E(u)rica International Workshop
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Studies of the Beta Decays of very neutron-deficient nuclei and a comparison with Charge Exchange reactions.

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W. Gelletly, F. Molina*, S. Orrigo, L. Kucuk et al

IFIC-Valencia(Spain)-Univ. Osaka
-Univ. Surrey-Istambul-Burdeaux….
*P.h.D Thesis

Layout of my talk

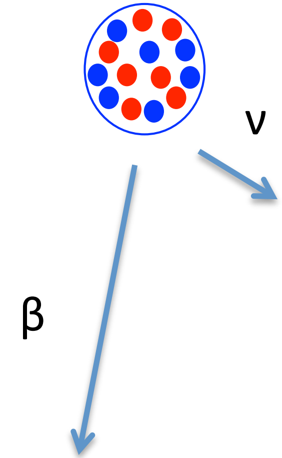
- Motivation: Isospin symmetry studies using two mirror processes, beta decay and charge exchange reactions
- Beta decay studies at GSI-FRS-Rising of Tz=-1 nuclei
- Beta decay studies at GANIL-LISE
- Possibilities at RIKEN

The two mirror processes are governed by the **στ** operator

Beta decay

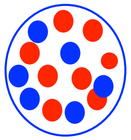
Charge Exchange Reactions

Radioactive initial nucleus



Advantages :

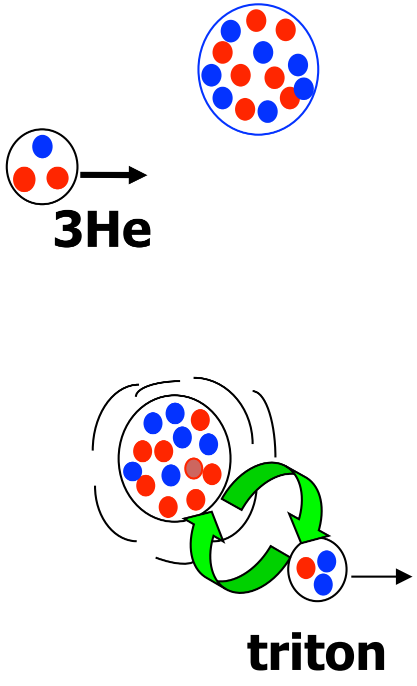
CE reactions: No restriction in excitation energy of Gamow-Teller states. At the stability.



Beta Decay: Absolute Normalization of B(GT). Far from stability.

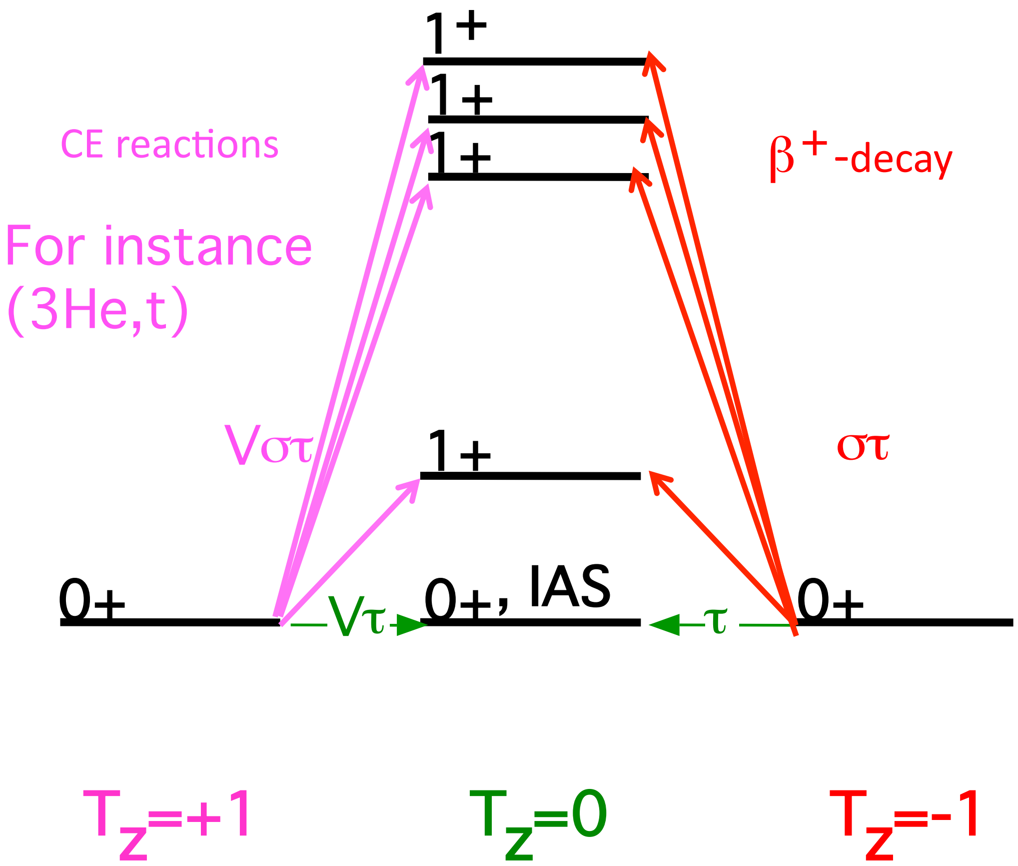
$$B(GT) = \left|\left\langle \psi_f \right| \sum_k \sigma_k \tau_k^{\pm} \left| \psi_i \right\rangle\right|^2$$

Stable Target



If isospin symmetry exists, mirror nuclei should populate the same states with the same probability, in the daughter nuclei, in the two mirror processes

In this work we will compare β decay and CE in Tz=-1 and Tz=+1 respectively (a simple case)



CE reactions

For instance (3He,t)

Advantages :

CE reactions: No restriction in excitation energy of Gamow-Teller states. At the stability.

Beta Decay: Absolute Normalization of B(GT). Far from stability.

In this paper we are interested in extracting information about the B(GT) strength in f-shell nuclei

Theoretically

$$B(GT) = \left| \langle \psi_f | \sum_k \sigma_k \tau_k^{\pm} | \psi_i \rangle \right|^2$$

Experimentally

$$B(GT)^{\beta} = k \frac{I_{\beta}(E)}{f(Q_{\beta} - E, Z) T_{1/2}}$$

$$B(GT)^{CE} \propto \frac{d\sigma}{d\Omega}(0^{\circ})$$

Combined analysis
Fujita et al.,
PRL95(2005)212501

From the present experiment

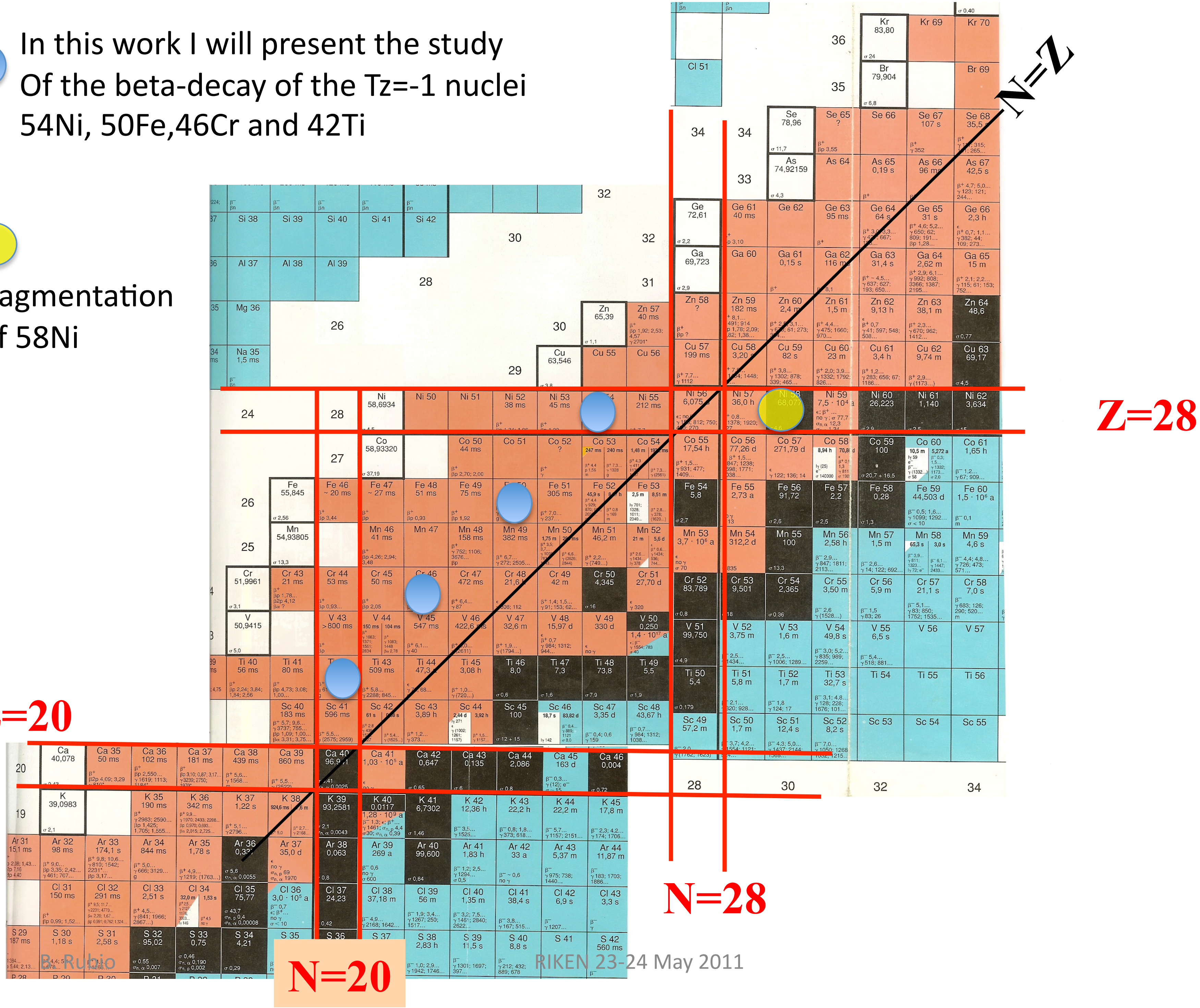
☞ $T_{1/2}$ Parent half life

☞ $I_{\beta}(E)$ Beta feeding to states in the daughter nucleus

● In this work I will present the study
Of the beta-decay of the Tz=-1 nuclei
54Ni, 50Fe,46Cr and 42Ti

●

Fragmentation
of 58Ni



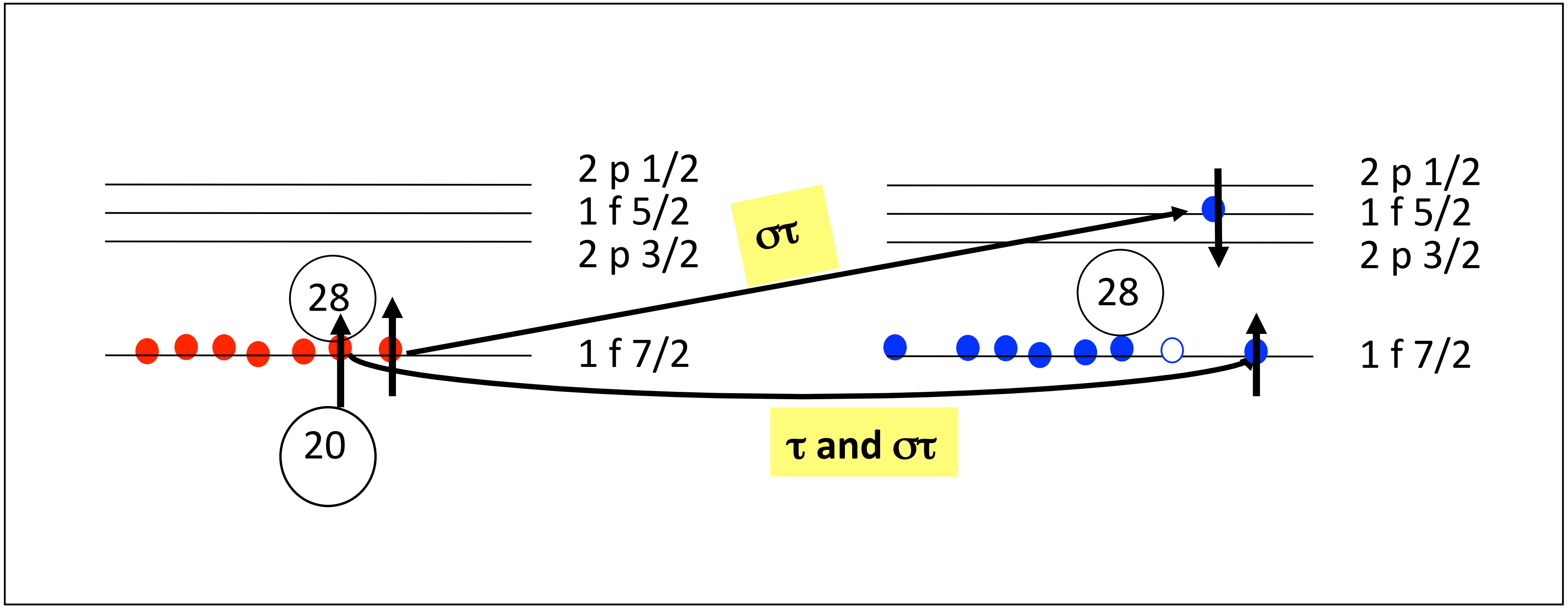
Simple scenario

We choose Tz=-1 nuclei with Z=22 to 28 because these cases are specially "clean" since they involve only

πf7/2 to νf7/2

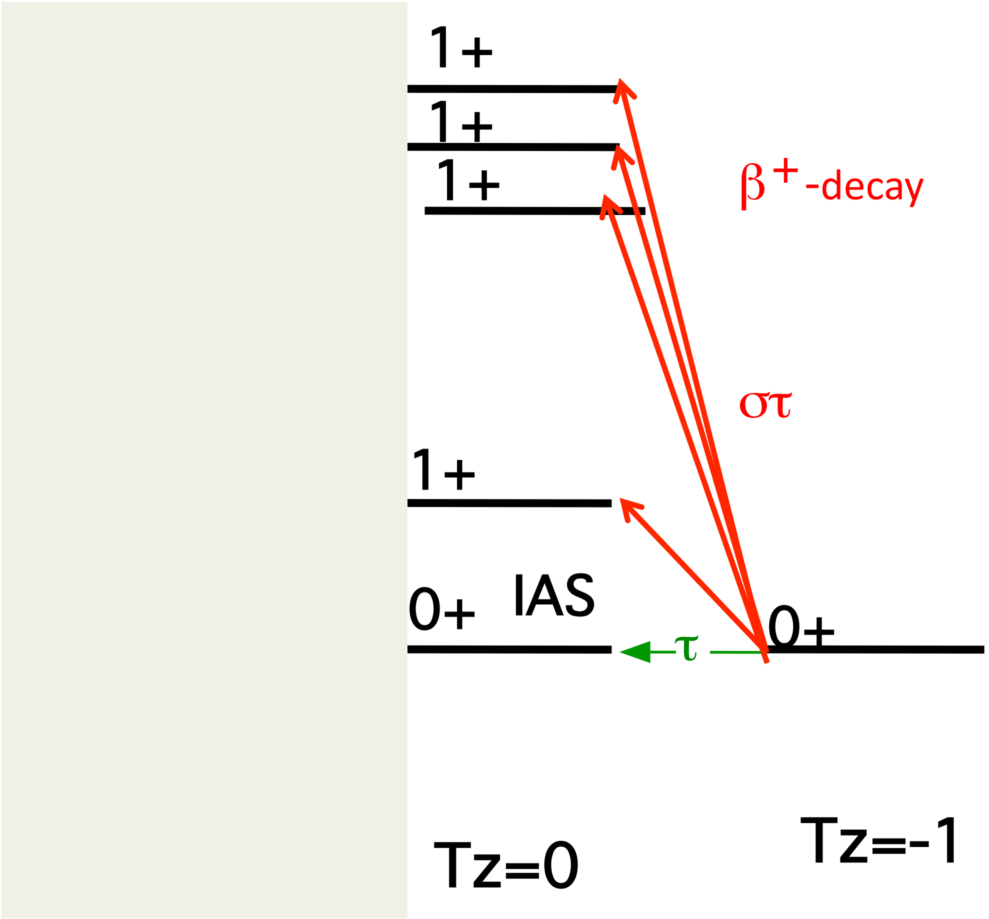
and

πf7/2 to νf5/2



This is the pattern we expect

“in isospin symmetry space”

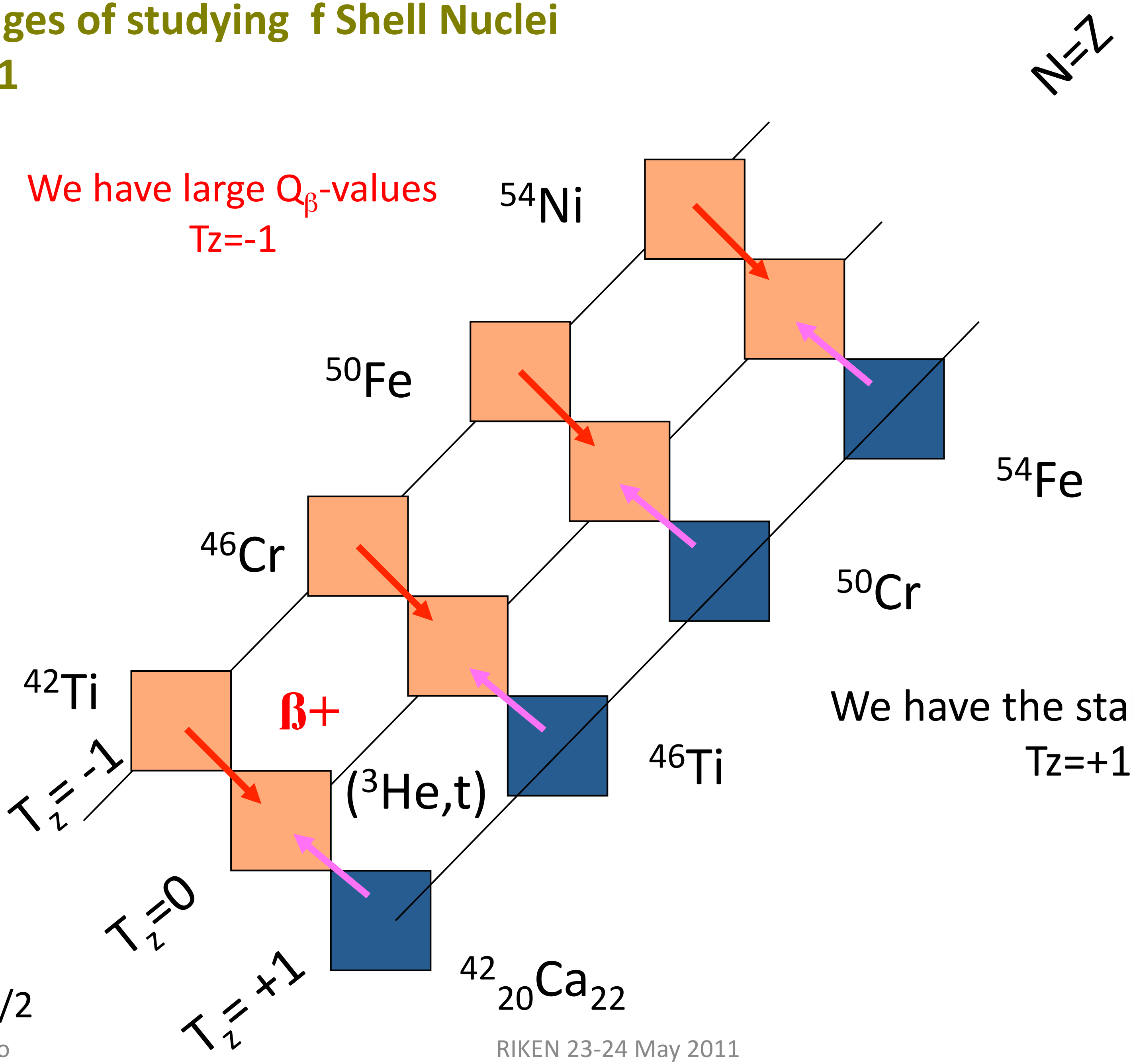


$(\pi f_{7/2})^2 \xrightarrow{\sigma\tau} \pi f_{7/2}\,\nu f_{5/2}$

$(\pi f_{7/2})^2 \xrightarrow{\sigma\tau} \pi f_{7/2}\,\nu f_{7/2}$

$(\pi f_{7/2})^2 \xrightarrow{\tau} \pi f_{7/2}\,\nu f_{7/2}$

Adventages of studying f Shell Nuclei with T=1

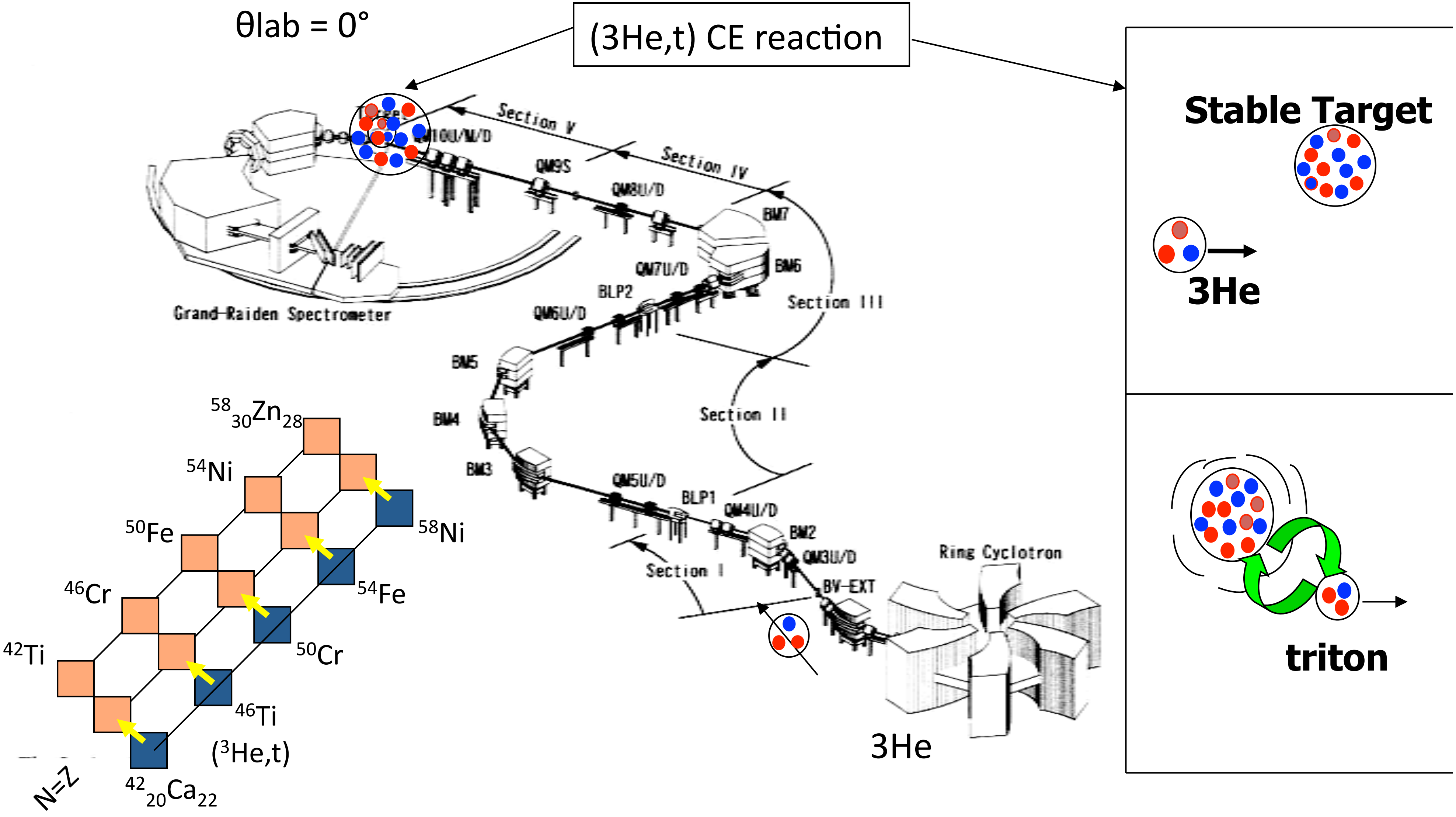


We have large Q_β-values
Tz=-1

We have the stable targets
Tz=+1

$Tz=(N-Z)/2$

(3He,t) CE Reactions @ RCNP(Osaka)


