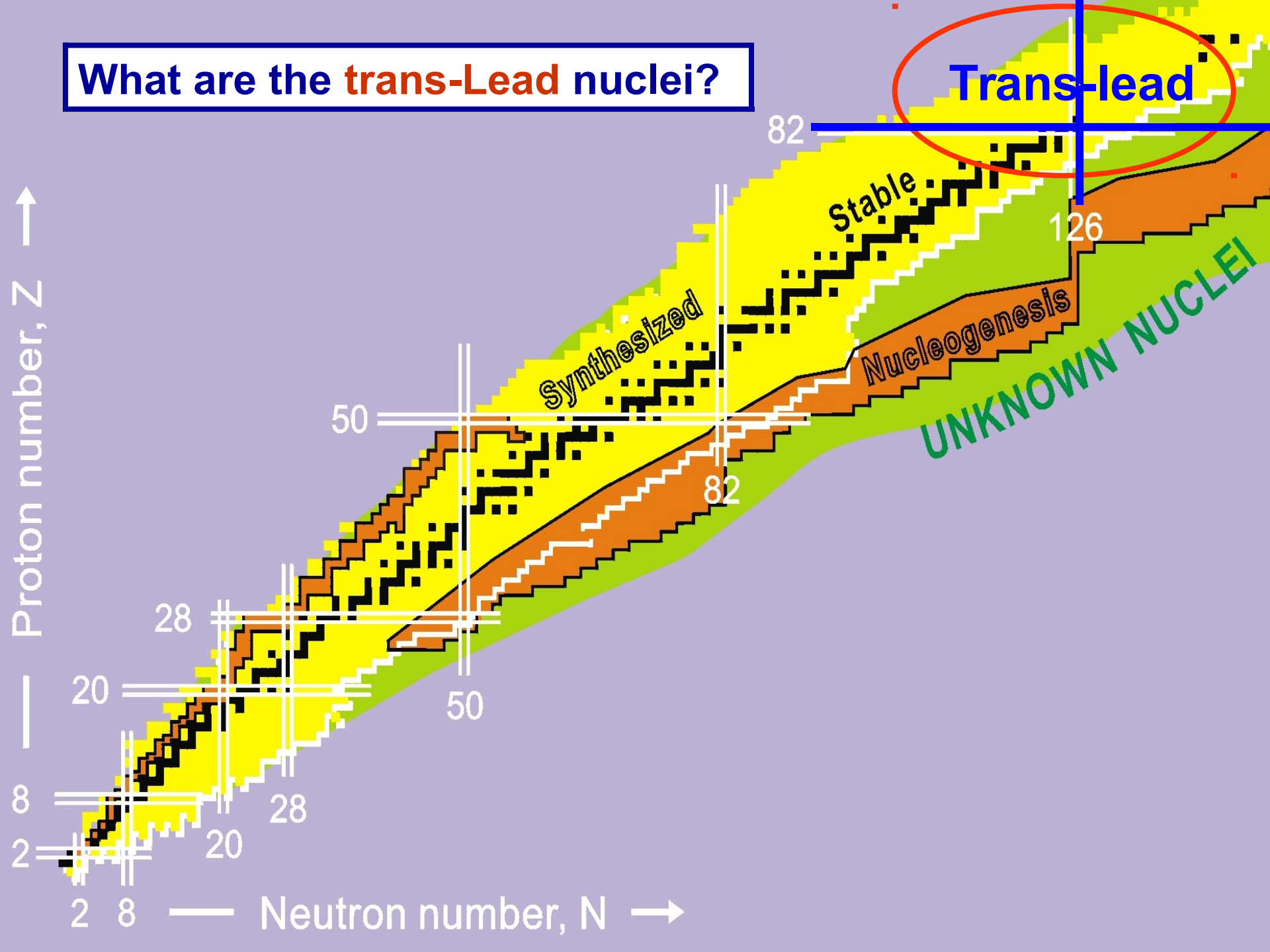
Investigation of magnetic rotational band and new isomeric level in 204At

