Banff Challenge

(Profile likelihood, Asimov ,LEE)

Ofer Vitells, Eilam Gross, Glen Cowan, Kyle Cranmer

Banff Workshop July 2010

General

- The likelihood function

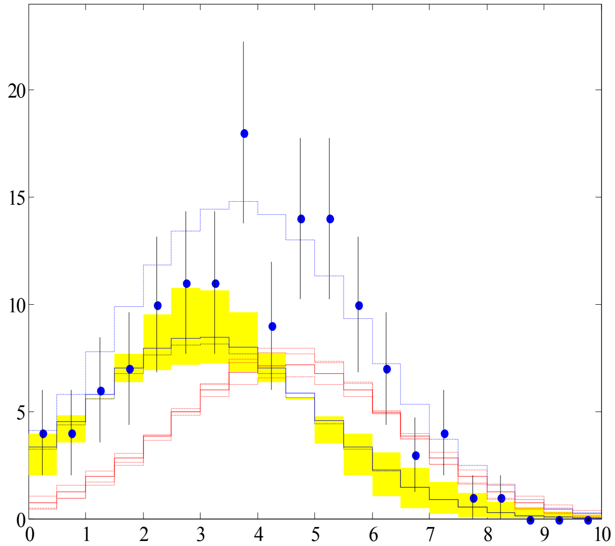
$$L = \Pi_i Poiss(n_i ; \mu s_i(\epsilon_s) + b_i(\epsilon_b, x_b)) \times Gauss(\tilde{\epsilon}_s ; \epsilon_s, 1) \times Gauss(\tilde{\epsilon}_b ; \epsilon_b, 1) \times Gauss(\tilde{x}_b ; x_b, 0.1)$$

"measurements"

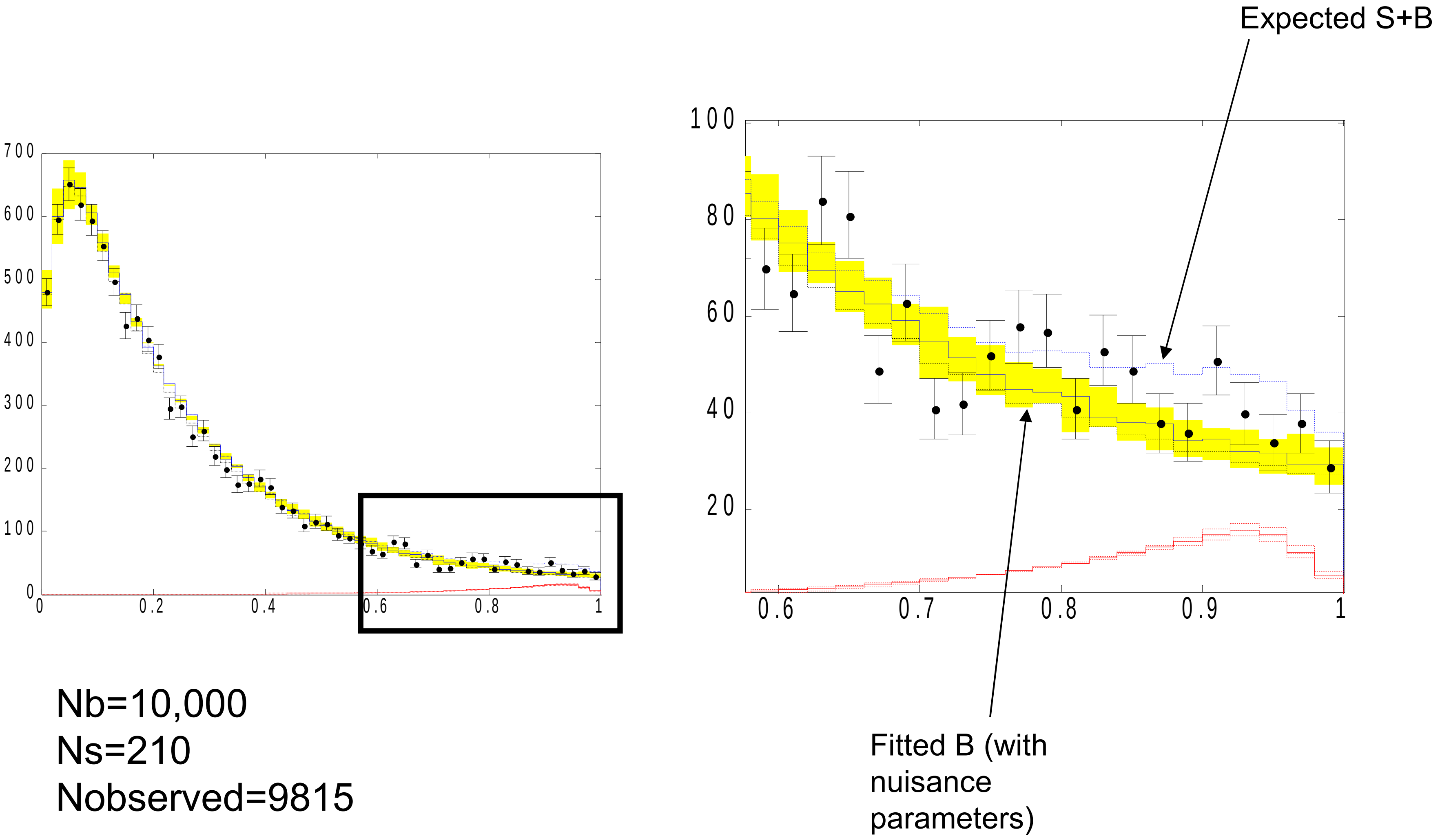
$$s(\epsilon_s) = s^0 + \epsilon_s \delta s$$
$$b(\epsilon_b, x_b) = (b^0 + \epsilon_b \delta b) x_b$$

