



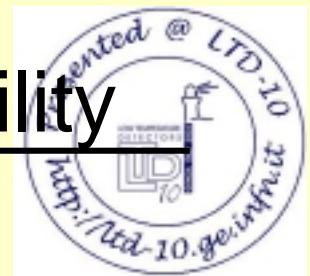
# Neutron detection by Superconducting Tunnel Junction on $\text{Li}_2\text{B}_4\text{O}_7$ single crystal absorber

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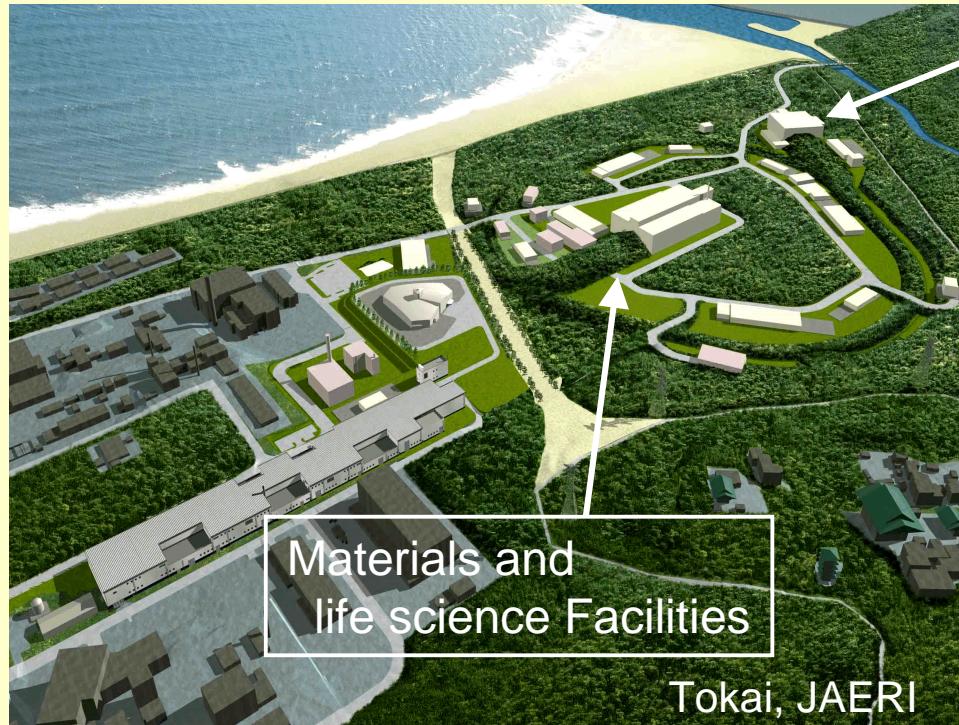
a) Japan Atomic Energy Research Institute (JAERI)

b) National Institute of Advanced Industrial Science  
and Technology (AIST)

# High-Intensity Proton Accelerator Facility

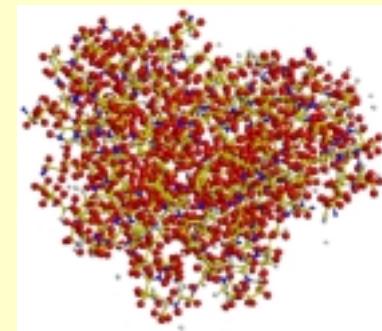


- High Intensity pulsed neutron source
- Now under construction in Tokai, JAERI



Materials and  
life science Facilities

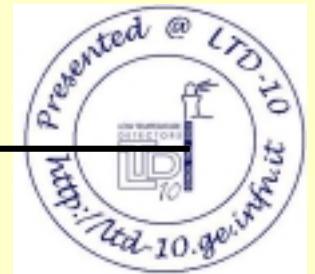
Biology



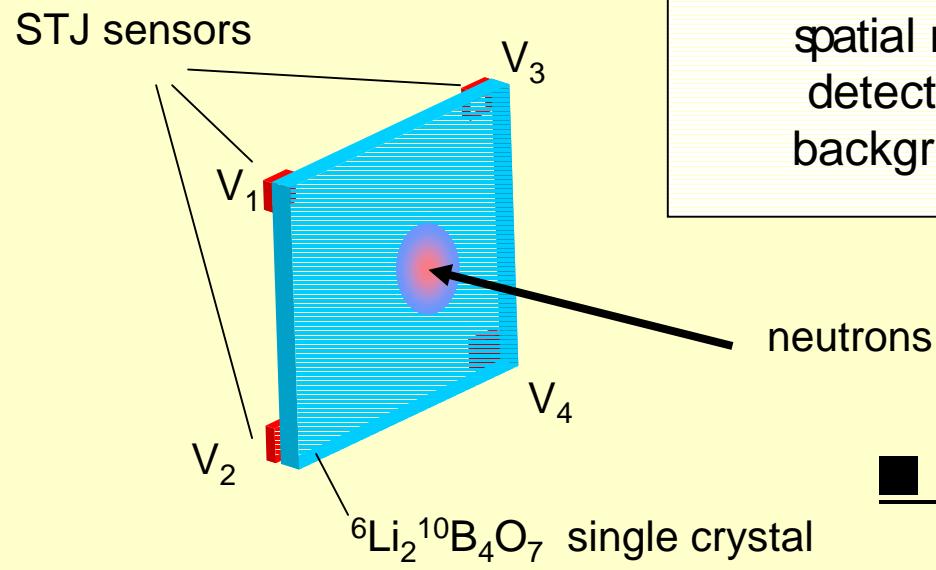
Structure of myoglobin

Neutron Science

# Novel tool to explore neutron science



## STJs on $\text{Li}_2\text{B}_4\text{O}_7$ single crystal



### ■ Performances (expected)

spatial resolution : < 10  $\mu\text{m}$   
detection efficiency : > 95% @ 1.8A  
background : very low

### ■ Detection principle

neutron absorption at LBO xtal  
phonon creation in a spot ~6  $\mu\text{m}$   
phonon detection at STJs

New Tools, New Science,...

# $\text{Li}_2\text{B}_4\text{O}_7$ single crystal

-- ideal absorber for neutrons --

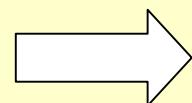


- Commonly used for
  - non-linear optical crystal
  - Surface acoustic waves(SAW) filter



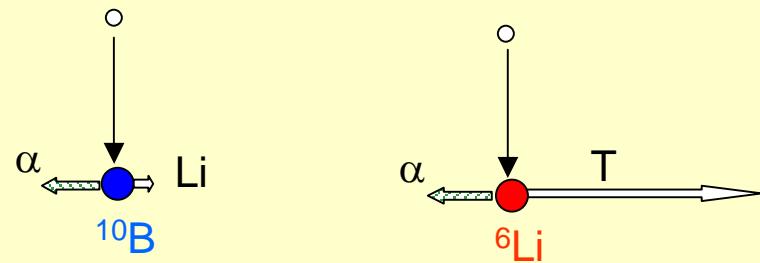
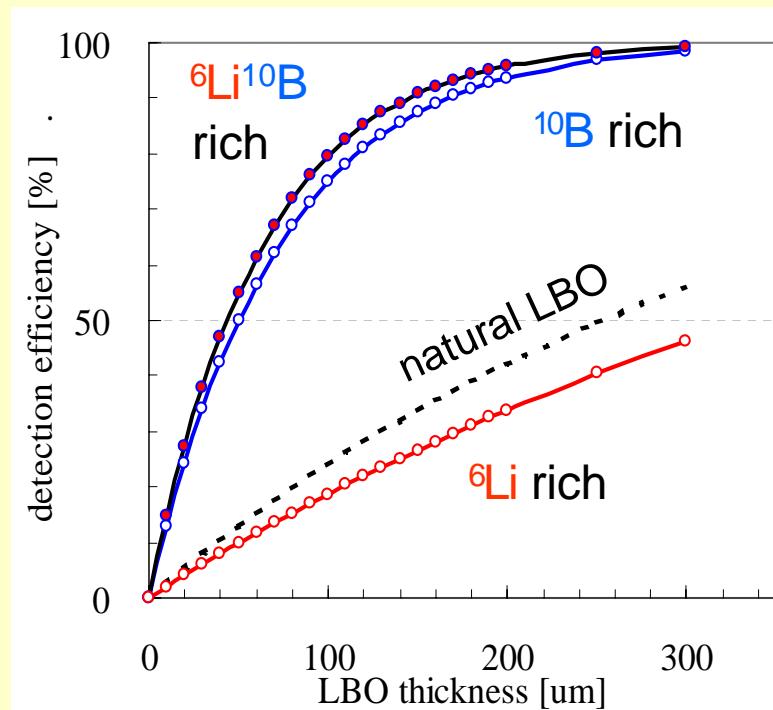
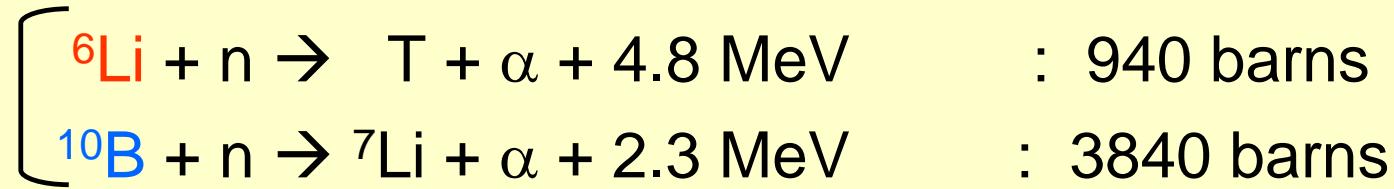
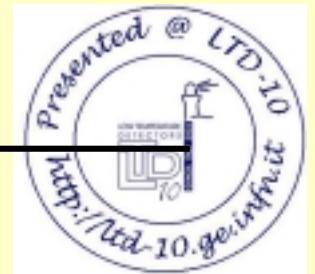
- Characteristics in terms of neutron detection,

large neutron-capture cross section of  ${}^6\text{Li}$ ,  ${}^{10}\text{B} \rightarrow >95\% @ 1.8\text{\AA}$   
short secondary particle range  $\rightarrow$  :  $< 6\text{um}({}^{10}\text{B})$ ,  $< 40\text{um} ({}^6\text{Li})$   
low density, low Z material:  $\rightarrow$  low background



Suitable as a neutron absorber

# Neutron-capture by LBO absorber

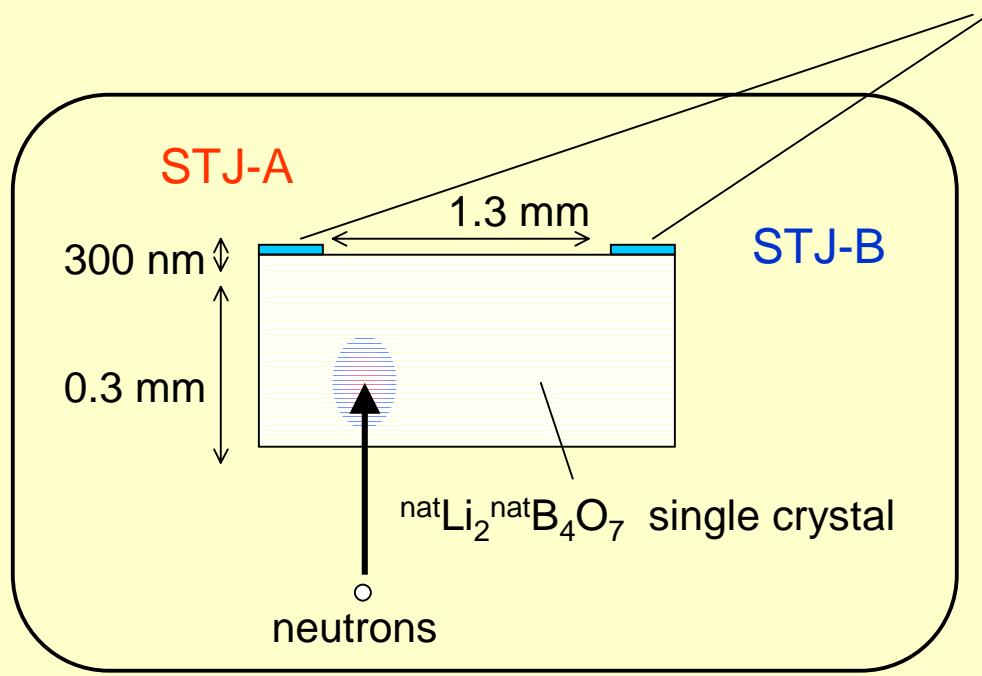


detection efficiency  
( $d = 0.3 \text{ mm}, 1.8\text{\AA}$ )      particle range

${}^6\text{Li}$ B O	46%	$\sim 40 \text{ }\mu\text{m}$
${}^6\text{Li} {}^{10}\text{B} \text{ O}$	98%	$\sim 6 \text{ }\mu\text{m}$
${}^6\text{Li} {}^{10}\text{B} \text{ O}$	$\sim 99\%$	$\sim 40,6 \text{ }\mu\text{m}$

For high spatial resolution, high efficiency,  
 ${}^6\text{Li} {}^{10}\text{B} \text{ O}$  is preferable.

# Prototype STJ/LBO neutron detector



## ■ STJ sensors AST

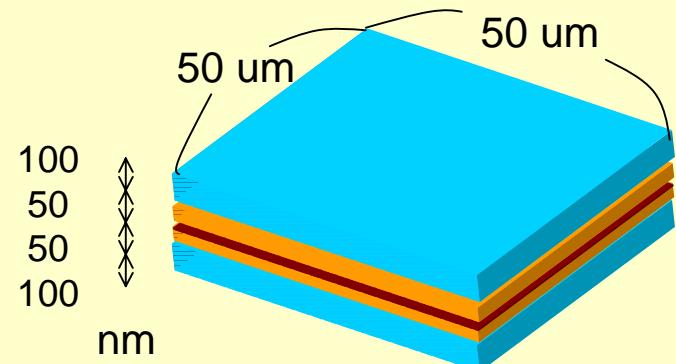
square-shaped, 50  $\mu m$  in a size

Nb - Al - AlOx - Al - Nb - LBO

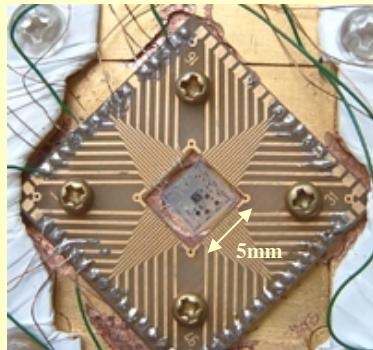
(no phonon buffer layer on LBO)

symmetric layer structure

lift-off, RIE + ion milling



STJ / LBO



## ■ STJ parameters

(similar in both STJs)

Energy gap  $\sim 1.2$  meV

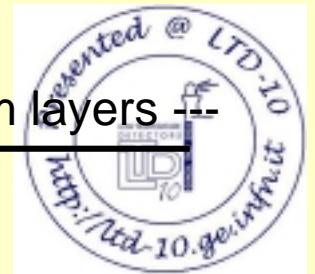
$dV/dI@0.2mV$

$\sim 50$  k $\Omega$  for STJ-A

$\sim 20$  k $\Omega$  for STJ-B

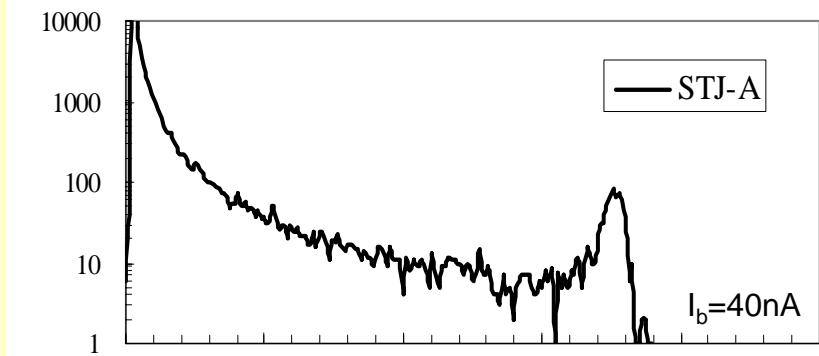
# X-ray detection

--- Direct photon absorption in niobium layers ---



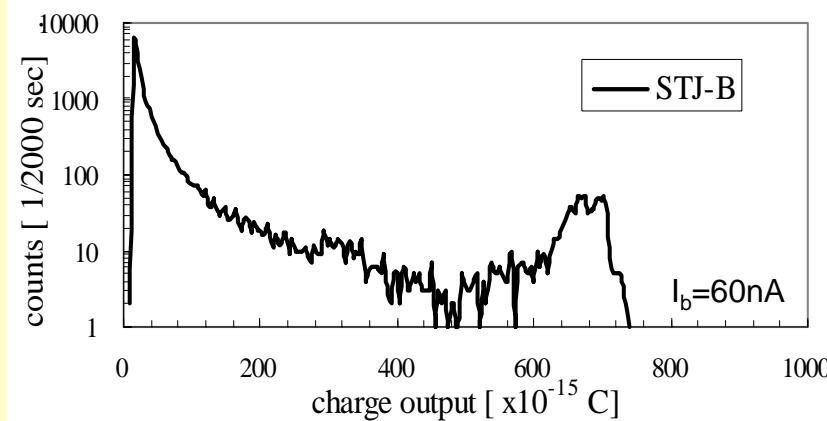
$^{55}\text{Fe}$ : 5.9keV x-ray

STJ-A



Energy resolution ~220eV

STJ-B

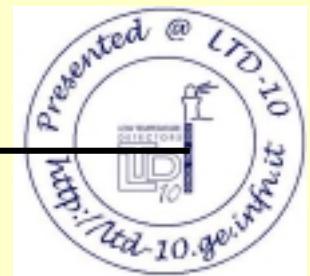


~440eV  
(due to double peak)

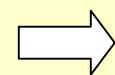
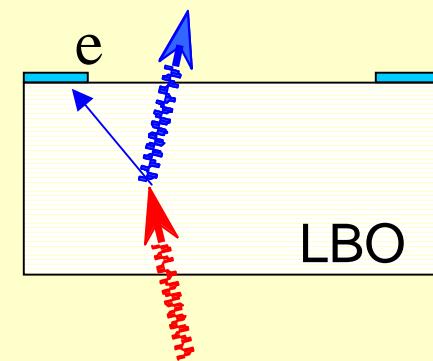
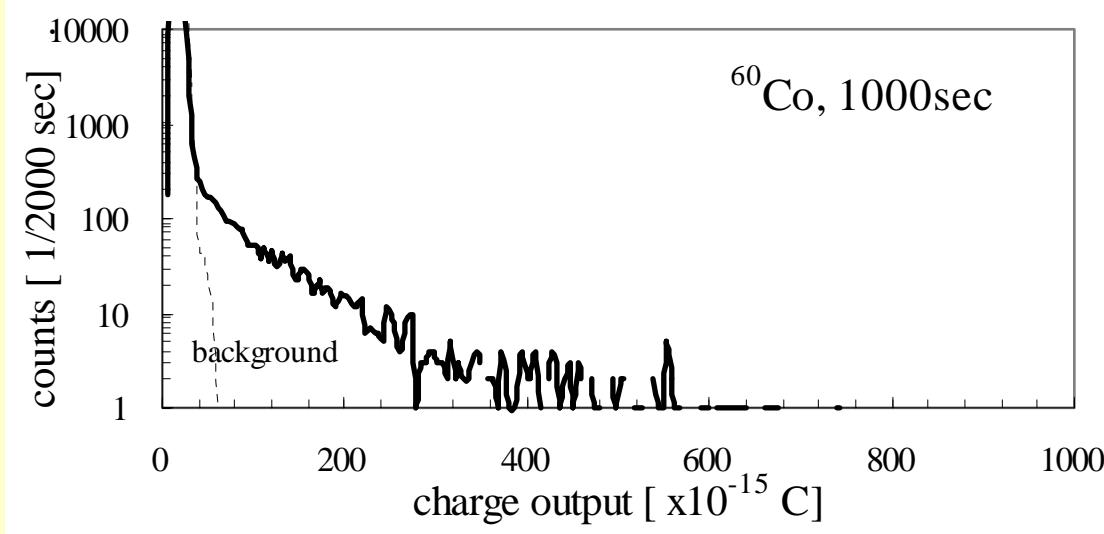
Similar performance  
for two STJs

- moderate energy resolution
- phonon sensitivity

# Gamma-ray detection by STJ-A



$^{60}\text{Co}$ : 1.1, 1.3MeV  $\gamma$ -ray



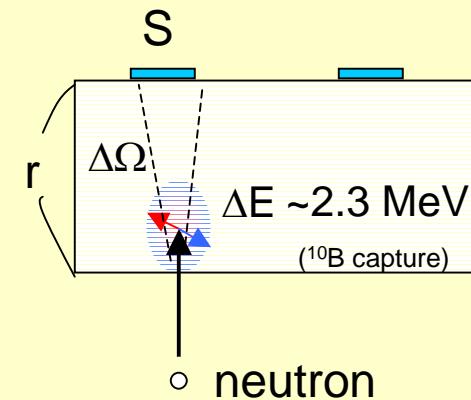
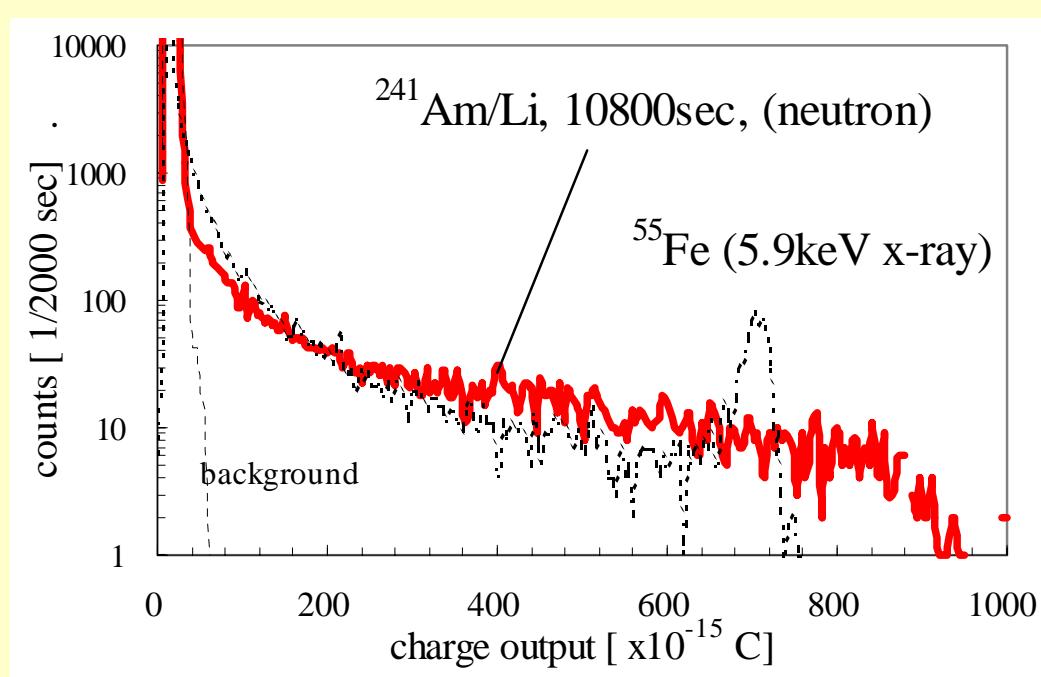
Events by Compton electrons

few counts in the coincident measurement in two STJs  
negligible sensitivity against 60keV x-ray from  $^{241}\text{Am}$

# Neutron detection by STJ-A



$^{241}\text{Am/Li}$  : < 10 n/s/cm<sup>2</sup> at detector position



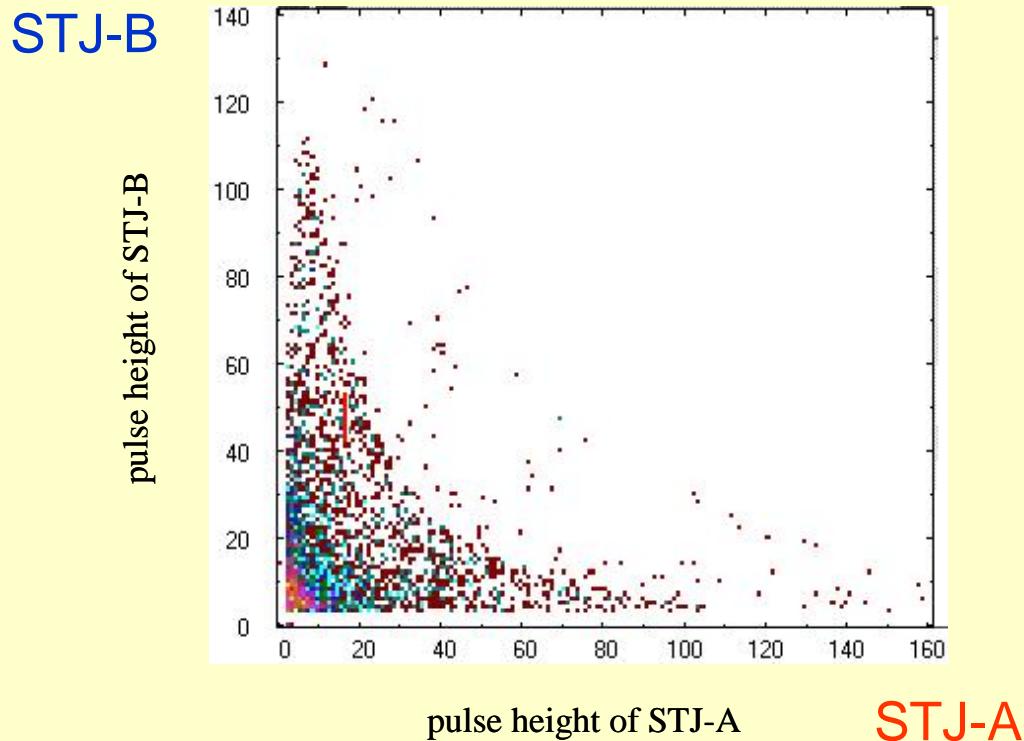
$$\begin{aligned} E_{\text{detect.}} &\sim \Delta E / \Delta \Omega \\ &\sim 5 \text{ keV (max.)} \end{aligned}$$

large numbers of signals detected in two STJ coincidence

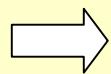


Neutron detection through phonons at the STJ

# Pulse-height correlation



Elliptical-like relation between two STJs



Capability of position resolution



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## Summary

- We demonstrated neutron detection by STJ/LBO detector.
- Possibility of position resolution was confirmed.

## Outlook

- Fabrication of STJs on the enriched Crystal,  
 $^6\text{LiBO}$  and  $\text{Li}^{10}\text{BO}$
- Arrayed STJs and neutron imaging