Determination of nuclear static moments using post-accelerated exotic beams:

Coulomb excitation of neutron-rich ^{44}Ar at SPIRAL

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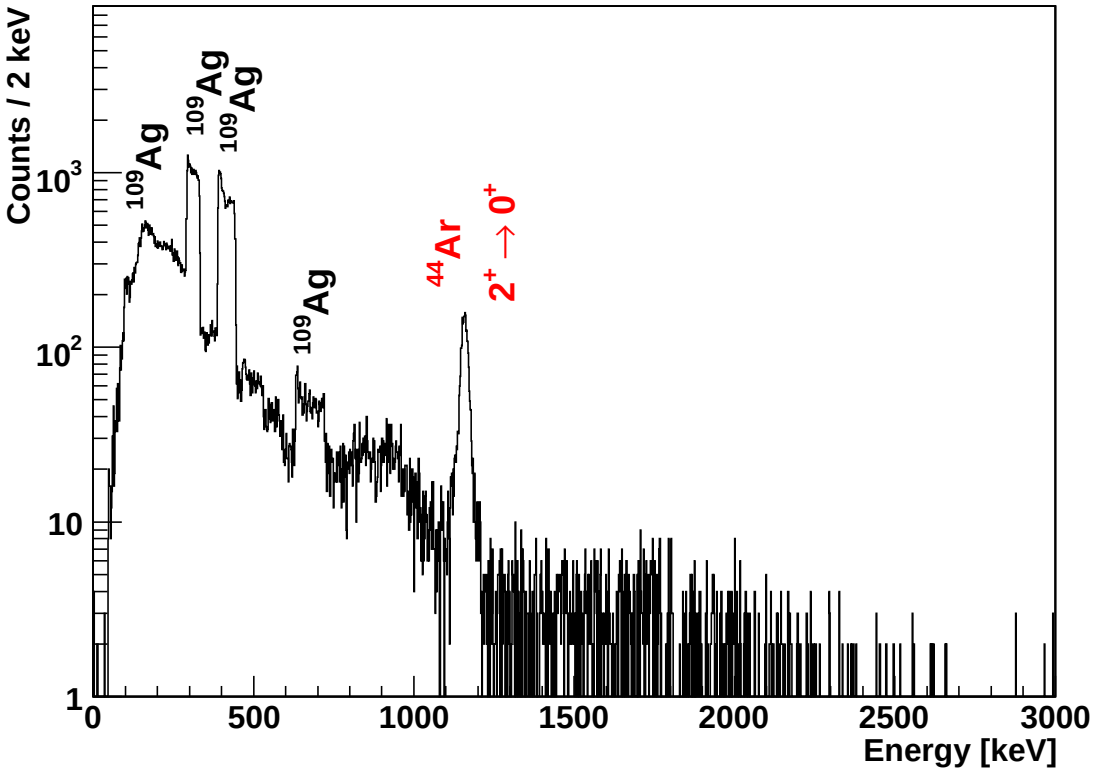
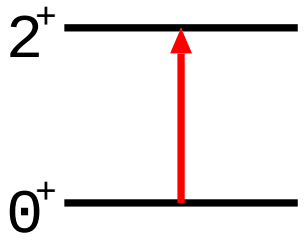
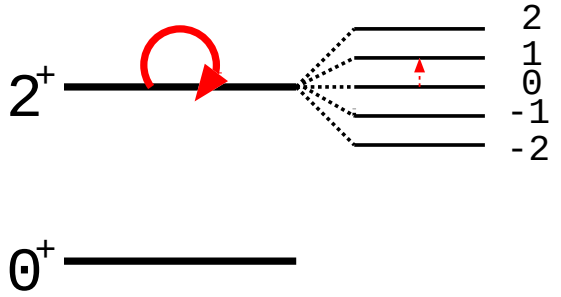
B(E2)'s in radioactive nuclei measured with Coulex

- usually only $2^+ \rightarrow 0^+$ transition visible
- normalisation to target excitation needed





