DEPARTMENT OF PHYSICS
AND ASTRONOMY
FACULTY OF SCIENCE
AARHUS UNIVERSITY

ISOLDE
CERN

Coulomb excitations of ^{84}Kr

-figuring out the shape of the nucleus

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REX-ISOLDE

Supervisor: Jarno Van de Walle
Miniball setup, REX-ISOLDE

^{84}Kr...

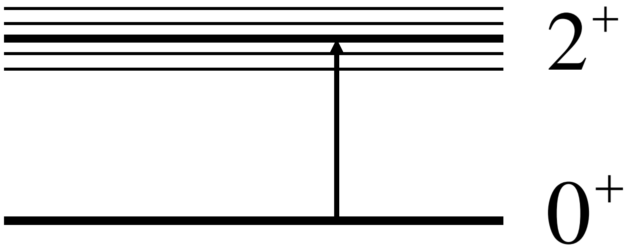
... a sphere, or not a sphere?

that is the question

The answer lies in the quadrupole moment

$$Q \propto \langle J | E2 | J \rangle$$

^{84}Kr...



^{84}Kr...

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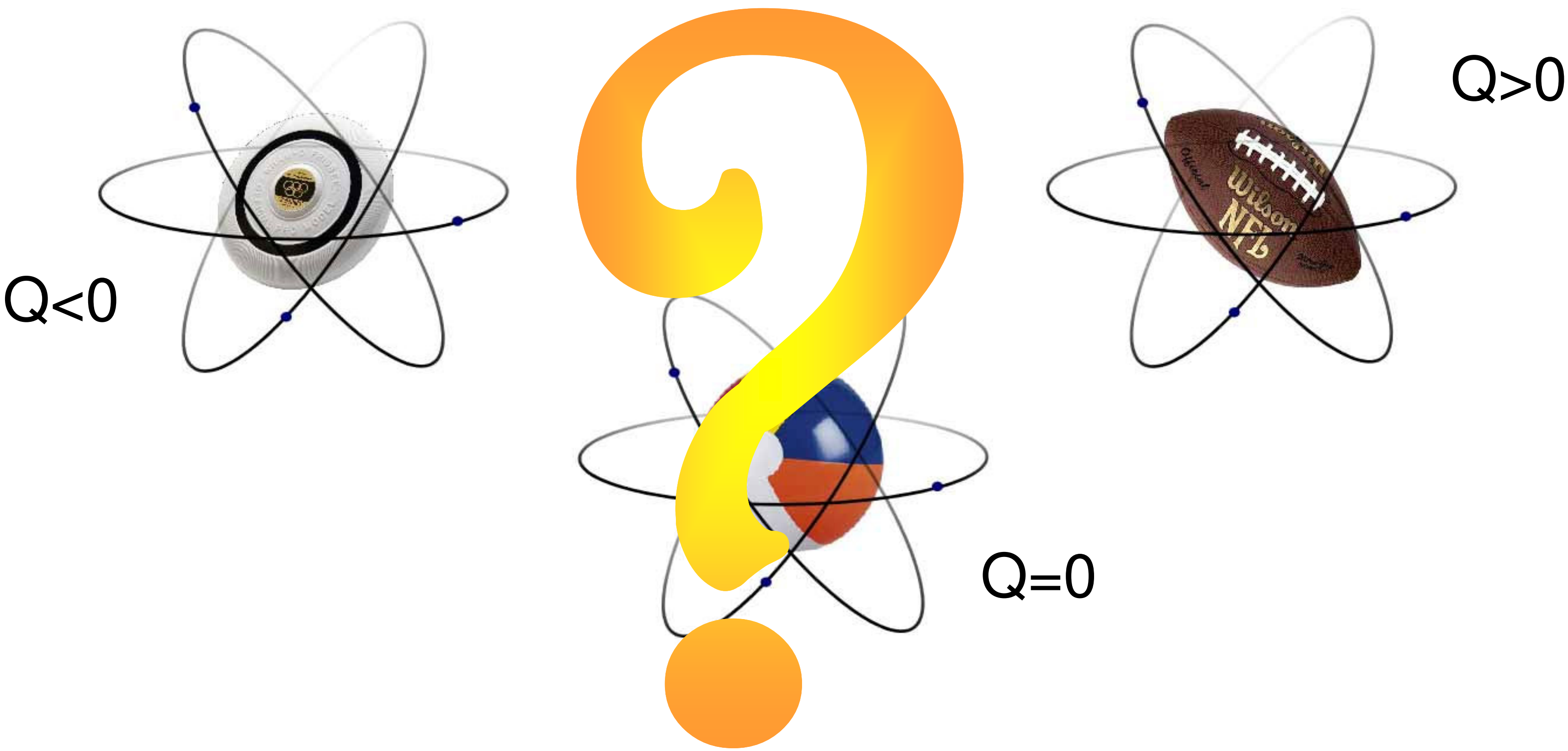
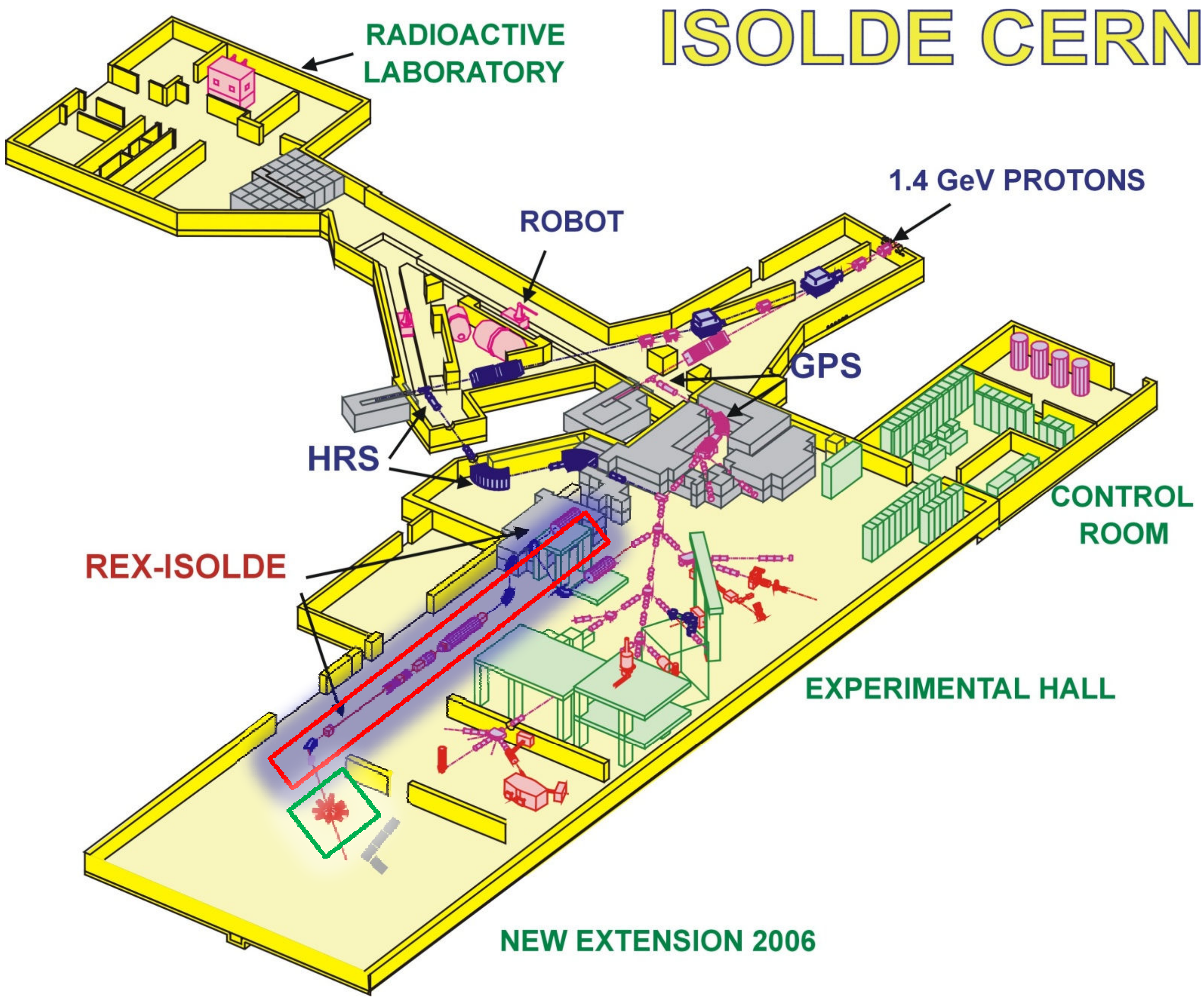
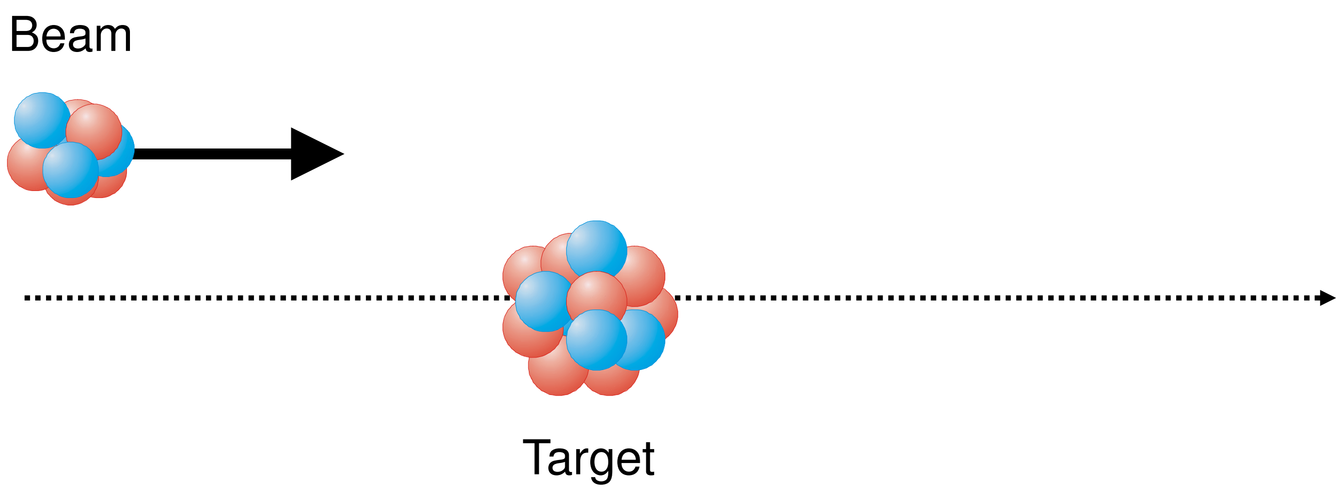
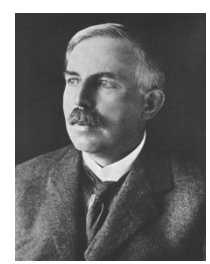



