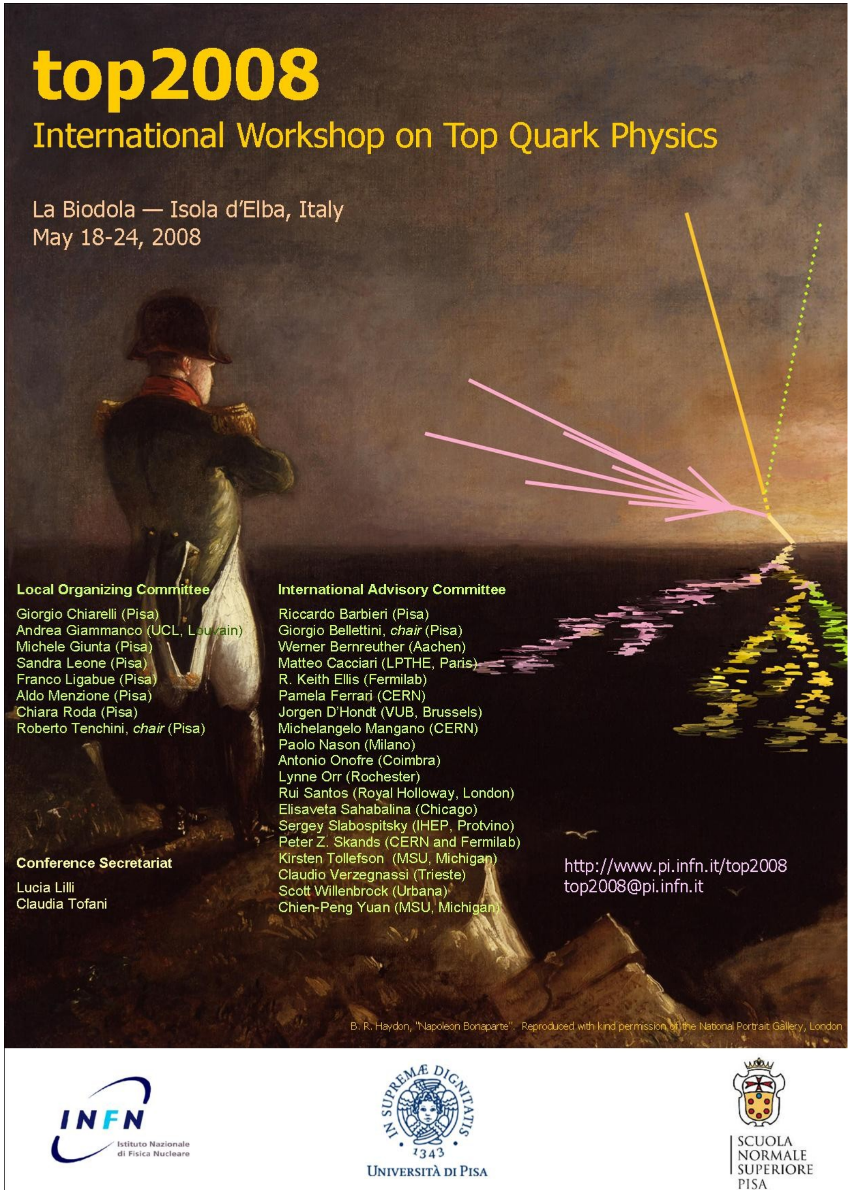
Report from TOP2008

Andrea Giammanco

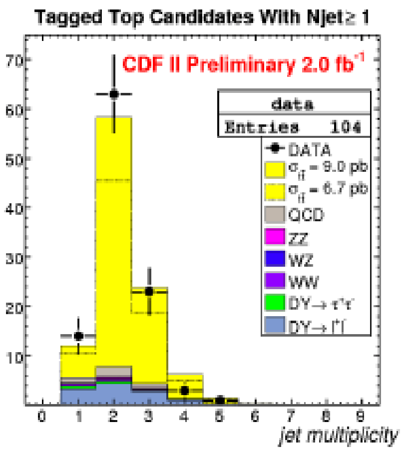
- Personal (biased) selection:
  - ttbar cross section
  - Top mass
  - Single top
- The Vtb issue

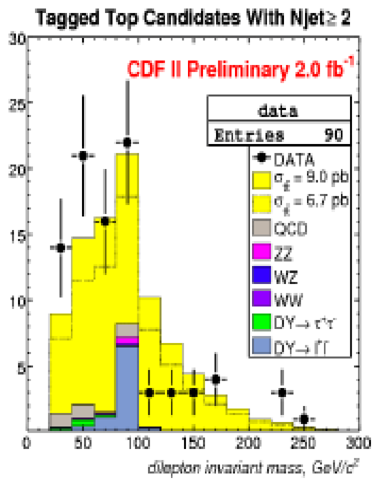


4 june 2008, CP3 lunch seminar

Cross section (2l)

Dilepton+b-tag (2fb^{-1})

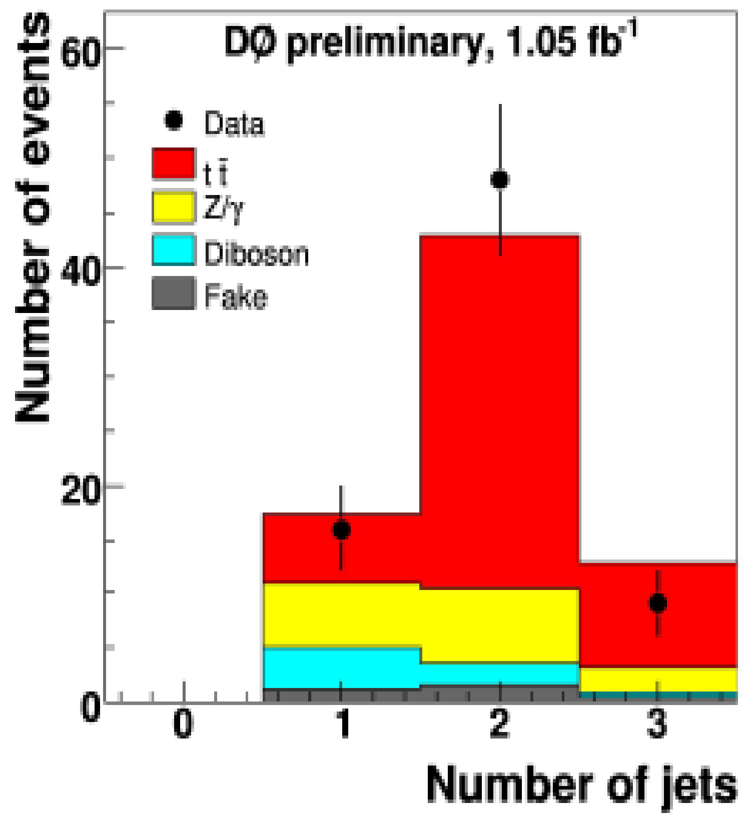




Signal region: n=90, b=13±2

$\sigma(tt)$ = 9.0 ± 1.1 (stat) ± 0.7 (sys) ± 0.5 (lum) pb

Dominant systematics: uncertainty on JES (3%) and background (2%)

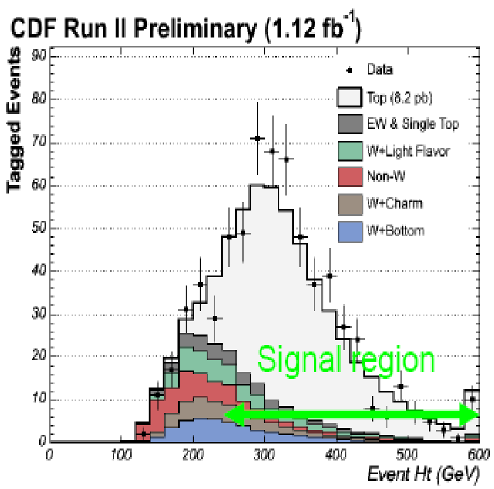


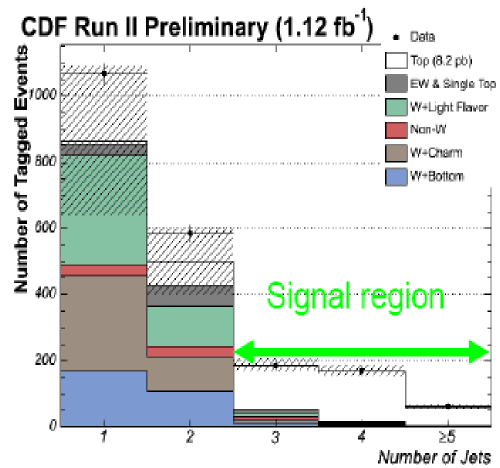
$\sigma = 6.8^{+1.2}_{-1.1}$ (stat) $^{+0.9}_{-0.8}$ (syst) ± 0.4 (lumi) pb

relative error : $\delta\sigma/\sigma$ ~22% m_t= 175 GeV

Cross section (1l)

Lepton+jets+b-tag (1.1fb^{-1})

