

The GAMMASPHERE+FATIMA proposal for ^{252}Cf fission fragment spectroscopy

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University of Surrey

19 March 2015

Topics

Introduction
ANL proposal

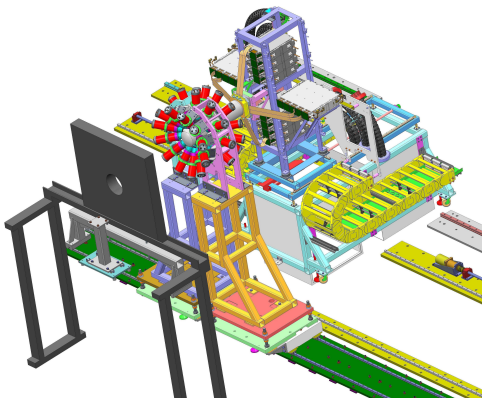
UK in FAIR - the UKNUSTAR Project

Institutions



Work Packages

- ▶ **R³B:** Si tracker
- ▶ **HISPEC:** LYCCA Large Stop detector
- ▶ **DESEPC:** FATIMA



UKDESPEC Status

Equipment

- ▶ **Detectors:** 36x 1.5in x 2in LaBr₃:Ce+H10570
- ▶ **EDAQ:** VME-based:
Analogue timing: CFD (V812), TDC (V1290A)
digital energy: digitizers + DPP-PSD (V1751C),
VME-PSI optical bridge
- ▶ **Mechanical frame:** built in Daresbury; 378 kg;
detectors arranged in three rings - one ring at 4° and two at ±44°
- ▶ **Use:** RIKEN, Grenoble, NIPNE, Birmingham



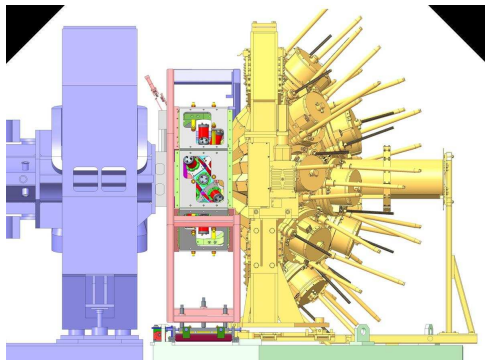
Planning

Remaining activities

- ▶ **TDR** (L.M.Fraile's talk)
- ▶ **Commissioning**

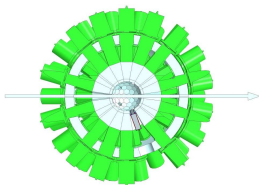
Possible sites

- ▶ **JYFL** (D.Cullen's talk)
- ▶ **GANIL** (P.John's experiment)
- ▶ **Argonne**



STFC Daresbury

ANL proposal



STFC Daresbury

Undertaken steps

- ▶ Discussions with ANL locals - ANL strategic plan
- ▶ Lol'14 - approved with highest priority
- ▶ Proposal - approved by the PAC 8-9 March
- ▶ ... further discussions on mechanical and EDAQ integration initiated

The proposal

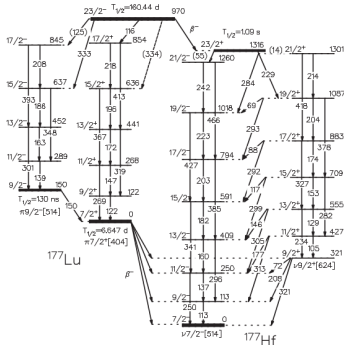
- ▶ **Aim:** To measure short half-lives in ^{252}Cf fission fragments
- ▶ **Equipment:** 74 GAMMASPHERE HPGe detectors
+ 36 LaBr₃:Ce detectors
- ▶ **Source:** $\approx 100 \mu\text{Ci } ^{252}\text{Cf}$
- ▶ **Efficiency:** assumed 7%
O.Roberts et al., NIMA**748** (2014) 91
- ▶ **Statistics:** 1 month run
- ▶ **EDAQ:** analogue timing + digital energy
- ▶ **'Beam-time':** December'15 - January'16
- ▶ **Competitiveness:** complementary to CARIBU
complementary to the EXILL+FATIMA in the mass regions 105-115 and 145-160

GS source experiment



BRIEF REPORTS

PHYSICAL REVIEW C **85**, 027304 (2012)



