BRIKEN Workshop @ RIKEN, 2013, July 30

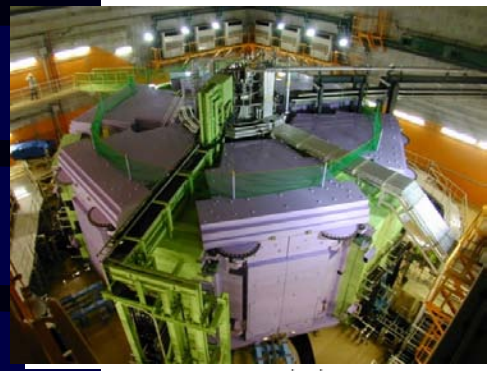
Beta-decay studies using BigRIPS at RIKEN Nishina Center

Shunji NISHIMURA

(RNC)

-Production yield
-Devices
-Location
-Beam time at RIBF

Location of Decay Station



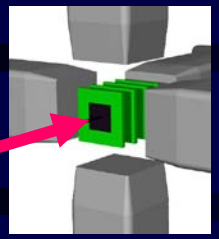
^{238}U … 345 MeV/u,

… Intensity = 5 – 12 pnA !

Decay Programs at RIBF

2009
2010
2011
2012
2013
2014

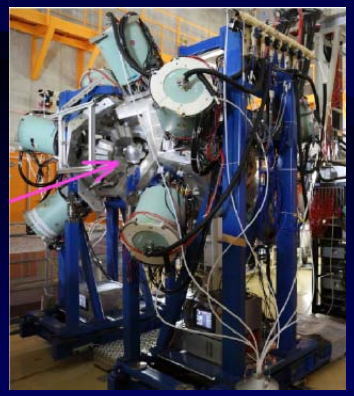
β-γ



^{110}Zr region
(3-days)

*PLB 696, 186 (2011)
*PRL. 106, 052502 (2011)
*PRL. 106, 202501 (2011)
*PLB 704, 270 (2011)

EURICA Project

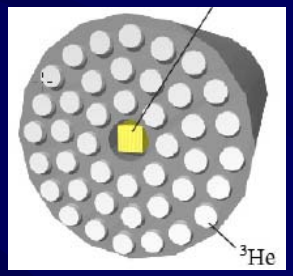


WAS3ABi (Si)

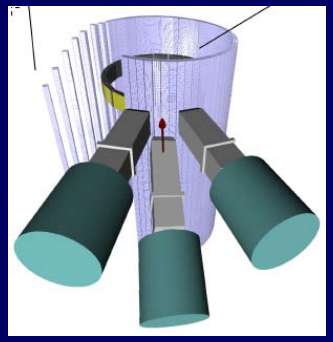
β-n
[high efficiency]

^{3}He counters (x 27)

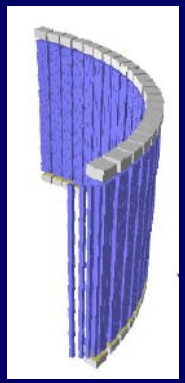
Neutron detectors



β-γ-n
[fast timing]



Neutron detectors
(TOF)
LaBr3 detectors



== 2014 Dec. EURICA → back to GSI ==

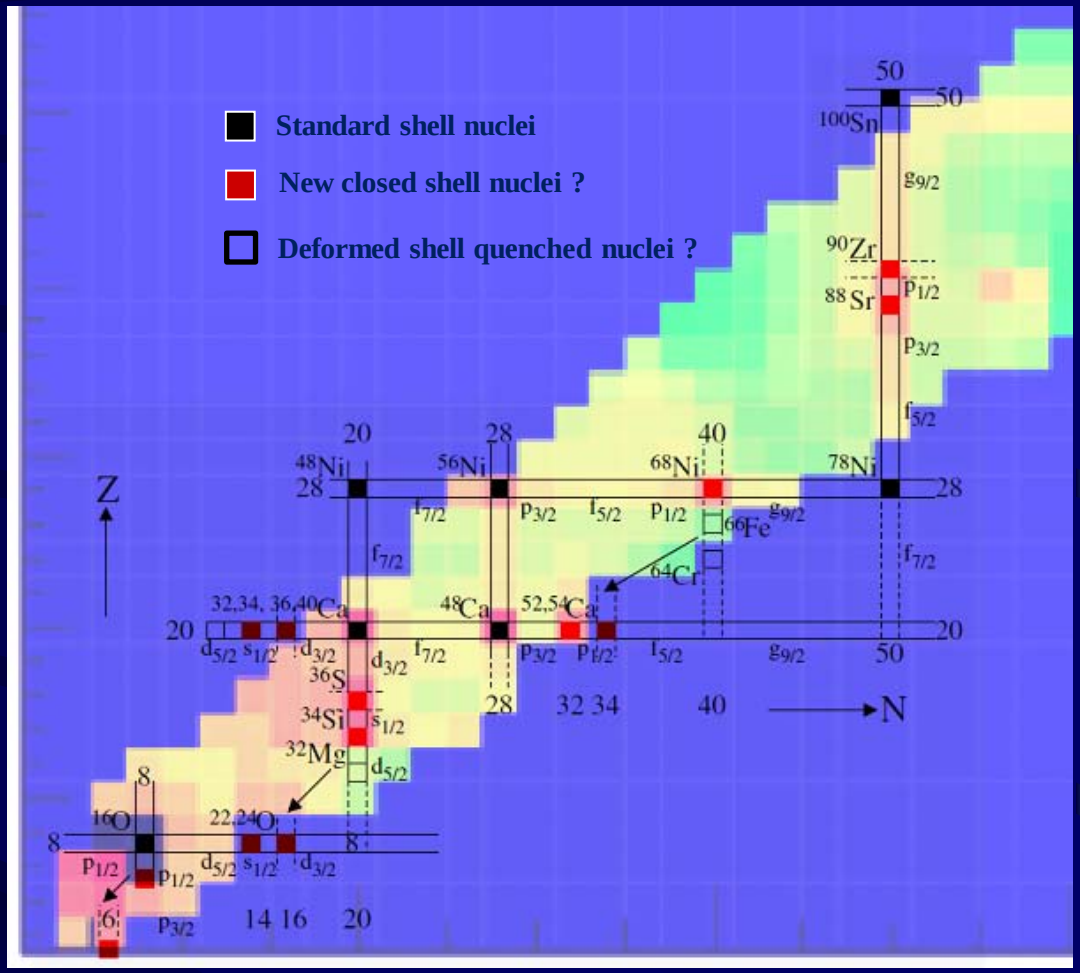
Motivation (Decay Spectroscopy)

