Decay Spectroscopy Experiments (RIBF-006, RIBF-009)

S.Nishimura

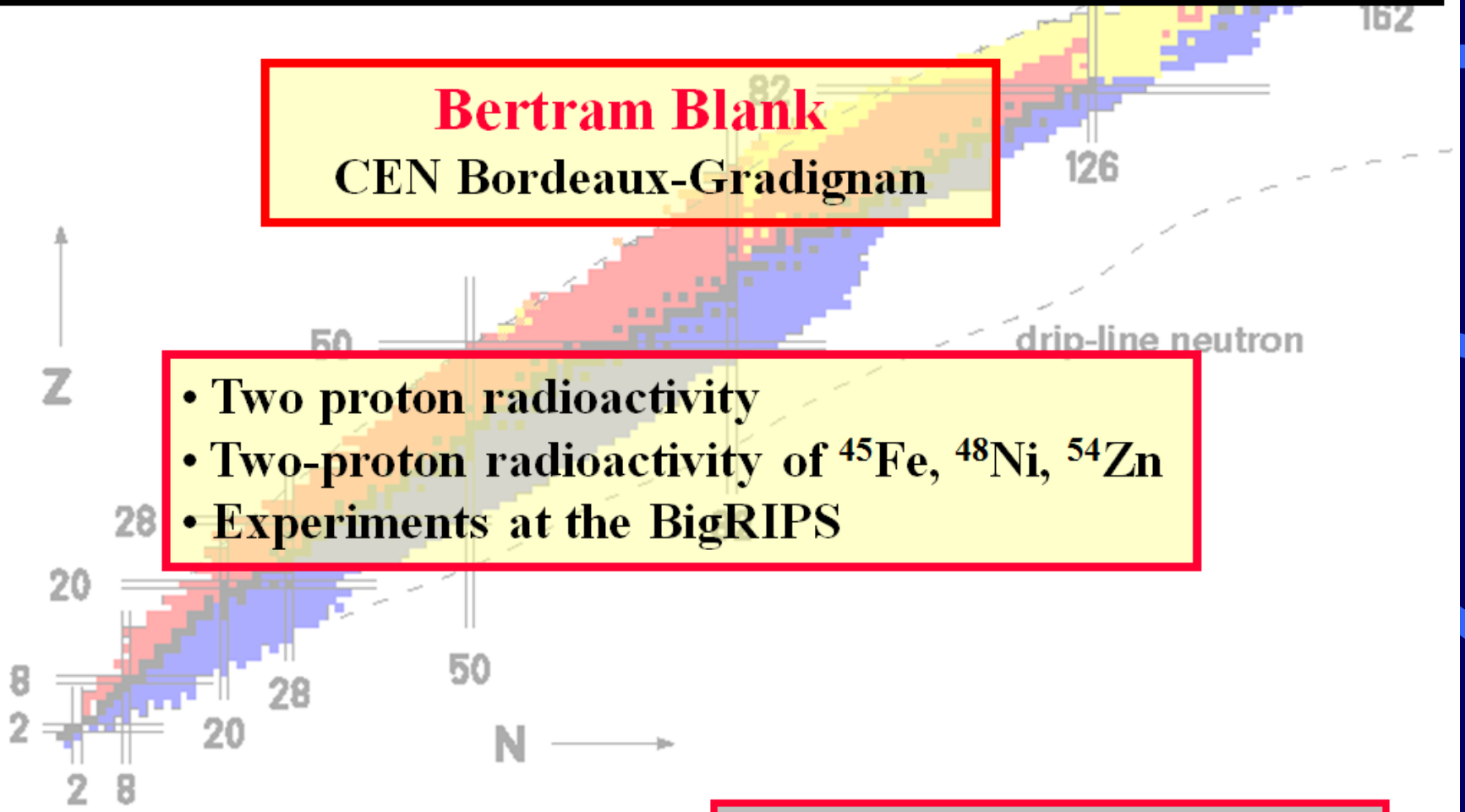
Instead of ..

* **RIBF-006** : "Search for two-proton radioactivity of 59Ge, 63Se, and 67Kr"
B.Blank, … (**5** days , primary beam = ^{78}Kr)

***RIBF-009** : "Decay spectroscopy in the vicinity of 100Sn"
M.Lewitowicz, R.Krucken, Nishimura, … (**10** days, primary beam = ^{124}Xe)

Search for two-proton radioactivity of ^{59}Ge, ^{63}Se, ^{67}Kr

Bertram Blank
CEN Bordeaux-Gradignan

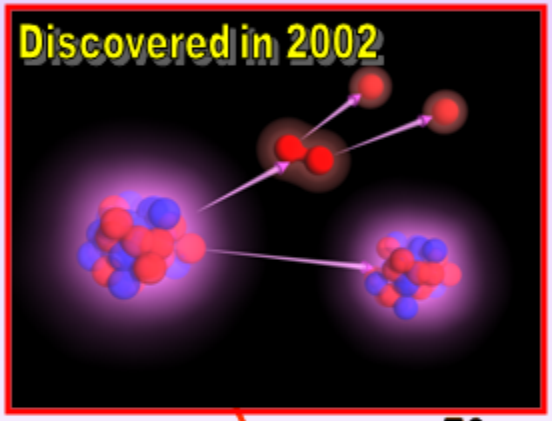


- Two proton radioactivity
- Two-proton radioactivity of ^{45}Fe, ^{48}Ni, ^{54}Zn
- Experiments at the BigRIPS

