HARDON BEAM COMPOSITION (BAYESIAN APPROACH)

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CURRENT GOALS AND METHODS

The main purpose of this study was to probe the reconstruction efficiency of the hadron beam structure, passing through the detector volume. Identification of pions, kaons and protons was performed by using the Likelihood method, which is in perspective one of the most effective methods of TRD PID analysis.

In each event, the response of the particle, traveling through the detector's volume, was simulated. For each track, likelihood functions were calculated for each of three hypothesis (pions, kaons, protons). After all these functions have been calculated, the most plausible hypothesis is chosen and at the hadron beam structure have been reconstructed. Selection of hypotheses was performed by three different methods, namely:

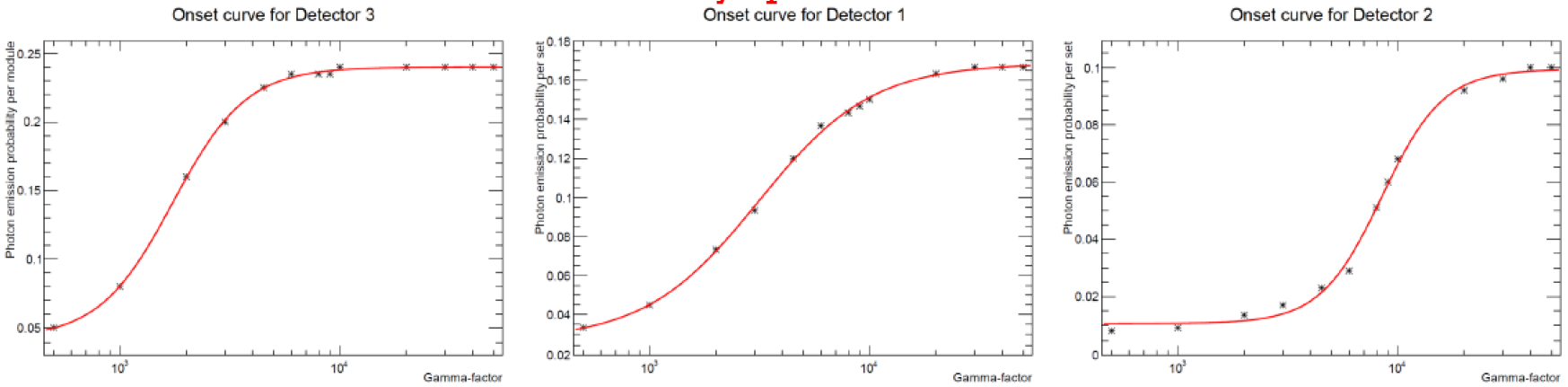
1. *LLH > 0.5.* In each event the most plausible hypothesis is the one, which have the value of the likelihood function greater than 0.5.
2. *LLH > 0.7.* The same algorithm as in previous case, but the value of the likelihood function was increased up to 0.7.
3. *Max LLH.* In each of the events considered to be the most probable hypothesis is that the value of the likelihood function for which more than two others.

