Odd-Z Superheavy Element Studies: New Results for Elements 113, 115 and 117

Nuclear Structure 2012

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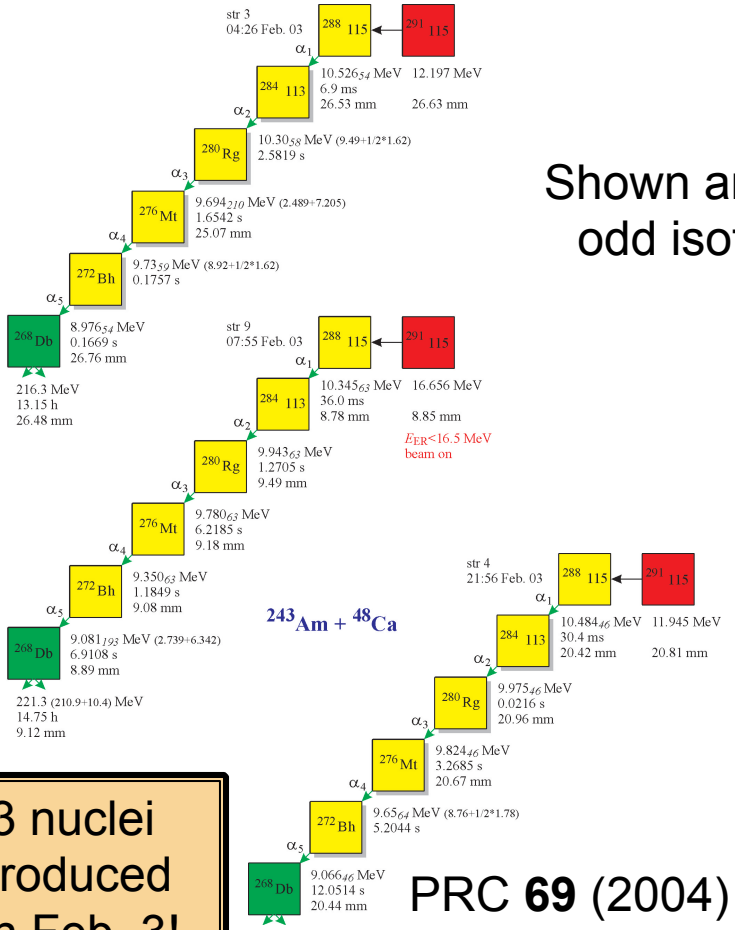
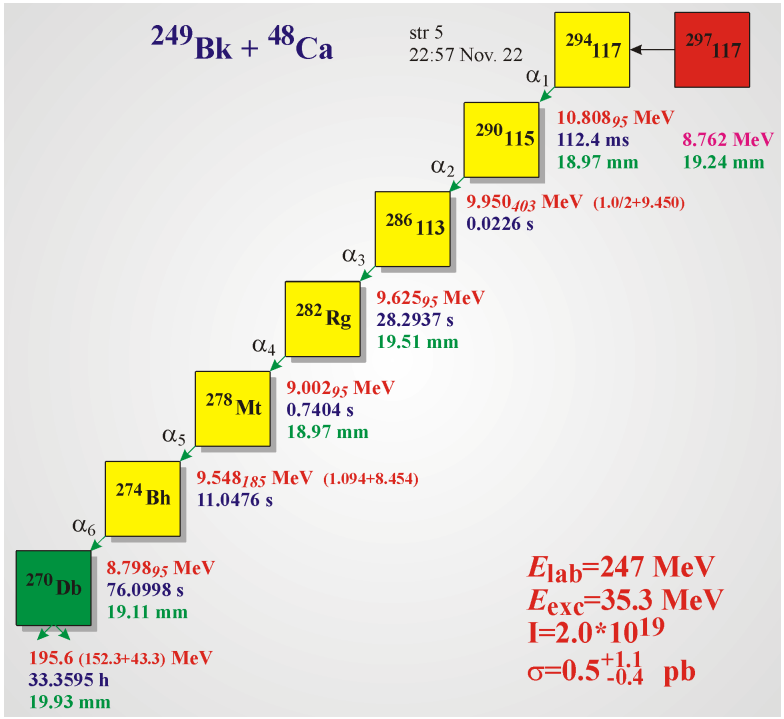
Our prior work had observed long α-decay chains for odd-Z elements



