TRIUMF

Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire
et en physique des particules

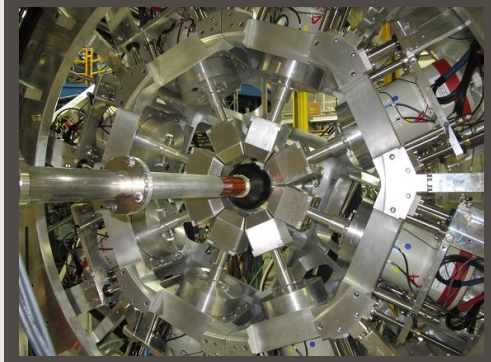
The First Radioactive Beam at GRIFFIN: ^{26}Na for Decay Spectroscopy

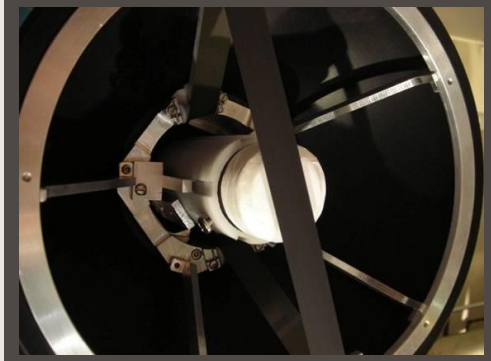
Nikita Bernier, UBC and TRIUMF
for the GRIFFIN collaboration

2015 Canadian Association of Physicists Congress

June 16th, 2015.

GRIFFIN

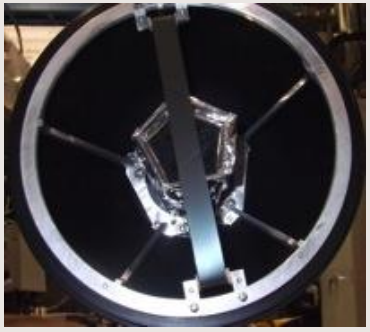




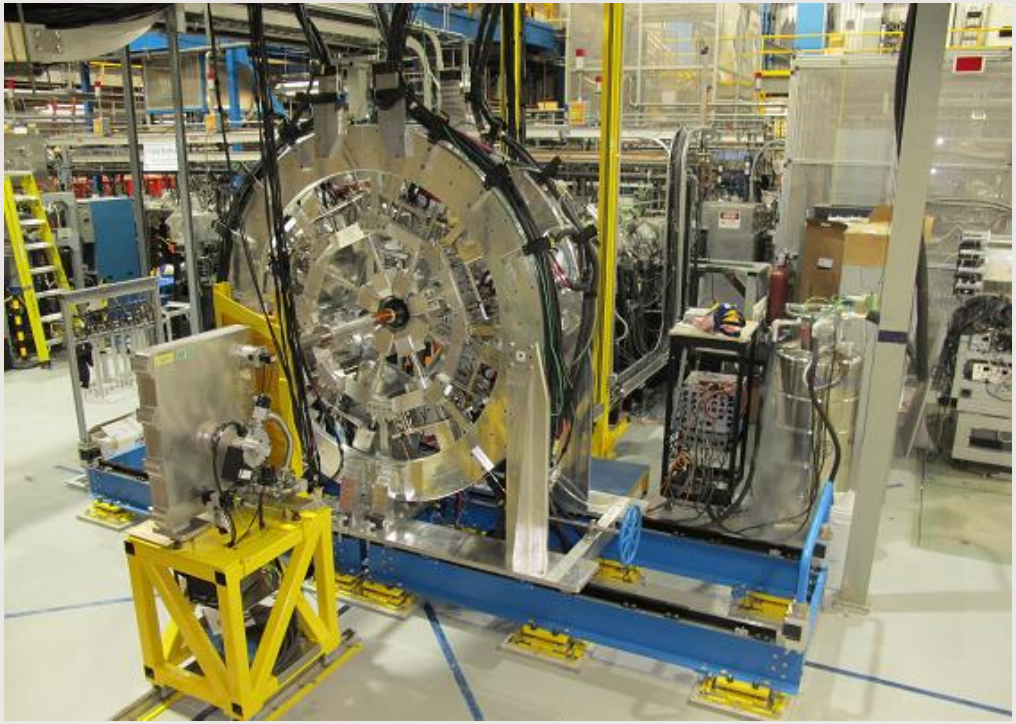
The GRIFFIN Spectrometer

- 16 large-volume clover-type High Purity Germanium [HPGe] detectors dedicated to **decay spectroscopy** research with the low-energy radioactive ion beams in ISAC-I at TRIUMF
- Five sub-systems are combined to create a high-efficiency decay spectrometer for sensitive measurements.

TRIUMF ISAC



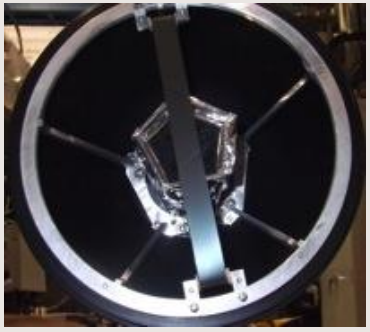
In-vacuum moving tape collector system



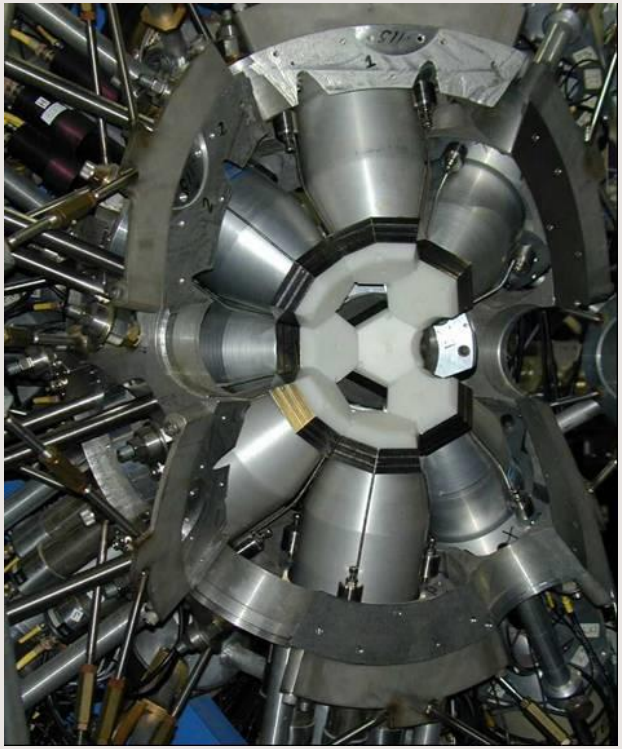
The 8π Spectrometer

- Moved to Simon Fraser University in 2014 after after **12 years** of operation at **ISAC-I**
- 20 HPGe γ-ray detectors, surrounded by Compton suppression shields formed from bismuth germanate (BGO) scintillators and equipped with removable white Delrin absorber layers.

TRIUMF ISAC

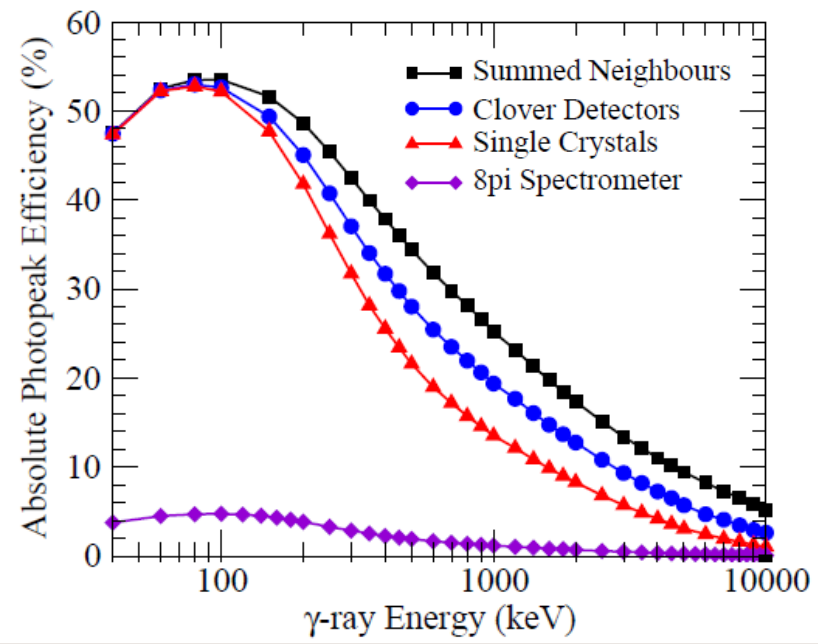


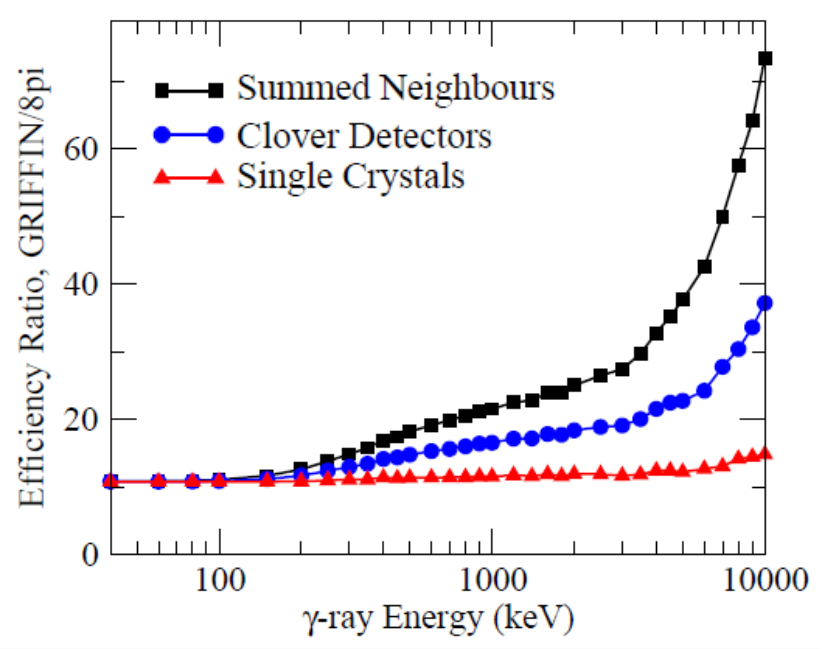
In-vacuum moving tape collector system



8π vs. GRIFFIN

- **GEANT4 simulations** show that **GRIFFIN** is
  - **22 times** more efficient at 1 MeV and
  - **70 times** more efficient for 10 MeV γ-rays
- In γ-γ coincidences, the relevant figure of merit is the **square** of the singles efficiency ratio
  - ~ 300 - 500 increase for typical experiments at ~ 1 MeV.



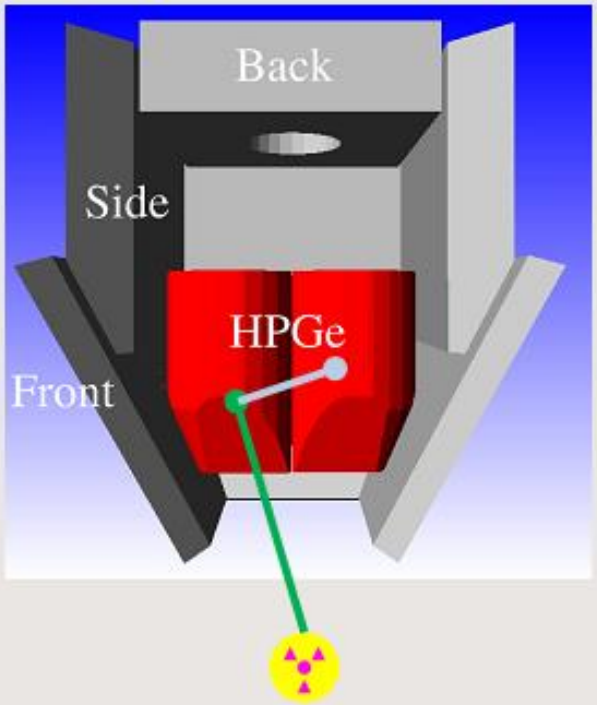


C.E. Svensson and A.B. Garnsworthy, Hyper. Int. 225, 127 (2014).

Addback with GRIFFIN

- High probability that an incoming γ- ray **Compton scatters**, or an annihilation photon, will **escape** the detector
  - Results in a continuous spectrum of lost energy and escape peaks.

