Particle identification with Cherenkov detector in VES experiment

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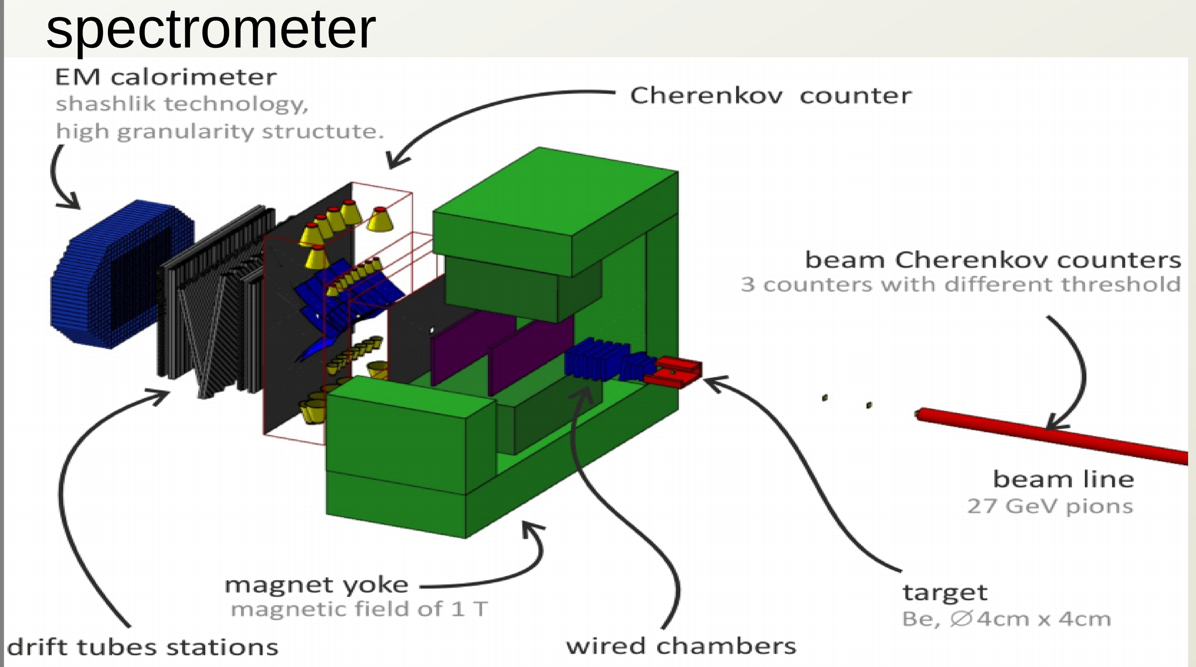
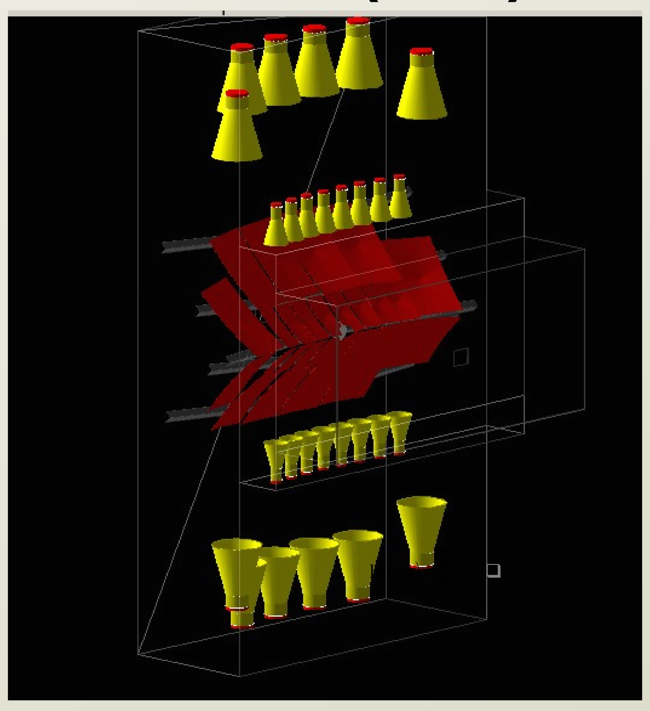
VES setup – wide aperture magnetic spectrometer



