



TRANSITION RATE MEASUREMENTS AT EXTREMES OF SHAPE COEXISTENCE

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Shapes and Symmetries in Nuclei: from Experiment to Theory SSNET
CSNM Orsay, 7-11 November 2016

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- **Introduction:** shape coexistence
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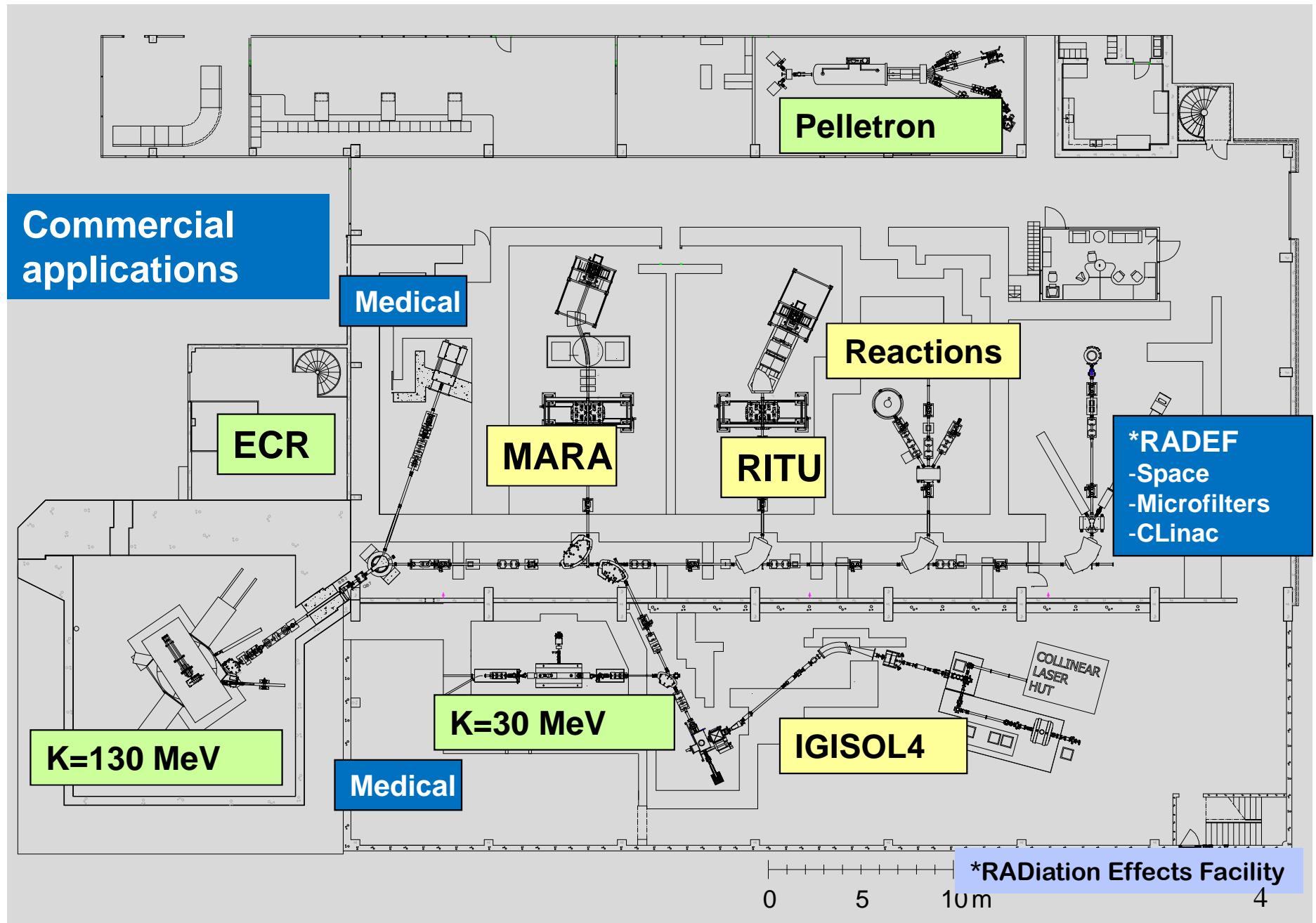


JYFL Accelerator Laboratory

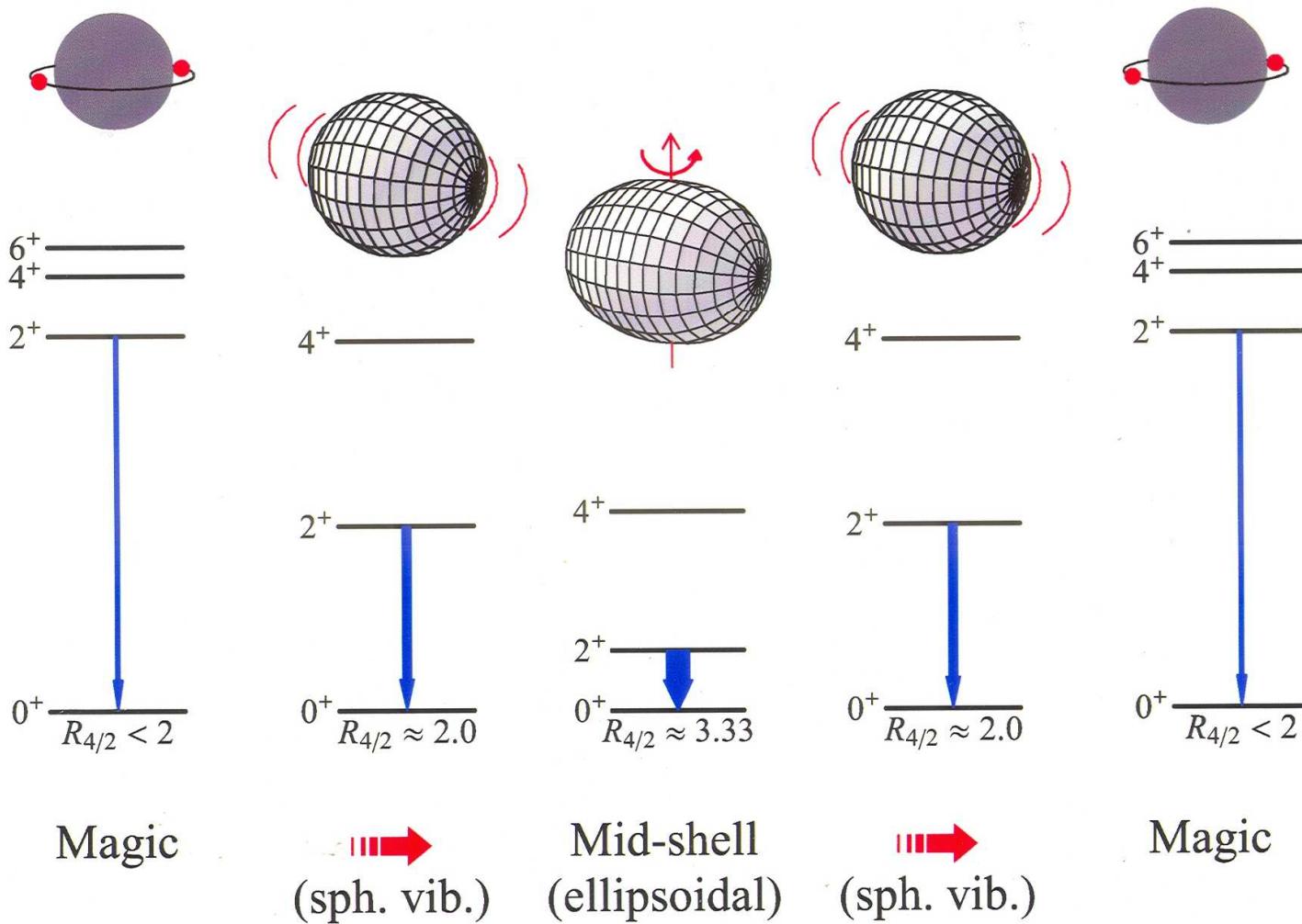
- **Four accelerators** serving international users for basic research, applications and commercial services:
 - K130 heavy ion cyclotron (+ three ECR ion sources and light ion source) (1992)
 - 1.7 MV Pelletron for ion beam analysis and modification of materials (2007)
 - MCC30 light ion cyclotron (2012)
 - Electron LINAC (2015)
- Integral part of the **Department of Physics**
- **National centre** for accelerator-based research and education
- **Centre of Excellence** of the Academy of Finland
- **EU access laboratory** (FP4→Horizon2020)
- In the **2014-2020 roadmap** of research infrastructures in Finland
- One of the three accredited test laboratories of European Space Agency (ESA)
- More than **300 foreign users** annually
- International research instrumentation worth of 10 M€
- Strong links to research at CERN and FAIR