Debasmita Bondyopadhaya

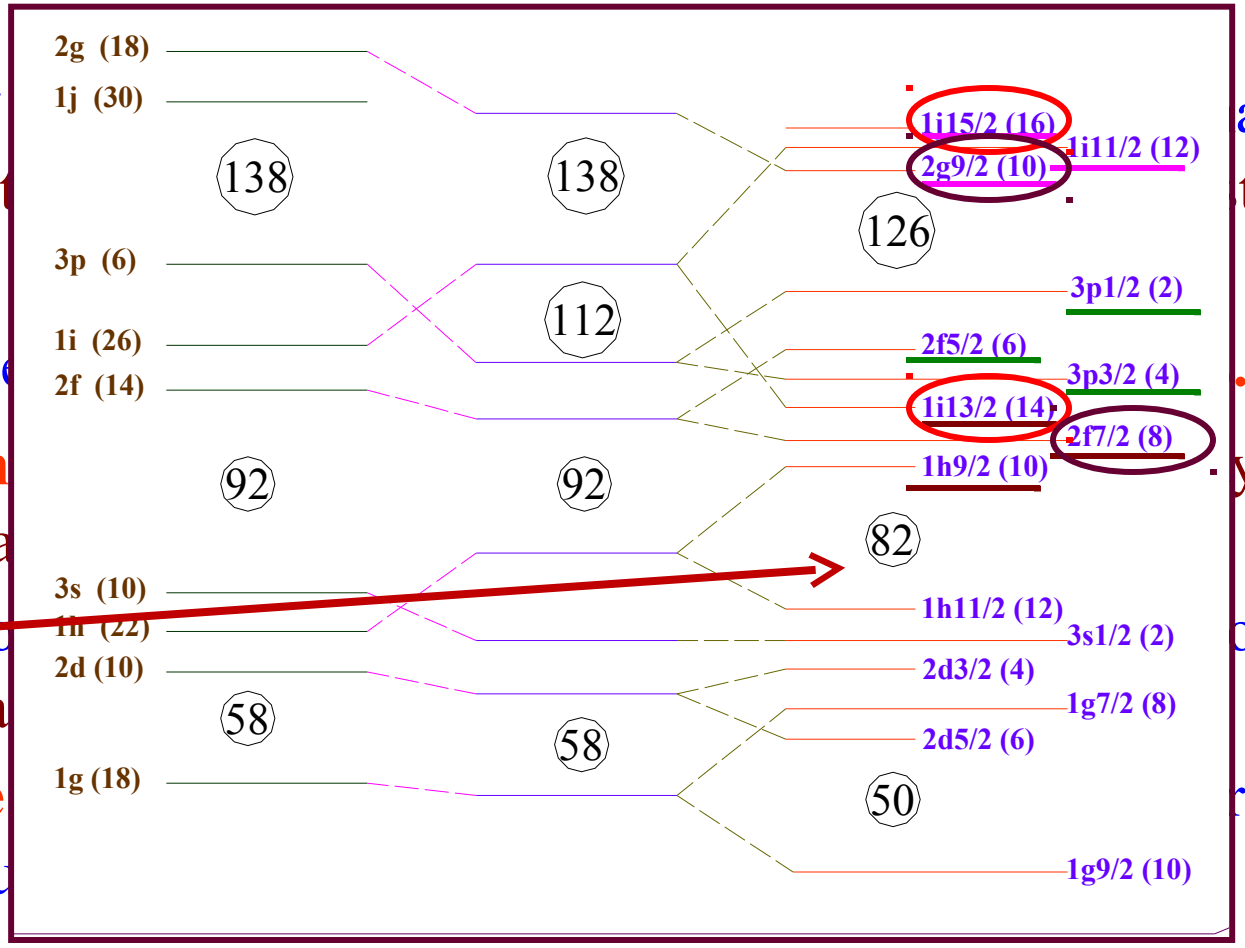
Raiganj Surendranath College, India

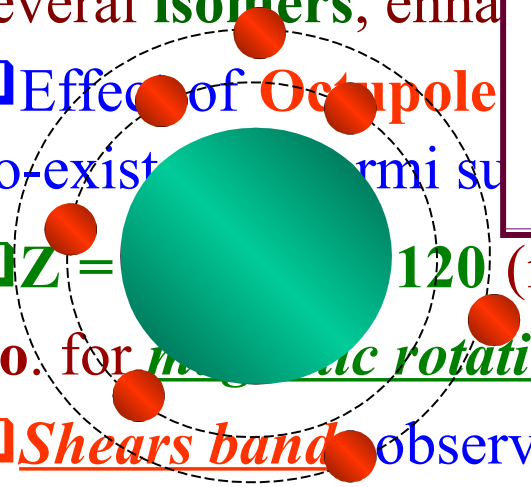
What are the trans-Lead nuclei?



Features of TRANS-LEAD Nuclei (Z > 82 & N < 126)

- Poor knowledge of ain.
- High spin states int tates like ($1h_{9/2}$, $2f_{7/2}$, $1i_{13/2}$)
- Important role playe
- **Po (Z= 84)** and **Rn** y the **onset of collectivity** a
- Detailed structure o opes, several **isomers**, enha
- Effect of **Octupole** rbital co-exist rmi su
- **Z = 120** (i.e. low deformation, $\beta_2 \leq 0.1$) predicted to be **magic no.** for ***magnetic rotation***. Several **Pb** & **Bi** isotopes exhibited this.
- ***Shears band*** observed in $^{205}_{86}Rn_{119}$, $^{204}_{85}At_{119}$ & $^{206}_{87}Fr_{119}$ isotone.





Difficulties & Challenges

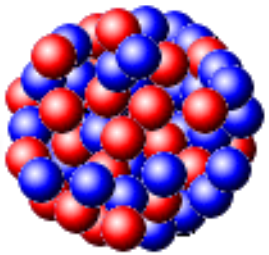
- Poor ER yield.
- Huge fission back ground (70-80%).
- Resulting large amount of unwanted fission gamma-rays.
- Random presence of isomers (few ns to ms or even more).
- Presence of highly converted low energy transitions.

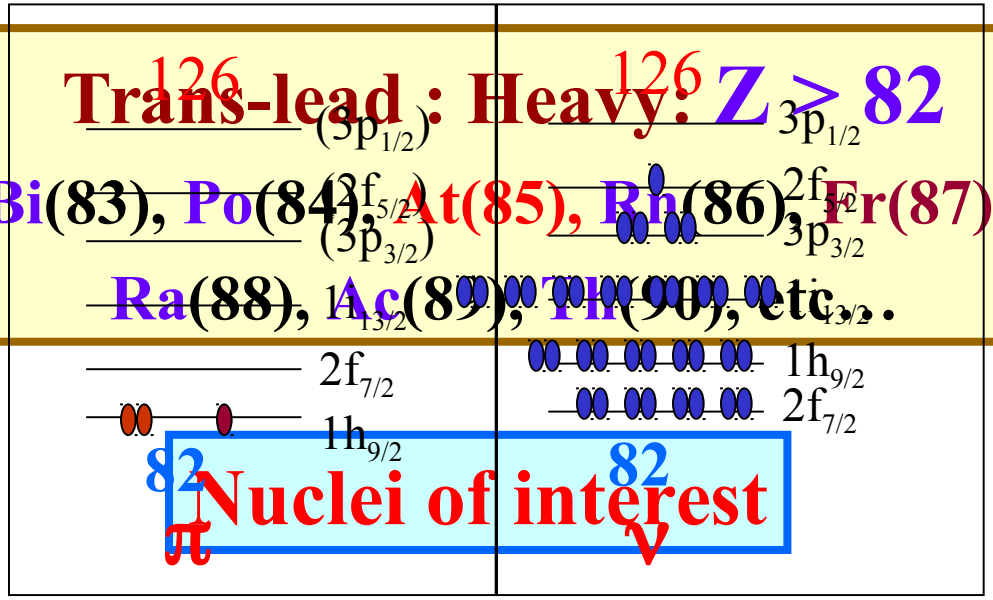
Possible technical solution

- Large array of detectors to get sufficient statistics.
- Recoil separators for recoil selection.
- LEPs detector to detect low energy γ-rays.
- Solenoid and Si detectors for conversion electrons.
- Various focal plane detectors for recoil selection.
- Time stamping in data acquisition

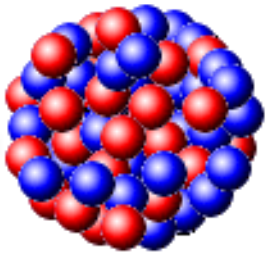
Trans-lead : Heavy: $Z > 82$

Bi(83), Po(84), At(85), Rn(86), Fr(87), Ra(88), Ac(89), Th(90), etc...