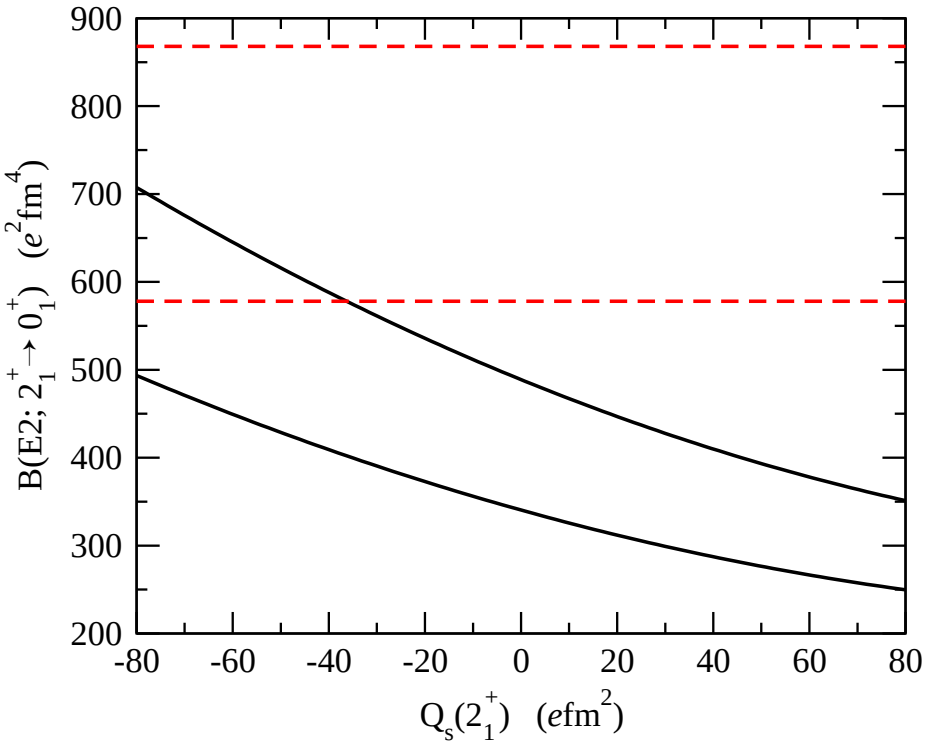
$\langle 2^+ || E2 || 0^+ \rangle^2$
$\sim$ B(E2; $2^+ \rightarrow 0^+$)



$\langle 2^+ || E2 || 2^+ \rangle \sim Q_0$

- Coulex cross-section depends both on the B(E2;$2_1^+ \rightarrow 0^+$) and the quadrupole moment!

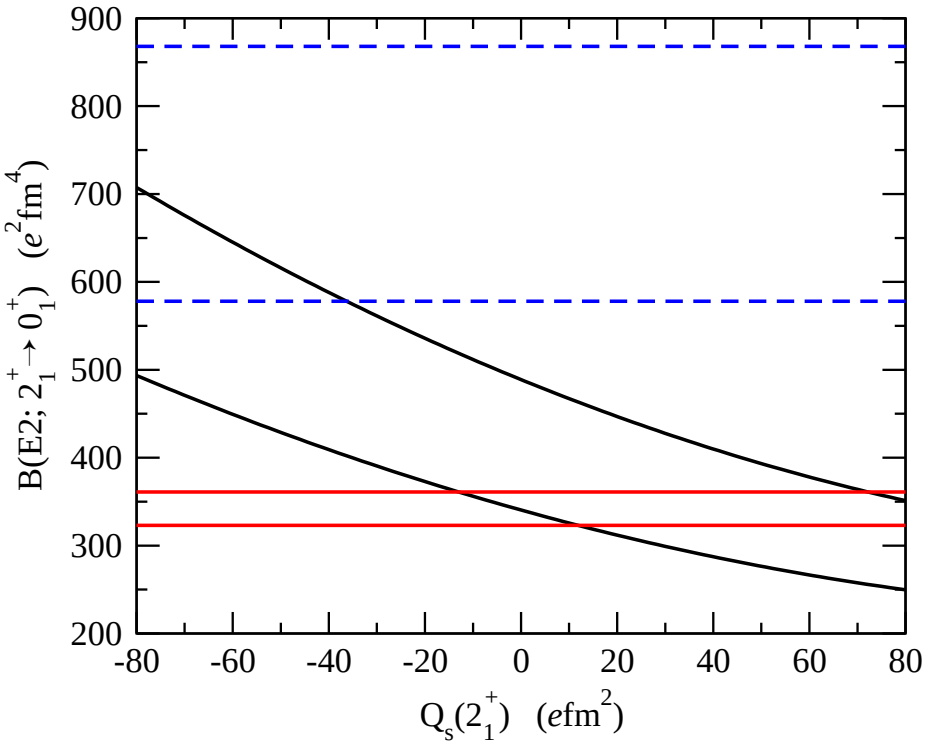
Measurement of the quadrupole moment in ^{70}Se



