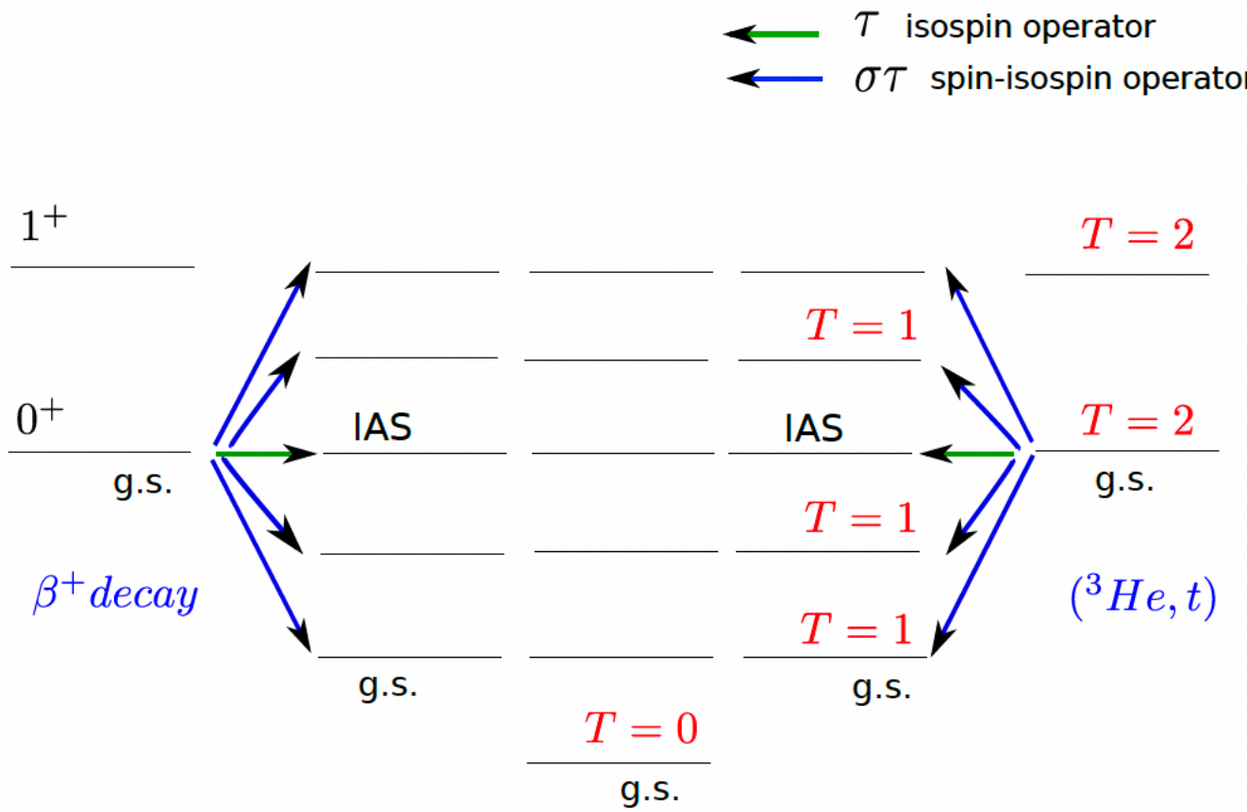
# The decay of Tz=-2 nuclei, the IAS and the AAS: does the AAS provide a useful information?

Berta Rubio, Instituto de Física Corpuscular, Valencia

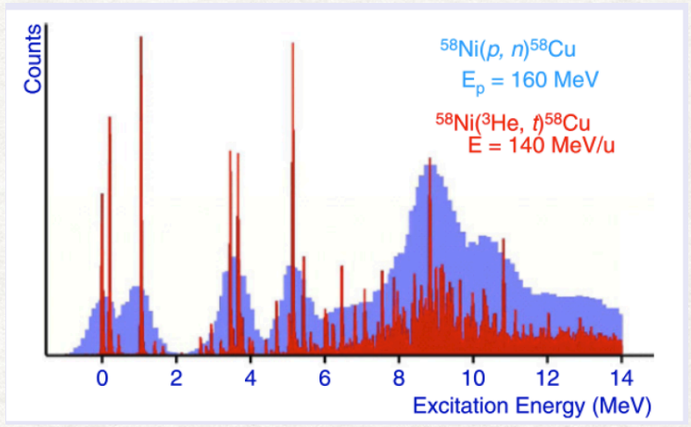
La Corrala Madrid
2023

# The original motivation to study the beta decay of TZ=-2 nuclei was to compare with the mirror process (3He,t)




$^{56}_{30}Zn_{26}$ $^{56}_{29}Cu_{27}$ $^{56}_{28}Ni_{28}$ $^{56}_{27}Co_{29}$ $^{56}_{26}Fe_{30}$

$T_z = -2$ $T_z = -1$ $T_z = 0$ $T_z = +1$ $T_z = +2$



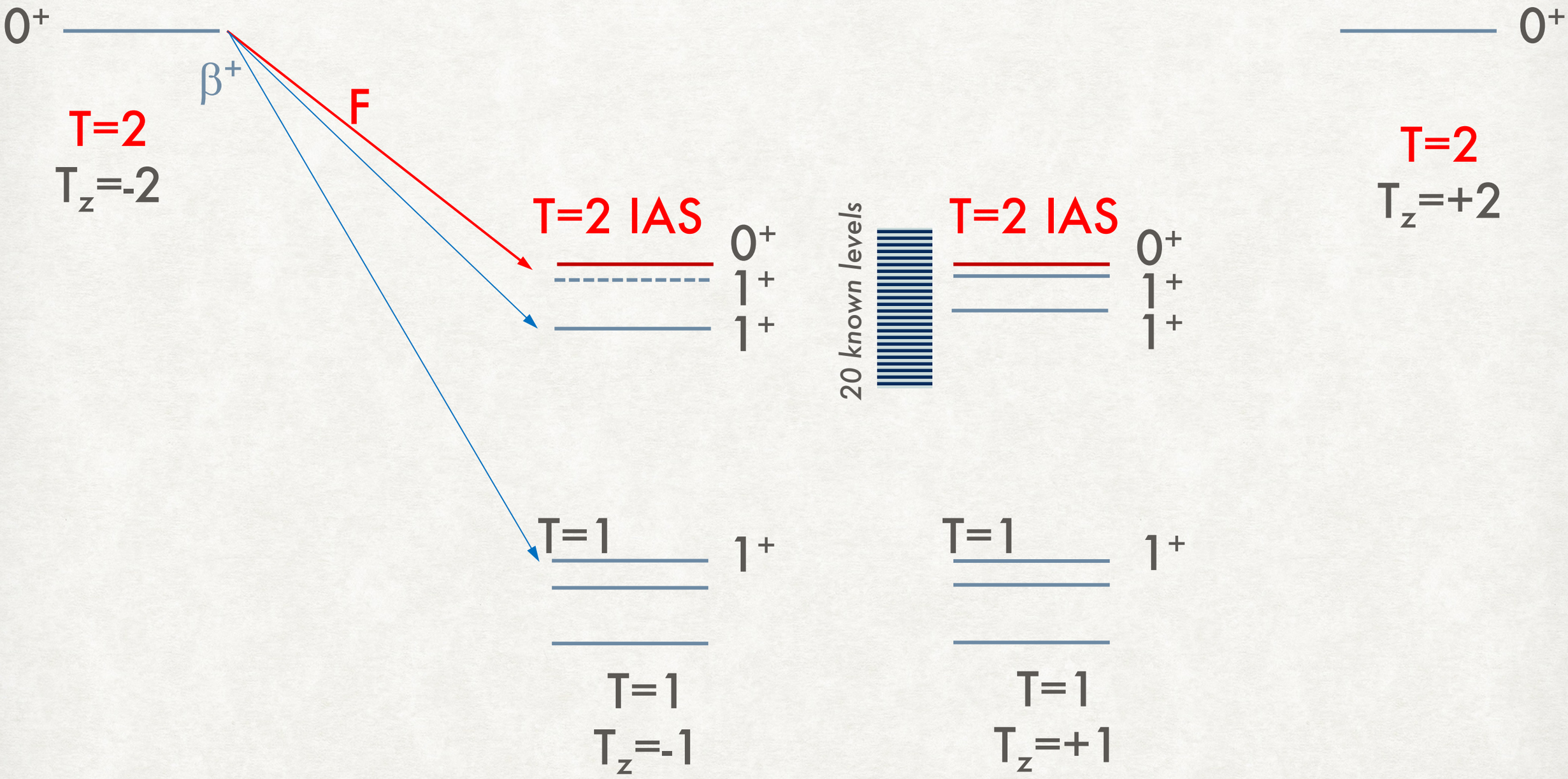
$^{58}$Ni

Fragmentation target

$T_z$=-2

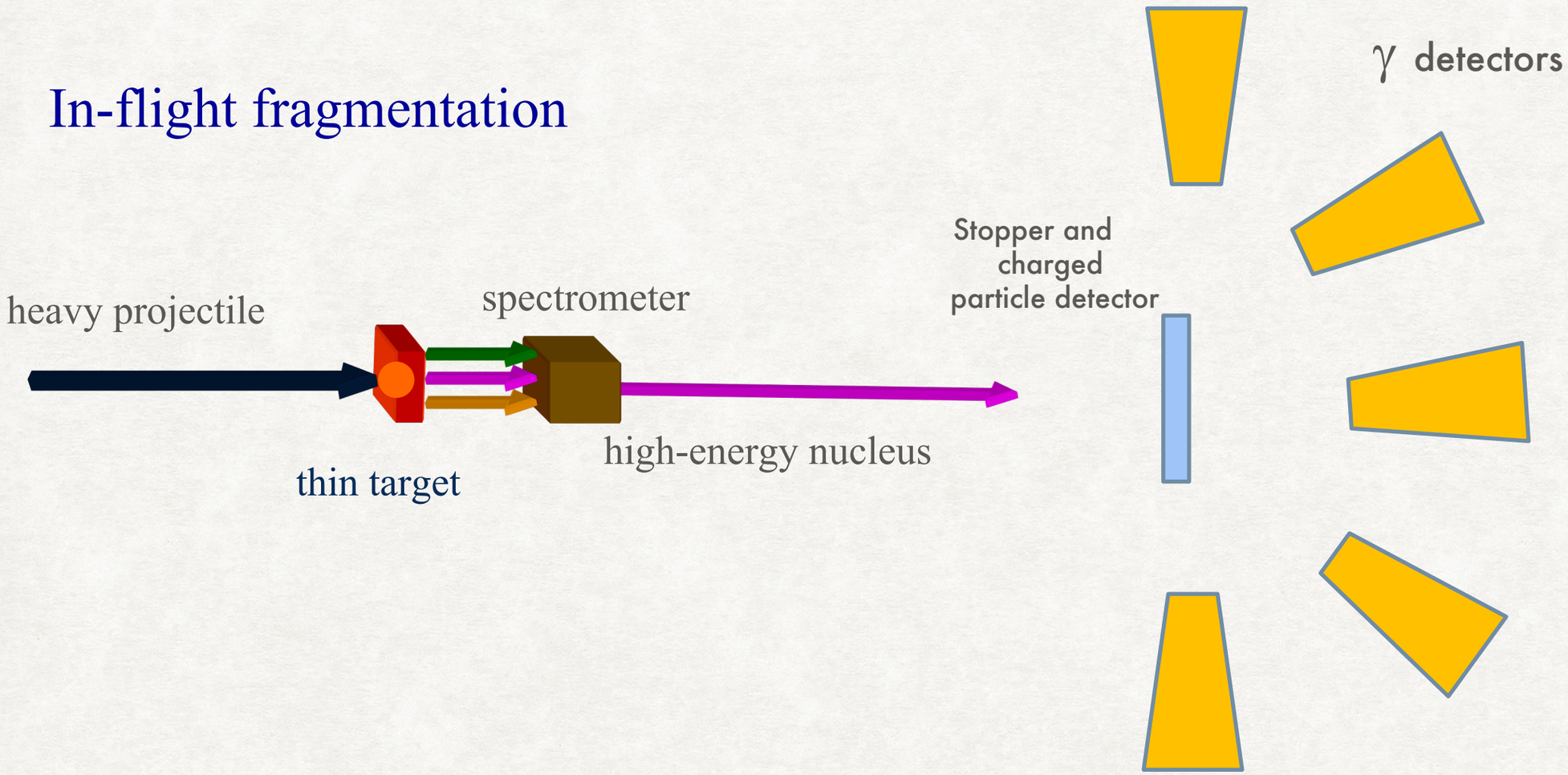
The first Tz=-2 cases were measured at GANIL (LISE), with the Fragmentation of 58Ni beam

# Studies of T=2 multiplet allow us to locate states of a well defined state at high excitation energy



These nuclei have half lifes of the order of 20-100 ms
One has to study them at fragment separators

