

# **MeV Photon Science and Technology at NewSUBARU**

## **BL1 Collaborators**

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*LASTI, HIT*

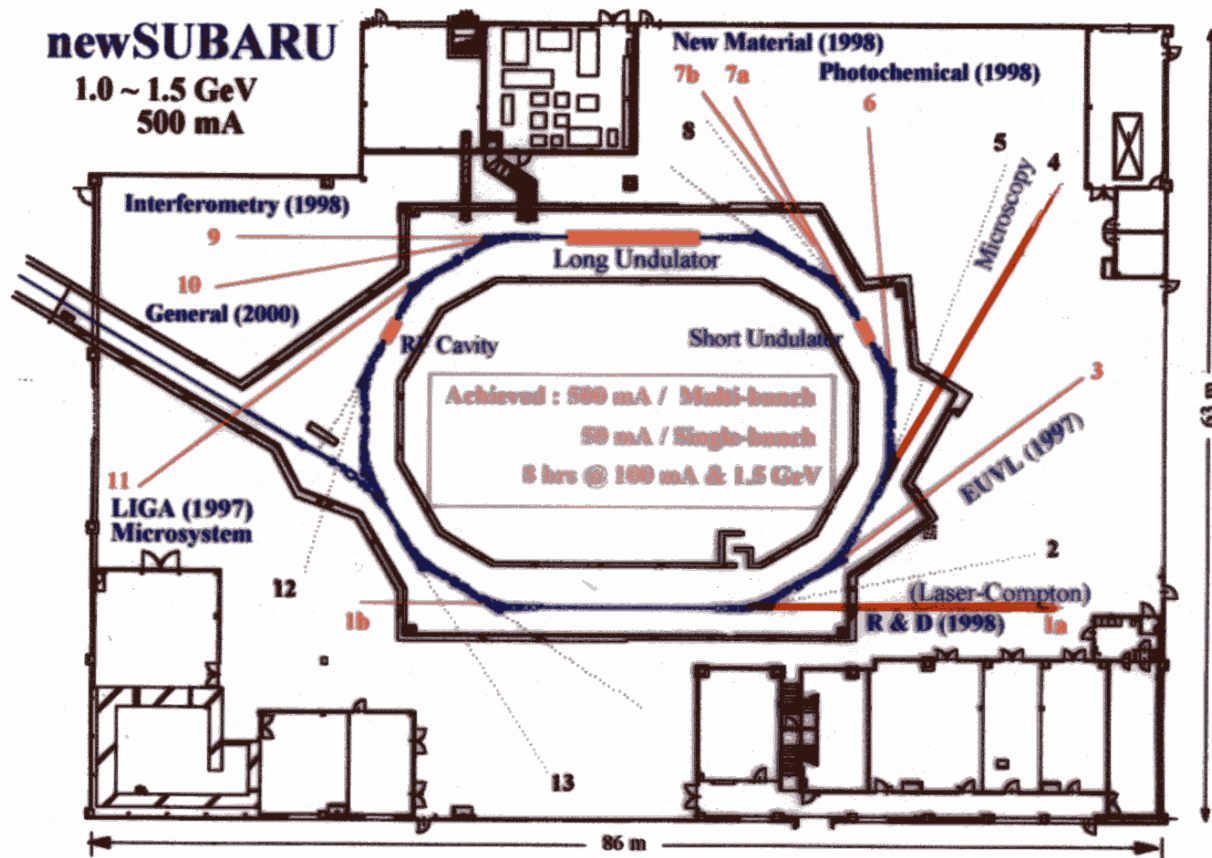
## **BL4 Collaborators**

**K.Aoki, K.Kinoshita, T.Hadame, H.Munenaga**

**S.Hashimoto, A.Ando**

*LASTI, HIT*

# NewSUBARU BL1, BL4



# BL1-System

**Electron:**

Energy 1 GeV

Current 5 – 30 mA

**Laser:**

Nd: YVO<sub>4</sub> (1 – 5 W, 1064nm)

Nd: YAG (0.7W, 1064nm)

**Pb Collimator:**

20mm , 10mm , 2mm

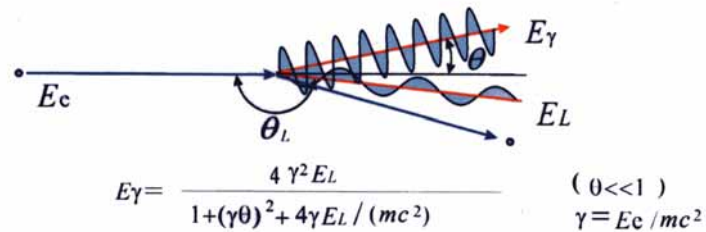
**Detectors:**

HPGe(180cm<sup>3</sup>) , NaI(3'' × 3'')

(0 ° measurement )

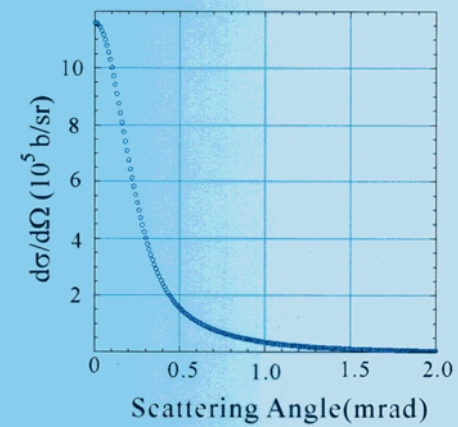
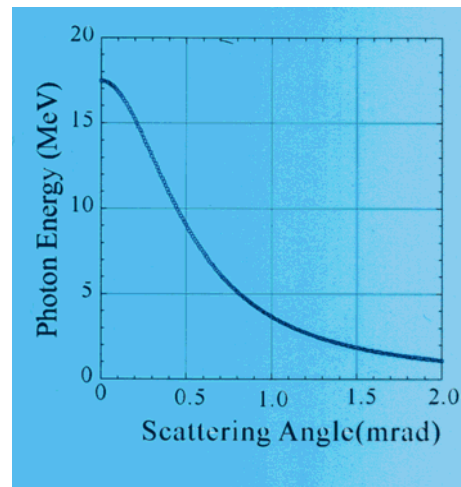
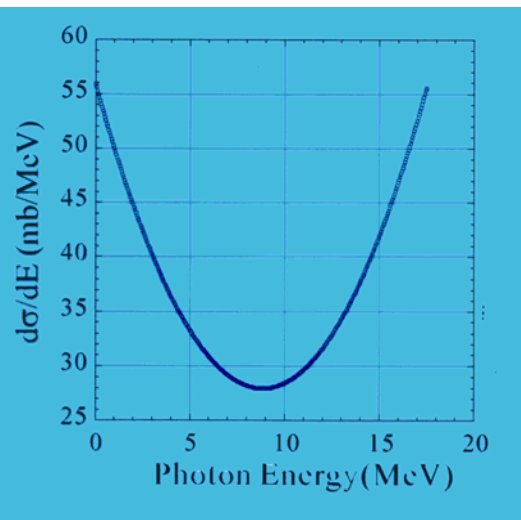
# Compton Backscattering

