New results from DGFRS experiments performed using ^{48}Ca beams on ^{243}Am, ^{249}Bk and ^{249}Cf targets

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for the collaboration

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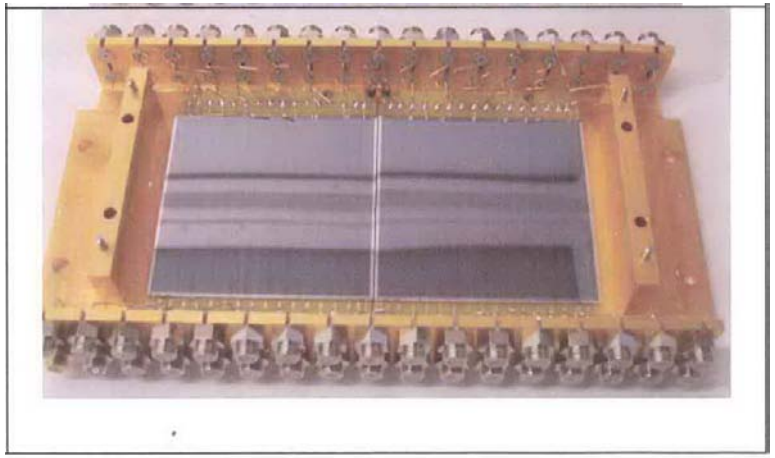

new implantation PSSSDs at the DGFRS
two detectors, 6x6 cm, 16 strips each
April 2012

Rose Boll and Shelley Van Cleve
purifying ^{249}Bk at REDC
ORNL, February 2012

U.S. DEPARTMENT OF ENERGY

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MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Outline

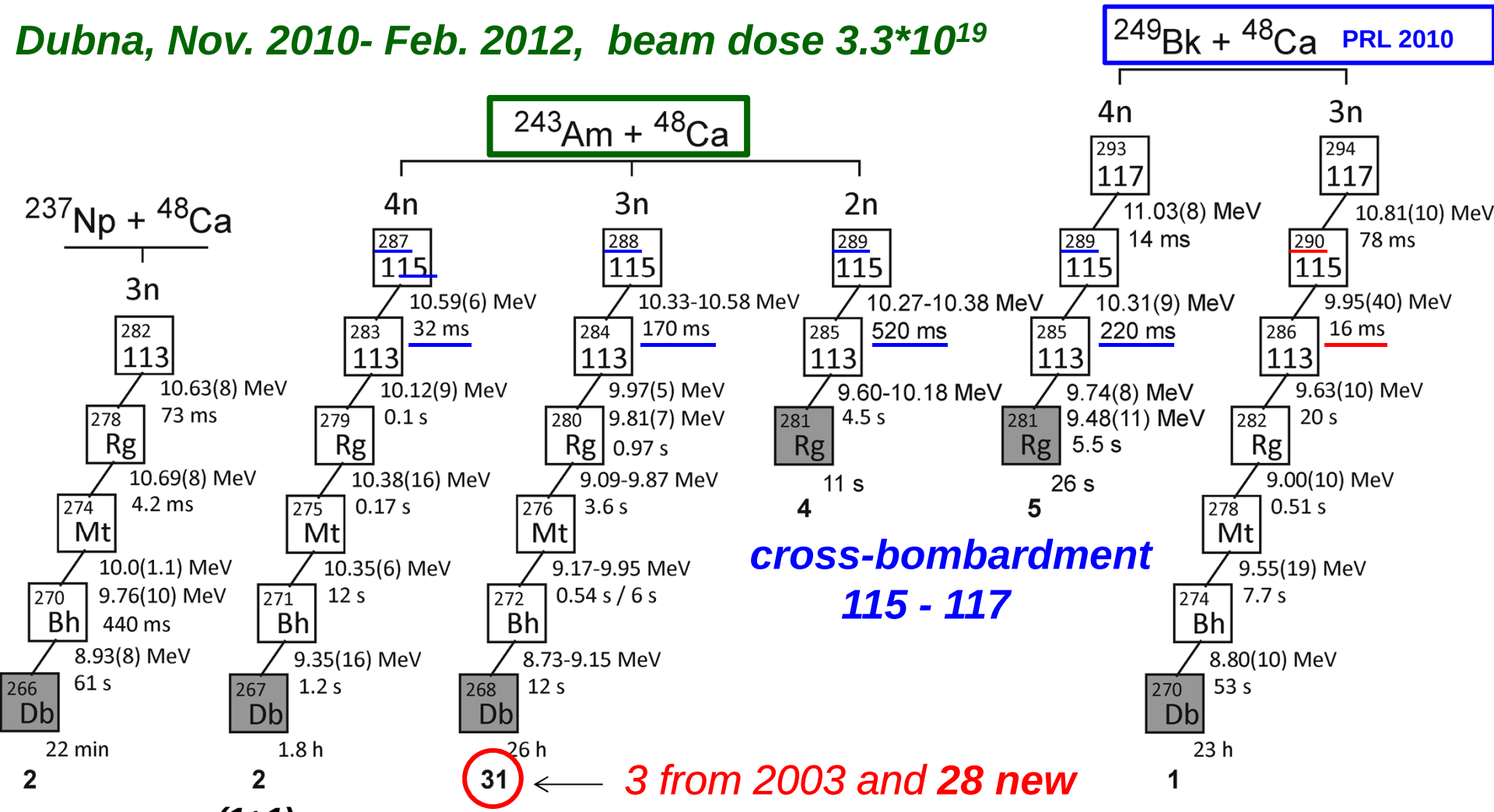
- **^{243}Am+^{48}Ca,** *November 1st, 2010 - February 27th, 2012*
  - *-decay properties (fine structure ?)*
  - *excitation function*
  - *^{289}115 from 2n reaction channel - "cross bombardment" for ^{293}117*

