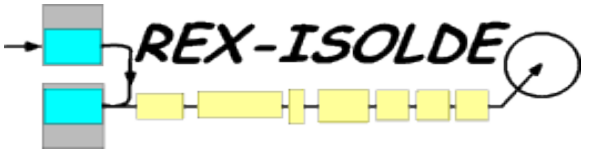


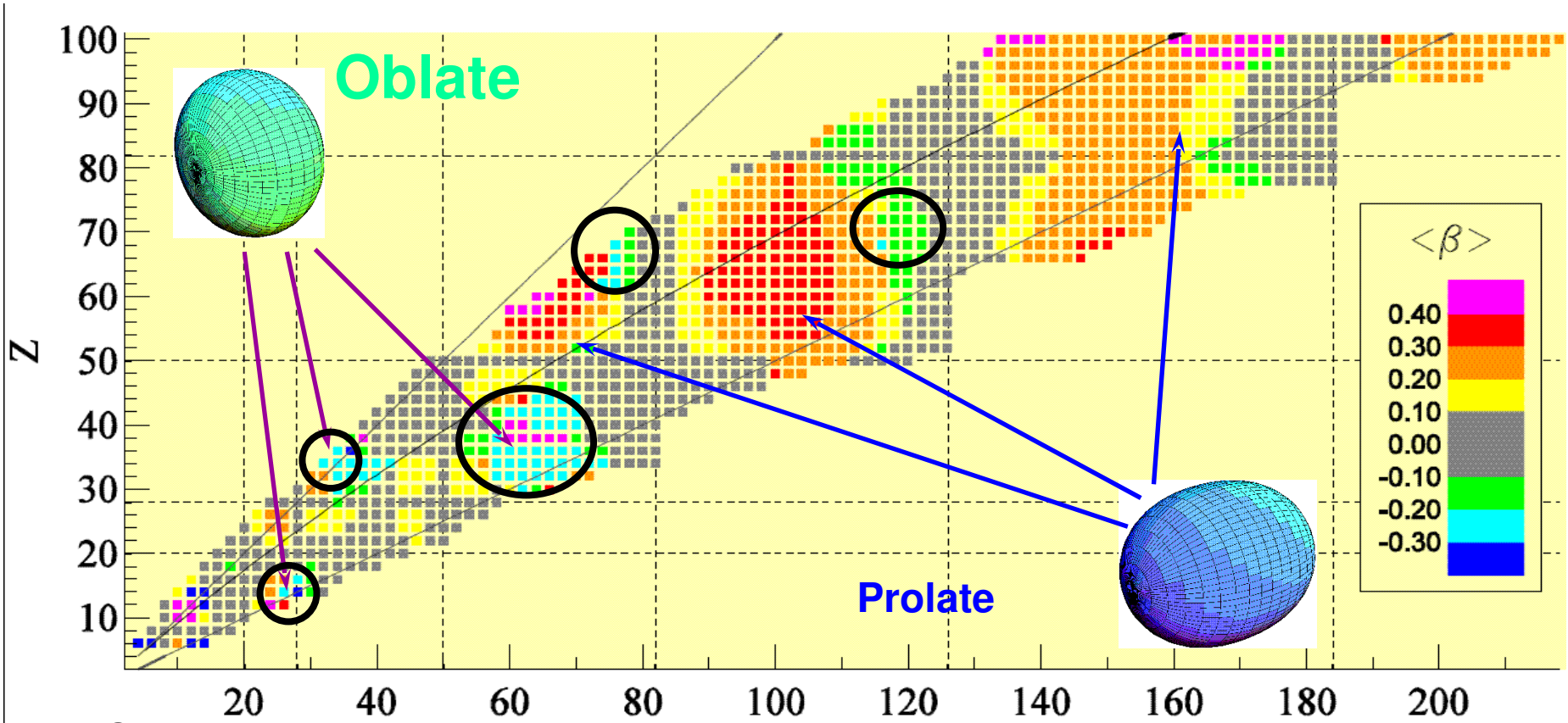
Shape coexistence in n-rich Sr isotopes studied by low energy coulomb excitation

IS451

E. Clément CERN/IN^{2}P^3-GANIL

A Görgen CEA-Saclay

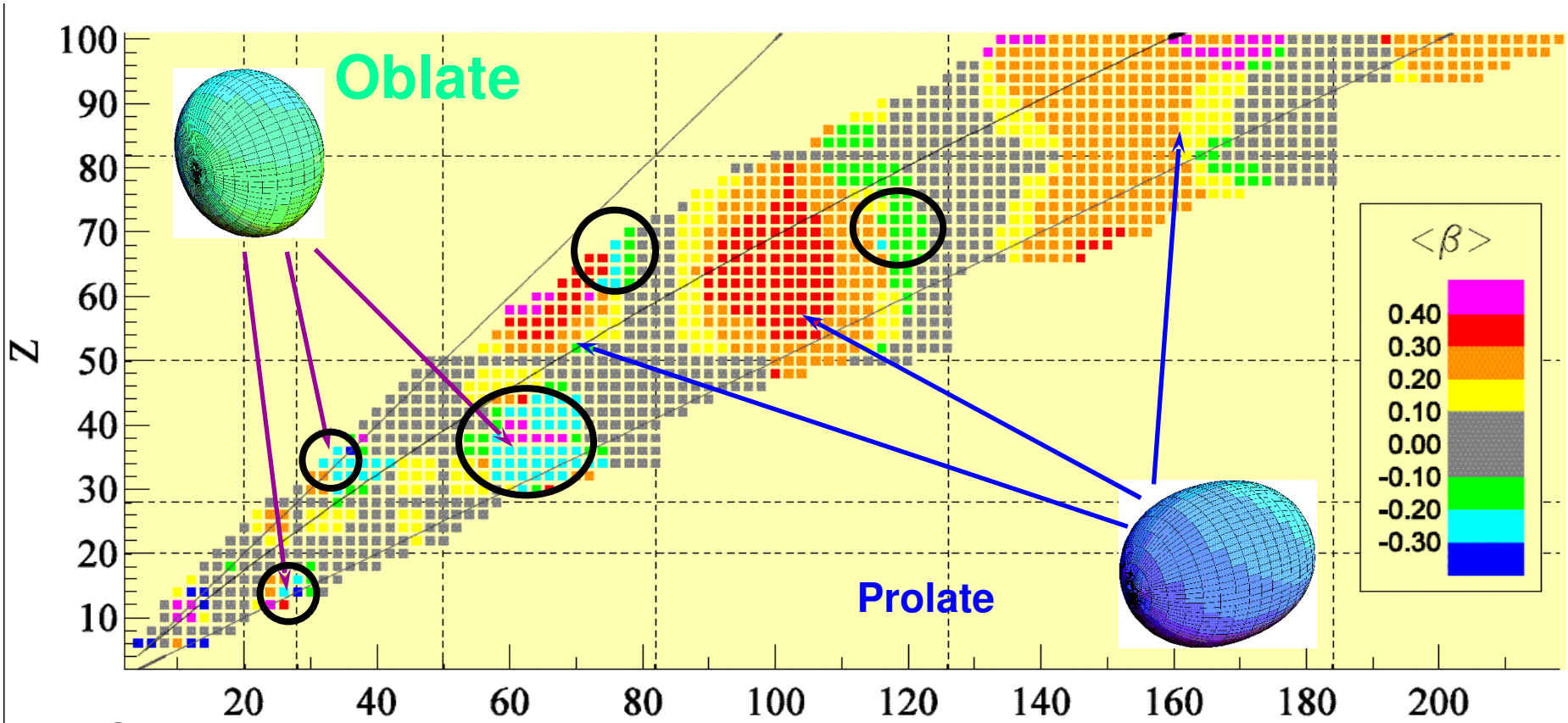
Shapes of exotic nuclei



Quadrupole deformation of the nuclear ground states

Bruyères-le-Châtel
M. Girod, CEA

Shapes of exotic nuclei



Quadrupole deformation of the nuclear ground states

Bruyères-le-Châtel
M. Girod, CEA

- Large area of competition between the oblate and prolate shapes which leads to unexpected symmetries and shape change
- Prolate, oblate or spherical states within small energy range : shape coexistence