A.M. Hurst *et al.*,
Phys. Rev. Lett. 98, 072501 (2007)

- Measurement of the Coulex yield
- Lifetime known from an earlier RDM experiment
- Negative quadrupole moment deduced

Measurement of the quadrupole moment in ^{70}Se

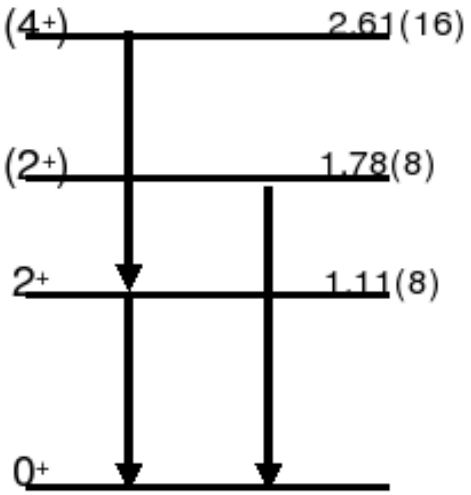


J. Ljungvall *et al.*,
Phys. Rev. Lett. 100, 102502 (2008)

- New, more precise lifetime measurement
- Positive quadrupole moment favoured

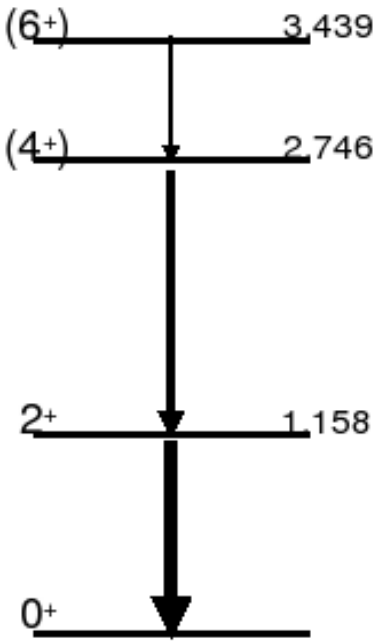
Spectroscopic data on ^{44}Ar

double fragmentation



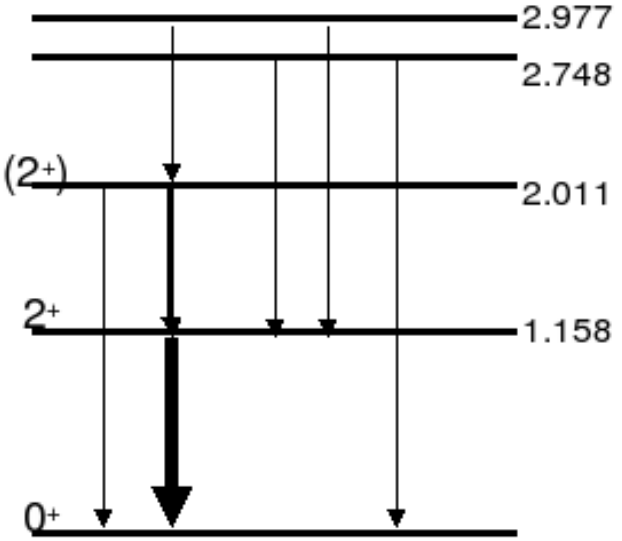
S. Wan et al.,
EPJA 6, 167 (1999)

