# Software

T.Hara (Osaka)

- Simulation
- Reconstruction

# Simulation

- There is no progress, sorry.
  - 1.0cm beam pipe + 6-lyr SVD are installed
    → SVD part : thnx to H.Kim
  - Reconstruction w/ Belle analysis tools
    → SVD part : thnx to K.Trabelsi
  - Inner two layers is being replaced with PXD
    → PXD part : thnx to H.Hoedlmoser
  - Beam pipe : design has not been fixed yet …

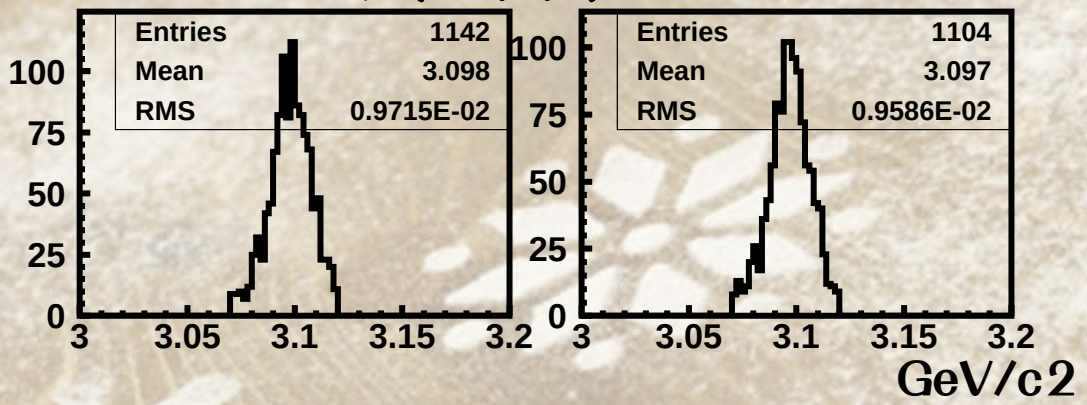
# Reconstrcution

(K.Trabelsi)

