# **DCBA** experiment for searching for Neutrinoless Double Beta Decay

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- Results of DCBA-T2
- Status of DCBA-T3
- Prospects of MTD (Magnetic Tracking Detector)
- Summary

**TAUP2007** Sendai,September 11- 15, 2007

# **DCBA**: **D**rift **C**hamber **B**eta-ray **A**nalyzer

**DCBA** collaboration
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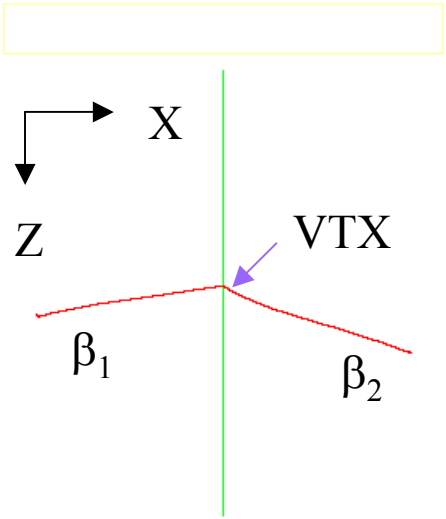
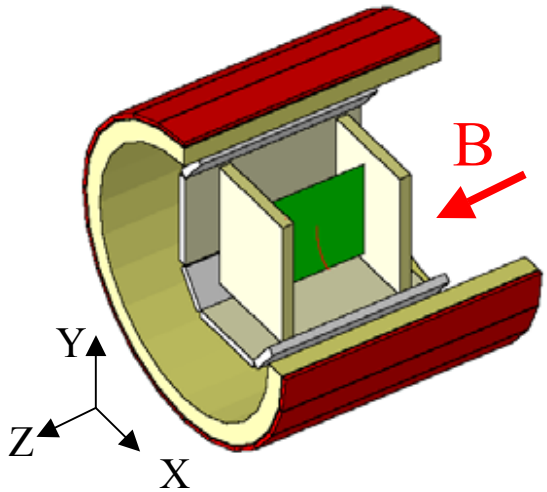



