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Astrophysically important ^{26}Si states studied with the (*d*,*t*) reaction

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(ANL, MSU, Tandar, NW, CSM, ND, WM * supp. by JINA)

1. Motivation
2. Previous experiments
3. Setup for ^{26}Si measurement
4. Pre-experiment with ^{28}Si(*d*,*t*)^{27}Si reaction
5. Preliminary result of ^{27}Si(*d*,*t*)^{26}Si measurement

Motivation

- ^{26}Al found as the first radioactive isotope seen in extra-solar γ-ray astronomy, by observation of ^{26}Al$^{g.s.}$ γ decay ($T_{1/2} = 7.2 \times 10^5$ yr).
- Reaction chain: ^{24}Mg (p, γ) ^{25}Al ($\beta^+ \nu_e$) ^{25}Mg (p, γ) ^{26}Al$^{g.s.}$
- Other possible route: ^{25}Al (p, γ) ^{26}Si ($\beta^+ \nu_e$) ^{26}Al* ($\beta^+ \nu_e$) ^{26}Mg$^{g.s.}$
- Level structure of ^{26}Si for the astrophysical reaction rate of ^{25}Al(p,γ)^{26}Si.
- Assignment of the spin-parity of two states in ^{26}Si to be analogous to the 1^+ state at 5.690 MeV and 3^+ state at 6.125 MeV in ^{26}Mg (proton threshold = 5.518 MeV).
- First measurement of the ^{27}Si(d, t)^{26}Si reaction with a new technique.

Previous measurements of the energy level structure of ^{26}Si

Previous works

Yale	2002 Caggiano	$^{29}Si(^{3}He,^{6}He)^{26}Si$	$5526(4^+)$, $5678(1^+)$, $5945(3^+)$
	2005 Parikh	$^{28}Si(p,t)^{26}Si$	$5517(4^+)$, $5672(1^+)$, $5915(0^+)$
ORNL	2002 Bardayan	$^{28}Si(p,t)^{26}Si$	$5515(4^+)$, $5916\ (0^+)$
	2006 Bardayan	$^{28}Si(p,t)^{26}Si$ (II)	$5914(3^+$ or $2^+)$
CNS	2006 Kwon (NIC IX)	$^{28}Si(^{4}He,^{6}He)^{26}Si$	5508, 5918
Ohio	2004 Parpottas	$^{24}Mg(^{3}He,n)^{26}Si$	$5515(4^+)$, $5670(1^+)$, $5912(3^+)$, $5946\ (0^+)$
MSU	H.Schatz, A. Chen		
ANL	2006 Seweryniak (Gammasphare)		$5517(4^+)$, $5677(1^+)$

