Investigations of nuclei in the vicinity of ^{100}Sn with EUROBALL and EXOGAM

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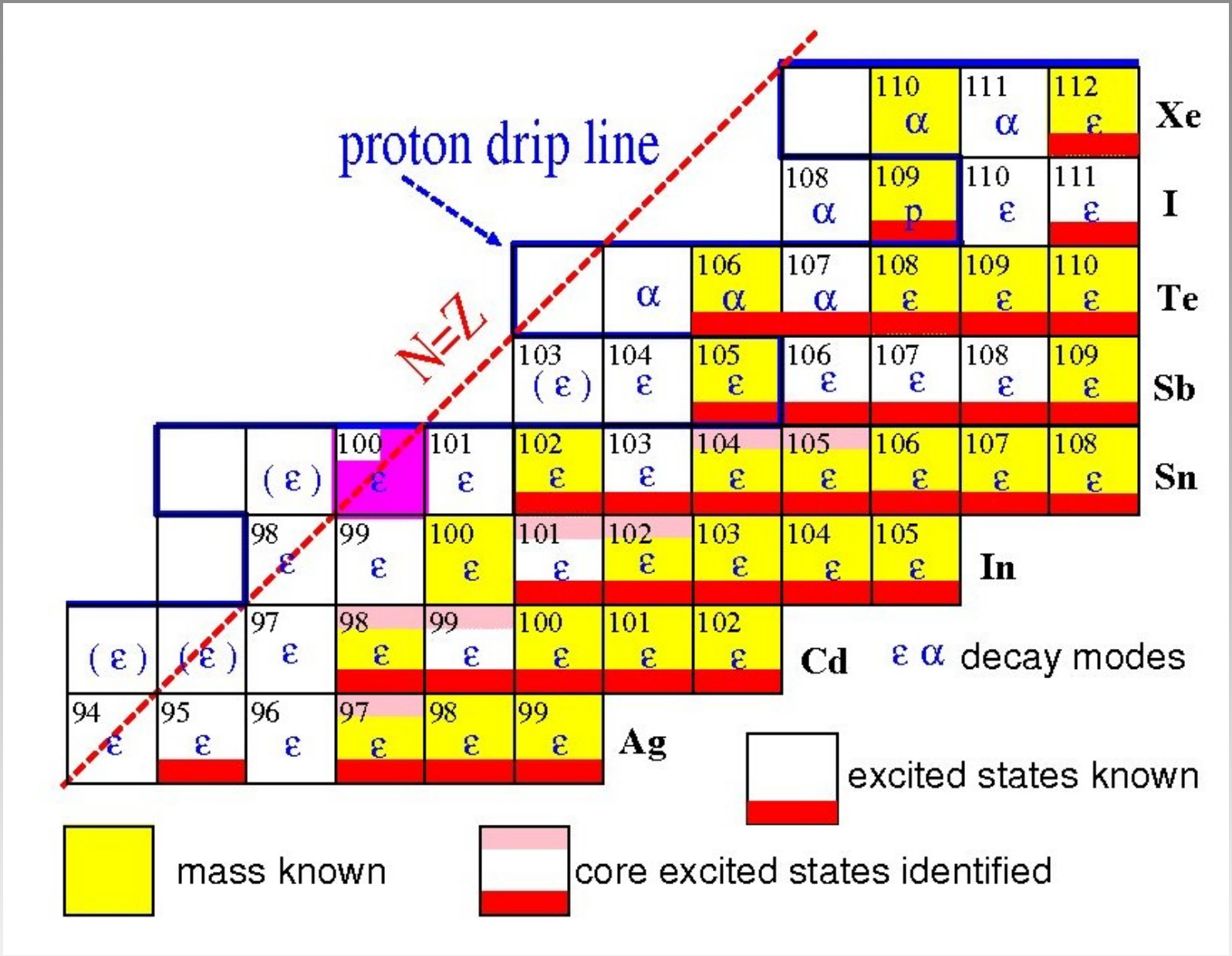
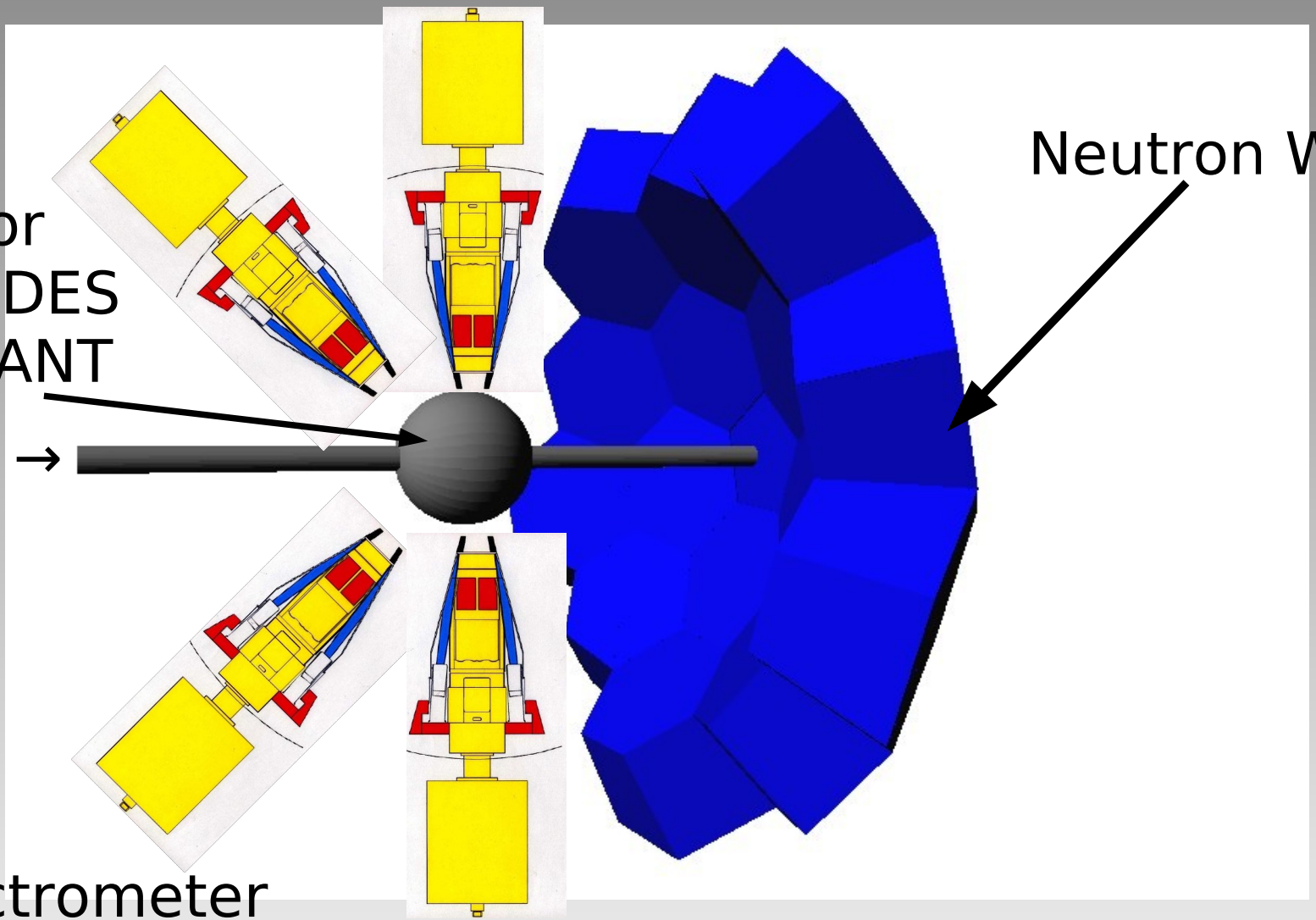
Motivation

