IS524 - Coulomb excitation of neutron-rich odd-A Cd isotopes

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INTC-P-306-ADD-1

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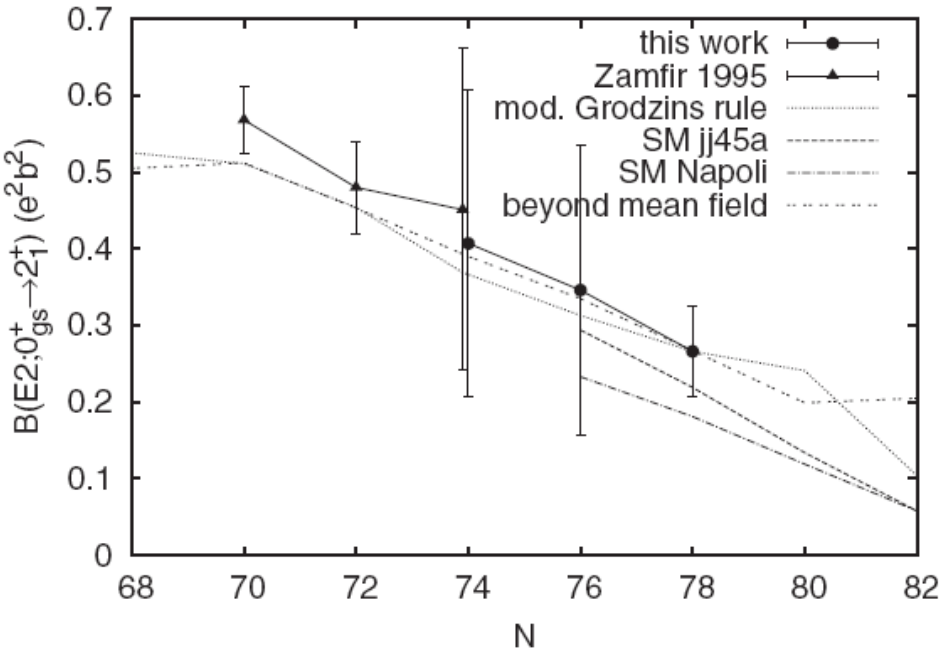
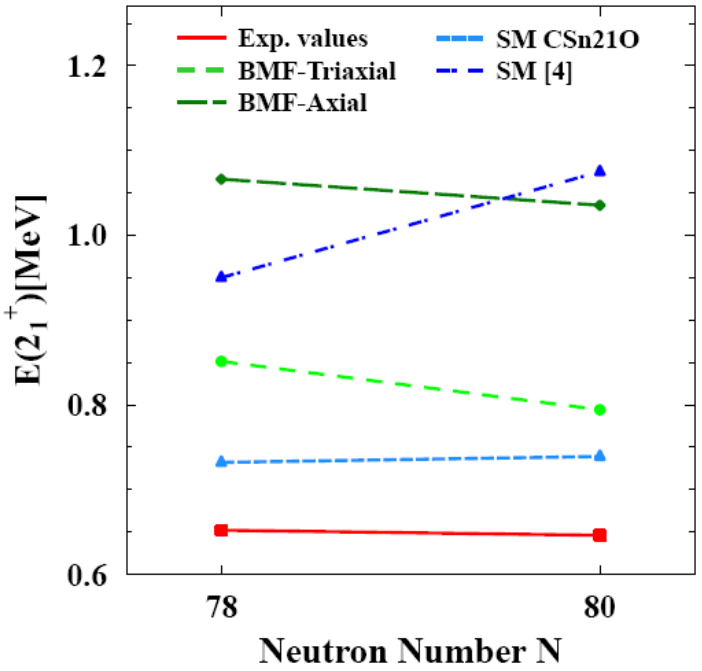
Collectivity in even Cd isotopes (IS411)

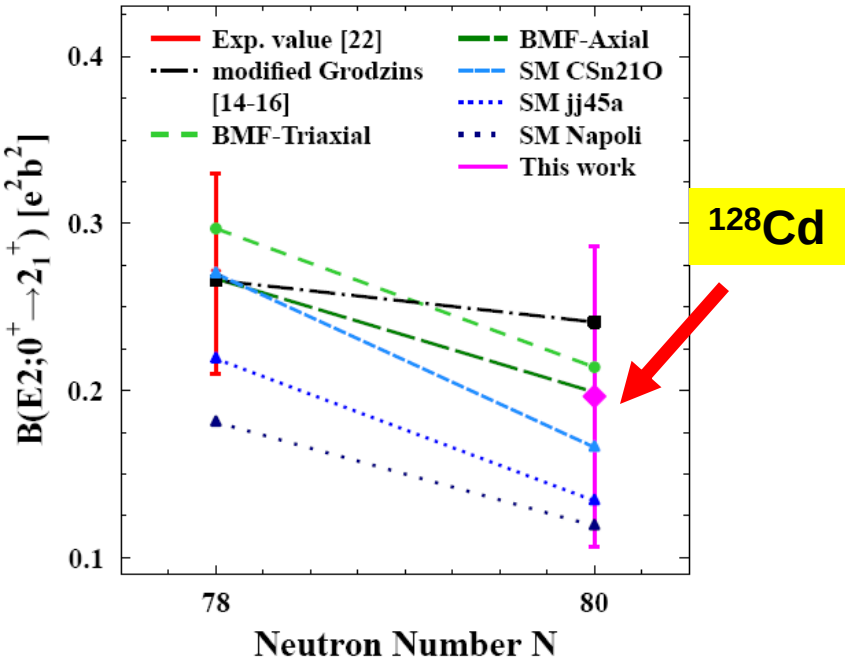


- shell model calculations tend to underestimate B(E2) values
- Beyond-Mean-Field calculations in better agreement ... but predict considerable deformation