## 1 GeV, 1064 nm, $E_{\max}=17.6$ MeV

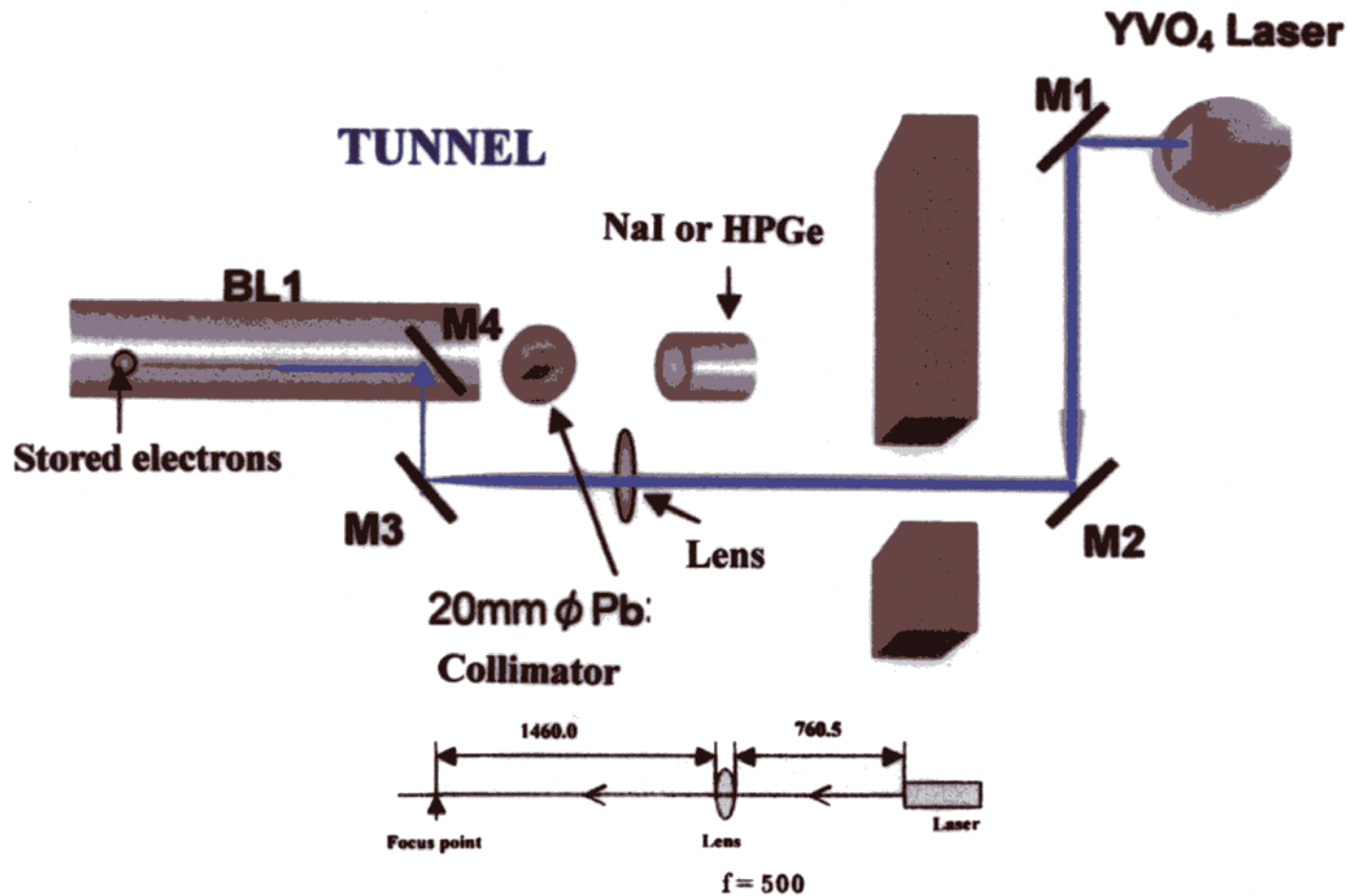


$$E_{\gamma} = \frac{4\gamma^2 E_L}{1 + (\gamma\theta)^2 + 4\gamma E_L / (mc^2)} \quad (0 \ll 1)$$

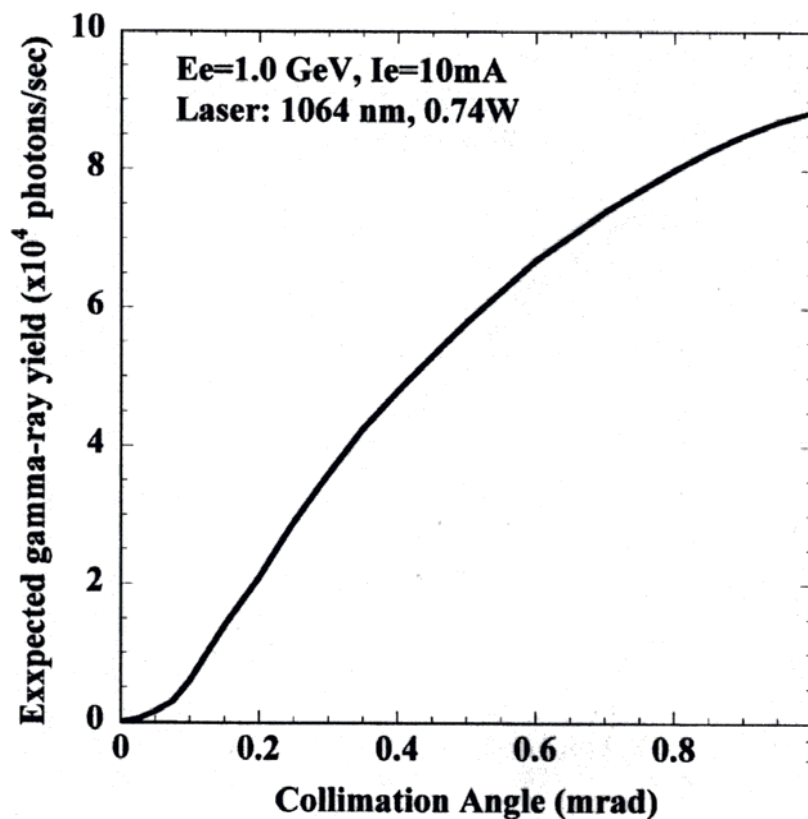
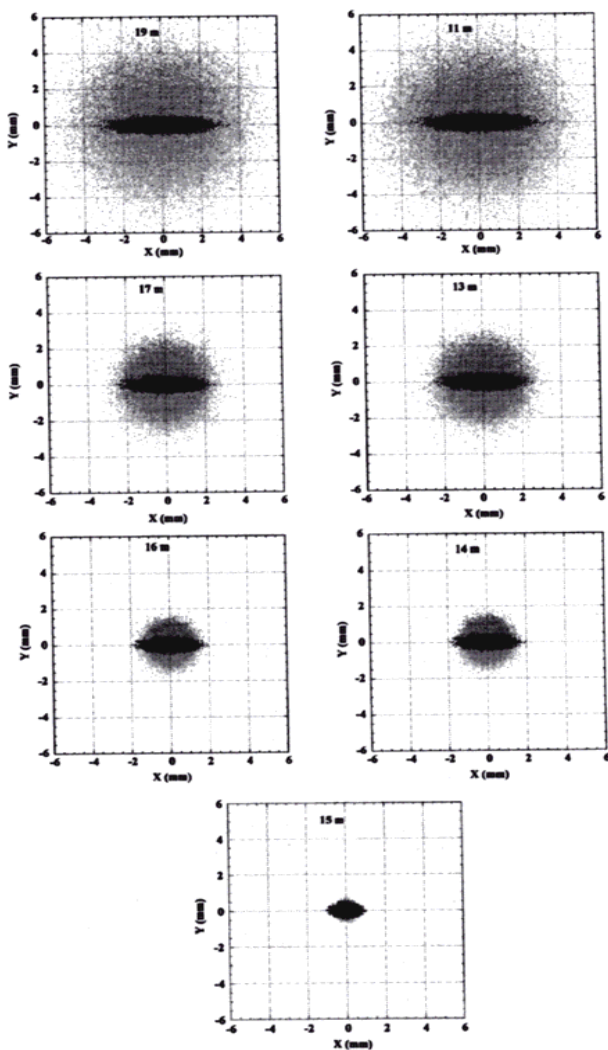
$$\gamma = E_c / mc^2$$