- ^{100}Sn – heaviest doubly magic N=Z nucleus
- challenging test ground for nuclear shell model, relativistic mean field and Hartree-Fock calculations
- np – interaction (T=0, np pairing?)
- collective phenomena
- isospin symmetries (mirror nuclei)
  – charge invariance of n-n forces
- astrophysical interest (rp-process)

Experimental Status

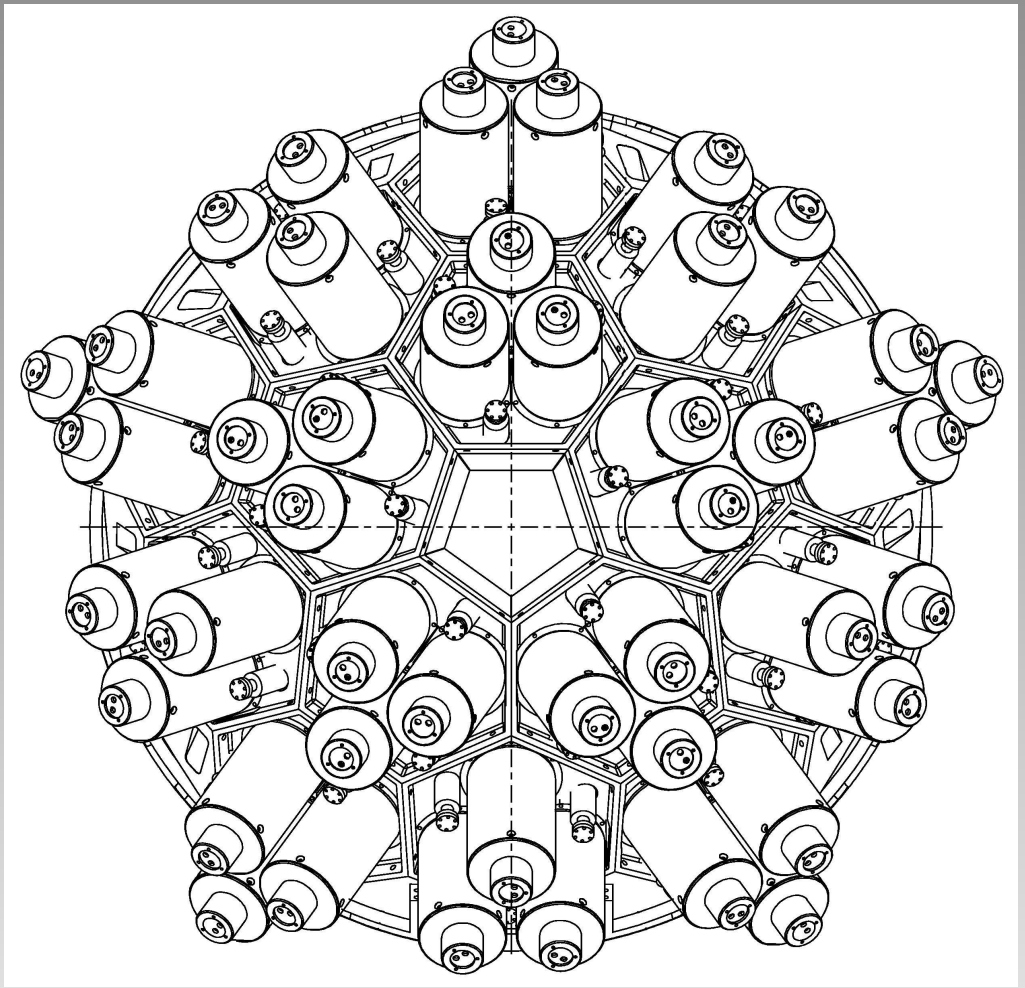


