Heavy-Ion Double Charge Exchange study via $^{12}C(^{18}O,^{18}Ne)^{12}Be$ reaction

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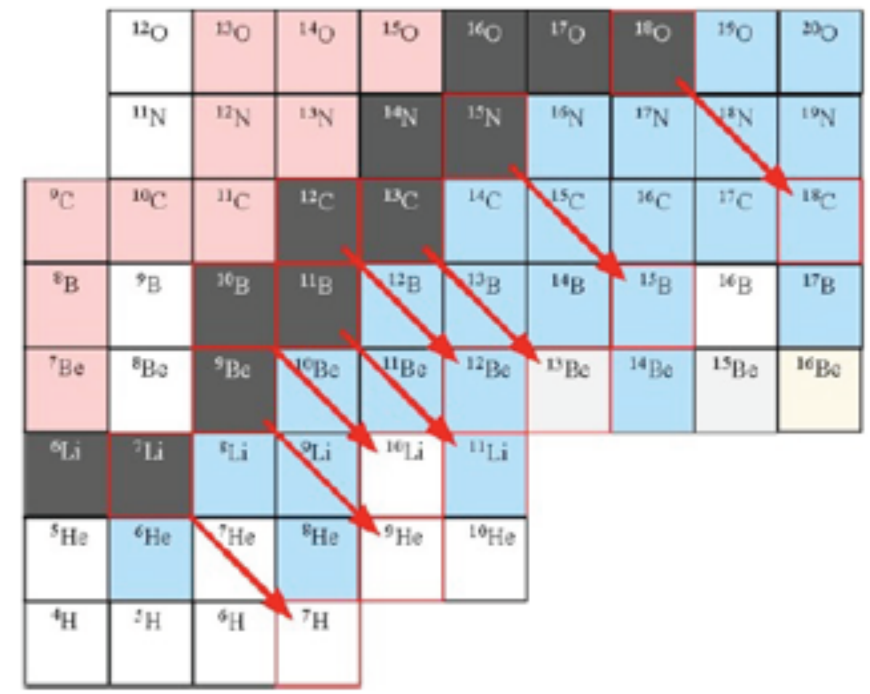
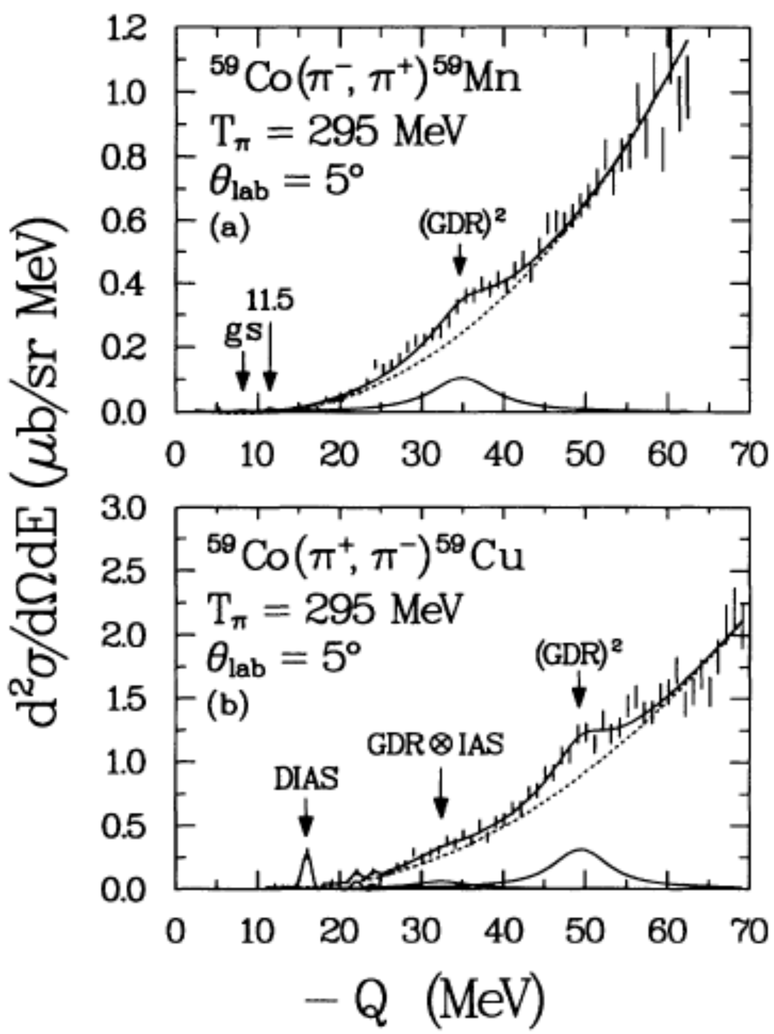
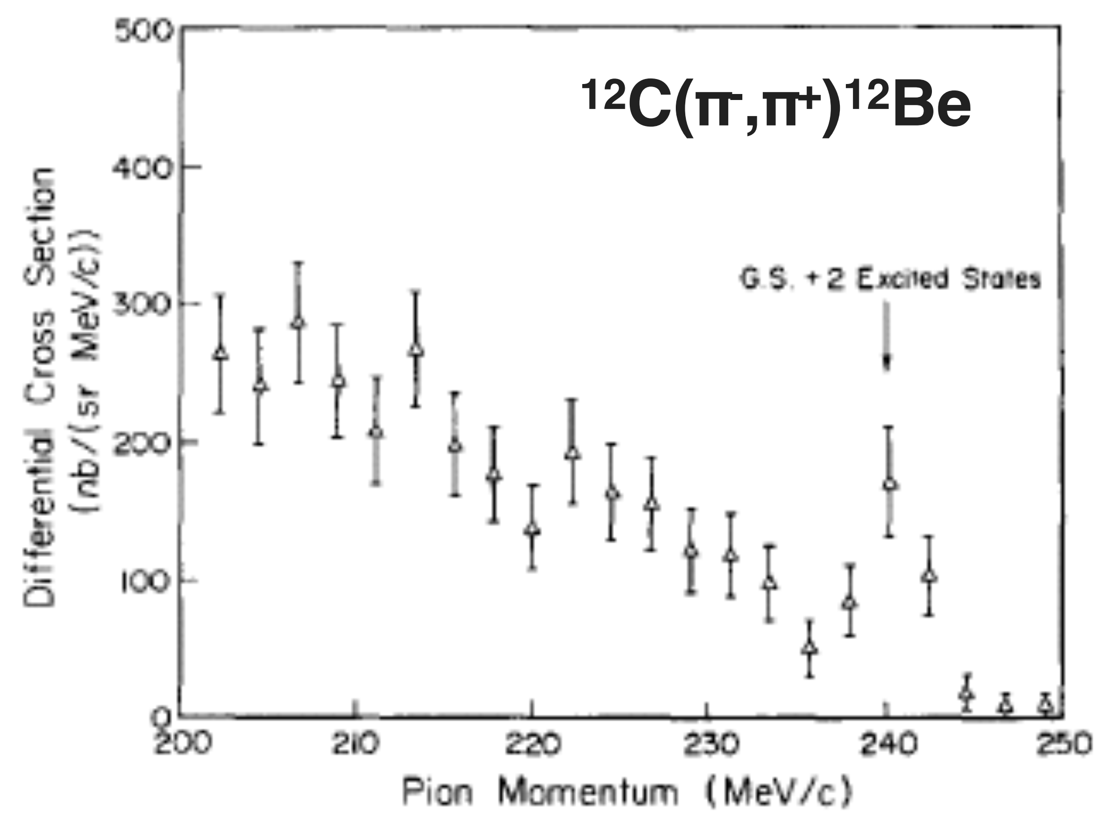
Double Charge eXchange (DCX) reaction