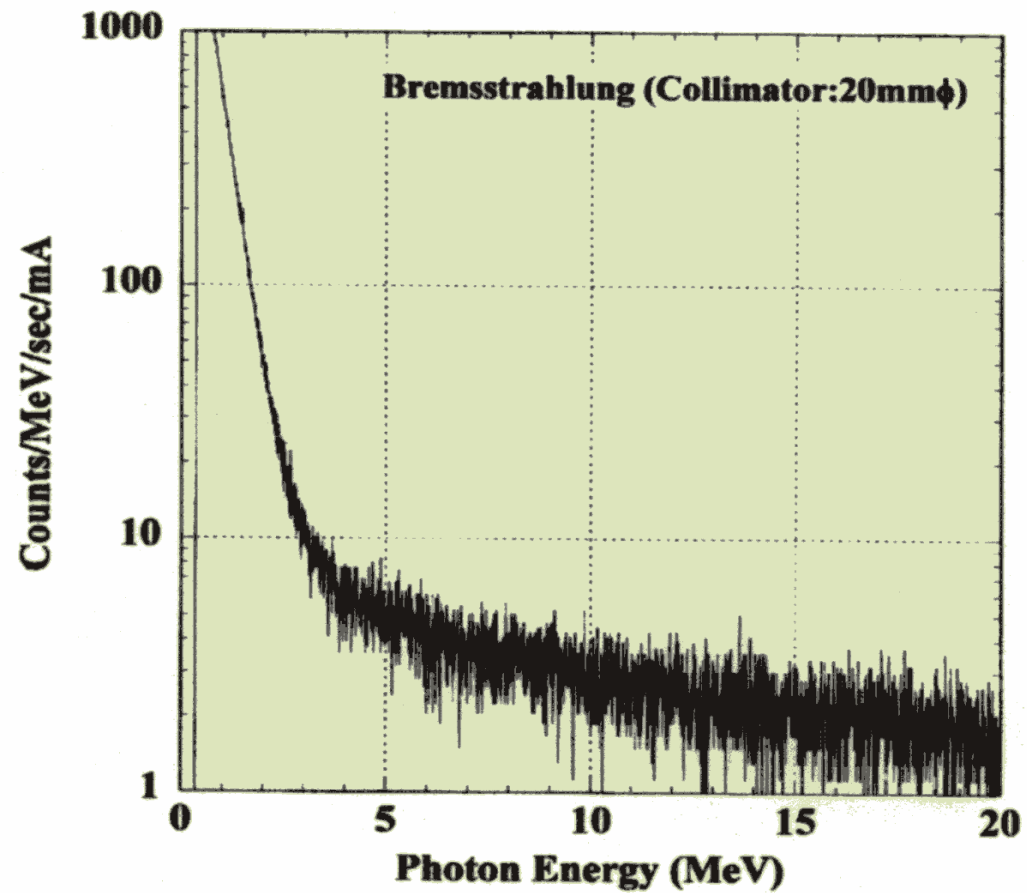
# Compton Backscattering Facility



# Calculated overlap areas between laser beam and electron beam and Expected $\gamma$ -ray Flux

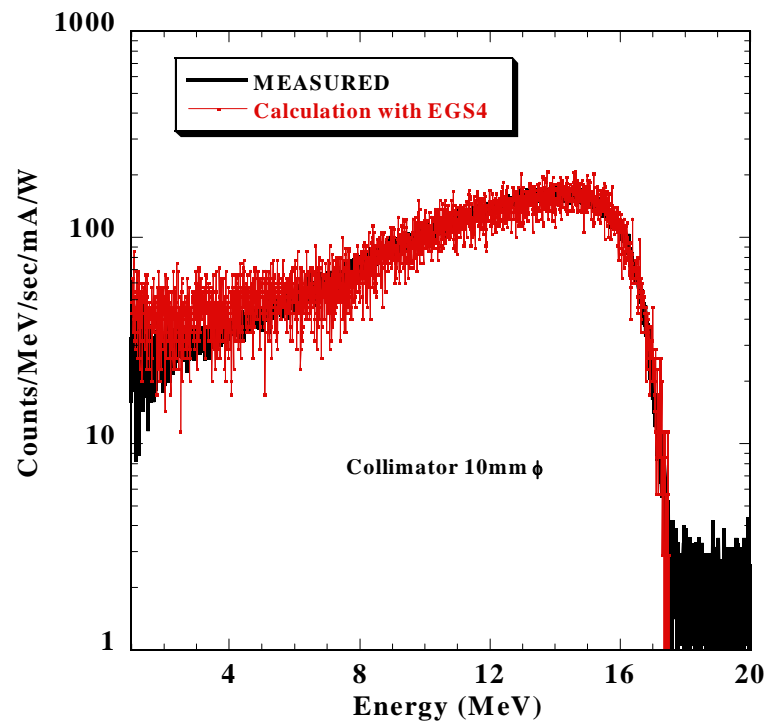
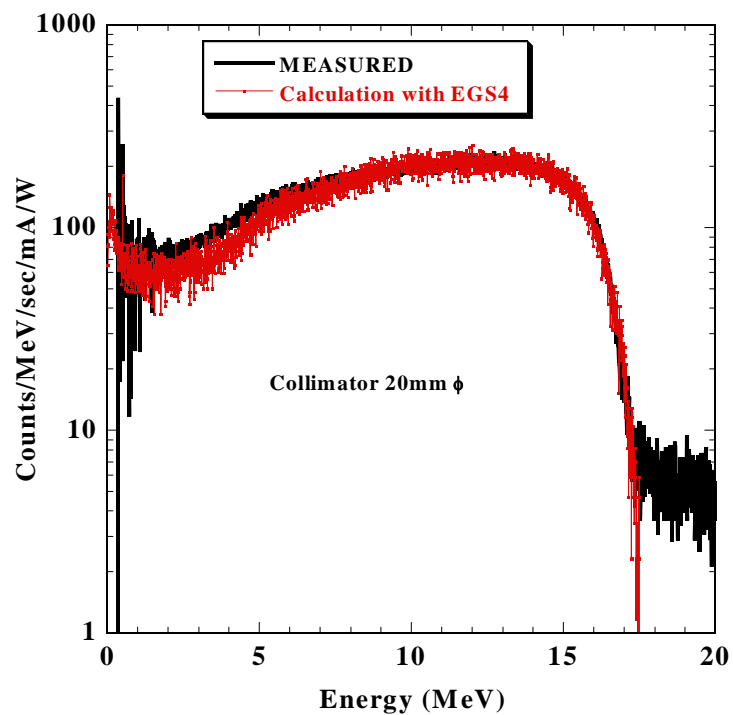


# Bremsstrahlung $\gamma$ -rays



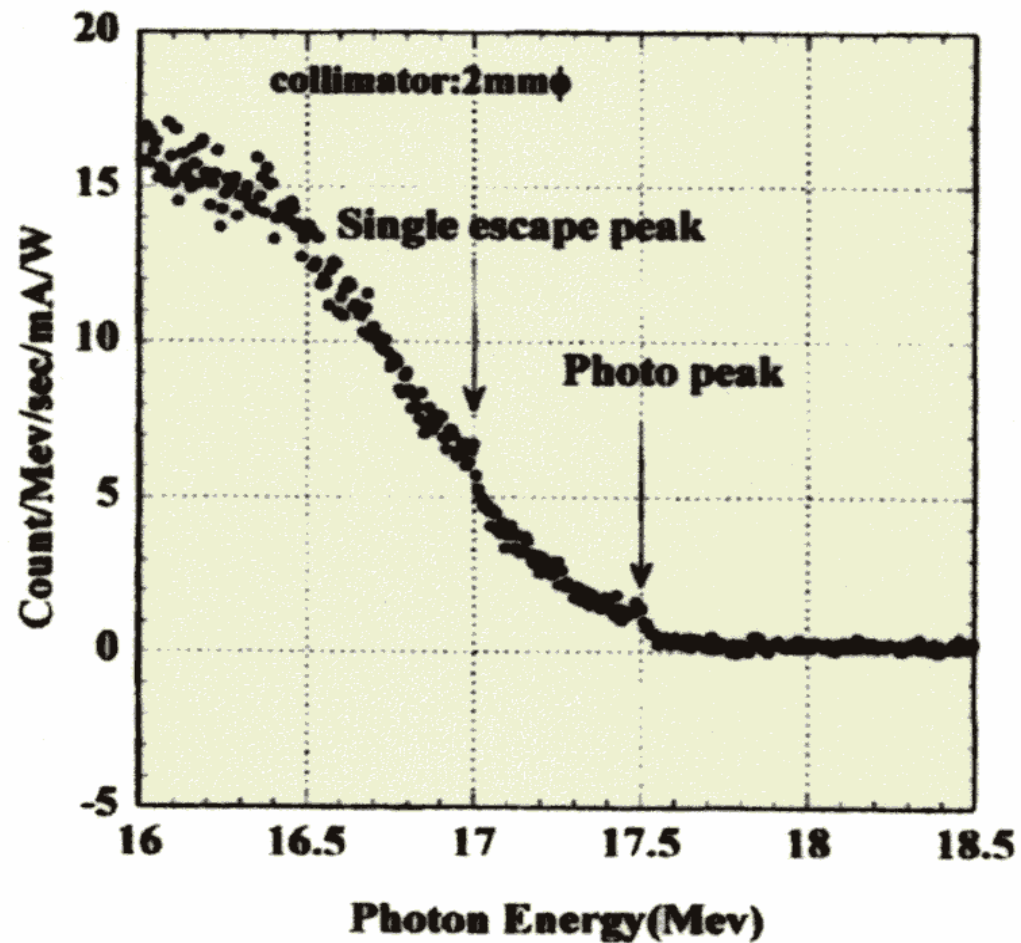
# Produced $\gamma$ -Ray Energy Spectra

Collimator: 20mm  $\phi$  , 10mm  $\phi$





# Energy Spectrum using 2mm Collimator



# Produced $\gamma$ -rays

Collimator	Energy	$\gamma$ -yields
20 mm	6.6-17.6 MeV	$\sim 3 \times 10^4$ 1/sec/mA/W
10 mm	12.4-17.6 MeV	$\sim 5 \times 10^3$ 1/sec/mA/W
2 mm	17.3-17.6 MeV	$\sim 5 \times 10^2$ 1/sec/mA/W

# Photon Attenuation Method

$$I/I_0 = \exp[-\mu_{\text{tot}}d]$$

This equation can be rewritten as

$$\mu_{\text{tot}}(\text{cm}^{-1}) = d^{-1} \ln(I_0/I)$$

from which  $\mu_{\text{tot}}$  can be obtained from measured values of  $I_0$ ,  $I$  and  $d$ , and

$$\mu_{\text{tot}} = \mu_{\text{A}} + \mu_{\text{N}}$$

where  $\mu_{\text{A}}$  and  $\mu_{\text{N}}$  are the atomic and the nuclear absorption coefficients, respectively.

