Nuclear structure close to N=Z=50

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G. de France (GANIL)

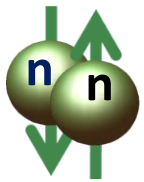
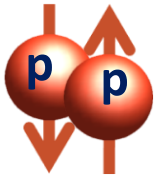
Goals of the collaboration

- Nuclear structure around ^{100}Sn
  - ^{92}Pd, ^{96}Cd
- Neutron detection expertise at Warsaw
  - Early electronics for the Nwall from Warsaw
  - Setup of the Nwall for the experiments at GANIL
- Simulation calculations using GEANT4
  - Nwall geometry built in Warsaw and included in the AGATA package
  - EXOGAM geometry from GANIL included in AGATA package
- Design of NEDA
  - M Palacz dedicated talk (June 6)

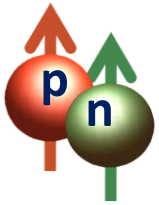
^{92}Pd and T=0 pairing

- Pairing along the N=Z line:

T=1, J=0 — isovector

T_z=1	T_z=0	T_z=-1
		

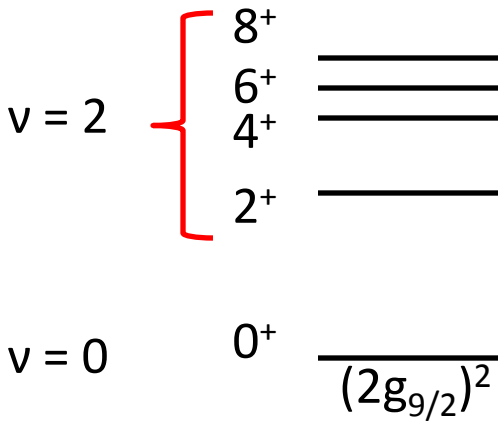
T=0, J>0 — Isoscalar

T_z=0


Badly known…

Our approach: search for isoscalar pairing in seniority violation

- The seniority ν is the number of nucleons that are not in pairs
- In a valence configuration j^n, the states can be labelled according ν:

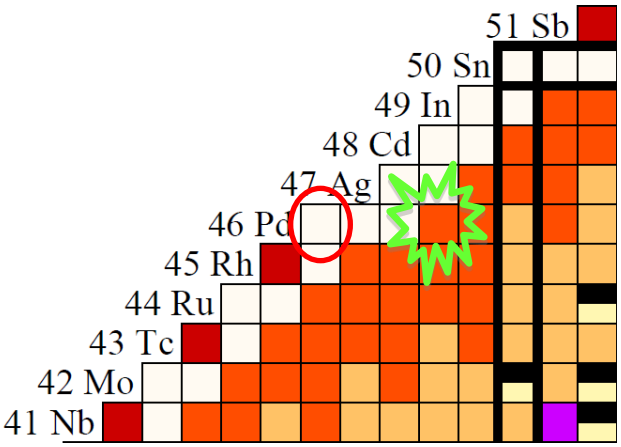


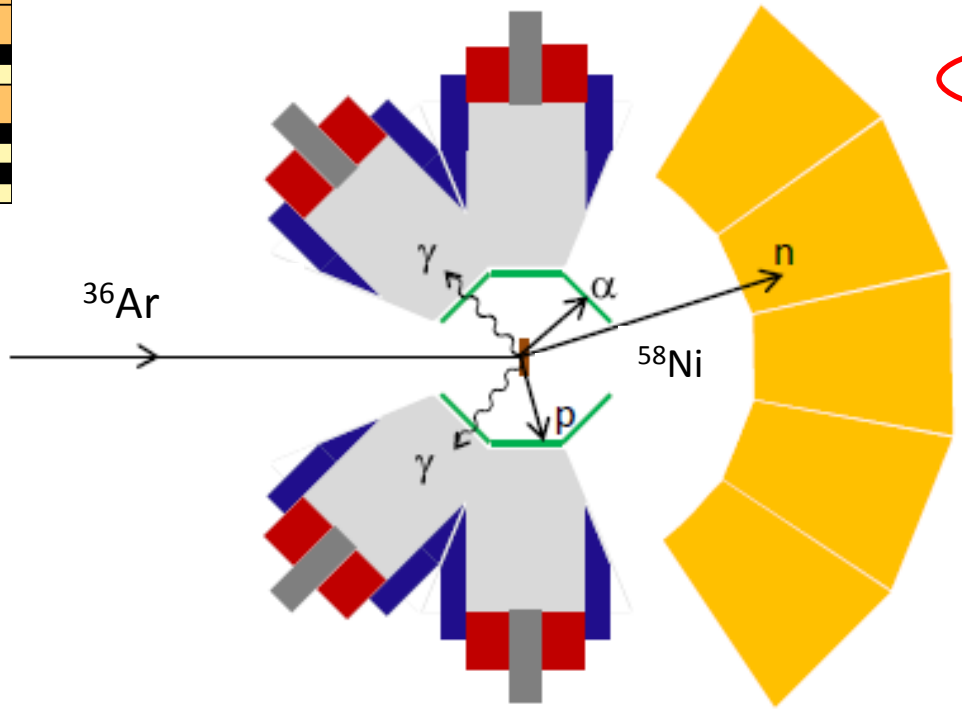
- The seniority scheme is revealed by the energy spacing between excited states

