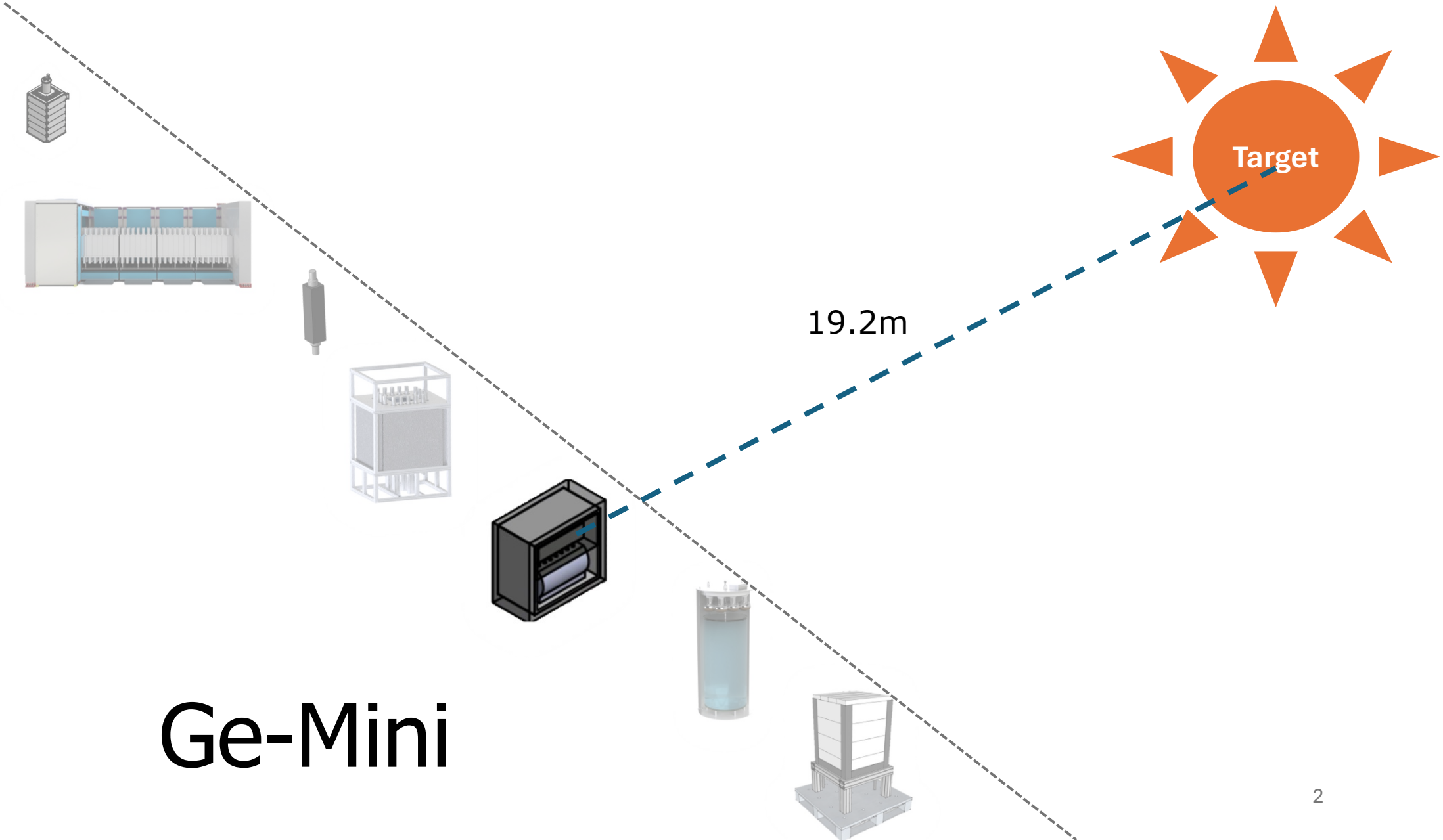
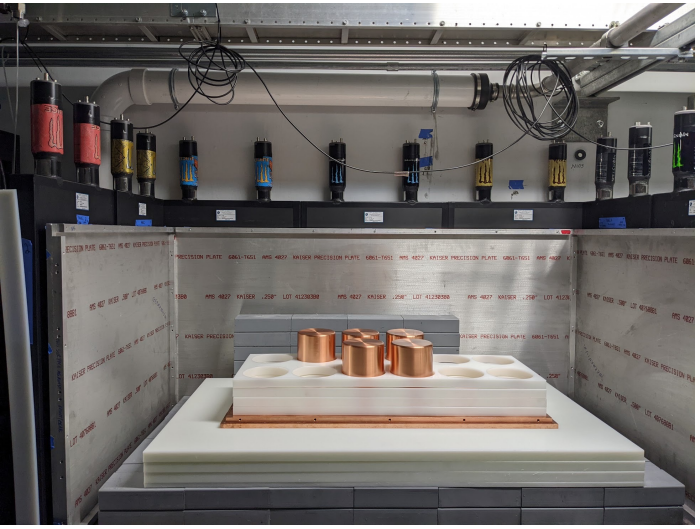
First Measurement of CEvNS on Germanium by COHERENT

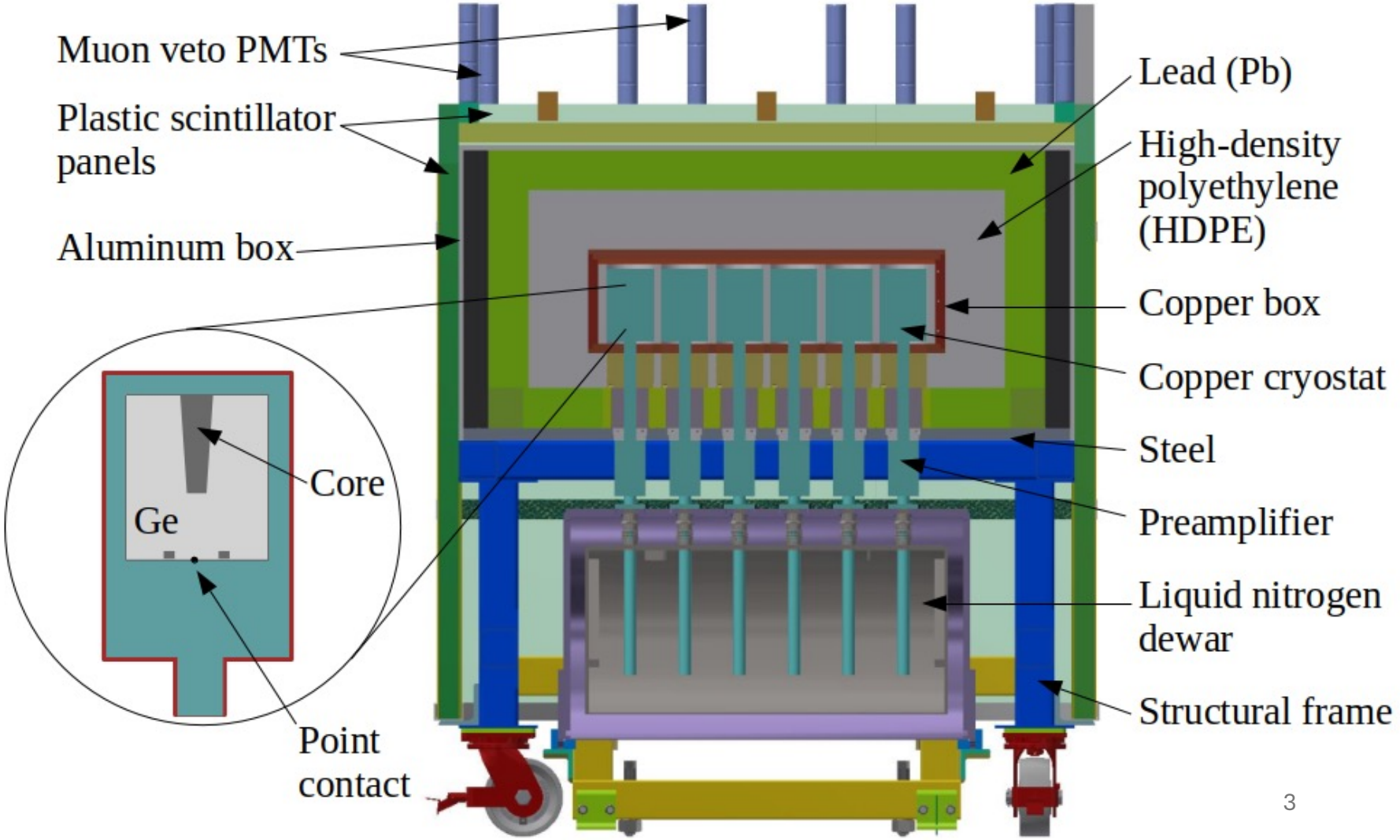
Ryan Bouabid on behalf of the COHERENT Collaboration