# Cross section

- $\sigma$  : cross section (b)  
 $\rho$  : density(g/cm<sup>3</sup>)

A : atomic mass

$\mu_n$  :

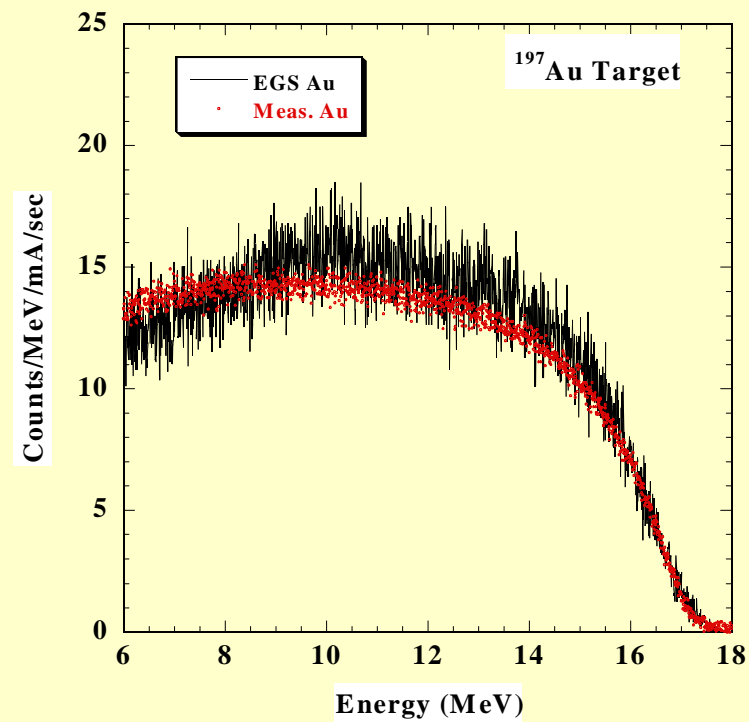
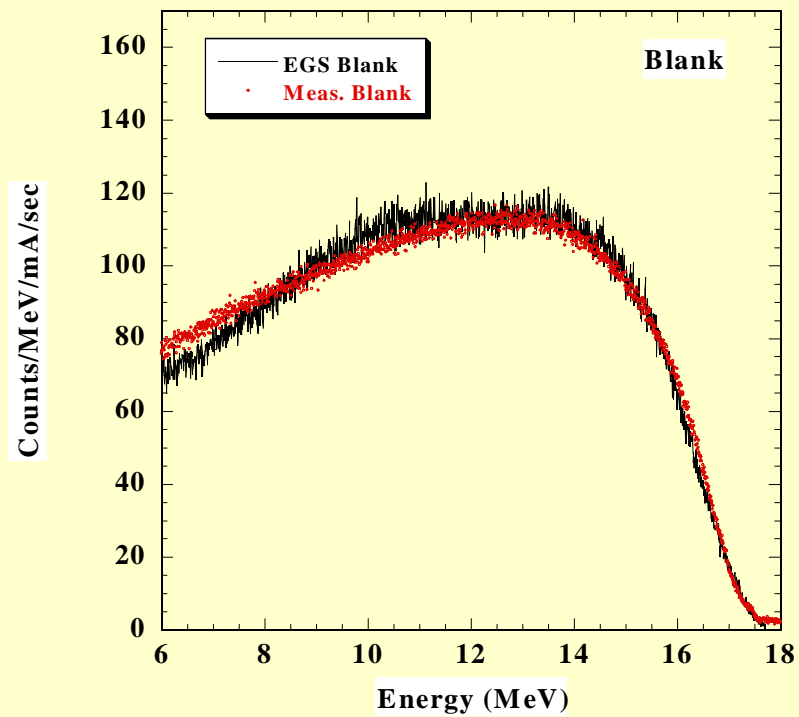
nuclear absorption  
(attenuation)  
coefficient(1/cm)

$$\sigma = 1.66054 \cdot \frac{\mu_n}{\rho} A$$

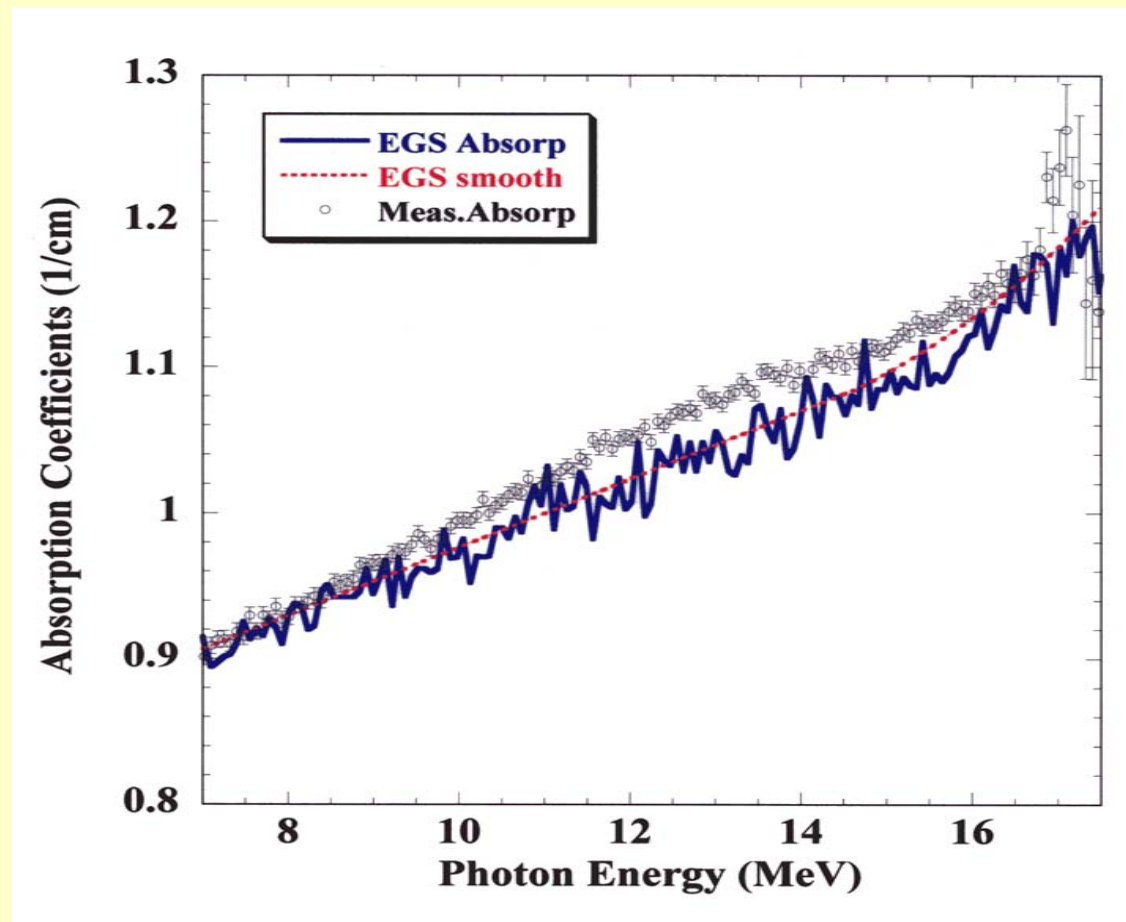
# Measurement of Photoabsorption Cross-section

- $^{197}_{79}\text{Au}$ (100%) 20mm thick, 25mm dia.
- $^{181}_{73}\text{Ta}$  (99.99%) 20mm thick, 25mm dia.

