Piotr Bednarczyk

Instytut Fizyki Jądrowej
im. Henryka Niewodniczańskiego
Polskiej Akademii Nauk

Theoretical and experimental investigations of the highly collective bands in the A~40,60 nuclei

COPIGAL Collaboration

IFJ PAN, Kraków, (*EXPERIMENT*)

*Piotr Bednarczyk, Magdalena Matejska-Minda**

*student PhD

IPHC, Strasbourg, (*LARGE SCALE SM*)

Frédéric Nowacki, Kamila Sieja, Etienne Caurier

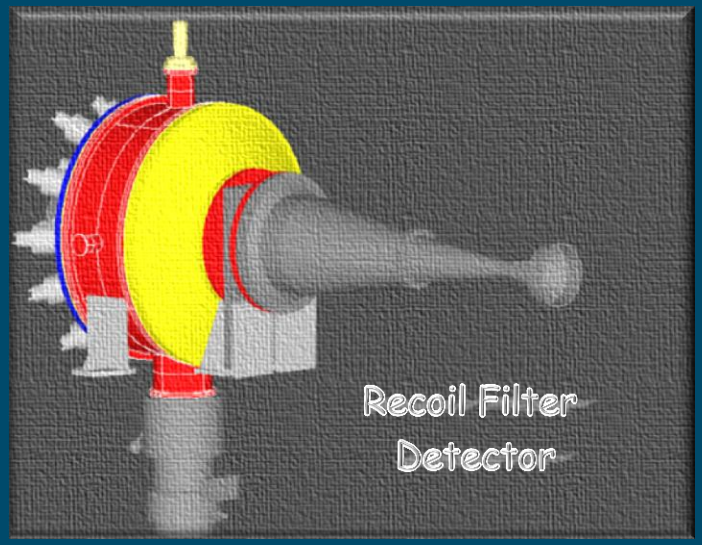
Collective effects in the $f_{7/2}$ shell nuclei

At low spin / < 1980/:

- Fast E2 transitions
- Collective bands of unnatural parity (hole states)

Experimental difficulties:

- fast recoil velocity (Doppler broadening)
- high energy transitions



Break through /~2000/:

- Arrays of Ge detector arrays (GASP, EUROBALL, GAMASPHERE)
- Ancillary particle and HI detectors

At high spin:

- Perfect rotor: ^{48}Cr
- Deformed core excited states in light-odd A $f_{7/2}$ nuclei: ^{43}Ca, ^{45}Sc, ^{45}Ti
- Superdeformation in $^{36,40}Ar$, $^{40,42}Ca$, ^{44}Ti

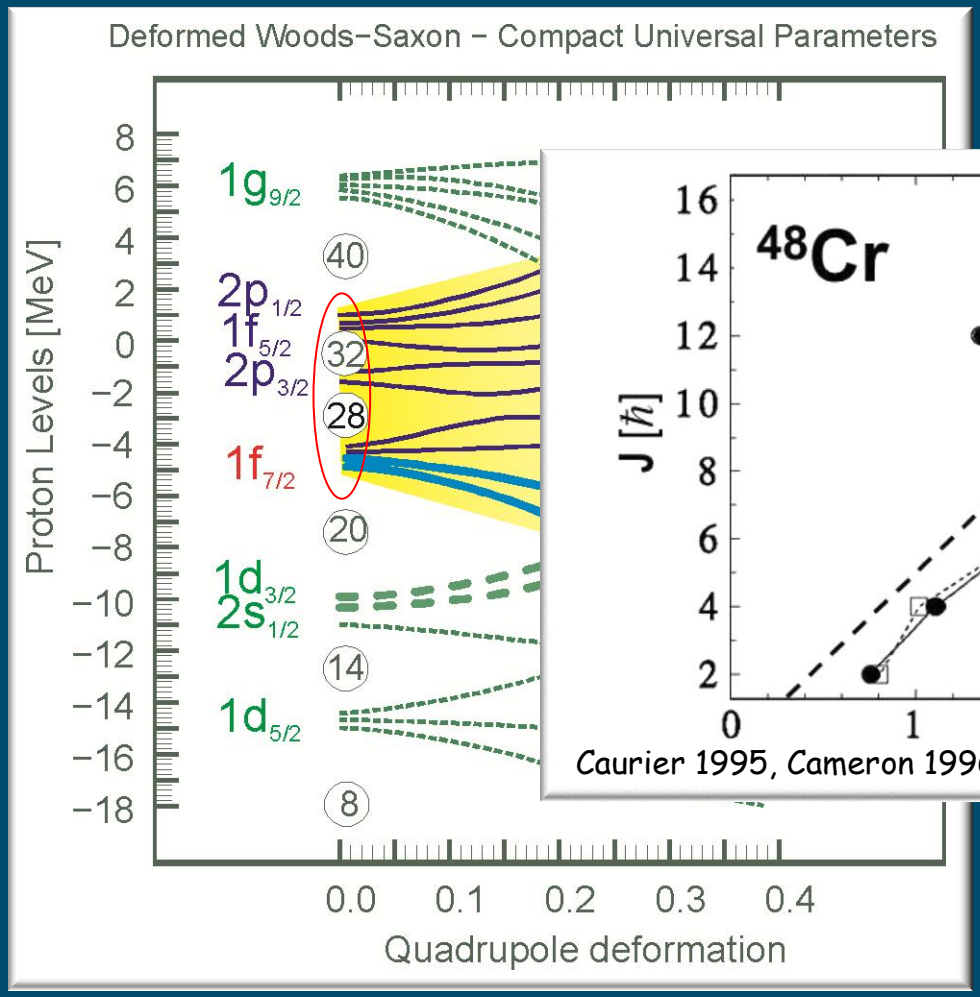
„Rotation" of ^{48}Cr – spectacular success of the large scale SM

