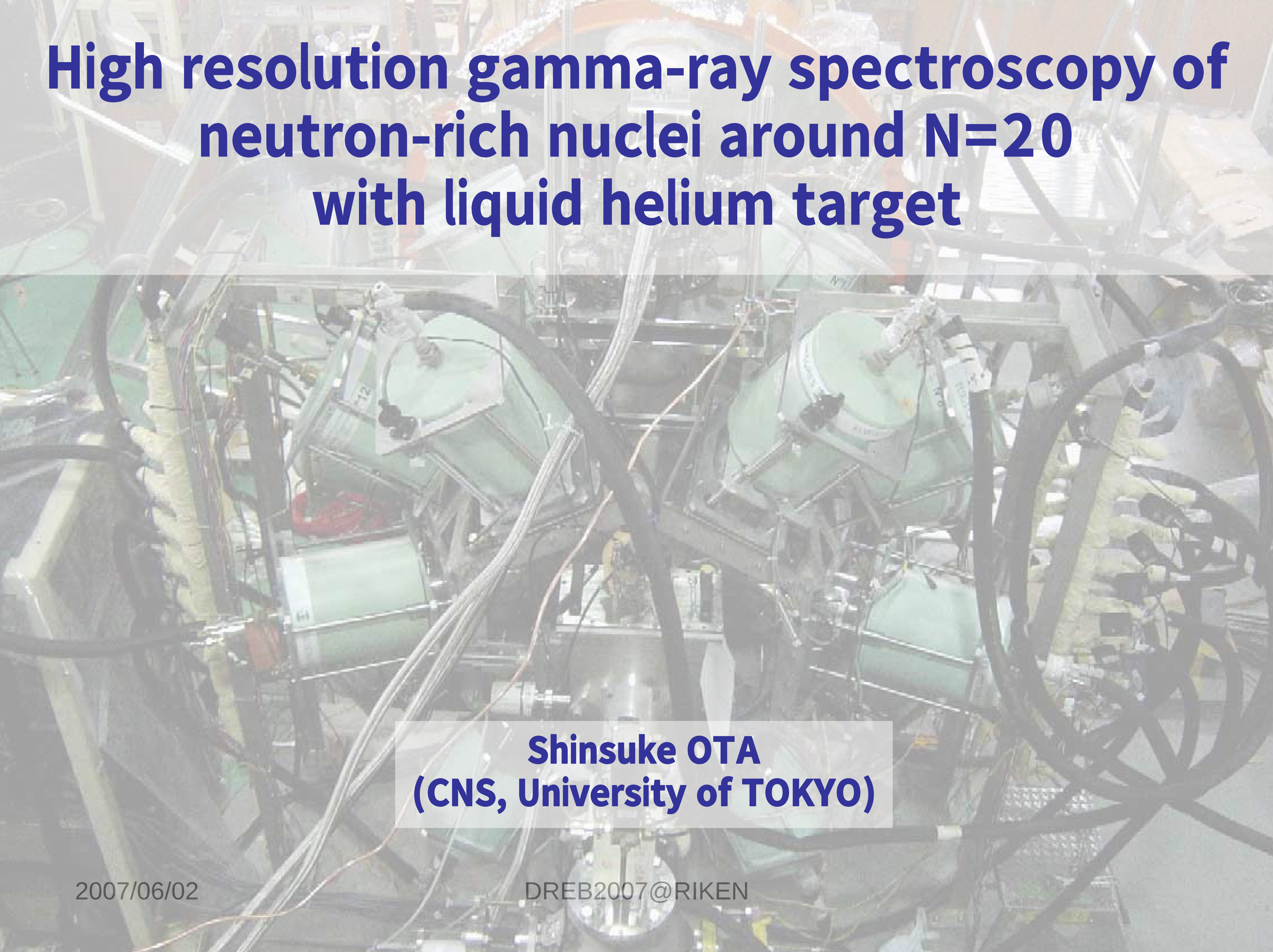
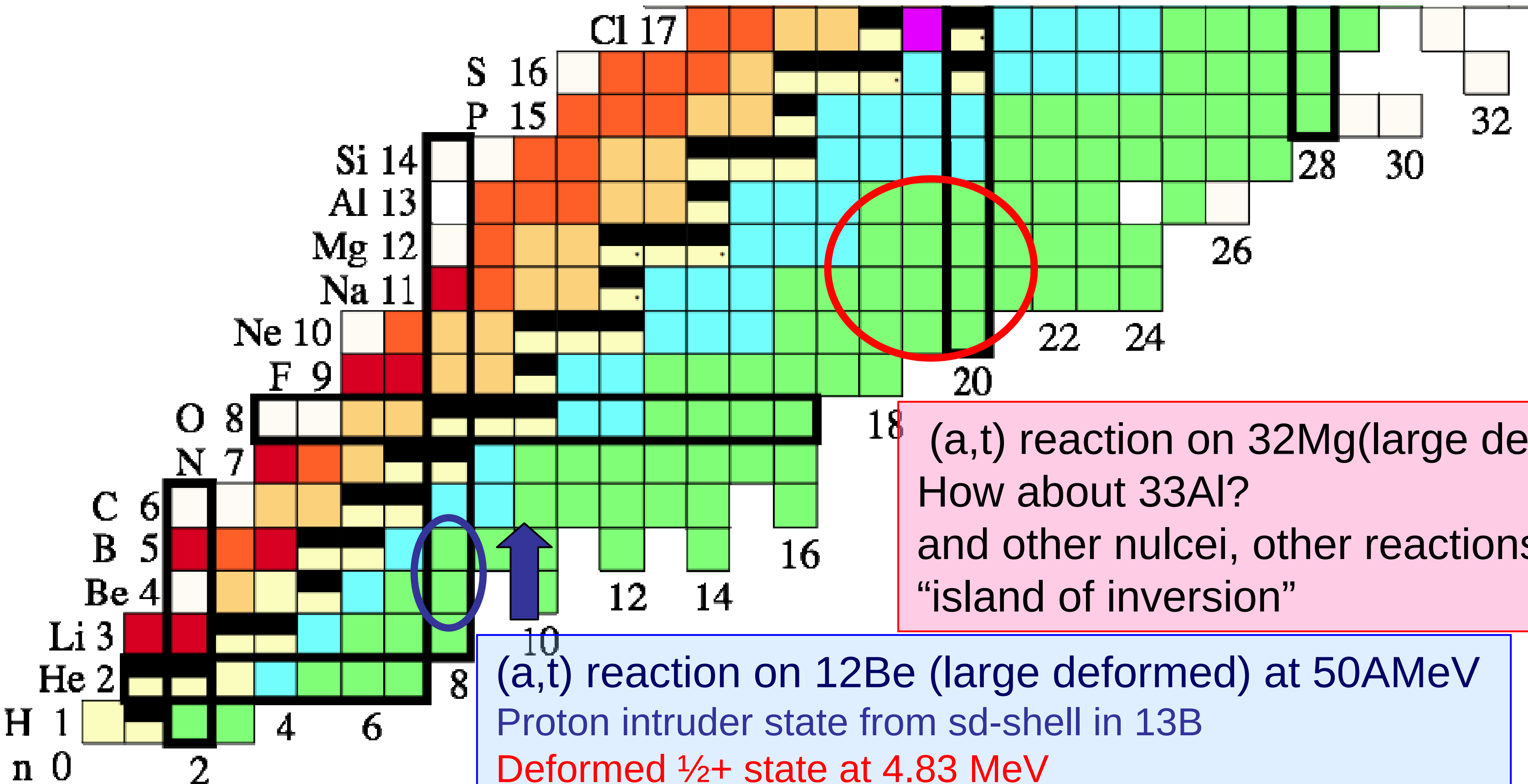