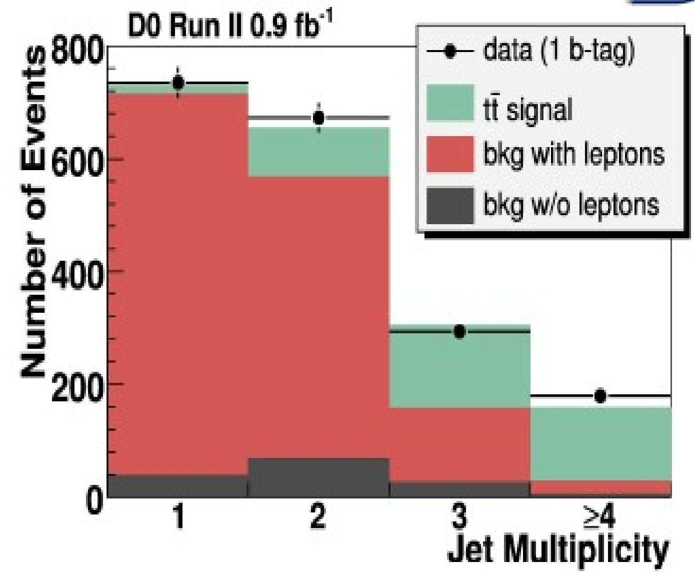


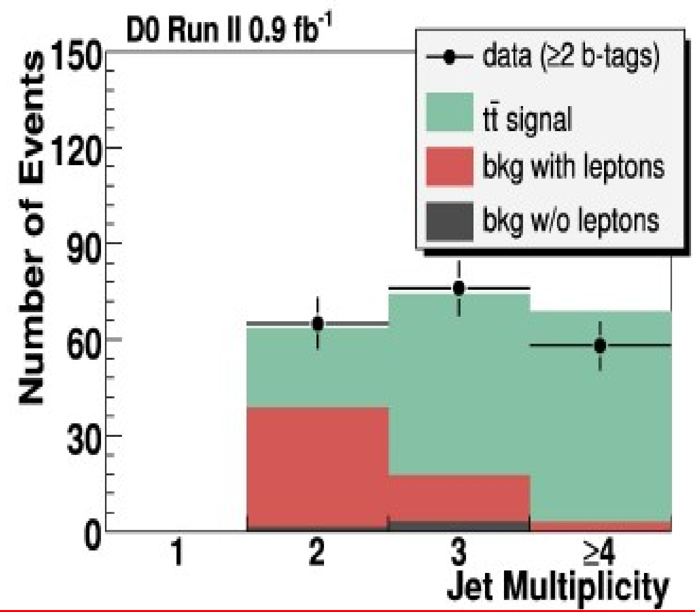


Signal region: n=416 tags, b=75 ±15

$\sigma(tt) = 8.2 \pm 0.5\ (\text{stat}) \pm 0.8\ (\text{sys}) \pm 0.5\ (\text{lum})$ pb

Best CDF individual measurement !

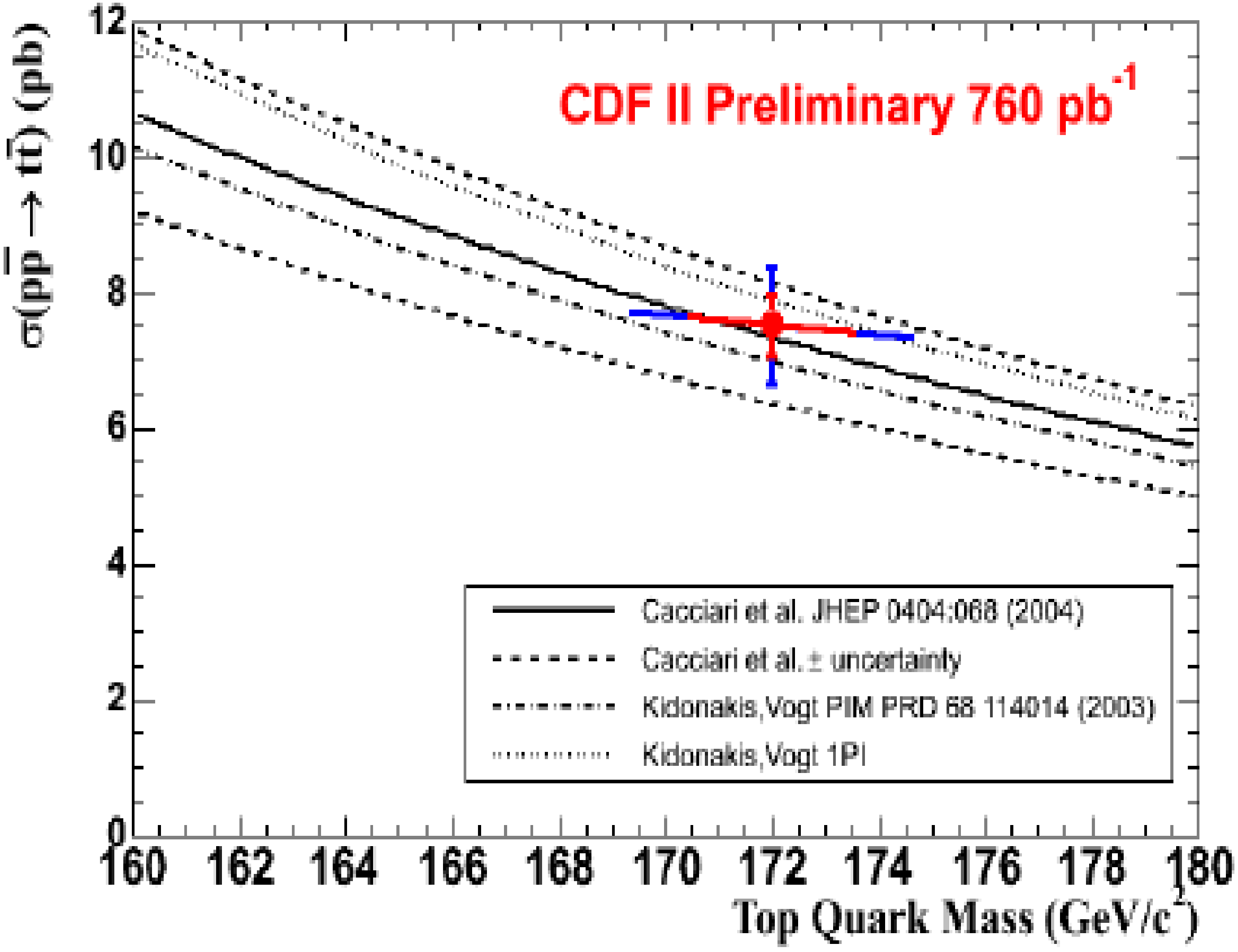




$\sigma = 8.1 \pm 0.5\,(\text{stat}) \pm 0.7\,(\text{syst}) \pm 0.5\,(\text{lumi})$ pb

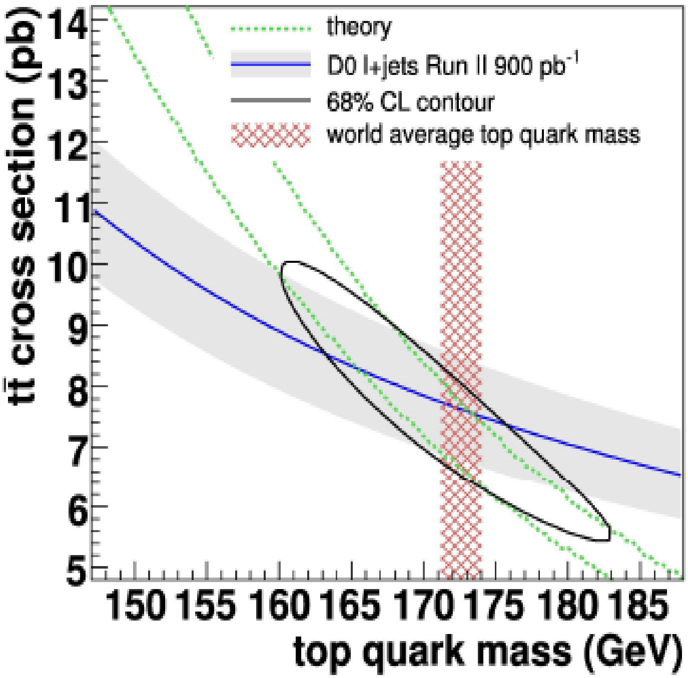
relative error : $\delta\sigma/\sigma \sim 12\%$ $m_t = 175$ GeV

Cross section vs mass, CDF



Cross section vs mass, D0

- Motivation:
  - not meant to compete in precision with direct measurement, but provides a complementary measurements
  - top mass definition (pole , running)
- Construct likelihood with measurements from lepton+jet and dilepton channels: Gauss(σ,$\delta\sigma$)
- Define theory likelihood according to PDF and scales uncertainties from
  - Kidonakis et al., PRD 68 114014
  - Cacciari et al., JHEP 0404:068



