β-*decay studies near N=28*

Zhihuan Li (RIKEN)

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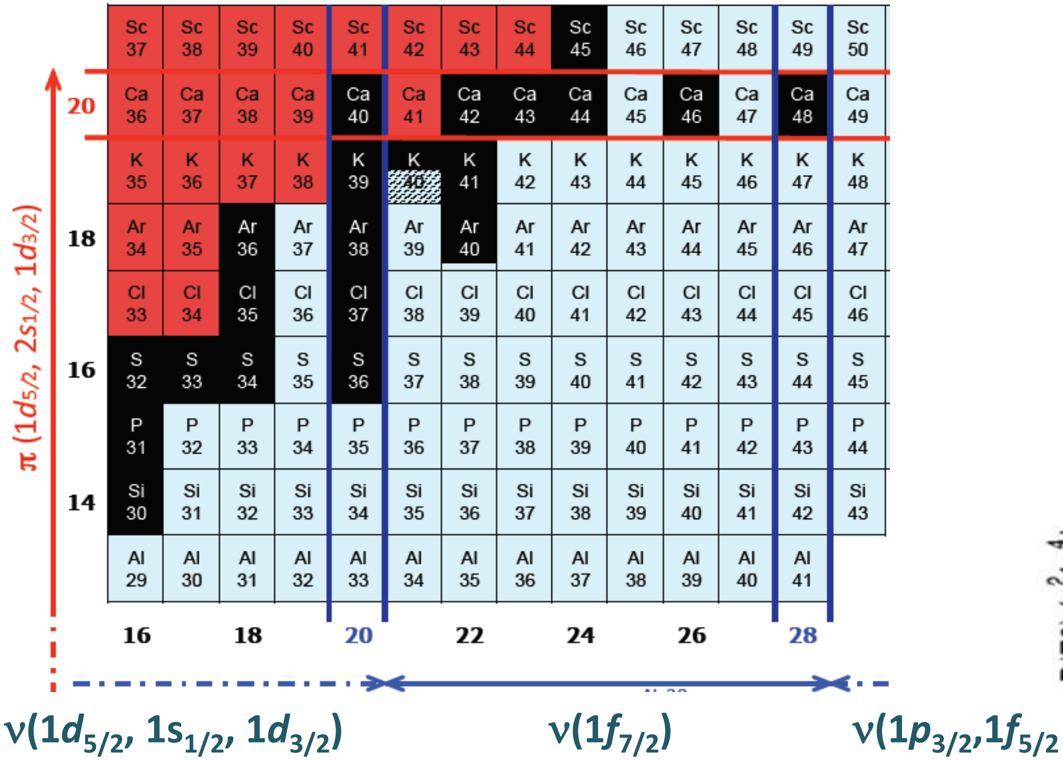
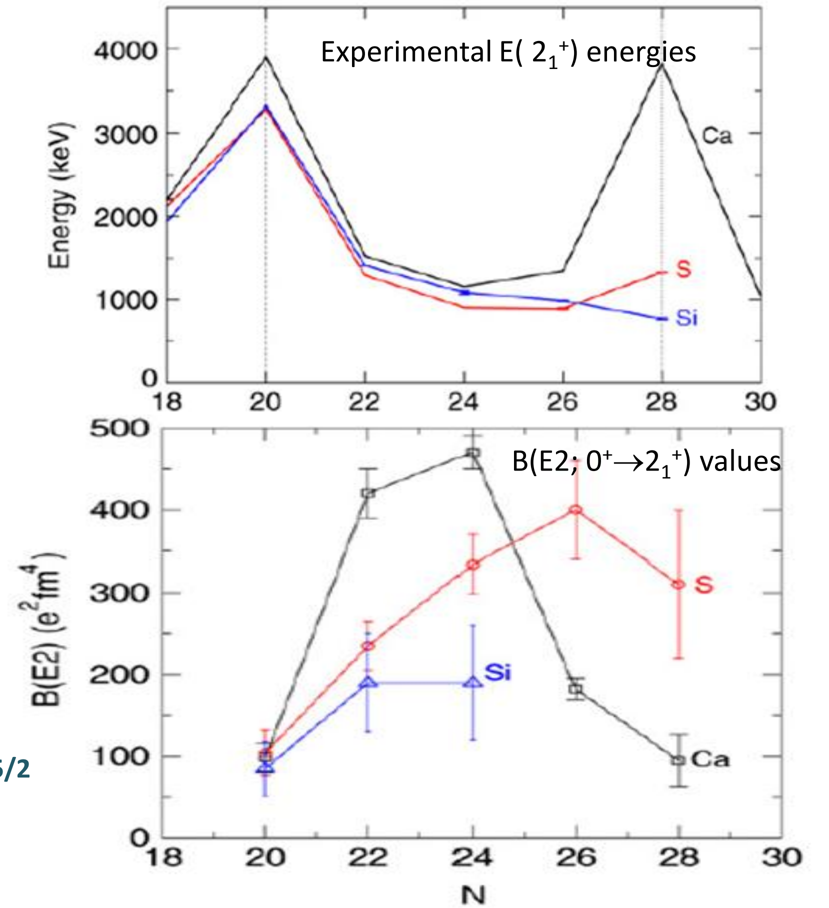
Shell evolution in N~28



