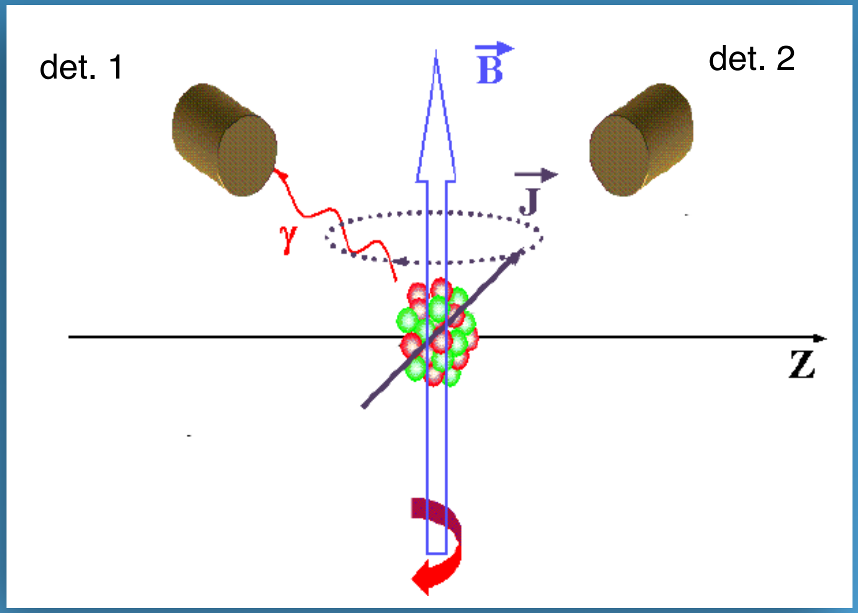
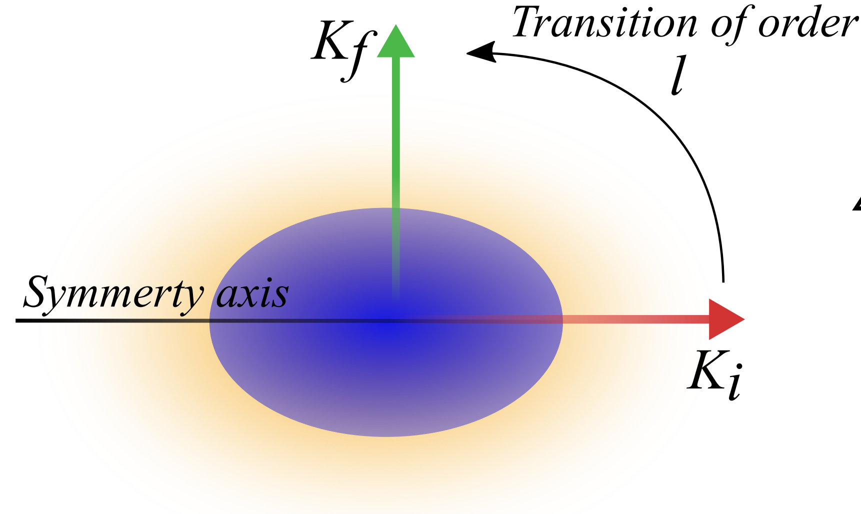
# g-factor measurements of isomeric states in $^{174}W$

Marco Rocchini




# K-Isomers

- K-Isomers: characterized by big orientation variations of the nuclear spin with respect to the nucleus symmetry axis

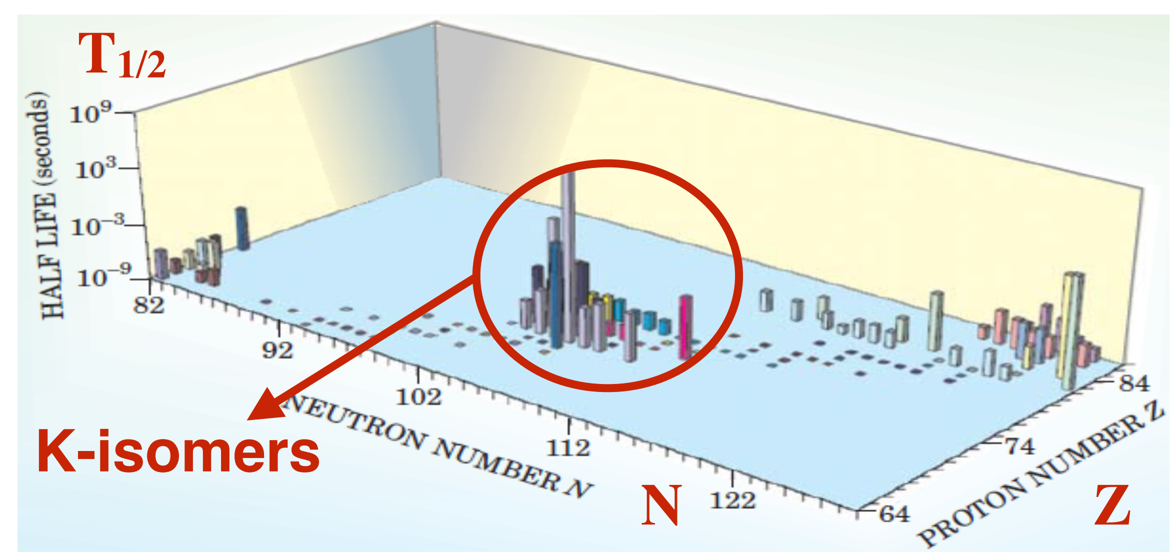



$$\Delta K = |K_f - K_i| \leq l$$

- K-hindered transition ($\Delta K > l$): is useful to define the degree of K-forbiddenness $\nu$ and the hindrance factor $F$

