

Study of shell evolution in the Ni isotopes via one-neutron transfer reaction in ^{70}Ni .

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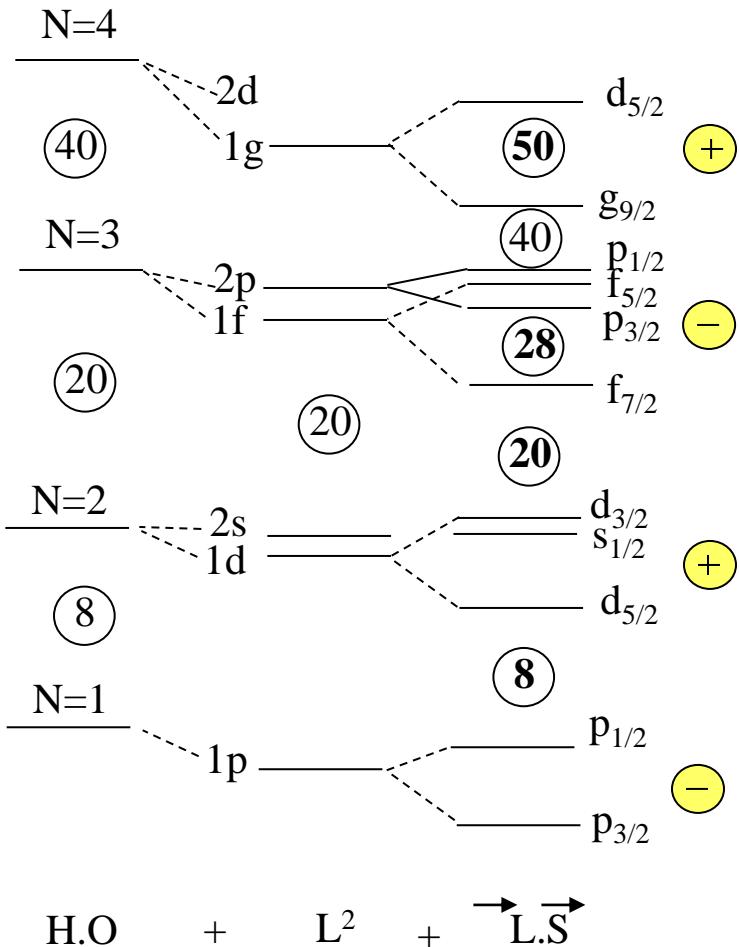
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Daniele Mengoni (Padova University, Italy)

Overview

- Scientific motivation
- Experimental details
- Beam time request

The “spin-orbit” magic numbers



Reduction of N=50 gap by tensor force $\pi f_{5/2}-\nu g$
Behaviour of ^{78}Ni ?

Reduction of N=28 gap by tensor force $\pi d_{3/2}-\nu f$
strongly deformed ^{42}Si

Reduction of N=20 triggered by $\pi d_{5/2}-\nu d_{3/2}$
Island of inversion, large collectivity

N=8 collapses at ^{12}Be
Triggered by the $\pi p_{3/2}-\nu p_{1/2}$ interaction

Tensor interaction

Systematic variation of effective single-particle energies due to the tensor interaction

