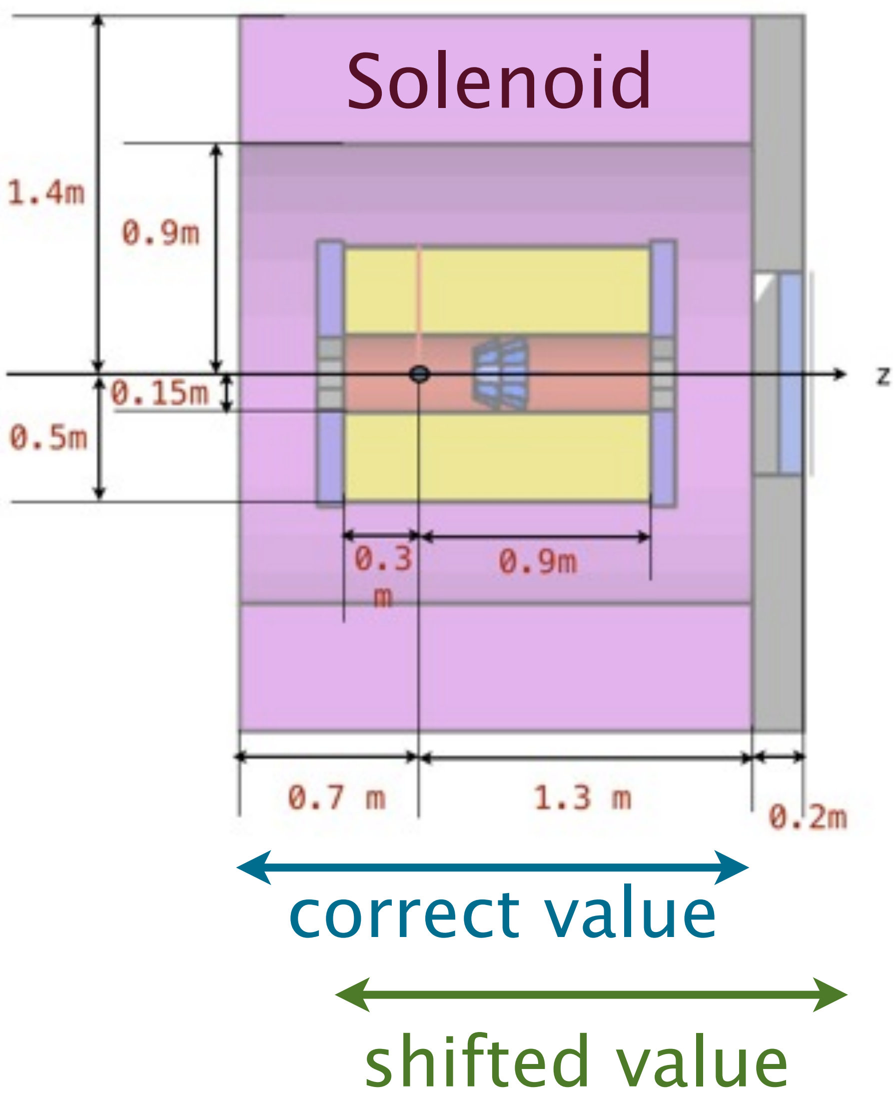
# 1. Solenoid Problem
# 2. fringe function for QD

**20130531 lab meeting**
**Songkyo Lee**

# Solenoid Problem

## NOTICE : Problem!!

**Solenoid B-Field from OPERA is not loaded properly**




1. A variable is not correct
   : Their name is given by GEANT4
   Correct : (x,y,z) = (Point[0],[1],[2])
   Current code : (Point[0],[1],[3])

2. The field range is wrong
   Correct : −0.7m ~ 1.3m
   Current code : −0.3m ~ 1.3m
   (Values are also shifted)

# Solenoid Problem

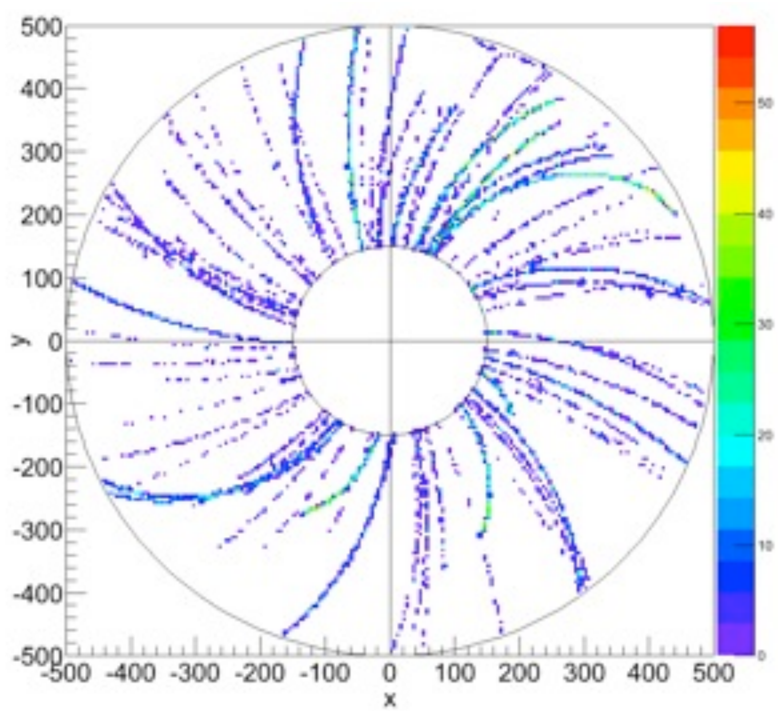


Comments from Young-Jin Kim (IBS)
LAMPS meeting 2013.05.03

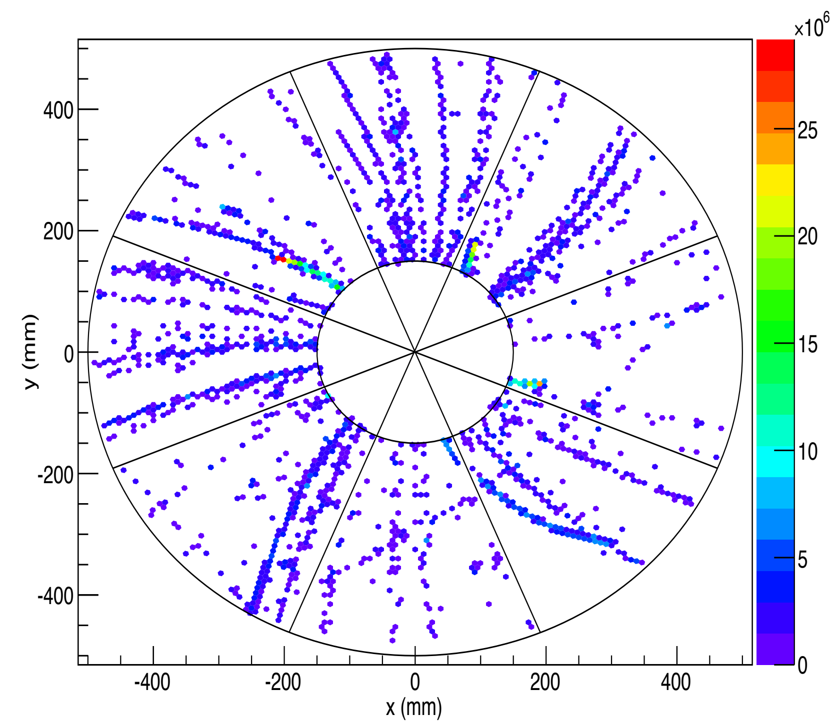
## 3. Direction of the B-field is the opposite

Before : Bz=+0.6T (positive)

Current code : Bz= -☆T (negative)




Before
(from Genie)




Current
(from Jung Woo)

# Solenoid Problem

- **Are the up-to-date simulation results reliable? (2012.12.28~)**

[Current GEANT4 Users]

1. Myself : FPD simulation – Solenoid field is turned off ⇒ OK
2. Eunah : Neutron simulation – not affected by B-field ⇒ OK
3. Yeonju : Not only neutron, charged particle included simulation
   – She is using the old code (constant B-field) ⇒ OK
   – It would be better to use OPERA
4. Jungwoo : TPC simulation ⇒ NOT OK!!!

- **Solution**

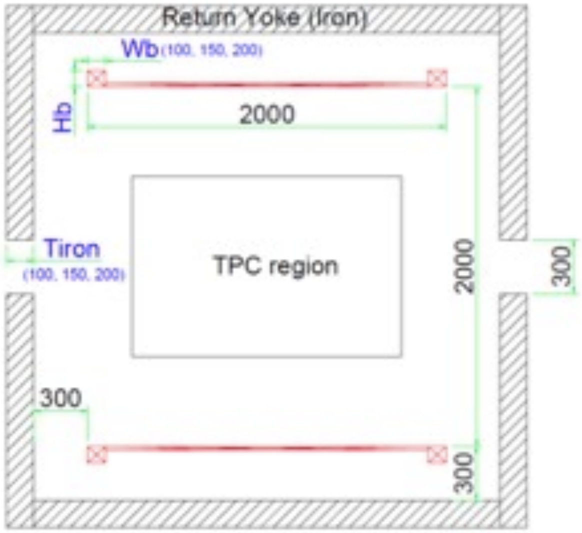
: I have fixed the problem for my code (discussed w/ Genie)
: update on the svn soon (http://nuclear.korea.ac.kr/websvn)
(planning to work with Jungwoo)

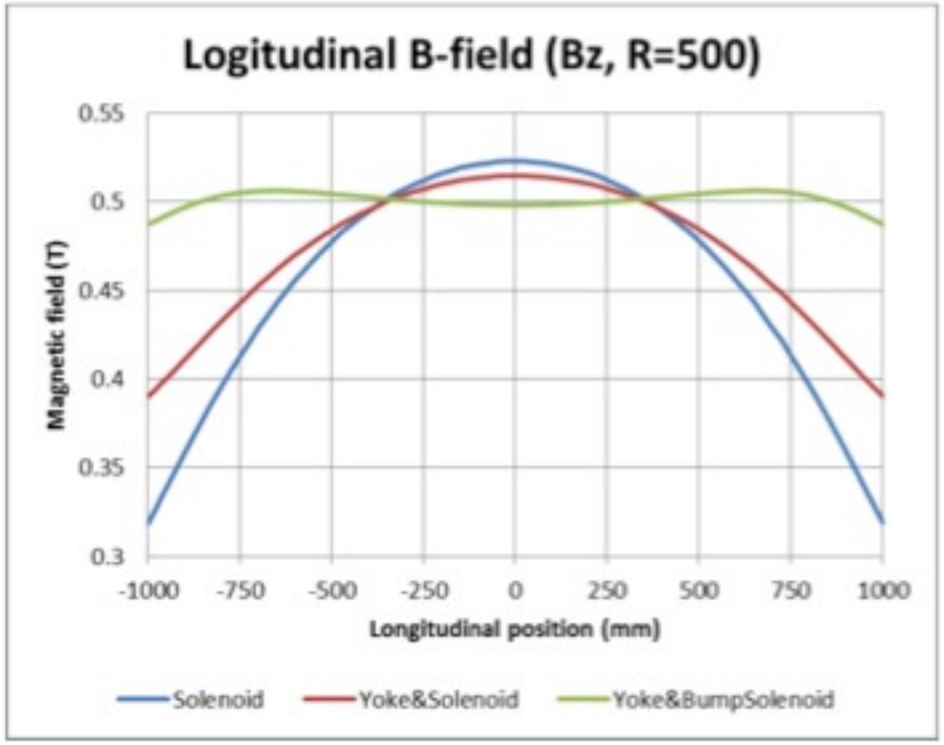
# Solenoid Problem

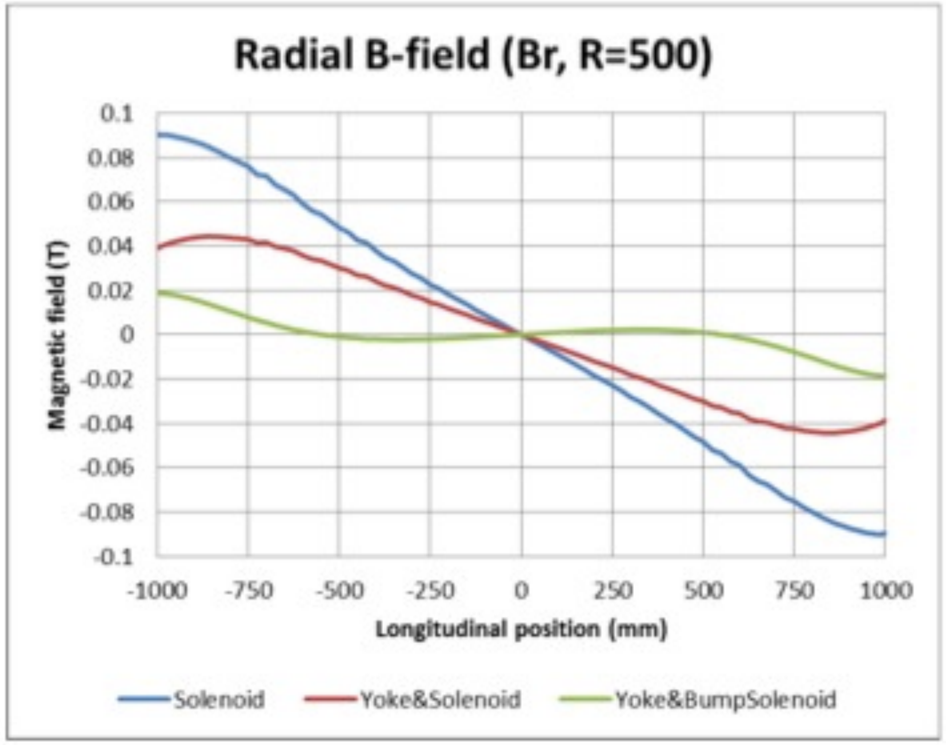
Dogyun Kim(IBS)
LAMPS workshop 2012.12.16

- **Question**

: Is the field map symmetric?
: Which configuration?
(Solenoid / Yoke&Solenoid / Yoke&BumpSolenoid)
: Is the solenoid inner diameter 1.8m or 2.0m?
: Is the fringe field outside not concerned (∵Yoke?)



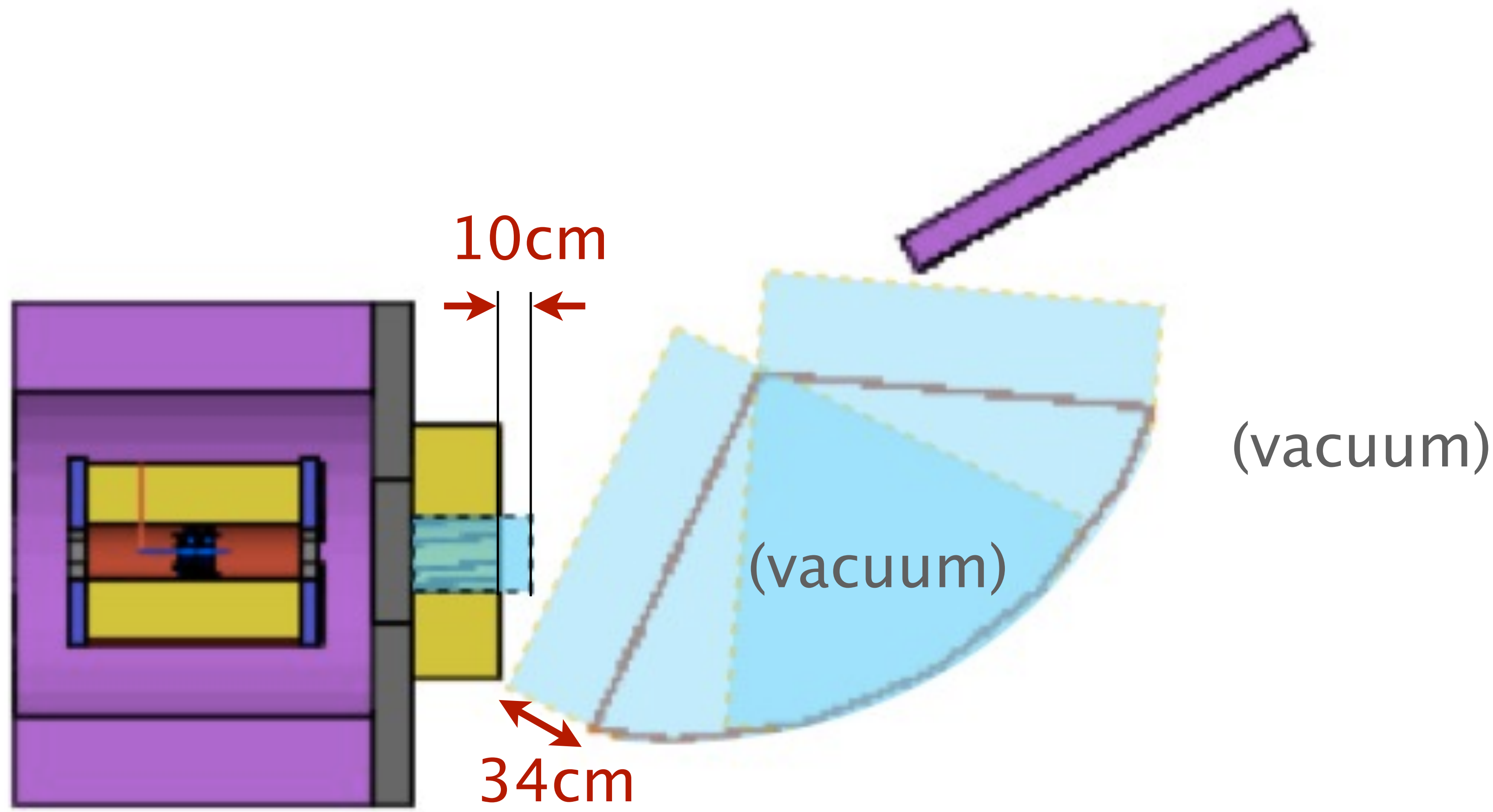



# Configuration

[07_LAMPS_QD_130401_fringe]

