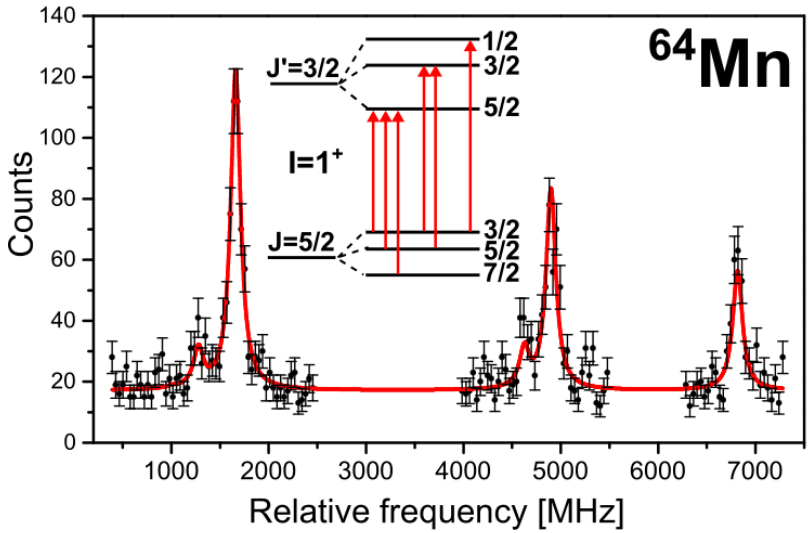


Proton and neutron excitations in Mn towards N = 40

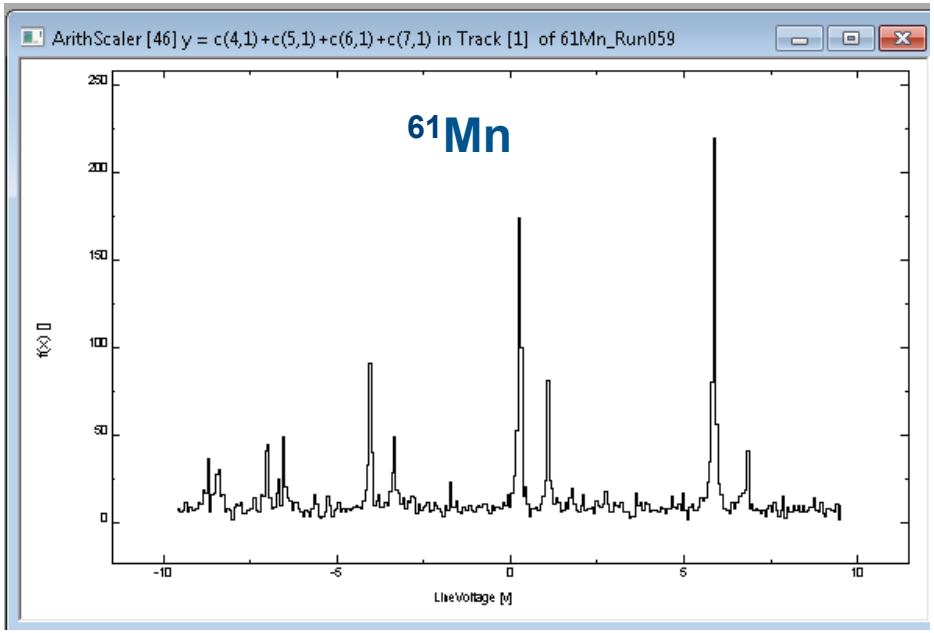
BriX

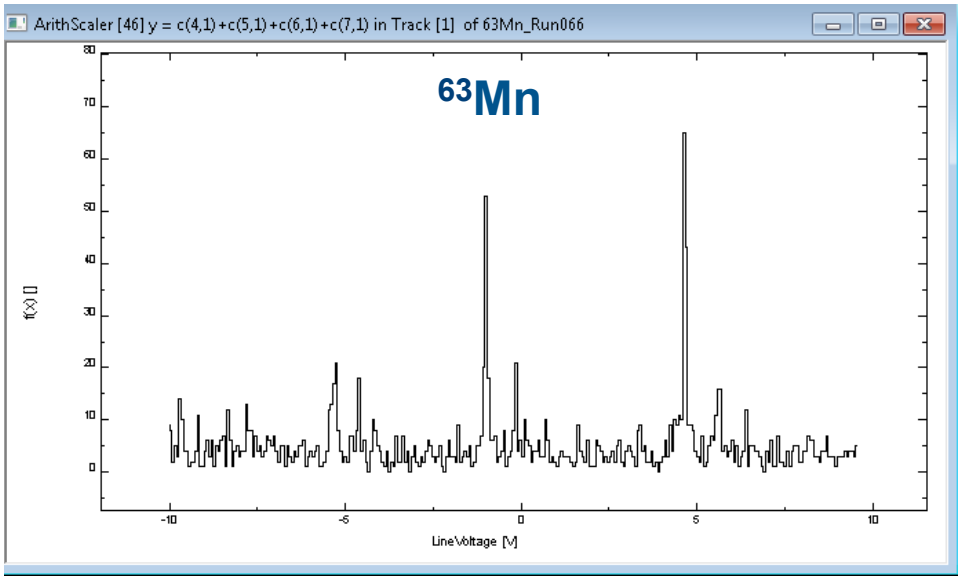
