Reaction cross section measurements for Ne and Mg isotopes towards the vicinity of neutron-drip line

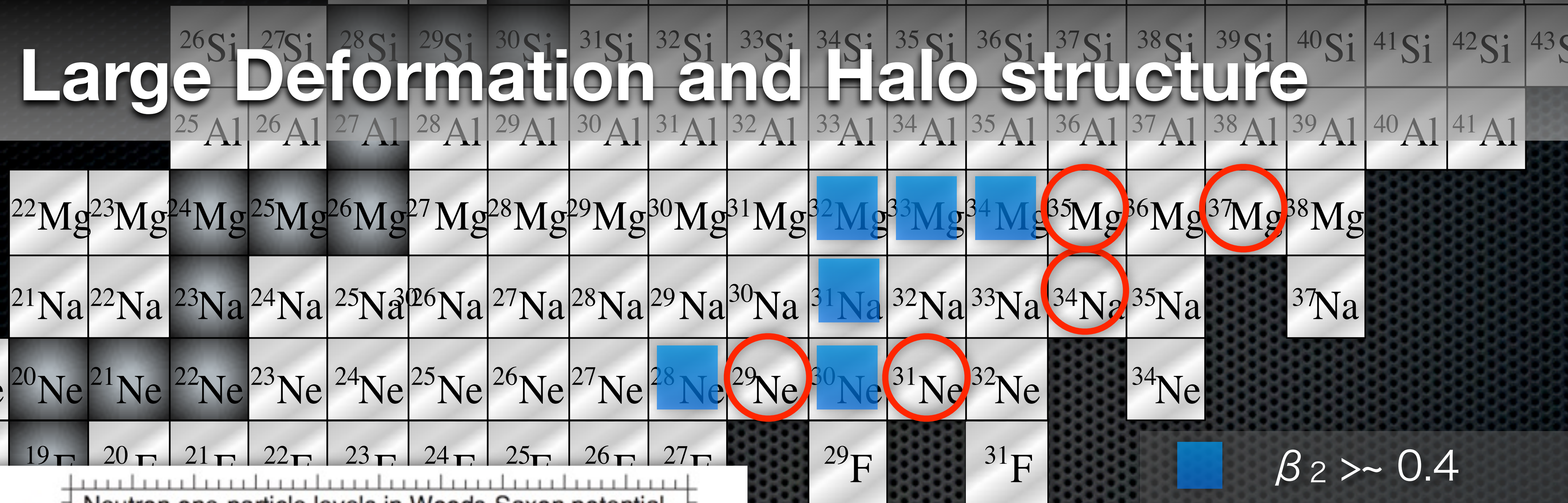
Maya Takechi

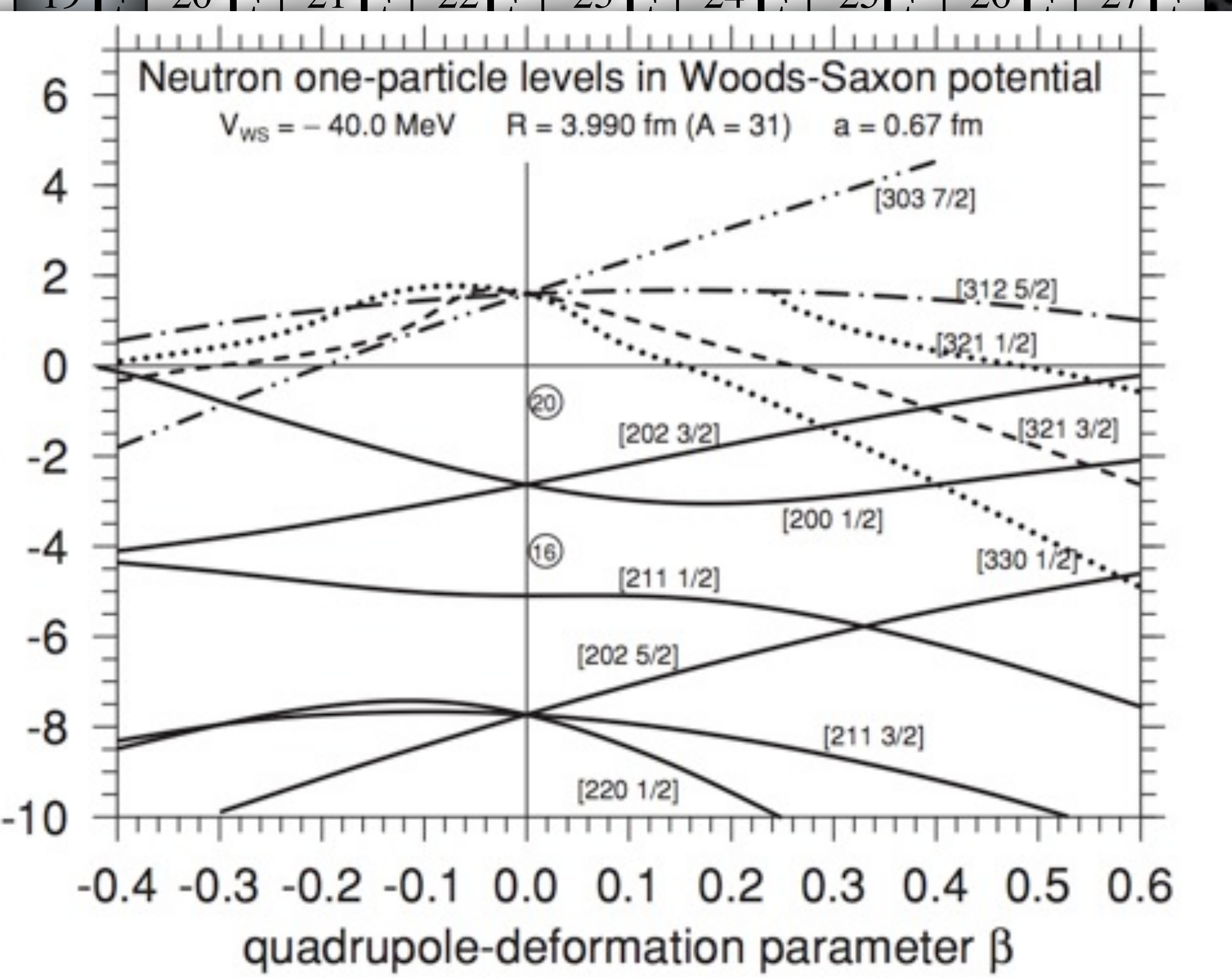
Collaborators

M. Takechi,[1, 2] S. Suzuki,[3] D. Nishimura,[7] M. Fukuda,[4] T. Ohtsubo,[3] M. Nagashima,[3]
T. Kuboki,[5] T. Suzuki,[5] T. Yamaguchi,[5] A. Ozawa,[6] T. Moriguchi,[6] H. Ohishi,[6] T. Sumikama,[2]
H. Geissel,[1] M. Ishihara,[2] N. Aoi,[2] Rui-Jiu Chen,[2] De-Qing Fang,[8] N. Fukuda,[2]
S. Fukuoka,[6] H. Furuki,[5] I. Hachiuma,[5] N. Inabe,[2] Y. Ishibashi,[6] T. Itoh,[3] Y. Itoh,[6]
T. Izumikawa,[3] D. Kameda,[2] T. Kubo,[2] K. Kusaka,[2] M. Lantz,[2] Yu-Gang Ma,[8] K. Matsuta,[4]
M. Mihara,[4] Y. Miyashita,[7] S. Momota,[9] D. Nagae,[6] K. Namihira,[5] R. Nishikiori,[6] T. Niwa,[6]
Y. Ohkuma,[3] T. Ohnishi,[2] M. Ohtake,[2] K. Okumura,[6] M. Ohtake,[2] K. Ogawa,[6] T. Ogura,[3]
H. Sakurai,[2] Y. Shimbara,[3] H. Suzuki,[6] H. Takeda,[2] S. Takeuchi,[2] K. Tanaka,[2] H. Uenishi,[4]
R. Watanabe,[3] M. Winkler,[1] Y. Yanagisawa,[2]

1Gesellschaft fu ̈r Schwerionenforschung GSI, 64291 Darmstadt, Germany
2RIKEN, Nishina Center, Wako, Saitama 351-0106, Japan
3Department of Physics, Niigata University, Niigata 950-2102, Japan
4Department of Physics, Osaka University, Osaka 560-0043, Japan
5Department of Physics, Saitama University, Saitama 338-8570, Japan
6Institute of Physics, University of Tsukuba, Ibaragi, 305-8571, Japan
7Department of Physics, Tokyo University of Science, Tokyo, 278-8510, Japan
8Shanghai Institute of Applied Physics, Chinese Academy of Sciences, 800-204, Shanghai 201800, China
9Faculty of Engineering, Kochi University of Technology Kochi, 782-8502, Japan
10Department of Physics, Kyushu University, Fukuoka 812-8581, Japan

Large Deformation and Halo structure





Hamamoto, Phys. Rev. C **76** 054319

- Large Deformation around N=20
- Inversion between normal sd-shell and intruder fp-shell
- Possible Halo Structures for Intruder states

