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Properties of Hot Nuclei at Extreme Angular Momenta

Workshop on Level Density and Gamma Strength in Continuum, Oslo, May 21-24, 2007

Nuclear Physics **A398** (1983) 119–129

THE $(\nu i^2_{13/2})_{8^+,10^+,12^+}$ TRIPLETS IN $^{190-196}$Hg

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Received 30 September 1982

Abstract: Decays of isomeric states in the even $^{190-196}$Hg isotopes are studied by in-beam conversion electron spectroscopy using the ^{181}Ta(^{14}N, 5n) and ^{192,194,196}Pt(α, 4n) reactions. A superconducting solenoid was used to transport conversion electrons emitted by the recoiling excited nuclei to cooled Si(Li) detectors and singles e^- as well as e^-e^- coincidence spectra were measured. The missing $12^+ \rightarrow 10^+$ transitions in ^{190,192,194}Hg were observed with transition energies of 24 keV, 28 keV and 52 keV. The B(E2) rates of the $12^+ \rightarrow 10^+$ and the $10^+ \rightarrow 8^+$ transitions are discussed.


ZAKOPANE 2004

Kong Adam i sitt paradis

Adam Malysz ble historisk da han vant i solskinnet i går. Han ble den første som har vunnet fire ganger i Holmenkollen. Og nå er han motivert for å fortsette.

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Skriv ut | Tips en venn | Abonnér

STEIN ERIK KIRKEBØEN

Siste 100 artikler

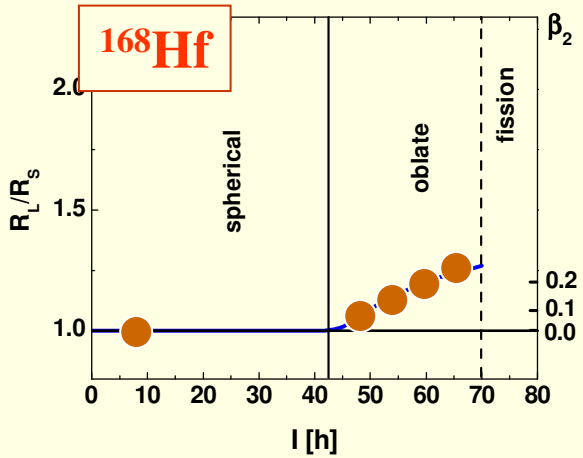
Ti år etter at den unge og ukjente polakken Adam Malysz vant sin første verdenscupseier i Holmenkollen, tok den polske veteranen Adam Malysz (28) sin fjerde - og viktigste Kollen-seier.

- Denne seieren har jeg ventet på i ett år. Jeg har slitt veldig denne sesongen, og bare vært på seierspallen én eneste gang. Jeg vet ikke hvorfor jeg har slitt så tungt, for jeg har jobbet mye og hardt, og forberedt meg veldig godt. Men jeg fikk ikke resultater. Etter OL (7. og 14. plass) var jeg så langt nede at

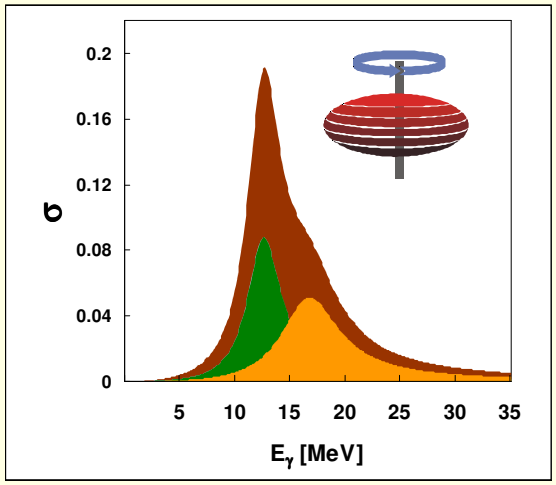
Adam Malysz var den store helten i Kollen i går. Det var ikke bare landsmennene med flagg i rødt og hvitt som satte pris på kongen av Kollen i går. (Foto: TROND TANDBERG)

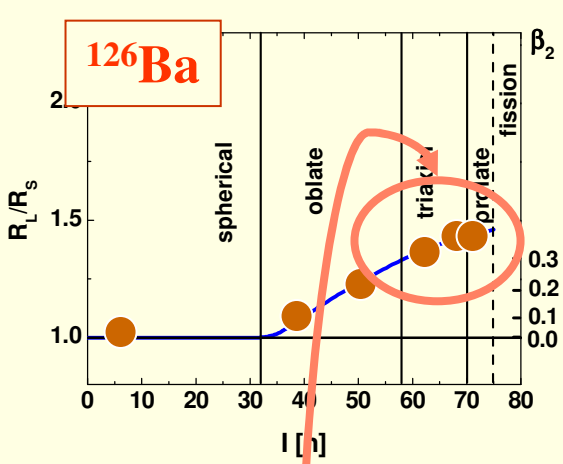
Søk med sesam
Aftenposten Sesam
guide.no
Søk
Siste | Mest tipset | Mest lest
- Skattejakt resulterte i milliardfunn
- Vaksine mot lungekreft
- Trekker seg som Rasool-advokat
- Funnet forslått, bevisstløs og nedkjølt
- Mann funnet død på gangsti

Evolution of the shape of hot nucleus as a function of spin probed by the GDR strength function shape

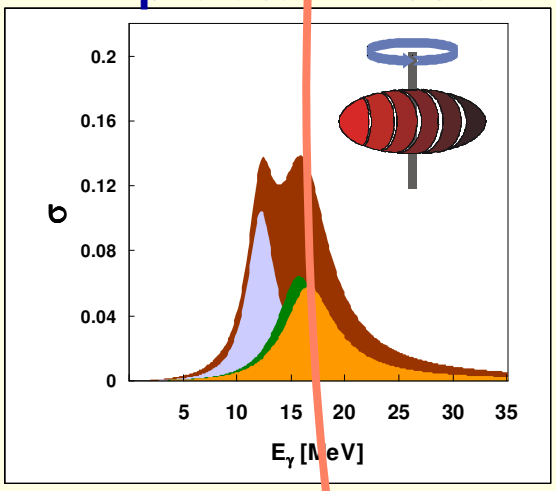


”Oblate”→fission





„Oblate” →3-axial→
→”prolate”→fission



„Jacobi shapes”

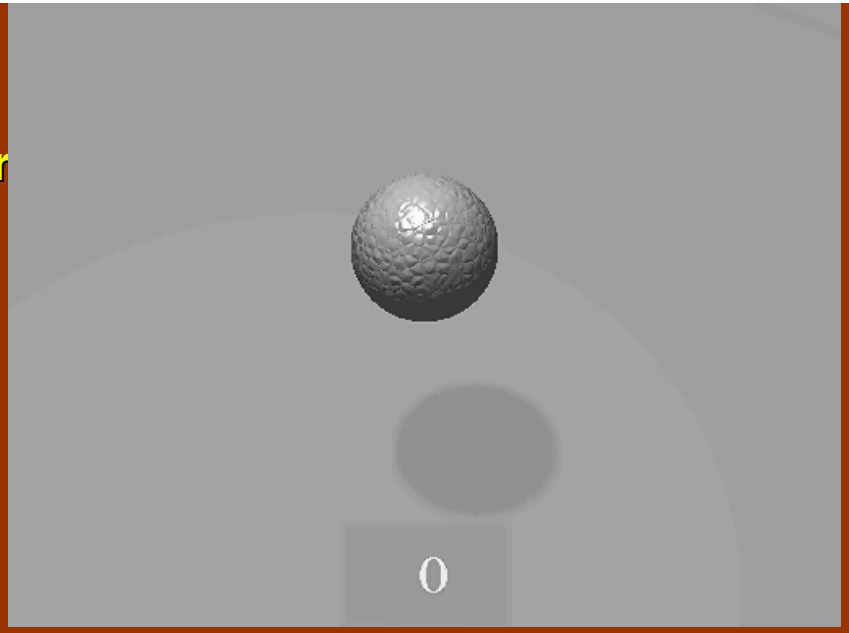
Plan of the talk

- Introduction – Jacobi shape transitions
- ^{46}Ti: shapes of light nuclei studied by the GDR γ-decay …
- … and charged particle emission
- ^{216}Rn: shape evolution of heavy nuclei
- Summary
- Outlook

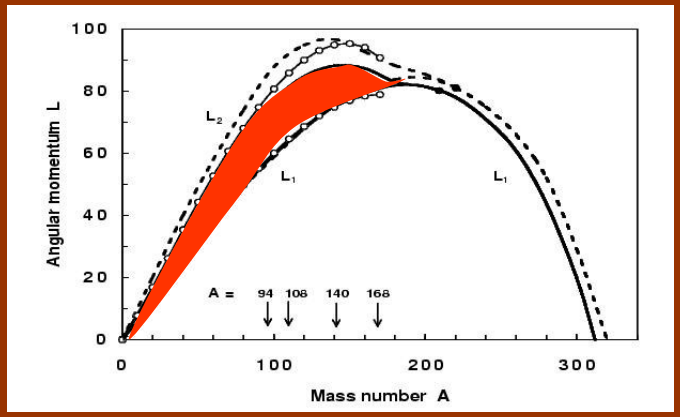
Introduction – Jacobi shape transition

Some history - theory

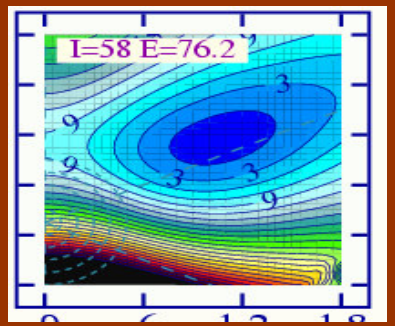
- C.G.J. Jacobi (1834): At certain angular velocity *gravitating mass rotating synchronously* changes abruptly the shape from oblate to elongated triaxial



- R. Beringer, W.K. Knox, *Phys. Rev.* 121 (1961) 1195: Similar phenomenon might be expected in nuclei at highest spins



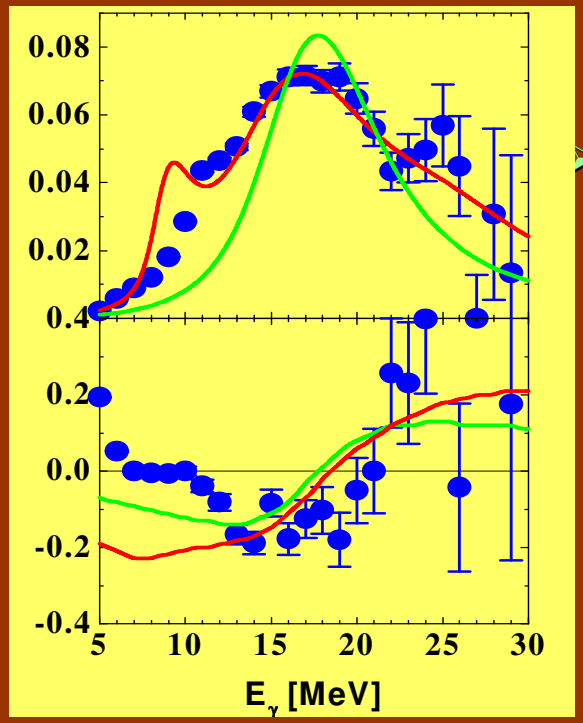
- S. Cohen, F. Plasil, W.J. Swiatecki, *Ann. Phys. (N.Y.)* 82 (1974) 557: Rotating liquid drop model
- W.D. Myers, W.J. Swiatecki, *Acta Phys. Pol* B27 (1996) 99: Semi-classical nuclear Fermi-Thomas model

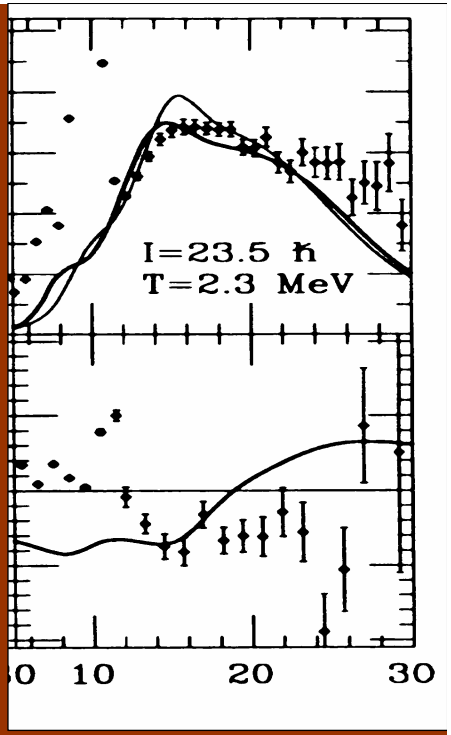


- K. Pomorski, J. Dudek, *Phys. Rev.* C67 (2003) 044316: LSD (Lublin-Strasbourg Drop) Model

Some history - experiment

- M. Kicińska-Habior *et al.*, *Phys.Lett.* B308 (1993) 225: *Seattle exp.* - Possible signature of the Jacobi shape transition for ^{45}Sc in the inclusive GDR spectrum





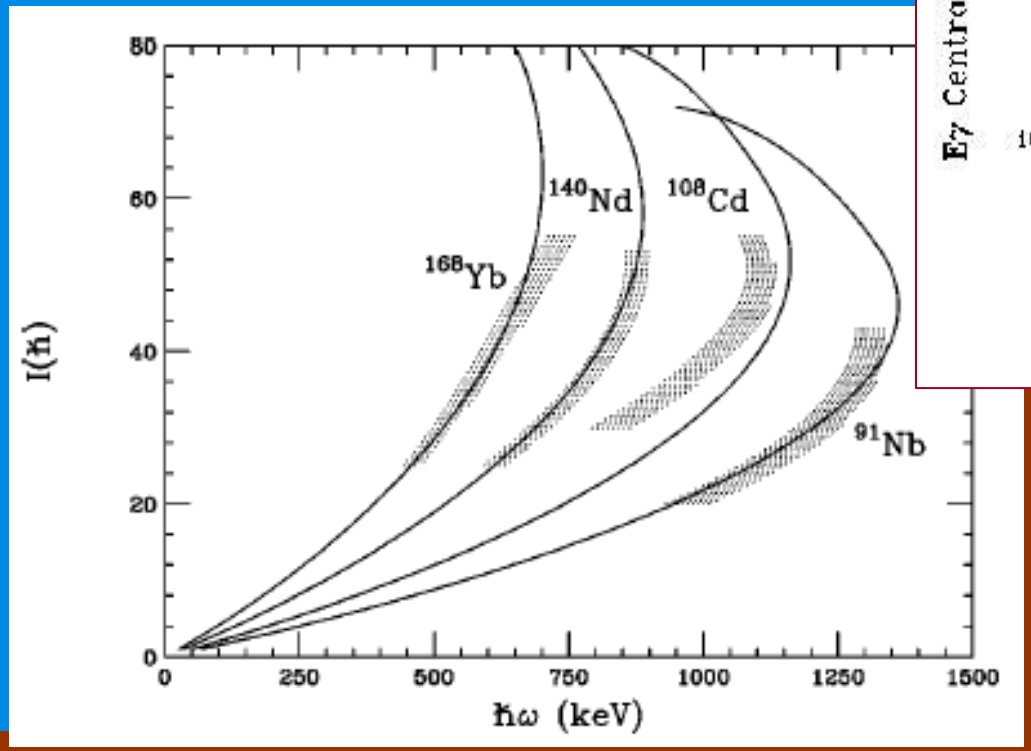
- A. Maj et al, *Nucl. Phys.* A687 (2001) 192: *NBI exp.* – Possible signatures of the Jacobi shape transition for ^{46}Ti in the multiplicity gated GDR spectra and angular distributions

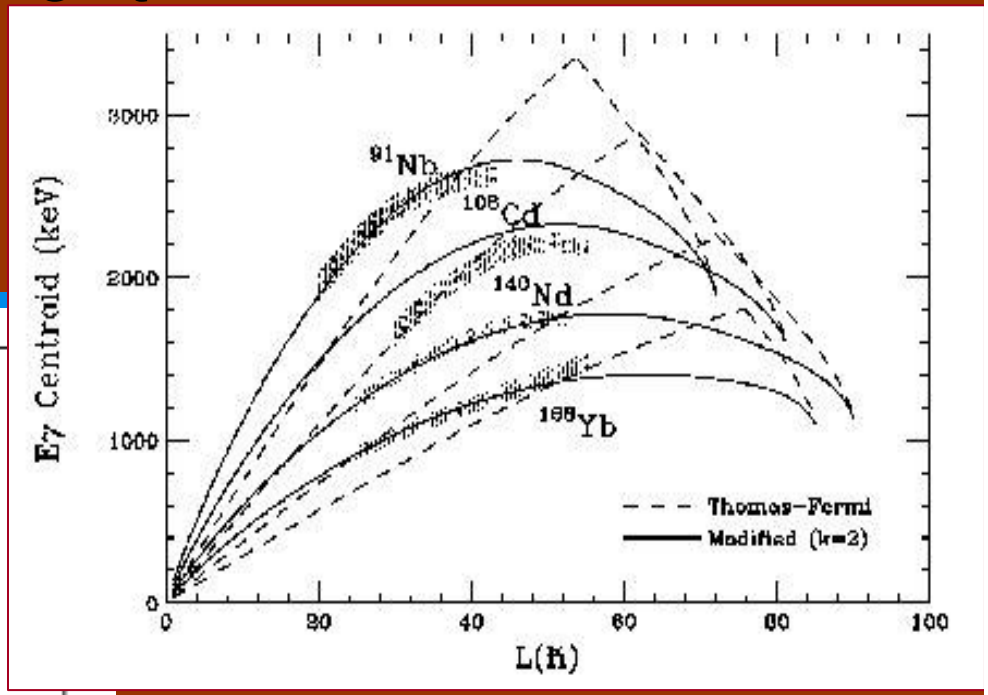
- P. Papka *et al.*, *Acta Phys. Pol.* B34 (2003) 2343 : *ICARE exp*: Extremely deformed shapes of ^{44}Ti from the charged particle spectra

- E. Ideguchi *et al.*, *Phys. Rev. Lett.* 87 (2001) 22250-1: *GAMMASPHERE exp*: Superdeformation in ^{40}Ca

Some history - experiment

- D. Ward *et al.*, *Phys.Rev.* C66 (2002) 024312-1: Giant backbend of the E2 quasicontinuum bump





- B. Herskind *et al.*, *Acta Phys. Pol.* B34 (2003) 2343 : *Search for HD populated from the Jacobi shapes of CN*

^{46}Ti case

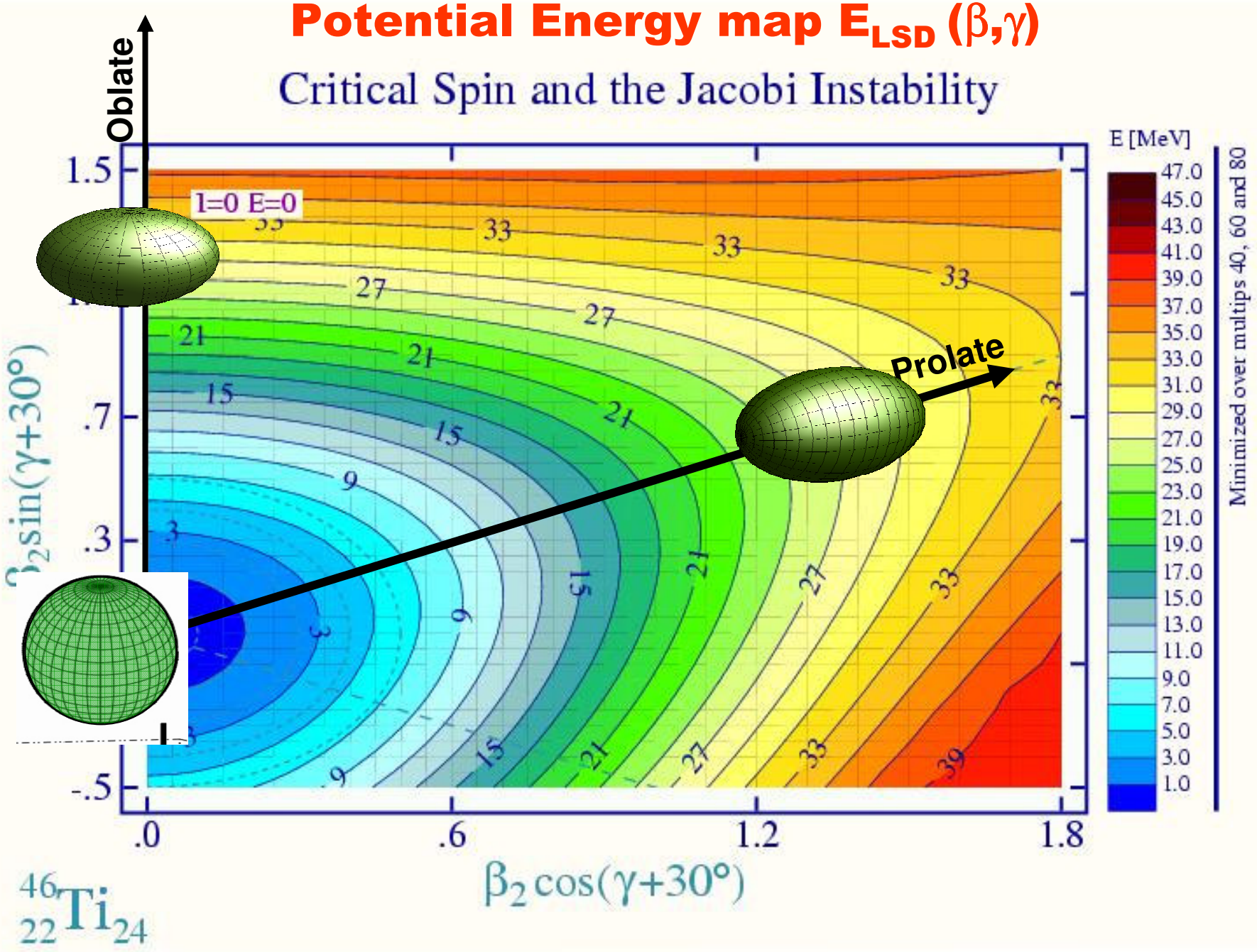
Lublin-Strasbourg Drop Model (LSD)

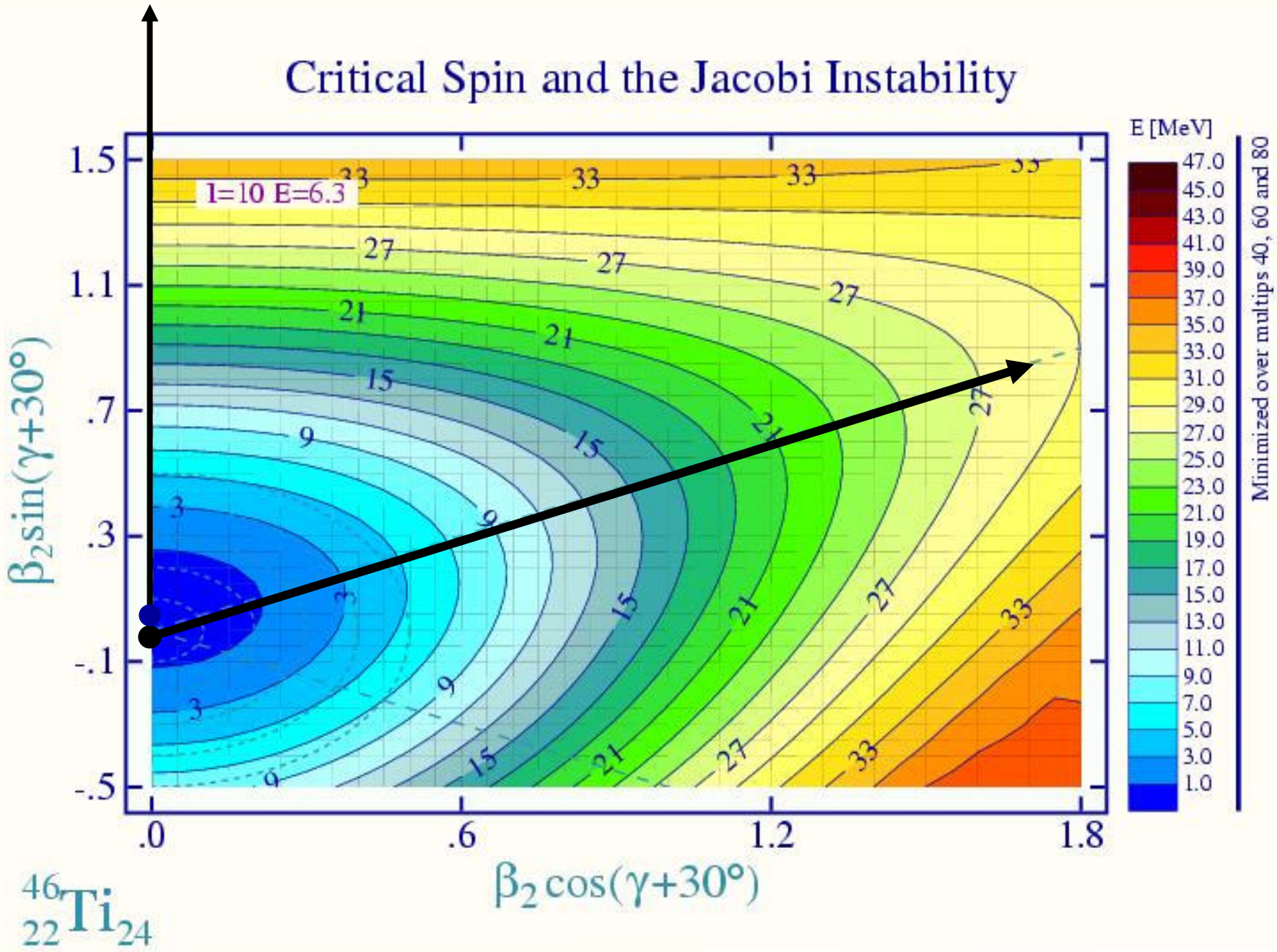
(cf. Talk of Krzysztof Pomorski)

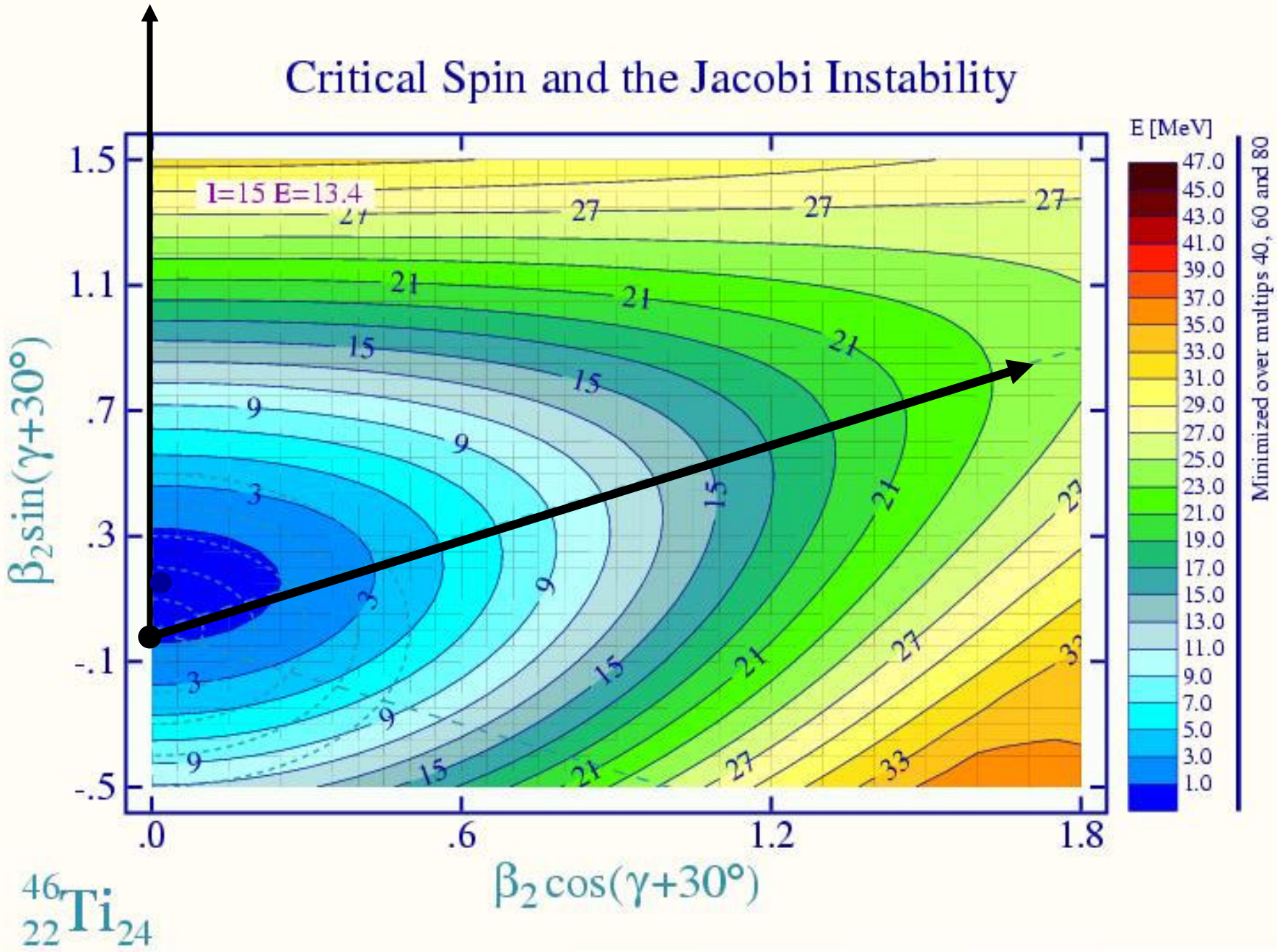
[K. Pomorski, J. Dudek, Phys. Rev. C 67,044316(2003)]. (A=Z+N; I=(N-Z)/A)

