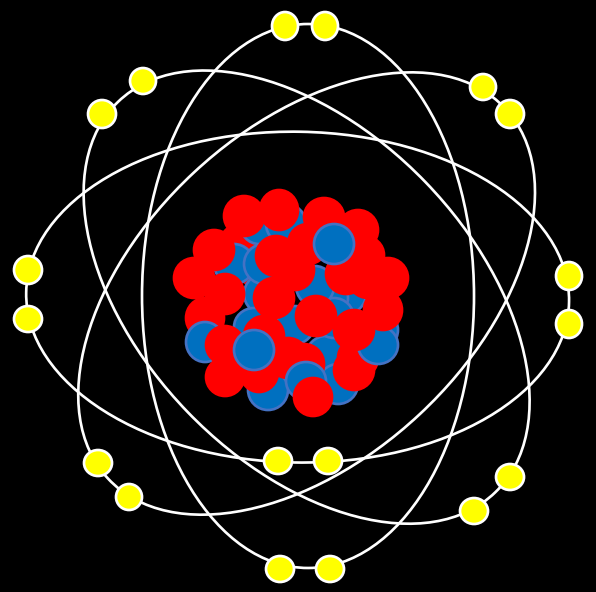
Investigating the Nuclear Shell Evolution in Neutron-Rich Calcium

Robin Coleman WNPPC 2022

Outline

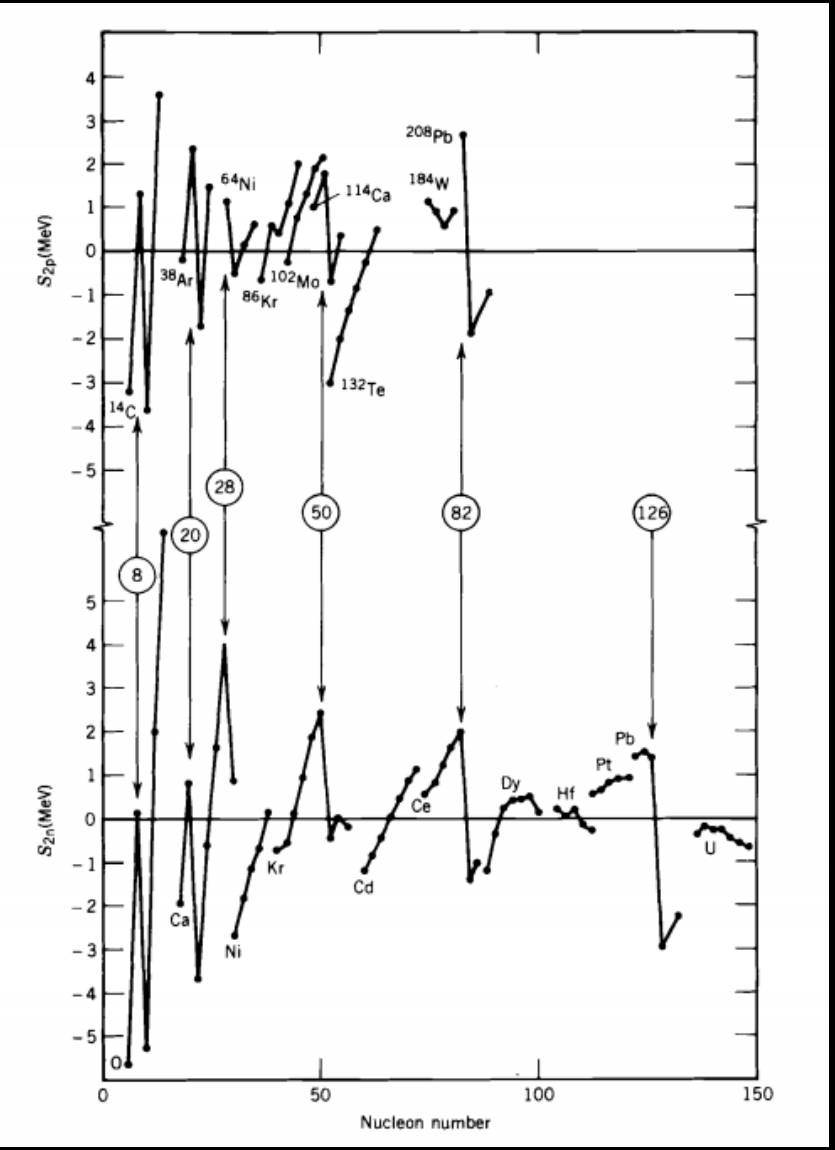
- Why calcium?
- How calcium?
- What calcium?



$^{53}Ca^{2+}$ Protons: 20
Neutrons: 33

Nuclear Structure

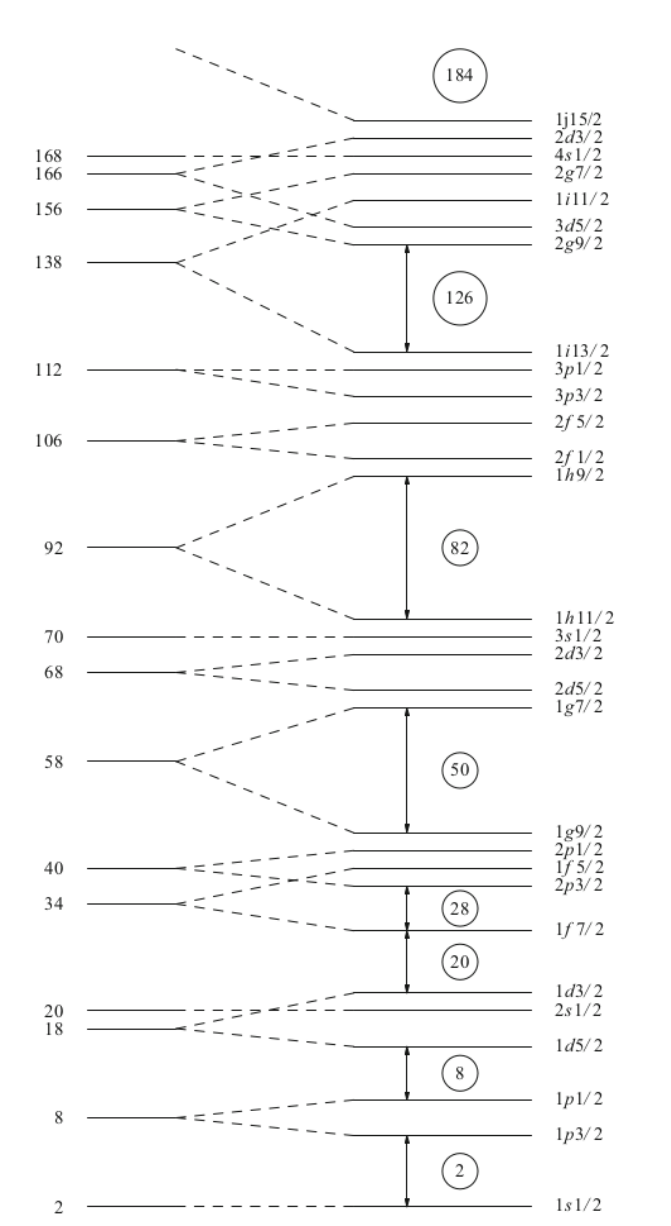
- Analogous to electron shells
- Experimentally observed shells
  - 2, 8, 20, 28, 50, 82, 126



•K. S. Krane, *Introductory Nuclear Physics* (John Wiley and Sons Inc., 1988).