- **Probe for unstable nuclei**
  - Using stable target with $\Delta T_z = 2$
- **Powerful tool to investigate IV Double Giant Resonances**
  - DIAS, DIVDR…





S. Mordechai et al., PRL 60, 408 (1988).

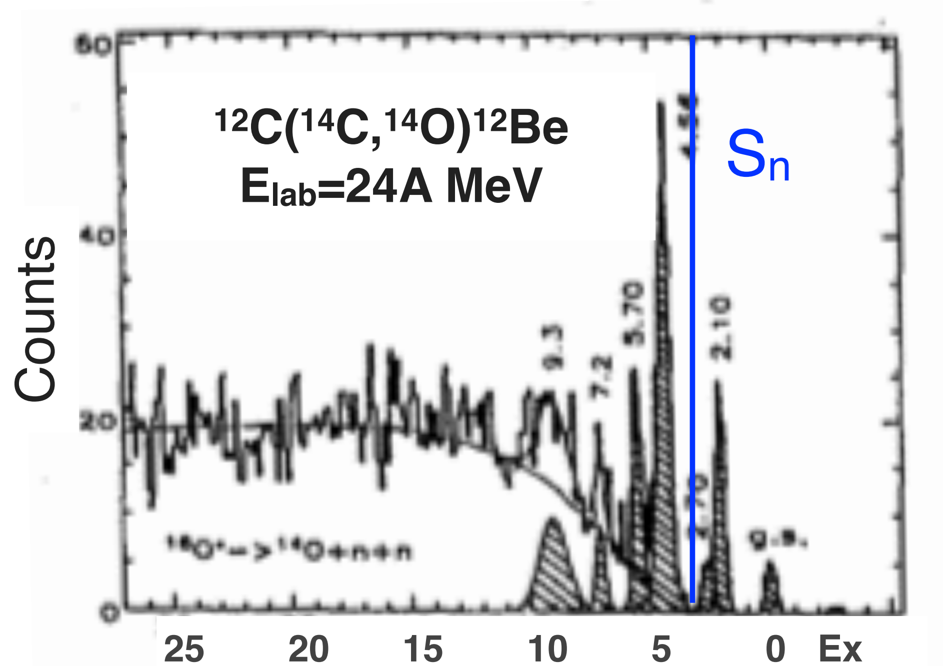


J.E. Ungar *et al.*, PLB, 144 333 (1984)

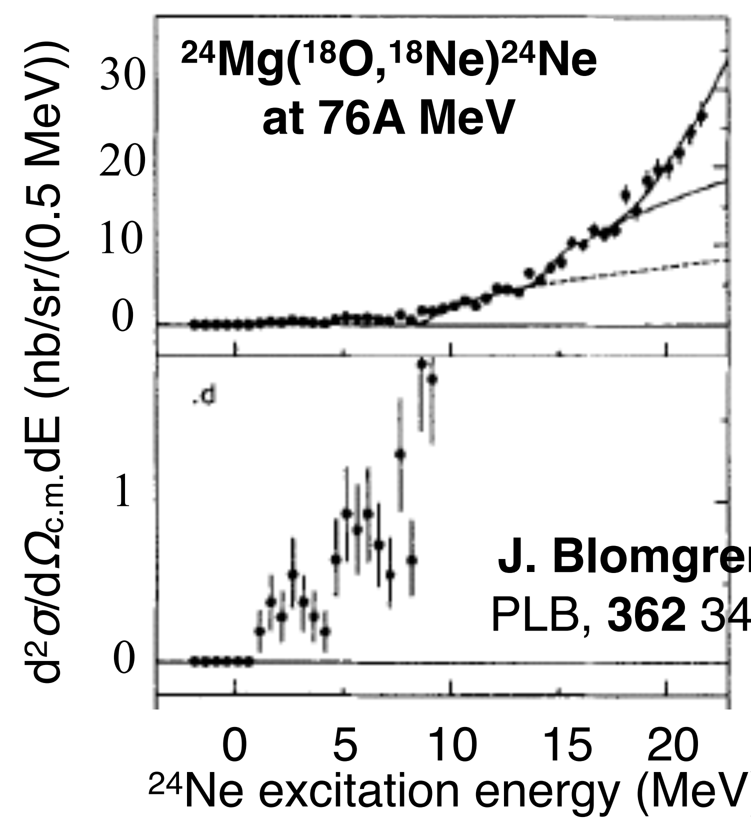
HIDCX with Missing mass method
at Intermediate energy

- **Heavy-ion**
  - **Double Spin and/or Isospin flip** (**ΔS=2, ΔT_z=2**)
- **Missing mass method**
  - **measure All excitation energy region on a same footing**
- **Intermediate energy (~ 100MeV/u)**
  - **direct reaction process dominance**
    - **simple reaction mechanism**
  - **ΔL sensitivity of angular distributions**
    - **multipole assignment**

We performed $^{12}C(^{18}O,^{18}Ne)$ reaction experiment in normal kinematics at 80 MeV/nucleon.