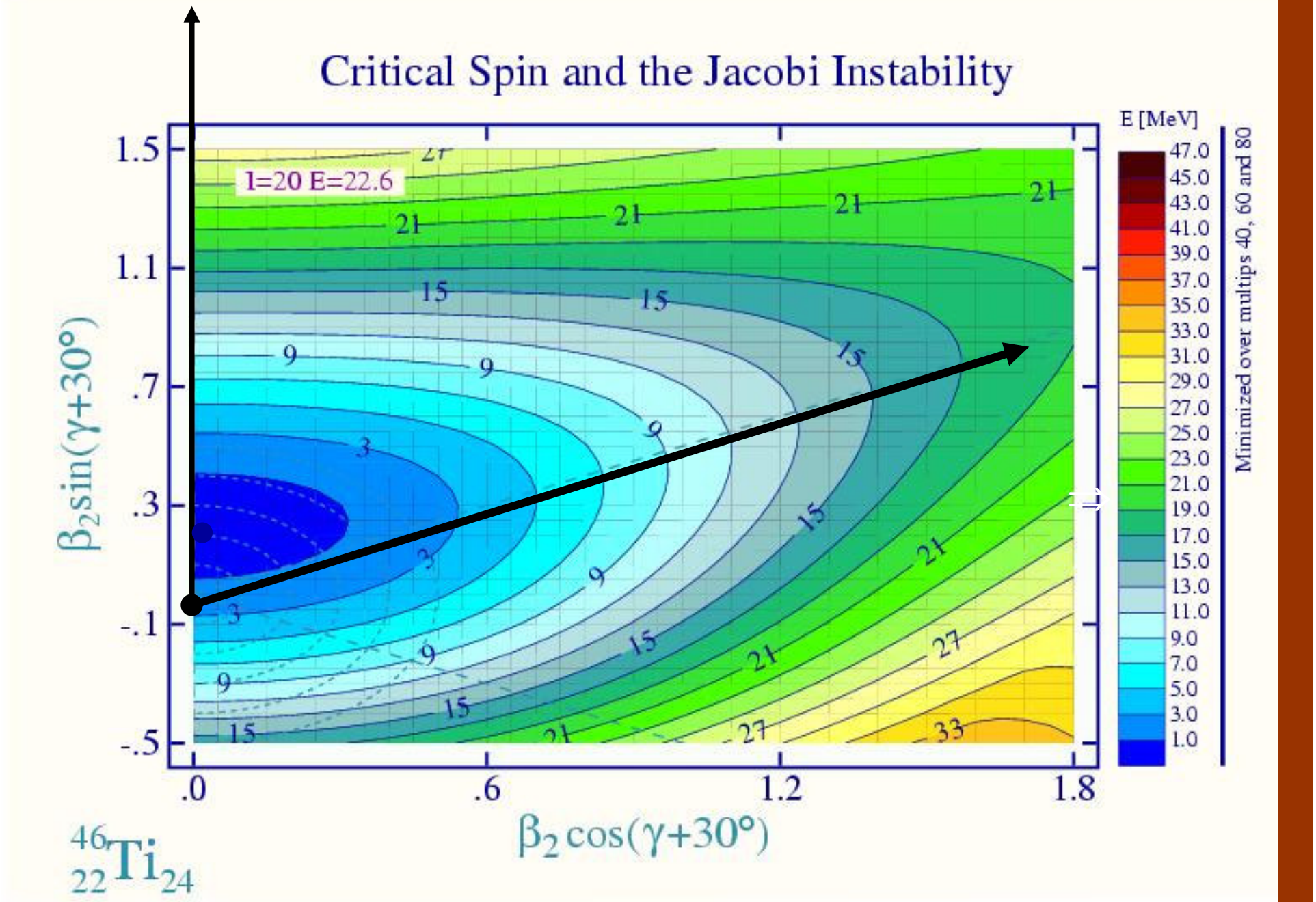
$$E_{LSD} = -15.4920(1 - 1.8601I^2)A + 16.9707(1 - 2.2938I^2)A^{2/3}B_{surf}(def)$$
$$+3.8602(1 + 2.3764I^2)A^{1/3}B_{curv}(def) + \frac{3}{5}e^2\frac{Z^2}{r_0^{ch}A^{1/3}}B_{Coul}(def)$$
$$-0.9181\frac{Z^2}{A} - 10 \cdot \exp\left(-4.2|I|\right)$$

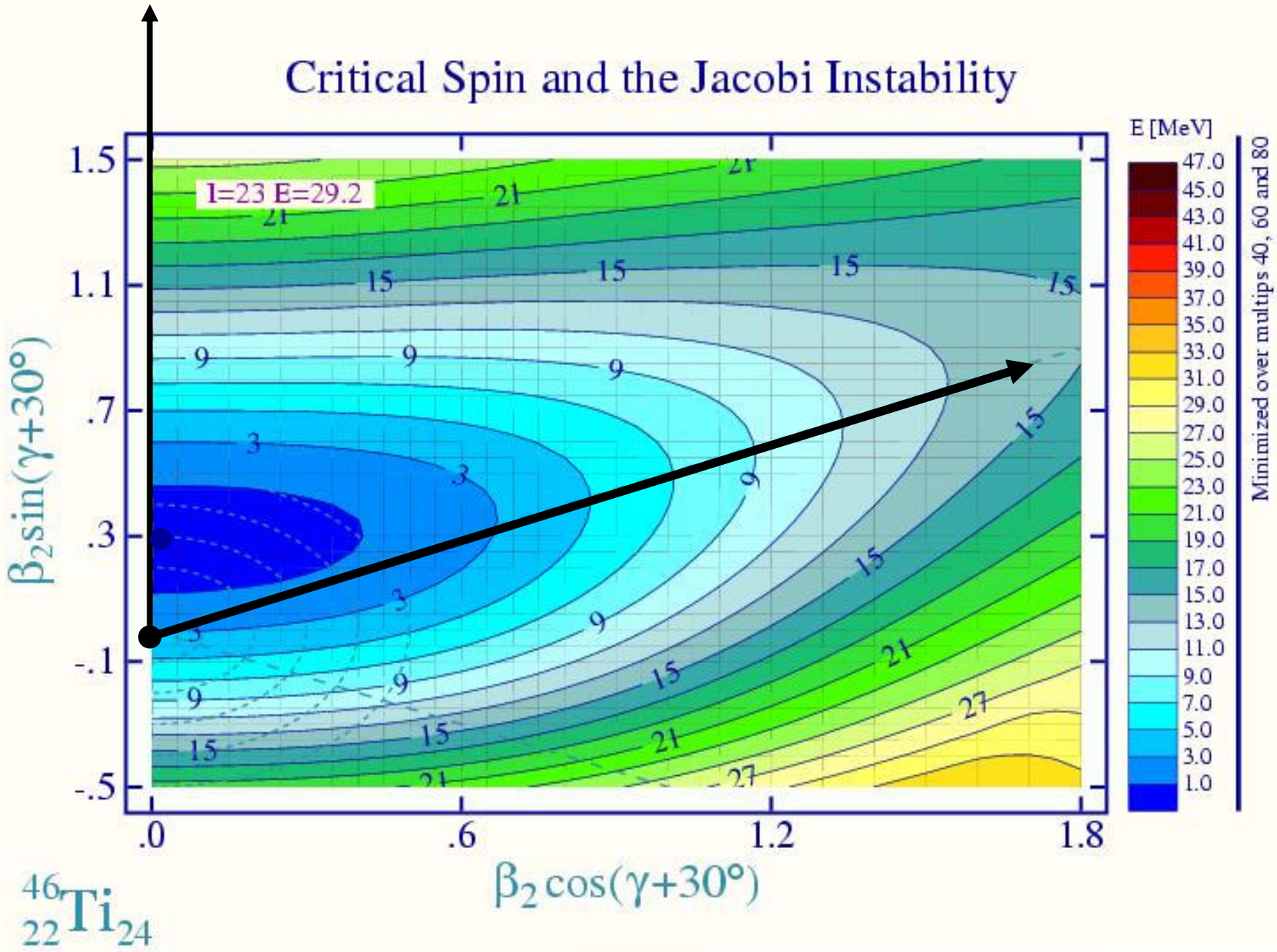
Potential Energy map $E_{LSD}(\beta,\gamma)$

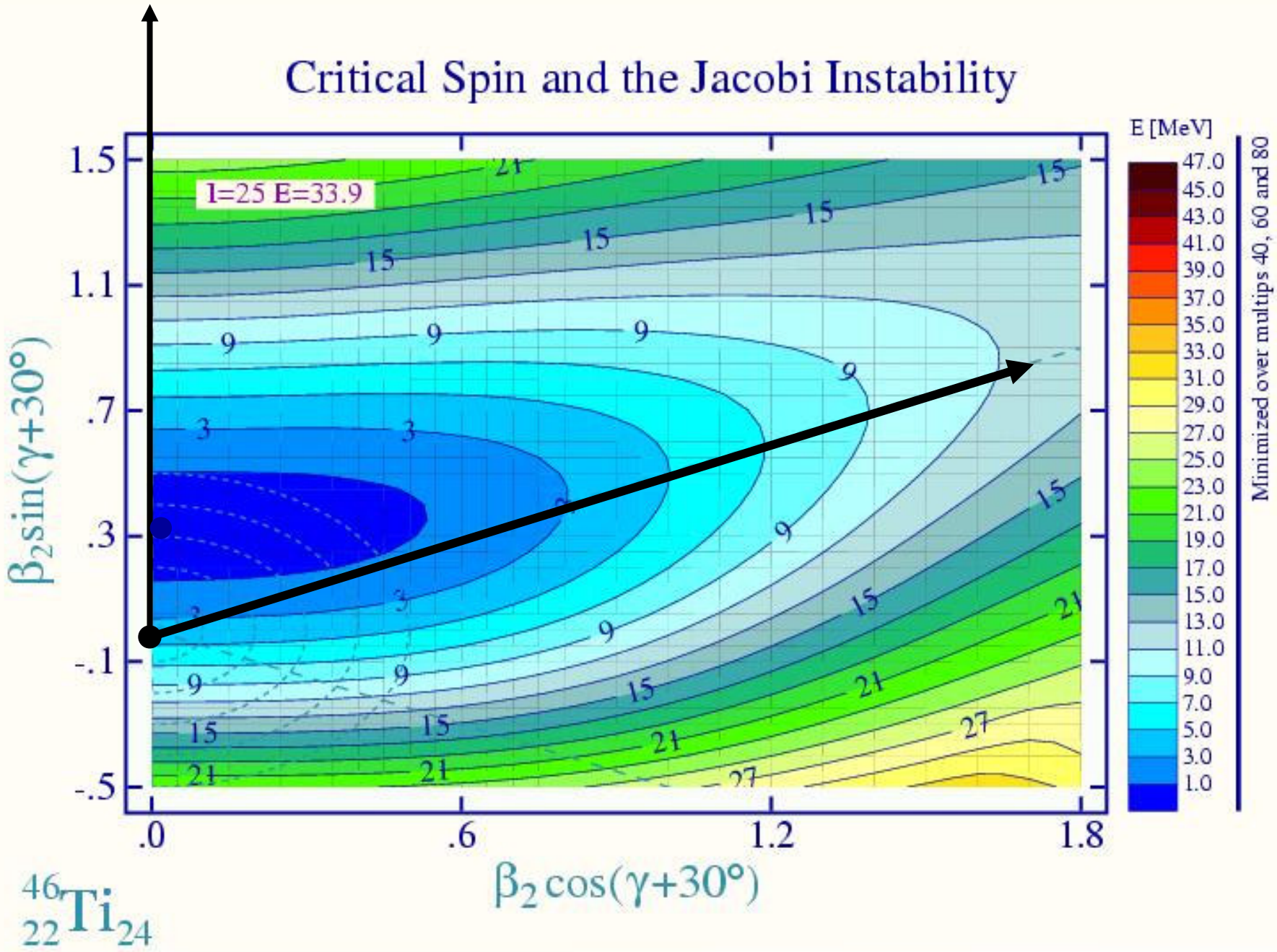


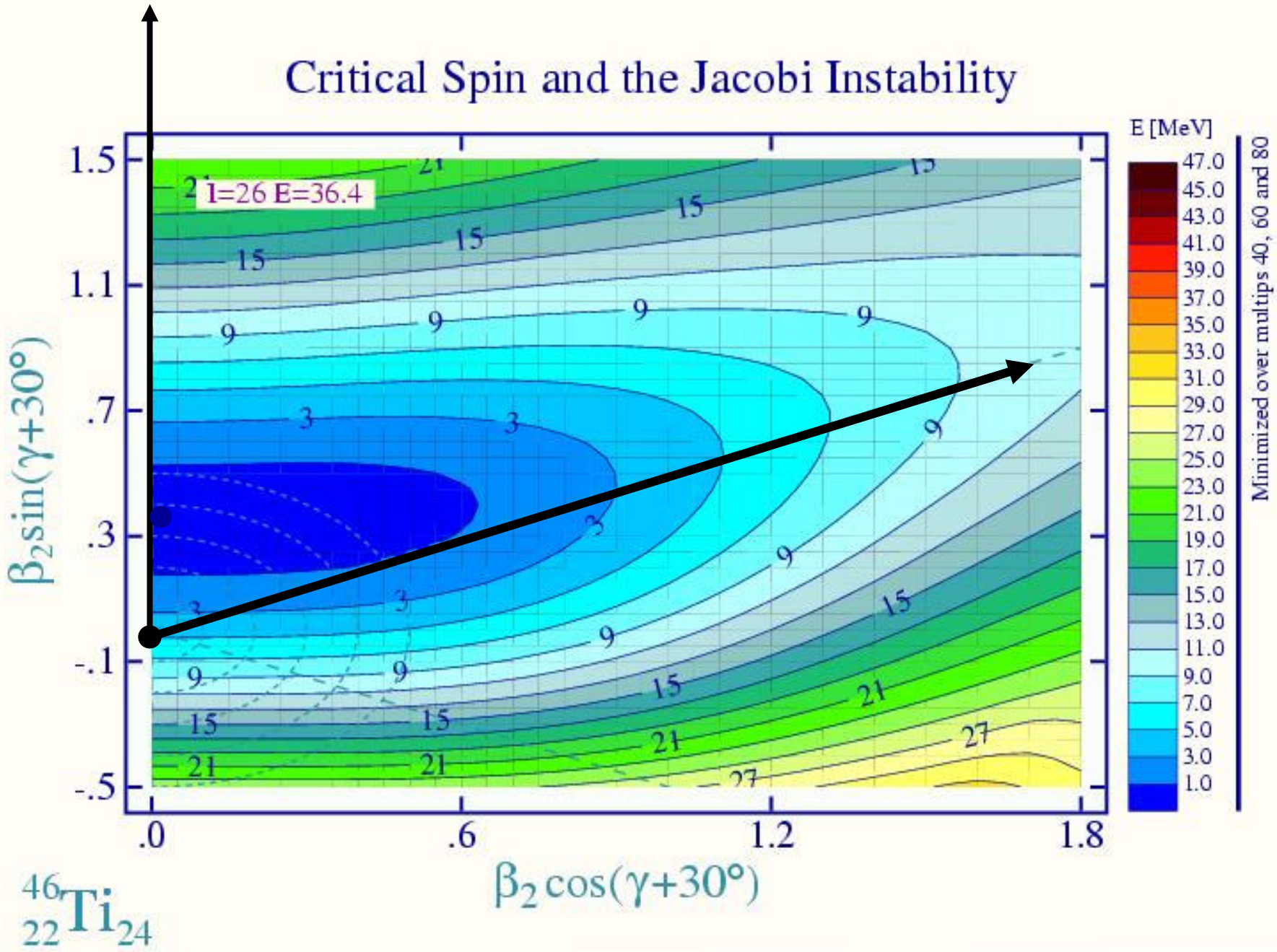

Critical Spin and the Jacobi Instability
1=10 E=6.3
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
.3
-.1
-.5
.0
.6
1.2
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=15 E=13.4
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
.3
-.1
-.5
.0
.6
1.2
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=20 E=22.6
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
.3
-.1
-.5
.0
.6
1.2
1.8
$\beta_2 \sin(\gamma+30°)$
$\beta_2 \cos(\gamma+30°)$
$^{46}_{22}Ti_{24}$