θlab = 0°

(3He,t) CE reaction

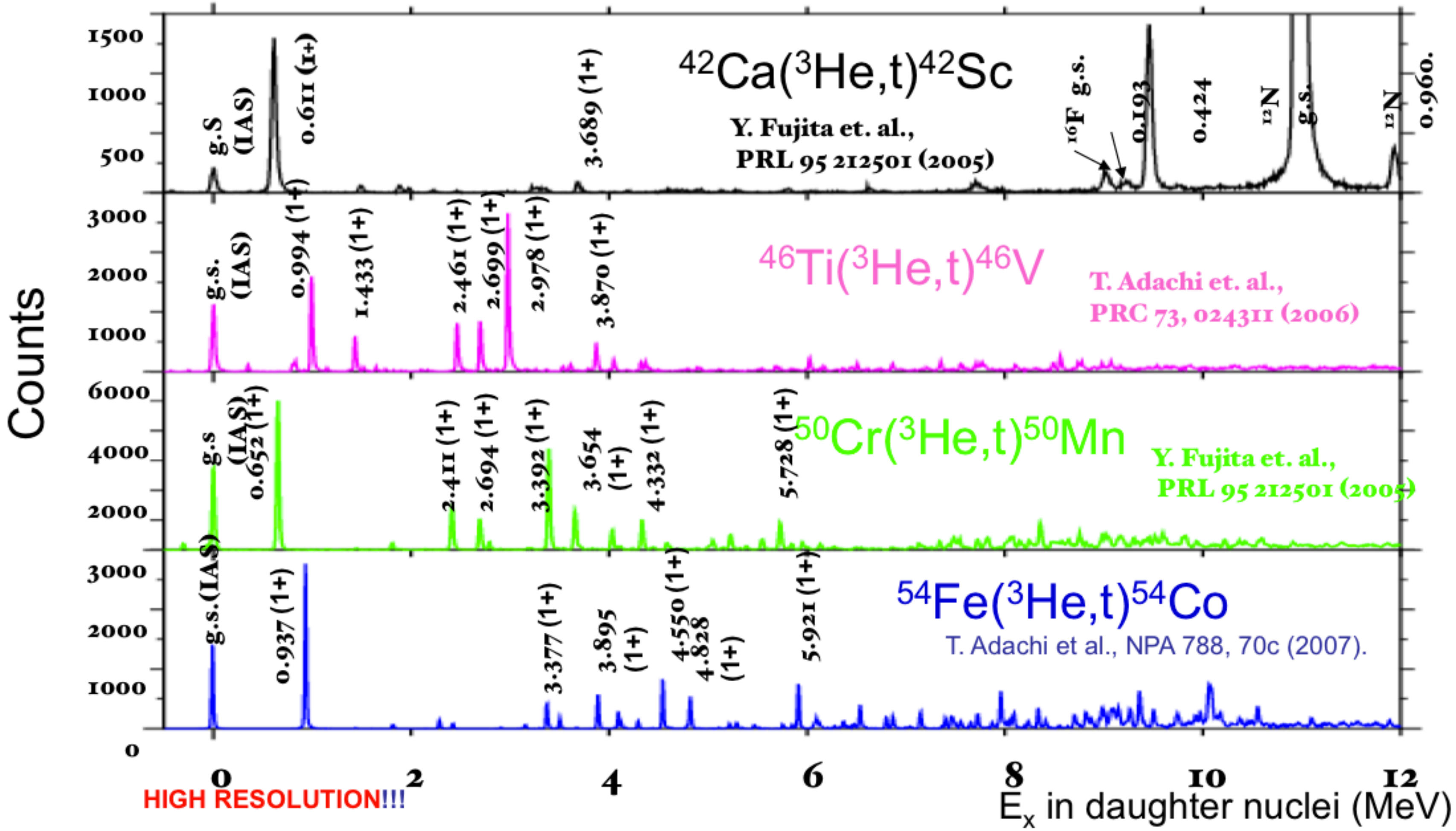
Stable Target

3He

triton

3He

Charge Exchange Reactions Results (RCNP-Osaka)

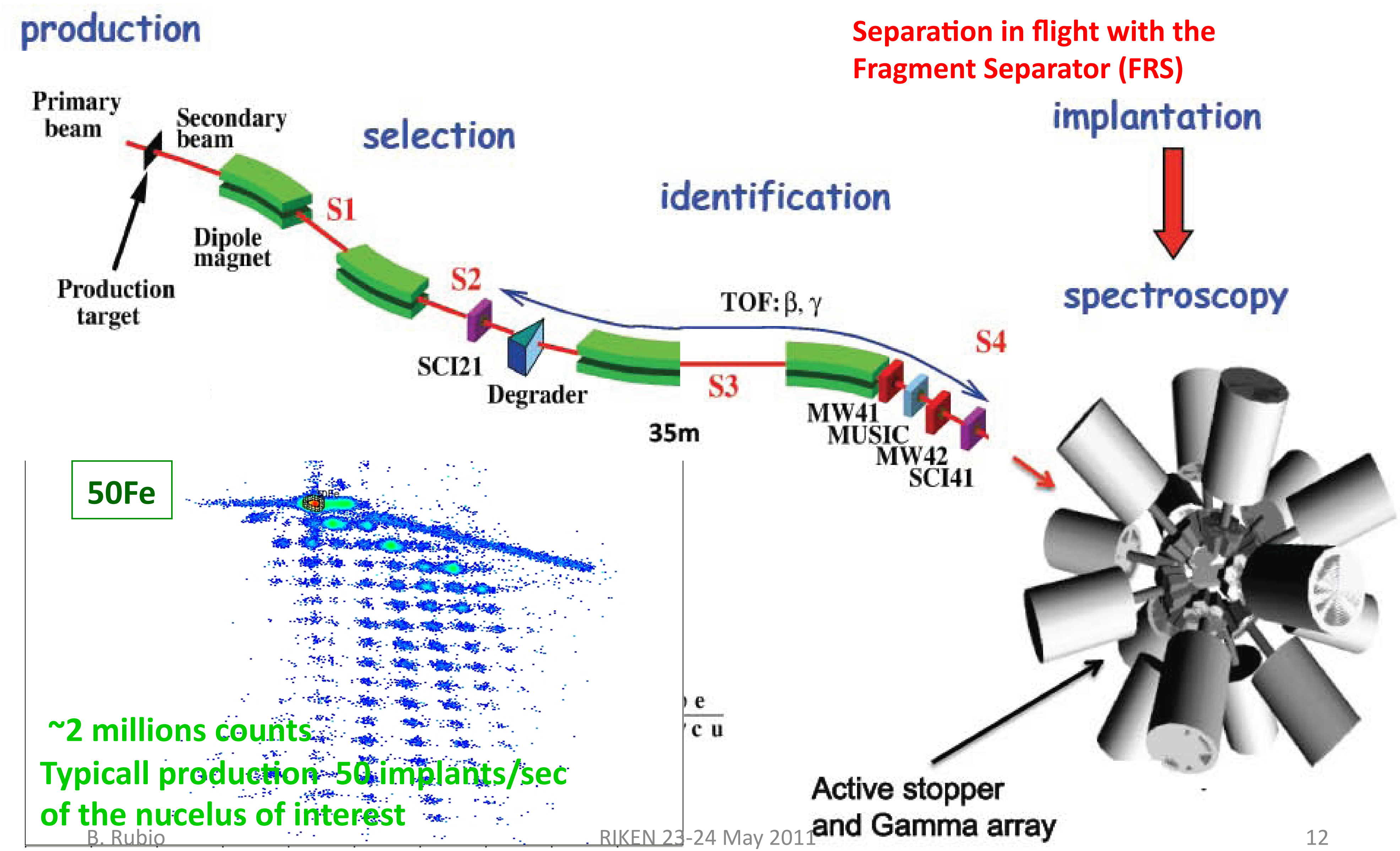


HIGH RESOLUTION!!!

Beta Decay Experiments @ RISING

Beam 58Ni@680 MeV/u 10^9 pps(part per spill) Target Be 4g/cm2

Separation in flight with the Fragment Separator (FRS)

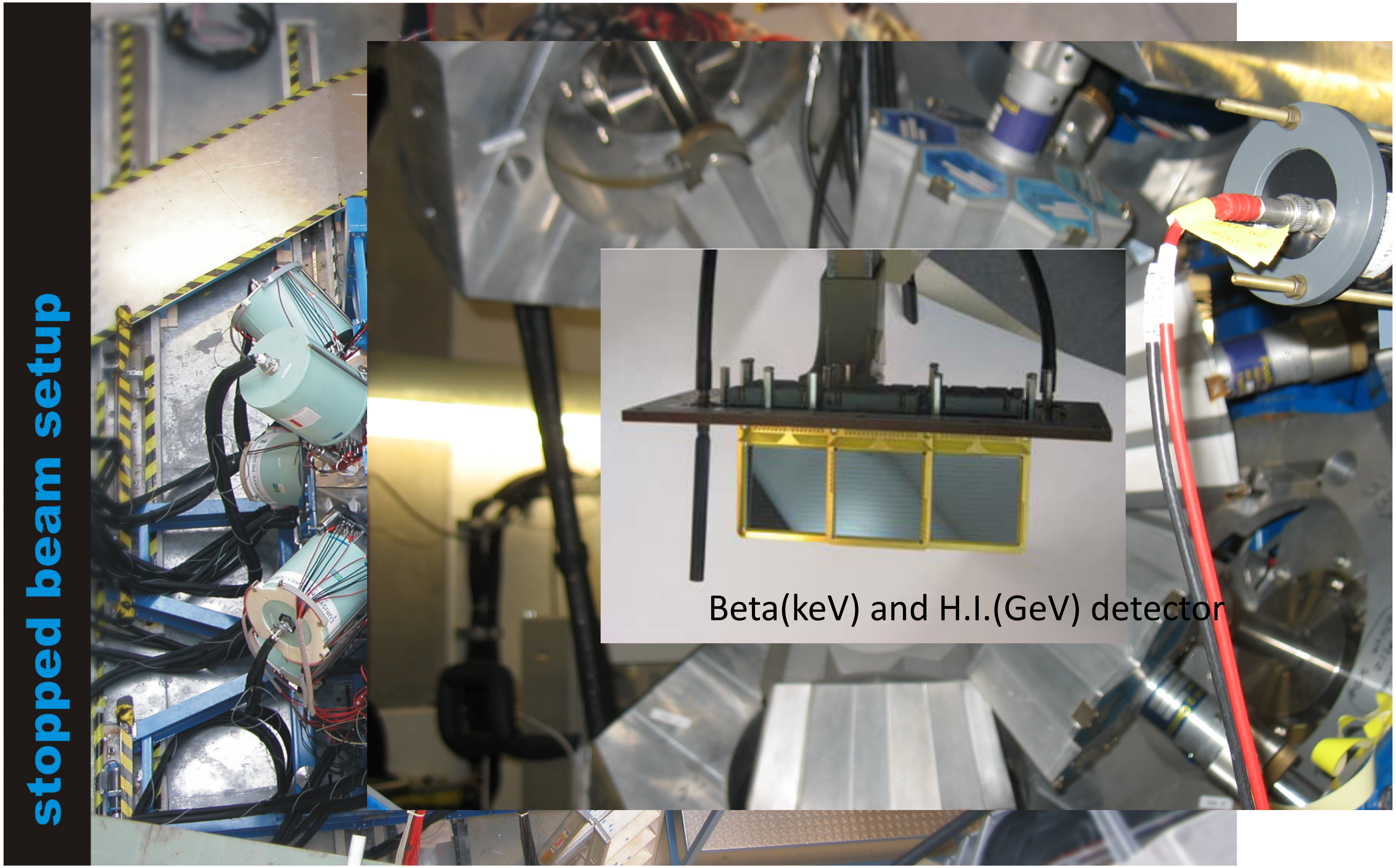


~2 millions counts

Typicall production 50 implants/sec of the nucelus of interest

RISING (Ge Array)

15 Euroball Cluster Ge Detectors (7 crystals each)

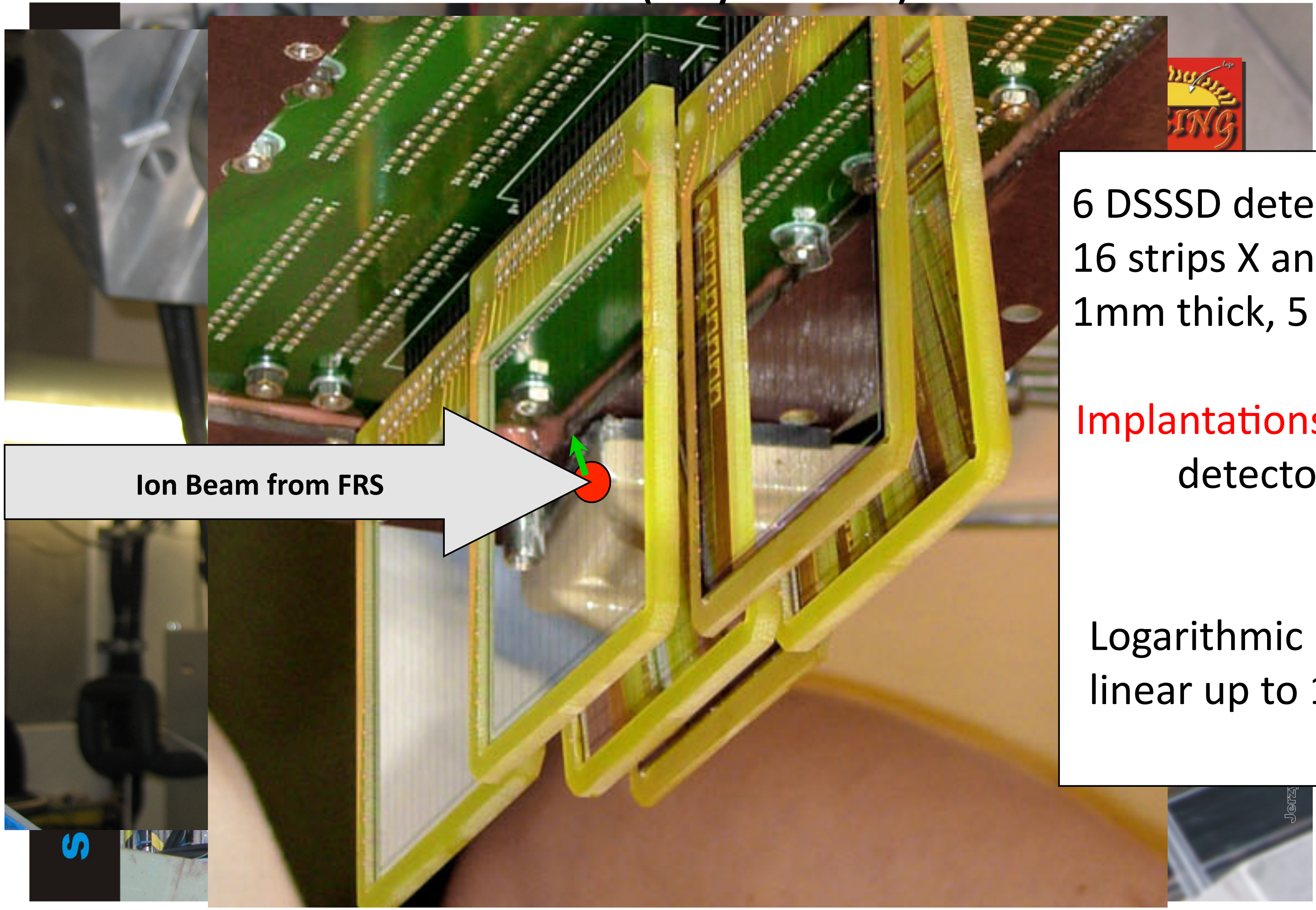


stopped beam setup

Beta(keV) and H.I.(GeV) detector

Detector Setup (Rising and DSSSD)

15 Euroball Cluster Ge Detectors (7 crystals each)



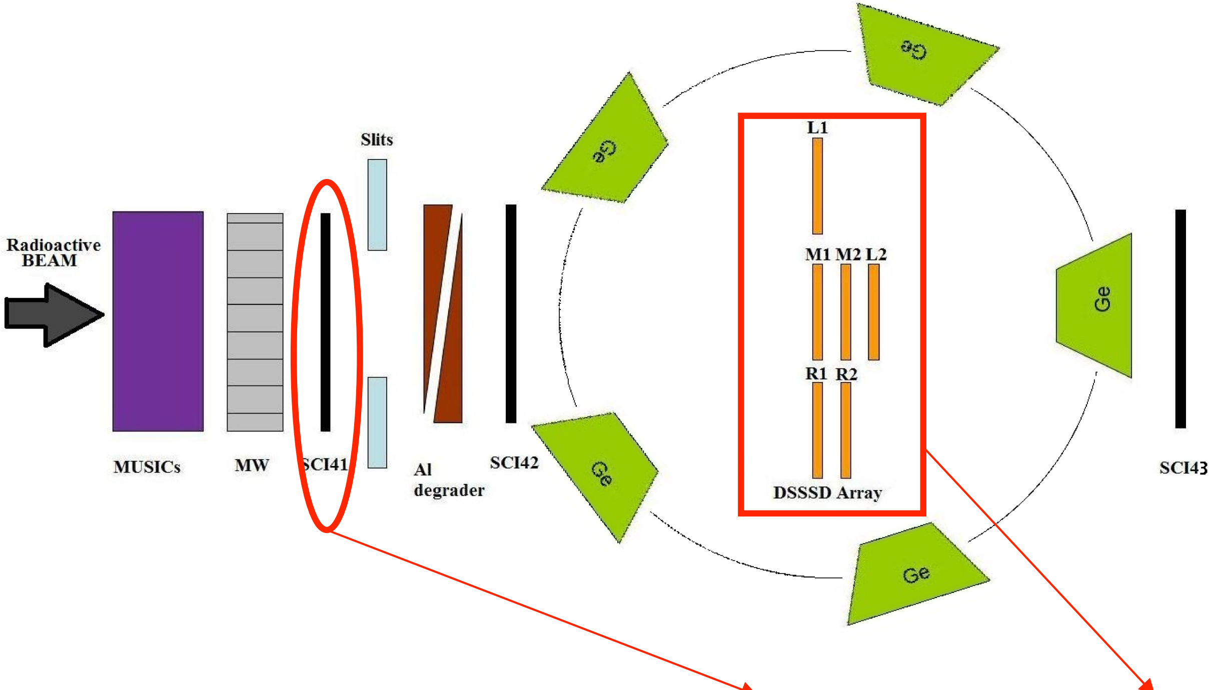
6 DSSSD detectors 1mm with 16 strips X and 16 strips Y, 1mm thick, 5 x 5 cm area

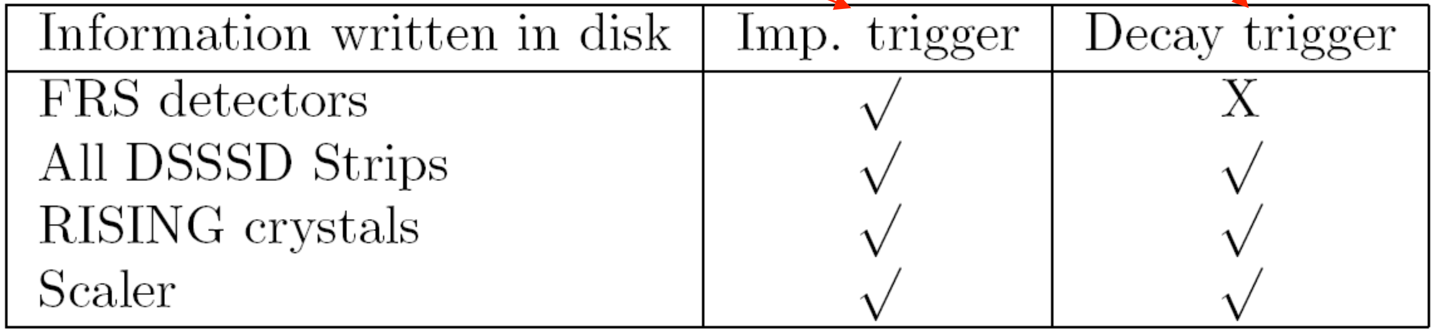
Implantations and Decay detectors

Logarithmic preamplifier linear up to 10 MeV.

Trigger

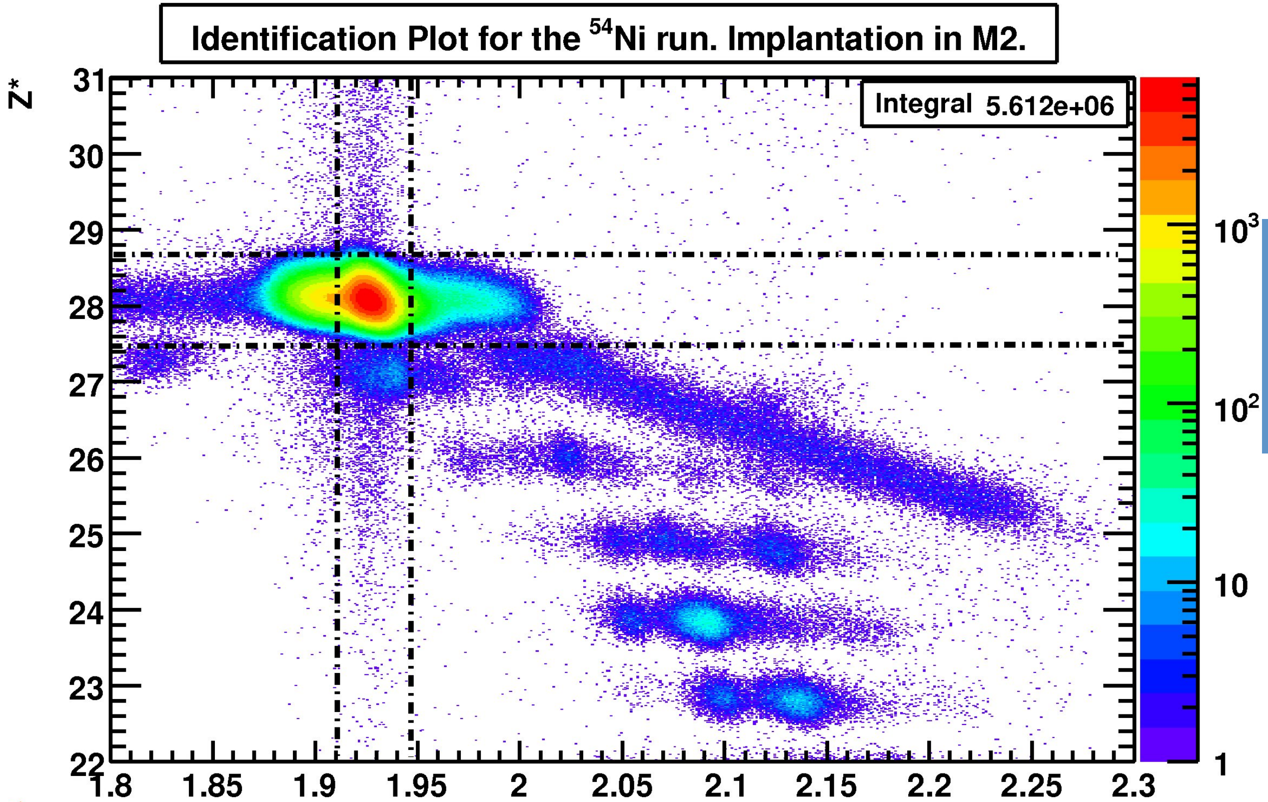
Two main triggers were used in this experiment: Implantation trigger (scintillator 41) and Decay trigger (OR signal of all the DSSSD)





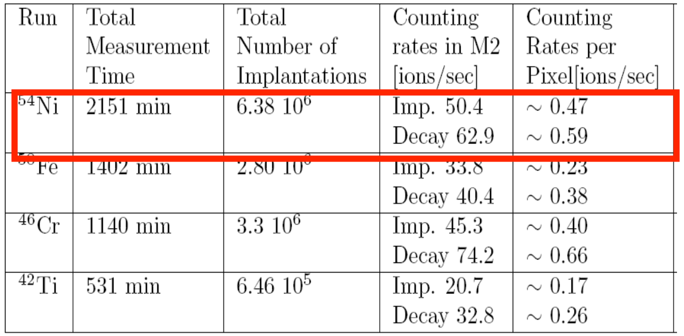
Information written in disk	Imp. trigger	Decay trigger
FRS detectors	√	X
All DSSSD Strips	√	√
RISING crystals	√	√
Scaler	√	√

54Ni Implantation ID stat.