^{100}Sn

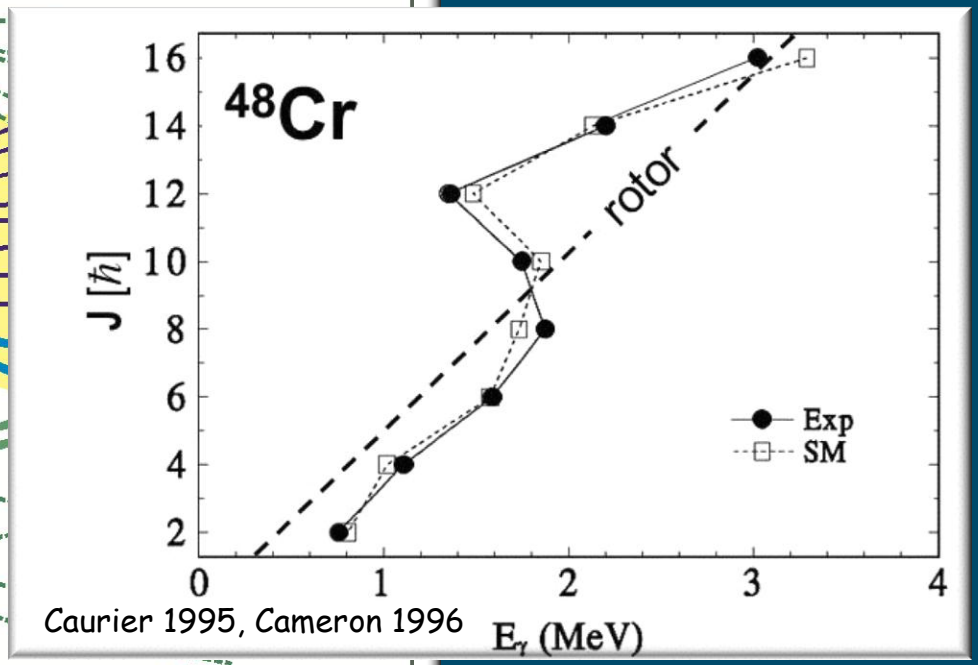
^{80}Zr

^{58}Ni

^{40}Ca



SM: extended *fp* shell



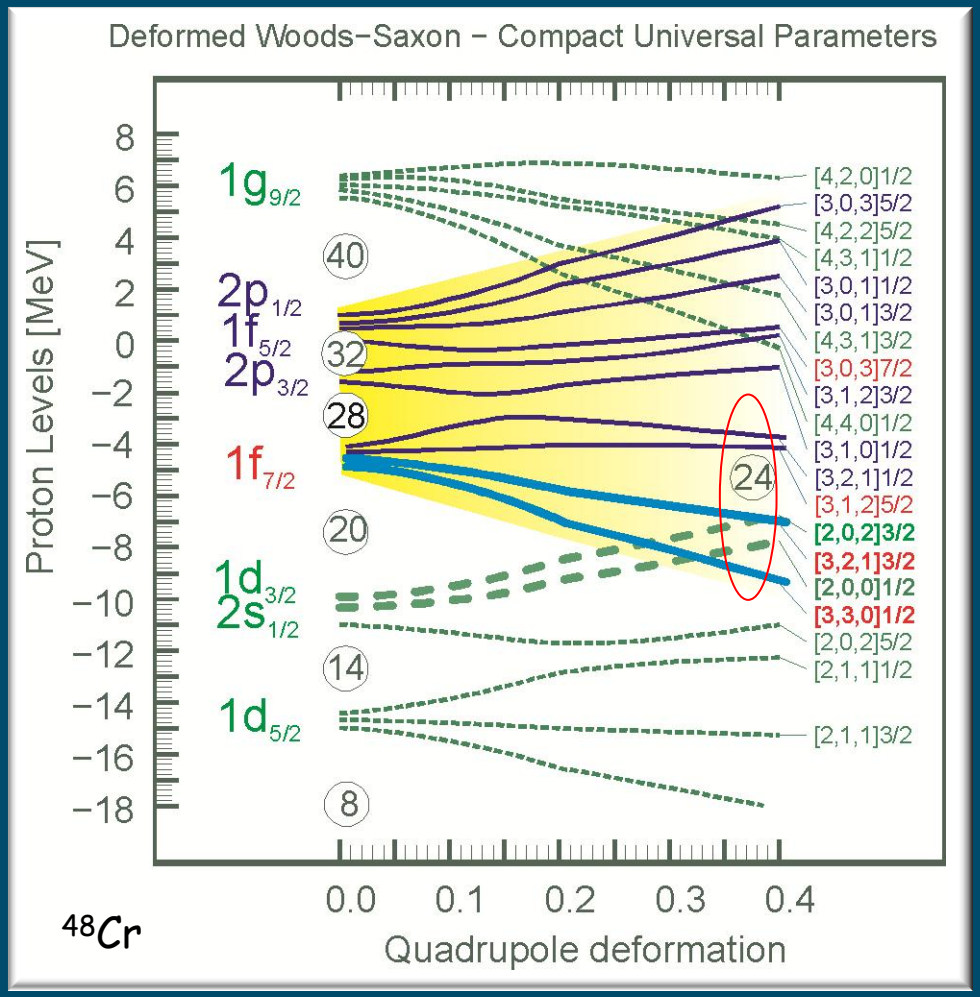