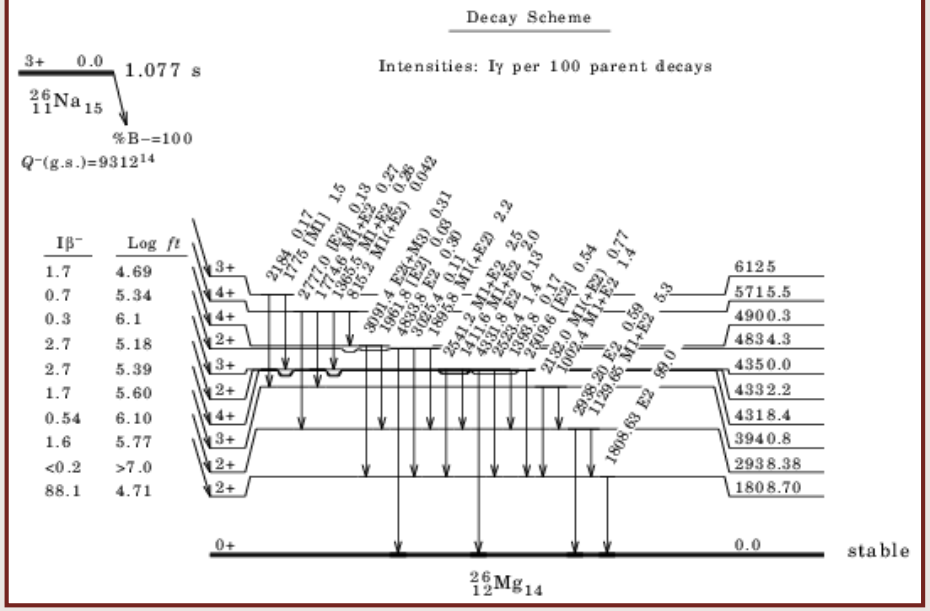
- If energy deposited in two crystals, treat as a **single incident γ-ray** :
  add energies.



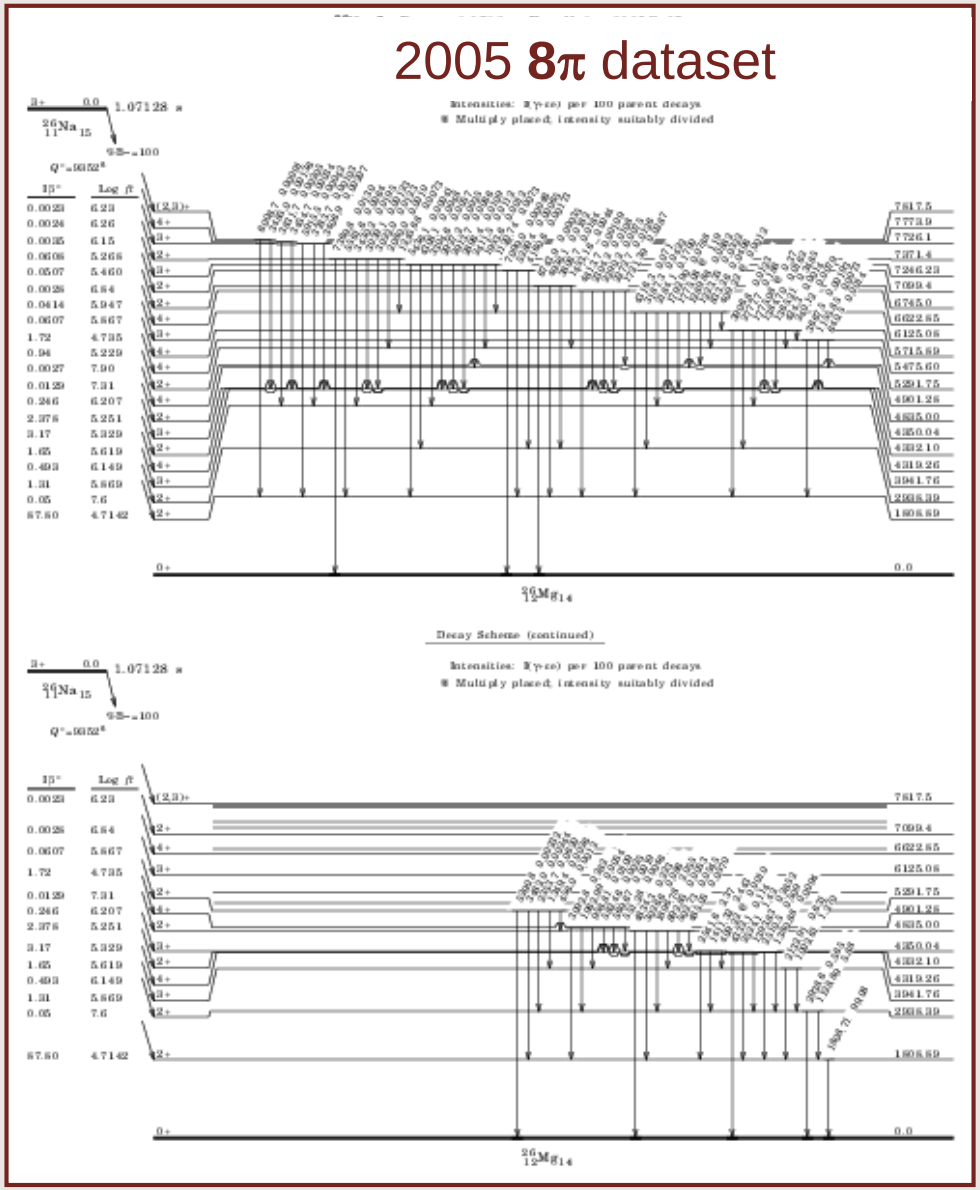
β-decay of ^{26}Na to ^{26}Mg

- Test case as first radioactive beam to **GRIFFIN**
- Scrutinize the performance of the new array with a well-known decay scheme.

