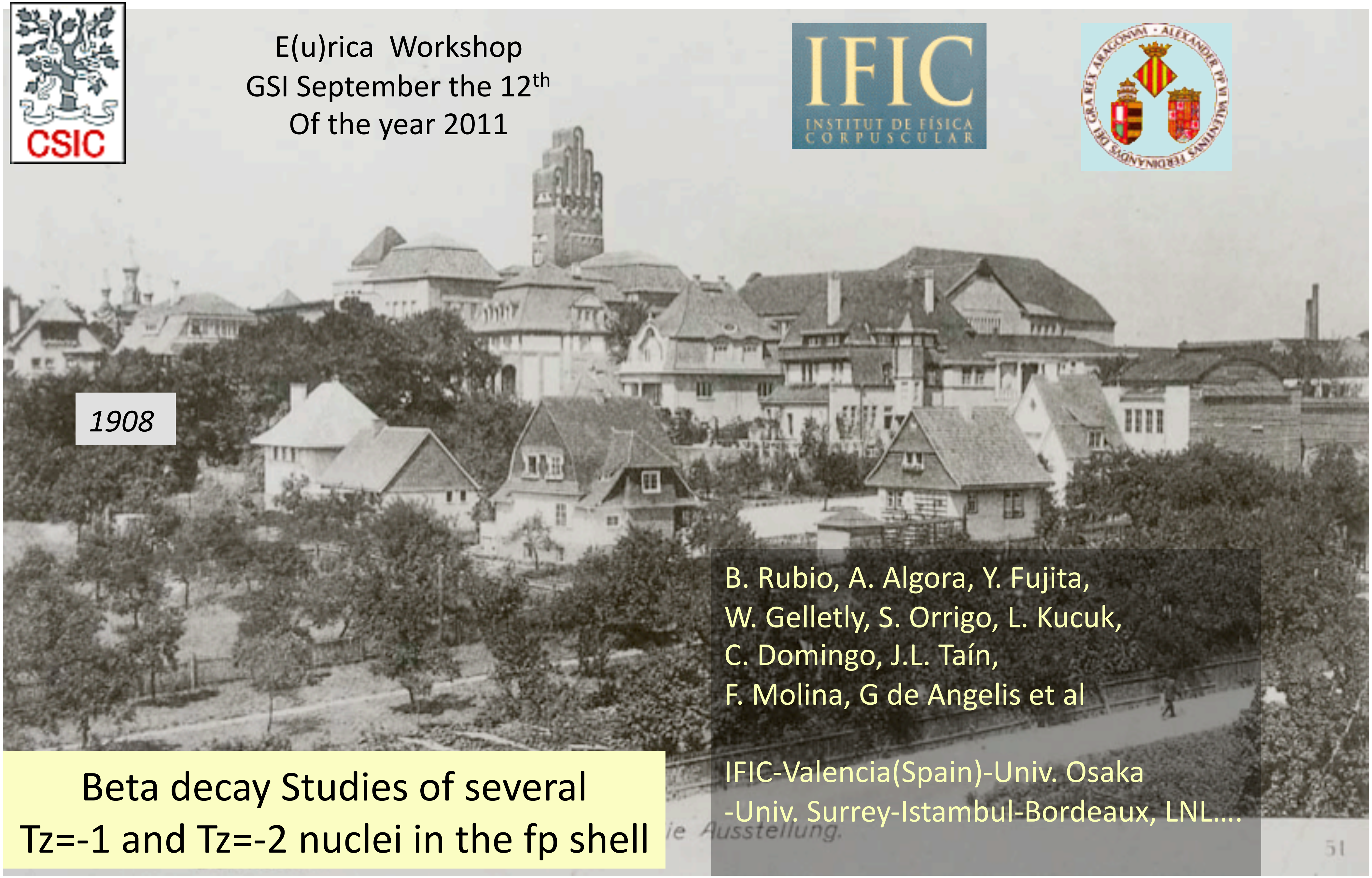


E(u)rica Workshop
GSI September the 12th
Of the year 2011

1908

Beta decay Studies of several Tz=-1 and Tz=-2 nuclei in the fp shell

B. Rubio, A. Algora, Y. Fujita,
W. Gelletly, S. Orrigo, L. Kucuk,
C. Domingo, J.L. Taín,
F. Molina, G de Angelis et al

IFIC-Valencia(Spain)-Univ. Osaka
-Univ. Surrey-Istambul-Bordeaux, LNL….

Layout of my talk

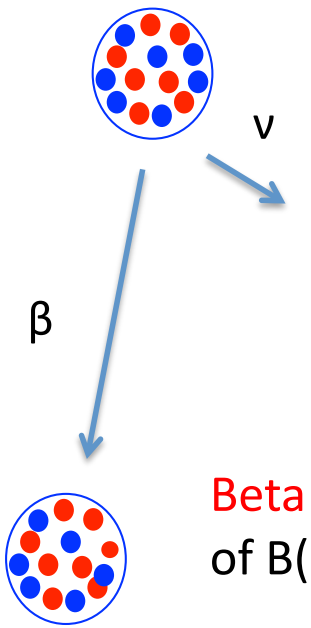
- Motivation: Isospin symmetry studies using two mirror processes, beta decay and charge exchange reactions
- Beta decay studies at GSI-FRS-Rising of Tz=-1 nuclei
- Beta decay studies at GANIL-LISE
- How to proceed further: RIKEN

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

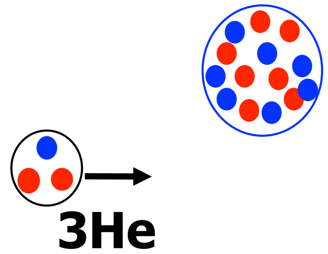
Beta decay

Charge Exchange Reactions

Radioactive initial nucleus



Stable Target

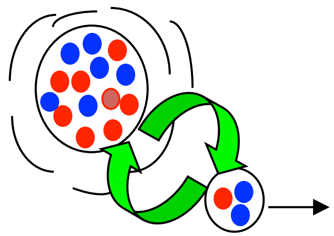


Advantages :

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

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

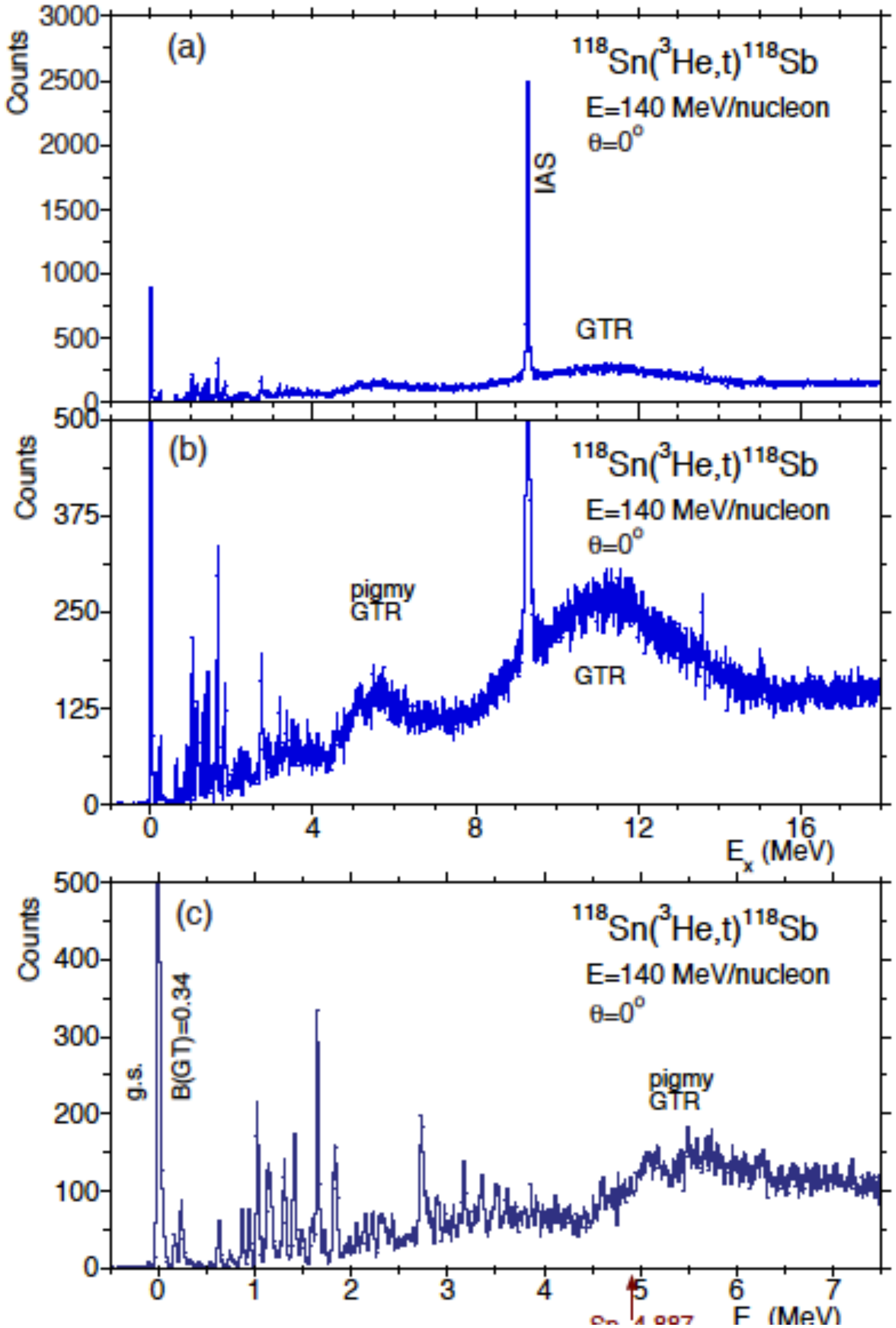
$$B(GT) = \left| \langle \psi_f | \sum_k \sigma_k \tau_k^{\pm} | \psi_i \rangle \right|^2$$



triton

Fermi and GT strength observed in CE reactions

This is very typically
what we can see today
Using the Grand Raiden
Spectrometer at RCNP



Fujita et al RCNP and
Fujita-Rubio-Gelletly
Progress in Particle
and Nuclear Physics
66 (2011) 549–606

Fermi and GT strength observed in CE reactions

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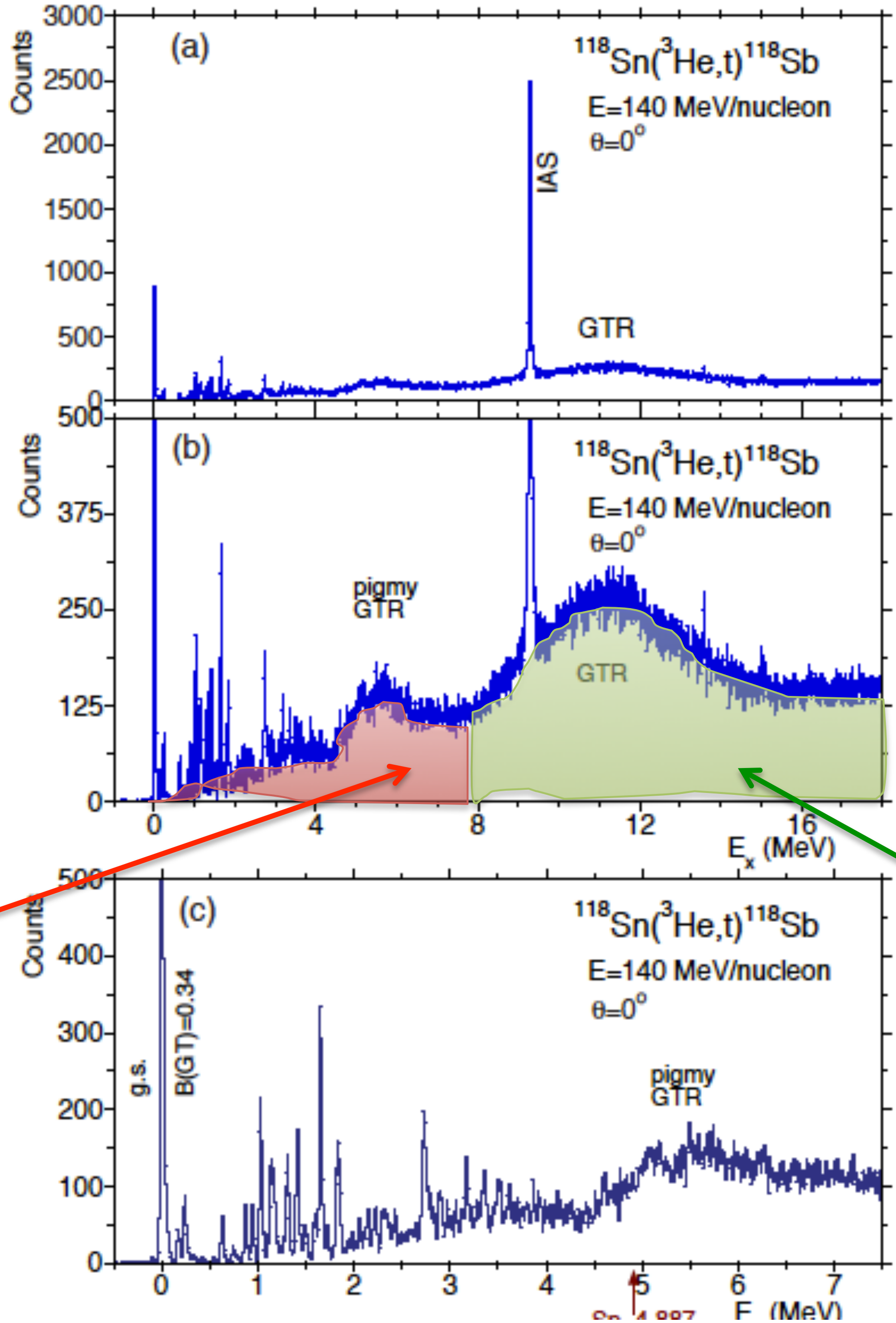