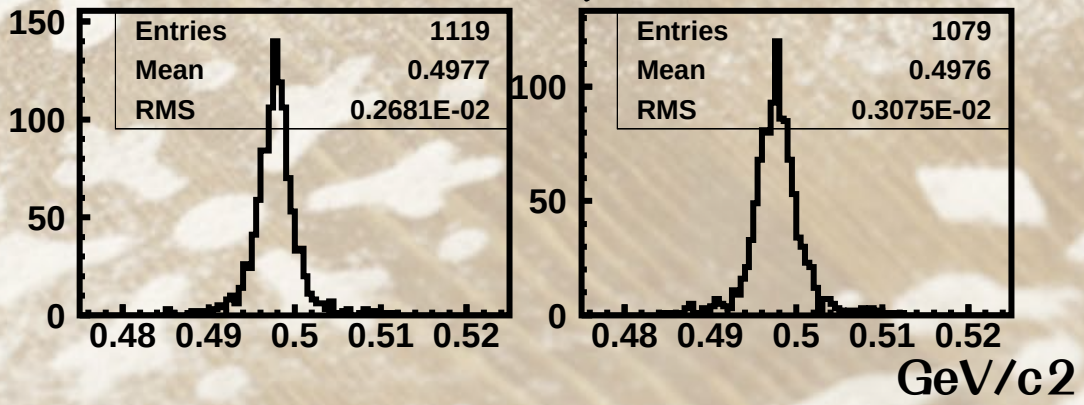
## reconstructed B

## $B \to J/\psi\ K_S$ (w/o PID)

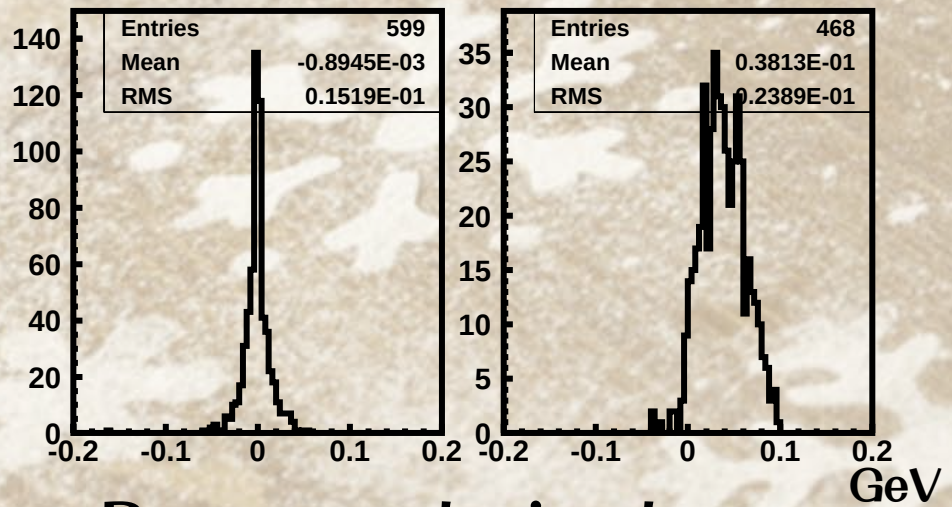
Belle $J/\psi(\to \mu\mu)$ mass sBelle



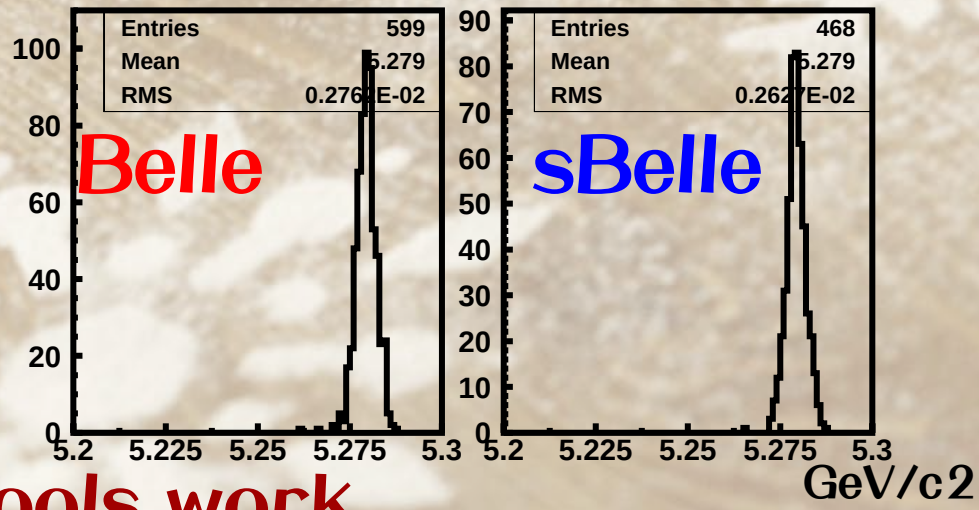

Belle $K_S(\to \pi\pi)$ mass sBelle




Belle ΔE sBelle




Beam constrained mass



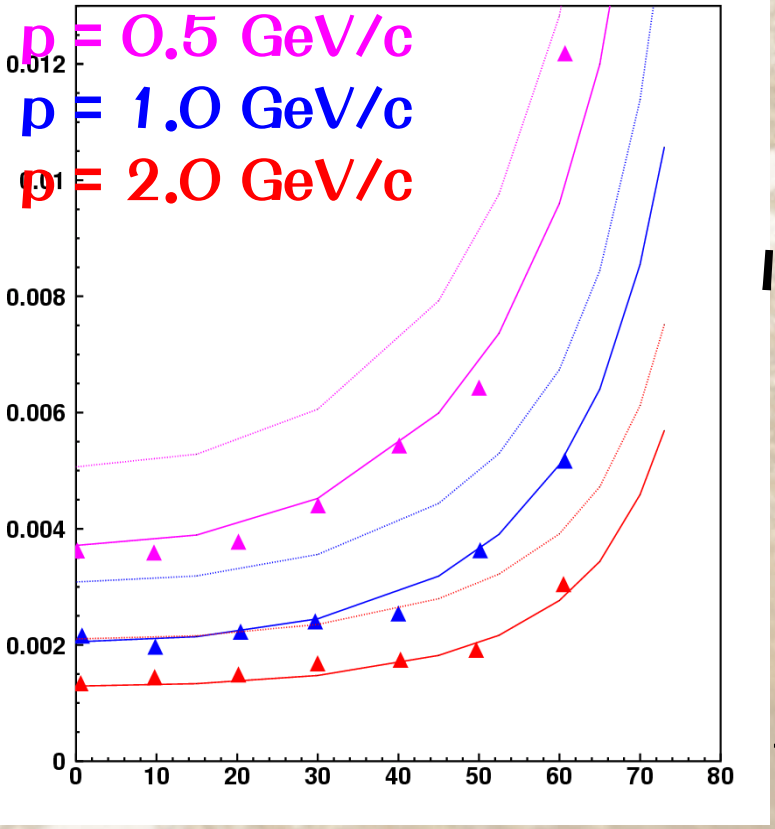

▶ minimum reconstrcution tools work.

# Reconstrcution

(K.Trabelsi)

reported in the 1st proto-Collaboration meeting

Impact Param. Resol in r-$\phi$(cm)




lines : TRACKERR

dotted : Belle (SVD2)

$R_{beampipe}$ = 1.5cm

$R_{1st\ lyr}$ = 2.0cm

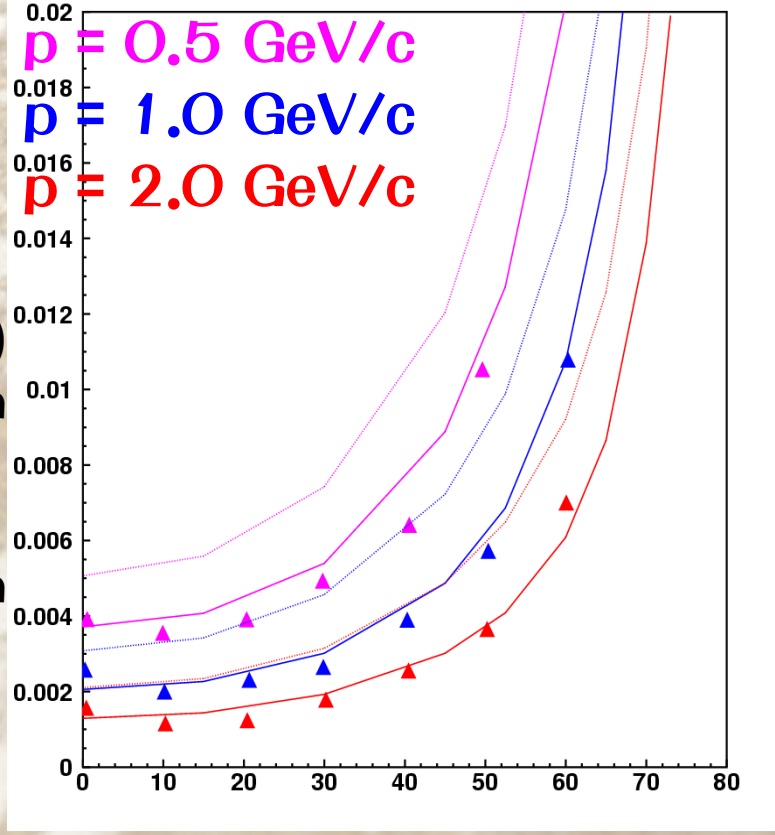
solid : sBelle

$R_{beampipe}$ = 1.0cm

$R_{1st\ lyr}$ = 1.3cm

triangles : G4

Impact Param. Resol in z(cm)




▶ minimum reconstrcution tools work.

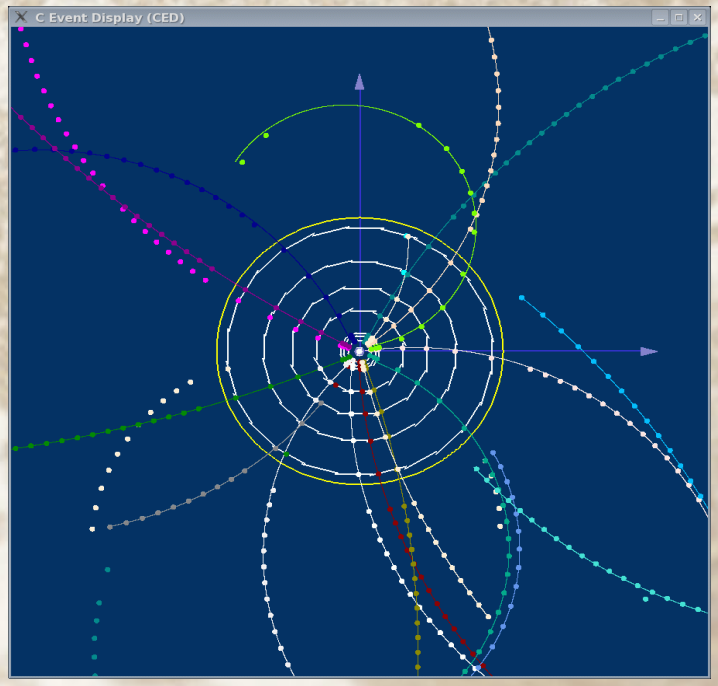
# Tracking Simulation with Pixel Detector and Related Software

Alexei Raspereza

*Belle Detector Upgrade Meeting, 4.12.2008*

## Outline

- Software tools
- Tracking system of sBelle
- Simulation/optimization studie
- Conclusion



