Beta decay and neutron emission studies of r-process nuclei near ^{137}Sb

Karl Smith

JINA Frontiers 2010

Astrophysical Motivation

Cs131 > 99	Cs132 > 99		Cs134 > 99	Cs135	Cs136 19.00	Cs137 > 99	Cs138 > 99	Cs139 > 99	Cs140 63.70	Cs141 24.94	Cs142 1.70	Cs143 1.78	Cs144 1.01	Cs145 0.59	Cs146 0.32	Cs147 0.23
			Xe133 > 99		Xe135 > 99		Xe137 > 99	Xe138 > 99	Xe139 39.68	Xe140 13.60	Xe141 1.73	Xe142 1.24	Xe143 0.30	Xe144 1.15	Xe145 0.90	Xe146
I129	I130 > 99	I131 > 99	I132 > 99	I133 > 99	I134 > 99	I135 > 99	I136 83.40	I137 24.50	I138 6.49	I139 2.28	I140 0.86	I141 0.43	I142	I143	I144	I145
	Te129 > 99		Te131 > 99	Te132 > 99	Te133 > 99	Te134 > 99	Te135 19.00	Te136 17.50	Te137 2.49	Te138 1.40	Te139	Te140	Te141	Te142	Te143	Te144
Sb127 > 99	Sb128 > 99	Sb129 > 99	Sb130 > 99	Sb131 > 99	Sb132 > 99	Sb133 > 99	Sb134	Sb135 1.66	Sb136 0.82	Sb137	Sb138	Sb139	Sb140	Sb141	Sb142	Sb143
Sn126 > 99	Sn127 > 99	Sn128 > 99	Sn129 > 99	Sn130 > 99	Sn131 56.00	Sn132 39.70	Sn133 1.20	Sn134 1.12	Sn135	Sn136	Sn137	Sn138	Sn139	Sn140	Sn141	Sn142
In125 2.36	In126 1.60	In127 1.09	In128 0.84	In129 0.61	In130 0.26	In131 0.28	In132 0.20	In133 0.18	In134	In135	In136	In137	In138	In139	In140	In141
Cd124 1.24	Cd125 0.65	Cd126 0.51	Cd127 0.43	Cd128 0.34	Cd129 0.27	Cd130 0.20	Cd131	Cd132	Cd133	Cd134	Cd135	Cd136		Cd138	Cd139	Cd140

Z=50

N=82

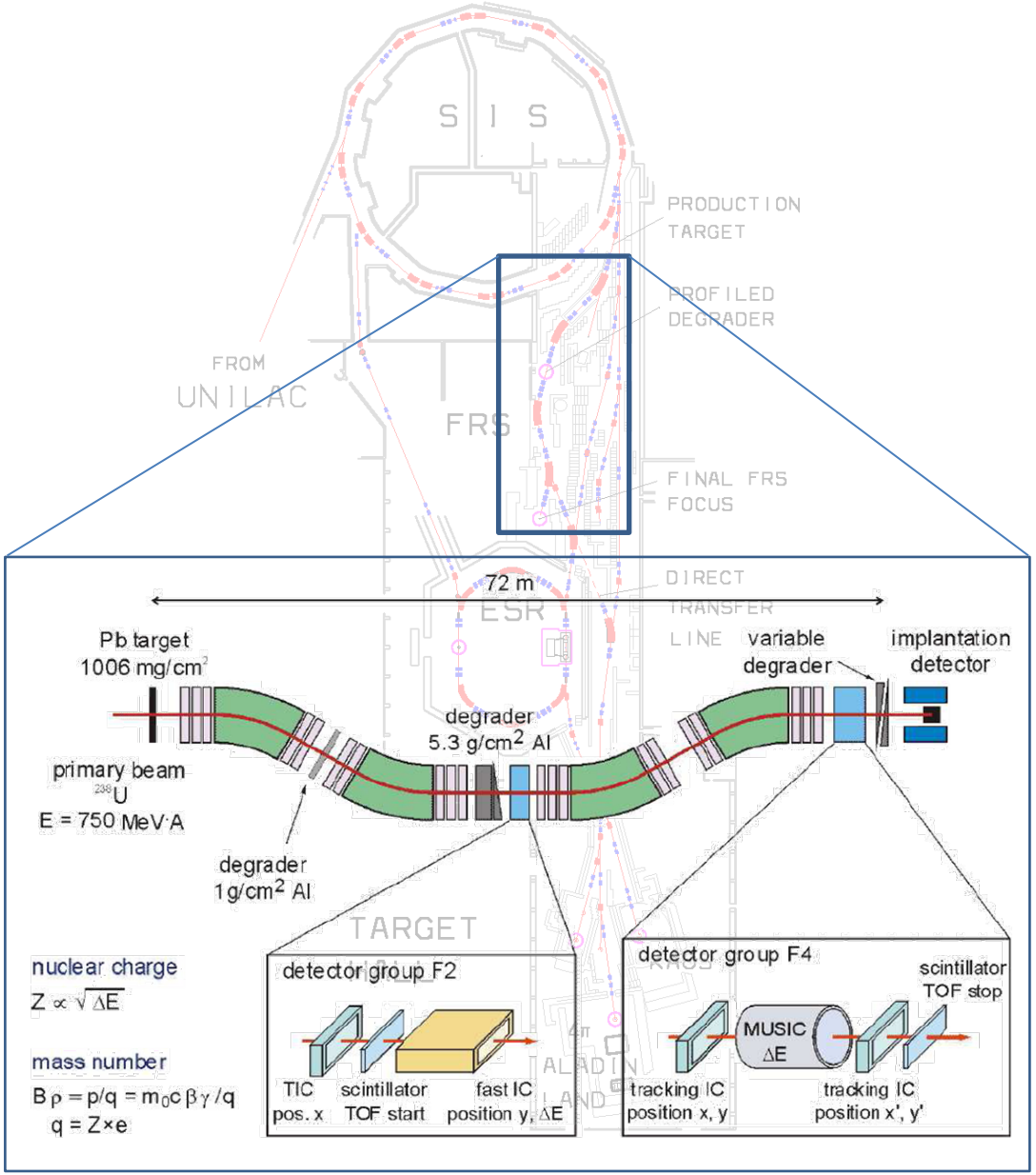
Experimental Setup

Experiment was performed at the Helmholtzzentrum für Schwerionenforschung (GSI)

