

# Emulsion spectrometer

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8th. March 2002

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# Motivation

We have developed an emulsion spectrometer using a permanent magnet.

Electric charge determination and momentum measurement by the magnetic field.

- **Advantage** -

- \* No electric power needed
- \* Compact

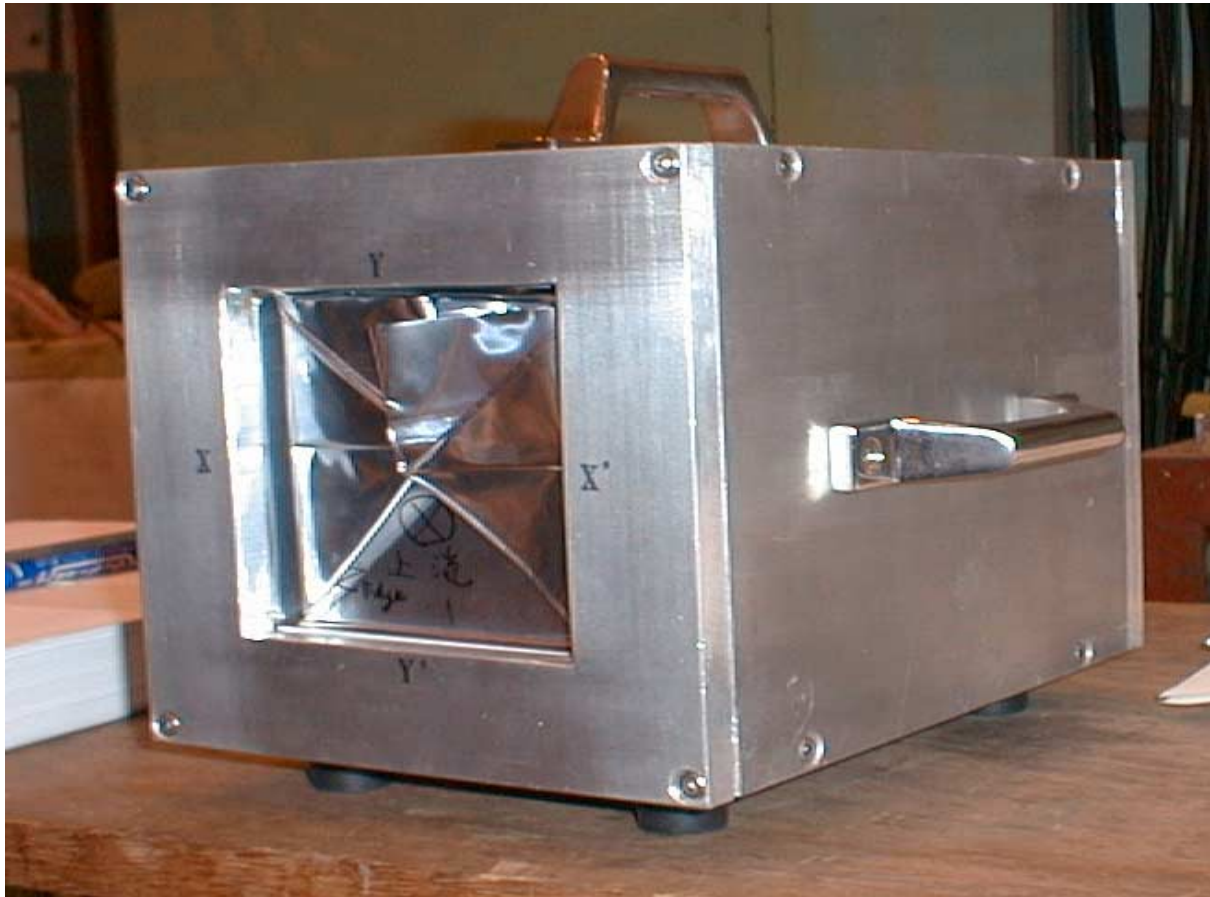
Beam exposure has been performed at KEK - High Energy Acceleration Research Organization -.

