DSSSD for β decay investigations of heavy neutron-rich isotopes

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Rising '04

Motivation

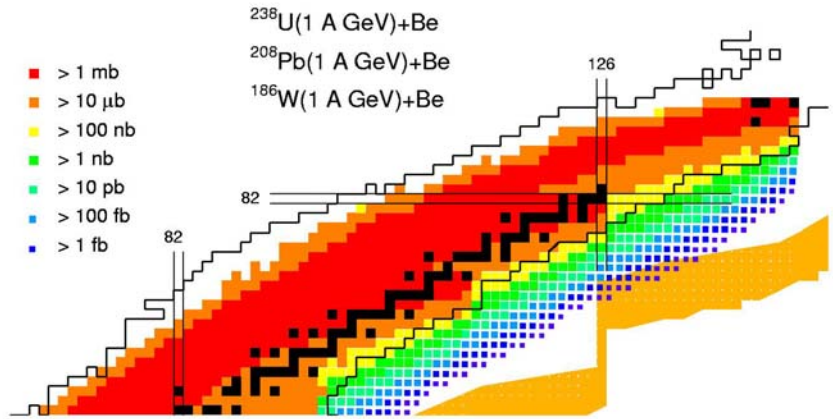
Nuclear structure and astrophysics around N=126 and Z=82

Production of heavy neutron-rich nuclei in cold-fragmentation reactions (S227):

- ✓ ^{197}Au(950 A MeV)+Be
- ✓ ^{238}U(1000 A MeV)+Be
- ✓ ^{136}Xe(1000 A MeV)+Be
- ✓ ^{208}Pb(1000 A MeV)+Be

β-decay investigation of heavy neutron-rich nuclei:

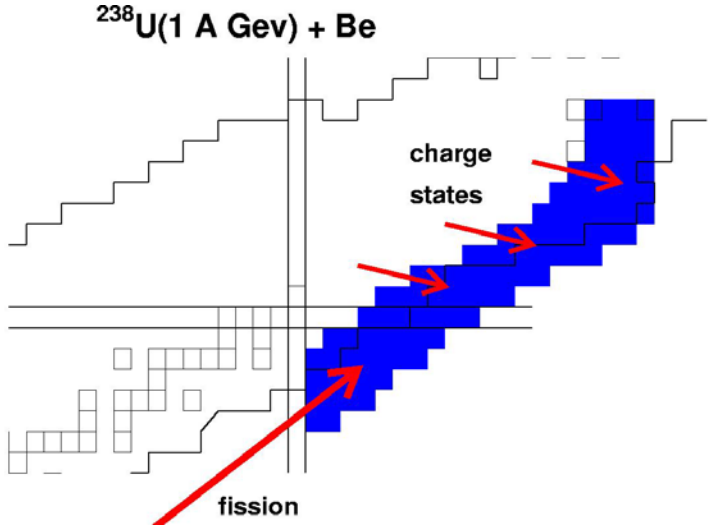
- ✓ β half lives
- ✓ Q values
- ✓ β-delay gamma emission
- ✓ β-delay neutron emission



Experimental method

Identification and implantation of fast-heavy neutron-rich isotopes (FRS):

- ✓ fission contamination
- ✓ charge states
- ✓ implantation range

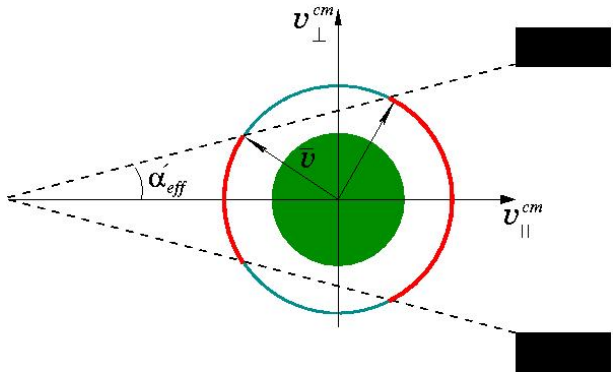


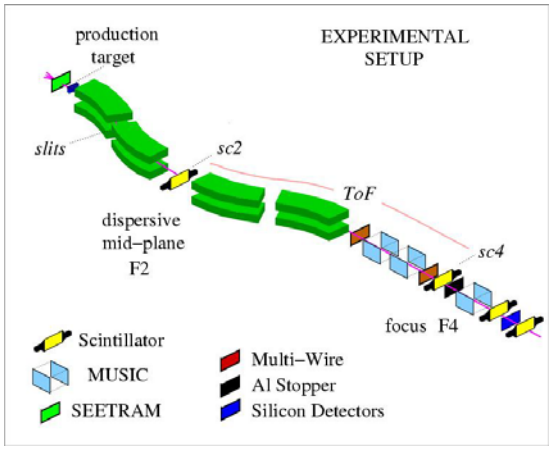
β-decay with half lives larger than the implantation rate (DSSD):

- ✓ implantation-decay time correlation
- ✓ implantation-decay position correlation
- ✓ implantation surface
- ✓ implantation range