degree of K-forbiddenness: $\nu = \Delta K - l$

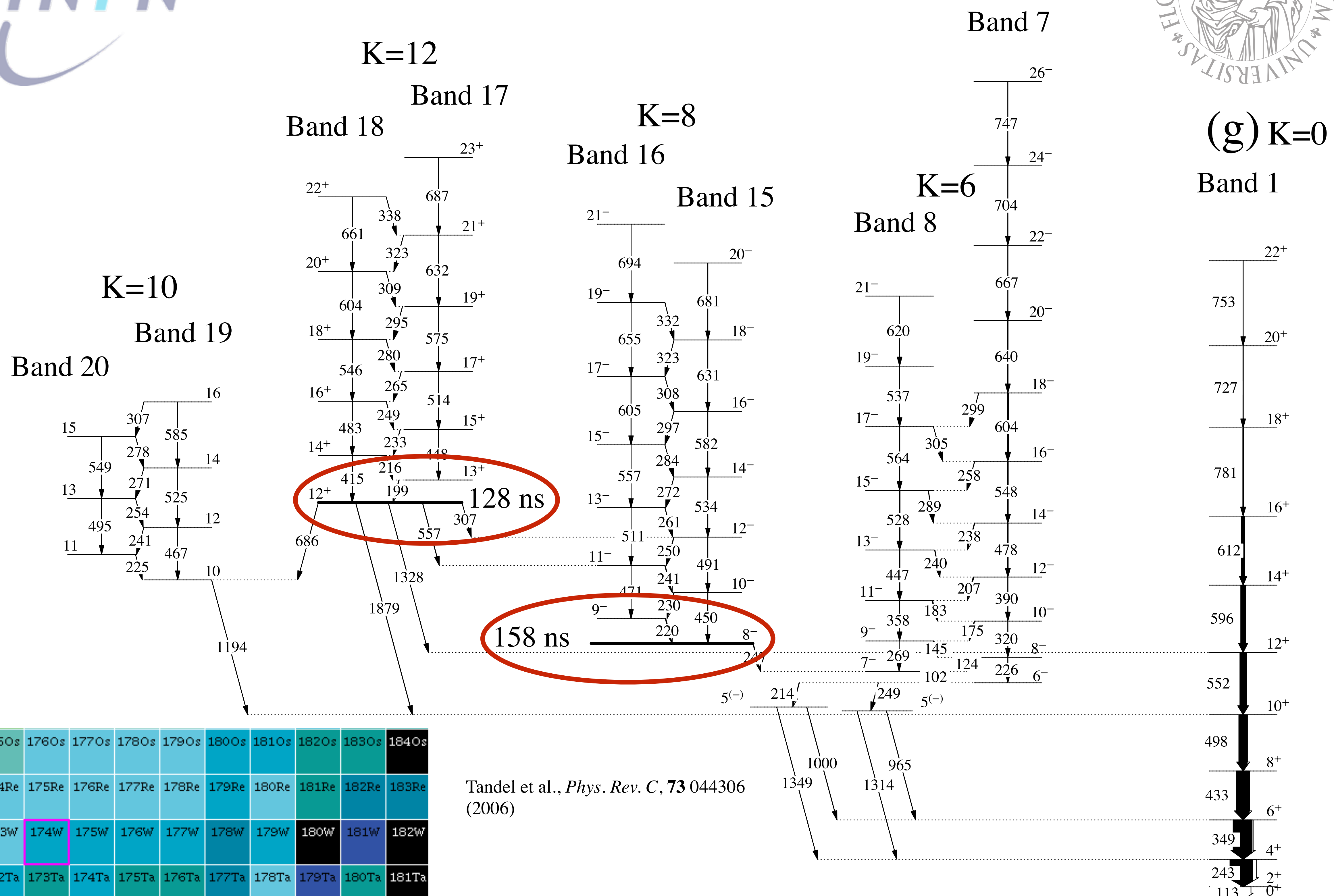
hindrance factor: $F = \frac{T_{1/2}}{T^{W}_{1/2}}$



# g-factor measurements of isomeric states in $^{174}W$

- **Physical Motivation**
- Experiment
- Results
- Level's Configurations
- Conclusions

# $^{174}W$

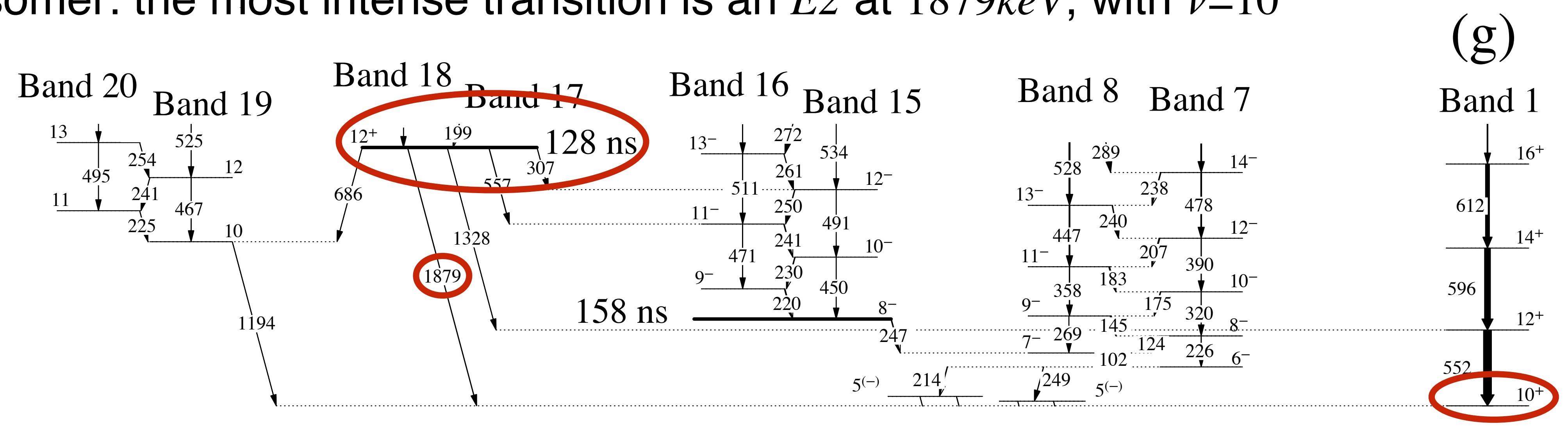



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 175Os | 176Os | 177Os | 178Os | 179Os | 180Os | 181Os | 182Os | 183Os | 184Os |
| 174Re | 175Re | 176Re | 177Re | 178Re | 179Re | 180Re | 181Re | 182Re | 183Re |
| 173W | 174W | 175W | 176W | 177W | 178W | 179W | 180W | 181W | 182W |
| 172Ta | 173Ta | 174Ta | 175Ta | 176Ta | 177Ta | 178Ta | 179Ta | 180Ta | 181Ta |
| 171Hf | 172Hf | 173Hf | 174Hf | 175Hf | 176Hf | 177Hf | 178Hf | 179Hf | 180Hf |

