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# Event Reconstruction in Drift Chamber of the CMD-3

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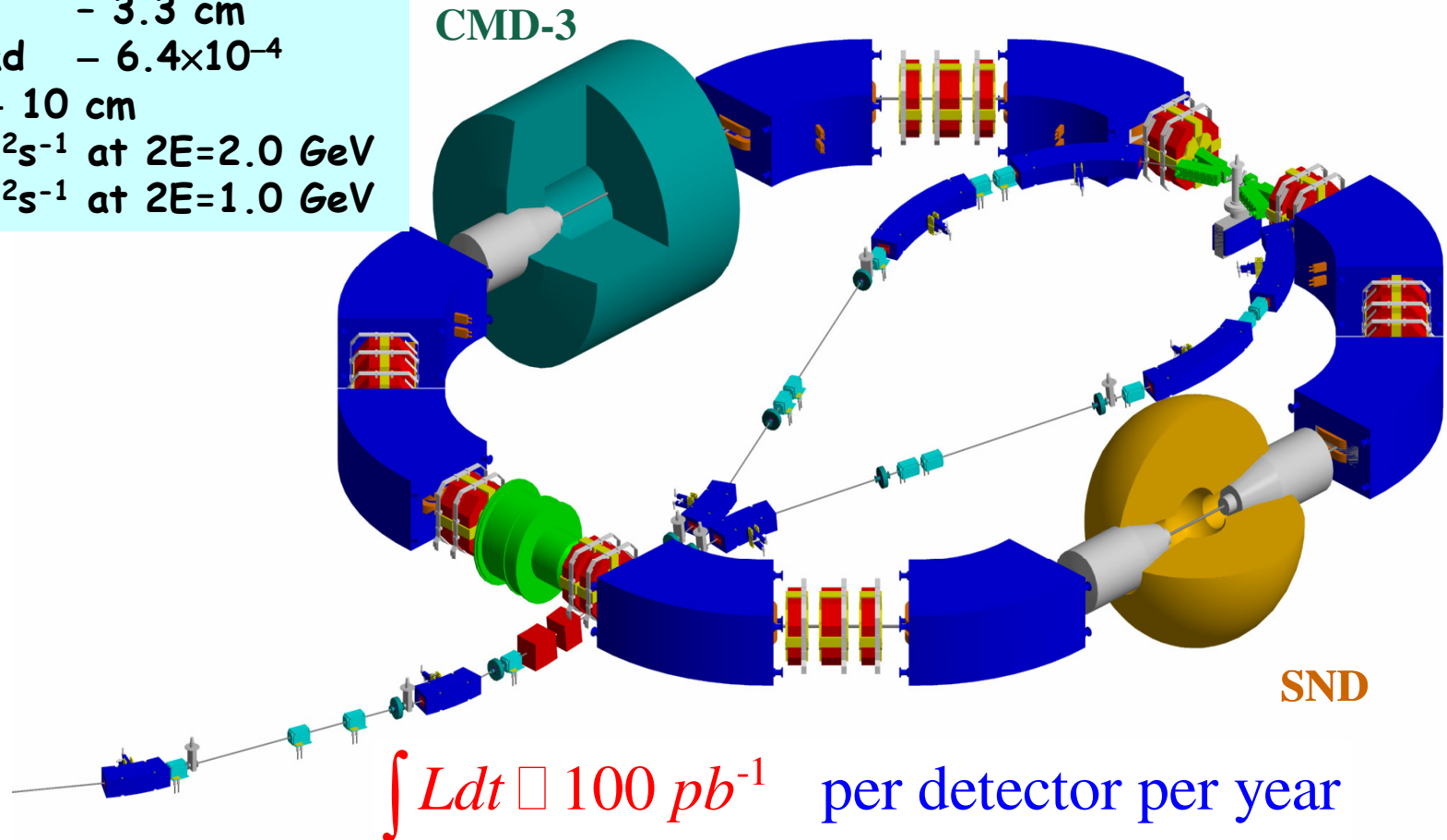
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*Young Researchers Workshop  
“Physics Challenges in the LHC Era”  
Frascati, Italy  
14 May 2009*

# VEPP-2000



- circumference - 24.38 m
- revolution time - 82 nsec
- beam current - 0.2 A
- beam length - 3.3 cm
- energy spread -  $6.4 \times 10^{-4}$
- $\beta_x = \beta_z = 4 \div 10$  cm
- $L = 10^{32} \text{ cm}^{-2}\text{s}^{-1}$  at  $2E=2.0 \text{ GeV}$
- $L = 10^{31} \text{ cm}^{-2}\text{s}^{-1}$  at  $2E=1.0 \text{ GeV}$





