Report on the AGATA@GANIL experiment E661

High spin states above the isomers in neutron rich Iodine nuclei near N=82

[1,2*]Banik R., [1,2]Bhattacharyya S., [3]Lemasson A., [3]Rejmund M., [3]Navin A., [3]Biswas S., [3]Kim Y.H., [3]Michelagnoli C., [4]Stefan I., [1,2]Bhattacharya S., [3]Clement E. *et al.* and AGATA collaboration

[1]*Variable Energy Cyclotron Centre, Kolkata,, India.*
[2]*Homi Bhabha National Institute, Mumbai, India.*
[3]*GANIL, CEA/DRF-CNRS/IN2P3, Caen, France.*
[4]*Institut de Physique Nucleaire, IN2P3-CNRS, Orsay, France.*

* ranabir.banik@vecc.gov.in

NuSPIN-2019

Neutron-rich nuclei in A~130 region

- Interplay of single particle and collective excitation with respect to the core of ^{132}Sn (Z=50, N=82) and few particles and holes outside it.

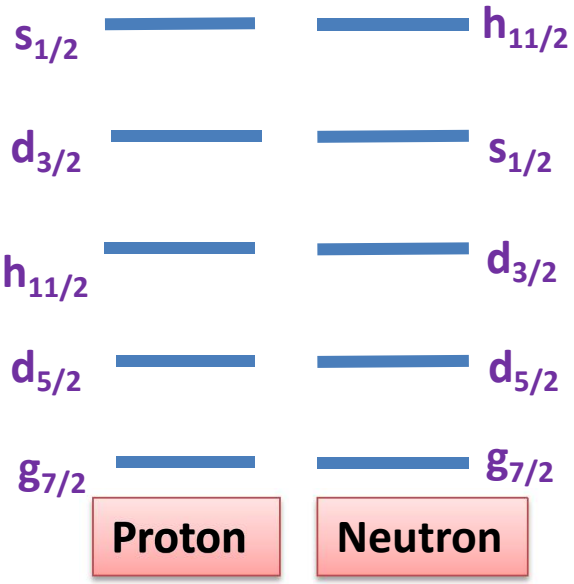
- Odd-odd nuclei around ^{132}Sn
  - effective n-p interaction near major shell closure

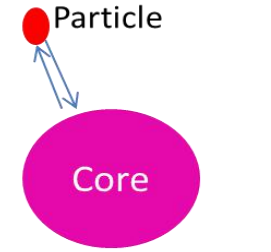
- To understand the evolution of single Particle states towards neutron rich isotopes
  - study the isotopes as a function of neutron number

- Single particle energies help to get better Theoretical models
  - Large scale Shell Model Calculations

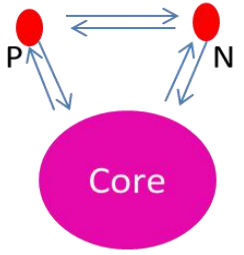
- Presence of high-j $h_{11/2}$ orbital
  - high angular momentum state
  - low lying high spin isomers

- Shape driving effects of orbitals
  - ($g_{7/2}$, $d_{5/2}$, $d_{3/2}$, $s_{1/2}$, $h_{11/2}$)





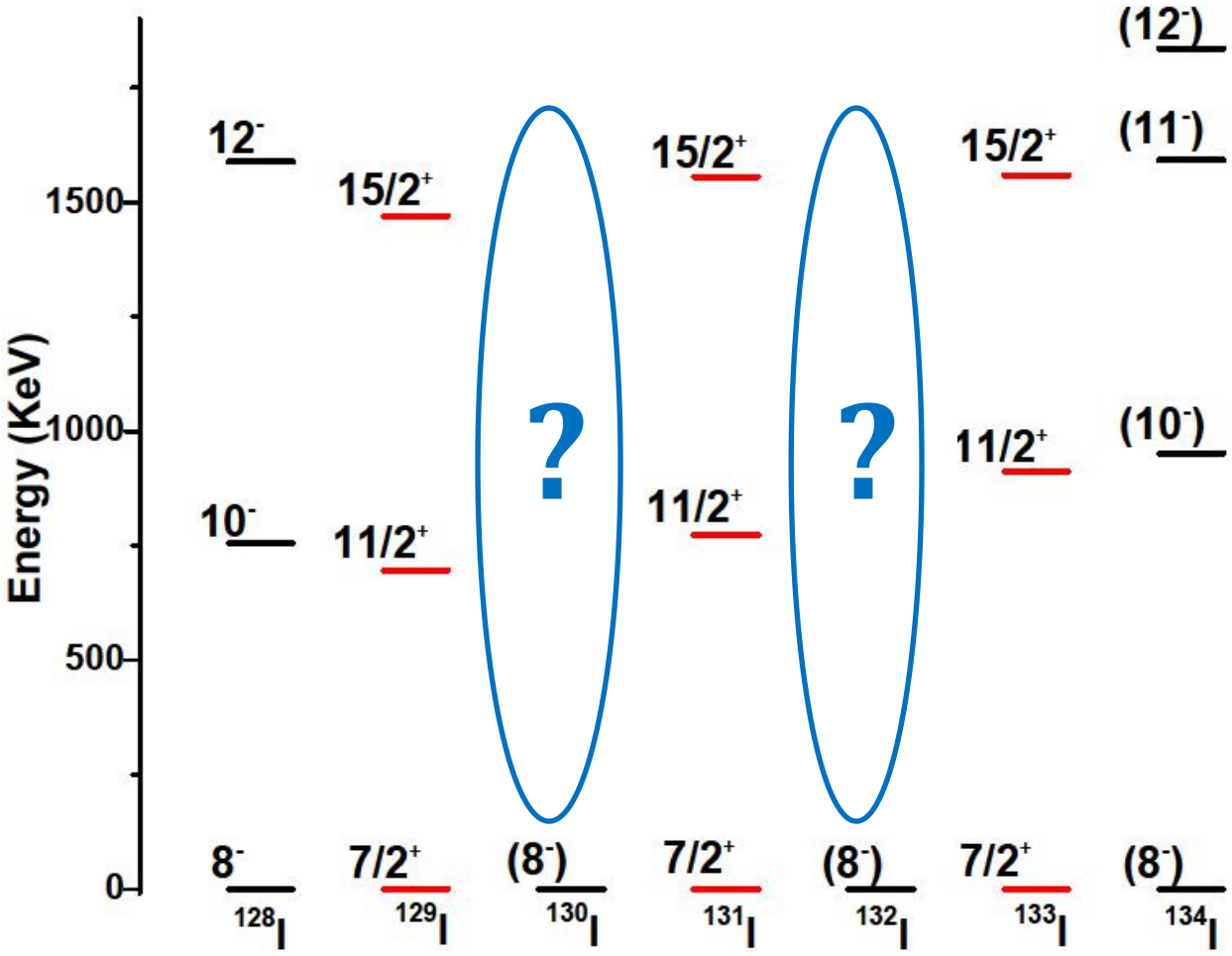
Odd-even system



Odd-Odd system

Iodine Chain around A~130 region

Iodine → 3 proton particles, few neutron holes } with respect to ^{132}Sn shell closure



