Modified Particle Identification in the CEDAR Using Likelihood Methods

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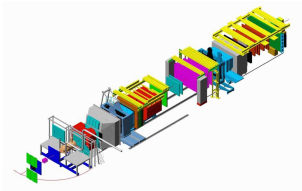


CEDARs at COMPASS

- CEDAR = ČErenkov Differential counters with Acromatic Ring focus
- CERN 82-13 „The CEDAR counters for particle identification in the SPS secondary beams: A description and an operation manual“

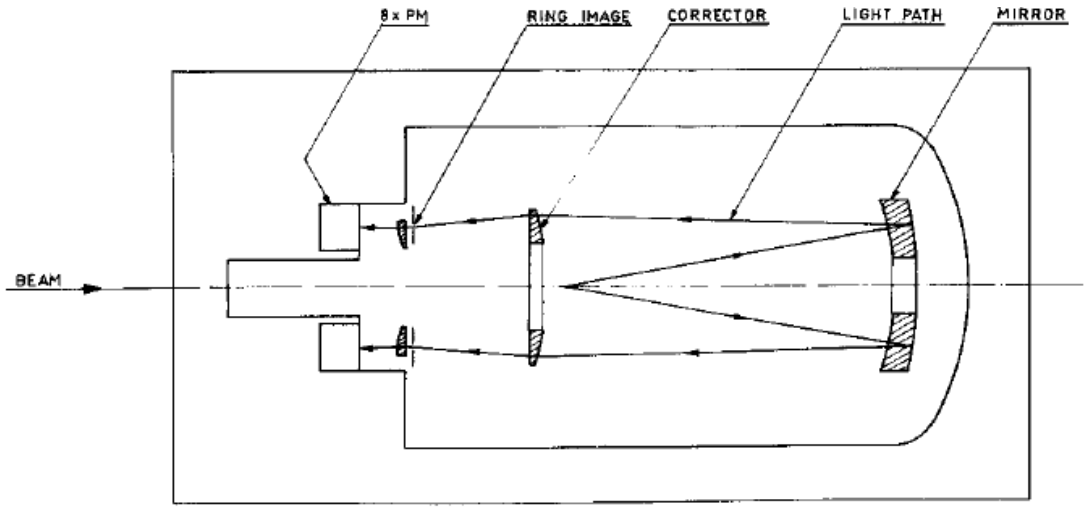
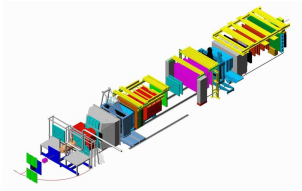
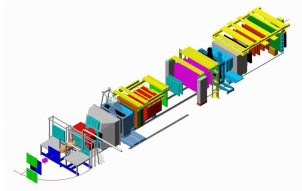


Fig. 2 Schematics of the optics of a differential Čerenkov counter (distorted scale)



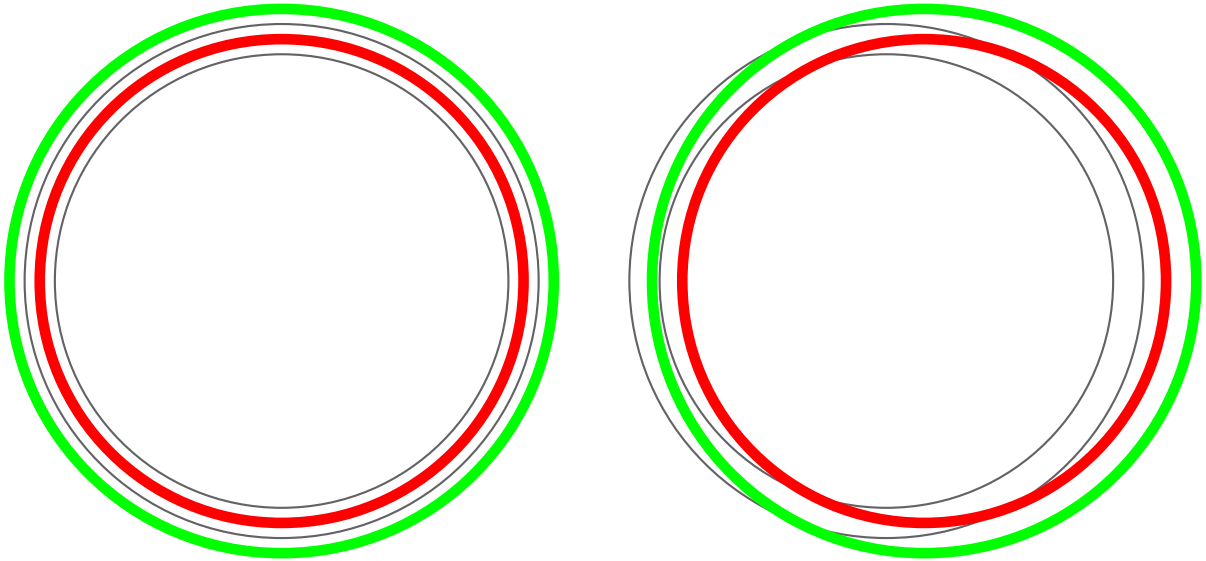
CEDARs at COMPASS

- CEDAR = Čerenkov light detected with 8 PMTs
- Particle identification using multiplicity cut manual“
- Does not work properly for divergent beams
- New method developed by J. Friedrich for 2009 Primakoff data
- Can this method be adapted to 2008 hadron data?