Ge-Mini



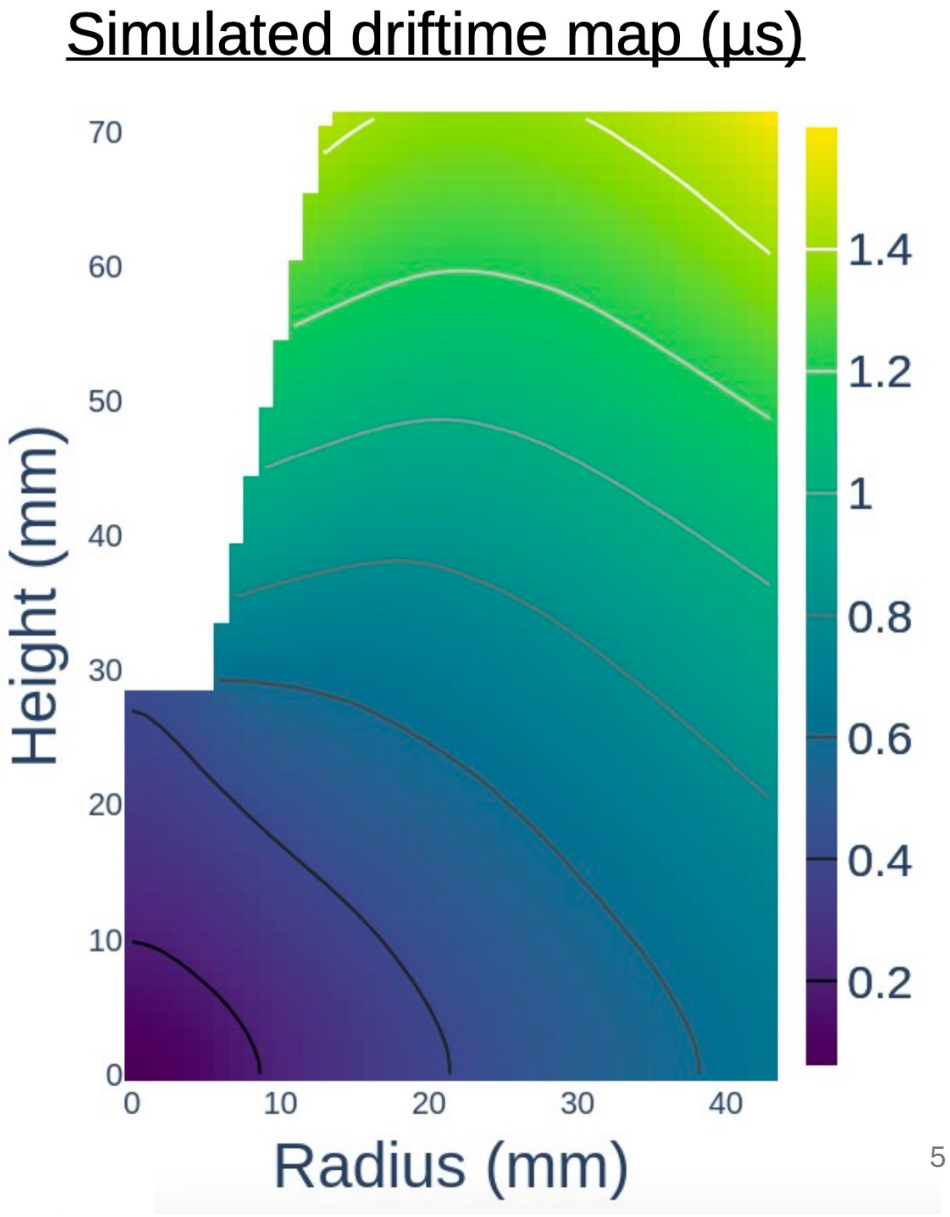
The Ge-Mini Detector System



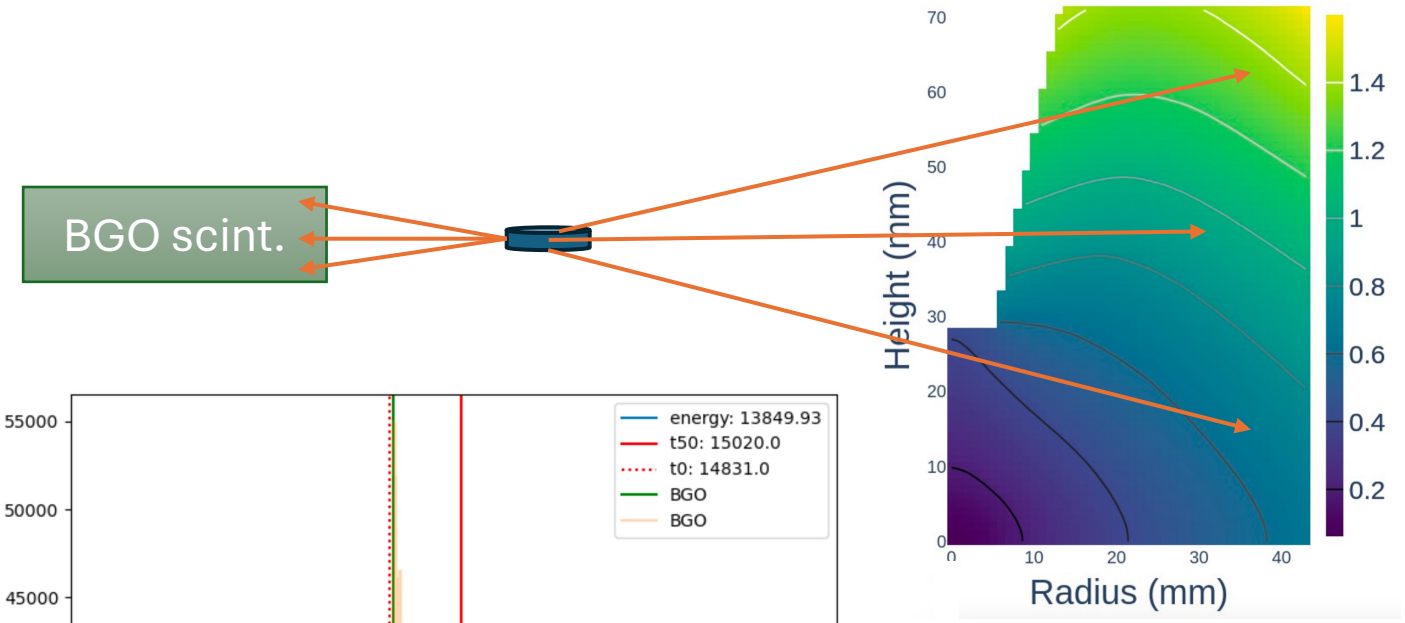
Detector	Mass [kg]	Pulser FWHM [eV]
Ge21	2.191	116
Ge22	2.215	---
Ge23	2.201	114
Ge24	2.260	145
Ge25	2.200	152
Ge26	2.270	146
Ge27	2.280	---
Ge28	2.290	135

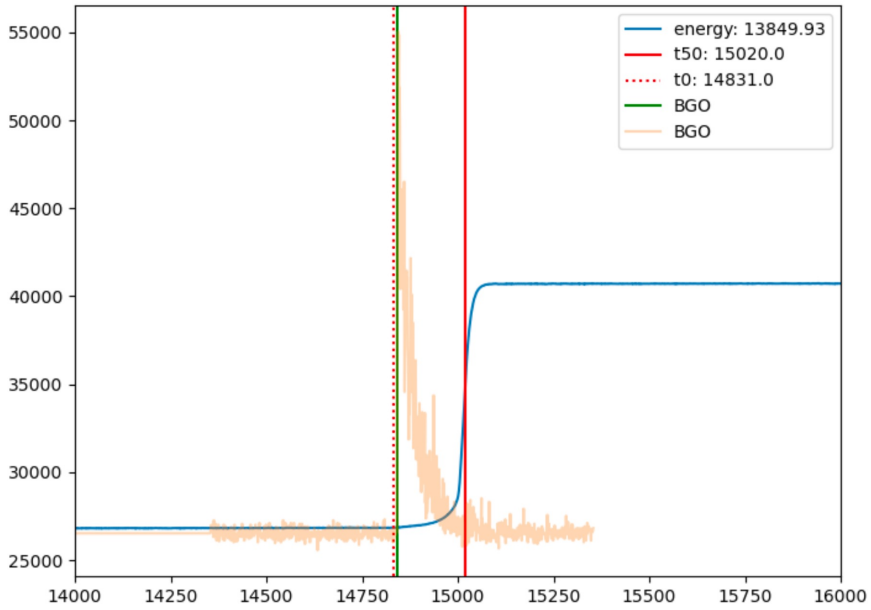
Ge-Mini HPGe's: 8 ICPC's

Larger crystals, longer drift times



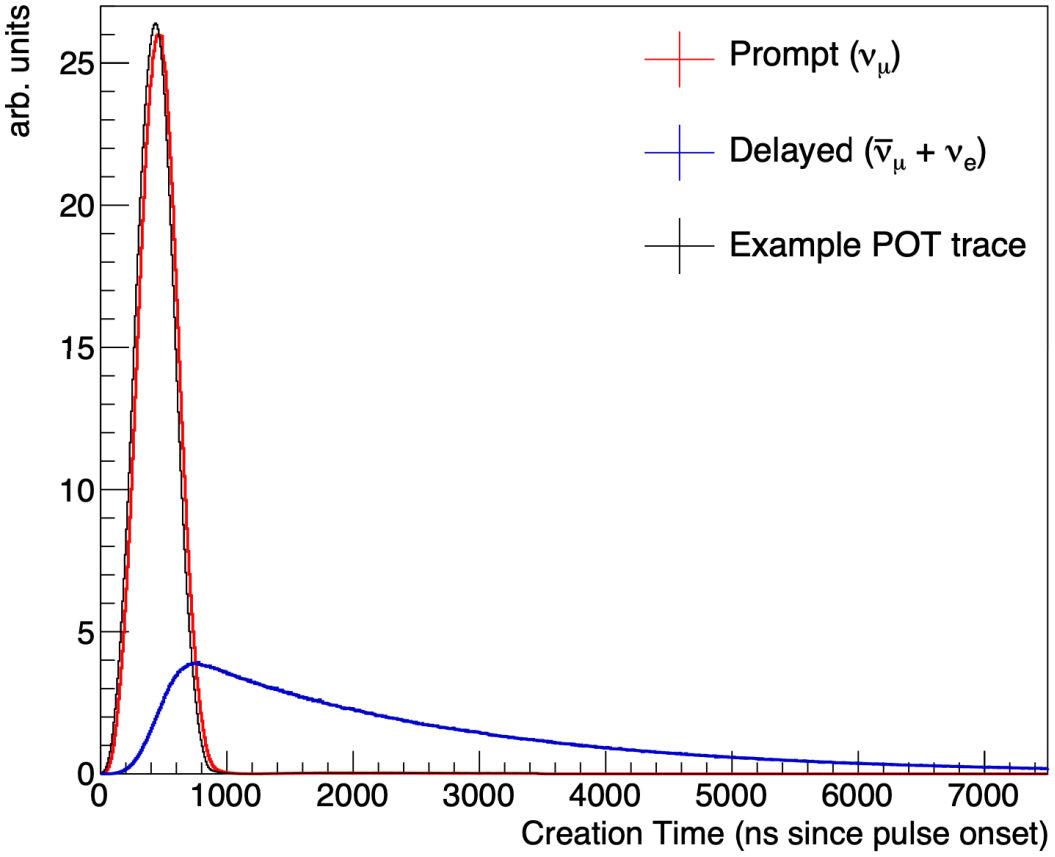
Drift time is a key part of an SNS measurement



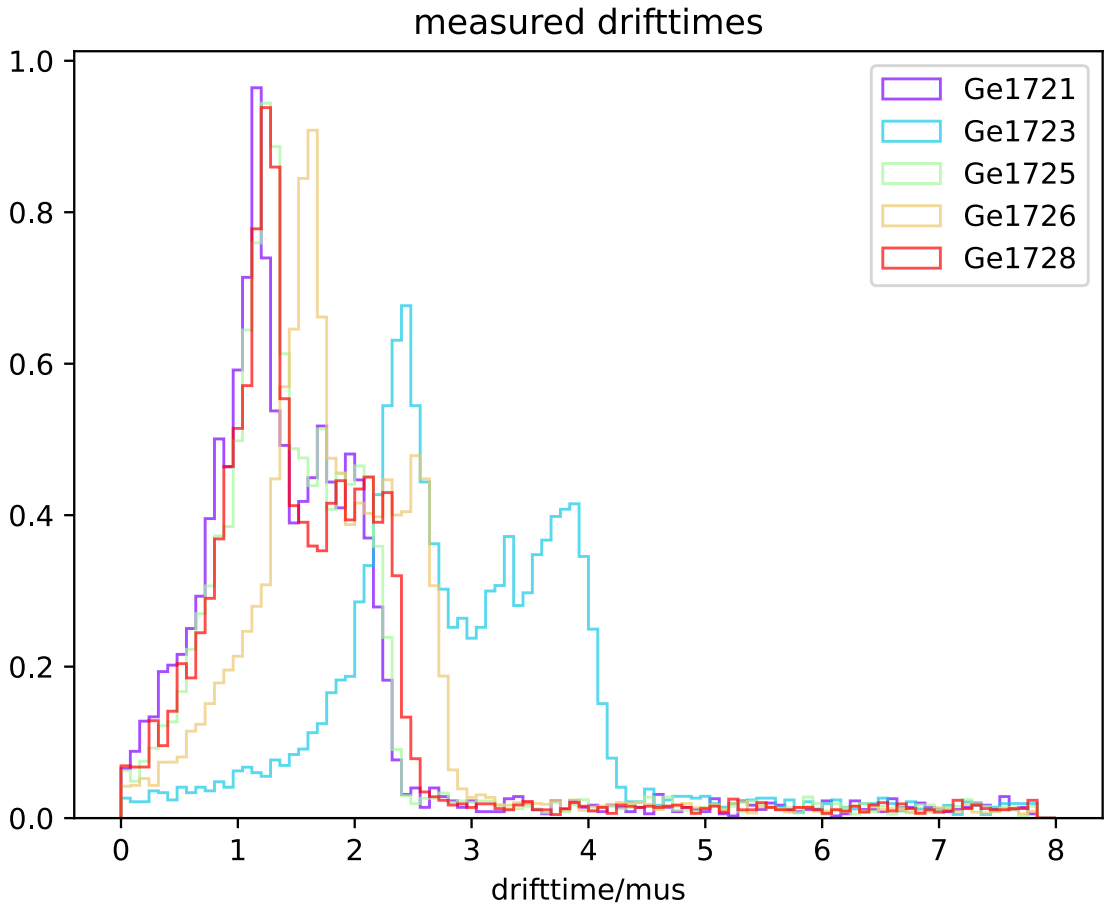


- Use a fast detector to get a "t_0"
- Measure time to "t_{50}": time to half of total charge collected

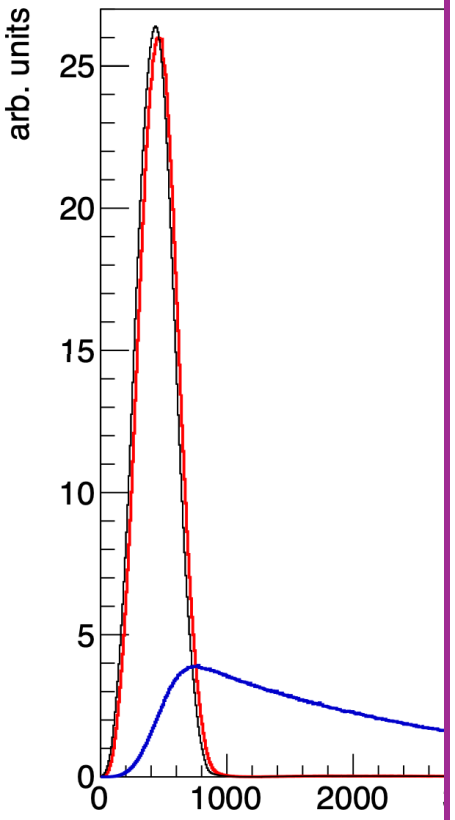
Combining drift time and neutrino arrival