# DCBA-T2

## Drift Chamber Beta-ray Analyzer

$^{150}Nd \rightarrow {}^{150}Sm + 2e^-$

$$p\cos\lambda = 0.3rB,$$

$$T = (p^2 + m_e^2)^{1/2} - m_e$$

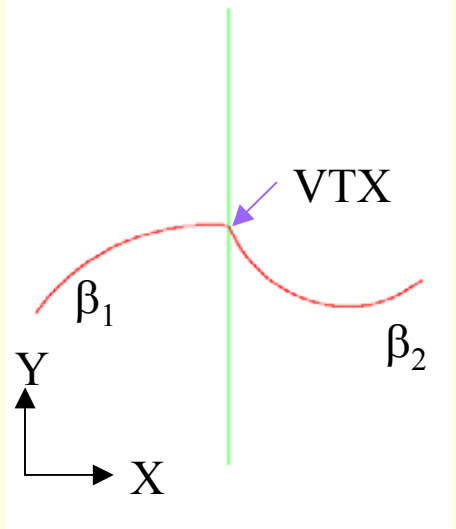
$p$ (MeV/c): momentum,

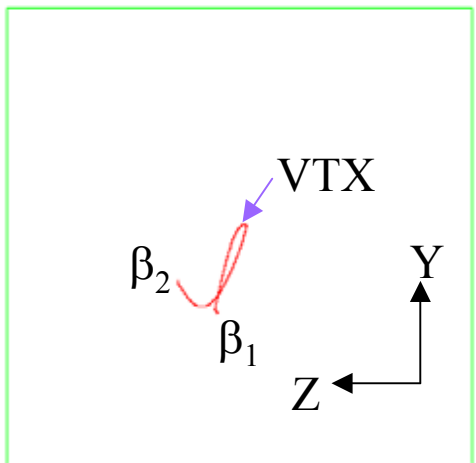
$r$ (cm): radius,

λ: pitch angle

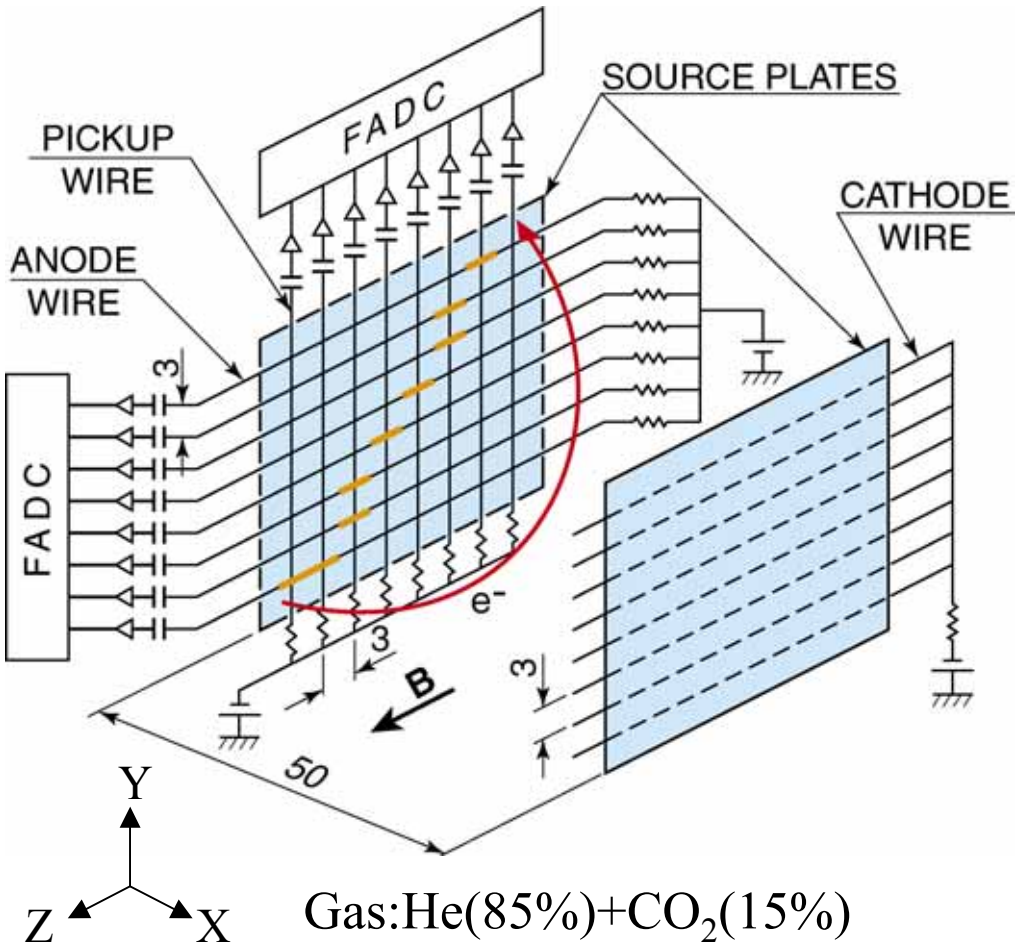
$B$ (kG): magnetic field,

$m_e$ (MeV/c$^2$): electron mass

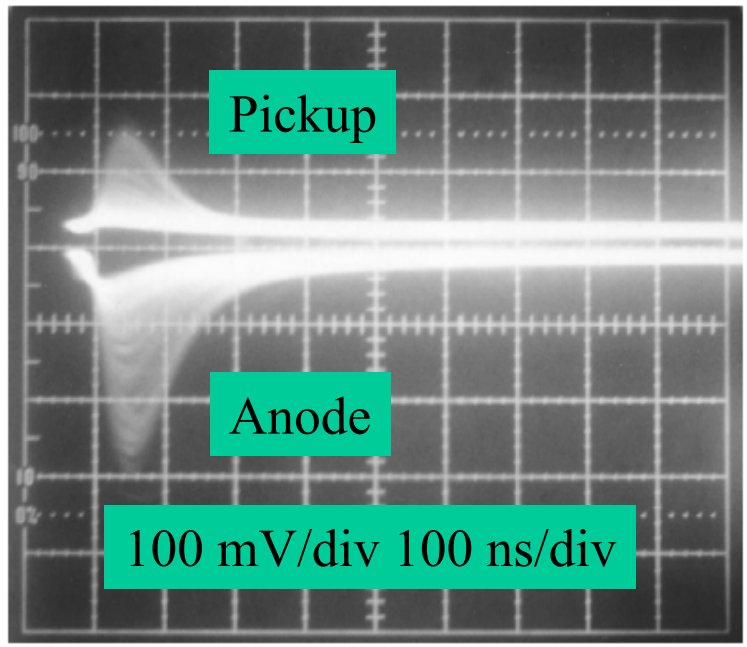


# Principle of **DCBA**

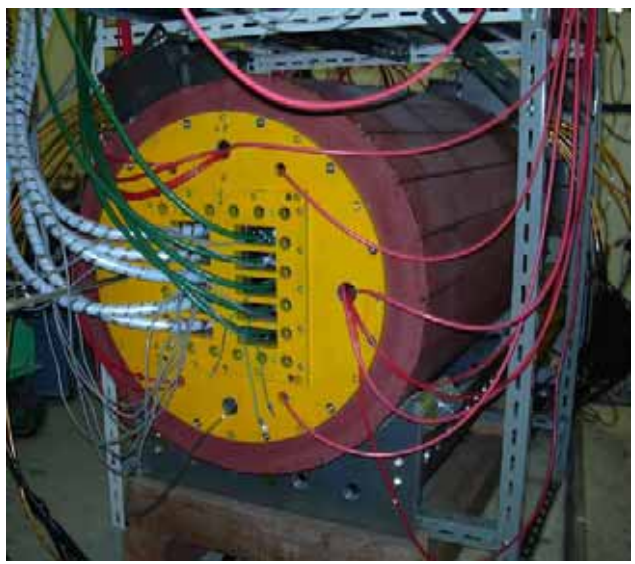



Gas:He(85%)+$CO_2$(15%)

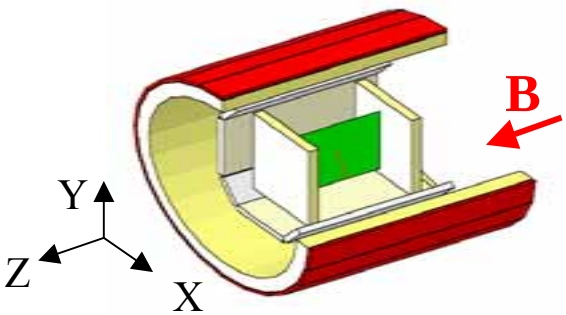


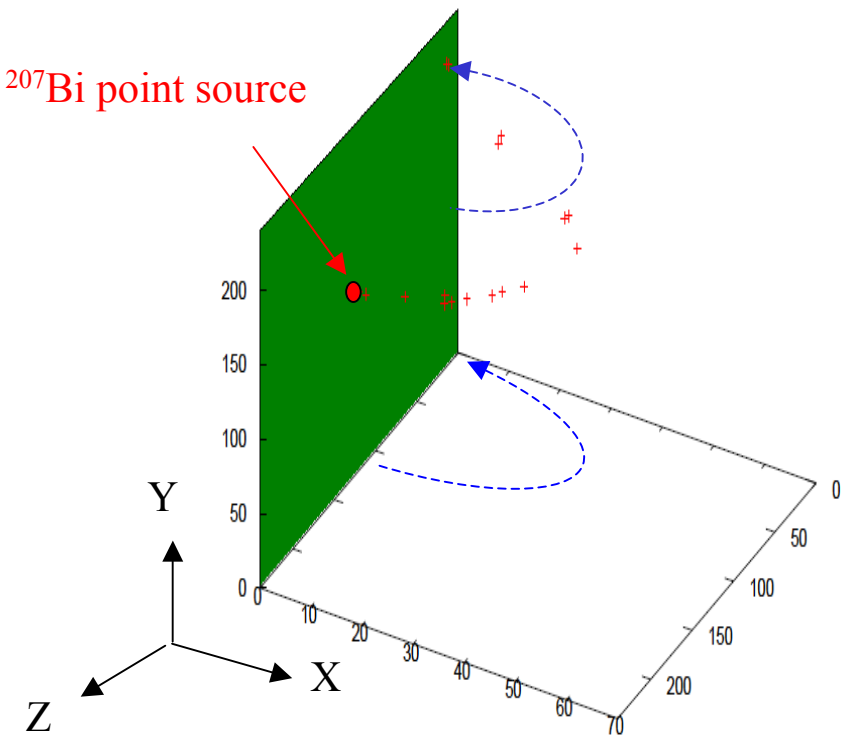
# DCBA-T2

- Drift chamber Multi-track capability
  - Anode wire pitch 6 mm
  - Pickup wire pitch 6 mm
  - Sensitive vol. 18(X) × 26(Y) × 26(Z) $cm^3$
  - Signal readout Flash ADC
  - X-position Drift velocity × Drift time ($\sigma_X \sim 0.5$ mm)
  - Y-position Anode wire position ($\sigma_Y \sim 0.5$ mm)
  - Z-position Pickup wire position ($\sigma_Z \sim 0.5$ mm)
- Magnet Solenoid coil + Flux return yoke
  - Magnetic field 0.8 kG (Max.)
  - Uniform Vol. 40 dia. x 70 $cm^3$ ($\delta B/B_0 < 1\%$)
- Veto-counters Scintillation counters

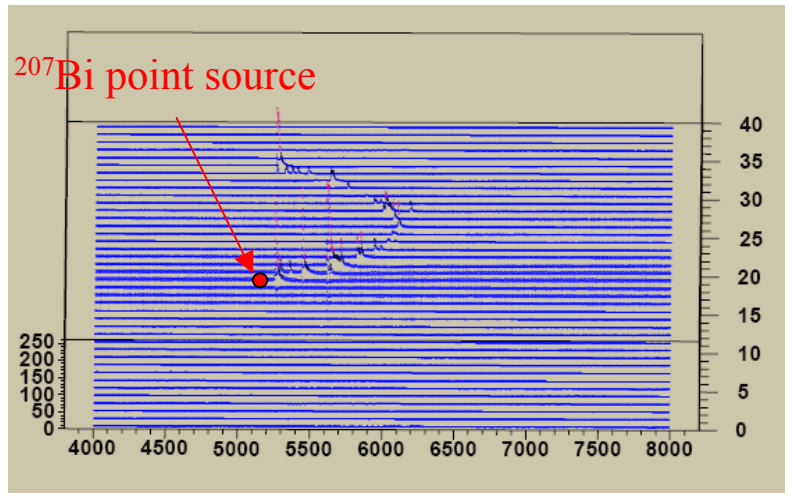


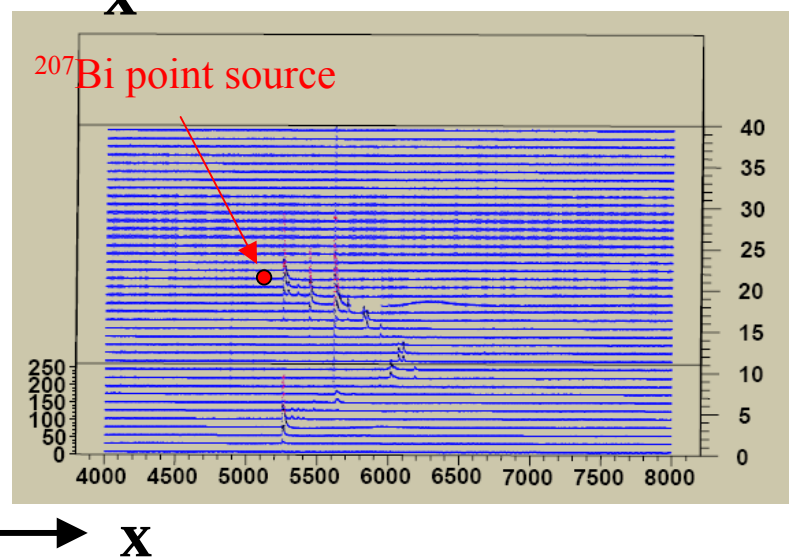
# Energy measurement of an I. C. electron from $^{207}$Bi



