Study of octupole deformation in n-rich Ba isotopes populated via β decay

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Collaboration:

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- University of West of Scotland, Paisley, Uk
- ILL, Greonoble, France
- Technische University of Darmstadt, Darmstadt, Germany
- Cern, Geneva, Ch
- IKP, University of Cologne, Cologne, Germany

As part of the IDS collaboration

Study of $^{150-151-152}$Ba isotopes via the β decay of $^{150-151-152}$Cs

- Unique capability of ISOLDE to produce
- high-intensity $^{150-151-152}$Cs beams

Nucleus	CARIBU (Cf)	RIKEN
	Yields x 1Ci	pps
^{148}Ba		~10^{-1}
^{150}Ba		~10^{-2}
^{148}Cs	$1.5*10^{-4}$	~10^{-2}
^{150}Cs	10^{-7}	

CERN	Yields [μC^{-1}]	pps [1.5 μA]
^{150}Cs	$1.2*10^4$	$1.8*10^4$
^{151}Cs	$1.7*10^3$	$2.5*10^3$
^{152}Cs ★	$1.0*10^2$	150

★ Extrapolation

- Exploit the newly upgraded ISOLDE Decay Station (IDS) with improved γ efficiency and possibility to access fast-timing measurements

- Two different aspects will be attached at the same time:
- β DECAY PROPERTIES
- STRUCTURE OF DAUGHTER NUCLEI

Octupole deformations

Existence of octupole static/dynamic deformations is a long standing quest attracting much attention

Strong octupole correlations **show up due to interaction of orbitals with ΔJ=ΔI=3**

Two predicted regions for octupole def. are around **Ba** and Th-Ra

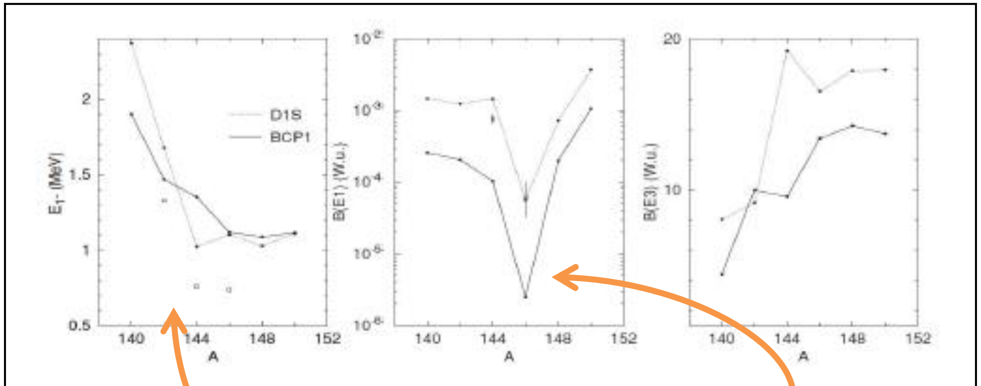
Possibility of having dynamic and static correlations

➔ Theoretical models do not agree on onset of static deformations

Experimental fingerprints are:

- **Low-lying negative parity states** of collective nature (1-,3-…)
- **Interspacing** of negative- and positive-parity states with sequence I^+,$(I+1)^-$,$(I+2)^+$…
- Large B(E1) transition probabilities ➔ **large dipole moments**
- Presence of **E3** transitions
- Retarded appearance of back-bending at increasing spins

Octupole deformations: Ba isotopic chain $^{140-142-144-146-148-150-152}$Ba



$^{140-144}$**Ba**: hints of octupole correlations

- Alternating-parity bands
- Large and constant B(E1) values

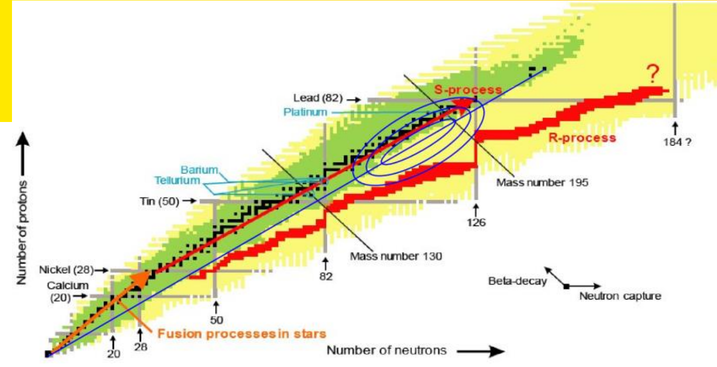
Abrupt change in structure for ^{146}**Ba**
➔ Vanishing of dipole moment due to shell effects