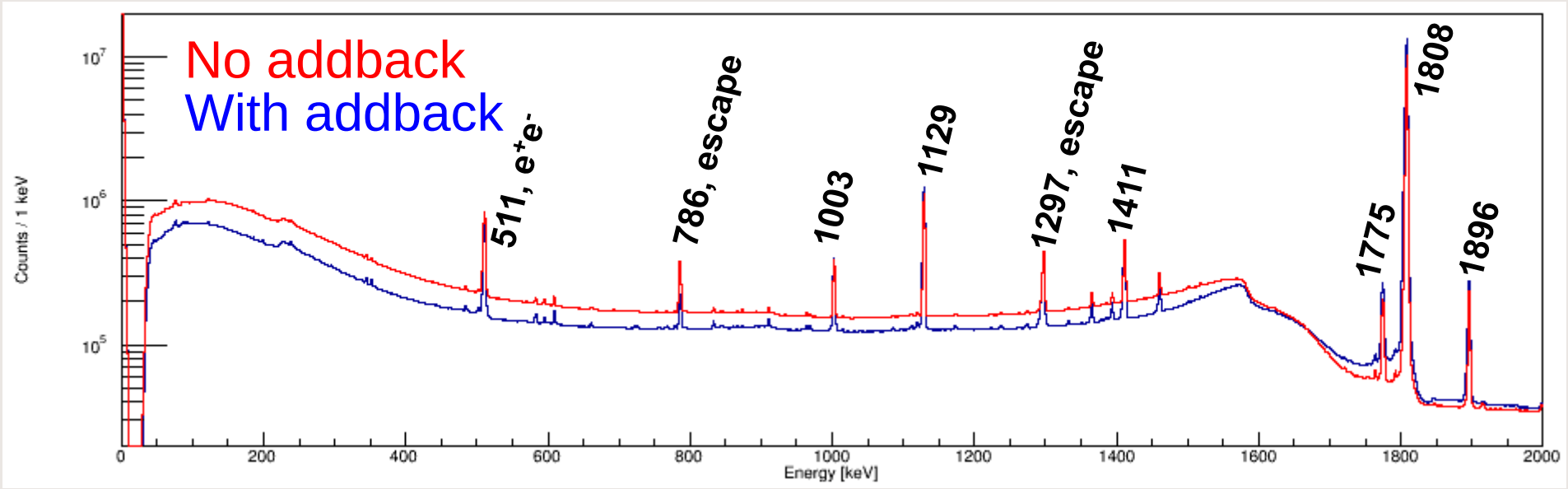
1973 and 1990 datasets

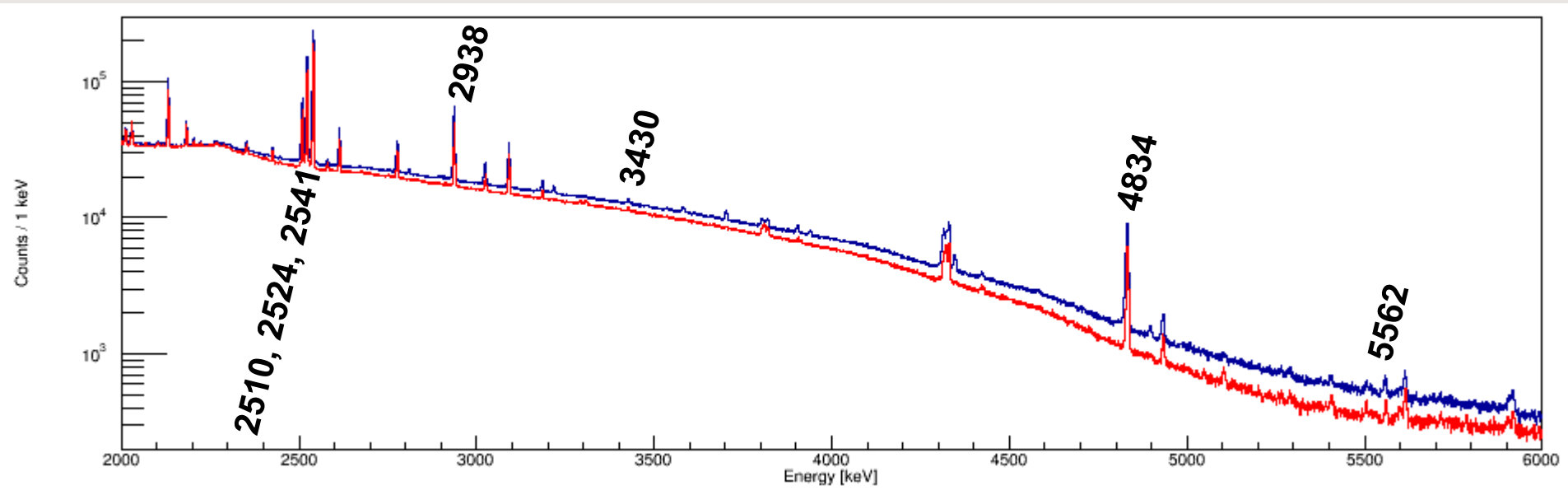


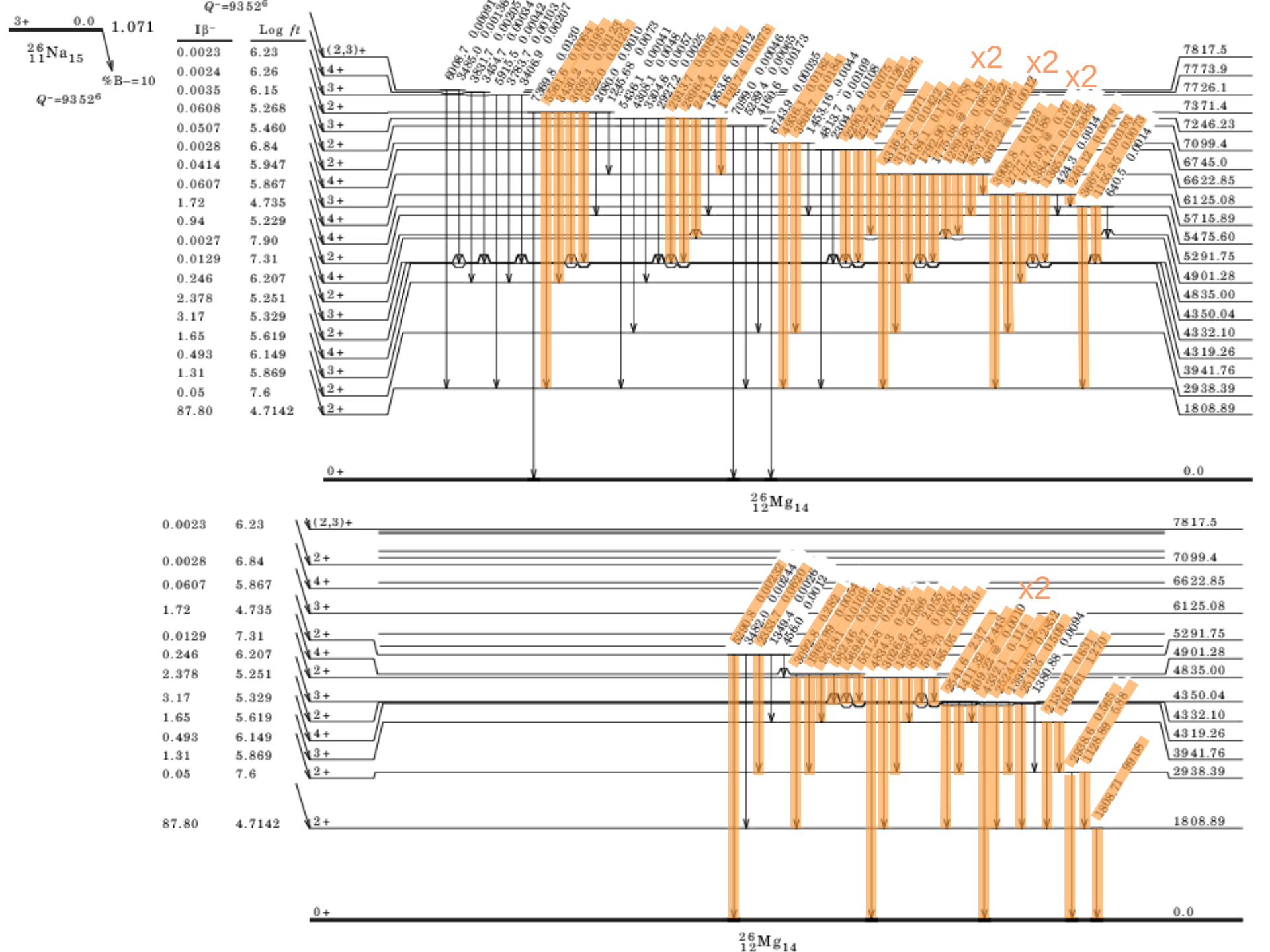
2005 8π dataset



^{26}Na with GRIFFIN

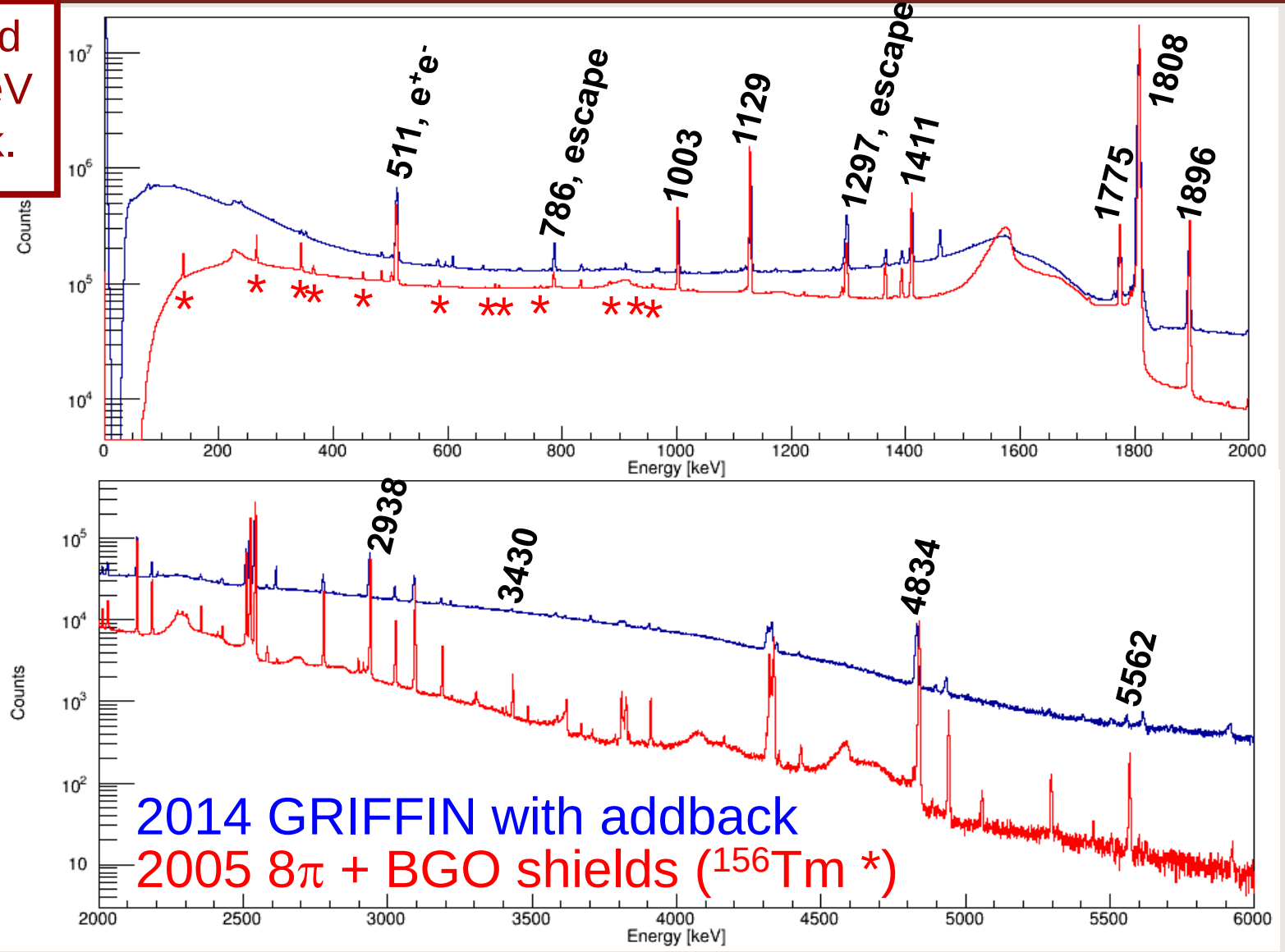





3+ 0.0 1.071
$^{26}_{11}Na_{15}$
%B−=10
Q^-=9352^6
Q^-=9352^6
Iβ⁻ Log ft
0.0023 6.23
0.0024 6.26
0.0035 6.15
0.0608 5.268
0.0507 5.460
0.0028 6.84
0.0414 5.947
0.0607 5.867
1.72 4.735
0.94 5.229
0.0027 7.90
0.0129 7.31
0.246 6.207
2.378 5.251
3.17 5.329
1.65 5.619
0.493 6.149
1.31 5.869
0.05 7.6
87.80 4.7142
(2,3)+
4+
3+
2+
3+
2+
2+
4+
3+
4+
4+
2+
4+
2+
3+
2+
4+
3+
2+
2+
0+
x2
x2
x2
7817.5
7773.9
7726.1
7371.4
7246.23
7099.4
6745.0
6622.85
6125.08
5715.89
5475.60
5291.75
4901.28
4835.00
4350.04
4332.10
4319.26
3941.76
2938.39
1808.89
0.0
$^{26}_{12}Mg_{14}$
0.0023 6.23
0.0028 6.84
0.0607 5.867
1.72 4.735
0.0129 7.31
0.246 6.207
2.378 5.251
3.17 5.329
1.65 5.619
0.493 6.149
1.31 5.869
0.05 7.6
87.80 4.7142
(2,3)+
2+
4+
3+
2+
4+
2+
3+
2+
4+
3+
2+
2+
0+
x2
7817.5
7099.4
6622.85
6125.08
5291.75
4901.28
4835.00
4350.04
4332.10
4319.26
3941.76
2938.39
1808.89
0.0
$^{26}_{12}Mg_{14}$

^{26}Na with 8π and GRIFFIN

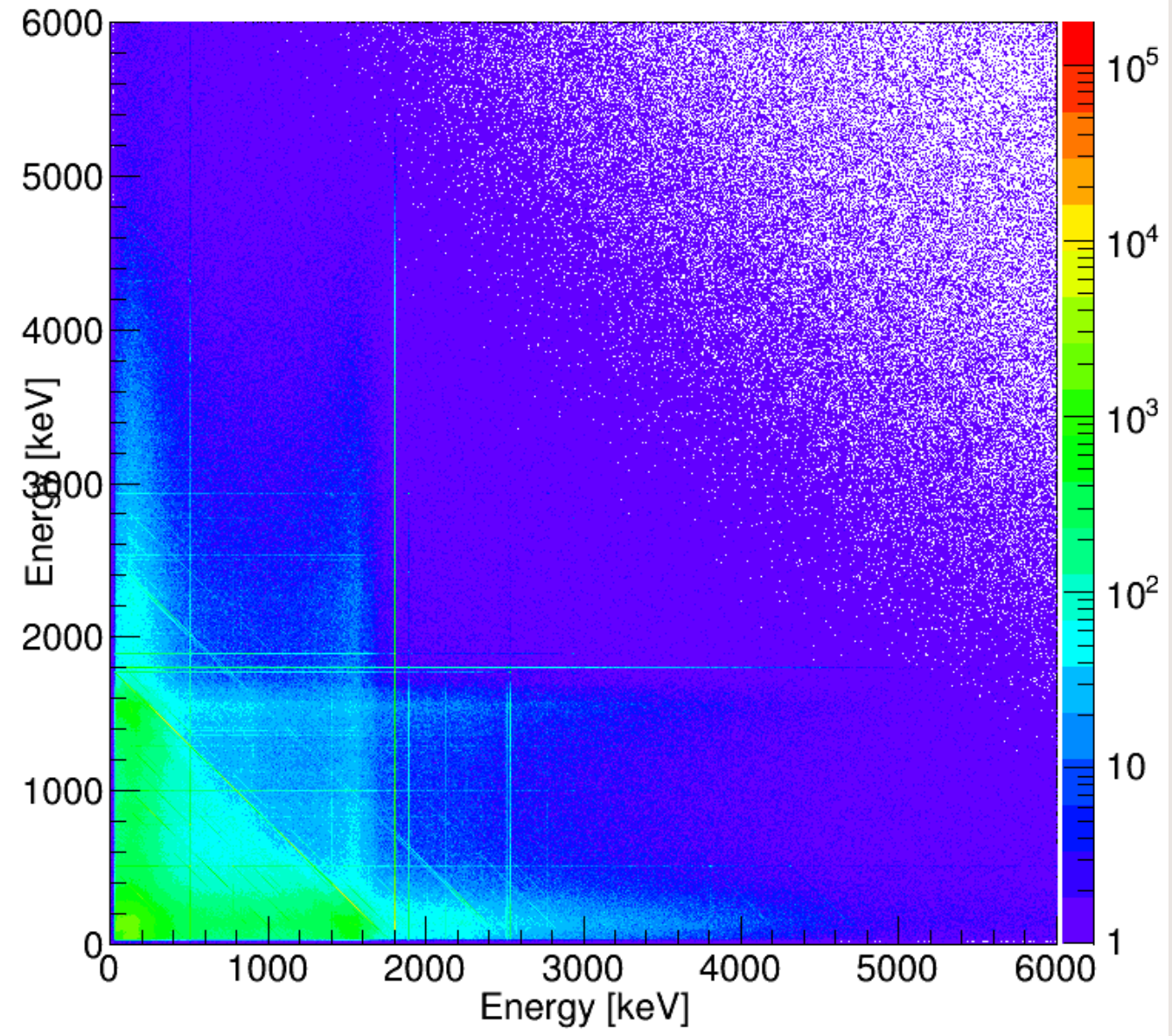
- Normalized to 1808 keV photopeak.



G.F. Grinyer et al., Phys. Rev. C 71, 044309 (2005).

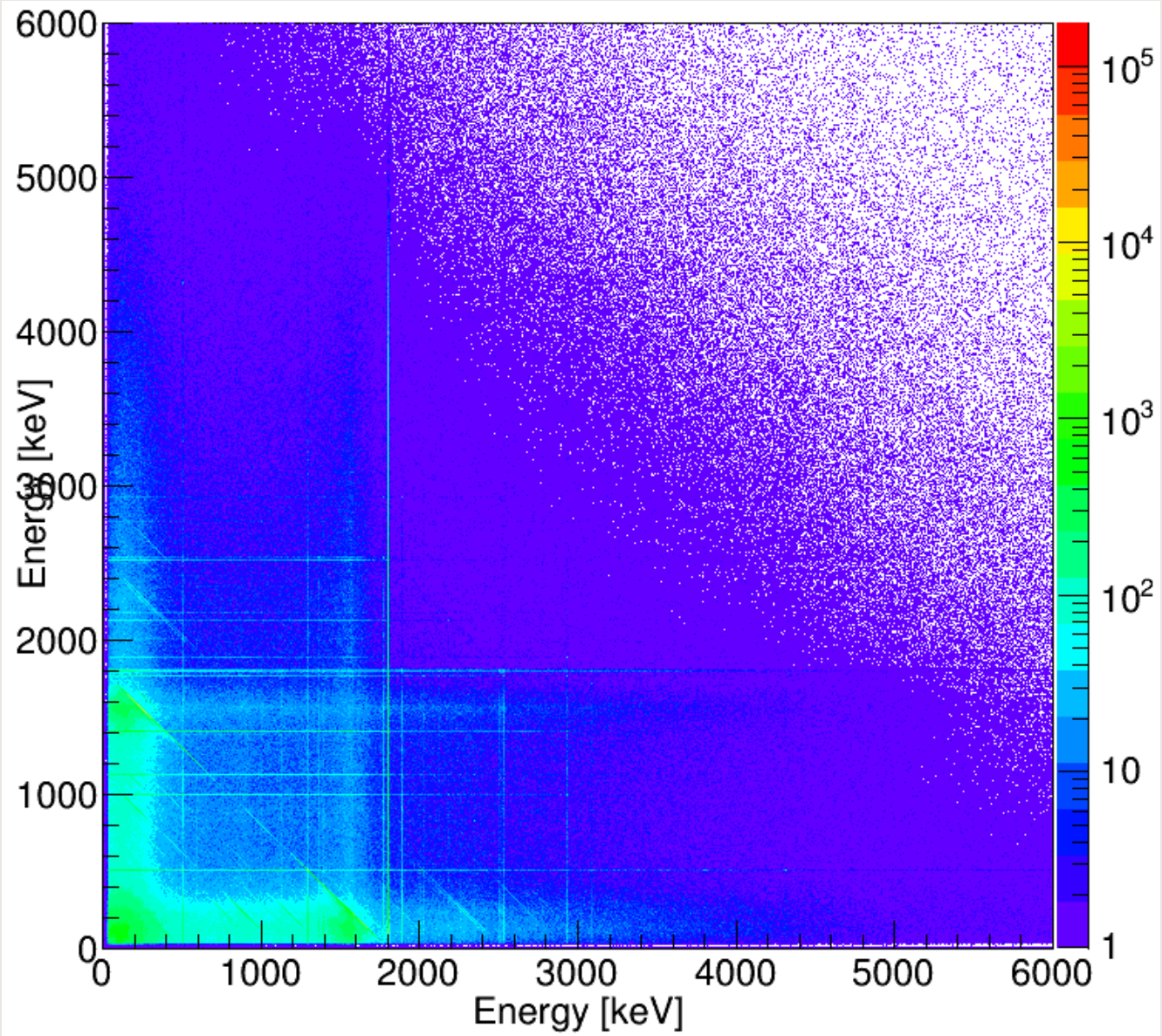
^{26}Na γ-γ coincidence

- No addback.