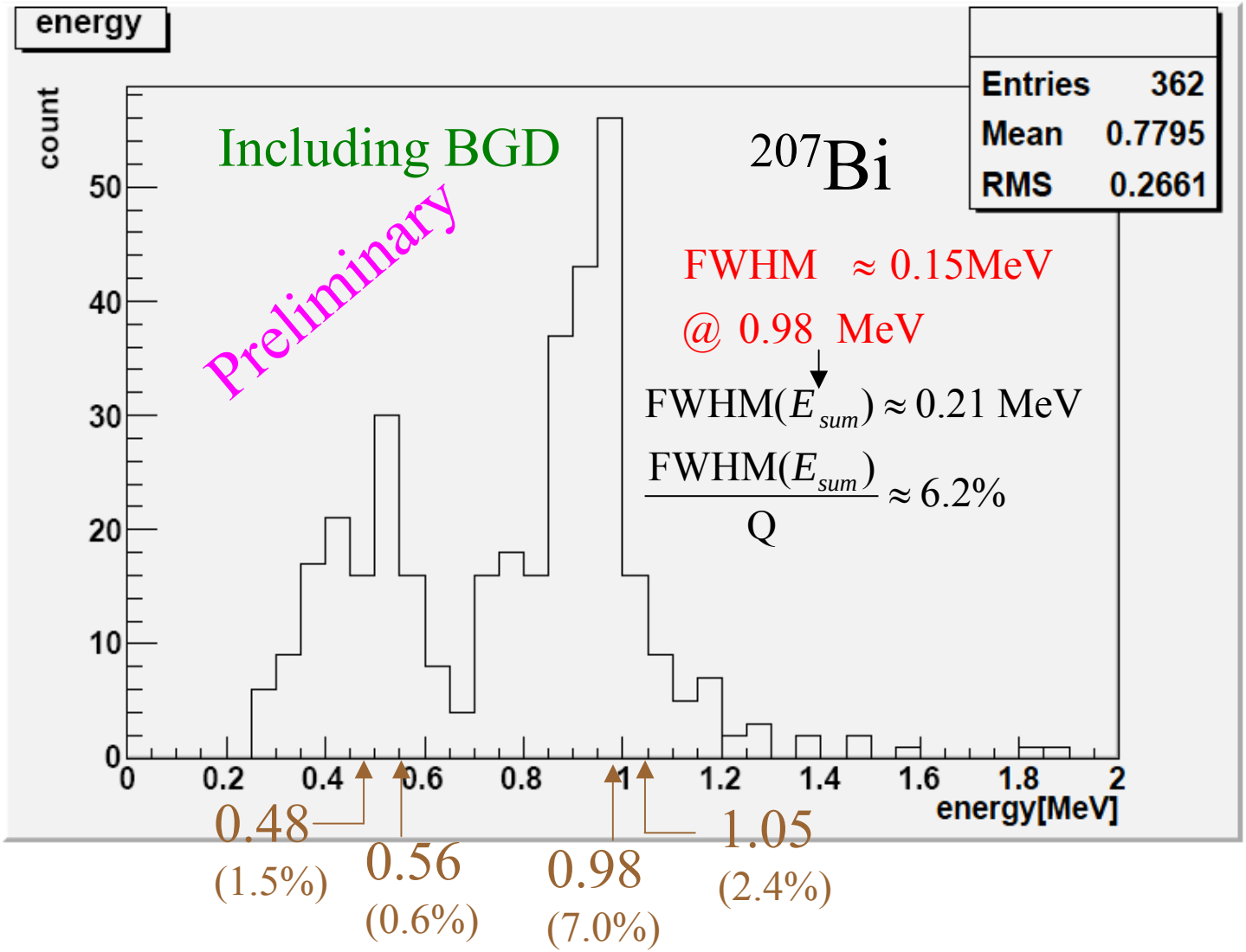




**Energy = 1073keV**

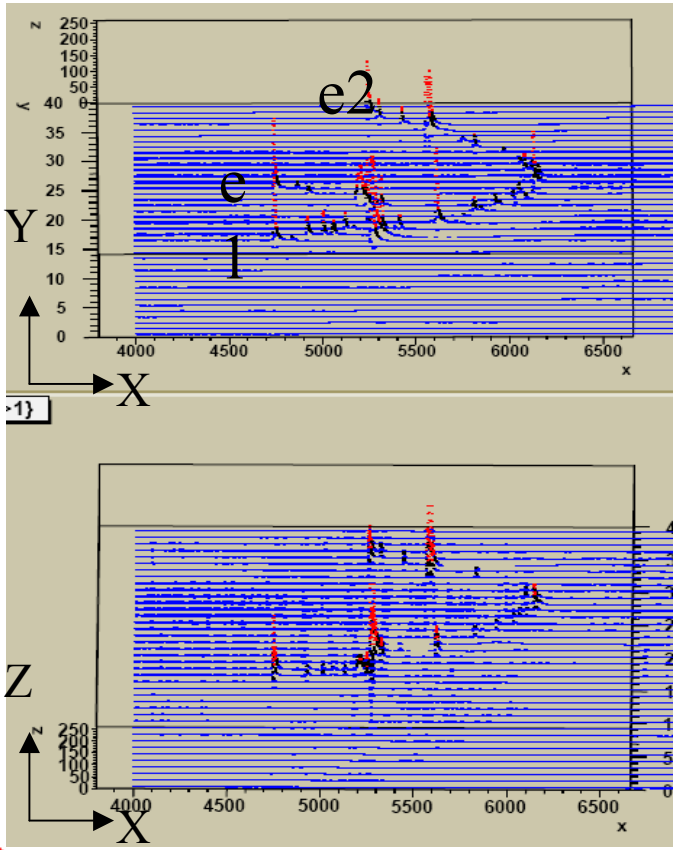


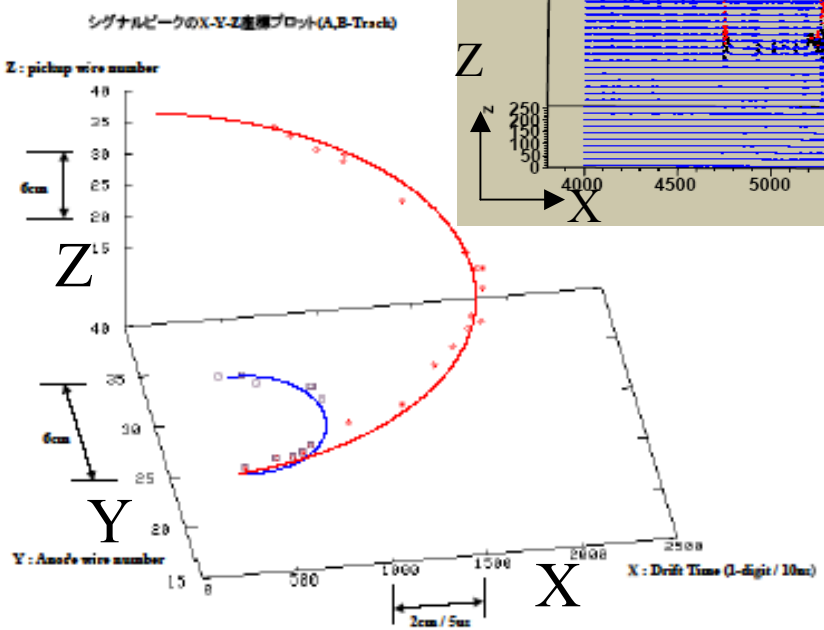



# Energy resolution of DCBA-T2

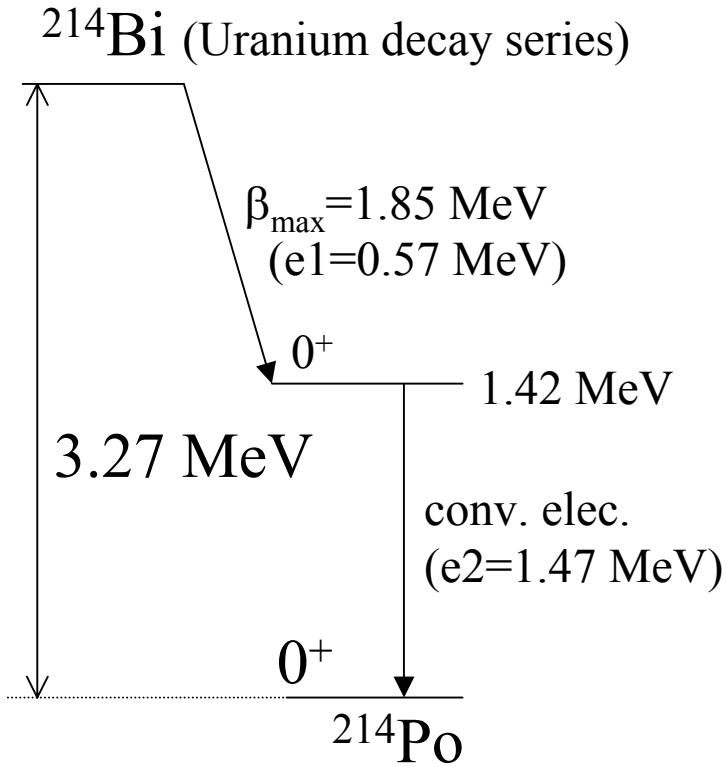