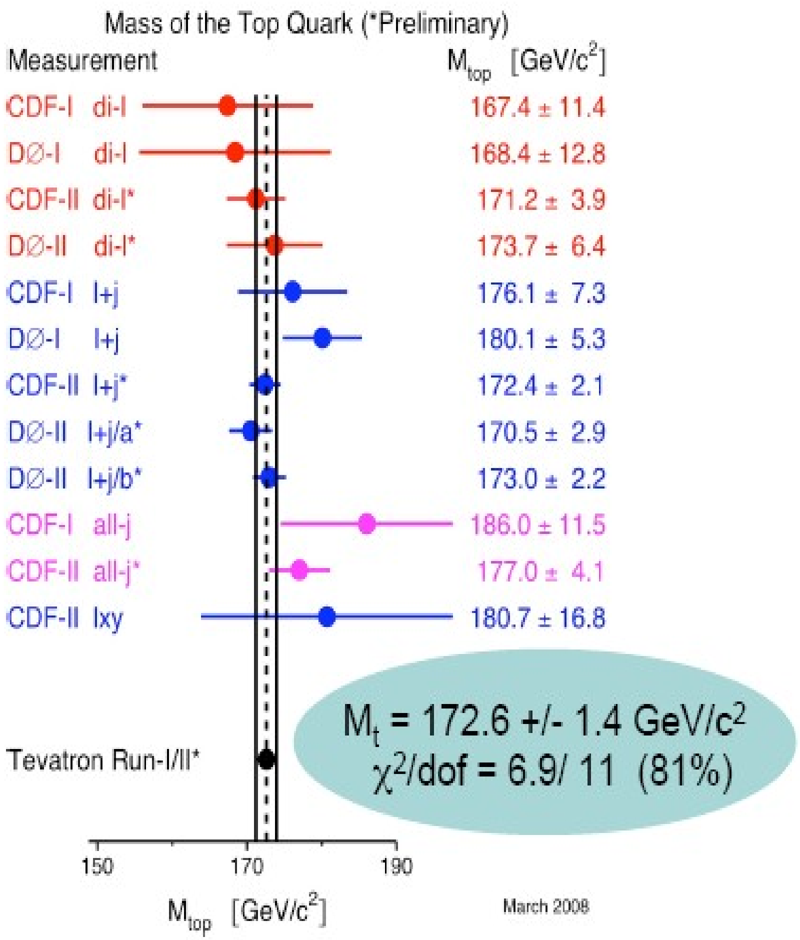
$m_t = 170.0 \pm 7$ GeV @ 68% C.L.

D0 combined, 1 fb^{-1}: 172.1± 2.4 GeV

- Multiply the theory and measurement likelihoods to obtain a joint likelihood. Integrate over the cross section to get a likelihood function that depends only on the top-quark mass and calculate 68% C.L.

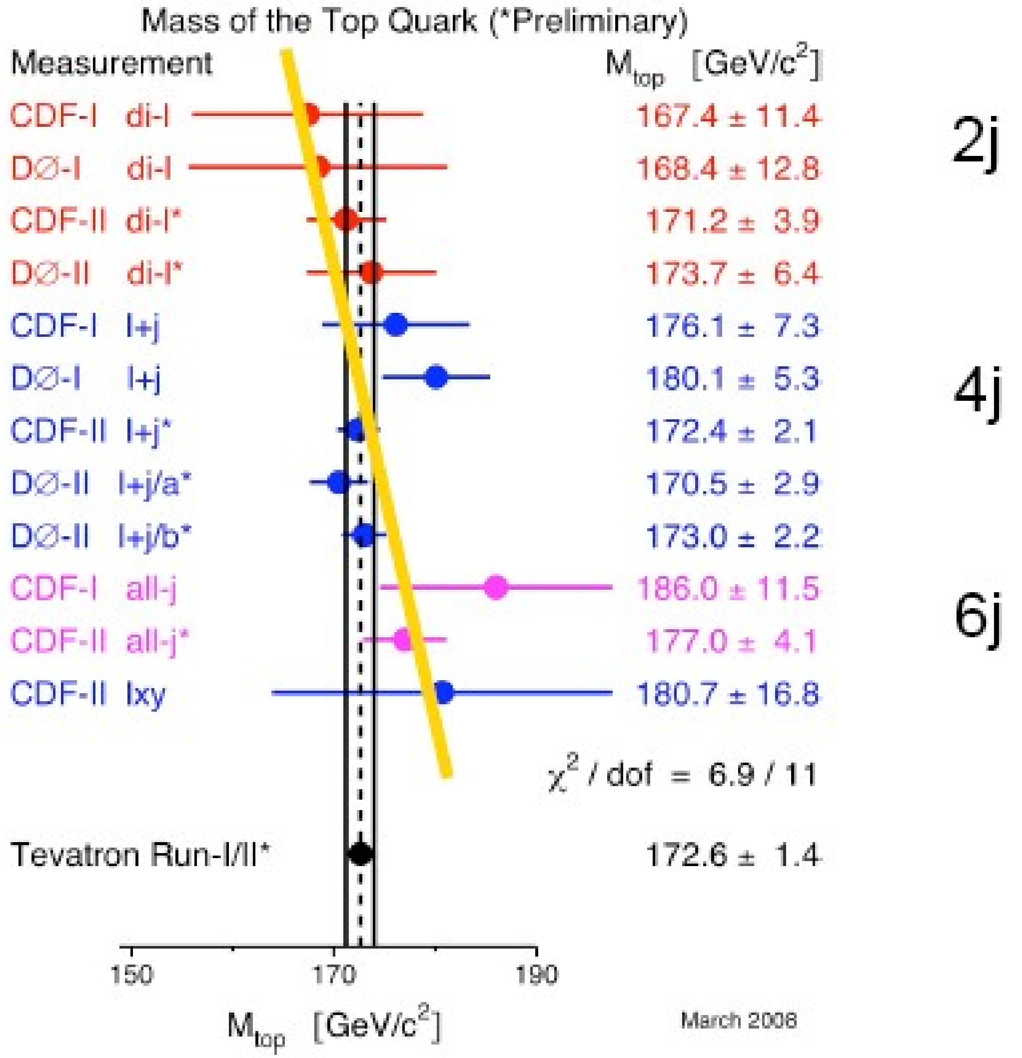
Mass from Tevatron

Combination Results



- Relative uncertainty: 0.8%

Consistency?



- Is there a systematic trend here?

Cross checks (I)

	Fit Value (GeV/c^2)	Total Correlation M(H)	M(L)	M(D)
M(HAD)	177.3 +/- 3.9	1		
M(LJT)	172.4 +/- 1.5	0.12	1	
M(DIL)	169.8 +/- 3.1	0.18	0.26	1

- Use this to calculate χ^2 comparison

$\Delta M(L-D) = 2.7 \pm 3.1$ $\quad$ $\Delta M(H-L)=4.9 \pm 4.0$ $\quad$ $\Delta M(H-D)=7.5 \pm 4.5$

$\chi^2(L-D) = 0.8/1$ (39%) $\quad$ $\chi^2(H-L)=1.5/1$ (23%) $\quad$ $\chi^2(H-D)=2.8/1$ (10%)

Cross checks (II)

- Fit to two observables: CDF, D0

$$M_t^{CDF} = 172.5 \pm 1.8\ \mathrm{GeV/c^2} \qquad \rho_{\text{C-D}} = 0.22$$

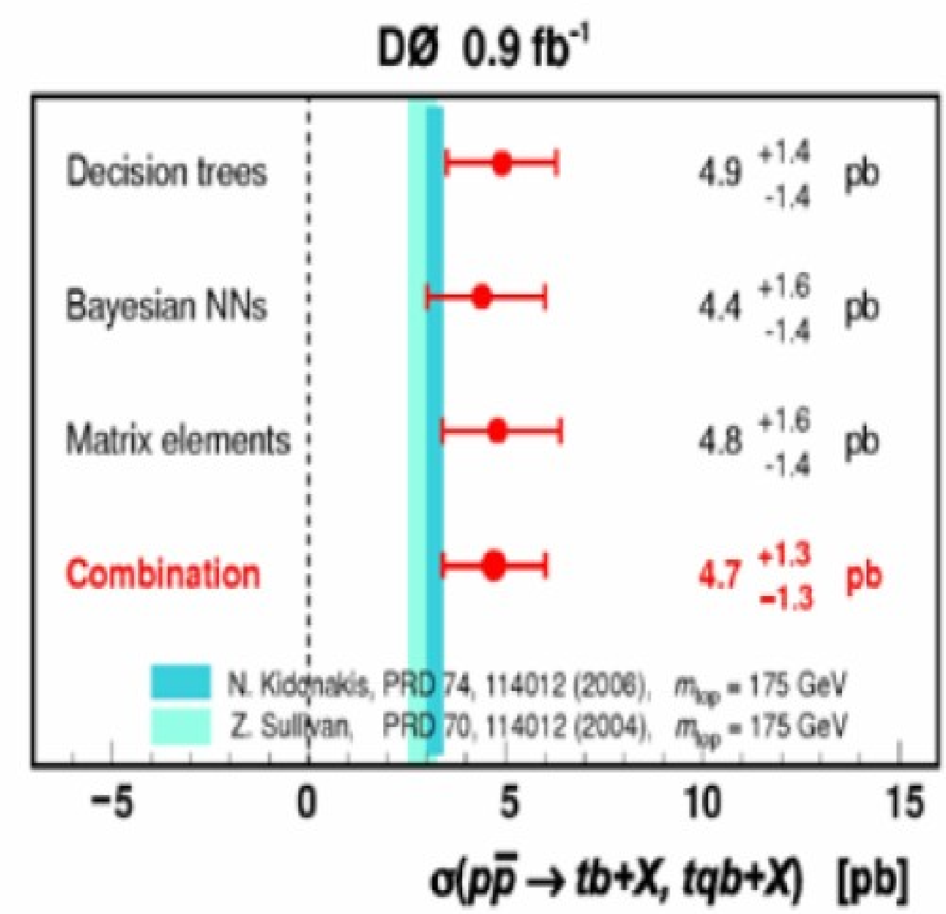
$$M_t^{D0} = 172.7 \pm 1.8\ \mathrm{GeV/c^2} \qquad \wp(\chi^2 = 0.01/1) = 92\%$$