KU LEUVEN

NUCLEAR AND RADIATION PHYSICS

Introduction

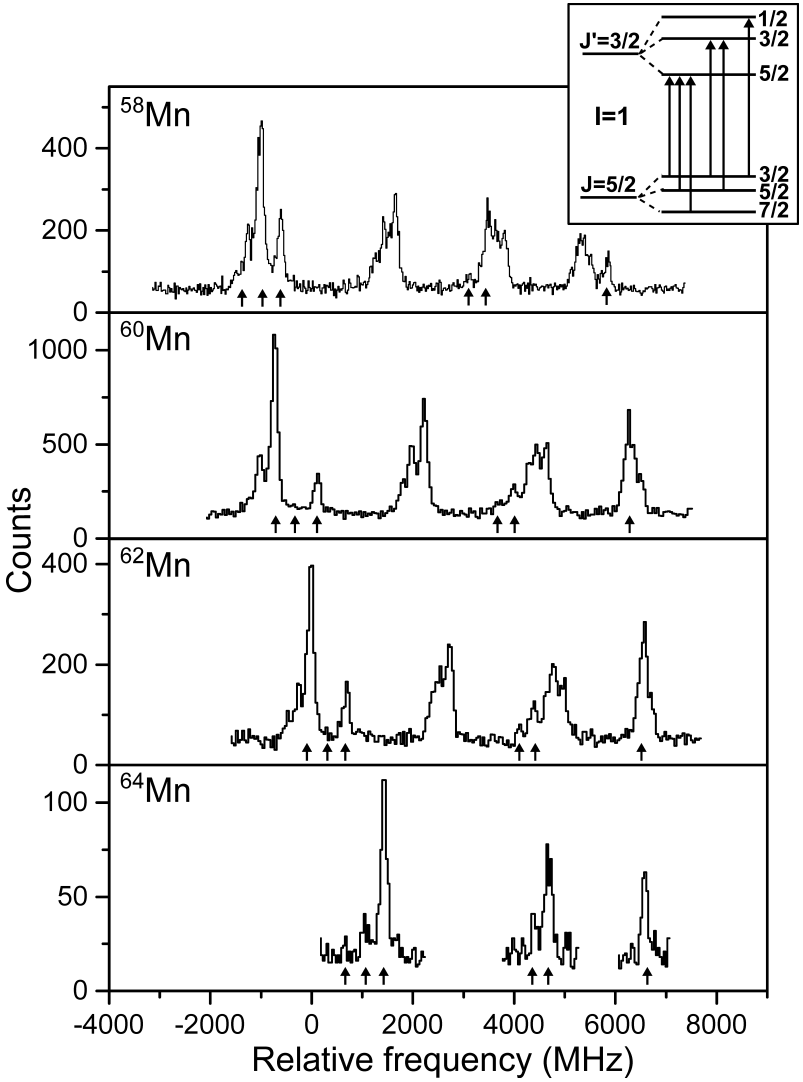
- Odd – even $^{53\text{-}63}$Mn
  - N = 28 – N = 38
- Quadrupole moments