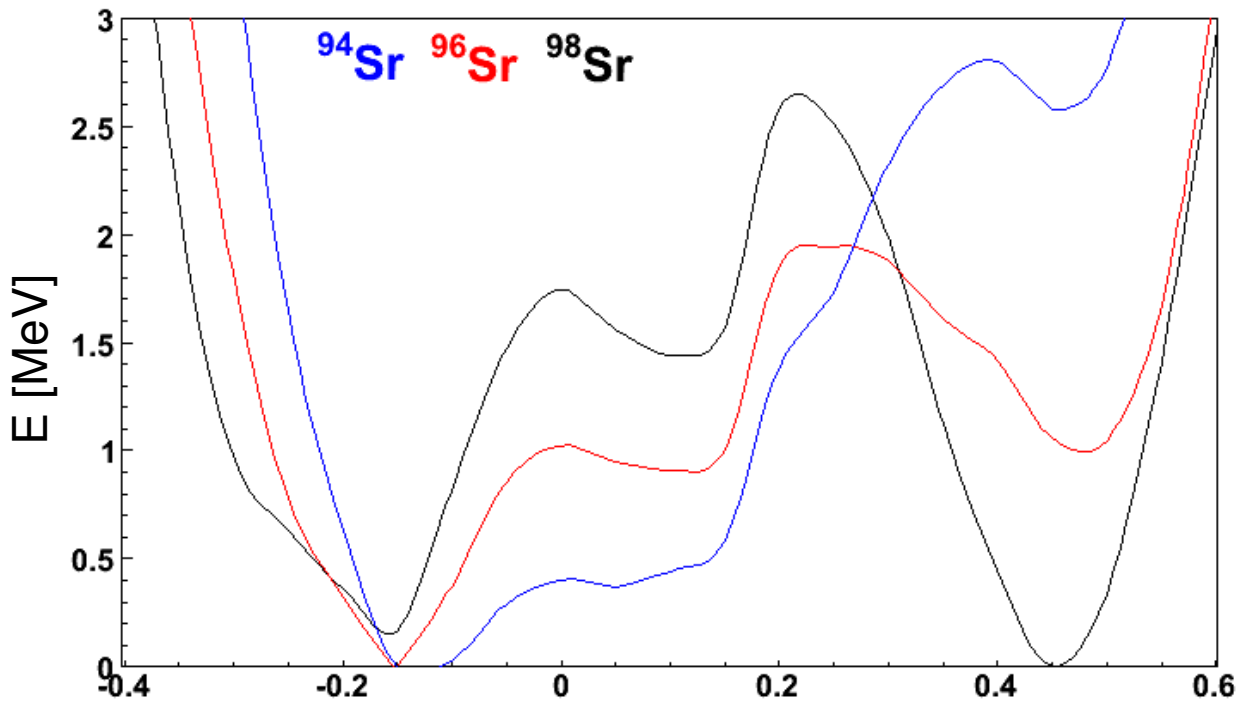
Important constraints for modern nuclear structure theories :

- Predicted values of β_2
- E (0^+_2), $\rho^2(E0)$, B(E2), Q_0 …

n-rich Sr and Zr isotopes

All theoretical calculations predict a sudden onset of quadrupole deformation at the neutron number N=60

… but differ for deformation parameter and excitation energy



HFB Gogny D1S

M. Girod

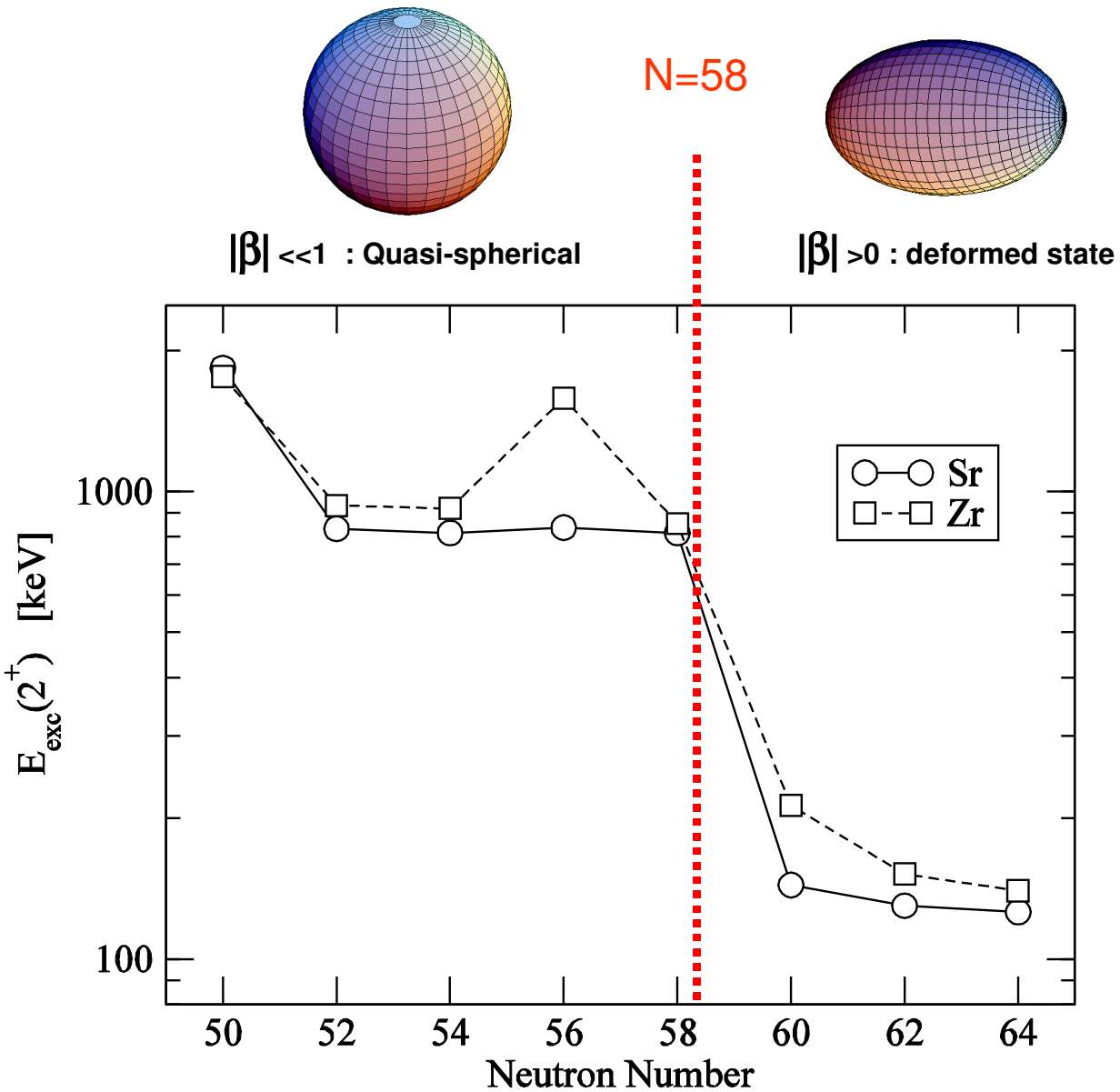
CEA Bruyères-le-Châtel

^{96}Sr is a transitional nucleus

- Both deformations should coexist at low energy
  - Shape coexistence between highly deformed and quasi-spherical shapes

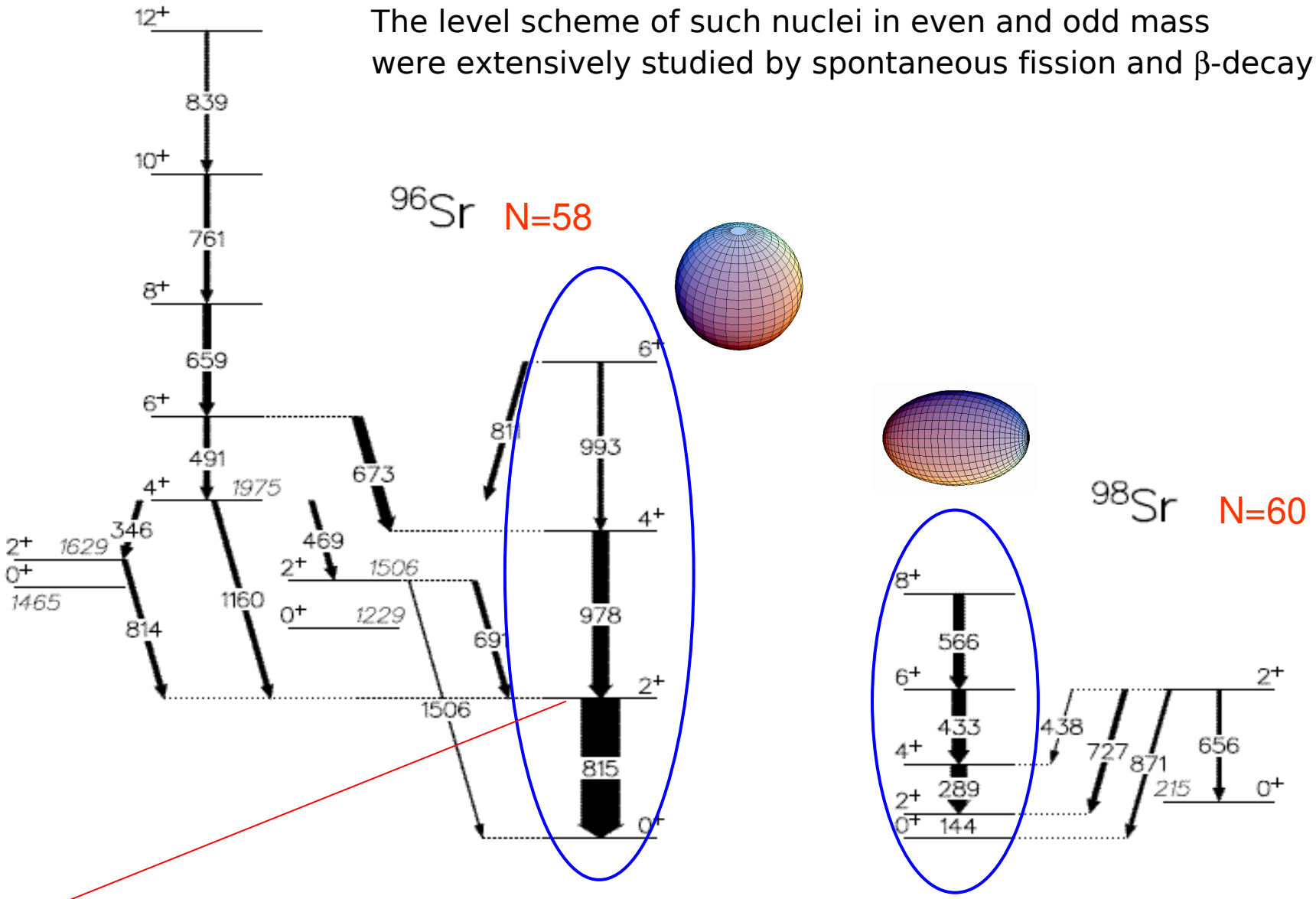
Evidence for shape coexistence in Sr and Zr

