

# Preliminary Measurement of $^{10}\text{Be}$ isotope by 1 MV AMS

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# *Ion beam application group of KIGAM*



**1 MV AMS**

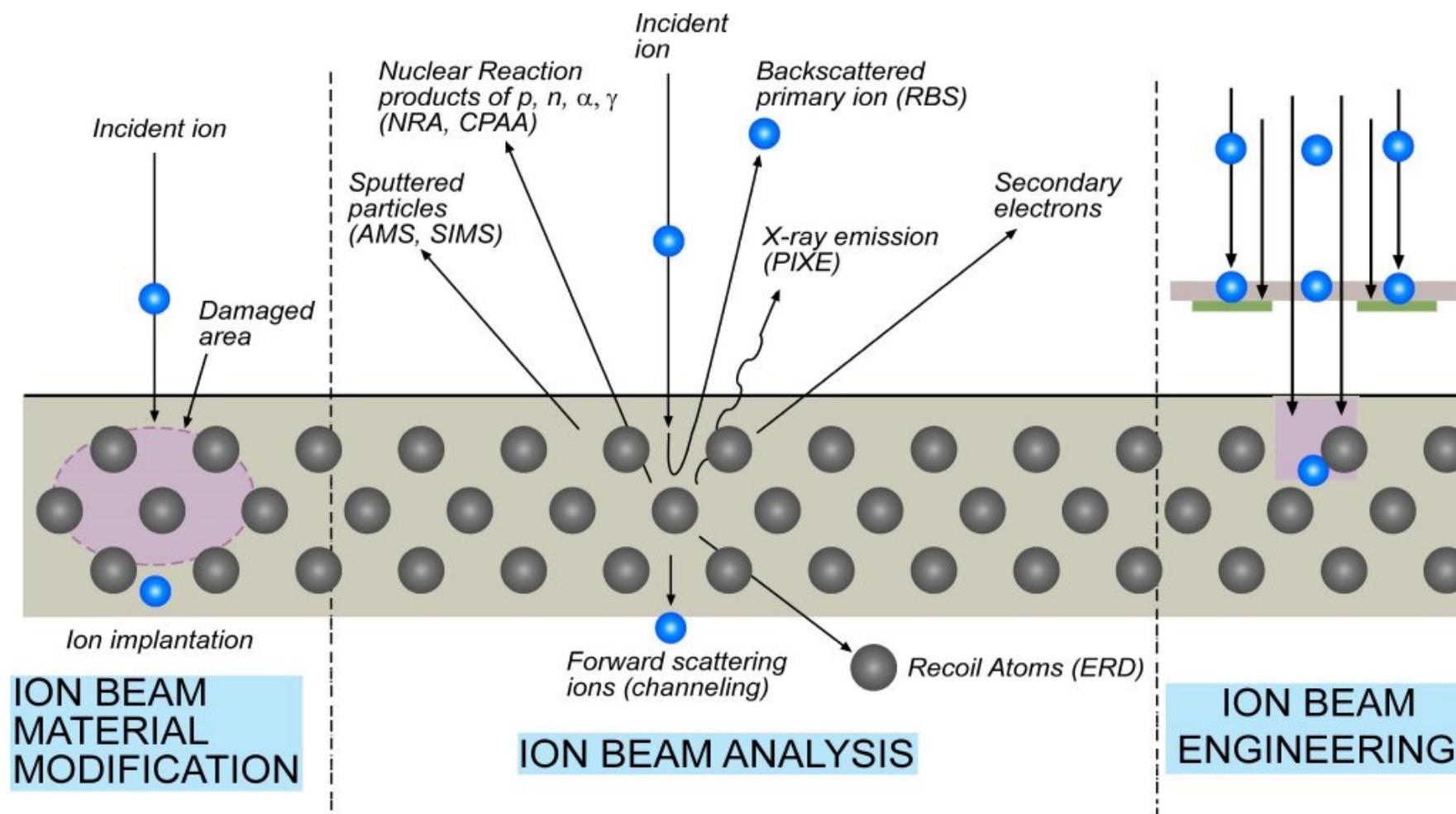


**1.7 MV Pelletron**

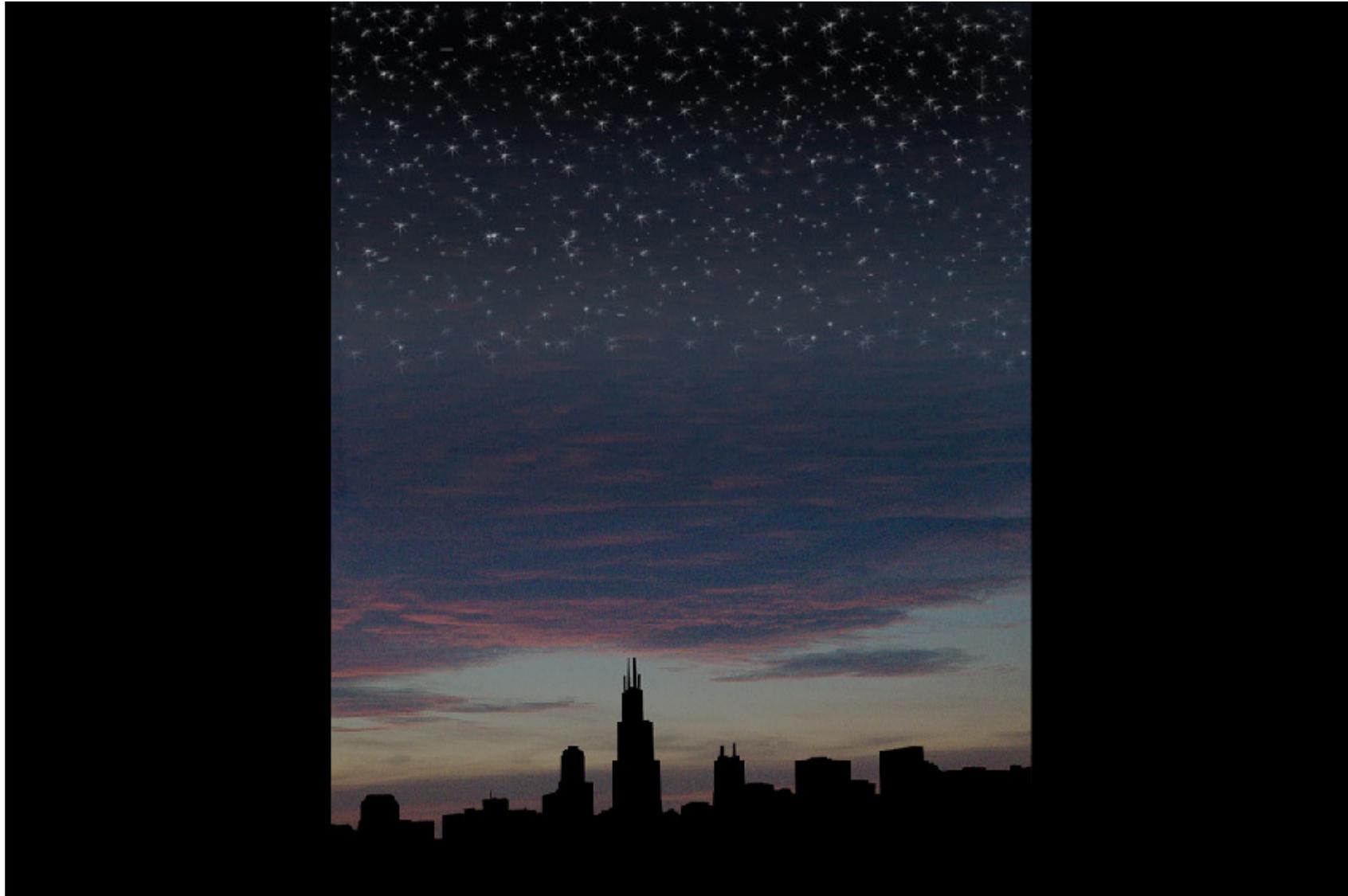
**500 kV single ended Implanter**



# Applications of the group



# Cosmogenic nuclide, $^{10}\text{Be}$

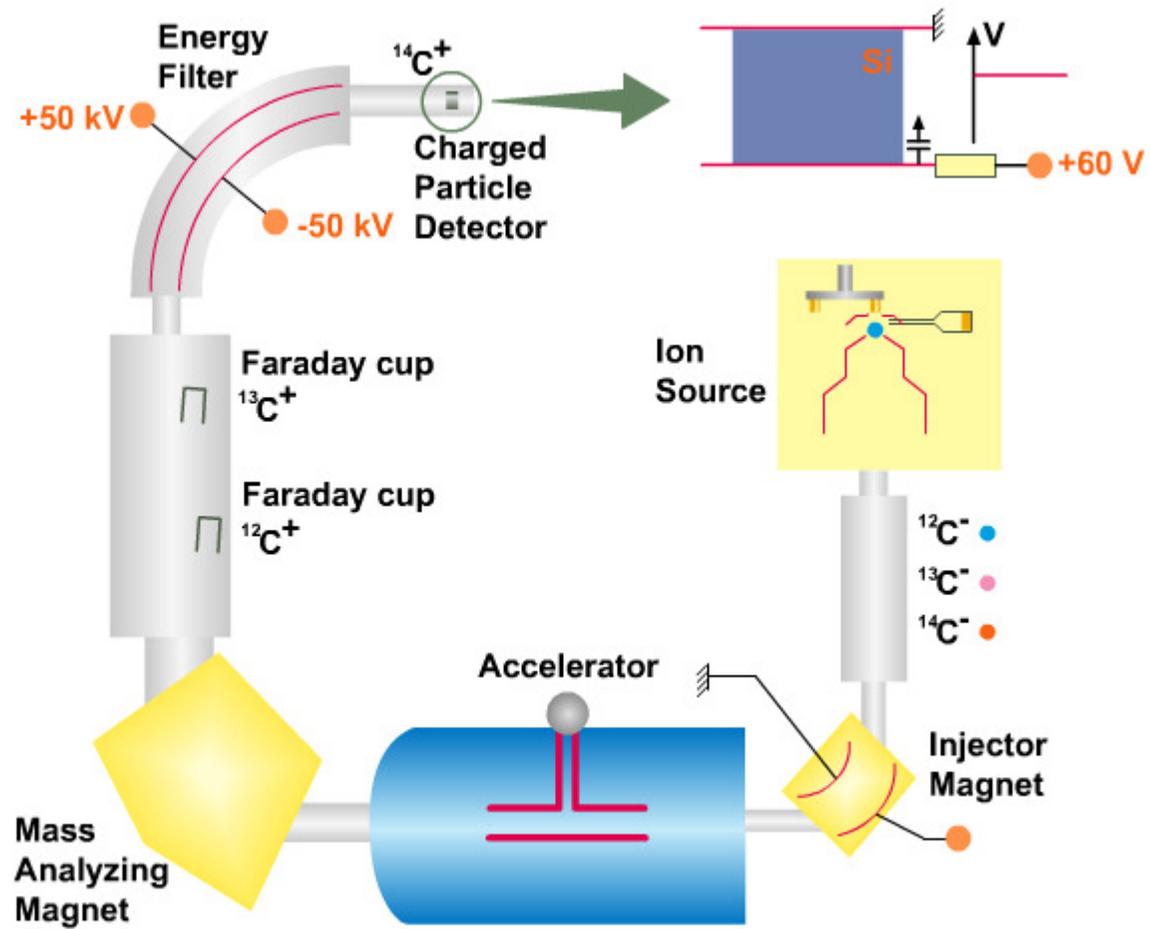


## Cosmogenic nuclide, $^{10}\text{Be}$

- Half-life: 1.5 million year
- Produced by spallation reaction between cosmic rays and  $^{16}\text{O}$  or  $^{14}\text{N}$ 
  - $1.21 \pm 0.70 \times 10^6$  atoms/cm<sup>2</sup>/yr in atmosphere
  - $0.35 \sim 1.89 \times 10^6$  atoms/cm<sup>2</sup>/yr in ice core and sediment
  - The production rate is inversely correlated with geomagnetic dipole moment.
- Abundance of  $^{10}\text{Be}$  in atmosphere
  - $7 \times 10^6$  atoms/m<sup>3</sup> in troposphere
  - $1.3 \times 10^6$  atoms/m<sup>3</sup> in stratosphere
- In-situ production in rocks by neutron spallation with  $^{16}\text{O}$  and by muon induced reaction
- Used to study on geology, mineralogy and geography as a tracer
- Isotope ratio:  $^{10}\text{Be}/^9\text{Be} = 1 \times 10^{-11}$  in marine sediment  
=  $5 \times 10^{-14}$  in rocks (in-situ)