Shown are odd-odd isotopes

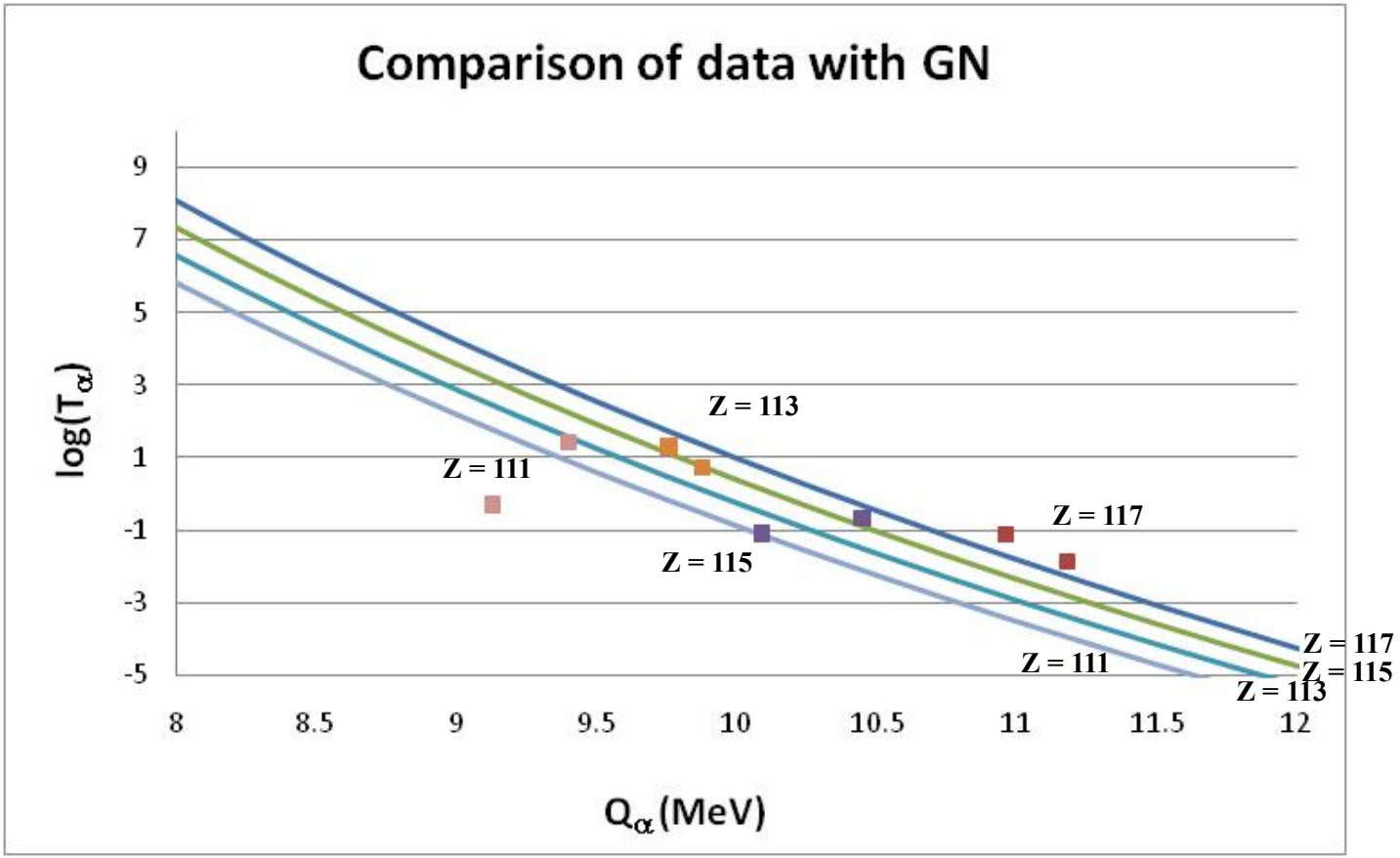


PRL **104** (2010) 142502

3 nuclei produced on Feb. 3!