Fusion evaporation reactions to reach the N~Z line

^{36}Ar (111 MeV) + ^{58}Ni ⟶ $^{94}Pd^*$ ⟶

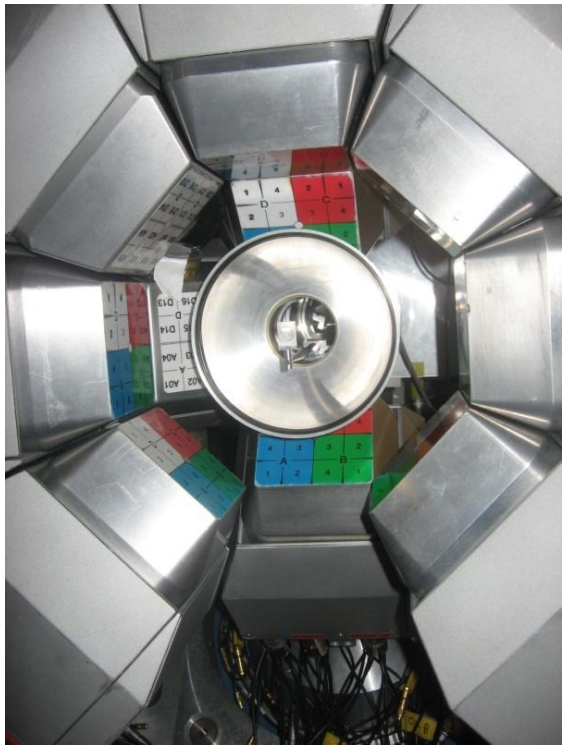
^{91}Tc + 3p
^{91}Ru + 2p1n
^{90}Mo + 4p
^{88}Mo + 4p2n
^{90}Tc + 3p1n
^{92}Rh + 2p
…
^{92}Pd + 2n



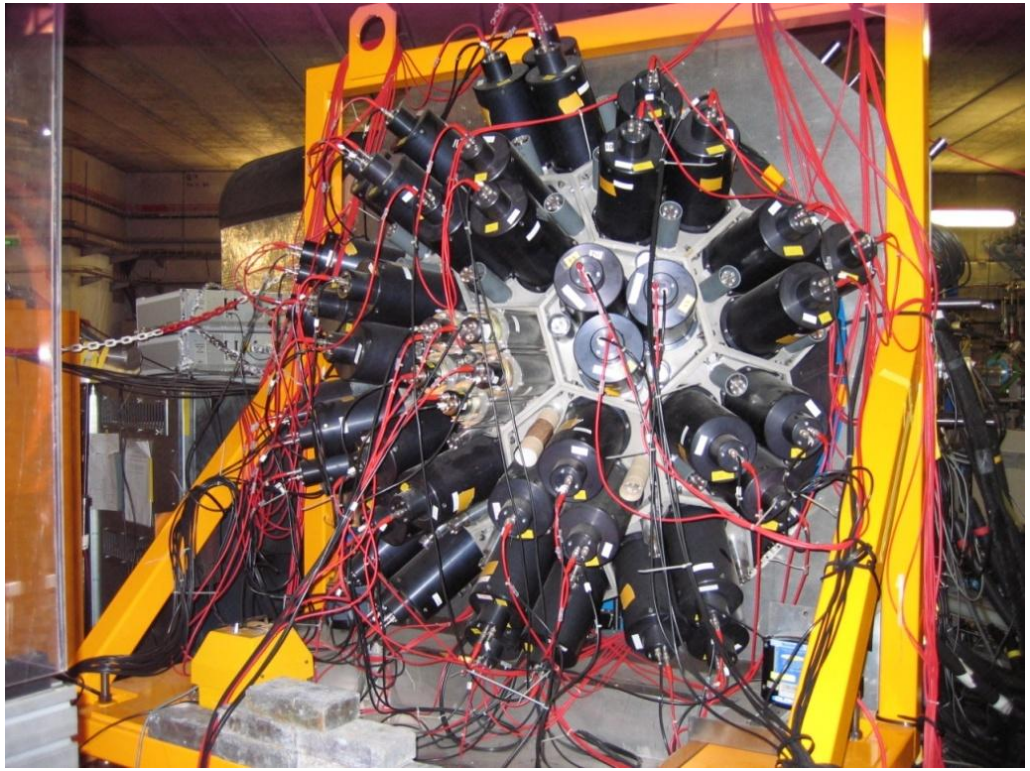


EXOGAM-NWall-DIAMANT:

The power of the coupling

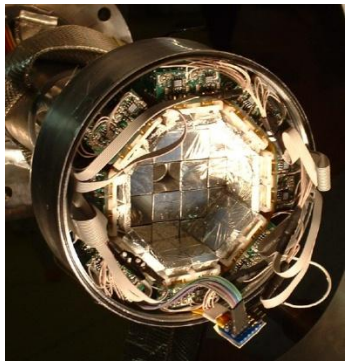


- EXOGAM: 11 Clovers with partial shield. $\varepsilon_p\omega$ ~ 10% for E_γ=1.3 MeV



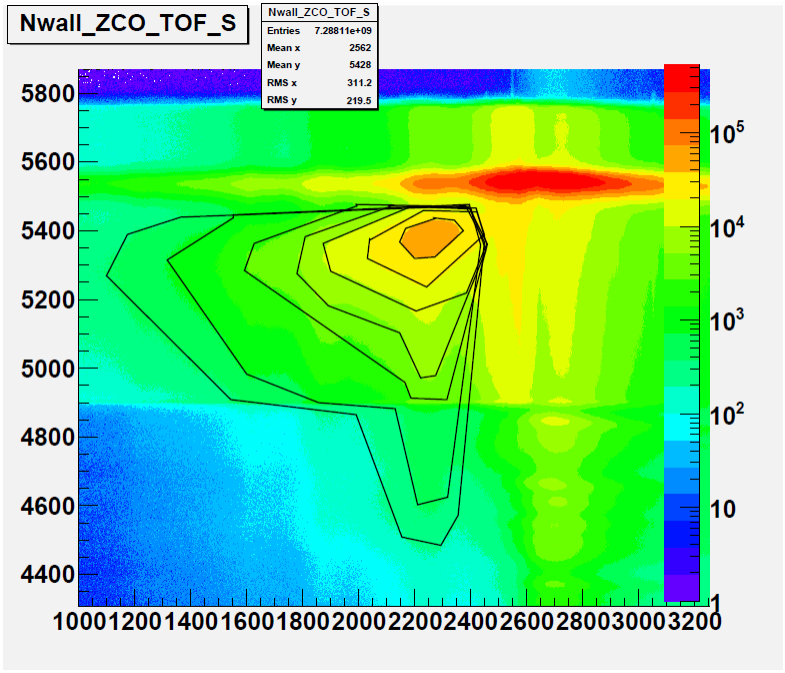
- The Neutron Wall: 50 liquid scintillator detectors. ε_{1n} ~ 23%

