Selected results on top physics at DØ

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On behalf of the DØ Collaboration

What can be studied on top ?

Mass

Charge

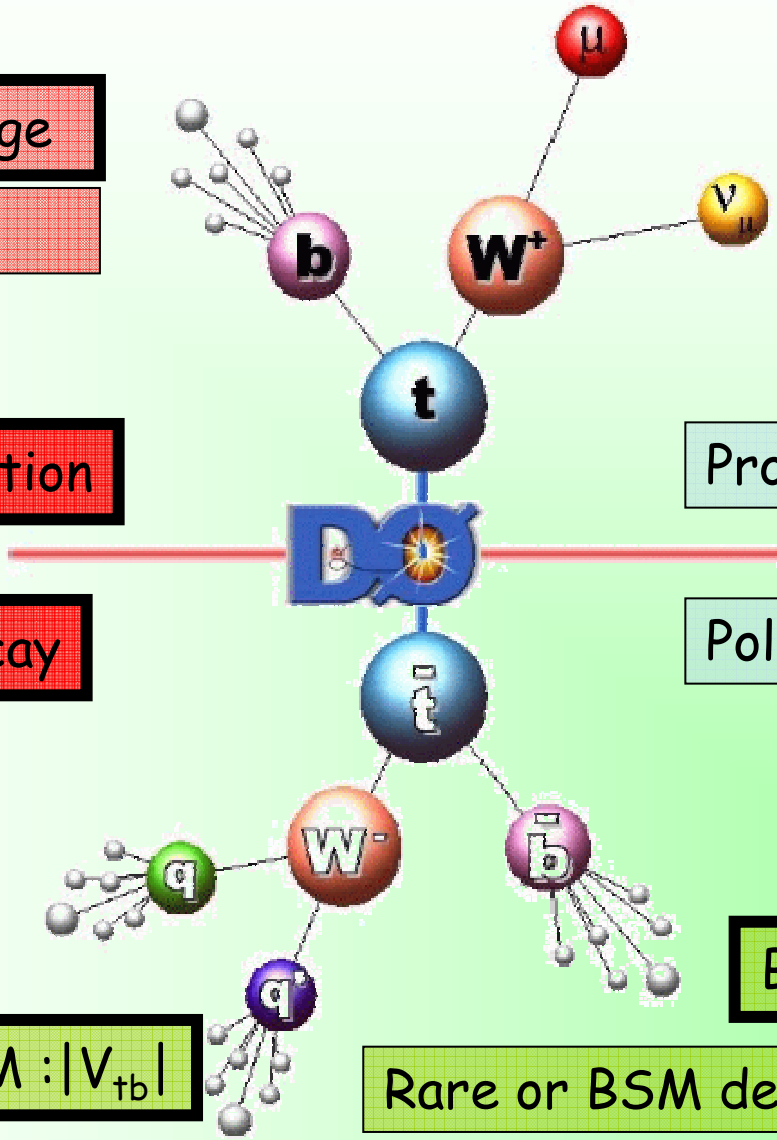
Width

Spin

W helicity

CP violation

Anomalous coupling



Production cross section

Production kinematics

Heavy resonance decay

Polarization

Branching ratios

CKM : $|V_{tb}|$

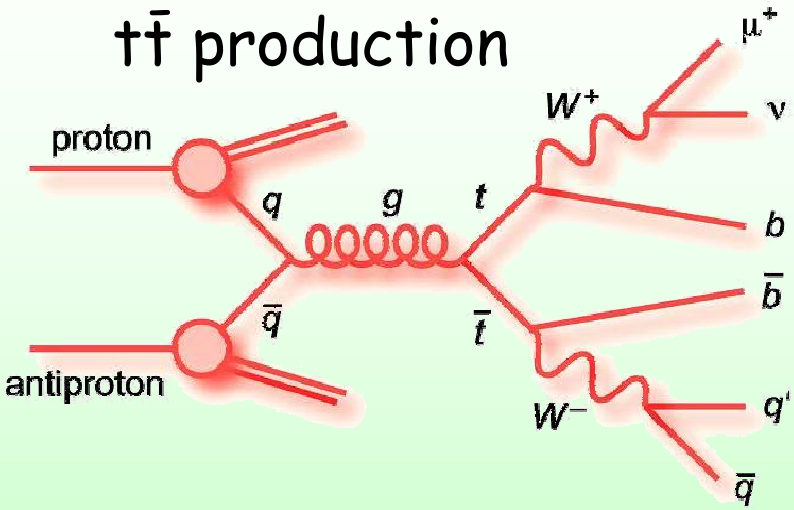
Rare or BSM decays

Top production modes

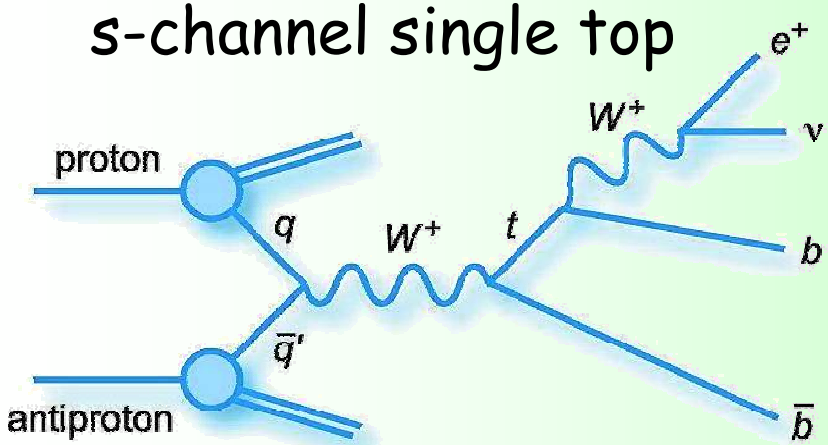
Strong interaction : $t\bar{t}$ pair production
Dominant mode σ_{NNLO}=6.77±1.2 pb
Used to study top properties

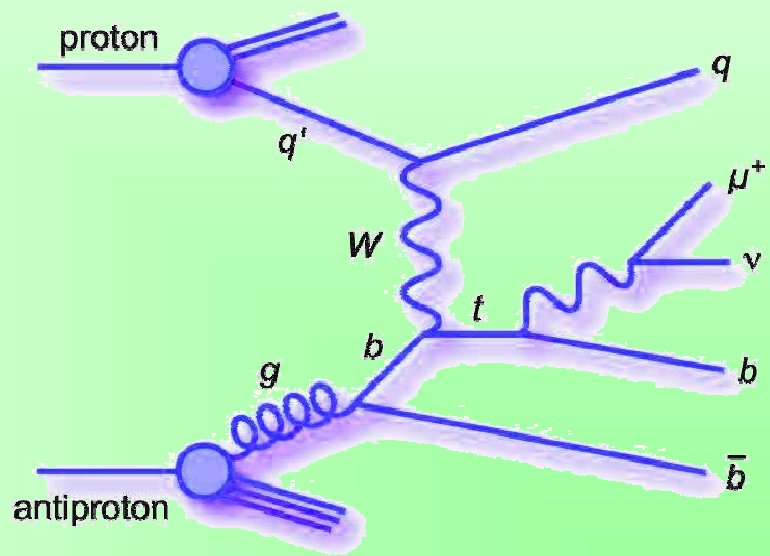
Electroweak interaction : Single top
Larger background, smaller cross section
->**not yet observed**
t-channel σ_{NLO} = 1.98 ± 0.30 pb
s-channel σ_{NLO} = 0.88 ± 0.14 pb
Allow direct measurement of CKM $|V_{tb}|$

$t\bar{t}$ production



s-channel single top





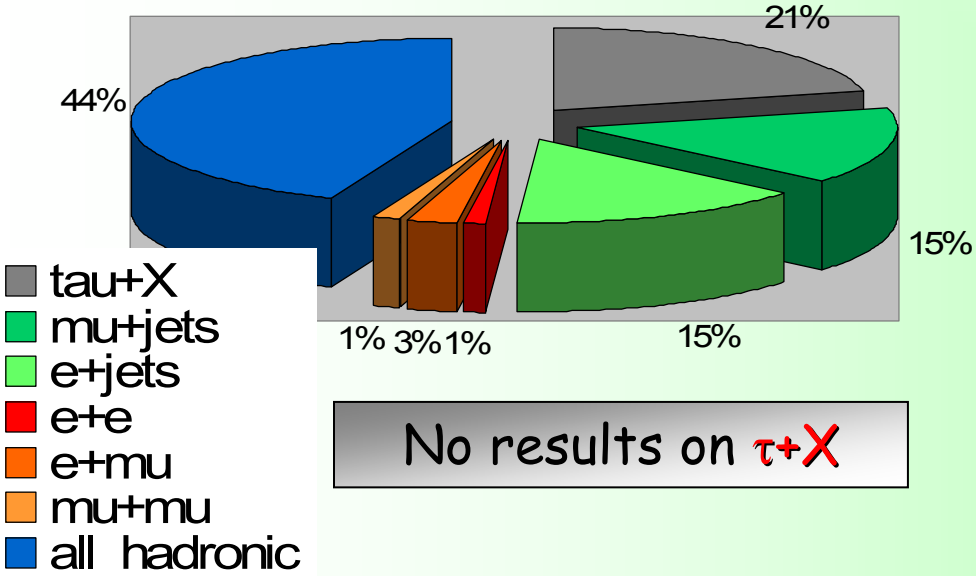
t-channel single top

Top pair final states

Top quark decays in : t->Wb
Analysis channels are characterized by the W bosons decays modes.