PRC **69** (2004) 021601
PRC **72** (2005) 034611

The alpha-decay data from two element 117 decay chains fit GN systematics well – deviations for these odd-Z nuclei are due to hindrance factors



V.E. Viola, Jr. and G.T. Seaborg, J. Inorg Nucl. Chem. 28 (1966) 741.
GN parameters from R. Smolanczuk Phys. Rev C 56 (1997) 812.

Many element 115 decay chains offers the chance for alpha spectroscopy

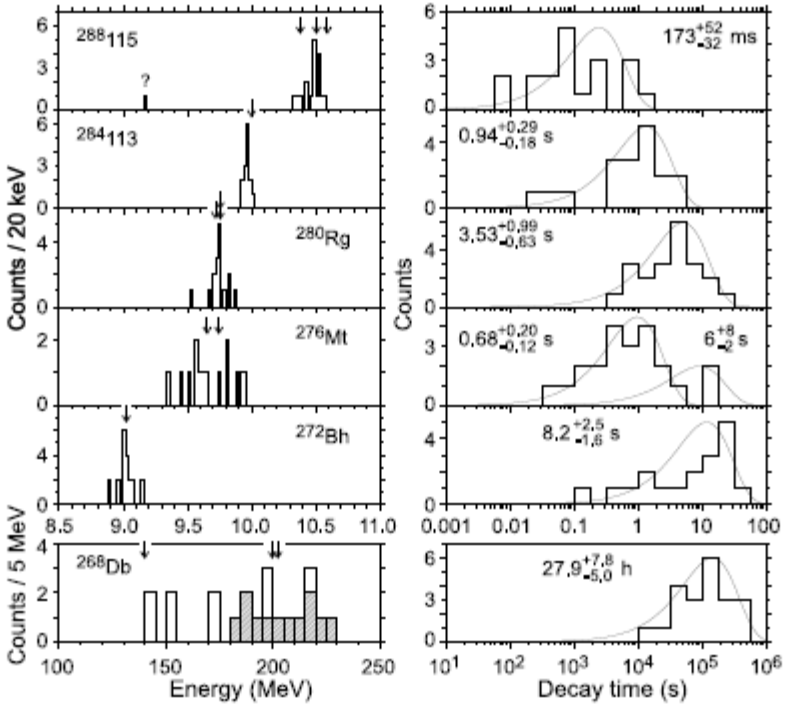
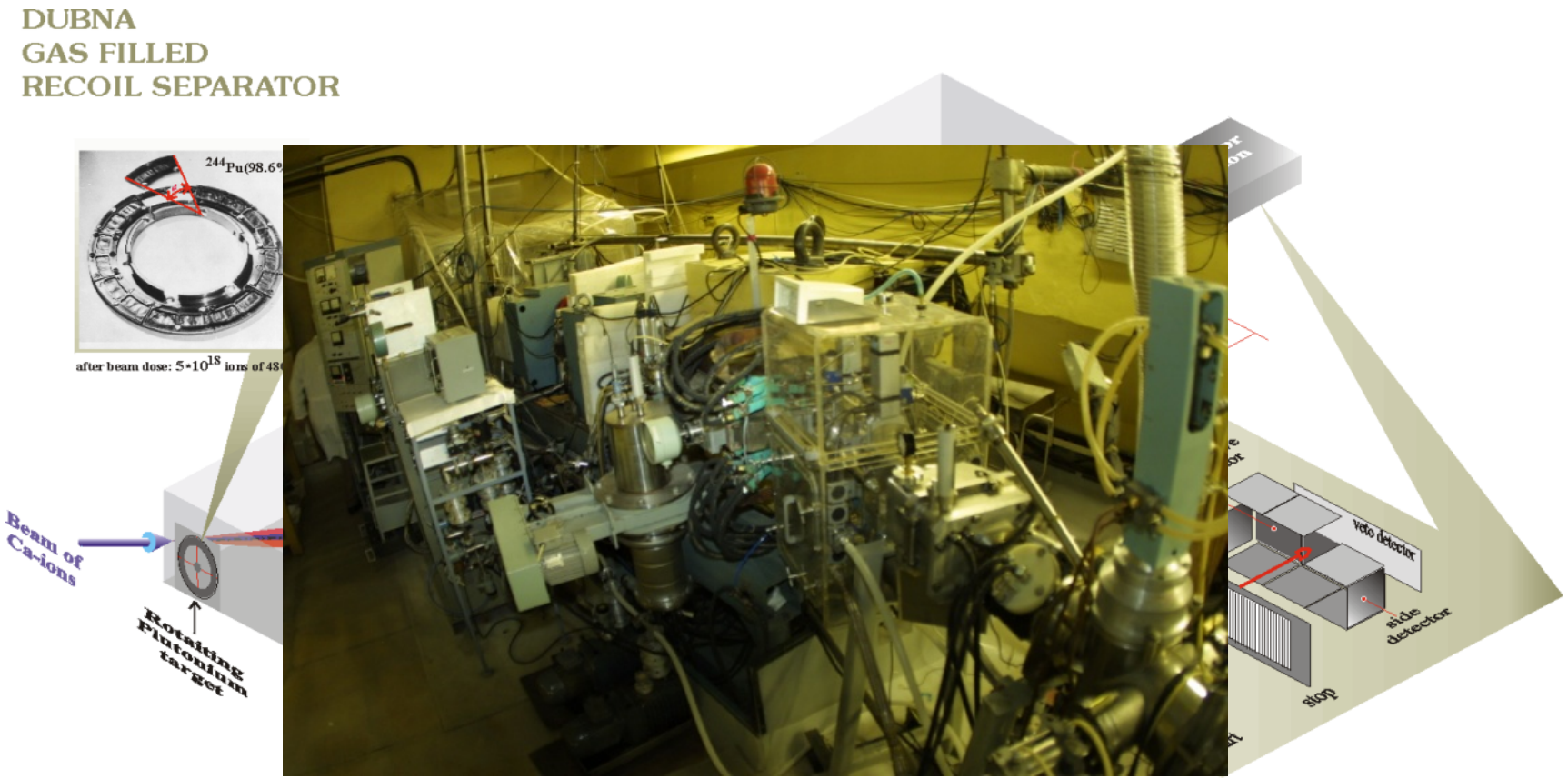