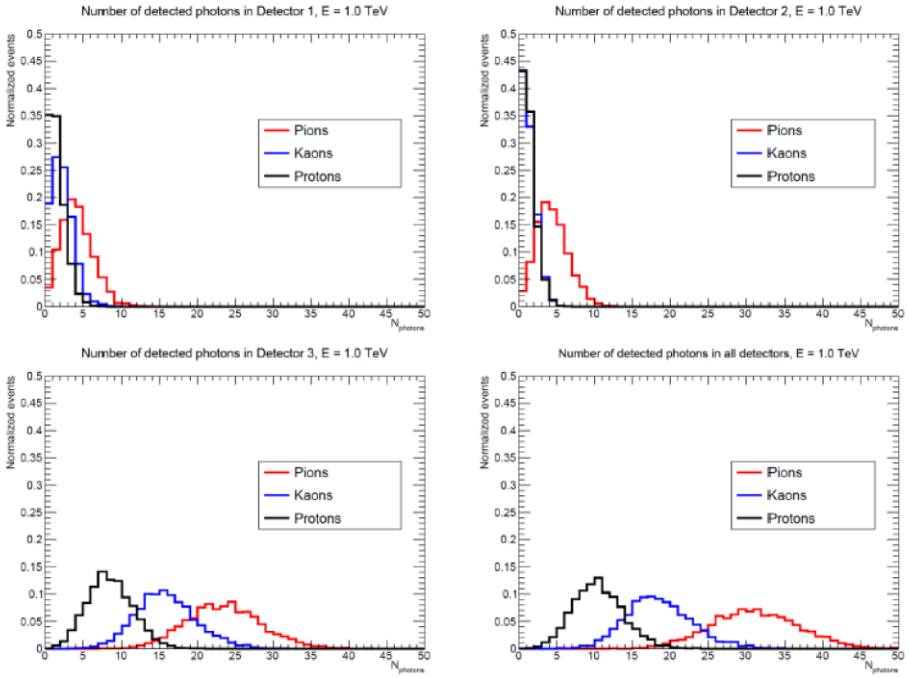
In this study the beam reconstruction efficiency was demonstrated for both Likelihood and Bayesian methods for difference beams configurations.

MONTE CARLO SIMULATION ALGORITHM

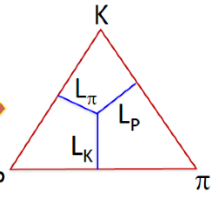
3 detectors: one TRT0type and two in one with Radiator type 1. 3.5 meters.

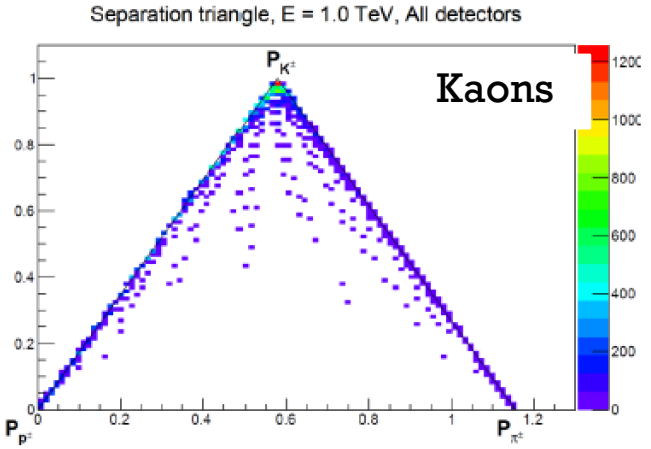
No any optimizations.