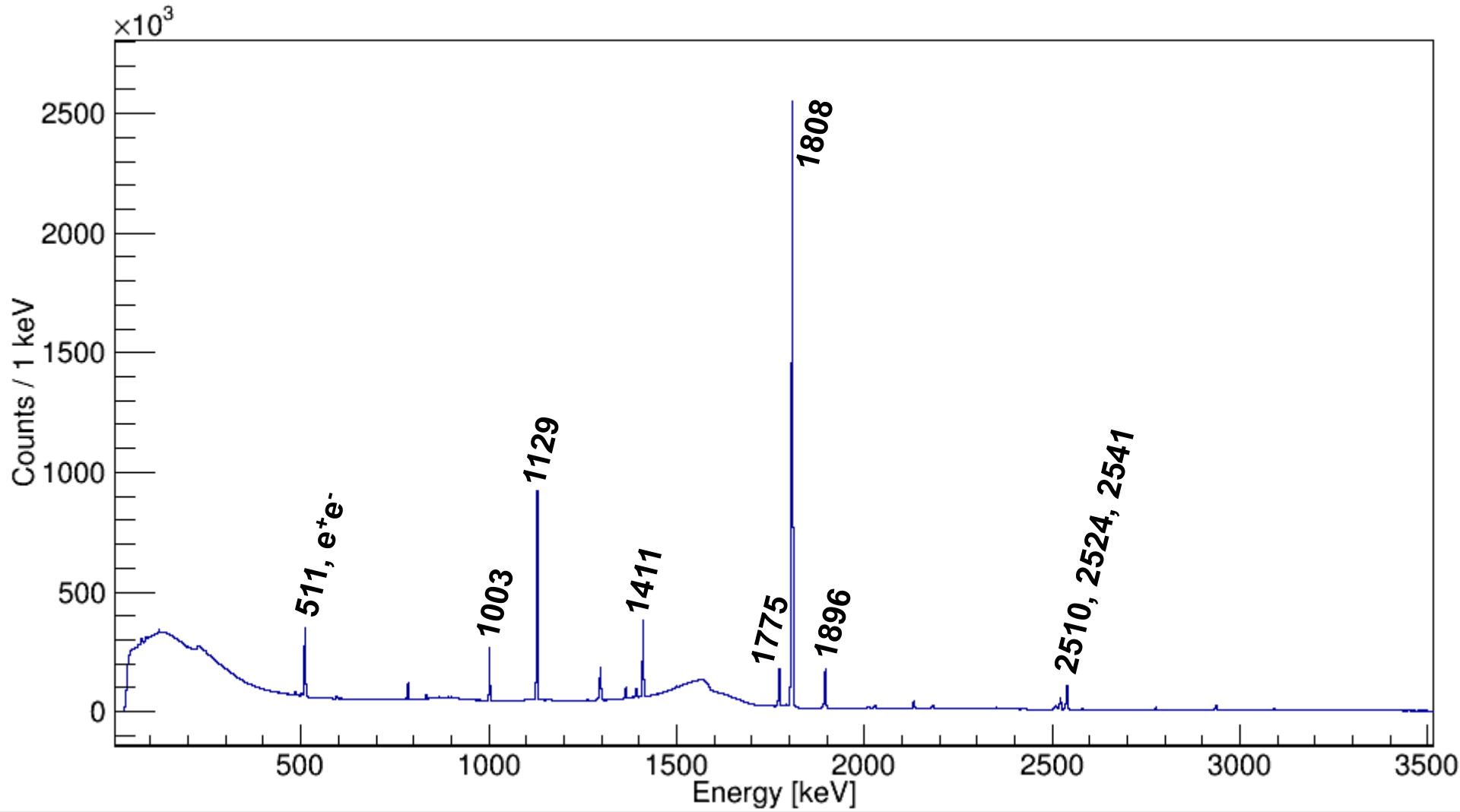


^{26}Na γ-γ coincidence

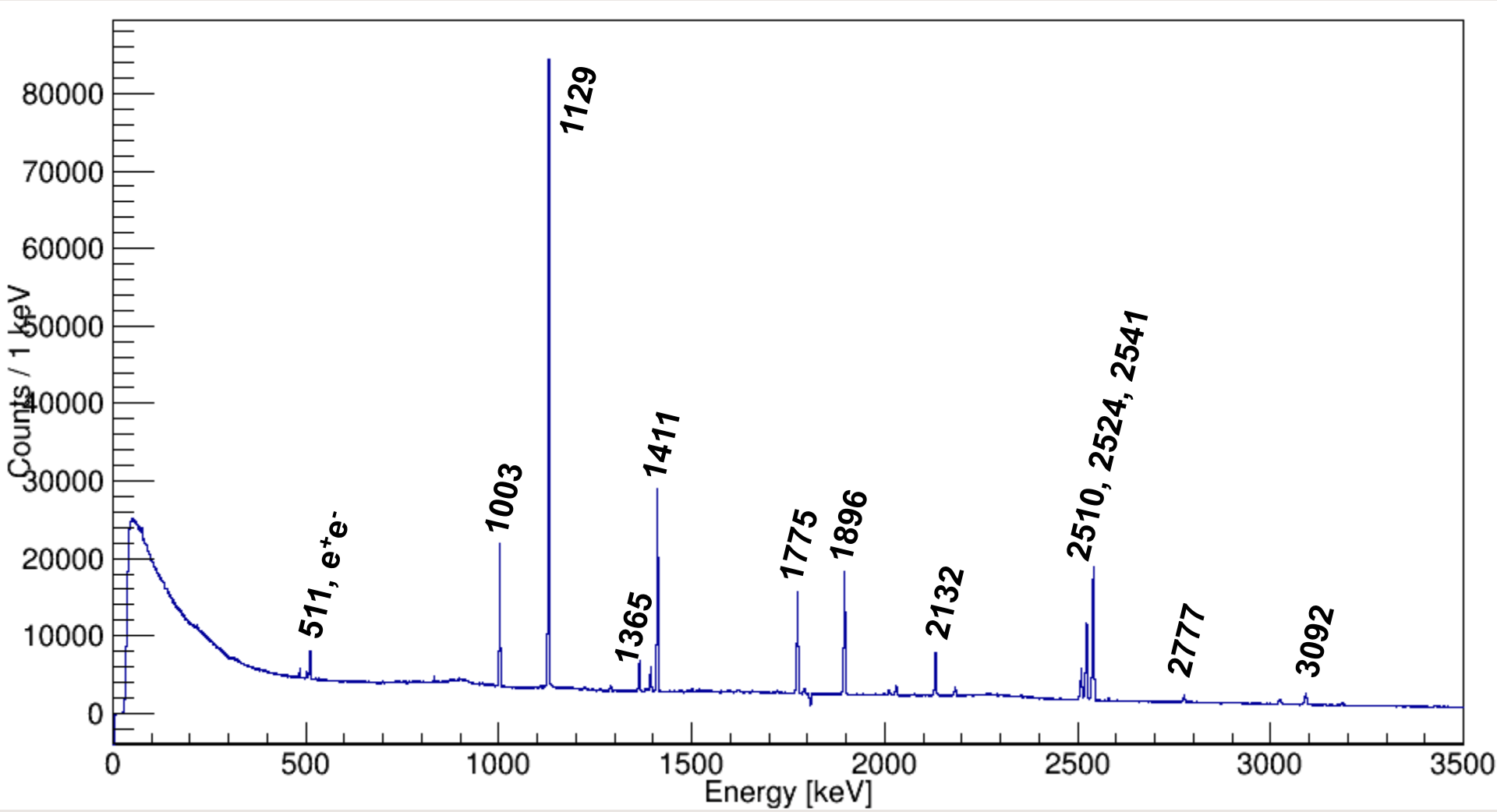
- With addback.