No high spin states above 8⁻ isomer in ^{130,132}I

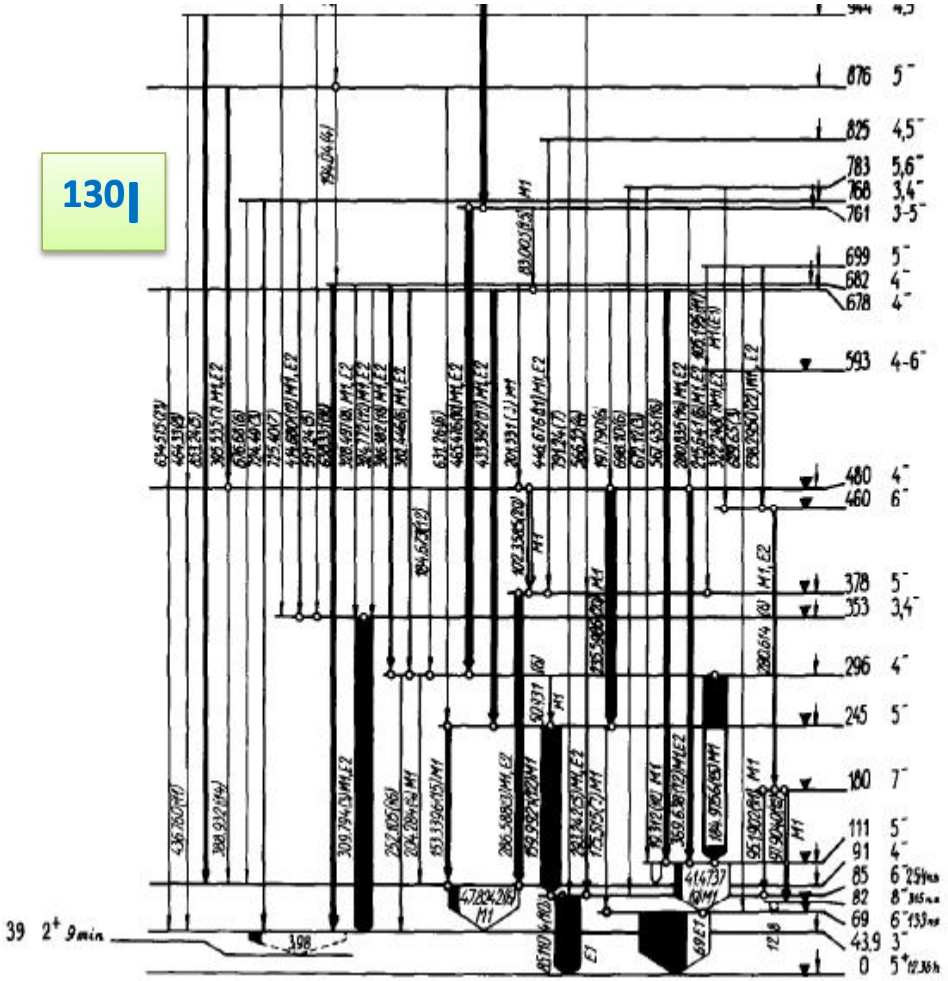
Configuration of 8⁻ isomer:

$(\pi g_{7/2}, \nu h_{11/2})_{8^-}$

or

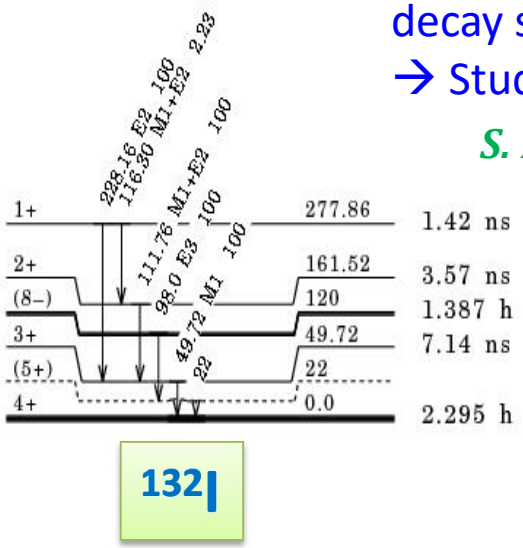
$(\pi d_{5/2}, \nu h_{11/2})_{8^-}$

Previous studies : Even mass Iodine below N=82



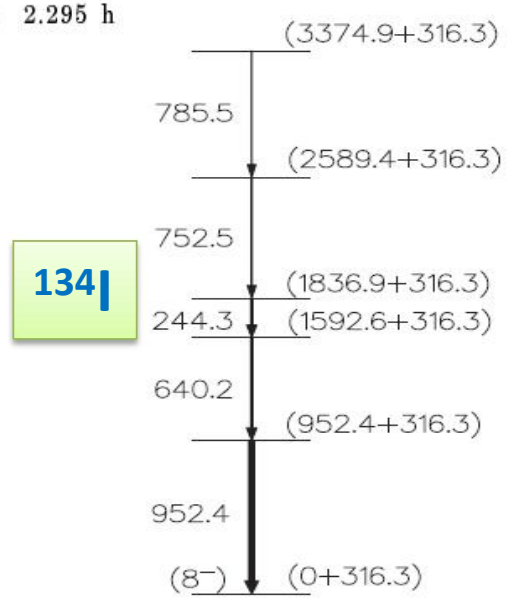
(n, γ) reaction : No high spin states reported

Sakharov et.al., NPA 494, 36 (1989)



Offline fission fragment decay spectroscopy at VECC → Study of low lying states

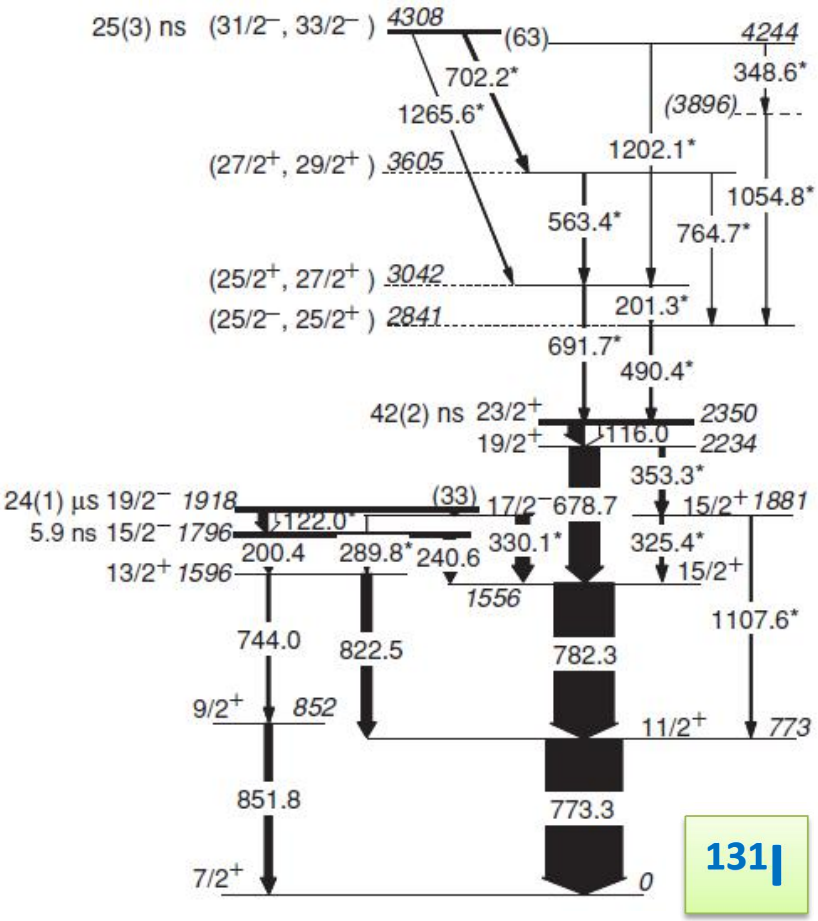
S. Bhattacharyya et.al., EPJ web of conf. 66, 02009 (2014)