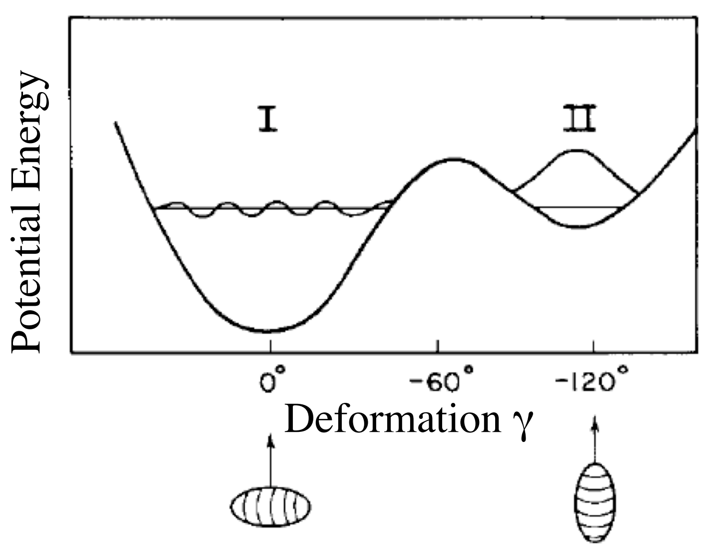
Tandel et al., *Phys. Rev. C*, **73** 044306 (2006)

# $^{174}W$

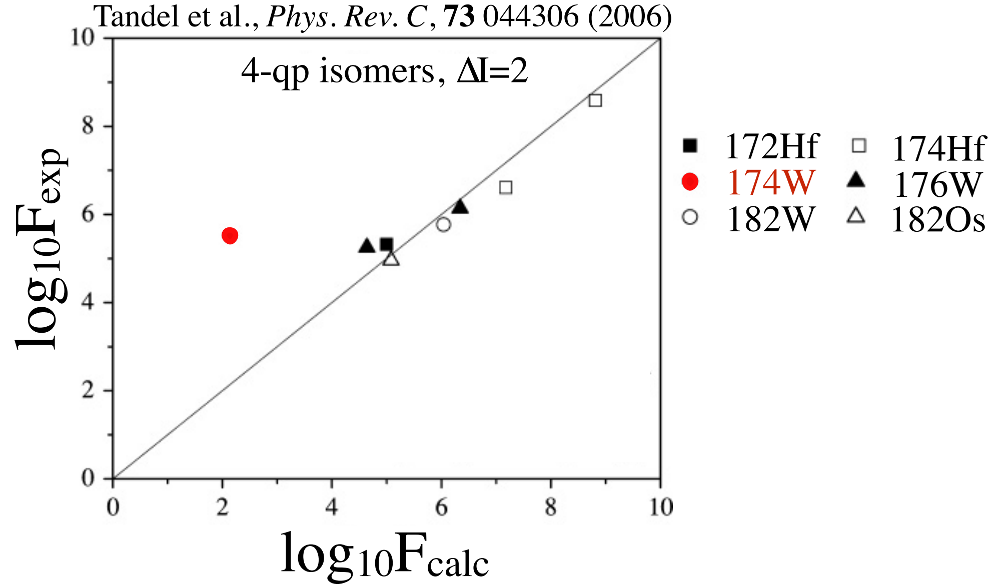
- $12^+$ isomer: the most intense transition is an $E2$ at $1879 keV$, with $\nu$=10




- $\gamma$-tunneling: tunneling of the nucleus through a barrier of $\gamma$ degree of freedom, along a line of constant $\beta$ deformation

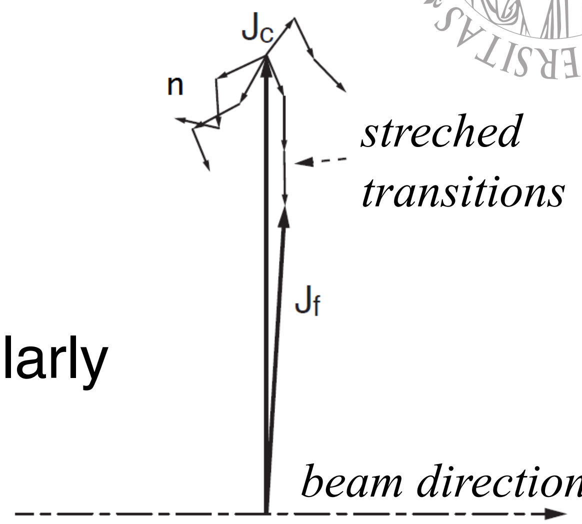



Tandel et al., *Phys. Rev. C*, **73** 044306 (2006)



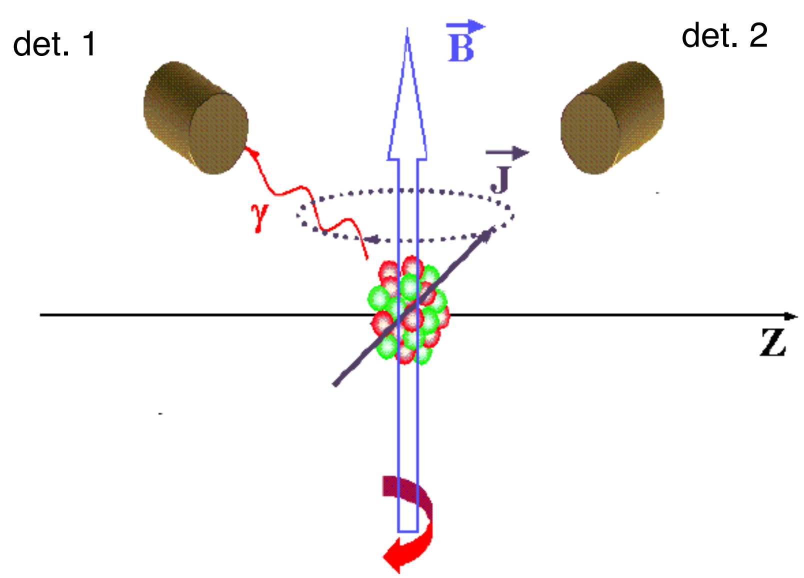

- g-factor measurements: information on the level's qp-configurations

# Time Differential Perturbed Angular Distribution technique




- Orientation: in the fusion-evaporation reaction the projectile transfers large angular momentum to the target, perpendicularly to the beam direction

- Interaction with an external magnetic field B: Larmor precession $\vec{\omega}_L = -\frac{g\mu_N}{\hbar}\vec{B}$