- DIAMANT: 80 CsI(Tl) dets. $\varepsilon_{p\ or\ \alpha}$ ~ 66%

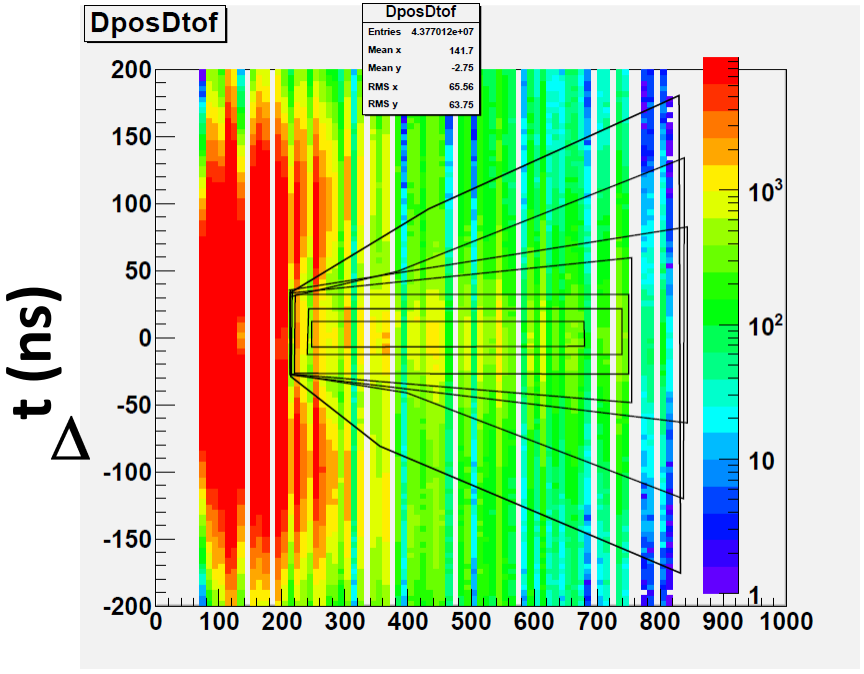


Neutron Wall performance

n-γ Separation

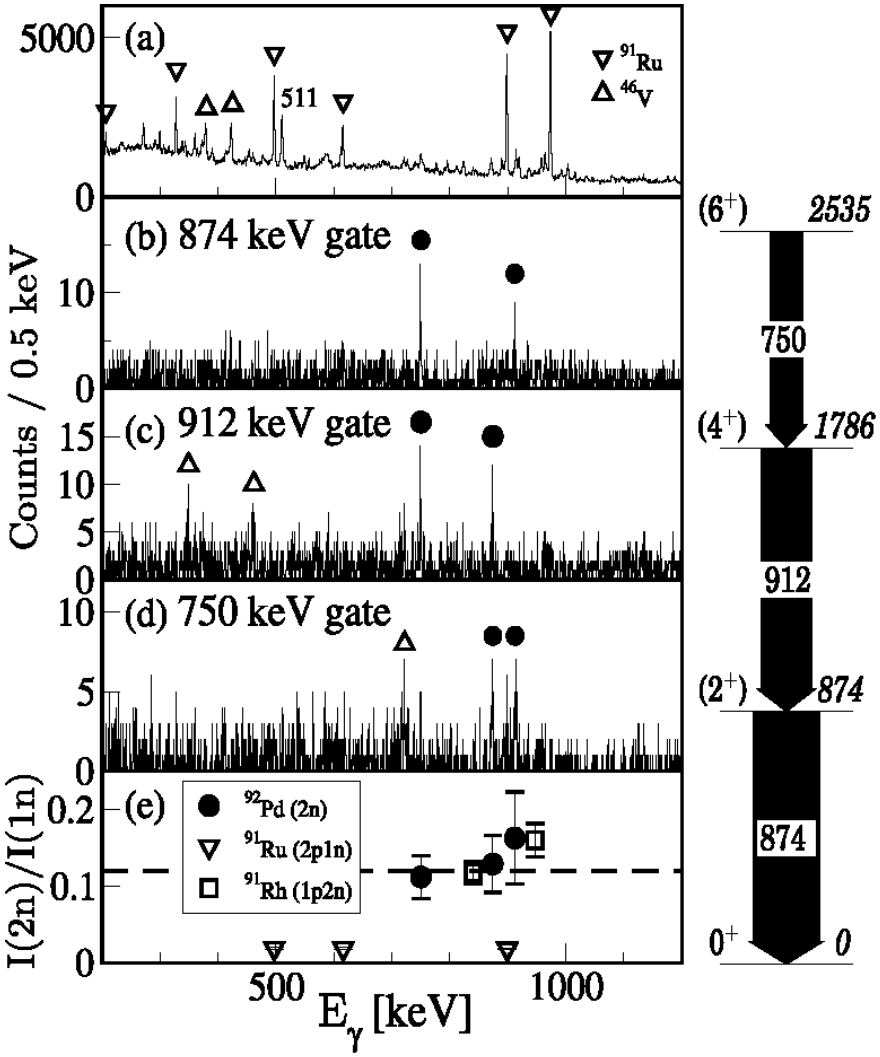


Rejection of n scattering



EXOGAM:

First identification of γ-rays in ^{92}Pd



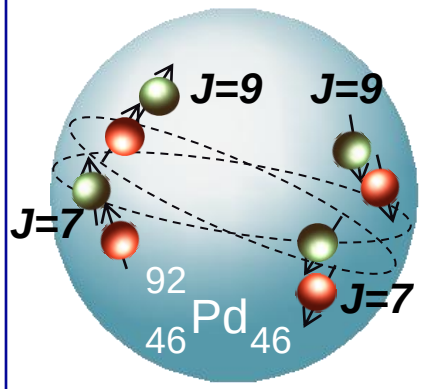
- Three γ-rays firmly identified
- In coincidence with 2n
- Not in coincidence with charged particles
- Mutually coincident
- All possible contaminants excluded
- ➔ Unambiguously assigned to ^{92}Pd

Production cross section ~ 0.5 μb

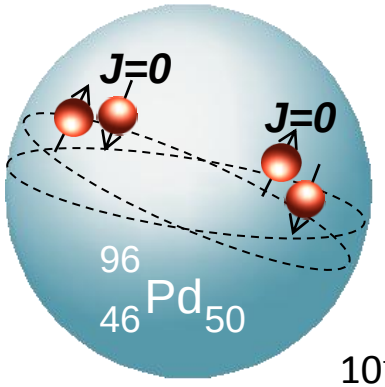
B Cederwall, F. Ghazi-Moradi, T Back, A Johnson, J. Blomqvist, E Clément, G. de France, R Wadsworth et al,

Nature 469, 68-71 (2011)

^{92}Pd: A new spin aligned np coupling scheme



Spin-aligned pairing phase



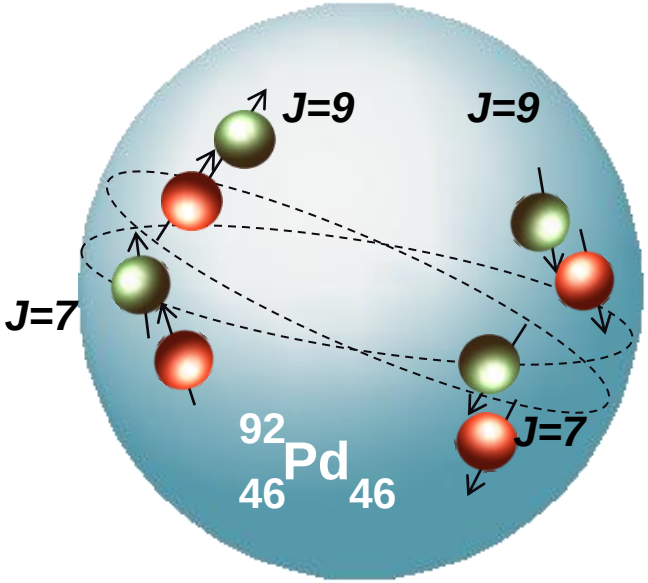
Normal, anti-aligned pairing phase

^{92}Pd, exp.		^{92}Pd, SM		^{96}Pd, exp.		^{96}Pd, SM	
		10^+	4072	10^+	3784	10^+	4131
		8^+	3127	8^+	2530	8^+	2636
(6^+)	2536	6^+	2466	6^+		6^+	
				4^+	2099	4^+	2224
(4^+)	1786	4^+	1708				
				2^+	1415	2^+	1460
(2^+)	874	2^+	878				
0^+	0	0^+	0	0^+	0	0^+	0

Enhanced collectivity?

• Aligned isoscalar np coupling:

$\Psi_{G.S.}=[(\{\nu g_{9/2}^{-1} \times \pi g_{9/2}^{-1}\}_{9+})^2]_{0+} \times [(\{\nu g_{9/2}^{-1} \times \pi g_{9/2}^{-1}\}_{7+})^2]_{0+}$

