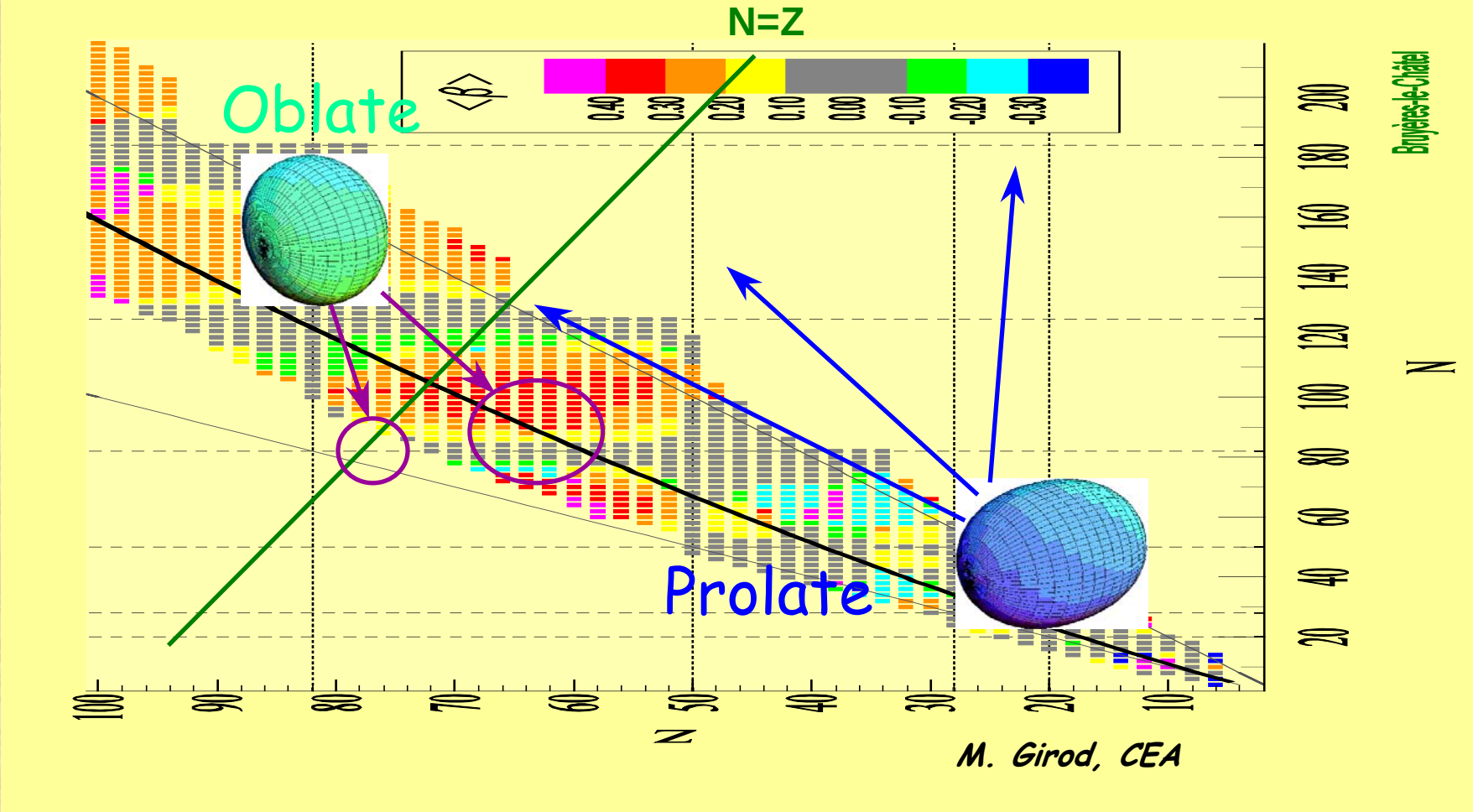
Shape coexistence in light Krypton isotopes studied through Coulomb excitation of radioactive beams

- Introduction : Shape coexistence
- Isomer spectroscopy after fragmentation
- Low-energy Coulomb excitation of ISOL beams
- Intermediate-energy Coulomb excitation of fragmentation beams
- Conclusions

Andreas Görgen
DAPNIA/SPhN/γ,
CEA Saclay, France

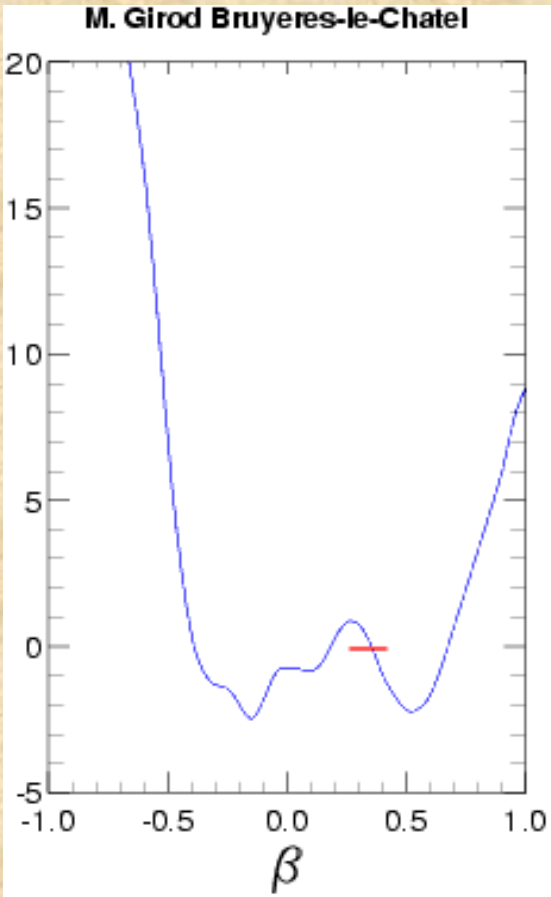
DSM - DAPNIA
Service de Physique Nucléaire
cea