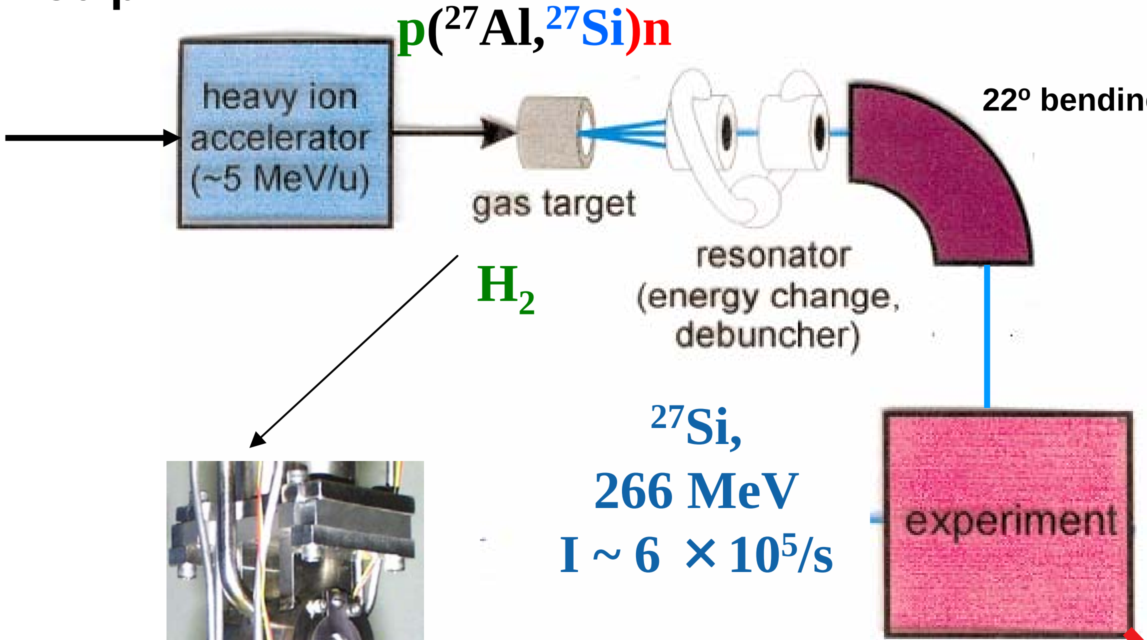
This work

$^{27}Si(d,t)^{26}Si$

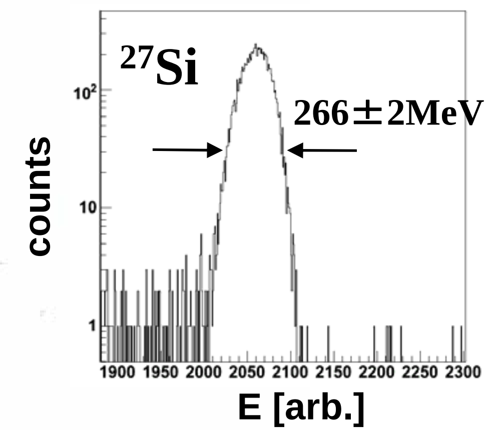
Radioactive Beam Production

^{27}Al, 276 MeV

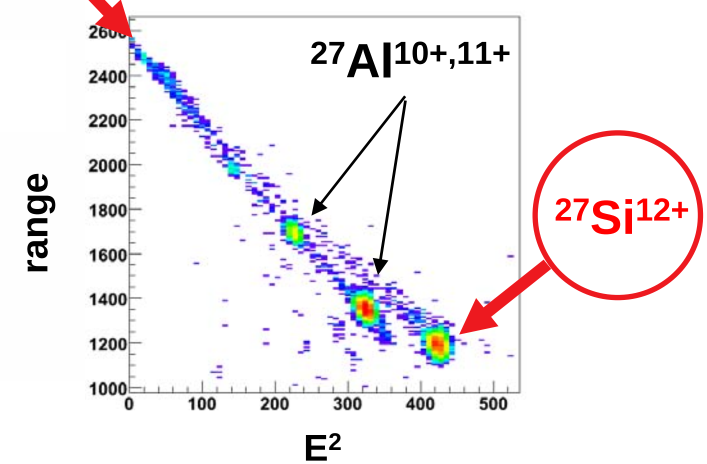