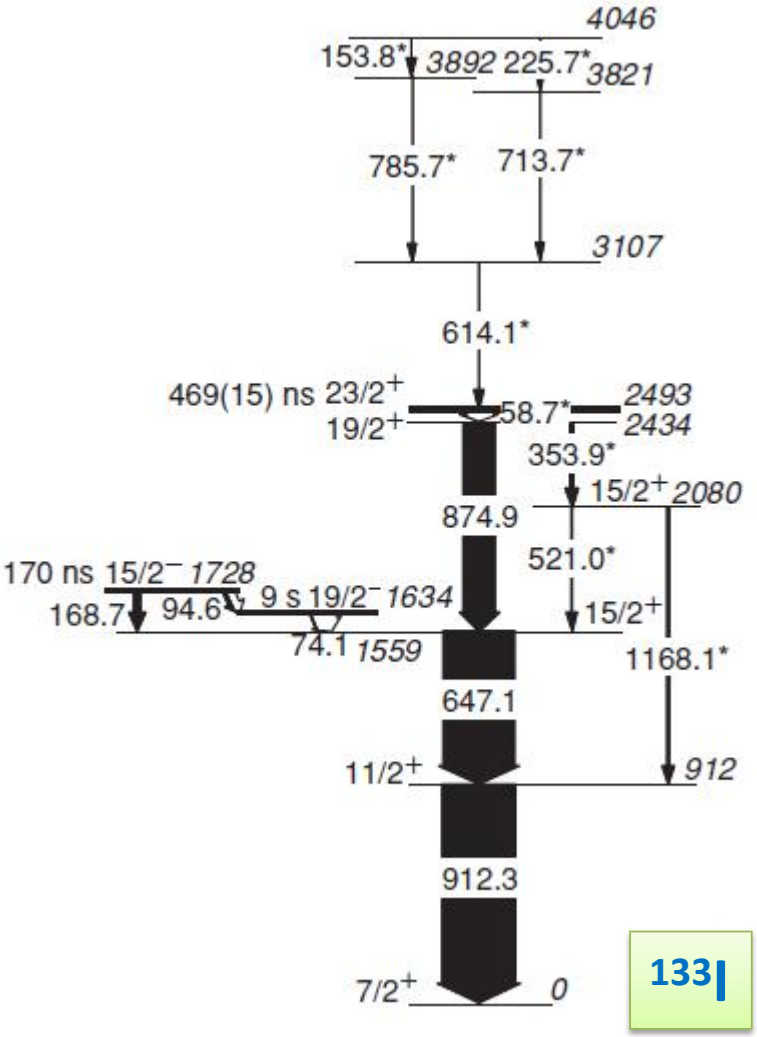


^{252}Cf fission : Gammasphere

Liu et.al., PRC 79, 067303 (2009)

Previous studies : Odd mass Iodine below N=82



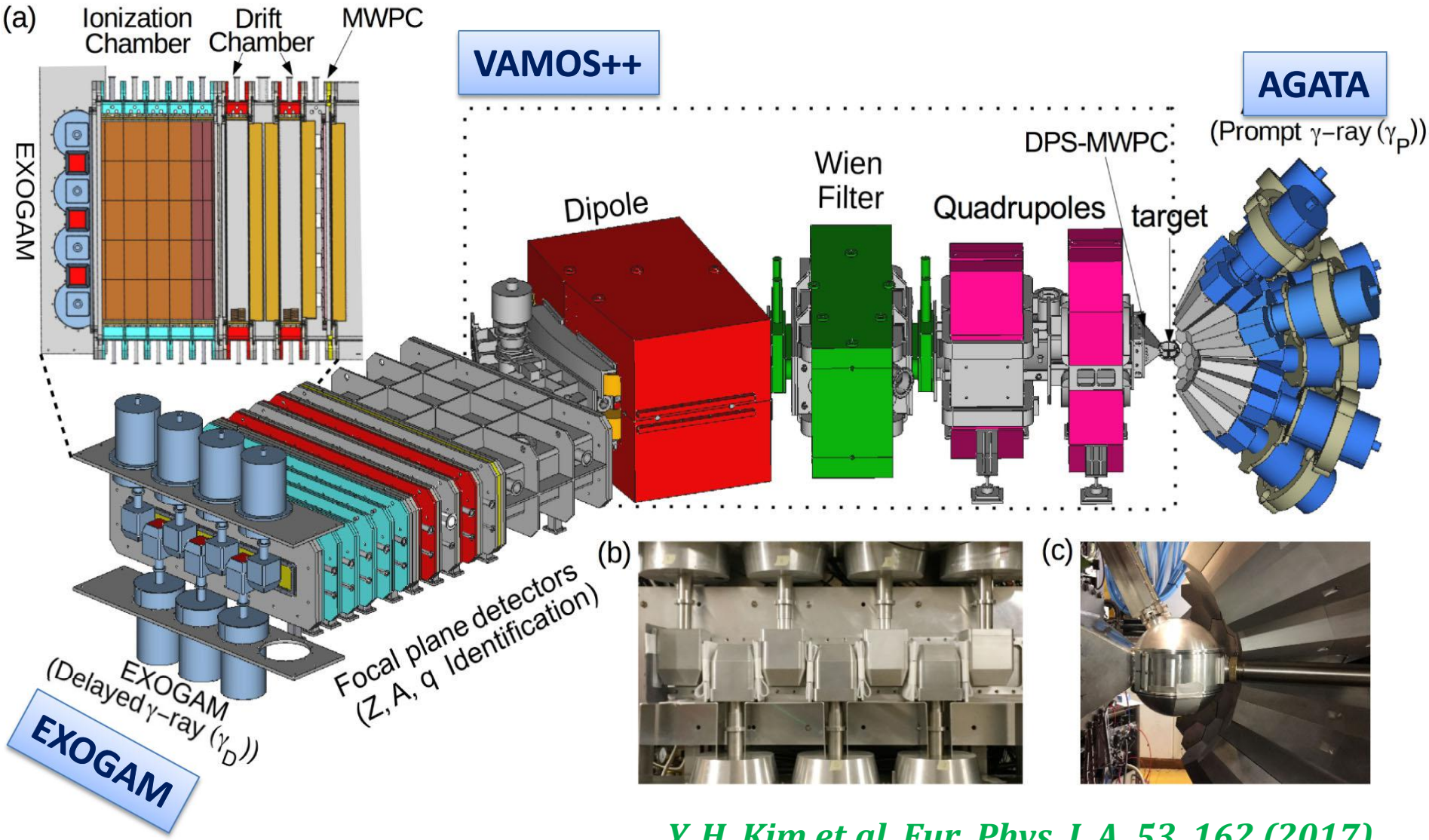


Multi-Nucleon Transfer reaction using ^{136}Xe beam

Watanabe et.al., PRC 79, 064311 (2009)