F.Kondev *et al.*, PRC85 (2012) 027304



γ -ray coincidence and fast-timing measurements using LaBr₃(Ce) detectors and gammasphere[®]

S. Zhu^{a,*}, F.G. Kondev^a, M.P. Carpenter^a, I. Ahmad^a, C.J. Chiara^{a,b}, J.R. Greene^a, G. Gurdal^a, R.V.F. Janssens^a, S. Lalkovski^a, T. Lauritsen^a, D. Seweryniak^a

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S.Zhu *et al.*, NIMA652 (2011) 231

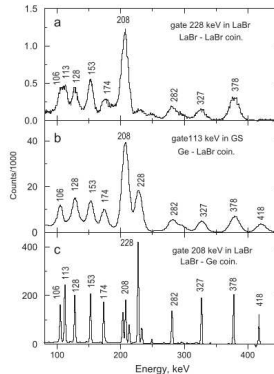


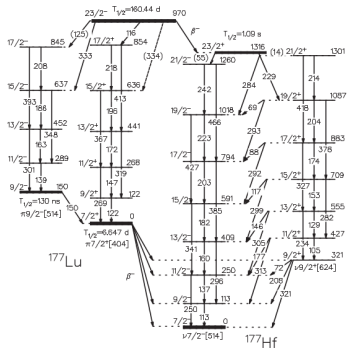
Fig. 3. γ -ray spectra measured for the LaBr and Ge detectors after requiring a coincidence with one of the transitions in the ^{177}Lu γ -ray cascade populated

GS source experiment



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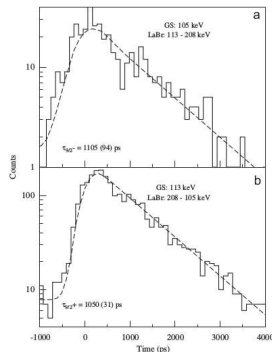


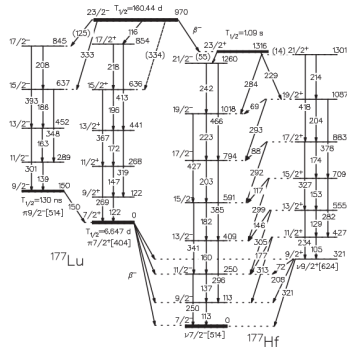
Fig. 4. Timing spectra measured by the two LaBr₃(Ce) detectors for selected transitions in ¹⁷⁷Hf after gating on another transition in Gammasphere, following the β -decay of the high-spin isomer in ¹⁷⁷Lu. Lifetimes were extracted from the slopes.

GS source experiment



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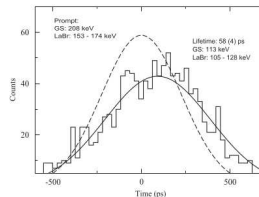
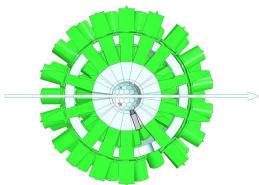


Fig. 5. Lifetime extracted from the TAC spectra using centroid shift method. The dotted line represents the prompt time distribution, while the solid line is a fit of the data points, see text for details.

ANL proposal



STFC Daresbury

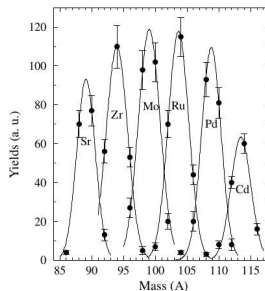
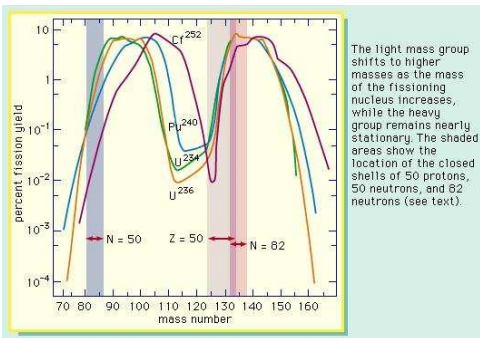
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Mass distribution



