

# Concept of the $K_S^0$ Rescue System for the Belle II Pixel Detector

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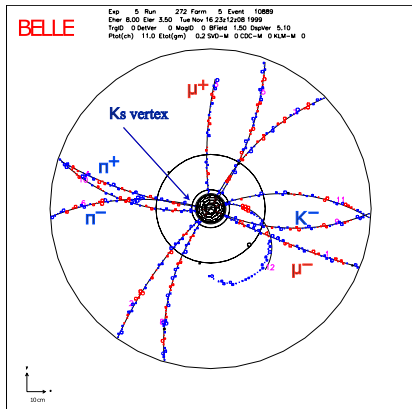
II. Physikalisches  
Institut



Bundesministerium  
für Bildung  
und Forschung

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# Motivation

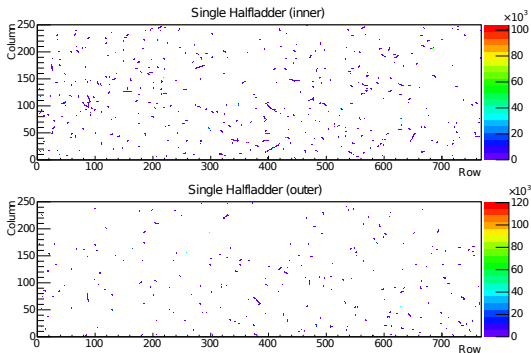


## B physics

- CP violation: eg.  
 $B^0 \rightarrow J/\psi K_S^0$
- Flavor Changing Neutral Currents: eg.  $b \rightarrow s \gamma$   
( $B^0 \rightarrow K_S^0 \pi^0 \gamma$ )
- $b \rightarrow c \rightarrow s$

$K_S^0 \rightarrow \pi^+ \pi^-$  are abundant in B meson decays

# PXD background

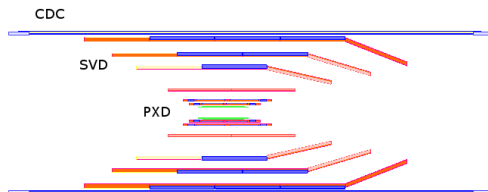


## background sources

- Beam - gas scattering
- Synchrotron radiation
- Touschek effect
- Radiative Bhabha
- Two photon QED

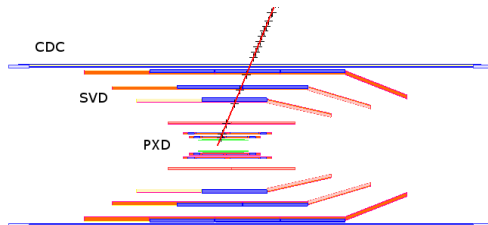
$\Rightarrow \leq 3\%$  occupancy  
 $\Rightarrow \sim 20$  GB/s PXD data output ( $\sim 10\times$  output from rest of detector)

# PXD Readout



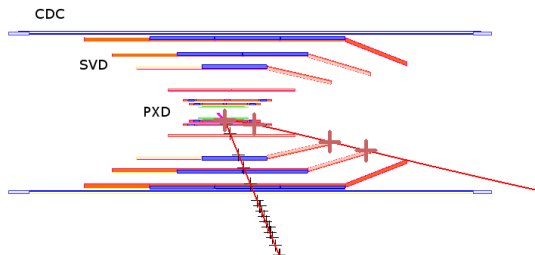
- Track leaving hits in PXD, SVD, and CDC
- Online tracking using SVD and CDC hits
- Extrapolate into PXD region → Region of Interest (ROI)
- Readout of PXD data inside of ROI
- Cluster Rescue mechanism saves clusters with high seedcharge (low  $p$ )

# PXD Readout



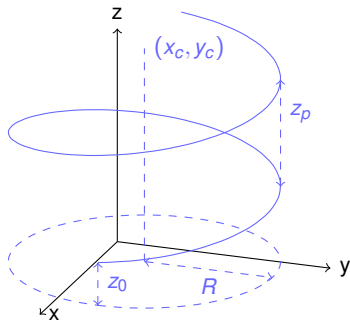
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# PXD Readout



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# Online Tracking with full VXD



## Parameters of a helix

- Radius:  $R$
- Center:  $(x_c, y_c)$
- Pitch:  $z_p$
- Z-offset:  $z_0$

Platform:

FPGA

## Track finding:

- 1 X-Y plane:
  - 1 Conformal transformation
  - 2 Fast hough transformation
- 2 Validate track by reconstructing z-component (fast hough transformation)

## Reduction of combinatorics

- 1 High PXD occupancy  $\rightarrow$  huge combinatorics ( $\sim 10 \times 10^{10}$  hit-hit combinations)
- 2 Secondary vertices  $\rightarrow$  choose hits in 3<sup>rd</sup> VXD layer as reference point for conformal transformation
- 3 Idea: Include only PXD hits, that 'fit' to the reference point

### MC simulation

- 10 000 inclusive  $B\bar{B}$  events
- No background included yet
- Select  $\pi^{\pm}$ :
  - No hits in CDC
  - $\leq 2$  hits in SVD
  - $\geq 3$  hits in VXD
  - Seedcharge < Cluster Rescue threshold

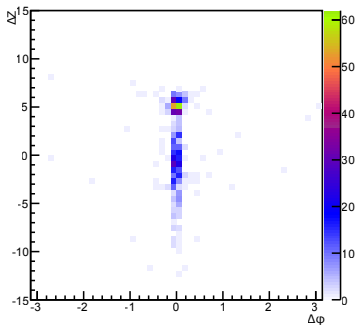


# Reduction of combinatorics

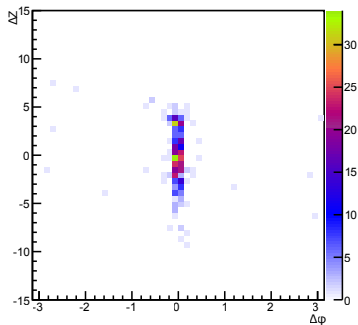
## Observables

- $\Delta Z_{i,j} = Z_{\text{hit, layer } i} - Z_{\text{hit, layer } j}$
- $\Delta \phi_{i,j} = \phi_{\text{hit, layer } i} - \phi_{\text{hit, layer } j}$

Layer 1 - Layer 3



Layer 2 - Layer 3



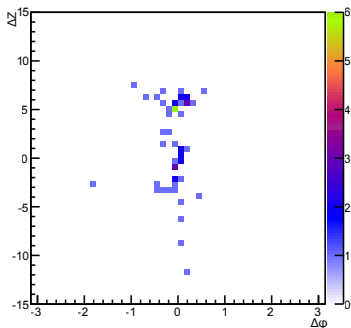
All  $\pi^\pm$

# Reduction of combinatorics

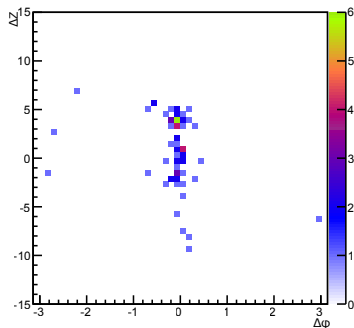
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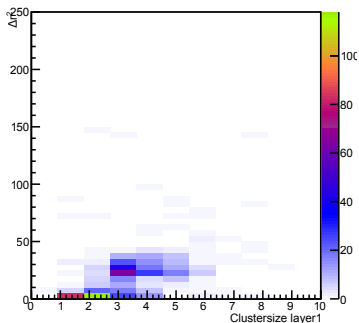
Only  $\pi^\pm$  from  $K_S^0$

