Takahashi, A. *Studies on 3D Fusion Reactions in TiDx under Ion Beam Implantation, PowerPoint slides*. in *Tenth International Conference on Cold Fusion*. 2003. Cambridge, MA: LENR-CANR.org.

Slide 1

Studies on 3D Fusion Reactions in Titanium Deuteride under Ion Beam Implantation

A. Takahashi, H. Miyamaru, K. Ochiai,
T. Hayashi, T. Dairaku

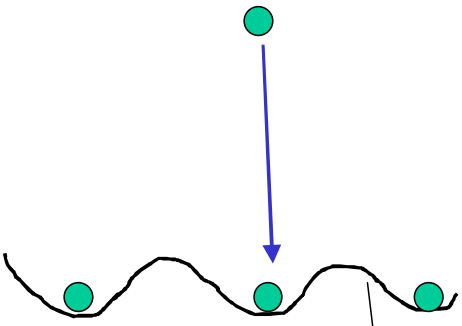
Osaka University

2003

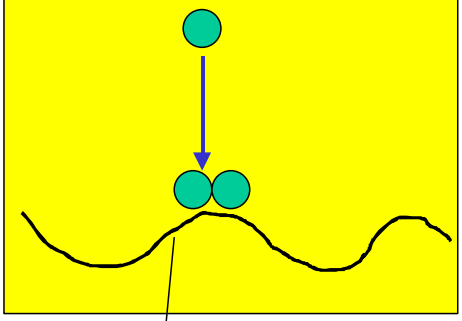
Slide 2

D-Beam Enhances 3D-Fusion if CF DD Fusion is Stimulated

- Without Stimulation results in 2D fusion



With Stimulation enhances 3D Fusion Rate

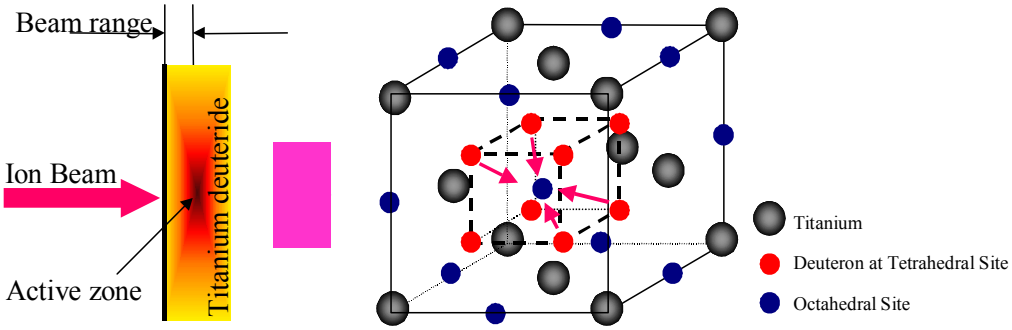


Lattice Trapping Potential

Slide 3

Aim: To Seek 3D Fusion in Solid

Using low energy ion beams, products of 3D fusion are detected.



Beyond the range of incident beam, active zone will be formed by

Electron phonon interaction in metal-deuteride.

In Active zone, transient D-cluster with electron quasi-particles will induce very enhanced 3D and 4D multi-body fusion reactions.

Slide 4

～Multibody Fusion in Condensed Matter～

Key Point

- High D-absorption （TiD_x x ~ 1.8）
- Regular lattice structure （out of beam stopping range）
- Screening effect by presumed electronic quasi-particle

Possible Branches

D+D+D → $^{6}Li^{*}$ → t(4.75MeV)＋^{3}He(4.75MeV) …(a)

→ d(15.9MeV)＋^{4}He(7.93MeV) …(b)

