Veto Scintillator testing with ABSuRD for CUORE

Johannes Rothe (Munich / Princeton)
&
Ritoban Basu Thakur (UIUC / Fermilab)

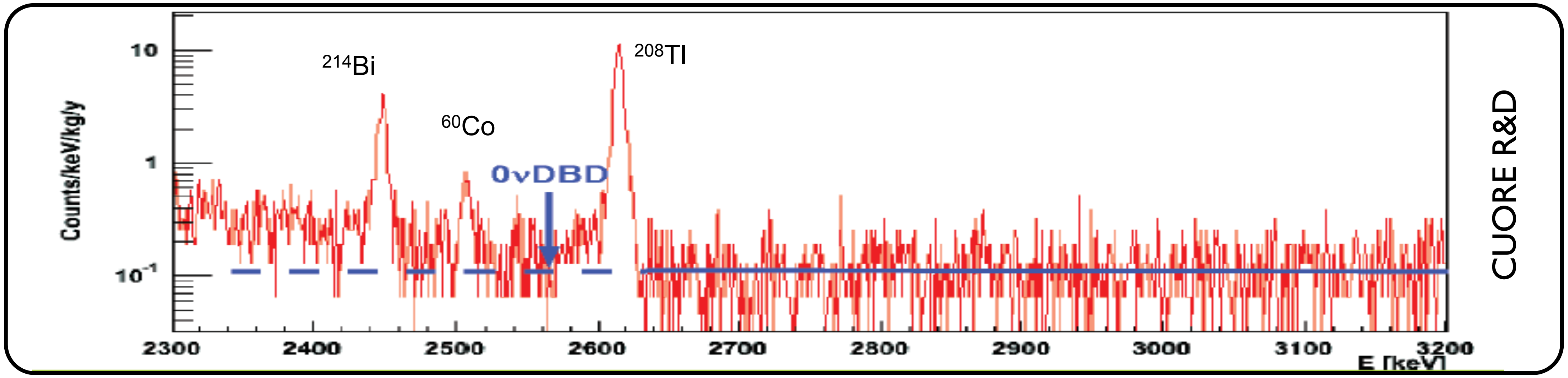
INFN / CUORE Mentors: Lucia Canonica & Carlo Bucci

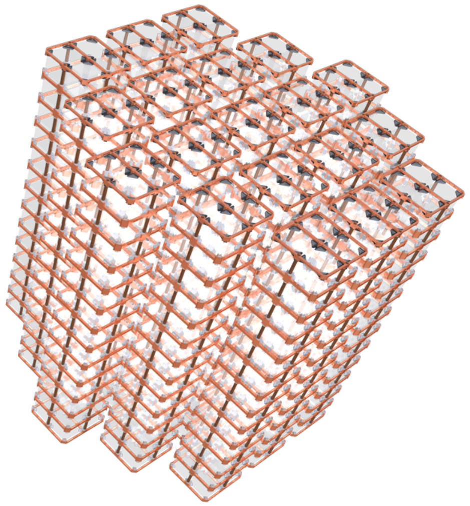
Introduction

ABSuRD: A Background-Surface Reduction Detector

Detector surfaces “polluted” with radioactive materials (αs)

Limiting background for CUORE / **0νββ** searches



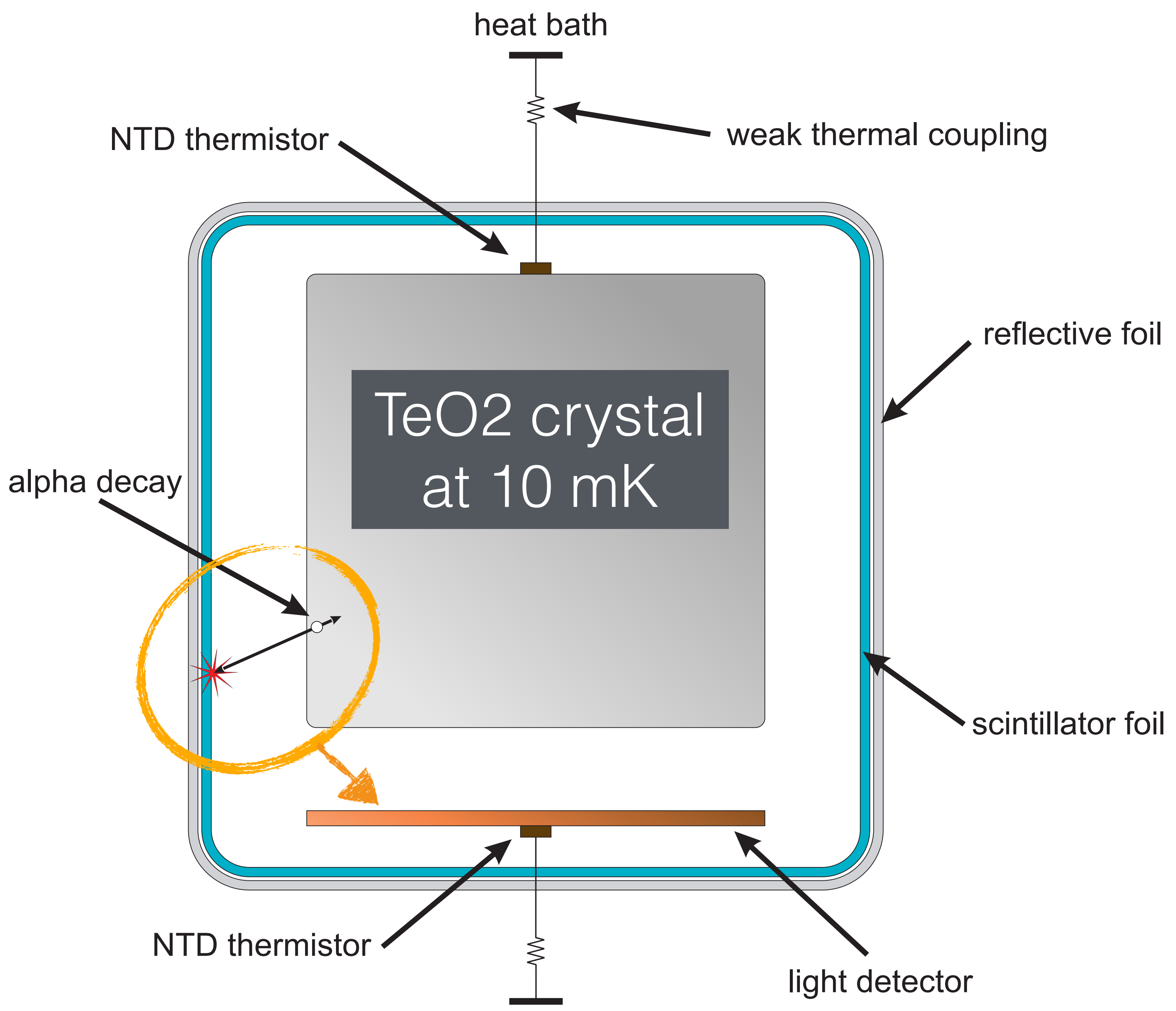


CUORE

Rare ➠ Background rejection at unprecedented levels !