High resolution gamma-ray spectroscopy of neutron-rich nuclei around N=20 with liquid helium target

Shinsuke OTA
(CNS, University of TOKYO)

Shell melting in neutron-rich unstable nuclei

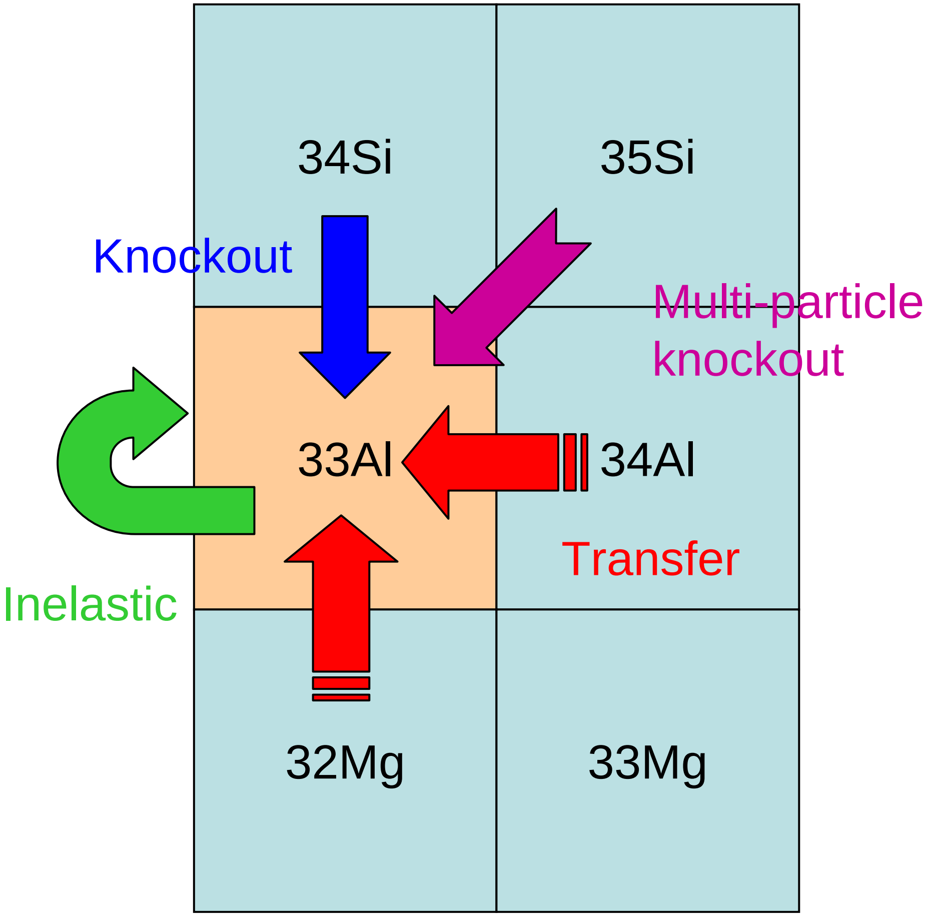


(a,t) reaction on 32Mg(large deformed)
How about 33Al?
and other nulcei, other reactions around
"island of inversion"