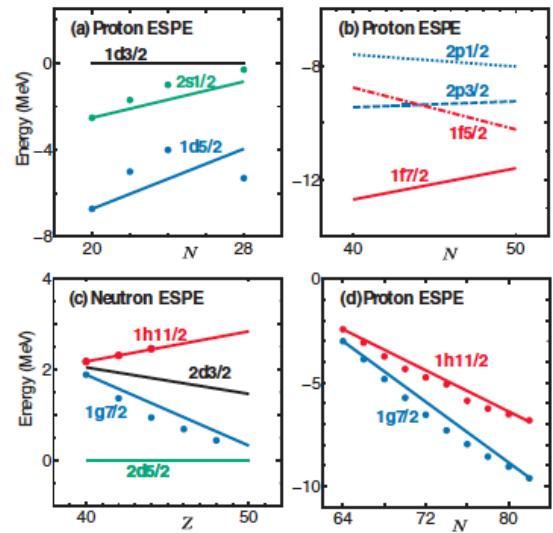
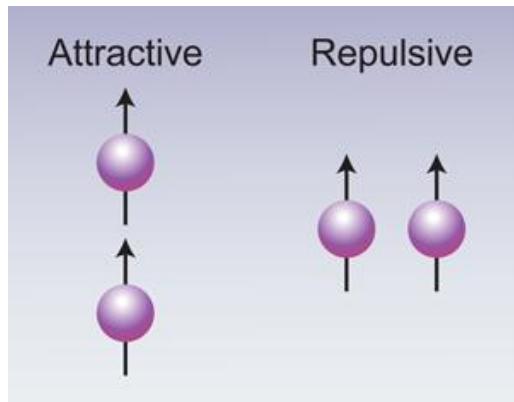
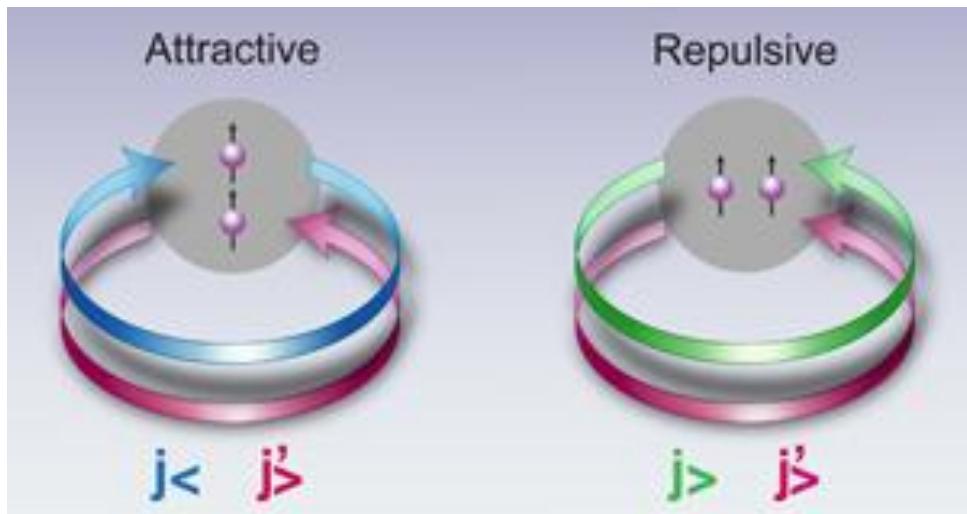
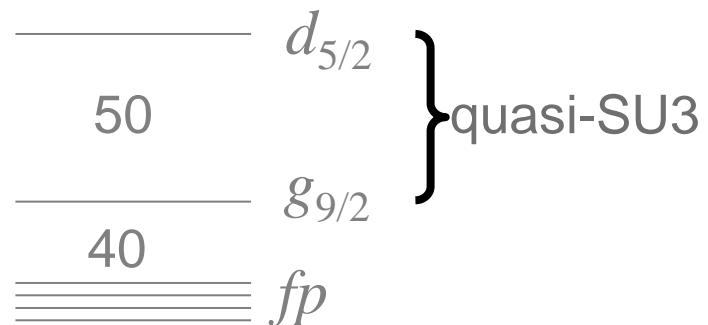
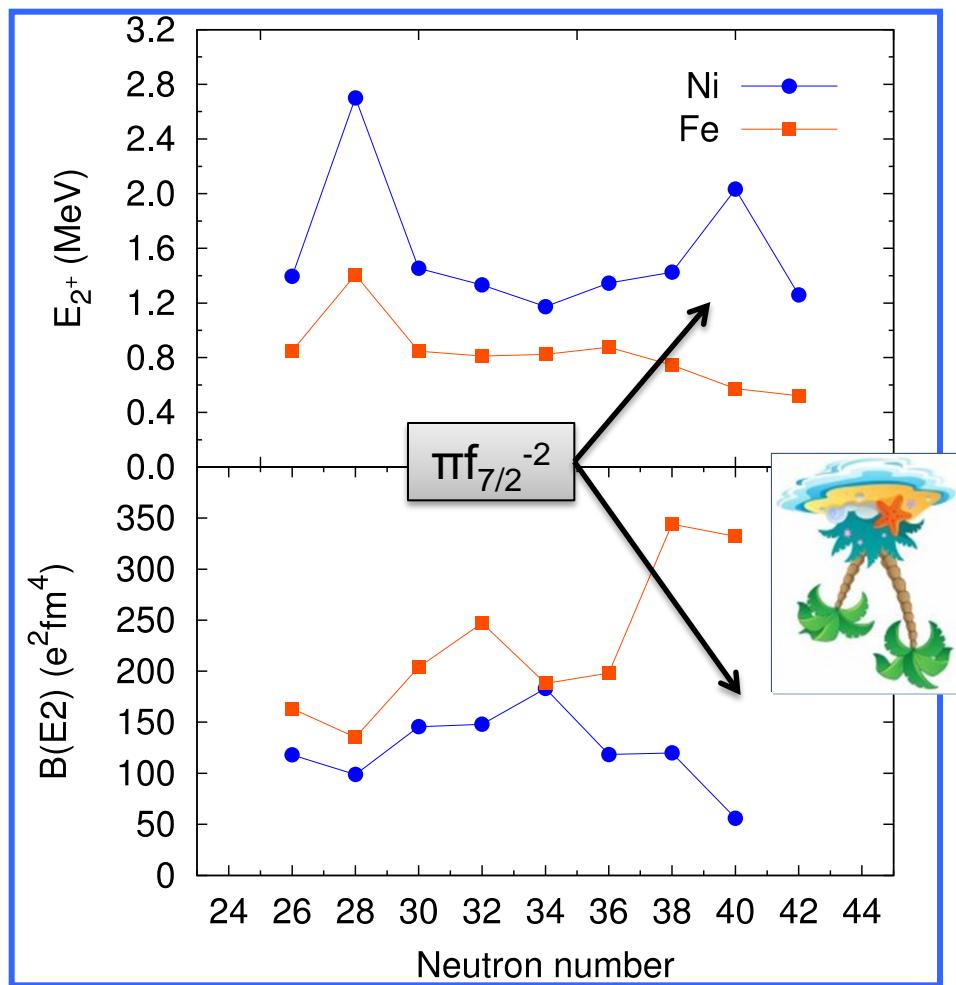