## In-flight fragmentation

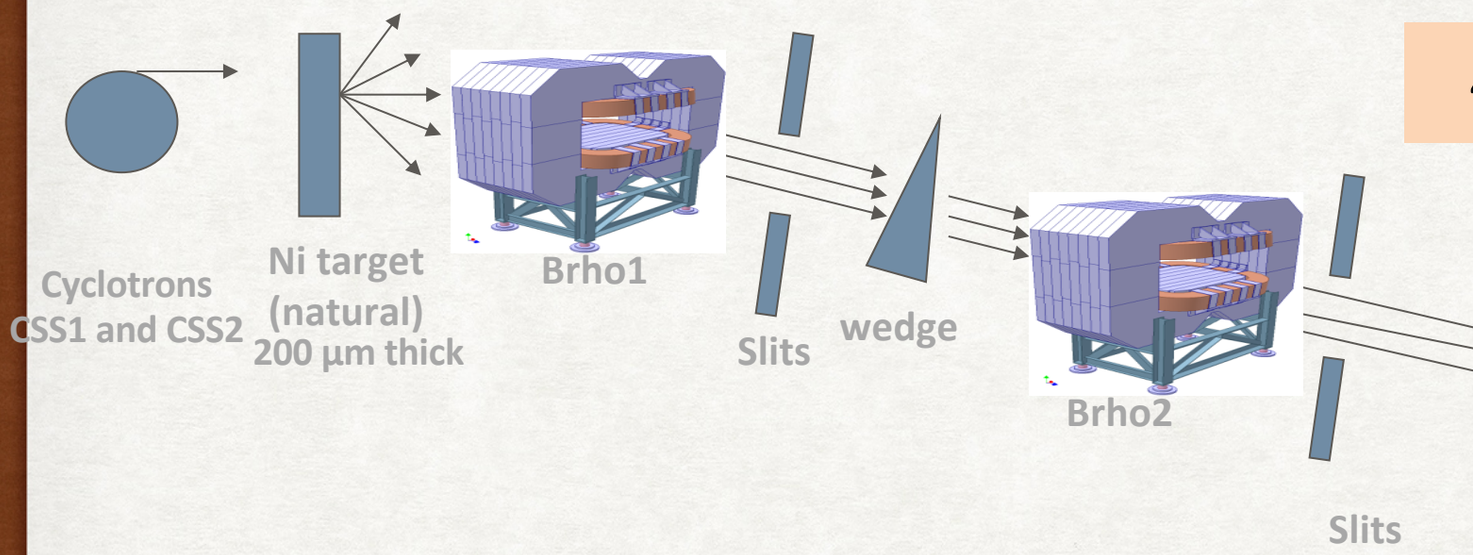


# $^{58}Ni^{26+}$ (74.5 AMeV) + $^{nat}Ni$ @ GANIL 2010

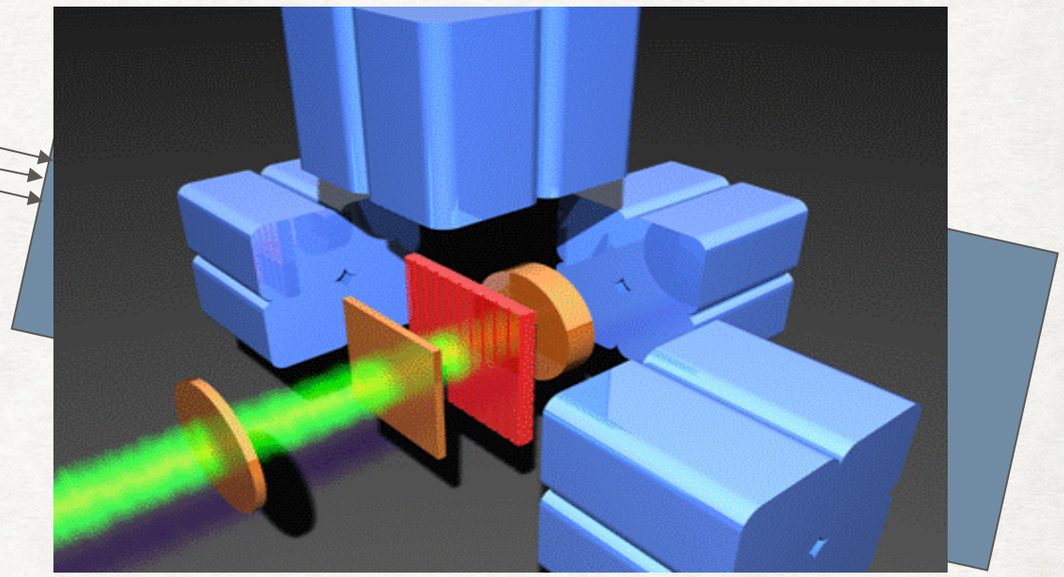
laboratoire commun CEA/DRF — CNRS/IN2P3

**74.5 MeV / nucleon**
**Incoming $^{58}Ni^{26+}$** 3.7 eμA intensity

LISE3 Fragment Spectrometer

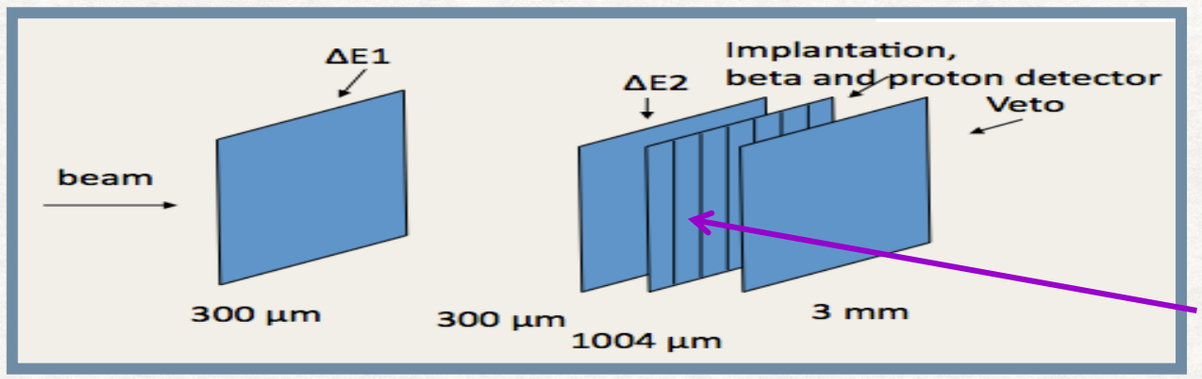



4 EXOGAM CLOVER Gamma Detectors



DETECTORS

1 DSSD implantation detector



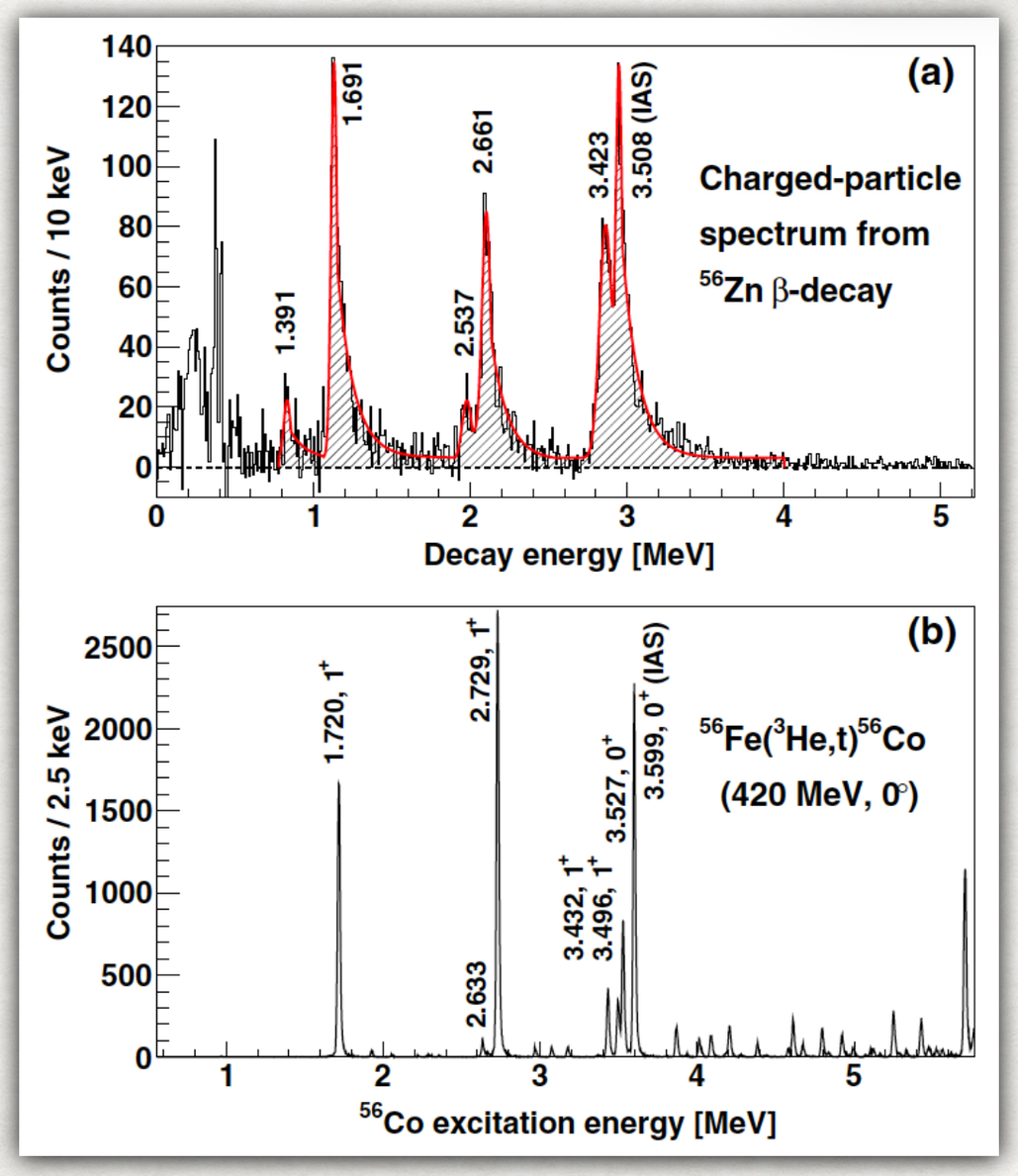

**DSSSD detector**
**Implantation and decay (β, p)**

# ISOSPIN MIXING OBSERVED IN BETA-DECAY

PRL **112,** 222501 (2014) PHYSICAL REVIEW LETTERS week ending 6 JUNE 2014

**Observation of the $\beta$-Delayed $\gamma$-Proton Decay of $^{56}$Zn and its Impact on the Gamow-Teller Strength Evaluation**

S. E. A. Orrigo,[1,*] B. Rubio,[1] Y. Fujita,[2,3] B. Blank,[4] W. Gelletly,[5] J. Agramunt,[1] A. Algora,[1,6] P. Ascher,[4] B. Bilgier,[7] L. Cáceres,[8] R. B. Cakirli,[7] H. Fujita,[3] E. Ganioğlu,[7] M. Gerbaux,[4] J. Giovinazzo,[4] S. Grévy,[4] O. Kamalou,[8] H. C. Kozer,[7] L. Kucuk,[7] T. Kurtukian-Nieto,[4] F. Molina,[1,9] L. Popescu,[10] A. M. Rogers,[11] G. Susoy,[7] C. Stodel,[8] T. Suzuki,[3]




β delayed proton spectrum

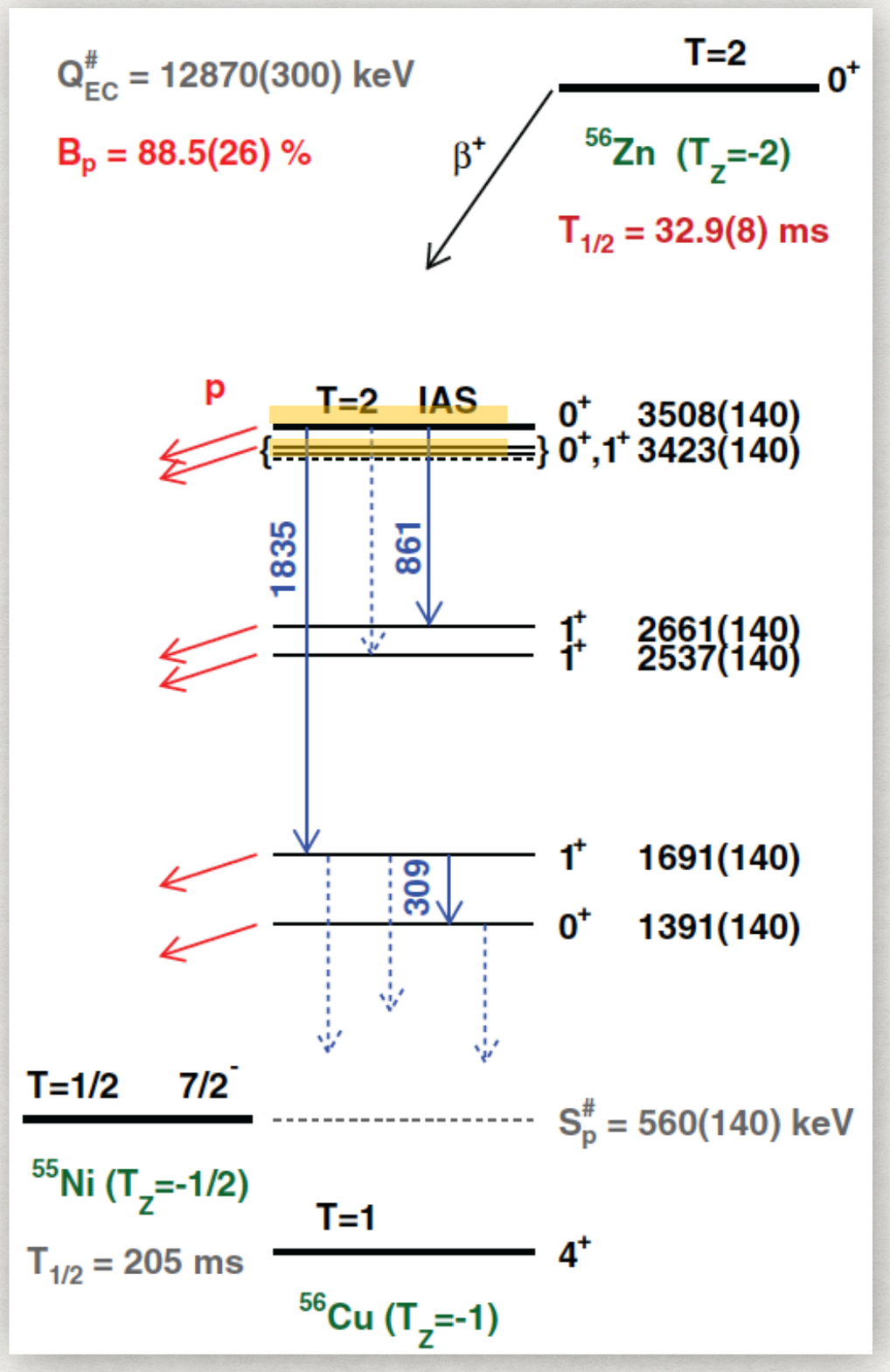
Triton spectrum

The B(F) strength splits between the two 0+ states providing a measure of the Isospin mixing

Level(3508)=77%(T=2)+33%(T=1)

mixing=40(23) keV

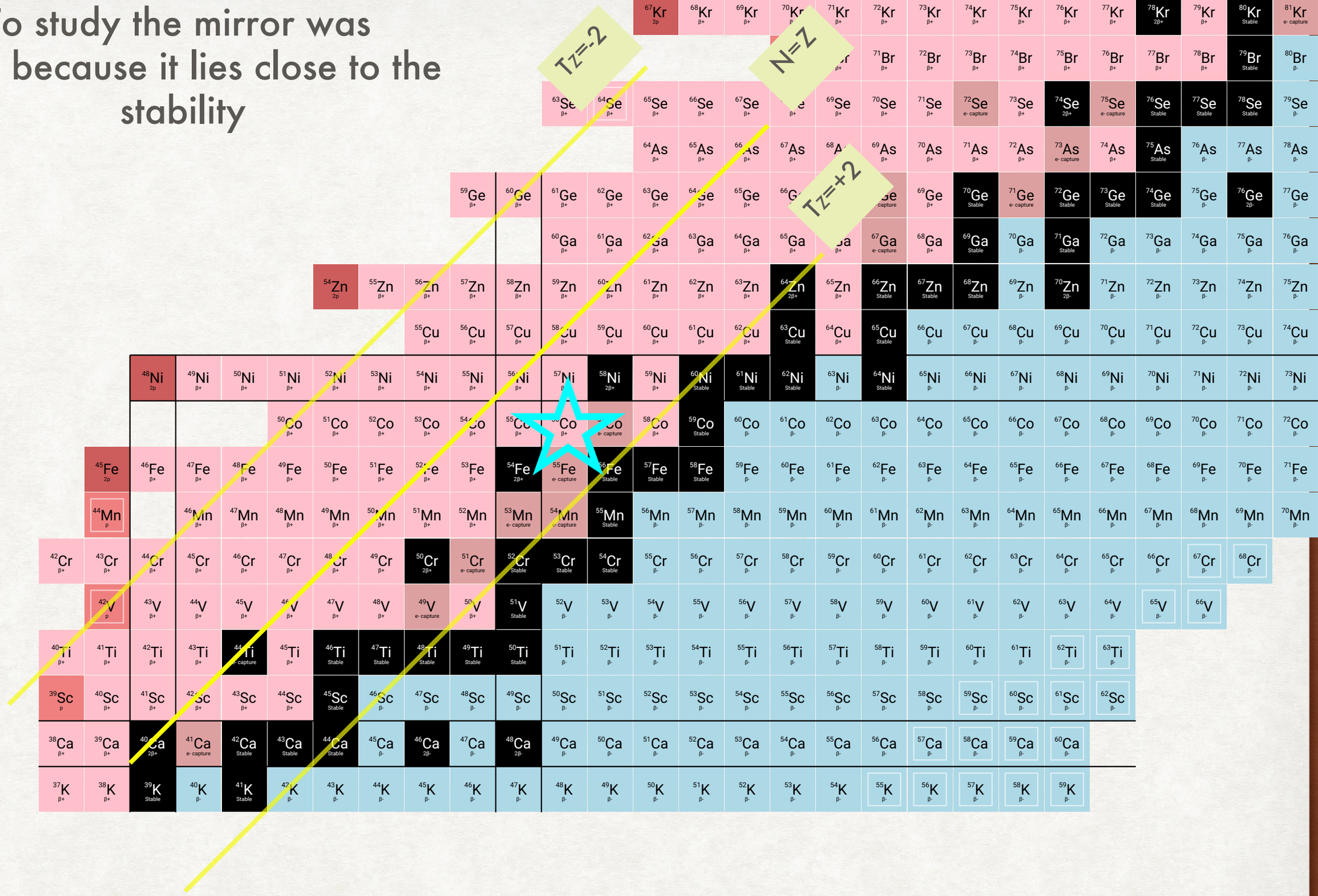
The data were nicely reproduced In Shell Model calculations by N. Smirnova el al PRC 93 (2016)044305 and A. Poves independently