Critical Spin and the Jacobi Instability
I=23 E=29.2
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
.3
-.1
-.5
.0
.6
1.2
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=25 E=33.9
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
.3
-.1
-.5
.0
.6
1.2
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=26 E=36.4
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
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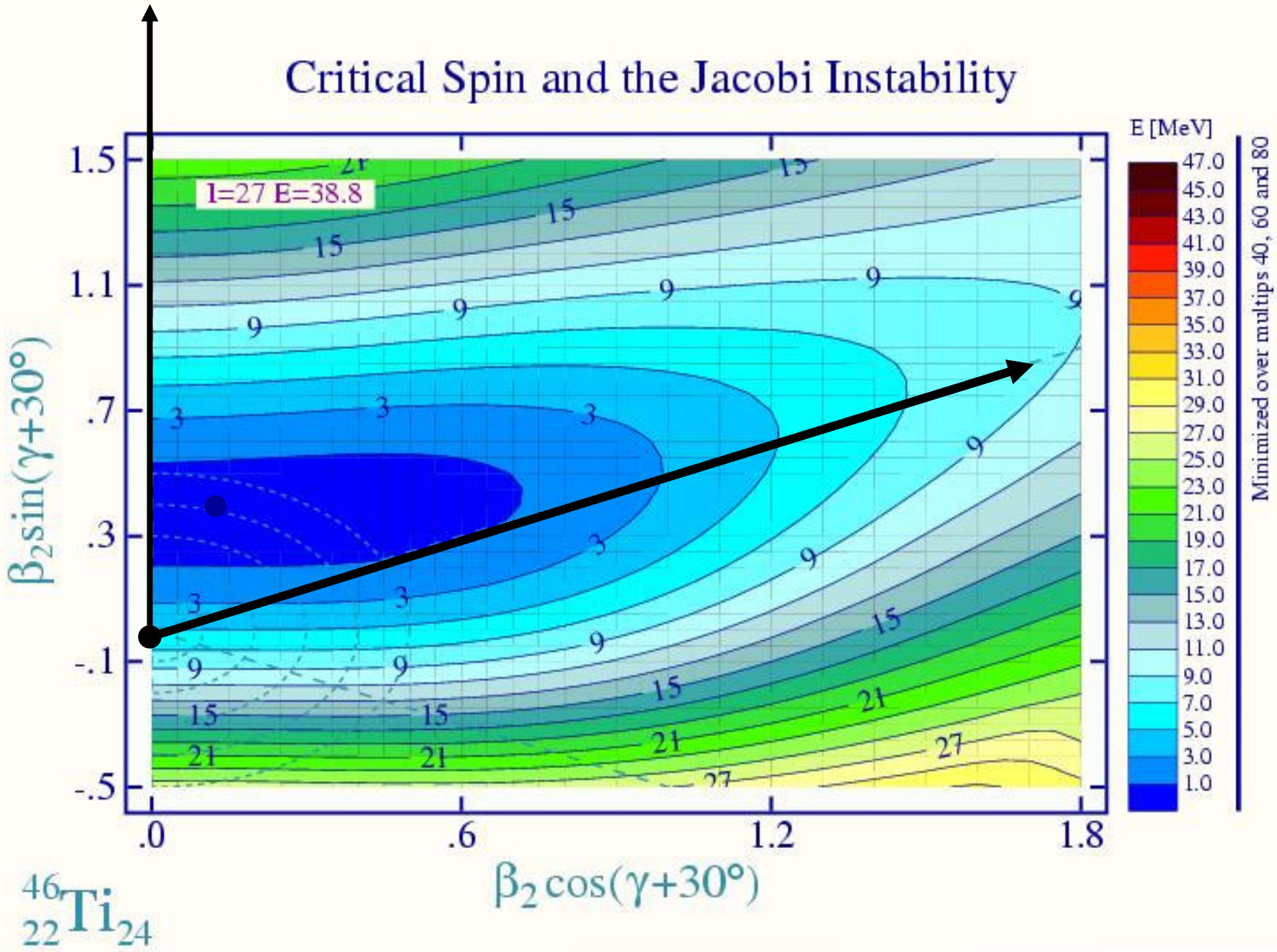
.0
.6
1.2
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=27 E=38.8
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
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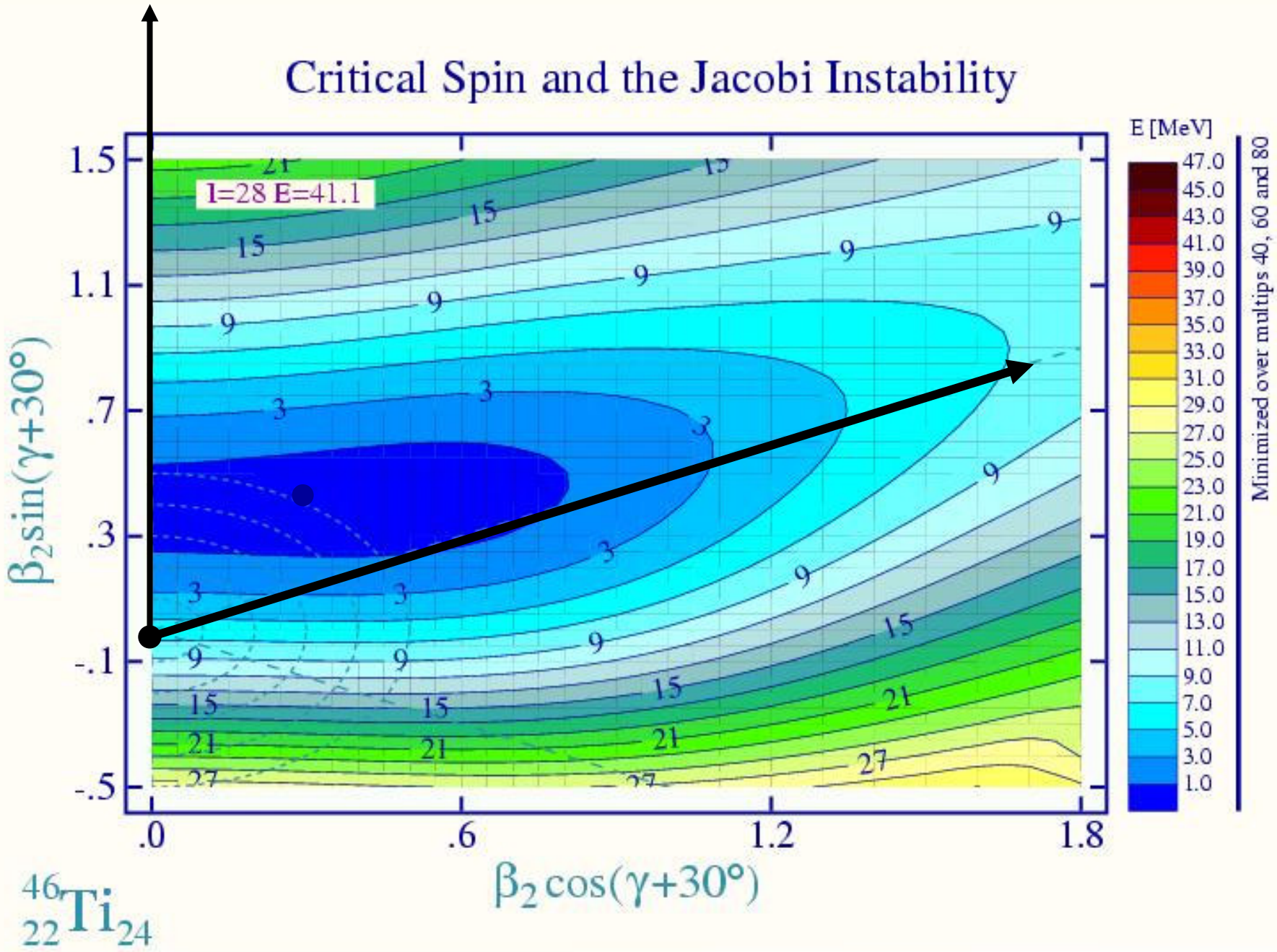
1.2
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=28 E=41.1
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
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Minimized over multips 40, 60 and 80
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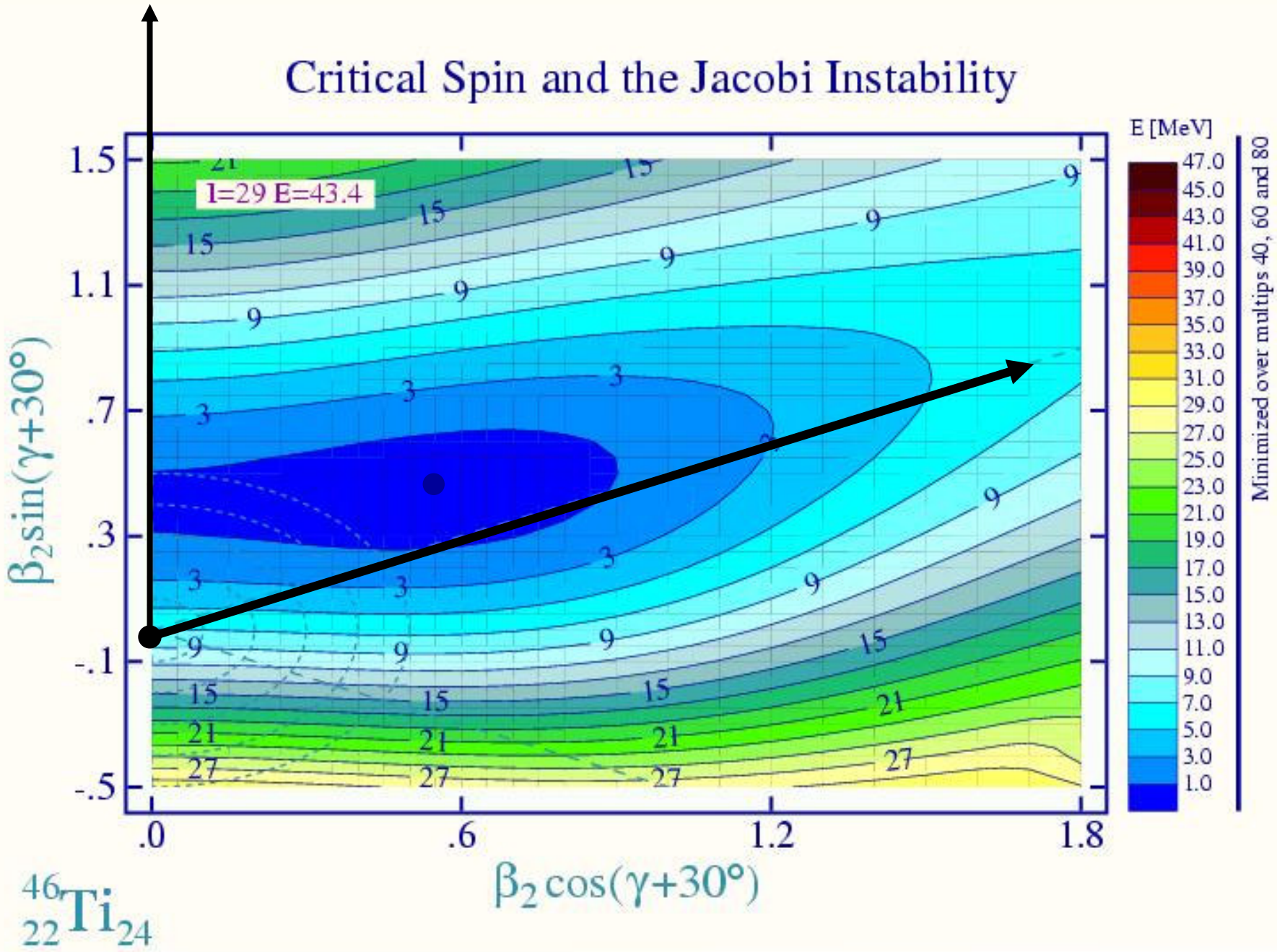
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=29 E=43.4
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
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1.0
Minimized over multips 40, 60 and 80
1.5
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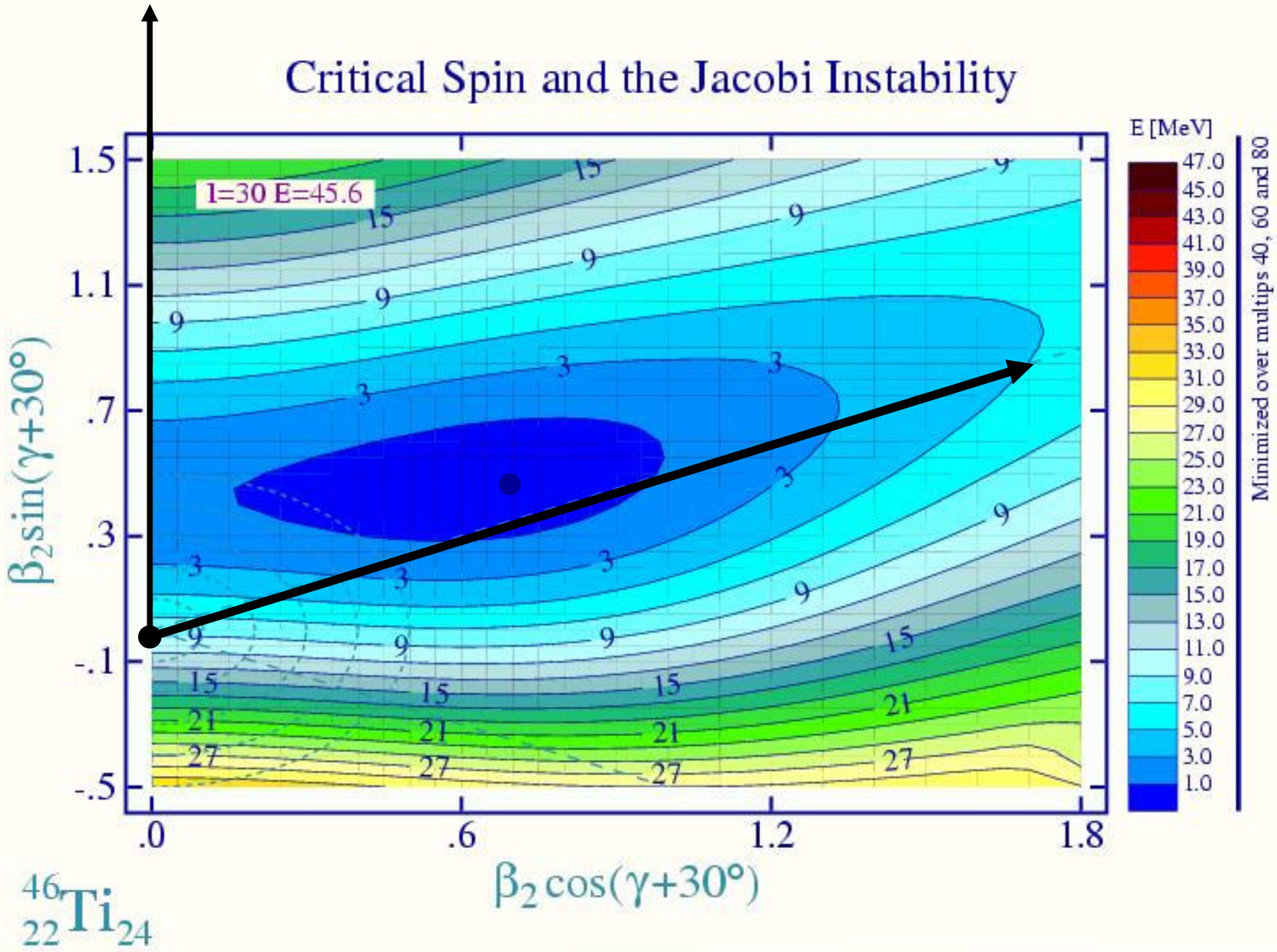
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
1=30 E=45.6
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
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9.0
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Minimized over multips 40, 60 and 80
1.5
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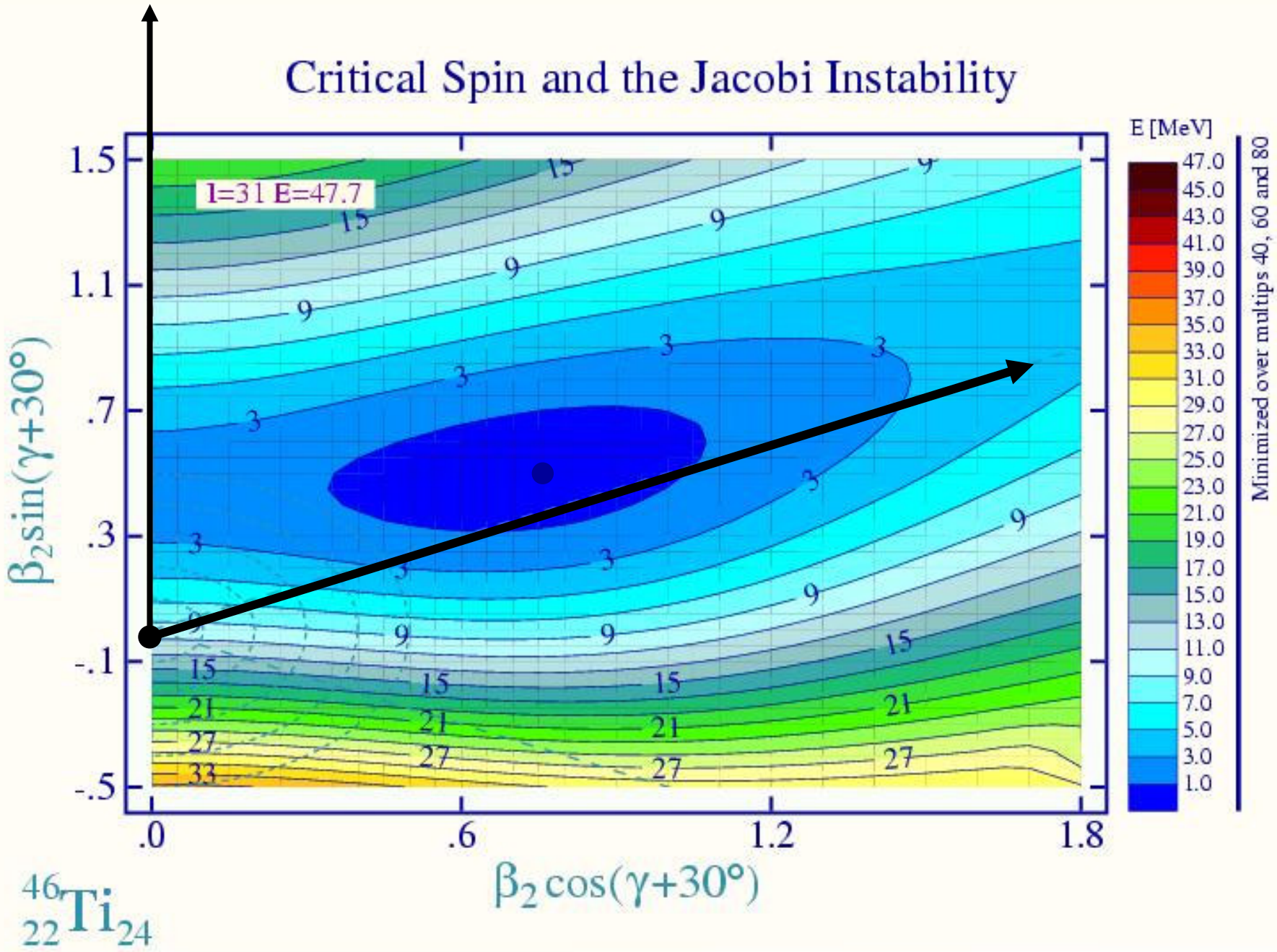
1.2
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=31 E=47.7
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
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3.0
1.0
Minimized over multips 40, 60 and 80
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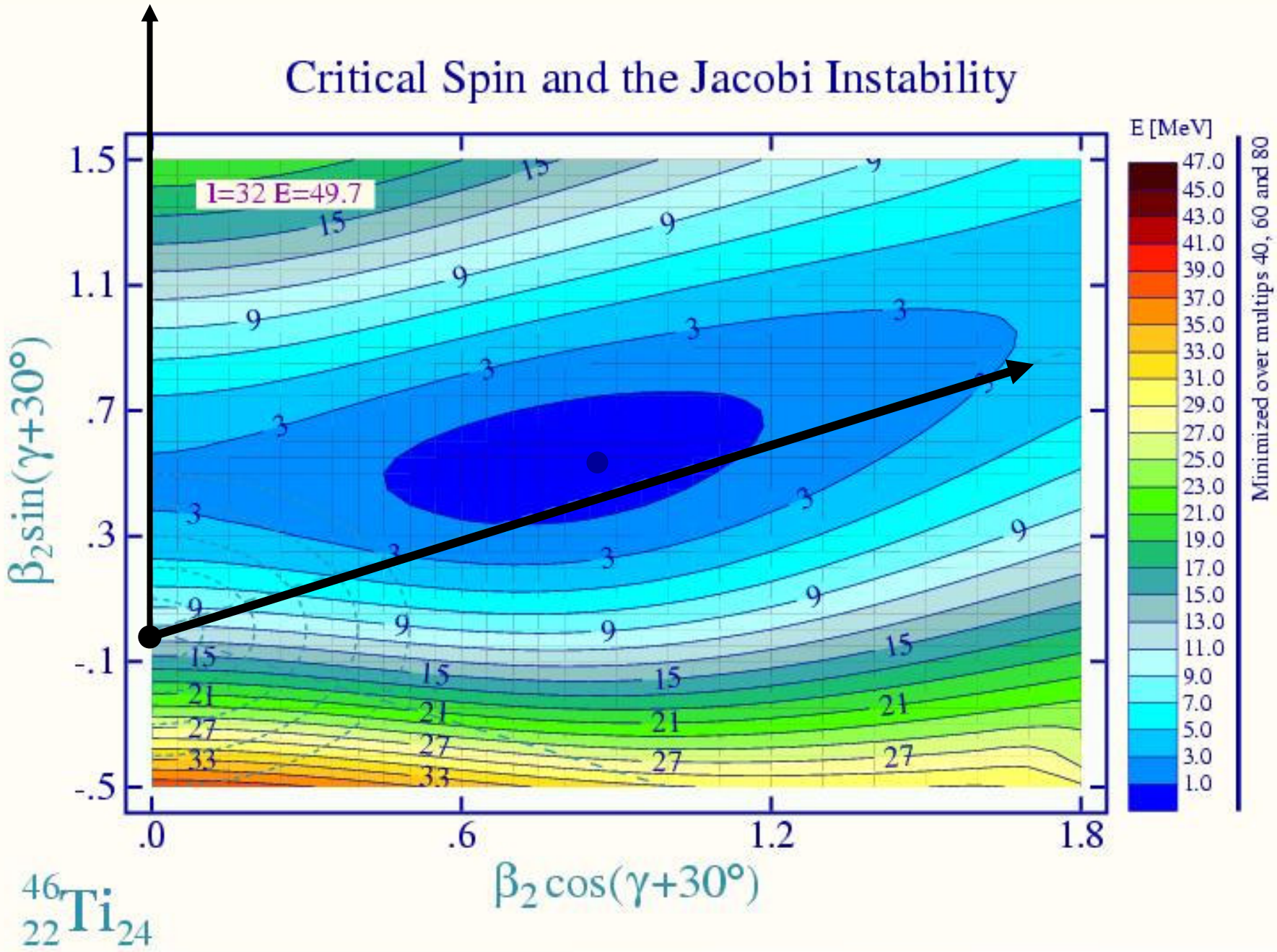
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=32 E=49.7
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
.3
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-.5
.0
.6
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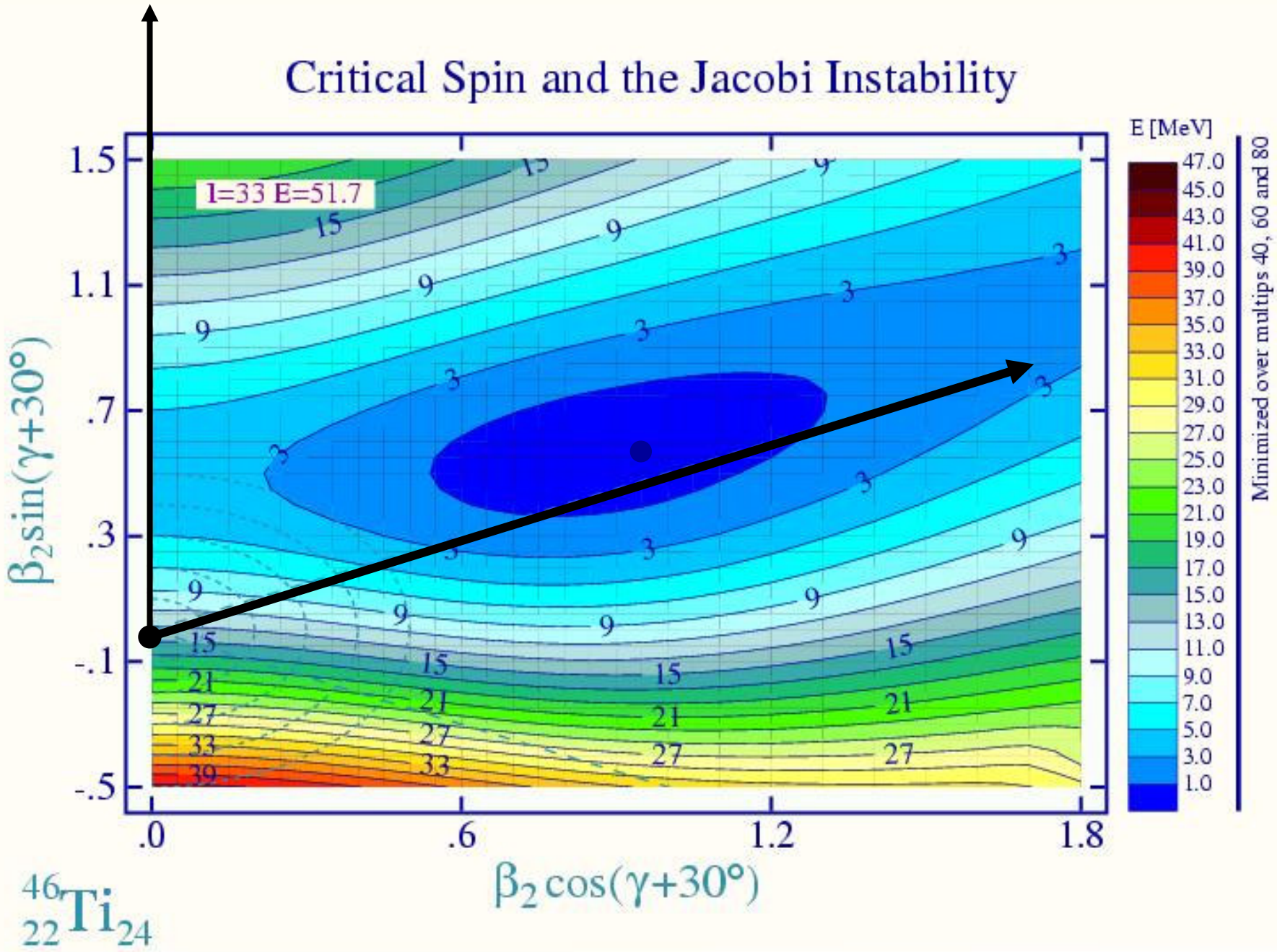
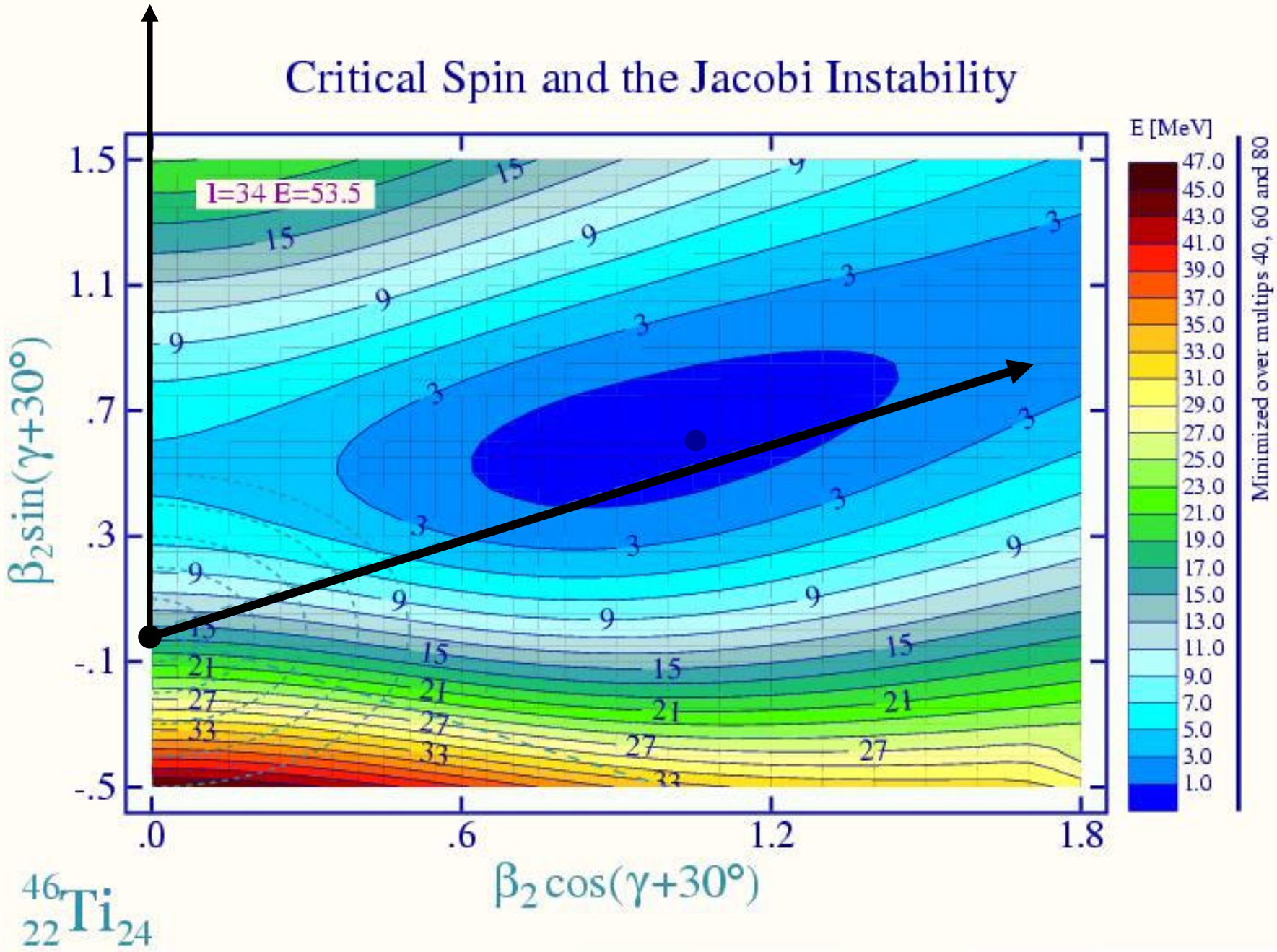
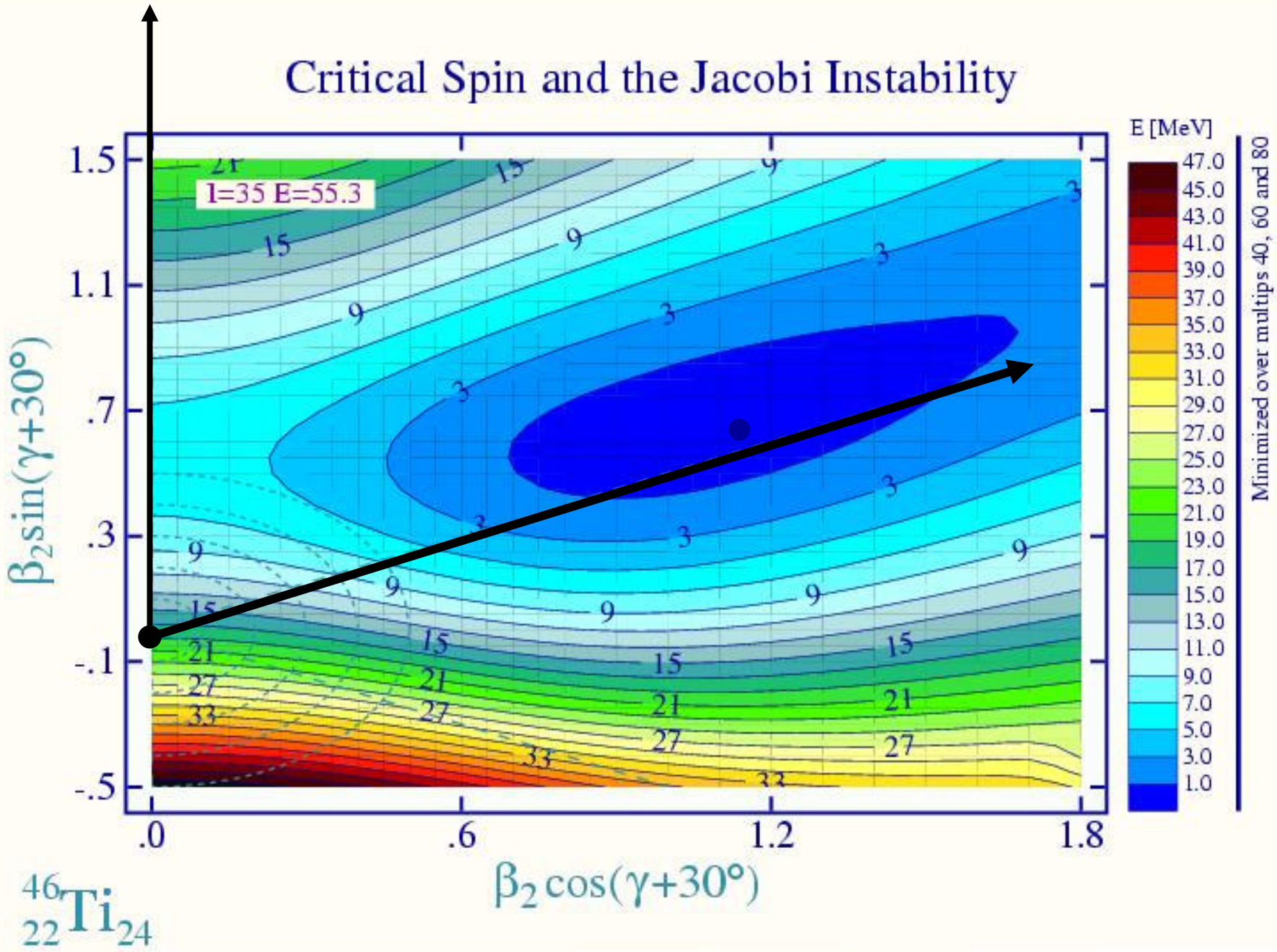
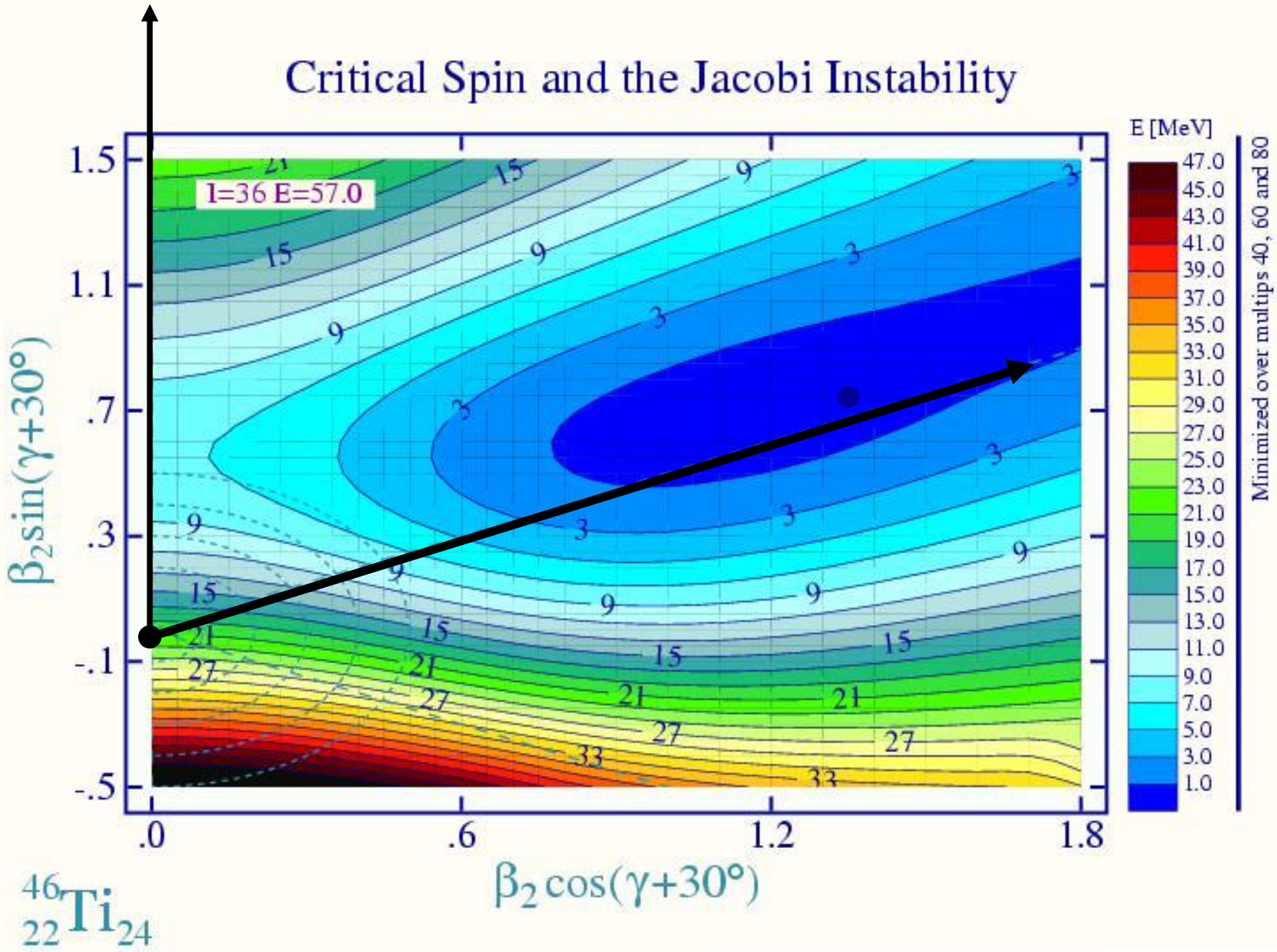
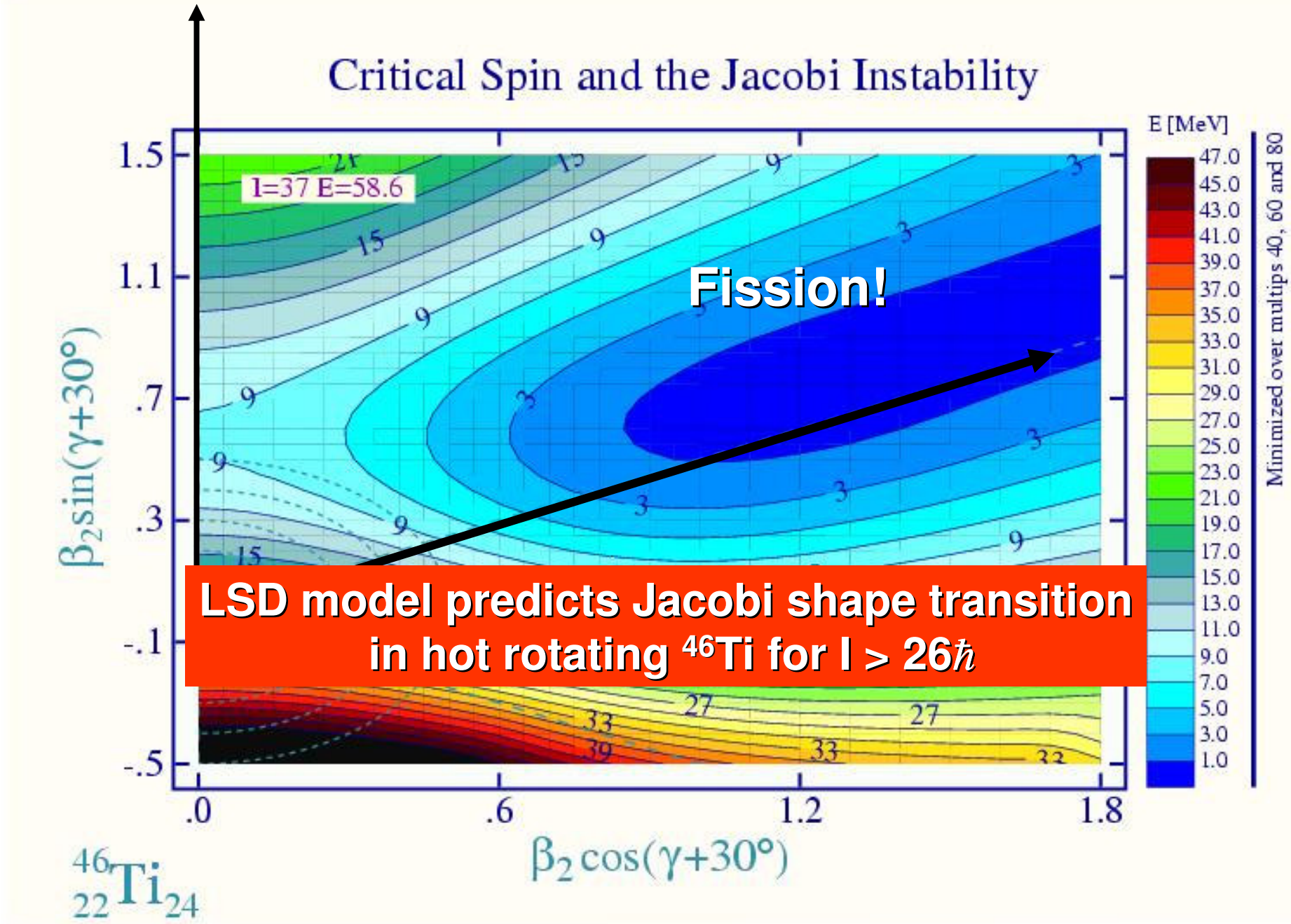
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=33 E=51.7
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
.3
-.1
-.5
.0
.6
1.2
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24

