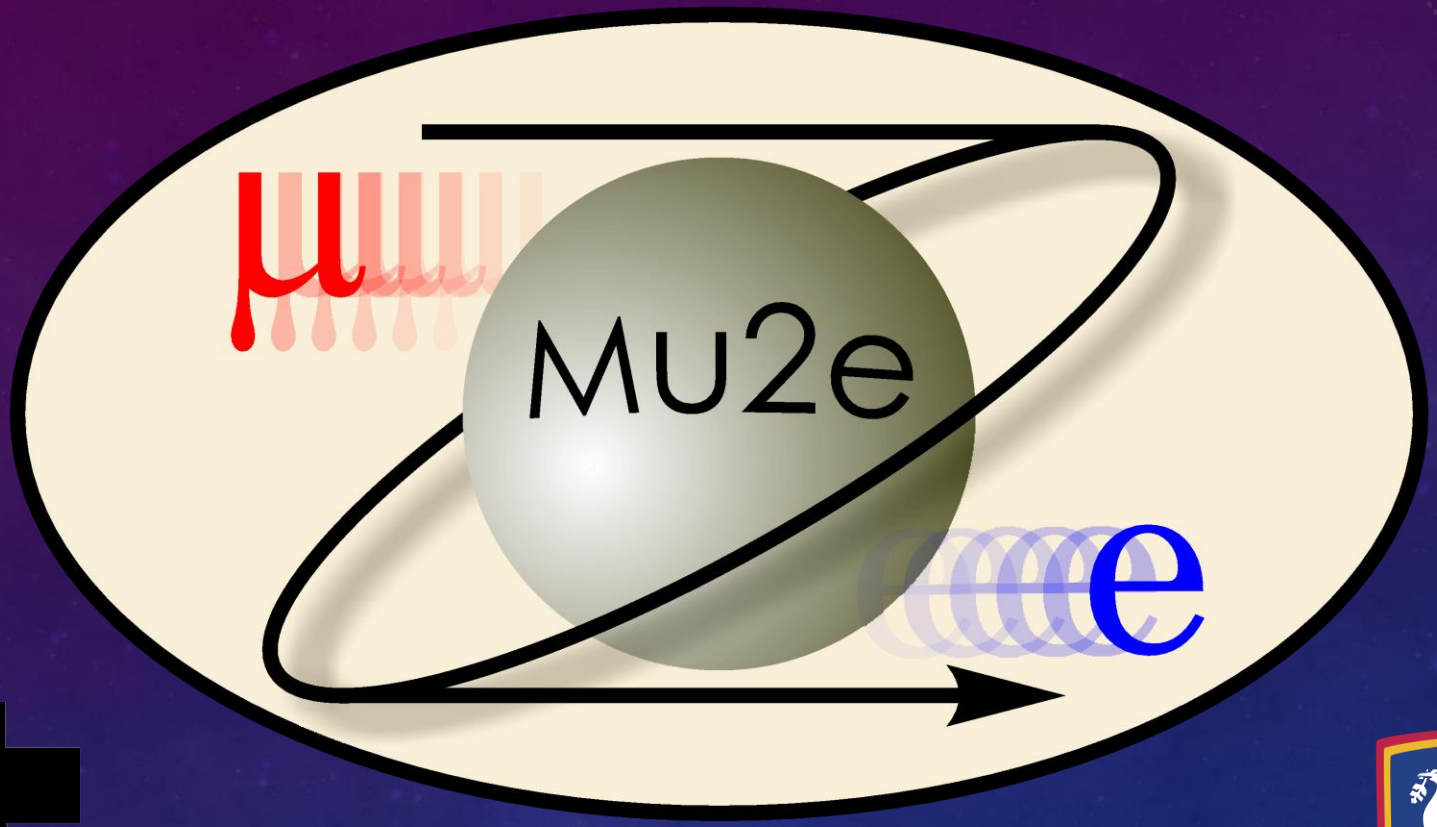


The Mu2e Experiment
STM HPGe Detector Update

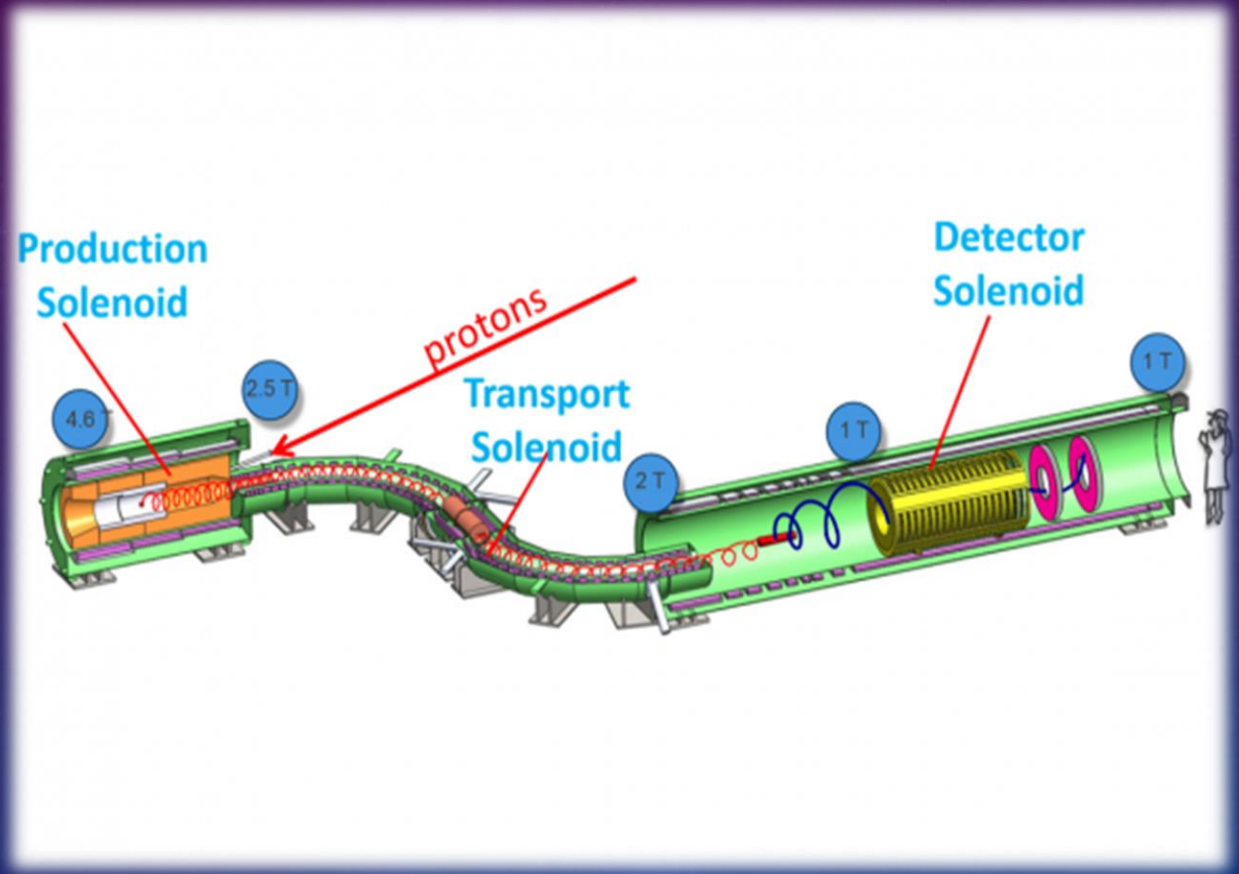
Steven Tickle

Thursday 19th December 2019

CONTENTS

- STM requirements at FNAL
- Current Liverpool Setup