- **^{249}Bk+^{48}Ca,** *from April 23rd, 2012 till ~ November 2012 (???)*
  - *-decay properties, in particular of ^{294}117 chain (only 1 event detected earlier)*
  - *excitation function*
  - *5n reaction channel ^{292}117 - "cross bombardment" for ^{288}115*
  - *2n reaction channel - heaviest nucleus ^{295}117*

- ***New digital detection system for Super Heavy Nuclei***
- ***Summary***

New studies of super heavy nuclei

Dubna, Nov. 2010- Feb. 2012, beam dose $3.3*10^{19}$



cross-bombardment 115 - 117

← *3 from 2003 and **28 new***

***"mass production"** (of ^{296}119 granddaughter)*

total number of observed decay chains (2003+new) is listed at the end of the chain

Oganessian et al., PRL 108, 022502, 2012 and submitted to PRC

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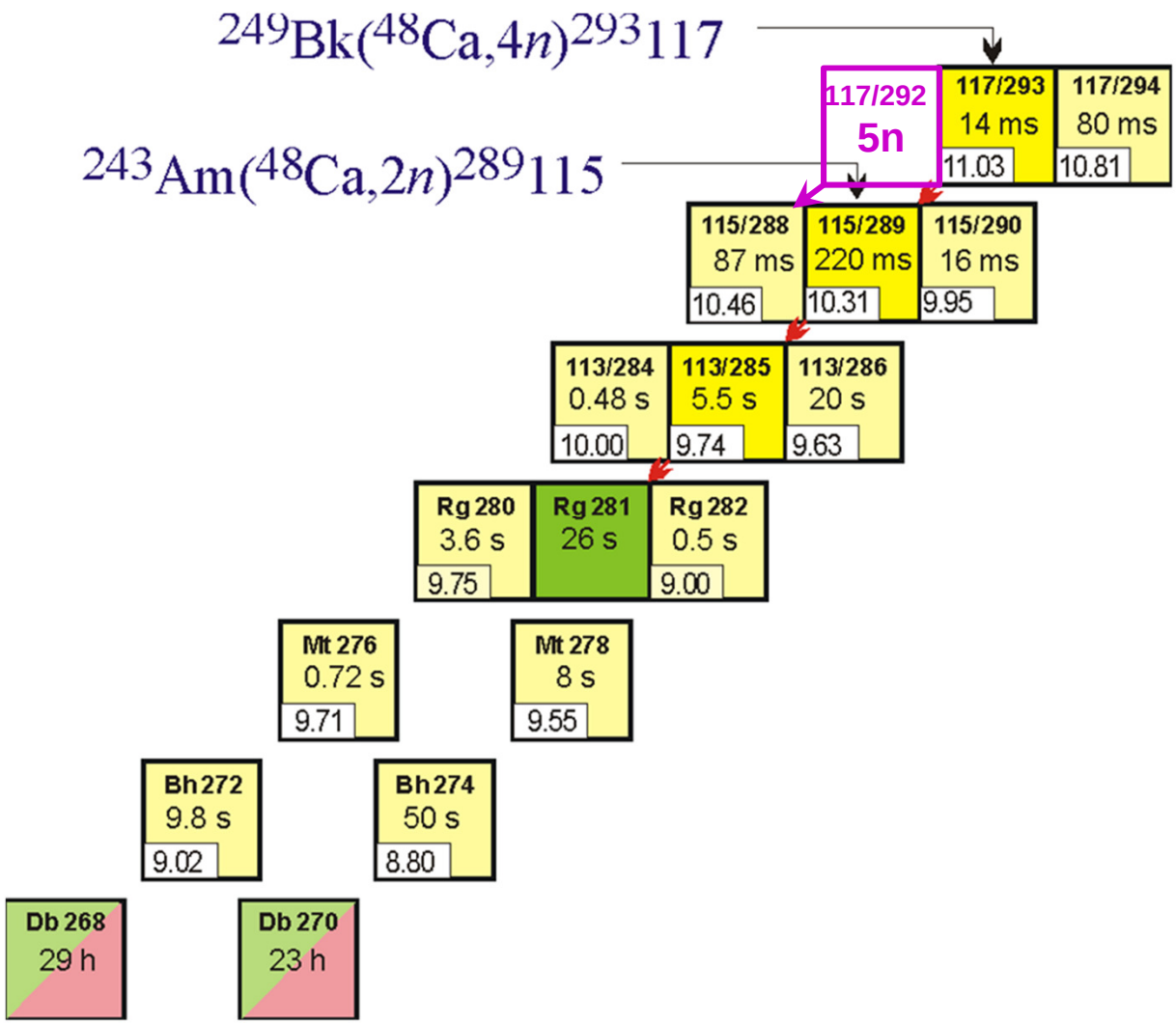
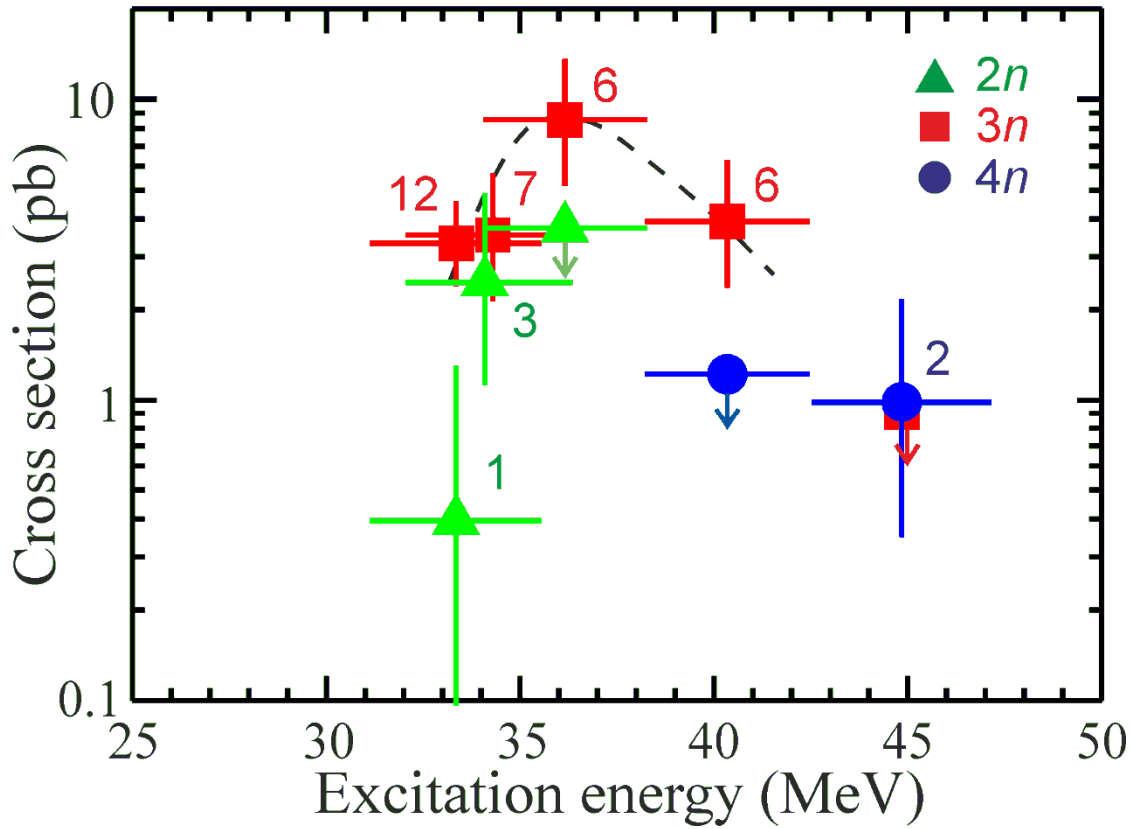
"Cross bombardment"