$$\lambda(\mu) = \frac{L(\mu, \hat{\hat{\theta}})}{L(\hat{\mu}, \hat{\theta})}$$

$$q_0 = \begin{cases} -2 \ln \lambda(0) & \hat{\mu} \geq 0 \\ 0 & \hat{\mu} < 0 \end{cases}$$



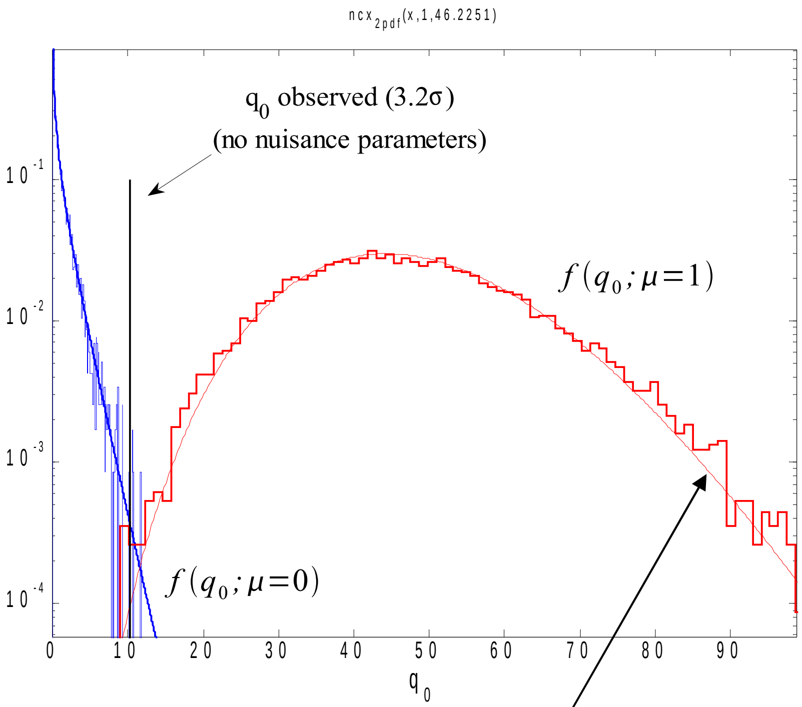
Problem #1

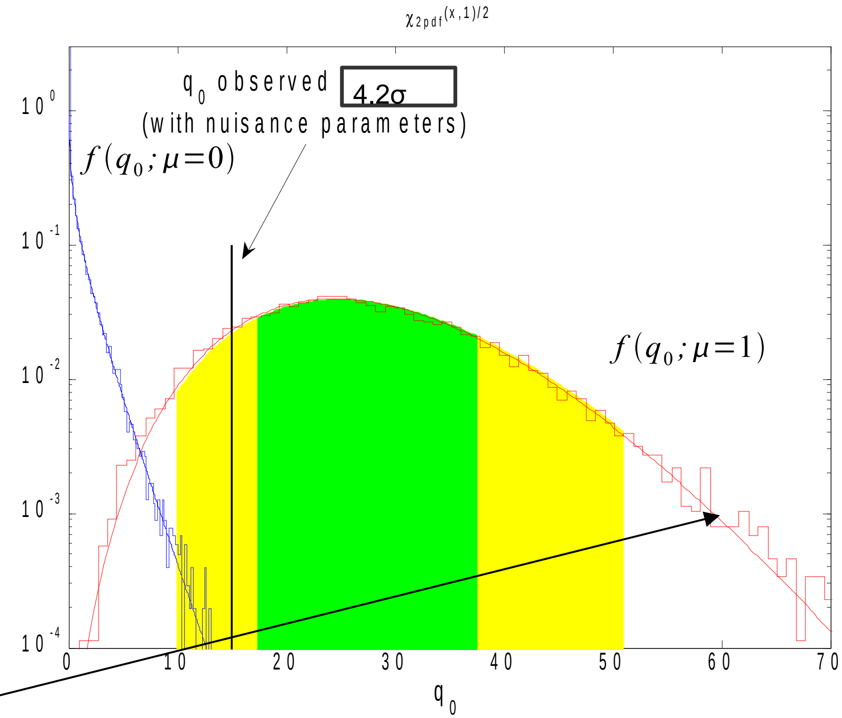


Nb=10,000
Ns=210
Nobserved=9815

w/o nuisance parameters

with nuisance parameters





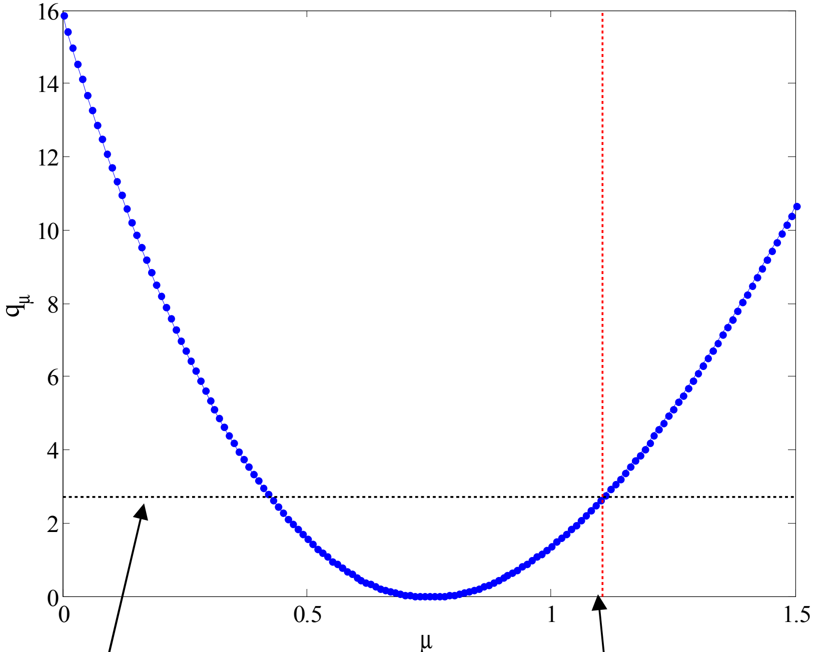
