KU LEUVEN

Characterization of the low-lying 0^+ and 2^+ states of ^{68}Ni

BriX

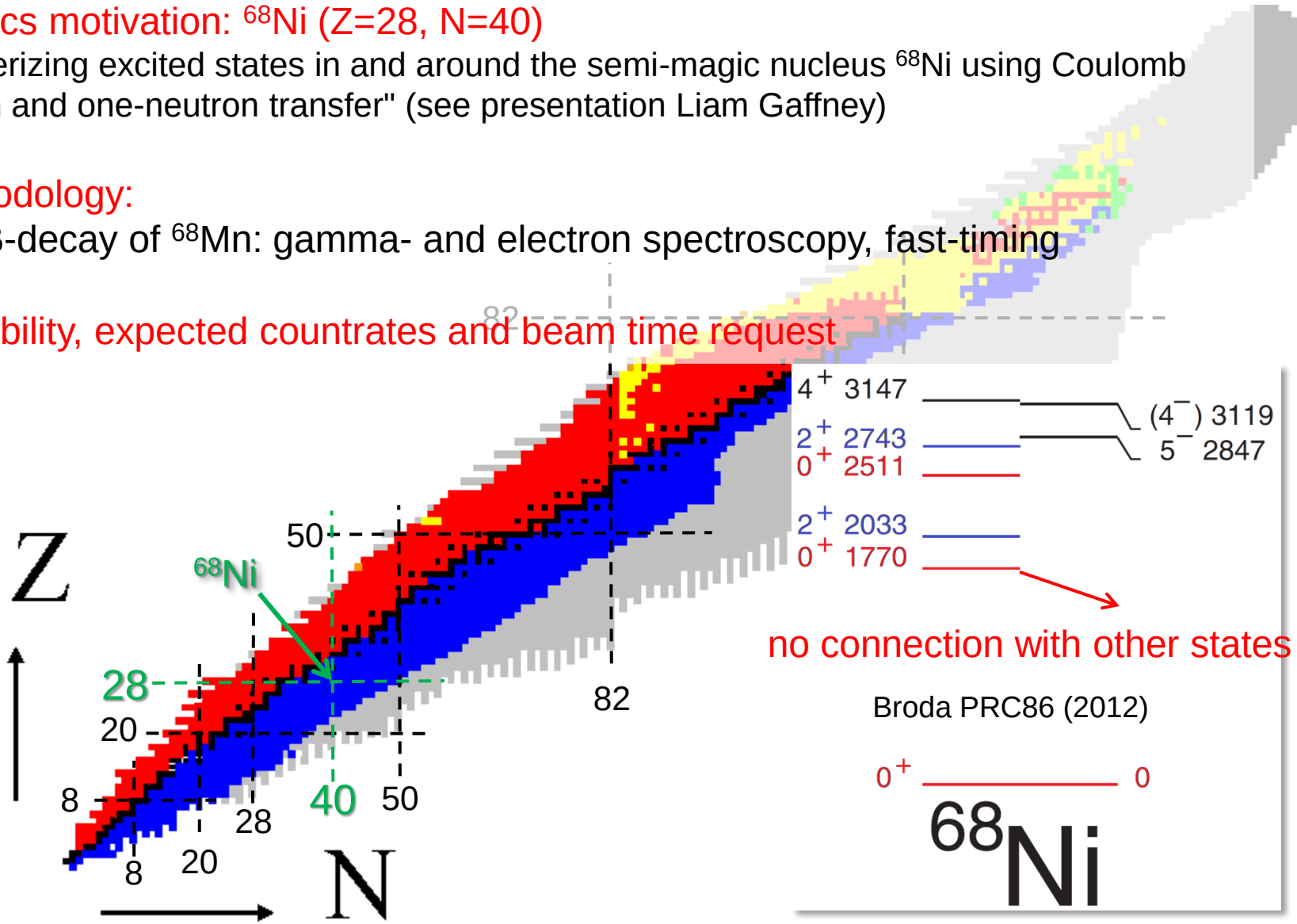
spokesperson: Ch. Sotty (KU Leuven), L.M. Fraile (Madrid)
and the IDS collaboration

- Physics motivation: ^{68}Ni (Z=28, N=40)

"Characterizing excited states in and around the semi-magic nucleus ^{68}Ni using Coulomb excitation and one-neutron transfer" (see presentation Liam Gaffney)

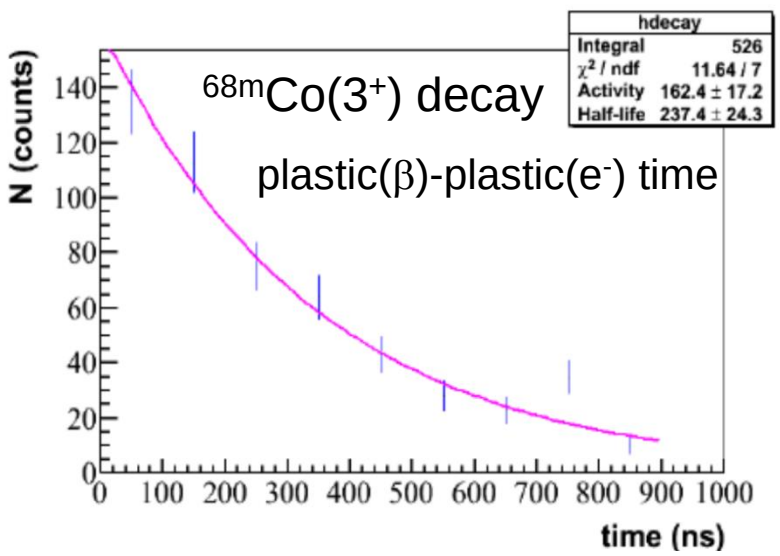
- Methodology:
  - β-decay of ^{68}Mn: gamma- and electron spectroscopy, fast-timing

