Direct measurement of S(E) factor for the ^{9}Be(p,a/d) reactions in low energy region (18-100 keV)

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Motivation

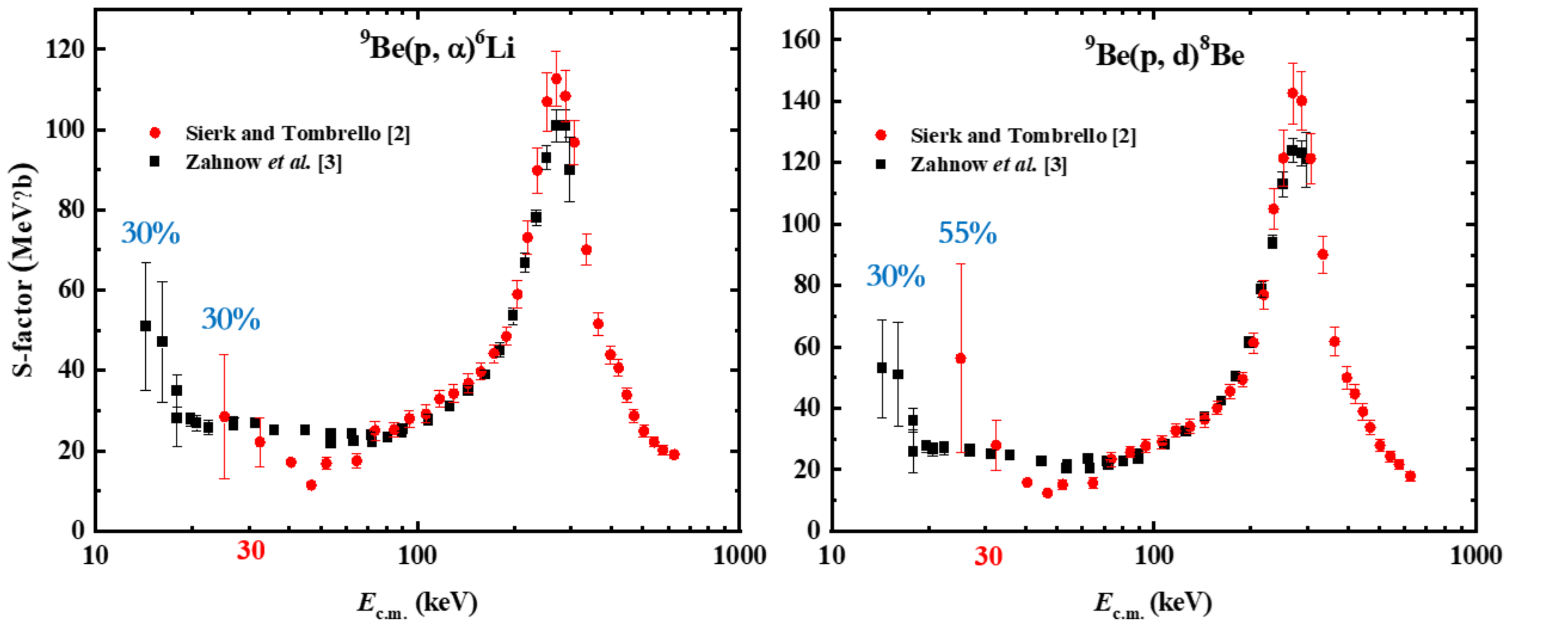
Why reaction rate of the p-^{9}Be reactions measure in low energy?

- Be depletion mechanisms must be well understood to differentiate between cosmic-ray and big-bang production models.
- In both stellar and primordial environments, LiBeB are mainly destroyed by proton-capture reactions via the (p,α) channel with a Gamow energy E_G ranging from 10 keV (for stellar nucleosynthesis) to 100 keV (for primordial nucleosynthesis).
- Primordial beryllium abundance could reveal insights into the Big Bang. Beryllium's reaction rate could be useful for constraining the nonstandard BBN models together with the Li and B.