E(U)RICA, May 23-24, 2011

exotic radioactivities

- predicted in the 1960's by Goldanskii

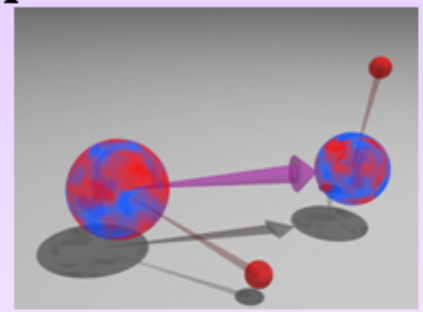


45Fe

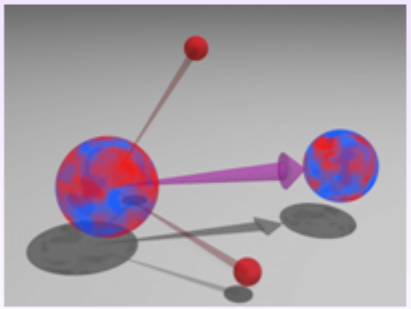
151Lu

Two-proton radioactivity

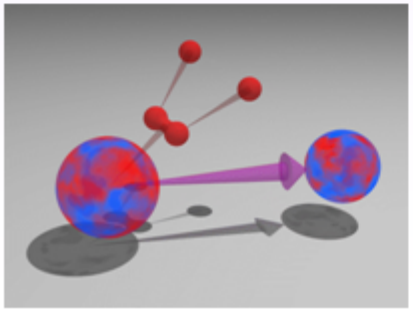
Sequential emission:



Three-body decay:



^{2}He emission:



Two types of 2p emission:

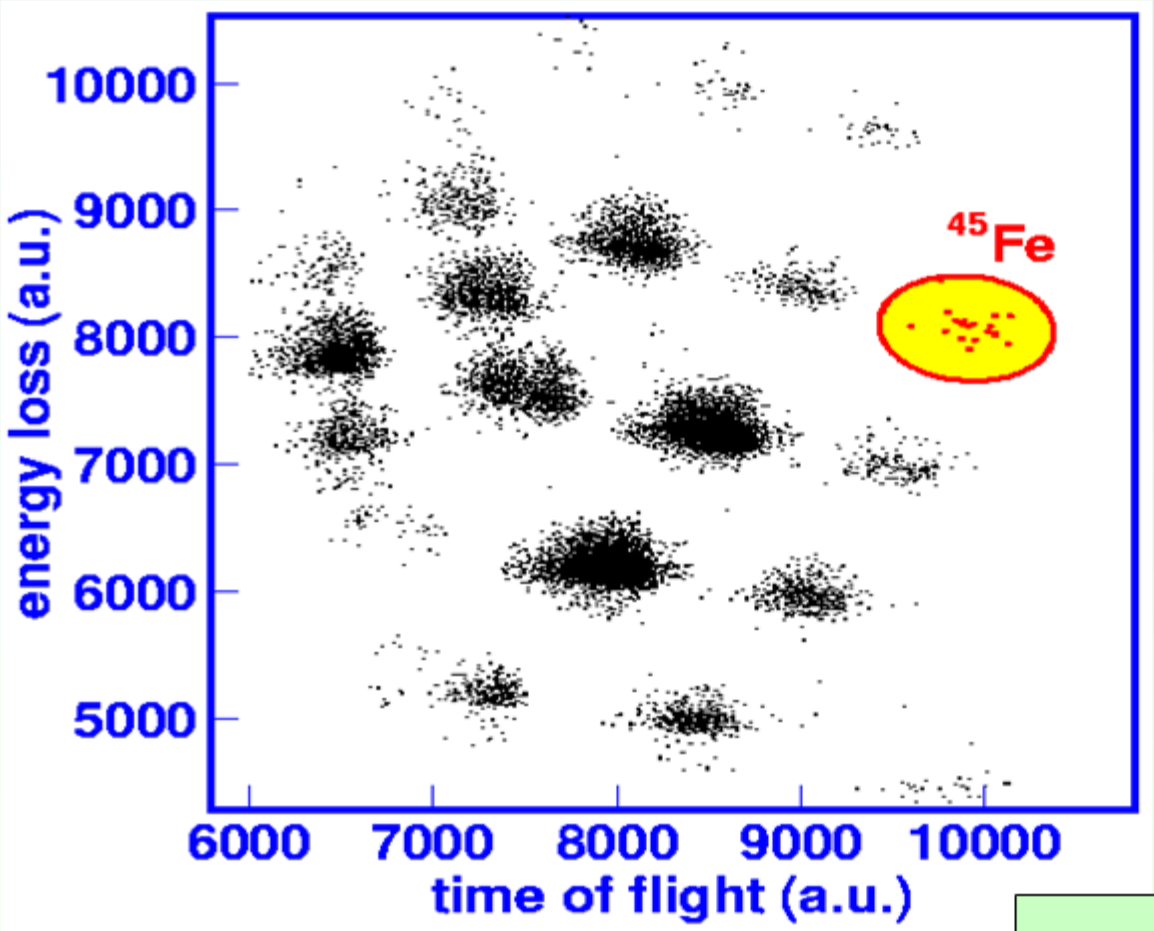
- emission from excited states
  - β delayed: ^{22}Al, ^{31}Ar, …
  - others: ^{14}O, ^{18}Ne, ^{17}Ne, ^{94}Ag