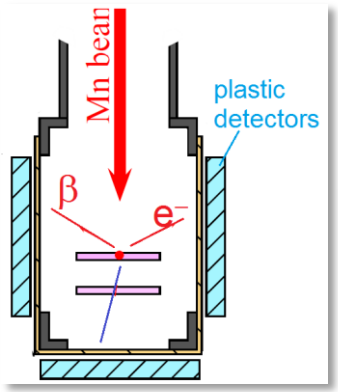
- Feasibility, expected countrates and beam time request

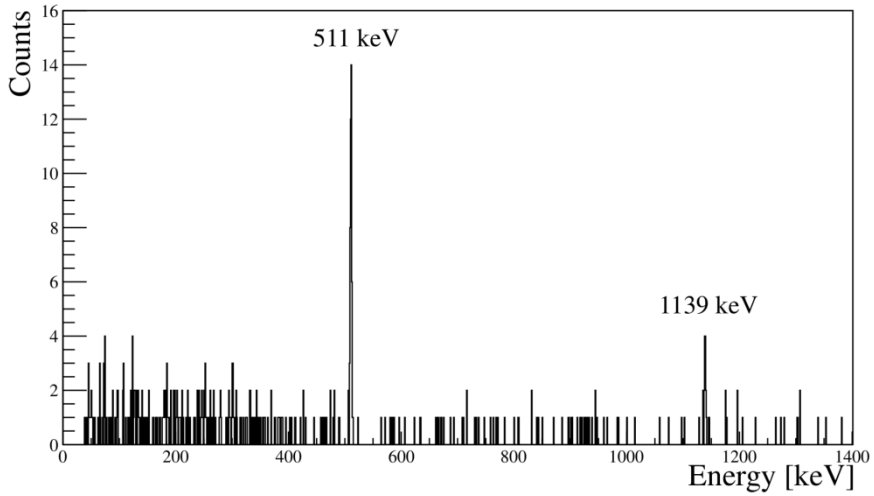


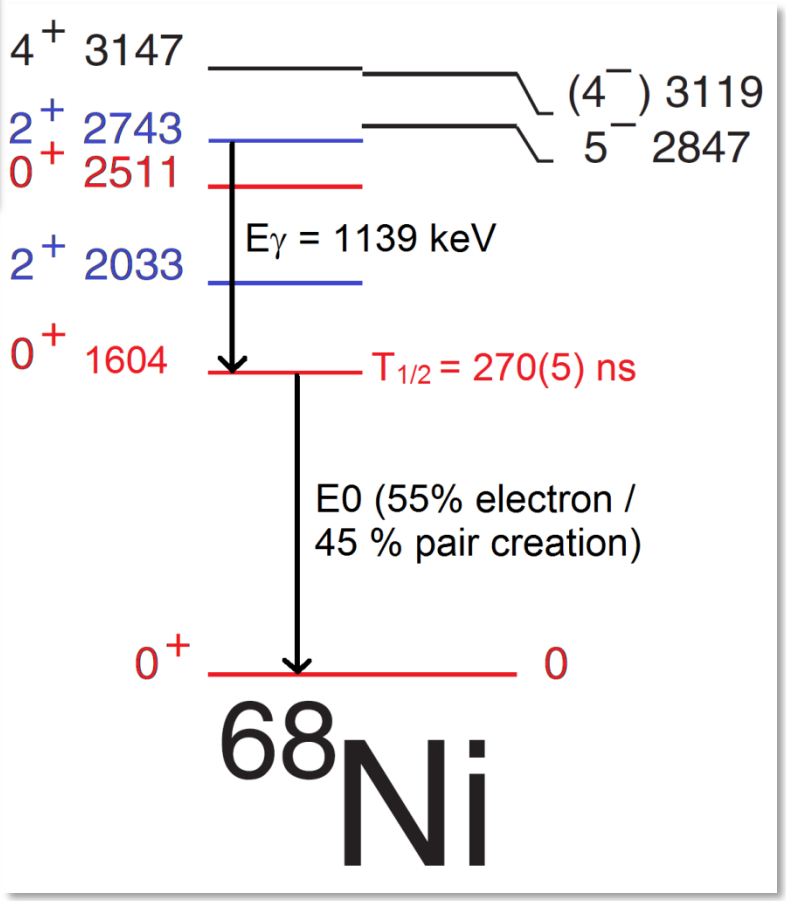
Physics motivation: ^{68}Ni (Z=28, N=40)

- Recent studies of ^{68}Ni:
  - fix position of the 0^+_2 state ^{68}Ni at 1603 keV (instead of 1770 keV)
    MSU-NSCL (Recchia, PRC (2013)) and ISOLDE (IS467)
  - firmly identified 0^+ and 2^+ states (Broda PRC86 (2012), Mueller PRC61 (2000))