Introduction

p-^{9}Be reactions：

Direct measurement



The astrophysical S(E) of the ^{9}Be(p, α)^{6}Li (left) and ^{9}Be(p, d)^{8}Be (right) reactions

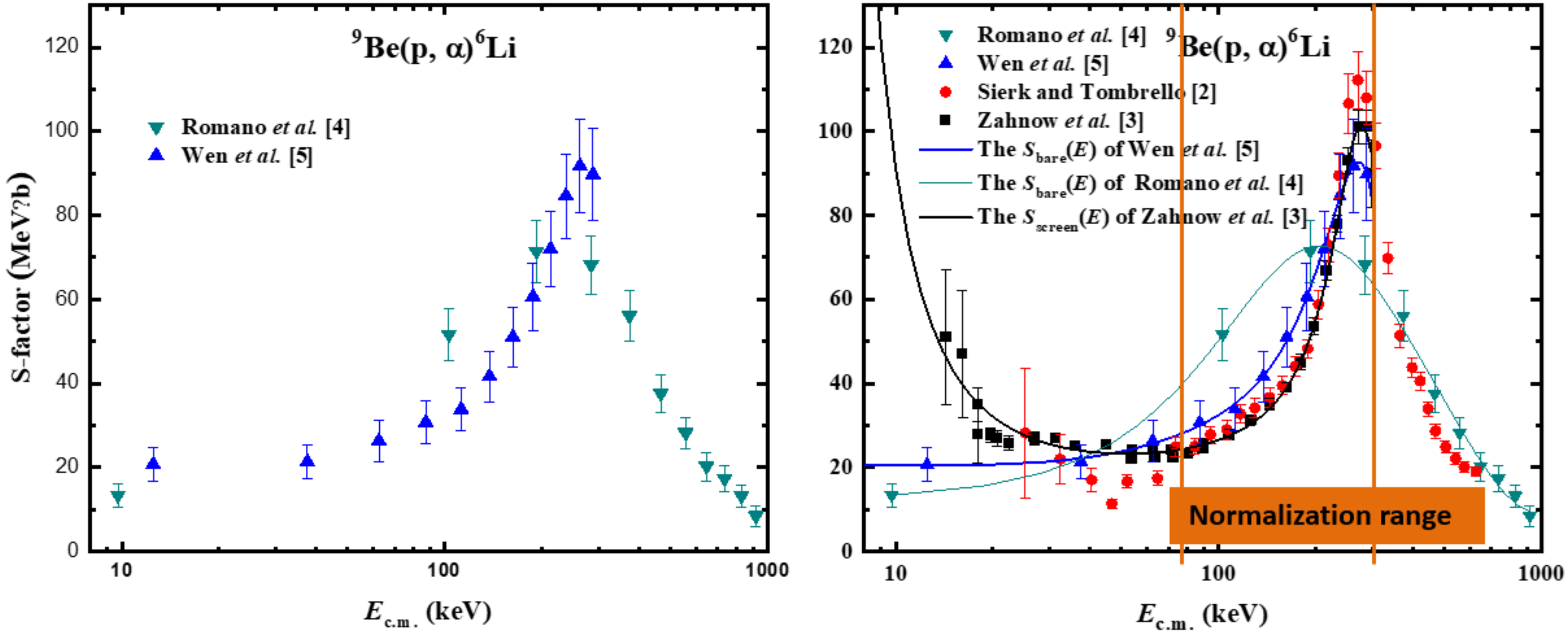
Large errors in low energy region.

[2]. A.J. Sierk, T.A. Tombrello, The ^{9}Be(p, α) and (p, d) cross sections at low energies, Nuclear Physics A, 210 (1973) 341-354.
[3]. D. Zahnow, et al., Low-energy S(E) factor of ^{9}Be(p, a)^{6}Li and ^{9}Be(p, d)^{8}Be, Nuclear Physics A, 359 (1997) 211-218.

Introduction

p-^{9}Be reactions：

Trojan horse method (THM)



The astrophysical S(E) of the ^{9}Be(p, α)^{6}Li (left) and ^{9}Be(p, d)^{8}Be (right) reactions