## *Specifications of AMS of KIGAM*

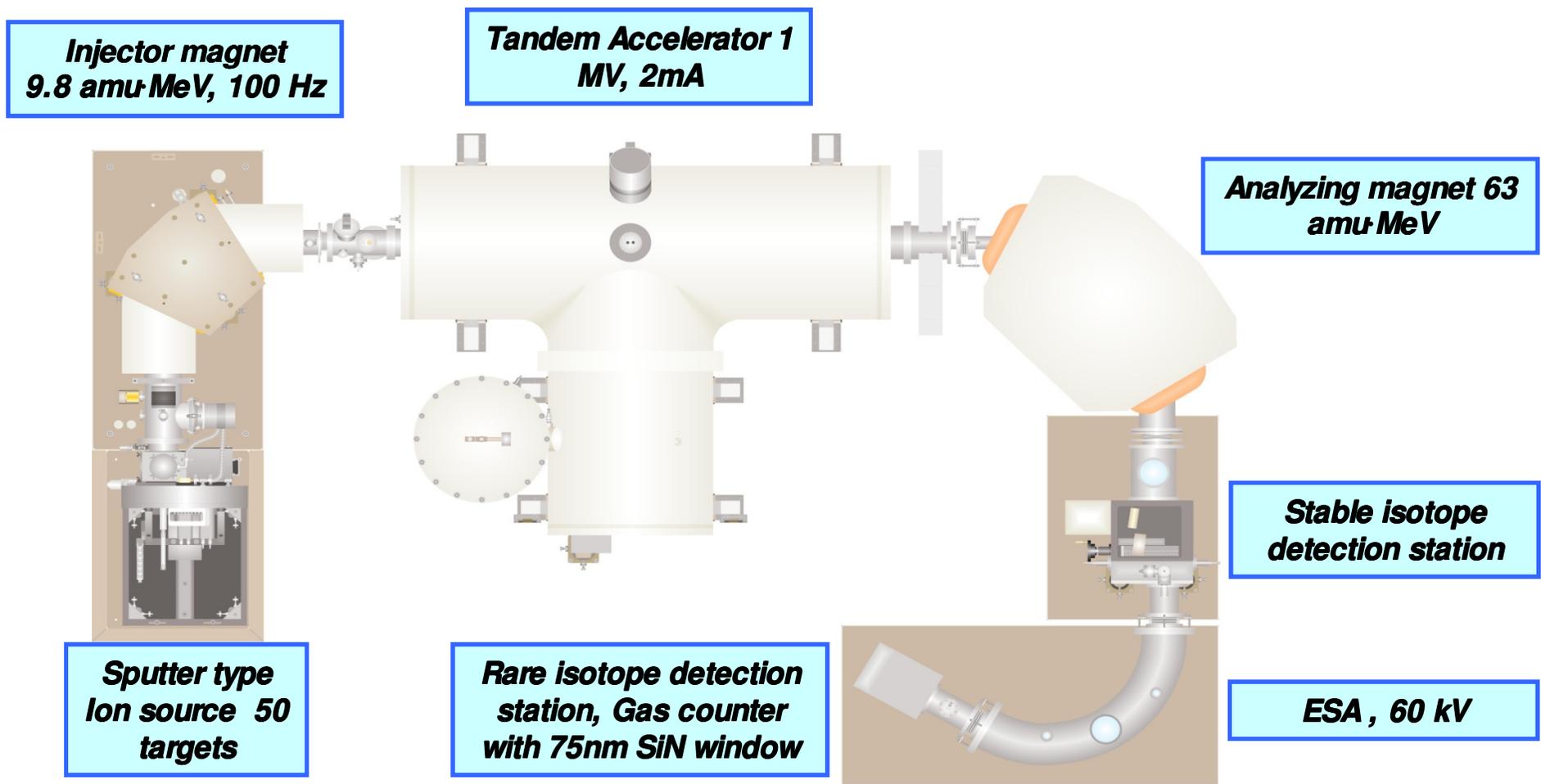
- Dimension : 4.2 m × 6.2 m
- 50 sample multi-cathode sputtering source (35 kV, 5 μA for beryllium)
- Low energy bending magnet: 90 deg., 9.8 MeV · amu
- Bouncing system: 3kV, 100 Hz, <sup>14</sup>C, <sup>10</sup>Be, <sup>26</sup>Al measurements are available
- 1 MV Tandem accelerator (2mA) with Ar stripper
- Analyzing magnet: 90 deg., 63 MeV · amu
- Absorber foil in front of ESA, 150 nm Si<sub>3</sub>N<sub>4</sub> foil
- Electric spherical energy analyzer (ESA): 120 deg., 60 kV
- Ionization chamber with two anodes, 75 nm Si<sub>3</sub>N<sub>4</sub> window
- Counting time: 40 minutes per a Be sample in typical case
- Background: <sup>10</sup>Be/<sup>9</sup>Be = 2 × 10<sup>-14</sup> in typical case





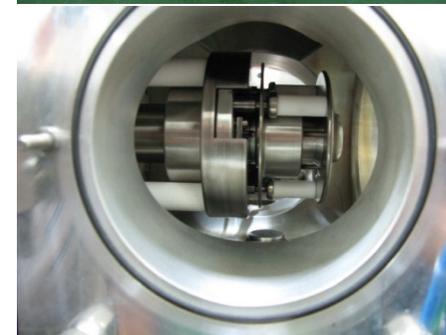
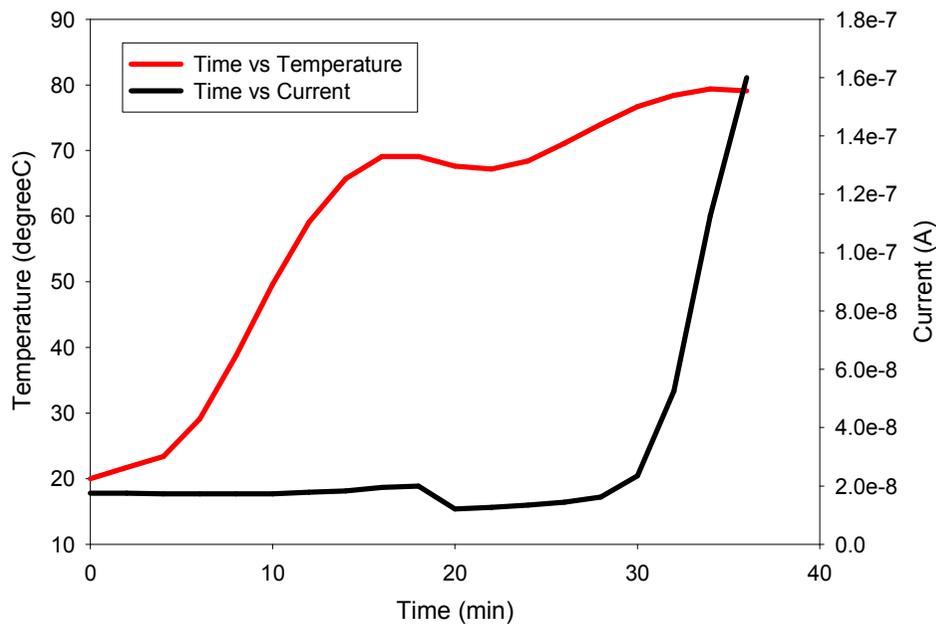
***1 MV AMS system of HVEE (4110Bo- AMS- 3)***