Nuclei of interest



^{204}**At:** $\pi\left(1h_{9/2}\right)^{+1} \otimes \nu\left(2f_{5/2}\right)^{-1}$

Some n- deficient isotopes of ***Astatine*** **: Z = 85**

^{204}At : N = 119, $T_{1/2}$ = 9.12 min, g.s spin = 7+

^{205}At : N = 120, $T_{1/2}$ = 26.9 min, g.s spin = 9/2-

^{206}At : N = 121, $T_{1/2}$ = 30.6 min, g.s spin = 7+

3 valence protons filling $1h_{9/2}$ & neutron holes largely in $3p_{1/2}$, $2f_{5/2}$ & $3p_{3/2}$ shell

Experiment at TIFR, India

Beam taken:- ^{12}C

Target taken :- ^{197}Au (99.95% purity)

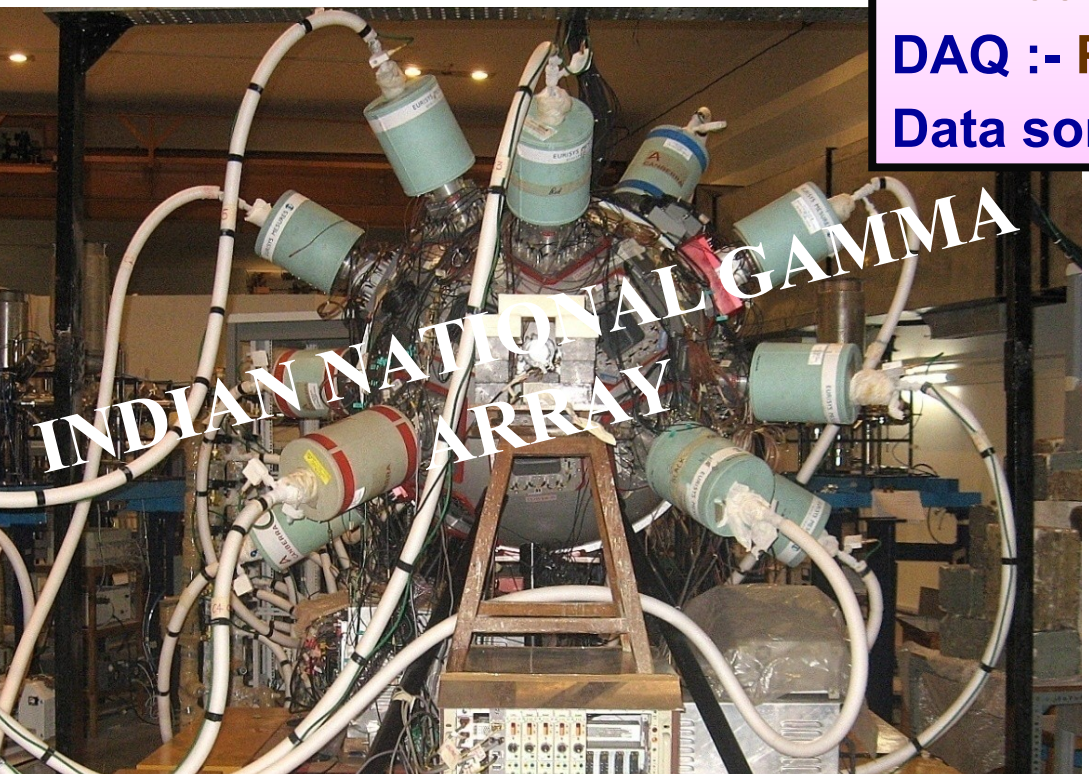