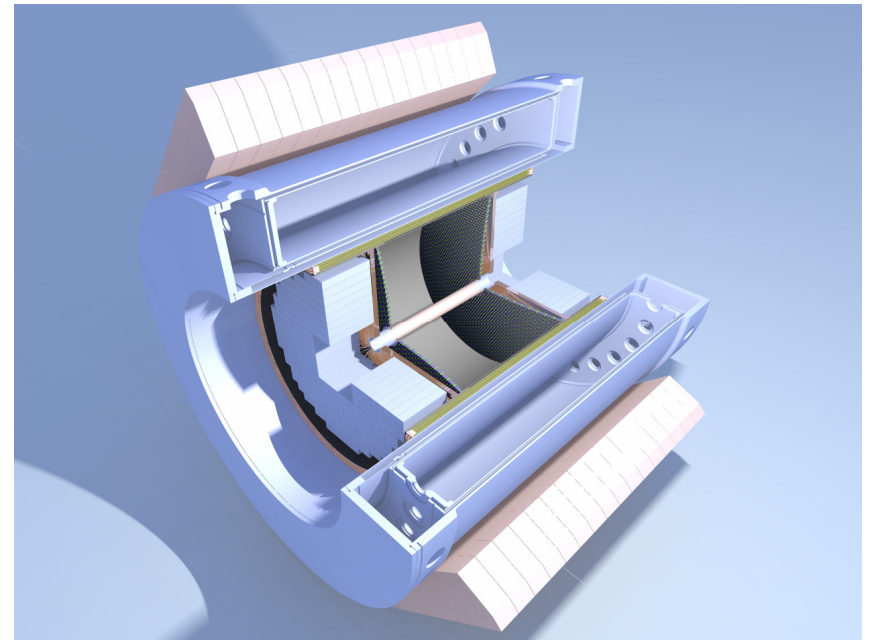
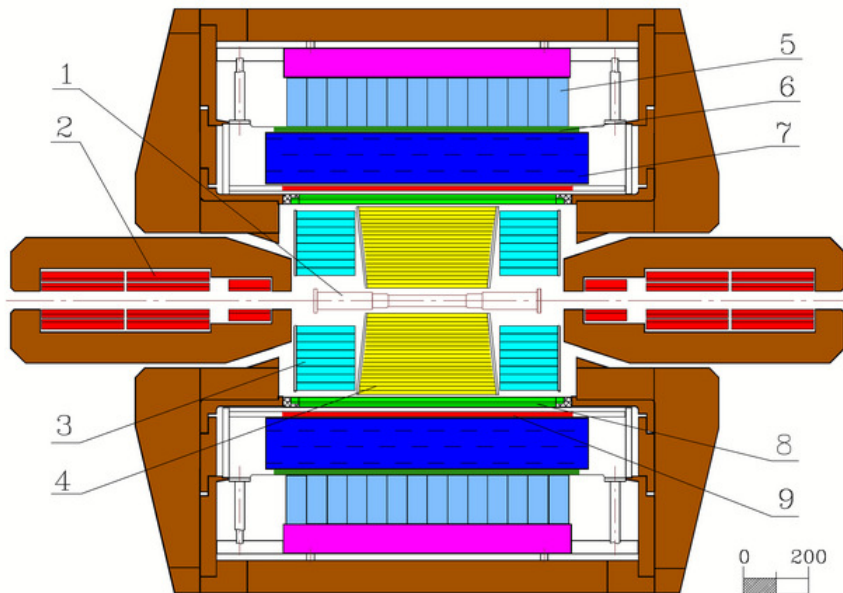
# Physics program



- Study of hadronic cross-sections  
 $e^+e^- \rightarrow 2h, 3h, 4h, \dots$   $h = \pi, K, \eta \dots$
  - Precision measurements of  
 $R = \sigma(e^+e^- \rightarrow \text{hadrons}) / \sigma(e^+e^- \rightarrow \mu^+\mu^-)$
  - Study of light vector meson radial excitations:  $\rho', \rho'', \omega', \phi' \dots$
  - Comparison of energy dependence of  $e^+e^- \rightarrow \text{hadrons}$  ( $I=1$ )  
with spectral functions in  $\tau$  decays to test CVC
  - Measurements of nucleon electromagnetic form factors and search  
for  $N\bar{N}$  resonances
  - Measurements of  $e^+e^- \rightarrow \text{hadrons}$  with ISR
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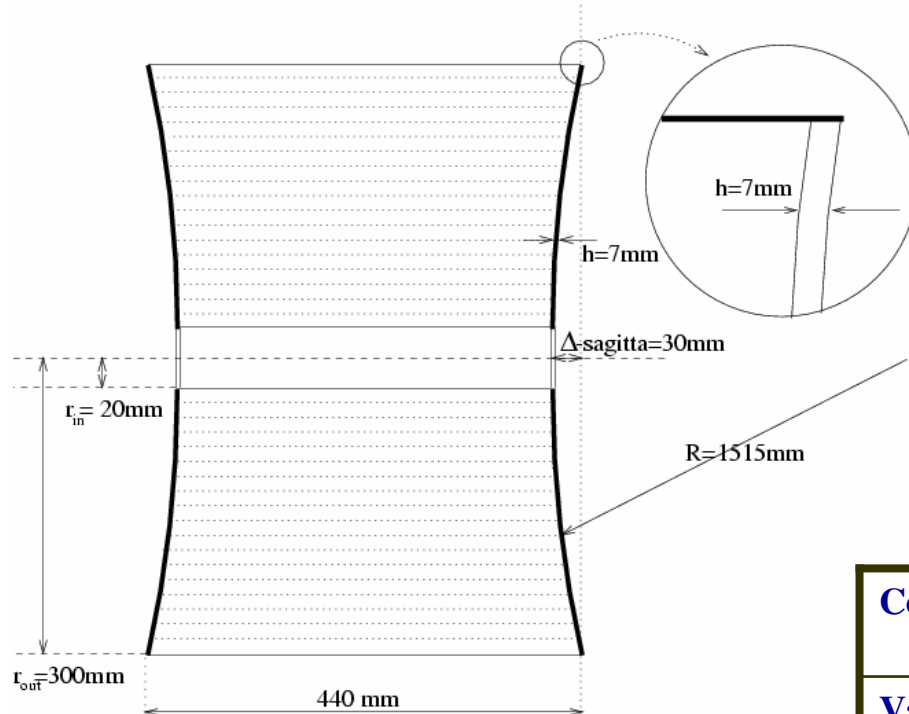
# CMD-3