- Performance Benchmark

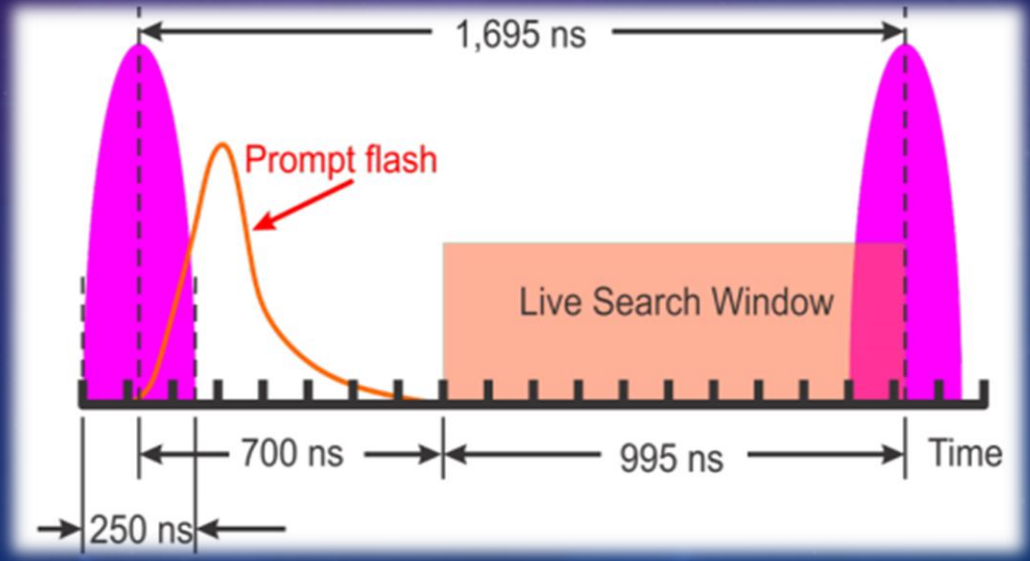
STM REQUIREMENTS - RECAP



STM is actually 34m from the end of the detector on the right!

STM REQUIREMENTS - PERFORMANCE

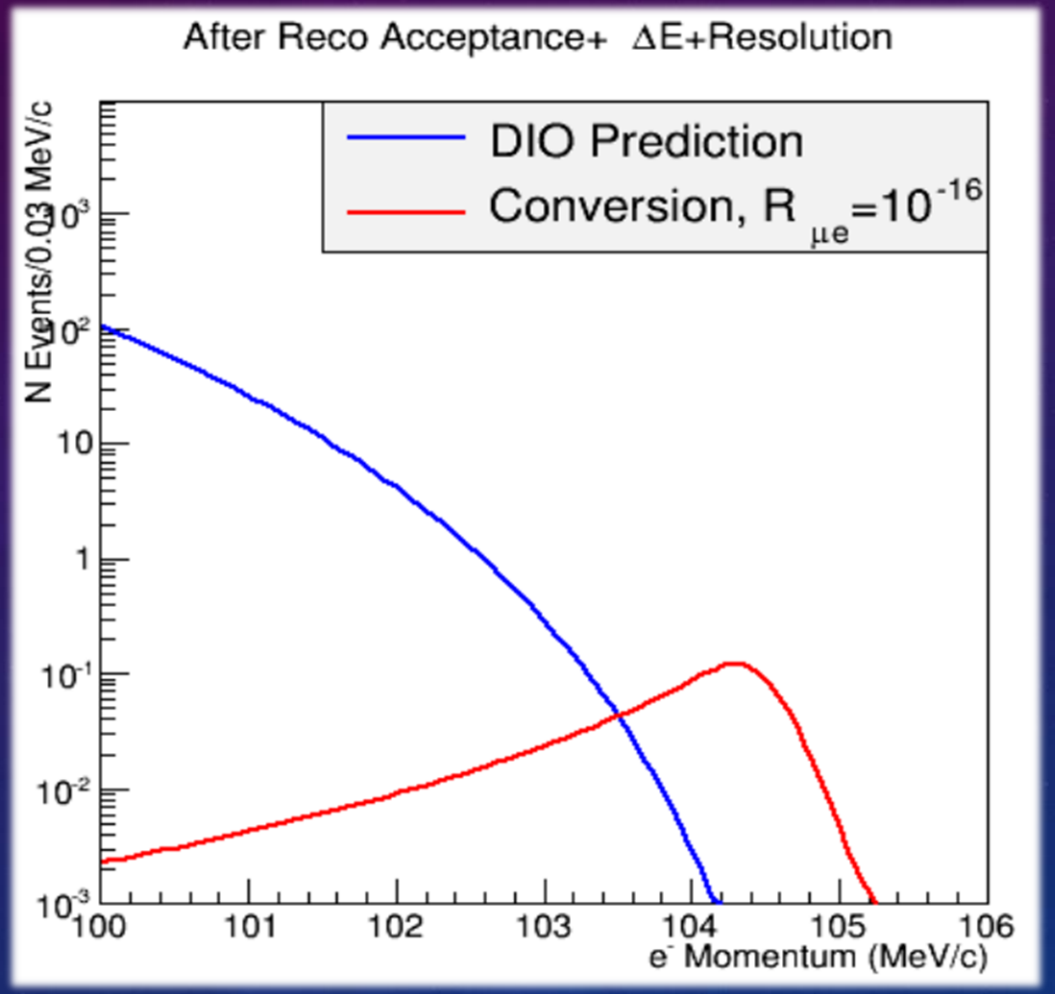
- Have FWHM ~2keV for all decays of interest
- Be able to handle ~1-4kHz photon count rate @ 0-2 MeV
- Electronics support for collection within 800-1000ns windows
- Withstand fast neutron radiation damage during operation