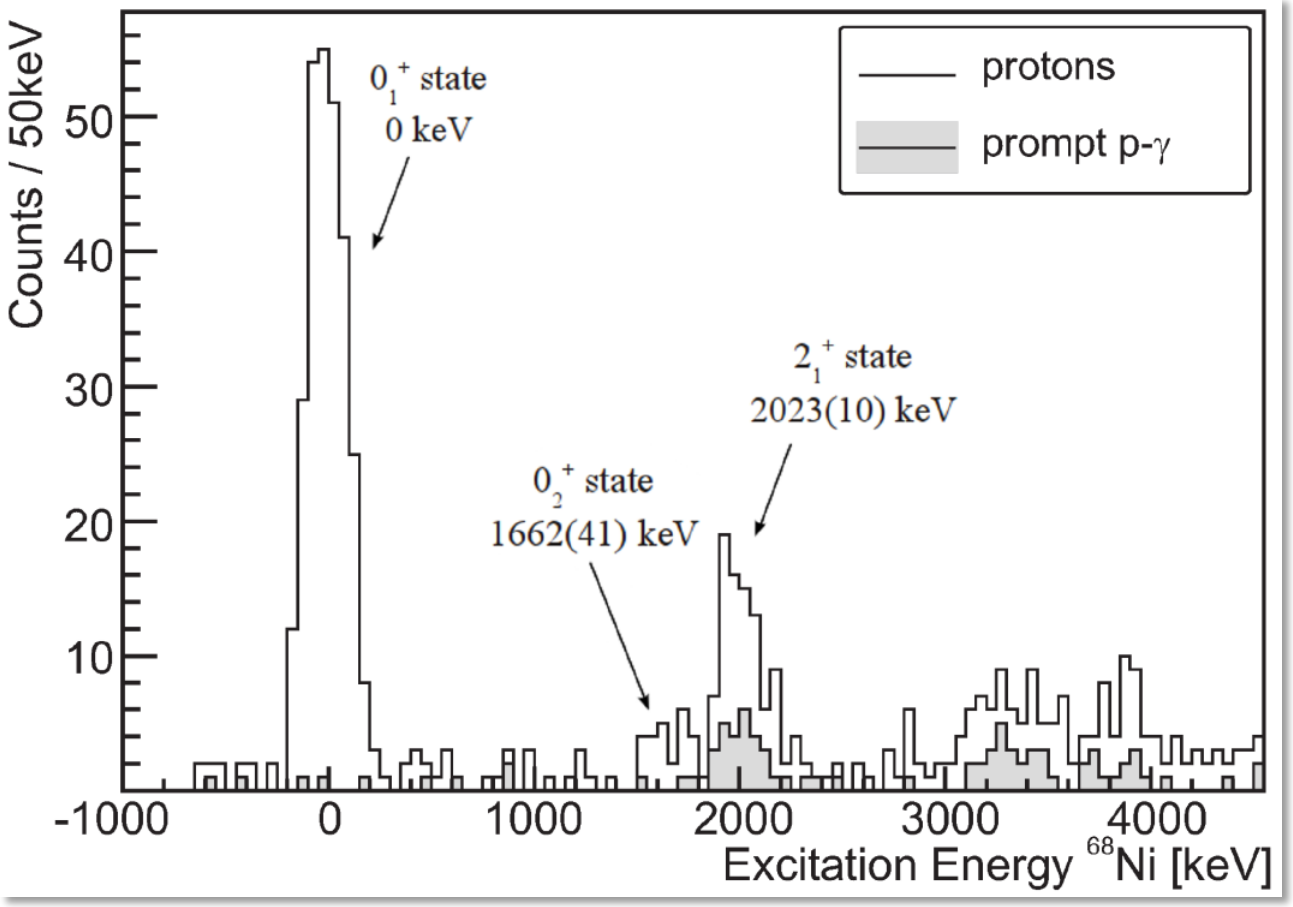


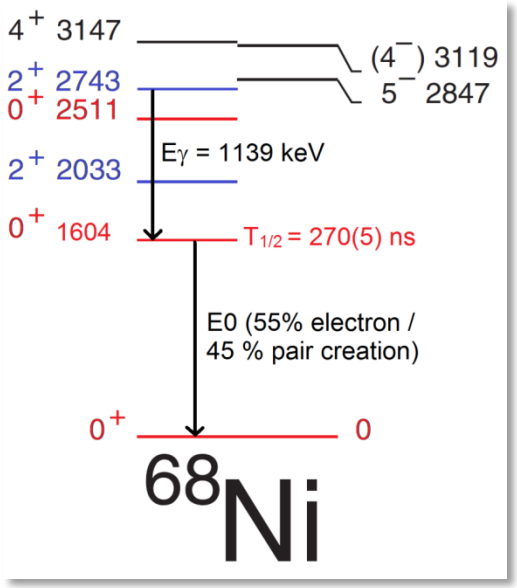






^{66}Ni(t,p)^{68}Ni (IS504 - Elseviers 2013)





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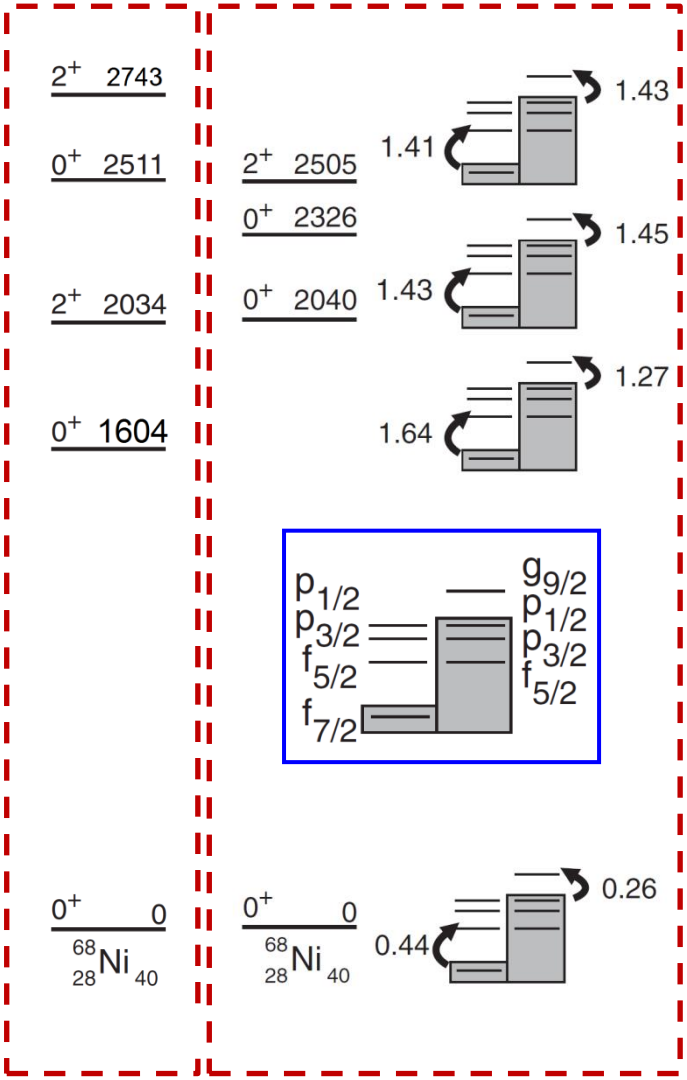
Shell model calculations



Liddick PRC87 (2013)

π pf - ν pfg$_{9/2}$ (^{48}Ca core)

"dominant proton configuration has exactly two $f_{7/2}$ protons less than the ground state"

0+ 2400

0+ 1140

"The 0^+_1 and 0^+_2 states "are characterized by "similar proton occupancies with leading 0p-0h (neutron) configuration for the 0^+_1 ground state and 2p-2h (neutron) configurations for the 0^+_2."