Target thickness :- 5 mg / cm^2

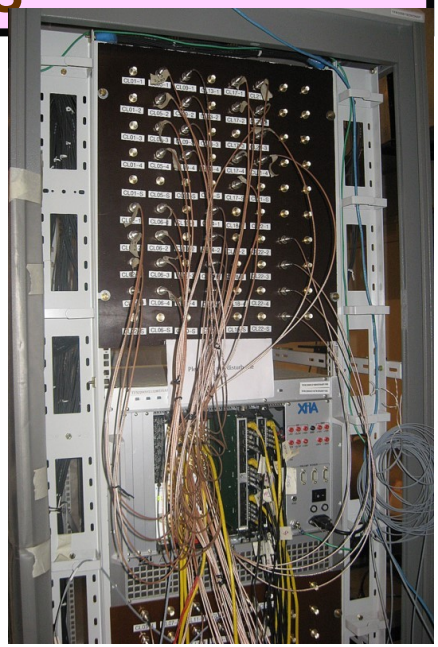
Beam Energy :- 65 and 75 MeV

Clover position :- 3 at -23°, 2 at -40°, 2 at -65°, 4 at 90°, 2 at 65 & 2 at 40°

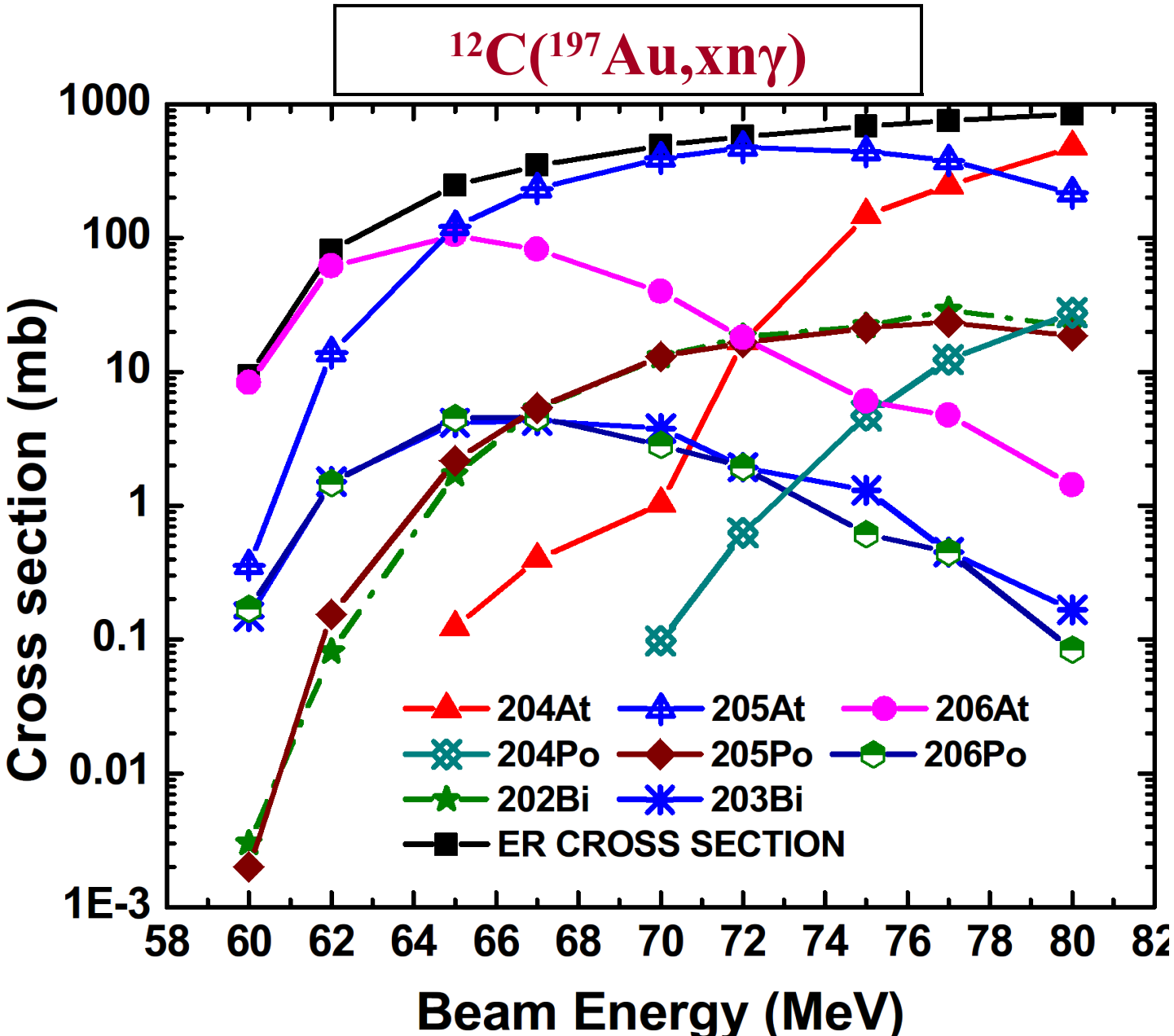
DAQ :- Pixie-16 module based fast DSP

Data sorting :- MARCOS



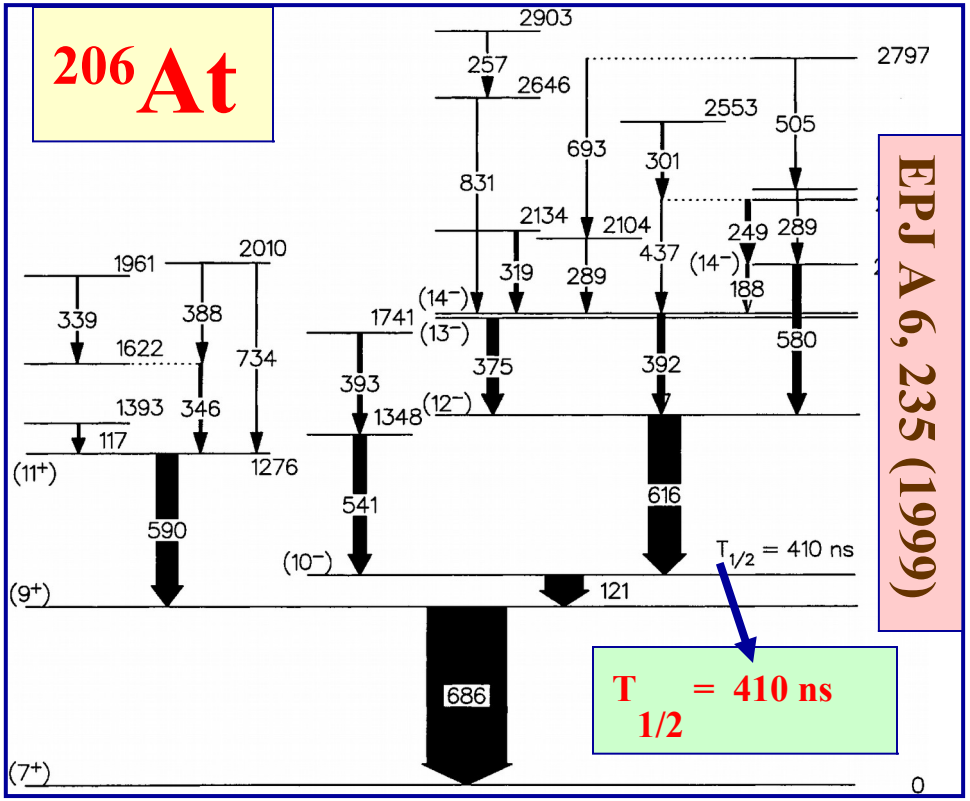


Excitation function based on PACE4



Level schemes present in literature

^{206}At

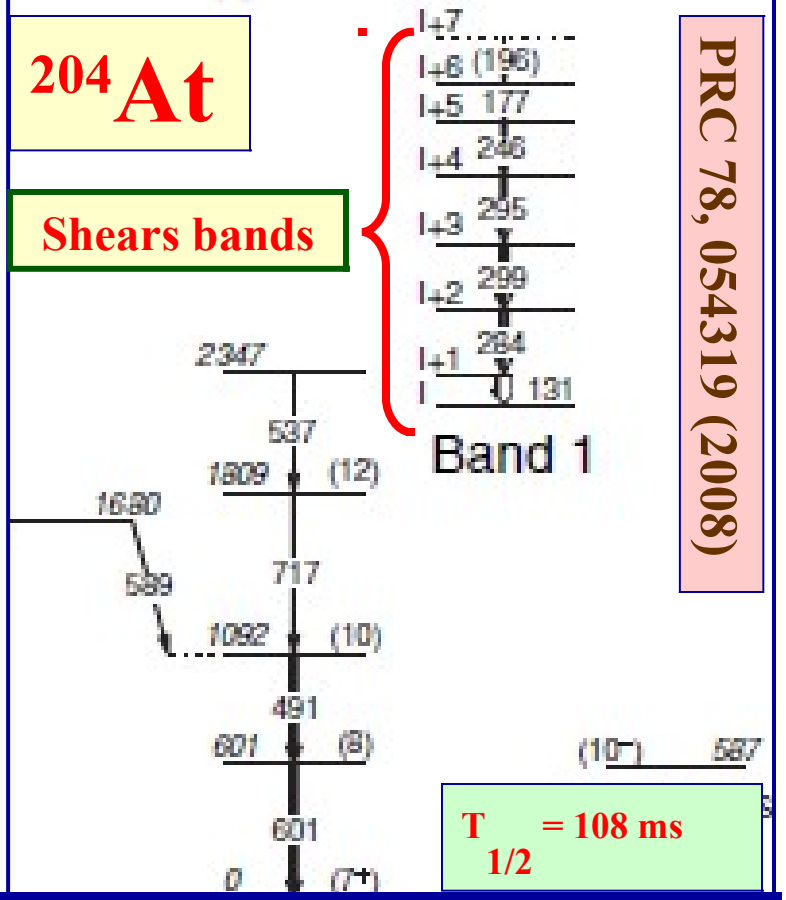


EPJ A 6, 235 (1999)

$T_{1/2}$ = 410 ns

- $^{12}C + ^{197}Au \rightarrow ^{209}At$ at 60-80 MeV