Typical experimental setup

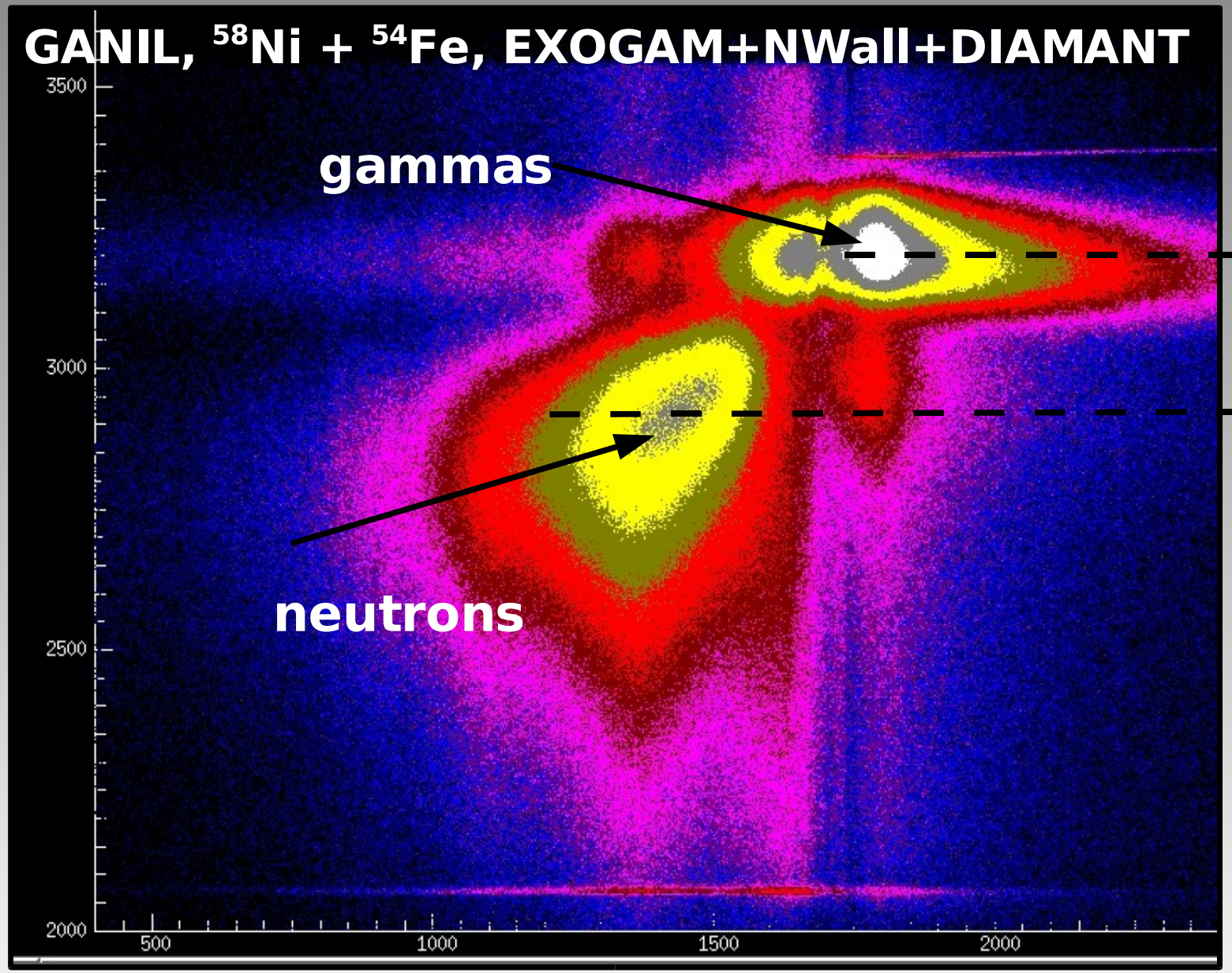


Neutron Wall

- 1π, liquid scintillator
- 50(or 45) detectors
- parameters: tof, zco, E
- ε_{abs} =0.15 (E_n=1.25 MeV)
- $\varepsilon_{fus\text{-}ev}$~0.27
- designed for EUROBALL currently located at GANIL
- used in 22 experiments with EUROBALL (Legnaro, Strasbourg) and 7 at GANIL (EXOGAM) (altogether 7 in the vicinity of ^{100}Sn)