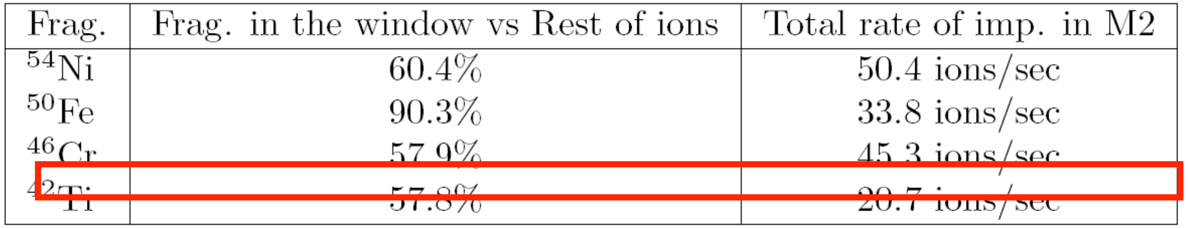
The most abundant nucleus produced, separated and identified up to sci41 corresponds to 54Ni

And also the most abundant nucleus Implanted in M2. Then we can assume that the most of the beta-events in M2 corresponds to the decay of 54Ni.

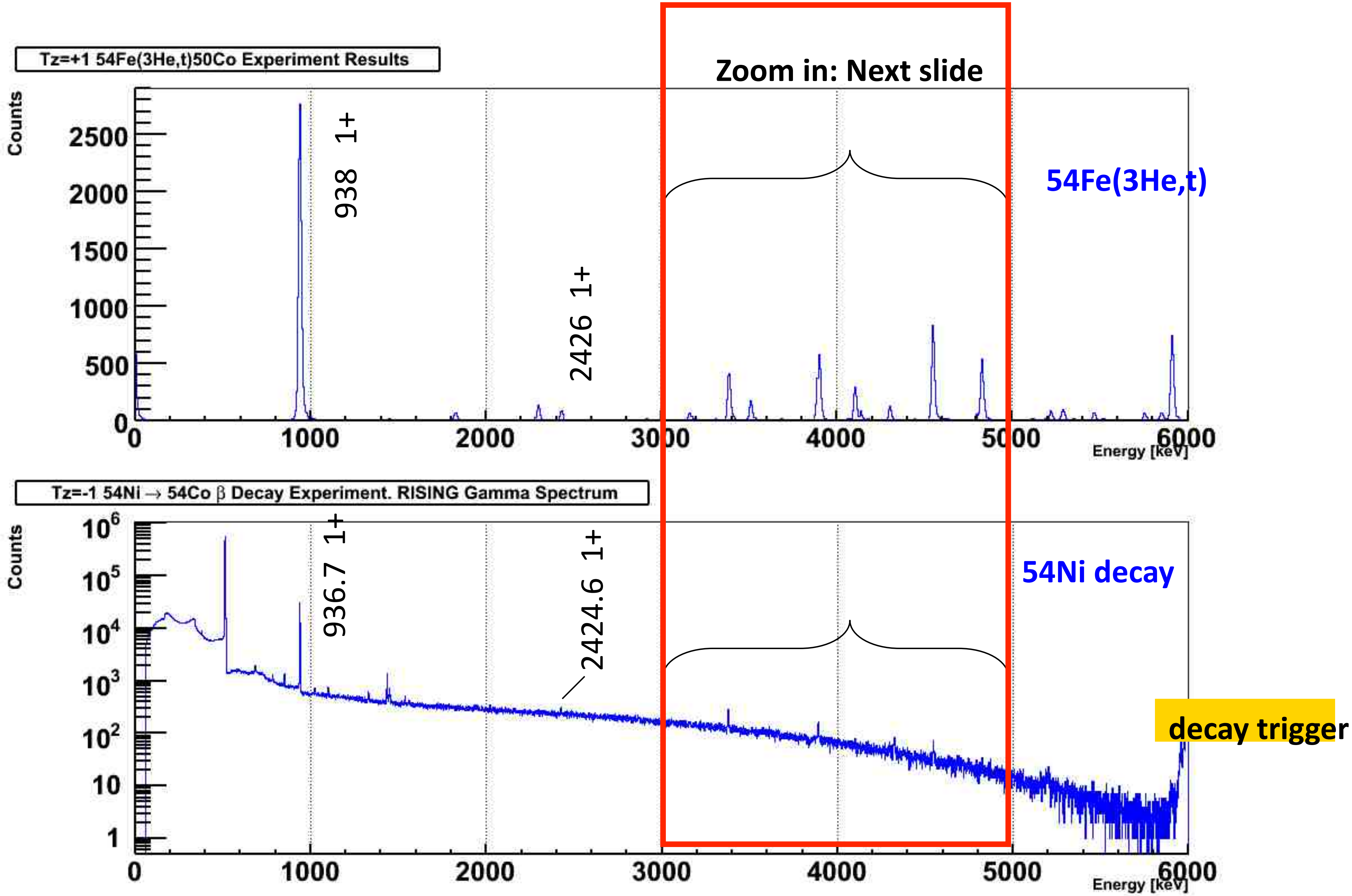


Run	Total Measurement Time	Total Number of Implantations	Counting rates in M2 [ions/sec]	Counting Rates per Pixel[ions/sec]
^{54}Ni	2151 min	$6.38\ 10^6$	Imp. 50.4 Decay 62.9	~ 0.47 ~ 0.59
^{50}Fe	1402 min	$2.80\ 10^6$	Imp. 33.8 Decay 40.4	~ 0.23 ~ 0.38
^{46}Cr	1140 min	$3.3\ 10^6$	Imp. 45.3 Decay 74.2	~ 0.40 ~ 0.66
^{42}Ti	531 min	$6.46\ 10^5$	Imp. 20.7 Decay 32.8	~ 0.17 ~ 0.26

Beta trigger, gamma spectrum



Frag.	Frag. in the window vs Rest of ions	Total rate of imp. in M2
^{54}Ni	60.4%	50.4 ions/sec
^{50}Fe	90.3%	33.8 ions/sec
^{46}Cr	57.9%	45.3 ions/sec
^{42}Ti	57.8%	20.7 ions/sec

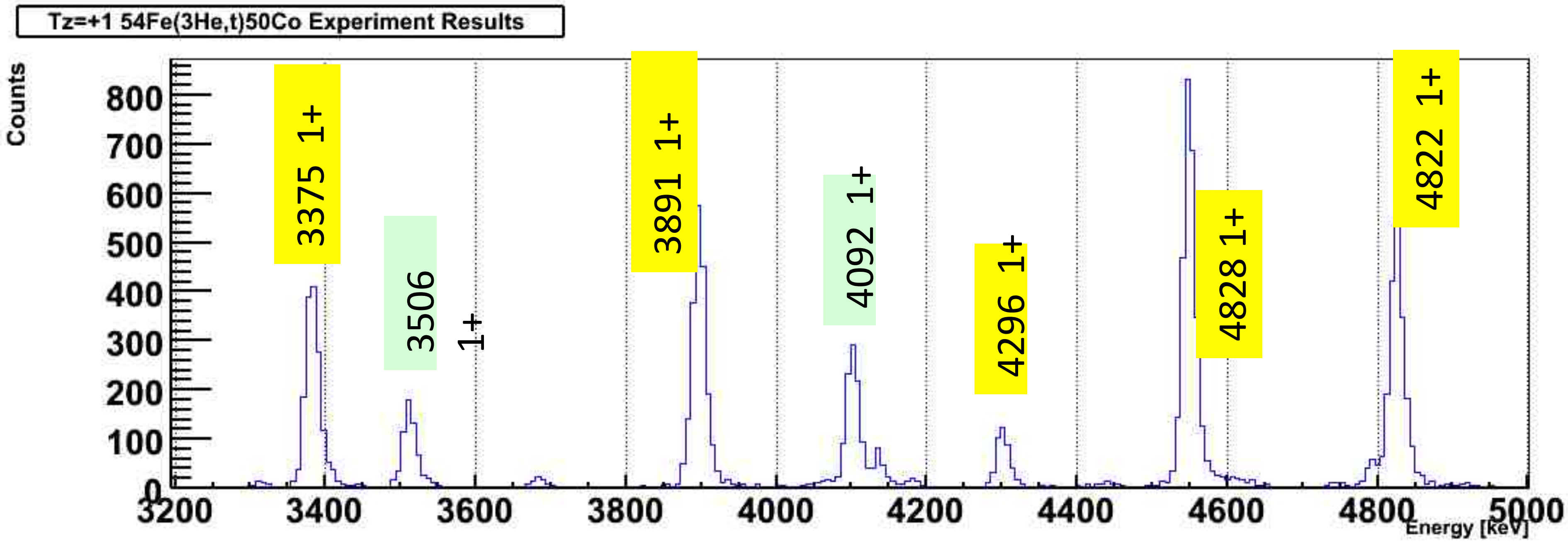


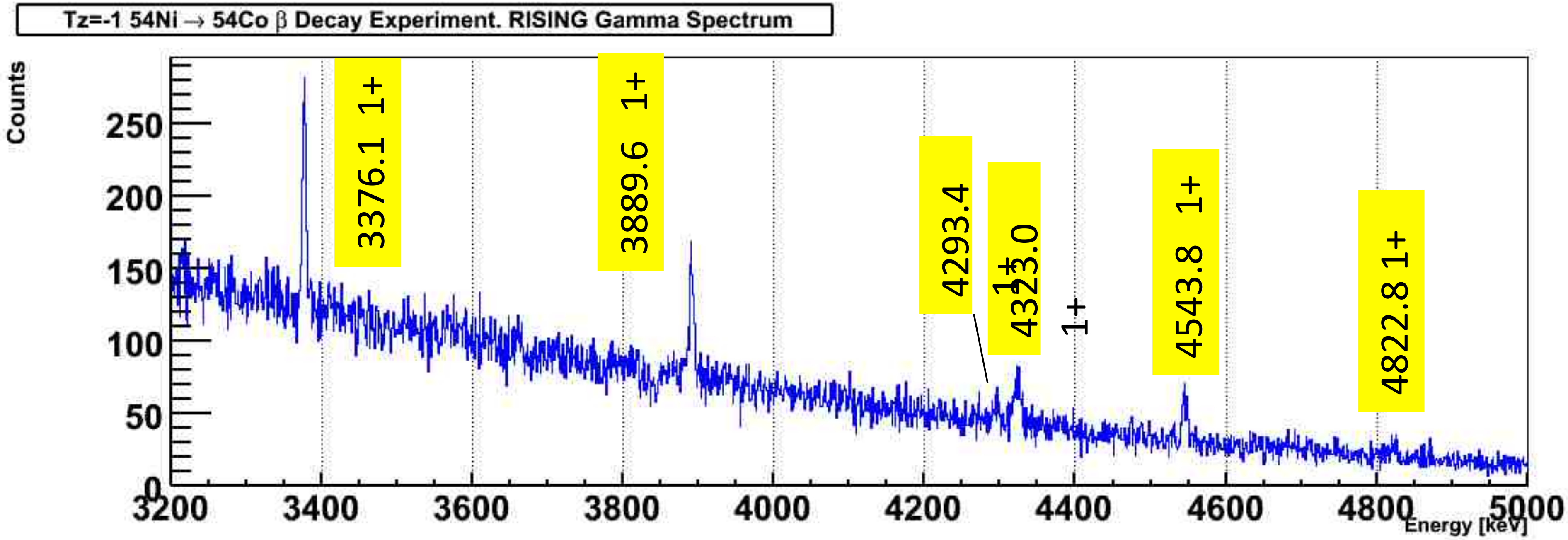
Zoom in: Next slide

54Fe(3He,t)

54Ni decay

decay trigger

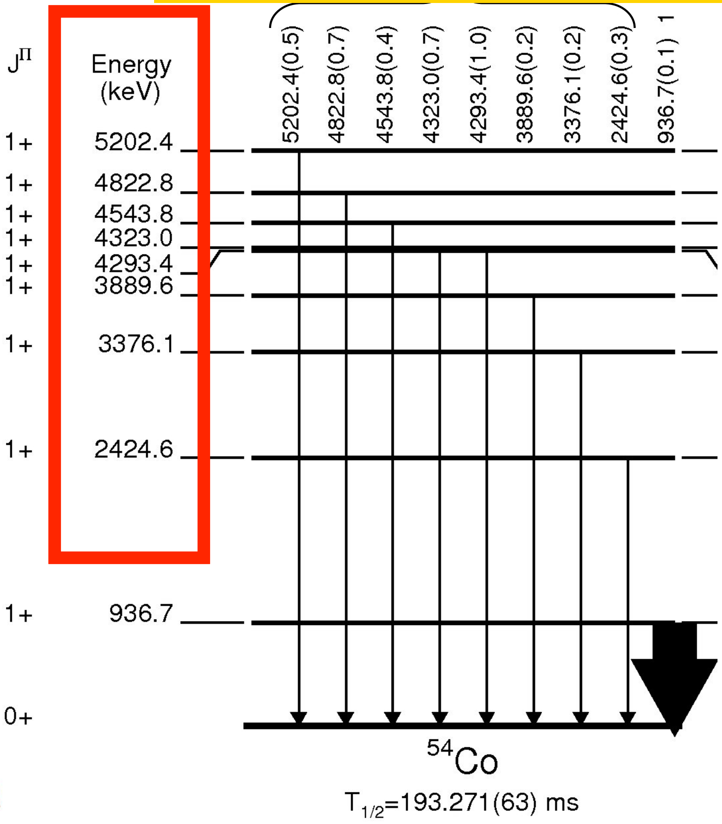

Tz=+1 54Fe(3He,t)50Co Experiment Results


Tz=-1 54Ni → 54Co β Decay Experiment. RISING Gamma Spectrum

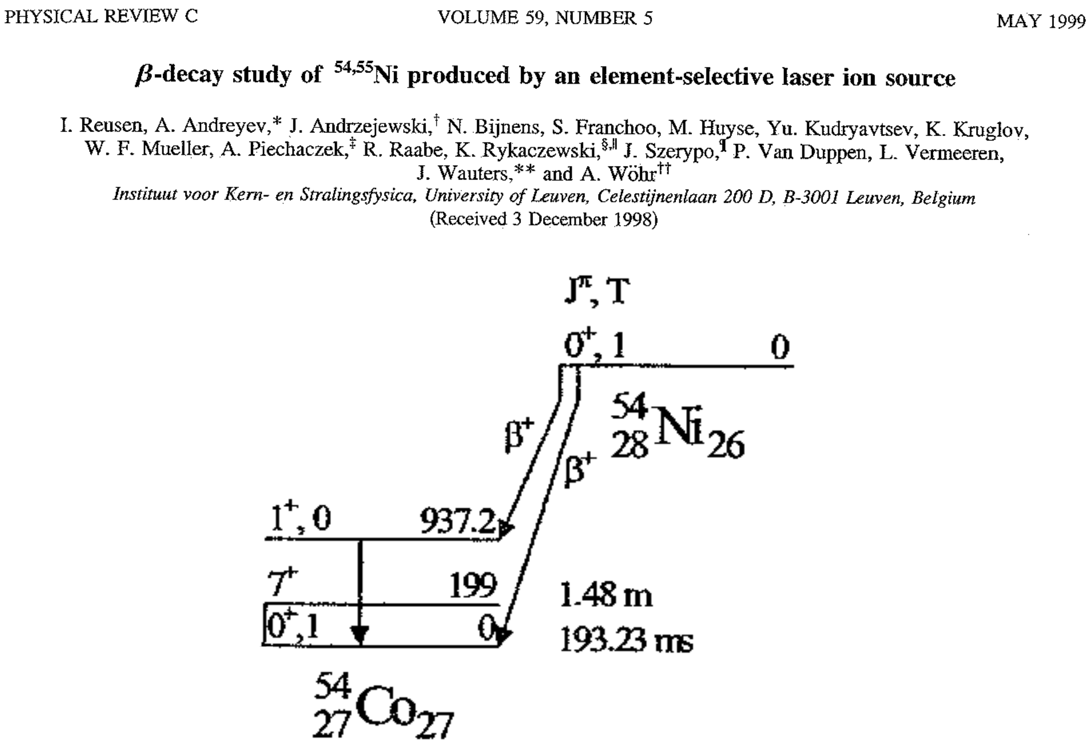
Gamma Analysis of 54Ni decay: Comparison with previous measurement

This work

Eight 1+ excited states seen for the first time in beta-decay experiments



I. Reusen et al. (1999)



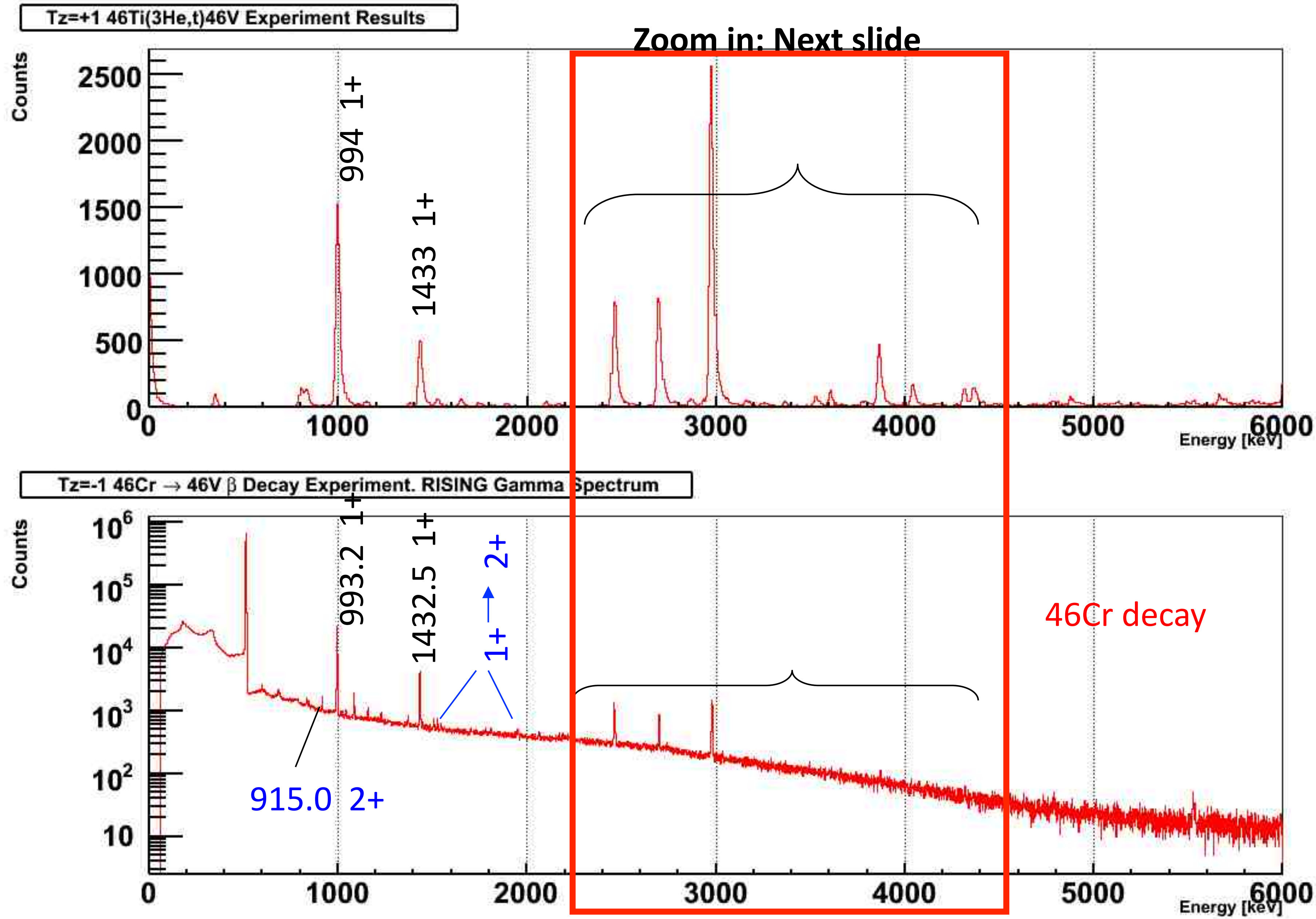
PHYSICAL REVIEW C VOLUME 59, NUMBER 5 MAY 1999

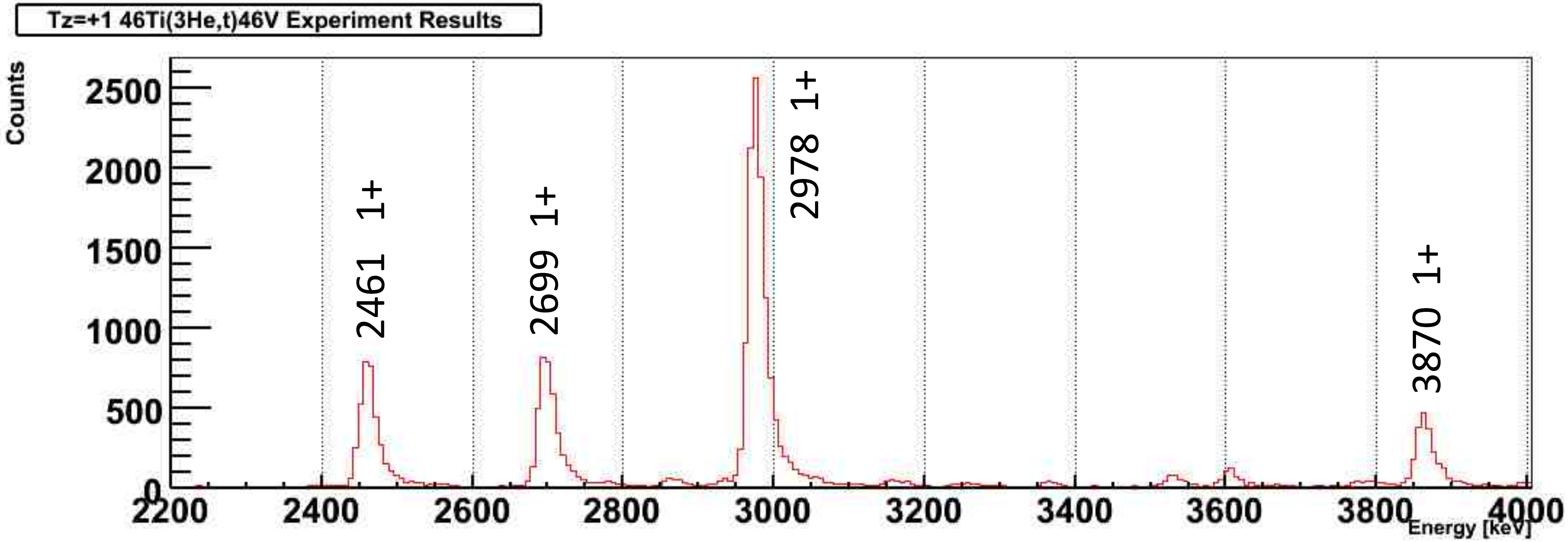
β-decay study of ^{54,55}Ni produced by an element-selective laser ion source

I. Reusen, A. Andreyev,* J. Andrzejewski,† N. Bijnens, S. Franchoo, M. Huyse, Yu. Kudryavtsev, K. Kruglov, W. F. Mueller, A. Piechaczek,‡ R. Raabe, K. Rykaczewski,§,‖ J. Szerypo,¶ P. Van Duppen, L. Vermeeren, J. Wauters,** and A. Wöhr††