Experimental Set-up:E661

Reaction : ^{238}U (^{9}Be, f) at 6.2 MeV/u at GANIL

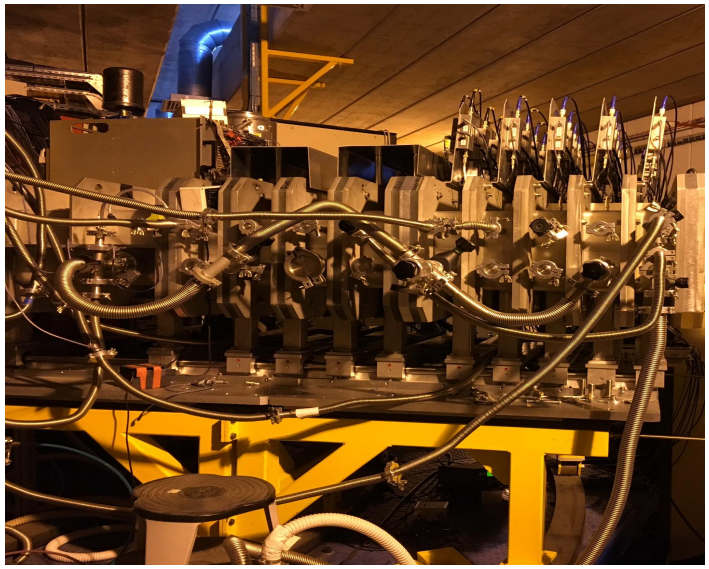


Y. H. Kim et.al, Eur. Phys. J. A, 53, 162 (2017)

Details of the experimental set-up

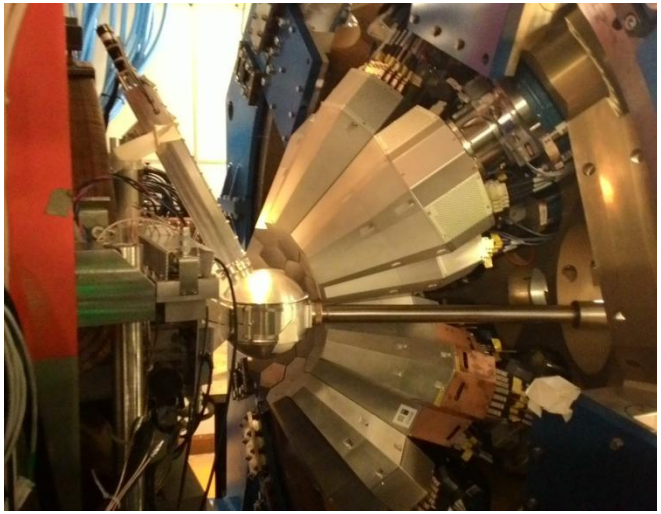
✓ **VAMOS++ Spectrometer :**

- ❑ **Focal Plane Detectors :**
  - **MWPC**
  - **Drift Chambers**
  - **Segmented Ionization Chambers**
- ❑ **Target position detectors**
  Dual Position Sensitive MWPC

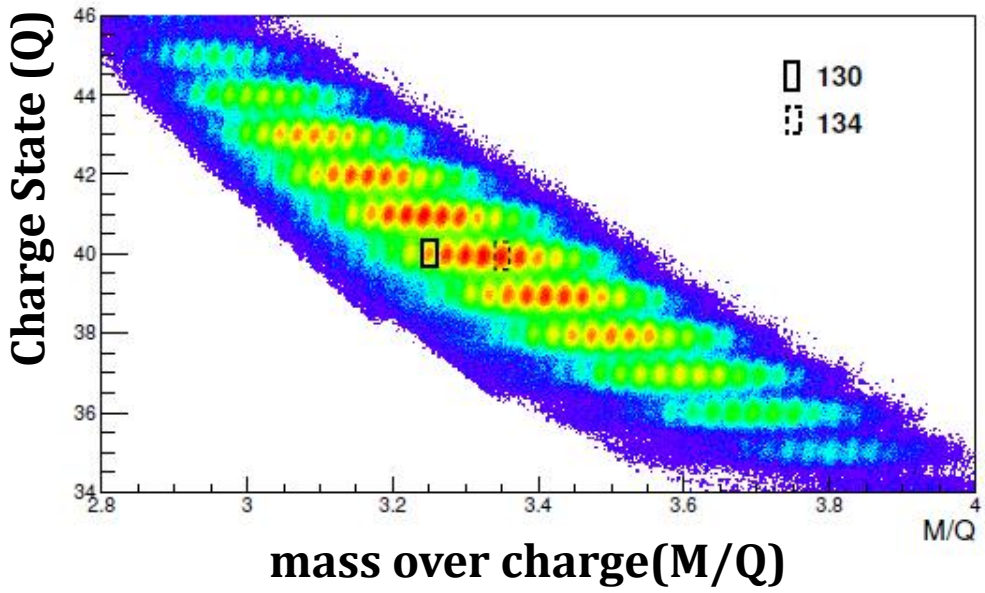


✓ **γ-ray detectors :**

- ❑ **AGATA tracking array : prompt γ-rays**
  32 Clusters
- ❑ **EXOGAM Clovers : delayed γ-rays**
  7 detectors