- Fixed-target experiment at Protvino(IHEP).
- Main goal: hadron spectroscopy.
  $\pi^- N_{target} \rightarrow m X^- k X^+ n \gamma N_{recoil}$
- Be target.
- π^- beam 29 GeV/c.

Multichannel Cherenkov counter(MCC)



- 28 mirrors (15x30cm^2,30x55cm^2).
- 28 light collecting cones.
- 1.6 m R-22 gas radiator.
- FEU-110, FEU-125.
- Measure ADC amplitude A_k.

Particle Identification Method:

- Main method – threshold (for physical analysis);
- There is possibility to identify events taking into account ADC amplitude A;
- Hypothesis for full set of tracks because of Cherenkov cones can overlap in a mirror;
- (e.g. $h_1=\pi^+\pi^-\pi^-$, $h_2=K^+\pi^-\pi^-$, …,h_n);
- Response probability for hypothesis:

$$\ln(p_{h_i}) = \sum_{k=1}^{N_{chan}} \ln \begin{cases} (1-\epsilon_k) e^{-n_k^{h_i}}, A_k < A_{thres}^k \\ 1-(1-\epsilon_k) e^{-n_k^{h_i}}, A_k > A_{thres}^k \end{cases}$$

ϵ_k- noise in k-th channel;
$n_k^{h_i}$ - number of ph.e. for k-th channel and h_i from track information and model.

- sort hypothesis $(h_1,\ldots h_n) \leftrightarrow (p_{max}, p_{next}, \ldots, p_{min})$
- Event is identified with hypothesis h_1, if: $\frac{p_{max}}{p_{next}} > \alpha$
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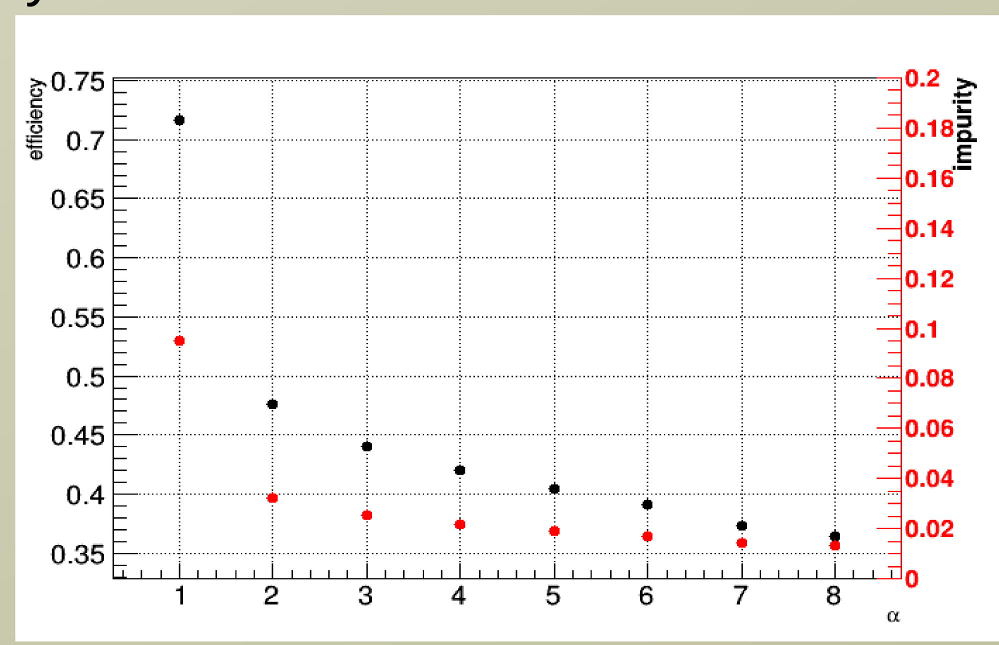
- α – parameter of balance between efficiency and purity of identification.



