Hindered proton collectivity in the proton-rich nucleus ^{28}S: Possible new magic number $Z=16$

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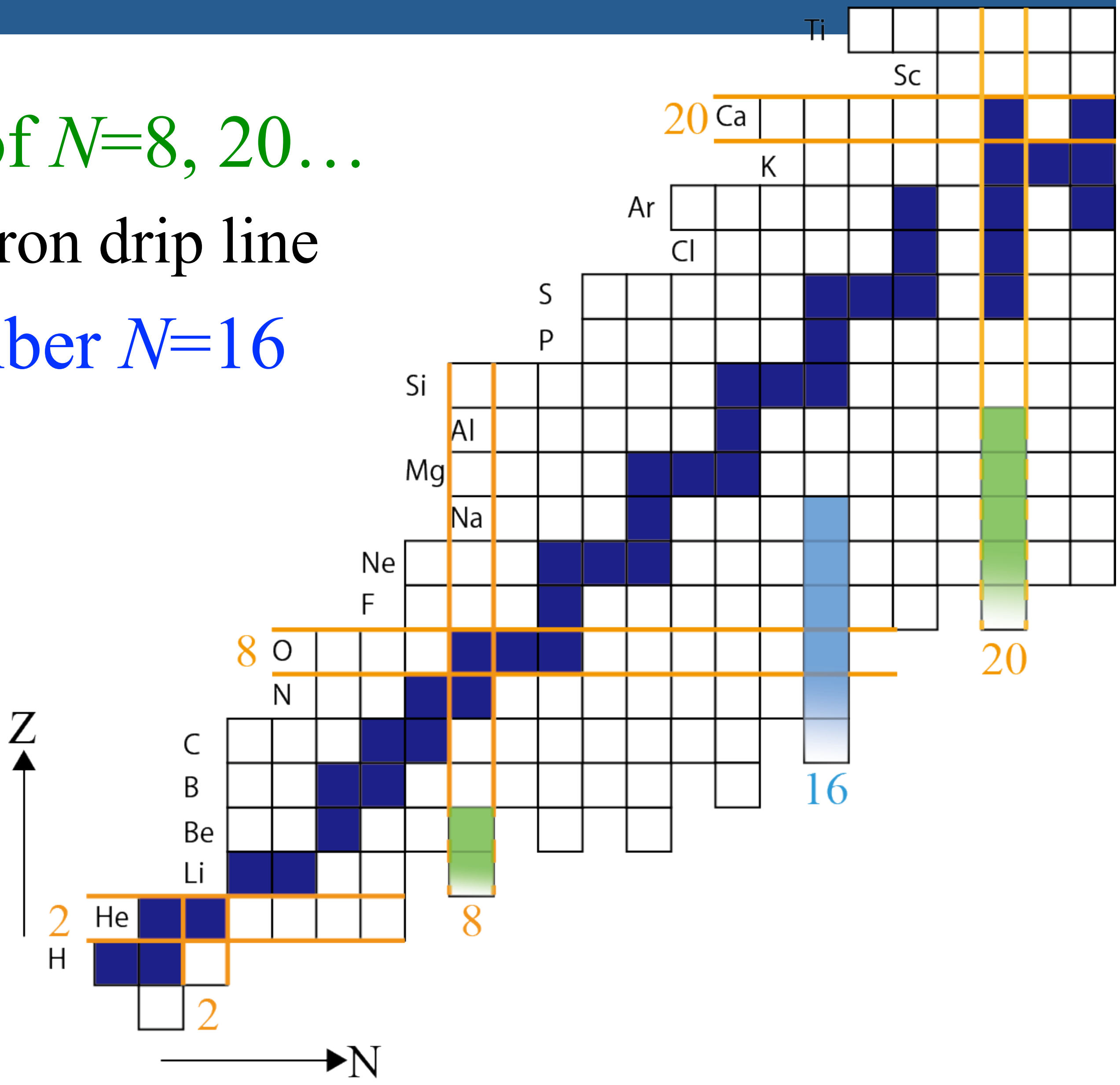
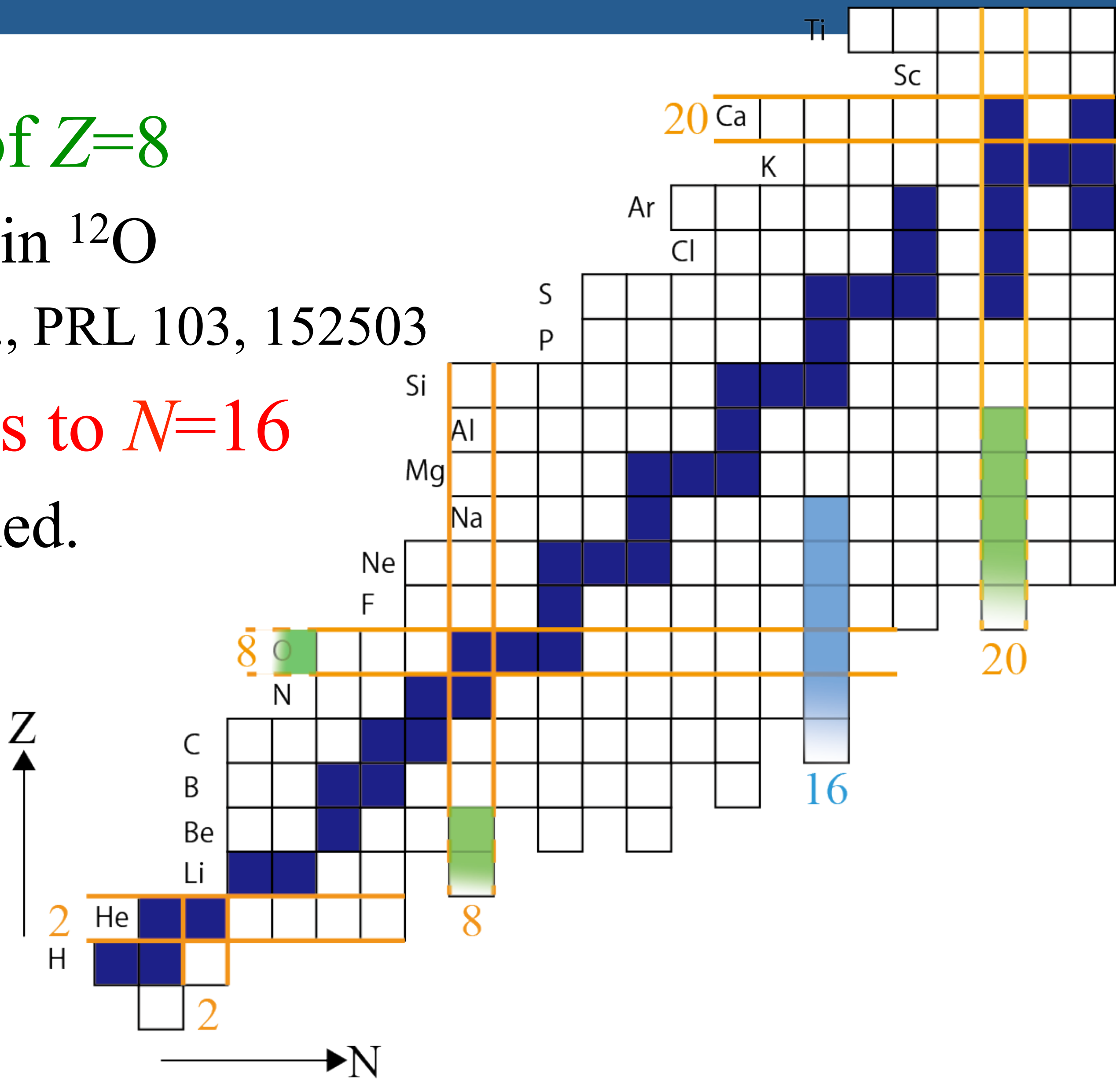
Magic numbers at neutron-rich nuclei