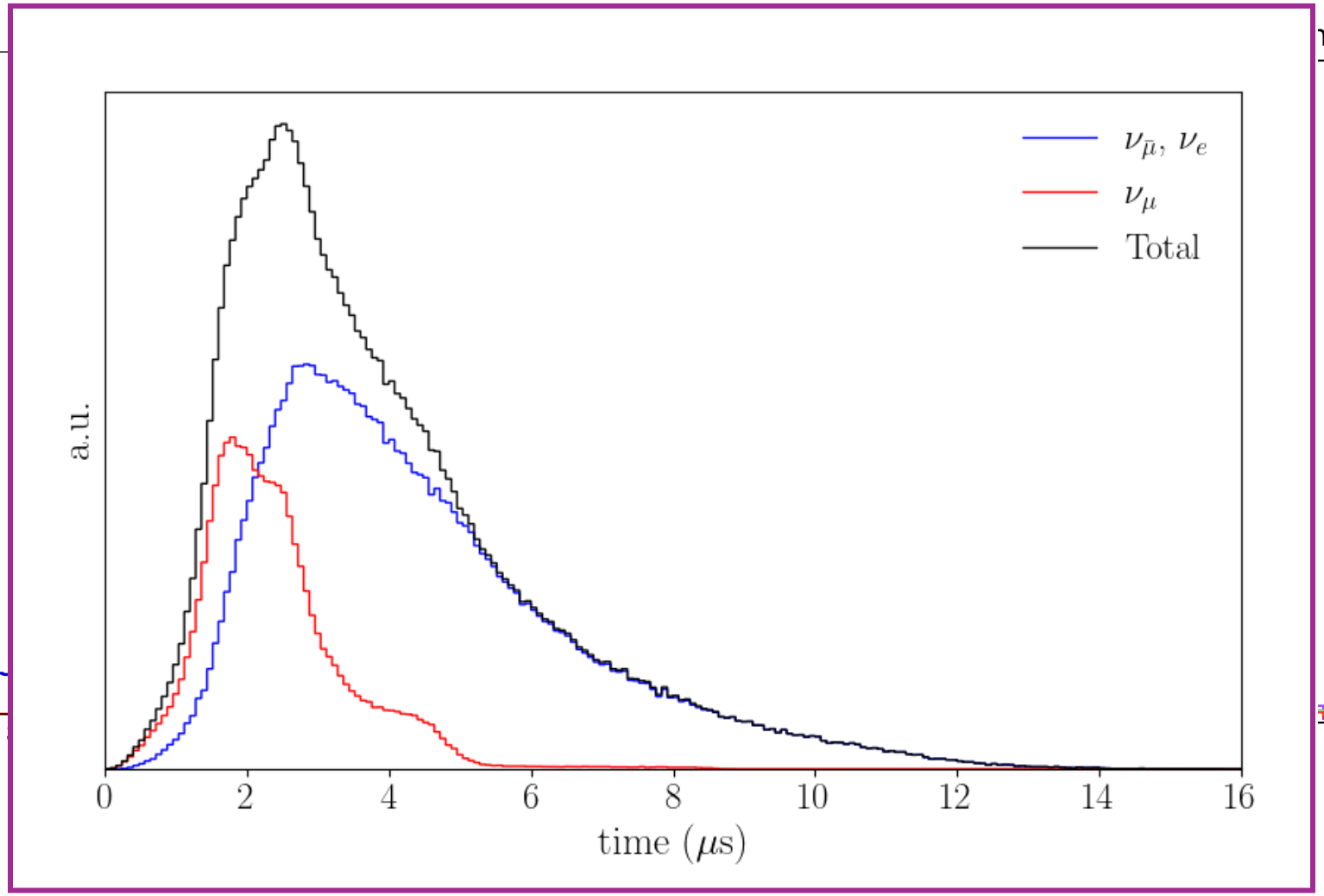


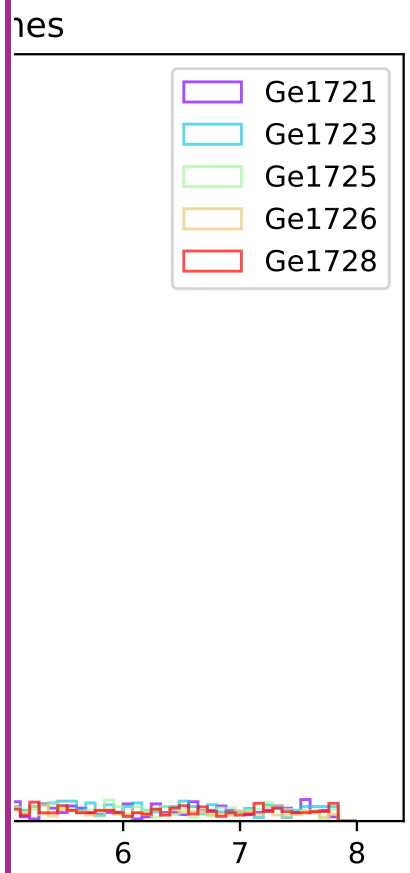
X



Combining drift time and neutrino arrival

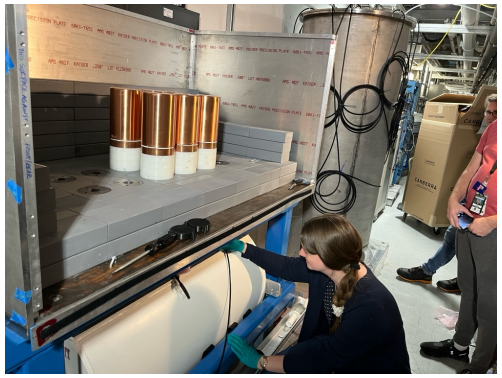






Ge-Mini arrives to the SNS; April 2022

First Campaign-1 LN fill in Neutrino Alley; Nov 2022



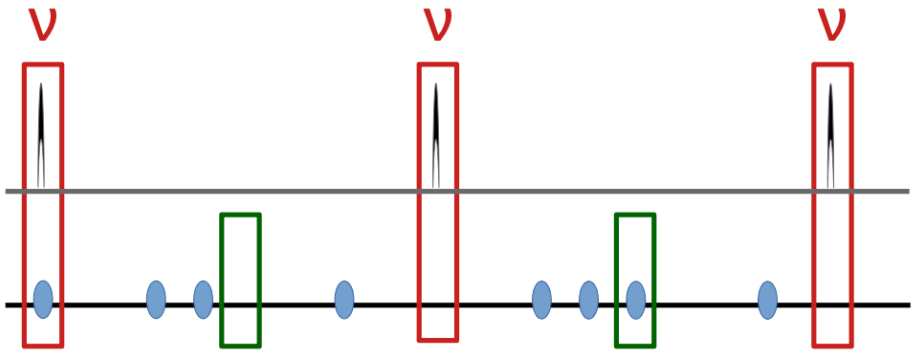
Final adjustments being made for Campaign-2; April 2023

Go!

Campain-2 Data Collection Schedule

internally triggered: calibration

externally triggered 120 Hz

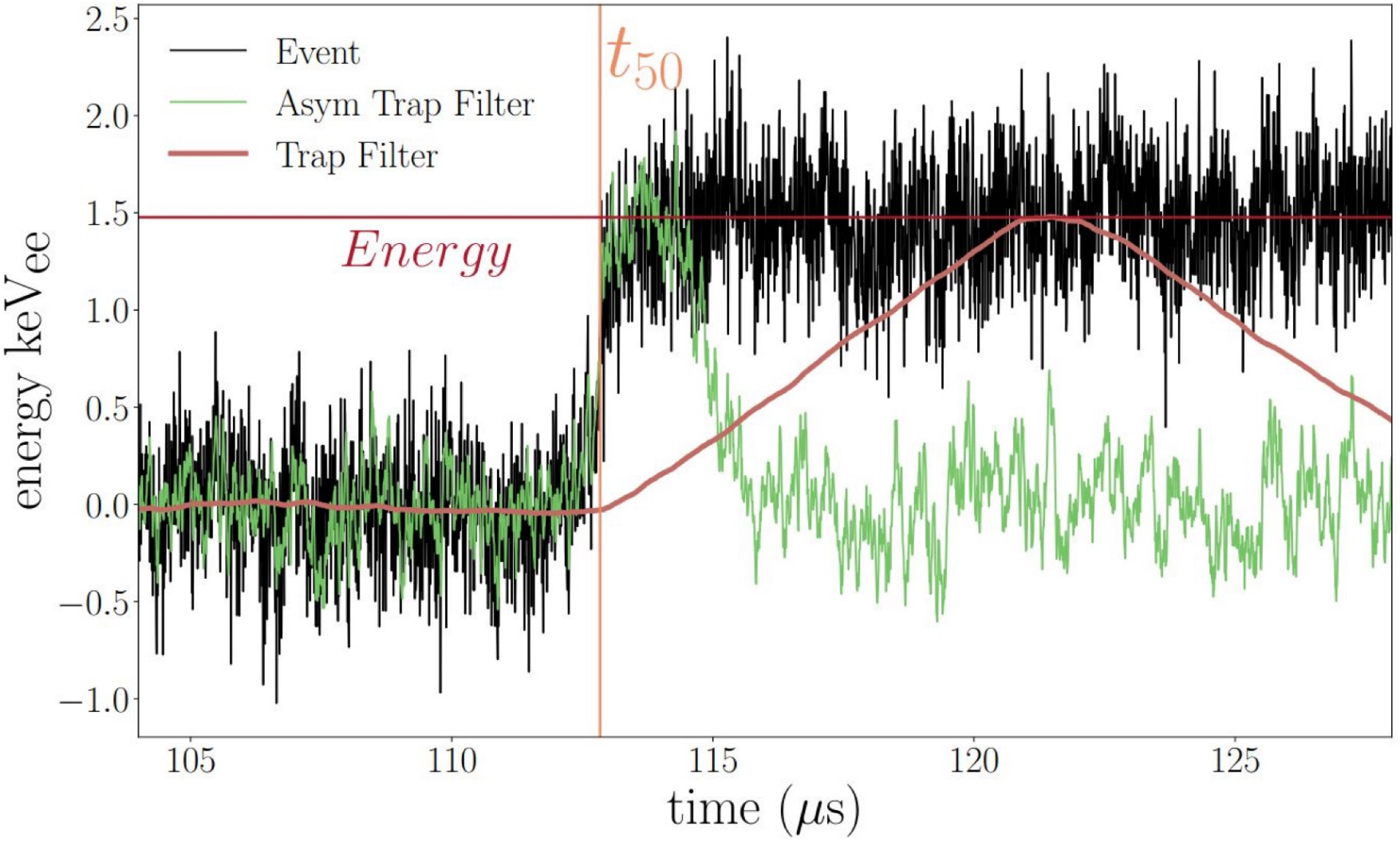


blinded beam windows
background windows

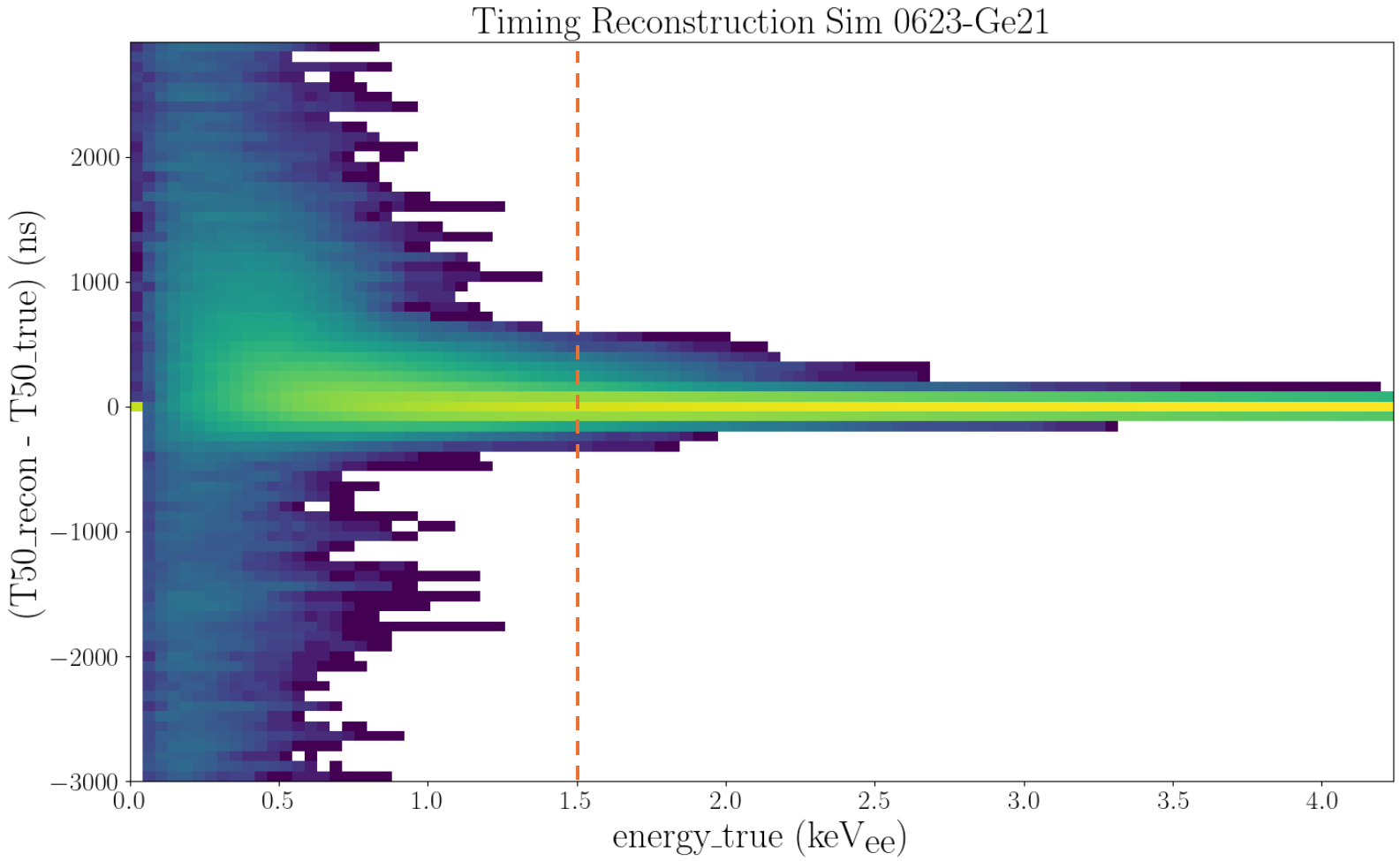
6/21	6/22	6/23	6/24	6/25	6/26	6/27
6/28	6/29	6/30	7/1	7/2	7/3	7/4
7/5	7/6	7/7	7/8	7/9	7/10	7/11
7/12	7/13	7/14	7/15	7/16	7/18	7/19
7/20	7/21	7/22	7/23	7/24	7/25	7/26
7/27	7/28	7/29	7/30	7/31	8/1	8/2
8/3	8/4	8/5	8/6	8/7	8/8	8/9
8/10	8/11	8/12	8/13	8/14	8/15	8/16