$L_\pi+L_P+L_K=1$

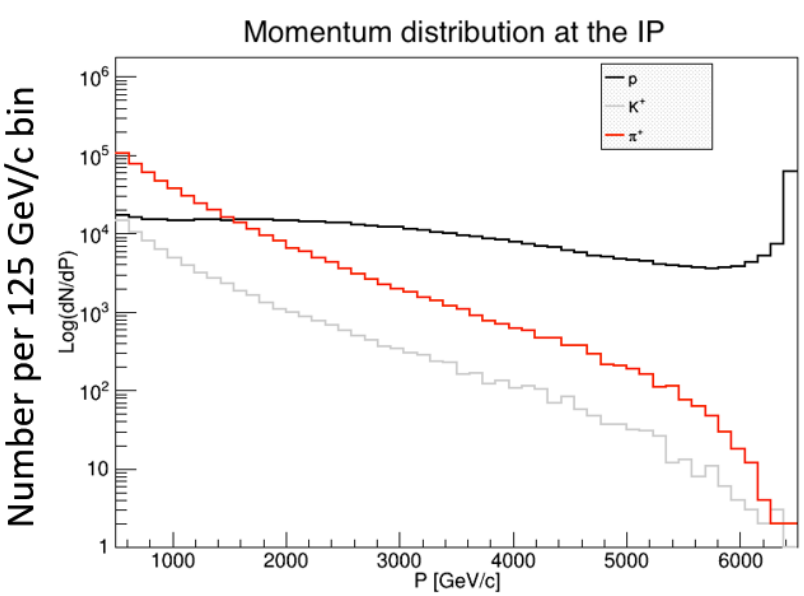




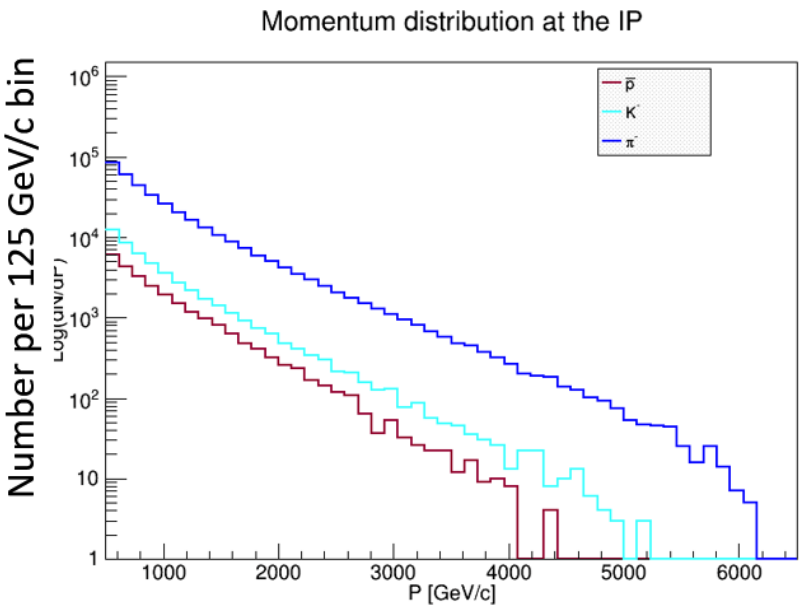
THE POSSIBLE HADRON SPECTRA

As far as one of the most important goals of the SAS experiments is the determine the hadron spectra, we should model more or less reasonable beam structure. For this purpose we can use preliminary simulation of positive and negative charged particles.