FIG. 4 (color). Proton (neutron) ESPE as a function of N (Z). Lines in (a)–(c) show the change of ESPE's calculated from the $\pi + \rho$ tensor force. Points represent the corresponding experimental data. (a) Proton ESPE's in Ca isotopes relative to $1d_{3/2}$. Points are from [13]. (b) Proton ESPE's in Ni isotopes; calculations only. See [19] for related experimental data. (c) Neutron ESPE's in $N = 51$ isotones relative to $2d_{5/2}$; points are from [21]. (d) Proton ESPE's in Sb isotopes; points are from [18]. Lines include a common shift of ESPE as well as the tensor effect (see the text).

$$V_T = (\tau_1 \tau_2) ([\sigma_1 \sigma_2]^{(2)} Y^{(2)}(\Omega)) Z(r)$$

New island of inversion: $g_{9/2}$ - $d_{5/2}$



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Spherical shell model description of rotational motion

A. P. Zuker,¹ J. Retamosa,² A. Poves,² and E. Caurier¹

ANSWER

OCTOBER 1995

Quasi-SU3

PHYSICAL REVIEW C 82, 054301 (2010)

Island of inversion around ^{64}Cr

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LNPS interaction

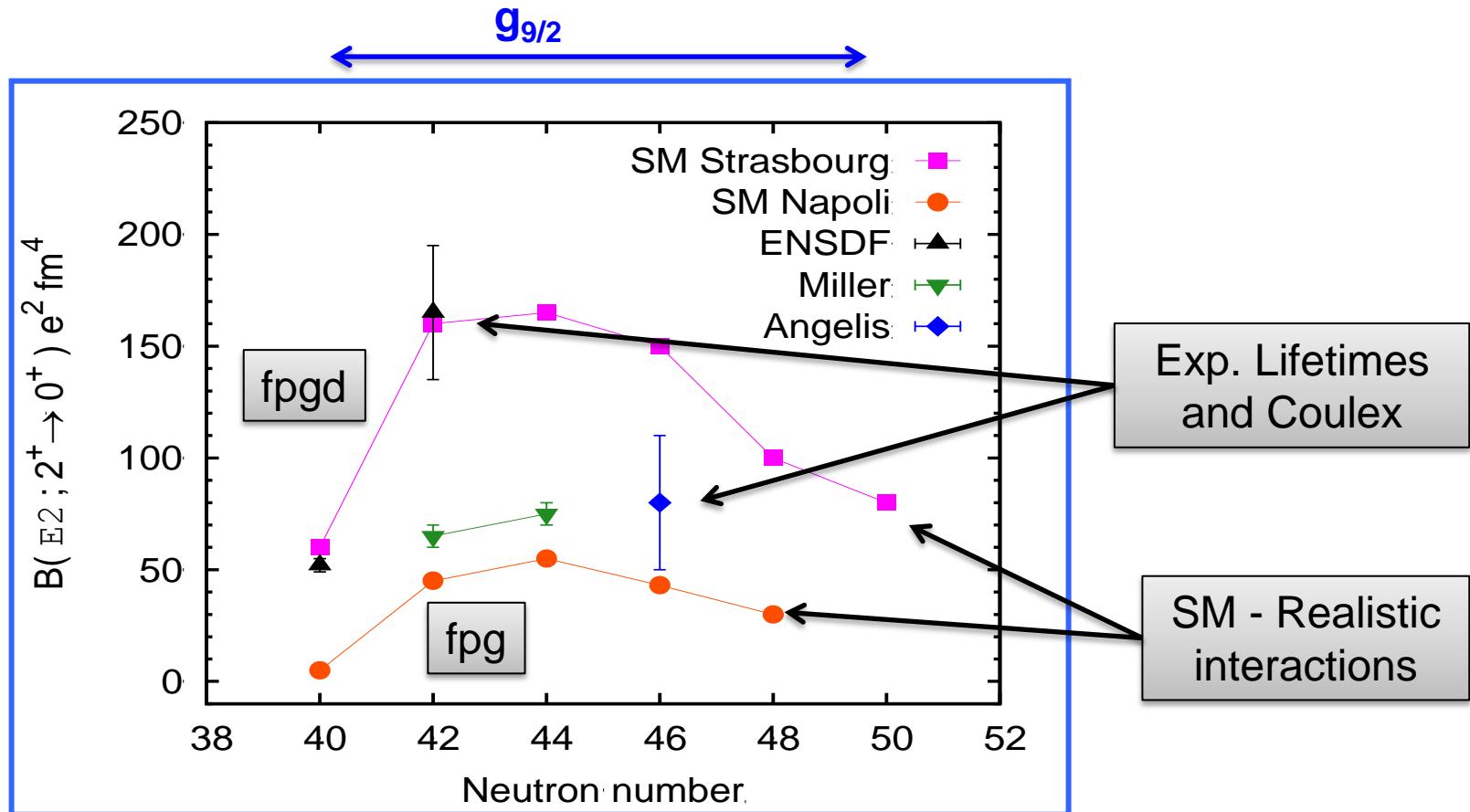
S. Lunardi et al., PRC**76**, 034303 (2007).