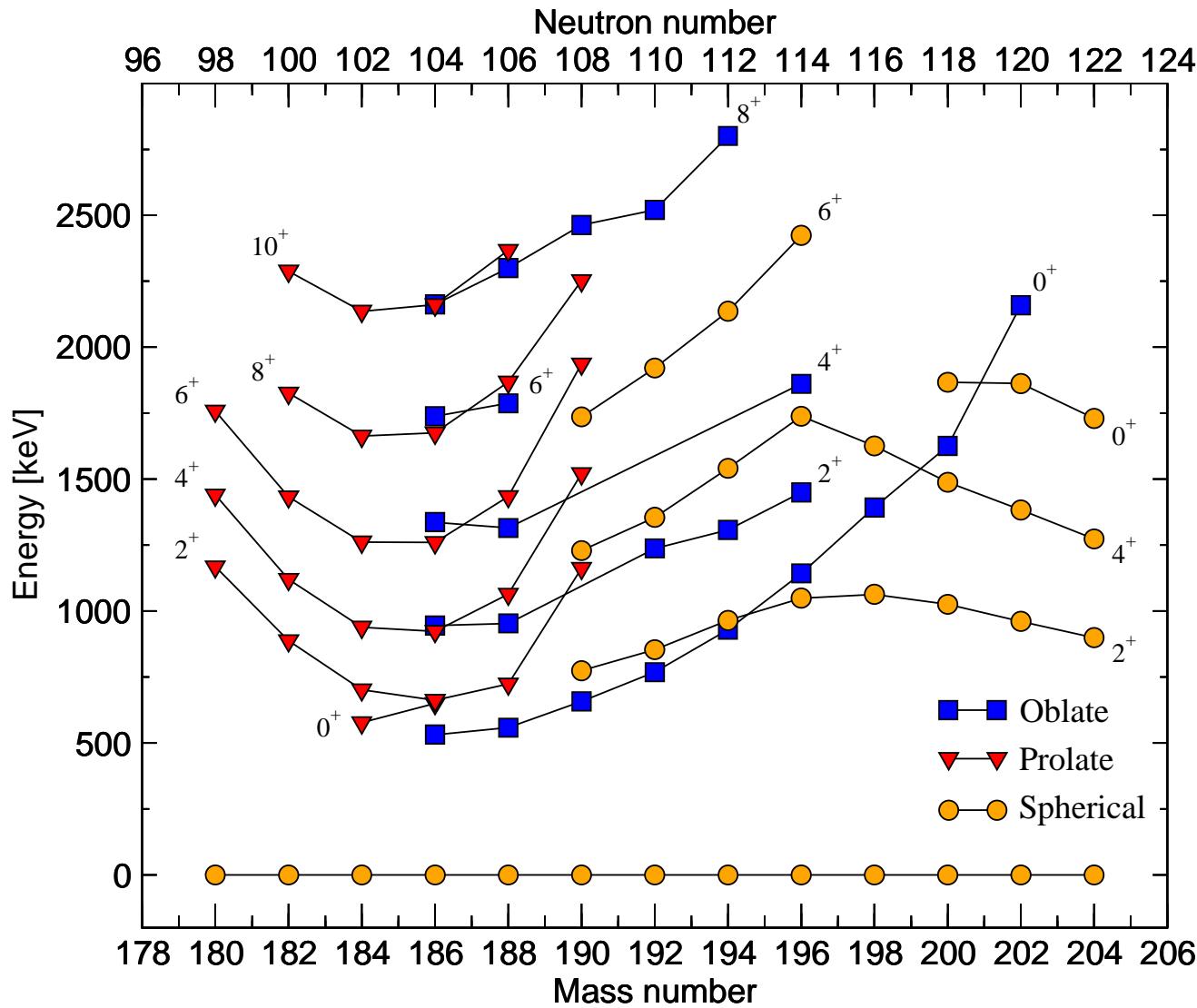
JYFL Accelerator Laboratory



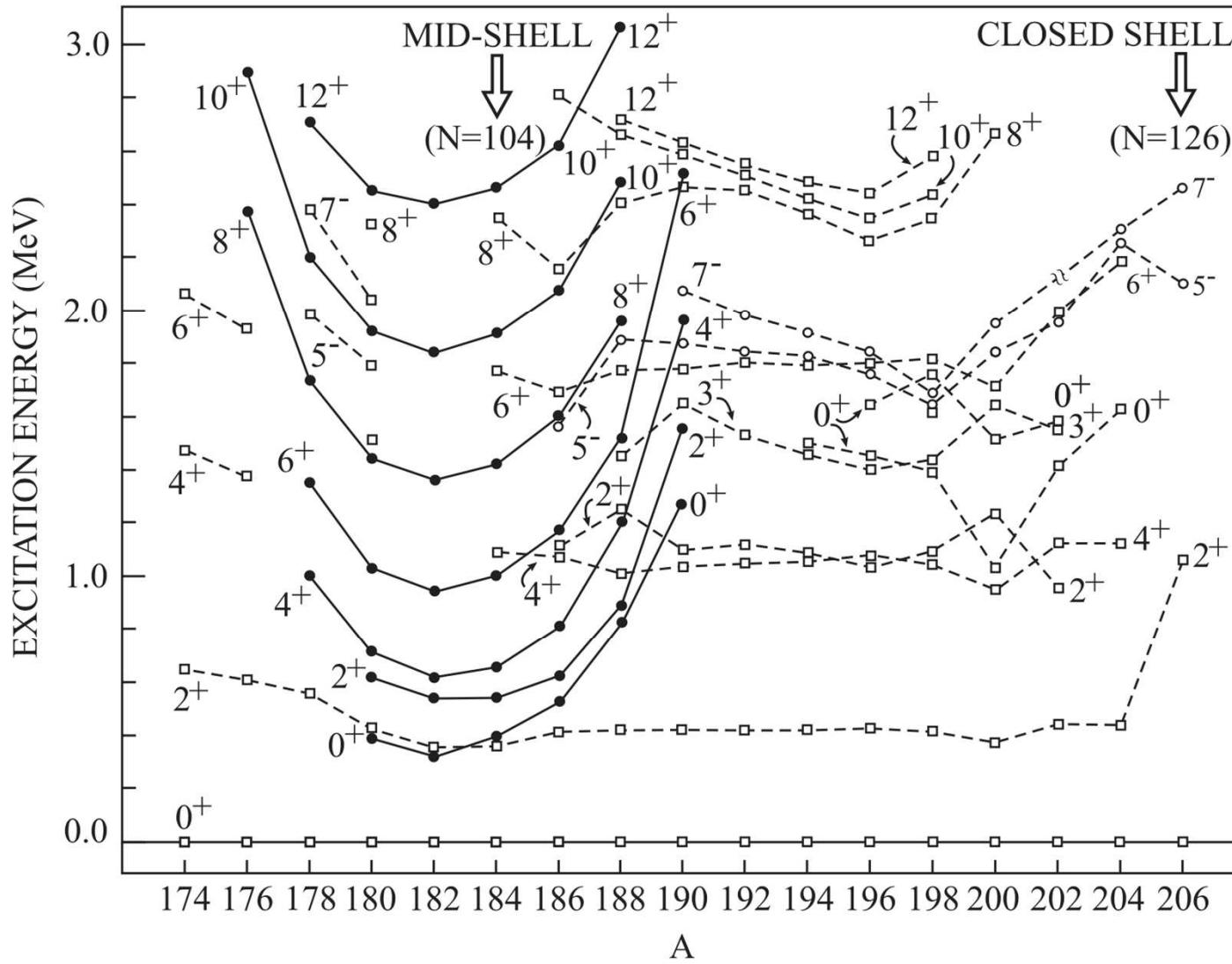
Collective vs. single-particle structures