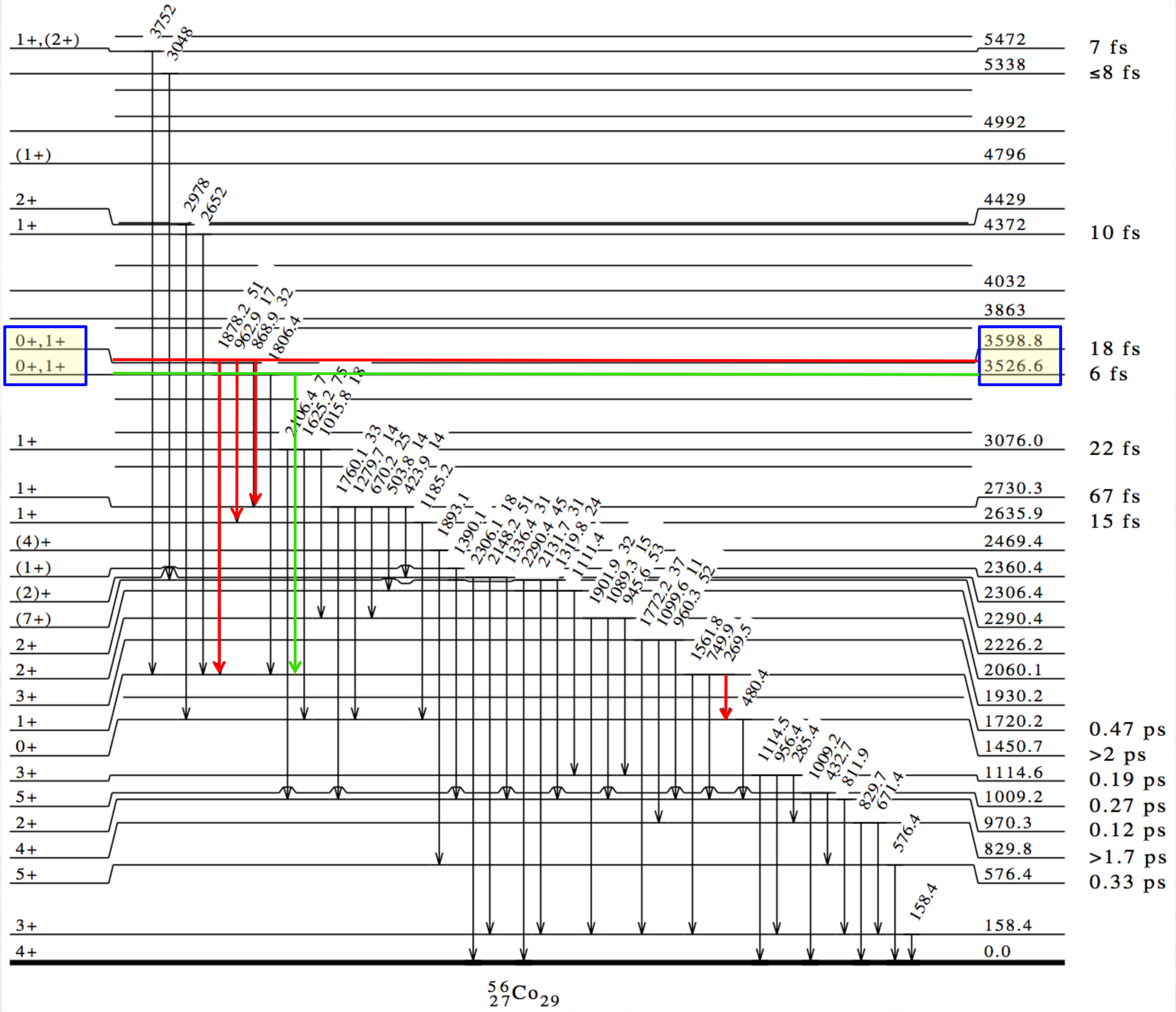

If the two states are so strongly Mixed, should not they decay in a similar way?

But this experiment was not sensitive enough to inspect the gamma decay in detail

# To study the mirror was easy because it lies close to the stability



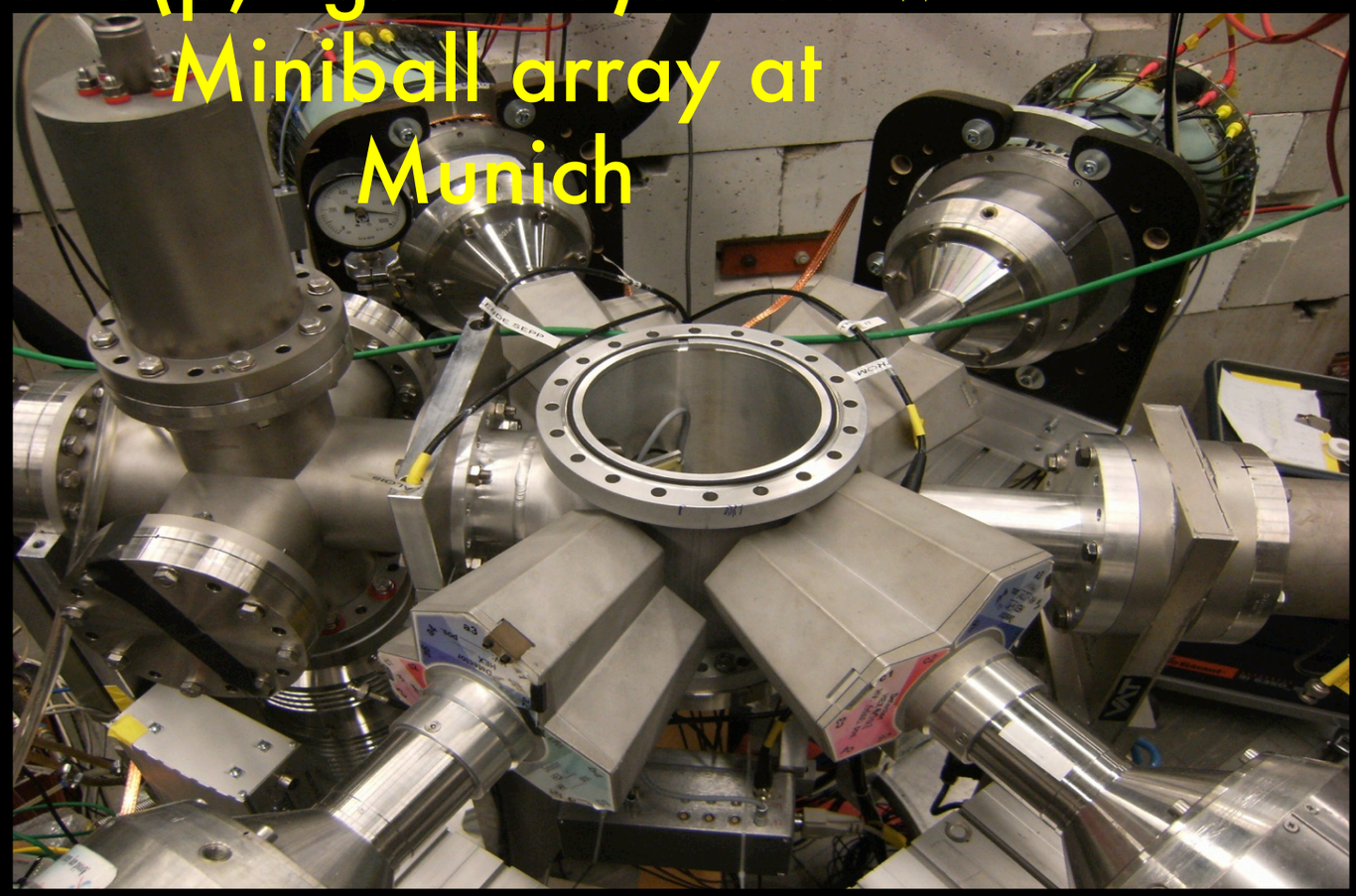
IAS



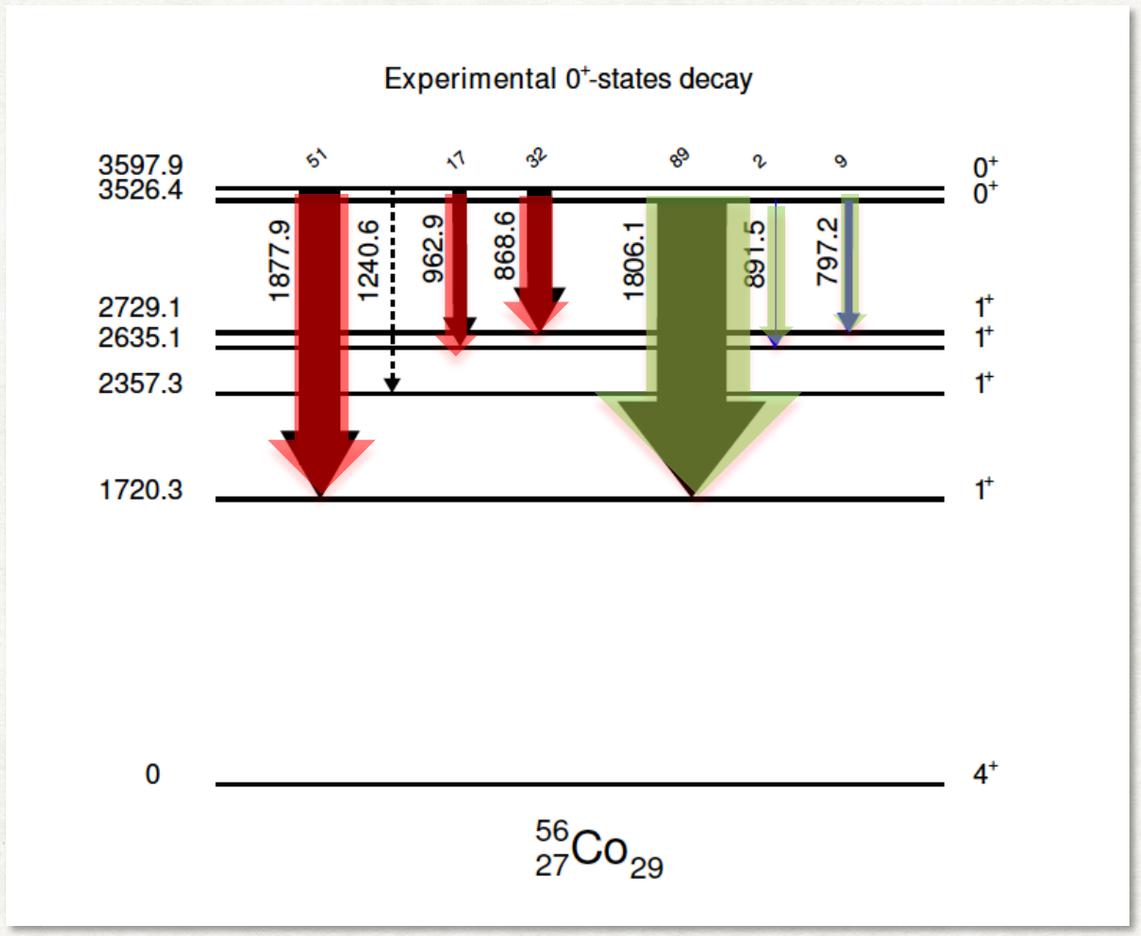

$^{56}_{27}Co_{29}$

A.Montaner-Piza, Ph. D thesis
eriment at Munchen, one of the latest
Beforeshut down of the facility

56Fe(p,n-gamma)56Co with Miniball array at Munich



Four Miniball CLUSTER detectors





Universitat de València - CSIC

Departament de Física Atòmica, Molecular i Nuclear

Institut de Física Corpuscular


# Isospin mixing and in-beam study of non-yrast states in $^{56}$Co

VNIVERSITAT DE VALÈNCIA


*Author:*
Ana Montaner-Pizá

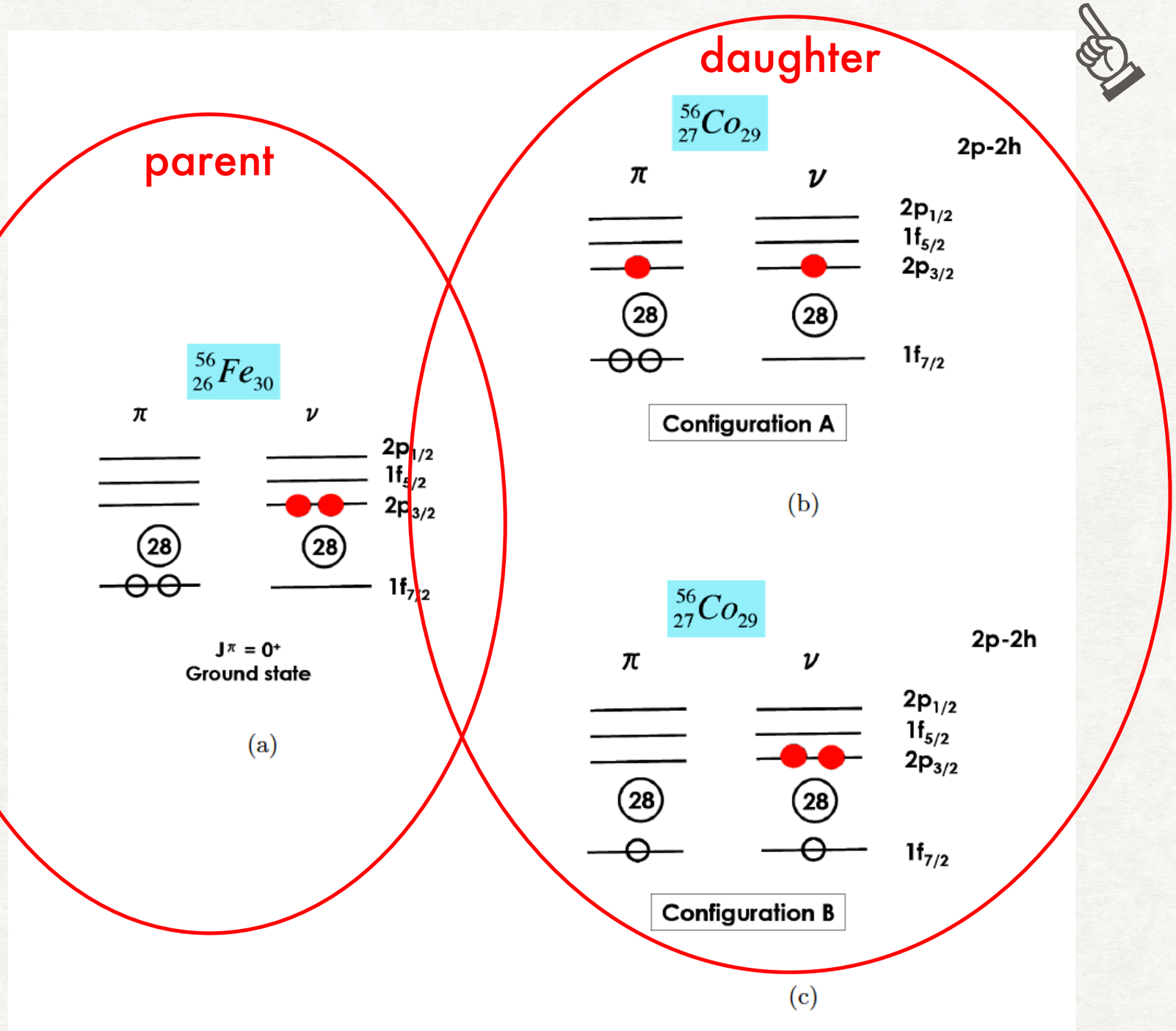
*Supervisor:*
Dra. Berta Rubio Barroso



València, Març de 2018
Programa de Doctorat en Física
Tesi presentada per obtenir el títol de Doctor per la Universitat de València


Shell-model calculations in a truncated fp-shell valence space with the ANTOINE code were made by Alfredo Poves. The effective interaction used was the KB3GR, an updated version of the KB3G interaction which improves the spectroscopy near and beyond N = Z = 28 nuclei.

