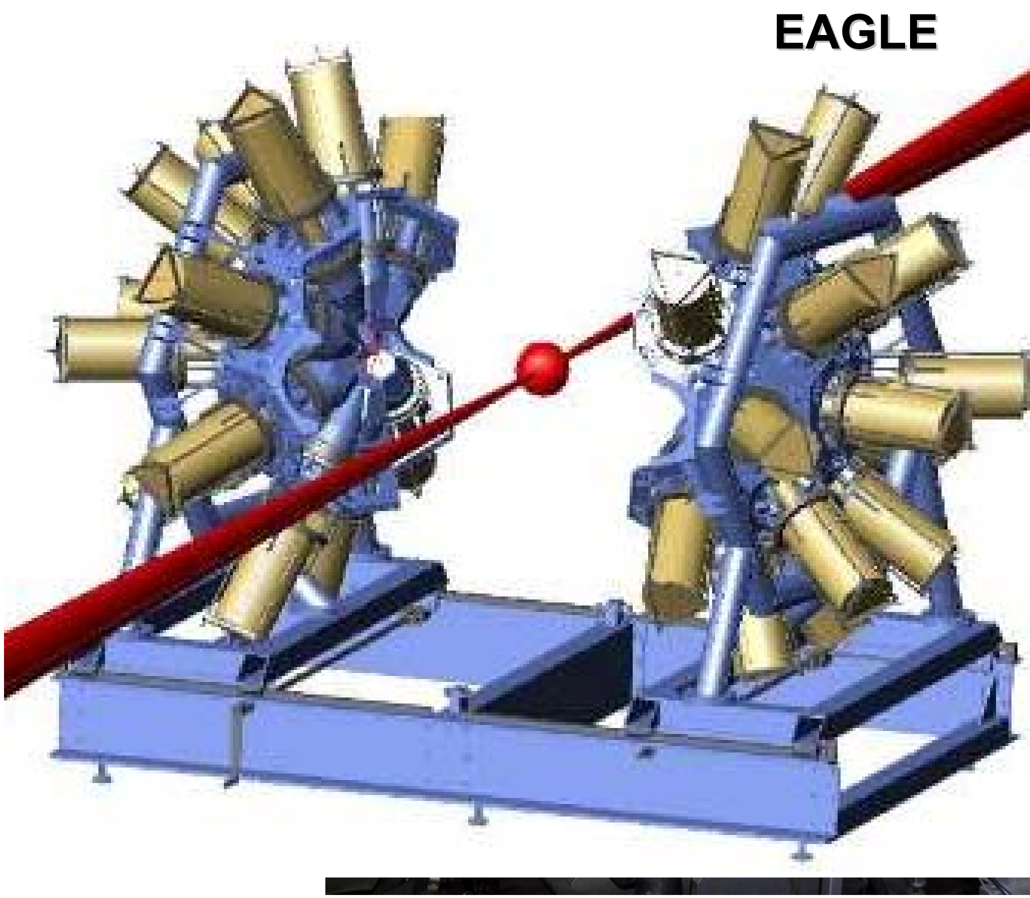
Scientific program of EAGLE campaign on beams of U200P cyclotron at Heavy Ion Laboratory, University of Warsaw

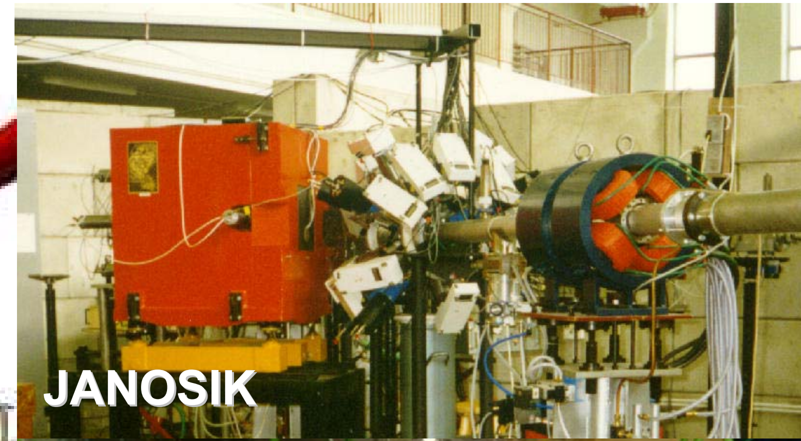
Julian Srebrny on behalf of the EAGLE collaboration

