Charged Kaon Mass Measurement using the MIPP RICH Detector

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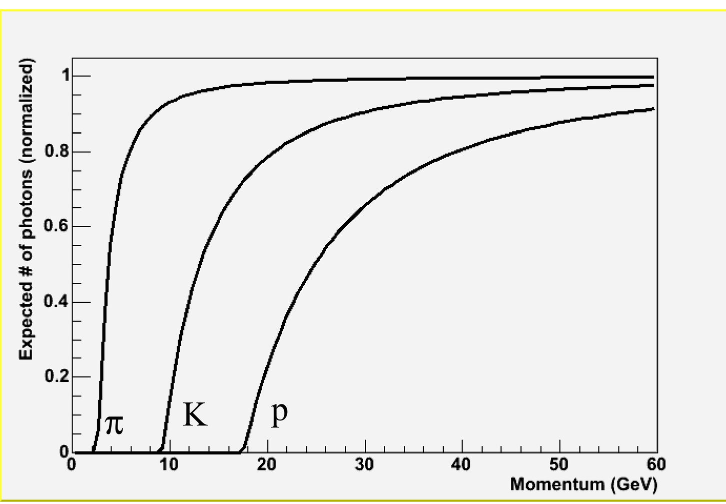
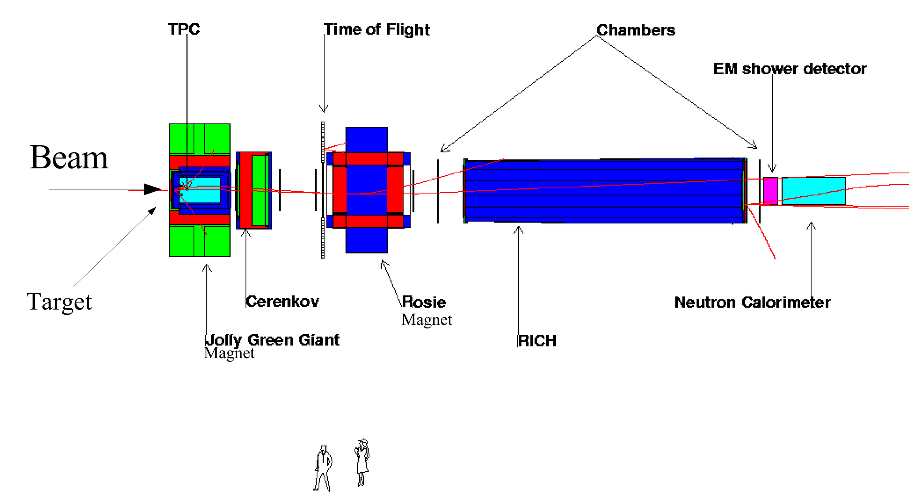
Large Area Threshold Cerenkov:
Particle identification from 2.5 to 9 GeV/c uses the large Ckov with 96 cells and C_4F_{10} gas.