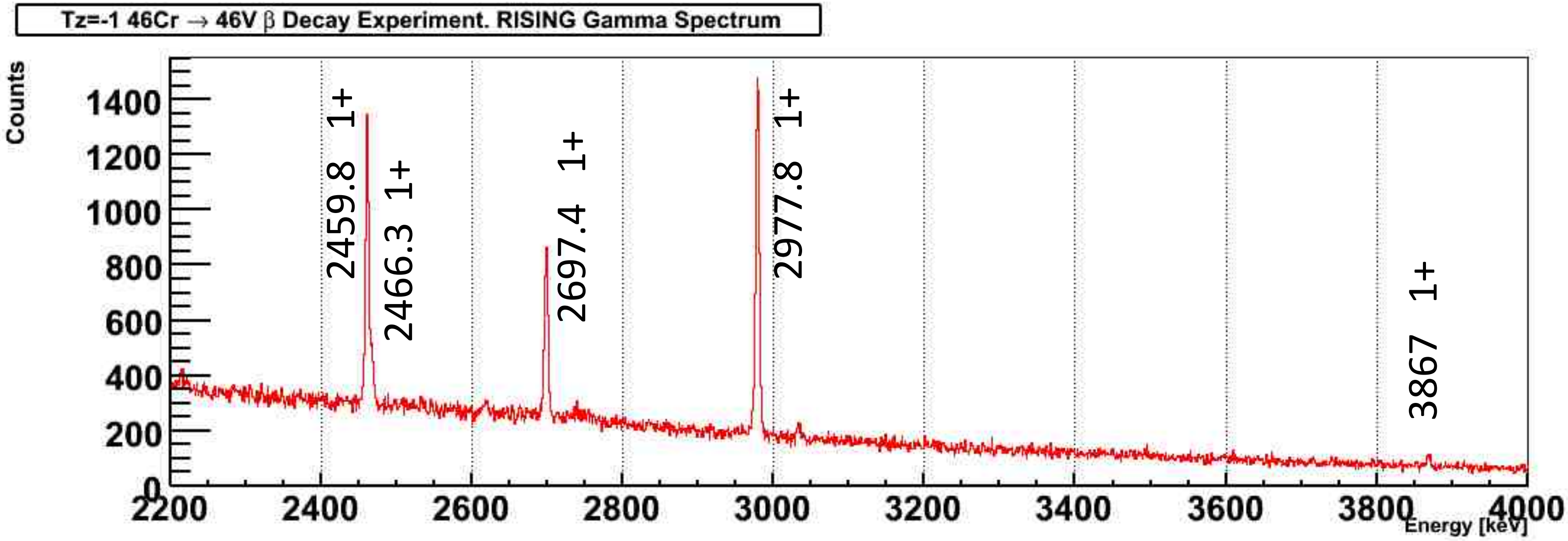
Instituut voor Kern- en Stralingsfysica, University of Leuven, Celestijnenlaan 200 D, B-3001 Leuven, Belgium

(Received 3 December 1998)


Tz=+1 46Ti(3He,t)46V Experiment Results
Zoom in: Next slide
Counts
2500
2000
1500
1000
500
0
994 1+
1433 1+
0
1000
2000
3000
4000
5000
6000
Energy [keV]
Tz=-1 46Cr → 46V β Decay Experiment. RISING Gamma Spectrum
Counts
10^6
10^5
10^4
10^3
10^2
10
993.2 1+
1432.5 1+
1+ → 2+
915.0 2+
46Cr decay
0
1000
2000
3000
4000
5000
6000
Energy [keV]

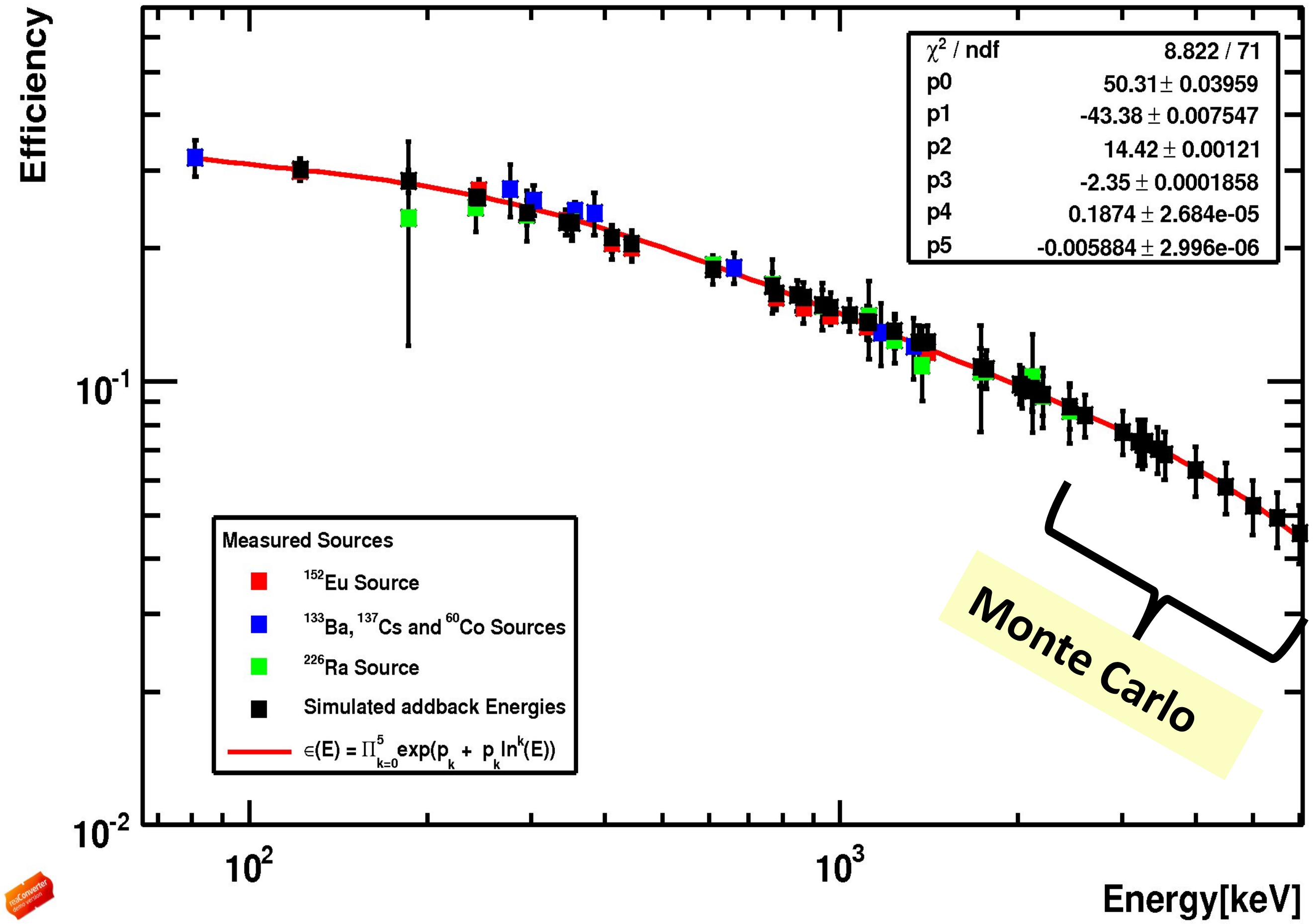


Tz=+1 46Ti(3He,t)46V Experiment Results



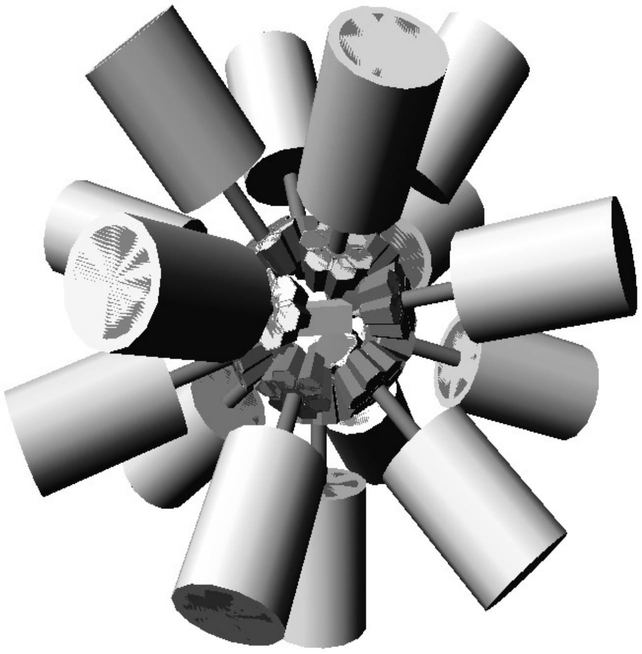
Tz=-1 46Cr → 46V β Decay Experiment. RISING Gamma Spectrum

RISING Gamma Efficiency in Addback mode



Rising Ge simulation

Including + Si + Box



Combined Analysis (CE – β Decay)

Fujita et al PRL 95 (2005) *212501*

$$(1/T_{1/2}) = (1/t_{\mathrm{F}}) + \sum_{j=\mathrm{GT}} (1/t_j).$$

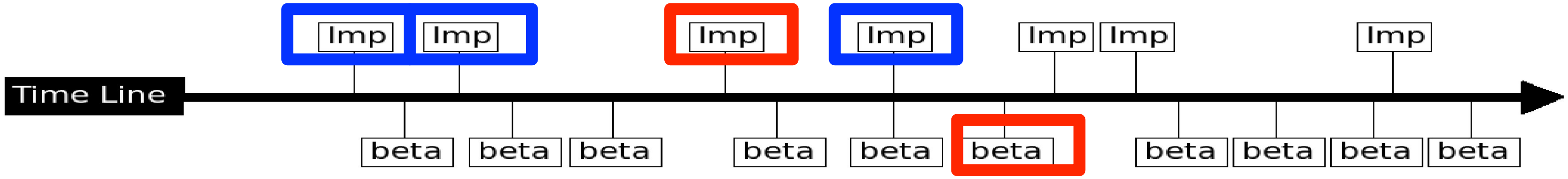
$$\frac{1}{T_{1/2}} = \frac{1}{K}\left[B(\mathrm{F})(1-\delta_c)f_{\mathrm{F}} + \sum_{j=\mathrm{GT}} \lambda^2 \boxed{B_j(\mathrm{GT})} f_j\right]$$

In β decay

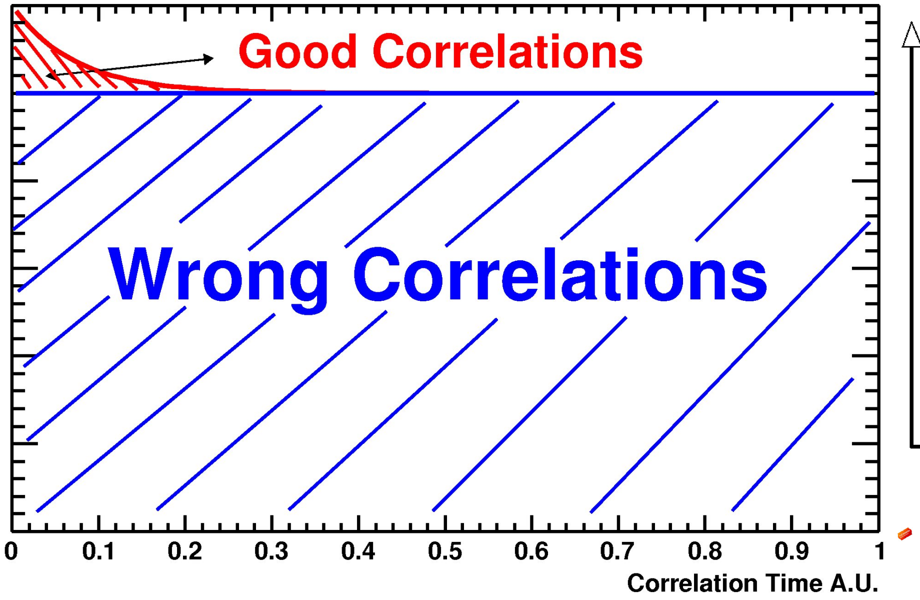
$$\begin{aligned}\frac{d\sigma^{j}_{\mathrm{GT}}}{d\Omega}(q,\omega) &\simeq K(\omega)N_{\sigma\tau}|J_{\sigma\tau}(q)|^2 B_j(\mathrm{GT})\\ &= \hat{\sigma}_{\mathrm{GT}}(q,\omega)\boxed{B_j(\mathrm{GT})},\end{aligned}$$

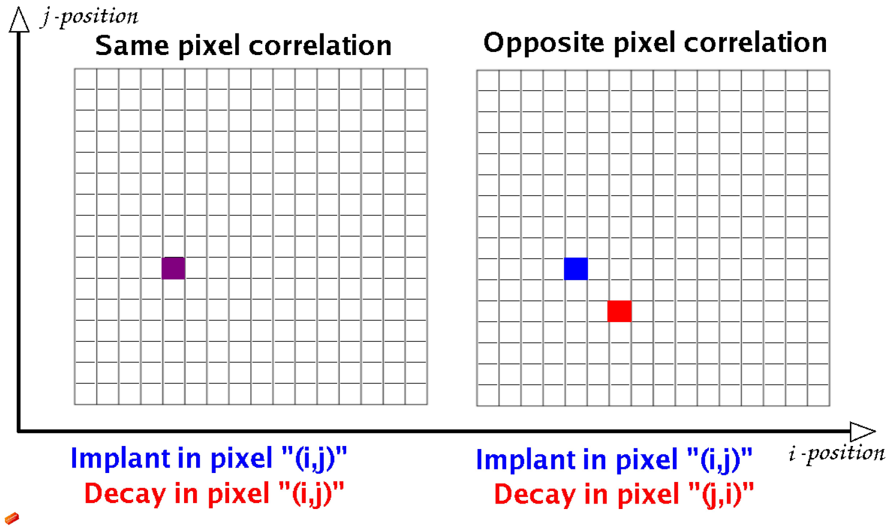
In charge exchange

➔ A precise value of the parent half-life is very important!!!



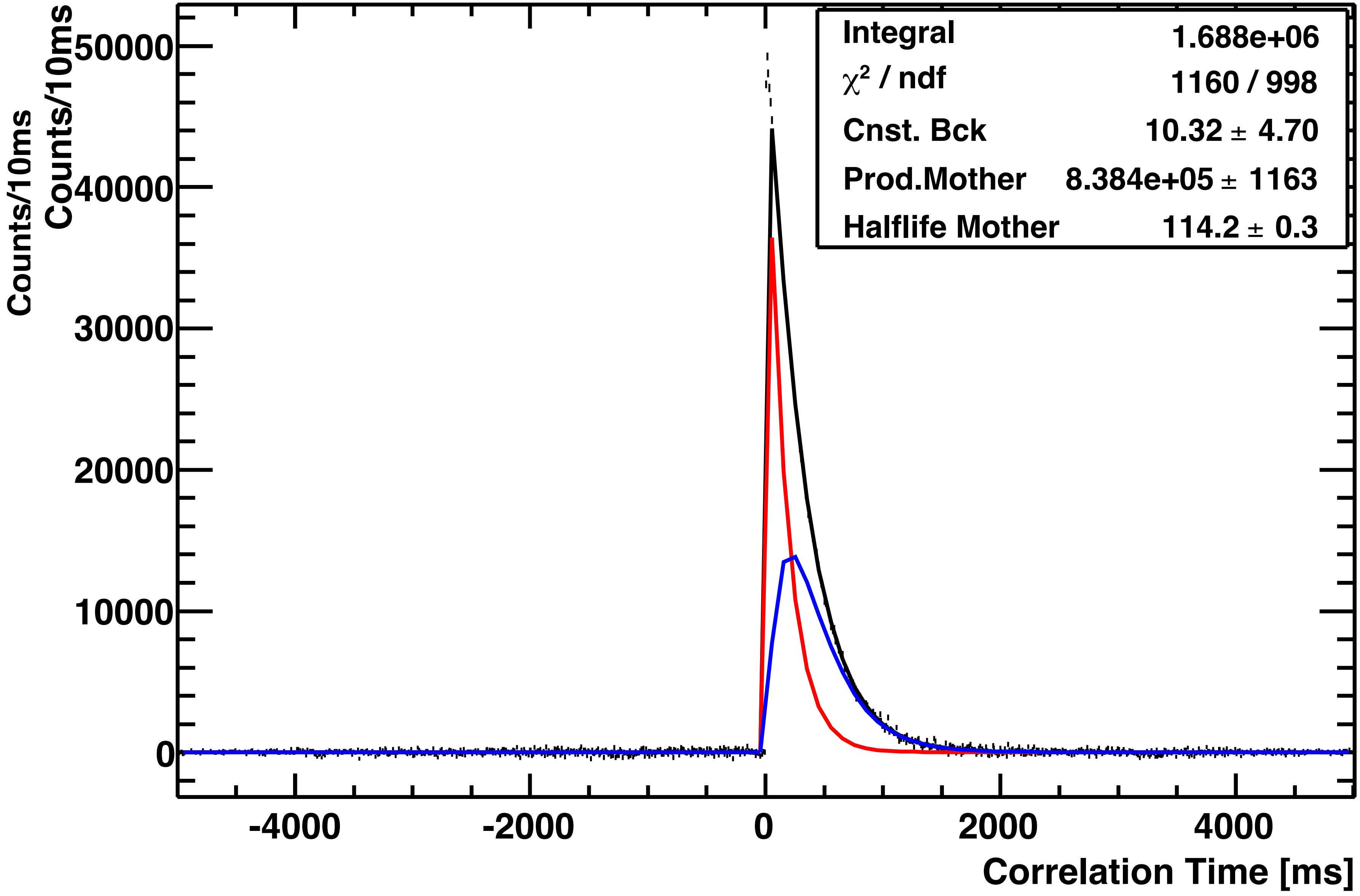
One can correlate each beta decay with all previous implantation





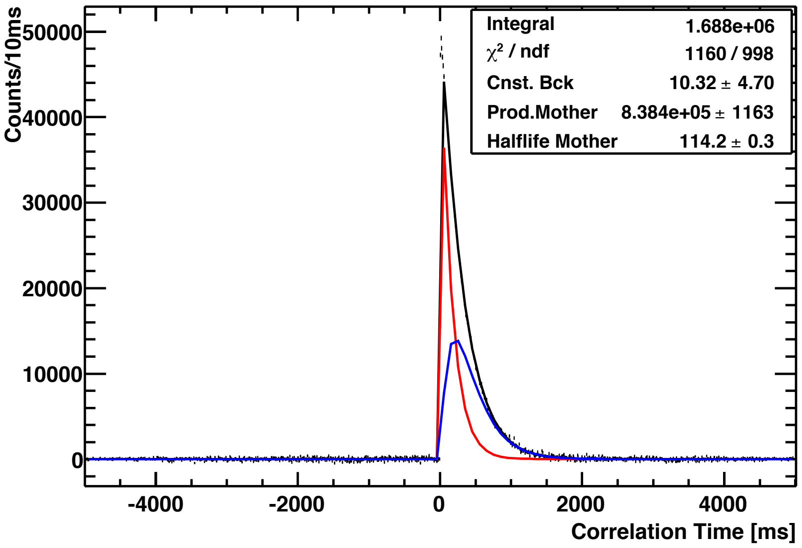
T1

54Ni Half Life. β - All Implants time correlations, random substracted

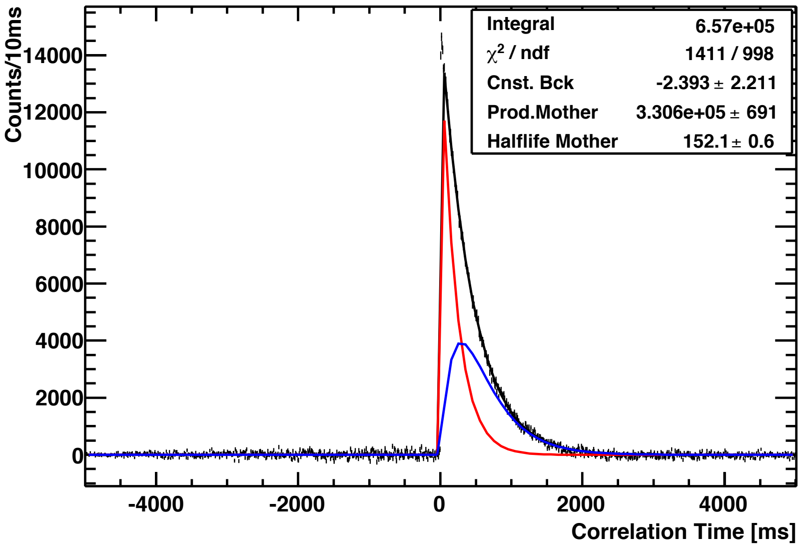


Least square fit

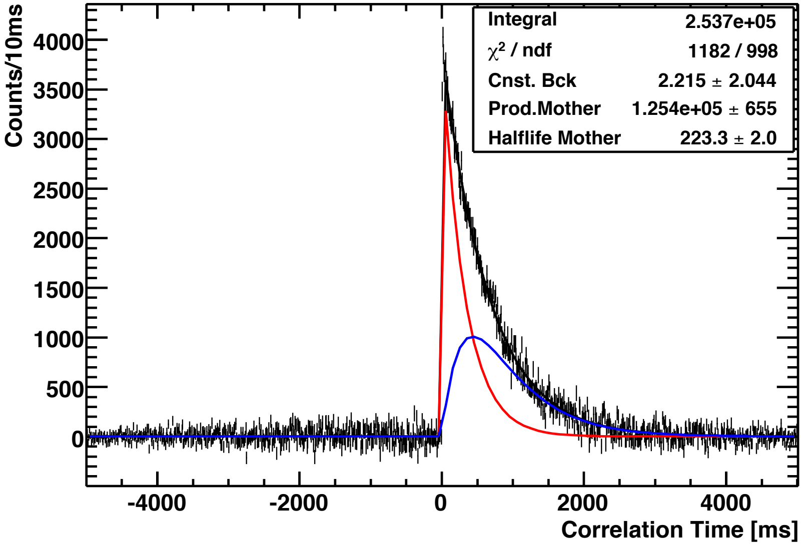
54Ni Half Life. β - All Implants time correlations, random substracted



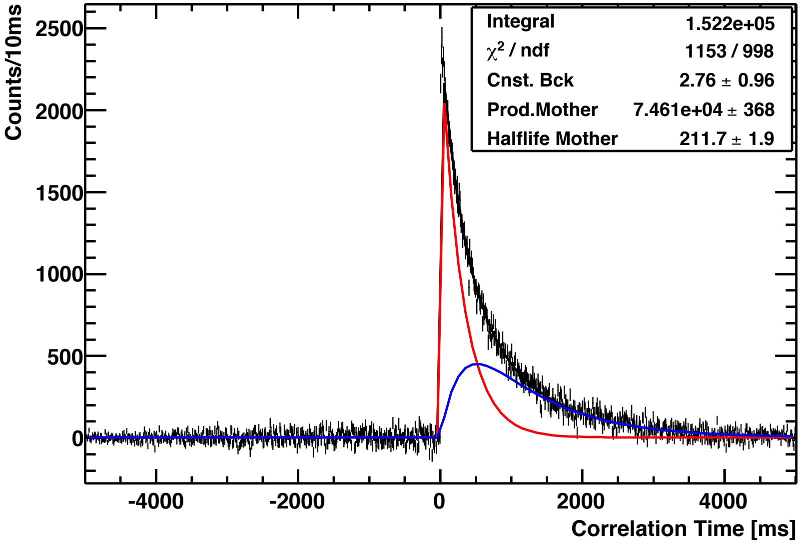
50Fe Half Life. β - All Implants time correlations, random substracted