$^{243}Am+^{48}Ca$ and $^{249}Bk+^{48}Ca$ reactions



Excitation function for $^{48}Ca+^{243}Am$ (2n, 3n, 4n)



$_{3n}$ at E~ 36(2) MeV=**8.5** (+6.4, -3.7) pb for ^{288}(115)*

Oganessian et al., PRL 108, 022502, 2012 and submitted to PRC

PRL 2010
5 events
lifetimes:

21 ms

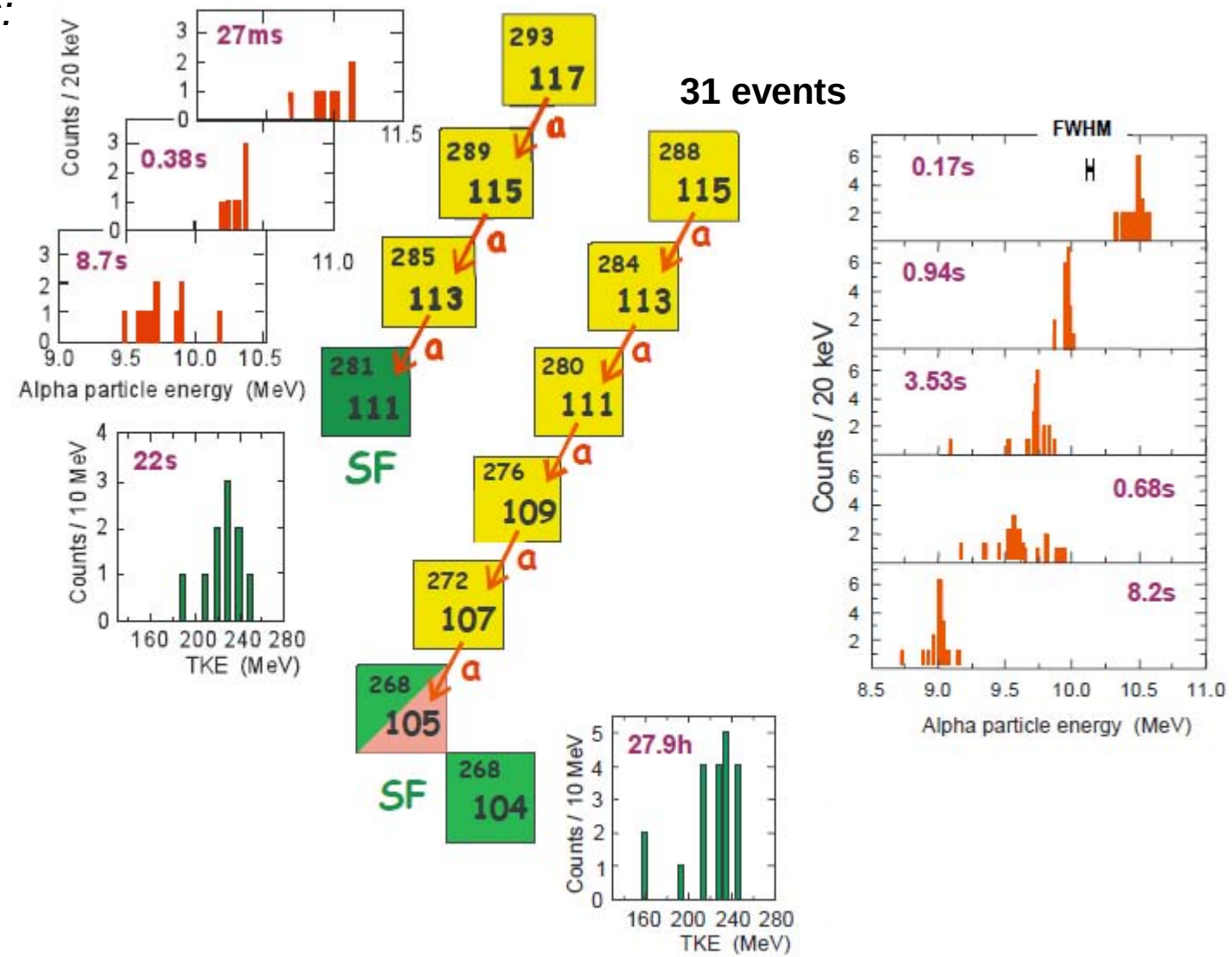
0.32 s

7.9 s

38 s

10 events (13)

31 events



- *- CE - X ray measurements needed and welcome !*

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New studies of super heavy nuclei
with Z=97 ^{249}Bk and Z=98 ^{249}Cf target materials

Dubna 2012 (ongoing exp)

*five (**8**) new events of ^{293}(117)*

	# 9	# 23	# 12	# 25	# 7
ER	9.91 MeV	13.23 MeV	11.76 MeV	11.00 MeV	9.36 MeV
293 117	10.90$_{10}$ MeV [a] 7.525 ms	11.142$_{65}$ MeV 3.305 ms	11.114$_{89}$ MeV [a] 153.948 ms	10.914$_{68}$ MeV 10.547 ms	10.598$_{49}$ MeV 109.878 ms
289 115	10.37$_{28}$ MeV [b] 0.2665 s	**10.310$_{65}$ MeV 0.1719 s**	missing α	**10.198$_{68}$ MeV 1.4348 s**	**10.217$_{49}$ MeV 0.1510 s**
285 113	9.857$_{40}$ MeV 1.5155 s	**missing α**	9.631$_{67}$ MeV *19.0456 s*	**9.36$_{30}$ MeV [b] 1.3153 s**	**9.683$_{49}$ MeV 18.3997 s**
281 Rg	204.0 MeV [c] 9.4192 s	**222.0 MeV [c] *7.4538 s***	212.8 MeV [c] 1.4809 s	**162.9 MeV [c] 103.406 s**	**150.8 MeV 42.1349 s**

*two (**3**)new events of ^{294}(117)*

	# 16	# 8
ER	12.64 MeV	13.11 MeV
294 117	10.960$_{70}$ MeV 100.72 ms	10.967$_{73}$ MeV 3.986 ms
290 115	**10.28$_{12}$ MeV [a] 0.3010 s**	**9.775$_{73}$ MeV 0.6976 s**
286 113	**9.61$_{11}$ MeV [a] 5.7895 s**	**9.750$_{11}$ MeV [a] 3.6525 s**
282 Rg	**9.18$_{30}$ MeV [b] 145.34 s**	**9.04$_{11}$ MeV [a] 29.202 s**
278 Mt	**9.396$_{70}$ MeV 4.1713 s**	**9.382$_{73}$ MeV 7.2154 s**
274 Bh	8.791$_{70}$ MeV 102.58 s	**8.69$_{30}$ MeV [b] 55.722 s**
270 Db	142.4 MeV 37.49 h	195.9 MeV [c] 23.49 h

0.39 s

^{249}Cf + ^{48}Ca

	# 23
ER	11.63 MeV
294 118	11.656 MeV $0.89^{+1.07}_{-0.31}$ ms
290 Lv	10.848 MeV $7.1^{+3.2}_{-1.7}$ ms
286 Fl	10.196 MeV 129^{+39}_{-24} ms
282 Cn	$0.82^{+0.30}_{-0.18}$ ms

294 118	11.679$_{65}$ MeV 0.135 ms
290 Lv	10.848$_{65}$ MeV 29.437 ms
286 Fl	**219.3 MeV [c] 3.486 ms**

new event of ^{294}(118)