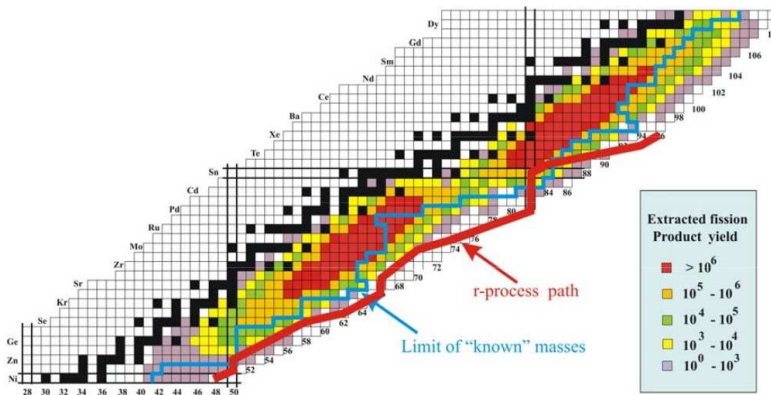
- ▶ The light mass peak of ^{252}Cf is shifted with respect to the ^{240}Pu and ^{236}U mass peaks
- ▶ The heavier peak yield is enhanced in 145-160 when comparing to the U and Pu n-induced fission

EPJA8 (2000) 177

Reaction: $^{28}\text{Si} + ^{176}\text{Yb} \rightarrow ^{204}\text{Po}^* \rightarrow ^{104}\text{Ru} + ^{93,94}\text{Zr}$;

Beam energy: 145 MeV

Mass distribution



Most exotic fragments

- ▶ **Light peak:** $^{104,106}\text{Zr}$, $^{108,110}\text{Mo}$, $^{112,114}\text{Ru}$, $^{116,118}\text{Pd}$
- ▶ **Heavy peak:** $^{156,158,160}\text{Sm}$, $^{162,164}\text{Gd}$ (Matthias' talk)

Yields

Table 1: Yield of selected exotic nuclei produced from the ^{252}Cf SF Decay and estimated statistics for timing measurements. The Yields are from [ER]. Details on the estimates for the quadrupole coincidences are given in the text. The level energy, spin/parity and half-life data is from NNDC [nnec]. The colour scheme is the same as in Fig.2. All half-lives, denoted as unknown are expected to be in the range 10 ps to 2 ns.

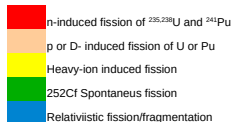
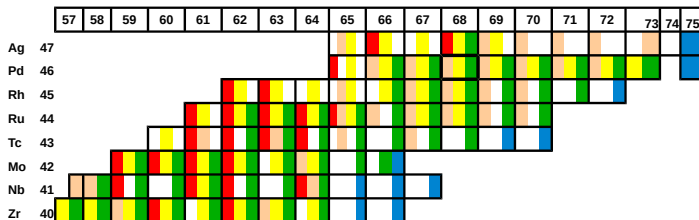
Nucleus	Yield (nuclei/sec per 100 SF decays)	Quad. Coinc./Month	Level spin	Level energy (keV)	Half-life (ns)
^{104}Zr	0.226	25,745	2_1^+	139	2.0(3)
^{106}Zr	0.006	684	2_1^+	152	unknown
^{108}Mo	0.677	77,122	2_1^+	193	0.5(3)
^{110}Mo	0.0231	2,631	2_1^+	213	unknown
^{112}Ru	0.962	109,588	2_1^+	236	0.32(3)
^{114}Ru	0.0192	2,187	2_1^+ 2_2^+	265 563	unknown unknown
^{116}Pd	0.841	95,804	2_1^+ 2_2^+	340 738	0.11(3) unknown
^{118}Pd	0.127	14,467	2_1^+ 2_2^+	379 812	unknown unknown
^{156}Sm	0.667	75,983	2_1^+	76	>2
^{158}Sm	0.316	35,998	2_1^+	78	unknown
^{160}Sm	0.0907	10,332	2_1^+	71	unknown
^{162}Gd	0.120	13,670	2_1^+	73	unknown
^{164}Gd	0.0294	3,349	2_1^+	73	unknown

Physics cases

- deformation in Zr
... but also in Sm and Gd
- shape phase transition in Mo
- triaxiality in Ru
- γ -instability in Pd

Segre chart - fission yields

Sheet1



Sub-nanosecond lifetime measurement with ^{252}Cf source and a hybrid Gammasphere

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