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# Analysis memo (14-Dec-2012)

T. Kobayashi

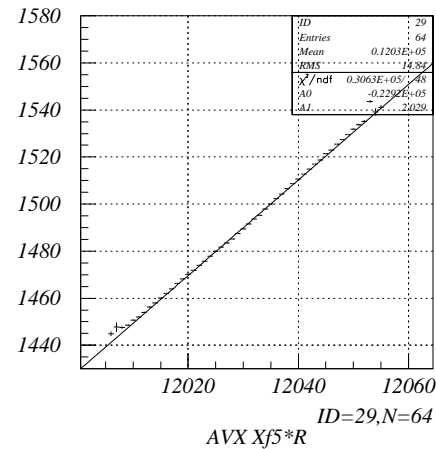
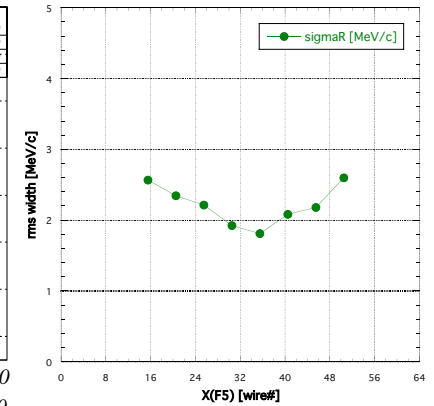
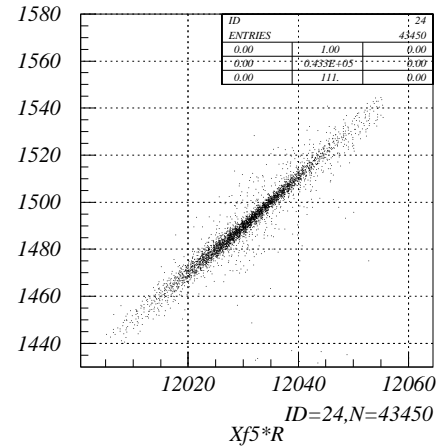
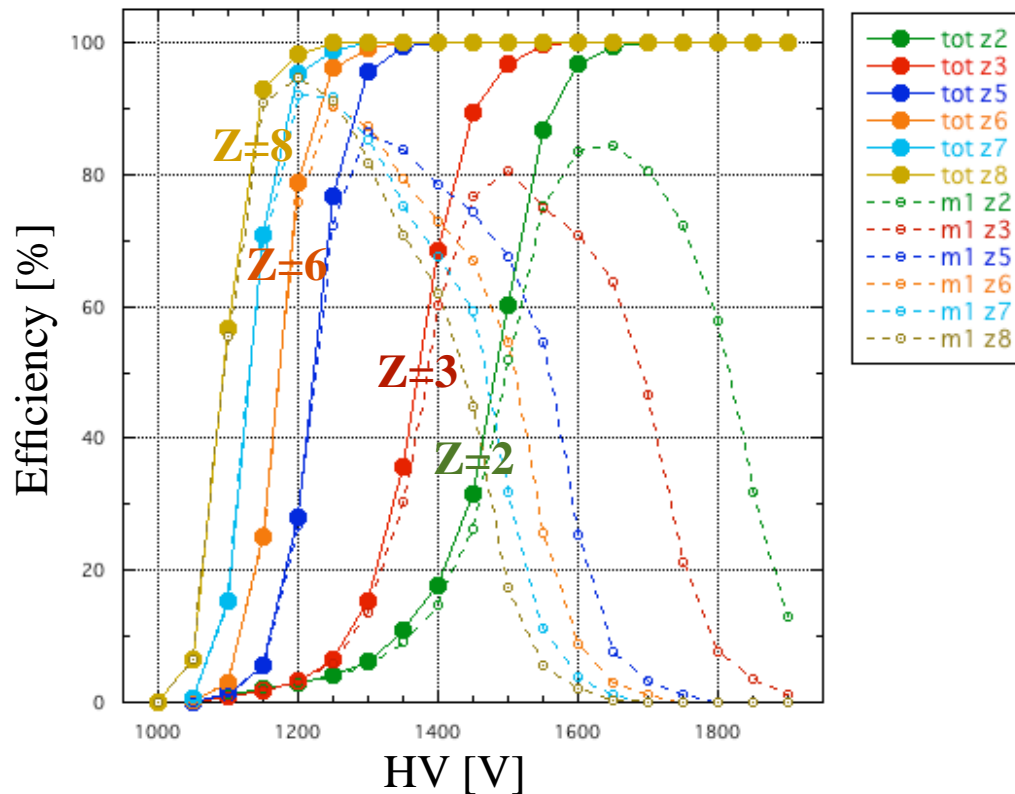
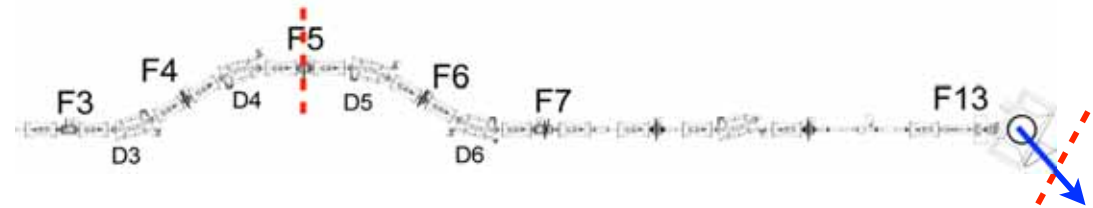
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- Position resolution : HV dependence (part)
  - BDC, FDC1, FDC2 :  $z=1$ ,  $z=6$
  - $\Delta E$  information
- Rigidity analysis
  - codeが2 – 3行間違っていた
  - BQ scan data
  - $\Delta p/p = \pm 3\%$  run
  - 磁場計算 / 測定の比較

# BPC - 2 : Response for Z=2~8

o Pressure= 50 torr,  $E_b= 250 \text{ MeV/A}$ ,  $V_{th}=-0.4\text{V}$

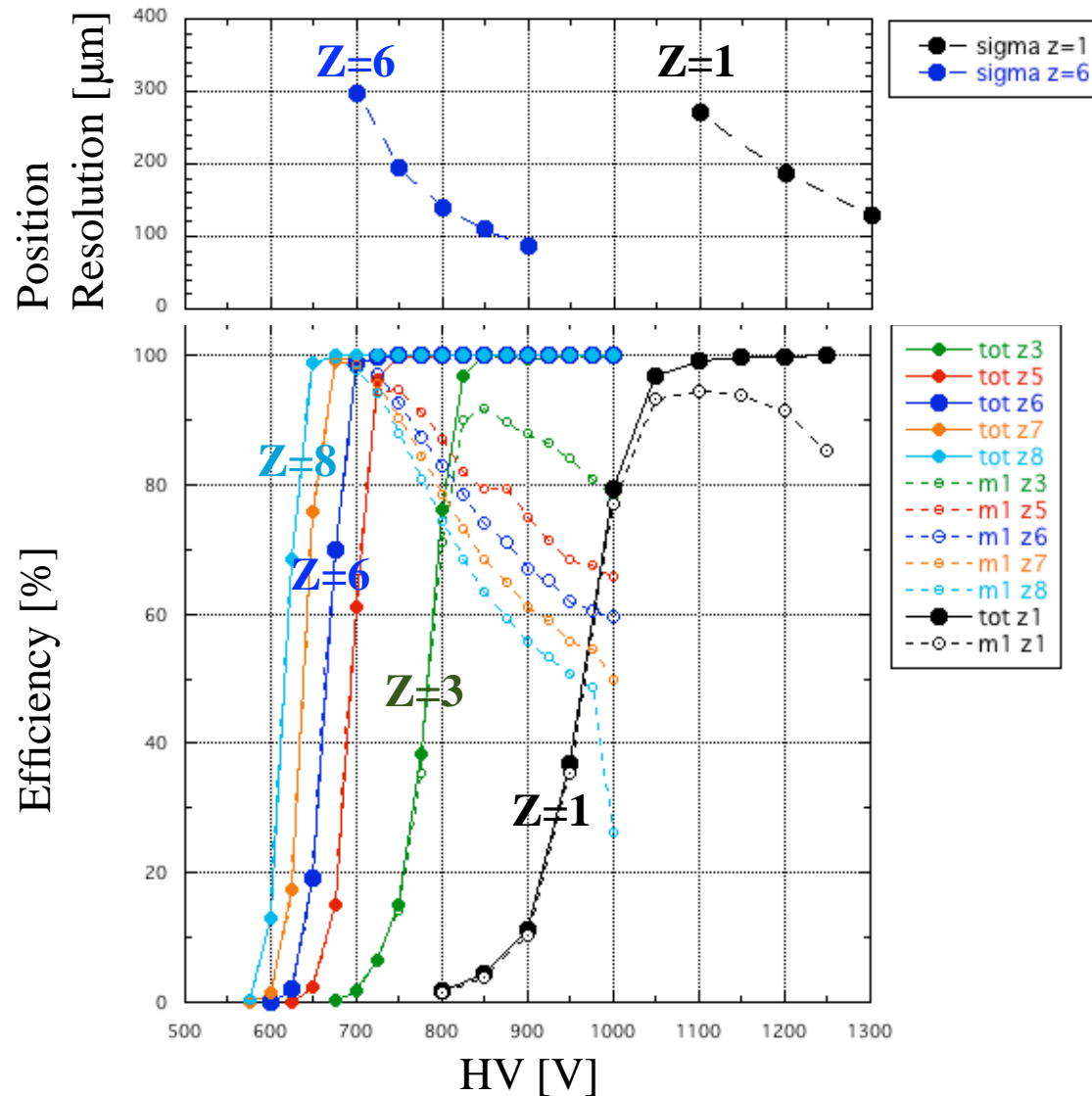
$$D \sim 33 \text{ mm}/\% \quad \frac{4[\text{mm}]}{\sqrt{12}} \frac{1}{33[\text{mm}/\%]} \approx 0.03\%$$



D(F5)~ 29.4 mm/%

# BDC - 2 : response for Z= 1~8

o Pressure= 100 torr,  $E_b = \sim 200$  MeV/A,  $V_{th} = -0.8$  V



\* Detection efficiency

stable plateau,  $\epsilon \sim 100\%$

\* Position resolution  $\sigma_x$

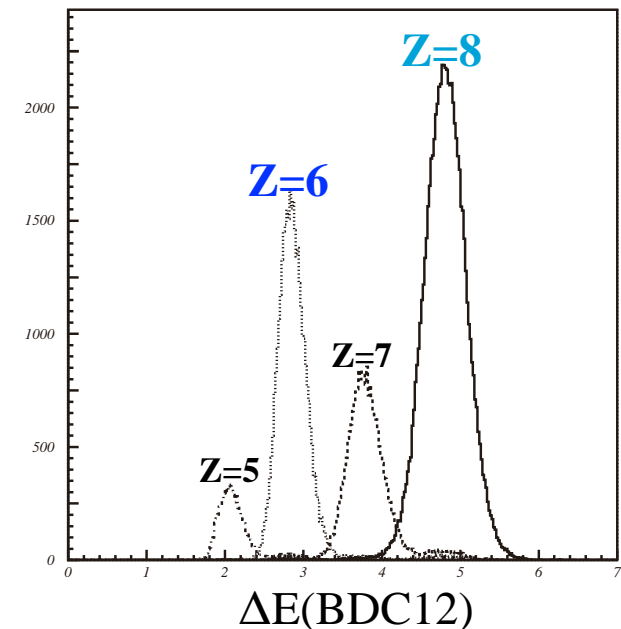
300  $\mu\text{m} \rightarrow < 200 \mu\text{m}$