# BGD event

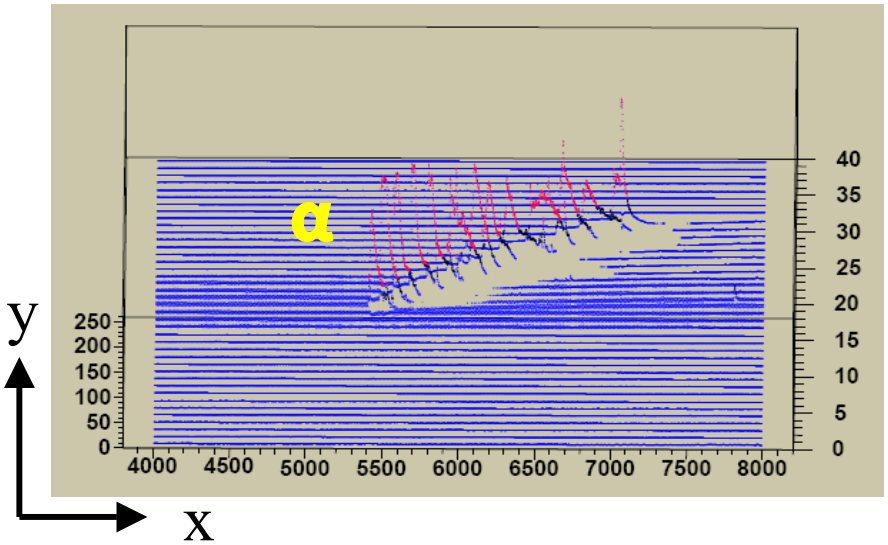


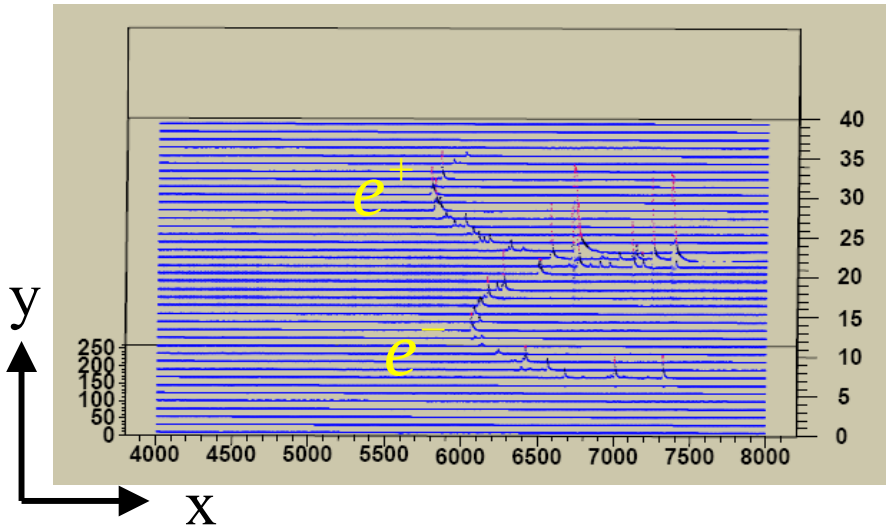



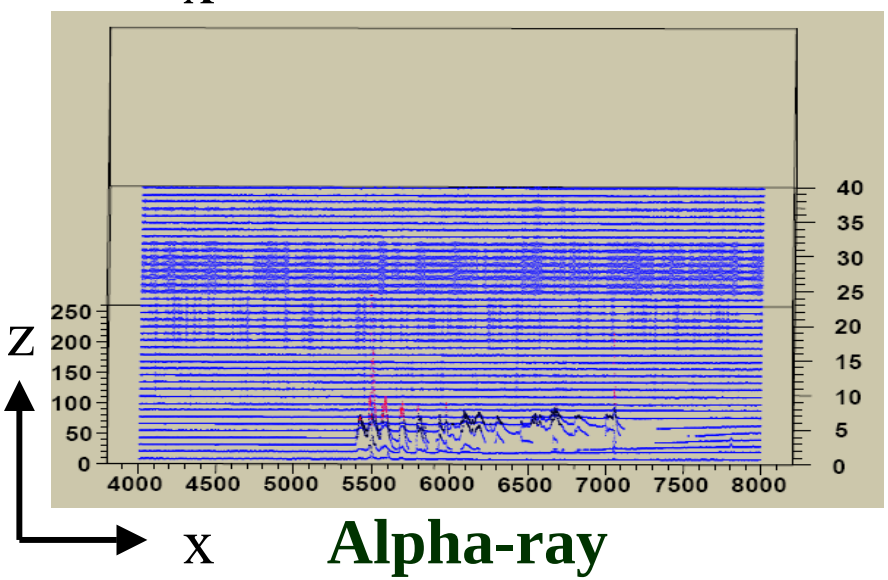

# 2-electron event



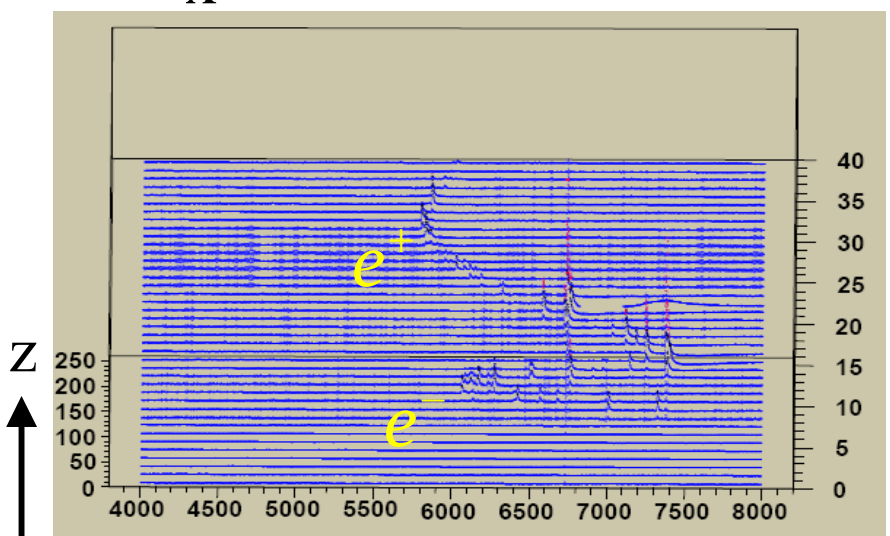
# Other BGD events (1)