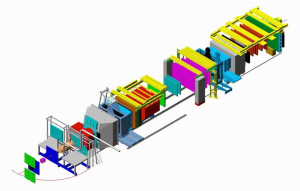


Influence of Beam Divergence

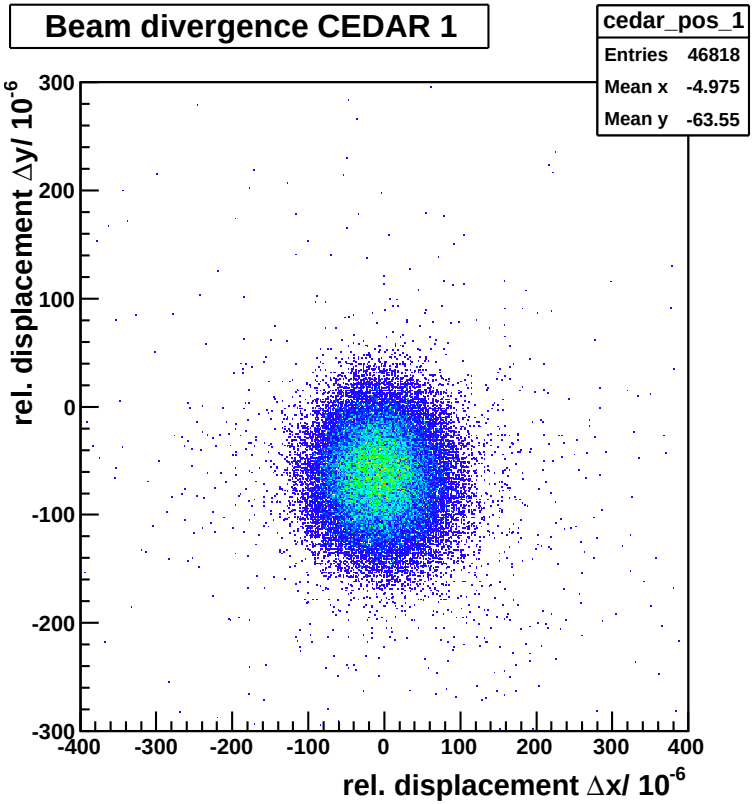
- Kaon ring leaves acceptance, pion ring enters

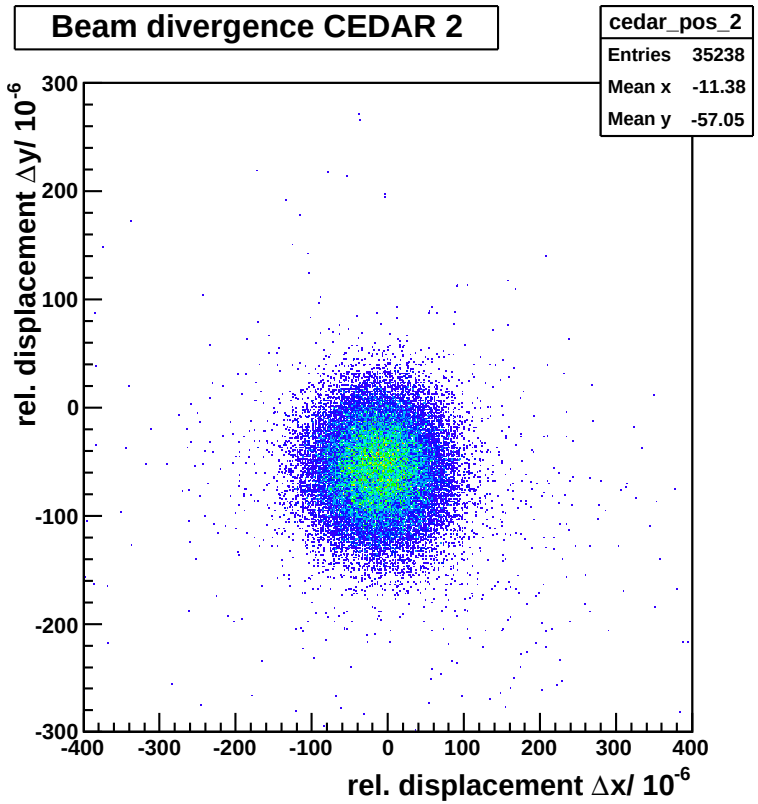


- Find a method to take beam divergence into account

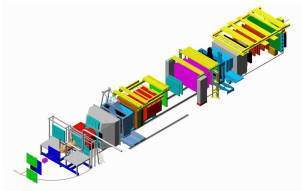


Beam Divergence in CEDAR region





$\Rightarrow$ Correct for zero position

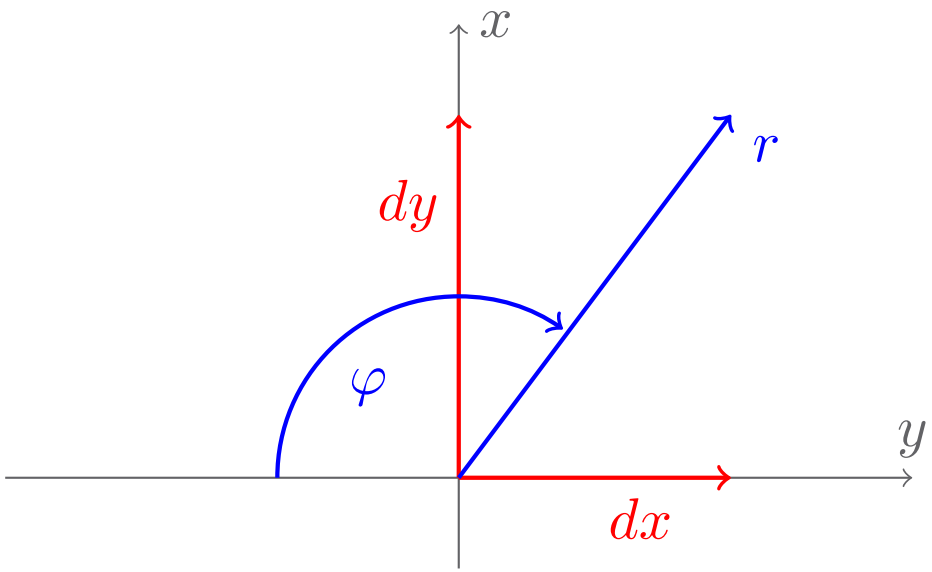


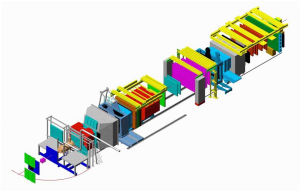
Beam Divergence

- Parametrize beam divergence:

„absolute value“ $r = \sqrt{dx^2 + dy^2} = \frac{1}{\Delta z}\sqrt{\Delta x^2 + \Delta y^2}$

$$\text{direction}\varphi = \begin{cases} \arctan\frac{dx}{dy} + \frac{\pi}{2} & \text{für } y \geq 0 \\ \arctan\frac{dx}{dy} + \frac{3\pi}{2} & \text{für } y < 0 \end{cases}$$

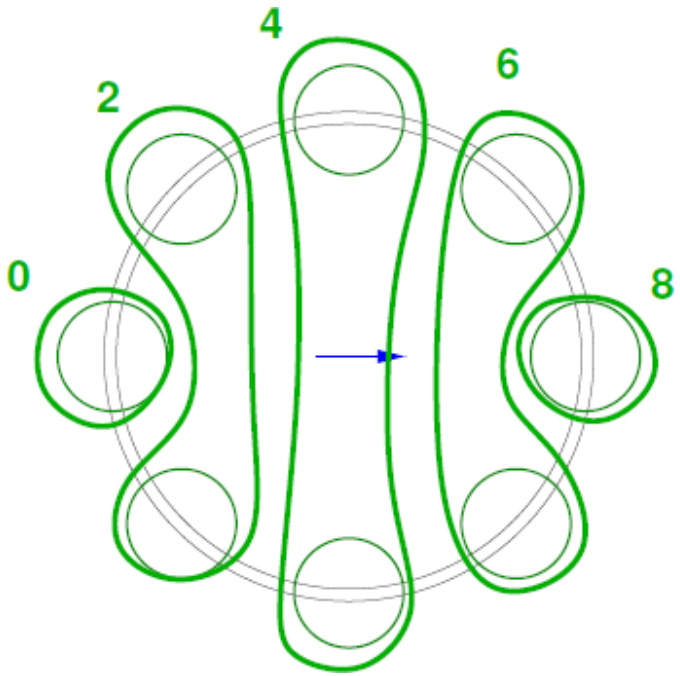


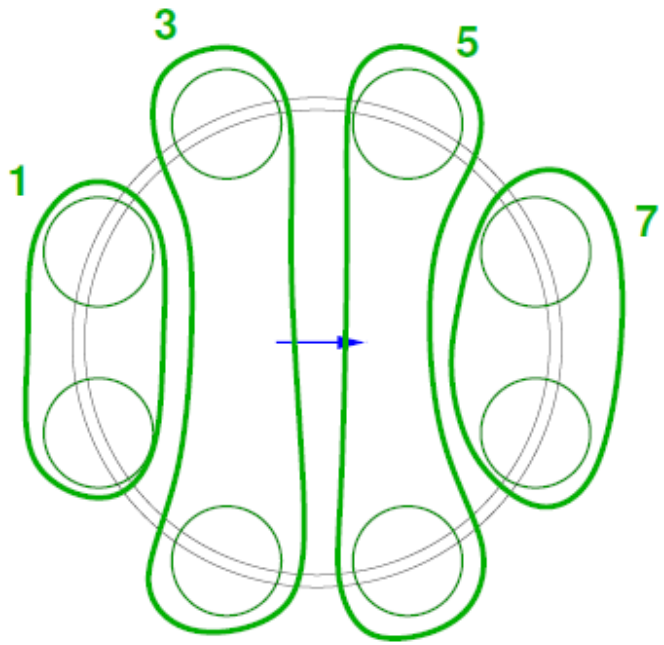


Grouping the Photomultipliers

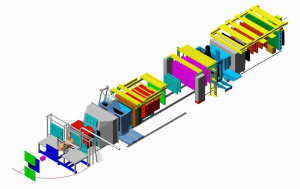
According to the direction φ one can distinguish two cases:

- Divergence points towards a certain PMT
- Divergence points between two PMTs



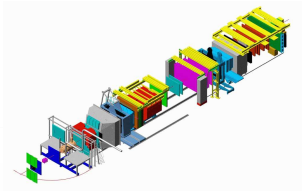


picture from „Jan Friedrich, CEDAR performance 2009, COMPASS Note 2010-15“



Counting the Hits

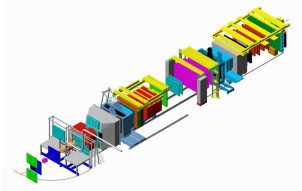
- Take a pure Kaonsample and a pure Pionsample
- For each single event (separately for π and K)
  - calculate r and φ for each CEDAR
  - group PMTs according to φ
  - count the hits in the single groups
  - fill histograms for number of hits in single groups in r-bins



Getting the Probabilities

- take all the histograms
- normalize bin by bin with the total number of events in that r-range
- fit the histograms

$\Rightarrow$ We obtain probability distributions $P^{\pi,K}_{c,g,h_g}(r)$ for h_g hits in group g at CEDAR c

