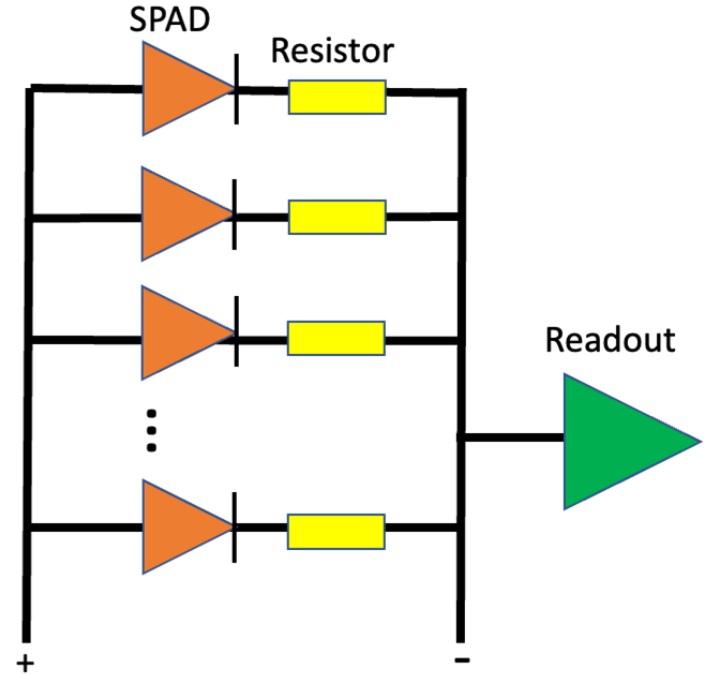


HAICU: Spectroscopic measurements of hydrogen energy levels in a magnetic trap

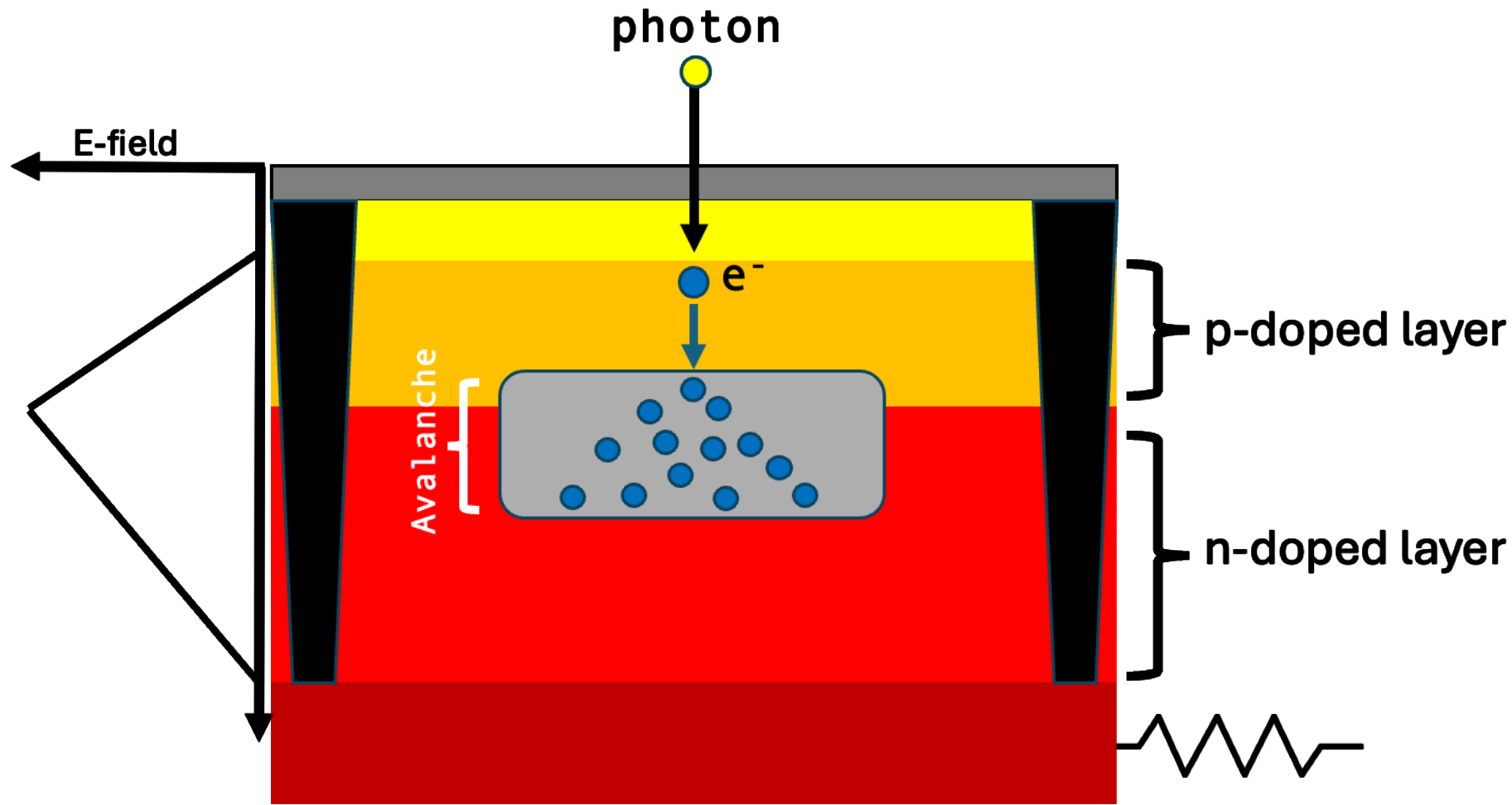


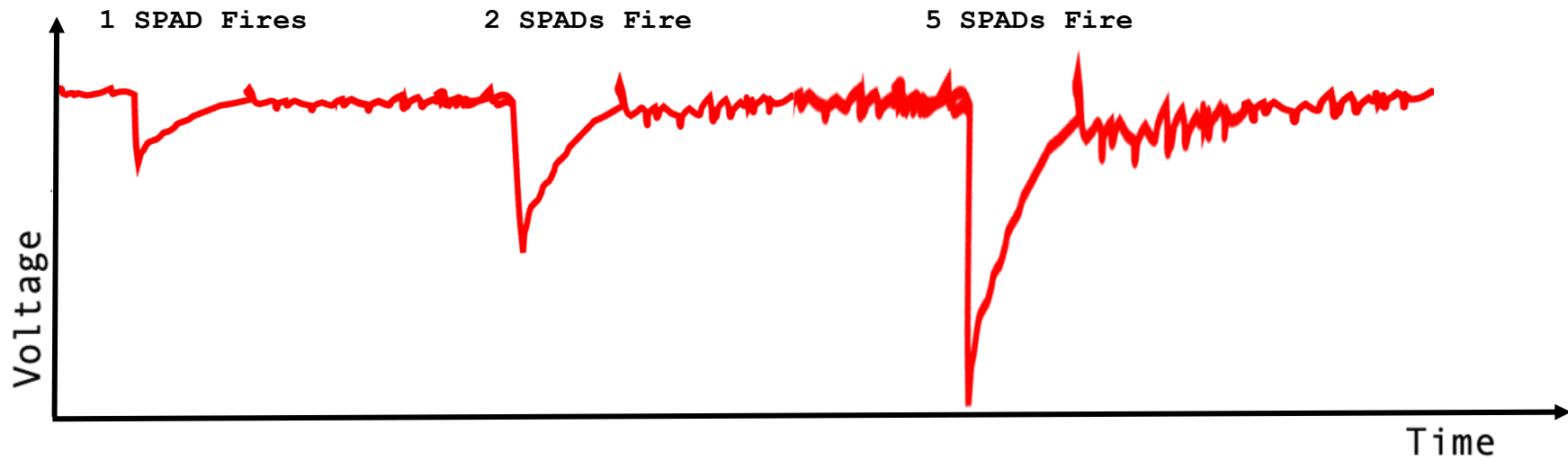
Silicon Photomultiplier (SiPM)

SPAD	SPAD	SPAD	SPAD	SPAD	SPAD
SPAD	SPAD	SPAD	SPAD	SPAD	SPAD
SPAD	SPAD	SPAD	SPAD	SPAD	SPAD
SPAD	SPAD	SPAD	SPAD	SPAD	SPAD
SPAD	SPAD	SPAD	SPAD	SPAD	SPAD
SPAD	SPAD	SPAD	SPAD	SPAD	SPAD
SPAD	SPAD	SPAD	SPAD	SPAD	SPAD