Measurements by decay exp.

- **Decay curve : $T_{1/2}$**
- **Excited states : $E(2^+)$, ..**
- **Isomeric states**
- **Q_β**
- **Neutron emission (P_n)**

Systematic Study

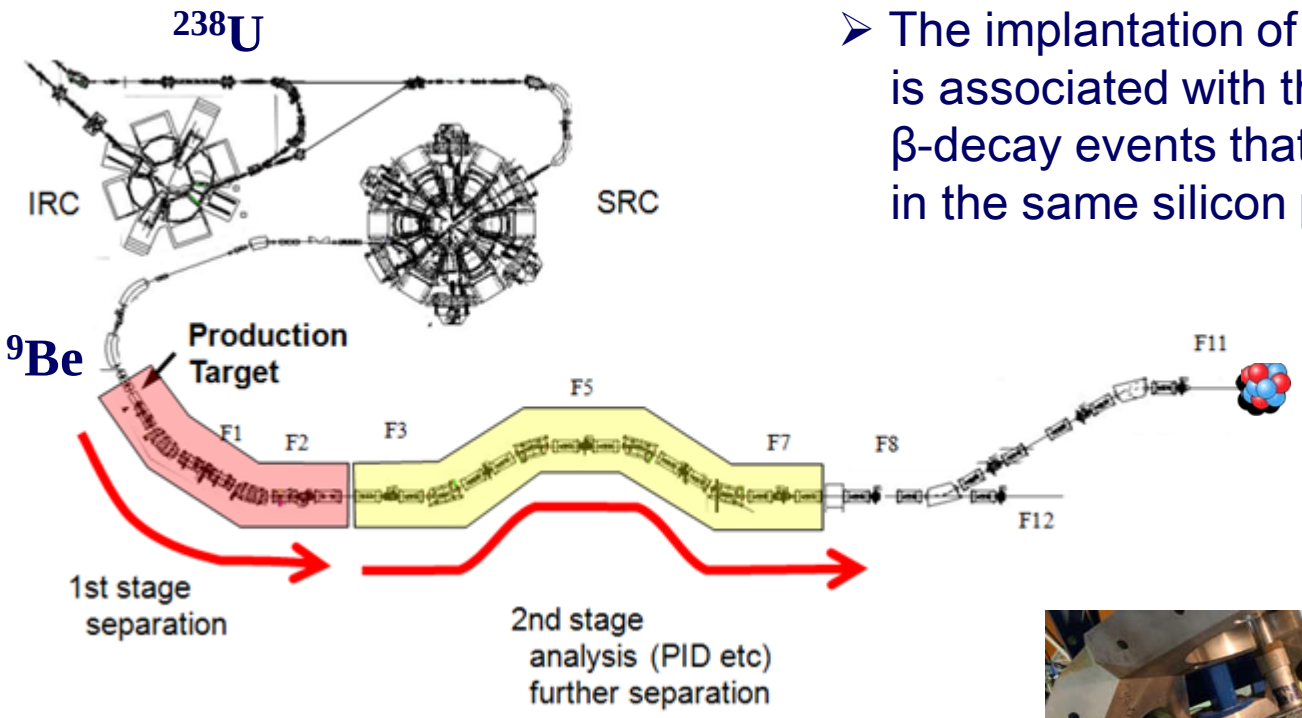
- Nuclear Structure
  - **New magic number ?**
  - **Disappearance?**
  - **Shell quenching?**
  - **Deformation?**