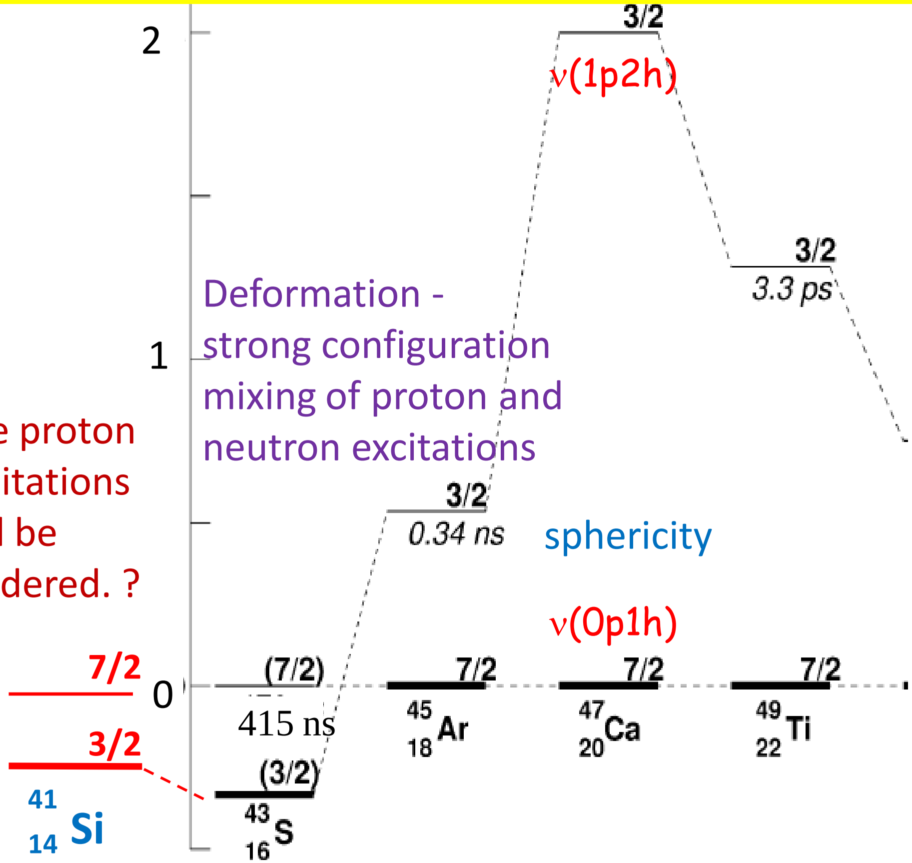


The experimental $E(2_1^+)$and B(E2) values in Ca Si, S isotopic chains

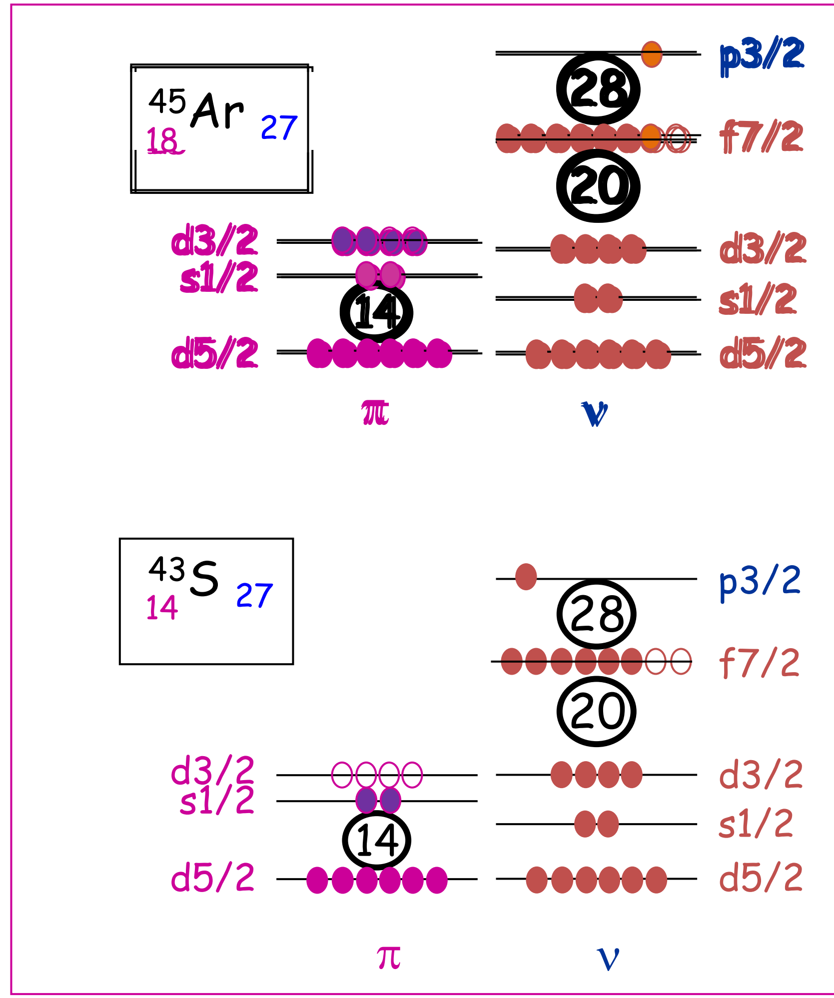
- The orders of their single-particle orbits may shift
- Appearance /disappearance of magic numbers
  Formation of new regions of deformation.
- New neutron magic number 14 and 16 in O isotopes
- Break down of magic number N=20 in the island of inversion region
- Disappearance of the neutron shell closure at N=28 in ^{42}Si.