- Two separate PXD detectors differing by the number of layers are considered
- Two new **databases** (subdectectors) in local MySQL were added.
- New **geometry driver** was written


**Used values:**

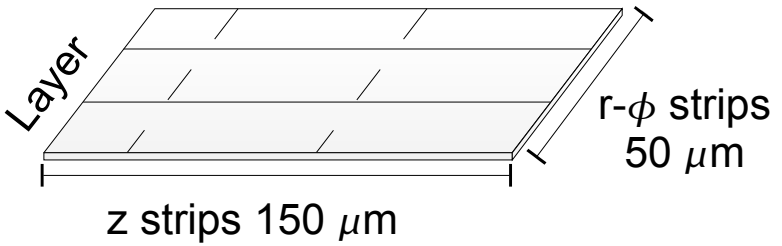
1st option

| # | r *(cm)* | sensor *(cmxcm)* | # sensor *in z* | #ladders *(around phi)* | thickness *(μm)* |
|---|---|---|---|---|---|
| 1 | 1.7 | 7.1x0.94 | 2 | 12 | 50 |
| 2 | 2.0 | 8.4x1.10 | 2 | 12 | 50 |

2nd option

| | | | | | |
|---|---|---|---|---|---|
| 1 | 1.2 | 5.1x0.66 | 2 | 12 | 50 |
| 2 | 1.7 | 7.1x0.94 | 2 | 12 | 50 |
| 3 | 2.0 | 8.4x1.10 | 2 | 12 | 50 |

- Double Sided Strip Detector (DSSD) is implemented within the same driver as pixel vertex detector



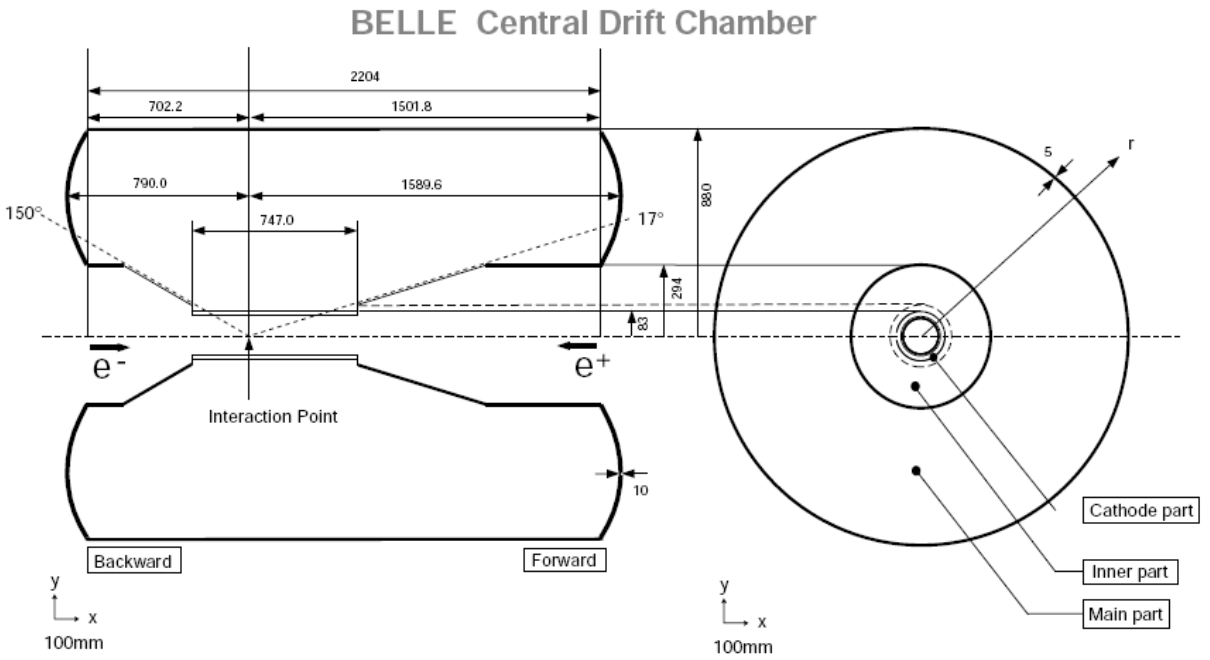

**Used values:**

DSSD layers

| # | r *(cm)* | sensor *(cmxcm)* | # sensor *in z* | #ladders *(around phi)* | thickness *(μm)* |
|---|---|---|---|---|---|
| 1 | 4.5 | 8.0x2.8 | 3 | 12 | 300 |
| 2 | 7.0 | 7.6x4.0 | 5 | 12 | 300 |
| 3 | 10.0 | 9.0x2.8 | 5 | 24 | 300 |
| 4 | 13.8 | 7.6x4.0 | 6 | 24 | 300 |

Simplified implementation of DSSD
⇒ each layer is represented by single Si plane,
DSSD signals are simulated assuming pixel readout scheme
( no ghost hits are produced )
Pad size (r-$\phi$,z) : 50$\times$150 $\mu$m$^2$

# Central Drift Chamber




Gas mixture:
$He/C_2H_6$ (50:50)

## Parameters envisaged for superBelle

| | |
|---|---|
| • Radius of inner boundary | 150 mm |
| • Radius of outer boundary | 1150 mm |
| • Radius of the innermost sense wire | 172 mm |
| • Radius of the outermost sense wire | 1120 mm |
| • Number of layers | 58 |
| • Effective radius of dE/dx measurements | 948 mm |

- Simplified digitization procedure:
  - G4 tracking

⇒ track intersection with measurement cylindrical layer

⇒ 3D point is smeared according to the average spatial point resolutions obtained in Belle

$\sigma(r\text{-}\phi) = 130\mu m$

$\sigma(z) = 800\mu m$

# Performance studies with single particles

- Single muons
  - *minimized bremstrahlung*
- Simulation is done with G4 `particle/gun`
- Momentum scan
  - *p = 0.2, 0.4, 0.7, 1.0, 2.0 GeV/c*
- Polar angle scan within acceptance
  - $\theta$ = 20, 40, 60, 80° and 180° – $\theta$
- Uniform smearing in $\phi$
- Performance is evaluated in terms of impact parameter (IP) resolutions
  - *Resolution is defined as RMS of the region around central value of IP distribuition, containing 90% of events*