Nuclear Structure

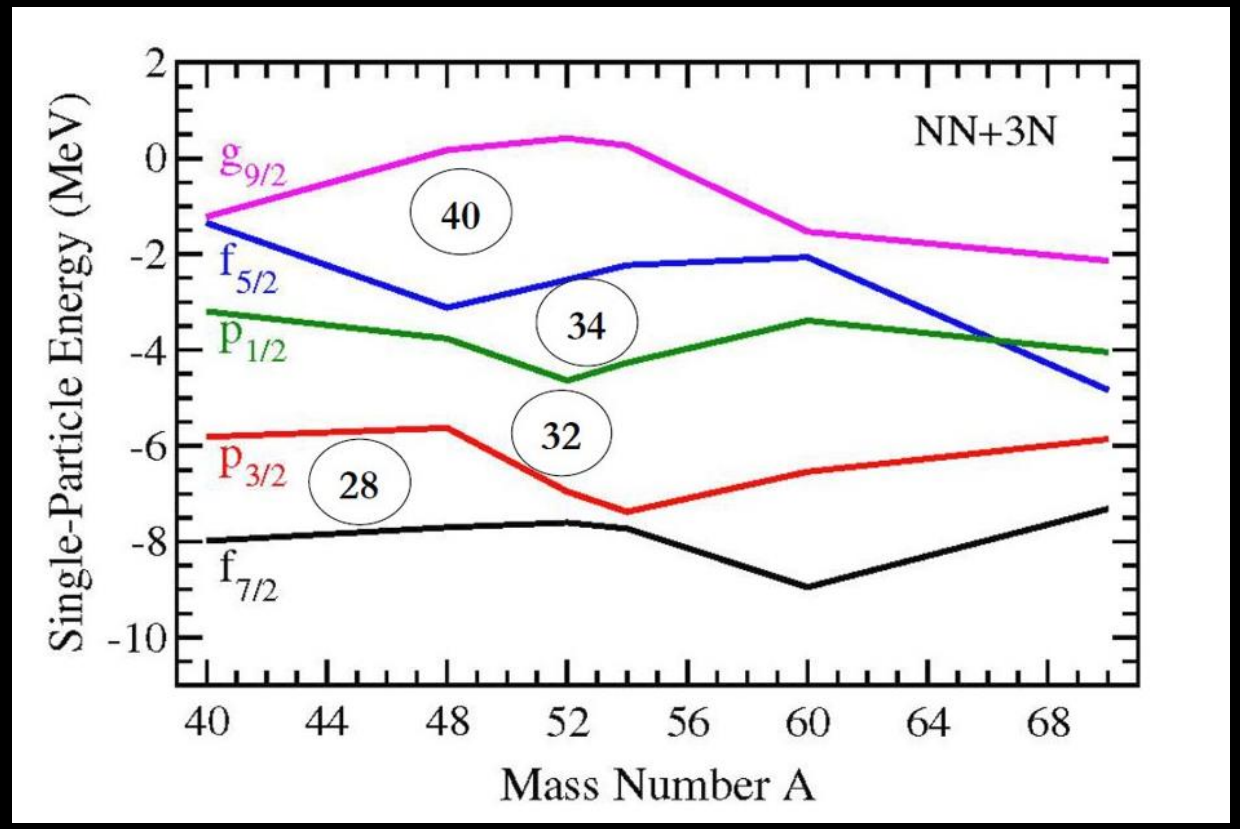
- Harmonic Oscillator
  - 2, 6, 12, 20, 30, ...
- Wood-Saxon Potential
  - 2, 8, 20, 40, 58, ...
- Spin-Orbit Coupling
  - 2, 8, 20, 28, 50, ...



•. Bacca, The European Physical Journal Plus **131**, 107 (2016).

Shell Model Evolution

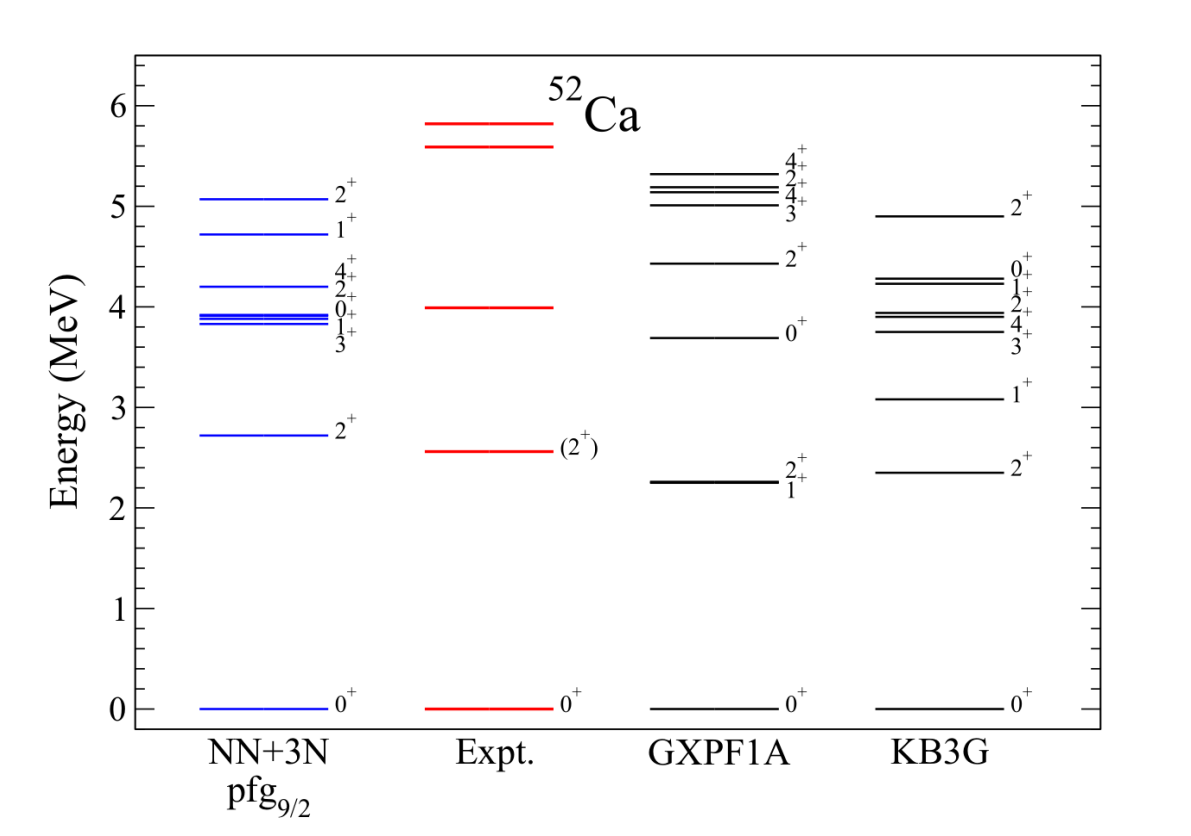
- Shells drift away from β-decay
- Creates new magic numbers



•. D. Holt, J. Menéndez, J. Simonis, and A. Schwenk, Physical Review C **90** (2014).