Distribution of positive charged particles



Distribution of negative charged particles



THE POSSIBLE HADRON SPECTRA

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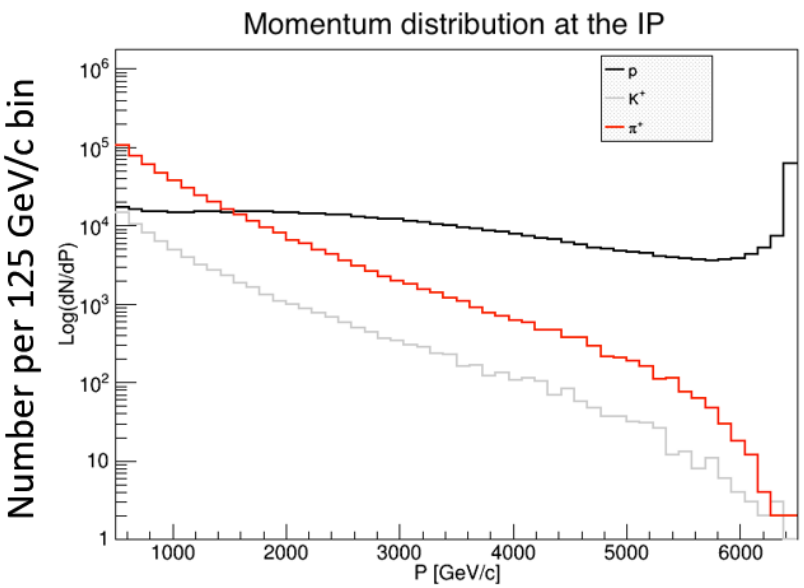
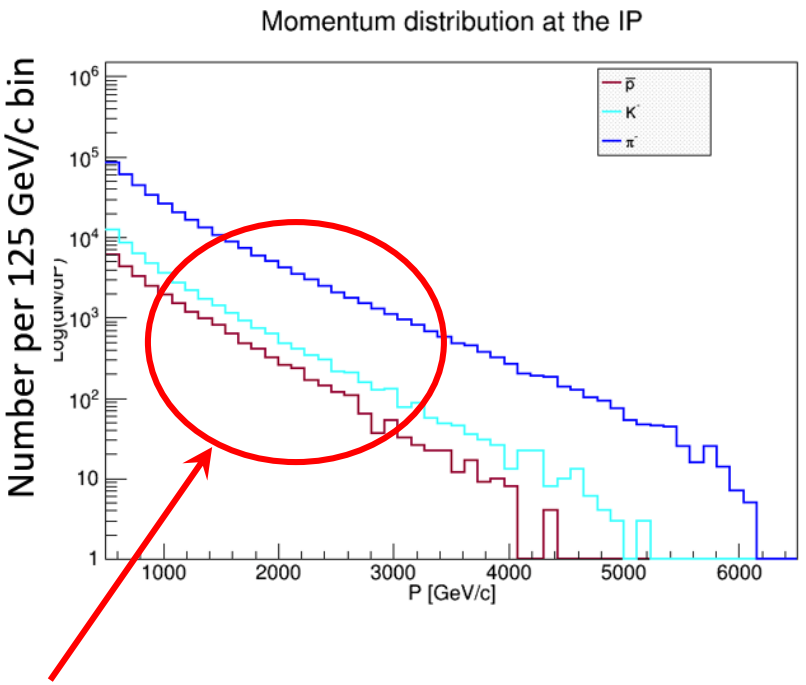
Distribution of positive charged particles