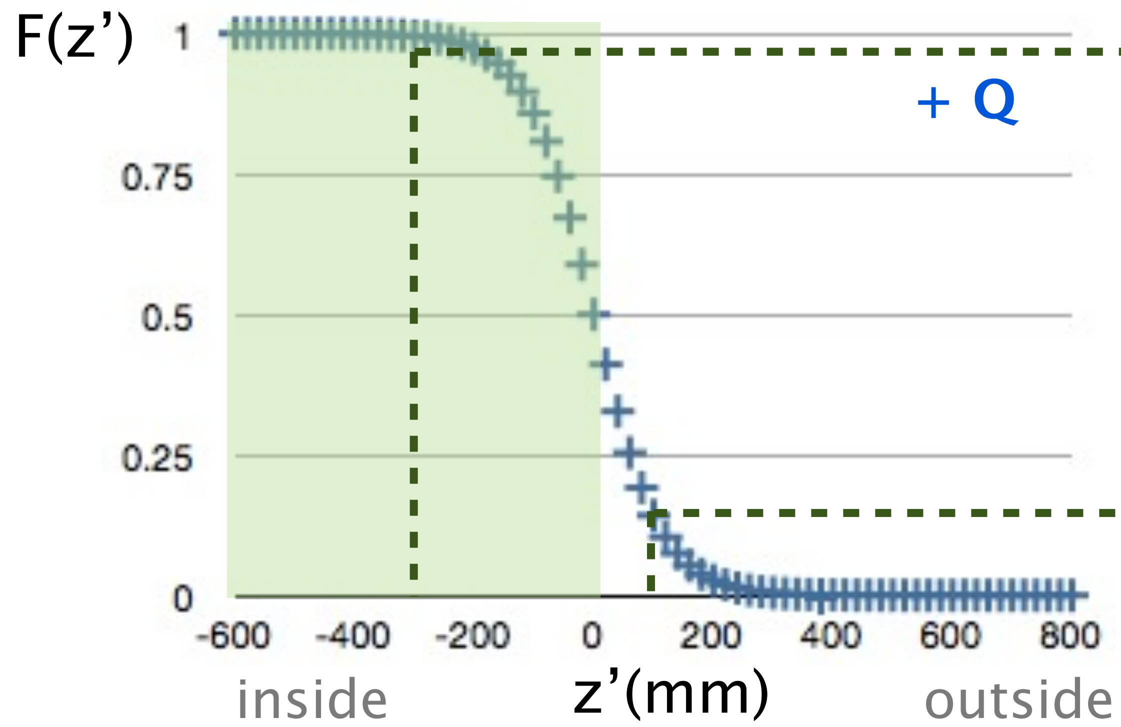
- **How to cut the field region (z')?**
  : Q & DP field region should not overlap (distance ~1cm)
  : At the same time, both Enge function value rather be similar




- No cut for inside the magnet
- No fringe function for the entrance region of Q-magnet

# Enge Function

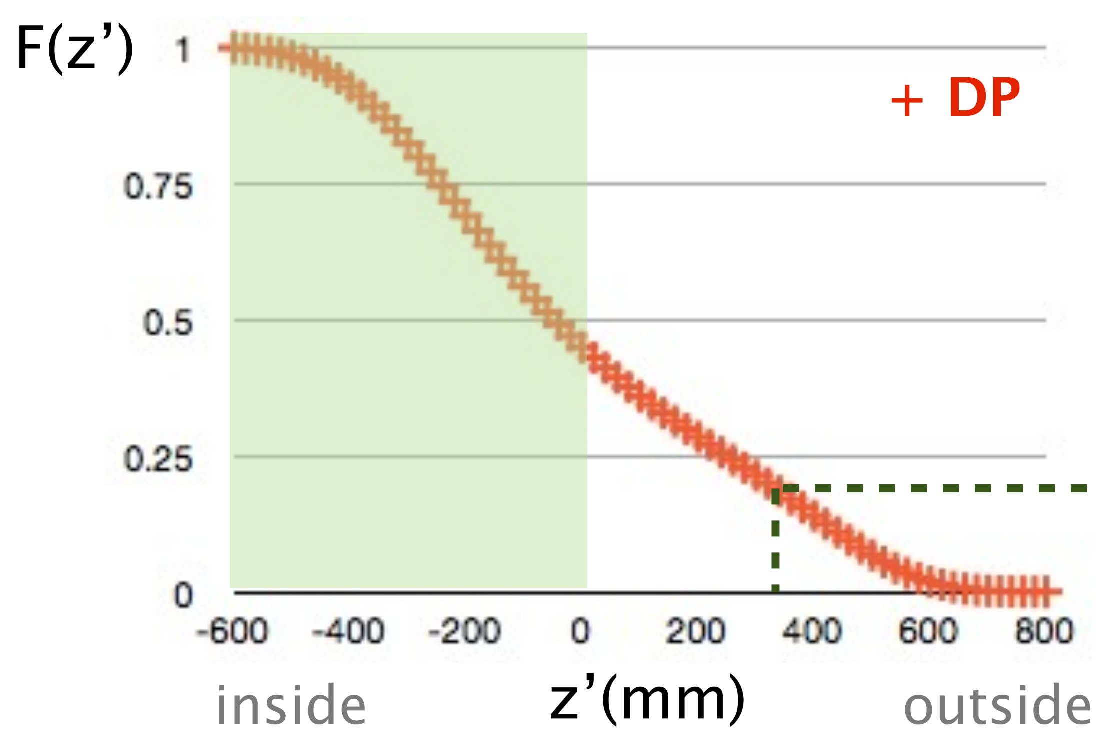
- for Q :




z'=25cm, F(z')~0.99

z'=10cm, F(z')~0.14

- for DP :



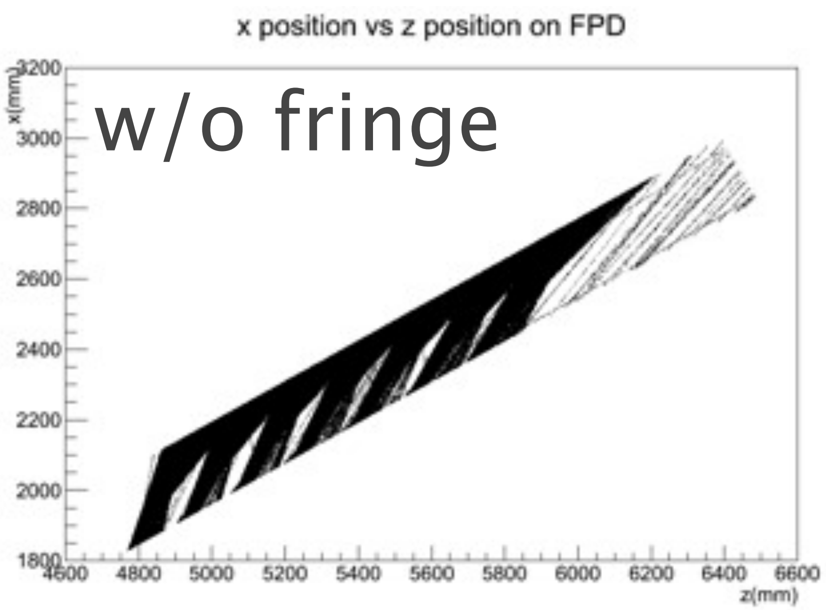

F(z')
comparable

z'=34cm, F(z')~0.18

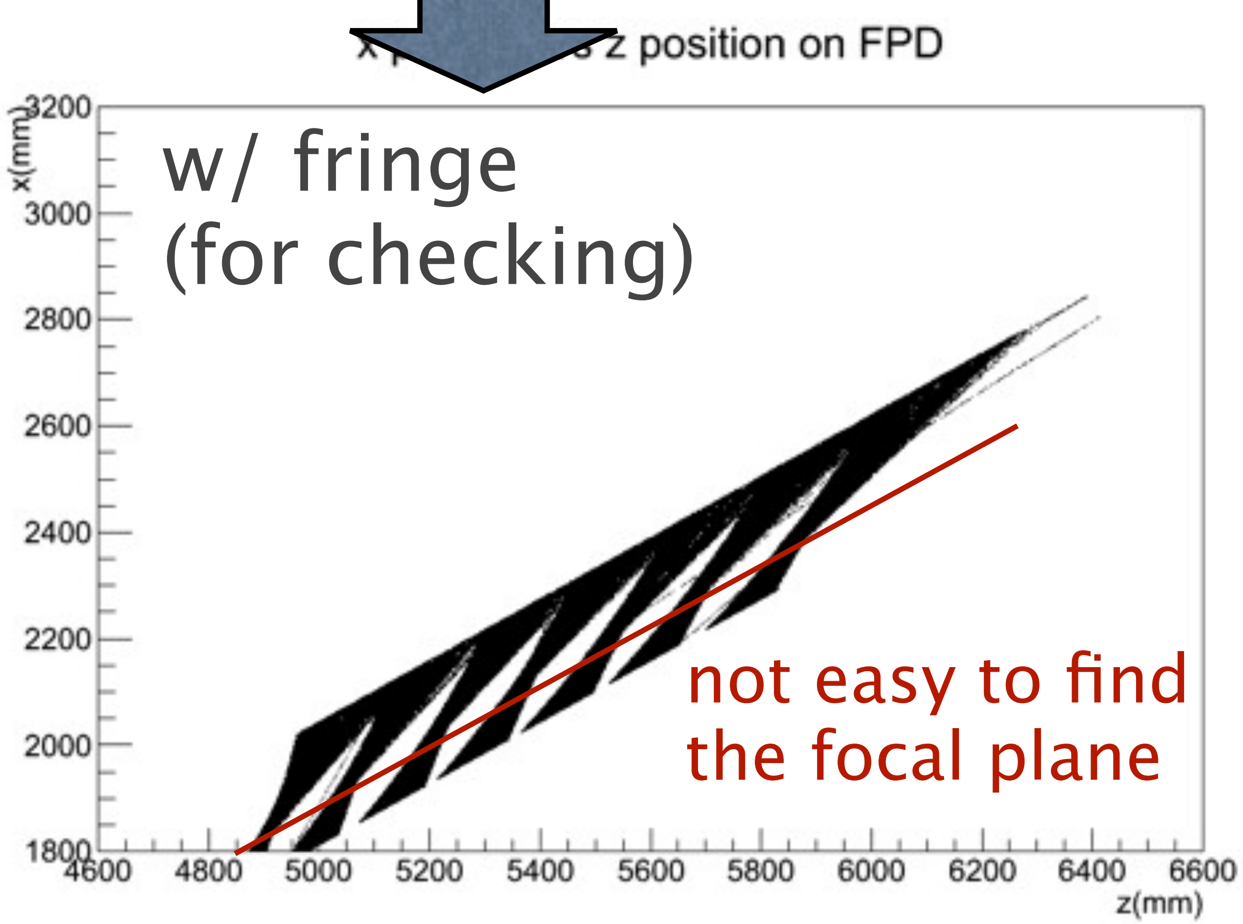
[130513_engeFunction]

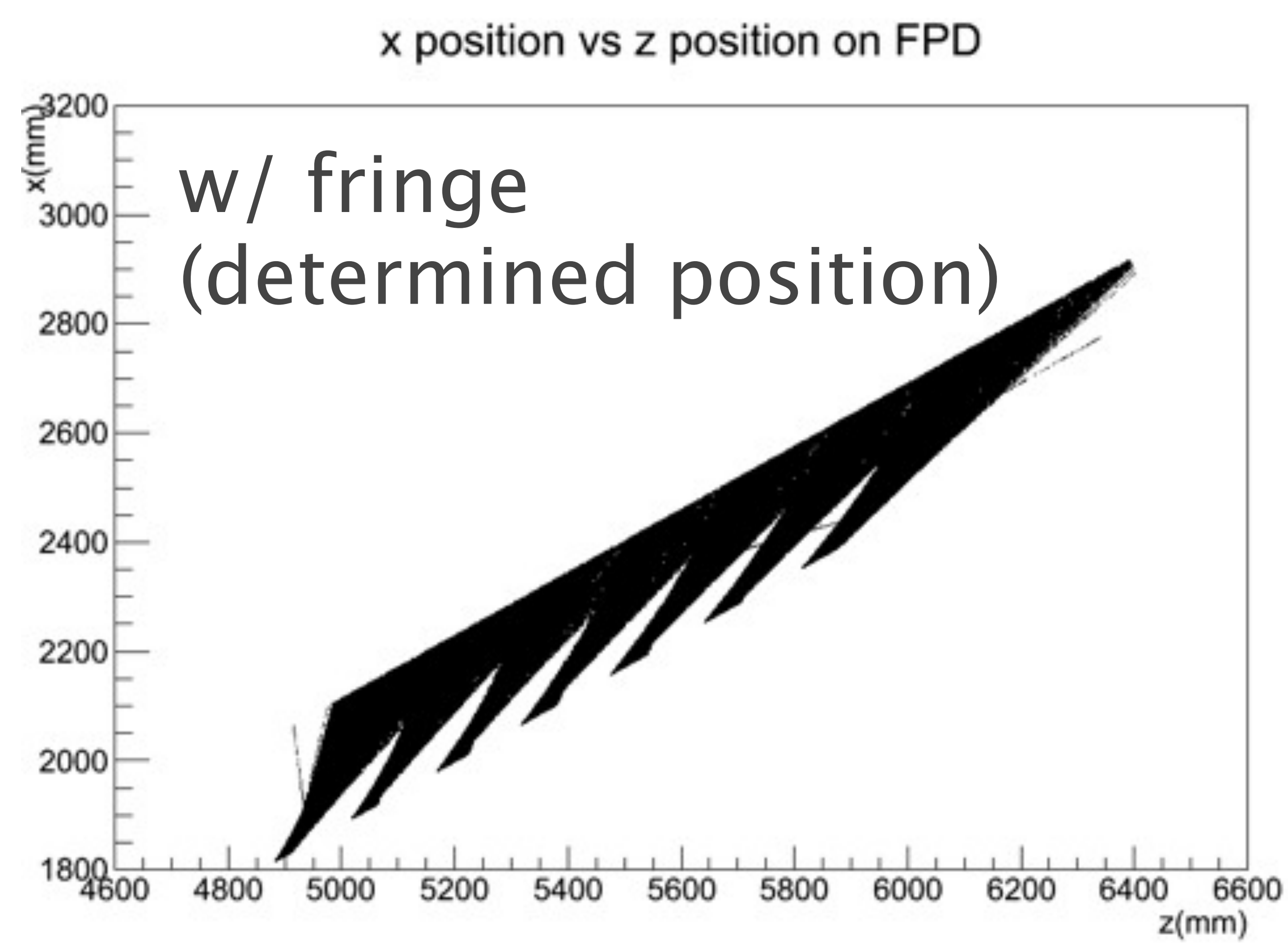
# FPD position

[07_LAMPS_QD_130401_fringe]
[draw_xPos_zPoz.cc]