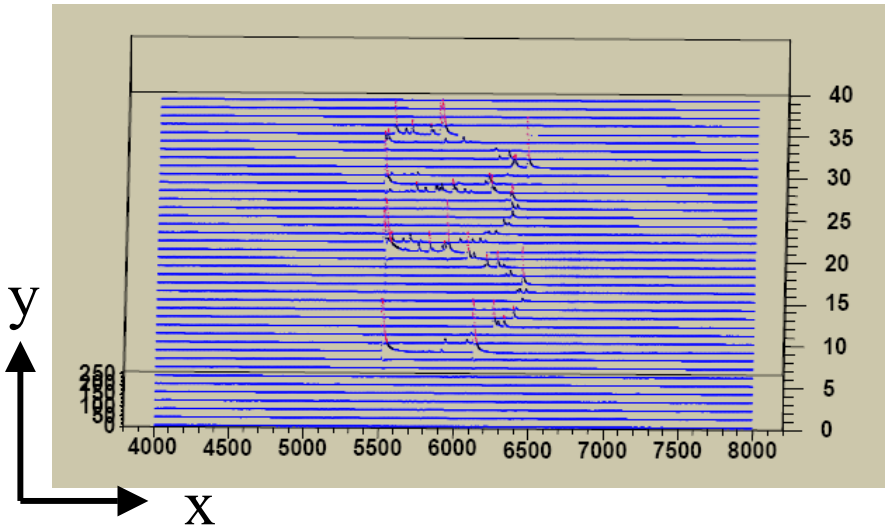



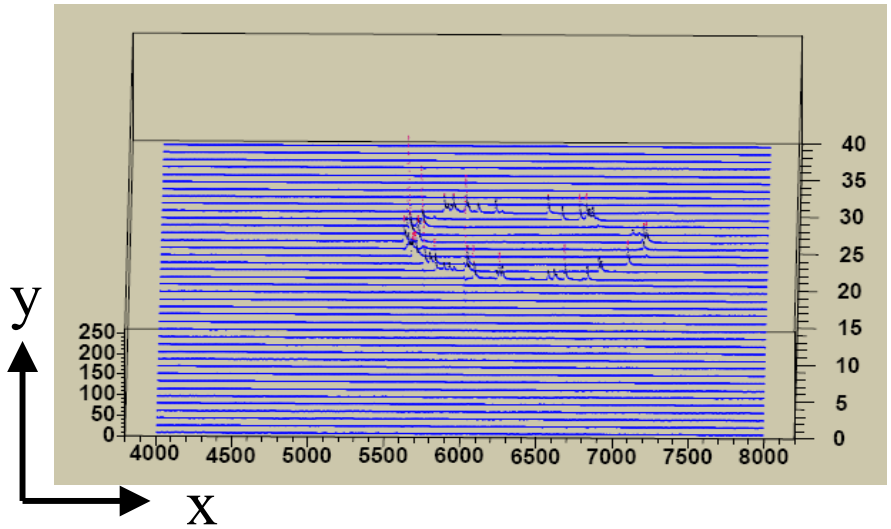

**Alpha-ray**

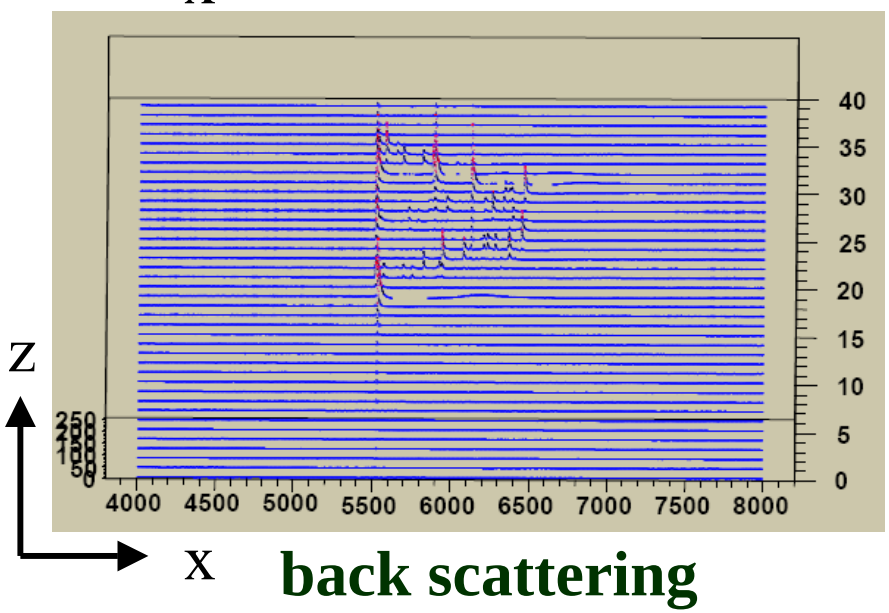



**pair creation**

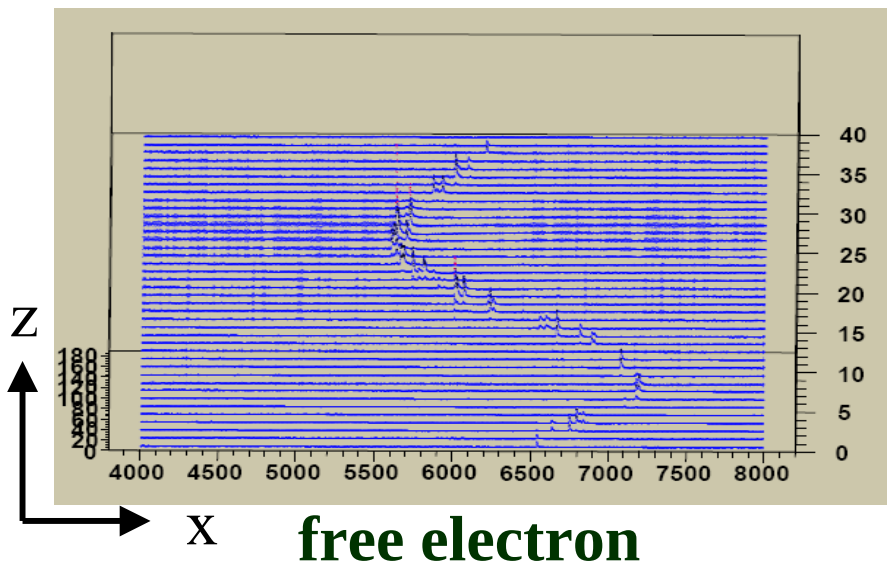
# Other BGD events (2)