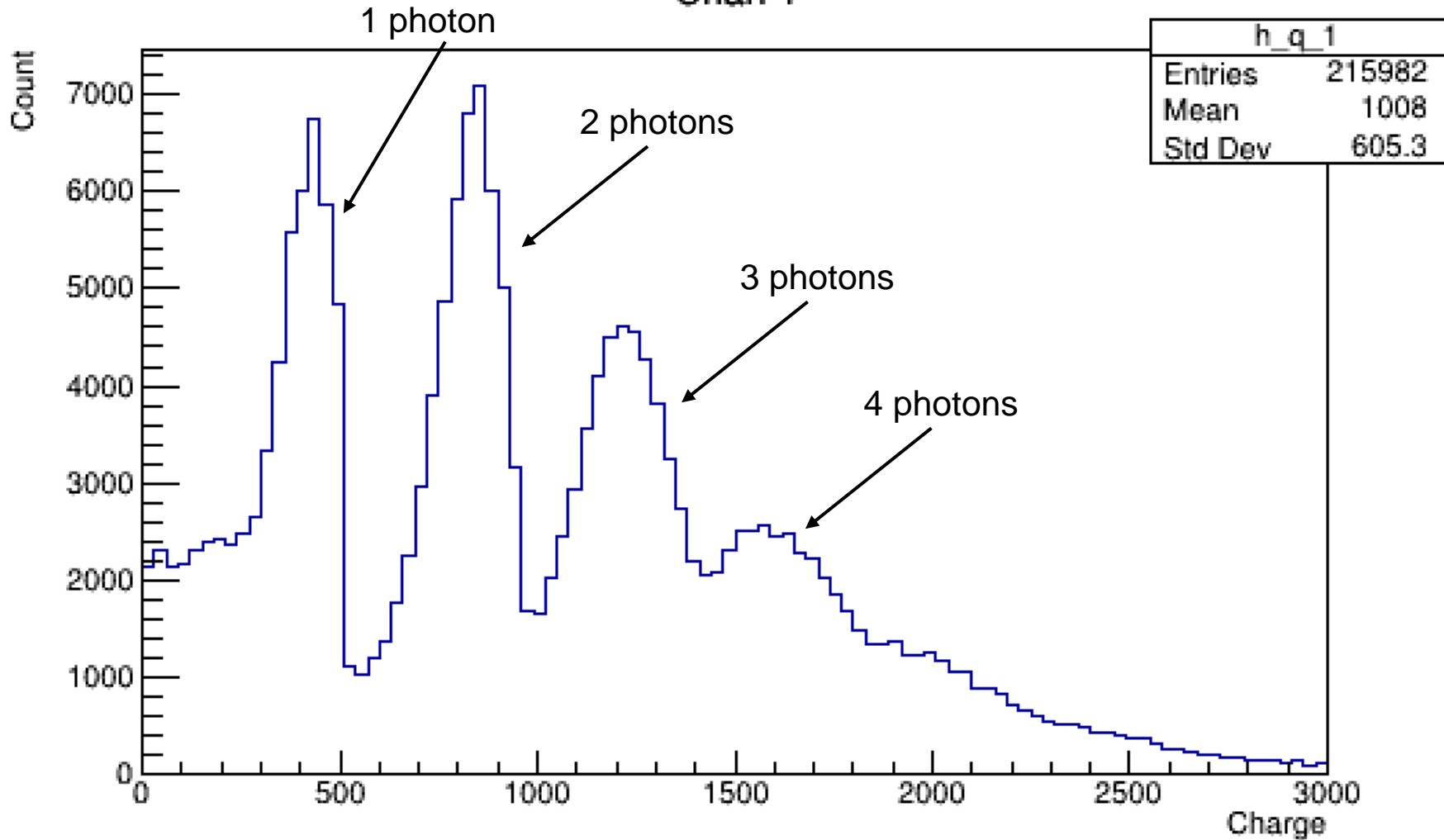


Single Photon Avalanche Diode (SPAD)