# Accelerator Mass Spectrometer at KIGAM

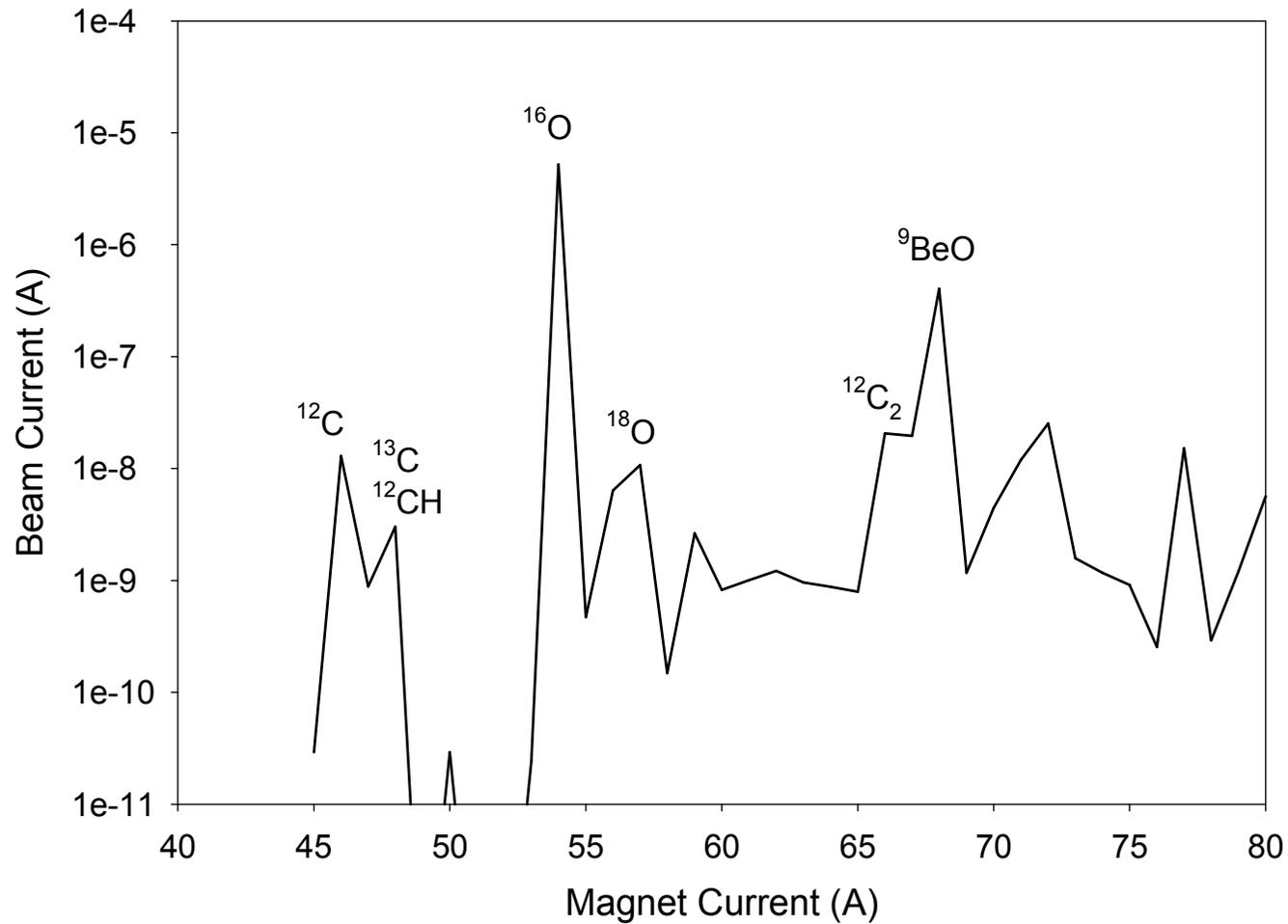


# SO110 Negative Ion source

- At Cs temperature = 95 °C
  - Max. Beam current = ~ 100  $\mu$ A for C<sup>-</sup>
  - ~ 300 nA for Al<sup>-</sup>
  - ~ 5  $\mu$ A for BeO<sup>-</sup>



# LE magnet scanning (BeO target)



## Accelerator condition

- Terminal voltage

$^{14}\text{C}$  measurement: 950 kV

$^{26}\text{Al}$  measurement: 700 kV

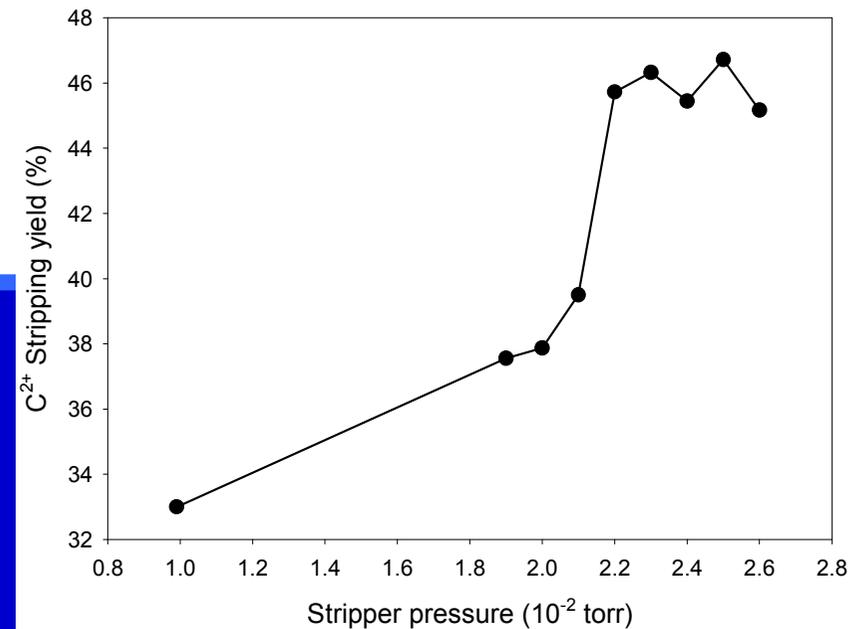
$^{10}\text{Be}$  measurement: 1000 kV (1.40 MeV)

- Ar stripper condition (transmission yield)

