Moments and spins of neutron rich Mg isotopes: towards ^{33}Mg

Leuven - Mainz - ISOLDE collaboration at CERN

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ISOLDE Workshop 2006

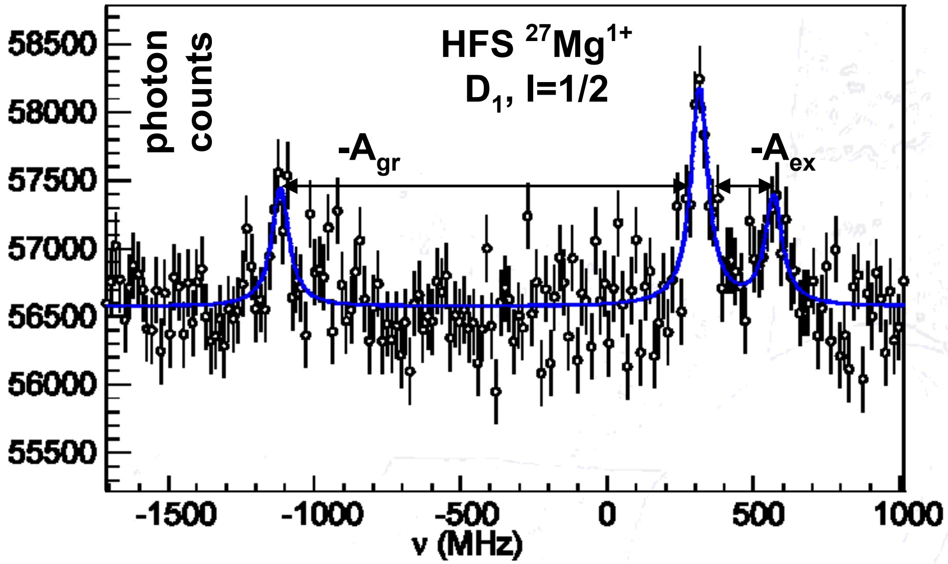
Table of Isotopes in the vicinity of The Island of Inversion

- Normal or not measured
- Measured Intruder
- This Work

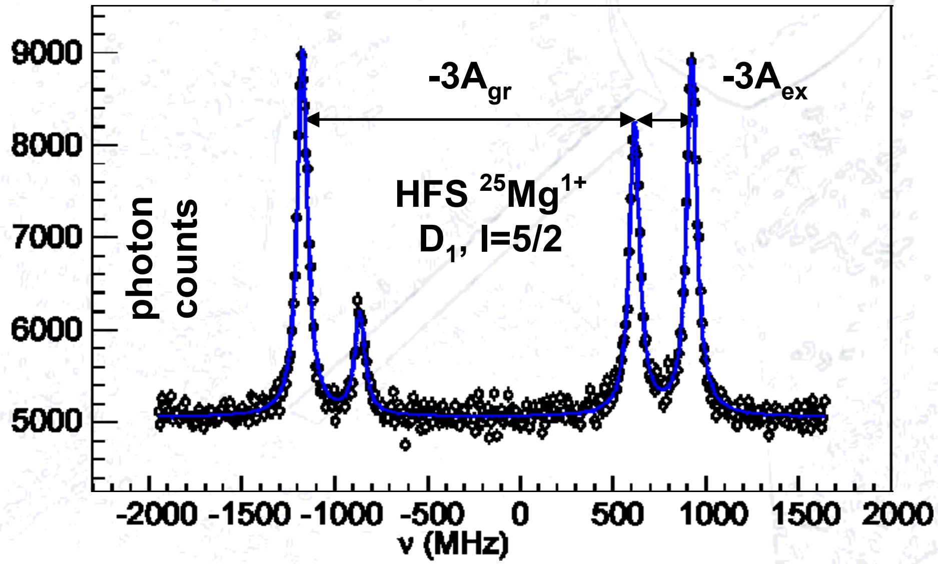
						N=20		
13			Al30 3.60 s 3+ β-	Al31 644 ms 5/2+ β-	Al32 33 ms 1+ β-	Al33 42 ms β-	Al34 56 ms β- n	Al35 39 ms β- n
Z=12	Mg27 9.458 m 1/2+ β-	Mg28 20.91 h 0+ β-	Mg29 1.30 s 3/2+ β-	Mg30 335 ms 0+ β-	Mg31 230 ms 1/2+ β- n	Mg32 120 ms 0+ β- n	Mg33 90 ms β- n	Mg34 20 ms 0+ β- n
11			Na28 30.5 ms 1+ β- n	Na29 44.9 ms 3/2+ β- n	Na30 48 ms 2+ β-n,β-2n,…	Na31 17.0 ms 3/2+ β-n,β-2n,…	Na32 13.2 ms β-n,β-2n,…	Na33 8.2 ms β-n,β-2n,…
10			Ne27 32 ms β- n	Ne28 17 ms 0+ β- n	Ne29 15 ms β-	Ne30 7 ms 0+	Ne31	Ne32

