Coulomb Excitation of Neutron-rich Isotopes around A~140 (IS 411)

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Physical motivation:
Evolution of B(E2) values around N=82

Experimental setup and realisation
at REX-ISOLDE with MINIBALL

Preliminary results
for ^{144}Xe & $^{124,126}Cd$

Conclusion & Outlook

Modified Grodzins' rule

Motivation

Setup

Results

Outlook

Grodzins' rule (version by Raman)

$$E(2_1^+)[\mathrm{keV}] * B(E2; 0_{gs}^+ \rightarrow 2_1^+)[e^2\mathrm{b}^2] = 2.57\, Z^2\, A^{-2/3}$$

[*S.Raman et.al.*, Atomic Data and Nucl. Data Tables **78**,1 (2001)]

Isospin dependent modification of Grodzins' rule

$$E(2_1^+)[\mathrm{keV}] * B(E2; 0_{gs}^+ \rightarrow 2_1^+)[e^2\mathrm{b}^2] = 2.57\, Z^2\, A^{-2/3}\left(1.288 - 0.088(N - \overline{N})\right)$$

[*D.Habs, R.Krücken*, INTC-P-156 (2002)]

Minimum mass for fixed A
(from Weizsäcker's mass formula)

$$\overline{N} = \frac{A}{2}\,\frac{1.0 + 0.0128\, A^{2/3}}{1.0 + 0.064\, A^{2/3}}$$