^{238}U beam on Pb target.

Fission fragments were separated in the FRagment Separator (FRS).

Isotopes of interest were then delivered to the implantation detectors at the final focal plane.



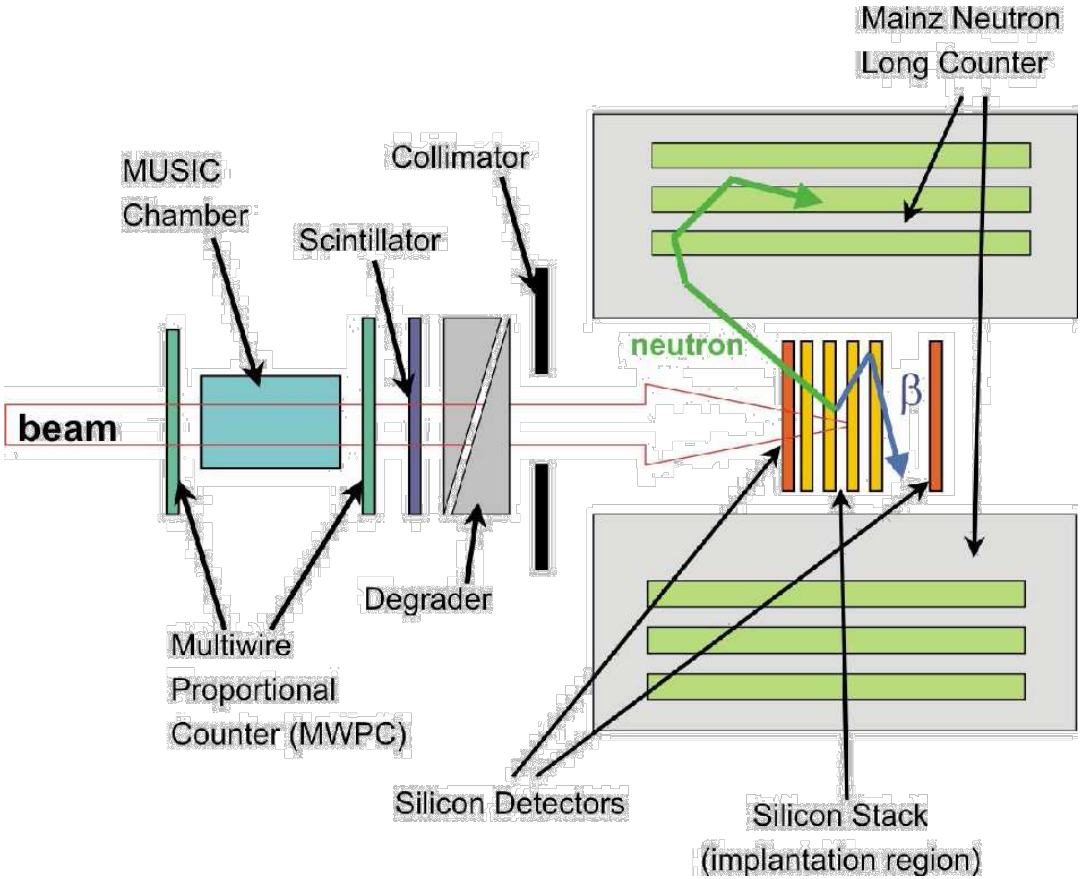
Implantation/Decay Detectors

Detectors

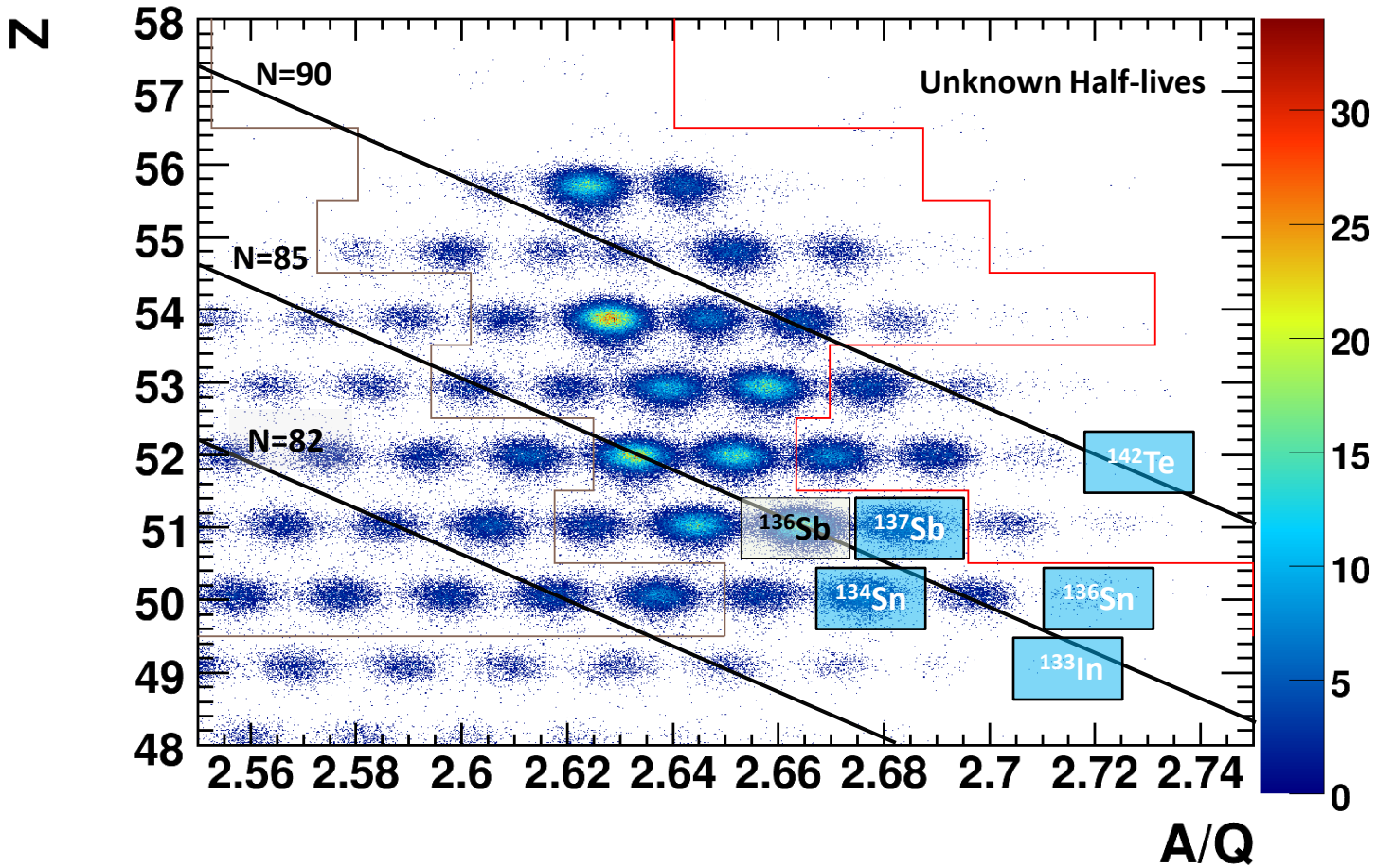
- Isotope Identification
  - Multiwire Proportional Counters
  - MUSIC detector
  - Scintillator
- Decay Identification
  - Silicon Detectors (DSSDs 4x128x16)
  - Neutron Detector

Beam degraded such that isotopes were implanted into the DSSDs.

When the implanted isotope decayed, the emitted β-particle was detected in a DSSD.