•nuclear moments and hyperfine structure of $^{25, 27, 29, 31, 33}Mg$

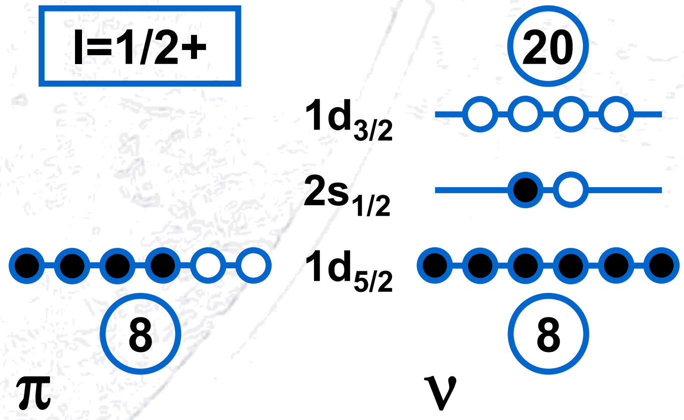
Hyperfine structure of $^{25,27}Mg$



	$^{27}Mg^{1+}$,MHz	$^{25}Mg^{1+}$,MHz
A, $3^2S_{1/2}$	-1431.6(46)	-596.43(18)
A, $3^2P_{1/2}$	-252.5(51)	-102.72(37)
$g(^{27}Mg)$ = -0.822(3)		
EXP. RESULTS - PRELIMINARY		



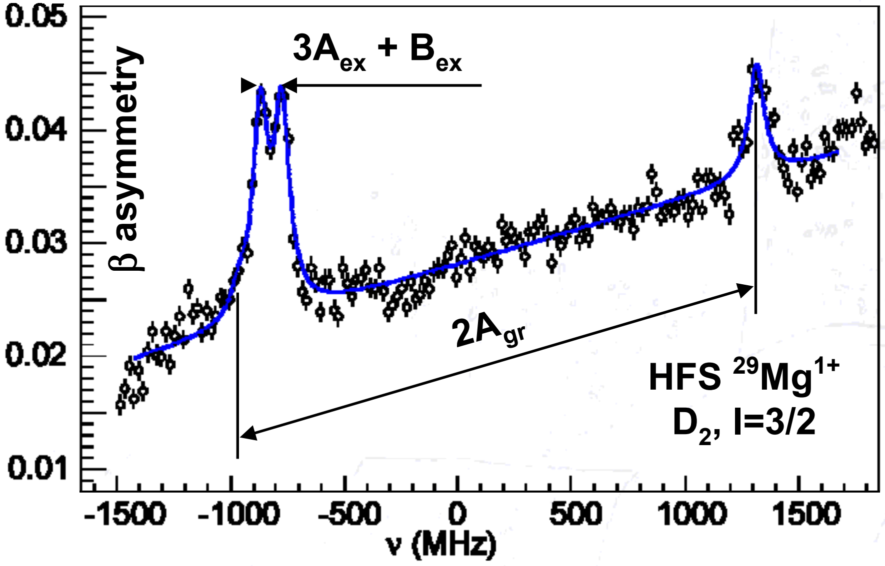
^{27}Mg (Z=12, N=15)



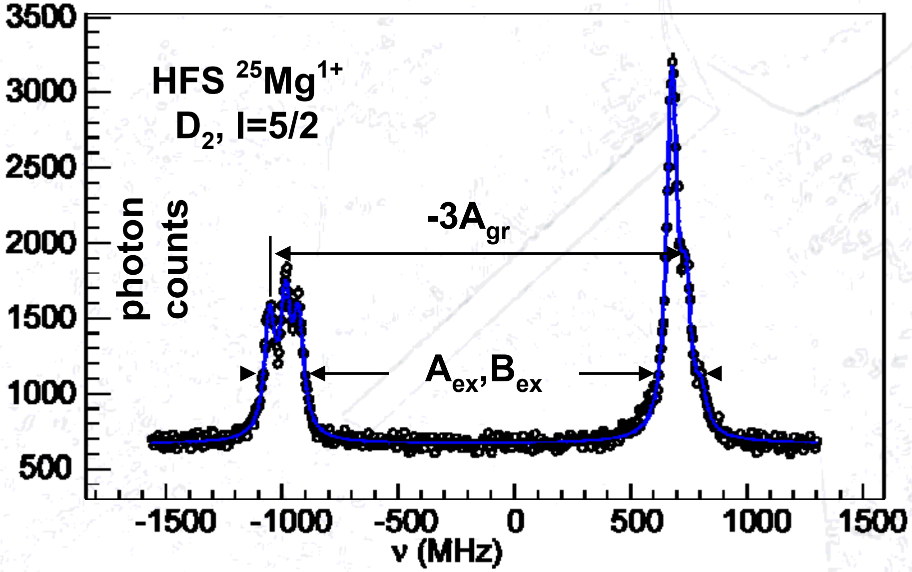
μ_{sd} = -0.42 μ_N, μ_{exp} = -0.4110(15) μ_N