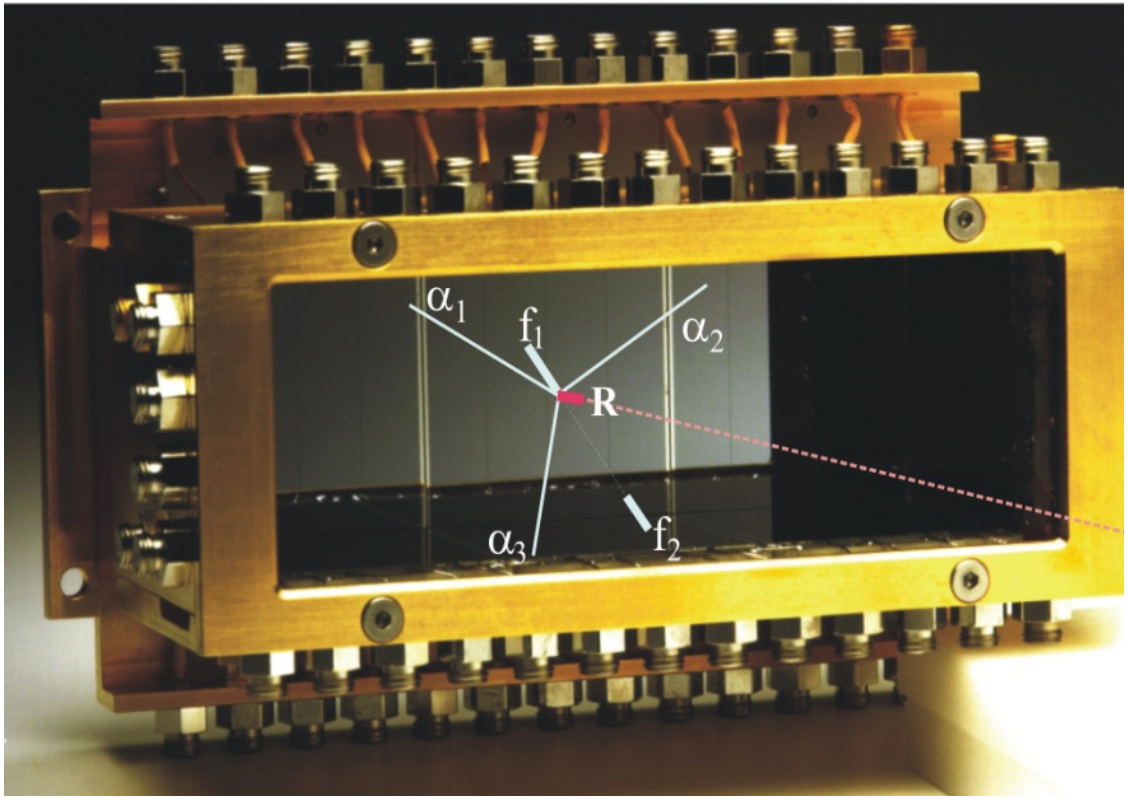
FIG. 3: α-particle and fission-fragment energy spectra registered by the focal detector (left panel) and decay time distributions in logarithmic scale (right panel) for isotopes originating from $^{288}115$. The arrows show energies of 3 events obtained in first experiment in 2003 [1, 2]. The fission-fragment energies were not corrected for the pulse height defect of the detectors. SF events detected by the focal detector are shown by open histogram, those detected by the both focal and side detectors – shaded histogram. The curves are time spectrum for exponential decays with half-lives $T_{1/2}$ shown in figures.