**Intensity**

$$I(t,\theta,B)=I(t=0)e^{-\frac{t}{\tau}}W(t,\theta,B)$$

**Distribution**

$$W(t,\theta,B)=\Sigma_{k=even}A_kB_k(J)P_k(\cos(\theta-\omega_L t))$$

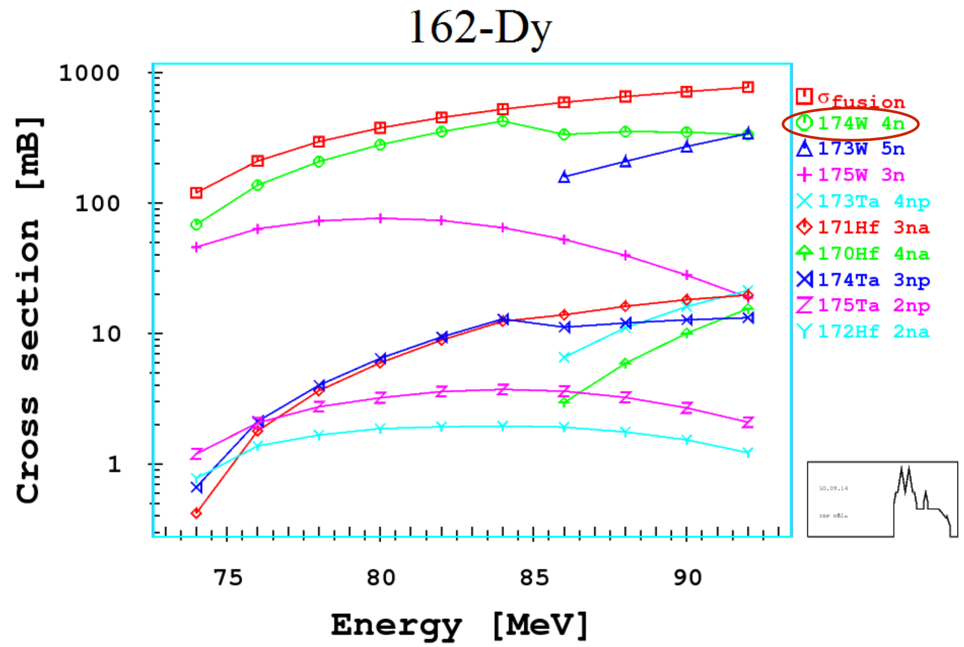
$$R(t,\theta,B)=\frac{I(t,\theta,B)-I(t,\theta+90°,B)}{I(t,\theta,B)+I(t,\theta+90°,B)}=\frac{3A_2B_2}{4+A_2B_2}\cos(2(\theta-\omega_L t))$$

# Reaction

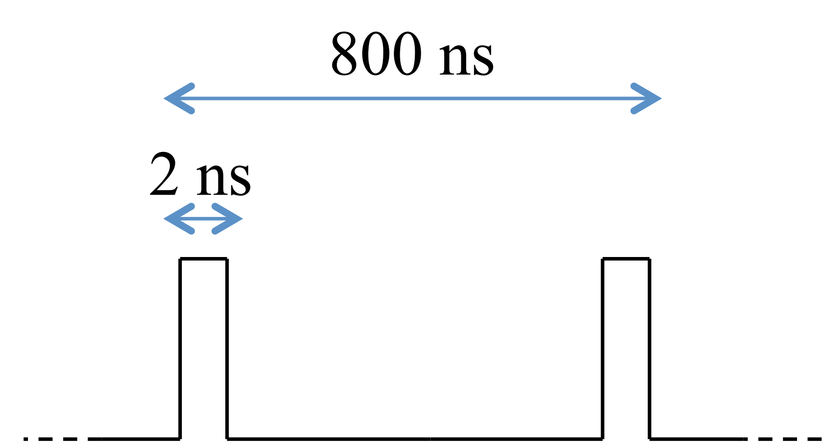
- Choice: CASCADE [1] code

$^{162}Dy(^{16}O,4n)^{174}W$ @$84MeV$

81.1% of the total cross section




- Pulsed beam: $2ns$ pulse for a good identification of the prompt peak and $800ns$ cycling time to observe the complete decay without overlap form different beam pulses