Restoration of the dipole moments for ^{148}**Ba**, and behaviour similar to ^{144}Ba

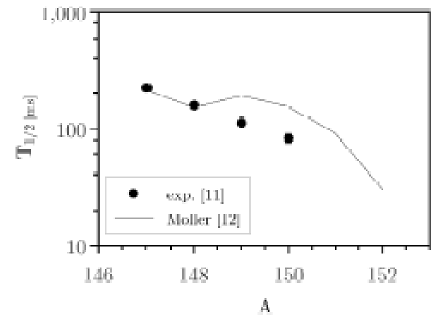
^{150}**Ba** expected to show maximum of octupolarity

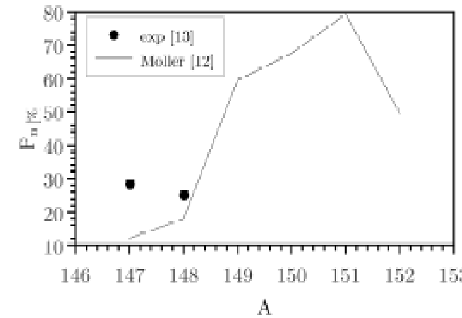
downward trend of the yrast 1^- states with increasing N, ➔ extend the systematics of the 1^- level up to $^{150-152}$Ba to locate the maximum of octupole def. in A=150 region.

β decay properties:



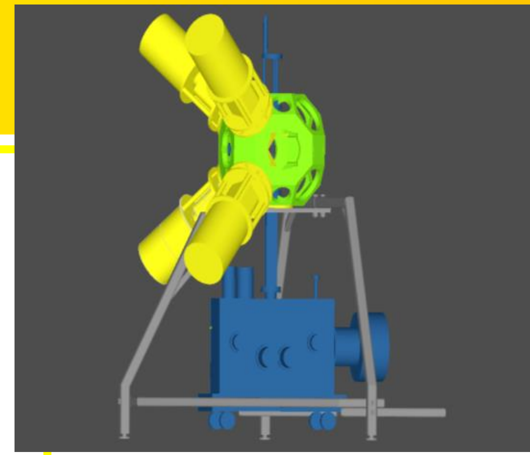
- Cs->Ba β decay gross properties will be investigated
- r-process path lies in proximity of accessible nuclei. Determination of lifetimes defines correct timescales and waiting points
- Gamma coincidences ➔ determination of apparent beta feeding and logft values of populated states
- Possible determination of n-emission competition





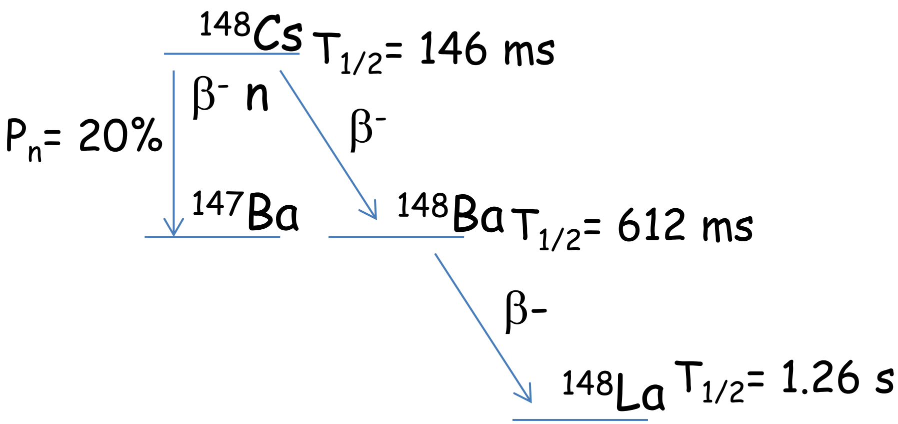
Information on the decay, such as lifetimes and delayed neutron-emission probabilities, will be extracted, together with the detailed spectroscopy of the daughter nuclei, via β–γ coincidences and lifetimes measurement of specific states.

Experimental details:



Improvements compared to past attempts:

- Use of tape transport system helps removing longer-living bg. contamination ➔ suppression of 1-2 orders of magnitude
- 4 Clover + 4 LaBr3 detectors
- Use of one LEP detector to distinguish X rays.