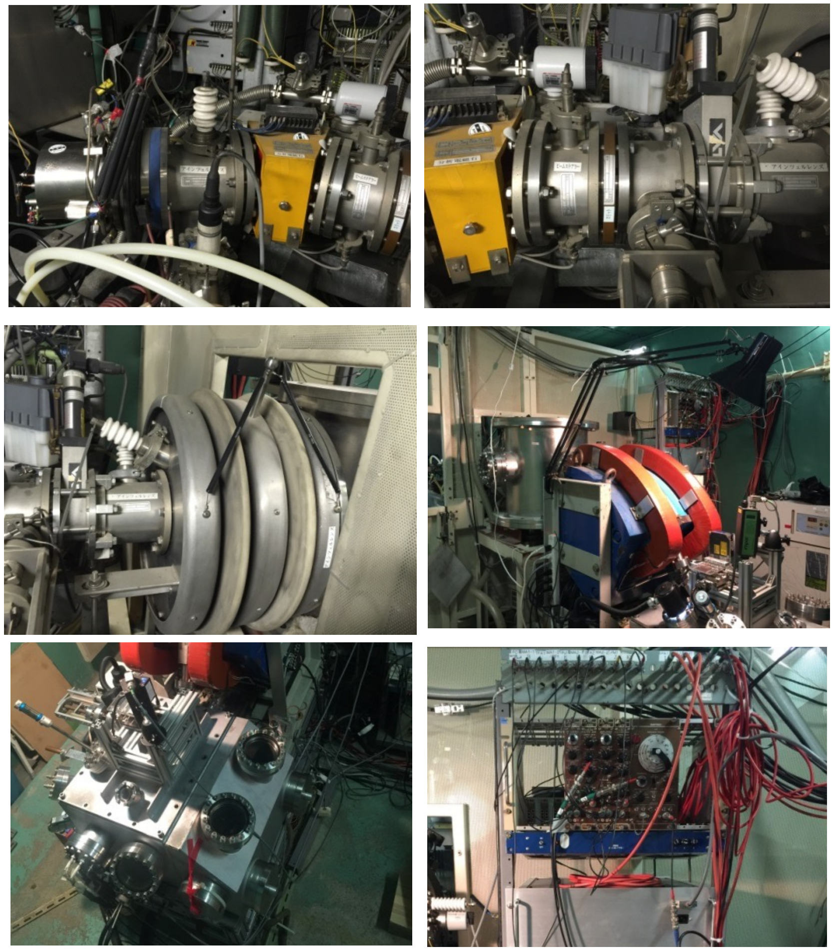
larger resonance width compared to direct measurements.

➢ Measure the cross section in the energy range from 18 to 100 keV.

[4]. S. Romano, et al., Study of the ^{9}Be(p, α)^{6}Li reaction via the Trojan Horse Method, The European Physical Journal A, 27 (2006) 221-225.
[5]. Q.G. Wen, et al., Trojan horse method applied to ^{9}Be (p,α) ^{6}Li at astrophysical energies, Phys.rev.c, 78 (2008).

Experimental setup

Low-energy high-intensity accelerator



1-100 keV high-current accelerator, Tohoku University

Accelerator parameters

Accelerator： $E_{p/d}$: 2 ~ 100 keV

I_{max} = 500 μA

ΔE = ± 35 eV

Filament life~150 hours

Vacuum： ion source~ 10^{-3} Pa

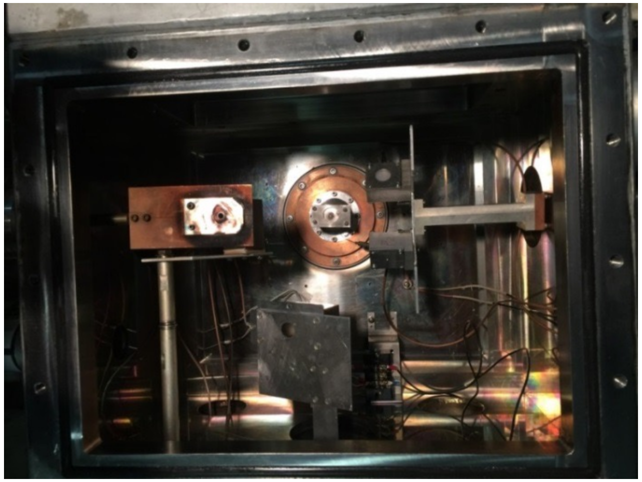
reaction chamber~ 10^{-5} Pa

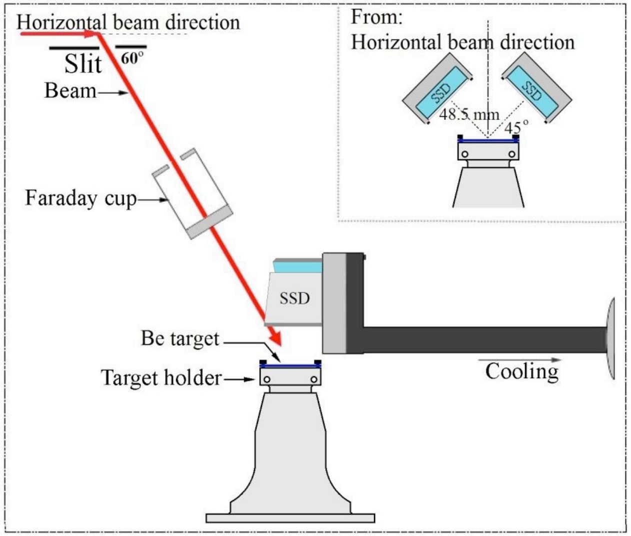
Monitor： Temperature-Infrared thermometer

Beam—Faraday cup (F.C.)