Shell Model Evolution

- Shells drift away from β-decay
- Various Interactions can describe this behavior
- Phenomenological models require spectroscopic validation



•. D. Holt, J. Menéndez, J. Simonis, and A. Schwenk, Physical Review C **90** (2014).

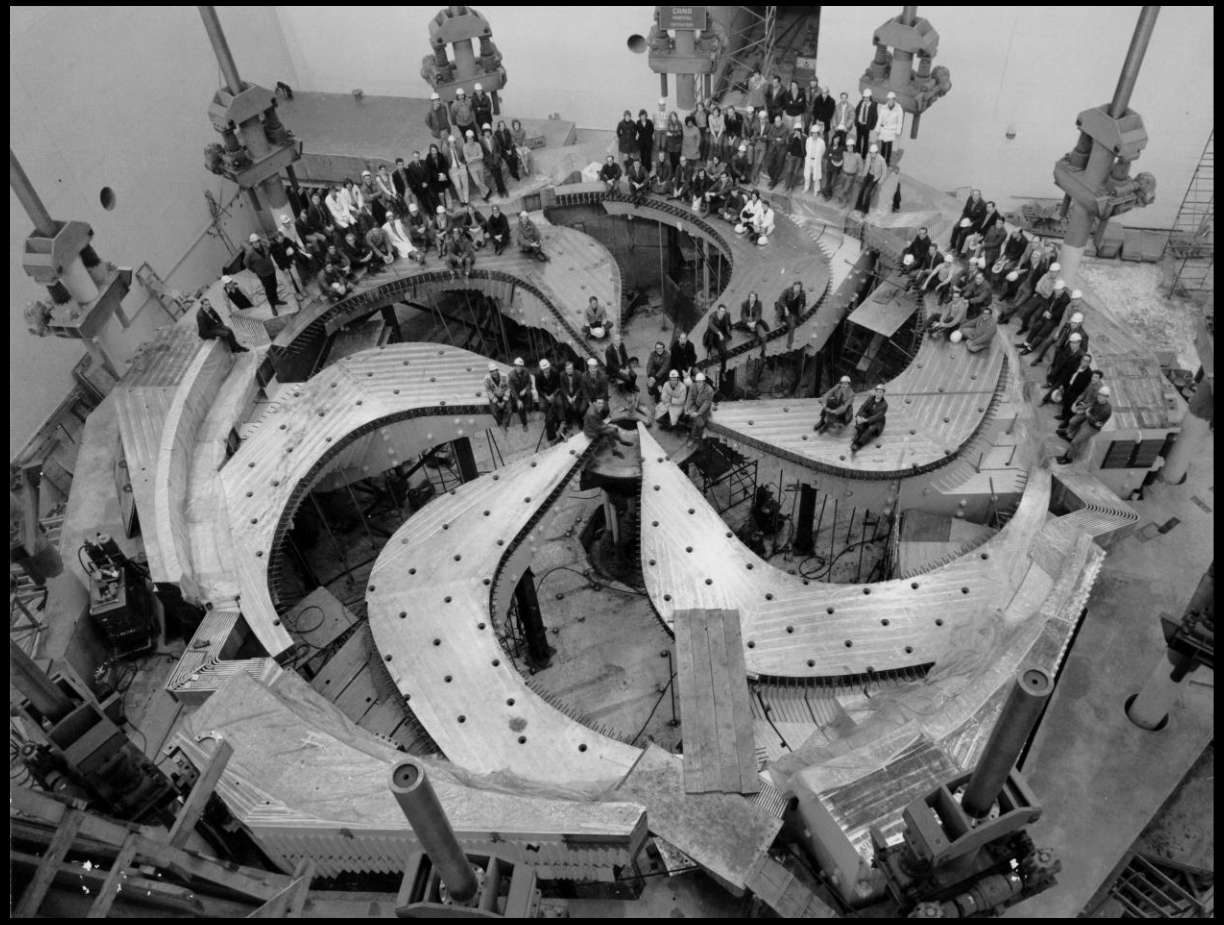
TRIUMF

TRI-**U**niversity **M**eson **F**acility

Established 1966 in Vancouver, BC

520 MeV Cyclotron

Isotope **S**eparation **O**n-**L**ine (ISOL) facility



"GRIFFIN Collaboration," triumf.ca

Beta Detectors

- **Beta Detectors**
  - **SC**intillating **E**lectron **P**ositron **T**agging **AR**ray (SCEPTAR)
  - **Z**ero **D**egree **S**cintillator (ZDS)

