Measurement Principle
Charged Particle Tracking

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Outline

- Measurement Principle
- Velocity Spectrometer – Kaon RICH, Pion RICH
- Magnetic Spectrometer – UMS, KEAT, DMS
- Simulations

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Measurement Principle

$BR(K^+ \to \pi^+\nu\bar{\nu}) \sim 1 \cdot 10^{-10}$
$BR(K^+ \to \mu^+\nu) = 0.635$
$BR(K^+ \to \pi^+\pi^0) = 0.212$
$BR(K^+ \to \pi^+\pi^+\pi^-) = 0.056$

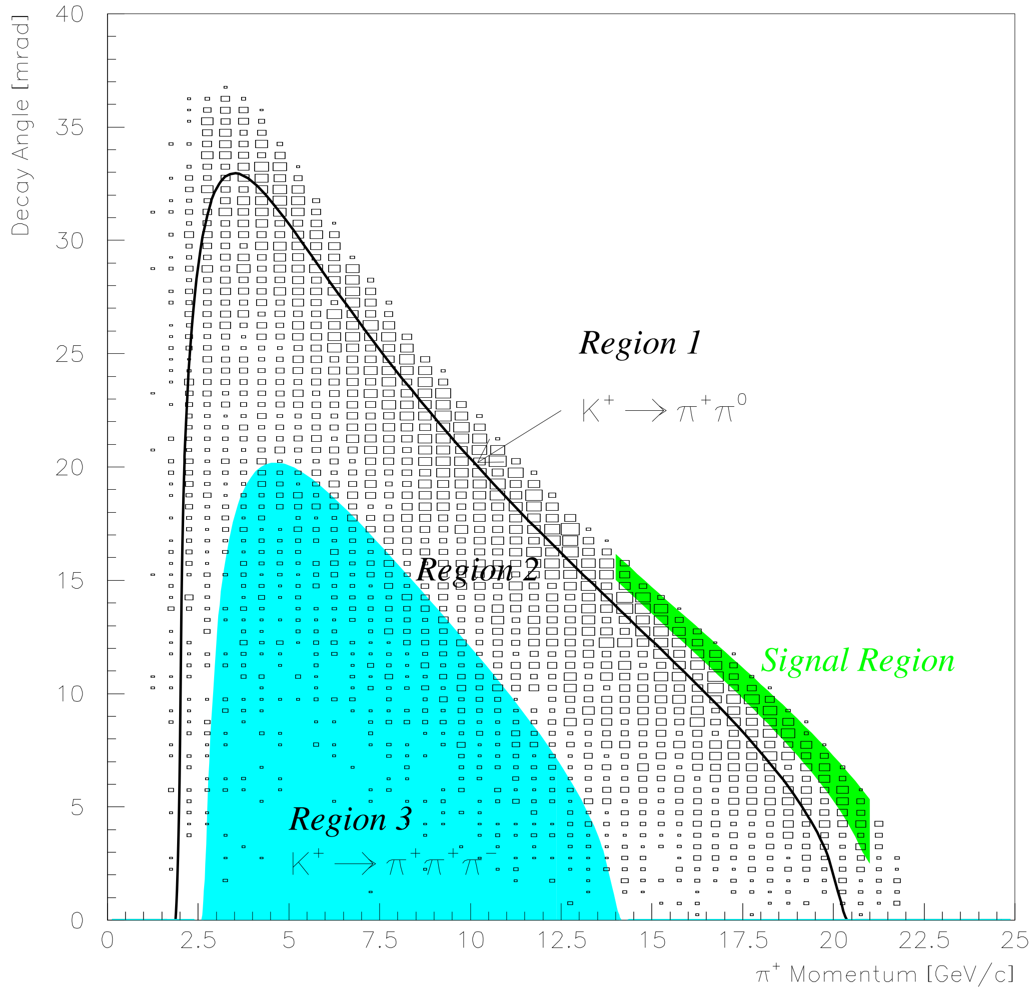
π^0 Rejection via Photon Veto System:
$< 1.6 \cdot 10^{-7}$

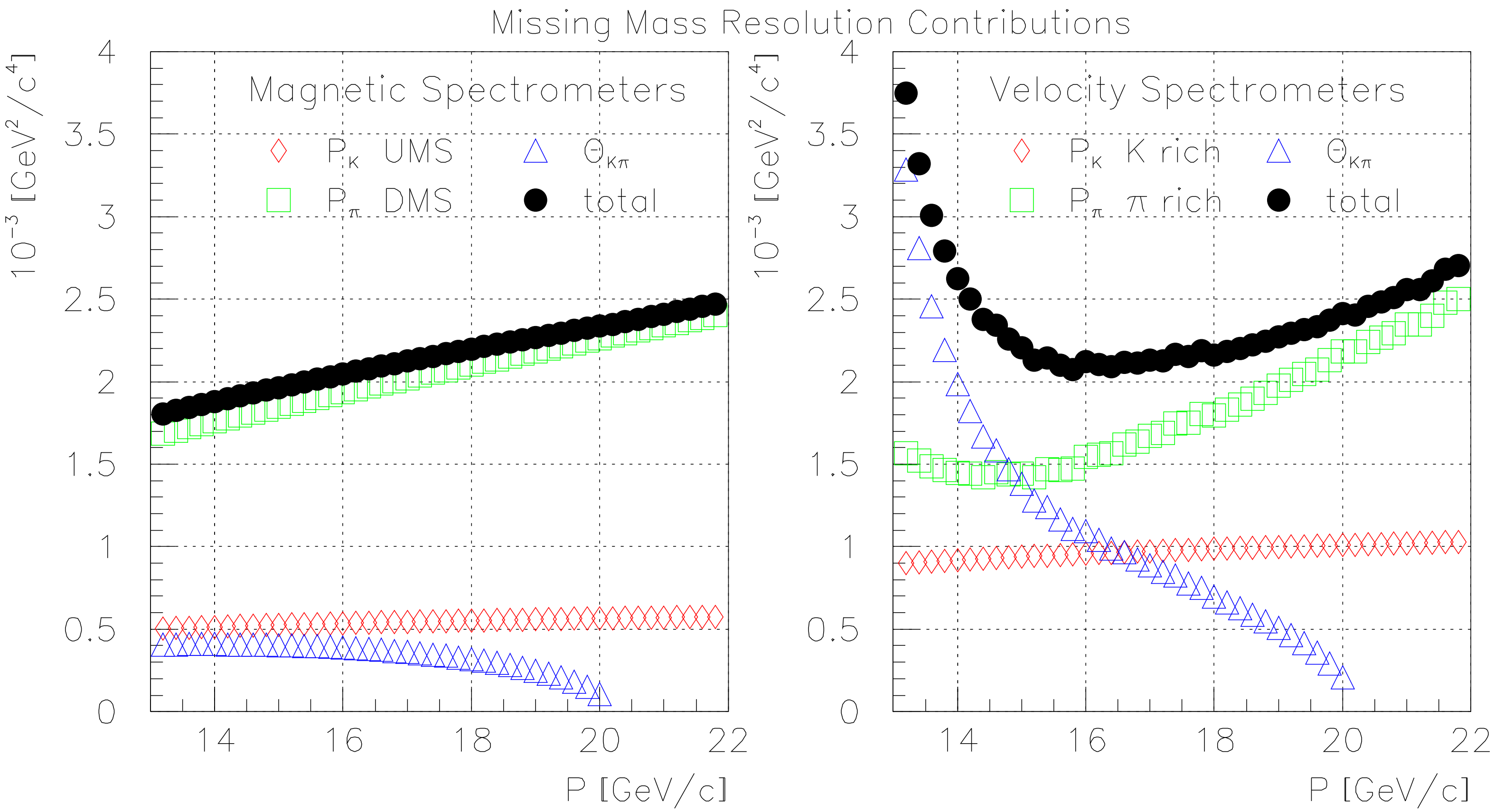
Kinematic rejection: $< 3 \cdot 10^{-5}$
From Velocity and Magnetic Spectrometers