Particle Identification

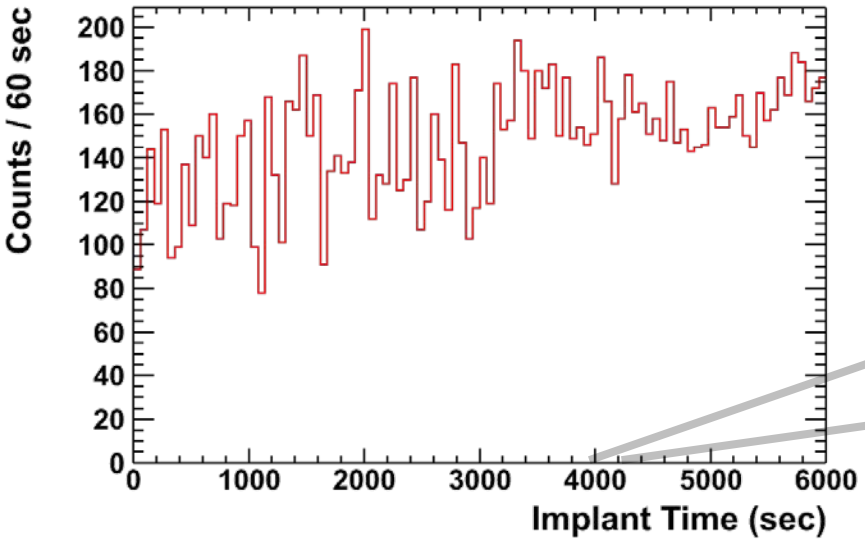


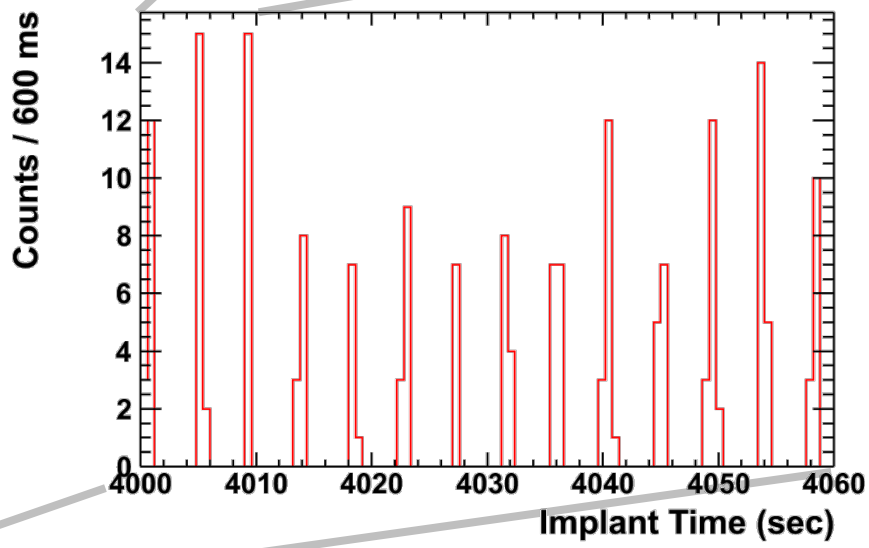
Time-Dependent Beam

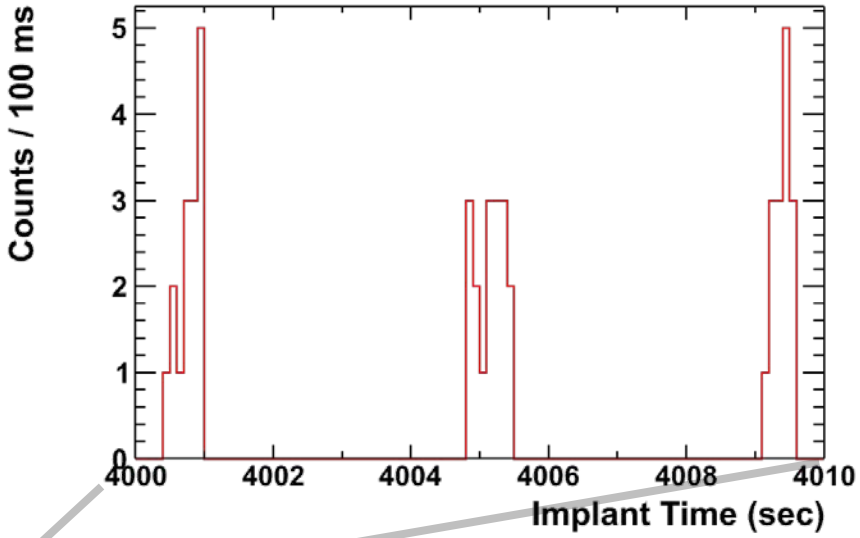
Implants are delivered in spills.

Spill to spill profile is not constant.

Beam induced background is not constant in time.