The first evidence is the energy of the 2^+_1 state



Evidence for shape coexistence in Sr

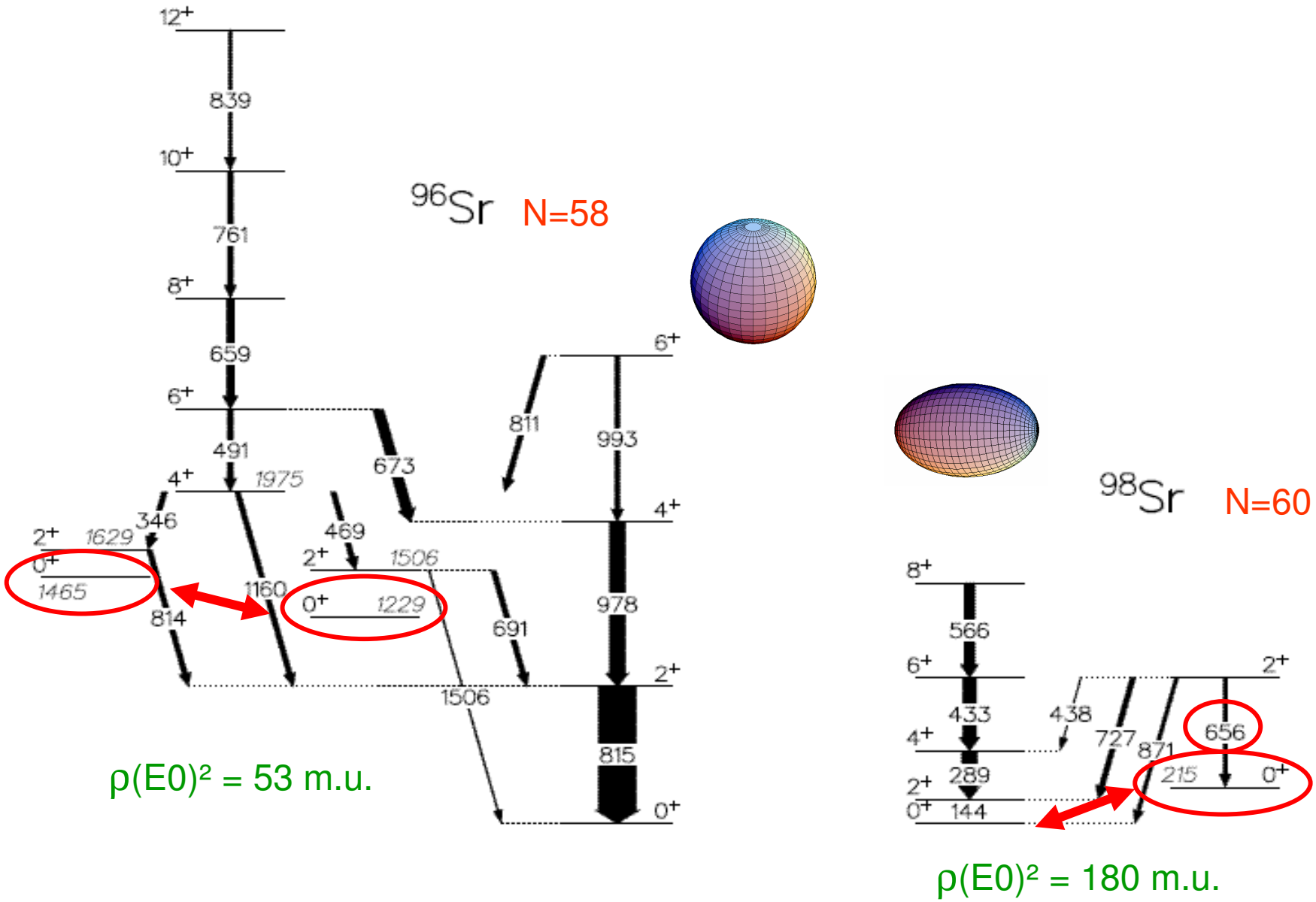
The level scheme of such nuclei in even and odd mass were extensively studied by spontaneous fission and β-decay