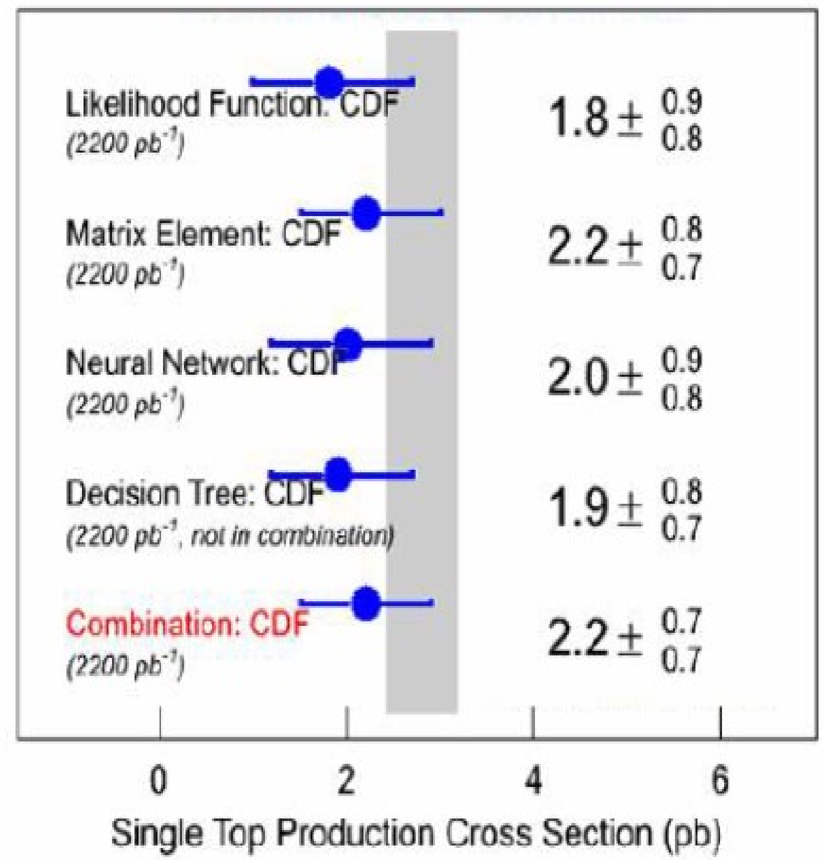
- Fit to two observables: Run-1, Run-2

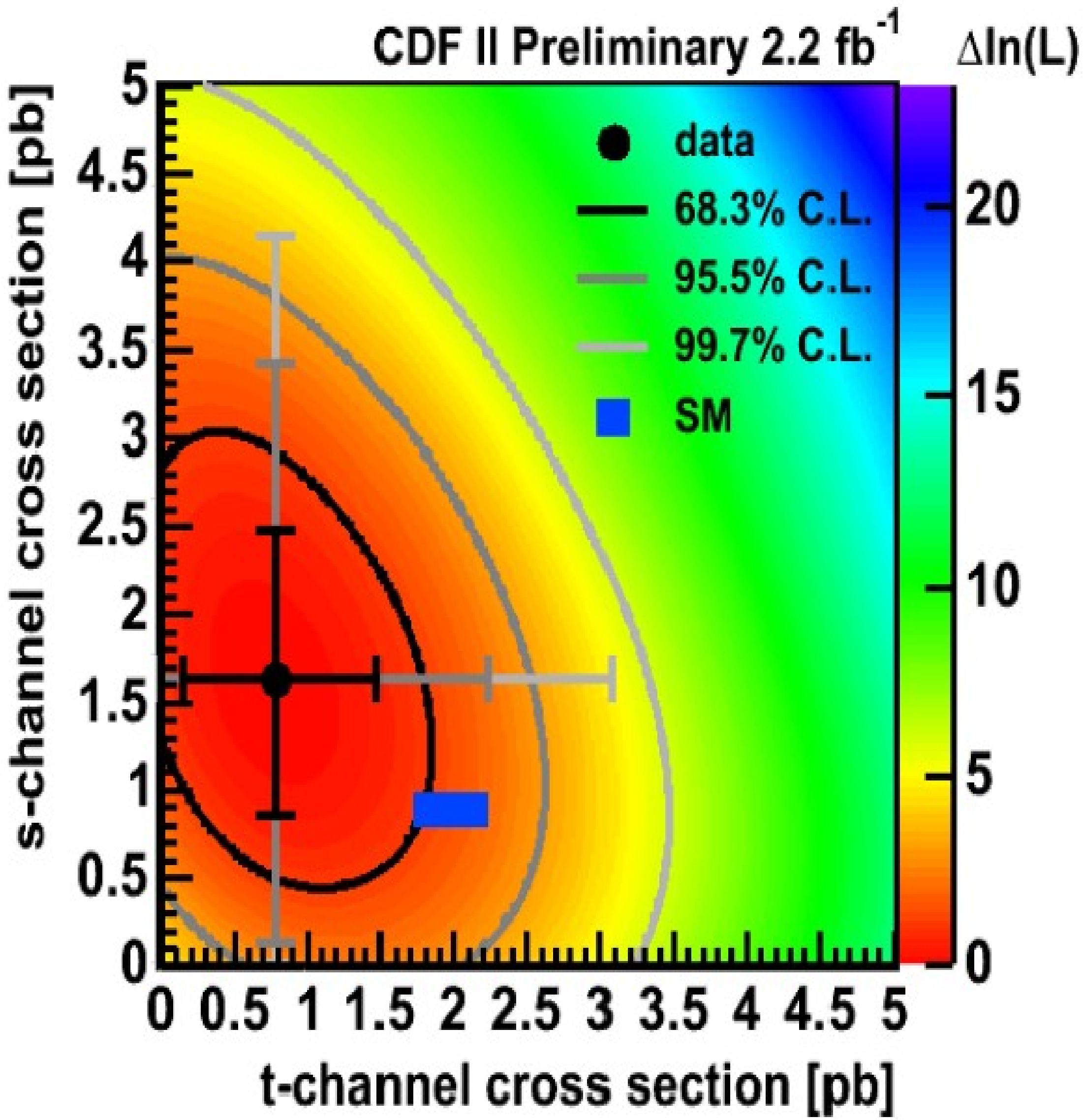
$$M_t^{Run1} = 178.2 \pm 4.3\ \mathrm{GeV/c^2} \qquad \rho_{\text{R1-R2}} = 0.42$$

$$M_t^{Run2} = 172.8 \pm 1.4\ \mathrm{GeV/c^2} \qquad \wp(\chi^2 = 1.9/1) = 17\%$$

Single top

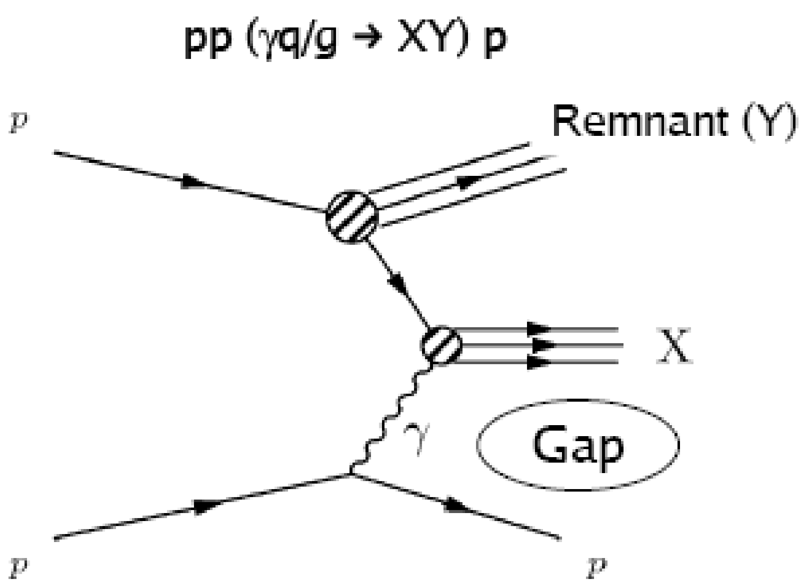

DØ 0.9 fb^{-1}
Decision trees
4.9 $^{+1.4}_{-1.4}$ pb
Bayesian NNs
4.4 $^{+1.6}_{-1.4}$ pb
Matrix elements
4.8 $^{+1.6}_{-1.4}$ pb
Combination
4.7 $^{+1.3}_{-1.3}$ pb
N. Kidonakis, PRD 74, 114012 (2006), m_{top} = 175 GeV
Z. Sullivan, PRD 70, 114012 (2004), m_{top} = 175 GeV
−5
0
5
10
15
$\sigma(p\bar{p} \to tb+X, tqb+X)$ [pb]