S. Ilieva et al., PRC 89, 014313 (2014)
T. Behrens, PhD thesis (TU München, 2009)
M. Thürauf, Master thesis (TU Darmstadt, 2012)

Collectivity in even Cd isotopes (IS477)





- improved shell model interaction CSn21O
  ... E(2⁺) anomaly described much better
- larger collectivity predicted
  ... in agreement with experiment
- Beyond-Mean-Field calculations
  extended to triaxial shapes

S. Bönig et al., submitted to PRL
S. Bönig, PhD thesis (TU Darmstadt, 2014)

Why to investigate odd Cd isotopes?

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Even neutron-rich Cd isotopes

Collectivity and E(2^+) anomaly are challenge for nuclear theory, in particular for shell model calculations

… some details of the two-body matrix elements are missing

… surprise as the region is near to the doubly-magic ^{132}Sn

Odd neutron-rich Cd isotopes

- **No B(E2) values known**
- **Level scheme is „divided“ in two parts:**
  - **positive parity states build on the ($3/2^+$) ground state ($\nu d_{3/2}$) (none experimentally known for A>123)**
  - **negative parity states build on the long-lived ($11/2^-$) isomer ($\nu h_{11/2}$)**

… selectivity to contributions from particular single particle orbitals

- **ISOLDE beam contains both the ground state and the isomer**
- **Proposed experiment profits from the unique capability of ISOLDE to deliver also isomerically purified beams**

^{123}Cd – current knowledge (2011)

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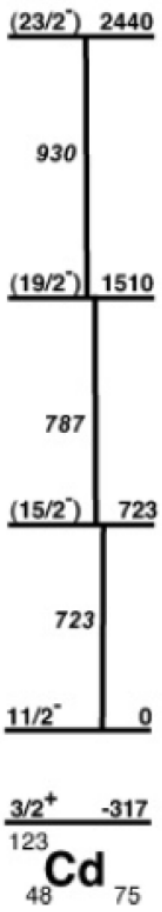