STM REQUIREMENTS - ENERGY

Background measurements:

- 347 keV X-ray 2p-1s transition in aluminium
- 1807 keV nuclear capture and conversion of aluminium to magnesium, with neutron kickout
- 844 keV emission from converted magnesium, lacking neutron kickout

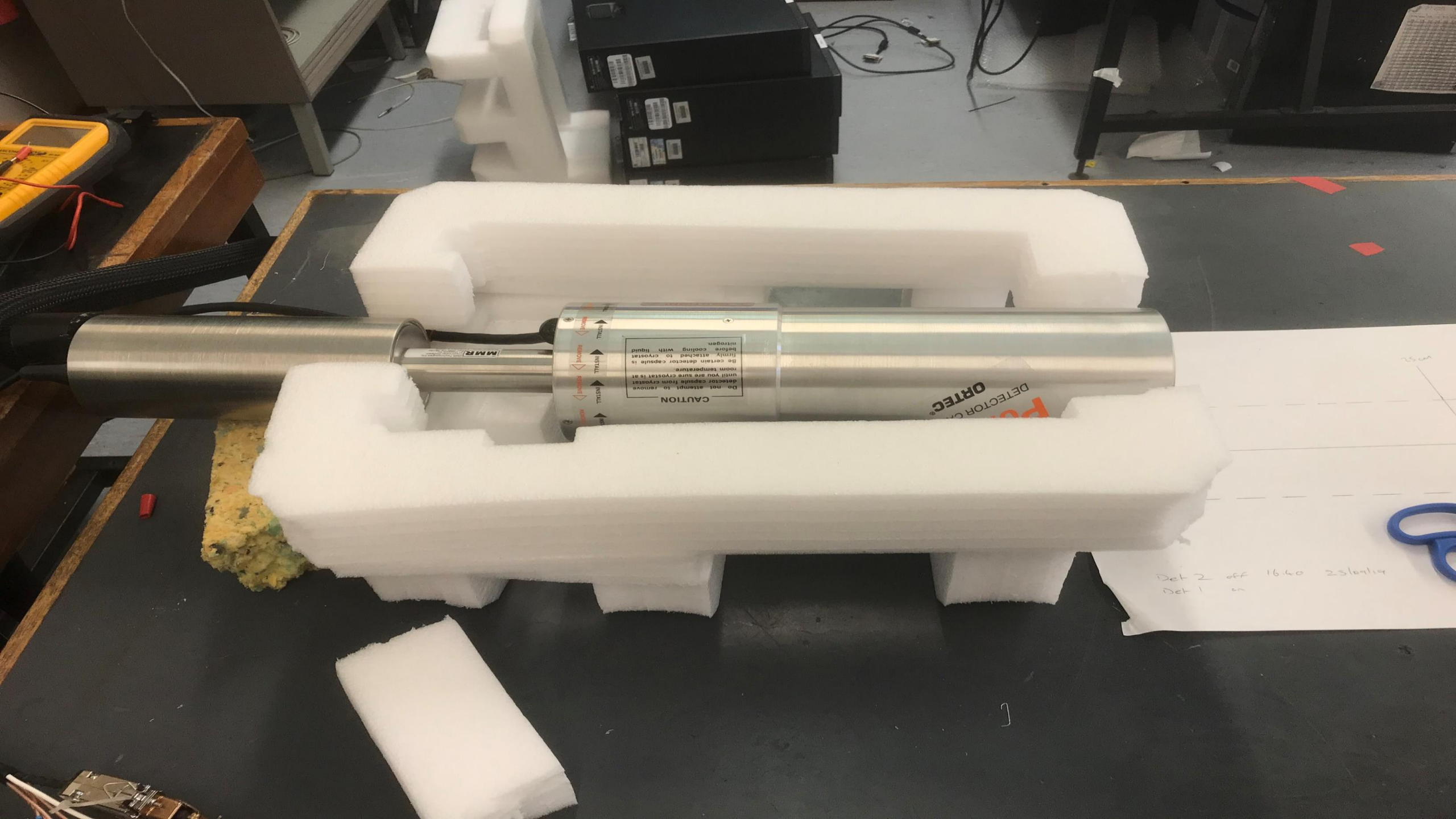


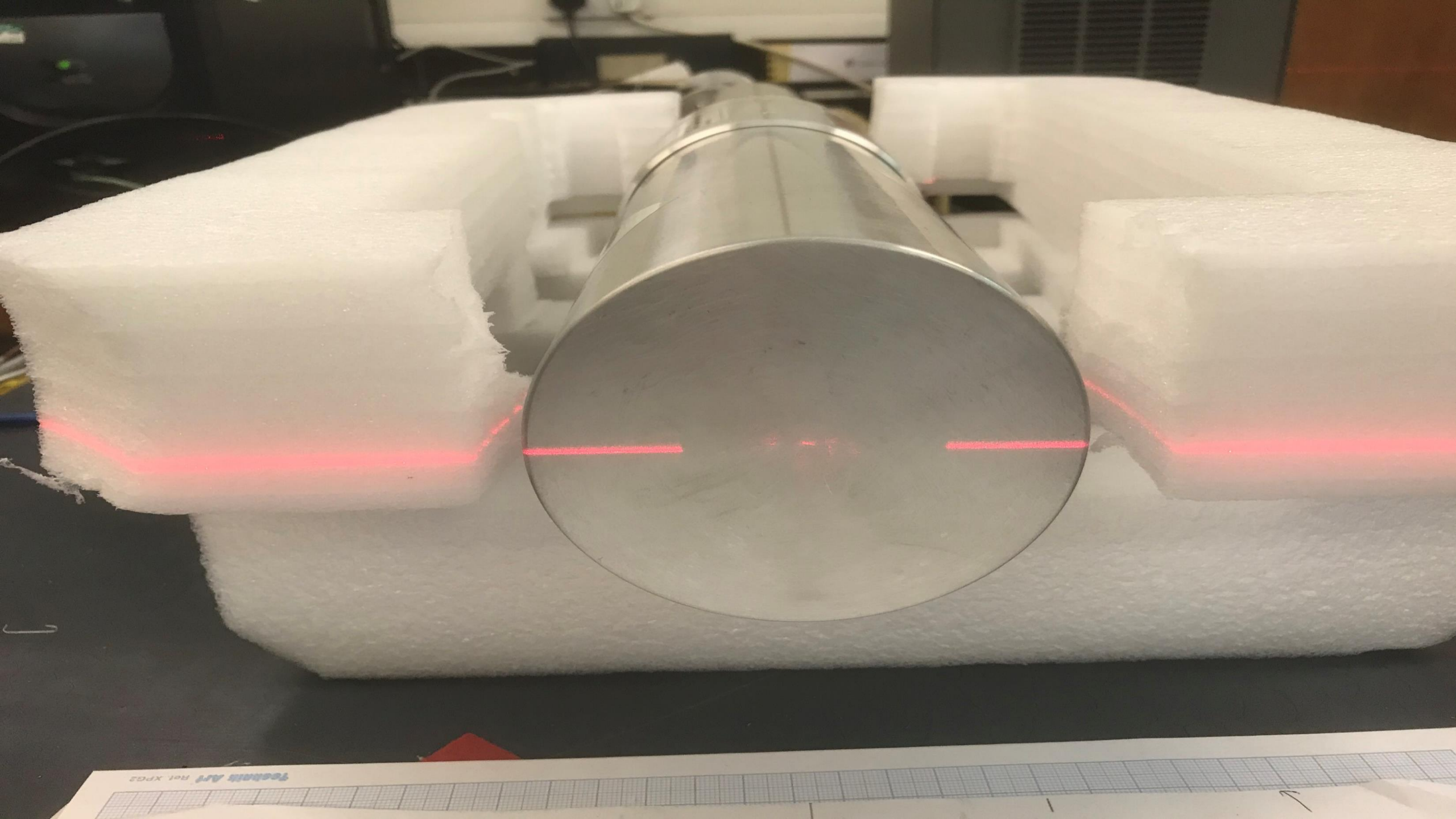
For stopped muons, the decay will produce electrons with energies identifiable from the muon mass