0+ 0

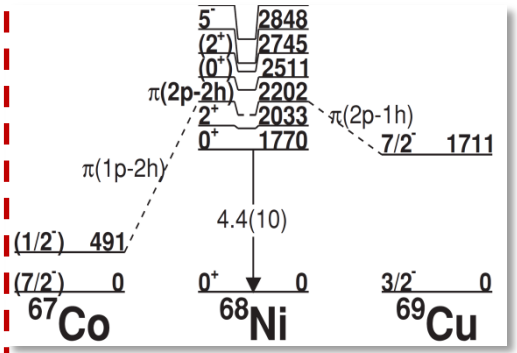
^{68}Ni$_{40}$

Lenzi PRC82 (2010)

π pf - ν pfg$_{9/2}$d$_{5/2}$ (^{48}Ca core)

0+ 2202

π(2p-2h)

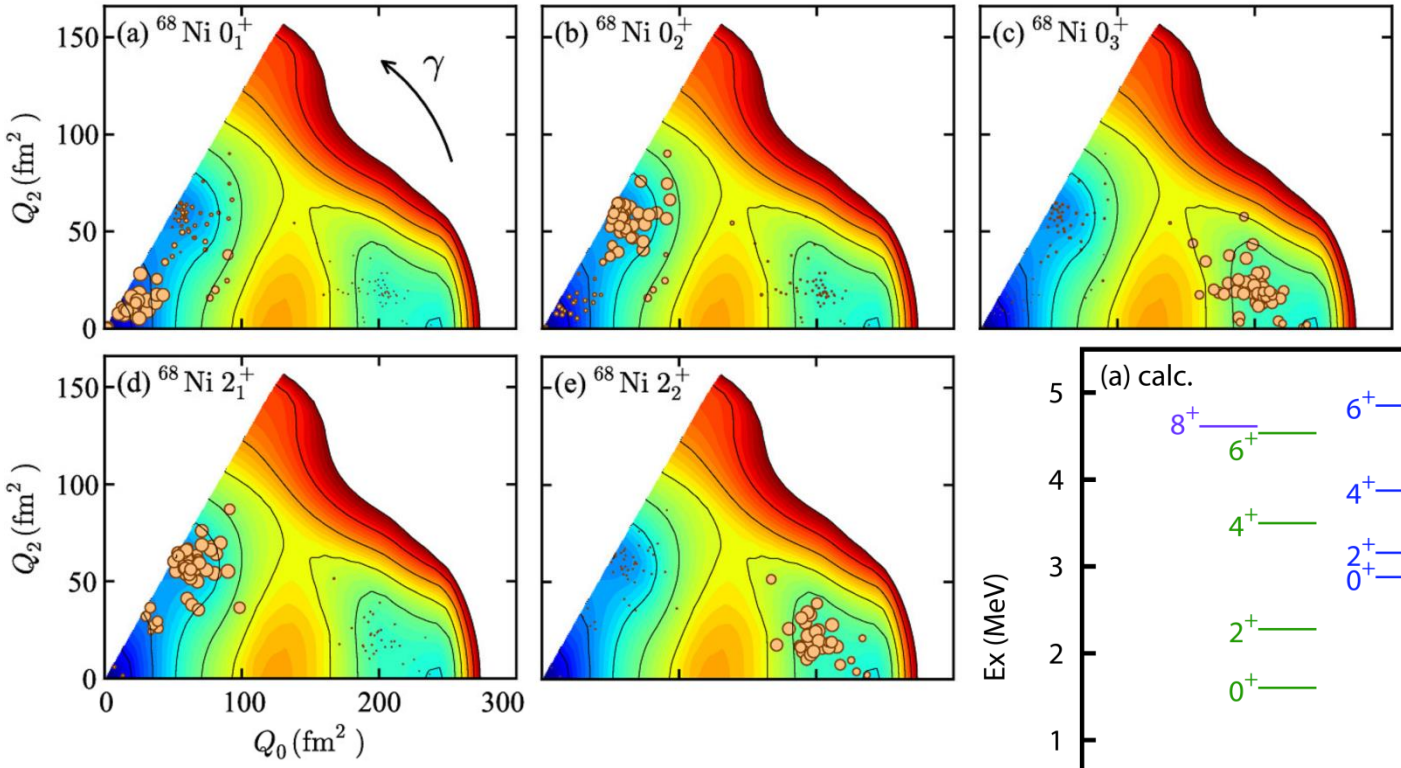


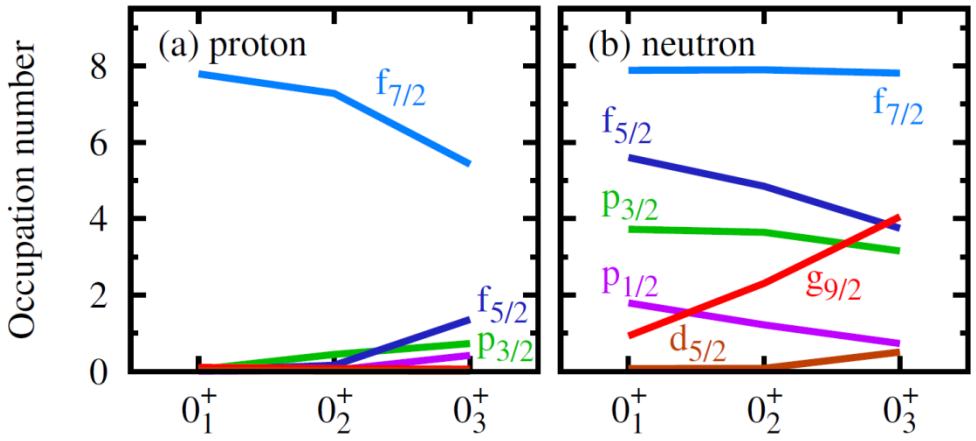
0+ 0

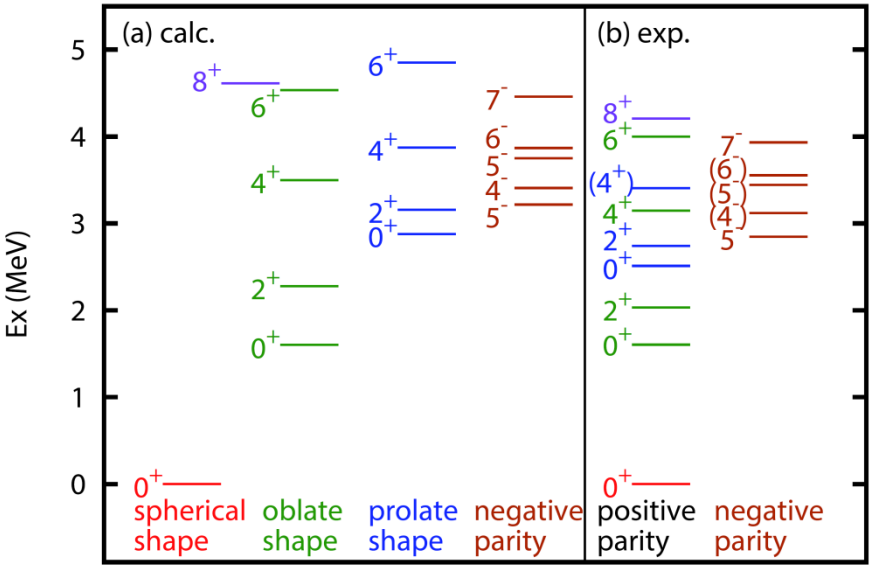
^{68}Ni$_{40}$

Pauwels PRC82 (2010)