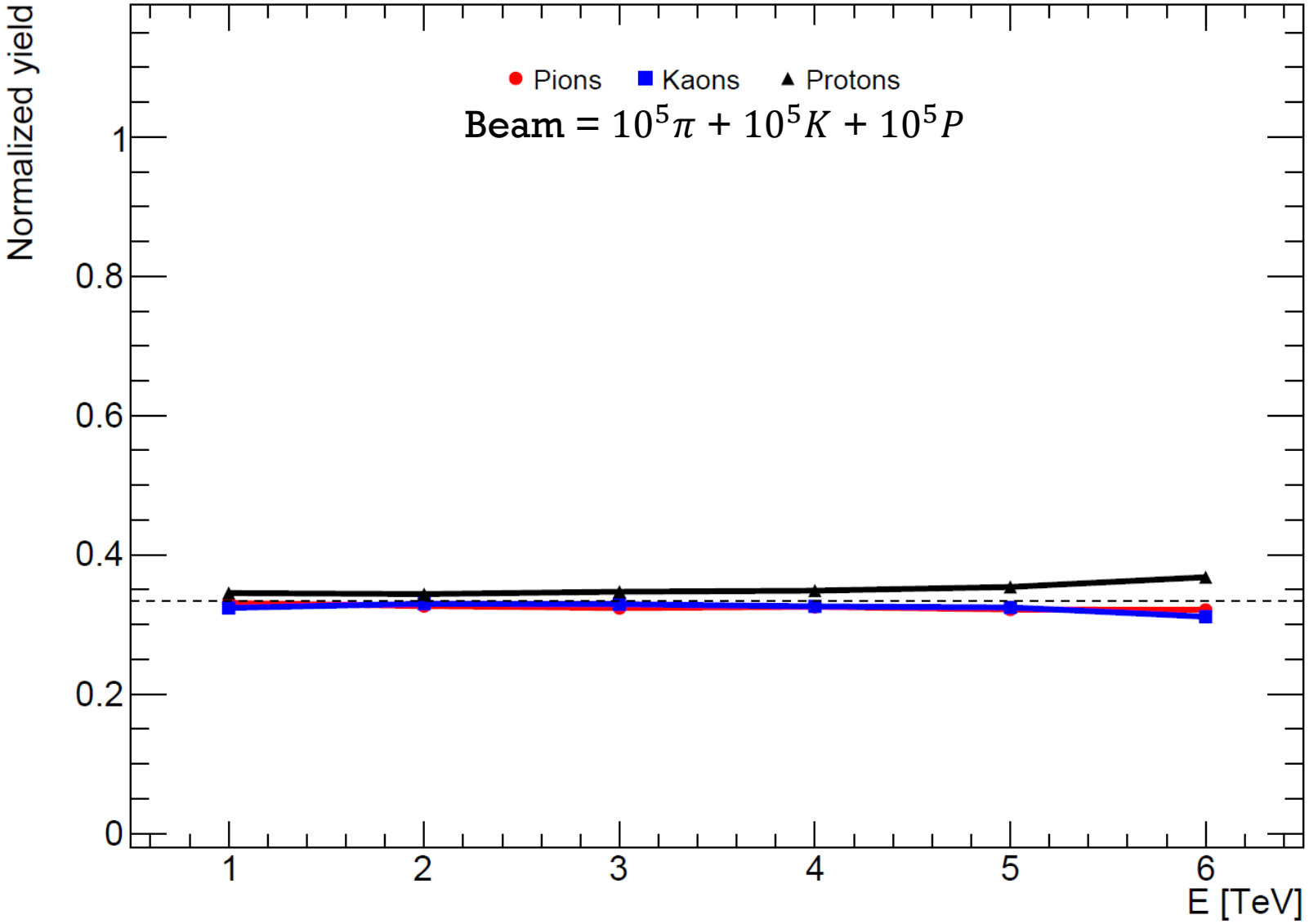


Distribution of negative charged particles

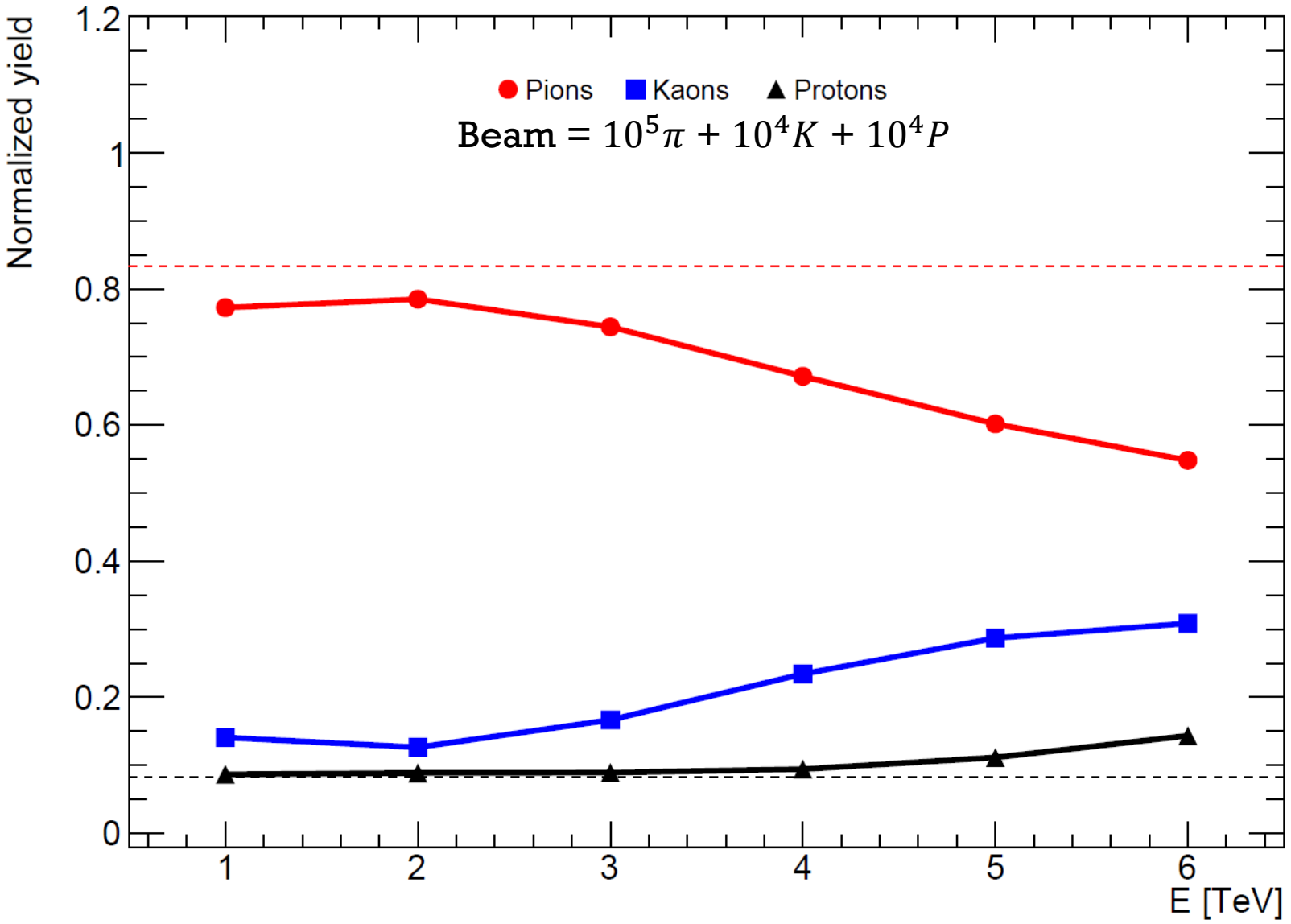