- 7 BGO(AC)HPGe detectors & 1 Ge planar detector were used
- Partial Level scheme exists consisting of 2 disconnected parts, from proton and n-hole excitations respectively.

^{204}At



Shears bands

PRC 78, 054319 (2008)

$T_{1/2}$ = 108 ms

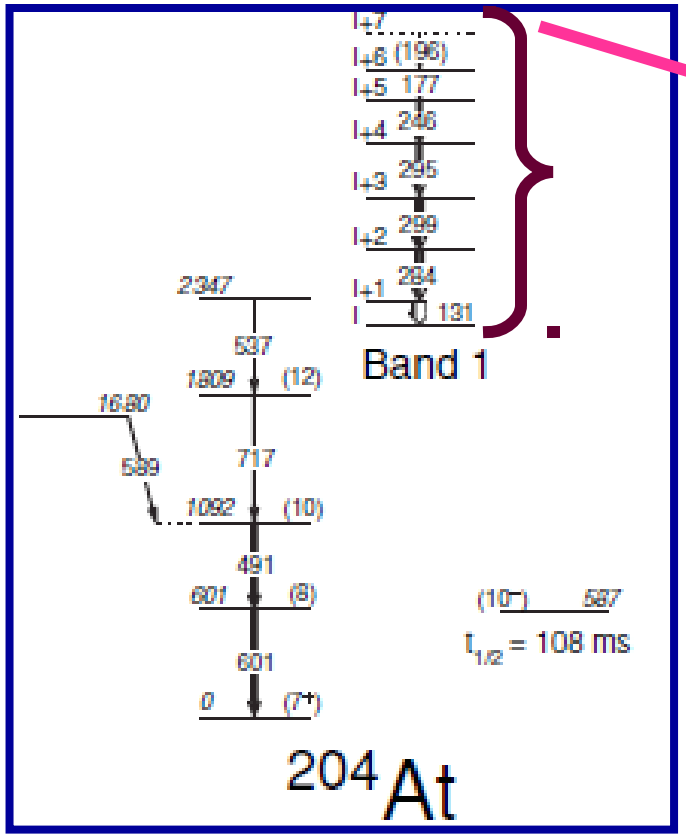
- $^{30}Si + ^{181}Ta \rightarrow ^{211}Fr$ at 152 MeV
- HERCULES-II for ER selection & Gammasphere for ER-gated γ rays
- Large B(M1)/B(E2) ratios for Band 1
- Incomplete Level scheme exits.
- Properties of Band 1 similar to MR bands in Pb but the spin and parity of the band head could not be assigned.

