(Exercises - day 2)

Todays exercises

ex9 – ML estimators

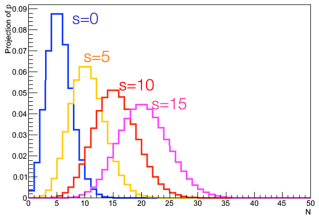
'ex09.C'

Example of Maximum Likelihood estimation

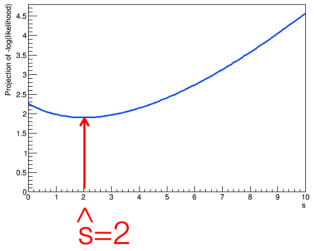
- Illustration of ML estimate on Poisson counting model

$$L(N \mid s) = Poisson(N \mid s + \tilde{b})$$

-log $L(N|s)$ versus N [s=0,5,10,15]



-log $L(N|s)$ versus s [N=7]



- Note that Poisson model is discrete in N, *but continuous in s!*

ex10 – Interval calculators

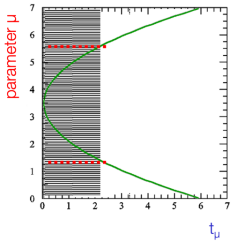
'ex10_roostats_plr_interval.C'

Connection with likelihood ratio intervals

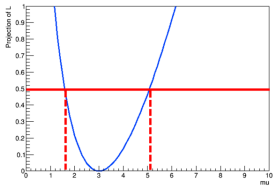
- If you assume the asymptotic distribution for t_μ,
  - Then the confidence belt is exactly a box
  - And the constructed confidence interval can be simplified to finding the range in μ where $t_\mu = ½ \cdot Z^2$

→ **This is exactly the MINOS error**

FC interval with Wilks Theorem



MINOS / Likelihood ratio interval

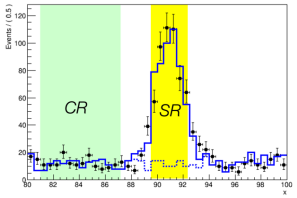


ex11 – Poisson Sidebands

'ex11_build_PoissonPoisson.C'

The sideband measurement

- Suppose your data in reality looks like this →



Can estimate level of background in the 'signal region' from event count in a 'control region' elsewhere in phase space

$$L_{SR}(s,b) = Poisson(N_{SR} \mid s + b)$$

NB: Define parameter 'b' to represents the amount of bkg is the SR.

$$L_{CR}(b) = Poisson(N_{CR} \mid \tilde{\tau} \cdot b)$$

Scale factor τ accounts for difference in size between SR and CR

"Background uncertainty constrained from the data"

- Full likelihood of the measurement ('simultaneous fit')

$$L_{full}(s,b) = Poisson(N_{SR} \mid s + b) \cdot Poisson(N_{CR} \mid \tilde{\tau} \cdot b)$$

ex12 – Subsidiary measurements

'ex12_build_PoissonGaussGlobs.C'

Generalizing the concept of the sideband measurement

- Background uncertainty from sideband clearly clearly not a 'systematic uncertainty'

$$L_{full}(s,b) = Poisson(N_{SR} \mid s + b) \cdot Poisson(N_{CR} \mid \tilde{\tau} \cdot b)$$

- Now consider scenario where *b* is not measured from a sideband, but is taken from MC simulation **with an 8% cross-section 'systematic' uncertainty**

'Measured background rate by MC simulation'

$$L_{full}(s,b) = Poisson(N_{SR} \mid s + b) \cdot Gauss(\tilde{b} \mid b, 0.08)$$

'Subsidiary measurement' of background rate

- *We can model this in the same way, because the cross-section uncertainty is also (ultimately) the result of a measurement*

Generalize: 'sideband' → 'subsidiary measurement'

Todays exercises

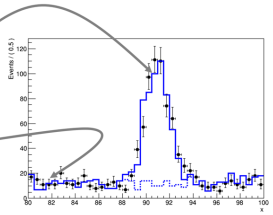
ex13 – template models

'ex13_build_binned.C'

The imperfect experiment

- When relying on simulation templates to build models, a whole world of problems awaits when considering that simulation predictions have many systematic uncertainties associated with them?

$$L(\vec{N} \mid \mu) = \prod_{bins} Poisson(N_i \mid \mu \cdot s_i + b_i)$$



Signal and background predictions are affected by (systematic) uncertainties