~ 50 pnA



Energy resolution



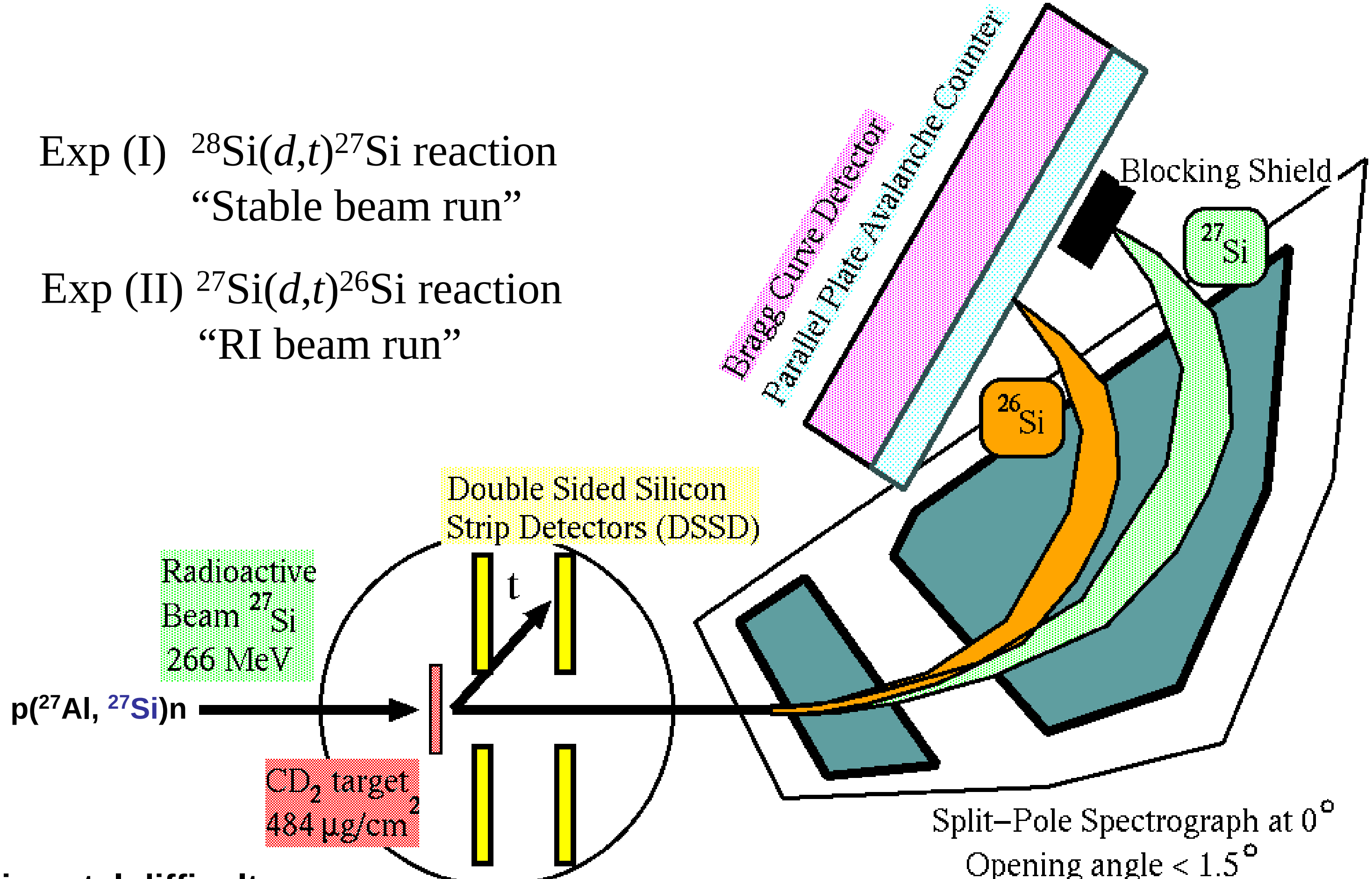
Particle identification



Experimental Setup in ATLAS/ANL

Exp (I) ^{28}Si(d,t)^{27}Si reaction
"Stable beam run"