- Disappearance of N=8, 20…
  - Vicinity of neutron drip line
- New magic number N=16
  - Around ^{24}O



Magic numbers at proton-rich nuclei

- Disappearance of Z=8
  - 2+ state energy in ^{12}O
    - D. Suzuki et al., PRL 103, 152503
- Z=16: Analogous to N=16
  - Not yet confirmed.



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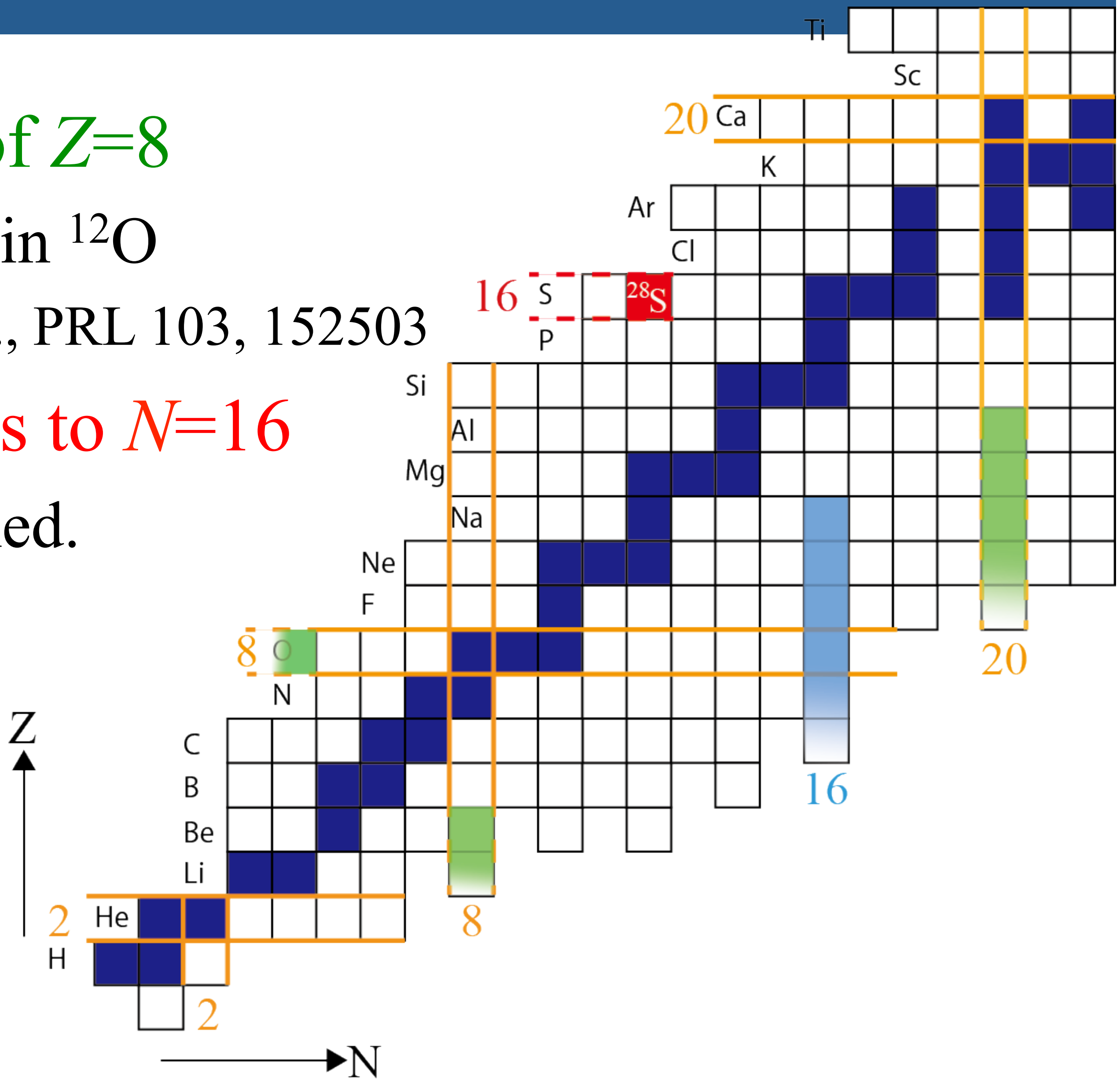
Coulomb excitation of ^{28}S