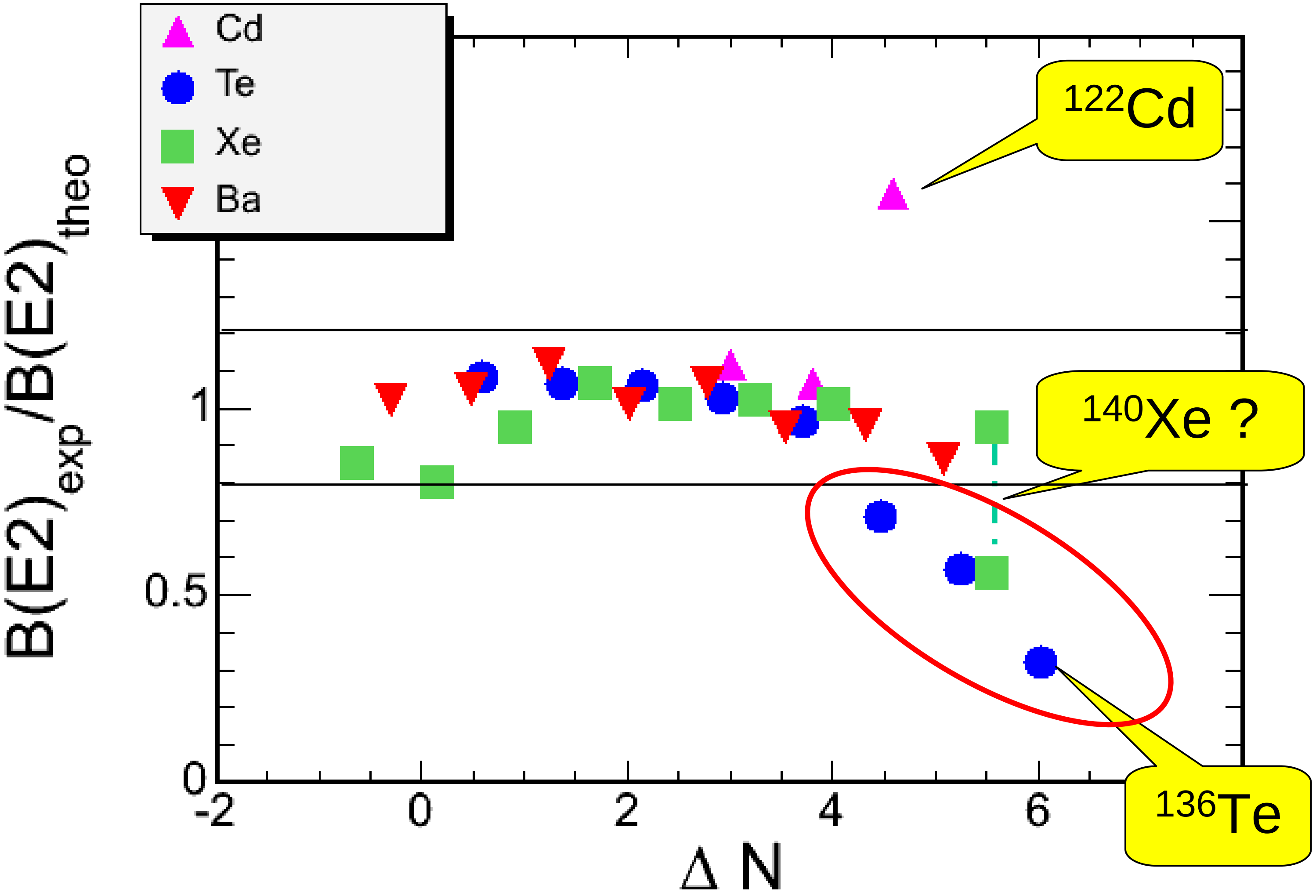
B(E2) values before IS411

Motivation

Setup

Results

Outlook



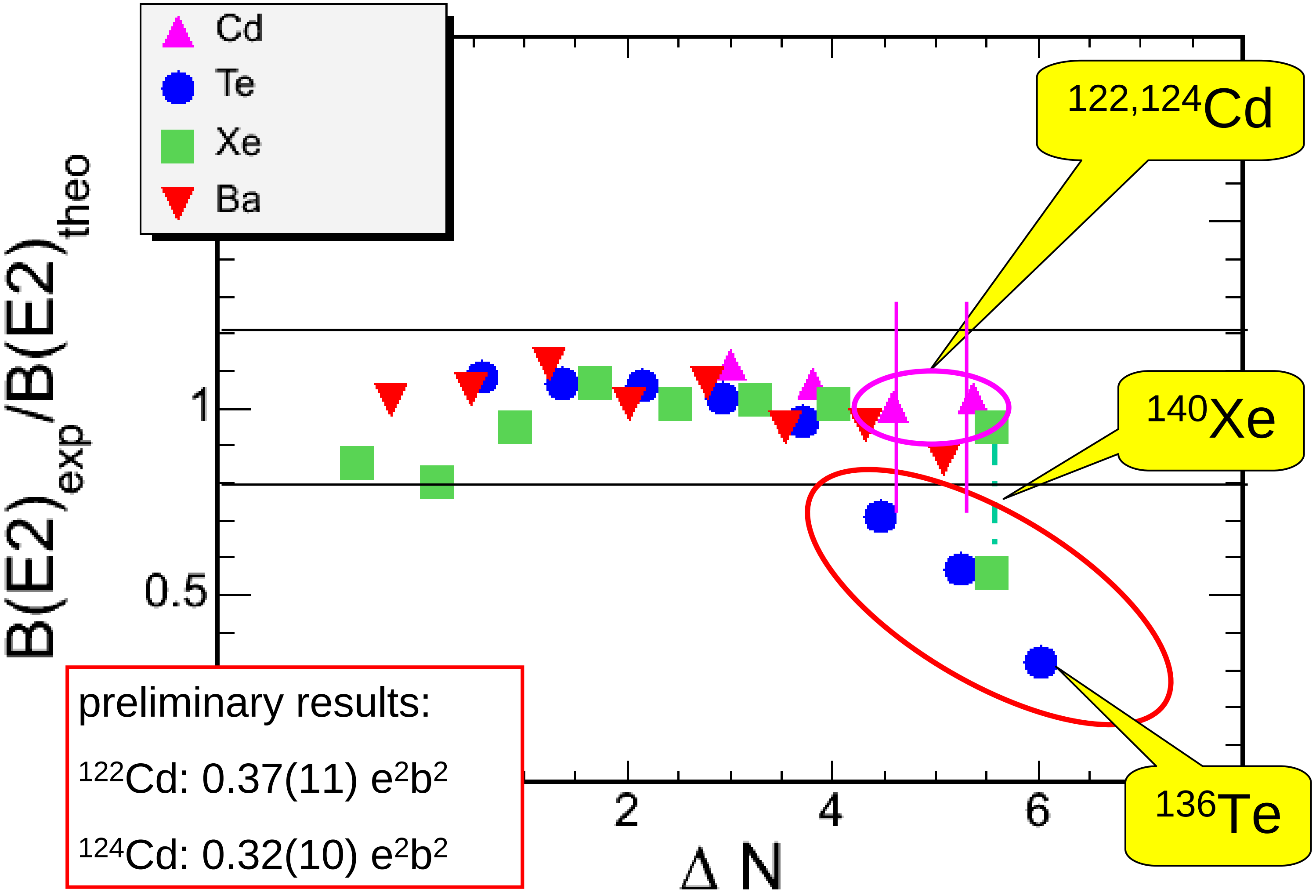
B(E2) values after 2004

Motivation

Setup

Results

Outlook

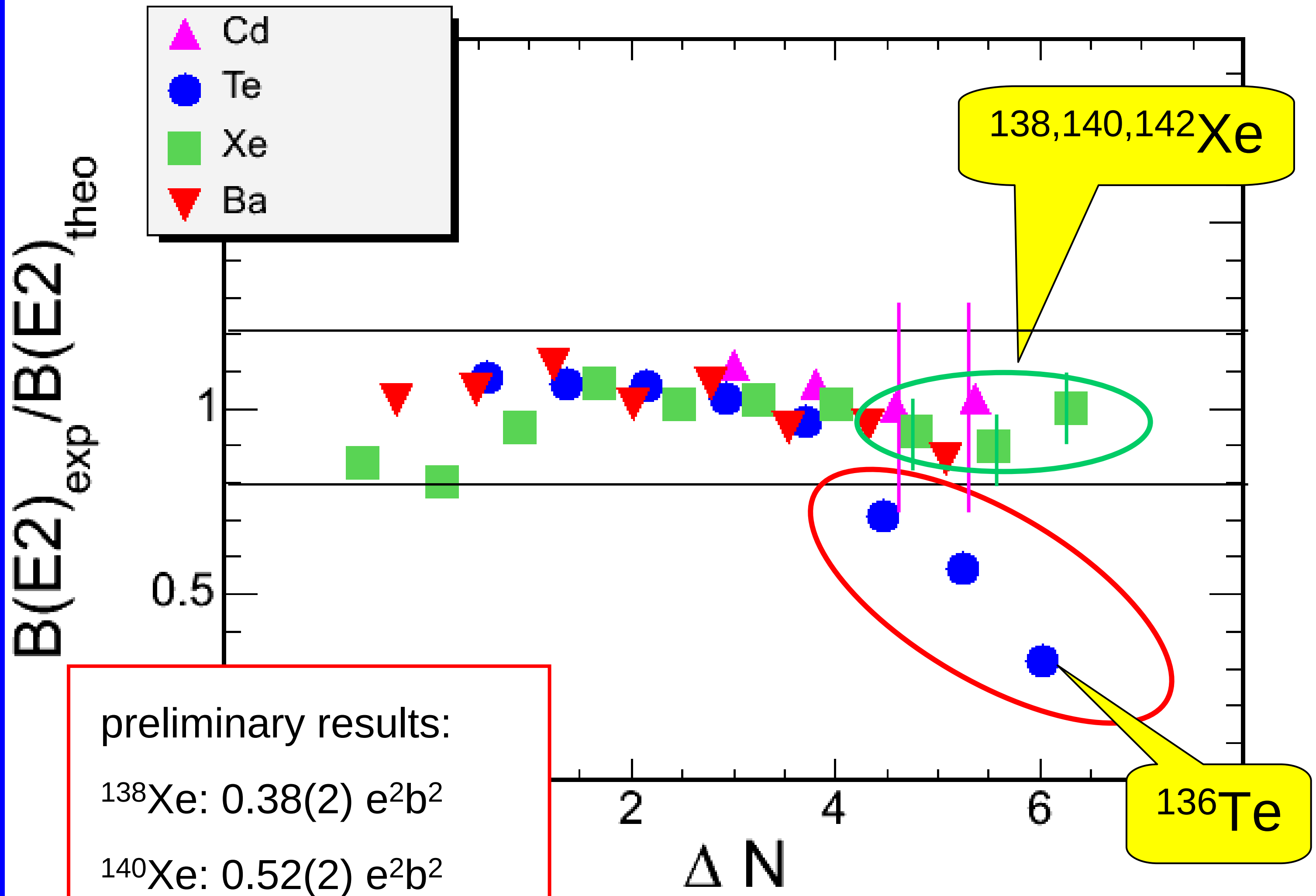


preliminary results:

^{122}Cd: 0.37(11) e^2b^2

^{124}Cd: 0.32(10) e^2b^2

B(E2) values after 2005



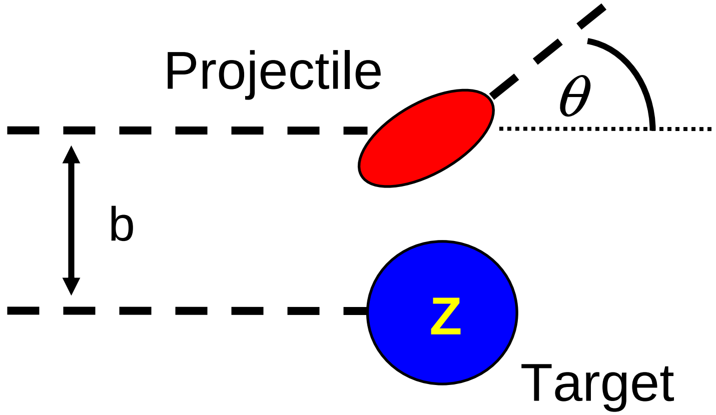
preliminary results:

^{138}Xe: 0.38(2) e^2b^2

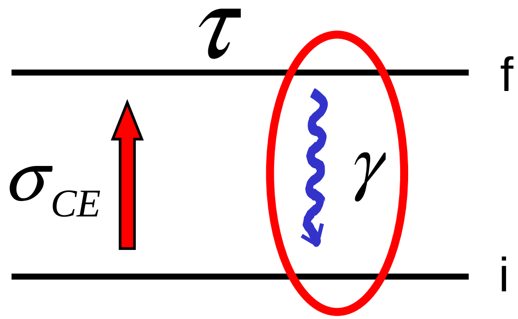
^{140}Xe: 0.52(2) e^2b^2

^{142}Xe: 0.69(2) e^2b^2

Coulomb Excitation



- Beam energy below Coulomb barrier
  ⇨"Safe Coulex"
- β_{proj} ~ 0.06 c
  (⇨Doppler correction)



$$B(E2) = \frac{1}{2J_i + 1}\left|\left\langle J_f \left\| M(E2) \right\| J_i \right\rangle\right|^2$$

$$\frac{\sigma_{CE}(^{126}Cd)}{\sigma_{CE}(^{64}Zn)} = \frac{\varepsilon_\gamma(^{64}Zn)}{\varepsilon_\gamma(^{126}Cd)} \times \frac{W_\gamma(^{64}Zn)}{W_\gamma(^{126}Cd)} \times \frac{N_\gamma(^{126}Cd)}{N_\gamma(^{64}Zn)}$$