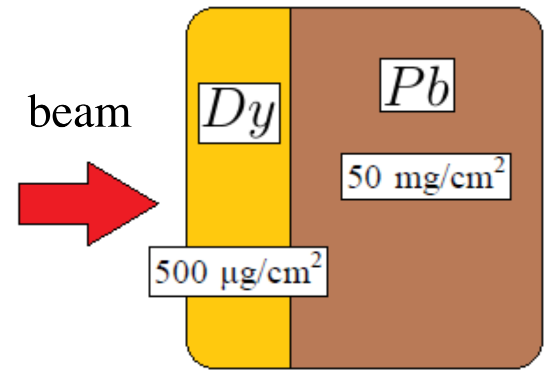


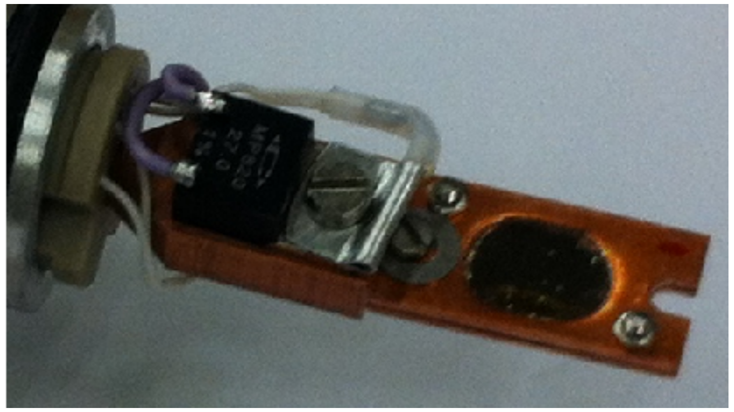

- Target

  Pb layer, for stopping tungsten

  Heated to $400K$

  Temperature control

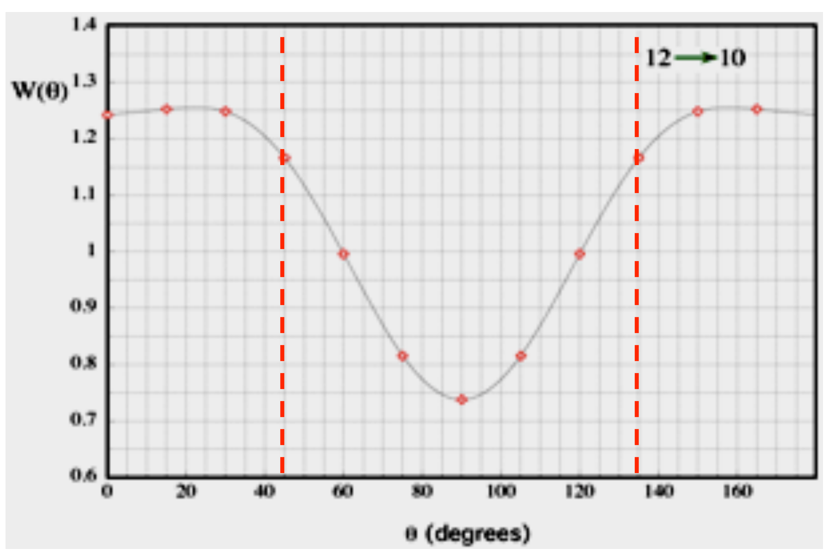


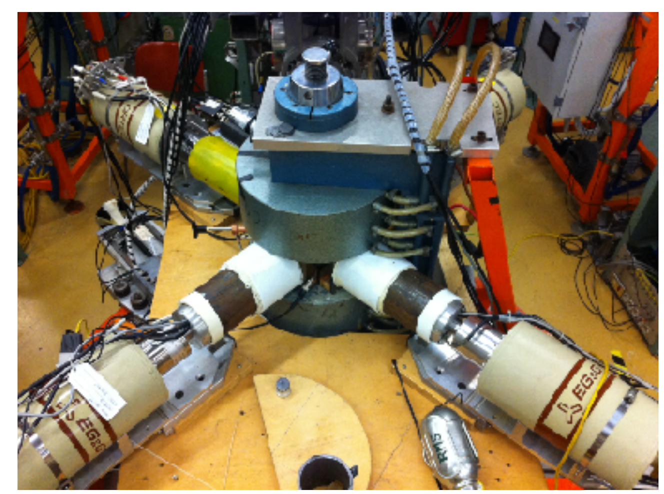



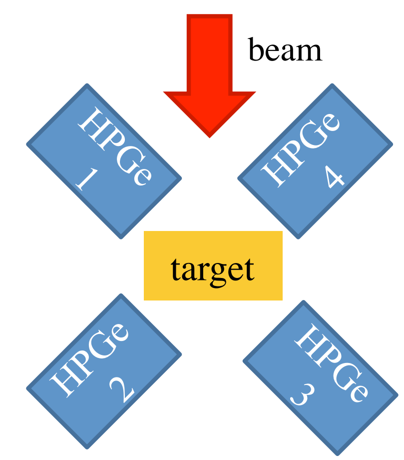
[1] Puhlohfer, *Nucl. Phys. A*, **280** 267 (1977)

# GAMIPE

- Detectors: 4 HPGe placed at ±45°, ±135° respect to the beam axis, since $W(t,\theta,B)$ is symmetric for a rotation of 180° the intensities of HPGe 1-3 and 2-4 can be summed for doubling the statistics



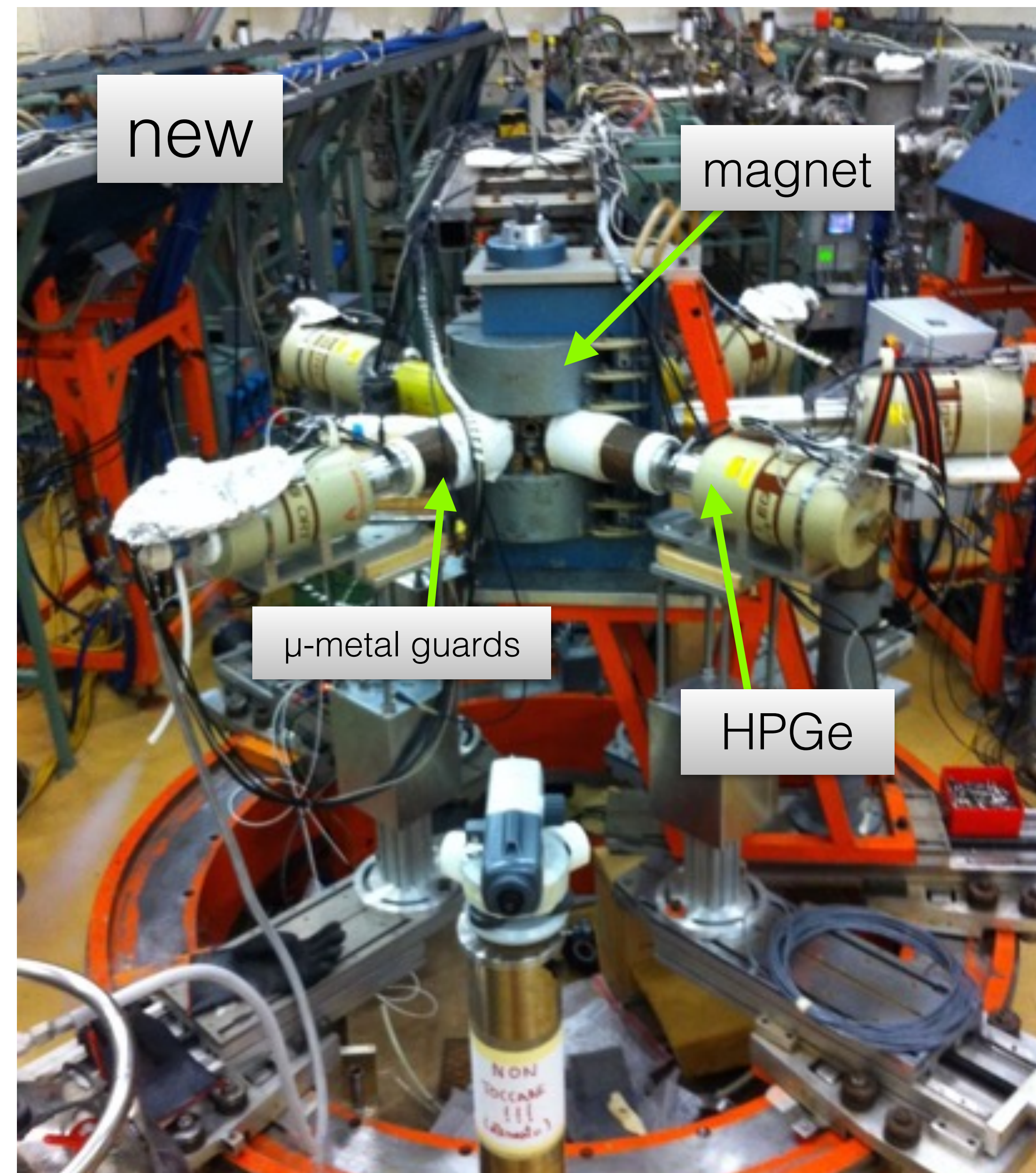






- Magnetic field: $B=(14.65\pm0.05)kG$, set at this value for observing 2-3 complete oscillations in the range of $3T_{1/2}$