\* Tracking efficiency

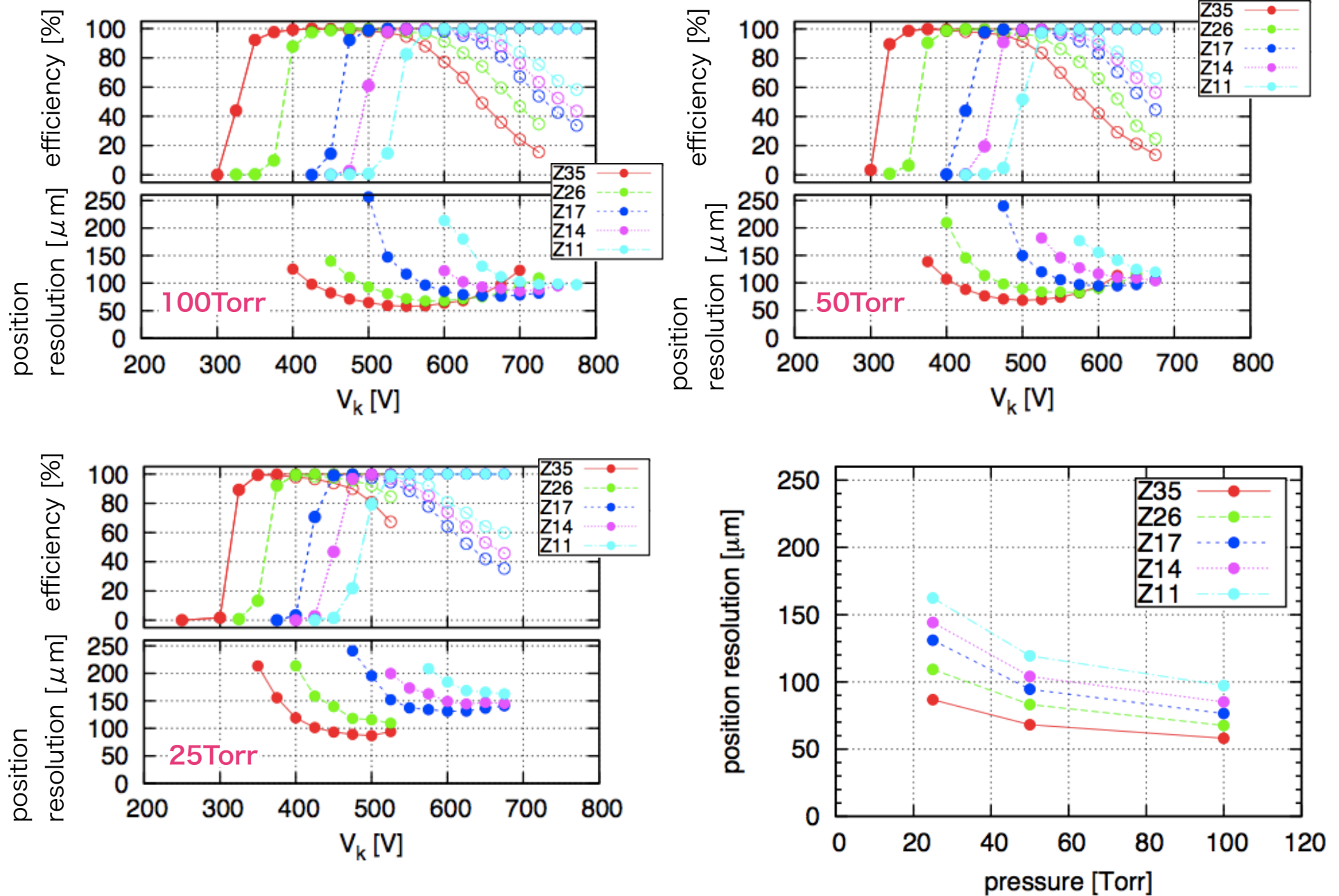
$\epsilon > 99.5\%$

\*  $\Delta E$  information

16 planes averaged  
moderate Z resolution

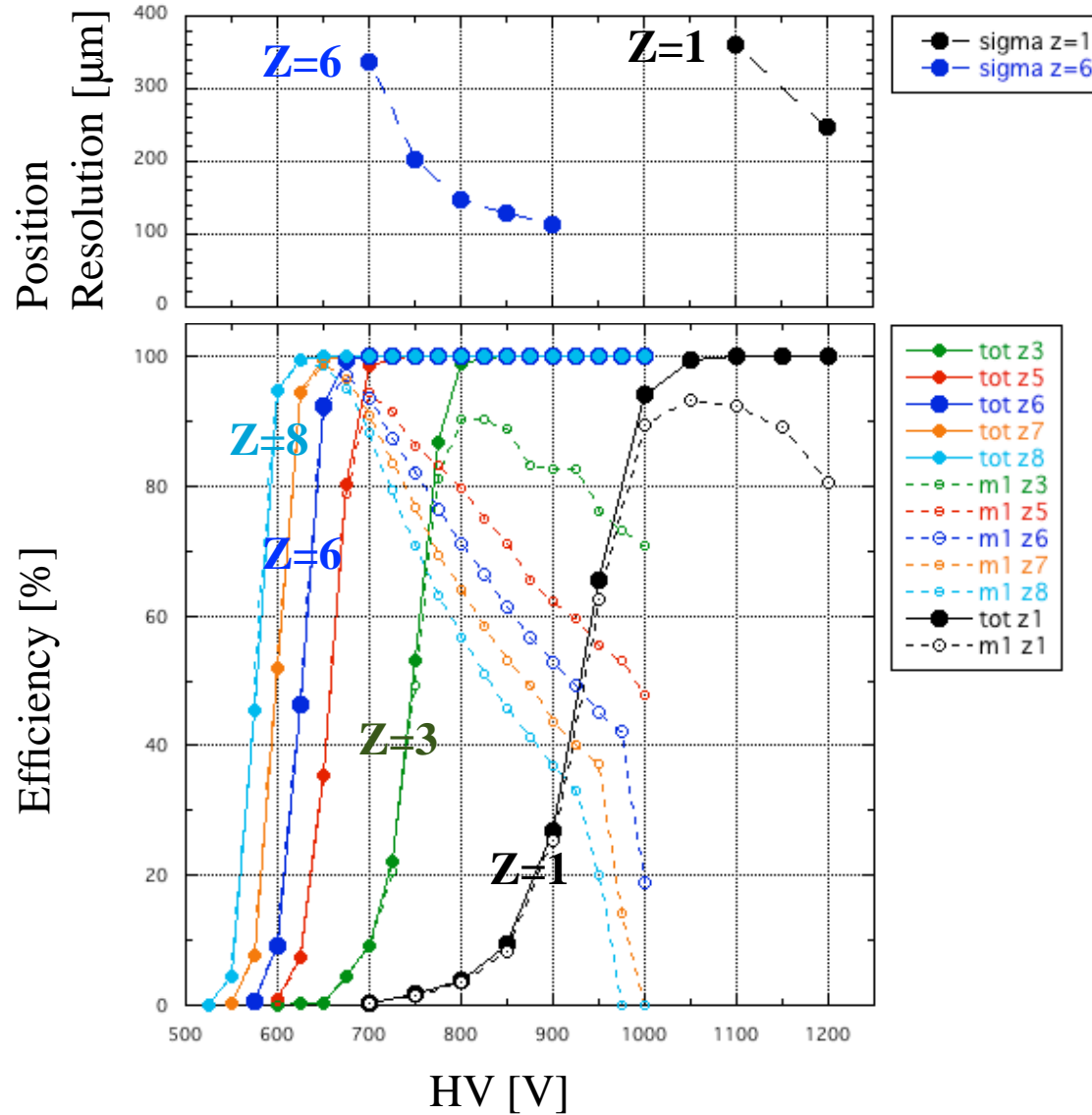


# BDC - 3 : position resolution for high z (11 ~ 35) @HIMAC



# FDC1 - 2 : response for $Z=1\sim 8$

o Pressure= 50 torr,  $E_b= 200$  MeV/u,  $V_{th}=-0.4$ V



\* Detection efficiency

stable plateau,  $\epsilon \sim 100\%$

\* Position resolution  $\sigma_x$

300  $\mu\text{m} \rightarrow < 200\mu\text{m}$  (z=6)