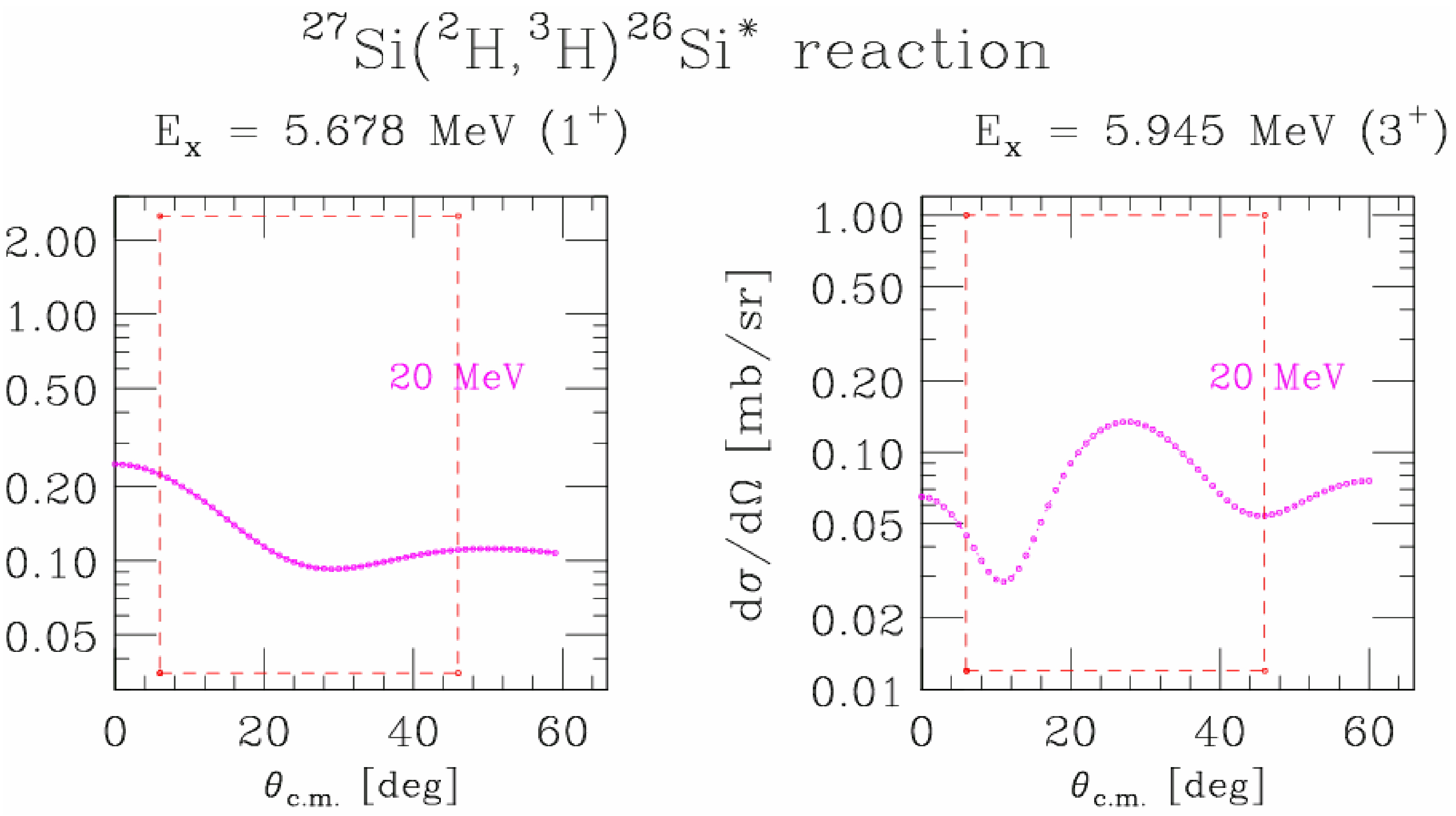
Exp (II) ^{27}Si(d,t)^{26}Si reaction
"RI beam run"



Experimental difficulty

- Low intensity ^{26}Si : ^{27}Si = 1/hr : 6 × 10^5/sec → 2 billion!
- Primary beam vs. RI beam
- First attempt with this setup