Introduction

ABSuRD: A Background-Surface Reduction detector



Employ scintillator cover

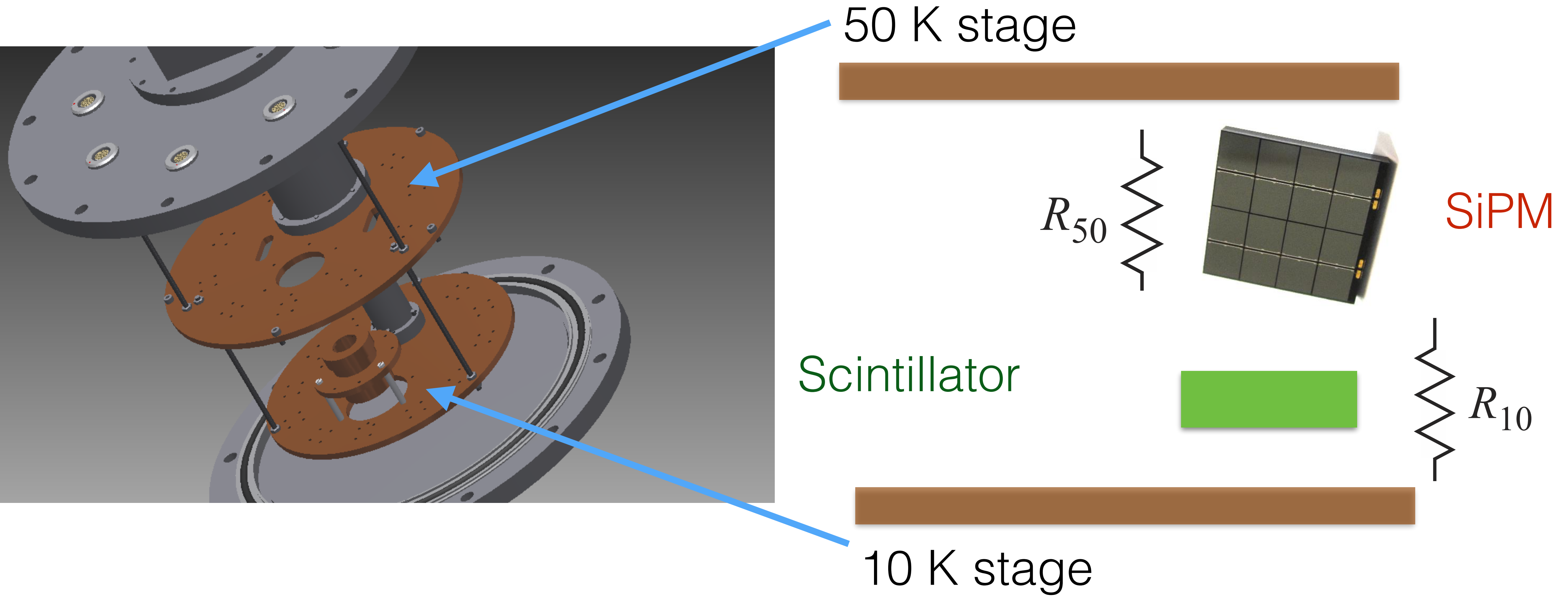
Veto events when the scintillator is active

Setup

Understand scintillation at low T (< 100 K)

Need **Si**licon **P**hoto **M**ultiplier to measure scintillation

➥ **characterize photon detectors at low T**



50 K stage

R_{50}

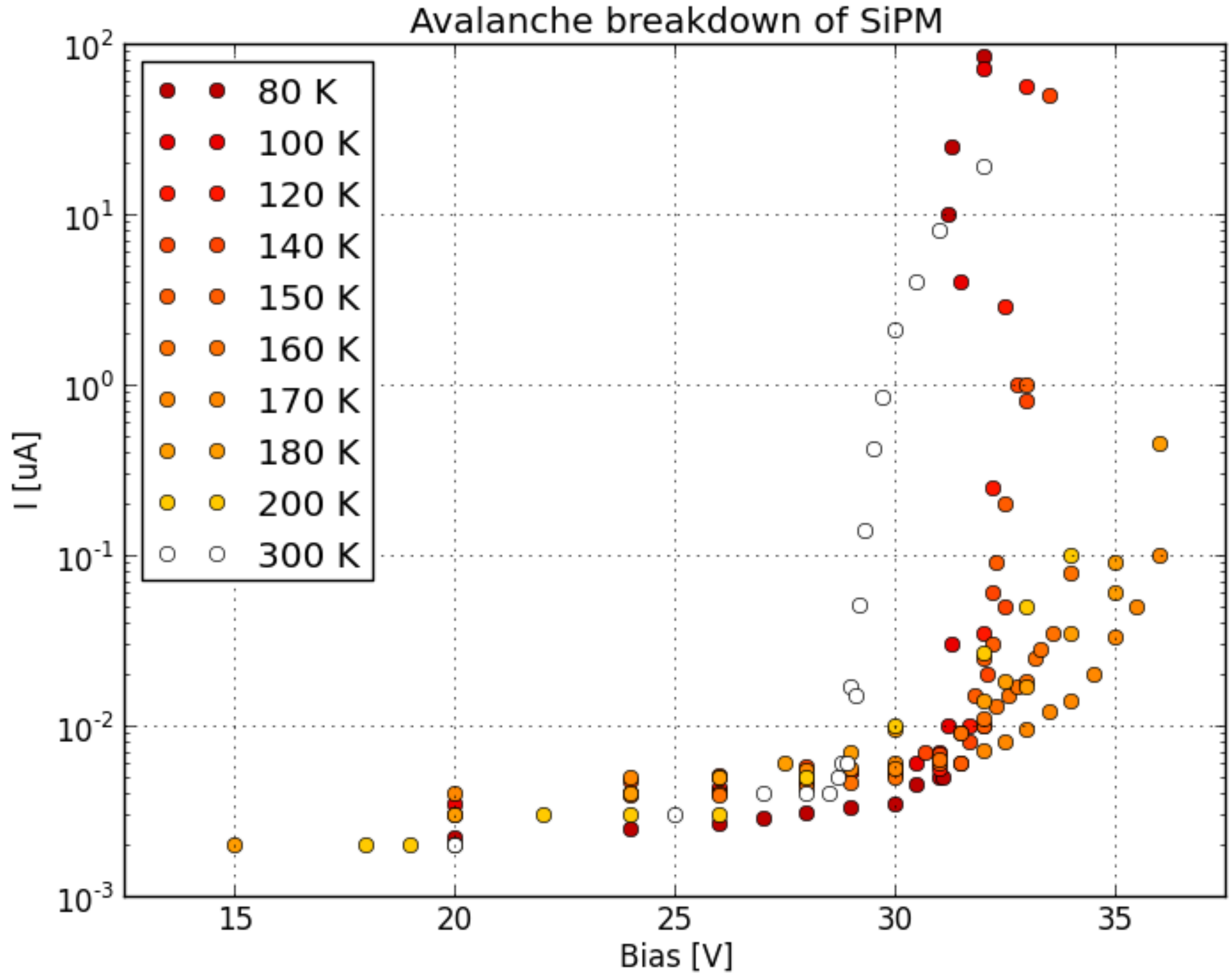
SiPM

Scintillator

R_{10}

10 K stage

SiPM performance



Break-down is largely independent of temperature (~30 V)

SiPM performance

Operate at 32 V bias

Need good pulses & low “noise triggers”
➥ good energy resolution.