- ground-state emission
  - short lived: ^{6}Be, ^{12}O
  - long lived: ^{45}Fe, ^{48}Ni, ^{54}Zn

To be measured:

- proton energies
- proton-proton angle

identification matrix



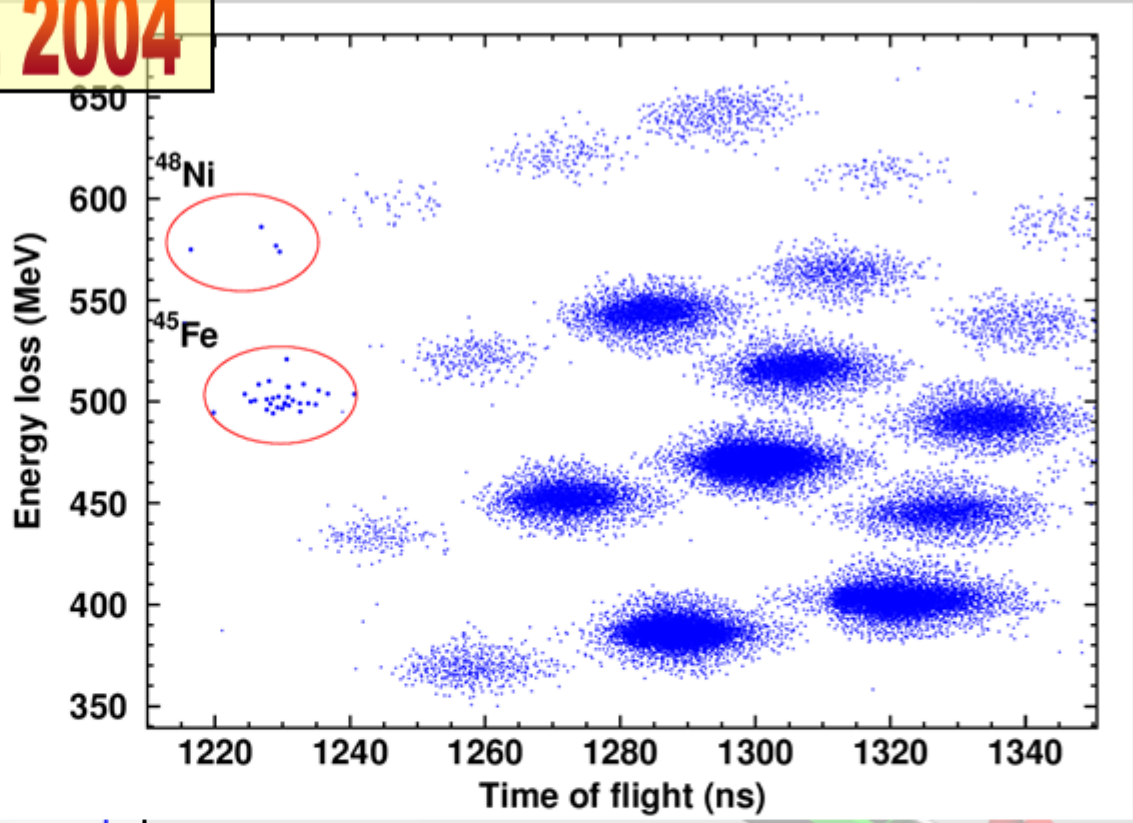
GANIL 2000

22 ^{45}Fe identified

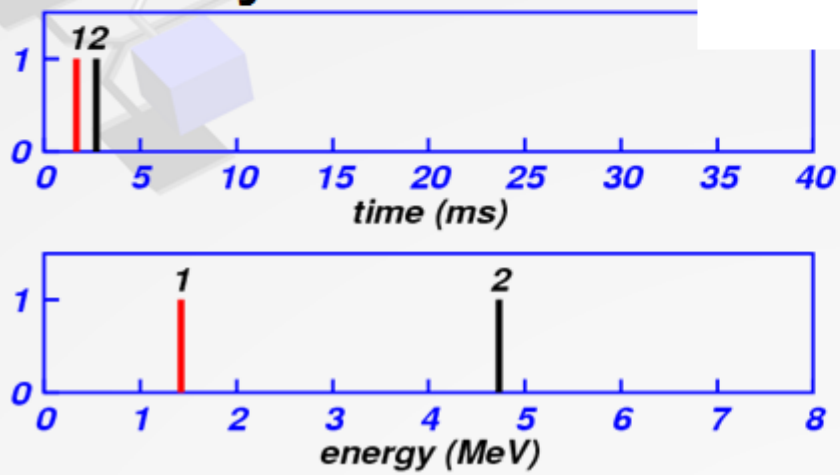
Conditions on 8 identification parameters

⇨ Background free spectra

nickel-48 from GANIL 2004



One decay event:



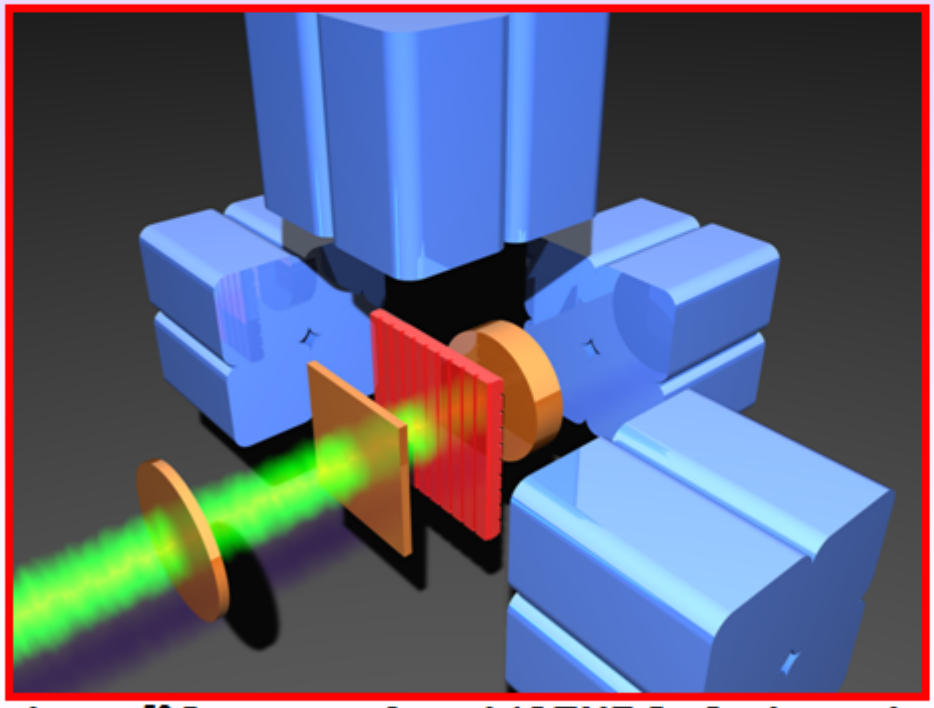
- identification of four ^{48}Ni
- three decays with β particle and high energy
- one event compatible with 2p radioactivity

➔ no conclusive picture, but…

Two-proton radioactivity experiments at the Big RIPS

1

- Nuclei of interest: ^{59}Ge, ^{63}Se, ^{67}Kr
- Production: ^{78}Kr fragmentation at 360 MeV/u, 100pnA
- Separation: BigRIPS
- Detection: standard BigRIPS detection + silicon telescope with DSSSD (1mm) + Germanium detectors



- Settings: ^{59}Ge, rate = 9 ppd (CENBG, Stolz et al. + EPAX2)
- Settings: ^{63}Se, rate = 6 ppd (Stolz et al. + EPAX2)
- Settings: ^{67}Kr, rate = 4 ppd (Stolz et al. + EPAX2)
- New isotopes: ^{59}Ge, ^{63}Se, ^{68,67}Kr
- Detailed spectroscopy of proton-rich nuclei: ^{60}Ge, ^{64}Se, …..

Beam-time request

- aim: observe for the first time ^{59}Ge, ^{63}Se, ^{67,68}Kr
  search for 2p decay of ^{59}Ge, ^{63}Se, ^{67}Kr
  observe about 10-20 decays
  identify two-proton radioactivity of new emitters

- beam time needed:

tuning and calibration of BigRIPS:	2 days
setting on ^{57}Zn to calibrated detectors:	2 days
setting on 2p candidate ^{59}Ge:	3 days
setting on 2p candidate ^{63}Se:	3 days
setting on 2p candidate ^{67}Kr:	3 days
total request:	13 days

- accepted beam time: 5 days

Collaboration:

- **CEN Bordeaux – Gradignan**
  B. Blank, G. Canchel, J. Giovinazzo, J. Huikari, I. Matea, J. Souin
- **GANIL Caen**
  J.C. Dalouzy, F. de Grancey, F. de Oliveira Santos, S. Grévy, M. Lewitowicz, I. Stefan
- **NIPNE Bucharest**
  C. Borcea
- **IPHC Strasbourg**
  M. Rousseau
- **RIKEN**
  H. Baba, T. Kubo, S. Nishimura, M. Nishimura, T. Ohnishi, H. Sakurai, H. Scheit, T. Sumikama
- **University of Tokyo**
  S. Hayakawa, Y. Ichikawa, H. Kimura, S. Kubono, T. Ohnishi, A. Shiraki, Y. Wakabayashi, H. Yamaguchi
- **KEK**
  H. Miyatake, Y. Hirayama
- **Osaka University**
  Y. Fujita, T. Fukuchi, A. Odahara, T. Shimoda
- **Kyushu University**
  T. Teranishi

Unprecedented high intensities for proton rich drip line nuclei

➔ ideal place to do 2p radioactivity studies

^{100}Sn at RIBF

Decay spectroscopy in the vicinity of ^{100}Sn

Collaboration (spokespersons):

- *GANIL, France*: S. Grevy, M. Lewitowicz, F. De Oliveira, O. Sorlin, W. Mittig,
- I. Stafan and J.-Ch. Dalouzy
- *TU Munich, Germany*: M. Böhmer, Th. Faestermann, J. Friese, R. Gernhäuser, Ch. Hinke, Th. Kröll, R. Krücken
- *RIBF/RIKEN, Japan*: Y. Ichikawa, T. Kubo, S. Nishimura, H. Scheit, T. Sumikama
- *GSI, Germany*: P. Bednarczyk, J. Gerl, H. Geissel, M. Górska, H. Grawe, E. Roeckl, K. Sümmerer, H. Weick
- *CEN Bordeaux-Gradignan, France*: B. Blank, G. Canchel, J. Giovinazzo, J. Huikari, I. Matea,
- J. Souin
- *Warsaw University, Poland*: Z. Janas, M. Karny M. Pfützner
- *IPHC Strasbourg, France:* M. Rousseau
- *IFI Valencia, Spain:* B. Rubio
- *Osaka Univ., Japan:* Y. Fujita, T. Fukuchi, T. Shimoda
- *KEK, Japan:* H. Miyatake, Y. Hirayama
- *Tokyo Univ.:* H. Kimura