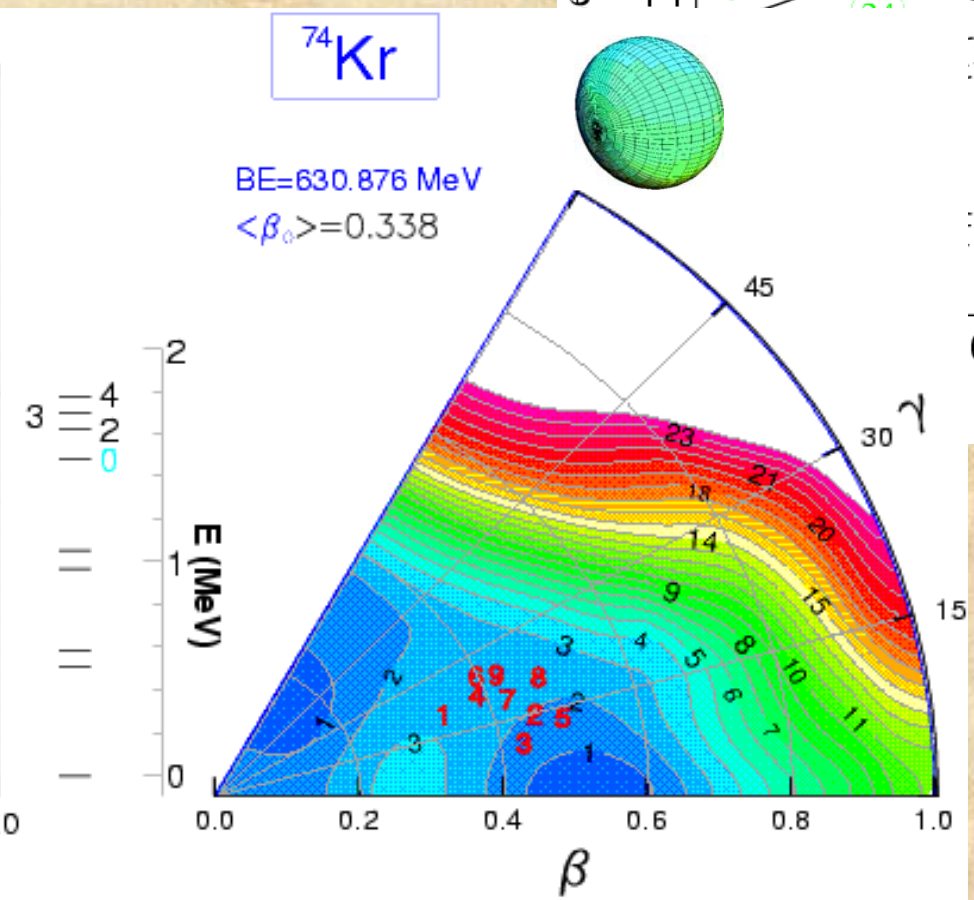
Nuclear shapes and shape coexistence

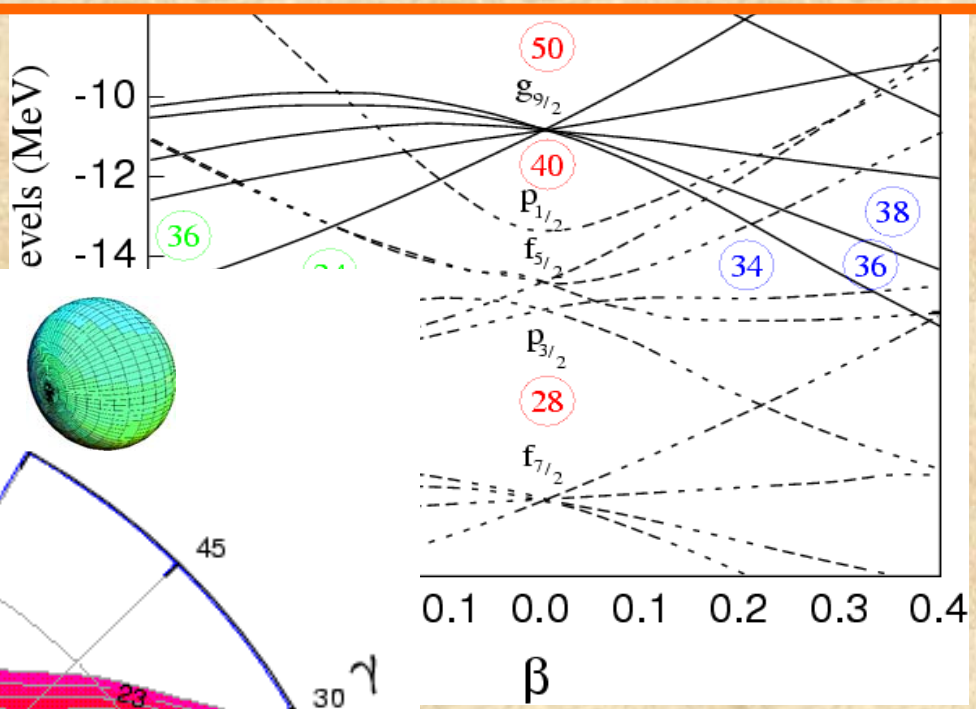


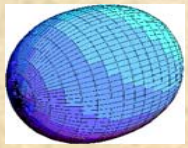
N~Z nuclei at A~ 70 show pronounced oblate minima

Shape coexistence in the light Kr isotopes









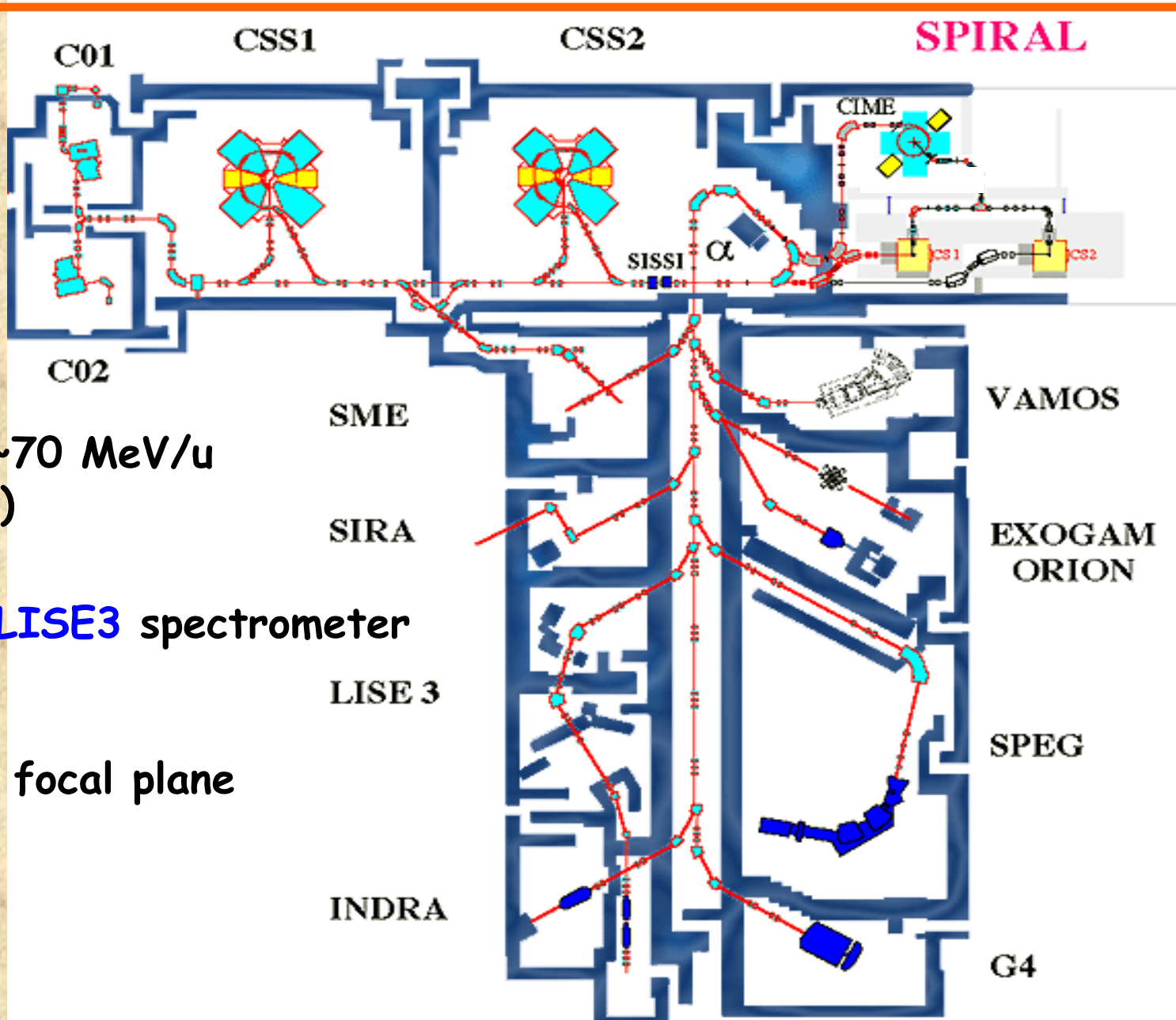
→ Possible 0^+ isomers and configuration mixing

Shape coexistence in light Krypton isotopes studied through Coulomb excitation of radioactive beams

- Introduction : Shape coexistence
- Isomer spectroscopy after fragmentation
- Low-energy Coulomb excitation of ISOL beams
- Intermediate-energy Coulomb excitation of fragmentation beams
- Conclusions

DSM - DAPNIA
Service de Physique Nucléaire
cea

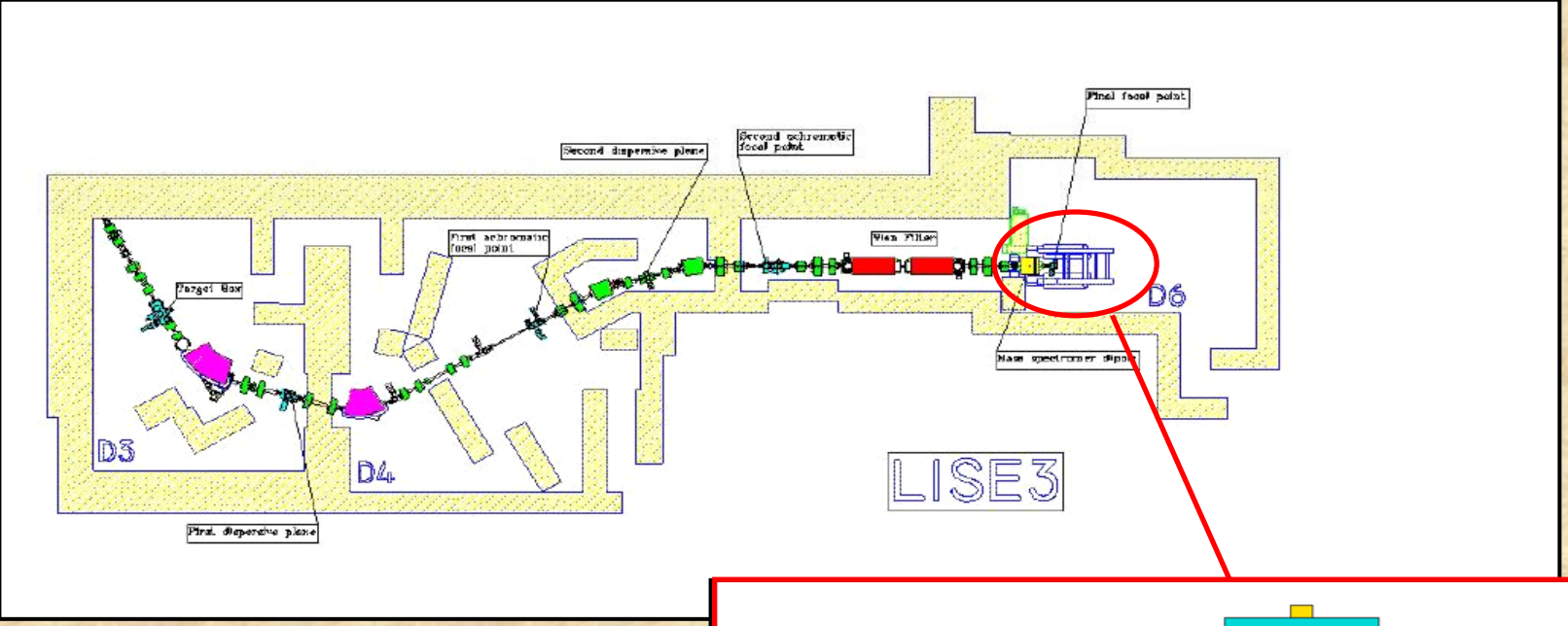
GANIL (Grand Accelerateur National d'Ions Lourds)