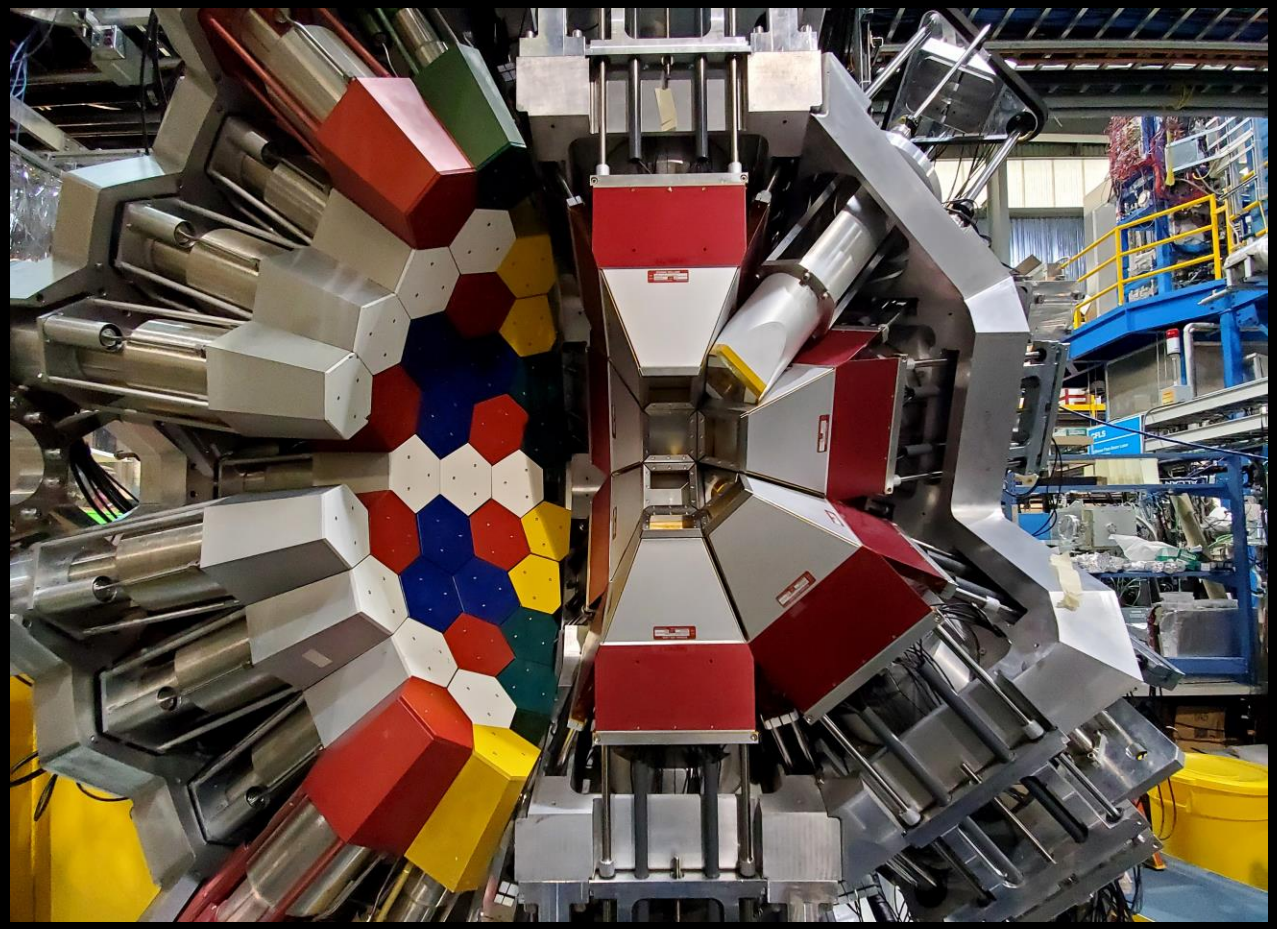
GRIFFIN + DESCANT

Gamma-**R**ay **I**nfrastructure **F**or **F**undamental **I**nvestigation of **N**uclei (GRIFFIN)

- 12 HPGe clover detectors

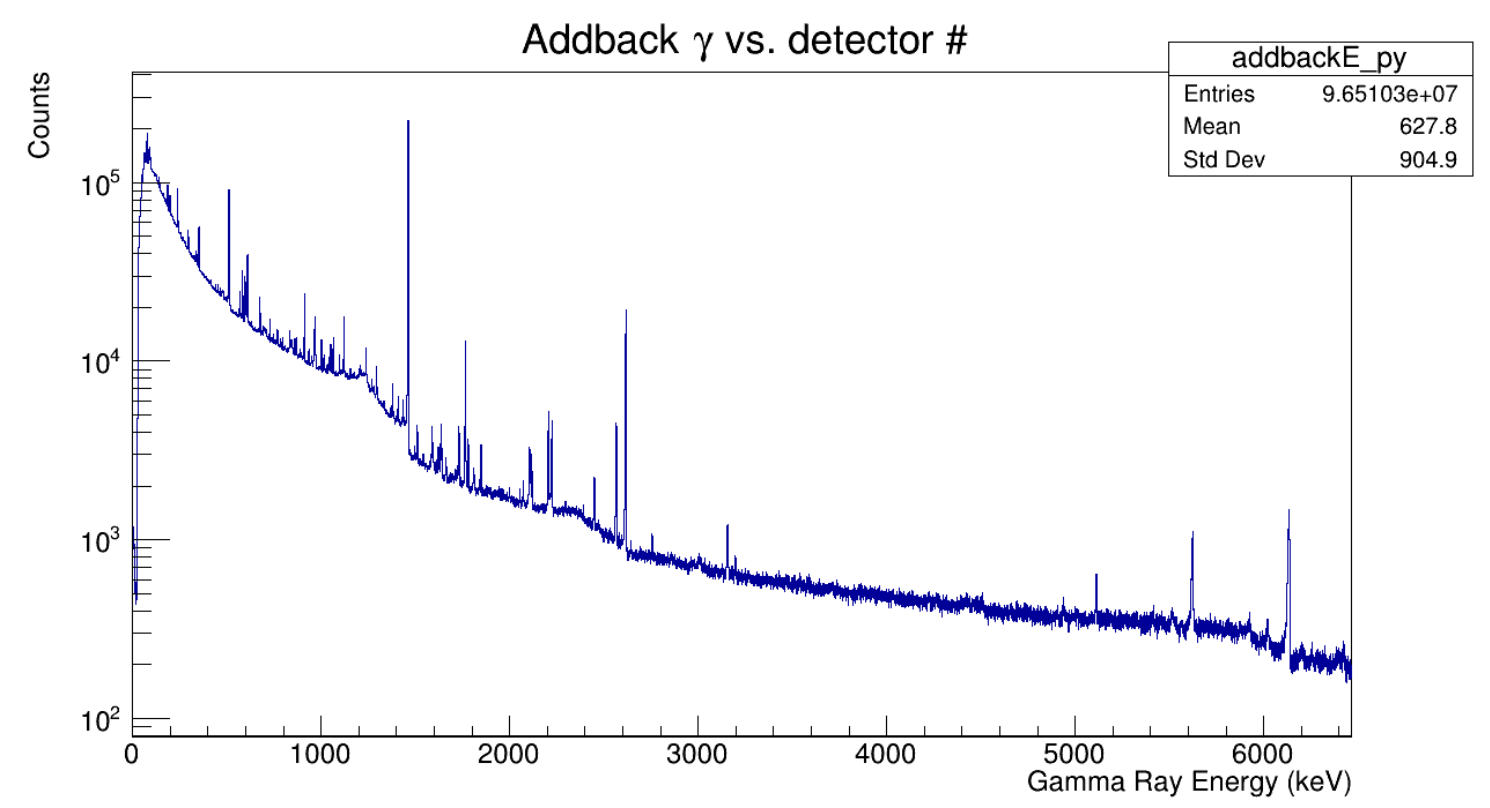
DEuterated **SC**intillator **A**rray for **N**eutron-**T**agging (DESCANT)