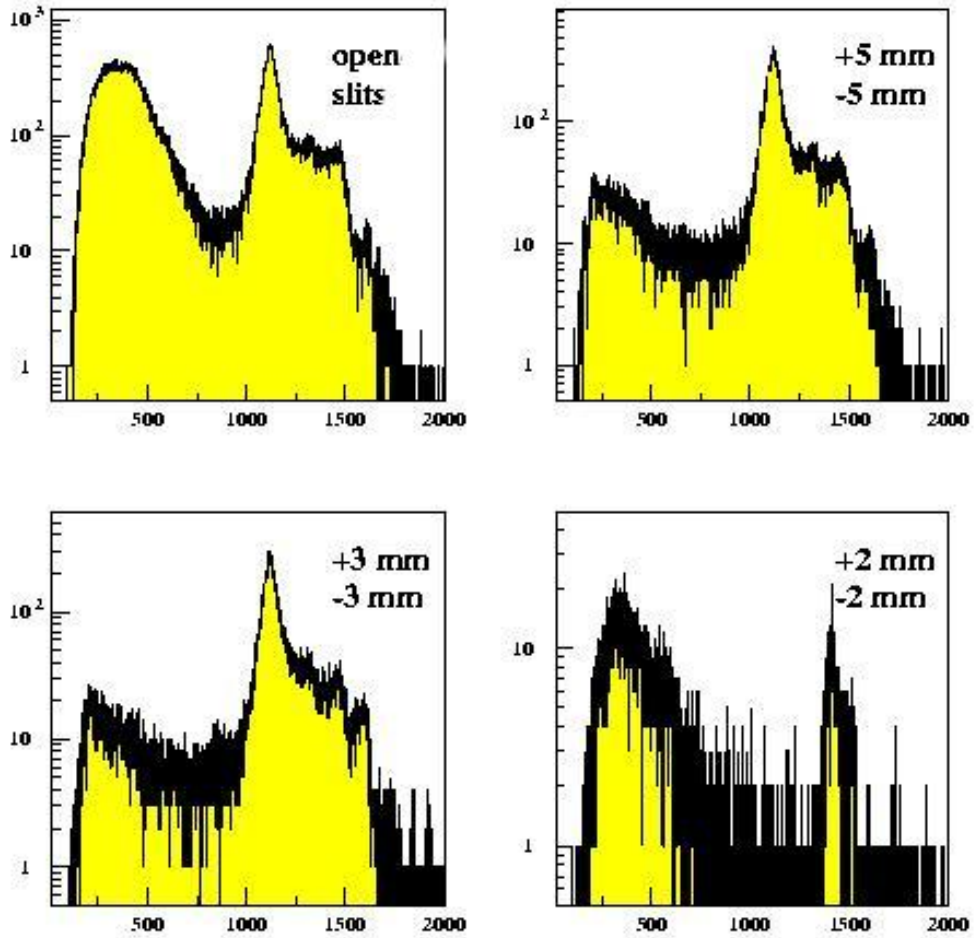
Suppression of fisssion pollution

Slits behind the target

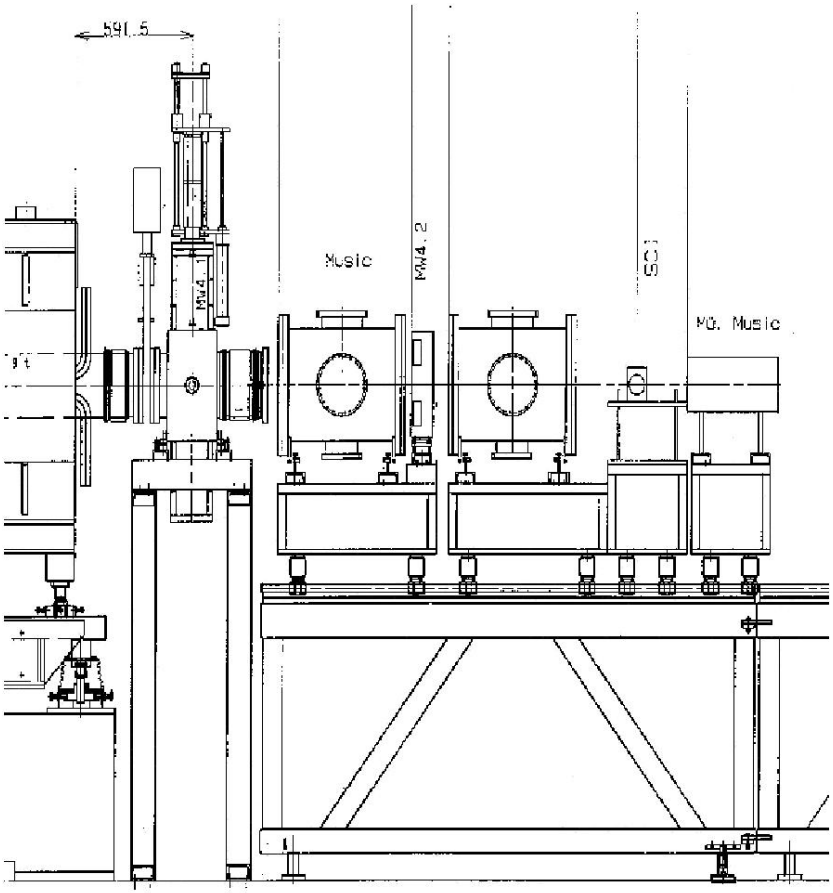




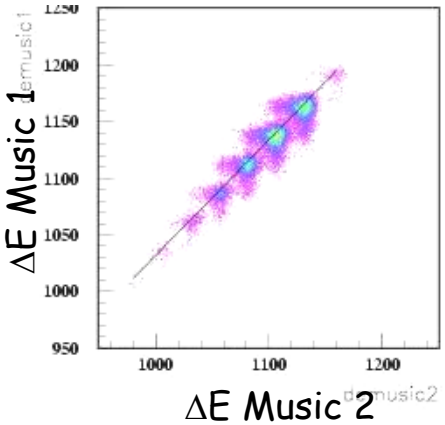
✓ ^{238}U(1000 A MeV)+Be

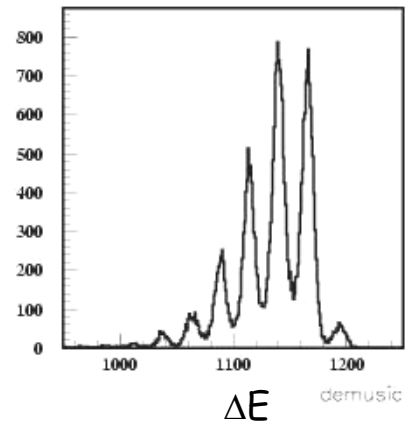


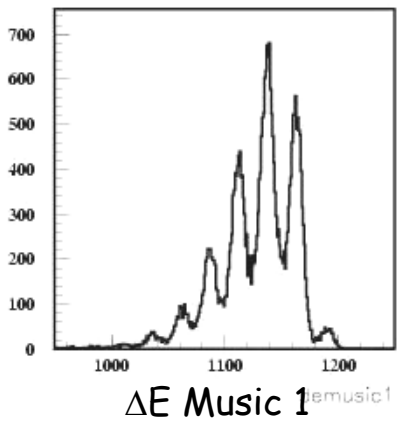
Charge states in the MUSICs: Z identification