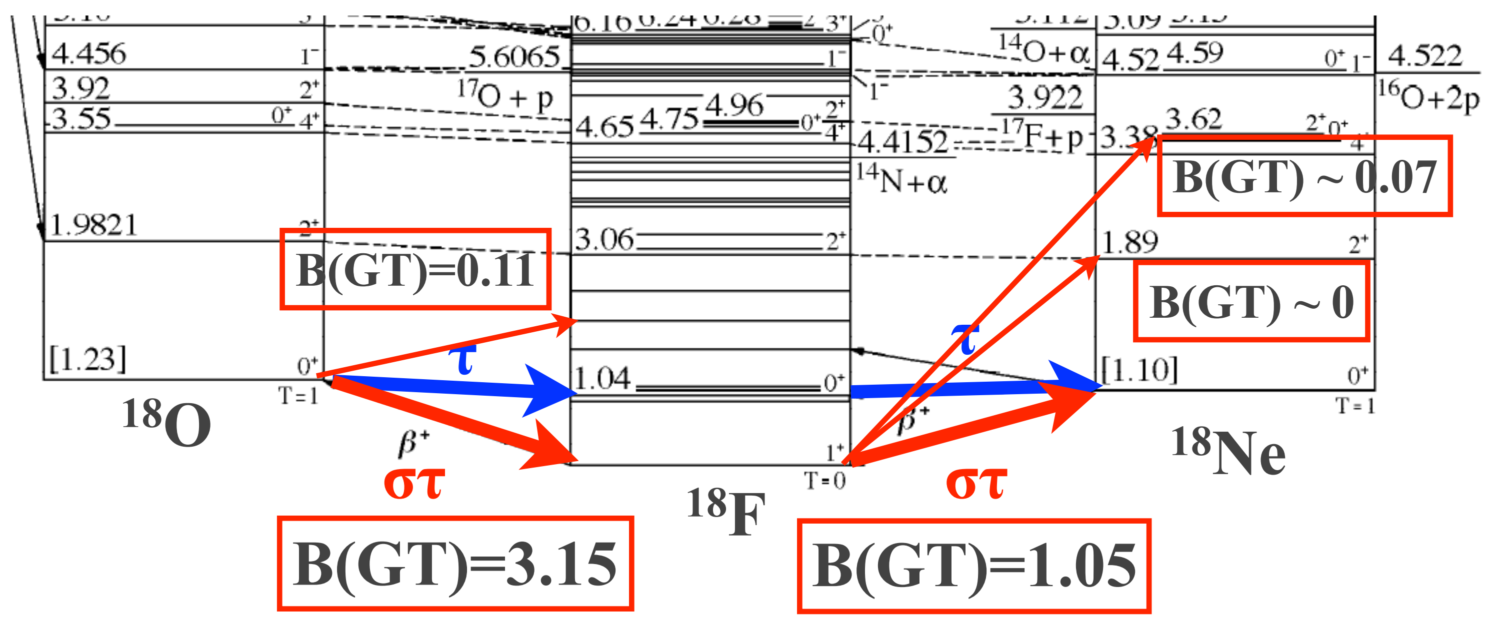
W. Oertzen *et al.*, NPA, **588** 129c (1995)



J. Blomgren *et al.* PLB, **362** 34 (1995)

(^{18}O,^{18}Ne) reaction

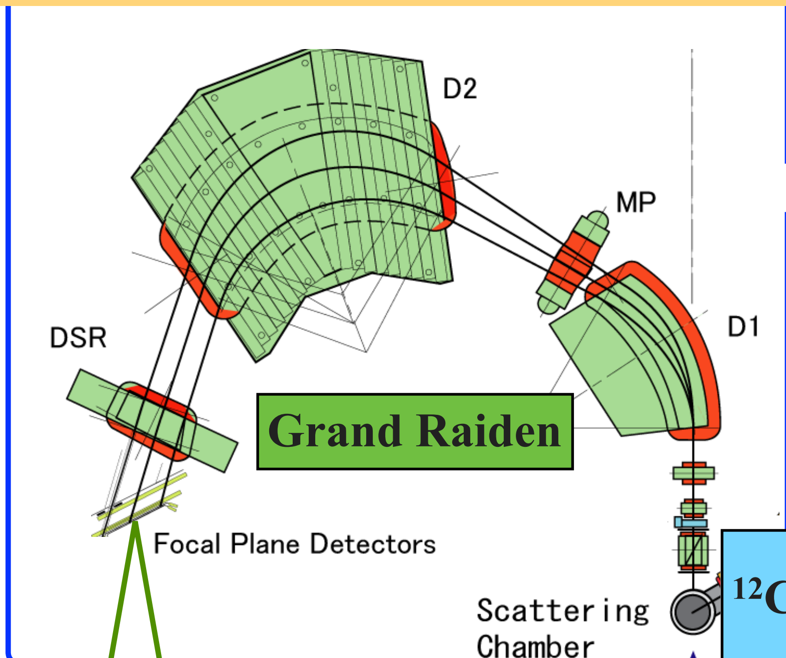
- Ground states of ^{18}O and ^{18}Ne are among the same super-multiplet.
  - simple transition process
  - large transition probability



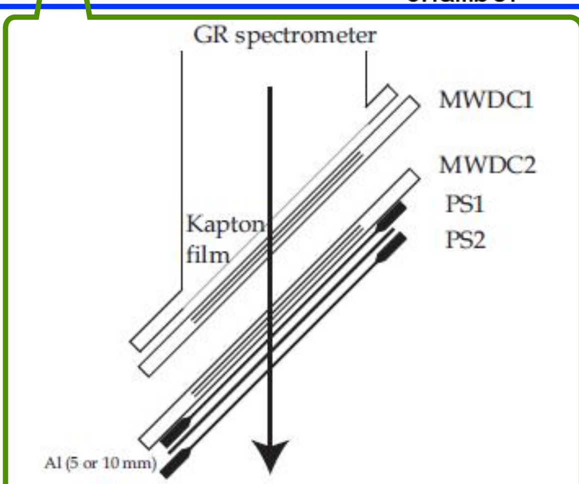
- A primary ^{18}O beam is employed
  - high intensity (> 10 pnA)
- Experiment can be performed at RCNP with GR spectrometer
  - high quality data with high energy resolution

Setup of the experiment

Energy resolution = 1.2 MeV(FWHM)