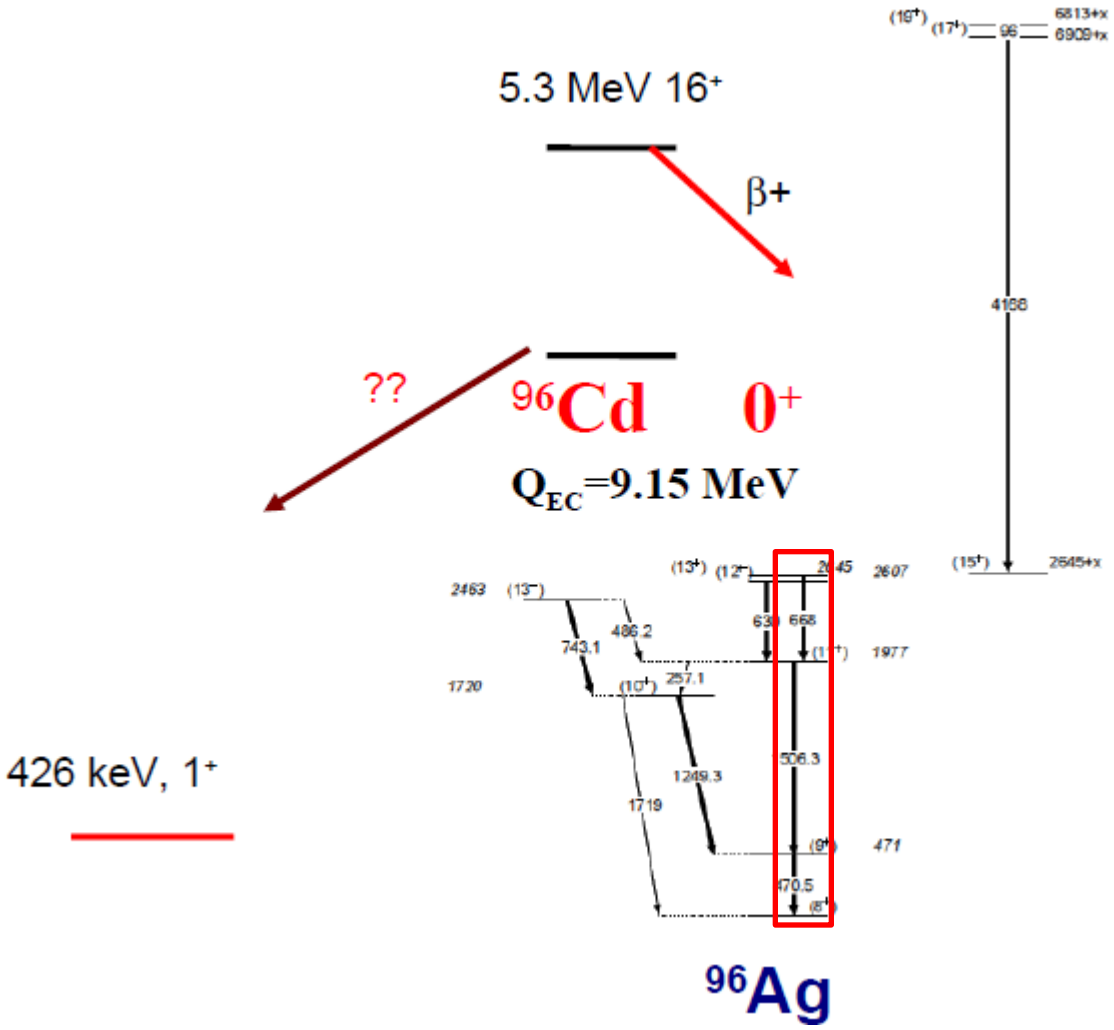


•The predicted 4-deuteron-hole like ground state has a significant intrinsic quadrupole moment

• Need next generation facility (S3@SPIRAL2) to measure magnetic moments, quadrupole moments,...

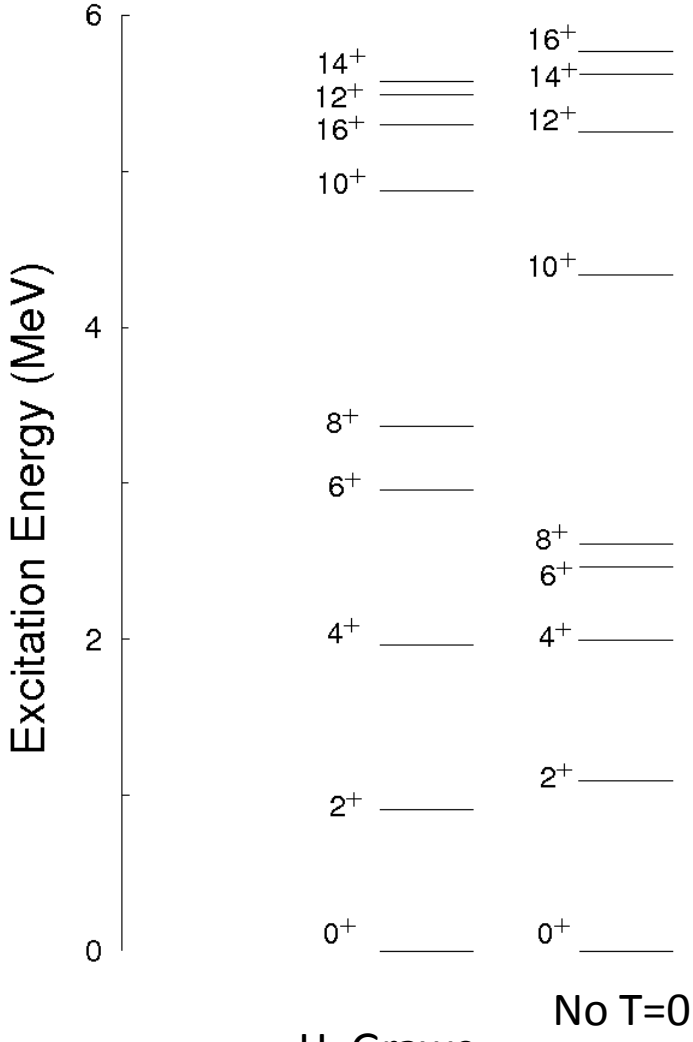
^{96}Cd GSI results

- Observe the decay of identified ^{96}Cd to an 15+ isomer in ^{96}Ag



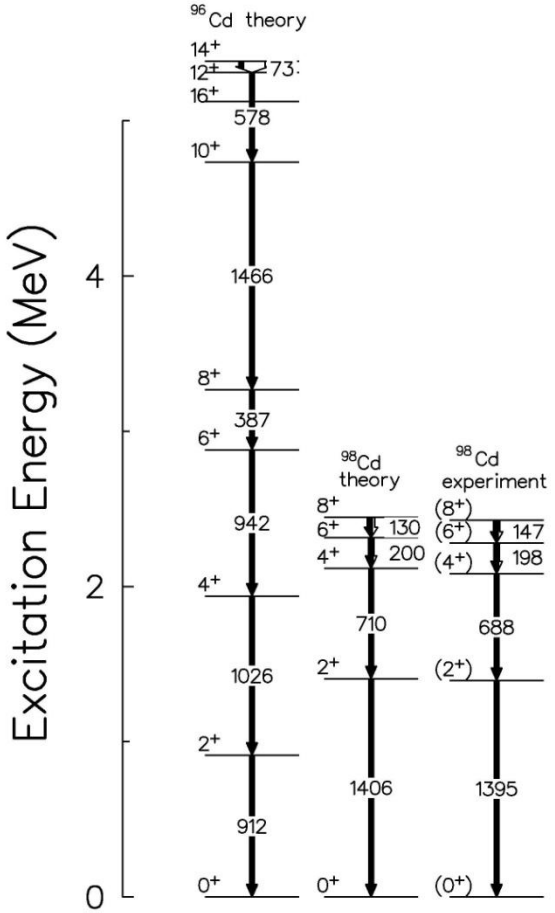
^{96}Cd GSI results

- Compatible with our interpretation:



H. Grawe

No T=0



J. Blomqvist (2007)

^{96}Cd in-beam experiment

B Cederwall, G de France, R Wadsworth

- Needed to observe the ^{96}Cd prompt gammas and complement the GSI results
- Same setup: EXOGAM+Nwall+DIAMANT
- ^{40}Ca + ^{58}Ni → ^{98}Cd*
- COPIGAL essential for testing, setting up and optimizing the Nwall (key detector for channel identification)
- Allows a very smooth and efficient organization of the Nwall campaign:
  - first tests in January 2012 (performances of the individual detectors, time alignment, thresholds, cabling,…)
  - in-beam test June 13-14 for the integration of EXOGAM, Nwall and DIAMANT electronics
  - runs in July

A side project:

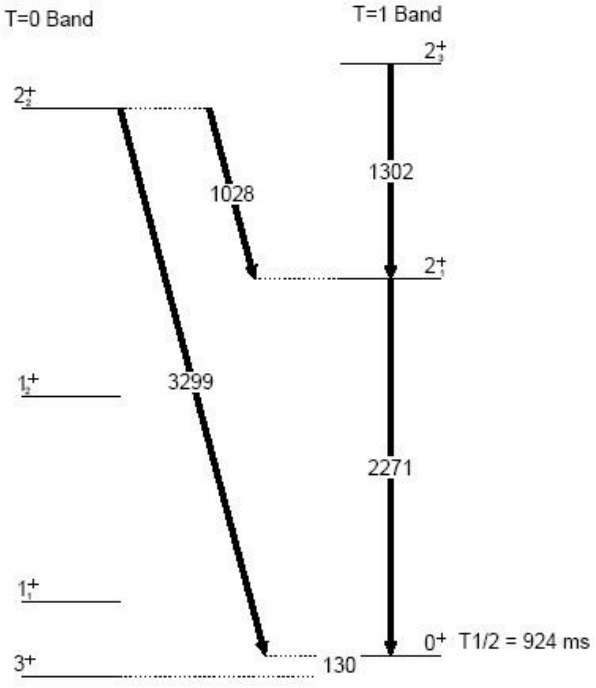
Isospin mixing in $^{38}_{19}K_{19}$

Isospin mixing

- Isospin non conserving forces mix states with the same quantum numbers but different isospin
- Mixing is maximum for heavy N=Z nuclei
- Small ΔE ➔ larger mixing ➔ o-o nuclei

(in e-e nuclei T=0 and T=1 states with same

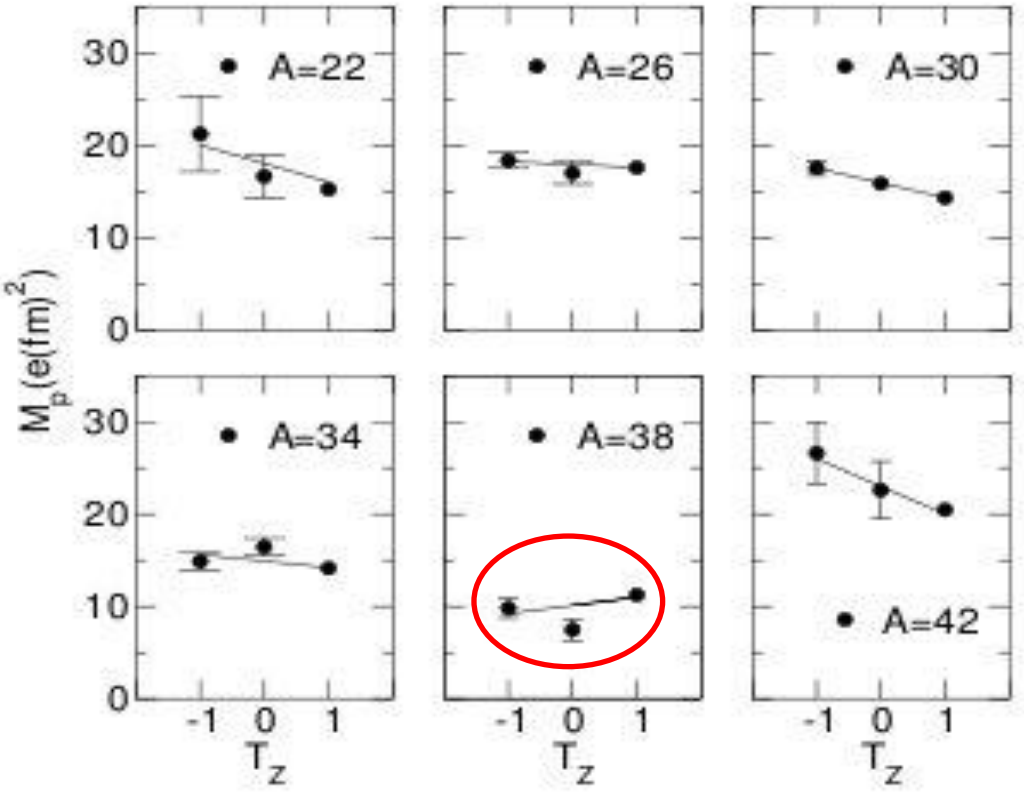
J^{π} are separated by ~6 MeV)