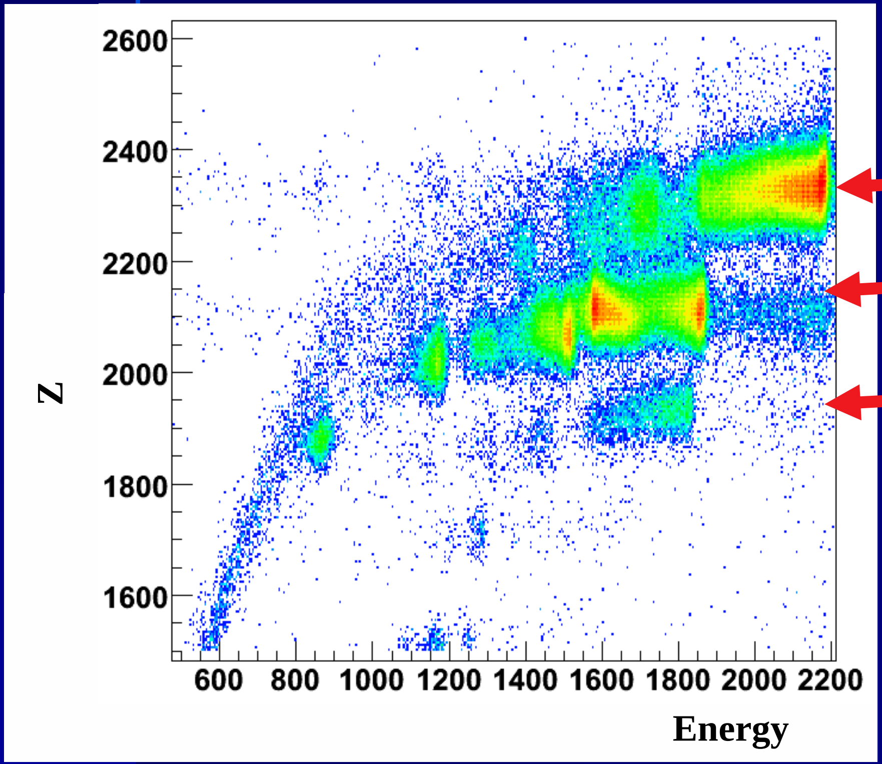
DWBA Calculation



Cross section for ^{26}Si calculated by DWBA code (PTOLEMY) using the optical potential parameters from the analog states of ^{26}Mg