Always 2 b jets

single / double b-tagging significantly reduce backgrounds.



No results on τ+X

All-jet : BR ~ 44 % (6 jets)

Large statistics
Dominated by QCD multijet bkg

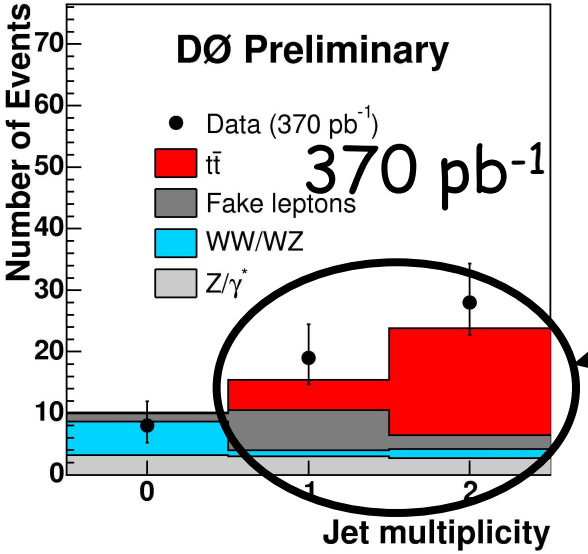
Lepton+jets : BR ~ 30 % (4 jets)
e+jet, μ+jet

Best compromise signal/bkg
Main background : W+jets

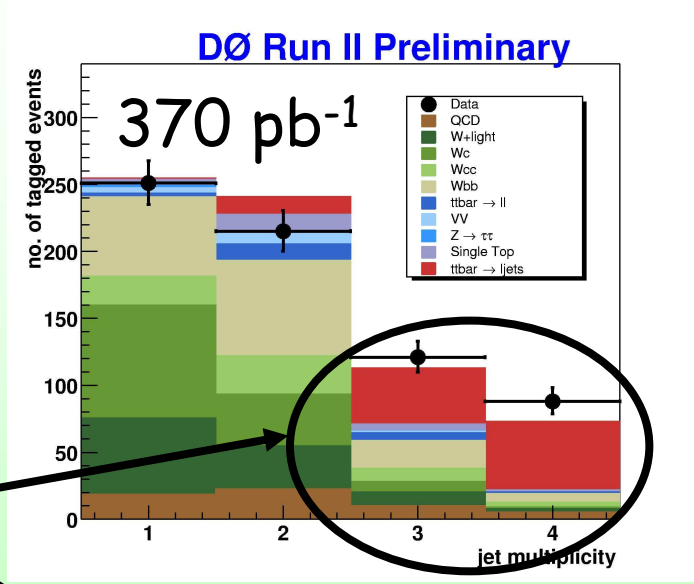
Dilepton : BR~5% (2 jets)
ee, eμ, μμ

Very clean signature, low rate
Main background : Z/W+jets

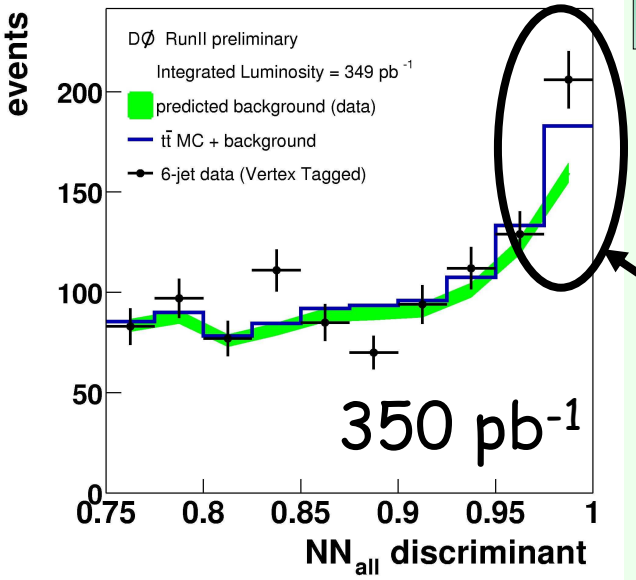
Cross section measurements



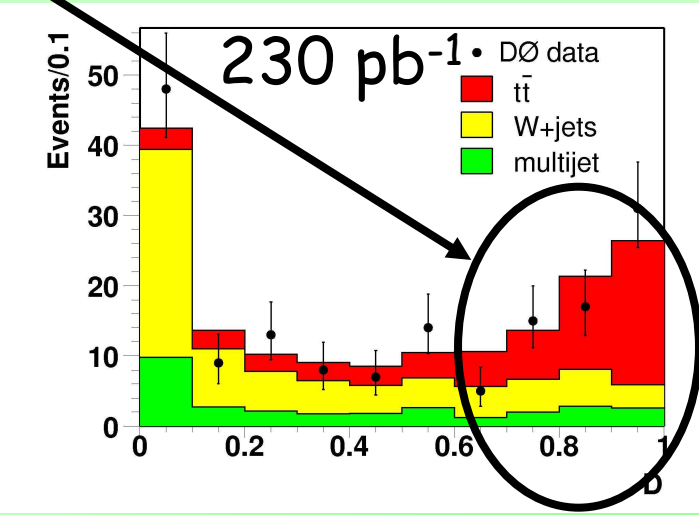
Dilepton :
Topological selection, no b-tagging.



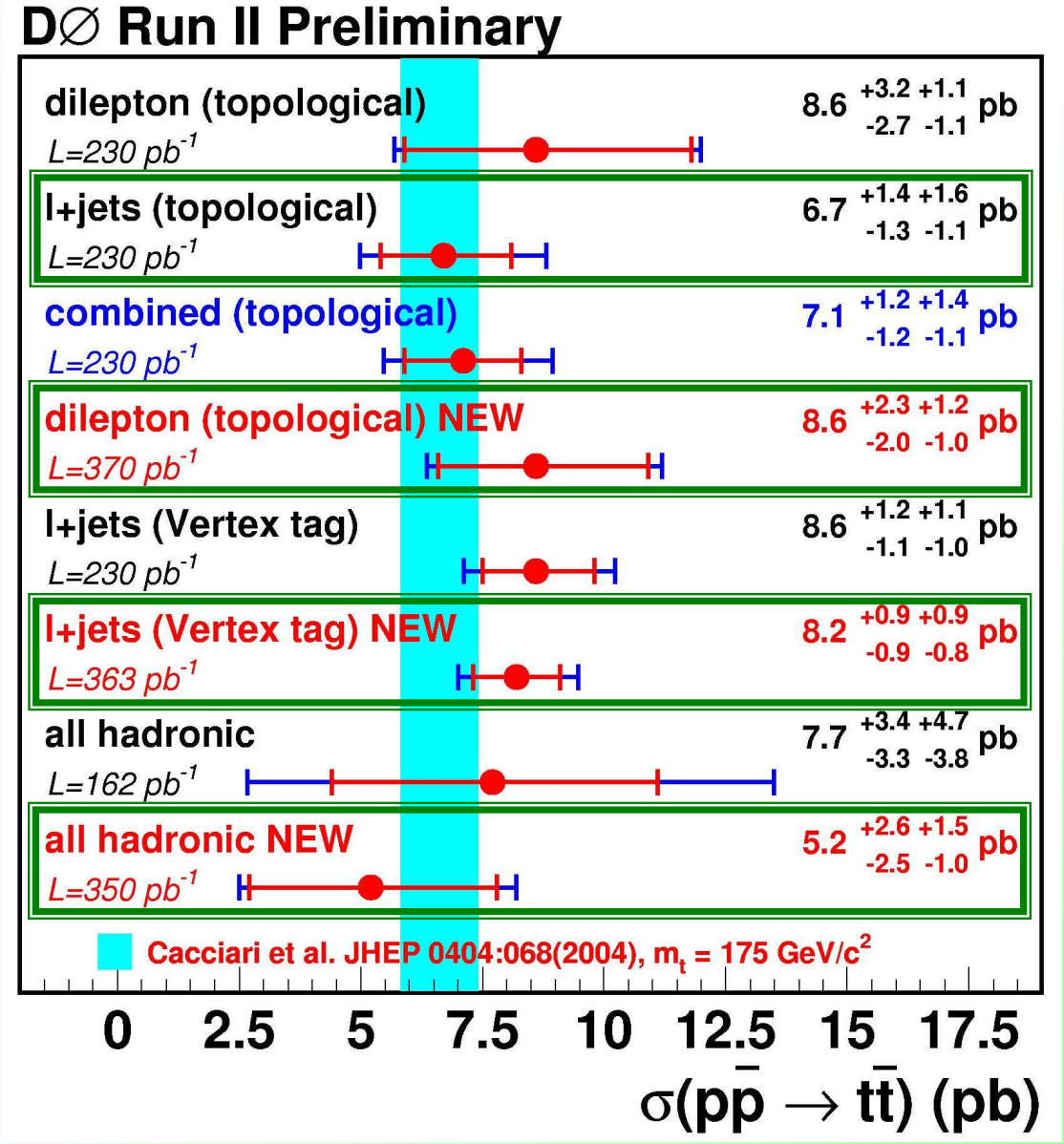
Lepton+jets :
Topological (LH)
Or b-tagging (SVT).