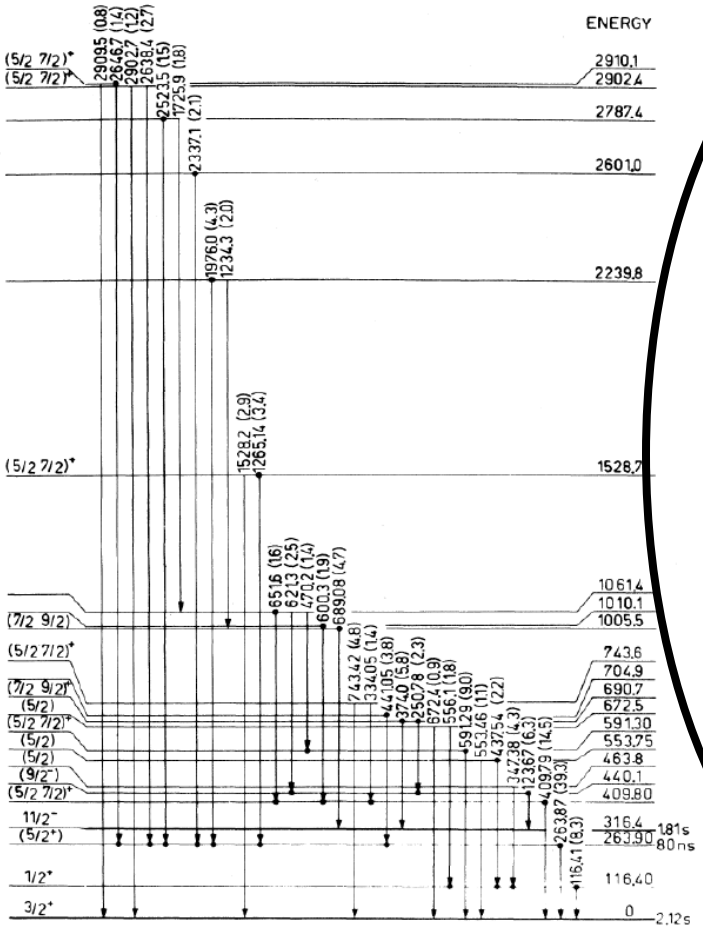

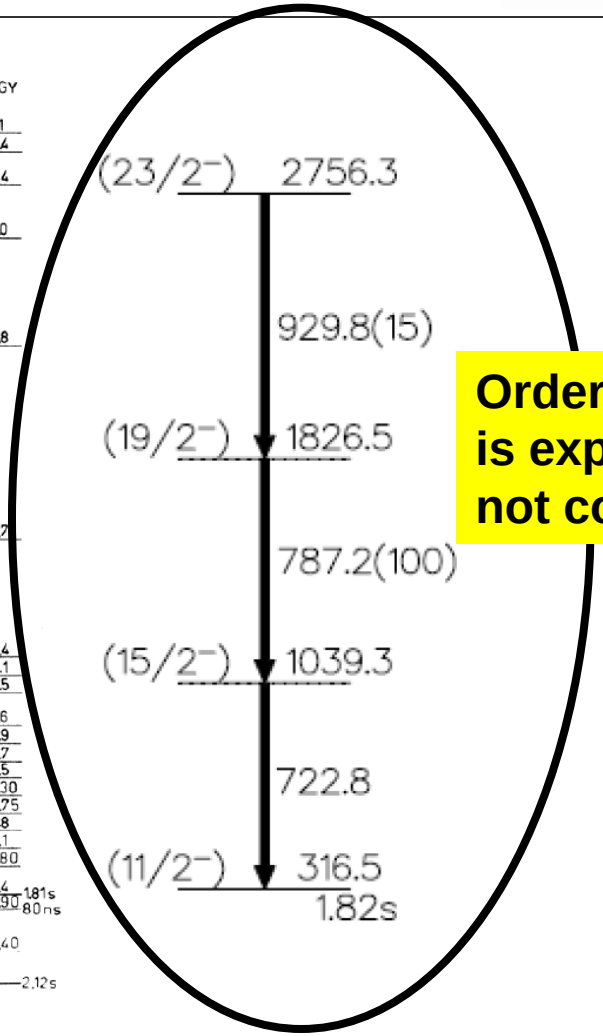

Ordering of levels is experimentally not confirmed

(also: similar decay exp. in Bill Walters group)

Odd Cd isotopes - mass measurements