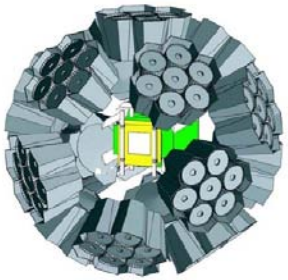
Inputs

- **Feedback to Nuclear Theory**
- **Study of Nuclear Astrophysics**

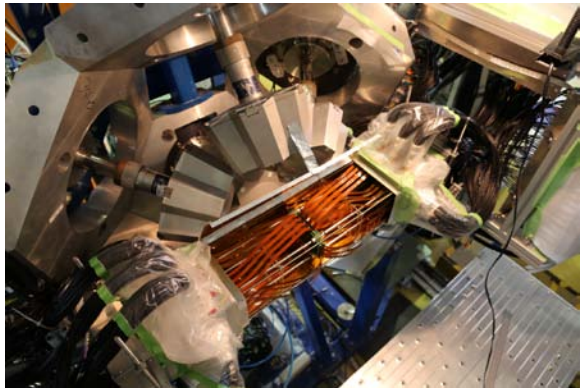
Beam Production at RIBF



- The implantation of an identified RI is associated with the following β-decay events that are detected in the same silicon pixel (DSSSD).

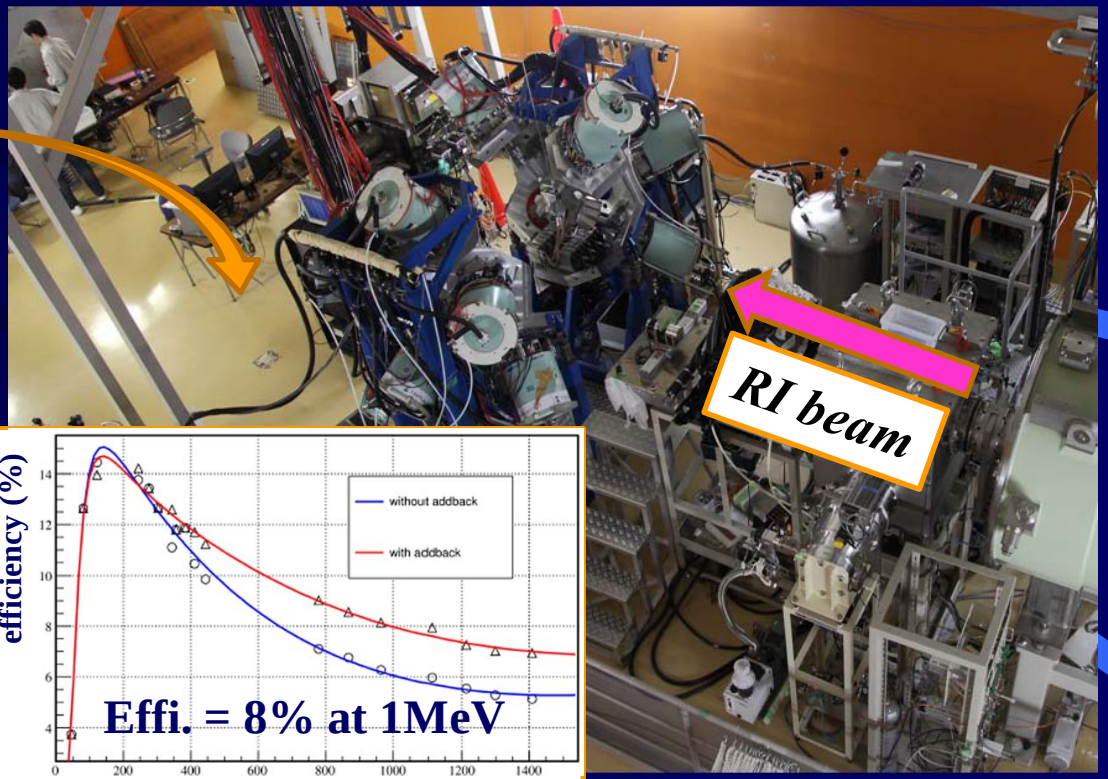


- ΔE-TOF-Bρ method using the focal plane detectors.



EURICA Project at RIBF

(EUROBALL RIKEN Cluster Array)



Euroball Cluster detectors
Support structure
Readout electronics
used for GSI-RISING

RIKEN RIBF (Japan)

Installation completed in 2012 Feb.