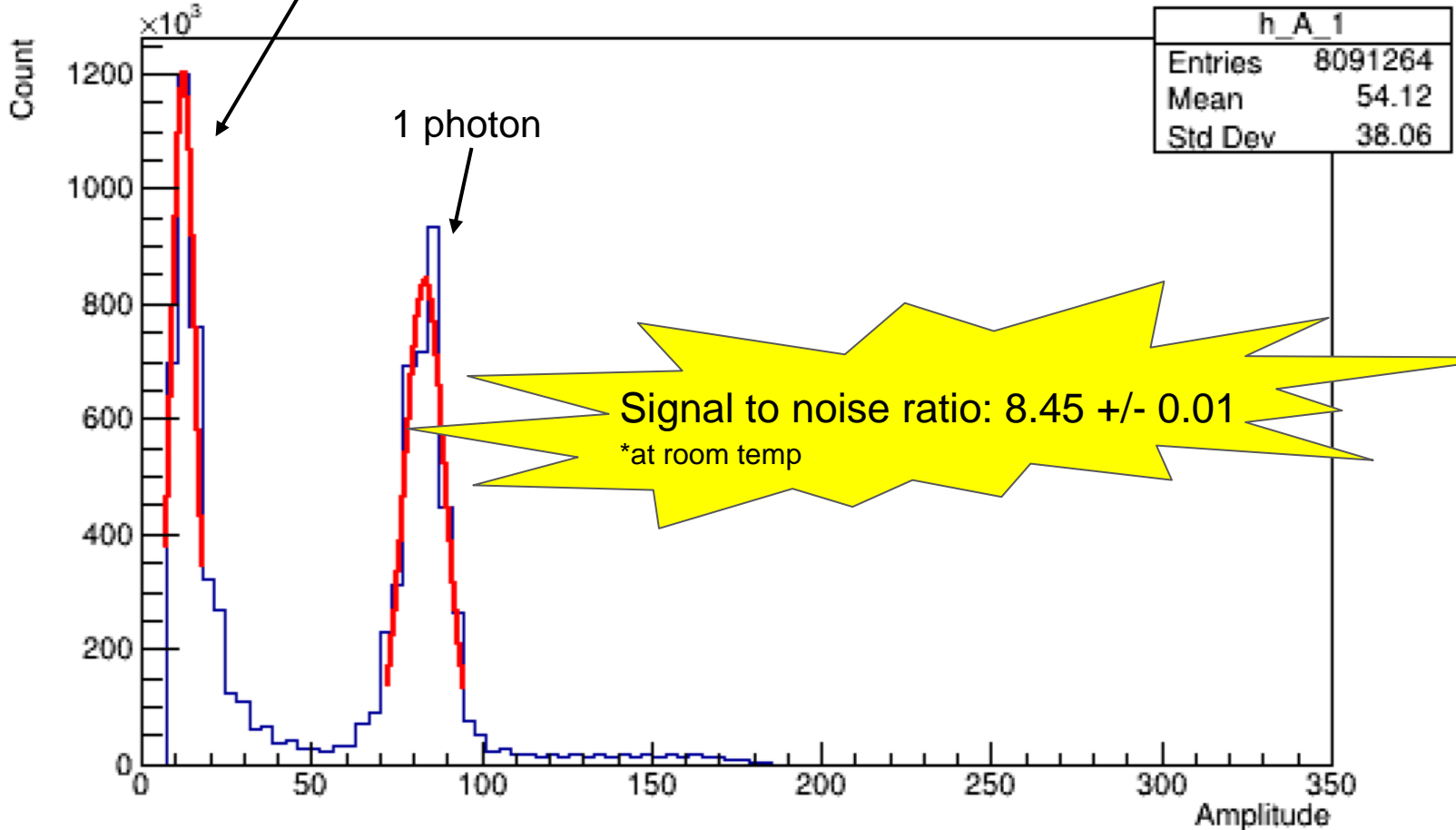
Chan 1



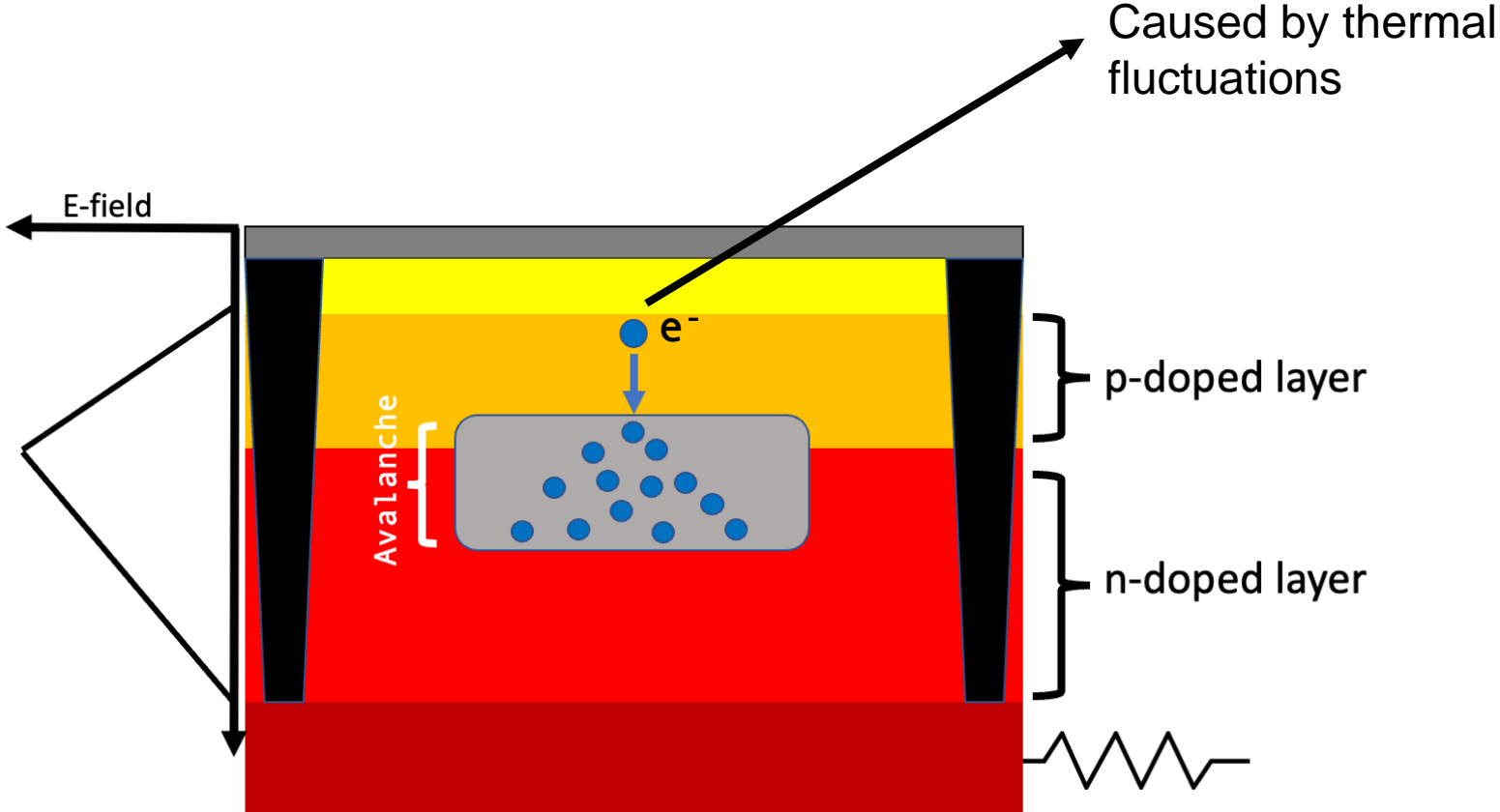
No light

0 photons (noise)