Calculating missing mass:

$$M^2_{\text{miss}} = M^2_K(1 - p/p_K) + m^2(1 - p_K/p) - pp_K\theta^2$$

Resolution in Missing mass:
$\sim M^2_{\pi^0}/10$ for $K^+ \to \pi^+\pi^0$

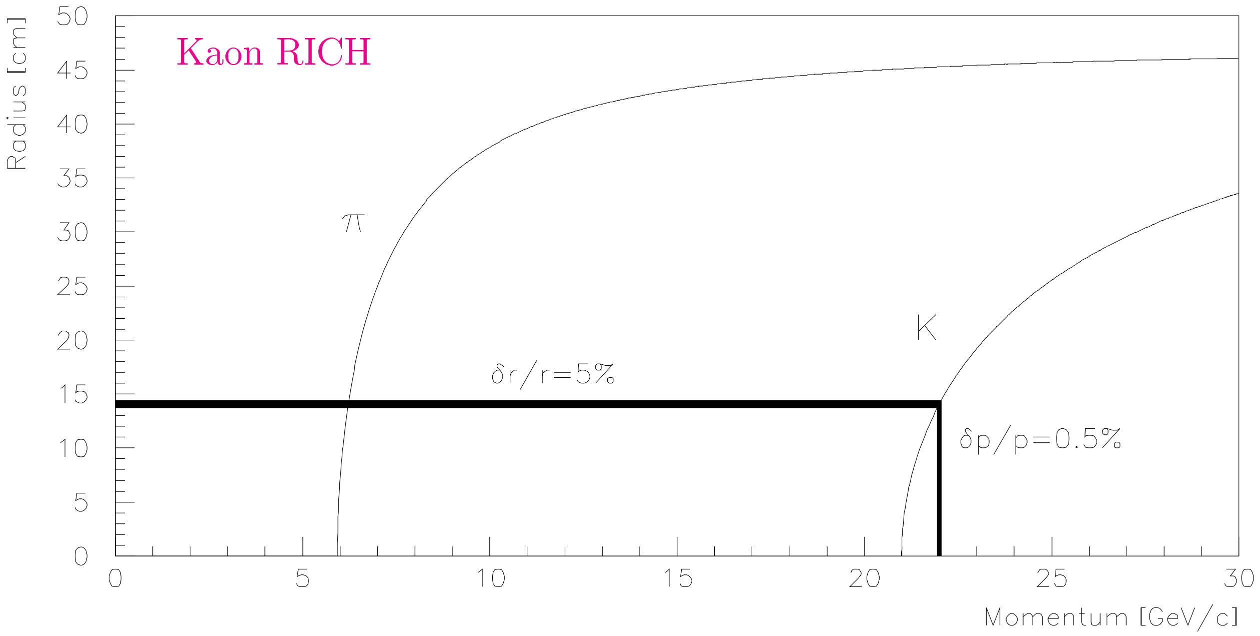


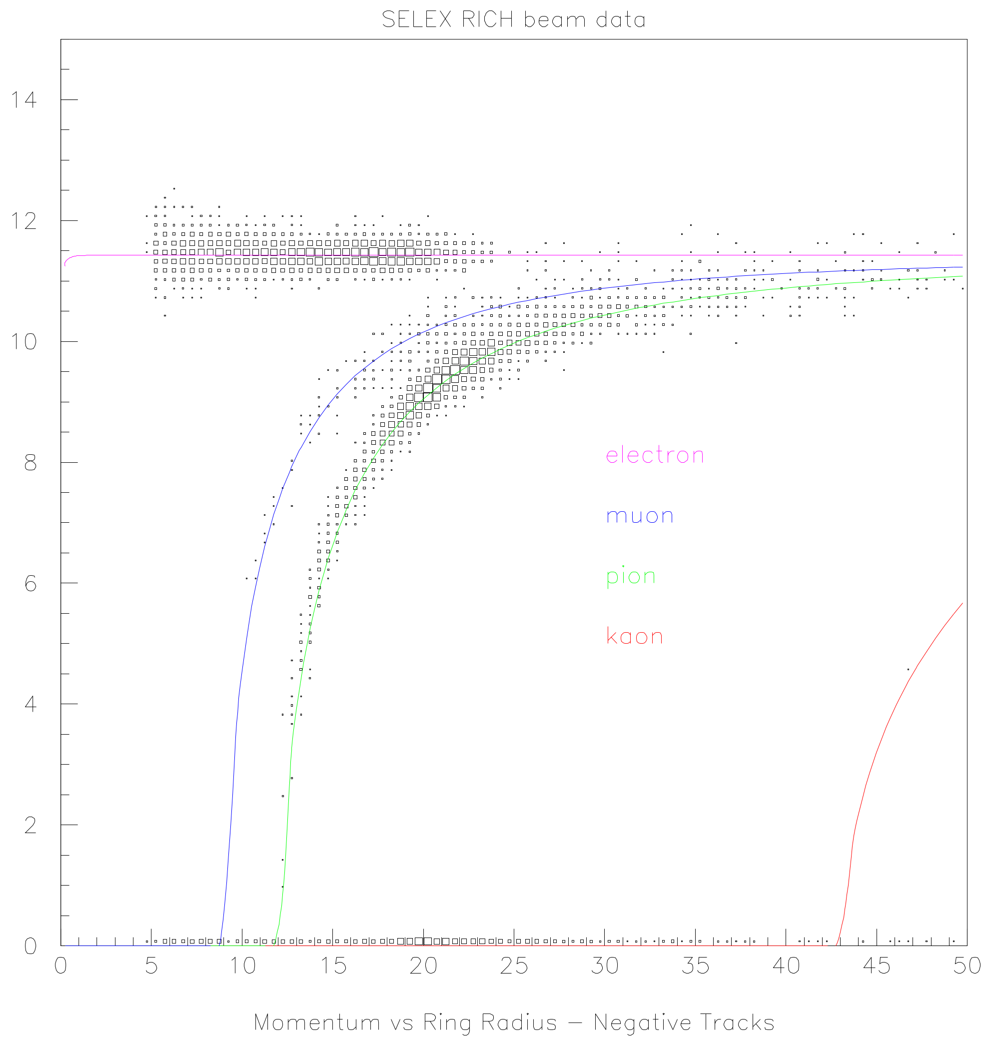


$$M^2_{\mathrm{miss}}(\pi^0) = 18.2 \cdot 10^{-3}\,\mathrm{GeV}^2/c^4$$

Velocity Spectrometer
Ring Imaging Cherenkov Counters

Design and Performance estimates based on data from SELEX RICH

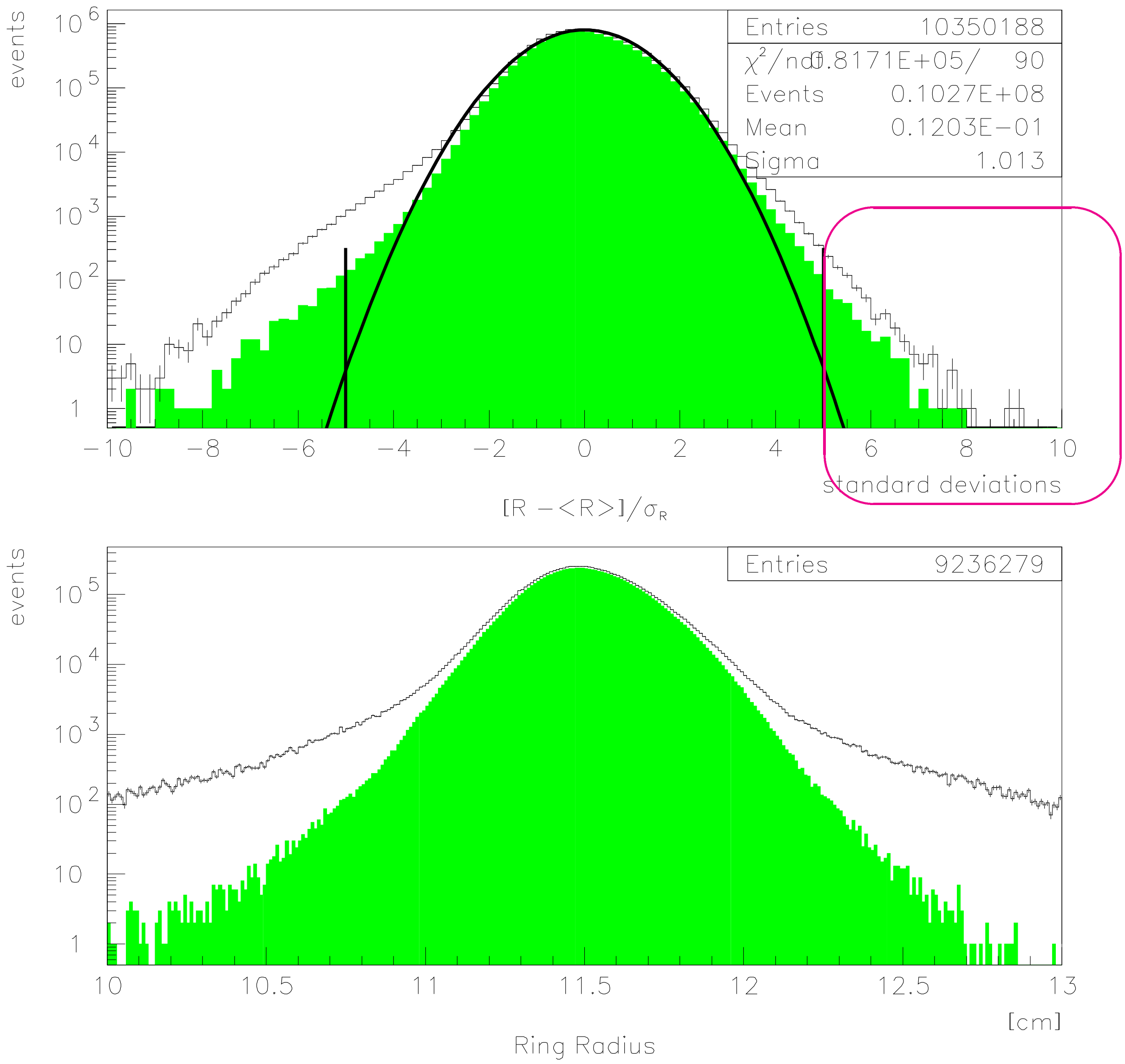




Ring Radius: velocity

Ring Center: angles

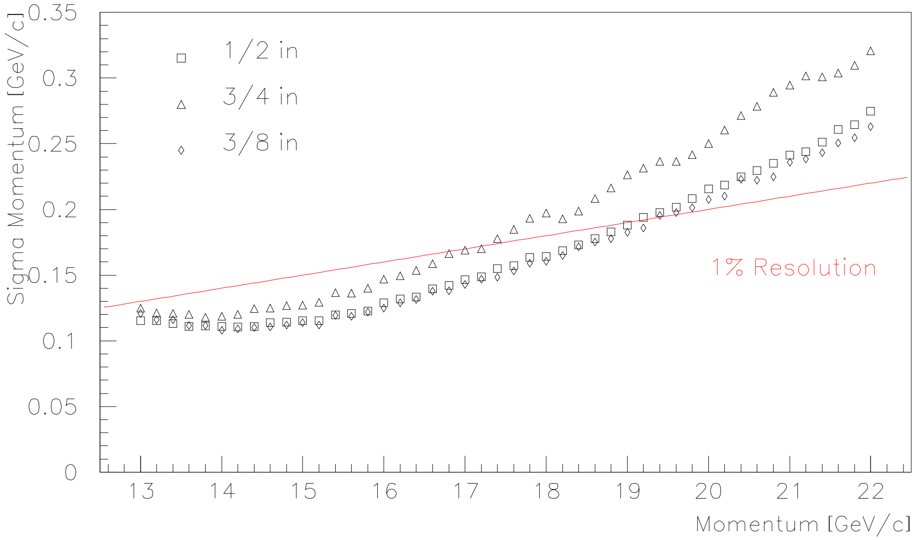
Study with SELEX single track data