- 69 detectors installed downstream



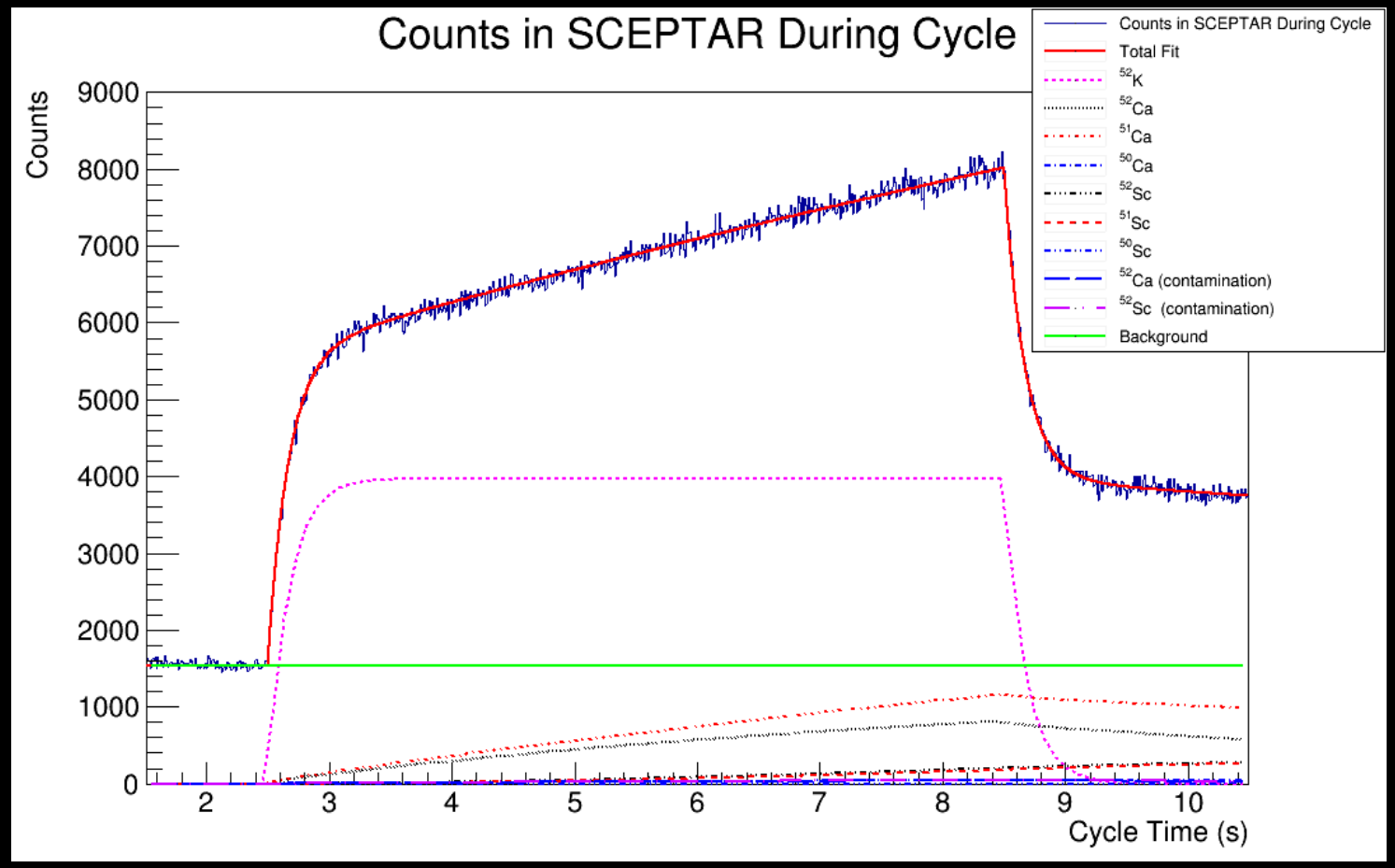
Gamma Data

- Gamma-rays from all isotopes produced
  - Calcium
  - Scandium
  - Titanium
- Coincident events help us assign each gamma-ray



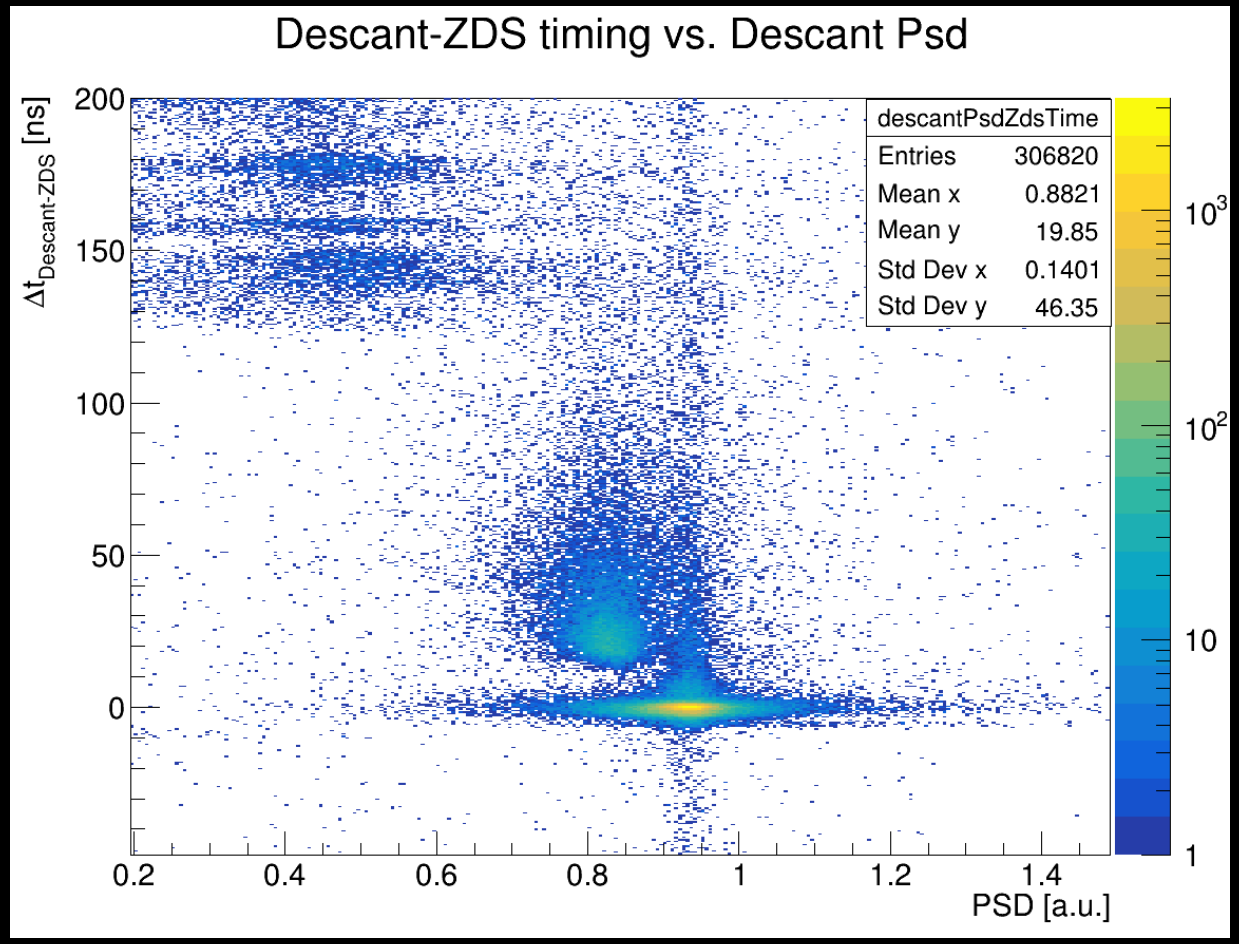
Beta Data

- Fit Function in three regions
  - Background
  - Beam on
  - Beam off
- Dependent on
  - Half lives
  - β-n probabilities
  - Relative efficiencies for nuclei