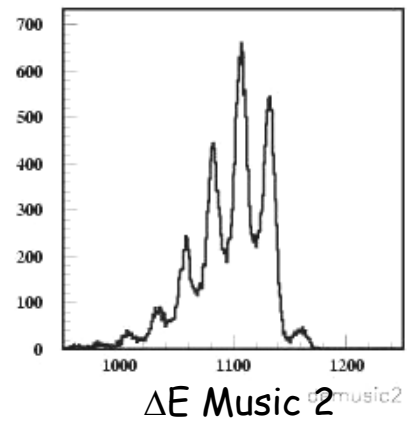


Correlated measurement with two MUSICs with a stripper in between





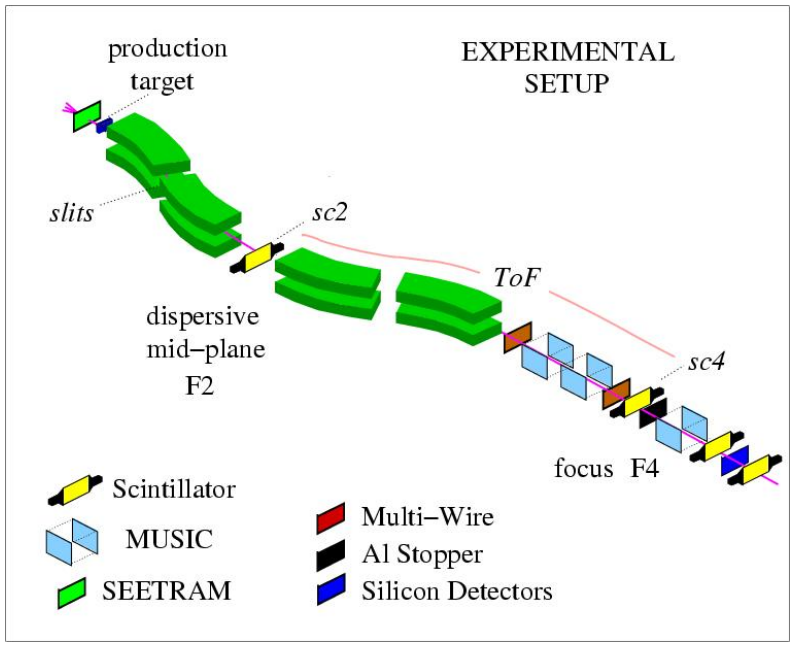


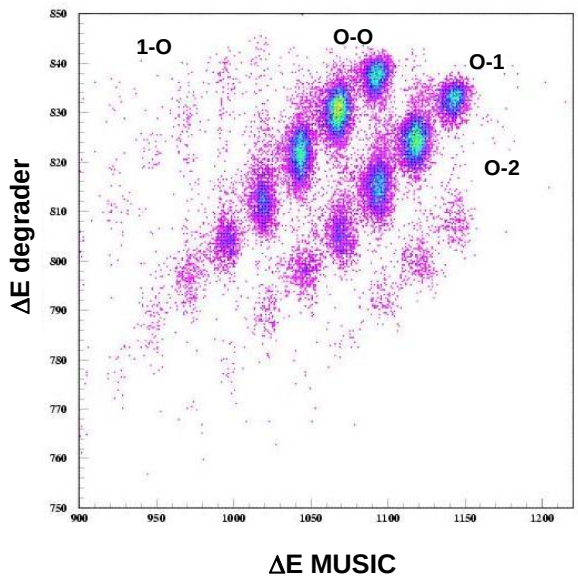


Charge states in the FRS: A/Q identification

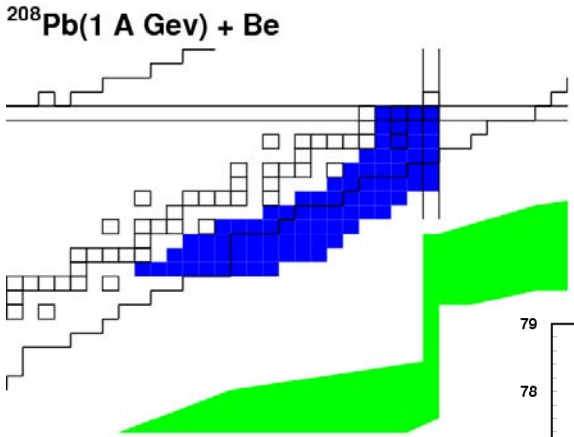
Difference between $B\rho_1$ and $B\rho_2$ with a degrader and a stripper at S2

$$\left(\Delta E_{\text{degrader}}/q\right)_{\text{nominal}} = e\left[\left(B\rho\right)_1/\beta_1 - \left(B\rho\right)_2/\beta_2\right].$$