Solid histogram gives already enough rejection

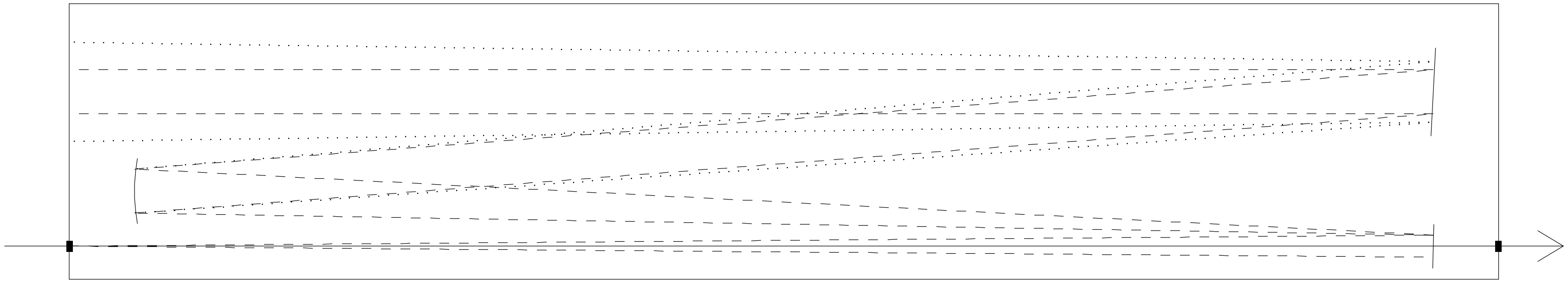
Pion RICH

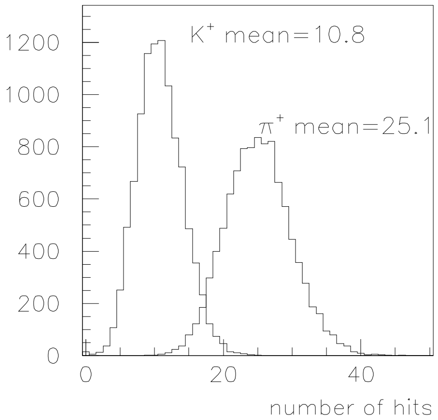
Straight Copy of the SELEX RICH; Gas: Neon at atmospheric pressure.
Change vessel length from 10 m to 20 m, Radius of Mirror(s) from 20 m to 40 m.

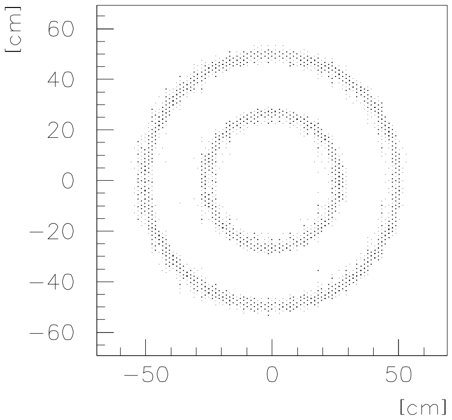


- Momentum Resolution $< 1\,\%$
- $\pi - \mu$ Separation $> 10\,\sigma$
- Rate per tube due to beam pions $< 400\,\mathrm{kHz}$
- Rate per tube due to kaon decay products $< 90\,\mathrm{kHz}$
- Resolution not limited by one factor (PM size, chromatic dispersion, mirror alignment)