SM descroption of (super)deformation

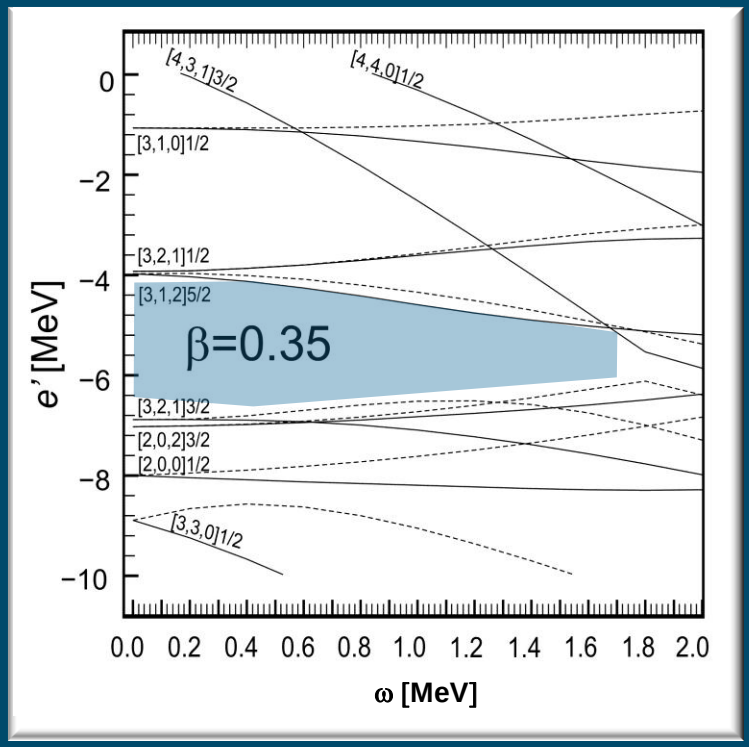
^{100}Sn

^{80}Zr

^{58}Ni

^{40}Ca

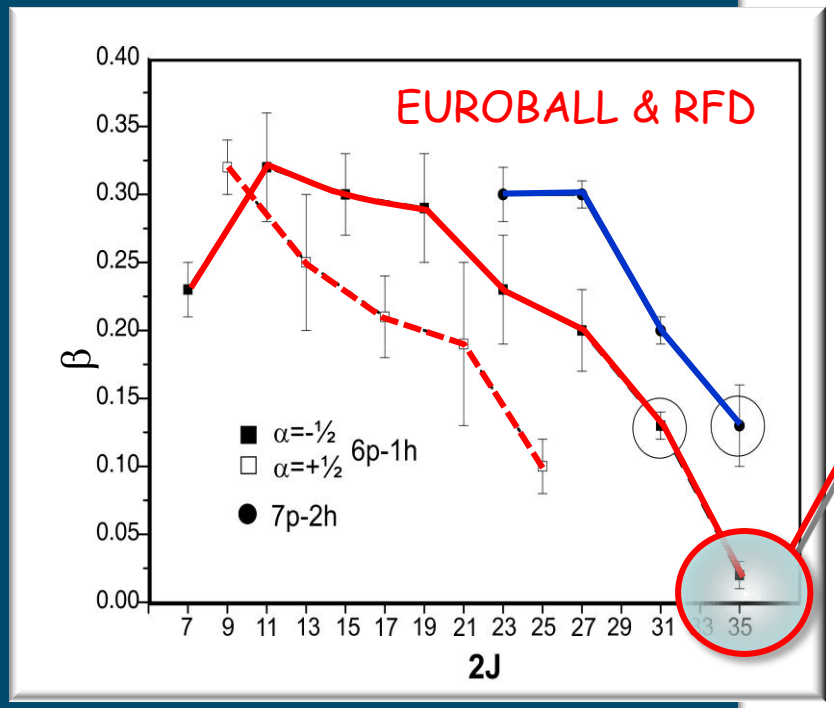