- x-focusing seems improved with the fringe function



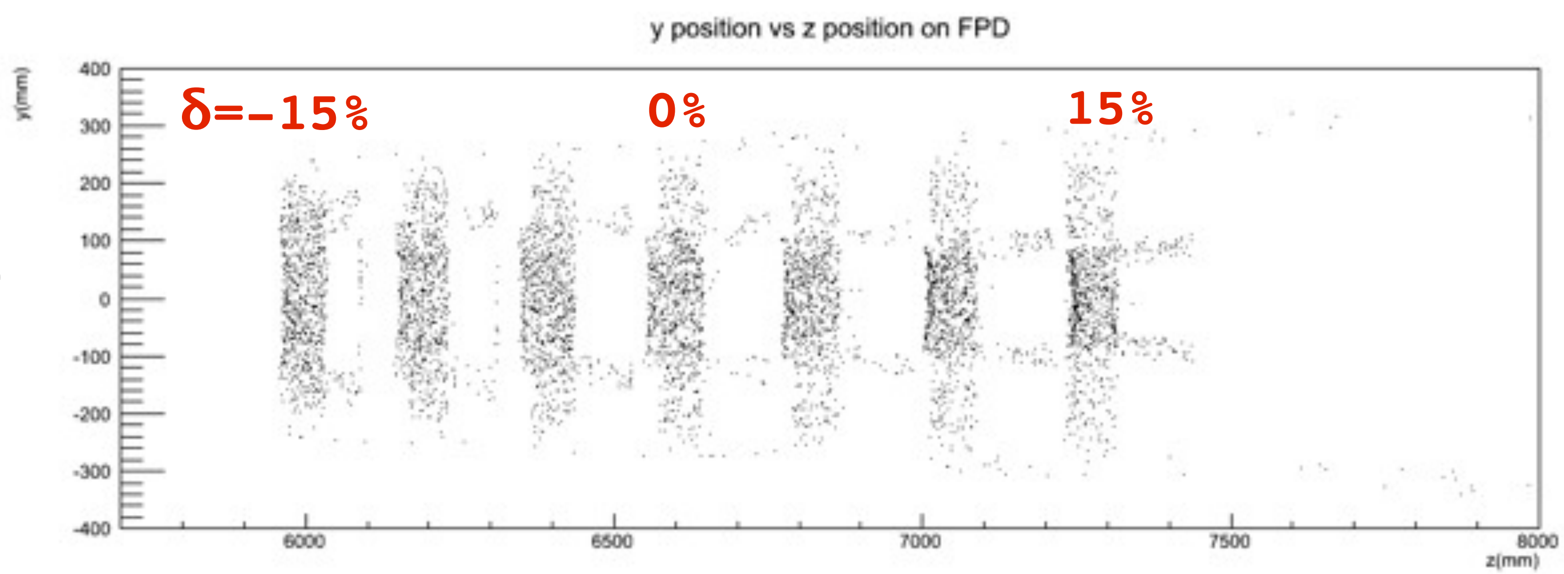



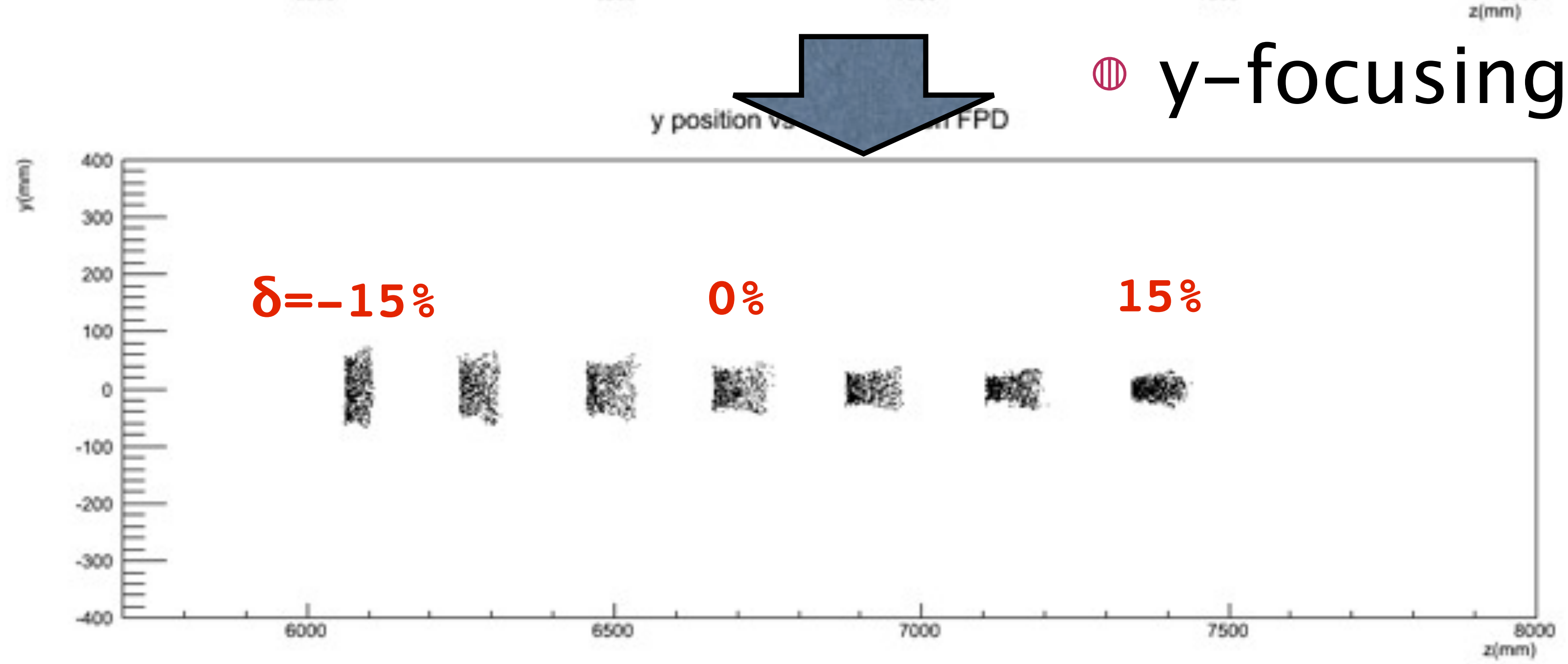
# FPD position

- central trajectory : proton with KE = 20MeV (p=194.7MeV/c)
- 7000 protons : 1000 protons for each δ (Δδ=5%)
- fastest hit on FPD only
- momentum direction random ( x′≤50mrad, y′≤50mrad )

[07_LAMPS_QD_130401_fringe]
[draw_yPos_zPoz_minTime.cc]

w/o fringe



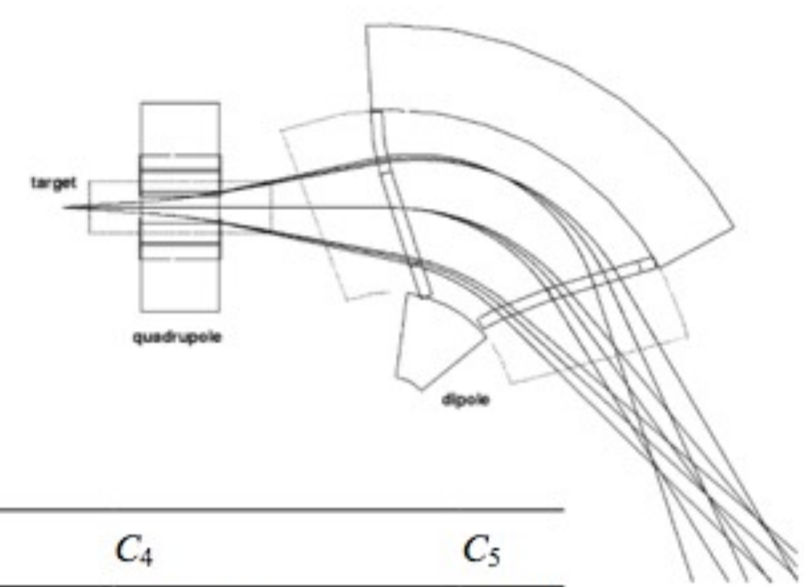

w/ fringe

◍ y-focusing also improved?

# SUMMARY & FUTURE PLANS

- **Need to check the current QD system more**
  : calculate resolving power
  : other study for FPD simulation

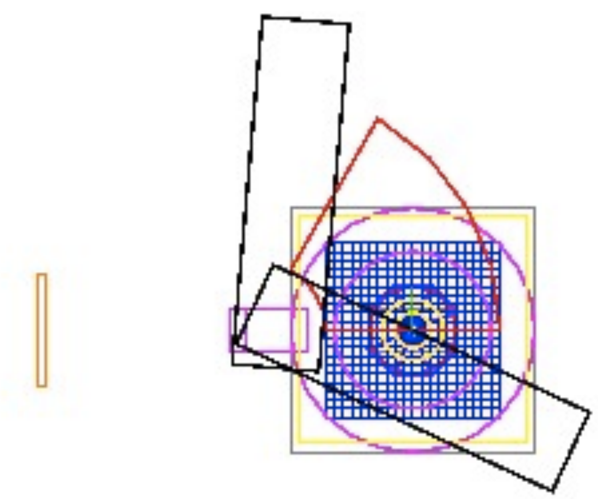
- **From Dr.Yun (Last discussion at HIM meeting)**
  : focal plane width 1m & momentum acceptance ±20% (not 30%)
  : To improve the focal points,
  need higher order multipole element?
  (In case of MAGNEX, surface coils on DP)
  : change the Enge-function parameter?




Parameters of the fringe field Enge functions for the dipole and the quadrupole

| | $C_0$ | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ |
|---|---|---|---|---|---|---|
| Dipole | 0.503 | 4.43 | −1.39 | 0.84 | −0.1590 | 0.0575 |
| Quadrupole | 0.3795 | 4.0034 | −2.1 | 1.1973 | −0.3683 | 0.0478 |

# BACK-UP

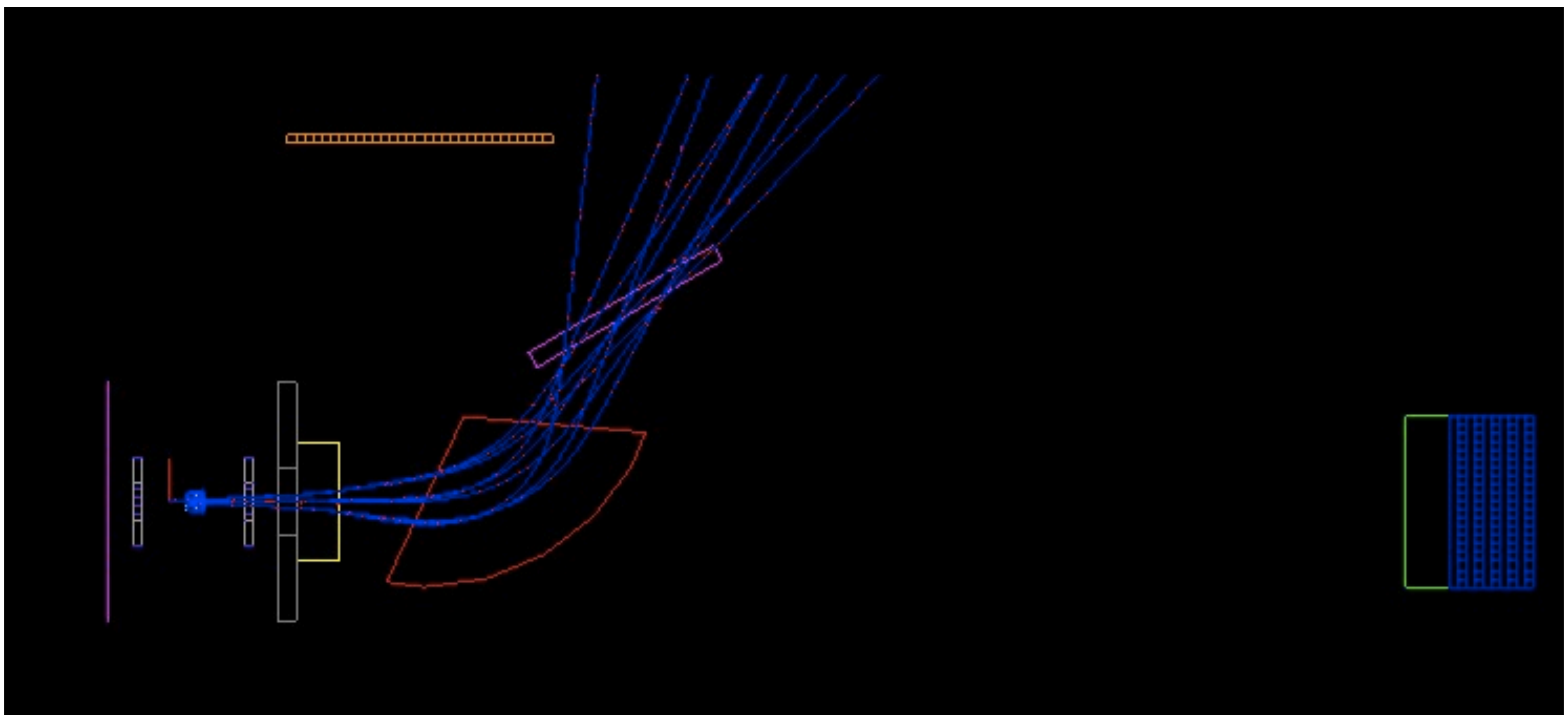


# Matrix

[07_LAMPS_QD_130401_fringe]

- HeGas for ExpHall & DP (for track visualization)

KE=14.5MeV (165.5MeV/c)   KE=20MeV (194.7MeV/c)   KE=26.3MeV (224MeV/c)



# NOTICE!

- rndmKE <- not random at the moment! (for useRandom 2)

[07_LAMPS_QD_130401_fringe]
[rigidity_numbers]

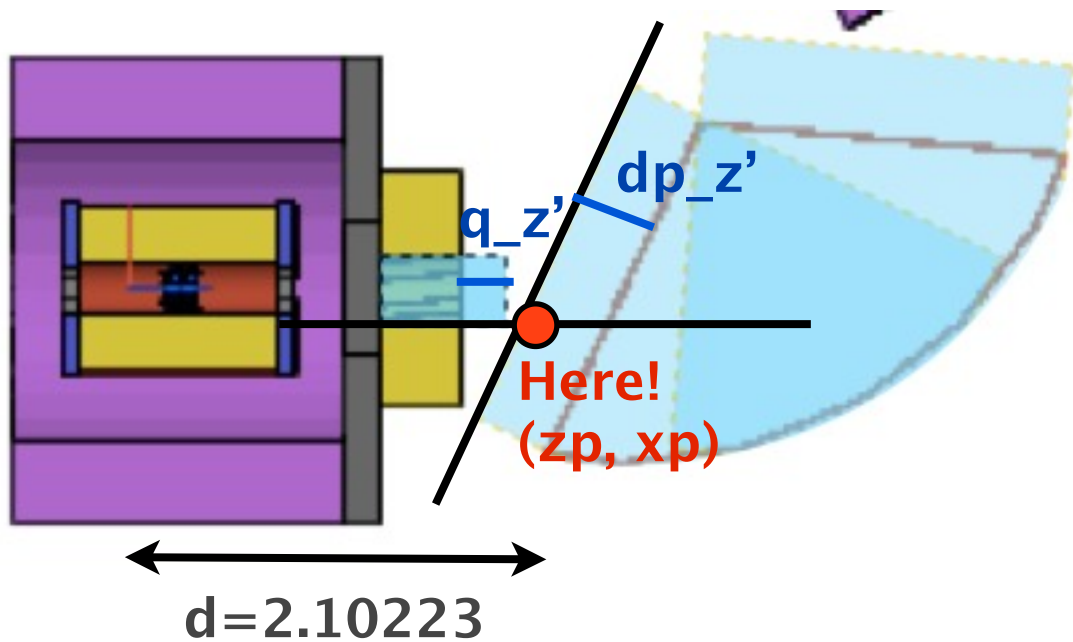
| δ(%) | rigidity(Tm) | p(MeV/c) | KE(MeV) |
|---|---|---|---|
| -20 | 0.51935605 | 155.806815 | 12.8484496 |
| -15 | 0.5518158 | 165.54474 | 14.4920878 |
| -10 | 0.58427554 | 175.282662 | 16.232247 |
| -5 | 0.61673531 | 185.020593 | 18.0684027 |
| 0 | 0.64919506 | 194.758518 | 20.0000002 |
| 5 | 0.68165481 | 204.496443 | 22.0264646 |
| 10 | 0.71411457 | 214.234371 | 24.1471975 |
| 15 | 0.74657652 | 223.972956 | 26.3617289 |
| 20 | 0.77906407 | 233.719221 | 28.6711319 |

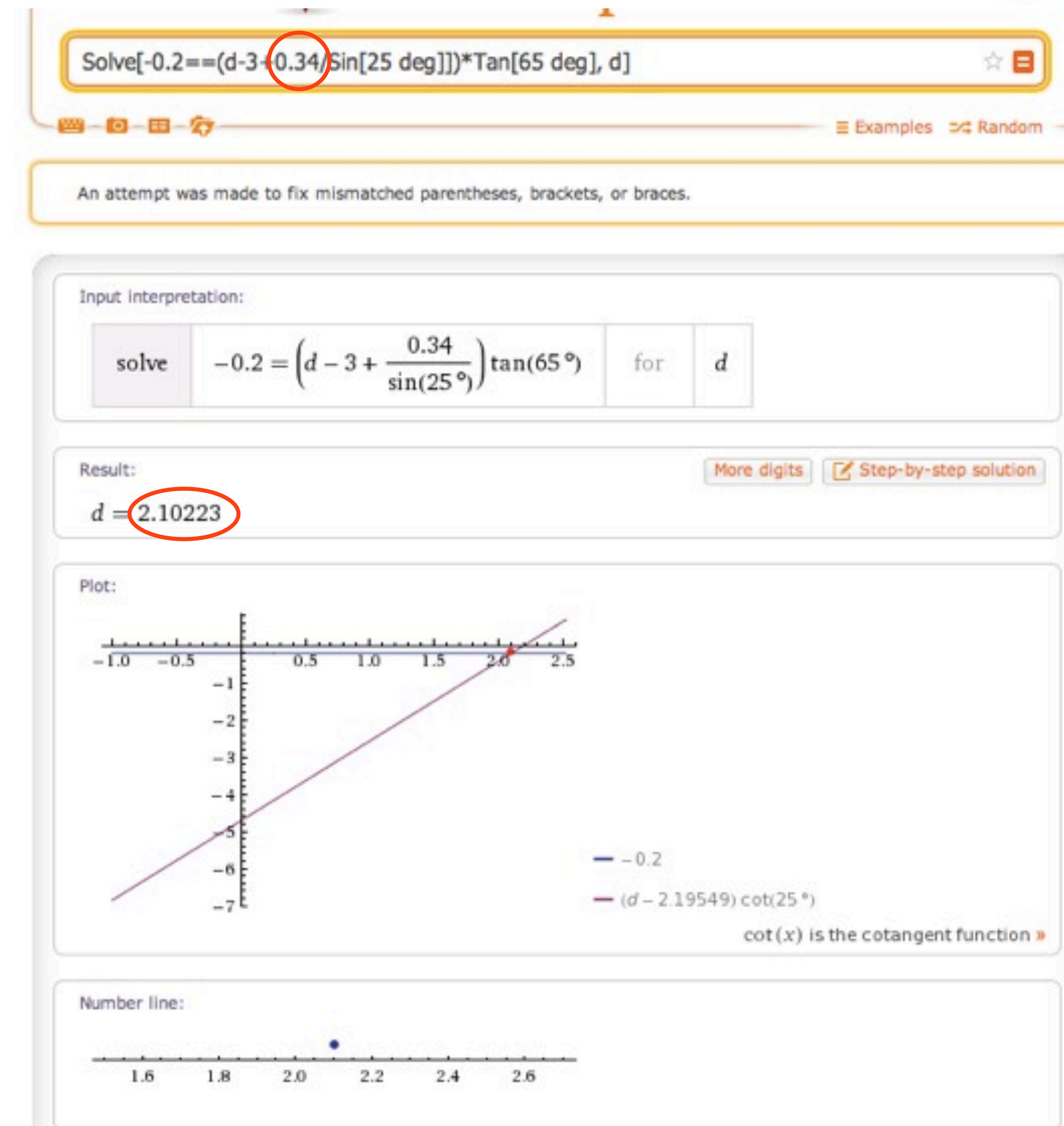
```
LAMPS(Idle)[/][100]:cd lamps/
LAMPS(Idle)[/lamps/][101]:useRandom 2
LAMPS(Idle)[/lamps/][102]:particle proton
LAMPS(Idle)[/lamps/][103]:rndmKE 20

Range of the Initial Kinetic Energy: 0 - 20 MeV
Range of the Inition Kinetic Energy Per Nucleon: 0 - 20 MeV
     Range of the Initial Momentum: 0 - 194.759 MeV/c
Range of the Initial Momentum Per Nucleon: 0 - 194.759 MeV/c

LAMPS(Idle)[/lamps/][104]:rndm_p_direction 5 5 100
LAMPS(Idle)[/lamps/][105]:/run/beamOn 1000
```