Curves from
"Asimov" data set
(expected S+B)

$$f(q_0|\mu') = \left(1 - \Phi\left(\frac{\mu'}{\sigma}\right)\right)\delta(q_0) + \frac{1}{2}\frac{1}{\sqrt{2\pi}}\frac{1}{\sqrt{q_0}}\exp\left[-\frac{1}{2}\left(\sqrt{q_0} - \frac{\mu'}{\sigma}\right)^2\right]$$

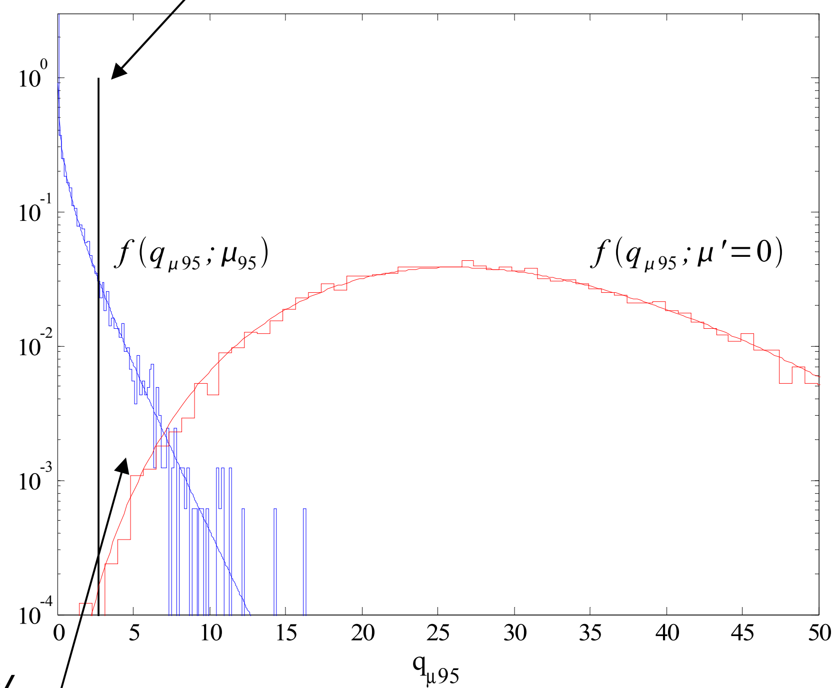
exclusion

$$q_\mu = \begin{cases} -2\ln\lambda(\mu) & \hat{\mu} \le \mu \\ 0 & \hat{\mu} > \mu \end{cases}$$