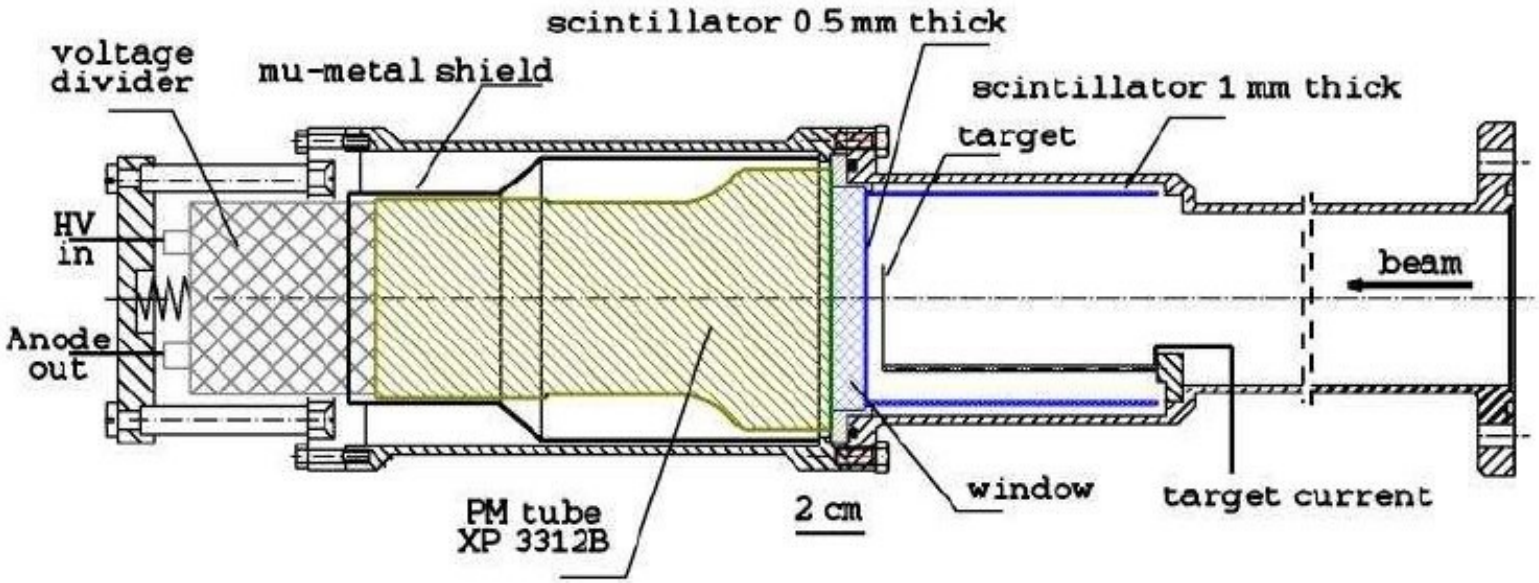
Discrimination n-γ



Charged particle detectors

- Select events in which a specific number of charged particles was emitted (in addition to neutrons)
- ISIS, EUCLIDES, DIAMANT: detection and identification of a few protons and α-particles
- In special situation a charged particle veto detector is sufficient (2n, 3n reaction channels) and more efficient

Charged particle veto detector CUP



built in Warsaw, used with EUROBALL aiming at:

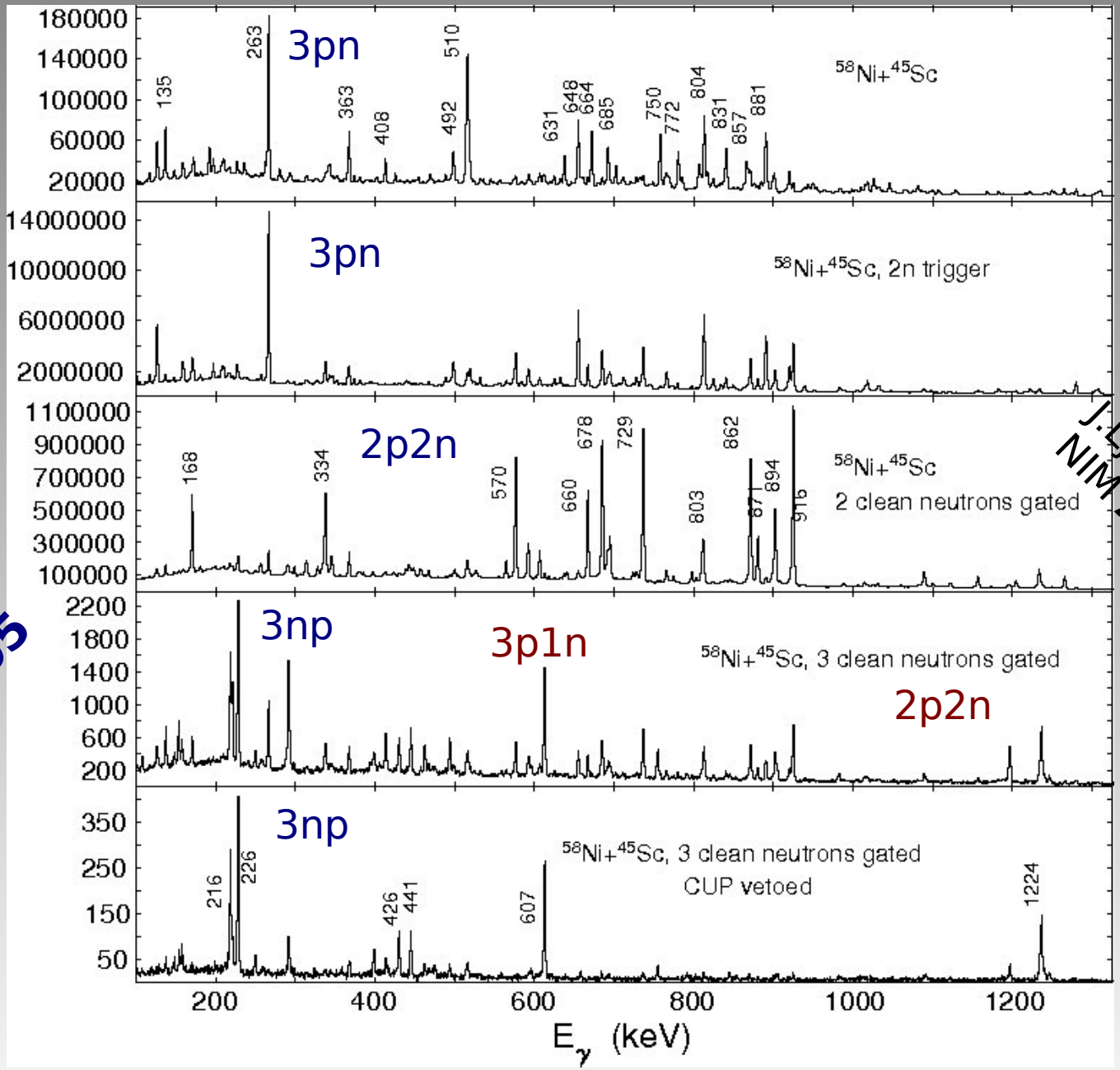
$^{58}Ni + ^{45}Sc \rightarrow ^{103}In\ (CN) \rightarrow ^{100}In + 3n$