Results from

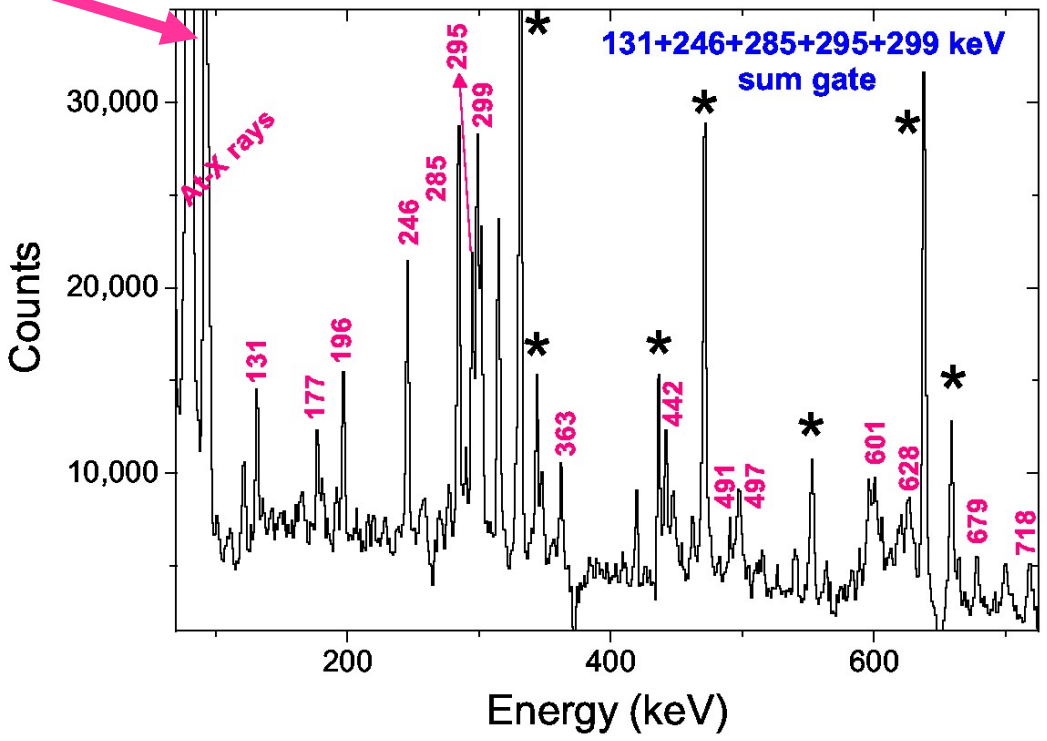
$\gamma\ \gamma$

Coincidence Measurement

Coincidence spectra @ 75 MeV

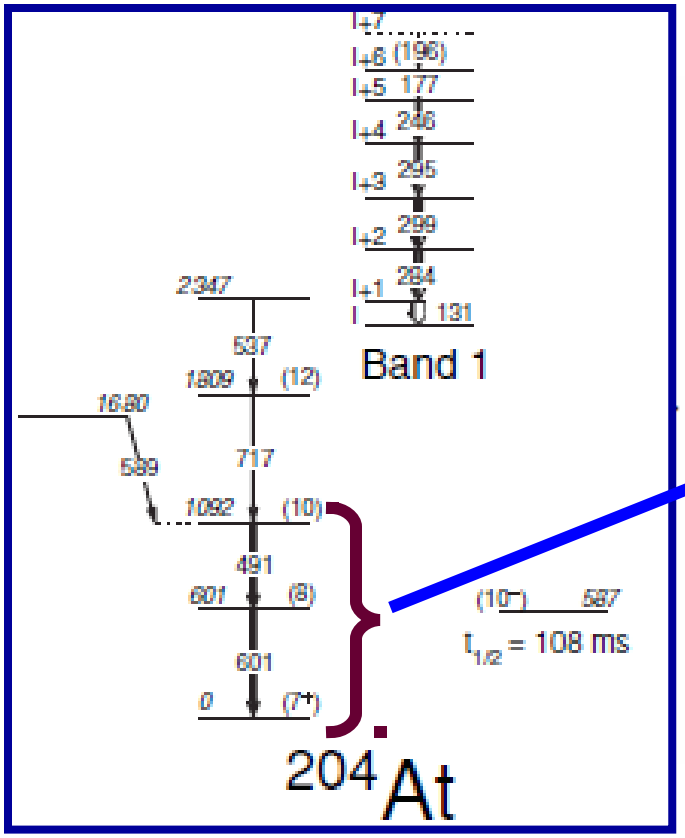


131+284+299+295+246 keV gate



- By gating on the known transitions of the **ΔI = 1** band, reveal a few new transitions including the weak cross over E2 transitions.
- A few new γ rays linking the **ΔI = 1** sequence to the main branch including **601** and **491** keV transitions could be seen in the spectrum.

Coincidence spectra @ 75 MeV



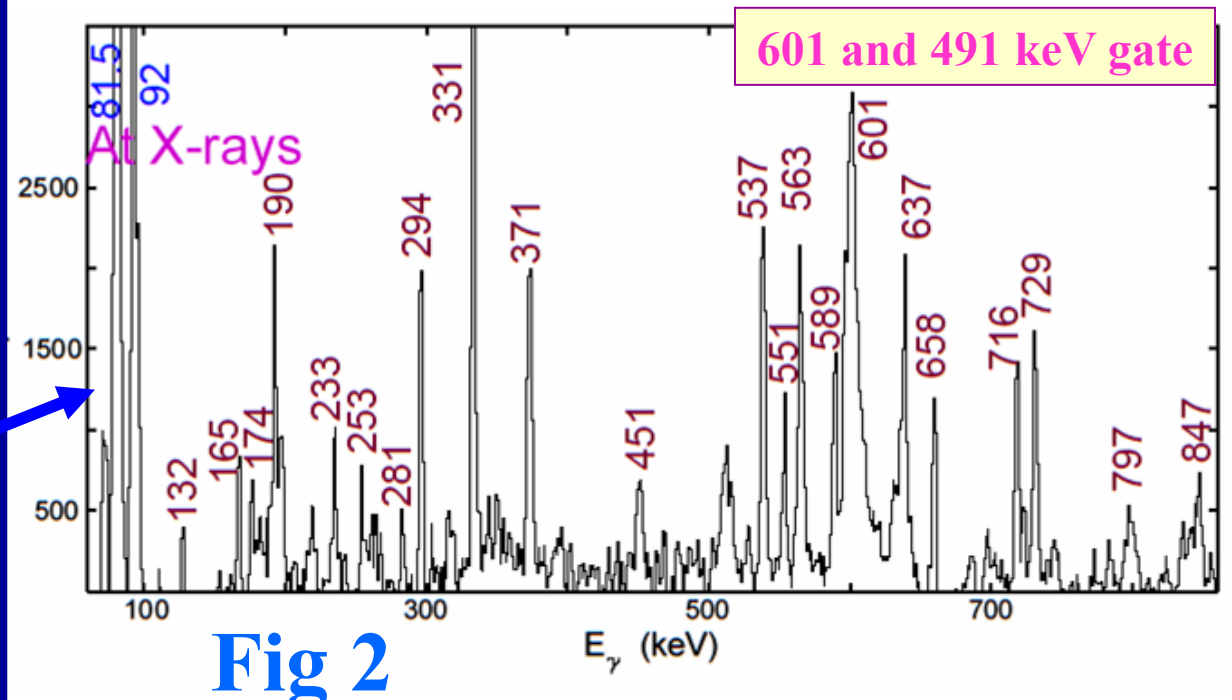
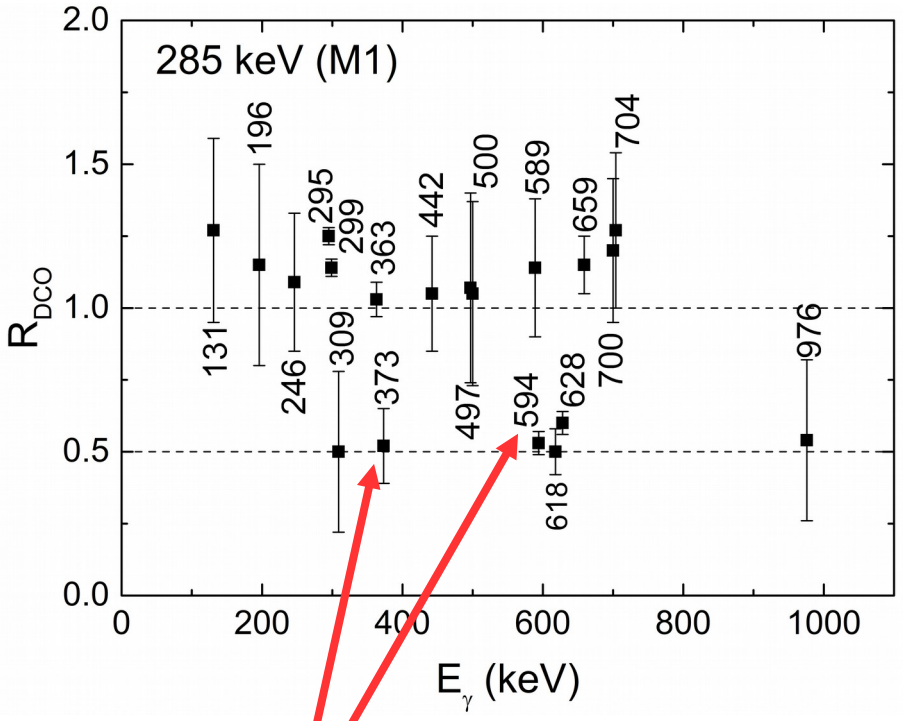