# distance ~1cm




x=-0.2m

x=tan65(x-3+dp_z'/sin25)

두개의 접점이 (zp,xp)

q_z'=0.1m (F=0.87, 0.18)

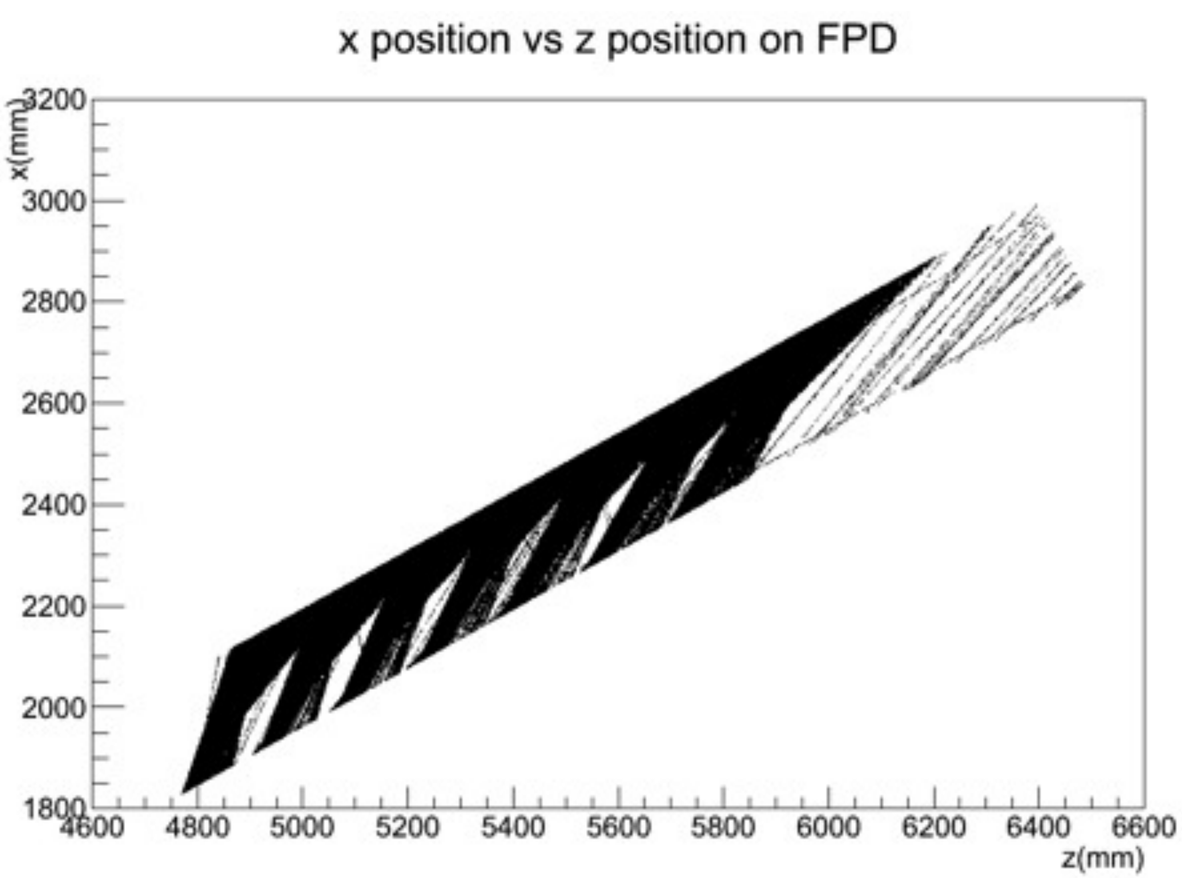
dp_z' = 0.34m (F=0.85, 0.14)

(파란 영역 간 거리 중 가장 짧은곳이 0.10223m임)

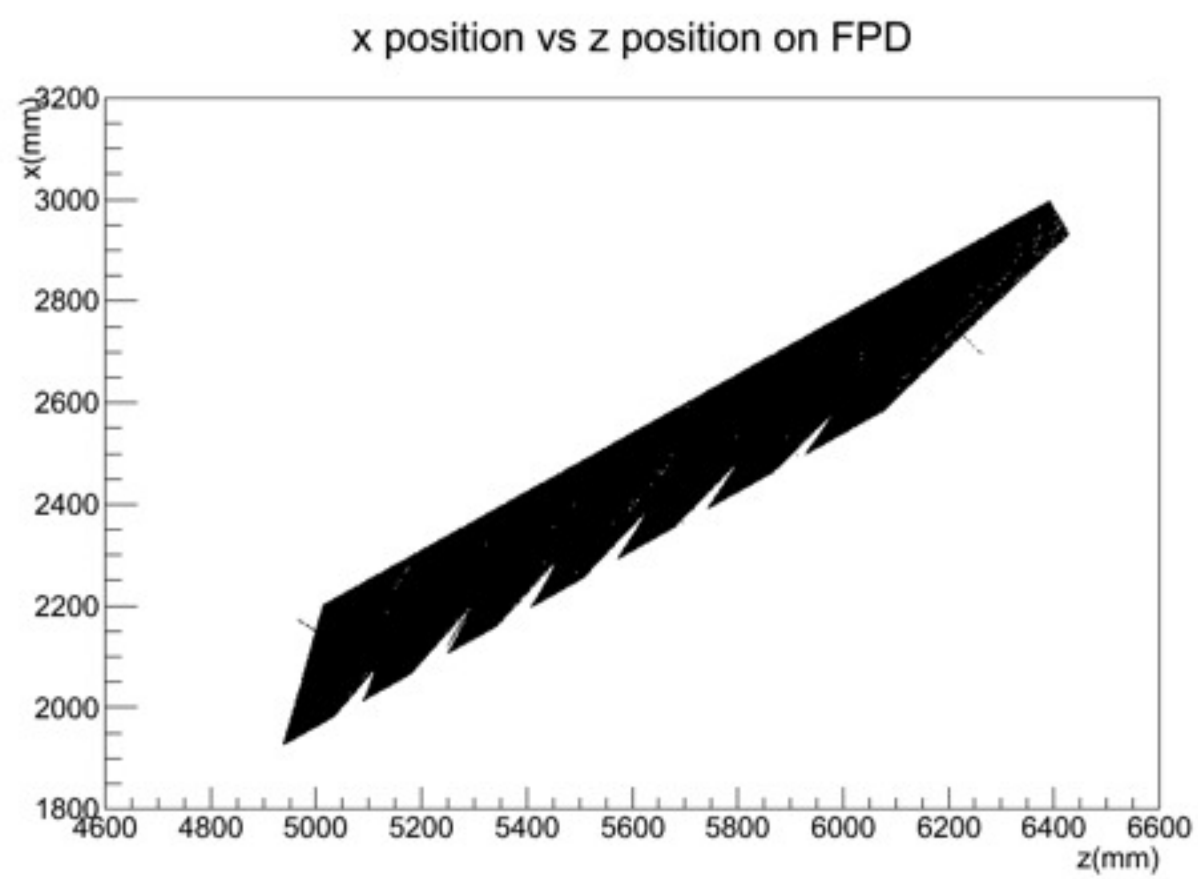
# X VS Z

[07_LAMPS_QD_130401_fringe]
[draw_xPos_zPos.cc]

- FPD (05_LAMPS)



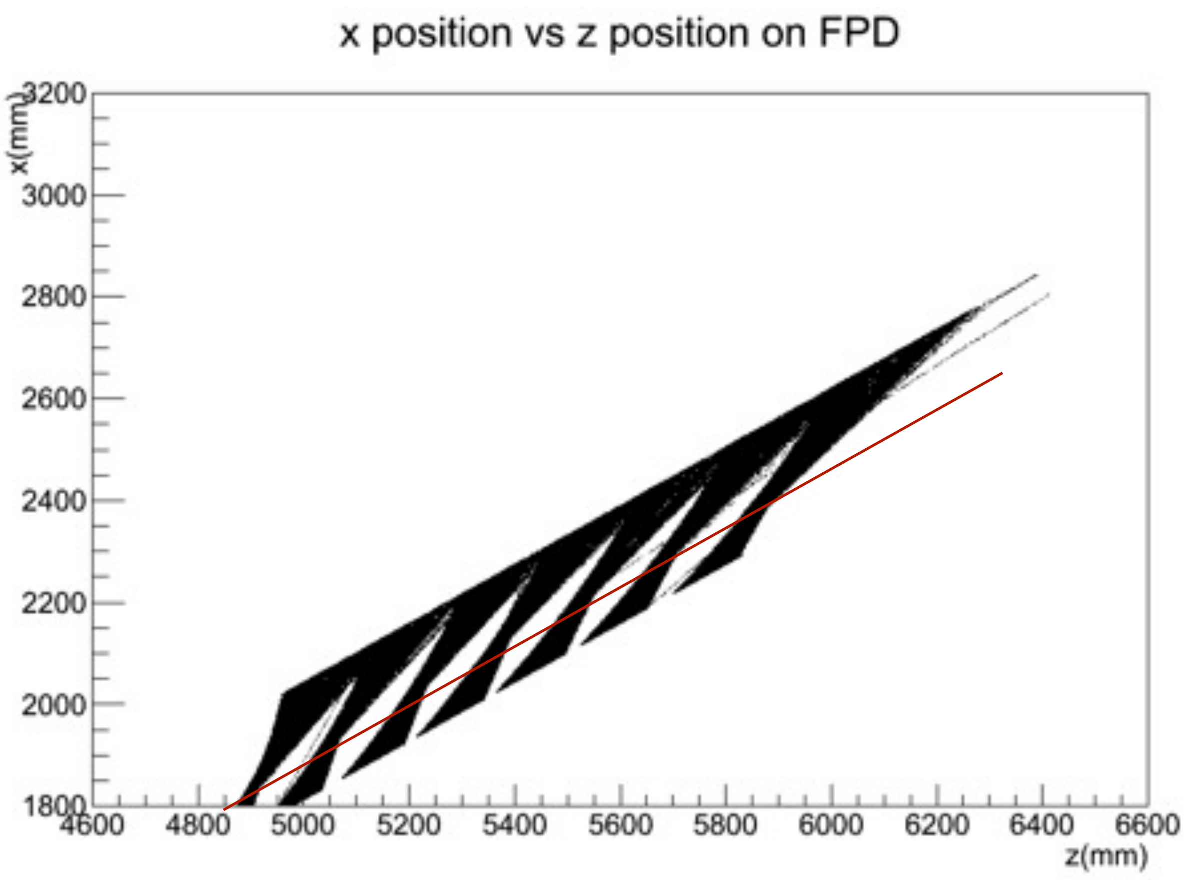

- FPD (07_LAMPS): same position w /05_LAMPS



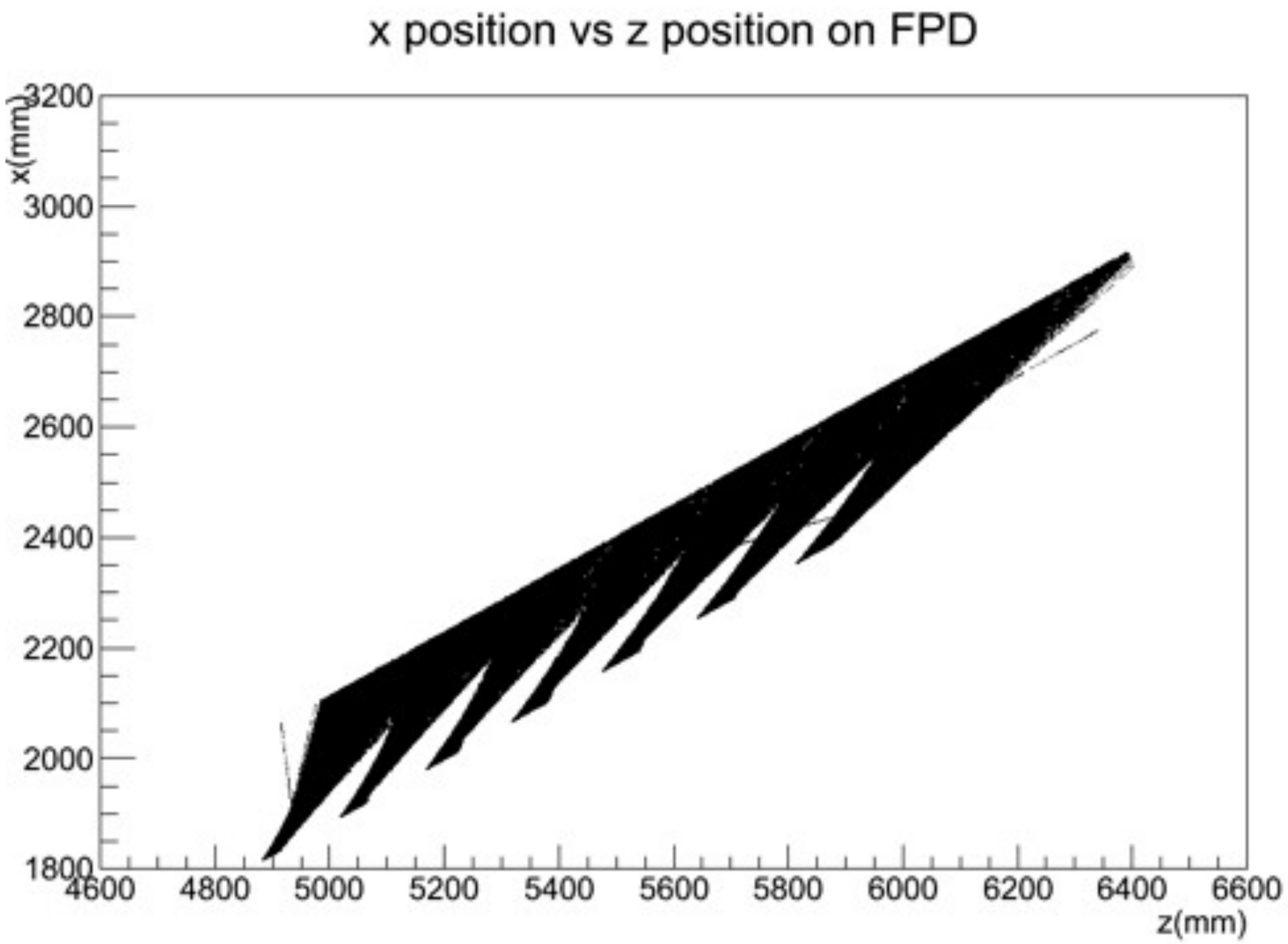
# X VS Z

[07_LAMPS_QD_130401_fringe]
[draw_xPos_zPos.cc]

- FPD : x-15cm



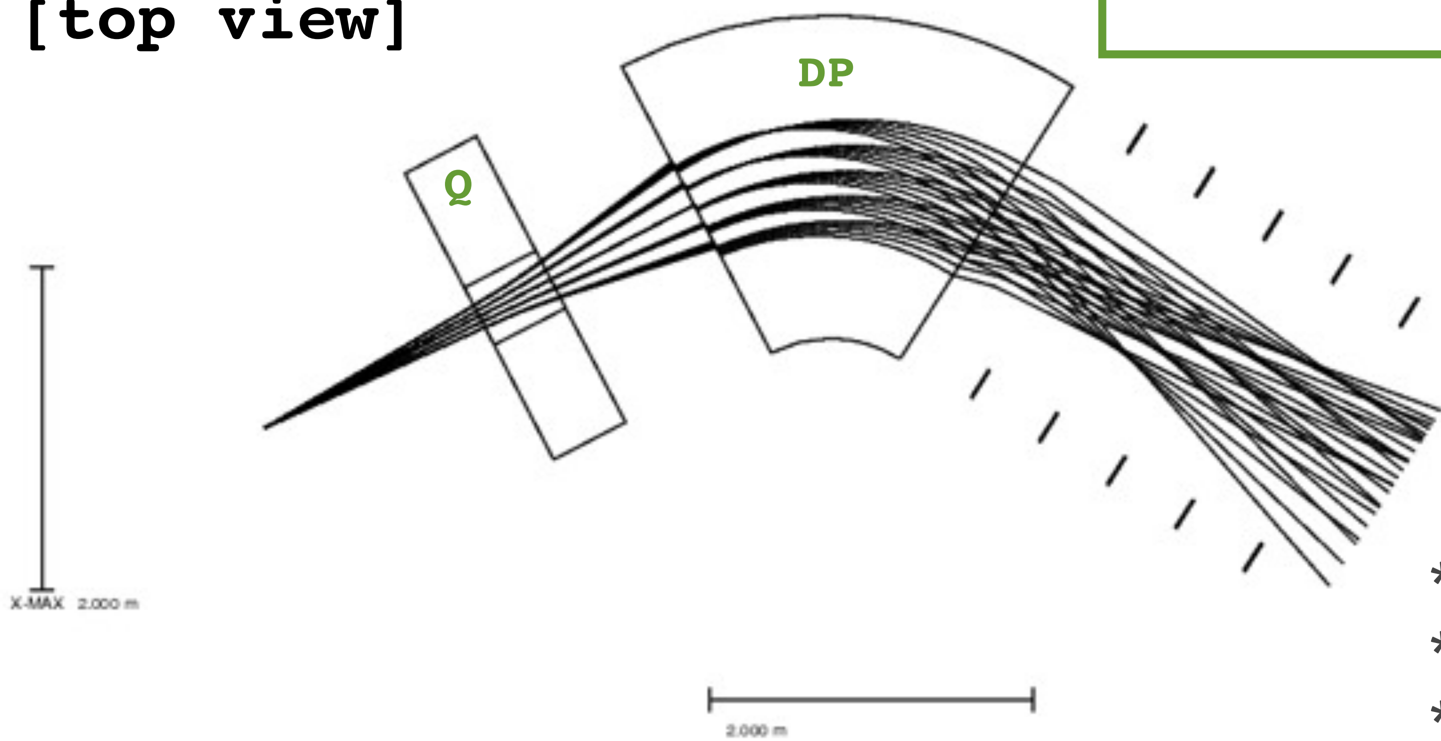

- FPD : x-8cm : detemined!