# The IAS of the 56Fe(T=2) ground state in 56Co (T=2) and the AAS (T=1)

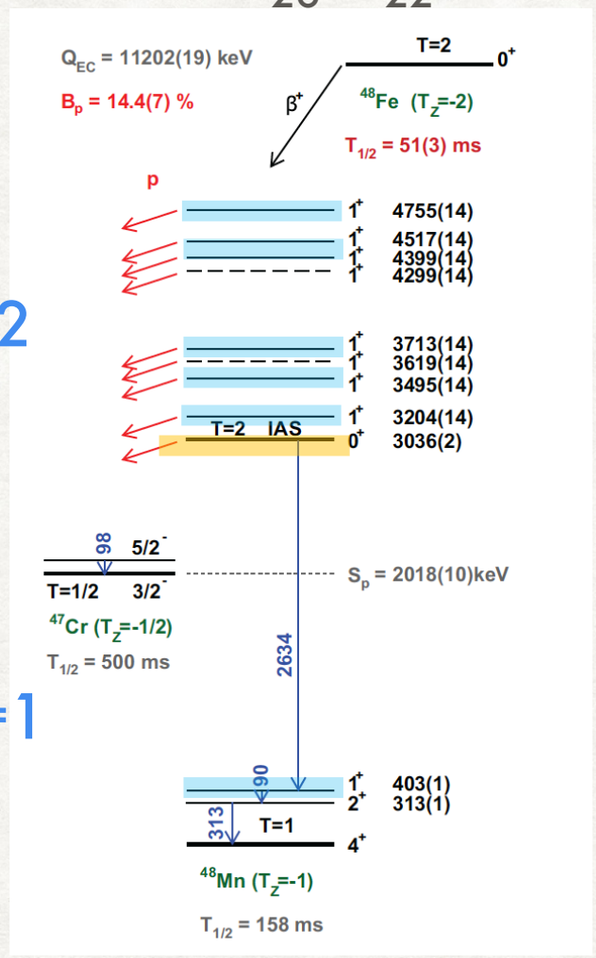



There are two states with a dominant A+B configurations, one at Low energy 1. 5 MeV and the other at high energy, 3.5 MeV

# Tz=-2 decays below 56Zn (in the f7/2 shell)

In the two cases bellow, AAS was not observed, that's normal since neither Fermi nor GT decay can populate it directly, so..., we forgot for a while

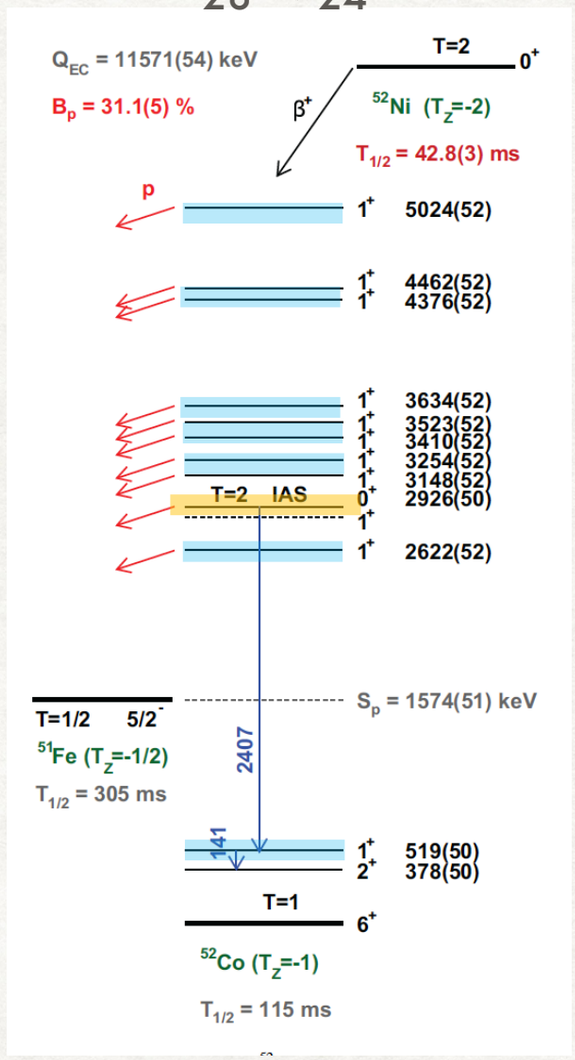
A=48 $^{48}_{26}Fe_{22}$




T=2

T=1

$^{52}_{28}Ni_{24}$ A=52



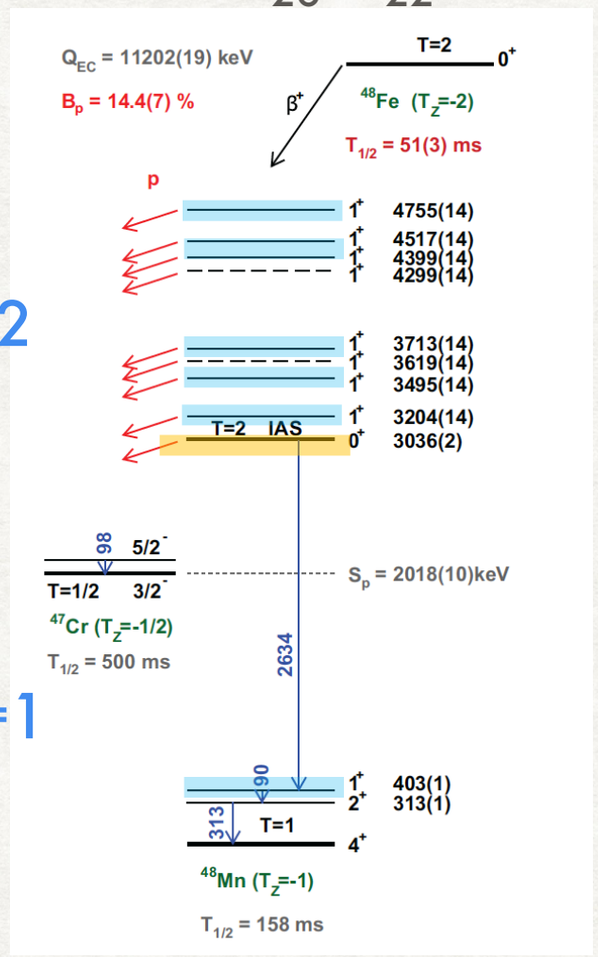

T=2

T=1

S. Orrigo PRC 93(2016)044336

# Tz=-2 decays below 56Zn (in the f7/2 shell)

## A=48 $^{48}_{26}Fe_{22}$

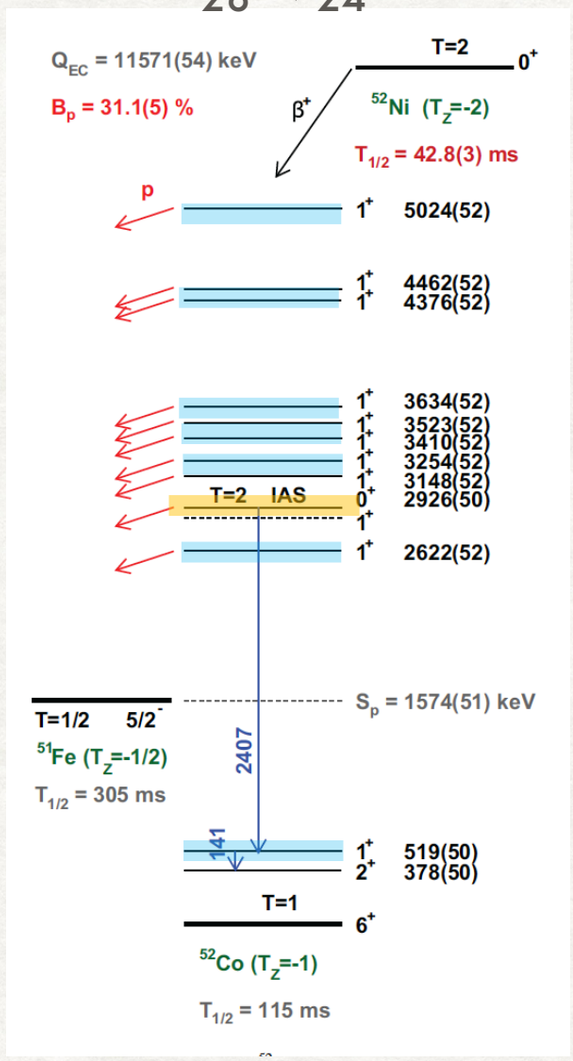



T=2

T=1

S. Orrigo PRC 93(2016)044336

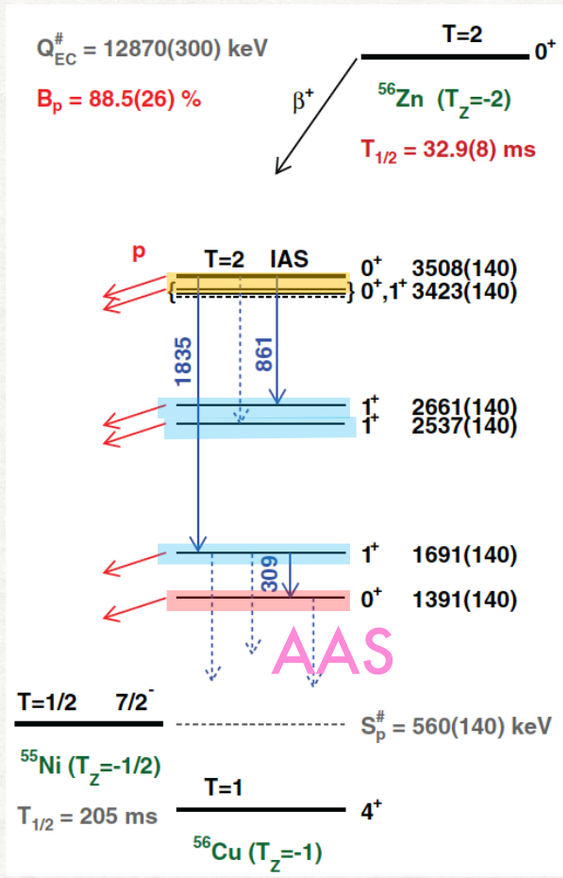
## $^{52}_{28}Ni_{24}$ A=52




T=2

T=1

## A=56 (56Zn)




T=2

T=1

S. Orrigo, PRL

With these experiments we saturate the possibilities to study Tz=-2 using fragmentation of $^{58}$Ni

**60Ge and 64Se are the heaviest Tz=-2 β-bound nuclei**

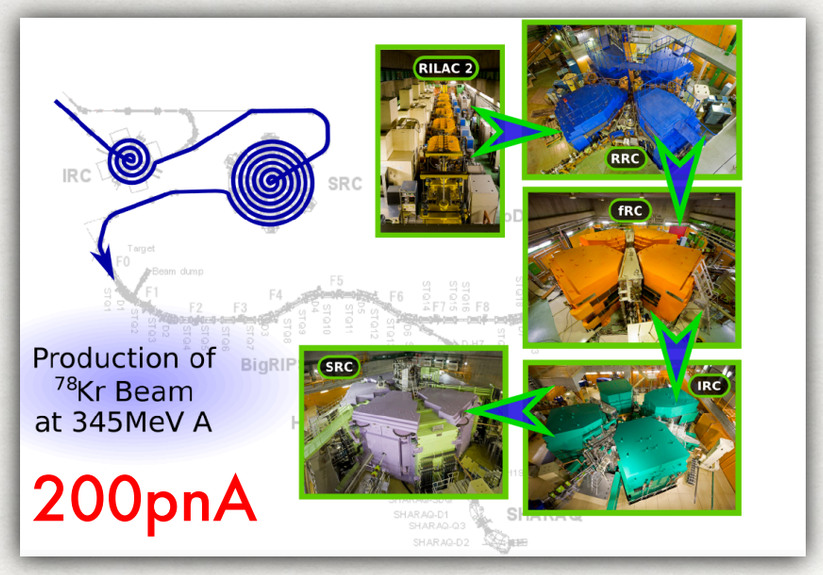
**But they were a lot more difficult to produce!! Because the needed fragmentation of 78Kr)**