τ = 7(4) ps → Nearly spherical ground state

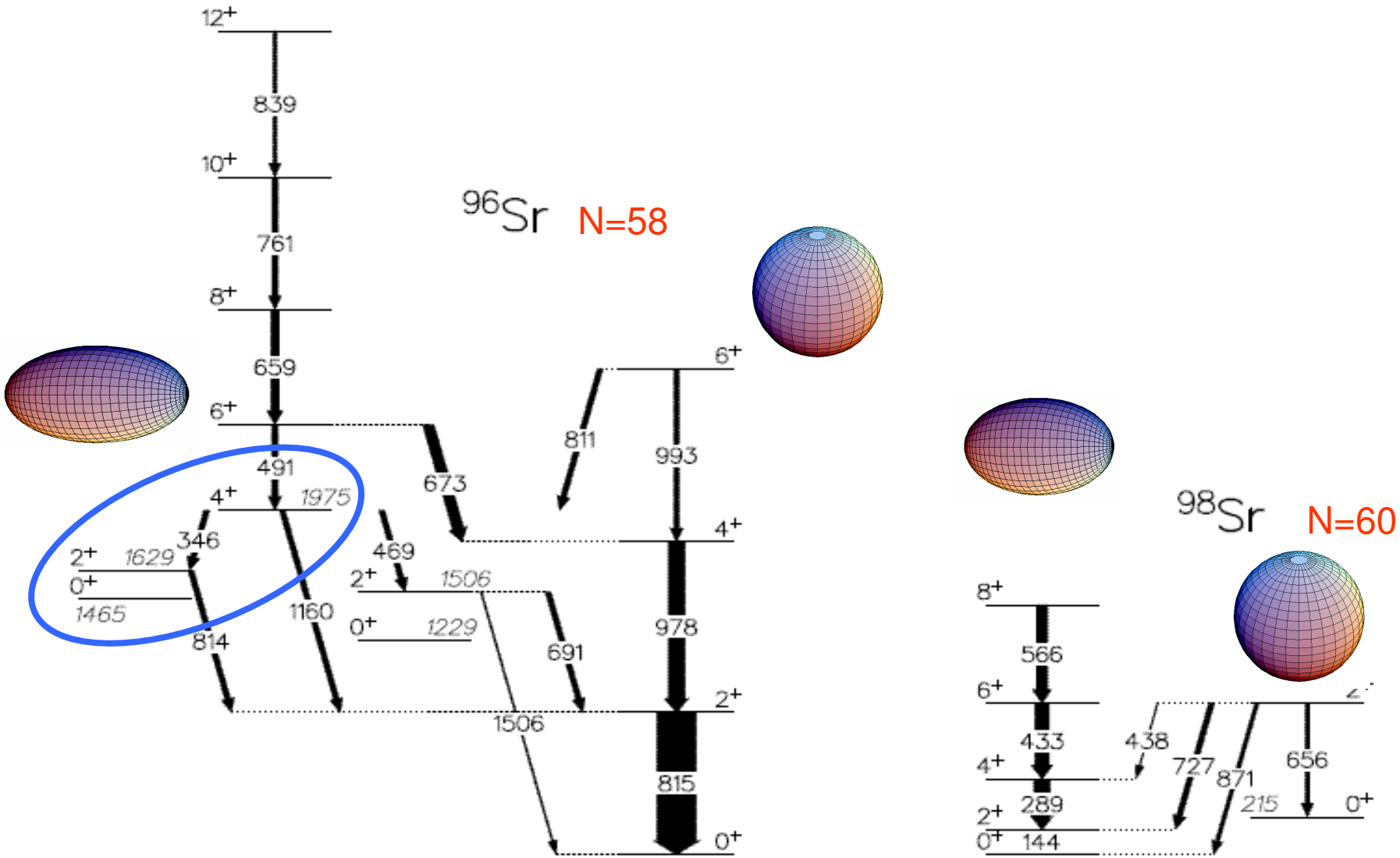
Highly deformed rotational band β ≈ 0.4

Evidence for shape coexistence in Sr



ρ(E0)² is directly linked to deformation and mixing configuration

Evidence for shape coexistence in Sr

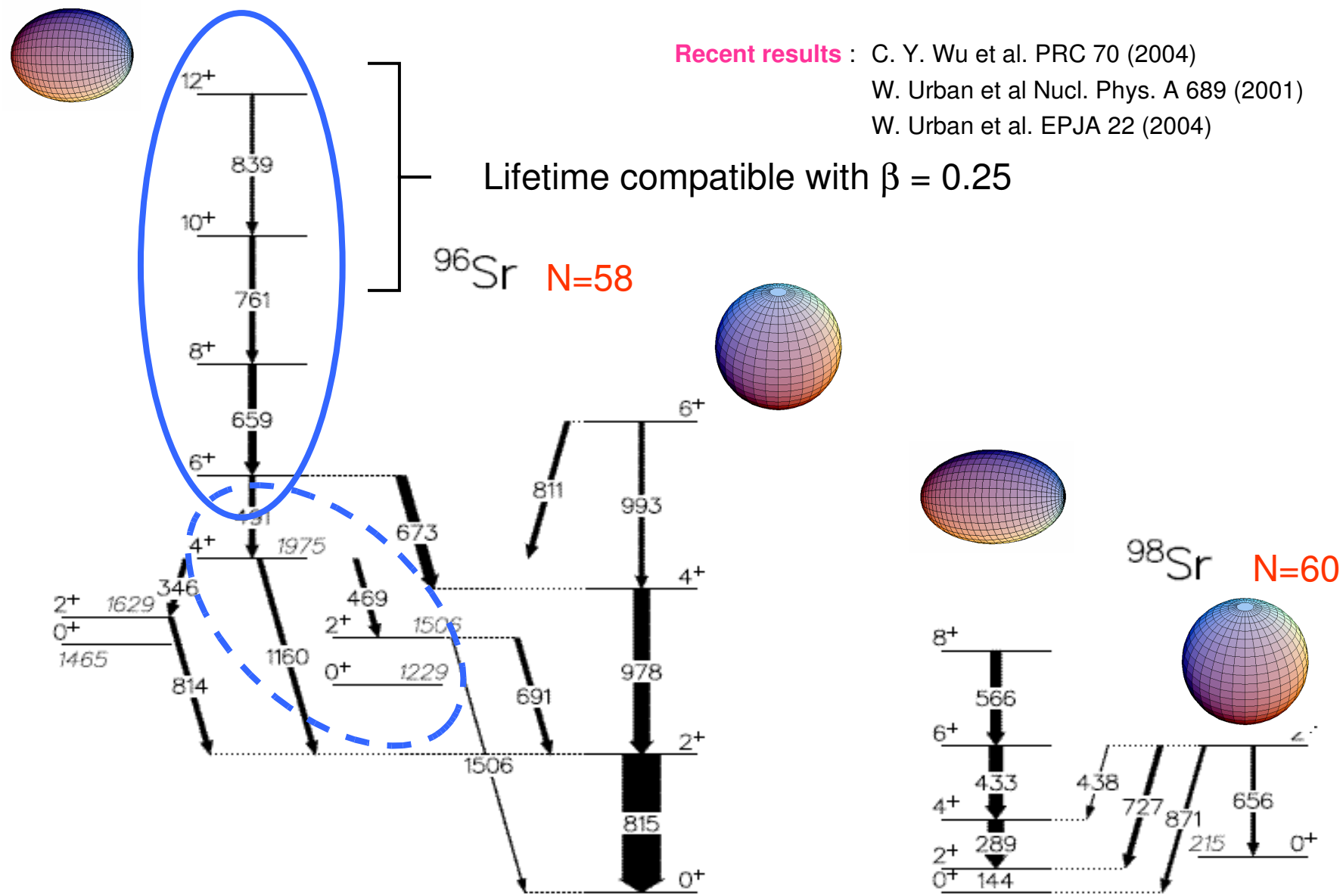


The highly deformed band $0^+_3 \rightarrow 2^+_3 \rightarrow 4^+_2$ becomes the ground state band in ^{98}Sr

Evidence for shape coexistence in Sr

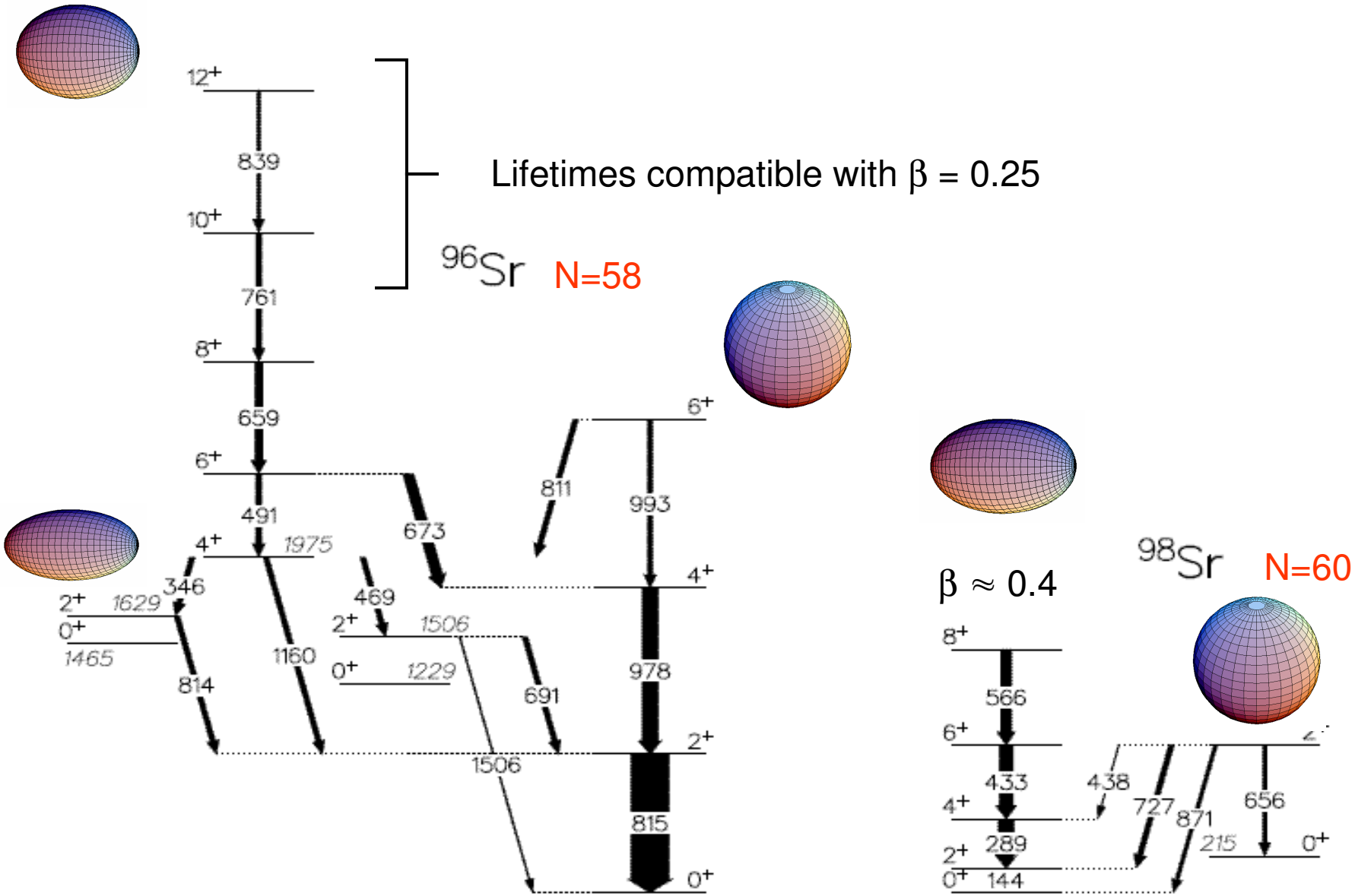
Recent results : C. Y. Wu et al. PRC 70 (2004)
W. Urban et al Nucl. Phys. A 689 (2001)
W. Urban et al. EPJA 22 (2004)

Lifetime compatible with $\beta = 0.25$



The onset of deformation around N=58 is maybe more gradual

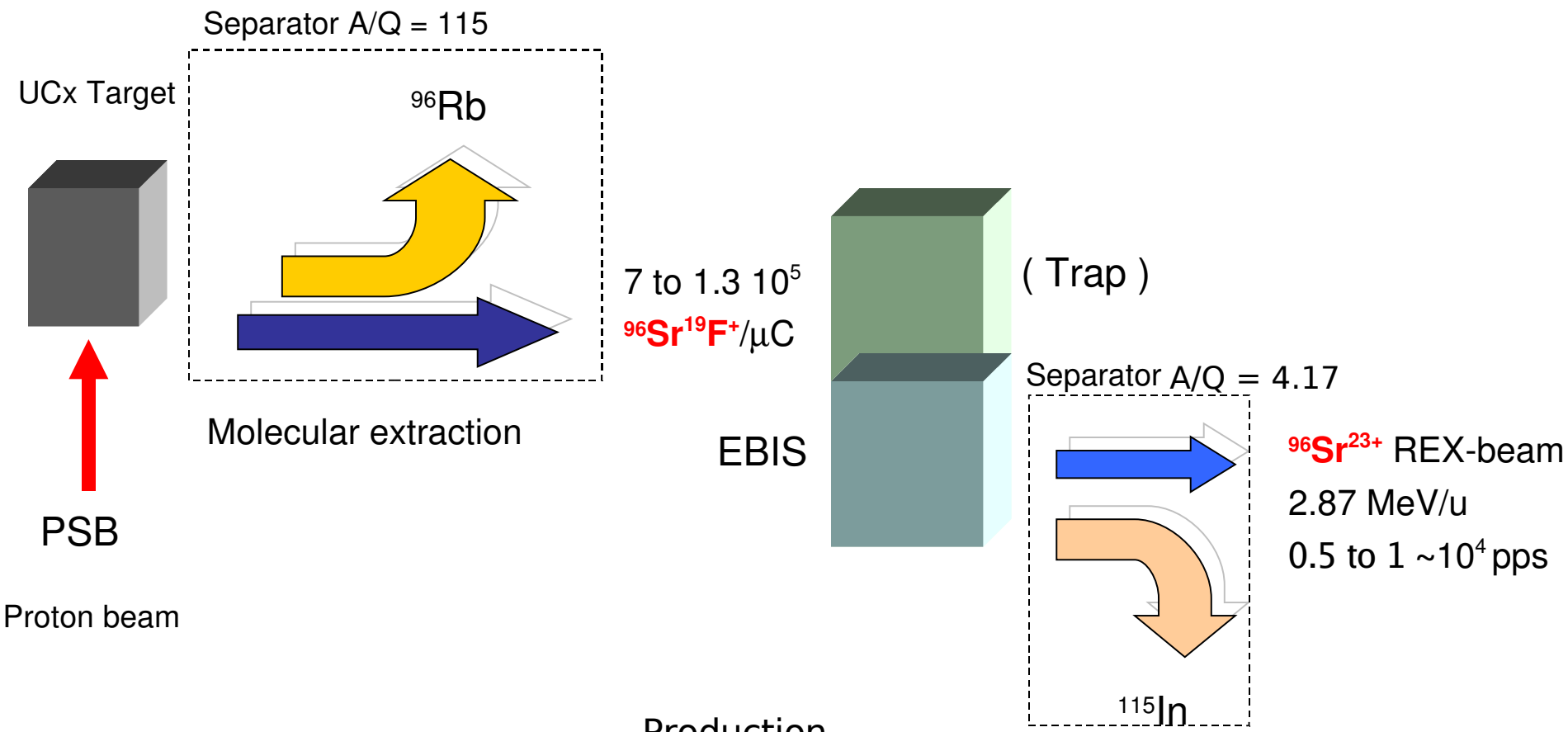
Evidence for shape coexistence in Sr



The measure of transition strength and intrinsic quadrupole moments is essential to understand the complex shape coexistence in Sr isotopes →
Coulomb excitation