# Reduction of combinatorics

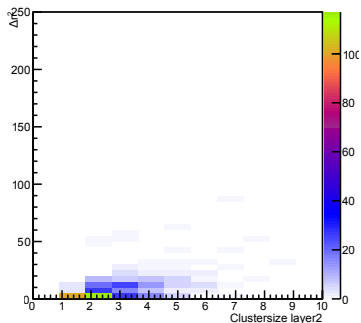
## Observables

- $\Delta r_{i,j}^2 = (\Delta\phi_{i,j})^2 + (\Delta z_{i,j})^2$
- Clustersize

Layer 1 - Layer 3



Layer 2 - Layer 3



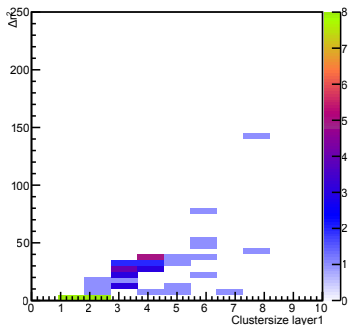
All  $\pi^\pm$

# Reduction of combinatorics

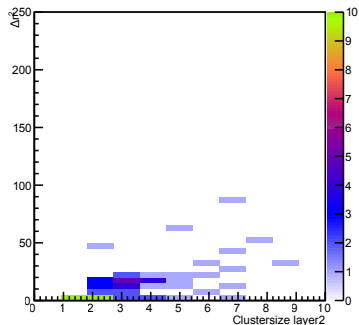
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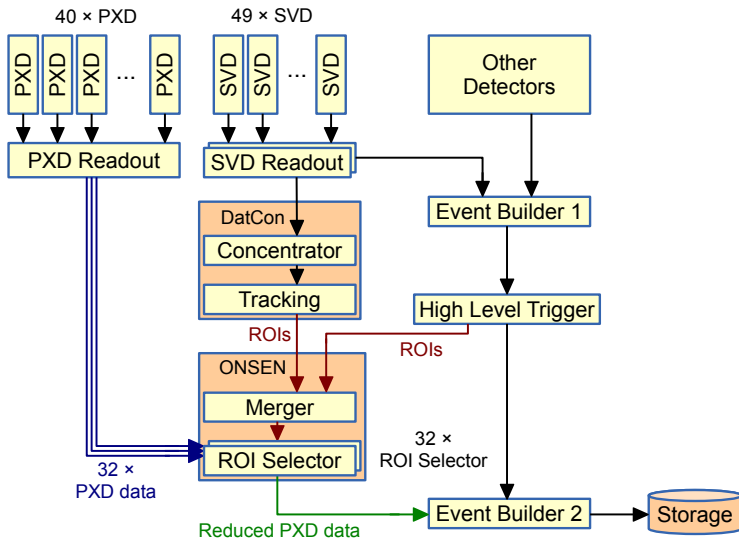
# Summary

- PXD data reduction via ROIs
- Tracks with too few hits in SVD + CDC  $\rightarrow$  no ROI
- Solution: Tracking with PXD + SVD
- Algorithm: Fast Hough Transformation
- Reduction of combinatorics

## To do:

- Include Background
- Efficiency study
- Implementation on hardware

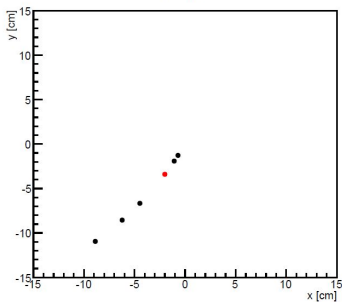
Thanks for your attention!



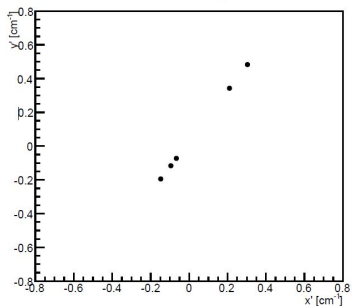
# Conformal Transformation

Convert a circle into a straight line

Real Space



Conformal Space



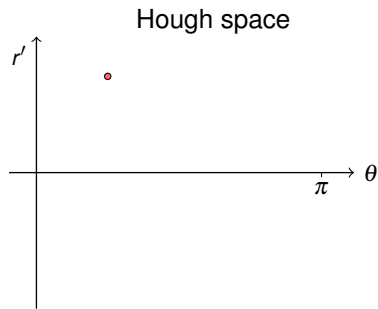
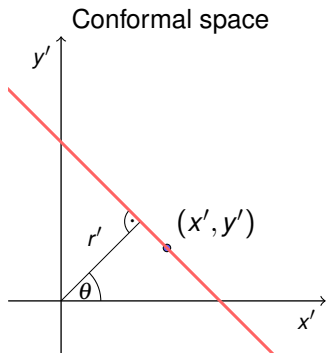
$$x \rightarrow x' = \frac{x - x_0}{r^2}$$

$$y \rightarrow y' = \frac{y - y_0}{r^2}$$

$$r^2 = (x - x_0)^2 + (y - y_0)^2$$

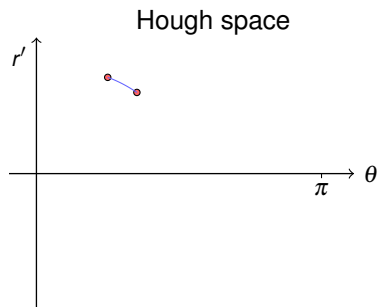
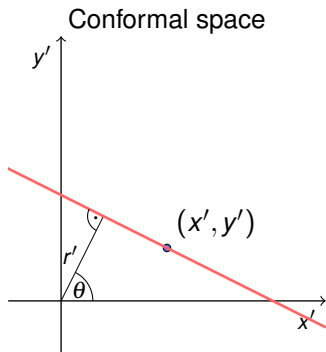