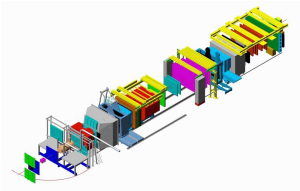


Calculating the Likelihoods

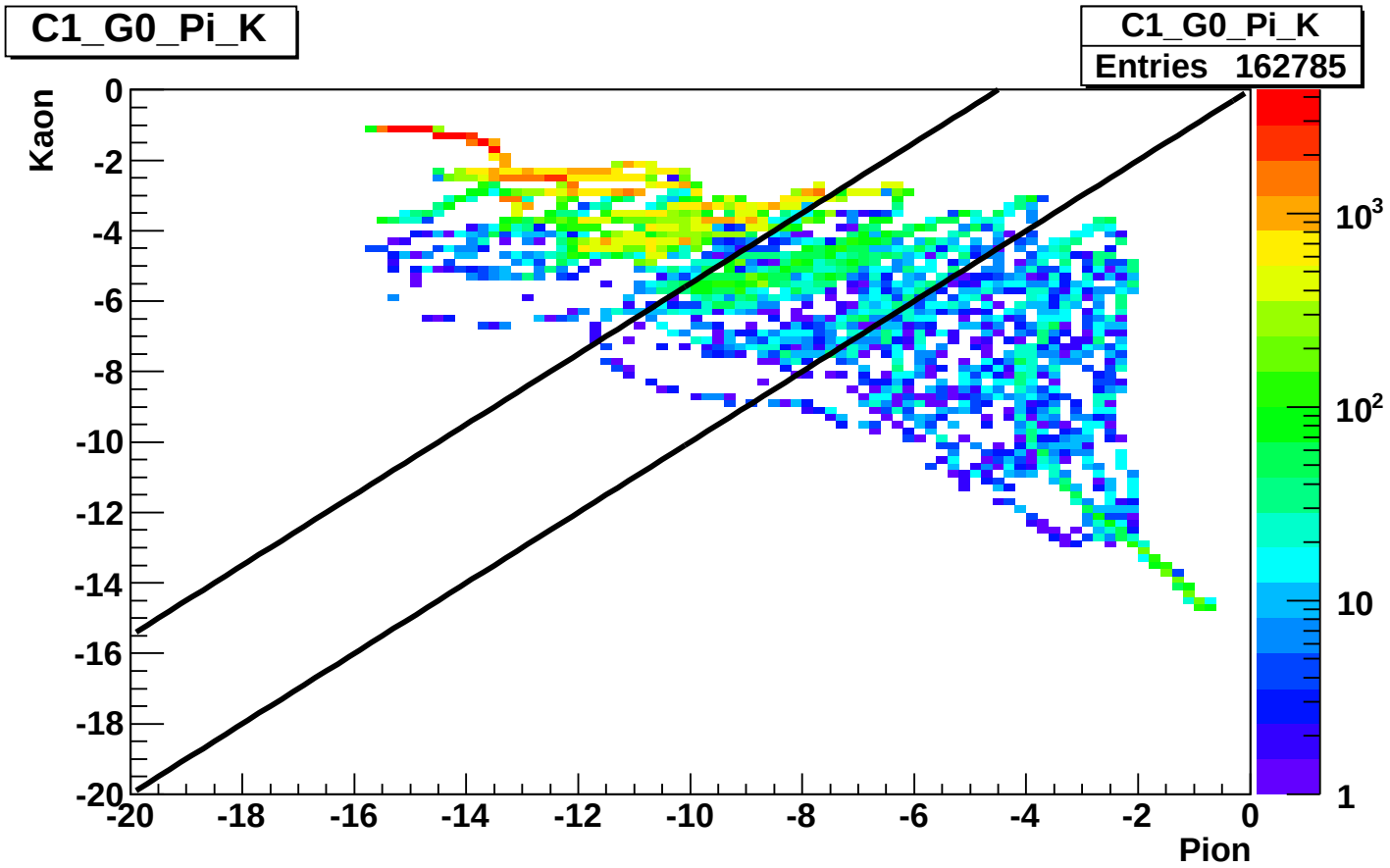
To identify a particle one has to calculate likelihoods:

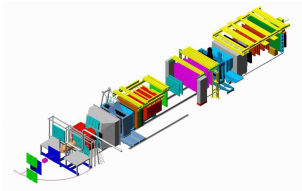
- calculate $\hat{r}$ and $\hat{\varphi}$ of the particle
- group PMTs and count the hits
- multiply according probabilities $P^{\pi,K}_{c,g,h_g}(r)$ for the given distribution of hits
- take the logarithm
- do so for Kaon and Pion hypothesis