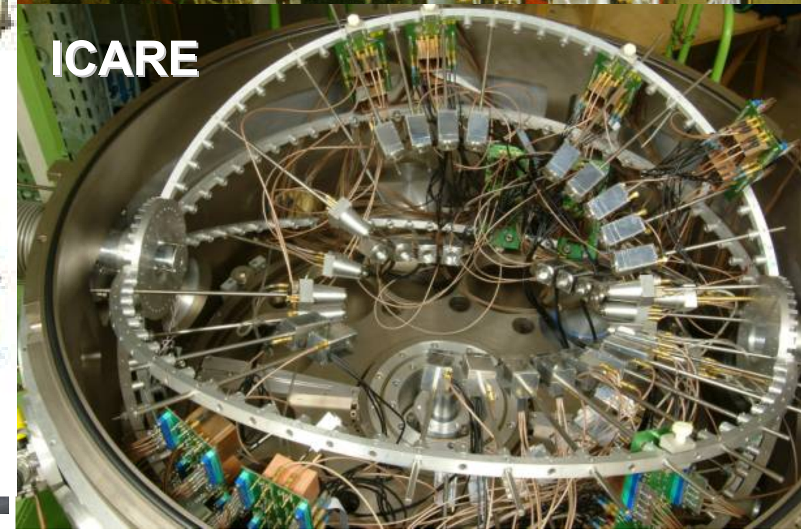
European GAMMAPOOL Workshop, Paris May 29, 2008

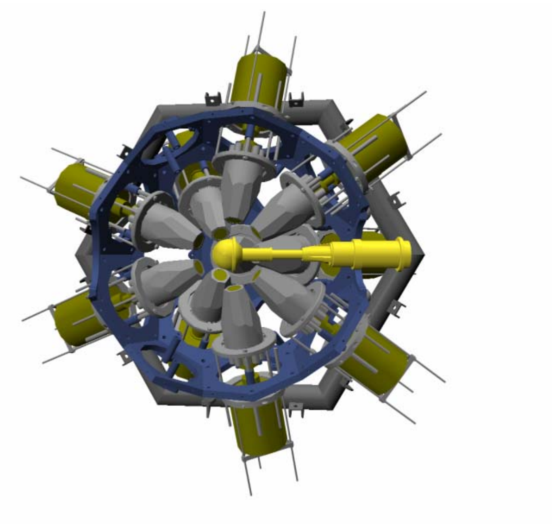
Heavy Ion Laboratory
University of Warsaw

Experimental Facilities @ HIL Experimental Hall







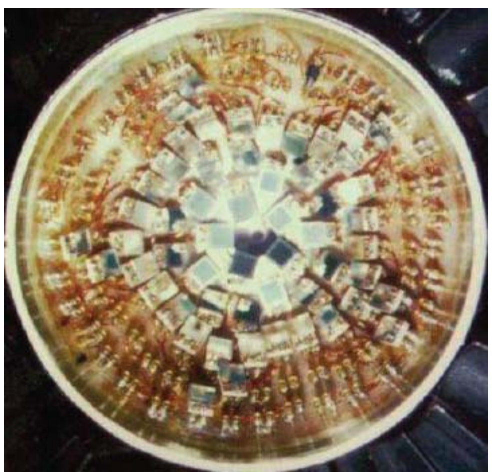


Shape dynamics and coexistence study by combining information from COULEX and DSAM or RDDSAM

Important for COULEX experiments performed with radioactive beams picoseconds lifetimes in the same nucleus studied on stable beams

Koln-Bucarest PLUNGER device (A. Dewald and V. Zamfir) coupled to the high-efficient multi Ge detector array

gamma-spectroscopy group from Saclay(DSM/DAPNIA/SPhN/Gamma)

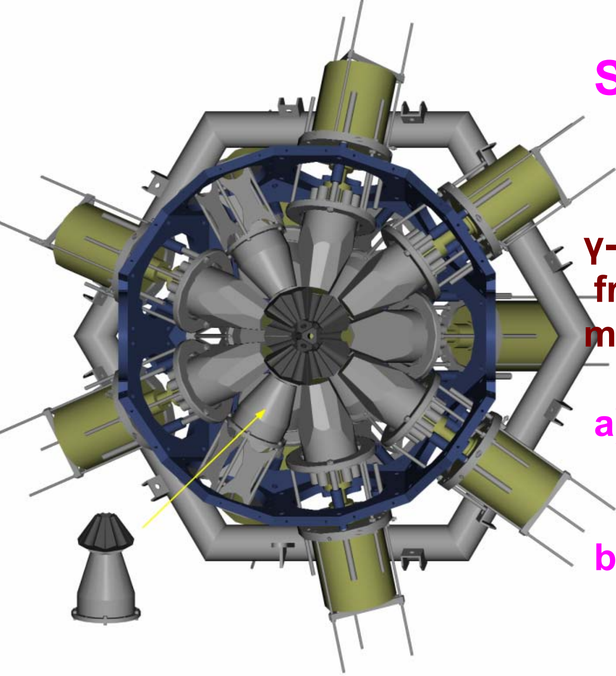


COULEX ^{40}**Ca beam on Ni and Pb target and**

DSAM and RDDSAM ^{12}**Ca (**^{32}**S, 2p2n)** ^{40}**Ca**

way to superdeformation in ^{40}**Ca and** ^{42}**Ca**

Rochester –Warsaw GOSIA training center in COULEX analysis and measurements



Study of the states populated after compound nucleus particle evaporation - entry state depopulation

γ-ray multiplicity and the sum energy in the continuum by BaF2 from the INNER BALL in coincidence with the discrete transitions, measured by Germanium detectors,

a) provide a crucial information about reaction mechanism as well as for the nuclear structure.