ISOLDE CERN
RADIOACTIVE LABORATORY
ROBOT
1.4 GeV PROTONS
GPS
HRS
REX-ISOLDE
CONTROL ROOM
EXPERIMENTAL HALL
NEW EXTENSION 2006

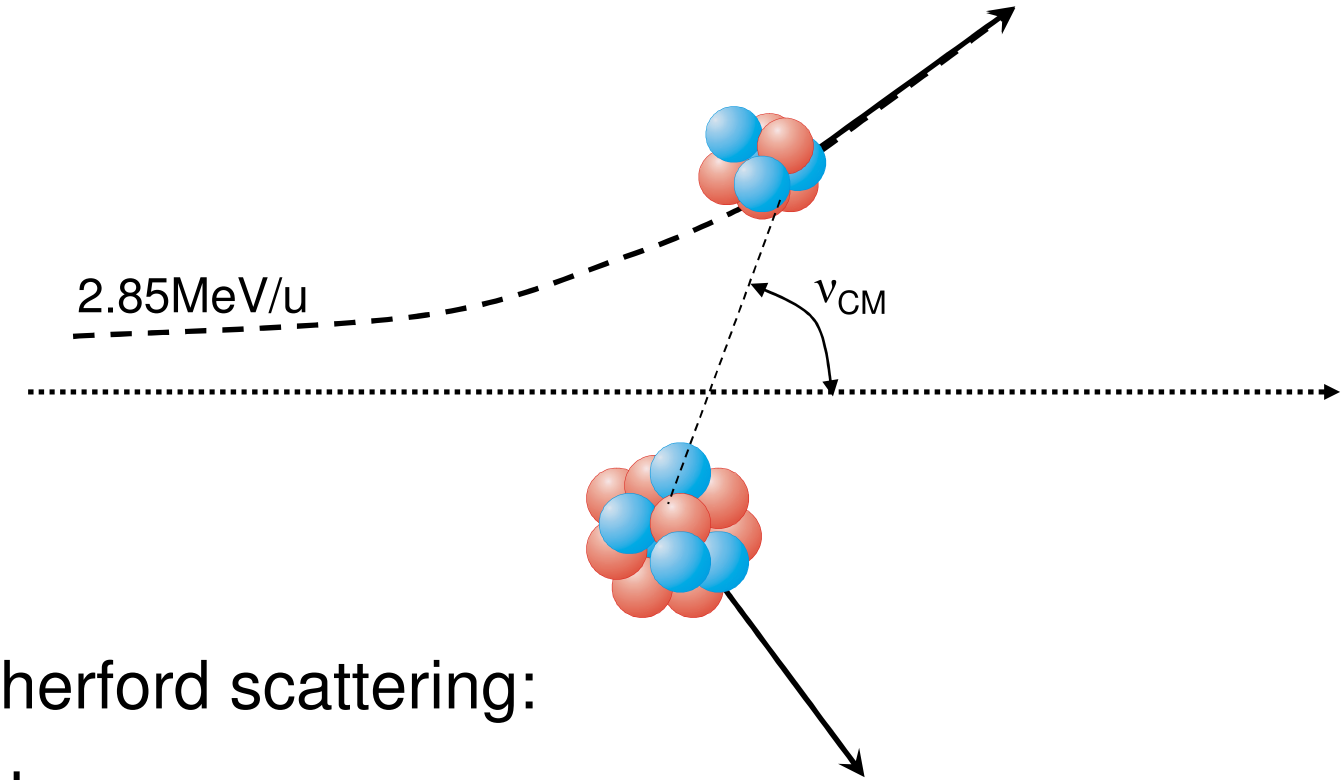
About the experiment



As Rutherford in 1911:
Alpha particles on a gold target,
which let to the discovery of the nucleus