Introduction

- Collinear laser spectroscopy of $^{51\text{-}64}$Mn at ISOLDE
  - Hyperfine spectra of N = 26 up to N = 39
  - Spins and magnetic moments
- Study nuclear structure in ^{68}Ni region around N = 40



- Why neutron-rich Mn?
- Collinear laser spectroscopy on exotic Mn
- What did we learn?

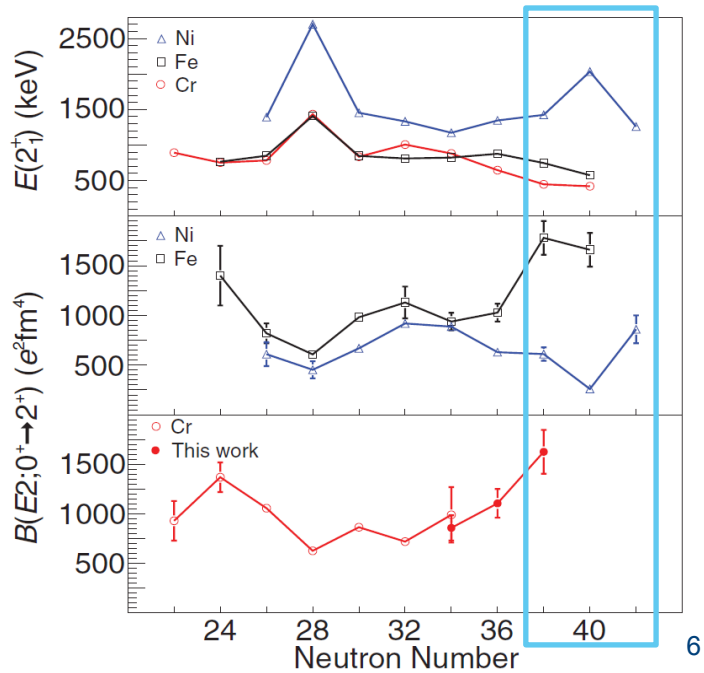
- **Why neutron-rich Mn?**
- Collinear laser spectroscopy on exotic Mn
- What did we learn?

Onset of deformation below ^{68}Ni

Z	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	
28	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	Ni
27	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	Co
26	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	Fe
25	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**Mn**
24	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	Cr

N

- Onset of deformation when protons are removed from Z = 28 shell ($\pi f_{7/2}$ orbital)
- Low-energy particle-hole excitations (*n*p – *n*h)
  - (Sub)shell gaps → energy cost
  - Quadrupole correlations → energy gain
    → Drive system to deformation



Baugher, PRC 86 (2012)