Study through Nuclear Size

Nuclear Size and Interaction Cross Sections

Reaction Cross Section

$\sigma_{tot} = \sigma_R + \sigma_{el}$

Interaction Cross Section

$\sigma_I = \sigma_R - \sigma_{inel}$

σ_I or σ_R ⟷ **Nuclear Size**

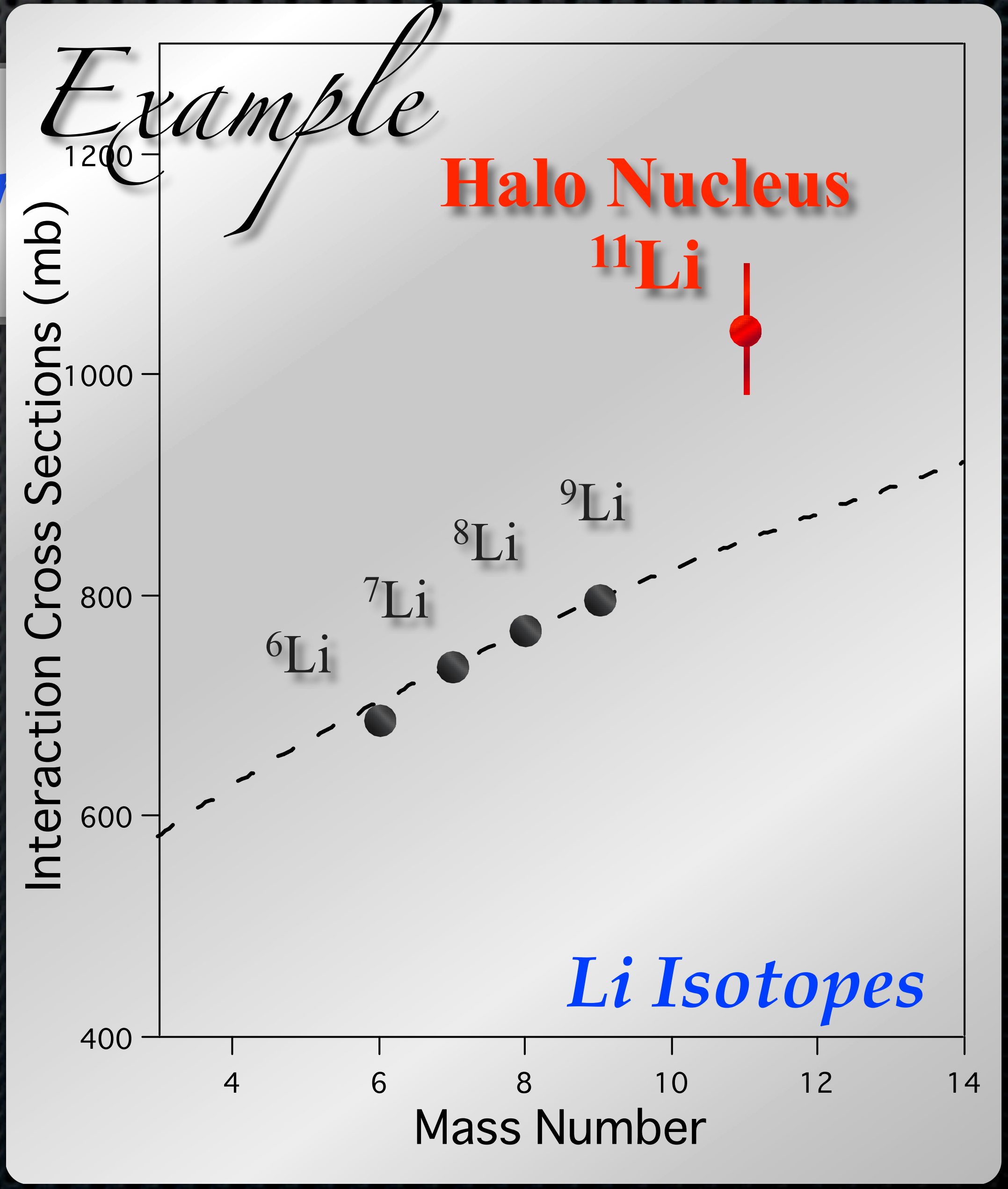
Glauber Calculation

$$\sigma_I = \int d\boldsymbol{b}\left[1 - \exp\left(-\int d^2\boldsymbol{r} \sum_{i,j} \sigma_{NN}(E)\, \rho_z^{P_i}(\boldsymbol{r})\, \rho_z^{T_j}(\boldsymbol{r}\right.\right.$$

σ_I can be uniquely calculated by **3** quantities

- ρ^P Projectile Density
- ρ^T Target Density
- σ_{NN} Nucleon- Nucleon Total Cross Section

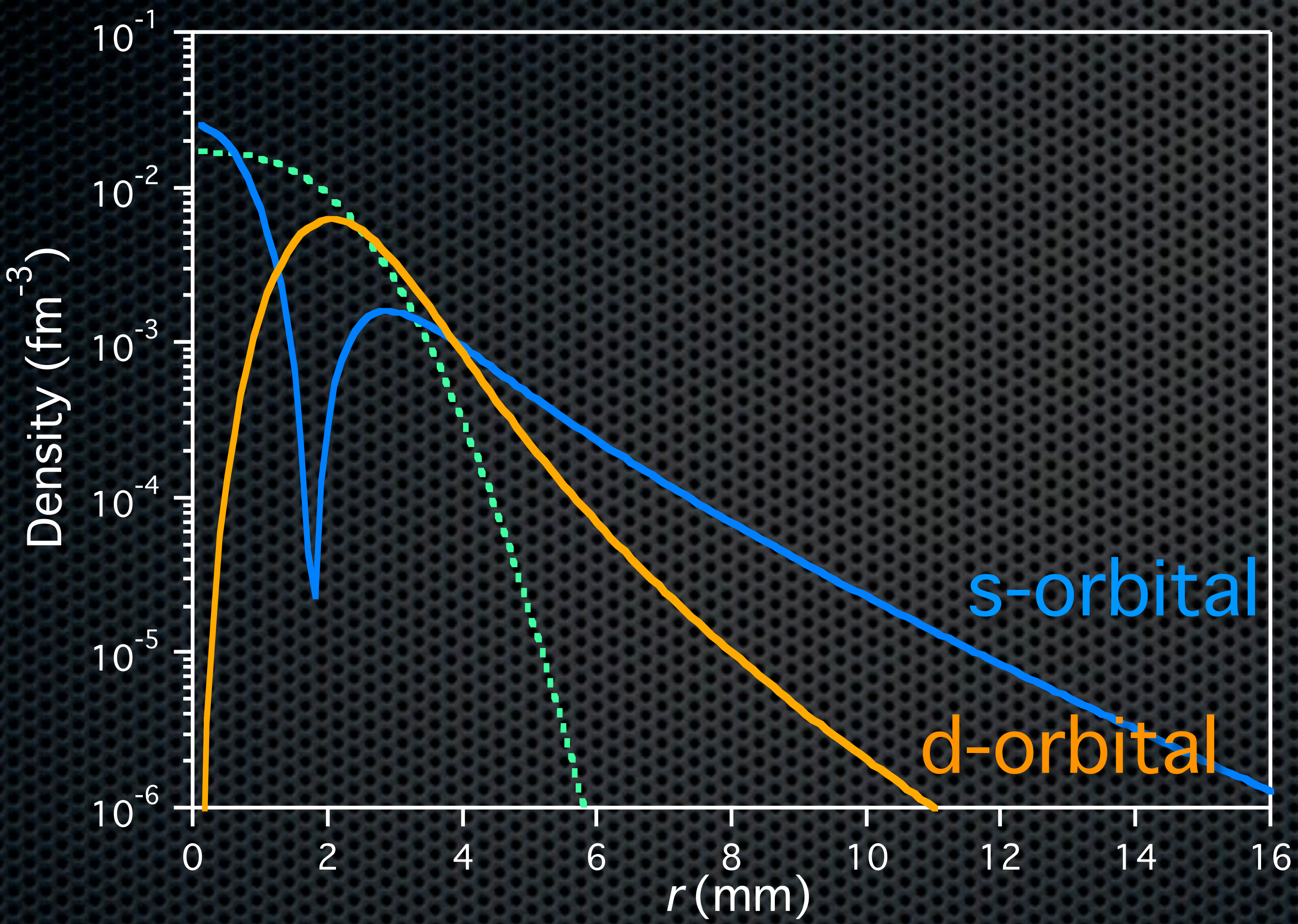
Nuclear Size of unknown Nuclei can be deduced by measuring σ_R