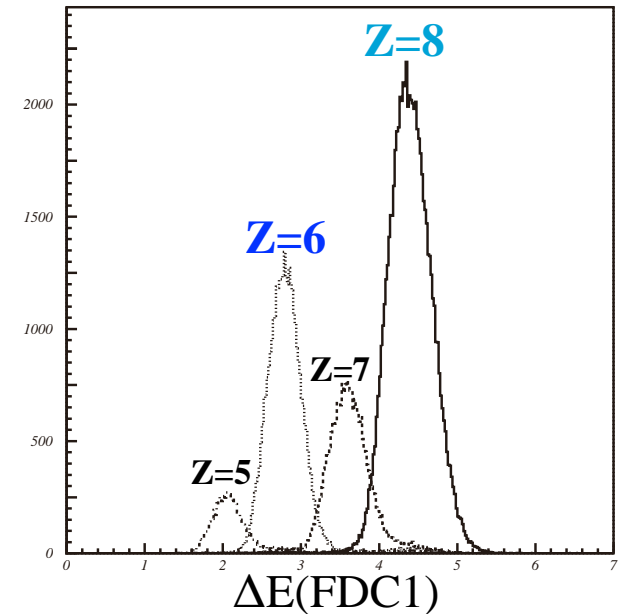
\* Tracking efficiency

$\epsilon > 99.5\%$

\*  $\Delta E$  information

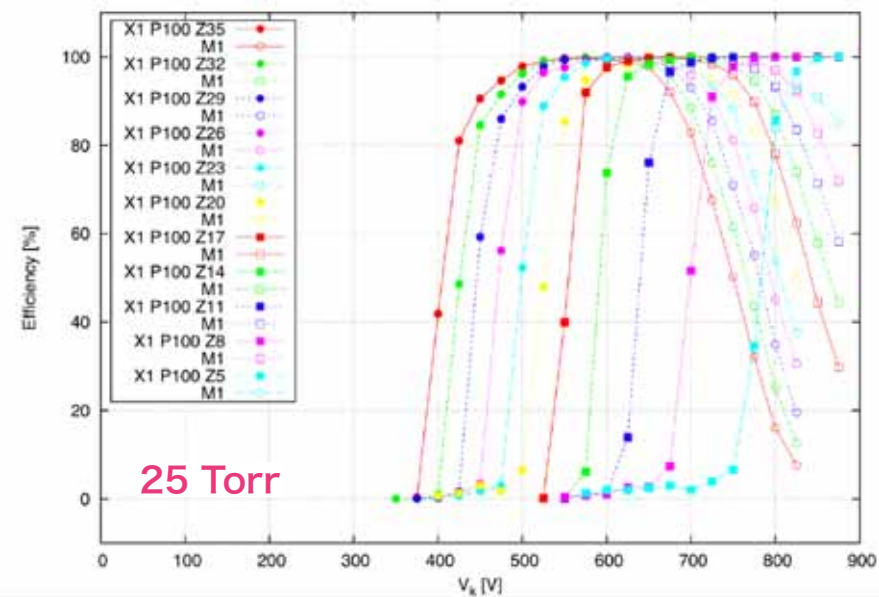
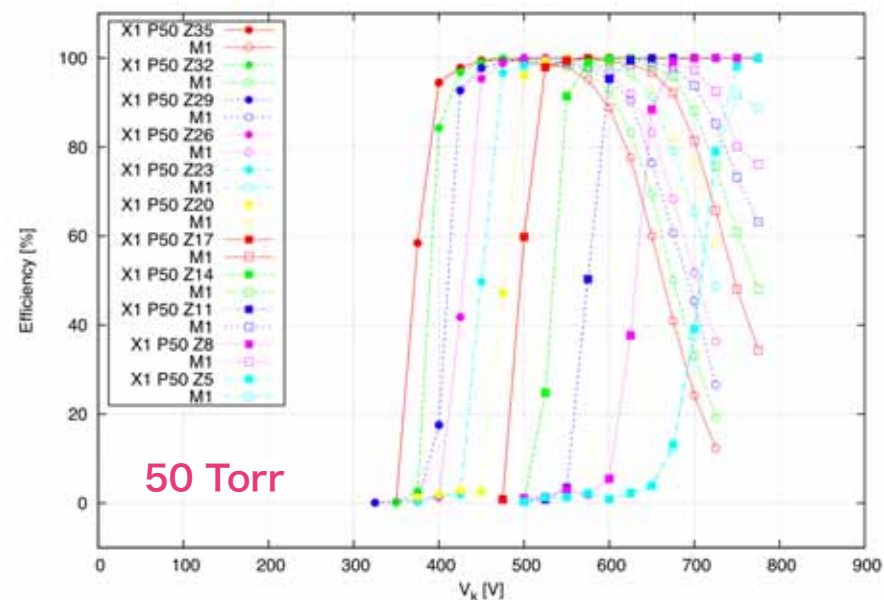
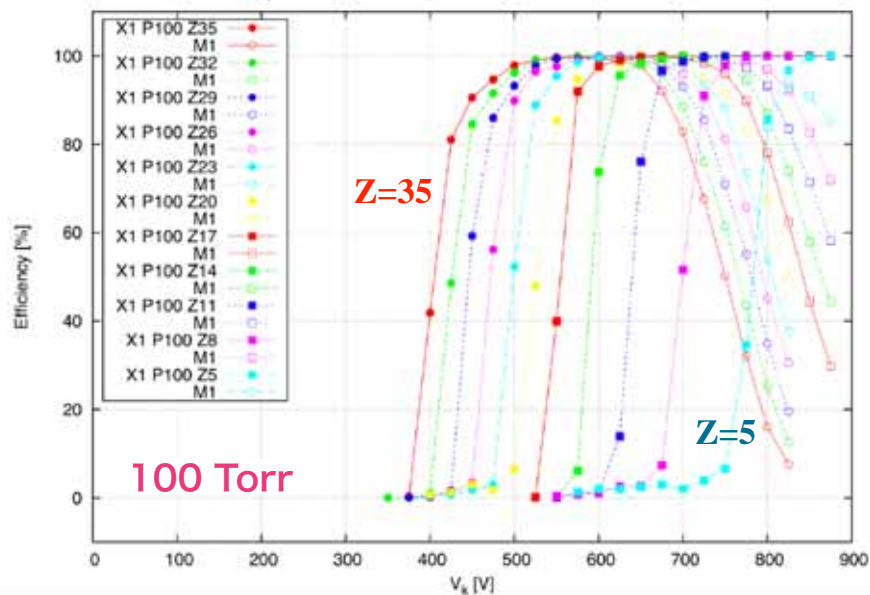
14 planes averaged

moderate Z resolution

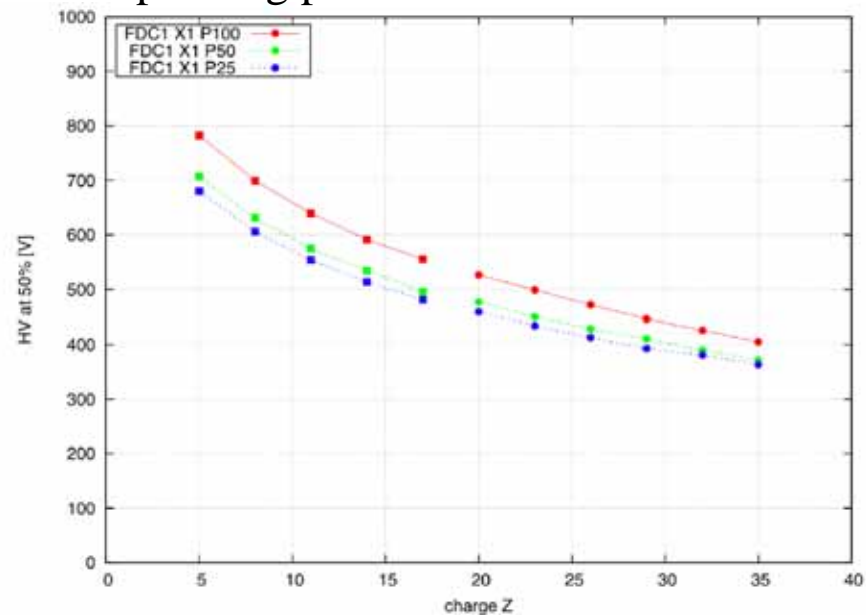


# FDC1 - 3 : response for high Z (5 ~ 35) @HIMAC

efficiency



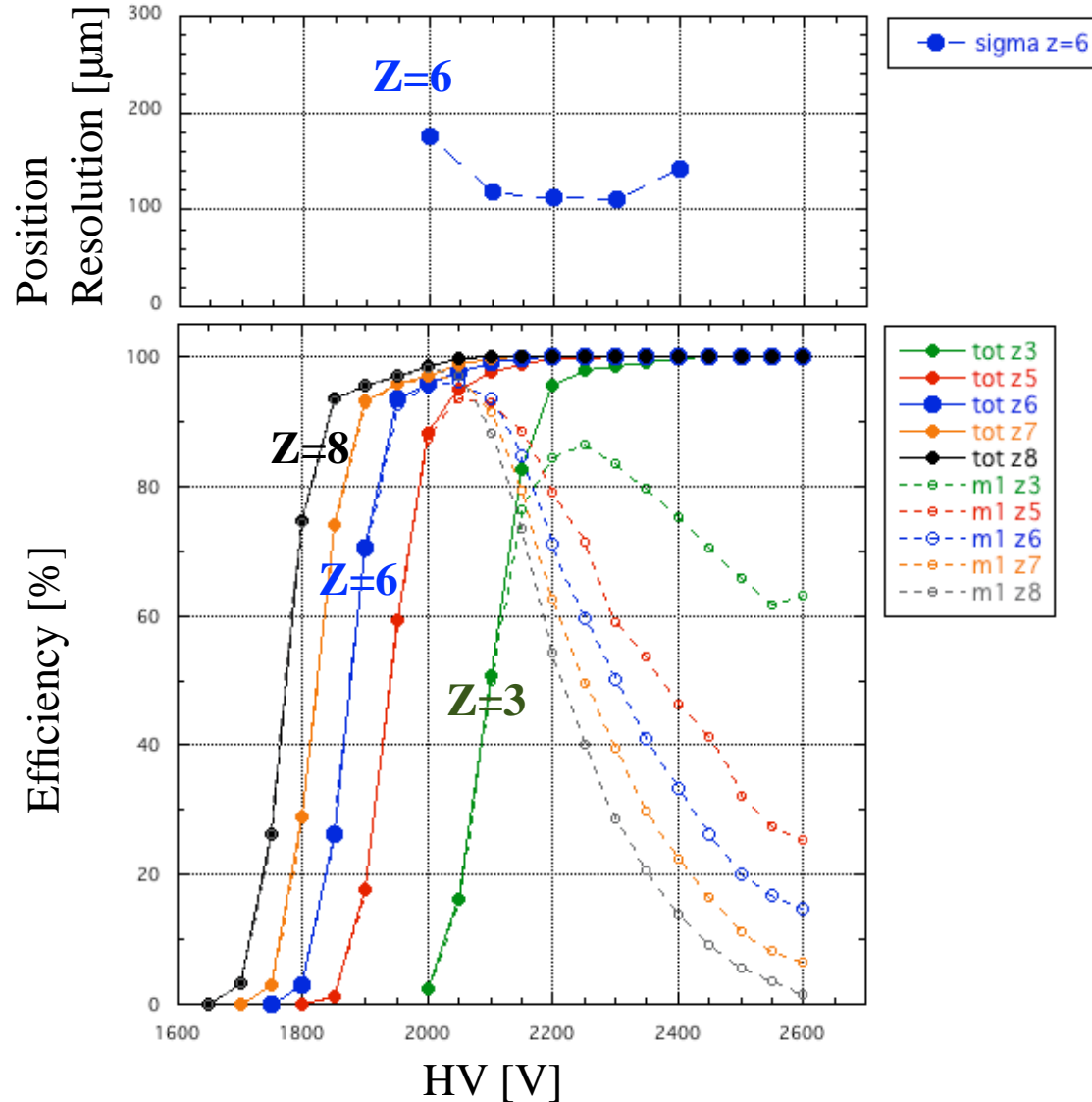
operating point





# FDC2 - 3 : response for Z=3~8

o  $E_b = 200 \text{ MeV/u}$ ,  $V_{th} = -0.8 \text{ V}$ , Gas = He+50% $\text{C}_2\text{H}_6$



\* Detection efficiency

stable plateau,  $\epsilon \sim 100\%$

\* Position resolution  $\sigma_x$

$200 \mu\text{m} \rightarrow \sim 100 \mu\text{m}$

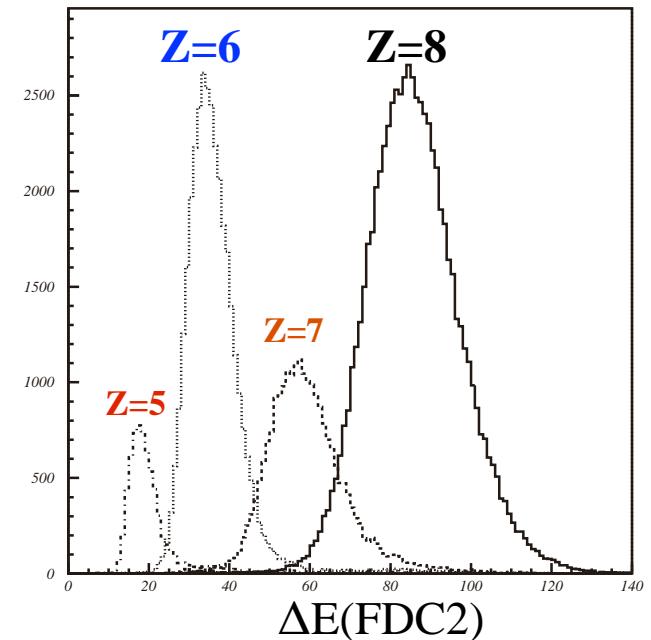
\* Tracking efficiency

$\epsilon > 99.5\%$

\*  $\Delta E$  information (cf. hex cell)