All-jet :
Topological (NN) + b-tag (SVT).



Cross sections summary

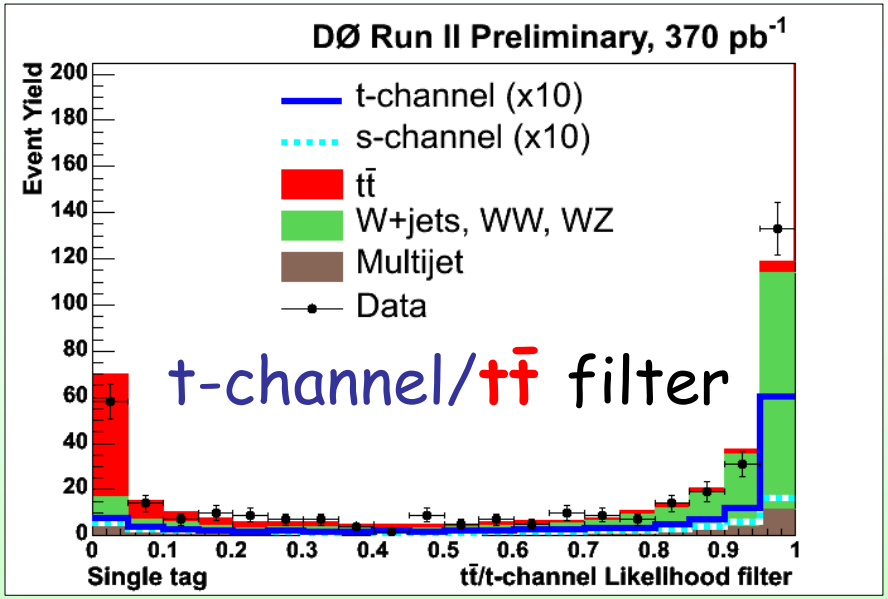


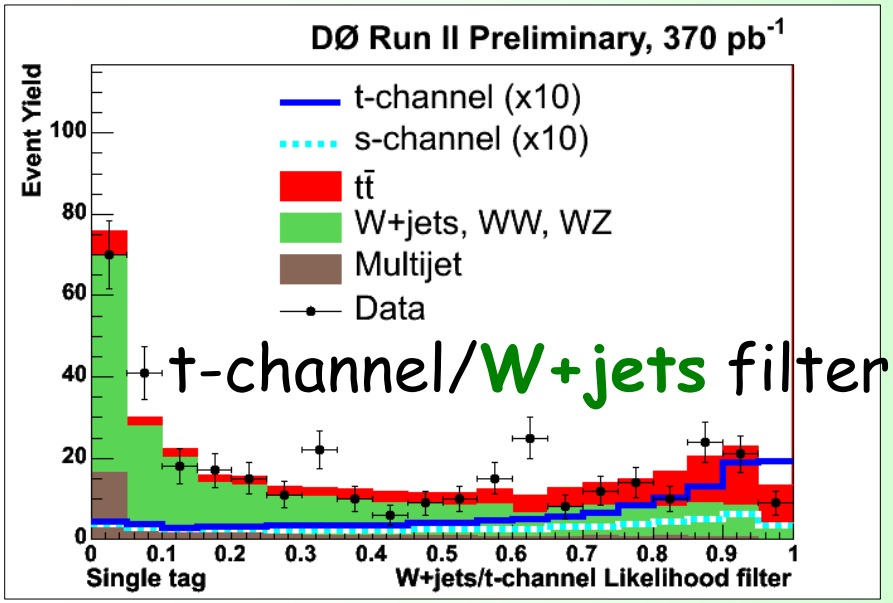
Single top production

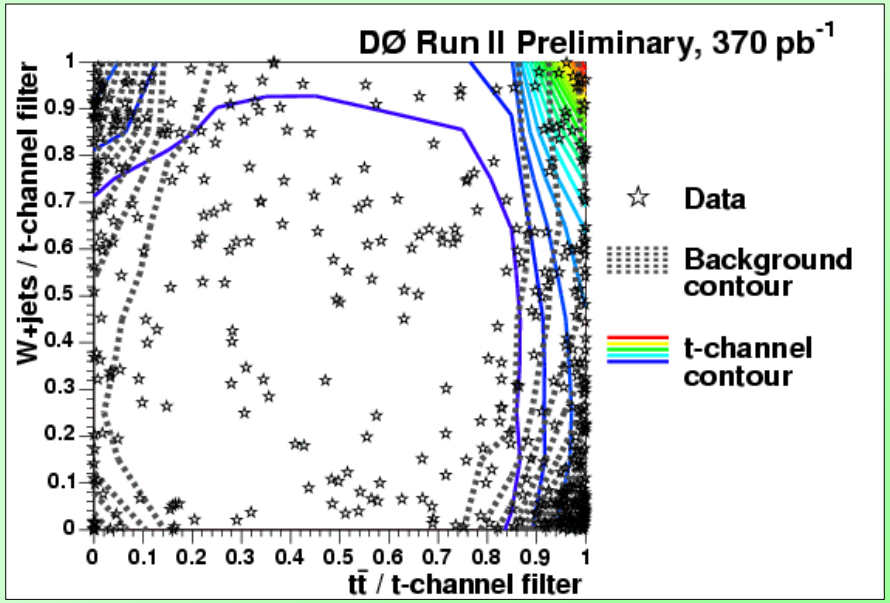
s and t channel searches

Select : 2-4 jets, 1 lepton, Missing transverse energy
Multivariate analysis : NN or Likelihood discriminant

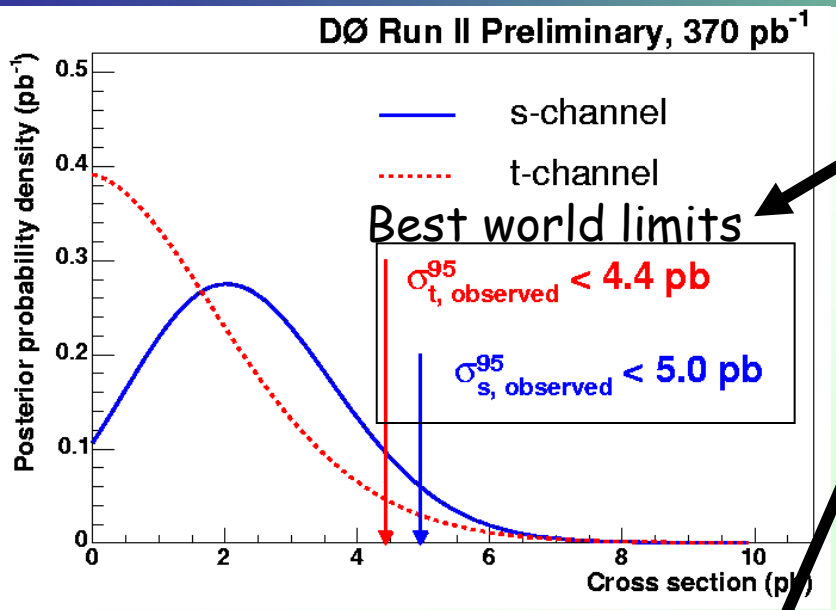
Use 2 filters to discriminate signal from main backgrounds