Experimental details

- First Sr beam at REX-ISOLDE → needed a new development
- The chosen option was the molecular extraction as $^{96}Sr^{19}F^{+}$



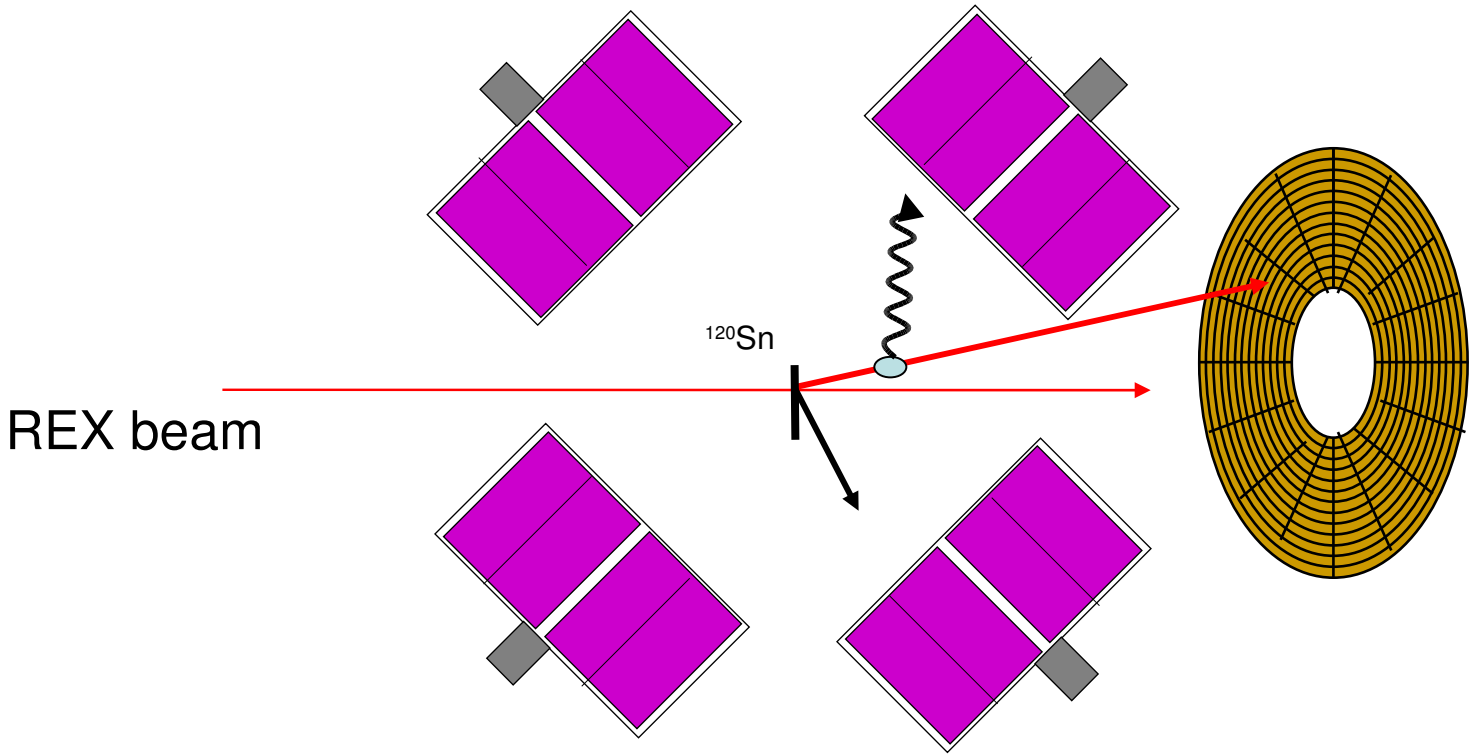
Suffered of a low beam intensity (10^5pps in the proposal)

- Production
- Low efficiency of the post-acceleration (low energy part ~1.9% ; linac 70%)

MINIBALL SET UP

Classical set up composed by :

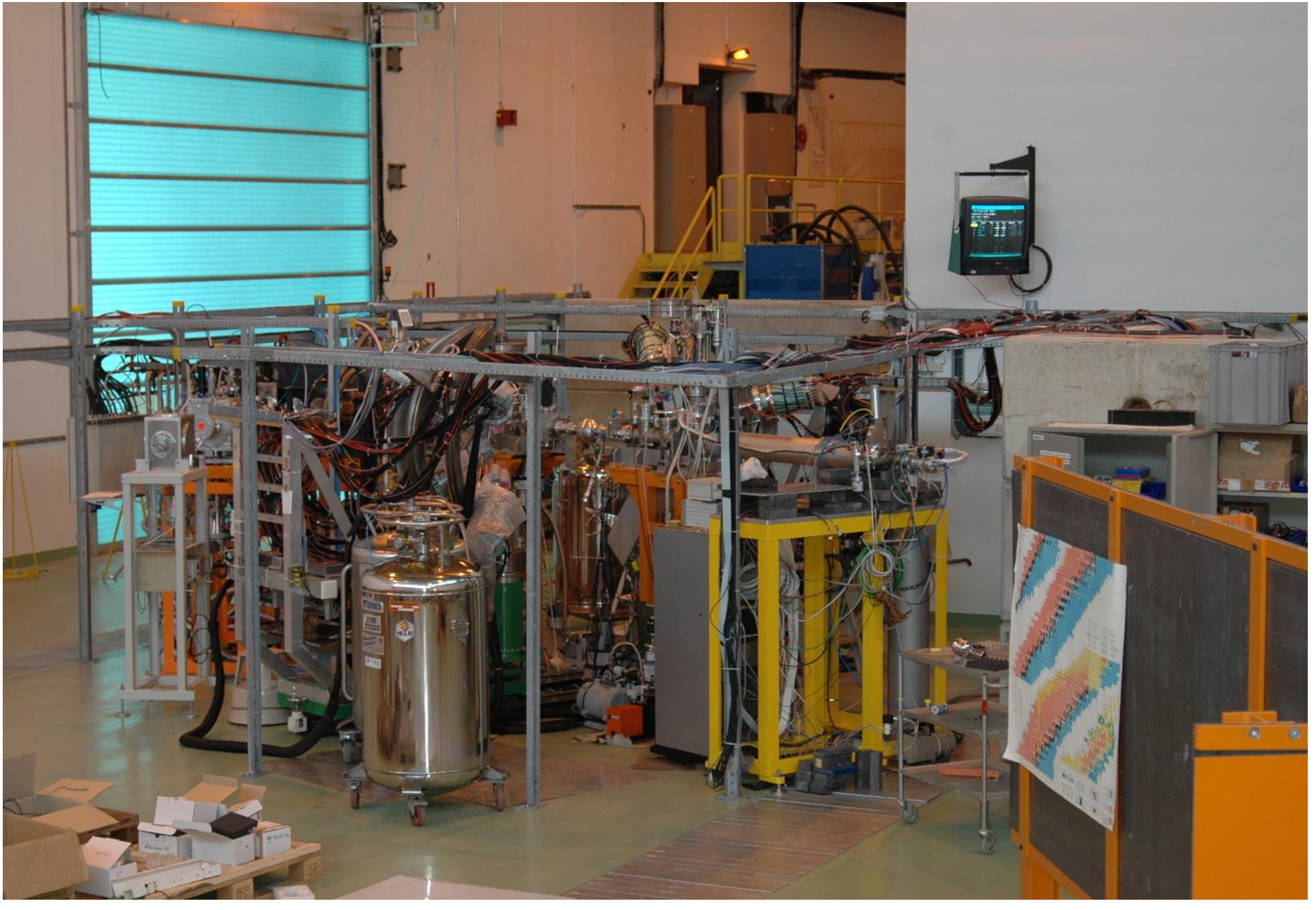
- The 7 clusters of MINIBALL
- Stripped silicon detector for particles detection (Doppler correction and differential cross section)



Coulomb excitation on ^{120}Sn and ^{109}Ag target :

- **Coulex normalisation possible through the Sn and Ag excitation**
- **Cross section between 27 and 150 deg in center of mass (differential cross section)**

MINIBALL SET UP (2007)