High g.s -> g.s decay expected
IDS setup is optimized for γ spectroscopy + suppression of impurities

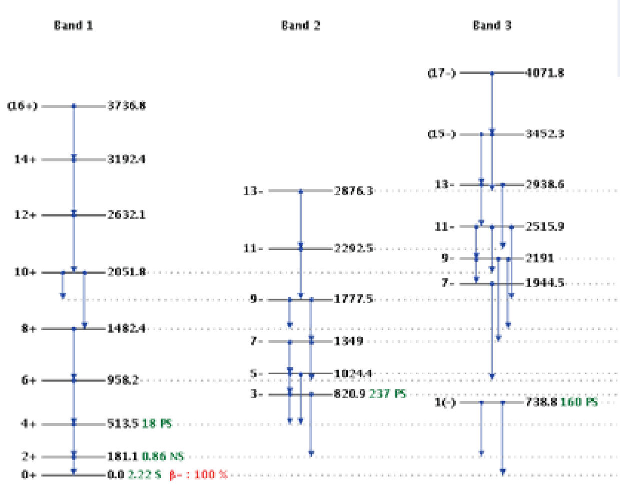
IDS station allow to identify the transitions in ^{150}Ba even if they represent only 5%** of the decay intensity of ^{150}Cs.

Energies of β delayed γ transitions are well separated and can be also measured in LaBr3 det.
➔ increase in statistics

** lower limit deduced by the previous measurement using a tape system.

Count rate estimates:

Event	Assumption	Events/s	Events/day
Implant 150Cs Populate 150Ba	ε_β= 60% Pn=20%	8640	7.5 E 8
2+->0+	I_β = 5% I_γ < 200 keV ε_γ = 5%	22	1.9 E6
Implant 151Cs Populate 151Ba	ε_β= 60% Pn=30%	1000	9.2 E7
2+->0+	I_β = 5% I_γ < 200 keV ε_γ = 5%	2.6	2.3 E5
Implant 152Cs Populate 152Ba	ε_β= 60% Pn=40%	50	4.5 E6
2+->0+	I_β = 5% I_γ < 200 keV ε_γ = 5%	0.1	1.2 E4



^{146}Ba

G.Benzoni (INFN-Milano) INTC proposal n. P-390

Conclusions:

- Propose to study the properties of $^{150-152}$Ba populated via b decay of $^{150-152}$Cs
- Importance of accessing to nuclei in this heavy mass region to define occurrence of octupole deformations and locate the maximum of octupole deformation in the A=150 region.
- By exploiting the β decay we can access the low-lying first excited states and check presence of 1^-, 3^- states
- Study of b decay properties (lifetimes and Pn) of importance to define r-process path and timescales

High intensity $^{150-152}$Cs beams are unique to ISOLDE at present
ISOLDE Decay Station in phase1 configuration
4 HPGe + LEP + 4 FAST-TIMING detectors $LaBr_3$

➔ Improved conditions compared to previous measurements
➔ we can determine halflives of decay and Pn
➔ Get information on low-lying levels and their properties to assess octupole def. in Ba isotopic chain

Beam request: 24 shifts (4 of ^{150}Cs + 8 of ^{151}Cs + 12 of ^{152}Cs)

TAC comments:

Large contamination: A=150-152 lanthanides +Ba. Is it a problem?
If yes, n-conv + LIST +RILIS. Challenging – full TISD needed.
Indications possible higher yields with nanoUCx

Based on past experience with Cs beams one can note that:

- The amount of Ba in the same mass expected to be 2 orders of magnitude lower than Cs;
- Ba can come out also as BaF+, in particular ^{131}Ba+^{19}F and ^{133}Ba+^{19}F
  ➔ ionization is low
  ➔ very long halflives (^{133}Ba has 10.5 years halflife, and ^{131}Ba 11.5 days)
  ➔ **we ask not to be scheduled with the same target as experiments requiring fluorination**
- Lanthanides would be ionized but they are not released from UCx.
- Cs is much better surface ionized than laser ionized ➔ **No need for RILIS**
- LIST implies a loss in efficiency
- Cs will ionize well already at very low line temperature while isobaric contaminants don't
  ➔ on-line optimization by lowering the line temperature
  ➔ consider the use of Ta or Nb line instead of W line
- We consider the option of having a neutron converter
- If available we can try nanoUCx target, but it is not essential