Kaon RICH

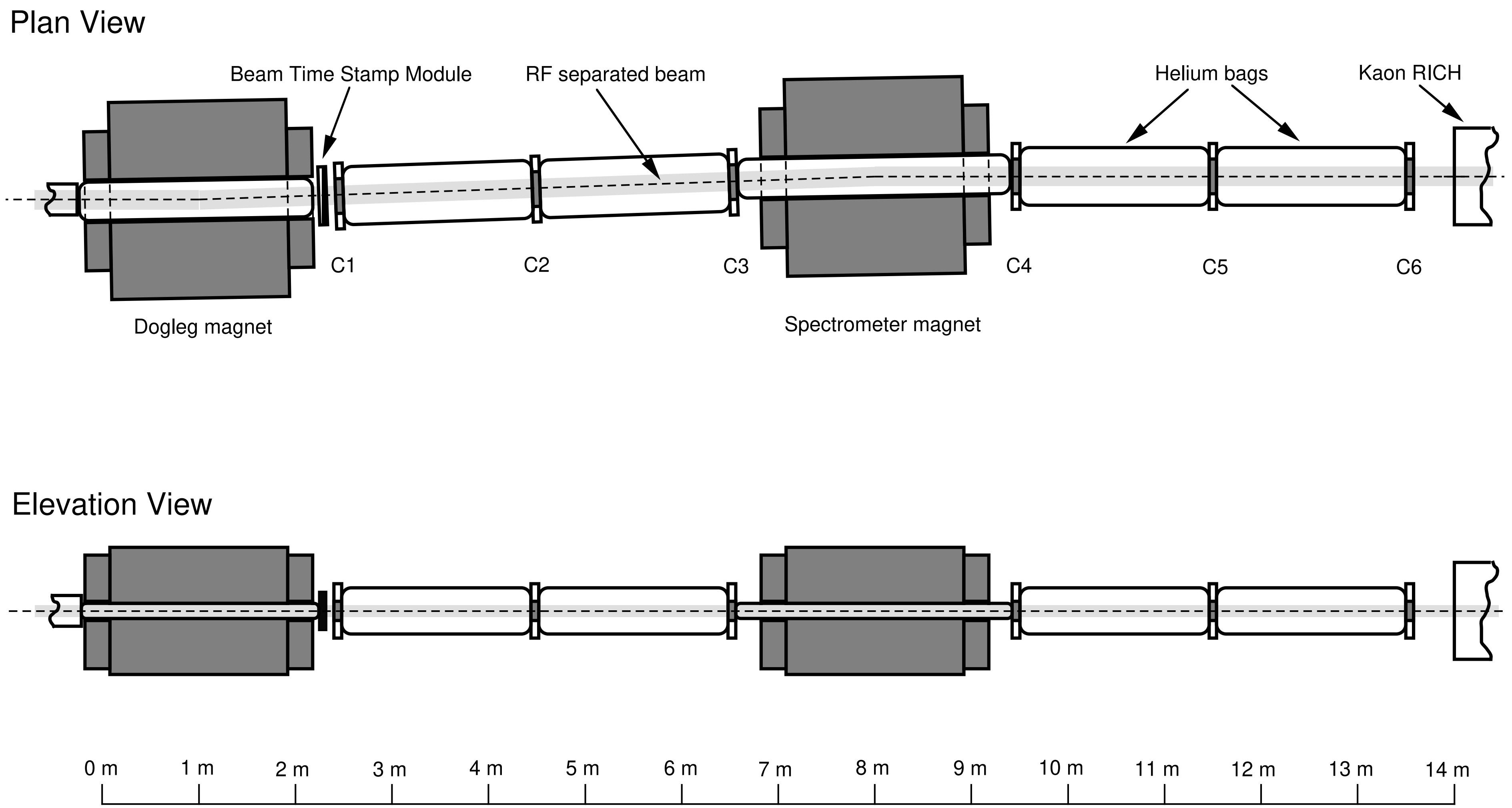


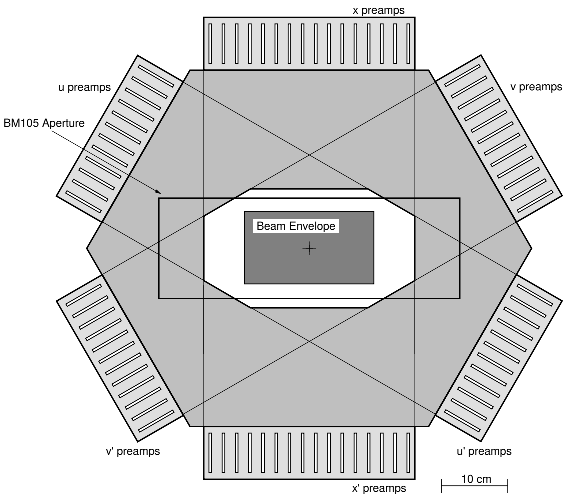




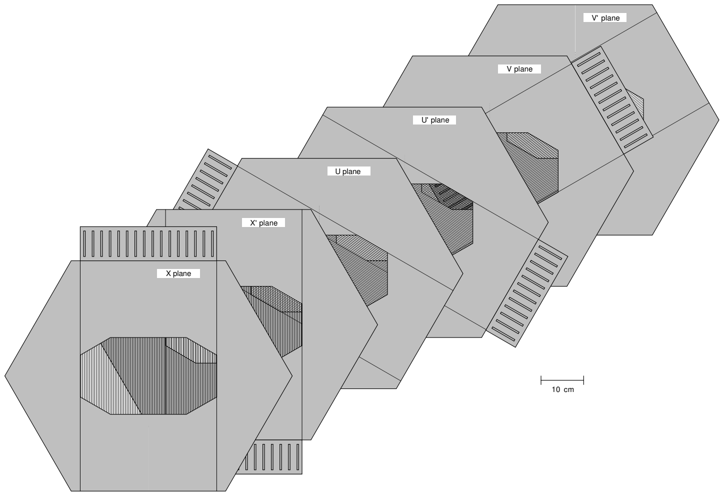
- 11 m long vessel
- double folded light path, $R = 40\,\mathrm{m}$
- Mirrors reflect only part of Cherenkov Photons from beam pions
- Pion and Kaon Rings nicely separated
- Rate per tube $< 1400\,\mathrm{kHz}$
- Resolution limited by chromatic dispersion