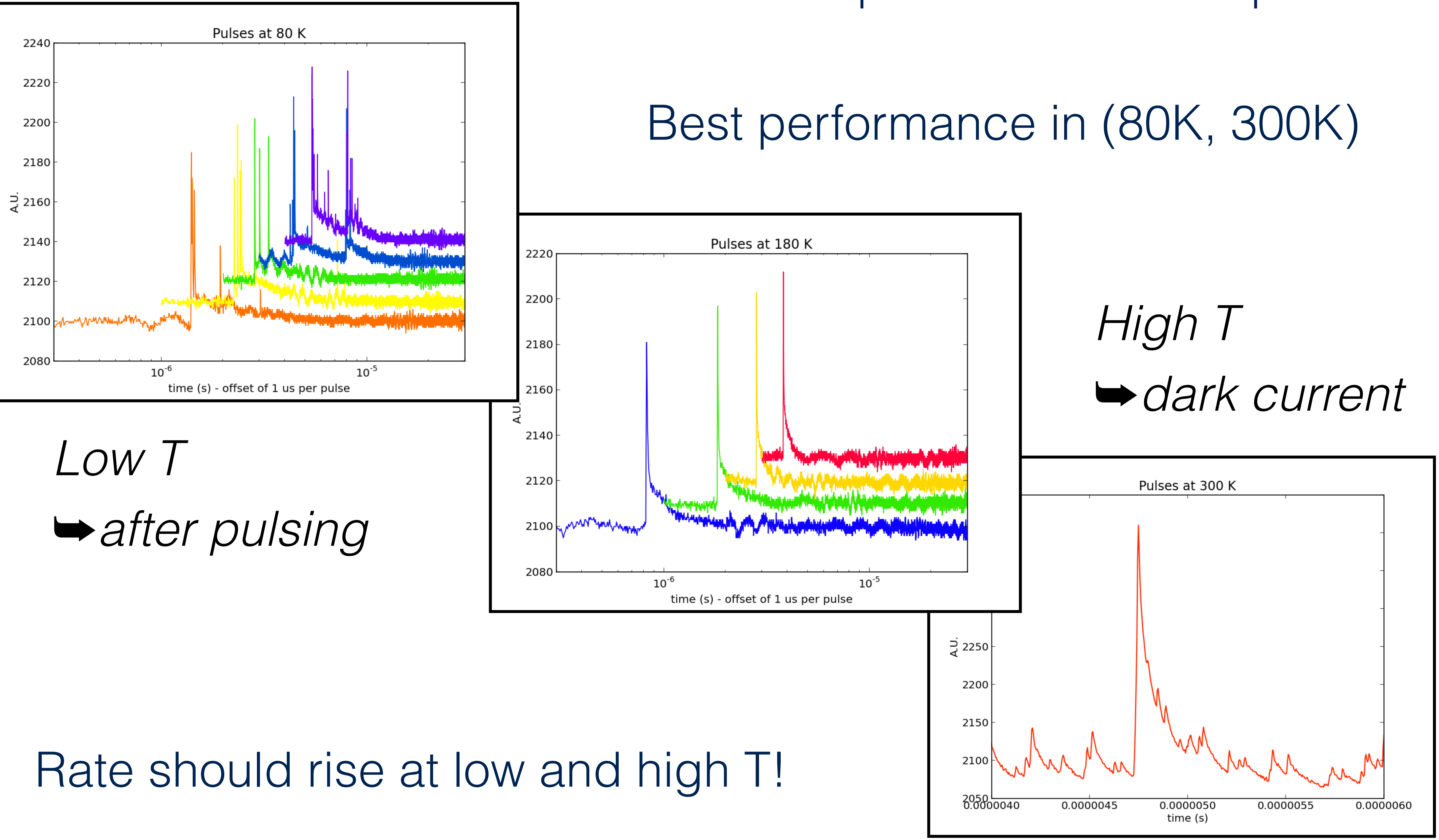
Benchmark on total rate and photoelectron statistics

Find best operating temperature

SiPM performance

Pulse shape varies with temperature

Best performance in (80K, 300K)