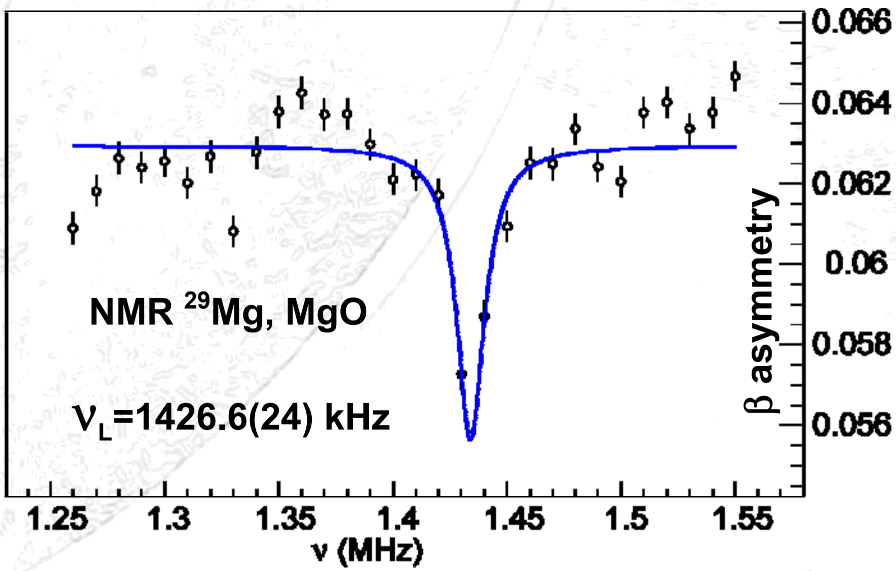
$\mu_{Schmidt} = -1.91\ \mu_N$

HFS and NMR of ^{29}Mg

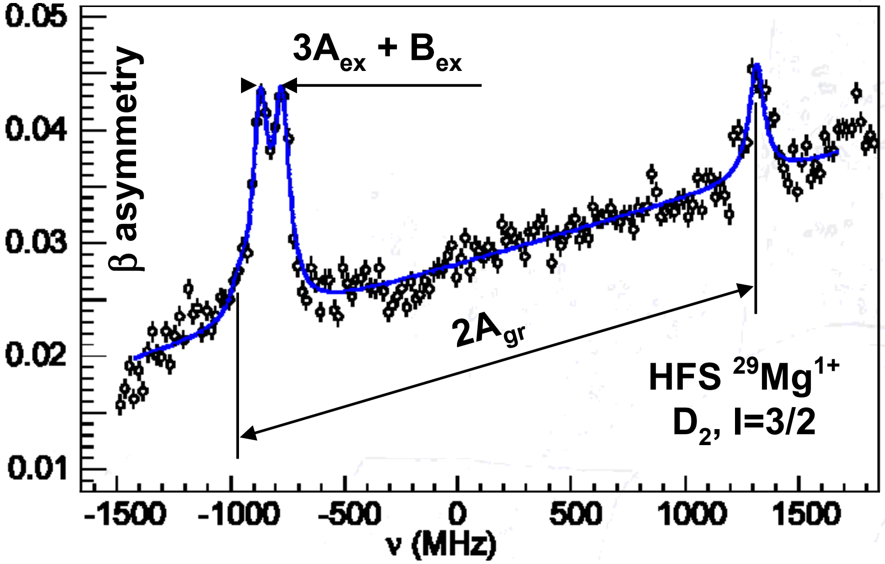


$g_{corr}(^{29}Mg) = 0.653(1)$		
	$^{25}Mg^{1+}$,MHz	$^{29}Mg^{1+}$,MHz
A, $3^2S_{1/2}$	-596.43(18)	1138.2(18)
A, $3^2P_{1/2}$	-102.72(37)	196.03(77)
A, $3^2P_{3/2}$	-18.73(41)	35.74(78)
B, $3^2P_{3/2}$	24.29(93)	-13(3)
Q (^{29}Mg) = -107(25) mb		
EXP. RESULTS - PRELIMINARY		





HFS and NMR of ^{29}Mg



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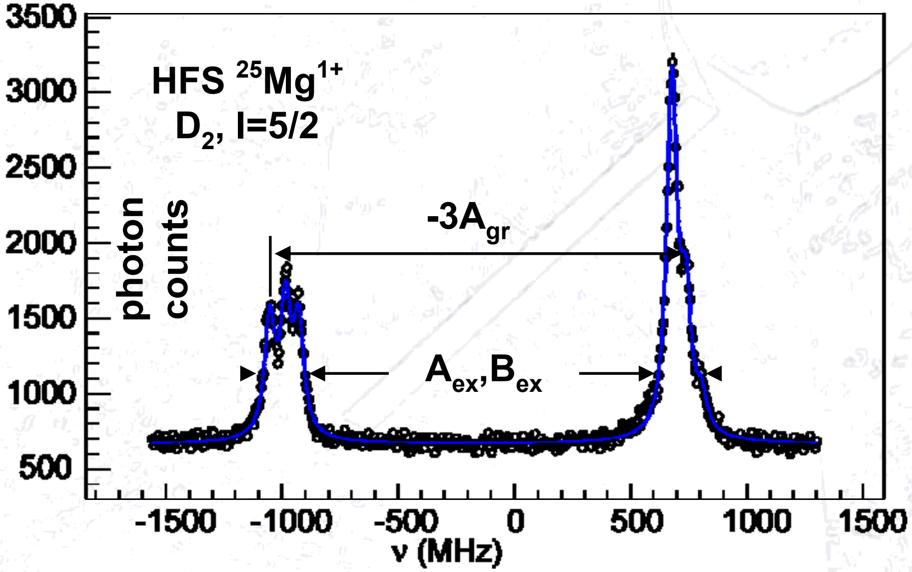
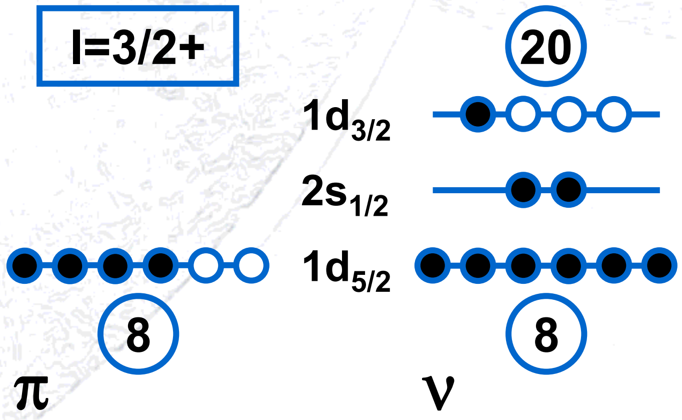


