1. Observation of double beta decay by $^{48}$Ca[1]

**Double beta decay**
- Two neutrino double-beta decay ($2
\nu\beta\beta$) is allowed within the standard model of particle physics and has been observed in several isotopes.

$$\begin{align*}
(A,Z) & \rightarrow (A,Z+2) + 2e^- + 2\nu_e \\
(A,Z) & \rightarrow (A,Z+2) + 2e^- + 2\nu_x 
\end{align*}$$

- Neutrino-less double-beta decay ($0\nu\beta\beta$), which can occur only if neutrinos are Majorana particles.

**CANDLES-Group**
We search for neutrino-less double beta decay ($0\nu\beta\beta$) of $^{48}$Ca.
- Why $^{48}$Ca : $Q_{\beta\beta} = 2.47$ MeV is higher than background(BG) $E_{BG}=2.6$ MeV.
- Low background and energy resolution is important to distinguish between $0\nu\beta\beta$ and background events.

**At Kamioka underground lab**
- Shielding system for background reduction
- Small natural abundance 0.19% (Condensation in R&D)

2. Measurement

**Ge semiconductor detector**
- A detector with good energy resolution when used for gamma-ray (X-ray) spectral measurements.
- The resolution : 0.33%(4.4 keV, FWHM of $^{60}$Co 1333 keV)

**Shielding system**
- Pb blocks (10 cm in thickness) around the Ge detector
  - reduction of γ-ray BG from (n,γ) reaction
  - 99.9% reduction
- Install Cu plates (1 cm in thickness) inside the Pb block
  - to reduce characteristic X-ray of Pb

3. Circuit configuration

4. Analysis

**ex: $^{208}$Tl (583 keV) peak**
- Suppose that the integration range is determined to be 574 – 592 keV.
- Accumulate the counts in the range corresponding to 574 – 592 keV.

**Sample measurement**
- High-purity crucible disc
  - Single-sided polishing
  - No polishing
- $^{261}$Th
- $^{235}$U

5. Result [2][3]

6. Summary and future outlook on research

- Resulting sample measurements were less than the detection limit.
- $CaF_2$ powder will be used as a shielding material for Ge detectors.
- Improve the sensitivity of the Ge detector 10~100 mBq/kg in the surface laboratory.

7. References

[2] 公益社団法人 日本アイソトープ協会 アイソトープ情報 11巻 8号 上半月版
[3] マルセル・ポル著 弥永 昌吉，矢野健太郎共訳 改訂増補 万能数値表