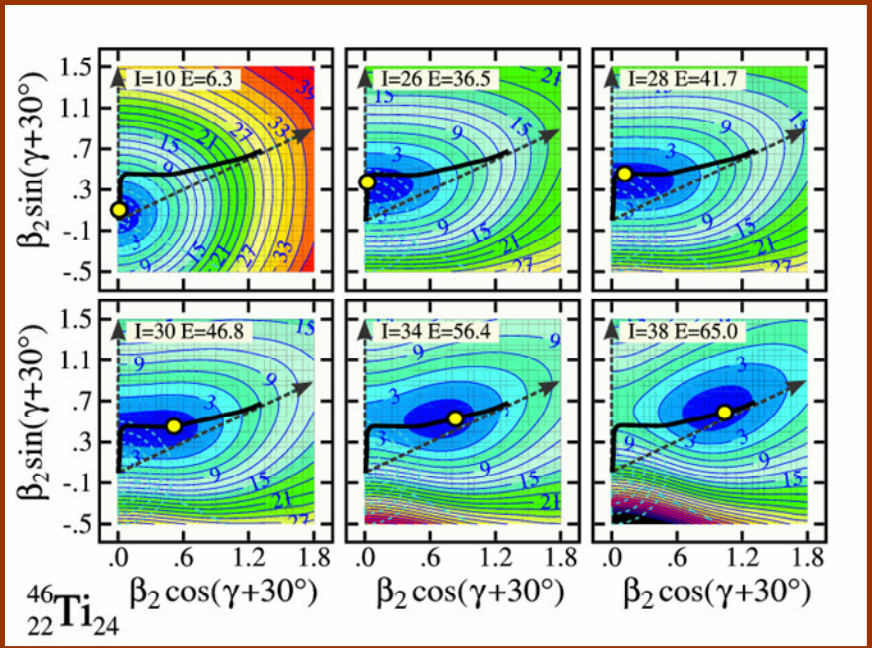

Critical Spin and the Jacobi Instability
I=34 E=53.5
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
.3
-.1
-.5
.0
.6
1.2
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=35 E=55.3
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
.3
-.1
-.5
.0
.6
1.2
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24


Critical Spin and the Jacobi Instability
I=36 E=57.0
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
.3
-.1
-.5
.0
.6
1.2
1.8
β2sin(γ+30°)
β2 cos(γ+30°)
46 22Ti24

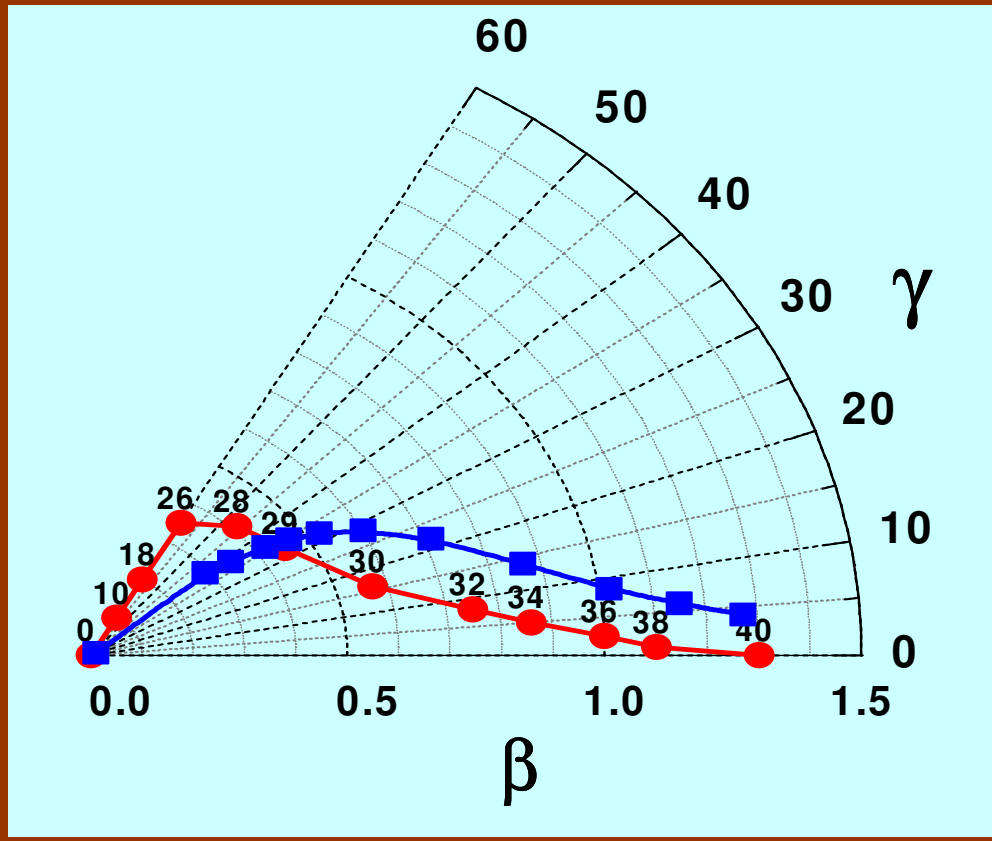

Critical Spin and the Jacobi Instability
I=37 E=58.6
Fission!
LSD model predicts Jacobi shape transition in hot rotating ^{46}Ti for I > 26ħ
E [MeV]
47.0
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
Minimized over multips 40, 60 and 80
1.5
1.1
.7
.3
-.1
-.5
.0
.6
1.2
1.8
$\beta_2 \sin(\gamma+30°)$
$\beta_2 \cos(\gamma+30°)$
$^{46}_{22}Ti_{24}$

Potential energy maps for ^{46}Ti

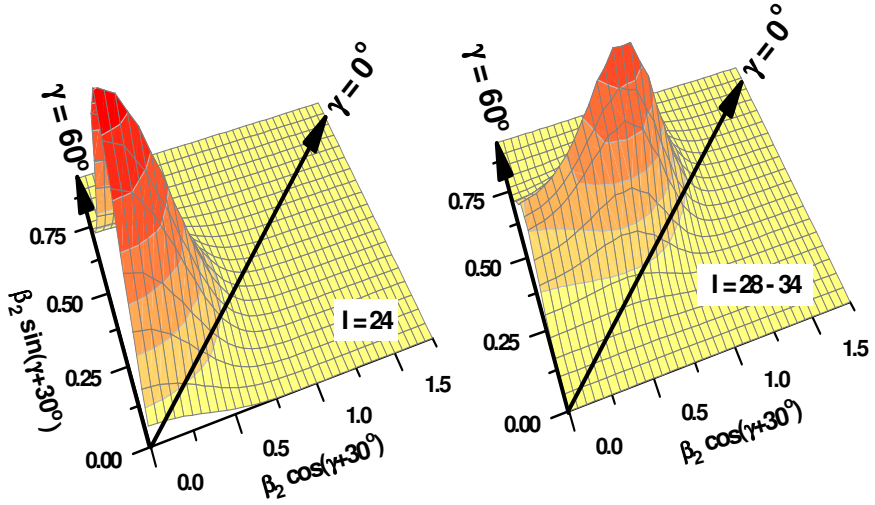


LSD model of Dudek & Pomorski

Evolution of equilibrium shape



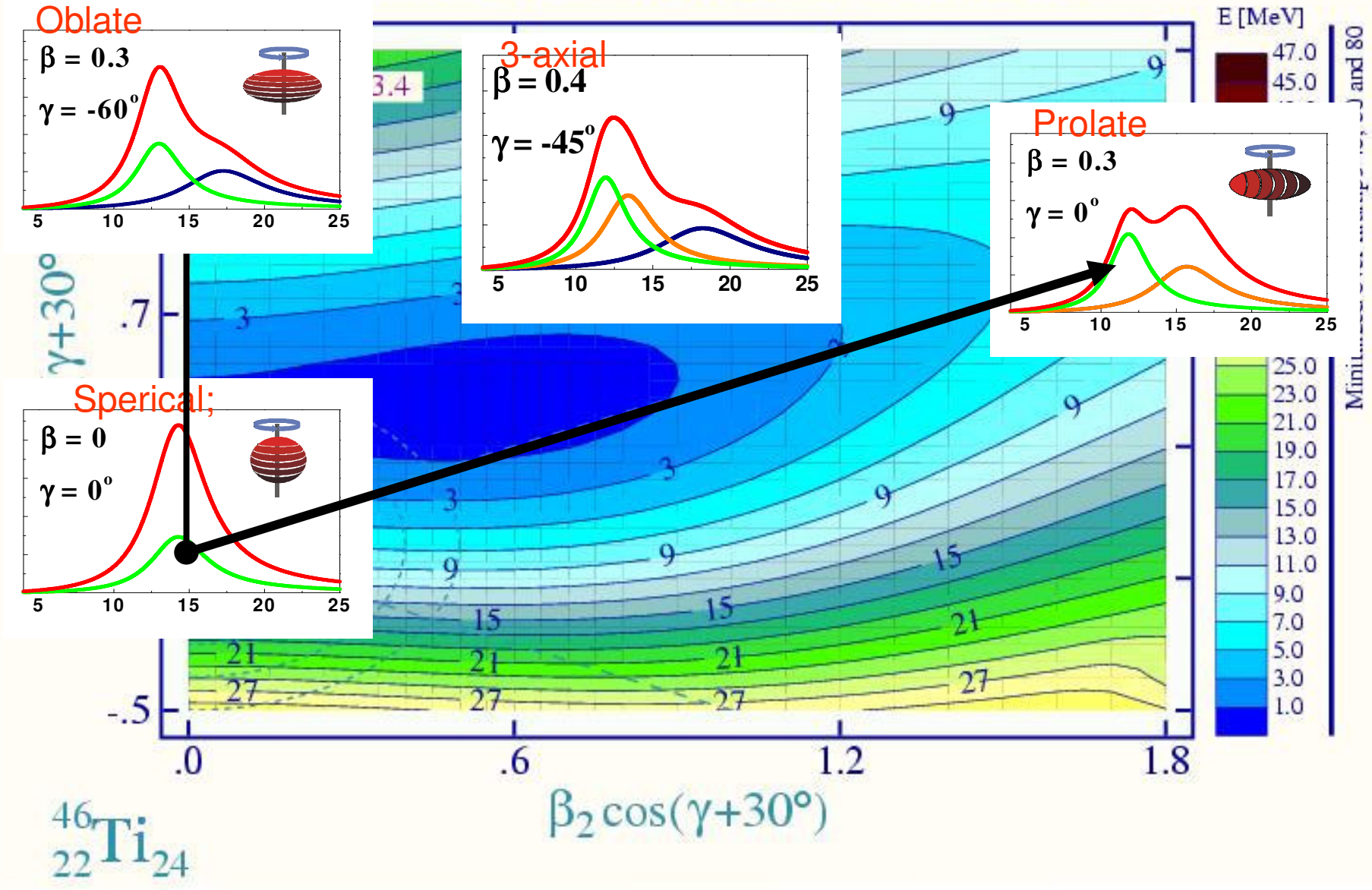
Hot nuclei: Probability *exp-(F/T)* distributions



… and of average shape

Average shapes can be different from equilibrium shapes

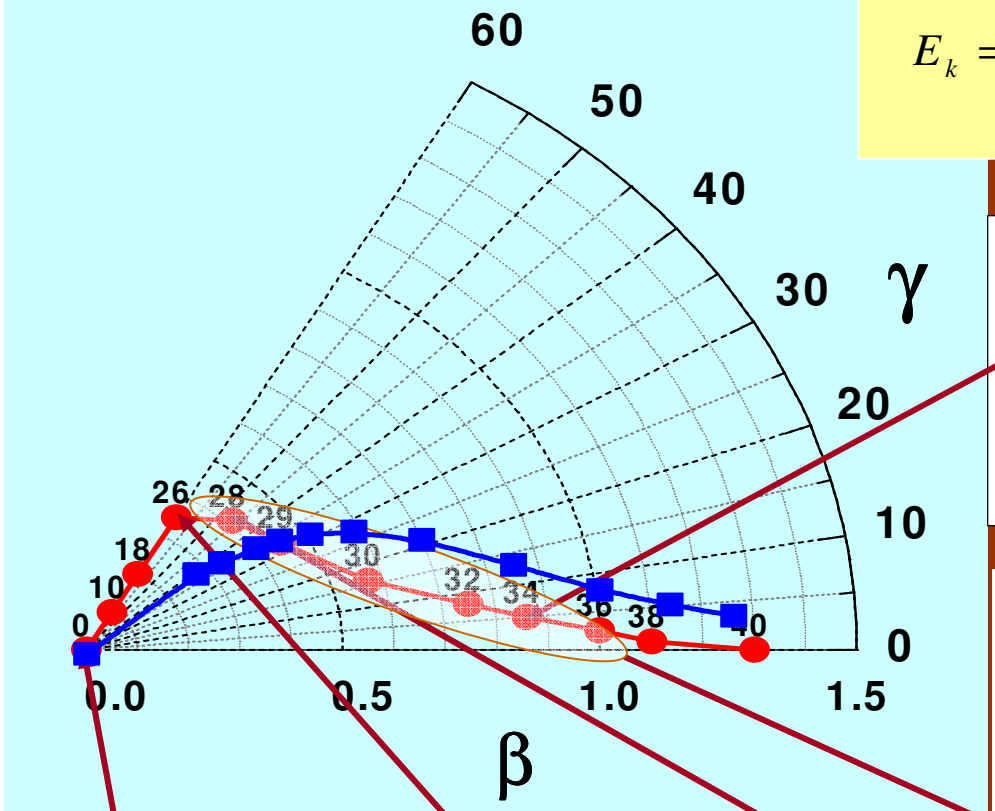
Giand Dipole Resonanse (*GDR*) as a probe of nuclear shapes

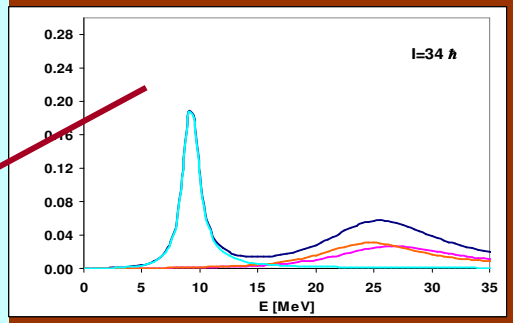


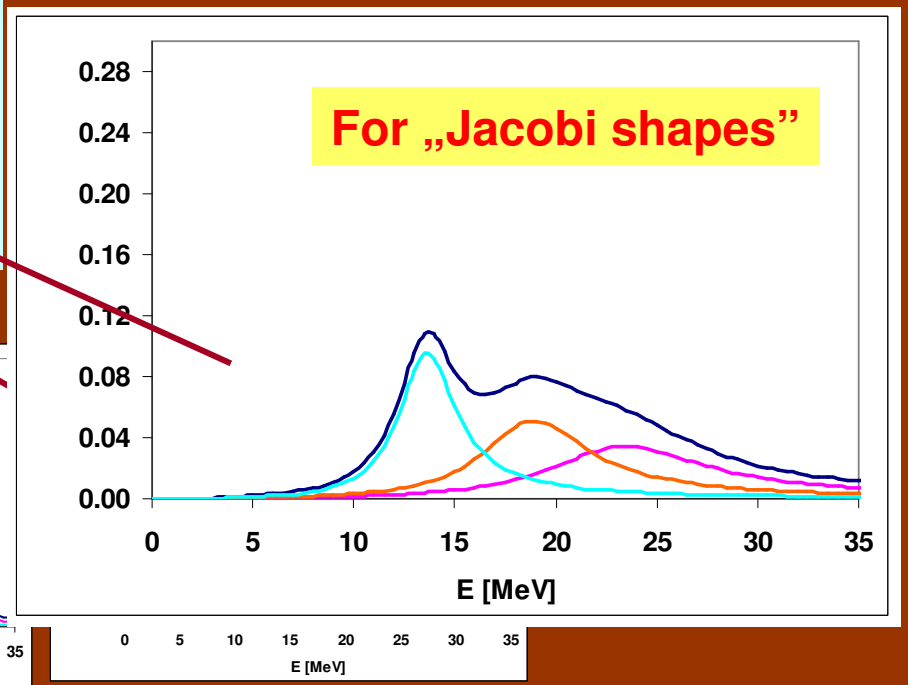
GDR as a probe of nuclear shapes

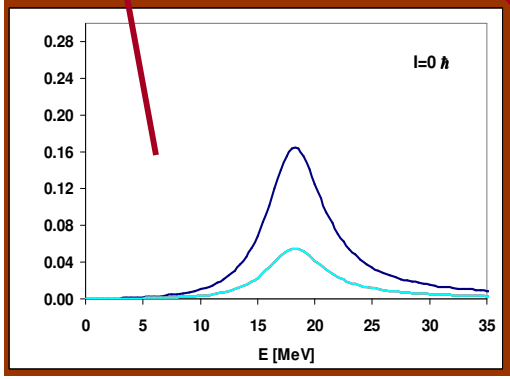
$$E_k = \hbar\omega_k = \hbar\omega_{GDR}\ \exp\left[-\sqrt{\frac{5}{4\pi}}\beta\cos(\gamma - \frac{2\pi}{3}k)\right]$$

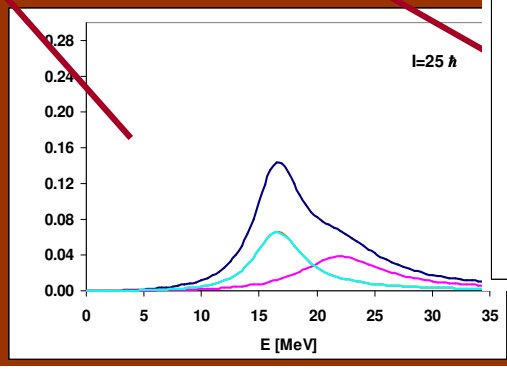
Hill-Wheeler parametrization









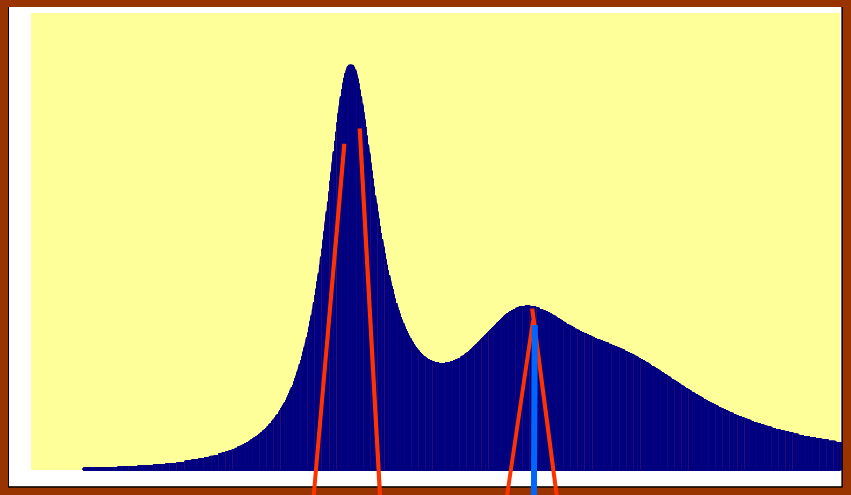


Coriolis splitting of the GDR

K. Neergård, *Phys. Lett.* **110B** (1982) 7

$$\Omega_{2,3}^2 = \frac{\omega_2^2 + \omega_3^2}{2} + \omega^2 \pm \sqrt{\Delta}$$

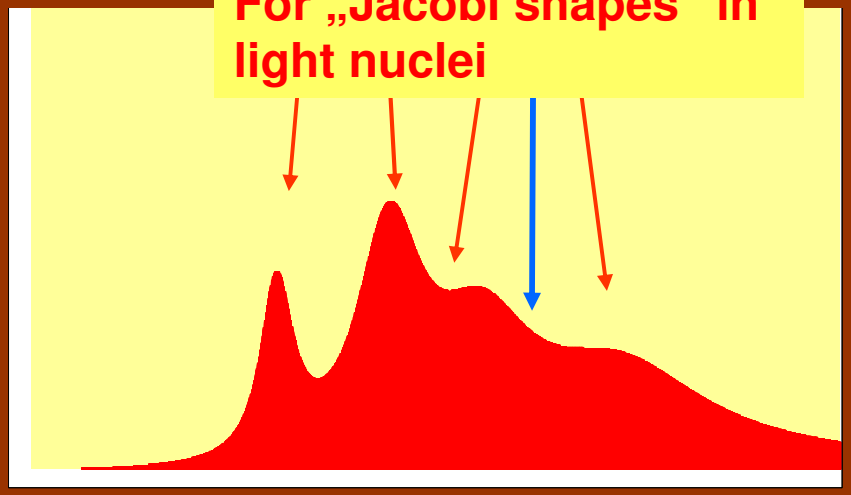
$$\Delta = \frac{1}{4}\left(\omega_2^2 - \omega_3^2\right)^2 + 2\omega^2\left(\omega_2^2 + \omega_3^2\right)$$



Prolate β=0.5

ω=0

For „Jacobi shapes" in light nuclei



ω=2.8

(I=30 for A=46)

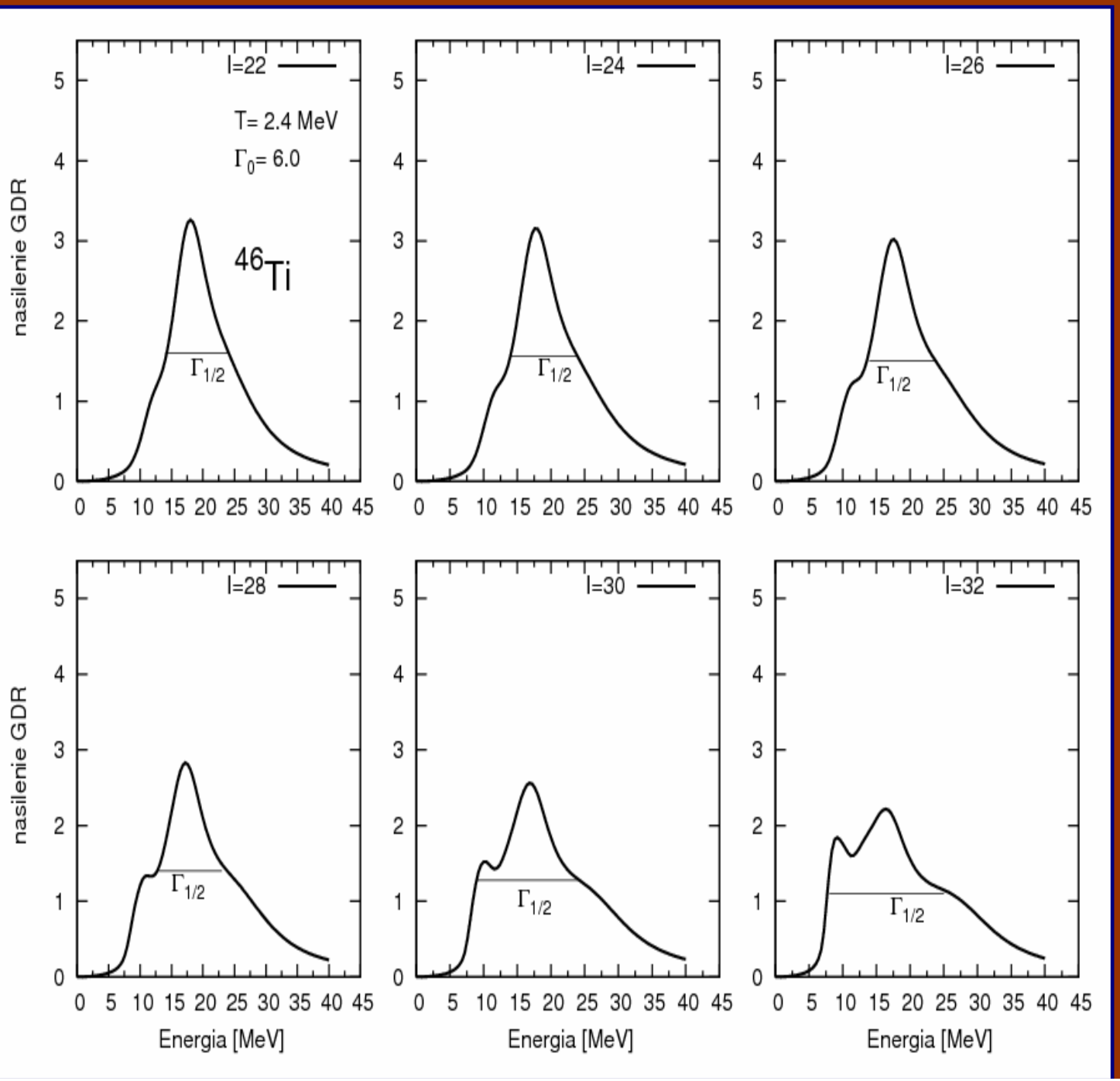
Frequency

$\omega = 0$ $\omega > 0$

$\omega_1 \rightarrow \omega_1$

$\omega_2 \rightarrow \Omega_2 + \omega$, $\Omega_2 - \omega$

$\omega_3 \rightarrow \Omega_3 + \omega$, $\Omega_3 - \omega$

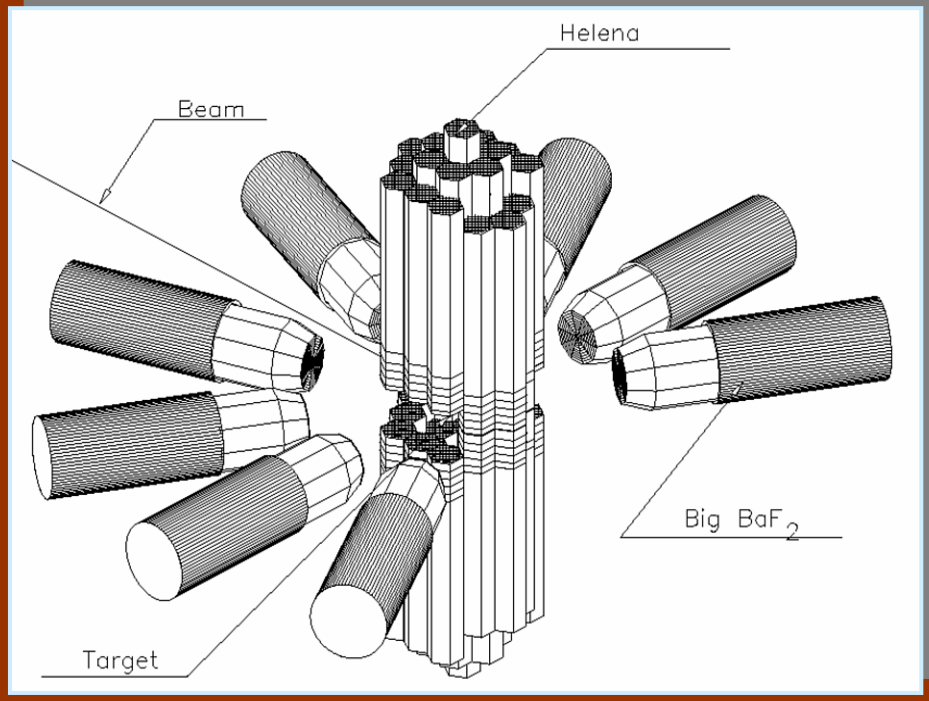


(cf. Talk of Kasia Mazurek)