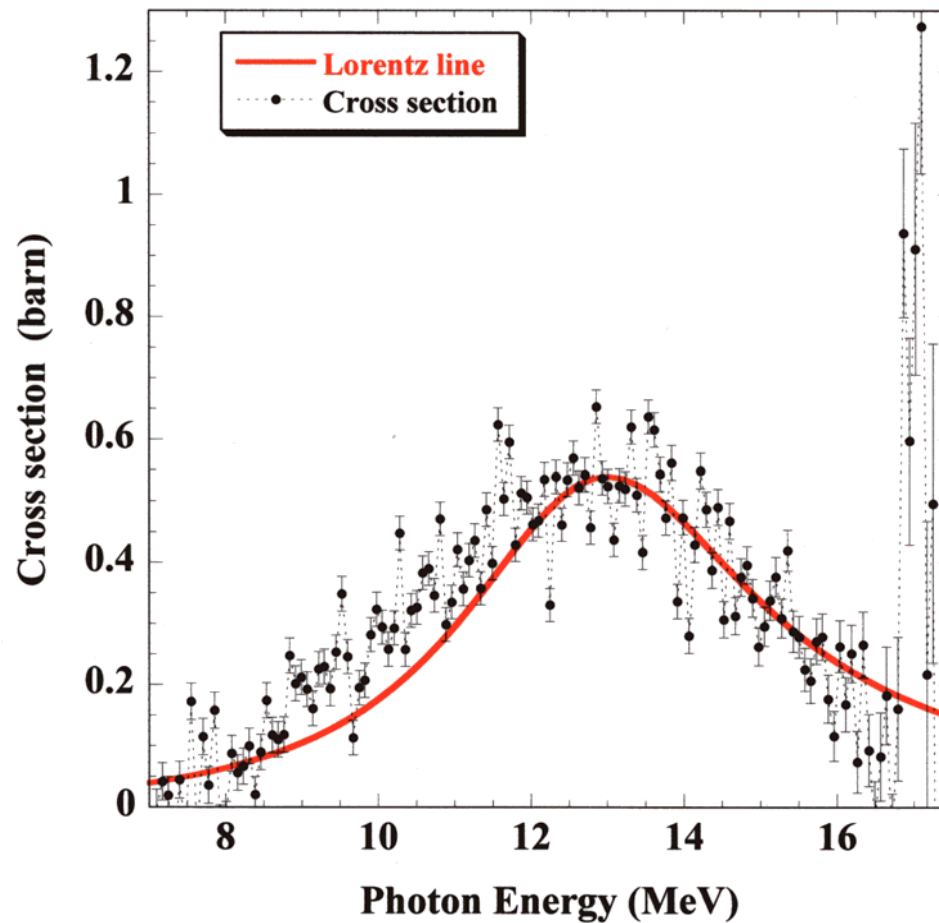
# Comparison with EGS4 calculations



# Measured absorption Coefficients

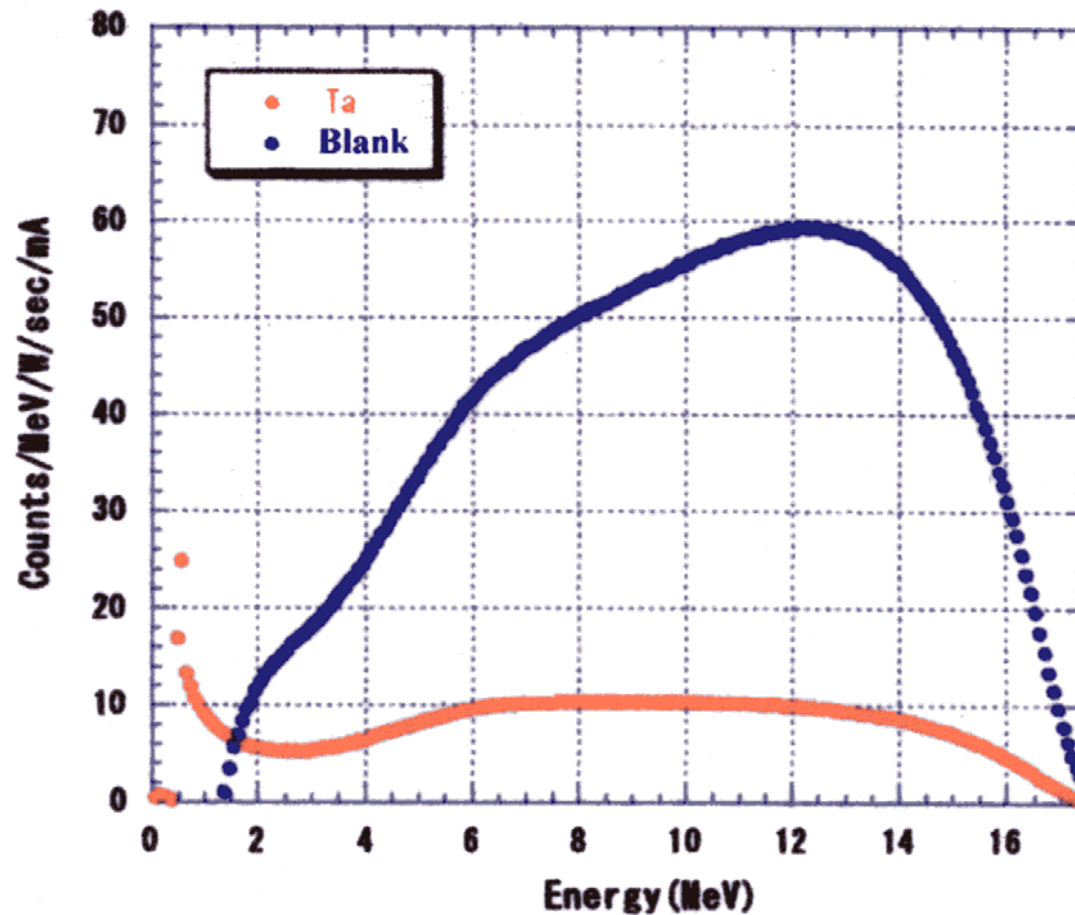


# Cross sections obtained for $^{197}\text{Au}$

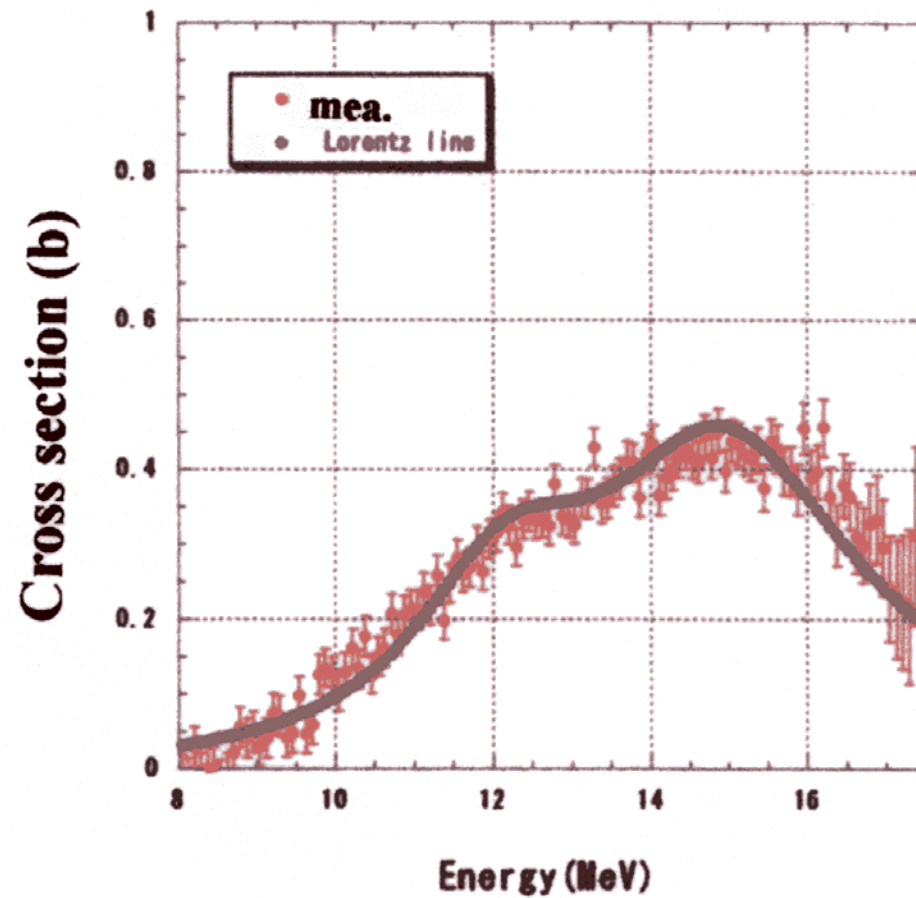




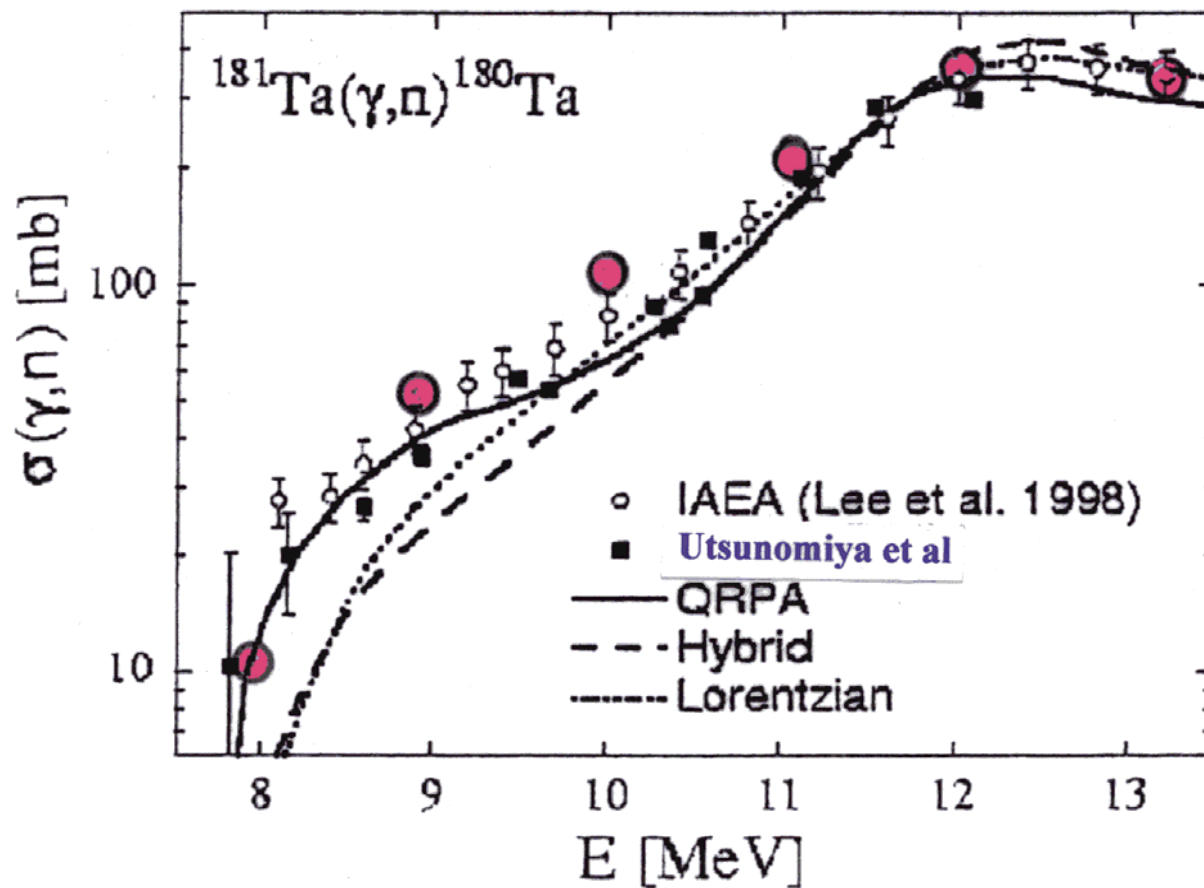
# Energy spectra for Ta-target and Blank target



# Cross-sections obtained for Ta