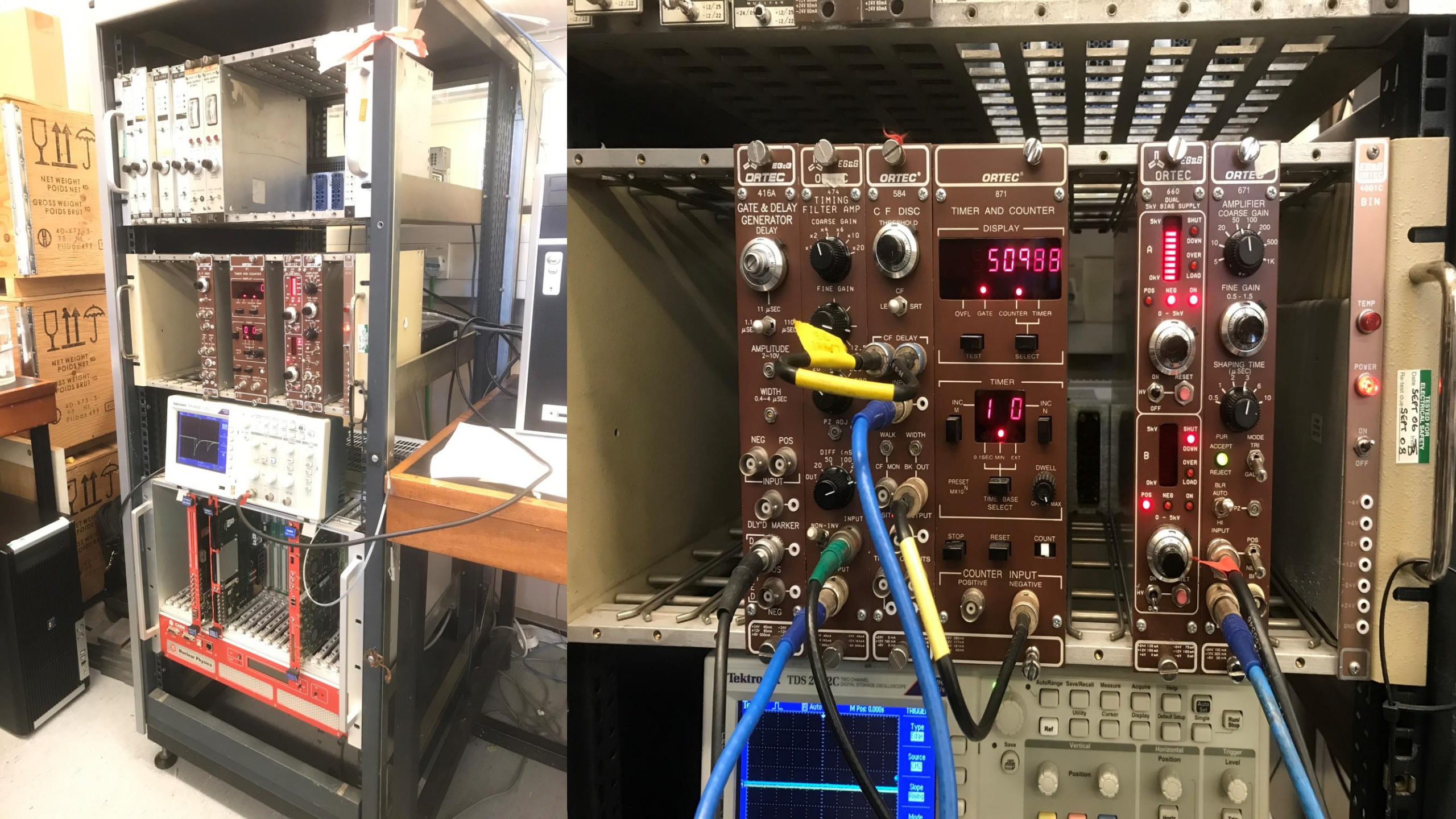
DIO: Decay In Orbit (muon stops), Reco – Nuclear Recoil Tail