Analysis of Data

$^{27}Si(d,t)^{26}Si$ reaction



Bragg Curve Detector

- Particle Identification for Si
- Gate on Si

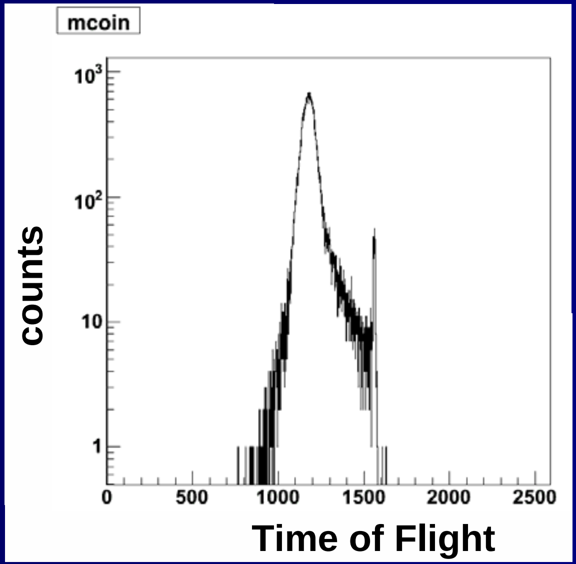
PPAC

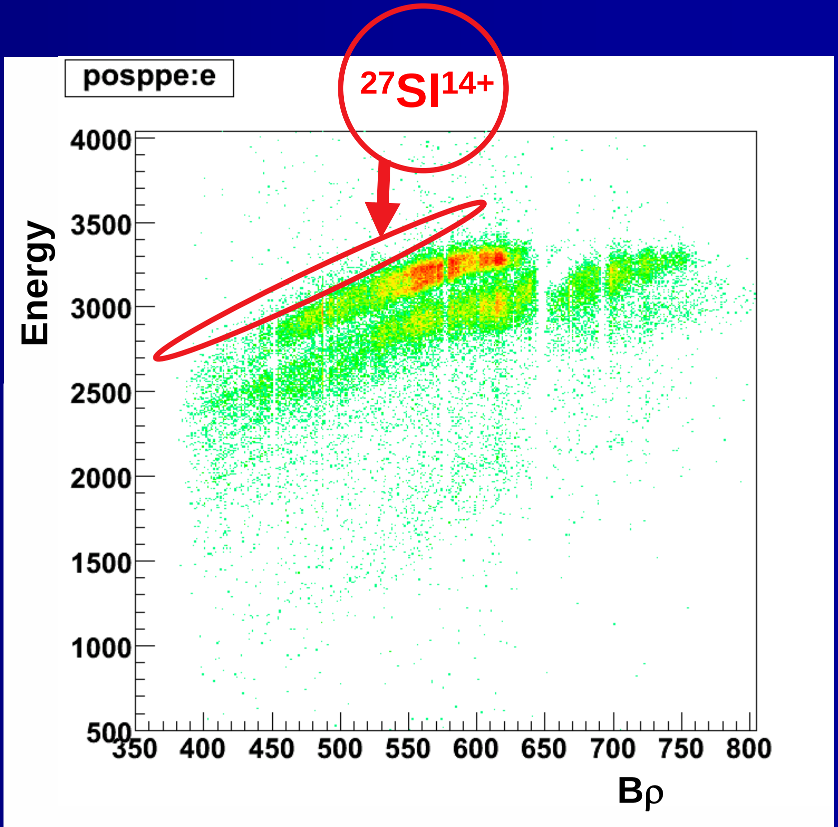
$^{27}Si^{14+}$

Result of Exp (I)

^{28}Si(d,t)^{27}Si reaction

- PI Gate ($^{27}Si^{14+}$)
- Coincidence Gate between triton and Si



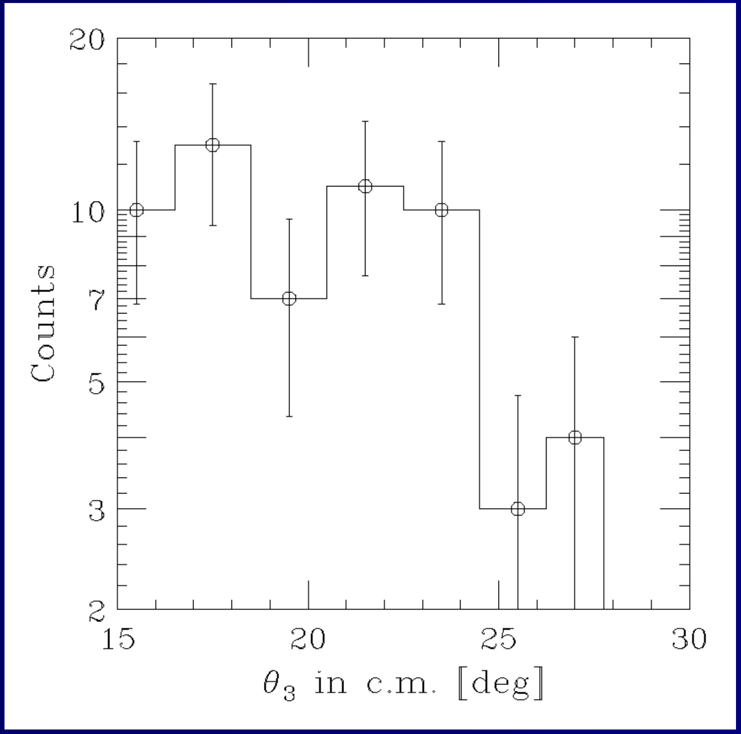


- DSSD Triton spectrum with the PI and Coincidence Gates

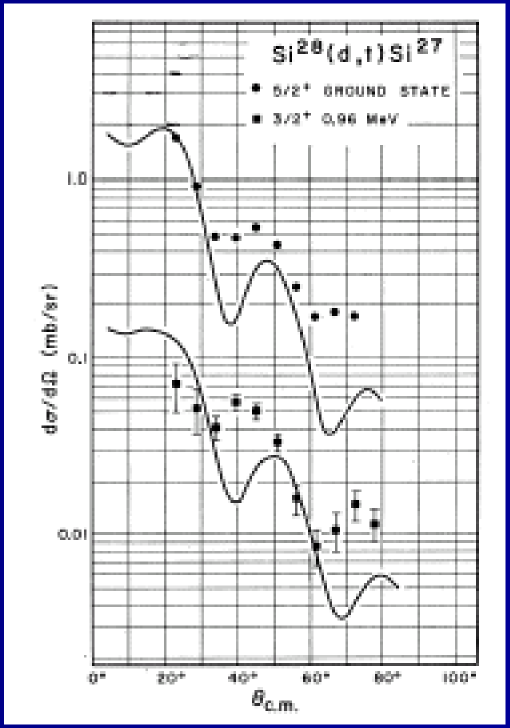
Result of Exp (I)

$^{28}Si(d,t)^{27}Si$ reaction

- Compare the angular distribution for $5/2^+$ g.s.