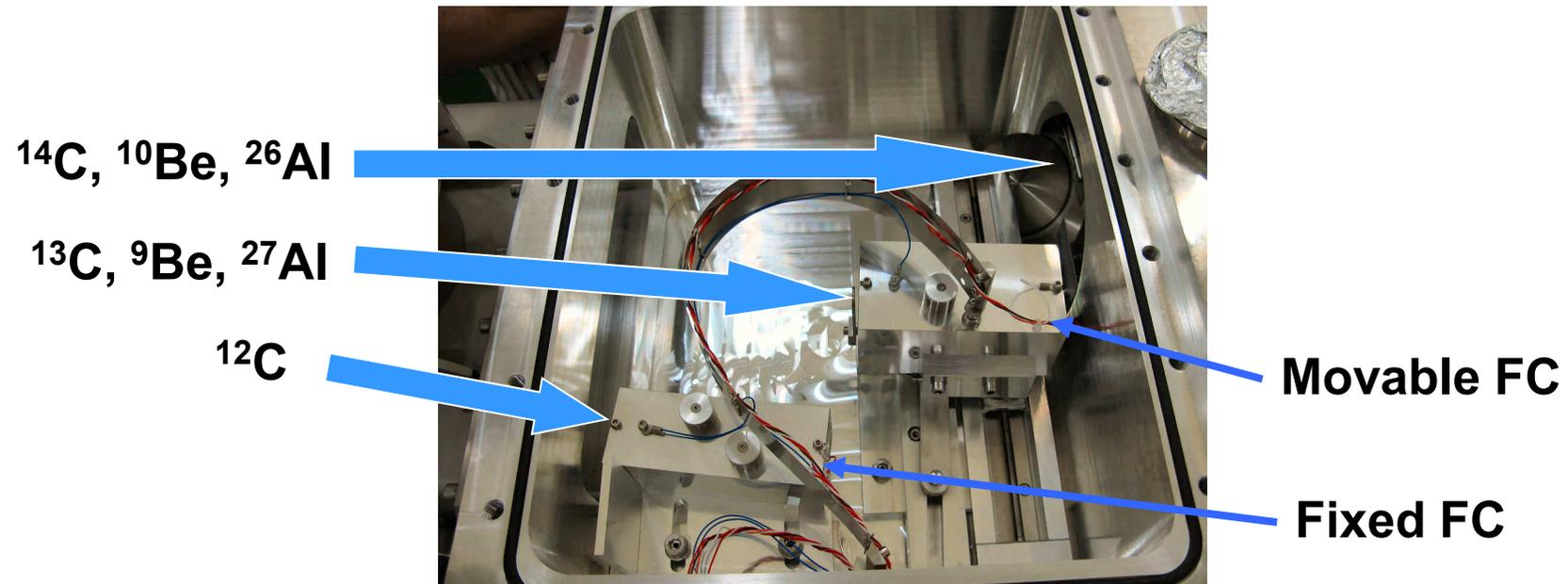
$^{14}\text{C}$  measurement:  $2.1 \times 10^{-2}$  torr ( $\sim ^{12}\text{C}^{2+} / ^{12}\text{C}^{1-} = 47\%$ )

$^{26}\text{Al}$  measurement :  $1.7 \times 10^{-2}$  torr ( $\sim ^{27}\text{Al}^{1+} / ^{27}\text{Al}^{1-} = 30\%$ )

$^{10}\text{Be}$  measurement :  $1.2 \times 10^{-2}$  torr ( $\sim ^9\text{Be}^{1+} / ^9\text{BeO}^{1-} = 47\%$ )



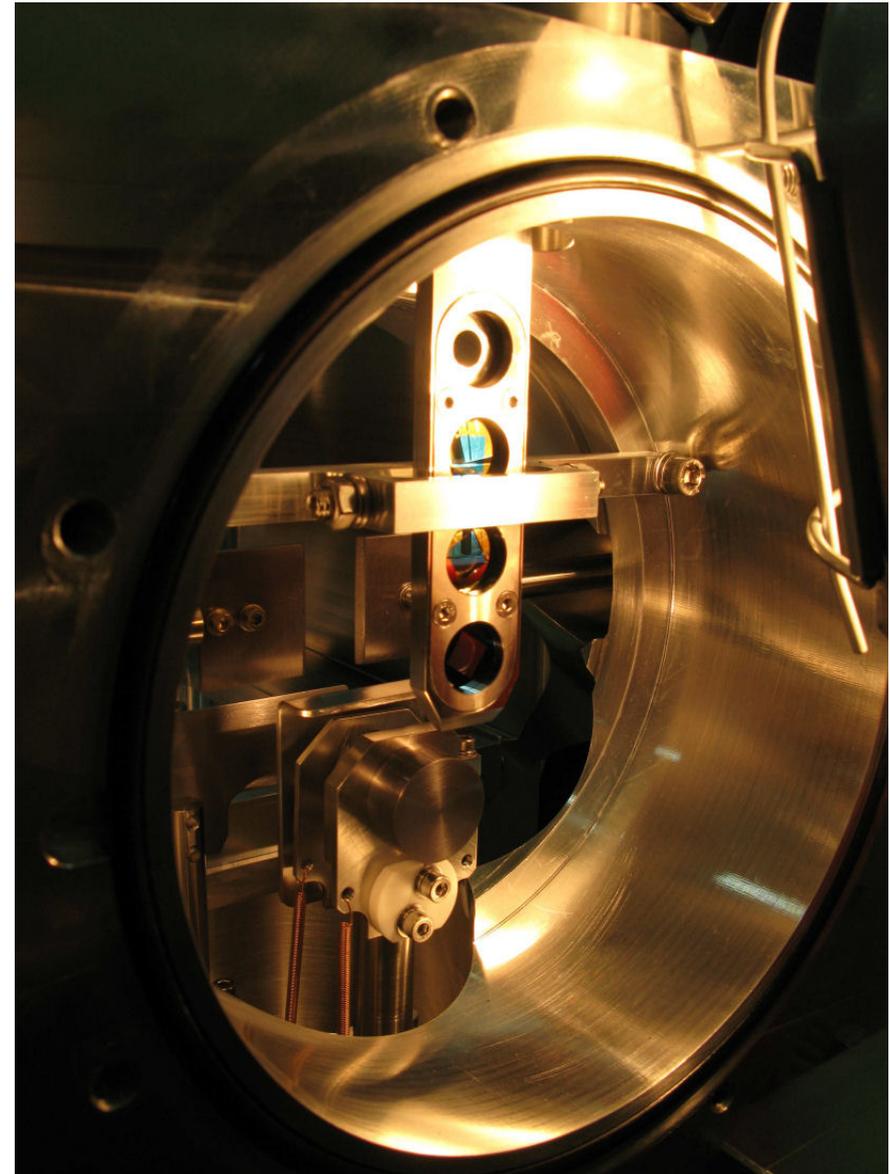
# Stable Isotope Measurement



- Movable FC position
- Beam center: 76 mm
- $^{13}\text{C}$  measurement: 150 mm
- $^{27}\text{Al}$  measurement: 15 mm
- $^9\text{Be}$  measurement: 209 mm