# $^{181}\text{Ta}(\gamma, n)^{180}\text{Ta}$



# Transmutation

- Transmutation rate  
(reaction rate)

$\sigma_R$ : Nuclear cross section

$$P(E) = \frac{\sigma_R(E)}{\sigma_R(E) + \sigma_P(E) + \sigma_C(E) + \sigma_{\text{photo}}}$$

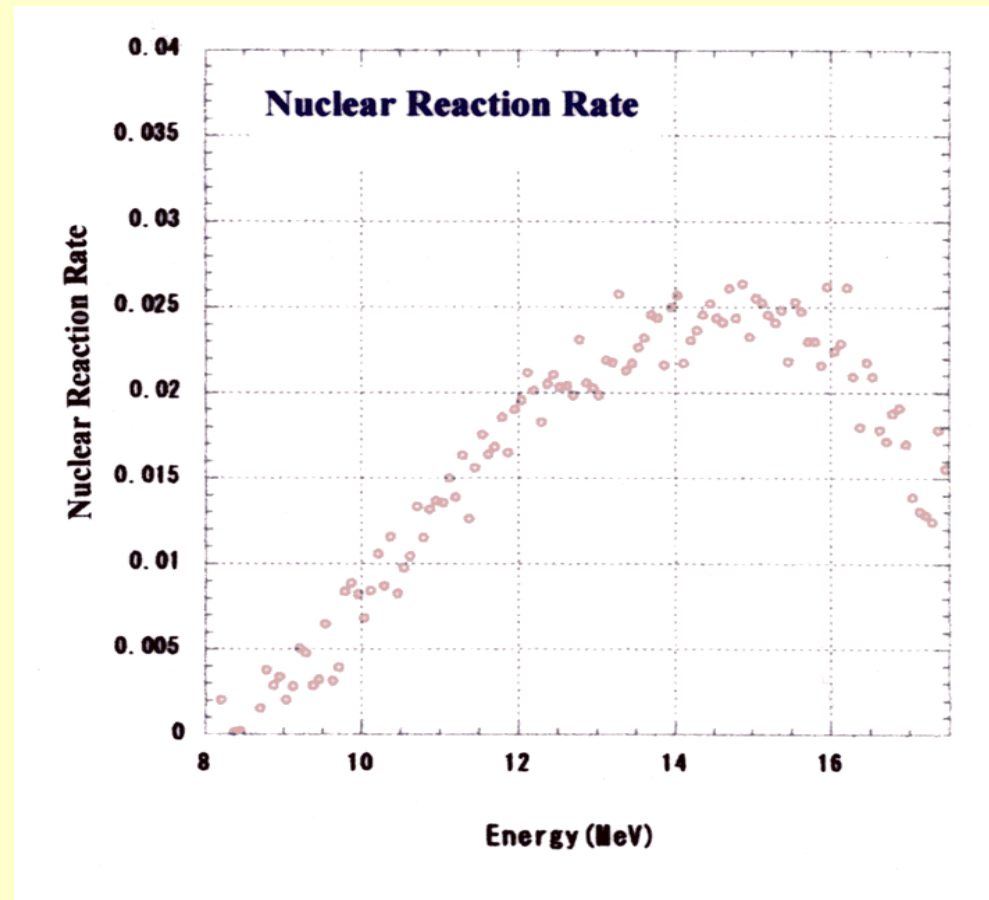
Transmutation

Velocity

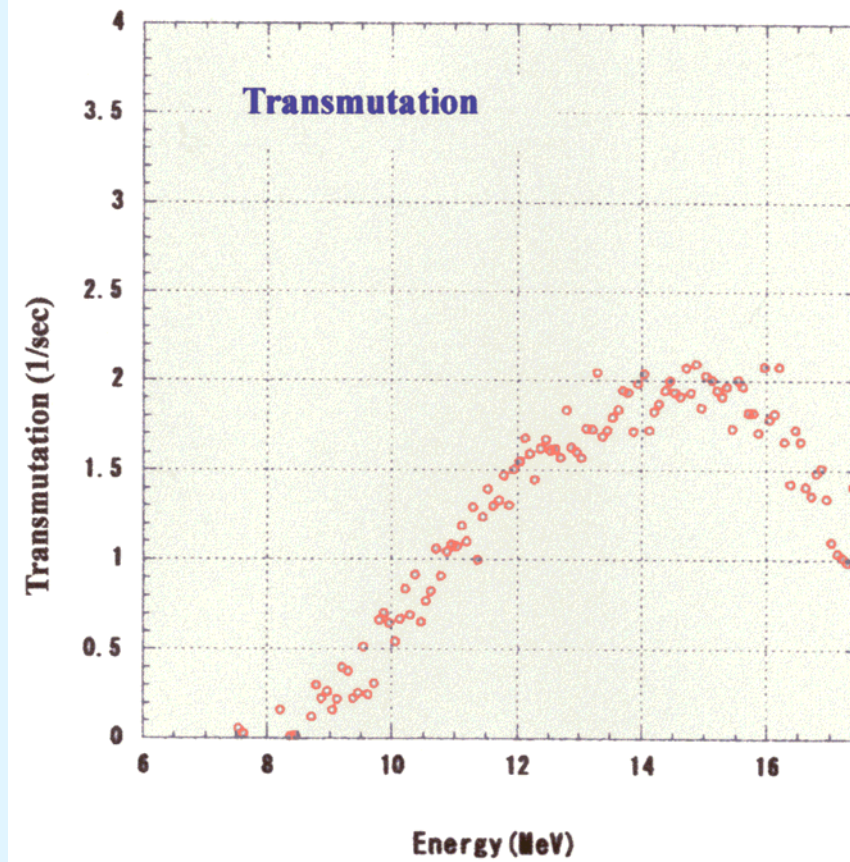
(E): Energy spectrum of  
incident  $\gamma$ -rays