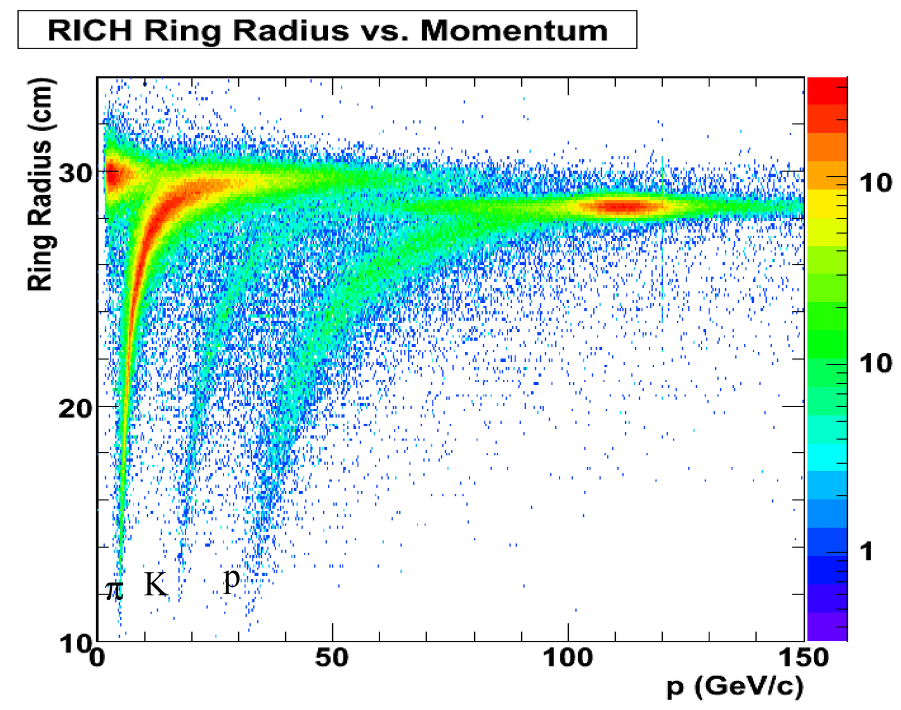
This detector identifies charged particles coming directly form the interaction vertex.

Cerenkov Detector Performance:

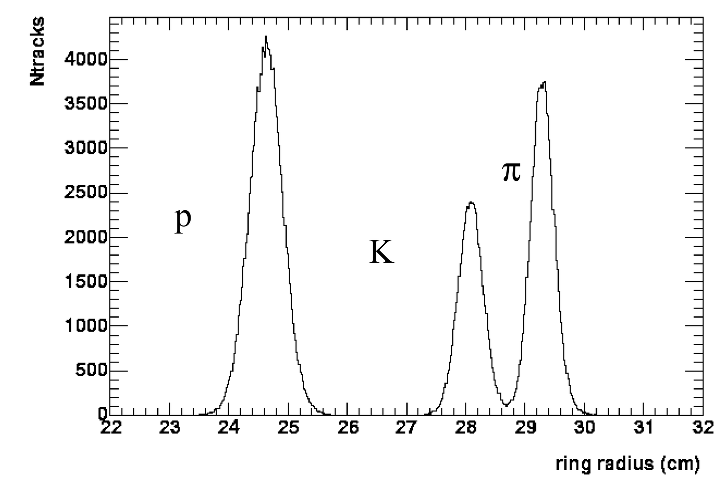
Detectors are performing well in various stages of calibration, which we expect to finish in July. Plots shown use data from the 2005 run without selection. Momentum determination is not yet using the true B-field map, nor final tracking method, but the next pass through the data in June will.



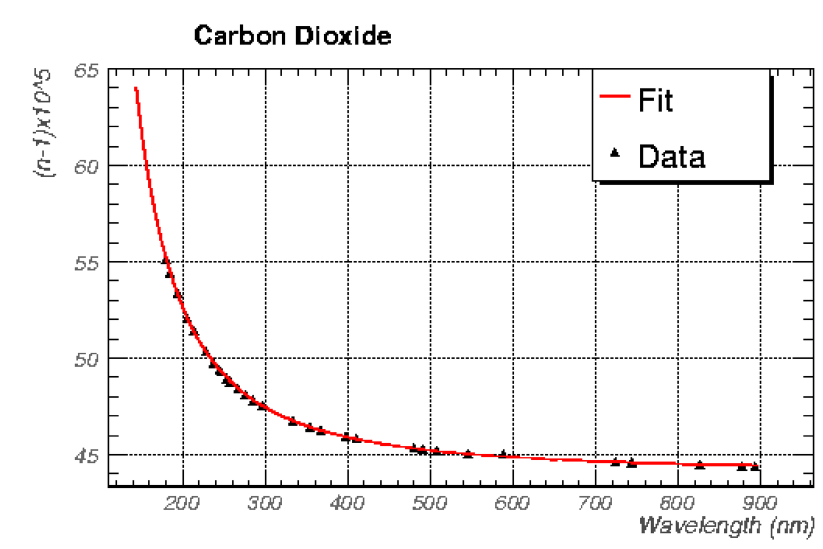
RICH:
Cerenkov Ring Radius Particle Identification
π,K separation up to 80 GeV/c. p,K separation up to 100 GeV/c