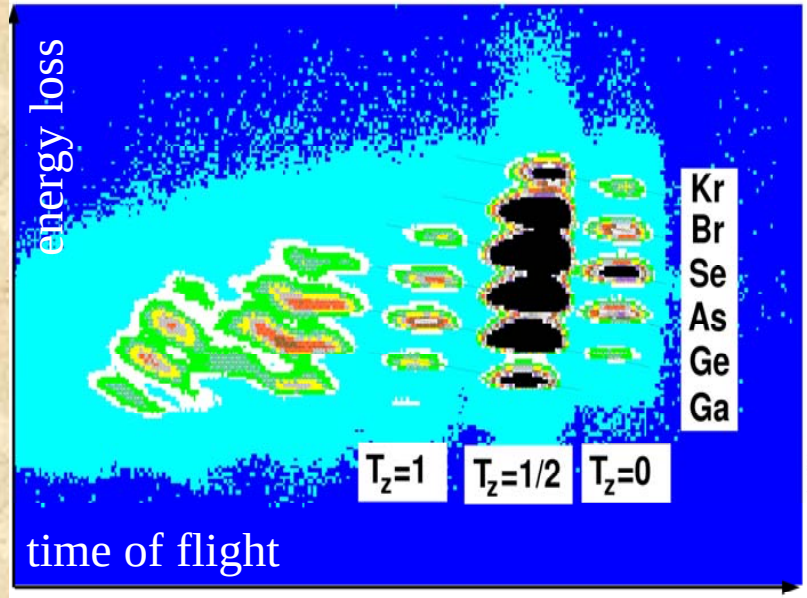


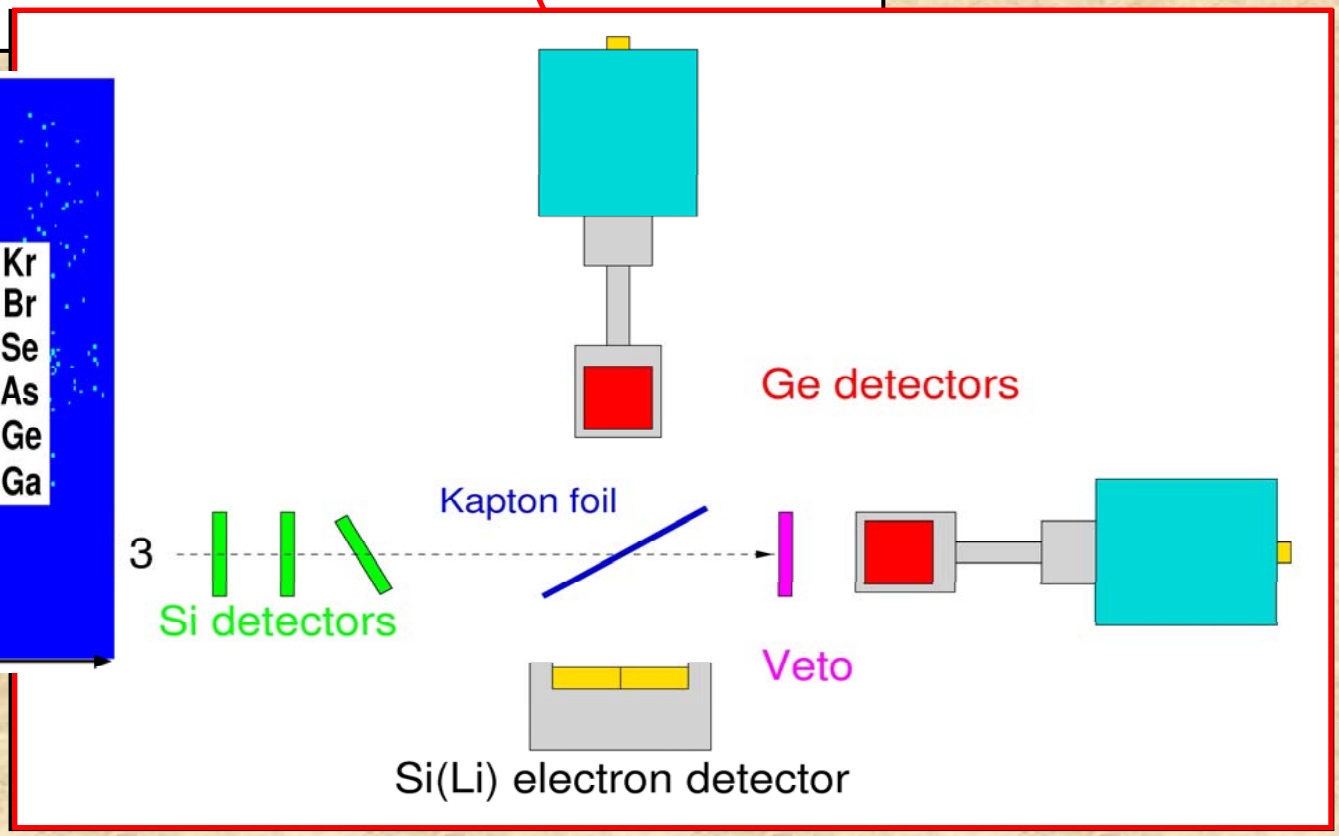
Fragmentation of a ~70 MeV/u
^{78}Kr beam (~10^{12} pps)

Separation with the **LISE3** spectrometer

Identification at the focal plane


Final focal point
Second dispersive plane
Second achromatic focal point
First achromatic focal point
Wien Filter
Target Box
D3
D4
D6
Mass spectrometer dipole
First dispersive plane
LISE3

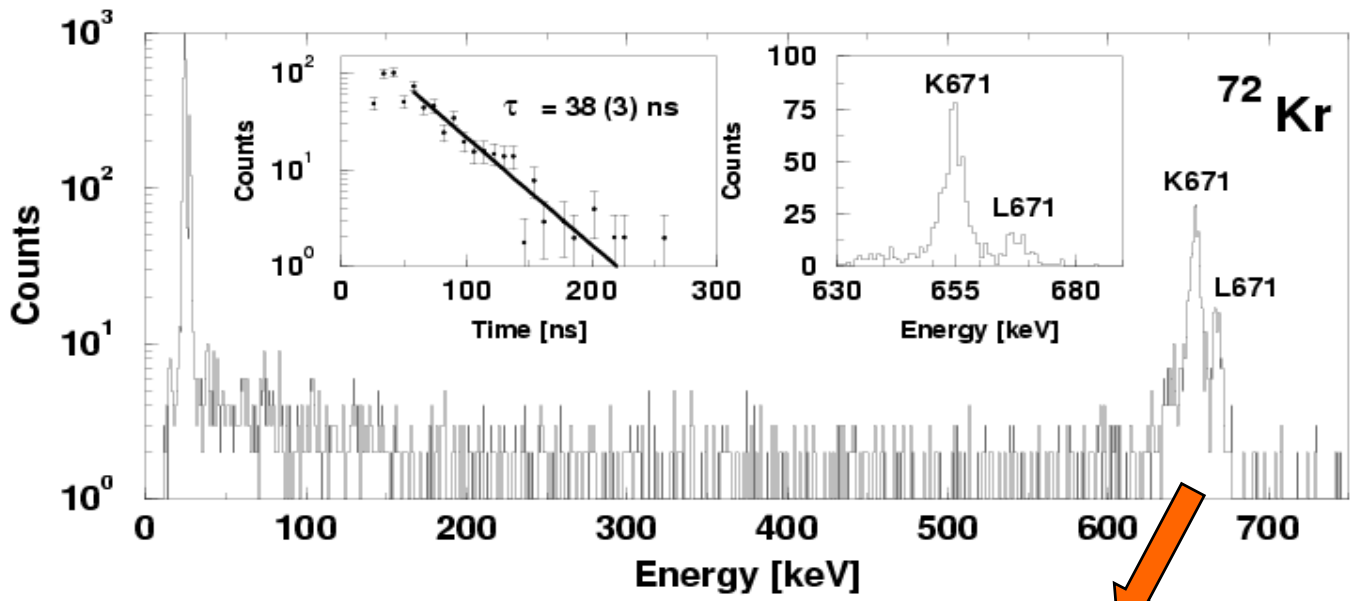

energy loss
Kr
Br
Se
As
Ge
Ga
T_z=1
T_z=1/2
T_z=0
time of flight


Ge detectors
Kapton foil
3
Si detectors
Veto
Si(Li) electron detector

Observation of a "shape isomer" in ^{72}Kr

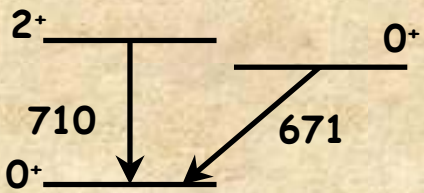
CE spectrum in coincidence with ^{72}Kr fragments