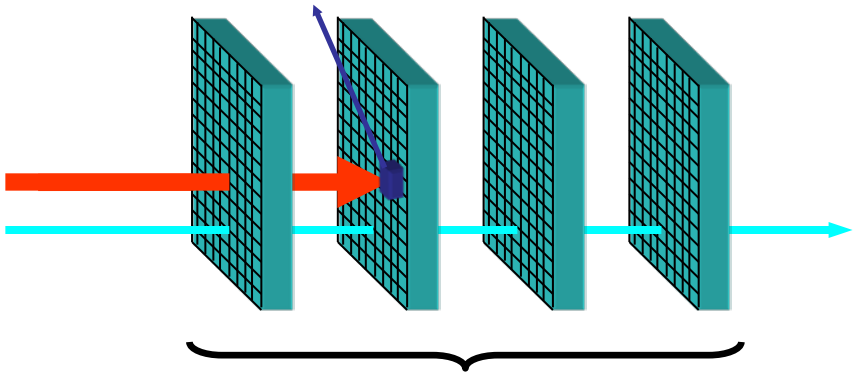






β-Decay Correlation

- Implantation DSSD:
  x-y position (pixel), time
- Light particles
- Decay DSSD:
  x-y position (pixel), time



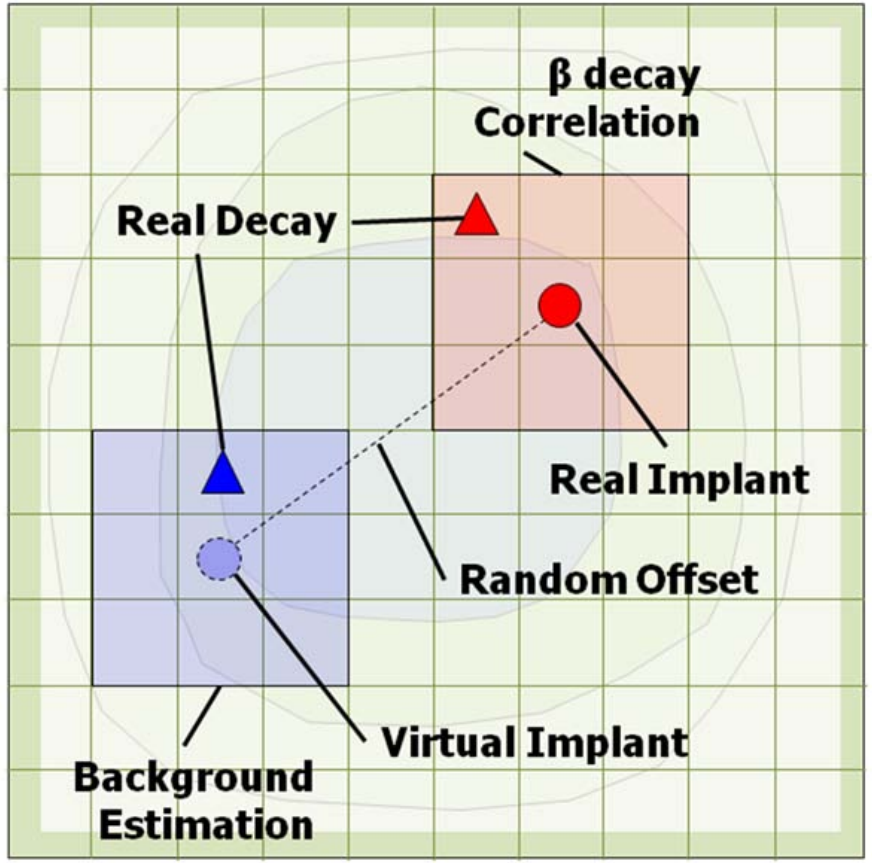
4 x DSSD
(128 x 16)

Background Estimation

Virtual implant generated for every real implant.