2logλ(μ) vs μ



Observed $q_{\mu 95}$ (2.7)



5%

μ^{95} (1.1)

2.7

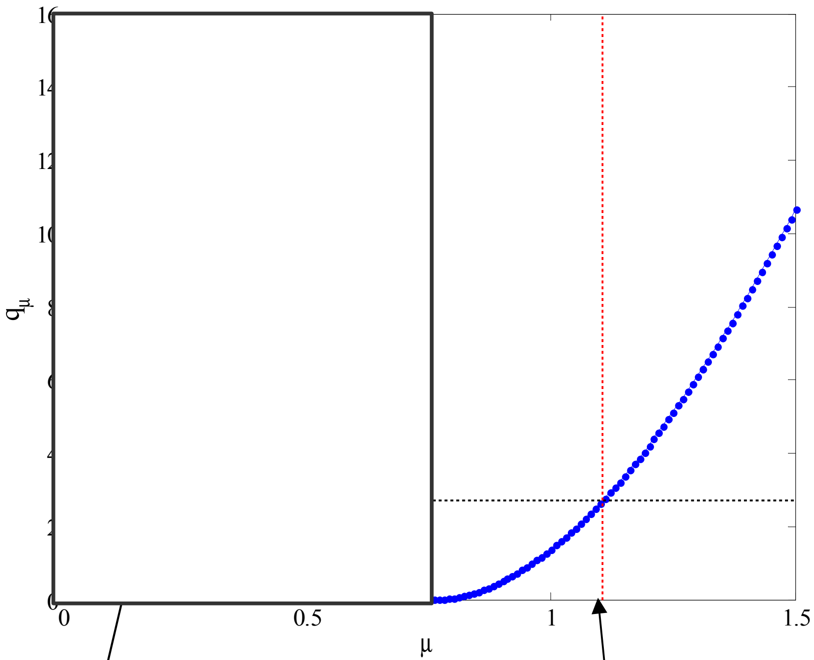
(5% χ^2 quantile)

$$f(q_\mu|\mu') = \Phi\left(\frac{\mu'-\mu}{\sigma}\right)\delta(q_\mu) + \frac{1}{2}\frac{1}{\sqrt{2\pi}}\frac{1}{\sqrt{q_\mu}}\exp\left[-\frac{1}{2}\left(\sqrt{q_\mu} - \frac{(\mu-\mu')}{\sigma}\right)^2\right]$$

exclusion

$$q_\mu = \begin{cases} -2\ln\lambda(\mu) & \hat{\mu} \le \mu \\ 0 & \hat{\mu} > \mu \end{cases}$$

2logλ(μ) vs μ

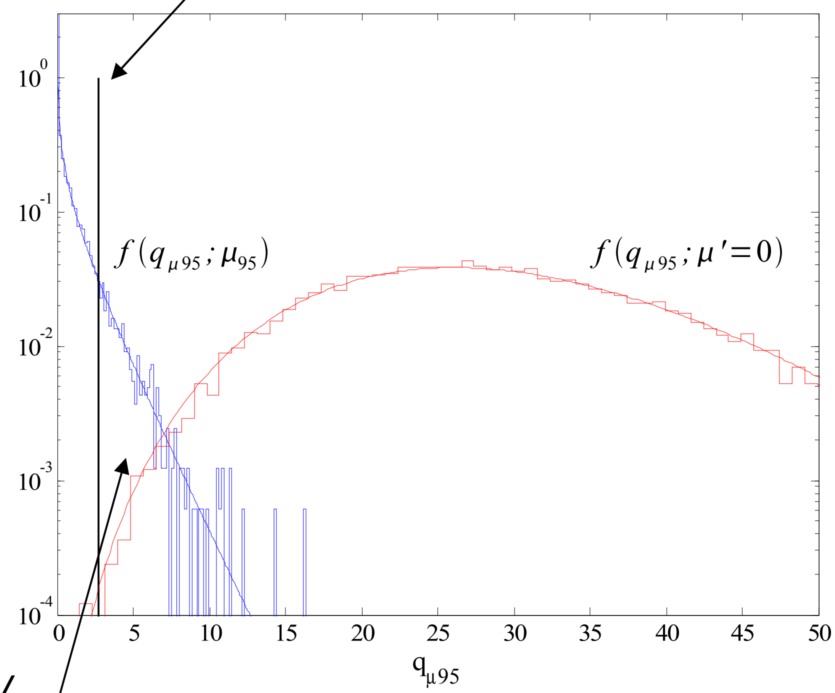


2.7

(5% χ^2 quantile)