→ n＋p＋^{4}He＋20.1MeV

Slide 5

Experimental Chamber and Measuring System

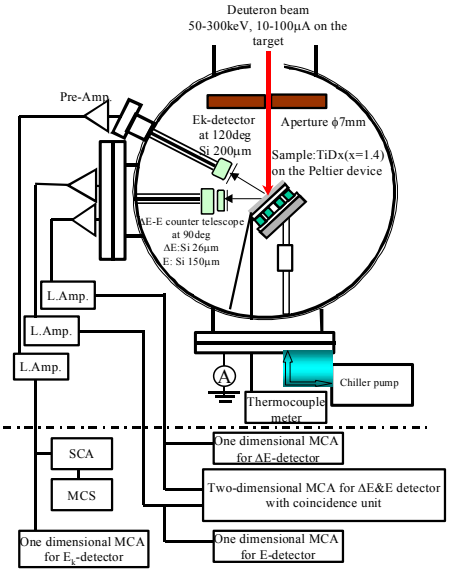


図5.6　固体内核反応重陽子ビーム注入実験体系図

- TiDx (x>1.7) was cooled with Peltier device.
- E & delta-E counter telescope type charged particle detector was used for Particle Identification.
- Ek detector was used for measuring total kinetic energy of particles.

Slide 6

Estimation of Particle-Energy-Losses by TRIM Code

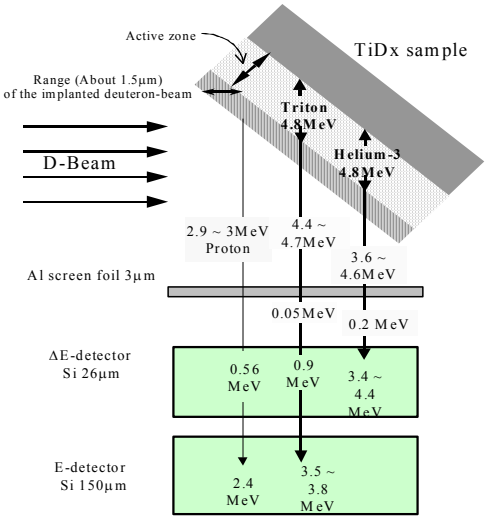
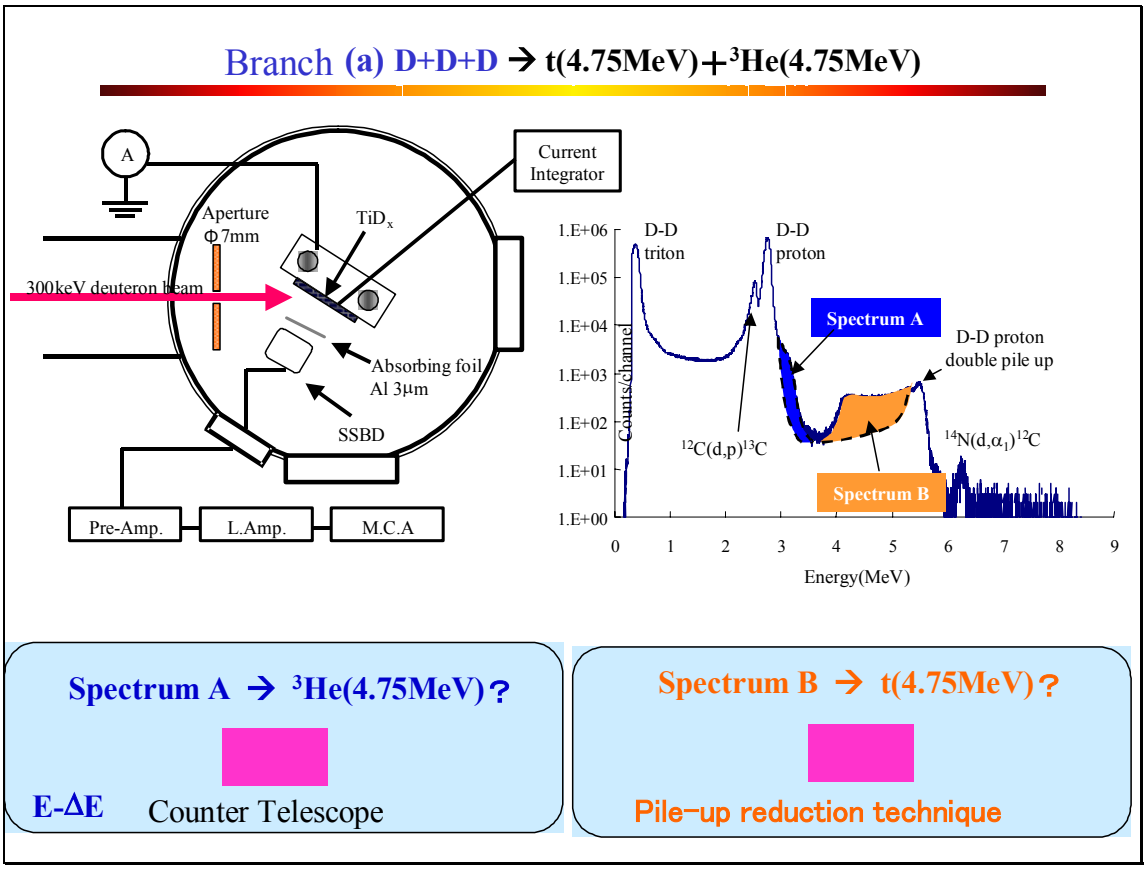