^{29}Mg (Z=12, N=17)

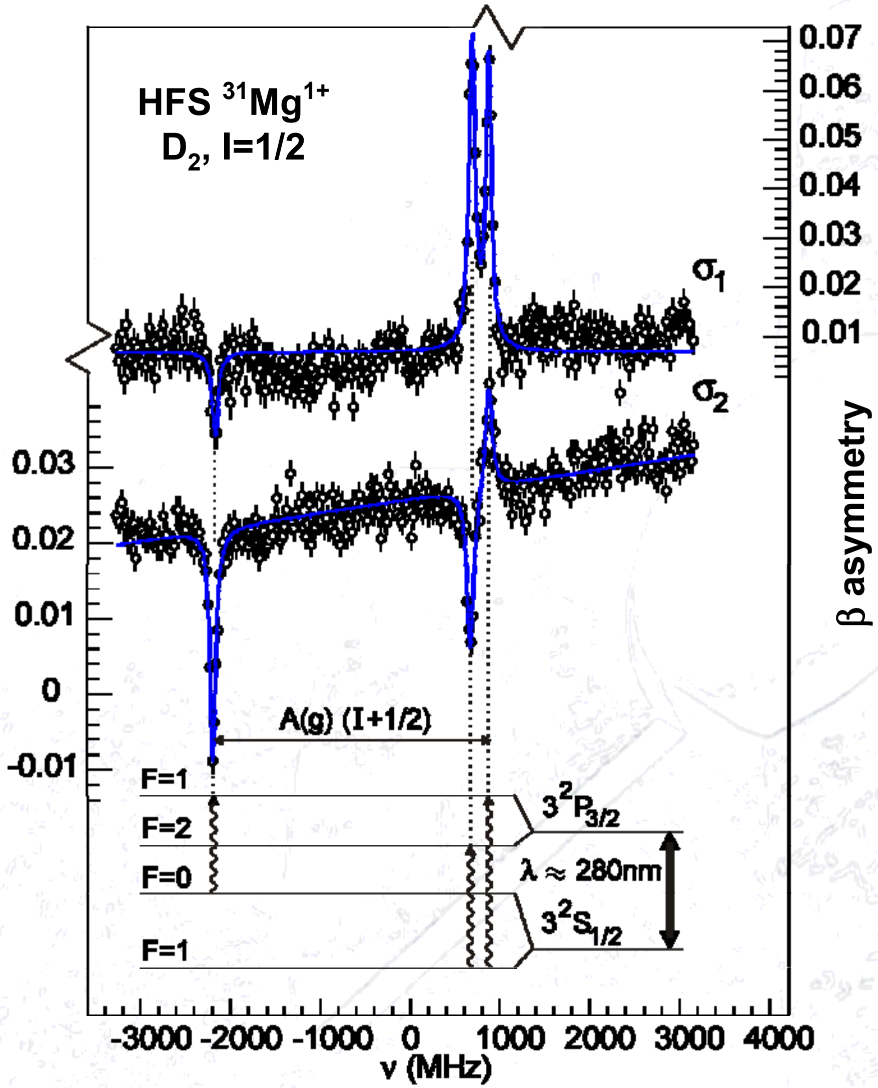
I=3/2+

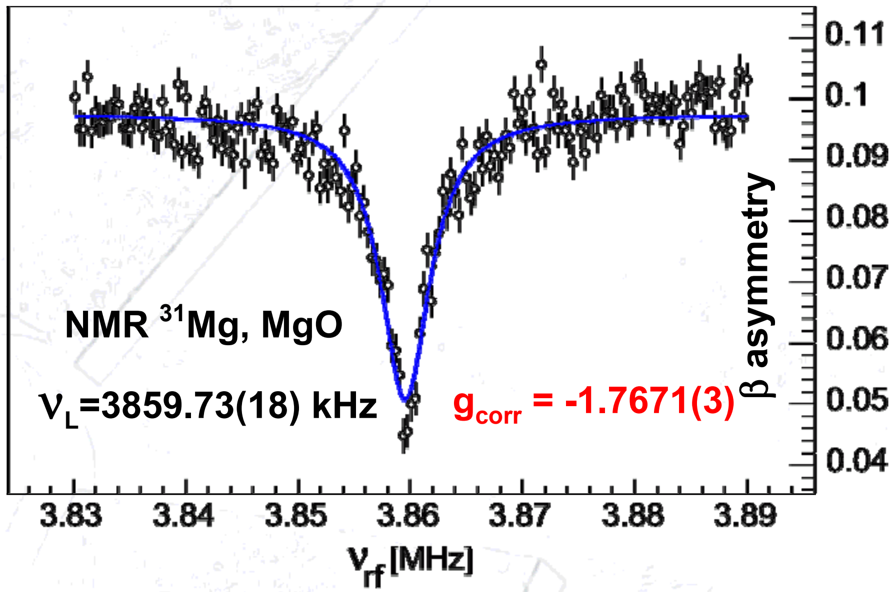


Q_{sd} = -95 mb, Q_{exp} = -107(25) mb

$\mu_{sd} = 0.96\ \mu_N$, $\mu_{exp} = 0.9795(15)\ \mu_N$, $\mu_{Schmidt} = 1.15\ \mu_N$