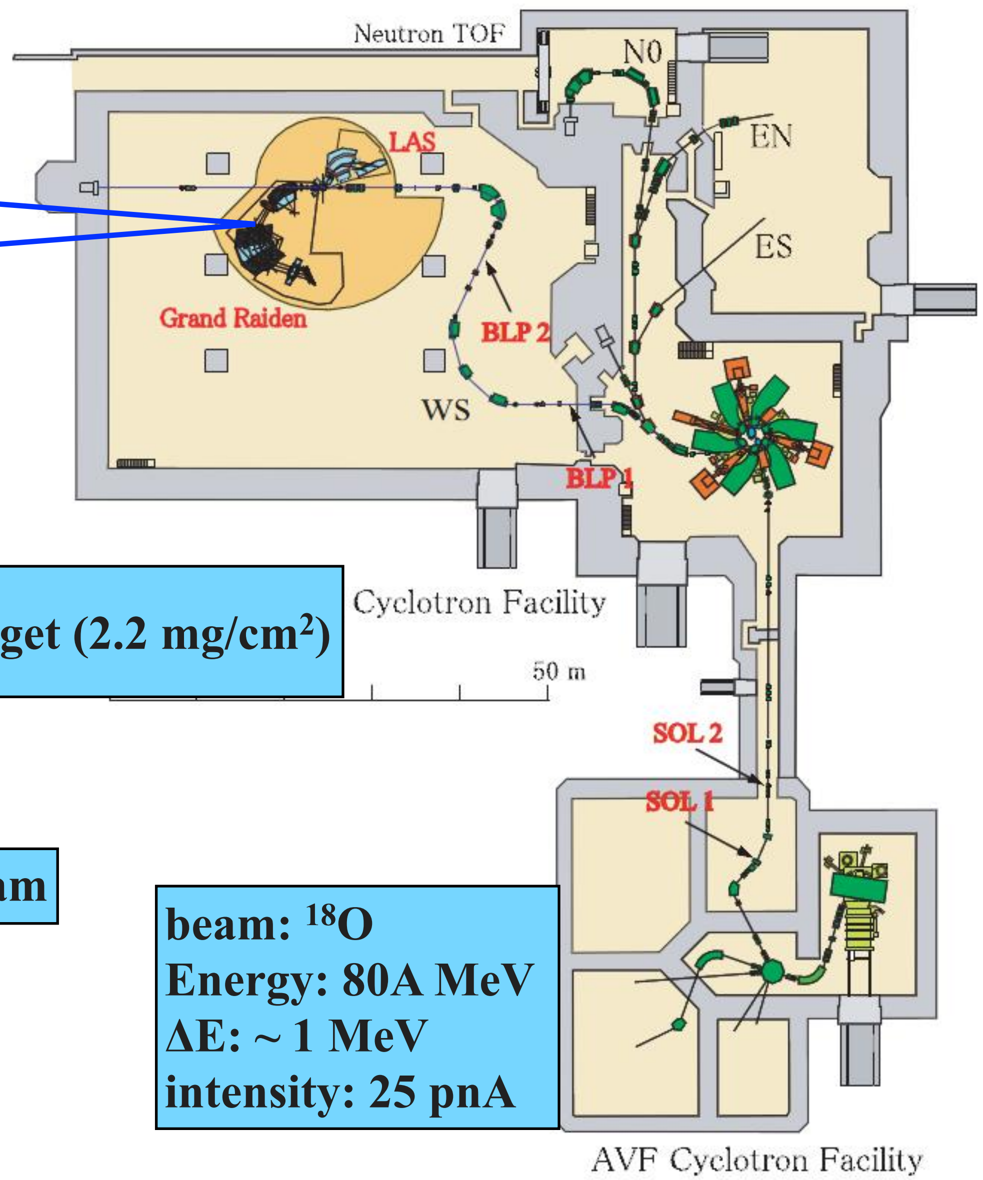
Grand Raiden



MWDCs and plastic scinti.

^{12}C target (2.2 mg/cm^2)

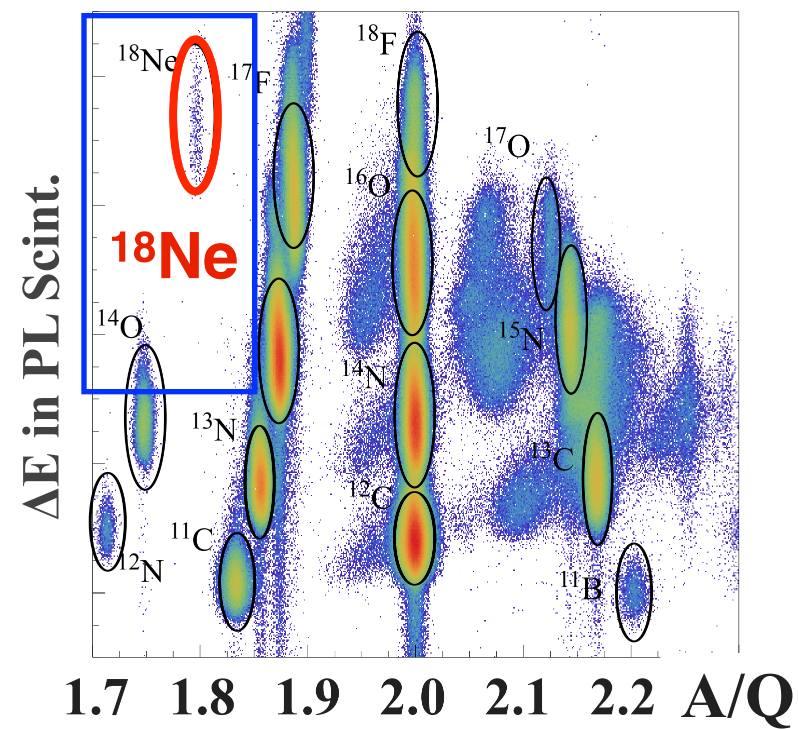
^{18}O beam

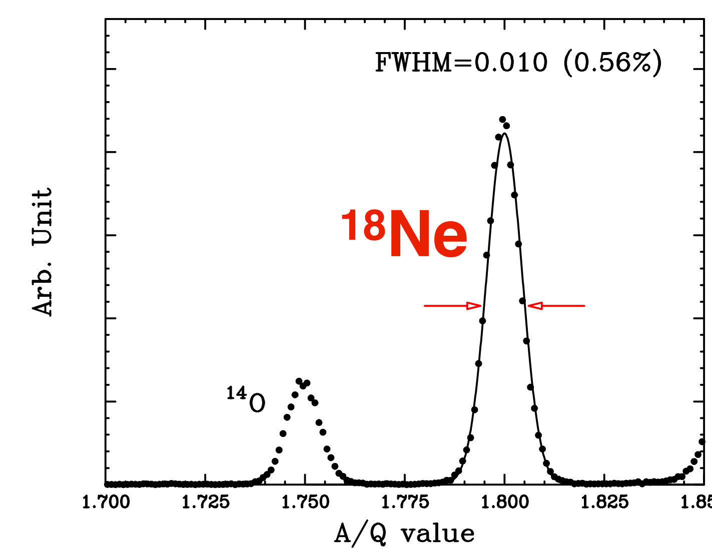


beam: ^{18}O
Energy: 80A MeV
ΔE: ~ 1 MeV
intensity: 25 pnA

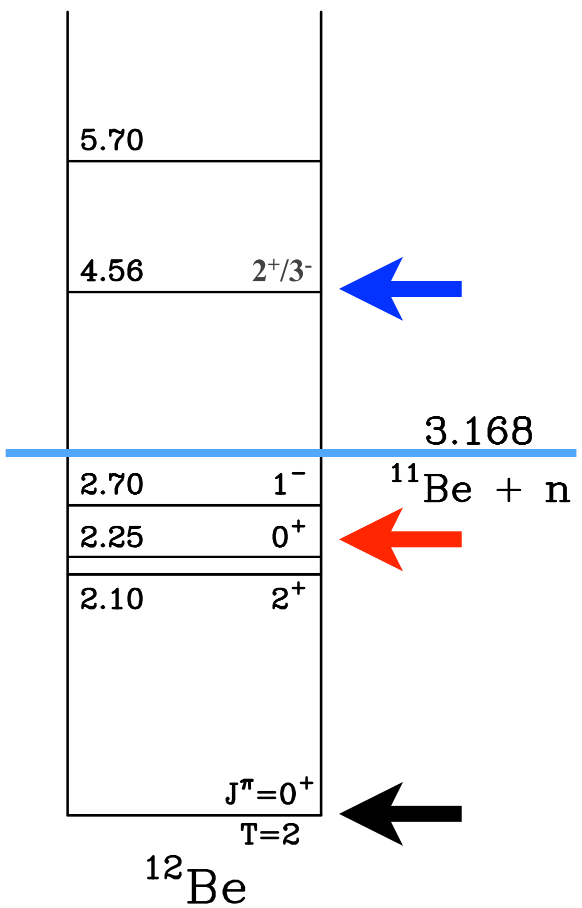
Ring Cyclotron Facility,
Research Center for Nuclear Physics,
Osaka University