REX-ISOLDE & MINIBALL

Motivation

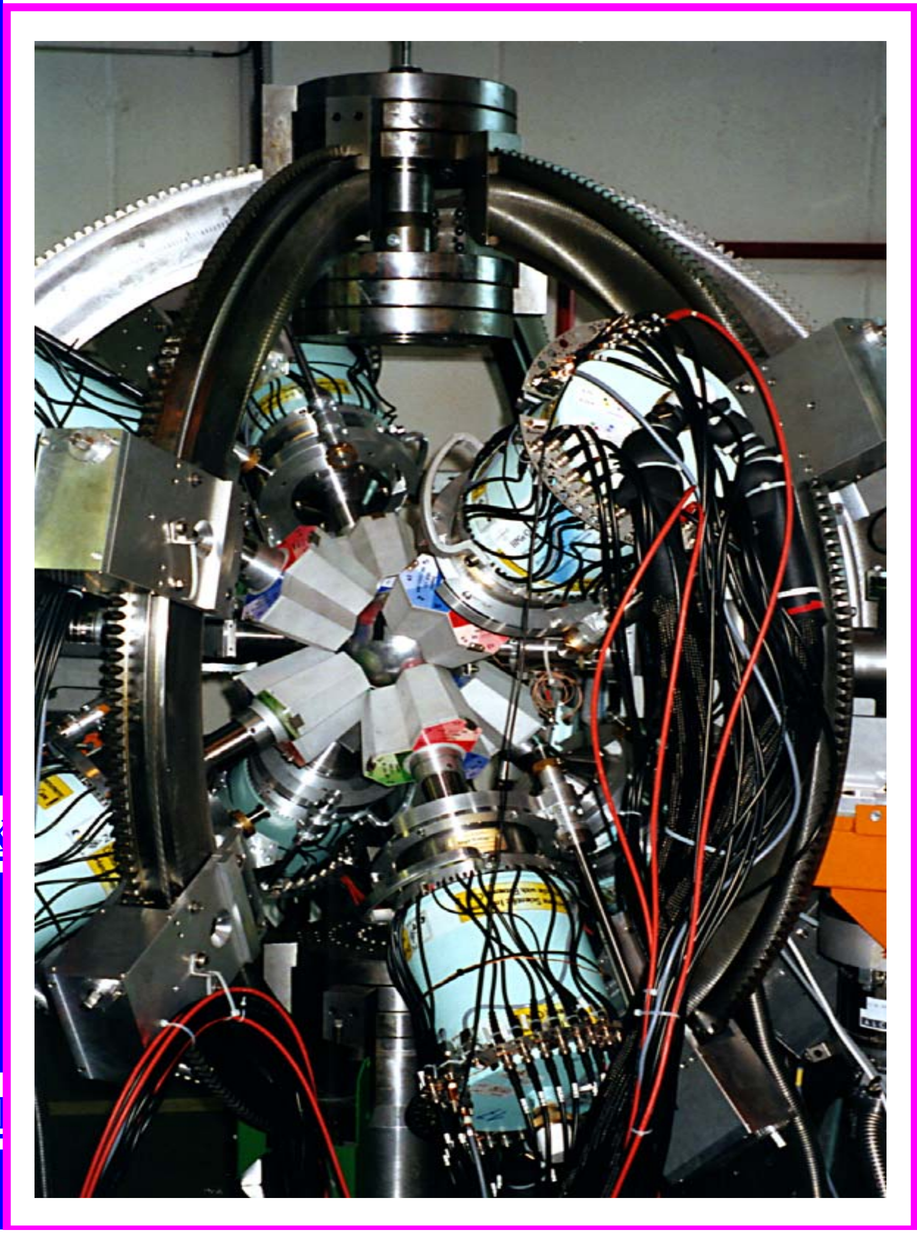
Setup

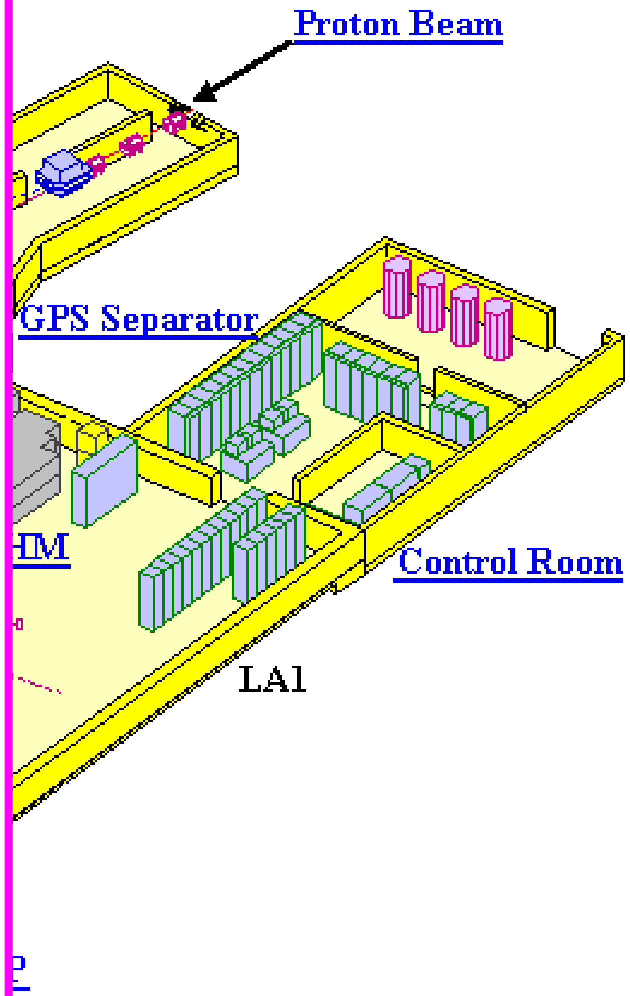
Results

REX

Outlook

MINI





Experimental Setup

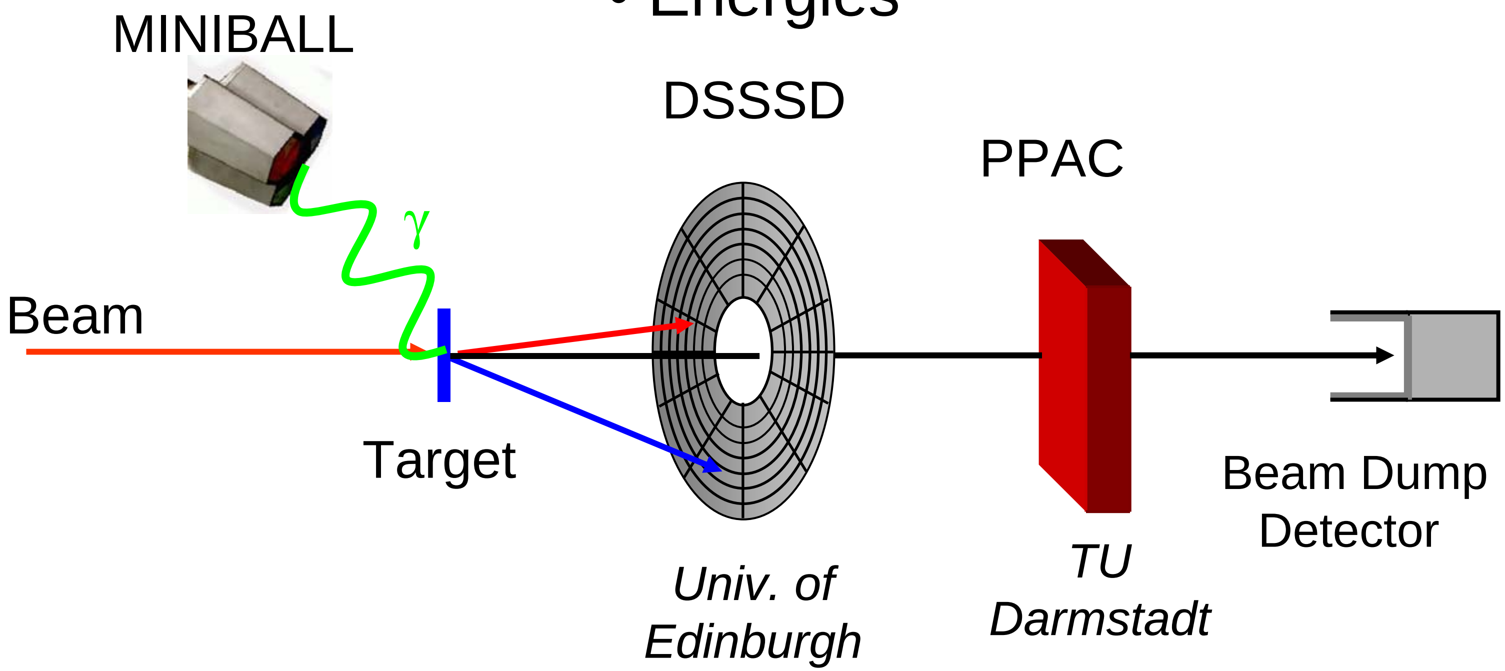
Motivation

Setup

Results

Outlook

Gamma-spectroscopy	Particles	Beam monitor	Beam purity
	• Angles • Energies		



Statistics for Cd isotopes

Isotop	Target [mg/cm^2]	Laser ON [h]	Laser ON/OFF [h]	E from REX [MeV/A]	beam intensity [10^4 pps]	beam purity [%]
^{124}Cd	^{64}Zn [1.8]	15	6.5	2.85	0.9 - 1.5	40 - 85
^{126}Cd	^{64}Zn [1.8]	26	7	2.85	1.4	75