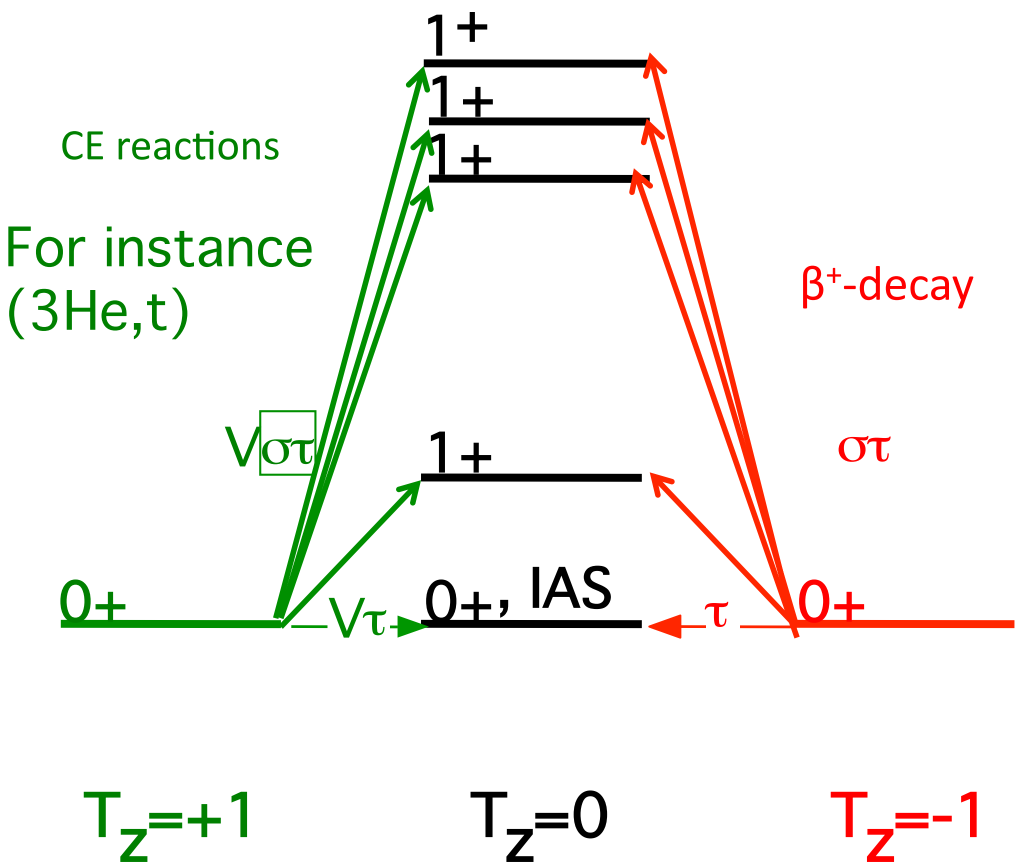
Fujita et al RCNP and Fujita-Rubio-Gelletly Progress in Particle and Nuclear Physics 66 (2011) 549–606

Typical beta decay range

We need CE if we want to know What happens here

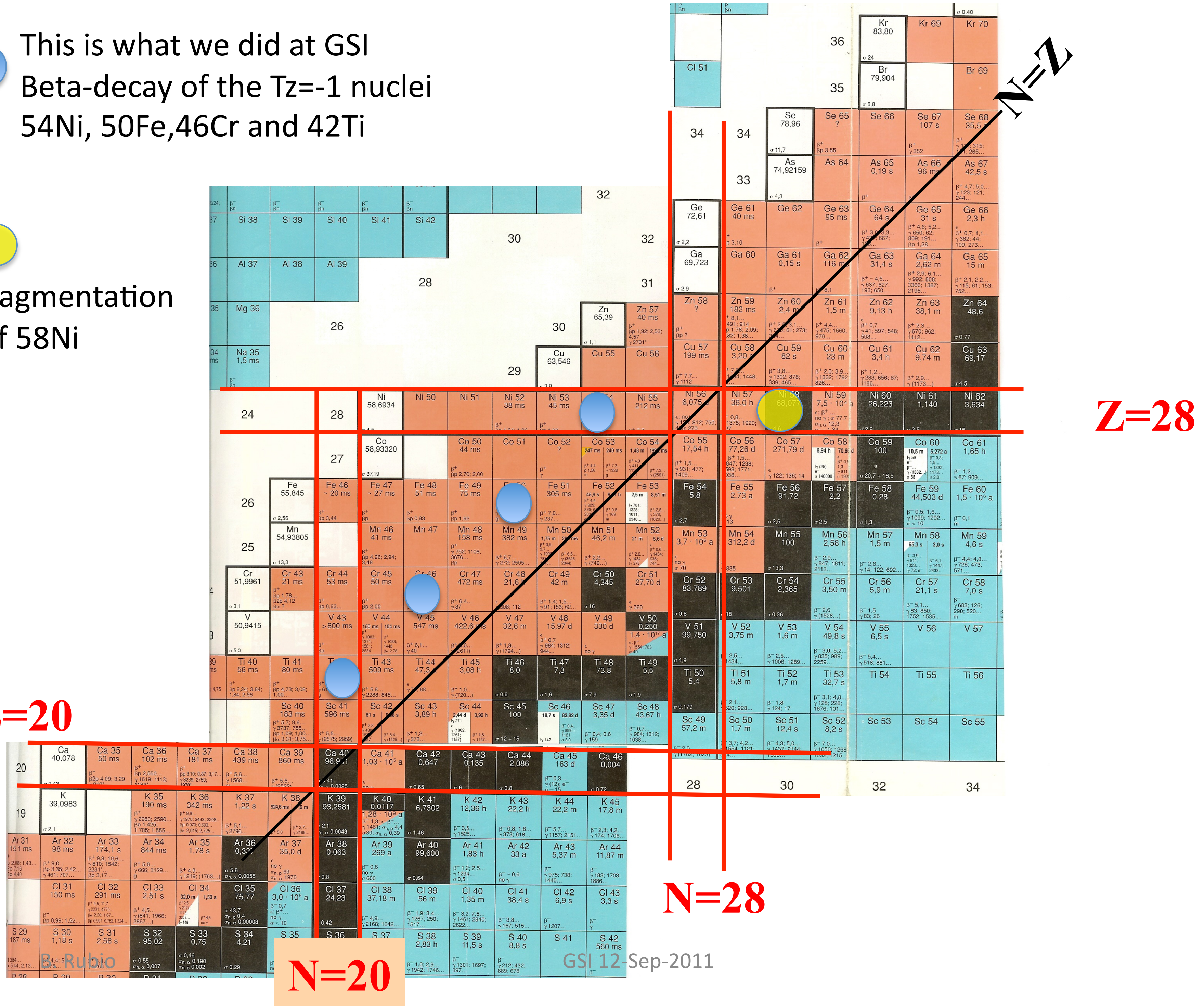
If isospin symmetry exists, mirror nuclei should populate the same states with the same probability, in the daughter nuclei, in the two mirror processes

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

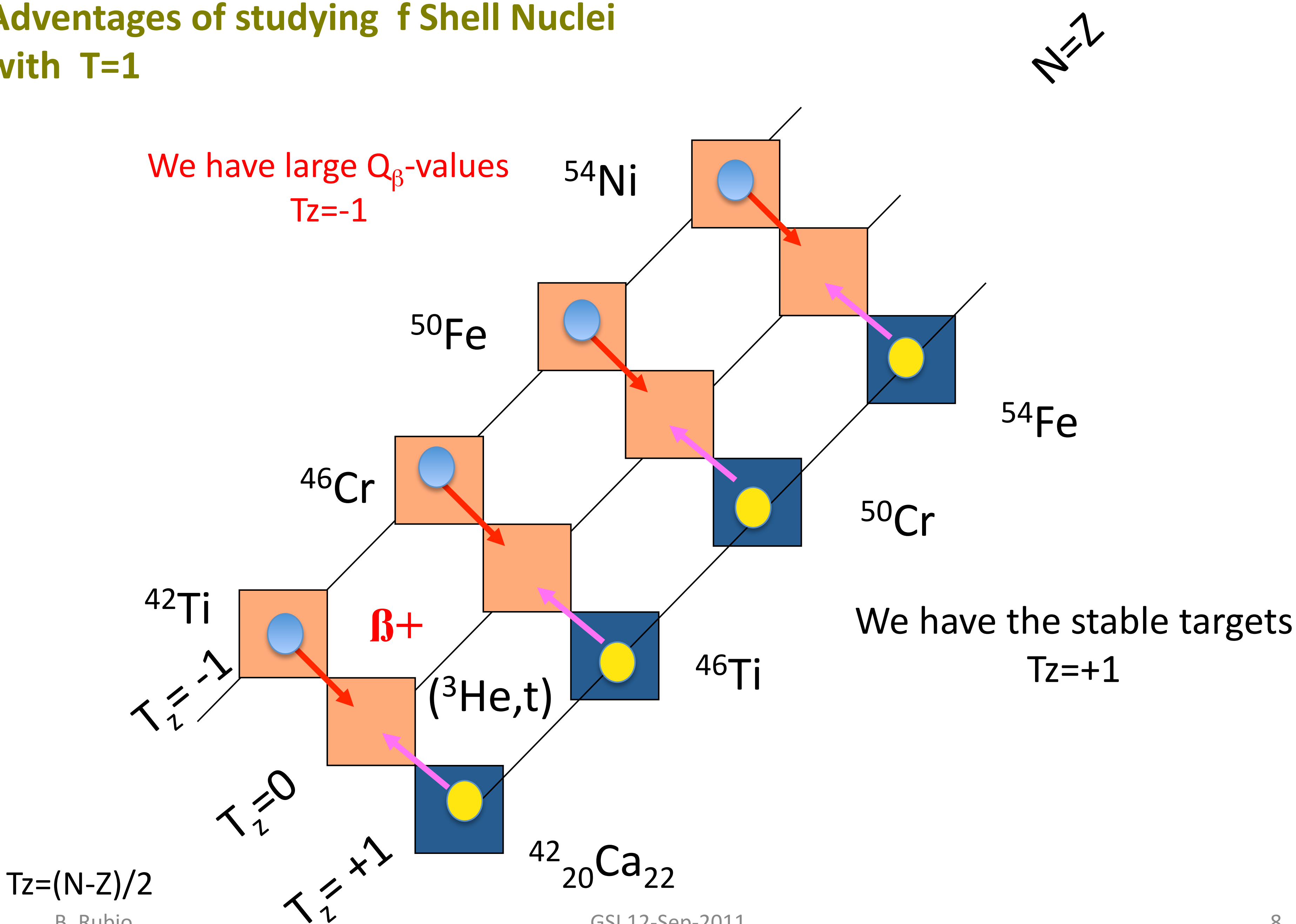


This is what we did at GSI
Beta-decay of the Tz=-1 nuclei
54Ni, 50Fe,46Cr and 42Ti