deep inelastic



B. Fornal et al.,
EPJA 7, 147 (2000)

beta decay

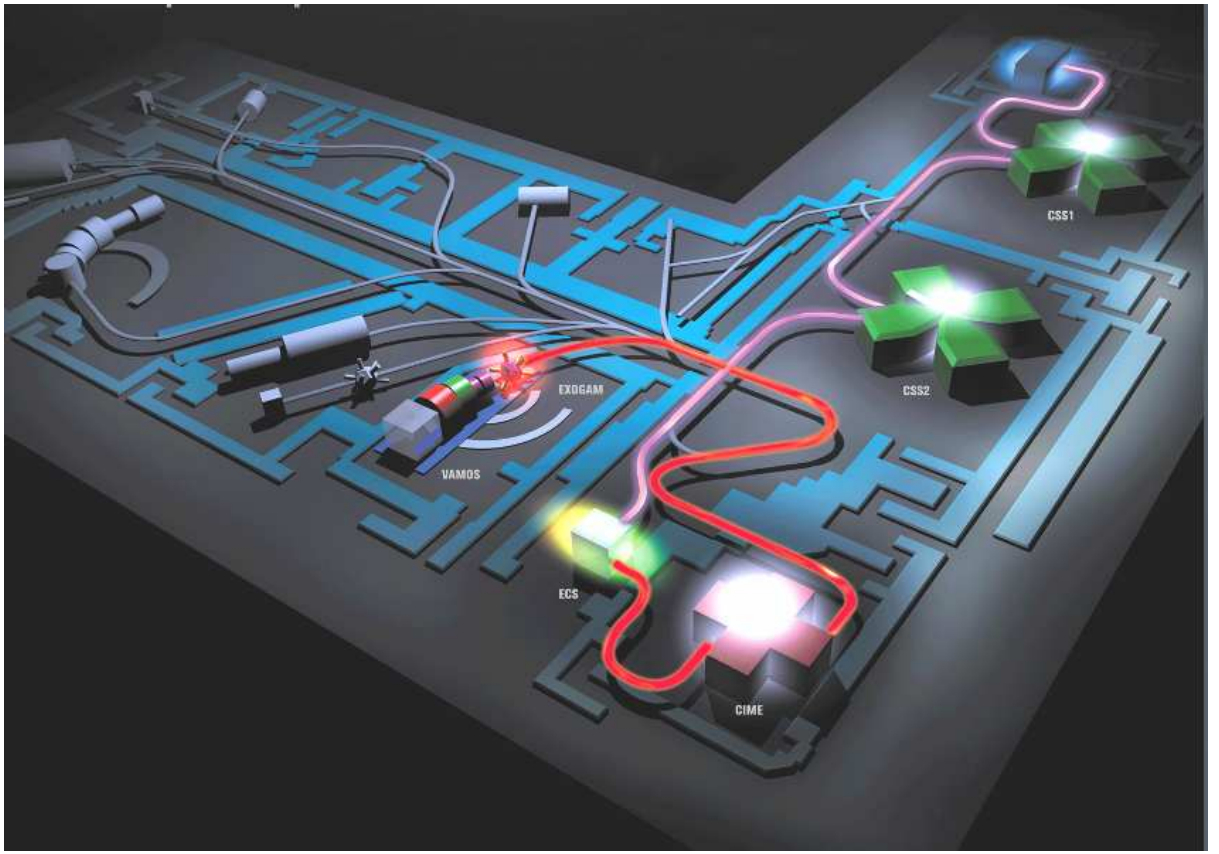


J. Mrazek et al.,
Nucl. Phys. A 734, E65 (2004)

- $B(E2;2^+ \rightarrow 0^+) = 345\ (41)\ e^2fm^4$

intermediate energy Coulex, Scheit et al., Phys. Rev. Lett. 77, 3967 (1996)