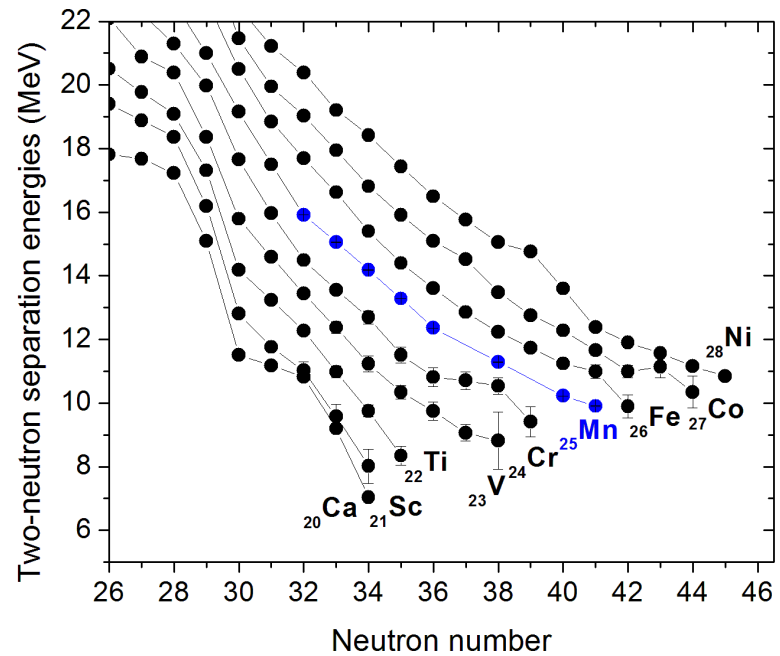
Why nuclear moments of Mn?

- Smooth S_{2n} across N = 40 but what is gs and isomer in ^{62}Mn?

  Naimi, PRC 86 (2012)

- Tentative spins I
- Nuclear moments only known up to ^{56}Mn (N = 31) Charlwood, PLB 690 (2010)
  - Magnetic moment μ: Nuclear configuration
  - Quadrupole moment Q: Deformation

Wang et al., Chin. Phys. C 36 (2012)
Wienholtz , Nature 498 (2013)



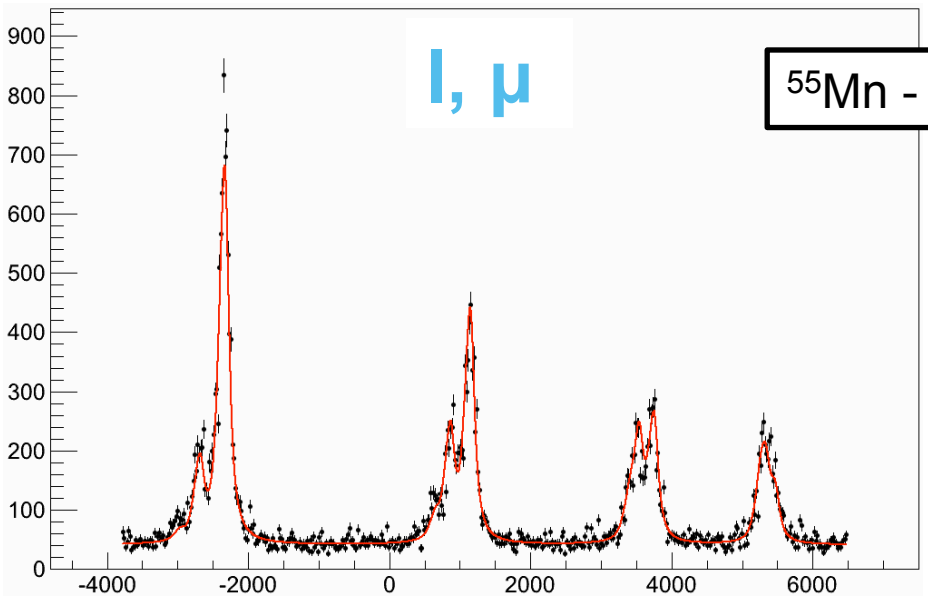
Study onset of deformation of Mn towards N = 40 via I, μ, Q

- Why neutron-rich Mn?
- **Collinear laser spectroscopy on exotic Mn**
- What did we learn?