$$\log L^{\pi,K}(c) = \sum_g \log\left(P^{\pi,K}_{c,g,h_g}(\hat{r})\right)$$

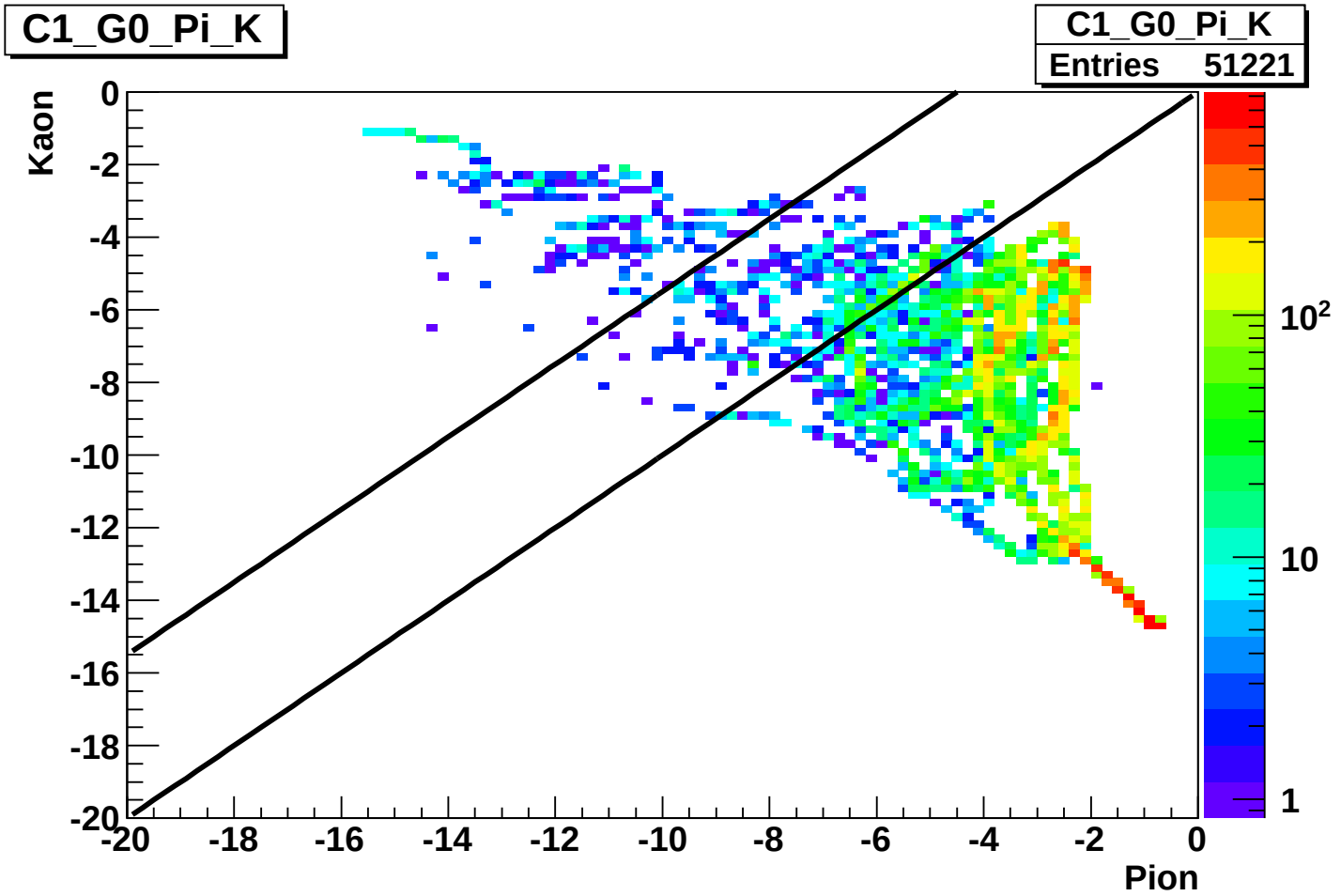


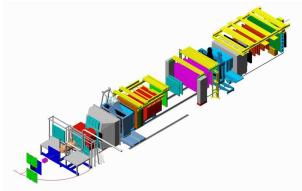
Comparing the Likelihoods – Pionsample





Comparing the Likelihoods – Kaonsample





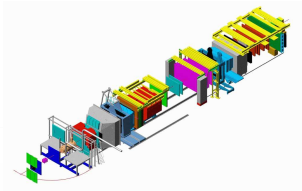
Decision

Decide between hypotheses (π, K) according to $\log L$ values:

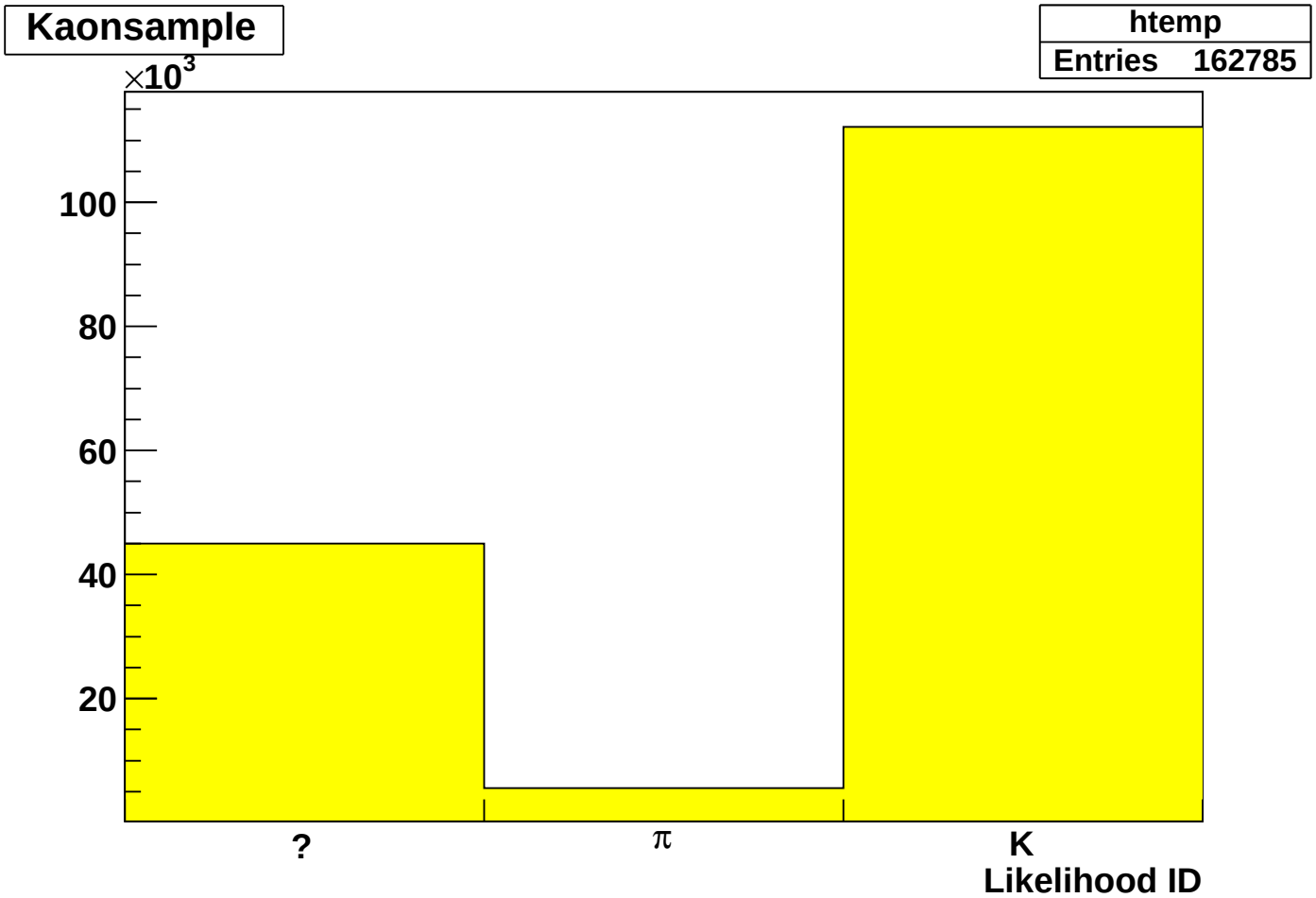
- $logL^{\pi}(c) > logL^{K}(c) \quad \mapsto$ Decision „Pion“
- $logL^{K}(c) > logL^{\pi}(c) + 4,5 \quad \mapsto$ Decision „Kaon“
- no decision „?“