# Hough Transformation



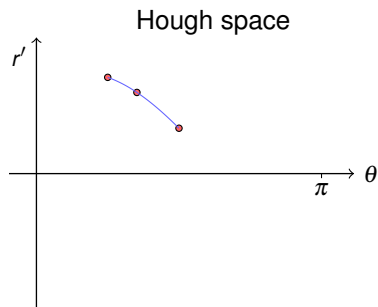
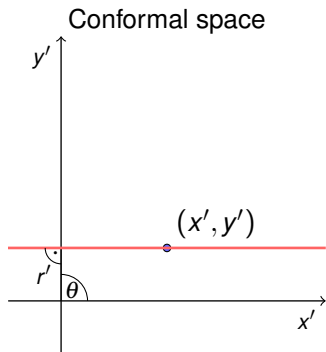
$$r' = x' \cos \theta + y' \sin \theta$$

# Hough Transformation



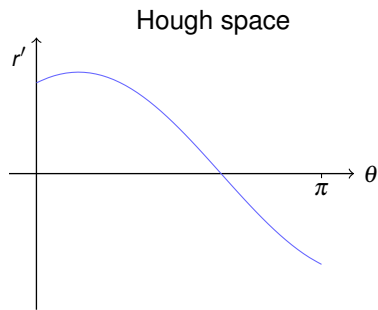
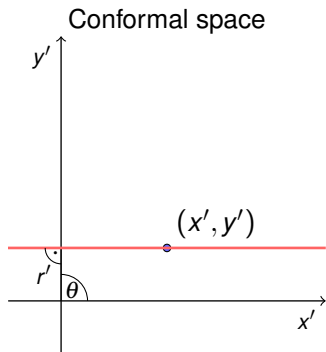
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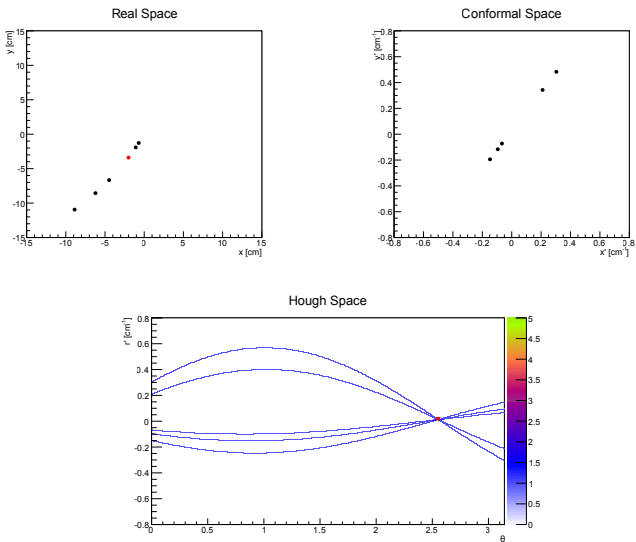
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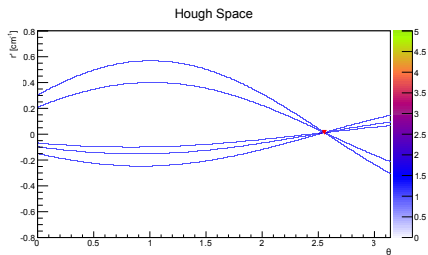
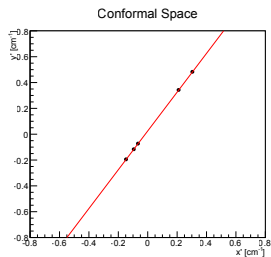
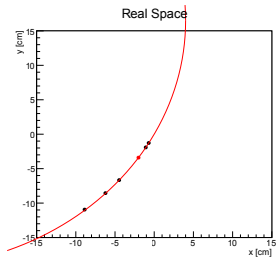