The low lying levels of ^{41}Si

The proton excitations will be hindered. ?



The systematic of the energies of the 3/2- states relative to 7/2 ones in N=27 nuclei.



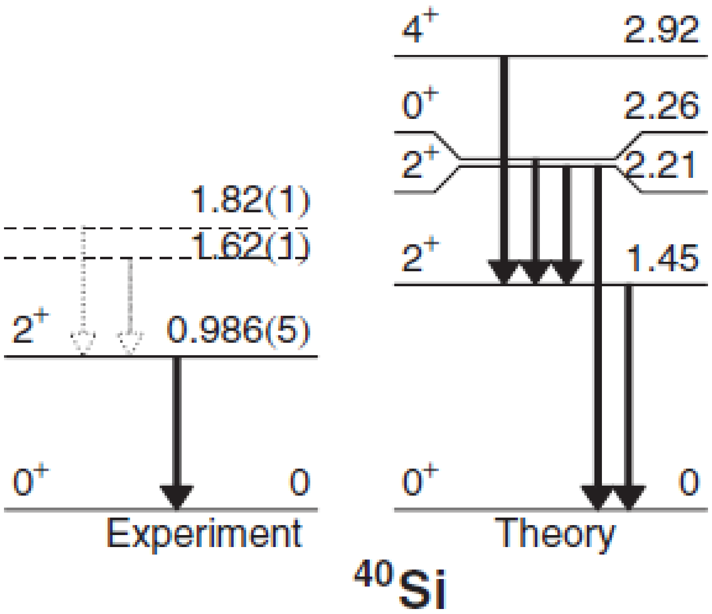
Predictions by L. Gaudefroy *et al.*,

Phys. Rev. C 78(2008)034307

Zs. Dombradi *et al.*, Nucl. Phys. A 727(2003)195

- The strength of the mixing of the two components could be get from the lifetime of the 7/2⁻ state.