Fragmentation
of 58Ni



Adventages of studying f Shell Nuclei with T=1



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

Theoretically

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

Experimentally

CE reactions

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

β-decay

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

From the present experiment

$T_{1/2}$ Parent half life

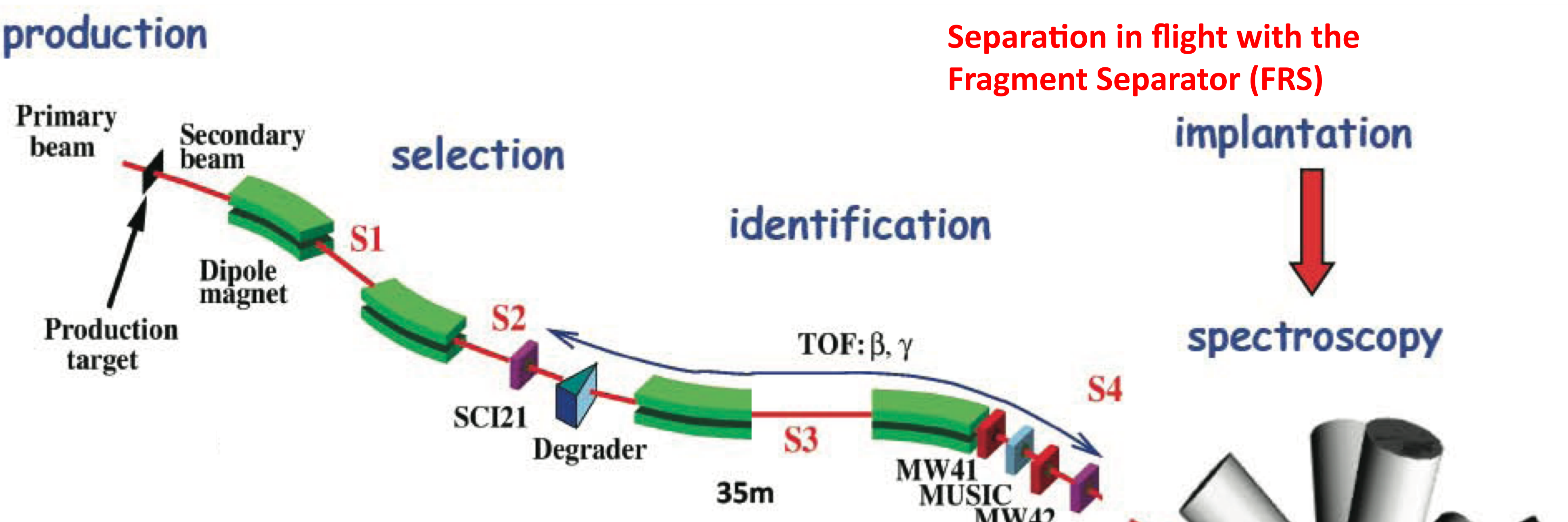
$I_{\beta}(E)$ Beta feeding to states in the daughter nucleus

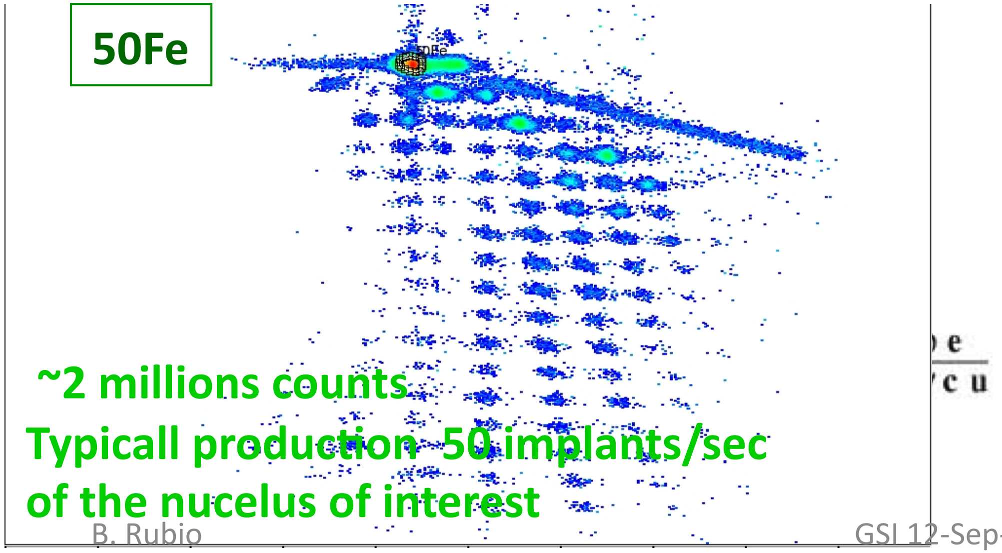
Here we needed the Cluster detectors

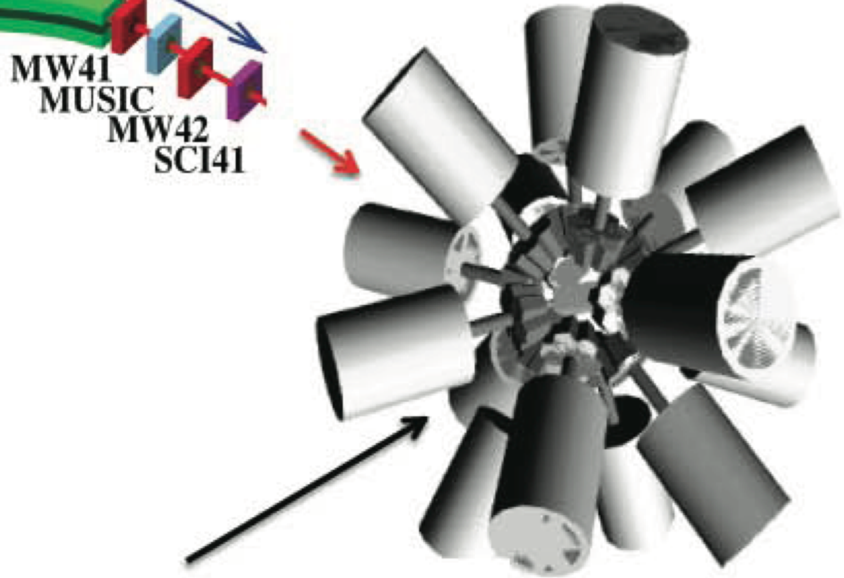
Beta Decay Experiments @ RISING

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

Separation in flight with the Fragment Separator (FRS)





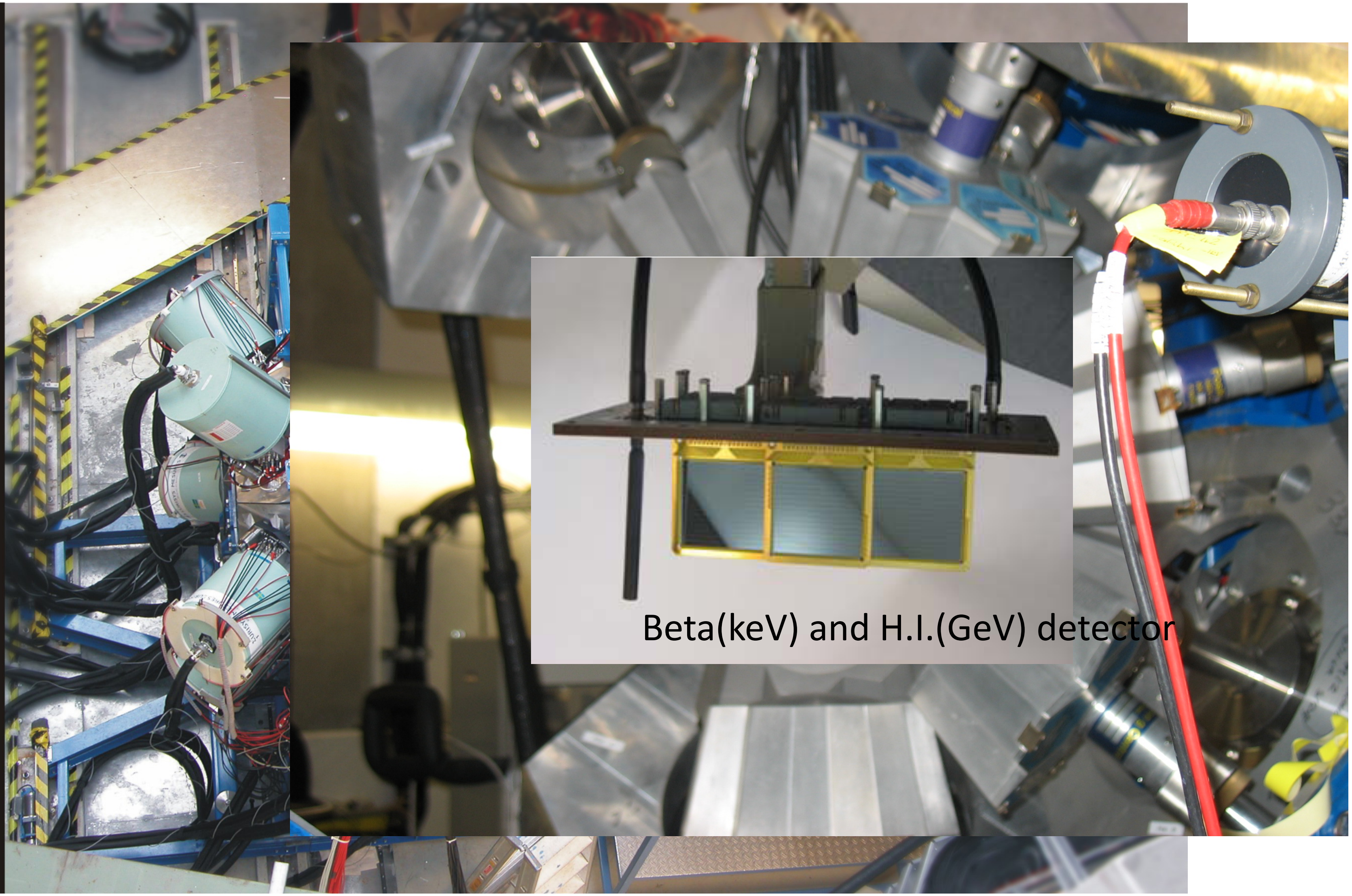


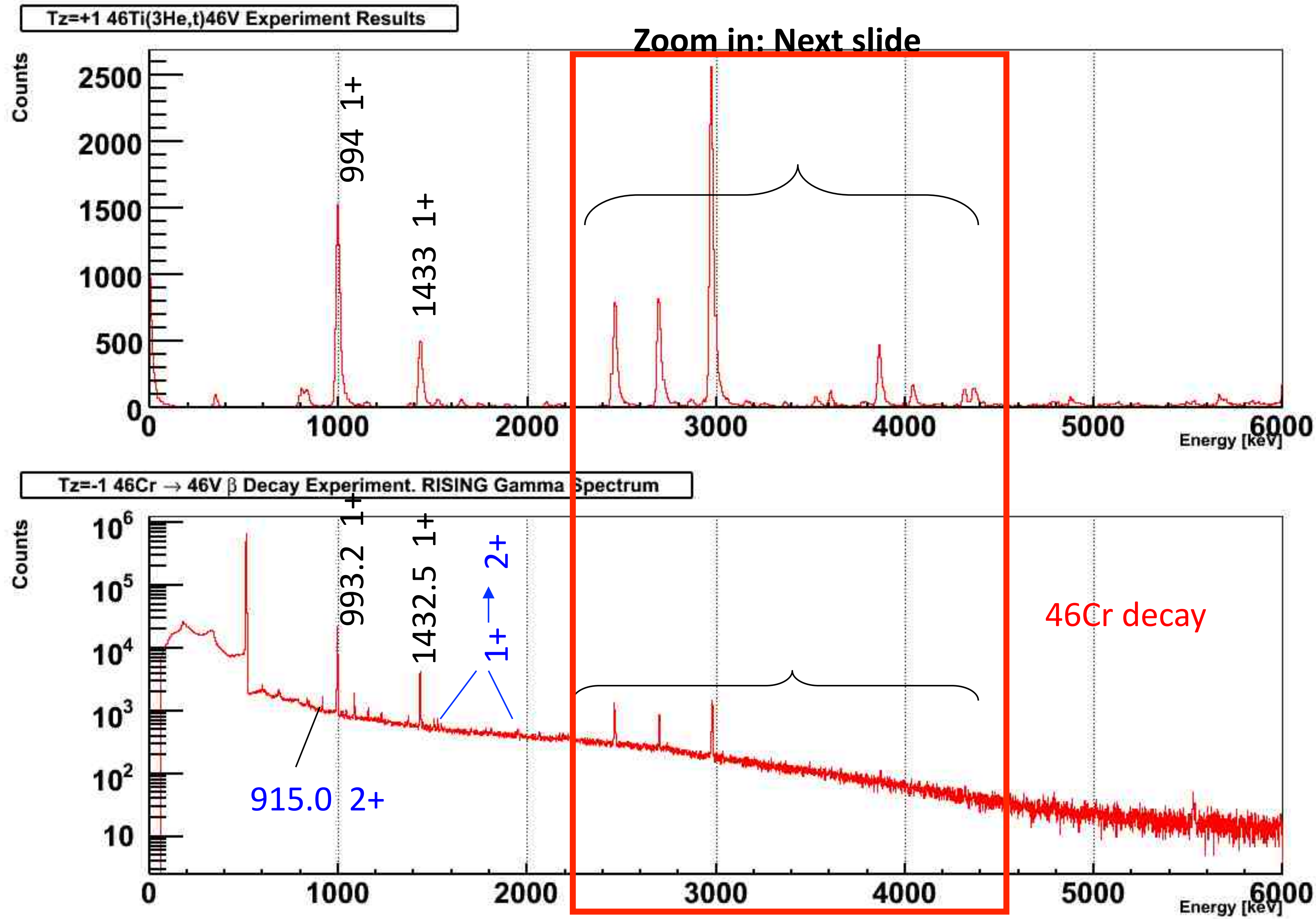
~2 millions counts
Typicall production 50 implants/sec of the nucelus of interest