μ^{95} (1.1)

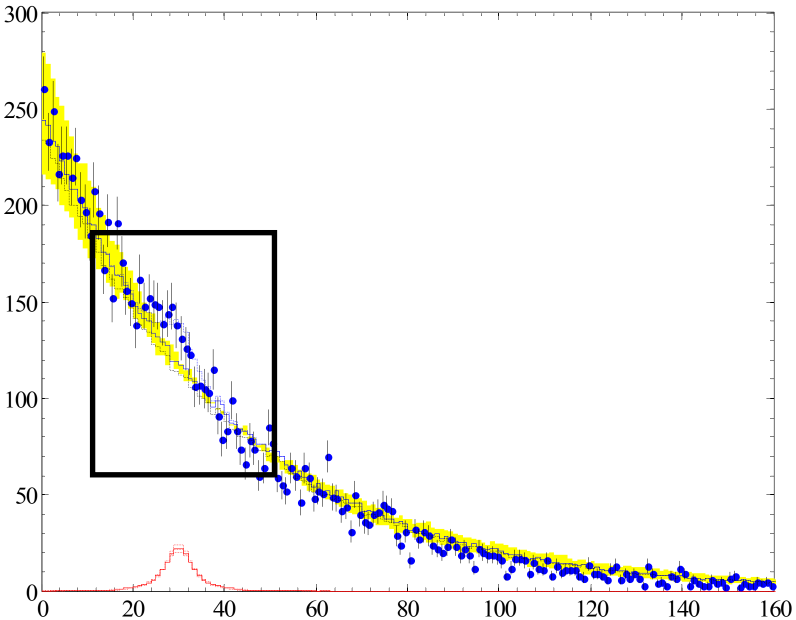
Observed $q_{\mu 95}$ (2.7)

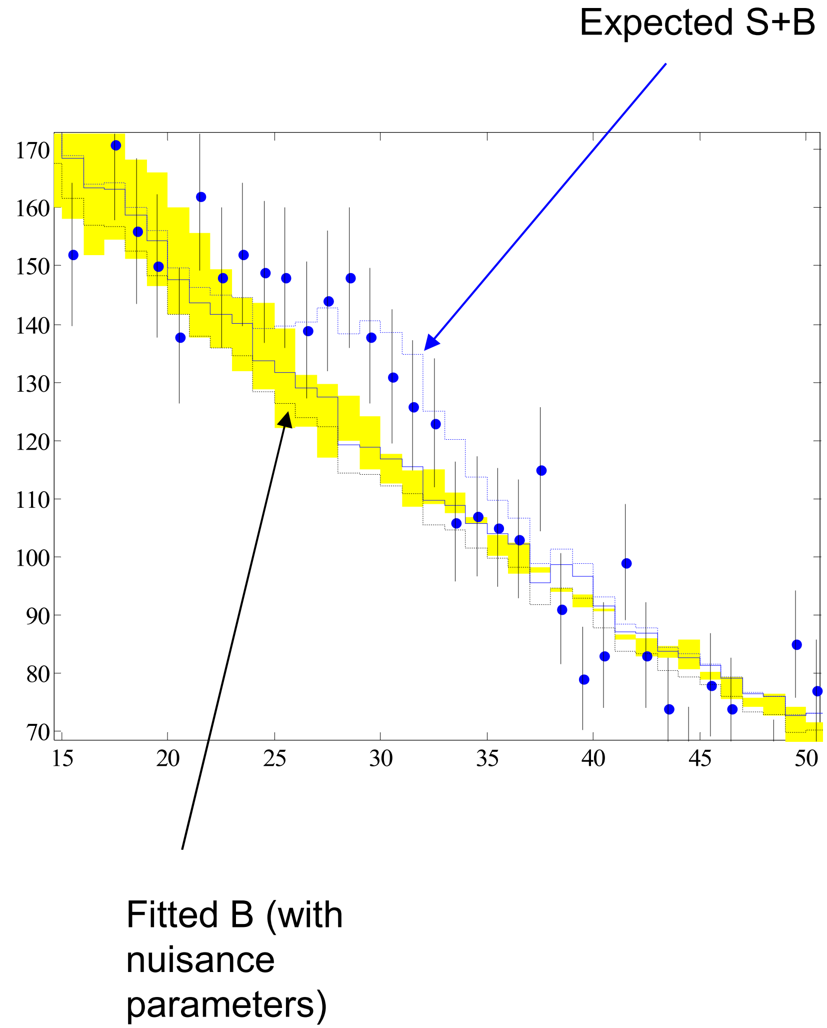


5%

$$f(q_\mu|\mu') = \Phi\left(\frac{\mu'-\mu}{\sigma}\right)\delta(q_\mu) + \frac{1}{2}\frac{1}{\sqrt{2\pi}}\frac{1}{\sqrt{q_\mu}}\exp\left[-\frac{1}{2}\left(\sqrt{q_\mu} - \frac{(\mu-\mu')}{\sigma}\right)^2\right]$$