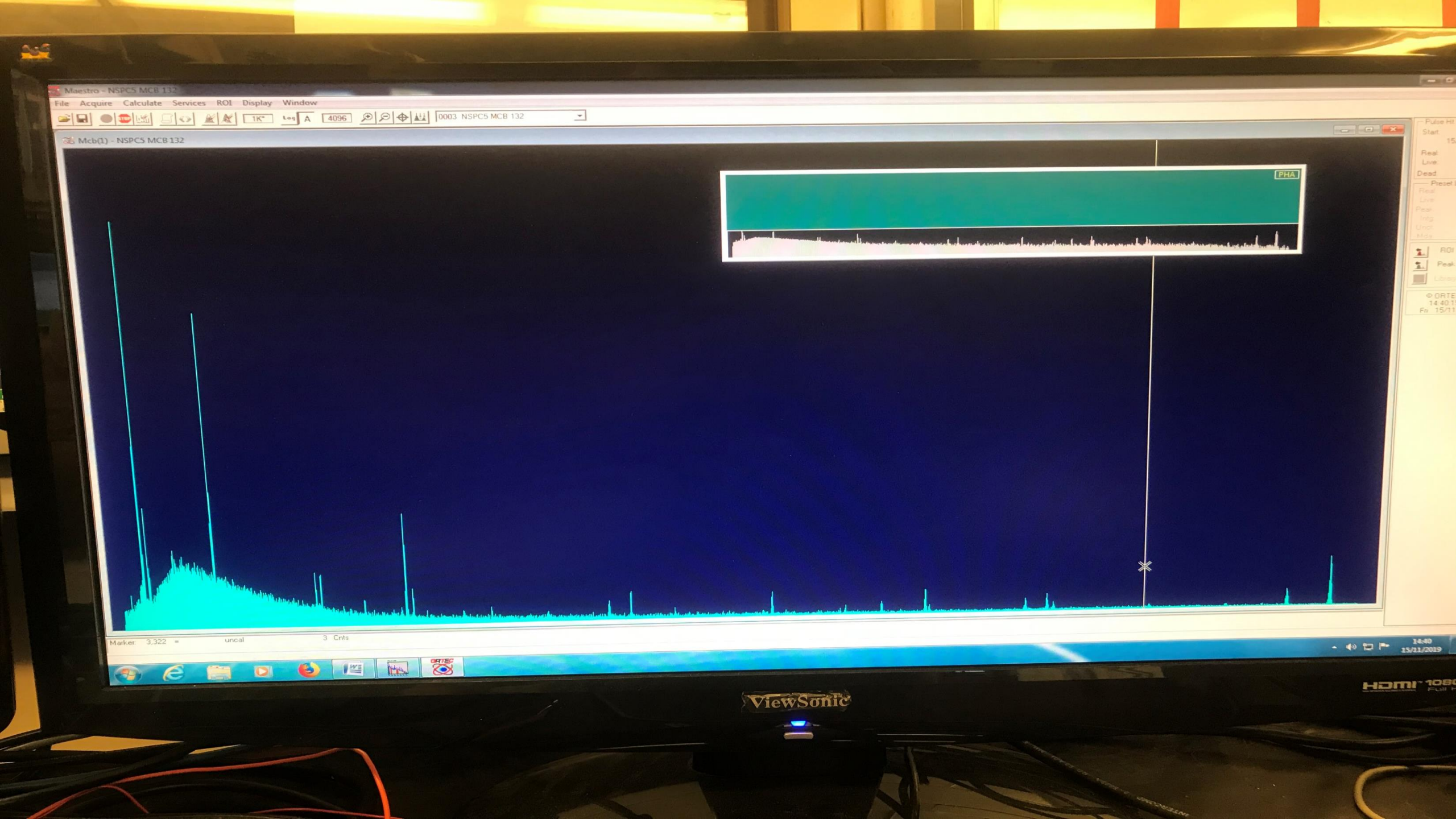
LIVERPOOL DETECTOR SETUP


QUALITY THAT
TOUCHES THE UNIVERSE
MODEL NO. GEM10P4-LSC-A-S
SERIAL NO. 47133215A
THIS INSTRUMENT HAS
UNDERGONE A COMPLETE
PROGRAM OF INSPECTION
AND TEST AND HAS BEEN
DEMONSTRATED TO MEET ITS
PUBLISHED SPECIFICATIONS
TECHNICIAN DF
DATE 7-16-19
PopTop™
DETECTOR CAPSULE
ORTEC®
INSTALL
REMOVE
CAUTION


CAUTION
Do not attempt to remove detector capsule from cryostat until you are sure cryostat is at room temperature.
Be certain detector capsule is firmly attached to cryostat before cooling with liquid nitrogen.
INSTALL
REMOVE
ORTEC
Det 2 off 16.40 2Sbatlig
Det 1 on