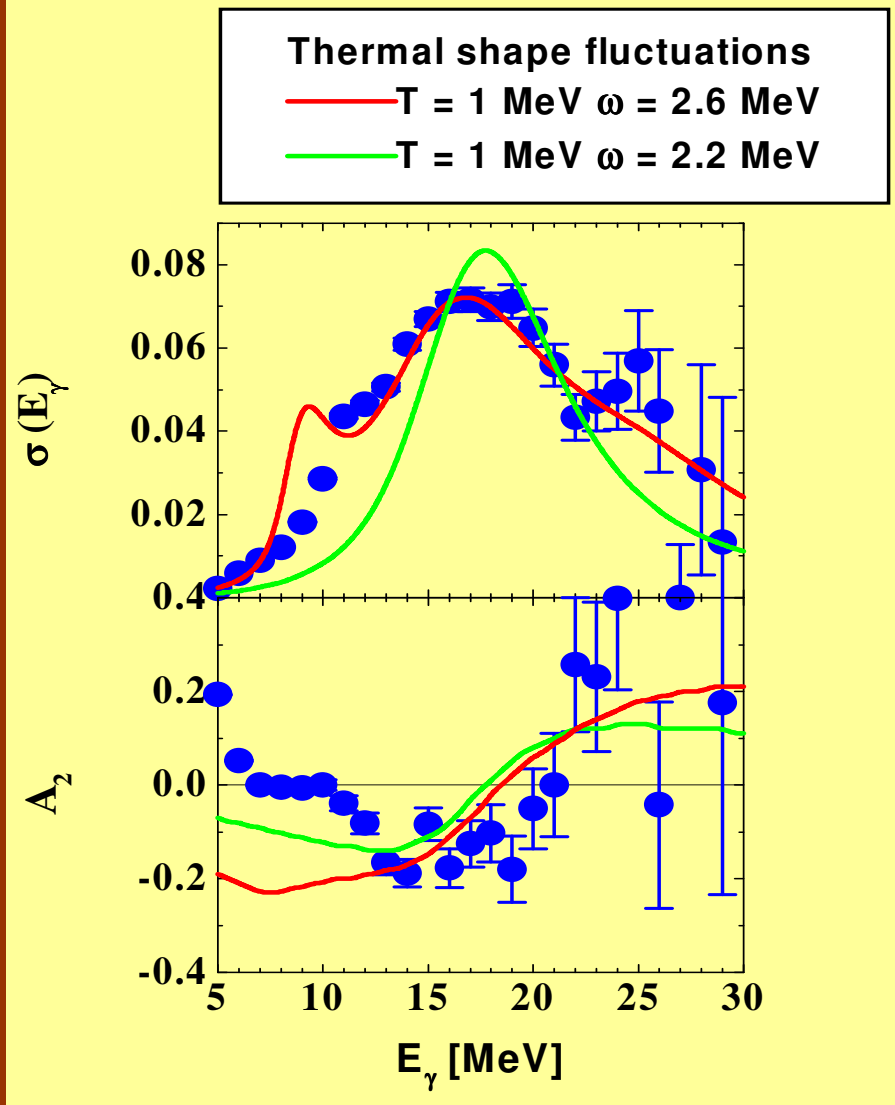
Earlier HECTOR experiment at NBI

96 MeV $^{18}O + ^{28}Si \Rightarrow ^{46}Ti^*$

$I_{max} \approx 32\hbar$, $E^* = 80$ MeV



A. Maj et al, *Nucl. Phys.* A687 (2001) 192



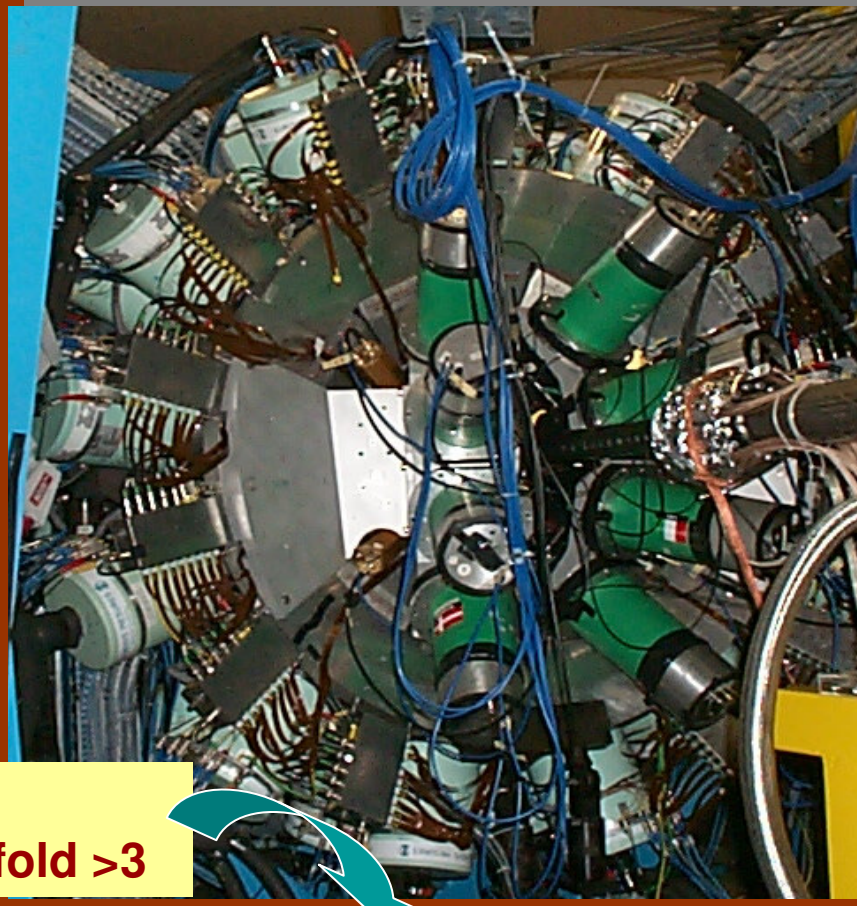
The experiment at VIVITRON

105 MeV $^{18}O + ^{28}Si \Rightarrow ^{46}Ti^*$

$l_{max} \approx 35\ \hbar$, $E^* = 88$ MeV

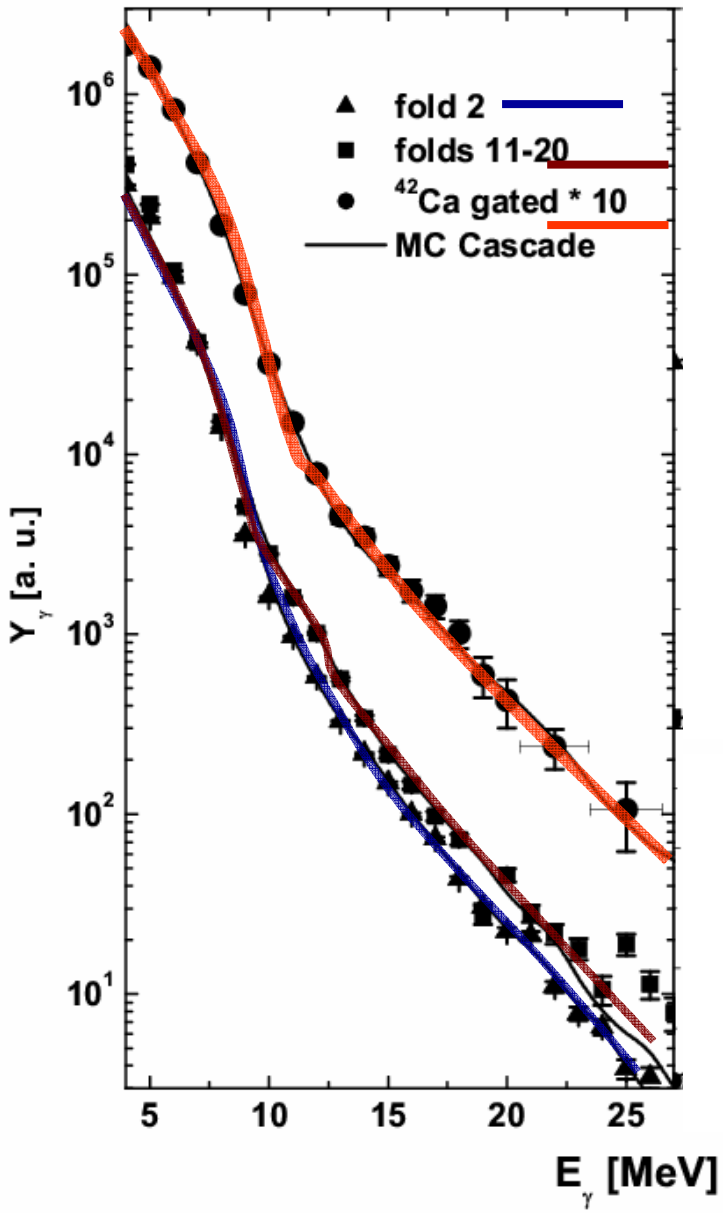
$^{41,42}Ca$ (2p*x*n)
$^{39,40,41}K$ (3p*x*n)
$^{36,37,38,39}Ar$ (2α*x*n, α2p*x*n)
$^{35,36,37}Cl$ (2αp*x*n)
.....

- **EUROBALL IV** (26 clovers + 15 clusters + 75% InnerBall)
- **HECTOR** (8 big BaF_2 + 4 small BaF_2)
- **EUCLIDES** (40 Si telescopes)



Master trigger:
2 clean Ge ∧ 1 big BaF ∧ 1 small BaF ∧ IB fold >3

Selection of high spins


fold 2
folds 11-20
^{42}Ca gated * 10
MC Cascade
10^6
10^5
10^4
10^3
10^2
10^1
Y_γ [a. u.]
5
10
15
20
25
E_γ [MeV]

Comparison to the calculated GDR shape based on LSD

Thermal shape fluctuations

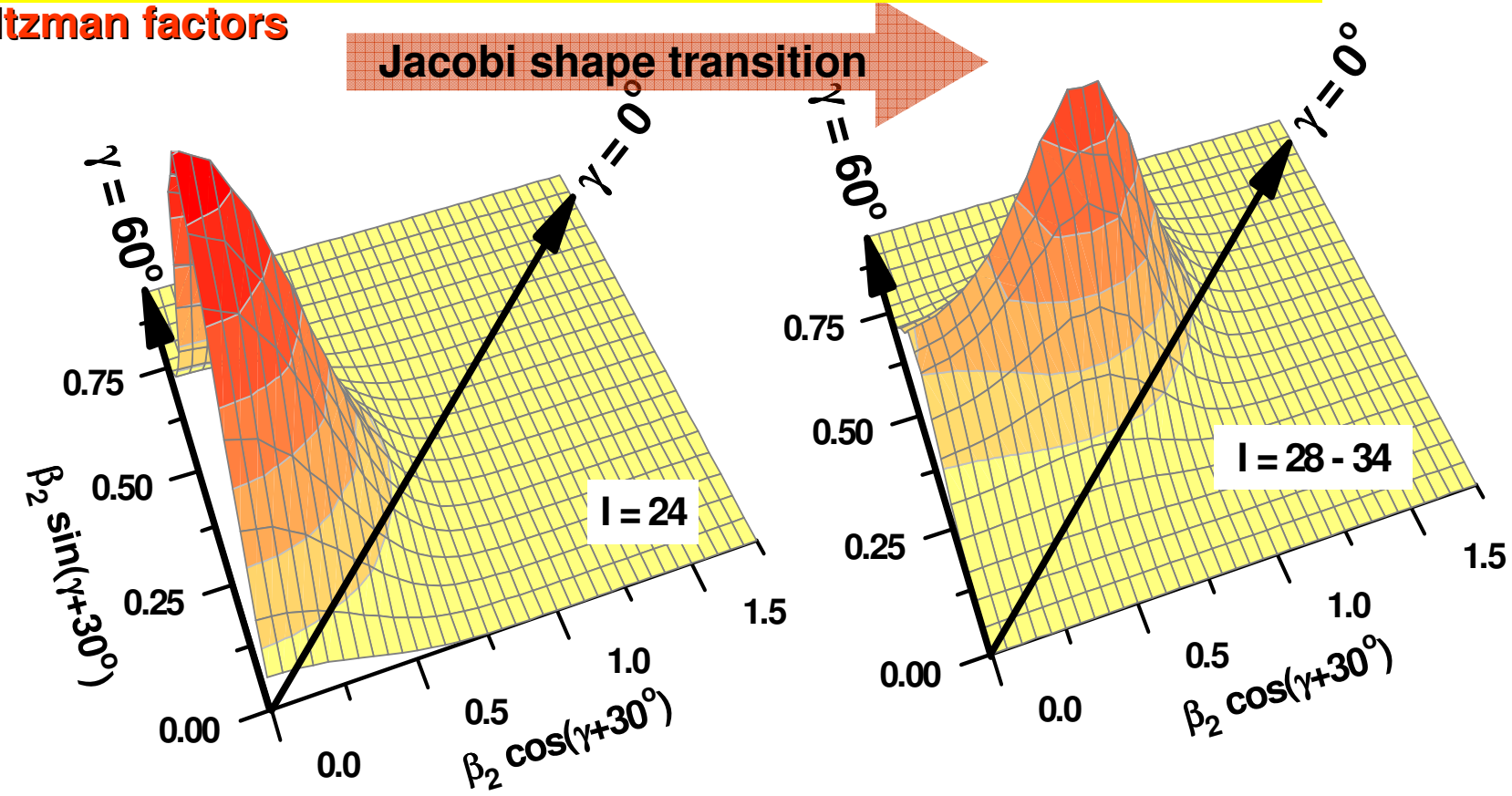
M. Gallardo et al., Nucl. Phys. A443, 415 (1985).
Y. Alhassid, B. Bush, S. Levit, Phys. Rev. Lett. 61, 1926 (1988).

N. Dubray, J. Dudek. A. Maj, *Acta Phys. Pol.* **B36** (2005) 1161
Cf. Talk of Kasia Mazurek

$$f_{GDR}^{av}(T,I) = \iint f_{GDR}(\beta,\gamma,\omega) e^{-F(T,I;\beta,\gamma)/T(I;\beta,\gamma)} \beta^4 \left|\sin(3\gamma)\right| d\beta d\gamma$$

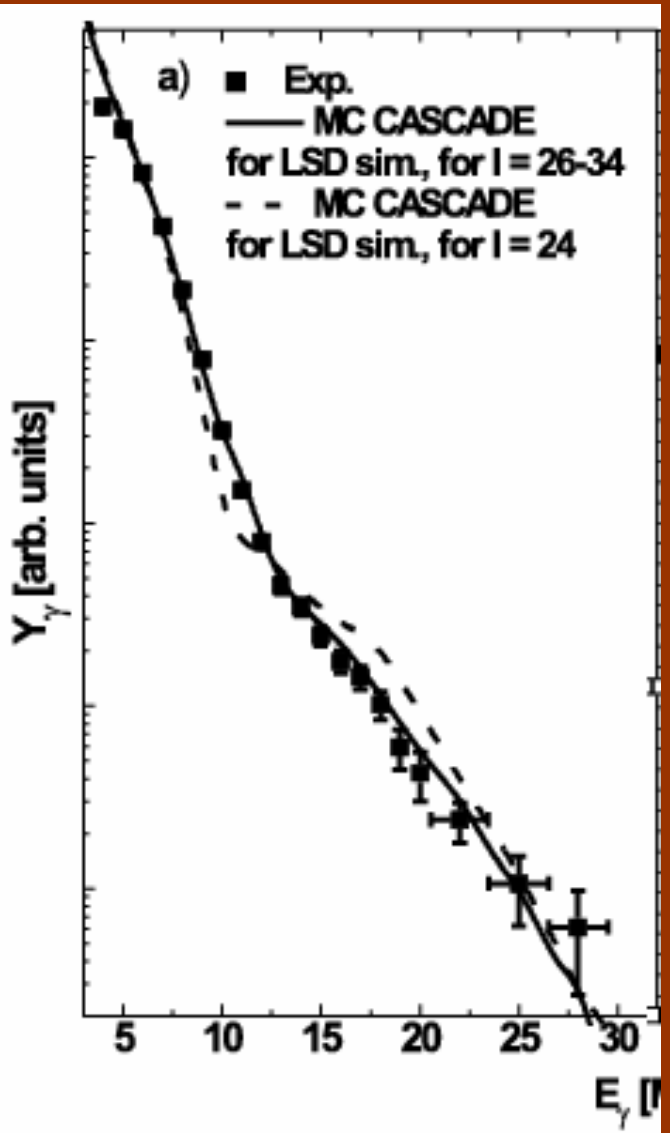
Boltzman factors

Jacobi shape transition

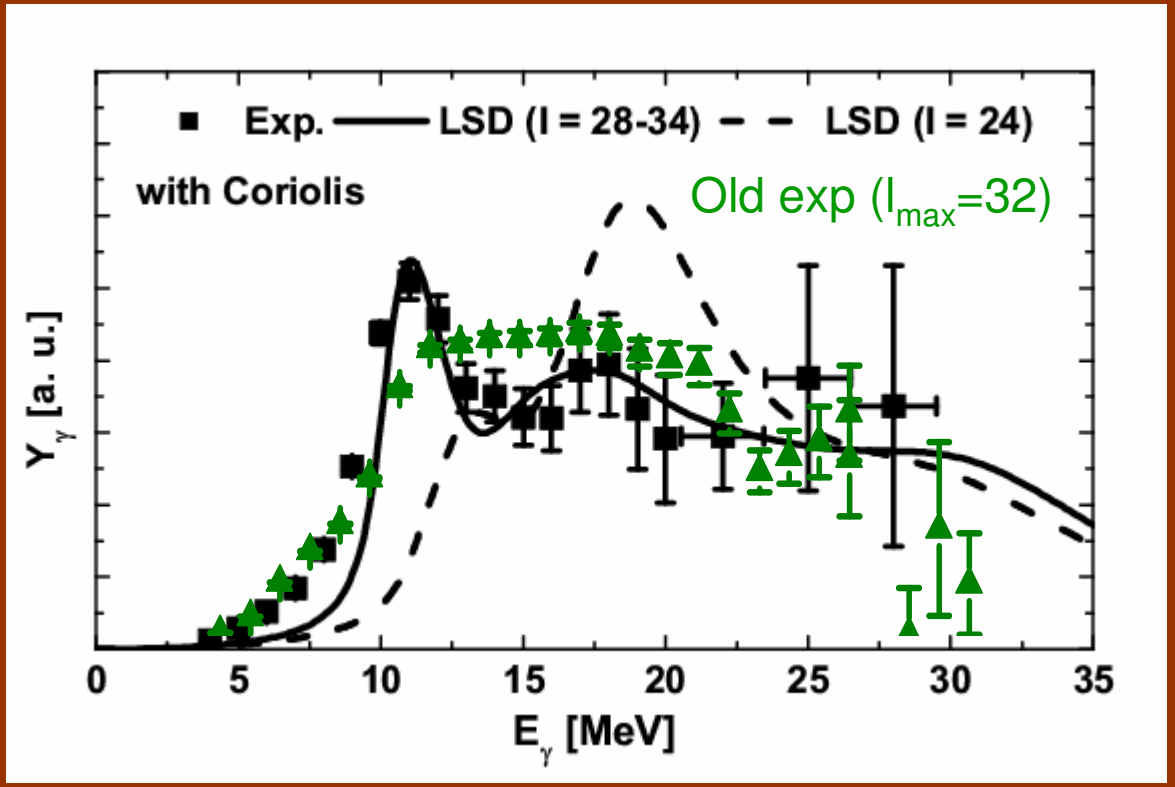


^{46}Ti - experimental results

Interpretation: Monte Carlo Cascade, with
Reisdorf level density parametrization

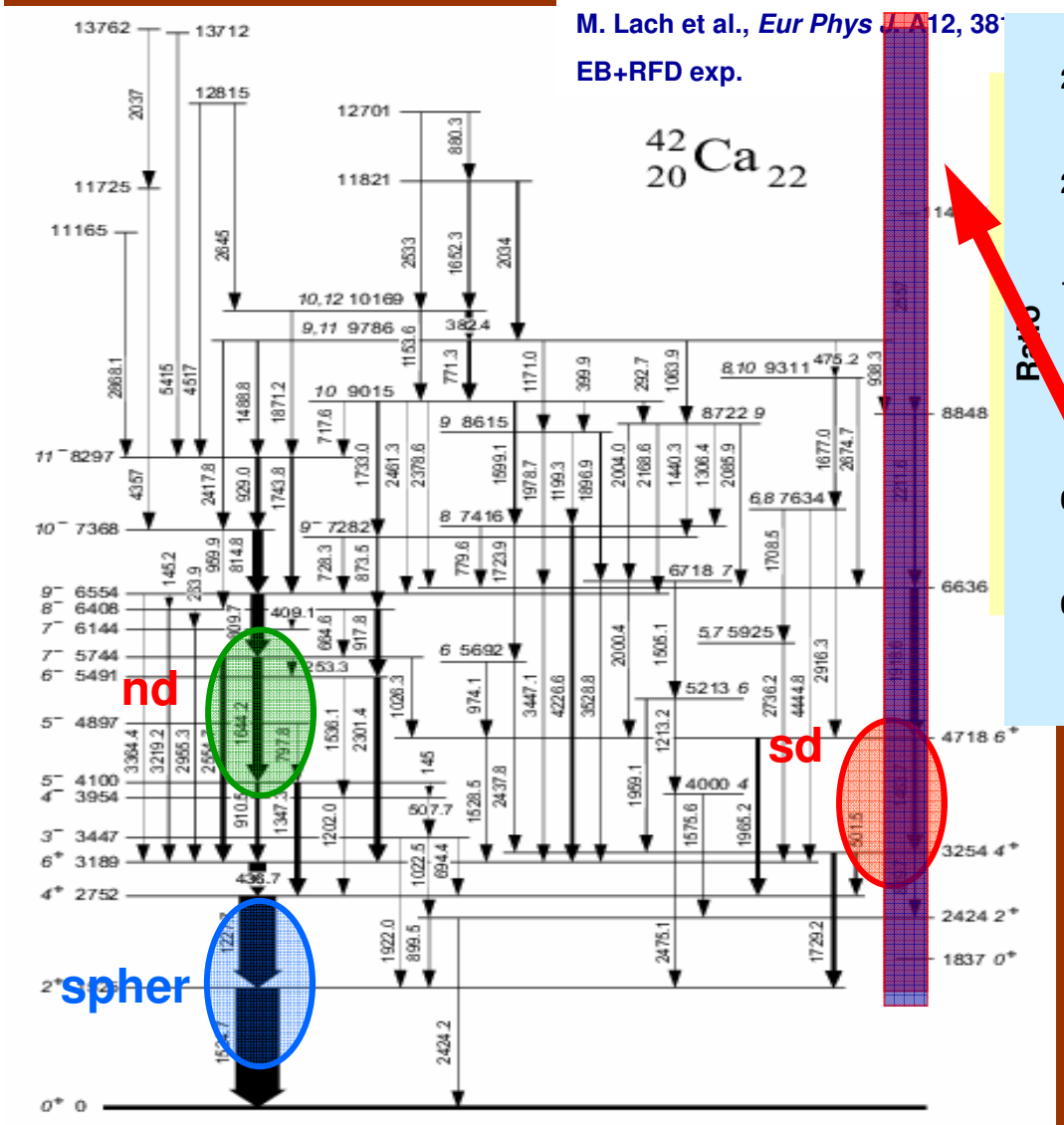


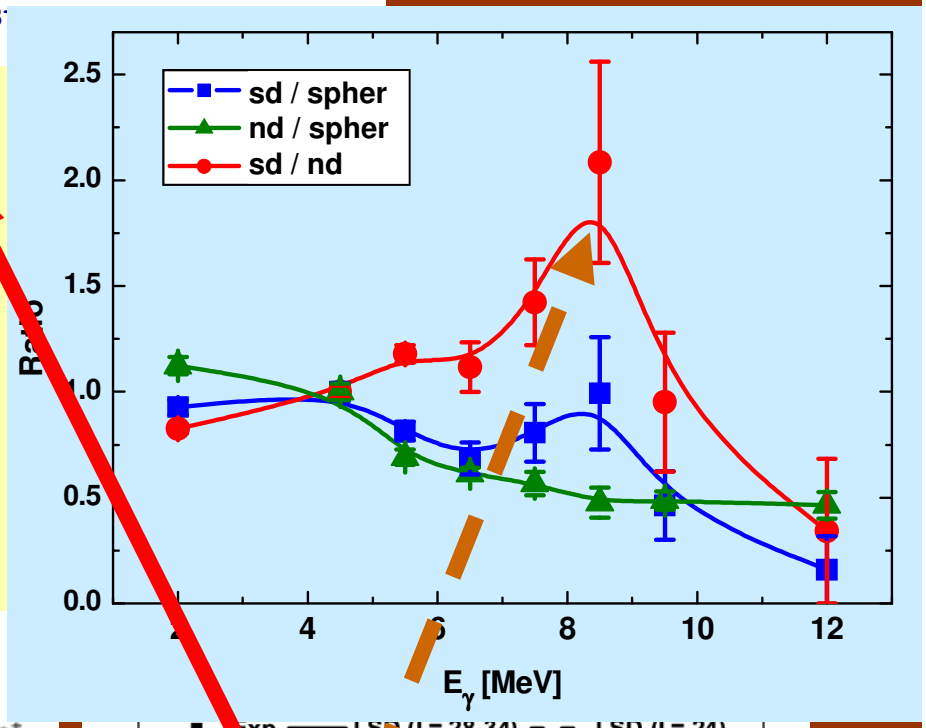
Indication of the Jacobi shape transition and (for the first time) of the Coriolis splitting

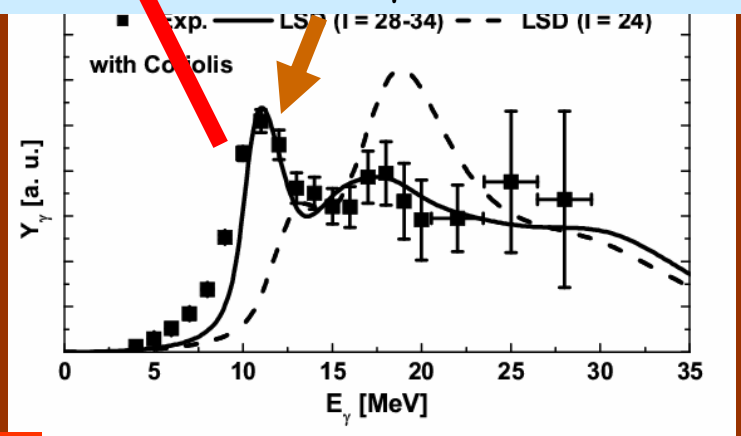


GDR feeding of the well deformed band in ^{42}Ca

M. Kmiecik et al.., *Acta Phys. Pol.* **B36** (2005) 1169



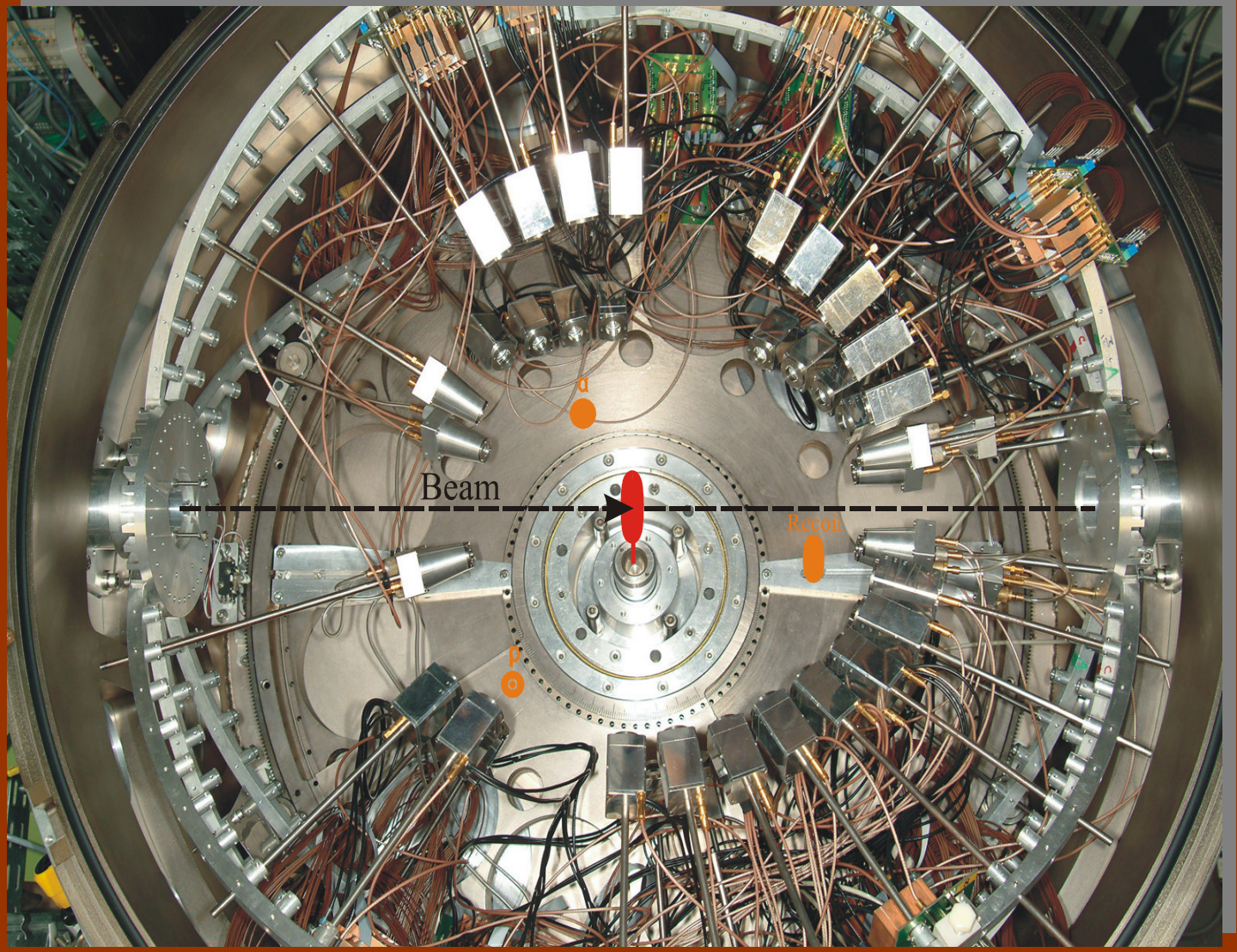




Jacobi shape transition – a gateway to SD or HD ?

