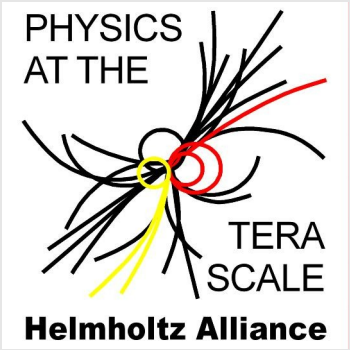
A short introduction to the BAT hypothesis testing and model comparison tutorial



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Outline:
- Hypothesis testing
- Model compoarison
- Physics motivation
- The tutorial
- Documentation

Hypothesis testing

Aim:

Judge if a hypothesis is true or not. In particular answer the question: a fit may return numbers, but is the fit reasonable?

Common hypothesis tests:

- *χ^2-test*
  - sum of differences (data, prediction) squared
  - depends on the number of degrees of freedom
  - assume Gaussian distribution of uncertainties

- *Kolmogorov-Smirnov test:*
  - compare cumulative distribution with prediction

- *p-value*
  - test how likely the observed data is given the best-fit parameters
  - different definitions on the market

Model comparison

Aim:

Directly compare two models. Does not judge the goodness of fit.

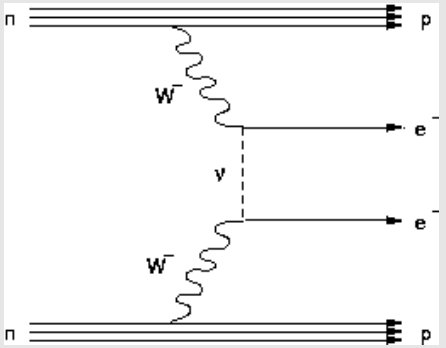
Common ways to compare models:

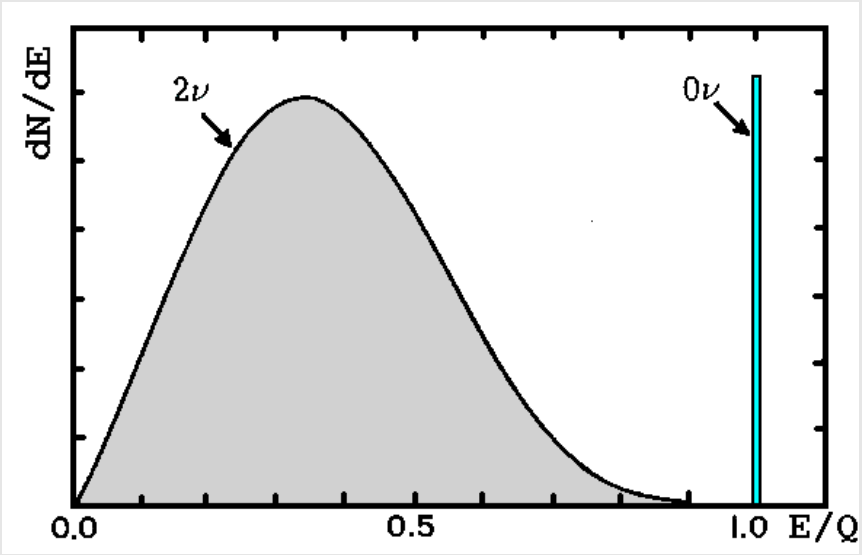
- *χ^2-test*
  - use the χ^2-probability
- *Maximum Likelihood*
  - compare the maximum Likelihood found in the fit
- *Posterior probability of the models*
  - integrate over all parameters
  - Occam‘s razor
- *Bayes factors:*
  - use ratio of posterior probabilities of the models

Neutrinoless double beta-decay

Neutrinoless double beta-decay:

- Rare, second order weak process
- Only possible if neutrino is its own anti-particle
- Observed rate can give a hint on the mass of the neutrino
- *Good:* know exact shape of the signal
- *Not so good:* very small rate
- *Bad:* dominated by background from natural radioactivity.
- *‚Low-background experiment‘*