~2 ^{72}Kr ions/sec, isomer ratio 6(2)%



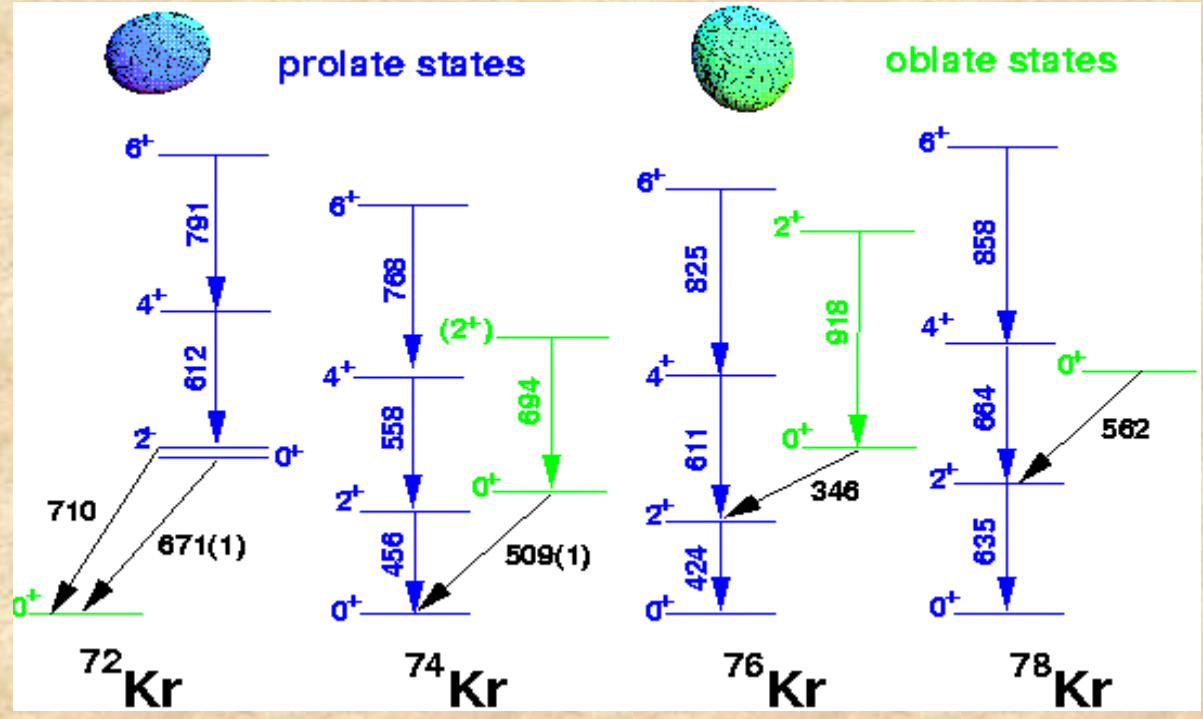
$\rho^2(0^+ \rightarrow 0^+)$ ~ 70 m.u

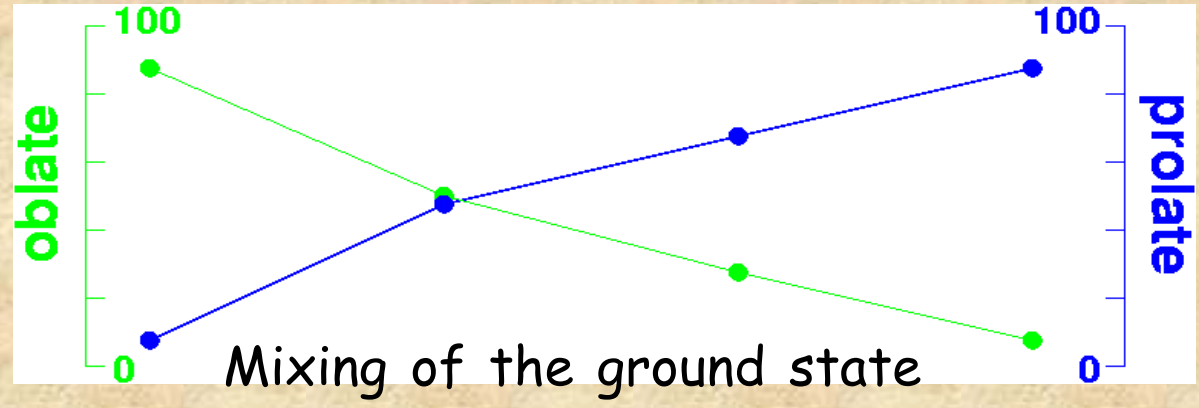
New excited 0^+ state in ^{72}Kr



non-negligible influence on rp process

Shape mixing properties of Kr isotopes





- Inversion of ground state shape for ^{72}Kr
- Coulomb excitation to determine the nuclear shapes

E. Bouchez et al.,
Phys. Rev. Lett. 90, 082502 (2003)

Shape coexistence in light Krypton isotopes studied through Coulomb excitation of radioactive beams

- Introduction : Shape coexistence
- Isomer spectroscopy after fragmentation
- Low-energy Coulomb excitation of ISOL beams
- Intermediate-energy Coulomb excitation of fragmentation beams
- Conclusions

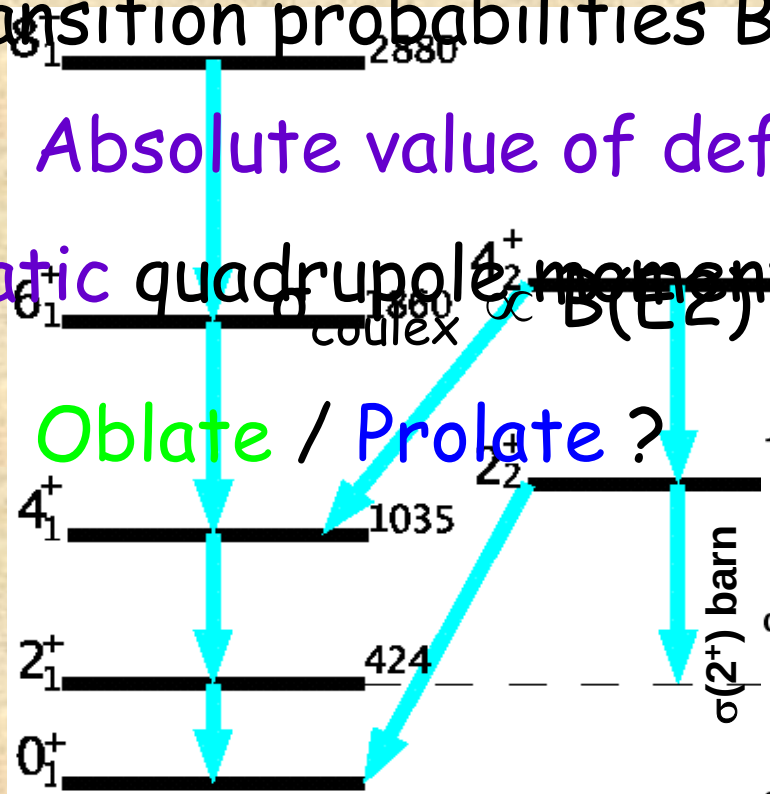
DSM - DAPNIA
Service de Physique Nucléaire
cea

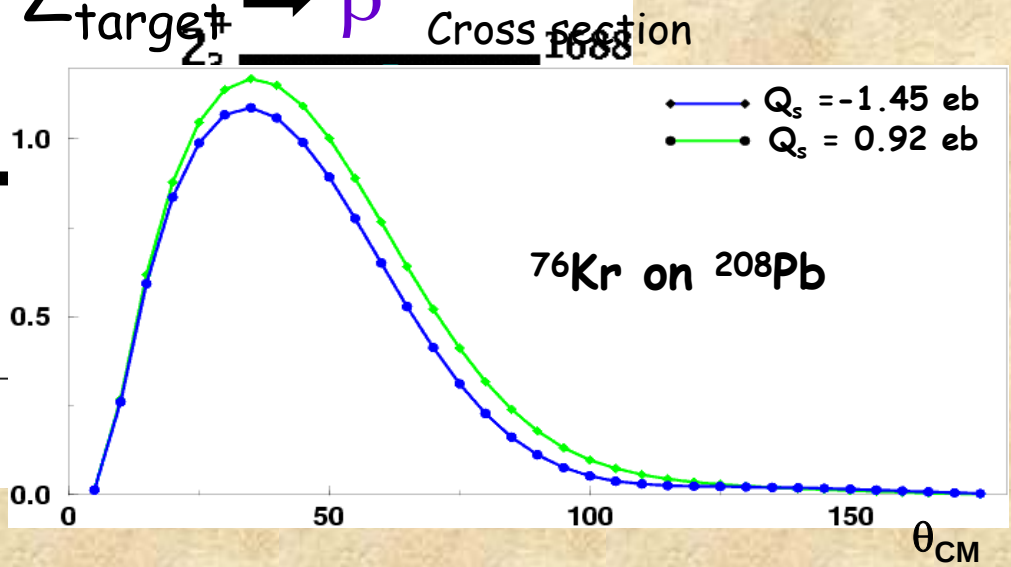
Coulomb excitation : the method

- Collective states : yrast and non-yrast
  - Multiple excitations
- Transition probabilities B(E2)
  - Absolute value of deformation
- Static quadrupole moments
  - Oblate / Prolate ?