S.M. Lenzi et al., PRC**82**, 054301 (2010).

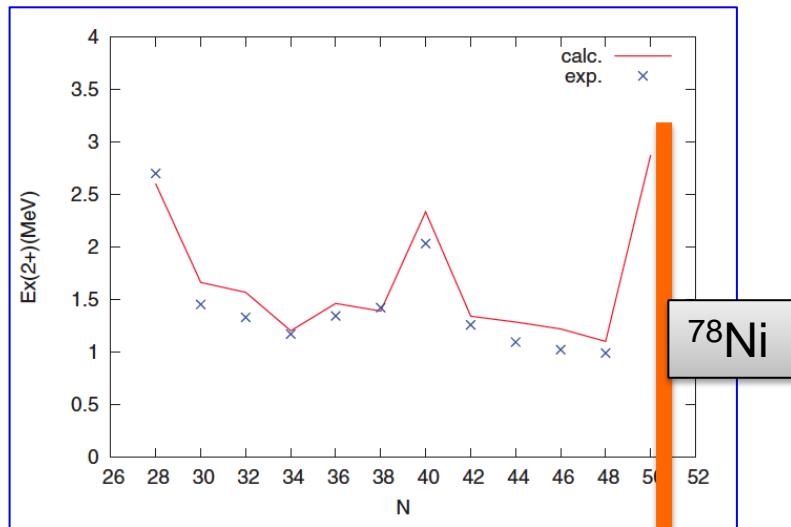
W. Rother et al., PRL106, 022502 (2011).

Ni isotopes panorama

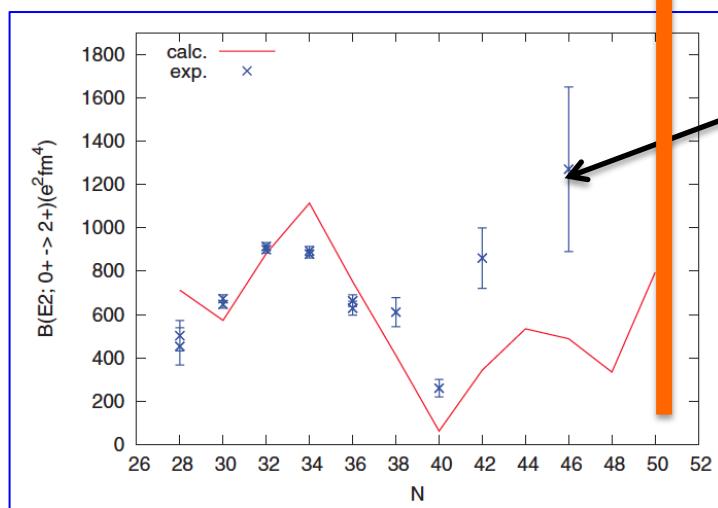
Large theoretical and experimental discrepancies.