# Impact Parameter Resolutions 2 Layer PXD (no background)

$$\sigma(d_0) = a_{d0} \oplus b_{d0} / p\beta \cdot \sin^{3/2}\theta$$

$a_{d0} = 14.7 \pm 1.2\ \mu m$

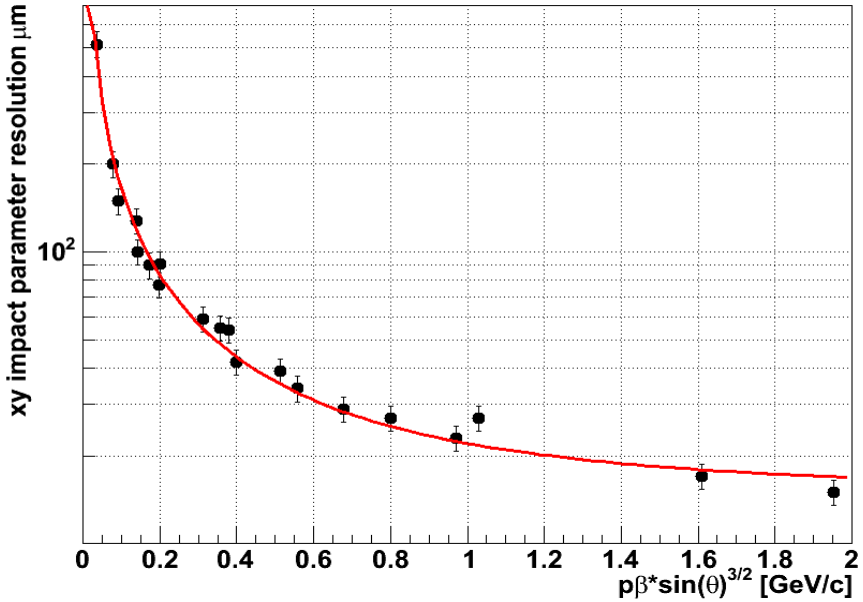
$b_{d0} = 16.4 \pm 0.6\ GeV/c \cdot \mu m$

$$\sigma(z_0) = a_{z0} \oplus b_{z0} / p\beta \cdot \sin^{5/2}\theta$$

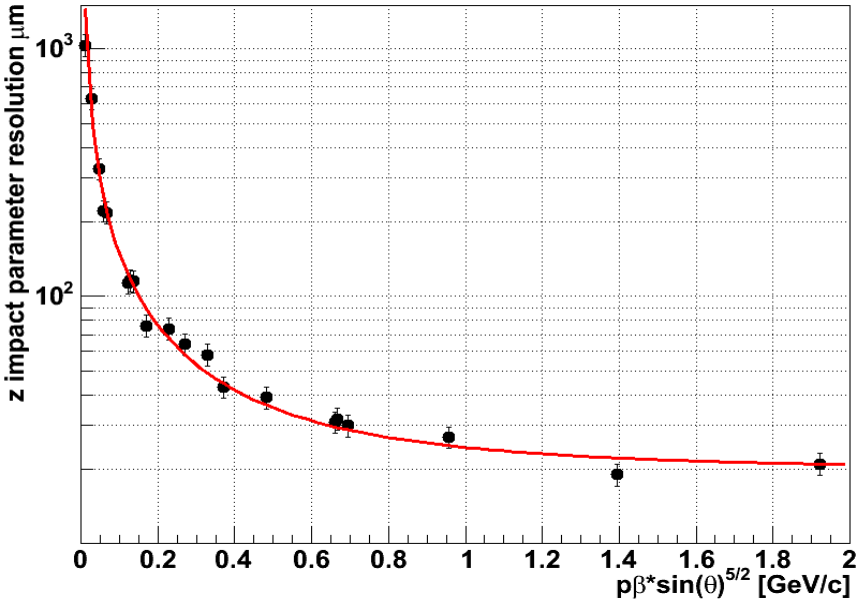
$a_{z0} = 19.5 \pm 1.3\ \mu m$

$b_{z0} = 14.8 \pm 0.5\ GeV/c \cdot \mu m$

xy Impact parameter resolution




z Impact parameter resolution



# Impact Parameter Resolutions 3 Layer PXD (no background)

$$\sigma(d_0) = a_{d0} \oplus b_{d0} / p\beta \cdot \sin^{3/2}\theta$$

$$a_{d0} = 12.4 \pm 0.8\ \mu m$$

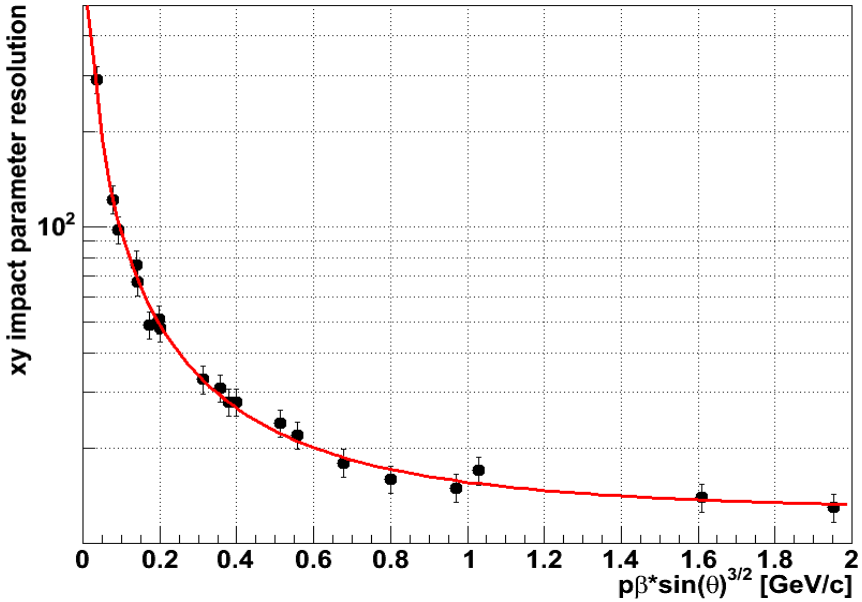
$$b_{d0} = 9.5 \pm 0.3\ GeV/c \cdot \mu m$$