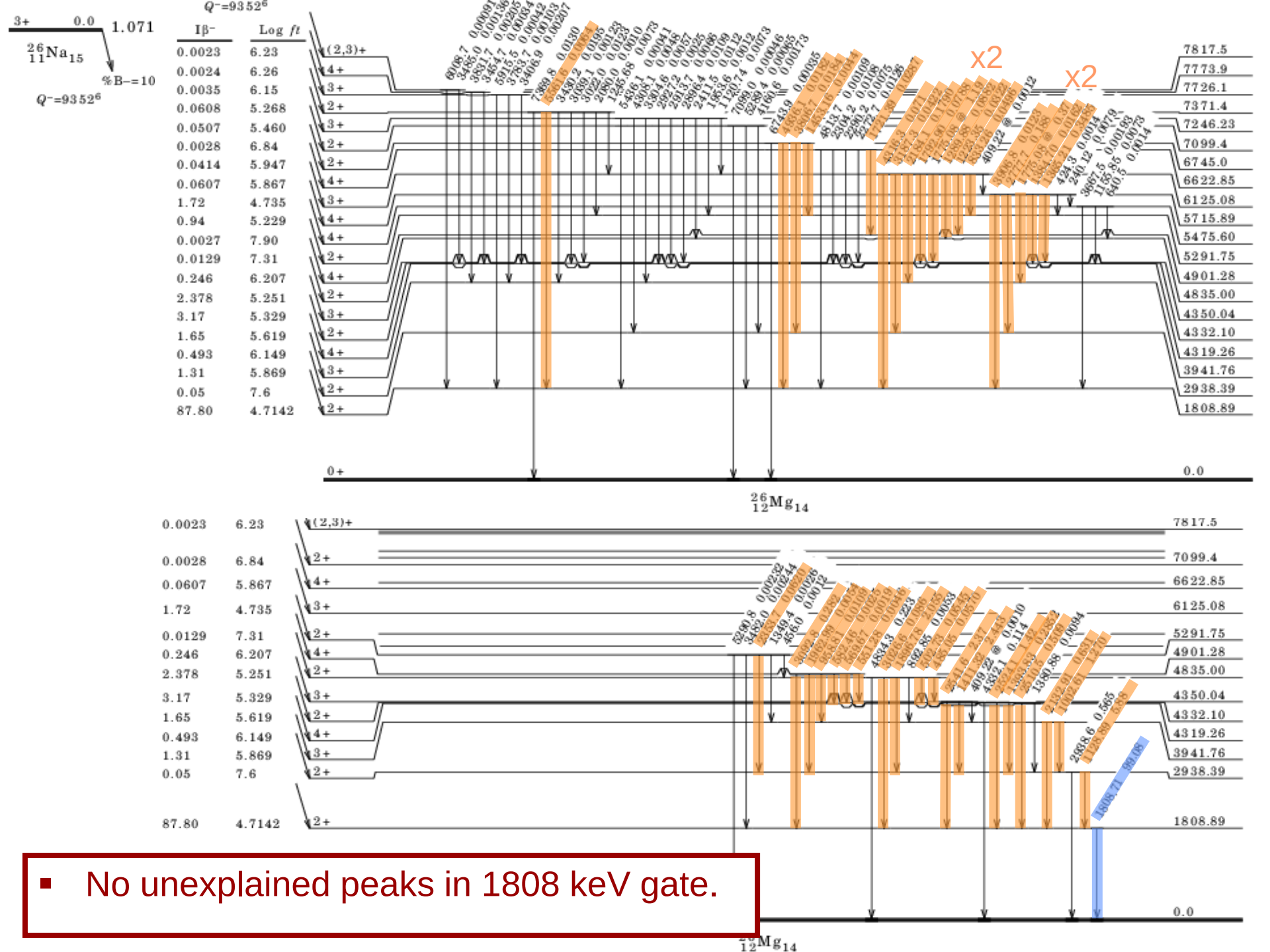


^{26}Na matrix total projection



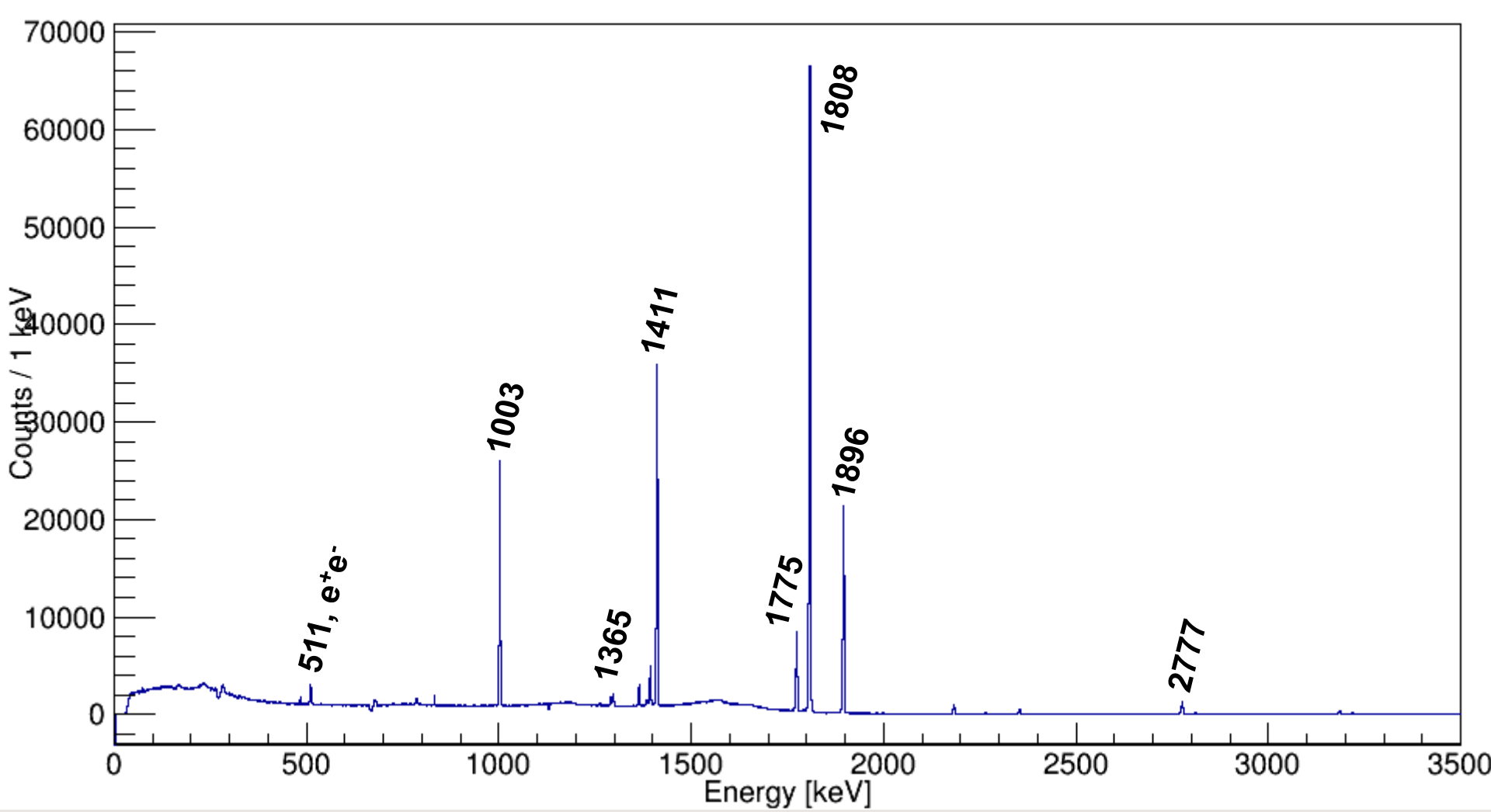
Spectrum gated on 1808 keV

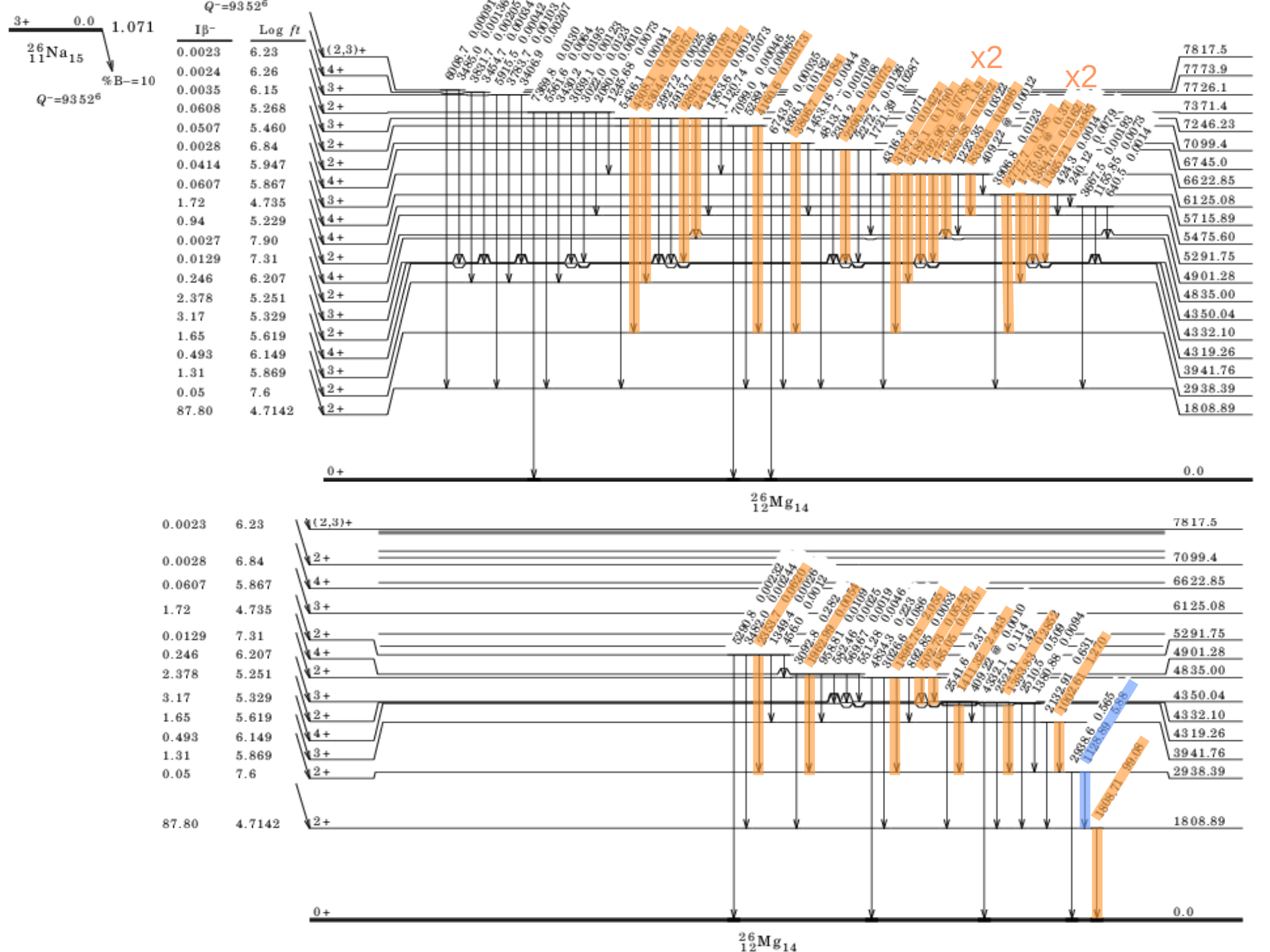




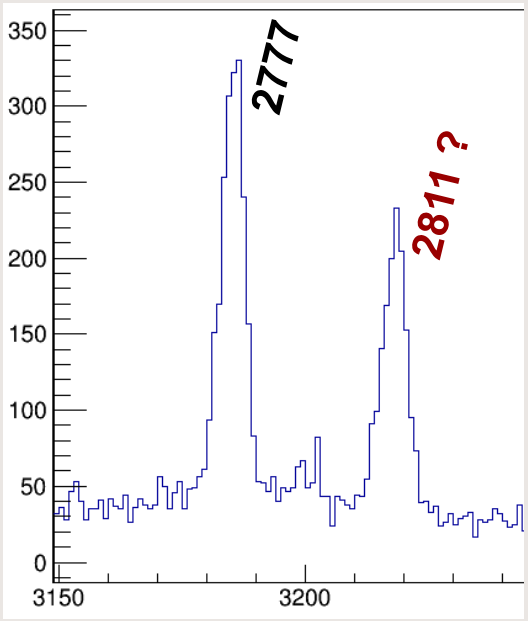
- No unexplained peaks in 1808 keV gate.

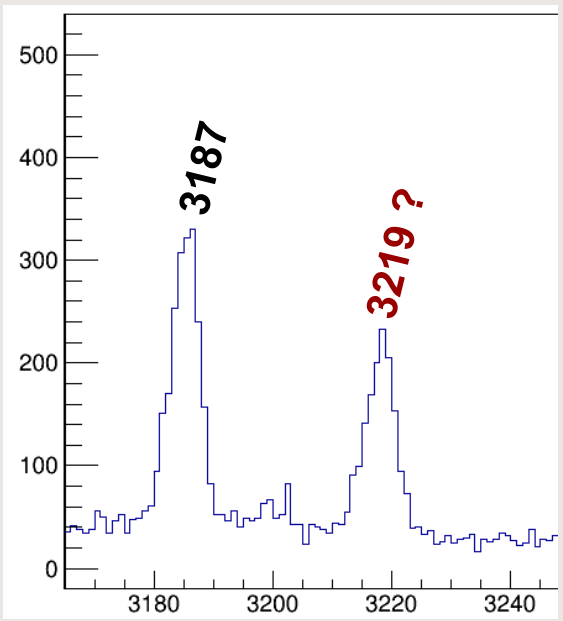
Spectrum gated on 1129 keV

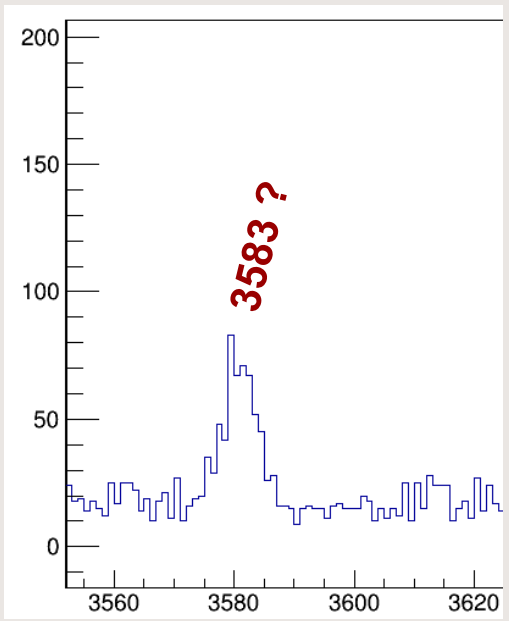


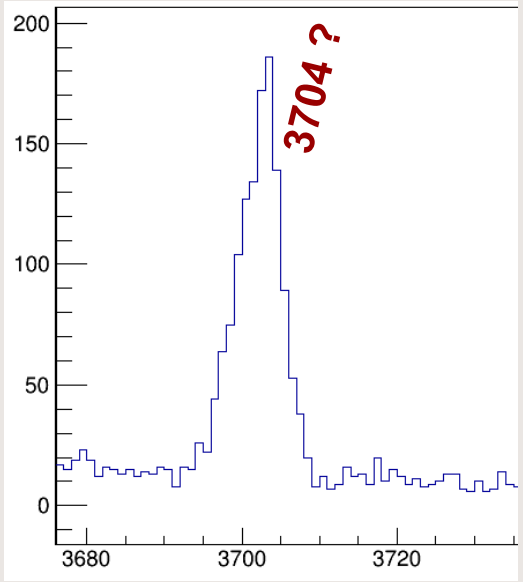

3+
0.0
1.071
$^{26}_{11}Na_{15}$
%B−=10
Q^-=9352⁶
Q^-=9352⁶
Iβ⁻
Log ft
0.0023 6.23
0.0024 6.26
0.0035 6.15
0.0608 5.268
0.0507 5.460
0.0028 6.84
0.0414 5.947
0.0607 5.867
1.72 4.735
0.94 5.229
0.0027 7.90
0.0129 7.31
0.246 6.207
2.378 5.251
3.17 5.329
1.65 5.619
0.493 6.149
1.31 5.869
0.05 7.6
87.80 4.7142
(2,3)+
4+
3+
2+
3+
2+
2+
4+
3+
4+
4+
2+
4+
2+
3+
2+
4+
3+
2+
2+
0+
x2
x2
7817.5
7773.9
7726.1
7371.4
7246.23
7099.4
6745.0
6622.85
6125.08
5715.89
5475.60
5291.75
4901.28
4835.00
4350.04
4332.10
4319.26
3941.76
2938.39
1808.89
0.0
$^{26}_{12}Mg_{14}$
0.0023 6.23
0.0028 6.84
0.0607 5.867
1.72 4.735
0.0129 7.31
0.246 6.207
2.378 5.251
3.17 5.329
1.65 5.619
0.493 6.149
1.31 5.869
0.05 7.6
87.80 4.7142
(2,3)+
2+
4+
3+
2+
4+
2+
3+
2+
4+
3+
2+
2+
0+
7817.5
7099.4
6622.85
6125.08
5291.75
4901.28
4835.00
4350.04
4332.10
4319.26
3941.76
2938.39
1808.89
0.0
$^{26}_{12}Mg_{14}$

