A. Introduction

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Statistical and numerical methods of data analysis

- Current physics experiments take data at a high rate: many Mbytes per second over a long period of time
- The essential result may be a single number, or a limit
- Statistical and numerical methods are needed in order to extract meaningful information from experimental data.

Examples for new data from HEP

Amplitude of the CP-violating asymmetry:

$$\begin{aligned} \sin 2\beta &= 0.34 \pm 0.20(\mathrm{stat}) \pm 0.05(\mathrm{syst}) && \text{BABAR} \\ \sin 2\beta &= 0.58^{+0.32\,+0.09}_{-0.34\,-0.10} && \text{BELLE} \end{aligned}$$

Measurement of the anomalous g value, $a_\mu = (g-2)/2$, for the positive muon:

$$a_{\mu^+} = 11\ 659\ 202(14)(6) \times 10^{-10}\ (1.3\ \mathrm{ppm}) \qquad \text{BNL}$$

Difference between the weighted experimental result and the theoretical value from the standard model corresponds to 2.6 times the error.

Example: neutrino mass

Data (1996) on the electron-neutrino mass m_ν from tritium β decay

Experiment	m_ν^2	(eV^2)	m_ν 95 % C.L. limit
Tokyo	-65	$\pm 85 \pm 65$	< 13.0 eV
Los Alamos	-147	$\pm 68 \pm 41$	< 9.3 eV
Zürich	-24	$\pm 48 \pm 61$	< 11.7 eV
Mainz	-39	$\pm 34 \pm 15$	< 7.2 eV
Livermore (LLNL)	-130	$\pm 20 \pm 15$	< 7.0 eV
Moskau (INR)	-22	± 4.8	< 4.4 eV

First error of m_ν^2 is statistical, second systematic. Upper limits for the neutrino mass are calculated using a certain method for 95 % confidence level.

PDG 2000: $m_\nu < 3$eV   Interpretation of tritium β decay is complicated by anomalies near the endpoint ("unknown effects cause an accumulation of events near the endpoint of the electron spectrum"), and the limits are not without ambiguity.

Example: Number of light neutrinos

Mark II collaboration at SLAC (1989): analysis which assumed Standard Model couplings but which fit for the Z mass and the number of neutrinos N_ν with result:

$$N_\nu = 2.8 \pm 0.6$$

95 % C.L. limit $N_\nu < 3.9$ excludes fourth massless neutrino

- Existence of at least three types on neutrinos was well established
- Ability to exclude $N_\nu = 4$ in this experiment due to downward fluctuation of measured N_ν from 3 to 2.8

PDG 2000: $N_\nu = 2.994 \pm 0.012$ from Standard Model fits to LEP data.

Literature

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