$\varepsilon_p = 0.80 \quad \varepsilon_\alpha = 0.63$

M.Palacz et al NIM **A505** (2005) 414

3n gating and charged particle veto

EUROBALL+NWall+CUP



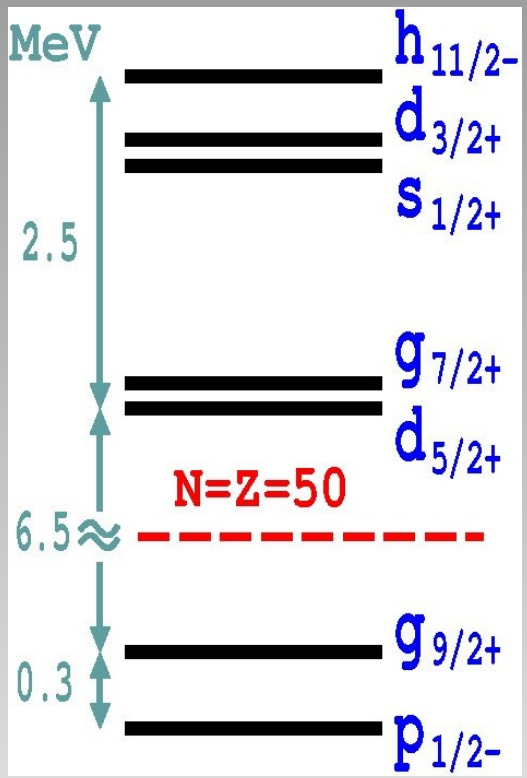
2n,3n discrimination:
J.Ljungval, M.Palacz,J.Nyberg
NIM **A528** (2004) 704