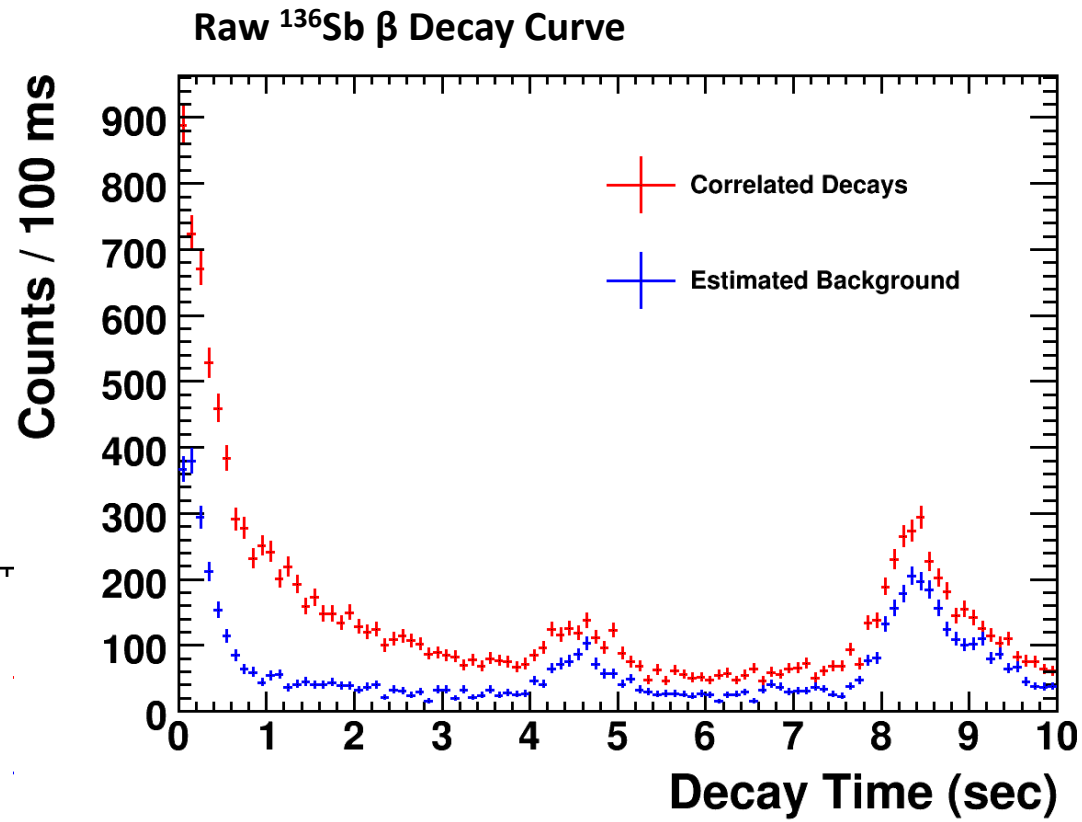
Virtual implant positions chosen to reproduce real implant position distribution.

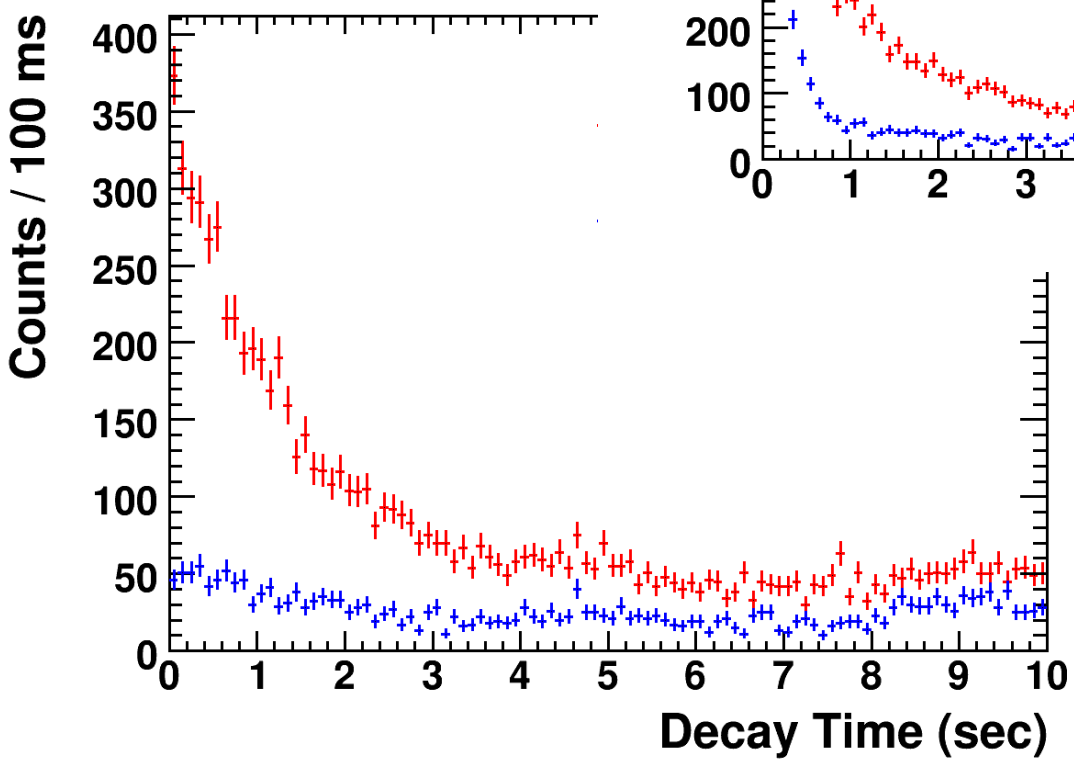
Virtual implants are then correlated in to decay-type events outside the correlation volume of the real implant.