Monte Carlo Shell Model



Monte Carlo Shell Model
calculations A3DA interation and
the fpgd model space



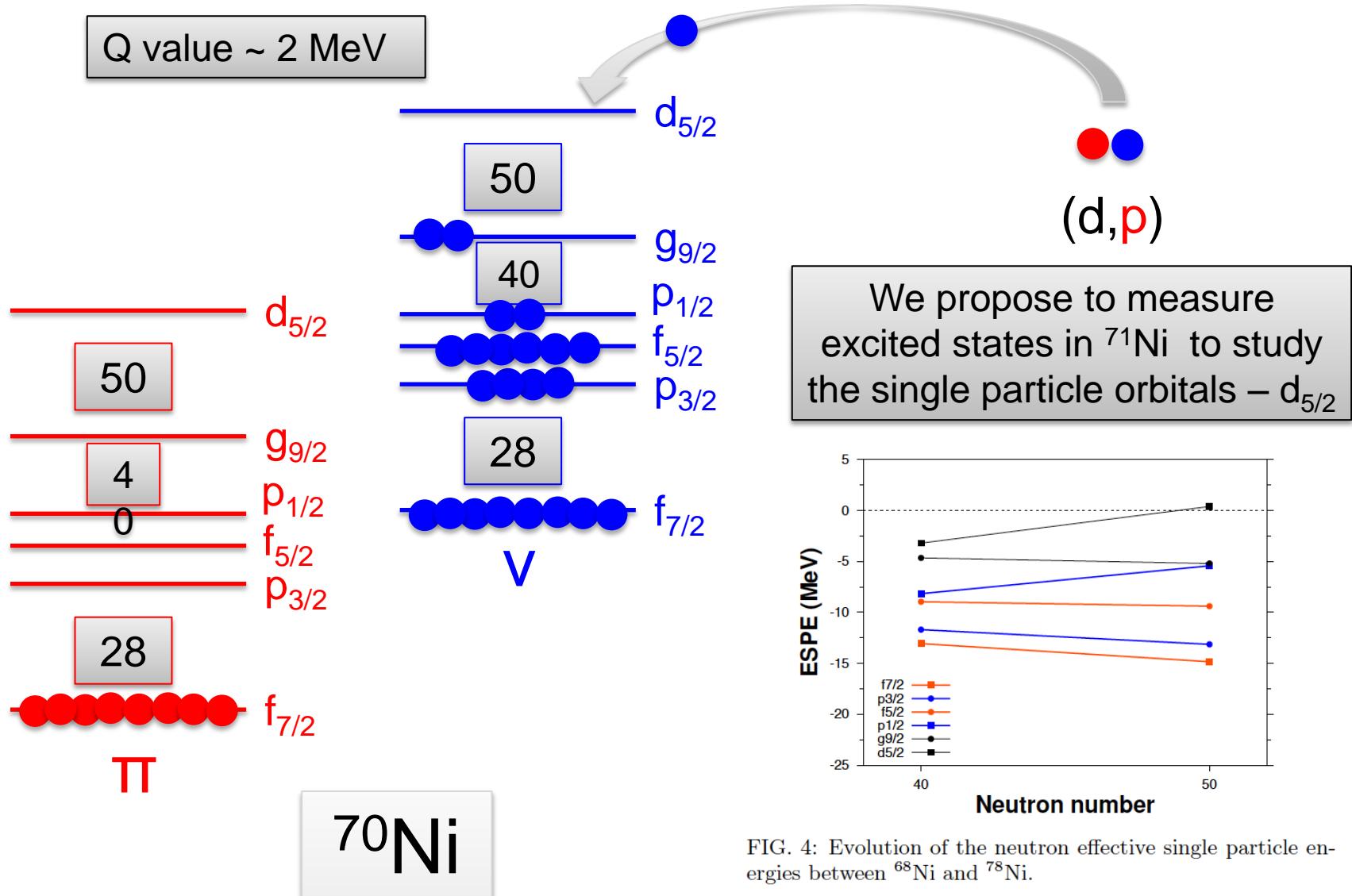
Deduced from N. Aoi PLB692
302 (2010) - $\delta=1.04(16)$ fm

(p, p')

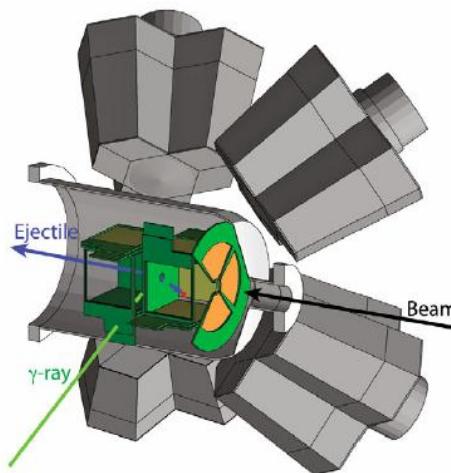
N. Aoi et al PLB692, 302 (2010)

Need of mapping the $d_{5/2}$ -
Study single particle properties
with direct transfer reactions