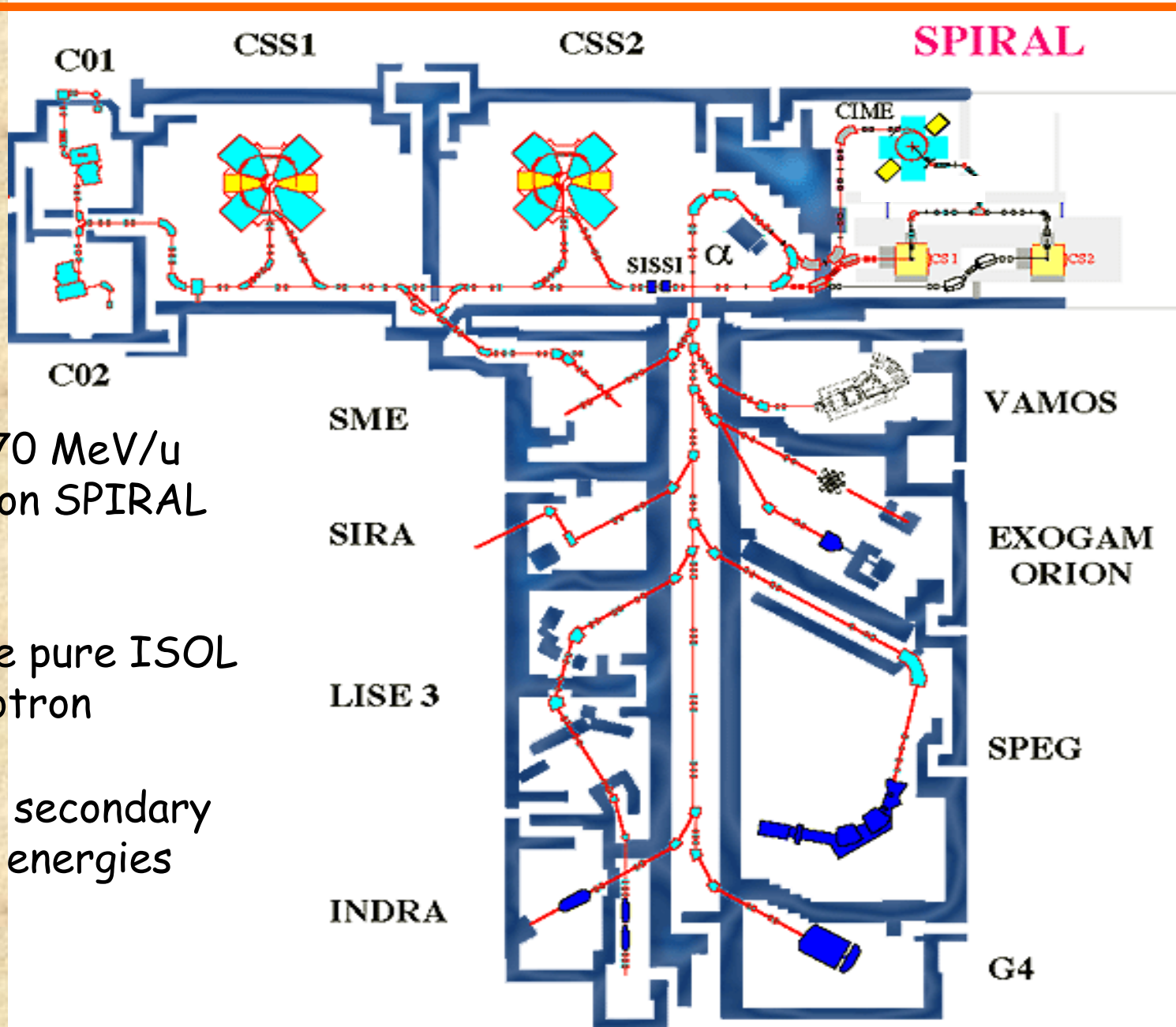
^{76}Kr

$\sigma_{coulex} \propto B(E2)\, Z_{target}^2 \rightarrow \beta^2$





GANIL

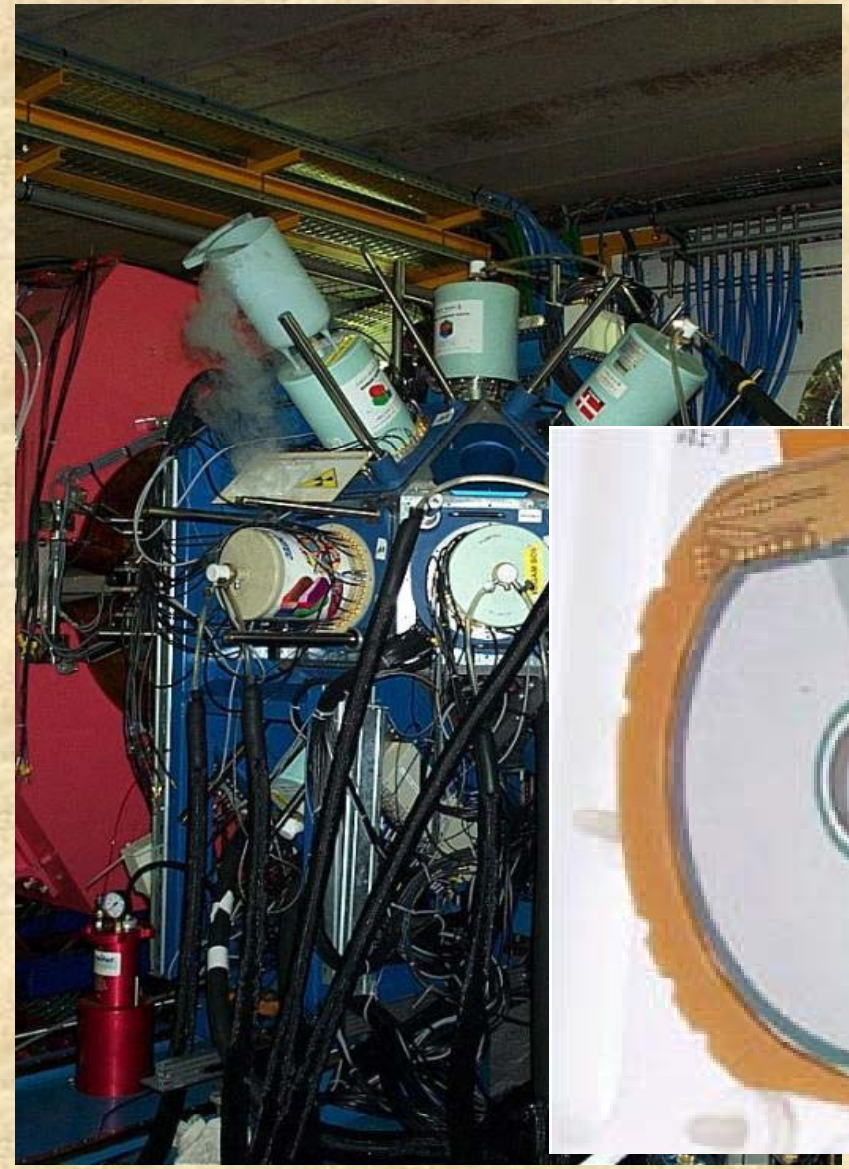


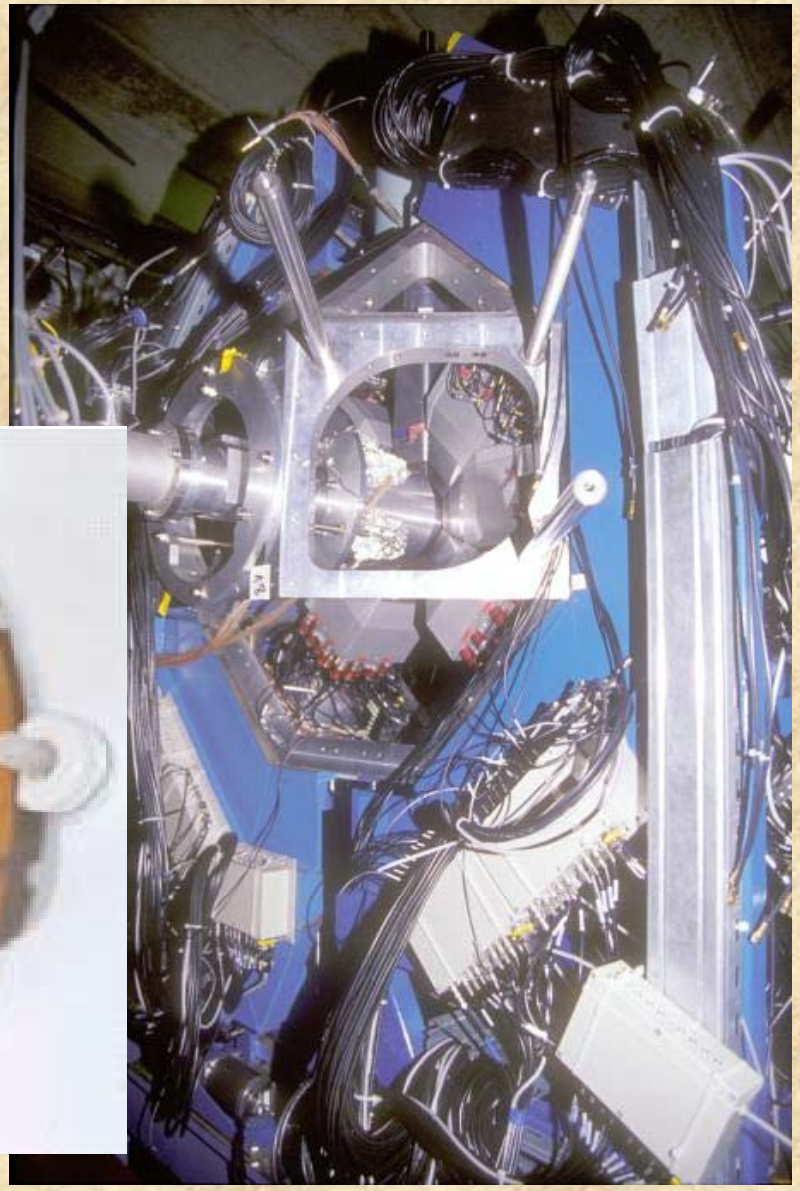
Fragmentation of a ~70 MeV/u ^{78}Kr beam (~10^{12} pps) on SPIRAL target