Beams and targets

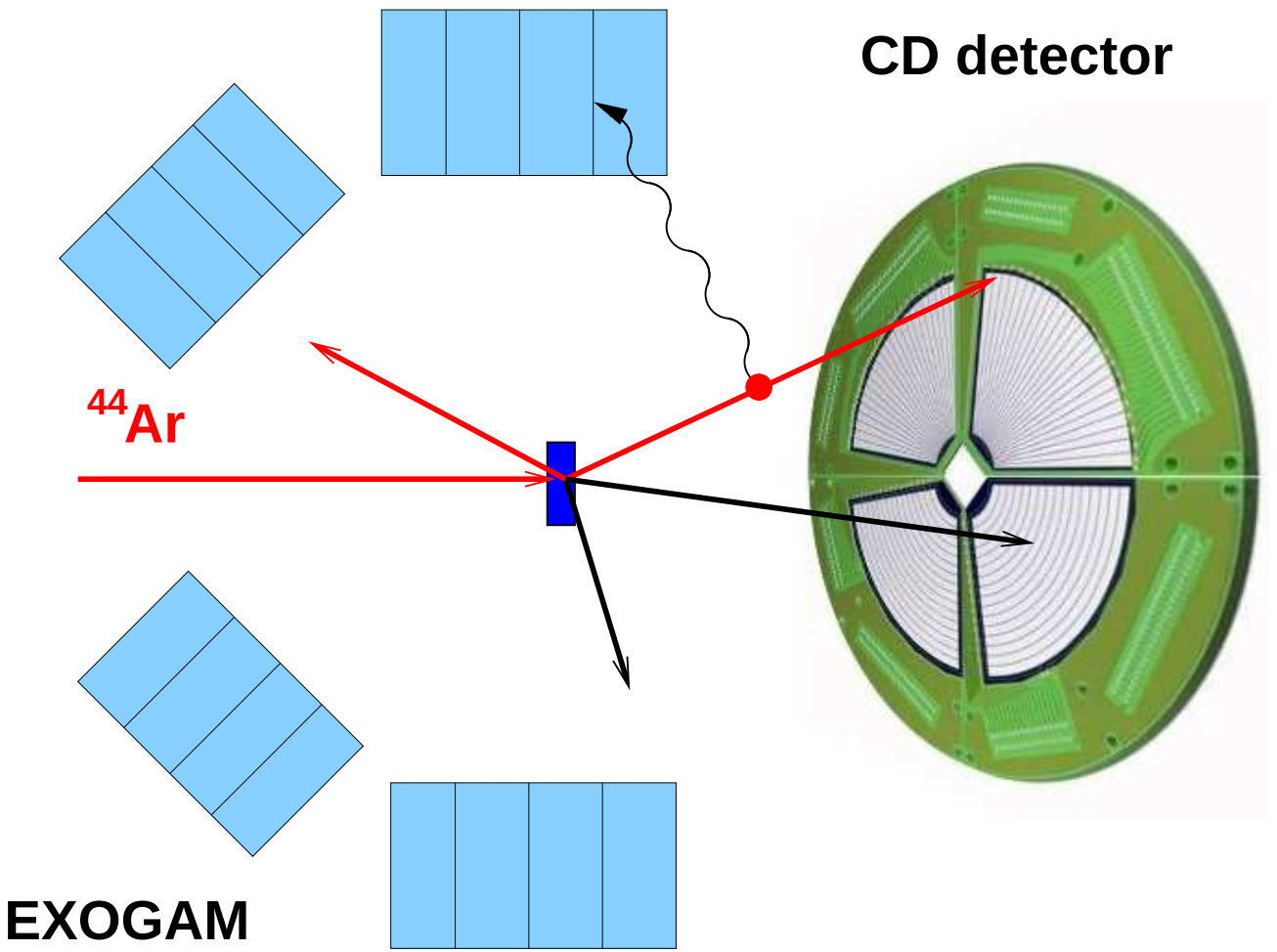


- Primary beam: ^{48}Ca
60 MeV/A,
3.5 μA (nearly 600W)