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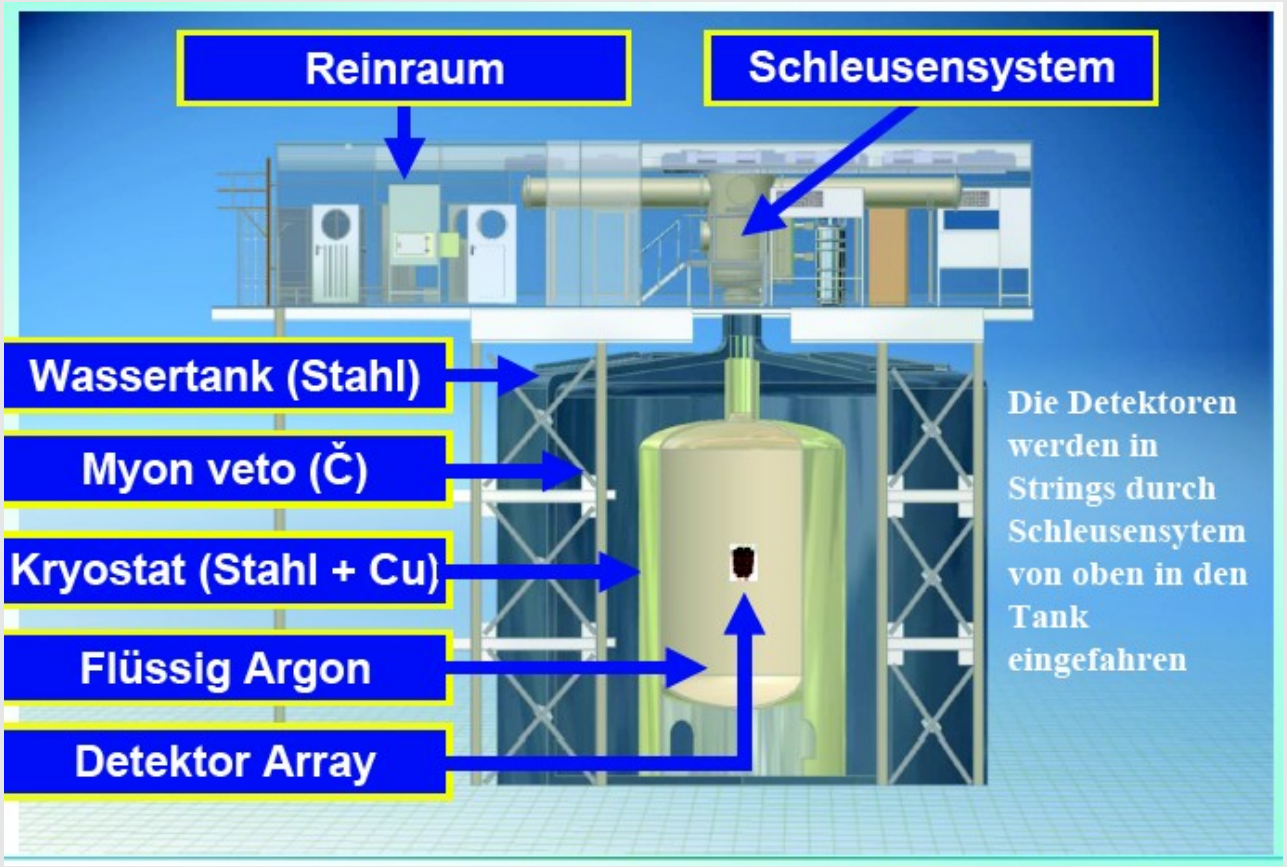
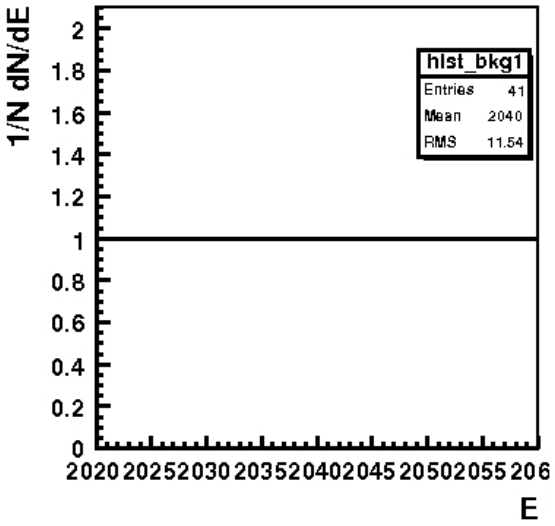
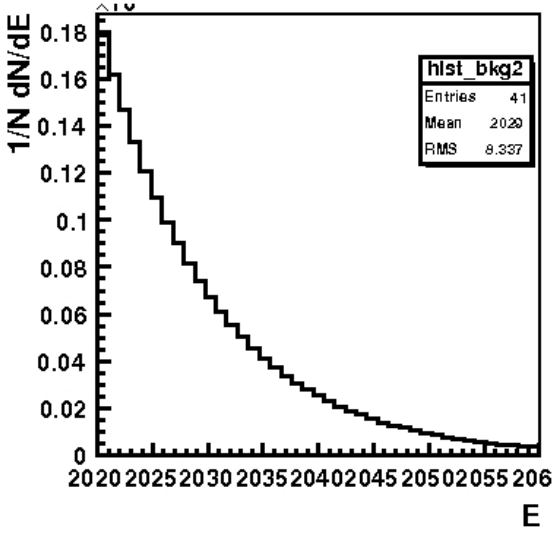

Reinraum
Schleusensystem
Wassertank (Stahl)
Myon veto (Č)
Kryostat (Stahl + Cu)
Flüssig Argon
Detektor Array
Die Detektoren werden in Strings durch Schleusensytem von oben in den Tank eingefahren