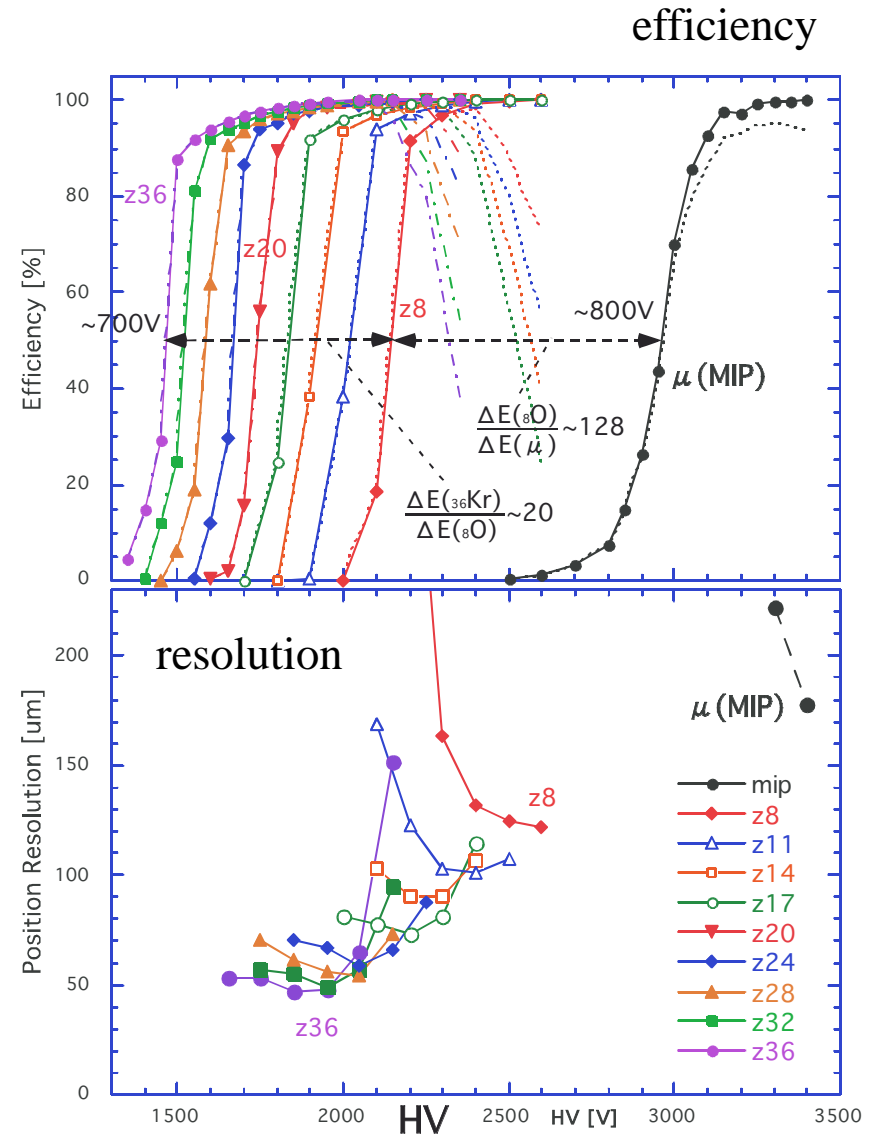
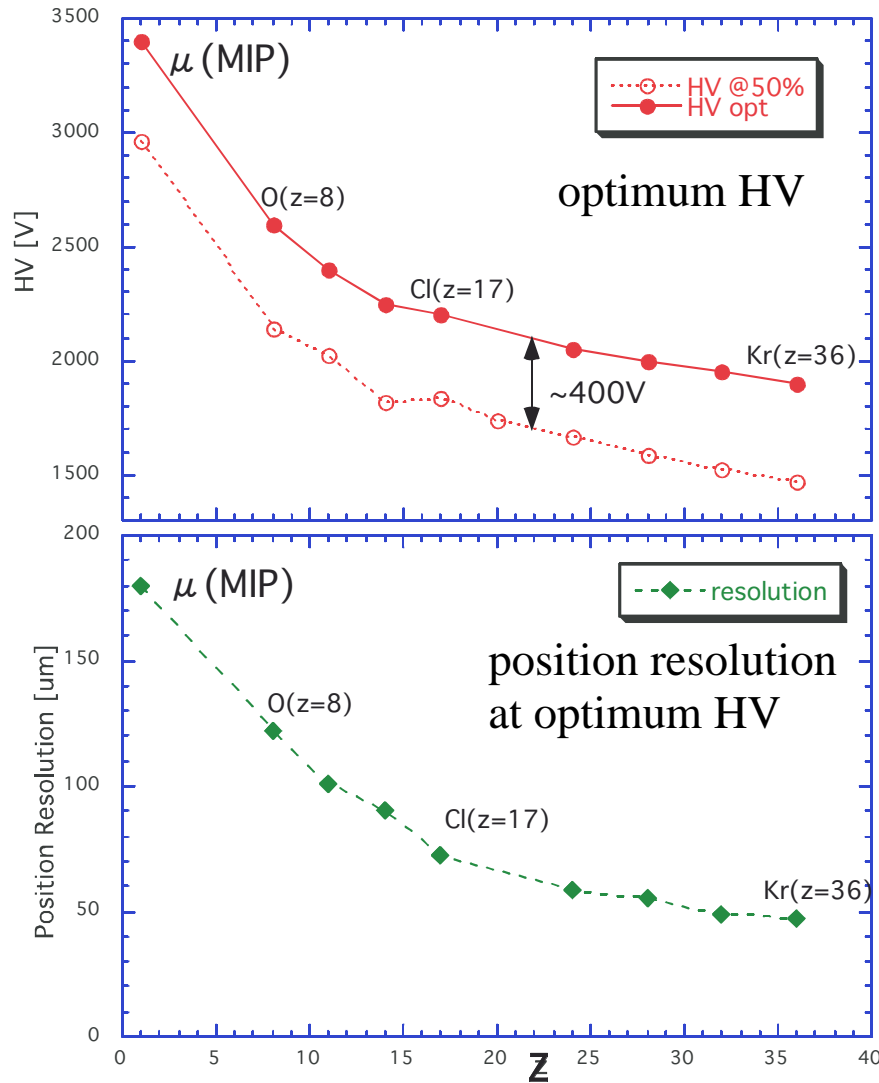
14 planes average

moderate Z resolution



# FDC2 - 4 : response for high Z (8 ~ 36) @HIMAC

\* gas : He+60%CH<sub>4</sub>

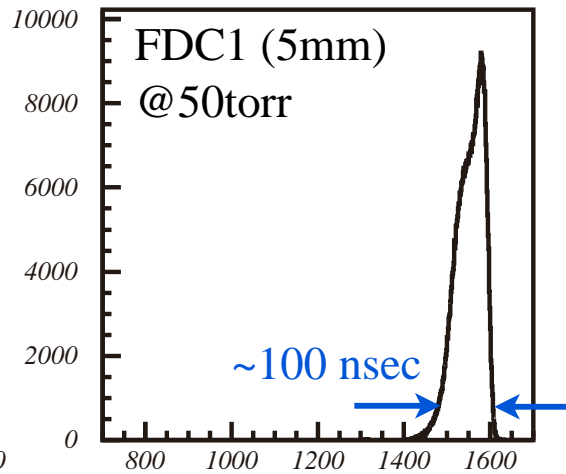
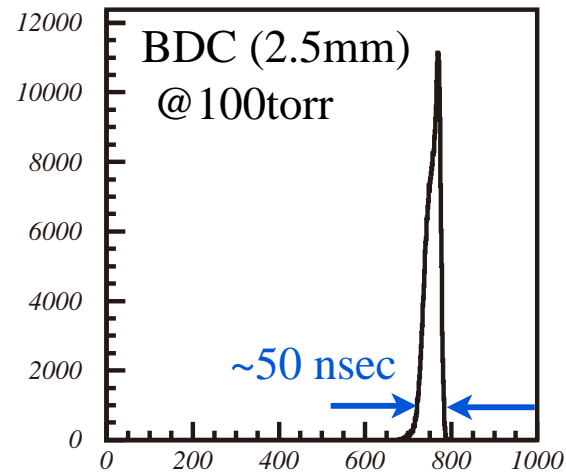




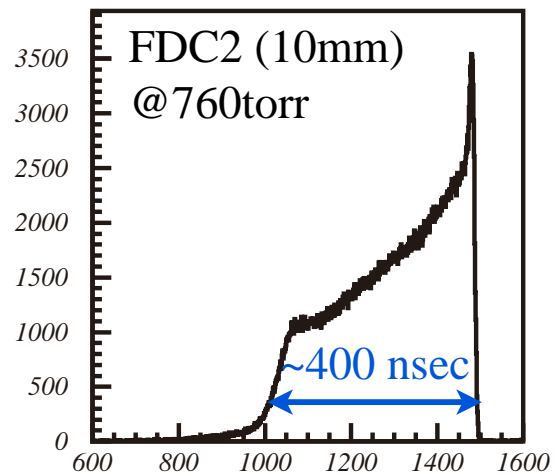
# Drift Chamber : memory time

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\* Drift (memory) time

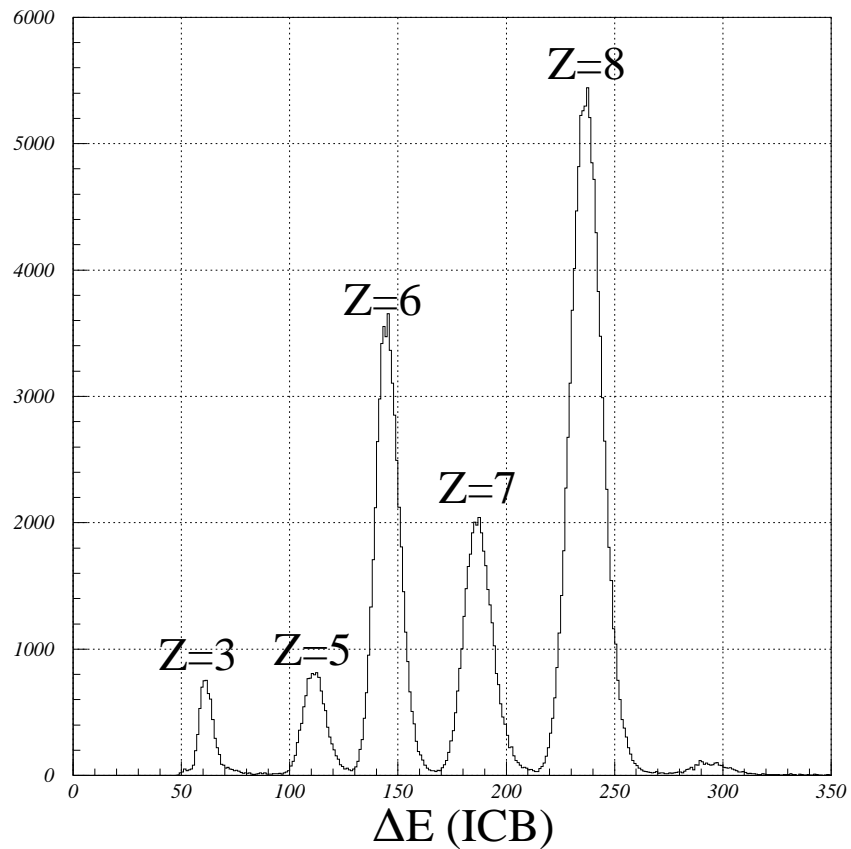


Drift Time (0.78nsec/ch)