$\varepsilon_{3n} \approx 0.005$

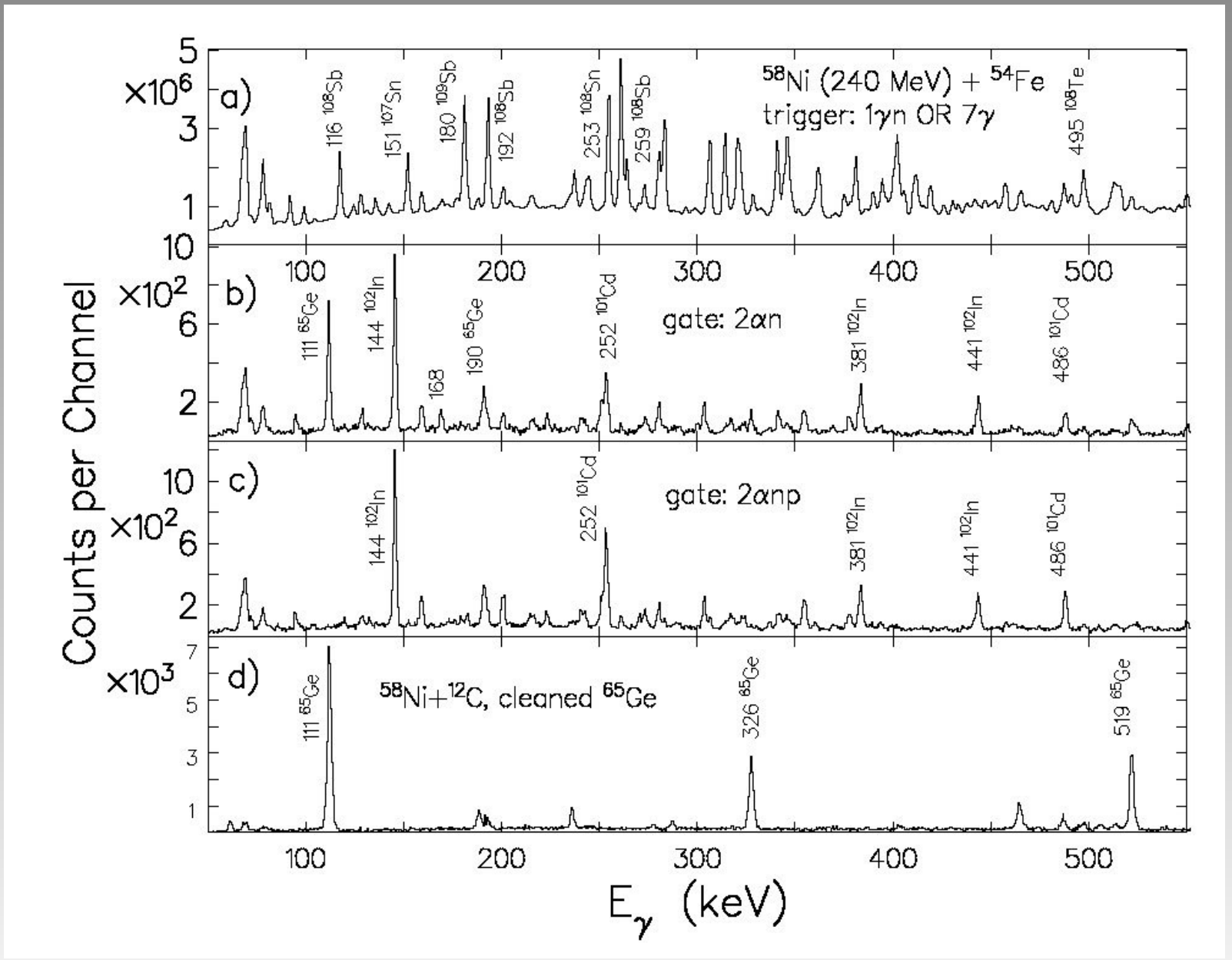
$\sigma_{100In} < 1\mu b$

Results: ^{103}Sn (1/3)

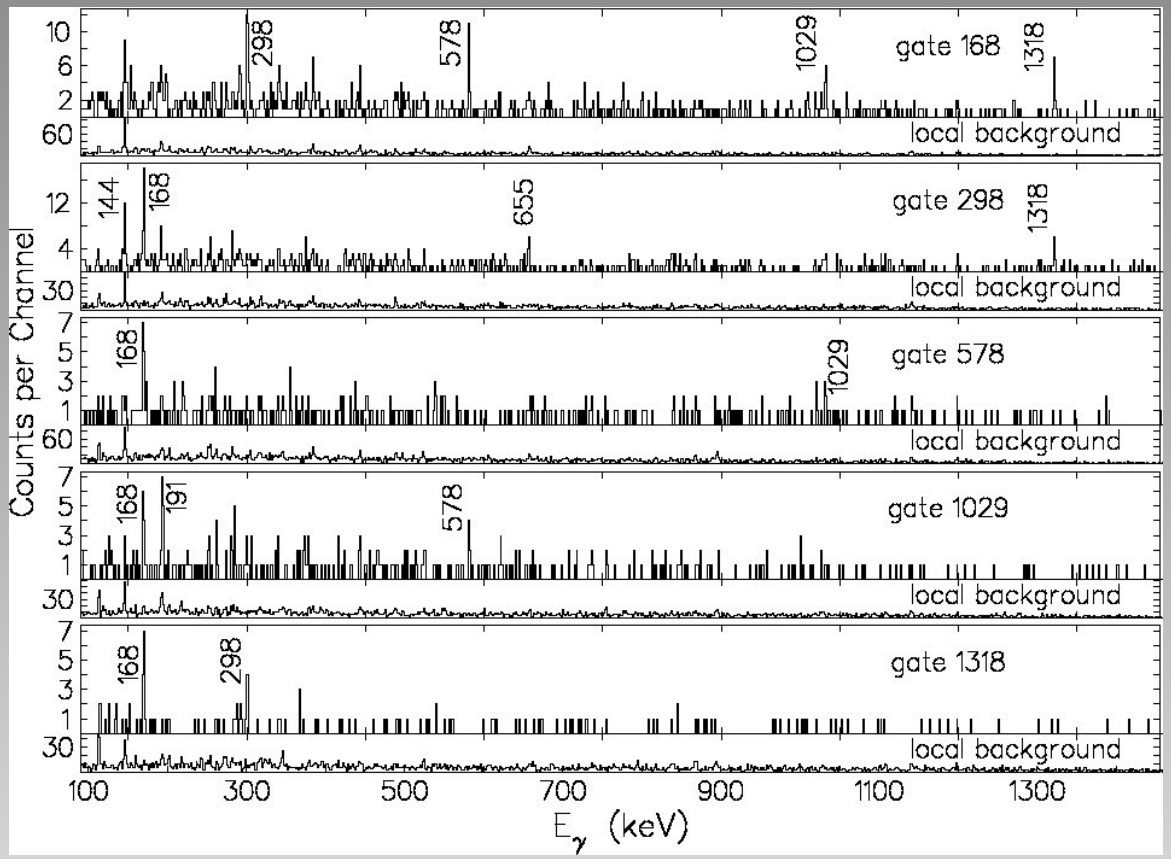
- As long as excited states in ^{101}Sn are not experimentally accessible, ^{103}Sn provides the best possible experimental information on neutron SPE
- EUROBALL+NWall+ISIS
- ^{58}Ni+^{54}Fe → ^{112}Xe (CN) → ^{103}Sn + 2αn