Low lying levels of ^{40}Si



- The inelastic scattering and nucleon removal reaction on a liquid hydrogen target

- To reproduce the experimental result, the reduction of the n-n interaction at Z=14 is needed, but this reduction will cause the overestimating size of N=28 shell gap

C. M. Campbell et al., Phys. Rev. Lett. 97(2006)112501

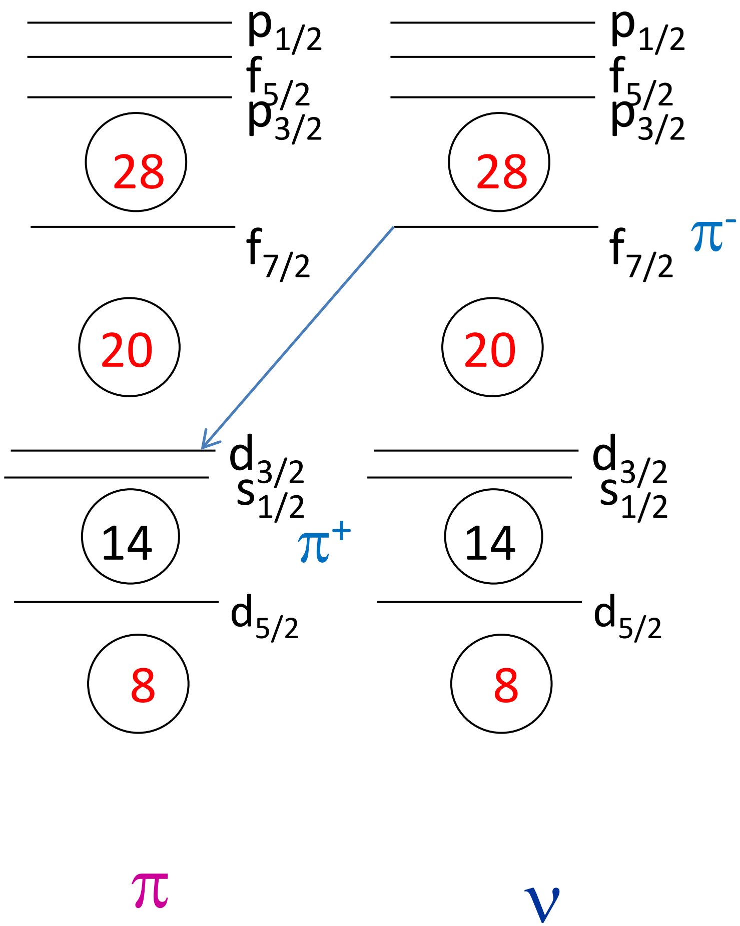
16	^{36}S Pn Half-life	^{37}S 5 ms	^{38}S 170 ms	^{39}S 11.5 s	^{40}S 8.8 s	^{41}S 1.99 s	^{42}S 1.0 s	^{43}S 40% 0.28 s	^{44}S 18 % 100 ms
15	^{35}P 47.3 s	^{36}P 5.6 s	^{37}P 2.31 s	^{38}P 12 % 640 ms	^{39}P 26% 280 ms	^{40}P 16% 125 ms	^{41}P 30 % 100 ms	^{42}P 50 % 48.5 ms	^{43}P 100 % ? 36.5 ms
14	^{34}Si 2.27 s	^{35}Si 780 ms	^{36}Si < 10 % 450 ms	^{37}Si 17 % 90 ms	^{38}Si ? ?	^{39}Si ? 47.5ms	^{40}Si ? 33 ms	^{41}Si ? 20 ms	^{42}Si ? 12.5 ms
13	^{33}Al 8.5 % 41.7 ms	^{34}Al 27 % 42 ms	^{35}Al 42 % 38.6 ms	^{36}Al <31 % 90 ms	^{37}Al ? 10.7 ms	^{38}Al ? 7.6 ms	^{39}Al ? 7.6 ms	^{40}Al ? ?	^{41}Al ? ?
	20	21	22	23	24	25	26	27	28