Neutron Selection

- Pulse Shape Discrimination
  - Ratio of short charge collection to total
- Time of Flight
  - ZDS starts the clock



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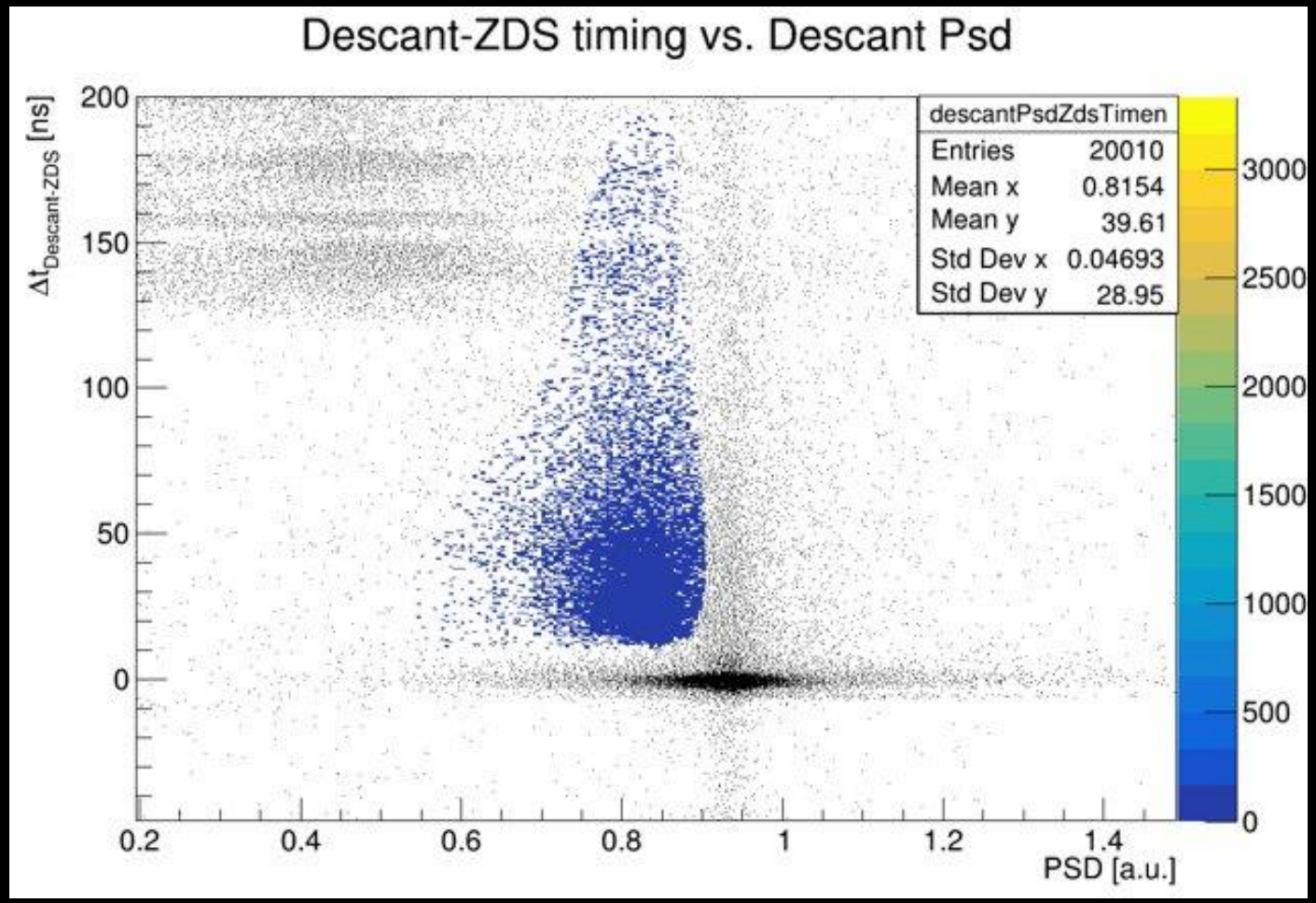
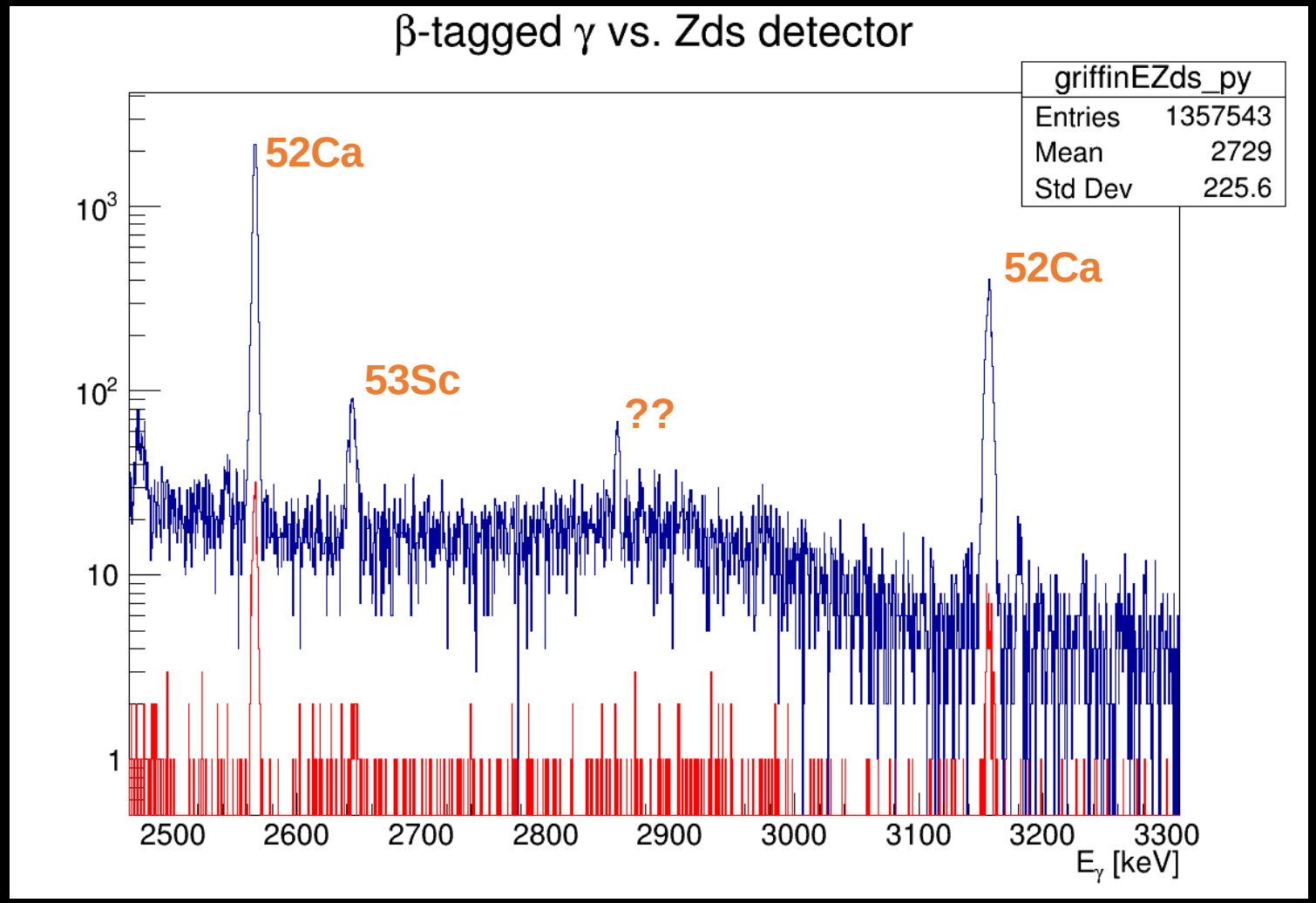