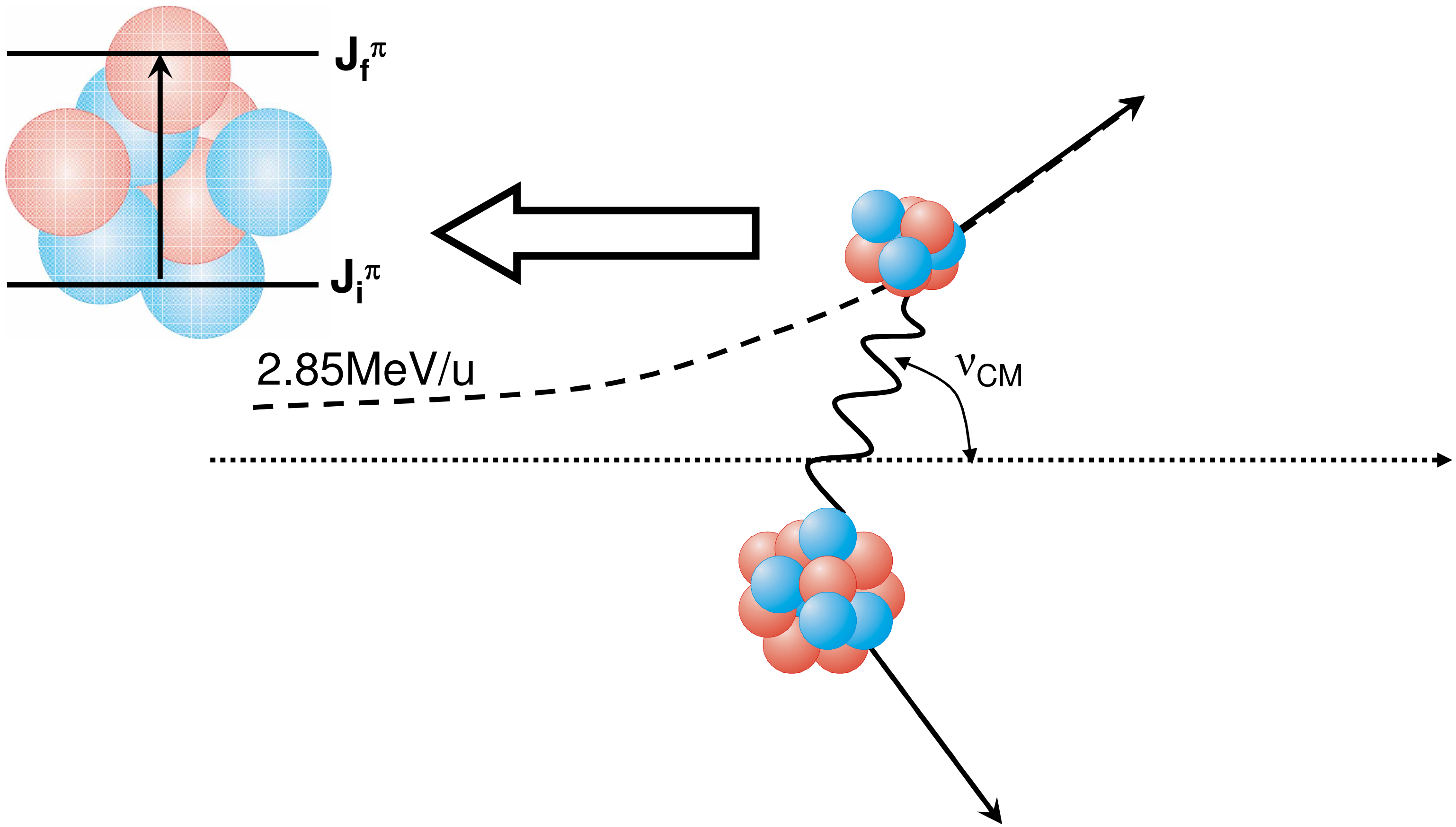
About the experiment



Rutherford scattering:

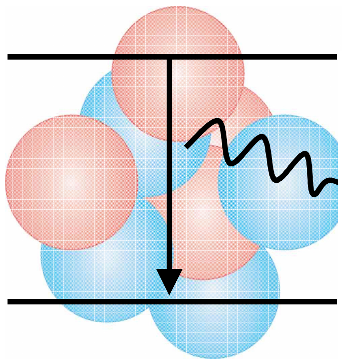
$$\frac{d\sigma}{d\Omega} \propto \sin^{-4} \frac{\nu_{CM}}{2}$$