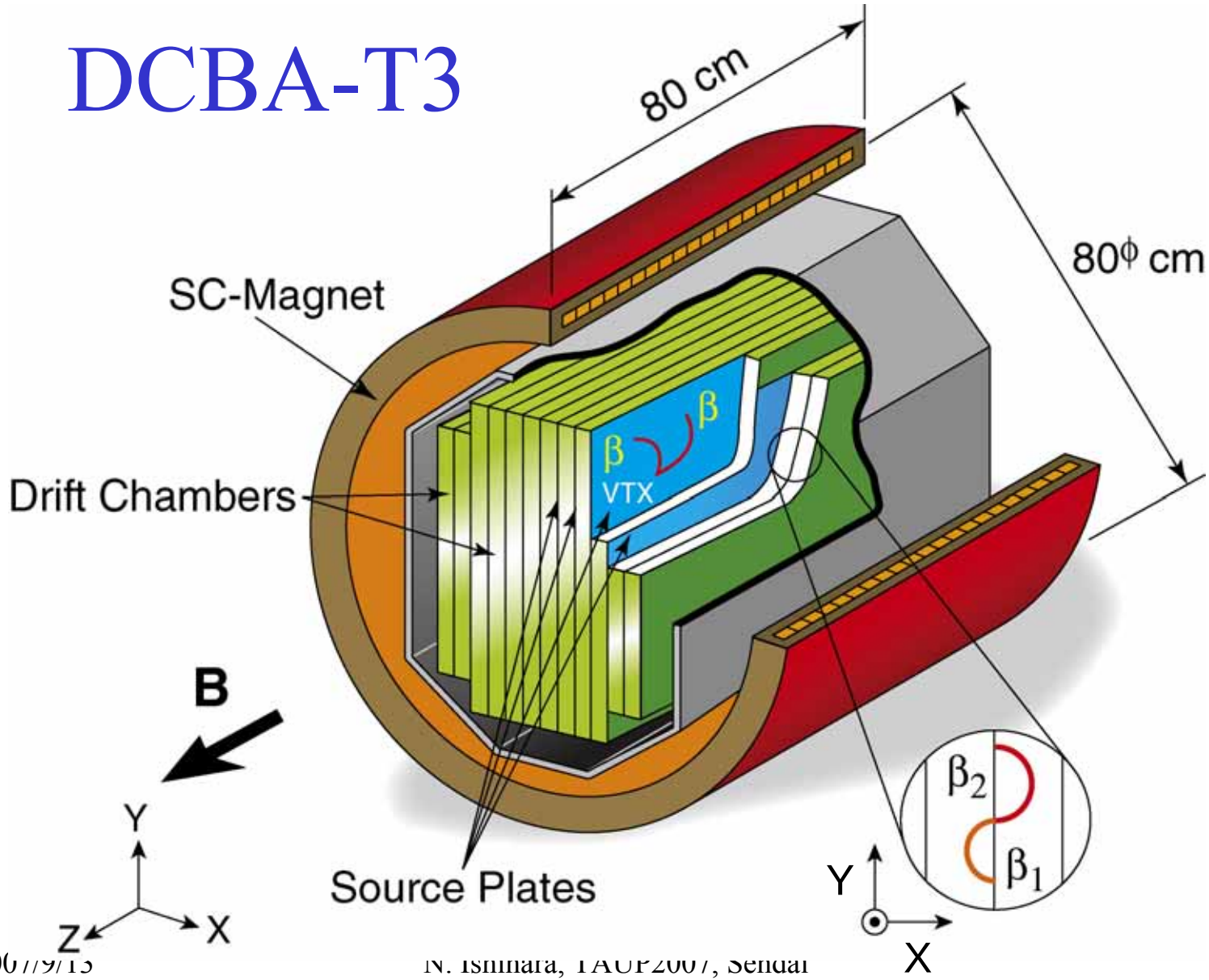




**back scattering**




**free electron**

# DCBA-T3


80 cm
80ϕ cm
SC-Magnet
Drift Chambers
β
β
VTX
B
Y
Z
X
Source Plates
β2
β1
Y
X

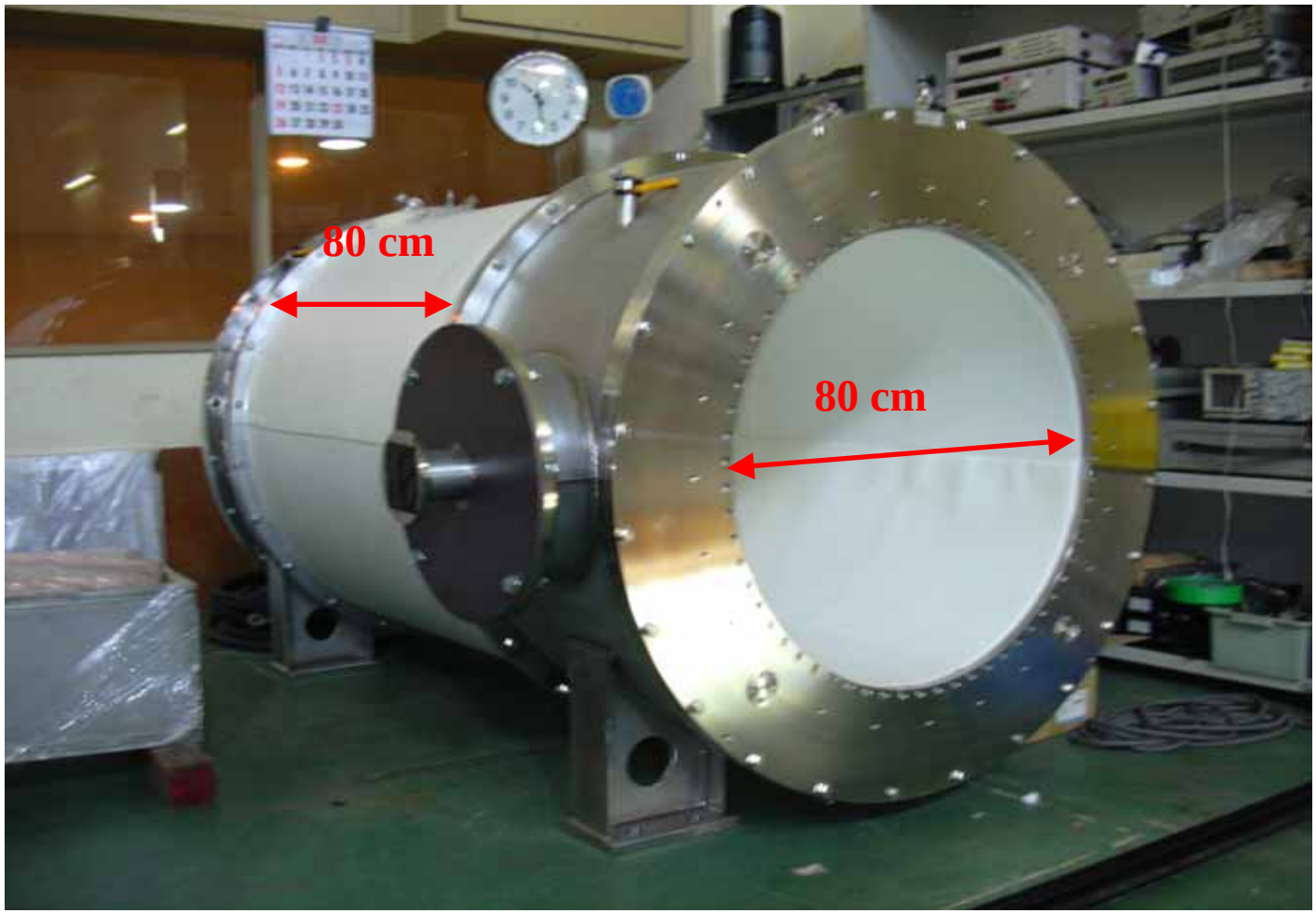
# Main parameters of DCBA-T3

| | |
|---|---|
| • Drift chamber | Multi-track capability |
| Source | $Nd_2O_3$ (40 mg/cm$^2$ ×13,760 cm2 = 550 g) ($^{150}$Nd = 0.18 mol) |
| Sensitive vol. | 4(X) × 44(Y) × 44(Z) cm$^3$/chamber: 8 chamber<br>4(X) × 20(Y) × 44(Z) cm$^3$/chamber: 4 chamber |
| Anode wire pitch | 3 mm |
| Pickup wire pitch | 3 mm |
| Signal readout | Flash ADC |
| X-position | Drift velocity × Drift time ($\sigma_X \approx 0.5$ mm) |
| Y-position | Anode wire position ($\sigma_Y \approx 0.2$ mm) |
| Z-position | Pickup wire position ($\sigma_Z \approx 0.2$ mm) |

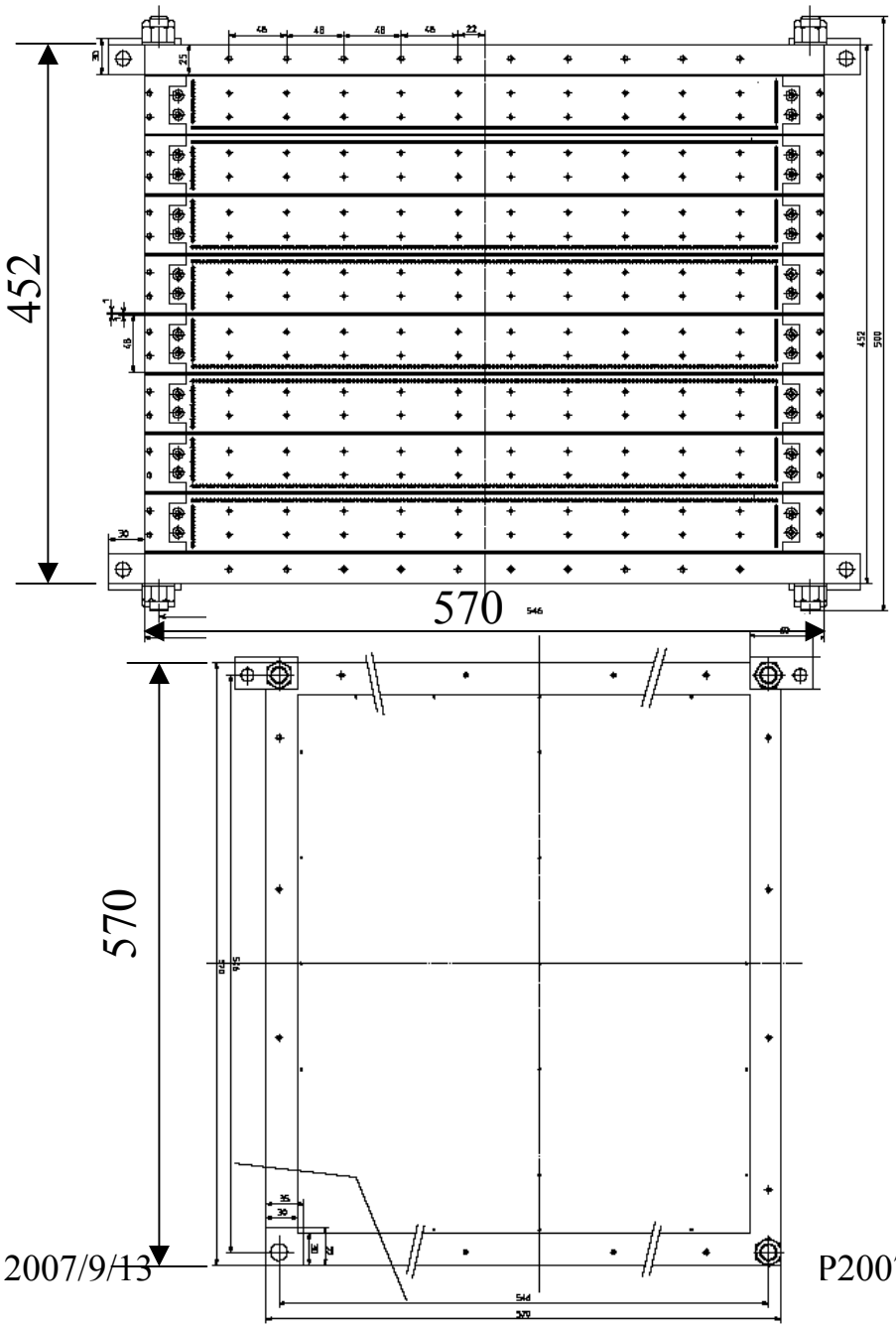
| | |
|---|---|
| • Magnet | Superconducting Solenoid + Flux return yoke |
| Magnetic field | 2.0 kG (Max.) |
| Uniform Vol. | 80 dia. x 80 cm$^3$ ($\delta B/B_0 < 1\%$) |