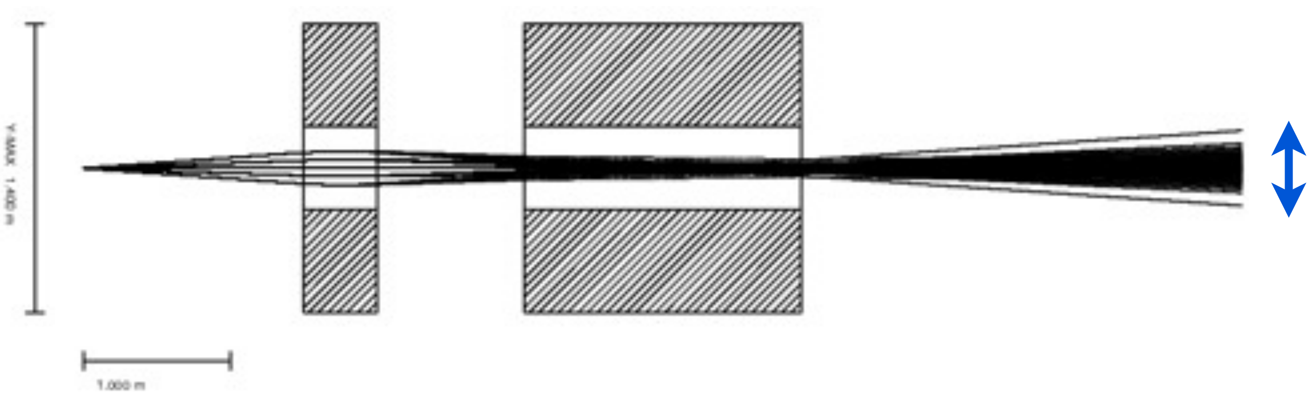
# QD system (GICOSY)

1.5m ->Q-> 1.0m ->DP-> 0.5m*6 -> C
***Q** : L=50cm, full_a=40m, B=-1.42T/m (y-focusing)
***DP** : θ=60°, half_gap=20cm, w1=2m?, w2=2m?,
R=1.8m, B =-0.36T, $\beta_1$=-25°, $\beta_2$=-25°

**[top view]**




**[side view]**



- **2nd order calculation**
- **angular acceptance = 50mr, 50mr**
- **momentum Range = ±15%**
  **(corresponding KE Range ~ ±30%)**

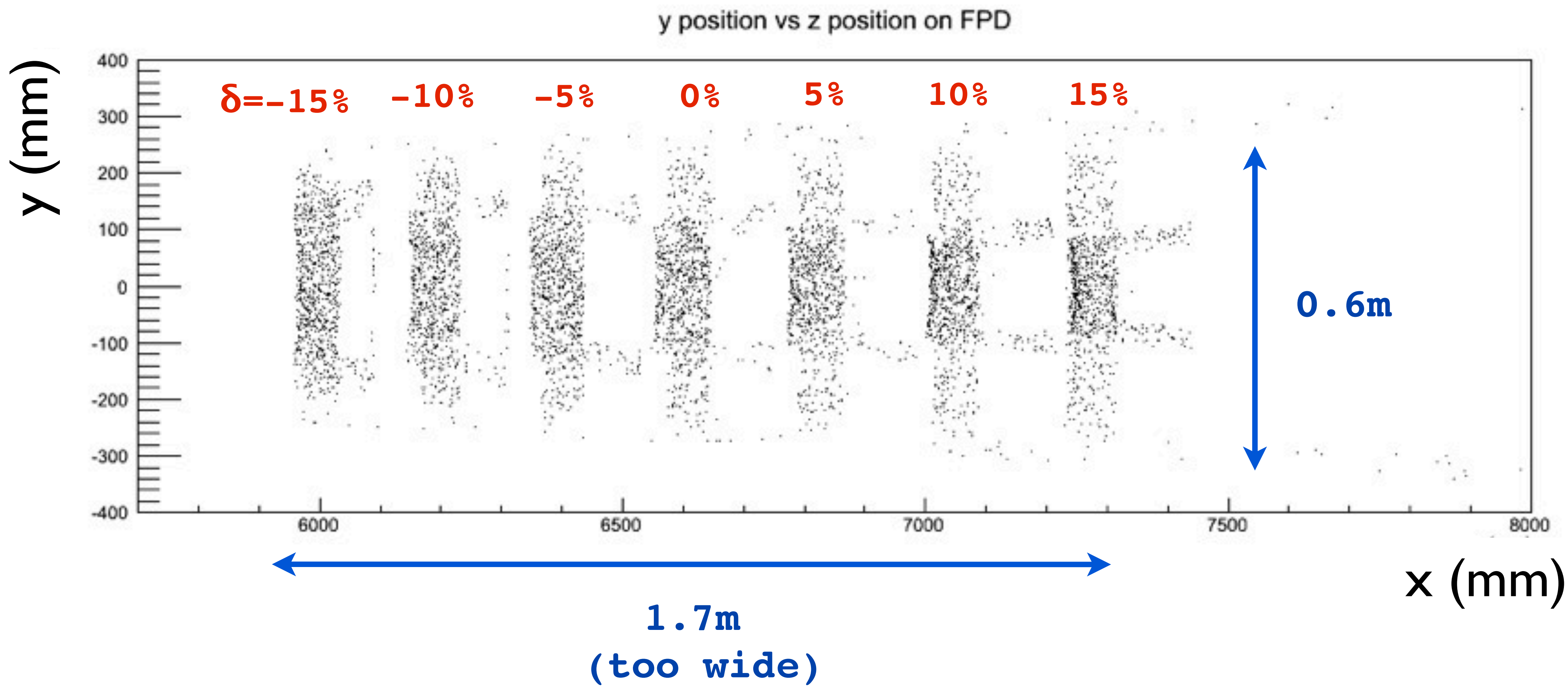
KE=14.5MeV (165.5MeV/c)    KE=20MeV (194.7MeV/c)    KE=26.3MeV (224MeV/c)

[04_QD_130401/GICOSYIN_2_drift.DAT]

# FPD Simulation

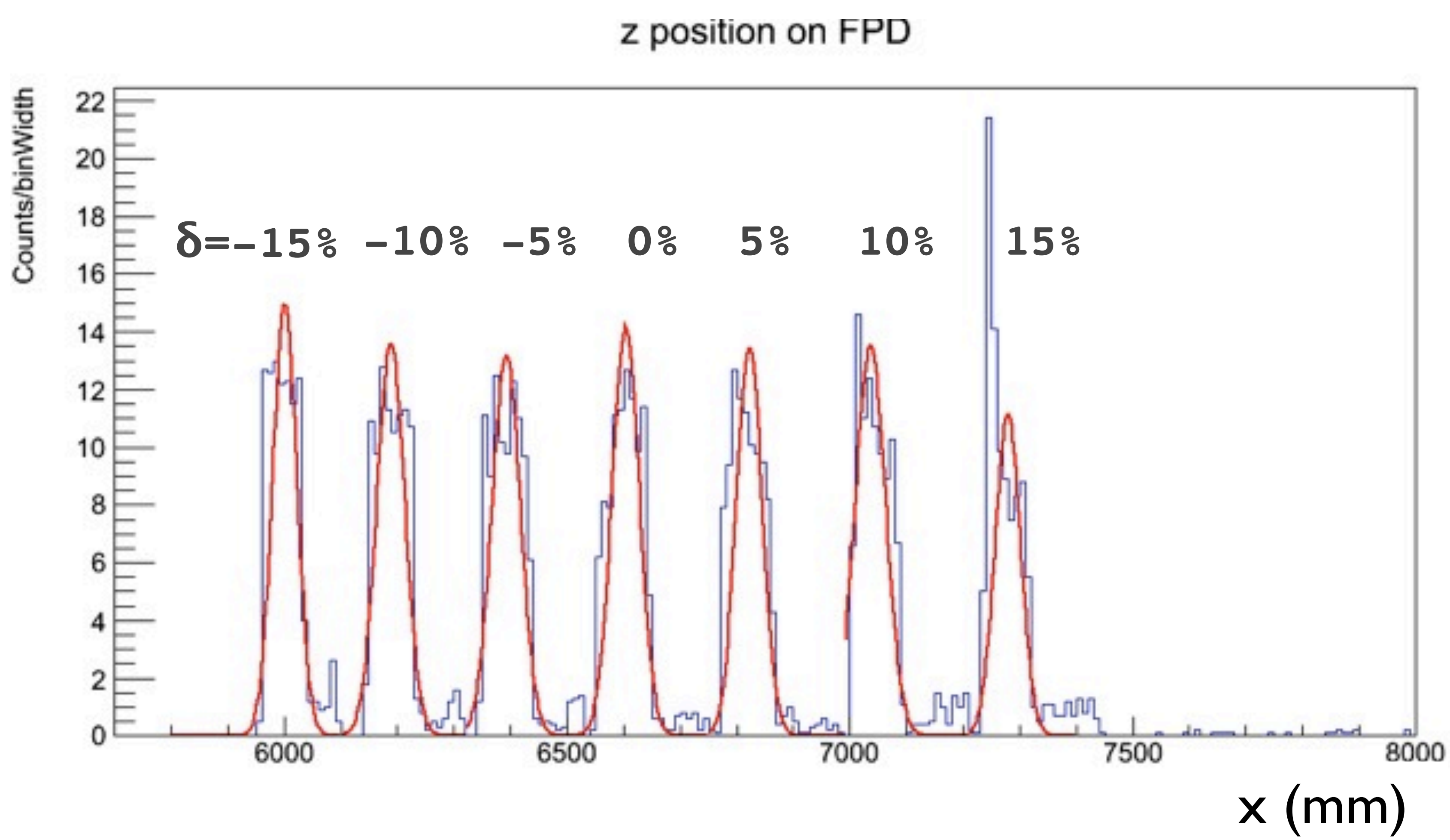
## * for constant B field

- central trajectory : proton with KE = 20MeV (p=194.7MeV/c)
- 7000 protons (1000 protons for each δ)
- fastest hit on FPD only



# FPD Simulation

## * for constant B field




- **Gaussian fitting**
  σ ≃ 2.4 cm ⇐ too large!

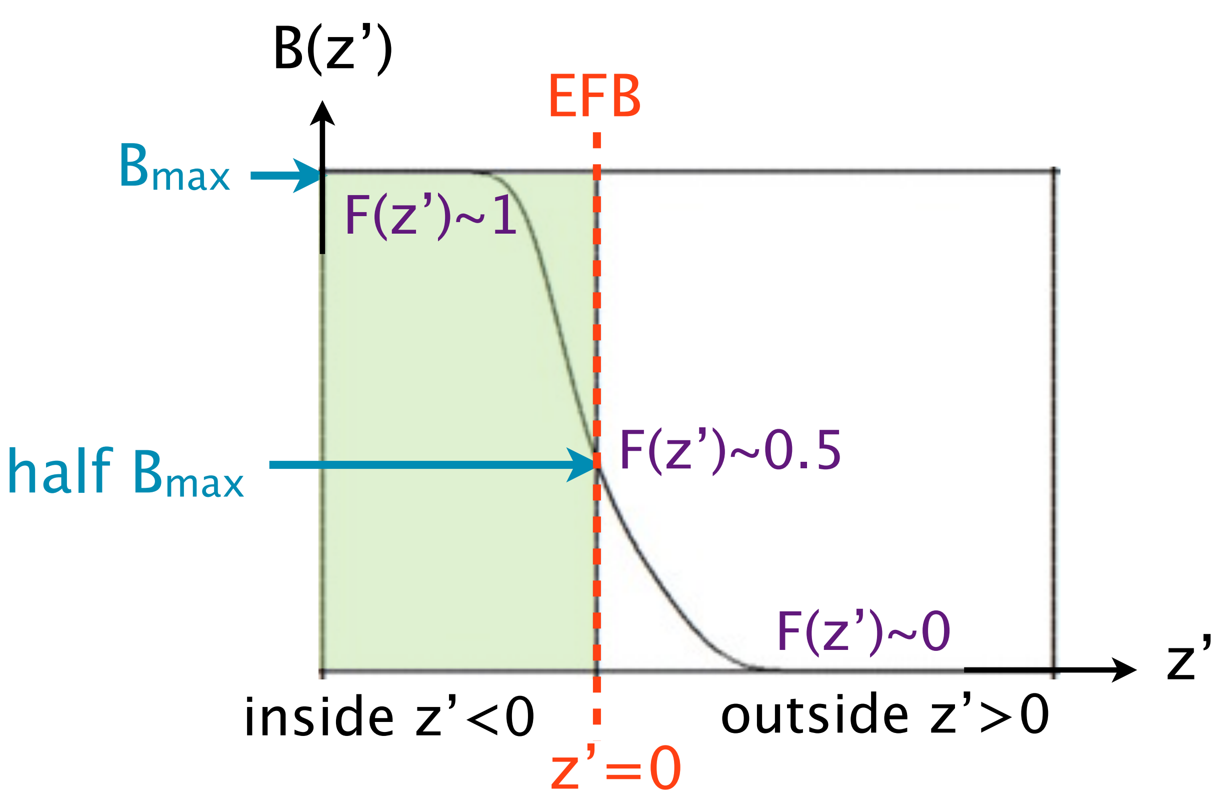
- **Dispersion D = 4.26[cm/%]**
- **Resolving power R ~ 180** ⇐ too bad!