- Protons on converter target (didn't hit the converter!)
- new quartz transfer line ⇨ improved purity!!
- Laser ionization (RILIS)
- varying beam intensities and purities (increasing In)
  ⇨ problems with the ISOLDE target
- tried different settings for line heating and target heating

Results

Outlook

Statistics for Xe isotopes

Isotop	Target [mg/cm^2]	Shield [mg/cm^2]	Running time [h]	E from REX [MeV/A]	beam intensity [10^4 pps]	beam purity [%]
^{144}Xe	^{96}Mo [1.7]	Al foil [4.1]	2.5	2.55	~5.4	~90
^{144}Xe	^{197}Au [1.0]	Al foil [1.5]	1	2.55	~5.4	~90
^{144}Xe	^{96}Mo [1.7]	My foil [1.6]	19	2.7	~5.4	~90

Results

Outlook

- shielding to slow down ejectiles at low θ_{lab}
 ⇨ changed due to low energy from REX
- changed target to check for scattered particles
 ⇨ beam was not focused, might have hit collimator
- changes of IH phase, line & target heating
 ⇨ improved intensity
- 2h on stopper foil ⇨ looking for decay lines of ^{144}Cs

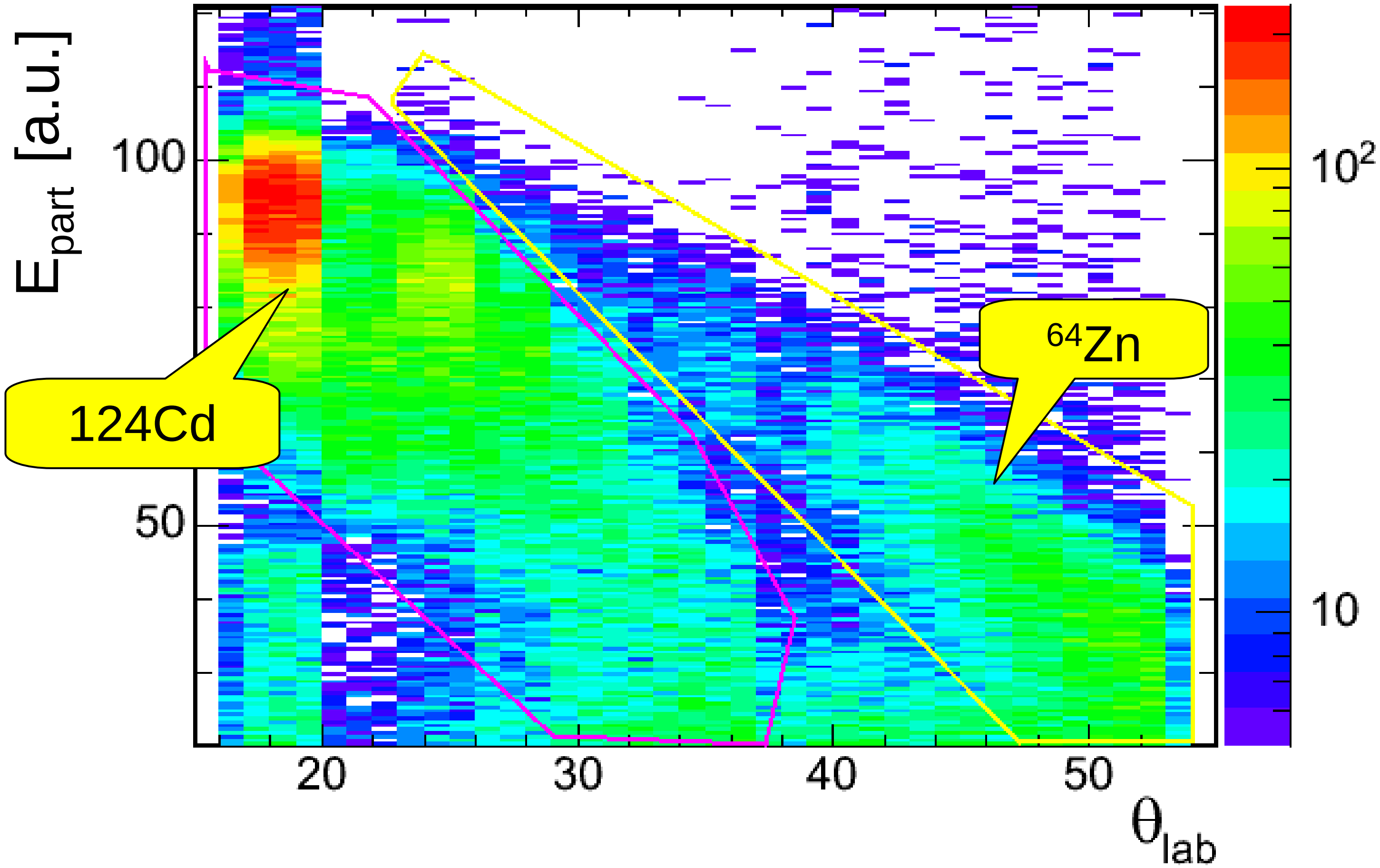
CD energy vs angle

Motivation

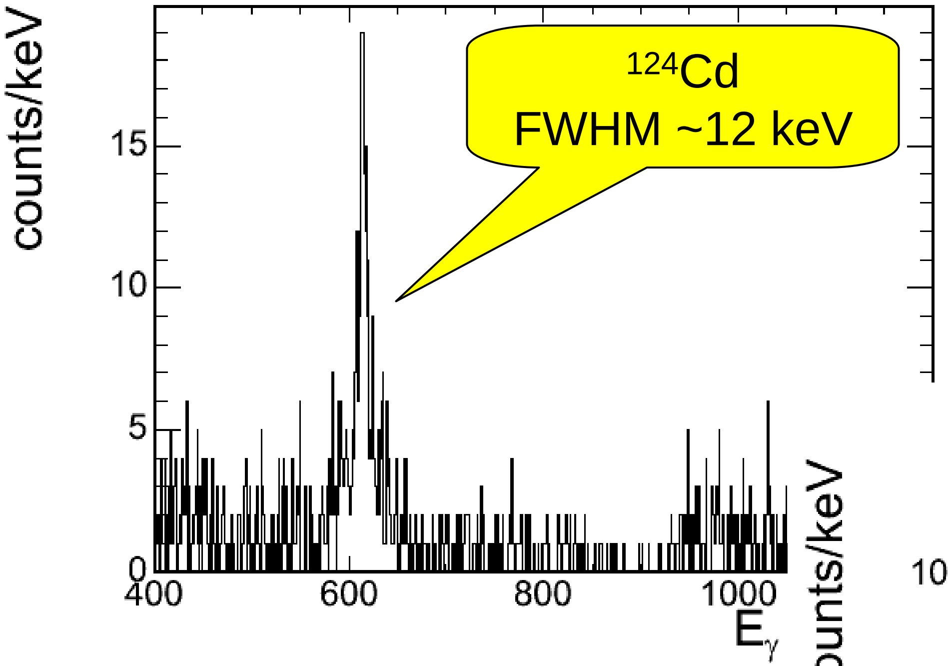
Setup

Results

Outlook



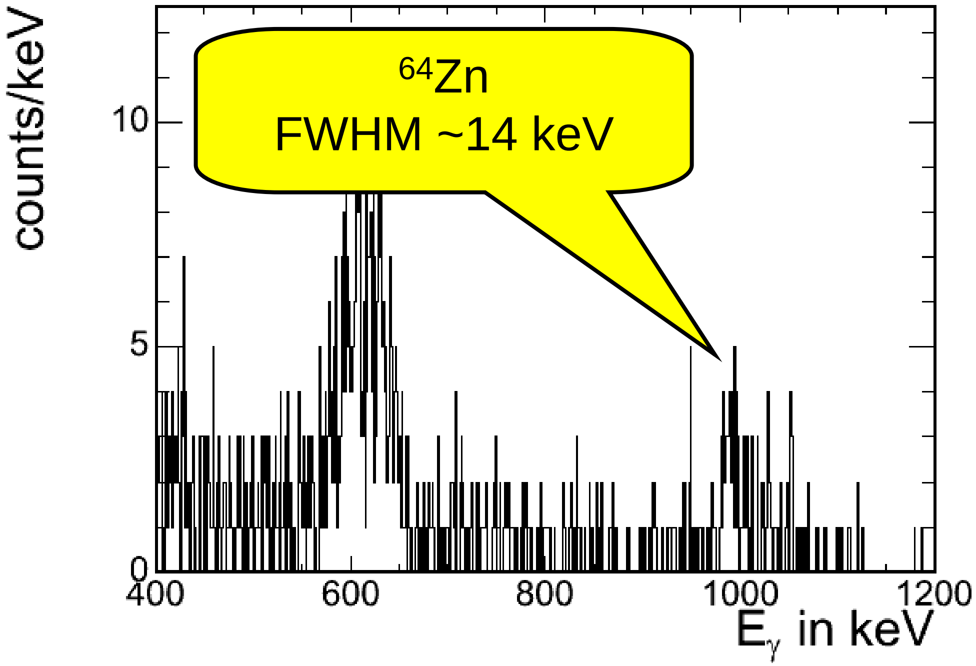
^{124}Cd: $E_\gamma(2_1^+)$ peaks



runnig time: ~15 h (Laser ON)

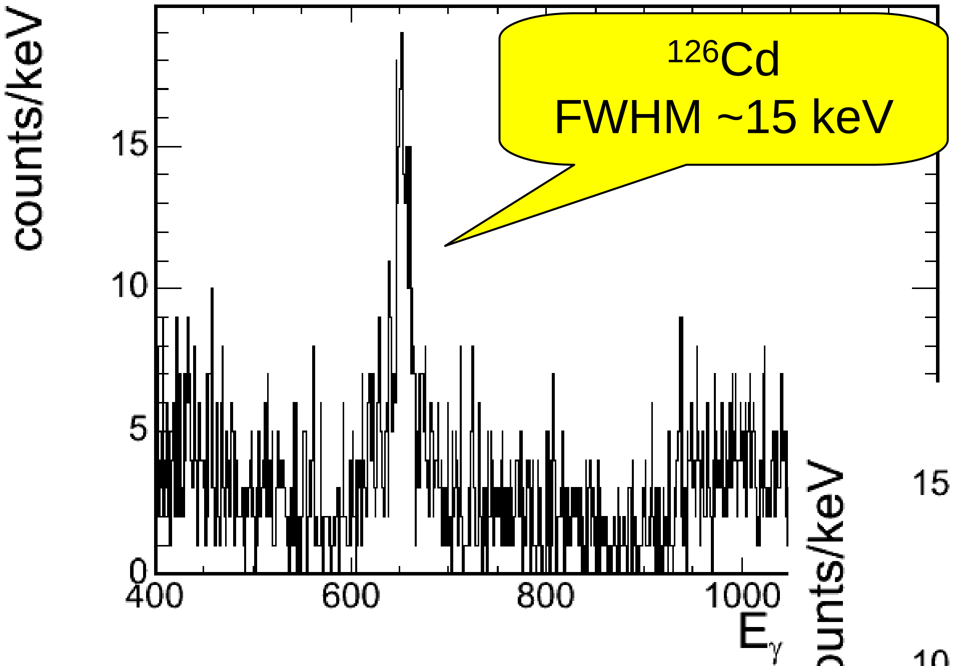
Doppler correction incl. particle reconstruction

Contaminants: ^{124}In, ^{124}Cs



Outlook

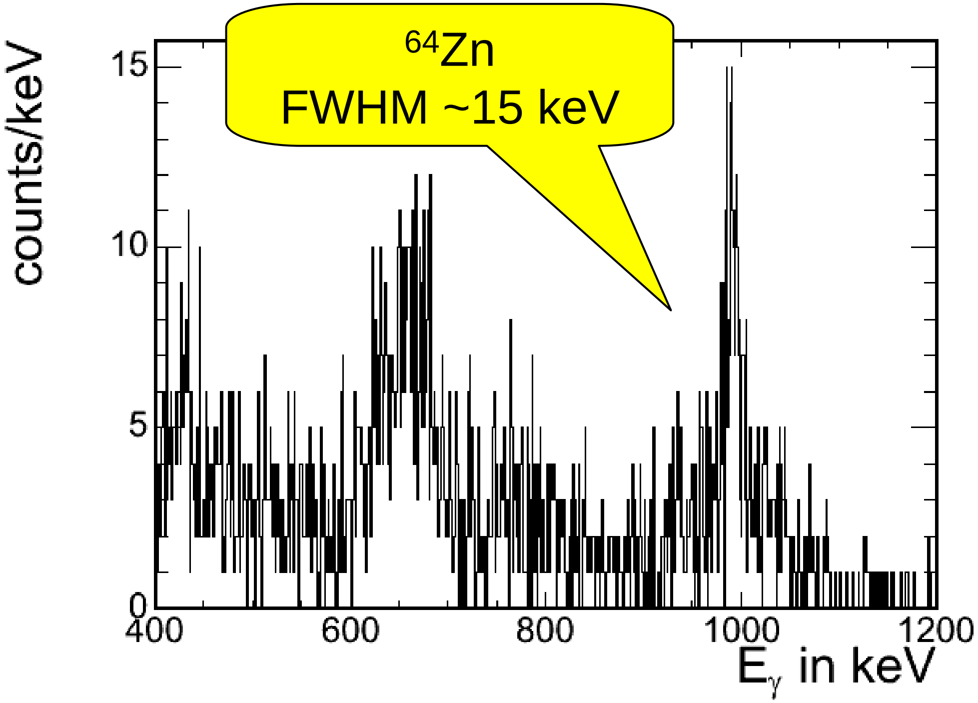
^{126}Cd: $E_\gamma(2_1^+)$ peaks



runnig time: ~26 h (Laser ON)

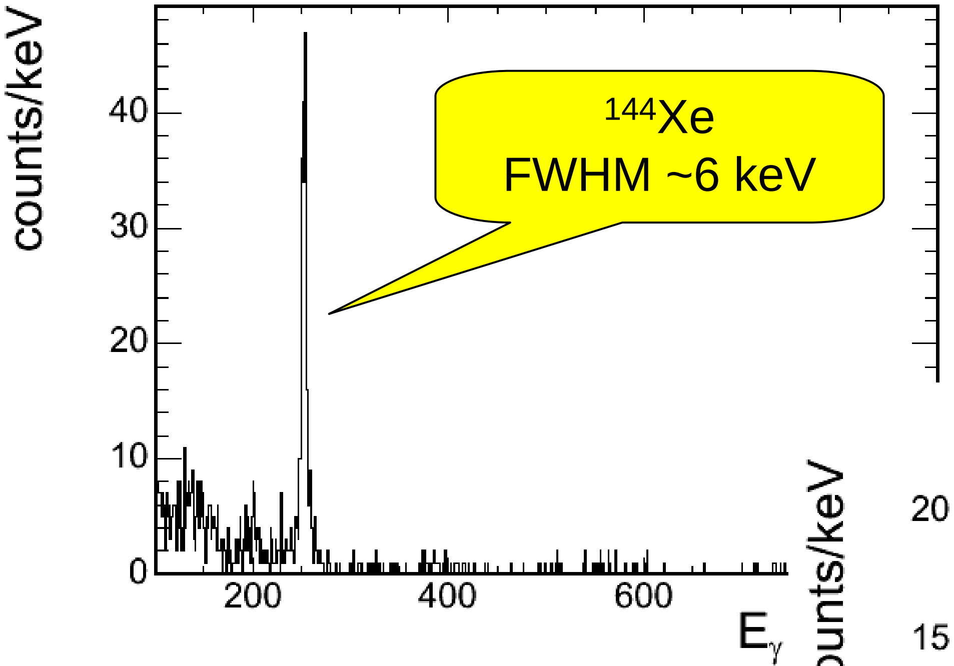
Doppler correction incl. particle reconstruction