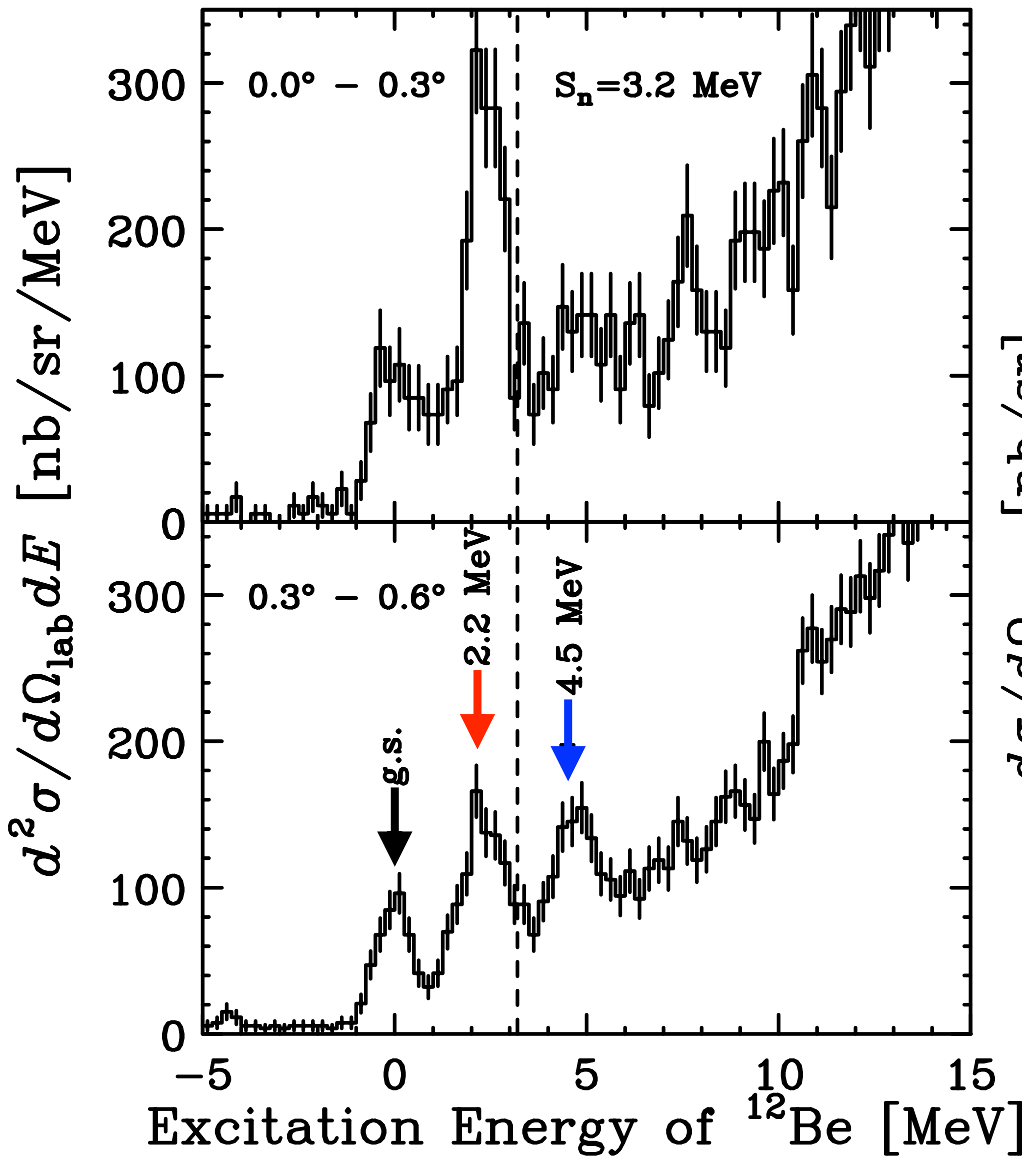
Good PID resolution

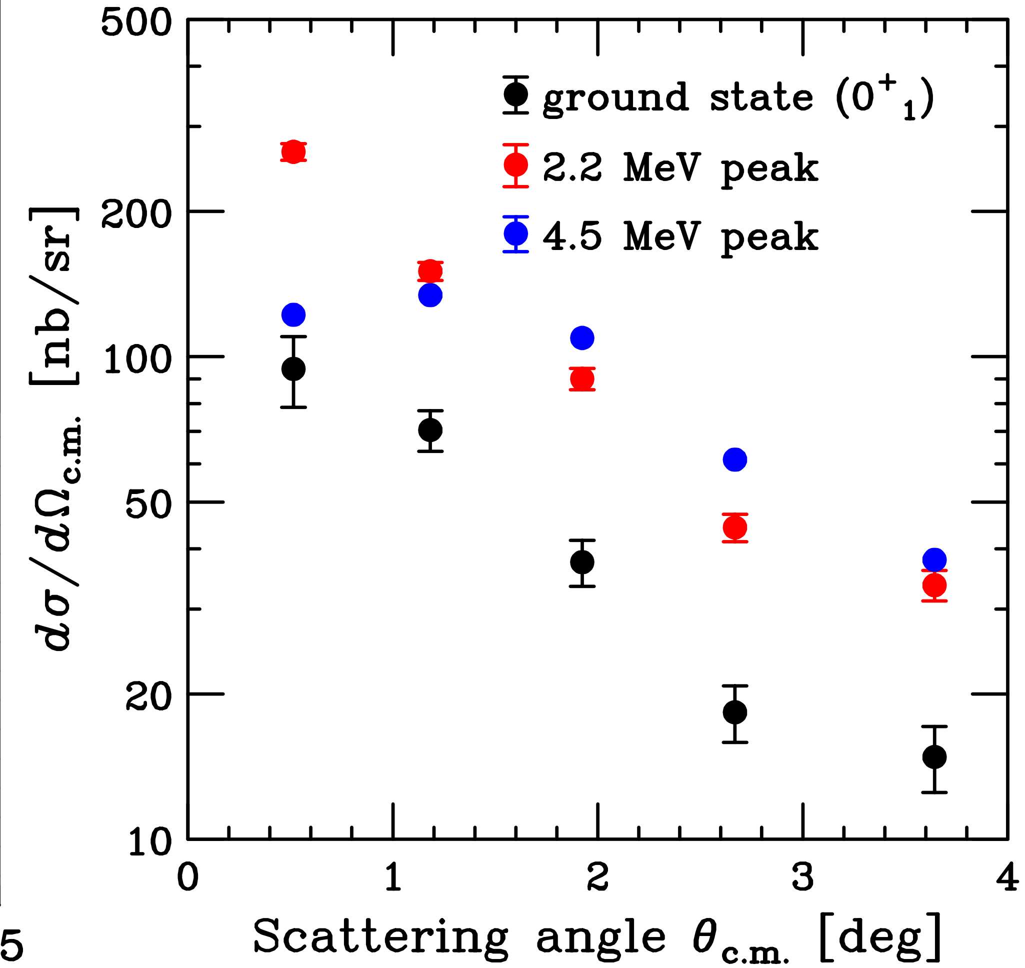




Successful result



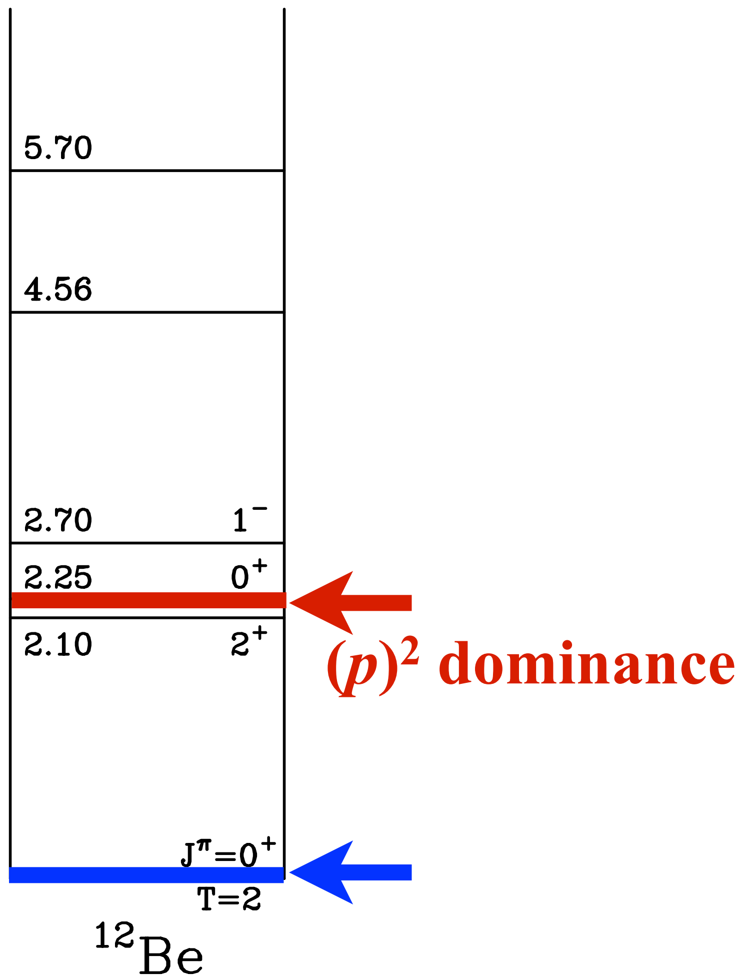


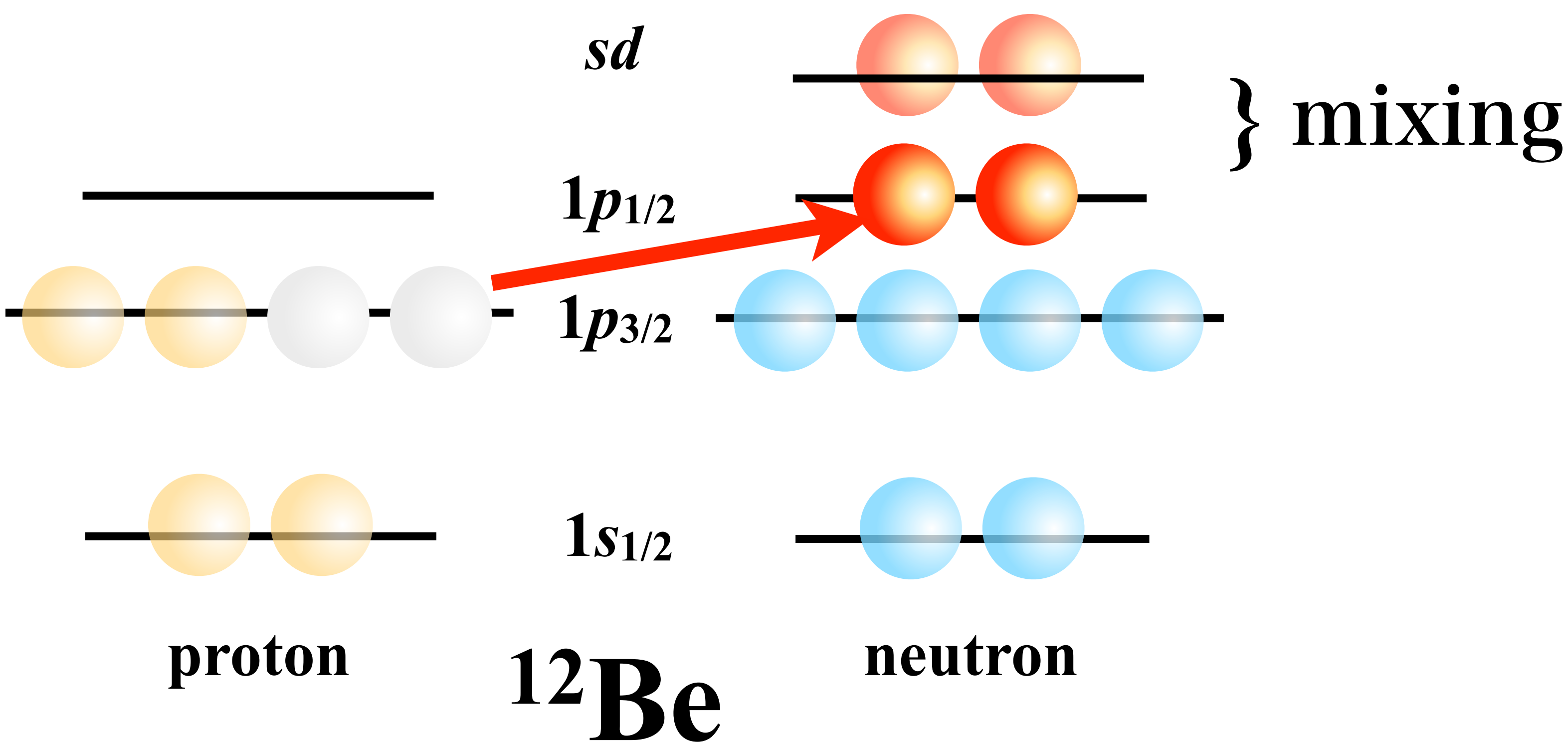


- **Bound and unbound states were observed in one-shot measurement.**
- **The 2.2 MeV peak has a larger cross section than the g.s.**
- **Different angular distribution of the 4.5 MeV peak.**