Beta counting system: WAS3ABi

(Wide-range Active Silicon-Strip Stopper Array
for Beta and ion detection)

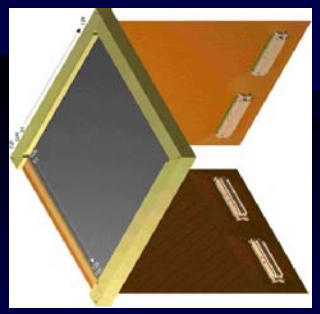
RIKEN,
IBS/TU München/York

(a)

(b)

(c) SIMBA → WAS3ABi

(d)



Micron BB13
(Univ. York)

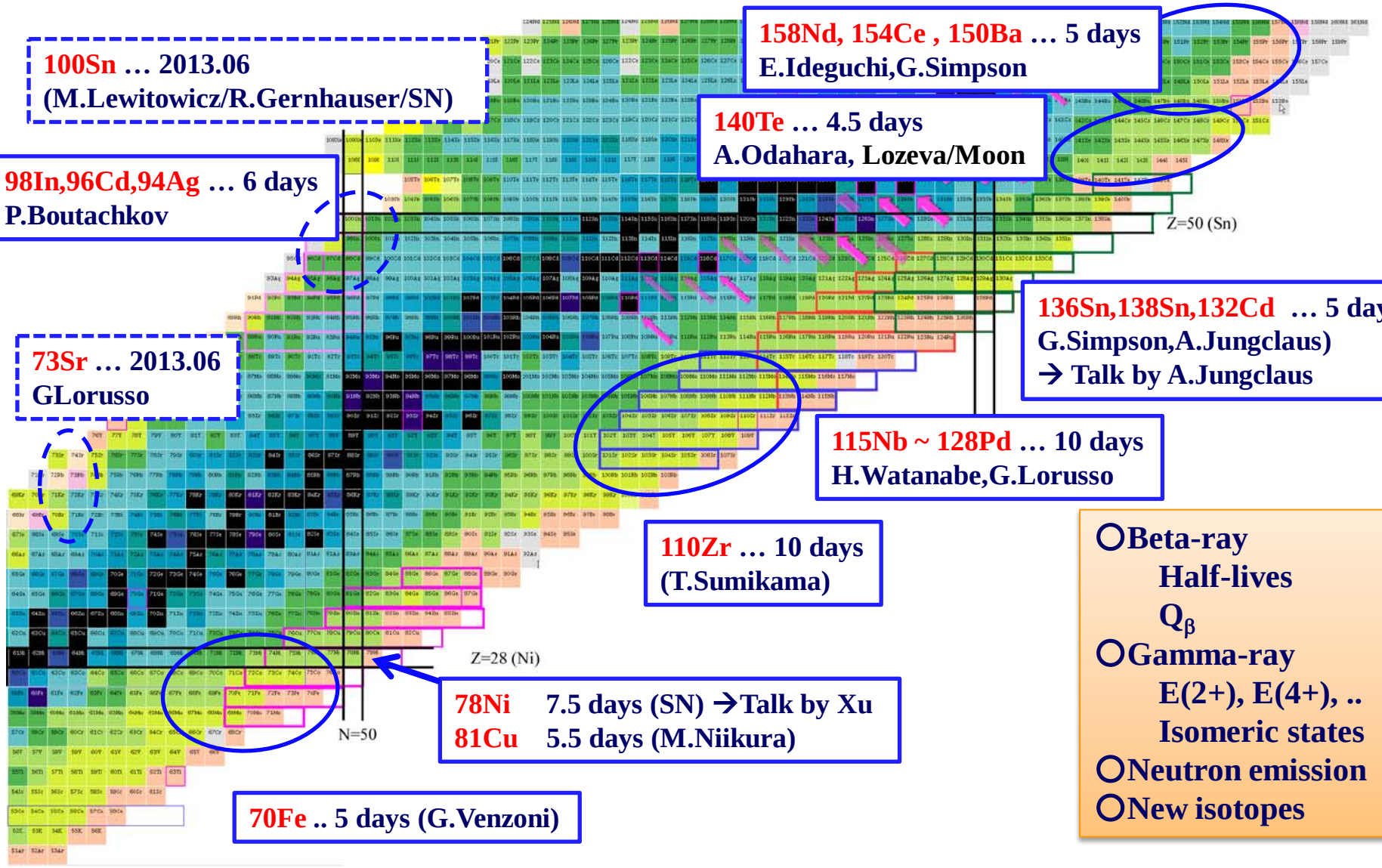
(a) 14,000pixels + Plastic (Qbeta) … 2012 U-beam

(b) 12,000pixels + Plastic (Fast timing) … 2013 U-beam

(c) 7,200 pixels + 10 x SSD (Qbeta)
SIMBA → Installed in WAS3ABi … 2013 Xe-beam

(d) 16,000 pixels + Plastic (Veto) … 2013 Xe-beam

Survey of Decay Properties with EURICA



100Sn … 2013.06
(M.Lewitowicz/R.Gernhauser/SN)

158Nd, 154Ce , 150Ba … 5 days
E.Ideguchi,G.Simpson

140Te … 4.5 days
A.Odahara, Lozeva/Moon

98In,96Cd,94Ag … 6 days
P.Boutachkov

136Sn,138Sn,132Cd … 5 days
G.Simpson,A.Jungclaus)
→ Talk by A.Jungclaus

73Sr … 2013.06
GLorusso

115Nb ~ 128Pd … 10 days
H.Watanabe,G.Lorusso

110Zr … 10 days
(T.Sumikama)