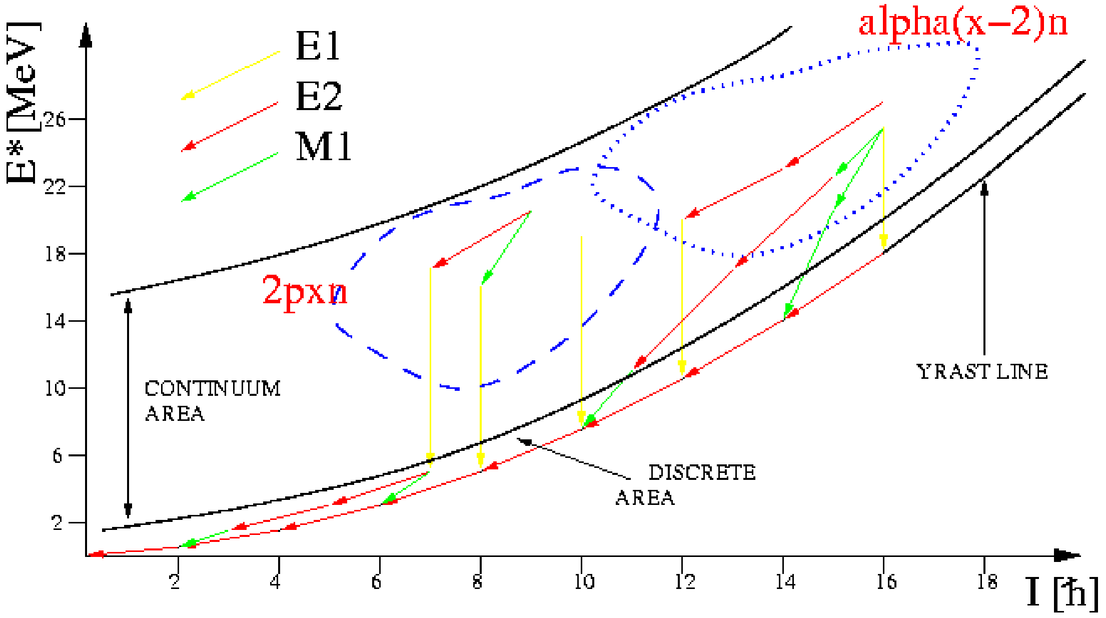
b) an important information needed for the test of the existing models (A.A. Pasternak et al. [1]) describing the side-feeding population of the discrete nuclear states.
such models are important for evaluation of picosecond lifetimes of weakly populated excited states, mainly in DSAM and RDDSAM

c) a good experimental basis in Warsaw for realization of the aims of the Electromagnetic Moments European Network (NEMO) and JRA-DAF proposal within I3-ENSAR.

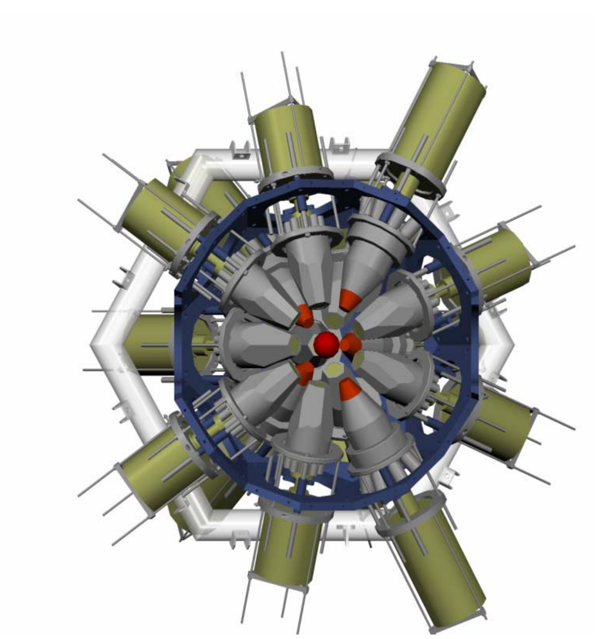
Entry state depopulation by γ-cascade

- sensitivity on the reaction mechanism

- sensitivity to side-feeding pattern[1]



[1] E. Grodner, A.A. Pasternak, Ch. Droste, T. Morek, J. Srebrny, J.Kownacki, W. Plociennik, A.A. Wasilewski, M. Kowalczyk, M. Kisielinski, R. Kaczarowski, E. Ruchowska, A. Kordyasz, and M. Wolinska *Lifetimes and side-feeding population of the yrast band levels in 131La* **Eur. Phys. J. A27 (2006) 325-340**

