

The ~~Uppsala/~~CH Method to Include  
Systematics:  
Facts ~~&~~ ~~Fictions.~~

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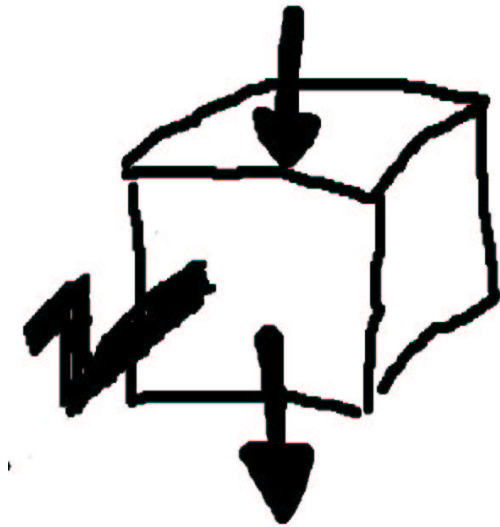
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# CONTENTS

- Some Intro
- Some Facts
- Some proposals for calculating limits with uncertainties.

# Limit Calc. for Runaways I: No systematics

$$P(n|s + b)$$



$$[\mu_{s1}, \mu_{s2}]_{1-\alpha}$$

J. Neyman, Phil. Trans. Royal Soc. London **A**, 333, (1937).

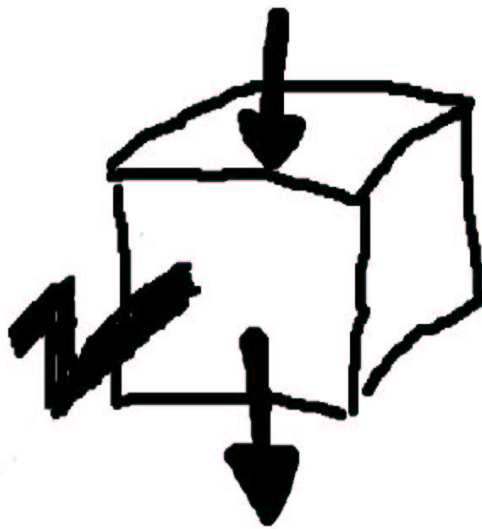
G. J. Feldman and R. D. Cousins, Phys. Rev **D57**, 3873, (1998).

B. P. Roe and M. B. Woodroffe, Phys. Rev. **D60**, 053009, (1999).

etc ....

# Limit Calc. for Runaways II: With systematics

$$q(n|s + b) = \frac{1}{\sqrt{2\pi\sigma_b^2}} \int_0^{\infty} db' P(n|s + b') e^{-\frac{(b-b')^2}{2\sigma_b^2}}$$



$$[\mu_{s1}, \mu_{s2}]_{1-\alpha}$$

R. D. Cousins and V. L. Highland, Nucl. Instrum. Meth. **A320**, 331, (1992).

J.C., in Proc. of Post ICRC workshop on Neutrino Telescopes, Hamburg (2000)

J.C., O. Botner, A. Hallgren & C. P. de los Heros, submitted to PRD,

hep-ex/0202013

J.C., O. Botner, A. Hallgren & C. P. de los Heros in Proc. of Adv. Stat. Tech. in

Part. Phys. Conf., Durham (2002), hep-ex/0206034

# Facts I

- The Uppsala method is nothing but the generalized Cousins & Highland (CH) method.

see NIM **A320**, 331, (1992).

Uppsala:

- ◇ extended to include background unc. (and corr.)
  - ◇ extended to use newer ordering algorithms.
  - ◇ extended to use different parametrizations of uncertainties (Gauss, logN, flat (triangular, popal.f90))
- The limit does not scale linearly with the uncertainties.

This is a feature, not a bug

For Gaussian uncertainties, 0 observed events  
zero bg and FC ordering, analytically:

$$(\mu_s)_{corr} = \frac{2.44}{\epsilon} (1 + 2.44 * \sigma_\epsilon^2 / 2)$$

## FACTS II

- The CH method is pretty common in Particle Physics.

It is not recommended by PDG  
but it (and its variations) has been used by (e.g.):  
BABAR, DELPHI, ALEPH, L3, OPAL, E791, CDF  
CLEO, SLD, KTeV, APEX, CHORUS, NOMAD, D0

- The CH method is not really frequentist.

Since integrating over a “true” quantity  
it uses partly Bayesian statistics.  
but it has well defined frequentist properties.

# Proposals for Limit calculation

- Do not include systematics in a quantitative way at all.

PROs:

Lack of knowledge on systematics reflects itself in our treatment of systematics.

CONs:

People expect that systematics are folded into the limit in some way. If not, these limits might not be taken seriously.

- Include systematics using some of the well known statistics methods.

# Proposals for Limit calculation II

The CH method:

PROs:

- ◇ well defined statistical properties  
e.g. only mildly increased coverage.  
hep-ex/0206034
- ◇ satisfactory intuitive behaviour.
- ◇ pretty common in particle physics
- ◇ machinery in place

CONs:

- ◇ *Relies on assumptions on shape and size of uncertainties*
- ◇ Is a frequentist/Bayes hybrid

The  $\chi^2$  method

- ◇ Use approximation:

$$\Delta\chi^2 = -2 \times \min_{\epsilon} \frac{\mathcal{L}(n_o, s, \epsilon)}{\mathcal{L}(s_{best}, \epsilon_{best})}$$

*This approach can also be used directly in likelihood ratio for Feldman & Cousins. → log-profile method.*

# Proposals for Limit calculation/presentation III

- Use some other fancier method.
  - sCL method (Punzi, Durham 2002)
  - PROs:
    - ◇ solves *all* problems.
  - CONs:
    - ◇ It is ignored by the community.
    - ◇ Difficult to understand.
    - ◇ Computationally cumbersome.
- Use our own method to include systematics.
  - e.g. some higher dimensional construction intervals with some clever projection.
  - PROs
    - ◇ if we are very smart, we might come up with sth which is less dependent on assumptions
  - CON:
    - ◇ we have to prove that the method has correct coverage (at least under the assumptions we make.)

# Proposals for Limit calculation/presentation IV

- Concluding Remark:

The problem is not how or if to include the systematics in our limit calculation.

This problem is IMHO reasonably treated by existing tools.

If we can not live with the present approximations then we have to try to quantify the uncertainties better.