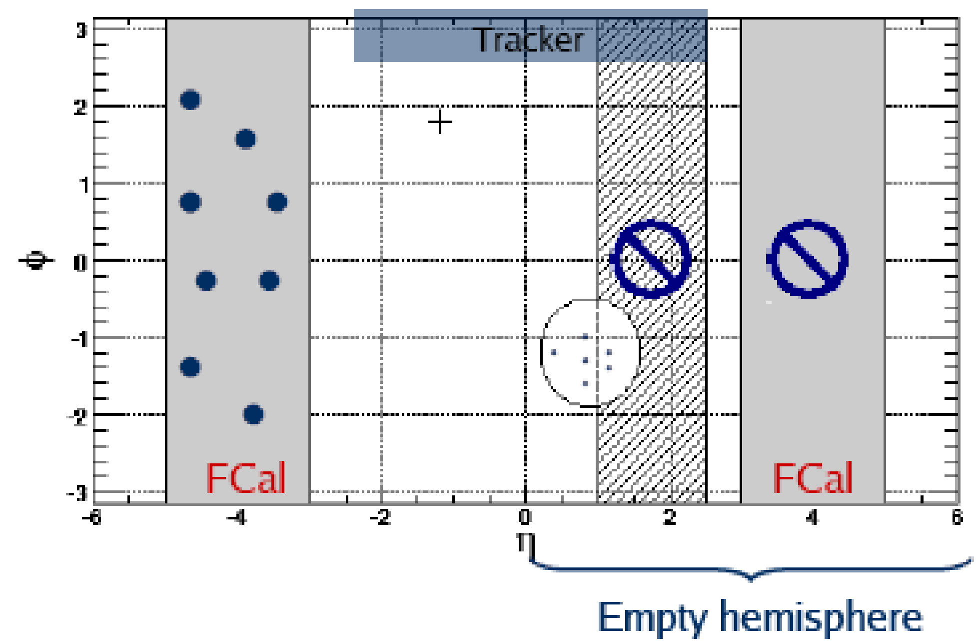

Likelihood Function: CDF
(2200 pb^{-1})
1.8 ± $^{0.9}_{0.8}$
Matrix Element: CDF
(2200 pb^{-1})
2.2 ± $^{0.8}_{0.7}$
Neural Network: CDF
(2200 pb^{-1})
2.0 ± $^{0.9}_{0.8}$
Decision Tree: CDF
(2200 pb^{-1}, not in combination)
1.9 ± $^{0.8}_{0.7}$
Combination: CDF
(2200 pb^{-1})
2.2 ± $^{0.7}_{0.7}$
0
2
4
6
Single Top Production Cross Section (pb)



$$\sigma_{\mathrm{t-channel}} = 0.8^{+0.7}_{-0.6}\,(\mathrm{stat.}+\mathrm{syst.})\ \mathrm{pb}$$
$$\sigma_{\mathrm{s-channel}} = 1.6^{+0.9}_{-0.8}\,(\mathrm{stat.}+\mathrm{syst.})\ \mathrm{pb}$$