- Need to use Photomultiplier with glass window (cutoff 300 nm)

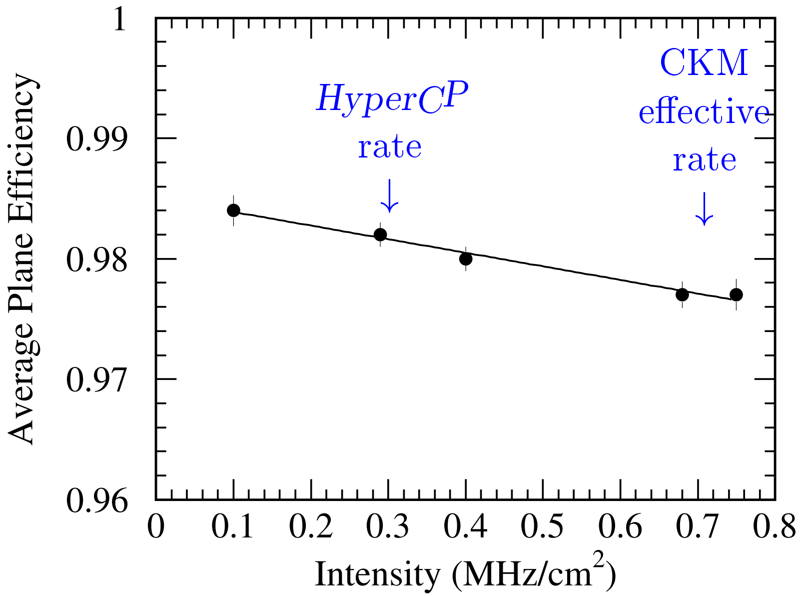
Upstream Magnetic Spectrometer (UMS)





- Changed from 1st edition of proposal
- Modeled after *HyperCP* chambers
- 6 stations
- Each station has 6 views
- Wire pitch 0.8 mm
- Rate per wire < 610 kHz





UMS Expected Performance

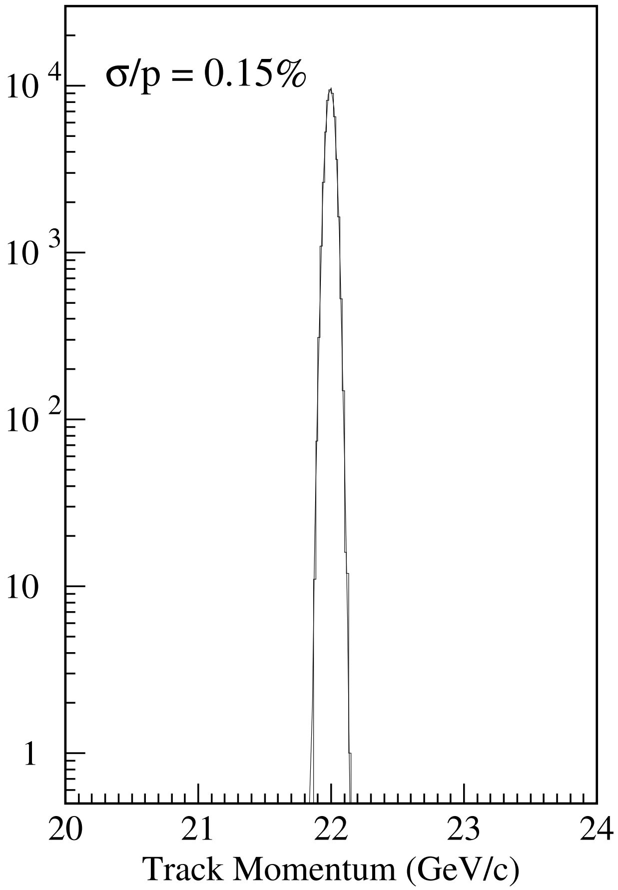


Figure 53: Momentum resolution without multiple scattering.