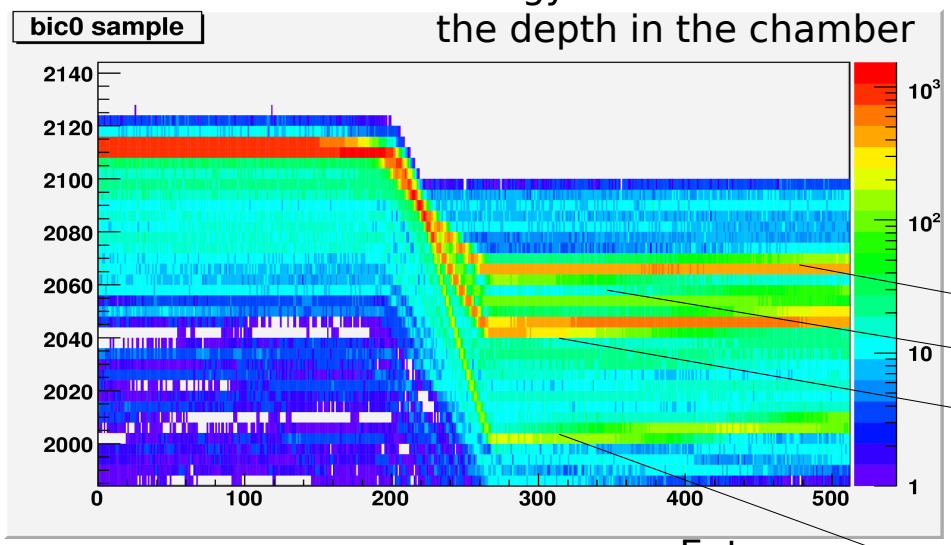


Beam composition

- In such experiment a crucial point for the B(E2) measurement is the beam composition

Since 2007, a Bragg detector *(T.U Munchen)* is placed at the end of the Miniball beam line and measures CONSTANTLY the beam composition in Z and A determination.

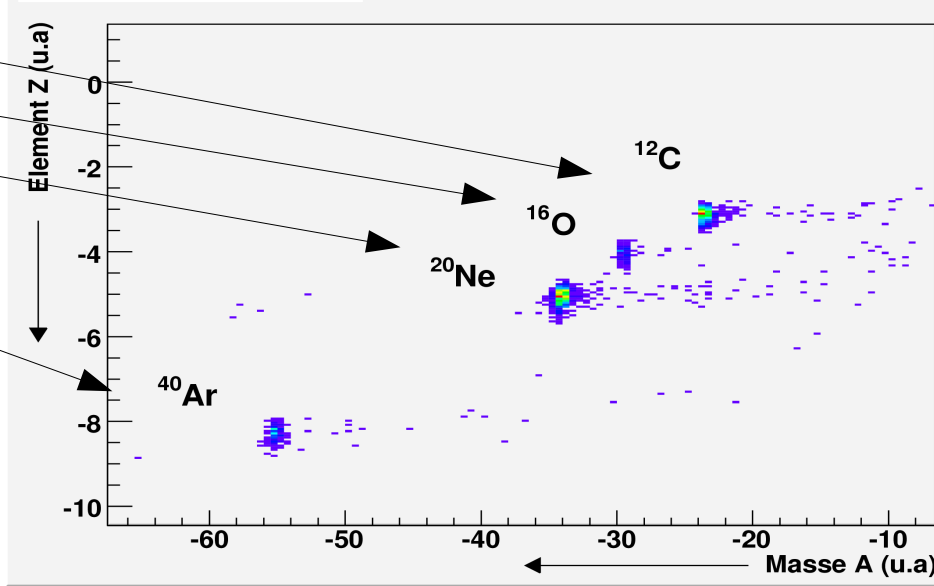
Energy loss as a function of the depth in the chamber



End

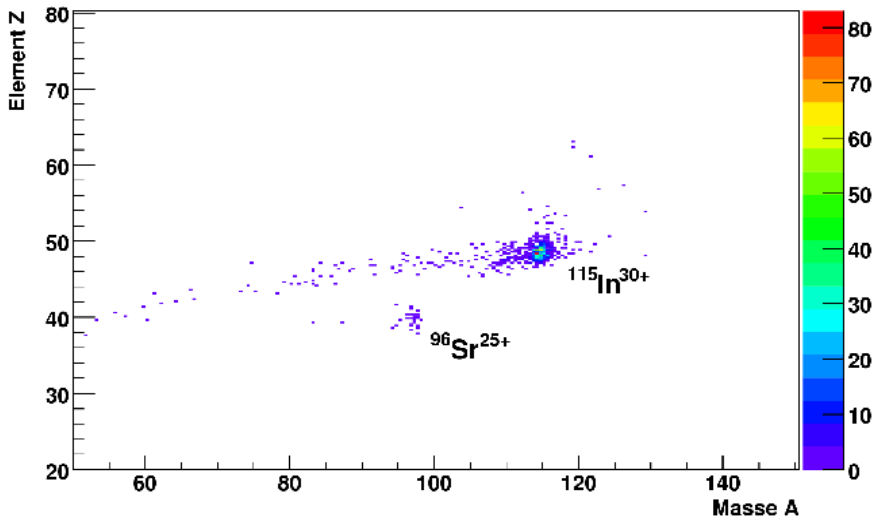
Entrance

A/Q beam test

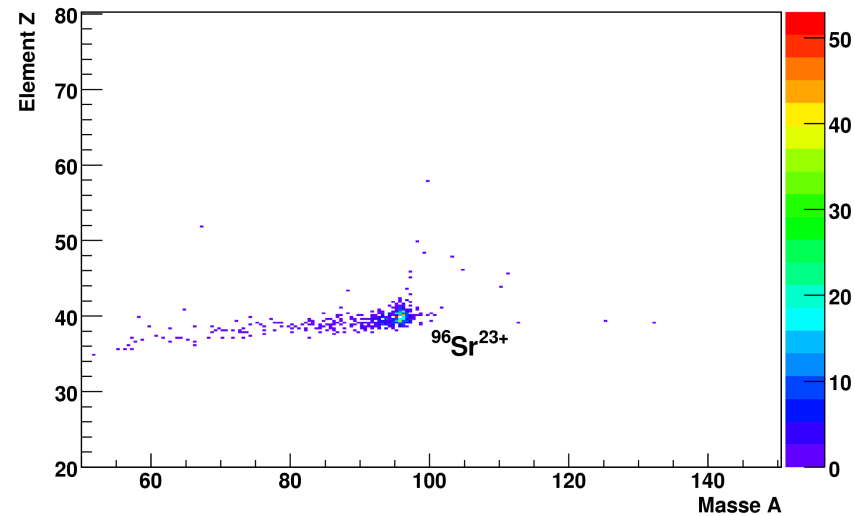


Beam composition in the IS451 run

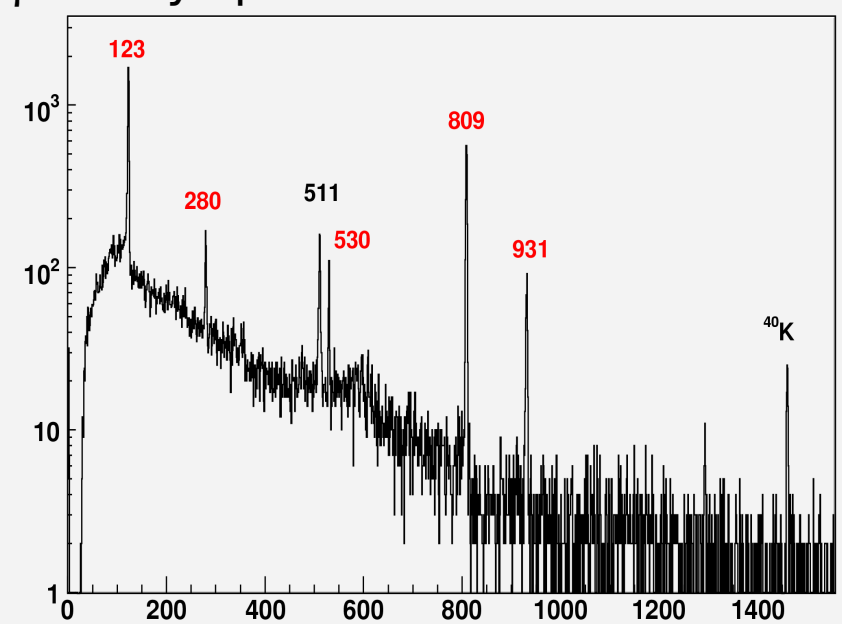
A/Q = 3.84 in REX



A/Q=4.17



β decay spectrum at Miniball



The weakness of beam is compensated by a pure radioactive beam :

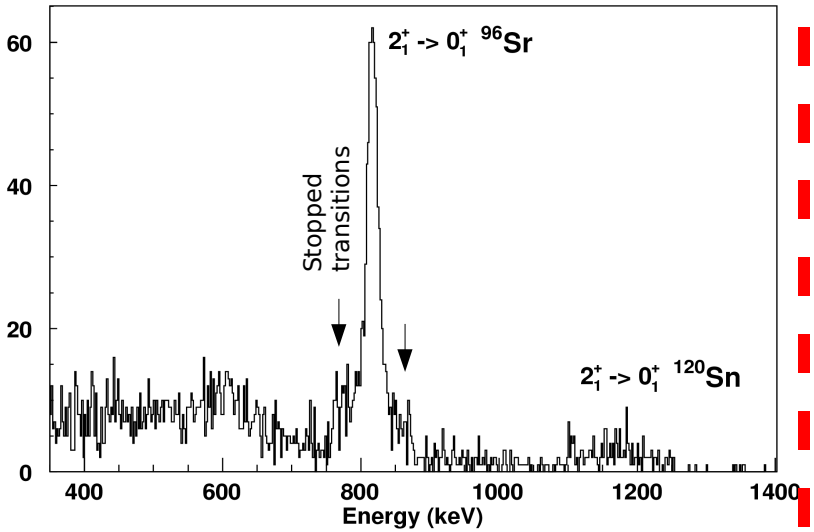
-> No systematic error due to the beam composition in the normalization by the target excitation