Cooling： water (5°C)

Experimental setup





The configuration of SSD detectors in chamber

Experimental conditions

Beams: H^+: $28 \leq E_{lab} \leq 100$ keV

H_3^+: $54 \leq E_{lab} \leq 102$ keV (ΔE=2 keV/amu)

I_A: 5~130 μA

Spot size: 8 mm

Target: Be (99%), $0.1 \times 25 \times 25$ mm^3

SSD: Area: 450 mm^2

Thickness: 300 μm

Al foil: 1.0 μm

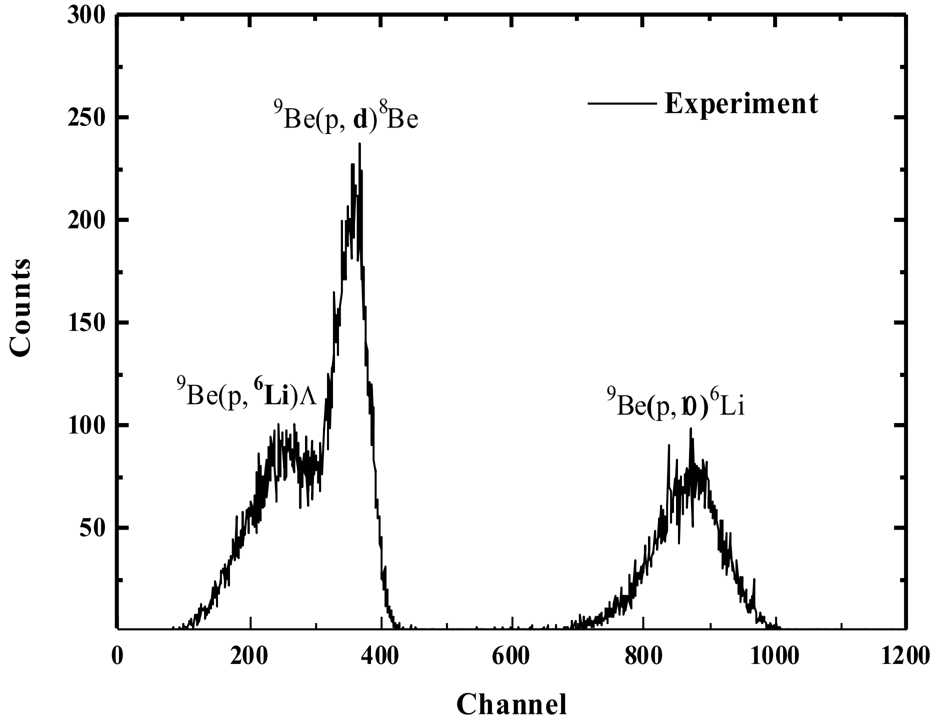
Detection angles: 127°

Solid angle: 0.42 ± 0.01 sr

Method: Thick target yield

Results and analysis

Experimental spectrum



The spectrum of p-^{9}Be reactions at E_p = 100 keV

The thick-target yield:

$$Yield(E_i) = \frac{Counts}{N_p}$$

$$\text{Yield}(E_P) = \frac{N_p N_t \Delta\Omega_{lab}}{4\pi} \int_0^{E_p} \frac{d\Omega_{c.m.}}{d\Omega_{lab}} W(\theta, E)\sigma(E) \times \left(\frac{dE}{dx}\right)^{-1} dE$$

$$\sigma_{bare}(E) = \frac{S_{bare}(E)}{E} \exp(-2\pi\eta(E))$$

$$Yield_d = Yield_{total} - Yield_{Li}$$

$$S(E_{\text{eff}}) = \frac{Y_{\text{exp}}(E_0) - Y_{\text{exp}}(E_0 - \Delta)}{\frac{N_p N_t \Delta\Omega_{lab}}{4\pi} \int_{E_0-\Delta}^{E_0} \frac{d\Omega_{c.m.}}{d\Omega_{lab}} W(\theta,\ E) \frac{\exp(-2\pi\eta)}{E} \left(\frac{dE}{dx}\right)^{-1} dE}$$

$$E_{eff} = E_0 - \Delta E + \Delta E \left\{ -\frac{\sigma_2}{\sigma_1 - \sigma_2} + \left[\frac{\sigma_1{}^2 + \sigma_2{}^2}{2(\sigma_1 - \sigma_2)^2}\right]^{1/2} \right\}$$

Thank you！

Welcome to my poster board！