Development Status of the Detector System for IF Separator at RAON

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Abstract

In-flight fragment (IF) separator at RAON aims to generate various rare isotopes and separate isotope beams of interest. Detector system for beam particle identification at the separator has been developed based on TOF-Bρ-ΔE method. Parallel plate avalanche counters (PPACs), plastic scintillators, and silicon detectors will be used to measure the position, timing and energy-loss of the isotopes produced by the separator. IF detectors and data acquisition (DAQ) system are currently being installed at the focal planes of IF separator. Details on the development status of IF detectors will be discussed in the presentation.

Detector System of IF Separator

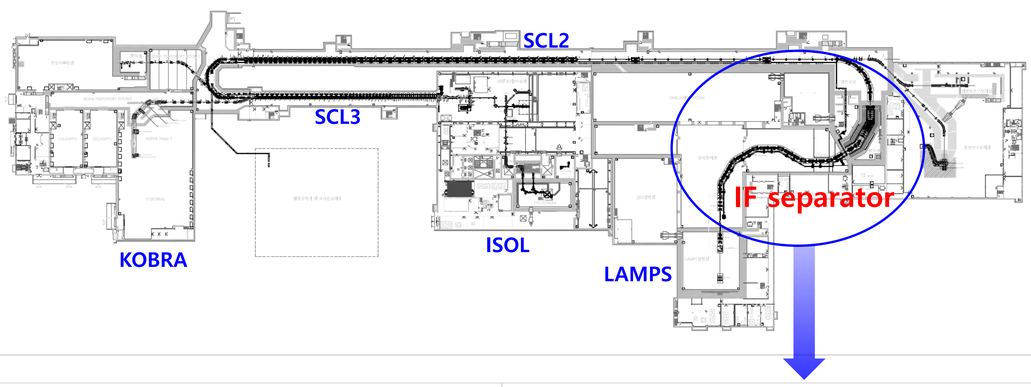
- **In-flight fragment (IF) separator**

Primary beams (from proton to uranium with power up to 400 kW and energies up to 200 MeV/u and higher for lighter beams) from the superconducting linear accelerator are injected into the IF system and impinge on a thin graphite target to produce rare isotopes (RI).

- Pre-separator: production of RI beams and separation of wanted and unwanted beams
- Main separator: tagging and particle identification of RI beams

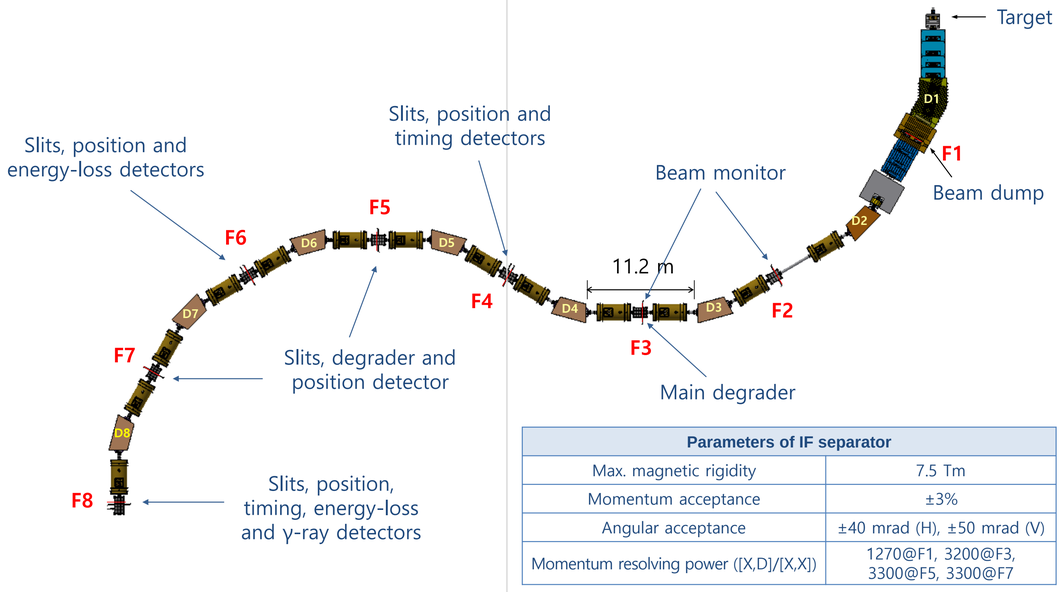
RAON facility

※ **RAON (**ISOL + IF for rare isotope production)
- ISOL : proton beam @ 70 MeV, 1 mA
- IF separator: uranium (proton) beam @ up to 200 MeV/u (600 MeV), 8 pμA