Physics Case

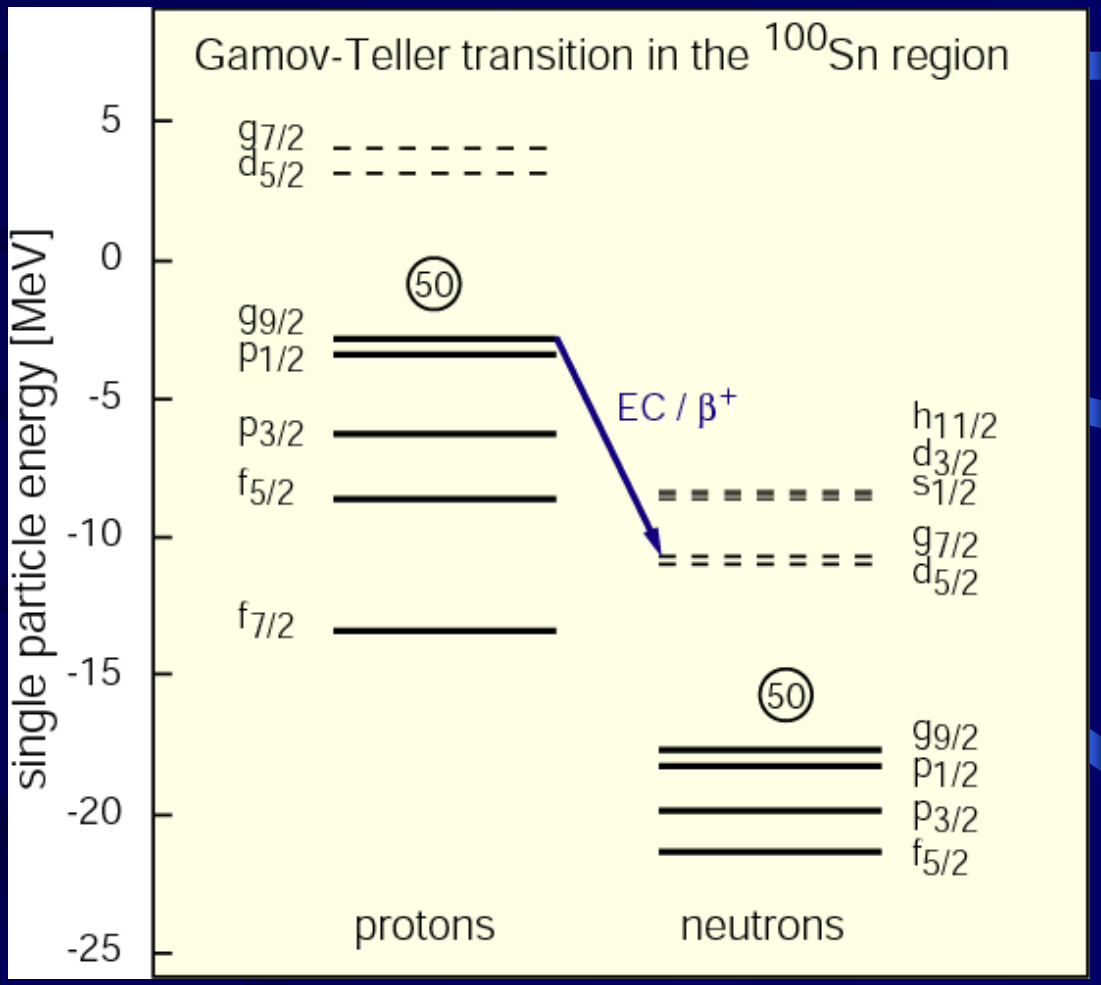
^{100}Sn

Highest Priority at RNC !!

Ideal testing ground
for GT-strength:

Pure spin-flip transition
$0^+ \Rightarrow (\pi g_{9/2}^{-1}\, \nu g_{7/2}) 1^+$
The purest GT transition in nuclear chart ?