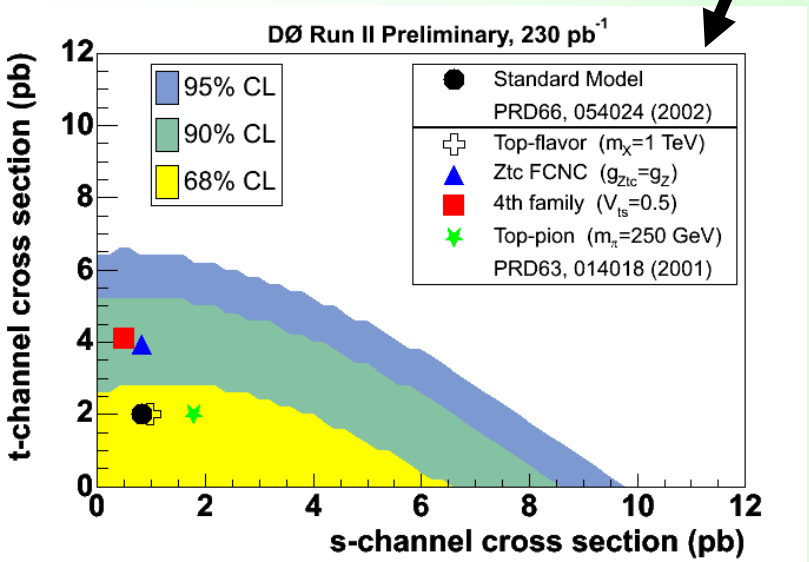


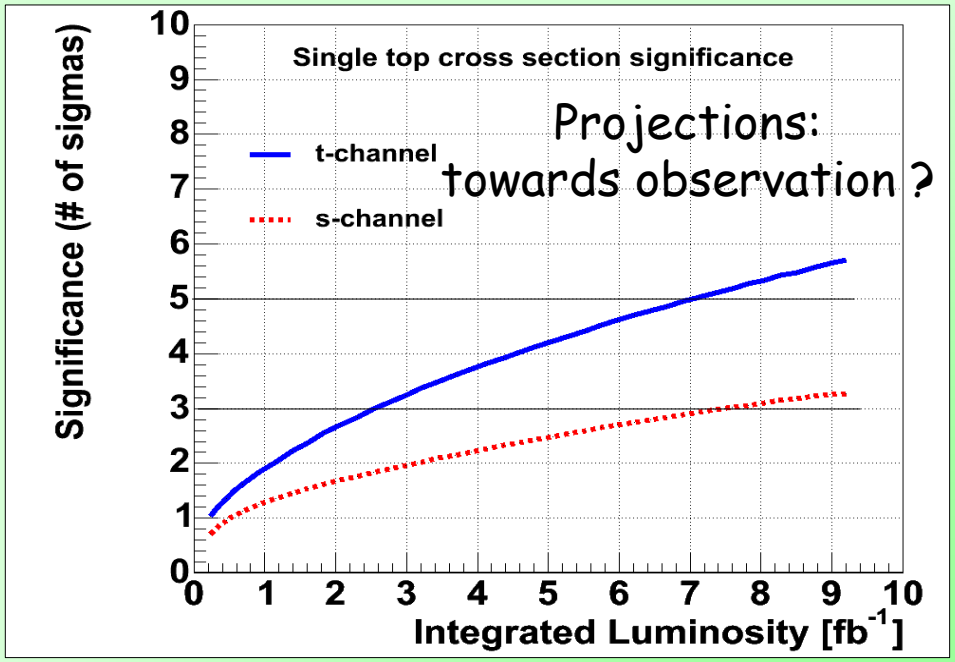
95% CL Bayesian limits



Use full 2D LH distribution to compute bayesian limits

s- and t-channel simultaneous fit : constraint on BSM (NN analysis, 230pb^{-1})





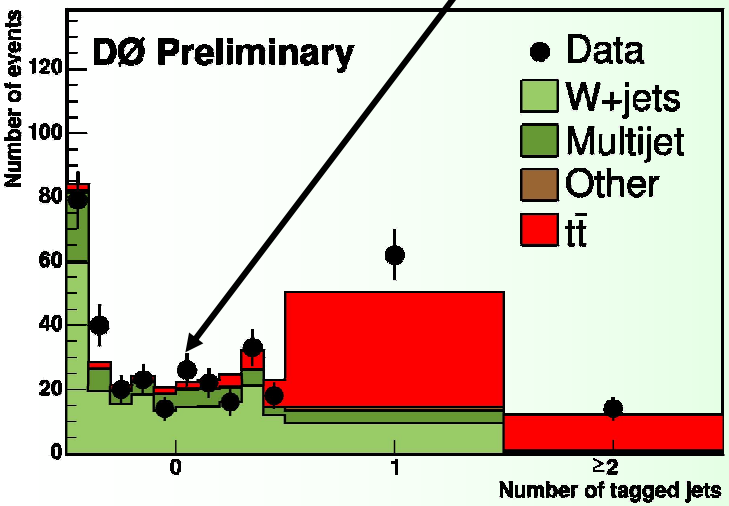
Simultaneous fit of σ_{tt} and R

- Branching ratio $B(t\to Wb)/B(t\to Wq)$:

$$R=\frac{B(t\to Wb)}{B(t\to Wq)}=\frac{|V_{tb}|^2}{|V_{ts}|^2+|V_{td}|^2+|V_{tb}|^2}=|V_{tb}|^2\sim 0.998$$

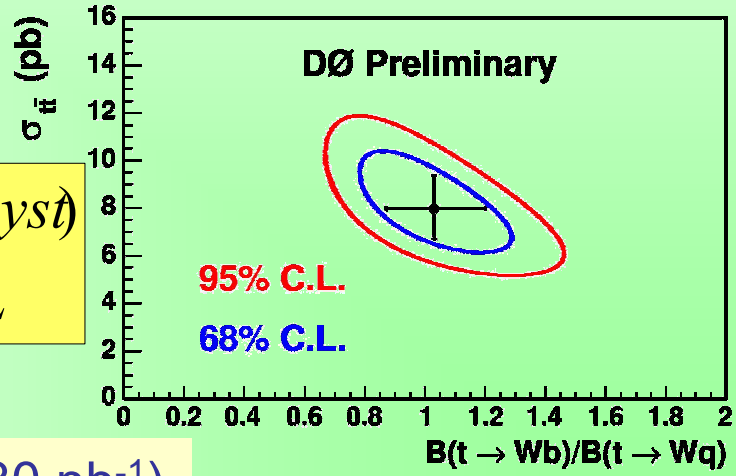
SM unitarity triangle constraint

- Compare events with 0, 1 and 2 b-tagged jet.
  - Use topological likelihood discriminant for 0 tags