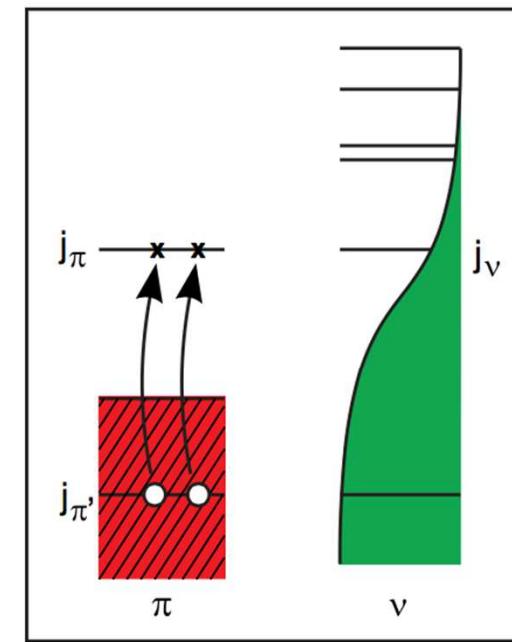
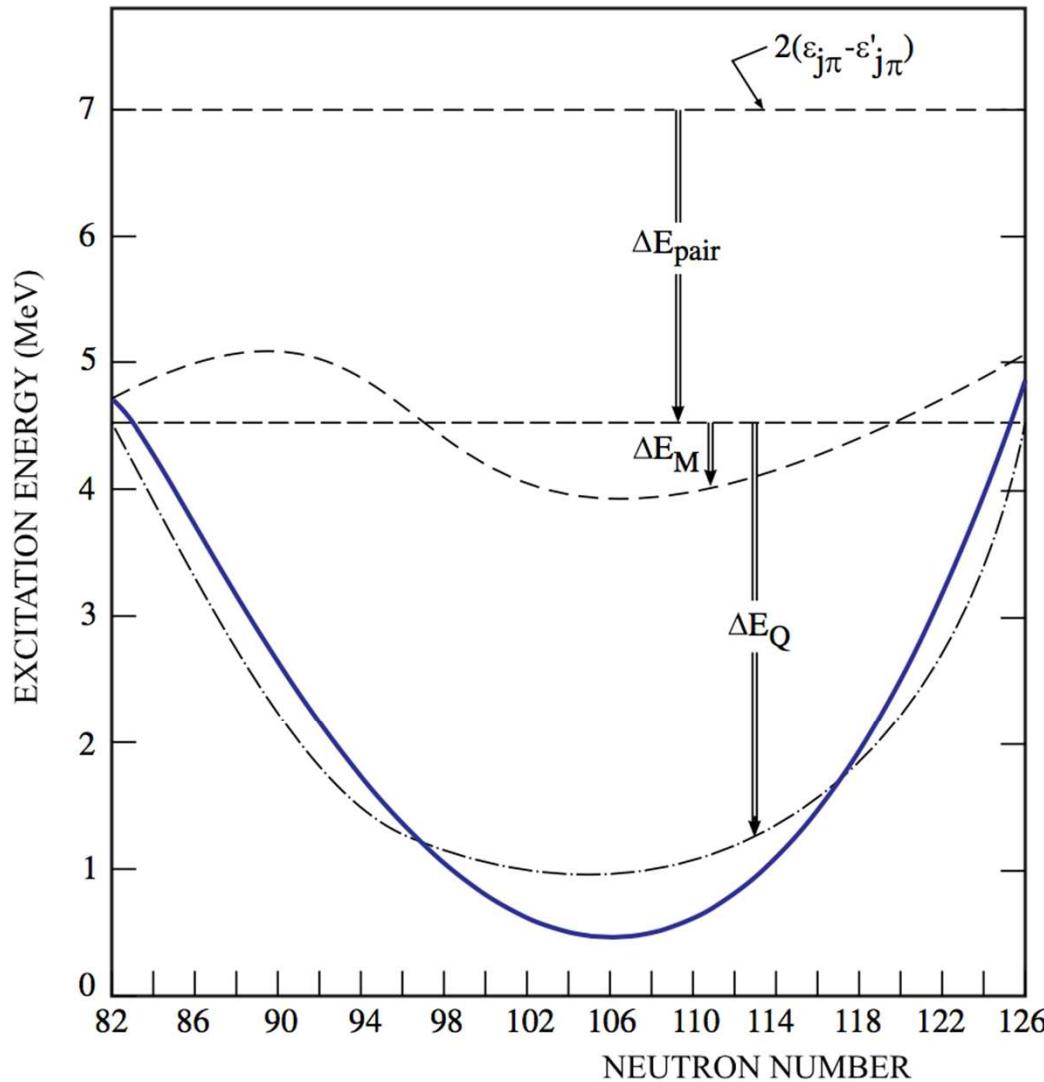