Re-acceleration of the pure ISOL beam with CIME cyclotron

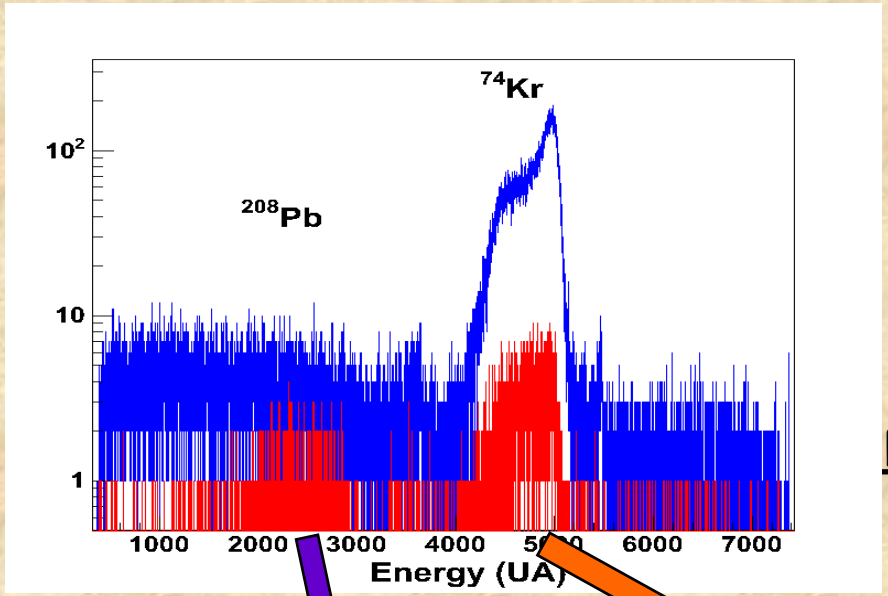
Coulomb excitation on secondary target at sub-barrier energies

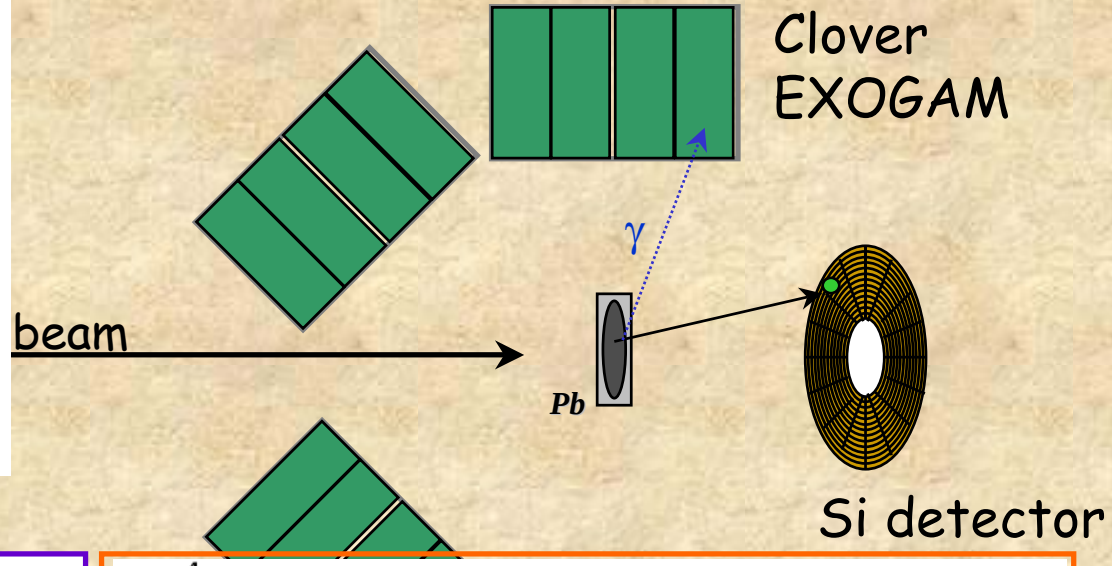
Experimental set-up

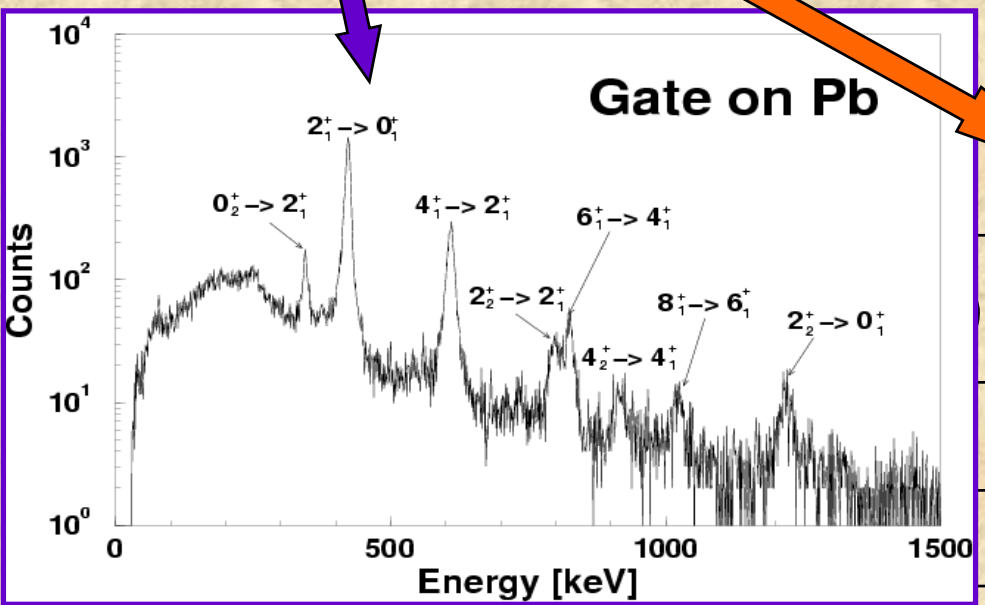


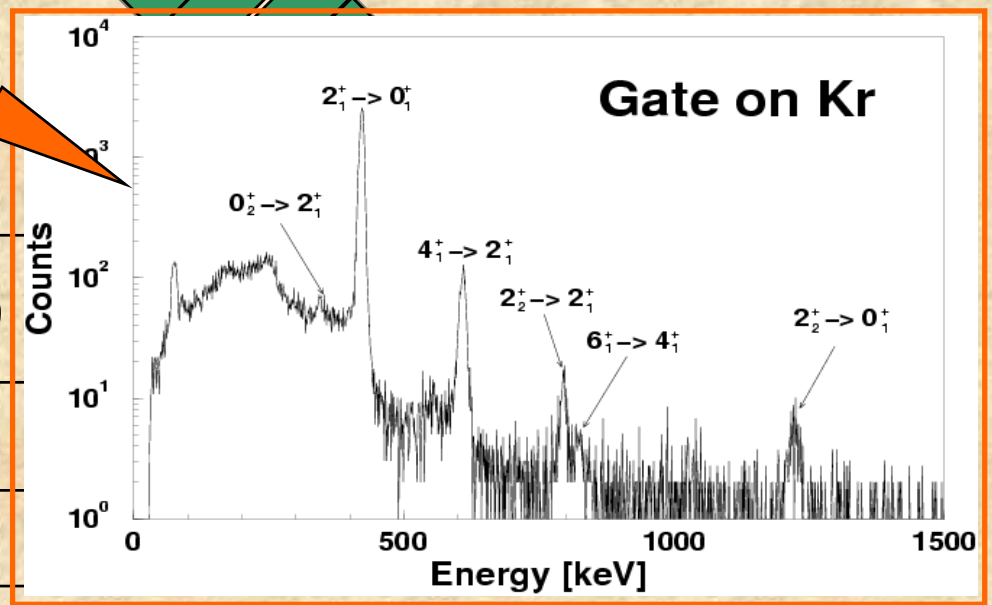


Experimental set-up





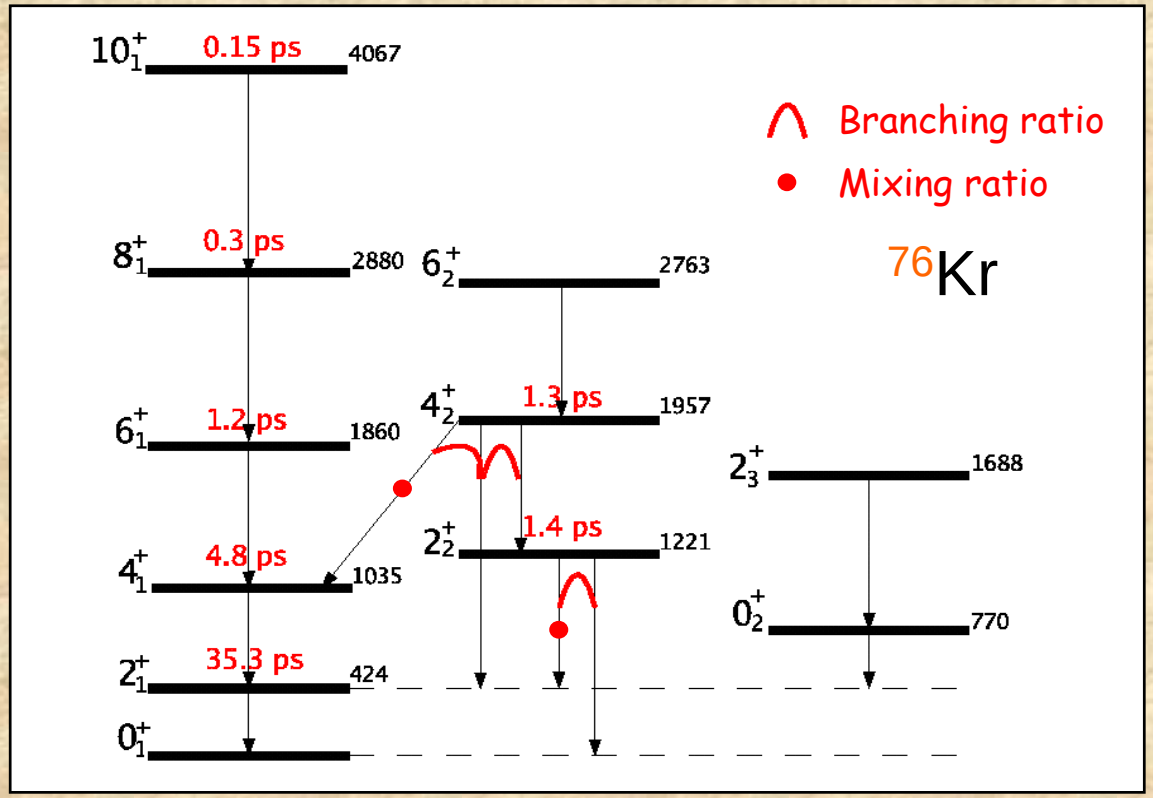




Calculations using the GOSIA code

T. Czosnyka, D. Cline and C.Y. Wu

- γ-yields for several CM scattering angles
  - two different targets in the ^{76}Kr case: ^{208}Pb, ^{48}Ti
- Known spectroscopic data
  - Lifetimes
  - Branching ratios
  - Mixing ratios