1. Vacuum Chamber
2. Solenoids of VEPP-2000
3. BGO Calorimeter
4. Drift Chamber



5. CsI Calorimeter
6. Time-of-Flight System
7. LXe Calorimeter
8. Z-Chamber
9. SC solenoid

# Drift Chamber



- 1218 hexagonal cells (side 9 mm)
- signal wire diameter 15  $\mu\text{m}$  (gold plated W-Re)
- tension 35 g (wire stretch 1.08 mm)
- tension loss due to end cap deflection  $\pm 1.8\%$
- field wire diameter 100  $\mu\text{m}$  (gold plated Ti)
- tension 120 g (wire stretch 0.6 mm)
- tension loss due to end cap deflection  $\pm 20\%$
- gas mixture - Ar isobutan (80/20)

Chamber body – carbon fibers:

$E \sim 2000 \text{ kg/mm}^2$ ,  $\rho \sim 1.6 \text{ g/cm}^3$

End plates are covered by 30  $\mu\text{m}$  copper foil

Inner surface of the outer shell is covered by 250  $\mu\text{m}$  of PET and copper plated G10 (discharge voltage 100 kV/mm)

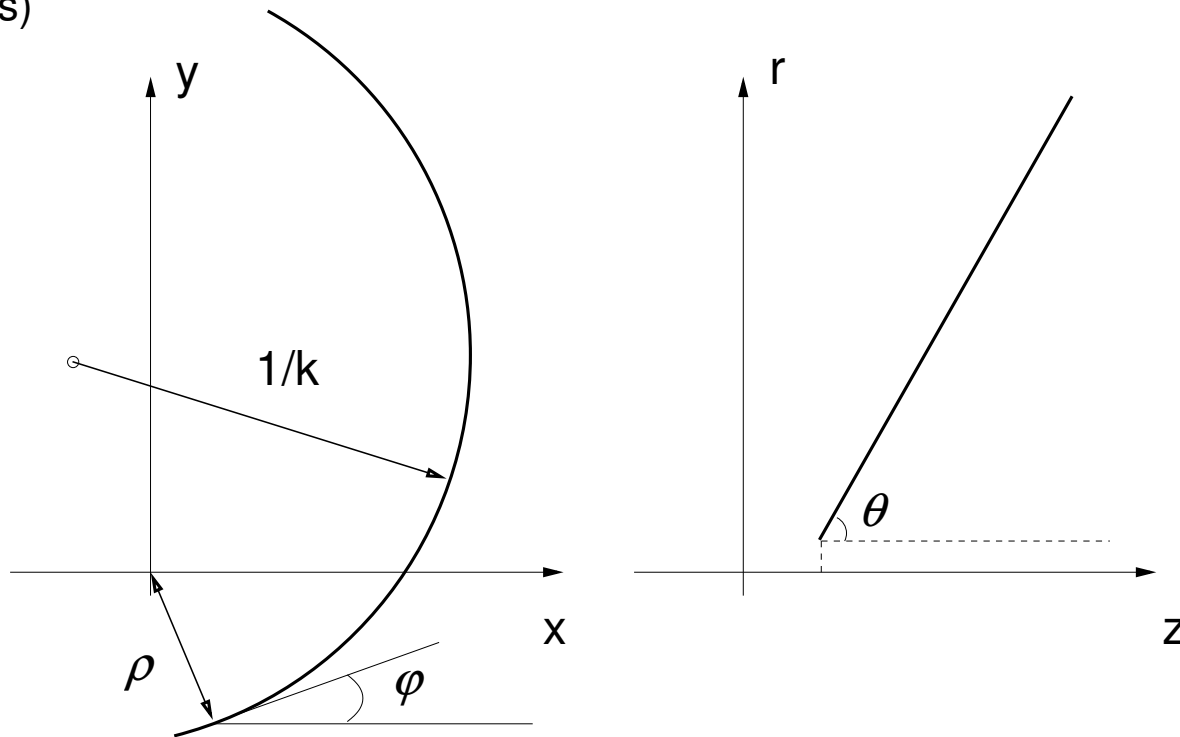
Inner shell is wrapped up with 30  $\mu\text{m}$  copper foil

## Material budget

Construction unit	Thickness, cm	Matter, $X_0$
Vacuum chamber (Be)	0.077	$2.1 \cdot 10^{-3}$
Inner shell (carbon fibers)	0.02	$0.7 \cdot 10^{-3}$
Outer shell (carbon fibers)	0.2	$1 \cdot 10^{-2}$
End caps (carbon fibers)	0.7	0.04
Gas mixture (Ar:isoC <sub>4</sub> H <sub>10</sub> (80:20))	30	$2.6 \cdot 10^{-3}$
Wires		$7.5 \cdot 10^{-4}$
Whole chamber		0.015