# Fringe function

- **Enge Function :** $F(z) = \frac{1}{1+\exp(a_1 + a_2 \cdot (z/D) + \ldots + a_6 \cdot (z/D)^5)},$

where D = gap parameter (=half-aperture)
z' = distance from the effective field boundary
$a_n$ = parameter for the $n_{th}$ order polynomial

- B-field is defined by $B(z') = B_{max} \times F(z')$




1. D = 200mm for Q and DP both
2. $a_n$ = extracted from the GICOSY (This is default value)

For dipole magnet
a1=0.205133
a2=0.840972
a3=-0.141308
a4=0.050050
a5=0.000076
a6=0.005197

For Q-magnet
a2=3.59463

3. z' = give a cut (see next slides)

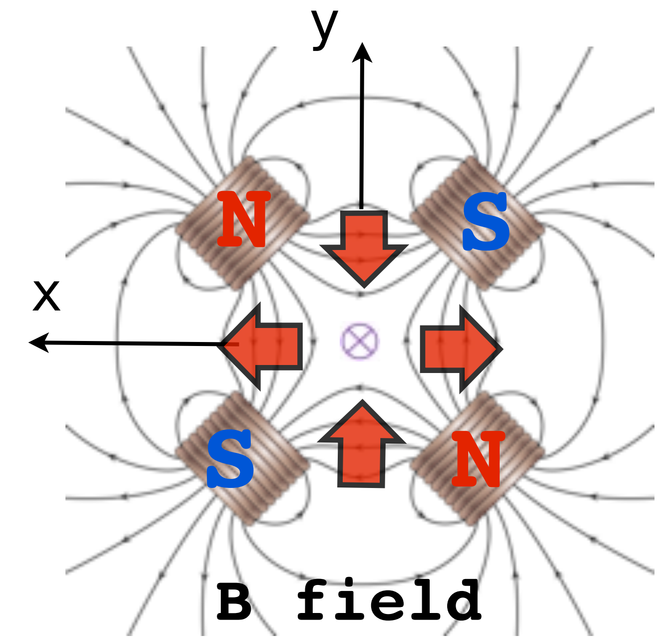
# Quadrupole

- **B-field w/o fringe**

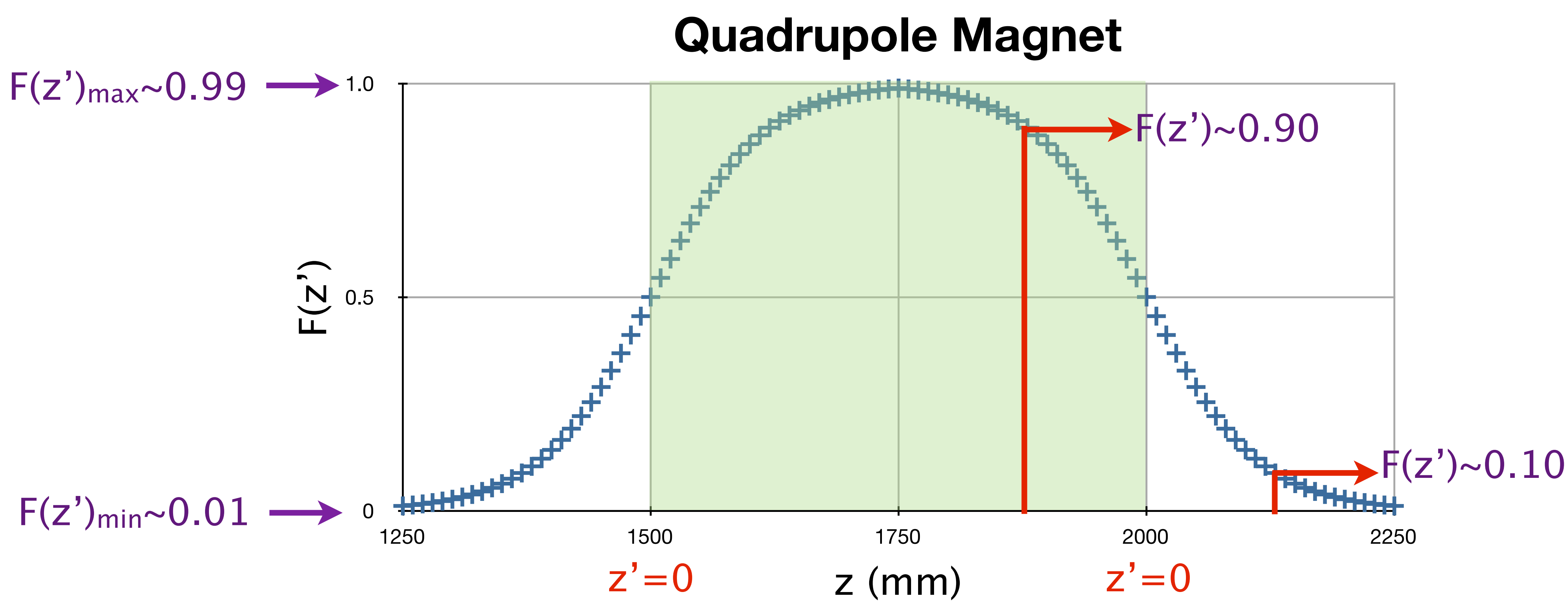
$$B_x = \frac{\partial B}{\partial y} \cdot y \qquad B_y = \frac{\partial B}{\partial x} \cdot x$$

Field gradient

$$K = \frac{\partial B}{\partial y} = \frac{\partial B}{\partial x}$$




- **B-field w fringe** $B_f = B \cdot F = \sqrt{(FB_x)^2 + (FB_y)^2}$



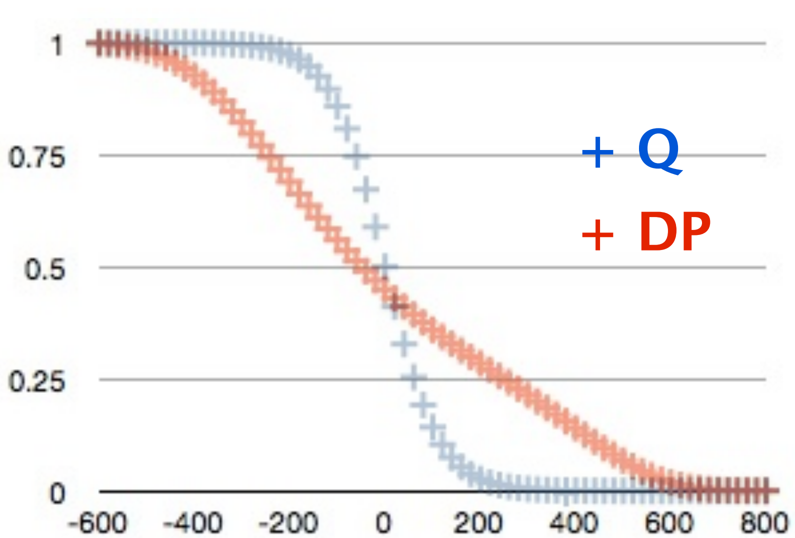
# Dipole

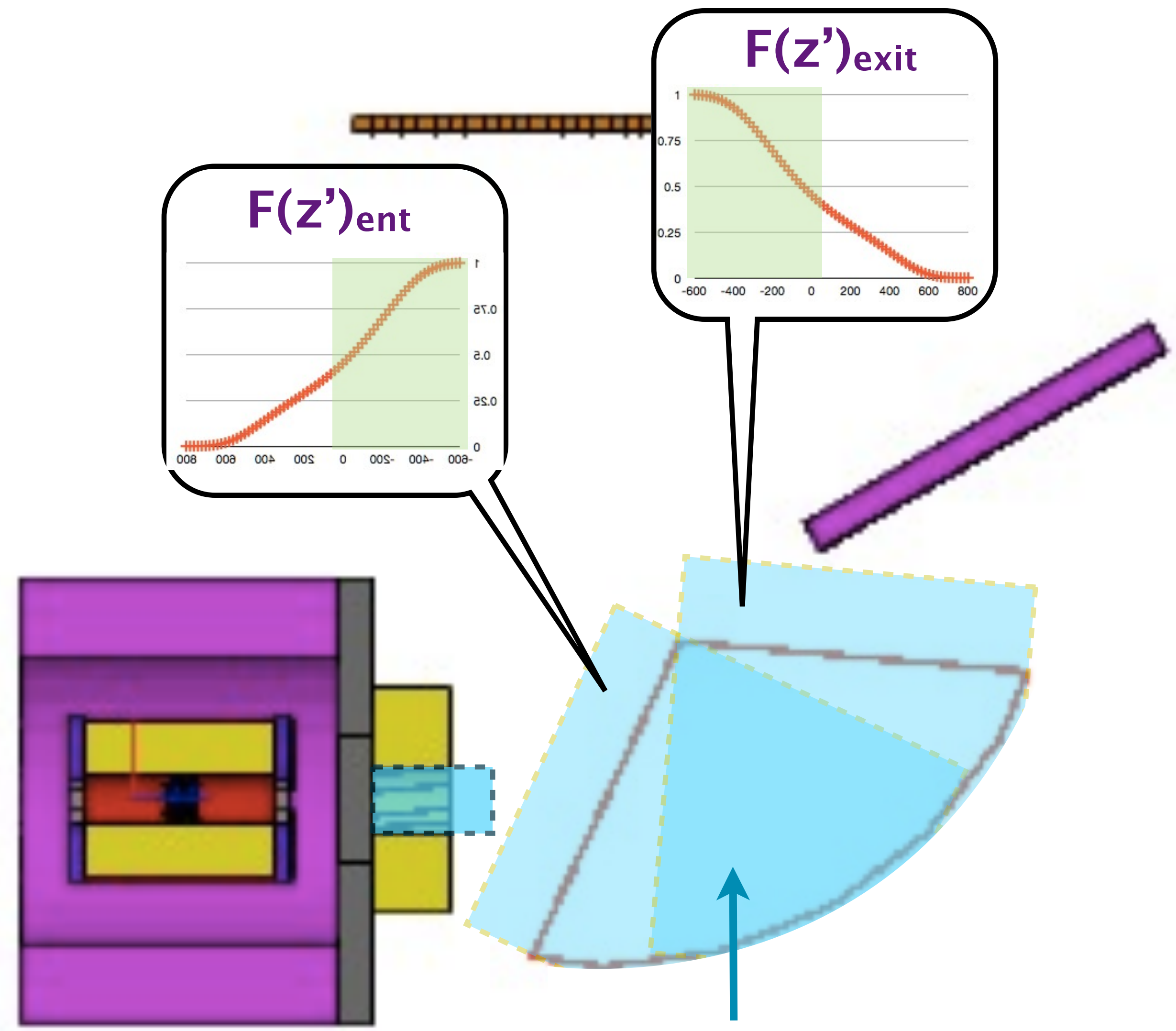
- **B-field w/o fringe**

  $B_y$ = −0.36 T (constant)

- **B-field w fringe**

: different Enge function for Q and DP



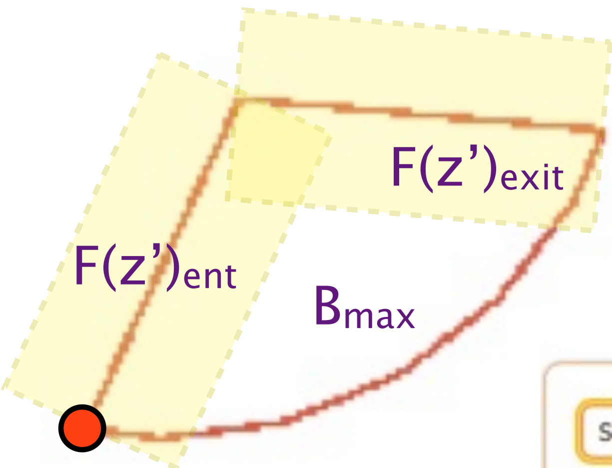

Overlapped region?