# Emulsion Spectrometer

- Permanent magnet

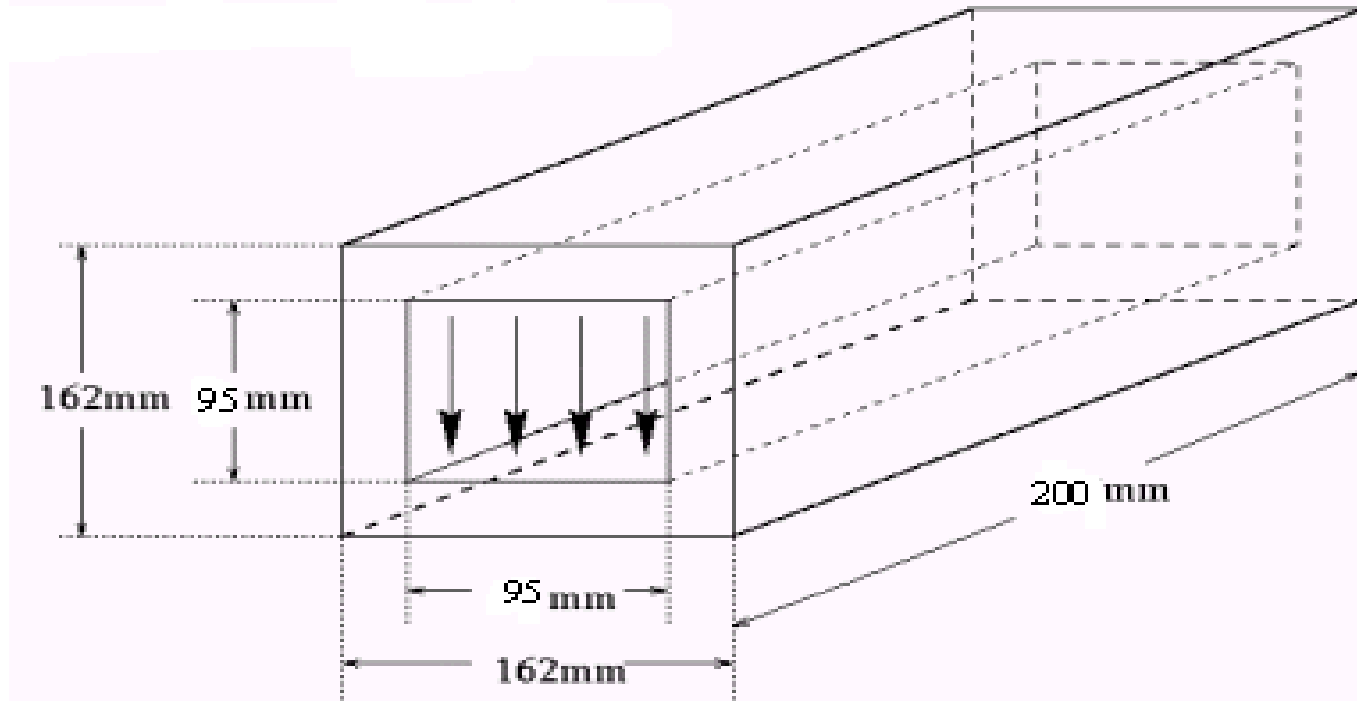
Sumitomo Special Metals Co., LTD.