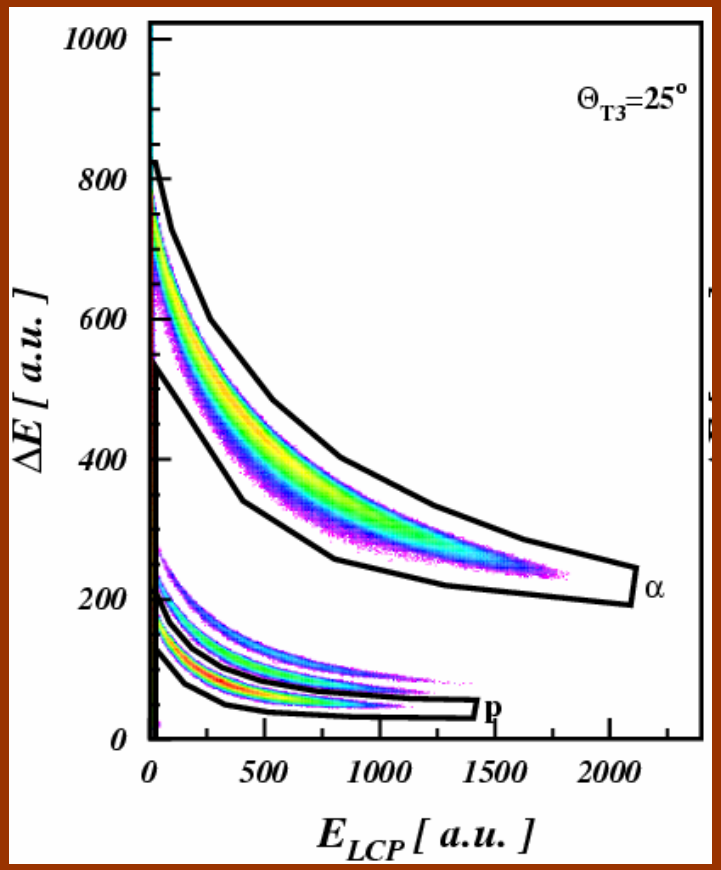
Large deformations of ^{46}Ti and the charged particle energy spectra

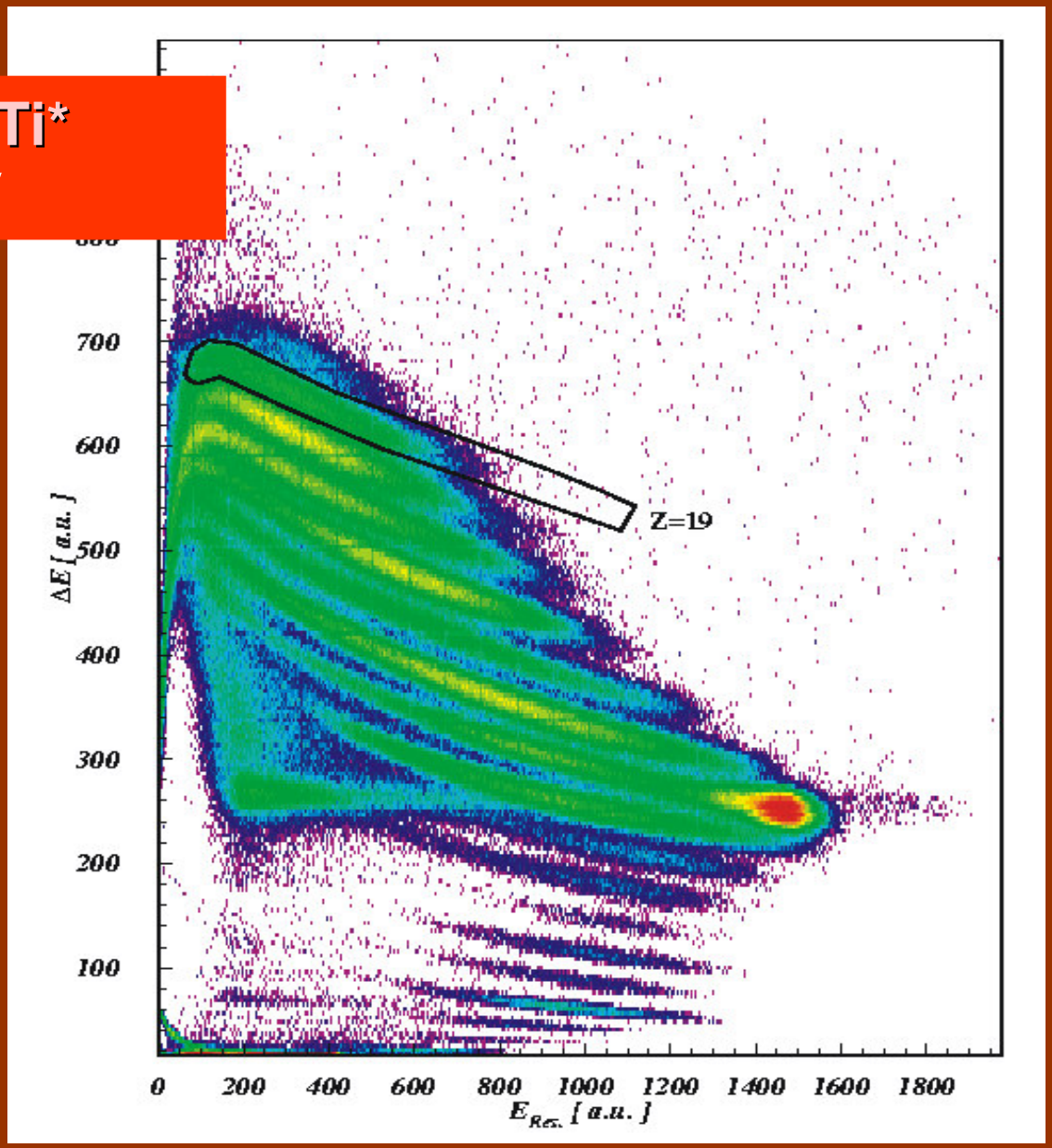
Last ICARE experiment at IRES Strasbourg



M. Brekiesz et al., *Acta Phys. Pol.* **B36** (2005) 1175
M. Brekiesz et al., nucl-ex/0608011

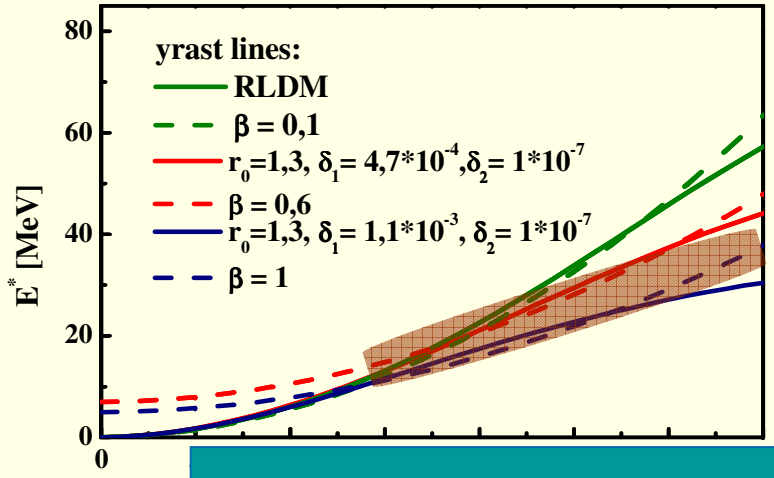
144 MeV ^{27}Al + ^{19}F $\Rightarrow$ ^{46}Ti*
$I_{max} \approx 35\ \hbar$, $E^* = 85$ MeV





α-particle spectra

M. Brekiesz et al, *Acta Phys. Pol.* **B36** (2005) 1175
M. Brekiesz et al., Nucl. Phys. A 788 (2007) 224c–230c



$E_Y = \hbar^2/2\Im_{eff}\,(L(L+1))$

$\Im_{eff} = \Im_{sphere}\,(1+\delta_1 L^2 + \delta_2 L^4)$

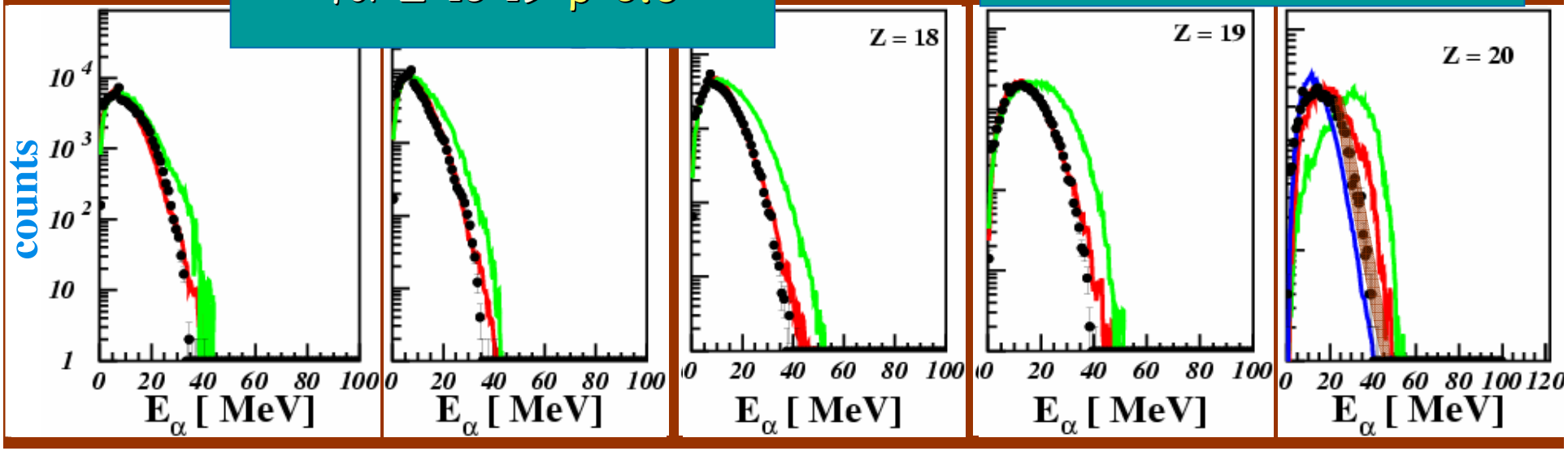
$\Im_{eff}$ - effective moment of inertia

$\Im_{sphere}$ - moment of inertia for spherical nucleus

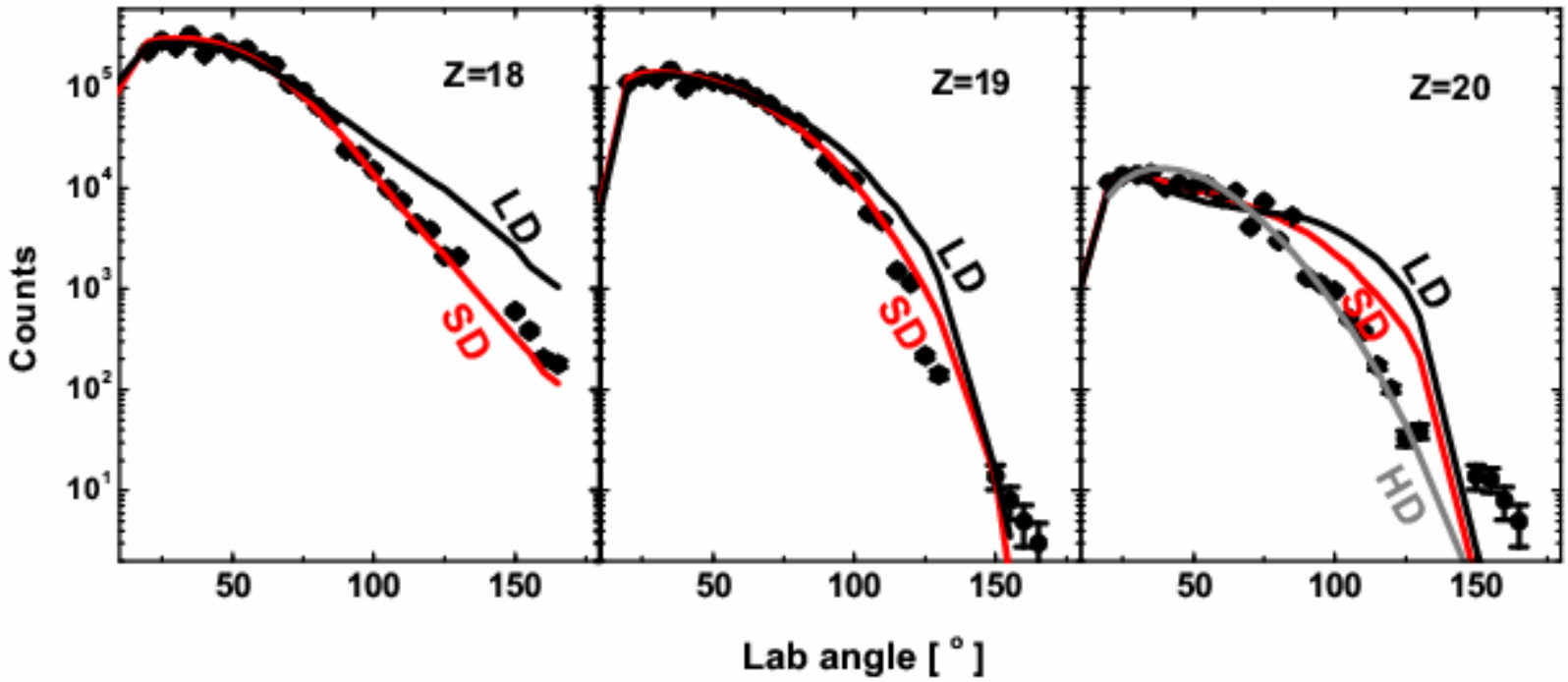
$\Im_{sphere} = 2/5 m R^2$, $R = r_0 A^{1/3}$

estimated deformation for Z=15-19: β=0.6

estimated deformation for Z=20: 0.8<β<1.0

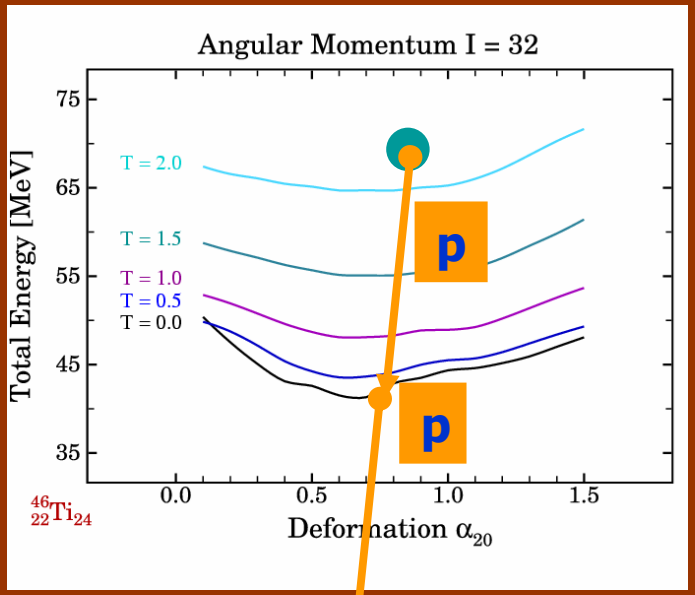


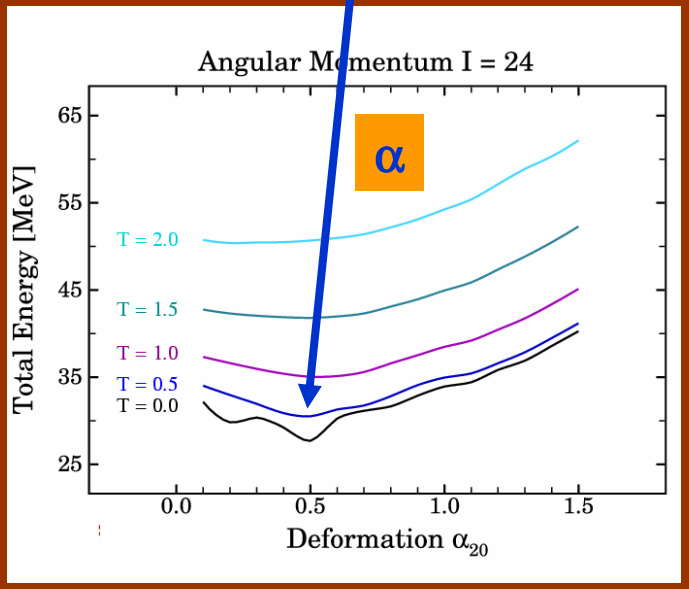
Angular correlations of α's in coincidence with ER at -10°



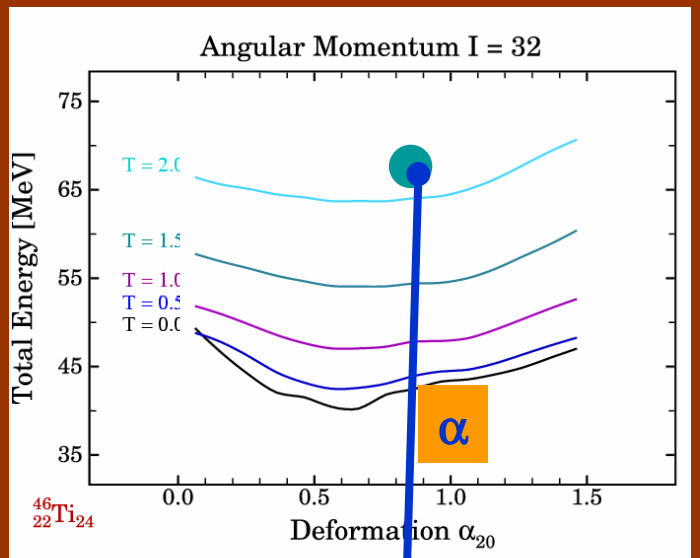
Possible explanations for this „hyperdeformation”

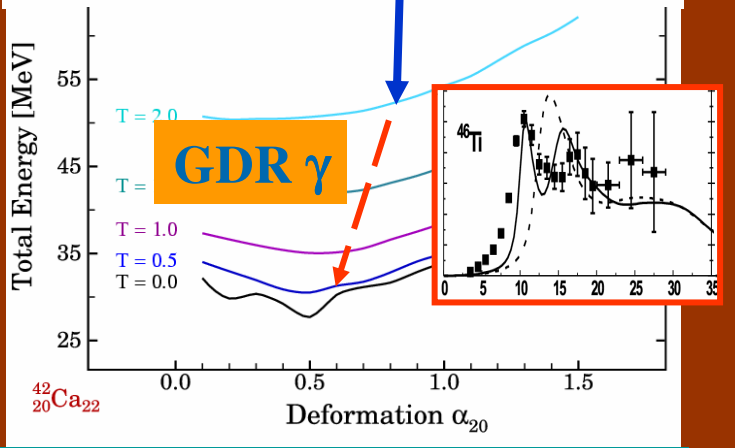
Z=18 (e.g. 2p-1α emission channel)





Z=20 (only 1α emission channel)

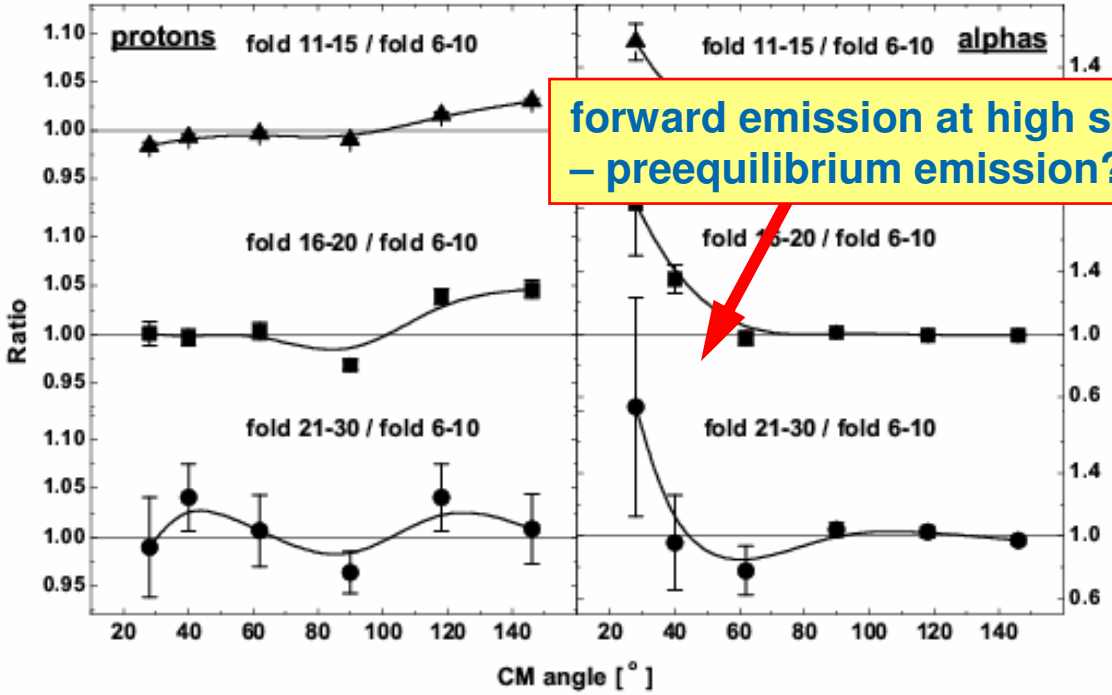




1. „Dynamical hyperdeformation”?

Similar effects were observed in $^{59}Cu^{*}$
- Fornal et al., *Phys. Rev.* **C40** (1989) 664

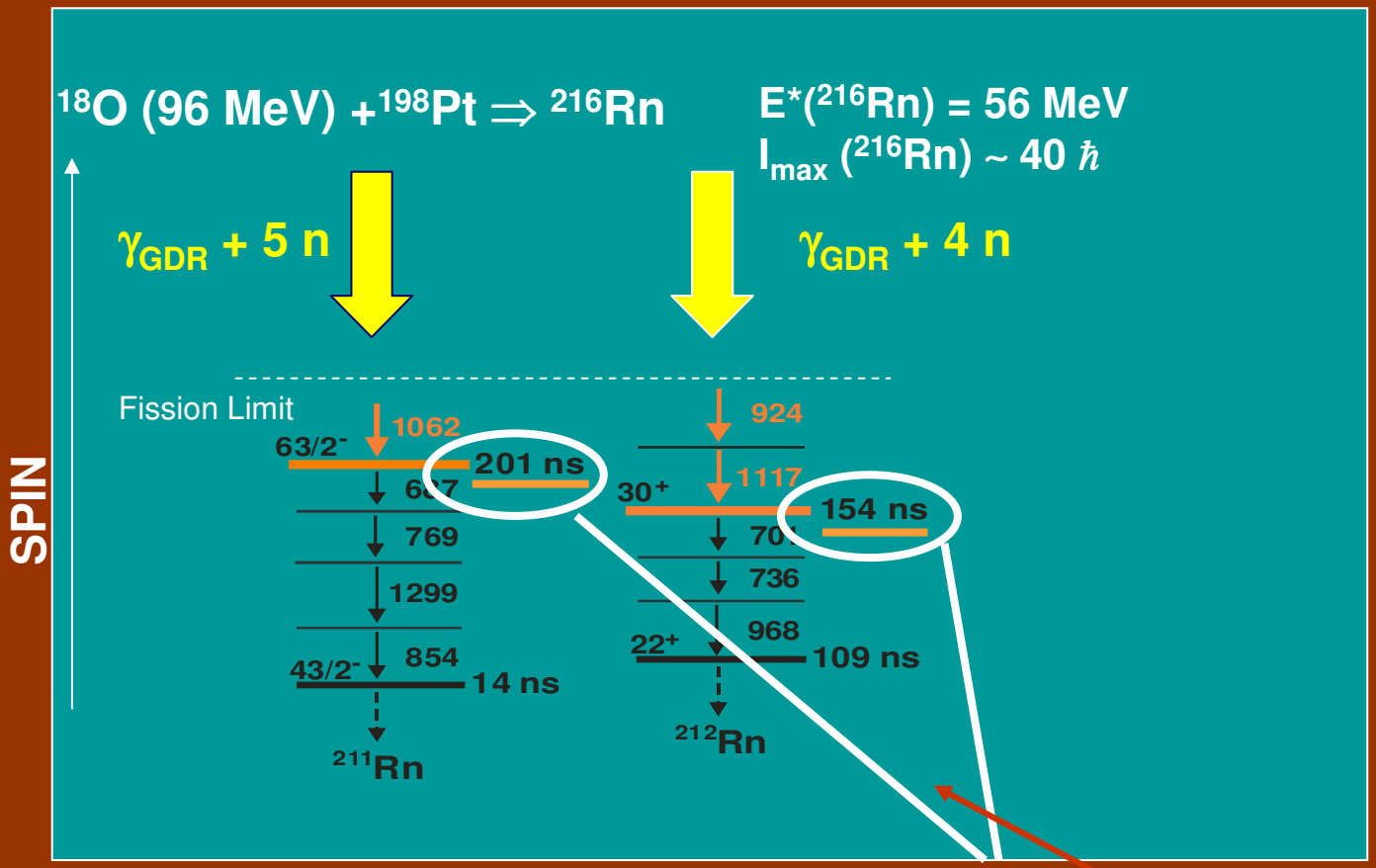
particle angular distributions
(HECTOR + EUROBALL + EUCLIDES exp.)



2. Preequilibrium α emission from „di-nuclear" system?

^{216}Rn case

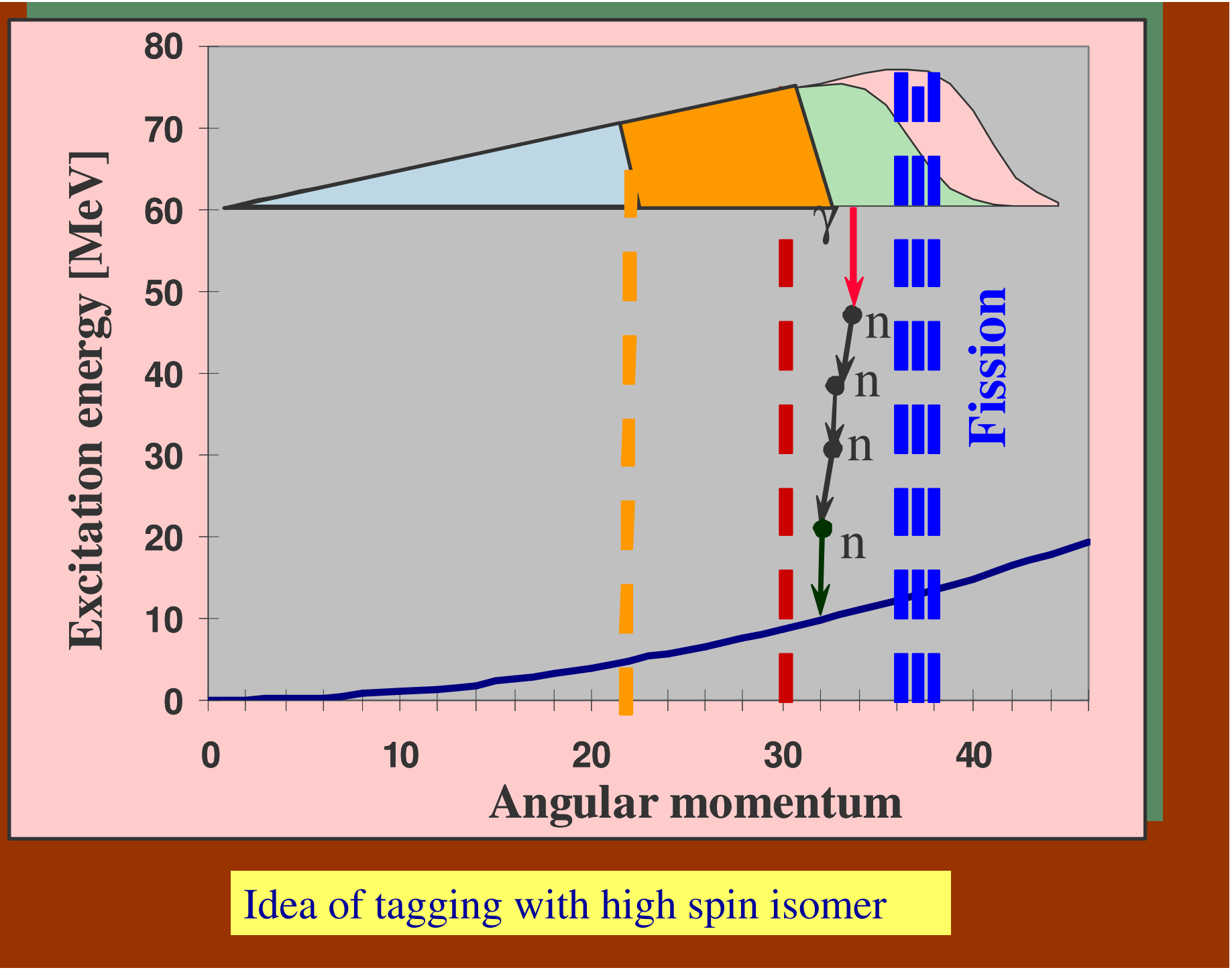
Nuclei surviving fission at moderate temperature