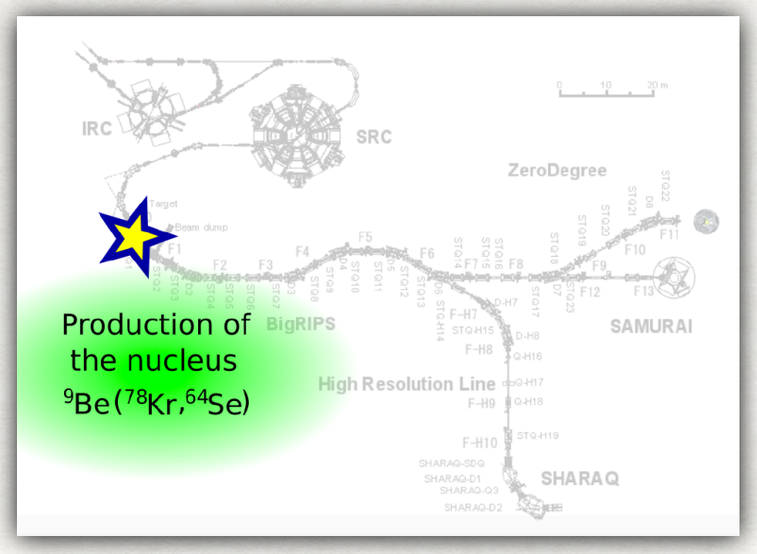
Tz=-2

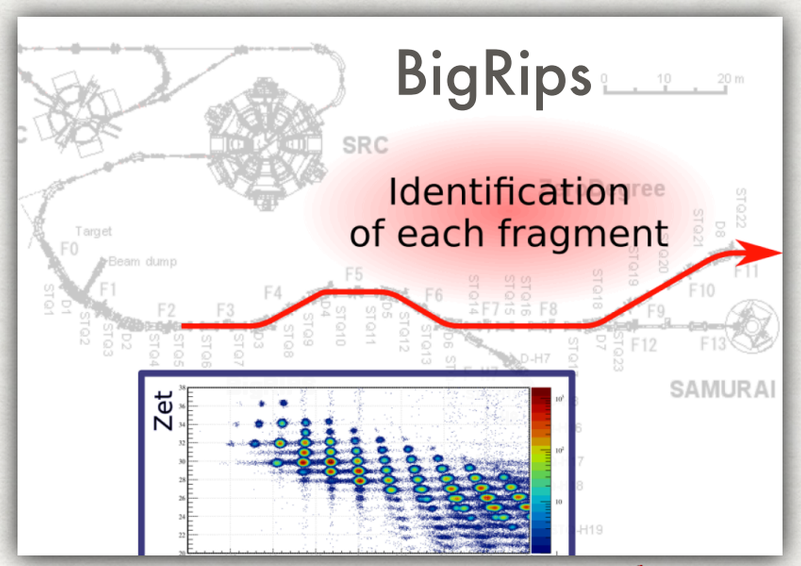
Tz=+2

**60Ni and 64Zn are the heaviest Tz=+2 stable targets**

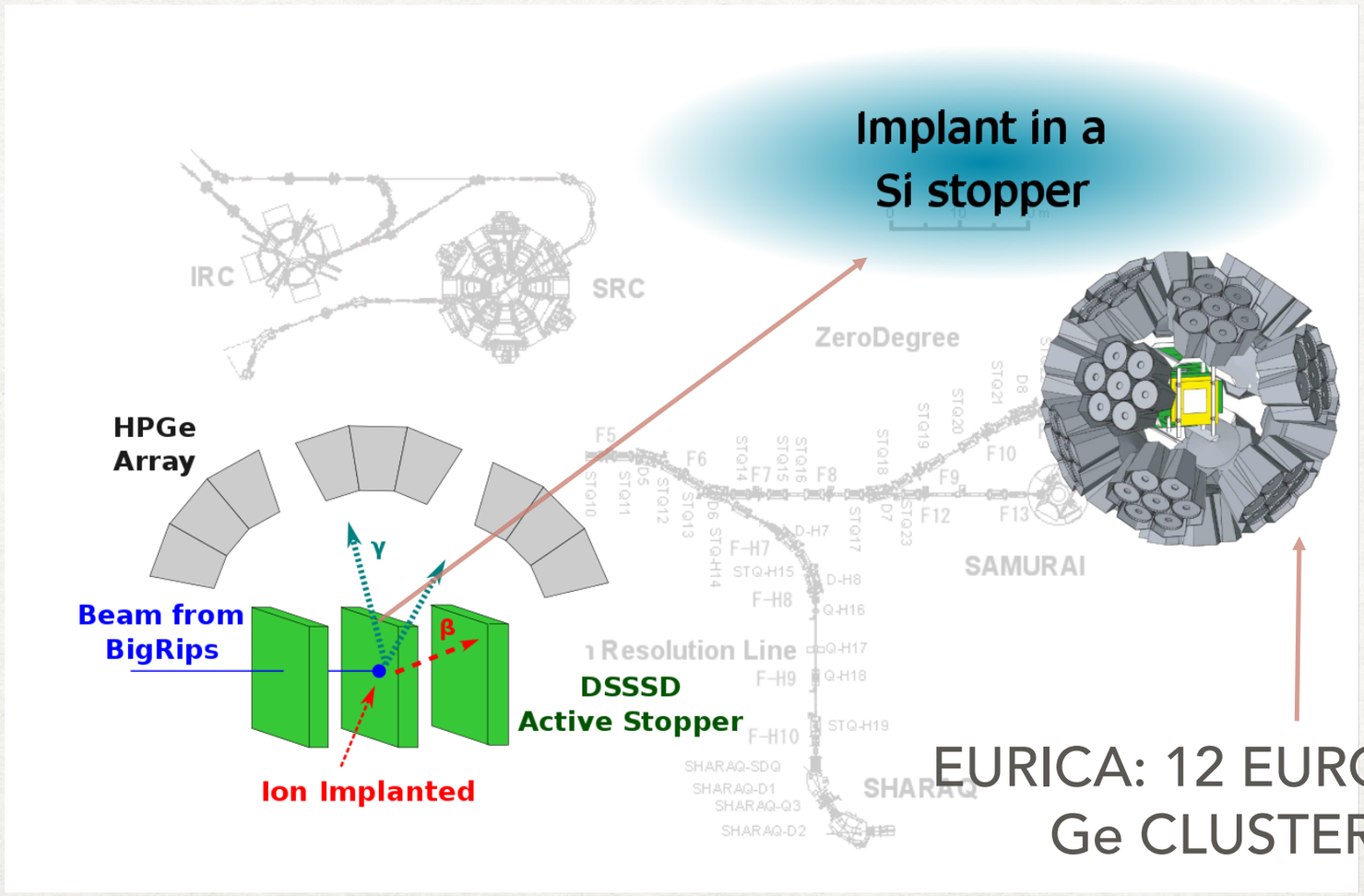

RIKEN



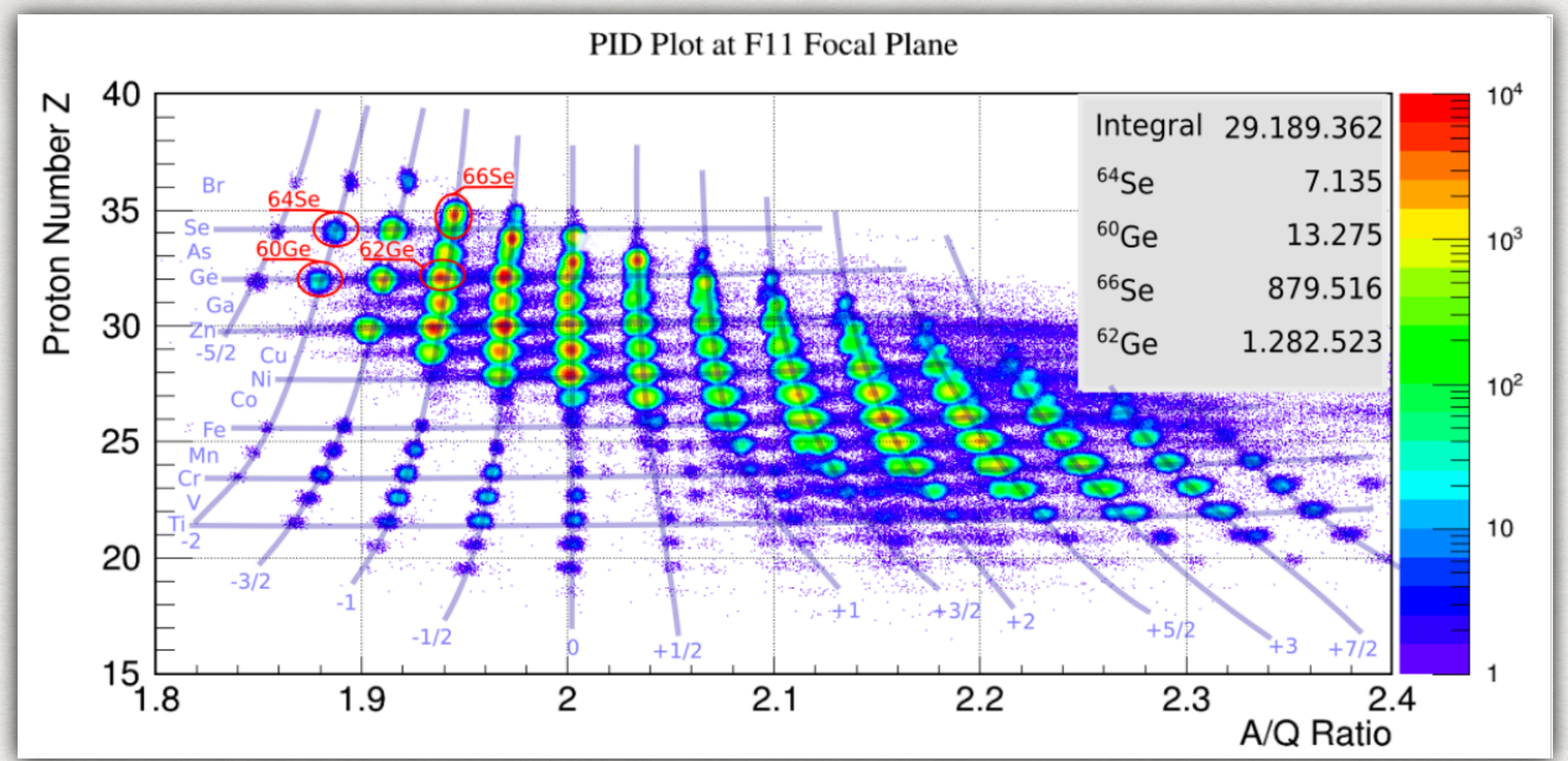

RIKEN NiSHiNA CENTER



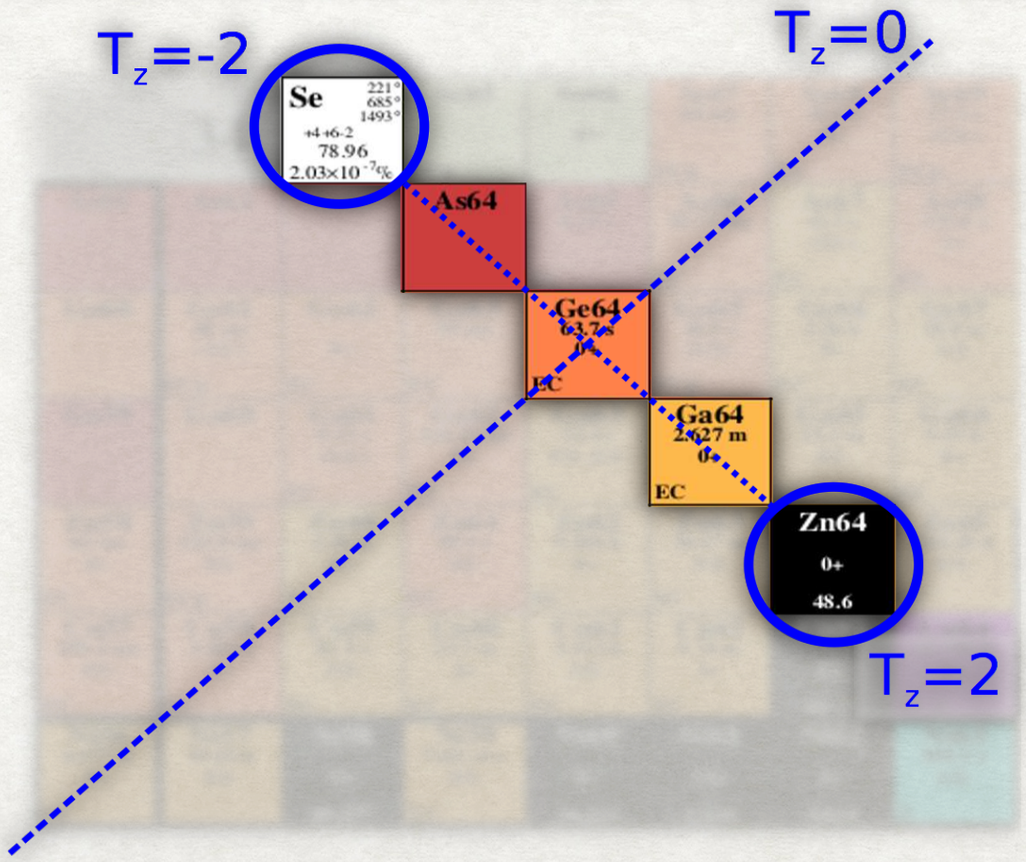

EURICA: 12 EUROBALL
Ge CLUSTERS

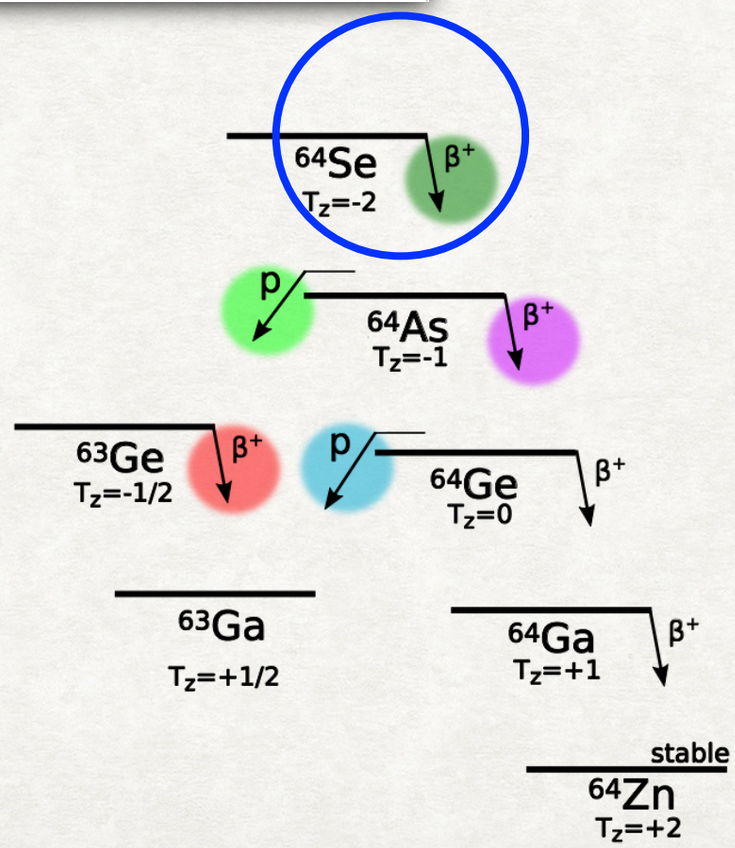
Tz=-2 60Ge
S. Orrigo el al. PRC
103(2021)014324

Tz=-2, 64Se
P. Aguilera, Ph. D

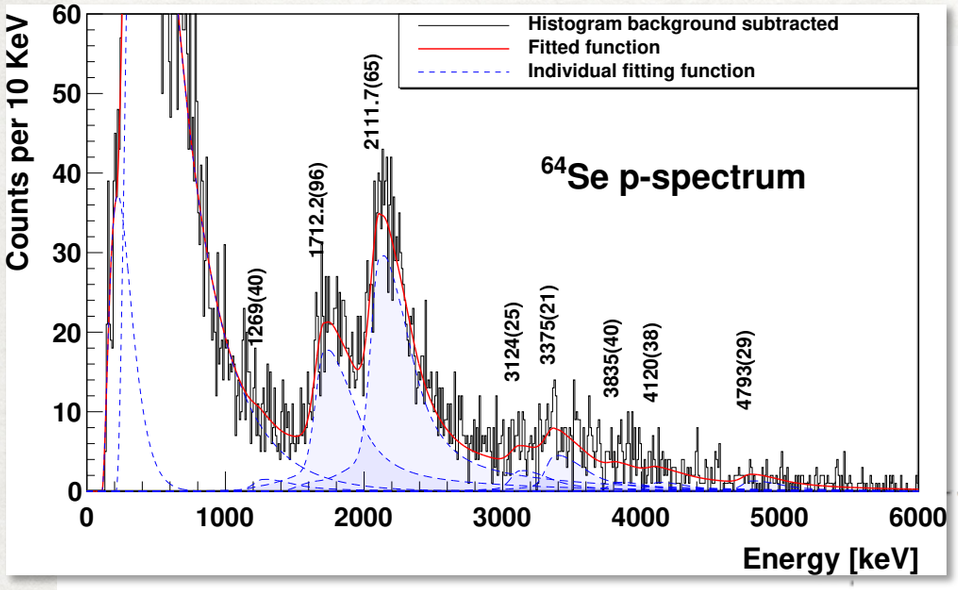



P.h. D Pablo Aguilera

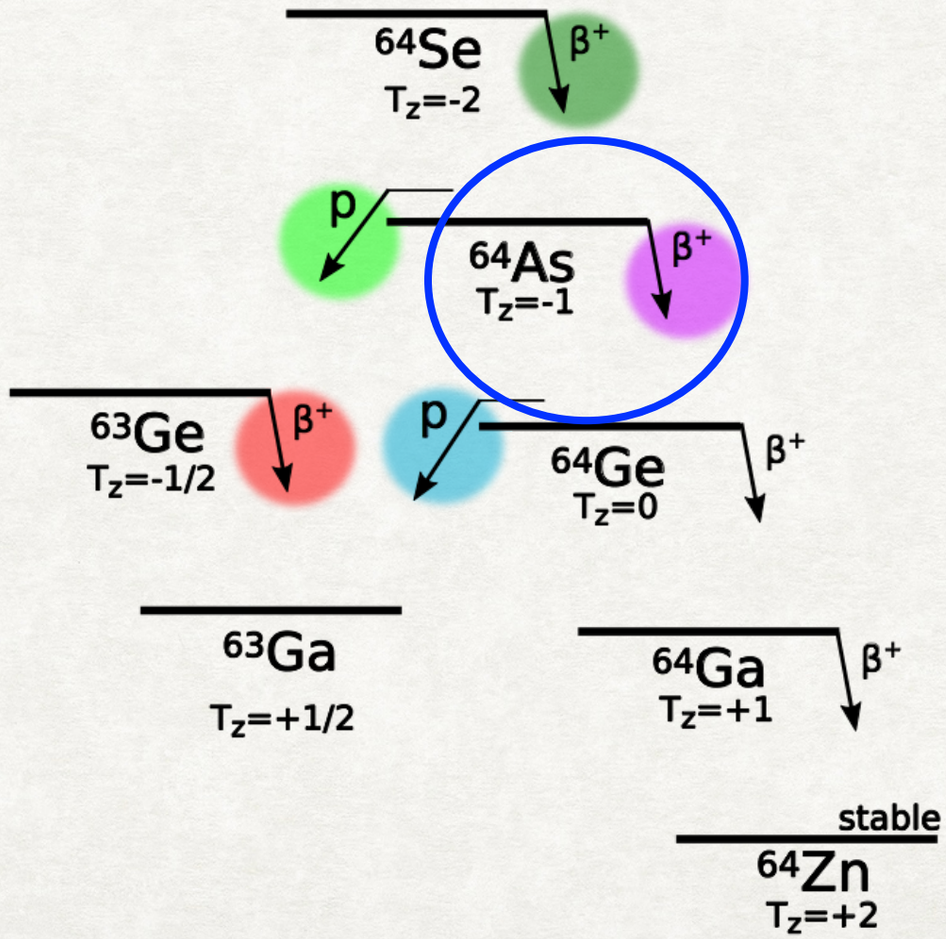


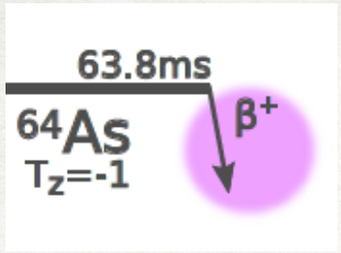



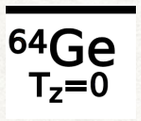
# The decay of Tz=-2 $^{64}$Se, the heaviest beta-decaying Tz=-2 that exists