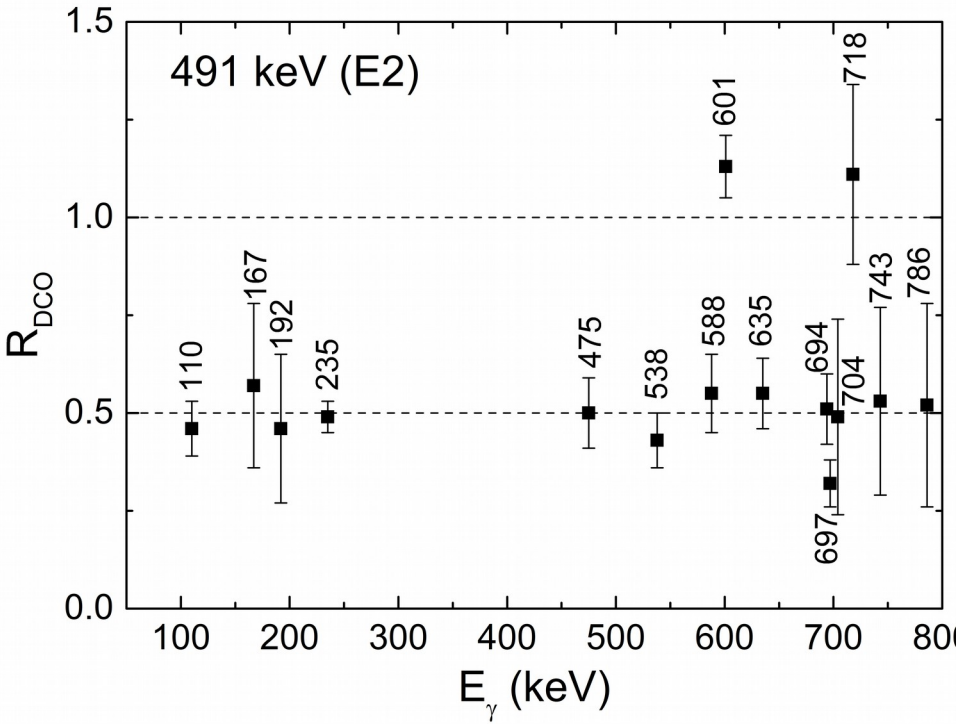
Fig 2

- Gates on the main sequence of transitions involving **601** and **491** keV γ-rays and also on the Astatine *X*-rays reveal a significant number of new transitions in the above spectrum (**Fig 2**).
- Further investigations into the cross-correlation of the transitions would possibly reveal the main yrast sequence.

Multopolarity determination from observed directional correlations

$$R_{DCO} = \frac{I\gamma_1 \; at \; 90^o \; , gated \; with \; \gamma_2 \; at \; 157^o}{I\gamma_1 \; at \; 157^o \; , gated \; with \; \gamma_2 \; at \; 90^o}$$