Externally triggered Internally triggered

Waveform Reconstruction



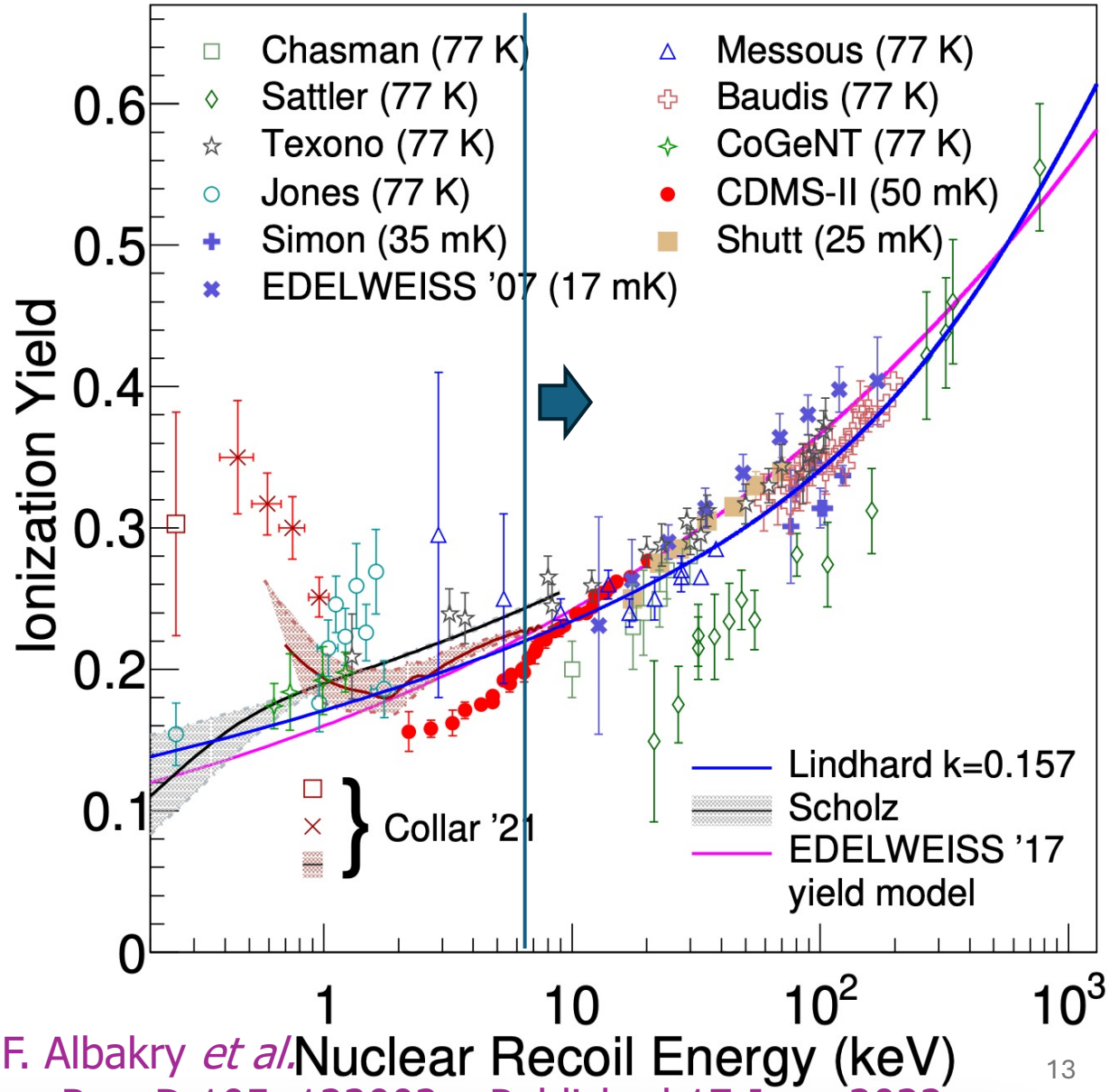
Reconstruction Fidelity



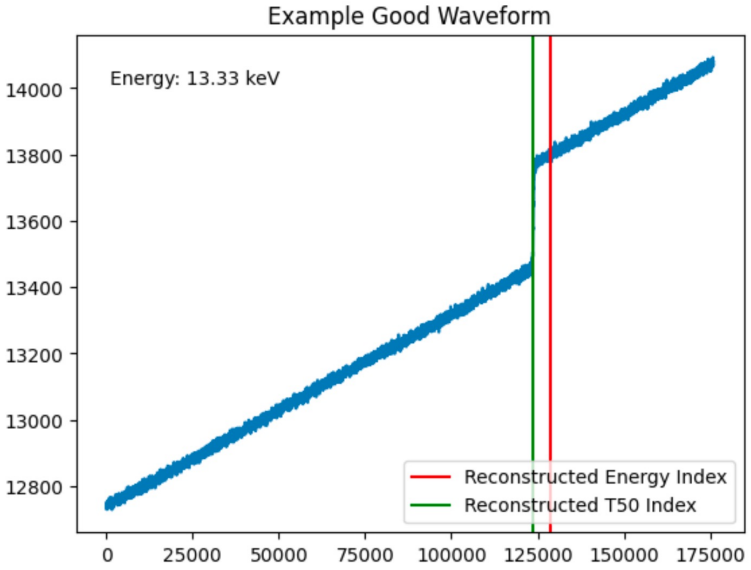
Campaign-2 thresholds limited by accurate timing reconstruction: ***1.5 keV$_{ee}$***

A quick note on Quenching Factors

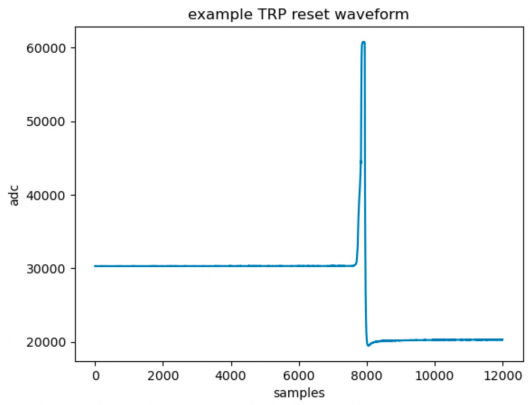
- *Linhard Model:* k = 0.157
- 1.5 keV_{ee} translates to 6.7 keV_{nr}

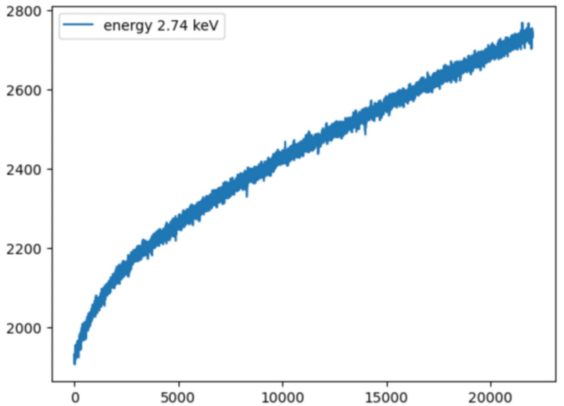


M. F. Albakry *et al.*
Phys. Rev. D 105, 122002 – Published 17 June 2022

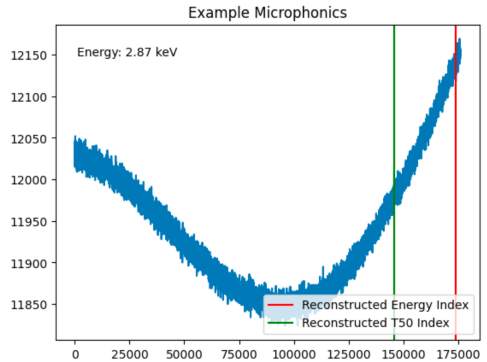


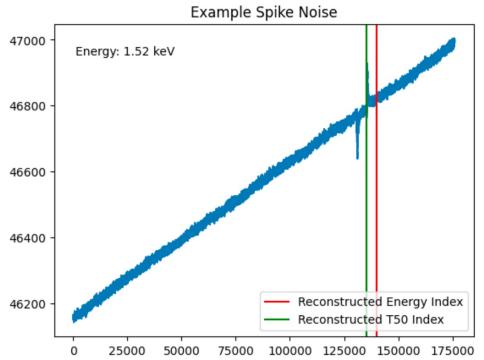
Separate these good events, from bad events with a few simple parameters