Our data also contained the odd-odd $^{64}$As Tz=-1 nucleus into the N=Z $^{64}$Ge.

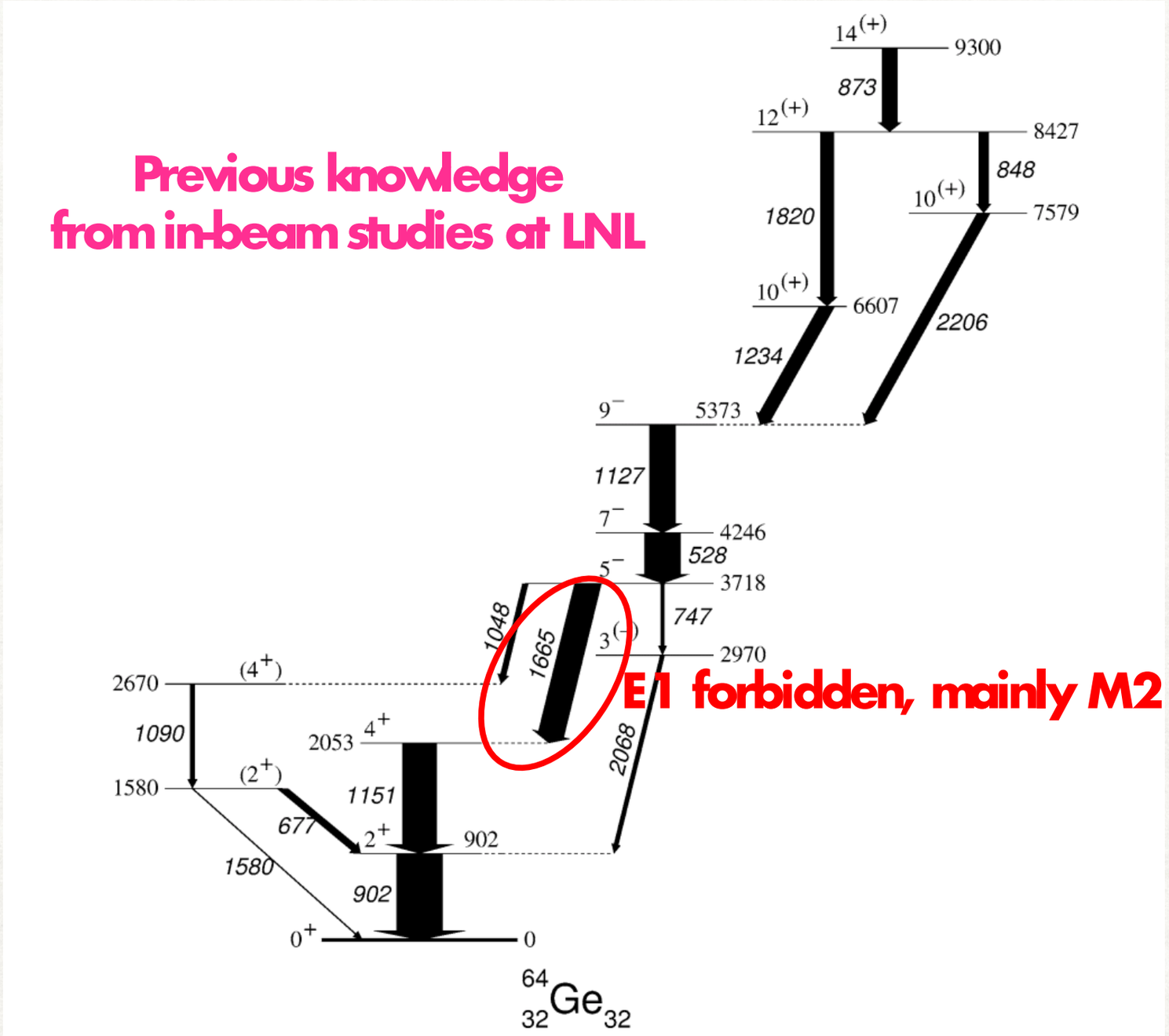





**N=Z nucleus**

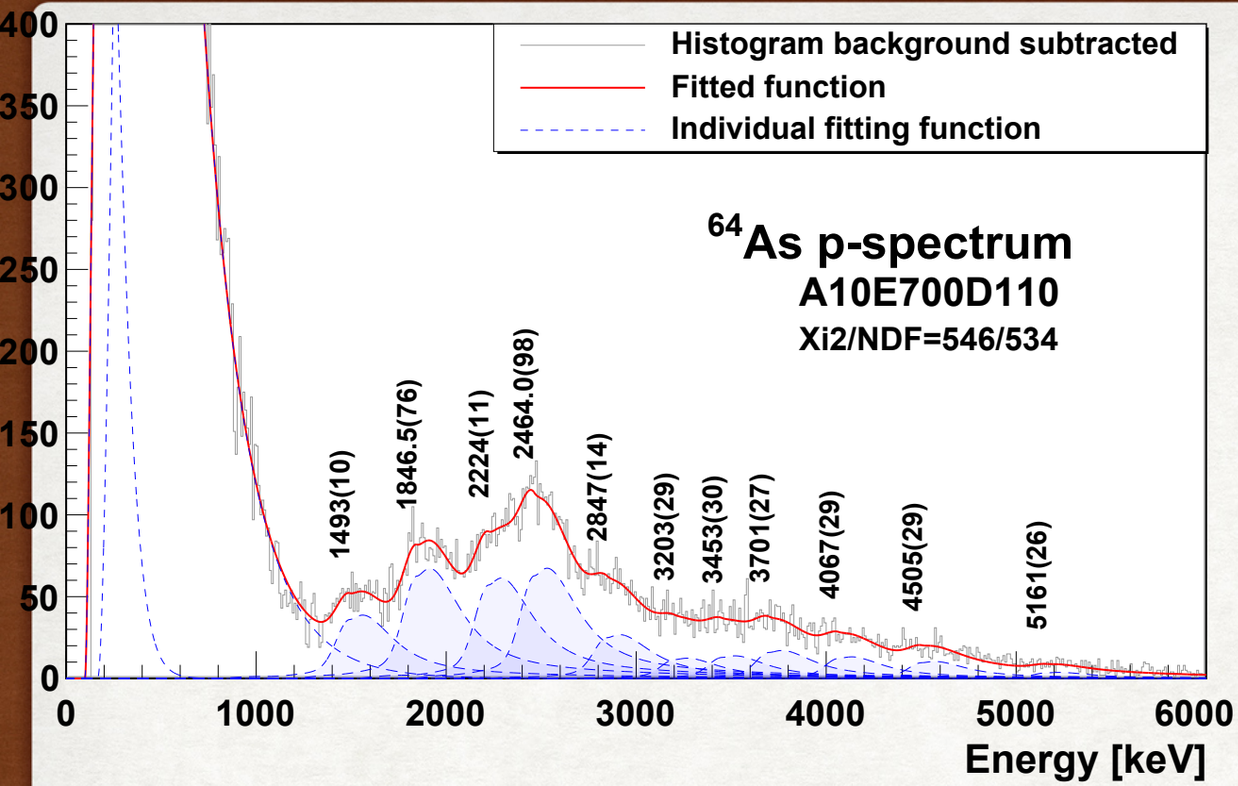
## Previous knowledge from in-beam studies at LNL