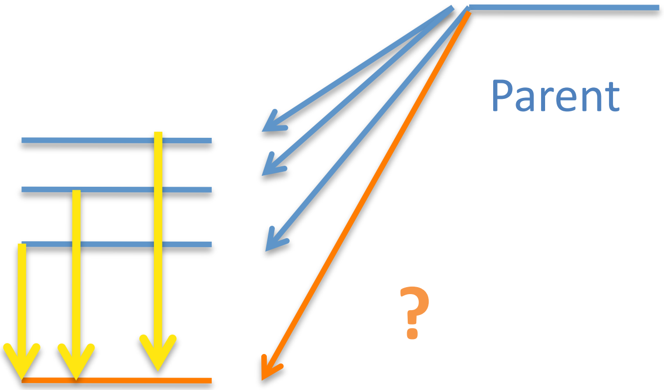


46Cr Half Life. β - All Implants time correlations, random substracted

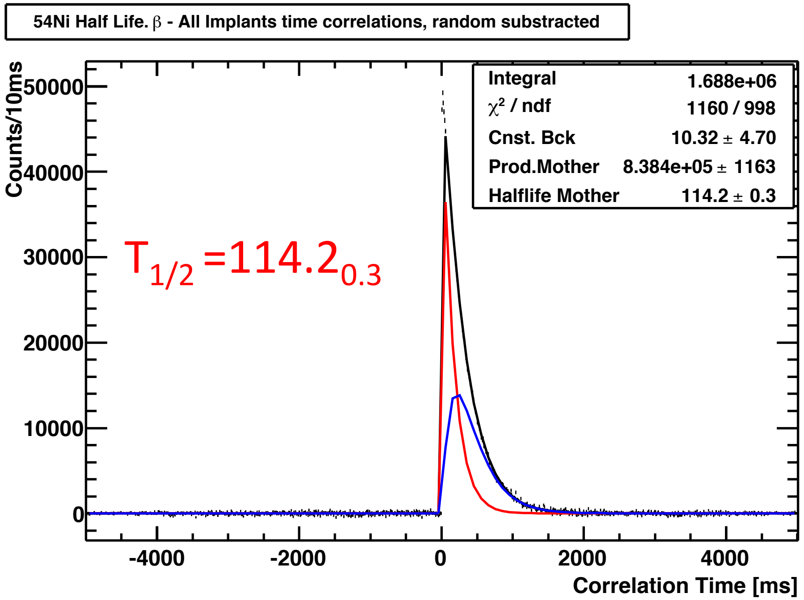


42Ti Half Life. β - All Implants time correlations, random substracted

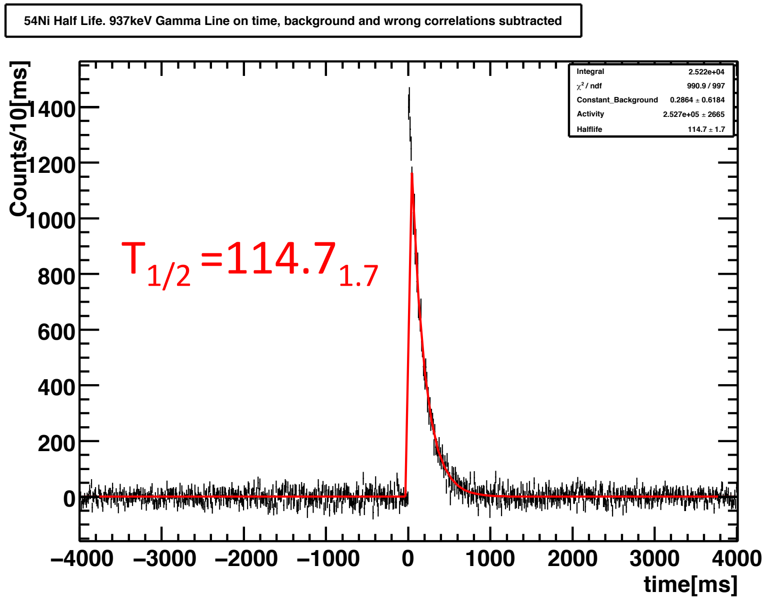




Experimental value of the ground state to ground state feeding estimation



$T_{1/2} = 114.2_{0.3}$

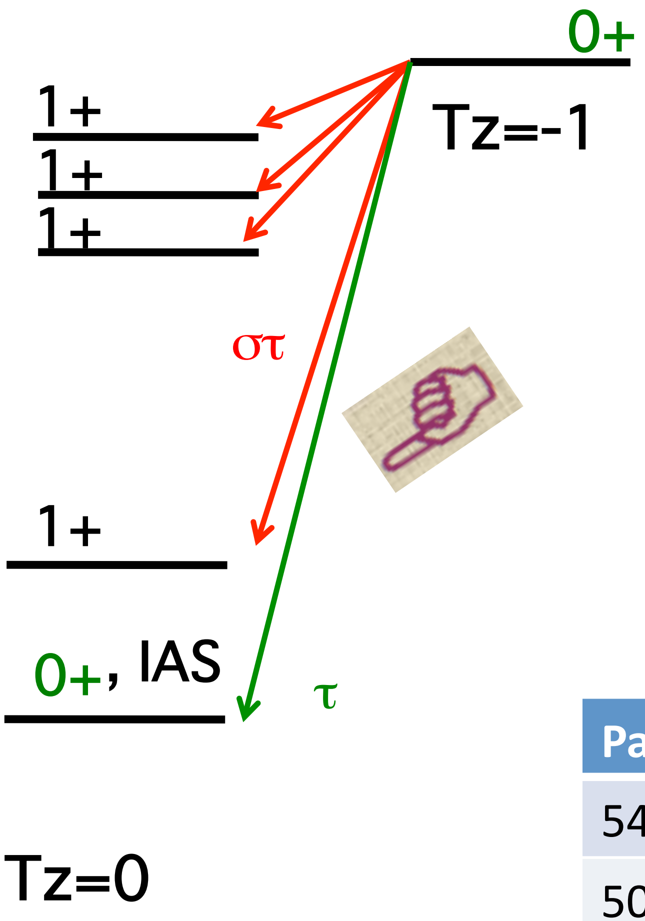


$T_{1/2} = 114.7_{1.7}$

Systematic errors such as beta efficiency error or survival probability errors cancels!, only gamma efficiency counts!!!

Experimental Result g.s. feed ^{54}Ni =0.79_2

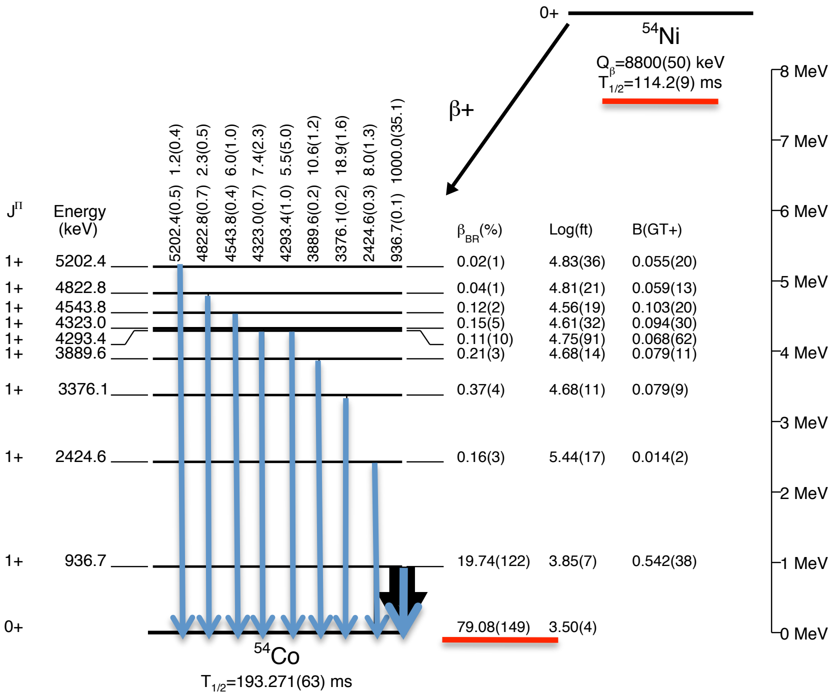
Comparison of “g.s to g.s feeding” estimated from Fermi transition probability and our experimental result

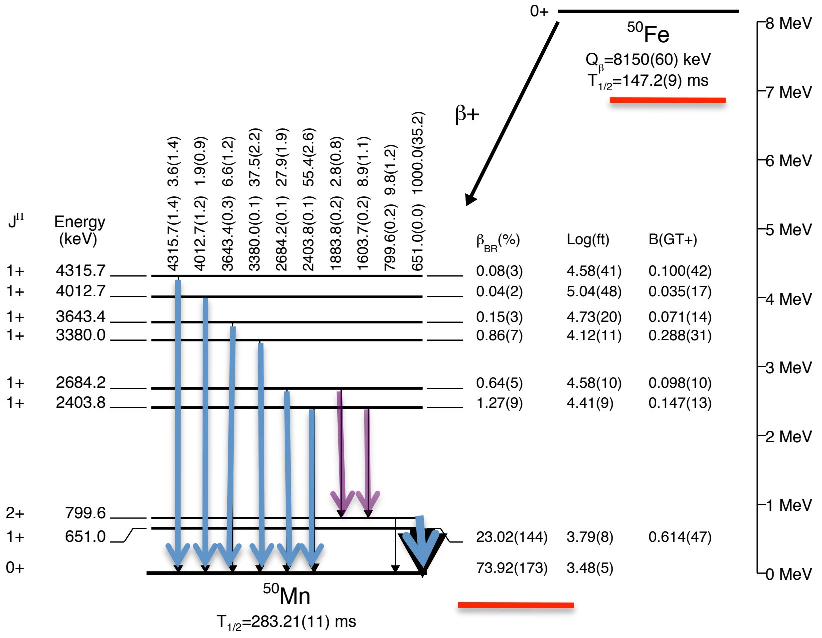


This is a super-allowed 0+➔0+ Fermi transition with B(F)=N-Z
And hence

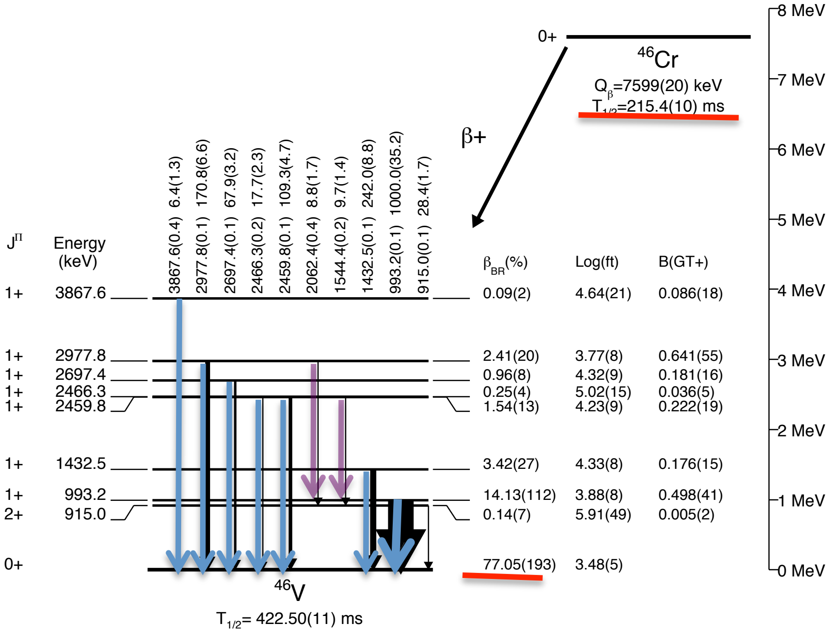
$$T_F = \frac{6144.0(16)}{2(1-\delta c) f}$$

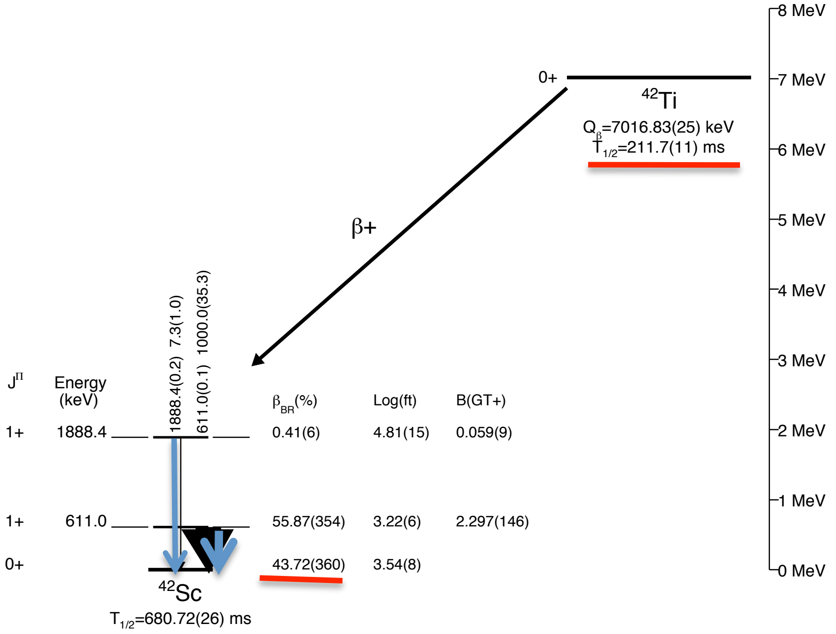
Parent	Fermi estim	Exp. G.s feed
54Ni	0.82(3)	0.79(2)
50Fe	0.74(4)	0.74(2)
50Cr	0.78(1)	0.77(2)
42Ti	0.49(1)	0.44(4)



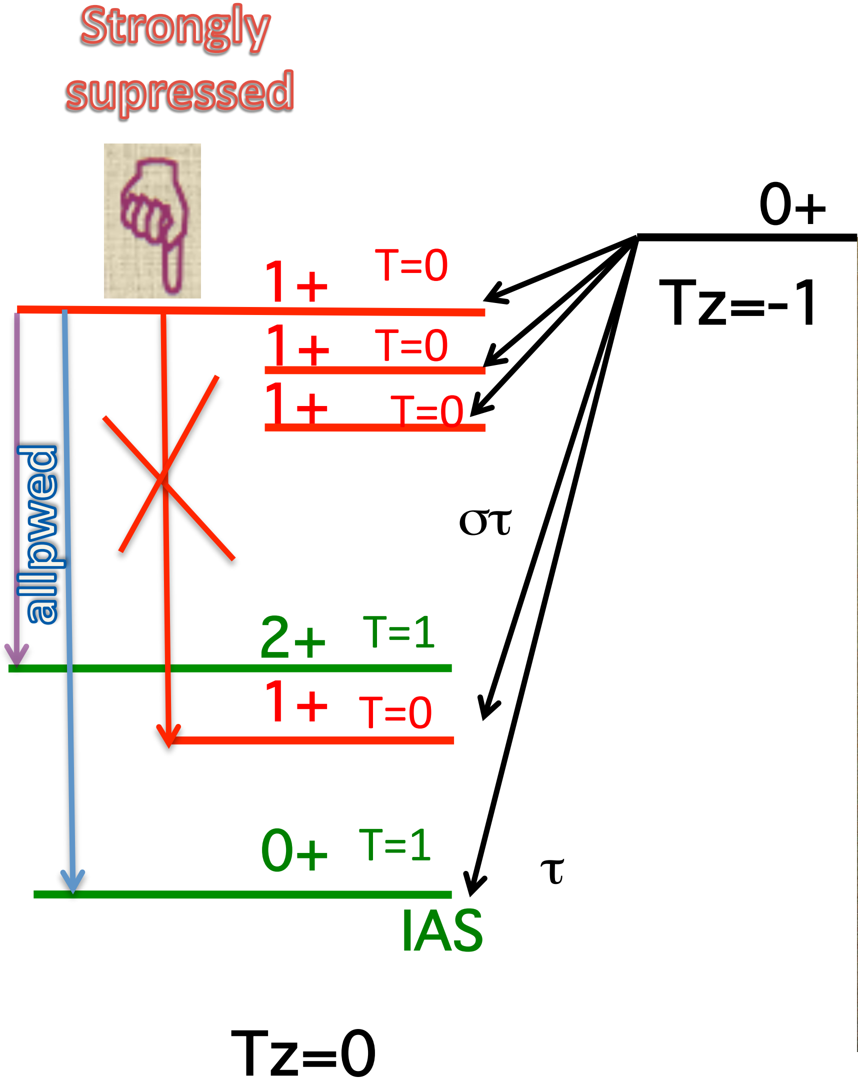


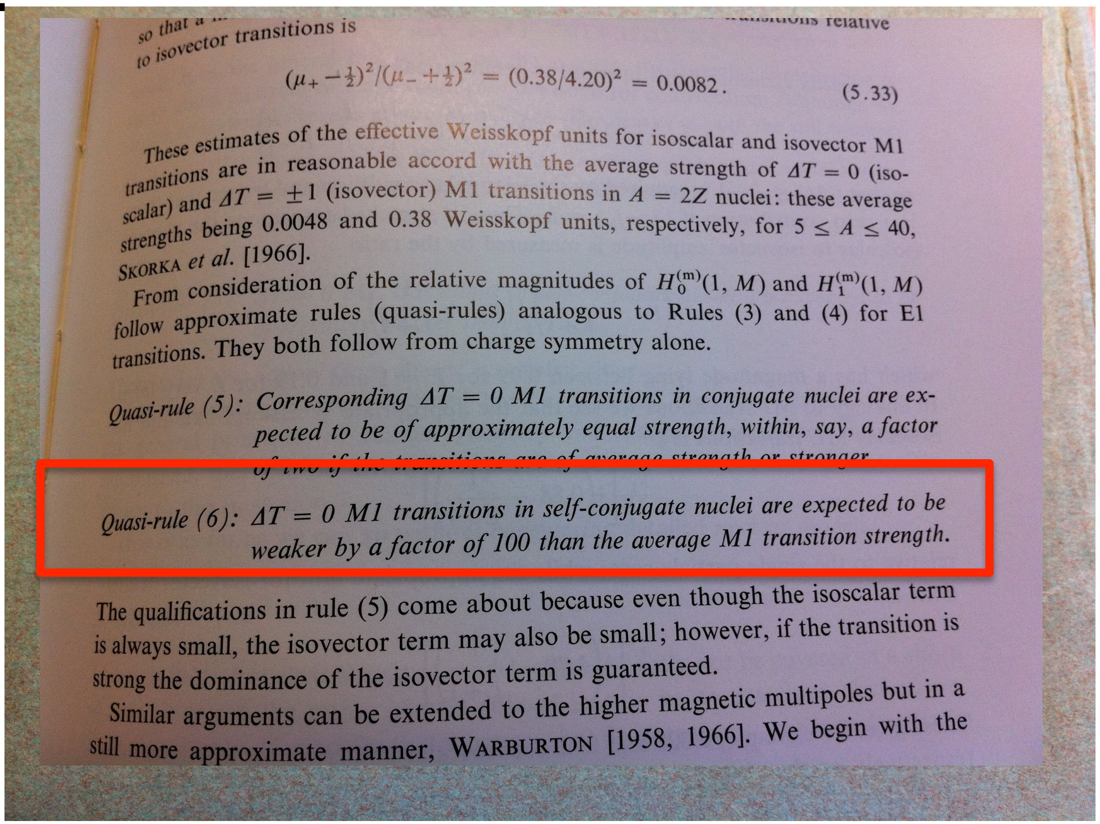
Many 1+➔ 0+ , few 1+ ➔2+, but never 1+➔ 1+ M1 transitions were observed!!!!





M1 transitions from T=0 to T=0 in self-conjugate nuclei are strongly suppressed!!!!




so that a
to isovector transitions is

$$(\mu_+ - \tfrac{1}{2})^2/(\mu_- + \tfrac{1}{2})^2 = (0.38/4.20)^2 = 0.0082\,. \qquad (5.33)$$

These estimates of the effective Weisskopf units for isoscalar and isovector M1 transitions are in reasonable accord with the average strength of $\Delta T = 0$ (isoscalar) and $\Delta T = \pm 1$ (isovector) M1 transitions in $A = 2Z$ nuclei: these average strengths being 0.0048 and 0.38 Weisskopf units, respectively, for $5 \leq A \leq 40$, Skorka *et al.* [1966].

From consideration of the relative magnitudes of $H_0^{(m)}(1, M)$ and $H_1^{(m)}(1, M)$ follow approximate rules (quasi-rules) analogous to Rules (3) and (4) for E1 transitions. They both follow from charge symmetry alone.

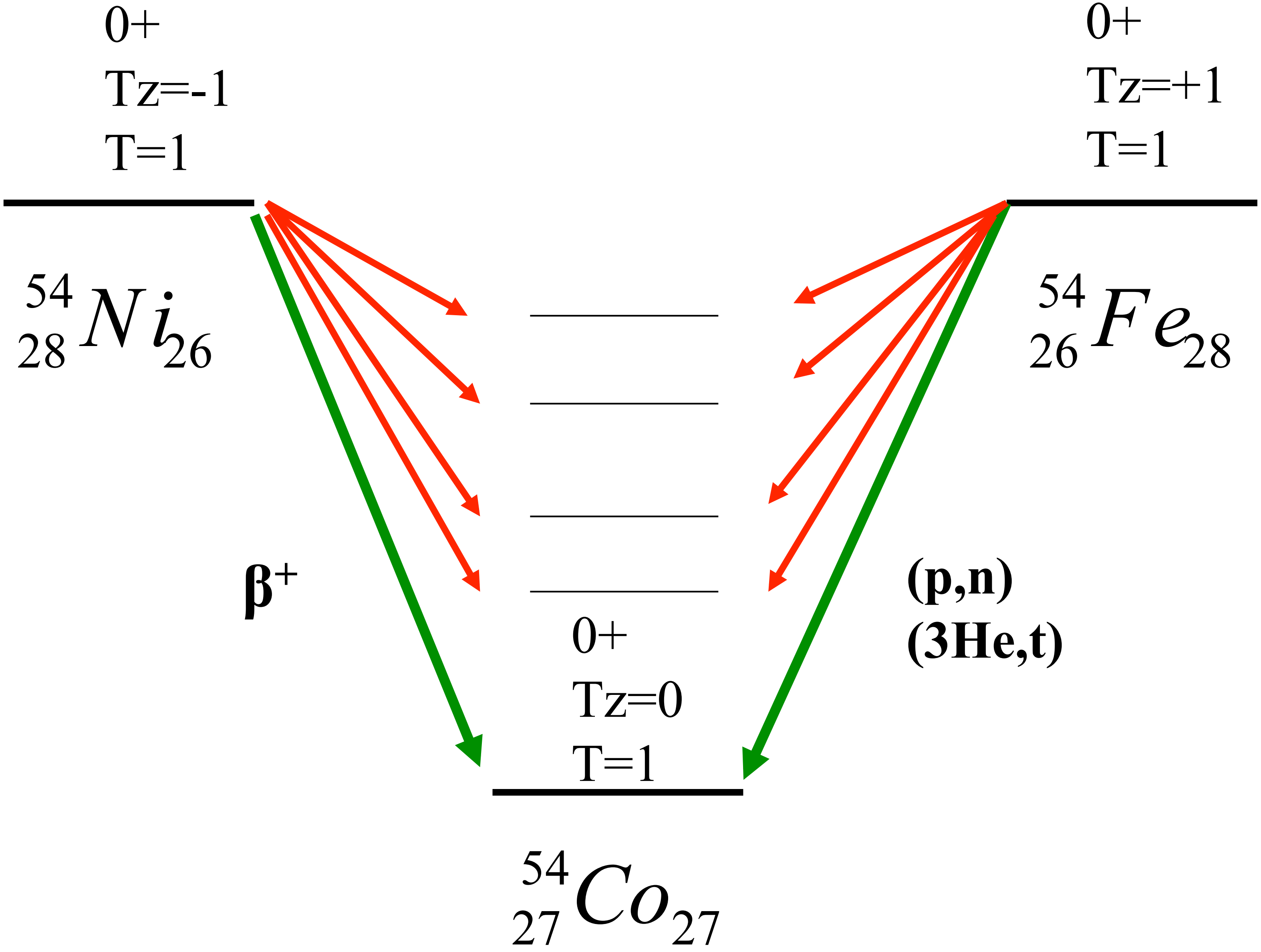
Quasi-rule (5): Corresponding $\Delta T = 0$ M1 transitions in conjugate nuclei are expected to be of approximately equal strength, within, say, a factor of two if the transitions are of average strength or stronger.

Quasi-rule (6): $\Delta T = 0$ M1 transitions in self-conjugate nuclei are expected to be weaker by a factor of 100 than the average M1 transition strength.

The qualifications in rule (5) come about because even though the isoscalar term is always small, the isovector term may also be small; however, if the transition is strong the dominance of the isovector term is guaranteed.