Monte Carlo Shell Model calculations: pf $g_{9/2}$ $d_{5/2}$ shell





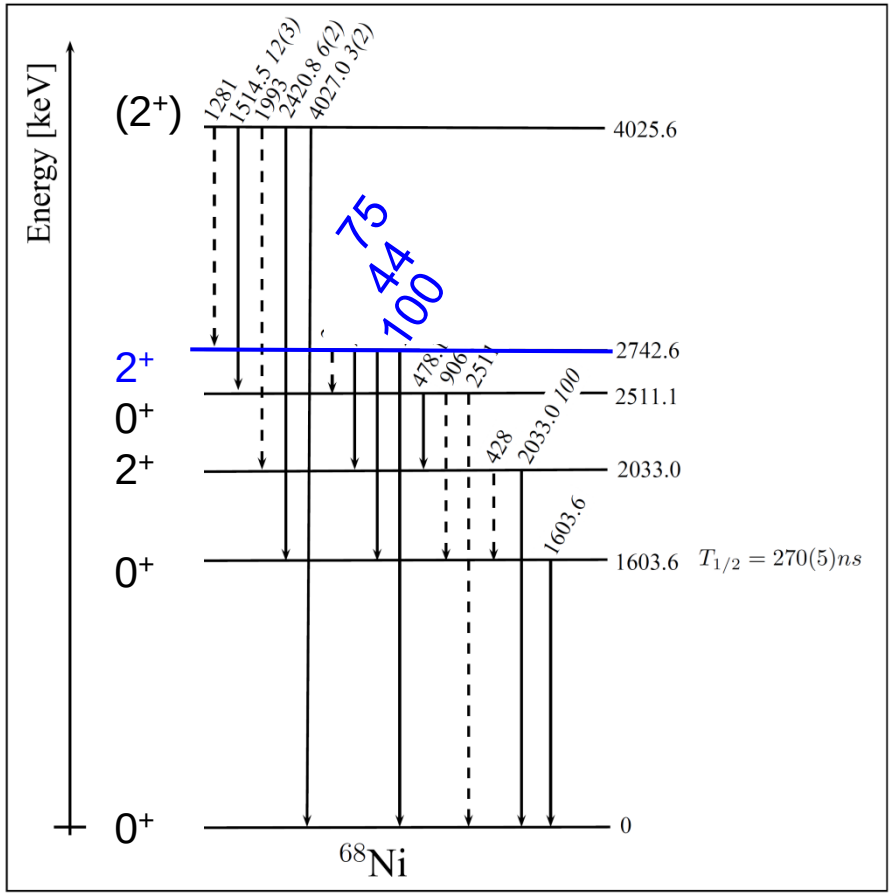


"… shell evolution inside the same nucleus occurs…. and results in remarkable shape coexistence…"

Tsunoda JPG (2013), [nucl-th] 1309.5851v1 (2013)

Physics motivation: ^{68}Ni (Z=28, N=40)