$$\sigma(z_0) = a_{z0} \oplus b_{z0} / p\beta \cdot \sin^{5/2}\theta$$

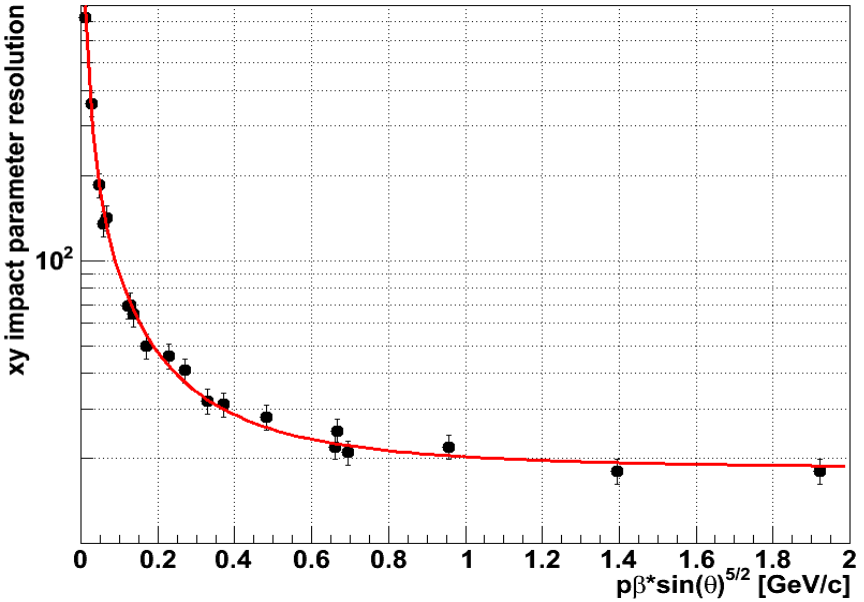
$$a_{z0} = 18.2 \pm 0.9\ \mu m$$

$$b_{z0} = 8.7 \pm 0.3\ GeV/c \cdot \mu m$$

xy impact parameter resolution

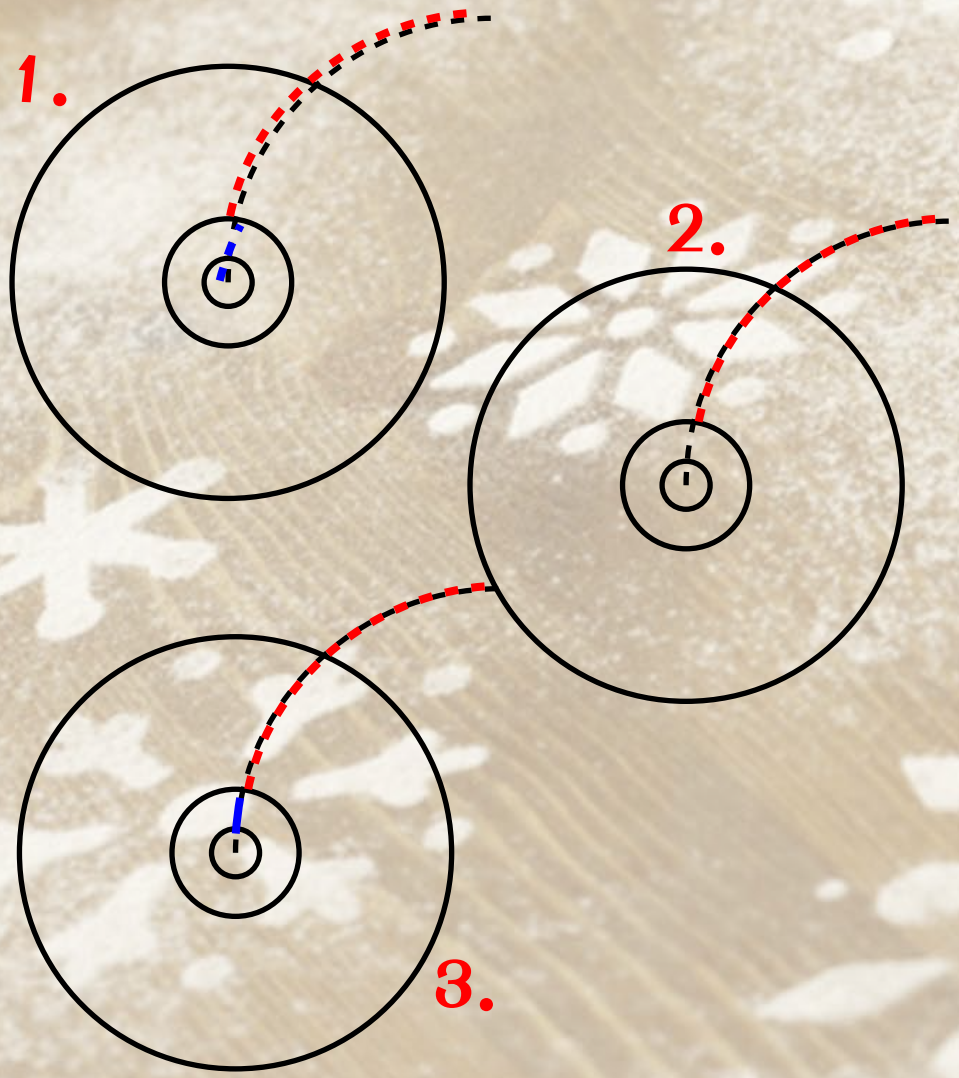



z impact Parameter resolution



# Other tracking tool (A.Raspereza)

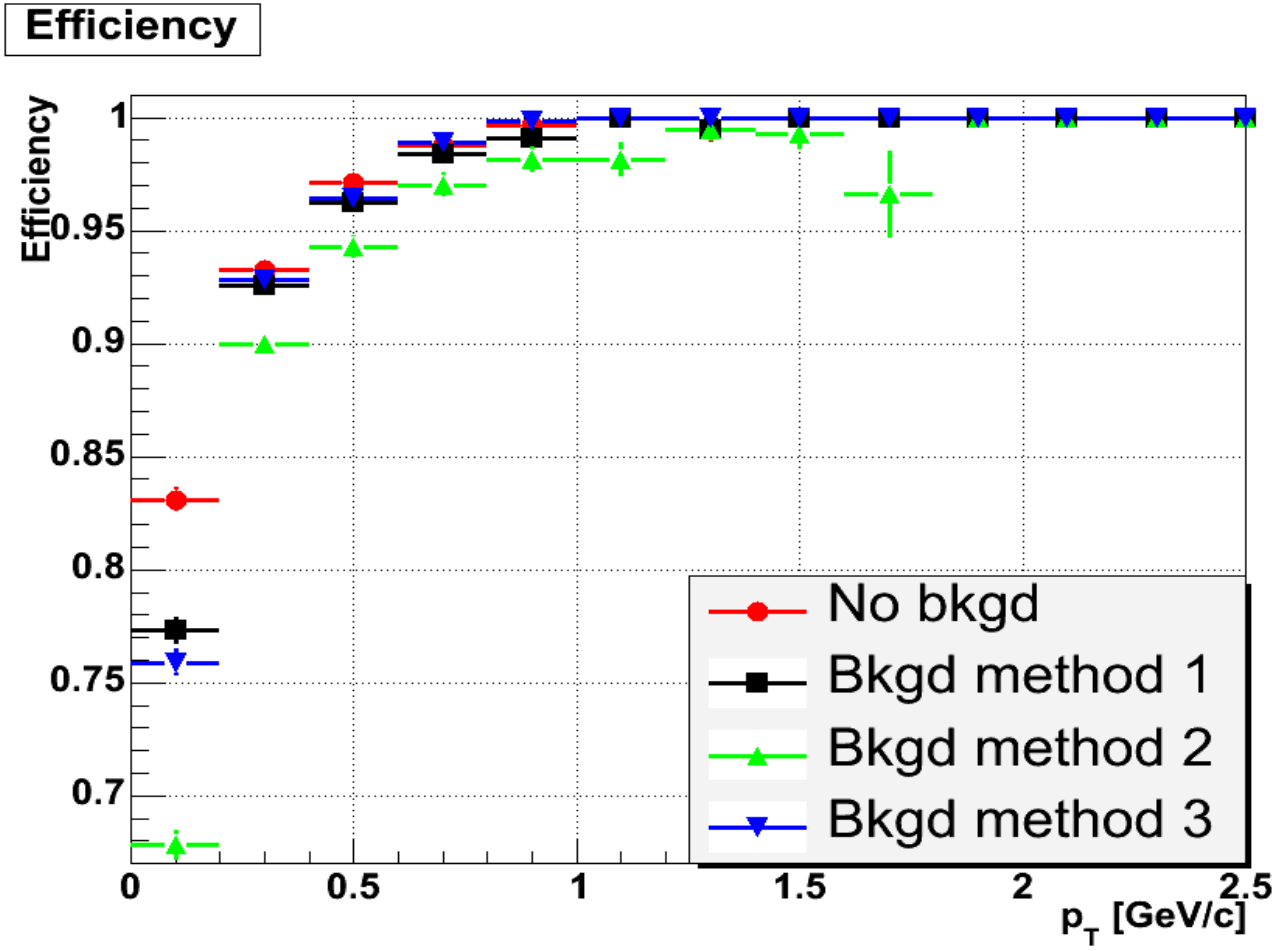
Pattern recognition & track reconstruction procedure