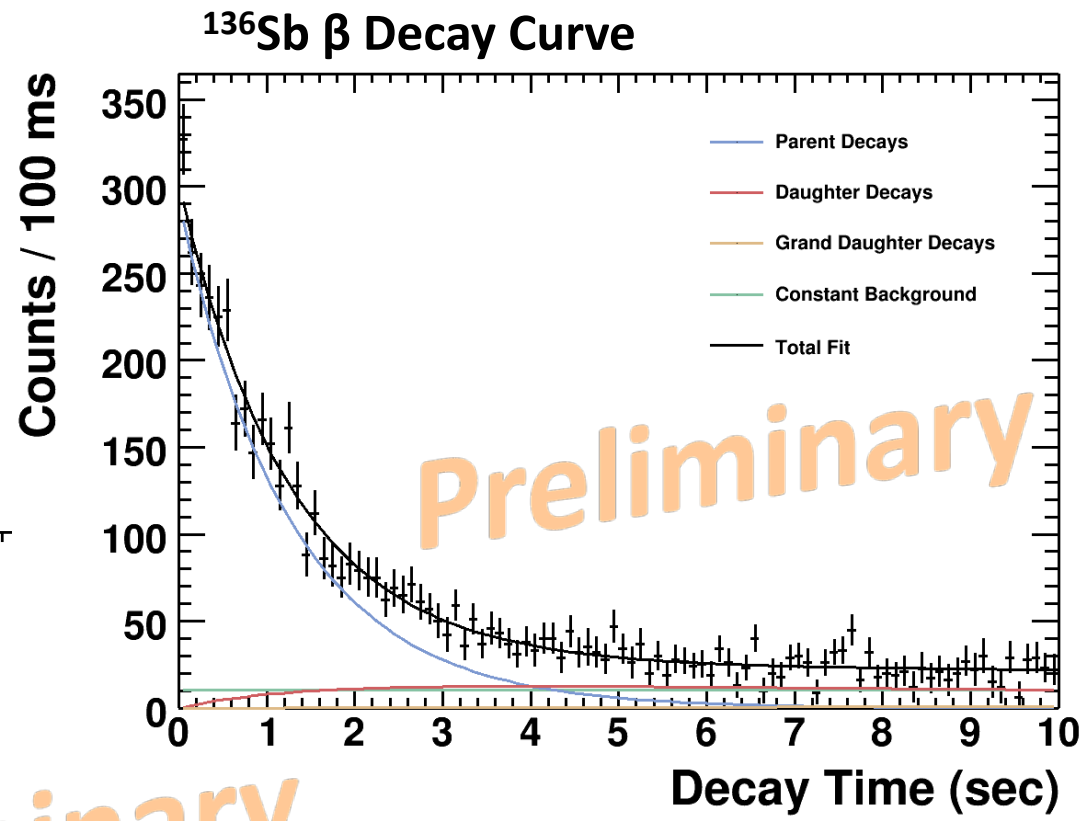
^{136}Sb Case

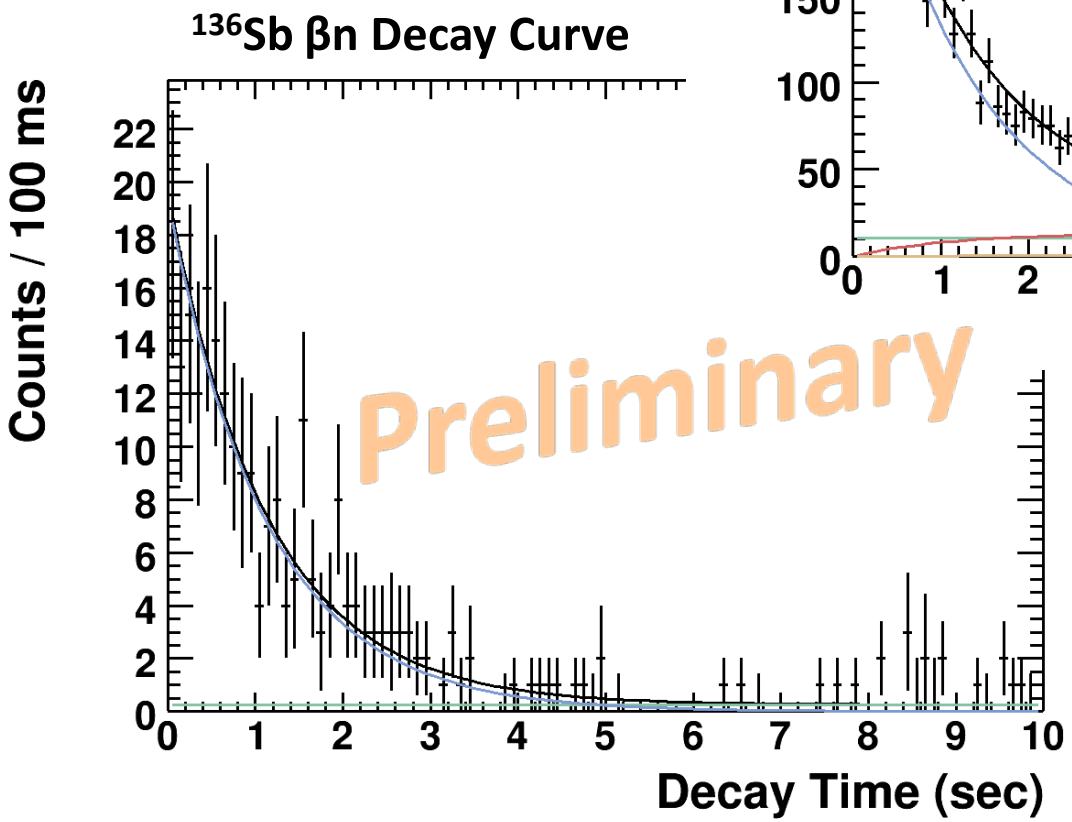
Decay-events with trajectories parallel to beam are rejected as background events.