NEOMAX ( $\text{Nd}_2\text{Fe}_{14}\text{B}$ )



# Emulsion Spectrometer

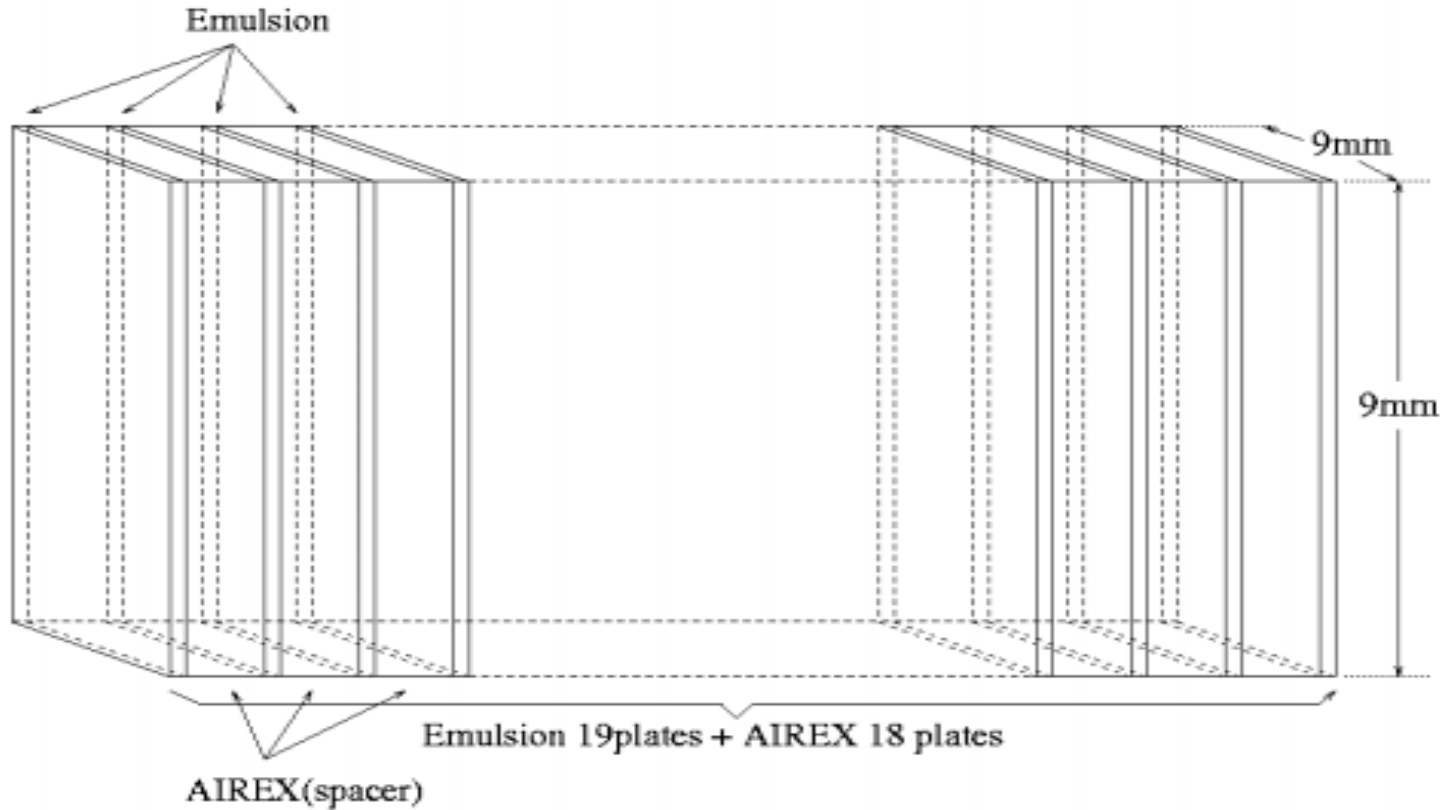
## Dimensions of the magnet



- > Magnetic field strength is about 0.35 [T] at center.
- > Emulsion stack is inside.