(a,t) reaction on 12Be (large deformed) at 50AMeV
Proton intruder state from sd-shell in 13B
Deformed ½+ state at 4.83 MeV
Change of proton shell in neutron-rich nuclei
Z=8 shell melting in excited state?

Direct reactions with cocktail beam

- **Reaction channels**
  - **Selectivity**
  - **Comparison**
    - **Structure of the excited state**
- **Angular distribution**
  - **DWBA analysis**
  - **Spin-parity information**



Similar situation for other nuclei

Gamma spectroscopy in inverse kinematics

- Doppler broadening
  - $\delta E_{cm} = f(\delta E_{det}, \delta \beta, \delta \theta)$
  - inverse kinematics
    - large velocity(β) of ejectile
  - finite size(θ) of the detector

  ⇒ needs position resolution for gamma ray and time resolution for ejectile

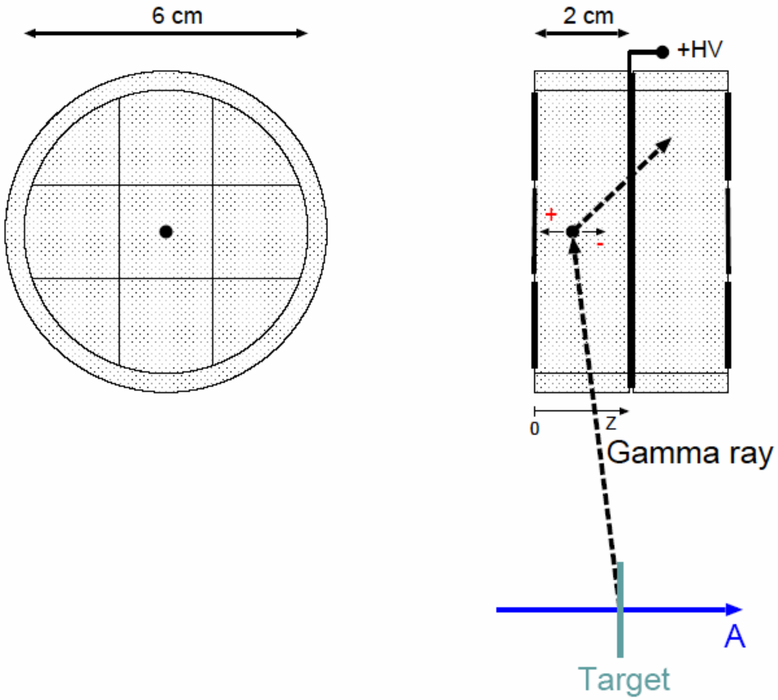
⇒ CNS GRAPE (Gamma-Ray detector Array with Position and Energy sensitivity)

GRAPE ~basic information~

Detector

Planar-type detector ×18

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



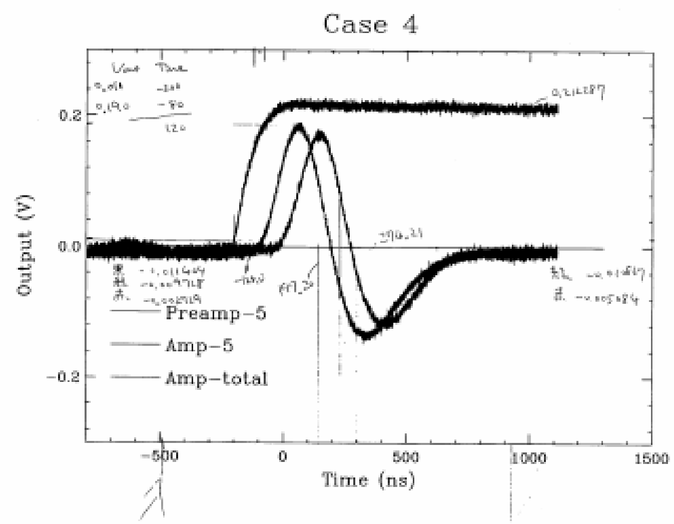
Z-Position (~ θ) ⇔
Drift length of electrons and holes