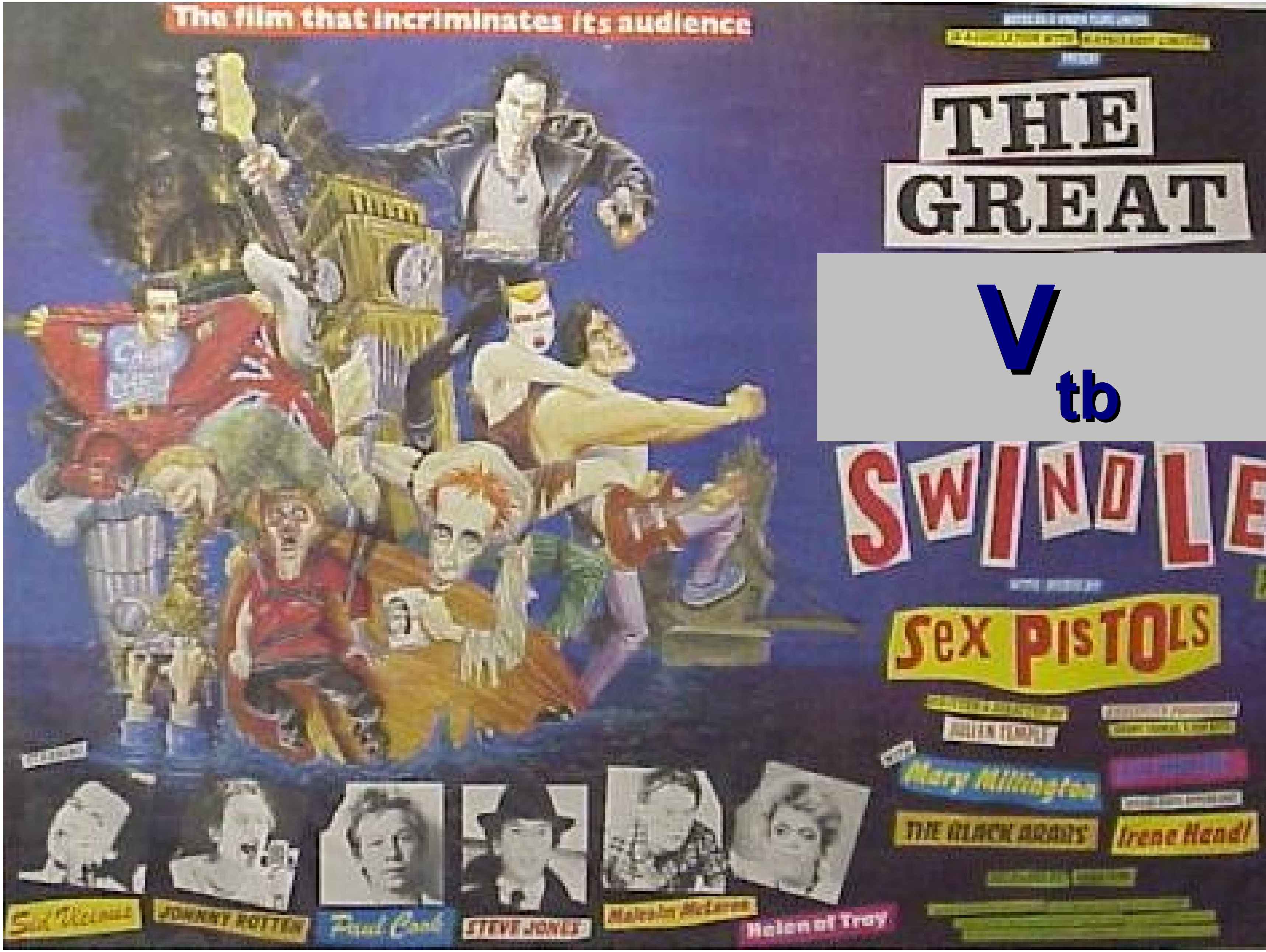
Single top in photon+proton



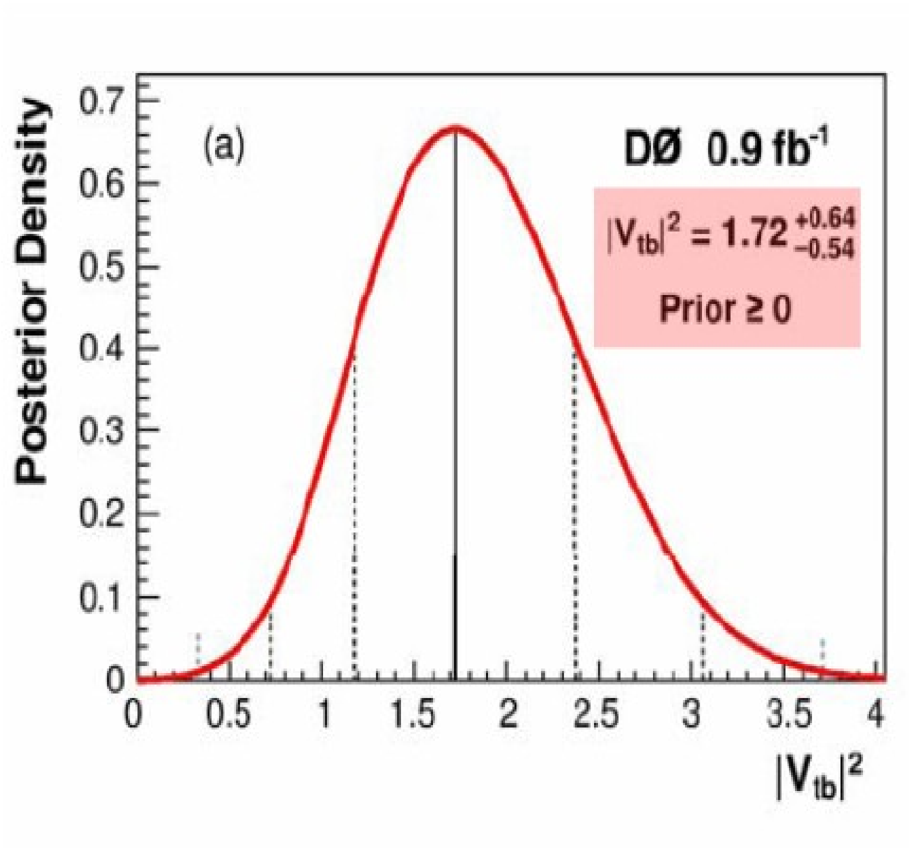


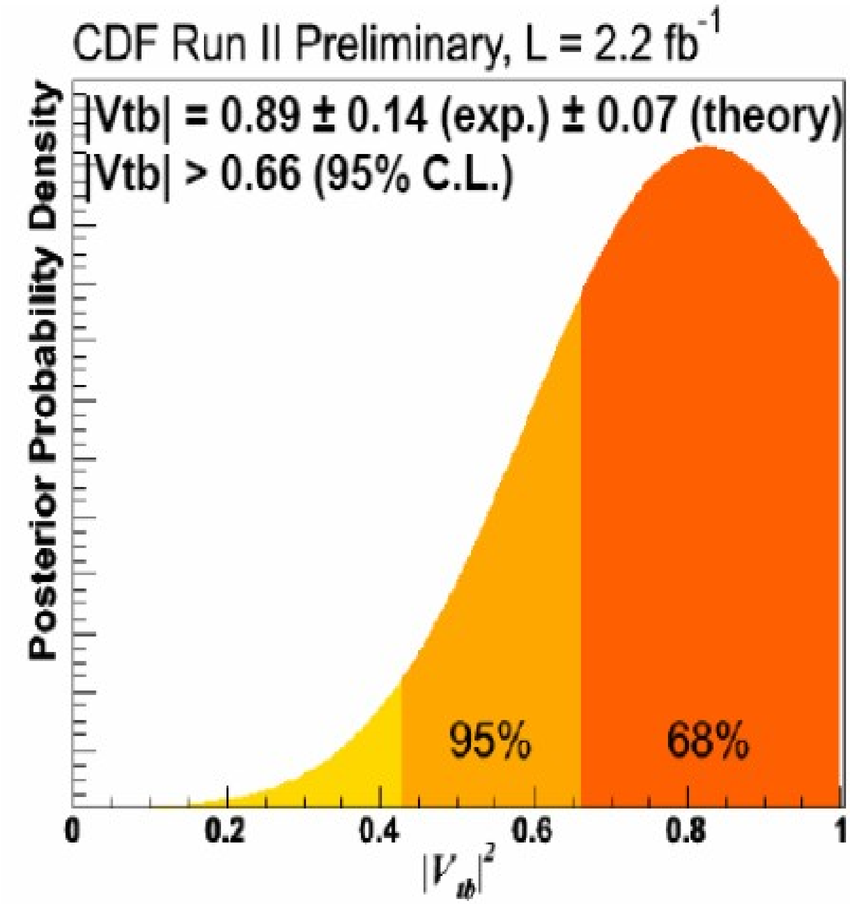
10% precision on Vtb achievable in Wt->2l (16% in Wt->1l) with 10/fb, competitive with standard pp->Wt analysis

Limits on anomalous top couplings better than HERA already after 1/fb
Access to $k_{tc\gamma}$, inaccessible at HERA



The film that incriminates its audience
THE GREAT
SWINDLE
X
SEX PISTOLS
Mary Millington
THE BLACK ARABS
Irene Handl
Sid Vicious
JOHNNY ROTTEN
Paul Cook
STEVE JONES
Malcolm McLaren
Helen of Troy





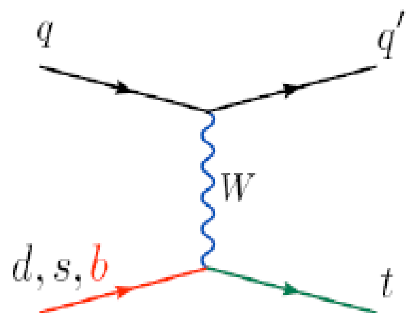
What they call $|V_{tb}|^2$ is σ(observed)/σ(SM).

Claimed (by the CDF and D0 speakers) to be “a model-independent extraction” of Vtb, or at least a determination “in the hypothesis of 3 generations”.

Very tight limit from D0 (since they observe an excess w.r.t. SM)

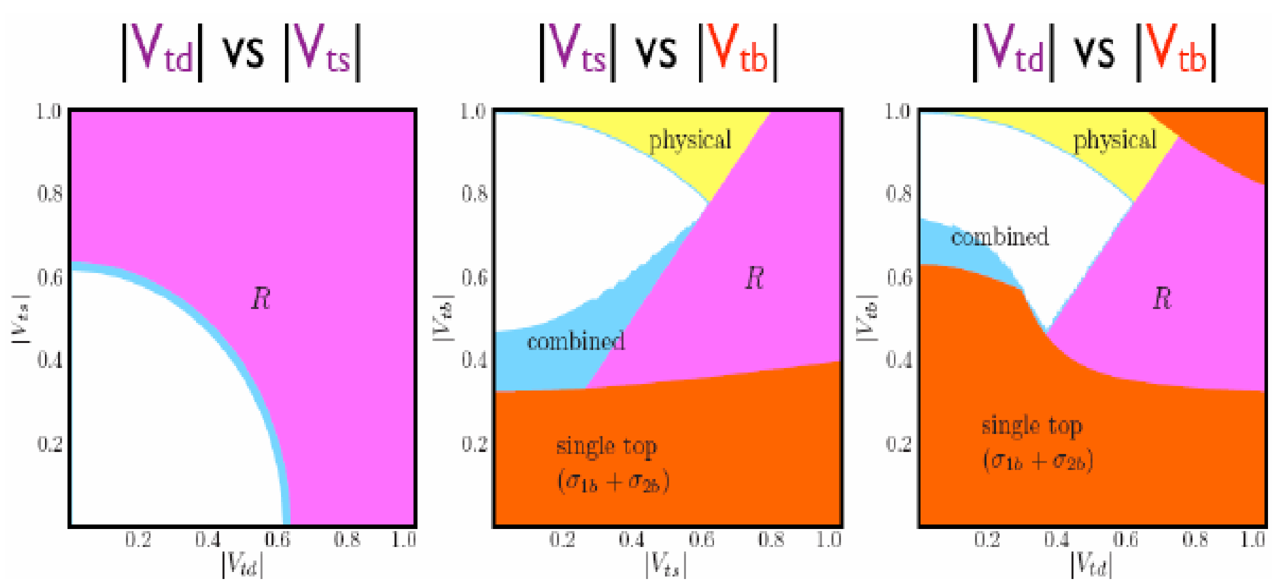
Solution was already in a talk of the day before (and repeated by Scott Willenbrock in the Summary Talk, just to make it clear):

Frederix



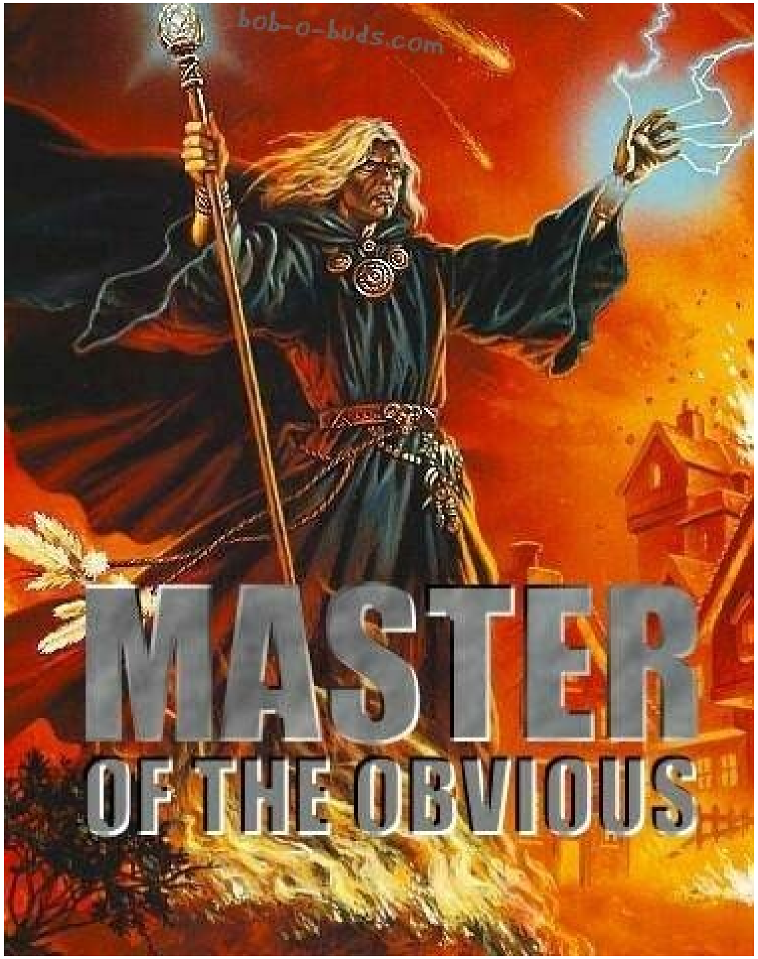
$$\sim |V_{td}|^2 \sigma_d^{\text{t-ch}} + |V_{ts}|^2 \sigma_s^{\text{t-ch}} + |V_{tb}|^2 \sigma_b^{\text{t-ch}}$$