Main separator
- Tagging & Particle identification

Pre-separator
- Production & Separation



Parameters of IF separator	
Max. magnetic rigidity	7.5 Tm
Momentum acceptance	±3%
Angular acceptance	±40 mrad (H), ±50 mrad (V)
Momentum resolving power ([X,D]/[X,X])	1270@F1, 3200@F3, 3300@F5, 3300@F7

Particle Identification at IF Separator

- **Particle identification (PID) of RI beam**

Bρ-TOF-ΔE method

$$B\rho = \frac{A}{Q}\frac{m_u c}{e}\beta\gamma$$

$$TOF = \frac{L}{\beta c}$$

$$\Delta E \sim Z^2/\beta^2$$

Measurement by detectors

PID plot (Z vs A/Q)

▶ **Detector requirements for ±3σ separation(A/Q, Z)**
- Position resolution $\sigma_x \leq 0.5$ mm
- Timing resolution $\sigma_{TOF} \leq 92$ ps ($\sigma_t \leq 65$ ps)
- Energy-loss resolution $\sigma_{\Delta E} \leq 0.66\%$

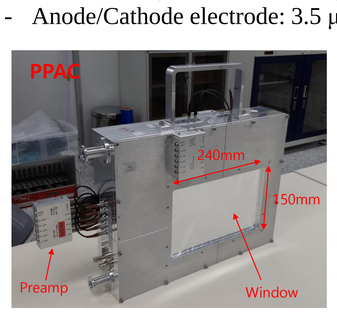
※ Reference particle: ^{136}Sn (Z=50) :
- (x|δ) = 30.65 mm/%
- TOF = 349 ns (F4 ~ F8) at 168 MeV/u
- Length (F4 ~ F8) ~ 55 m

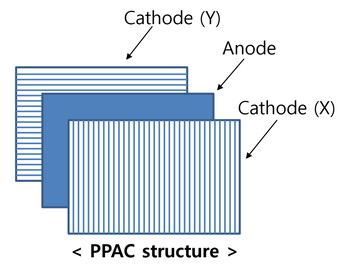
- **PID detectors for measurement**
  - Bρ (position detector): PPAC
  - TOF (timing detector): Plastic scintillator
  - ΔE (energy-loss detector): Si detector, ion chamber (IC)
  - γ-ray (PID confirmation): Ge-detector

IF Detectors

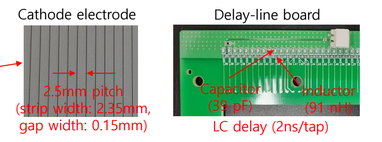
- **PPAC (Parallel Plate Avalanche Counter)**

: Position measurement of RI beams
- Active area: 240 × 150 mm² (10 EA), 120 × 150 mm² (4 EA)
- Window: 12 μm Aluminized Mylar
- Anode/Cathode electrode: 3.5 μm Mylar (Ag evaporation)