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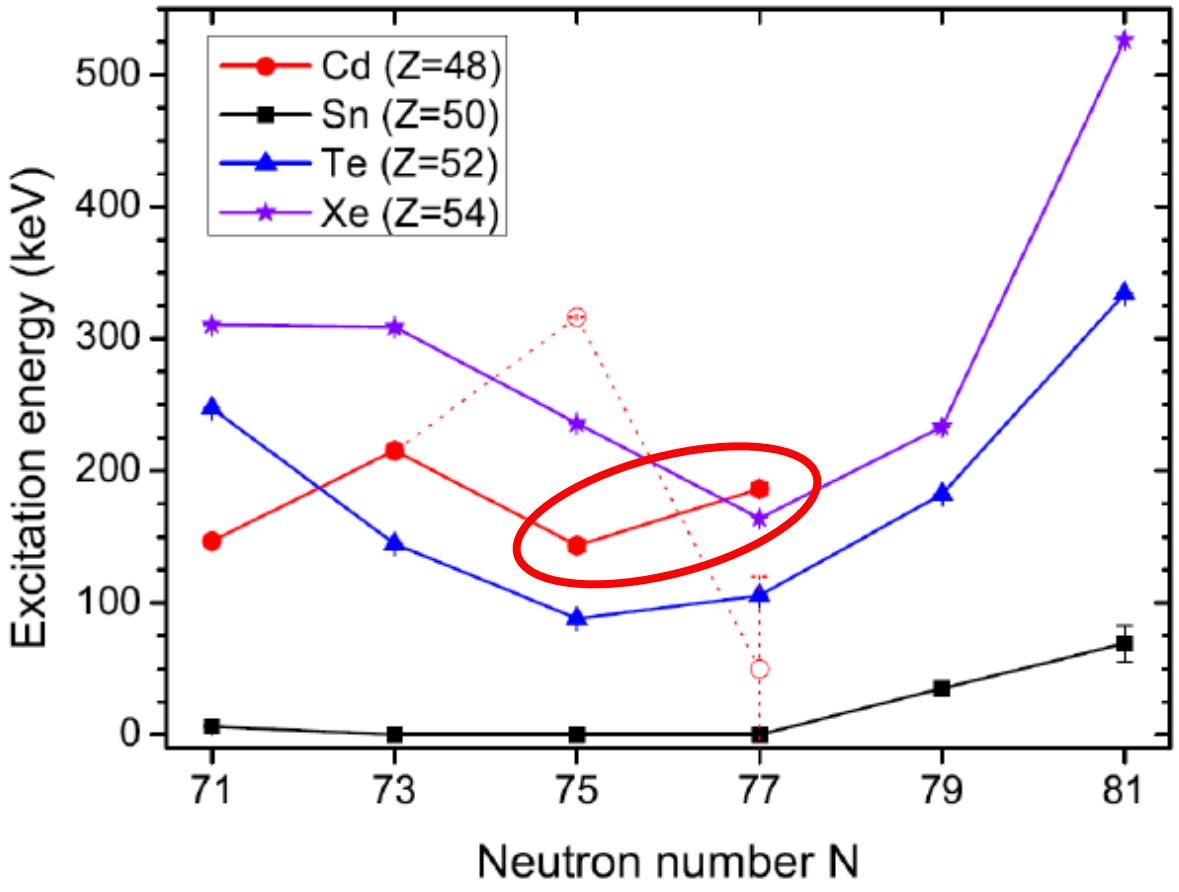
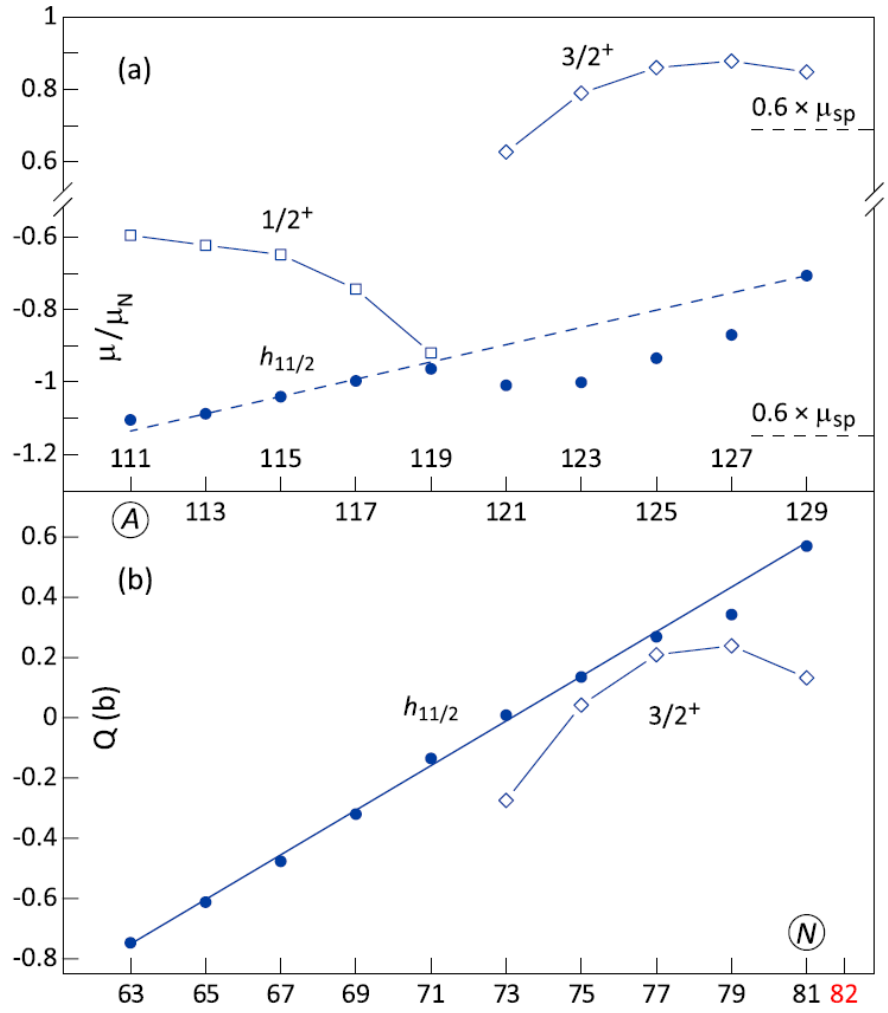
Excitation energies of $11/2^-$ isomers in ^{123,125}Cd had been corrected