Efficiency and impurity for $\pi^- N_{target} \rightarrow \pi^+ \pi^- \pi^- N_{recoil}$ **MC events versus α**

Cherenkov counter MODEL

Fast simplified	GEANT4
High speed	More detailed geometry
Possibility of tuning parameters	Physical process in material
Time dependency of refraction index	Photons reflect in cones
Effective account for physical and apparatus noises	Explicit account for reflection index dispersion
Response only for reconstructed tracks	Response for all charged particles

Model Parameters:

- Counter position;
- Mirrors position;
- Mirror angles;
- Noises of channels;
- Refraction index of gas n;
- Coefficients photons to photoelectrons k_{phe}.

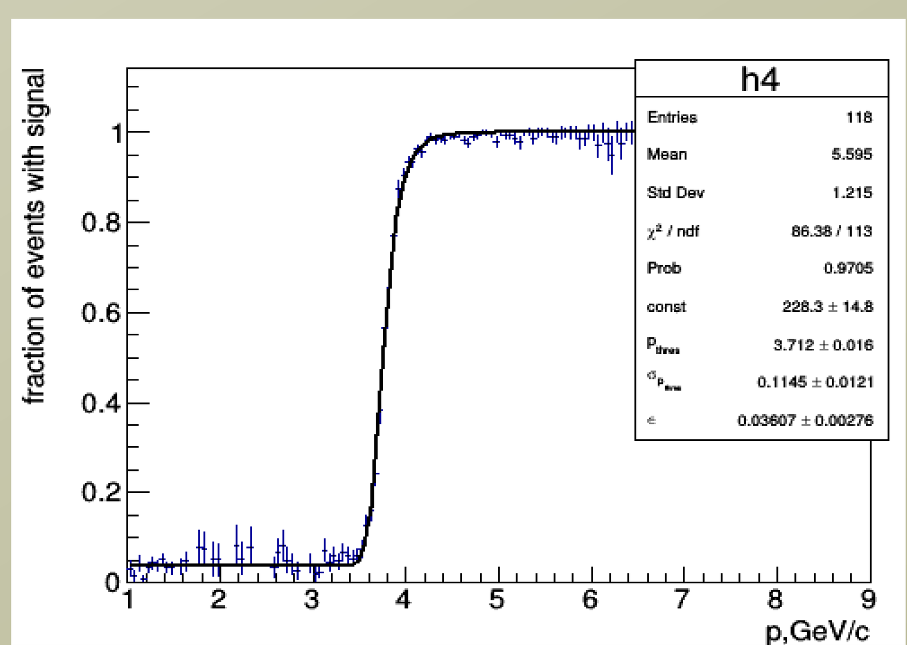
Model Parameters are obtained and verified using various experimental data samples.

Main reaction: $\pi^- N_{target} \rightarrow \pi^- 2\pi^0 N_{recoil}$ (K^-<0.5%).

Likelihood maximization to get mirror angles and $k_{ph.e.}$.

$$L = \sum_{i=1}^{N_{ev}} \sum_{k=1}^{28} \ln \begin{cases} (1-\epsilon_k) e^{-n_{k_i}}, A_k < A_{thres_k} \\ 1-(1-\epsilon_k) e^{-n_{k_i}}, A_k > A_{thres_k} \end{cases}$$

Fit curve to get threshold momentum of cherenkov radiation



$$F(p) = 1-(1-\epsilon) e^{-N}$$
$$N = f(p) * gauss(p_{thres}, \sigma_{p_{thres}})$$
$$f(p) = \begin{cases} 0, p < p_{thres} \\ const \cdot (1 - \frac{p_{thres}^2}{p^2}), p > p_{thres} \end{cases}$$

* - convolution operator;
$gauss(p_{thres}, \sigma_{p_{thres}})$ – for effective account for refraction index dispersion.