$$F = \int P(E)\Phi(E)dE$$

# Nuclear Reaction Rate



# Transmutation



# Transmutation

- Results at NewSUBARU

**$I_e=1 \text{ mA}$ ,  $P_L=1 \text{ W}$  : Produced  $\gamma$ -rays**

**$10^4 \sim 10^5 \text{ 1/sec}$**

**Transmutation Velocity  $\sim 130 \text{ /sec}$**

**ex.  $I_e=500\text{mA}$   $P_L=1\text{MW}$   $V= \sim 5 \times 10^{10} \text{ 1/sec}$**

**(  $1000\text{MW}$  reactor High level waste**

**$10^{17} \text{ /sec}$ )**

# From NOW (Polarization)

( , 0 ° ):

Yield for the elastically scattered photons in the plane parallel to the electric vector of the incoming photons

$$A(\theta) = \frac{1}{p} \left( \frac{\sigma(\theta, 0^\circ) - \sigma(\theta, 90^\circ)}{\sigma(\theta, 0^\circ) + \sigma(\theta, 90^\circ)} \right),$$

( , 90 ° ): perpendicular

( , ) Experiment



# **Measurement of Electron Beam-size with Laser-wire Monitor**

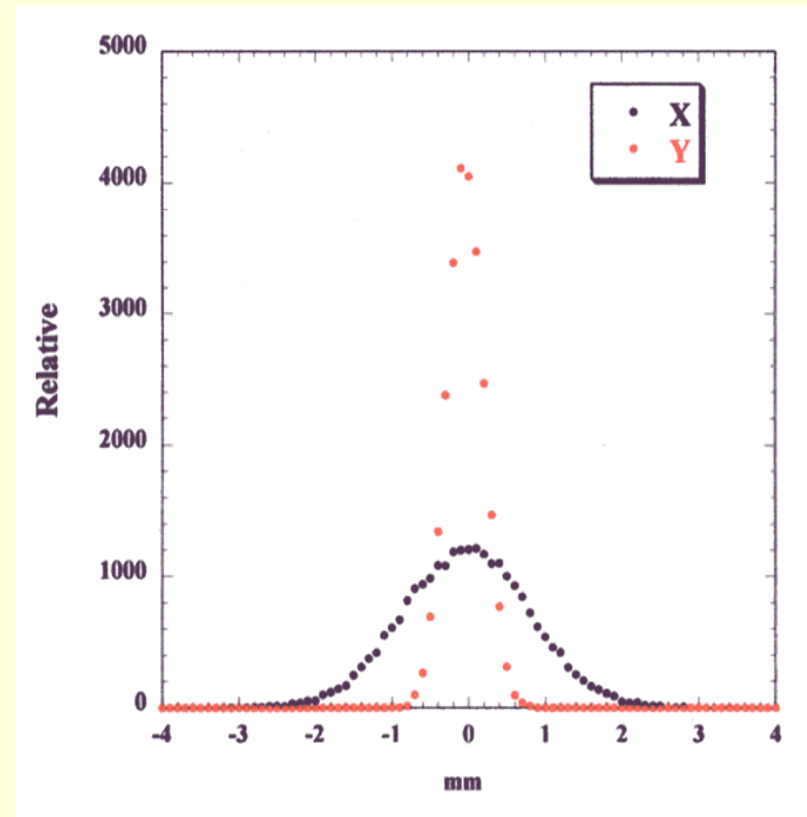
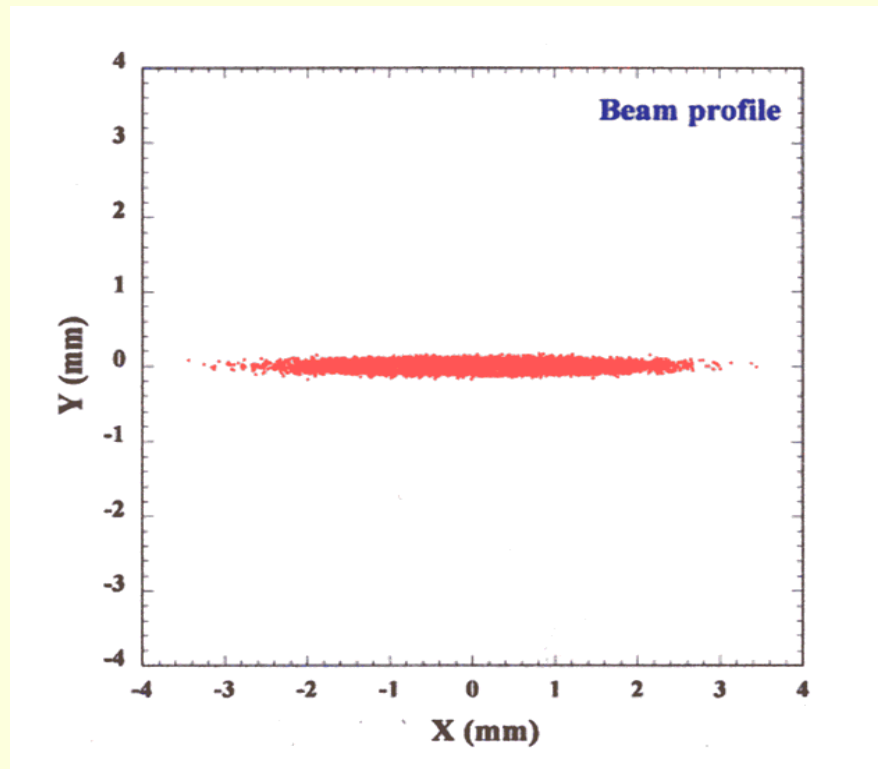
## **Laser-wire Monitor**

**measurement of vertical beam size**

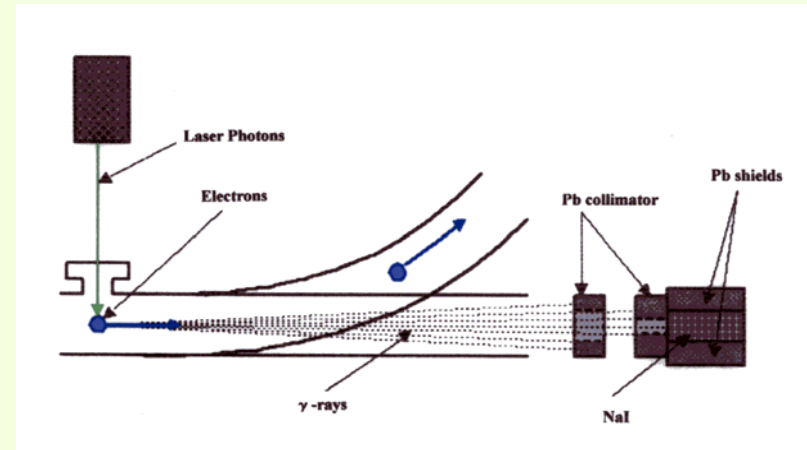
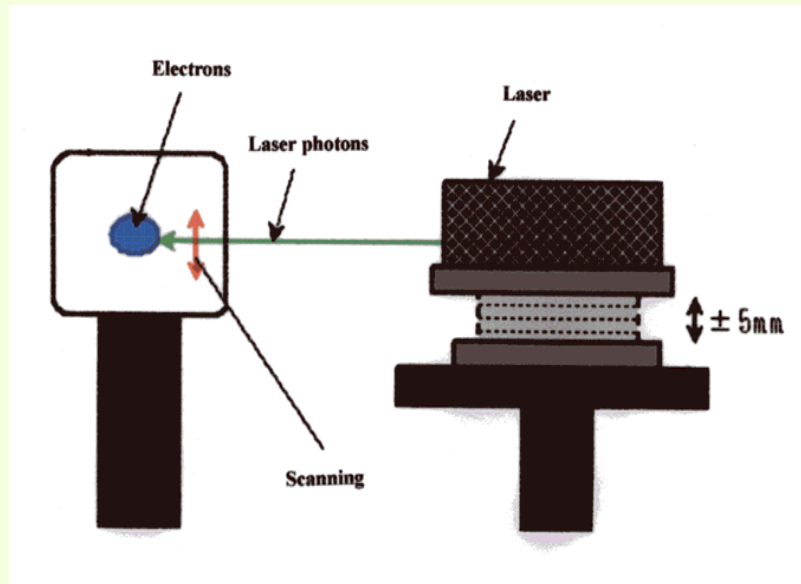
**( ~ 300  $\mu$  m )**