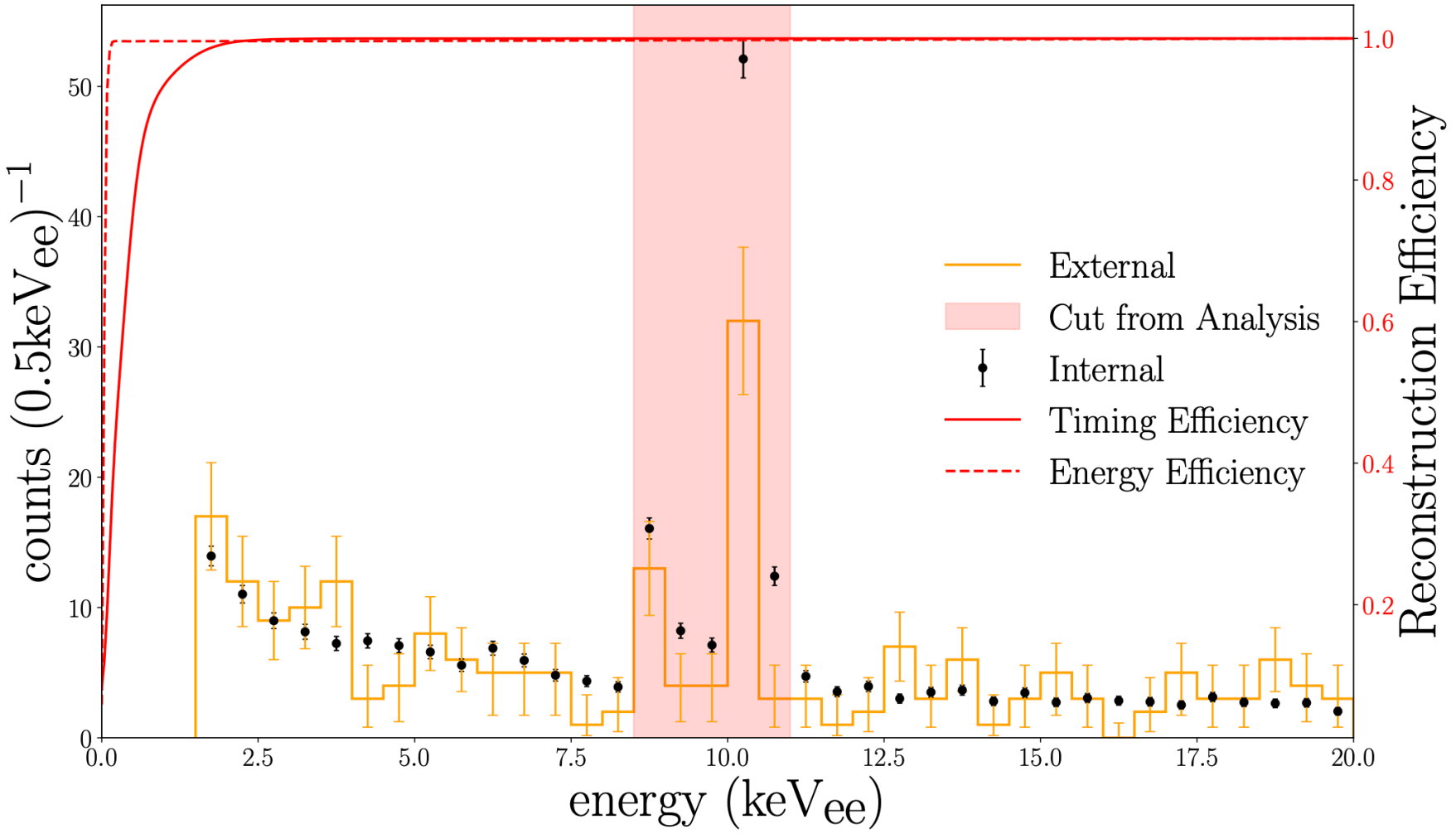
Preamplifier reset related events





Other types of bad waveforms Microphonics, chirps, etc

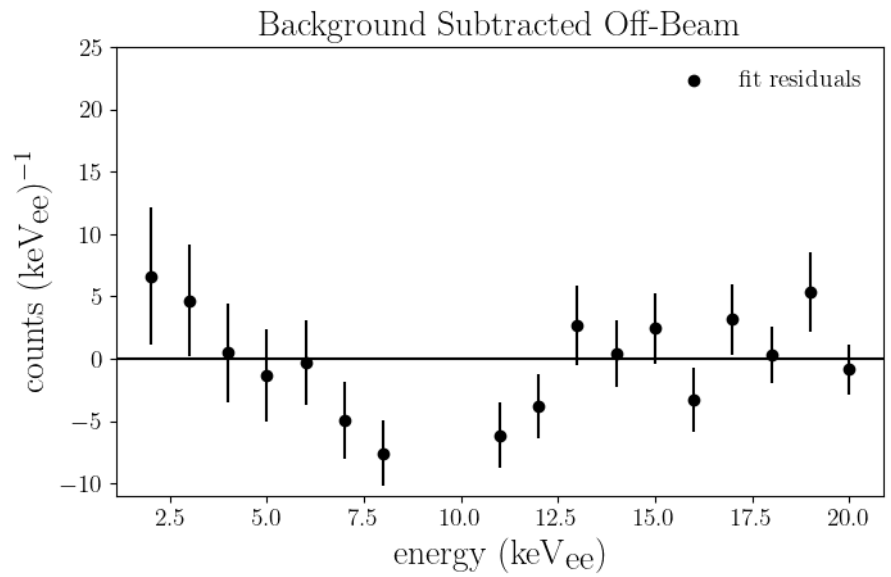
- PDF shape from high stats internal trigger data
- Measure background in "off-beam" external trigger

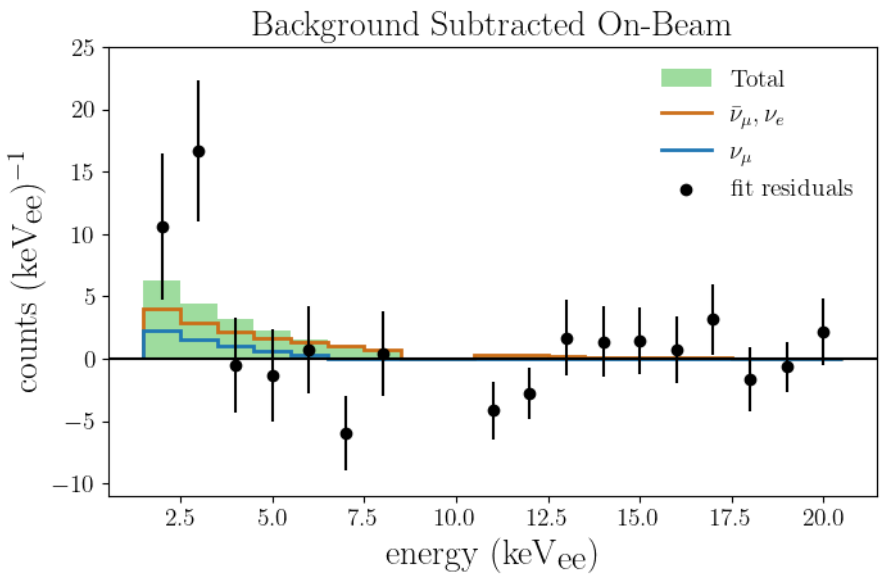


Counting analysis:

21 ± 7.8

[1.5,8.5] keV$_{ee}$ & [0,8] μs



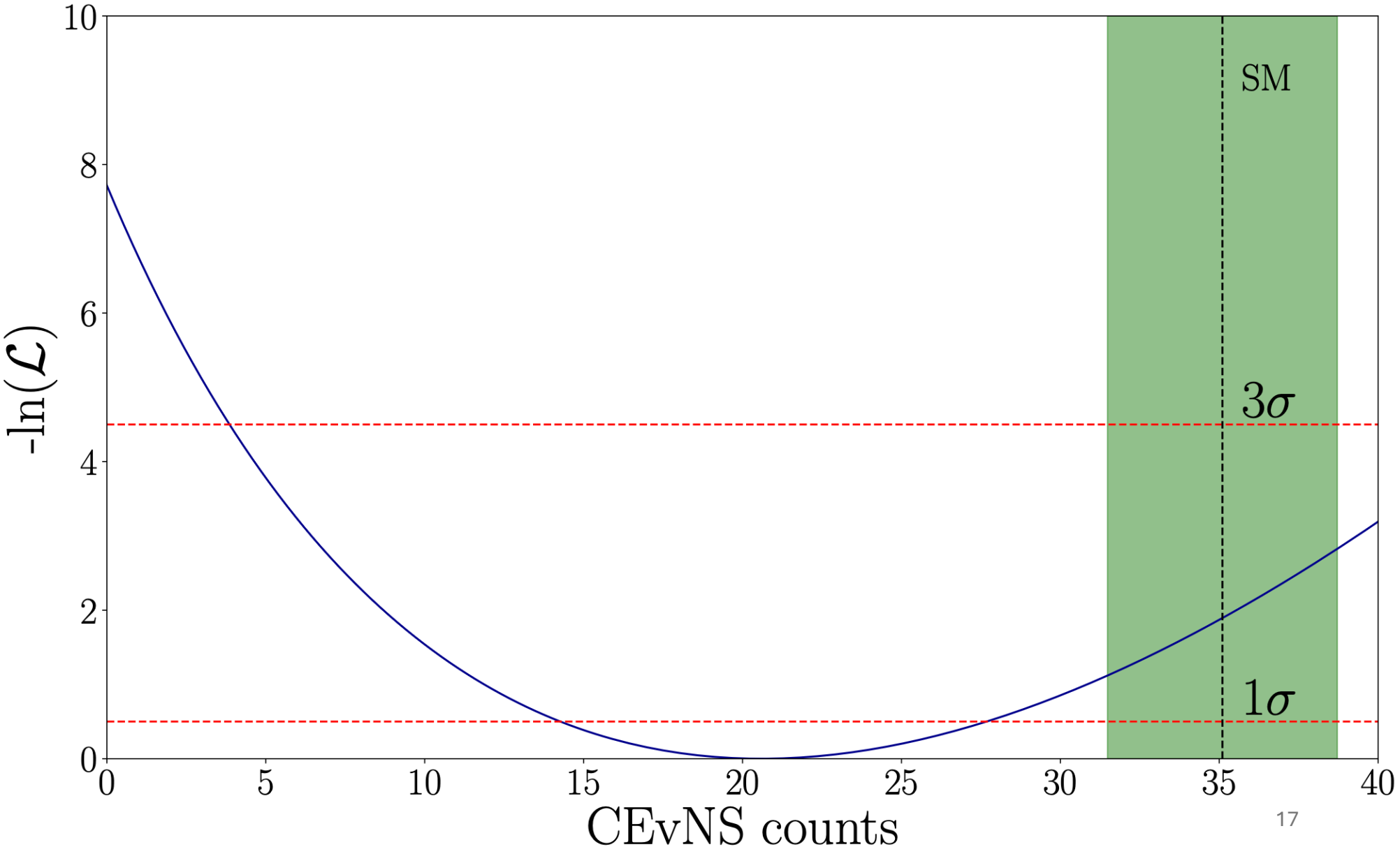


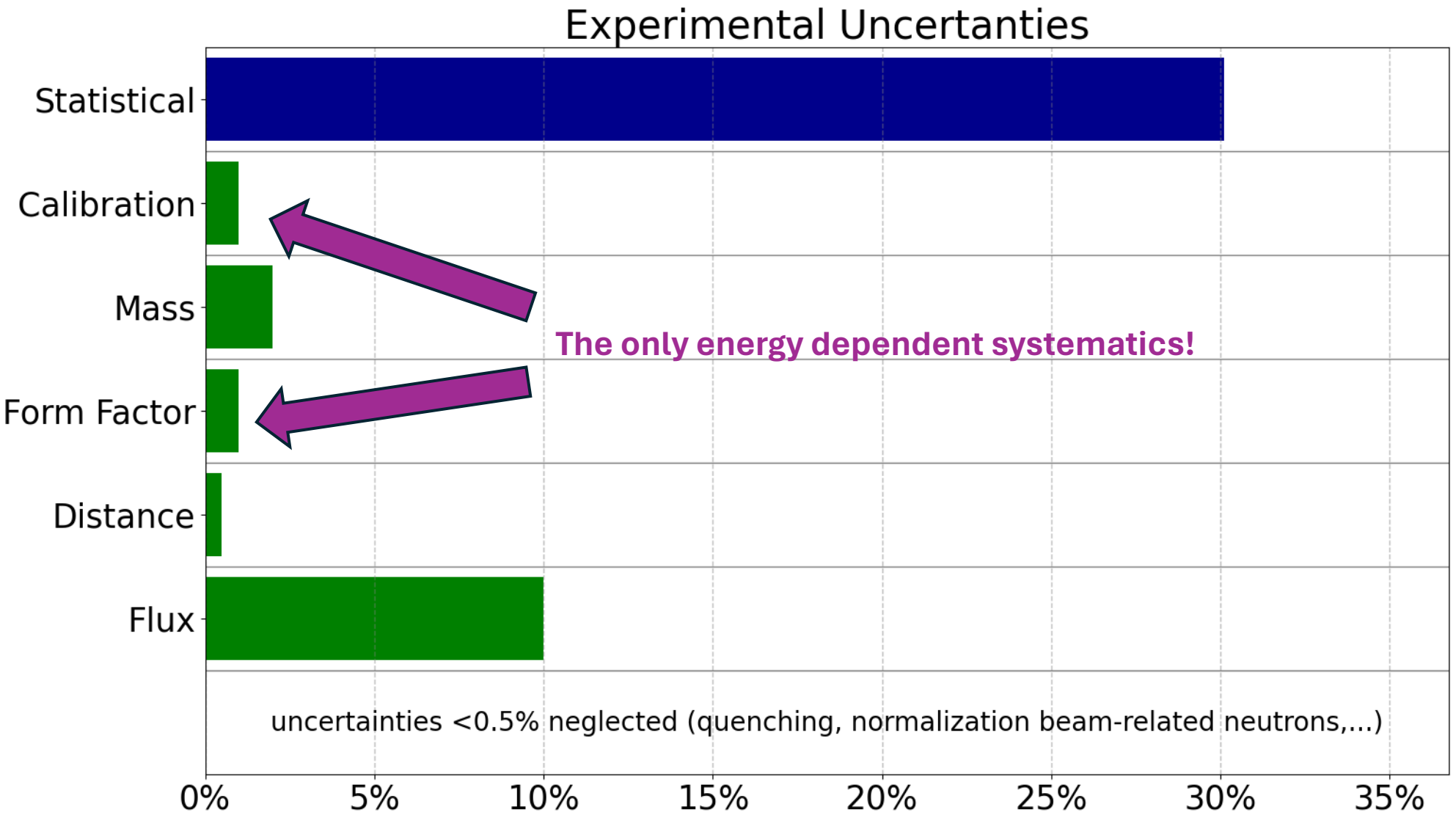
2d extended un-binned NLL fit:
20.6 (-6.3 +7.1)