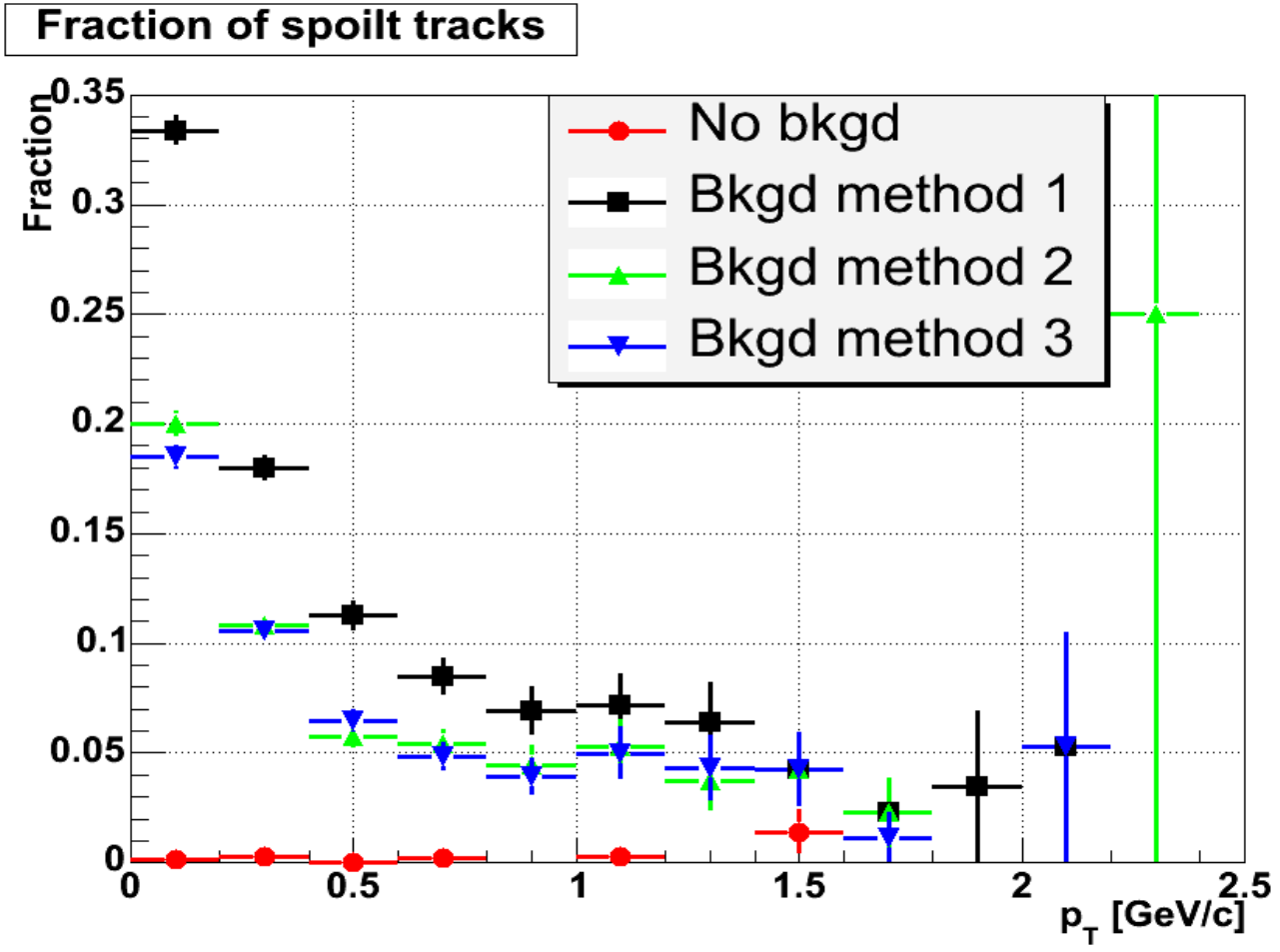

- Pattern recognition in CDC : inward search for continuoous hit patterns compatible with helix hypothesis (DELPHI code)
- Fit CDC tracks with Kalman filter
- Three different methods to combine patrec in CDC and Si tracker

1. Perform separate patrec in Si tracker ; combine CDC and Si tracks ; refit combined tracks
2. Propagate track back into Si tracker ; pick up hits on backward helical road ; refit track each time new hit is added
3. Perform separate patrec only in SVD, combine CDC & SVD tracks ; extrapolate track back into area of PXD; assign hits on backward helical road; refit track after inclusion of new hits