A. Kankainen et al., Phys. Rev. C 87, 024307 (2013)

Odd Cd isotopes - laser spectroscopy



- magnetic moments deviate from quenched Schmidt values
  ... increasing effect towards N=82
  ... not understood yet

- linear behaviour of quadrupole moments of $11/2^-$ isomer
  ... only partially understood*

Exp: D. T. Yordanov et al., PRL 110, 192501 (2013)
*Theo: P.W. Zhao et al., PRC 89, 011301(R) (2014)

Results from run of IS524 in 2012

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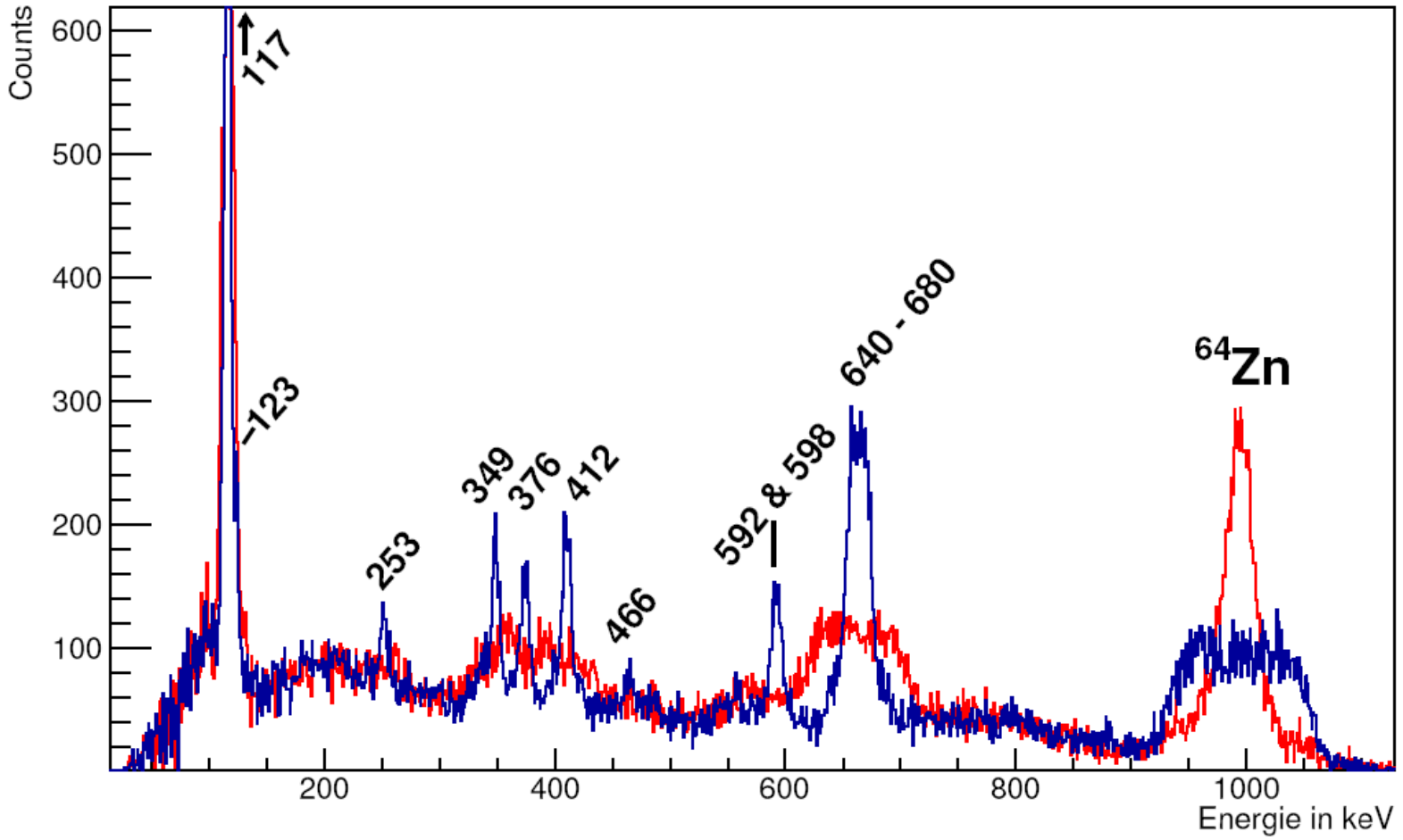

Analysis: Anna-Lena Hartig, Master thesis (TU Darmstadt, 2014)

Results from run of IS524 in 2012

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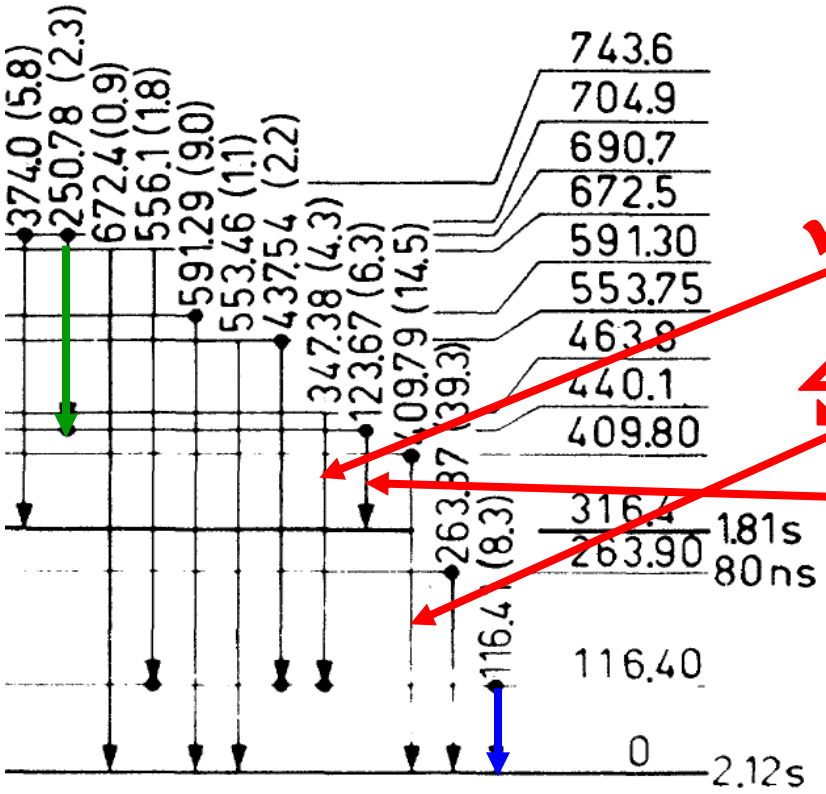
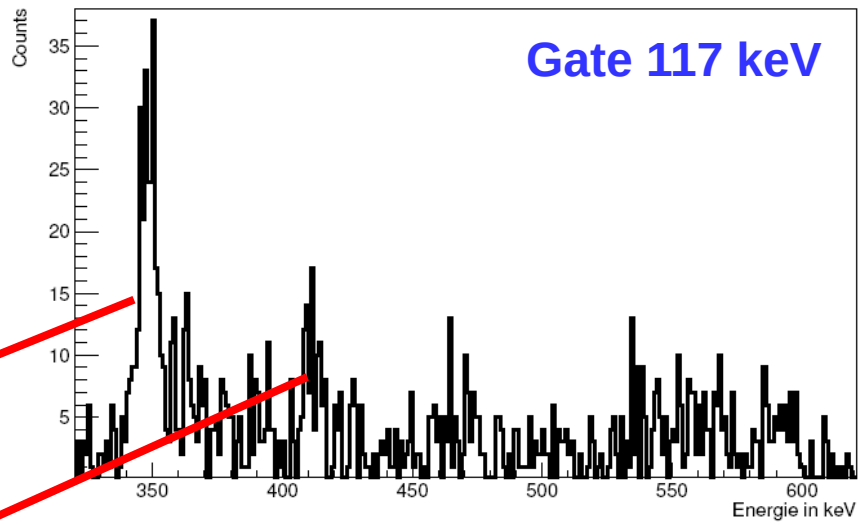
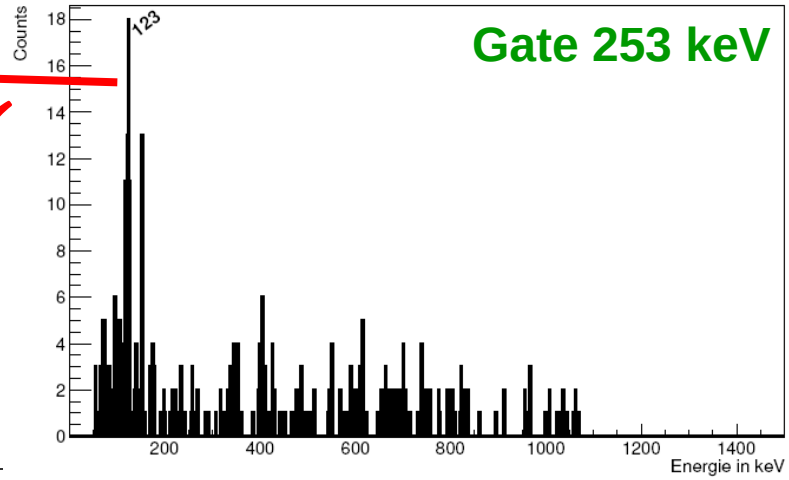
Low γγ statistics
... is exactly the idea of the experiment to keep multiple Coulex small!!!