High T

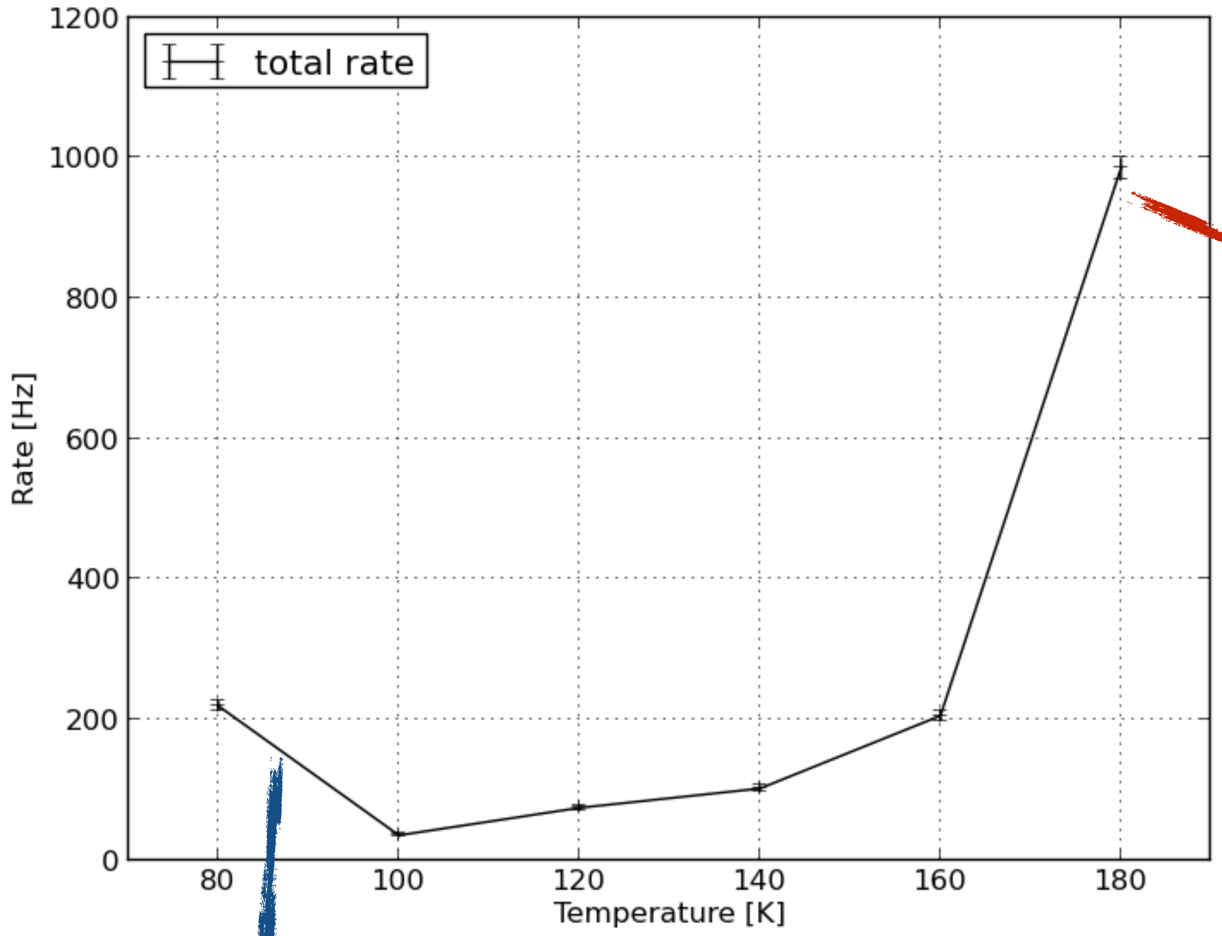
➥*dark current*

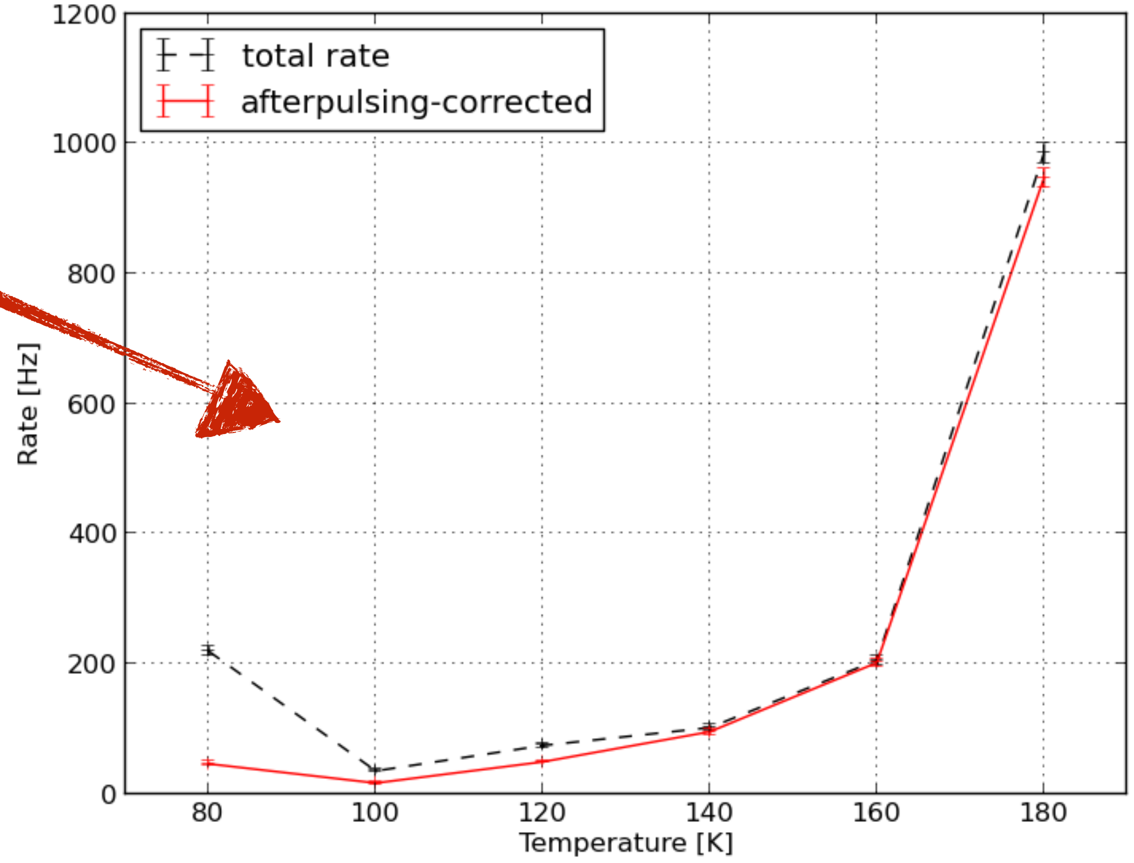
Low T

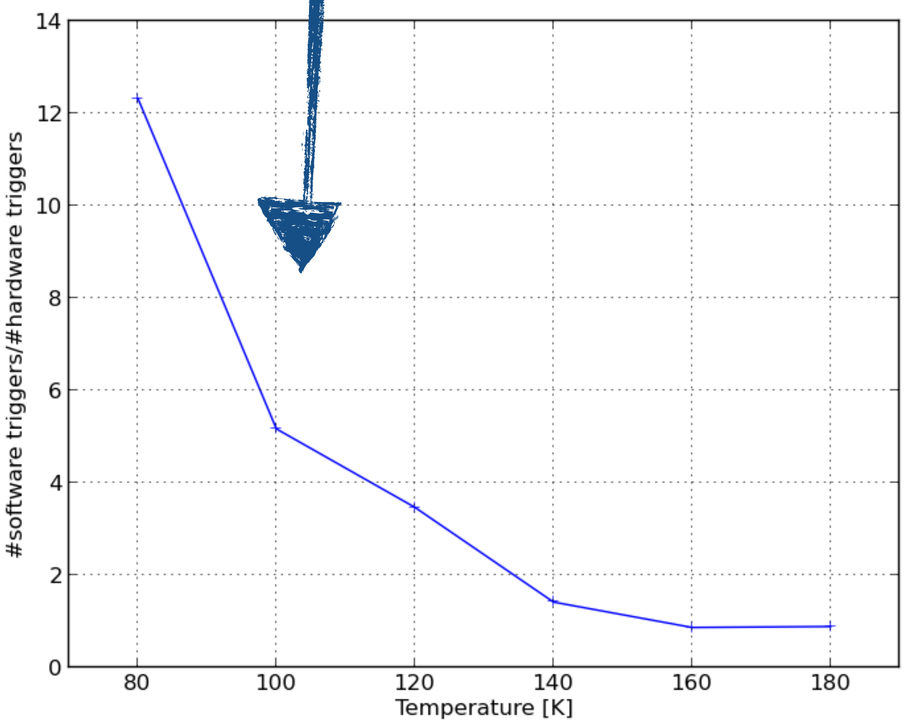
➥*after pulsing*

Rate should rise at low and high T!