**in preparation at BL4**

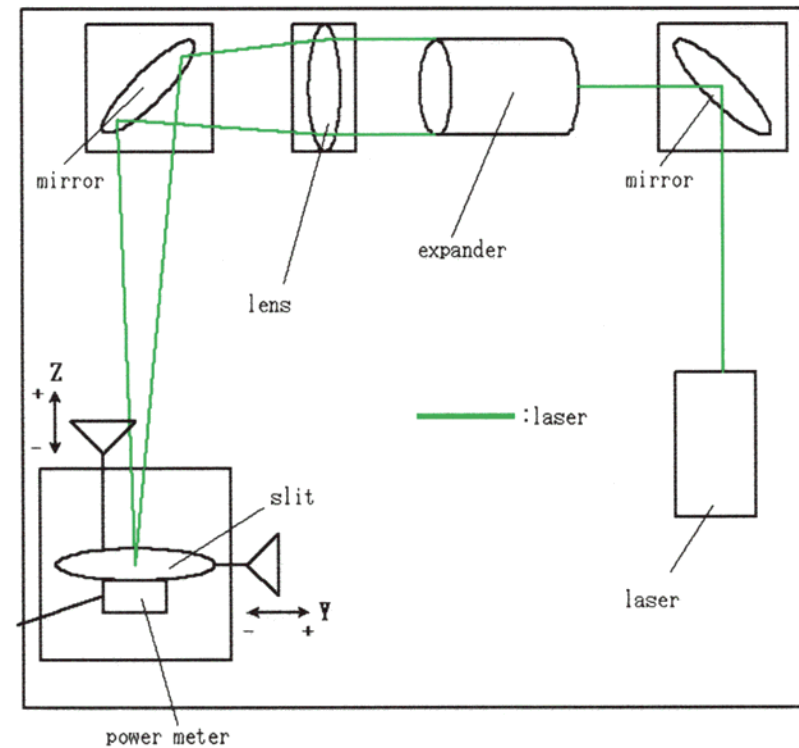
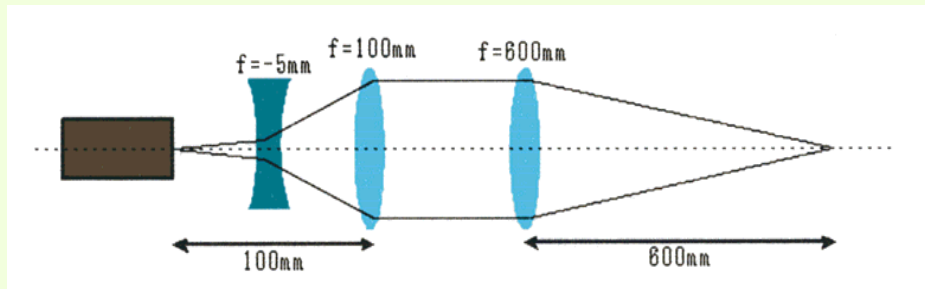
# Electron Beam Profile BL4 (calculation)



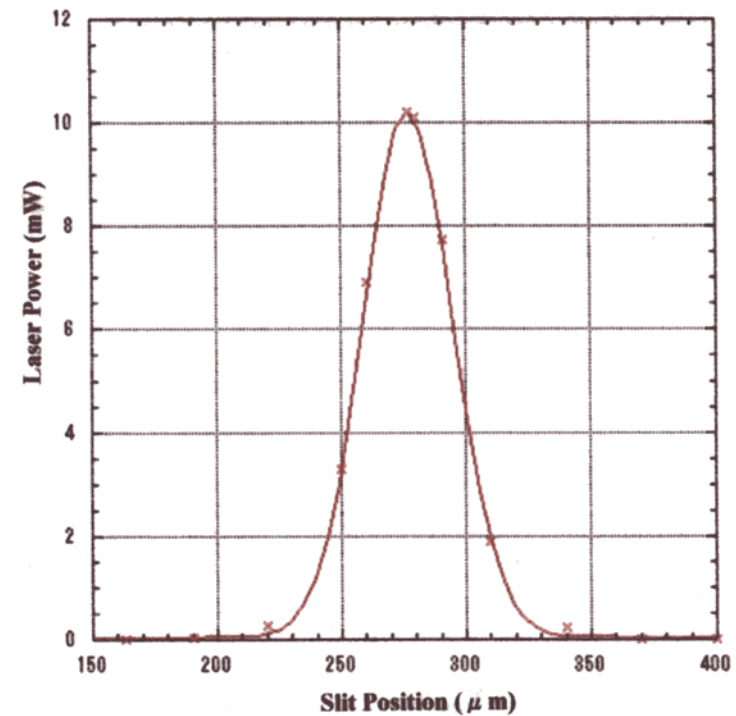
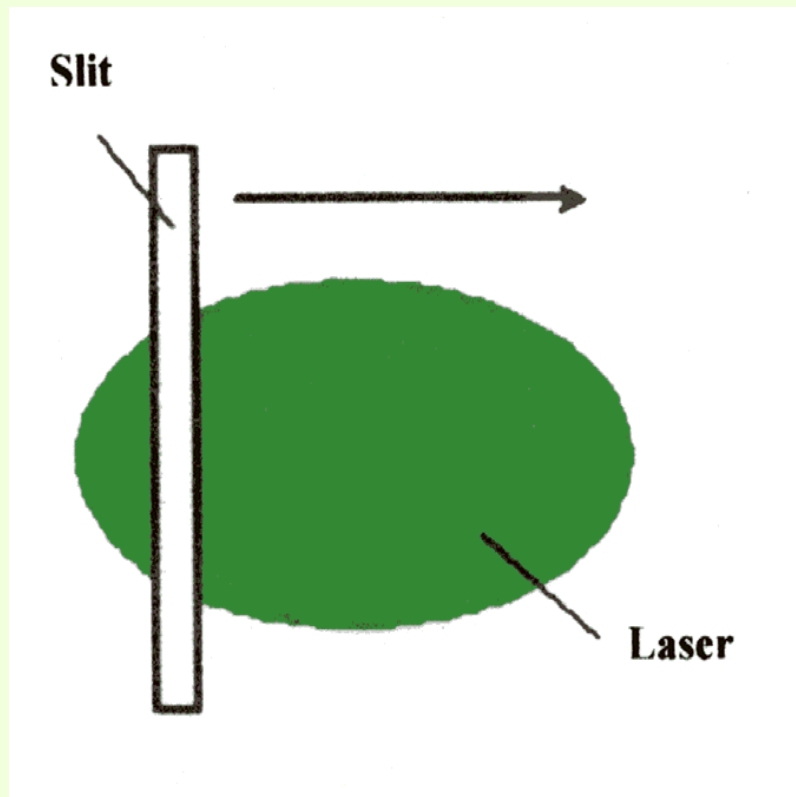
# System for Measurement of Electron Beam-size



# Laser Optics



# Measurement of Laser-beam Profile



## **-ray yield**

	<b>laser profile</b>	<b>-rays</b>
<b>System</b>	<b>(1 .)</b>	
	<b>(counts/sec/0.5W/mA)</b>	
<b>without lens</b>	<b>~ 2 mm</b>	<b>1.6</b>
<b>with lens</b>	<b>~ 36 <math>\mu</math> m</b>	<b>19</b>

**From now**

**Measurement of**

**Electron s vertical beam size**

**with laser wire beam profile monitor**

**This monitor is based upon**

**the laser-electron Compton scattering**

**Thank you**