Collinear laser spectroscopy

- Hyperfine interaction
  - Nucleus
  - Electrons

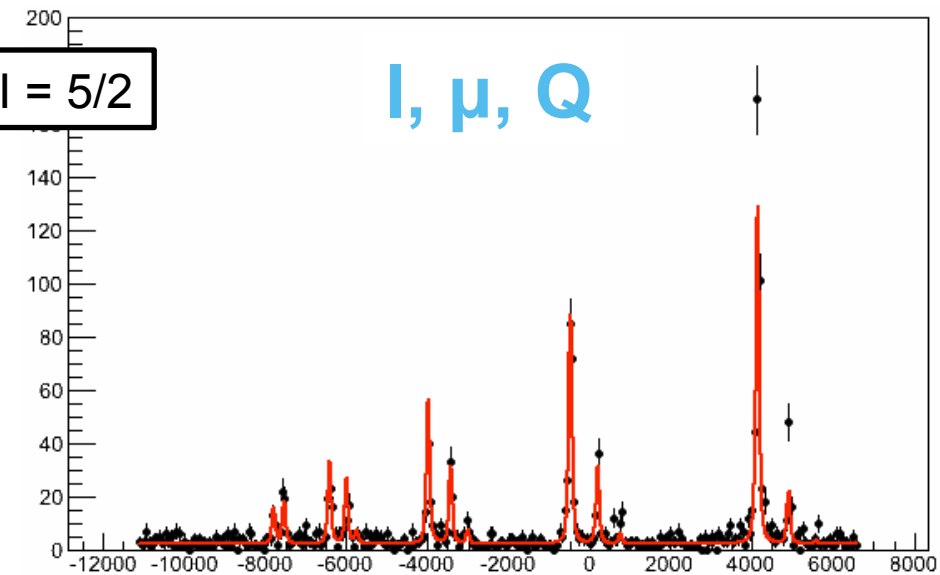
$^{6}S_{5/2} \rightarrow {}^{6}P_{3/2}$ atomic gs transition



Frequency [MHz]

^{55}Mn - I = 5/2

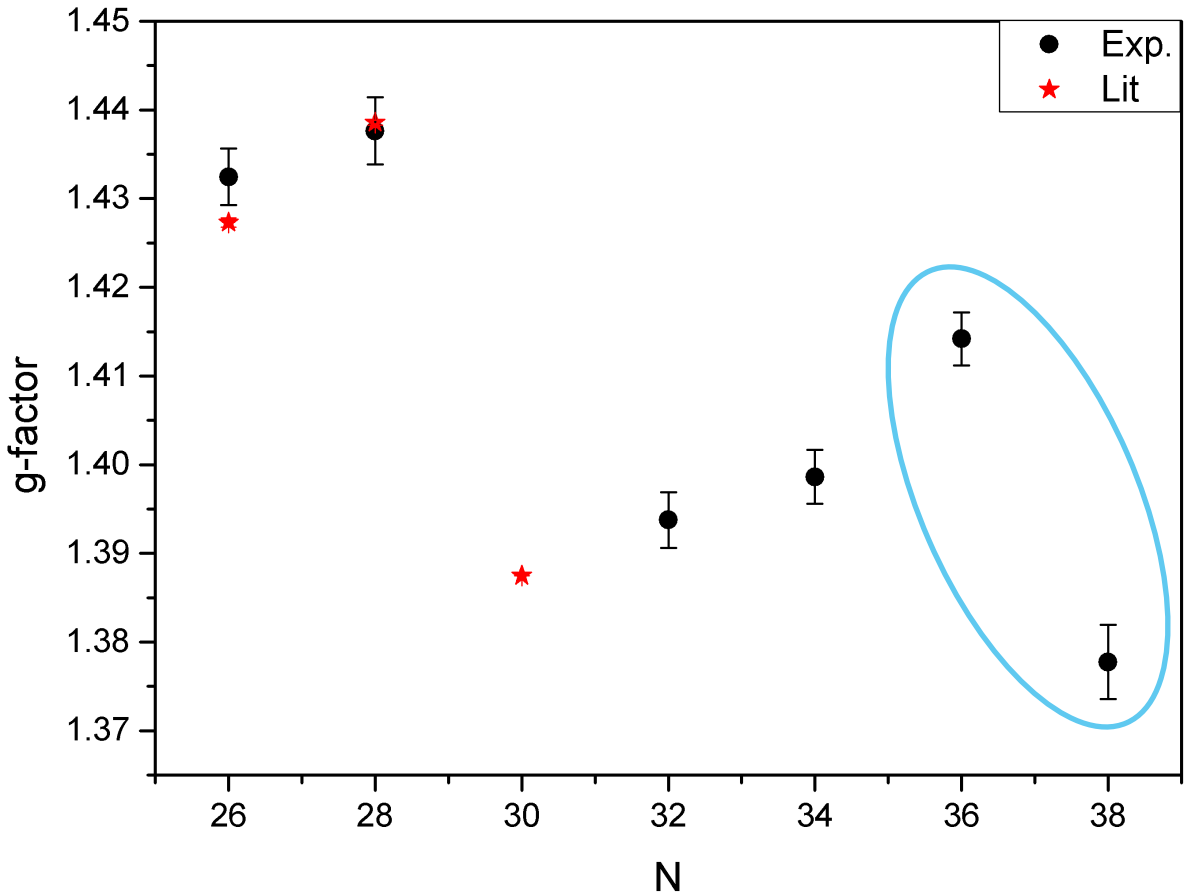
$^{5}S_{2}$ (metastable) $\rightarrow {}^{5}P_{3}$ ionic transition