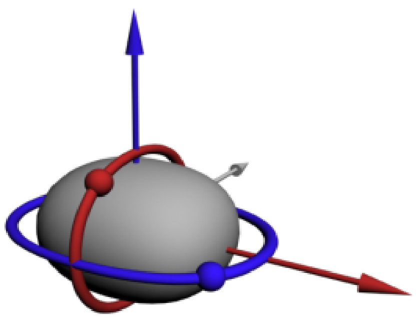


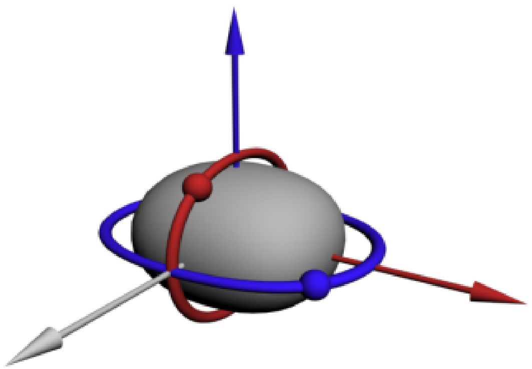
Experimental study of the nuclear chirality

three penpedicular angular momenta can form

right- or left-handed systems

for A ≈ 130   triaxial core, proton particle, neutron hole





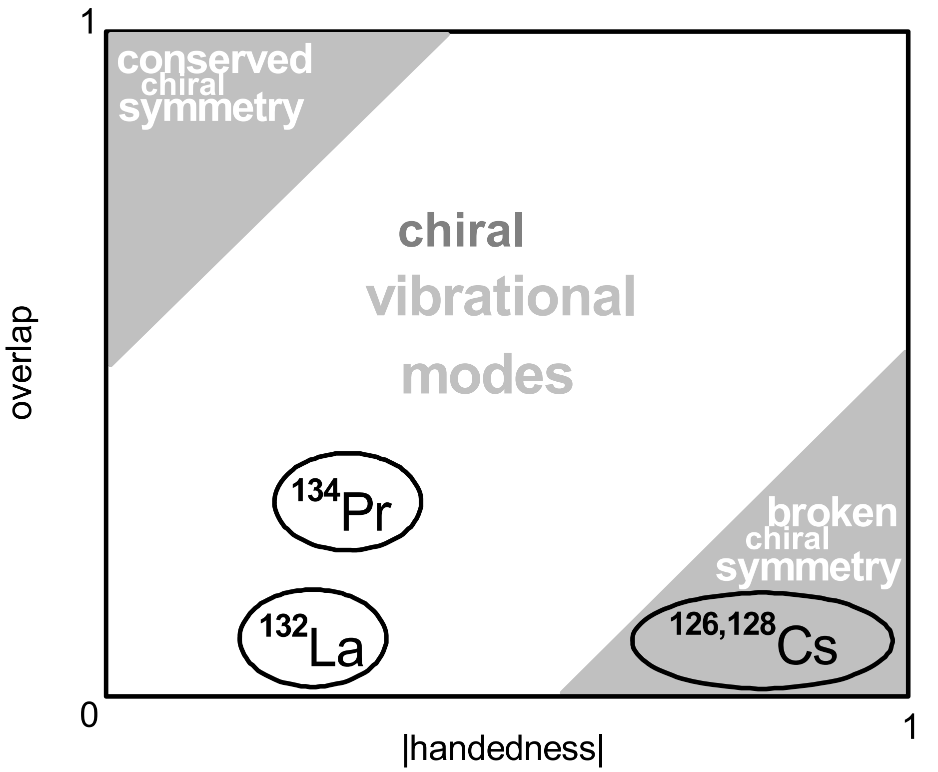
the search for such subsystems in atomic nuclei

about   15 cases in odd-odd nuclei can indicate such features:

two partner bands: levels with the same I^{π} nearly the same energy

qualitative clasification of chiral symmetry braking in atomic nuclei

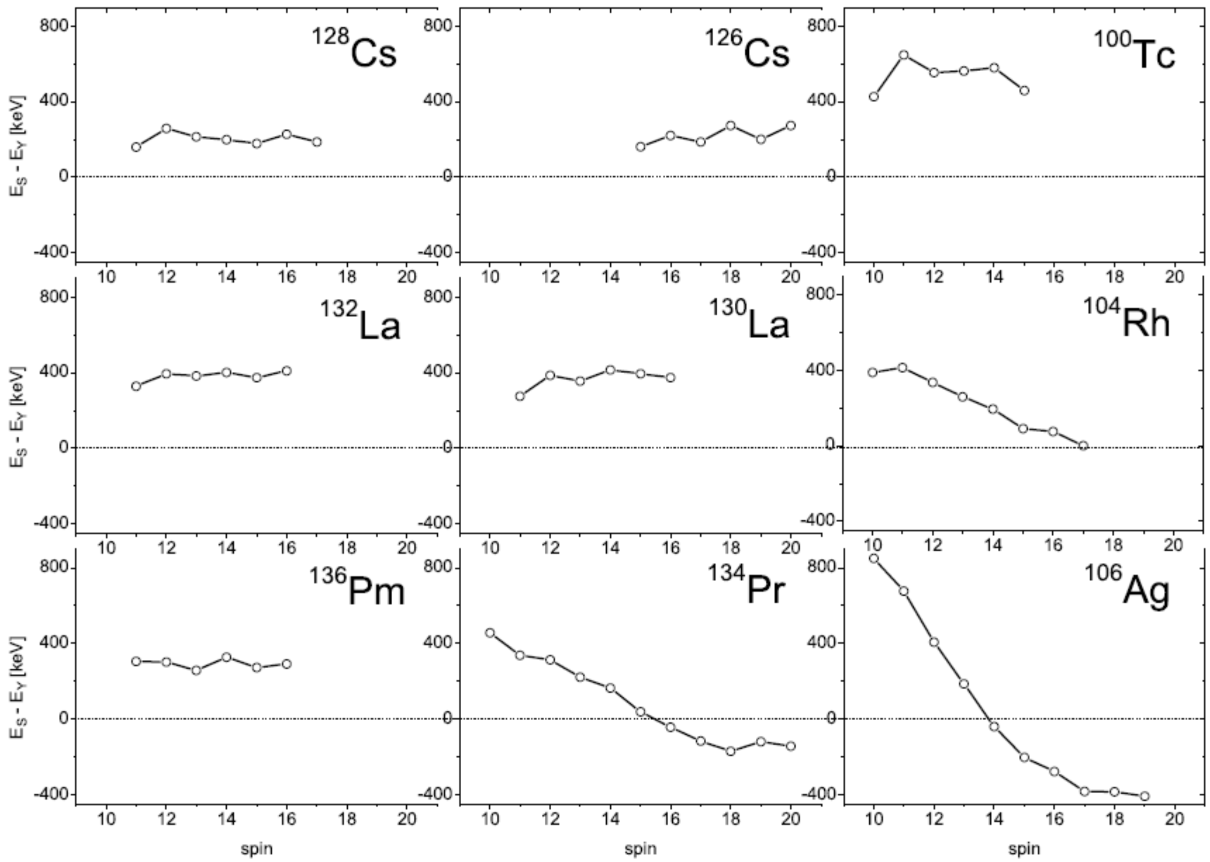
looking for a new dynamical variable describing structure of odd-odd nuclei
- cooperation with Institute of Theoretical Physics University of Warsaw
S.G. Rohozinski, J. Dobaczewski, W. Satula, P. Olbratowski



overlap of left- and right-handed systems vs. absolute value of handedness

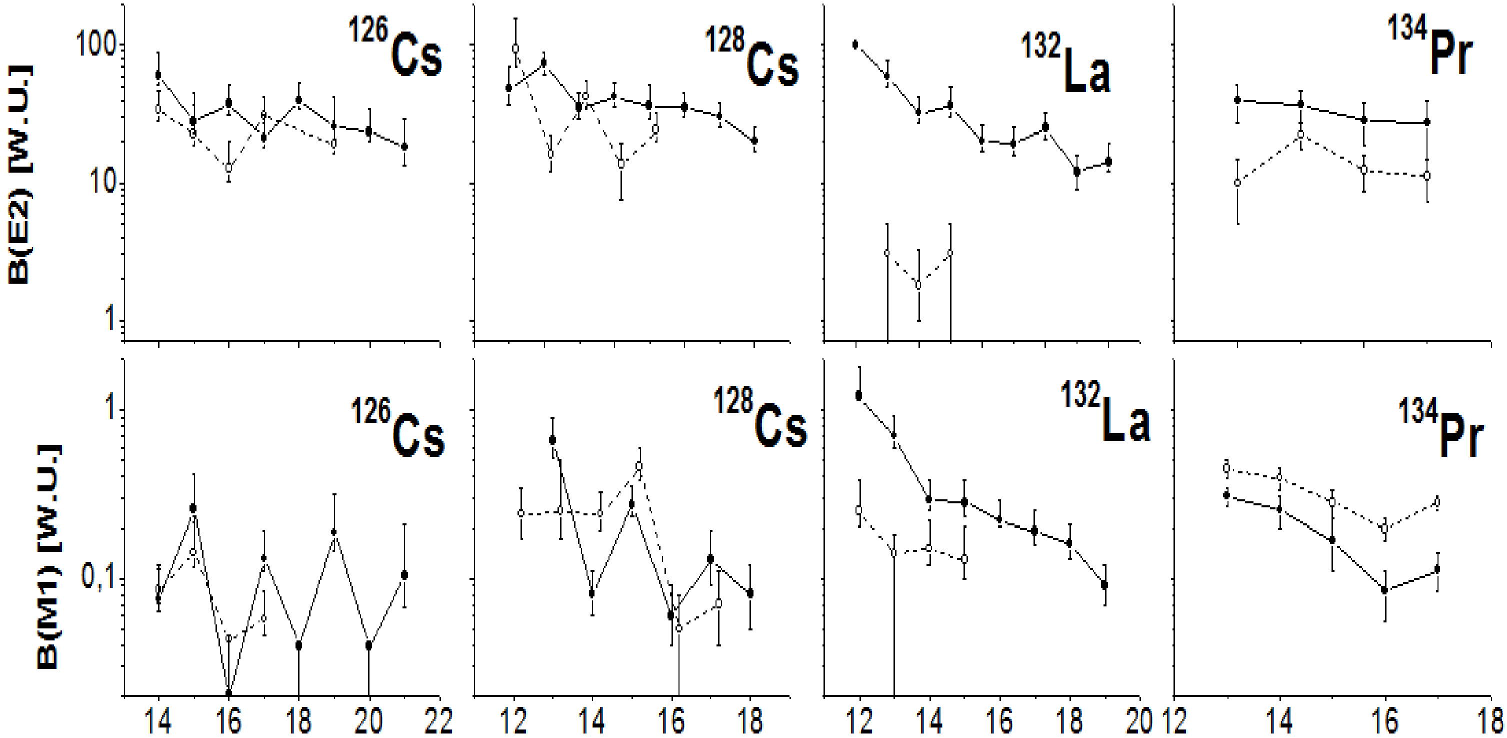
Energy diference between side(Es) and yrast (Ey)