Similar arguments can be extended to the higher magnetic multipoles but in a still more approximate manner, Warburton [1958, 1966]. We begin with the

B(GT) comparison



0+
Tz=-1
T=1

${}^{54}_{28}Ni_{26}$

0+
Tz=+1
T=1

${}^{54}_{26}Fe_{28}$

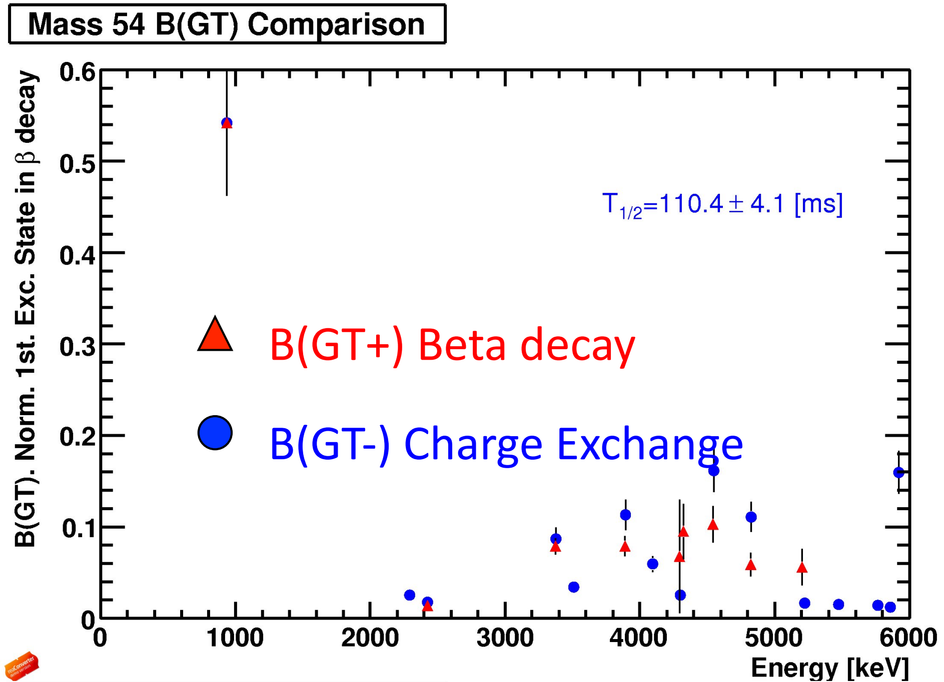
β^+

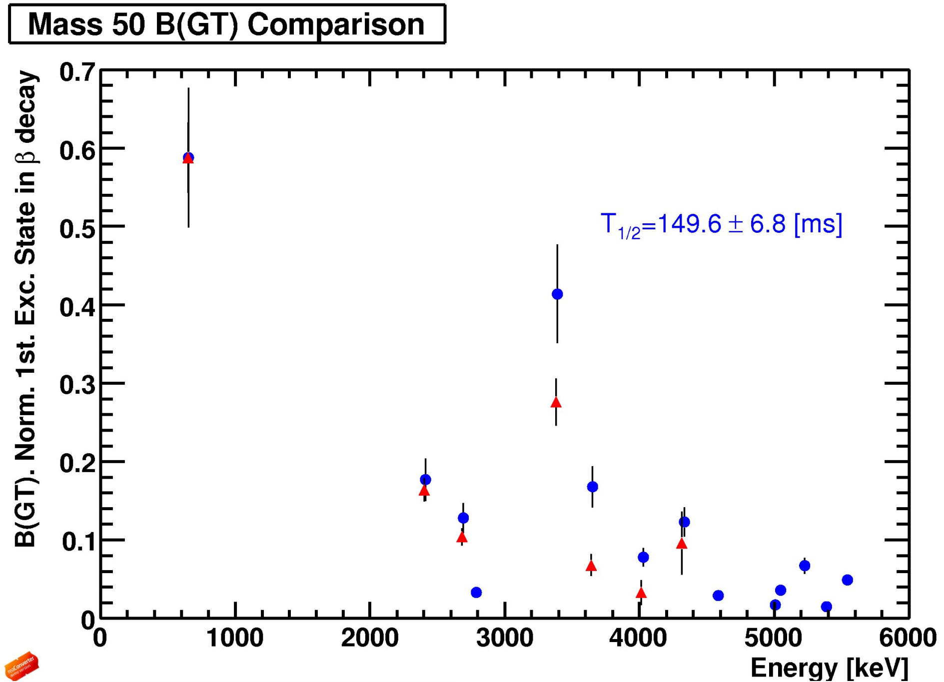
(p,n)
(3He,t)

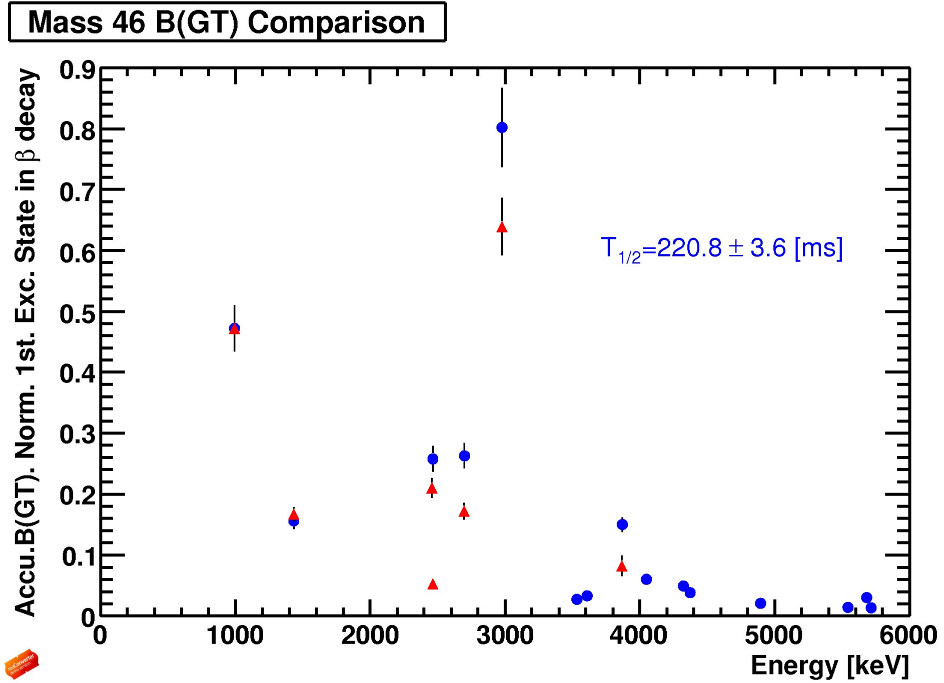
0+
Tz=0
T=1

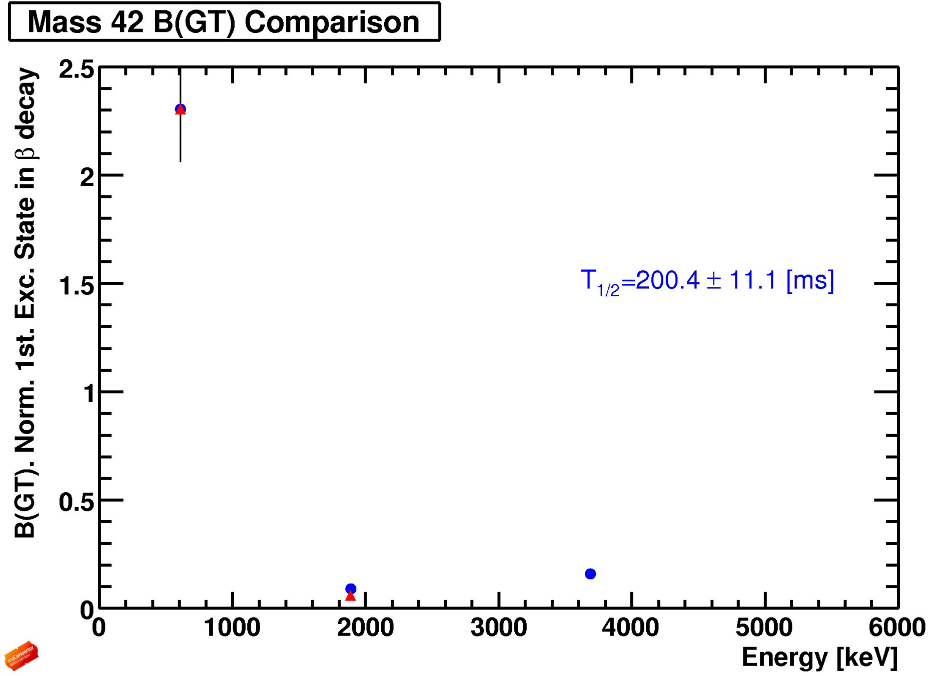
${}^{54}_{27}Co_{27}$

Normalised to the 1^{st} excited state

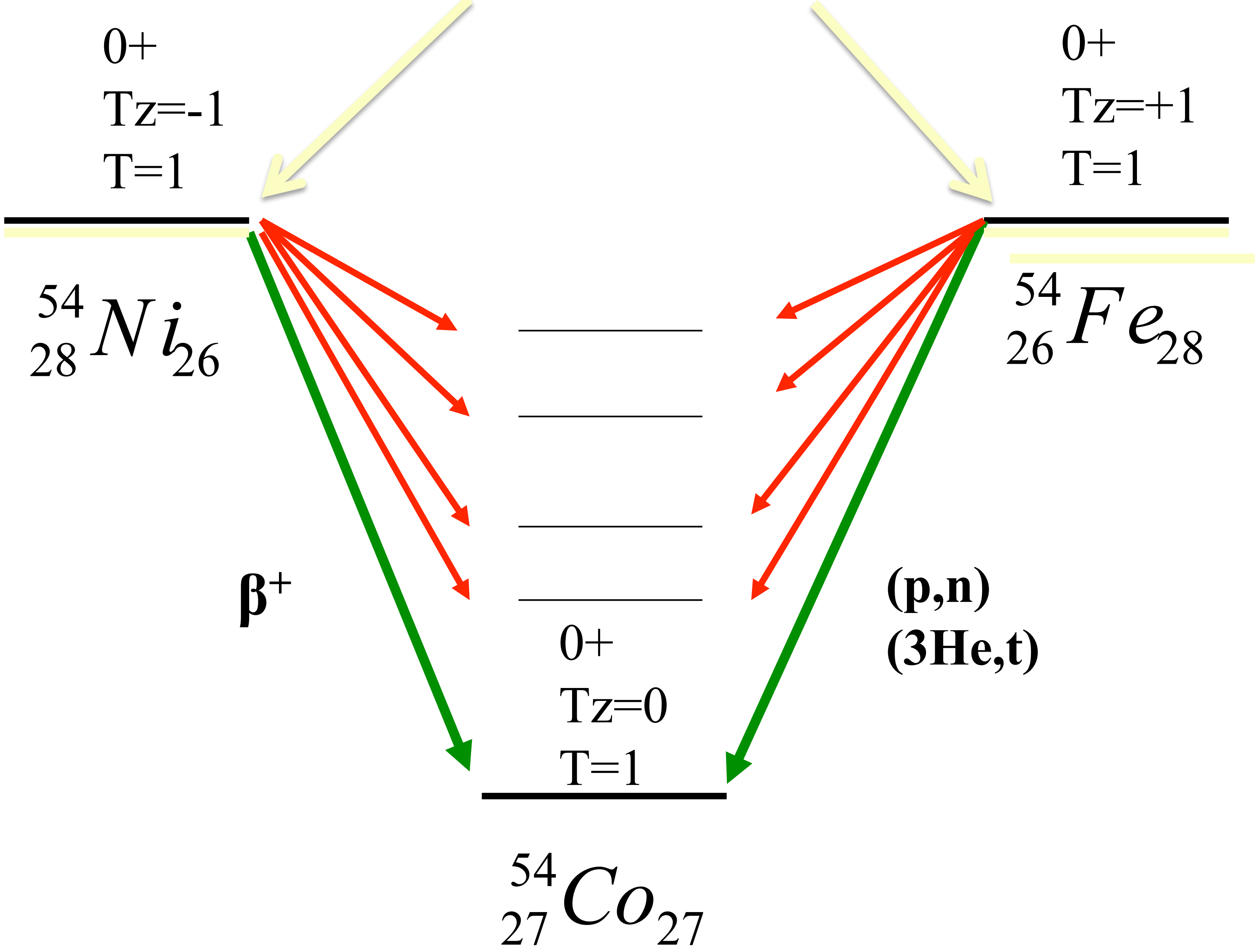








Possible reasons: Maybe the two mirror ground states are not identical



0+
Tz=-1
T=1

$^{54}_{28}Ni_{26}$

0+
Tz=+1
T=1

$^{54}_{26}Fe_{28}$

β^{+}

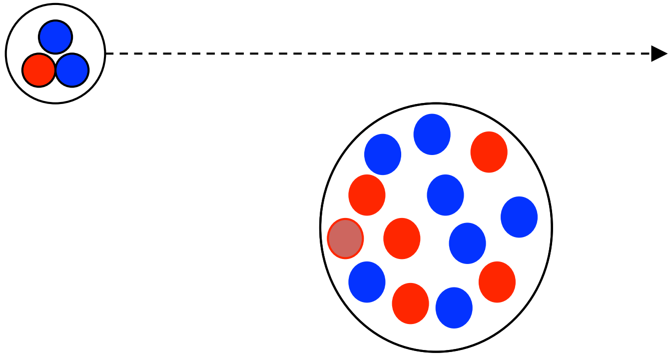
(p,n)
(3He,t)

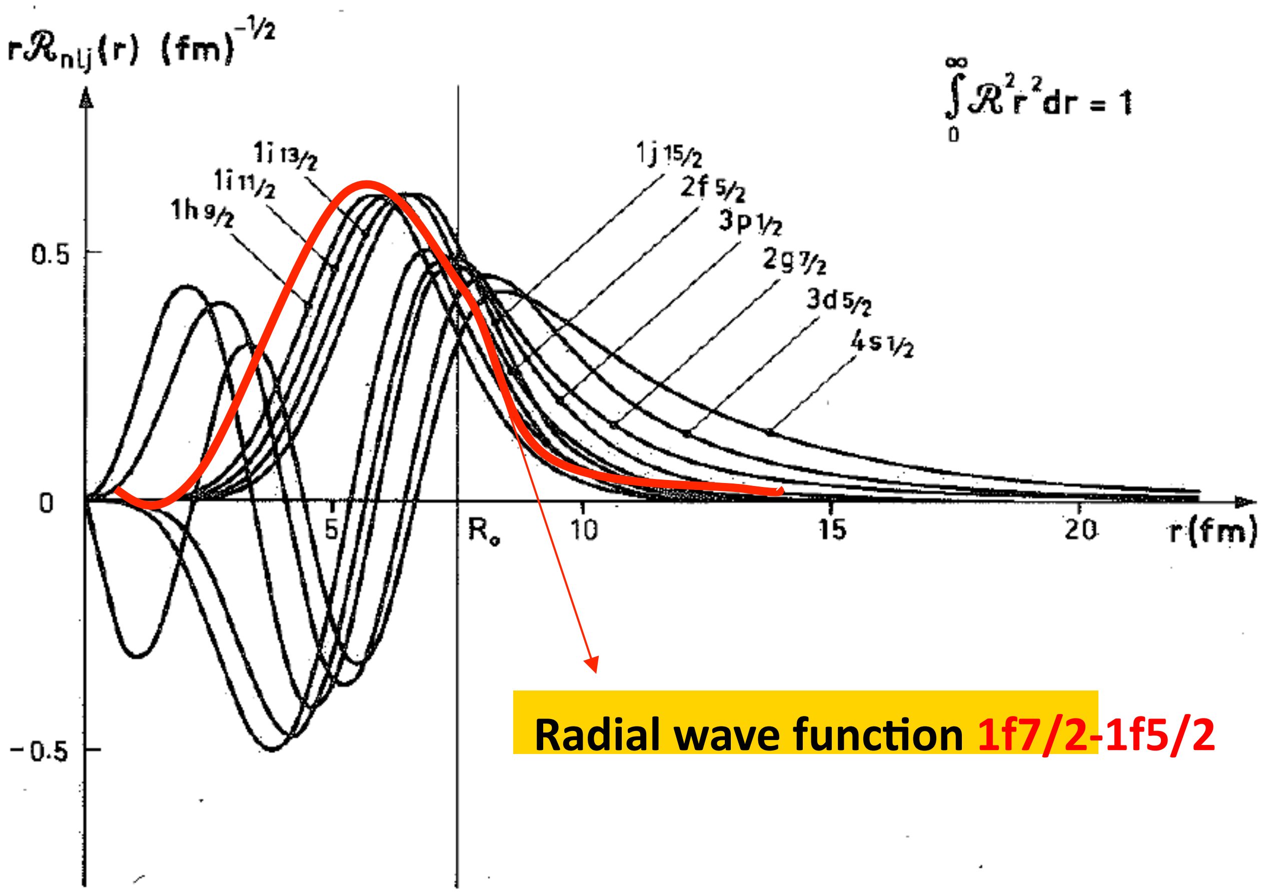
0+
Tz=0
T=1

$^{54}_{27}Co_{27}$

Another possible explanation explanations for these differences

1.- Hadronic probes like (p,n) – (3He,t) are mainly peripherical,





Radial wave function 1f7/2-1f5/2

Beta decay we think it is also peripherical, but it can be not so peripherical.

We need therоretical calculations!

summary

We have studied the beta decay of four Tz=-1 nuclei in the f7/2 shell

They were all “well” produced in fragmentation of 58Ni beams

In spite of the complex set-up we could get extremely clean results

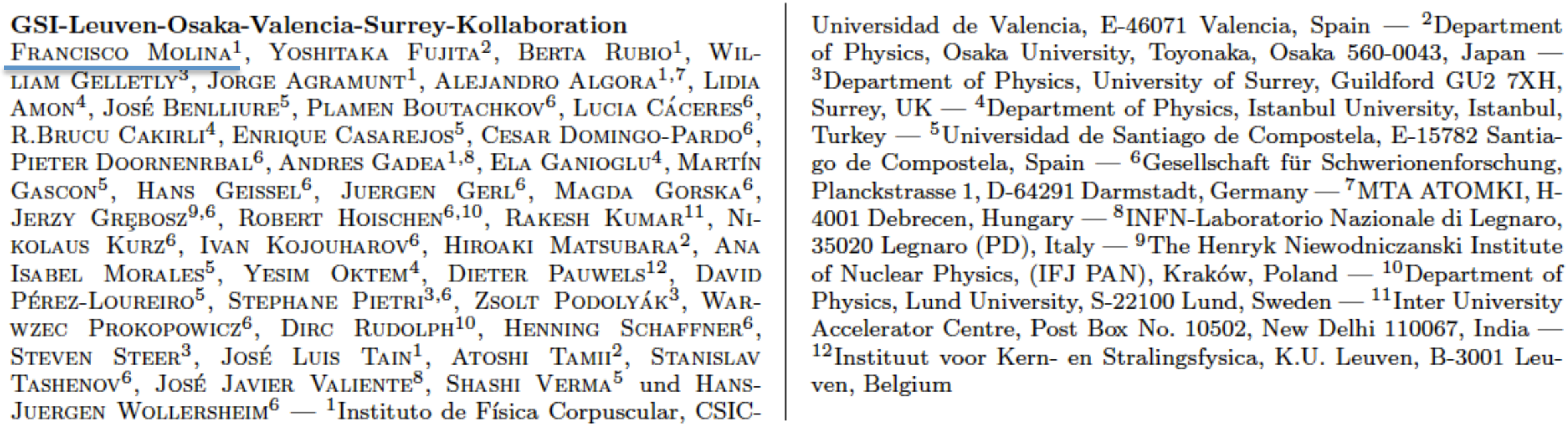
Very precise T1/2, g.s beta feeding and feeding to the excited states were obtained

The four decay schemes and the corresponding B(GT) values for all observed levels could be determined where only Q-beta was taking from the literature.

A very selective isospin Quasi selection rule was observed for the first time in f-shell nuclei

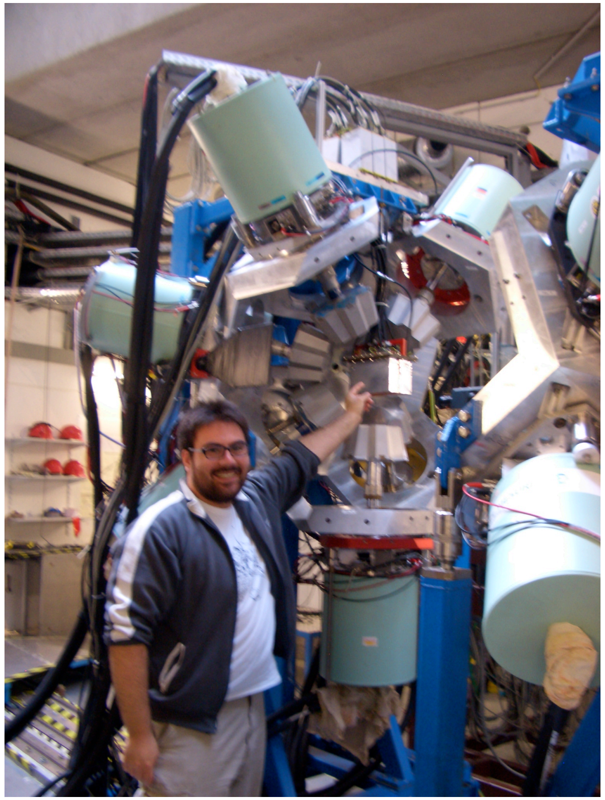
The results were compared with the mirror CE reaction process..
The isospin symmetry works well for the strong transitions but small transitions show differences up to 50% which still have to be understood.