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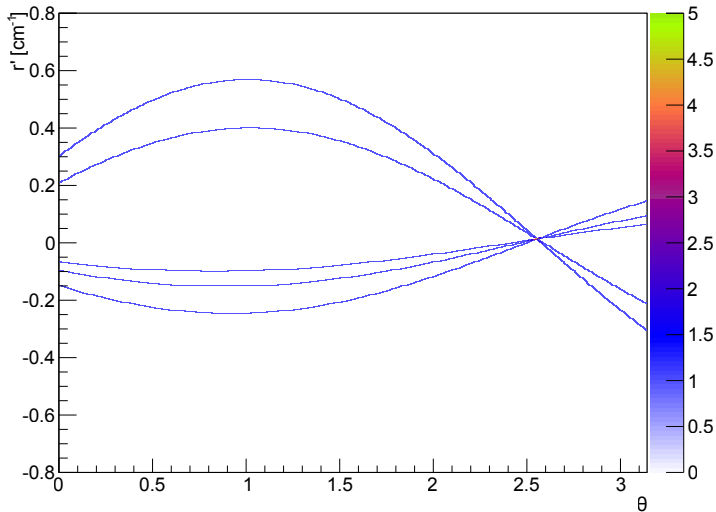


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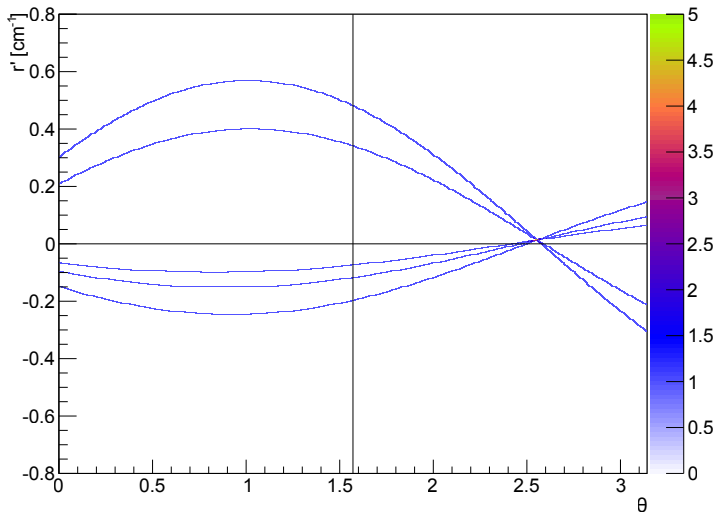
# Fast Hough Transformation

## Hough Space



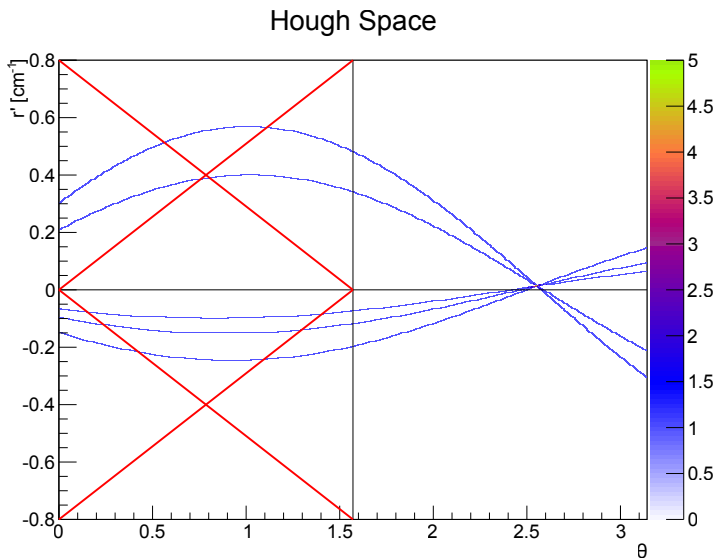
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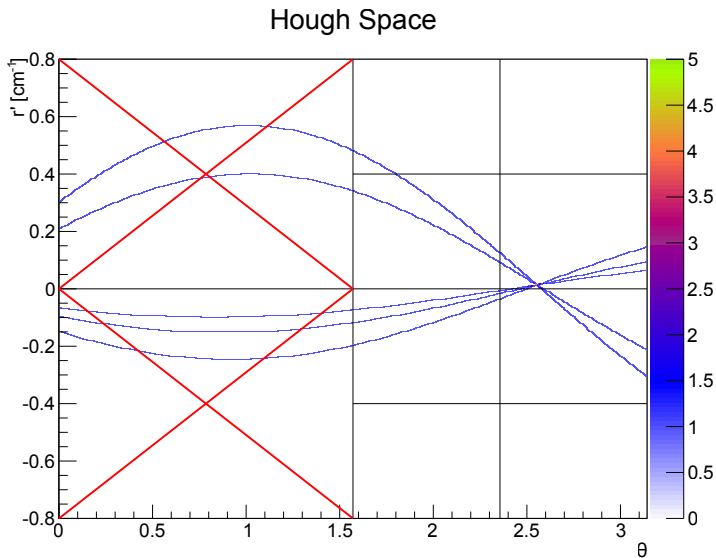