- least square fit of ~30 matrix elements

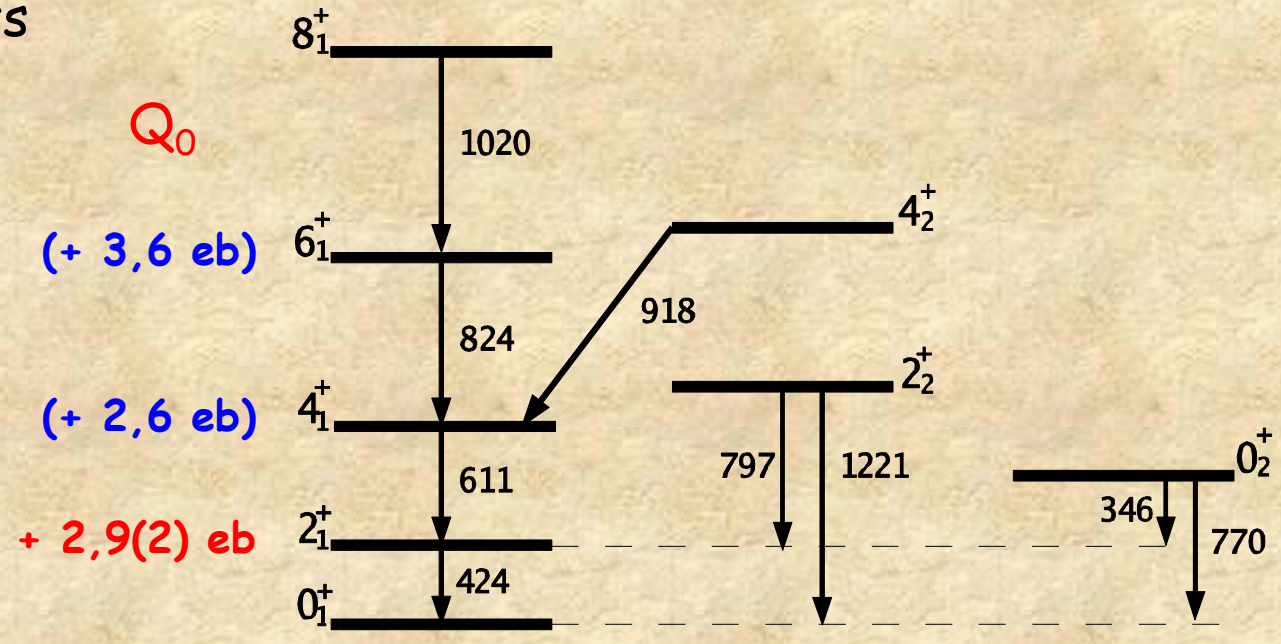
Quadrupole moments in ^{76}Kr

E. Bouchez, PhD thesis 2003

- Transitional matrix elements
  - Significantly improved precision on B(E2) values
  - Constant (absolute) value of the quadrupole moment : Q_t~ 2.8 eb

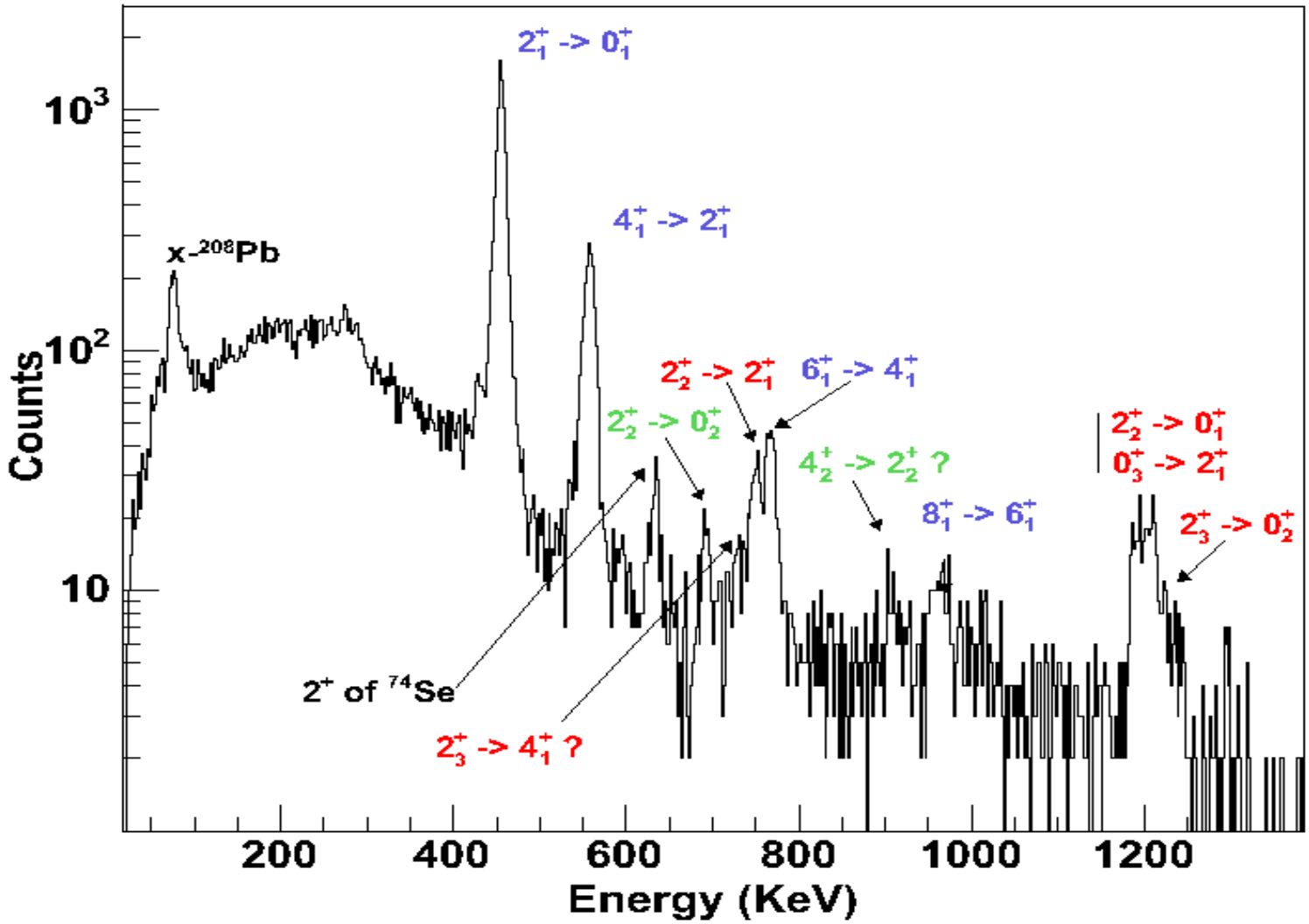
- Diagonal matrix elements

prolate deformation
β ~ + 0.38



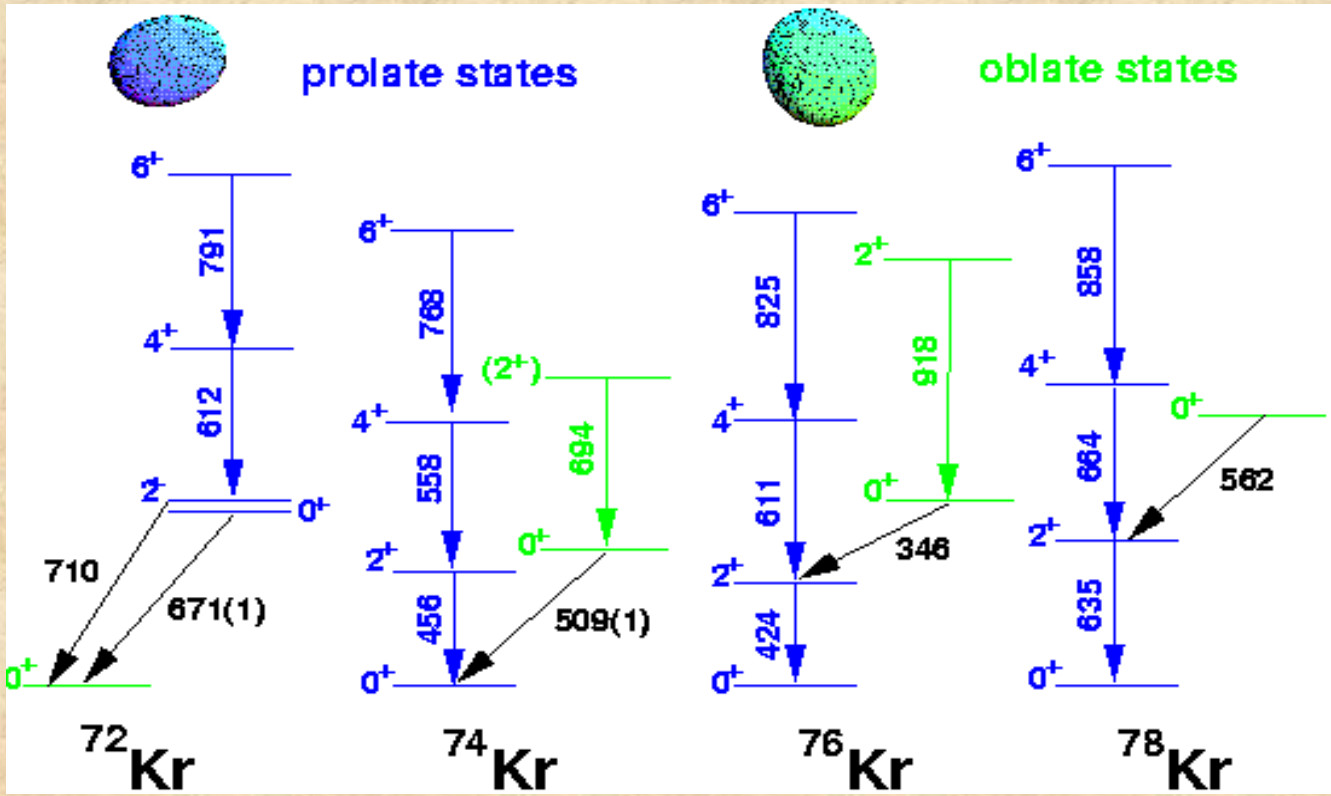
First reorientation measurement with a radioactive beam