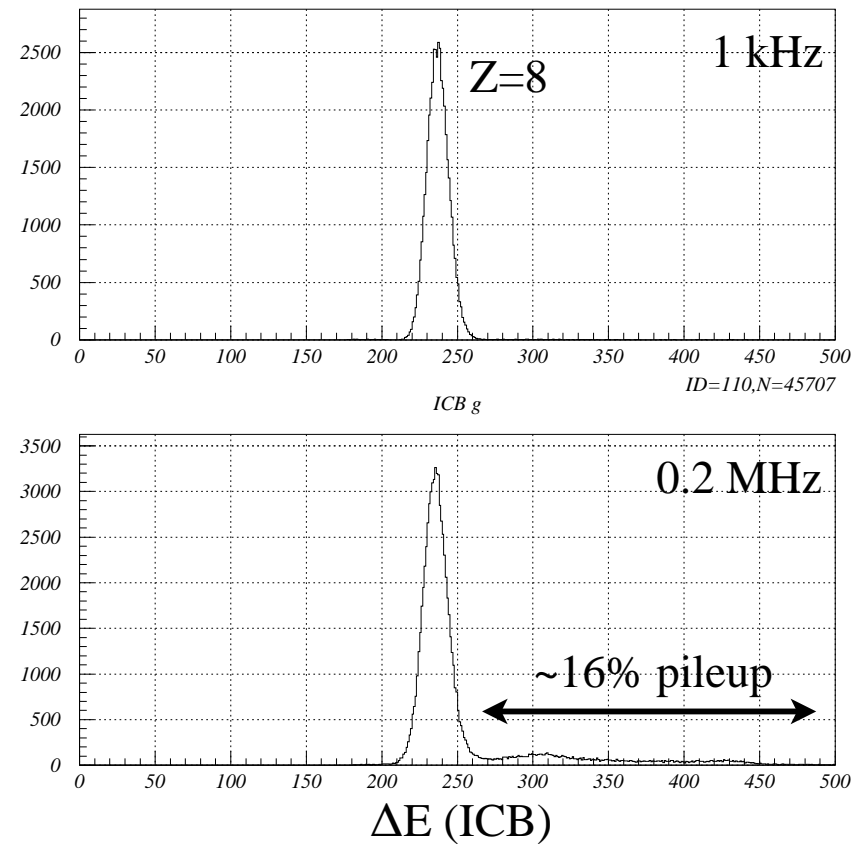
# ICB - 2 : response

\* Z= 3~8 (A/Z=2) @250MeV/u



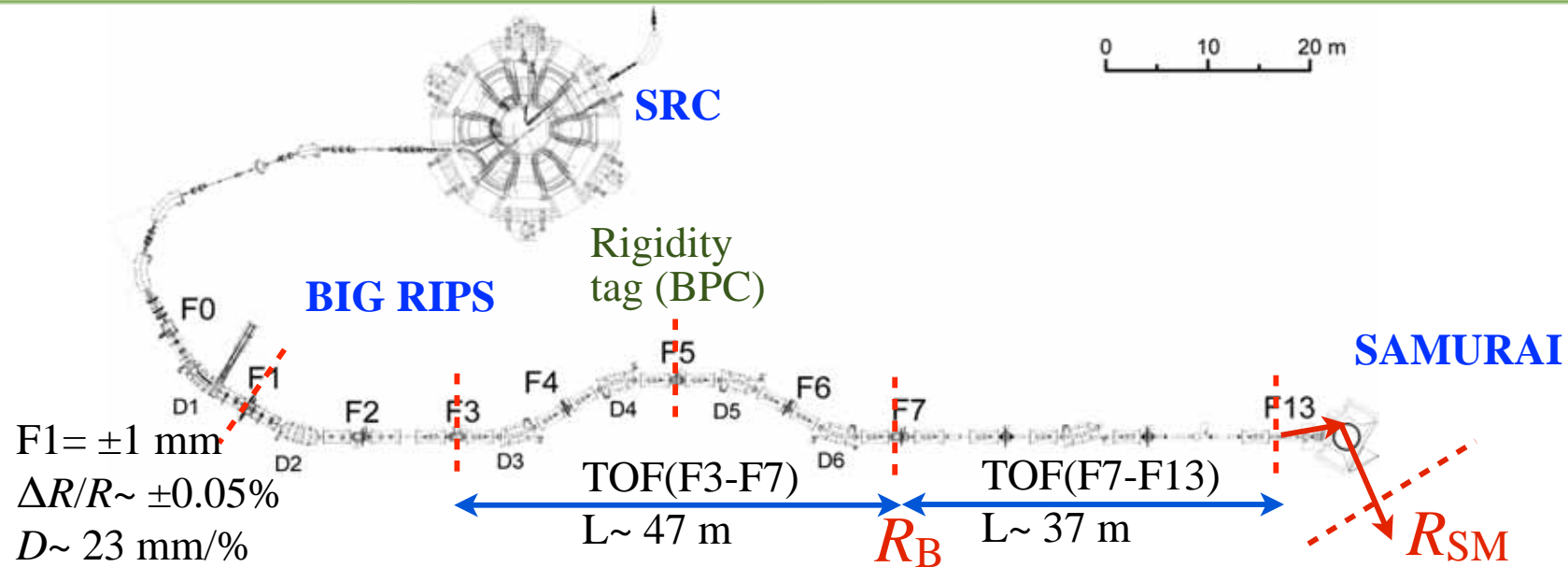
better resolution than 2mm<sup>t</sup> plastic

\* Rate dependence



• 要調査

# $B\rho$ scan & Rigidity reconstruction



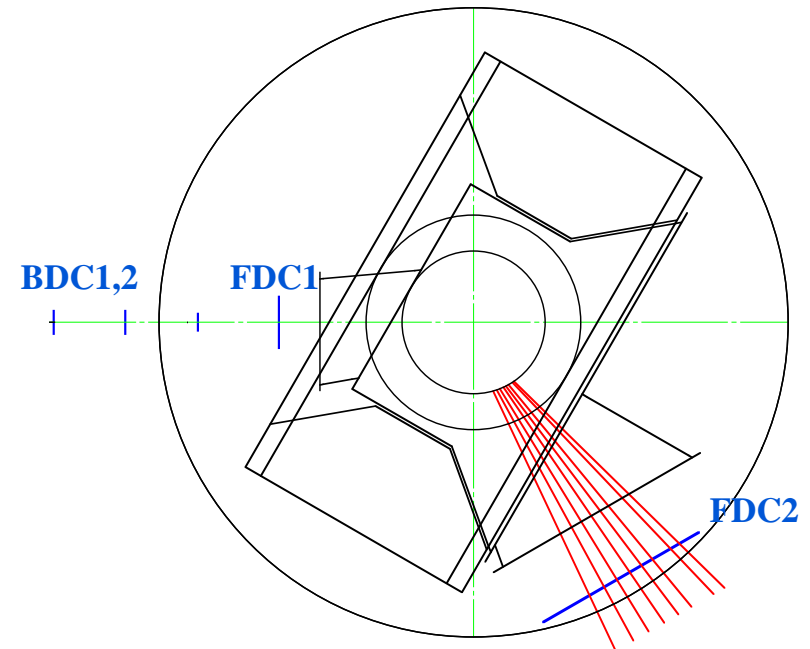
\*  $\Delta R_B/R_B \sim \pm 0.05\%$  ( $F1 = \pm 1 \text{ mm}$ )

with TOF(F3-F7) & TOF(F7-F13)

$B_{SM} = 2.0 \text{ T} : {}^{10,11,12,15}\text{C} \quad R = 1347 \text{ MeV}/c \pm 21\%$

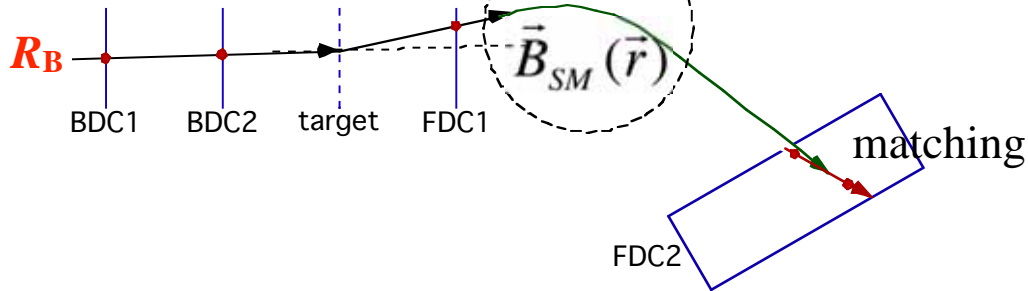
$B_{SM} = 2.5 \text{ T} : {}^{12,15,16,17}\text{C} \quad R = 1676 \text{ MeV}/c \pm 18\%$

$B_{SM} = 3.0 \text{ T} : {}^{10,11,12,14}\text{Be} \quad R = 2011 \text{ MeV}/c \pm 17\%$



# Magnetic Field & Detector Position

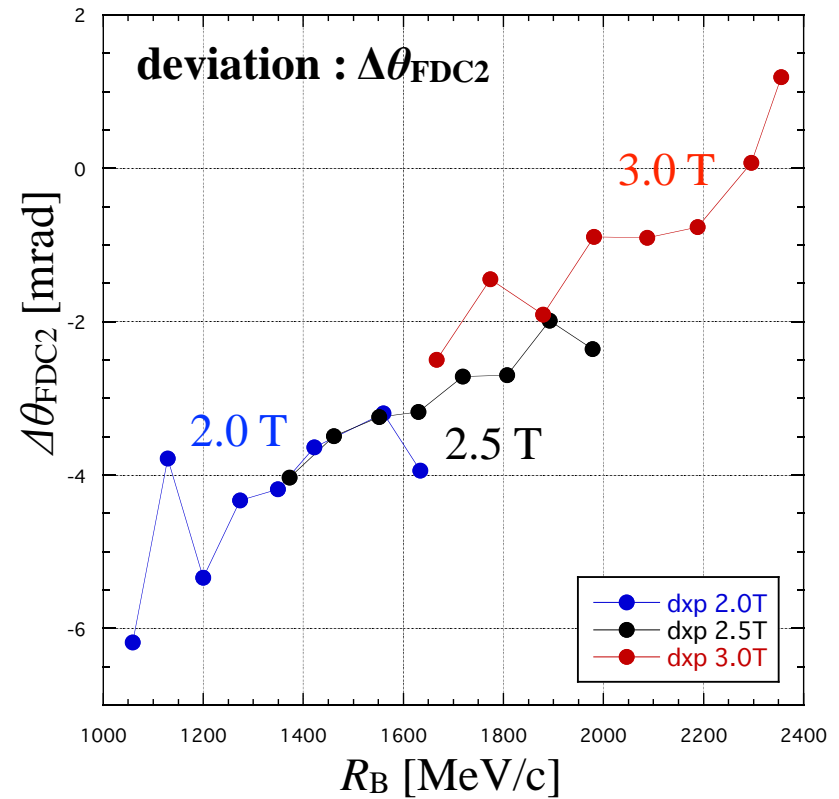
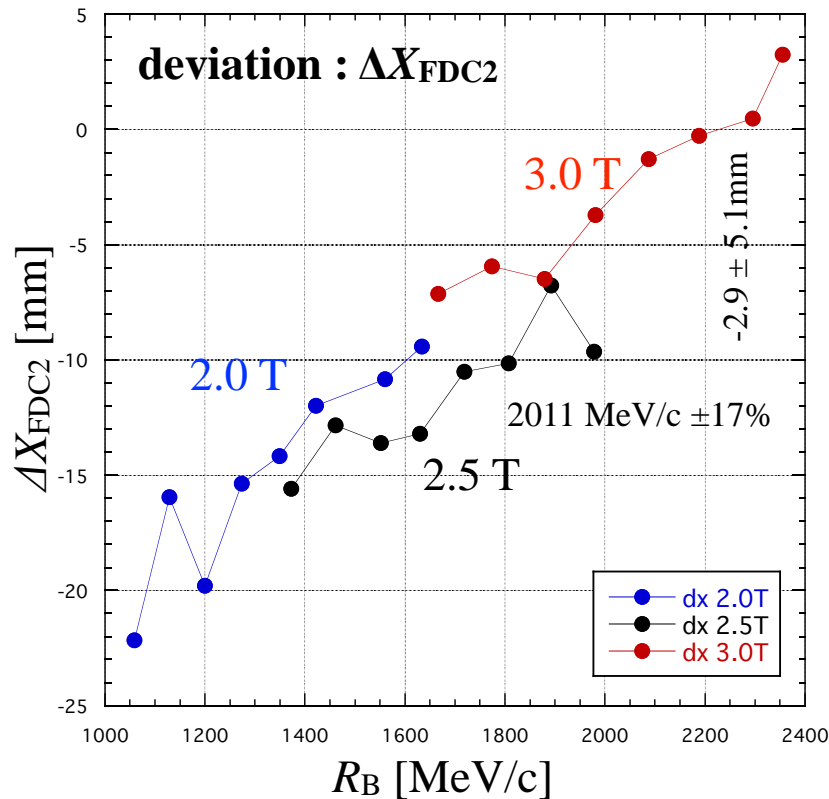
- Method