Coulomb excitation of ^{96}Sr

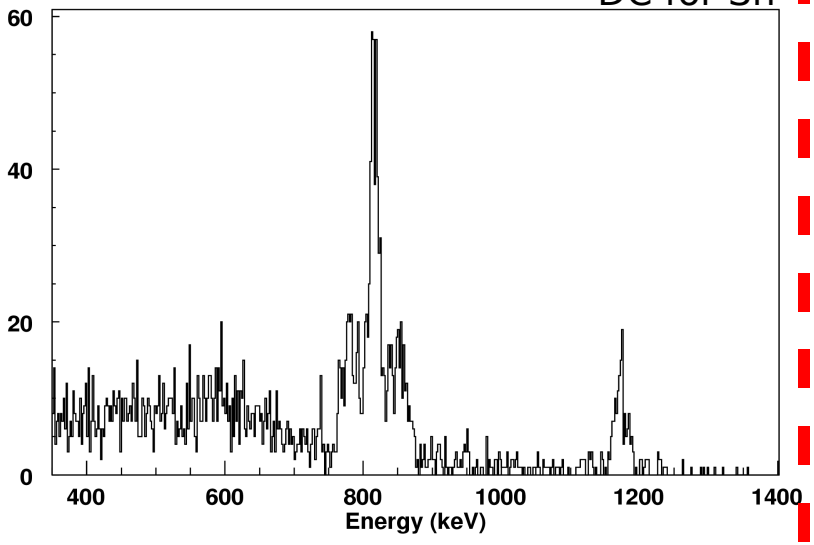
Preliminary spectra

Sn target

DC for Sr

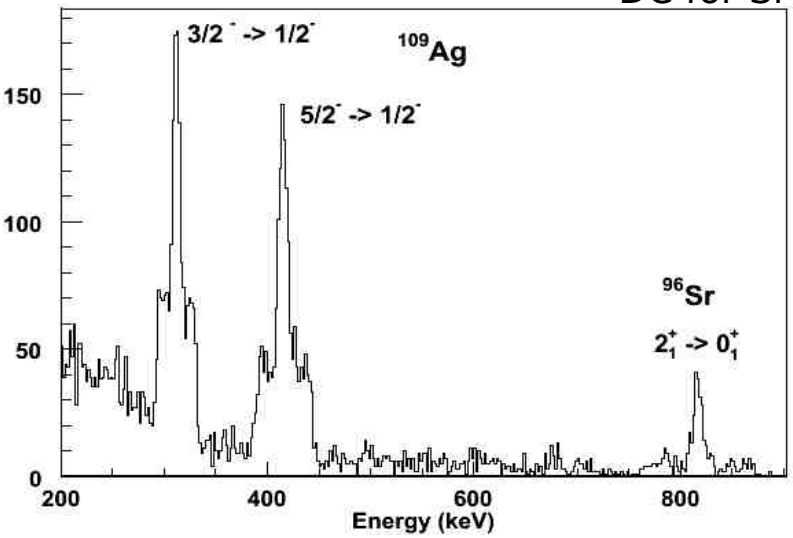


DC for Sn

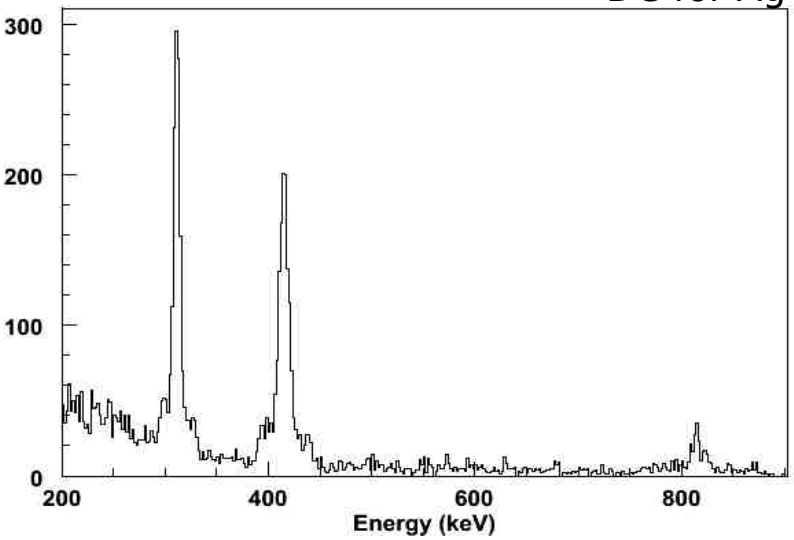


Ag target

DC for Sr

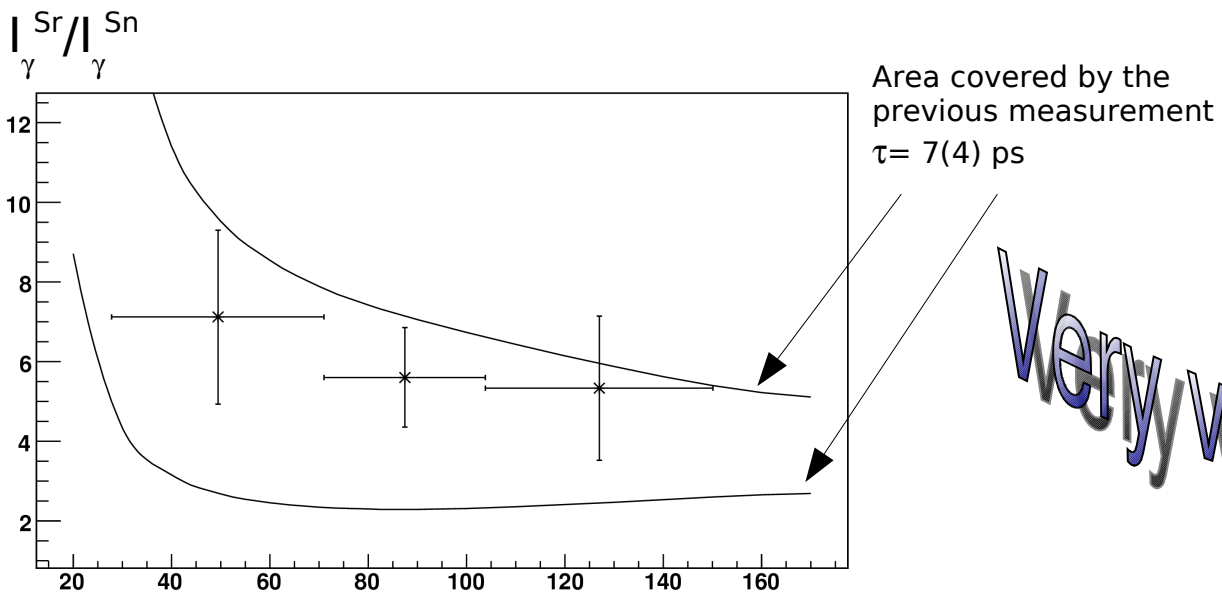


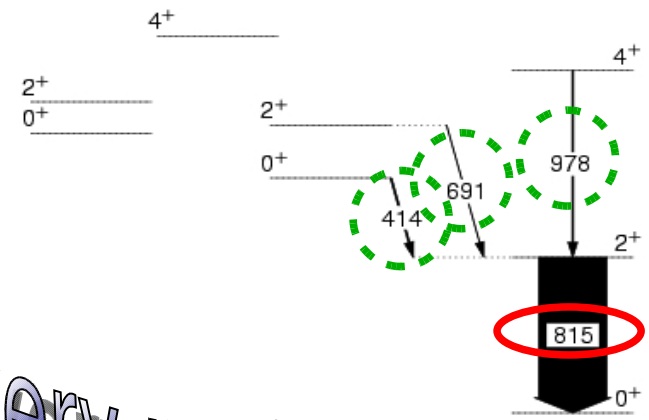
DC for Ag



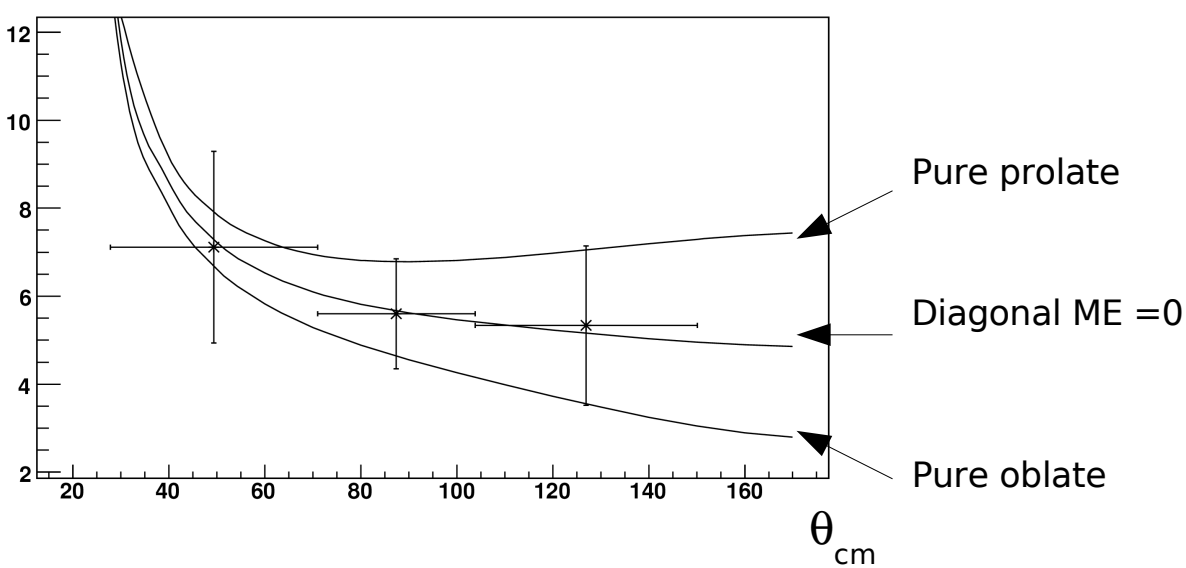
Matrix element extraction

Ag and Sn target : differential cross section measurement





Very very preliminary



- No other gamma lines observed -> Still an information !
- Known spectroscopic informations
- Simultaneous minimization in the coulex analysis of the Ag and the Sn data (errors, influence of others states, Q_s ...)