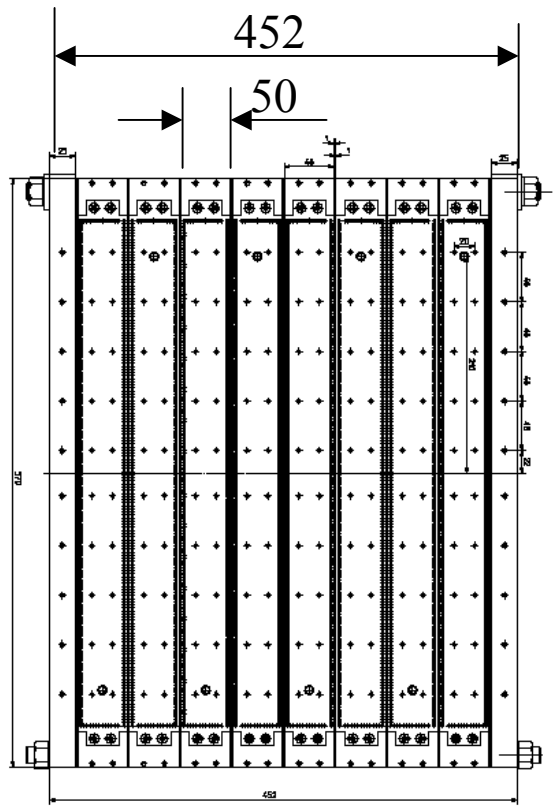
| | |
|---|---|
| • Veto-counters | Scintillation counters |