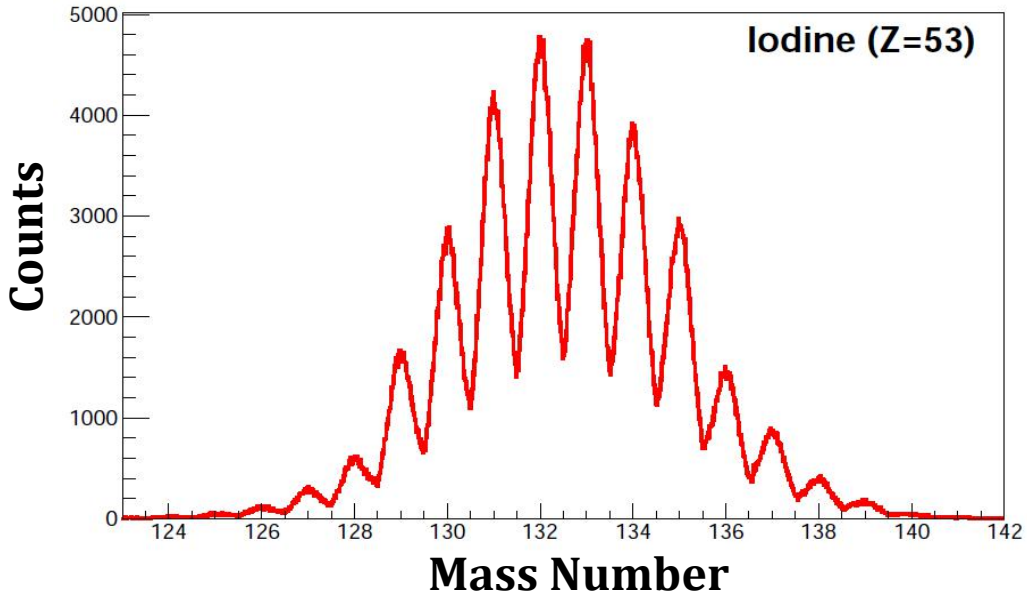


Identification of Iodine isotopes at Focal Plane



Iodine Z = 53
A = 130-134

Charge state (Q) vs mass over charge(M/Q) for Z=53

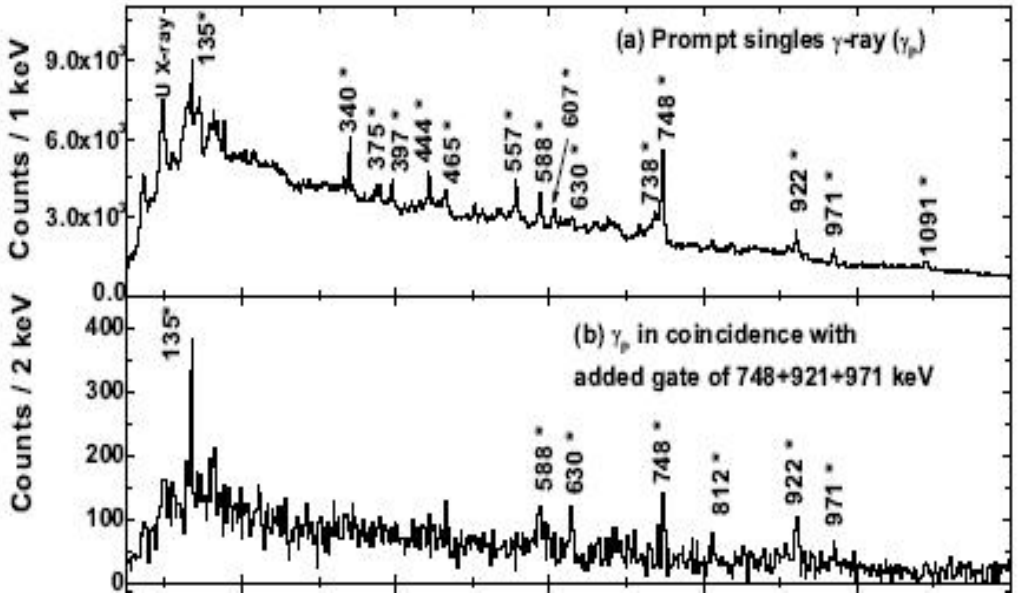


Mass distribution
→ Iodine

Results : ^{130}I

First time observation of excited states above (8^-) isomer : fragment-γ and prompt γ–γ coincidence

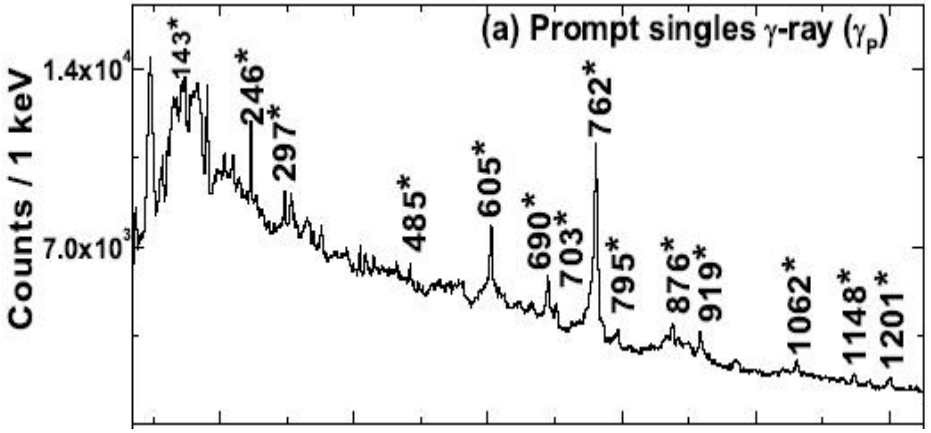
- New states have been identified above 8- isomer.
- 11 new γ transitions are placed.
- Upto ~3 MeV excitation energy.
- Both negative and positive parity states have been identified.
- Tentative spin assignments from systematics.

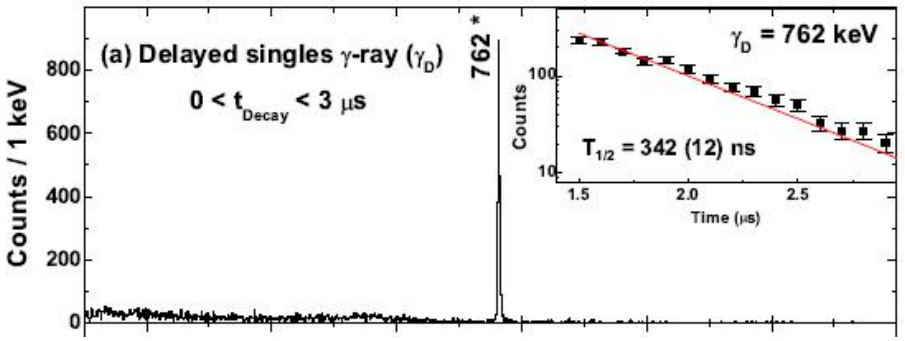


Results : ^{132}I

- First time observation of excited states above the long lived isomer
  - fragment-γ and
  - Prompt γ–γ coincidence
  - Prompt-delayed coincidence

- New states have been identified above long lived 8^- isomer (1.38 hr.).
- 13 new γ transitions are placed.
- Upto ~3 MeV excitation energy.
- Identification of new isomer
  $T_{1/2}$= 342 (12) ns
- Both negative and positive parity states have been identified.
- Tentative spin assignments from systematics.