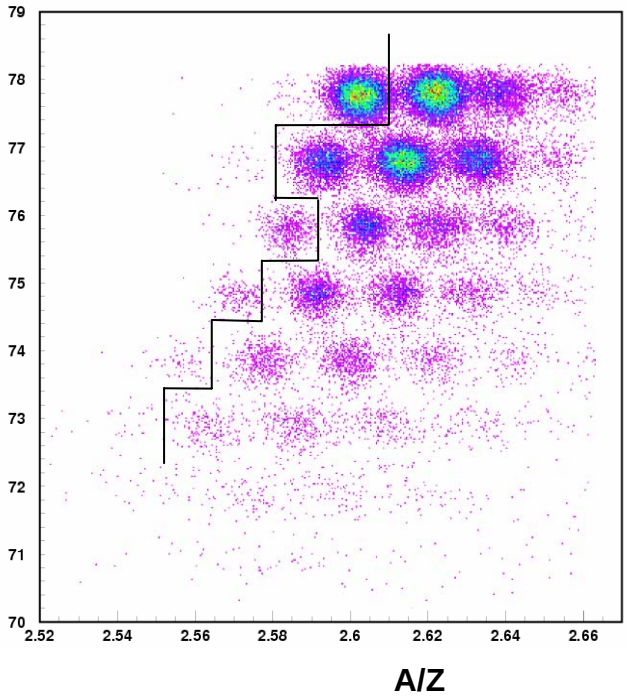


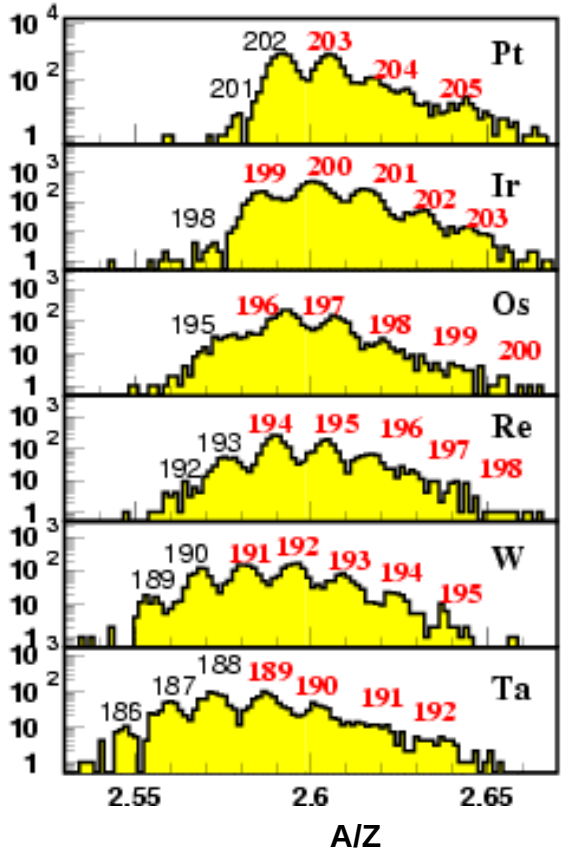


Identification matrix



More than 30 new isotopes





^{194}W 2h 41 min

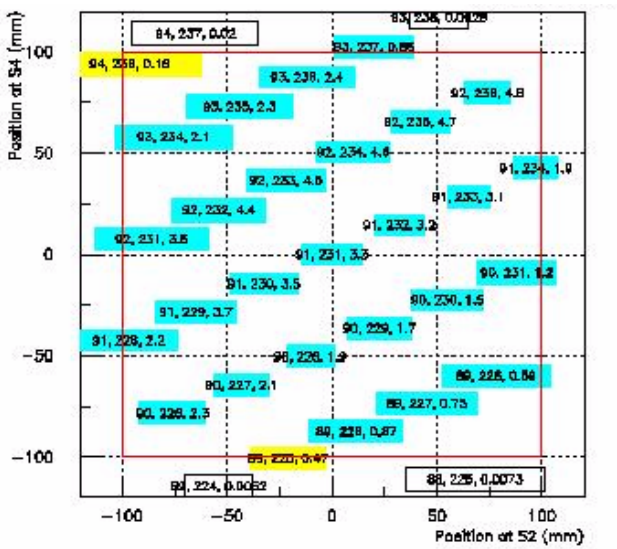
^{186}Lu 10 h 45 min

Implantation range

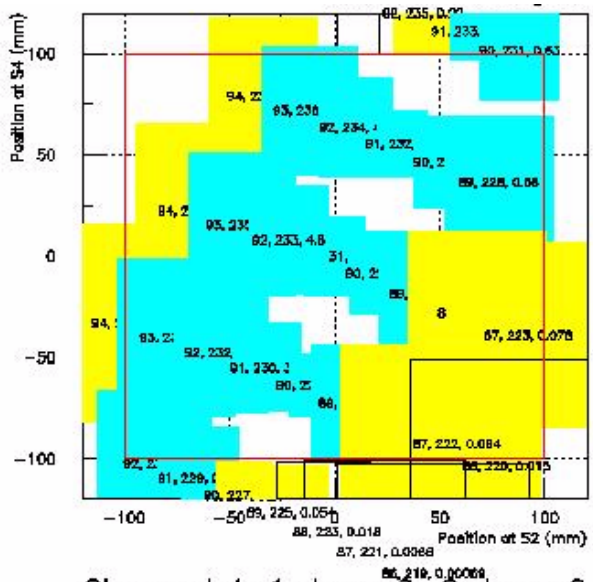
Monoenergetic degrader at S2:

- ✓ larger implantation surface at S4
- ✓ smaller dispersion in the implantation range