# GAMIPE

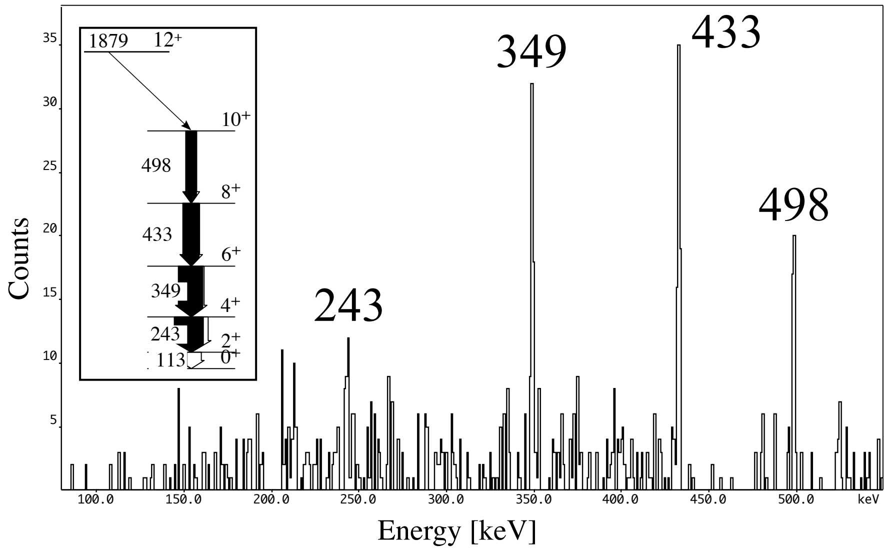
## Upgrade

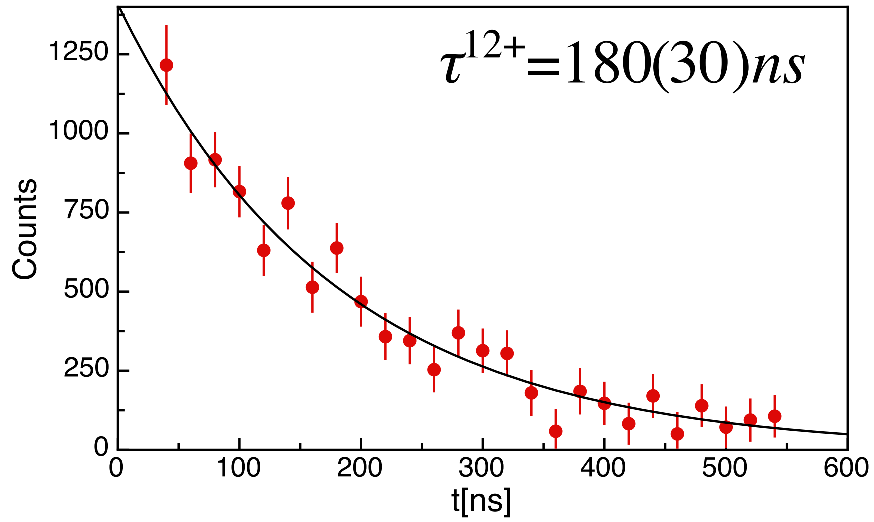

- New digital acquisition system: we have installed TNT2 cards based on Moving Time Deconvolution Window

# Results $12^+$

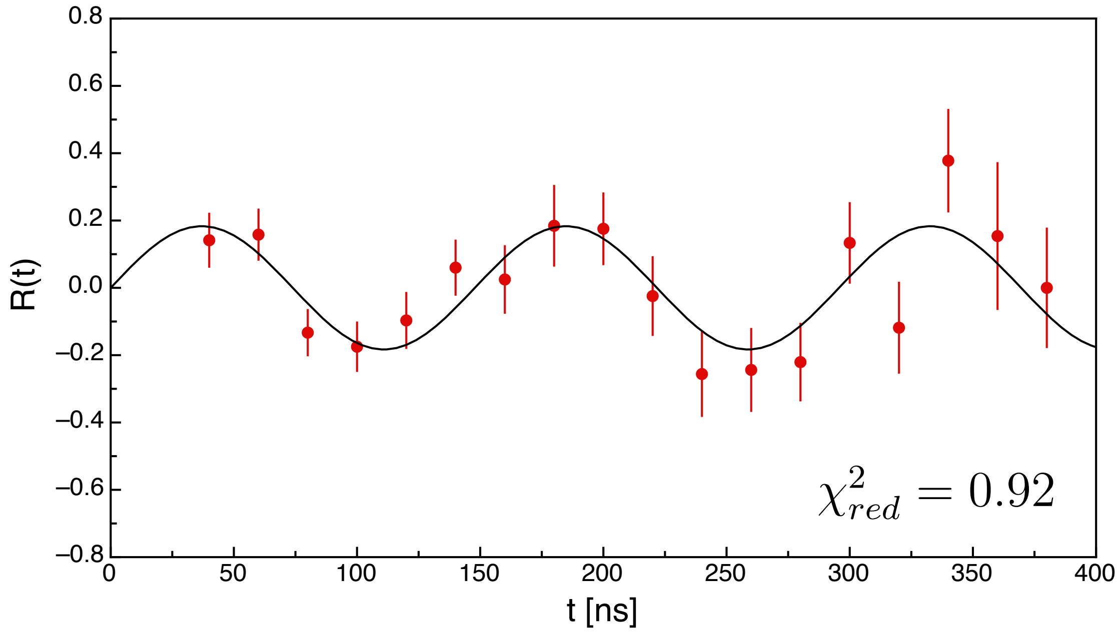
- Delayed transitions in coincidence with $1879keV$




- Mean life of $12^+$: confirmed literature value $\tau^{12+}$=186(12)$ns$ (Tandel et al., *Phys. Rev. C*, **73** 044306 (2006))