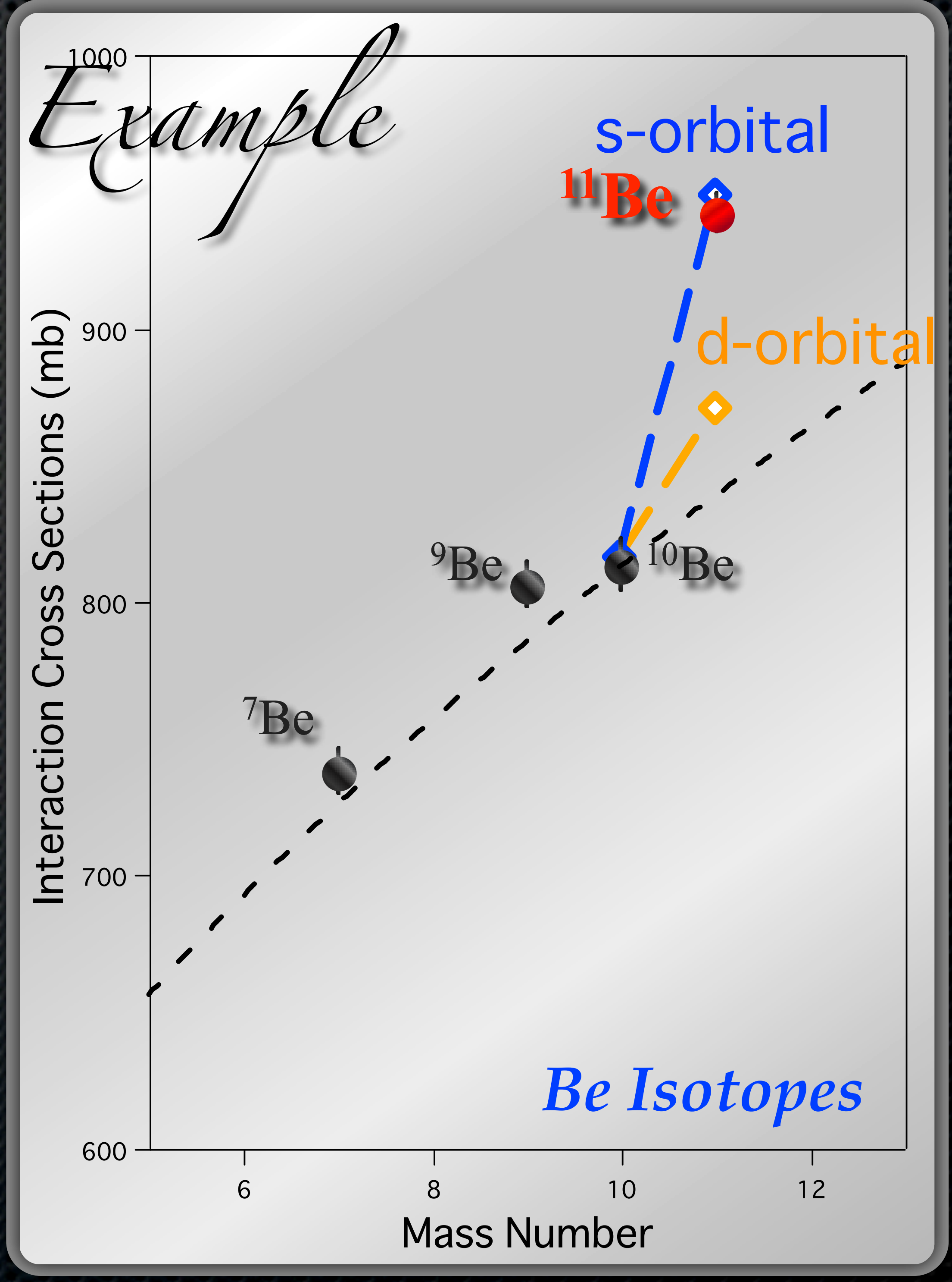


Nuclear Size and Halo Structure

Nuclear size reflects the orbital of valence nucleon

Halo Structure



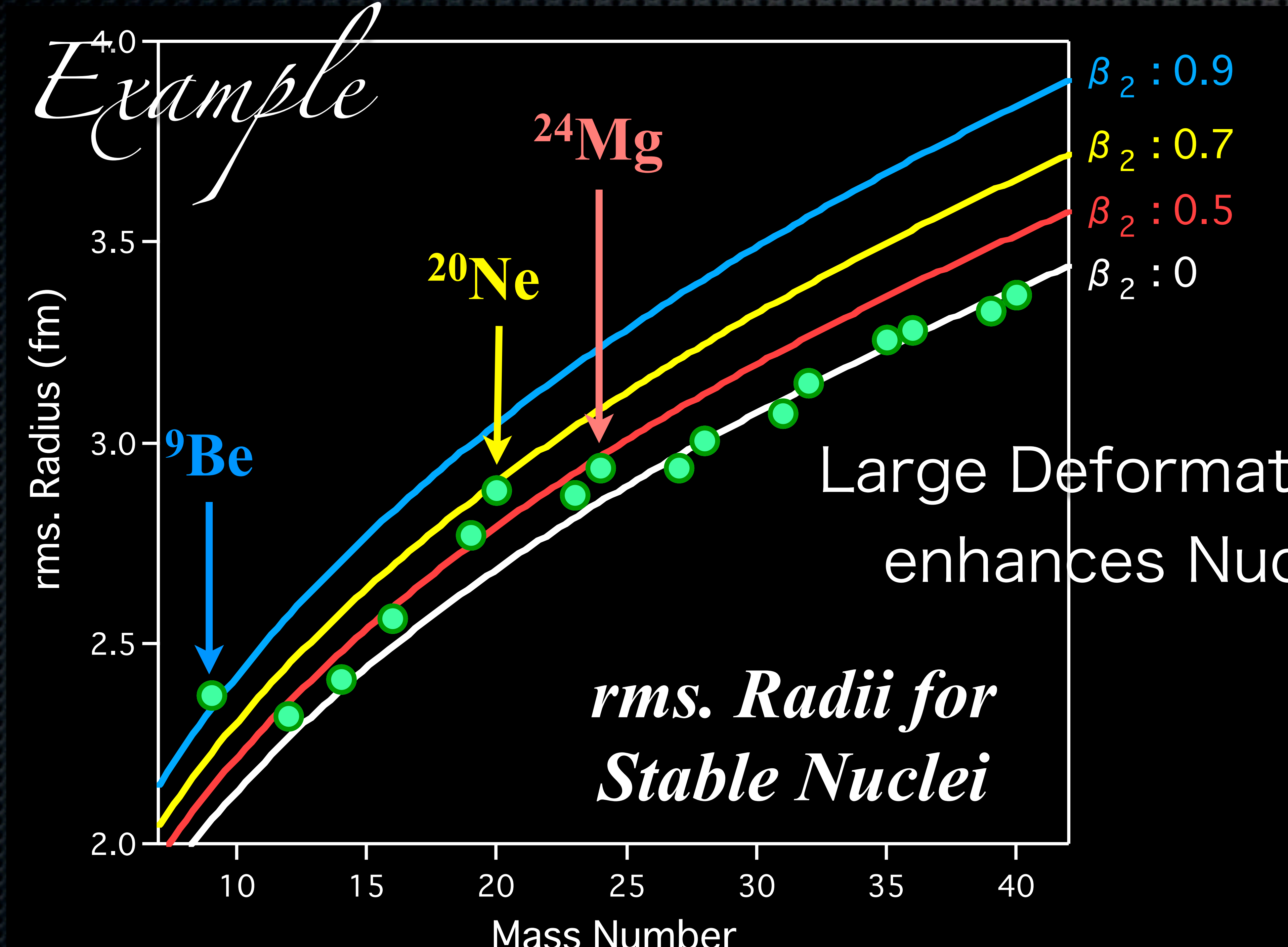


Halo Structure
can be discussed

Nuclear Size and Deformation

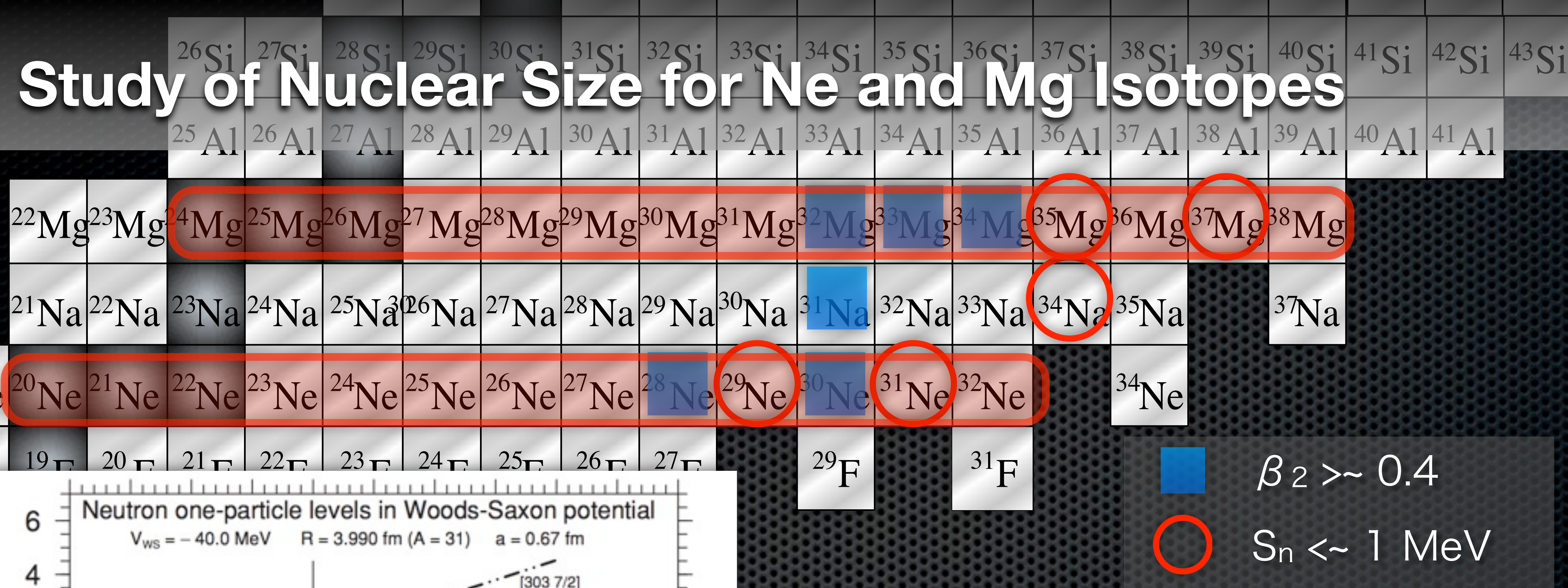
Spherical → Deformed

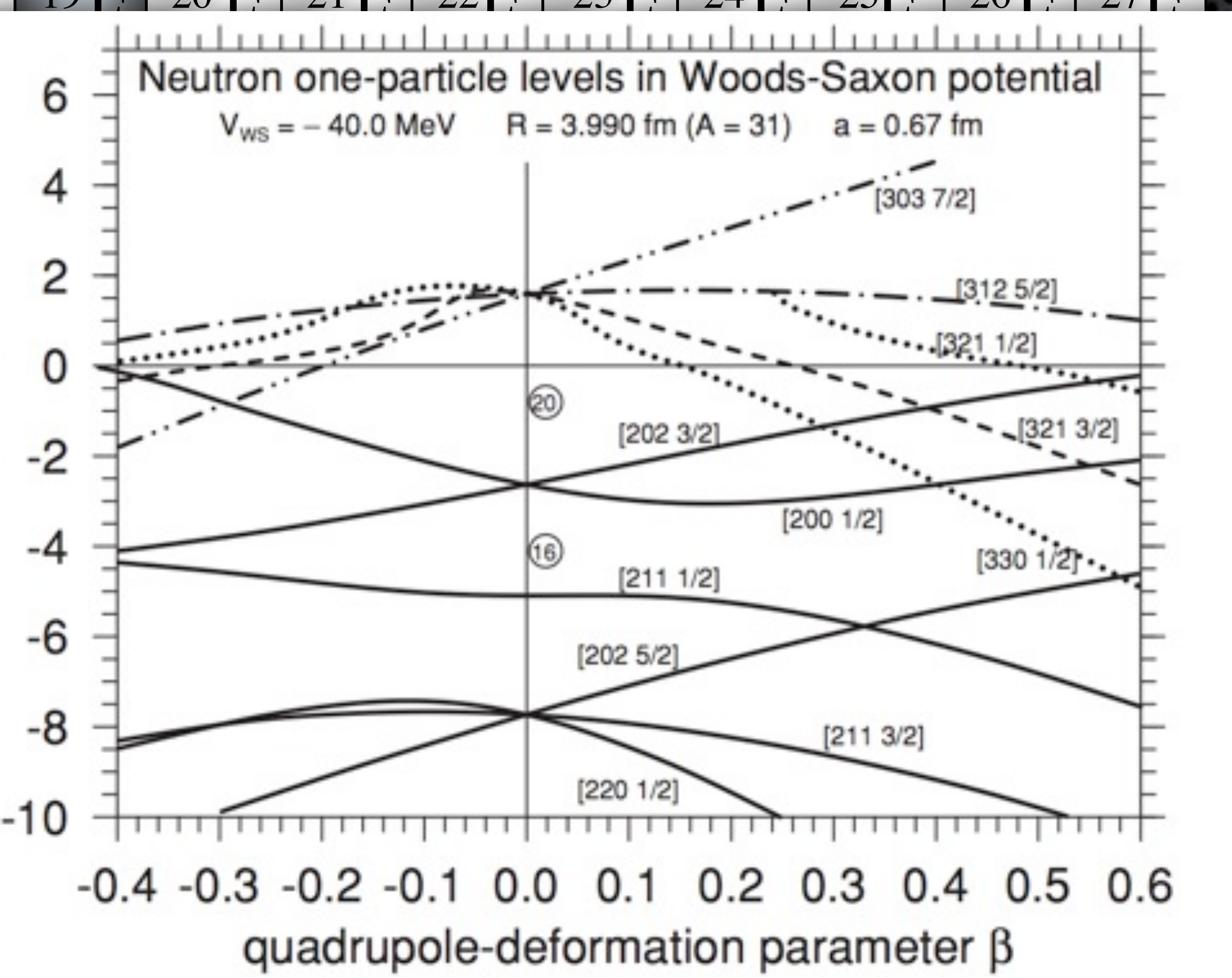
Radius : $r_0A^{1/3}$ → $r_0A^{1/3}(1 + 5/4\pi \cdot \beta^2)^{1/2}$