$^{38}_{19}K_{19}$

^{38}K is a very good candidate from all these constraints

IAS in isobaric triplets in the A=22-42 mass region

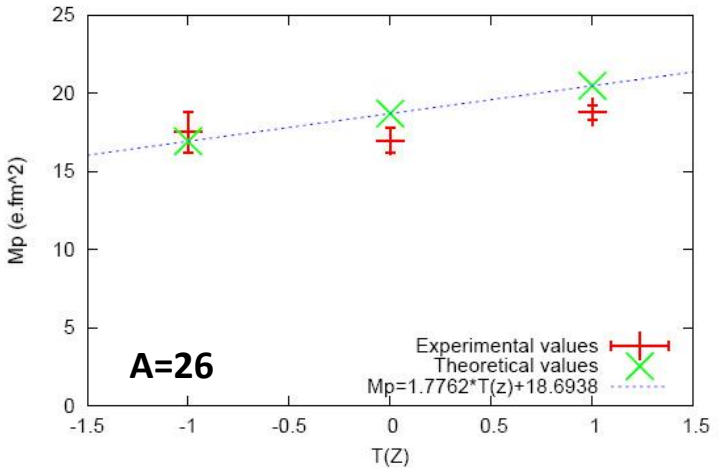


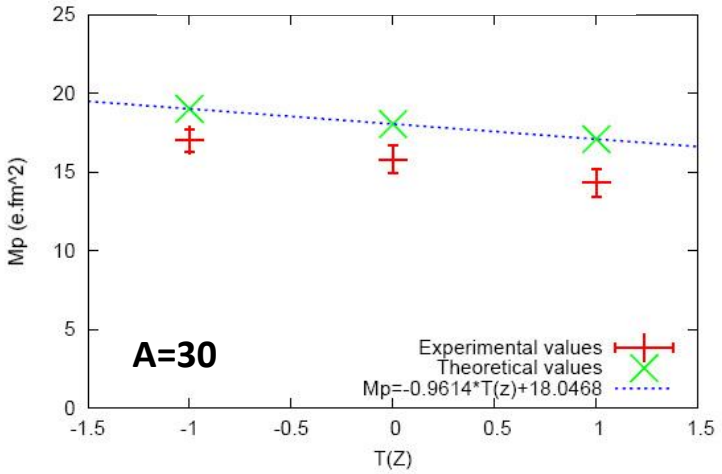
- Fit to the data
- If isospin symmetry were not broken (i.e. exactly 1 here), the Mp for IAS should vary linearly with Tz
- Anomaly in A=38

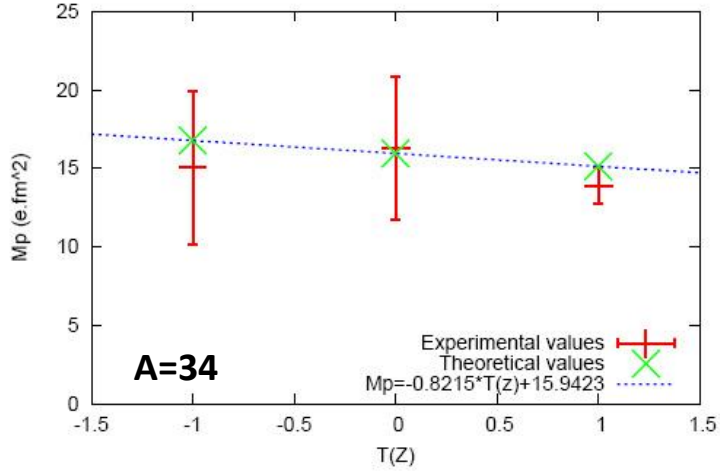
F.M. Prados Estévez *et al* PRC 75, 014309 (2007)

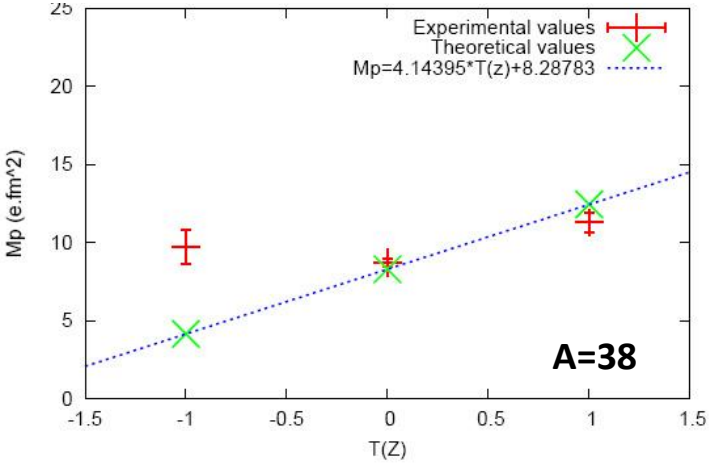
The A=26-38 triplets

Comparison between SM calcs and experimental data





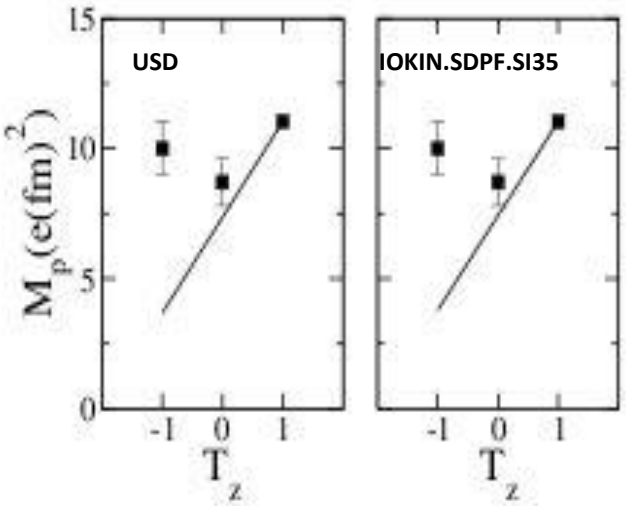




➔ SM calcs OK except for A=38…

The A=38 triplet

Comparison between SM calcs and experimental data



F.M. Prados Estévez *et al* PRC 75, 014309 (2007)