$B(z') = B_{max} \times F_{ent}(z') \times F_{exit}(z')$

# Matrix

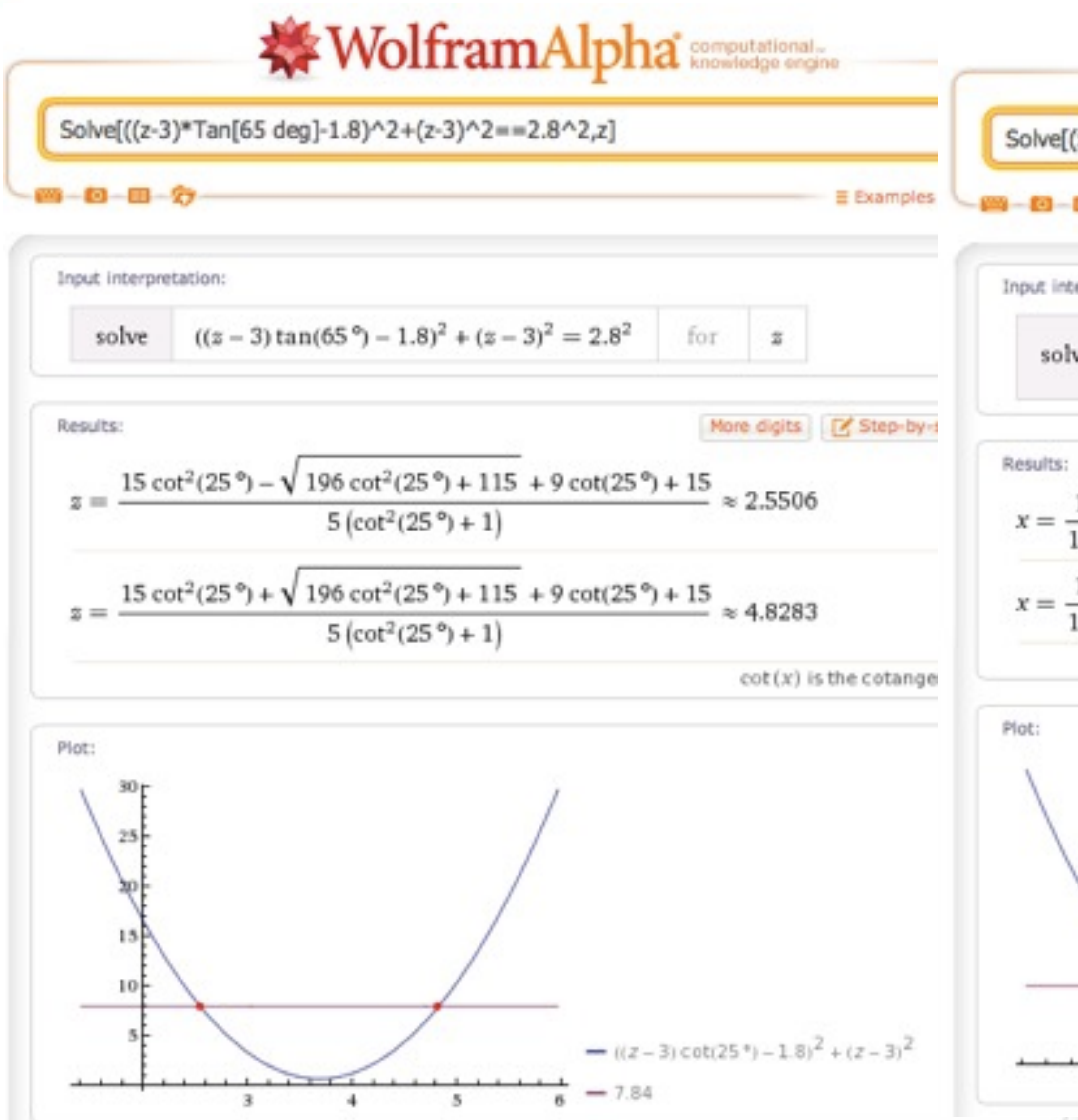
(x-1.8)^2=(z-3)^2=2.8^2
x=(z-3)tan65deg

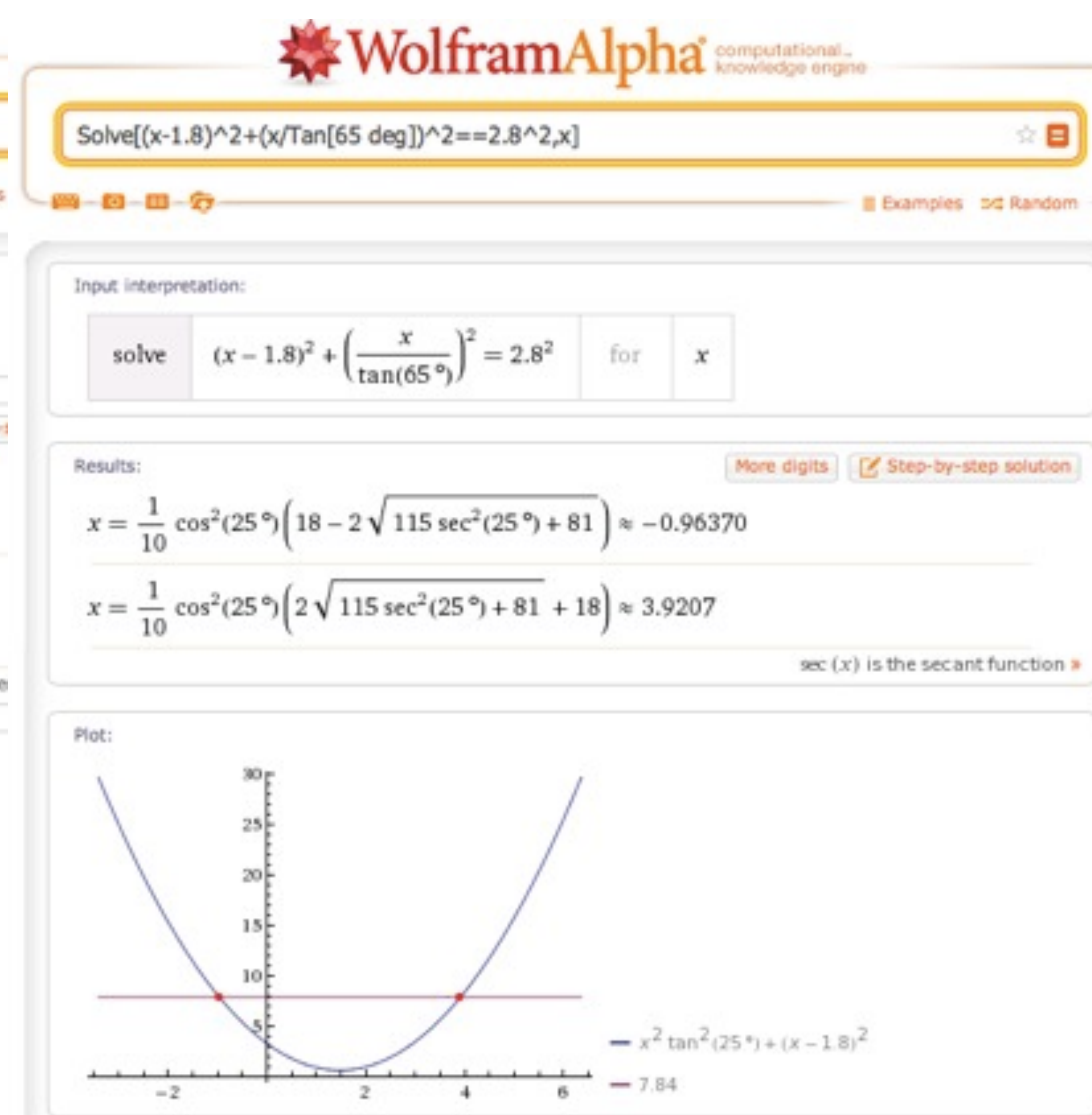
원식과 직선식 바로 연립한 결과들 ㅇㅇ



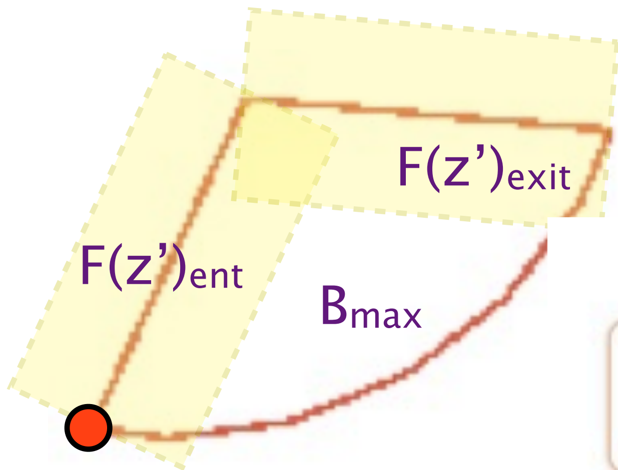

**Here!**

z=2.5506
x=-0.96370



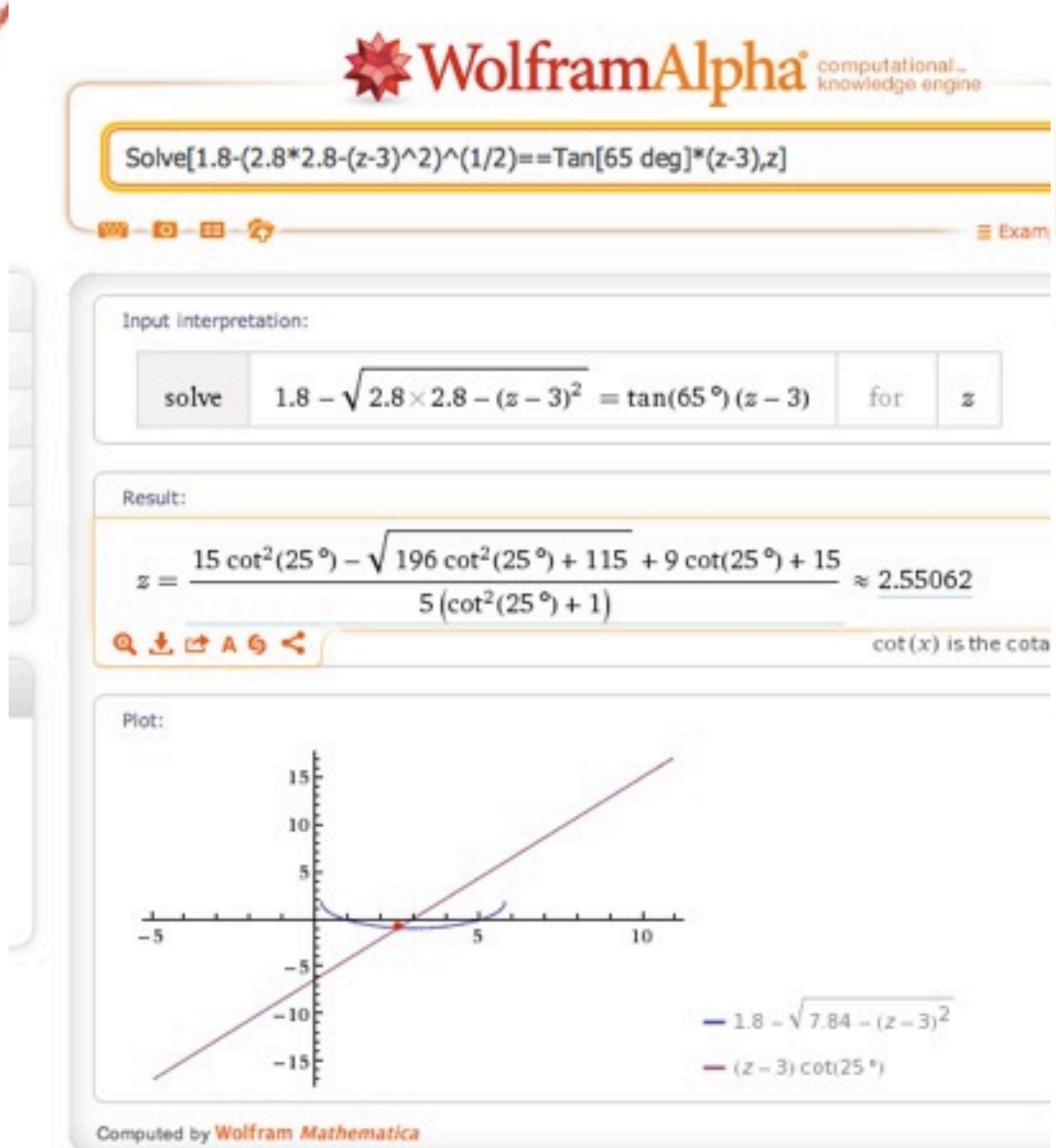



# Matrix

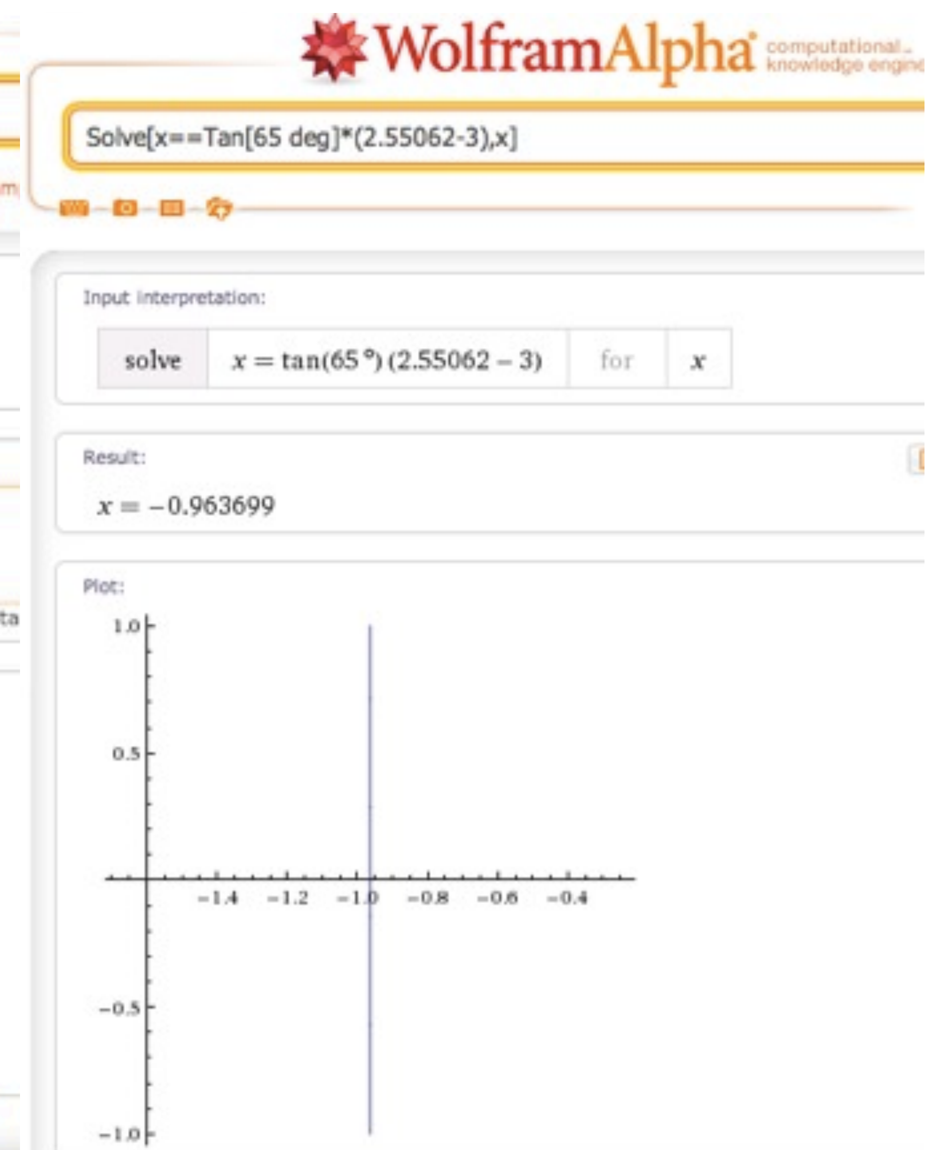



반원식 이용

x=1.8-(2.8^2-(z-3)^2]^(1/2)




그 z값을 직선식에 넣음

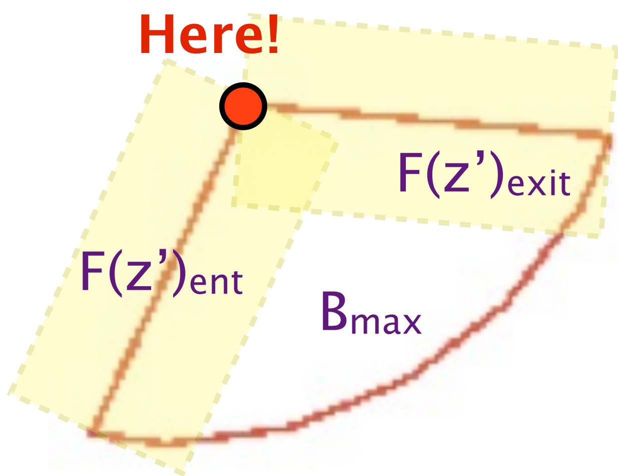



z=2.55062

x=-0.963699

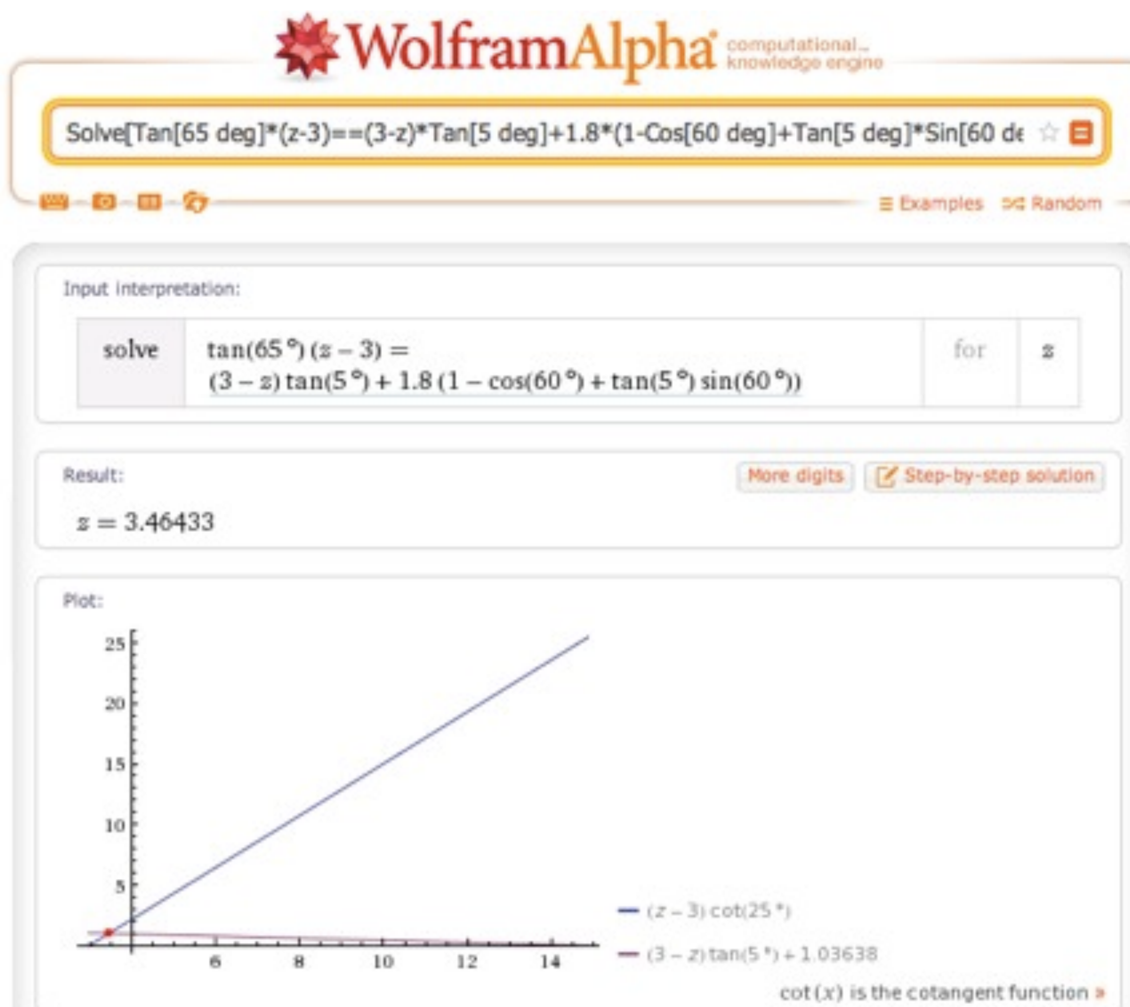
# Matrix






두 직선의 접점

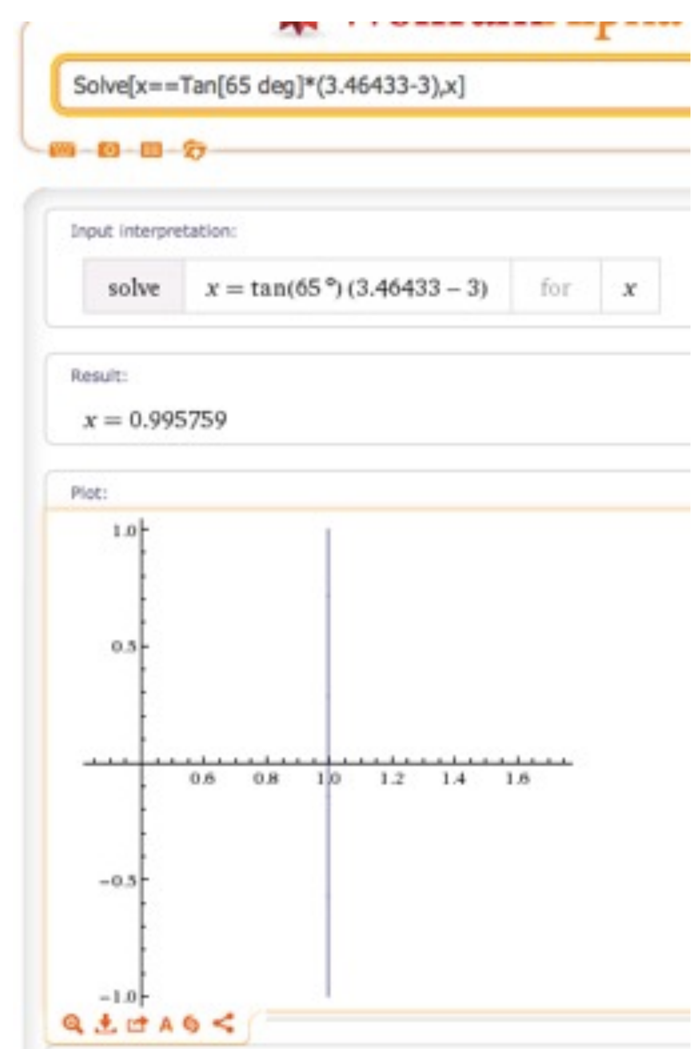
Solve[Tan[65 deg]*(z-3)==(3-z)*Tan[5 deg]+1.8*(1-Cos[60 deg]+Tan[5 deg]*Sin[60 deg]),z]