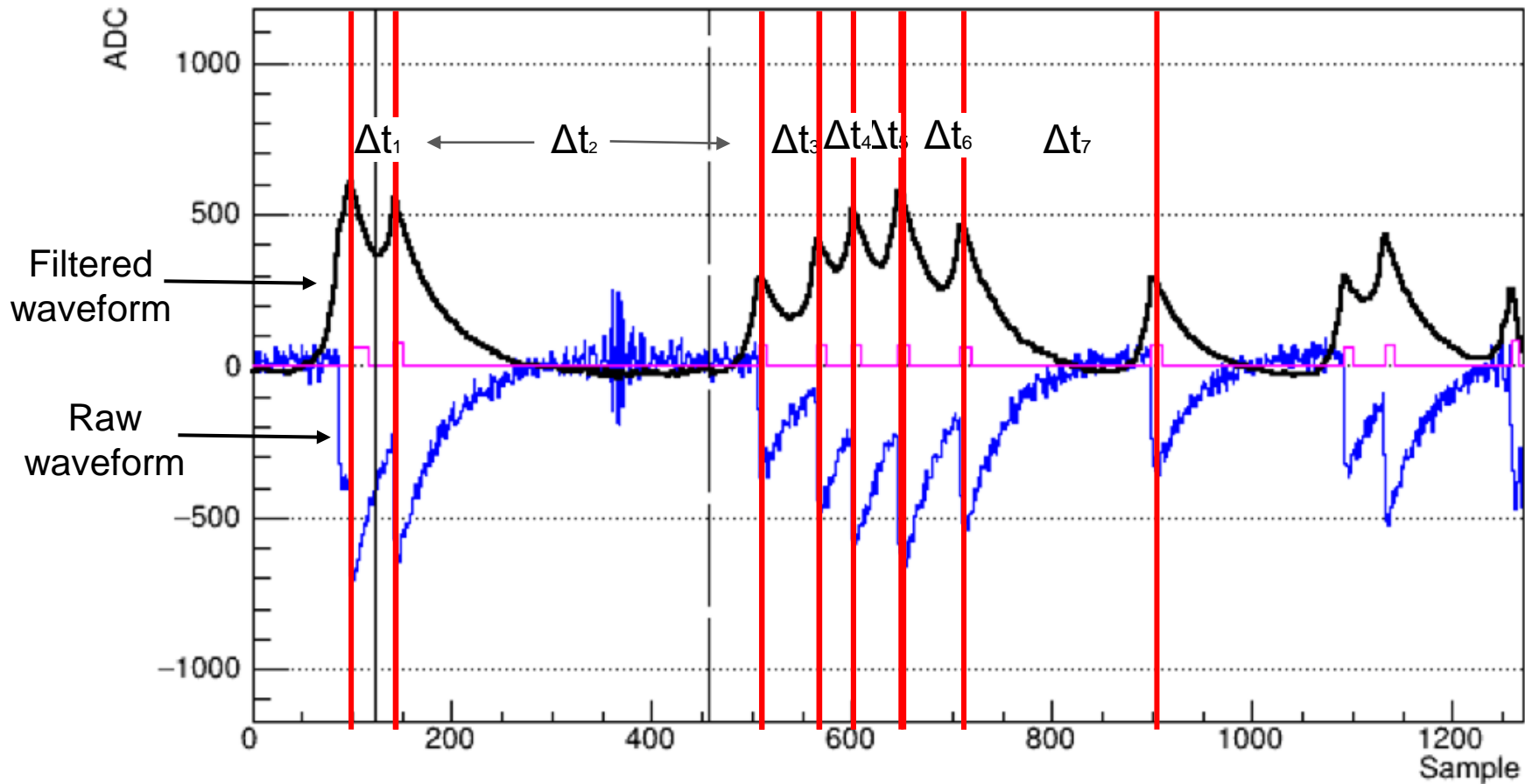
Chan 1



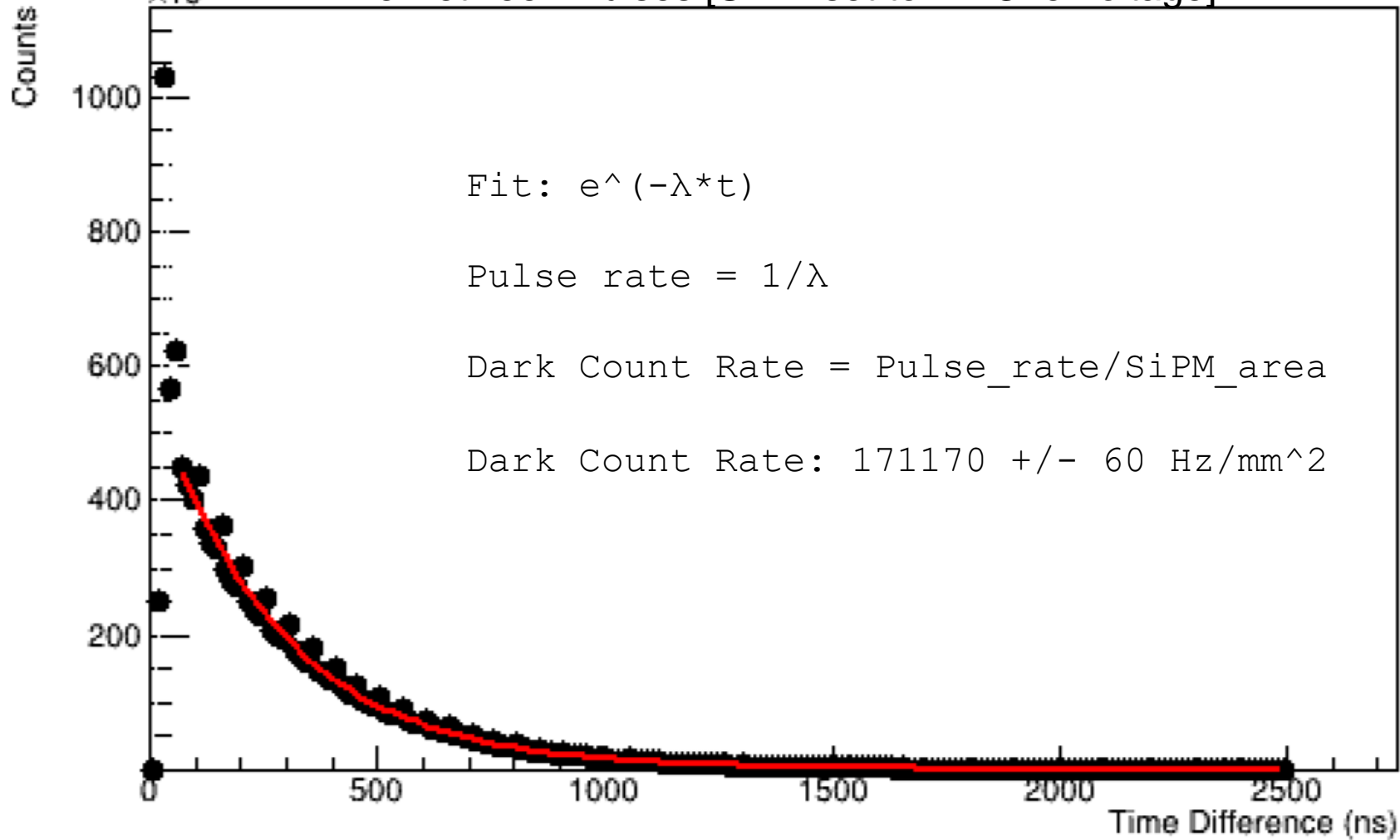
Dark noise:



Waveform Pedestal