Large Deformation also can enhances Nuclear Radii

Study of Nuclear Size for Ne and Mg Isotopes





Study of Ne and Mg isotopes via σ_R

Halo and Deformation

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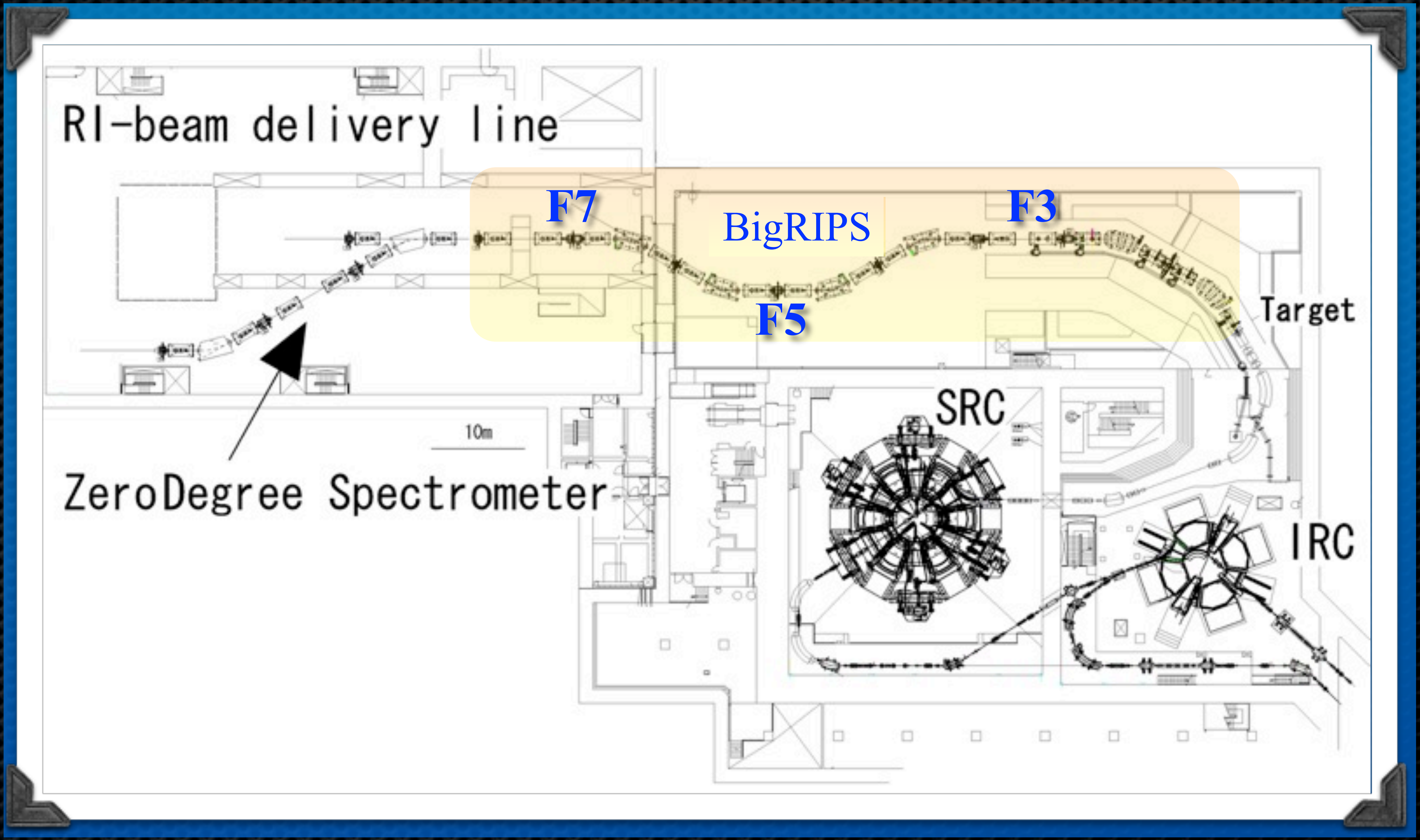
Experiment : Measurements of σ_R

Primary Beam **^{48}Ca** 345A MeV, ~10^2 pnA

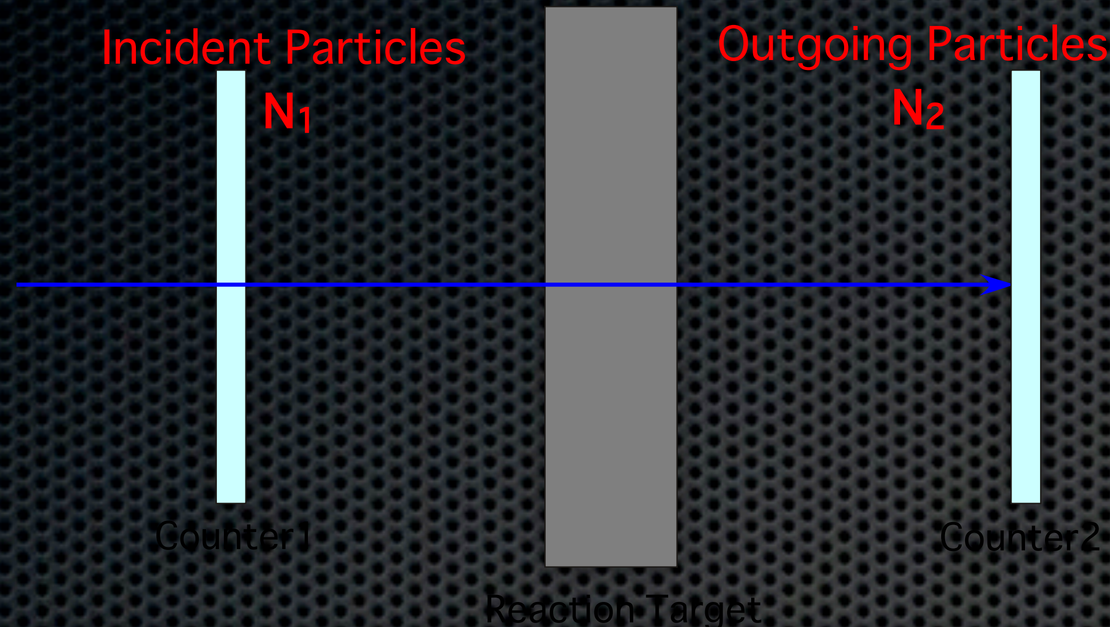
Secondary Beam **$^{20-32}$Ne, $^{24-38}$Mg**

σ_R were measured using BigRIPS (F3 - F7)