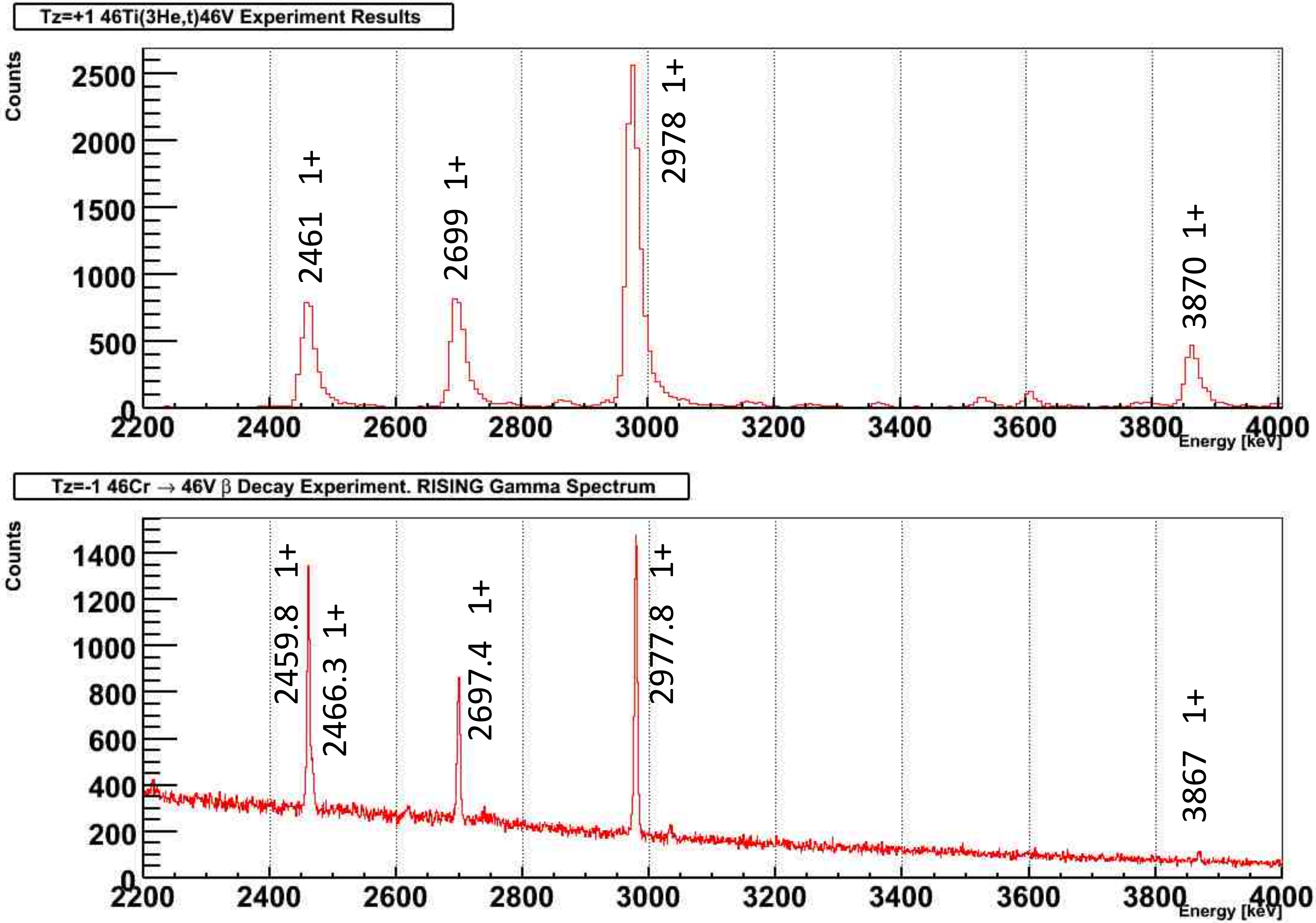
RISING (Ge Array)

15 Euroball Cluster Ge Detectors (7 crystals each)

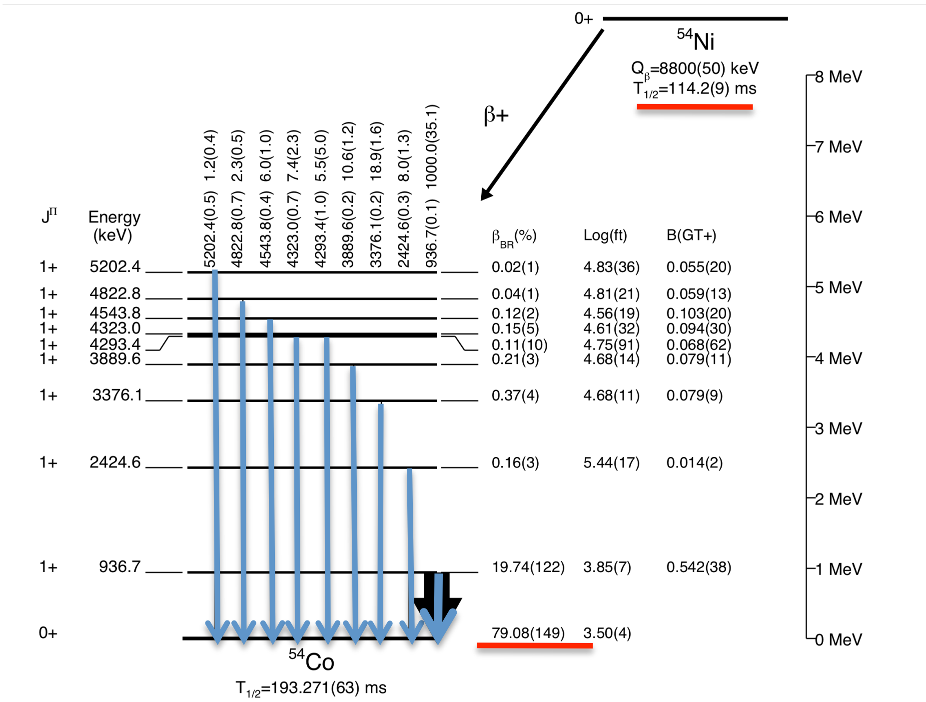
stopped beam setup

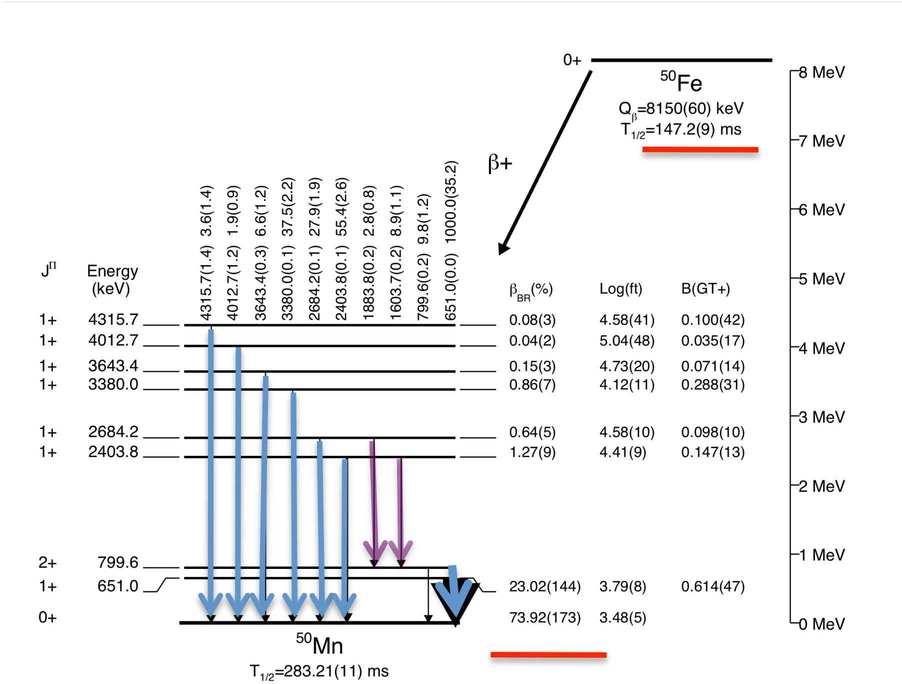



Tz=+1 46Ti(3He,t)46V Experiment Results
Zoom in: Next slide
Counts
994 1+
1433 1+
Energy [keV]
Tz=-1 46Cr → 46V β Decay Experiment. RISING Gamma Spectrum
993.2 1+
1432.5 1+
1+ → 2+
46Cr decay
915.0 2+
Counts
Energy [keV]

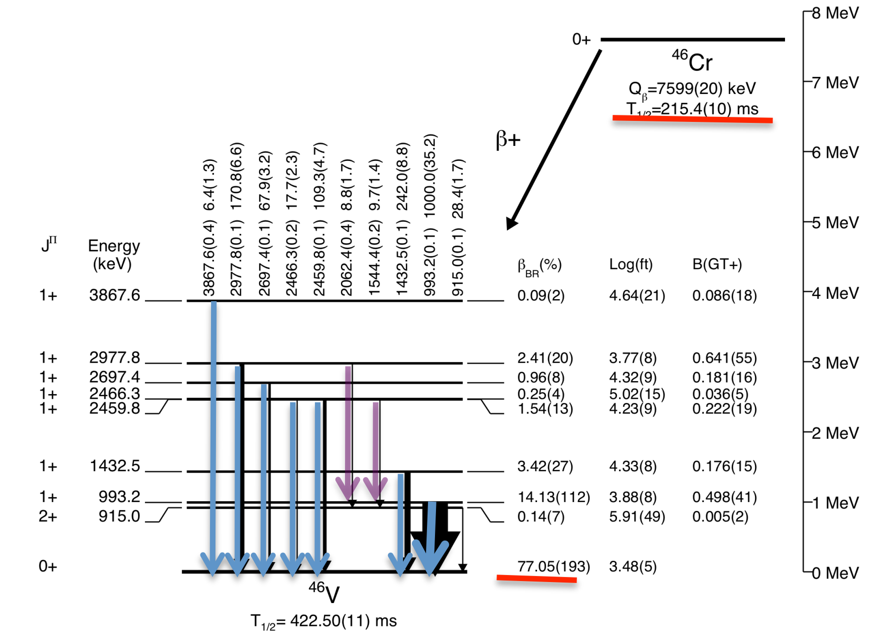


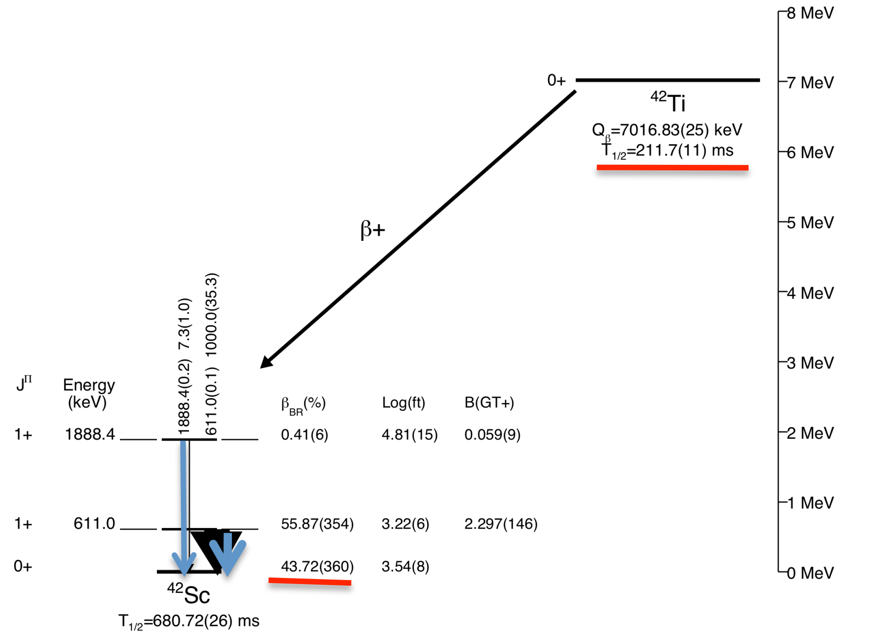
Tz=+1 46Ti(3He,t)46V Experiment Results
Counts
2461 1+
2699 1+
2978 1+
3870 1+
Energy [keV]
Tz=-1 46Cr → 46V β Decay Experiment. RISING Gamma Spectrum
Counts
2459.8 1+
2466.3 1+
2697.4 1+
2977.8 1+
3867 1+
Energy [keV]