Enhancement due to large *d* and *s* densities

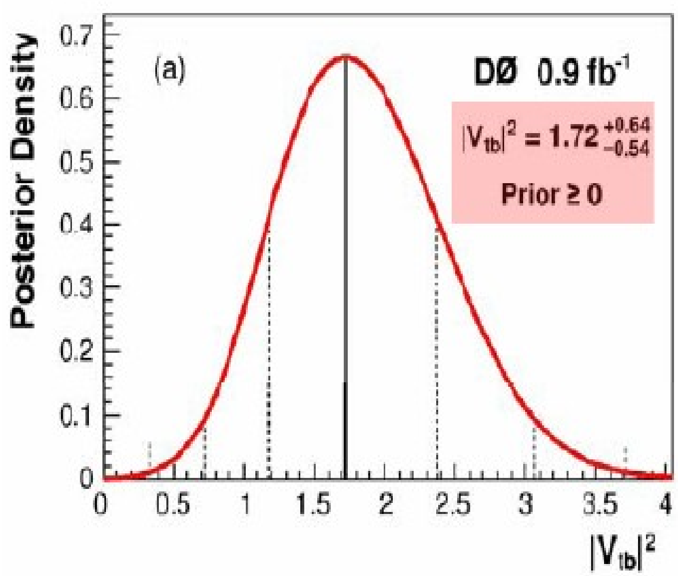


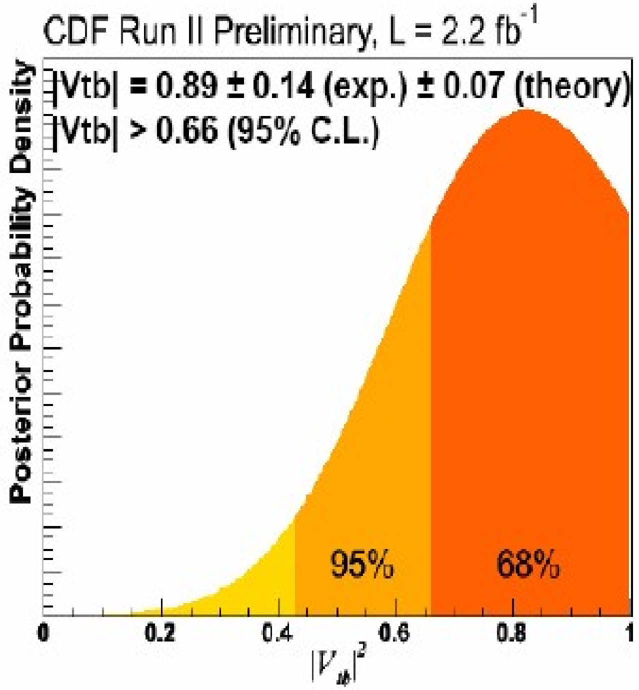
Scott Willenbrock - top2008

If your analysis makes an implicit use(*) of a particular value of a parameter, you cannot use its result to deduce the value of the parameter itself(**).



(*) e.g., your multivariate discriminants are trained to recognize “signal” vs “background” with a definition of signal such that a non-SM signal would be treated as background.
(**) but you can still do a “hypothesis testing”!





~~Assuming three generations~~

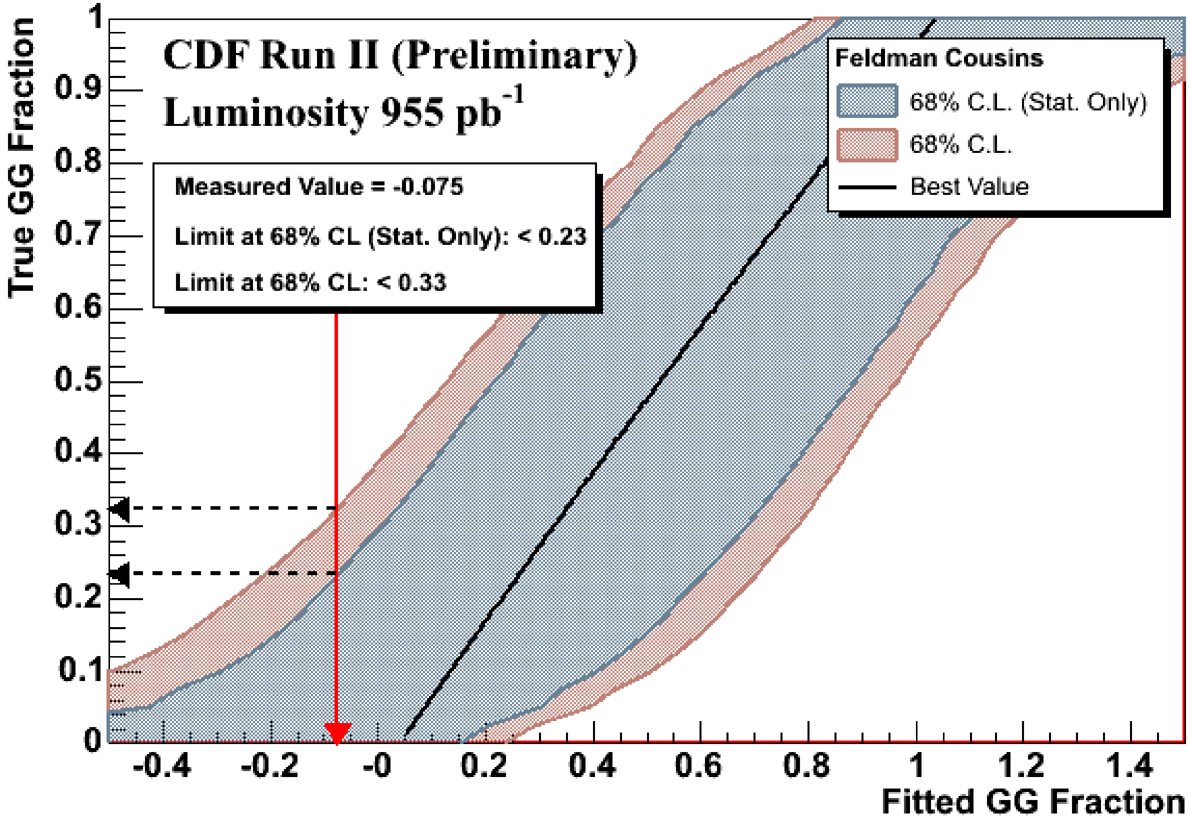
$\boxed{\text{Assuming } V_{tb} \gg V_{ts}, V_{td}}$

Scott Willenbrock - top2008

...this made everybody happy.

About imposing physical constraints

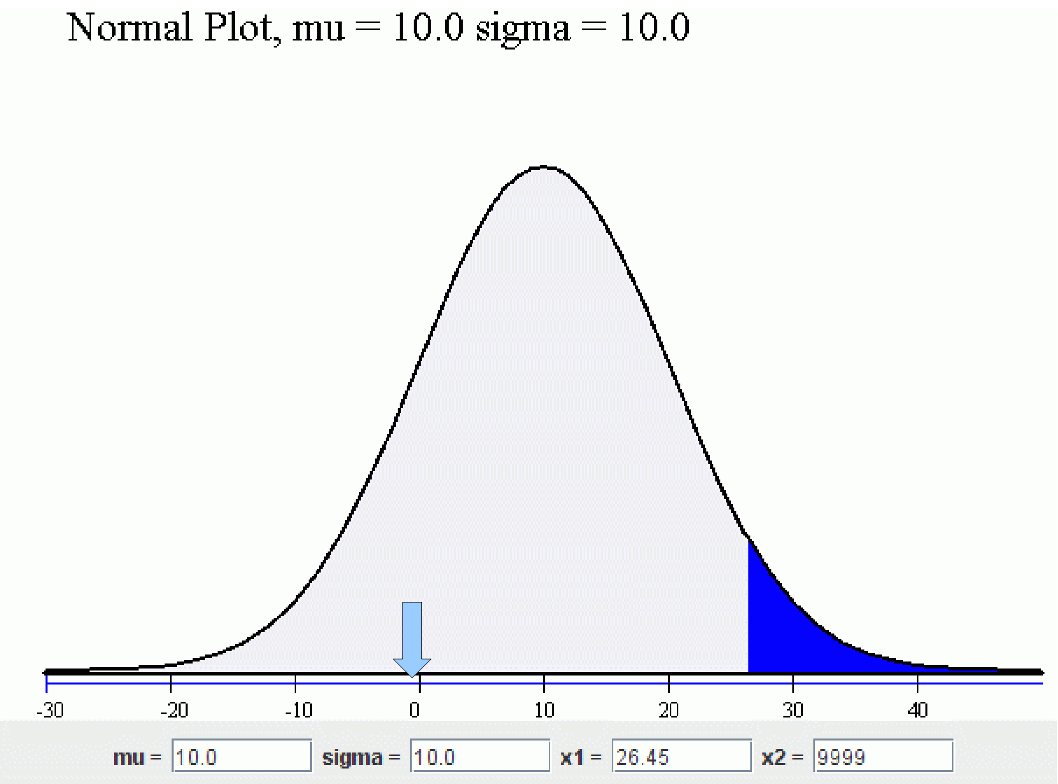
- Recurrent question: does it make sense to quote Confidence Levels for a parameter, when its best fit value is outside the physical boundaries?
- E.g., a negative cross section, a BR>1, an imaginary mass
- Another example from TOP2008:

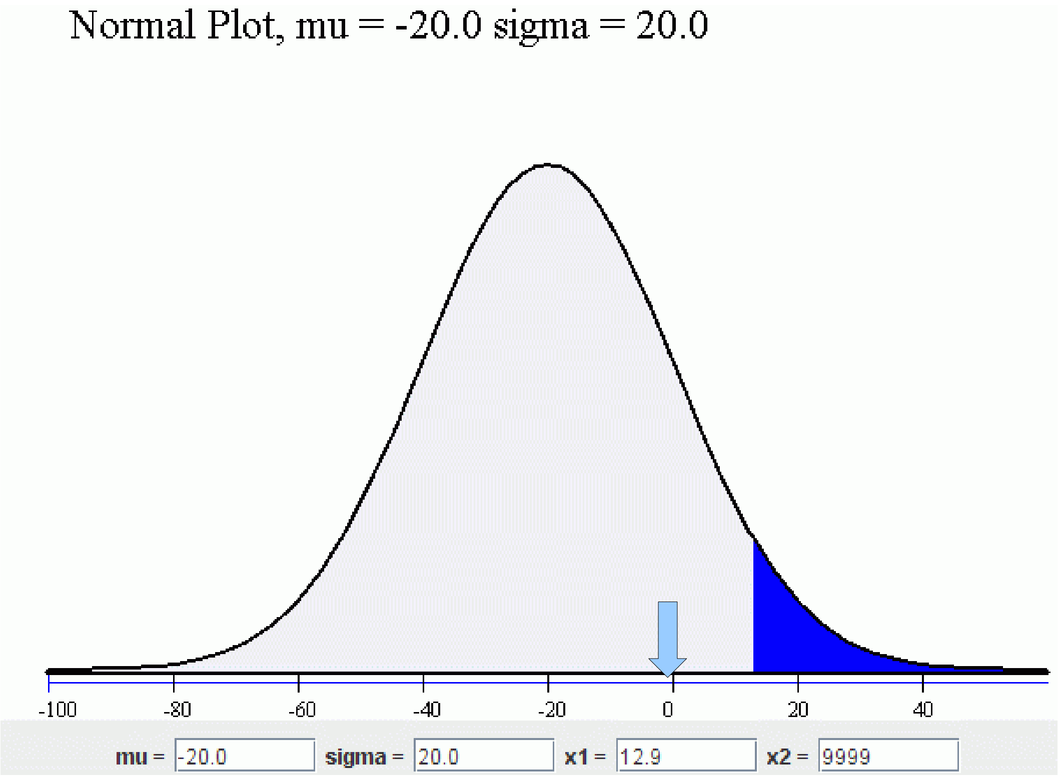


Gedankenexperiment

- Two experiments with different sensitivities
- Both measure a cross section
- Both have results consistent with 0
- But Exp.A gives (10±10)pb, while Exp.B gives (-20±20)pb
  - Which means a downward fluctuation of the background
  - (or New Physics intervening?)
  - (or an unknown systematic effect?)

95%CL limits (naif)





σ<25.5 pb

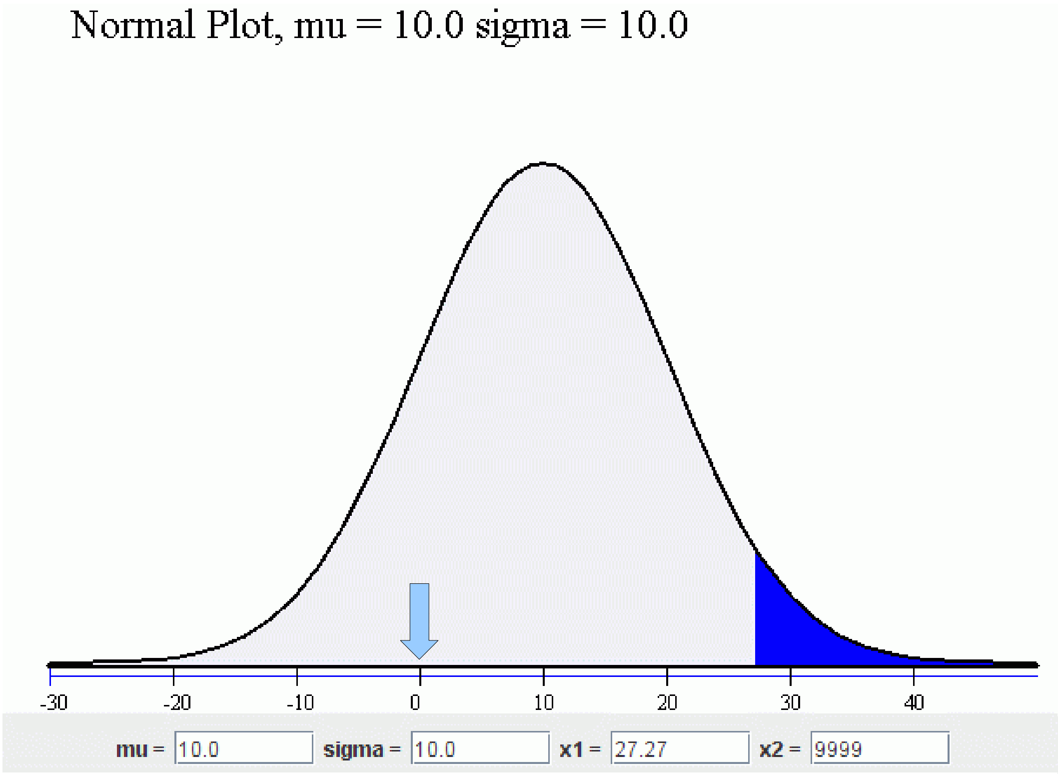
σ<12.9 pb

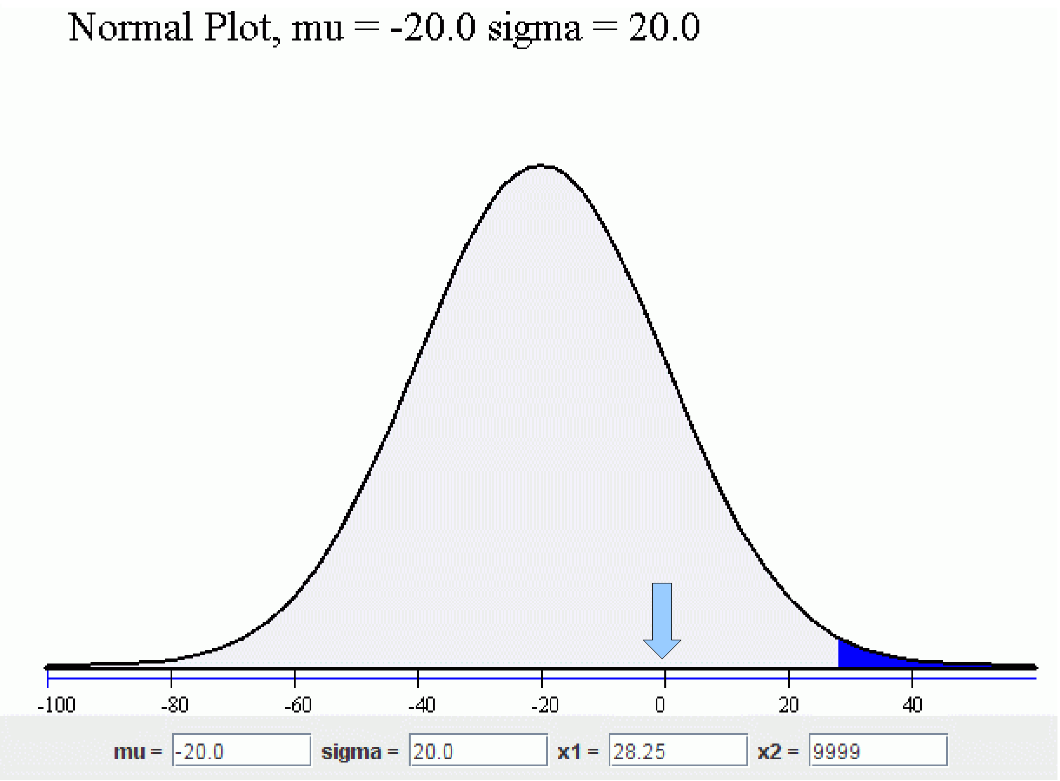
...the experiment with worse resolution is giving better limits!

The “smart PhD student” paradox

- An experiment expects b=2, counts n=0, and sets limits on cross section since $\sigma=(n-b)/\varepsilon L$
  - Typical in neutrino and dark matter experiments
- A smart PhD student finds that a new cut improves the background rejection, with little loss of signal
- Now the experiment expects b=1, obviously n is still 0, the efficiency is almost the same, L is the same
- So the limit is worse!
  - The Feldman-Cousins method of setting limits, although more ingenious than simple application of Poisson formula, suffers from this paradox
  - (But for large n you don't need to care)

95%CL limits with constraint σ>0





σ<27.3 pb

σ<28.3 pb

So it is clearly the best choice...

- ... or not?
- What if the “downward fluctuation of the background” is due to a real physics effect (yet unknown), or to a miscalibration, or...?
- How do you behave if σ=(-20±10)pb? And if σ=(-20±5)pb?
- The “hypothesis testing” step should be clearly separated from the “parameter extraction”
- In the single top case, I believe that the stress should be, at the moment, on testing the SM: is the cross section consistent with our assumptions, which include V_{tb}~1?
- Until a conclusive answer is found, setting limits on V_{tb} is premature (and it hides too much information)

Conclusions

- Very instructive conference
- Lots of lively discussions
  - (only one reported here; the debate about the definition of top mass was also full of passion)
- Next conference in this series will be TOP2010