Homework (Lecture2)

1. We measured the thickness of 200 sheets of paper (T) and got the result: $T = 3.3 \pm 0.1$ cm

1a) What is the thickness of a single sheet and its uncertainty?

1b) What is the advantage of using this technique over a thickness measurement of a single sheet?

2. Consider:

$$x = \frac{1}{2}(a + 2b)$$

$$y = \frac{1}{2}(a - 2b)$$

Assuming $\sigma_a > \sigma_b$ and $\rho_{ab}=-0.5$, calculate σ_x and σ_y and cov(x,y) (i.e U matrix elements) using:

3a) $$U_{kl} = \text{cov}[y_k, y_l] \approx \sum_{i,j=1}^{n} \left[\frac{\partial y_k}{\partial x_i}\frac{\partial y_l}{\partial x_j}\right]_{\vec{x}=\vec{\mu}} V_{ij}$$

3b) matrix algebra:

$$U = AVA^T \,, \quad \text{where} \quad A_{ij} = \left[\frac{\partial y_i}{\partial x_j}\right]_{\vec{x}=\vec{\mu}}$$

A^T = transpose of A

3. To check the activity of radioactive sample, an inspector places the sample in a liquid scintillation counter to count the number of decays in a 2-minute interval and obtains 33 counts.

3a) What should he report as the number of decays produced by the sample in 2 minutes?

3b) What should he report as the decay rate [Hz]?

Suppose, instead he had monitored the same sample for 50 minutes and obtained 907 counts. What would be his answer for the number of decays in 50 minutes? What would be his answer for the decay rate [Hz]?

Find the percent uncertainties in these two measurements (σ_r/r) and comment on usefulness of counting for a longer period.

4. Consider an experiment such as the measurement of the length of the table. The results are: 15.62, 15.61, 15.61, 15.62, 15.62, 15.615,15.625,15.61,15.62, 15.62,15.605, 15.61. What is the best estimate (and its uncertainty) for the length of this object?

5. Consider the following process: $p + p^{\uparrow(\downarrow)} \rightarrow \pi^0 + X$

Let $N_{\uparrow}(N_{\downarrow})$ be the number of events when protons are transversely polarized and have spin up (down) and R is the relative beam luminosity:

$$R = \frac{L_{\uparrow}}{L_{\downarrow}}$$

We measured: $N_{\uparrow} = 1000$, $N_{\downarrow} = 780$ and $R = 1.100 \pm 0.005$.

The measured asymmetry ε is given by:

$$\varepsilon = \frac{N_{\uparrow} - R \times N_{\downarrow}}{N_{\uparrow} + R \times N_{\downarrow}}$$

Determine the analyzing power A_N for this process (and its uncertainty) using:

$$A_N = \frac{\varepsilon}{P_{beam}}$$

for the known (measured) beam polarization: $P_{beam} = 0.50 \pm 0.05$