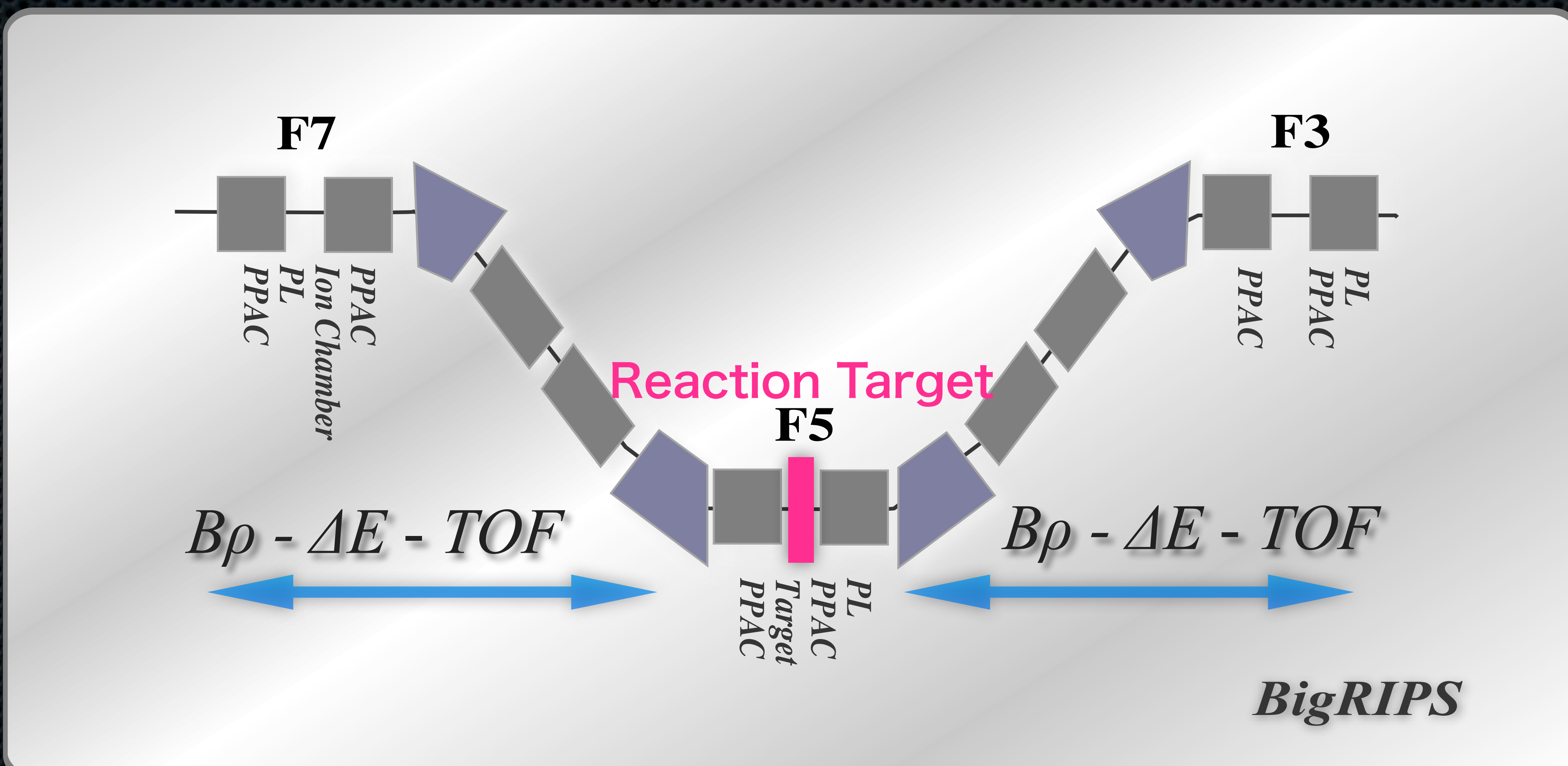


Experiment : Measurements of σ_R

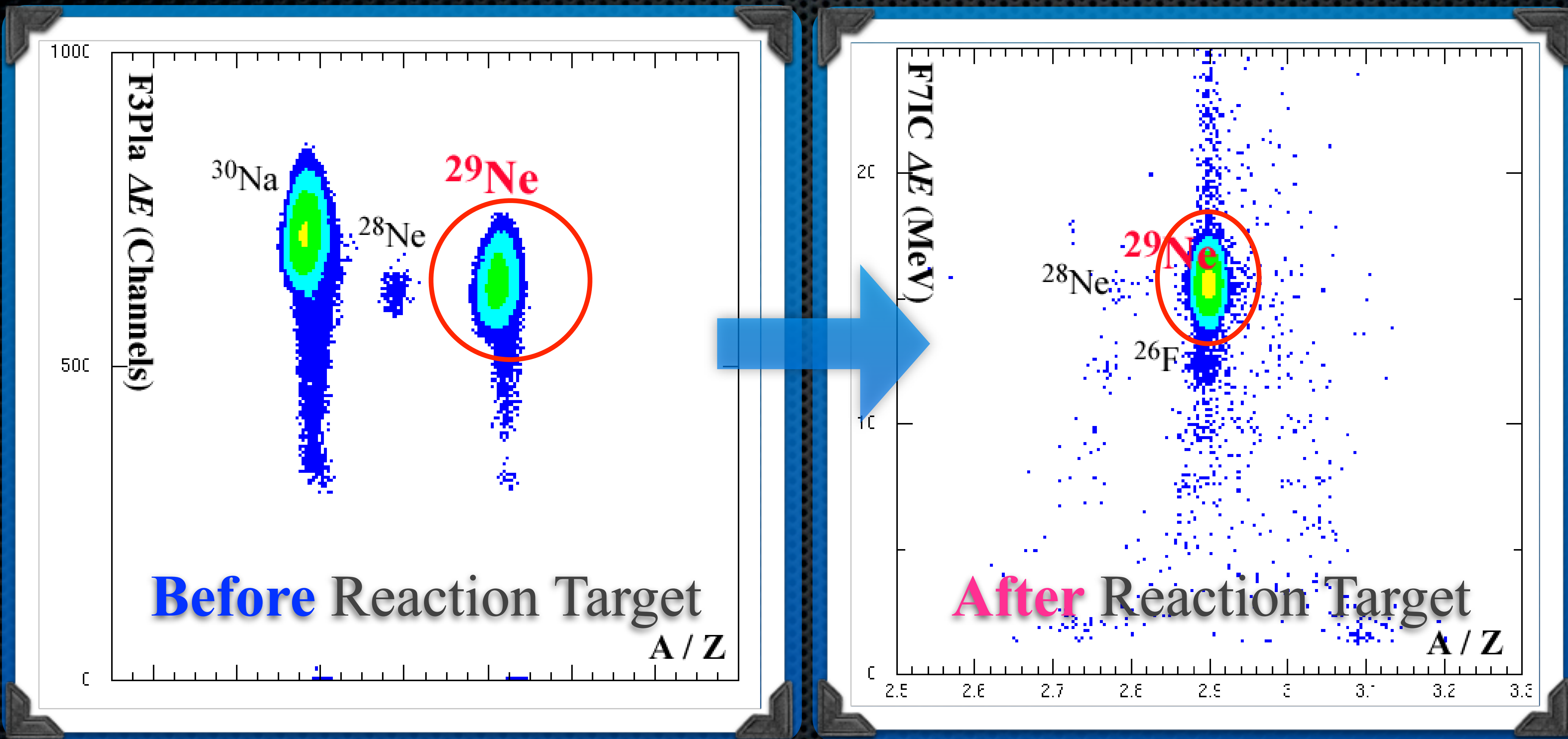
Transmission Method



$$\sigma_R = -\frac{1}{t}\ln\left(\frac{N_2}{N_1}\right)$$

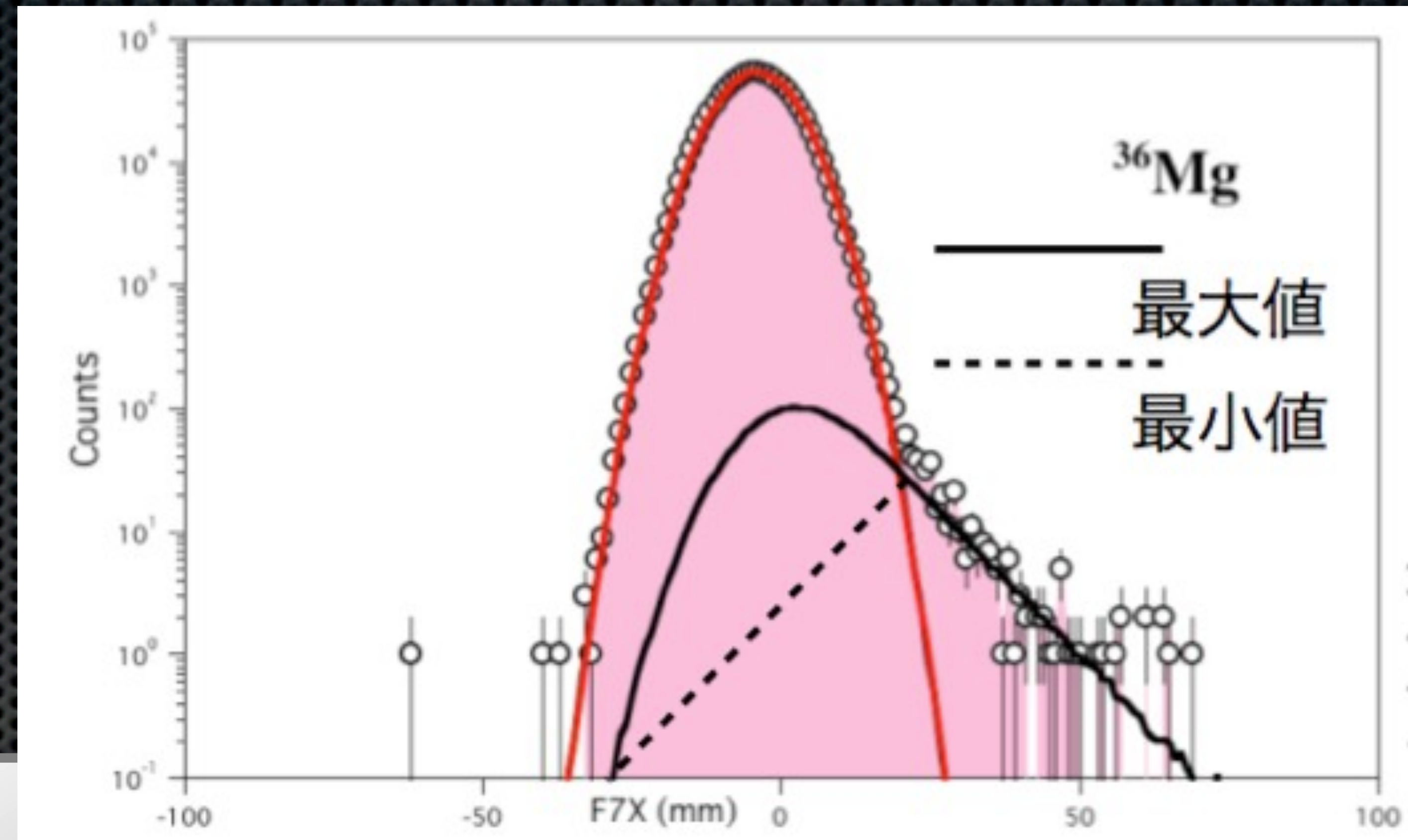


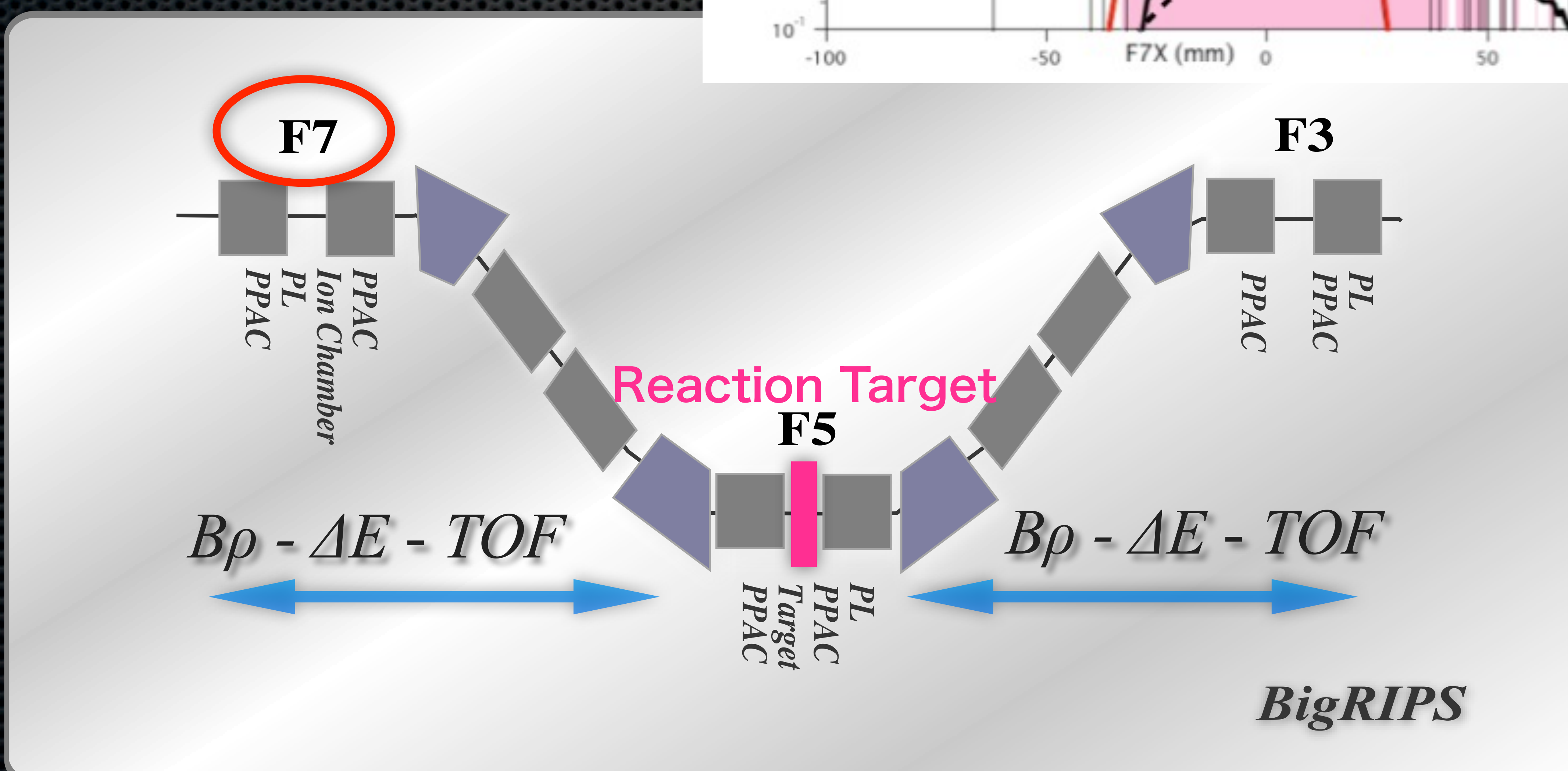
Experiment : Measurements of σ_R



Inelastic scattering cross section

Inelastic scttering events
Same A and Z, but different Energy
Analyzed from the Br(F5-F7) information