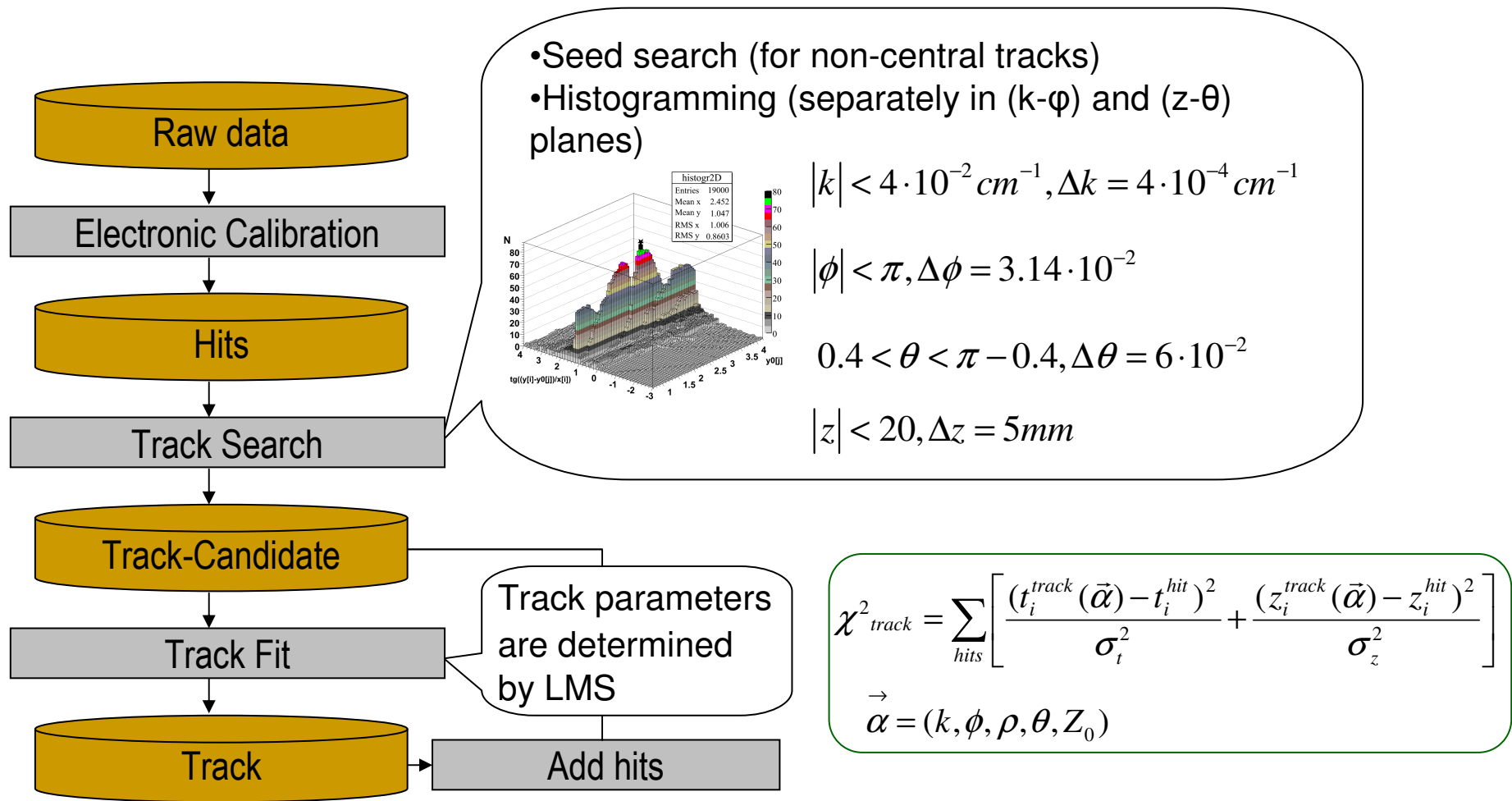
# Track Parameters

- In a uniform magnetic field helix describes trajectory of a charged particle :
  - $k$  — curvature;
  - $\varphi, \theta$  — angles;
  - $Z_0$  —  $z$ -coordinate at point of closest approach of projected circle to the origin of coordinates;
  - $\rho$  — impact parameter (distance from track projection on  $(x,y)$  to origin of coordinates)



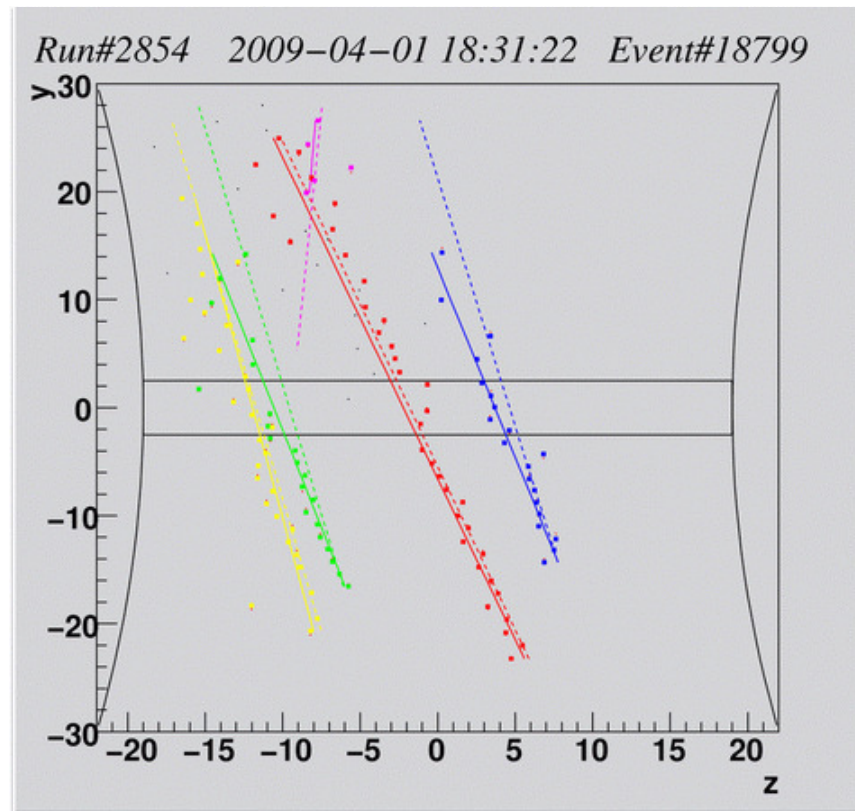
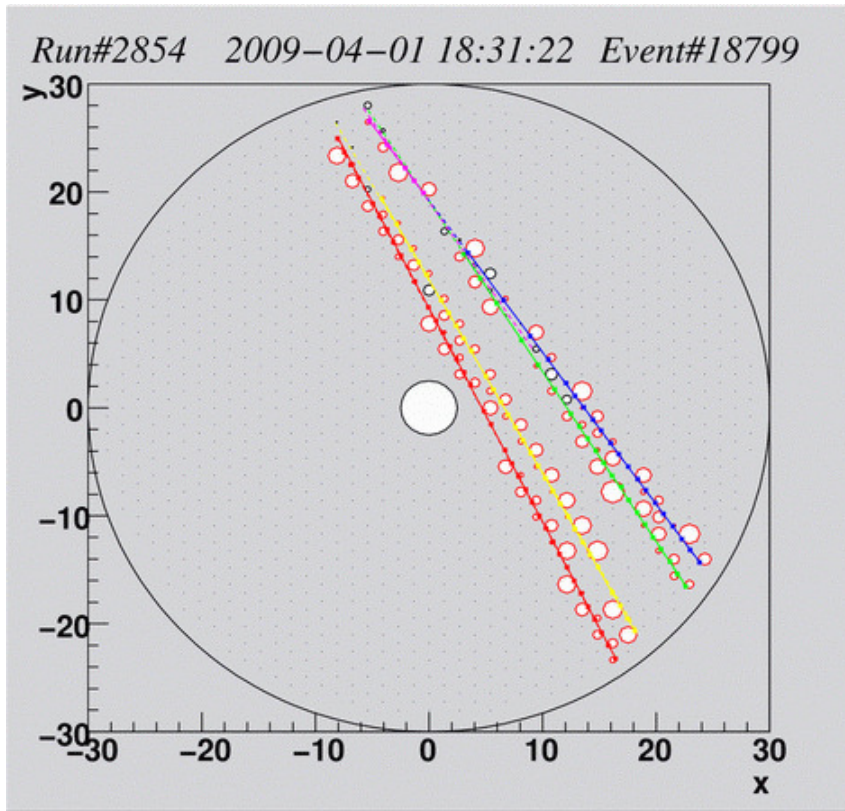
# Track Reconstruction