Large decay energy
=> most of GT resonance
in β - decay window



M.Lewitowicz, GANIL

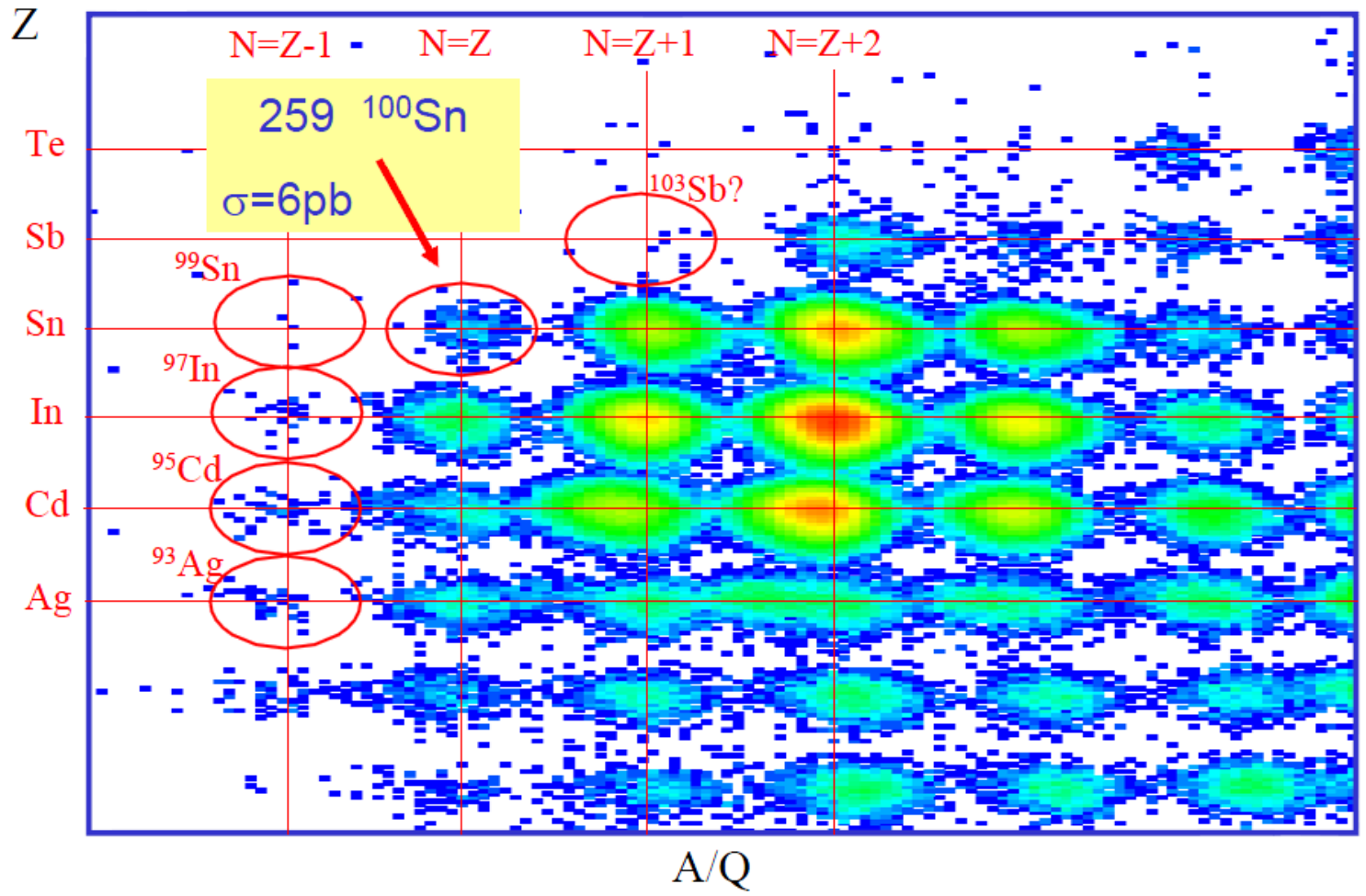
After 100Sn proposal in 2007

^{100}Sn history

year	where	production	events	quantity		
1994	GSI	fragm. ^{124}Xe	7	$T_{1/2}$	E(β)	E(γ)
1994	GANIL	fragm. ^{112}Sn	11		ident.	
1996	GANIL	fusion	11		Δm	
1998	GSI	fragm. ^{112}Sn	1	$T_{1/2}$	E(β)	E(γ)