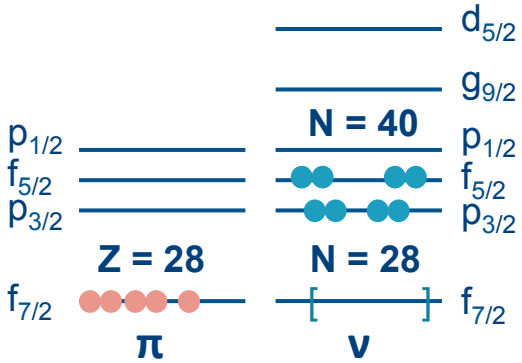


Frequency [MHz]

- Why neutron-rich Mn?
- Collinear laser spectroscopy on exotic Mn
- **What did we learn?**

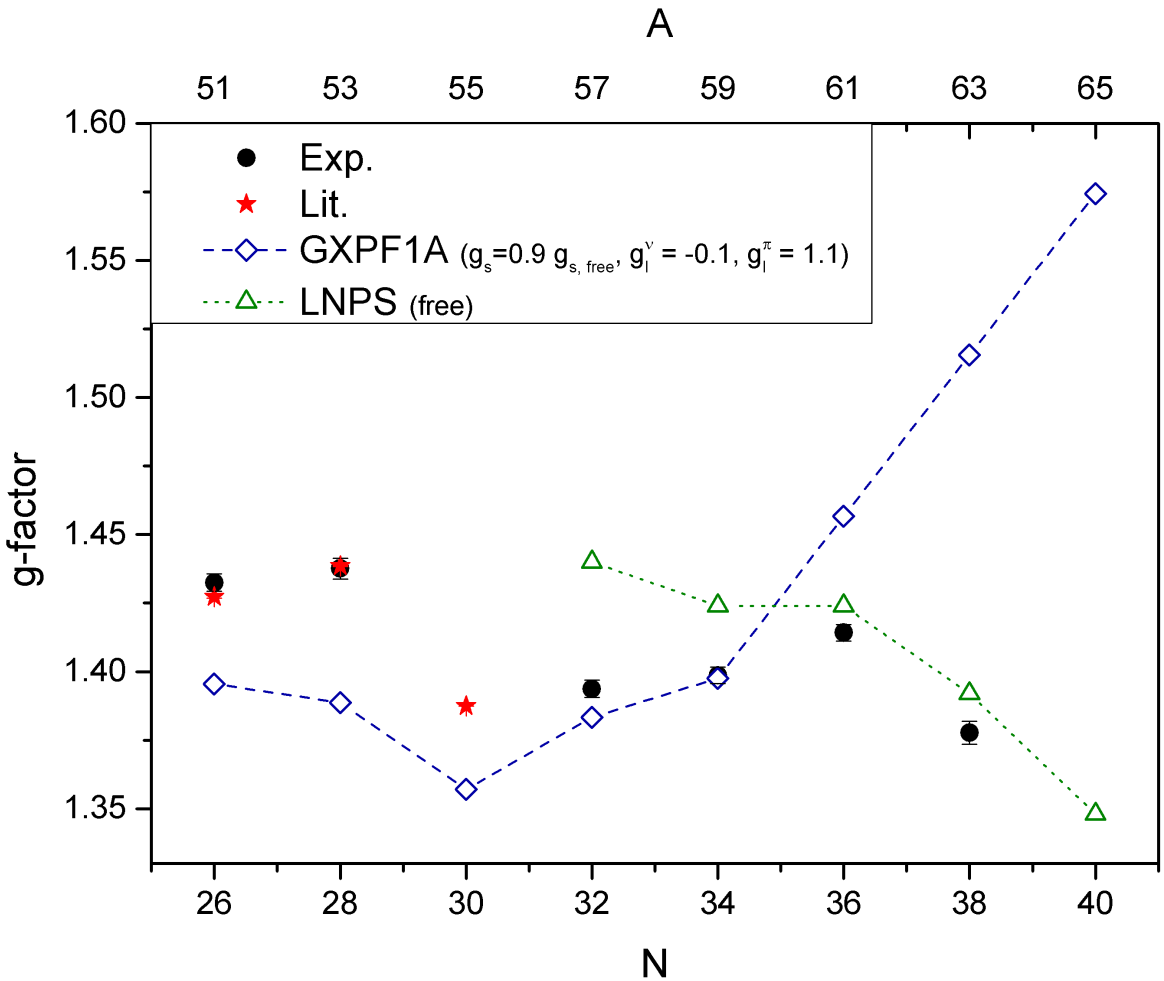
g-factors of odd-even Mn

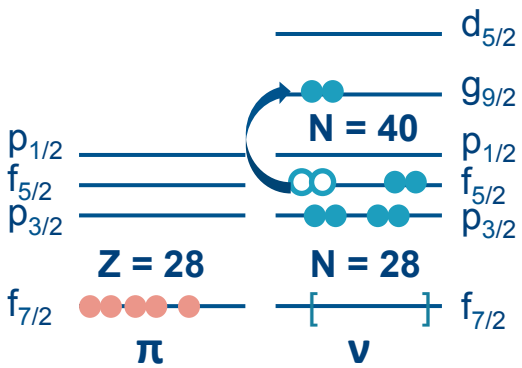




- $g = \mu/I$
- Single-particle $g(\pi f_{7/2}) = 1.66$

Understanding g-factors of odd-even Mn



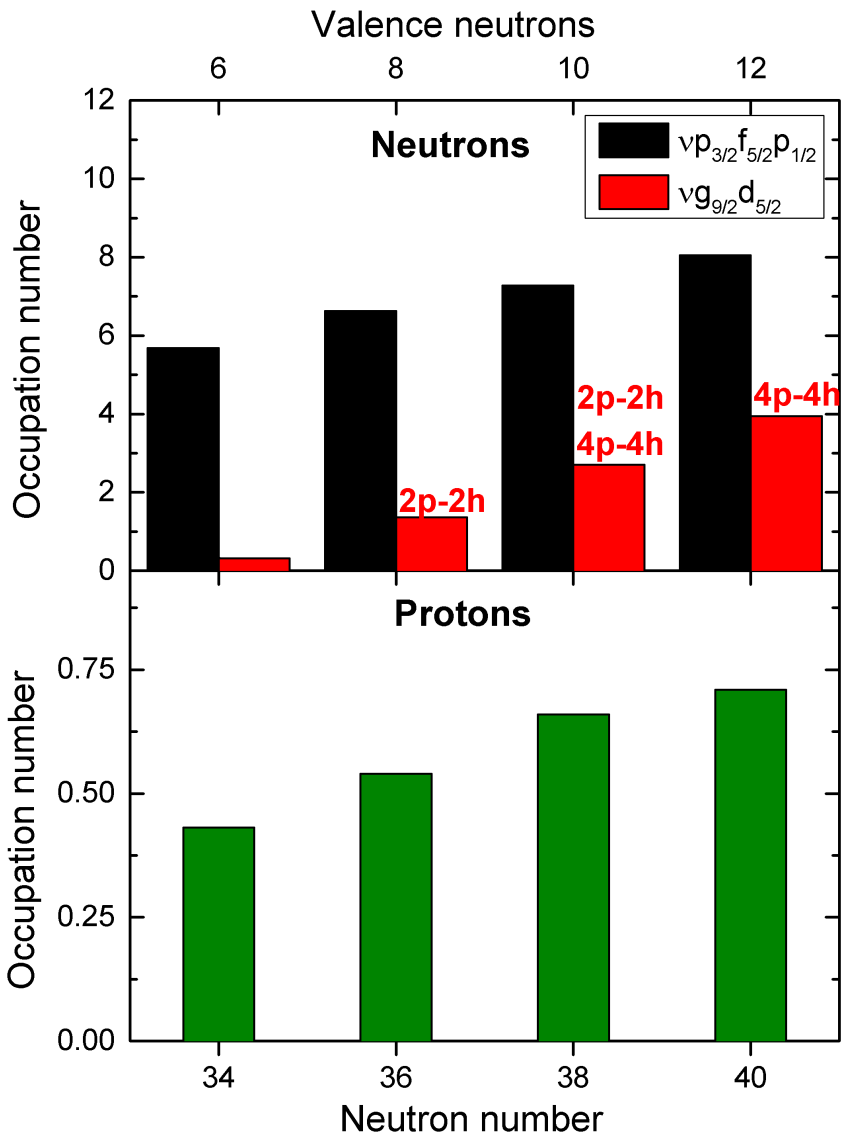