HFS and NMR of ^{31}Mg



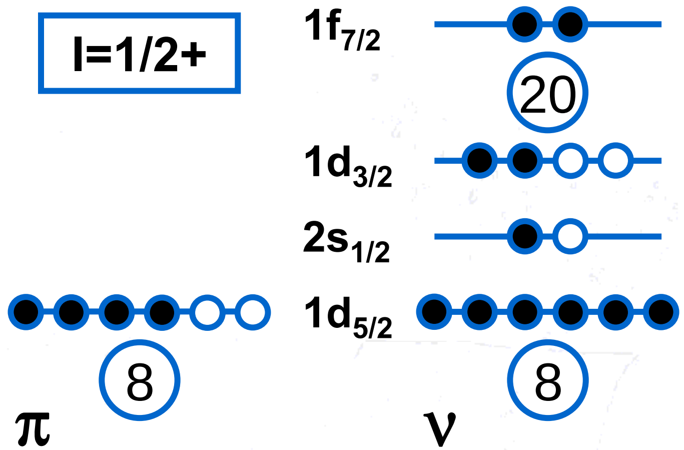


	$^{31}Mg^{1+}$,MHz	
A, $3^2S_{1/2}$	-3077.6(38)	-3080(1)
A, $3^2P_{1/2}$	-530.3(39)	-530.5(19)
A, $3^2P_{3/2}$	-96.34(74)	-96.7(21)
	HFS fit, I=1/2	*calc. from g*
EXP. RESULTS - PRELIMINARY		

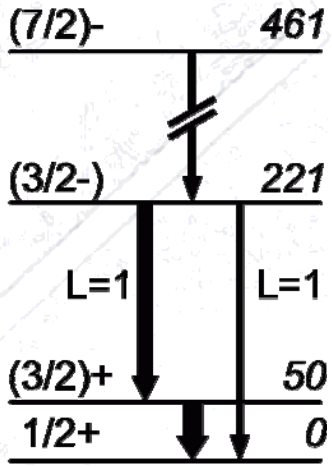
[1] G. Neyens *et al.*, Phys. Rev. Lett. **94**, 022501 (2005)

^{31}Mg (Z=12, N=19)

I=1/2+



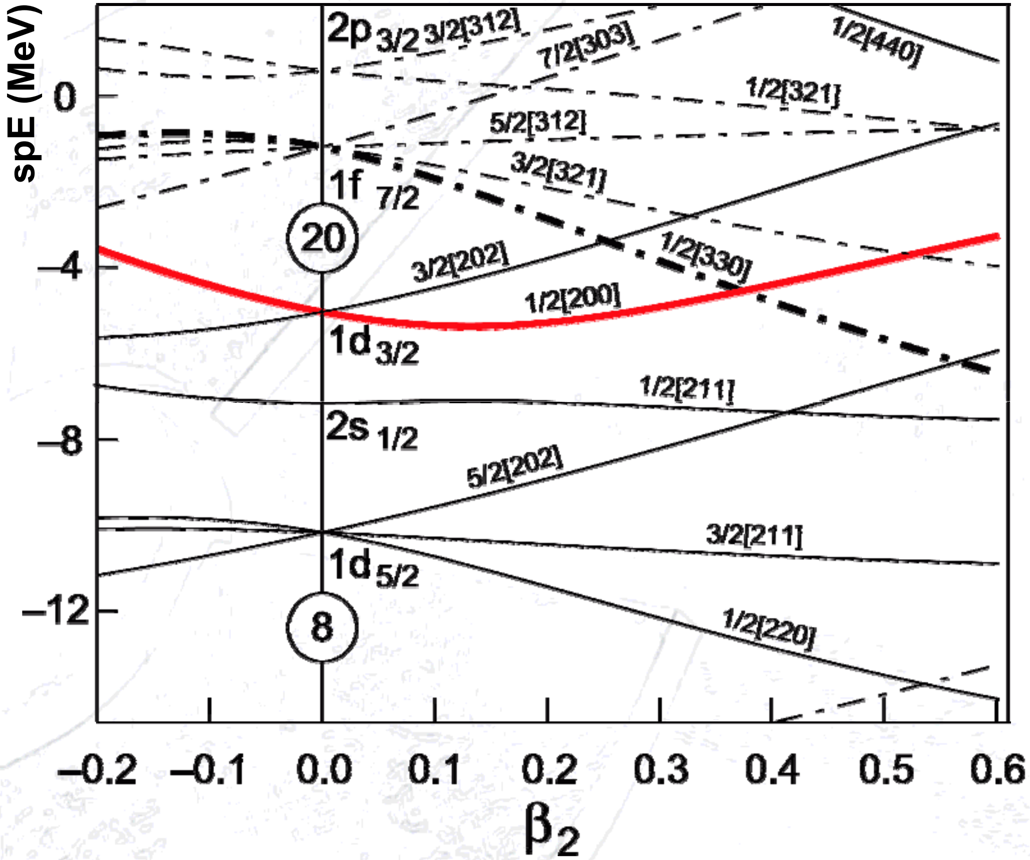
$\mu_{sd\text{-}pf}$ = -0.84 μ_N, μ_{exp} = -0.88355(15) μ_N