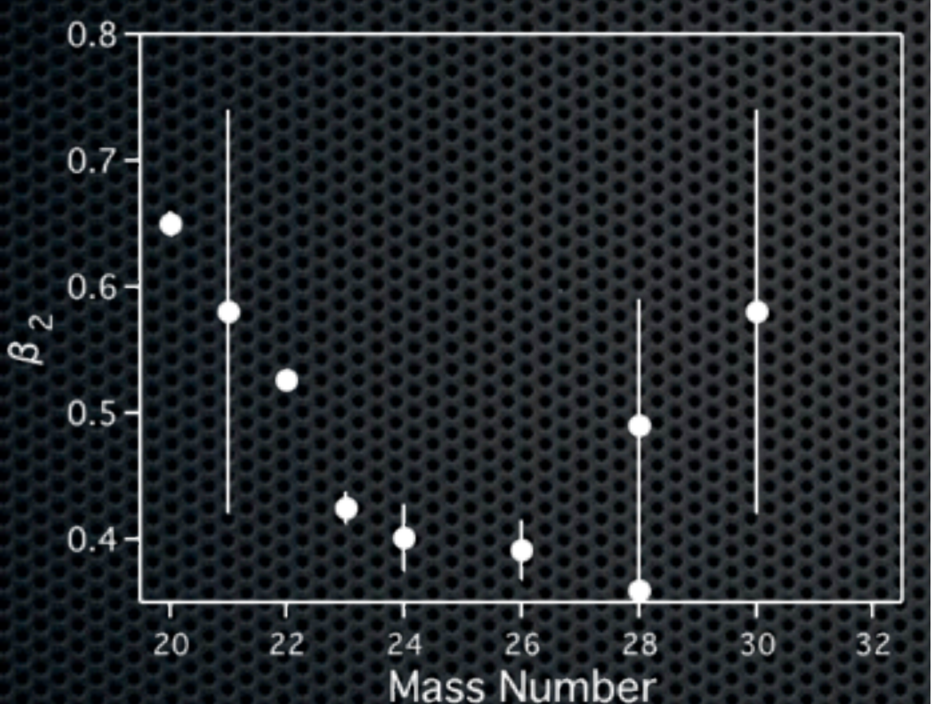
Ne Isotope

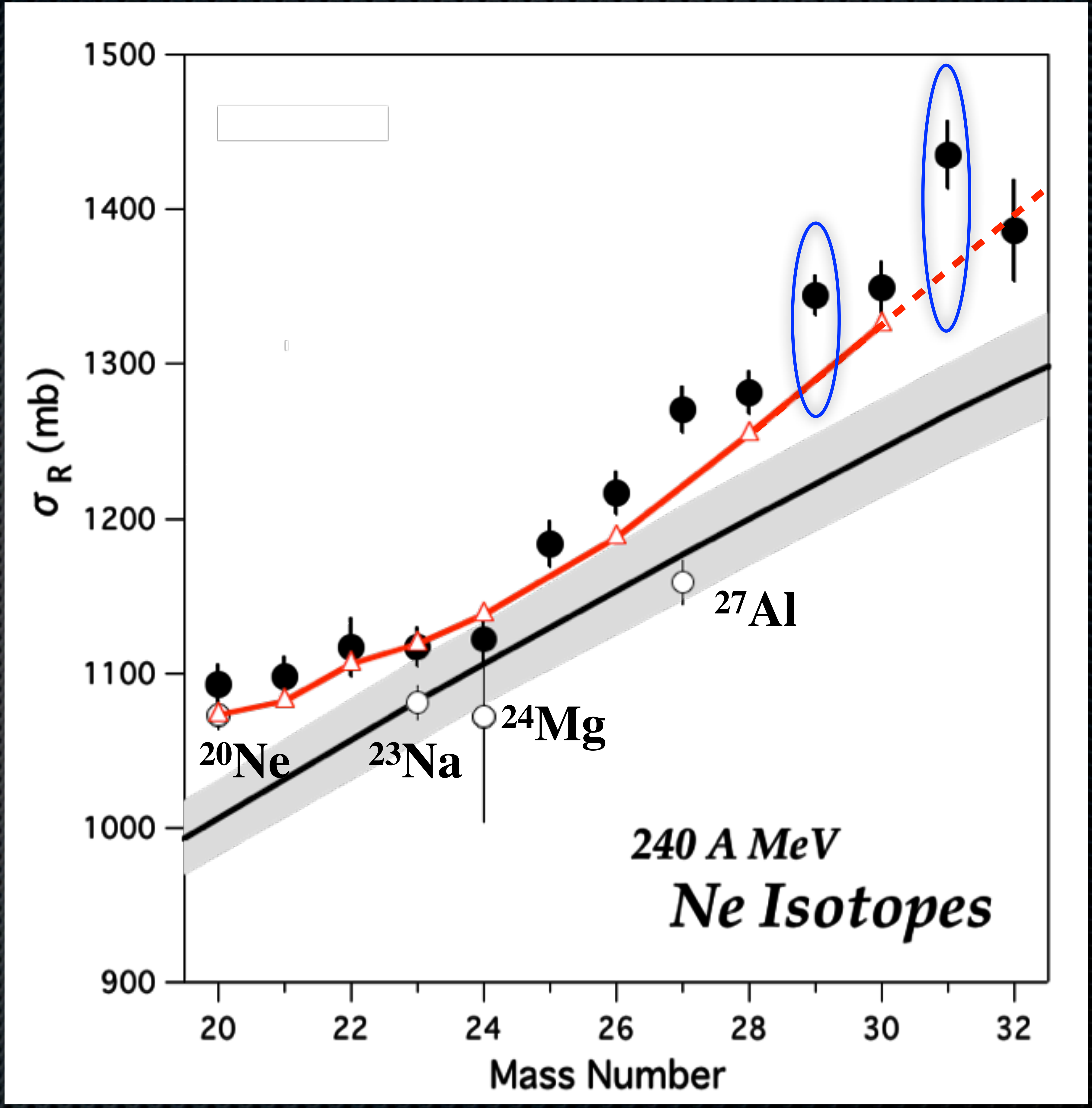
M. Takechi et al., Phys. Lett. **B 707** (2012) 357.

Radius : $r_0 A^{1/3}$

$r_0 A^{1/3}(1 + 5/4\pi \cdot \beta^2)^{1/2}$

β_2 deduced from experimental B(E2) and Q moment





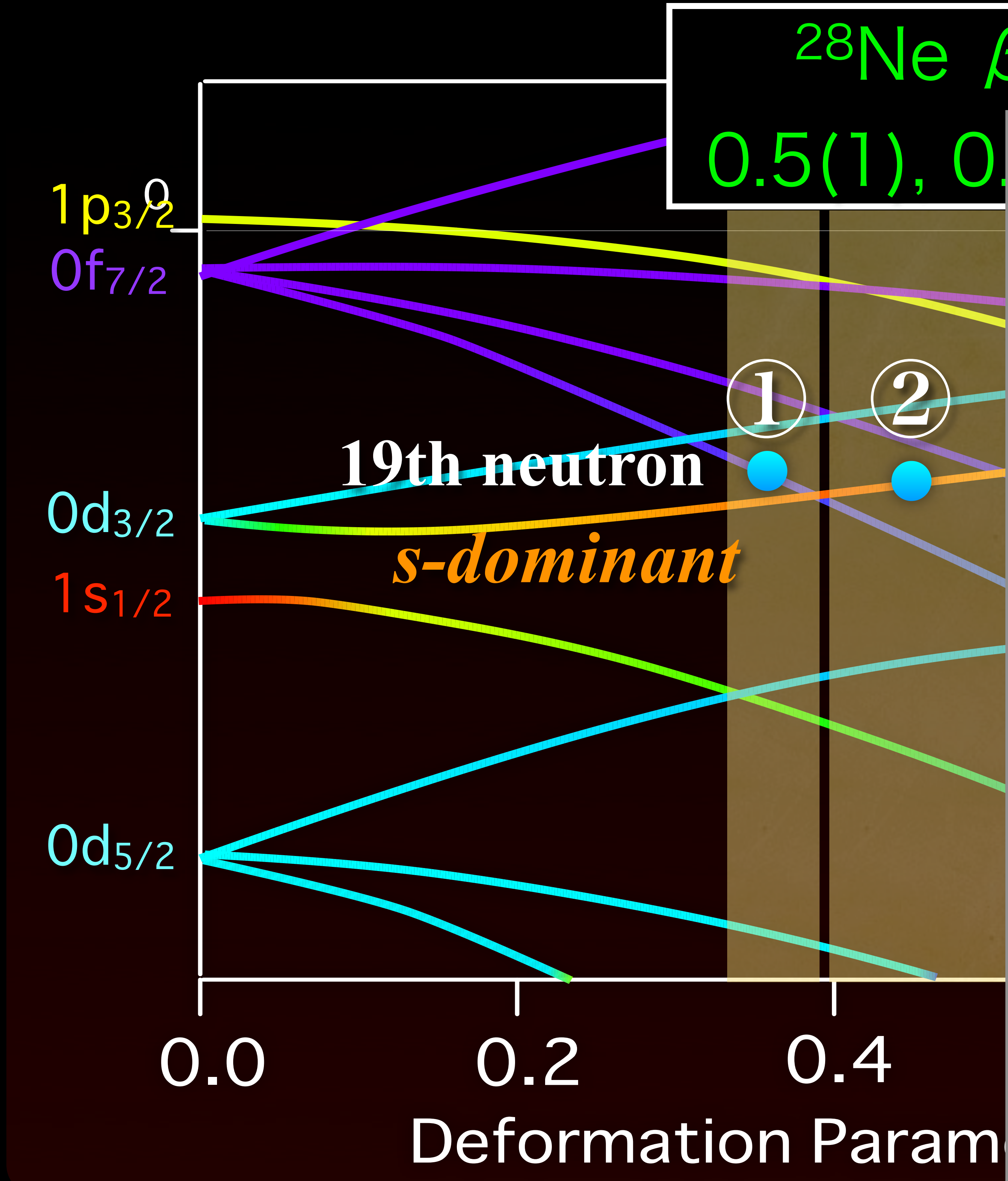
Halo Effect in ^{29}Ne

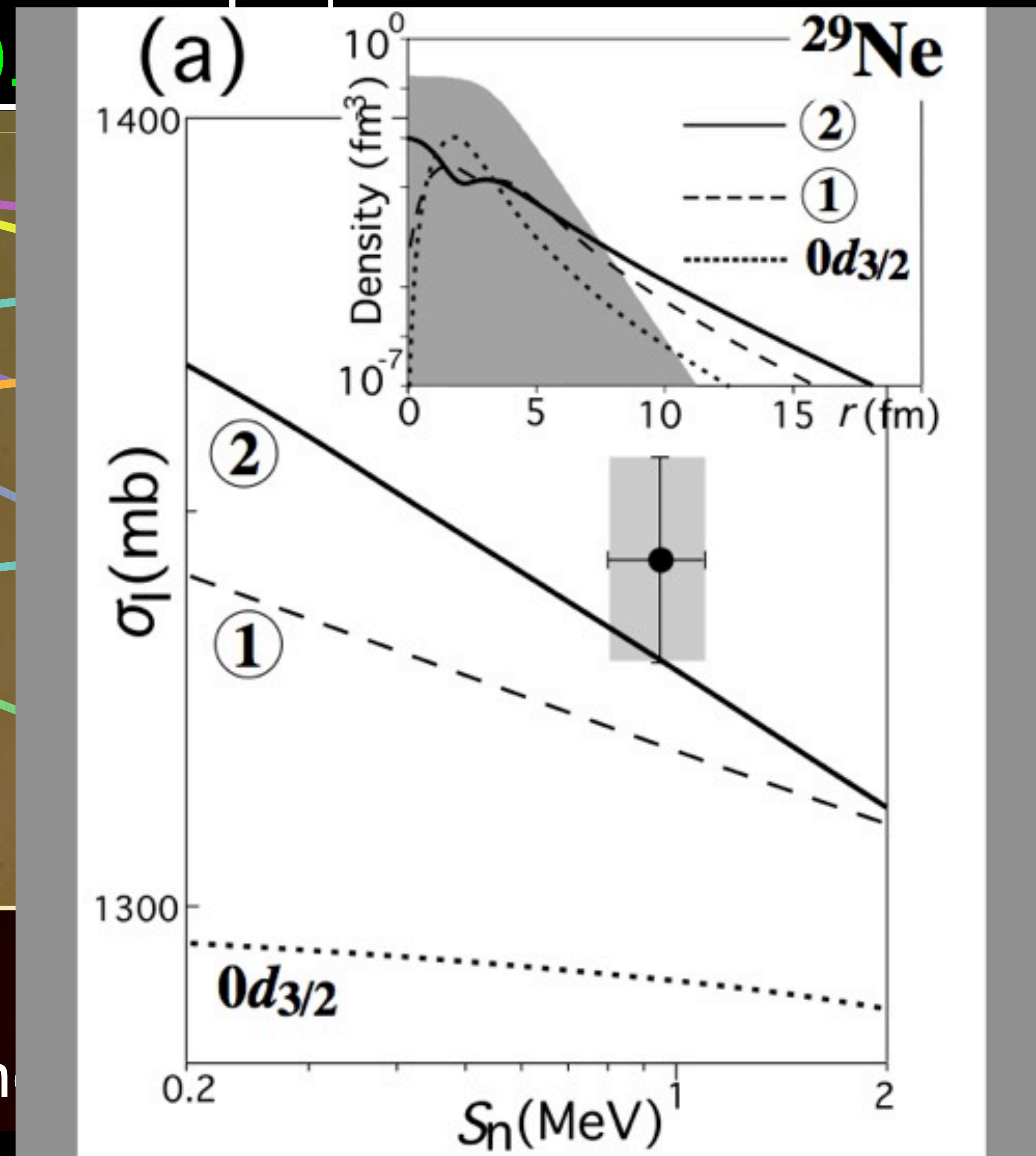
M. Takechi et al., Phys. Lett. **B 707** (2012) 357.