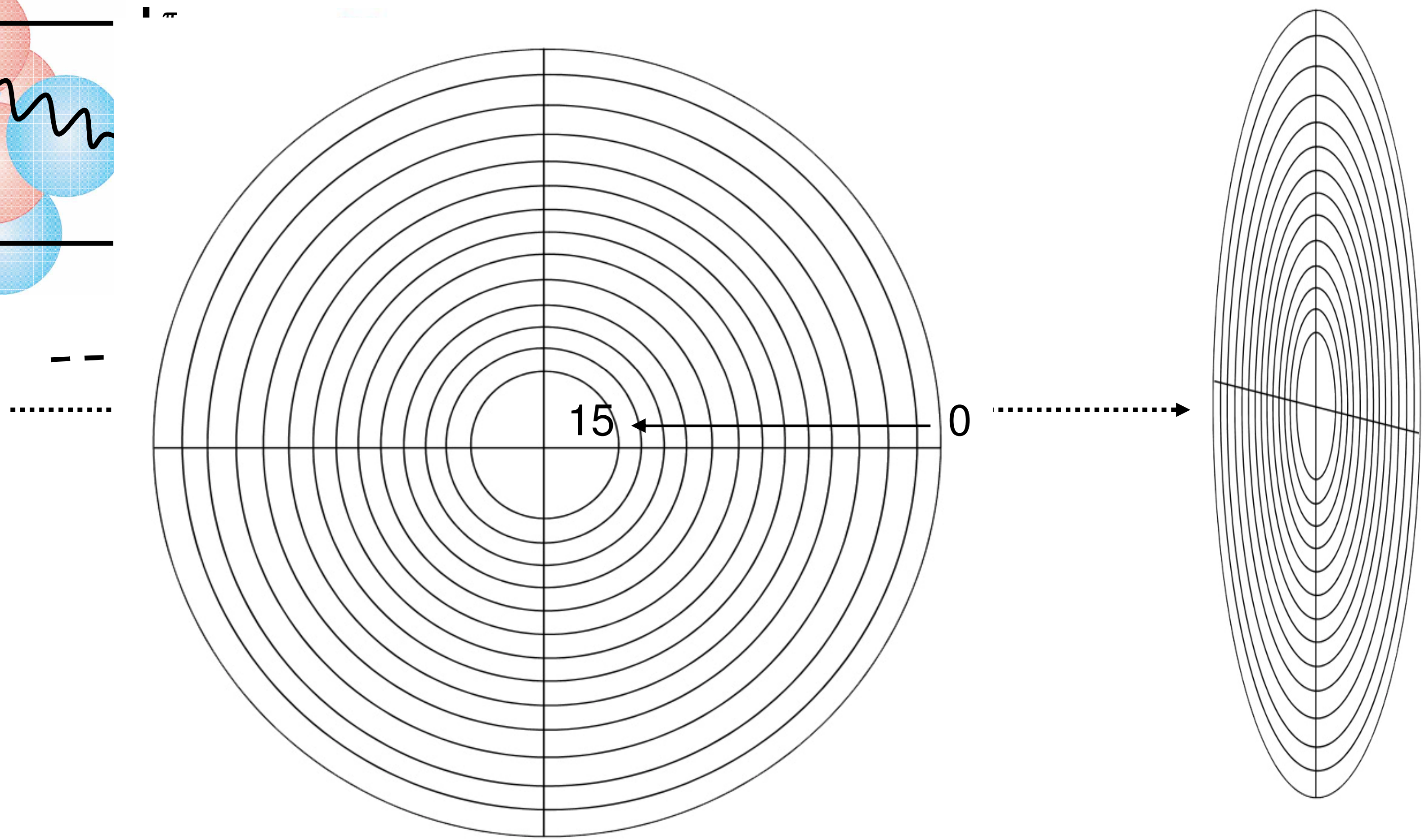
About the experiment



Coulomb excitations

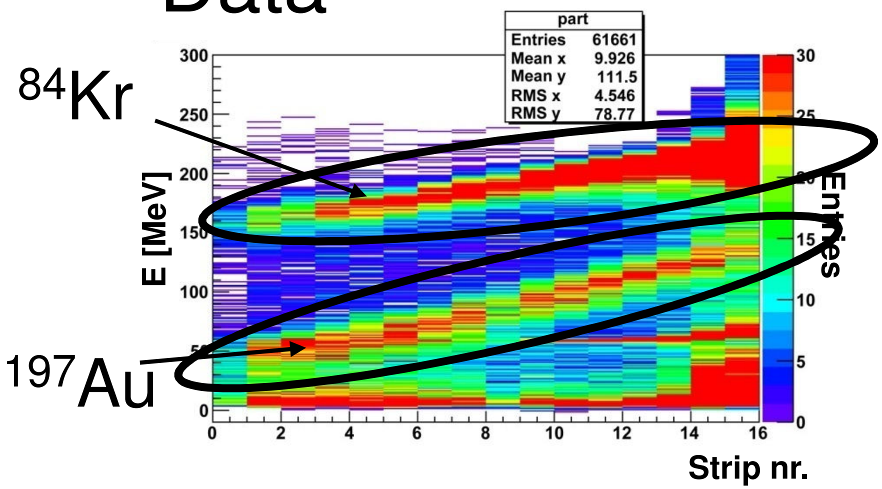
About the experiment



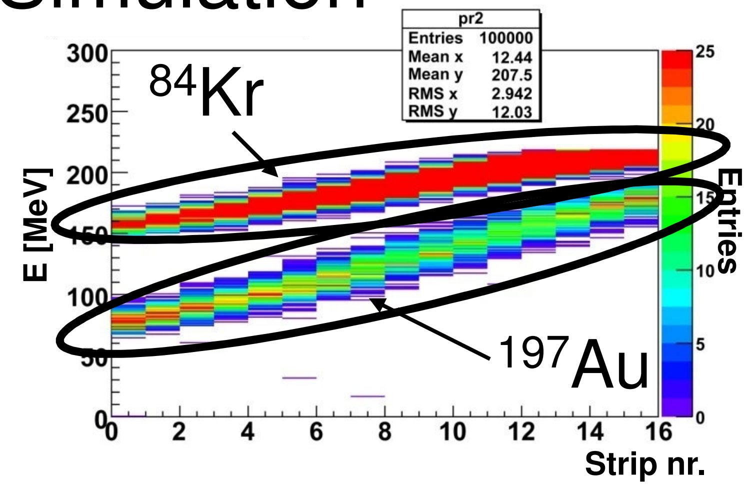


^{84}Kr on ^{197}Au

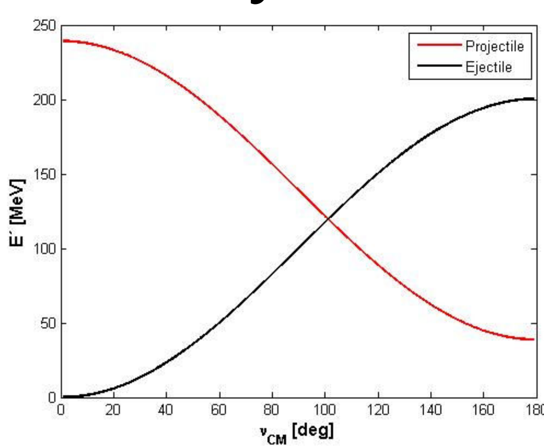
Data

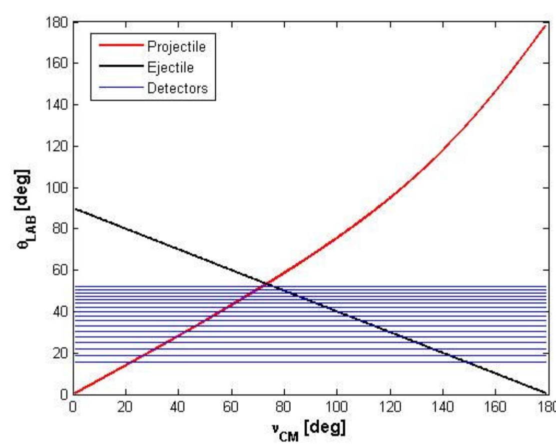


Simulation



Analytical calculations* of kinematics

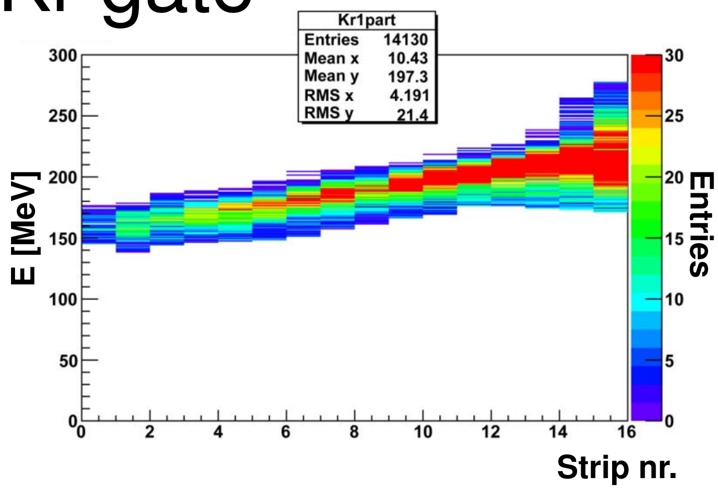


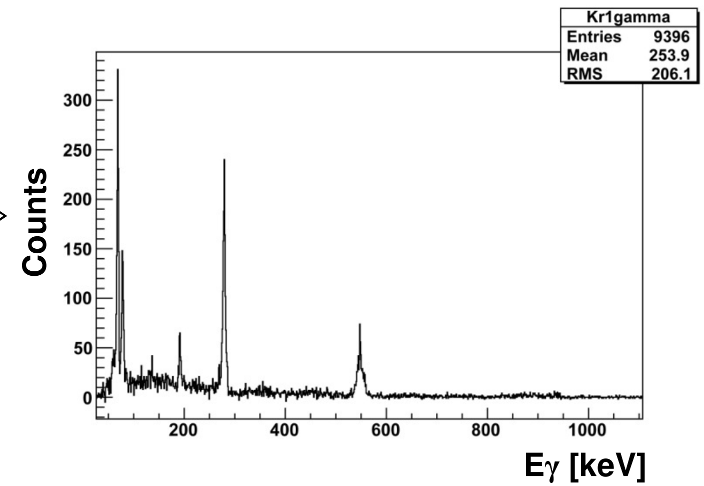