Level energies in even-mass Pb nuclei



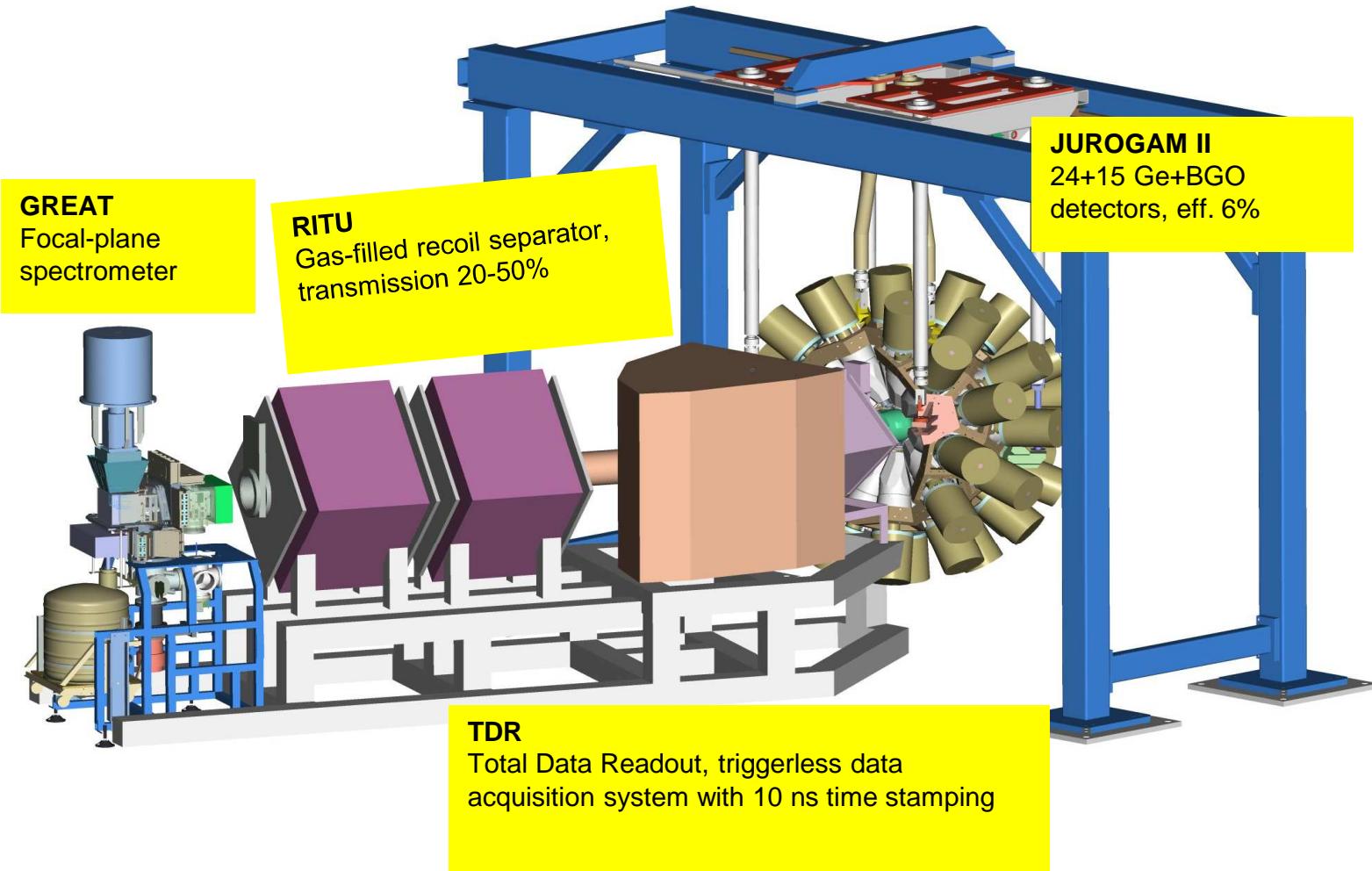
Level energies in even-mass Hg nuclei



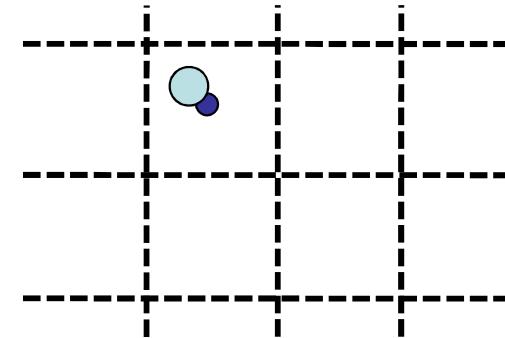
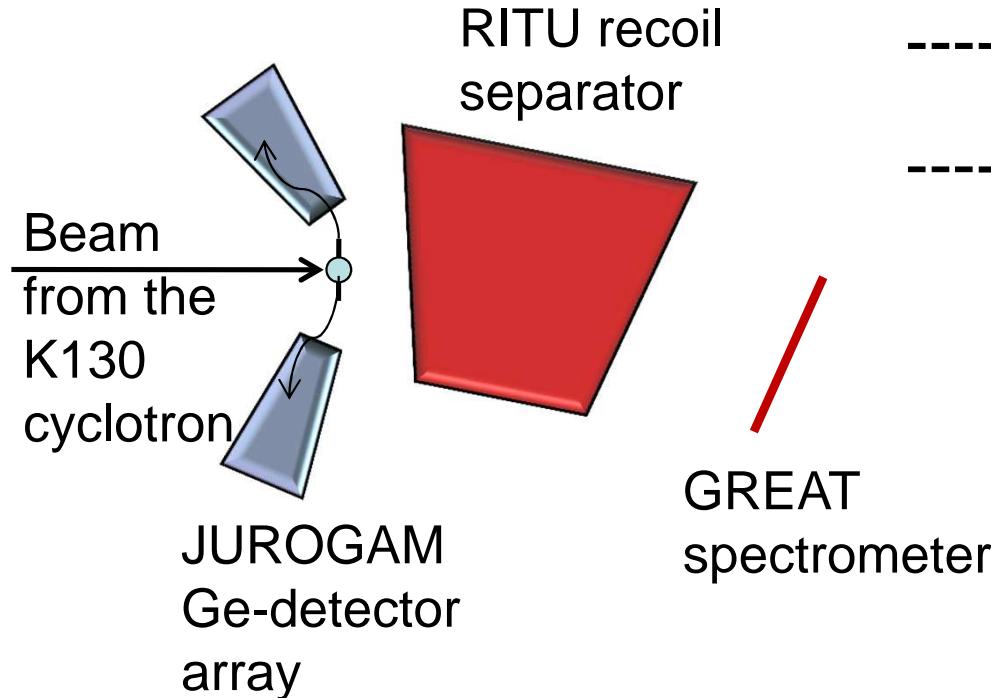


$$E_{\text{intr}}(0^+) = 2(\varepsilon_{j\pi} - \varepsilon'_{j\pi}) - \Delta E_{\text{pair}} + \Delta E_M + \Delta E_Q$$

Tagging instrumentation at JYFL



Recoil-Decay Tagging (RDT) method

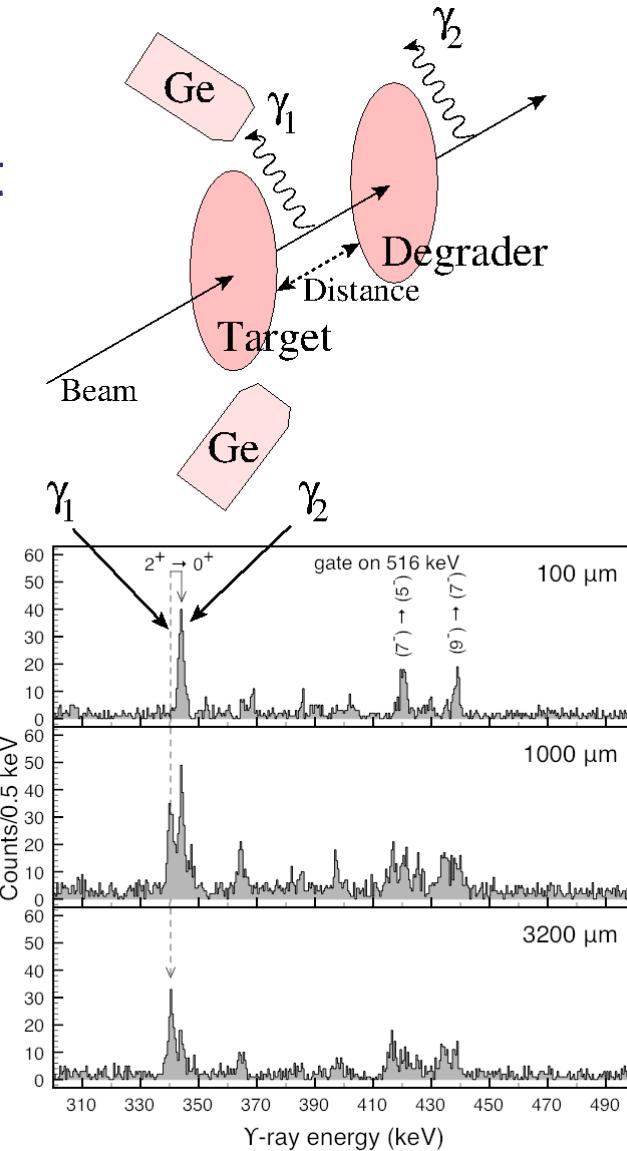
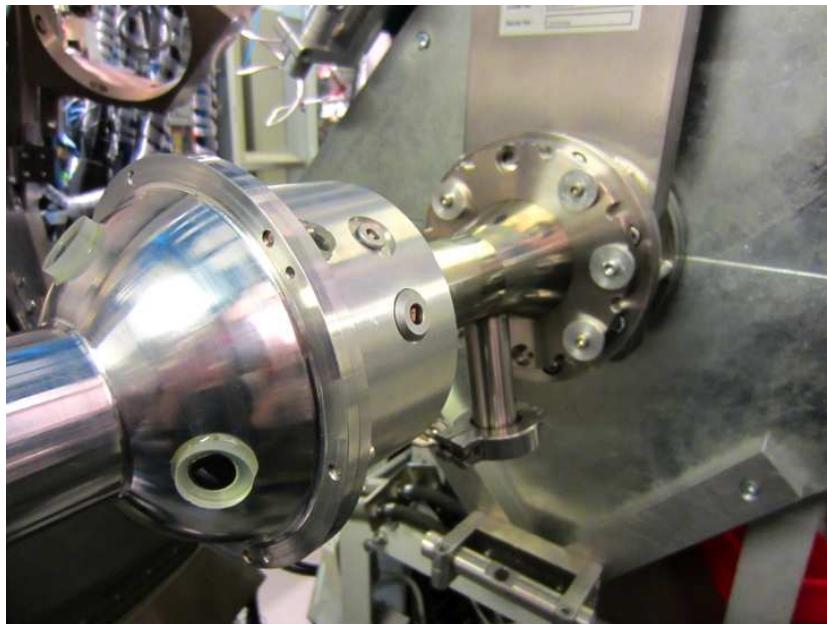