Expected contributions to data

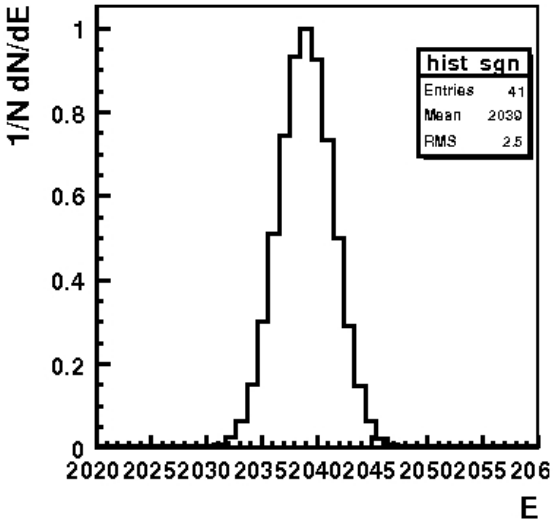
Background shape 1

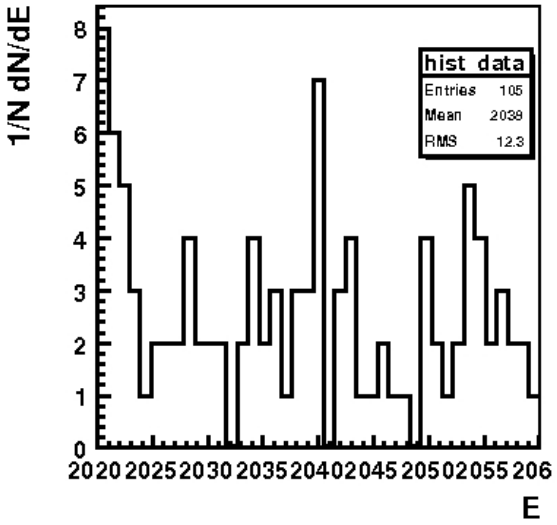




Background shape 2

Signal shape





Example for data set

A tutorial on hypothesis testing

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http://www.mppmu.mpg.de/bat/?page=tutorials&name=hypothesis_

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BAT

Bayesian Analysis Toolkit

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Signal search in the presence of background - a BAT tutorial

Physics motivation

The search for a weak signal in the presence of background is a common situation in particle physics. In part background level reached by experiments. In this case, the signal process - if present - would cause a sharp li the experiments. The expected number of signal and background events can reach a level of the order of 10 in bin. Approximations valid for large statistics do not apply in this case.

Tutorial

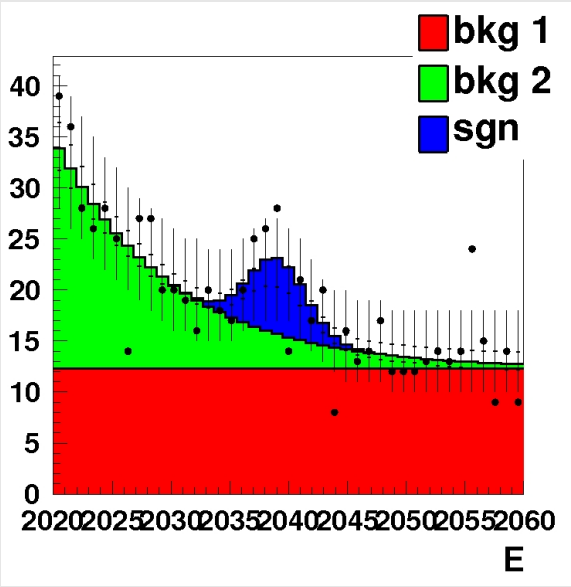
This tutorial shows how to judge the validity of models and how to compare those models. Different goodness- following: the data is assumed to be composed of events from different contributions, e.g., various background are assumed to be known and stacked on top of each other. A binned Likelihood fit, assuming independ distributions, or templates. The scale factors of the contributions are the parameters of the model and named *N*

The tutorial is split into six steps:

- Step 1 - Reading in the data
- Step 2 - Fitting a background-only model
- Step 3 - Introduction to the goodness-of-fit tests
- Step 4 - Goodness-o
- Step 5 - Comparing
- Step 6 - Testing more

Step 1 - Getting starte

Done



Tutorial is available here:
http://www.mppmu.mpg.de/bat/?page=tutorials

Documentation

Documentation:

- A. Caldwell, D. Kollar, K. Kröninger,
  BAT – The Bayesian analysis toolkit,
  Comp. Phys. Comm. **180** (2009) 2197 [arXiv:0808.2552]
- BAT webpage:
  http://www.mppmu.mpg.de/bat/
- Introduction to BAT:
  http://www.mppmu.mpg.de/bat/?page=documentation
- Talks on BAT:
  http://www.mppmu.mpg.de/bat/?page=meetings
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