This work (Data for 7 hrs)

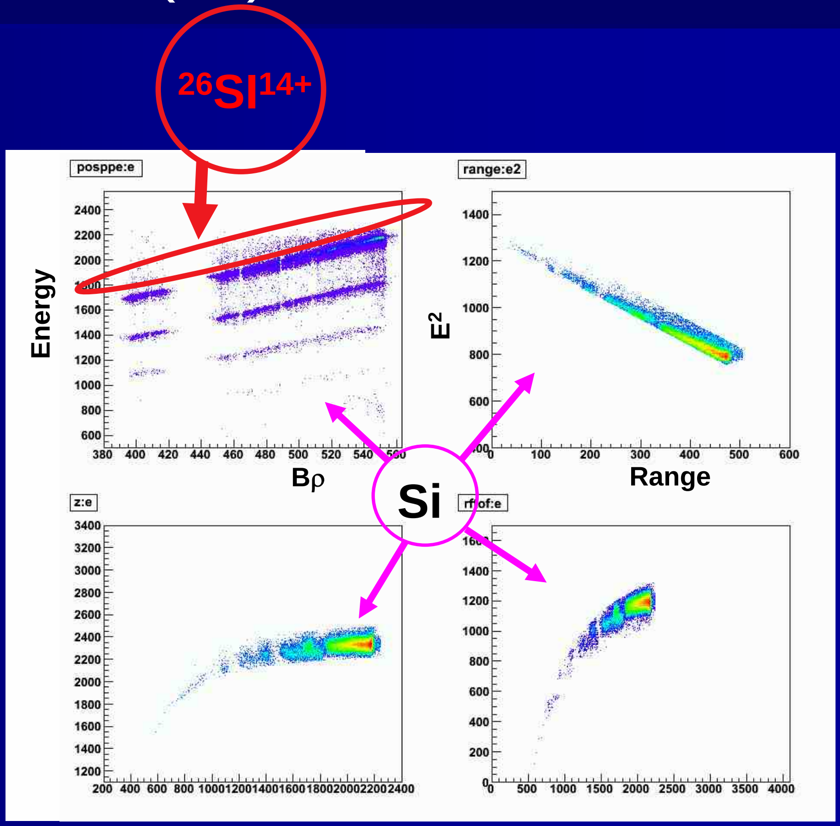


Ref. C. A. Whitten *et al.*, PRC1, p.1455 (1970)
E(d) = 21 MeV

Our new system works for the spin-parity assignment!

Result of Exp (II)

^{27}Si(d,t)^{26}Si reaction



- Experiment with RI beam
- PI Gate (^{26}Si^{14+})
- Coincidence Gate between triton and Si

  <u>looks unclear</u>
- Second DSSD burnt out
- DSSDs spectrum with the Gates

Summary

- Confirmed the functionality of our new system for the spin-parity assignment with $^{28}\mathrm{Si}(d,t)^{27}\mathrm{Si}$ reaction, by measuring the angular distribution of the known states such as $5/2^+$ g.s. in $^{27}\mathrm{Si}$.
- Data analysis of the $^{27}\mathrm{Si}(d,t)^{26}\mathrm{Si}$ reaction in progress.

Future Plans

- The angular distribution of tritons will determine the spin-parity assignment of 5.678- and 5.945-MeV states in ^{26}Si.
- To calculate the reaction rate of ^{25}Al (p, γ) ^{26}Si using our result to improve nucleosynthesis models.
- To apply the new technique to measure a series of astrophysically important reactions involving ^{22}Mg, ^{30}S, and ^{34}Ar.