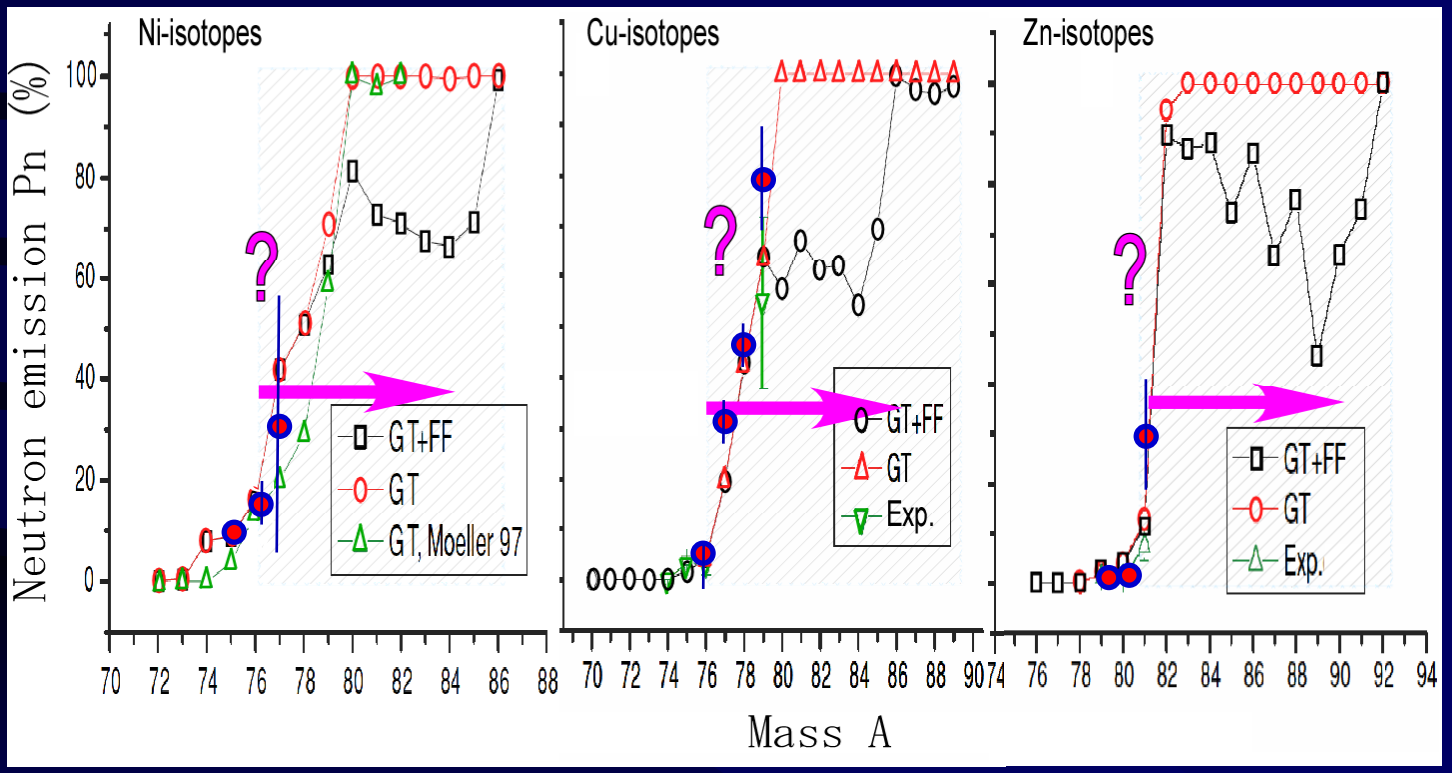
78Ni 7.5 days (SN) →Talk by Xu
81Cu 5.5 days (M.Niikura)

70Fe .. 5 days (G.Venzoni)

- **Beta-ray**
  - **Half-lives**
  - **Q_β**
- **Gamma-ray**
  - **E(2+), E(4+), ..**
  - **Isomeric states**
- **Neutron emission**
- **New isotopes**

Neutron Emission

I.N.Borzov Phys. Rev. C71 (2005) 065801 + P.Hosmer, PRC82 (2010)



Rapid increase of neutron emission prob. around 78Ni.

Upgrade of EURICA in 2013

18 detectors
φ1.5” x 2”

