Neutrinoless Double Beta Decay Experiment with DCBA

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Contents

• Outline of DCBA experiment
• R&D using a test apparatus DCBA-T
• New data acquisition system for DCBA-I
DCBA Experiment

Drift Chamber Beta-ray Analyzer
Drift Chamber + Solenoid Magnet + Veto-counters

1. DCBA-T
   Test apparatus for technical development

2. DCBA-I (4 × DCBA-T)
   Standard module (SM) with natural Nd source

3. DCBA-II(1)
   100 SM with natural Nd of 7.7 mol $^{150}$Nd

4. DCBA-II(2)
   100 SM with 124 mol $^{150}$Nd of enriched source
   Sensitivity of effective neutrino mass $\sim 0.05$ eV
DCBA-T

Drift Chamber Beta-ray Analyzer – Test apparatus
<table>
<thead>
<tr>
<th>Component</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drift chamber Source</td>
<td>Nd$_2$O$_3$ (40 mg/cm$^2$) ($^{150}$Nd =0.015mol)</td>
</tr>
<tr>
<td>Sensitive vol.</td>
<td>21(X) x 24(Y) x 60(Z) cm$^3$</td>
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<tr>
<td>Signal readout</td>
<td>Flash ADC</td>
</tr>
<tr>
<td>X-position</td>
<td>Drift velocity x Drift time ($\sigma_X \sim 0.5\text{mm}$)</td>
</tr>
<tr>
<td>Y-position</td>
<td>Wire position ($\sigma_Y \sim 0.05\text{mm}$)</td>
</tr>
<tr>
<td>Z-position</td>
<td>Charge division ($\sigma_Z \sim 6\text{mm}$)</td>
</tr>
<tr>
<td>Magnet</td>
<td>Solenoid coil + Flux return yoke</td>
</tr>
<tr>
<td>Magnetic field</td>
<td>0.8 kG (Max.)</td>
</tr>
<tr>
<td>Uniform Vol.</td>
<td>40 dia. x 70 cm$^3$ ($\delta B/B_0 &lt; 1%$)</td>
</tr>
<tr>
<td>Veto-counters</td>
<td>Scintillation counters</td>
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</tbody>
</table>

**Specifications (designed)**
\[ p \cos \lambda = 0.3rB, \]

\[ T = \left( p^2 + m_e^2 \right)^{1/2} - m_e \]

- \( p \) (MeV/c): momentum, \( r \) (cm): radius, \( \lambda \): pitch angle
- \( B \) (kG): mag. field, \( m_e \) (MeV/c^2): electron mass

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Illustration of Track Detection
DCBA-T MAGNET

\[ \delta B/B_0 = -0.1\% \]

\[ B_0 = 0.8 \text{ kG (Max)} \]

A-A cross section

\( R=25 \text{ cm} \)

\( \frac{1}{4} \text{ CROSSSECTION} \)

CHamber

Solenoid CoiI

RETURN YOKE

COIL

ENDCAP

CENTER

\( 50 \text{ cm} \)

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Data Acquisition System for DCBA-T
Position resolution study using cosmic ray
X-position resolution
(Preliminary)

After simple correction

\[ \square \approx 0.7 \text{ mm} \]
Z-position resolution
(Preliminary)

\[ \sigma \approx 13 \text{ mm} \]
Example of an Electron Track (2)

Conversion Electron from $^{207}$Bi

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\[ \sigma_z \] and Analysis method should be improved.

\[ \sigma \sim 220 \text{ keV} \]

Temporary
E-resolution vs. Z-resolution

\[ \sigma_E/E (\%) \]

\[ \sigma_X = 0.8 \text{ mm} \]

\[ \sigma_Y = 0.05 \text{ mm} \]

already obtained
CompactPCI (cPCI) FADC
Online discrimination of $^{214}\text{Bi}$ events

cPCI-FADC
Data Acquisition System for DCBA-I

Readout channels: 640
Comparison of Detectors

Mass Sensitivity

\[ \mathbb{m} = \sqrt{\frac{C \cdot (BG)^{1/2}}{(\ln 2) \cdot k \cdot N_0}} \cdot t^{-1/4} \]

- \( C \): calculated \( T_{1/2}^{0\nu} \) [\( \mathbb{m} \) \( \Box \)]
- \( (yr \cdot (eV)^2) \) \( \{= (G^{0\nu}|M^{0\nu}|^2)^{-1}\) \( \}
- \( BG \): BGNDD event rate (1/yr)
- \( t \): measuring time (yr)
- \( k \): detection efficiency
- \( N_0 \): number of nuclei

Summary

1. DCBA is a magnetic tracking detector for measuring the momentum of each electron in DBD.
2. DCBA-T is a test apparatus for R&D, especially for improving energy resolution.
3. Sensitivity of DCBA for effective neutrino mass is expected to be 0.05 eV in the final stage, DCBA-II(2), using the decay source of $^{150}$Nd enriched to 90%.