CONCLUSION, ONE CAN PERFORME DELICATE SPECTROSCOPY STUDIES IN FRAGMENTATION REACTIONS IF ONE ACHIEVES CLEAN IMPLANTATION



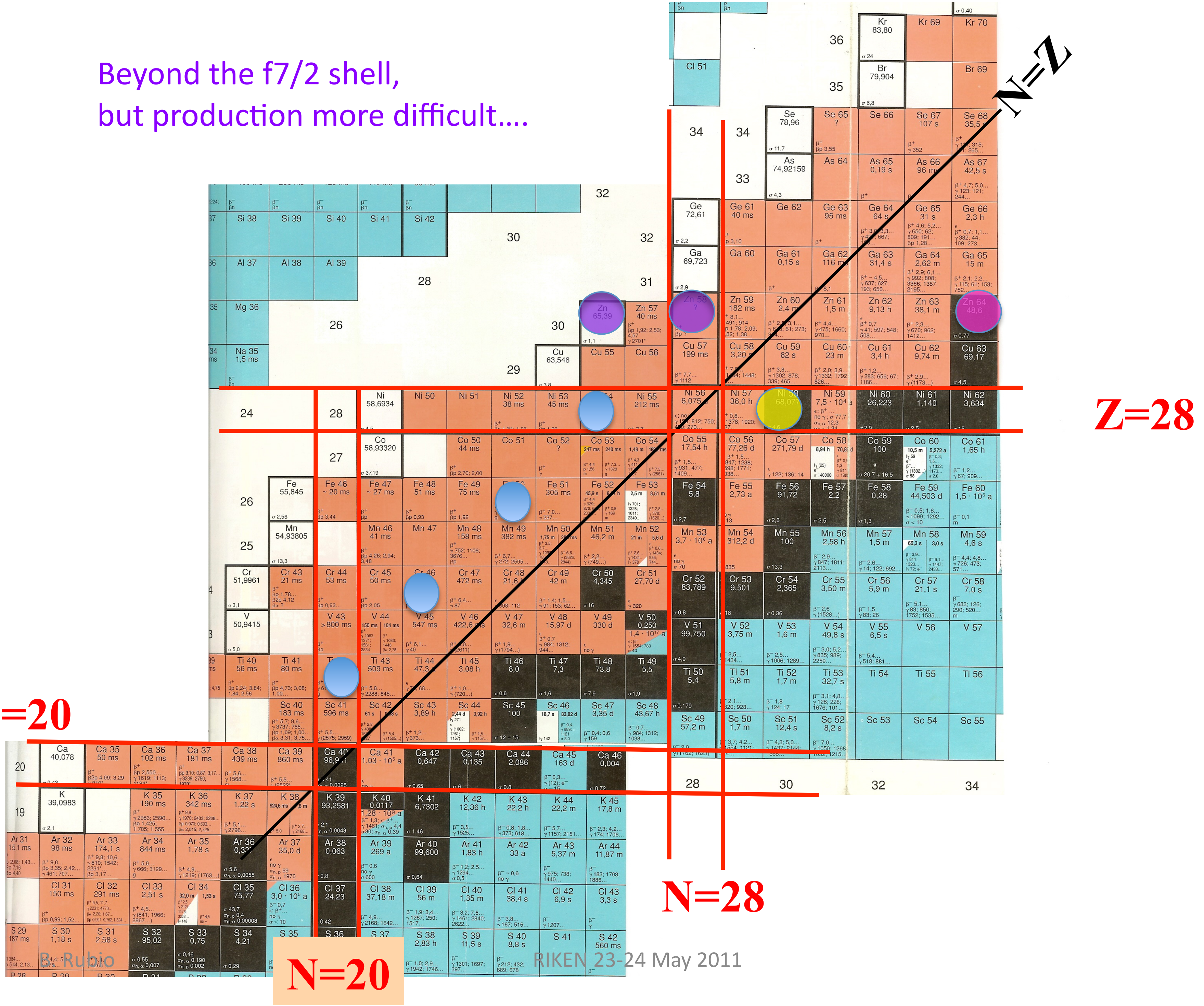
GSI-Leuven-Osaka-Valencia-Surrey-Kollaboration

Francisco Molina[1], Yoshitaka Fujita[2], Berta Rubio[1], William Gelletly[3], Jorge Agramunt[1], Alejandro Algora[1,7], Lidia Amon[4], José Benlliure[5], Plamen Boutachkov[6], Lucia Cáceres[6], R.Brucu Cakirli[4], Enrique Casarejos[5], Cesar Domingo-Pardo[6], Pieter Doornenrbal[6], Andres Gadea[1,8], Ela Ganioglu[4], Martín Gascon[5], Hans Geissel[6], Juergen Gerl[6], Magda Gorska[6], Jerzy Grębosz[9,6], Robert Hoischen[6,10], Rakesh Kumar[11], Nikolaus Kurz[6], Ivan Kojouharov[6], Hiroaki Matsubara[2], Ana Isabel Morales[5], Yesim Oktem[4], Dieter Pauwels[12], David Pérez-Loureiro[5], Stephane Pietri[3,6], Zsolt Podolyák[3], Warwzec Prokopowicz[6], Dirc Rudolph[10], Henning Schaffner[6], Steven Steer[3], José Luis Tain[1], Atoshi Tamii[2], Stanislav Tashenov[6], José Javier Valiente[8], Shashi Verma[5] und Hans-Juergen Wollersheim[6] — [1]Instituto de Física Corpuscular, CSIC-Universidad de Valencia, E-46071 Valencia, Spain — [2]Department of Physics, Osaka University, Toyonaka, Osaka 560-0043, Japan — [3]Department of Physics, University of Surrey, Guildford GU2 7XH, Surrey, UK — [4]Department of Physics, Istanbul University, Istanbul, Turkey — [5]Universidad de Santiago de Compostela, E-15782 Santiago de Compostela, Spain — [6]Gesellschaft für Schwerionenforschung, Planckstrasse 1, D-64291 Darmstadt, Germany — [7]MTA ATOMKI, H-4001 Debrecen, Hungary — [8]INFN-Laboratorio Nazionale di Legnaro, 35020 Legnaro (PD), Italy — [9]The Henryk Niewodniczanski Institute of Nuclear Physics, (IFJ PAN), Kraków, Poland — [10]Department of Physics, Lund University, S-22100 Lund, Sweden — [11]Inter University Accelerator Centre, Post Box No. 10502, New Delhi 110067, India — [12]Instituut voor Kern- en Stralingsfysica, K.U. Leuven, B-3001 Leuven, Belgium

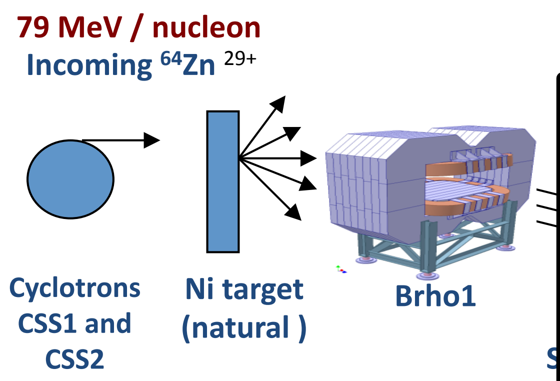


Encouraged by these results………

Beyond the f7/2 shell, but production more difficult....

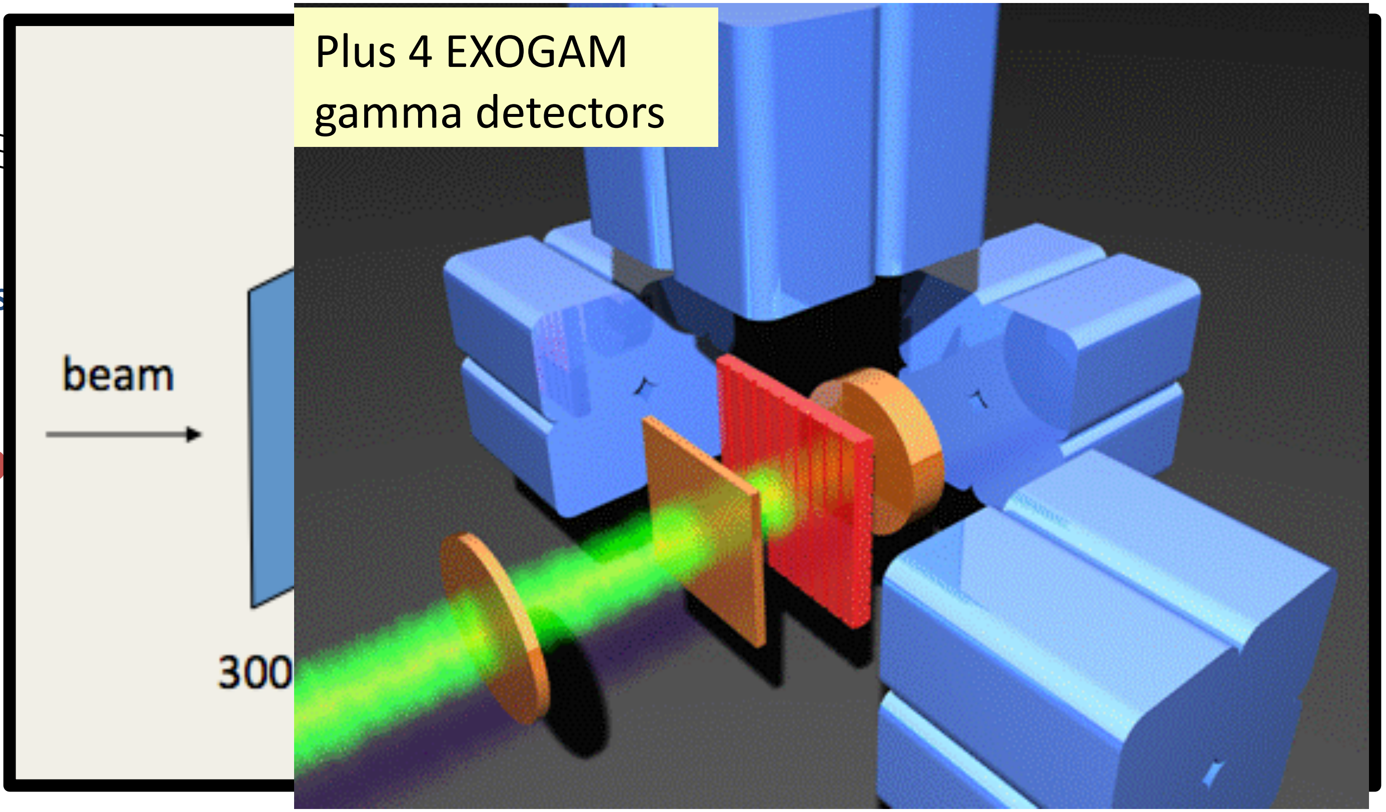


Reaction: ^{64}Zn^{29+} (79 MeV.A) + ^{nat}Ni @ GANIL **2008**



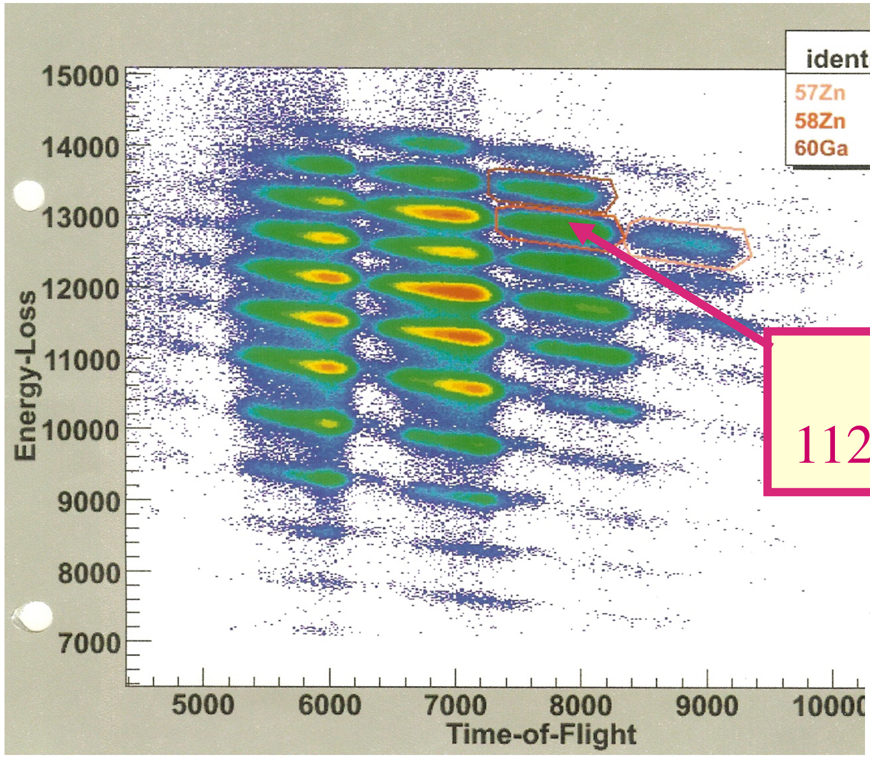
Incoming beam intensity : 500

Target Thickness:1.8 mgr/cm2



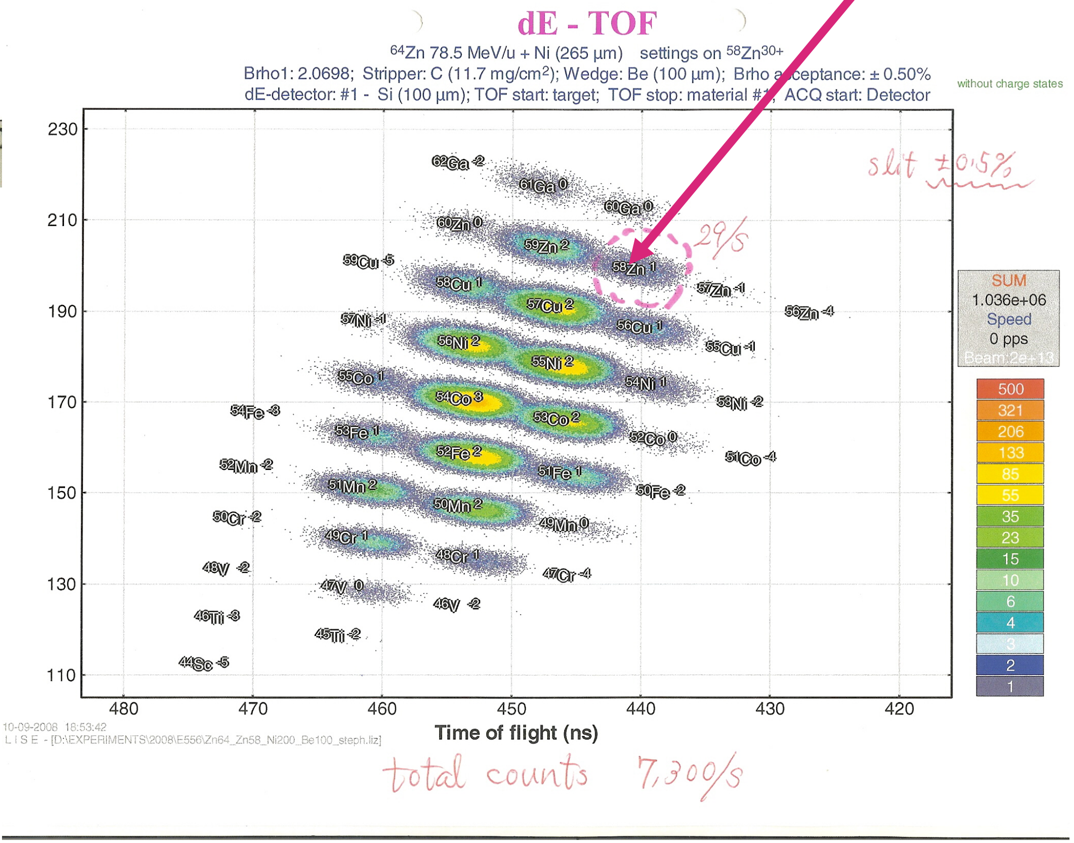
Plus 4 EXOGAM gamma detectors

The experiment worked well,
Unfortunately the 6n and 8n removal cross sections were 30 times lower than estimates from advanced codes



On line analysis
112366/37*3600=0.84 part/sec

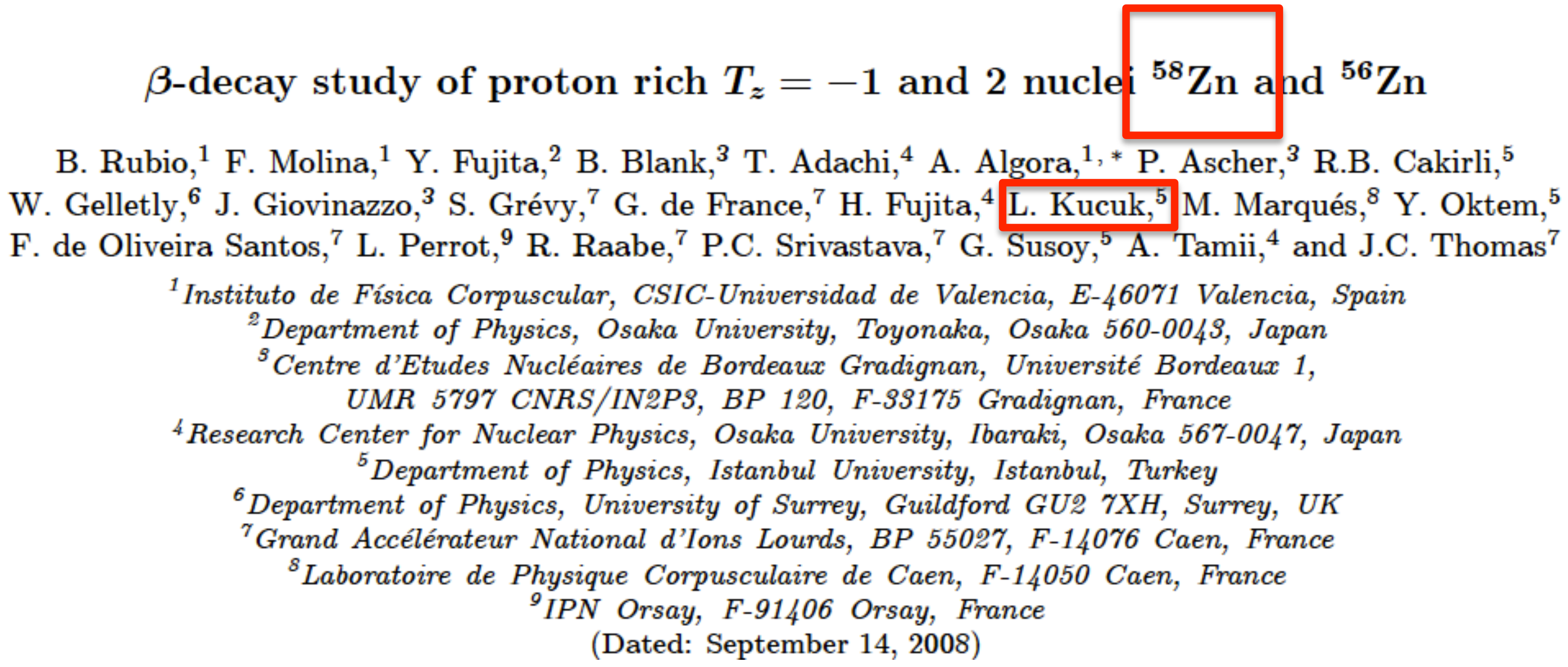
Lise estimation
29 part/sec



slit ±0.5%

29/s

total counts 7,300/s

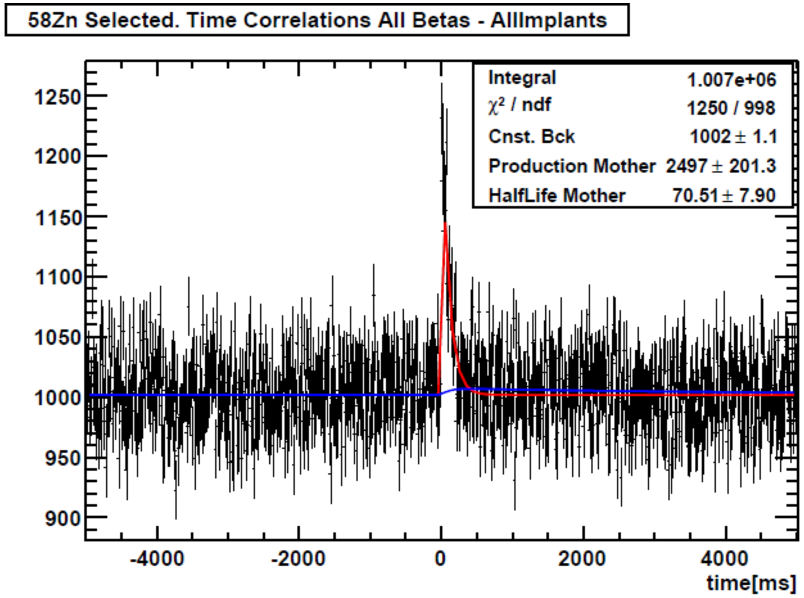


β-decay study of proton rich $T_z = -1$ and 2 nuclei ^{58}Zn and ^{56}Zn

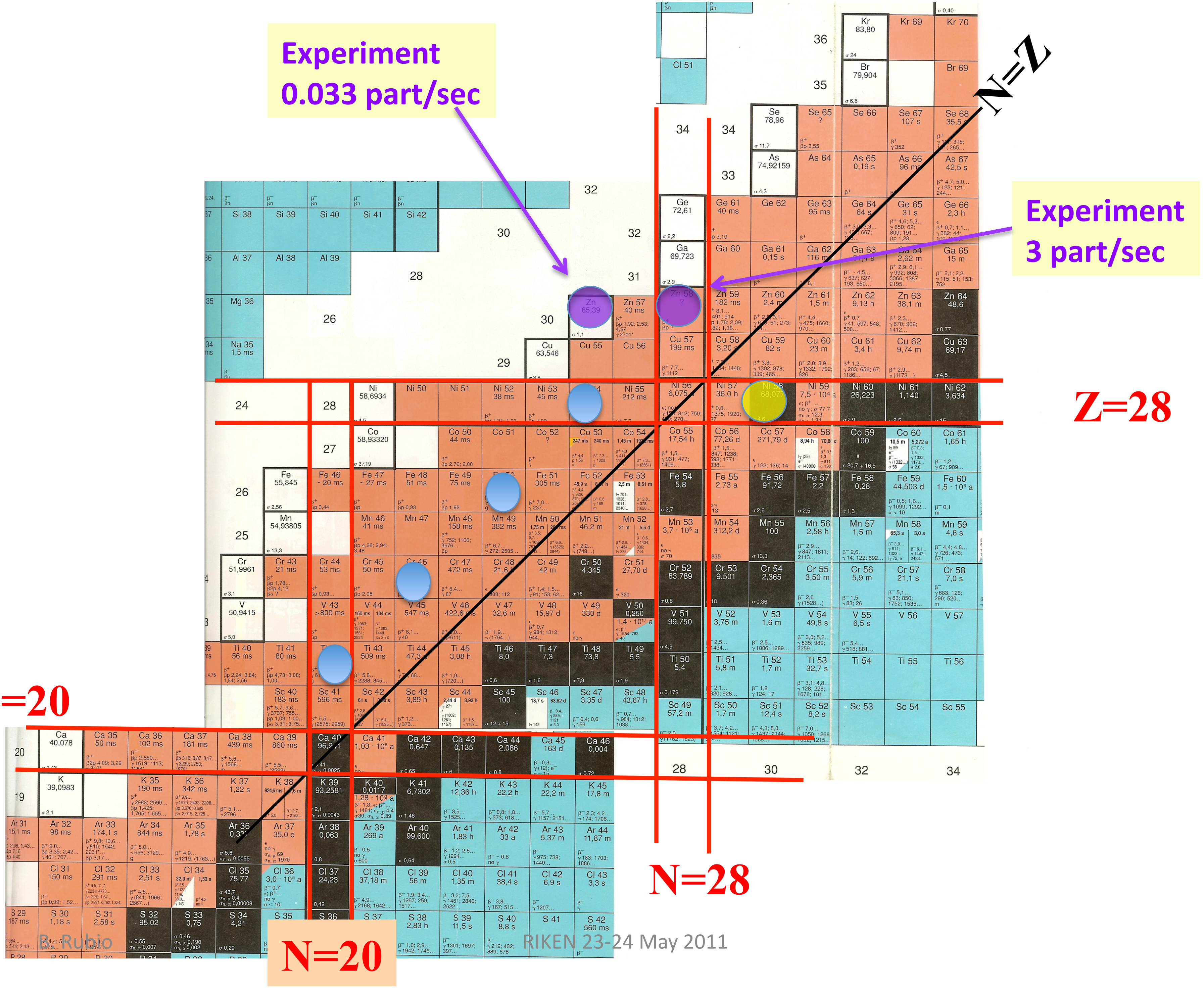
B. Rubio,[1] F. Molina,[1] Y. Fujita,[2] B. Blank,[3] T. Adachi,[4] A. Algora,[1,*] P. Ascher,[3] R.B. Cakirli,[5]
W. Gelletly,[6] J. Giovinazzo,[3] S. Grévy,[7] G. de France,[7] H. Fujita,[4] L. Kucuk,[5] M. Marqués,[8] Y. Oktem,[5]
F. de Oliveira Santos,[7] L. Perrot,[9] R. Raabe,[7] P.C. Srivastava,[7] G. Susoy,[5] A. Tamii,[4] and J.C. Thomas[7]

[1] Instituto de Física Corpuscular, CSIC-Universidad de Valencia, E-46071 Valencia, Spain
[2] Department of Physics, Osaka University, Toyonaka, Osaka 560-0043, Japan
[3] Centre d'Etudes Nucléaires de Bordeaux Gradignan, Université Bordeaux 1,
UMR 5797 CNRS/IN2P3, BP 120, F-33175 Gradignan, France
[4] Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567-0047, Japan
[5] Department of Physics, Istanbul University, Istanbul, Turkey
[6] Department of Physics, University of Surrey, Guildford GU2 7XH, Surrey, UK
[7] Grand Accélérateur National d'Ions Lourds, BP 55027, F-14076 Caen, France
[8] Laboratoire de Physique Corpusculaire de Caen, F-14050 Caen, France
[9] IPN Orsay, F-91406 Orsay, France

(Dated: September 14, 2008)