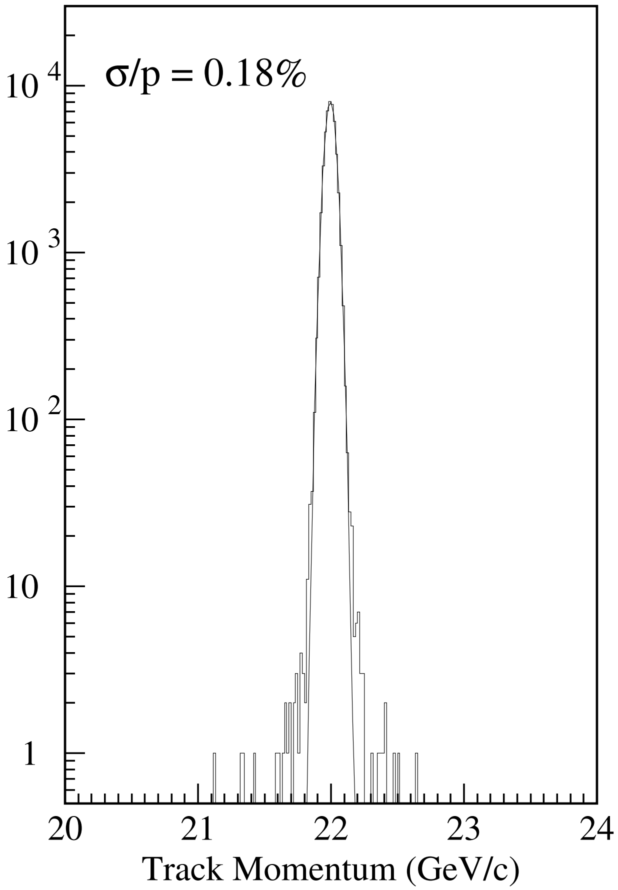


Figure 54: Momentum resolution with multiple scattering.

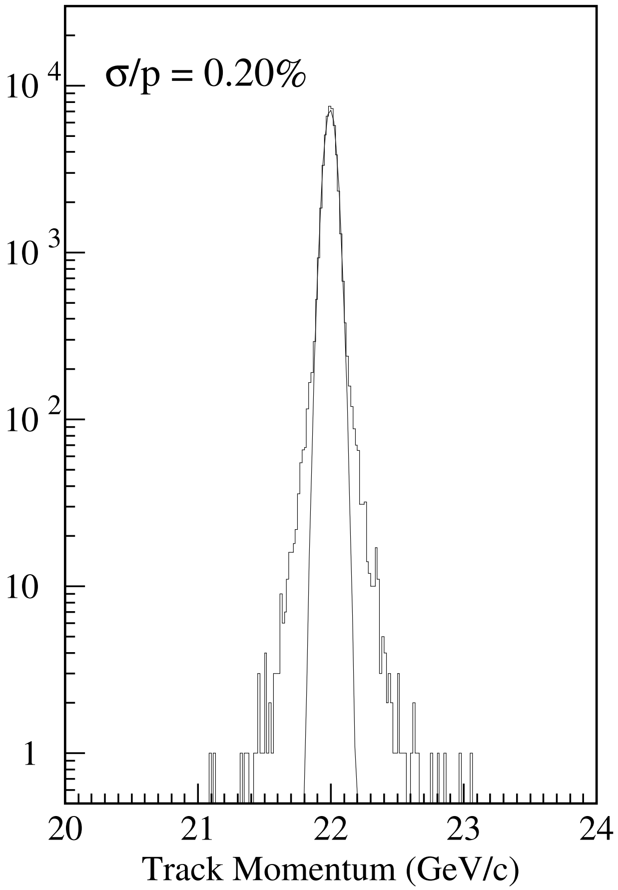
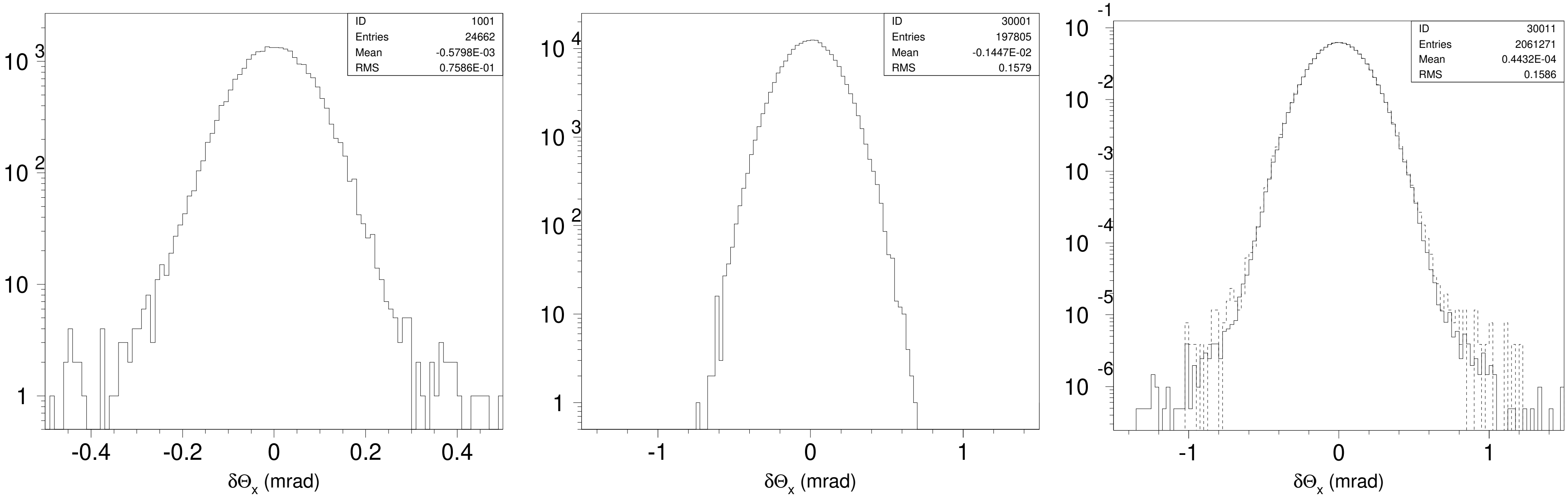


Figure 55: Momentum resolution with 1.53 tracks per event.