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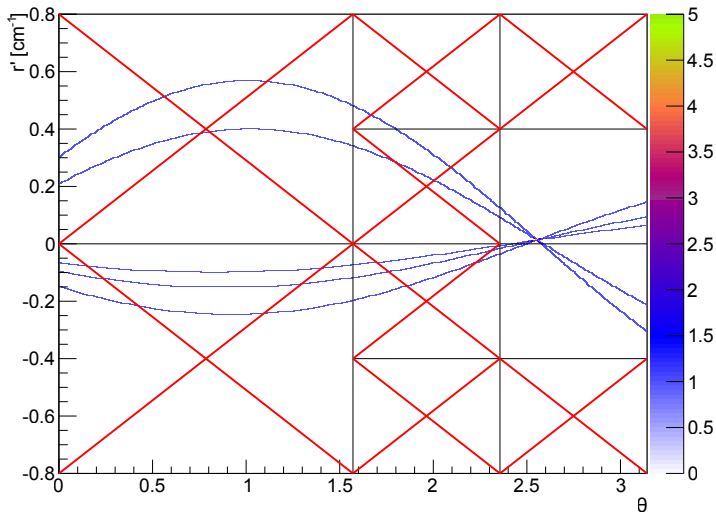


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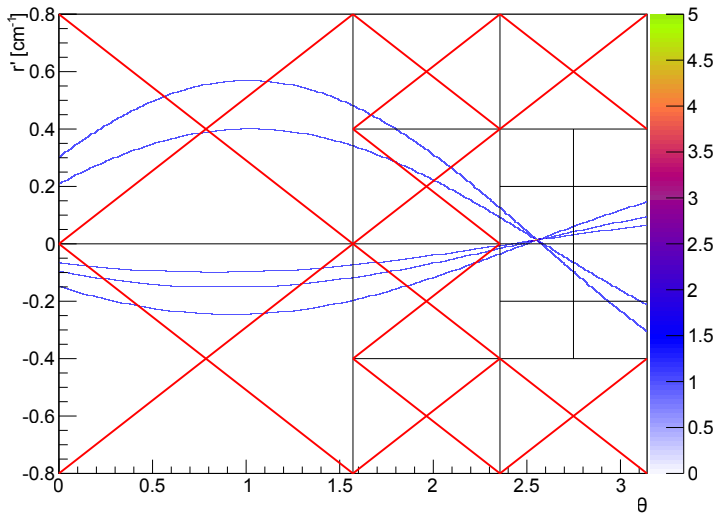
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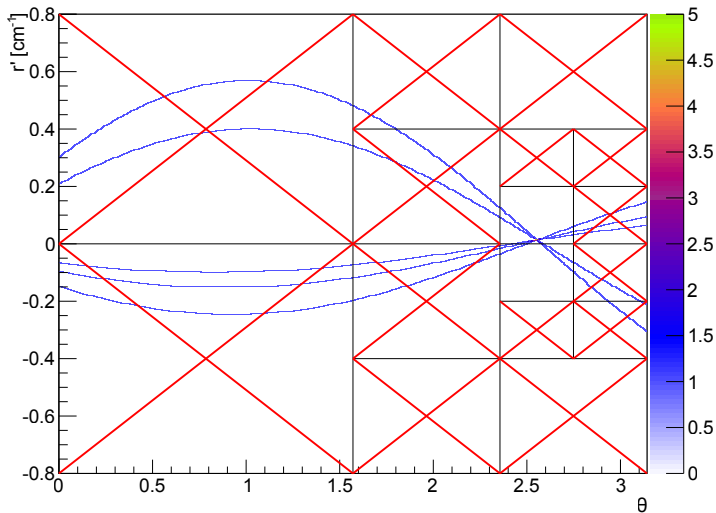
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