SiPM performance



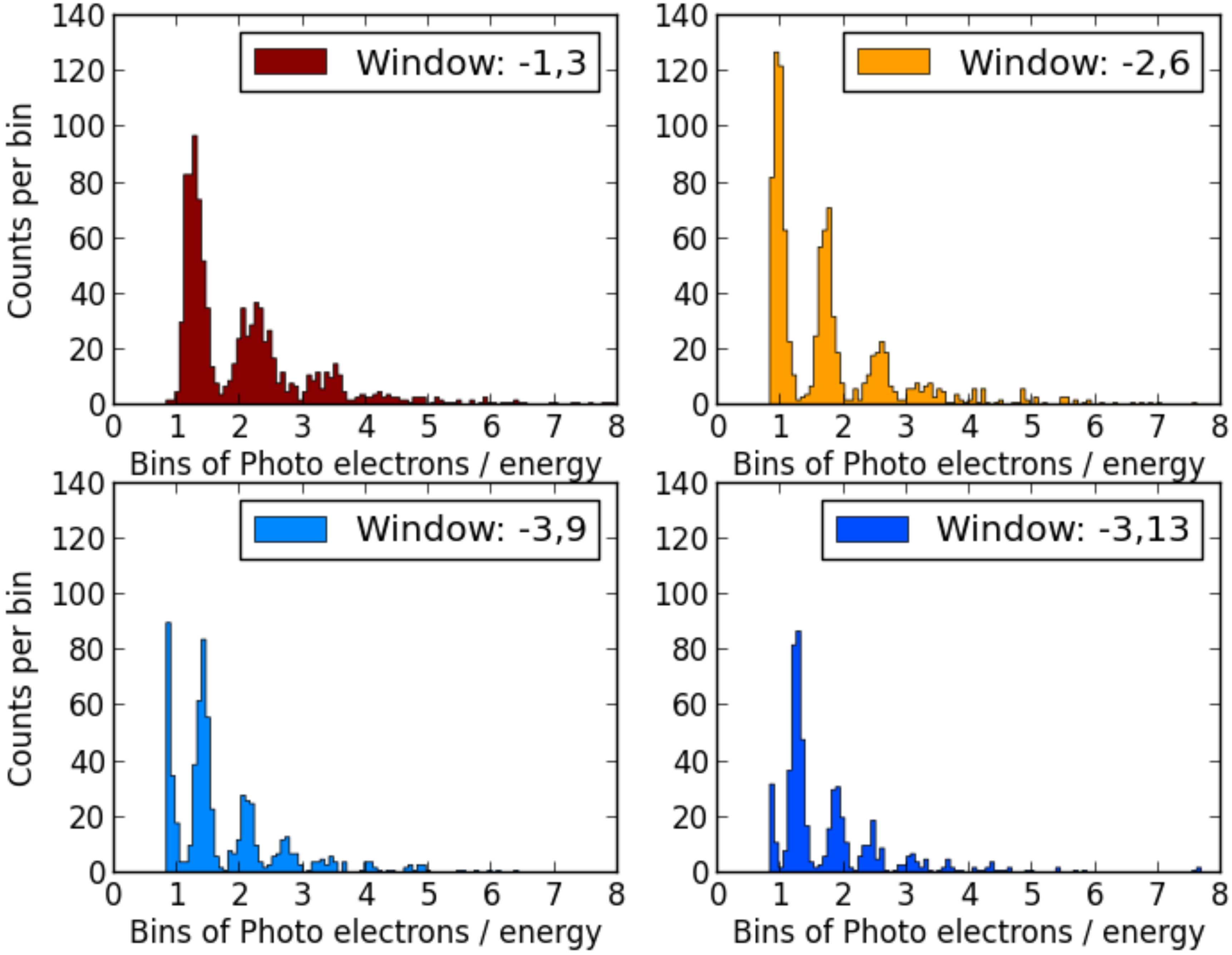




Total rate is low between 80 and180 K

Independently decompose total rate into after-pulsing and dark current rates

SiPM performance



Results from a180K run

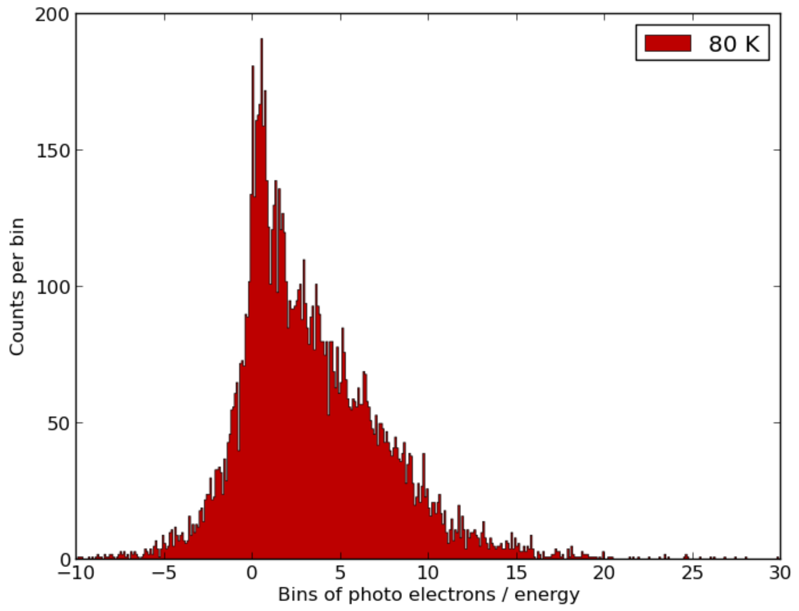
Energy from $\int$ pulse

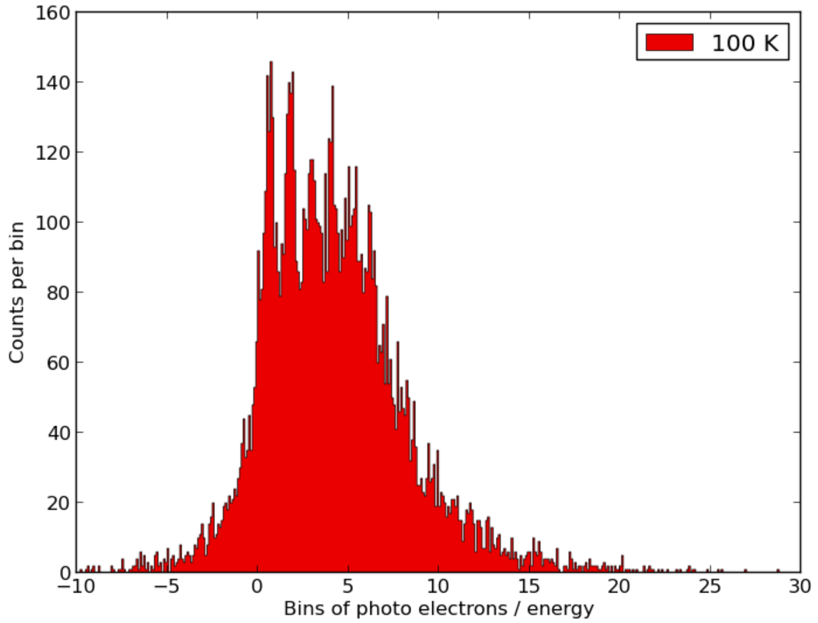
Integer photoelectrons clearly resolved

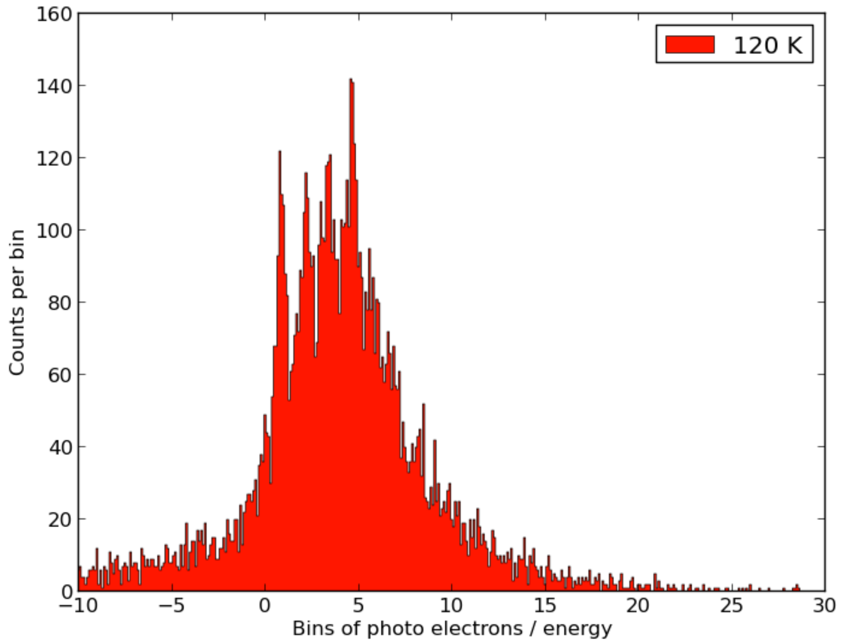