By Thomas Faestermann

New Isotopes



By Thomas Faestermann TUM

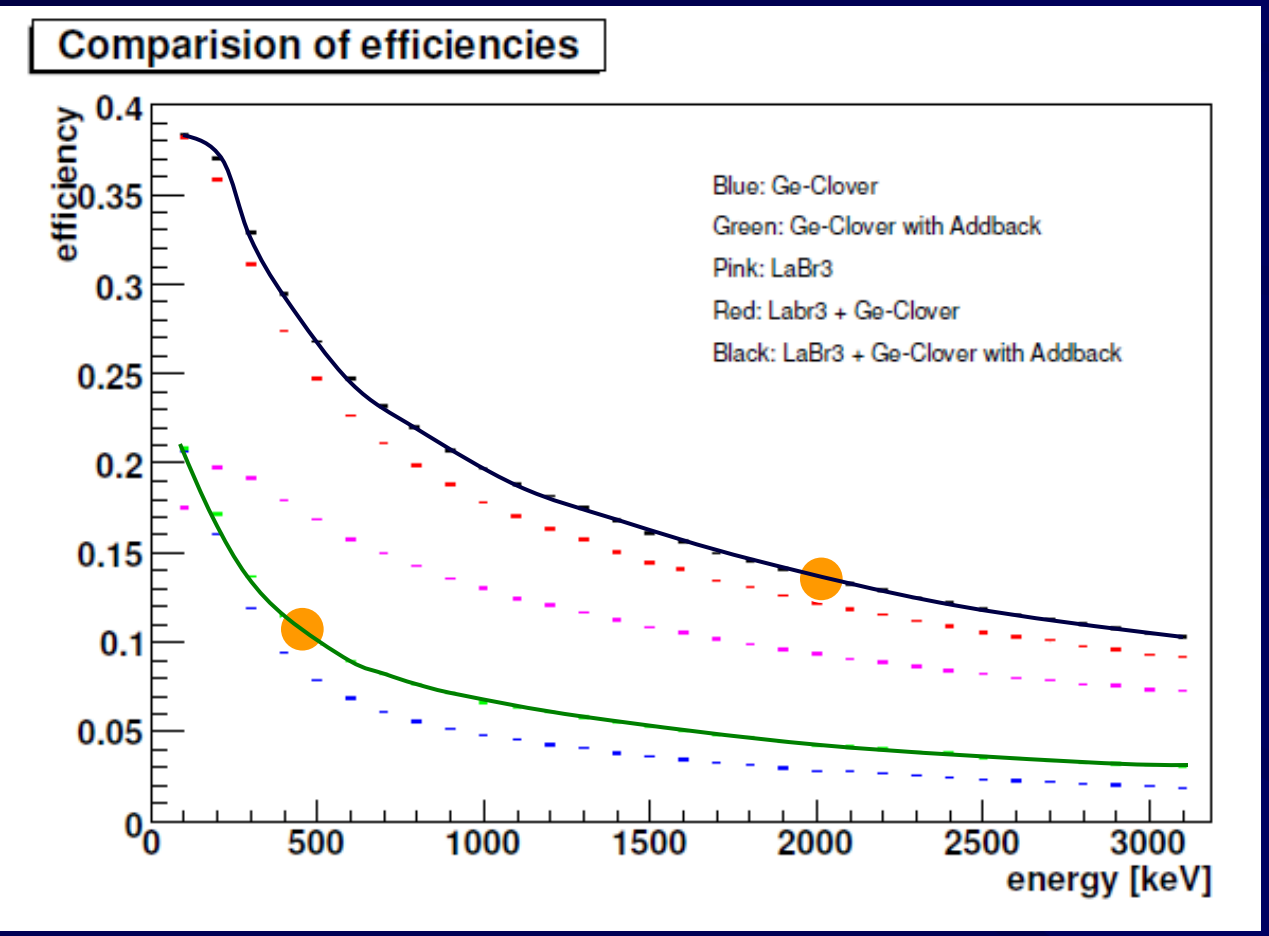
Comparison : GSI vs RIKEN

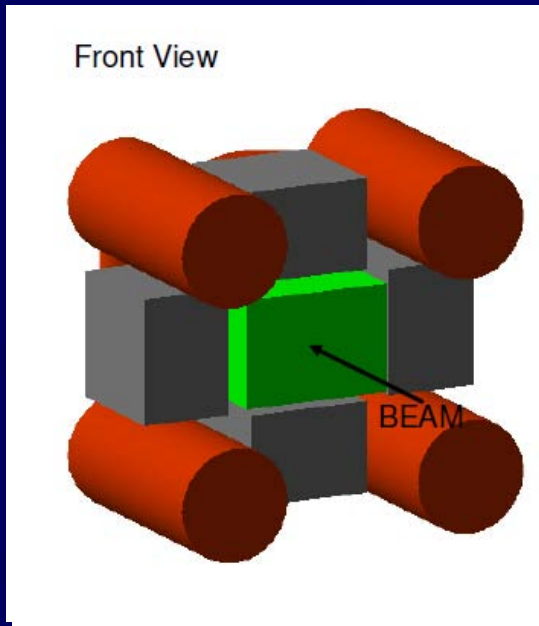
GSI, FRS		RIKEN, BigRips	
0.6 pnA ^{124}Xe, 1 AGeV		10 pnA ^{124}Xe, 345 AMeV	x 60
4g Be target, 20 days	**not linear.**	1g Be target, 10 days	x 1/6
σ = 5.8 pb		σ =< 5.8 pb **?**	
transmission 0.85 * 0.50	**ion optics+ ch.state, destruction**	transmission 0.98 * 0.54	x 5/4
detection rate 0.7/ h		detection rate ~20 / h	
duty factor 90%, 80%	**accelerator+ Exp calib.**	duty factor 75 %, 80%	x 5/6
total production : **259**		total production : **4000**	
total counts for $\gamma\gamma$: 80		total counts for $\gamma\gamma$: 2500	