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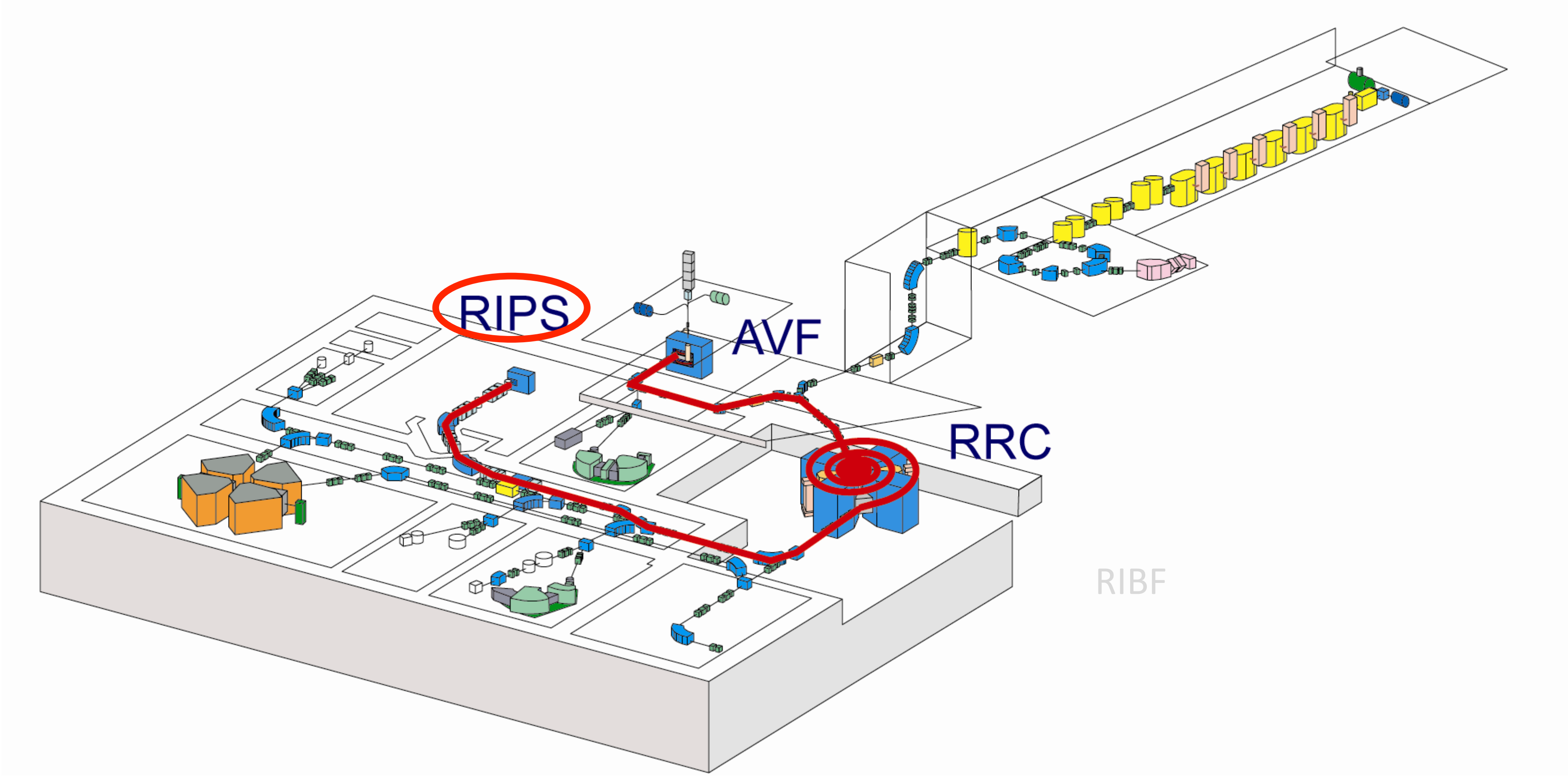
- Primary beam: 115 MeV/u ^{36}Ar
  - AVF-RRC → RIPS