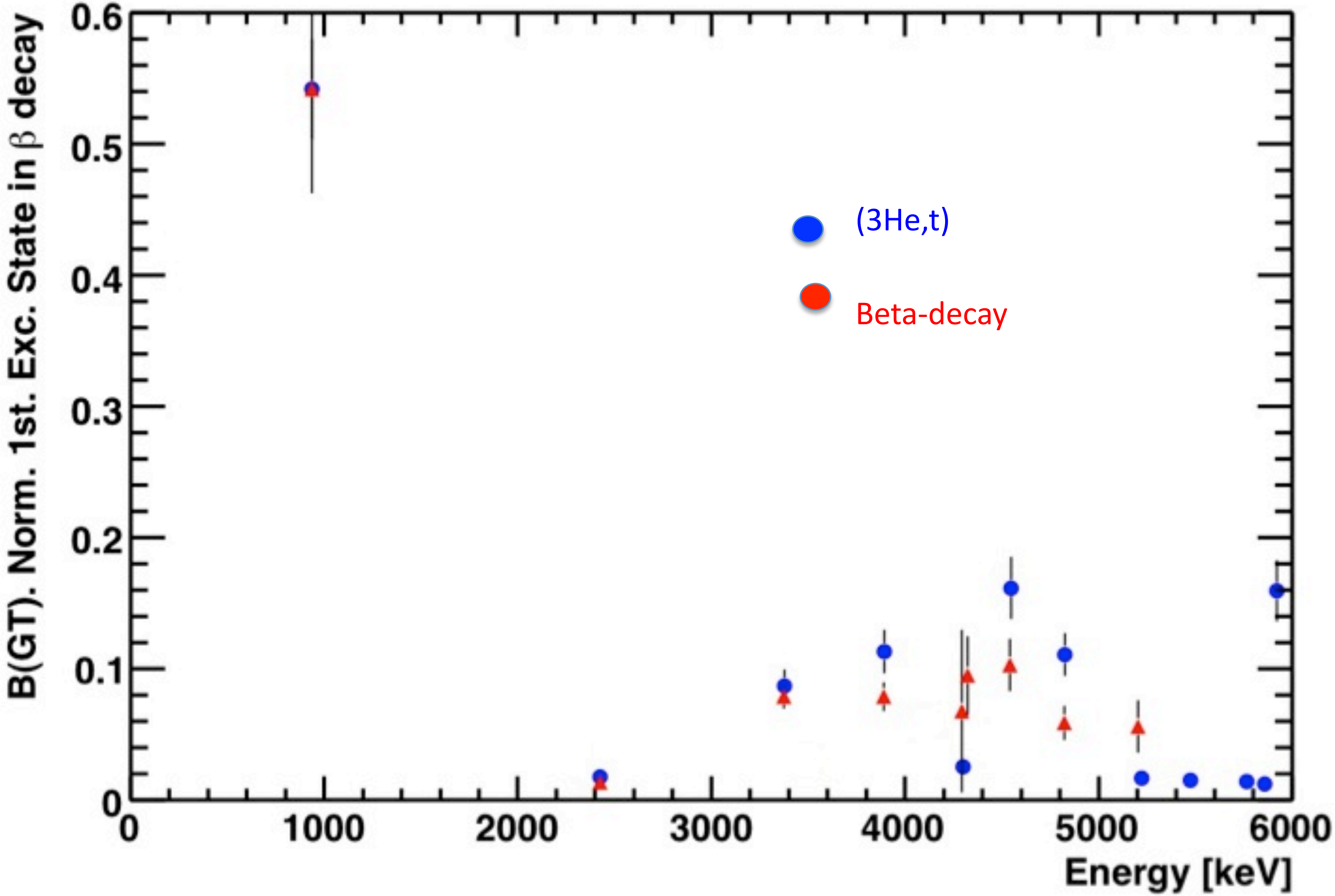


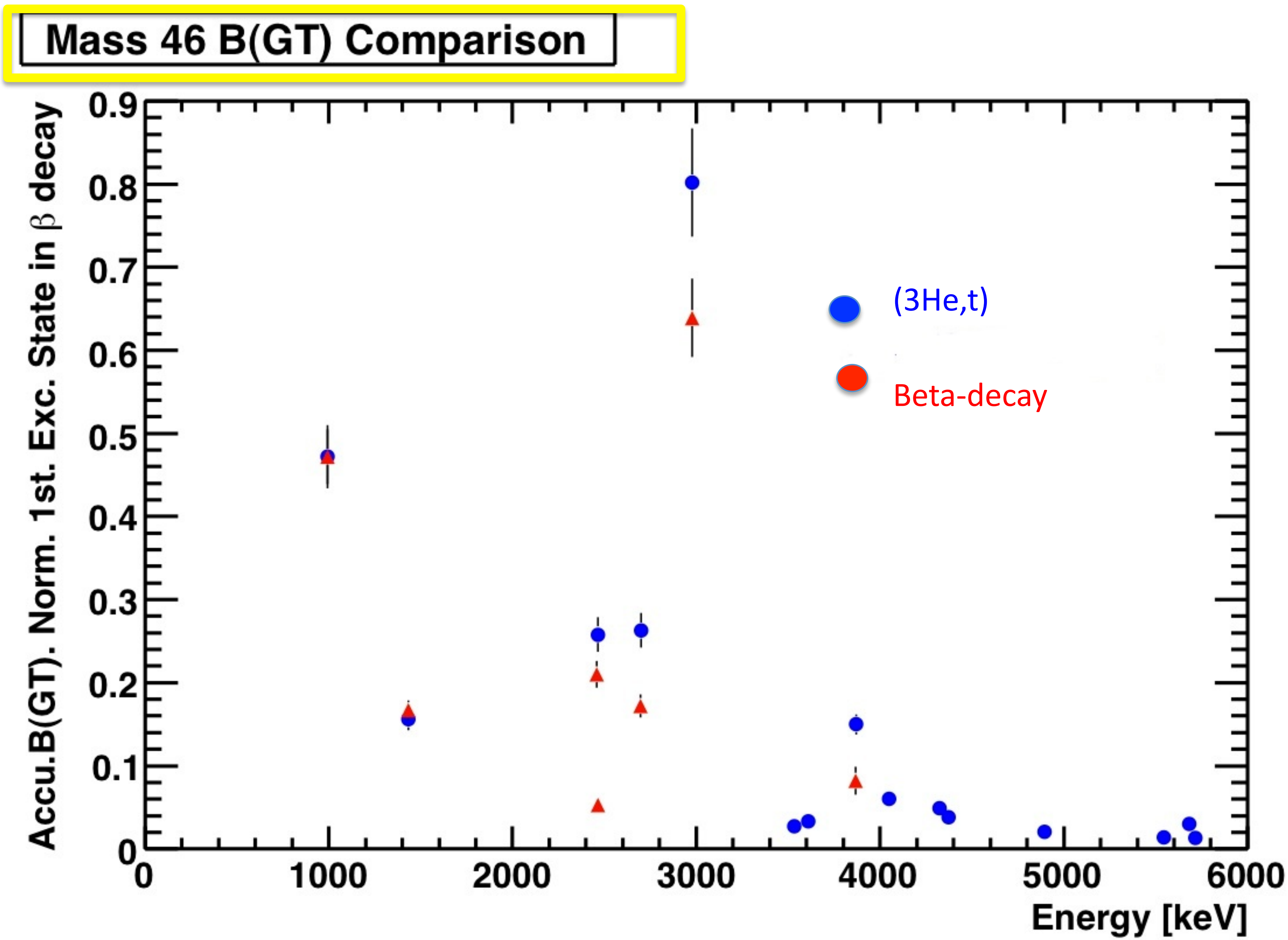
M1 transitions from T=0 to T=0 in self-conjugate nuclei are strongly suppressed!!!
(Warburton and Weneser quasi rule, 1956)

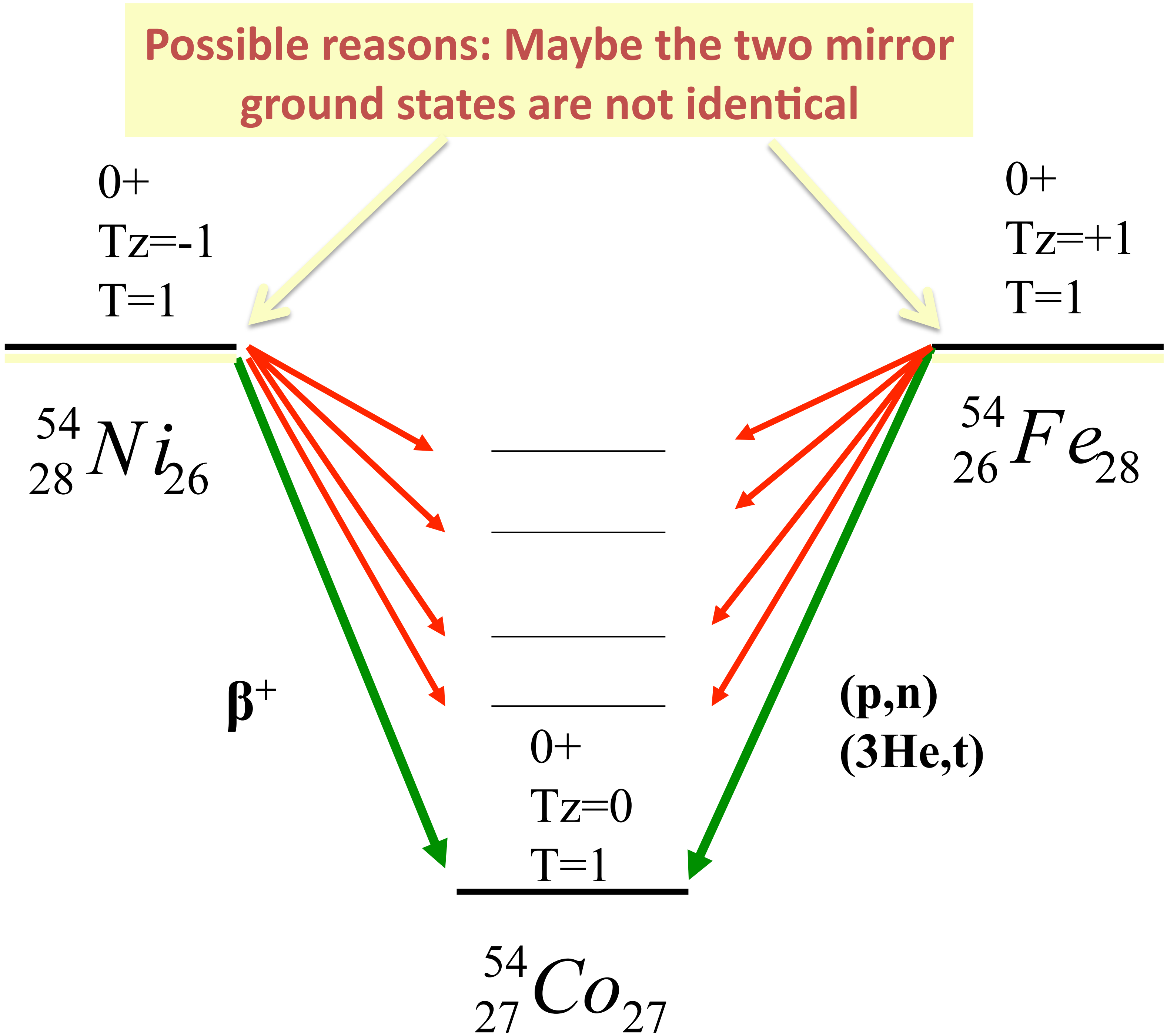




Mass 54 B(GT) Comparison



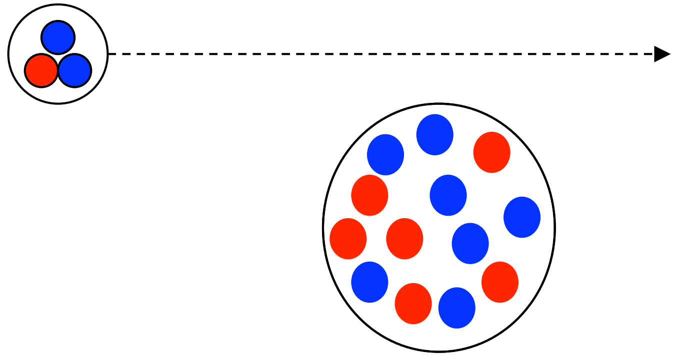

Mass 46 B(GT) Comparison
Accu.B(GT). Norm. 1st. Exc. State in β decay
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1000
2000
3000
4000
5000
6000
Energy [keV]
(3He,t)
Beta-decay