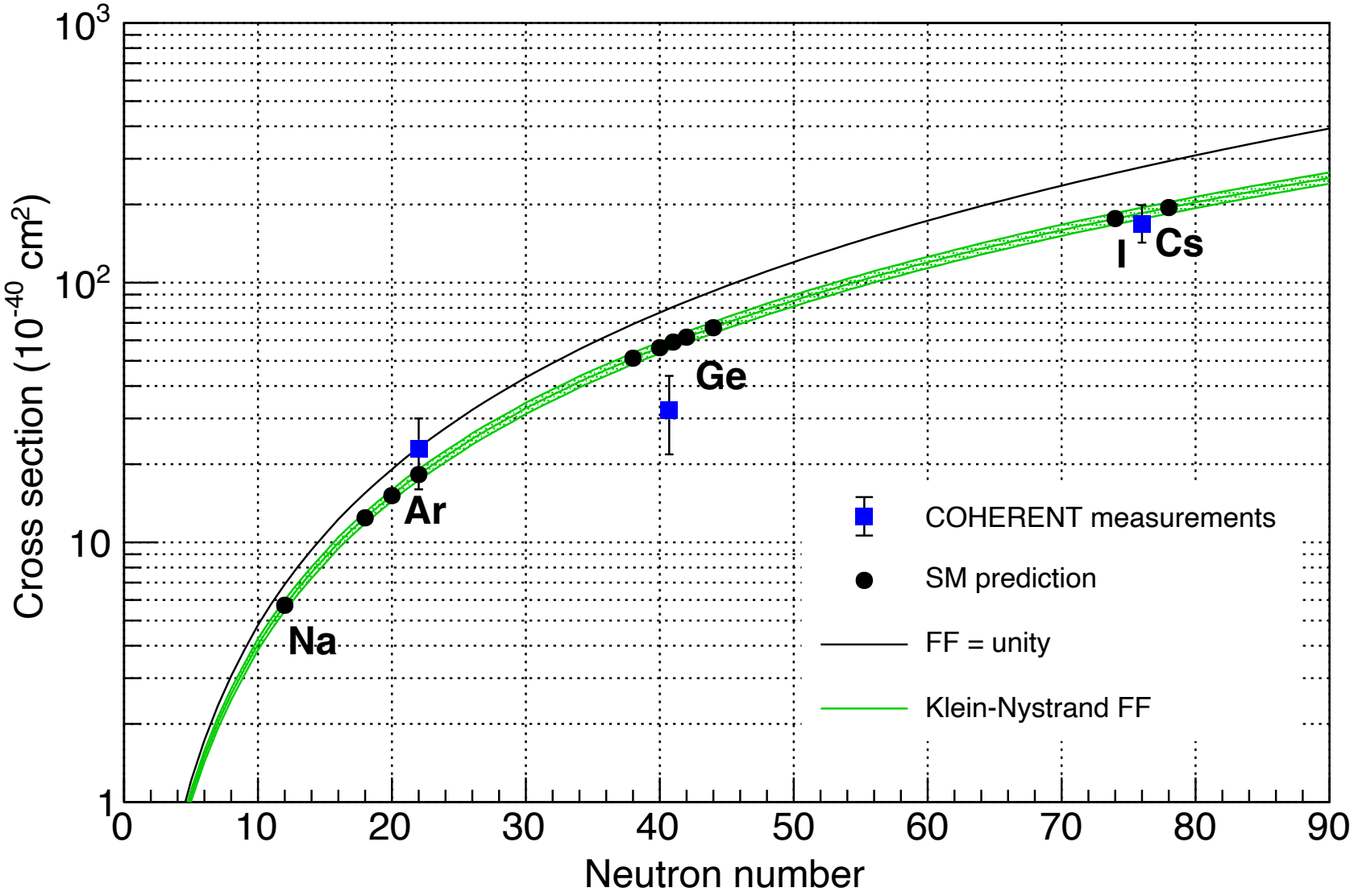
3.9σ rejection of null hypothesis

Standard Model:
35.1±3.6

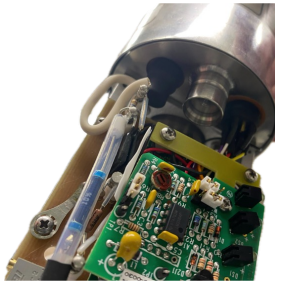
~1.9σ below SM

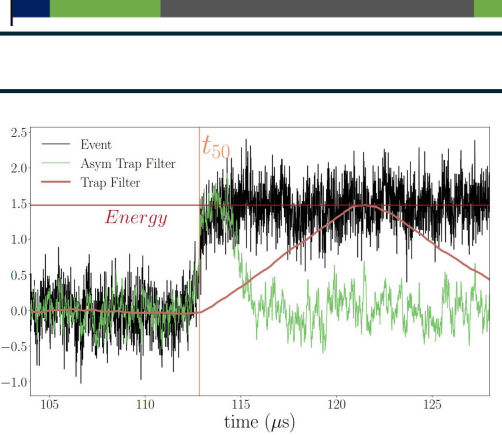


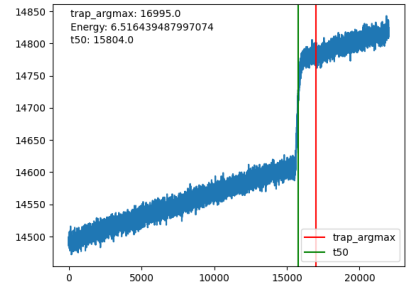

Experimental Uncertanties
Statistical
Calibration
Mass
Form Factor
Distance
Flux
The only energy dependent systematics!
uncertainties <0.5% neglected (quenching, normalization beam-related neutrons,...)
0%
5%
10%
15%
20%
25%
30%
35%


Cross section (10^{-40} cm^2)
10^3
10^2
10
1
0
10
20
30
40
50
60
70
80
90
Neutron number
Na
Ar
Ge
I
Cs
COHERENT measurements
SM prediction
FF = unity
Klein-Nystrand FF

- More mass
  - *Get all detectors online*
- More neutrinos
  - *SNS upgrades, more flux*
- Lower thresholds
  - *better timing reco*
- Lower backgrounds
  - *PSD on slow pulses*



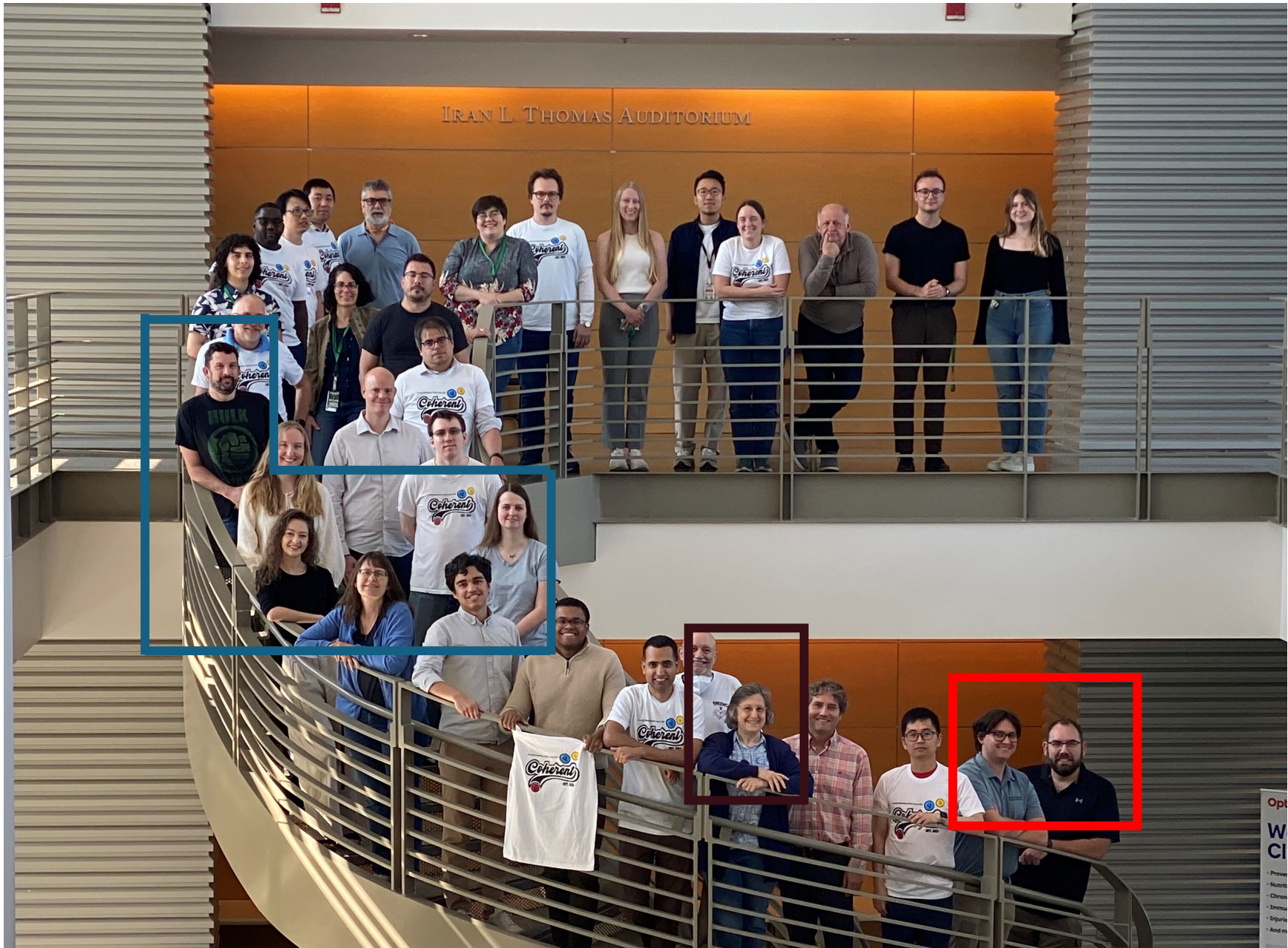




Thank you

The Team

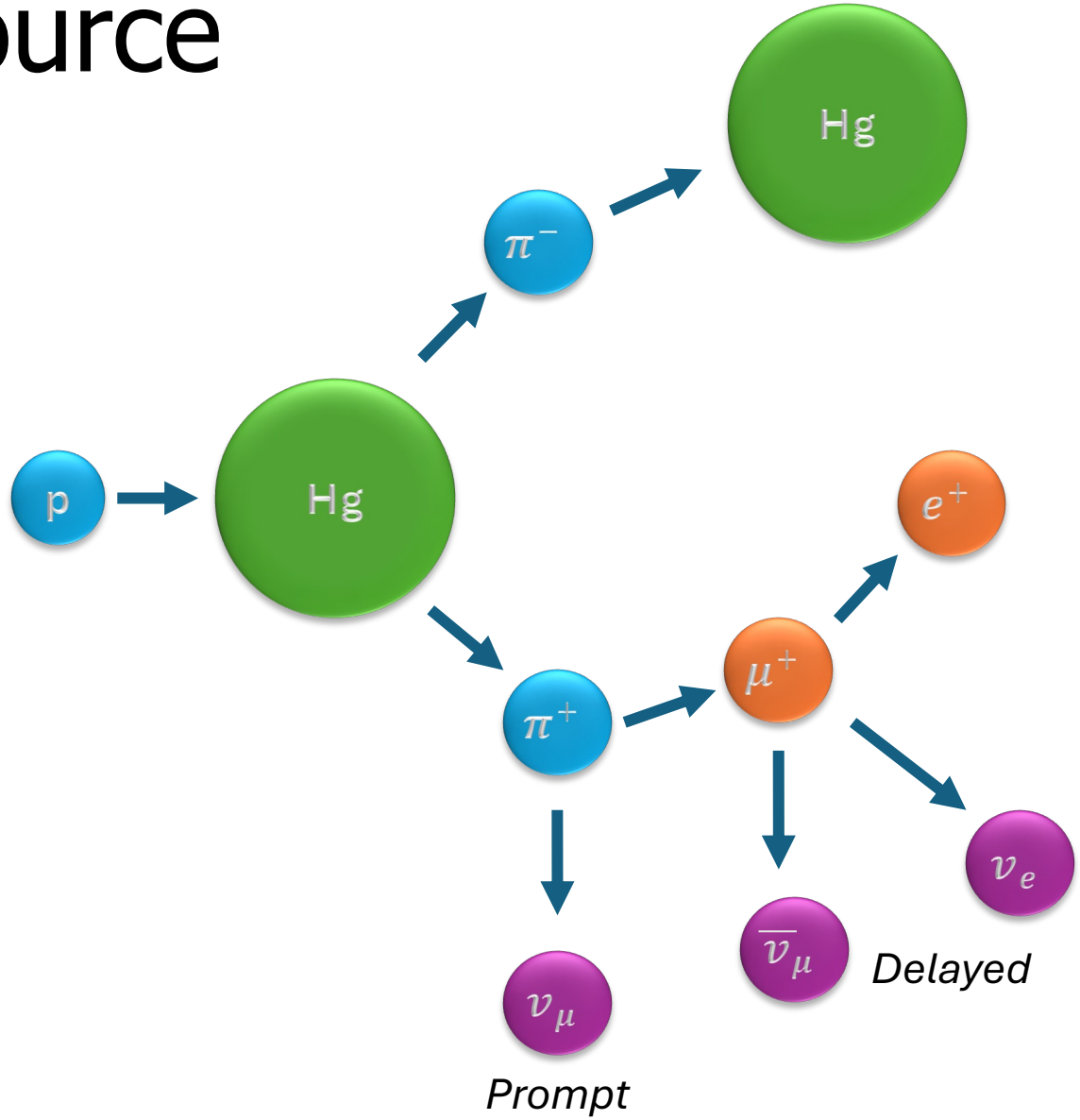
- *Duke University:*
  - Phil Barbeau
  - Kate Scholberg
  - Janina Hakenmüller*
  - Emma van Nieuwenhuizen
  - Ryan Bouabid
- *North Carolina Central University*:
  - Diane Markoff
- *North Carolina State University:*
  - Matt Green†
  - James Browning