*The formulas can be found in ”Electromanetic Excitation” by Alder & Winther

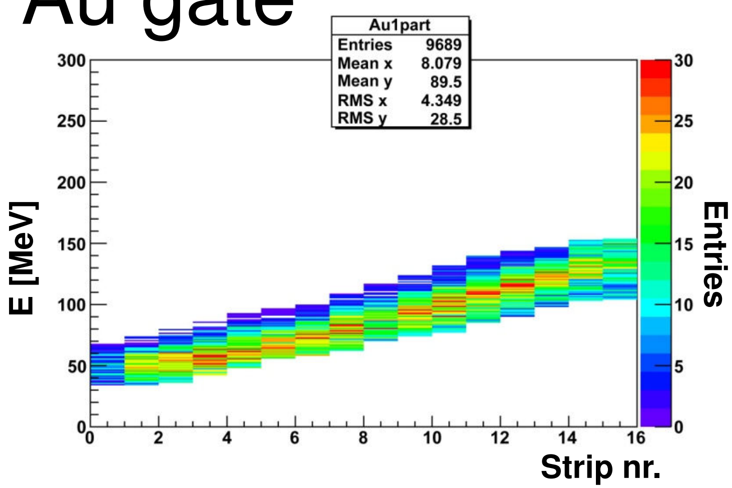
^{84}Kr on ^{197}Au

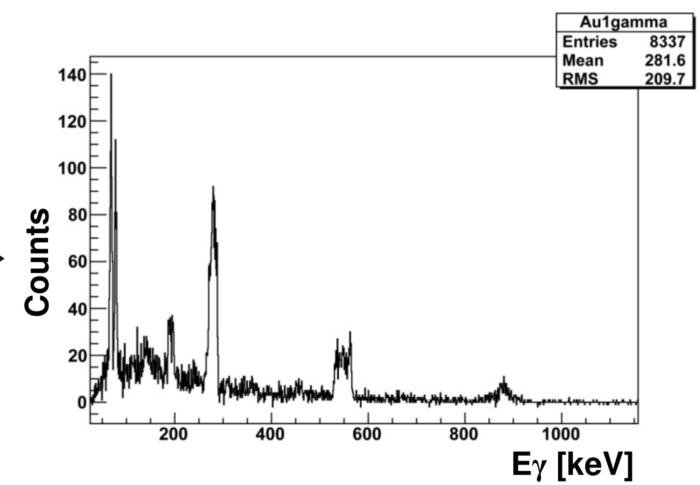
Kr gate



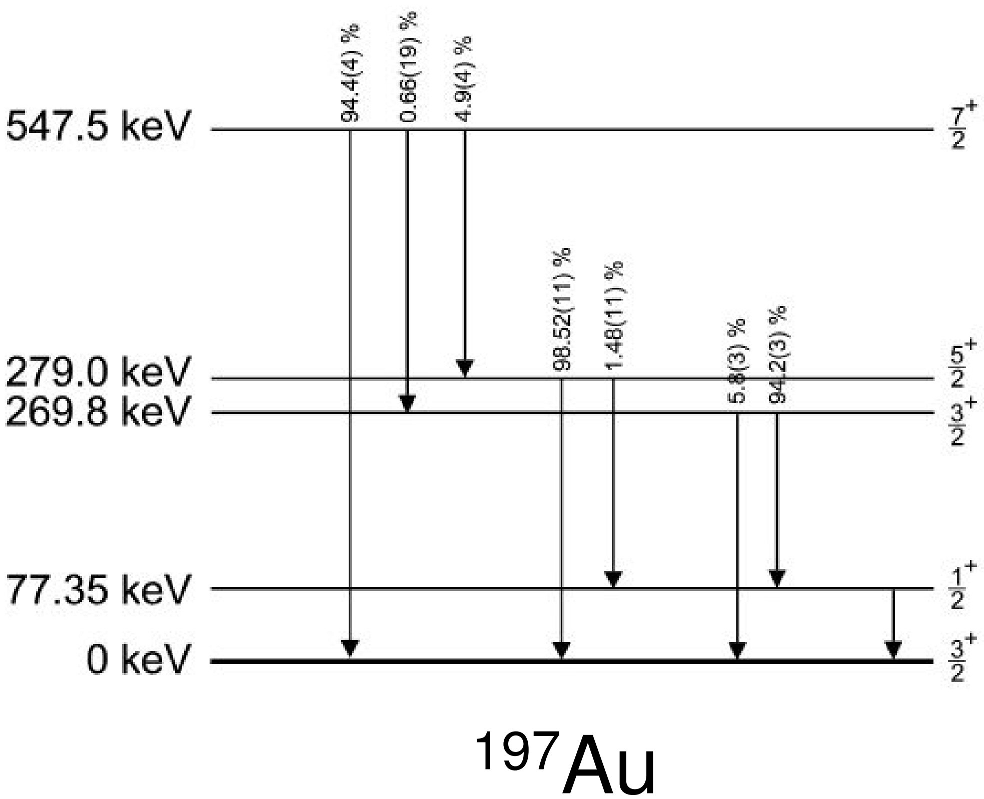


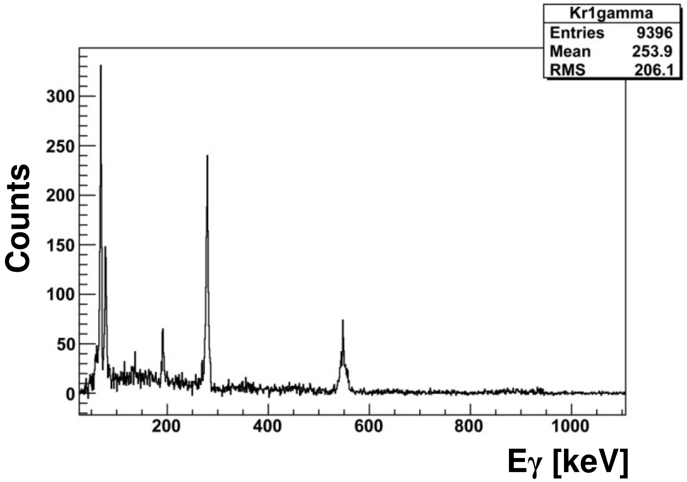
Au gate

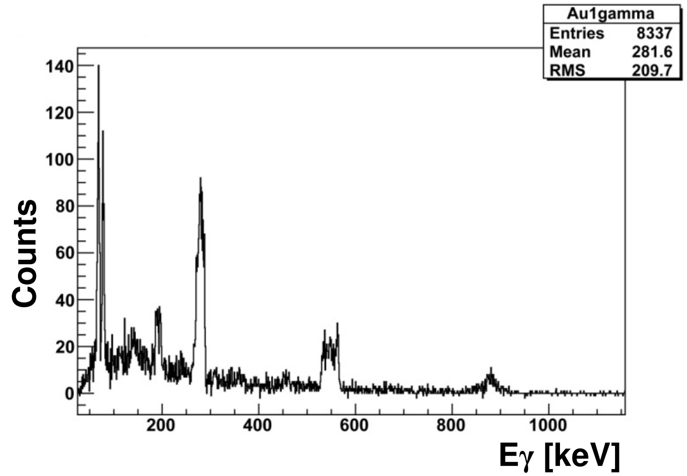




^{84}Kr on ^{197}Au

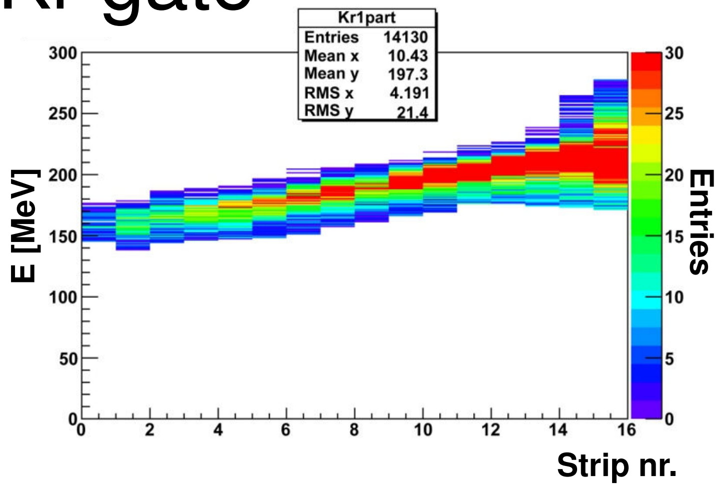


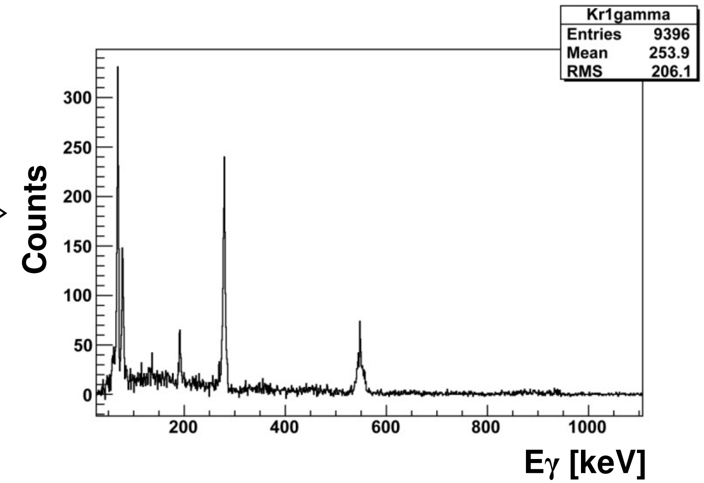




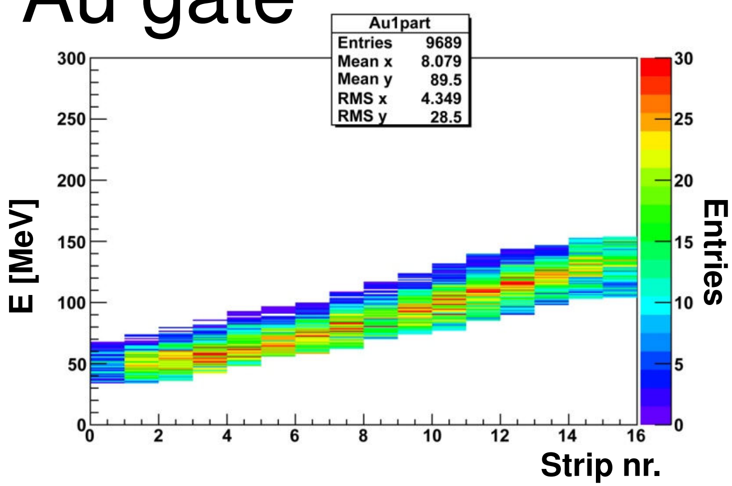