chiral bands levels



E. Grodner,
Quest for the chiral symmetry breaking in atomic nuclei
Acta Physica Polonica B39 (2008) 531

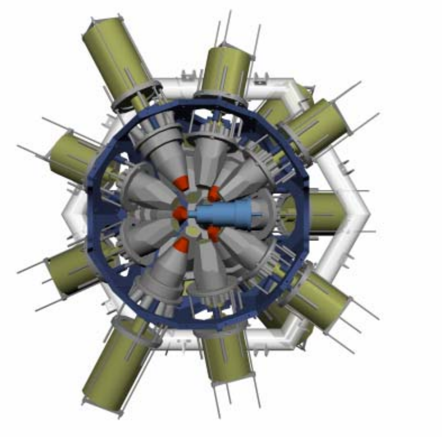
results of lifetime measurements by DSAM



reduced E2 (upper part) and M1(lower part) transition probabilities as a function of the initial spin value.

● ***solid lines – yrast band*** ○ ***dotted lines - side band***

[2] E. Grodner, J. Srebrny, A. A. Pasternak, I. Zalewska, T. Morek, Ch. Droste, J. Mierzejewski, M. Kowalczyk, J. Kownacki, M. Kisielin´ski, S. G. Rohozin´ski, T. Koike, K. Starosta, A. Kordyasz, P. J. Napiorkowski, M. Wolinska-Cichocka, E. Ruchowska, W. Płociennik, and J. Perkowski
128Cs as the Best Example Revealing Chiral Symmetry Breaking
Phys. Rev. Let. 97, 172501 (2006)



Tests of K-quantum number conservation by study of K-isomer electro-magnetic excitation and decay

COULEX particle-gamma measurements
γ - γ and γ – e coincidences

Both the electro-magnetic (EM) excitation and decay of high-K states can be greatly hindered by conservation of the K quantum number. Electromagnetic excitation and deexcitation probabilities decrease by many orders of magnitude with increasing multipole order.

The unexpected population of high-K isomers by COULEX has brought into question the validity or "goodness" of the K quantum numbers (see [3]). One of the mechanism of K-isomer EM population experimentally confirmed for 178Hf was high-K component admixture to low K bands [3].

[3] A.B. Hayes, D. Cline, C.Y. Wu, J. Ai, H. Amro, C. Beausang, R. F. Casten, J. Gerl, A.A. Hecht, A. Heinz, R. Hughes, R.V. F. Janssens, C. J. Lister, A. O. Macchiavelli, D. A. Meyer, E. F. Moore, P. Napiorkowski, R. C. Pardo, Ch. Schlegel, D. Seweryniak, M.W. Simon, J. Srebrny, R. Teng, K. Vetter, and H. J. Wollersheim
Breakdown of K Selection in 178Hf
Phys. Rev. Let. 96, 042505 (2006)

high-K component admixture to low K bands observed also in the A ≈130 region [4], where the nuclei show significant softness in their shapes.

the another mechanism of the weakening of the K-forbidness due to the triaxiality