Fraction of antiparticles is more or less constant for the whole momentum region → would be nice configuration of the beam for the first look. Amount of pions inside the beam should be 10 times higher than both kaons and protons.

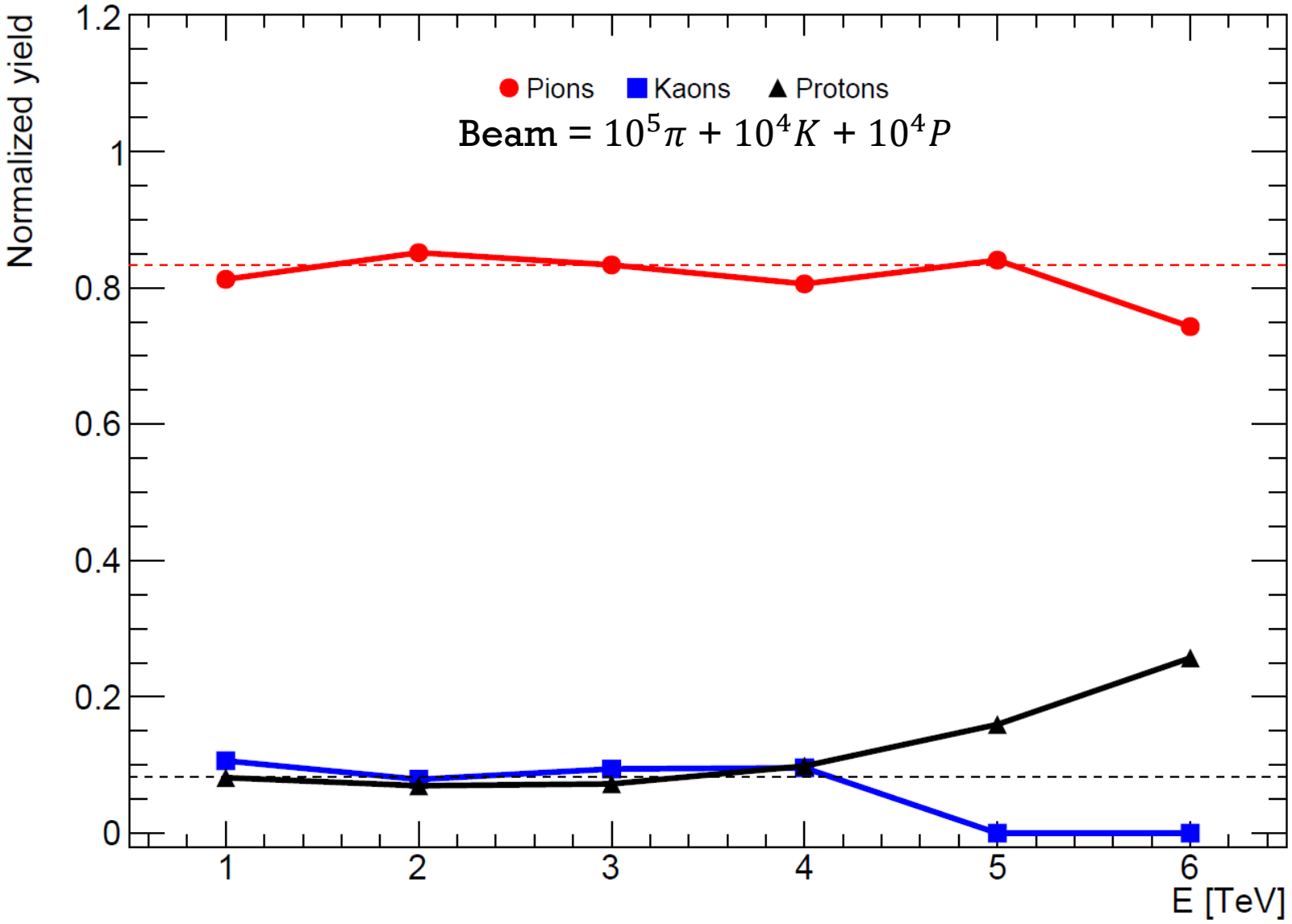
PID Efficiency (maximum LLH)