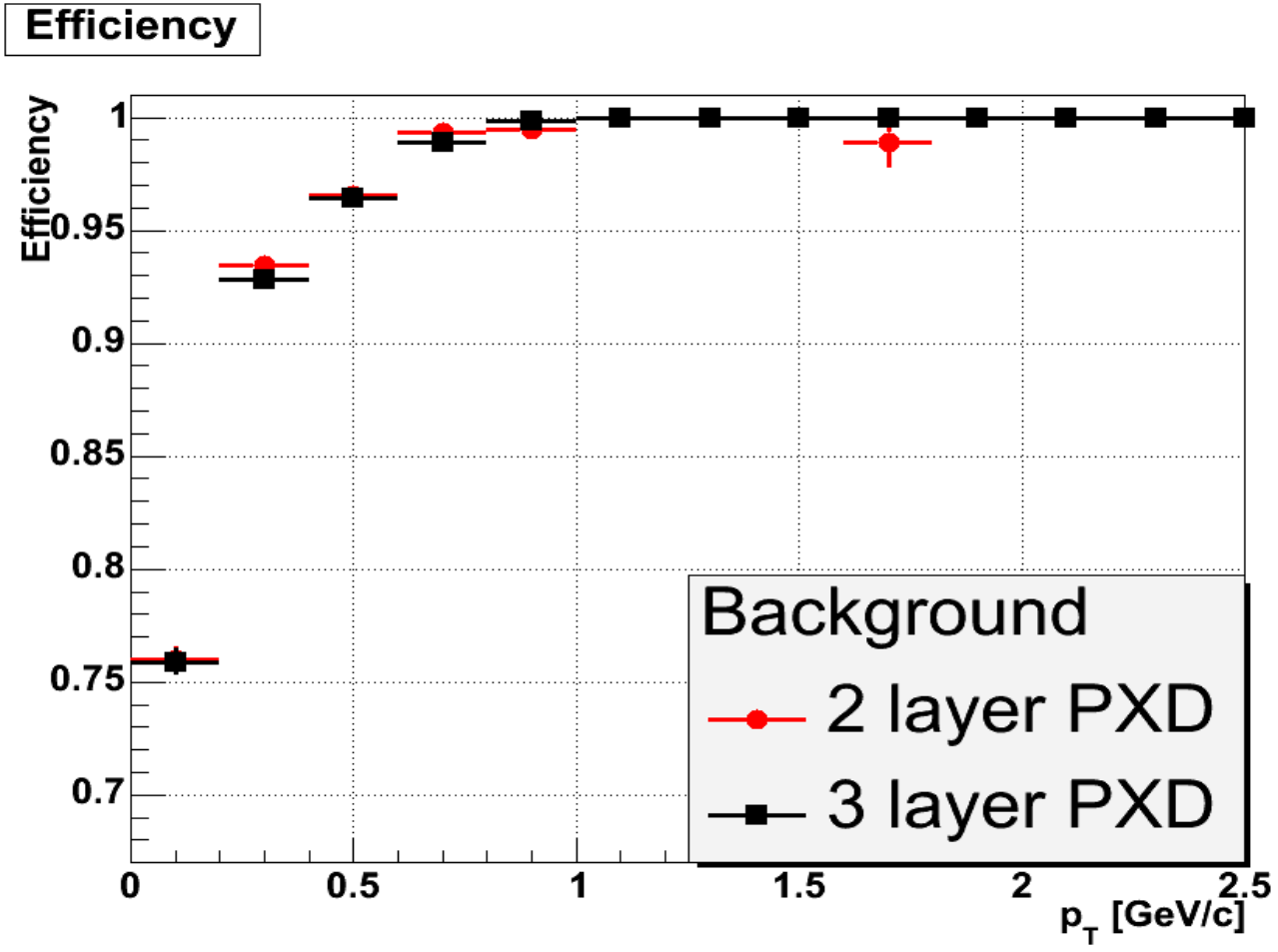
# Track Finding Efficiency Comparison of methods 3 layer PXD Option



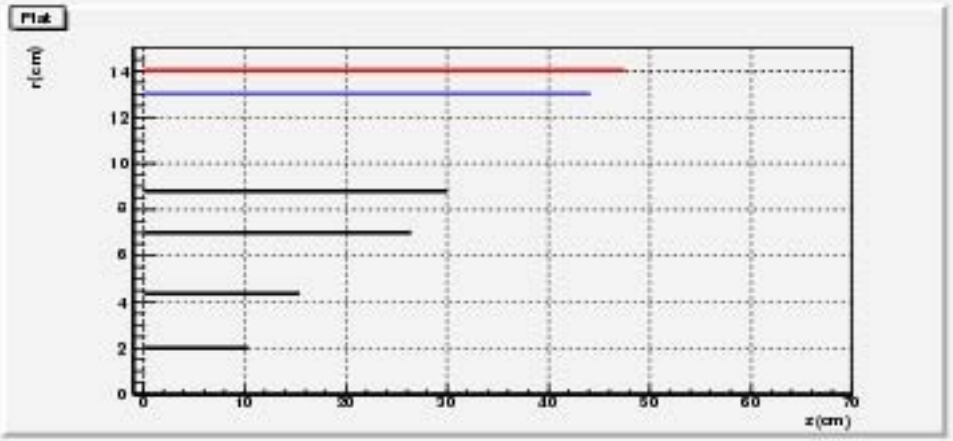
# Spoilt Track Fraction Comparison of methods 3 Layer PXD Option

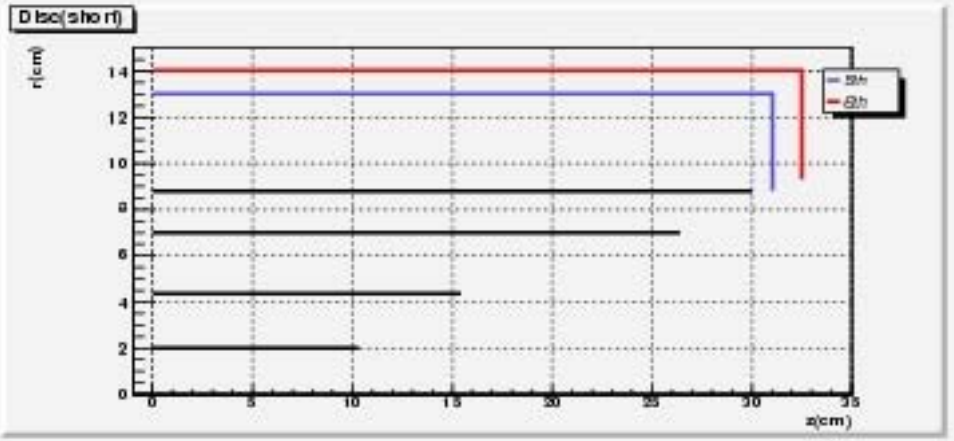


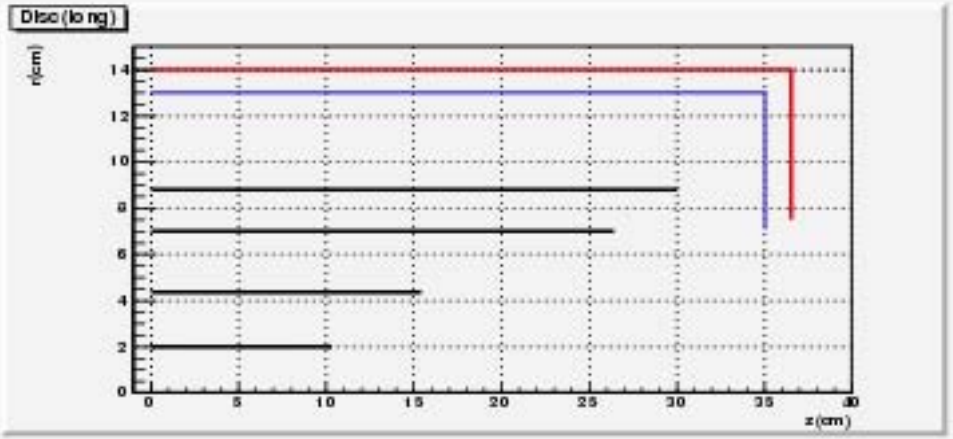
# Track Finding Efficiency
# 3d Reconstruction Method
# Comparison between PXD Options