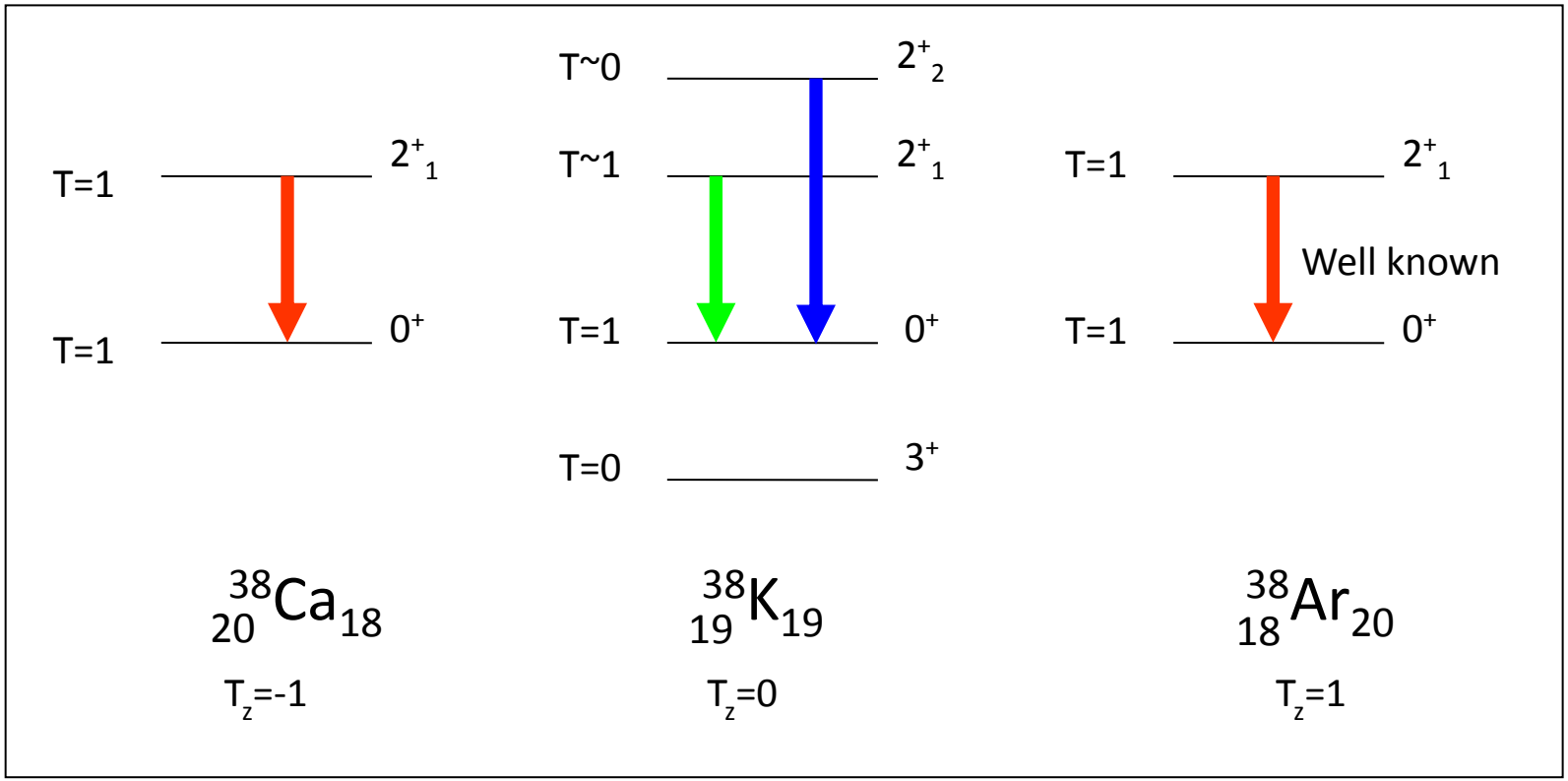
- Different interactions; very similar results
- Strong deviation between exp. and SM calcs.
  - ➔ wrong exp. value for ^{38}Ca ?
  - ➔ Isospin mixing ?

Our goals:

- Re-measure ^{38}Ca ➔ transfer exprt in HIL Warsaw
- Measure the isospin mixing in ^{38}K *in a model independent way* ➔ SPIRAL1

What do we have to measure?

A few B(E2) values:



$$\Phi = \frac{M(0,1) - M}{M(0,2)}$$

Two experiments

- Lifetime measurement in ^{38}Ca (exprt approved in Warsaw)
  - Transfer reaction: ^{12}C(^{36}Ar,^{38}Ca)^{10}Be
  - The EAGLE array
  - Plunger device from Bucarest

- Coulomb excitation of an isomeric beam (^{38}K) at SPIRAL1
  - RIB from ^{40}Ca fragmentation
  - g.s. is 3^+; 0^+_1 state has 924ms lifetime
  - Coulex of 0^+_1 to populate 2^+_1 (T=1) and 2^+_2 (T=0)
  - Simultaneous measurement of the isomeric ratio

Summary

- COPIGAL is a fantastic tool for our collaboration to:
  - organize our experiments in a smooth and efficient way
  - To use the Warsaw and GANIL facilities in a complementary way: e.g. isospin symmetry studies in A=38 isospin triplet with radioactive beam experiment at GANIL and stable beam experiment at SLCJ
  - design the future neutron array NEDA (see Marcin's talk)