Probing of the configuration mixing

Mixing degree between *p*- and *sd*-shell components in 0^+ states of ^{12}Be



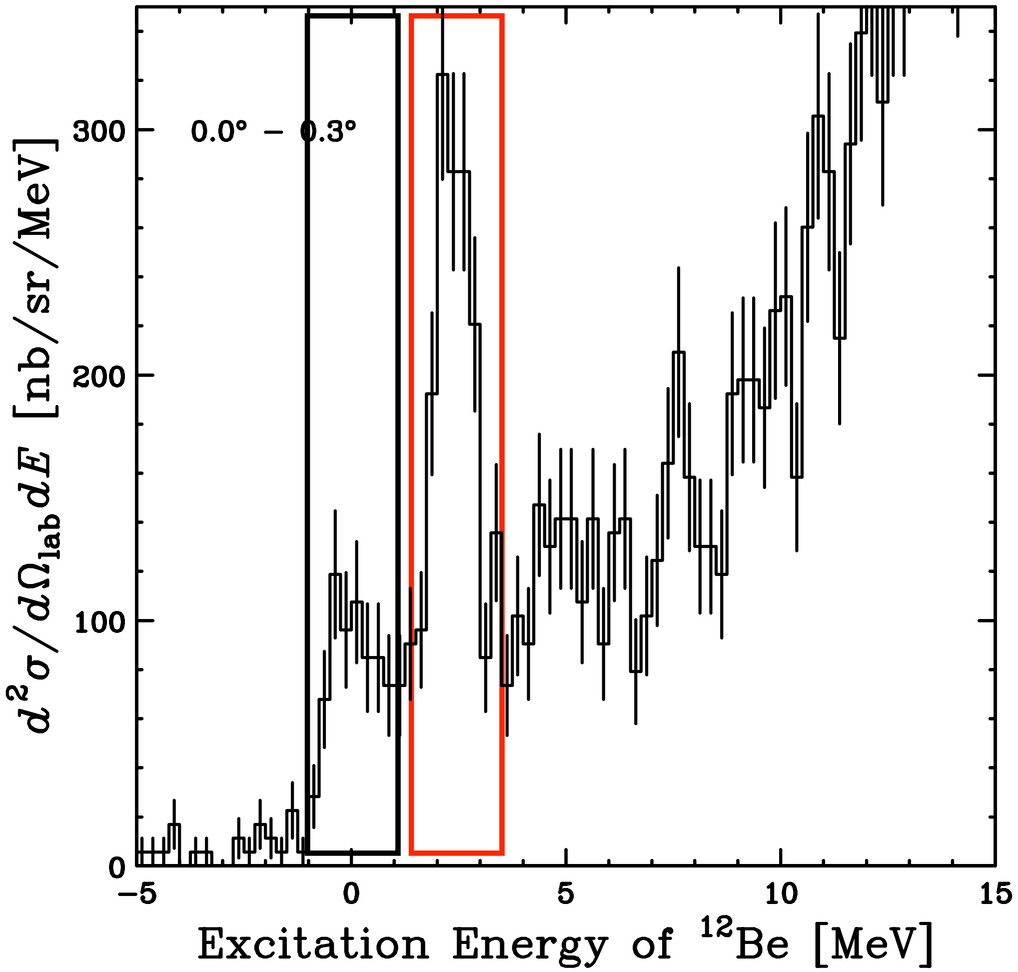


The cross section for the two 0^+ states at forward angle

➡dominated by **double Gamow-Teller transition(ΔL=0, ΔS=2, ΔT=2).**

➡mainly reflect **the *p*-shell contribution**.

Evaluation of *p*-shell contribution to 0^+ states of ^{12}Be



Assumption:
1. ^{12}C g.s. has only p-shell configuration.
2. The transition occurs in the 0hω

relative cross section between $0^+_{g.s.}$ and 0^+_2
←→ ratio of *p*-shell contributions