Subtracted ADC: 0 CH: 3



Time Between Pulses [SiPM set to 4V Overvoltage]



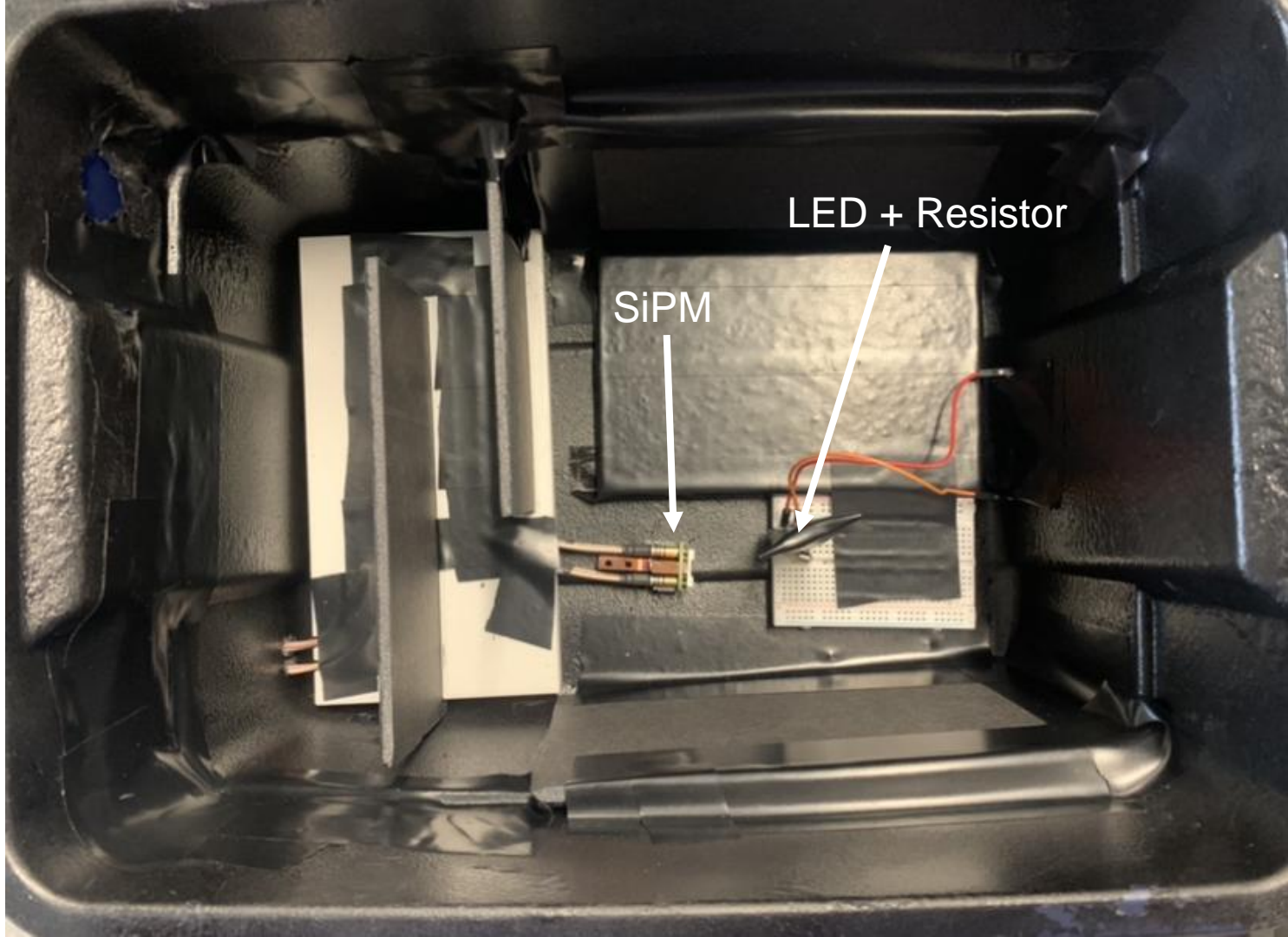
To recap:

- Very brief overview of characterizing a SiPM
- Identified 1 photon, 2 photon, .., pulses at room temperature
- Quantified the SiPM signal to noise ratio
- Characterized the dark noise rate

Thanks for Listening!

Special thanks to my supervisors Andrea Capra, Ina Carli, and Makoto Fujiwara, as well as the entire ALPHA and HAICU collaborations for making this all possible.

Backup Slides



LED + Resistor

SiPM



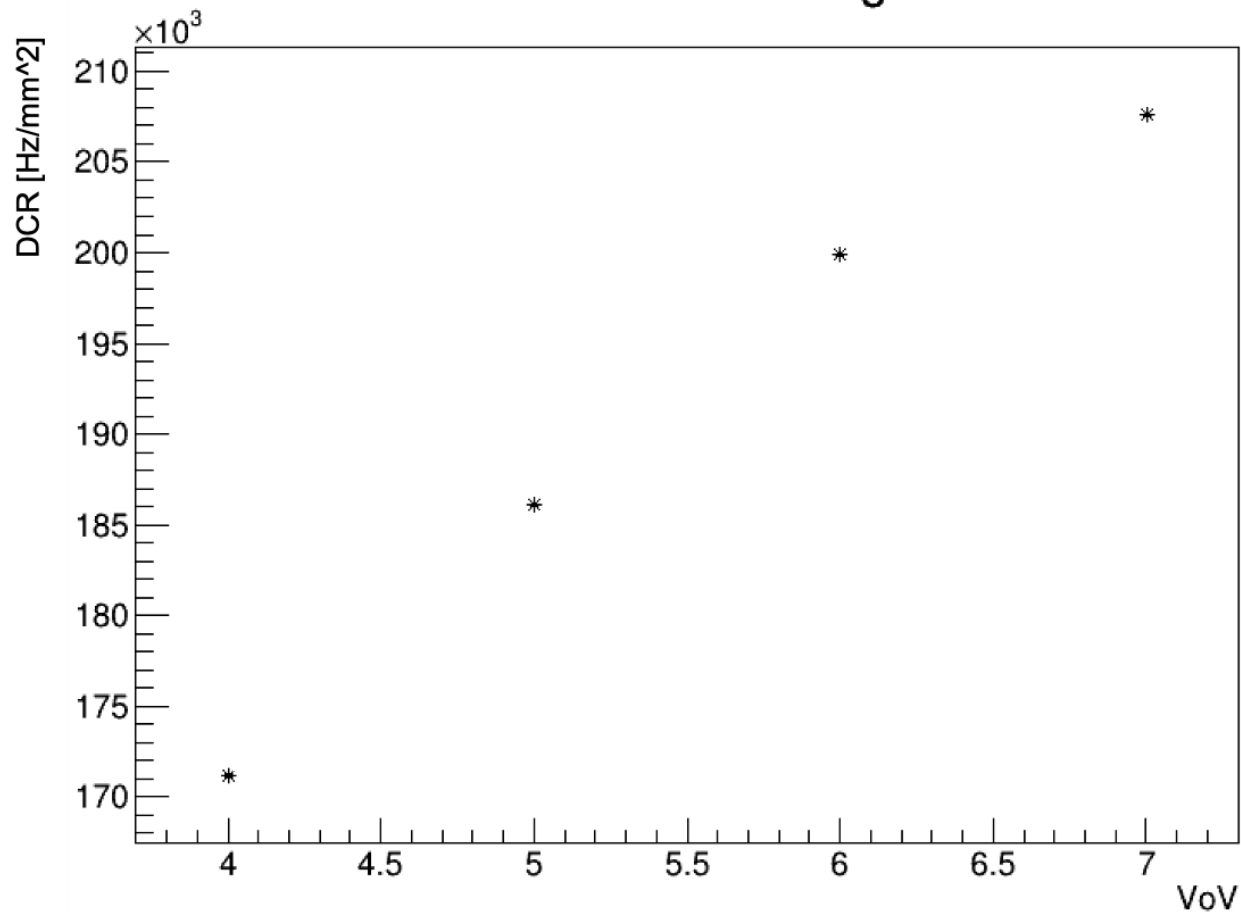
1. Voltage Board
→ Controls SiPM voltage