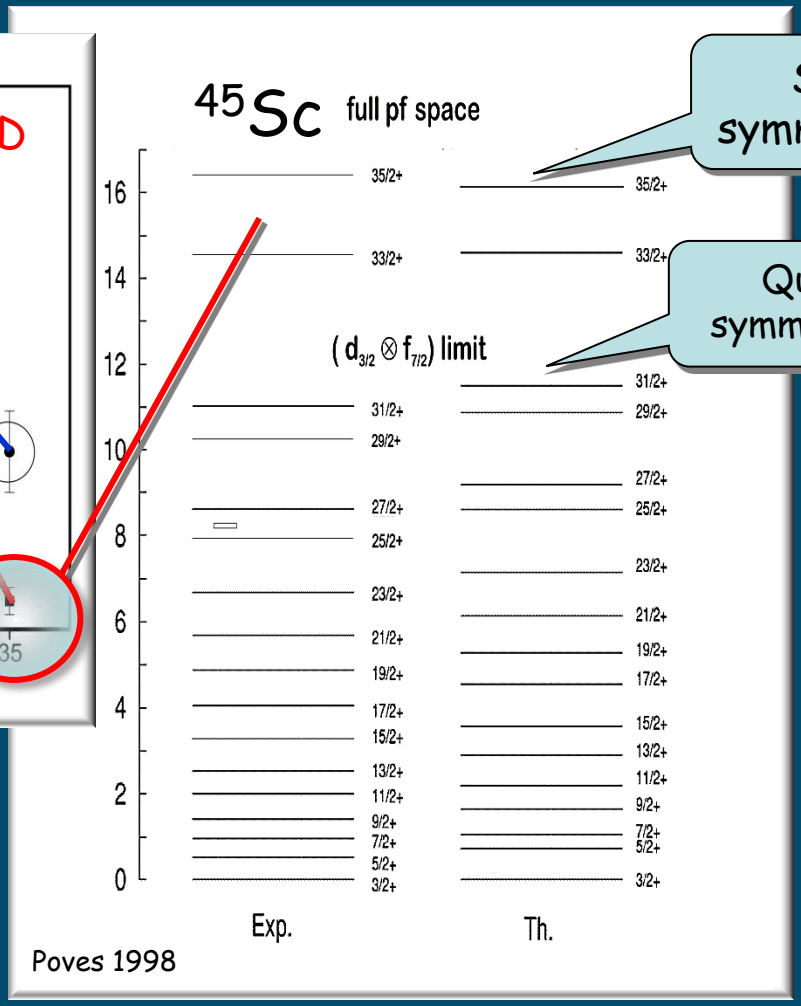


^{36}Ar, ^{40}Ca –SD bands (β~0.5)

- 8 holes - $1d_{3/2}$
- 4, 8 particles - $1f_{7/2}$ ([330]1/2, [321]1/2)