Kaon Entrance Angle Tracker (KEAT)

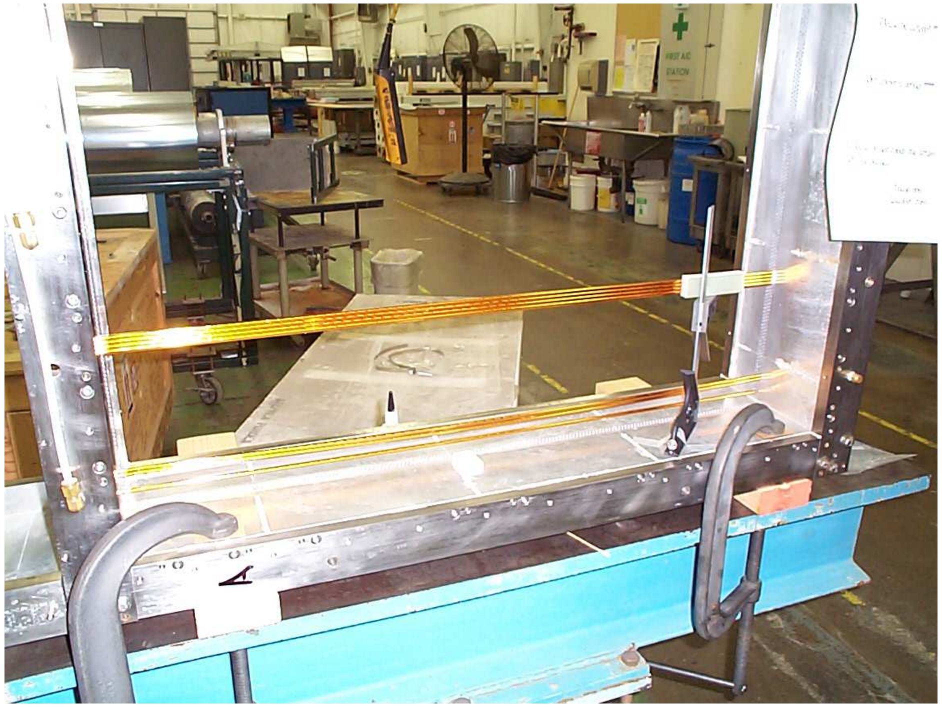
Same Technology as UMS



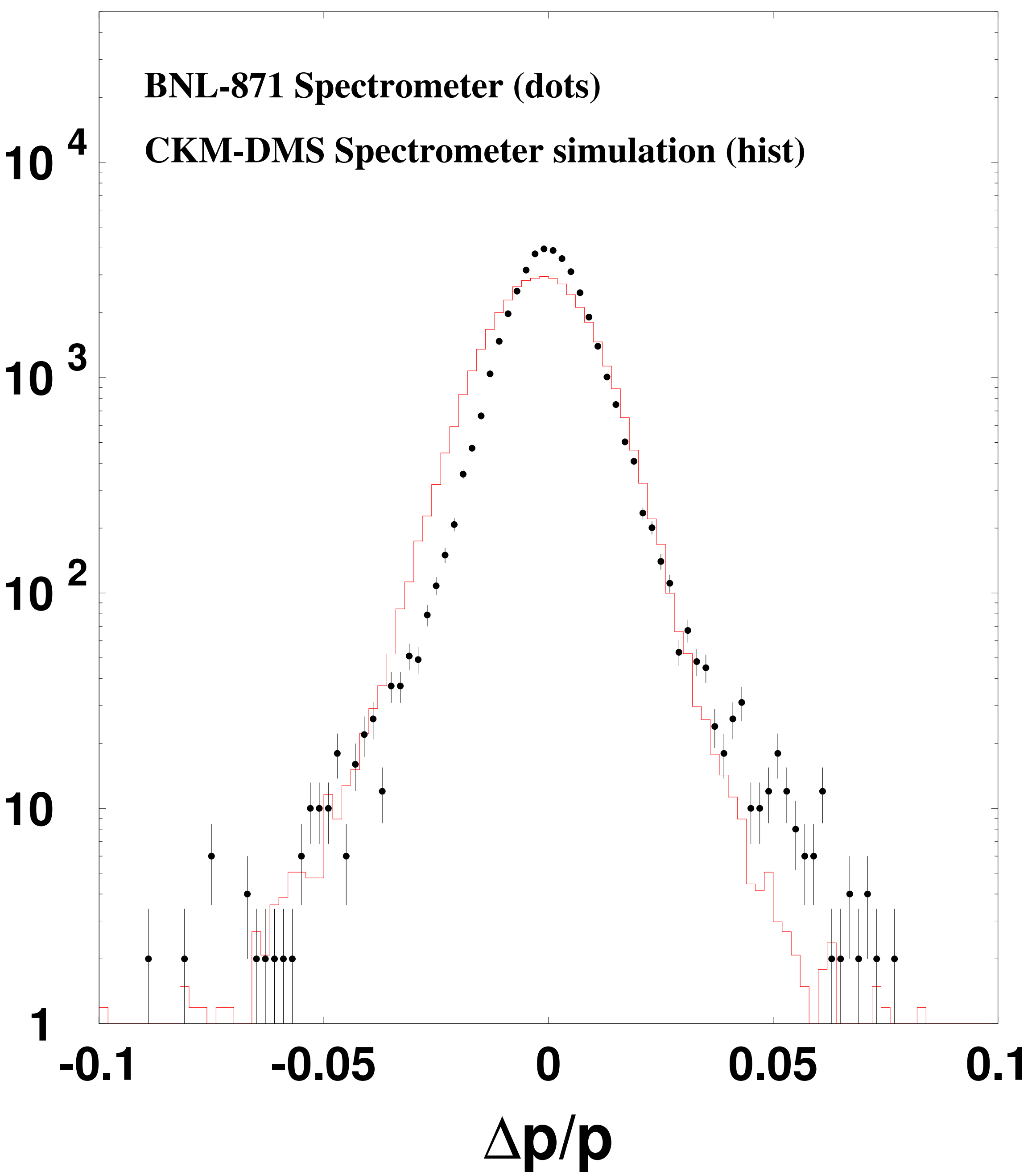
- Simulation of expected resolution verified with *HyperCP* data
- Resolution the same for 1- and 2-track events

Downstream Magnetic Spectrometer (DMS)

- 4 planar straw drift chambers (after BNL E871)
- 5 / 8 / 8 / 8 views
- Each straw: 5mm diameter
- Drift time $\approx$ 25 nsec
- Deadened in beam
- Maximum rate 120 kHz per straw
- Situated in Vacuum



Comparison of DMS Momentum Resolution to BNL-871 System



- Comparable resolution
- Higher tails in data: We understand some of the differences

Geant Monte Carlo Simulation

Simulation and Analysis Efforts

Full Geant Simulation of all detectors, verified with data

Hit level reconstruction and pattern recognition

Verify resolution and background estimates from 1$^{\mathrm{st}}$ edition of proposal