Contaminants: ^{126}In, ^{126}Cs



Outlook

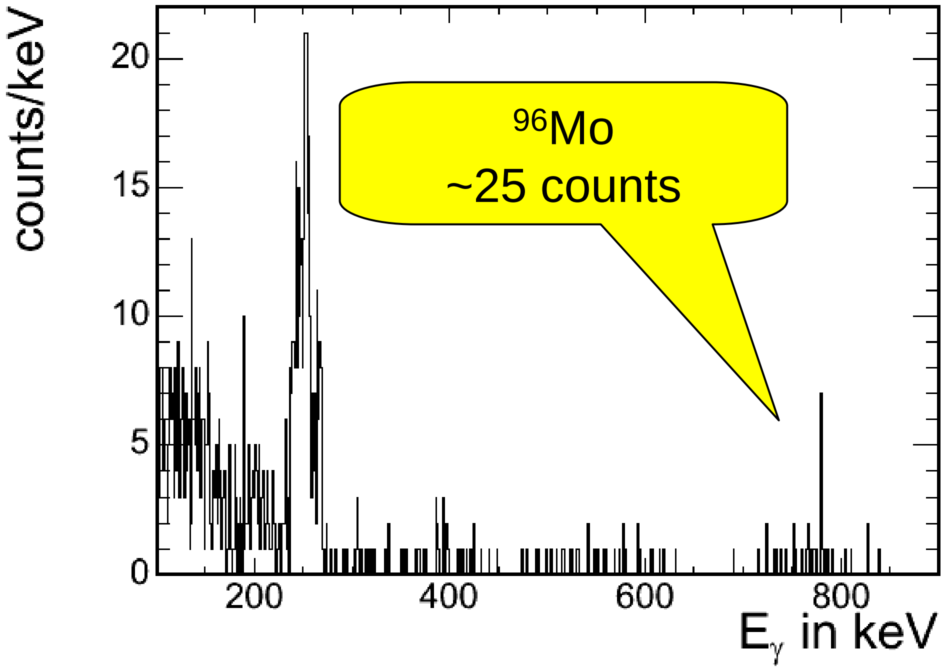
^{144}Xe: $E_{\gamma}(2_1^+)$ peaks



runnig time: ~19 h (2.7 MeV/A)

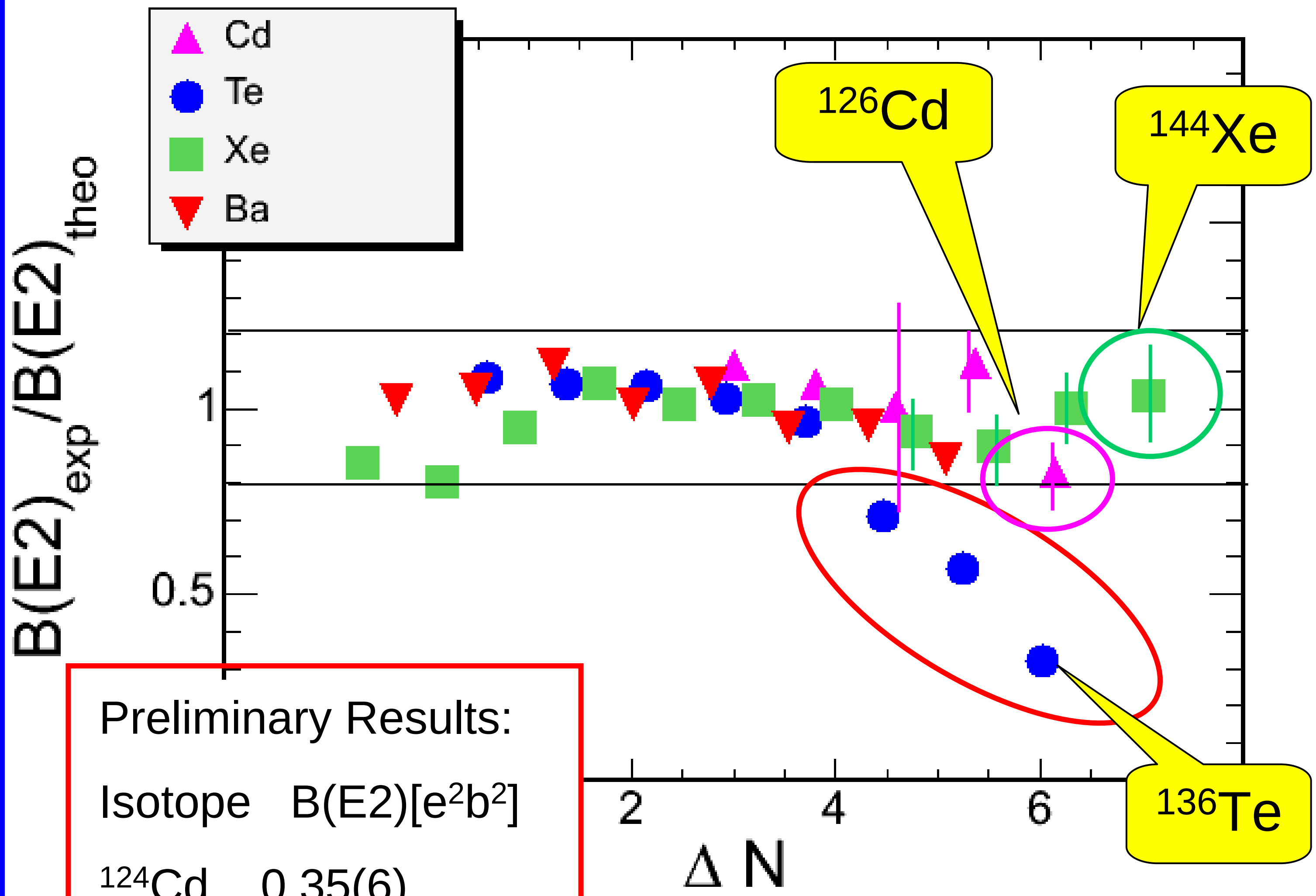
Reconstruction of Recoils
for Doppler correction

⇨ elastic scattered Xe to be
used for normalization



Outlook

B(E2) values after 2006



Preliminary Results:

Isotope	B(E2)[e^2b^2]
^{124}Cd	0.35(6)
^{126}Cd	0.22(3)
^{144}Xe	0.73(18)

Conclusion & Outlook

Results

Outlook

successful measurement of ^{144}Xe & ^{124,126}Cd

⇨ no derivation from systematic

open tasks:

- beam contamination
- CD efficiency
- angular distribution of γ's
- ^{144}Xe: normalize to Rutherford

proposed:

- development of BaF^+ beams for Ba isotopes
- ^{128}Cd is feasible

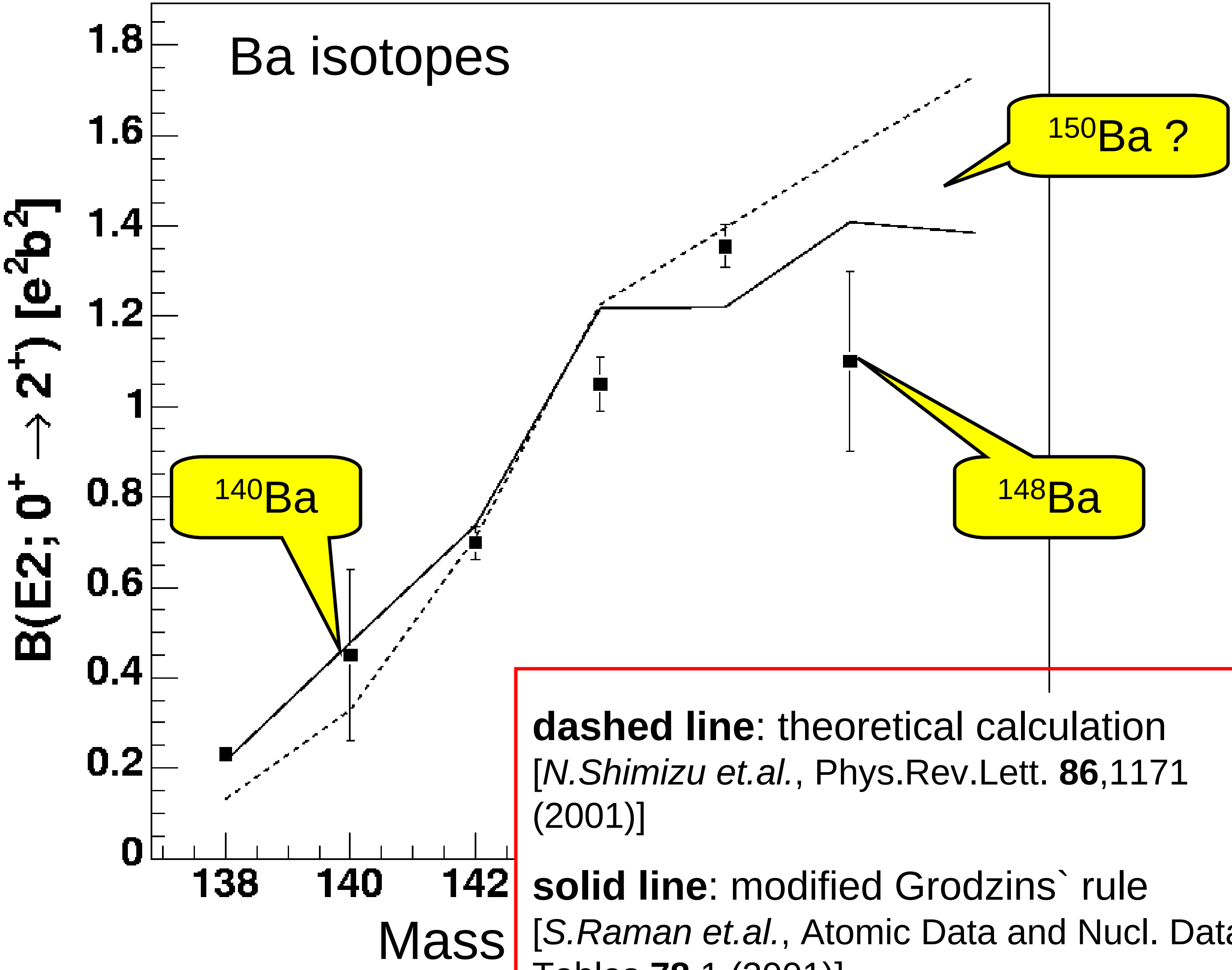
Future Experiments

Motivation

Setup

Results

Outlook



dashed line: theoretical calculation [*N.Shimizu et.al.*, Phys.Rev.Lett. **86**,1171 (2001)]

solid line: modified Grodzins` rule [*S.Raman et.al.*, Atomic Data and Nucl. Data Tables **78**,1 (2001)]

Helping hands and heads...

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and the **REX-MINIBALL** collaboration

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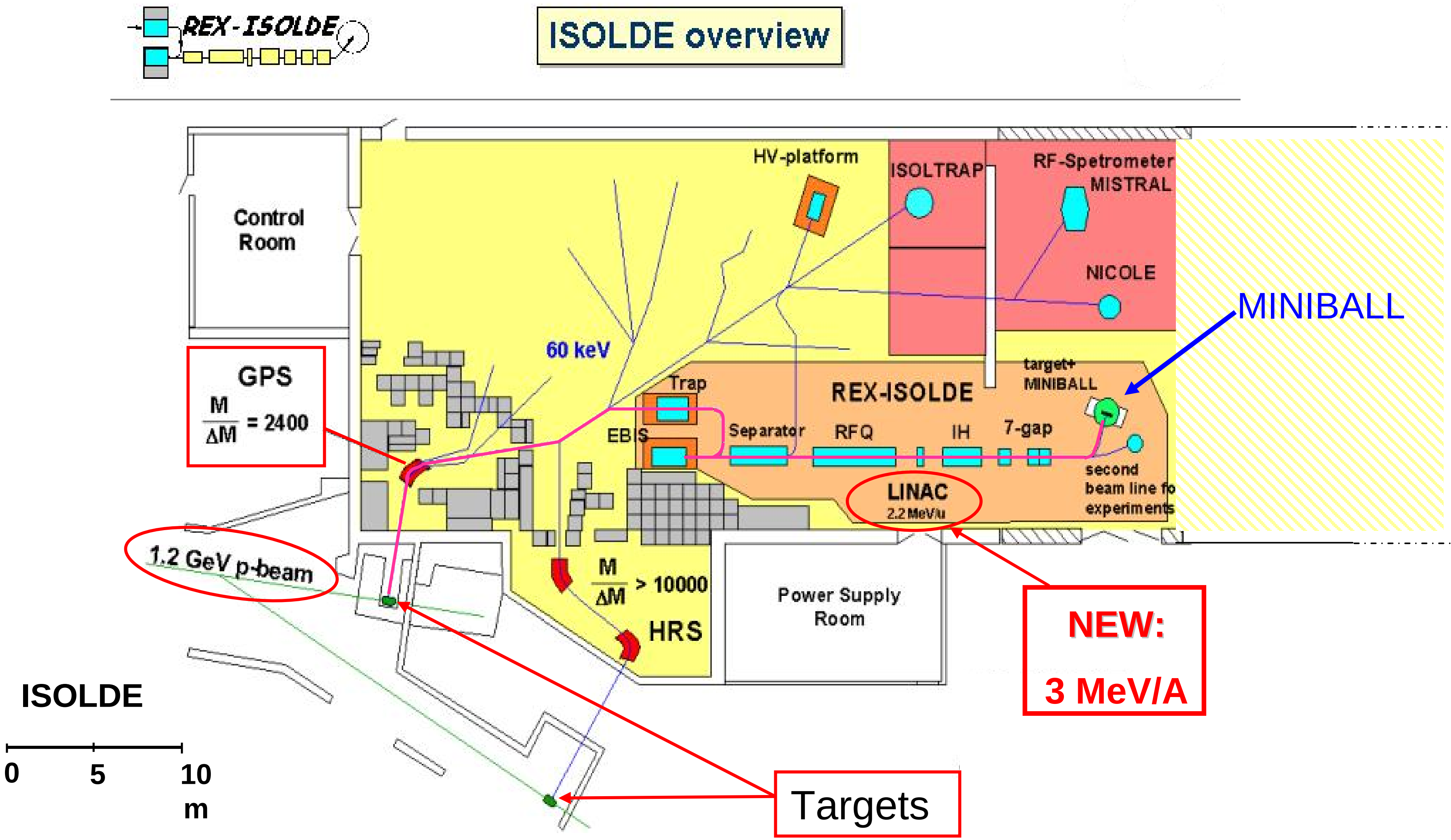
[4]IPN Orsay, [5]KU Leuven, [6]CERN,
[7]Lund University, [8]University of Edinburgh,

Thank you for your attention!