Z=97 ^{249}Bk → Z=98 ^{249}Cf

$T_{1/2}$=330 days

E(^{297}118) ~ 31 MeV*

Oganessian et al., PRL, in press, September 2012

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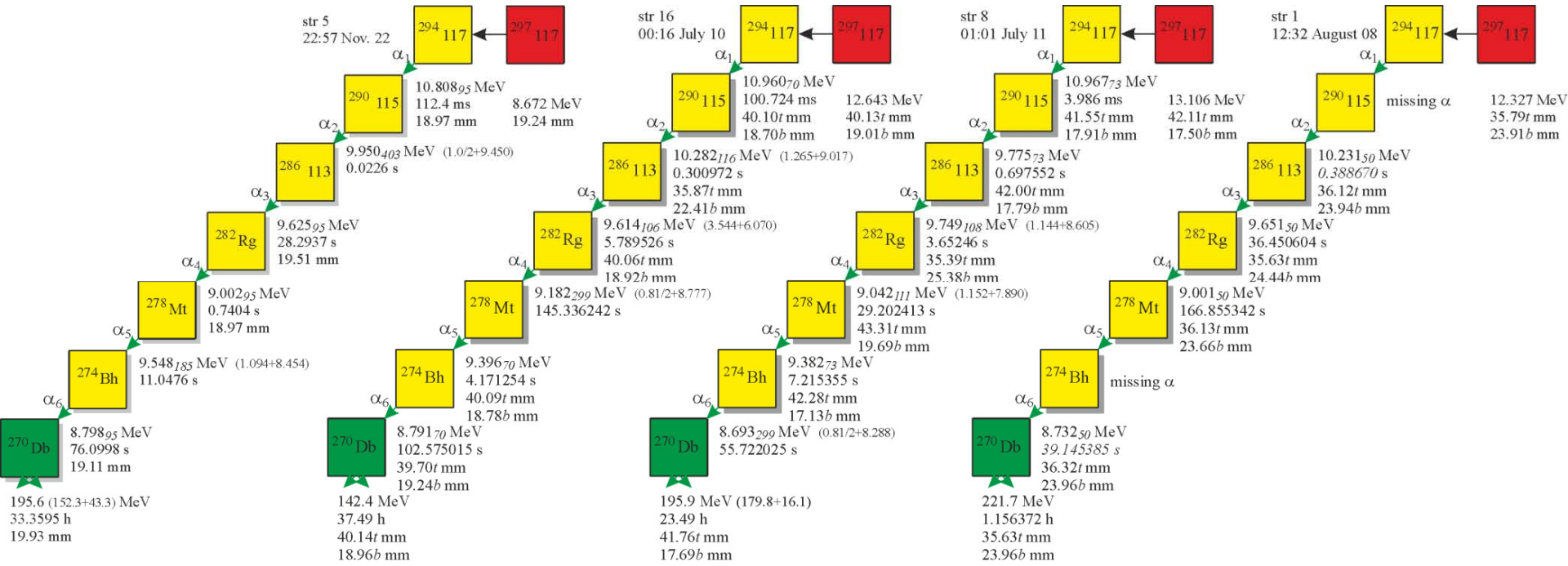
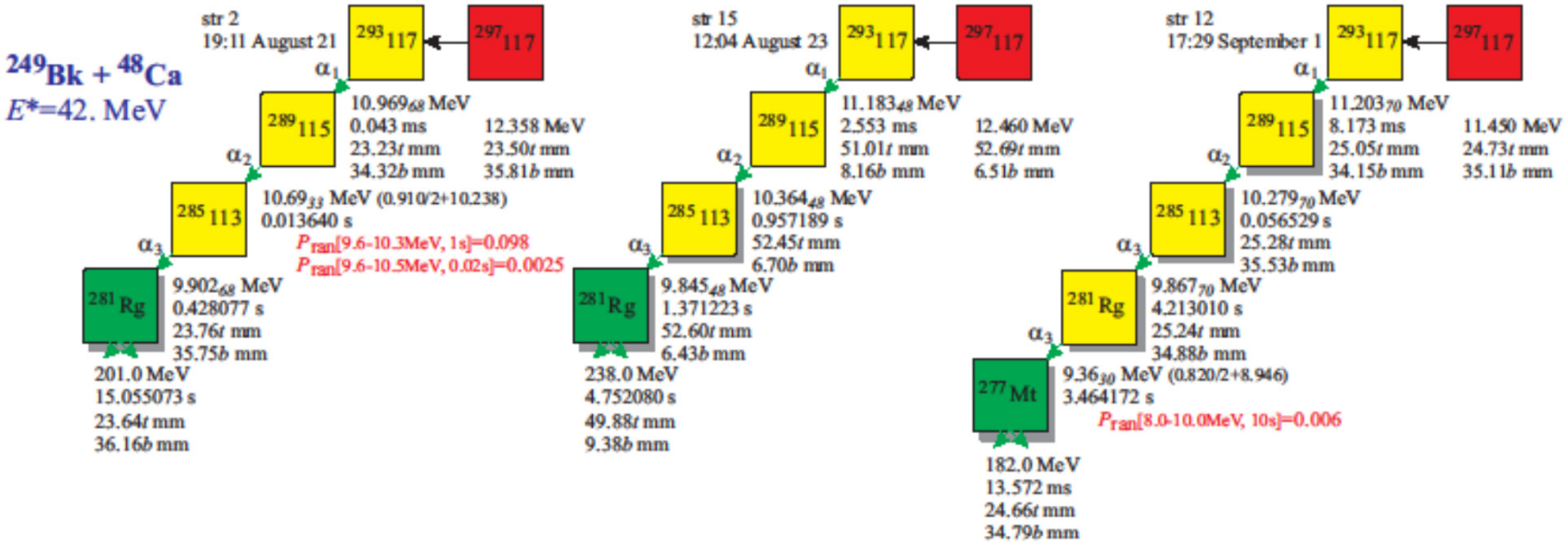
Total of four $^{294}117$ decay chains observed so far



E~ 35 MeV denotes the calculated excitation energy E* of $^{297}117$ compound nucleus ranging from 32.8 MeV to 37.5 MeV*



first observations
of -decay of ^{281}Rg
and new isotope ^{277}Mt
(14 ms SF after -decay)