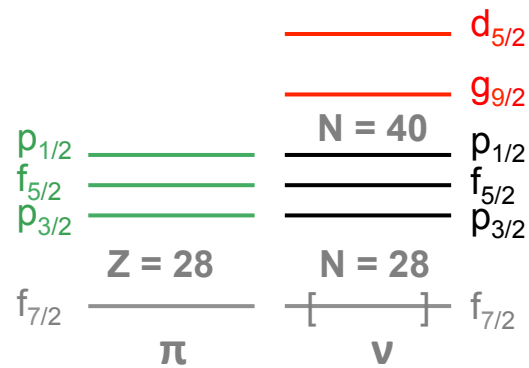
GXPF1A vs LNPS

- Neutron excitations across N =40

Honma, PRC65 (2002); Lenzi, PRC82 (2010)

Understanding g-factors of odd-even Mn





LNPS calculations

- Significant increase in neutron excitations across N = 40 along with proton excitations across Z = 28

Summary

- Hyperfine structures of $^{51\text{-}64}$Mn (up to N = 39)
  - Isomers in ^{58,60,62}Mn

- Firm spin assignments
  - I = 5/2 for ^{59,61,63}Mn
  - I = 1 and I = 4 in ^{58,60,62}Mn and I = 1 in ^{64}Mn

- g-factors are compared to shell model calculations using GXPF1A and LNPS effective interactions
  - Neutron excitations across N = 40
  - Proton excitations across Z = 28

~~Next?~~ Very recent past

- Quadrupole moments of odd Mn
  - Different optical transition with larger quadrupole splitting

Questions?

COLLAPS collaboration (2014)