Model applications:

- Calculate response for different event hypothesis and identify events;
- For modeling of events efficiency and misidentification;

Model allows to generate ADC signals:

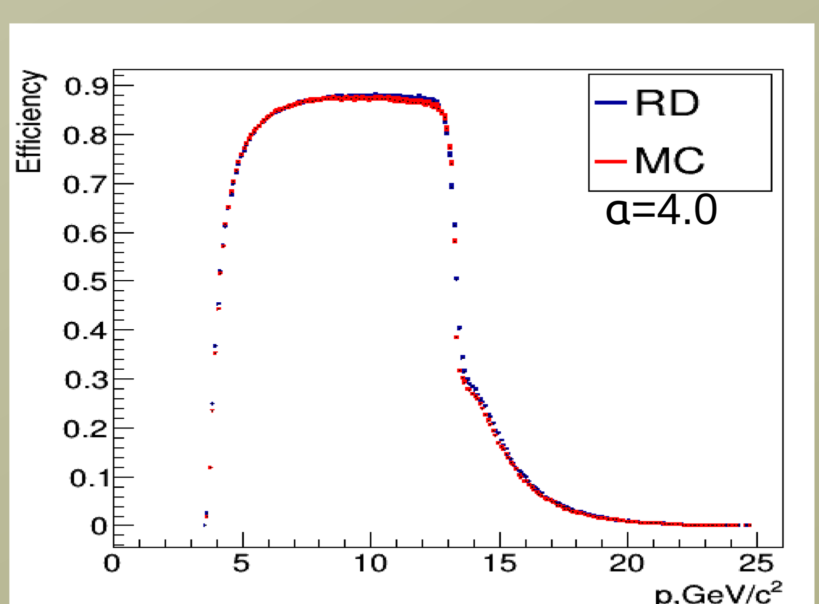
$$A = A_{sig} + A_{noise}$$

A_{sig} – signal amplitude - random number from distribution:

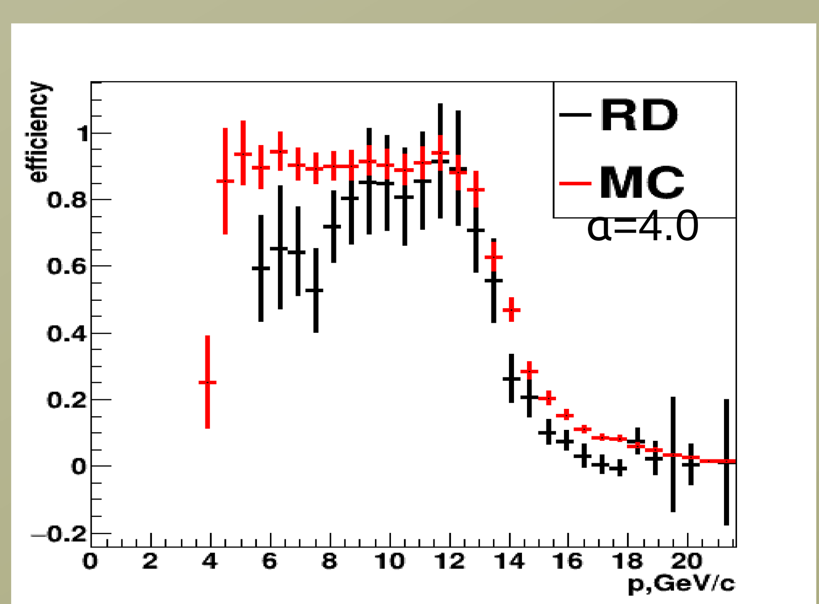
$$S_k = \sum_{i=1}^{30} \frac{n_k^i e^{-n_k}}{n_k!} s_k^i$$

n_k – number of ph.e. for k-th channel;
s_k^i- i-times convolution of single electron spectrum for k-th channel.