$$R=1.03^{+0.19}_{-0.17}(stat+syst)$$

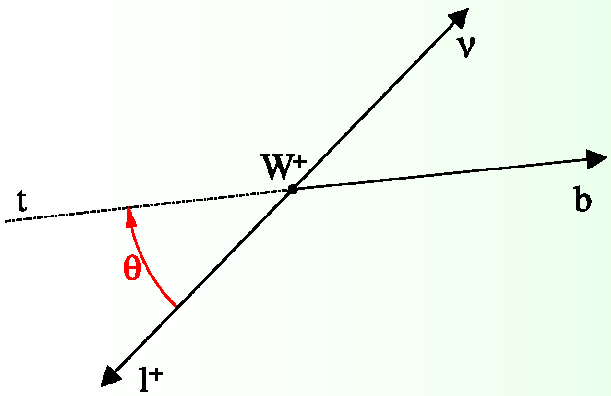
$$R>0.64@95\%\text{CL}$$

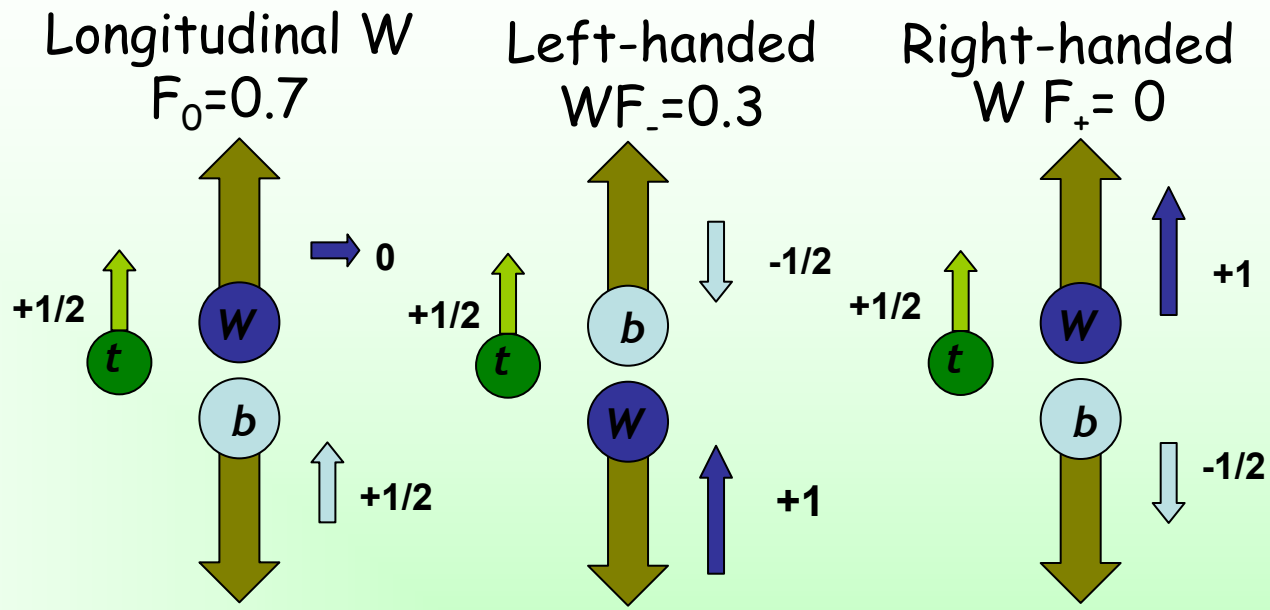


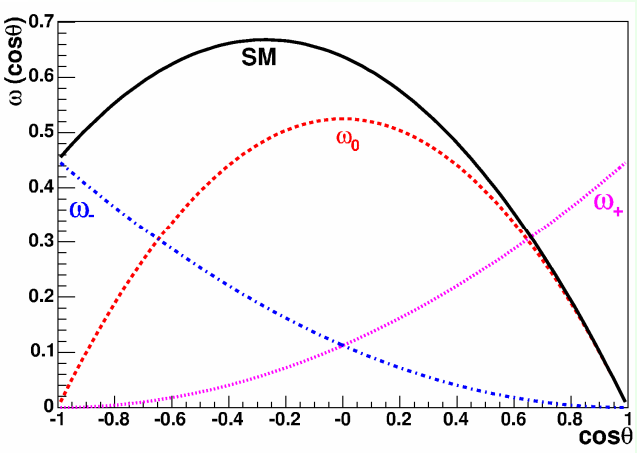
Lepton+jets (~230 pb^{-1})

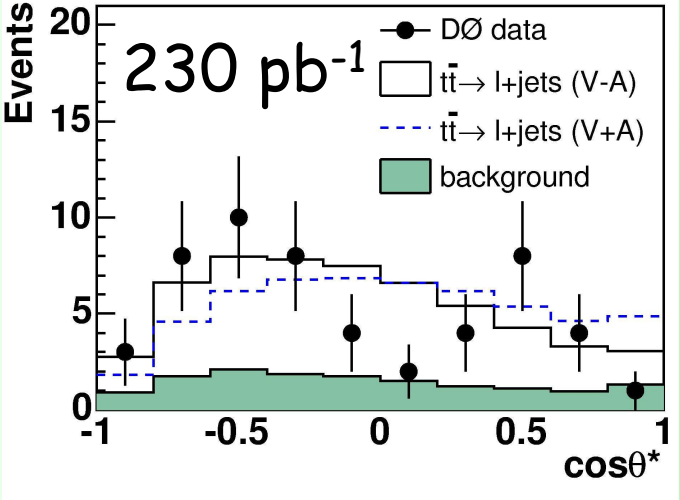
W helicity in top decays

$M_{top} >> M_b, M_W$
Right-handed W suppressed by V-A coupling.









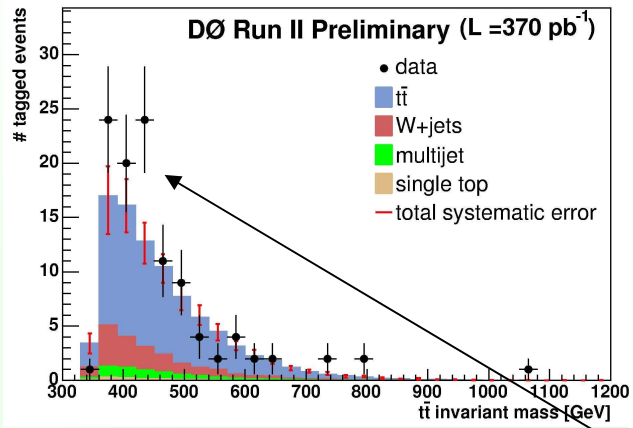
$F_+ = 0.00 \pm 0.13 \pm 0.07$

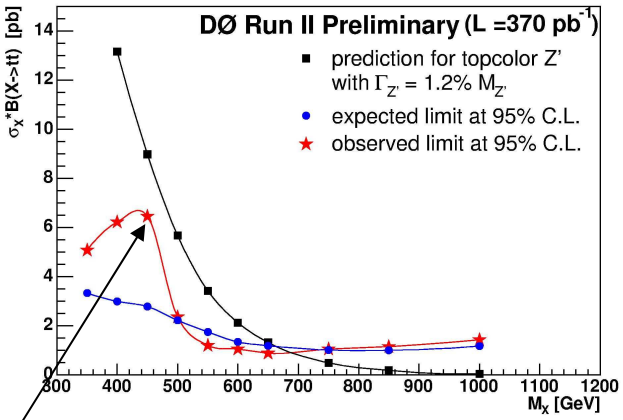
$F_+ < 0.25$ @ 95% CL

Other properties

Heavy resonance X->tt (GUT, ED):

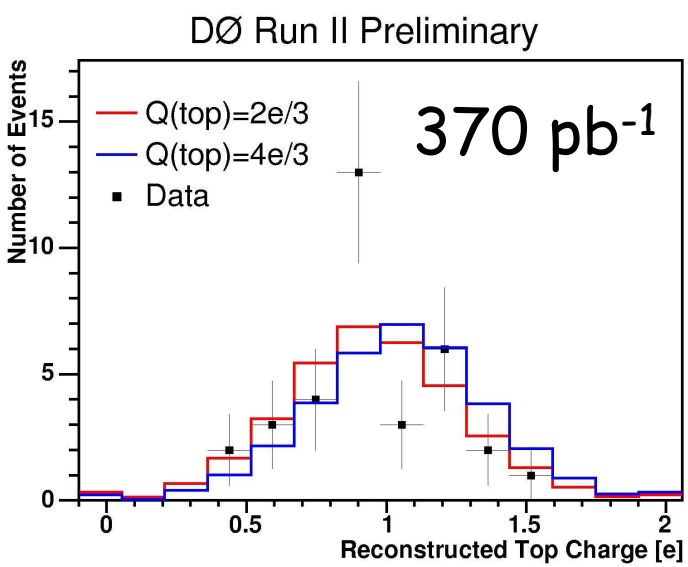
Reconstruct invariant mass of tt system in lepton +jet events.





Small excess at m_X~450 GeV

Not statistically significant



Top charge : is it top or some exotic quark with Q=4/3 ? (compatible with EW data)

W.-F. Chang et al.,hep-ph/9810531, E. Ma et al. , hep-ph/9909537

Use lepton charge + jet charge algorithm:

$$Q_{jet} = \sum_{tracks} q.p_T \Big/ \sum_{tracks} p_T$$

Exclude Q=4/3 at 94% CL

Top quark mass

Lepton+jets :
Dynamic fits (matrix elements) : use all reconstructed information in event by event likelihood
Topological fits (templates)
Dilepton : Dalitz and Goldstein, RunI method

Reducing Jet energy scale systematics
Simultaneous fit of top mass and JES on hadronic W in lepton+jet events

Dilepton (230pb^{-1}):

$155^{+14}_{-13}(\text{stat}) \pm 7(\text{syst})\text{GeV}$

Lepton+jet:

Templates topological (230pb^{-1}):

$169.9 \pm 5.8(\text{stat})^{+7.8}_{-7.1}(\text{syst})\text{GeV}$

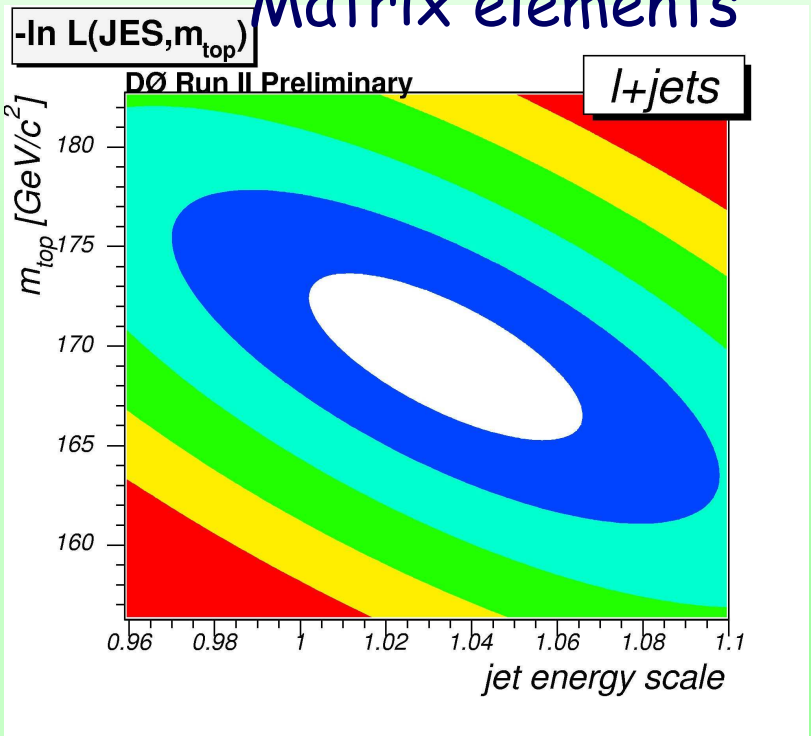
Template btag (230pb^{-1}):