Z=111 ^{281}Rg SF ~ 20 s
Z=109 ^{277}Mt SF ~ 14 ms "fission corridor"

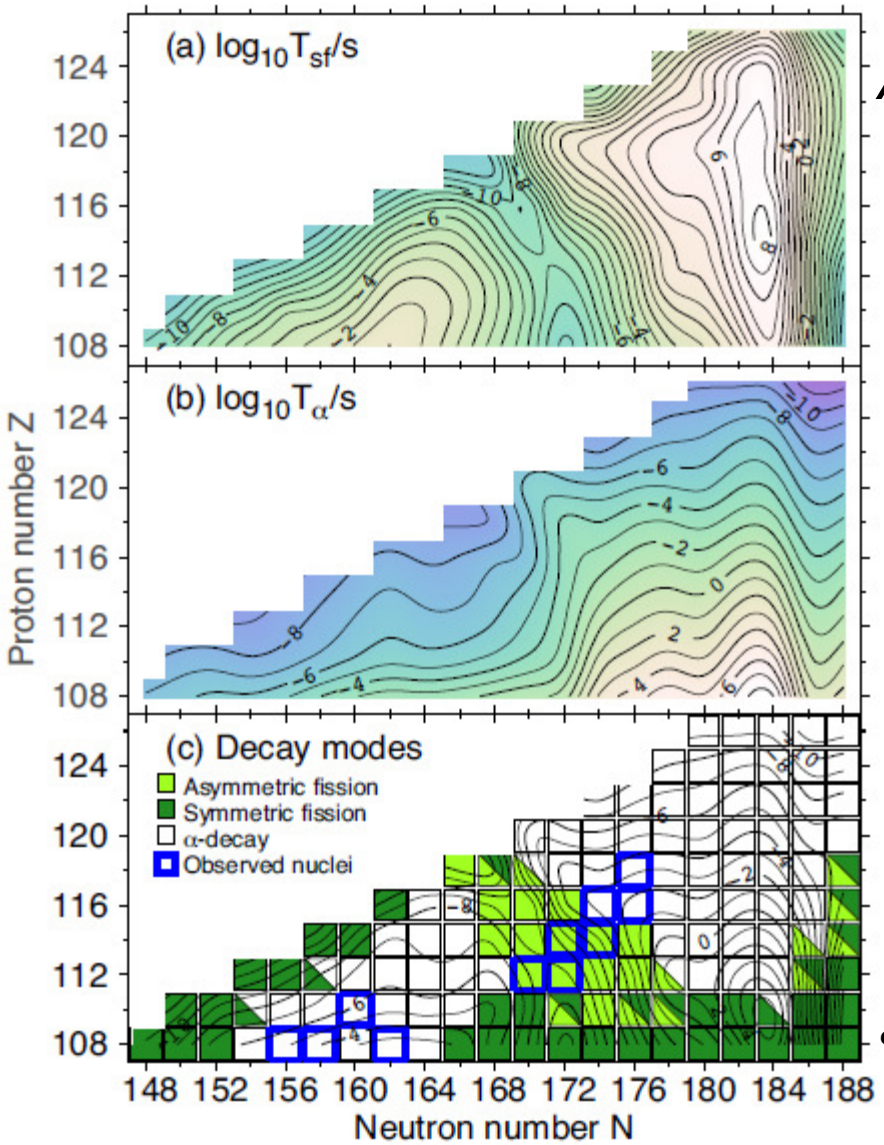


FIG. 4. (Color online) Summary of our SkM* results for decay modes of SH nuclei. (a) SF half-lives $\log_{10} T_{sf}$ (in seconds). (b) α-decay half-lives $\log_{10} T_{\alpha}$ (in seconds). (c) Dominant decay modes. If two modes compete, this is marked by coexisting triangles.

A.Staszczak, A. Baran and W.Nazarewicz
"Spontaneous fission modes and lifetimes of super heavy nuclei in the nuclear density functional theory"
(see arXiv.org)

so far ONLY EVEN-EVEN SHE nuclei
advanced analysis of shapes
and
symmetric vs asymmetric fission modes affecting SHE lifetimes

I see pretty good agreement for $T_{1/2}$'s of even-even alpha emitters, but the SF mode at the end of "Dubna Island" decay chains appears to be much too fast in the calculations.

calc. $T_{1/2}(^{298}120) \sim 10$ s

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Cross section data ^{249}Bk + ^{48}Ca

	4n - ^{293}(117)		3n - ^{294}(117)
exp	***E* ~ 39(2) MeV***	***E* ~ 42(2) MeV***	***E* ~ 35 and 33 MeV***
2009-2010	**1.3(+1.5,-0.6) pb** *5 events*	-	**0.5(+1.1, -0.4) pb** *1 event*
2012	***2.0(+2.2, -1.0) pb*** *5 events*	***~ 2-3 pb*** *3 events*	***3.6(+6.1, -2.5) pb*** *2+1 events*

average values:

1.5(+1.1,-0.5) pb for 4n, 293(117) at E~ 39 MeV*

1.1(+1.2,-0.6) pb for 3n, 294(117) at E ~ 35 MeV*

Oganessian et al., PRL 2012, in press

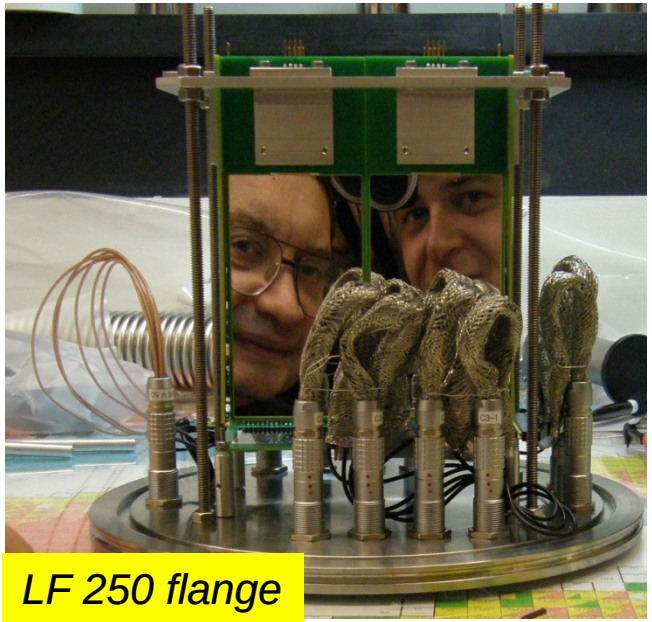
New detectors and digital data acquisition system

(similar DAQ now at SHIP serving PSSD+Si-box+MCPs)

MICRON

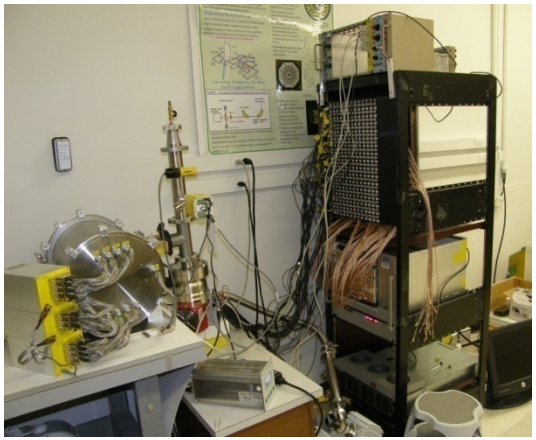
128 x48 mm
1 mm wide strips DSSD

six 120 x 65 mm single Si forming Si-box
all Si-wafers 300 m thick



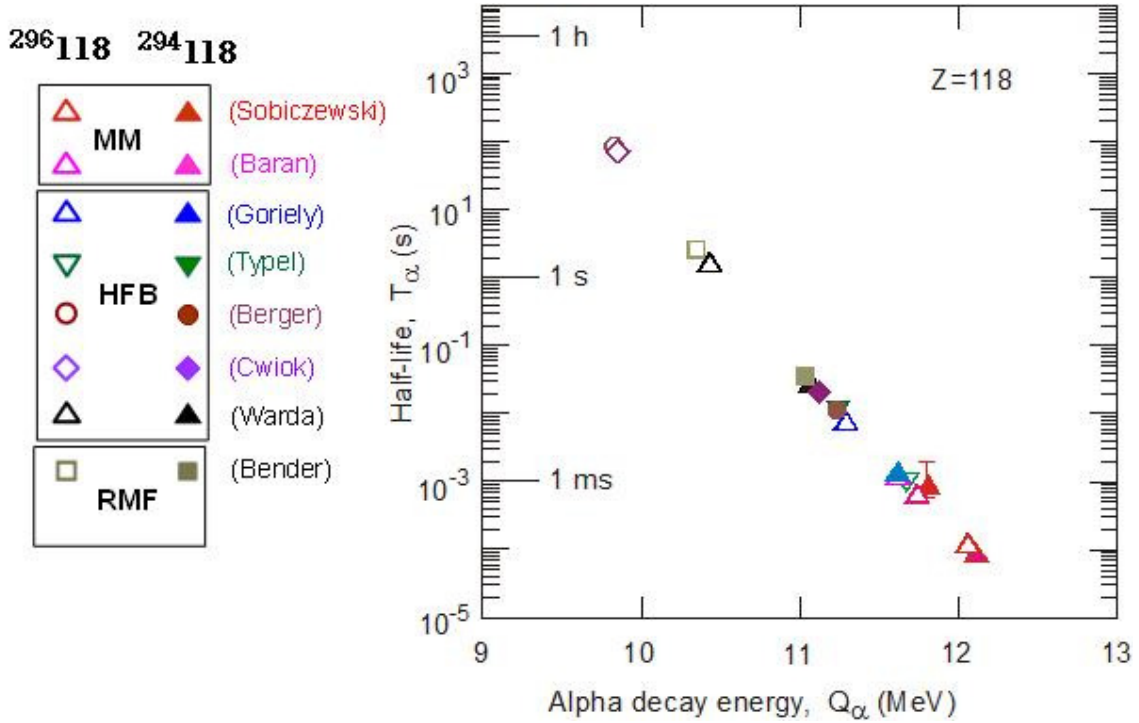
LF 250 flange

MESYTEC
lin-log preamps
ISEG NIM HV
XIA Pixie16 rev D (208 channels)
Dell Power Edge