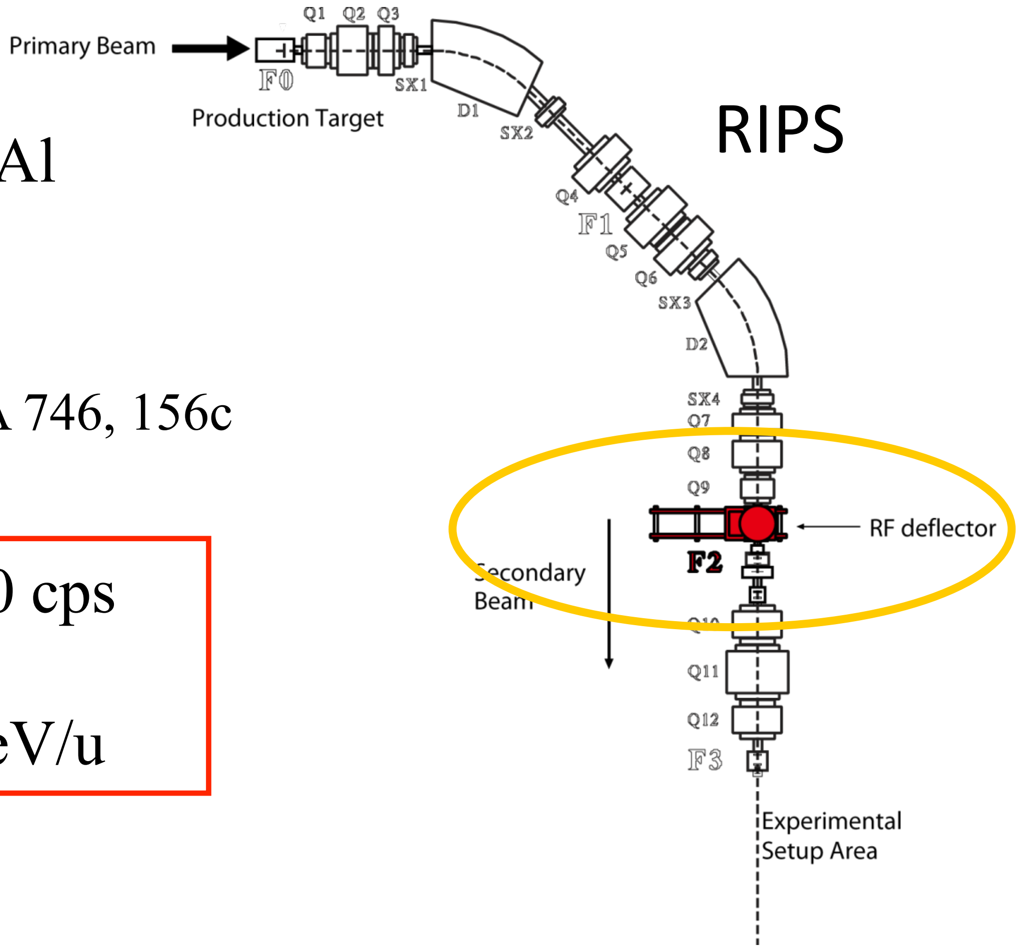


RIPS + RF deflector

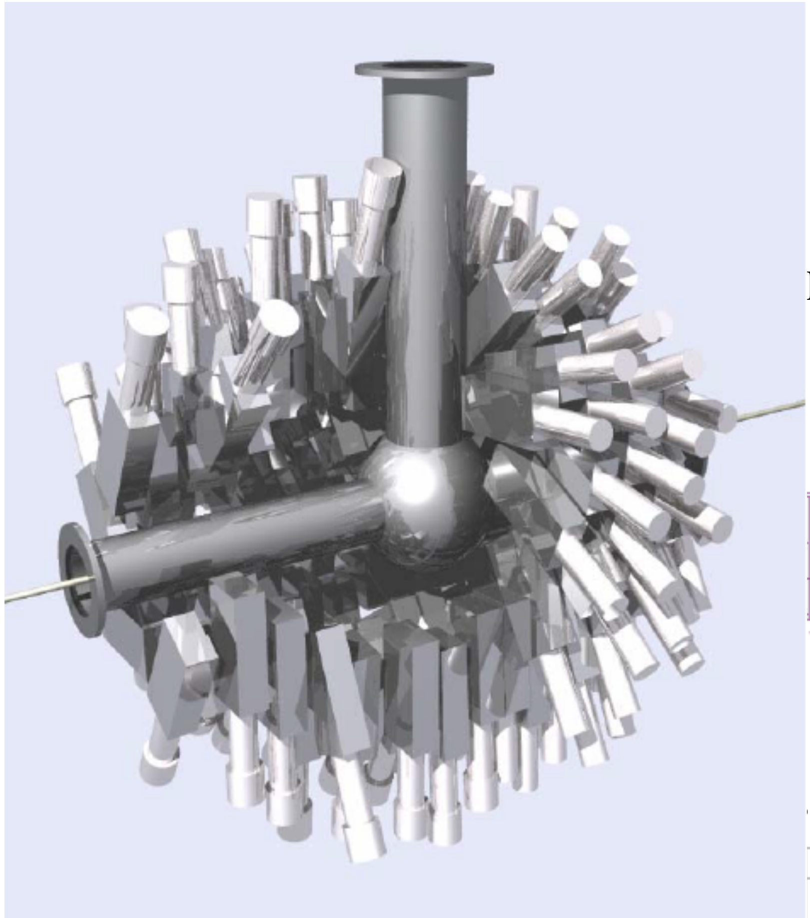
- Primary beam: 115 MeV/u ^{36}Ar
- Target: 531 mg/cm^2 Be
- Degrader at F1: 221 mg/cm^2 Al
- RF-deflector
  - To purify the beam
  - K. Yamada et al., Nucl. Phys. A 746, 156c