GRIFFIN Results

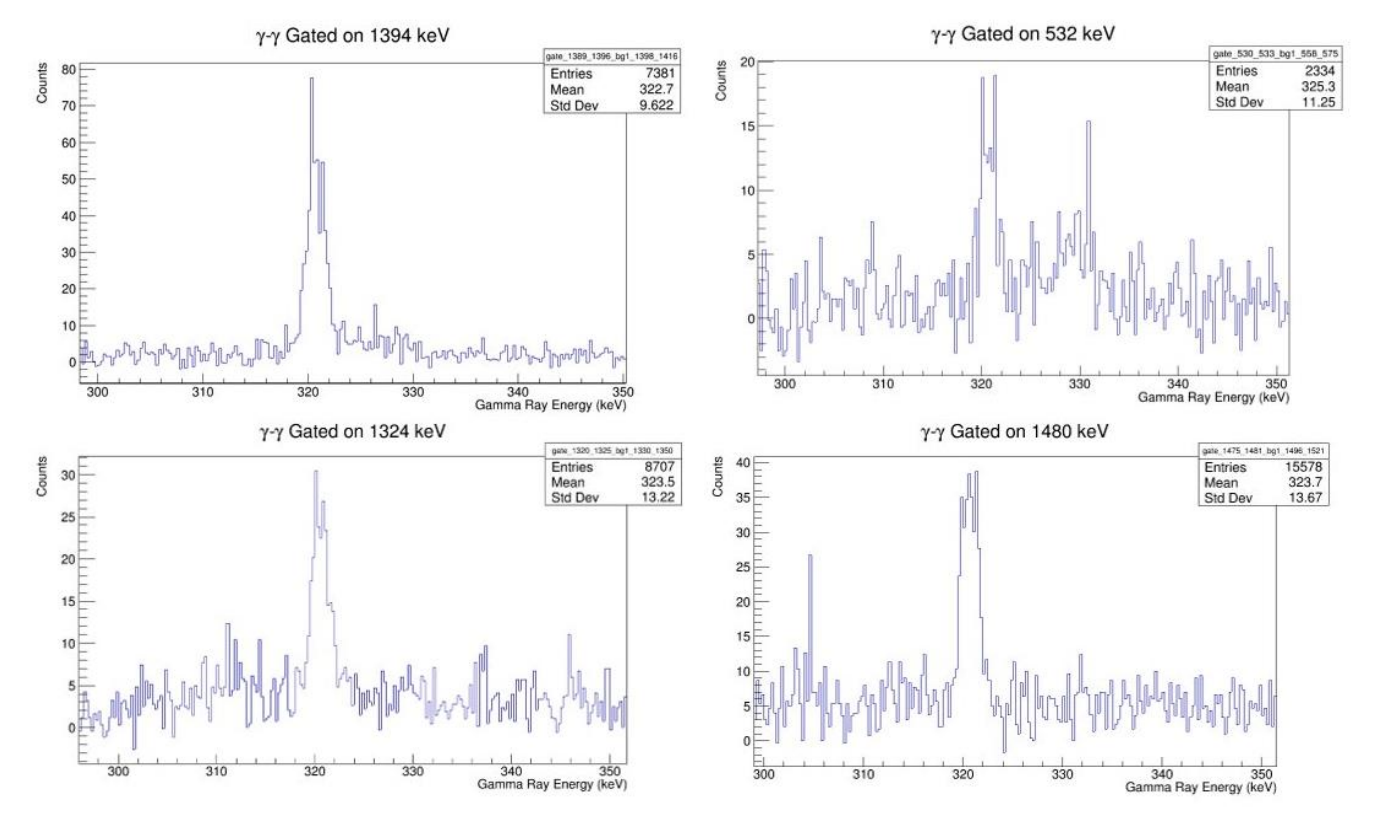
- Gate on ZDS
- Gate on Neutrons
- Discriminate between beta and beta-n branches



Building Level Scheme

New transition placed between existing levels

- Gamma-ray seen in previous work but attributed to ^{51}V
- Proven to be from ^{51}Sc from gamma-gamma coincidences