Plans for 2013 –search for Z=118 isotopes

Models do not agree about the decay properties of $^{294}118$ and $^{296}118$



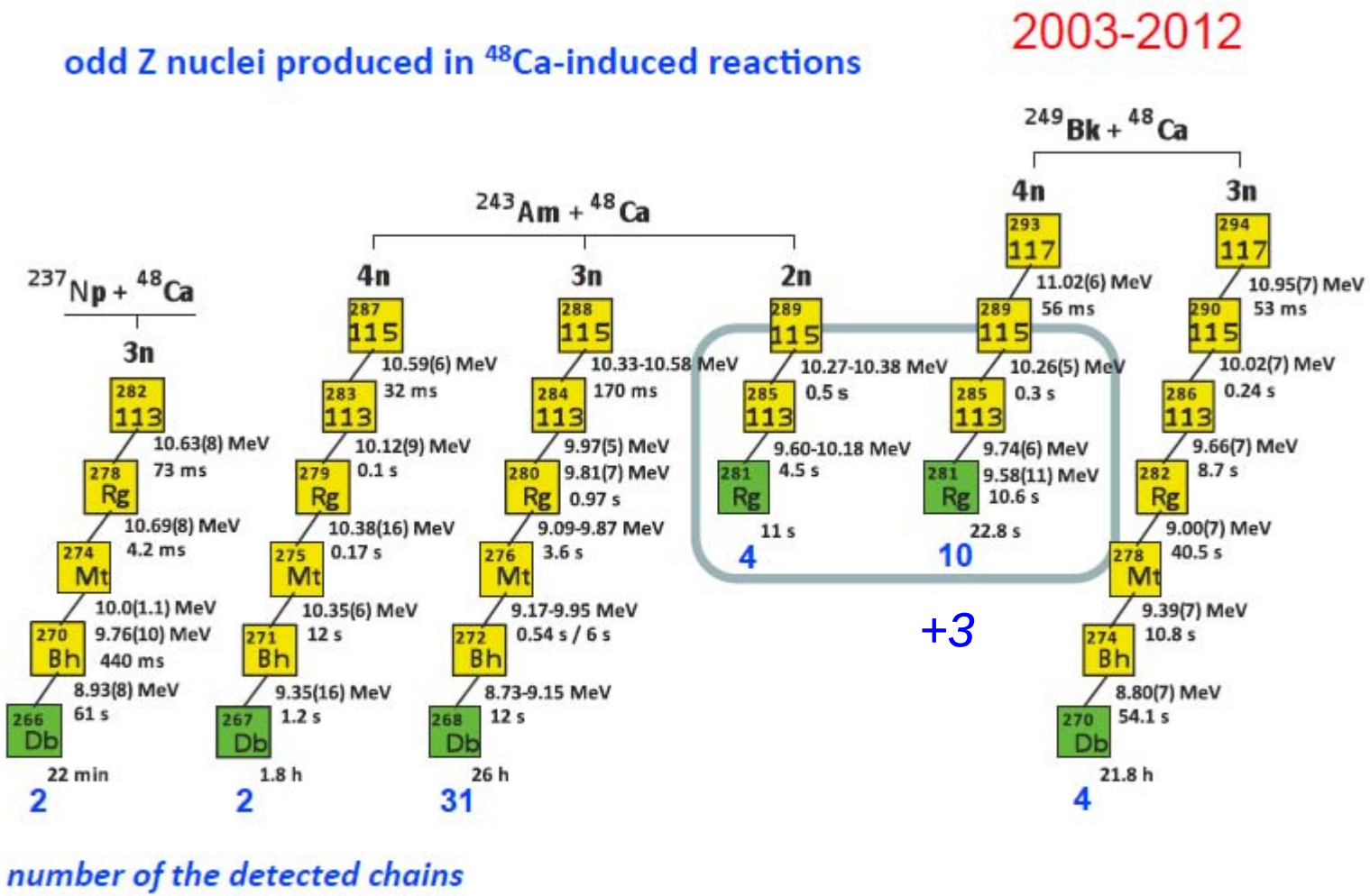
exp data on $^{294}118$ -decay:
E =11.7 MeV
$T_{1/2}$ ~ 0.7 ms

Long study with a mixed-Cf target and ^{48}Ca beam has a potential to identify new isotopes $^{295}118$ and $^{296}118$

	^{249}Cf	^{250}Cf	^{251}Cf	^{252}Cf	Total Cf
Mass (mg)	7.35	2.03	5.05	0.0027	14.45
Wt%	50.9	14.1	35	0.02	

2E7 n/s *6E6 n/s*

Summary



Yuri Oganessian. Nuclei from the Island of SHE. August 15, 2012, Int. Conf. "NS-2012", ANL, USA

Yu.Ts. Oganessian et al., PRL 108, 022502 and PRL, September 2012, in press

Summary

- *new data consistent with earlier results on Z=117, 115 , 113 (and 118)*

- *"cross bombardment" achieved in ^{48}Ca-induced reactions:*
  4n (^{249}Bk target, ^{293}117) and 2n (^{243}Am, ^{289}115) reaction channels

- *nearly "mass production" of Z=115 isotopes , $_{MAX}$ ~ 9 pb*

- *total of 31 events of ^{288}115 and better statistics for ^{293}117 (13 events)*
  and ^{294}117 (4 events) help to determine the decay properties
  along these observed decay chains

- *an evidence for a broadening of -spectra (fine structure ?)*

- *new isotope ^{277}Mt (~ 14 ms SF !) observed at the of ^{293}117 decay chain*

- *¯ (^{293}117) ~ 1.5 pb, ^{294}118 observed with ingrown ^{249}Cf target component*

-*new detectors and digital electronics should operate at DGFRS in CY 2013*

Yu.Ts. Oganessian et al., PRL 108, 022502, PRL, in press, and submitted to PR C

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