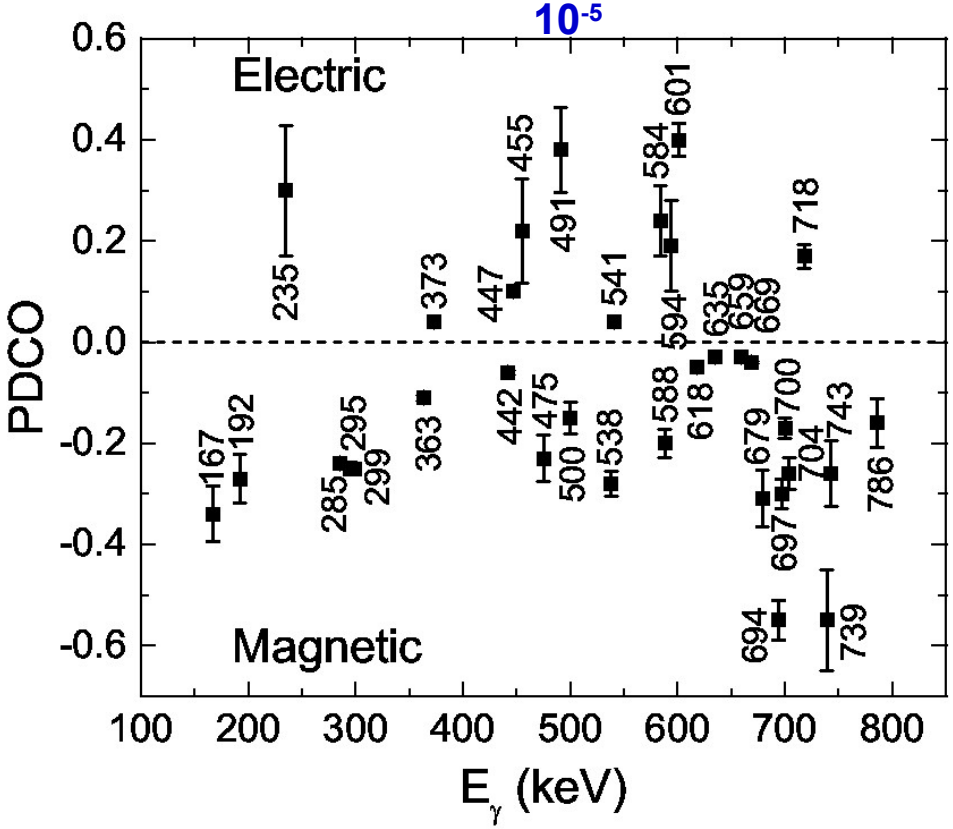
Cross over E2 transitions

Polarisation Measurement : Electric or Magnetic ?

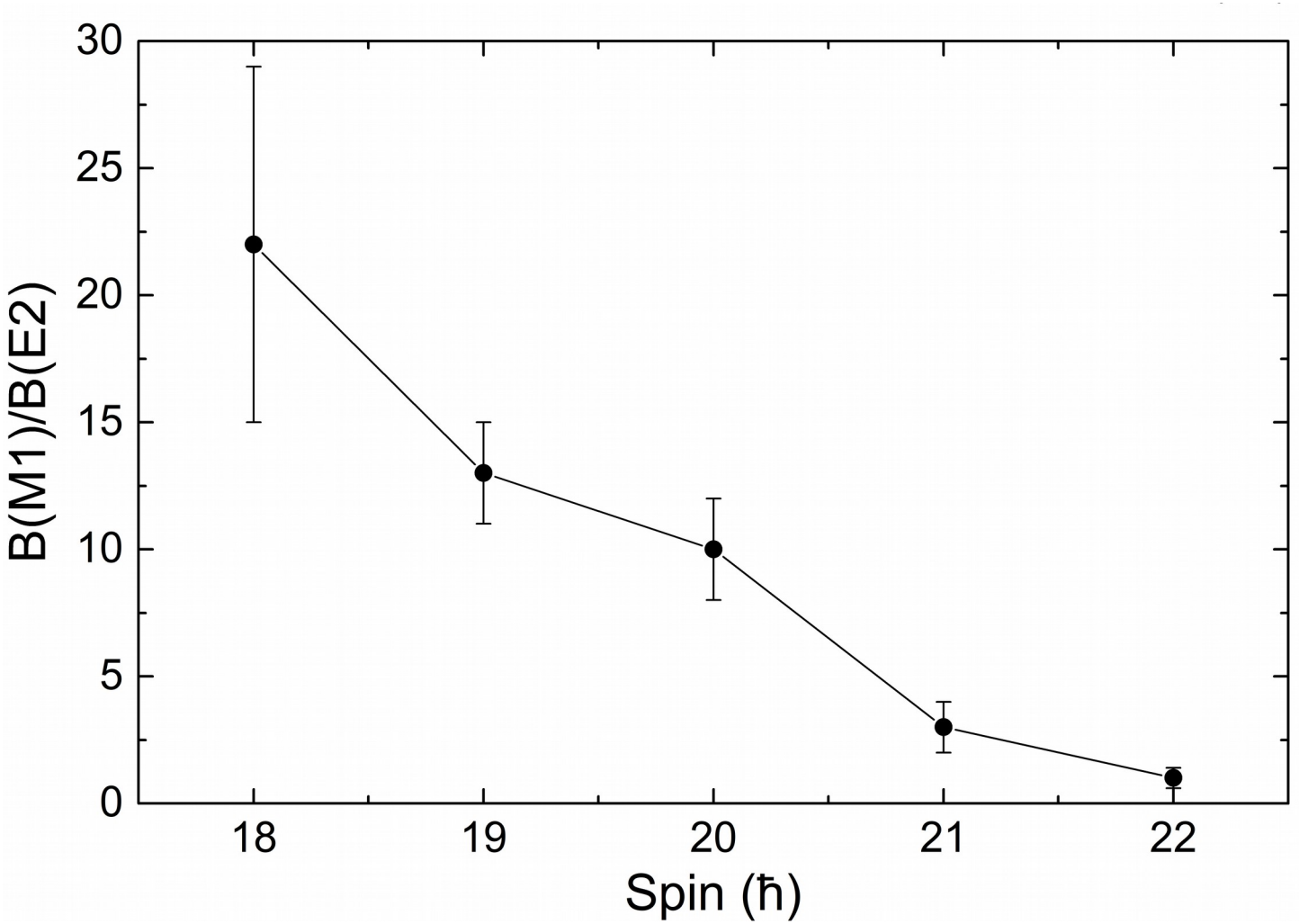
$$\Delta_{IPDCO} = \frac{a(E\gamma)N_{per} - N_{par}}{a(E\gamma)N_{per} + N_{par}}$$

$a(E\gamma) = a_0 + a_1(E\gamma)$

$a_0 = 1.023(6)$ and $a_1 = -1.02(27) * 10^{-5}$



Nature of B(M1)/B(E2) with spin in M1 band



Summery and Results

- High spin states & isomeric levels in 204At are investigated starting from a few transitions and Tentative level scheme for 204At is obtained analyzing γ-γ coincidence spectra.
- By putting gates on 601 and 491 keV gamma rays, and also on Astatine X-rays, a significant number of transitions were identified.
- DCO and PDCO are measured whenever possible for tentative assignment of the spin-parity. Based on this, the sequences in band $\nabla I = 1$ is found to be $\Delta I = 1$ magnetic in nature involving h9/2 and i13/2 proton and neutron holes.
- There also may be a few more isomeric levels, that can not be observed due to limited statistics.

Thank You