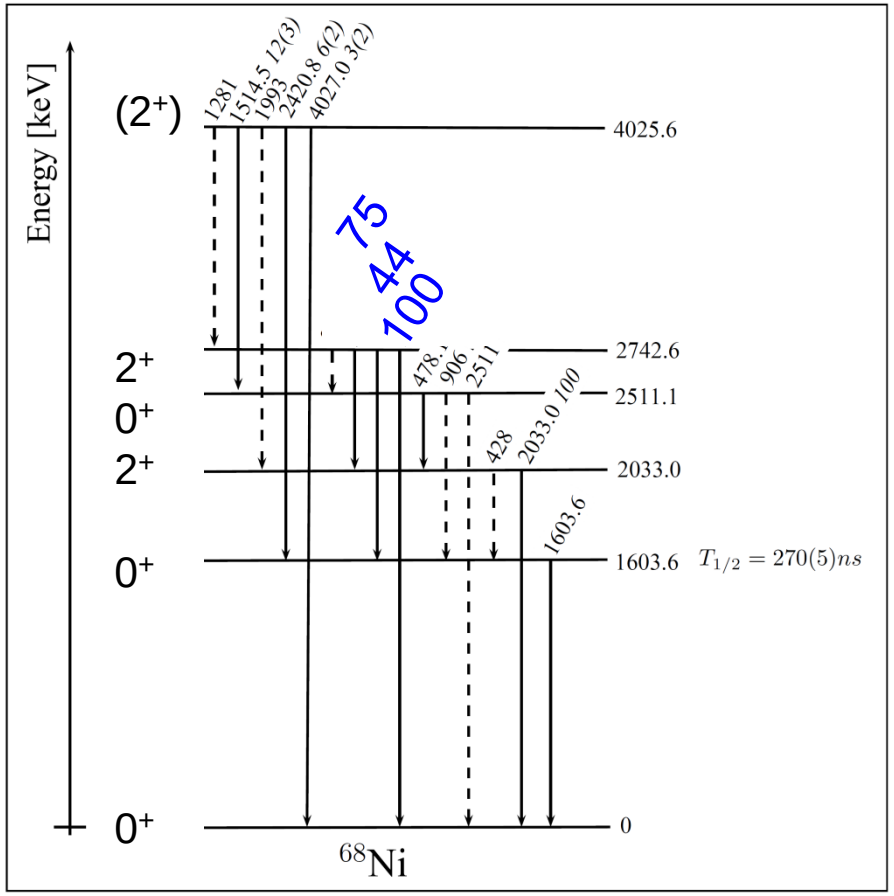
- Aim:
  - obtain precise gamma- and electron transition intensities between the 0^+ and 2^+ states (also important for the Coulomb excitation experiment - see L. Gaffney)

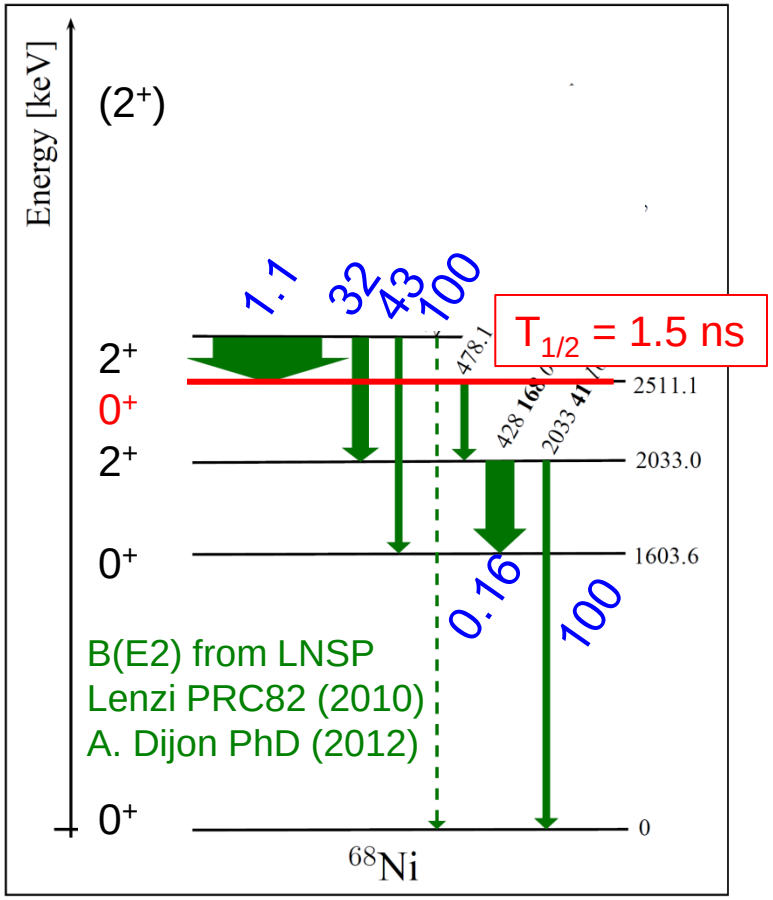


Mueller PRC (2000), Flavigny (2013, IS467)

Physics motivation: ^{68}Ni (Z=28, N=40)

- Aim:
  - obtain precise gamma- and electron transition intensities between the 0^+ and 2^+ states (also important for the Coulomb excitation experiment - see L. Gaffney)
  - life time measurement of the 0^+_2 state at 2511 keV



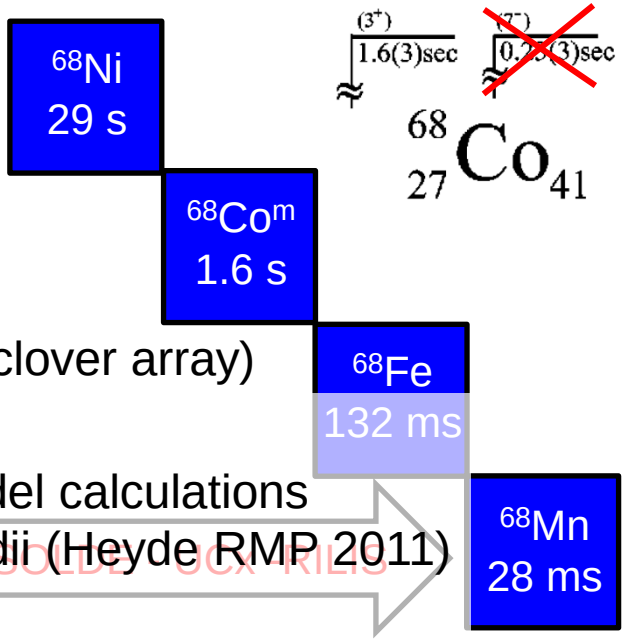


Mueller PRC (2000), Flavigny (2013, IS467)