GREAT DSSD
Recoiling evaporation residue and its subsequent characteristic decay can be observed
⇒ **provides unique tag for the prompt radiation.**

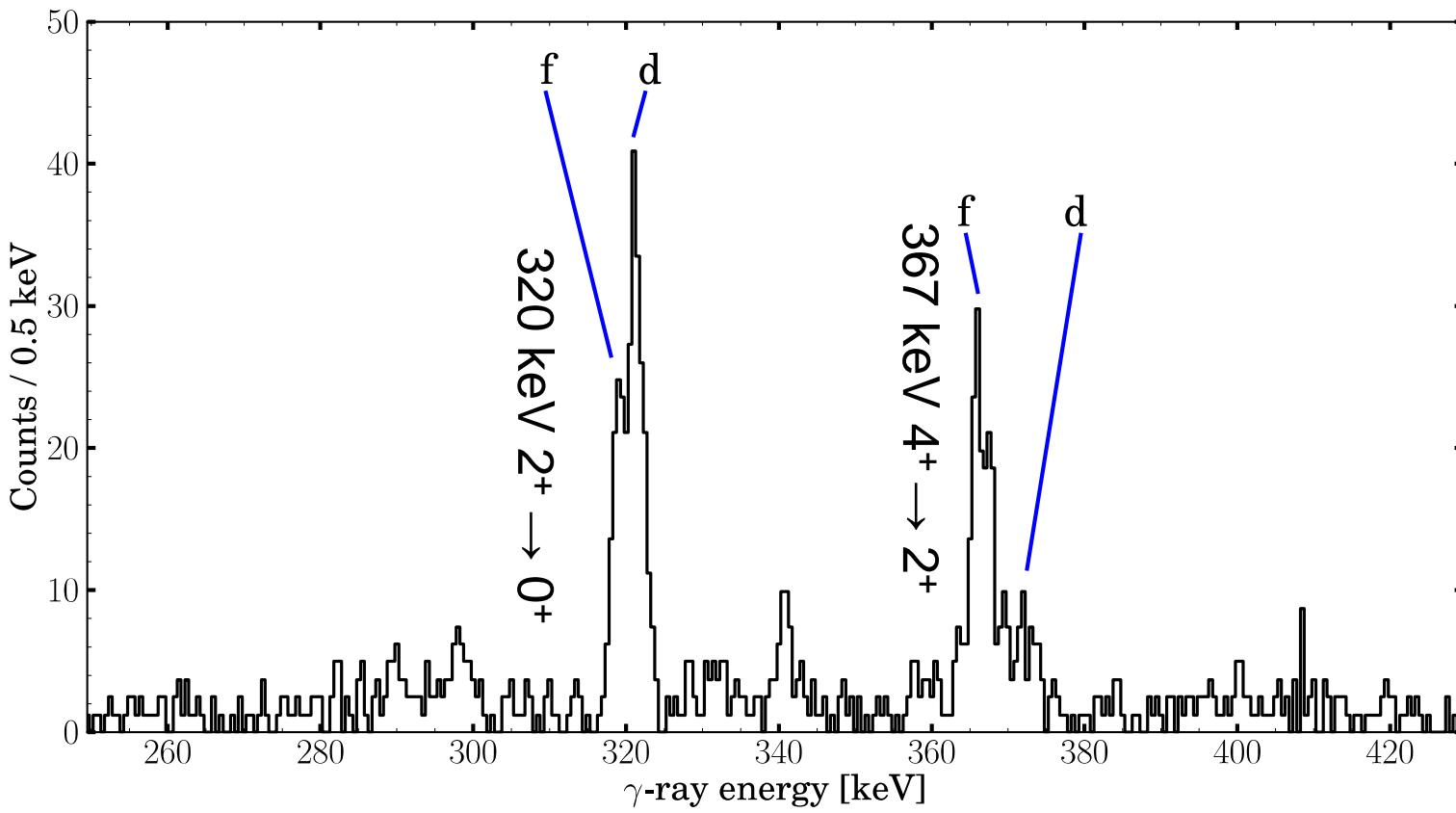


Lifetime measurements at JYFL

Recoil distance Doppler-shift (RDDS) lifetime measurement (plunger) is combined with selective tagging techniques



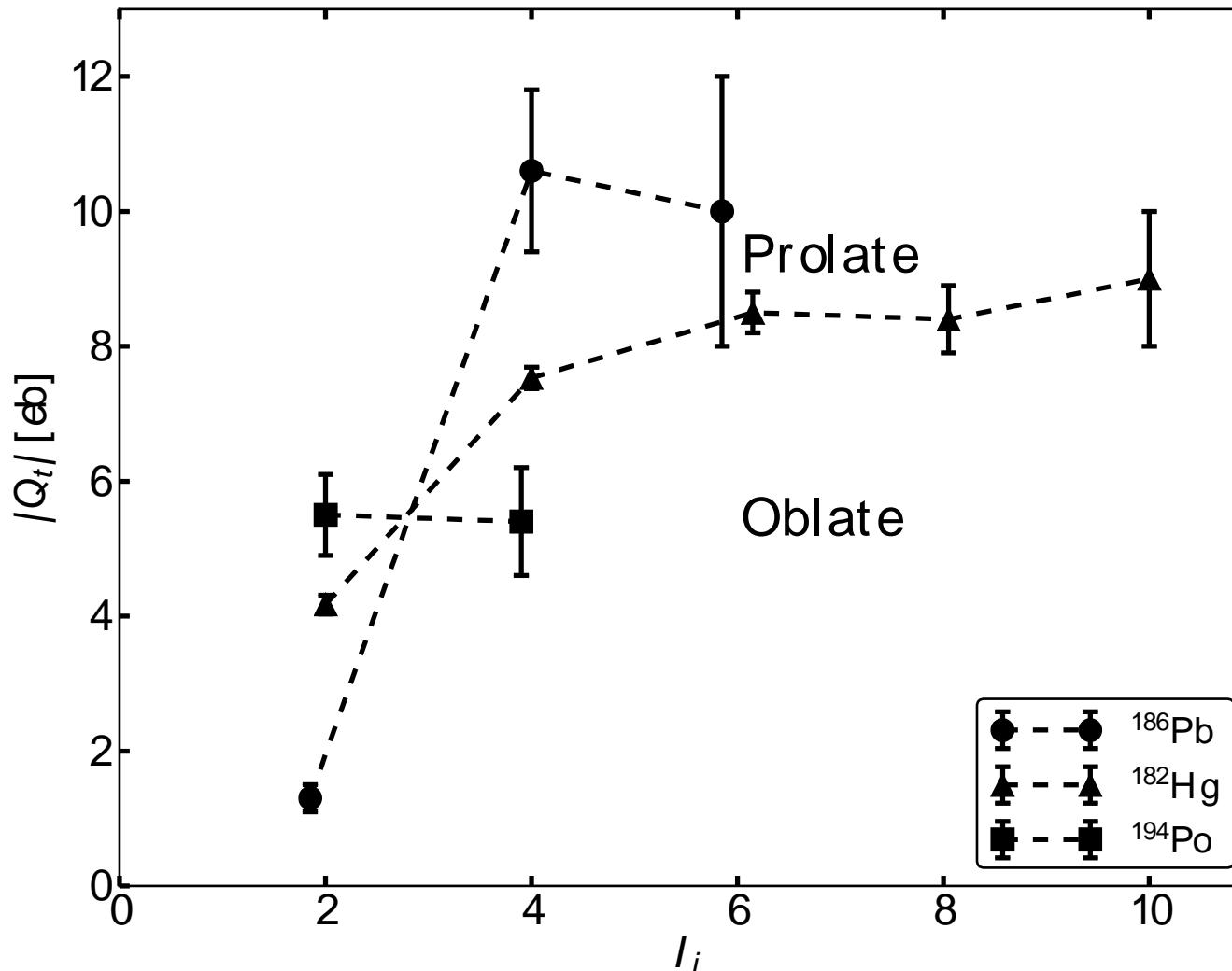
$^{114}\text{Cd}(^{83}\text{Kr}, 3n)^{194}\text{Po}$
RDT γ -ray spectrum