A ≈130 region the first results of γ - γ and γ – e measurements for decay of $K^{\pi}= 8^{-}$ isomer in ^{132}Ce confirm the important role of the triaxiality

visible by $B(E3; 8^{-} \rightarrow 5^{+}) / B(E3; 8^{-} \rightarrow 6^{+})$

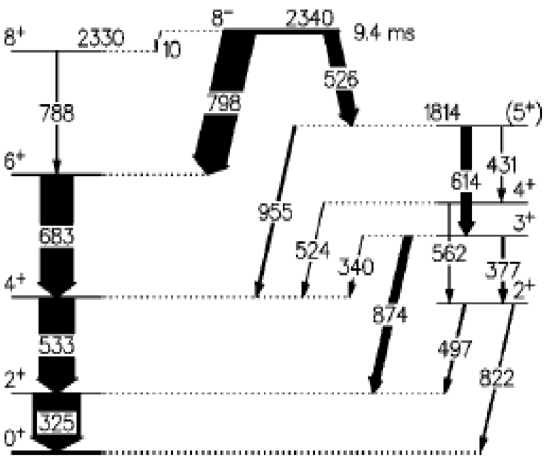
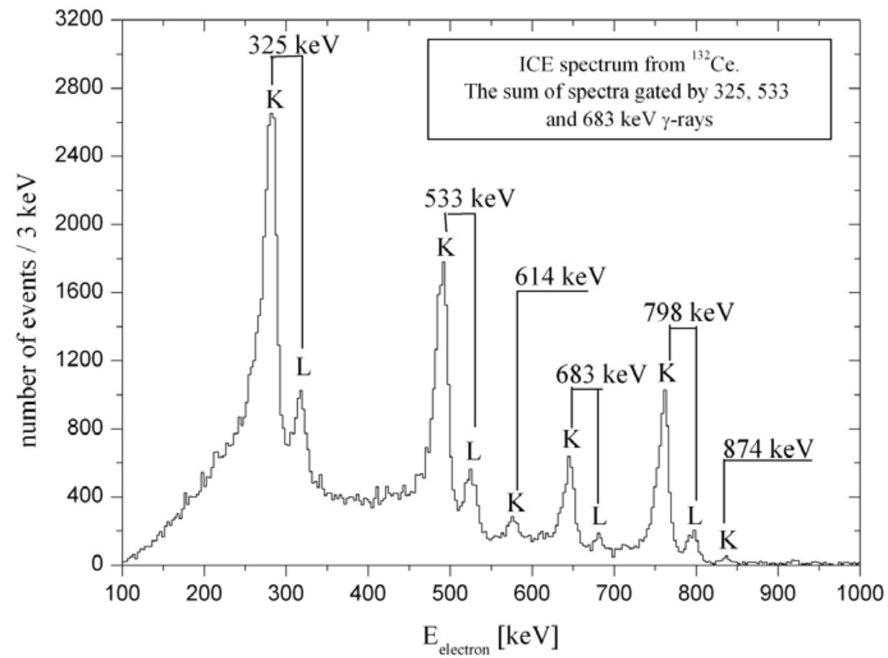


FIG. 1. Decay scheme of the $K^{\pi}=8^{-}$ isomer in the nucleus ^{132}Ce as established in the present study. The transition energies are given in keV. The widths of the arrows are proportional to the relative intensities of the observed γ transitions.



[4] T. Morek, J. Srebrny, Ch. Droste, M. Kowalczyk, T. Rząca-Urban, K. Starosta, W. Urban, R. Kaczarowski, E. Ruchowska, M. Kisieliński, A. Kordyasz, J. Kownacki, M. Palacz, E.Wesołowski, W. Gast, R. M. Lieder, P. Bednarczyk, W. Męczyński, J. Styczeń

Investigation of the $K^{\pi}= 8^{-}$ isomer in 132Ce

Phys. Rev. C63, 034302(2001)

Collaboration members

J. Andrzejewski[4], A. Bruce[18], G. Cata-Danil[11], J. Choinski[1], E. Clement[19], A. Dewald[5], J. Dobaczewski[3], Ch. Droste[2], C. Fahlander[12], A. Goergen[10], E. Grodner[2], J. Iwanicki[1], A. Jakubowski[1], J. Jastrzebski[1], G. Jaworski[16], K. Hadynska[1], R. Kaczarowski[6], M. Kicinska-Habior[2], M. Kisielinski[1,6], A. Kordyasz[1], A. Korman[6], W. Korten[10], M. Kowalczyk[1,2], J. Kownacki[1], A. Król[4], S. Lalkovski[13], H. Marginean[11], T. Matulewicz[2], W. Meczynski[8], C. Mihai[11], H. Mierzejewski[15], J. Mierzejewski[1,2], T. Morek[2], P. J. Napiorkowski[1], P. Olbratowski[3], M. Palacz[1], A. A. Pasternak[9], J. Perkowski[4], D. Pietak[14], J. Pluta[16], B. Pomorska[7], L. Próchniak[7], S. G. Rohozinski[3], T. Rzaca-Urban[2], I. Sankowska[2], W. Satuła[3], K. Sobczak[4] J. Srebrny[1], A. Trzcinska[1], A. Turowiecki[2], W. Urban[17], R. Wojtkiewicz[4], M. Wolinska-Cichocka[1], K. Wrzosek[1], N.V. Zamfir[11], M. Zielinska[1].