Results from run of IS524 in 2012

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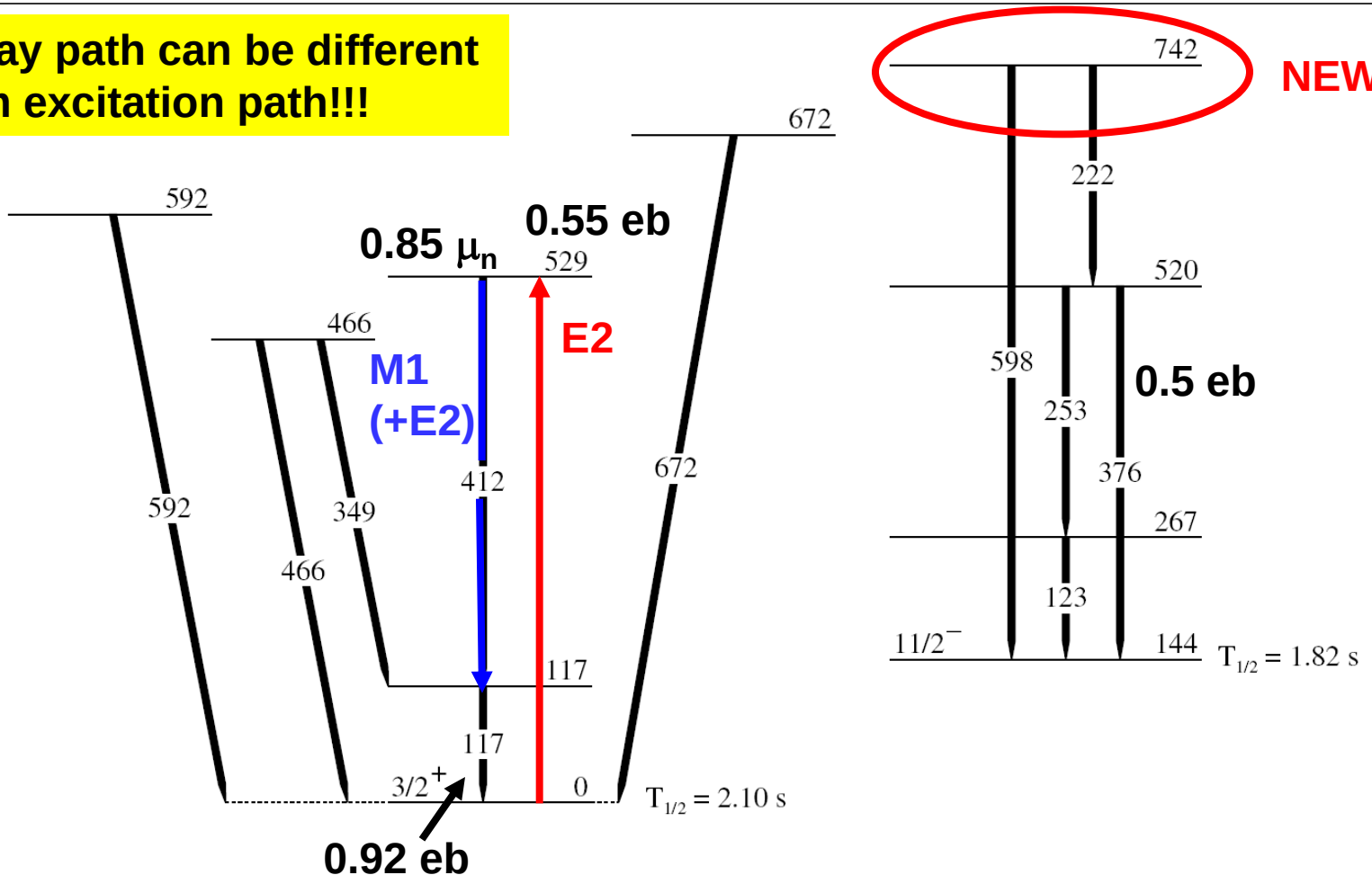
Decay path can be different from excitation path!!!