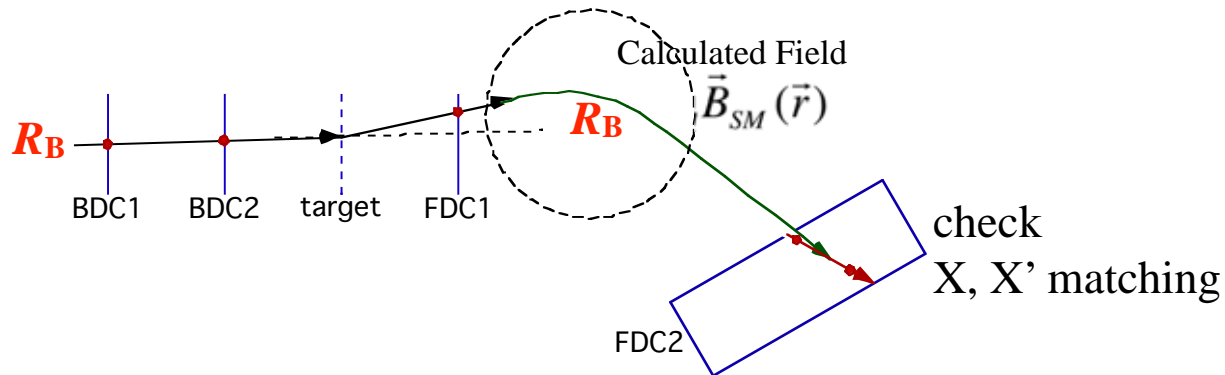
- Scattering angle resolution

$$\sigma_{\theta}(H,V) \sim 1 \text{ mrad}$$

- Consistency check using  $B\rho$  scan data :  $\Delta R_B/R_B \sim \pm 0.05\%$  @  $B_{SM} = 2.0, 2.5, 3.0 \text{ T}$



# Magnetic Field & Detector Position

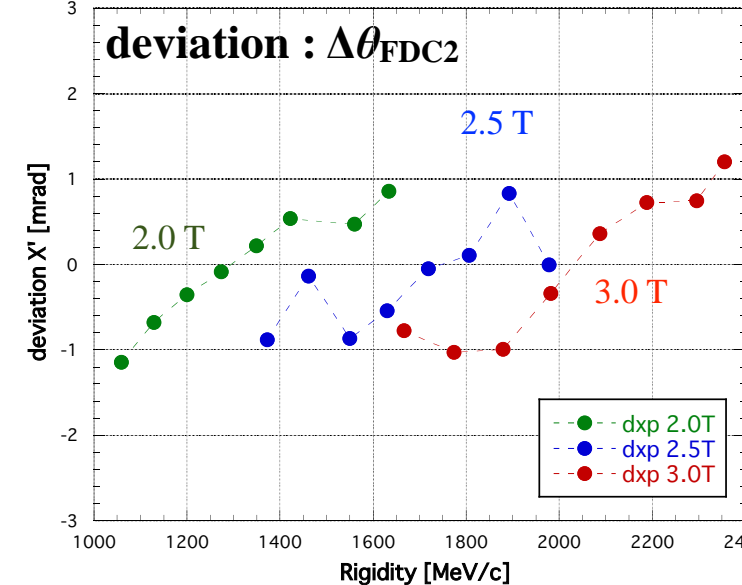
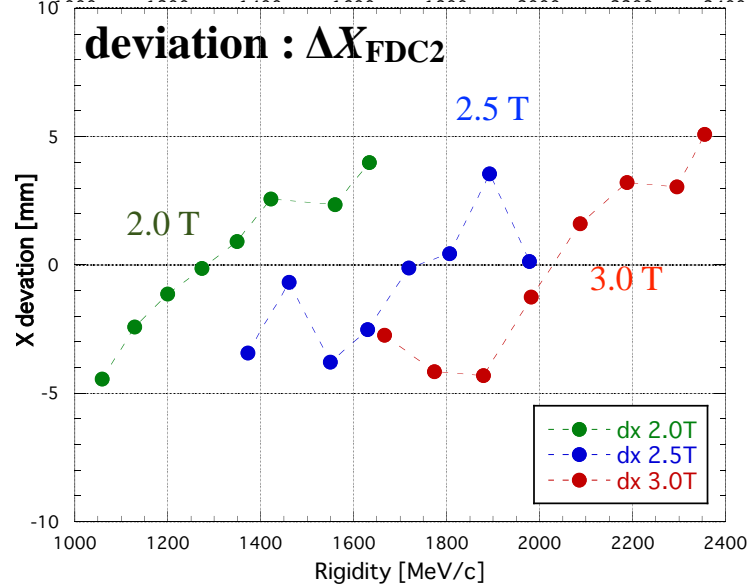
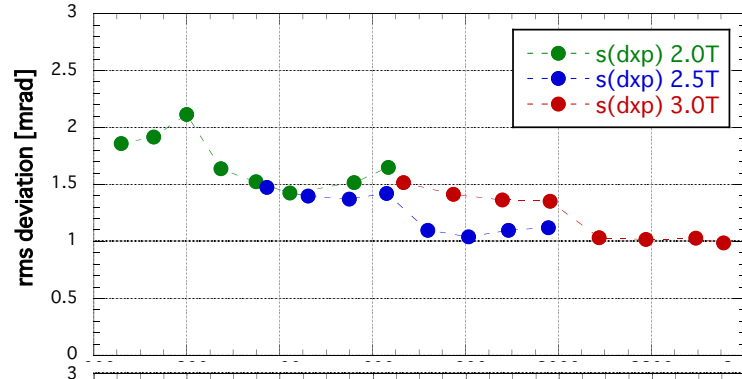
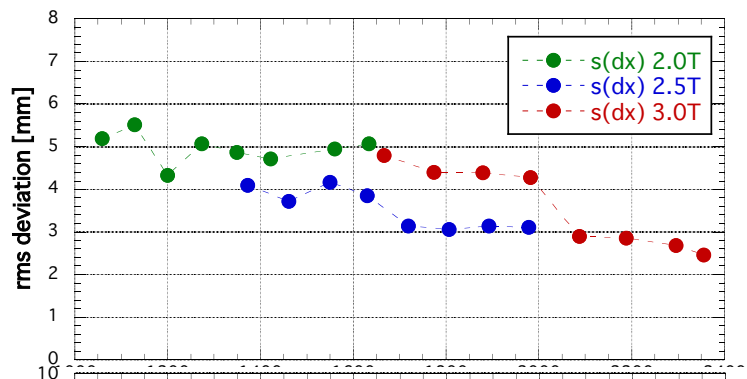


\* Magnetic Field scaled

$$f(2.0T) = +0.45\%$$

$$f(2.5T) = +0.35\%$$

$$f(3.0T) = +0.10\%$$



\* Deviation

$$\Delta x \sim \pm 5 \text{ mm}$$

$$\sigma(\Delta x) = 2 \sim 6 \text{ mm}$$

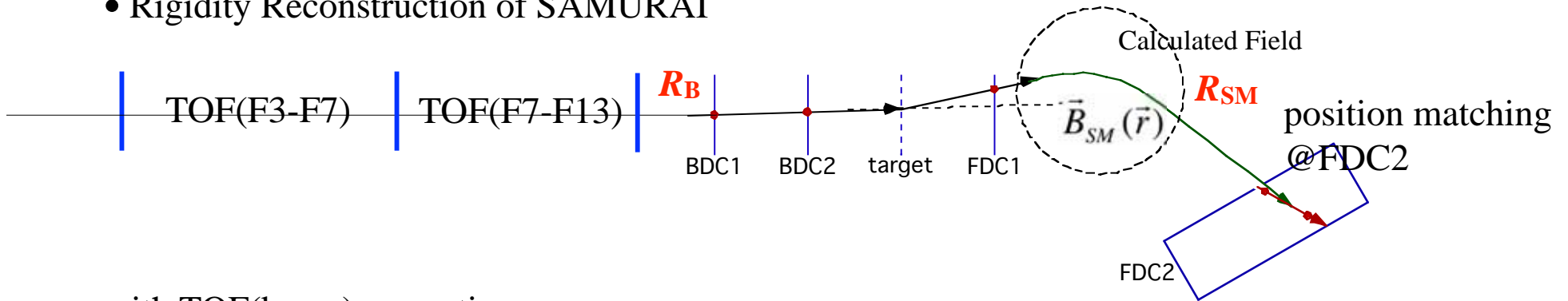
$$\Delta x' \sim \pm 1 \text{ mrad}$$

$$\sigma(\Delta x') = 1 \sim 2 \text{ mrad}$$

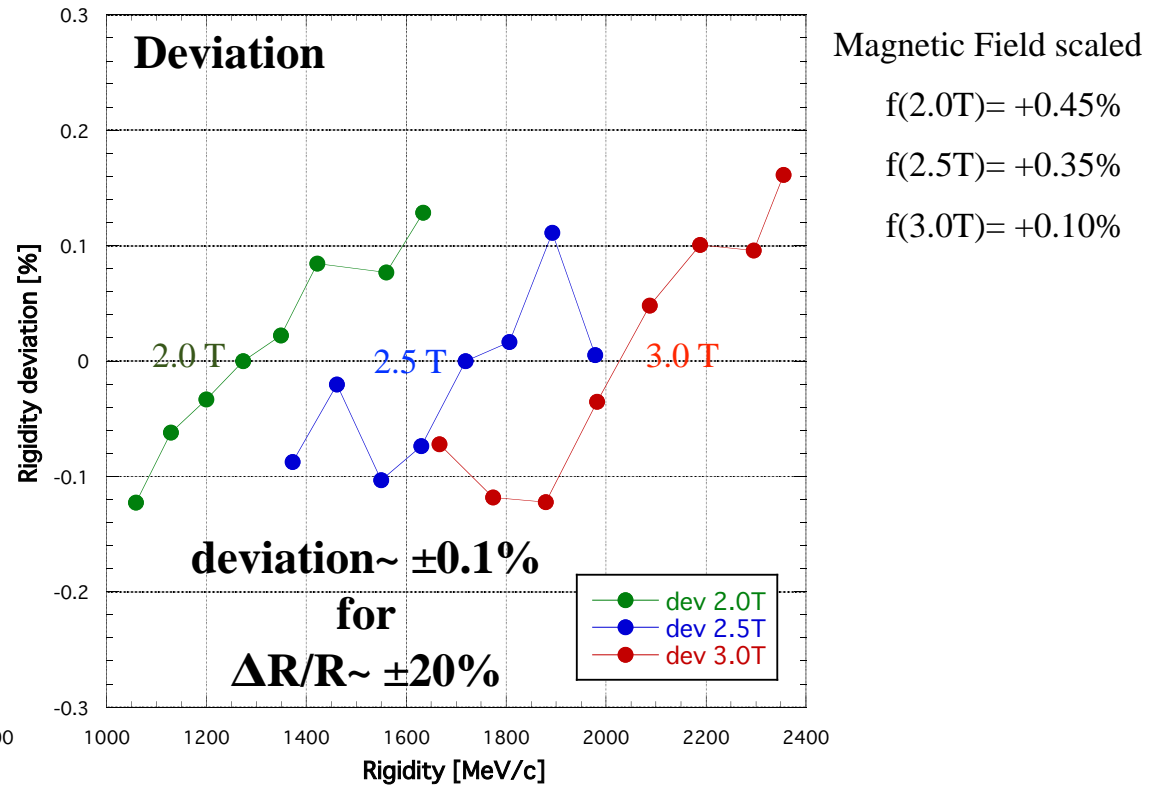
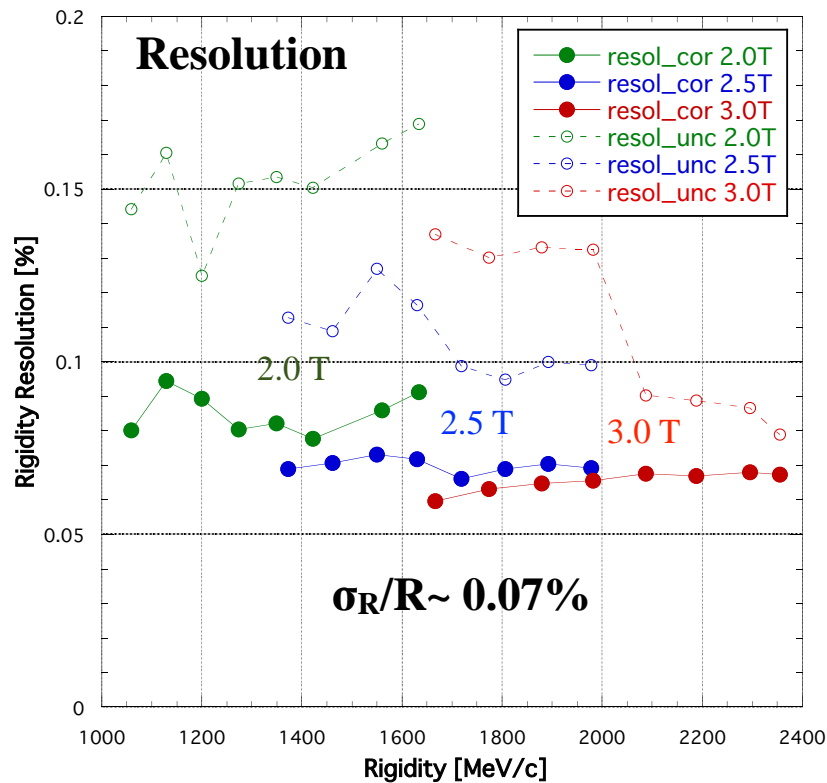
for  $\Delta R/R \sim \pm 20\%$