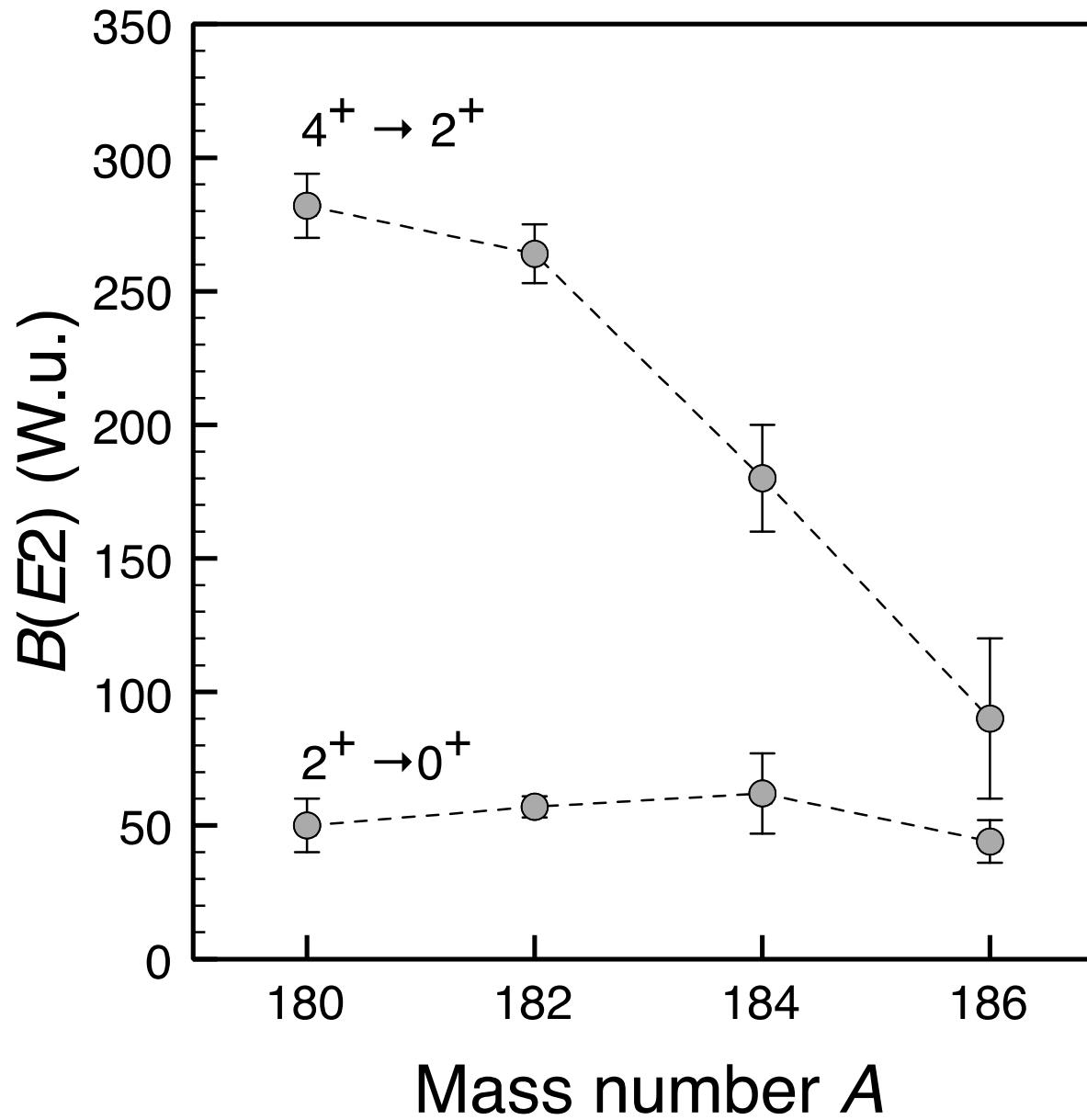
Five detectors at 158° , $700\text{ }\mu\text{m}$ target-to-degrader distance



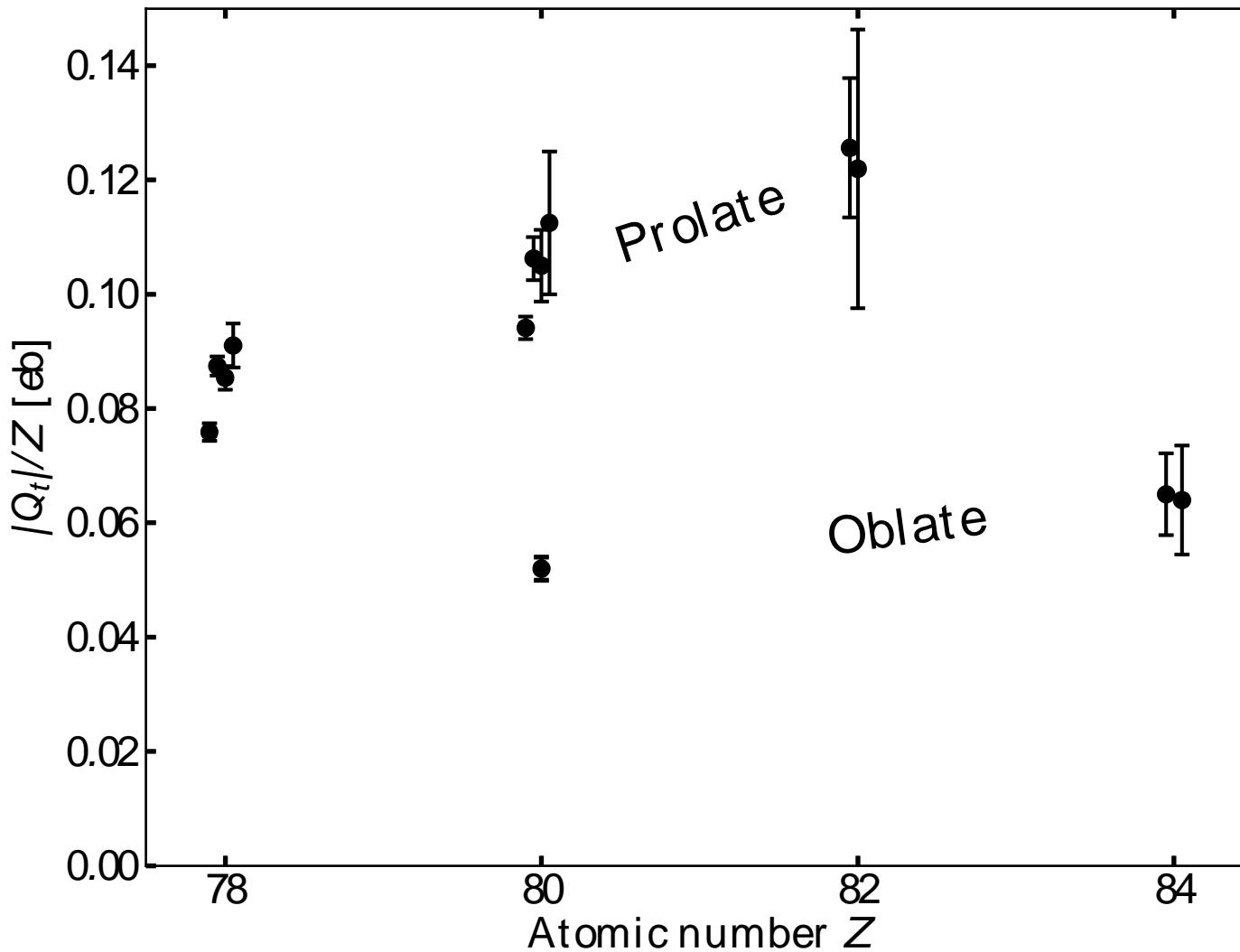
Shape coexistence in the neutron-deficient Pb region