Matrix elements in both “halfs” of the level scheme are of similar size

Results from run of IS524 in 2012

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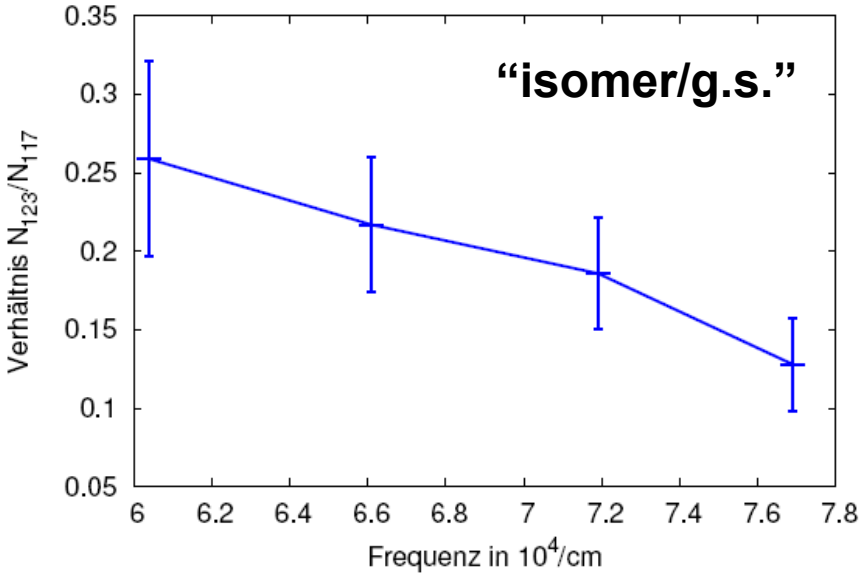
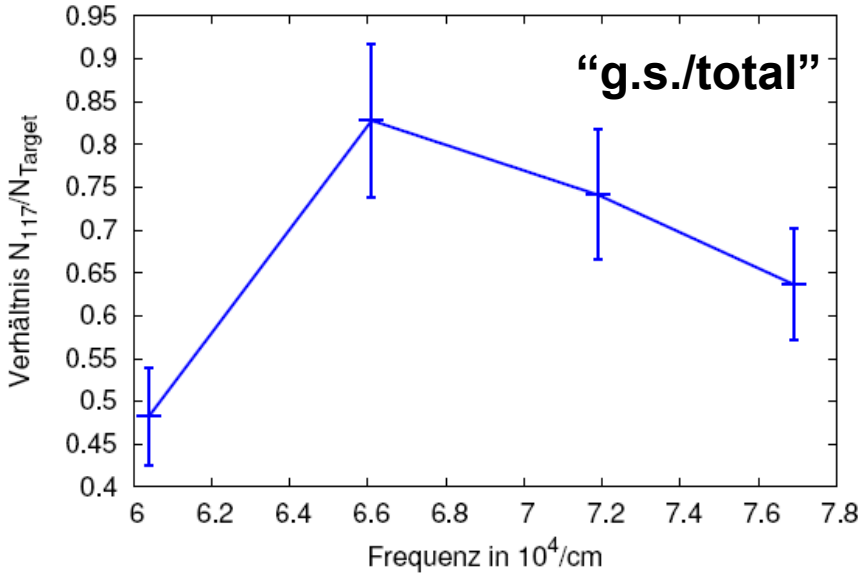
Scan of central frequency of broad band laser (very short test!!!!)