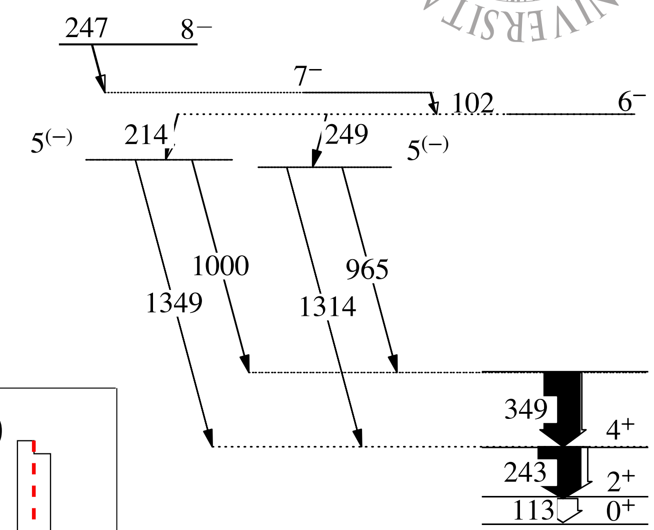

- g-factor



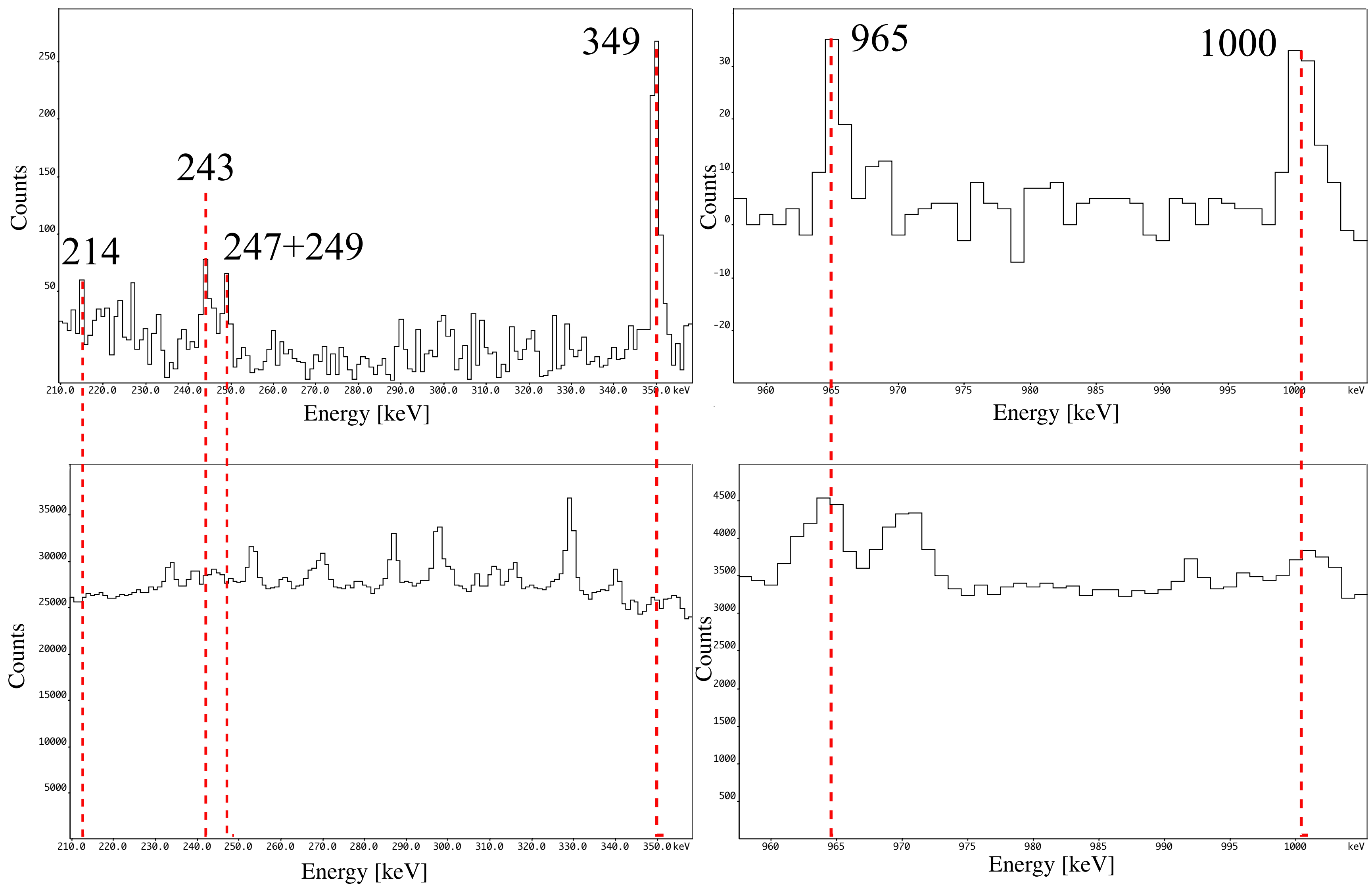

$g^{12+}$=0.304(7)

The systematic contributions are still under analysis, so probably the error is little underestimated

# Results
# 8-




- For the $8^-$ level the analysis is very complicated due to the large background contributions (still ongoing)




Delayed transitions in coincidence with $243keV$ and $247keV$

Example of $20ns$ delayed spectrum ($60$-$80ns$ after the prompt peak) g-factor measurements of isomeric states in $^{174}$W