Beyond band termination



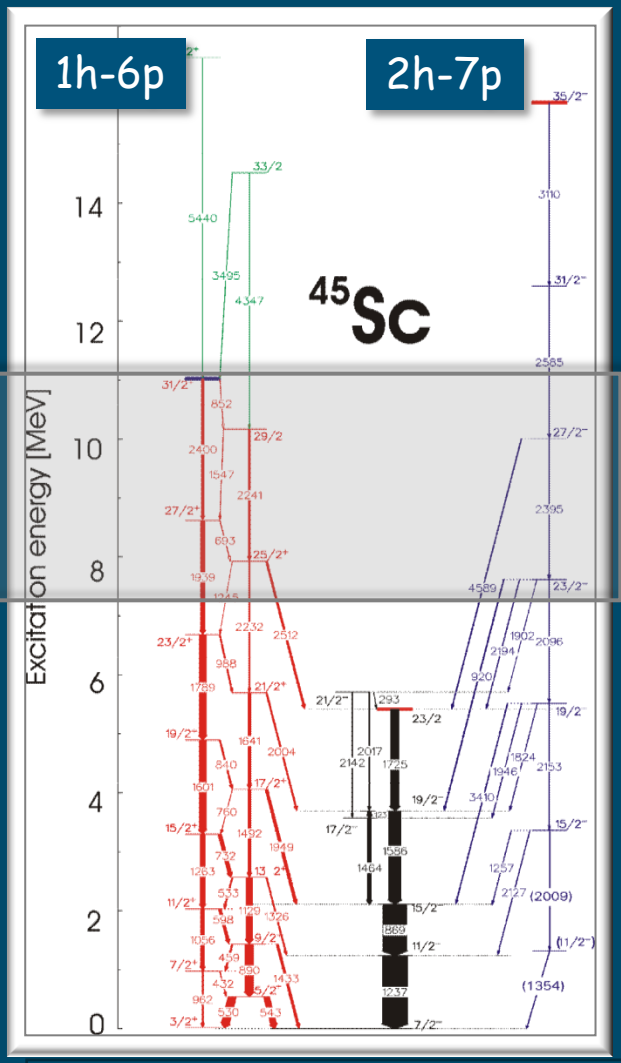


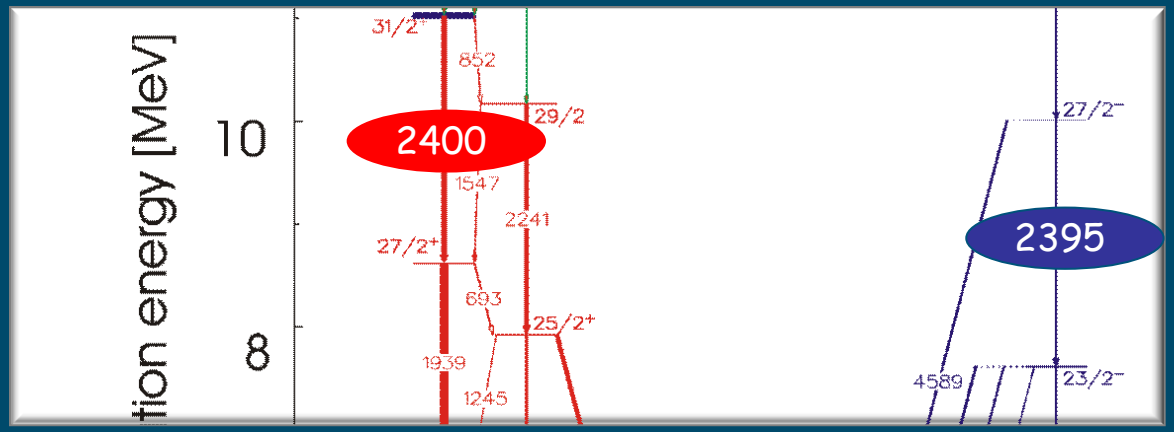
Spherical symmetry states

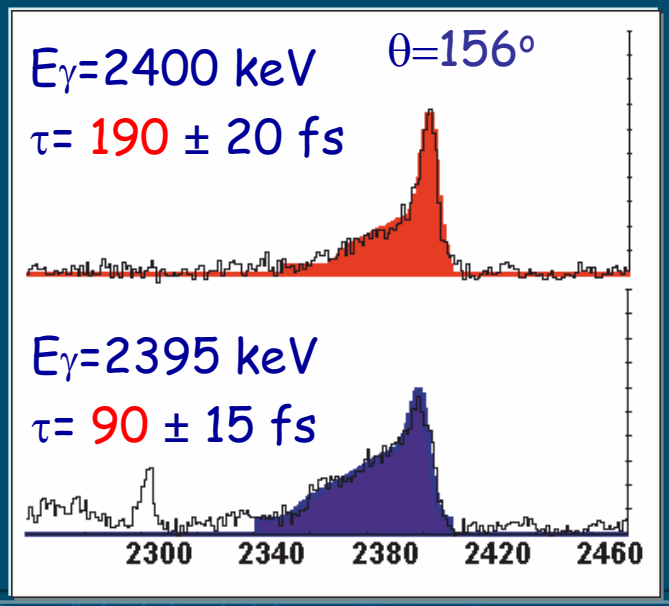
Quadrupole symmetry states

- *ANTOINE*
- *sdpf.sm: KB3 (pf) + sd holes*

Lifetimes in ^{45}Sc (*RFD method*)