- Secondary beam: ^{44}Ar

Beam energy	Beam intensity	Target	Target thickness	Duration
3.68 MeV/A	$2.4 \cdot 10^5$ pps	^{208}Pb	1 mg/cm^2	13 UT
2.68 MeV/A	$2.0 \cdot 10^5$ pps	^{109}Ag	0.9 mg/cm^2	8 UT

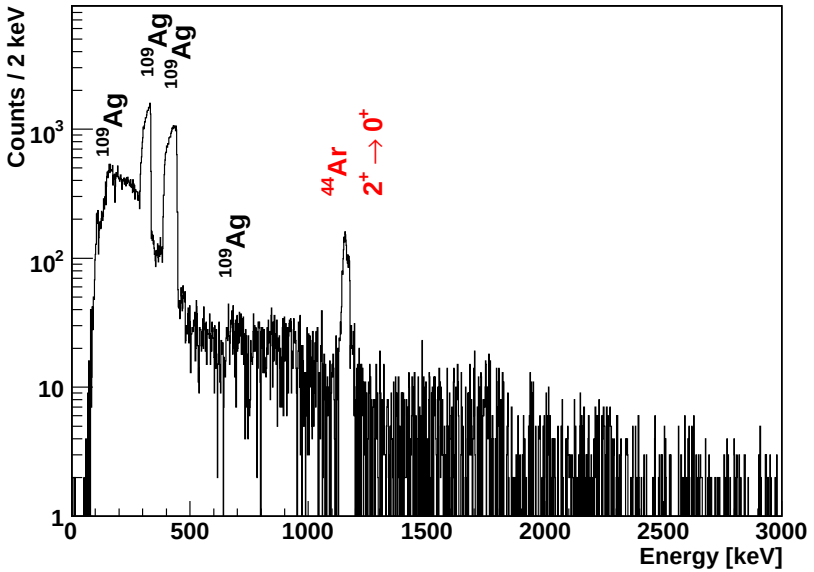
Experimental setup



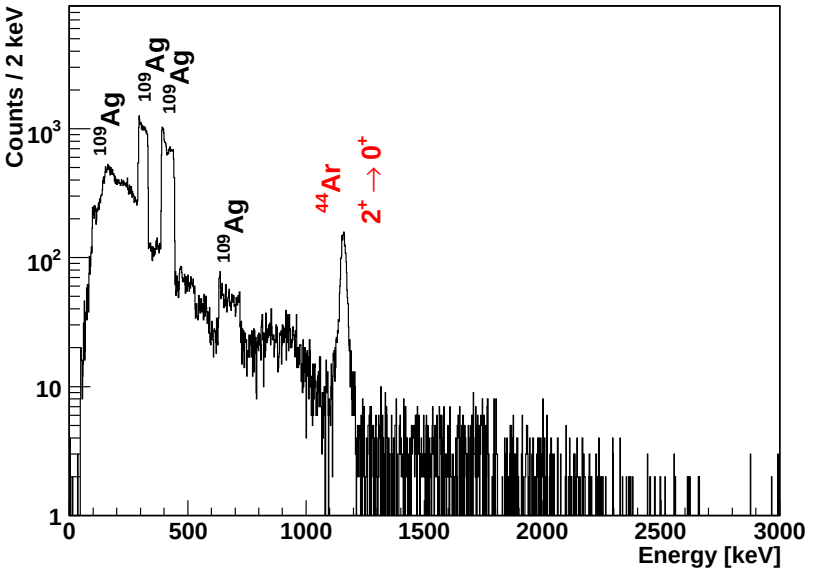
- 10 segmented clovers in EXOGAM
- highly segmented particle detector: 96 strips, 16 rings