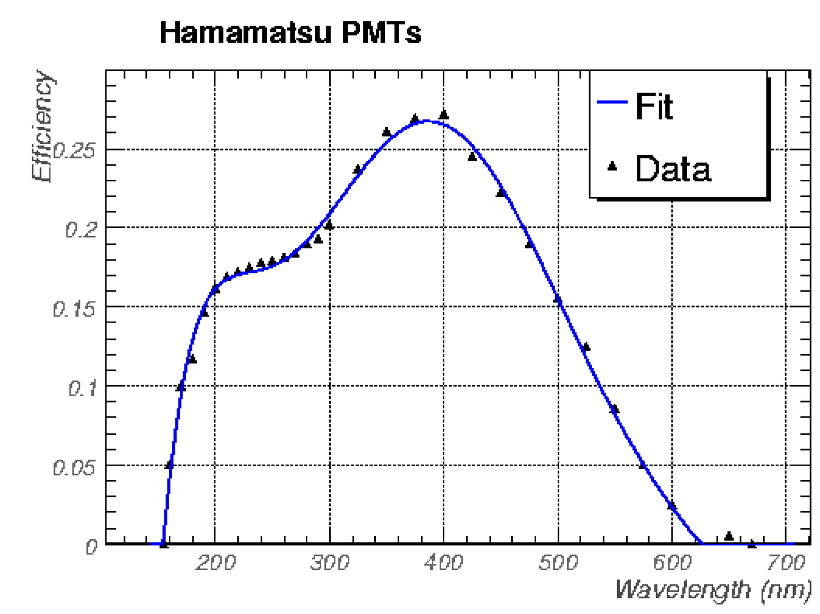


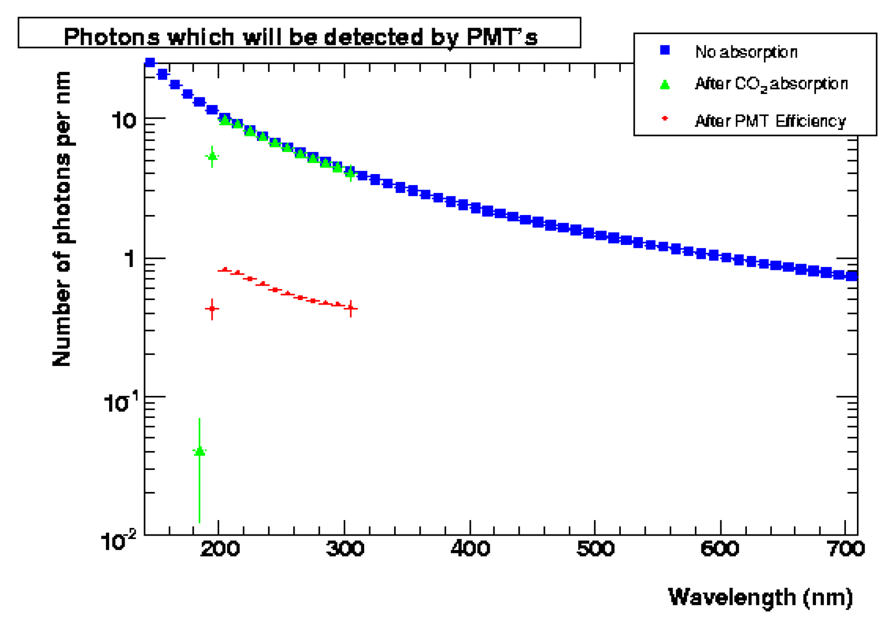
In a slice from 57 to 61 GeV/c



Detector uses ~2100 FEU, Hamamatsu PMTs. Vessel filled with CO2.