# Emulsion Spectrometer

- Emulsion stack



# Emulsion Spectrometer

## > Emulsion 19 plates (OPERA film)

Size : 9 cm × 9 cm

Thickness : 42 [μ m] emulsion (both sides), 200 [μ m] base

$X_0$  : 5.5 [cm] (emulsion), 31 [cm] (base)

$x / X_0$  :  $2.1 \times 10^{-3}$  / plate

## > Spacer (AIREX) 18 plates

Size : 9 cm × 9 cm

Material : poly ether imide (PEI)

Density : 0.08 [g/cm<sup>3</sup>]

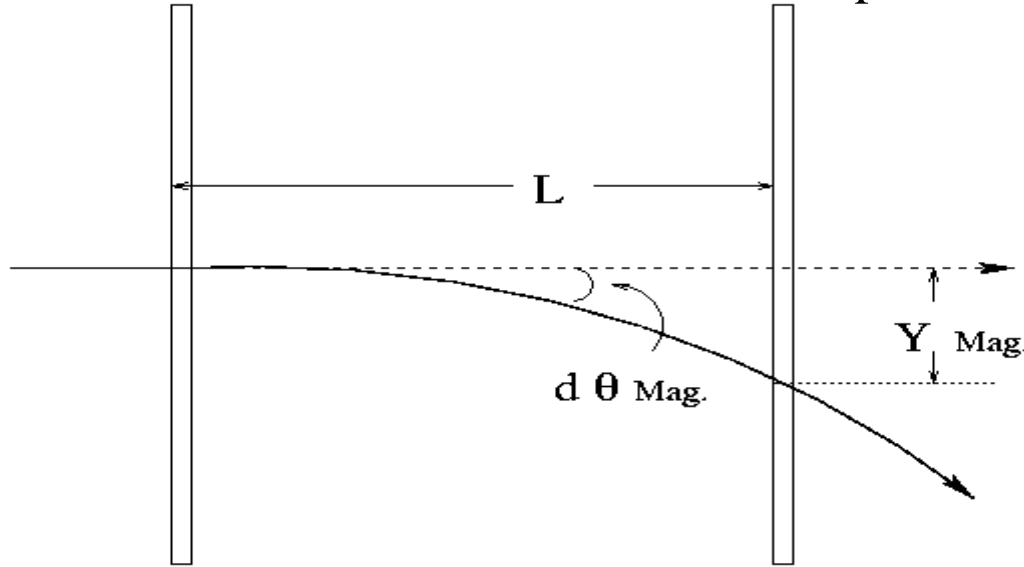
Thickness : 1.0 [cm]

$X_0$  : 515 [cm]

$x / X_0$  :  $1.9 \times 10^{-3}$  / plate

# Momentum calculation

- Momentum is calculated from bend of particles by magnetic field.



$$B = 0.35 [T]$$

$$L = 200 [mm]$$

$$d\theta_{\text{mag}} = \frac{0.3 \times B \times L}{p},$$

$$Y_{\text{mag}} = \frac{d\theta_{\text{mag}} \times L}{2}$$

$$d\theta_{\text{mag}} = \frac{0.019 [MeV / c]}{p},$$

$$Y_{\text{mag}} = \frac{(0.019/p) \times 0.18}{2} = \frac{1.7 \times 10^{-3}}{p} [m]$$

- Multiple scattering

$$\theta_{\text{ms}} = \frac{0.0136}{p\beta c} \sqrt{\frac{x}{X_0}} [1 + 0.038 \ln(\frac{x}{X_0})]$$