Conclusion (of the proposal ....)

Coulomb excitation at low energy offers an unique opportunity to understand the complex scenario of shape coexistence in Sr isotopes

- Improvement of the B(E2,2^+_1 → 0^+_1) value
- ~~Measure of the B(E2) related to the $0^+_{2,3}$ and $2^+_{2,3}$ states~~
- Measure of the diagonal matrix element of the 2^+_1 state
- ~~Measure of the diagonal matrix elements of the 2^+_2 and 2^+_3 states~~

Collaboration

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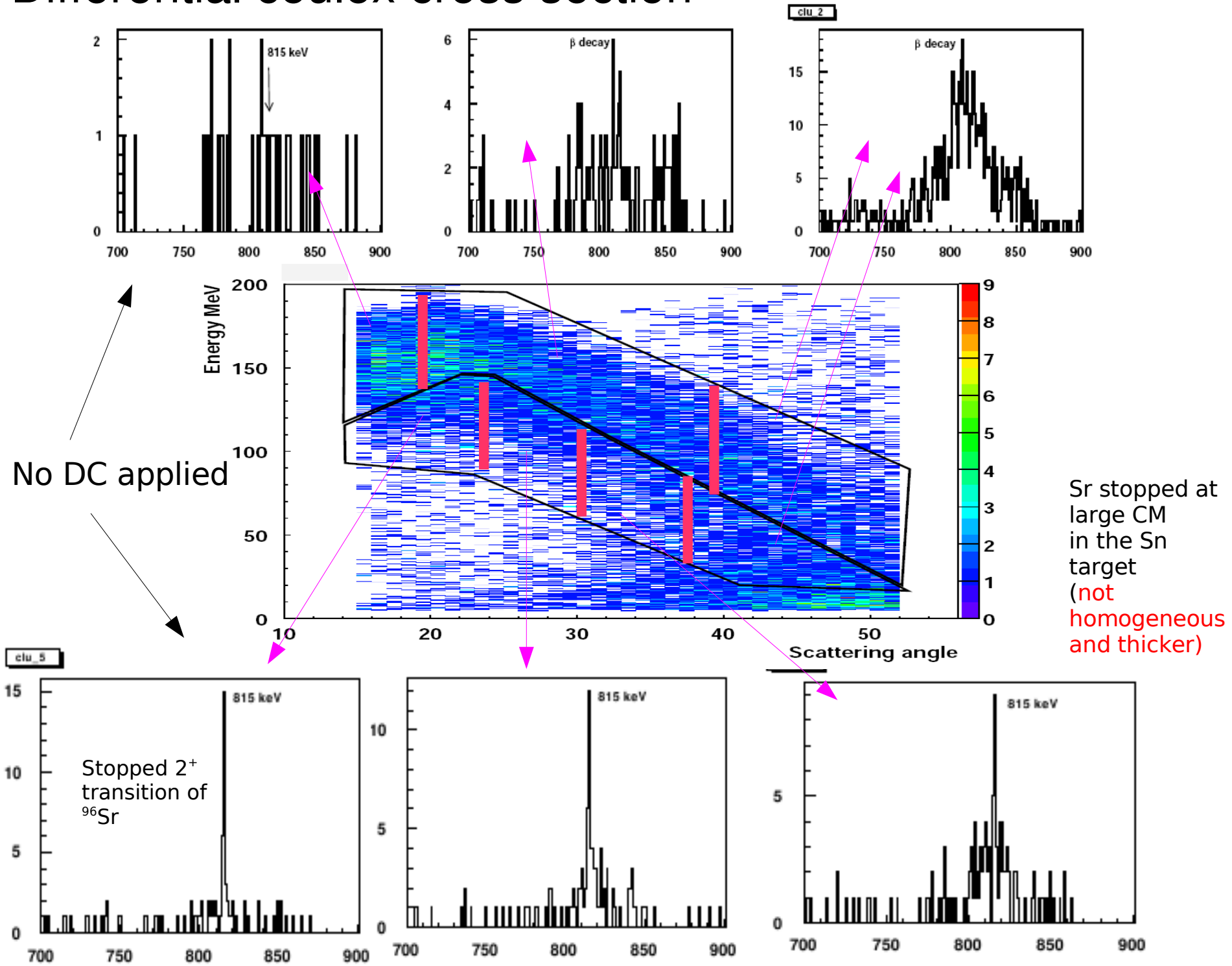
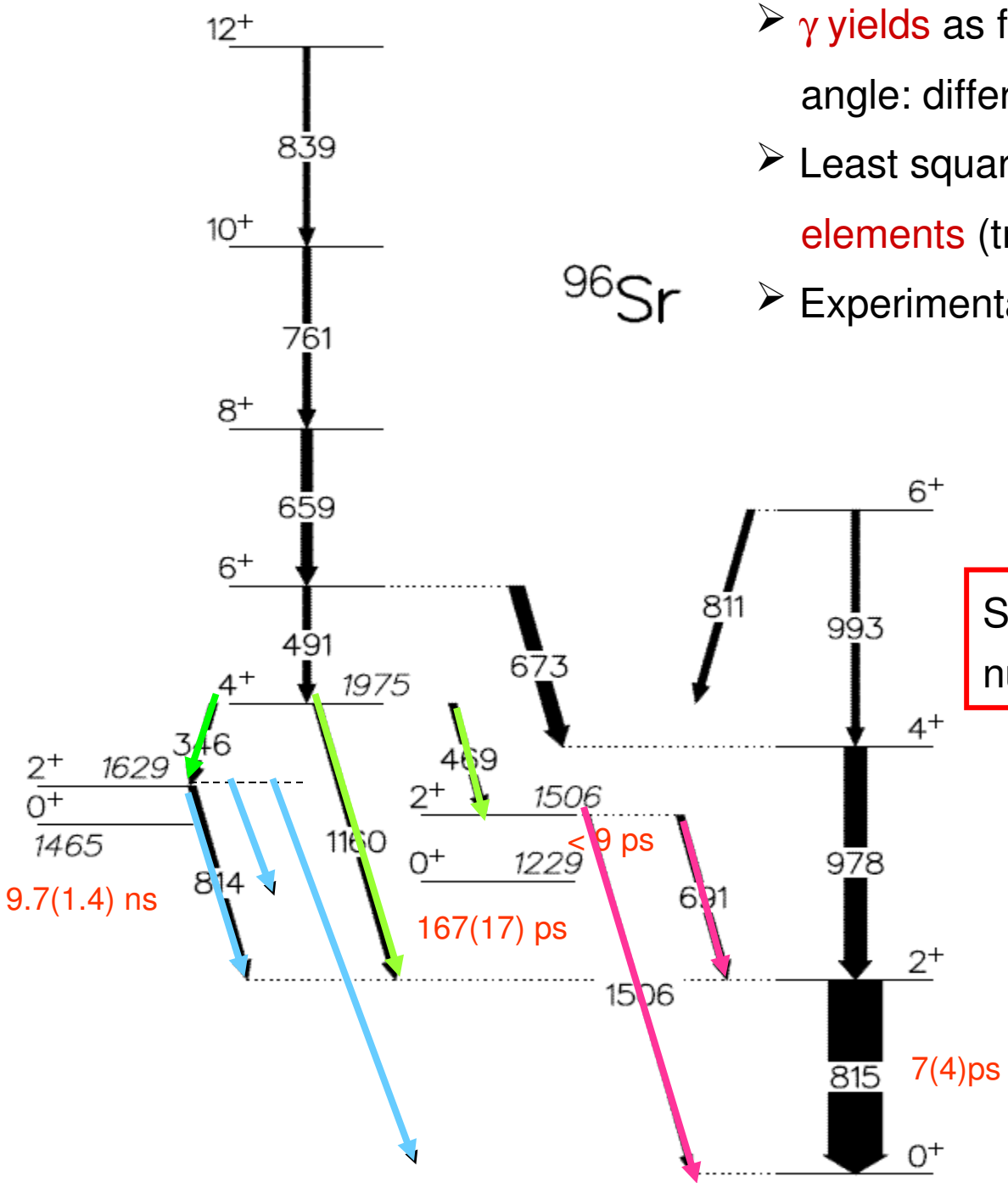
Differential coulex cross section



Coulomb excitation analysis : GOSIA*

*D. Cline, C.Y. Wu, T. Czosnyka; Univ. of Rochester

- γ yields as function of scattering angle: differential cross section
- Least squares fit of matrix elements (transitional and diagonal)
- Experimental spectroscopic data
  - Lifetimes
  - Branching ratios



Spectroscopic data limit the number of degrees of freedom