Top Left: Refractive index of carbon dioxide at STP

Top Right: Photomultiplier tube efficiency

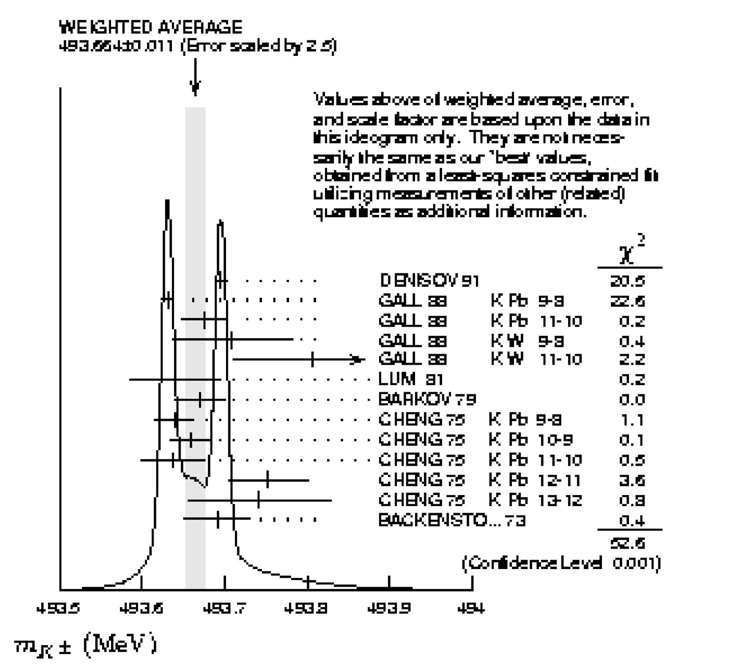
Left: Calculated number of photons detected by tubes

$$\frac{\partial N}{\partial \lambda \partial x} = \frac{2\pi\alpha}{\lambda^2}\left(1 - \frac{1}{n^2(\lambda)\beta^2}\right)$$

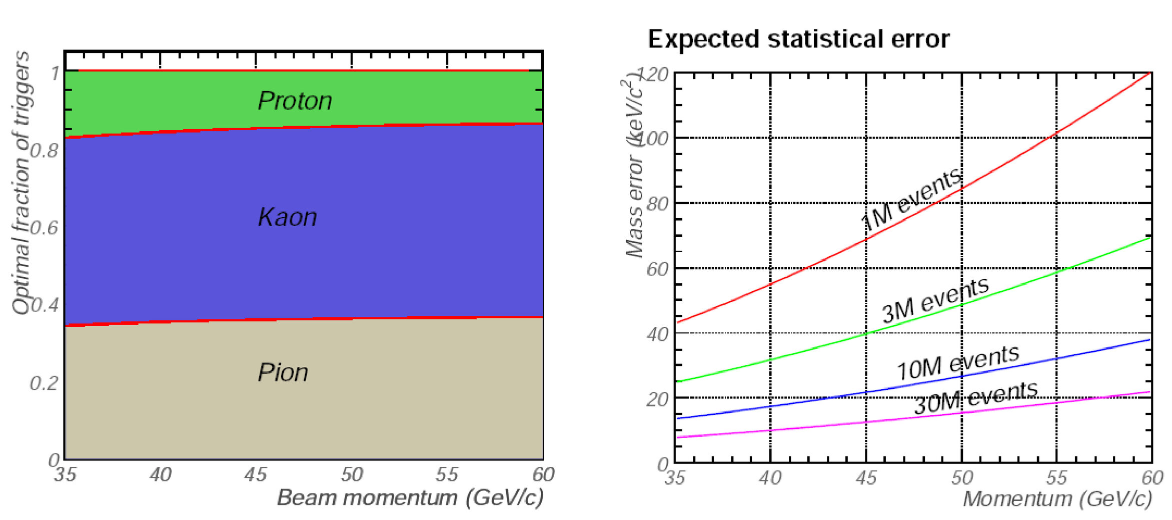
Current Value of Charged Kaon Mass:

The current value of 493.677 +/- 0.013 MeV as given by the Particle Data Group is dominated by two precise measurements of kaonic atom x-ray energies. These two measurements, as seen in the plot to the right, differ by 122 ppm.

The charged kaon mass is an important factor in determining the CKM matrix element V_{us} from measurements of the branching ratio of the decay $K^+ \to \pi^0 e^+ \nu$ (K^+_{e3})



Source: S. Bidelman et al. (Particle Data Group), Phys. Lett. B **592**, 1 (2004)

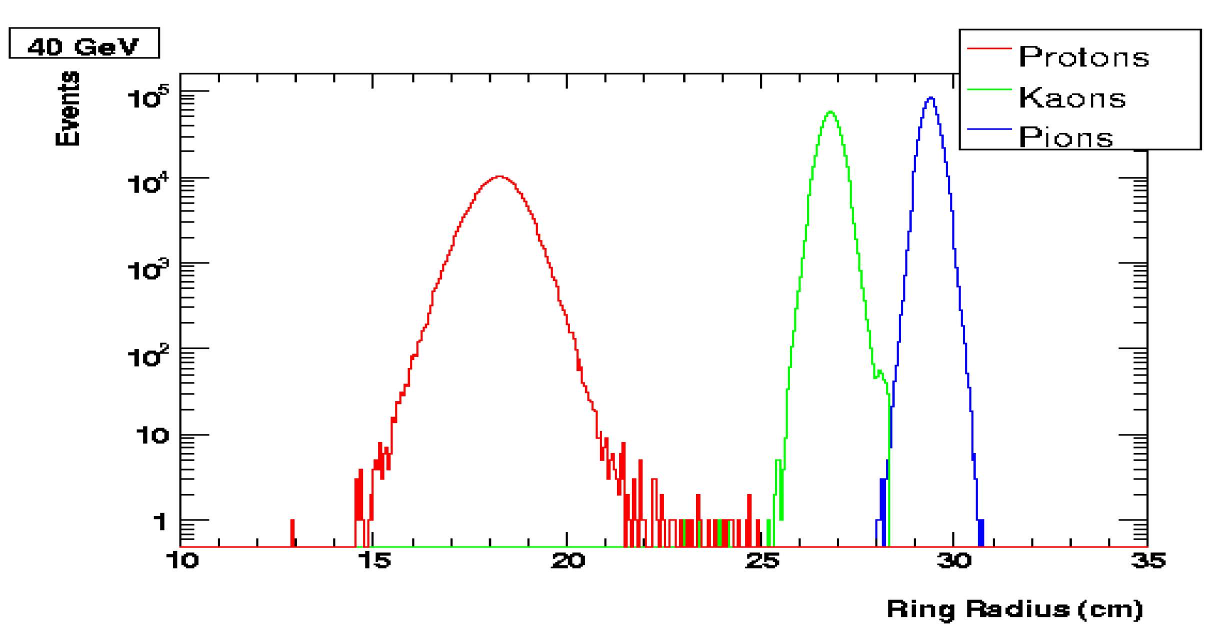


Expected Statistical Error

The statistical error is proportional to the square of momentum, so a measurement at low p is ideal. Also important is running above proton threshold (~31 GeV/c). 40 GeV/c was decided as being optimal. With ~10 M events, a competitive measurement can be made.