- Low lying levels of ^{40}Si and ^{41}Si via the beta decay of ^{40}Al and ^{41}Al

- beta decay of ^{40,41,42} Si and ^{41,42,43}P
  to test the shell model in wide range in near N=28 region

β- decay spectroscopy

- The β-decay measurement for the nuclei near N=28 below ^{48}Ca.
  - The parities of the ground-states of the parent and daughter are different. It will limit the possibility for direct feeding to the ground state.
  - The large Q-value window allows a large number of excited states to be populated.
  - Large P_n, β-delayed gamma and neutron measurements are needed.



Lifetime measurement

•The isomeric state produced in the fragmentation

•The long-lived excited state populated in the β-decay

- Time-delayed $\beta\gamma\gamma(t)$ measurement

Plastic scintillator: Timing (start)

Fast time response

$LaBr_3$: Timing (stop)

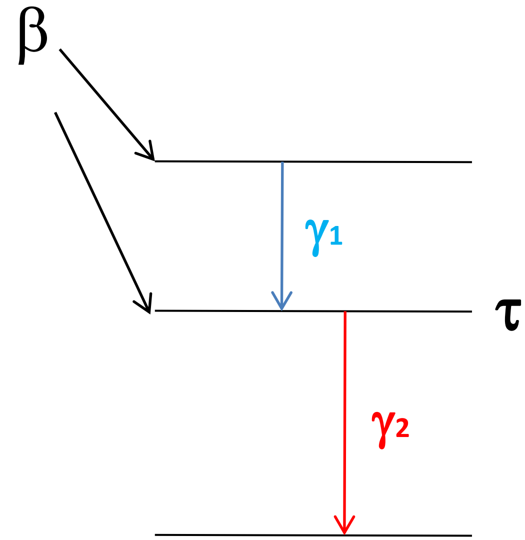
Fast time response

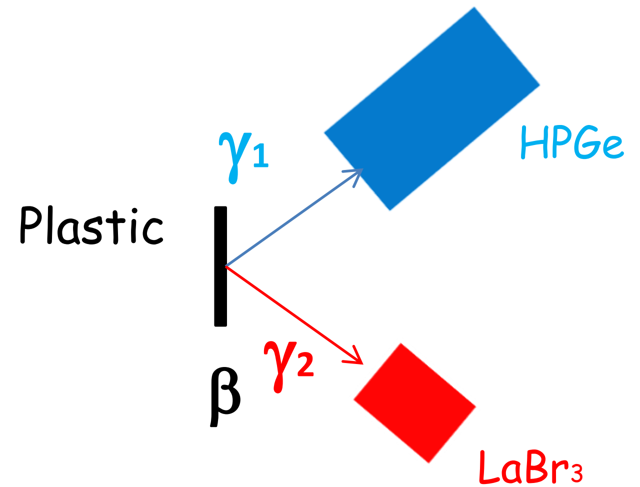
Poor energy resolution

HPGe: Branch selection

High energy resolution

Poor time response





$\tau >$ 30 ps by fitting the slope of time spectrum

$\tau \sim$5-10 ps by centroid shift of time spectrum relative to the prompt position