1p – 1h

2p – 2h

^{31}Mg, experimental level scheme



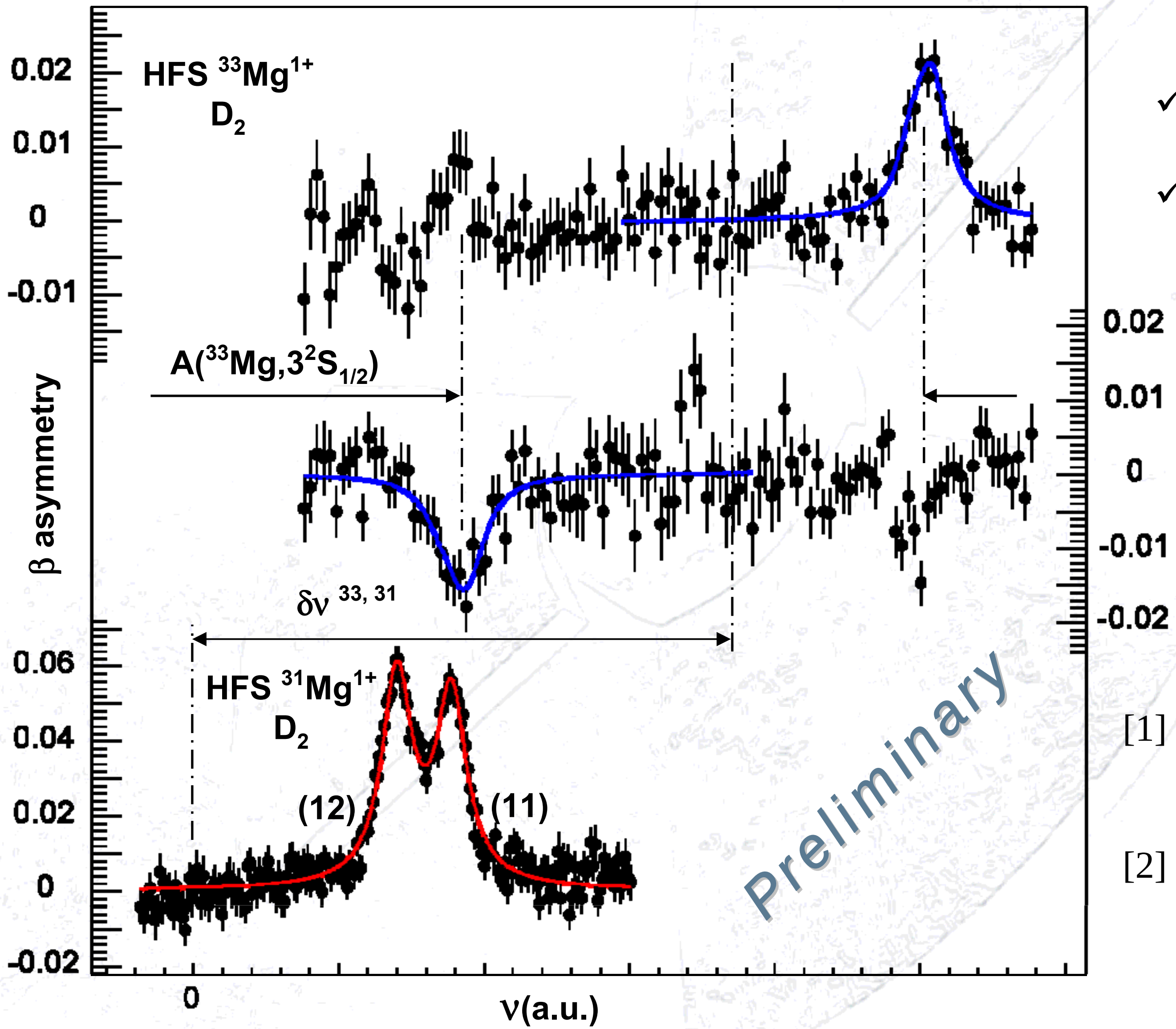
Neutron single particle levels Woods-Saxon potential

[1] F. Marechal *et all.*, Phys. Rev. **C 72**, 044314 (2005)

[2] H. Mach *et al.*, EPJ **A 25** (2005)

[3] G. Klotz *et al.*, Phys. Rev. **C 47**, 2502 (1993)

HFS of ^{33}Mg



✓A(^{33}Mg,$3^2S_{1/2}$) ± 15%

✓g_I(^{33}Mg) ± 15%

[1] S. Nummela *et al.*, Phys. Rev. **C 64**, (2001) **I = (3/2+)**

[2] B. V. Pritychenko *et al.*, Phys. Rev. **C 65**, (2002) **I = (5/2+)**

Conclusions & Outlook

- ✓ ^{27,29}Mg are far out of the Island of Inversion
- ✓ ^{31}Mg has nearly pure 2p-2h intruder gr. state
- ✓ The first exited states also have intruder nature

Mg27	Mg28	Mg29	Mg30	Mg31	Mg32	Mg33	Mg34
9.458 m	20.91 h	1.30 s	335 ms	230 ms	120 ms	90 ms	20 ms
1/2+	0+	3/2+	0+	1/2+	0+		0+
β-	β-	β-	β-	β- n	β- n	β- n	β- n

- ✓ Unambiguously determine the gr. state spin of ^{33}Mg by NMR
- ✓ Access the deformation through rms charge radii