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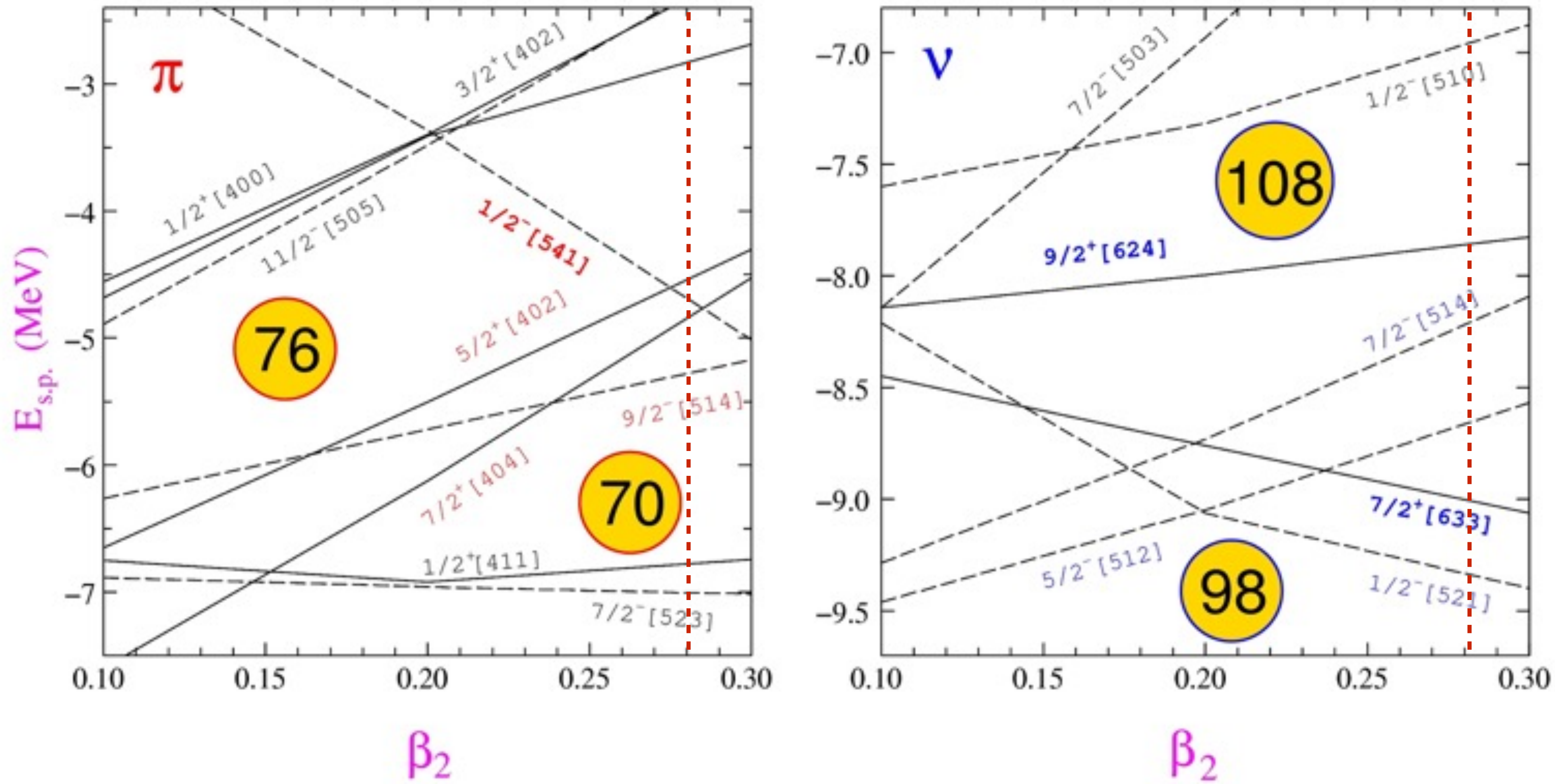
# Level's Configurations

- The level's qp-configuration are given by combination of single orbitals near the Fermi surfaces

A~180 mass region




- For $^{174}$W: $\beta_2$=0.271, $\beta_4$=-0.007, $\gamma$=0° (Tandel et al., *Phys. Rev. C*, **73** 044306 (2006))

# Level's Configurations

- gyromagnetic factor for a well define $K$ state [1]

$$K>1/2: \quad g=g_R+(g_K-g_R)\frac{K^2}{J(J+1)}$$

$$K=1/2: \quad g=g_R+\frac{g_K-g_R}{4J(J+1)}(1+(2J+1)(-1)^{J+1/2}b)$$

$b$ magnetic decoupling parameter [2]

rotational part

$$g_R=0.25(5)$$

obtained from the known gyromagnetic factor of the $2^+$ levels in the isotopes of Tungsten [3] (confirmed by measurement in $^{176}$W [4])

intrinsic part ($i$ is number of considered orbitals)

$$Kg_K=\Sigma_i \Omega_i g_{\Omega_i}$$

obtained from the experimental g-factors in the near nuclei with a single nucleon in the valence orbital

[1] Bohr A. & Mottelson B.R., *"Nuclear Structure, Volume II: Nuclear Deformations"*, World Scientific, Singapore, (1998)
[2] Stuchbery et al., *Nuclear Phys. A*, **669** 27 (2000)
[3] Firestone R.B. & Shirley V.S., *"Table of Isotopes"*, John Wiley, New York, (1996), Appendix E, Nuclear Moments
[4] Ionescu-Bujor et al., *Phys. Lett. B*, **541** 219 (2002)

# Level's Configurations $12^+$

- Level configuration: spin $12^+$ and similar energy ($3516keV$) [1], [2]

| proton orbitals | neutron orbitals | $g_{calc}(12^+)$ |
|---|---|---|
| $7/2^+[404], 9/2^-[514]$ | $1/2^-[521], 7/2^+[633]$ | **0.678(13)** |
| $5/2^+[402], 7/2^+[404]$ | $5/2^-[512], 7/2^-[514]$ | **0.533(11)** |
| $5/2^+[402], 7/2^+[404]$ | $5/2^+[642], 7/2^+[633]$ | **0.403(11)** |
| | $5/2^-[512], 7/2^-[514], 5/2^+[642], 7/2^+[633]$ | **-0.161(9)** |

- Experimental value measured in this work: **$g^{12+}=0.304(7)$**
- The level's configuration might not be a pure 4qp-configuration

[1] Tandel et al., *Phys. Rev. C*, **73** 044306 (2006)
[2] Crowell et al., *Phys. Rev. C*, **53** 1173 (1996)

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# Conclusions

- Upgrade to GAMIPE apparatus, a modern set-up for g-factor and Q-value measurements at LNL in Legnaro (Pd, Italy)
- Confirmed mean life value for $12^+$ level: $\tau^{12+}=180(30)ns$
- First measure of the g-factor for the level $12^+$: $\mathbf{g^{12+}=0.304(7)}$
- The level $12^+$ might not be a pure 4-qp configuration
- The analysis on the level $8^-$ is still ongoing

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M. Rocchini[1], A. Nannini[1], G. Benzoni[2], B. Melon[1], P.R. John[3], M. Ottanelli[1], A. Perego[1], R. Avigo[2], N. Blasi[2], G. Bocchi[2], S. Bottoni[2], A. Bracco[2], F. Camera[2], S. Ceruti[2], F.C.L. Crespi[2], A. Giaz[2], S. Leoni[2], B. Million[2], A.I. Morales[2], L. Pellegri[2], O. Wieland[2], D. Bazzacco[3], R. Menegazzo[3], D. Mengoni[3], C.A. Ur[3], V. Modamio[4], D.R. Napoli[4], J.J. Valiente-Dobon[4], A. Gottardo[5], C. Michelagnoli[6], G. Georgiev[7]

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[4] *INFN Laboratori Nazionali di Legnaro, Legnaro (Padova), Italy*
[5] *CNRS, Paris, France* [6] *GANIL, Caen, France* [7] *CSNSM, Orsay, France*