The Dubna gas-filled separator uses a combination of chemistry and physics to suppress unwanted reaction products



Yuri Oganessian FLNR (JINR) June 14, 1999

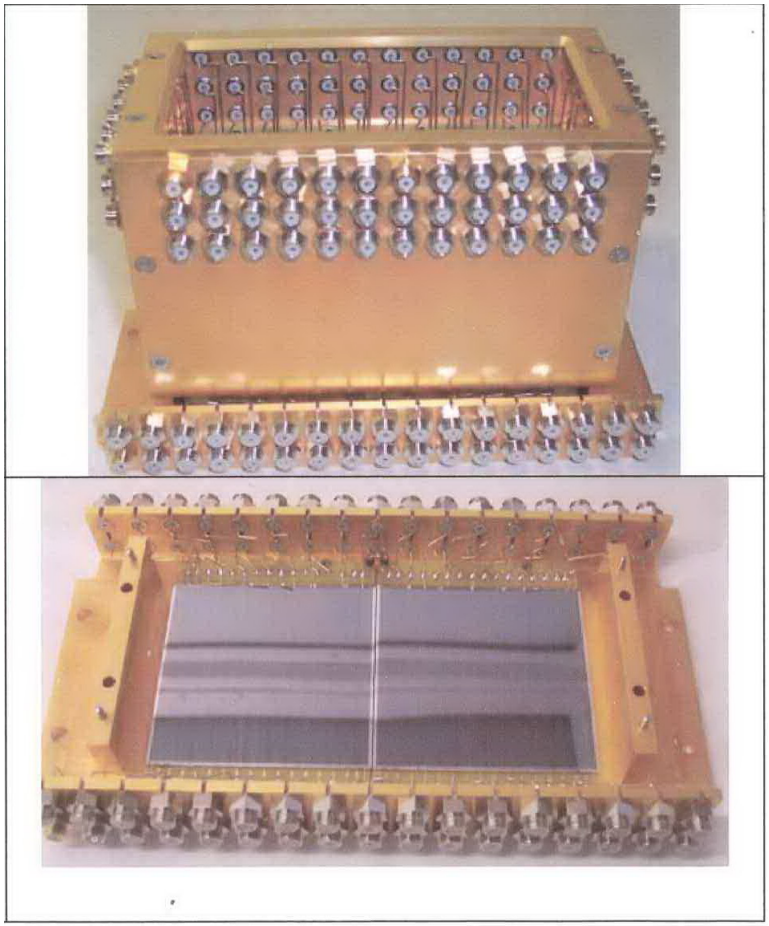
The high-efficiency detector system

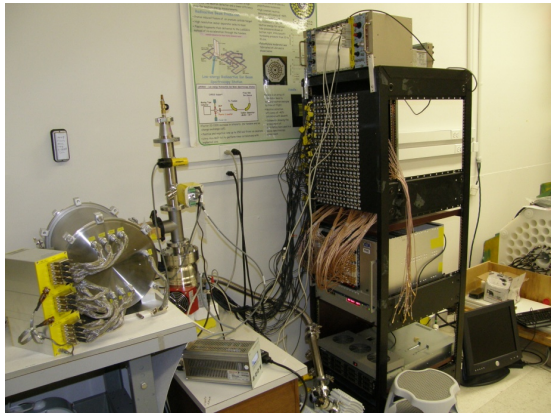


The addition of the top, bottom, and side detectors increased the geometry for counting α particles from 50% to 87%.

Veto detectors mounted behind the focal plane were used to identify and reject light charged particles passing through the separator.