^{84}Kr on ^{197}Au

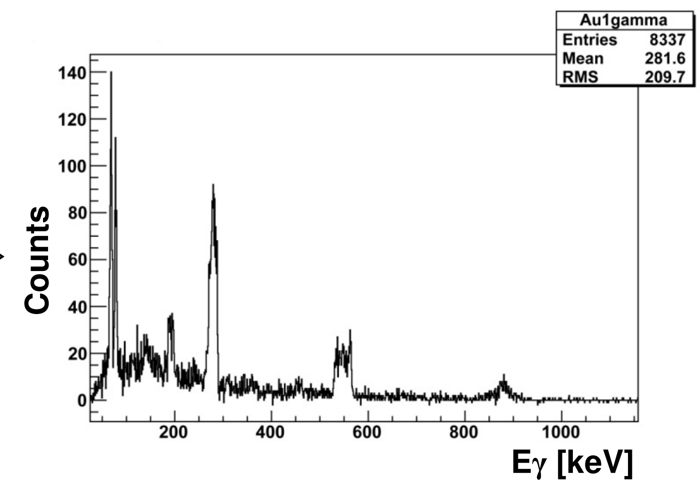
Kr gate





Au gate



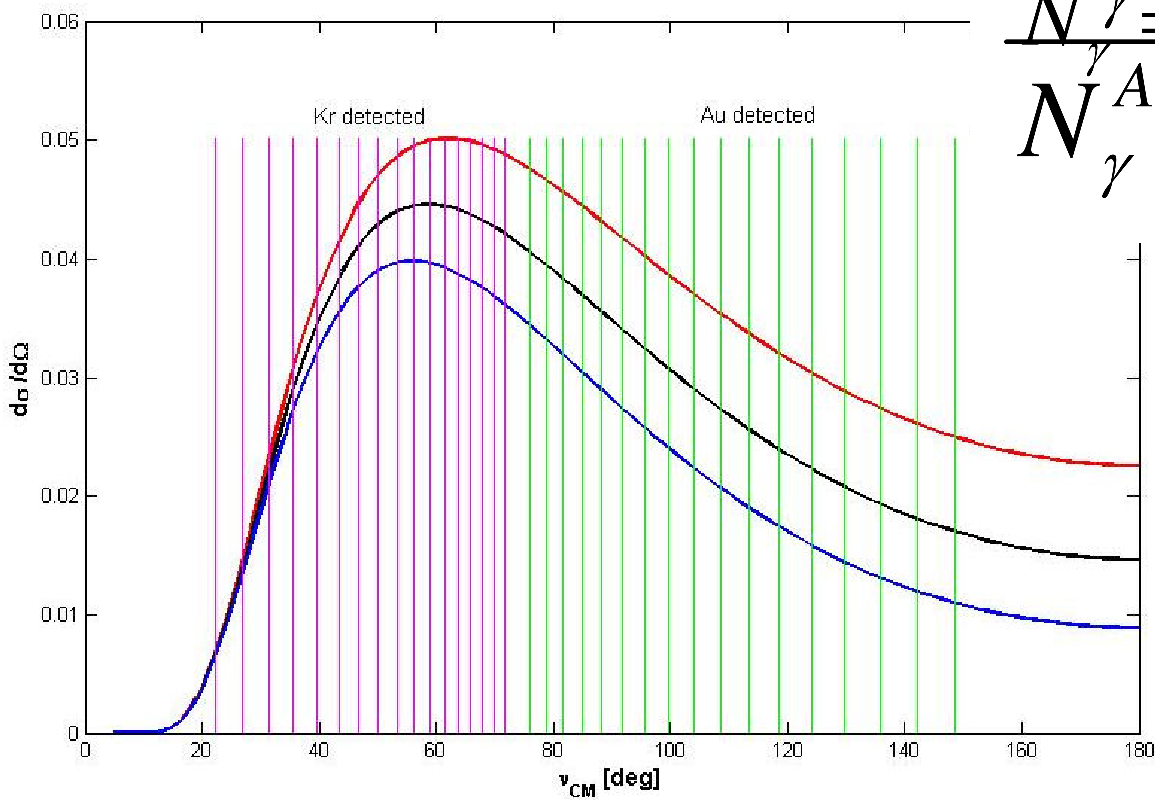


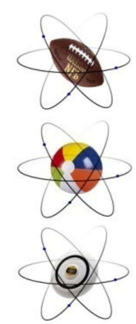
^{84}Kr on ^{197}Au

Cross-section

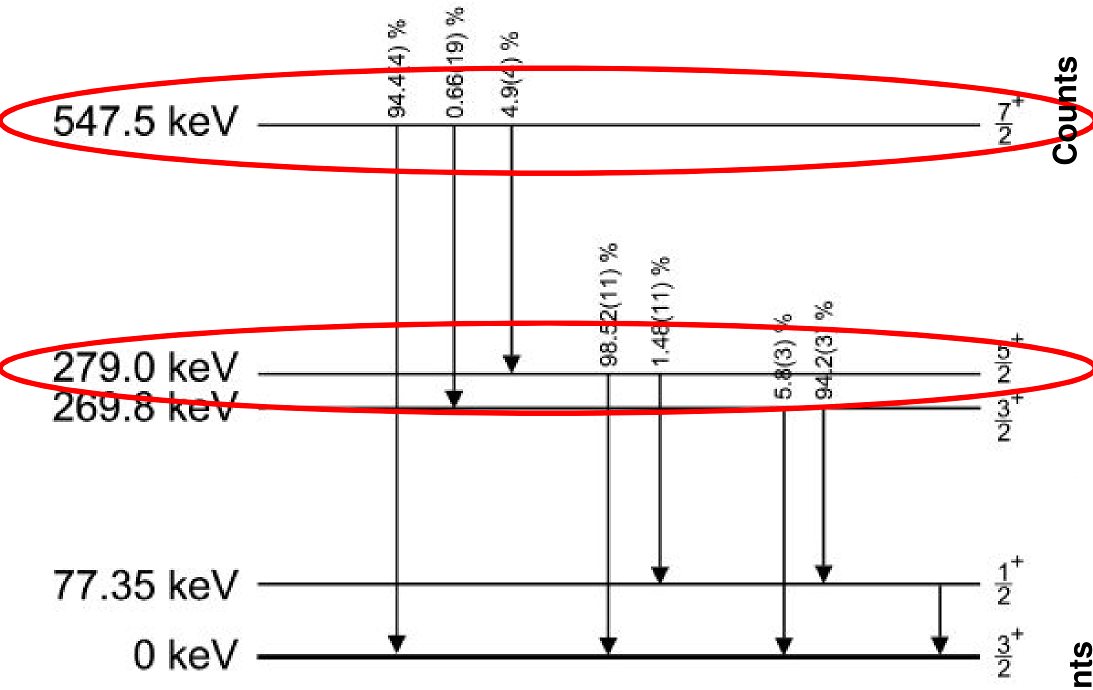
$$\frac{N_\gamma^{Kr}}{N_\gamma^{Au}} = \frac{\sigma^{Kr}\varepsilon^{Kr}}{\sigma^{Au}\varepsilon^{Au}}$$

$$N_\gamma = \varepsilon \cdot \sigma \cdot \frac{\rho d \cdot N_A}{A_E} \cdot I_P$$