$$= \frac{3.6 \times 10^{-3}}{p\beta c} [MeV / c]$$

$$Y_{\text{M.S.}} = \frac{1}{\sqrt{3}} L \theta_{\text{M.S.}}$$

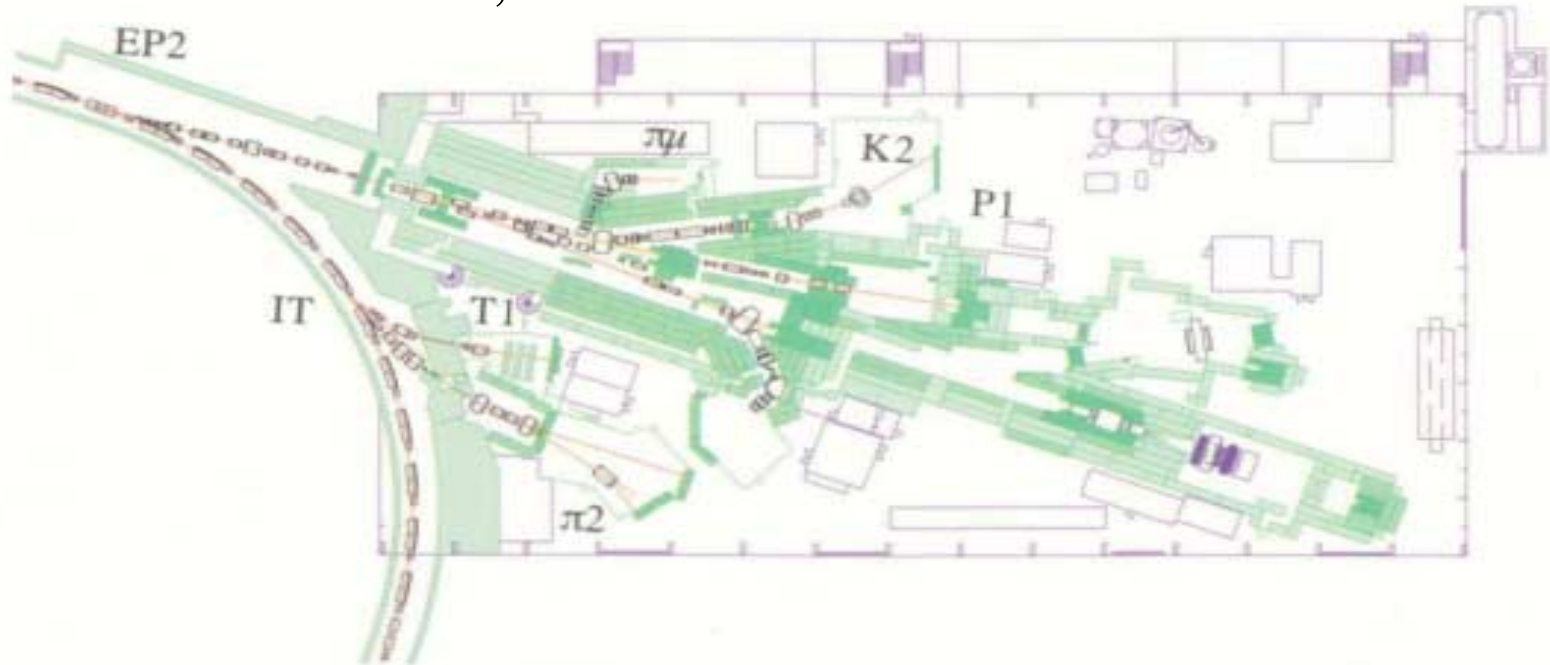
$$= \frac{0.4 \times 10^{-3}}{p\beta c} [m]$$

# Beam exposure

- Beam line

KEK - high energy accelerator research organization -

East counter Hall,  $\pi^2$  beam line



- Momentum -4.0,-2.0,-1.0,+2.0,+1.0 [GeV/c] pions
- Incident angle was changed for each momentum.



# Beam exposure

exposure	momentum[GeV/c]	magnetic field [T]	angle y [rad]	angle z [rad]
1	-4.0	0.00	0.000	0.220
2	+1.0	0.35	0.200	0.000
3	+2.0	0.35	0.100	0.000
4	-4.0	0.35	0.000	0.000
5	-2.0	0.35	-0.100	0.000
6	-1.0	0.35	-0.200	0.000
7	-4.0	0.00	0.000	-0.220