^{28}Ne + 1n model

① $1p_{3/2}$ (59%) and $0f_{7/2}$ (37%)

② $1s_{1/2}$ (74%) and $0d_{3/2}$ (16%)





^{28}Ne : H. Iwasaki et al., Phys. Lett. B 620 (2005) 118

^{28}Ne : B. V. Pritychenko et al., Phys. Lett. B 461 (1999) 322.

Halo Effect in ^{31}Ne

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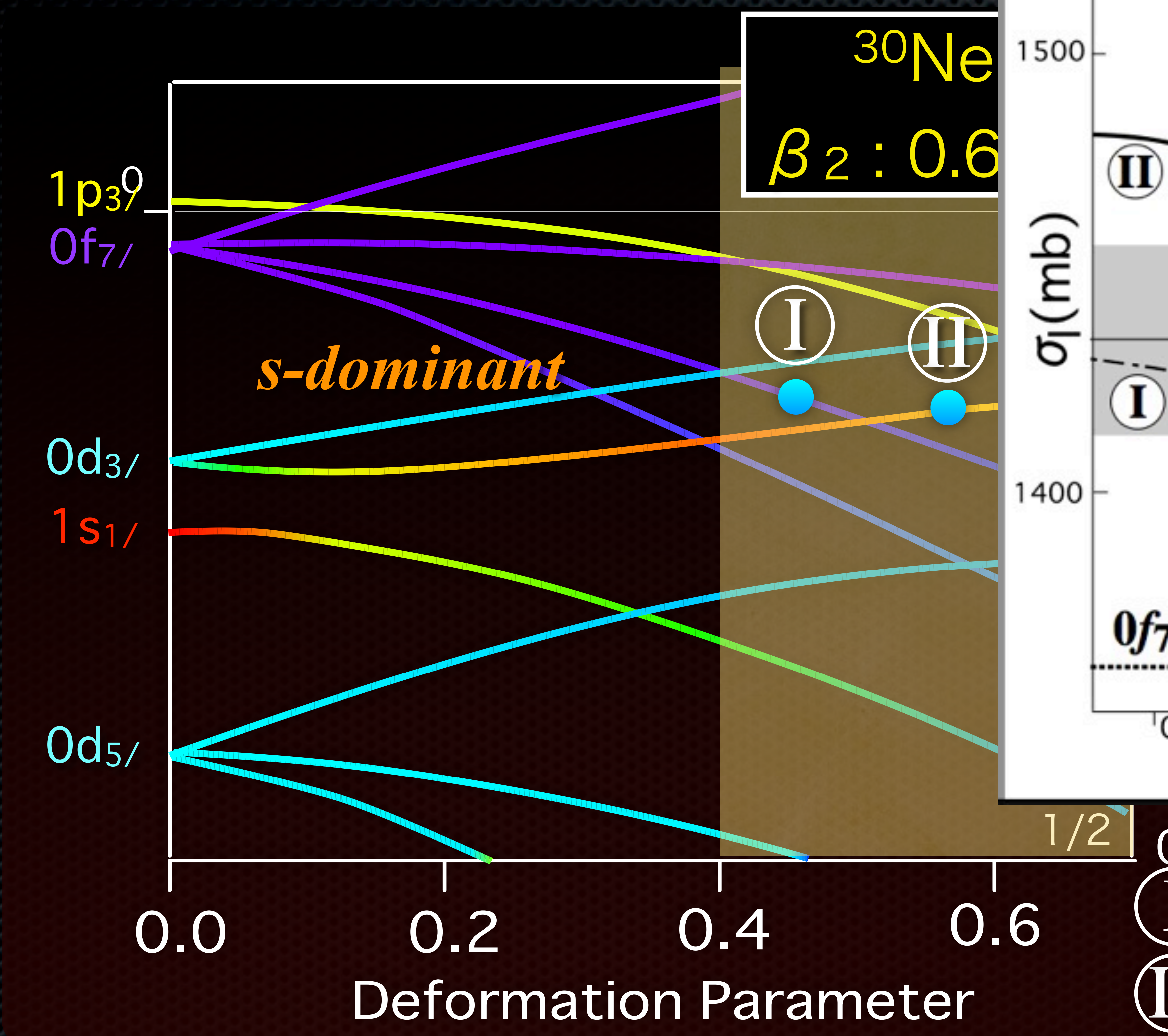
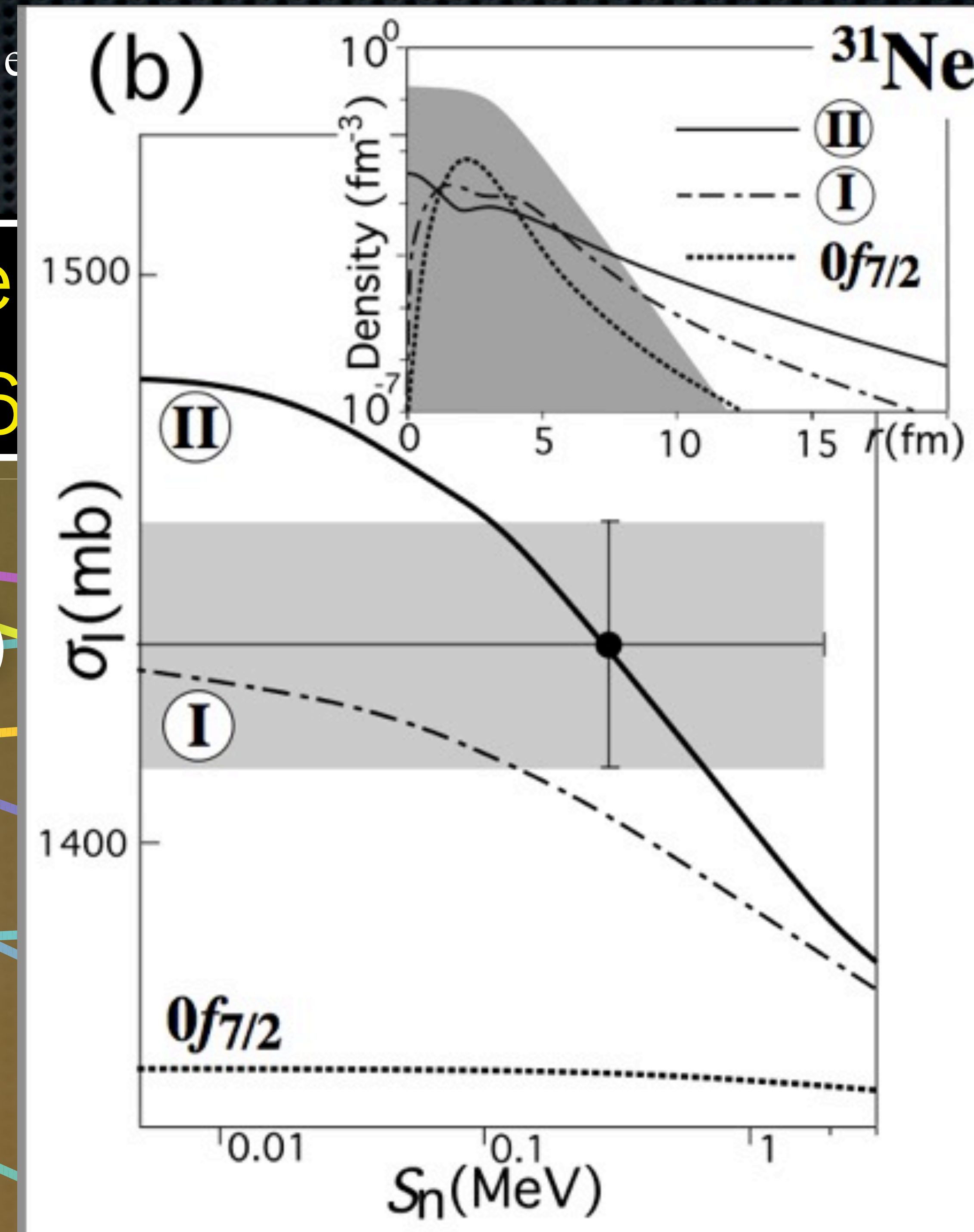
^{31}Ne + 1n model





