GET electronics for missing mass spectroscopy at RIBF

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Workshop on Active Targets and Time Projection Chambers for High-intensity and Heavy-ion beams in Nuclear Physics
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New devices for missing mass spectroscopy at RIBF

Active target ‘CAT-M’
→ Shinsuke Ota’s talk

Silicon array ‘TiNA’
→ this talk

GET system
New silicon detector array TiNA for transfer reactions \((d,p)\), \((t,p)\), \((d,^{3}\text{He})\)... at RIBF

D. Steppenbeck et al., Nature 502, 207 ('13)

From 250 MeV/u down to 10 ~ 50 MeV/u.
OEDO beam line (complete 2017)

Degrader

Courtesy N. Imai
The RF deflector has the following specifications:

- Frequency: $f_{RF} = 18.25 \text{ MHz}$
- Maximum Voltage: $V_{max} = 350 \text{ kV}$
- Gap: $\text{Gap(H)} = 200 \text{ mm}$
- Length: $L(Z) = 1200 \text{ mm}$
- Width: $W(V) = 400 \text{ mm}$
Commissioning: $^{107}$Pd slowed from 170 to 33 MeV/u

$^{107}$Pd @ 170MeV/u → RF HV: 250kV, Phase: 80 deg. → 20mm (FWHM)

$^{107}$Pd@ 33MeV/u

$^{107}$Pd$^{45+}$

$^{107}$Pd$^{44+}$

20mm (FWHM)

Courtesy N. Imai
Silicon detector array TiNA-Phase 1
Phase 1: Micron YY1 + CsI + NIM circuit

16 strips*5 mm = 8 cm

300 μm

5*5*2.5 cm³

1.8*1.8*5 cm³

16*6 (YY1) + 12 (CsI) = 48 channels in total
In-beam test (July 2017)

@ Tandem facility of the Kyushu University
$^{12}\text{C} \oplus 20\text{ MeV} + \text{TiD}_2\text{ target}$

![Graph showing the energy loss ($\Delta E$) vs. scattering angle ($\Theta$) for protons, deuterons, and protons from $(d,p)$ reactions.]

*Courtesy P. Schlock, K. Wimmer*
First \((d,p)\) experiment at OEDO (Nov. 2017)

- Transmute Long-Lived Fission Product (LLFP) \(^{79}\text{Se}\) \((t_{1/2} = 3 \times 10^5\) years\) to \(^{80}\text{Se}\) (stable)
- Surrogate method: 
  \[\sigma(d,p) \rightarrow \sigma(n,\gamma)\]
$^{79}\text{Se}(d,p)^{80}\text{Se}$ reaction at 20 MeV/u

$S_n = 9.9$ MeV

4 mg/cm$^2$ CD$_2$ (GANIL)

Courtesy N. Imai
TiNA-Phase 2 upgrade

Micron Type TTT (DSSD of MUST2)
128 strips on each surface

More than 1,000 channels in total
TTT + GET electronics @RIBF-3F
Data taking by internal trigger
Example of waveform taken with $^{241}$Am

After subtraction: (1) – (2)

- Sampling 25 MHz or 4 ns/time bucket
- Gain 1 pC
- Peaking time 1 μs
Energy spectra

After subtraction

Counts/10 ADC units

ADC units

ch.12

ch.13

ch.14

ch.15

Counts/10 ADC units

ADC units

CoBo0_AsAd0_2017-08-04T14:27:57.615_0000.graw
Energy resolution for $^{241}$Am

After subtraction
CAT-M test with 200 MeV/u $^{136}$Xe beam (HIMAC)

Hamamatsu S10938-9340(X) $9 \times 9 \text{ cm}^2$, 8 strips
Overview of GET electronics

Courtesy N. Kitamura
**Number of delta-ray**

- Delayed Down Scale Beam trigger
- Beam Intensity: 1Mppp
- Full readout mode
- Sampling Rate: 25MHz
- Multiple threshold = 50 (M=1)
- Silicon position: LTD-1
- Event #: 9547

Counts rate
- 0.1 counts / 0.5 us / 1strip @ 1Mppp → Pile-up event will be small enough
- $19 \times 10^6$ counts / s / all Si det. @ 1Mppp → Too much for trigger rate need to cut

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*Courtesy C. Iwamoto*
Beam intensity dependence of delta-ray

Wave form (Sample VS Time backet)

- Delayed Down Scale Beam trigger
- **Full readout mode**
- Sampling Rate: 25MHz
- Multiple threshold = 50 (M=1)
- Silicon position: LTD-1

10kppp

100kppp

500kppp
Summary

- New active target CAT-M and silicon detector array TiNA are being developed for future missing mass studies at RIBF.
- These new devices are equipped with GET electronics.
- Reduced version of TiNA was successfully operated to measure $^{79}$Se($d,p$) reaction at 20 MeV/u at the new OEDO beam line of RIBF.
- GET system was tested with a TTT silicon detector for the full version of TiNA. Internal trigger for $M = 1$ was successful.
- CAT-M and GET system were tested using a 200 MeV/u $^{136}$Xe beam. Delta ray spectra were obtained from waveform data of silicon detectors.
### OEDO

**Center for Nuclear Study, University of Tokyo**

**Riken Nishina Center**

**Niigata University**  **Kyushu University**
K. Chikaato, M. Takechi  Y. Watanabe, K. Nakano, S. Kawase, T. Teranishi, K. Iribe

**KEK**  **Osaka University**  **Tokyo Institute of Technology**

### TiNA

**Center for Nuclear Study, University of Tokyo**
P. Schrock, N. Imai, N. Kitamura, H. Yamaguchi, K. Wimmer

**Riken Nishina Center**  **Osaka University**  **Kyushu University**  **Université Paris-Sud**
D. Suzuki, H. Baba, T. Isobe  H. J. Ong  T. Teranishi, K. Iribe  Y. Beaujeault-Taudière

### H307-8 (CAT-M test at HIMAC)

**Center for Nuclear Study, University of Tokyo**

**Riken Nishina Center**  **Osaka Electro-Comm. University**
T. Isobe, S. Nishimura, D. Suzuki, J. Zenihiro  H. Mizoi

**Kyoto University**  **Toho University**
T. Murakami  T. Harada