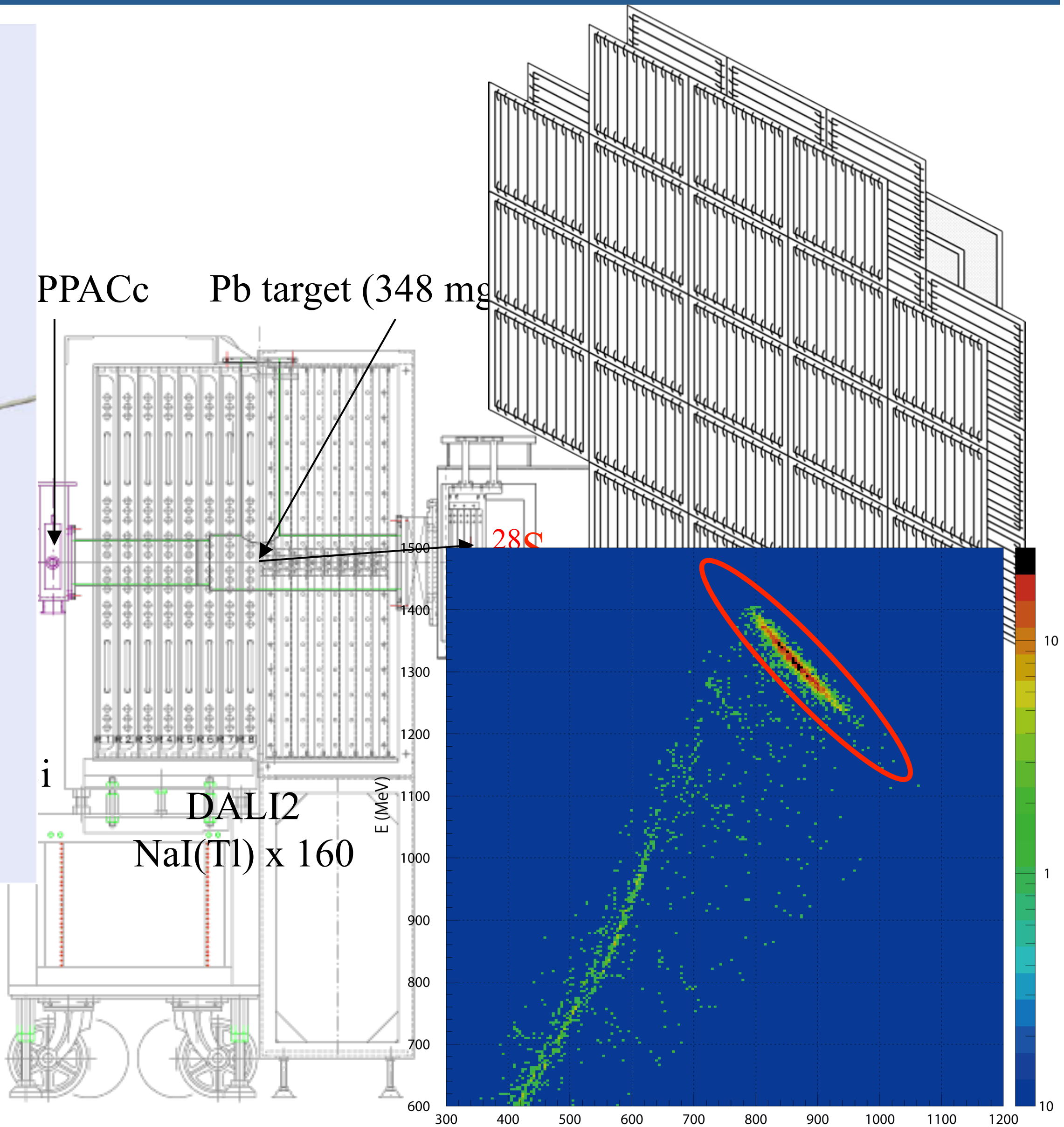
^{28}S

Intensity: ~120 cps
Purity: 1.9%
Energy: 53 MeV/u



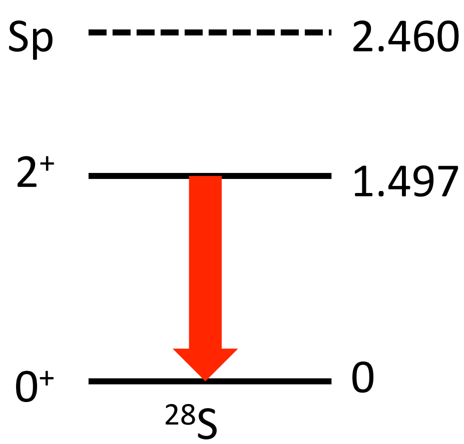
Experimental Setup

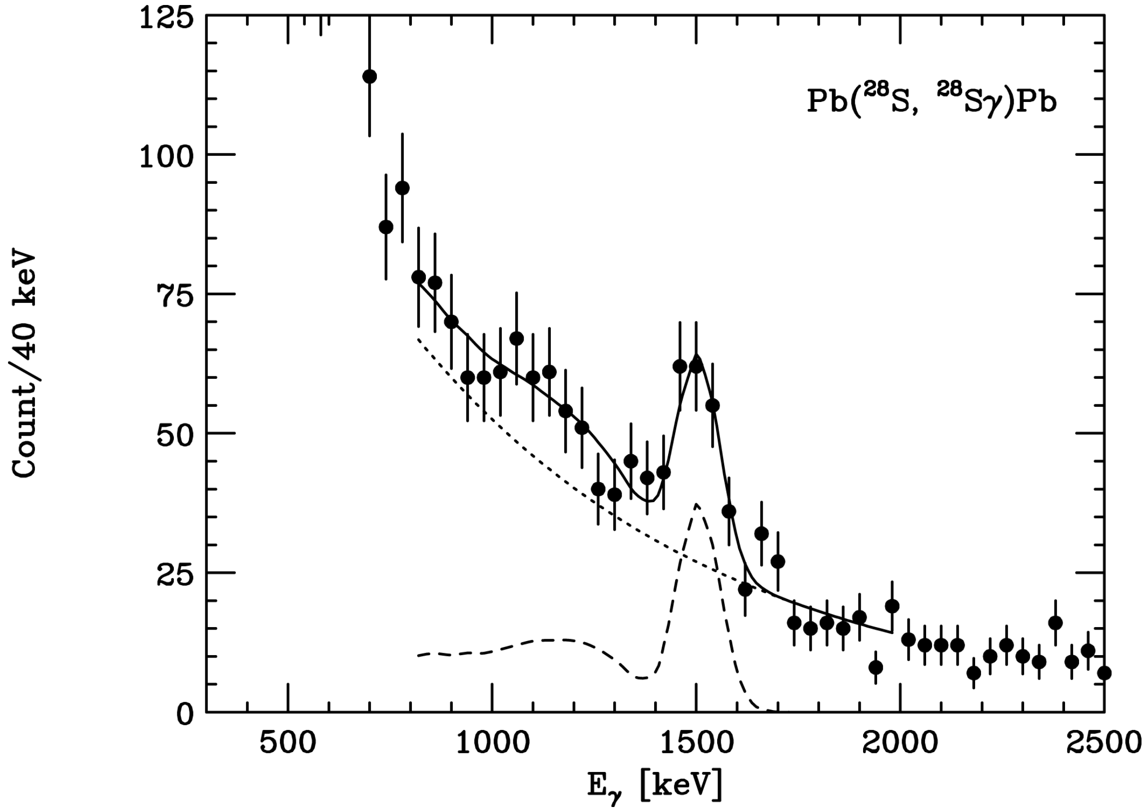




Gamma-ray energy spectrum

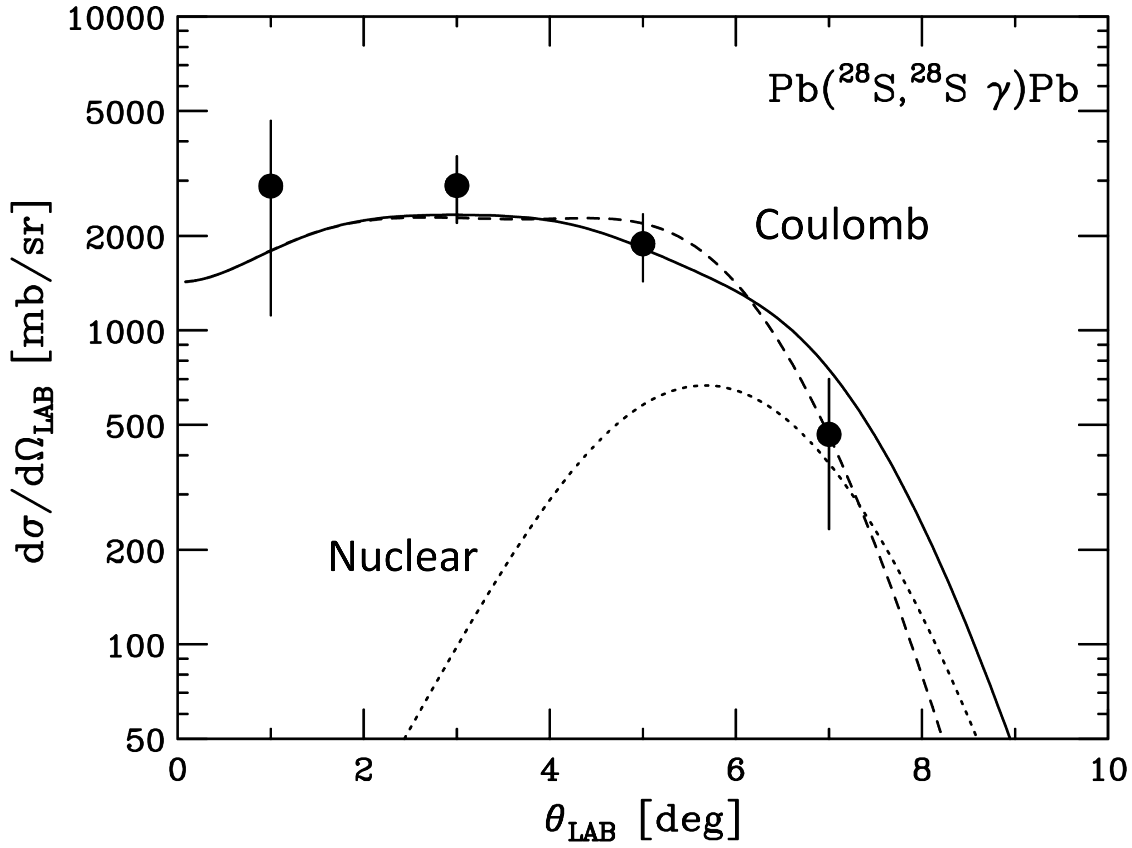
- Ex=1.497(11) MeV
  - Consistent with previous result: 1.512(8) MeV
    - 2 neutron-knockout from ^{30}S (K. Yoneda et al. PRC 74, 021303)





Angular distribution of $^{28}S^*$

- Angle integrated cross section: 99(16) mb.
- DWBA analysis
  - Optical potential parameters: $^{17}O + ^{208}Pb$ at 97 MeV/u