# Rigidity Resolution

- Rigidity Reconstruction of SAMURAI



with TOF(beam) correction

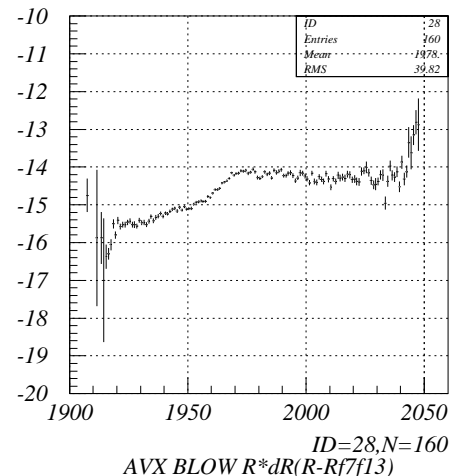
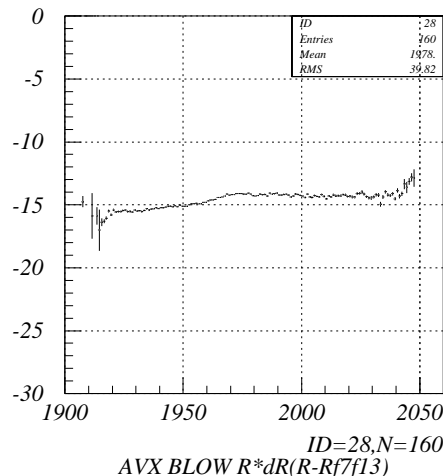
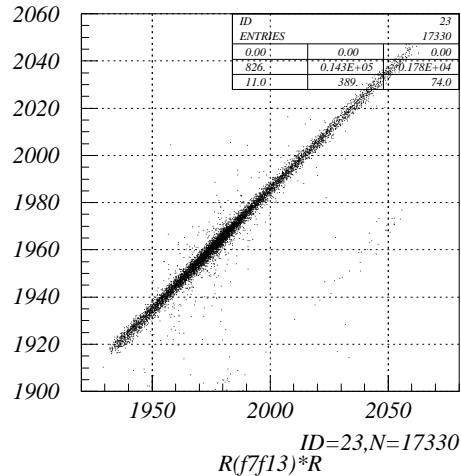
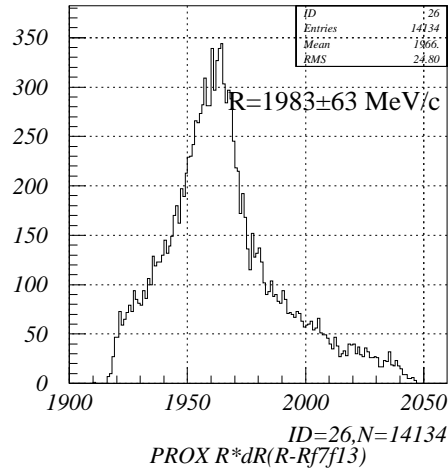
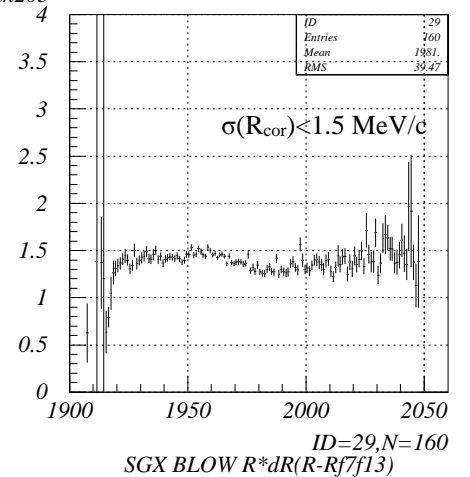
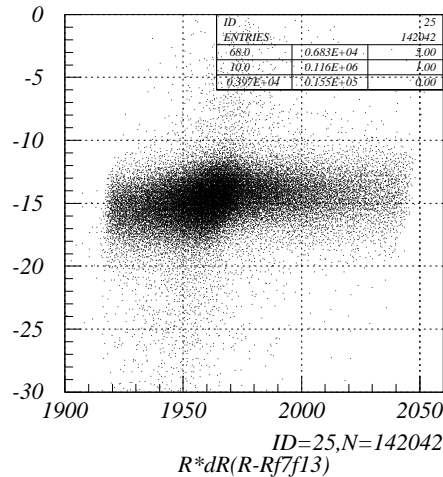
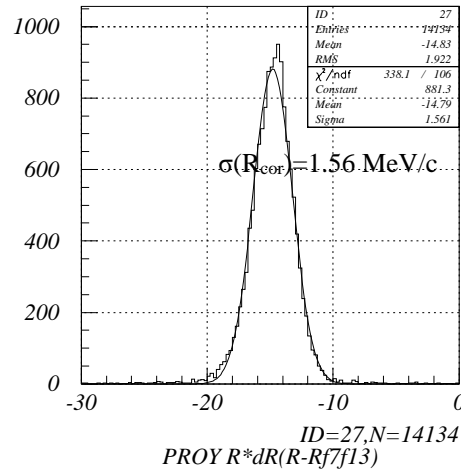
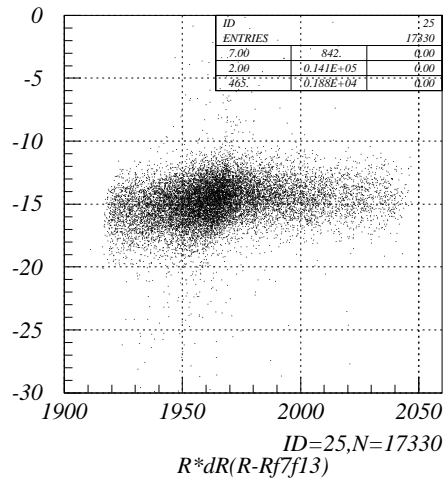


\* at least, inside the phase space tested

要：磁場計算／測定の比較



• Correlation :  $R_{\text{SM}}$  &  $R_{\text{beam\_from\_TOF(F7-F13)}}$



- 相関がある: 全幅で~1.5MeV/c
- 中心運動量で $\sigma(R_{\text{cor}})/R \sim 0.065\%$ 
  - 両側で少し広い: tilt angleの効果?

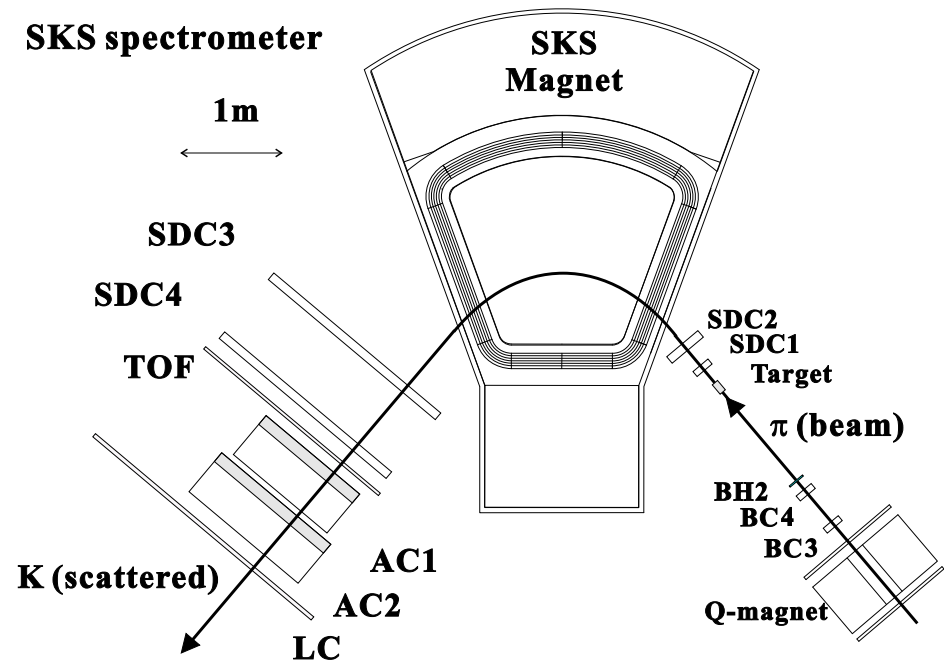
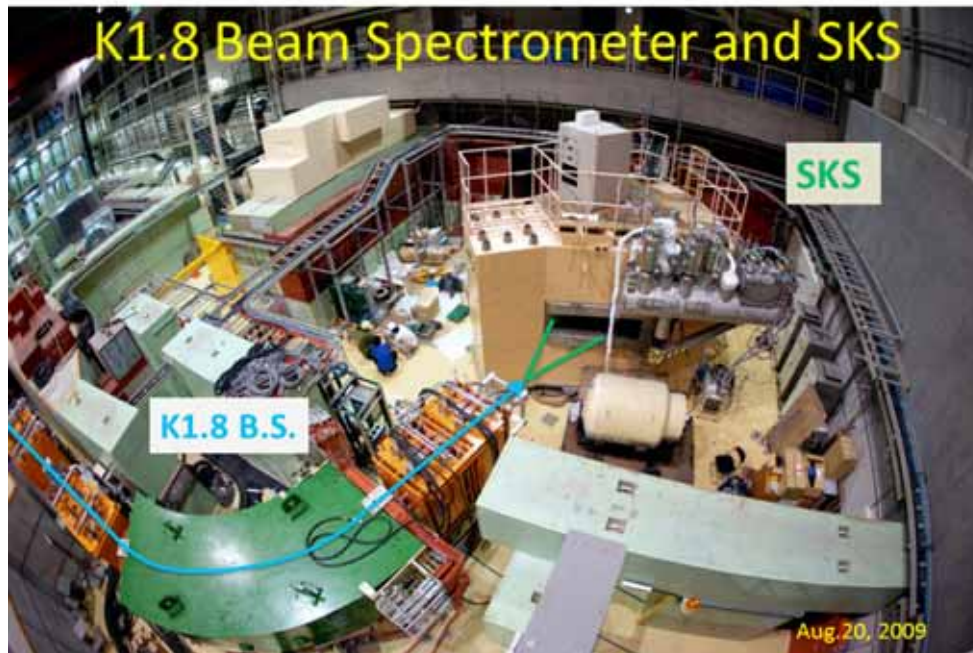
# SKS