$170.6 \pm 4.2(\text{stat}) \pm 6.0(\text{syst})\text{GeV}$

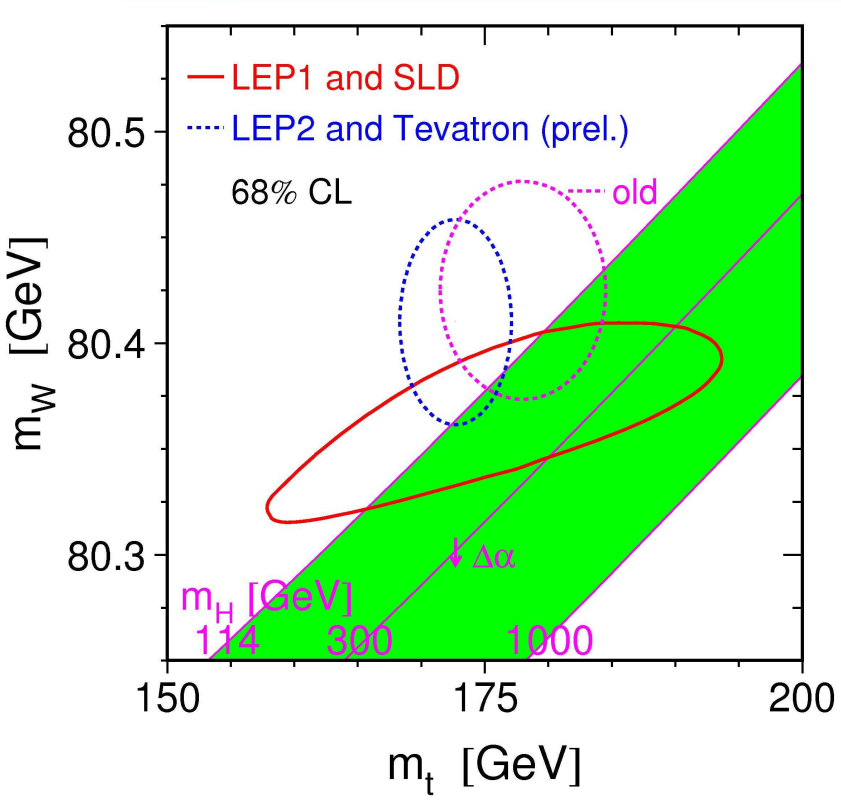
Matrix element (370pb^{-1}):

$169.5 \pm 4.4(\text{stat} + \text{JES})^{+1.7}_{-1.6}(\text{syst})\text{GeV}$

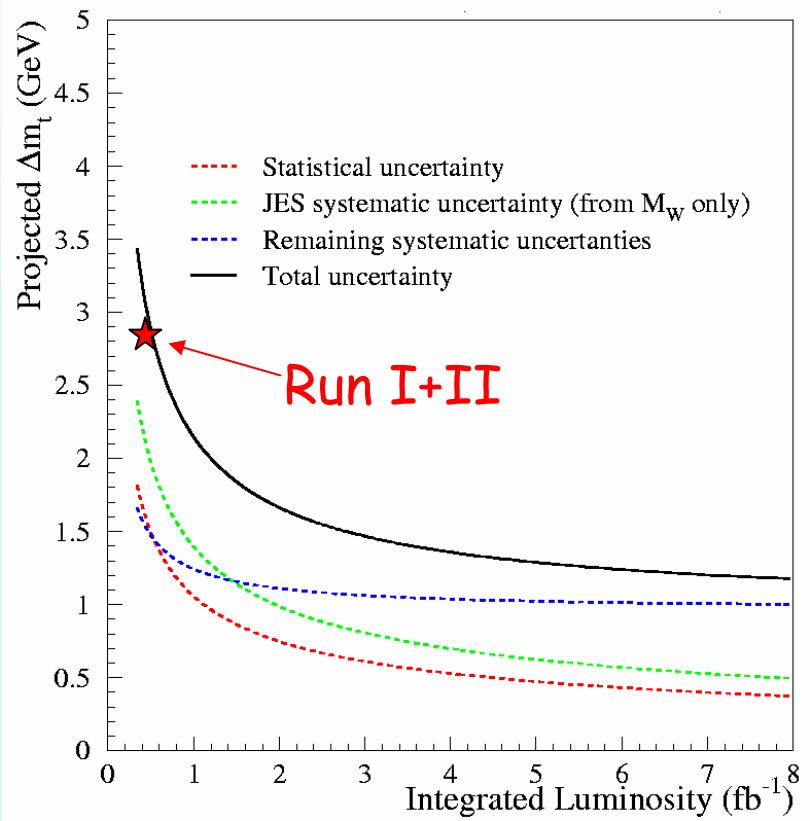
Matrix elements



Top Mass results and prospects



Prospect for RunII (CDF+D0)
$\Delta m_{top} < 1.5$ GeV/c^2
with 2 fb^{-1}



m_W = 80.425 ± 0.038 GeV/c^2 (LEP2)
m_{top} = 172.7 ± 2.9 GeV/c^2 (DØ+CDF)

Conclusion

Top physics is a sector to probe the standard model at the energy of the EW symetry breaking (Yukawa coupling~1).

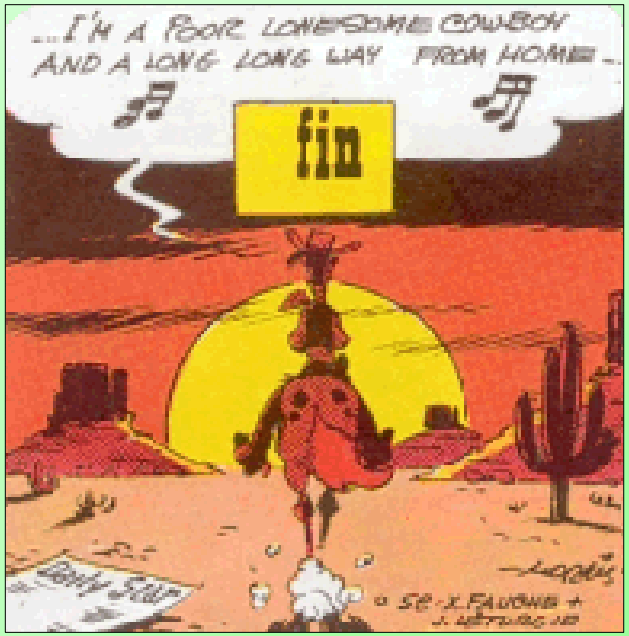
New physics could appear in top properties : need precise studies -> W helicity, top kinematics, rare decays,…

Can only be studied at the Tevatron (until LHC shows up…)

Updated results in a few weeks/months : ~1 fb^{-1} of data

- reduced top mass uncertainties
- towards single top observation
- top properties : charge, W helicity

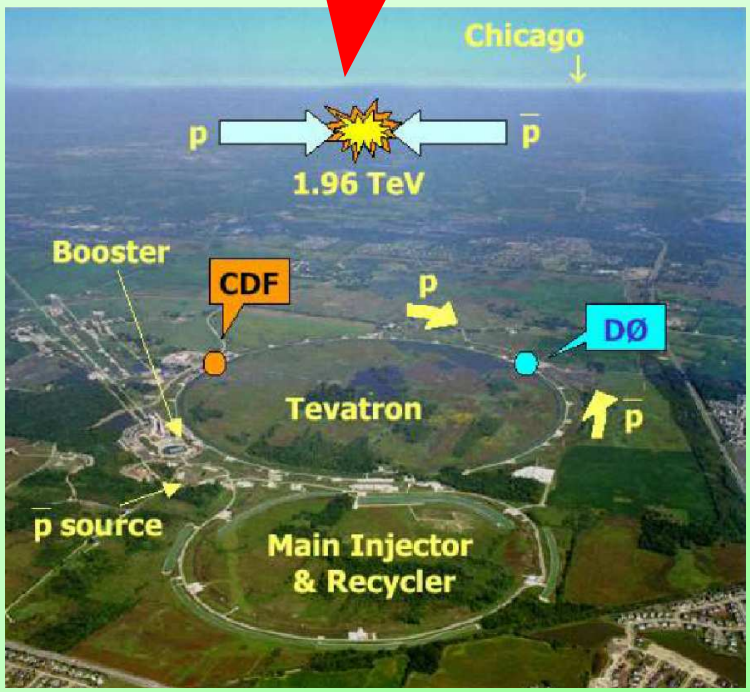
Many exciting results coming…



Backup

Tevatron $p\bar{p}$ collider

	Run I	Run IIa	Run IIb
Bunches / turn	6 × 6	36 × 36	36 ×36
√s (TeV)	1.8	1.96	1.96
Luminosity ($cm^{-2}s^{-1}$)	1.6×10^{30}	1×10^{32}	3×10^{32}
∫ Ldt (pb^{-1}/week)	3	17	50
Crossing time (ns)	3500	396	396
Interactions/crossing	2.5	2.3	8
Duration	92/96	01/06	06/09