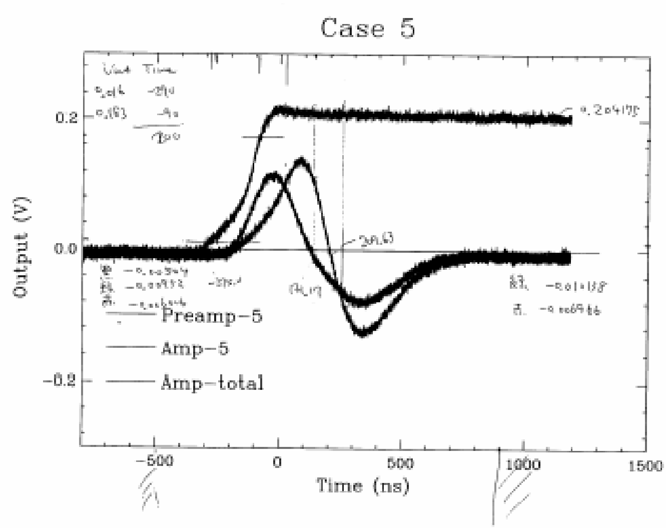
Active Volume: $2^{t} \times 6^{\phi}$ **cm**^{3}

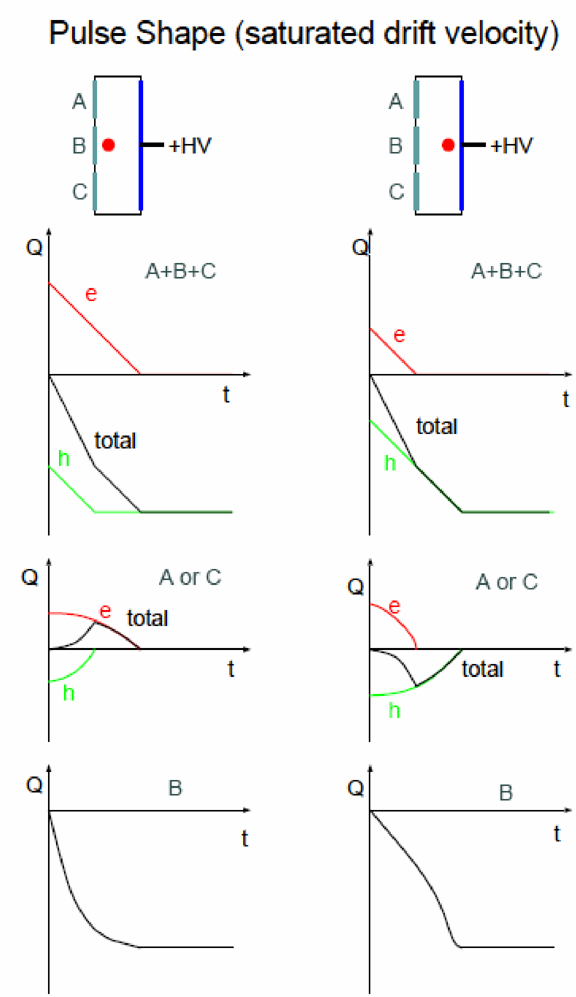
Segmentation: 3×3

2 crystals in 1 cryostat

GRAPE ~basis of PSA~



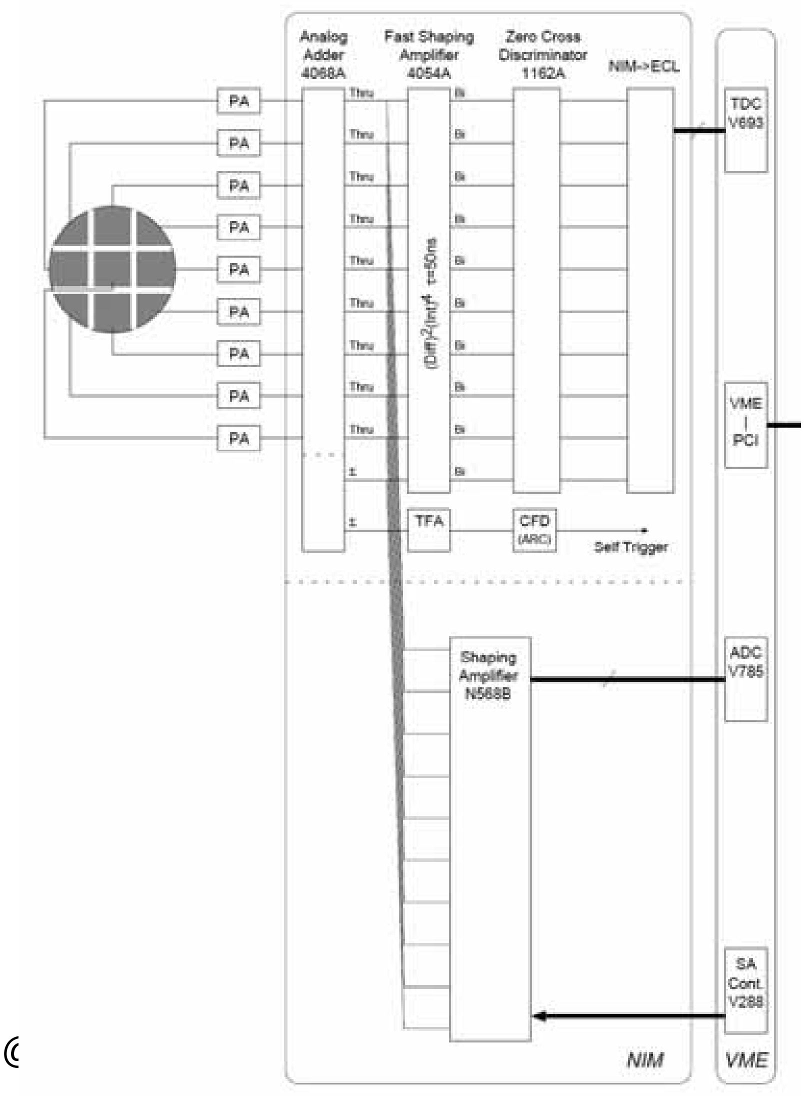




Small Pixel Effect

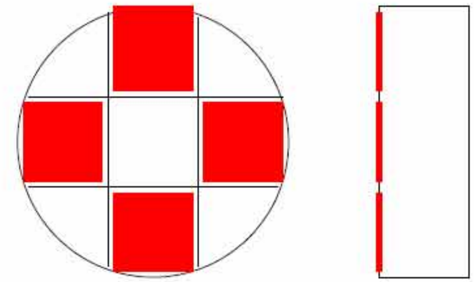
GRAPE ~PSA with analog circuit~