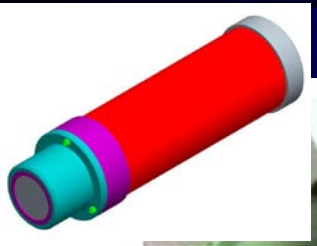
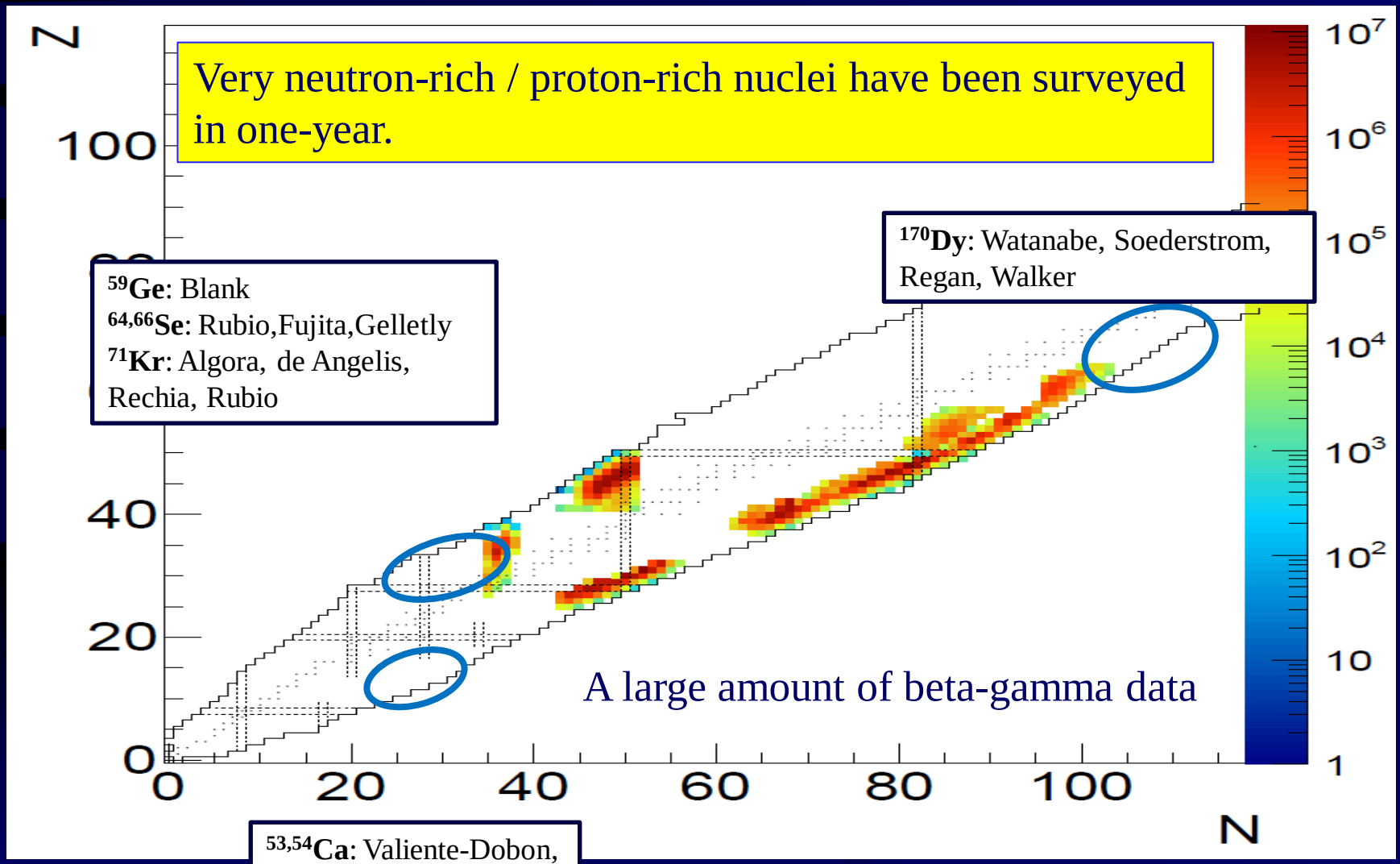


Figure 2: Configuration of $LaBr_3$:Ce detectors within EURICA.

UK ・ $LaBr_3$ detectors

- For short life-times a $LaBr_3$ array for fast timing has been installed to complement the HPGe detectors

EURICA Campaign



Interesting physics results are coming !