Combine decisions of both CEDARs

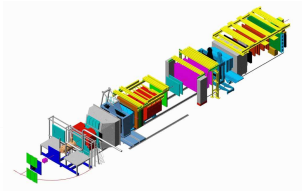
&	?	π	K
?	?	π	?
π	π	π	?
K	?	?	K



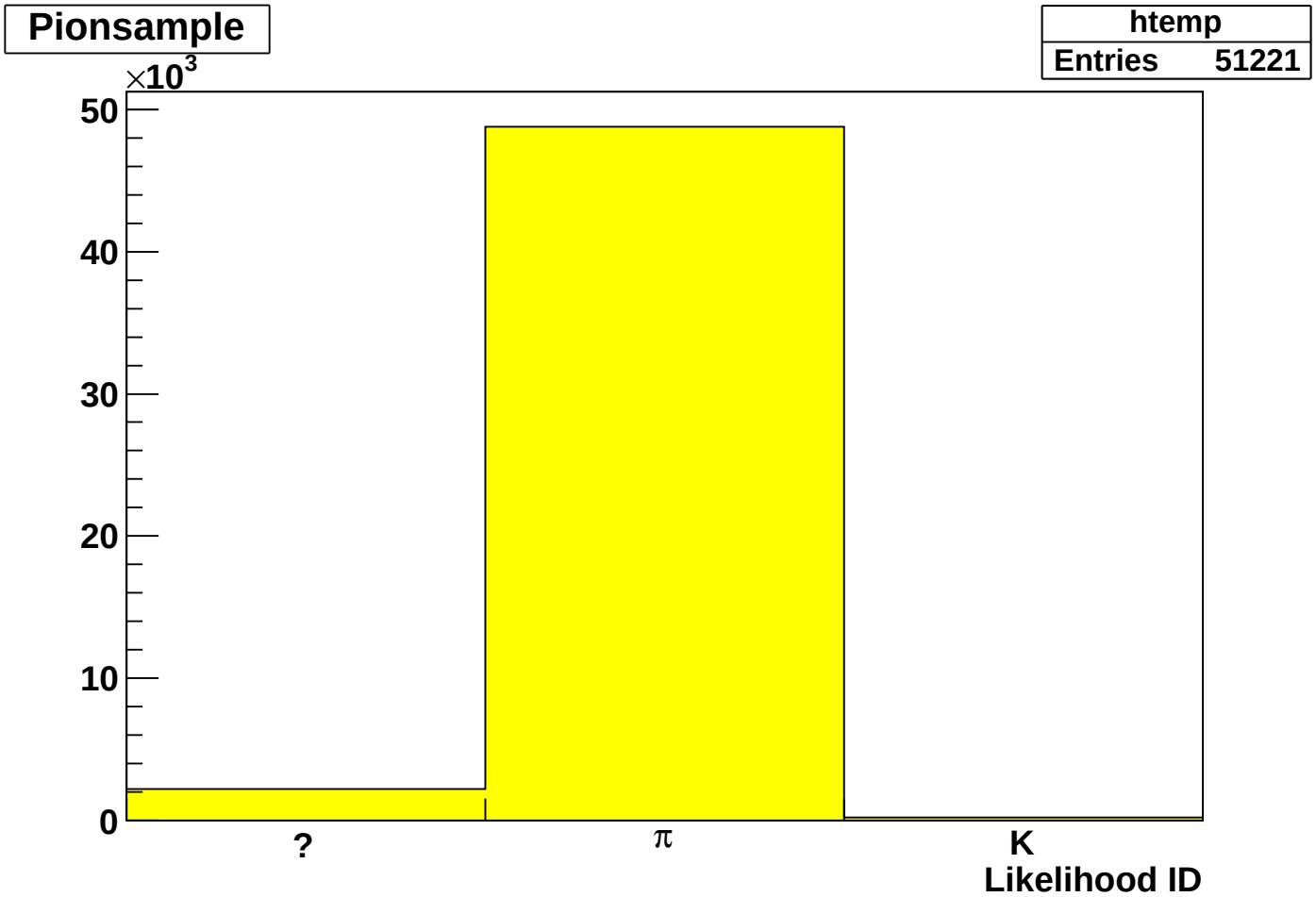
Result for Kaonsample



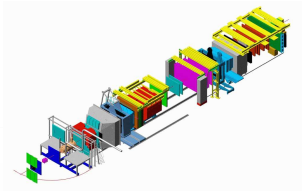
- 69% identified as kaons
- 3.4% misidentified as pions