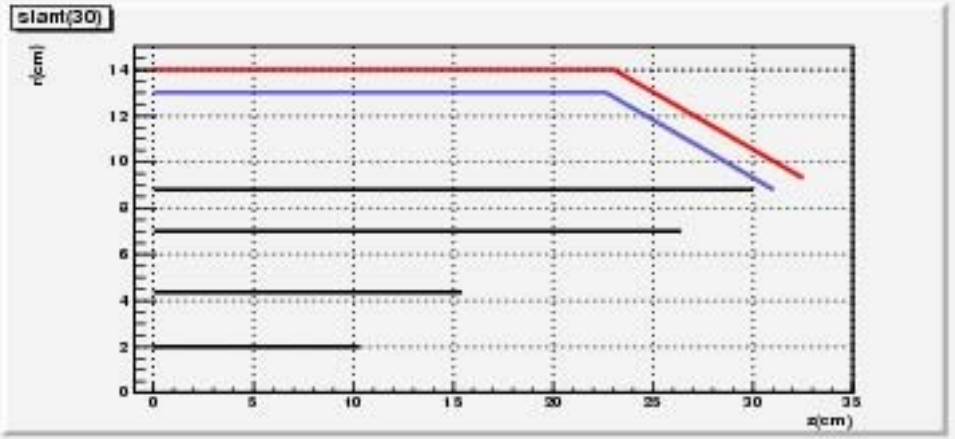


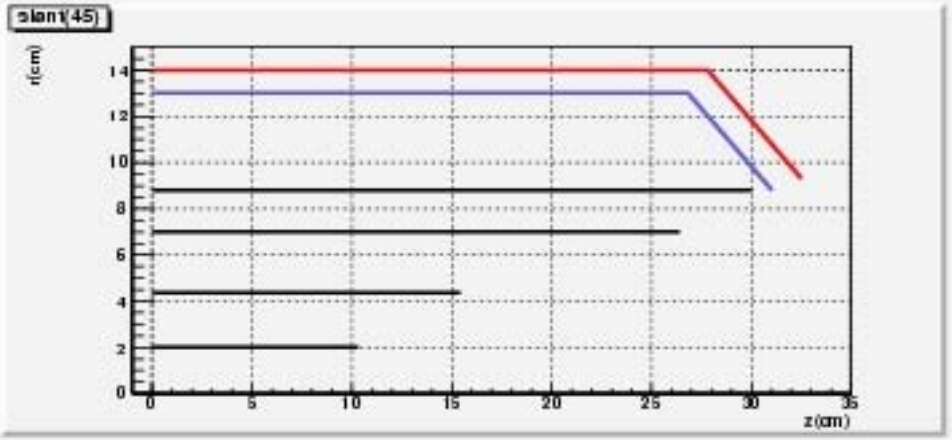
# Optimization of geometry for slanted-part or disk-type

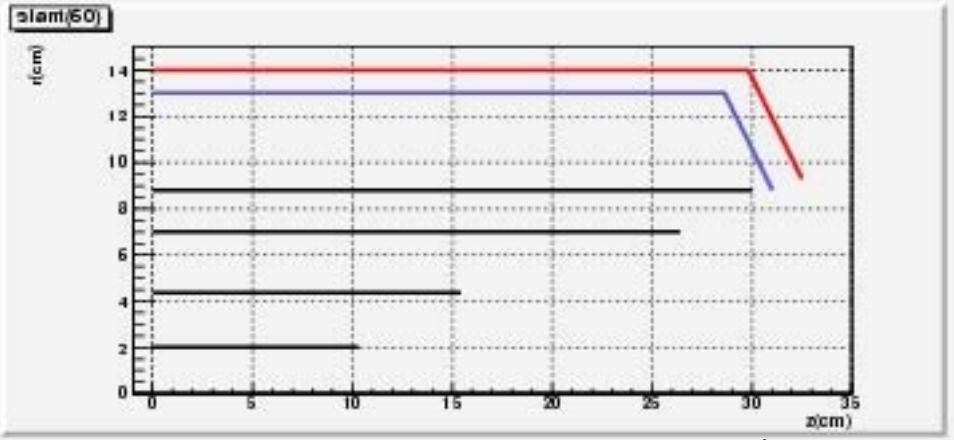



Otagiri (Niigata)

# Summary

- For G4 simulation, I'll be back to work soon
- For reconstruction
  - tracking tools used in Belle work
    - hard to implement tons of geometery designs in both sim/rec
    - SVD track finding is not ready ...
  - tracking tools w/ ILC software also work
    - is it possible to implement the slated-part ? (now assume cylinder)
    - SVD+PXD track finder works

      → powerful tools for optimization of the detector

      → but need to design the class object carefully
- need to decide the SVD design
  - 4-layer SVD+2-layer PXD
  - Slanted-part or Disk-type ?

at least, the schedule for SVD design should be decided !

time is ticking ...

# Sources of backgrounds at Belle/superBelle

1. Synchrotron radiation
2. Particle background (beam-gas interactions, intra-bunch scattering)

- Background rate estimate for Belle : $r_{BG} \approx$ *23500* $s^{-1}mm^{-2}$ (inner layer)
- Factor of 6 increase in background at superBelle (initial phase)
- $1/R^2$ dependence of background

- Integration time for DEPFET sensors (ILC configuration) : ***25μs***

  $\tau_{\text{int}} \propto L_{sensor}/L_{pixel} \Rightarrow$ (SuperBelle configuration): ***10μs***

$$Occupancy = r_{BG} \cdot \langle Cluster\_size \rangle \cdot Pixel\_area \cdot \tau_{\text{int}}$$

| R [*cm*] | Bkgd [$s^{-1}mm^{-2}$] | Occupancy |
|---|---|---|
| 1.2 | 430000 | 1.6% |
| 1.7 | 210000 | 0.8% |
| 2.0 | 150000 | 0.6% |