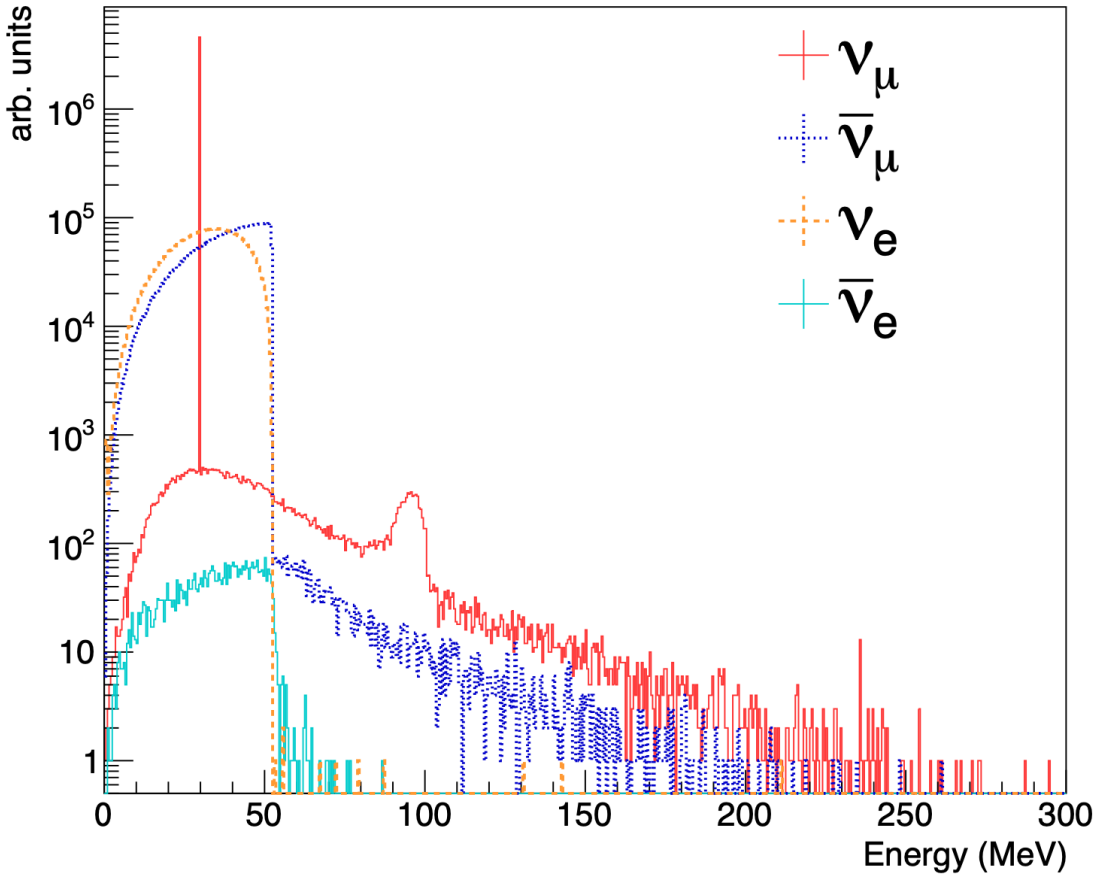
† Working group coordinator
* Analysis coordinator

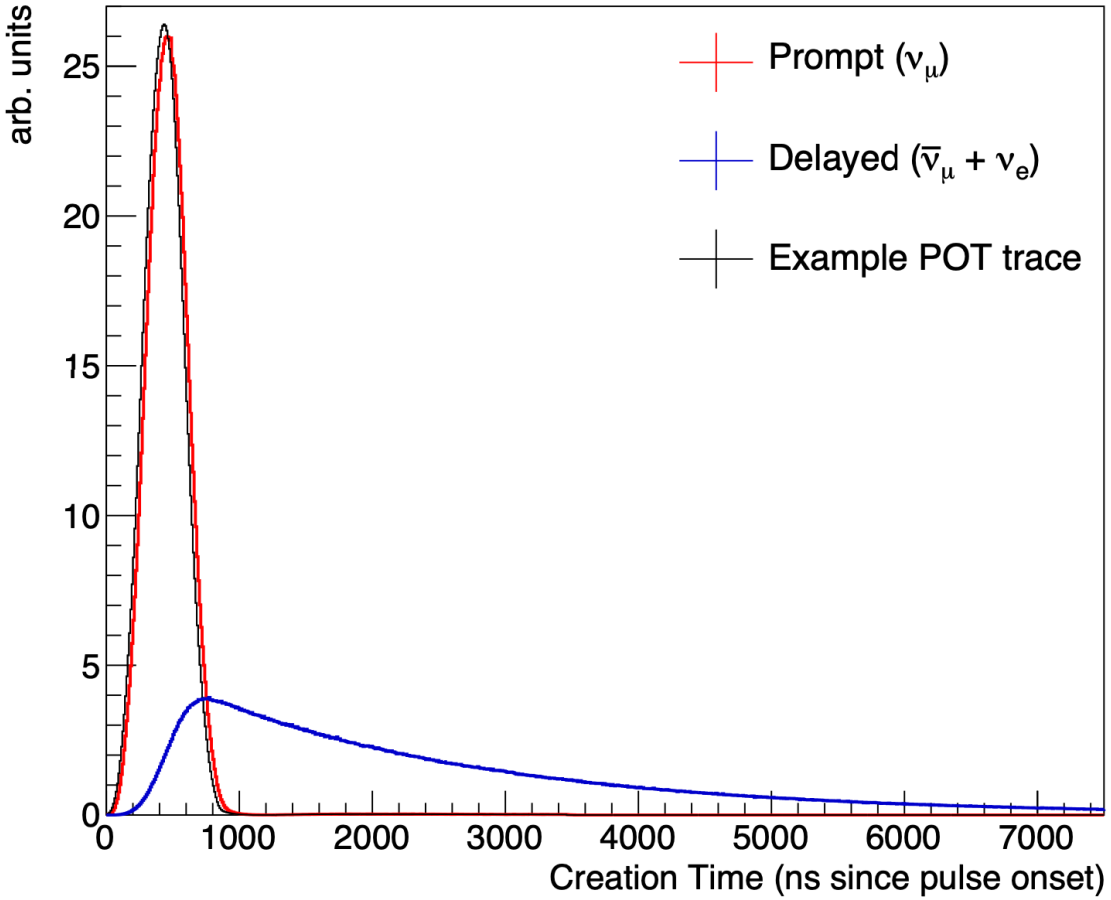
Backup

Spallation Neutron Source

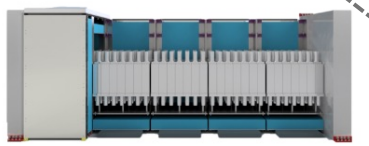


Spallation ~~Neutron~~ *Neutrino* Source



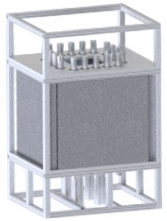


CENNS-10



NaIvETe

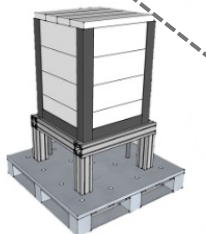
Pb glass Demonstrator



NuThor

Ge-Mini

D2O

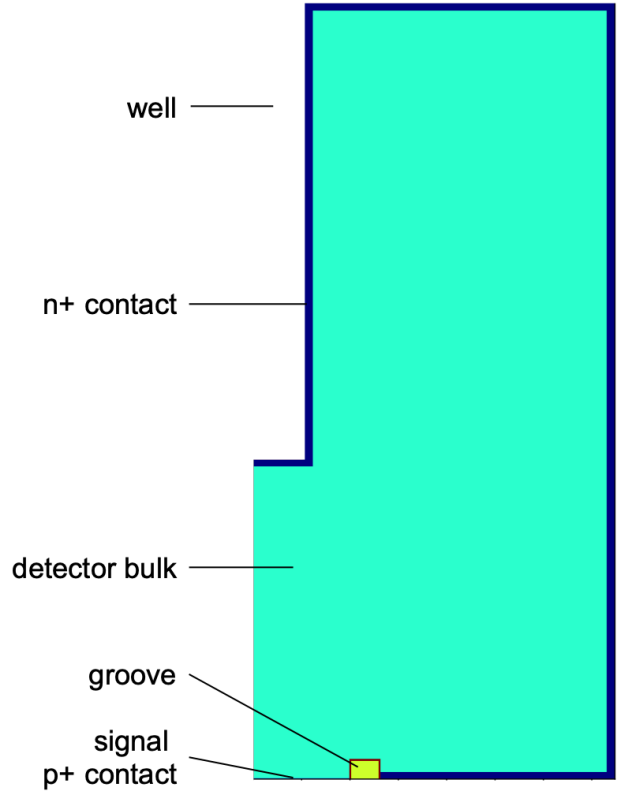


NaIvE-185

Neutrino Alley

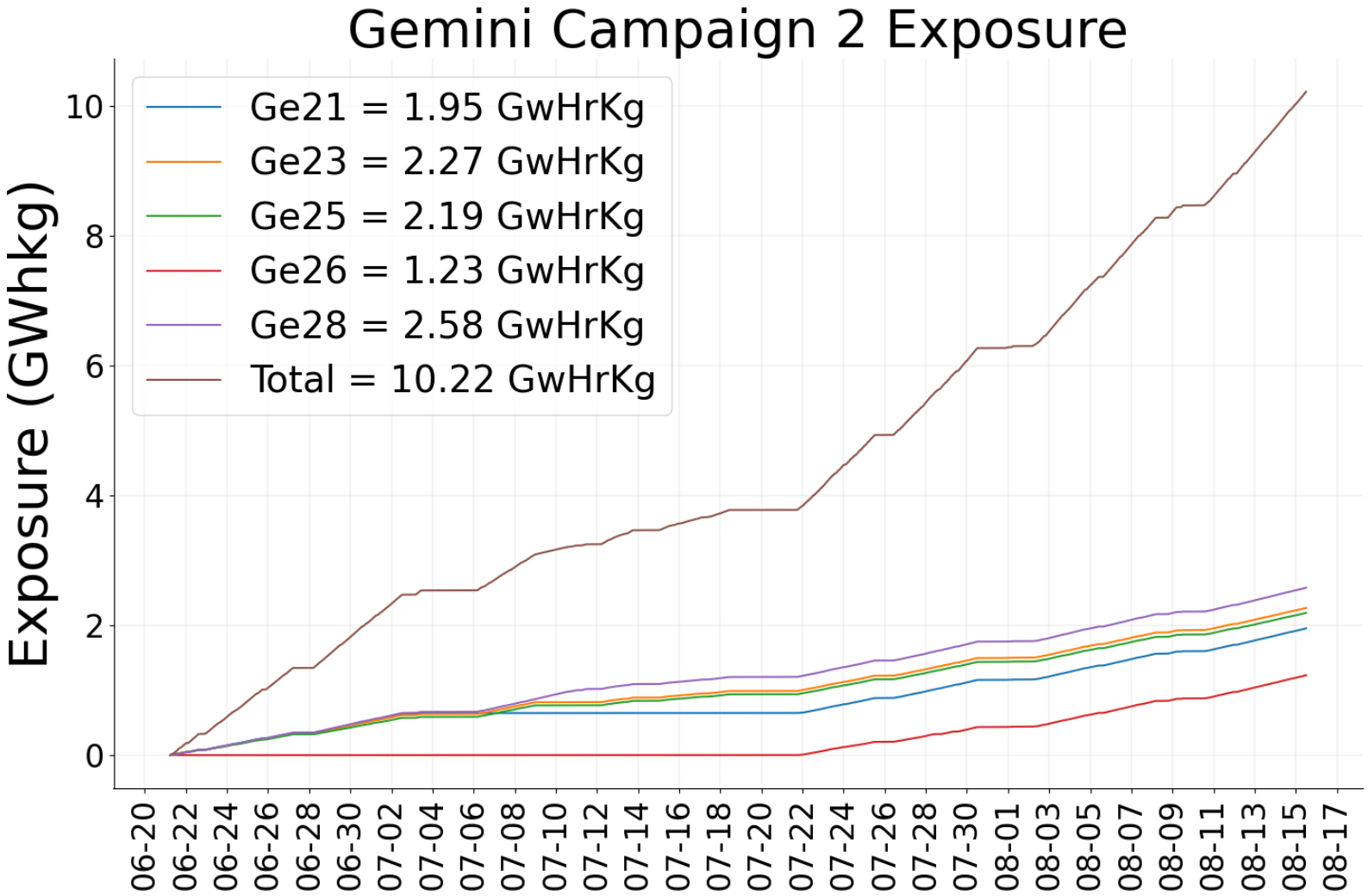
Detector	Mass [kg]	Pulser FWHM [eV]
Ge21	2.191	116
Ge22	2.215	---
Ge23	2.201	114
Ge24	2.260	145
Ge25	2.200	152
Ge26	2.270	146
Ge27	2.280	---
Ge28	2.290	135