# Scanning

- Alignment

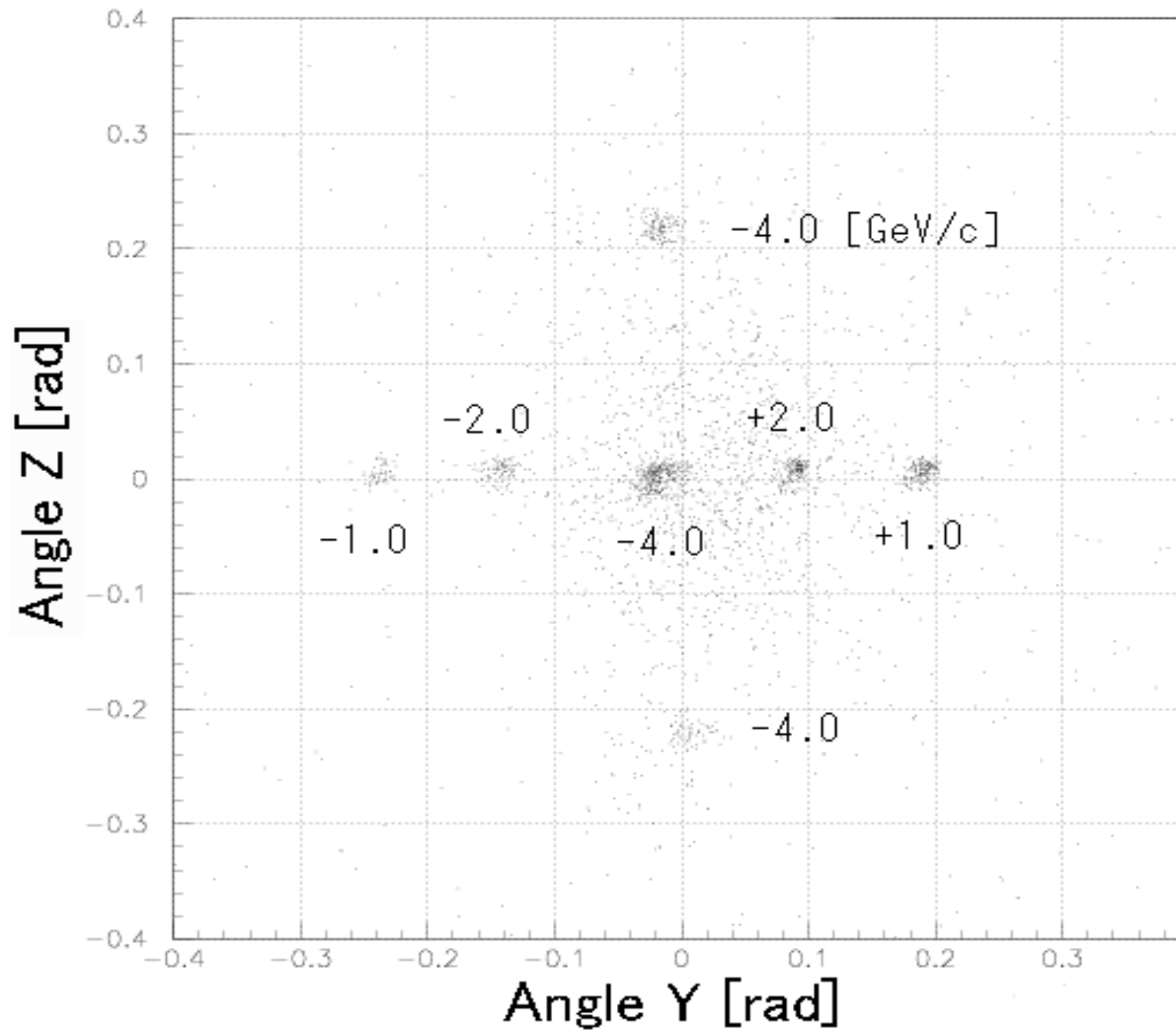
1. General scan using UTS at four points in an emulsion plate.
2. Beam center is picked up.

Rotation , x-shift , and y , z-shift are adjusted.

At present , the work is in progress.