- Zero-Cross timing of 2nd Derivative of Charge pulses for Hit & Total
  - Analog Adder [Total signal]
  - Fast Shaping Amplifier [(RC)4-(CR)2]
  - Zero-Cross Timing Discriminator
- Conventional Shaping Amplifier
- VME ADC
- VME TDC

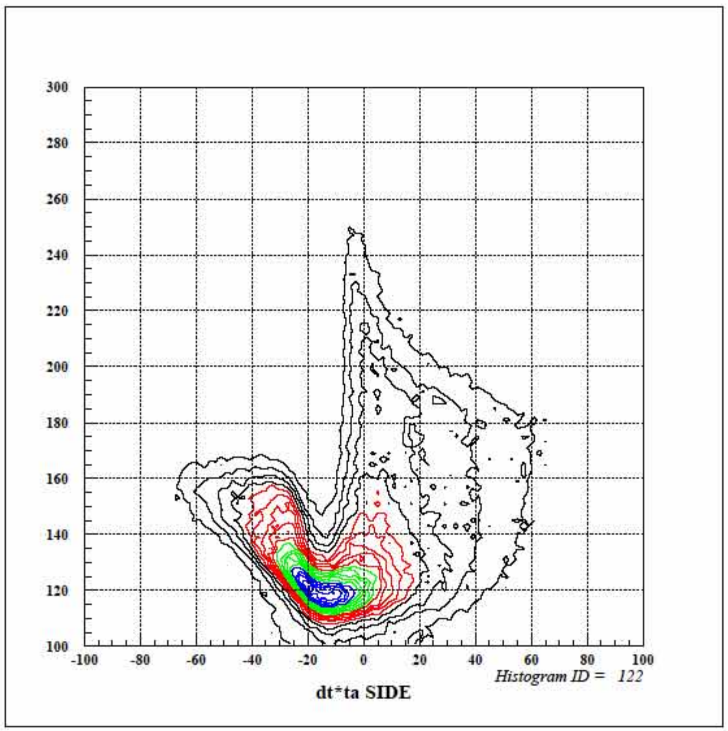


Pulse Shape Analysis

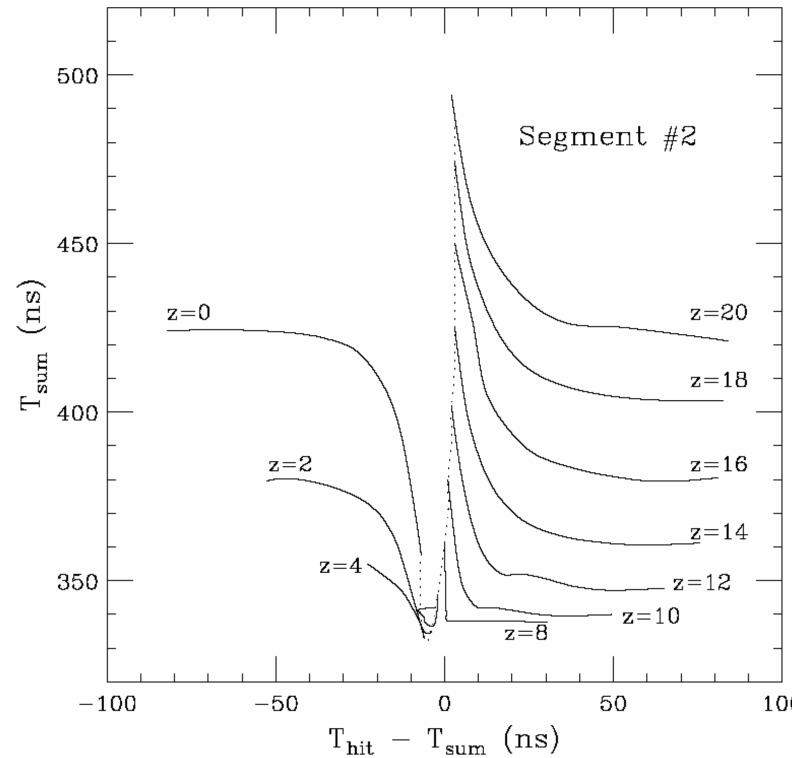
(Example)