Unexplained peaks in 1129 keV gate

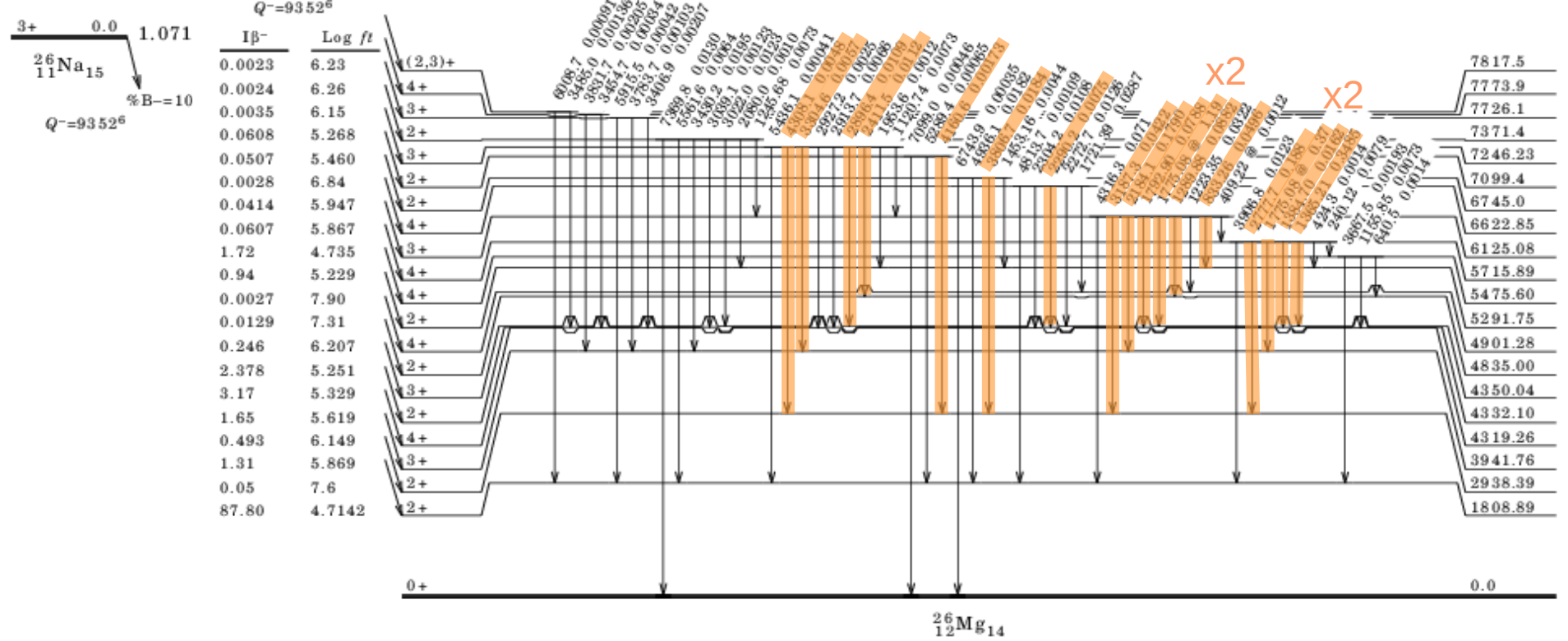


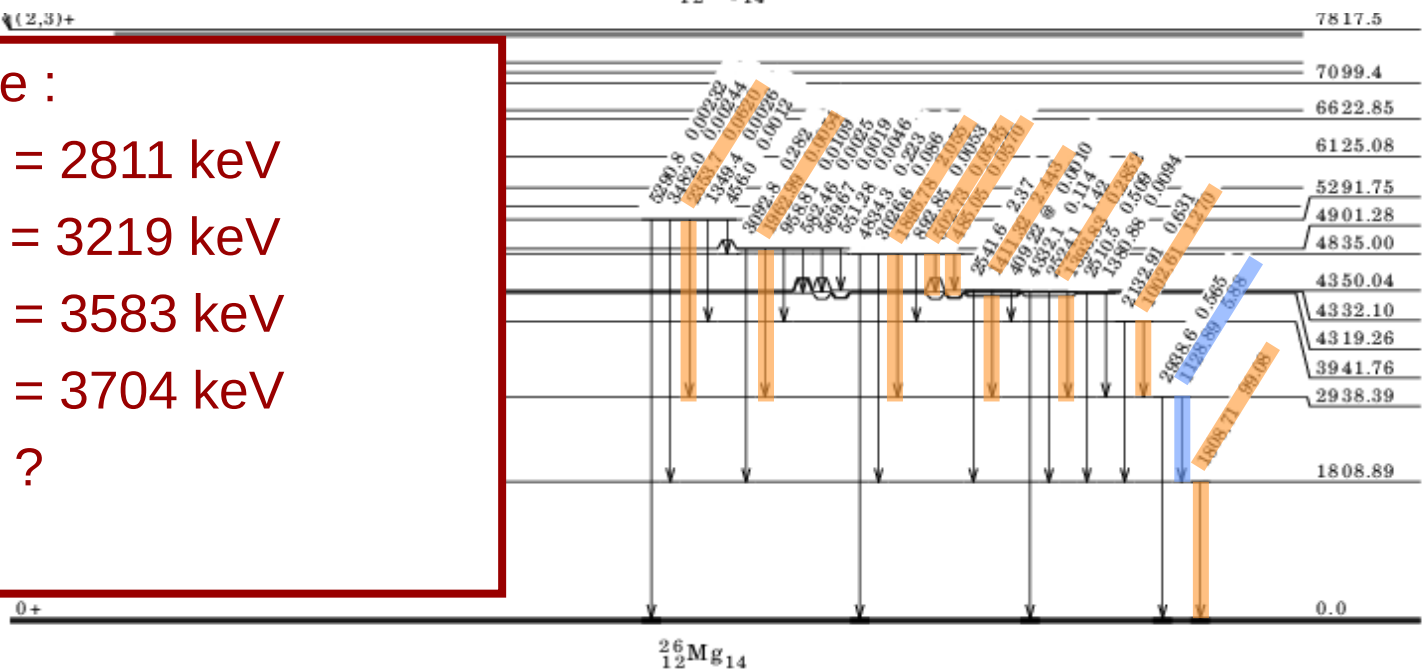






- All 4 unknown peaks are in β-gated spectrum as well.



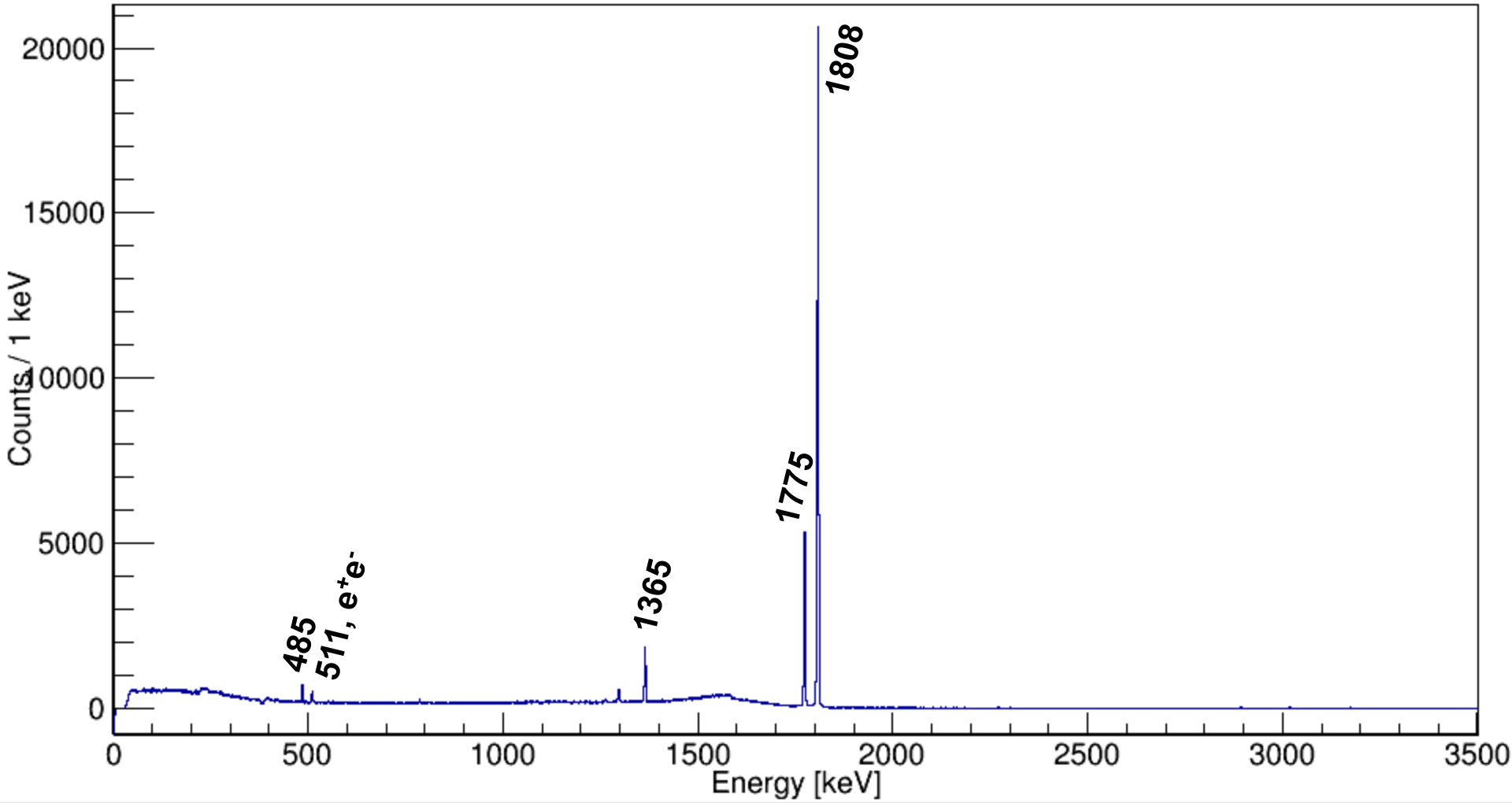


In 1129 keV gate :

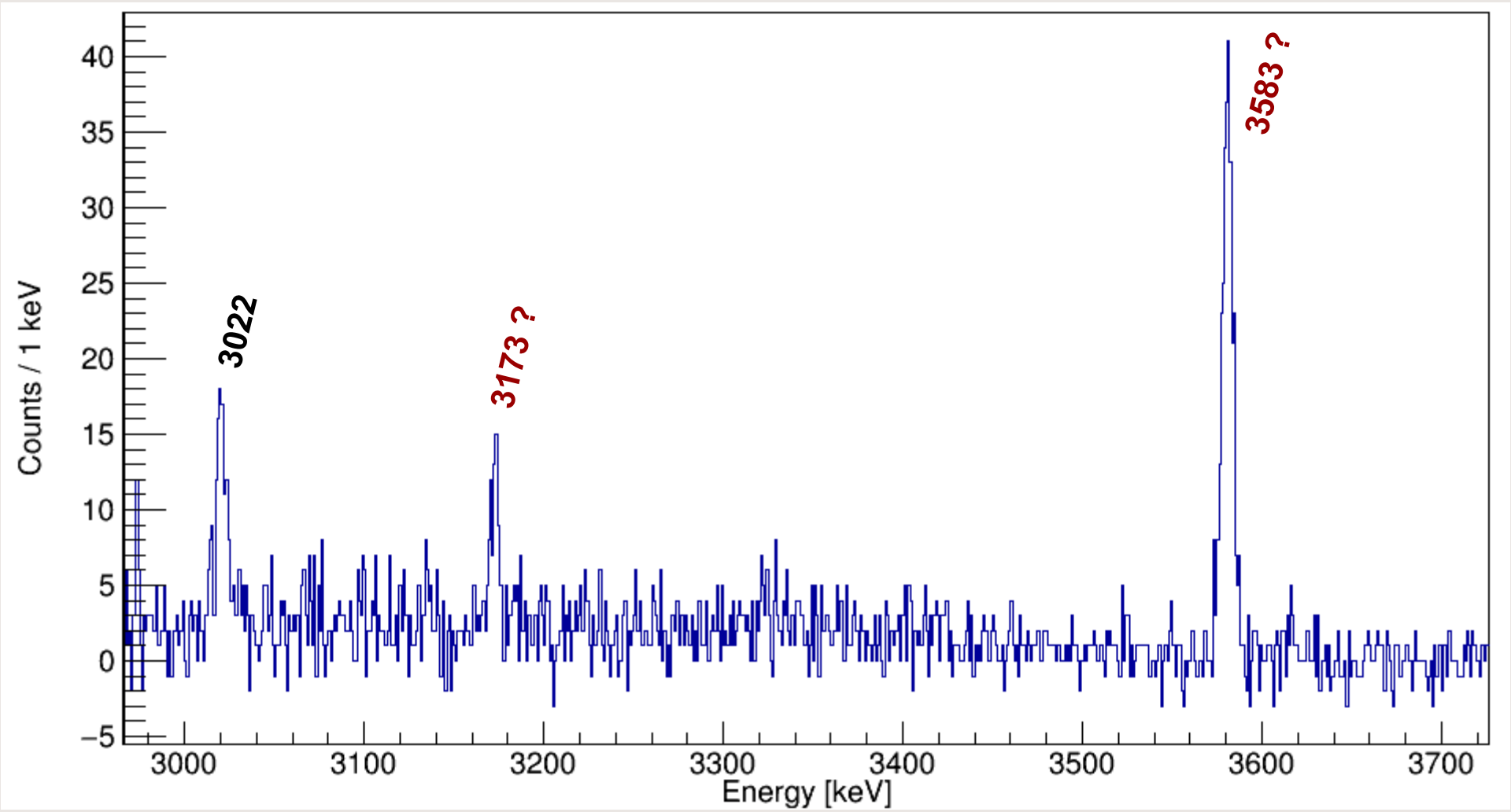
- 1808 + 1003 = 2811 keV
- 1808 + 1411 = 3219 keV
- 1808 + 1775 = 3583 keV
- 1808 + 1896 = 3704 keV