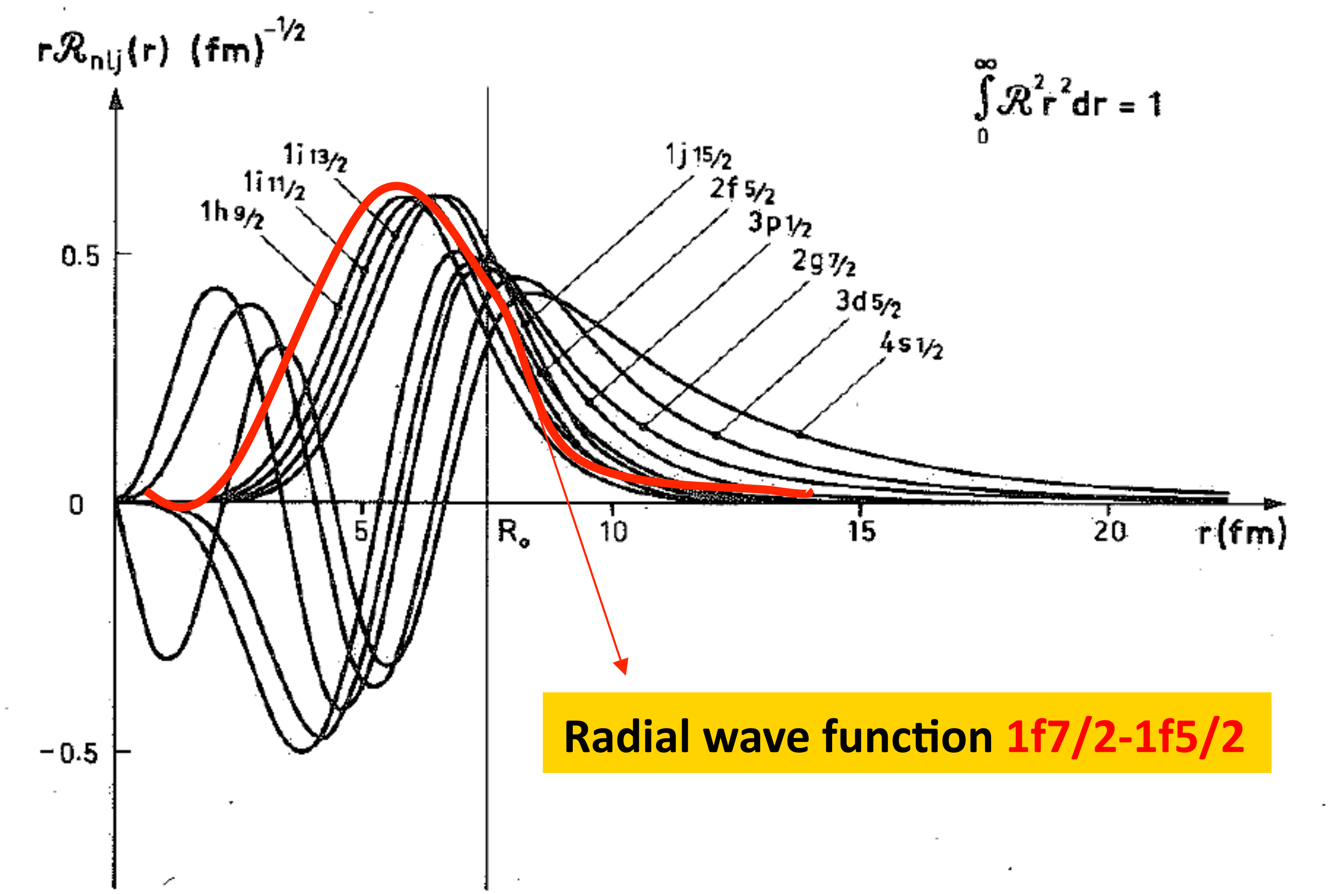


Possible reasons: Maybe the two mirror ground states are not identical
0+
Tz=-1
T=1
0+
Tz=+1
T=1
$^{54}_{28}Ni_{26}$
$^{54}_{26}Fe_{28}$
β+
(p,n)
(3He,t)
0+
Tz=0
T=1
$^{54}_{27}Co_{27}$

Another possible explanation explanations for these differences

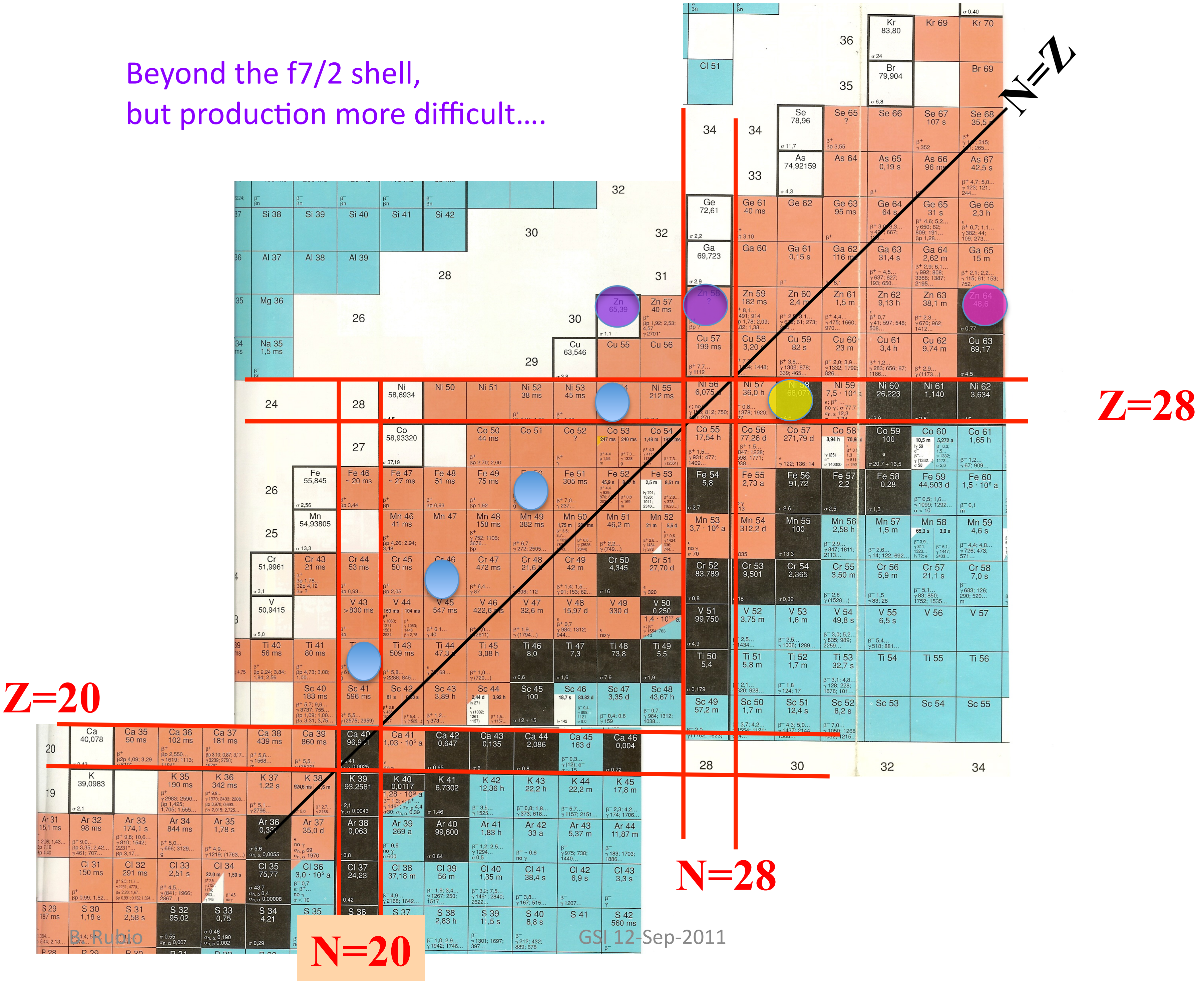
1.- Hadronic probes like (p,n) – (3He,t) are mainly peripherical,
2.- Beta decay can happen "anywhere" in the nucleus



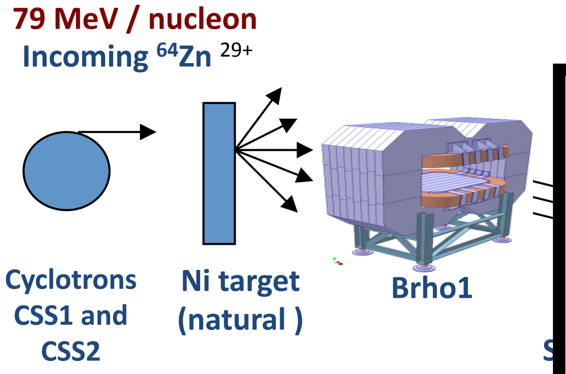


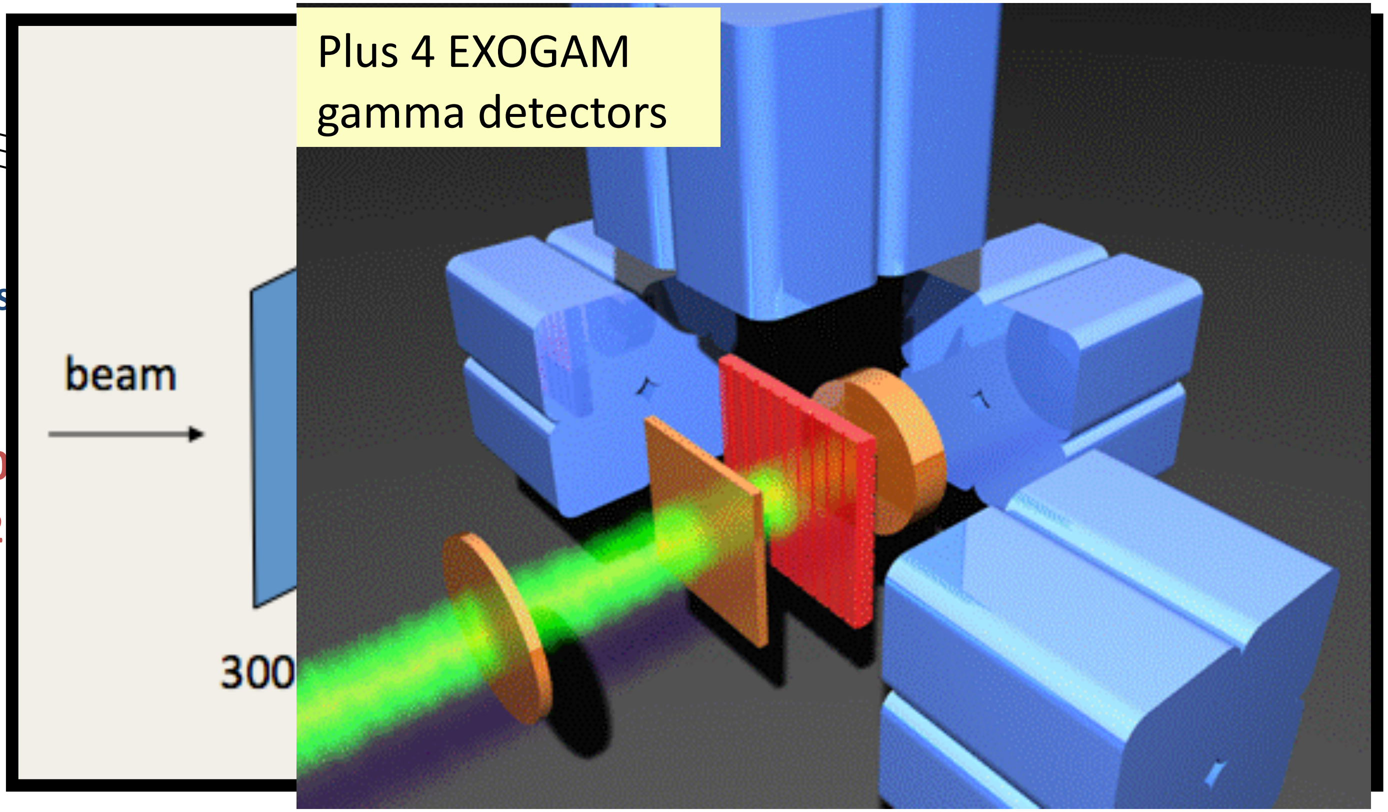
Very important to explore the p-subshell………