Experiment

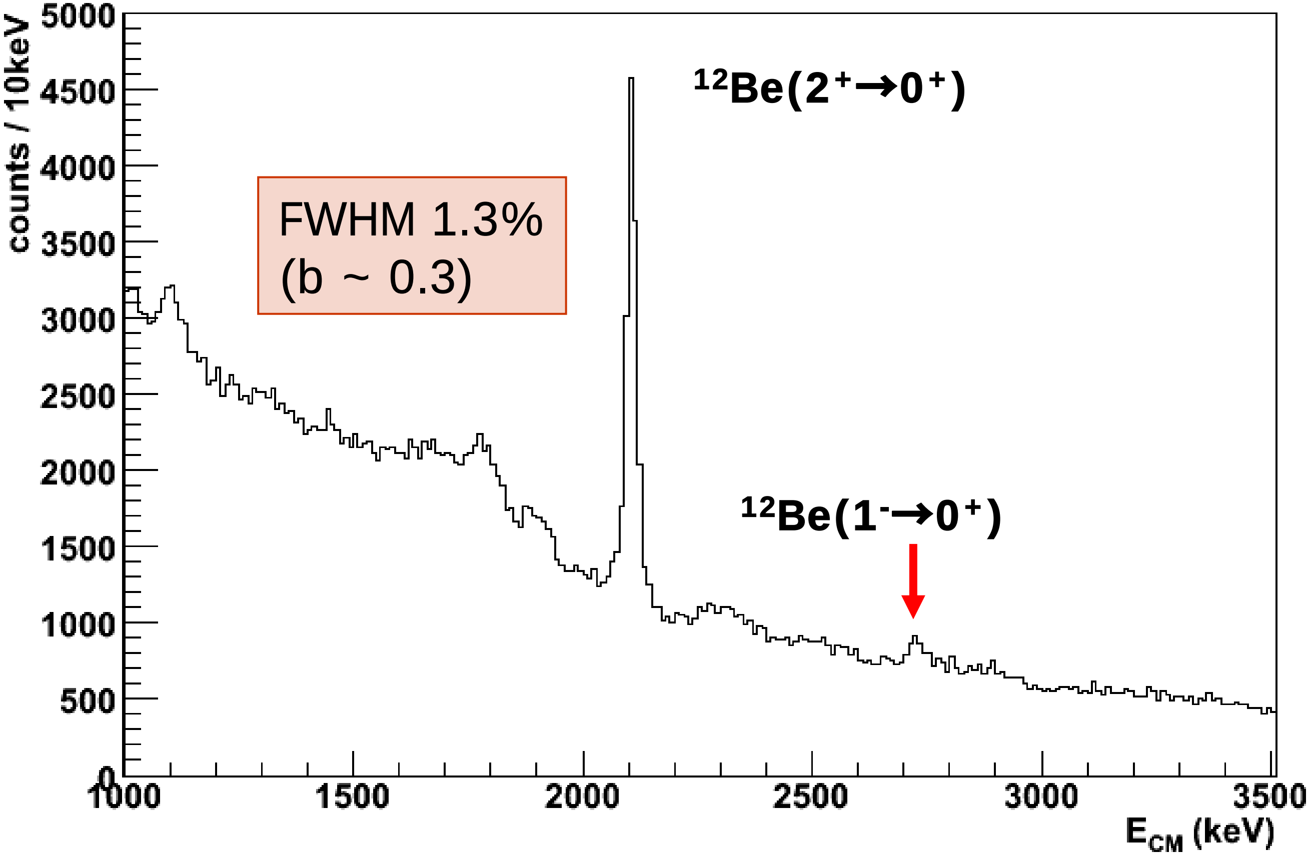


Simulation

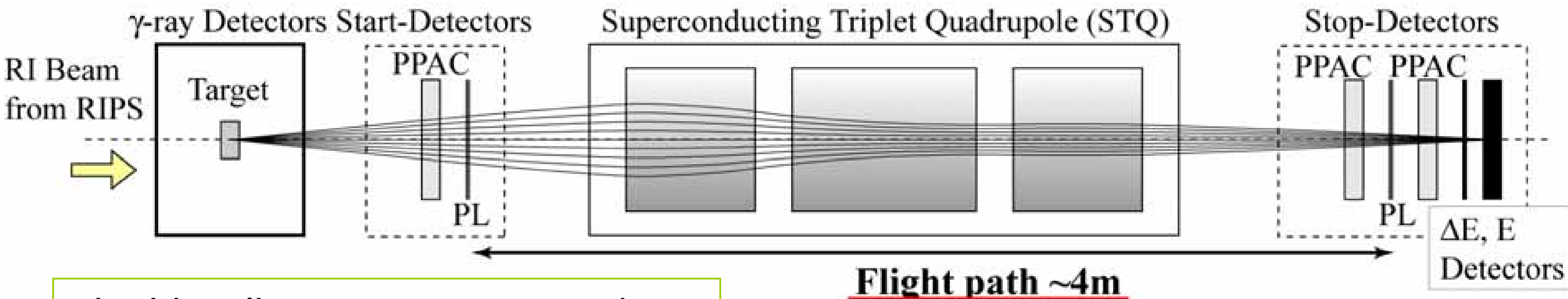


$$T_{\mathrm{HIT}} - T_{\mathrm{SUM}} \text{ vs. } T_{\mathrm{SUM}}$$

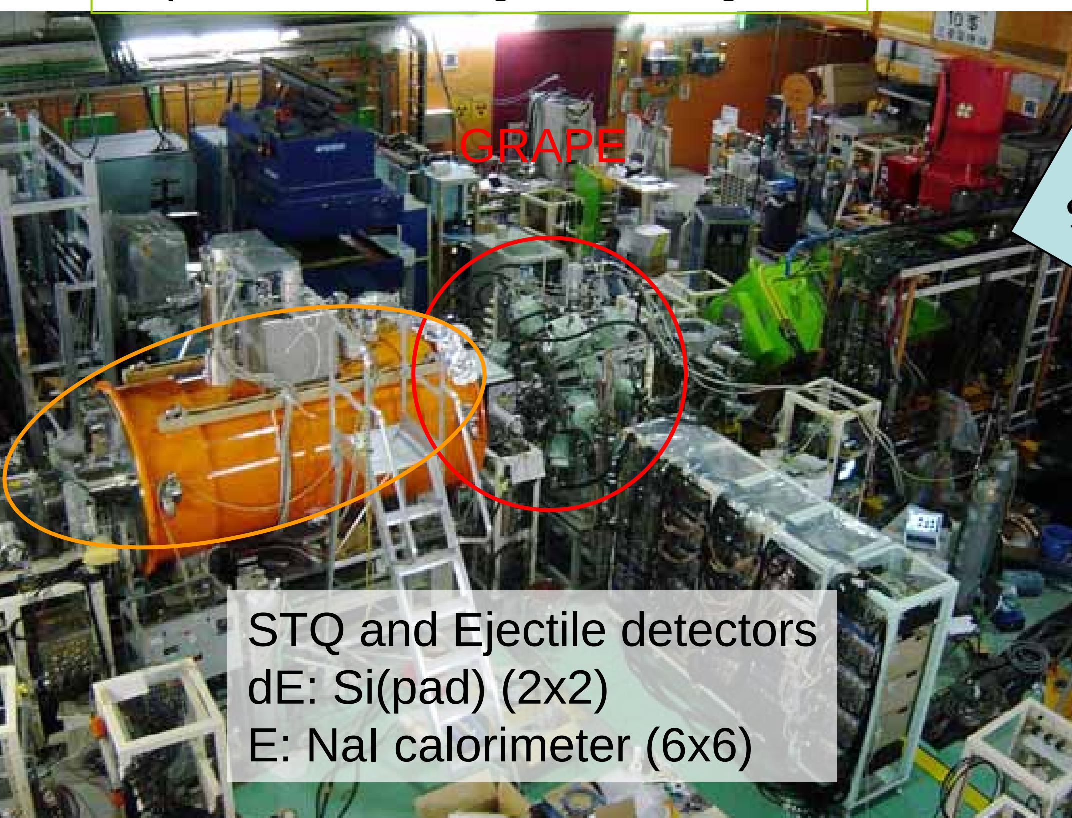
GRAPE ~performance~



Experiment @ RIPS



Liquid Helium Target ~140mg/cm2



40Ar 65AMeV (~600pnA) + Be,C

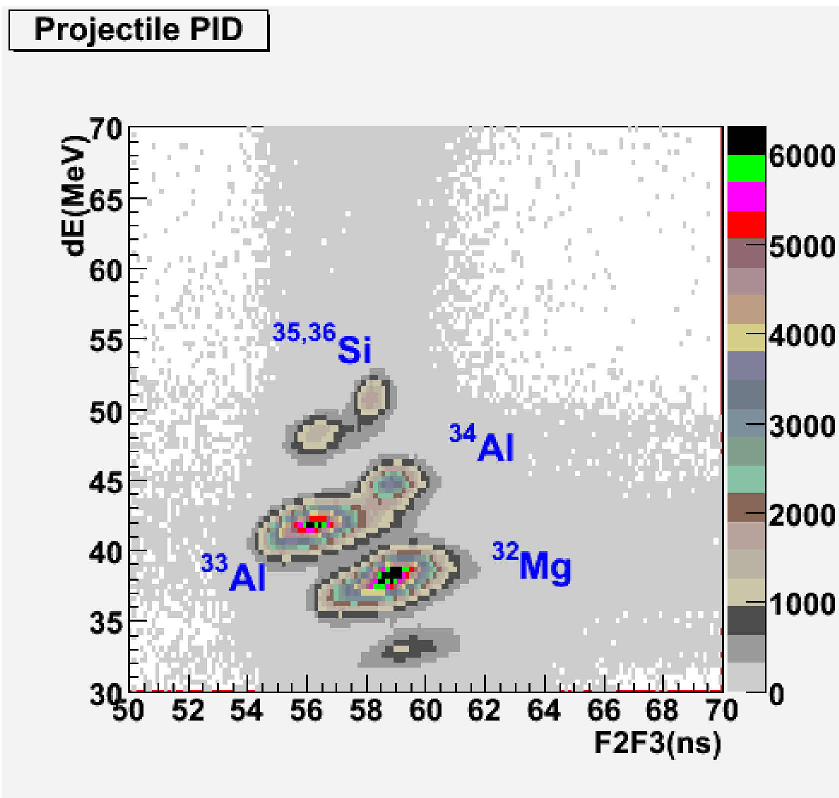
Secondary beam

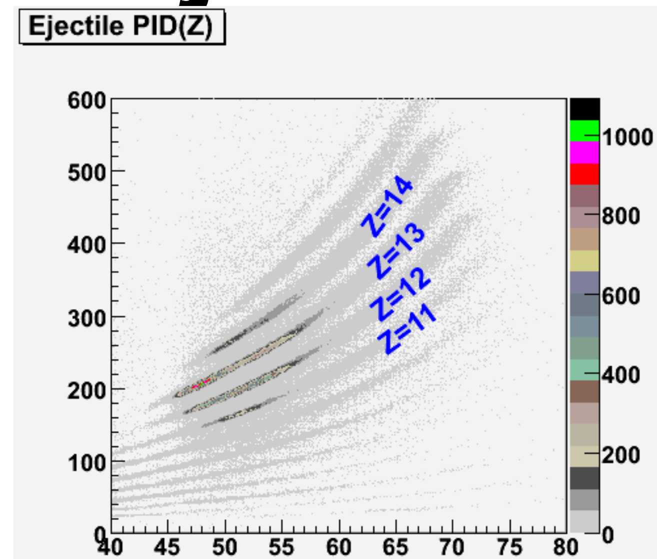