Resolution depends on window of $\int$ pulse

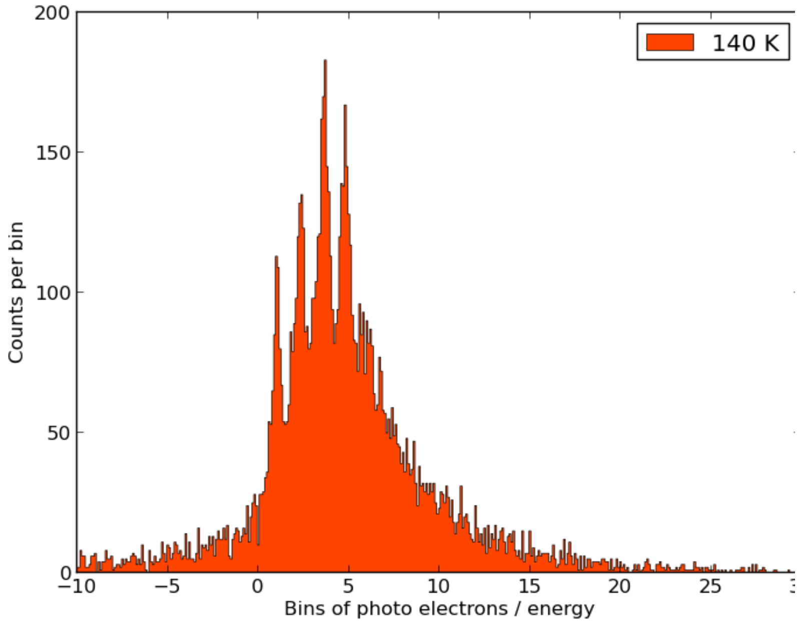
SiPM performance

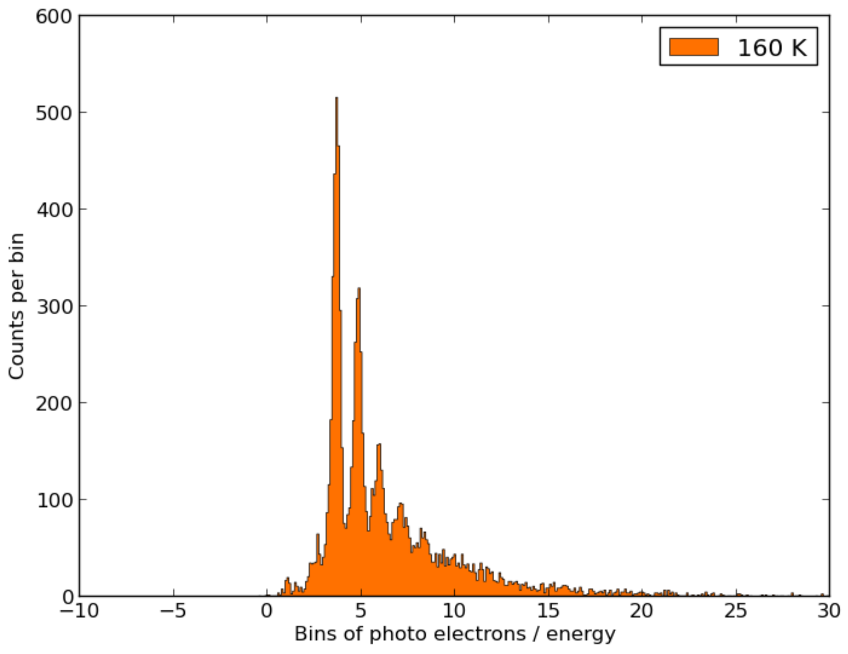
Photon counting reveals optimal SiPM operations at 160-180 K

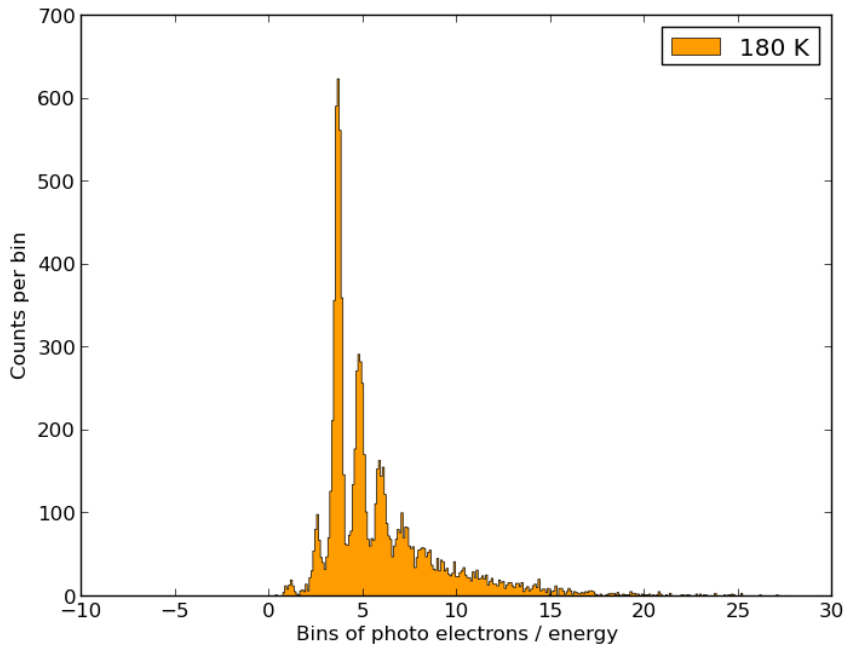












Conclusions

ABSuRD will reduce surface (main) backgrounds for CUORE by utilizing scintillator cover around the detectors