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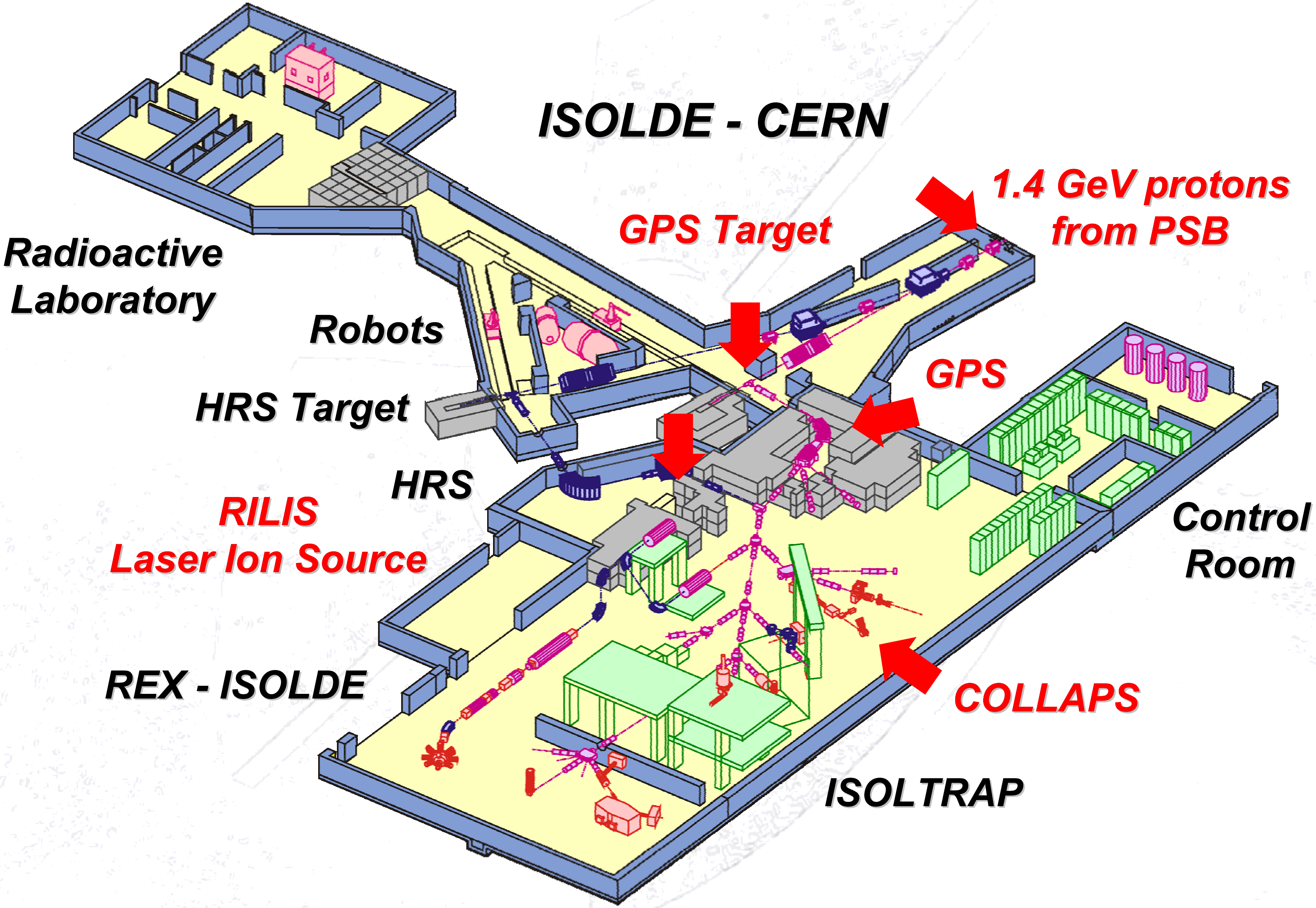
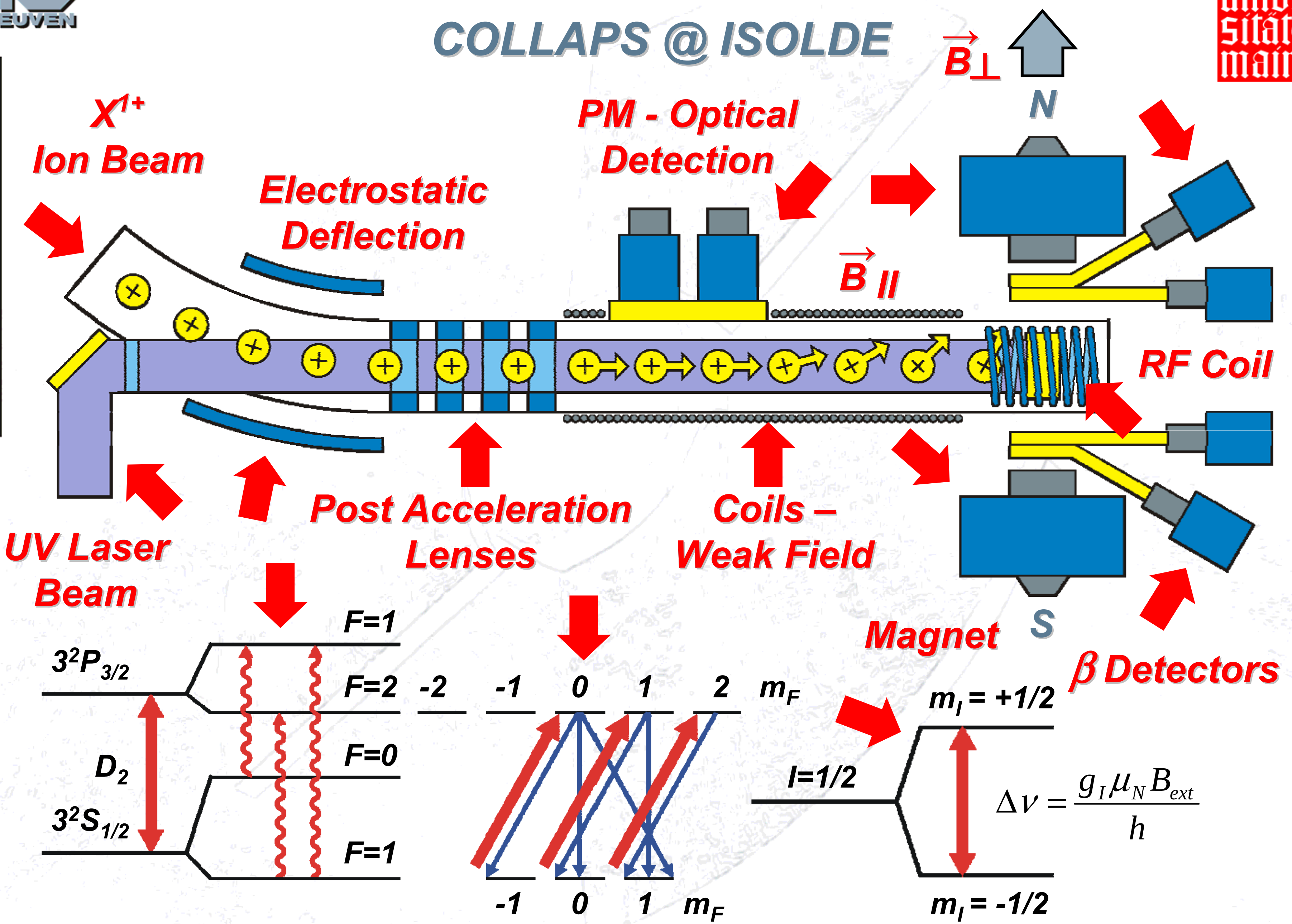