Results from the ^{109}Ag target

^{109}Ag target, projectile detected



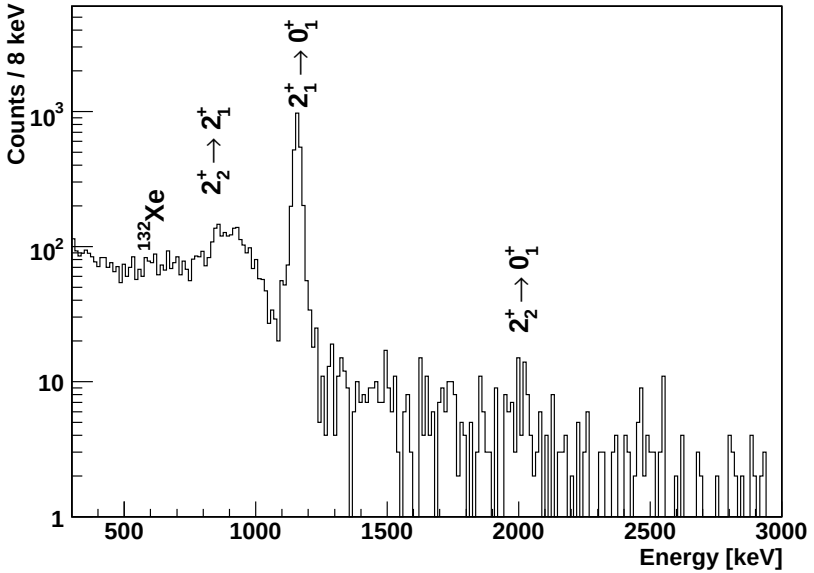
recoil detected



- statistics sufficient to subdivide the data into several angular ranges:
  - $\sim$4300 counts in the $2_1^+ \rightarrow 0^+$ line (1158 keV)
  - $\sim$50 counts in the $2_2^+ \rightarrow 2_1^+$ line (852 keV)
  - for normalization: more than 50 000 counts in 310 keV and 415 keV lines in ^{109}Ag

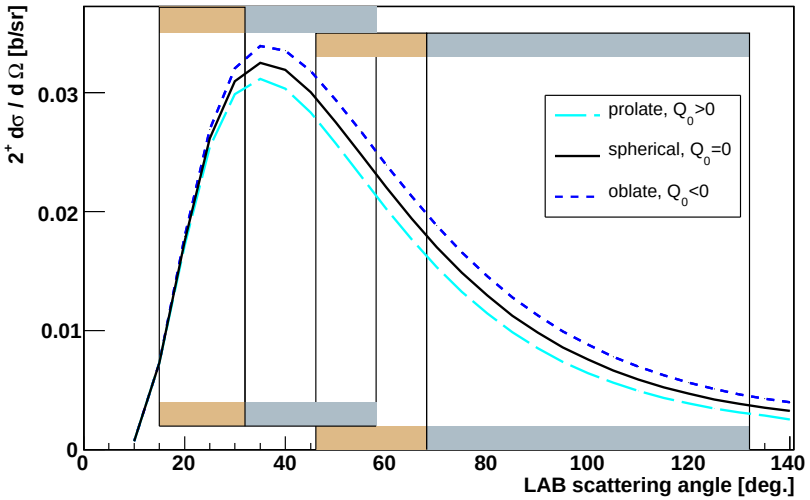
Limitations of GOSIA2

^{208}Pb target, recoil detected



- data collected on two different targets
- at least four matrix elements needed to describe the excitation process: how to calculate their uncertainties?