Ge-Mini HPGe's: 8 ICPC's

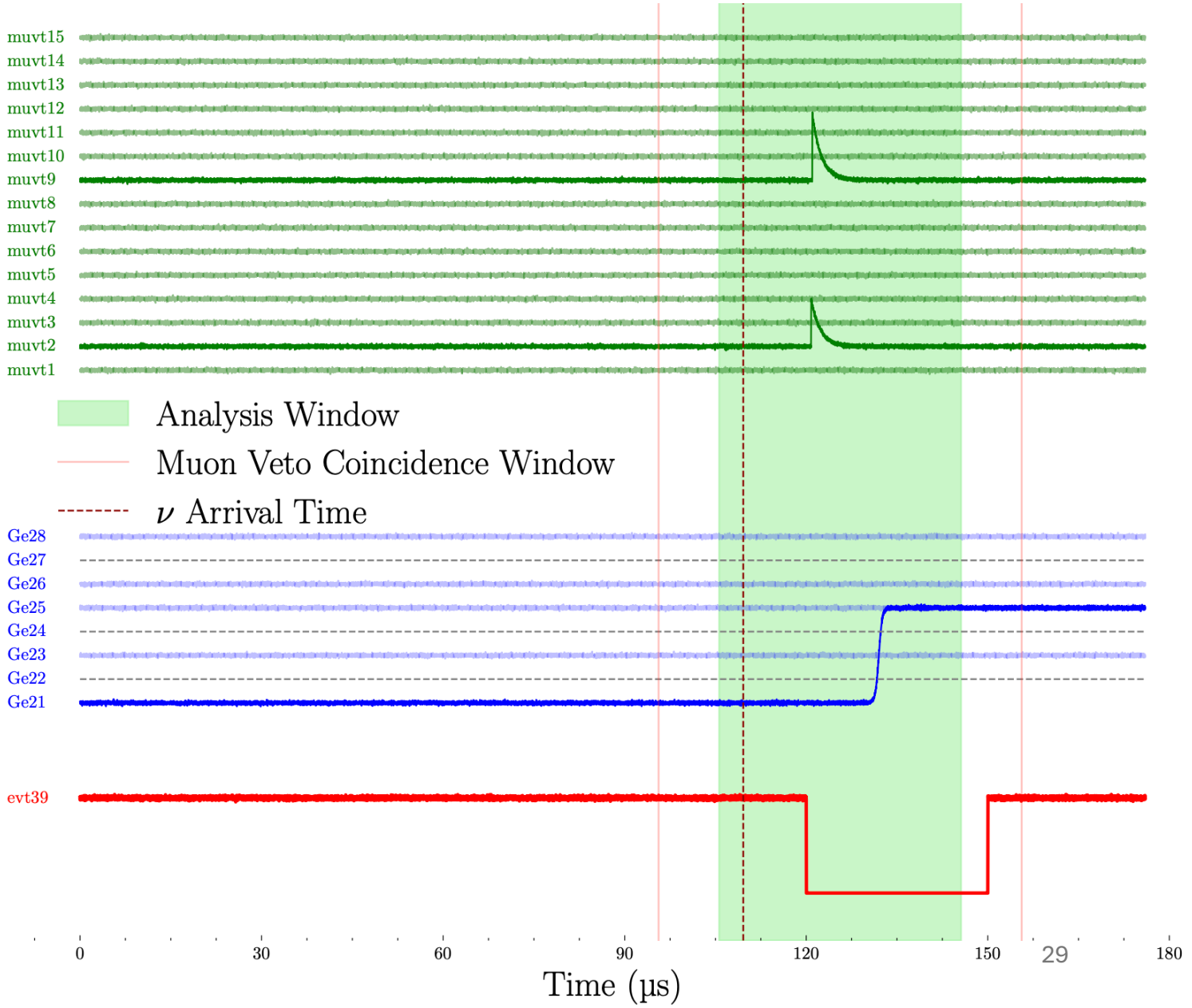


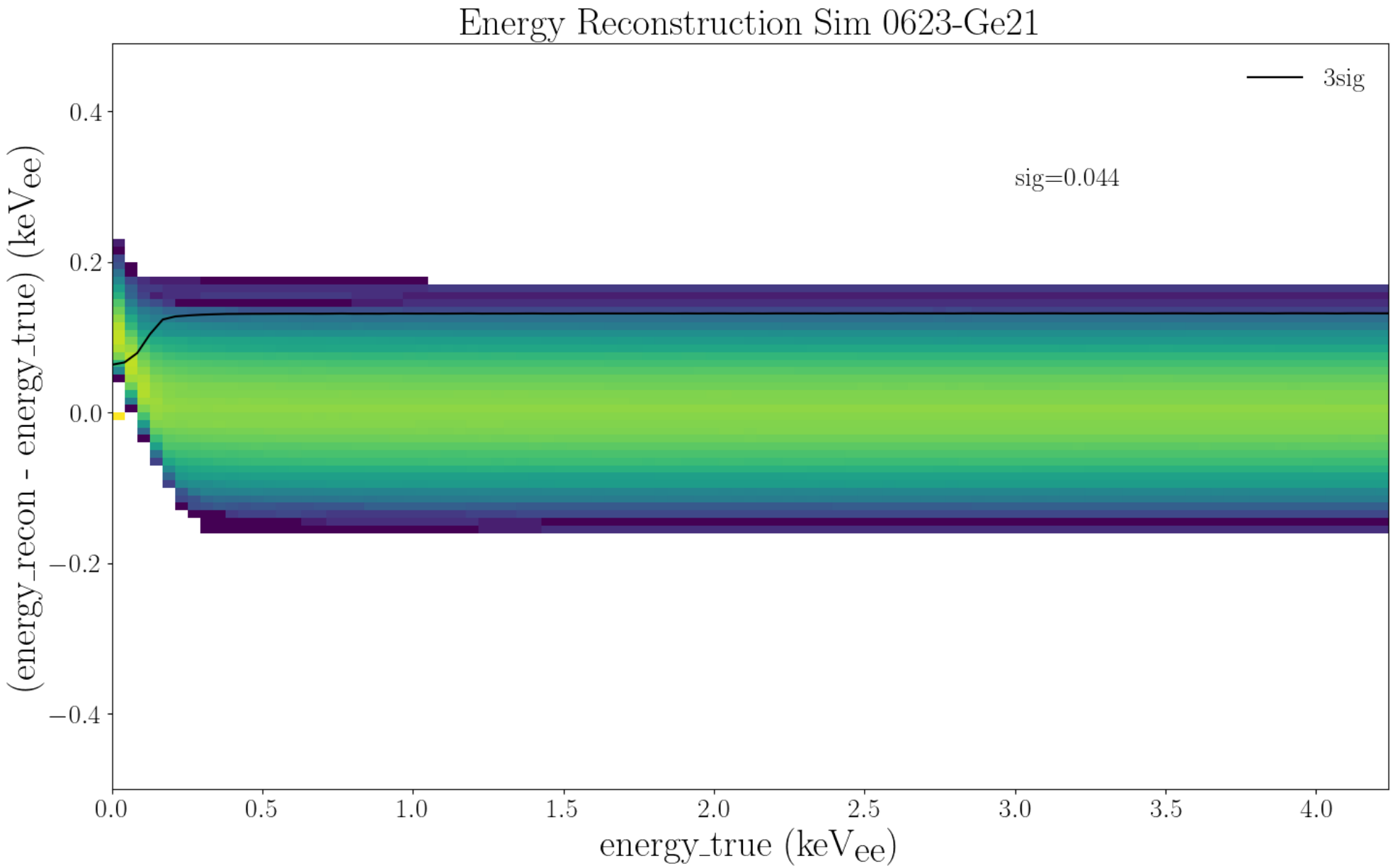
Data Collected

- ~2 months of beam time
- ~11kg deployed
- 3 detectors not used in this run



- Data acquisition is triggered on an SNS timing signal for POT
- We consider every Ge event in an energy and timing ROI
- Long muon veto windows catch straggling neutrons




Energy Reconstruction Sim 0623-Ge21
3sig
sig=0.044
0.4
0.2
0.0
−0.2
−0.4
(energy_recon - energy_true) (keVee)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
energy_true (keVee)

BRNs: MCNP

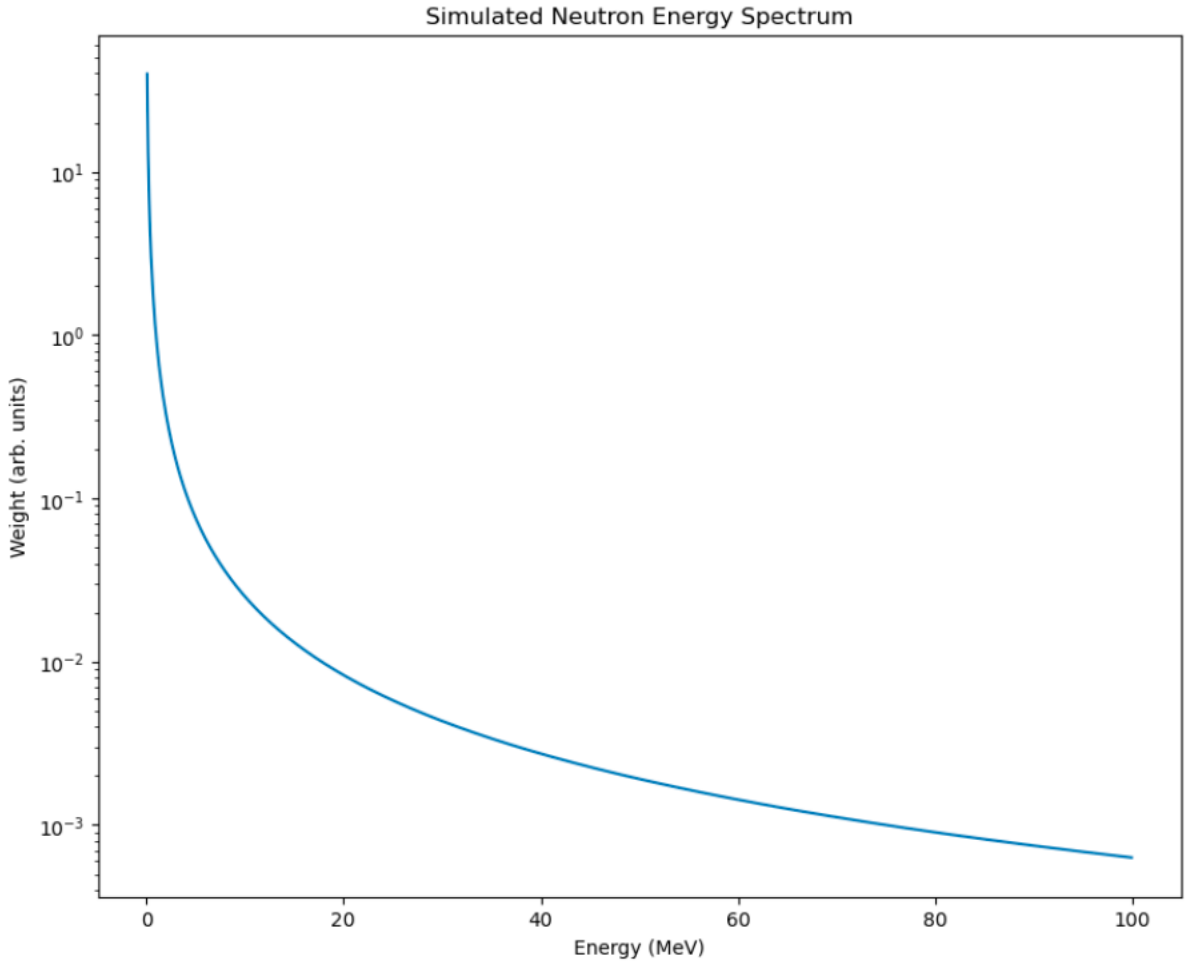


Table 6: Number of counts expected for the two
Campaign-2 exposure. The number of counts has

detector	wall/cts	hall way/cts
Ge21	0.176	0.025
Ge23	0.402	0.063
Ge25	0.198	0.058
Ge26	0.196	0.048
Ge28	0.228	0.232
total	1.200	0.426

Signal Prediction