## Reconstruction Chain



# Track Reconstruction

- Experiments with cosmic rays without magnetic field



Speed of track reconstruction is 550 Hz

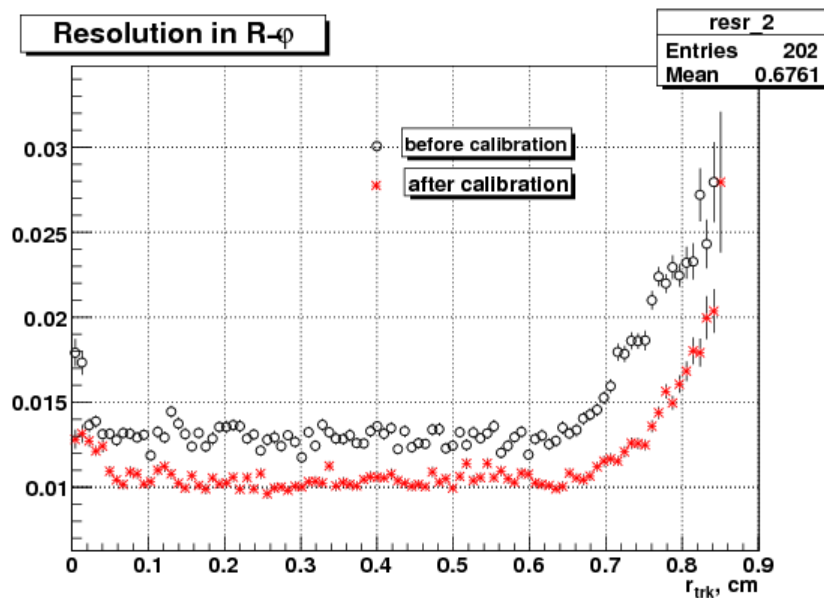


# Offline Calibration

## ■ Isochrone

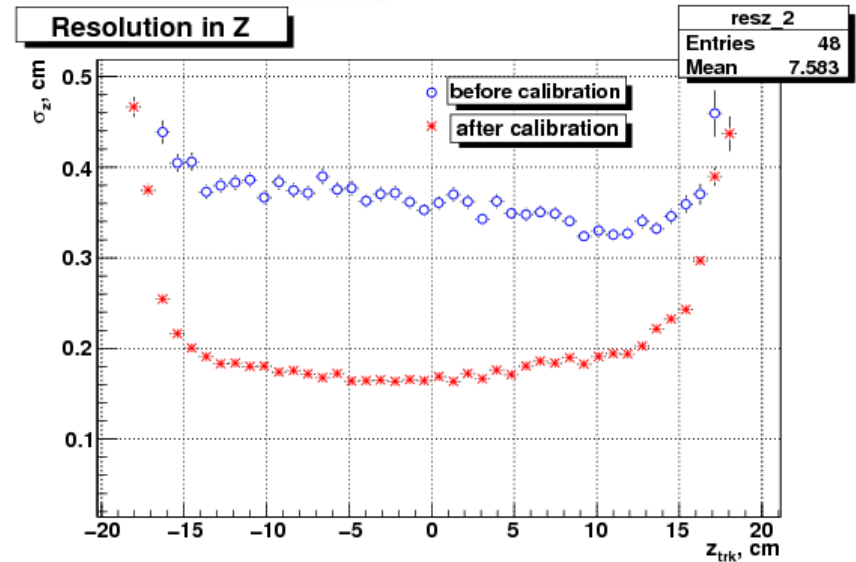
Initial estimate  $t(r, \varphi)$  from Garfield is corrected:

$$\delta t(r, \varphi) = t(r, \varphi)_{track} - t(r, \varphi)_{drift}$$



## ■ Z-coordinate

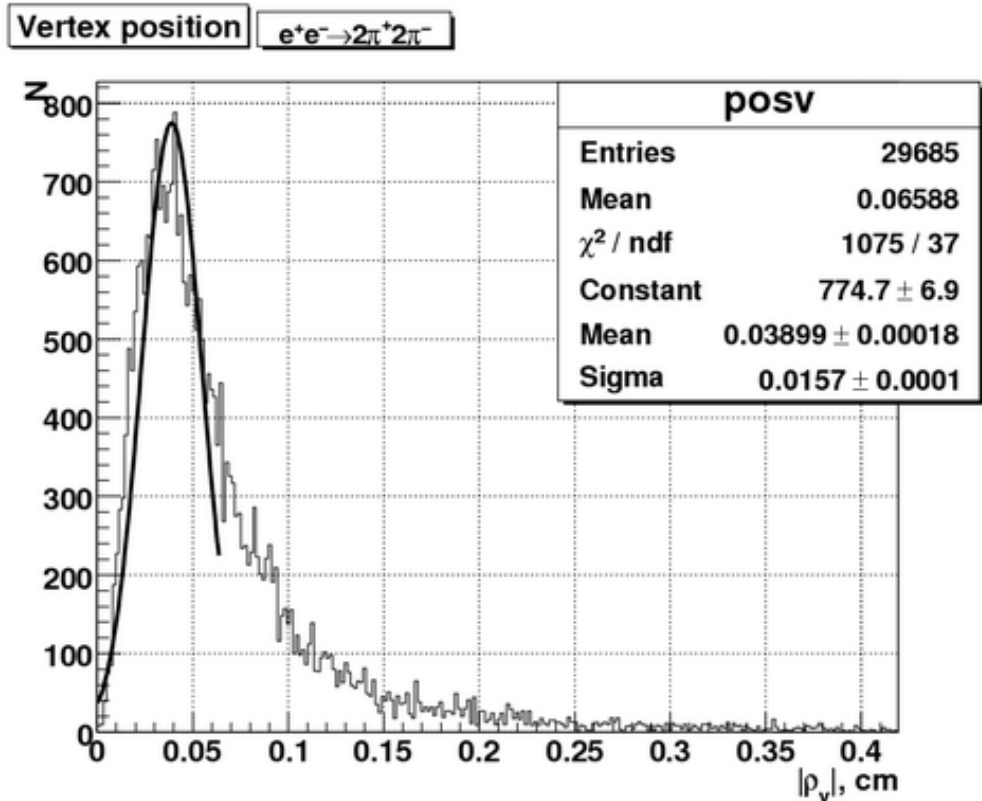
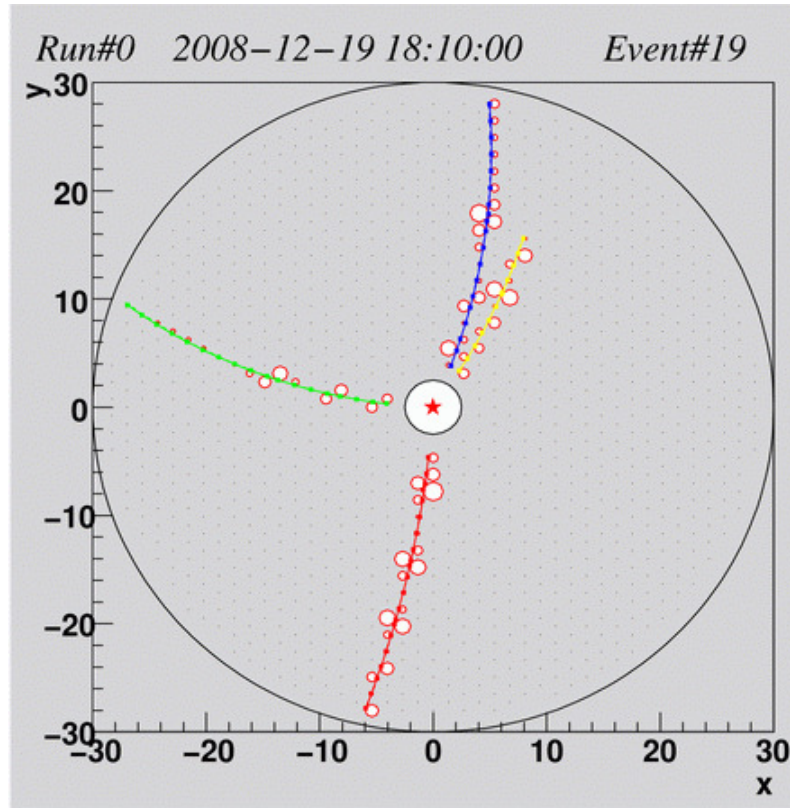
Residuals between measured z-coordinate and z-coordinate of track are minimized. Parameters of calibration are length of wire, pedestals, gain and input impedances