Problem #2





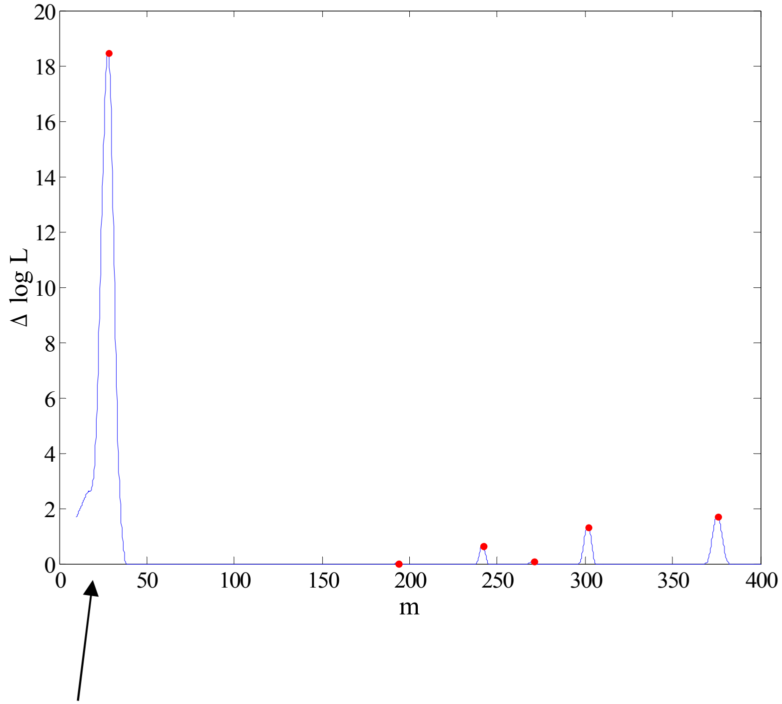
Significance (fixed mass) :

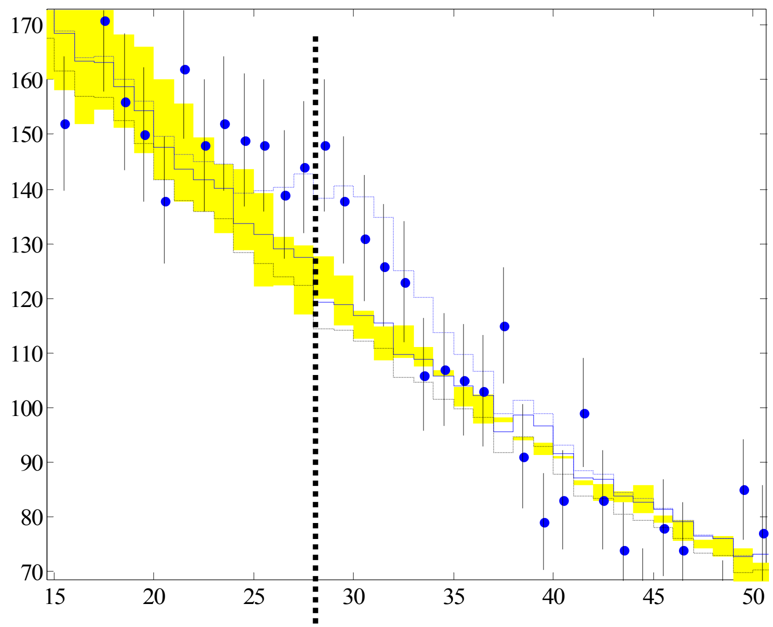
3.97 (no nuisance parameters)

4.28 (with nuisance parameters)

Look elsewhere effect (signal location a-priori unknown)