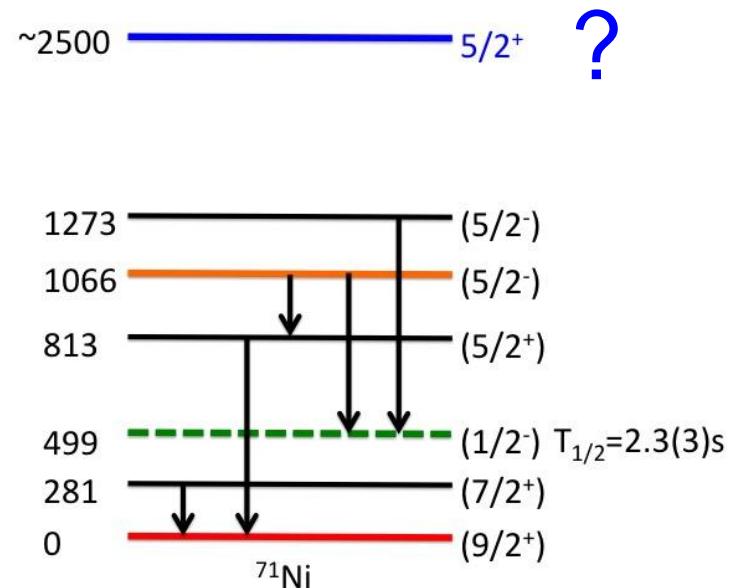
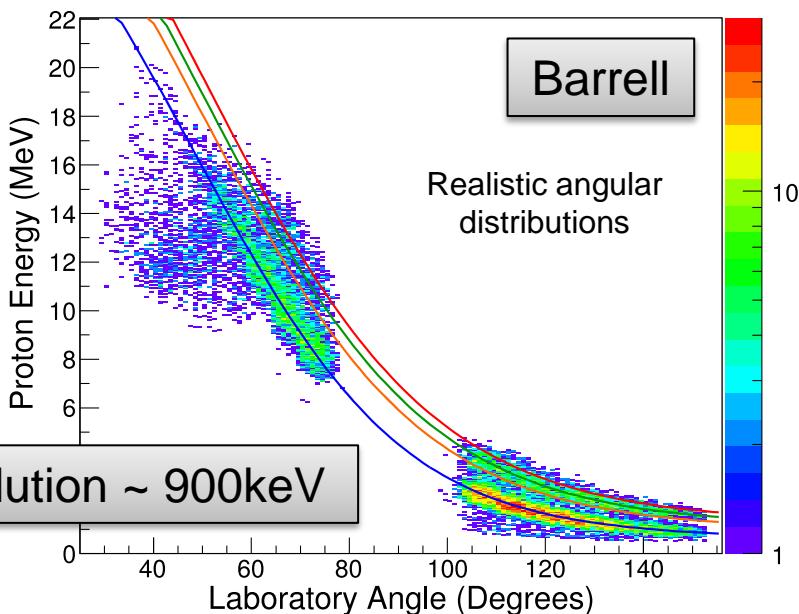
Experimental details



Experimental setup

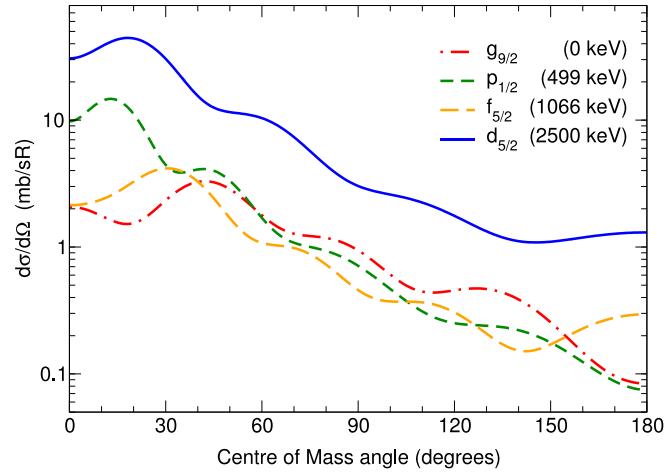


- Beam of ^{70}Ni 5.5 MeV/u (HIE-ISOLDE)
- Current: $2 \cdot 10^5$ at/ μC (UCx) – $1.4 \cdot 10^4$ pps at MINIBALL (transmission eff. 5%)
- 1 mg/cm² deuterated polyethylene (CD_2)
- T-REX (barrell+ backward CD) + MINIBALL