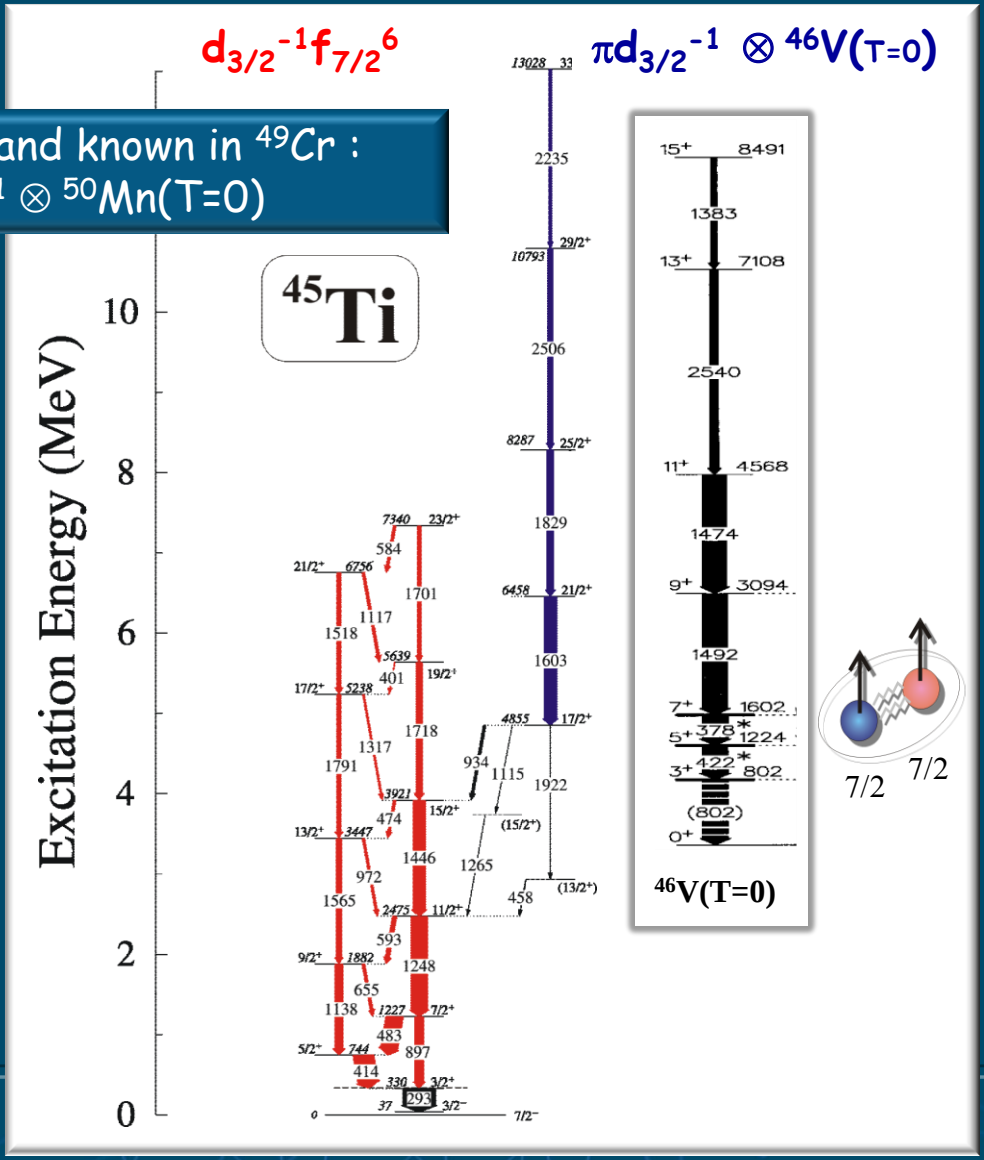






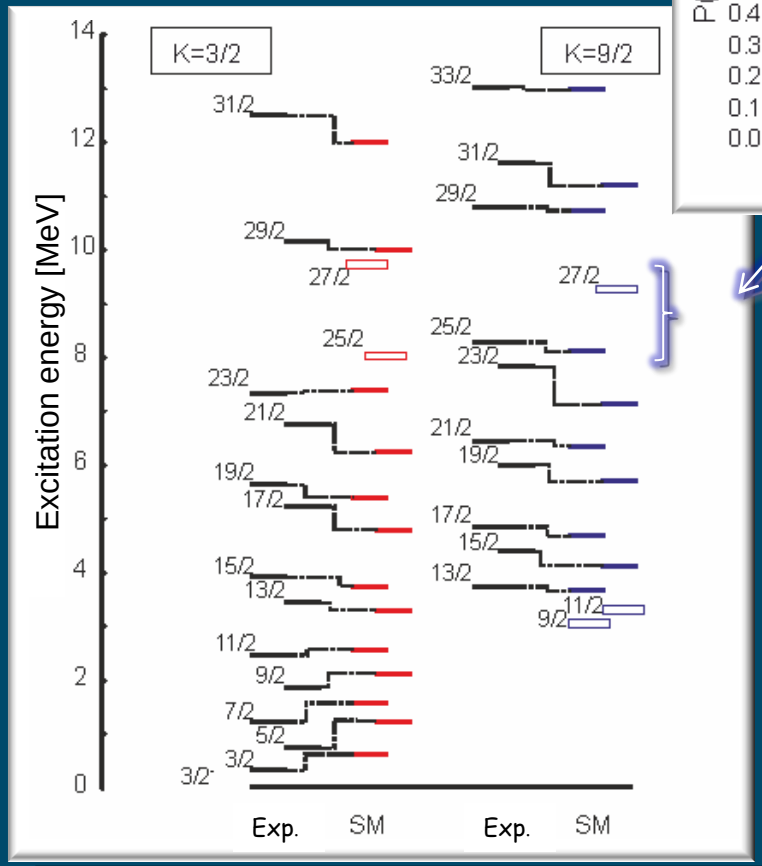
Isospin effects in ^{45}Ti ?