Selection Cuts

Aperture, Cleanliness

Decay angle $\theta > 2.5\,\mathrm{mrad}$ to get good z vertex

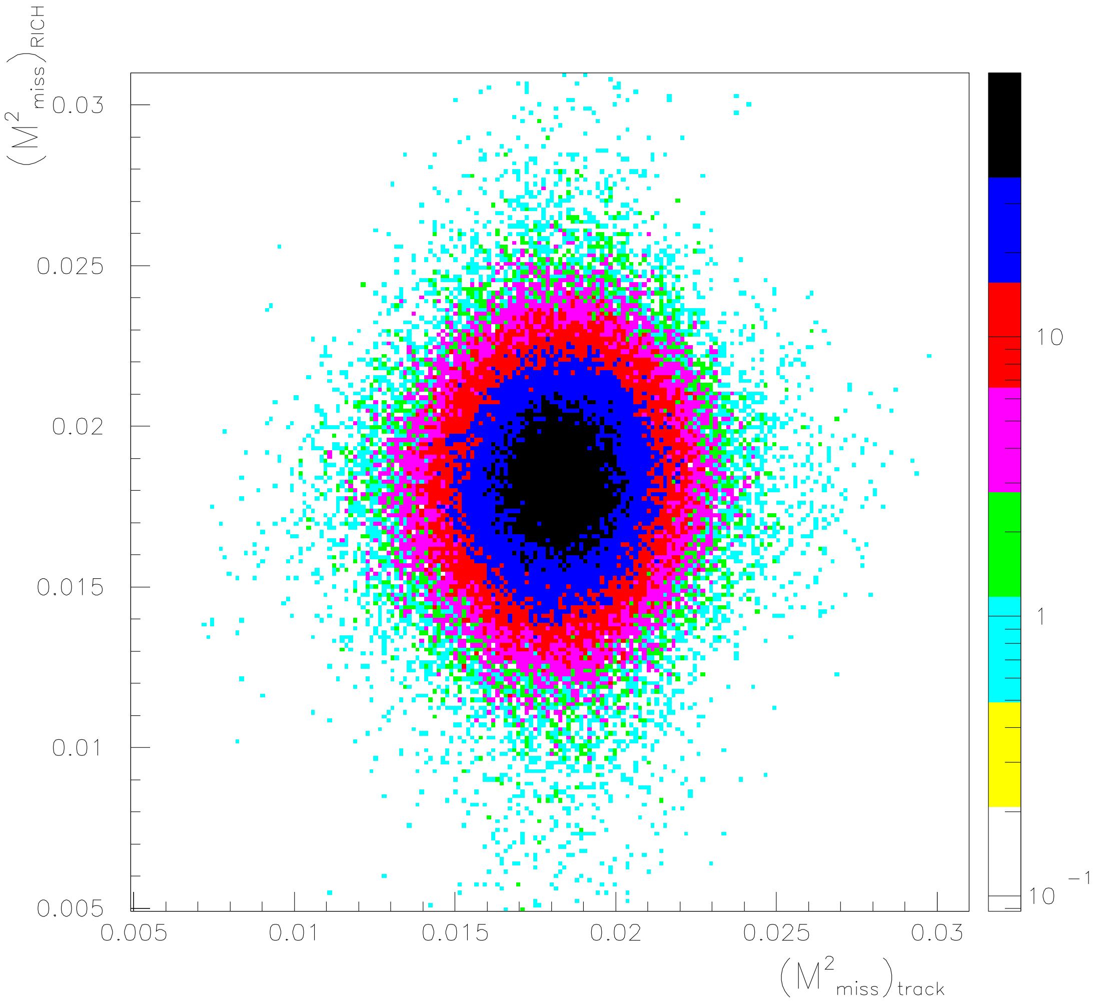
Fiducial volume $1860\,\mathrm{cm} < z < 4160\,\mathrm{cm}$, x and y on beam

Distance of closest approach $< 1\,\mathrm{cm}$

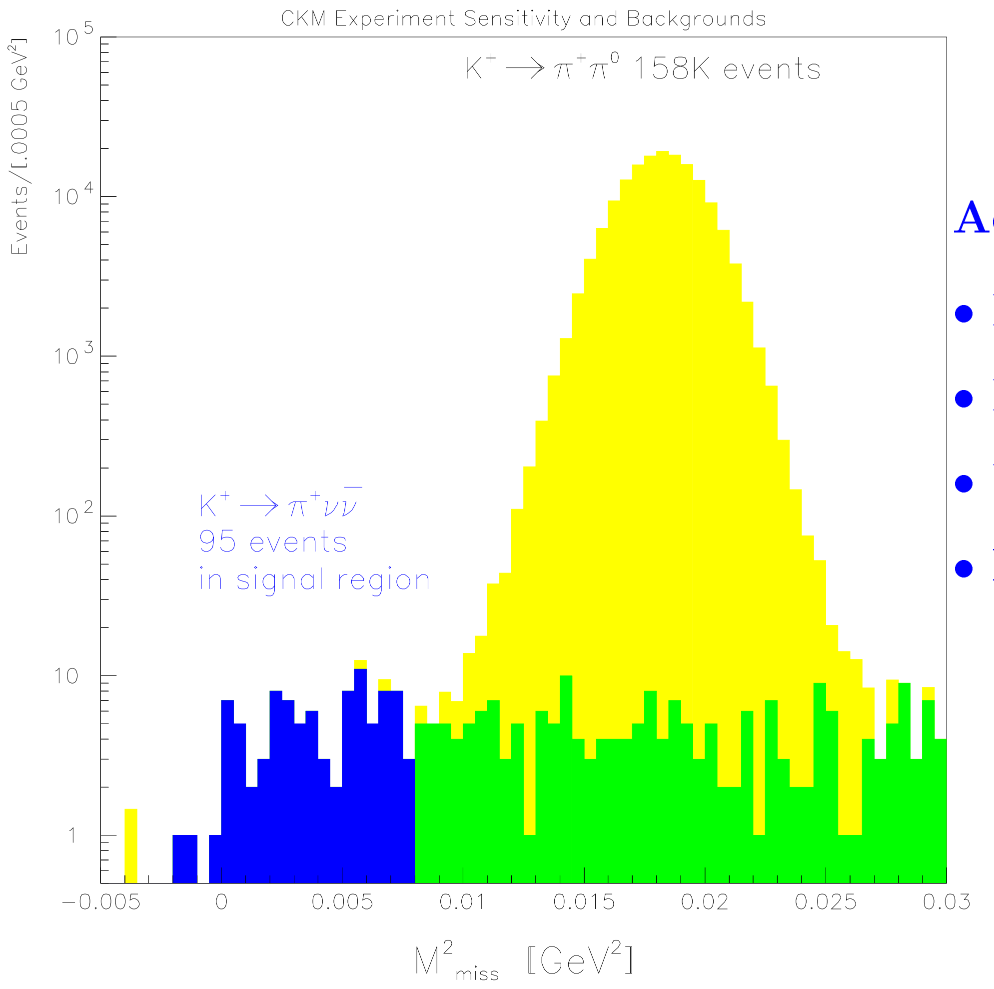
Momentum and velocity spectrometer measurements agree

Momentum of decay product $14\,\mathrm{GeV}/c < p < (p_{K^+} - 1)\,\mathrm{GeV}/c$

Missing Mass distribution of $K^+ \to \pi^+\pi^0$
Comparison of Momentum and Velocity Spectrometers



Final Signal Sensitivity



Acceptance increase compared to 1st edition

- From 1.8 % to 2.3 %
- Decay region increase from 20 m to 23 m
- Upper cut on pion momentum increased
- Include also resolution smeared events close to $M^2_{\mathrm{miss}} = 0$