Development of TOF detector for Rare-RI ring

Low energy Gr.
201720248 Daiki Kamioka

contents

• Required performances for TOF detector
• Detector design
• Performance test with the heavy ion beam
Rare-RI Ring

- Development for mass measurement of short-lived RI is in progress...

\[
\frac{m_1}{q_1} = \frac{m_0}{q_0} \frac{T_1}{T_0} \sqrt{\frac{1 - \beta_1^2}{1 - \left(\frac{T_1}{T_0} \beta_1\right)^2}}
\]

\(T_0, m_0, q_0\): revolution time, mass, charge of reference nucleus

\(T_1, m_1, q_1\): revolution time, mass, charge of target nucleus
Required performance for TOF detector

1. **Timing resolution** $\sigma < 100$ ps
   $\Delta(m/q)/(m/q) \sim 10^{-6} \Rightarrow \Delta\beta/\beta \sim 10^{-4}$

2. **Detection efficiency** $\varepsilon \sim 100\ %$
   Production rate of neutron rich nuclei is few counts per day

3. **Detector should be as thin as possible**
   The change of ion’s velocity should be less then $10^{-4}$

4. **Large acceptance**
   Excepted beam size is $\sim \varphi 30$ mm at focal plane
Operating principle of TOF detector

- use secondary electrons emitted from a thin foil where ions pass through
## Detector design

<table>
<thead>
<tr>
<th><strong>Magnetic field</strong></th>
<th>$\sim 150$ Gauss</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electric field</strong></td>
<td>$\sim 580$ V/mm</td>
</tr>
<tr>
<td><strong>Foil</strong></td>
<td>aluminum coated ($\sim 100$ nm) on mylar (1 $\mu$m)</td>
</tr>
<tr>
<td><strong>Effective area</strong></td>
<td>$\sim \phi 40$ mm</td>
</tr>
</tbody>
</table>

### Diagram

- **Magnetic field**
- **Electric field**
- **Foil**: aluminum coated ($\sim 100$ nm) on mylar (1 $\mu$m)
- **Effective area**: $\sim \phi 40$ mm
Experimental setup

$^{84}\text{Kr}^{36+}$ of 200 MeV/nucleon
@ HIMAC (Heavy Ion Medical Accelerator in Chiba) in NIRS
Result

Forward

\[\varepsilon_F = 98(7)\%\]
\[\sigma_F = 86(3)\text{ ps}\]

Backward

\[\varepsilon_B = 96(7)\%\]
\[\sigma_B = 53(2)\text{ ps}\]
Position dependence of detection efficiency

- Almost 100% in the whole region of the foil
Position dependence of timing resolution

- Large beam position dependence is not seen in timing resolution.
Summary

• We are developing the TOF detector which measures both **velocity** and **revolution time** in R3. The detector uses **secondary electrons** emitted from a thin foil where ions pass through.

• We use **aluminum (~100 nm) coated on mylar (1 µm)** for a thin foil.

• The timing resolution achieved **less than 100 ps**, the maximum detection efficiency recorded **98 %** and both forward and backward electrons were detected with high efficiency in **the whole region of the foil**.

• Large beam position dependence is not seen in detection efficiency and timing resolution.