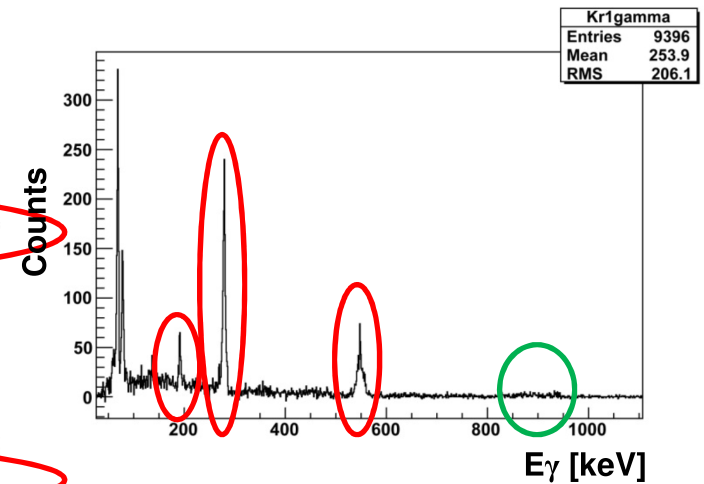


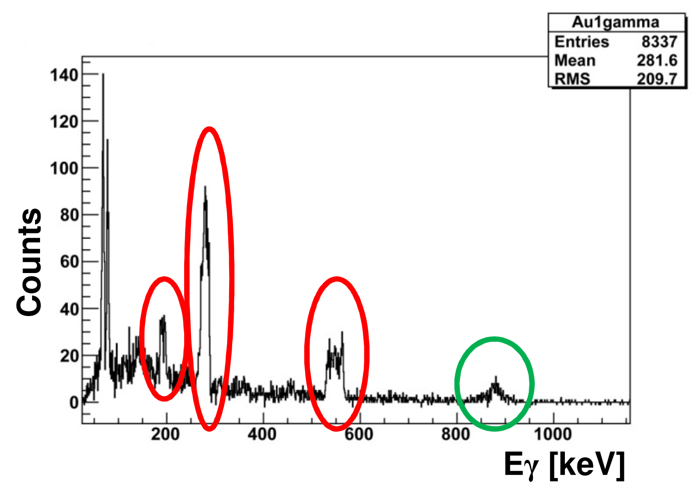


^{84}Kr on ^{197}Au



^{197}Au





^{84}Kr on ^{197}Au

Kr gate

279.0 keV

σ^{Kr} = 0.126 (12) b

Q	σ^{Kr}
-1.00	0.117
-0.80	0.122
-0.60	0.127
-0.50	0.130
-0.40	0.133

547.5 keV

σ^{Kr} = 0.134 (13) b

Q	σ^{Kr}
-0.30	0.136
-0.20	0.138
-0.10	0.141
-0.00	0.144
0.10	0.147

Au gate

279.0 keV

σ^{Kr} = 0.163 (16) b

Q	σ^{Kr}
-0.50	0.148
-0.40	0.156
-0.35	0.160
-0.30	0.165
-0.20	0.174

547.5 keV

σ^{Kr} = 0.180 (19) b

Q	σ^{Kr}
-0.15	0.178
-0.10	0.183
-0.05	0.188
-0.00	0.193
0.05	0.198

$$Q = -0.29\ (12)\ eb$$

Physics Letters B 546 (2002) 48–54

First measurement of the quadrupole moment in the 2_1^+ state of ^{84}Kr

A. Osa [a], T. Czosnyka [b], Y. Utsuno [a], T. Mizusaki [c], Y. Toh [a], M. Oshima [a], M. Koizumi [a], Y. Hatsukawa [a], J. Katakura [a], T. Hayakawa [a], M. Matsuda [a], T. Shizuma [a], M. Sugawara [d], T. Morikawa [e], H. Kusakari [f]

Table 3
The comparison of the experimental electromagnetic quantities with the shell-model calculation. The fourth and fifth columns show experimental values measured in the present experiment and the adopted values in Nuclear Data Sheets [12], respectively, while the sixth column shows the corresponding shell-model values. The B(E2), quadrupole moment, and B(M1) values are in unit of $10^{-2}e^2\,b^2$, e b and μ_N^2, respectively

Quantity	State		Experiment		Theory
	Initial	Final	Present	MDS [12]	SM
B(E2)	2_1^+	0_1^+	2.4 ± 0.3	2.45 ± 0.11	2.81
	2_2^+	0_1^+	0.55 ± 0.06	$0.57^{+0.20}_{-0.13}$	0.41
	2_2^+	2_1^+	2.4 ± 1.0	$2.4^{+0.9}_{-0.7}$	3.12
	4_1^+	2_1^+	5.3 ± 0.7	4.8 ± 0.7	3.33
	4_2^+	2_1^+		0.034 ± 0.004	0.20
	4_2^+	2_2^+		0.35 ± 0.05	1.09
	6_1^+	4_1^+		1.51 ± 0.39	2.02
	12_1^+	10_1^+		0.81 ± 0.09	1.19
Q moment	2_1^+		-0.26 ± 0.13		-0.18
B(M1)	2_2^+	2_1^+	0.025 ± 0.007	0.021 ± 0.007	0.060
g factor	8_1^+			-0.246 ± 0.002	-0.24
	12_1^+			$+0.17 \pm 0.01$	$+0.20$

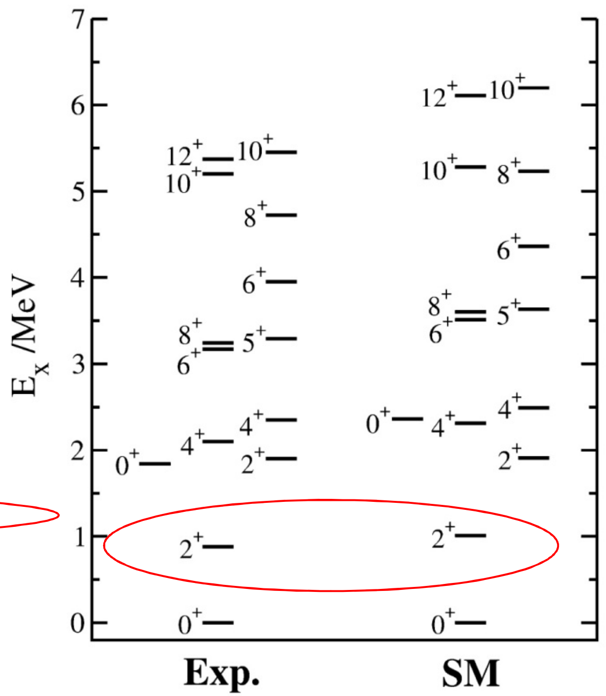
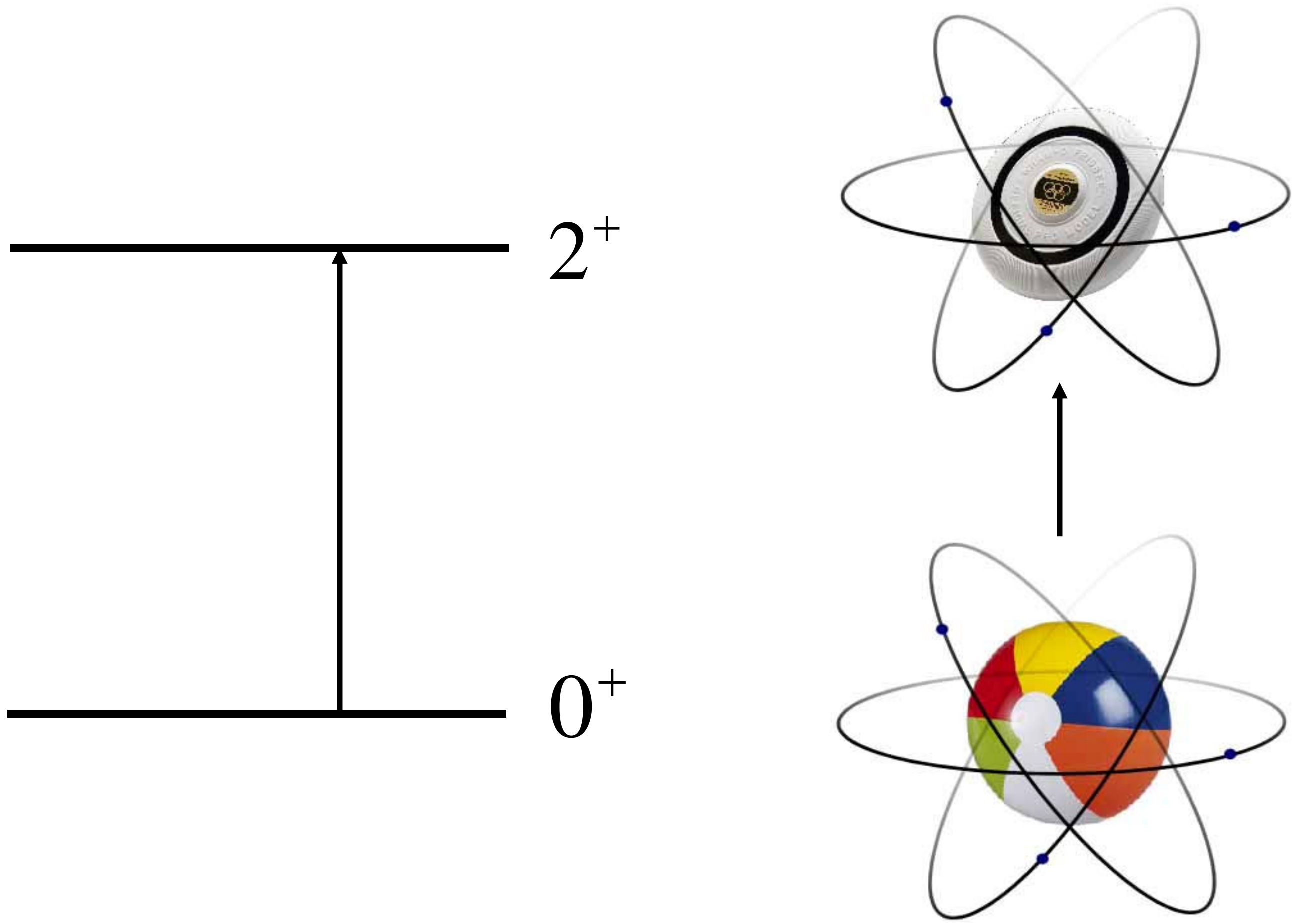