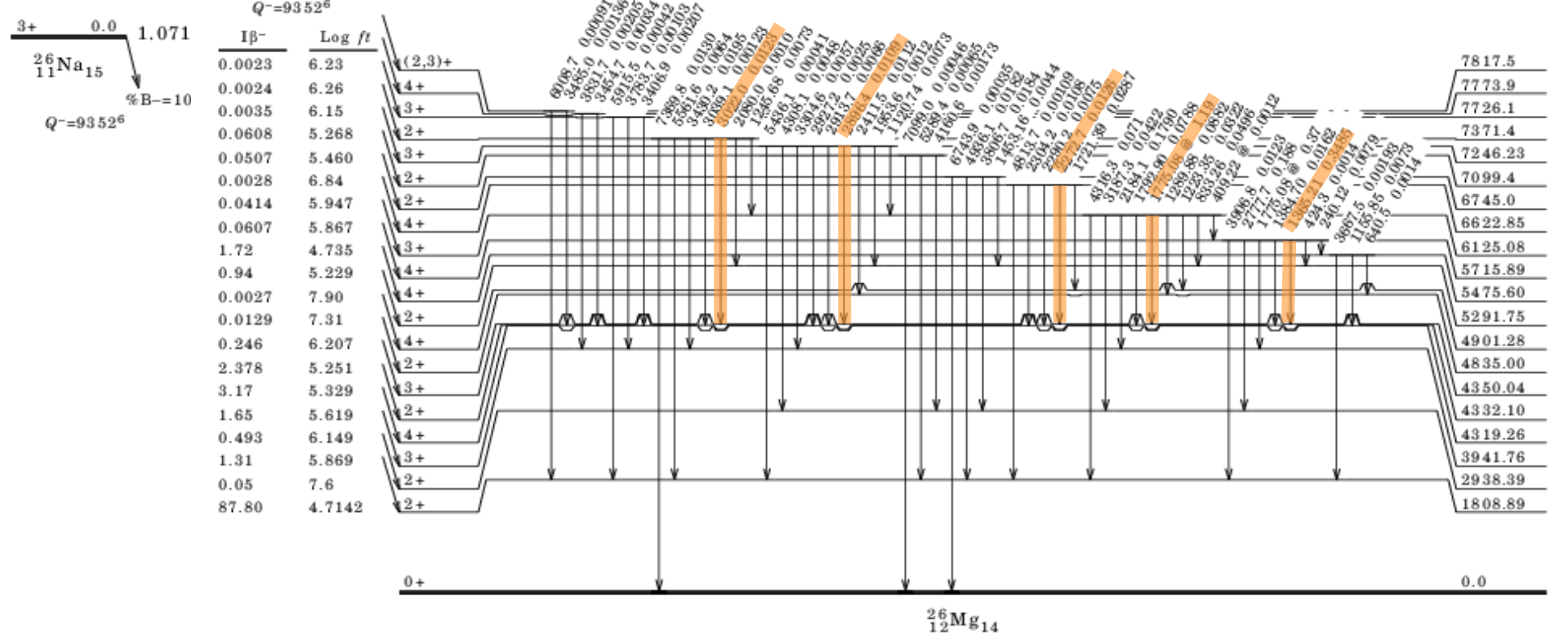
Summed peaks ?

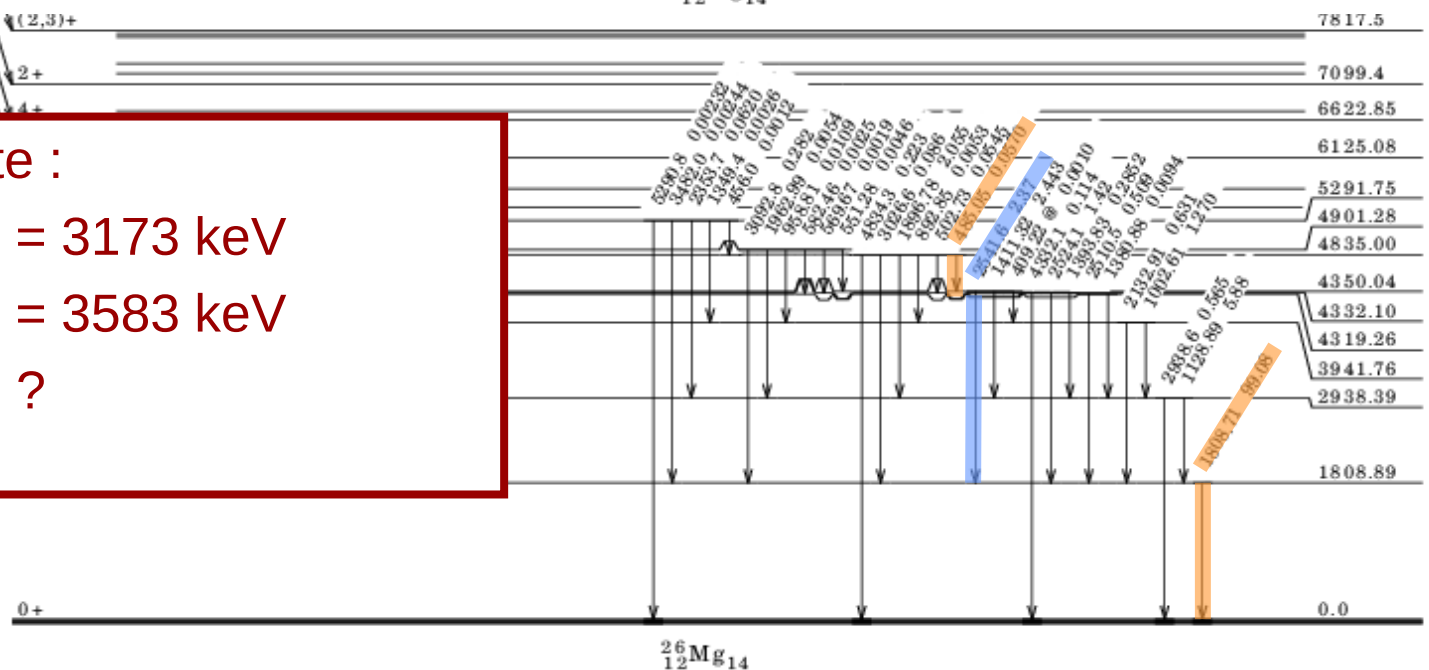
Spectrum gated on 2541 keV



Unexplained peaks in 2541 keV gate







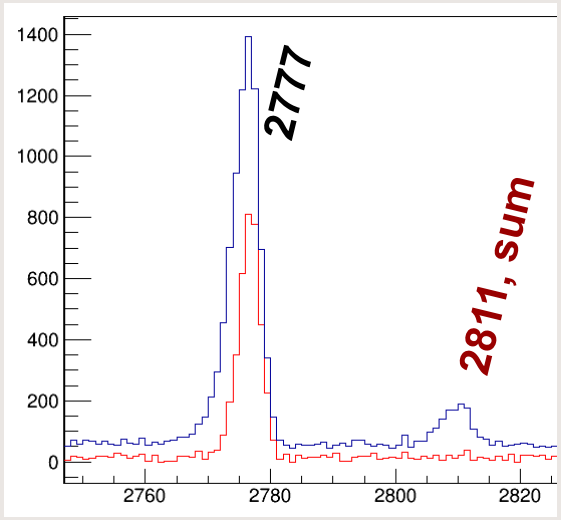
In 2541 keV gate :

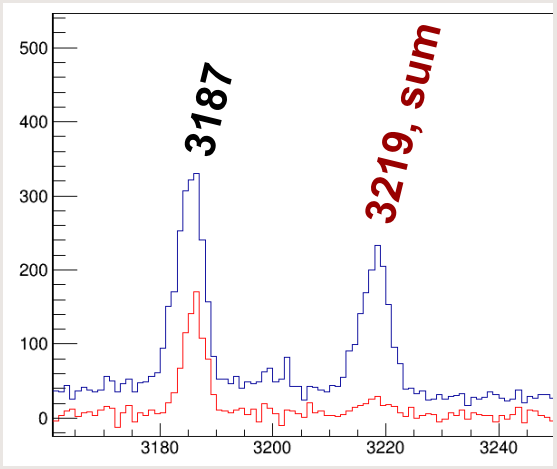
- 1808 + 1365 = 3173 keV
- 1808 + 1775 = 3583 keV

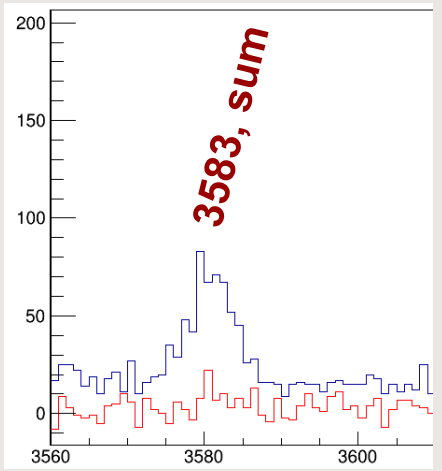
Summed peaks ?

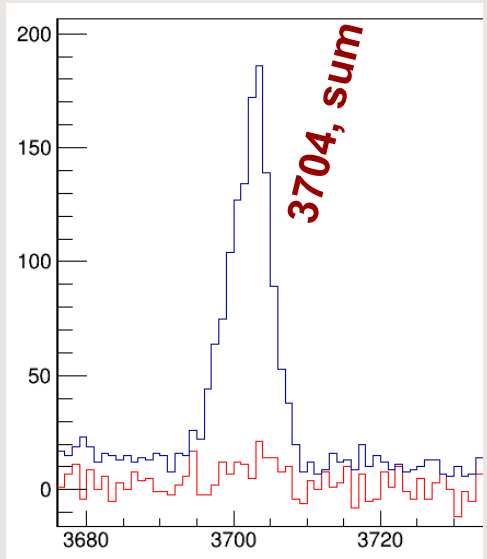
Summed Peaks

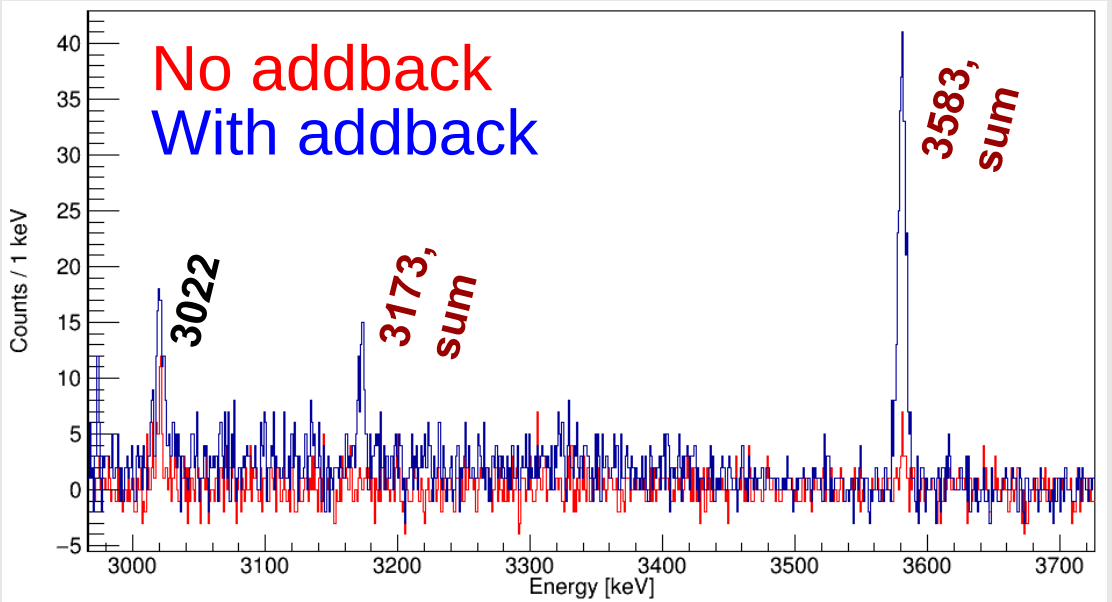
- ‘Unknown’ peaks greatly reduced without addback.