# Scanning

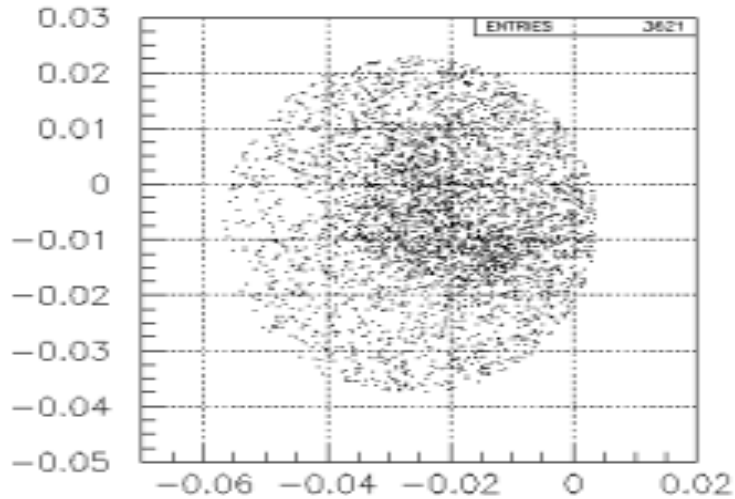
- Beam profile



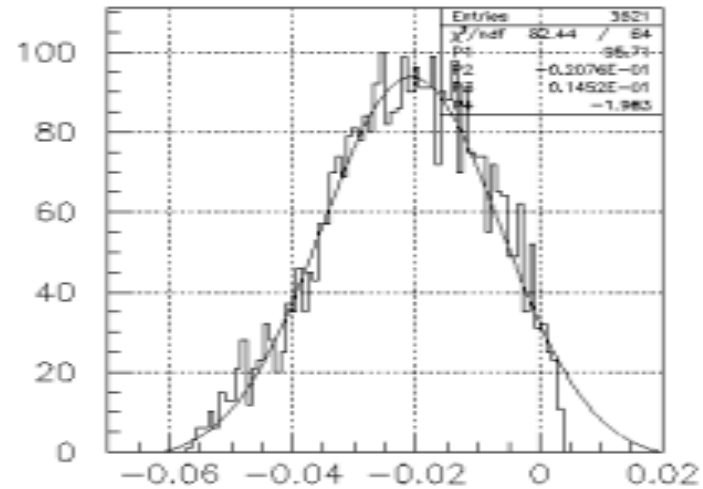
Angle distribution

# Scanning

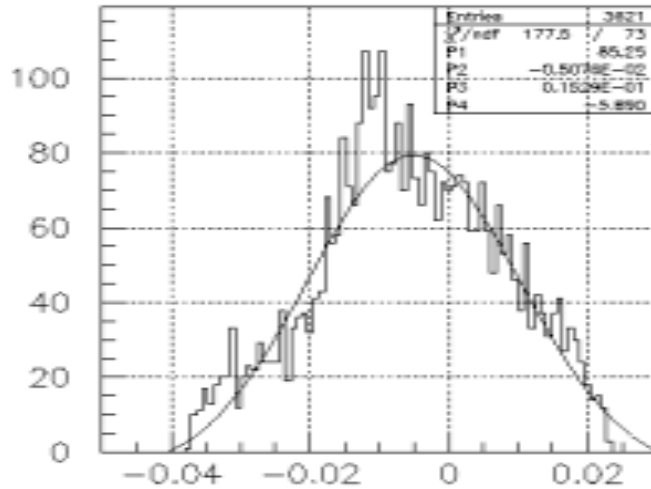
beam4



az v.s. ay



Angle hist ay



Angle hist az

- 4 GeV/c pion beam
  - $\sigma = 0.015$  [rad]
  - $3\sigma$  cut  $\rightarrow$  3621 [tracks]
  - density = 1,0319 [tracks / cm<sup>2</sup>]

# Conclusion

- We developed emulsion spectrometer using permanent magnet, and performed beam exposure at KEK.
- Alignment of emulsion plates is performed.
- The momentum will be measured.