(a) Verhältnis $\frac{N_{123}}{N_{117}}$



(b) Verhältnis $\frac{N_{117}}{N_{Target}}$

- **ratio g.s./isomer can be slightly changed**
  ... very promising for a narrow band laser scan
- **total yield changes too**

Transition strengths

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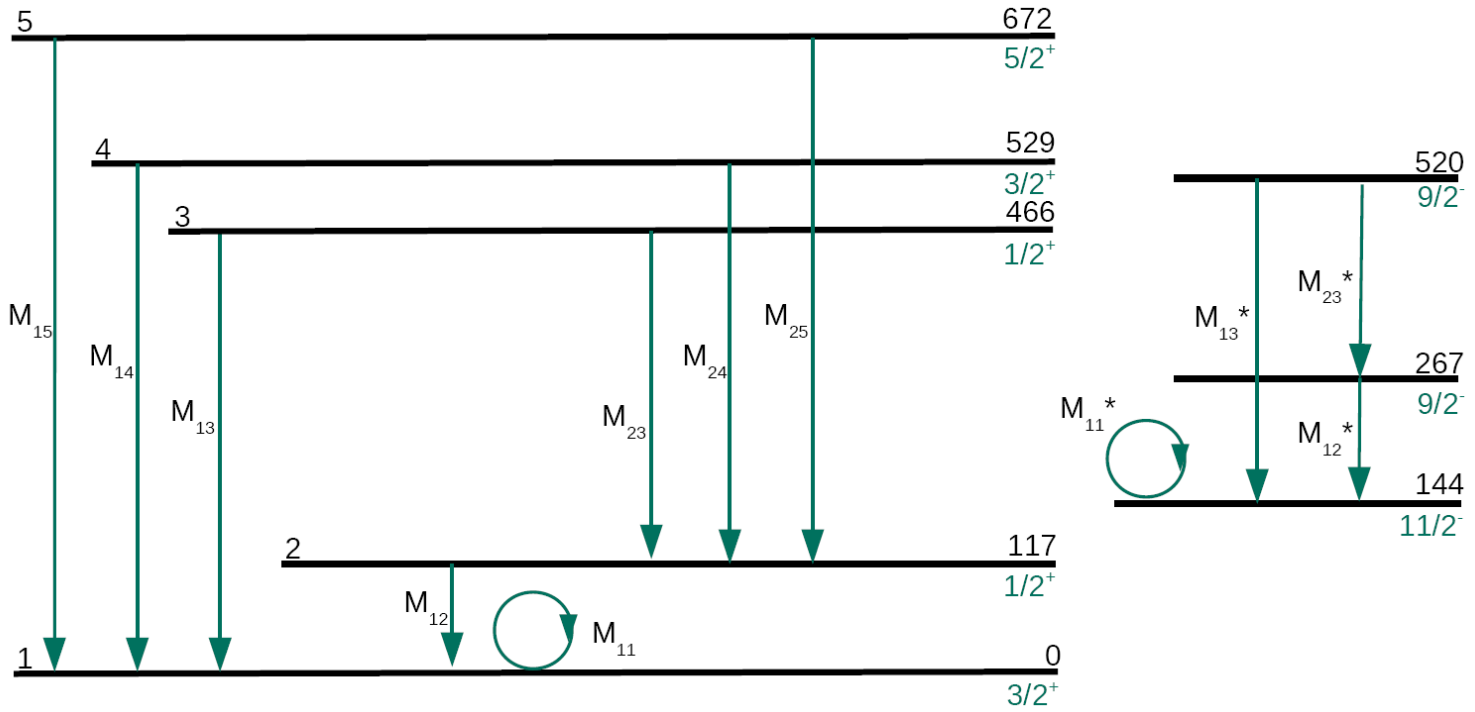
- exp. diagonal ME for g.s. and isomer D. T. Yordanov et al., PRL 110, 192501 (2013)
  ... all others neglected
- unknown spins assumed (systematics, branching ratio, ...)



Multiple Coulex has to be kept small ... beam energy 3 MeV/u preferred!!!

What remains open?

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Level scheme of ^{123}Cd

- second strongest transition (multiplet at 640-680 keV) is not assigned yet (NOT observed in decay spectroscopy)
  Transitions not seen in coincidence feed directly either the g.s. or the isomer
  … and states will be also populated directly in one-step excitation

➔ narrow band laser scan to change ratio g.s./isomer !!!
(decay spectroscopy, could be done with IDS too)

Transitions strengths

- large errors bars due to low statistics

Spin / parity assignments

- particle-gamma angular correlations
  … not enough statistics so far

➔ Contribute to comprehensive picture how nuclear structure evolves along the Cd isotopic chain approaching N=82

➔ Challenge for new theory calculations

Rate estimate / beam request

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- Standard MINIBALL + CD set-up (T-REX possible), ^{64}Zn target (1.5 mg/cm^2)
- UC_x production target, yield: 3 · 10^6/μC
- Proton intensity 2 μA, ε=3%, neutron converter
- Quartz transfer line + RILIS
  No ^{123}In observed in 2012 … (for comparison: 79% purity for ^{124}Cd in IS411)

- Beam energy 3 MeV/u

➔ typically 20-40 particle-γ-coincidences/h for ^{123}Cd per excited level
B(E2) values with 5% statistical error within 2 x 8 shifts

➔ 2 settings of the laser (8 shifts each) with different g.s./isomer ratio
(no „pure“ beam preparation required!!!)

\+ 2 shifts for the narrow band laser scan (MINIBALL or IDS)

We request 18 shifts (6 days) of beam time