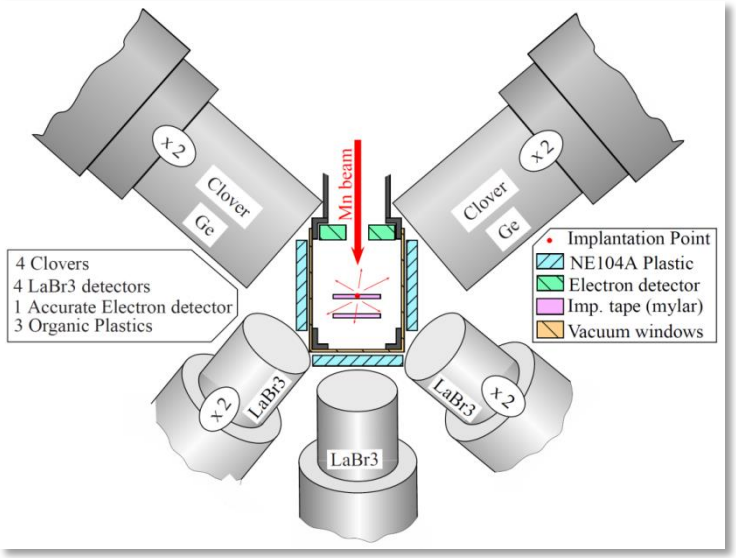
Methodology: β decay of ^{68}Co (low-spin isomer)

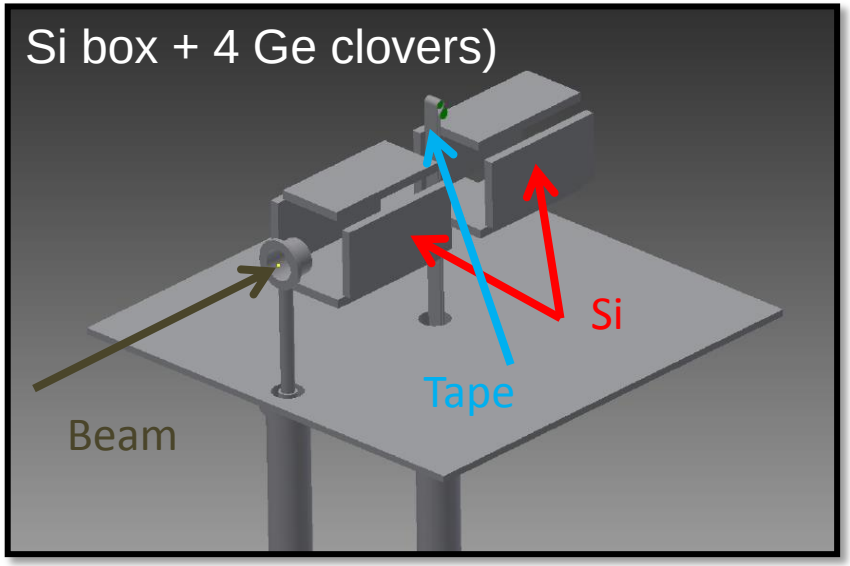
- ^{68}Mn - ^{68}Fe(0^+) - ^{68}Co (low spin 1^+-3^+)
  - UCx target - RILIS (Mn)

  (NanoUCx, microgating, n-convertor)
- ISOLDE Decay Station (IDS)
  - Life-time measurements (LaBr3 - 4 x Ge clovers)
  - Gamma- and electron spectroscopy (Si box - Ge clover array)
- Expected results:
  - Absolute/relative B(E2) values: compare with model calculations
  - ρ(E0:0^+_3-0^+_1)): mixing and difference in charge radii (Heyde RMP 2011)



$$\rho^2(E0) = \frac{Z^2}{R_0^4} a^2(1-a^2)[\Delta\langle r^2\rangle]^2$$





Rates and Beam Time Request

- Yield (^{68}Mn): 4 μC^{-1} (cf. 2 μC^{-1} at the end of IS467 run)
- Transport - βdn -> 5.5 pps of ^{68}Mn

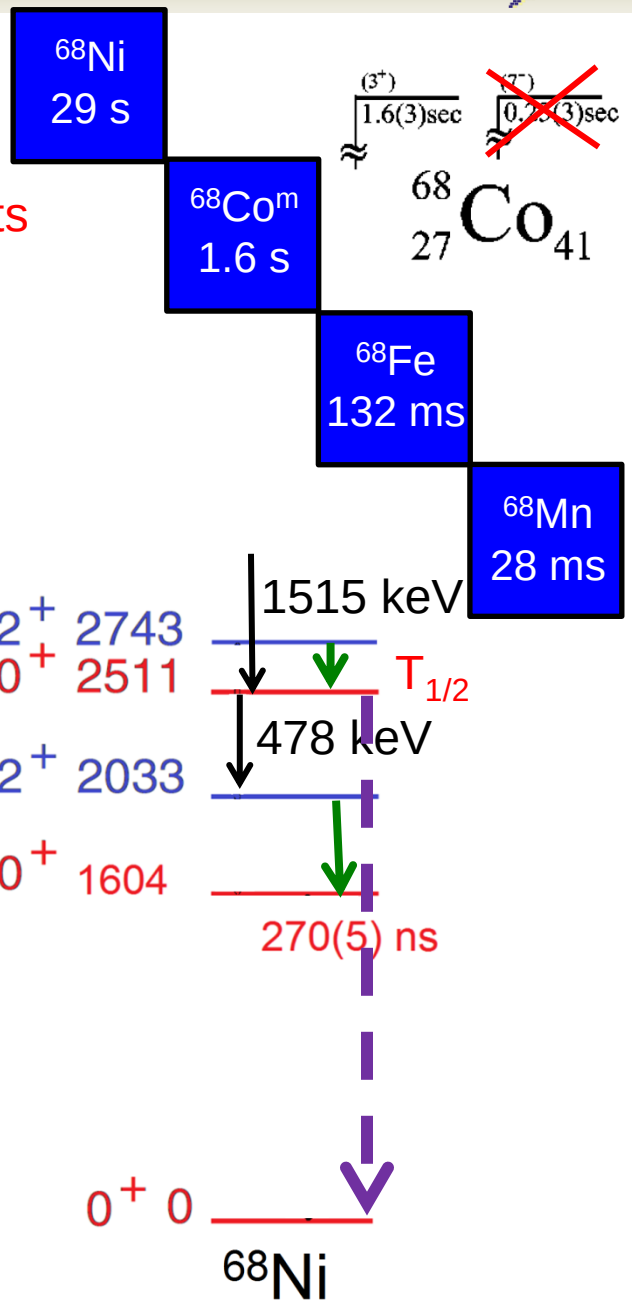
- Life timing measurement of the 0^+_3 state: 14(2+12) shifts
  - Efficiency of $LaBr_3$ detectors at 478 keV: 2.6%
  - Efficiency beta detectors: 60%
  - Ge eff. for 1515 keV detection: 1.96 %