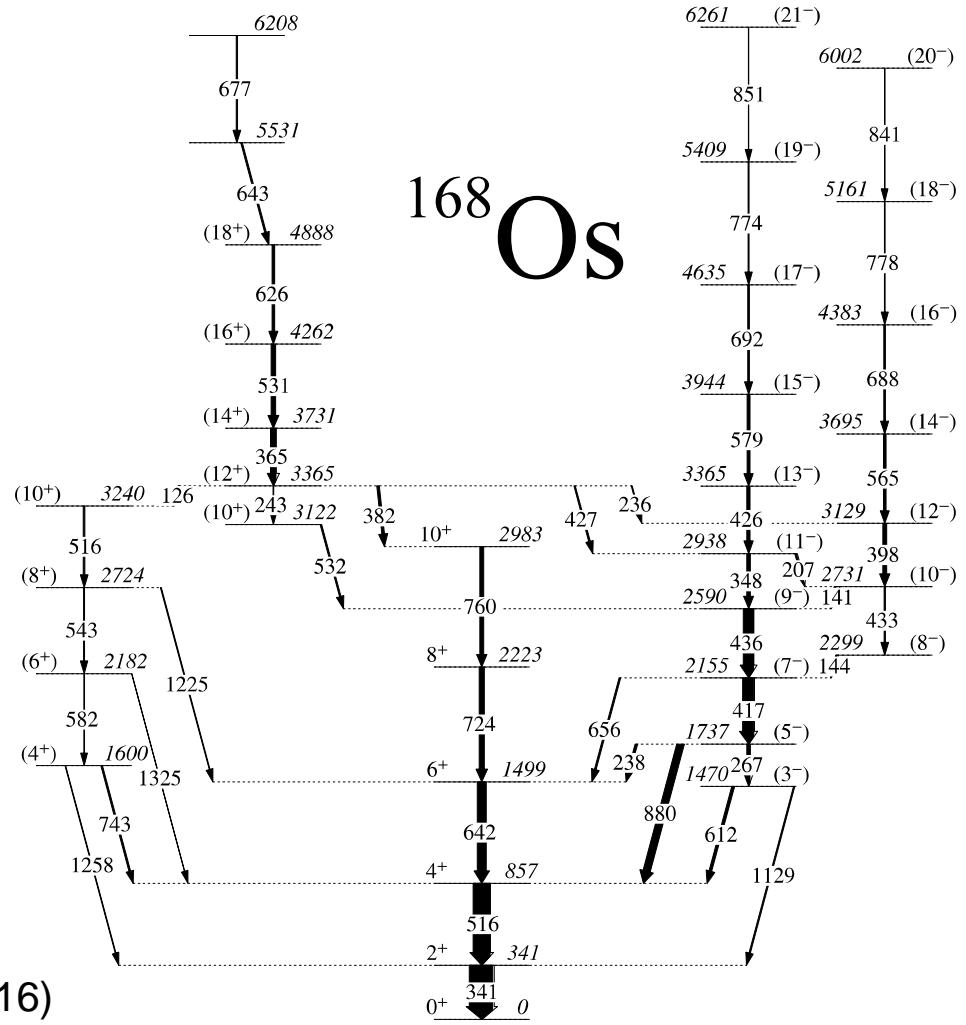
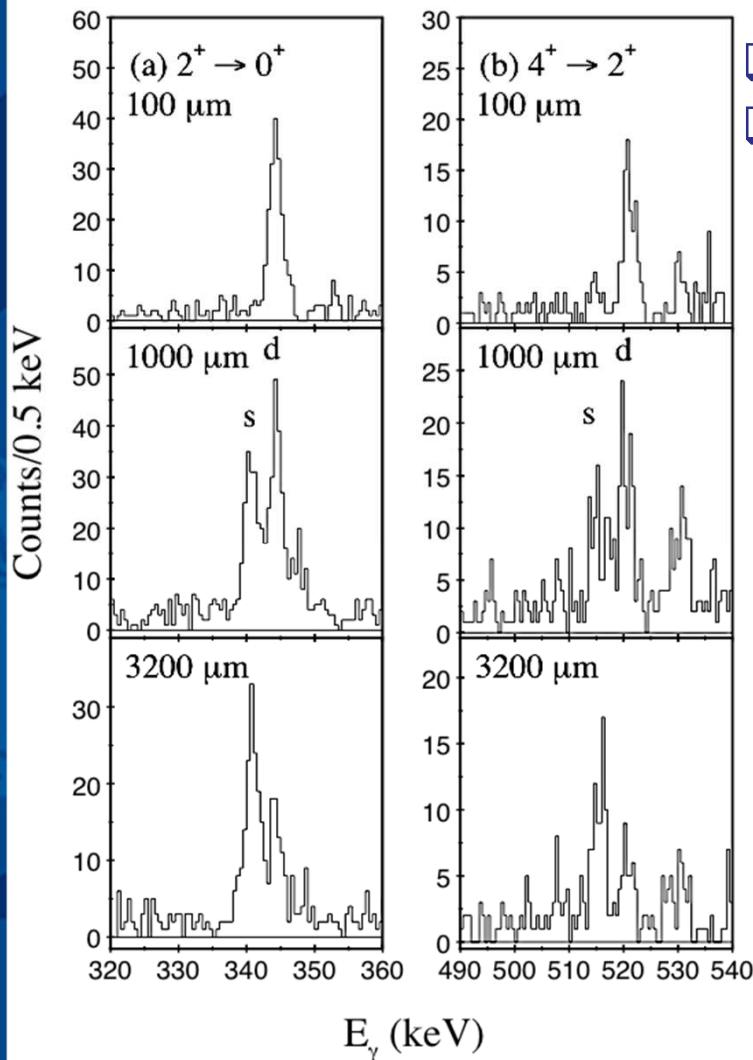
$B(E2)$ values in Hg



