Simulations of the inclined Čerenkov detectors for p-d separation in forward direction at ANKE

C. Leim

The forward detection system of ANKE is equipped with Čerenkov detectors for the separation between deuterons and protons in reactions like pp $\rightarrow$ dX, where X can be an (unobserved) meson, e.g. ω or a_0^+ [1]. To understand their behaviour and to optimize the setup, a simulation program in C++ was developed, based on a program used for simulation of the Čerenkov counters in the K$^-$-detection system of ANKE [2].

In the simulation, particles (p or d) are tracked from the target through the magnetic field of D2, thus giving realistic incident positions, momenta and angular distributions on the detector. The initial momenta of the particles at the target are obtained from a phase-space simulation of the reaction at different beam energies. Position, size and inclination angle of the detector can be chosen by the user as a free parameter. If any particle hits the detector with $\beta > \frac{1}{n}$, the resulting Čerenkov photons are placed randomly on a cone around the particle path with an opening angle $\cos\vartheta_{\check{C}} = \frac{1}{\beta n}$. The number of photons per unit path length depends on the particle's velocity via $\frac{N_{phot}}{cm} = 370 \cdot \sin^2\vartheta_{\check{C}}$ as the mean value of a Poisson-distribution. Every photon is tracked inside the material until it either reaches the photo multiplier (PM) or is lost. Photons reaching the PM are detected (and counted) with an efficiency of 20%. To obtain a more realistic detector response, several parameters were implemented:

- *Photon loss*: Due to surface impurities, photons may not be reflected at a detector surface even if the incident angle is larger than the total reflection angle. This probability has to be treated as a free parameter and is non-zero [3]. It was chosen to be 15% for each reflection, such that the resulting spectra have approx. the same peak height/FWHM-ratio as the experimental ones. The average number of reflections per photon is ≈10. . .15 (without photon loss). Photon loss in the material itself sums up to ≈2% only, because the attenuation length for lucite is ≈2m. This mechanism was also implemented.

- *Variation of angle*: Due to surface impurities, the angle of a photon trajectory relative to the surface may change locally. This is simulated by a random change: $\Delta\delta\epsilon[-1°; 1°]$, using a Gaussian around 0°, cut at ±1°. This value was estimated from experimental data [3]. This mechanism shifts the spectra to smaller amplitudes and reduces the FWHM, but causes smaller effects than the photon loss probability.

- *Minimal path length*: To avoid edge effects, only particles with path lengths >5cm are accepted. In the analysis of the experimental data [4] a different criterion was applied: only hits on the front side with a distance of 1.5 cm and 0.4 cm from the vertical and horizontal edges, respectively, were accepted. In principle, both methods are equivalent and the latter will alternatively be implemented.

The resulting spectra are shown in fig.1 (solid line) and are similar to the experimental distribution (dashed line). The measured data, however, show a tail of low-rate signals starting from channel zero, which cannot be found in the simulation. The reason for that may be a wrong value for the photon loss probability or a too optimistic value for the PM efficiency.

The spectra differ from those of an ideal Čerenkov detector, which is simulated with all parameters mentioned above set to zero. It that case (dot-dashed line in fig. 1), the peak is shifted towards larger amplitudes. The tail at the low-amplitude side of the peak is caused by events with path lengths <5cm.

Future plans involve examination of polarization effects (which might yield an explanation of the empirical photon loss parameter) and small-angle scattering in the detectors in front of the Č-counters (which might cause the low-signal tail). The response for deuterons (which should be close to zero) and other beam enenergies and parameters (in particular the inclination angles) will also be investigated.

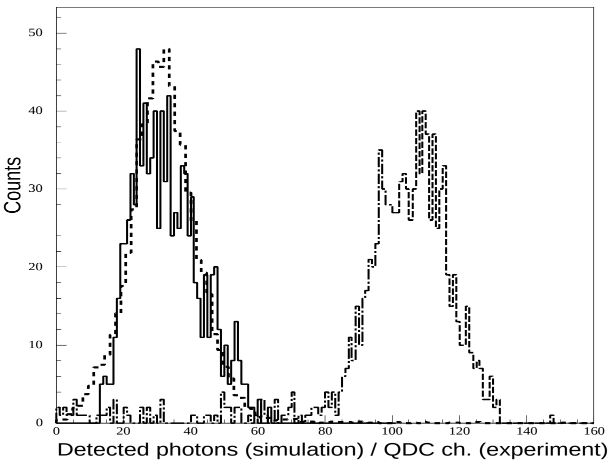

Figure 1: Simulated and measured detector response: protons at a beam energy of 2000 MeV for an inclined detector (angle: 10°). The solid histogram shows a realistic simulation with all effects switched on (see text), whereas the dot-dashed histogram is obtained with all parameters set to zero. The experimental results are shown in the dashed histogram.

References:

[1] V.Kleber et al., contribution to this report

[2] H.R.Koch et al., IKP annual report 1999, p.28

[3] M.Hennebach: Untersuchungen zum Einsatz von Čerenkovzählern mit Totalreflektion für die Teilchenidentifikation an ANKE, Diploma thesis Univ. Köln, Dec. 1999

[4] G.Macharashvili et al., contribution to this report