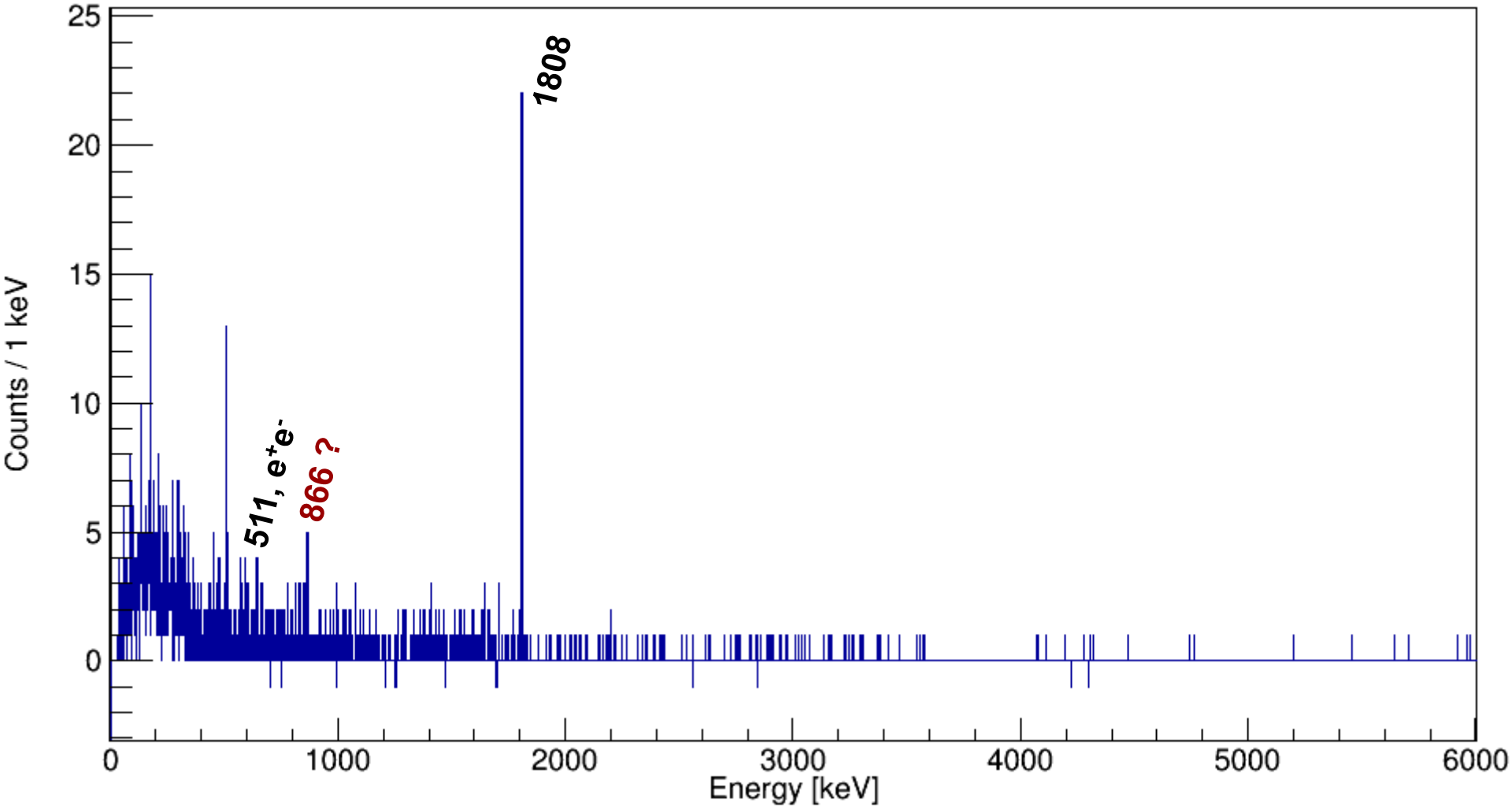


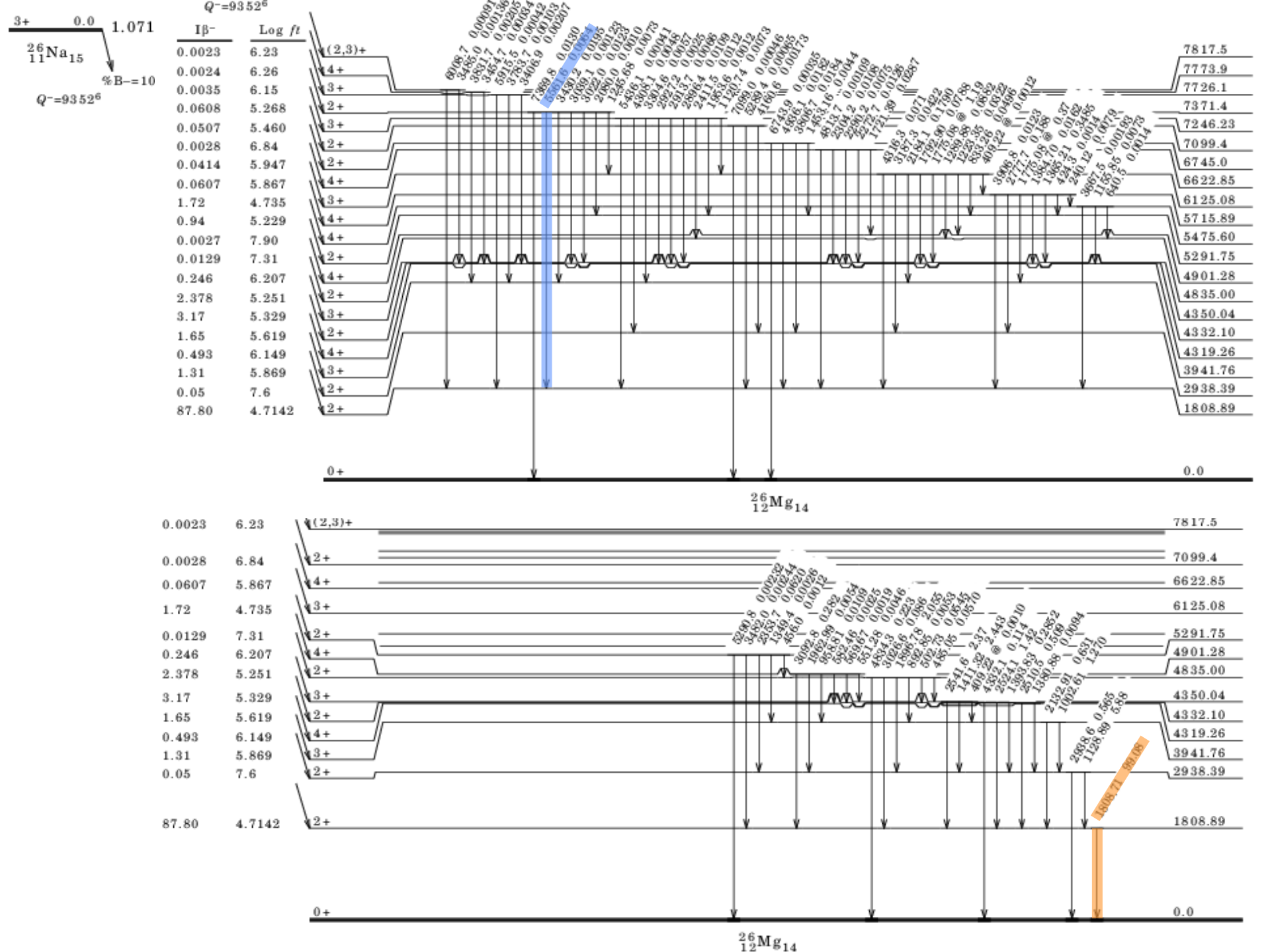




Spectrum gated on 5562 keV

- **Weakest** transition seen so far : 0.0064% intensity.

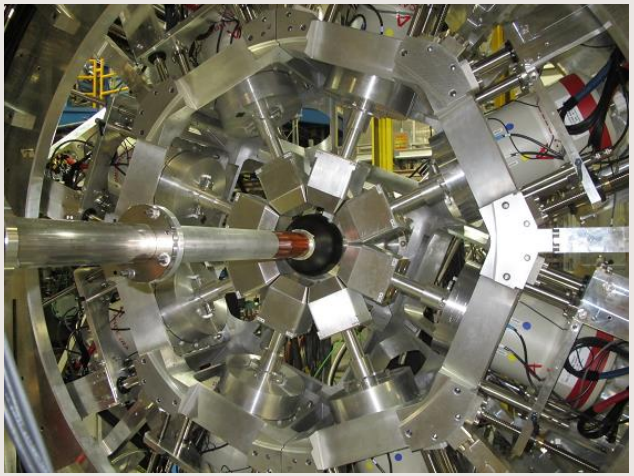



3+ 0.0 1.071
$^{26}_{11}Na_{15}$
%B−=10
Q^-=9352^6
Q^-=9352^6
Iβ⁻ Log ft
0.0023 6.23
0.0024 6.26
0.0035 6.15
0.0608 5.268
0.0507 5.460
0.0028 6.84
0.0414 5.947
0.0607 5.867
1.72 4.735
0.94 5.229
0.0027 7.90
0.0129 7.31
0.246 6.207
2.378 5.251
3.17 5.329
1.65 5.619
0.493 6.149
1.31 5.869
0.05 7.6
87.80 4.7142
(2,3)+
4+
3+
2+
3+
2+
2+
4+
3+
4+
4+
2+
4+
2+
3+
2+
4+
3+
2+
2+
0+
7817.5
7773.9
7726.1
7371.4
7246.23
7099.4
6745.0
6622.85
6125.08
5715.89
5475.60
5291.75
4901.28
4835.00
4350.04
4332.10
4319.26
3941.76
2938.39
1808.89
0.0
$^{26}_{12}Mg_{14}$
0.0023 6.23
0.0028 6.84
0.0607 5.867
1.72 4.735
0.0129 7.31
0.246 6.207
2.378 5.251
3.17 5.329
1.65 5.619
0.493 6.149
1.31 5.869
0.05 7.6
87.80 4.7142
(2,3)+
2+
4+
3+
2+
4+
2+
3+
2+
4+
3+
2+
2+
7817.5
7099.4
6622.85
6125.08
5291.75
4901.28
4835.00
4350.04
4332.10
4319.26
3941.76
2938.39
1808.89
1808.71 99.08
0.0
$^{26}_{12}Mg_{14}$

Overview

- **GRIFFIN** provides enormous gains in high-energy and γ-γ coincidence efficiency, enabling both high-precision branching ratio measurements for complex high Q-value β-decays and detailed spectroscopic studies of the most exotic beams produced by the new **ARIEL** facility with intensities **below 0.01 ions/s**.
- The ^{26}Na commissioning is a great opportunity with this well known decay scheme to **scrutinize the performance** of the array and investigate various features of the new device in order to fully understand the new experimental datasets.

GRIFFIN



TRIUMF

Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

N. Bernier, R. Krücken
UBC and TRIUMF

G.C. Ball, P.C. Bender, I. Dillmann, L.J. Evitts, A.B. Garnsworthy, K.G. Leach, D. Miller, L. Morrison, M. Moukaddam, C. Pearson, J.K. Smith, D. Southall
TRIUMF

V. Bildstein, C.D. Burbadge, M.R. Dunlop, R.A. Dunlop, P. Finlay, P. Garrett, B. Hadinia, B. Jigmeddorj, A.T. Laffoley, A.D. MacLean, B. Olaizola, A.J. Radich, E.T. Rand, C.E. Svensson, A.D. Varela
University of Guelph

C. Andreoiu, D.S. Cross, J.L. Pore, U. Rizwan
Simon Fraser University

Merci!

Thank you!

UBC a place of mind THE UNIVERSITY OF BRITISH COLUMBIA
PHYSICS & ASTRONOMY

TRIUMF: Alberta | British Columbia | Calgary | Carleton | Guelph | Manitoba | McGill | McMaster | Montréal | Northern British Columbia | Queen's | Regina | Saint Mary's | Simon Fraser | Toronto | Victoria | Western | Winnipeg | York

Canada
British Columbia The Best Place on Earth
Canada Foundation for Innovation
Fondation canadienne pour l'innovation
CIHR IRSC Canadian Institutes of Health Research / Instituts de recherche en santé du Canada
NRC·CNRC From Discovery to Innovation...
NSERC CRSNG
Western Economic Diversification Canada
Diversification de l'économie de l'Ouest Canada
Natural Resources Canada
Ressources naturelles Canada
BC Cancer Agency Care + Research
CINP ICPN
Institute of Particle Physics
imagination at work Canada
nordion
Selkirk College
cpdc Centre for Probe Development and Commercialization
AAPS Advanced Applied Physics Solutions
LAWSON Health Research Institute
Positron Emission Tomography Imaging at The University of British Columbia
Pacific Parkinson's Research Institute