To study scintillators at low T we need to first characterize SiPM

SiPM operating temperatures and bias voltages were explored

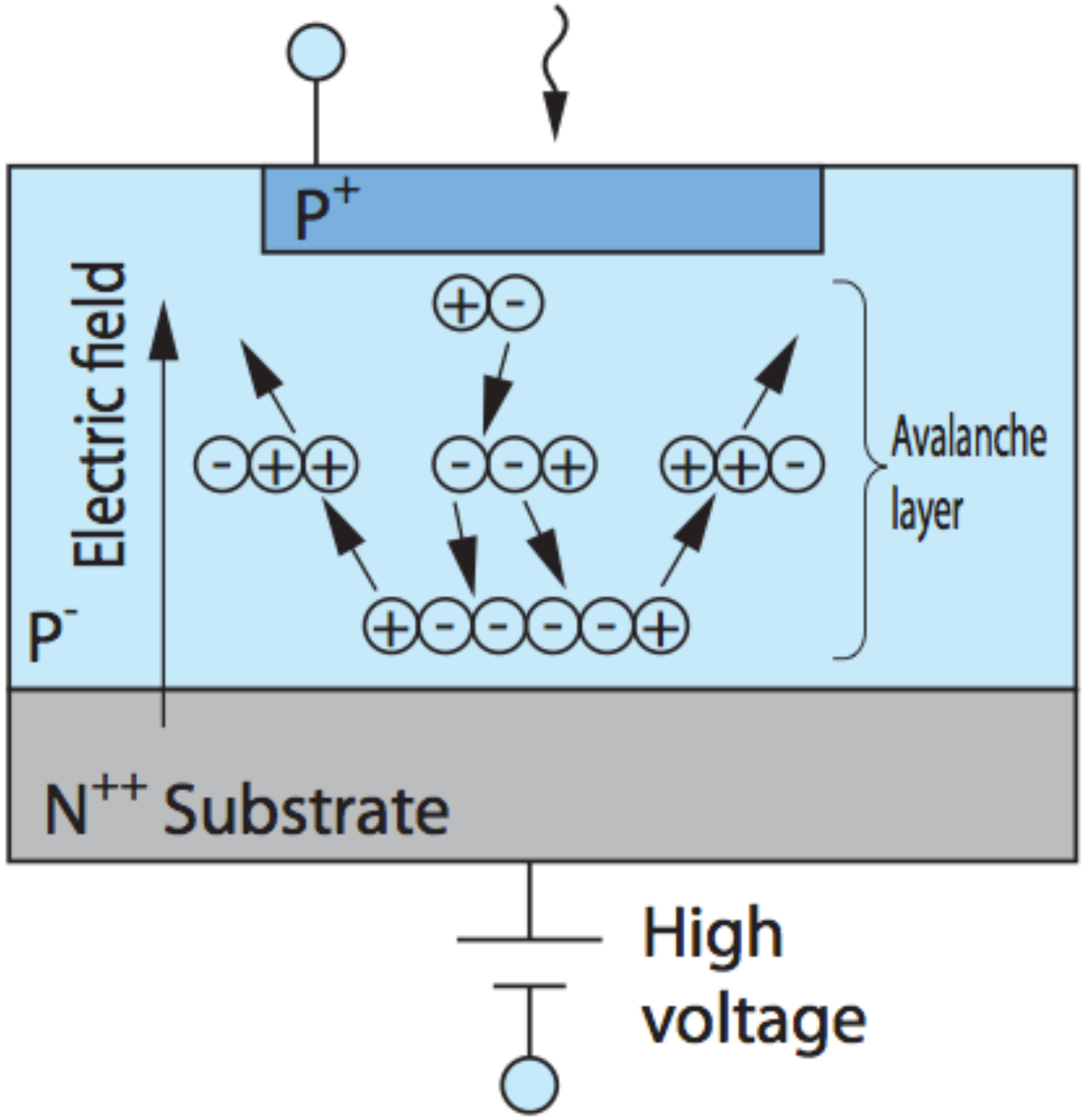
Dark current data quality suggests operation around 160K and 32V