A new detector has been installed at the DGFRS focal plane

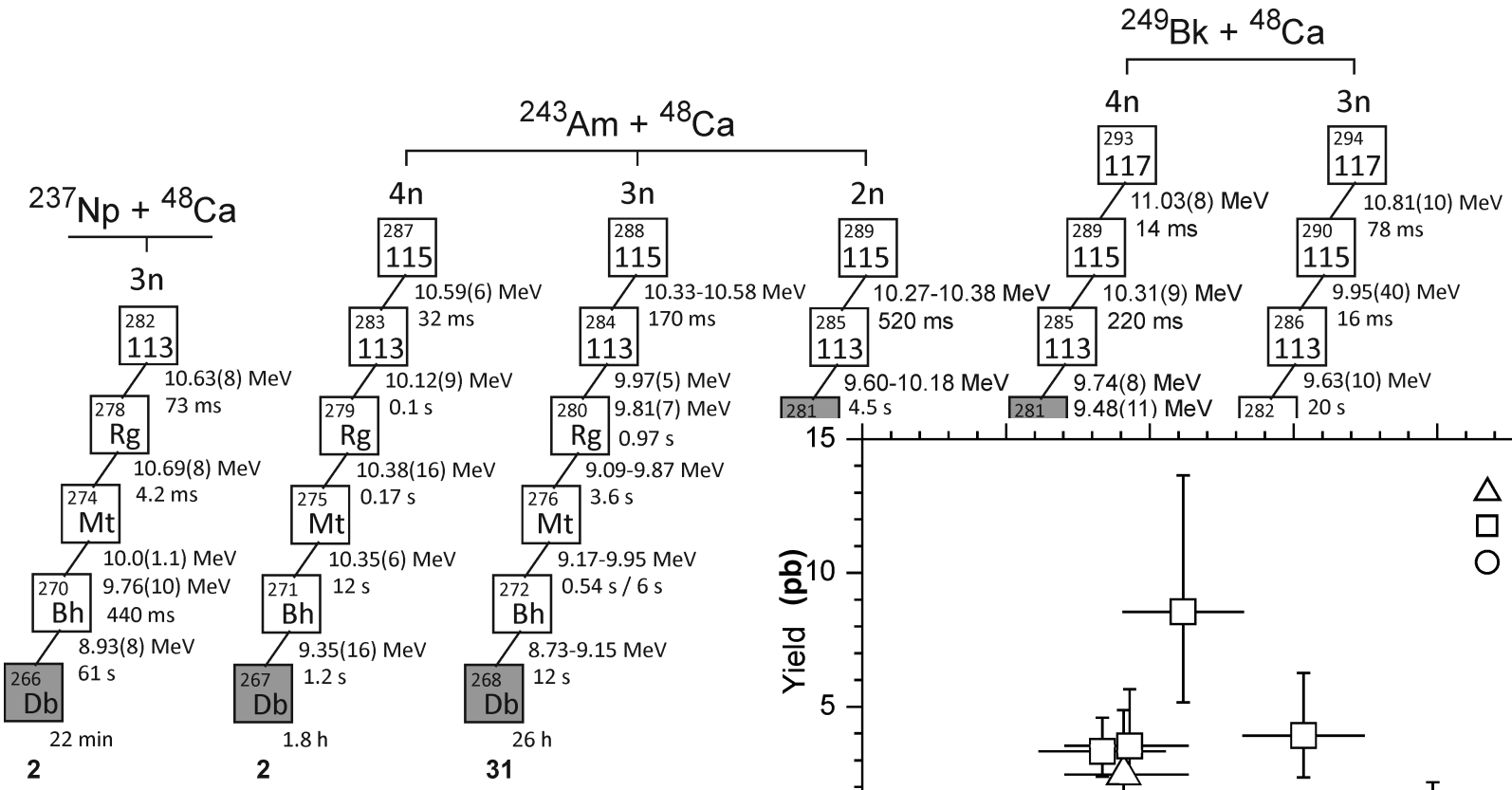




New digital electronics being tested at HRIBF and to be implemented soon in Dubna by ORNL