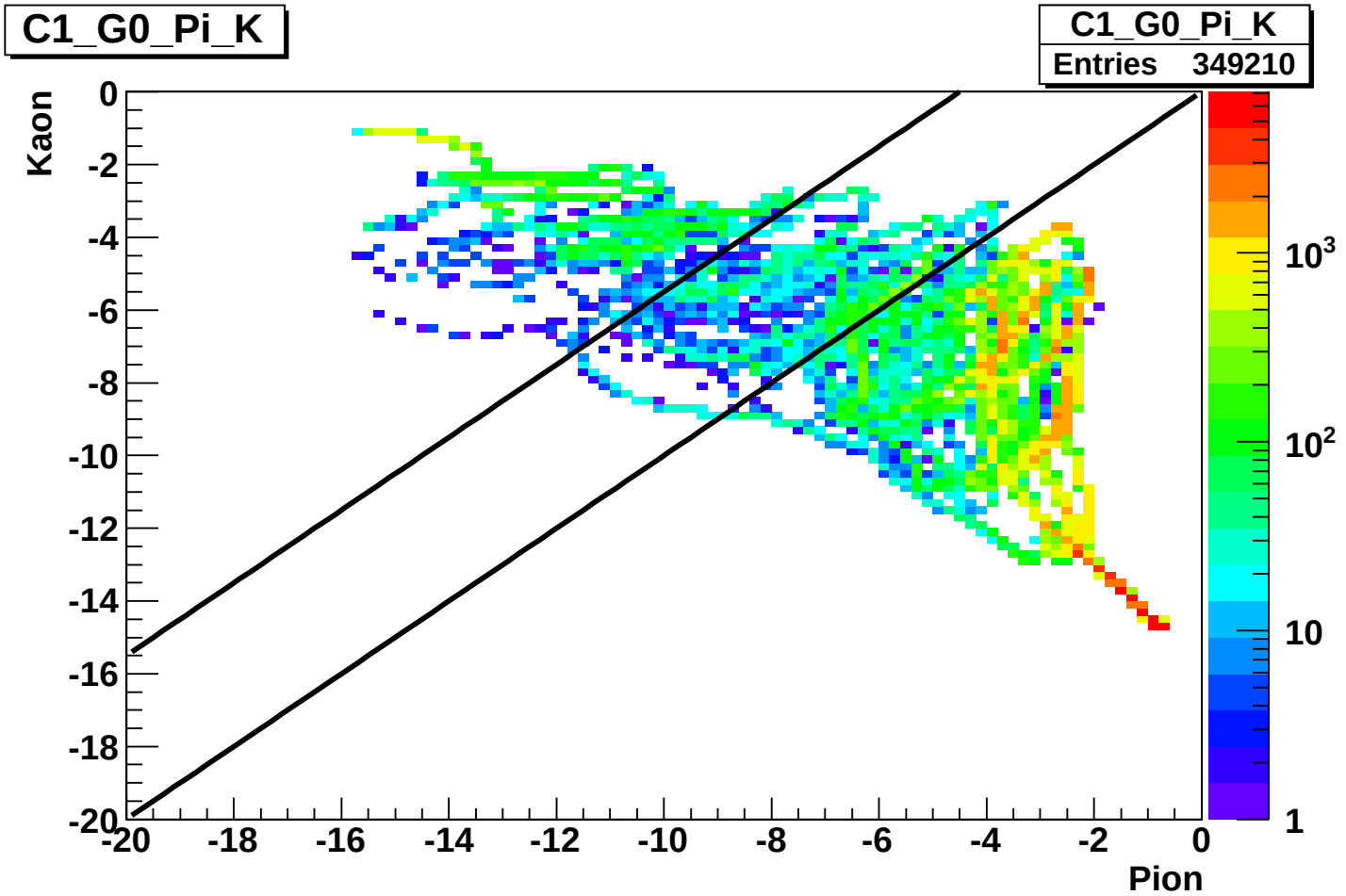
Result for Pionsample

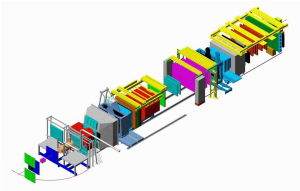


- 95% identified as pions
- 0.4% misidentified as kaons

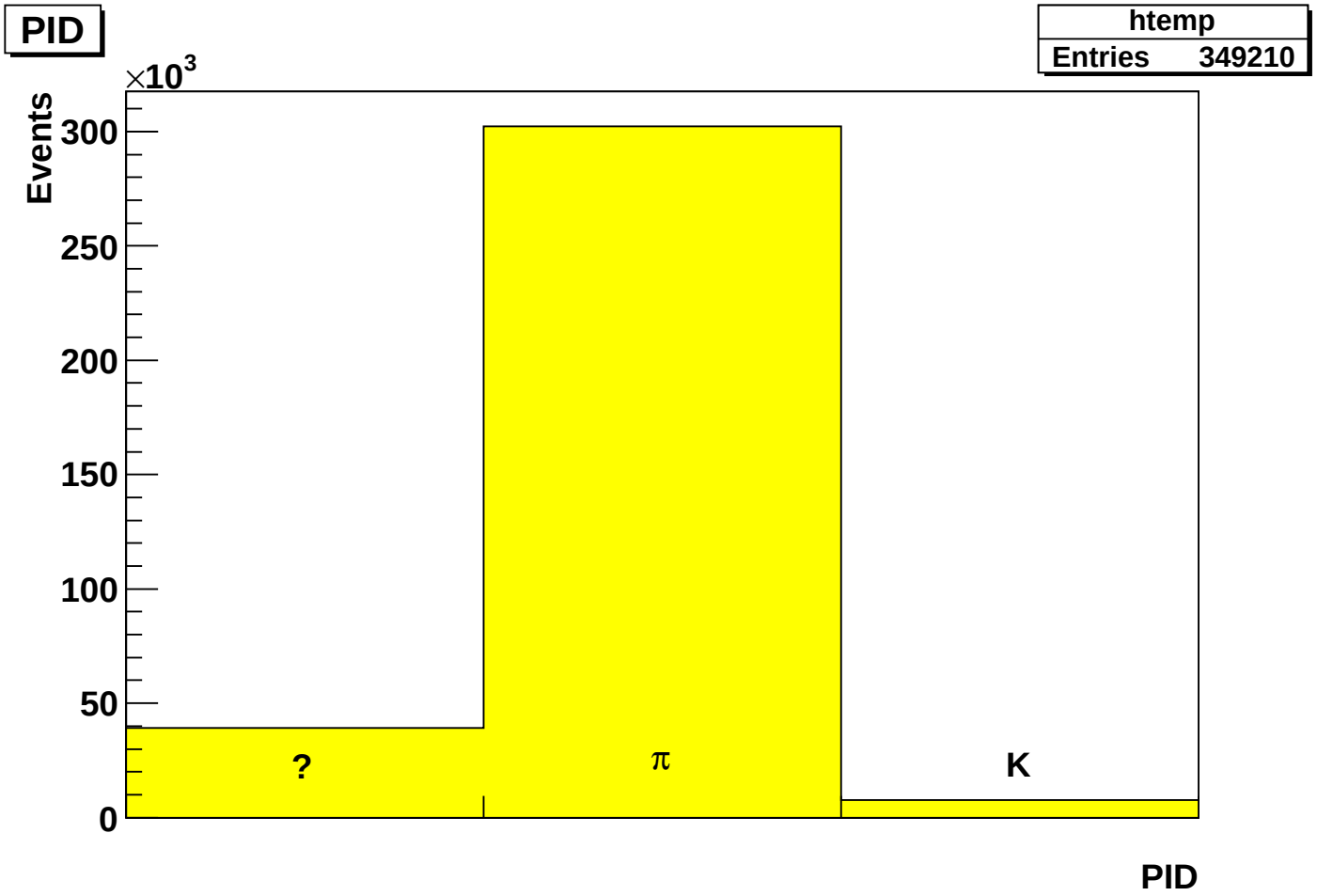


Testing on Beam

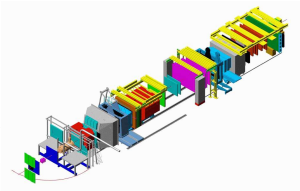




Testing on Beam



Result: $2,2\%$ kaons, $86,6\%$ pions, $11,2\%$ without PID

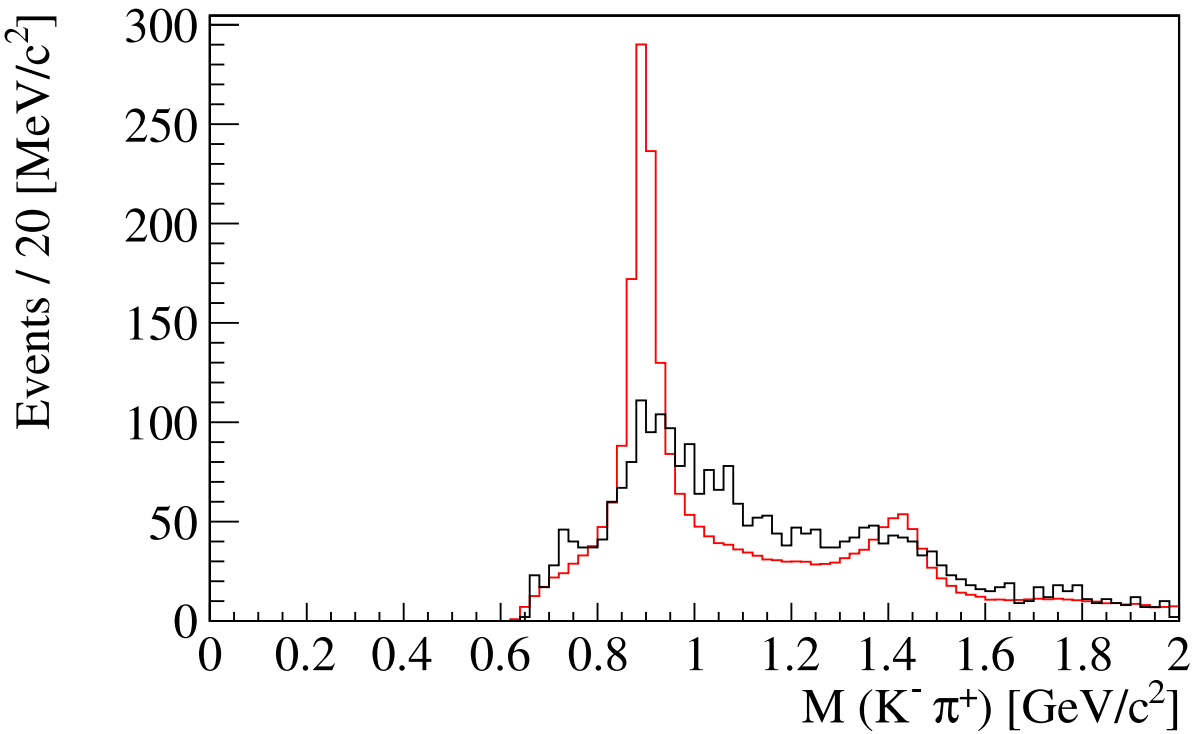


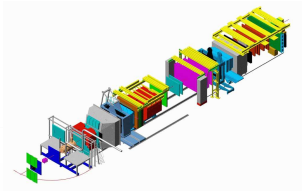
First Real Test

- P. Jasinski's $K\pi\pi$-analysis

red: majority cut

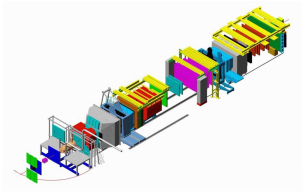
black: likelihood cut



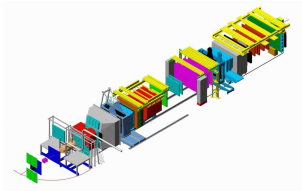


Conclusion

- method does not seem to work properly for real analyses
- further testing needed
- larger statistics for training the likelihoods might help
- method LikeID_new can be found in CEDAR-Helper



Backup

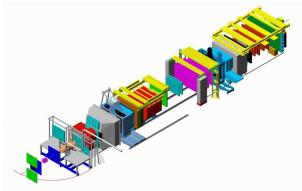


Kaonsample

Freie Kaonzerfälle $K^- \to \pi^-\pi^-\pi^+$ in W33, W35, W37 aus 2008

- Kaontrigger
- Primärvertex außerhalb des Targets
- 3 auslaufende Teilchen (- - +)
- $E(3\pi) = 190 \pm 4\,\mathrm{GeV}$
- $m(3\pi) = m_K \pm 50\,\mathrm{MeV}$

Insgesamt 156671 Ereignisse



Pionsample

Ereignisse mit drei auslaufenden Teilchen unter kleinen Winkeln mit ähnlichen Impulsen

- $\theta < 0,2\,\mathrm{rad}$
- $\Delta p_{ij} < 10\,\mathrm{GeV}$

Insgesamt 51221 Ereignisse