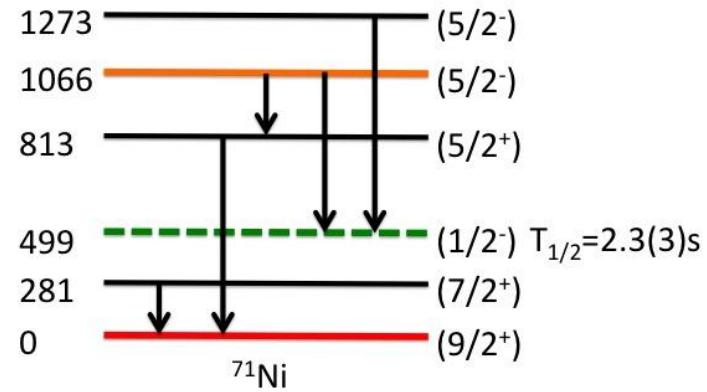
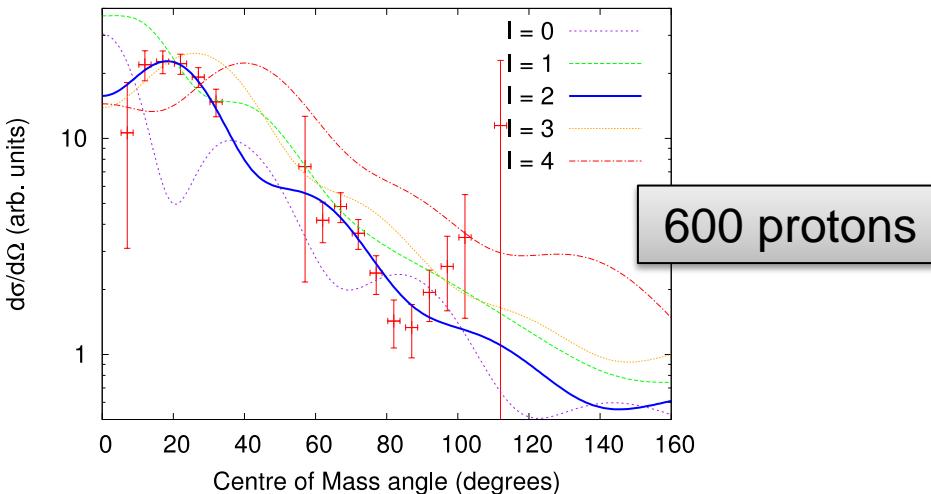


M.M. Rajabali et al., PRC85, 034326 (2012)
I. Stefanescu et al., PRC79, 044325 (2009)

Proton angular distributions



- DWBA calculations (DWUCK4, TWOFRN)
- The optimum Q-value favours the populations of the states around 2.0-2.5 MeV
- $^{68}\text{Ni}(\text{d},\text{p})^{69}\text{Ni}$ present a $5/2^+$ state at 2.6 MeV (M. Moukaddam et al., Acta Phys. Pol. B42 541 (2011) & thesis)
- SM calculations LNPS interaction ~2.5 MeV



Beam time request

- Considering a gamma eff. of 3.4% for MINIBALL
- Considering the protons detected at T-REX (GEANT4 simulations)
- We expect 100 particle-gamma coincidences per day.
- Total of 6 days enough to distinguish the L (simulations)
- Protons coming from fusion evaporation (H or ^{12}C) are negligible
→ previous experience Diriken $^{66}\text{Ni}(\text{d},\text{p})^{67}\text{Ni}$ + gamma gate
- New neutron converter geometry is expected to achieve a ^{70}Ga contamination on the ^{70}Ni beam of ~ 50%

Considering this scenario we request 12 days of beam time
(6 days laser ON + 6 days laser OFF) + 1 day for setup.
Total 13 days

Collaboration

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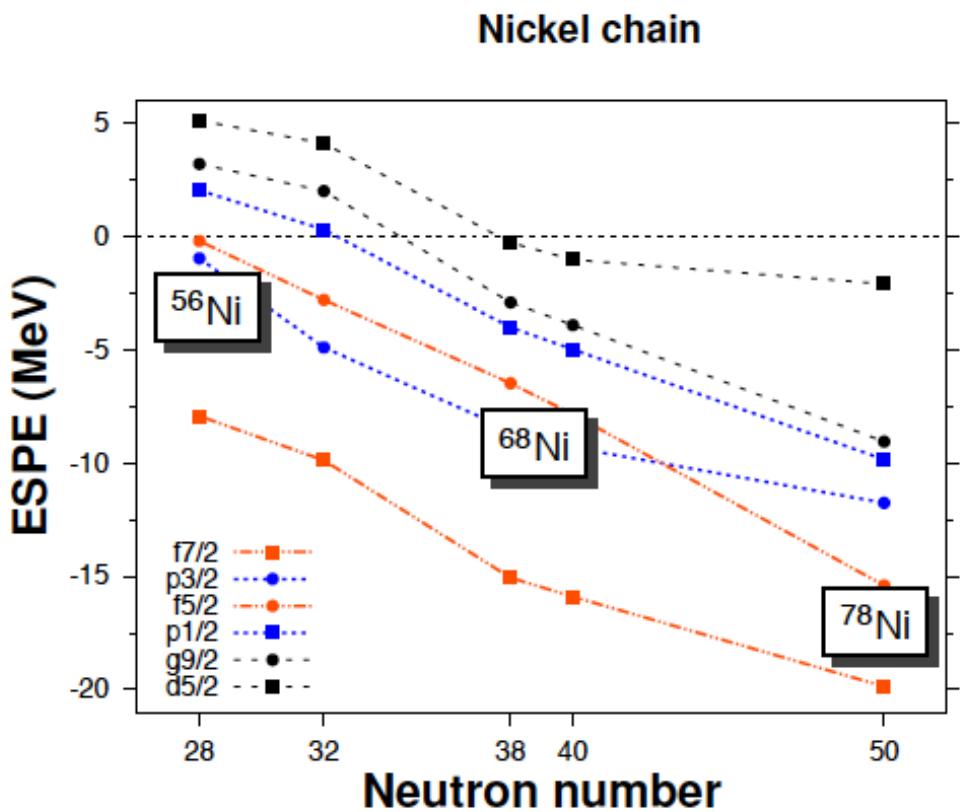
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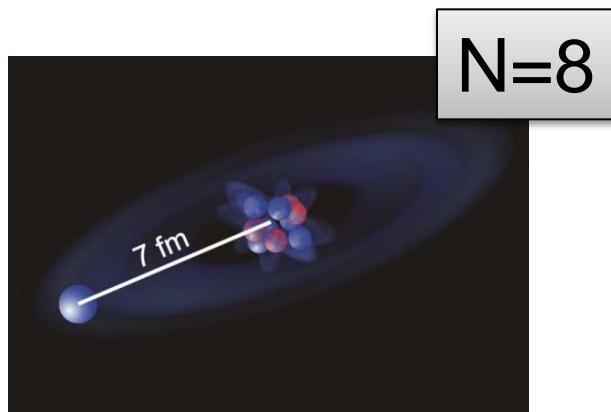
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ESPE towards ^{78}Ni