- Sector magnet

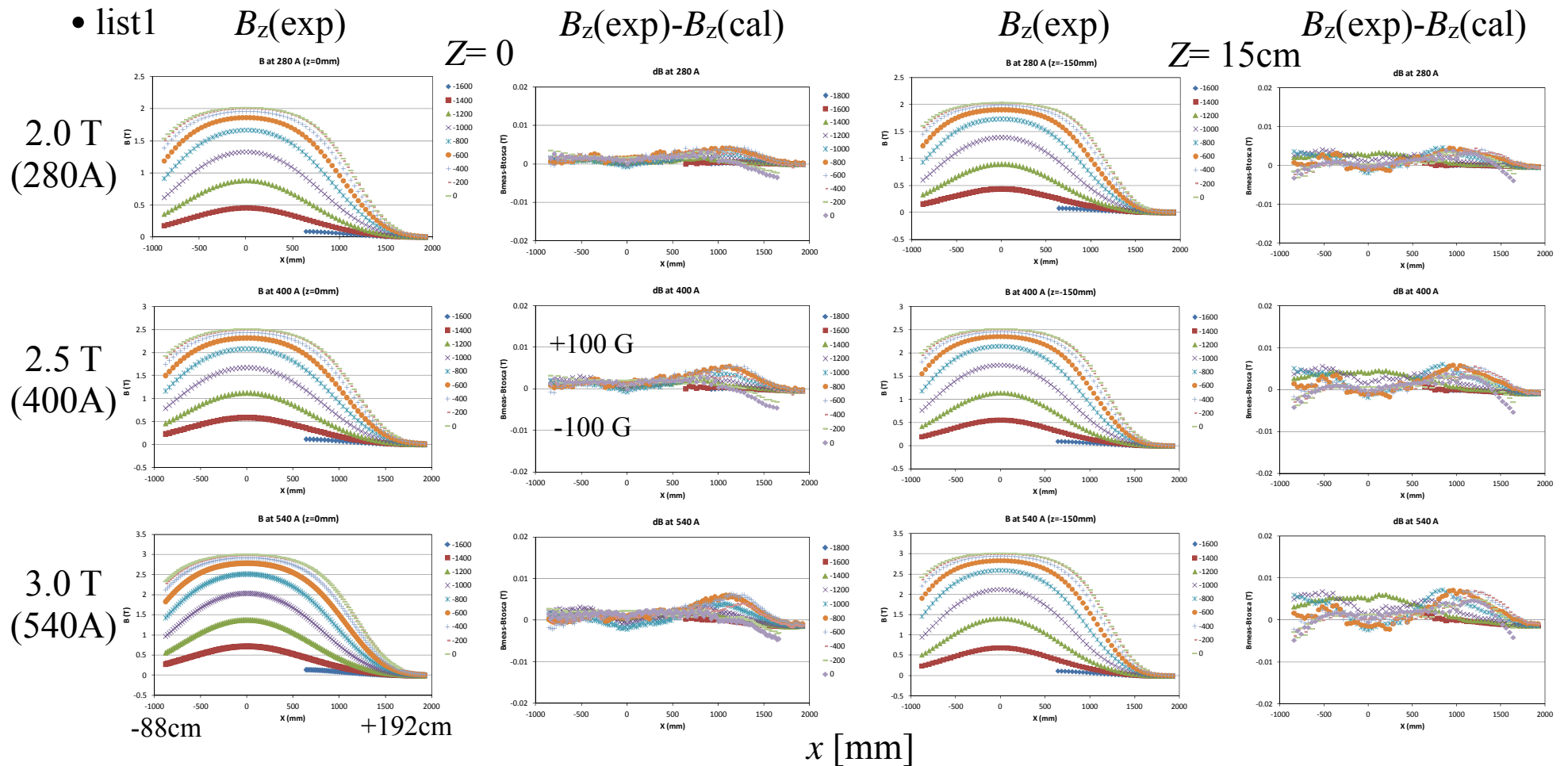
- $B_{\max}$  : 2.5T
- Stored energy : 6.3 MJ
- Ampere turn : 2.1 MAT
- $I_{\max}$  : 400A
- Total weight : 280 t
- Pole gap : 0.5m

- Performance

- Momentum range : 0.7 - 1.1 GeV/c
- Momentum resolution :  $\sim 0.2\%$  FWHM @1GeV/c
- Bending angle :  $100^\circ$
- Solid angle : 0.12 sr
- Vertical focusing :



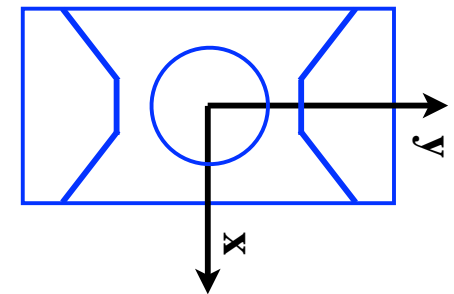
# Rough Field Measurement & Calculation



\* After normalization at origin

• Tentative conclusion

- ~consistent with the position error of probe
- use  $\mu$  out of available few sets (經過不明)



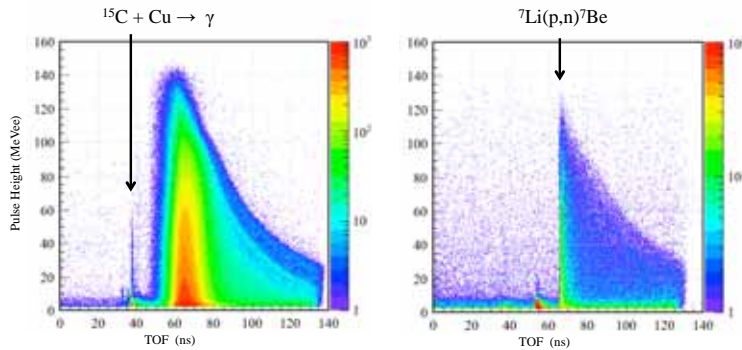
# EMISで使ったNEBULA関連のトラペ

## NEBULA - 3 : performance

by R.Tanaka (TIT)

- Detection Efficiency, Energy Resolution  
 ${}^7\text{Li}(p,n){}^7\text{Be}(gs+0.43\text{MeV})$  @ $E_p=200, 250\text{ MeV}$
- TOF Time Zero  
 $C({}^{15}\text{C},\gamma X)$  @ $E({}^{15}\text{C})=240\text{ MeV/A}$

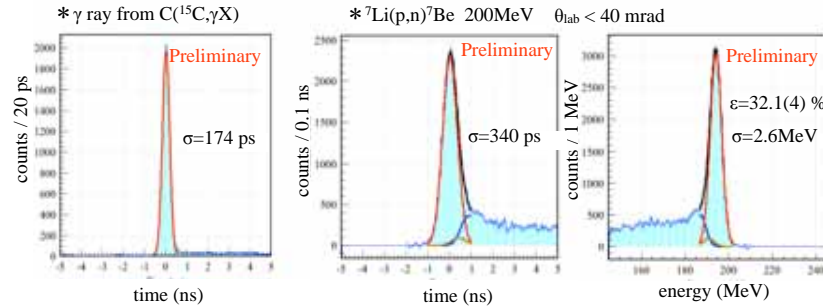
\* TOF - Pulse height



## NEBULA - 4 : Time / Energy Resolution, Efficiency

by R.Tanaka (TIT)

Preliminary



$V_{th}(\text{soft})=6\text{ MeVee}$

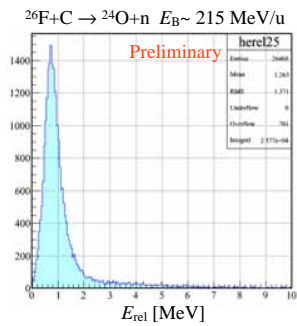
Intrinsic resolution

- $\gamma$  ray :  $\sigma_t=171\text{ ps}$
- 200 MeV neutron :  $\sigma_t=263\text{ ps}$ ,  $\sigma_p/p=0.57\%$

## Invariant-Mass Spectroscopy (check) - 1 : ${}^{25}\text{O}$

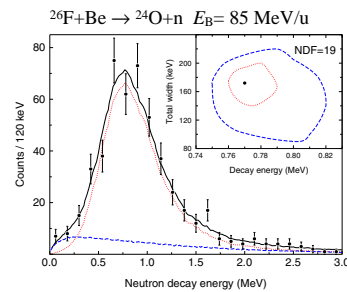
by Y. Kondo (TIT)

- ${}^{26}\text{F} + \text{C} \rightarrow {}^{24}\text{O} + n$ 
  - beam :  $E_B \sim 215\text{ MeV/u}$ ,  $I_B \sim 2.5\text{ kHz}$
  - target :  $2\text{ g/cm}^2\text{ C}$
- Relative energy distribution



\* no empty subtraction

• Previous data

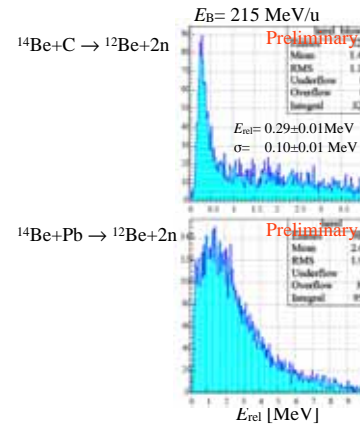


C.R.Hoffman et al., PRL100, 152502 (2008)  
 $E({}^{26}\text{F})=85\text{ MeV/u}$ ,  $I_B=20\text{ Hz}$ , @NSCL

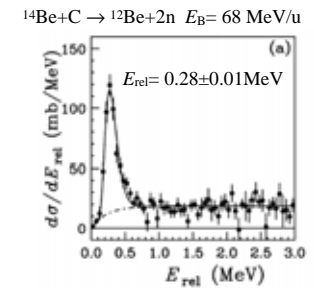
## Invariant-Mass Spectroscopy (check) - 2 : ${}^{14}\text{Be}$

by R. Tanaka (TIT)

- ${}^{14}\text{Be} + \text{Pb/C}/\text{emp} \rightarrow {}^{12}\text{Be} + 2n$ 
  - beam :  $E_B \sim 215\text{ MeV/u}$ ,  $I_B \sim 50\text{ kHz}$
  - target :  $\sim 2\text{ g/cm}^2\text{ Pb, C}$
- Relative energy distribution (no empty subtraction)



• Previous data



T. Sugimoto, et al., Phys. Lett. B 654 (2007) 160

$\sigma(E_{rel}) \sim 0.19\sqrt{E_{rel}}$   
 at both energies