Uncertainties: Bayesian vs. Frequentist

Students
• Fabrizio Rompineve, Alessandra Baas, Mathis Kolb, Anja Butter

General
• Studied main properties of Bayesian and Frequentist approach e.g. different definition of probability and according advantages and disadvantages

Definition of probability
• Frequentist:
  ○ Probability is defined in terms of a large number of identical, independent trials $N$ as the limit ratio $s/N$, where $s$ states how often something happened
  ○ Uses $pdf$ for data, for fixed parameter values
• Bayesian:
  ○ Probability as a personal degree of belief
  ○ Bayes Theorem
    ▪ Conditional Probability: $P(A|B)$ probability of $A$, given that $B$ has happened
    ▪ $P(A|B) = P(B|A) P(A) / P(B) \rightarrow$ posterior probability distribution

Hypothesis testing
• Frequentist approach based on $p$-value and or likelihood ratio
• Basic concept studied with simple counting experiment
• Look Elsewhere Effect leads to dilution of significance
• Investigation of CIs method with frequentist terminology
• Bayesian approach more naturally suited for making statements about degree of believe about two hypothesis in the light of data
• Complication: nuisance parameters require integration and need of prior for these

Review
• Clarification of basic terminology
• Deeper understanding of approximate methods in context of bayesian and frequentist approach
• Recapitulated use of $p$-values in context of a search analysis; problems arising from treatment of systematics
• Follow-up: Investigate in full detail an example of hypothesis testing in Bayesian case; Intensify understanding of application possibilities of approximate methods in context of coverage or goodness of fit test; Further studies on treatment of Look Elsewhere effect in modern analysis

References
• Feldman, Cousins: A Unified Approach to the Classical Statistical Analysis of Small Signals
• Louis Lyons: BAYES AND FREQUENTISM: A PARTICLE PHYSICIST'S PERSPECTIVE
• A.L. Read, Modified frequentist analysis of search results