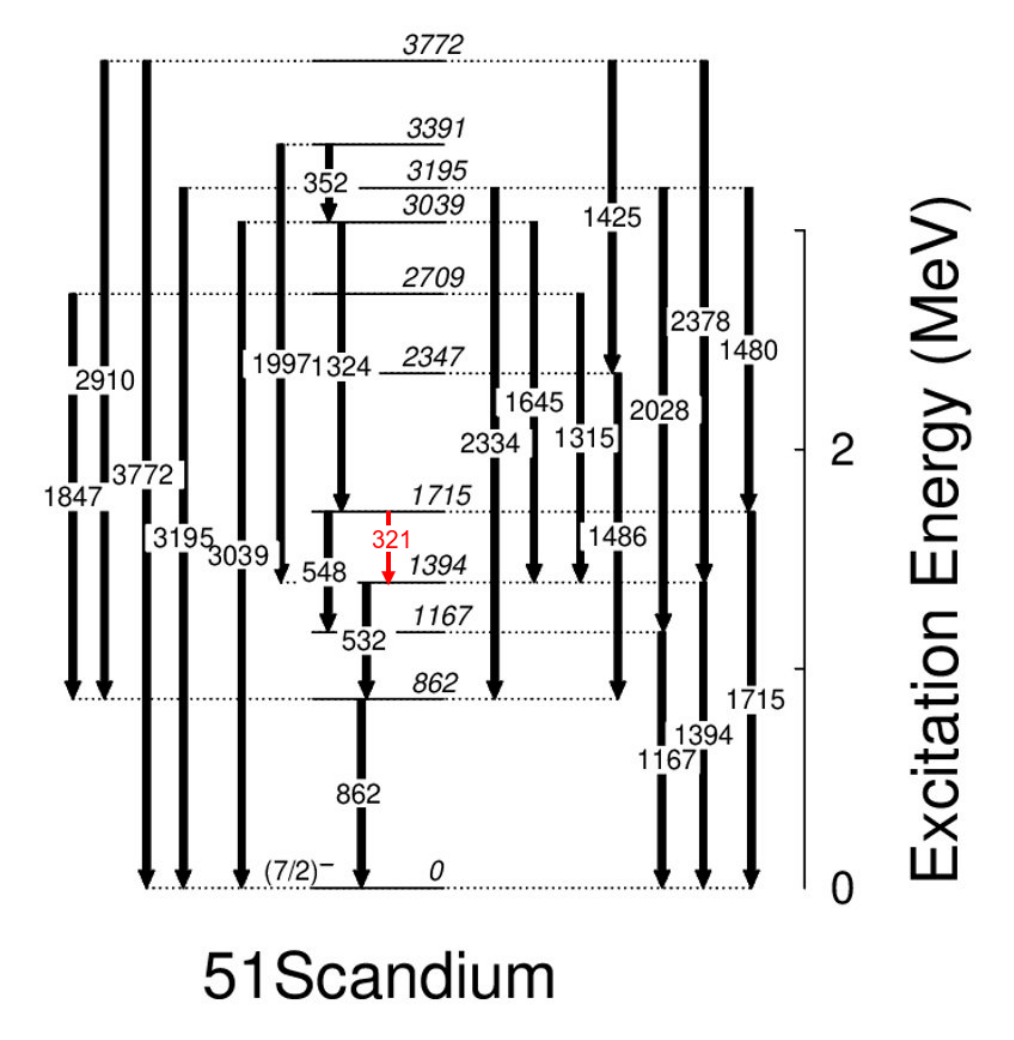


Building Level Scheme

All previous levels confirmed

New transition placed between existing levels

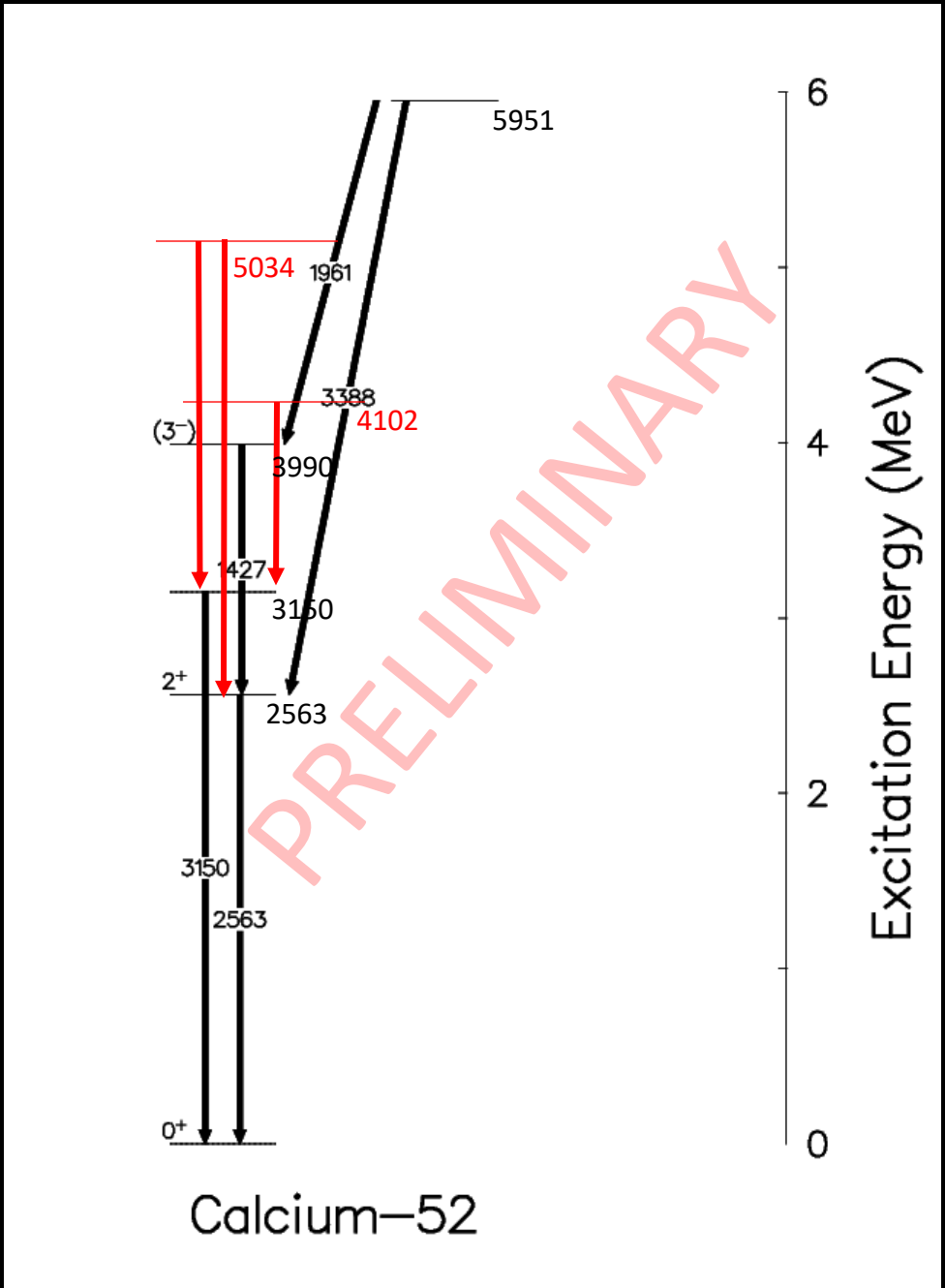
- Gamma-ray seen in previous work but attributed to ^{51}V
- Proven to be from ^{51}Sc from gamma-gamma coincidences



Building Level Scheme

Previous Beta populated levels confirmed

New levels populated only through beta-n branch in 52Ca



Acknowledgements

C.E. Svensson
H. Bidaman
V. Bildstein
S. Buck
P.E. Garret
A.T. Laffoley
A.D. MacLean
A.J. Radich
M. Rocchini
T. Zidar

G.C. Ball
S.S. Bhattacharjee
G. Carpenter
A.B. Garnsworthy
C. Griffin
R.S. Lubna
R. Lafleur
B. Olaizola
C. Paxman
C. Porzio
V. Vedia
D. Yates

C. Andreoiu
F.H. Garcia
M. Martin
K. Whitmore
F. Wu

S. Sharma
A. Talbitaher

M. Hanley
C.R. Natzke
F. Sarazin
S. Shadrick

Thank You

ANY QUESTIONS?