π^- identification efficiency versus momentum in reaction $\pi^- N_{target} \rightarrow \pi^- 2\pi^0 N_{recoil}$

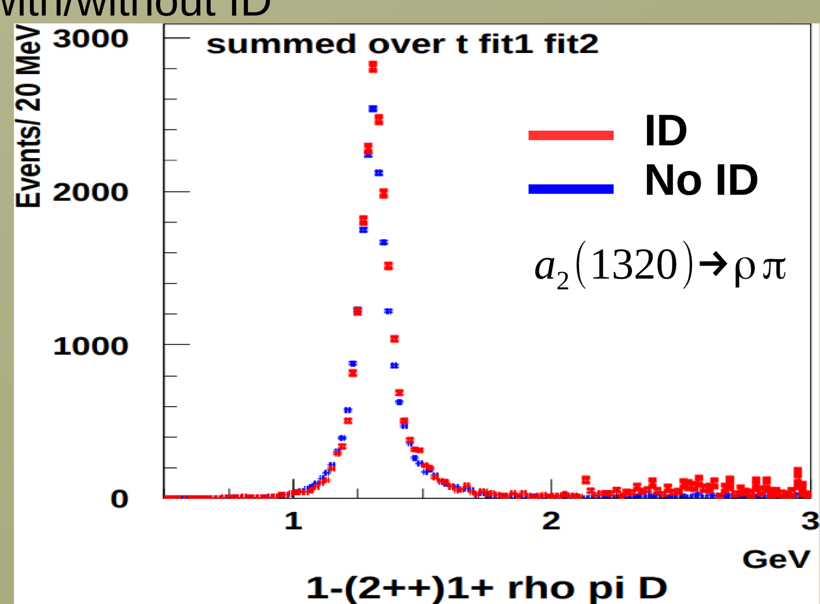


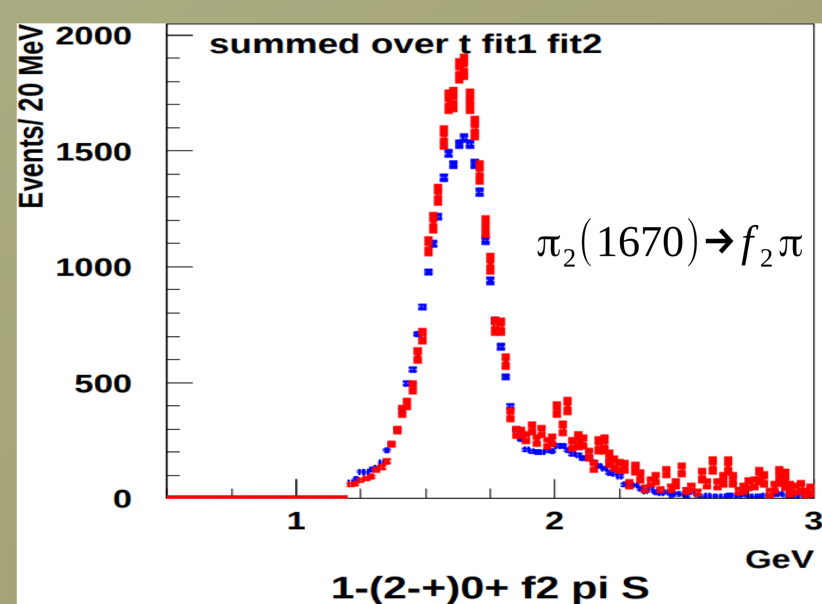
K^- identification efficiency versus momentum in reaction $\pi^- N_{target} \rightarrow a_2(1320) \rightarrow K^- K^0 N_{recoil}$



Partial Wave Analysis of $\pi^- N_{target} \rightarrow \pi^- 2\pi^0 N_{recoil}$ reaction as a benchmark for ID characterization

Acceptance corrected intensities for representative waves with $J^P=2^+$ and $J^P=2^-$ with/without ID





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