Increase anti-proton production:

antiprotons recycler (fall 2004)
electron cooling (summer 2005)

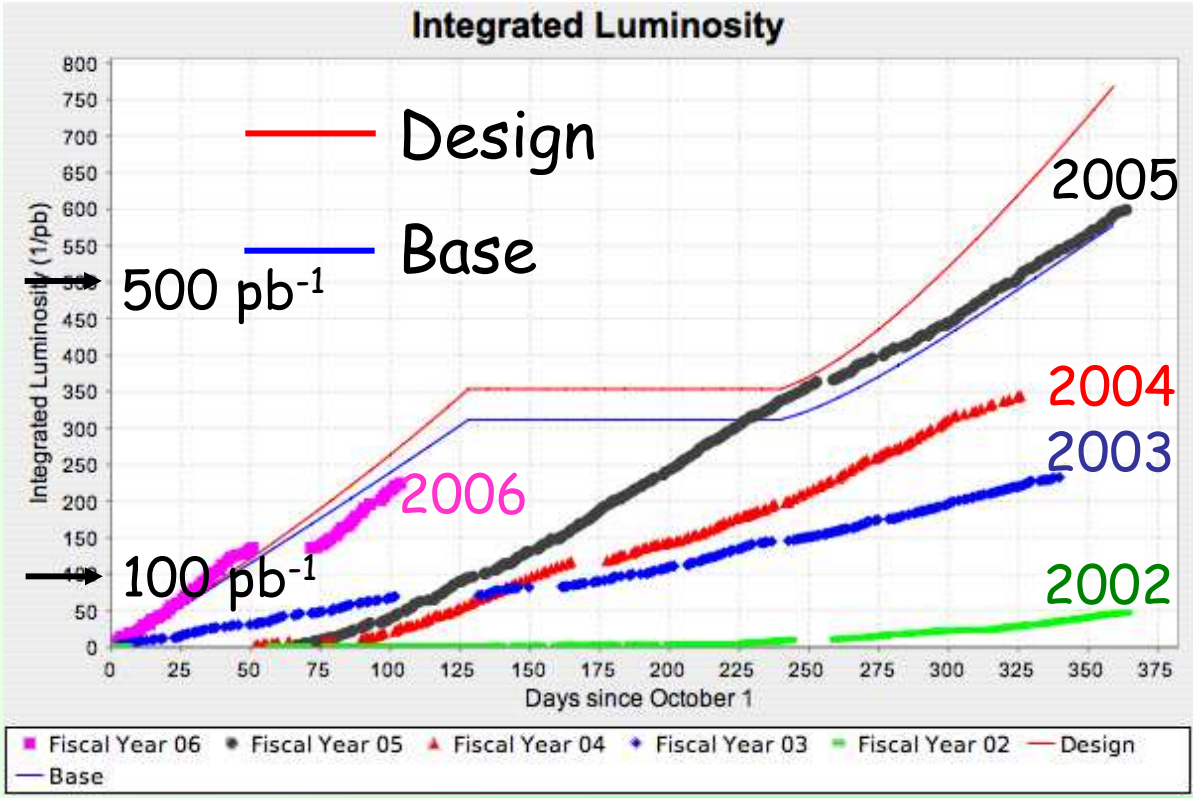
Luminosity

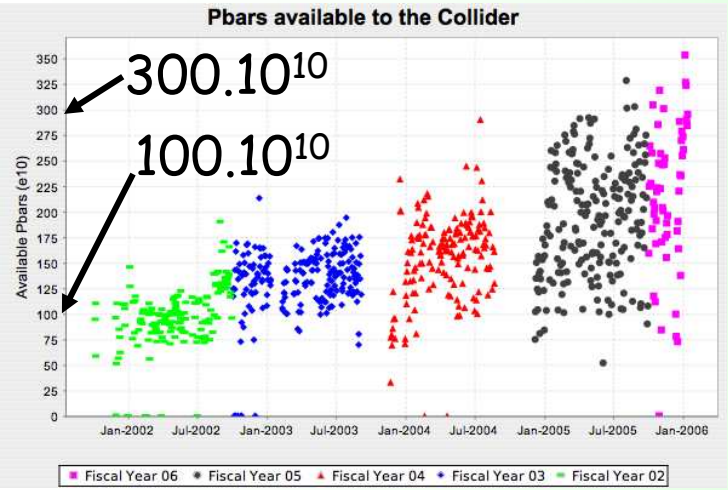
Start physics data taking in april 2002:

~1.4 fb^{-1} delivrered

~ 1.15 fb^{-1} recorder

Efficiency : ~83%

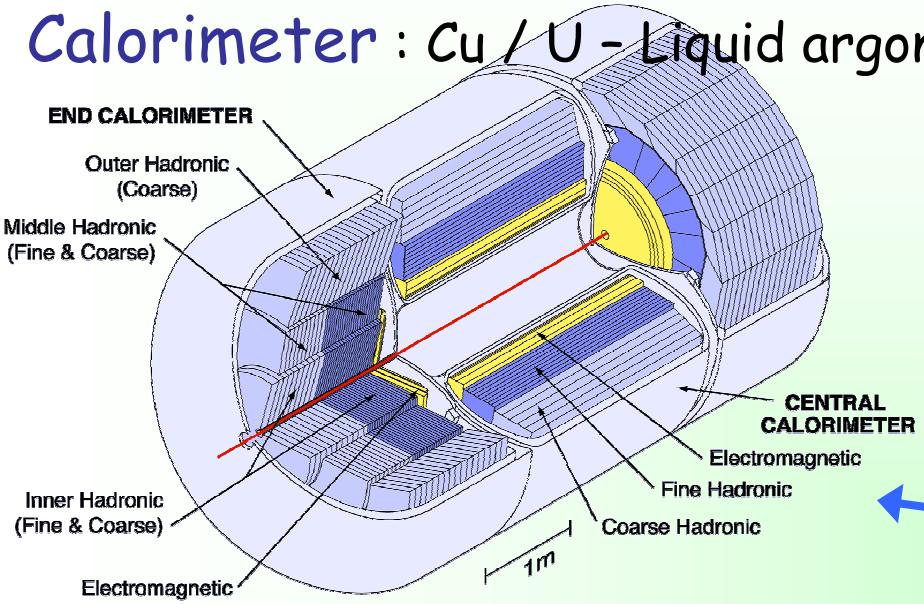




<- Number of antiprotons available

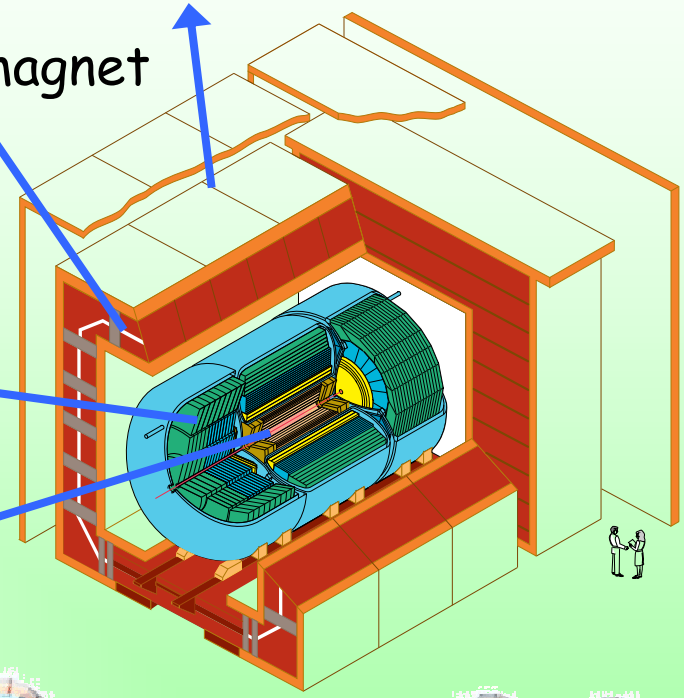
The DØ detector

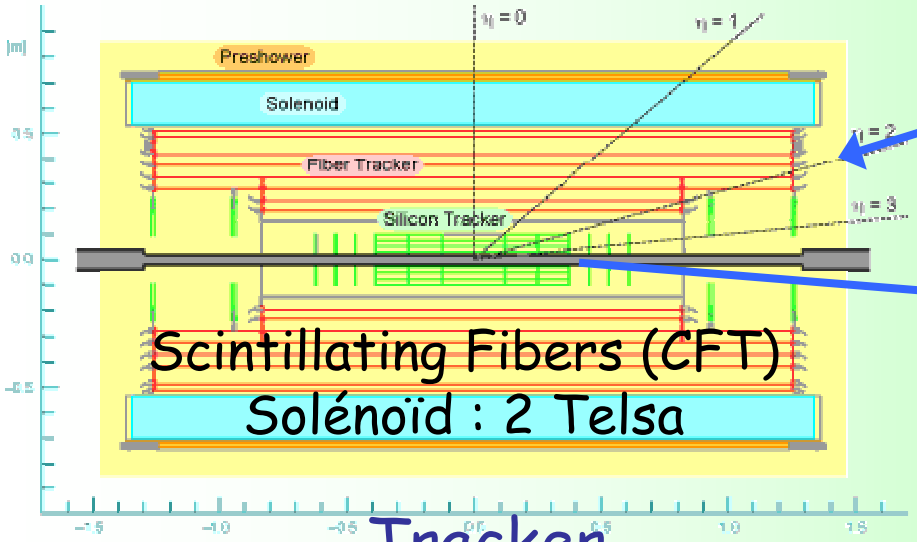
Calorimeter : Cu / U - Liquid argon



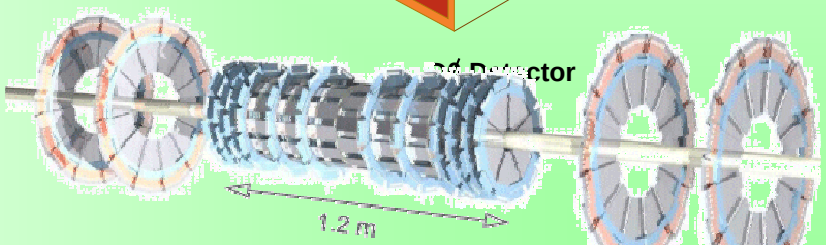
Muons chambers :
Drift tubes and scintillators

Toroïd magnet





Tracker



Vertex detector : silicon microstrip tracker (SMT)

b-jets identification

Very important in top physics, Higgs search (H->bb) and some SUSY channels (sbottom, stop)

Bottom hadrons charactristics

Decay through weak interaction with change of family : large lifetime(~10^{-12}s)

- Tracks with large impact parameters (IP) wrt. PV -> JLIP
- Secondary decay vertex (decay length ~ a few mm) -> SVX

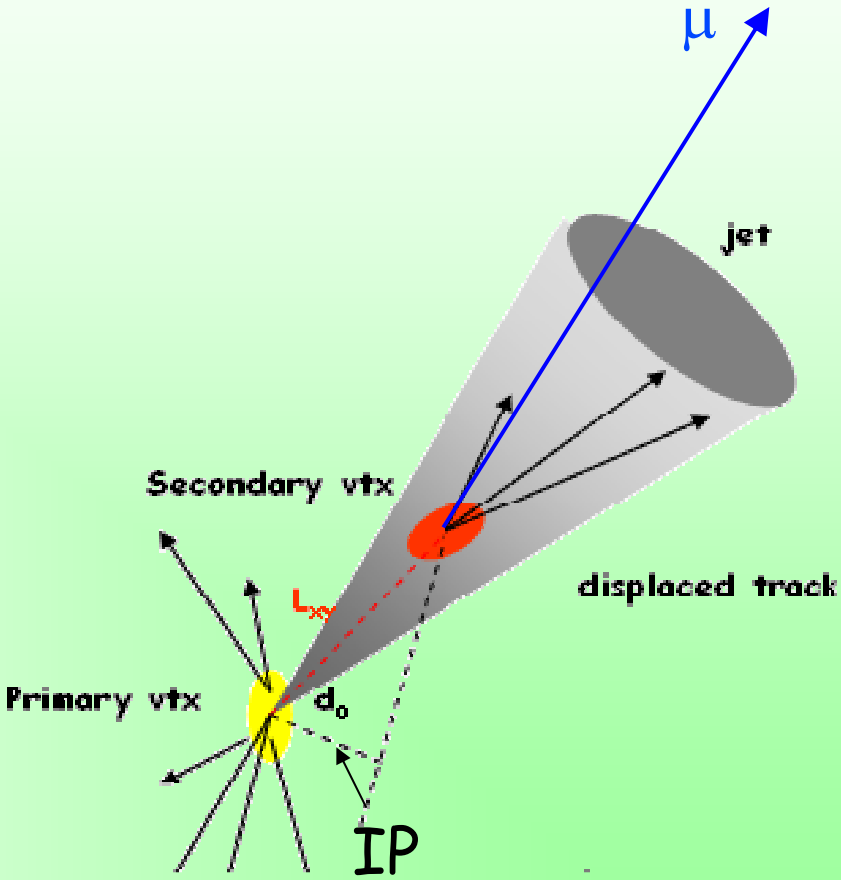
High mass (~4.5 GeV/c^2) :

- Large invariant mass of tracks in SV.
- Hard fragmentation : open jets.

Large semi-leptonic decay rate (~20%) :

- Muons or electrons within jets.

-> SLT



B-tagging algorithms

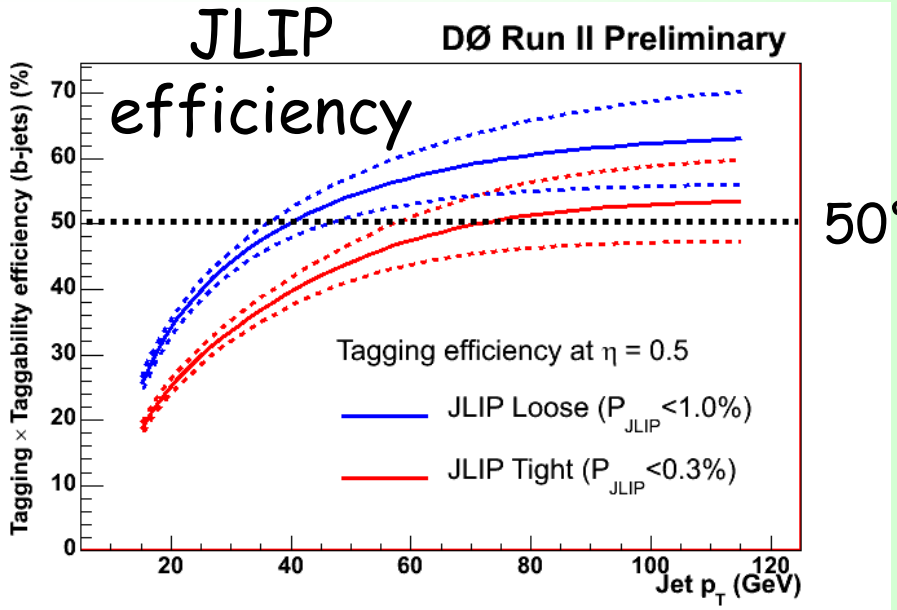
Three algorithms at DØ :

SLT : *Soft Lepton Tagger*, identify muon/electron within a jet.

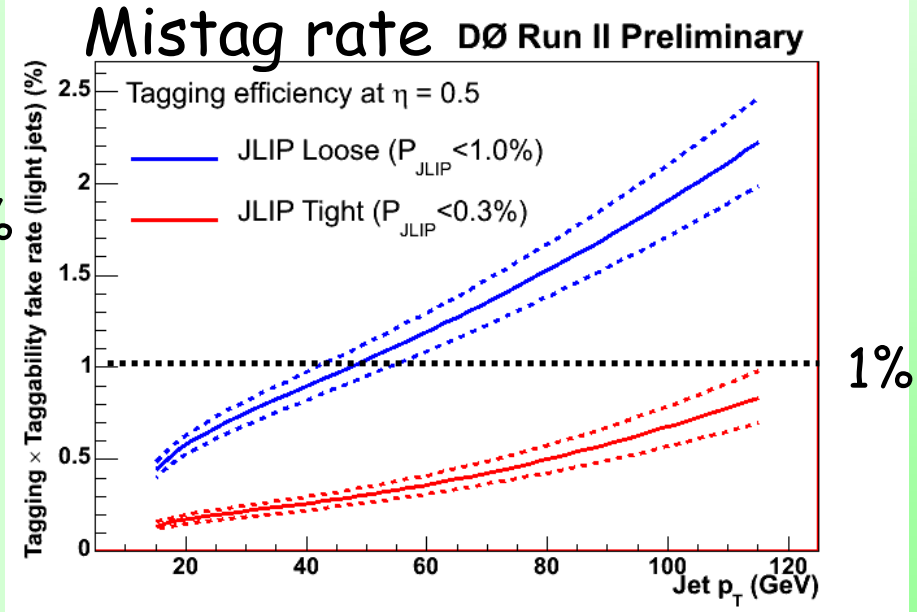
SVX : Reconstruction of secondary vertices with large dacay length

JLIP : *Jet Life Time Probability*, combine IP of tracks within a jet into a probability for the jet to originate from the primary vertex.

Both efficieny and mistag are measured in real data.



50%



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