Achromatic degrader

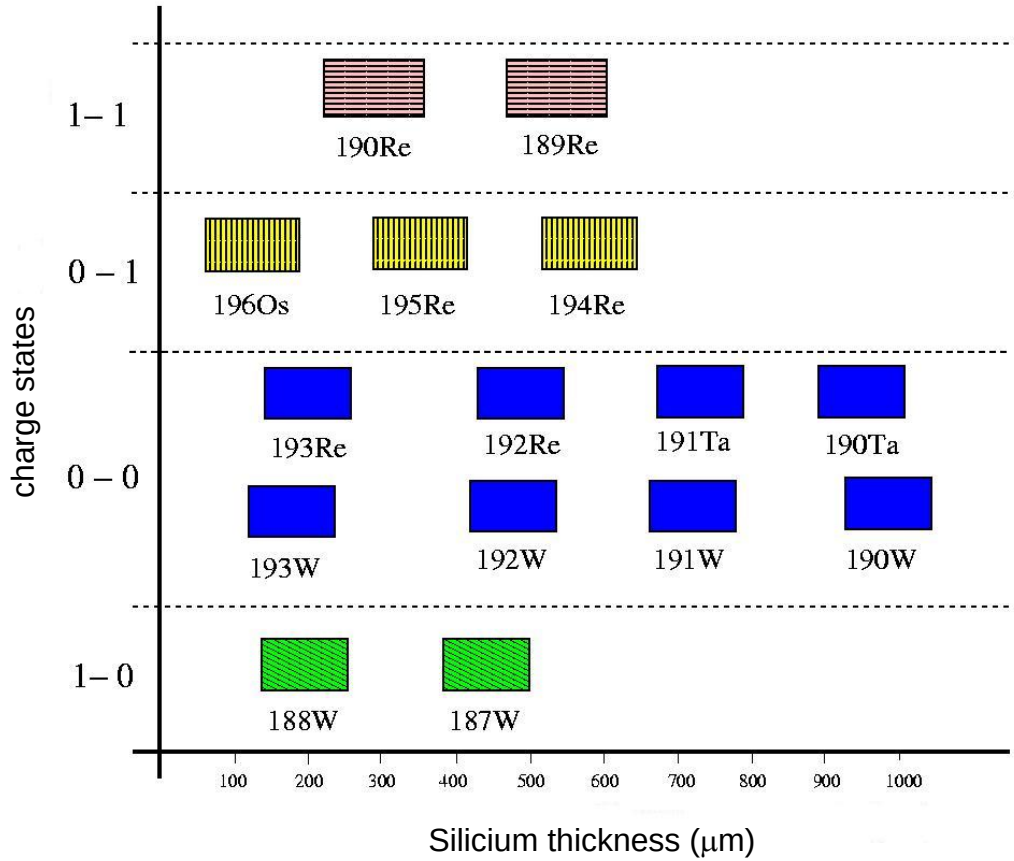


Monoenergetic degrader



Implantation range

Estimated implanted isotopes for a setting centered on ^{192}W in 1 mm thickness silicium with a monoenergetic degrader at S2



Detector setup for β half lives measurement

Active catcher for implantation-decay correlations

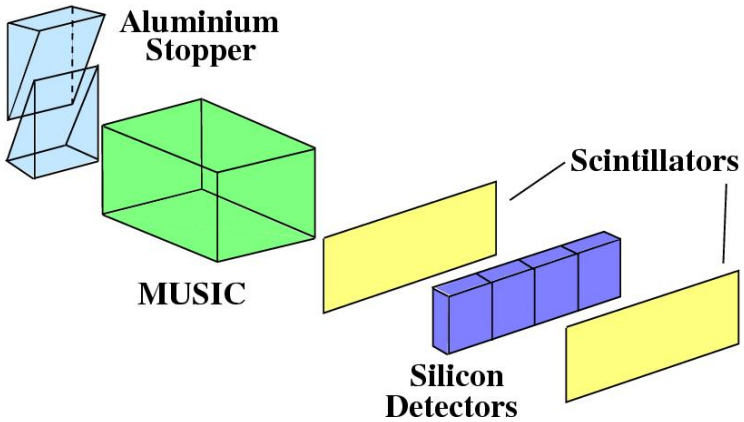
Implantation-decay correlations with large background
(half lifes similar to the implantation rate):

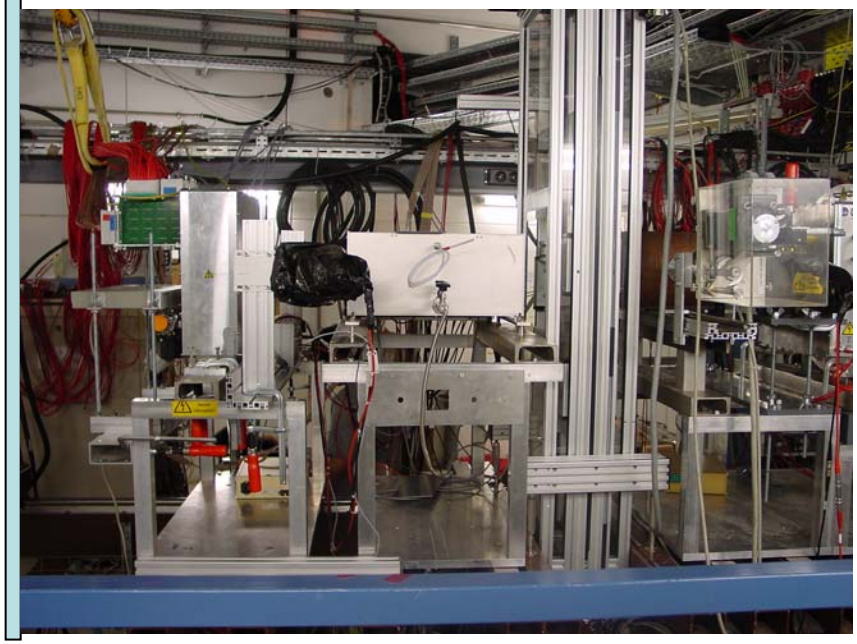
- ✓ implantation-decay time correlation: active catcher
- ✓ implantation-decay position correlation: granularity
- ✓ implantation of several ions: thickness and area
- ✓ energy of the implanted ion and the emitted β

4 double-side silicon-strip detectors

- surface 5x5 cm^2
- thickness 1 mm
- 2x16 3.125 mm strips
- manufactured by MICRON

Experimental setup at S4





Detectors:

- ✓ Ionisation chamber
  (rejection of reactions in the stopper)
- ✓ 2 plastic scintillator detectors (implantation)
- ✓ 4 double-side silicon-strip detectors

Electronics:

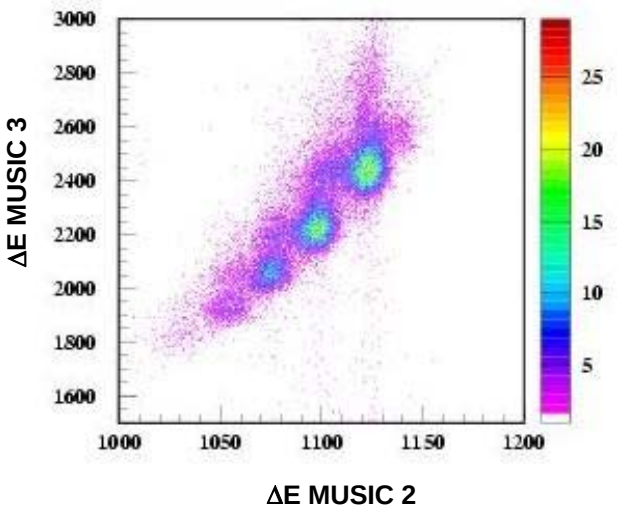
- ✓ 10 carts x 16 charge sensitive preamplifiers
  from GANIL one channel per strip
  (implantation signals saturated)
- ✓ 16 channel spectroscopic amplifiers
  CAEN N568B

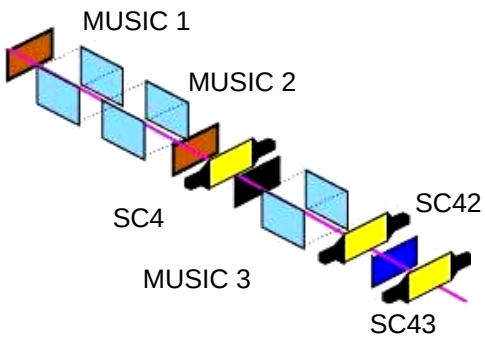
DAQ:

- ✓ 3x32 channel multievent peak sensing
  CAEN ADC V785

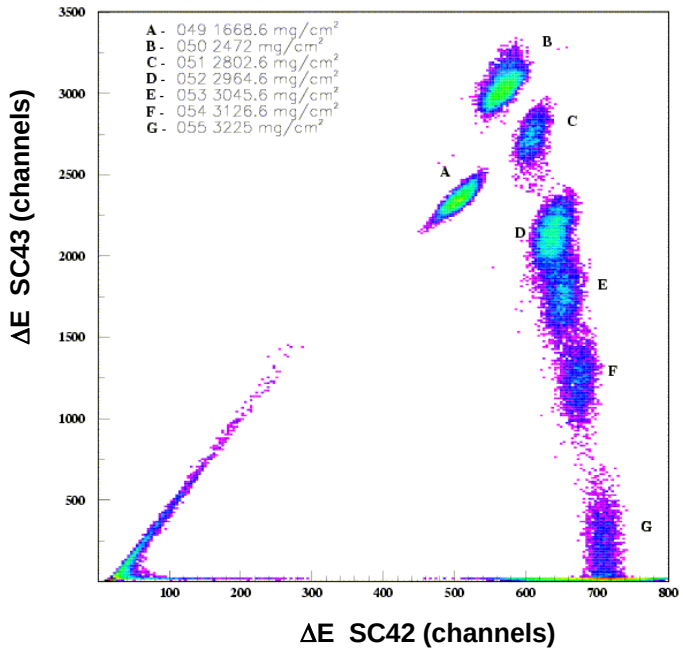
Implantation procedure

Reaction rejection





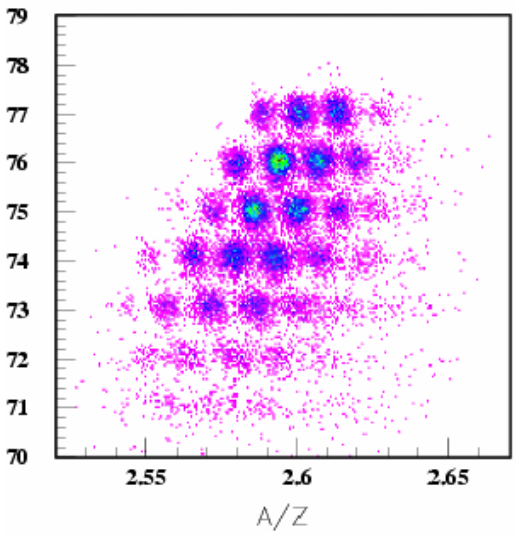
Stopper thickness



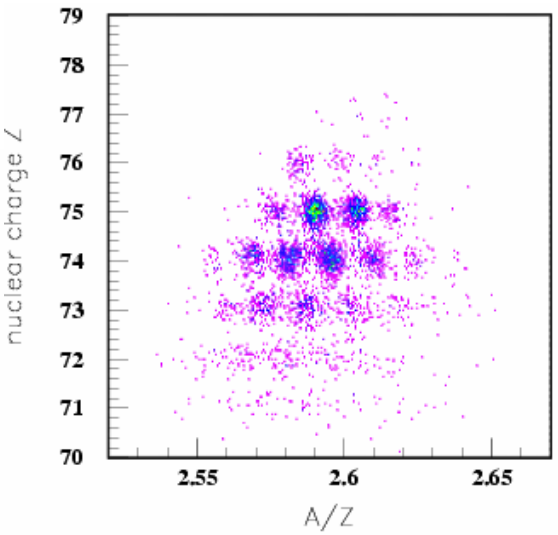
Implantation procedure

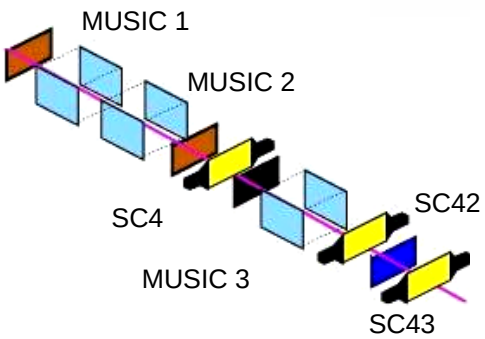
Setting centered on ^{186}Lu

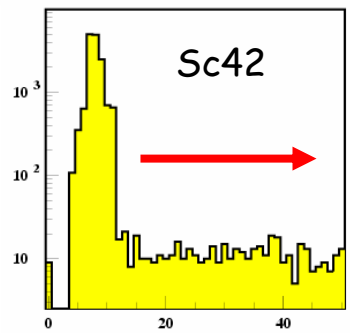
Produced

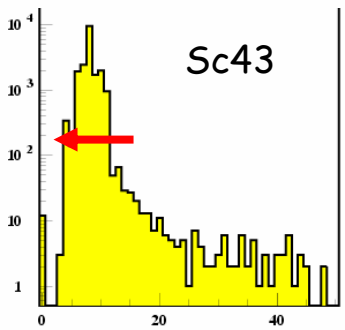


Implanted



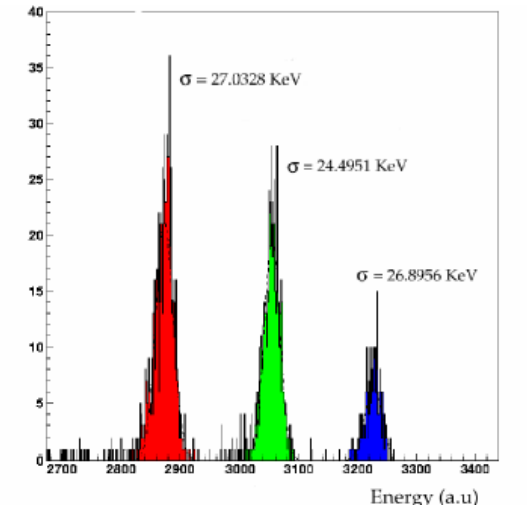






DSSD response: energy resolution

Energy resolution (1%)