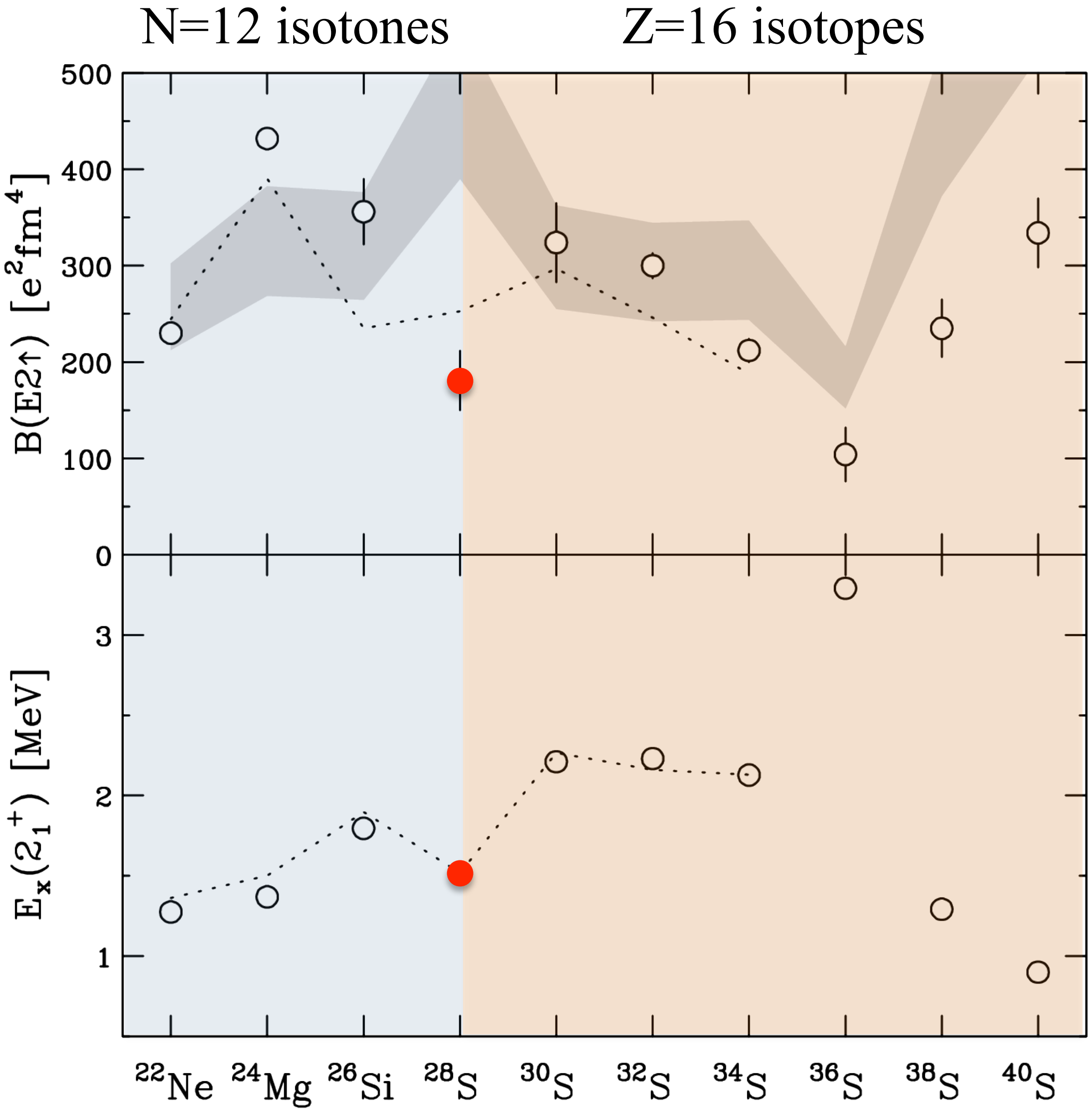
Coupling potential:
E2 Coulomb +
derivative of opt. pot.

$B(E2;0_{gs}^{+}\rightarrow 2_{1}^{+}) = 181(31)\ e^2\mathrm{fm}^4$

B(E2) values and Ex(2^+_1)

- $B(E2)$ systematics
  - $B(E2) \propto 1/\mathrm{Ex}(2+)$
    - S. Raman et al.
    - At. Data. Nucl. Data. Tables 78, 1
- USDB shell model
- ^{28}S
  - Smaller $B(E2)$
  - Smaller Ex(2^+)

n-dominant excitation?
cf. ^{16}C



Double ratio $|M_n/M_p|/(N/Z)$

- $M_{n(p)}$: neutron (proton) transition matrix amplitude
- $|M_n/M_p|/(N/Z)$
  - Relative contribution of p/n to a transition
  - > 1.0: Neutron dominance ← Singly *p* magic nuclei
    - cf. $^{18,20}O$, Sn isotopes (A. M. Bernstein, PLB 103, 255)
- $|M_p|$= sqrt($B(E2)/e$)
- $|M_n|$: M_p of the mirror partner ← $B(E2)$ of ^{28}Mg