図5.16　固体内コヒーレント3体重水素核反応によるトリトン（4.75 MeV）及びヘリウム－3（4.75 MeV）の発生プロセスの概念図（ビーム飛程より深い領域（アクティブ･ゾーン）で発生すると推測）

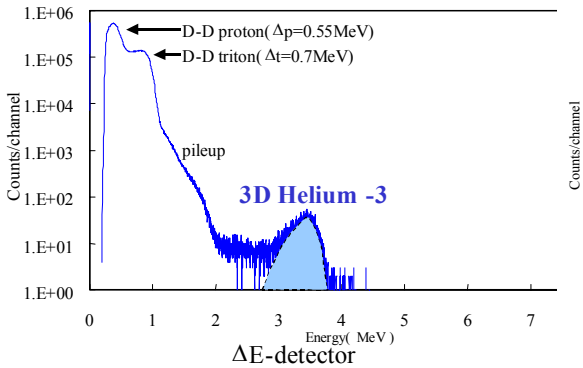
- D + D → p + t + 4.02 MeV
- → ^{3}He + n + 3.25MeV
- 3D → t + 3He + 9.5 MeV

Slide 7

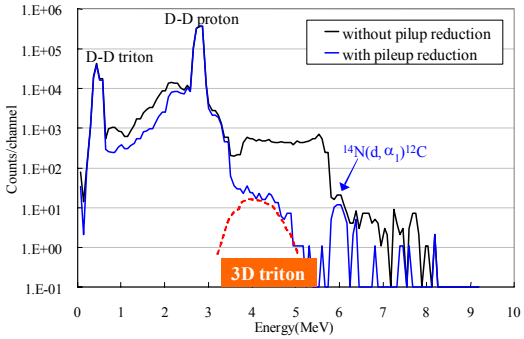

Branch (a) D+D+D → t(4.75MeV)+3He(4.75MeV)
A
Aperture
Φ7mm
TiDx
Current
Integrator
300keV deuteron beam
Absorbing foil
Al 3μm
SSBD
Pre-Amp.
L.Amp.
M.C.A
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
Counts/channel
D-D
triton
D-D
proton
Spectrum A
D-D proton
double pile up
12C(d,p)13C
14N(d,α1)12C
Spectrum B
0
1
2
3
4
5
6
7
8
9
Energy(MeV)
Spectrum A → 3He(4.75MeV)?
E-ΔE
Counter Telescope
Spectrum B → t(4.75MeV)?
Pile-up reduction technique

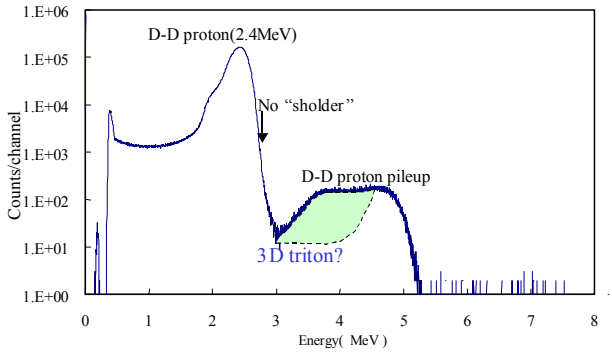
Slide 8

Branch (a) D+D+D → t(4.75MeV)+^{3}He(4.75MeV)



ΔE-detector





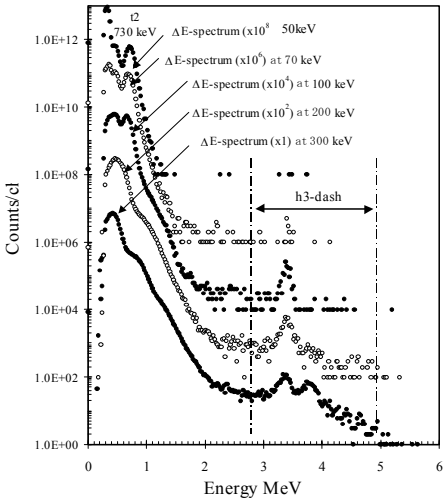
E-detector

[^{3}He by 3D]/[p by 2D] = 1.1E-4

[t by 3D]/[p by 2D] = 1.2E-4

[3D]/[2D] = 1.15E-4

Spectra by delta-E Detector; TiDx Sample



- Data are taken for 50, 70, 100, 150, 200 and 300 keV of D-beam energy
- Peak around 3.5 MeV may correspond to ^{3}He by 3D fusion
- To this evaluation, integral counts in h3-dash window were used

Slide 10

Yields by h3-dash ([3D]) vs. 2D Yields and Impurity Reaction

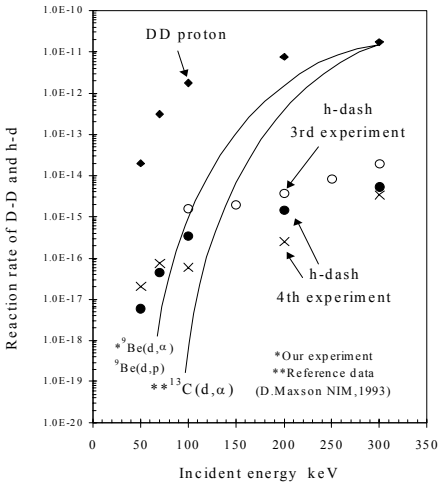


図5.12 重水素ビームの入射クーロン数で規格化したh3-dash収量比の入射エネルギー依存性

- Energy Dependence of h3-dash yields show much slower decrease than that of possible impurity reactions.
- Data for h3-dash were reproduced for 4 times.

Slide 11

D-Beam Energy Dependence of [3D]/[2D] Ratios

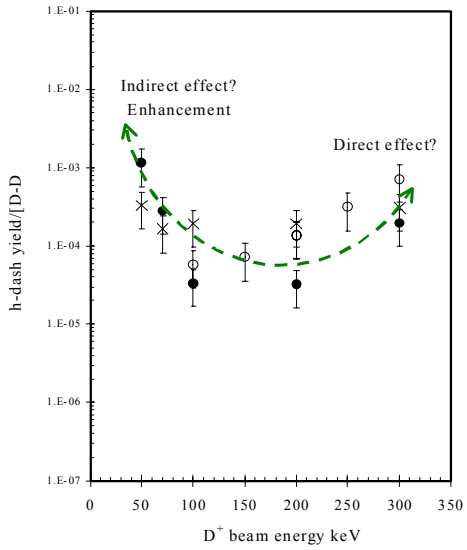
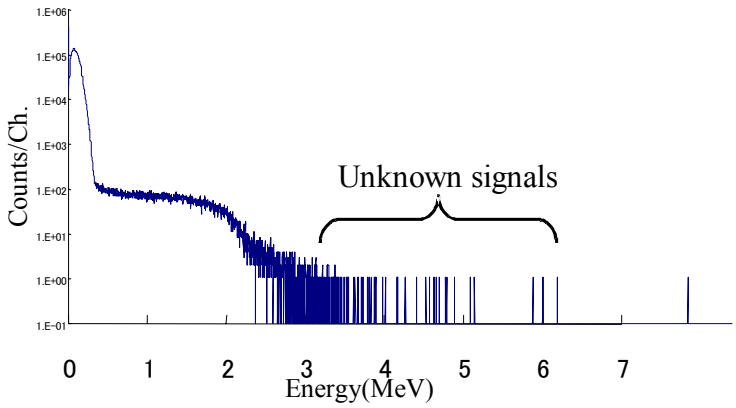


図5.14 D-Dプロトン収量比で規格化したh-dash収量比のエネルギー依存性

- [3D]/[2D] Yield Ratios by Experiment are in the order of 1E-4 to 1E-3.
- Increasing trend in lower energy region than 100 keV may result in indirect 3D reactions.
- Theoretical values by the conventional Random Nuclear Reaction Theory has given [3D]/[2D] ratio to be in the order of 1E-30
- Experiment shows 1E+26 anomalous enhancement.

Slide 12

Branch (b) D+D+D → d(15.9MeV)+^{4}He(7.93MeV)

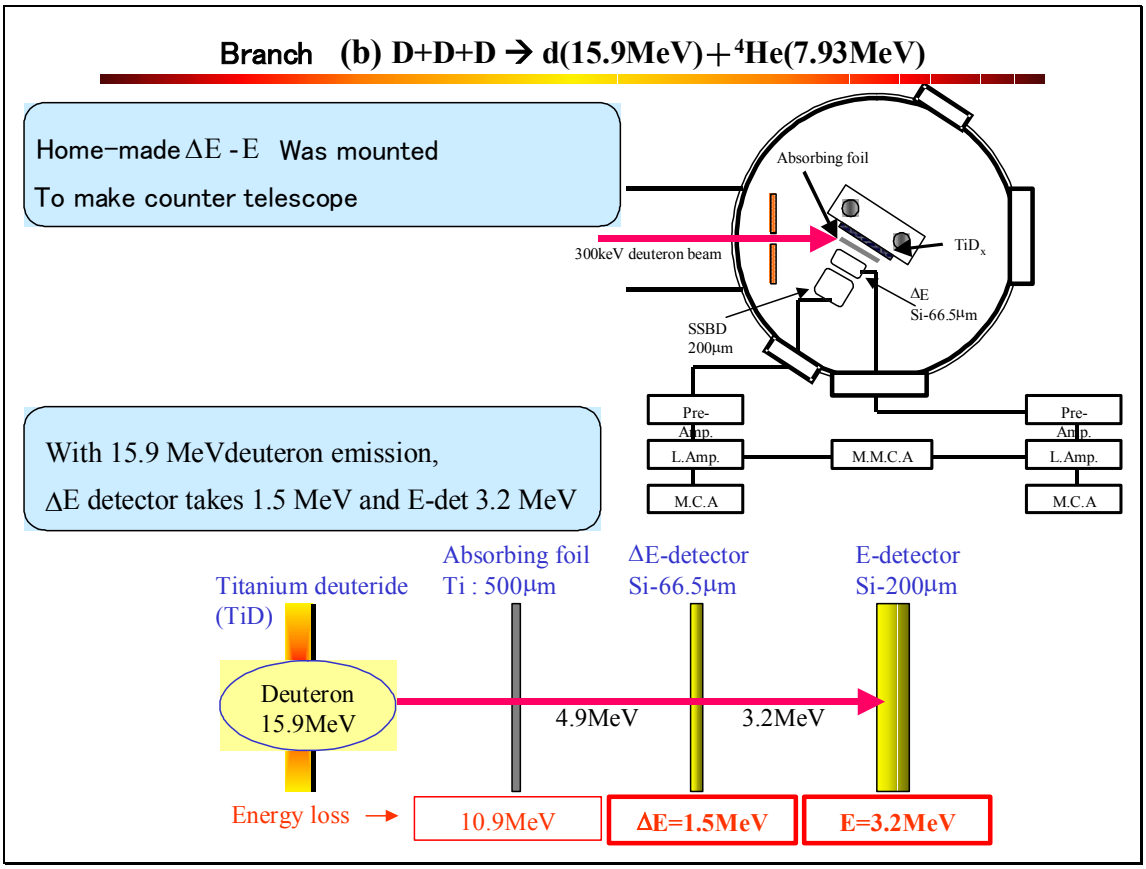


500μm did not stop unknown signals which should have high energy

3D Fusion emits 15.9 deuterons.

Particle identification by E-ΔE Counter Telescope

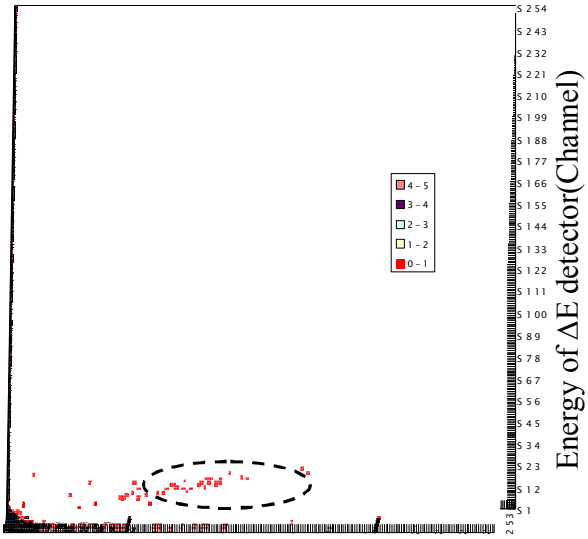
Slide 13


Branch (b) D+D+D → d(15.9MeV)+⁴He(7.93MeV)
Home-made ΔE - E Was mounted
To make counter telescope
With 15.9 MeVdeuteron emission,
ΔE detector takes 1.5 MeV and E-det 3.2 MeV
Absorbing foil
TiDx
300keV deuteron beam
ΔE
Si-66.5μm
SSBD
200μm
Pre-Amp.
L.Amp.
M.M.C.A
M.C.A
Titanium deuteride
(TiD)
Deuteron
15.9MeV
Absorbing foil
Ti : 500μm
ΔE-detector
Si-66.5μm
E-detector
Si-200μm
4.9MeV
3.2MeV
Energy loss
10.9MeV
ΔE=1.5MeV
E=3.2MeV

Slide 14

ブランチ(b) D+D+D → d(15.9MeV)＋^{4}He(7.93MeV)

Branch



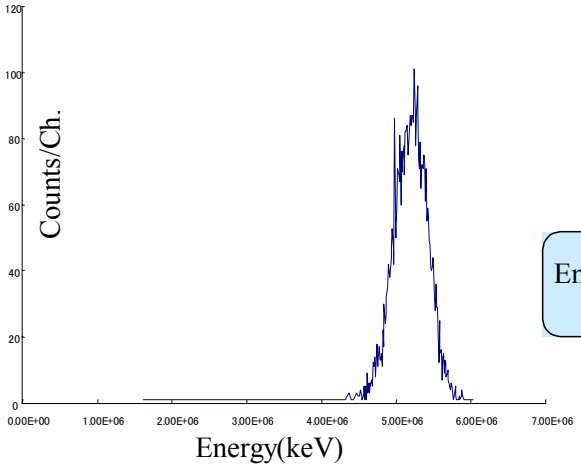
Two dimensional charged particle spectrum
measured by E-ΔE counter telescope

Slide 15

Branch (b) D+D+D → d(15.9MeV)+^{4}He(7.93MeV)

Measured energies are considerably scattered.

Ti500μm filter makes considerable energy struggling.

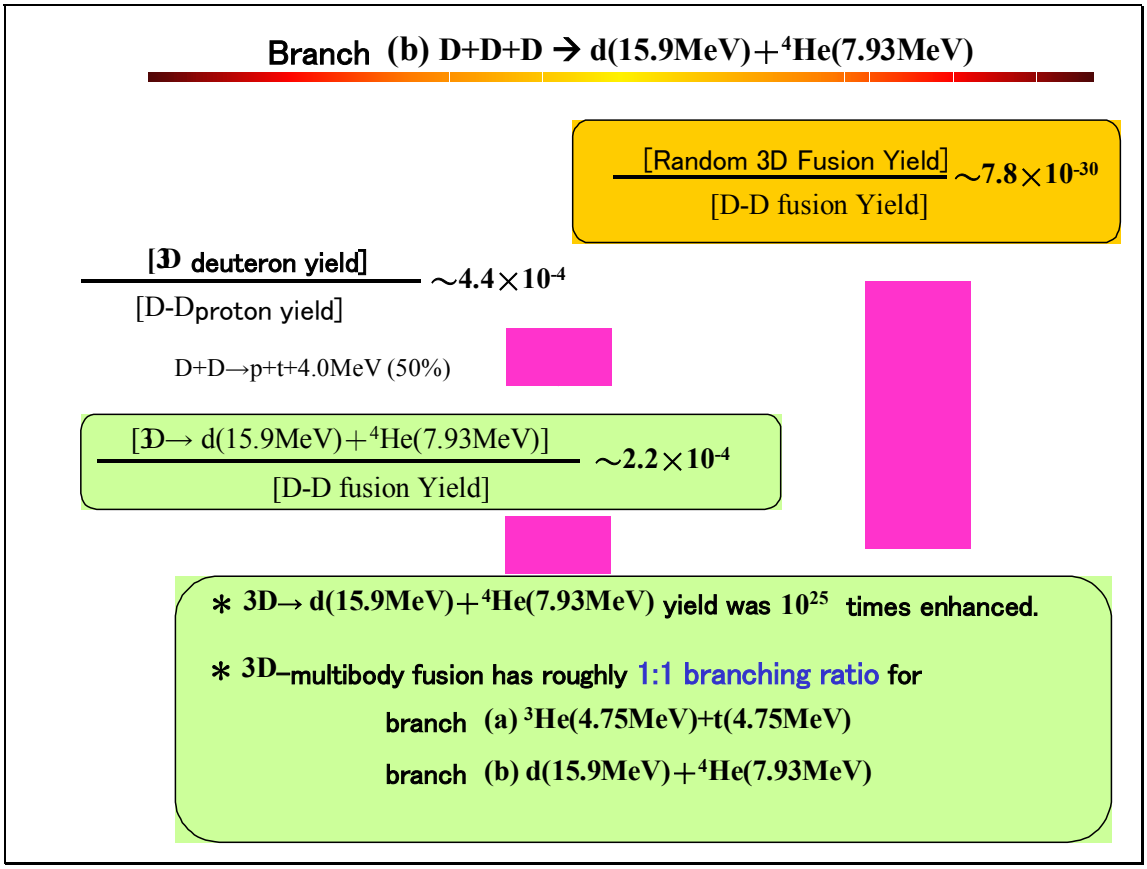


TRIM calculation gave simulation

Energy struggling from 4.5 to 6 MeV was Estimated by TRIM

Measured particles can be 15.9 MeV
Deuterons from 3D fusion reaction

Slide 16


Branch (b) D+D+D → d(15.9MeV)+4He(7.93MeV)
[Random 3D Fusion Yield] / [D-D fusion Yield] ~7.8×10-30
[3D deuteron yield] / [D-Dproton yield] ~4.4×10-4
D+D→p+t+4.0MeV (50%)
[3D→ d(15.9MeV)+4He(7.93MeV)] / [D-D fusion Yield] ~2.2×10-4
* 3D→ d(15.9MeV)+4He(7.93MeV) yield was 10^25 times enhanced.
* 3D–multibody fusion has roughly 1:1 branching ratio for
branch (a) 3He(4.75MeV)+t(4.75MeV)
branch (b) d(15.9MeV)+4He(7.93MeV)

Slide 17

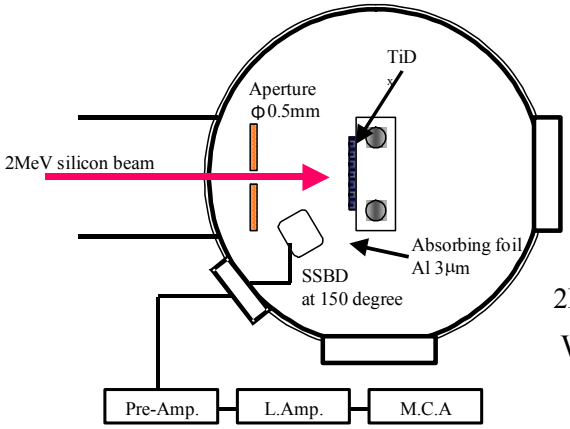
Experiment with Si beam

Merits

* **Si beam can be used only for excitation.**

  We can discuss about whether multi-body fusion reaction contains only direct Beam effect or with **indirect 3D fusion reactions which is true CF phenomenon.**

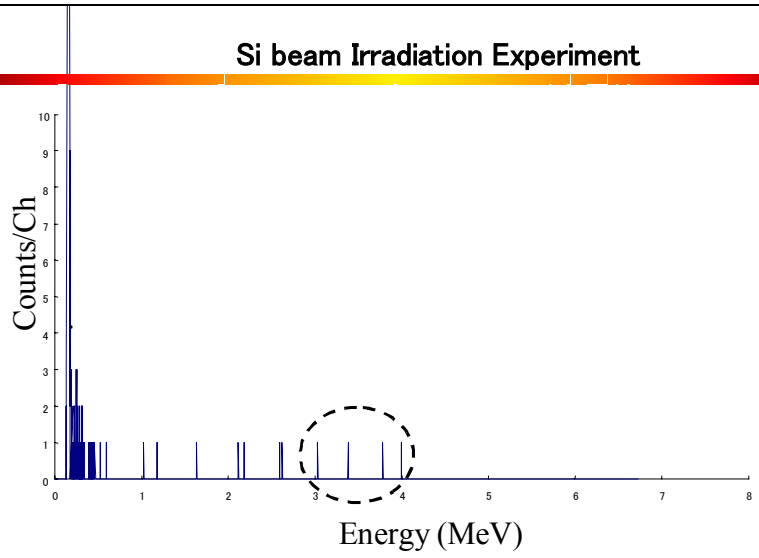
* **No impurity reactions → easy to detect aimed signals**



2D fusion reactions by knocked-on cascade
Will be detected and what ?

Slide 18

Si beam Irradiation Experiment



In 3 MeV～4MeV region, we detected **some signals**

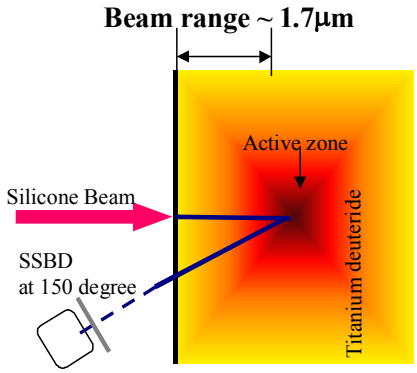
Which suggests unusual reactions.

3D → ^{3}He(4.75MeV)+t(4.75MeV) ？？

Slide 19

Prediction for Si beam Experiment

3D → ^{3}He(4.75MeV)+t(4.75MeV) makes What energy deposits？



Active Zone is assumed as 1.7 μm

Charged particle	Estimated Energy (MeV)
t	4.5
^{3}He	3.9

Detected unusual signals may be these triton and He-3 by 3D fusion.

However, due to poor statistics, we need further study to conclude.

Slide 20

Conclusions

Reaction Branch	Beam	Method	Result	Ratio to D-D
(a) 3D→ ^{3}He(4.75MeV)+t(4.75MeV)	Deuteron	E-ΔE counter telescope	^{3}He	2.2×10^{-4}
		Pile-up Reduction	t	2.0×10^{-4}
	Silicon	SSBD	3D ?	
(b) 3D→ D(15.9MeV)+^{4}He(7.9MeV)	Deuteron	E-ΔE counter telescope	d	4.4×10^{-4}
HDD→ P(19.1MeV)+^{4}He(4.75MeV)	Proton	With various Absorption foils	p	

* **E-ΔE measurements gave detection of t, ^{3}He and high energy d.**

3D fusion branching (a) and (b) → 1 : 1

Conclusions-2

- Experimental [3D]/[2D] yield ratios were in the order of 1E-3 to 1E-4, compared with 1E-30 by random nuclear reaction theory.
- Anomalous enhancement ratio of 1E26 suggests that electron screening effect on d-d Coulomb repulsion in TiDx lattice dynamics is far greater than that of Thomas-Fermi gas model.
- EQPET (Transient Electronic Quasi-Particle Expansion Theory) model can basically explain the unusual enhancement of screening effect.