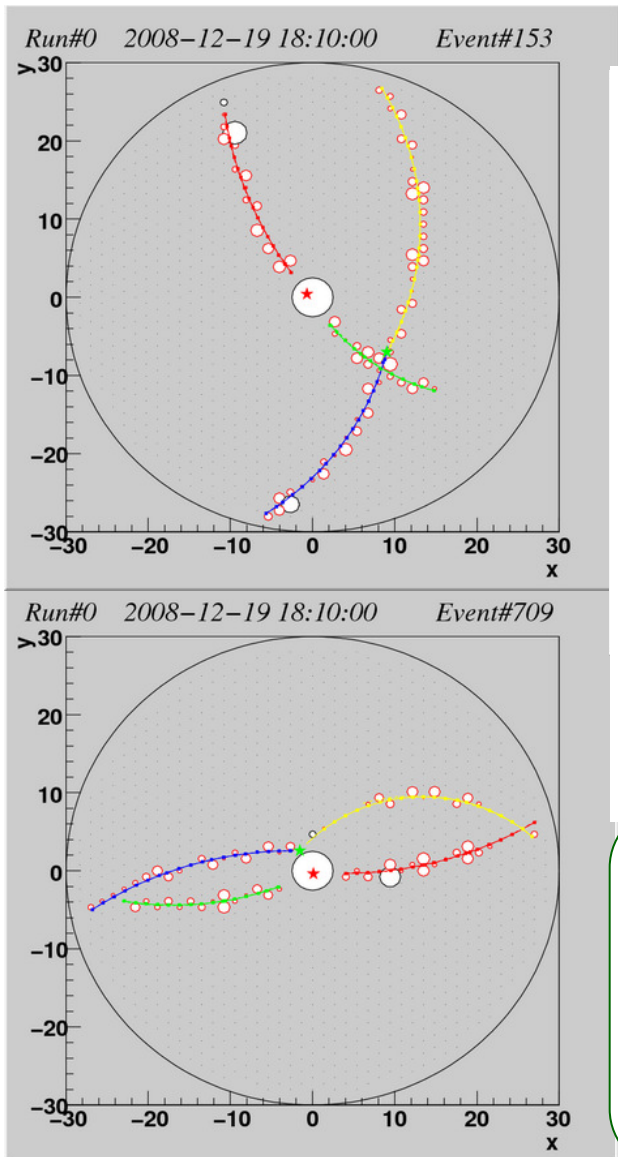
# Vertex reconstruction

- Test on simulation  $e^+e^- \rightarrow 2\pi^+2\pi^-$   $\sqrt{s}=1.5$  GeV

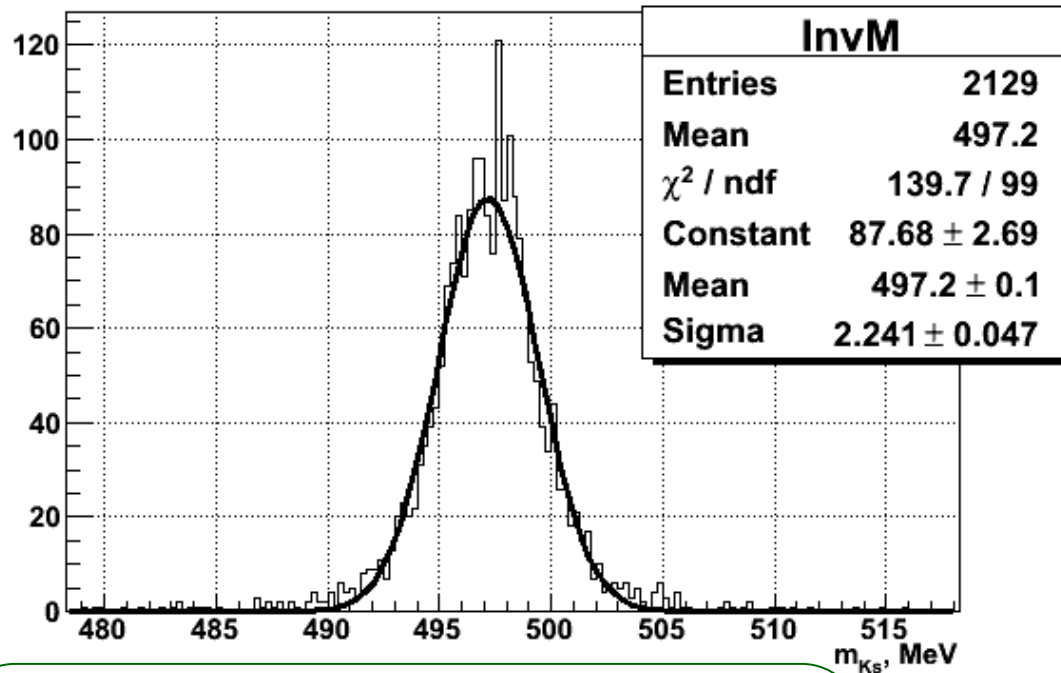


# Vertex reconstruction

- Test on simulation  $e^+e^- \rightarrow K_S K_L \pi^+ \pi^-$   $\sqrt{s}=1.02 \text{ GeV}$



Reconstructed invariant mass



$$\chi^2 = (\vec{\alpha}(\vec{V}, \vec{p}_V) - \vec{\alpha}_0)^T C_{\alpha_0}^{-1} (\vec{\alpha}(\vec{V}, \vec{p}_V) - \vec{\alpha}_0)$$

$$\vec{\alpha} = (k, \phi, \rho, \theta, Z_0)$$

$\vec{\alpha}_0$  and  $C_{\alpha_0}$  from track fitting

$\vec{V}$  vertex position,  $\vec{p}_V$  particle momentum in vertex

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# Results

- Programs for event reconstruction in drift chamber of the CMD-3 detector were developed.
- Offline calibration of isochrones and z-coordinate are implemented
- Programs for track reconstruction were used in runs with cosmic particles without magnetic field  
(with different voltages, thresholds, electronics modifications)
- Obtained resolution :
  - 100  $\mu\text{m}$  (minimum) in (x,y) plane
  - 1.6 mm along wires