## Absorber foil

- Masses of  $^{10}\text{Be}$  and its isobar,  $^{10}\text{B}$   
 $^{10}\text{B}$ : 10.0129 (1398.472 keV)  
 $^{10}\text{Be}$ : 10.0135 (1398.486 keV)  
 $\Delta M$ : 0.0006 (60 ppm)  
 $\Delta E$  before the foil: **0.014 keV (10 ppm)**
- $\text{Si}_3\text{N}_4$  absorber  
Thickness = 150 nm  
 $dE$  at the foil of  $^{10}\text{Be}$  = 170.72 keV  
 $dE$  at the foil of  $^{10}\text{B}$  = 221.04 keV  
Trans. Energy of  $^{10}\text{Be}$  = 1227.8 keV  
Trans. Energy of  $^{10}\text{B}$  = 1177.43 keV  
 $\Delta E$  after the foil: **50.34 keV (4.1 %)**
- Beam disperses at the foil

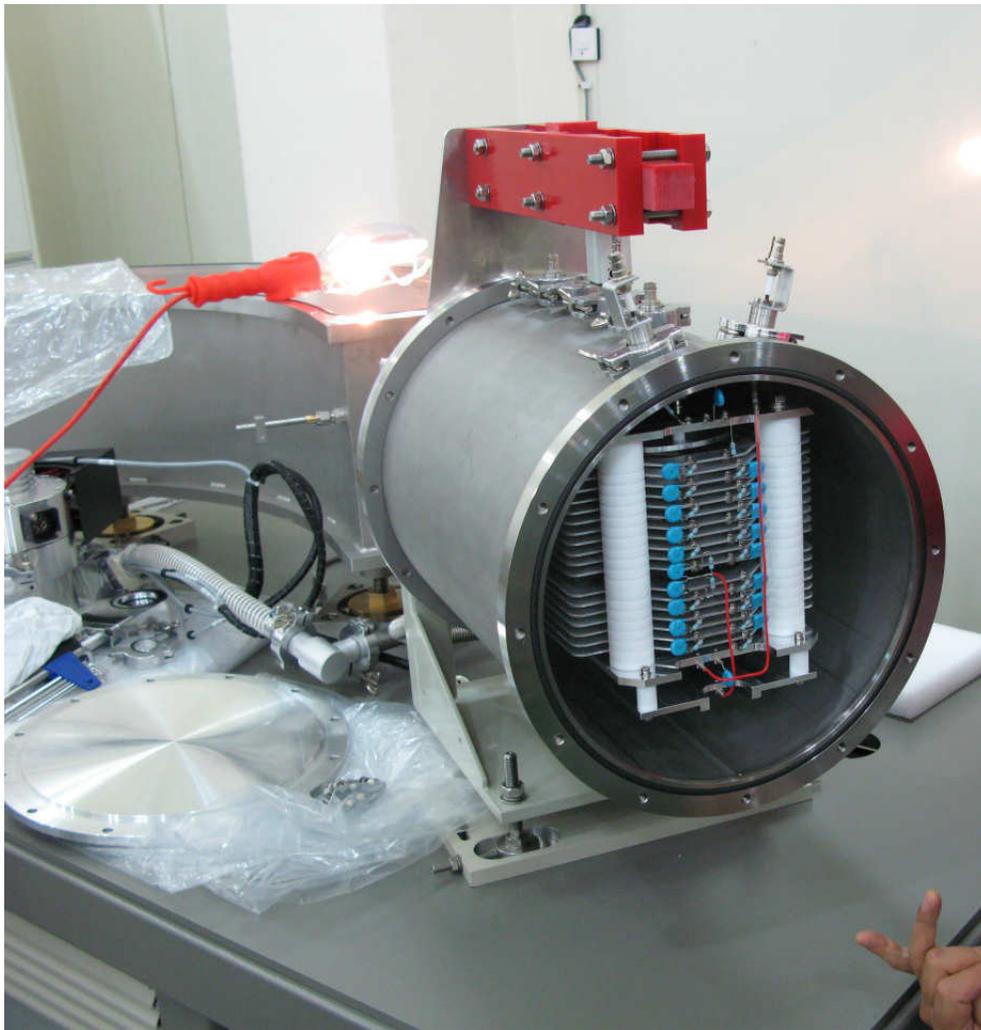


## *Electrostatic spherical Analyzer*



- Angle: 120 °
- Radius: 650 mm
- Gap between electrodes: 25 mm
- Maximum bias: 60 kV
- $^{14}\text{C}$  measurement: 55 kV
- $^{10}\text{Be}$  measurement: 49 kV
- $^{26}\text{Al}$  measurement: 55 kV