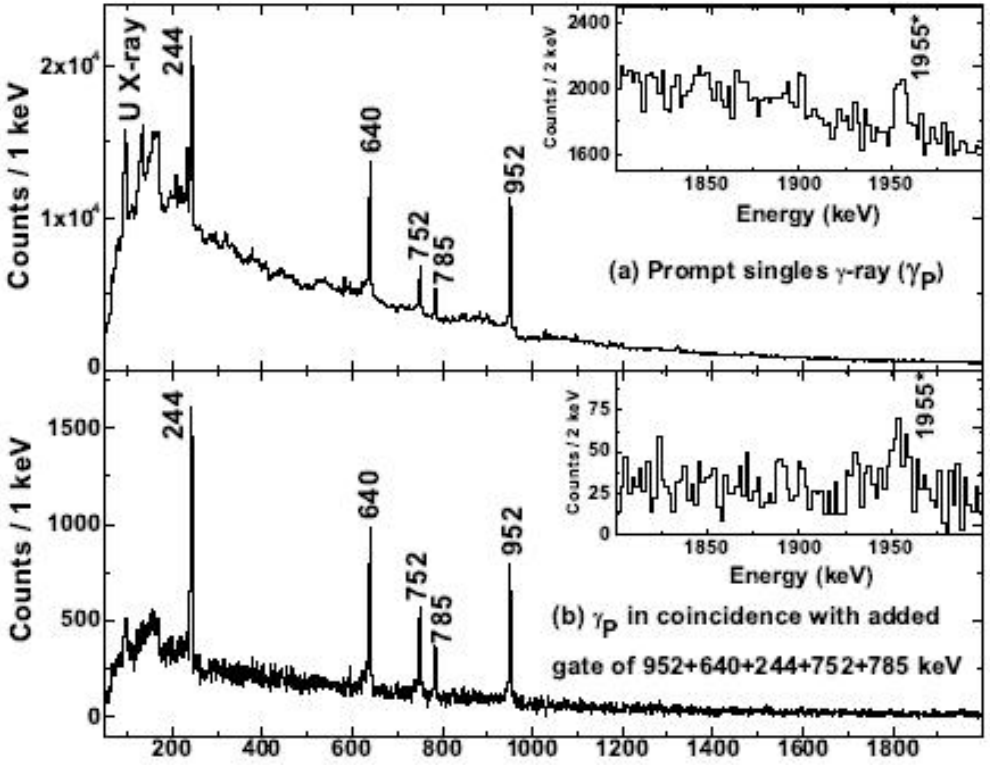




Results : ^{134}I

- New γ-ray placed
  -from fragment-γ and prompt γ–γ coincidence

- 1 new γ transition is added to the yrast sequence.
- Upto ~5.5 MeV excitation energy.
- Tentative spin assignments from systematics.

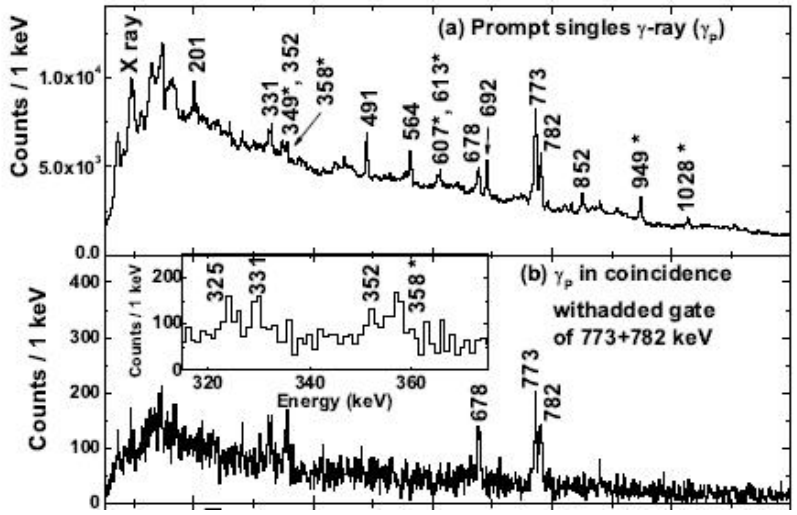


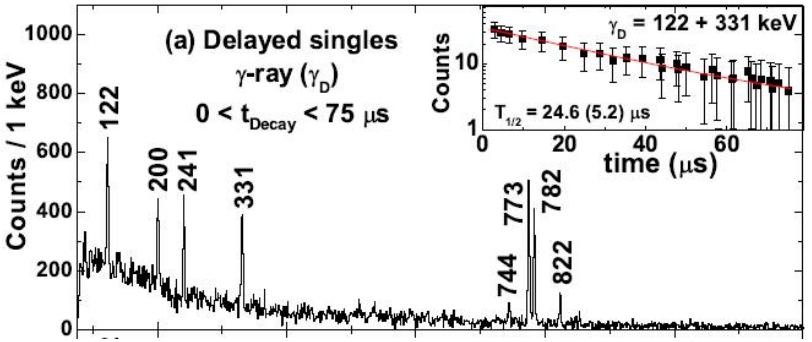
Results : ^{131}I

First time observation of new states above the $19/2^-$ (24 μs) isomer :

- from fragment-γ
- prompt γ–γ coincidence
- Prompt-delayed coincidence

- New states have been identified above the $19/2^-$
- Lifetime of the known isomer at $19/2^-$ has been reproduced as 24.6 (5.2) μs.
- 4 new γ transitions are placed.
- Upto ~ 4 MeV excitation energy.
- Tentative spin assignments from systematics.



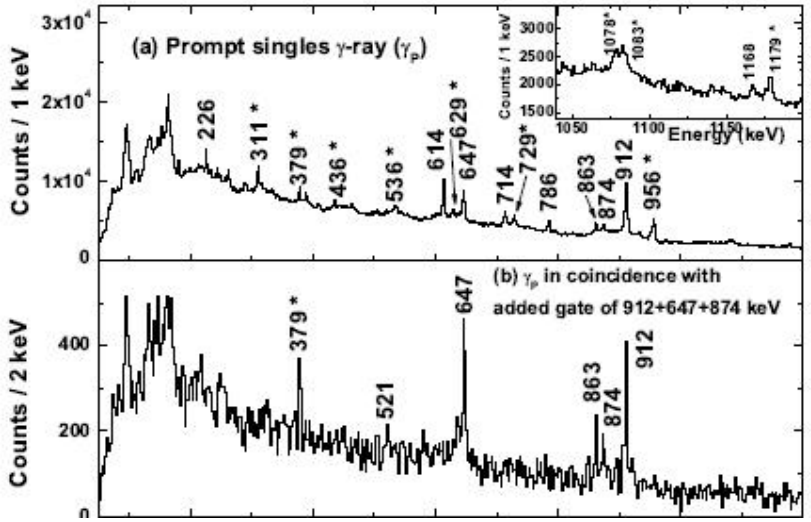


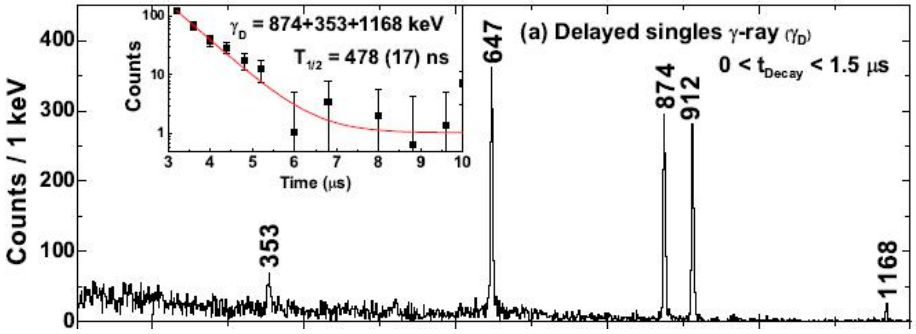
Results : ^{133}I

First time observation of new states above the $19/2^-$ isomer :