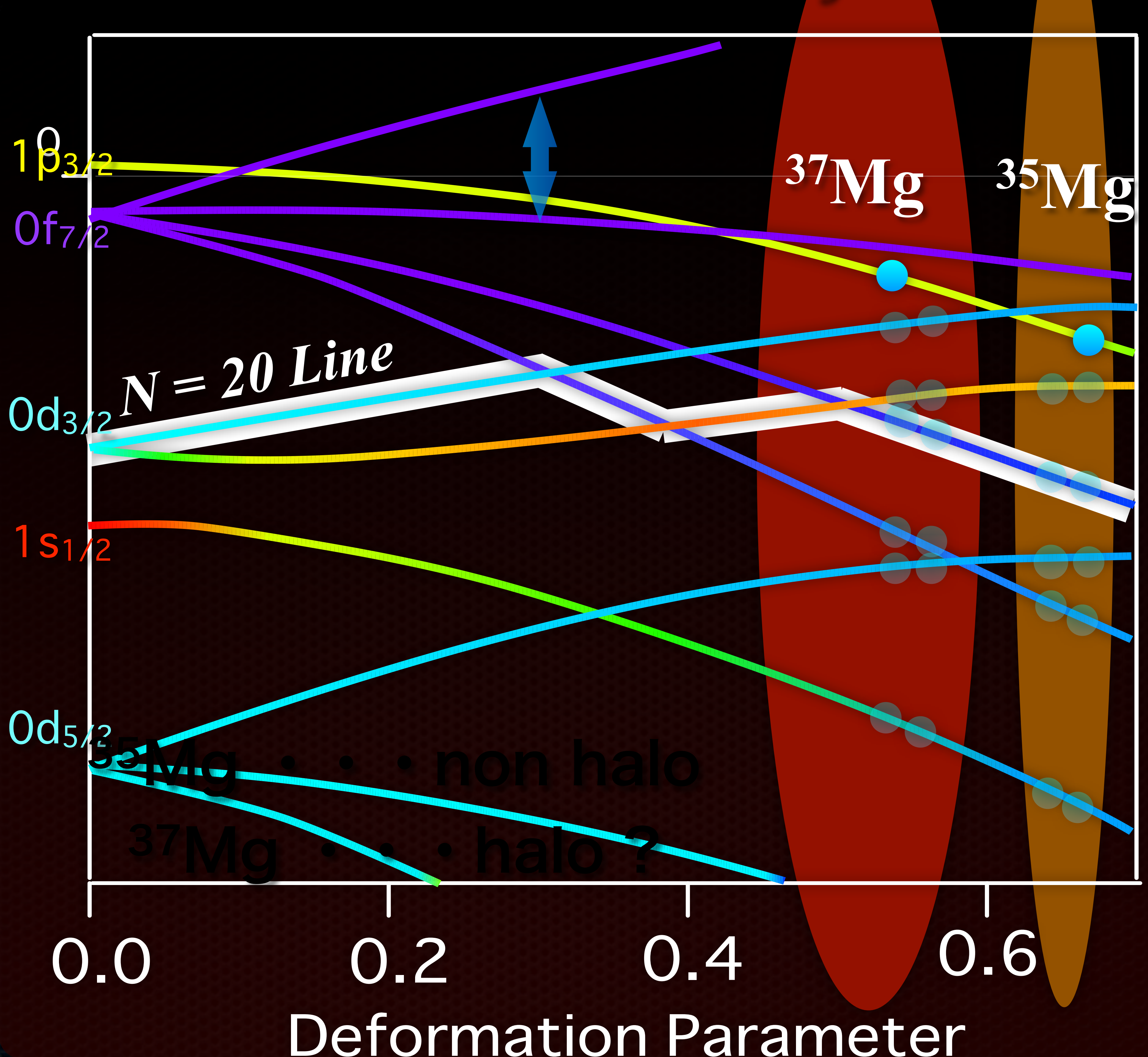
I: $0f_{7/2}$ (70%) and $1p_{3/2}$ (22%)

II: $1s_{1/2}$ (82%), $0d_{3/2}$ (9%)

^{30}Ne : Y. Yanagisawa et al., Phys. Lett. **B 566** (2003) 84.

Mg Isotope

Possible p-orbital Halo for Mg isotopes



^{35}Mg

$S_n = 1.0(5)$ MeV

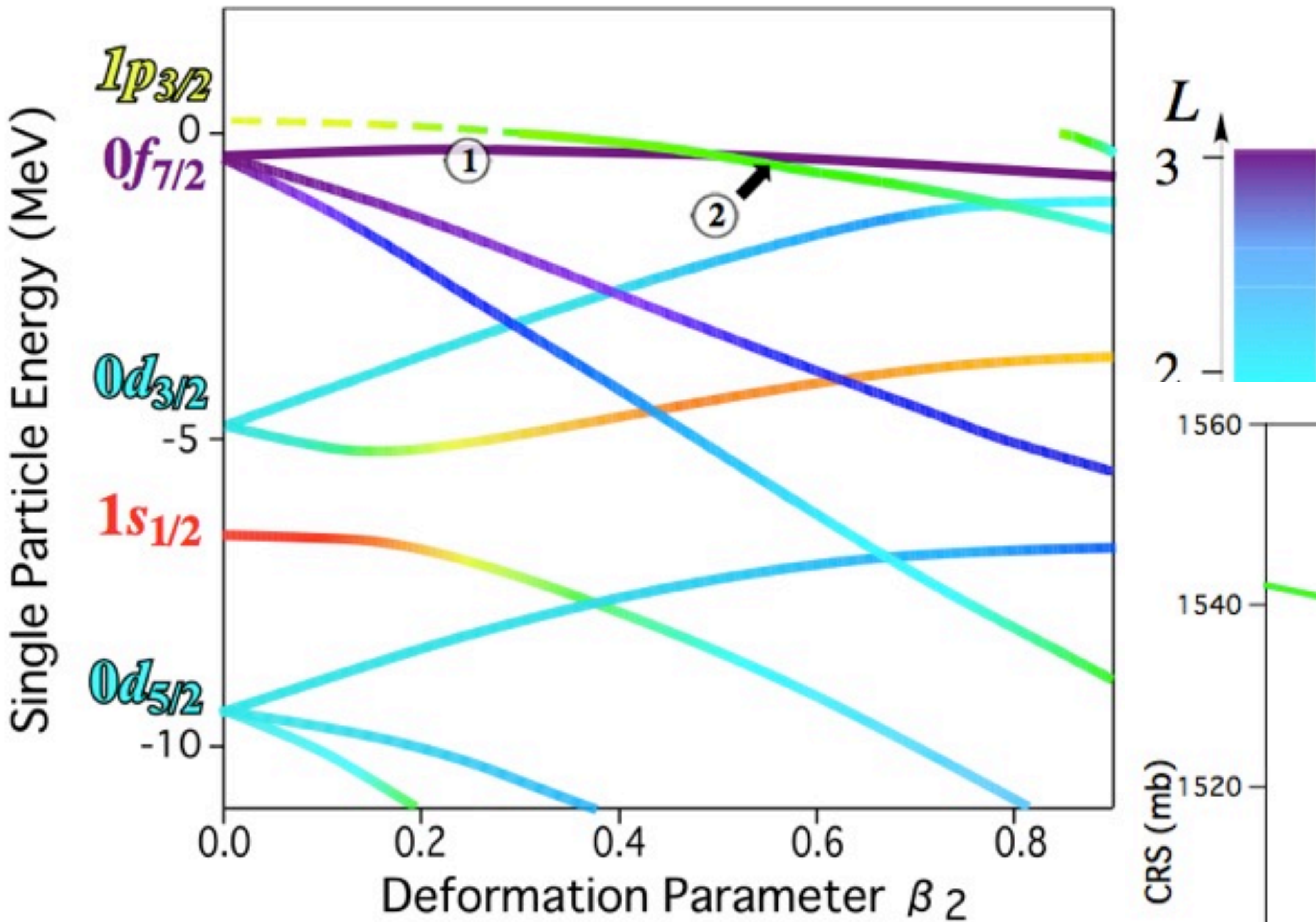
B. Jurado et al., PLB 649 (2007) 43

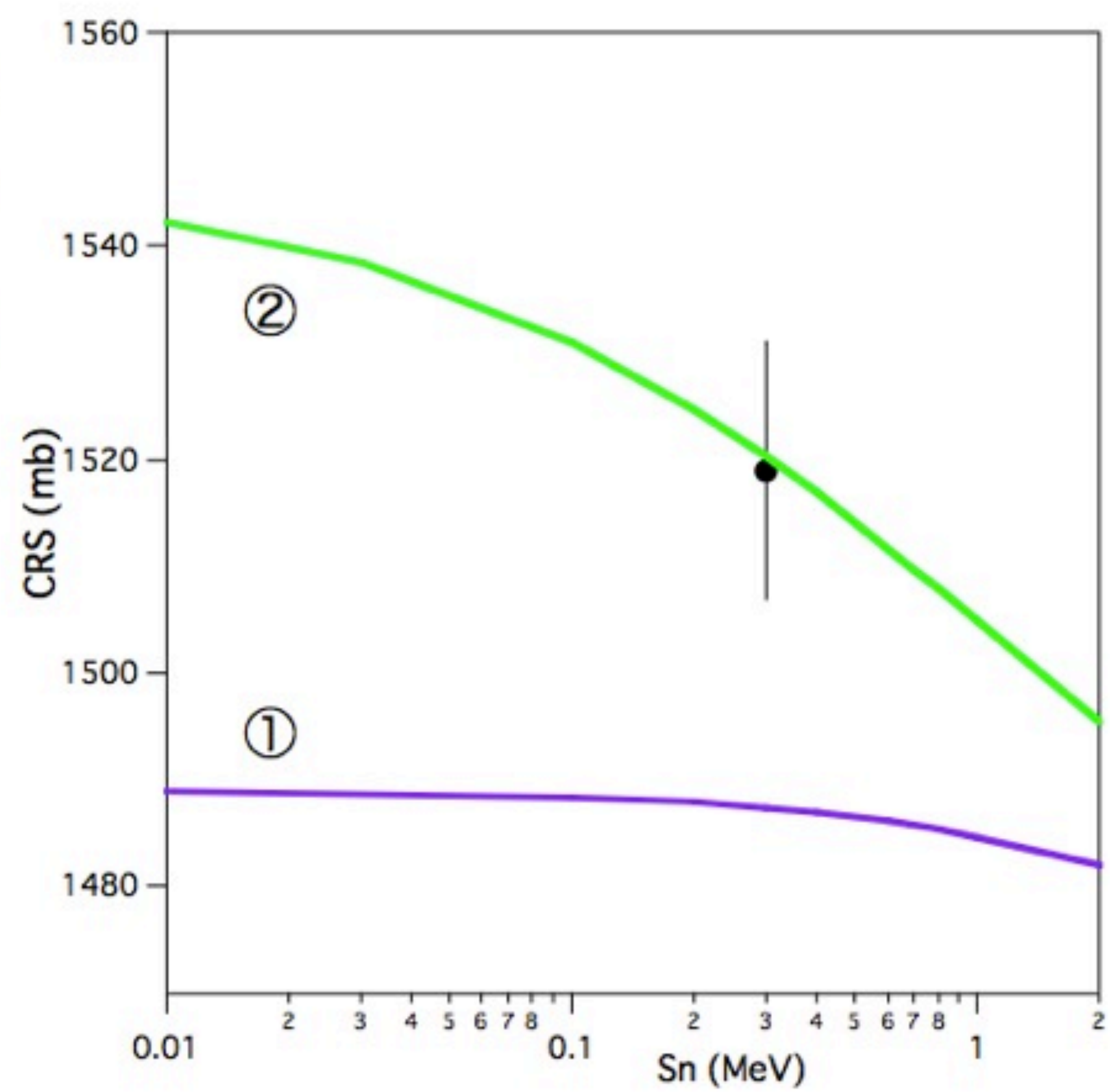
^{37}Mg

$S_n \sim 0.3$ MeV

(Empirical)

Possible p-orbital Halo for Mg isotopes





Summary

- σ_R for Ne and Mg Isotopes have been precisely measured at RIBF.

- $\sigma_R \leftrightarrow$ nuclear size reflect the nuclear deformation and changes of deformation towards the island of inversion region can be seen.

- Possible Halo structures in ^{31}Ne, ^{29}Ne, and ^{37}Mg are suggested. *p*-orbital halo structure in ^{31}Ne is indicated by theoretical analysis.