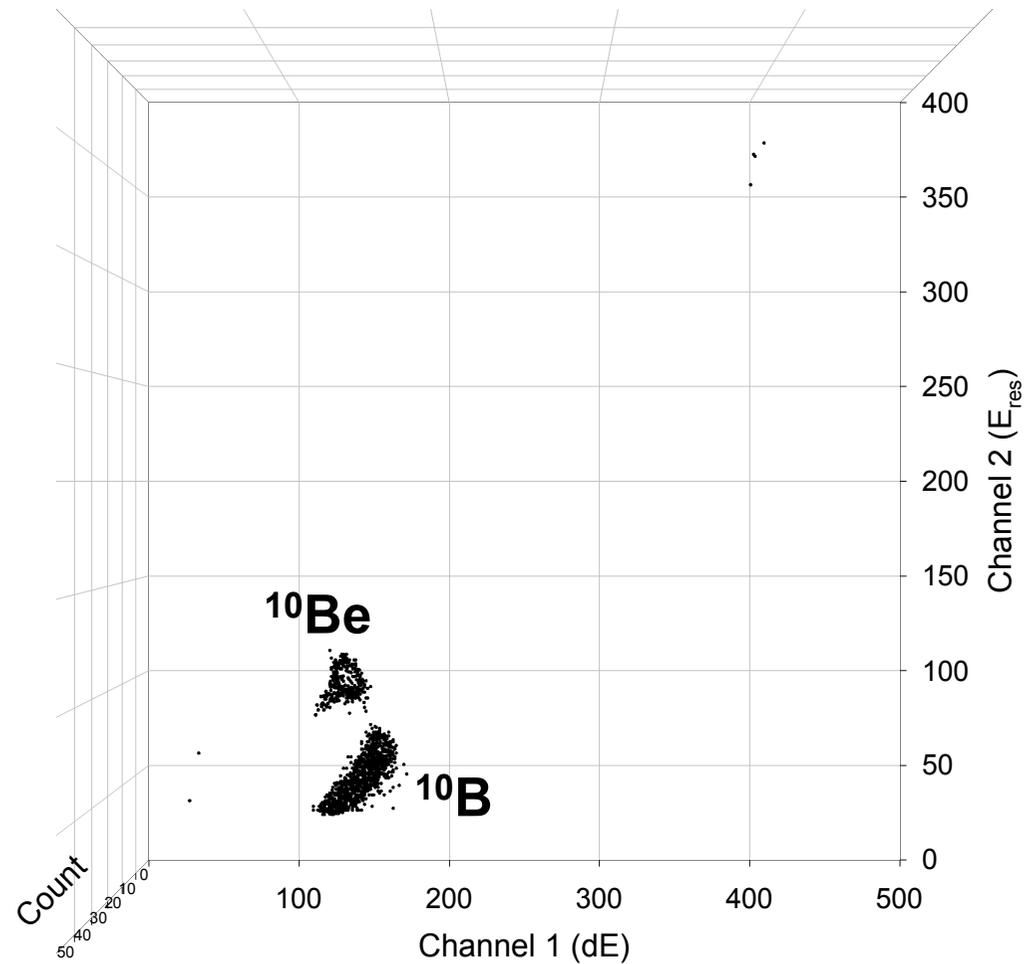
# Gas Ionization Chamber



- Bias: 300 V
- Gas: Isobutane
- Window:  $\text{Si}_3\text{N}_4$ , 75 nm
- Window size: 10 mm $\Phi$
- Length: ~430 mm
- Acquisition system: MPA, FASTCOM

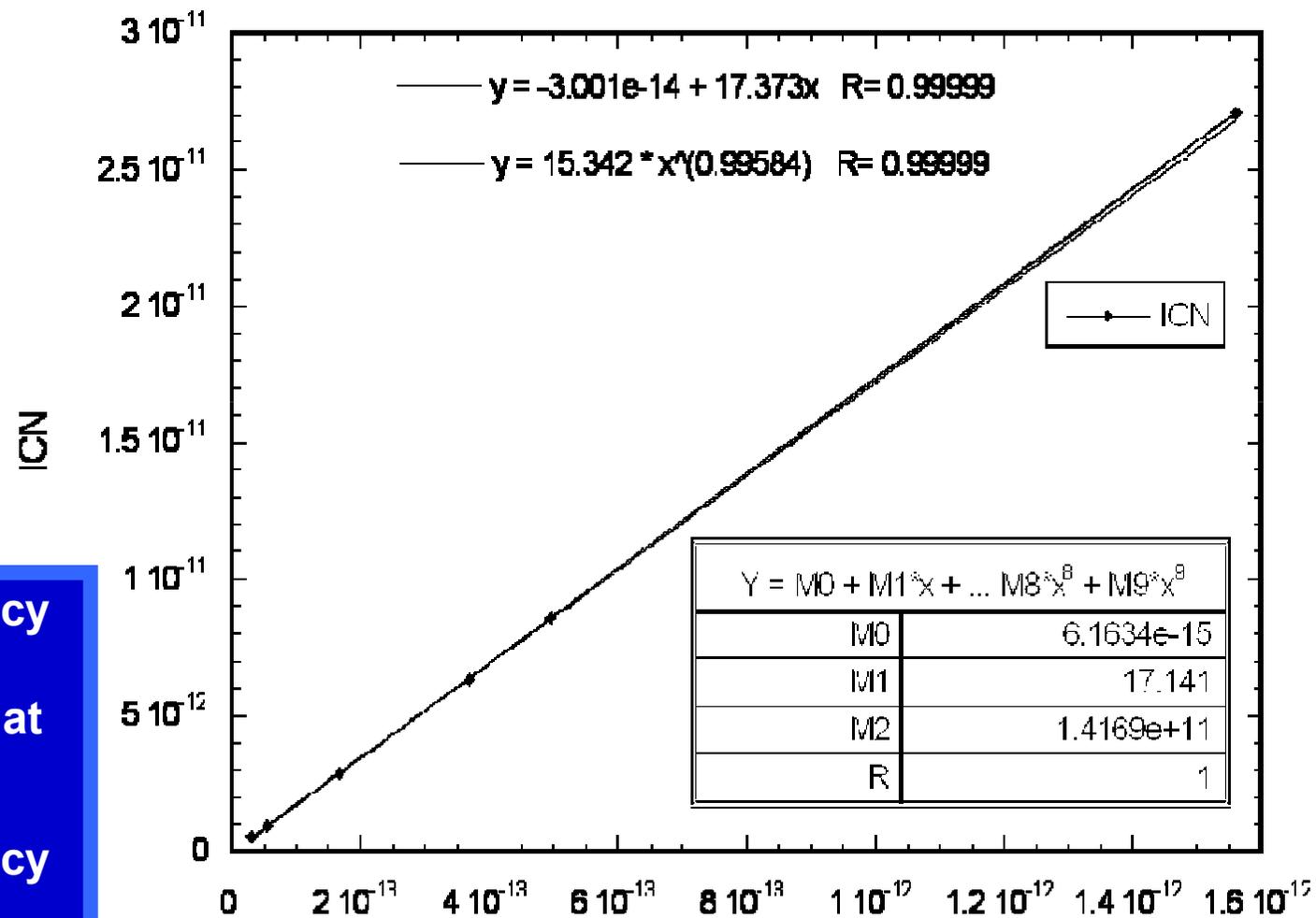
- Gas pressure
  - $^{14}\text{C}$  measurement: 8.4 mbar
  - $^{26}\text{Al}$  measurement: 7.7 mbar
  - $^{10}\text{Be}$  measurement: 7.2 mbar

# A typical $^{10}\text{Be}$ spectrum



**Detector gas pressure: 7.2 mbar**

# Correction curve of $^{10}\text{Be}/^9\text{Be}$ ratio



- Counting efficiency decreases due to beam dispersion at the absorber foil
- Counting efficiency ~6 %