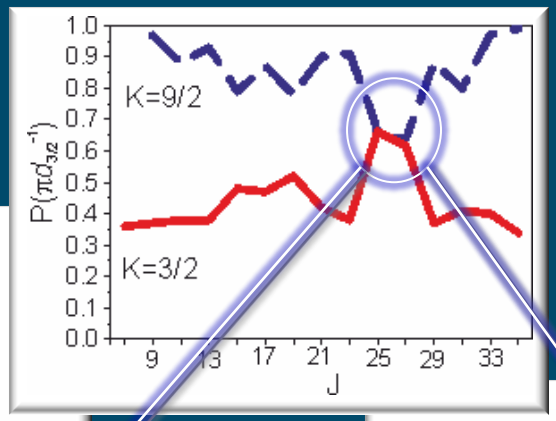
similar band known in ^{49}Cr :
$\pi d_{3/2}^{-1} \otimes {}^{50}$Mn(T=0)



^{45}Ti – SM results

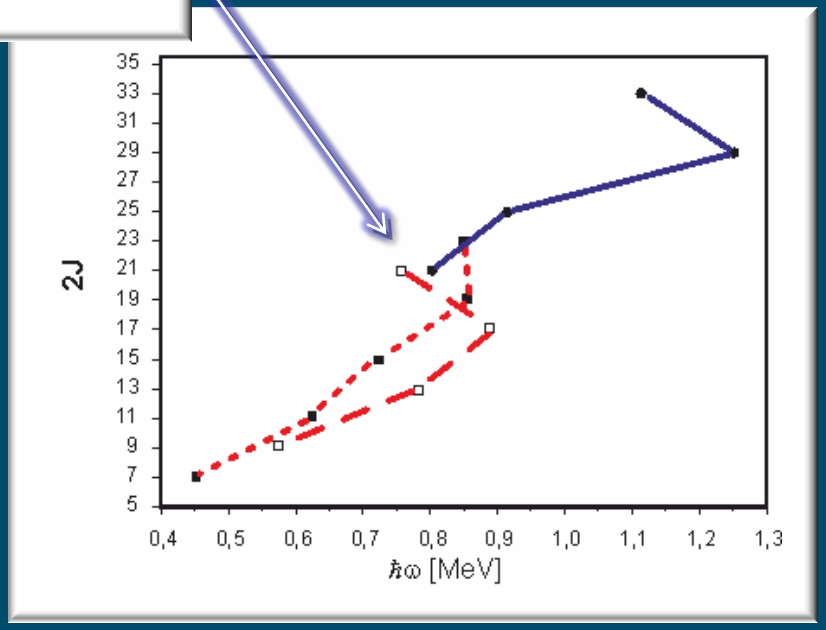
- *ANTOINE*
- *sdpf.sm*



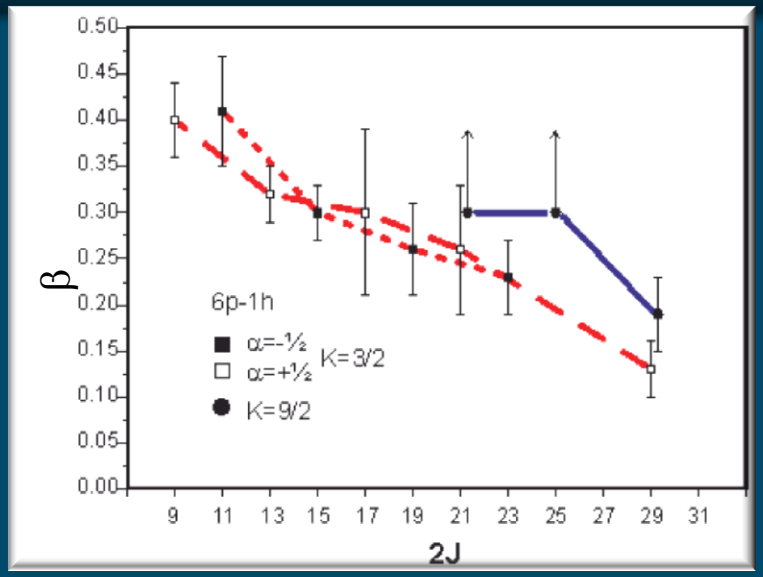


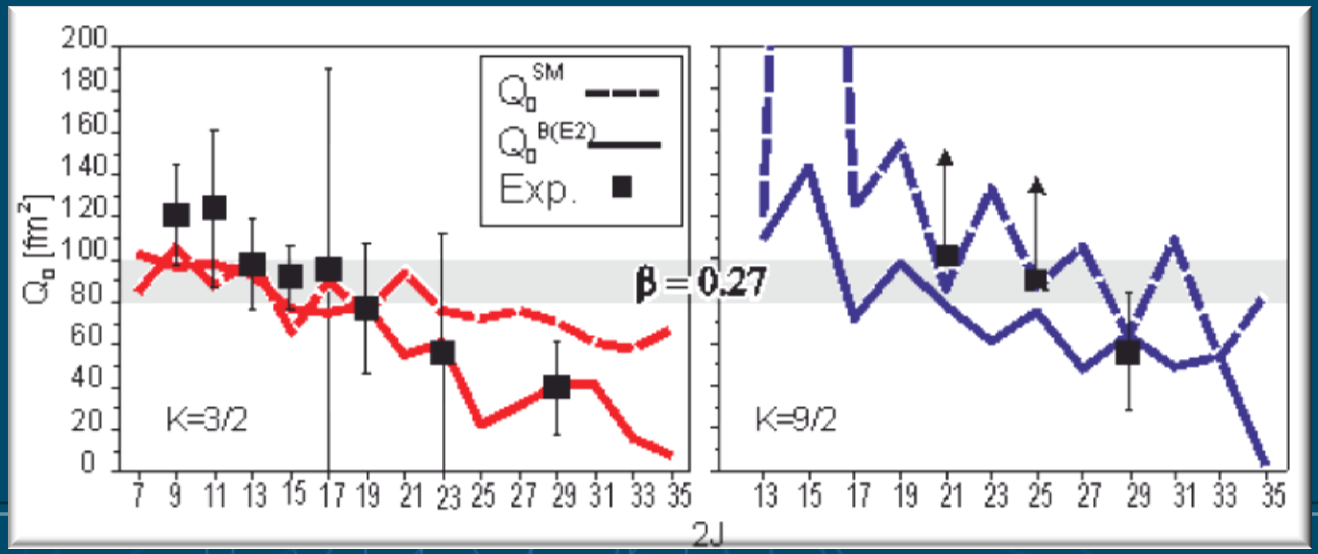
π hole (^{46}V analogue)

