Dependence between drift velocity and air humidity in the COSY-11 drift chambers

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Replacing the mechanical instable needle valves by mass flow controllers in the gas mixing system of the COSY-11 drift chambers [1] a few years ago ensured a proper 50–50 Argon–Ethan gas mixture and thus reduced the time dependent variation of the drift velocity significantly. Still, not neglectable variations over the duration of a typical run exist.
To find the reason for these fluctuations a mechanical thermo-hygrograph was installed inside the COSY tunnel in the vicinity of the drift chambers during several beamtimes. The curves written on paper sheets showed that the temperature of the air surrounding the drift chambers is rather constant within 5 % due to the various power supplies installed there which do continuous heating. The relative humidity of the air surrounding the chambers, however, varies over 15 % as can be seen in the upper part of figure 1.
For further investigation, the mechanically recorded data were digitized by scanning the charts, identifying all the pixels belonging to the written curve, and correcting for the non-linearity of the mechanical measuring system.
A small data analysis program was written, which mainly does a simple drift time calibration using the normal COSY-11 data sets recorded during beam time. The spectrum, which is created by filling a histogram with all TDC values taken for a specific drift cell during one run, shows a somehow trapezoidal shape [1]. Its width at half maximum corresponds to the distance between the sense wire and the edge of the drift cell and is therefore a measure for the drift velocity. For each run, the mean value of the drift velocities of all cells was calculated. As an example these measured drift velocities are shown in figure 1 for the data taken in May 1999.
It is obvious that the variations of the drift velocity reflect themselves in the shape of the air humidity curve — but inverted, and somehow scaled and shifted. One can assume that water mulecules diffusing through the large (140×20 cm^2) and 0.02 mm thick Kapton windows into the chambers reduce the drift velocity, a fact, that has already been studied by the DELPHI collaboration [2].
To extract the relation between humidity and drift velocity, the mean value of the humidity averaged over the measurement time of each experimental run (about 3 hours) was calculated, which resulted in two data sets with the same time base.
A linear relation was assumed to calculate the drift velocity (v) as a function of the relative air humidity (h):

$$v(h) = a \times h + b \tag{1}$$

Fitting this function to the data resulted in $a = -0.237$ and $b = 57.916$. The calculated and the measured drift velocities are shown in the center part of figure 1.
The difference between the measured and the calculated drift velocity shows clearly, that taking the relative air humidity into account minimises the uncertainty caused by fluctuations of the drift velocity by a factor of 3. The variation of ±1.5 mm/μs is reduced to ±0.5 mm/μs thus making an online data analysis possible without the need of time consuming calibrations to be done in advance.

References:

[1] B.Gugulski et al., KFA-IKP(I)-1992-3;
[2] A.Cattai et al., DELPHI 89-63;

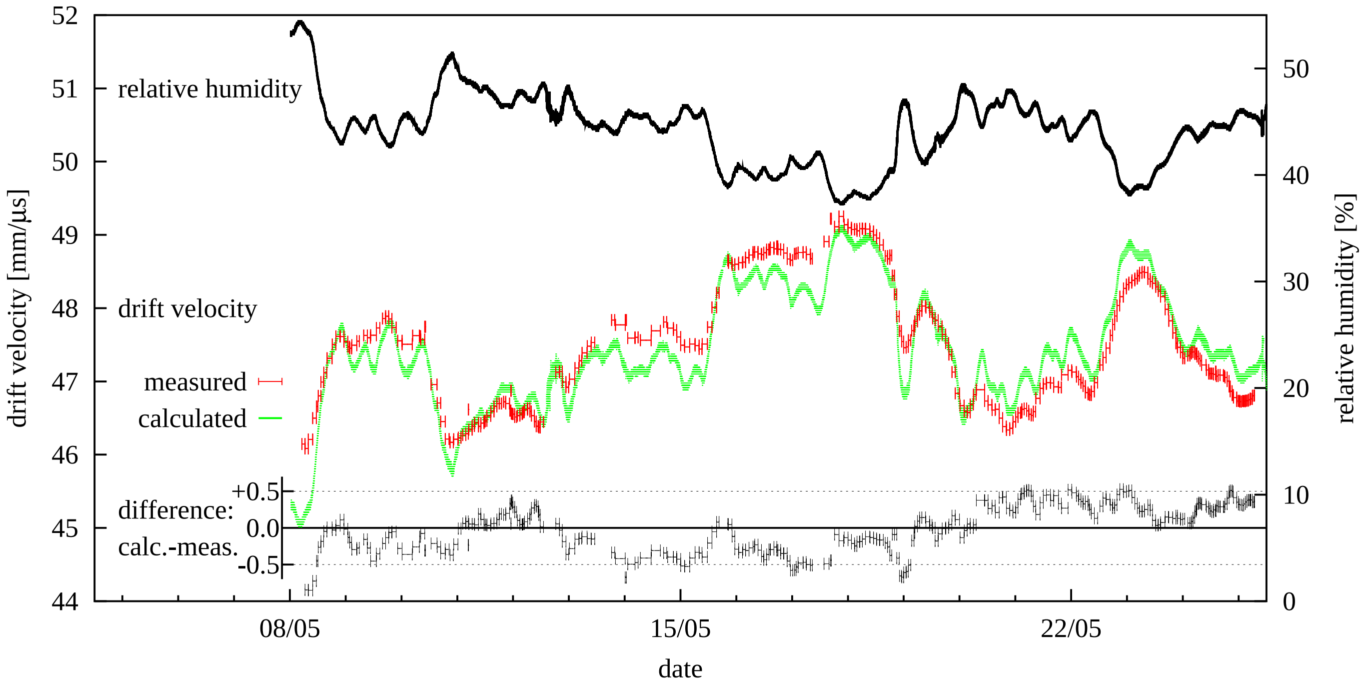

Fig. 1: upper part: relative air humidity measured with a thermo-hygrograph; center part: measured drift velocity, and calculated drift velocity according to eq. 1; lower part: the difference $v(h) - v_{measured}$