Static quadrupole moments in ^{74}Kr (preliminary)



Bu

The next step: ^{72}Kr



intensity of (re-accelerated) ^{72}Kr SPIRAL beam is currently too low for low-energy Coulomb excitation

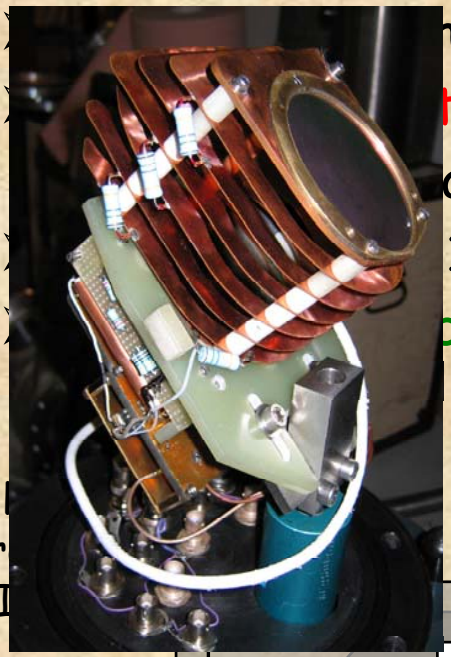
Shape coexistence in light Krypton isotopes studied through Coulomb excitation of radioactive beams

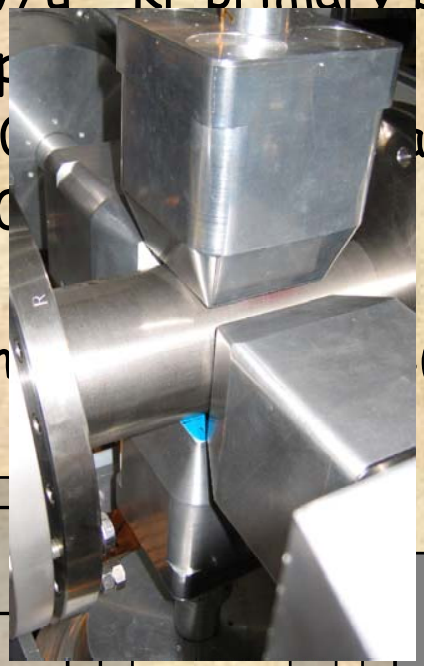
- Introduction : Shape coexistence
- Isomer spectroscopy after fragmentation
- Low-energy Coulomb excitation of ISOL beams
- Intermediate-energy Coulomb excitation of fragmentation beams
- Conclusions

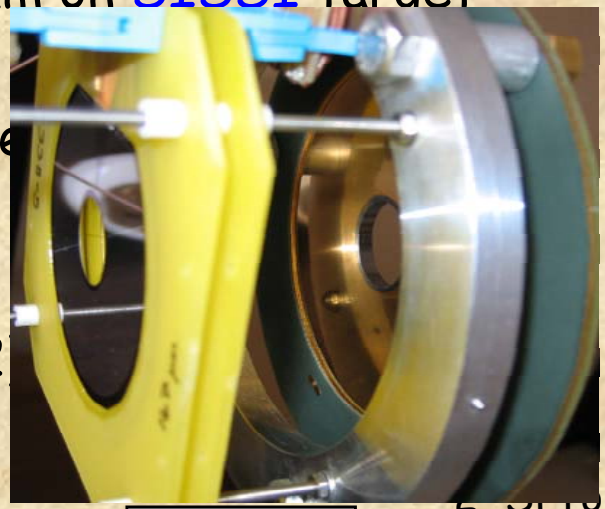
DSM - DAPNIA
Service de Physique Nucléaire
cea

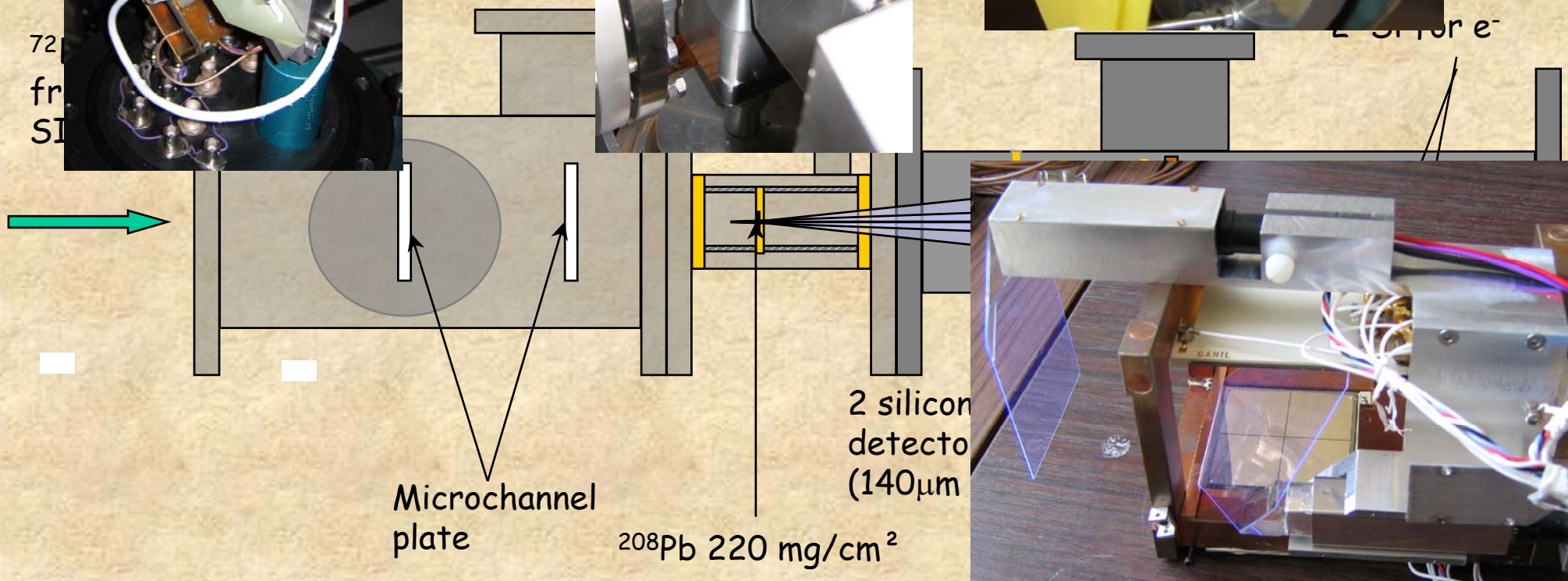
Intermediate-energy Coulomb excitation in ^{72}Kr

- Fragmentation of 70 MeV/u ^{78}Kr primary beam on SISSI target
- he LISE sp
- tion of ~50 agme
- arget: 220
- 100 pps
- plate 2$^+$ an (E2 2$^+$









Conclusions

- Isomer spectroscopy after fragmentation reactions
  - shape isomers in ^{72}Kr and ^{74}Kr
  - systematics in the chain of isotopes / mixing

- Low-energy Coulomb excitation of ISOL beams
  - transitional and static quadrupole moments in ^{74}Kr and ^{76}Kr
  - confirmation of shape coexistence scenario
  - feasible with ~ 10^4 pps

- Intermediate-energy Coulomb excitation of fragmentation beams
  - use of thick secondary target $\Rightarrow$ feasible with ~ 100 pps
  - attempt to measure oblate and prolate 2^+ in ^{72}Kr

Collaboration

Thesis works of Emmanuelle Bouchez and Emmanuel Clément at Saclay

- DAPNIA/SPhN, CEA Saclay
- GANIL, Caen
- IPN Orsay
- NBI Copenhagen
- Warsaw University
- GSI Darmstadt
- Univ. of Liverpool
- Univ. of Surrey
- CENBG Bordeaux
- IPN Lyon
- ISN Grenoble
- NIPNE Bucarest
- Univ. of Jyväskylä