ISOLDE - CERN
1.4 GeV protons from PSB
GPS Target
Radioactive Laboratory
Robots
HRS Target
GPS
HRS
RILIS
Laser Ion Source
Control Room
REX - ISOLDE
COLLAPS
ISOLTRAP

COLLAPS @ ISOLDE



Nuclear Orientation

$$P = \sum_{m_I} m_I W(m_I)/I$$

$$W(\theta) \approx 1 + (v/C) P A \cos(\theta)$$

$$\beta_{asymmetry} = \frac{N(0) - N(\pi)}{N(0) + N(\pi)}$$

Nuclear Magnetic Resonance

$$\Delta E_{nucleus} = h\nu = g_I \mu_N B_{ext}$$

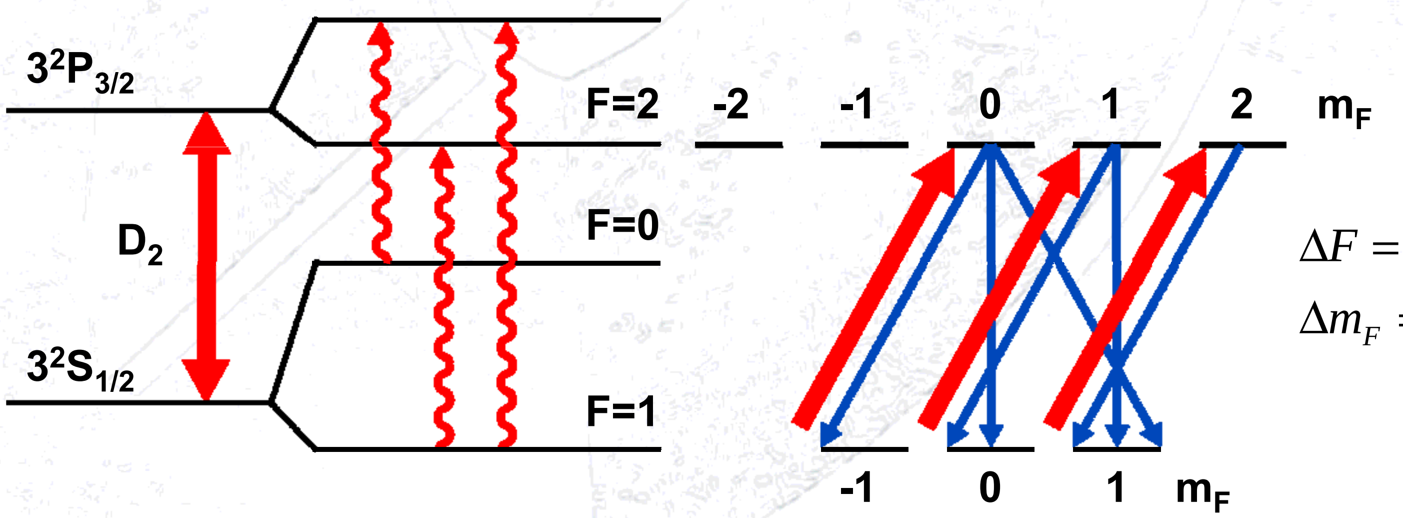
HyperFine Structure

$$\boldsymbol{F} = \boldsymbol{I} + \boldsymbol{J}$$

$$A = g_I \mu_N B(0)/J$$

$$B = eQ \partial^2 V / \partial z^2$$

Optical Pumping



$$\Delta F = 0, \pm 1$$

$$\Delta m_F = 0, \pm 1$$