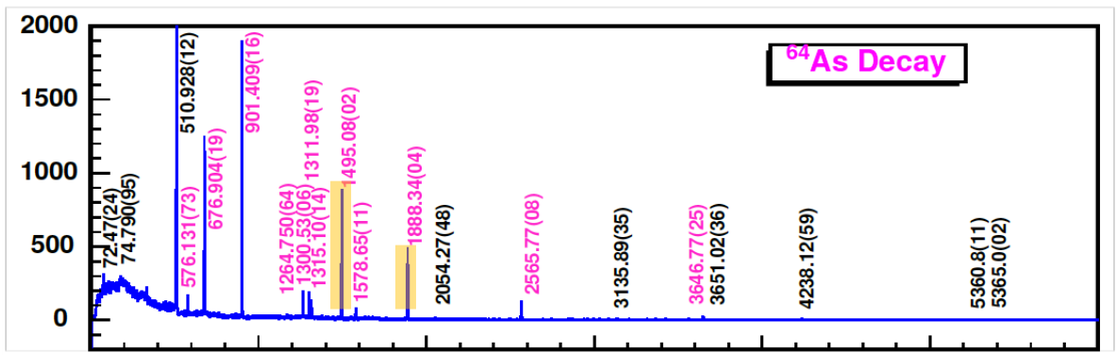


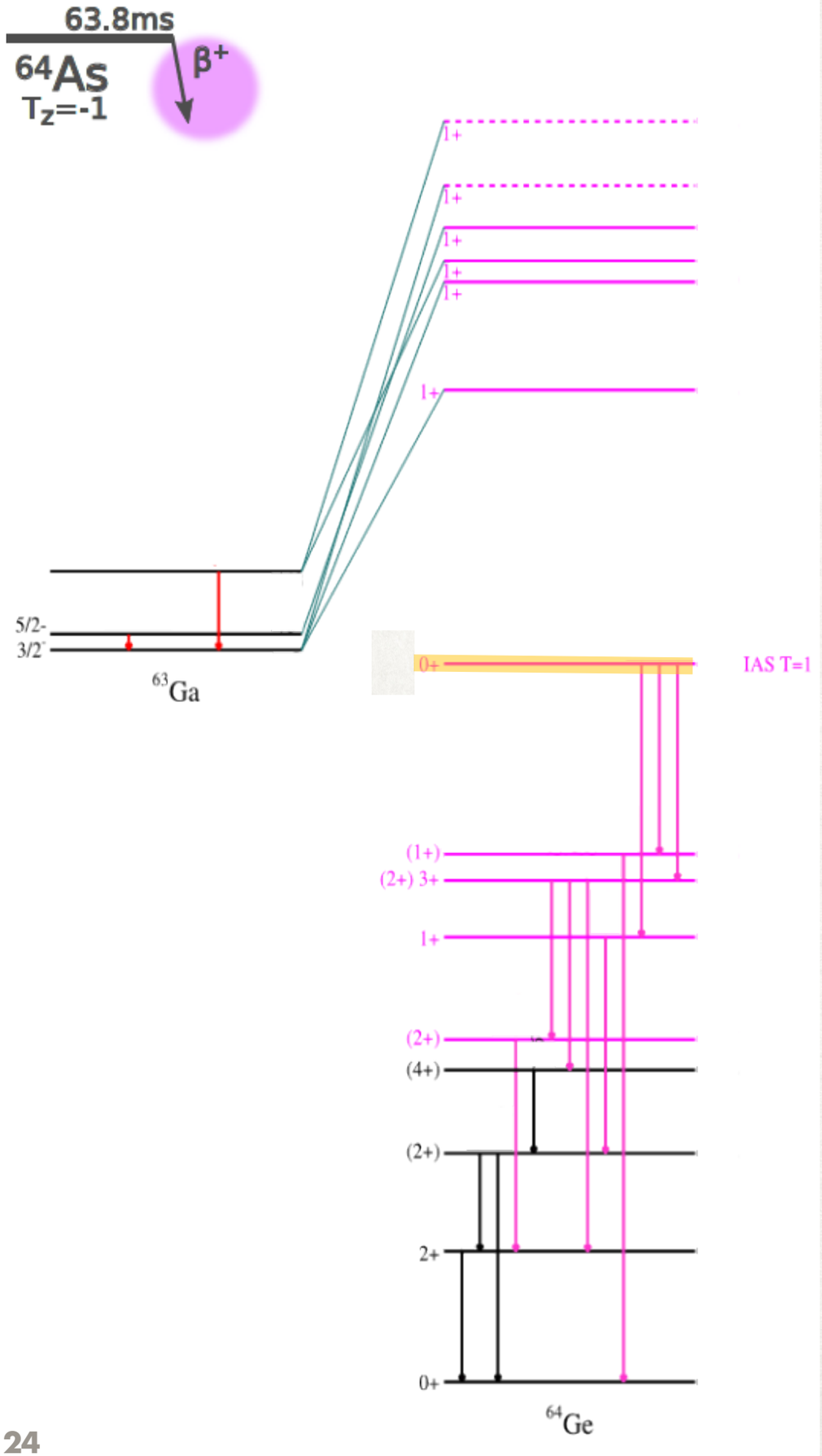

**E1 forbidden, mainly M2**

Isospin mixing in the $N = Z$ nucleus $^{64}$Ge

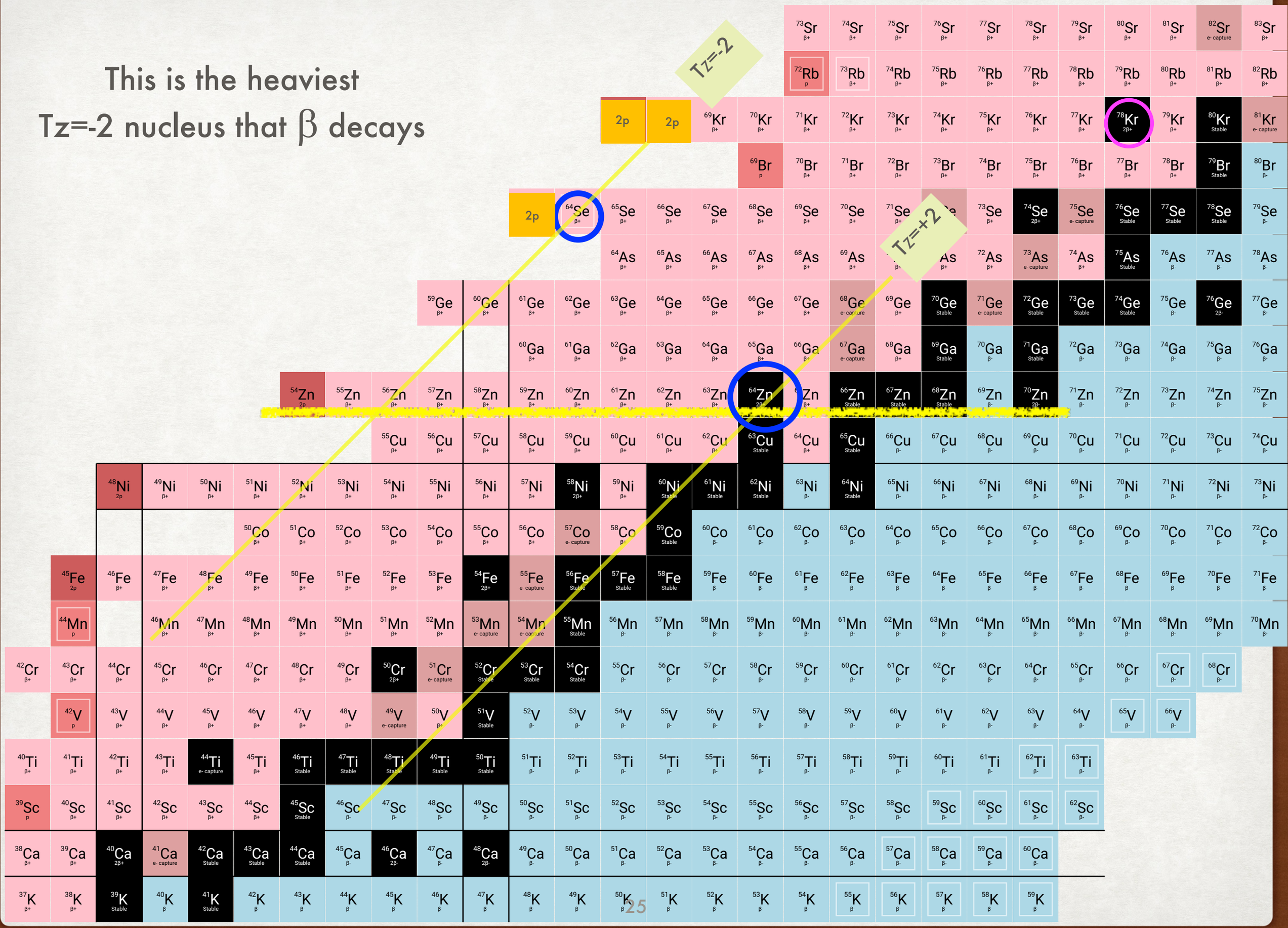
E. Farnea et al. Phys. Lett B 551 (2003) 56–62


Histogram background subtracted
Fitted function
Individual fitting function
64As p-spectrum
A10E700D110
Xi2/NDF=546/534
1493(10)
1846.5(76)
2224(11)
2464.0(98)
2847(14)
3203(29)
3453(30)
3701(27)
4067(29)
4505(29)
5161(26)
Energy [keV]

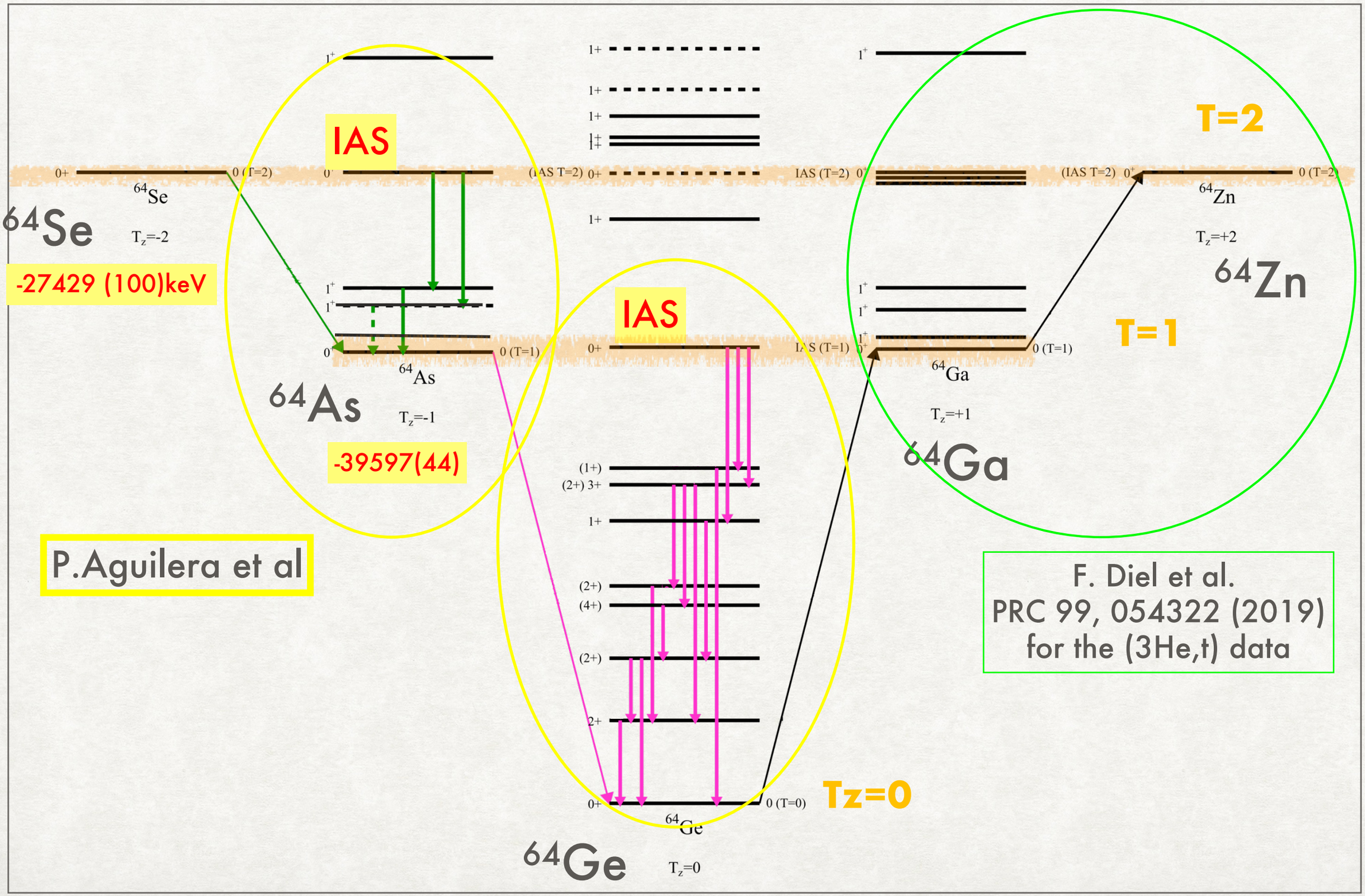

64As Decay
72.47(24)
74.790(95)
510.928(12)
576.131(73)
676.904(19)
901.409(16)
1264.750(64)
1300.53(06)
1311.98(19)
1315.10(14)
1495.08(02)
1578.65(11)
1888.34(04)
2054.27(48)
2565.77(08)
3135.89(35)
3646.77(25)
3651.02(36)
4238.12(59)
5360.8(11)
5365.0(02)


63.8ms
64As
Tz=-1
β+
1+
5/2-
3/2-
63Ga
0+
IAS T=1
(1+)
(2+) 3+
1+
(2+)
(4+)
(2+)
2+
0+
64Ge

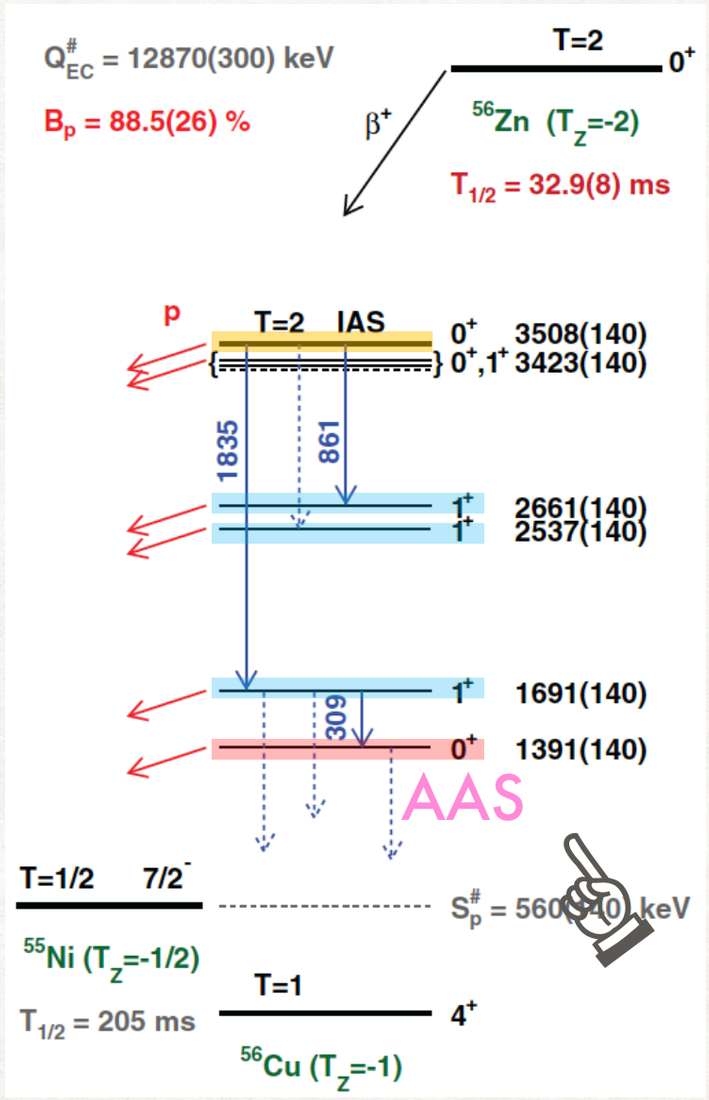
This is the heaviest
Tz=-2 nucleus that β decays



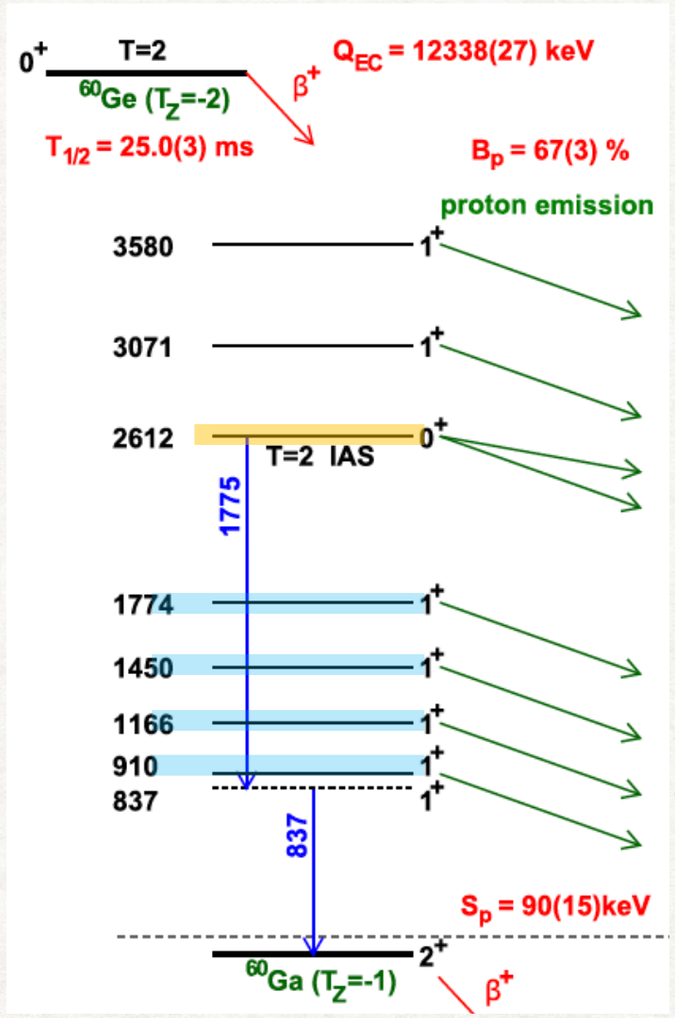
# This is the heaviest T=2 multiplet that exits



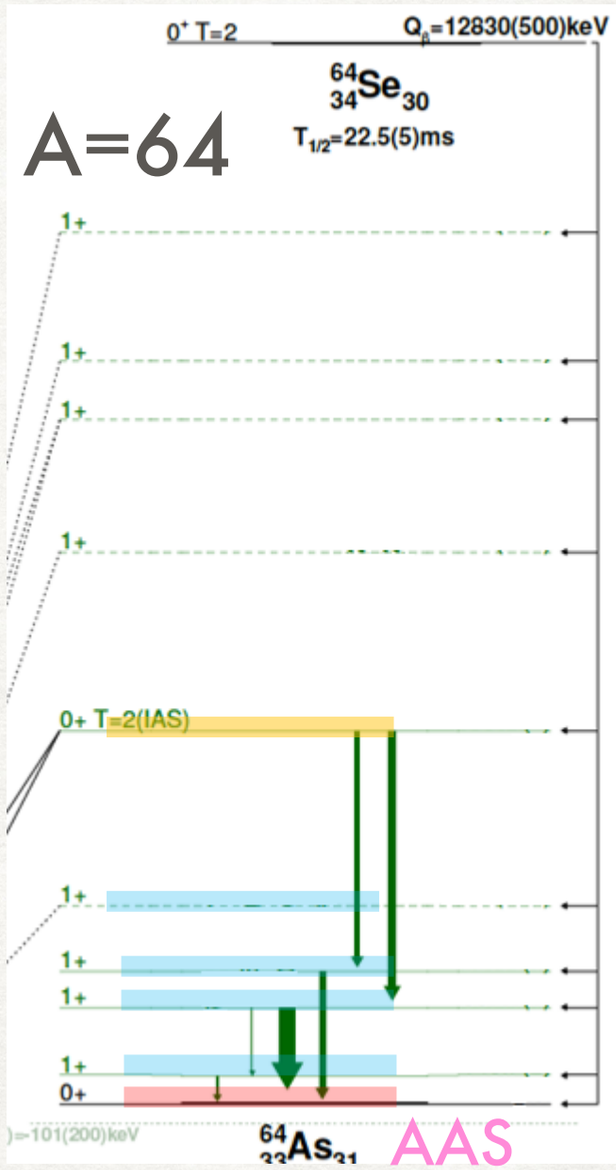
# A=56 (56Zn)