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



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

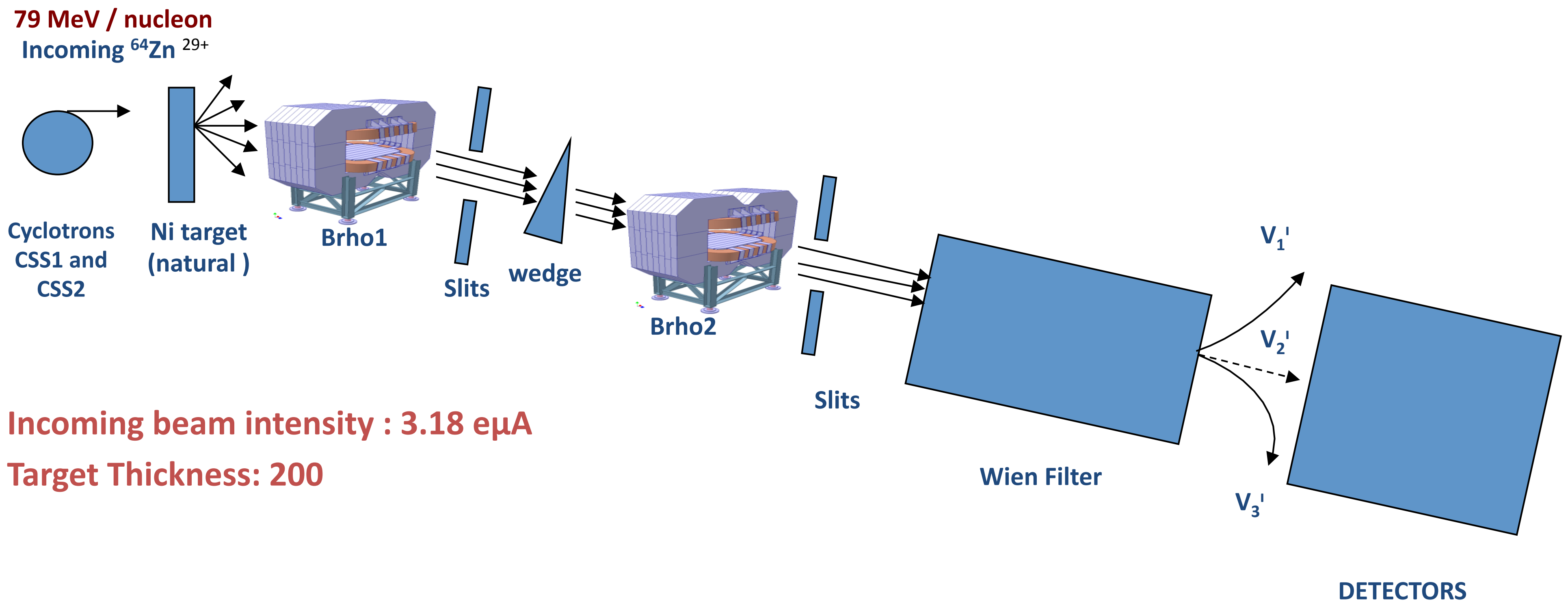




Incoming beam intensity : 500

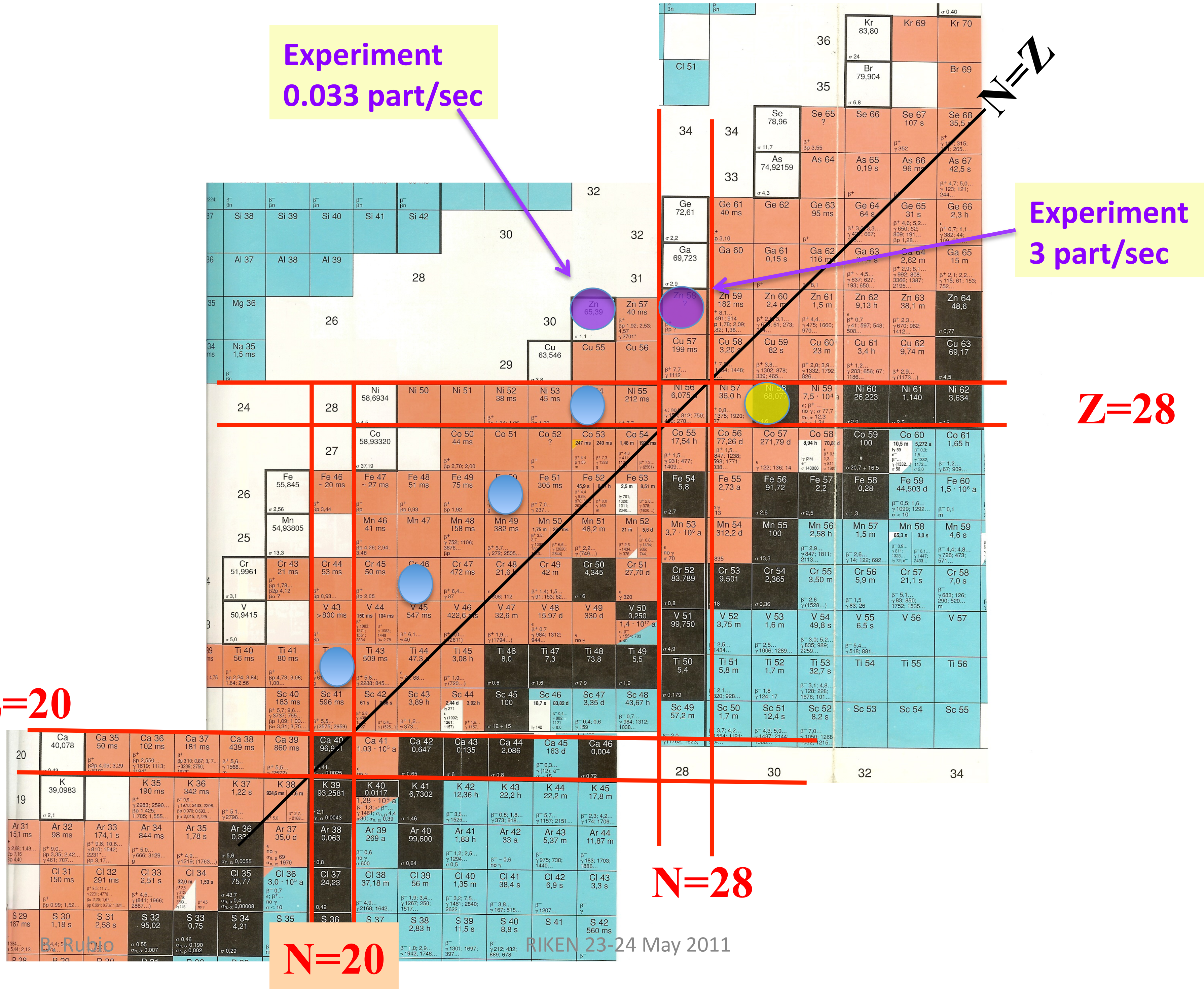
Target Thickness:1.8 mgr/cm2

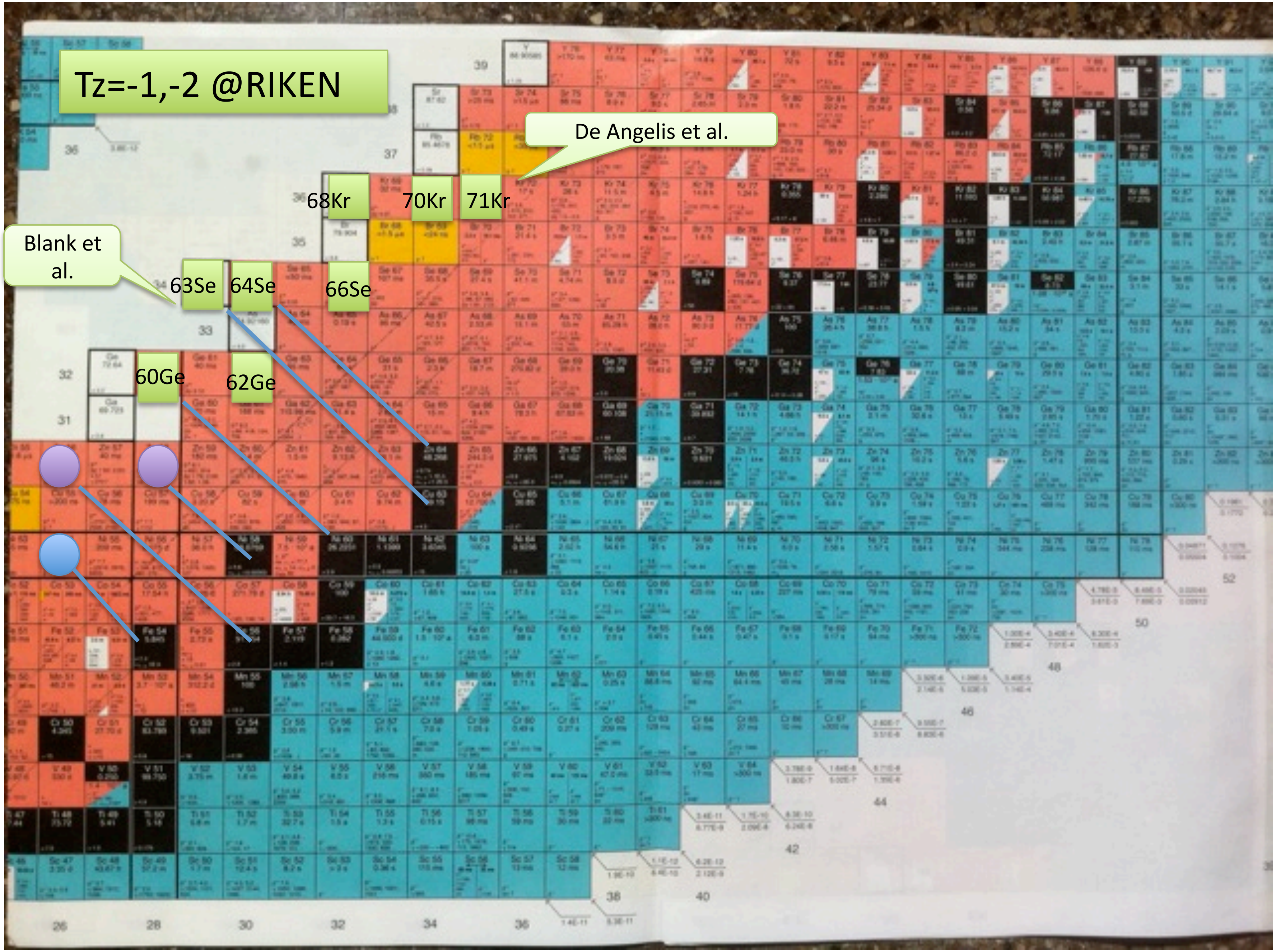
Reaction: $^{58}Ni^{26+}$ (79 MeV.A) + ^{nat}Ni @ GANIL 2010



Incoming beam intensity : 3.18 eμA

Target Thickness: 200


Experiment
0.033 part/sec
Experiment
3 part/sec
N=Z
Z=28
Z=20
N=28
N=20


Tz=-1,-2 @RIKEN
De Angelis et al.
Blank et al.
68Kr
70Kr
71Kr
63Se
64Se
66Se
60Ge
62Ge

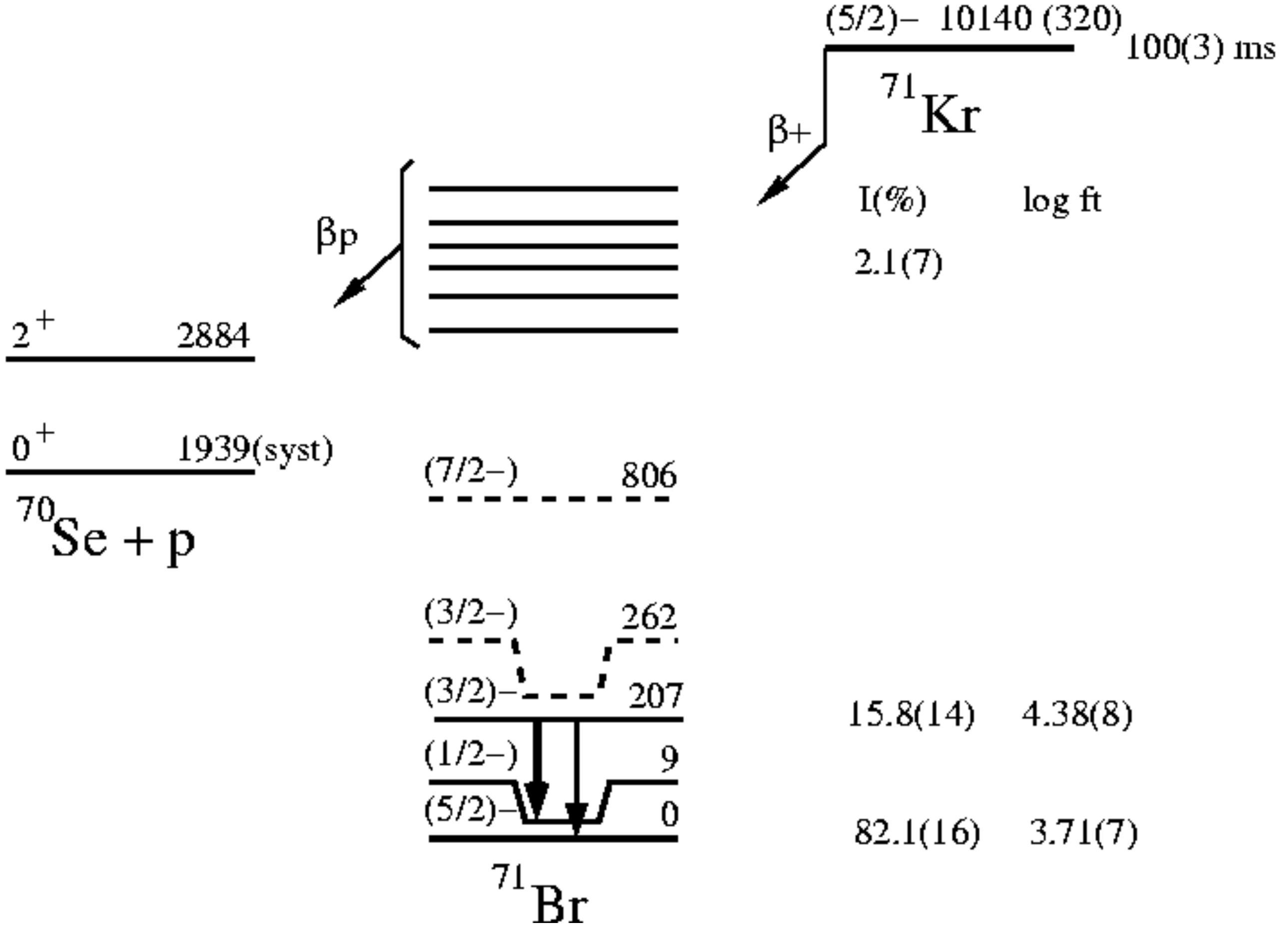
STOPPED BEAM CAMPAIGN - A

Proposal A;4 (S314)

Exotic Beta decays near the proton-drip line:
study of the beta decay of $^{70,71}Kr$.