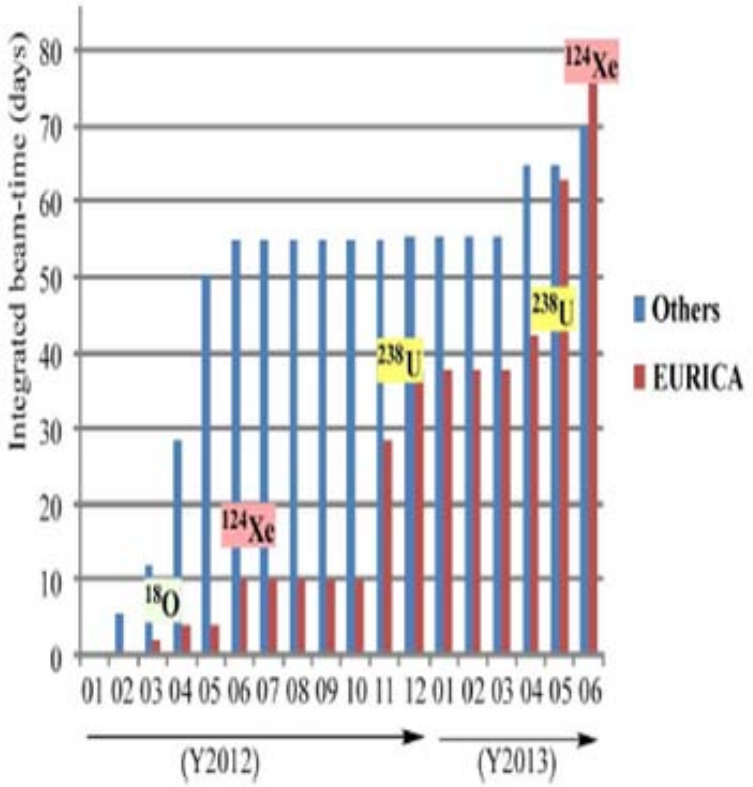
EURICA Beam time at RIBF

A, S/A, S-rank Experimenta at RIBF

^{238}U-beam … 9 proposals completed
^{124}Xe-beam … 2 proposals completed

Date (Period)	Experiment	Spokesperson
2012.03 (2 days)	EURICA-MS(^{18}O)	Nishimura/Doornenbal
2012.04 (2 days)	EURICA-MS(^{18}O)	Nishimura/Doornenbal
2012.06 (6 days)	EURICA (^{124}Xe)	Boutachkov
2012.11 (7.5 days)	EURICA(^{238}U)	Nishimura
2012.11 (6 days)	EURICA(^{238}U)	Watanabe/Lorusso
2012.11 (5 days)	EURICA(^{238}U)	Simpson/Jungclaus
2012.11 (3.7 days)	EURICA(^{238}U)	Watanabe/Lorusso
2012.12 (5.5 days)	EURICA(^{238}U)	Niikura
2013.04 (4.5 days)	EURICA(^{238}U)	Odahara/Lozeva/Moon
2013.05 (9.5 days)	EURICA(^{238}U)	Sumikama
2013.05 (5.5 days)	EURICA(^{238}U)	Ideguchi/Simpson
2013.05 (5.7 days)	EURICA(^{238}U)	Benzoni
2013.06 (12 days)	EURICA(^{124}Xe)	Lewitowicz/Krücken/Gernhäuser/Nishimura
2013.06 (2.5 days)	EURICA(^{124}Xe)	Lorusso

Table 1: Summary of performed experiments and used beam Time for data runs with EURICA at the RIBF. Beam time necessary to prepare the secondary beams and to calibrate the BigRIPS beam line detectors for the various settings is not included.