Data

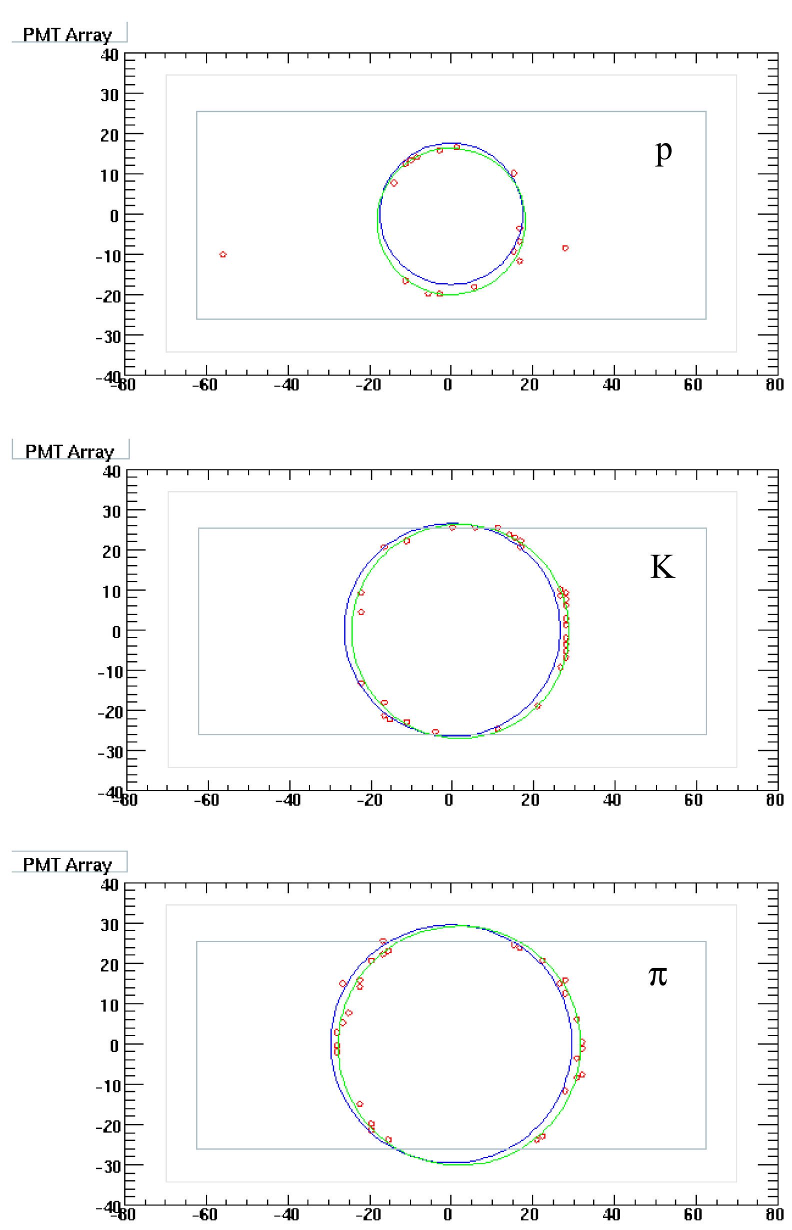
Data was taken opportunistically during downtime for analysis magnets at different momenta. 14 million events collected in total, of which approximately 5 million were taken at 40 GeV/c during dedicated running.



Centers of radius distributions correlated by

$$R = L\sqrt{1 - \frac{1}{(n^2(\lambda)\beta^2)}}$$

where R is the ring radius, L is the length of the RICH vessel, and n is the index of refraction.



Sample event displays with ring fits

Data Analysis Plan

Calculate likelihood based on expected number of photoelectrons for each PMT in array and Poisson statistics. Minimize negative log likelihood with respect to mass, momentum, and ring center position to get best mass value for each event. Adjust parameters such as L,n to match proton and pion mass peaks with well known values of these masses. Use position of remaining mass peak as measurement of kaon mass