$|M_n/M_p|/(N/Z) = 1.9(2)$

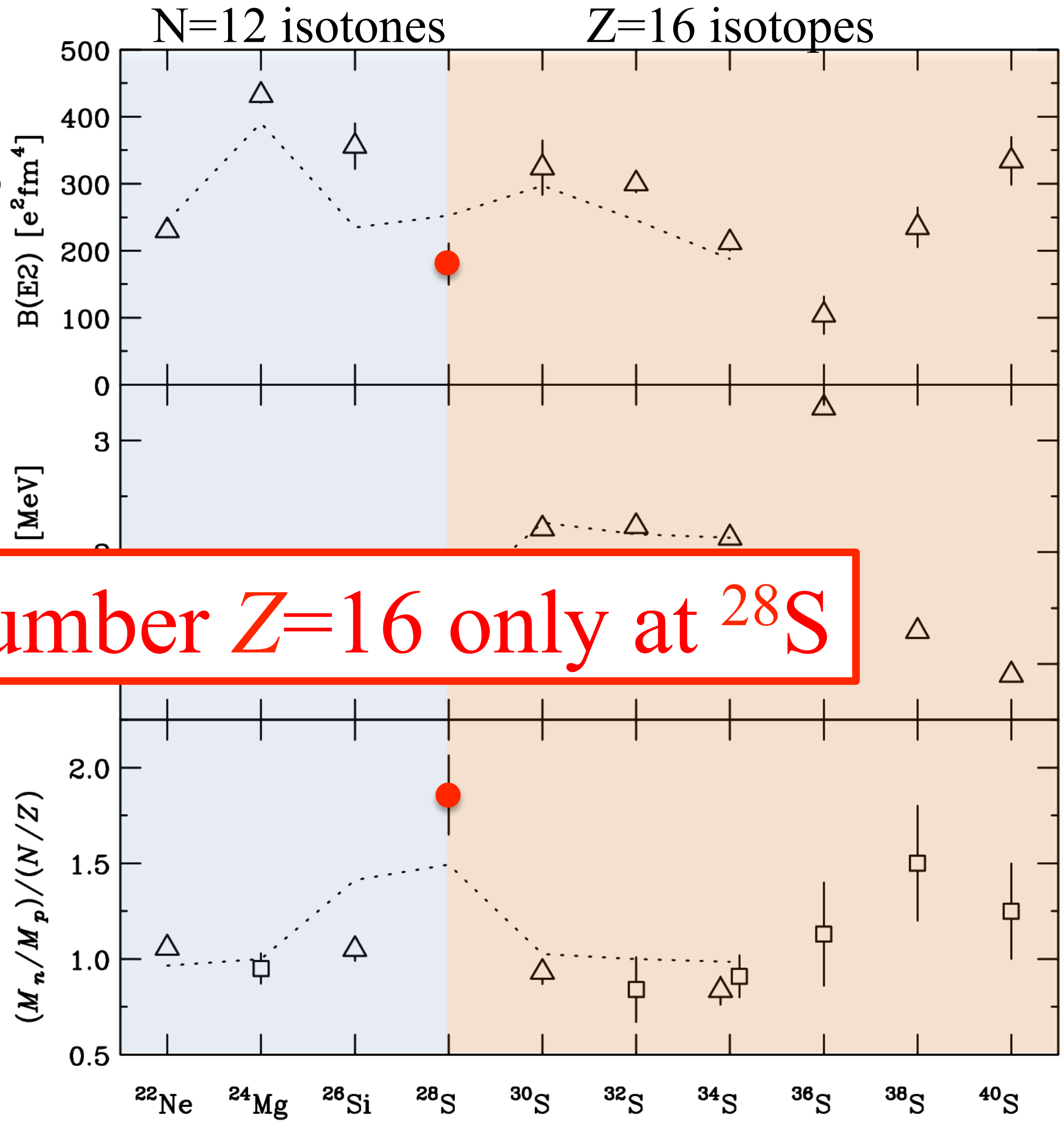
^{28}S: Singly *p* magic nucleus ← Z=16

Double ratio $|M_n/M_p|/(N/Z)$

- N=12 isotones, $^{30\text{-}36}S$
  - Double ratio ~ 1
- $^{38,40}S$
  - – Neutron skin effect

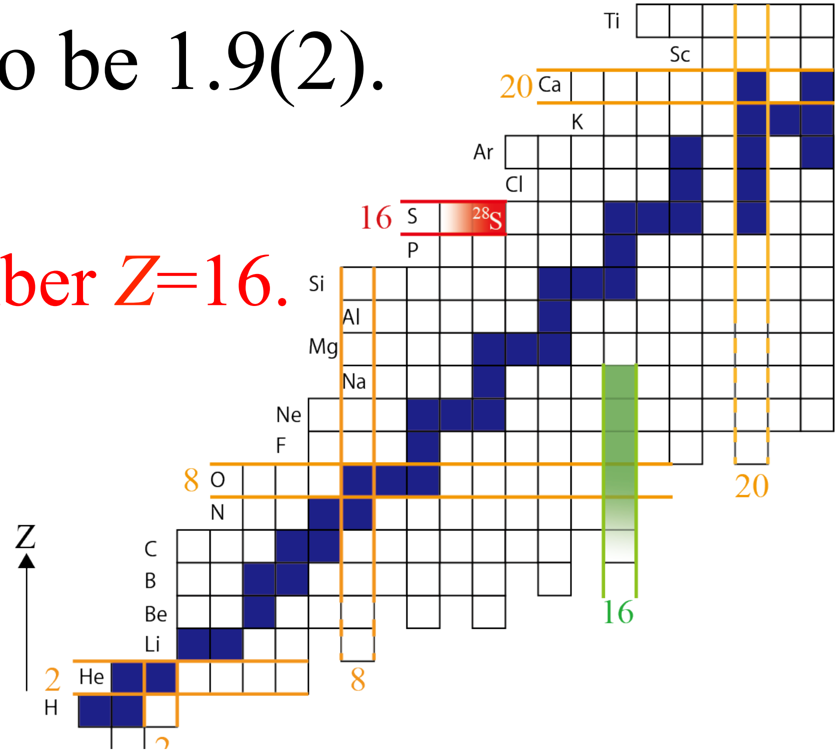
New magic number Z=16 only at ^{28}S

- ^{28}S
  - – Sudden increase



Summary

- $B(E2;0^{+}_{gs}\rightarrow 2^{+}_{1})$ of ^{28}S was obtained experimentally to be 181(31) e^2fm^4 using Coulomb excitation at 53 MeV/nucleon.
  - Smaller *B*(E2) than neighboring isotopes/isotones.
- $|M_n/M_p|/(N/Z)$ was obtained to be 1.9(2).
  - Neutron dominant excitation.
  - Emergence of new magic number Z=16.



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