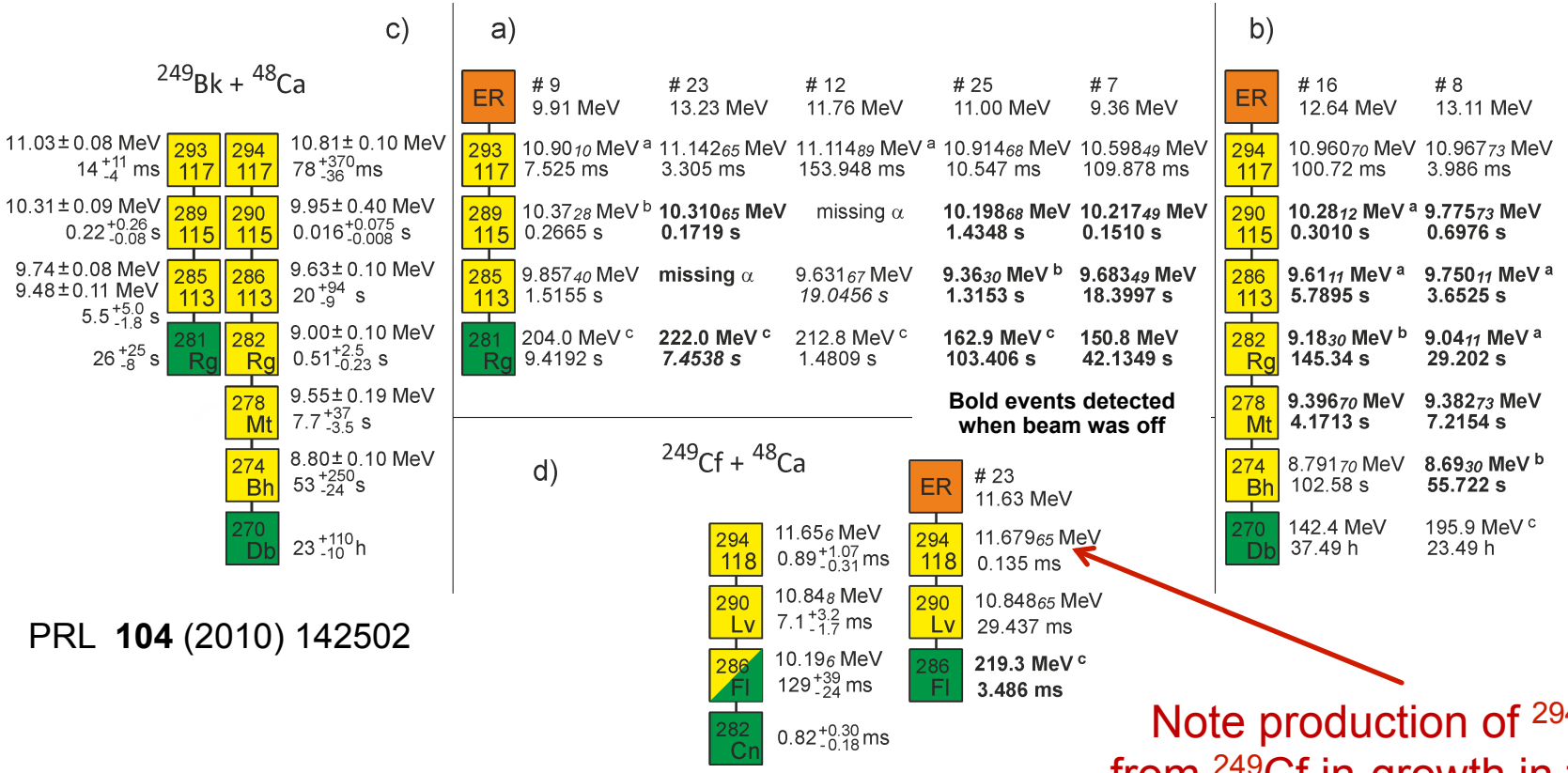
The new detector is comprised of 6 × 6 cm^2 16–strip Si detectors. Because the focal plane detector is larger the side detectors are also larger—the net result is that the detection efficiency is the same as the prior detector ~87%

New data from the ^{48}Ca + ^{243}Am reaction



Excitation functions for these reactions have been measured

New data from the ^{48}Ca + ^{249}Bk reaction



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Note production of ^{294}118 from ^{249}Cf in-growth in target!

At the time of production, the target was 28% ^{249}Cf

Conclusions

- The decay characteristics of the isotopes $^{287}115$ and $^{288}115$ (and correspondingly of the daughters $^{283}113$ and $^{284}113$), were confirmed
- Alpha spectroscopy of element 115 (and 117) decay chains indicates chance for Z identification with the detection of x-rays
- Additional decay chains originating from the 4*n*-evaporation product, $^{293}117$, and two decay chains of the 3*n* channel, $^{294}117$ were observed
- The average cross sections for the production of $^{293}117$ and $^{294}117$ nuclei in the $^{249}Bk+^{48}Ca$ reaction at E^*=39 MeV and 35 MeV determined from the observation of 10 and 3 events amounts to 1.5(+1.1,-0.5) pb and 1.1(+1.2,-0.6) pb, respectively
- One more decay chain of $^{294}118$ and its daughter nuclei ^{290}Lv and ^{286}Fl was observed

Cross-bombardment results form a consistent picture for the odd-Z elements

Future work

- $^{48}Ca + {}^{249}Bk$ reaction running currently in Dubna through about Jan. 2013 – this is when the target will be 50% ^{249}Cf
- Future $^{48}Ca + {}^{249,251}Cf$ experiment to make element 118 depending on target availability
- Spectroscopy experiments at LBL to measure Z of SHE and investigate nuclear structure