Background Subtracted Decay Curves for ^{136}Sb





Acknowledgments

[1] *National Superconducting Cyclotron Laboratory, Michigan State University*

[2] *Dept. of Physics and Astronomy, Michigan State University*

[3] *Joint Institute for Nuclear Astrophysics, Univ. of Notre Dame*

[4] *Helmholtzzentrum für Schwerionenforschung (GSI)*

[5] *TU Müchen*

[6] *Univeristät Mainz*

[7] *University of Edinburgh*

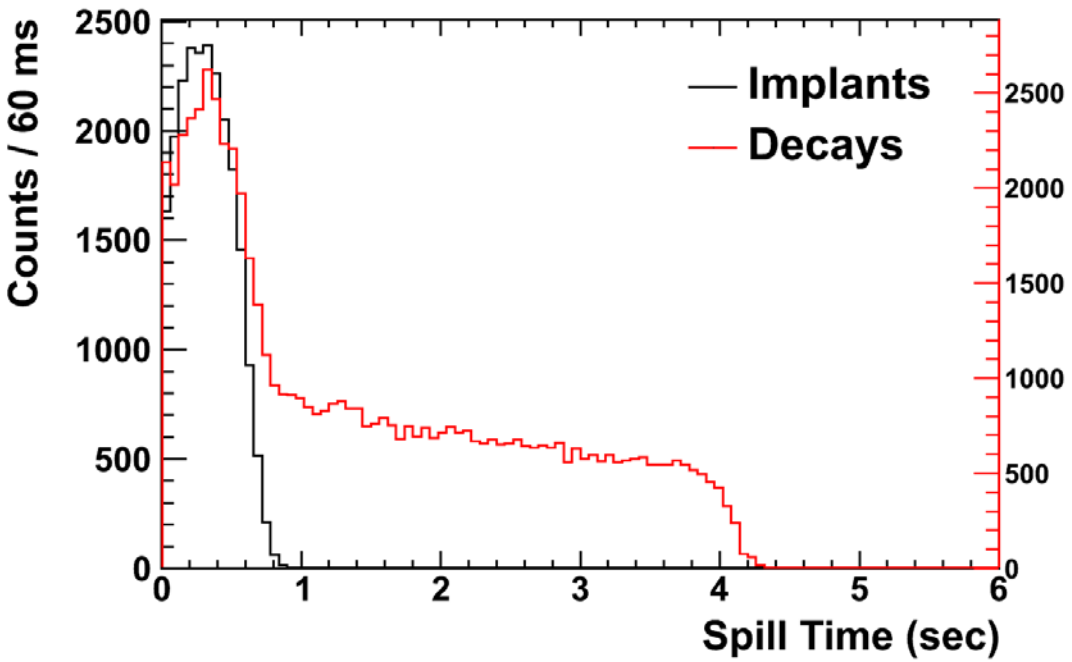
[8] *Lund University*

[9] *Los Alamos National Laboratory*

[10] *Univeristät Giessen*

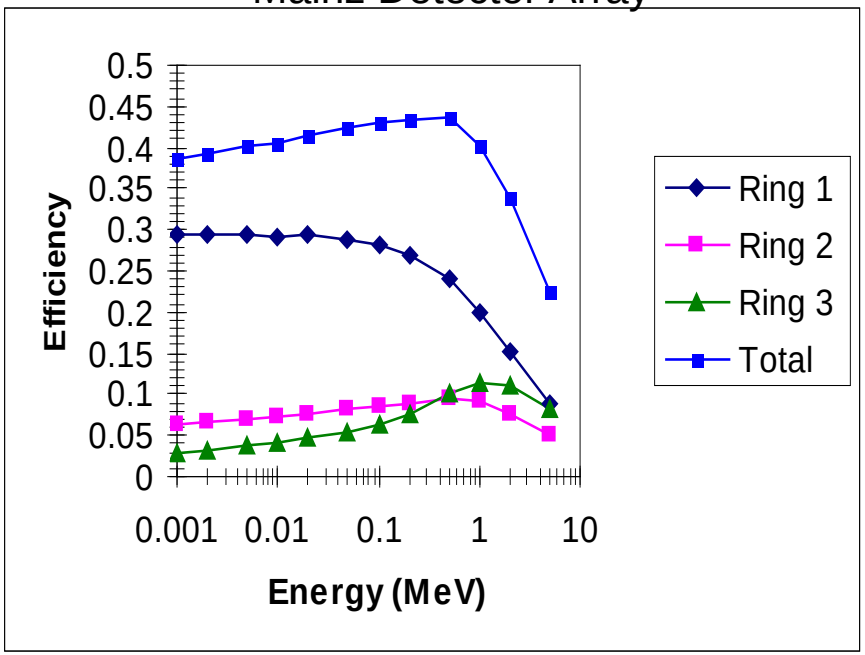
- F. Attallah[4]
- T. Faestermann[5]
- H. Geissel
- M. Hannawald[6]
- M. Hausmann[4]
- M. Hellström[4]
- R. Kessler[6]
- K.-L. Kratz[6]
- H. Mahmud[7]
- M. Mineva[8]
- F. Montes[1,3]
- G. Münzenberg[4]
- B. Pfeiffer[6]
- J. Pereira Conca[1,3]
- P. Santi[9]
- H. Schatz[1,2,3]
- C. Scheidenberger[4]
- K. Schmidt[4]
- R. Schneider[5]
- A. Stolz[1,2]
- K. Sümmerer[4]
- J. Stadlmann[10]
- E. Wefers[5]
- P.J. Woods[7]