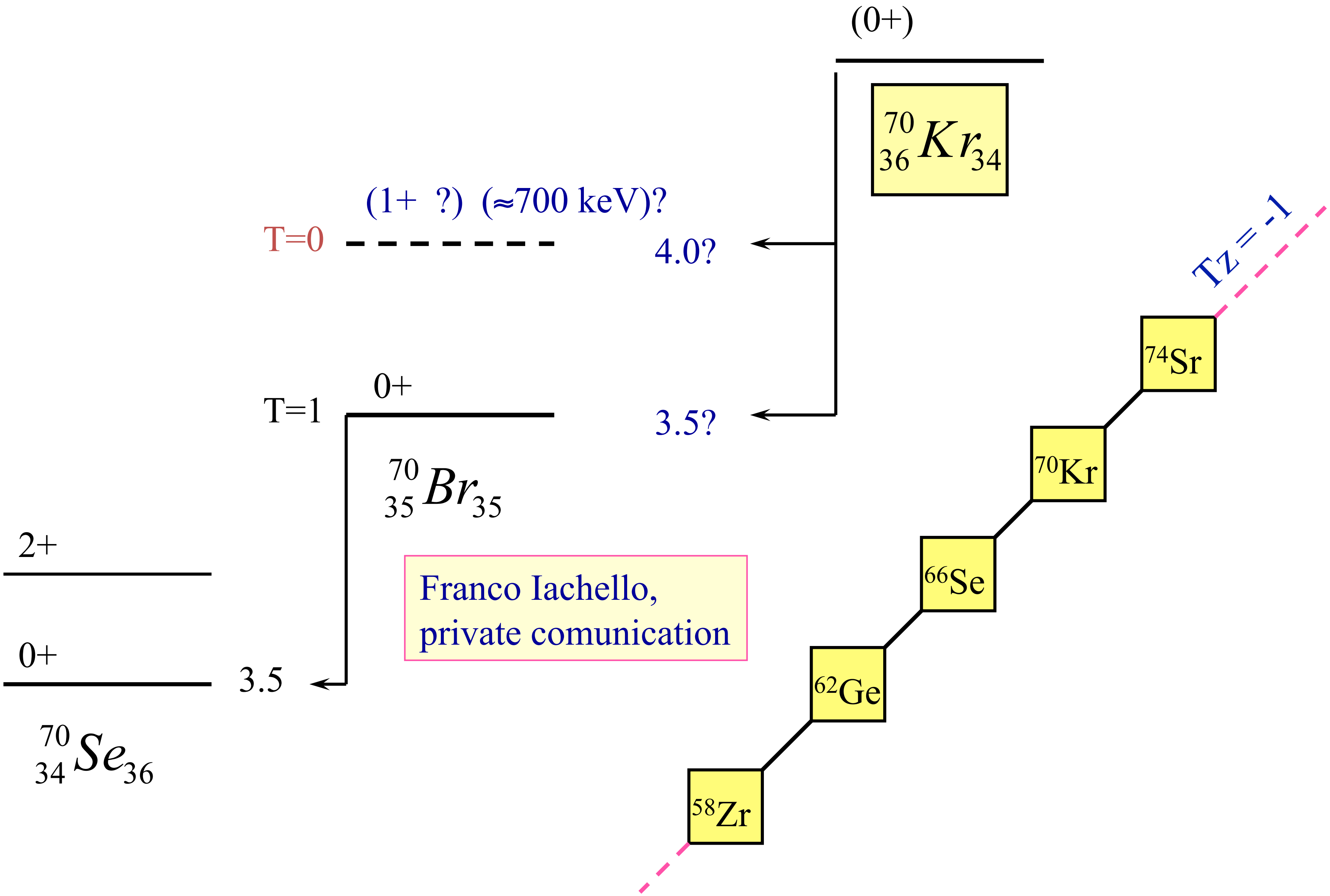
A. Algora, B. Rubio, W. Gelletly et al.,

^{71}Kr case II

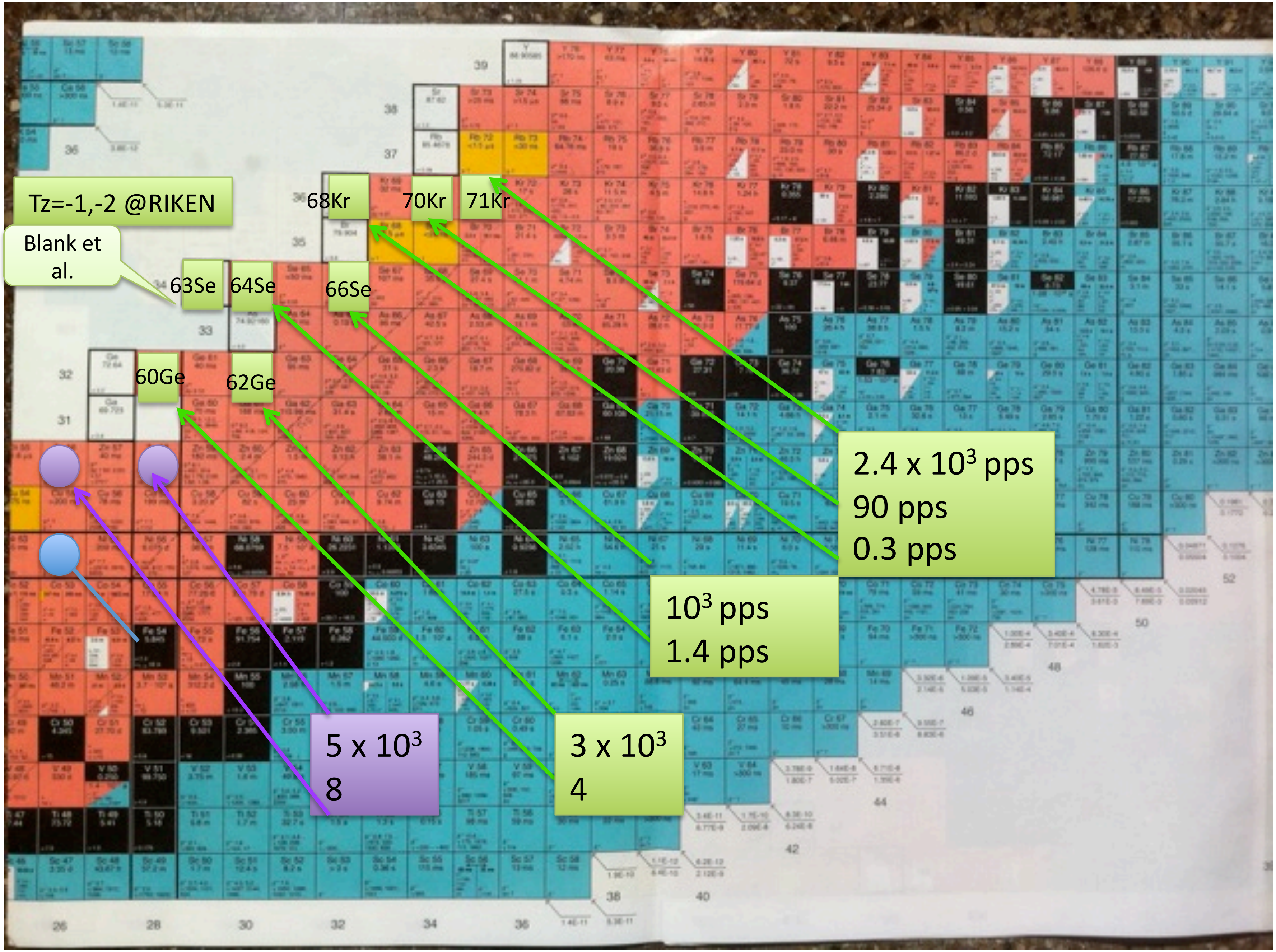


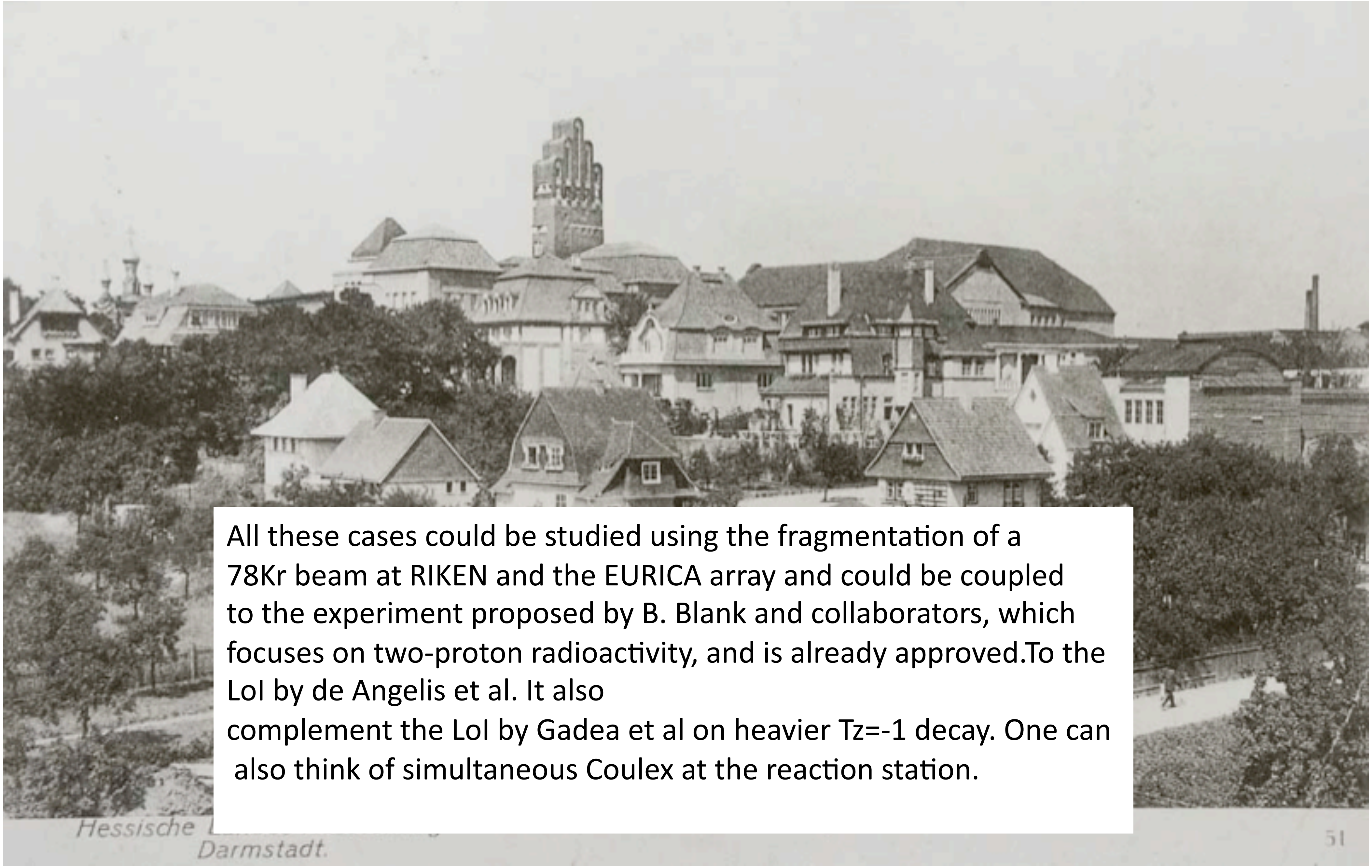
Ref. Oinonen *et al* PRC 52 (1997) 745

^{70}Kr case II



(0+)
$^{70}_{36}Kr_{34}$
(1+ ?) (≈700 keV)?
T=0
4.0?
T=1
0+
3.5?
$^{70}_{35}Br_{35}$
2+
0+
3.5
$^{70}_{34}Se_{36}$
Franco Iachello,
private comunication
Tz = -1
^{74}Sr
^{70}Kr
^{66}Se
^{62}Ge
^{58}Zr


Tz=-1,-2 @RIKEN
Blank et al.
63Se
64Se
66Se
68Kr
70Kr
71Kr
60Ge
62Ge
2.4 x 10^3 pps
90 pps
0.3 pps
10^3 pps
1.4 pps
3 x 10^3
4
5 x 10^3
8



All these cases could be studied using the fragmentation of a 78Kr beam at RIKEN and the EURICA array and could be coupled to the experiment proposed by B. Blank and collaborators, which focuses on two-proton radioactivity, and is already approved.To the LoI by de Angelis et al. It also complement the LoI by Gadea et al on heavier Tz=-1 decay. One can also think of simultaneous Coulex at the reaction station.