RooStats Exercises

Getting Started

- all RooStats classes are in a namespace
- recommended to add at beginning of macro:
  - using namespace RooStats
- this will also load automatically the RooStats library
- note that RooStats methods start with upper case letter while RooFit start with lower case
- RooStats calculator are quite verbose, useful to suppress many info messages"

```
RooMsgService::instance().setGlobalKillBelow(RooFit::WARNING) ;
```

Roostats reference guide:

http://root.cern.ch/root/htmldoc/ROOSTATS_Index.html

RooStats tutorial macros:

http://root.cern.ch/root/html/tutorials/roostats

RooStats Exercises (1)

- Exercise 1
  - Start familiarize with creating models and workspaces
    - make workspace with a Gaussian model
    - generate 100 events random data set
    - import data set in workspace
    - create ModelConfig class (→ slide 11)
    - import ModelConfig in workspace
    - save workspace in a file

RooStats Exercises (2)

- Exercise 2:
  - Run Profile Likelihood Calculator reading workspace from the file
    - create class passing data, ModelConfig and parameter of interest (→ slide 14)
    - compute the 68% CL interval (using GetInterval)
    - look at upper/lower limit
    - plot the interval using the LikelihoodIntervalPlot class
      - suggestion: can customize plot range using plot.SetRange(xmin,xmax)

RooStats Exercises (3)

- Exercise 3:
  - make now a Poisson model (counting experiment)
    - Poisson (nobs | mu);
  - do as in Exercise 1 and save the workspace in a ROOT file
    - NB: make dataset with only one event.
    - Suggestion: do not use RooAbsPdf::generate but just add one event in data set
      - create RooDataSet using the constructor
      - set nobs value (w.var("nobs")->setVal(3))
        - use nobs = 3 since we can compare results
      - use RooDataSet::add
  - Run ProfileLikelihood calculator and obtain a 68% interval result

RooStats Exercises (4)

- Exercise 4:
  - Run the BayesianCalculator on the simple Poisson model (nobs = 3) (→ slide 16)
  - Create a uniform prior which needs to be added in the model
    - Compute the 68% central and shortest interval and 95% upper limit
      - compare results with Cousins paper
    - use 1/s or 1/sqrt(s) prior on the signal and compute again lower/limit
    - plot also result
- suggestion: use a non-zero value for the minimum range of the parameter (w.var("s")->setMin(1.E-6);

Solutions

- Make Gaussian model: GaussianModel.C
- Make Poisson model: PoissonModel.C
- Likelihood interval: LikelihoodIntervalDemo.C
- Bayesian interval: BayesianNumericalDemo.C
- Poisson model results for nobs = 3 (no background)

Table I. 68% C.L. confidence intervals (μ_1,μ_2) for the mean of a Poisson distribution, based on the single observation $n_0=3$, calculated by various methods.

Method	Prior	Defining equation(s)	Interval	Length	Coverage?
Root-mean-square deviation	···	$n_0 \pm \sqrt{n_0}$	(1.27, 4.73)	3.46	no
Classical central	···	Eqs. (6) and (7)	(1.37, 5.92)	4.55	yes
Classical shortest	···	Method of Crow and Gardner[a]	(1.29, 5.25)	3.96	yes
Likelihood ratio	···	Eq. (9)	(1.58, 5.08)	3.50	no
Bayesian central	1	Eqs. (16) and (17)	(2.09, 5.92)	3.83	no
Bayesian shortest	1	Eq. (16); minimum $\mu_2-\mu_1$	(1.55, 5.15)	3.60	no
Bayesian equal ±	1	Eq. (16); $\hat{\mu}-\mu_1=\mu_2-\hat{\mu}$	(1.15, 4.85)	3.70	no
Bayesian central	$1/\mu_t$	Eqs. (16) and (17)	(1.37, 4.64)	3.27	no
Bayesian shortest	$1/\mu_t$	Eq. (16); minimum $\mu_2-\mu_1$	(0.86, 3.85)	2.99	no
Bayesian equal ±	$1/\mu_t$	Eq. (16); $\hat{\mu}-\mu_1=\mu_2-\hat{\mu}$	(1.36, 4.63)	3.27	no

[a]Reference 31.

from

Why isn't every physicist a Bayesian?

Robert D. Cousins

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RooStats Exercises (5)

- Exercise 5:
  - Add to the Poisson model a background with a Gaussian constraint
    - Poisson(nobs | s + b) Gauss(b | b_0, $sigma_b$)
  - optional: try to use also a Gamma constraint
  - obtain 68% interval (or 95% limit) for ProfileLikelihood and BayesianCalculator with a uniform prior
  - use also Bayesian MCMC calculator to get interval
  - optional: add also systematics (additional nuisance parameter) in the signal rate (efficiency)

Exercise 6

- Exercise 6:
  - Use exponential falling background model plus a gaussian peak made for previous RooFit exercise
  - Obtain interval or limit using the Bayesian MCMCalculator on number of signal events (→ slide 90)
  - Let the mass also vary in the model
    - make the 68% contour of Ns vs mass using MCMC
    - use also Profile likelihood calculator and obtain contour
      - compare the two obtained results

Solutions (2)

- Make Poisson with background model: PoissonModelWithBackg.C
- intervals :
  - ProfileLikelihoodDemo.C
    BayesianNumericalDemo.C
    BayesianMCMCDemo.C
    - these are similar to RooStats tutorials
    - StandardXXDemo.C (e.g. StandardProfileLikelihoodDemo.C)
      - in this case one needs to give also workspace, ModelConfig and data set name
- Signal plus exponential background model:
  - SPlusBExpoModel.C
  - run MCMC using BayesianMCMCDemo.C