ORTEC
416A
GATE & DELAY GENERATOR
DELAY
11 µSEC
AMPLITUDE 2–10V
WIDTH 0.4–4 µSEC
NEG POS
INPUT
DLY'D MARKER
NEG
474
TIMING FILTER AMP
COARSE GAIN
FINE GAIN
PZ ADJ
DIFF (nS)
OUT
MON-INV
INPUT
584
C F DISC
THRESHOLD
CF
SRT
CF DELAY
WALK
WIDTH
CF MON BK OUT
871
TIMER AND COUNTER
DISPLAY
50988
OVFL GATE COUNTER TIMER
TEST
SELECT
TIMER
1 0
INC M
INC N
0.1SEC MIN EXT
PRESET MX10
TIME BASE SELECT
DWELL
STOP
RESET
COUNT
COUNTER INPUT
POSITIVE
NEGATIVE
660
DUAL 5kV BIAS SUPPLY
5kV
0kV
A
B
SHUT
DOWN
OVER
LOAD
POS
NEG
ON
0 - 5kV
ON
RESET
HV
OFF
671
AMPLIFIER
COARSE GAIN
50 100
20 200
10 500
5 1K
FINE GAIN
0.5 - 1.5
SHAPING TIME (µSEC)
0.5 1 2 3 6 10
PUR
ACCEPT
REJECT
MODE
TRI
GAU
BLR
AUTO
PZ
HI
INPUT
POS
4001C
BIN
TEMP
POWER
ON
OFF
+6V
+6V
-12V
+12V
-24V
+24V
GND
TESTED FOR ELECTRICAL SAFETY
Date Sept 06
Re-test due Sept 08
Tektronix TDS 2
AutoRange Save/Recall Measure Acquire Help
Utility Cursor Display Default Setup Single
Ref
Run/Stop
Vertical
Position
Horizontal
Position
Trigger
Level
Save
Type
Source
Slope
Mode
NET WEIGHT
POIDS NET
GROSS WEIGHT
POIDS BRUT
Nuclear Physics


Maestro - NSPC5 MCB 132
File Acquire Calculate Services ROI Display Window
1K Log A 4096
0003 NSPC5 MCB 132
Mcb(1) - NSPC5 MCB 132
PHA
Marker 3,322 = uncal 3 Cnts
ViewSonic

HPGE PERFORMANCE BENCHMARK - ORTEC

Expectation for Detector 1

- -4.5kV bias voltage
- Resolution (FWHM) @ 1.33MeV (2.3keV warranted, 2.3keV measured)
- Peak-to-Compton ratio: (60:1 warranted, 64:1 measured)
- Relative efficiency @ 1.33MeV (70% warranted, 78% measured)
- Peak shape FWTM/FWHM (2.0 warranted, 2.0 measured)
- Resolution at 122keV (1.5keV warranted, 0.817keV measured)
- Amplifier shaping time 6uS

Expectation for Detector 2

- -4.8kV bias voltage
- Resolution (FWHM) @ 1.33MeV (2.3keV warranted, 2.3keV measured)
- Peak-to-Compton ratio: (60:1 warranted, 64:1 measured)
- Relative efficiency @ 1.33MeV (70% warranted, 73% measured)
- Peak shape FWTM/FWHM (2.0 warranted, 2.0 measured)
- Resolution at 122keV (1.5keV warranted, 0.819keV measured)
- Amplifier shaping time 6uS

HPGE PERFORMANCE BENCHMARK - LIVERPOOL

Measurements for Detector 1

- Resolution (FWHM) @ 1.33MeV (2.49±0.01keV measured)
- Peak-to-Compton ratio: (58.6:1 measured)
- Relative efficiency @ 1.33MeV (80±4% measured)
- Peak shape FWTM/FWHM (1.93 measured)
- Resolution at 122keV (1.09keV measured)

This is acceptable, but not great.

Measurements for Detector 2

- Resolution (FWHM) @ 1.33MeV (2.14±0.01keV measured)
- Peak-to-Compton ratio: (63:1 measured)
- Relative efficiency @ 1.33MeV (71±4% measured)
- Peak shape FWTM/FWHM (1.87 measured)
- Resolution at 122keV (0.88keV measured)

This is good!

WHAT NEXT?

- FNAL requires digital electronics and not analogue systems, which will need to be attached to the HPGe system
- Functions need to be fit to model the efficiency curves and FWHM linearity for each detector, which is currently ad-hoc
- Detectors need to be confirmed for purchase from Ortec before they get fit to a portable system designed for overseas transport to mu2e
- Investigation into system neutron damage is problematic due to high unit cost for practical methods, but will have to occur during deployment with annealing ongoing