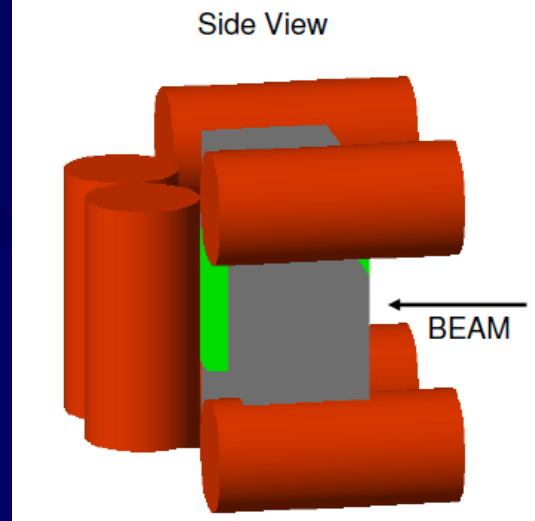
Numbers are only 10% precise

By Roman Gernhäuser, Christoph Hinke TU-München

4xClover + 6xLaBr3 Efficiency







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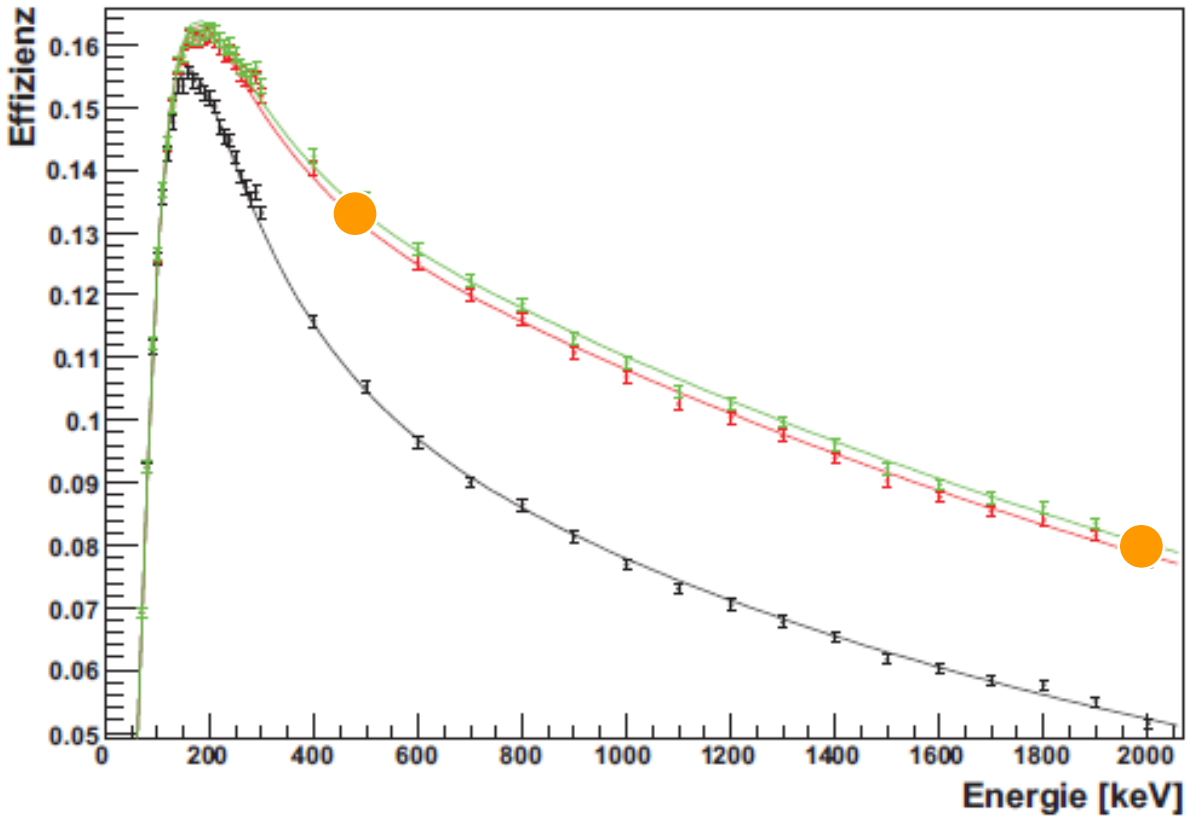
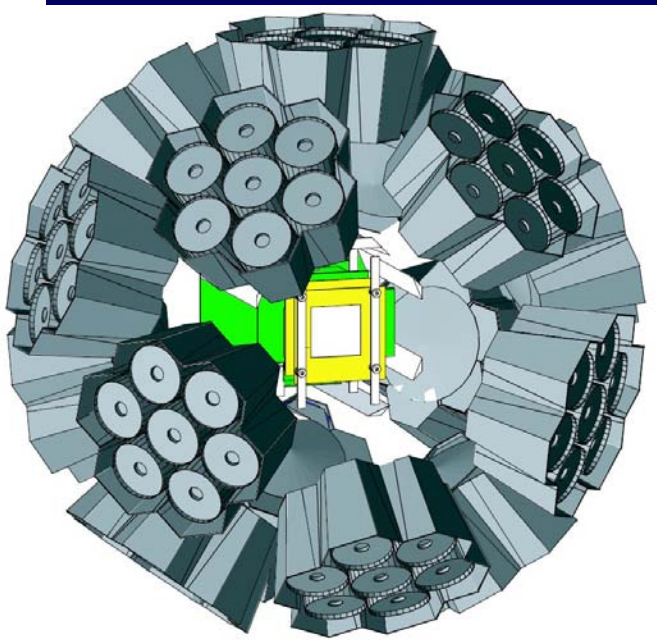
RISING Efficiency





By Roman Gernhäuser, Christoph Hinke TU-München

Comparison

Rising:
ε_{low} = 12% ε_{high} = 9%

well known setup
good energy resolution

higher granularity
isomer measurement
could be extended with LaBr.

owners club
transport
LN2 Installation
maintenance

Clover + LaBr:
ε_{low} = 9 % ε_{high} = 14%

New mounting structure
sufficient energy resolution
intrinsic BG
low granularity
(prompt flash)
very tight setup

Angela Bracco
new frame design

Proposed Study of RIBF-009

- Search for new isotopes (ex.^{98,99}Sn, $^{94\text{-}96}$Cd)

93Ag, 95Cd, 99Sn @ GSI → 98Sn

- Measurement of the GT - strength in the decay of ^{100}Sn and neighboring nuclei

More precision !?

- Search for & study of isomeric states in ^{100}Sn and neighboring nuclei
  - ^{96}Pd, (15^{+}) and ^{98}Cd, (12^{+}) and an expected ^{99}In, $17/2^{+}$ provide crucial information on the ^{100}Sn shell gaps and the residual interaction in the sdg model space **100Sn**

6+ Isomer is still under discussion

- Identification of new proton/alpha emitters

(ex. $^{103\text{-}105}$Sb, ^{104}Te)

M.Lewitowicz → C.Hinke, T.Faestermann,..

Recommendation for EURISOL

do not compromise

on the

detection systems!

Best of

- Production yield (RIBF)
- DSSSD & Readout electronics (SIMBA & RIKEN readout)
- gamma-ray detectors (E(U)RICA + LaBr3)

Thank you
for your attention