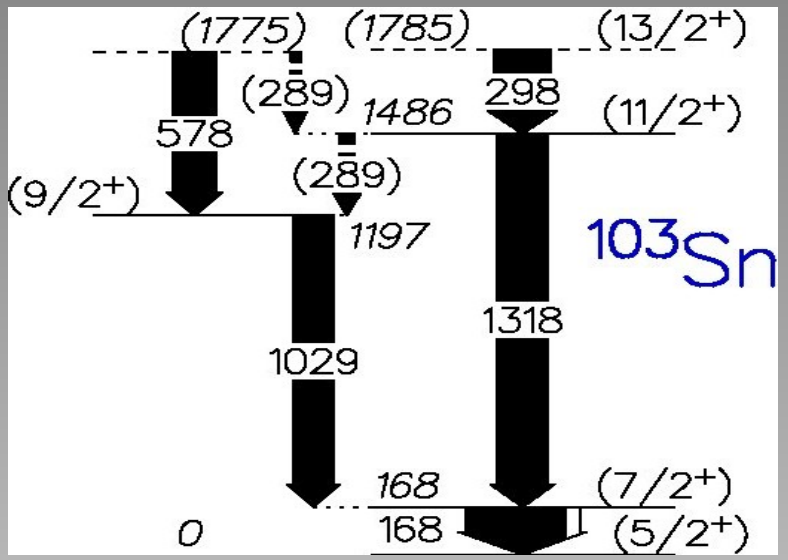


Results: ^{103}Sn (2/3)



Results: ^{103}Sn (3/3)





E_γ (keV)	I_γ	R
168.0 ± 0.1	100.0 ± 7.4	0.62 ± 0.07
289.0 ± 0.2	35.4 ± 6.9	
298.4 ± 0.1	53.9 ± 7.5	0.57 ± 0.12
578.2 ± 0.2	41.2 ± 7.3	0.99 ± 0.32
1029.0 ± 1.0	40 ± 23	
1318.2 ± 0.3	50.4 ± 9.4	1.07 ± 0.30

quadrupole: $R = 0.97$

dipole: $R = 0.60$

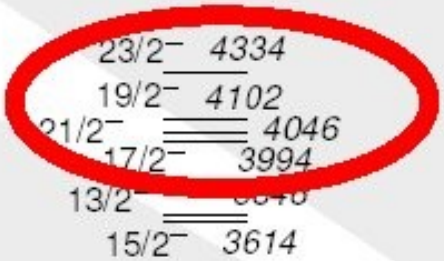
$$\varepsilon(g_{7/2}) - \varepsilon(d_{5/2}) = 110 \pm 40 \text{ keV}$$

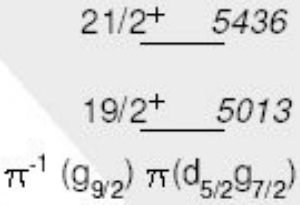
C.Fahlander et al. Phys. Rev. **C63** 021307(R) 2001

^{103}Sn – next step (at GANIL)

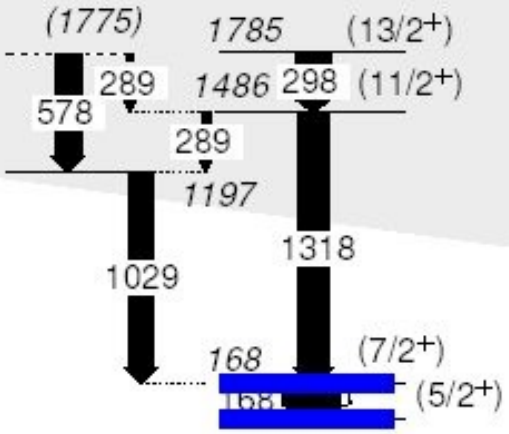
J. Blomqvist, SM calculations
$\nu(d_{5/2}g_{7/2}d_{3/2}s_{1/2}h_{11/2})$
empirical interactions

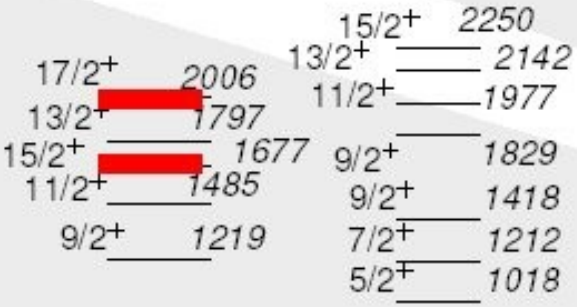
$\epsilon(g_{7/2} - d_{5/2})$
main uncertainity:
$J^{\pi} = 0^{+}$
interactions

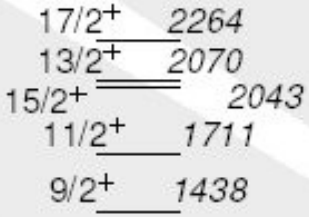


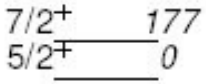


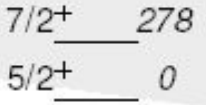
F. Nowacki
$\pi\nu(g_{9/2}d_{5/2}g_{7/2}d_{3/2}s_{1/2})$
up to 3 ph excitattions