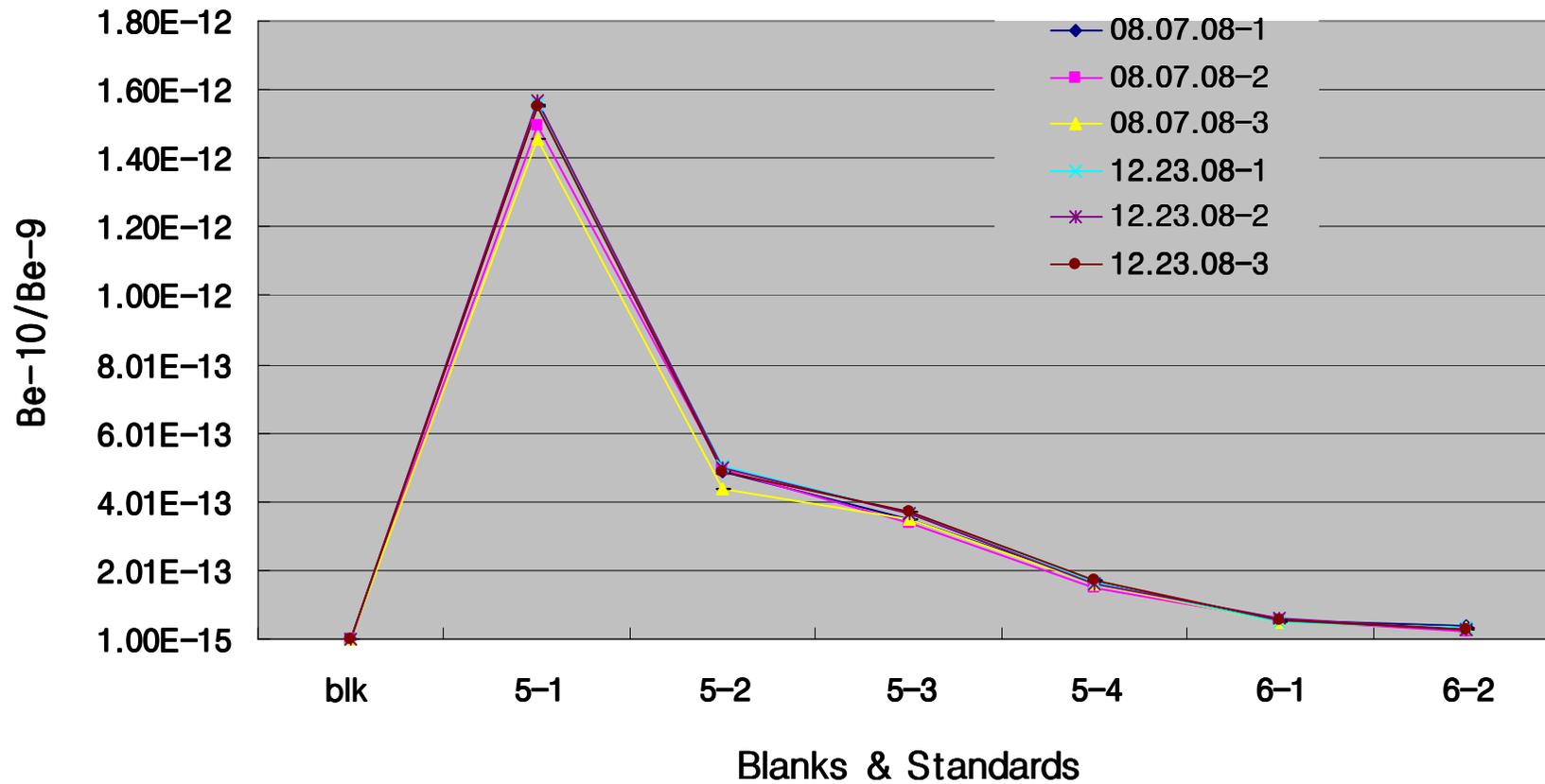
KIGAM 12.23.08

## Results of standard and blank samples

Sample ID	Certified $^{10}\text{Be}/^9\text{Be}$	Raw $^{10}\text{Be}/^9\text{Be}$	Corrected $^{10}\text{Be}/^9\text{Be}$	Error	Error (%)
blank	-	$5.90 \times 10^{-16}$	$1.63 \times 10^{-14}$	$7.59 \times 10^{-15}$	46.63
5-1	$2.71 \times 10^{-11}$	$1.56 \times 10^{-12}$	$2.71 \times 10^{-11}$	$1.44 \times 10^{-13}$	0.53
5-2	$8.56 \times 10^{-12}$	$4.95 \times 10^{-13}$	$8.53 \times 10^{-12}$	$7.95 \times 10^{-14}$	0.93
5-3	$6.32 \times 10^{-12}$	$3.69 \times 10^{-13}$	$6.35 \times 10^{-12}$	$6.22 \times 10^{-14}$	0.98
5-4	$2.85 \times 10^{-12}$	$1.67 \times 10^{-13}$	$2.87 \times 10^{-12}$	$5.14 \times 10^{-14}$	1.79
6-1	$9.72 \times 10^{-13}$	$5.55 \times 10^{-14}$	$9.57 \times 10^{-13}$	$3.08 \times 10^{-14}$	3.22
6-2	$5.35 \times 10^{-13}$	$3.04 \times 10^{-14}$	$5.27 \times 10^{-13}$	$1.88 \times 10^{-14}$	3.56

# Reproducibility of $^{10}\text{Be}$ measurement

Be-10 AMS Measurements



## Unknown sample measurement of $^{10}\text{Be}$

Sample name	Raw $^{10}\text{Be}/^9\text{Be}$ (blank value subtracted)	$\pm \sigma$	$^{10}\text{Be}/^9\text{Be}$ (counting efficiency corrected)	$\pm \sigma$
NR-1	3.773E-15	9.499E-16	1.386E-13	2.867E-14
NR-2	3.600E-15	8.087E-16	1.334E-13	2.441E-14
NR-3	4.364E-15	1.766E-15	1.564E-13	5.332E-14
NR-4	4.577E-15	1.518E-15	1.629E-13	4.581E-14
NR-5	9.238E-16	5.078E-16	5.261E-14	1.533E-14
NR-6	1.616E-15	6.463E-16	7.350E-14	1.951E-14
NR-7	6.868E-16	1.103E-15	4.546E-14	3.331E-14
NR-8	1.589E-14	8.391E-15	5.044E-13	2.533E-13
DLR-2	1.802E-14	9.491E-16	5.686E-13	2.865E-14
DLR-3	1.972E-14	1.018E-15	6.200E-13	3.073E-14
DLR-4	2.142E-14	8.939E-16	6.714E-13	2.698E-14
DLR-5	3.004E-14	1.501E-15	9.314E-13	4.530E-14

## Summary

- A **compact AMS** system with **1 MV TV** installed at KIGAM in 2007 (the second AMS machine in Korea) has dedicated to not only  $^{14}\text{C}$  measurement but also  **$^{10}\text{Be}$  measurement**
- Be measurement with a AMS with small TV is a challenge
- Key point of successful  $^{10}\text{Be}$  measurement is effective **suppression** of isobar,  $^{10}\text{B}$ .
- An **absorber foil** ( $\text{Si}_3\text{N}_4$ ) with thickness of 150 nm was adopted to enhance the energy difference between Be and B isotopes.
- **Large counting efficiency change** due to using of a foil should be estimated and corrected
- With this effort, **almost all kind of samples** except for in-situ rock samples could be measured successfully.