REX-ISOLDE @ CERN



Thomas Behrens

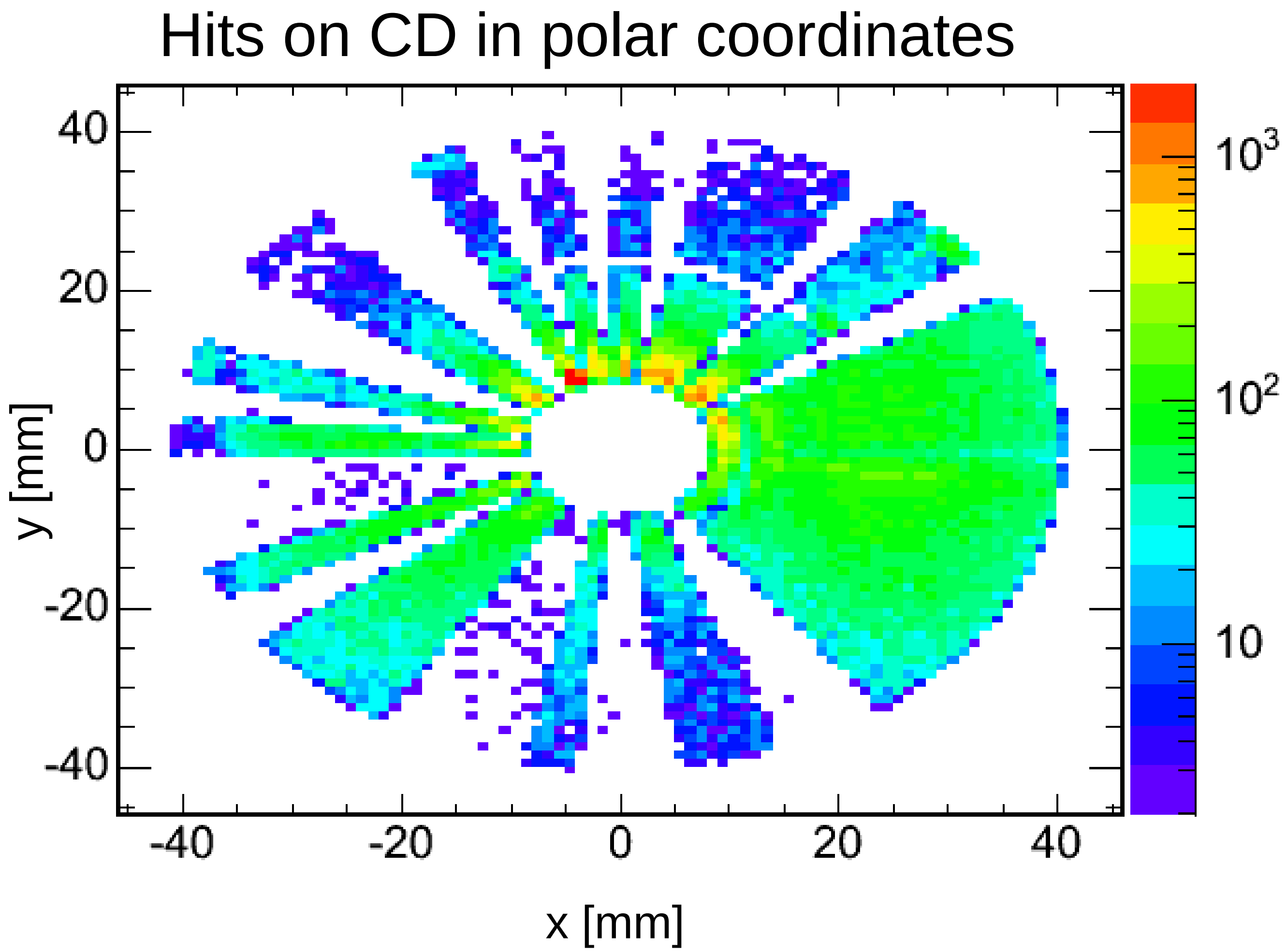
IS411 – Intensity on CD

Motivation

Setup

Results

Outlook



^{96}Mo(^{144}Xe,^{144}Xe)^{96}Mo:

Beam shift: ~2 mm

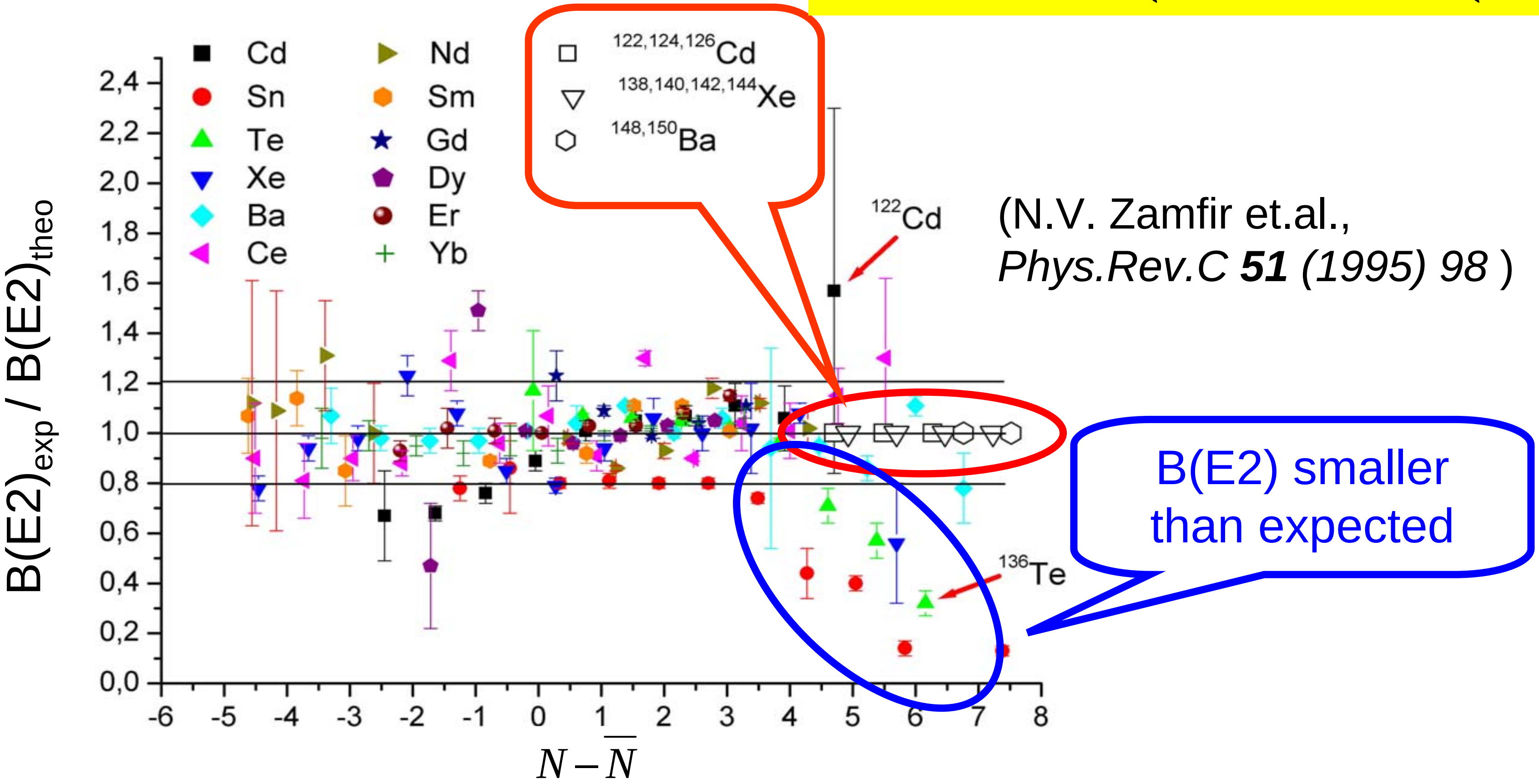
Physical Motivation

Empirical relation between E(2$^+$) and B(E2) [Grodzins' Rule]

Modified version

(Habs, Krücken, *INTC-P-156 (2002)*)

$$E(2_1^+)*B(E2)\uparrow = 2.57*Z^2A^{-2/3}(1.288-0.088(N-\overline{N})$$



(N.V. Zamfir et.al., *Phys.Rev.C* ***51*** *(1995) 98*)