Separated by RIPS
PID with two plastic and one Si (TOF-dE)

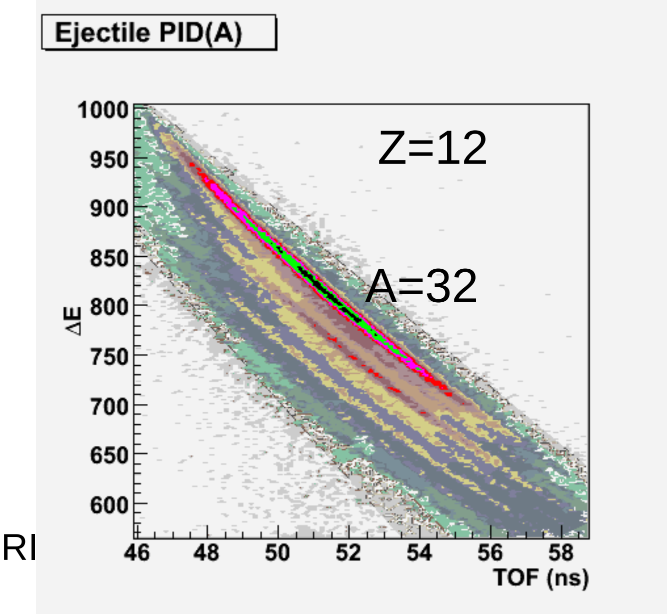
Momentum of projectile and ejectile: PPACs

EN

Projectile and Ejectile



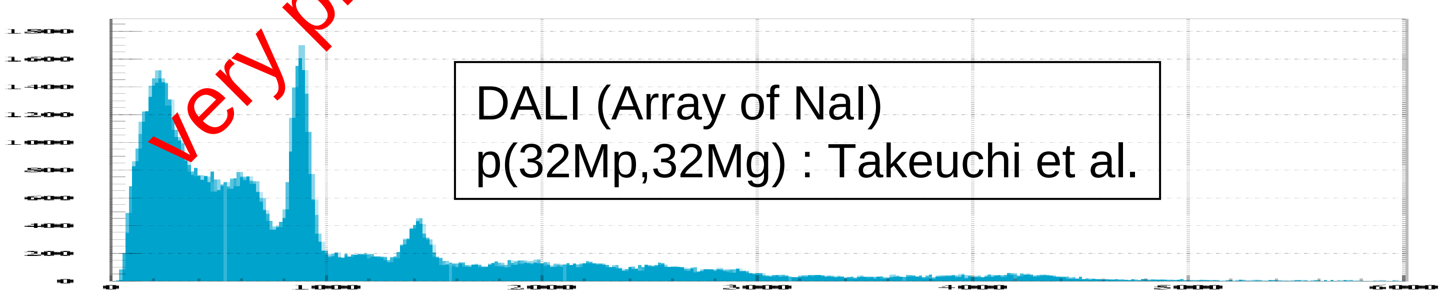




Gamma-ray energy spectrum

GRAPE (Array of Ge)
α(X,32Mg) : present work

very preliminary



much better resolution,
and can be improved

Summary and Future plan

- **α** induced reaction on various nuclei around "island of inversion" in inverse kinematics.
- Father analysis
  - (a,t) reaction channel and other reaction channels related to 33Al
  - Other nuclei
  - Tuning the position of GRAPE and the PSA

- 1.3 % energy resolution can be achieved at b~0.3 by using GRAPE with PSA
  - High resolution will be achieved even in RIBF (**β**~0.6)

Collaborators

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