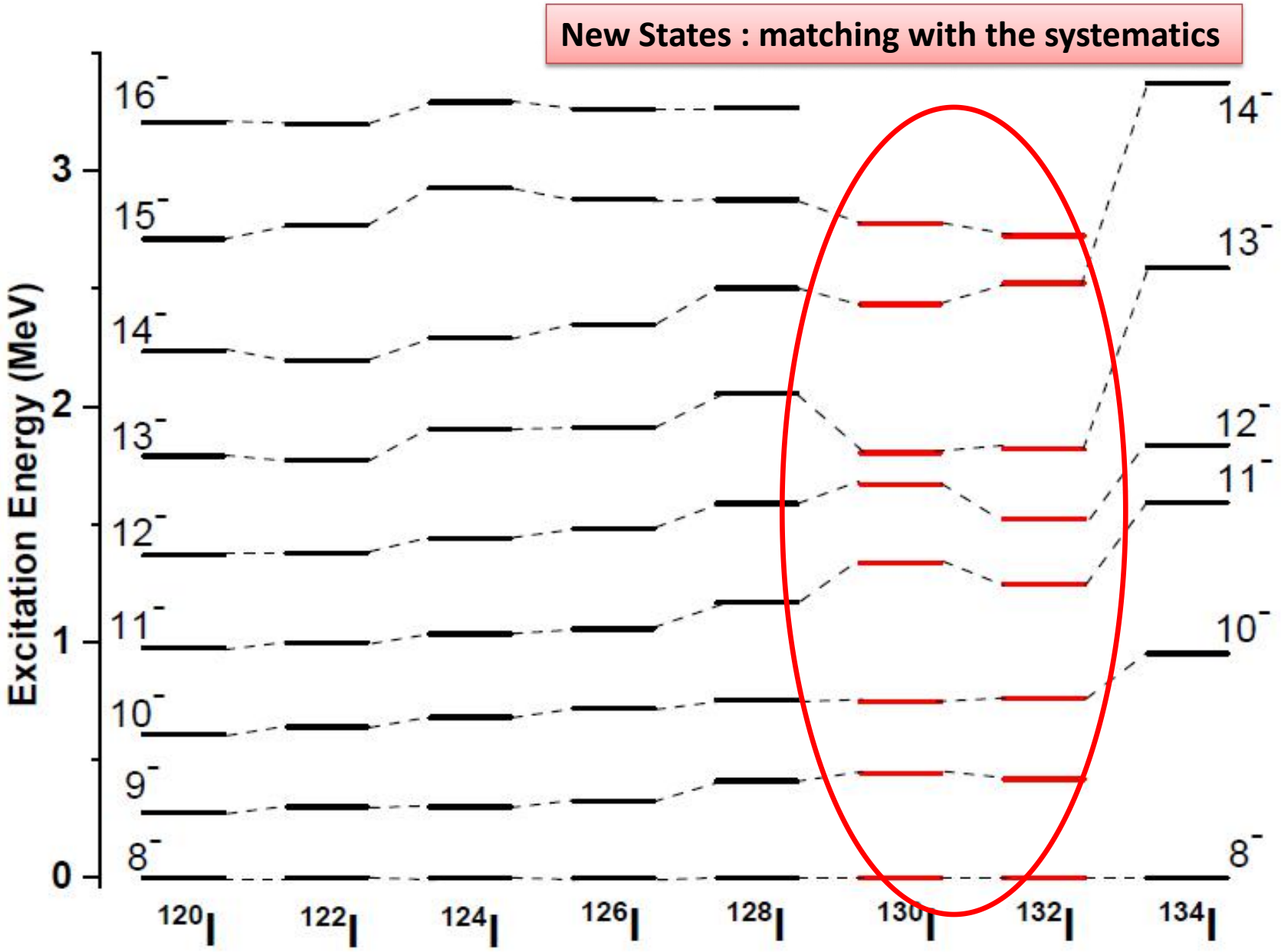
- from fragment-γ
- prompt γ–γ coincidence
- Prompt-delayed coincidence

- New states have been identified above the $19/2^-$ from systemetics of neighboring Sb isotopes
- Lifetime of the known isomer at $23/2^+$ has been reproduced as 478 (17) ns.
- 6 new γ transitions are placed.
- Upto ~ 5 MeV excitation energy.