H.Mach *et al.*, Nucl. Phys. A523(1991)197

Experimental setup

BigRIPS+ZeroDegree ^{48}Ca beam at 350AMeV with 200pnA

- PID: event-by-event $B\rho$-ΔE–TOF
- β-ray

  plastic scintillator
- β-delayed γ

  Clover Germanium detectors

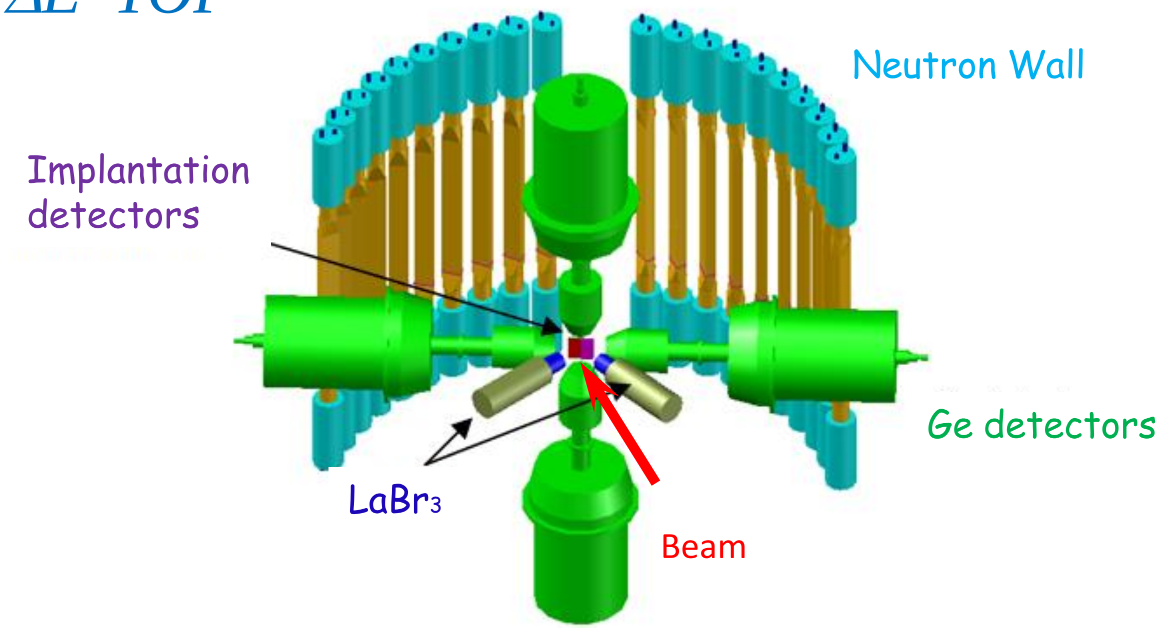
  $\varepsilon_\gamma > 5\%$ @ 1 MeV
- β-delayed neutron

  plastic scintillation bars

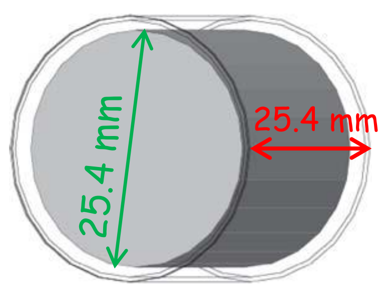
  $\varepsilon_n \sim 5\%$ @ 1 MeV
- Lifetime by time-delayed βγγ(t)

  two 1 inch×1 inch LaBr3 counters

  $\varepsilon_\gamma \sim 2.6\%$ @ 1 MeV



Schematic drawing of the experiment setup



Beam estimation

Isotopes of interest	Half-life (ms)	Beam on/off periods (ms)	Rate (pps)	Main contaminants	Days
^{41}Al	~5 ?	Continuous mode	5	^{42}Si(60%)	**1**
^{40}Al	~5 ?	Continuous mode	13	^{41}Si(60%)	**1/2**
^{42}Si	12.5	40/50	125	^{43}P(33%)	**1/2**
^{41}Si	20	60/80	844	^{42}P(7%)	**2/3**
^{40}Si	33	100/130	4650	^{41}P(12%)	**1/3**
^{43}P	36.5	110/140	2740	^{44}S(1%)	**1/3**
^{42}P	48.5	150/200	12600	^{43}S(4%)	**1/3**
^{41}P	100	300/400	54600	^{42}S(6%)	**1/3**
electronics adjustment& calibration					**1**
total					**5**

The conditions of BigRIPS are optimized with minimal change of target and wedge configurations.

Summary

- **The goals of the experiment**

  Beta decay studies near N=28

  - low lying states of ^{41}Si, ^{40}Si
  - beta decay of $^{40,41}Al$, $^{40,41,42}Si$, $^{41,42,43}P$

- **Experimental method**

  - beta delayed gamma, neutron measurement
  - lifetimes for long-lived states by $\beta\gamma\gamma(t)$ measurement