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12 Department of Physics, Lund University, Sweden
13 Department of Atomic Physics, University of Sofia 'St. Kliment Ohridski',Bulgaria
14 Department of Electronics and Information Technology, Warsaw University of Technology, Poland
15 Faculty of Production Engineering, Warsaw University of Technology, Poland
16 Faculty of Physics, Warsaw University of Technology, Poland
17 Institute of Experimental Physics, Division of Nuclear Spectroscopy,University of Warsaw, Poland
18 School of Environment and Technology, Brighton, England
19 GANIL, Caen, France

SUMMARY

HIL UW - active accelerator center

atract young students and postdocs

close collaboration with theory(Warsaw, Lublin)

EAGLE - 20-30 HpGe ACS,

60 BaF_2 , Munich COULEX chamber, Łódź electron spectrometer,

Koln - Bucharest PLUNGER, 30 Si Ball, Cracow RFD

OSIRIS II - examples of experiments,

good starting point to be developed with EAGLE

- Shape dynamics and coexistence study
  COULEX at HIL and RIB combined
  with RDDSAM and DSAM

- Entry state depopulation,
  multiplicity and sum energy
  reaction mechanism,
  structures in the continuum,
  side-feeding model

- Chirality, a new dynamical variable important to understand
  the structure of odd-odd nuclei

- K-isomer electro-magnetic excitation and decay:
  test of K-quantum number conservation
  weakening of the K-forbidness due to the triaxiality

- Presently, 8 HPGe ACS detectors of 35%
- efficiency and 12 HPGe ACS detectors of 20-30% efficiency are available. The future permanent
- array with the use of those Ge detectors is planned for photopeak efficiency about 1%. The
- efficiency of the upgraded system with the use of 20 Phase I HPGe ACS detectors will be
- increased by about 4 times in singles, 15 times in doubles and 55 times in triples coincidences.
- The new Ge spectrometer will increase the accuracy in gamma line shape analysis, particularly
- important in picoseconds lifetime measurements.

- 1. **Experimental study of the nuclear chirality**
- The manifestation of chirality in atomic nucleus, suggested in 1997 and vigorously
- investigated over the past few years from both the experimental and theoretical standpoint,
- continues to be a subject of intense discussion. The calculations, based on different theoretical
- models, namely Tilted Axis Cranking, Core-Particle-Hole Coupling and Tilted Skyrme Hartree-Fock,
- pointed out the possibility of spontaneous breaking of chiral symmetry in the intrinsic reference
- frame of the nucleus. This phenomenon manifests itself experimentally in the appearance of two
- rotational (chiral partner) bands with the same spin and parities and almost equal excitation
- energy. Such partner bands were found in more than ten nuclei in the A ≈130 and A ≈ 100 mass
- region. Their observation was considered to be a proof for chiral symmetry breaking in the atomic
- nucleus. The last studies [2] of electromagnetic properties of 128Cs, 132La and 134Pr clearly have
- shown that investigation of chirality would be impossible without lifetime measurements. As such
- there is a need of systematical study of electromagnetic transition probabilities in all nucler
- systems supposed to show chiral symmetry breaking. To approach this goal we need a higher
- efficiency setup, which will allow us to study the electromagnetic transition probabilities and to
- confirm spin and parity assignments in all bands supposed to be chiral, including experimentally
- less favourably cases.

- 6. One of the advantages of a small accelerator centre is the easer and faster access to the beam
- than in the bigger and rich facilities. It is **particularly visible for non-standard ideas and**
- **proposals.**
- I
- n the following sections the mechanical drawings of our new project of central European Array for Gamma Levels Evaluation (EAGLE) are attached.
- **References**

- [1] E.Grodner et al.
- *Lifetimes and side-feeding population of the yrast band levels in 131La*
- Eur. Phys. J. A27 (2006) 325-340
- [2] E.Grodner, et al
- *128Cs as the best example revealing the chiral symmetry breaking phenomenon*
- Phys. Rev. Lett. 97 (2006) 172501.
- [3] A.B.Hayes et al.
- *Breakdown of K Selection in 178Hf*
- Phys. Rev. Lett. 96, 042505 (2006).
- [4] Morek T et al.
- *Investigation of the Kπ=8 - isomer in 132Ce*
- Phys. Rev. C63, 034302 (2001).
- [5] E.Clement, et al.
- *Shape coexistence in neutron-deficient krypton isotopes*
- Phys.Rev. C 75, 054313 (2007).

- 5. **Gamma-spectroscopy with spontaneous fission fragments**
- The increase of efficiency and granularity of the system will provide an unique opportunity
- to study the structure of nuclei, produced in spontaneous fission. In the last decade there was a
- huge breakthrough in this domain of the nuclear since. A variety of nuclear phenomena have been
- observed in the neutron-rich nuclei, produced in spontaneous fission. However, for most of these
- nuclei the information presently available is restricted to the transition energies and intensities. The
- increasing of the number of available detectors in Warsaw with the 20 HPGe detectors will lead to
- more than 50 times increase of the efficiency in triples, which is crucial for the gammaspectroscopy
- with fission fragments. Coupling of the charge-particle detectors as well as fasttiming
- circuits to the updated gamma-pool will provide an unique opportunity to obtain a deeper
- insight into the nuclear structure in these exotic nuclei.