Experiment made in Legnaro

M. Kmiecik et al. PR C70, 064317 (2005)

Tagging on these Isomers selects only those nuclei which survive fission

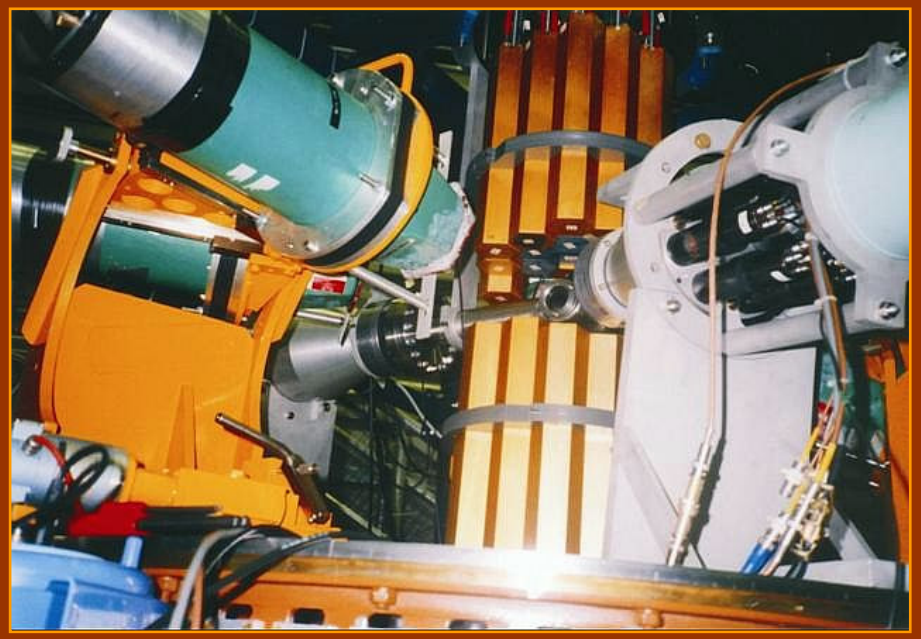


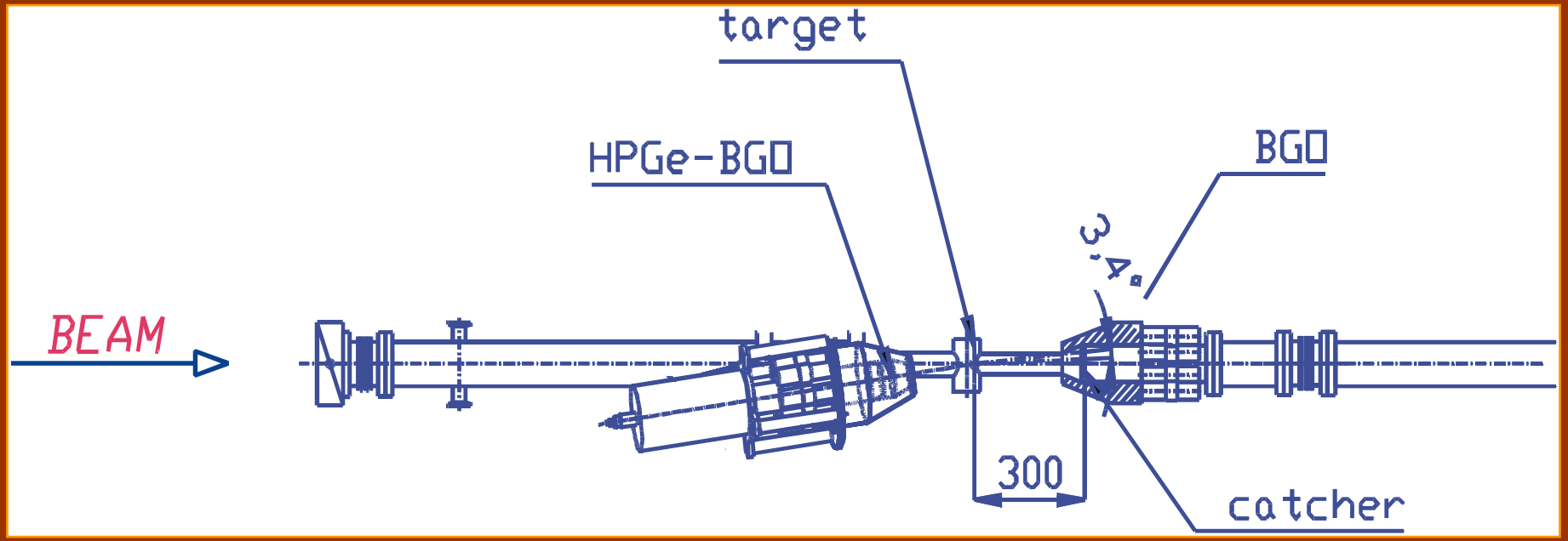
Idea of tagging with high spin isomer

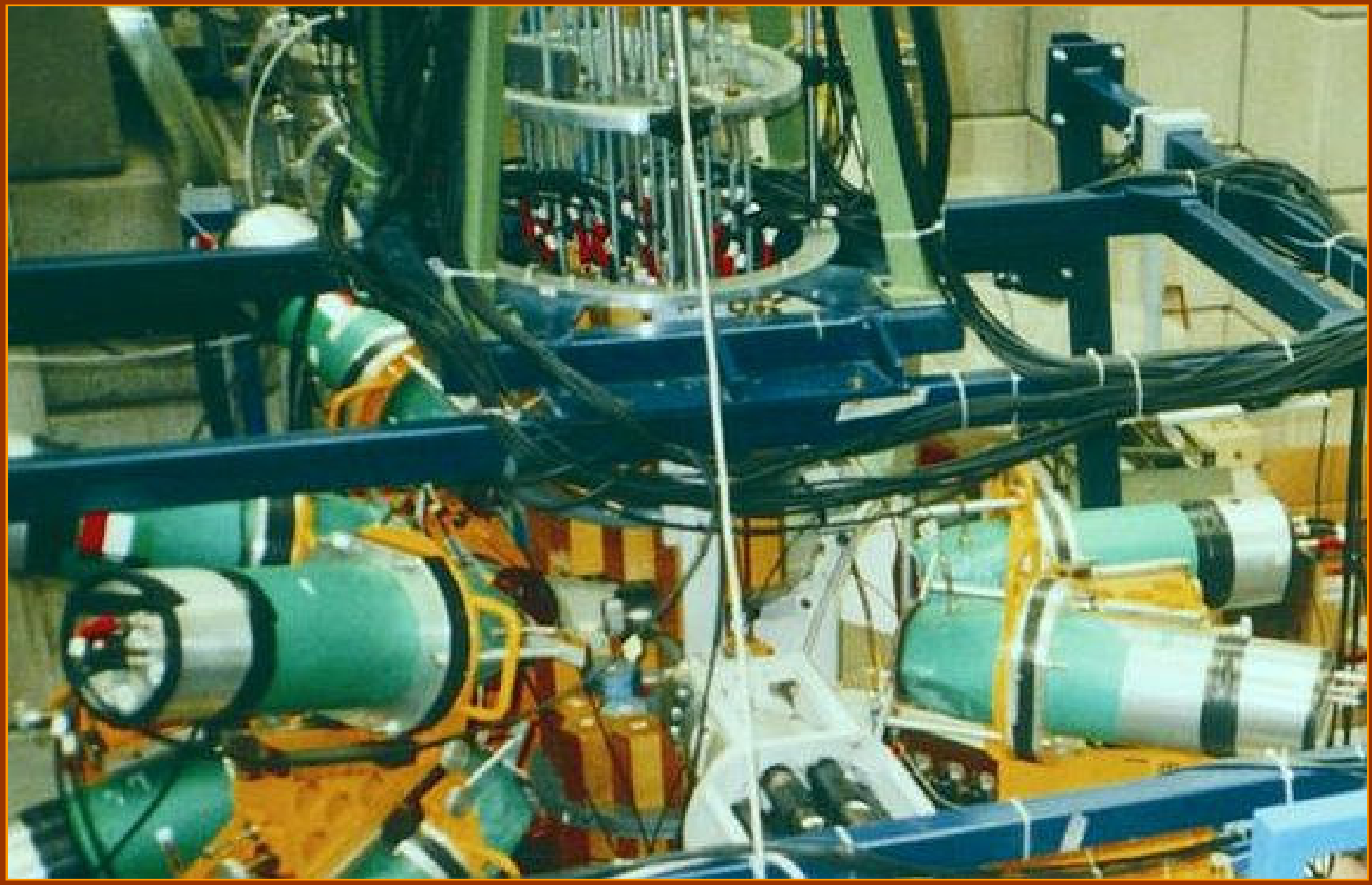
Experiment at LNL :

- **HECTOR** (High energy gamma rays)
- **HELENA** (gamma multiplicity)
- **Catcher + BGO** (isomer selection)
- **Ge** (low energy gamma rays - High resolution)

A pulsed beam 10 ns long every 400 ns was used



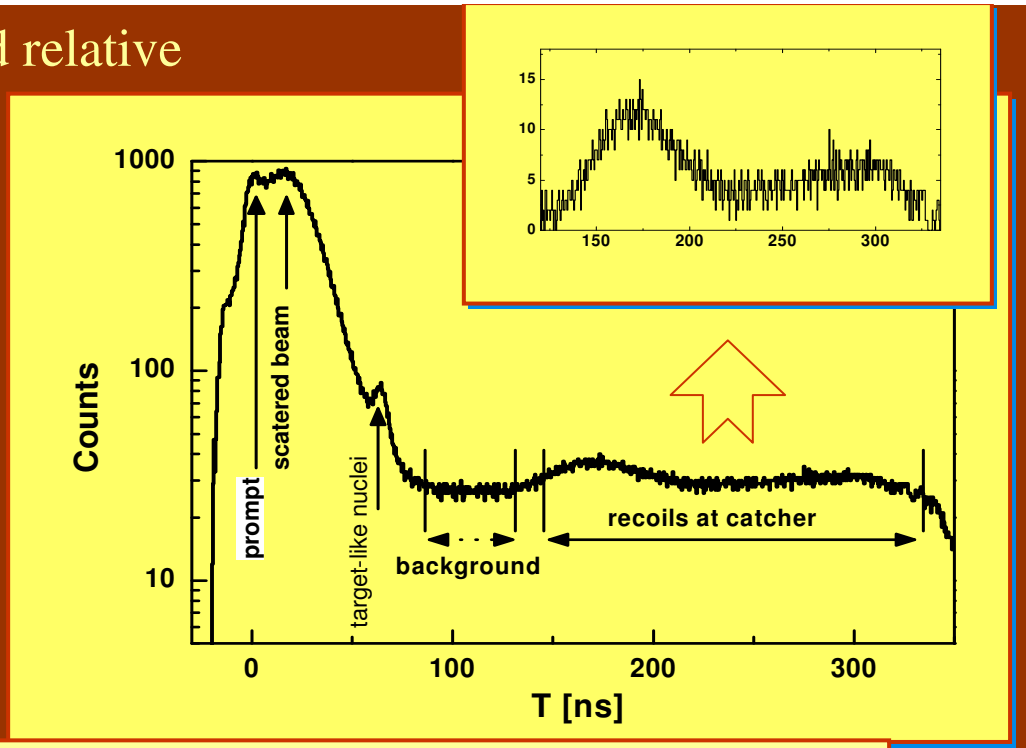


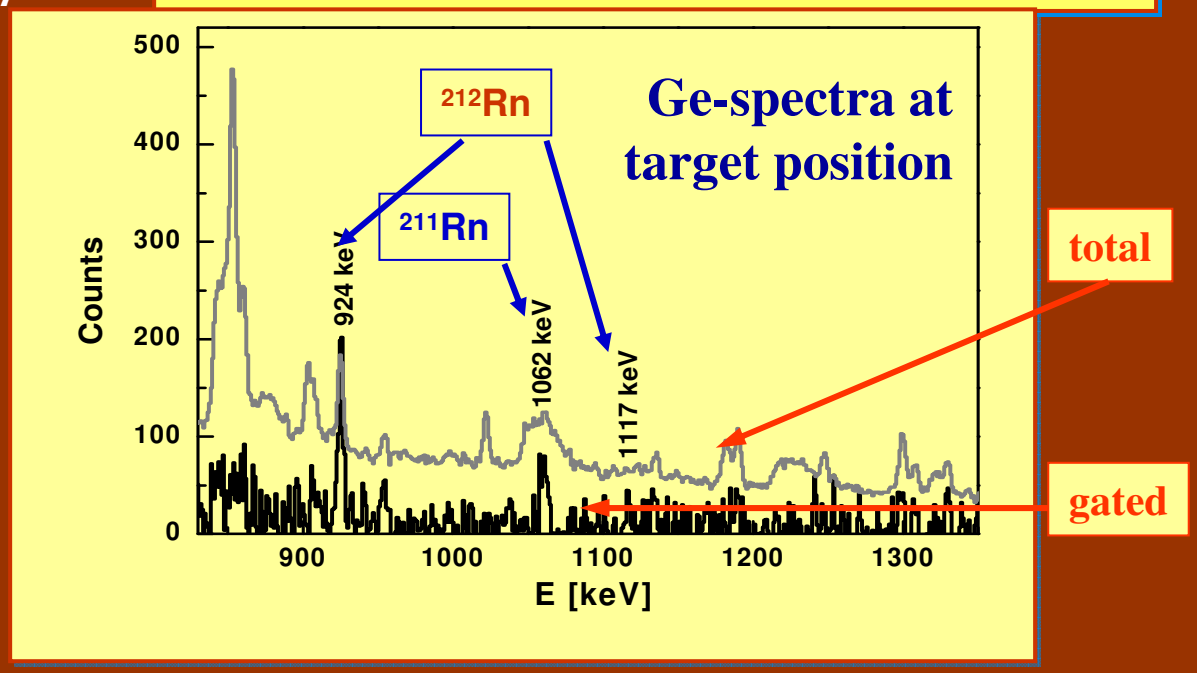


Time spectrum: catcher BGO shield relative to t0 from HELENA

By gating on delayed events in the BGO around the catcher the observed lines in HPGe around the target are only those above the isomers

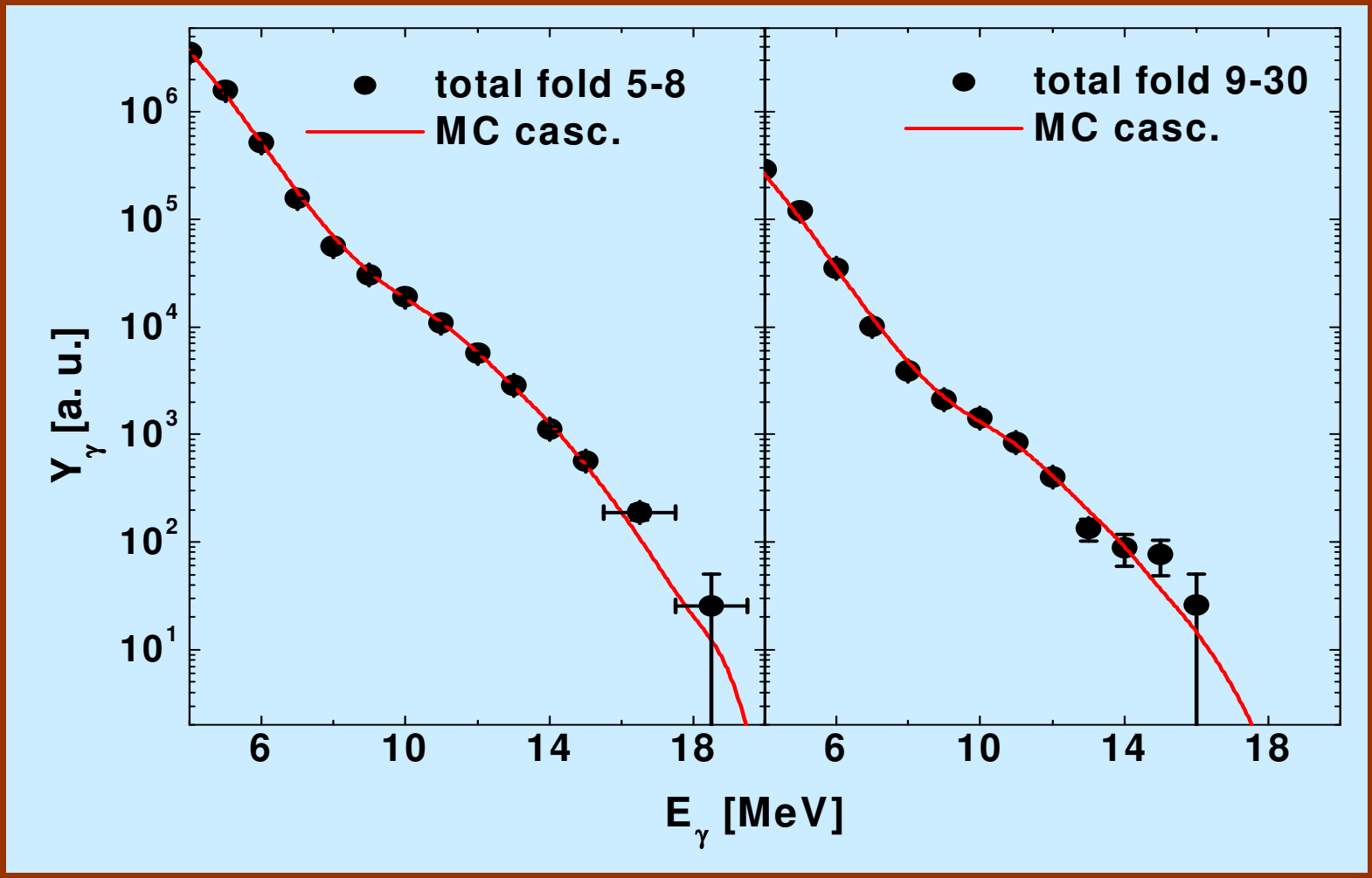
M. Kmiecik et al. PR C70, 064317 (2005)





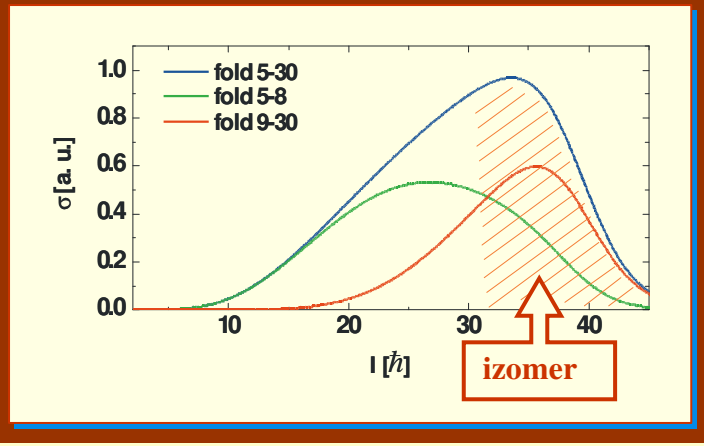
Analysis of the fold gated GDR spectra

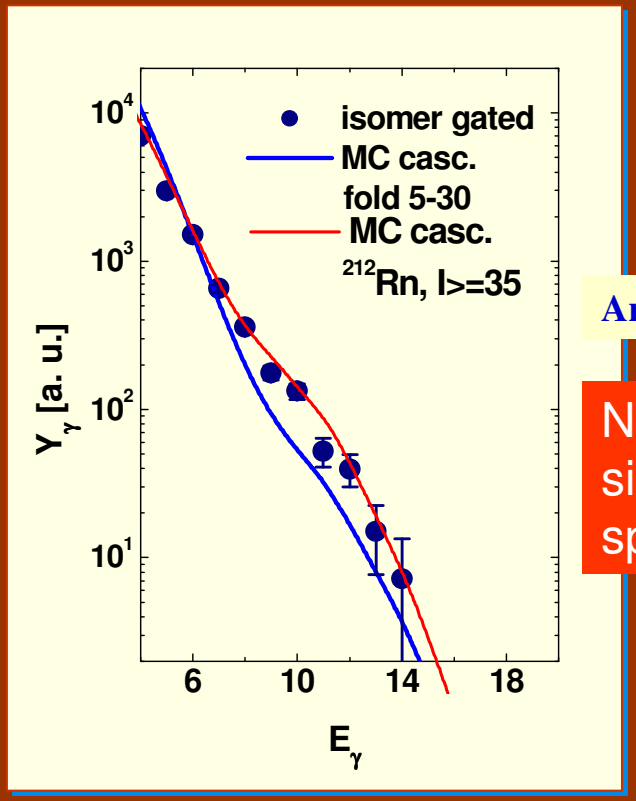
- fit – Monte Carlo CASCADE



$\Gamma = 7$ MeV $\pm$ 0.3 $\Gamma = 7$ MeV $\pm$ 0.4

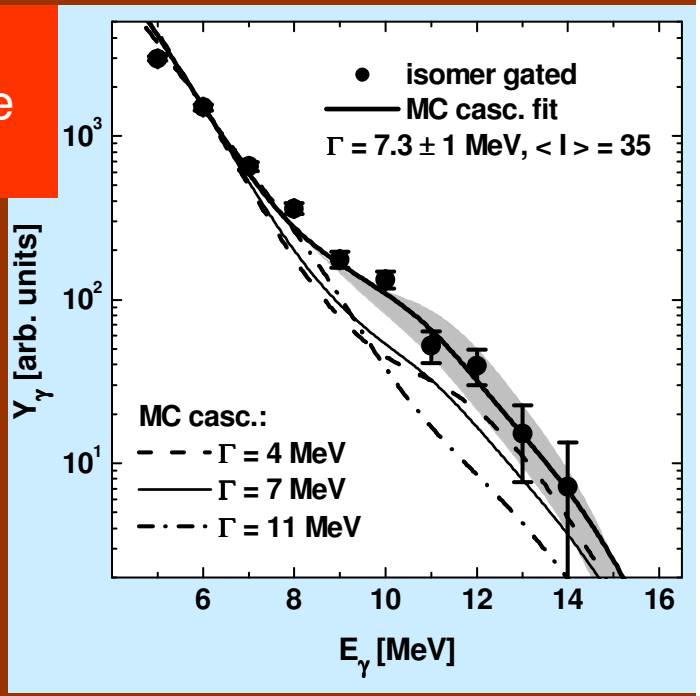
Isomer gated GDR spectrum





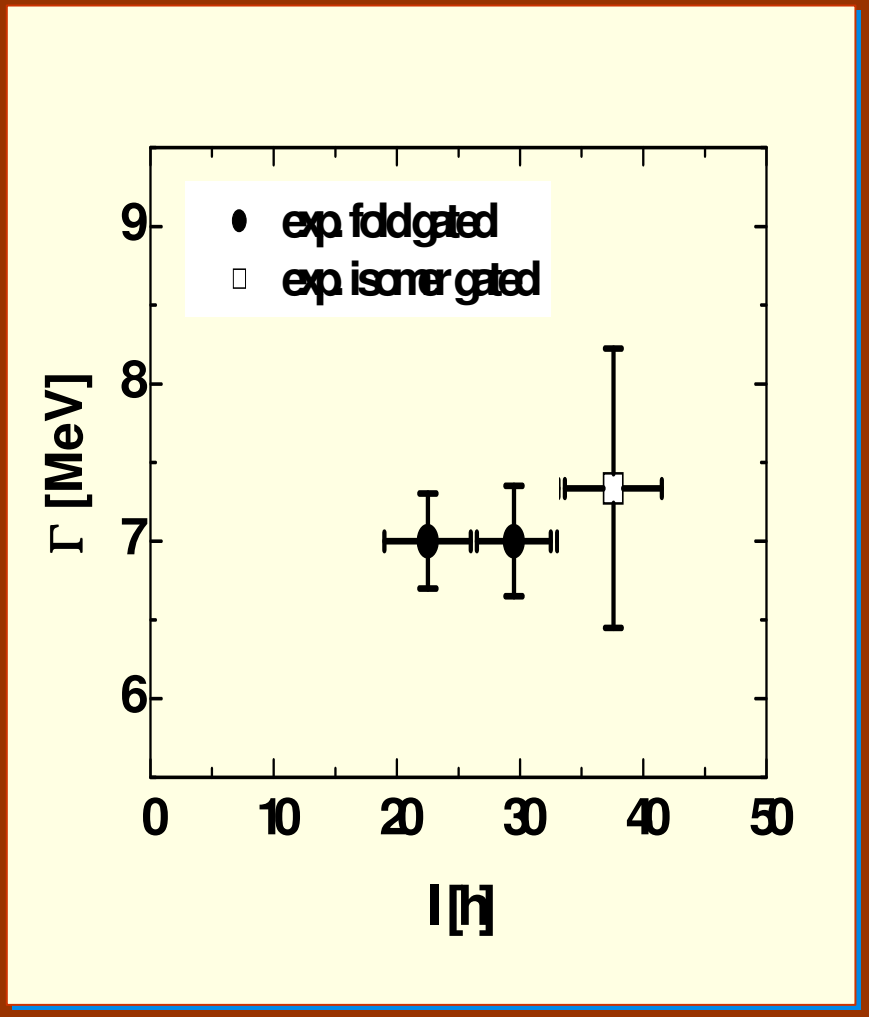
Are the differences related to difference in the nuclear shape?

No! The shape is similar – just phase space effect



$\Gamma = 7.3 \pm 1.0$ MeV

Experimental GDR Width for Rn



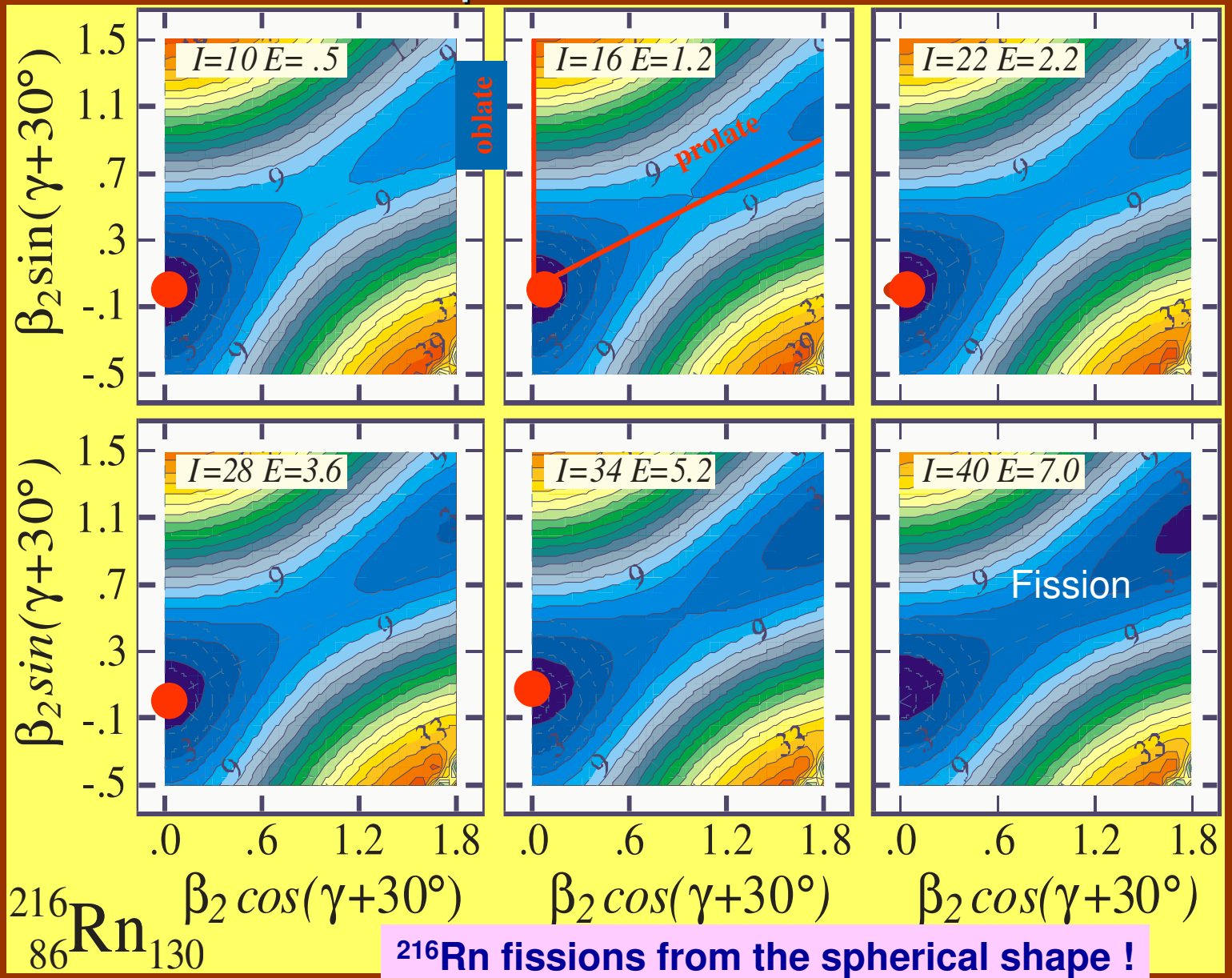
Γ does not change with spin:

Same nuclear shape

Is this in contrast to the predictions?