# Plan

- Analysis of event reconstruction efficiency with MC
  - To implement Kalman filter for reconstruction of low momentum particle tracks
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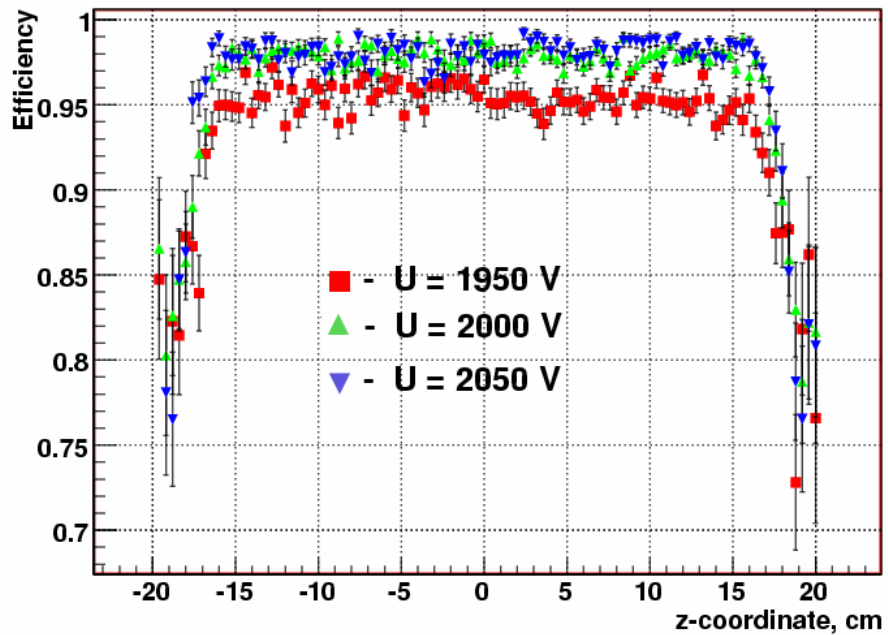
Thank you for your attention!

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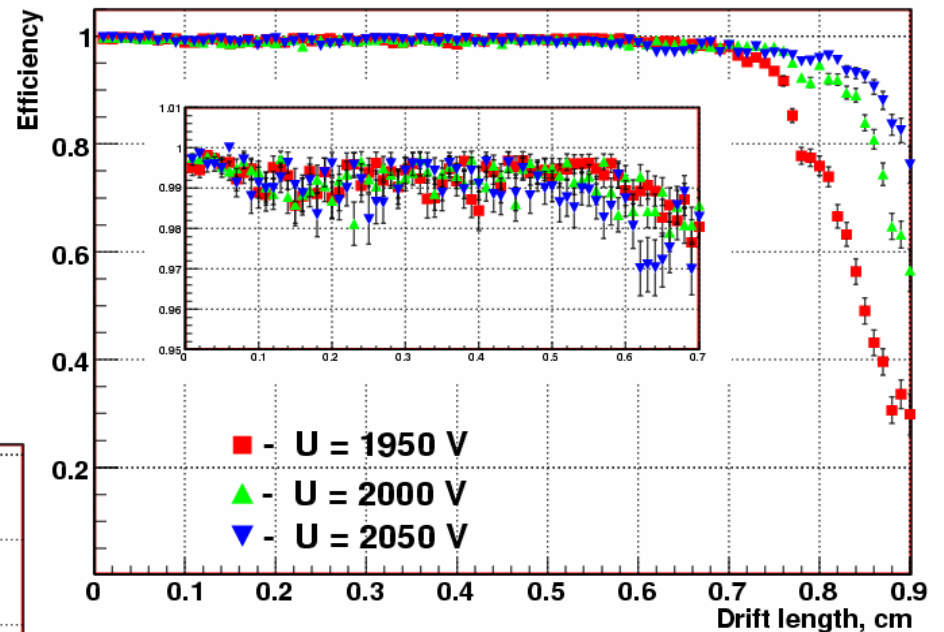
# Cell Efficiency

Cell efficiency vs distance from track to sense wire was measured

Efficiency vs z

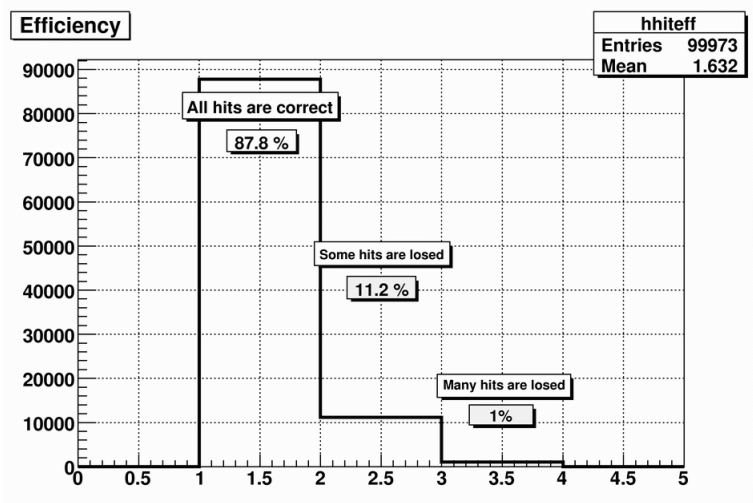


Efficiency vs distance



# Track Reconstruction

- Simulation of  $e^+e^- \rightarrow \mu^+\mu^-$  (magnetic field  $B = 1.5$  T,  $\sqrt{s}=1$  GeV)



Efficiency of track finding

Efficiency of track reconstruction is 99.97 %