  β–γ($LaBr_3$): 2663 counts/experiment
  β–γ(Ge)–γ($LaBr_3$): 40 counts/experiment

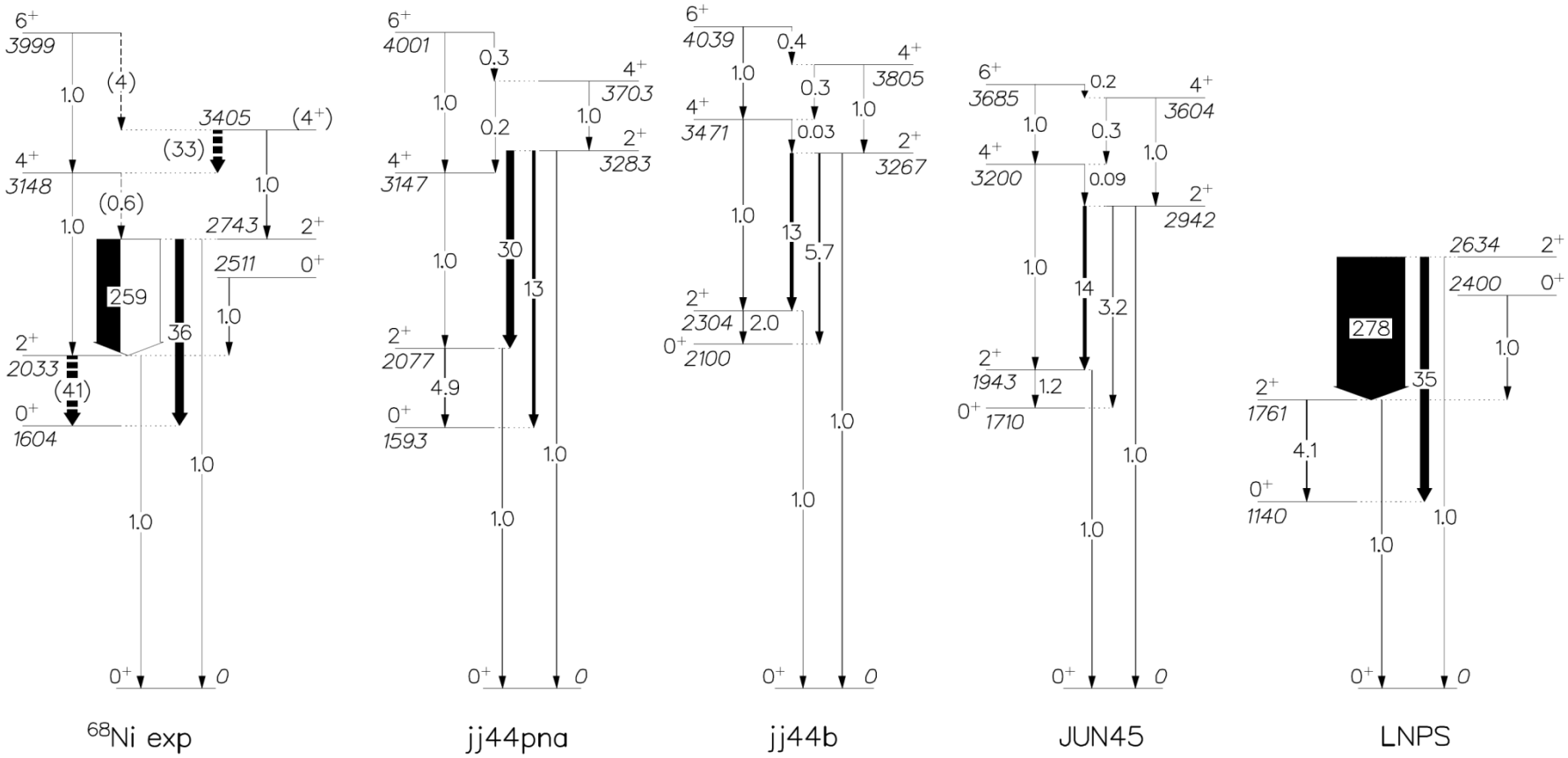
- γ and electron spectroscopy: 14(2+12) shifts
  - Ge eff. for 2033 keV detection: 3.4 %
  - β/electron efficiency: 60%

  β – γ(2033): 26600 counts/experiment
  → Iγ (limit) < 0.1% (delayed E0(0^+_1-0^+_2) coinc.)
  β – (e+-e-2.5 MeV pair) – γ(511): 43 counts (0^+_3-0^+_1)

- Summarizing the request:
  - 2+2 shift beam preparation
  - 12+12 shift measurement
  - In total 28 shifts



Recchia PRC (2013)



Lenzi PRC82 (2010)

protons pf and neutron pfg9/2d5/2 (48Ca core)