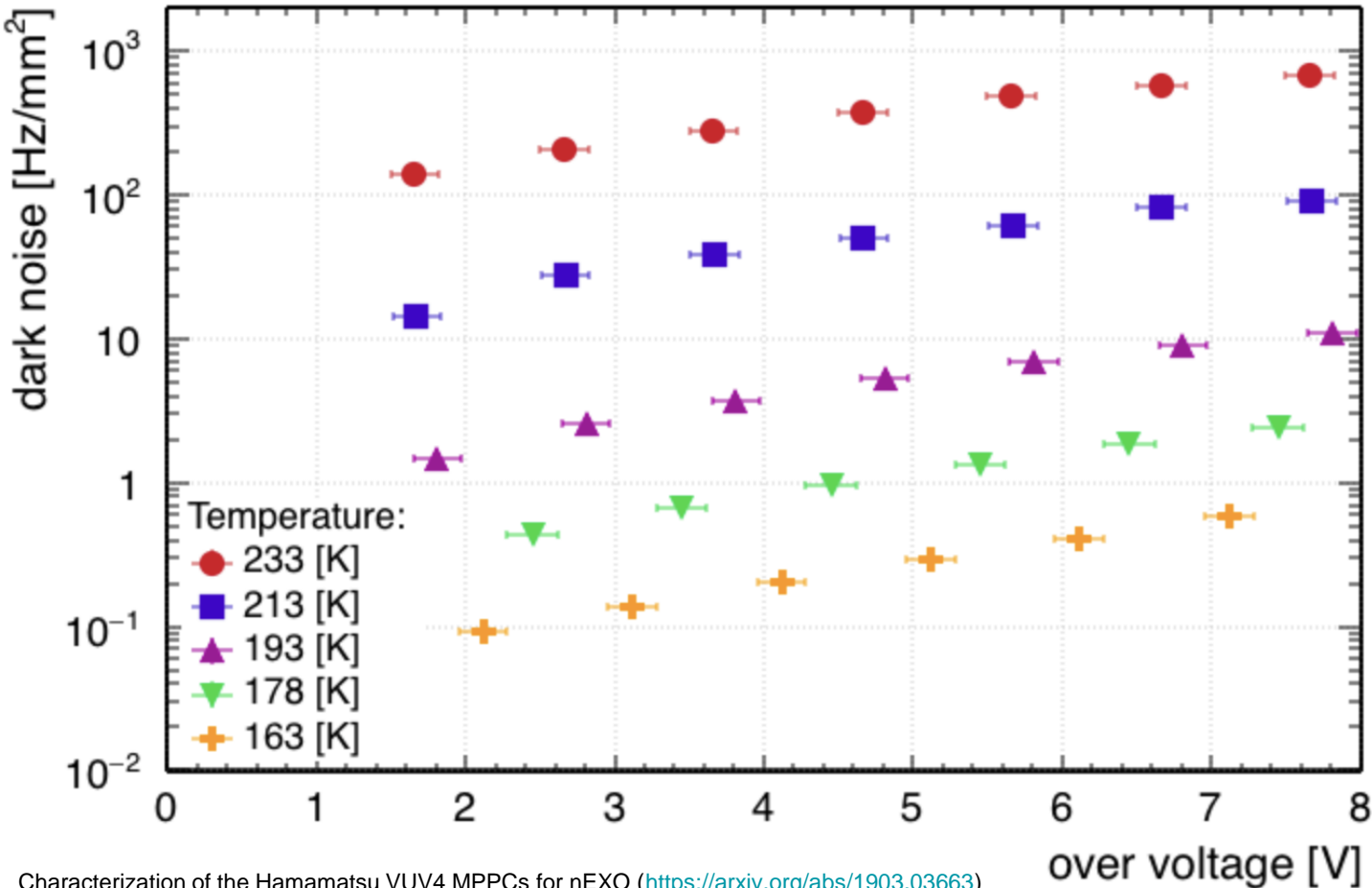
2. Digitizer
→ Digitizes the SiPM output waveforms

3. Box shown in previous slide
→ Holds SiPM and LED

4. Pulser
→ Generates pulses for LED and external trigger

DCR vs Overvoltage





Order of magnitude estimation:

An increase of $\sim 20\text{K}$ results in DCR increasing by a factor of ~ 10

Going from 233K to room temp ($\sim 293\text{K}$) is an increase of 60K ie, 3 orders of magnitude

At 233K and 4VoV DCR is $\sim 2 \cdot 10^2$ Hz/mm², so we expect a DCR of $\sim 2 \cdot 10^5$ at 293K and 4VoV