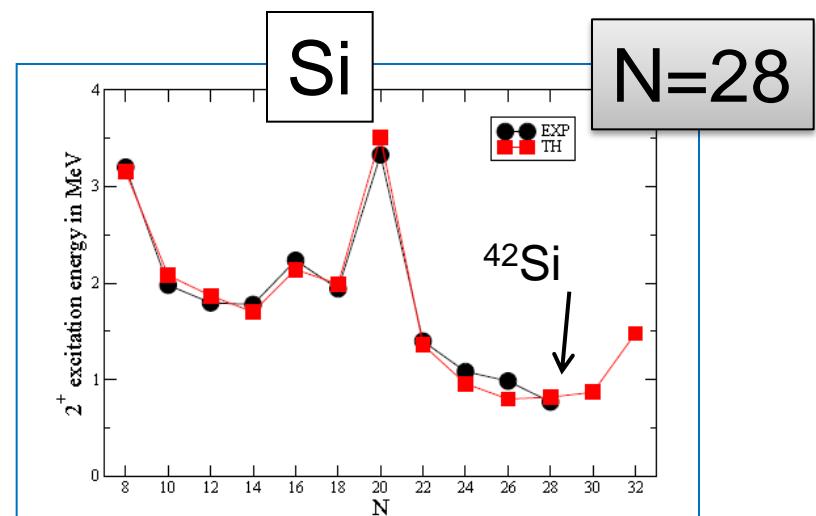
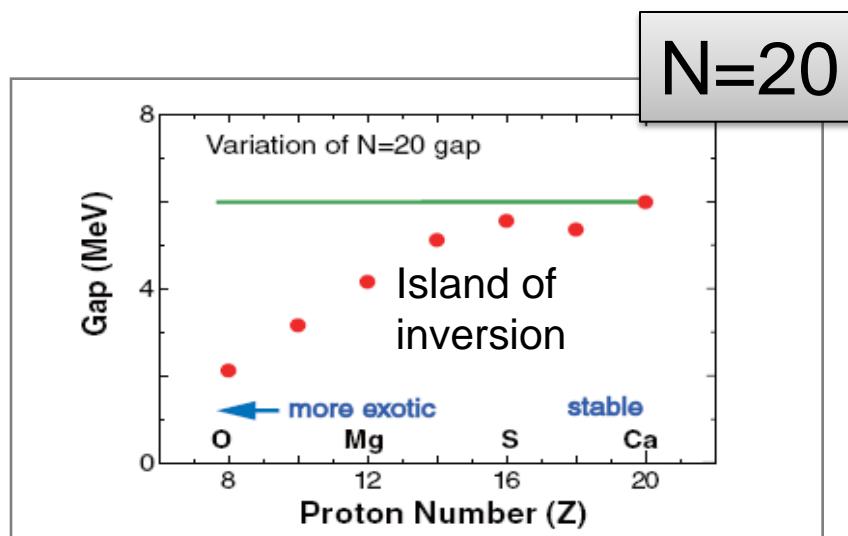


- ^{56}Ni : well doubly-magic, gap 6.5 MeV
- ^{68}Ni mixture of magic and superfluid. O.Sorlin PRL 88 092501 (2002)
- ^{78}Ni is supposed to be doubly-magic with a proton gap 5.0 MeV and neutron 4.6 MeV

The magic numbers N=8,20,28 vanish



At N=8, 20 and 28 the shell gap vanishes for very neutron rich nuclei. Deformed intruder configurations fall below the spherical ones.



Ni isotopes panorama