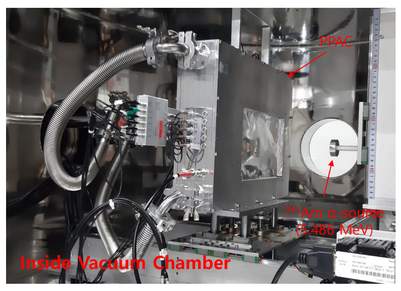


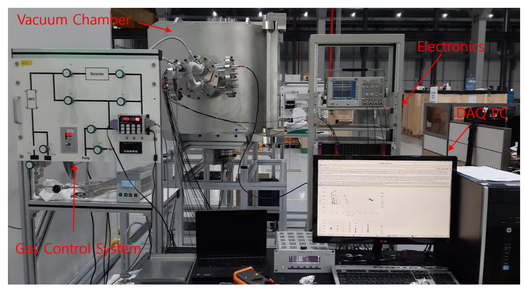
< PPAC structure >



Position $x = k(T_2 - T_1) + x_0$

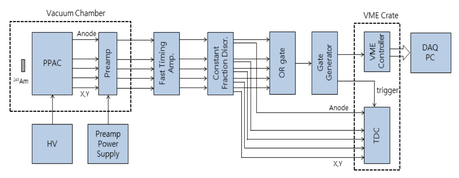
▶ **Performance Test of PPAC**





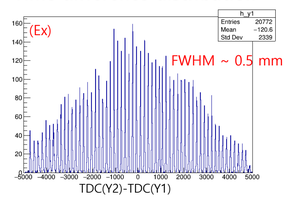
< Test Condition >
- VC: ~ 10^{-5} mbar
- Gas: C_3F_8
- Flow rate: 10 sccm
- Pressure: 16 Torr
- HV = 1170 V

< Test setup >



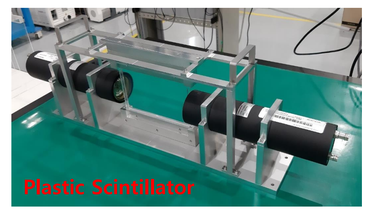
< Electronics diagram for test >

Time difference distribution

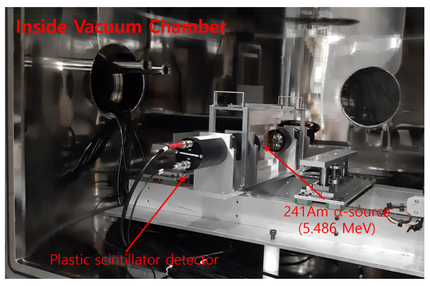


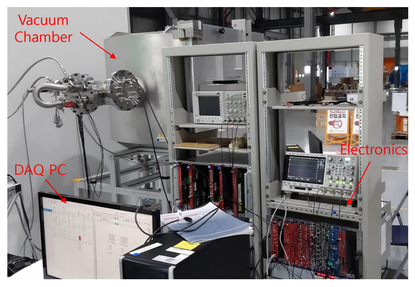
- **Plastic Scintillator**

: Timing measurement of RI beams
- Plastic Scintillator (EJ-230) + PMTs (H1949-51)
- Scintillator Thickness: 200 μm
- Active Area: 150 × 100 mm² (3 EA), 100 × 150 mm² (1 EA)



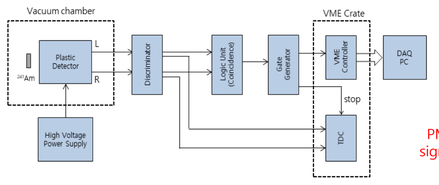
▶ **Performance Test of Plastic Scintillator**



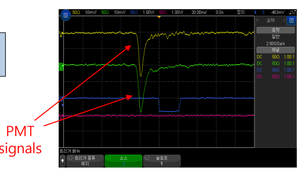


< Test Condition >
- VC pressure : ~ 10^{-5} mbar
- HV = -1500 ~ -2000 V

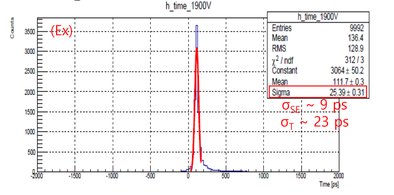
< Test setup >



< Electronics diagram for test >



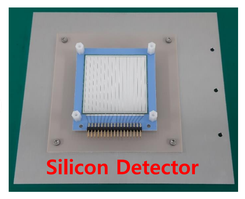
$$T = \frac{t_L + t_R}{2} + const, \quad \Delta t = t_L - t_R \quad \rightarrow \quad \sigma_T \sim \frac{1}{2}\sigma_{\Delta t}$$



- **DAQ system**

- **Silicon detector**

: Energy-loss measurement of RI beams
- 16 channel Silicon Strip Detector (SSD)
  : W1(SS) type (Micron Semiconductor Ltd)
- Thickness: 300 μm
- Active Area: 50 × 50 mm² (2 EA)



Summary

- Particle identification at IF separator will be performed by using PPACs, plastic scintillators and silicon detectors to measure position, timing and energy-loss of RI beams.
- 14 PPACs, 4 plastic scintillators and 2 silicon detectors have been fabricated and will be installed at each focal plane of IF separator by the end of this year.
- Readout electronics and data acquisition system for signal processing of IF detectors are being installed.
- Control systems for IF detectors are being developed.

Acknowledgement

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