# DCBA-T3 SC Magnet

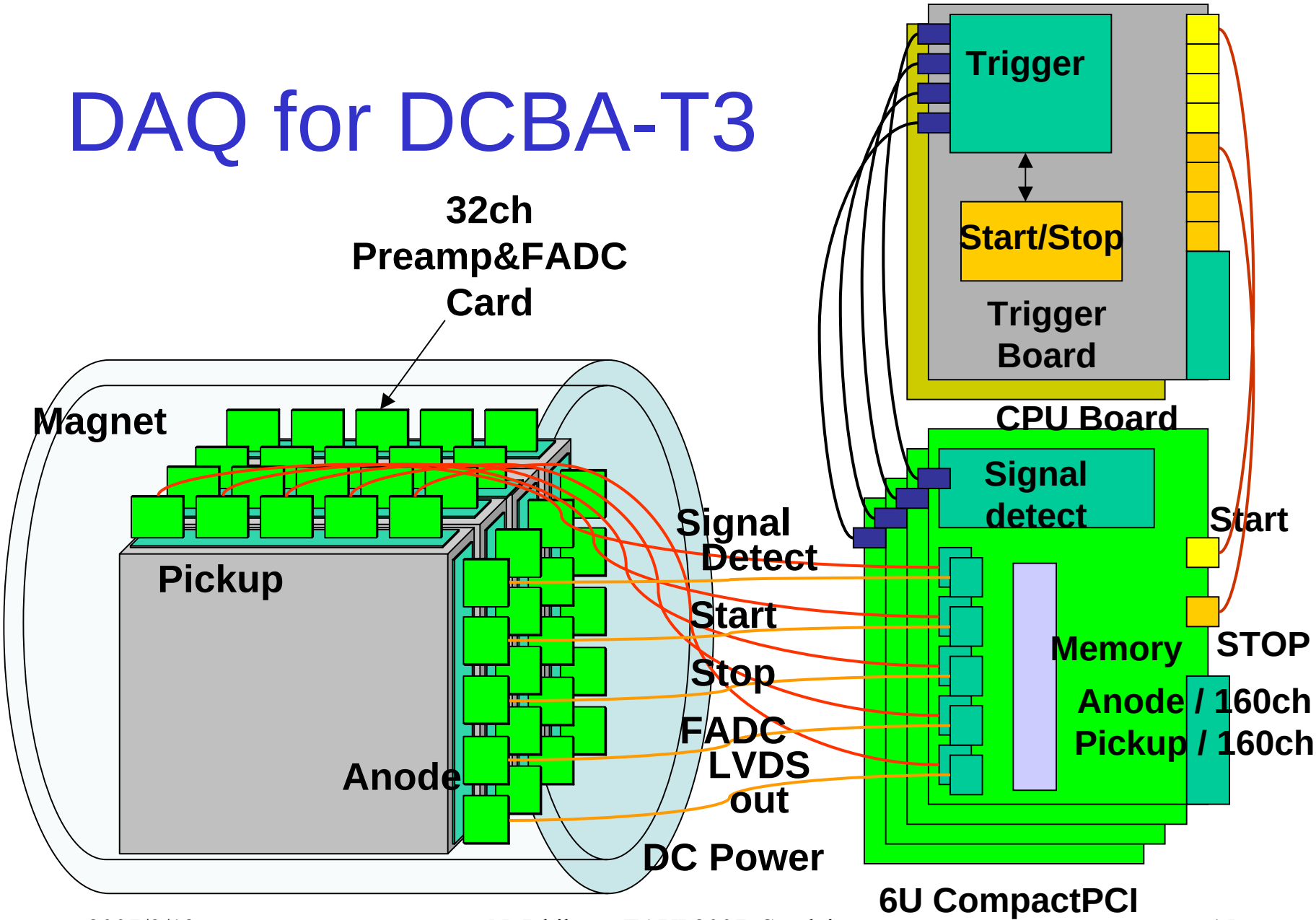


# DCBA-T3
# Drift Chambers
## (Central part)

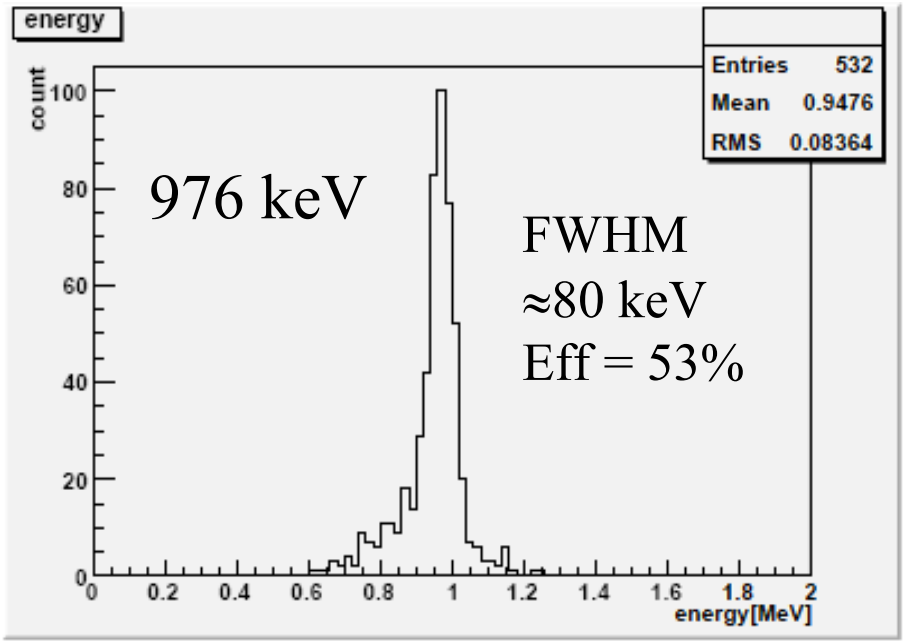


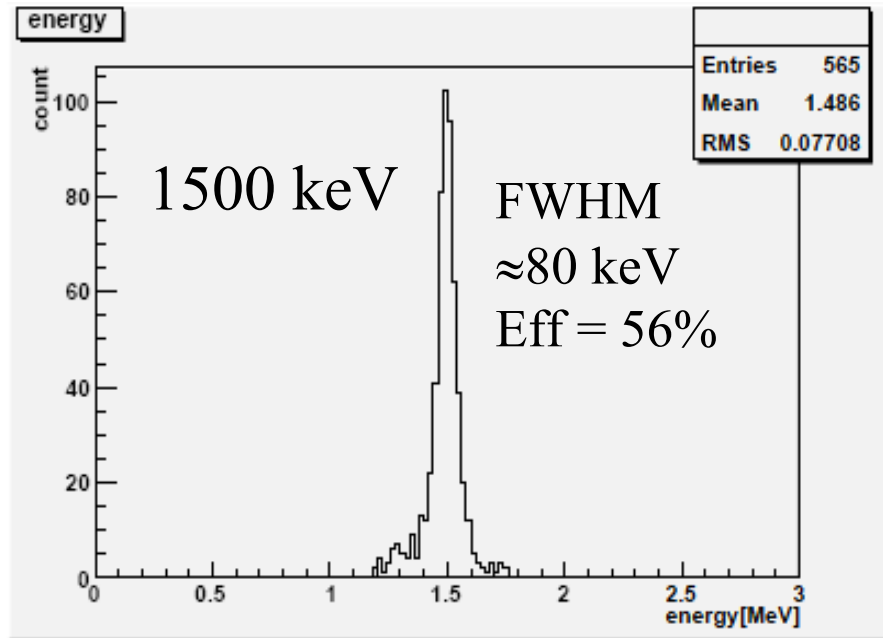



# DAQ for DCBA-T3



# Geant4 studies of energy resolution



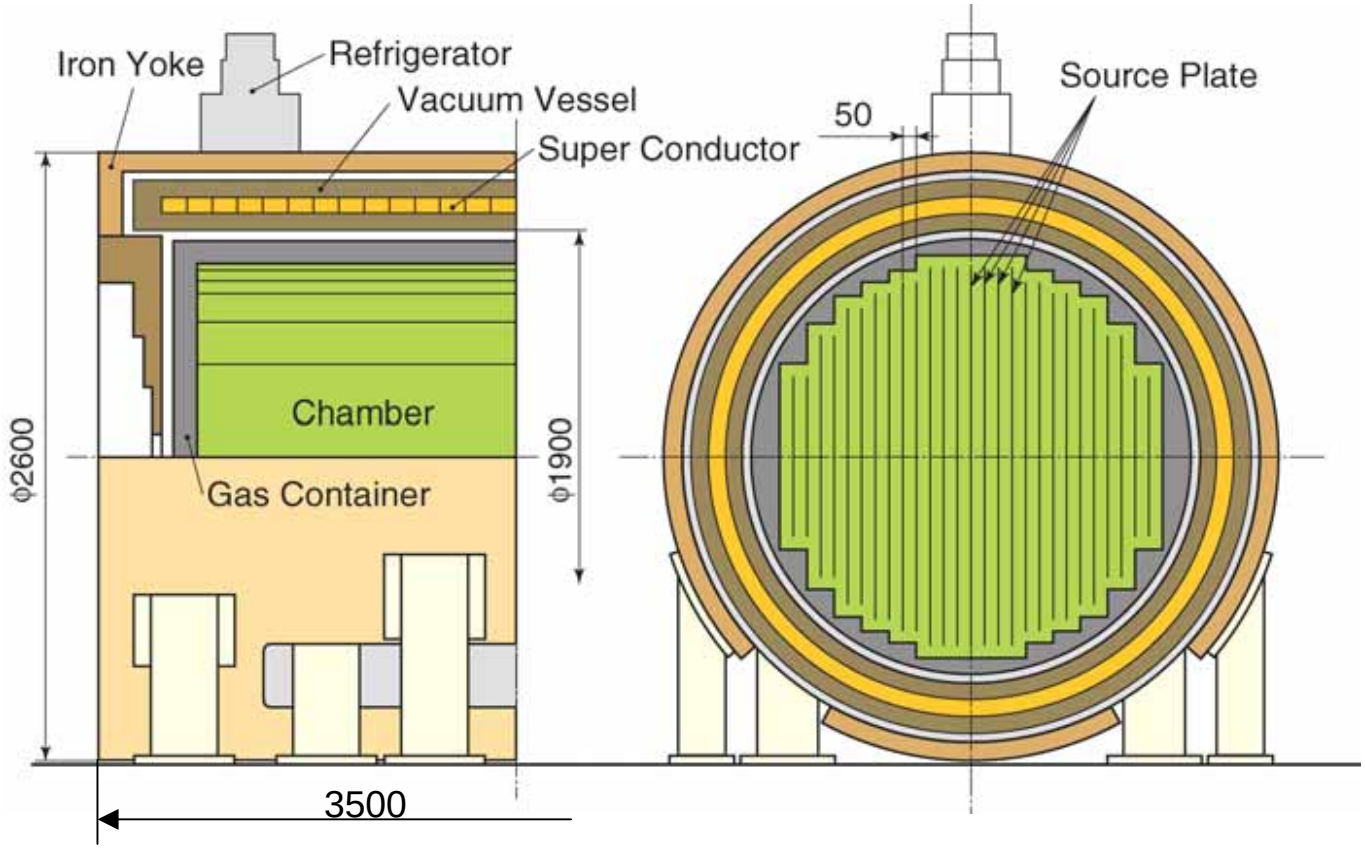

## DCBA-T3

Expected energy resolution

$$\frac{\mathrm{FWHM}(E_{sum})}{Q_{150\mathrm{Nd}}(=3.37\mathrm{MeV})} \approx 3.4\%$$

Magnetic field = 1.8 kG
Wire pitch = 3 mm
Max. drift length = 40 mm
Gas : He (85%) + $CO_2$ (15%)

# Magnetic Tracking Detector (MTD: temporary name)




Source plate: 80 $m^2$/module

Thickness: 15 (40) mg/$cm^2$ Source weight: 12 (32) kg/module

$$< m_\nu >_{sns} \approx 0.8(0.5)\,\text{eV for normal Nd/mod.yr}$$

$$< m_\nu >_{sns} \approx 0.2(0.1)\,\text{eV for 60\% } ^{150}\text{Nd/mod.yr}$$

# Half-life and Effective Mass Sensitivities of DCBA for $^{150}$Nd, $^{100}$Mo and $^{82}$Se (Tentative)

| | Natural Nd (5.6%$^{150}$Nd) | $^{150}$Nd (80% enr.) | $^{100}$Mo (90% enr.) | $^{82}$Se (90% enr.) |
|---|---|---|---|---|
| DCBA Amount (mol) (600 kg: 50 modules) | 190 | 2700 | 5400 | 6600 |
| $T_{1/2}^{0\nu}$ sns (yr) | $9 \times 10^{24}$ | $1 \times 10^{26}$ | $2 \times 10^{26}$ | $3 \times 10^{26}$ |
| $\langle m_\nu \rangle$sns (eV) | 0.06 | 0.02 | 0.07 | 0.04 |

Nucl. Matrix Element: A. Staudt et al. Europhys. Lett. 13 (1) (1990) 31

# Summary

♦ DCBA (Drift Chamber Beta-ray Analyzer) is an R&D project for constructing Future MTD (Magnetic Tracking Detector).

♦ DCBA-T2 have shown that the energy resolution is about 150 keV (FWHM) at 980 keV, and background events are clearly identified.

♦ DCBA-T3 is scheduled to be constructed in 2007 and operated in 2008. Target energy resolution is about 80 keV (FWHM) at 980 keV.

♦ New international collaboration using MTD will be able to investigate the effective neutrino mass down to around 30 meV.