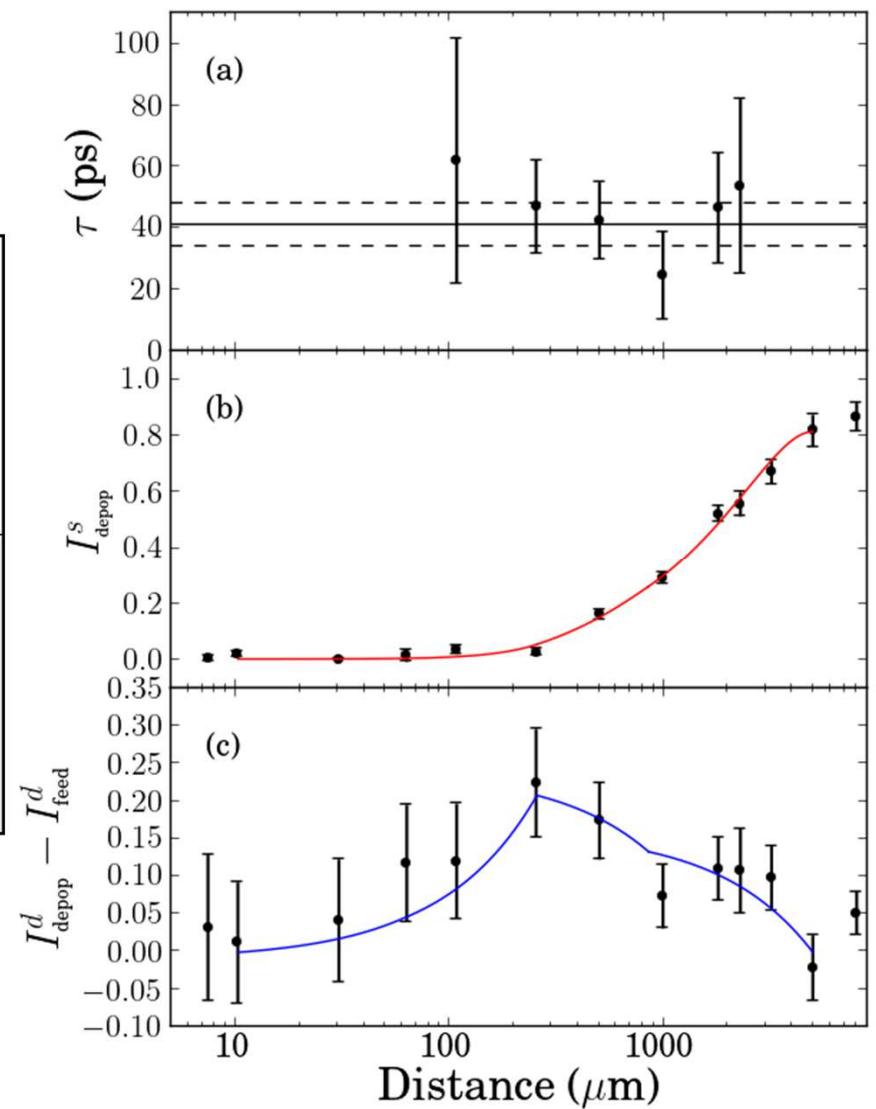
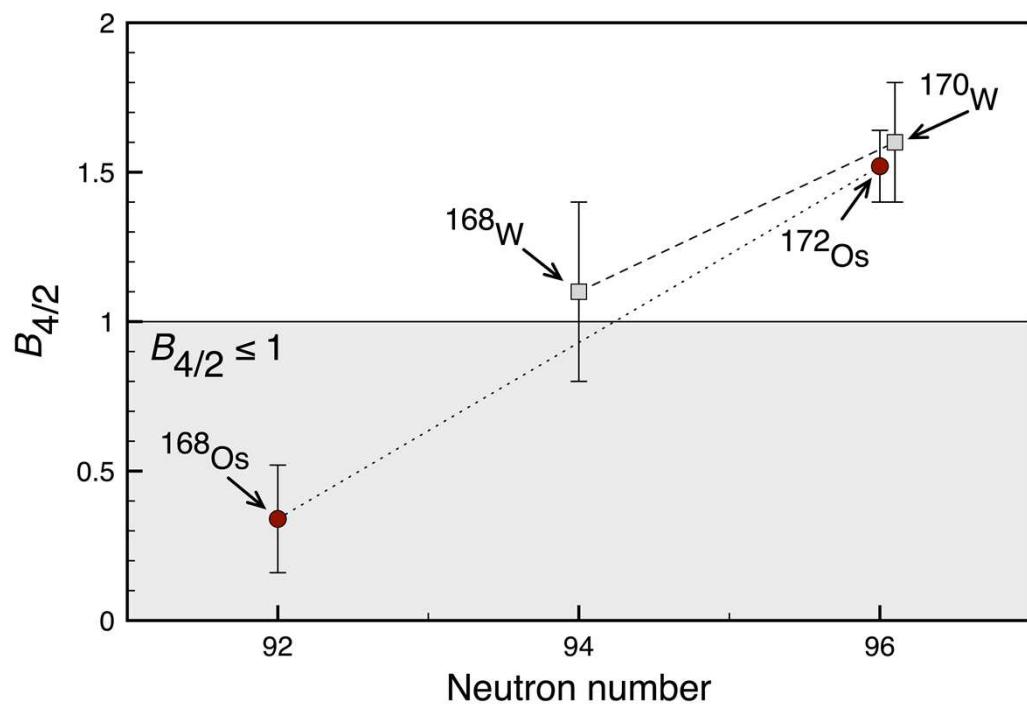
The Z -dependence of collectivity—or the lack thereof



- Reaction: $^{92}\text{Mo}(^{78}\text{Kr}, 2\text{p})^{168}\text{Os}$ at 345 MeV.
 - Köln plunger device: 1.0 mg/cm² ^{92}Mo target,
1.0 mg/cm² Mg degrader.
 - Recoil velocity: $v/c = 3.8\% \Rightarrow 2.8\%$.
 - 13 target-to-degrader distances.



$\tau_{2+} = 41(7)$ ps, $B(E2) = 74(13)$ W.u.
 $\tau_{4+} = 16(8)$ ps $B(E2) = 25(13)$ W.u.
 $\Rightarrow B_{4/2} = 0.34(18)$



Unusual $B_{4/2}$ ratio – conclusions

Two known scenarios:

Seniority scheme:

- When high- j orbitals dominate, near the closed shells.
- At mid- j shell the $B(E2)$ values can decrease within a band.

Shape coexistence:

- $4^+ \rightarrow 2^+$ transition connects two coexisting structures (interband transition).
- Hindered transition strength

Typically appearing at or near the shell closures.

Deformed coexisting band at \approx 2 MeV, ^{168}Os away from the midshell.

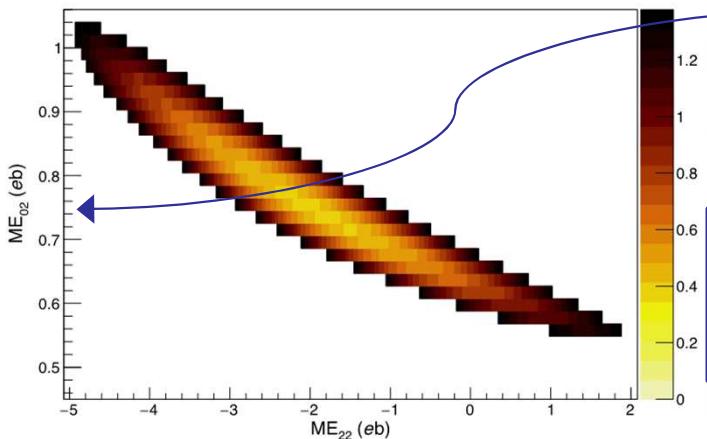
⇒Further investigations required. Completed, but not published cases:
 $^{166,168}\text{W}$ and ^{170}Os





Summary:

- **Shape coexistence** and **transitions** studied at JYFL through RDDS lifetime measurements
- **Selective tagging techniques** are the key to these weakly populated cases
- **Complementary** and **constraining** to Coulomb excitation measurements (J. Pakarinen's talk)



Lifetime measurement will provide the transition matrix element

Outlook: RDDS plunger measurements with radioactive ion beams