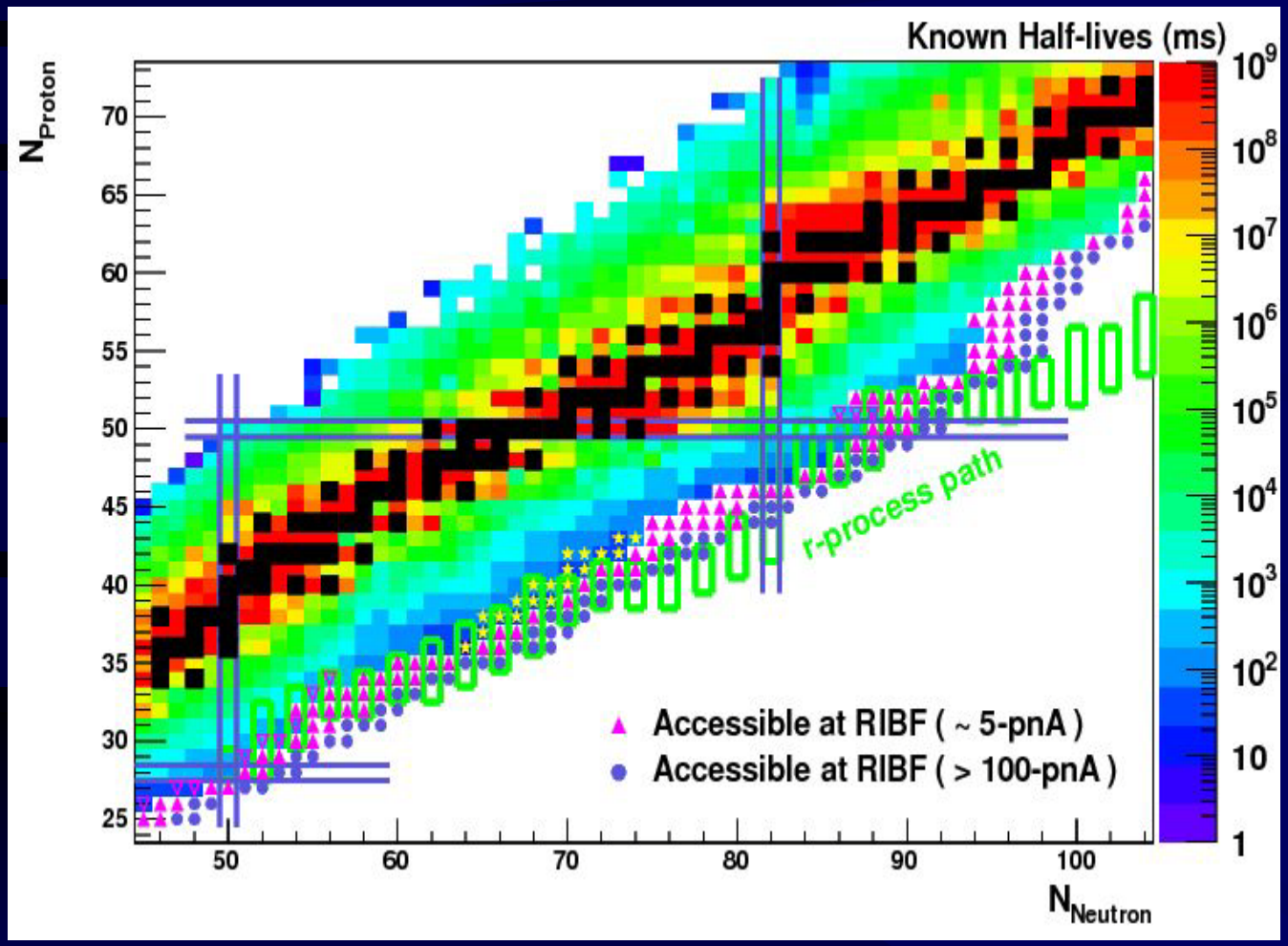


^{238}U-beam … 1 proposal
^{76}Kr-beam … 3 proposals
^{70}Zr-beam … 1 proposal

Summary

- EURICA project
  - June 2012: ^{124}Xe
  - Fall 2012: ^{238}U
  - Spring 2013: ^{238}U, ^{124}Xe
- Results are all very promising
  - Beta-delayed neutron (P_n, P_{2n}, P_{3n}) could be deduced for some of the RIs
- BRIKEN
  - U-beam : 10 pnA → ** pnA ? in 2014 / 2015..
  - High efficiency 3He detectors will enable us to measure Pn

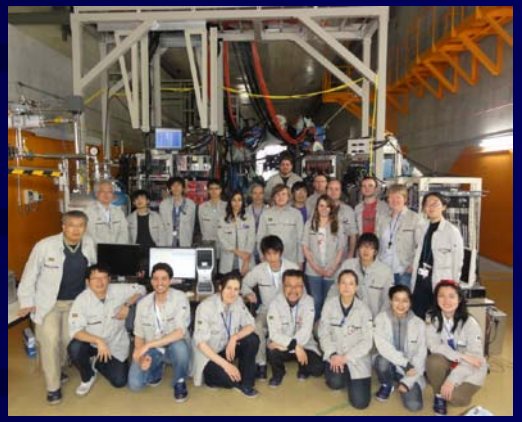
In five years… (U-beam int. ≥ 100 pnA!?)



Several hundreds of new beta-decay half-lives in five years.
→ Significant contribution in nuclear structure and r-process nucleosynthesis.

EURICA Collaboration and Support

2012 Nov.-Dec.



2013 May

2012 June

Collaboration:
Tohoku, Univ. Tokyo, Brighton Univ. Debrecen, Joseph Fourier, Osaka Univ. Peking, LPSC, IBS, Oslo, Consejo Sup. De Inv. Cientificas, IPN Orsay, Padova, Leuven, SKKU, INFN, ANU, Koeln, TU Muenchen, Fisica, Legnaro, ATOMKI, INFN-Milano, INFN-Firenze, INFN-LNL, Univ. di Padova, Surrey, GSI, ANL, Yale, Milano, Univ. Madrid, Tech. Univ. Darmstadt, Univ. Istanbul, CNS, CEA, RCNP, Univ. Notre Dame, Inst. voor Kern-en Stralings Fysica, Hoseo Univ., Univ. Tsukuba, Inst. Plurid. Hubert Curien, and RIKEN

International Supporting Program

PhD Student	Institute	Term	Status
Moschner, Kevin	University of Cologne	Jun. 2012 – Aug. 2012	Completed
Browne, Frank	University of Brighton	Oct. 2012 – Sep. 2013	Active
Taprogge, Jan	IEM CSIC	Oct. 2012 – Dec. 2012	Completed
Vajta, Zsolt	ATOMKI, Debrecen	Oct. 2012 – Dec. 2012	Completed
Gey, Guillaume	University J. Fourier	Oct. 2012 – Jan. 2013	Completed
Rice, Simon James	University of Surrey	Mar. 2013 – Jul. 2013	Completed
Patel, Zena	University of Surrey	Mar. 2013 – Sep. 2013	Active
Sinclair, Laura	University of York	Apr. 2013 – Jul. 2013	Active
Lubos, Daniel	Technische Universität München	May 2013 – Dec. 2013	Active
Kuti, Istvan	ATOMKI, Debrecen	Oct. 2013 – Jan. 2014	In preparation
Montaner, Ana	Institut de Fisica Corpuscular	TBD	In preparation

Table 3: List of IPA Students from European Institutes that participated in the EURICA project.

- Non-Japanese doctoral candidate attending overseas graduate school participating in RIKEN's research
- Contingent reserved for EURICA students
- Stay from three to twelve months
- IPA students so far: