

# Status of CNS GRAPE and $\gamma$ -ray spectroscopy community in Japan

Eiji Ideguchi

CNS, University of Tokyo

# Status of GRAPE

# Members

## CNS

S. Shimoura (P)

E. Ideguchi (L)

S. Ota (PD)

M. Niikura (D3)

H. Miya(B4)

## CNS collaborators

T. Fukuchi (RIKEN)

M. Kurokawa (RIKEN)

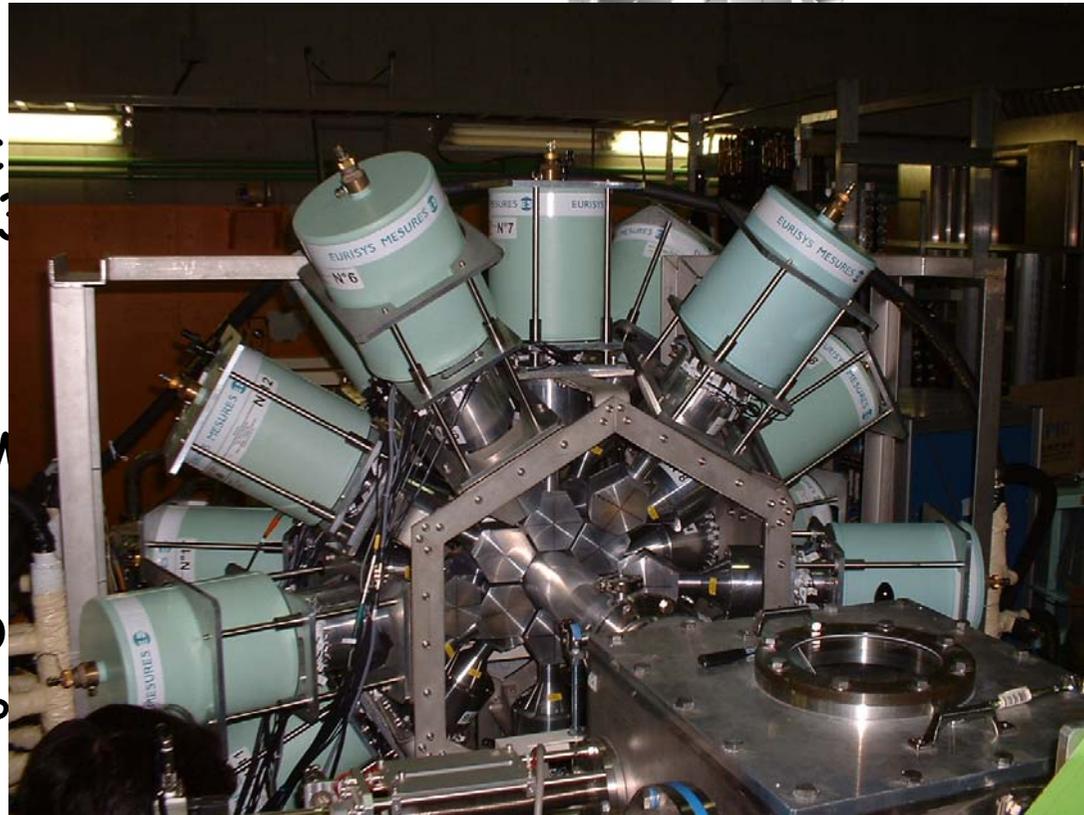
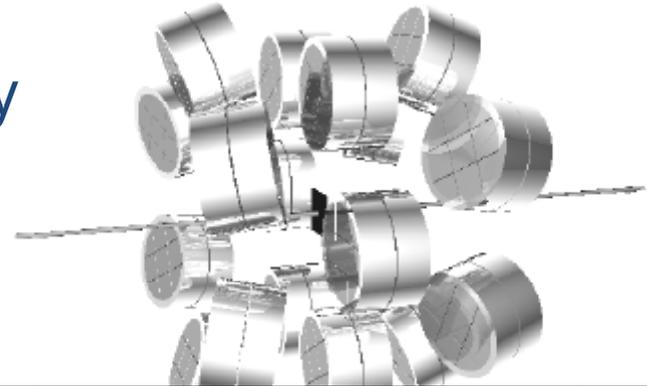
S. Michimasa (CNS)

H. Baba (RIKEN)

CNS-UT-RIKEN-Rikkyo-  
-Kyoto... Collaboration

# GRAPE (Gamma-Ray detector Array with Position and Energy sensitivity)

- 18x2 segmented Ge detectors
- High Resolution
  - 2.5 keV intrinsic resolution for 1.3 MeV  $\gamma$
- High Sensitivity
  - $\epsilon\Omega \sim 5\%$  for 1 MeV
- Position Sensitive
  - Resolution of DoC Correction  $\sim 1\%$



Goal: 1mm position resolution for z-direction

# Reactions for the study of excited states

- Direct Reactions (>30 MeV/u)
  - Heavy Nuclei: Strong Coulomb Field
    - Coulomb Excitation, Coulomb Dissociation
      - E1, E2, (M1) / Isovector
  - H, D,  $^4\text{He}$  [Liquid targets]
    - Inelastic Scattering
      - Isovector (H) / Isoscalar (H, D,  $^4\text{He}$ )
      - Spin-Flip (H, D) / Spin-Non-Flip (H, D,  $^4\text{He}$ )
    - Charge Exchange
      - Fermi type (H) / Gamow-Teller type (H, D)
    - Nucleon Transfer
      - (a,t), (a, $^3\text{He}$ ) Reaction
    - Knockout
  - ◆ Other (Be, C, ...)
    - Knockout / Fragmentation
      - Spectroscopic Factor / States with various Spin
- Fusion (& Multiple Coulex, Deep inelastic) (<20 MeV/u)
  - High Spin States

Low multiplicity

Liquid target

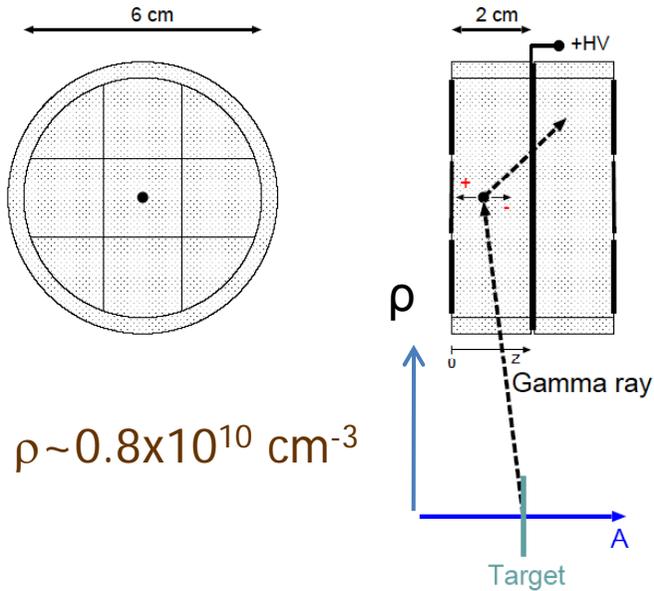


High multiplicity

# Detector

Planar-type detector

Pulse-shape analysis to determine vertex points in the direction parallel to that of the Electric Field



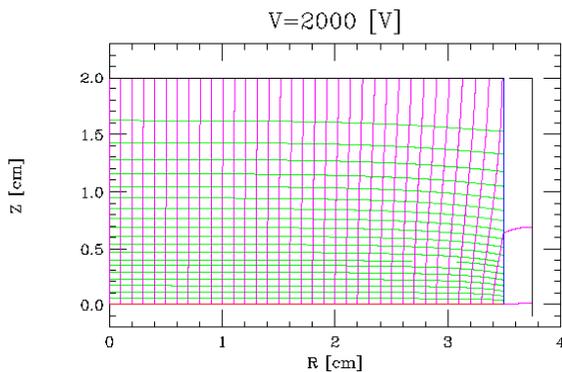
Z-Position ( $\sim \theta$ )  $\Leftrightarrow$   
Drift length of electrons and holes

Active Volume:  $2^r \times 6^{\phi} \text{ cm}^3$

Segmentation:  $3 \times 3$

2 crystals in 1 cryostat

P-type,  $\rho \sim 0.8 \times 10^{10} \text{ cm}^{-3}$



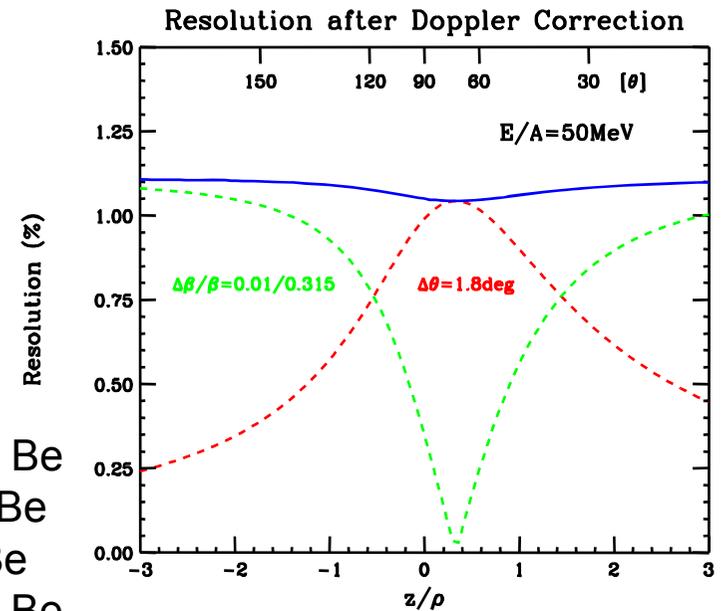
$\Delta\beta=0.01$ :

50AMeV  $^{12}\text{Be}$  + 250mg/cm $^2$  Be

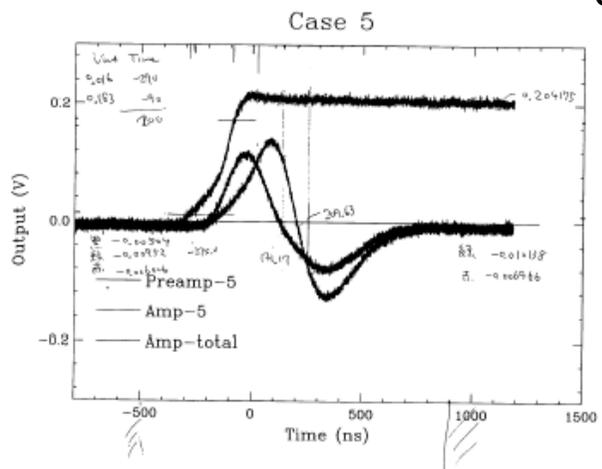
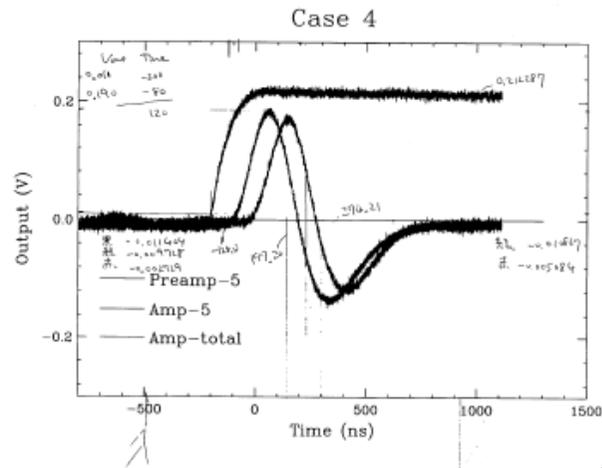
50AMeV  $^{32}\text{Mg}$  + 70mg/cm $^2$  Be

50AMeV  $^{68}\text{Ni}$  + 30mg/cm $^2$  Be

200AMeV  $^{68}\text{Ni}$  + 200mg/cm $^2$  Be



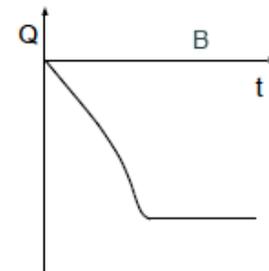
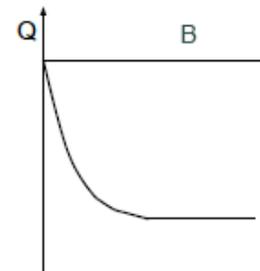
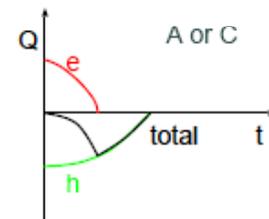
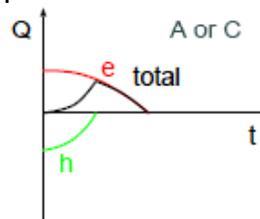
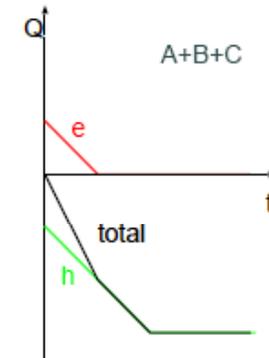
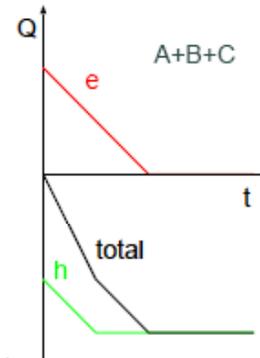
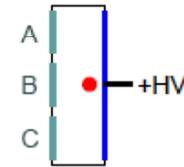
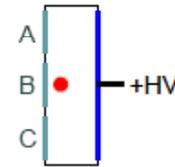
# Pulse Shape vs. Pos.



$(CR)^2 - (RC)^4$   
shaping

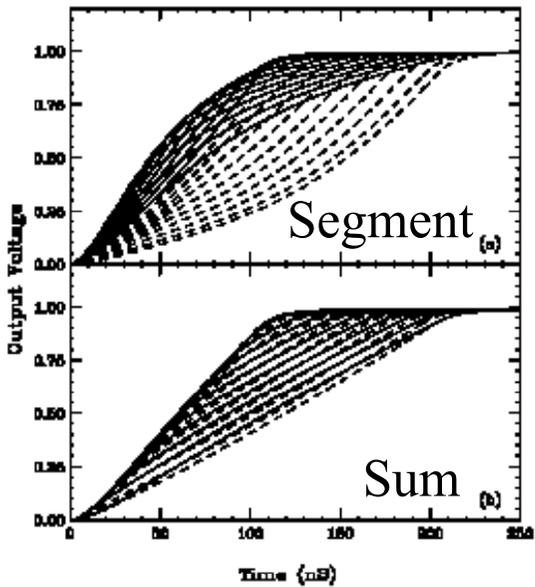
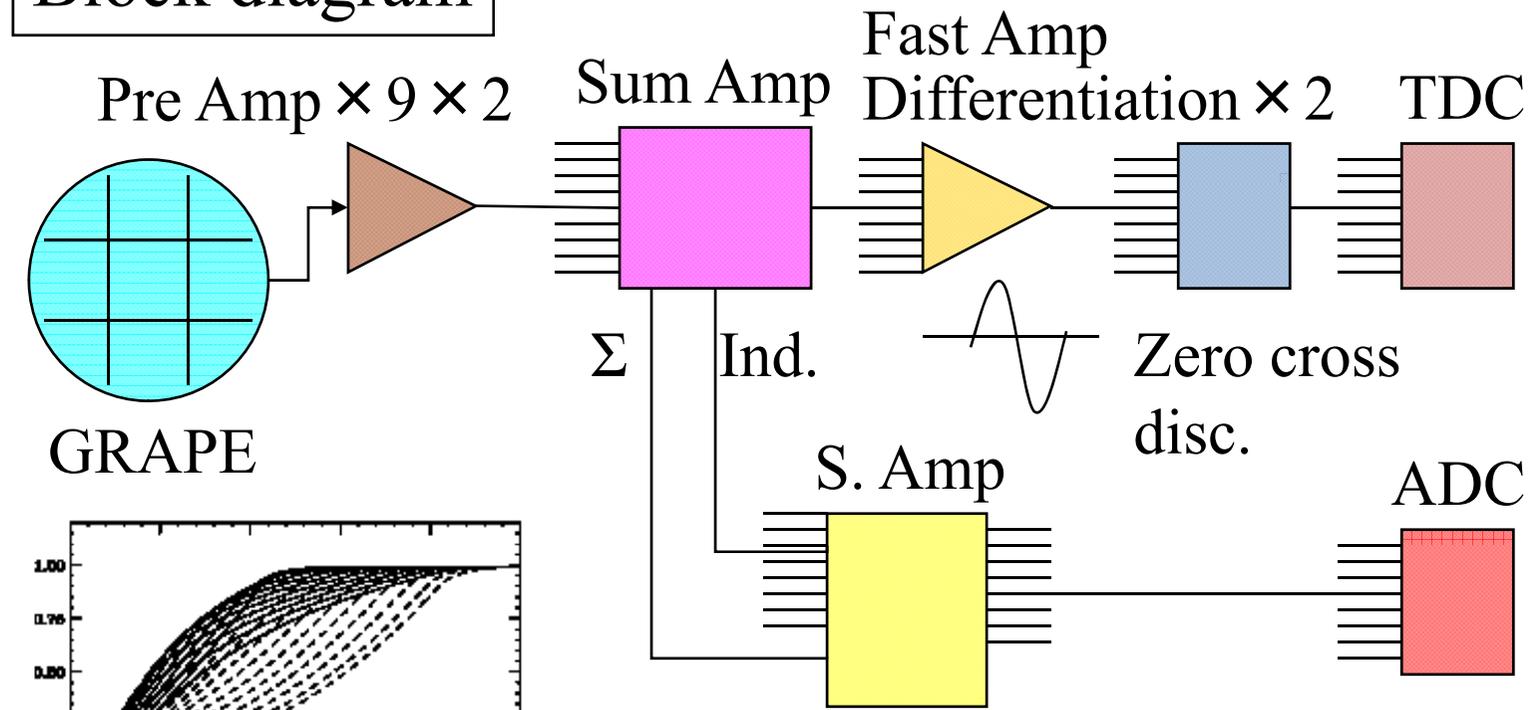


Pulse Shape (saturated drift velocity)

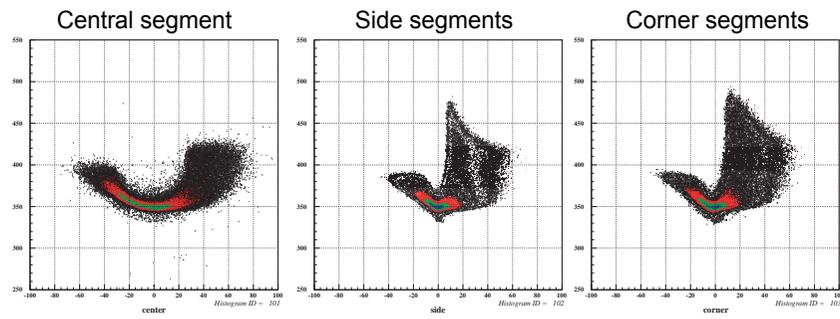


Small Pixel Effect

# Block diagram



Tsum - (Thit-Tsum)



# $^4\text{He} (^{12}\text{Be}, ^{13}\text{B} \gamma)$

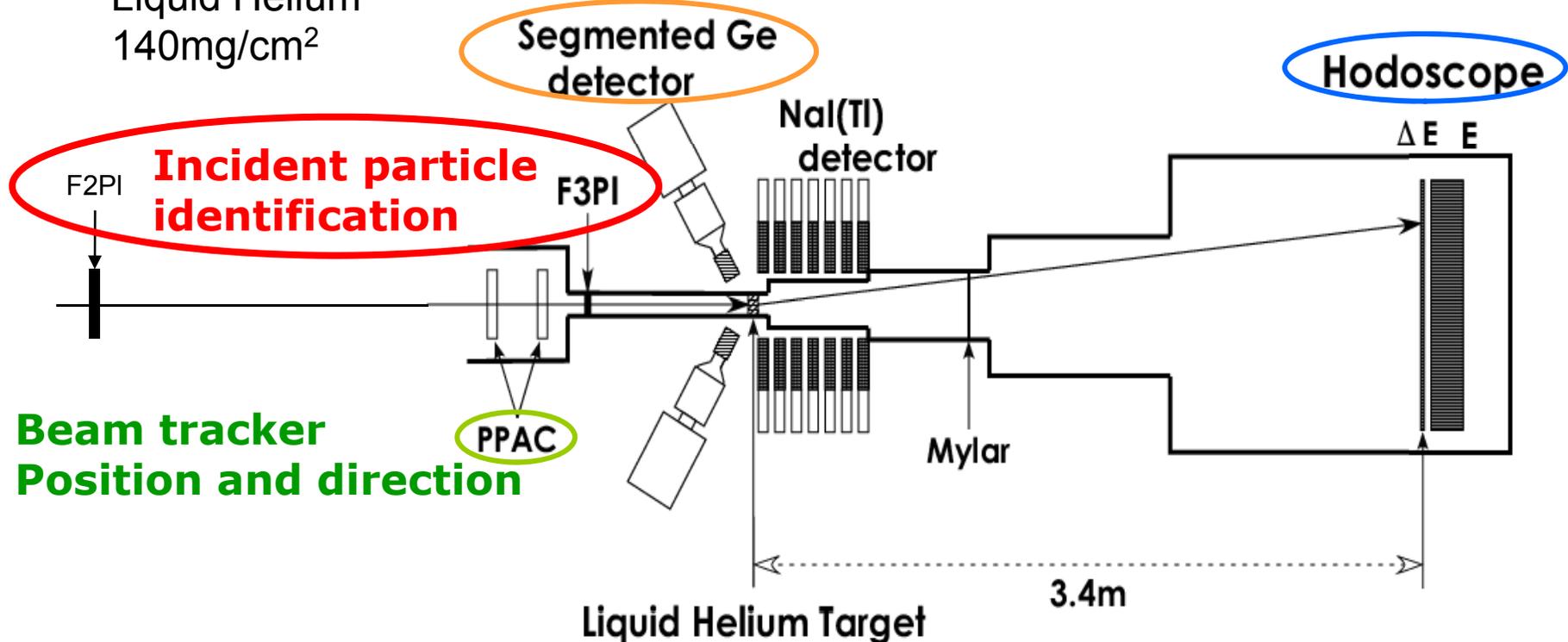
Beam  
 $^{12}\text{Be}$  50 A MeV  
 200 kcps  
 55% purity

Doppler shift: 30%  
 $\beta \sim 0.3$   $\theta \sim 140^\circ$   
 1.3% (FWHM) for 2.1 MeV

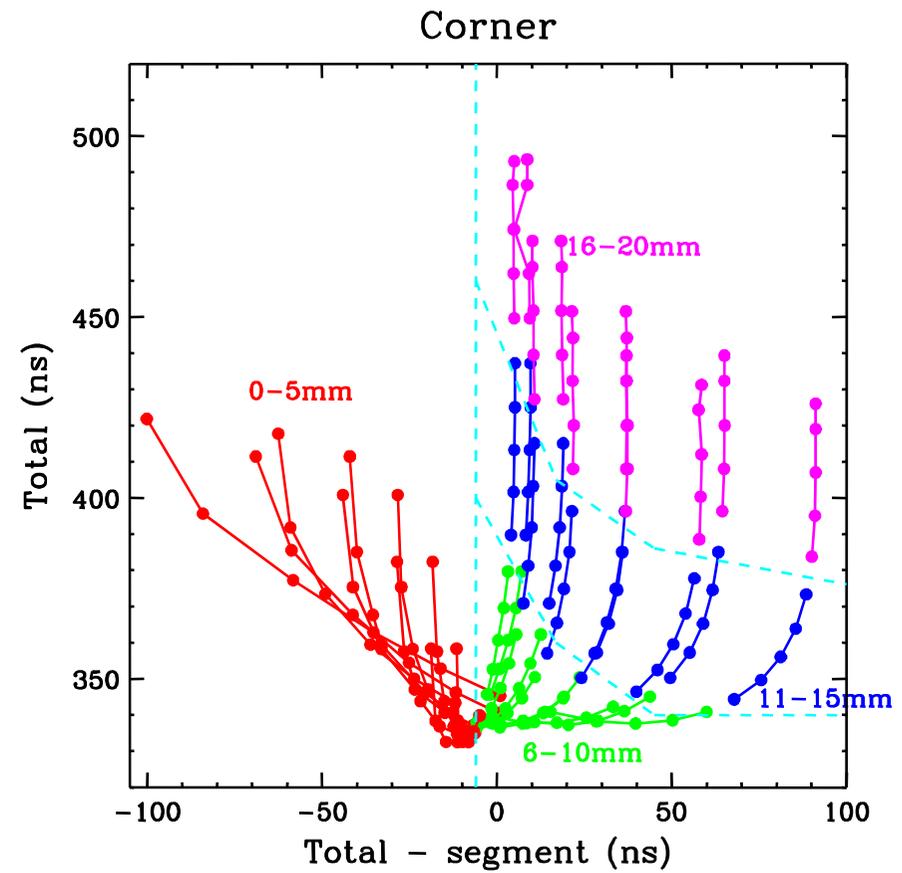
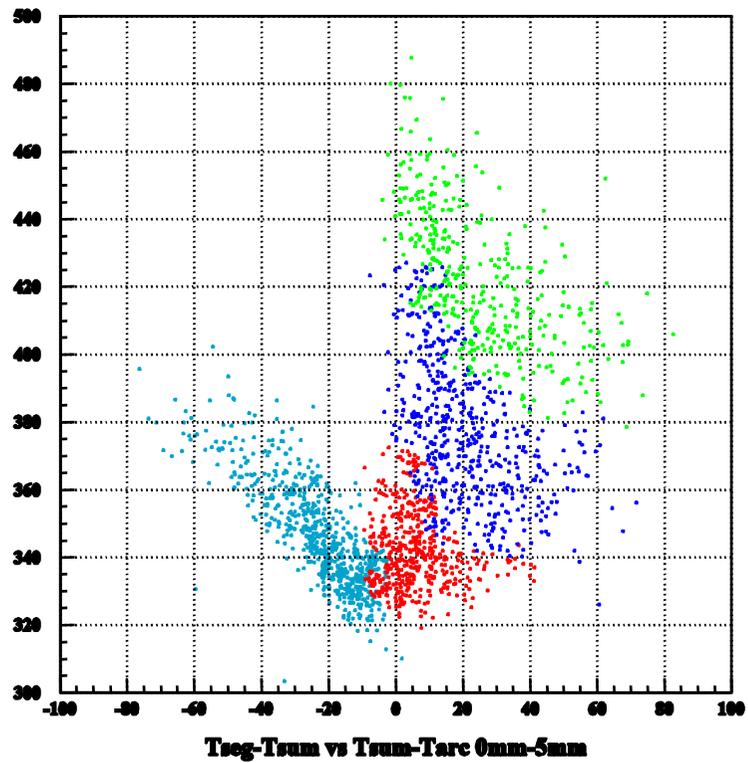
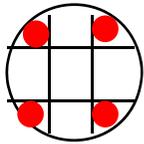
Target  
 Liquid Helium  
 140 mg/cm<sup>2</sup>

**Gamma-ray detector**

**Charged particle detector**  
**Plastic scintillator**  
 $\Delta E, E,$  and position



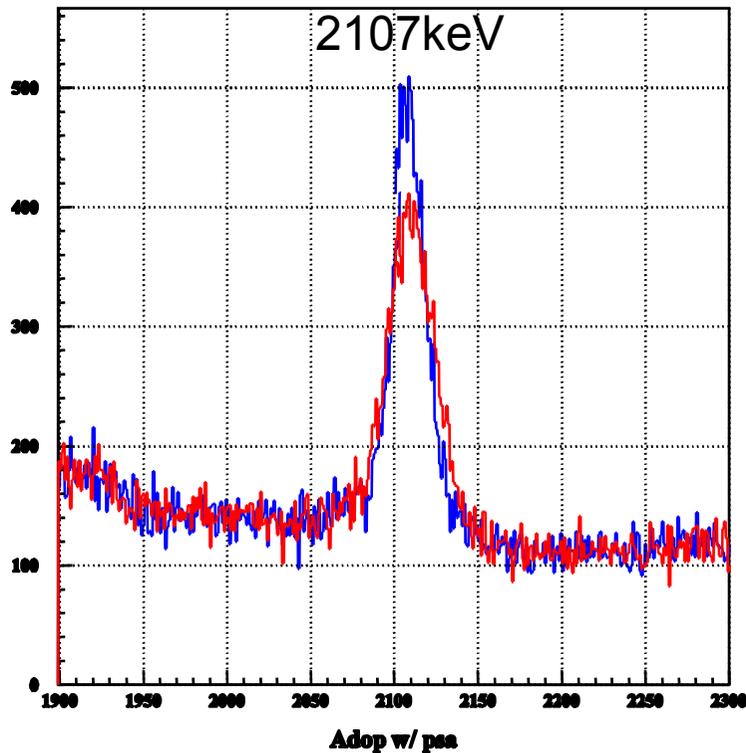
# Pulse Shape Analysis



Kurokawa-san's calculation

# Doppler correction using PSA

$^4\text{He}(^{12}\text{Be}, ^{12}\text{Be}\gamma)$



After Doppler correction without  
PSA: take center of each detector  
As detector position and used fixed  $\theta$

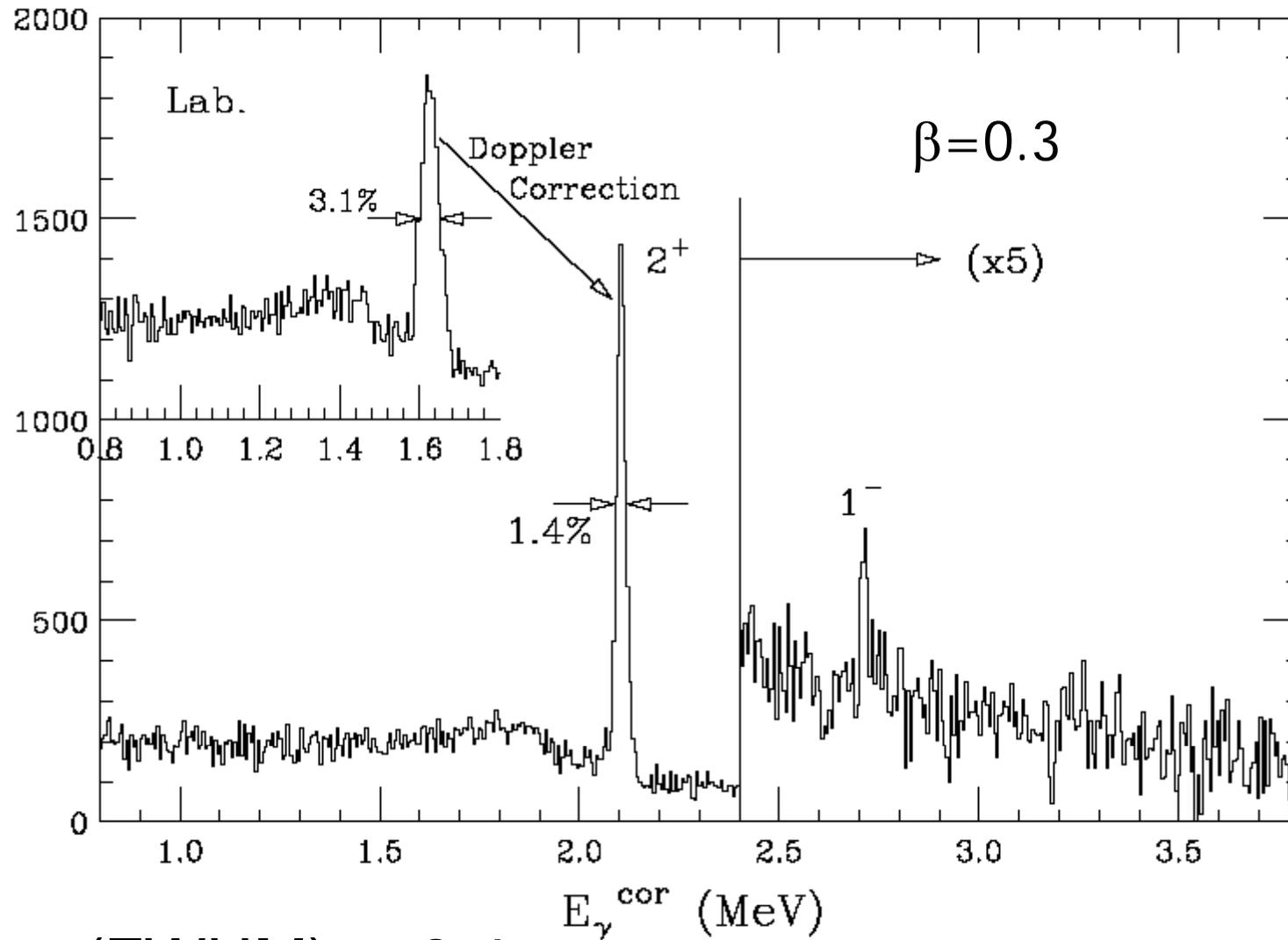
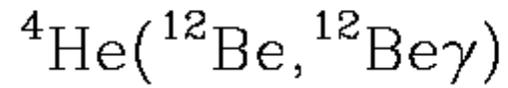
FWHM  $\sim$  1.8%



After Doppler correction with PSA

FWHM  $\sim$  1.3%

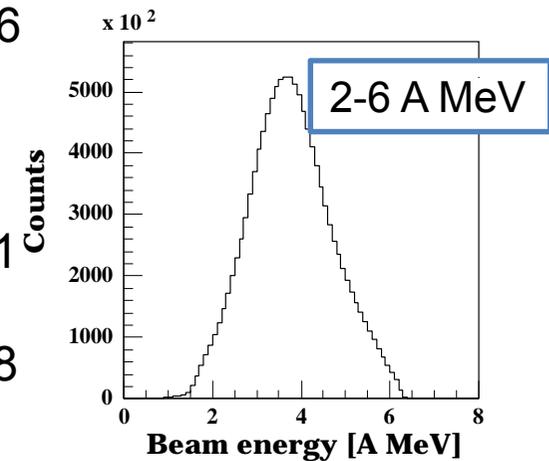
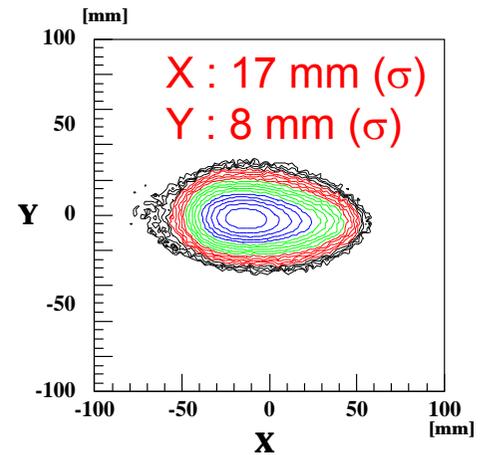
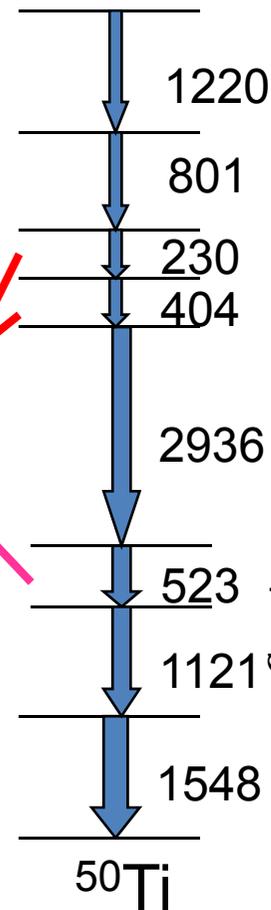
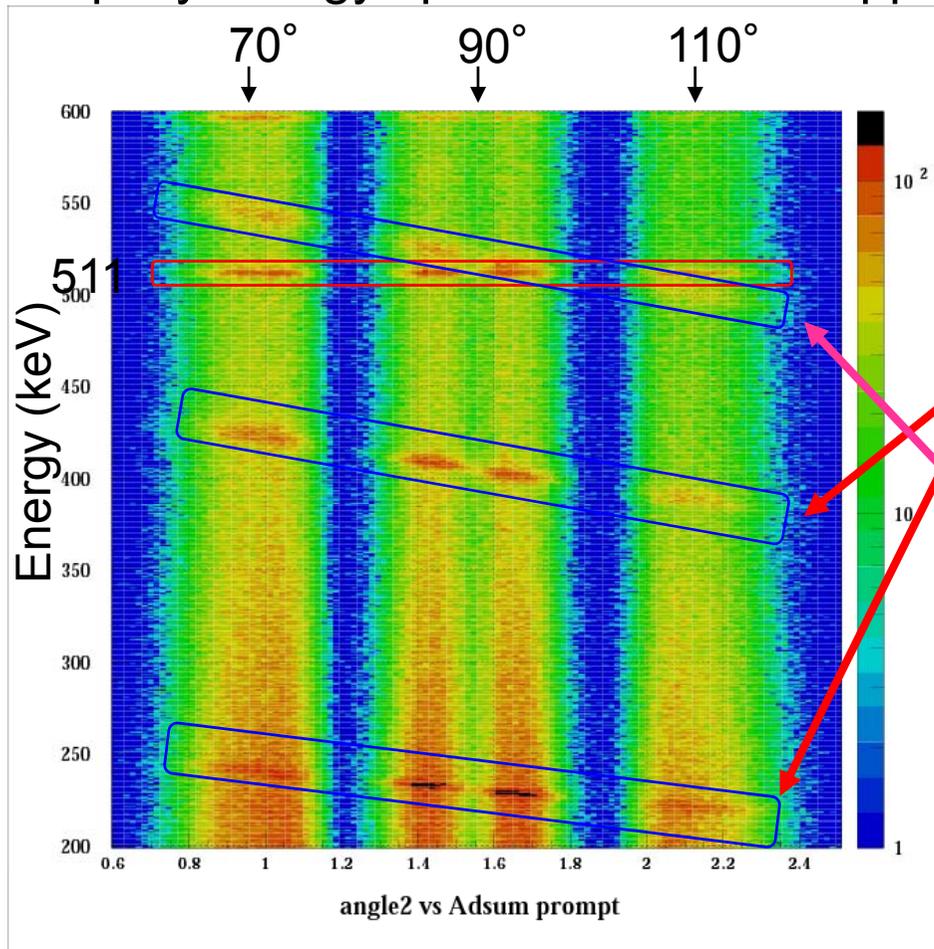
$^{12}\text{Be}$  : 49MeV/A at center of target  
Target: Liq.He 143mg/cm<sup>2</sup>



$$\Delta z \text{ (FWHM)} \sim 3.4 \text{ mm}$$

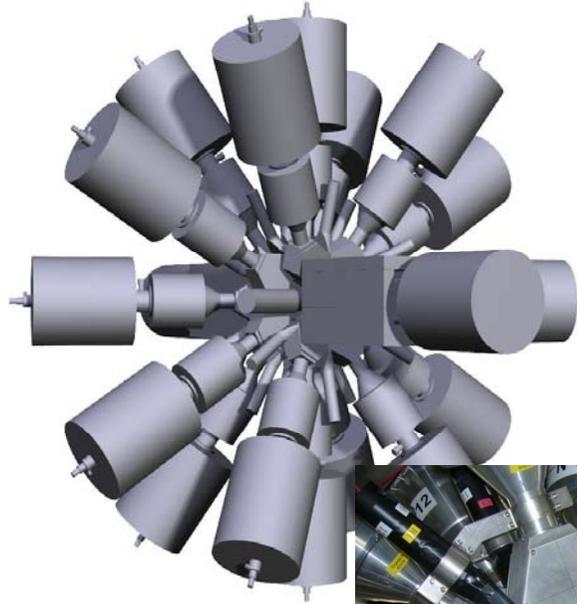
# Doppler Correction with Energy Degraded beam

$\gamma$ -ray energy spectrum before Doppler correction

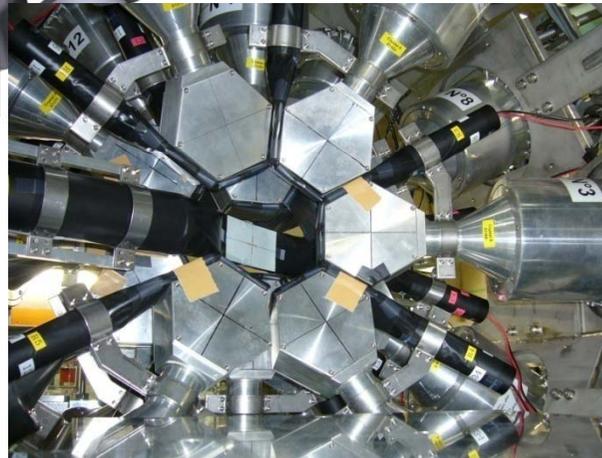


# Special setup

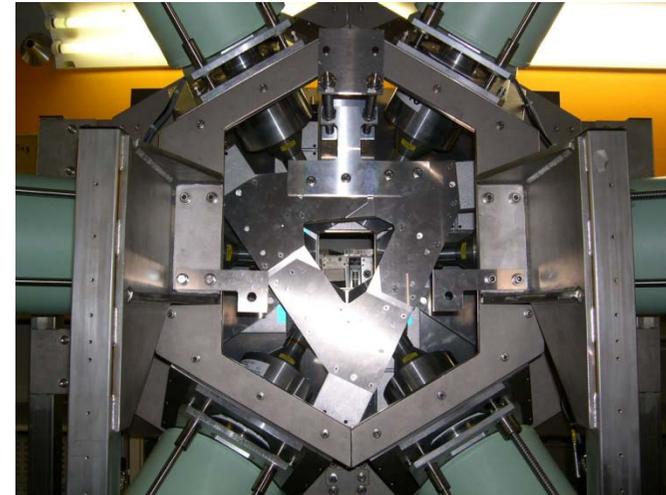
$\beta$  -  $\gamma$  spectroscopy by using  
GRAPE + Clover Ge  
R396n, T.K.Onishi et al.



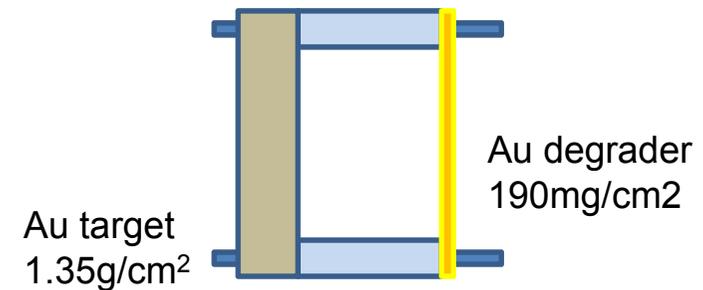
$\epsilon(1\text{MeV}) \sim 3\%$



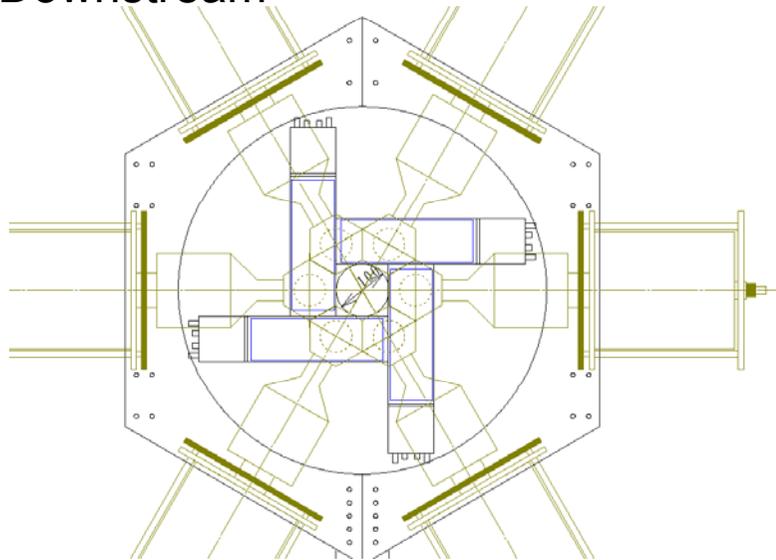
Life time measurement by  
Recoil Distance Method:  
GRAPE with BGO  
R400n, M.Suzuki et al.



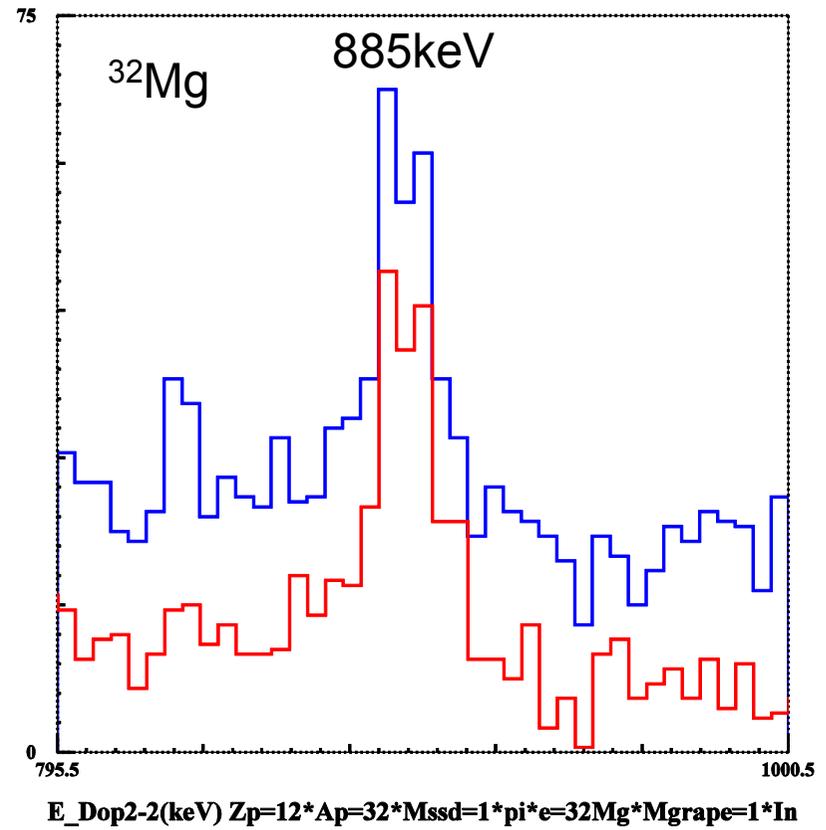
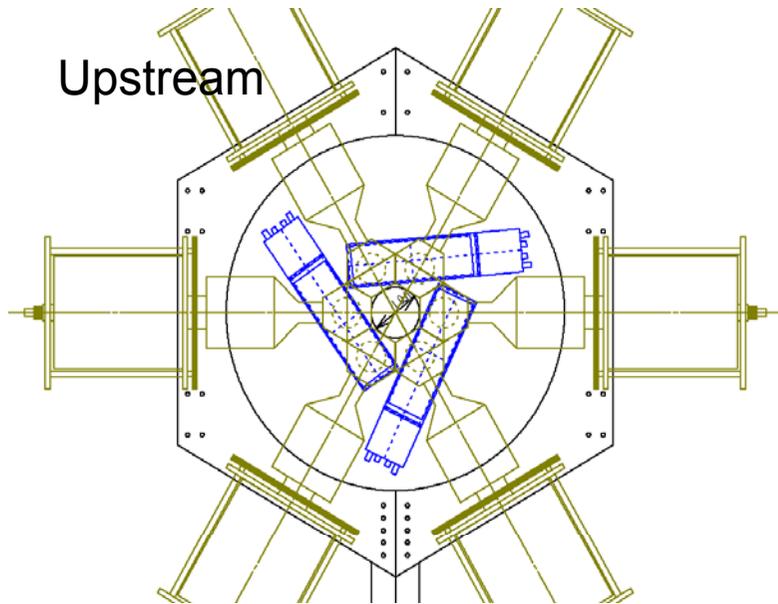
Spacer



Downstream



Upstream



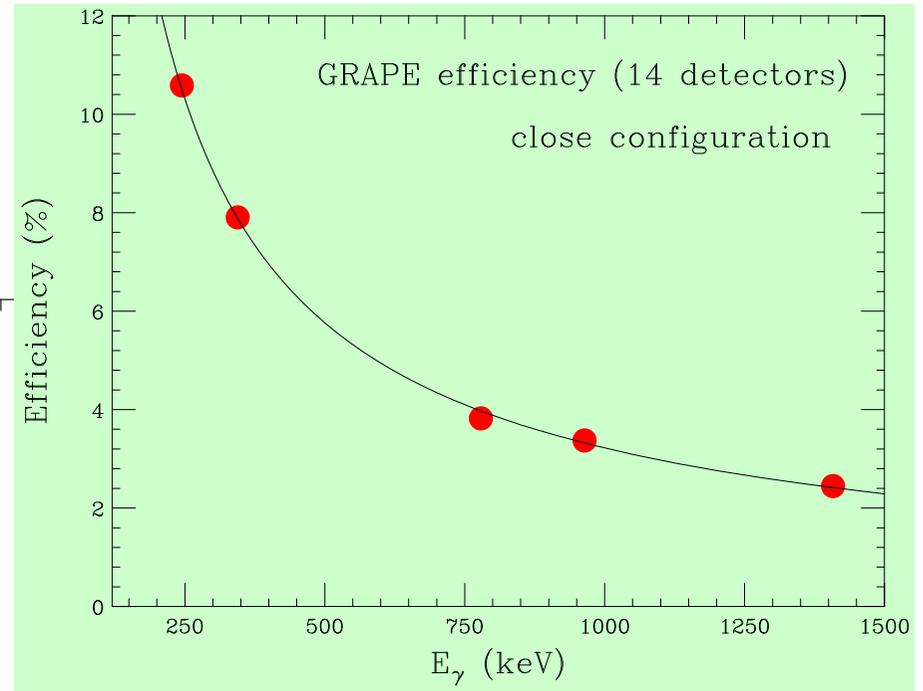
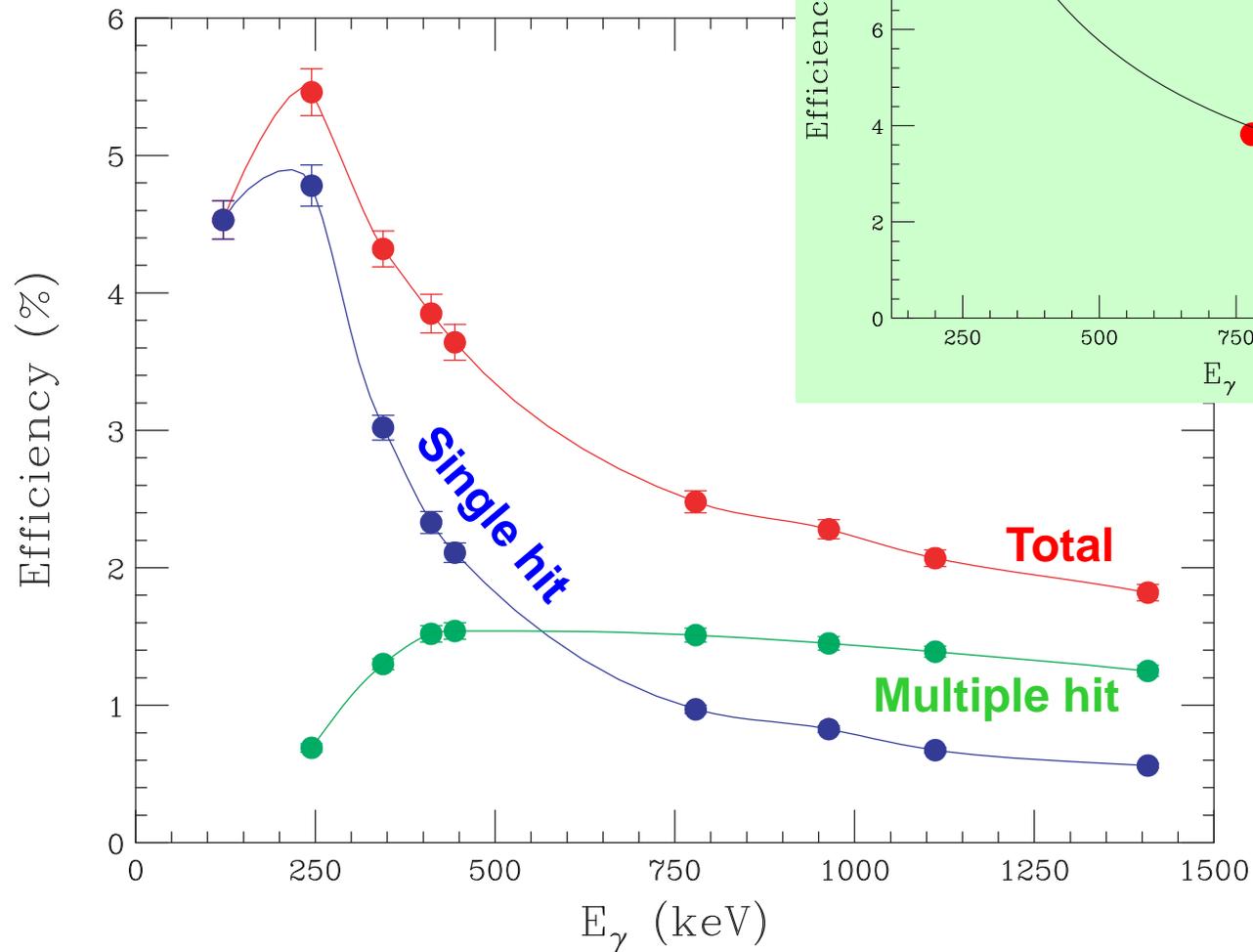
Without BGO



With BGO

S/N ratio is improved  
Factor 2.5

# Efficiency curve



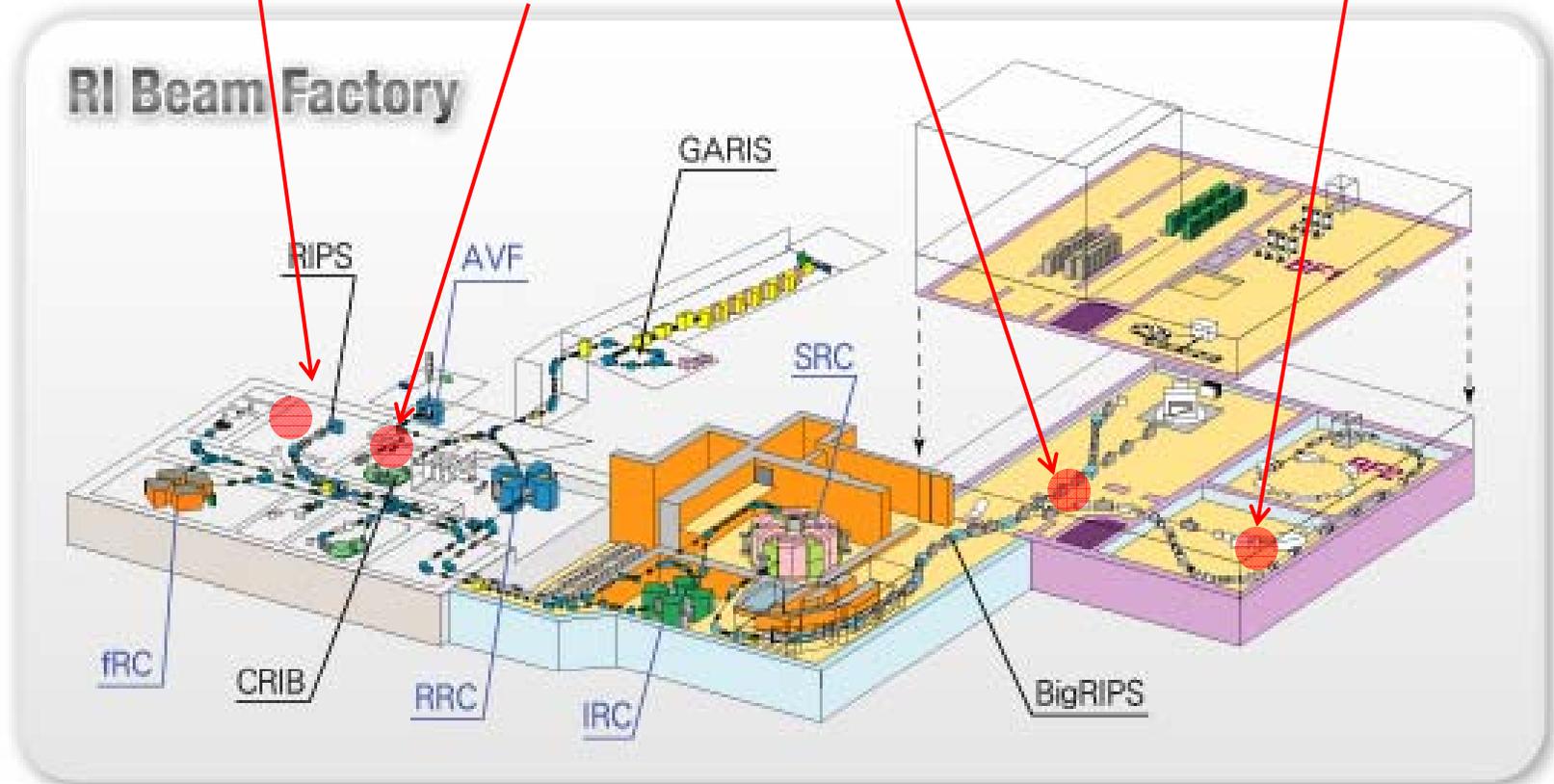
# GRAPE at RIBF

With RIPS

With AVF  
(Stable beam)

With BigRIPS+ZDS

With BigRIPS  
+SHARAQ

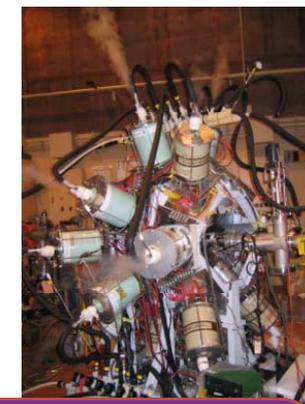


# Gamma-ray spectroscopy community in Japan

# Low-energy beam facility in Japan

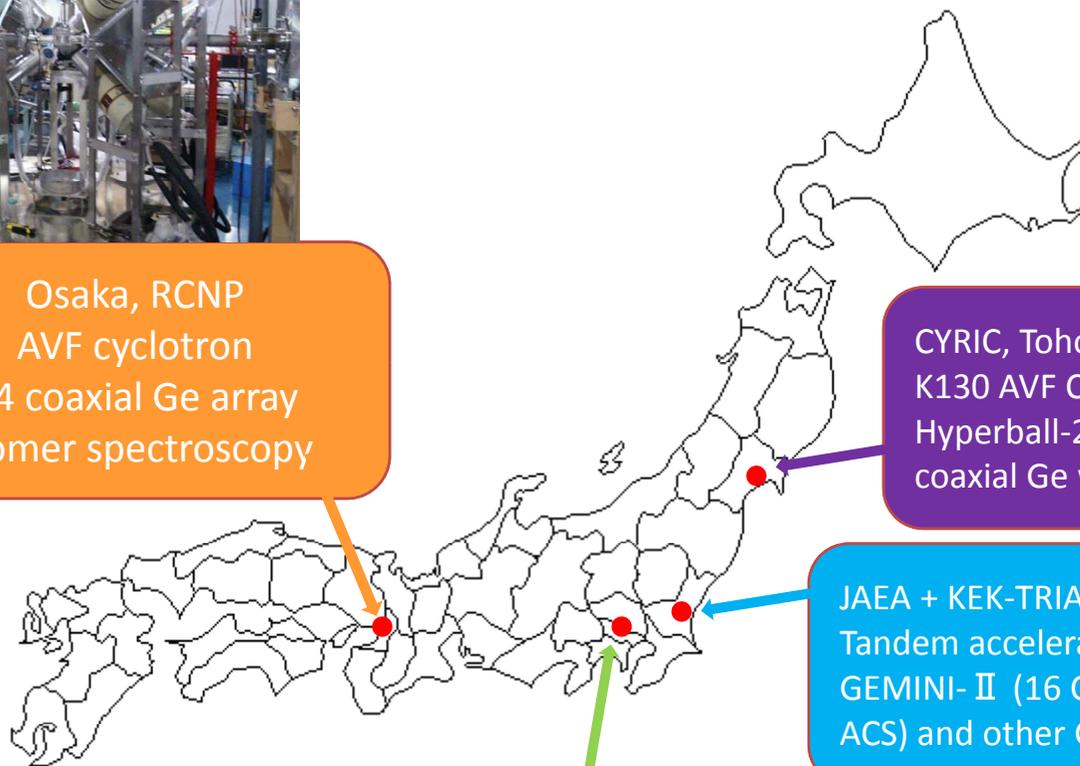


## Major places for $\gamma$ -ray spectroscopy



Osaka, RCNP  
AVF cyclotron  
14 coaxial Ge array  
Isomer spectroscopy

CYRIC, Tohoku University  
K130 AVF Cyclotron  
Hyperball-2 (6 Clover Ge and 14 coaxial Ge with BGO ACS)



JAEA + KEK-TRIAC  
Tandem accelerator + booster  
GEMINI- II (16 Coaxial Ge with BGO ACS) and other Ge's



Wako, Saitama  
CNS: GRAPE (18 segmented Ge)  
RIKEN: AVF cyclotron,  
Ring cyclotron, RIBF



# Japanese Gamma-ray Spectroscopy Association (JGSA)

- Started from March 2007.
- Purpose
  - Exchange information between research groups
  - Develop collaborative research activities
    - Experimentalists  $\Leftrightarrow$  Experimentalist  $\Leftrightarrow$  Theorist
  - To define strategic target of this community (Detector, Physics, etc.)
- Present Organizers
  - E. Ideguchi (CNS, Chair), N. Aoi (RIKEN), A. Odahara (Osaka), T. Koike (Tohoku), T. Nakatsukasa (RIKEN)
- Web: <http://www.cns.s.u-tokyo.ac.jp/gamma/>
  - Now it appears in Japanese language.
  - Internationalization will be discussed.
- Mailing-list: [gamma-ml@mail.cns.s.u-tokyo.ac.jp](mailto:gamma-ml@mail.cns.s.u-tokyo.ac.jp)

- Numbers of registered members: 51 (as of Jan. 24, 2008)
  - Experimentalists: 42, Theorists: 9
  - Affiliation: 3 Institutes and 10 Universities  
CNS, RIKEN, JAEA, KEK, Tokyo, Tohoku, Osaka, Kyoto, Kyushu, Niigata, Saitama, Chiba, Chiba Inst. Tech., Tokyo Univ. Sci.
- Regular meetings
  - At biannual JPS meeting (Spring and Fall)
    - 1<sup>st</sup> Meeting: March 26, 2007 @ Tokyo Metropolitan Univ.
      - Kickoff meeting
    - 2<sup>nd</sup> Meeting: Sep. 22, 2007 @ Hokkaido Univ.
      - Exchange Information between groups (11 groups)
      - Discussion about future collaboration
    - 3<sup>rd</sup> Meeting: March 23, 2008 @ Kinki Univ.
      - Exchange Information between groups
      - Collaboration development

# CNS-RIKEN Joint International Symposium on Frontier of gamma-ray spectroscopy and Perspectives for Nuclear Structure Studies (gamma08)

Date: April 3-5, 2008

Place: Nishina Hall in RIKEN Wako Campus

Organizers: E. Ideguchi (CNS, Chair), N. Aoi (RIKEN), S. Michimasa (CNS),  
H. Scheit (RIKEN), A. Odahara (Osaka), T. Koike (Tohoku), T. Ishii (JAEA),  
T. Nakatsukasa (RIKEN), S. Shimoura (CNS), T. Motobayashi (RIKEN),  
T. Otsuka (CNS/Tokyo)

Main topics to be discussed are:

- \* Collectivities and shell effects in neutron/proton-rich nuclei
- \* Shell structure and stability of very heavy nuclei
- \* Exotic deformation / new collective motion at low and high spin
- \* Single particle motion in isomeric states
- \* Development of detectors and experimental methods

Web: <http://www.cns.s.u-tokyo.ac.jp/gamma08/> → Registration,  
abstract

Deadlines

- \* Deadline for abstract submission: **February 15, 2008**
- \* Deadline for registration: **March 21, 2008**