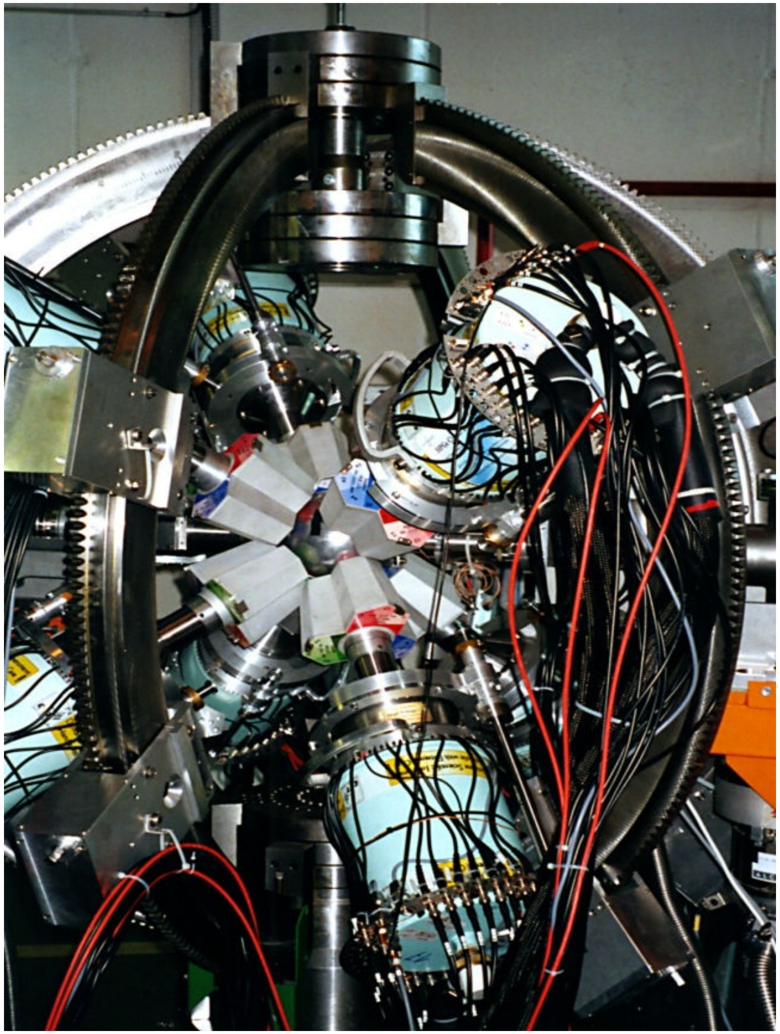
Fig. 4. Experimental energy levels of ^{84}Kr (Exp.) compared with the corresponding ones calculated by the shell model (SM).

My value: Q = -0.29 (12) *e*b

^{84}Kr...
Conclusion

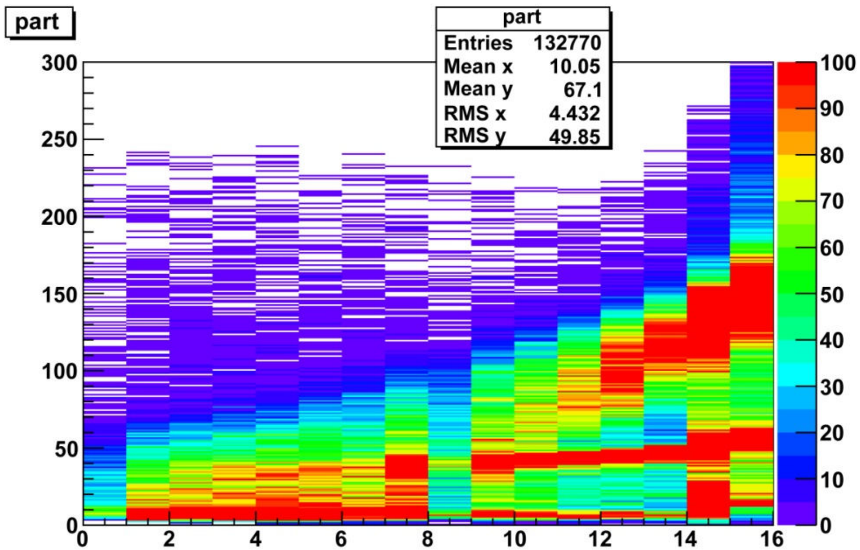


Questions?

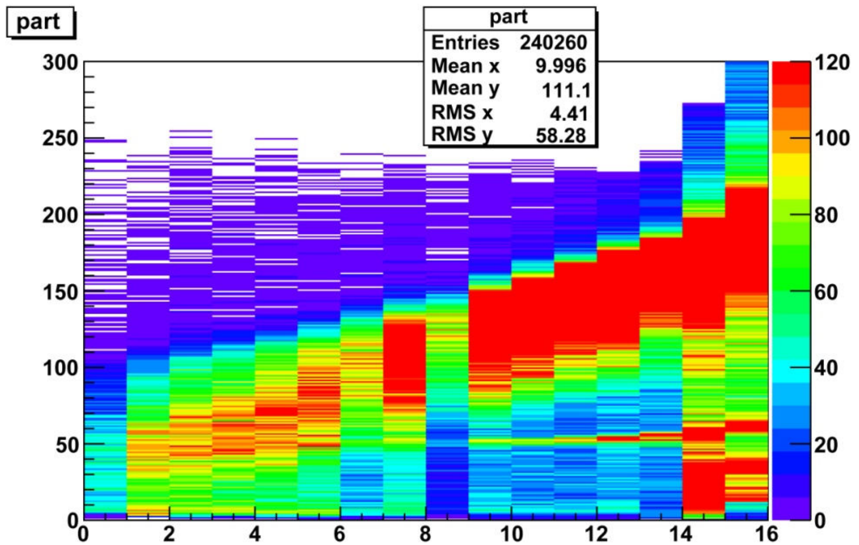


^{84}Kr...

The next step



^{84}Kr on ^{60}Ni



^{84}Kr on ^{109}Ag