$$\sigma(0_2^+)/\sigma(0_{\mathrm{g.s.}}^+) = 2.4(2)$$

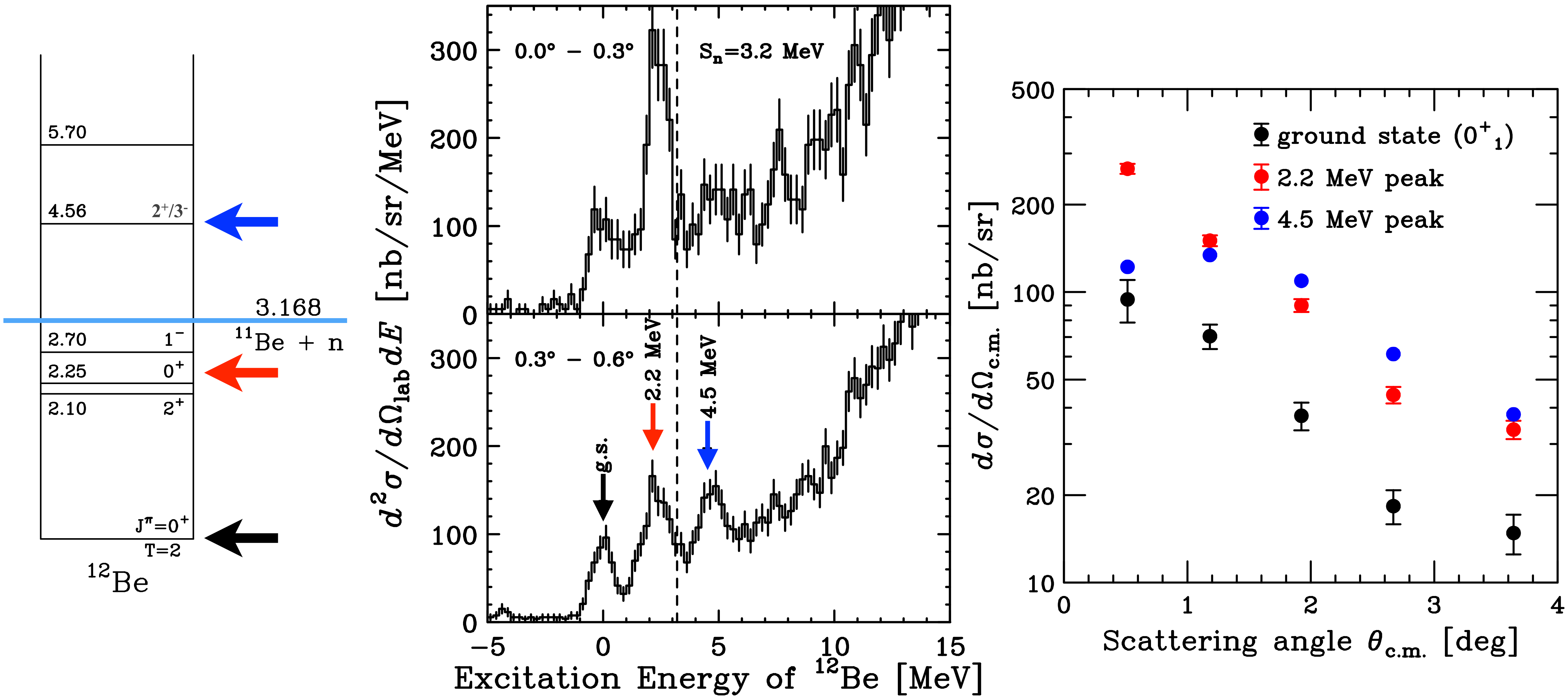
only statistical error

Similar spectroscopic value with earlier works

p-shell contribution in 0				
	0+	0	0+	methods
Meharchant	25	60	2.4±0.5	12
Fortune	32	68	2.1	SM
Barker	31	42	1.4	SM

R. Meharchant et al., PRL 122501, **108** (2012)
H. T. Fortune et al., PRC, 024301, **74** (2006)
F. C. Barker, Journal of Physics G, 2(4), **L45** (1976)

Conclusion



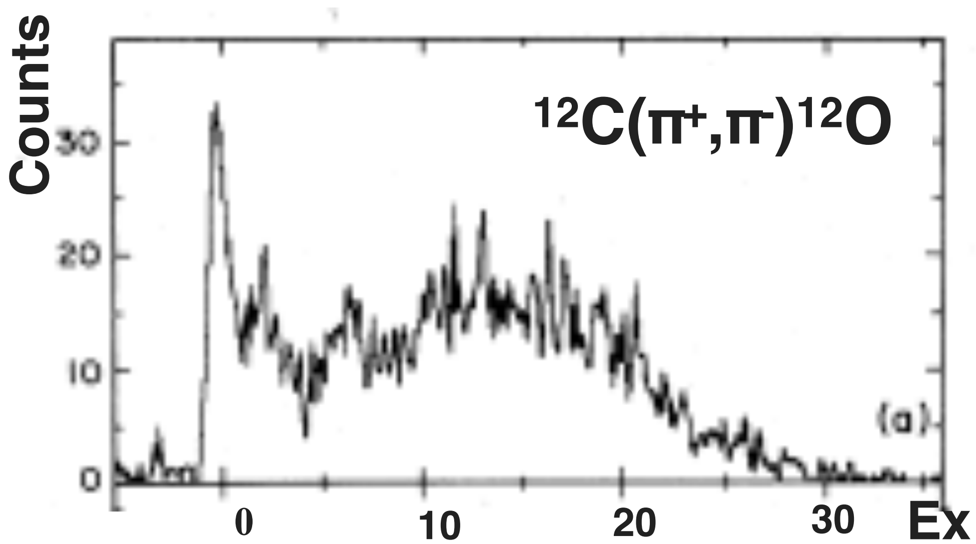
- The 2.2 MeV peak has a larger cross section than the g.s.
  - The *p1/2* component dominantly contributes to the 0^+_2 state.
- The different angular distribution of the 4.5 MeV peak
  - The HIDCX reaction can assign multipolarities.

Summary

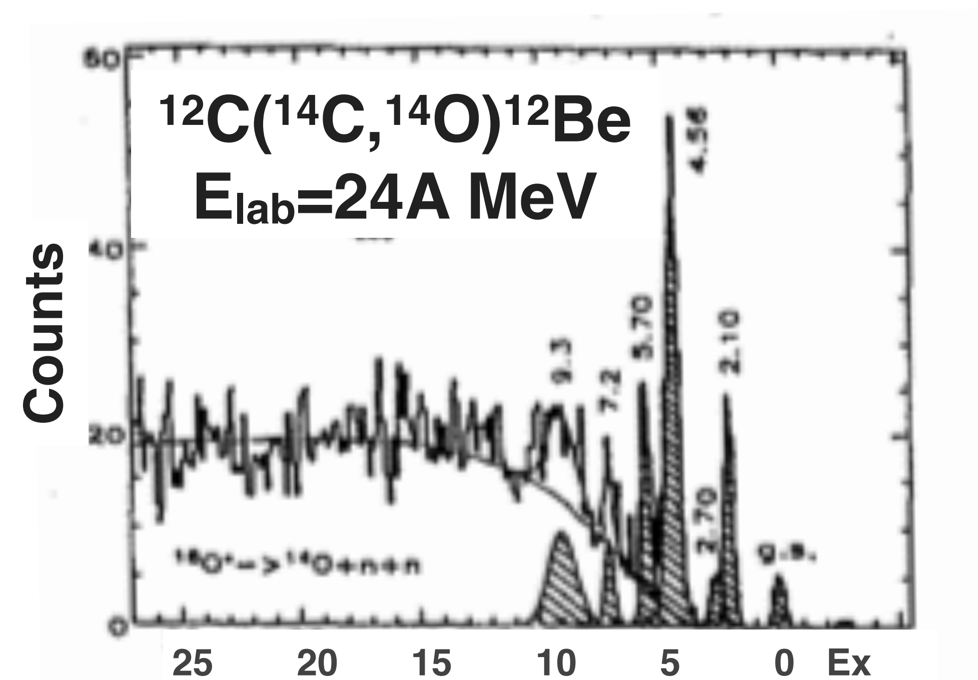
- HIDCX reactions are unique probe for light unstable nuclei and IV double giant resonances, especially spin-flip excitations.
- The HIDCX $^{12}C(^{18}O,^{18}Ne)$ reaction experiment was performed.
  - Three clear peaks were observed at Ex=0.0, 2.2 and 4.5 MeV.
  - Larger cross section for the $^{12}Be(0^{+}_{2})$ state reflects the degree of the *p*-shell contribution for the two 0^{+} states in ^{12}Be.
  - The different angular distributions of the cross sections suggest a sensitivity to multipolarities.
- This study shows that spectroscopic studies with the HIDCX reaction are a valid and feasible!

Thank you for your attention.

Backup



S. Mordechai *et al*.,
PRC, 32 999 (1985)



W. Oertzen *et al.,*
NPA, 588 129c (1995)

Test Experiment to prove experimental feasibility