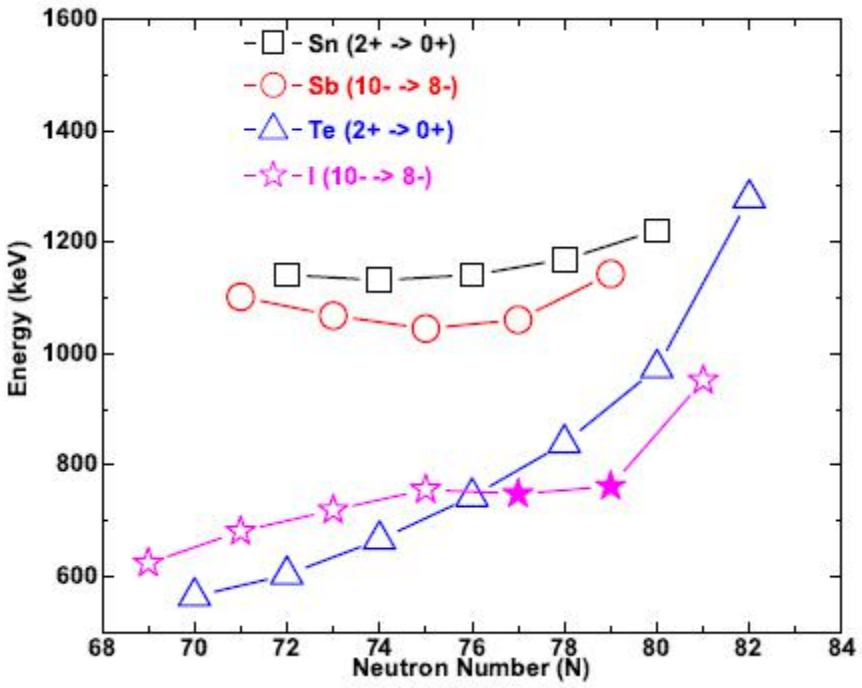


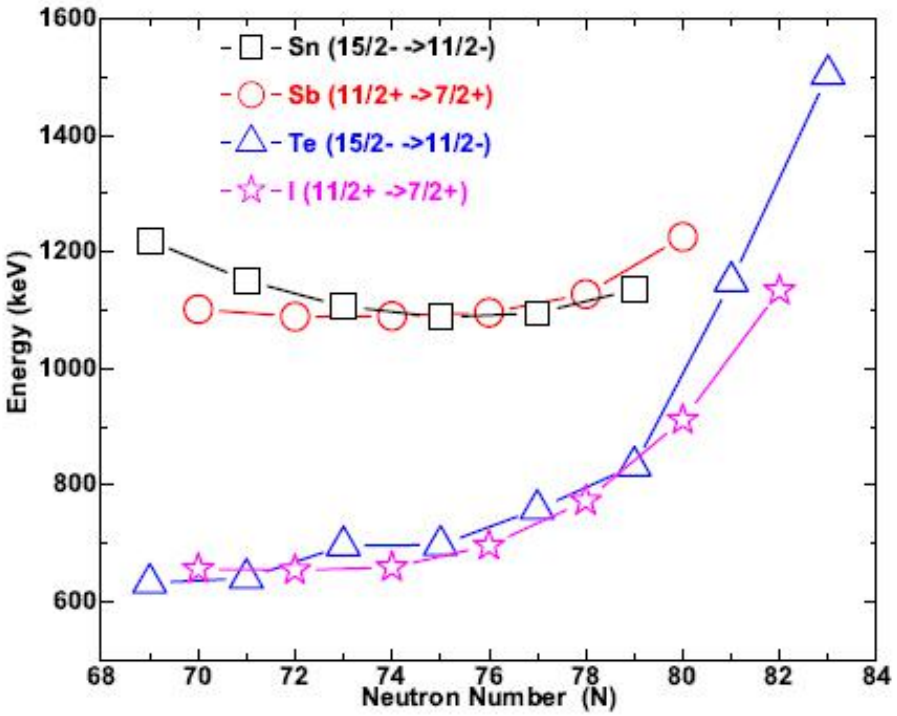


Spin evolution : even Iodine



Systematics





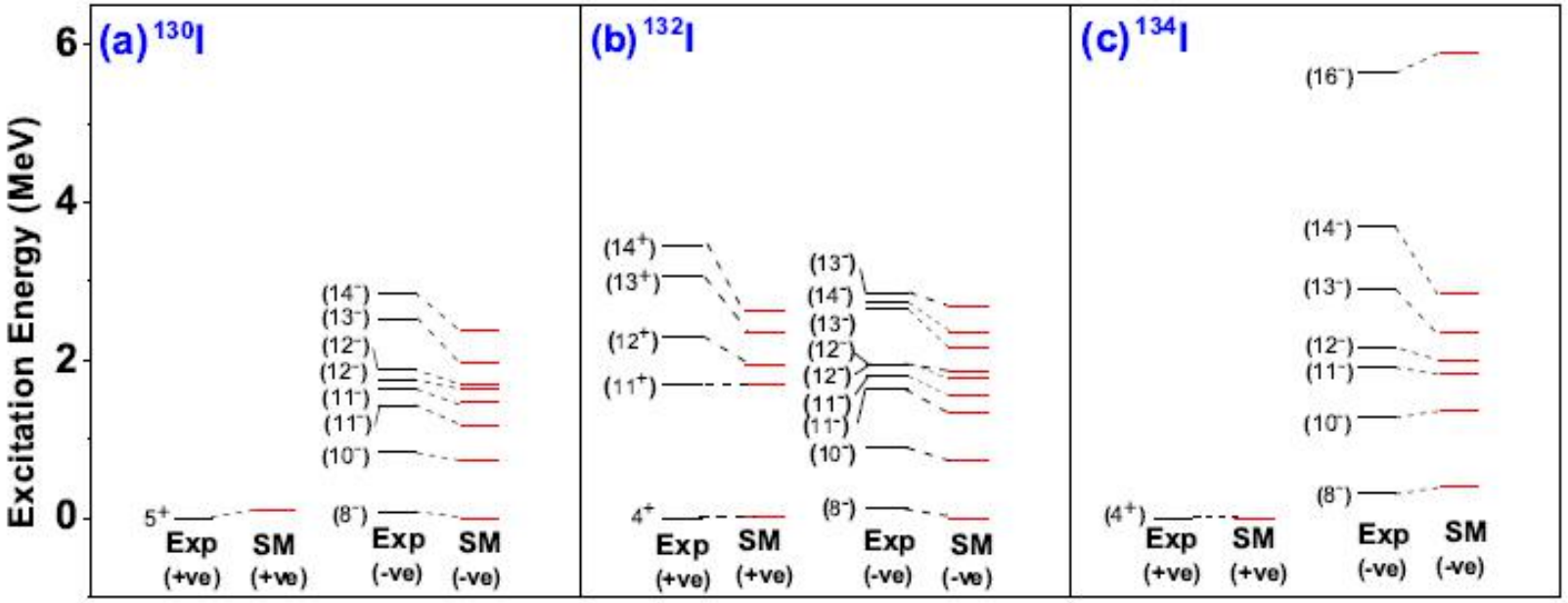
Even Mass Iodine

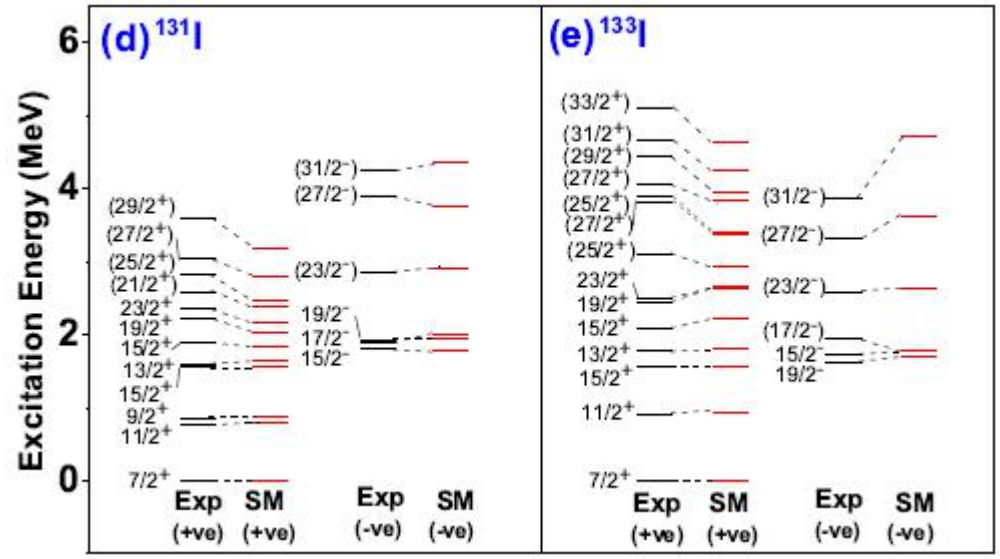
10- →8- of Sb & I follows 2+→0+ of even-even Sn & Te : extra valance nucleons outside the corresponding Sn and Te core holds good for these low lying states.

Odd Mass Iodine

11/2+ →7/2+ of Sb & I follows 15/2-→11/2- of even-even Sn & Te : extra valance proton outside the corresponding Sn and Te core holds good for these low lying states.

Shell Model Calculation





- The large basis shell model calculations : **NuSHELLX**
- effective interaction used : **sn100pn**
- Calculation done **without any restriction** in valence orbitals.
- Valence Orbitals :

  $1g_{7/2}$, $2d_{5/2}$, $2d_{3/2}$, $3s_{1/2}$, $1h_{11/2}$

Summary

- Fission reaction to populate the $^{130\text{-}134}$I nuclei.
- VAMOS++, AGATA, EXOGAM used for fragment-γ, prompt γ–γ and prompt-delayed γ–γ coincidence.
- First time observation of high spin excited states above 8^- isomer in ^{130,132}I.
- Identification of new isomer in ^{132}I.
- New states in ^{131,133}I from prompt delayed coincidence.
- Shell model calculations for interpretation of the results.

Acknowledgement:

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THANK YOU