Likelihood fit



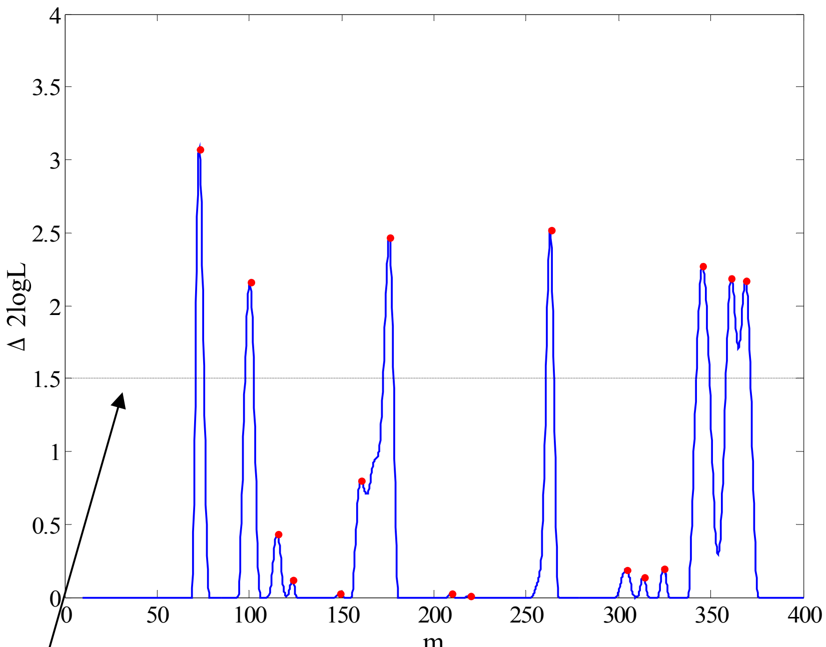


Best mass fit=28

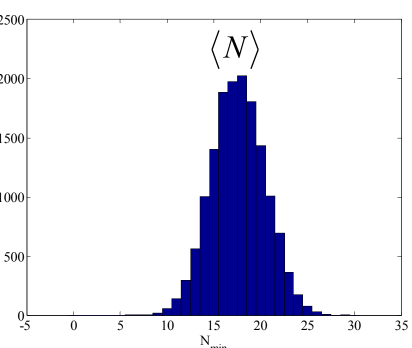
“Local” significance = 4.3σ

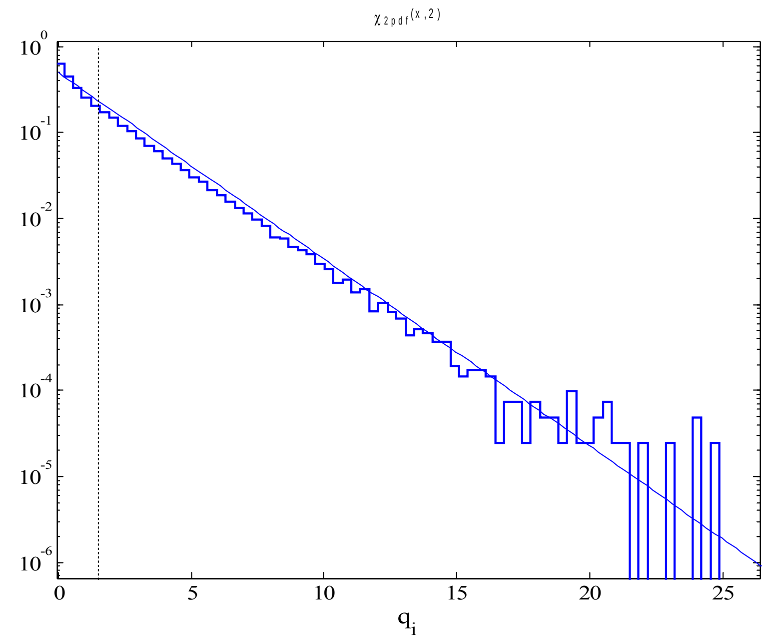
Look elsewhere effect

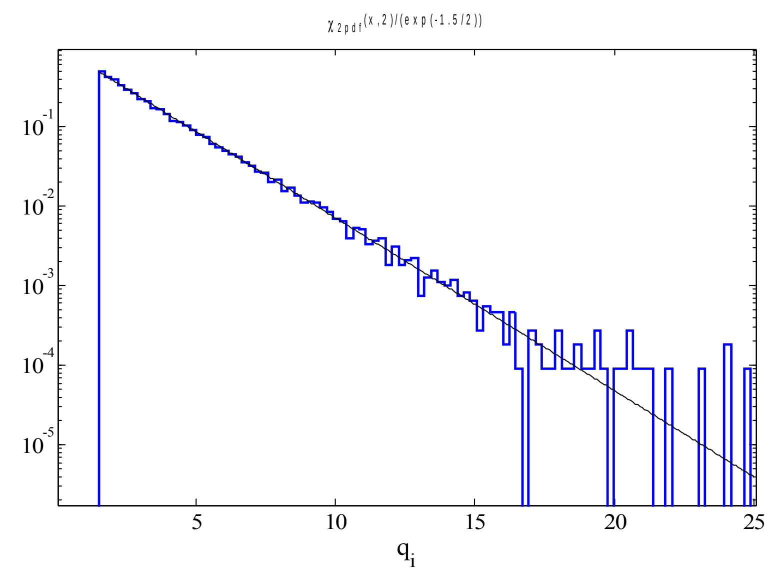
Background-only pseudo experiment



q^{cut}

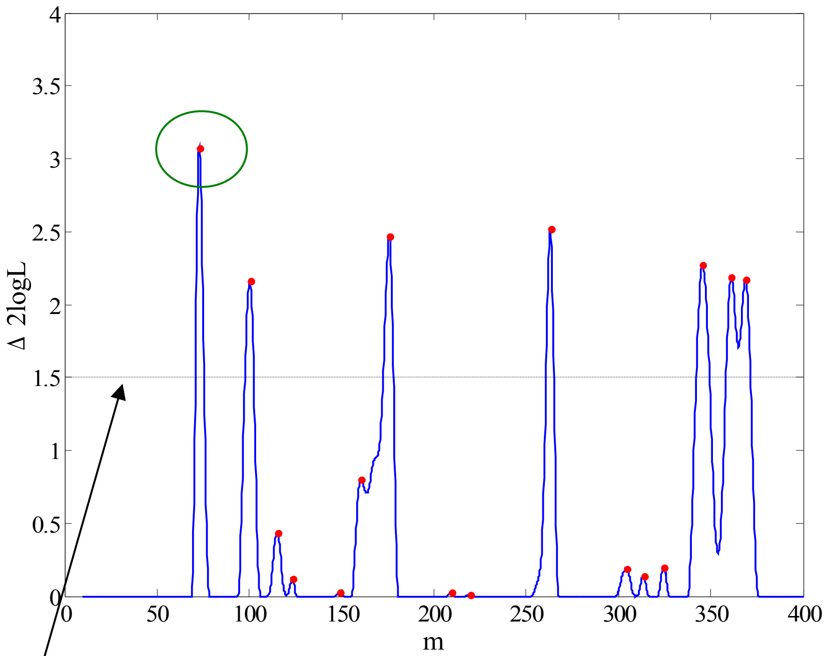