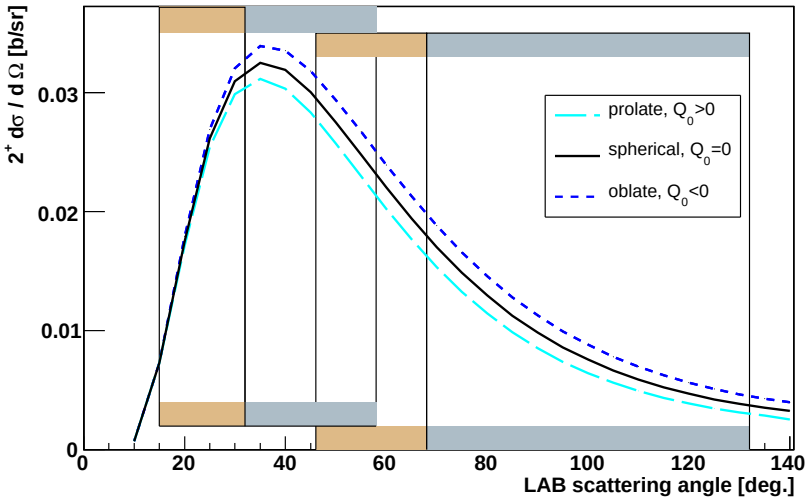
Extraction of E2 matrix elements



- lowest angular range – influence of quadrupole moment negligible $\longrightarrow$ determination of B(E2;$2_1^+ \longrightarrow 0^+$)

- information from other bins + data collected on Pb target $\longrightarrow$ determination of quadrupole moment of the 2_1^+ state and other B(E2)'s using standard GOSIA code
- relative normalization of the bins based on target excitation

Extraction of E2 matrix elements

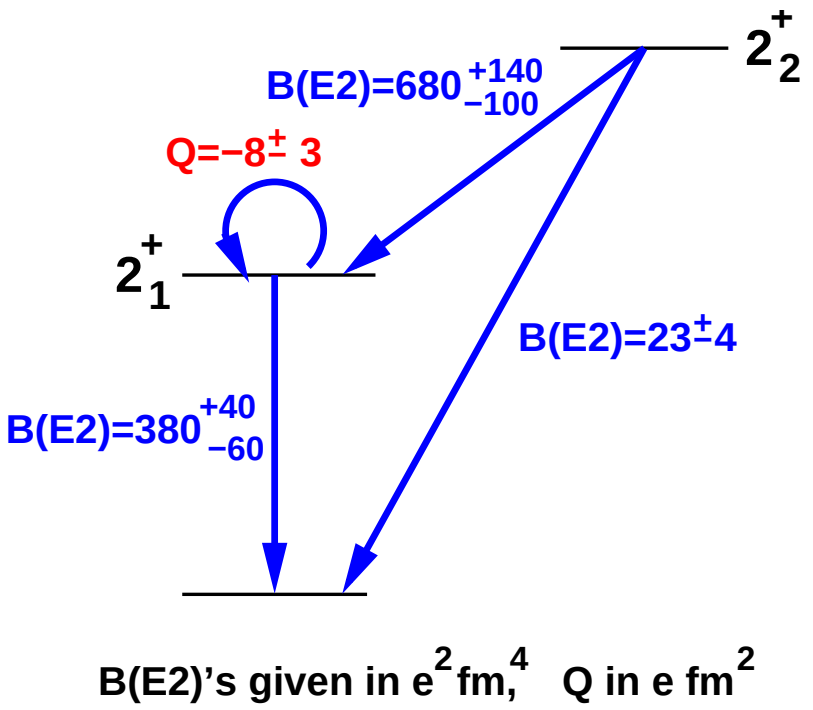


- several methods of data subdivision tested (3, 4, 6, 7, 8 bins)

- compromise between level of statistics in an individual experiment and number of γ-ray yields corresponding to different ranges of the scattering angle
- obtained values of the quadrupole moment consistent
- accuracy varies from 35 % to 70 %

Results

- B(E2; $2_1^+ \rightarrow 0^+$) in agreement with the result from intermediate energy Coulex (345 (41) e^2fm^4)
- quadrupole moment of the 2_1^+ state measured with precision of 35%
- B(E2)'s for transitions deexciting 2_2^+ state measured for the first time



- β deformation: nearly 0.3
- diagonal matrix element – 50% of the rotational value $\rightarrow$ triaxiality ?

- test case for JACOB code - implementation of genetic algorithm to Coulex data analysis (D. Pietak, presented at EURONS Town Meeting in Helsinki)