Spill Lengths

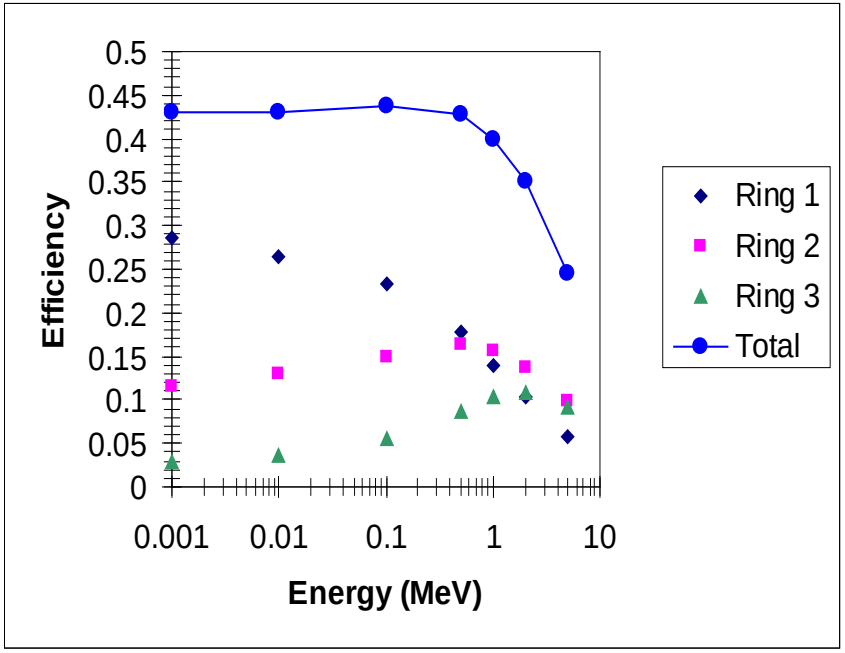


Performance of Neutron Detector Arrays (MCNP)

Mainz Detector Array

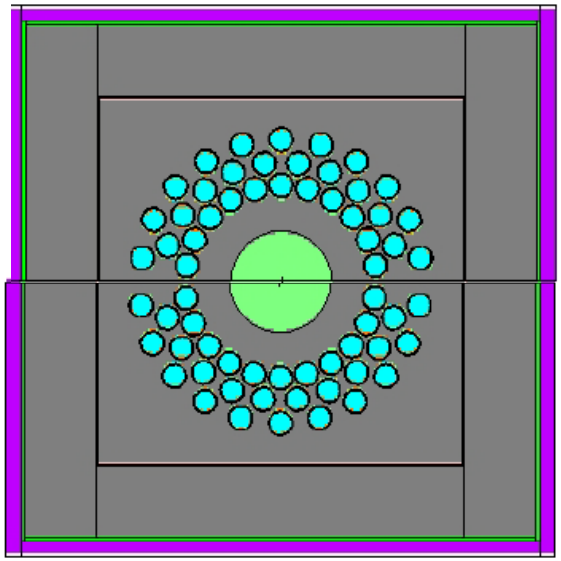


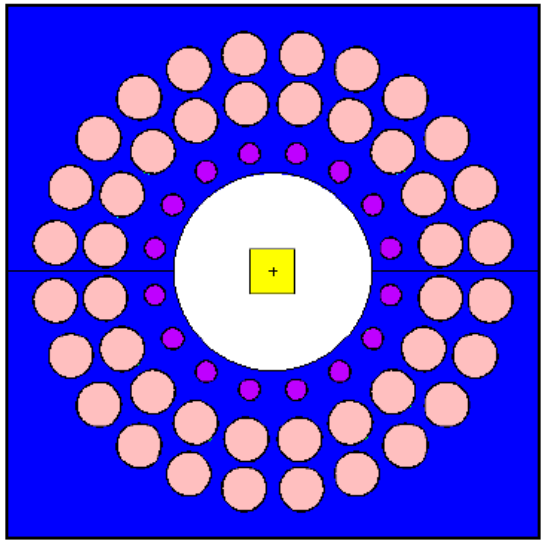
NERO



R_1 = 10.5 cm
R_2 = 13.0cm
R_3 = 15.5 cm
R_{beam} = 5.5 cm

64 ^{3}He detectors





R_1 = 13.6 cm
R_2 = 19.2 cm
R_3 = 24.8 cm
R_{beam} = 11.2 cm

16 ^{3}He detectors
44 BF_3 detectors