z=3.46433

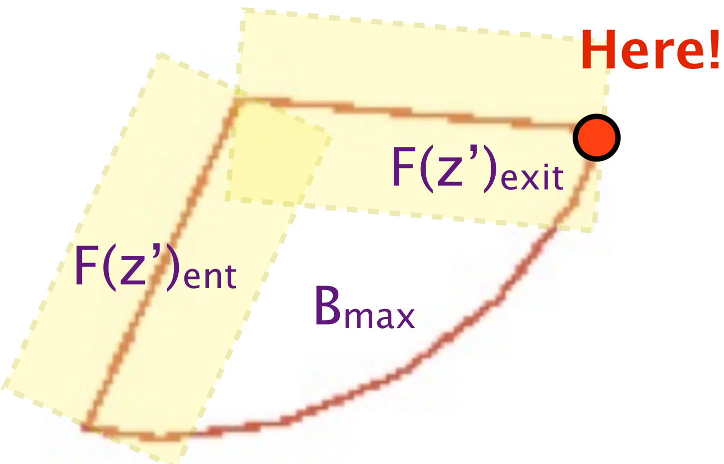
x=0.995759

그 z값을 ent 직선식에 넣음




그 z값을 exit 직선식에 넣음

# Matrix

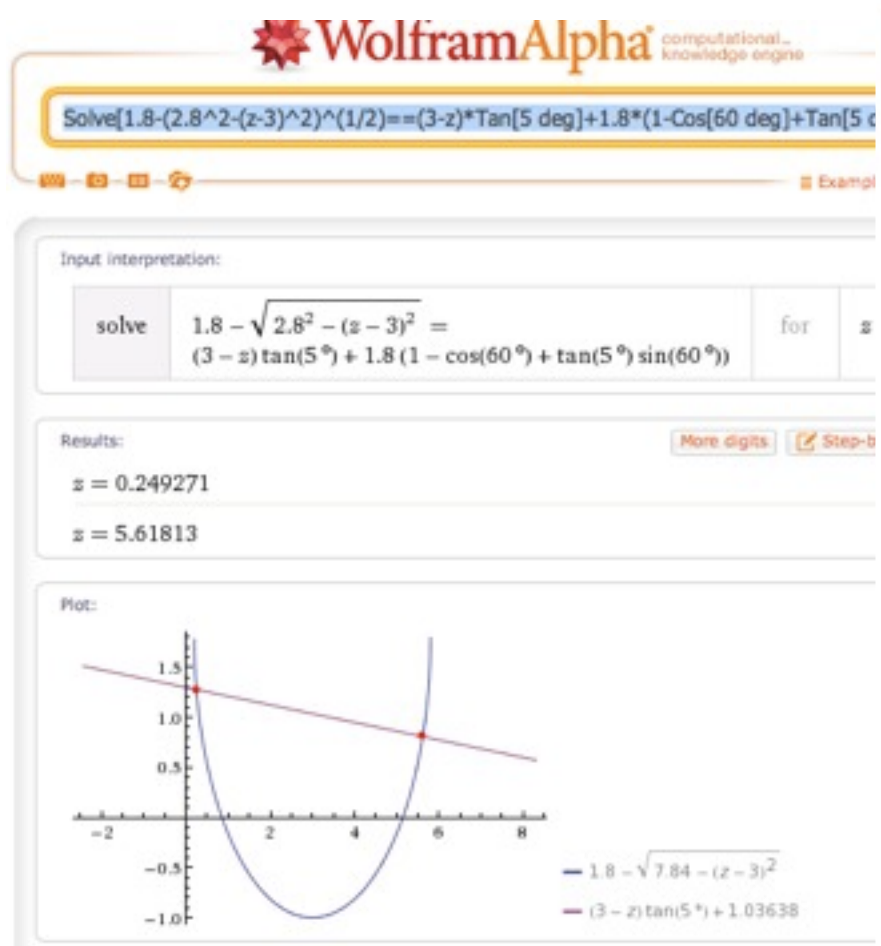


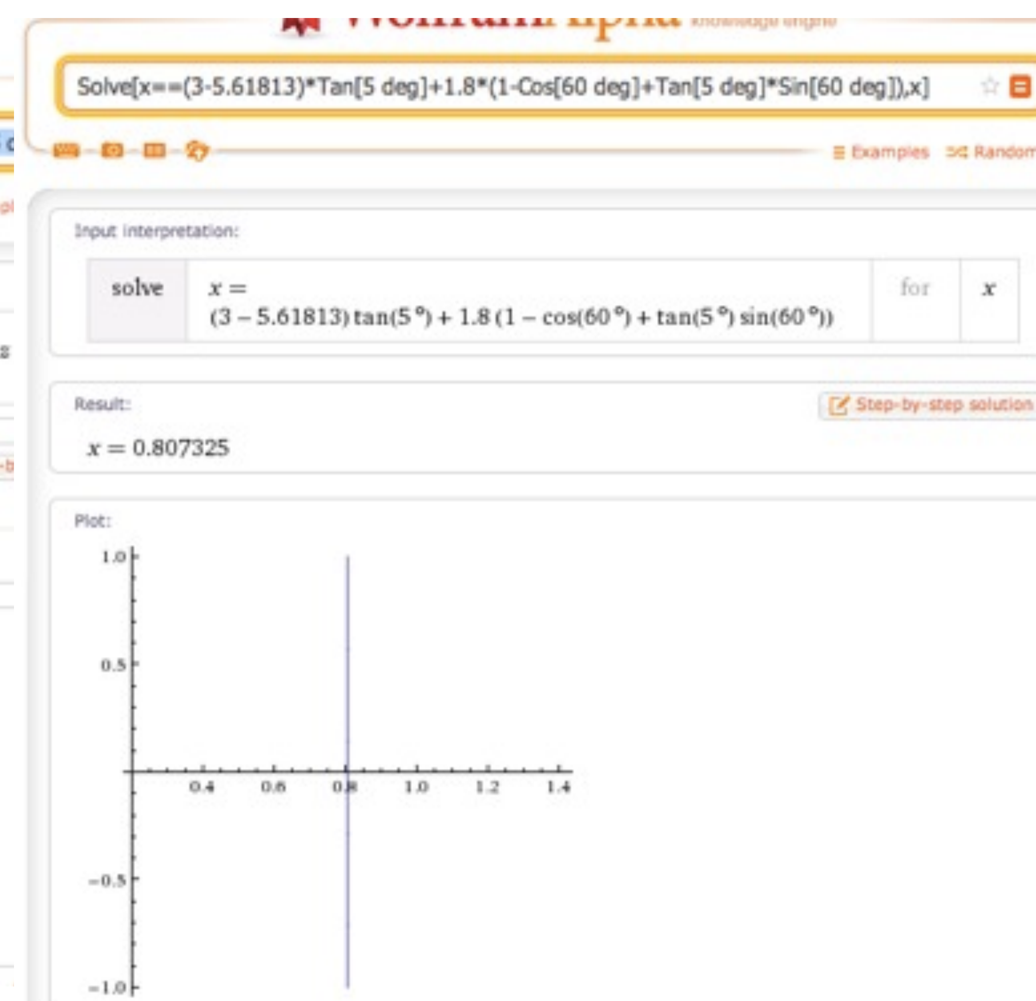

반원과 직선 접점

Solve[1.8-(2.8^2-(z-3)^2)^(1/2)==(3-z)*Tan[5 deg]+1.8*(1-Cos[60 deg]+Tan[5 deg]*Sin[60 deg]),z]

그 z값을 직선식에 넣음

Solve[x==(3-5.61813)*Tan[5 deg]+1.8*(1-Cos[60 deg]+Tan[5 deg]*Sin[60 deg]),x]

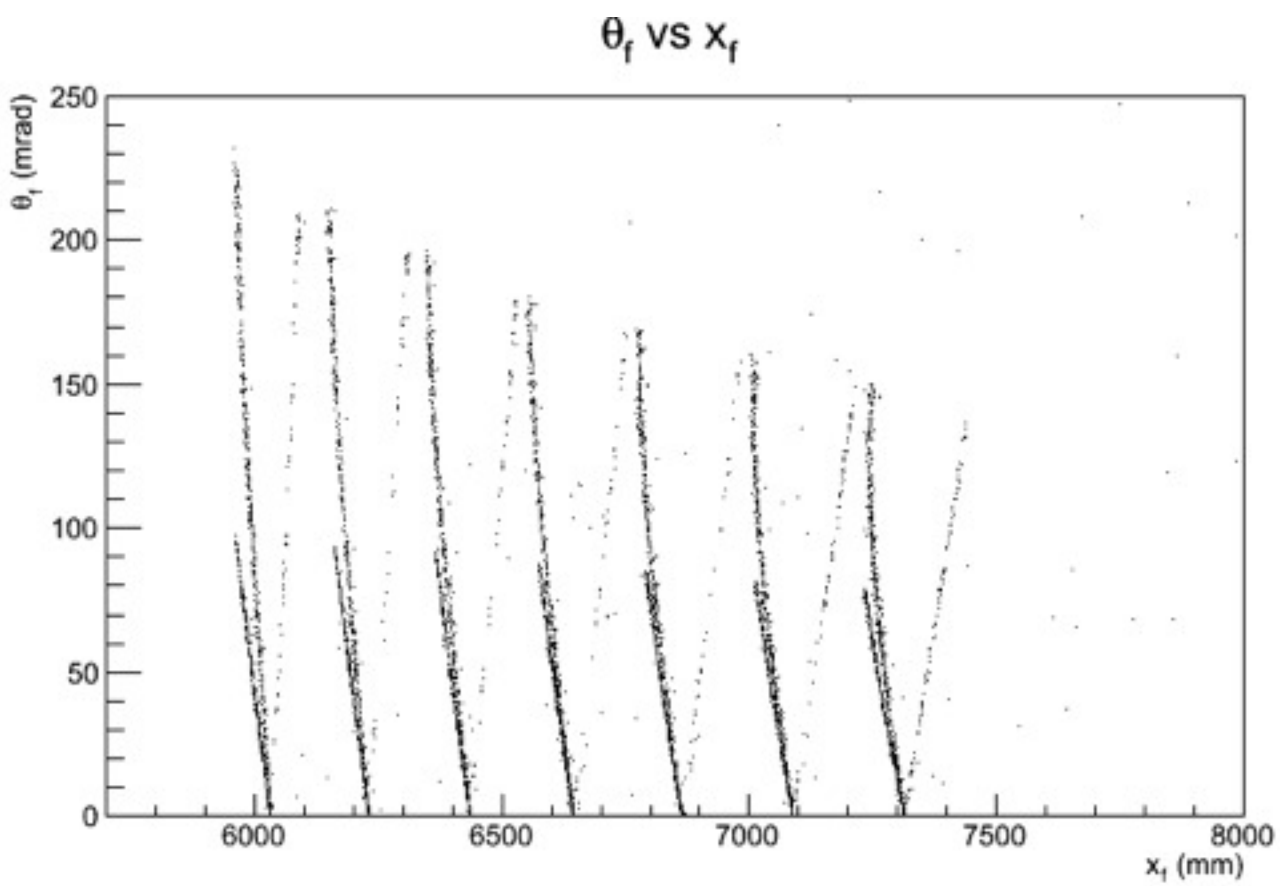


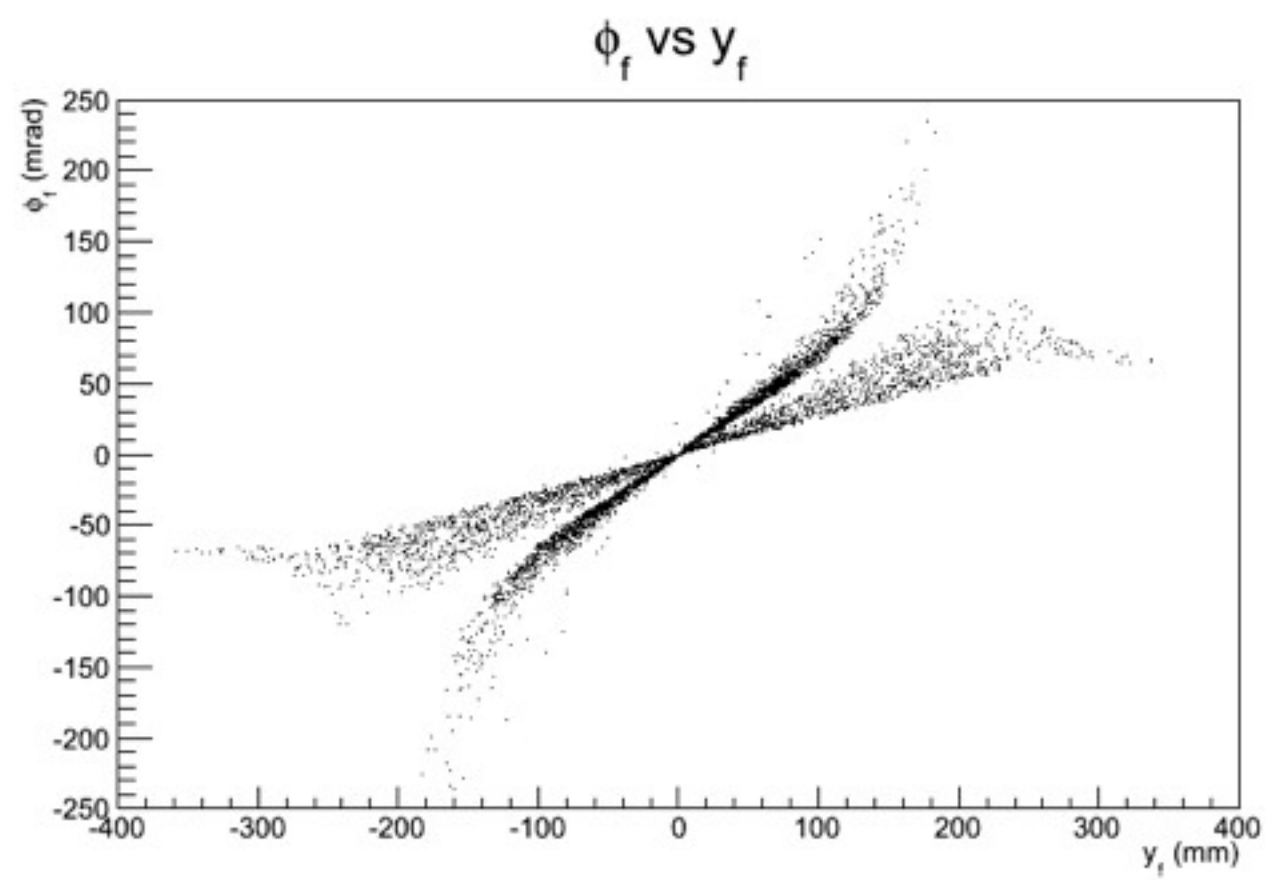




z=5.61813
x=0.807325

# FPD Simulation

**- for constant B field**




**- ideal $\theta_f$ vs $x_f$ should show vertical lines**
**- need some correction (hardware & software)**

# Matrix elements

NON SYMPL. SYSTEM TRANSFER MATRIX AT PATH-LENGTH L= 6.484955592E+00 M

| | | X | A | Y | B | L |
|---|---|---|---|---|---|---|
| 0 | | -1.920690E-12 | 1.795882E-12 | 0.000000E+00 | 0.000000E+00 | 6.484956E+00 |
| 1 | X | -3.228867E-01 | -1.504057E+00 | 0.000000E+00 | 0.000000E+00 | 2.607833E+00 |
| 2 | A | -4.814135E-02 | -3.321310E+00 | 0.000000E+00 | 0.000000E+00 | 6.163611E+00 |
| 3 | Y | 0.000000E+00 | 0.000000E+00 | -5.210447E+00 | -1.865086E+00 | 0.000000E+00 |
| 4 | B | 0.000000E+00 | 0.000000E+00 | -5.956890E-01 | -4.051498E-01 | 0.000000E+00 |
| 5 | G | 1.452690E-10 | 4.744609E-11 | 0.000000E+00 | 0.000000E+00 | 2.831984E-11 |
| 6 | P | 1.864604E+00 | 6.089987E-01 | 0.000000E+00 | 0.000000E+00 | 3.634962E-01 |
| 7 | XX | 1.394942E+00 | 7.260802E-01 | 0.000000E+00 | 0.000000E+00 | 3.011746E+00 |
| 8 | XA | 6.768649E+00 | 3.048345E+00 | 0.000000E+00 | 0.000000E+00 | 1.443217E+01 |
| 9 | XY | 0.000000E+00 | 0.000000E+00 | 3.184842E+00 | 2.733940E+00 | 0.000000E+00 |
| 10 | XB | 0.000000E+00 | 0.000000E+00 | -4.819811E+00 | -1.660342E+00 | 0.000000E+00 |
| 11 | XG | 3.759681E-10 | 5.452944E-11 | 0.000000E+00 | 0.000000E+00 | -1.980798E-10 |
| 12 | XP | 4.825723E+00 | 2.203998E+00 | 0.000000E+00 | 0.000000E+00 | -2.542550E+00 |
| 13 | AA | 8.092666E+00 | 3.111975E+00 | 0.000000E+00 | 0.000000E+00 | 1.826328E+01 |
| 14 | AY | 0.000000E+00 | 0.000000E+00 | 6.811118E+00 | 5.933088E+00 | 0.000000E+00 |
| 15 | AB | 0.000000E+00 | 0.000000E+00 | -1.247842E+01 | -4.317974E+00 | 0.000000E+00 |
| 16 | AG | 9.028511E-10 | 3.464278E-10 | 0.000000E+00 | 0.000000E+00 | -8.027996E-10 |
| 17 | AP | 1.154035E+01 | 4.446505E+00 | 0.000000E+00 | 0.000000E+00 | -4.140684E+00 |
| 18 | YY | -2.740048E+00 | 9.684104E-02 | 0.000000E+00 | 0.000000E+00 | 3.946395E+00 |
| 19 | YB | -2.339261E-01 | -4.188925E-02 | 0.000000E+00 | 0.000000E+00 | 2.673577E+00 |
| 20 | YG | 0.000000E+00 | 0.000000E+00 | 5.734884E-10 | 3.196443E-11 | 0.000000E+00 |
| 21 | YP | 0.000000E+00 | 0.000000E+00 | 7.361062E+00 | 2.275357E+00 | 0.000000E+00 |
| 22 | BB | -3.777320E-01 | -2.672593E-01 | 0.000000E+00 | 0.000000E+00 | 1.561350E+00 |
| 23 | BG | 0.000000E+00 | 0.000000E+00 | 9.227170E-10 | 2.893497E-10 | 0.000000E+00 |
| 24 | BP | 0.000000E+00 | 0.000000E+00 | 1.124814E+01 | 3.714041E+00 | 0.000000E+00 |
| 25 | GG | -2.118185E-10 | -6.918158E-11 | 0.000000E+00 | 0.000000E+00 | -4.129153E-11 |
| 26 | GP | 2.111316E-10 | 1.086773E-10 | 0.000000E+00 | 0.000000E+00 | 1.224395E-10 |
| 27 | PP | -1.363878E+00 | -4.950346E-01 | 0.000000E+00 | 0.000000E+00 | 2.557992E-01 |

R22 → -3.321310E+00 (row 2 A, column A)

R16 → 1.864604E+00 (row 6 P, column X)

T126 → 1.154035E+01 (row 17 AP, column X)

$$T^{\psi}_{126} = \frac{T_{126} + R_{22}R_{16}\tan(\psi)}{\cos(\psi)}$$

$$\tan(\psi) = -\frac{T_{126}}{R_{22}R_{16}}$$