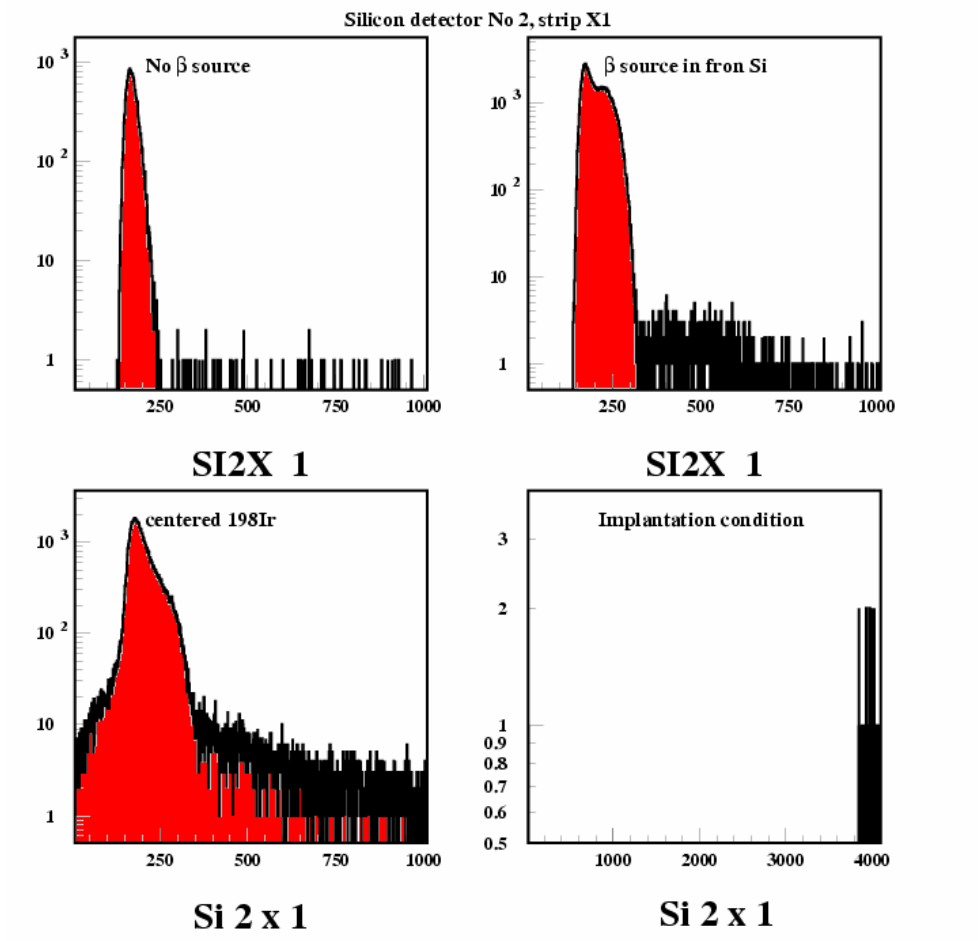
3 α source

^{239}Pu E->5148,85 keV

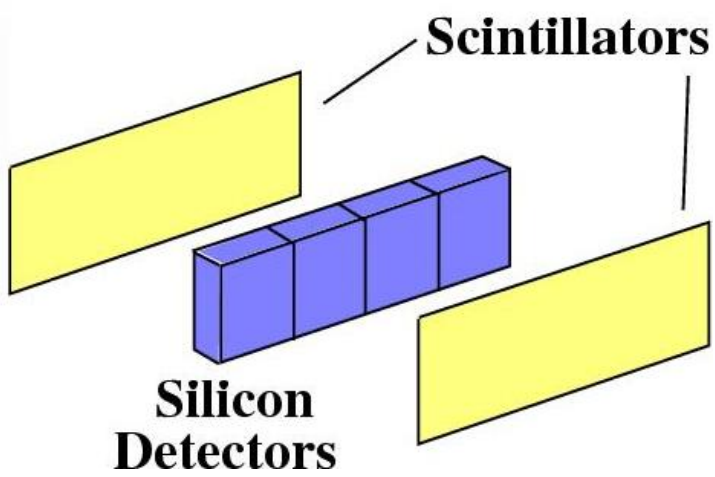
^{241}Am E-> 5478,38 keV

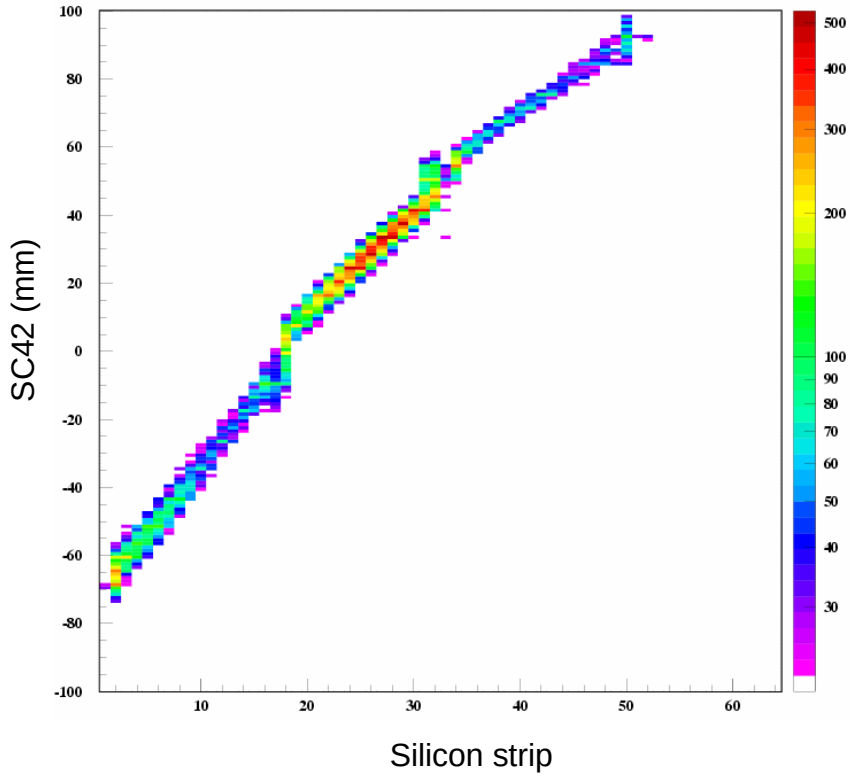
^{244}Cm E->5794,88 keV

Energy spectra

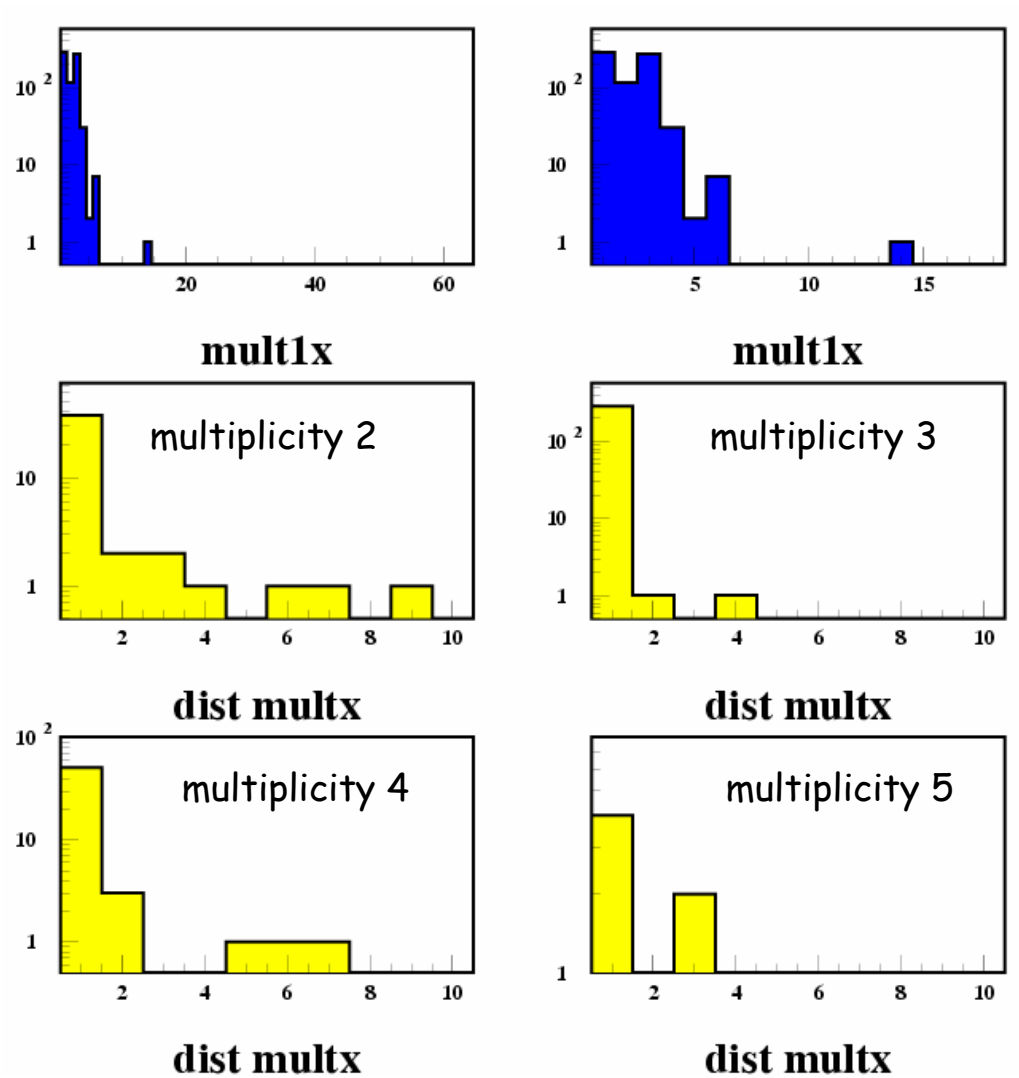


DSSSD response: position correlation





DSSSD response: hit multiplicity



Summary and future plans

Summary

-Validation of the production and identification of heavy neutron-rich isotopes:

- -Cold fragmentation
- -Charge states discrimination
- -Production cross section determination

-Around 35 new heavy neutron-rich isotopes in the region Z=71->78 has been discovered

-Optimum setup for position and time correlation:

- -Implantation procedure
- -Position correlation
- -Energy resolution
- -Time correlation (in progress)

Future plans

- Propose dedicated experiments to investigate the north-east of the chart of the nuclides
- New preamplifiers (double gain)
- - Additional detectors to improve β detection efficiency
- - Coupling to gamma arrays