# A=60 (62Ge)



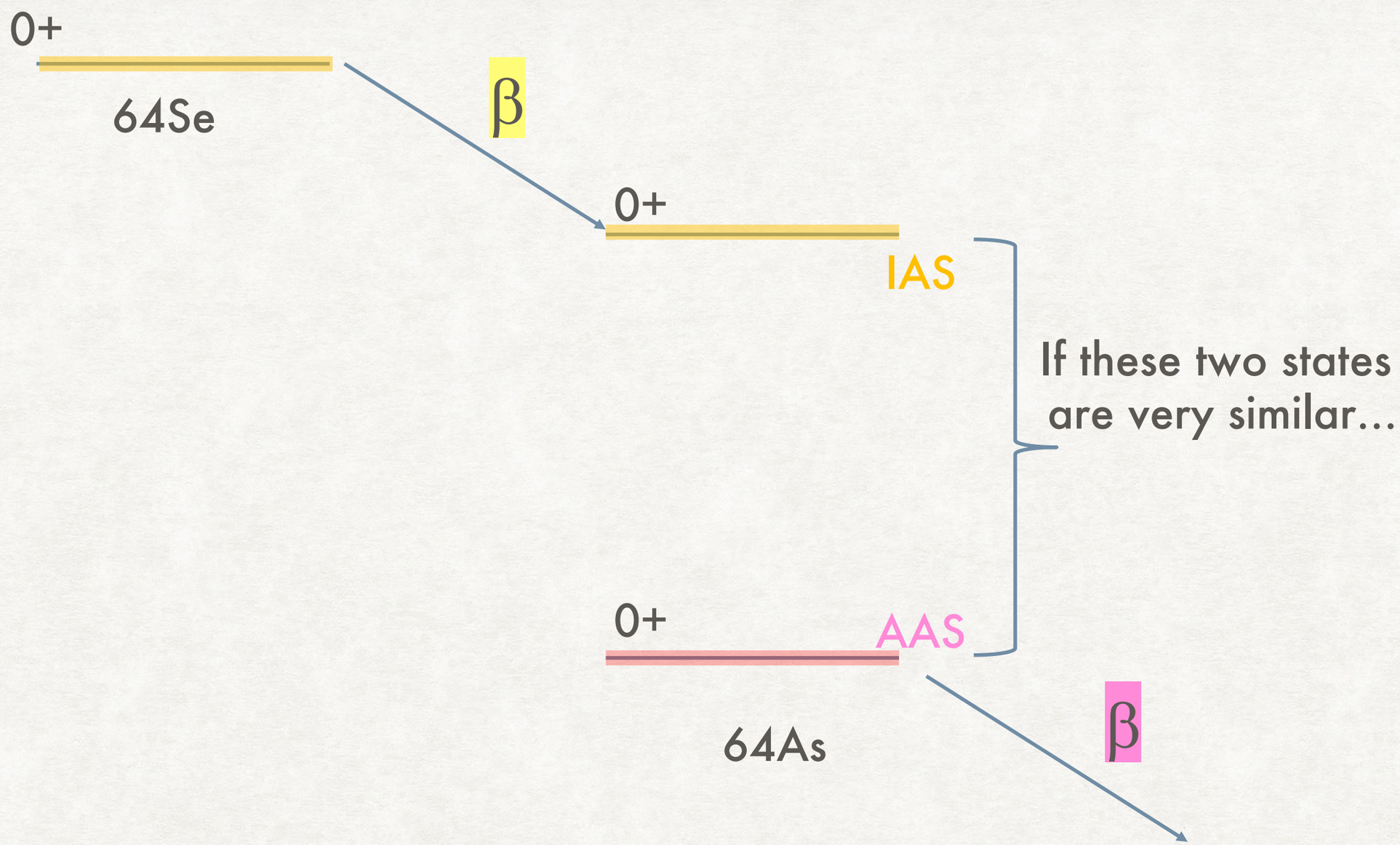

# A=64

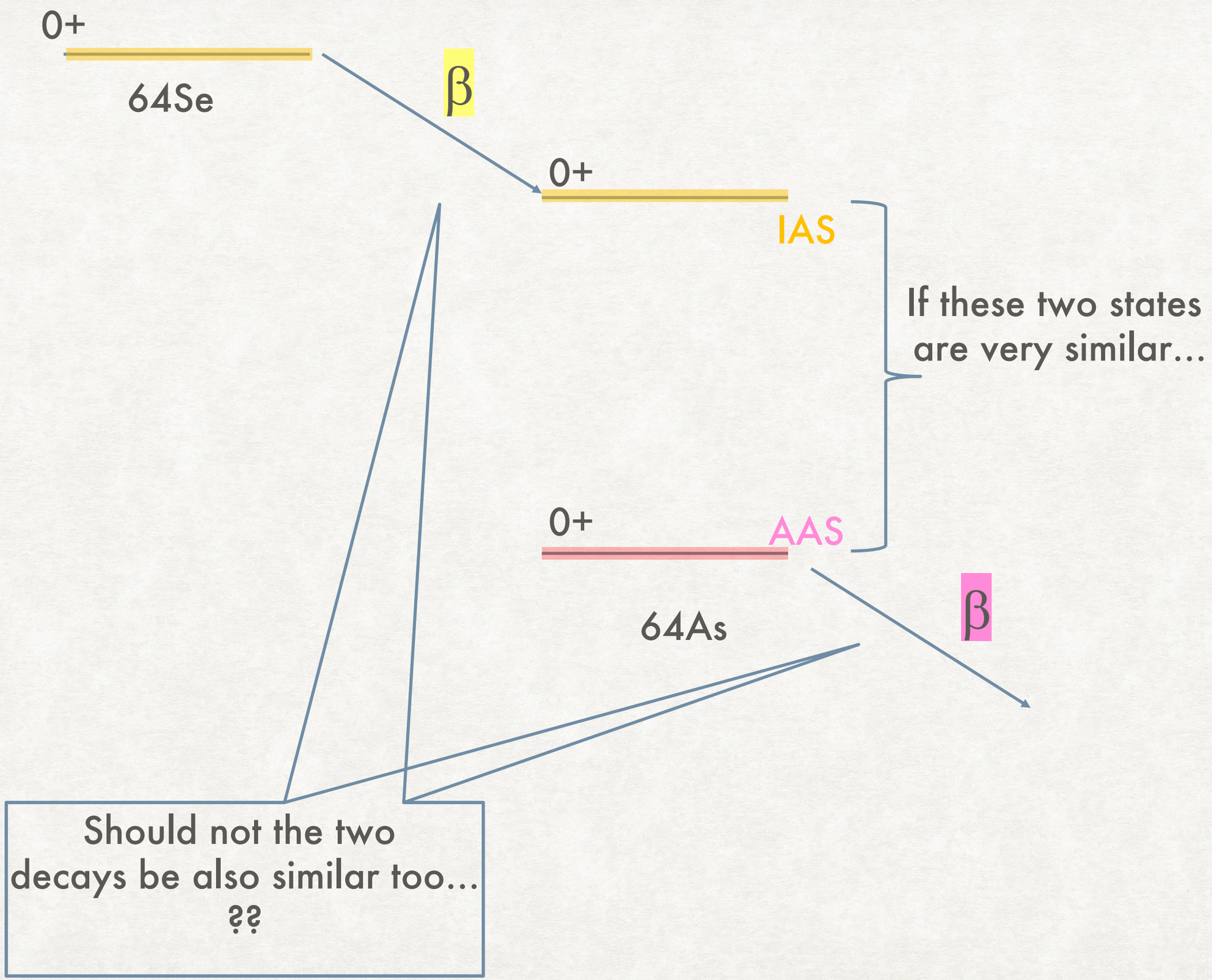



S. Orrigo el al. PRL 112(2014)222501

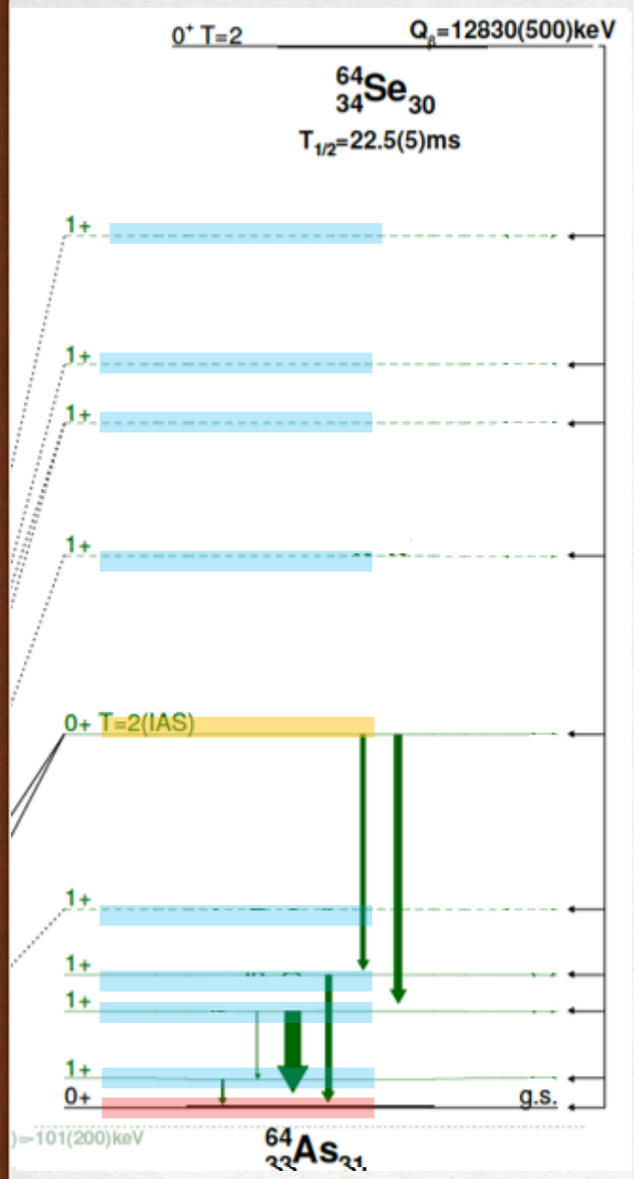
S. Orrigo el al. PRC 103(2021)014324

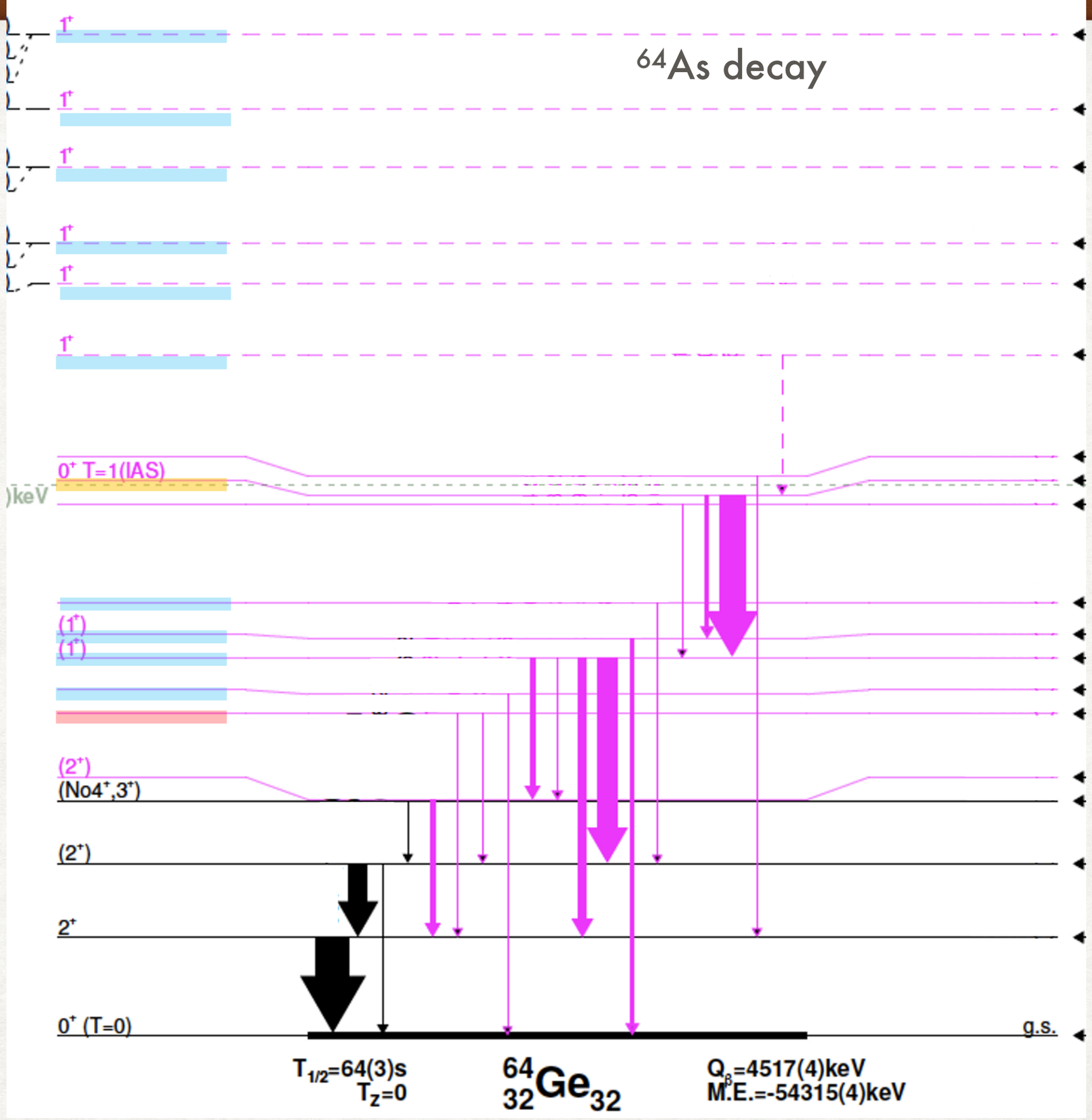
P. Aguilera Ph.D and preprint


0+
64Se
β
0+
IAS
If these two states are very similar…
0+
AAS
64As
β


0+
64Se
β
0+
IAS
If these two states are very similar…
0+
AAS
64As
β
Should not the two decays be also similar too… ??

# $^{64}$As decay




P. Aguilera Ph.D and preprint

0+

64Se

0+

IAS

If these two states are very similar…

0+

AAS

64As

Should not the two decays be also similar… ??

**If this idea is backed up by some theoretical calculations, it might be a way to reach information about an state with isospin N+2 by looking at N+1 (talk by J. Menendez tomorrow??)**

# The Collaboration

P. Aguilera
S. Orrigo
F. Molina
B. Rubio
W. Gelletly
Y. Fujita


H. Arellano[3],
J. Agramunt[1],
A. Algora[1],
V. Guadilla[1],
A. Montaner-Piza[1],
A. I. Morales[1],
S.E.A. Orrigo[1],
B. Blank[7],
P. Ascher[7],
M. Gerbaux[7],
T. Goigoux[7],
J. Giovinazzo[7],
S. Grévy[7],
T. Kurtukian Nieto[7],
C. Magron[7],
D.S. Ahn[8],
P. Doornenbal[8],
N. Fukuda[8],
N. Inabe[8],
G. Kiss[8],
T. Kubo[8],
S. Kubono[8],
S. Nishimura[8],
H. Sakurai[8,9],
Y. Shimizu[8],
C. Sidong[8],
P.-A. Söderström[8],
T. Sumikama[8],
H. Suzuki[8],
H. Takeda[8],
P. Vi[8],
J. Wu[8],
F. Diel[9],
D. Lubos[10],
G. de Angelis[11],
D. Napoli[11], C.Borcea[12],
A. Boso[13],
R.B. Cakirli[14],
E. Ganioglu[14],
G. de France[15],
S. Go[16],
J. Chiba[17],
D. Nishimura[17],
Y. Takei[17],
S. Yagi[17],
M. Tanaka[18]

[1] Instituto de Física Corpuscular, CSIC-Universidad de Valencia, E-46071 Valencia, Spain,
[2] Comisión Chilena de Energía Nuclear, Santiago, Chile,
[3] Universidad de Chile, Santiago, Chile,
[4] Department of Physics, University of Surrey,Guildford GU2 7XH, Surrey, UK,
[5] Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567-0047, Japan,6
Institute of Nuclear Research of the Hungarian Academy of Sciences, Debrecen, Hungary,7
Université de Bordeaux - UMR 5797 CNRS/IN2P3,8
RIKEN Nishina Center, Tokyo, Japan,9
University of Cologne,
[10] Technische Universität München,
[11] Nazionali di Legnaro dell'INFN,
[12] IFIN-HH,
[13] Universit'a di,
[14] Istanbul University,
[15] National d'Ions Lourds,
[16] University of Tennessee,
[17] Tokyo University of Science,
[18] Tokyo University.


Thank you for
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