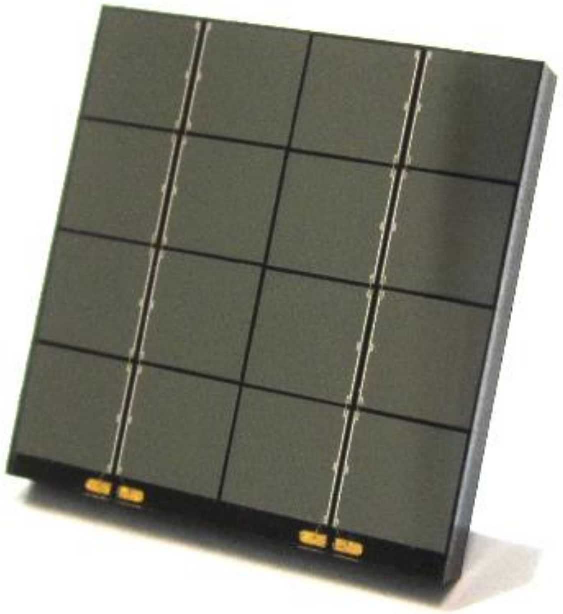
Extra Slides

SiPM

We use **Si**licon **P**hoto **M**ultiplier sensors

Photons excite electrons / holes leading to avalanche i.e. high amplification



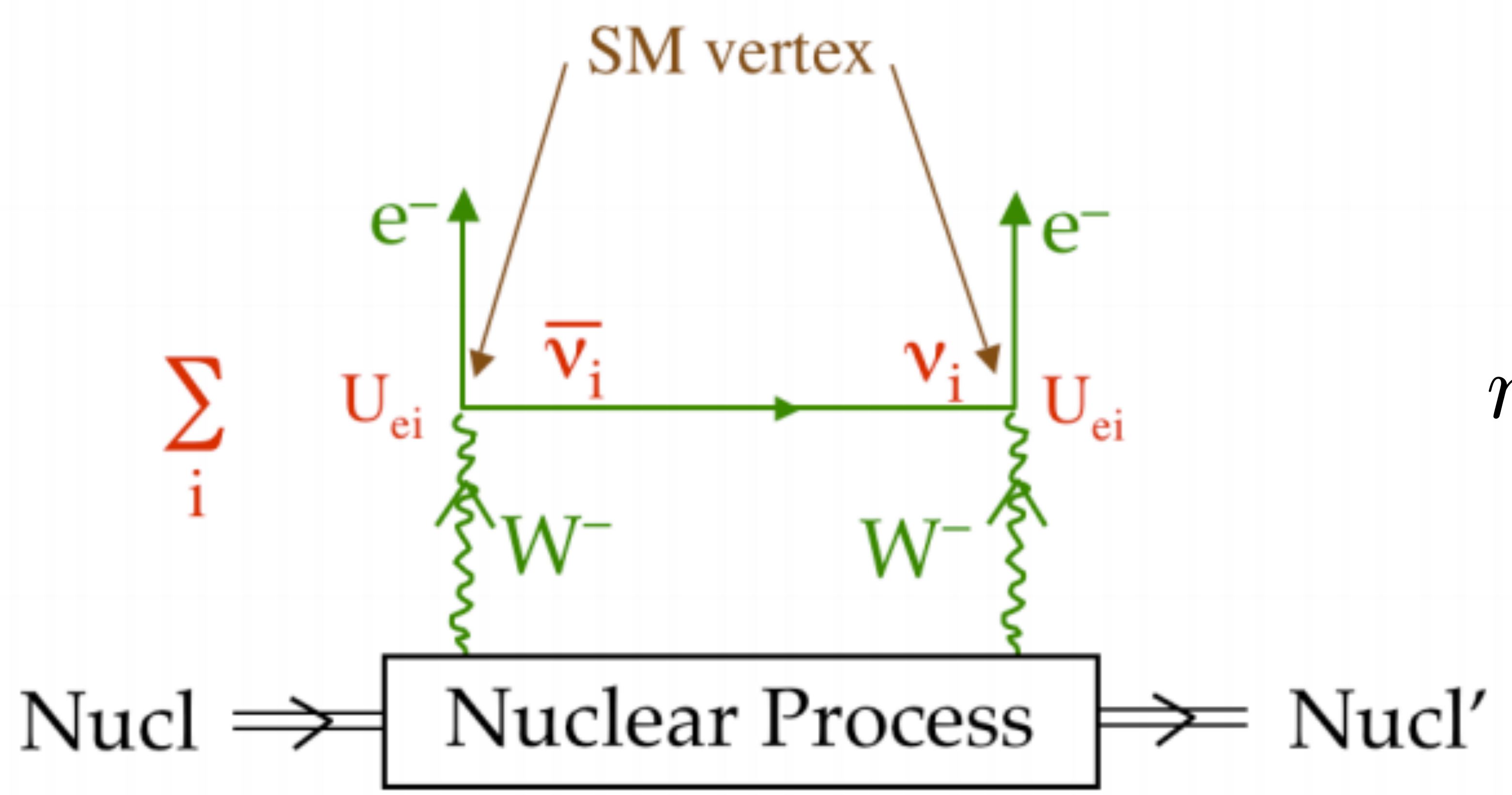


Features

- Detection of extremely faint light
- Very high gain (10^6)
- Extremely good timing performance
- Insensitive to magnetic fields
- Not damaged by ambient light
- Small and compact

Double beta decay probe

The possibility of Majorana neutrinos and the mass scale



$$m_{\beta\beta} = |\sum_k m_i U_{e,i}^2 \ \nu_i|$$

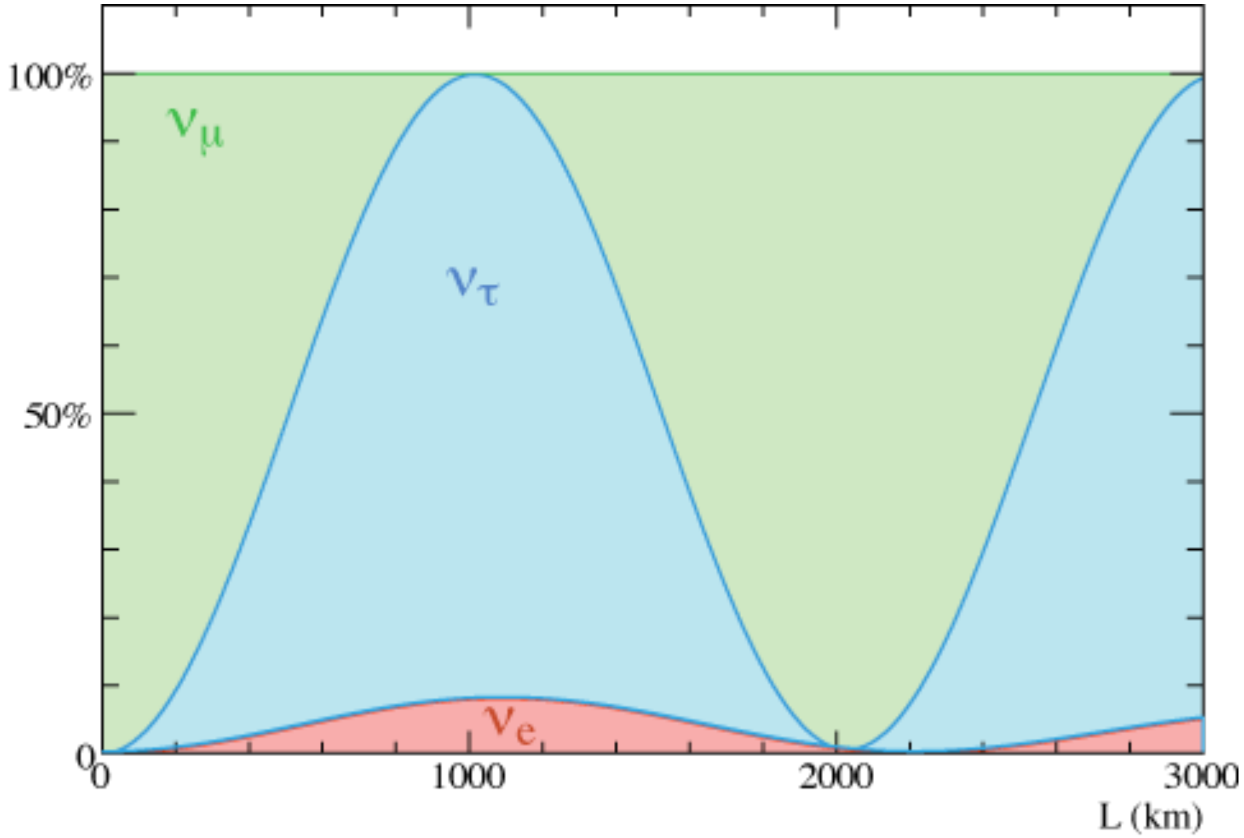
Neutrino Physics: Motivation

Known

3 types of neutrinos from cosmology and particle physics measurements

Flavor(leptonic) eigenstates: ν_e, ν_μ, ν_τ

Mass eigenstates: ν_1, ν_2, ν_3



Types evidenced by mass differentials

These are measured in oscillating content of a neutrino beam

Ex: flavor modulation of NOVA's ν_μ beam with distance.

Neutrinos

Known

3 types of neutrinos from cosmology and particle physics measurements

Flavor / mass eigenstates: ν_e, ν_μ, ν_τ / ν_1, ν_2, ν_3

Unknown

What are the individual masses, mass scale and mass hierarchy ?

Since mass > 0, spin > 0, and charge = 0, neutrinos can be their own antiparticle; are they ?