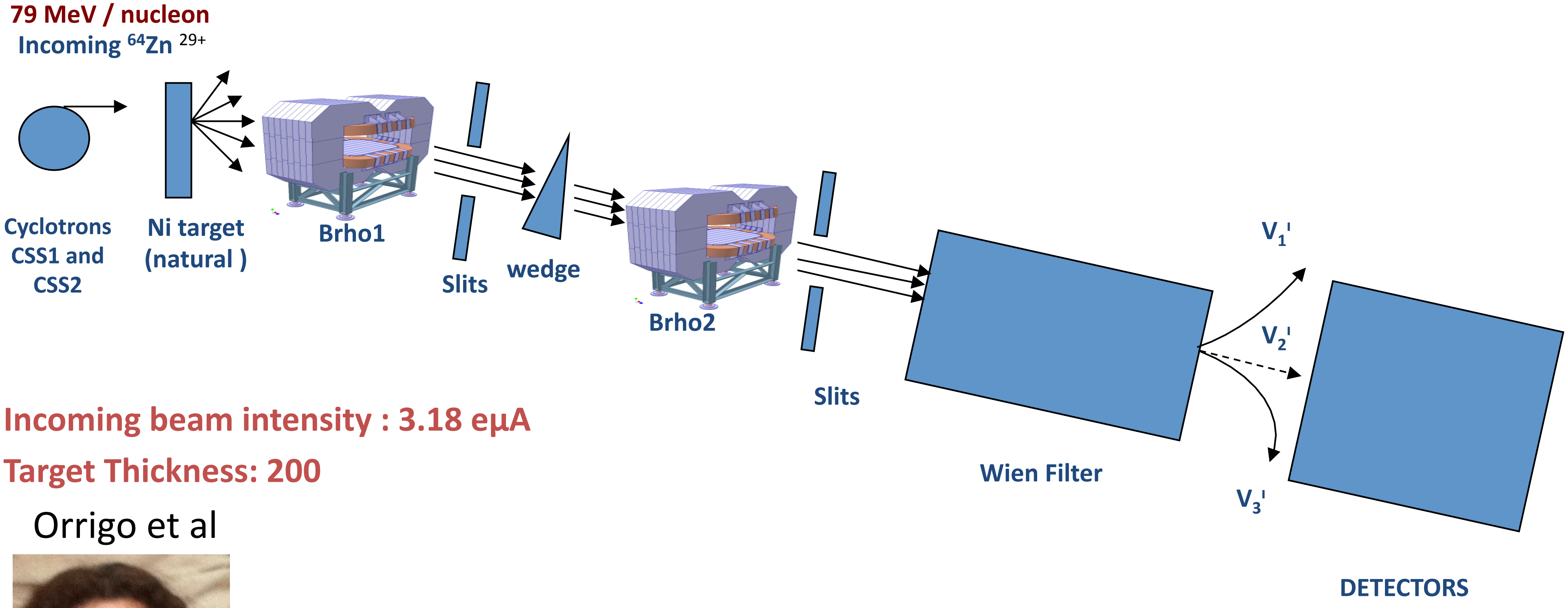
Kucuk et al, preliminary analysis



Experiment
0.033 part/sec

Experiment
3 part/sec

Reaction: $^{58}\mathrm{Ni}^{26+}$ (79 MeV.A) + $^{nat}\mathrm{Ni}$ @ GANIL **2010**

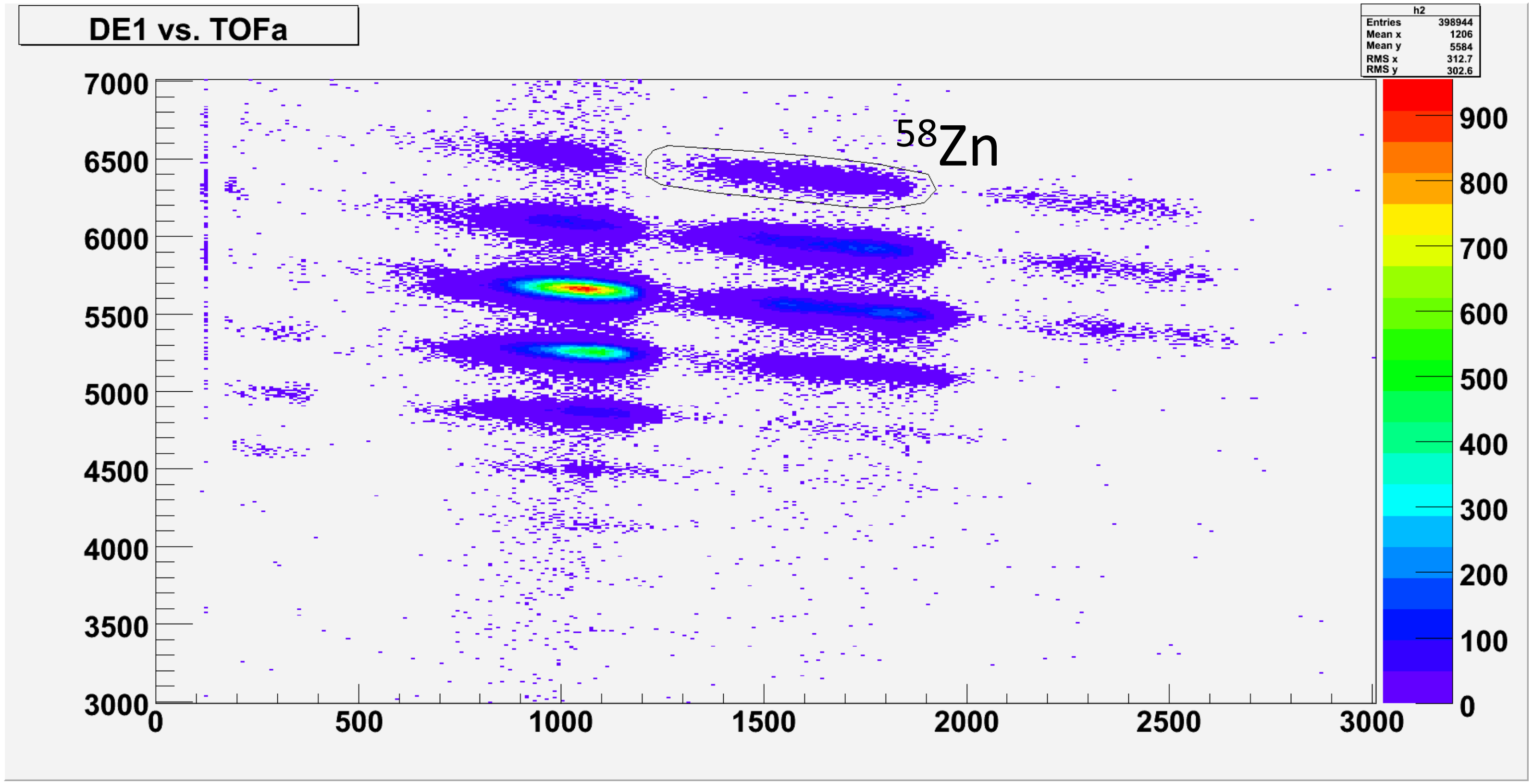


Incoming beam intensity : 3.18 eµA

Target Thickness: 200

Orrigo et al

Y. Fujita[a], B. Rubio[b], B. Blank[c], W. Gelletly[d] J. Agramunt[b], A. Algora[b], P. Ascher[c], B. Bilgier[e], L. Cáceres[f], R.B. Cakirli[e], E. Ganioğlu[e], M. Gerbaux[c], J. Giovinazzo[c], S. Grévy[c], O. Kamalou[f], H.C. Kozer[e], L. Kucuk[e], T. Kurtukian-Nieto[c], F. Molina[b], L. Popescu[9], A.M. Rogers[h], G. Susoy[e], C. Stodel[f], T. Suzuki[i], A. Tamii[i] J.-C. Thomas[f],



In 7 runs (8 hours):

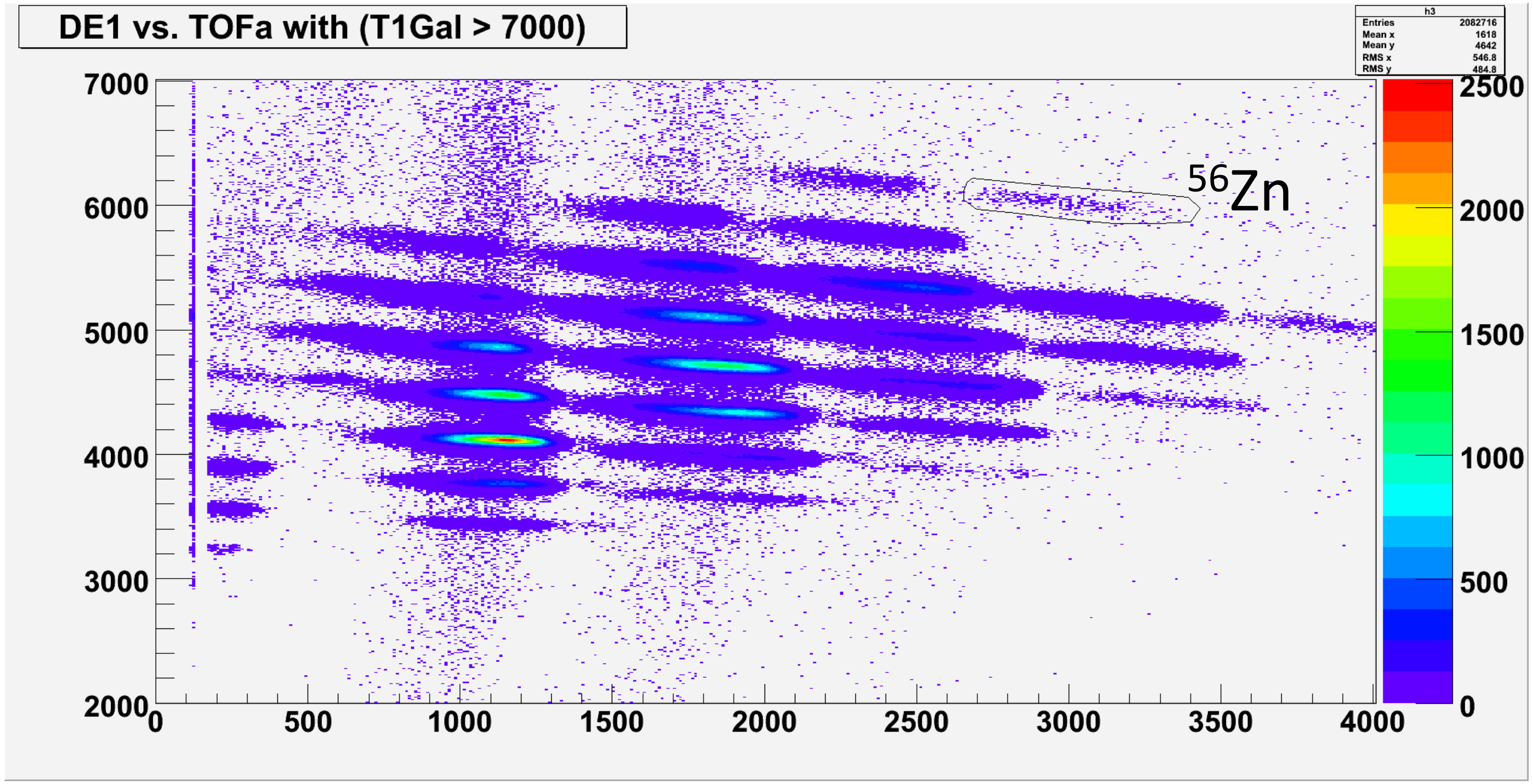
Total ^{58}Zn implantations = 85119

2.9 imp/s

In 128 runs (3 days):

Total ^{56}Zn implantations = 8837

0.033 imp/s

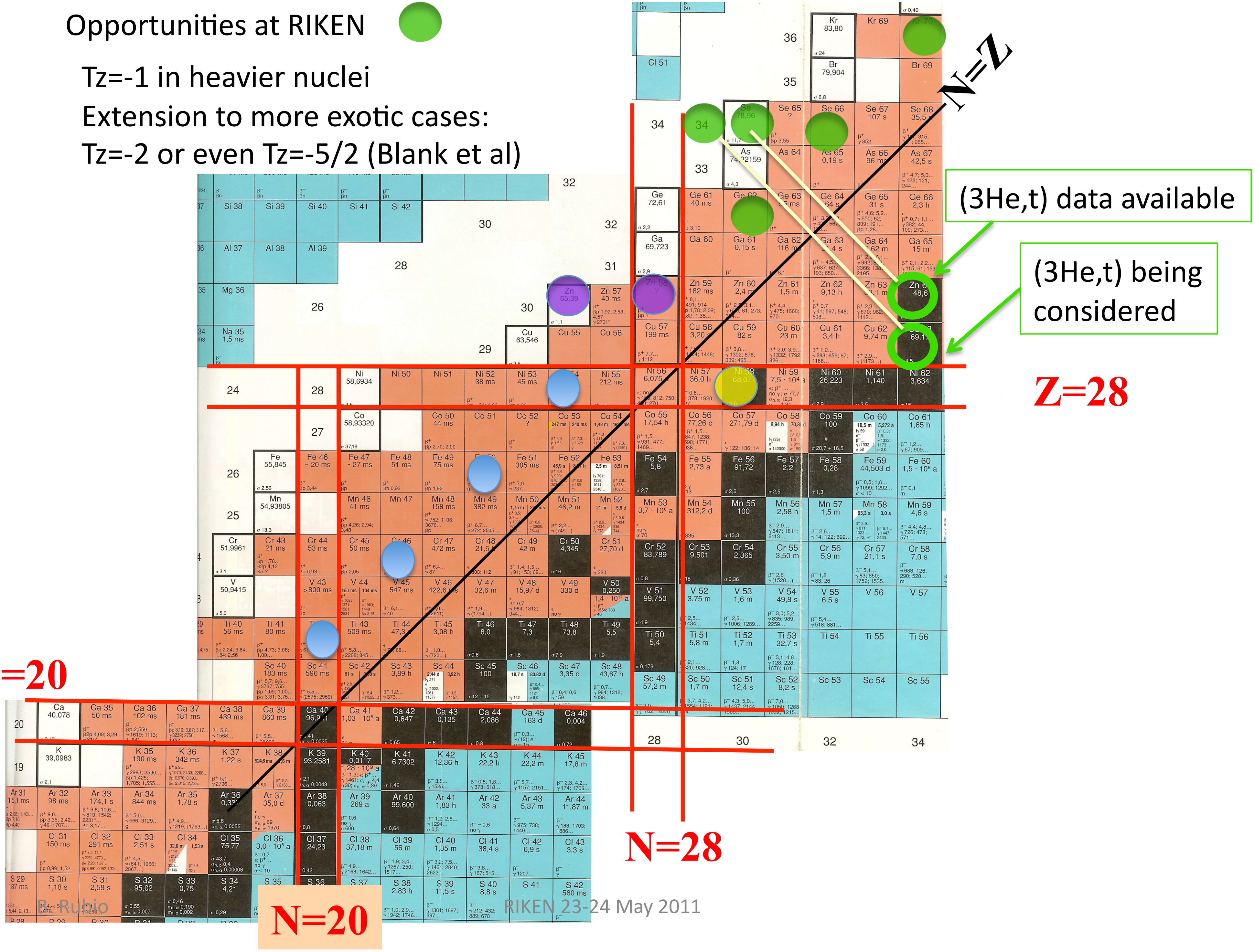


Opportunities at RIKEN ●

Tz=-1 in heavier nuclei

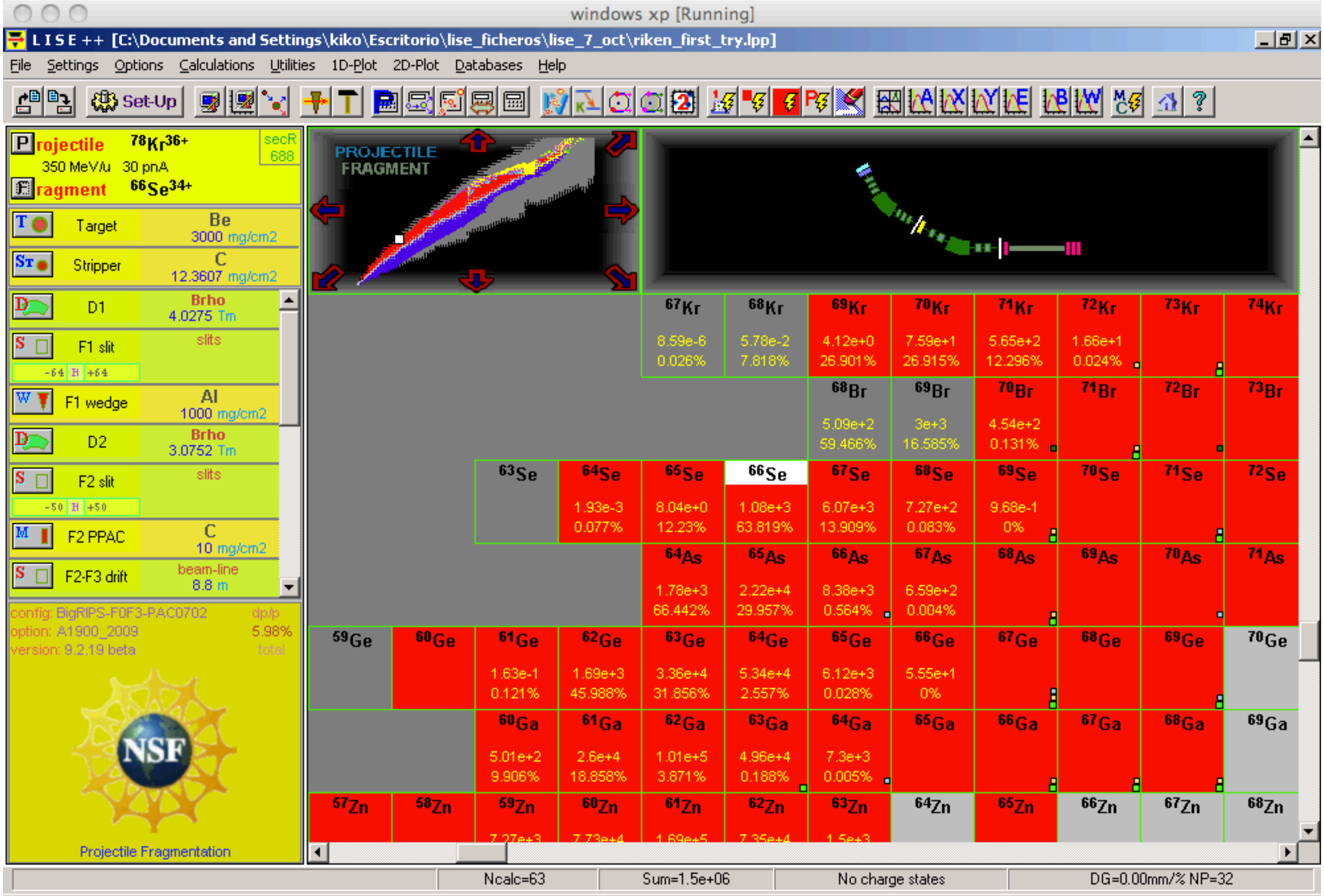
Extension to more exotic cases:

Tz=-2 or even Tz=-5/2 (Blank et al)



(3He,t) data available

(3He,t) being considered



L I S E ++ [C:\Documents and Settings\kiko\Escritorio\lise_ficheros\lise_7_oct\riken_first_try.lpp]

Projectile $^{78}\mathrm{Kr}^{36+}$ secR 688
350 MeV/u 30 pnA
Fragment $^{66}\mathrm{Se}^{34+}$

T	Target	Be 3000 mg/cm2
St	Stripper	C 12.3607 mg/cm2
D	D1	Brho 4.0275 Tm
S	F1 slit -64 H +64	slits
W	F1 wedge	Al 1000 mg/cm2
D	D2	Brho 3.0752 Tm
S	F2 slit -50 H +50	slits
M	F2 PPAC	C 10 mg/cm2
S	F2-F3 drift	beam-line 8.8 m

config: BigRIPS-F0F3-PAC0702 dp/p
option: A1900_2009 5.98%
version: 9.2.19 beta total

Projectile Fragmentation

				^{67}Kr 8.59e-6 0.026%	^{68}Kr 5.78e-2 7.818%	^{69}Kr 4.12e+0 26.901%	^{70}Kr 7.59e+1 26.915%	^{71}Kr 5.65e+2 12.296%	^{72}Kr 1.66e+1 0.024%	^{73}Kr	^{74}Kr
						^{68}Br 5.09e+2 59.466%	^{69}Br 3e+3 16.585%	^{70}Br 4.54e+2 0.131%	^{71}Br	^{72}Br	^{73}Br
		^{63}Se	^{64}Se 1.93e-3 0.077%	^{65}Se 8.04e+0 12.23%	^{66}Se 1.08e+3 63.819%	^{67}Se 6.07e+3 13.909%	^{68}Se 7.27e+2 0.083%	^{69}Se 9.68e-1 0%	^{70}Se	^{71}Se	^{72}Se
				^{64}As 1.78e+3 66.442%	^{65}As 2.22e+4 29.957%	^{66}As 8.38e+3 0.564%	^{67}As 6.59e+2 0.004%	^{68}As	^{69}As	^{70}As	^{71}As
^{59}Ge	^{60}Ge	^{61}Ge 1.63e-1 0.121%	^{62}Ge 1.69e+3 45.988%	^{63}Ge 3.36e+4 31.856%	^{64}Ge 5.34e+4 2.557%	^{65}Ge 6.12e+3 0.028%	^{66}Ge 5.55e+1 0%	^{67}Ge	^{68}Ge	^{69}Ge	^{70}Ge
		^{60}Ga 5.01e+2 9.906%	^{61}Ga 2.6e+4 18.858%	^{62}Ga 1.01e+5 3.871%	^{63}Ga 4.96e+4 0.188%	^{64}Ga 7.3e+3 0.005%	^{65}Ga	^{66}Ga	^{67}Ga	^{68}Ga	^{69}Ga
^{57}Zn	^{58}Zn	^{59}Zn 7.27e+3	^{60}Zn 7.73e+4	^{61}Zn 1.69e+5	^{62}Zn 7.35e+4	^{63}Zn 1.5e+3	^{64}Zn	^{65}Zn	^{66}Zn	^{67}Zn	^{68}Zn

Ncalc=63 Sum=1.5e+06 No charge states DG=0.00mm/% NP=32

L I S E ++ [C:\Documents and Settings\kiko\Escritorio\lise_ficheros\lise_7_oct\riken_first_try_64Se.lpp]

Projectile ^{78}Kr^{36+} secR 688
350 MeV/u 30 pnA
Fragment ^{64}Se^{34+}

Target	Be	3000 mg/cm2
Stripper	C	12.3607 mg/cm2
D1	Brho	3.8700 Tm
F1 slit -64 H +64	slits	
F1 wedge	Al	1000 mg/cm2
D2	Brho	2.8801 Tm
F2 slit -50 H +50	slits	
F2 PPAC	C	10 mg/cm2
F2-F3 drift	beam-line	8.8 m

config: BigRIPS-F0F3-PAC0702 dp/p
option: A1900_2009 5.98%
version: 9.2.19 beta total

Projectile Fragmentation

							^{67}Kr 8.58e-3 26.228%	^{68}Kr 1.29e-1 17.451%	^{69}Kr 8.1e-1 5.286%	^{70}Kr	^{71}Kr
									^{68}Br 9.21e-1 0.108%	^{69}Br	^{70}Br
					^{63}Se 1.38e-2 14.805%	^{64}Se 1.35e+0 54.127%	^{65}Se 9.18e+0 13.971%	^{66}Se 3.55e+0 0.21%	^{67}Se 1.47e+0 0.003%	^{68}Se	^{69}Se
							^{64}As 1.87e+1 0.701%	^{65}As 3.71e+0 0.005%	^{66}As	^{67}As	^{68}As
			^{59}Ge	^{60}Ge 1.18e+0 22.985%	^{61}Ge 4.59e+1 34.014%	^{62}Ge 1.19e+2 3.247%	^{63}Ge 5.82e+1 0.055%	^{64}Ge 2.87e+0 0%	^{65}Ge	^{66}Ge	^{67}Ge
					^{60}Ga 1.82e+2 3.595%	^{61}Ga 5.97e+2 0.433%	^{62}Ga 2.01e+2 0.008%	^{63}Ga	^{64}Ga	^{65}Ga	^{66}Ga
^{54}Zn	^{55}Zn	^{56}Zn	^{57}Zn	^{58}Zn 1.72e+2	^{59}Zn 1.2e+3	^{60}Zn 1.71e+3	^{61}Zn 3.92e+2	^{62}Zn	^{63}Zn	^{64}Zn	^{65}Zn

Opens an existing document

I believe gamma spectroscopy can provide valuable information on exotic nuclei. There is a large gap of knowledge before everything decay by proton emission.

proton rich nuclei below 100Sn are still relatively simple. Beta decay transition probabilities and electromagnetic transition probabilities are very sensitive probes for nuclear model.

in some of these cases one can get detailed information on the mirror nuclei thanks to the excellent resolution of the Big Ridden spectrometer at Osaka.

This measurements are complementary to the one proposed by Blank et al focussed on one and two proton decays

FIN