PID Efficiency (maximum LLH)



PID Efficiency (LLH > 0.7)



BAYESIAN APPROACH: IDEA AND PRELIMINARY RESULTS

One of the possibilities to increase the beam reconstruction efficiency is to use the Bayesian approach. This method is some kind of "modification" of the classical Likelihood approach studies at previous slides.

Let $\vec{S}$ be the signal left by the particle traveling through the detector's volume. H_i is the particle type hypothesis $(i = \pi, K, P)$. The main difference compared to the Likelihood method is that we are now interested in a probability of the signal be produced by the particle type H_i, while previously we were considering the probability that particle of type H_i will produce measured signal. The equation which connecting both probabilities can be written as following:

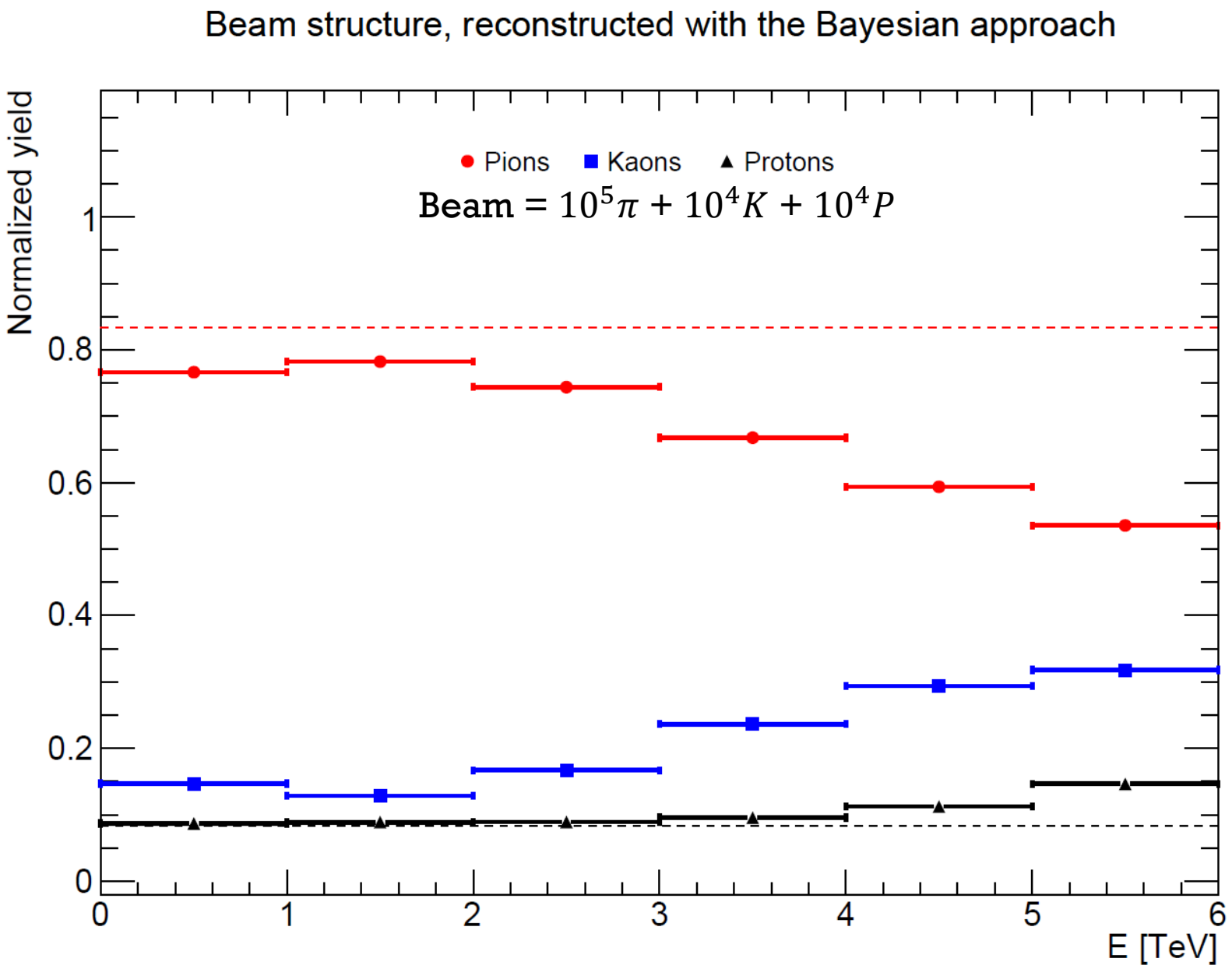
$$P(H_i|\vec{S}) = \frac{P(\vec{S}|H_i)C(H_i)}{\sum_{k=e,\mu,\pi,\ldots} P(\vec{S}|H_k)C(H_k)}, \quad (1)$$

where $P(\vec{S}|H_i)$ is normalized Likelihood ratio – probability that particle of type H_i will produce measured signal; $P(H_i|\vec{S})$ is the Bayesian probability; $C(H_i)$ – probability to fine the particle type H_i inside the beam (prior probabilities).

Priors $C(H_i)$ should be first determined by using the iterative procedure. As a first iteration are assuming that all priors are equal to one. Then we calculate the Bayesian probabilities according to equation (1) and using this normalized values as priors during the next iteration.

During this study such procedure was performed with 10 iterations, but this is a point to discuss during the future research.

After we obtain priors, we can use them to "correct" standard Likelihood values and then use one of the methods, described at slide (2) to reconstruct the beam structure.


Beam structure, reconstructed with the Bayesian approach
Pions
Kaons
Protons
Beam = $10^5\pi + 10^4K + 10^4P$
Normalized yield
0
0.2
0.4
0.6
0.8
1
0
1
2
3
4
5
6
E [TeV]

CONCLUSION

In this study we probed the hadron beam reconstruction efficiency of various beams configurations with both Likelihood and Bayesian methods.

By using the classical Likelihood approach we calculated beam reconstruction efficiencies for two beams configurations: one with the equal amount of particles of each type and the other one with the pion-dominant structure. The obtained results show that the most favorable method which is using for the beam reconstruction should be chosen based on the experimental condition and proposed spectra.

By using the Bayesian approach all of the likelihood values are used to model the spectra and obtained priors are pretty much the same as the Maximum LLH method.

For now, we can achieve impressive results and reconstruct the beam structure effectively, but these studies will definitely be continued and aimed on the optimization of the detector configuration and identification methods.

THANKS FOR YOUR ATTENTION!