Theoretical predictions

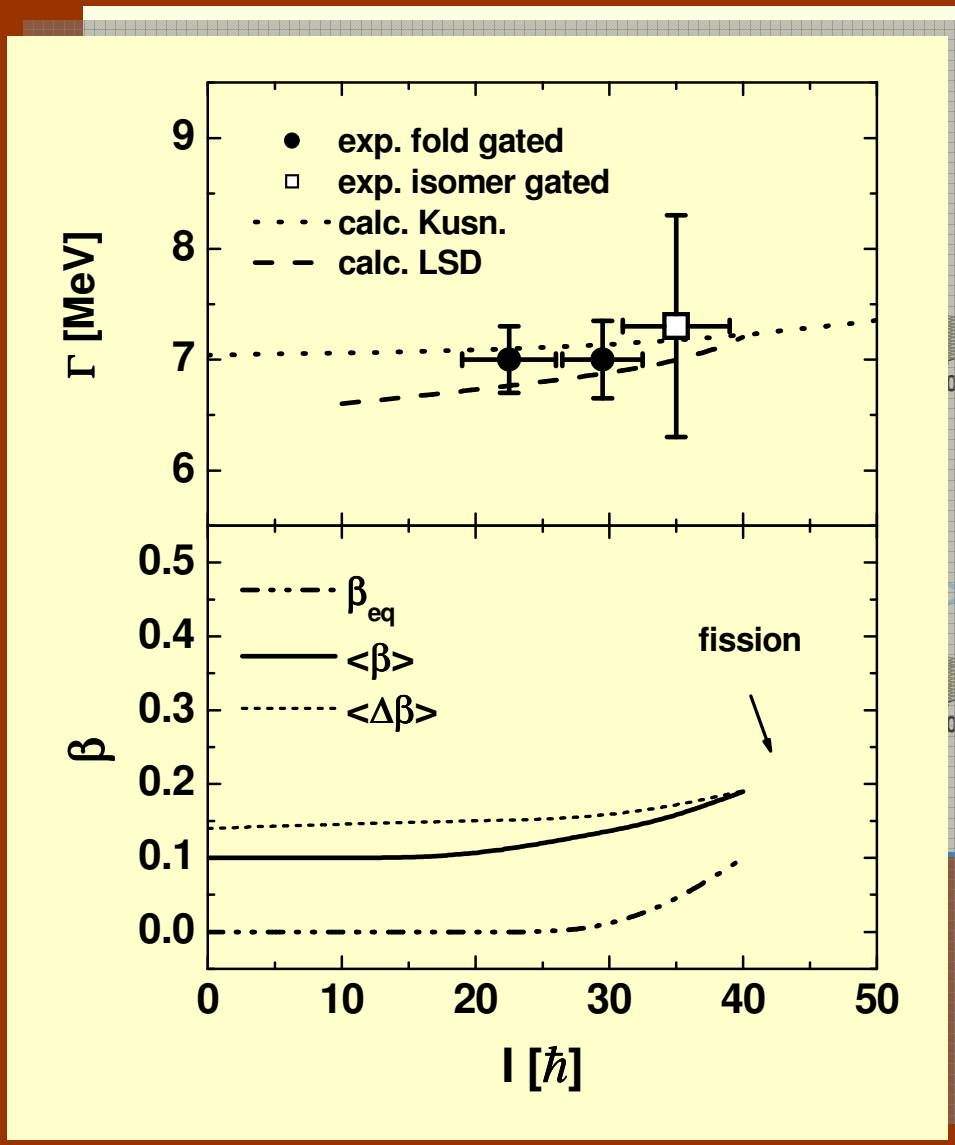
LSD (Lublin-Strasburg Drop)

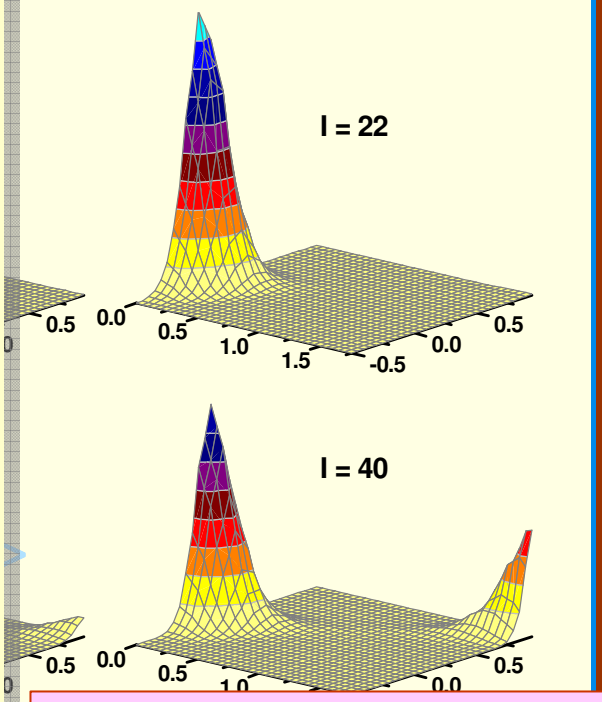


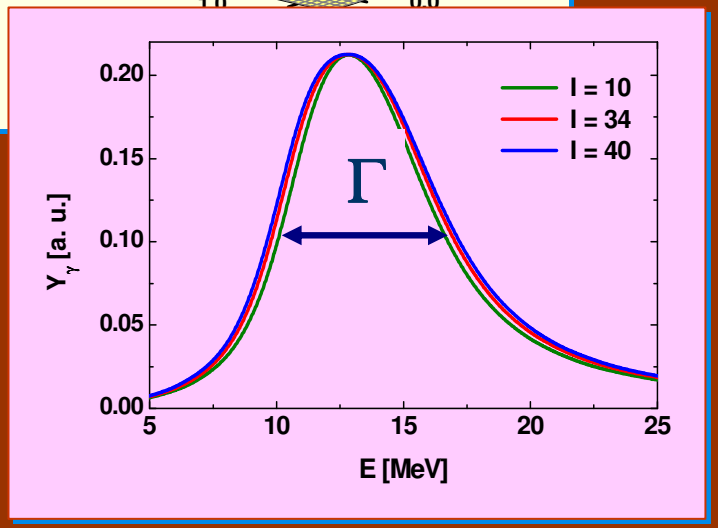
$^{216}_{86}Rn_{130}$

^{216}Rn fissions from the spherical shape !

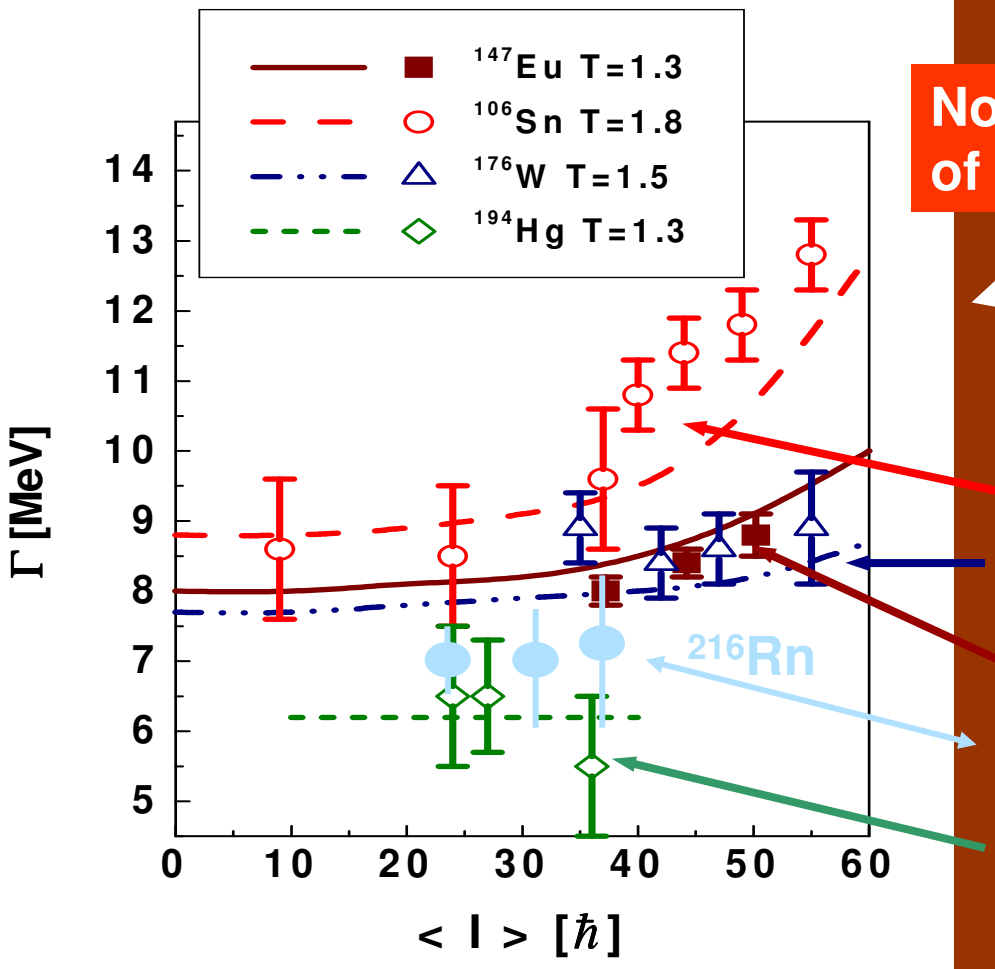
P (β,γ)


exp. fold gated
exp. isomer gated
calc. Kusn.
calc. LSD
Γ [MeV]
β
β_eq
<β>
<Δβ>
fission
I [ħ]


I = 22
I = 40


I = 10
I = 34
I = 40
Γ
Y_γ [a. u.]
E [MeV]

GDR width evolution with spin



Note the effect of rotational frequency!

M.Matiuzzi et al. *Nucl. Phys.* **A612** (1997) 262

M.Kmiecik et al. *Nucl. Phys.* **A674** (2000) 29

M. Kmiecik et al.,
Phys. Rev. **C70**, 064317 (2005)

F. Camera et al.
Phys. Rev. C60 (1999) 014306

Conclusions on experimental results

☞ High-energy γ-ray spectrum measured in coincidence with the ^{42}Ca residues shows **highly fragmented GDR strength** function with a broad „15-25 MeV" structure and narrow low energy „9-10 MeV" component - the result of the **Jacobi shape transition** and strong **Coriolis effects (first time observed)**

☞ **Low energy GDR component feeds** preferentially the **highly-deformed** (SD) band in ^{42}Ca

☞ Charged particle spectra from ^{46}Ti suggest a presence of very large deformations

☞ Possible effects of „dynamical hyperdeformation" or/and pre-equilibium in 1α emission channel

☞ ^{216}Rn has almost spherical shape up to the fission

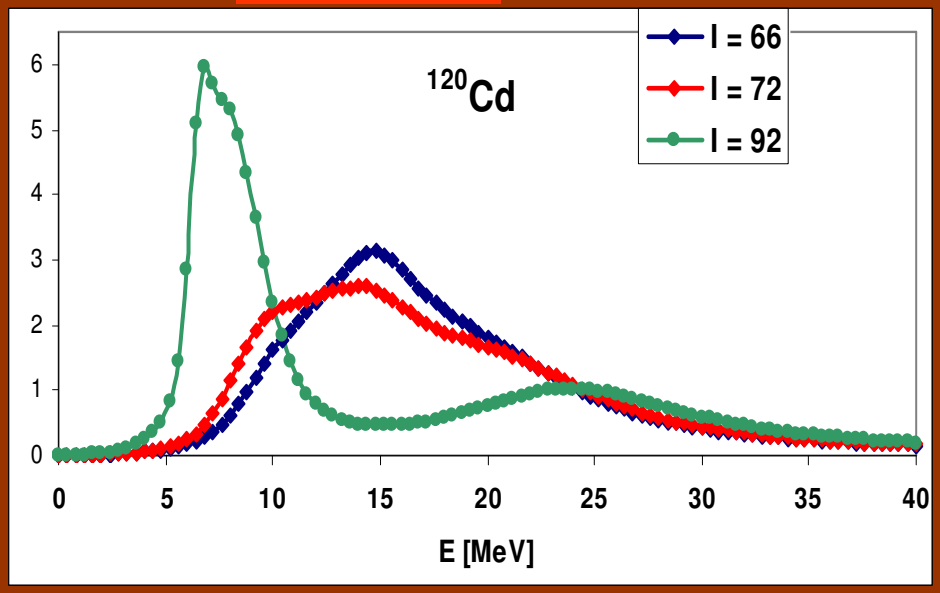
☞ Different types of evolution at extreme angular momenta for light and heavy nuclei: **LSD seems to work in both mass region**

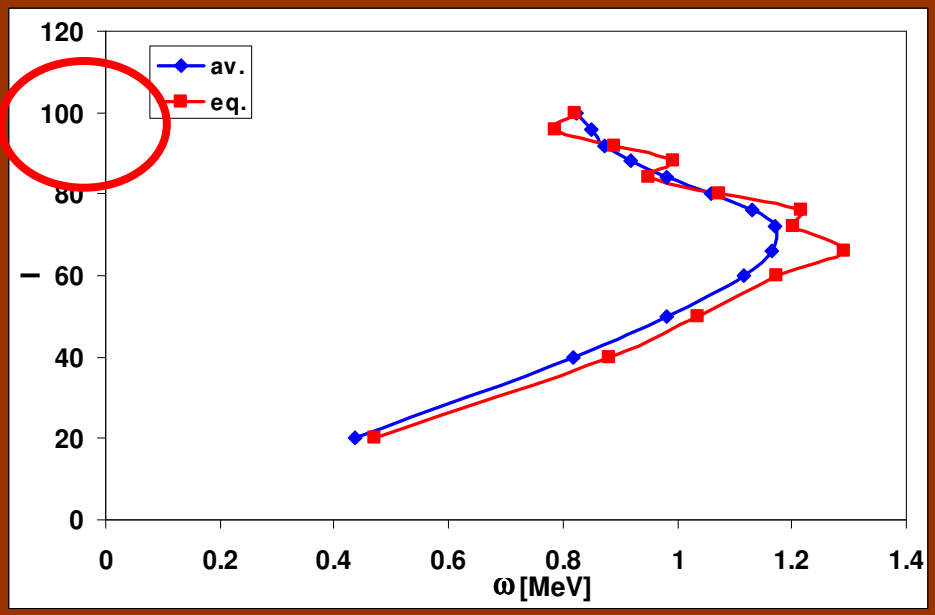
Outlook:
Advent of high intensity radioactive beams
(e.g. SPIRAL2, FAIR)

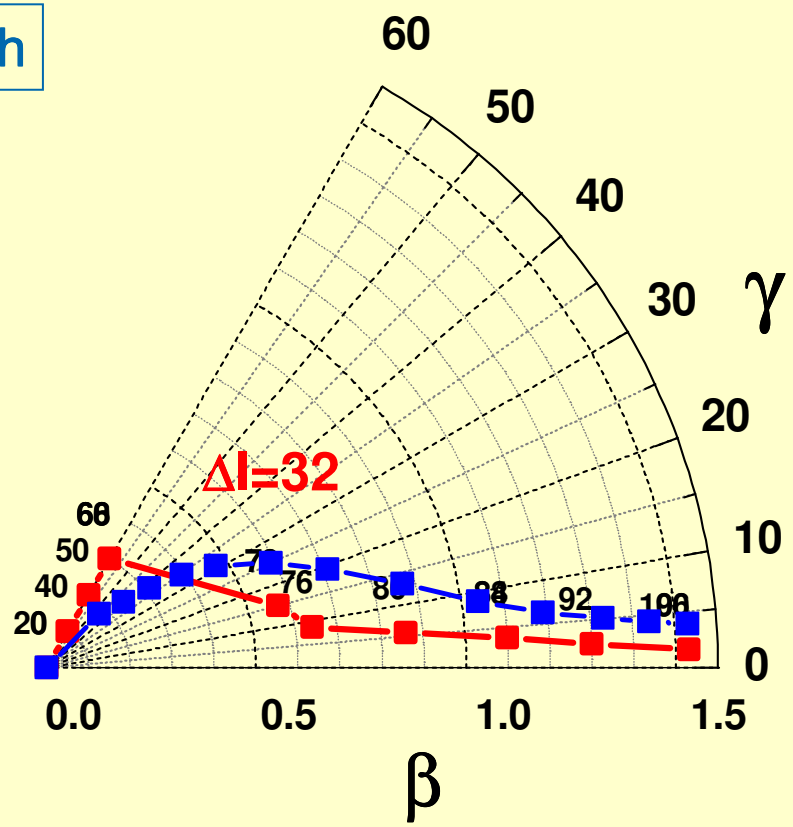
^{120}Cd

900 MeV ^{94}Kr on ^{26}Mg I_{max}=100h

SPIRAL2







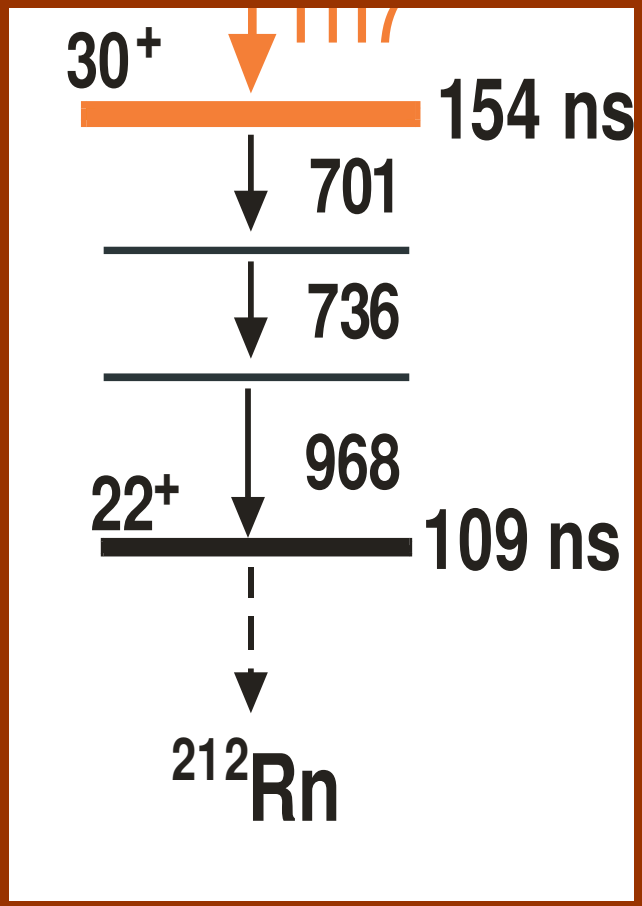
Extremely wide window for Jacobi regime

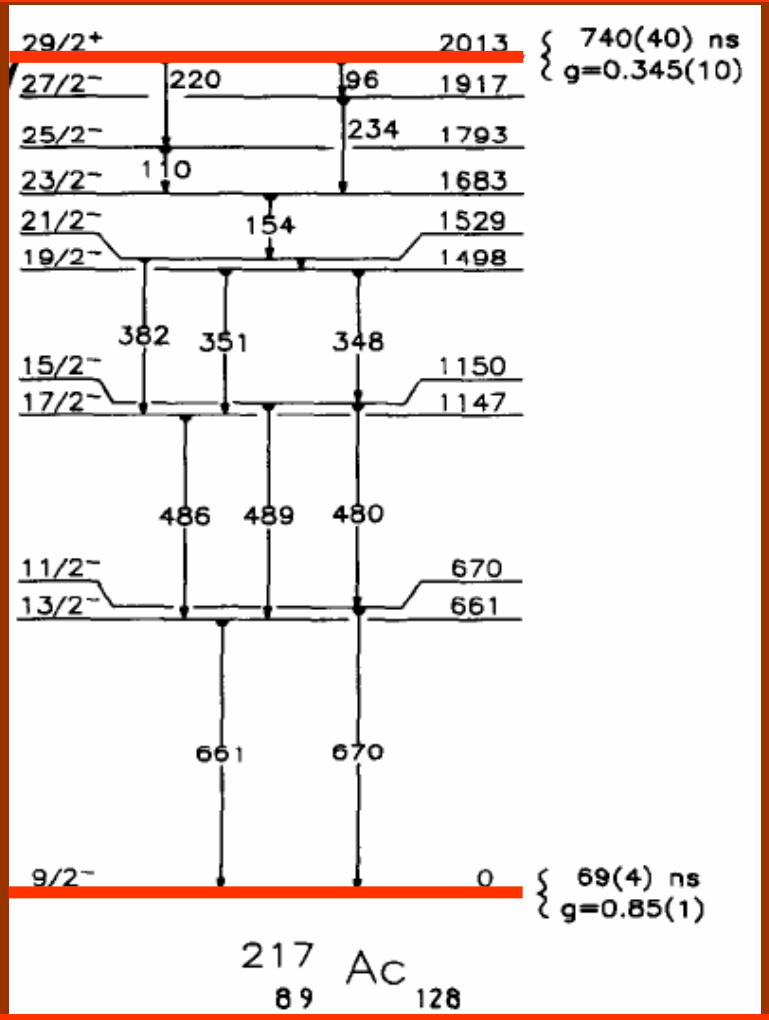
Extremely large spins

Long chain of accesible isotopes (A=98-120) – effect of isospin possible to study

FAIR @ GSI

Relativistic isomeric beams offer a possibility
to Coulomb excite GDR build on isomers (e.g. ^{212}Rn, ^{217}Ac)





from: D.J. Decman, (A. Maj, M. Guttormsen) et al., Nucl. Phys. A436, 311 (1985)

Final conclusion:

New highly efficient BALL
for high-energy gamma-rays
is needed for
GDR, gamma-multiplicity and sum-energy studies
within SPIRAL2 and FAIR projects

This can be a new project ….

Adam.Maj@ifj.edu.pl
http://chall.ifj.edu.pl/~maj

www.paris.w.pl

PARIS

PHOTON ARRAY FOR STUDIES WITH RADIOACTIVE ION AND STABLE BEAMS

Letter of Intent for SPIRAL 2

Title: High-energy γ-rays as a probe of hot nuclei and reaction mechanisms

Spokesperson(s) *(max. 3 names, laboratory, e-mail - please underline among them one corresponding spokesperson):*
Adam Maj, IFJ PAN Krakow, Adam.Maj@ifj.edu.pl
Jean-Antoine Scarpaci, IPN Orsay, scarpaci@ipno.in2p3.fr *(EXL and R3B contact)*
David Jenkins, University of York (UK), dj4@york.ac.uk

GANIL contact person
Jean-Pierre Wieleczko, GANIL, wieleczko@ganil.fr

http://gdr.ifj.edu.pl/SPIRAL2_LOI/calorimeter/SAC/LOI_8.pdf

Project positively recommended by SAC

PHOTON ARRAY FOR STUDIES WITH RADIOACTIVE ION AND STABLE BEAMS

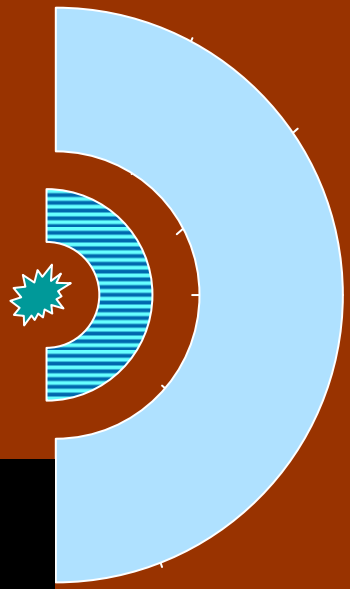
According to the request shared by the above physics cases,
the present proposal is intended to develop
a **versatile γ-calorimeter**
for high-energy (3-50 MeV) photons and
for multipicity/sum-energy of low energy (100 keV – 3 MeV) γ-transitions

- ✓ **Large angular acceptance (4π or 2π or 1π)**
- ✓ **Modular (in order to couple with other detectors)**
- ✓ **High granularity**
- ✓ **Energy resolution: c.a. 3%**
- ✓ **Time resolution: < 1 ns**
- ✓ **Energy range 100 keV-50 MeV**
- ✓ **High efficiency for gamma rays:** (>25% at 1.3 MeV, ~5% at 20 MeV)

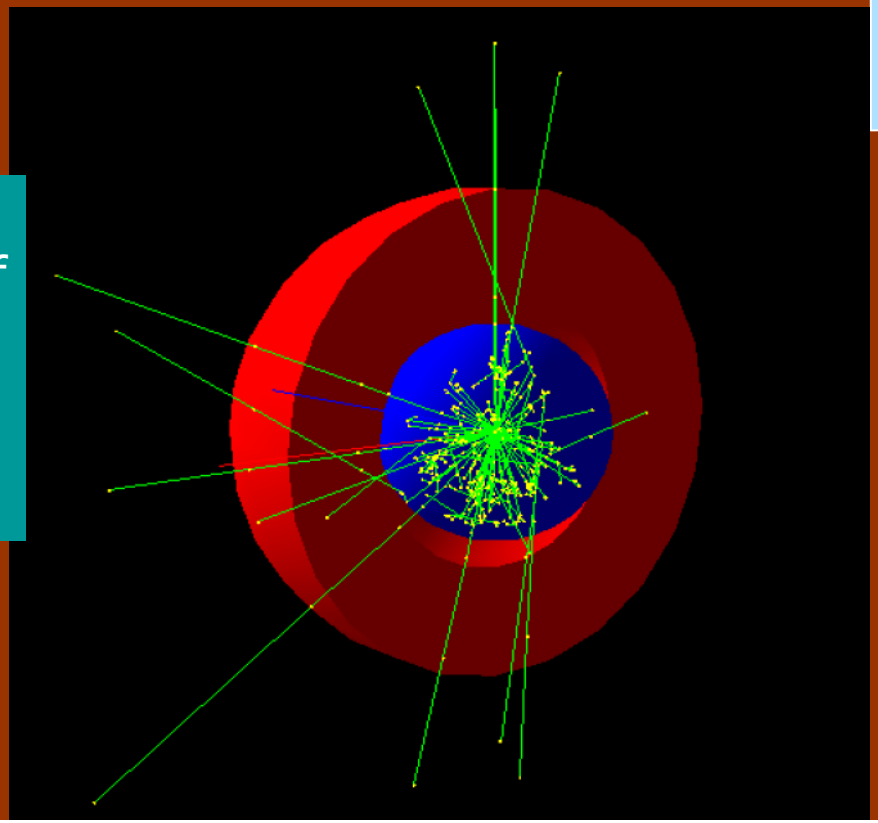
A clear plan for **a new γ-calorimeter** can only arise from
an intensive **R&D program**,
with GEANT4 simulations being a key component of this work

R&D phase to be performed in synergy with the EXL-R3B and HISPEC/DESPEC collaborations
within NUSTAR@FAIR community
and especially with other SPIRAL2 LoIs
(„Collective modes in continuum", GASPARD, EXOGAM2, …)

One possibility: **New „γ-telescope":**
highly granular inner (hemi-)sphere made from e.g. $LaBr_3$ for low energies (and pairs) detection
+ less granular outer (hemi-)sphere (either new or from existing high-energy γ-detectors (for high energies)



Name **PARIS**
since it is a natural follow-up of
HECTOR+HELENA array
from
Milano-Krakow-Copenhagen
collaboration



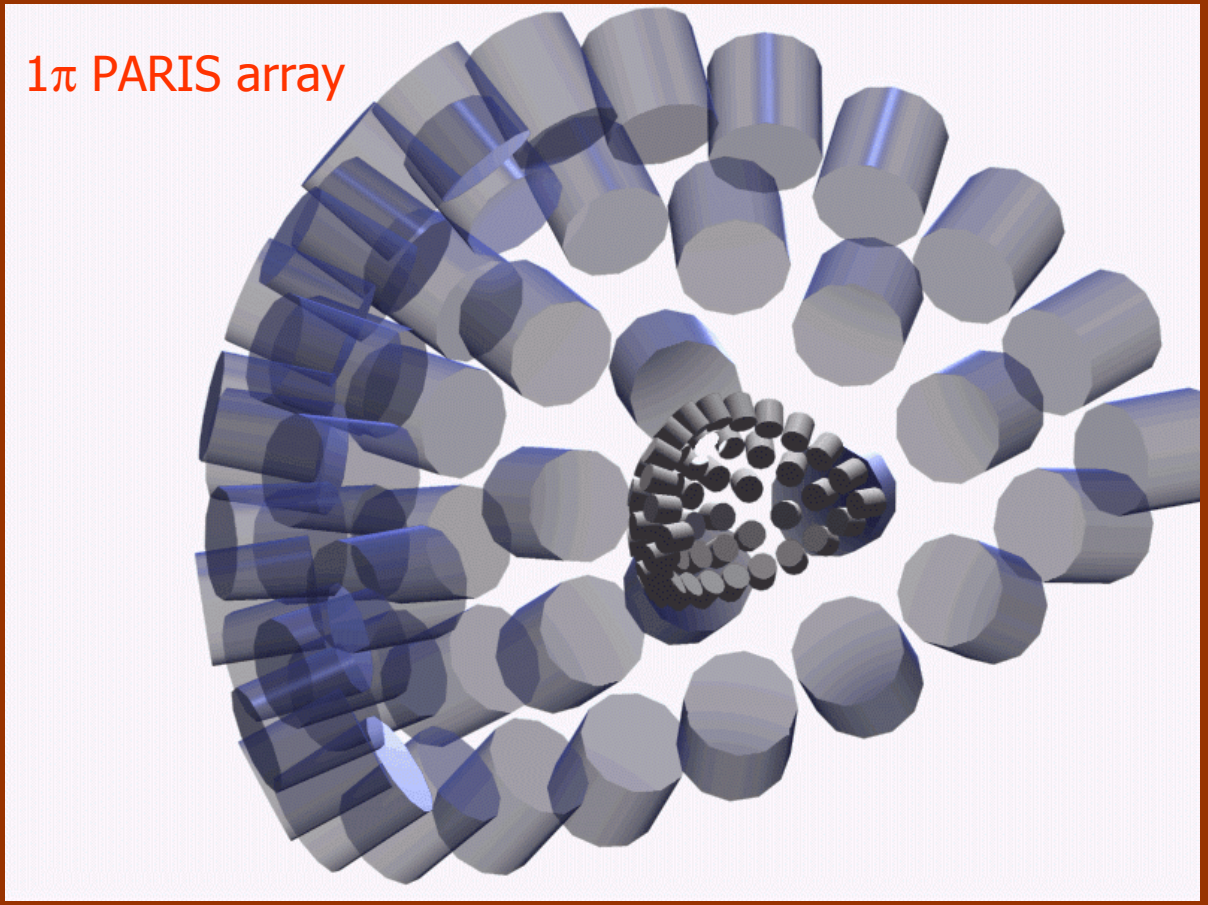
PHOTON ARRAY FOR STUDIES WITH RADIOACTIVE ION AND STABLE BEAMS

www.paris.w.pl

PARIS collaboration is open for new participants:

LD community is welcomed to join

Contact Adam.Maj@ifj.edu.pl



Animation by M. Ciemała

Collaborators

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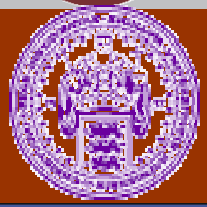

B. Herskind

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V. Rauch, M. Rousseau, A. Sanchez I Zafra

E. Farnea, G. De Angelis, D.R. Napoli

M. Kicińska-Habior

THEORY

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TAK !