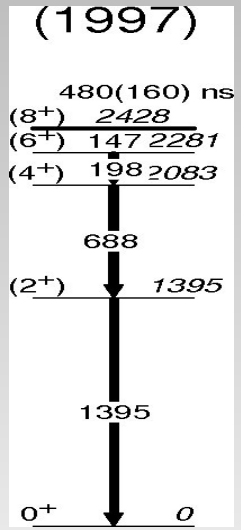


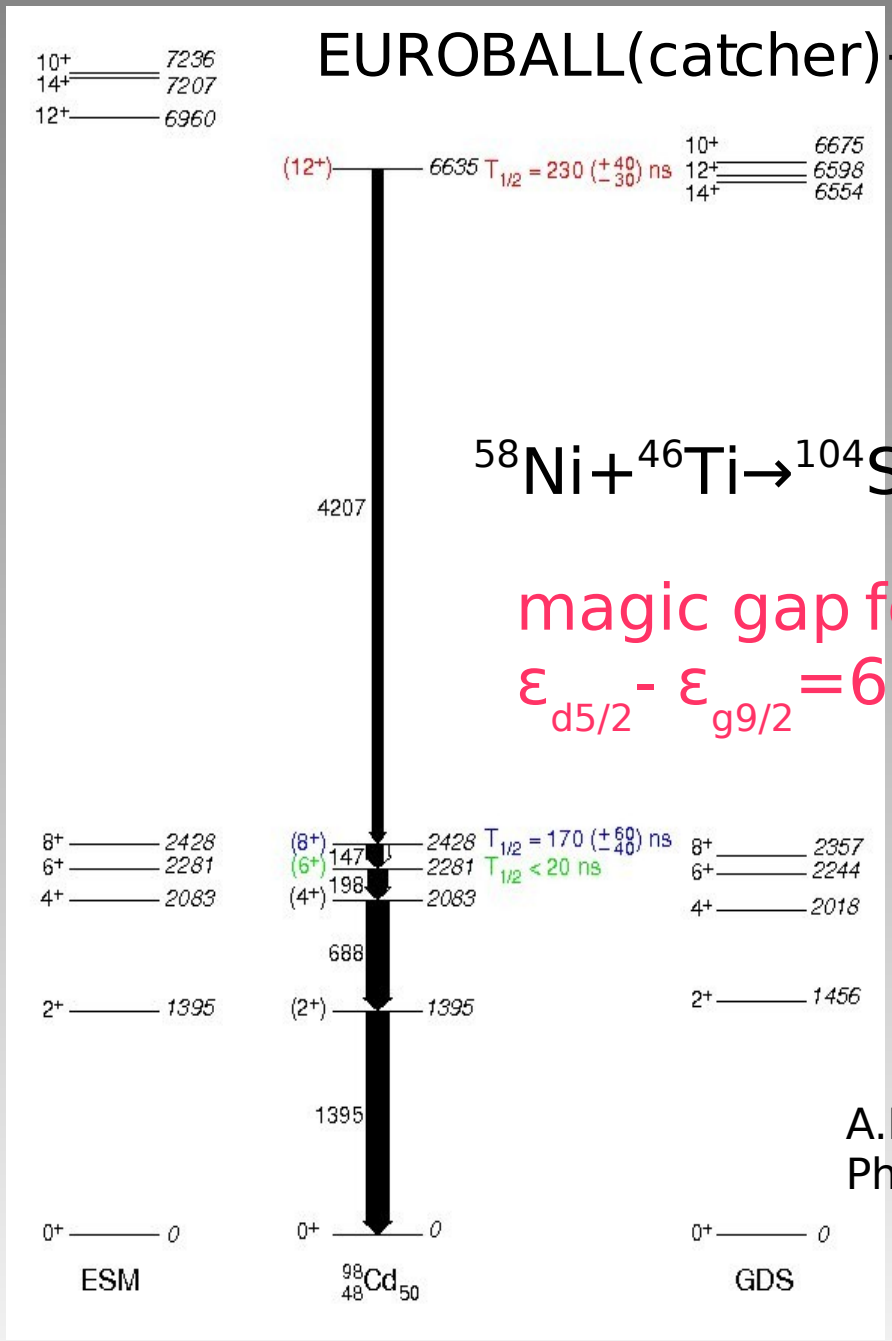




Results: ^{98}Cd

EUROBALL(catcher)+NWall+EUCLIDES





$^{58}Ni+^{46}Ti \rightarrow ^{104}Sn(CN) \rightarrow ^{98}Cd+\alpha 2n$

magic gap for N=50

$\varepsilon_{d5/2} - \varepsilon_{g9/2} = 6.46(15)$ MeV

A.Blazhev et al.
Phys. Rev **C69**,064304(2004)

Future plans

- GANIL/SPIRAL: NWall, EXOGAM (AGATA demonstrator), DIAMANT,...
- Main aim: determining SPE and nn-interactions
- Flagship of the experimental program: ^{101}Sn

Reaction	Beam intensity (pps)
^{58}Ni+^{46}Ti → ^{101}Sn + 3n	~1x10^{12} pps (100 pnA)
^{57}Ni+^{46}Ti → ^{101}Sn + 2n	>1x10^{9} pps
^{56}Ni+^{54}Fe → ^{101}Sn + 2αn	>1x10^{8}pps

  In the „meantime”: ^{103}Sn, ^{100}In, ^{96}Ag, ^{97}Cd,^{96}Cd,...

- Detector developments: improving neutron and charged particle (veto) detection

Principal collaborators

- Warsaw: J.Kownacki
  J.Iwanicki, G.Jaworski, P.J.Napiorkowski, L.Pieńkowski, M.Wolińska, K.Wrzosek, M.Zielińska
- Uppsala: J.Nyberg
- GSI: M. Górska, H. Grawe, A.Blazhev
- Stockholm: J.Blomqvist, B.Cederwall, L.-O. Norlin, K.Lagergren
- Lund: C.Fahlander, D.Rudolph
- Legnaro: G. De Angelis, A.Gadea, E.Farnea (ISIS, EUCLIDES)
- Świerk: M. Moszyński, D.Wolski
- Debrecen: D.Sohler, Zs.Dombradi, B.Nyako (DIAMANT)
- Strasbourg: O.Dorvaux
- Kraków: P.Bednarczyk, M.Zięblíński
- GANIL: G. de France
- LNL, IreS and GANIL staff
- HIL staff (CUP design and construction)