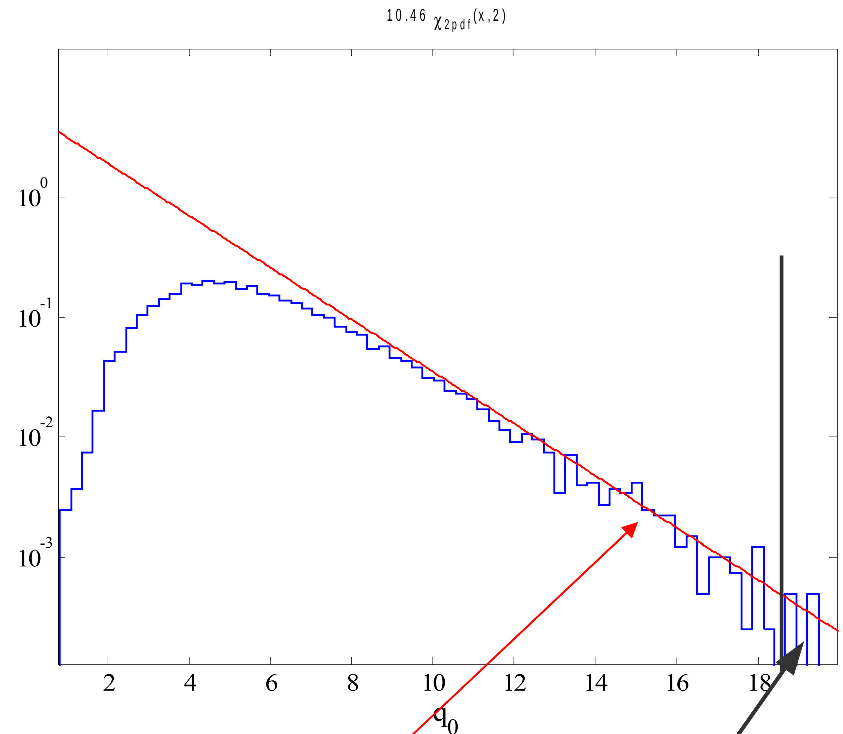


Look elsewhere effect

Background-only pseudo experiment



q^{cut}



$$\frac{\langle N^{cut}\rangle}{1-F_{\chi^2}(q^{cut})}\, p_{\chi^2_2}$$

P=4.6x10^{-4}
(3.3σ)

$$trial\#_{observed} \simeq \langle N\rangle \sqrt{\frac{\pi}{2}}\sqrt{t_{obs}} = \langle N\rangle \sqrt{\frac{\pi}{2}} Z_{fix}$$

Problem #3