mixed π,ν hole



Deformation driven high spin structure of ^{45}Ti

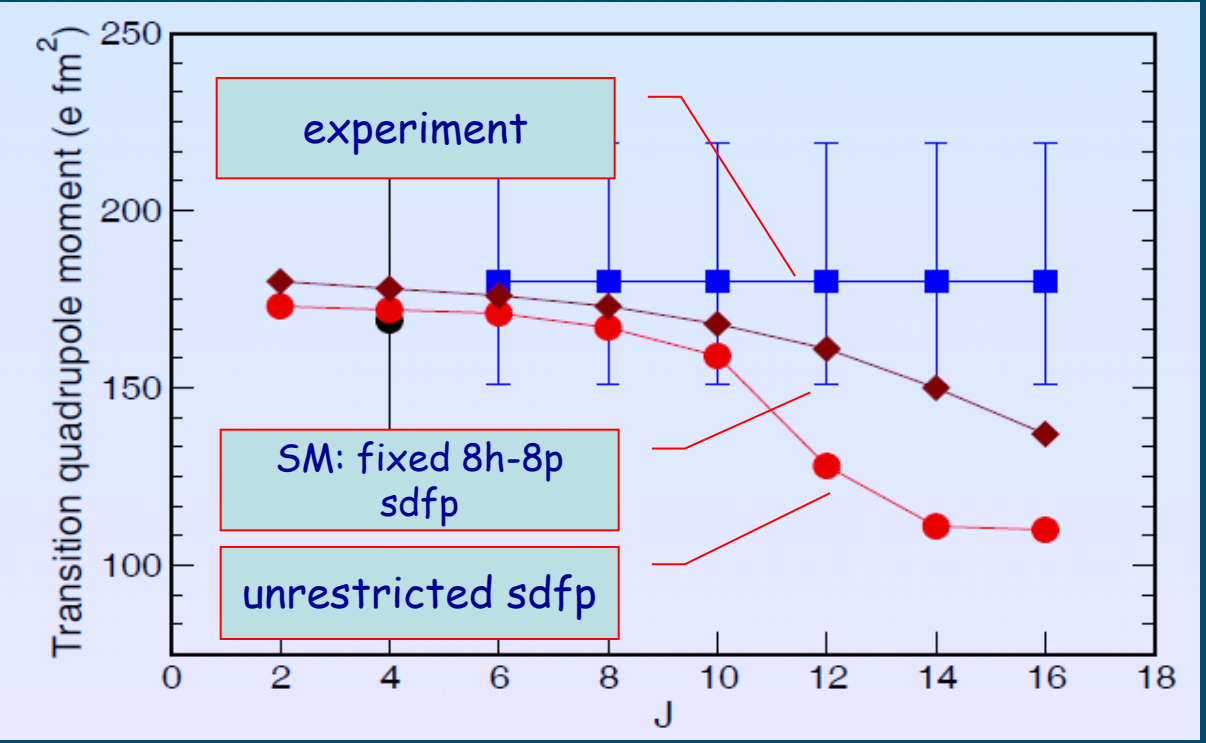




PUZZLE : SD band termination in ^{40}Ca

- Unexpectedly, in ^{40}Ca the 8p-8h SD band seems NOT to lose the collective character at highest spins (the only such a case)
- Contradiction to large scale SM calculations

- More precise lifetime measurements in this region are needed



C. J. Chiara et al, Phys.Rev. C 67, 041303 (2003)

E. Caurier et al., PRC 75, 054317(2007)

Towards heavier (more collective) systems

At high rotational frequencies pairing correlations are considerably quenched and can often be neglected. A most interesting nuclear region is the one with $A \sim 60$ ($N \approx Z \approx 30$), where a large variety of rotational structures such as (smooth) terminating, highly deformed, and superdeformed (SD) rotational bands are expected to be observed up to very high rotational frequencies in the same nucleus.

A. V. Afanasjev, I. Ragnarsson, P. Ring

PHYSICAL REVIEW C, VOLUME 59, NUMBER 6, JUNE 1999

To be continued by the next speaker…