EXP5-Analyse von Z0-Zerfällen

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FPrak: Review Day

Universität Hamburg
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CLUSTER OF EXCELLENCE
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Scientific content

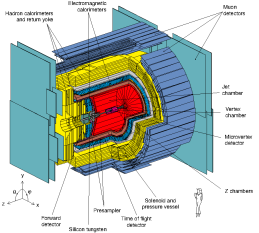
- Measurement of several physical parameters using the data and simulations from the e^+e^--collisions with center of mass energies near the Z0-mass from the OPAL experiment at LEP.
- Parameters measured:
  - Cross sections of the Z0 decay channels.
  - Z0-mass and width.
  - Partial widths of the Z0 decay channels.
  - Weinberg angle (often not enough time in presentations).
  - Number of light neutrino generations.
- Program:
  - First part: Analysis and discussion of event displays of the different decay channels of Z0, creation of selection criteria.
  - Second part: Analysis of Monte Carlo samples to improve the selection criteria and calculate the efficiencies of the selections.
  - Third part: Apply the selection to a dataset and calculate all physical parameters through formula and fit.

Aim of the experiment

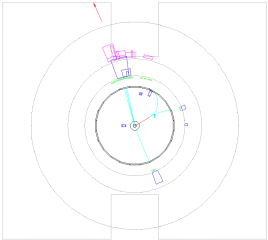
- Better understanding of the experimental methods used in modern particle physics, from detectors to parameter estimation with uncertainties.
  - Overall knowledge of detectors used in colliders and the applications of the subdetectors.
  - Understanding the meaning of the various occuring uncertainties, which one is is a statistical uncertainty, which one is a systematic uncertainty.
  - Application of a programming language (Python) to an actual analysis.

Experimental setup

- No hands-on experience possible, as the experiment closed in 2000.
- Discussion of the detector setup and reasons for the choices (e.g. Why are different subdetectors used?).



- Application on event displays to learn the physics of the processes occuring in the detector.
- Use of the event displays to define selection criteria for the different particles from the Z0 decay.



Data analysis method

- First part: Analysis of event displays in software GROPE (old, needs virtual box for Ubuntu 14), plotting using matplotlib, creation of selection criteria.
- Second part: Analysis on Monte Carlo samples with matplotlib and Jupyter Notebooks (templates with data structures like dictionaries). Evaluation of the selection results and efficiencies in numpy.
- Third part: Application of the selection criteria on data samples, correction through efficiencies. Calculation of the various physical parameters with corresponding statistical and systematic uncertainties with numpy. Fit of the Z0 Breit-Wigner resonance peak with scipy.
- Also mit pandas possible, but requires a new library (again).

Key scientific results and their relevance, link to modern research

- All physics parameters estimated can be used to test the Standard Model of particle physics. Especially number of neutrino generations very easily understood.
- Same analysis methods used in more recent analyses, e.g. search for Higgs boson or its parameters. Several other searches for new particles over resonances. Particular topics of interest in different subgroups of our group.
- Lower number of events $\rightarrow$ less precise results than LEP analysis, else same data.
- Higgs research $\rightarrow$ also one of the pillars of the cluster.
- Jupyter Notebooks also used in current research.

Student feedback

- Duration ok.
- Physics knowledge needed mostly ok.
- Python knowledge required a bit low before the experiment for some.

Overall complexity

- Duration: 3-4 days average.
- Protocol: around 30 pages with exercises.
- Rating of the complexity from 1 (high) to 5 (low):

Theory/preparation	Setup/experimental	Data taking	Analysis	Protocol
2	5	5	1	2