Measurement of the top pair production cross section in the lepton+jets channel using a soft-muon *b*-jet tagger

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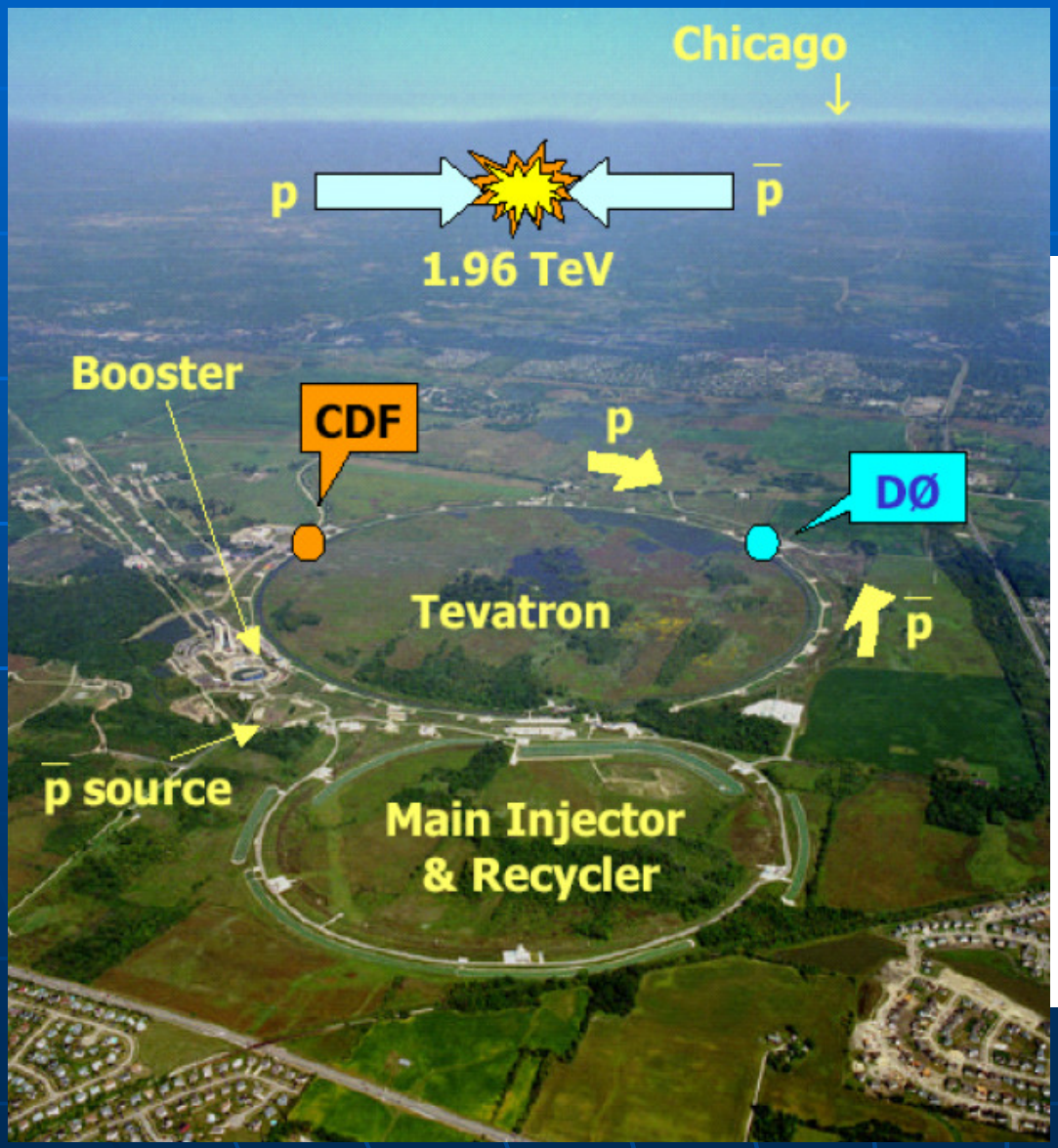
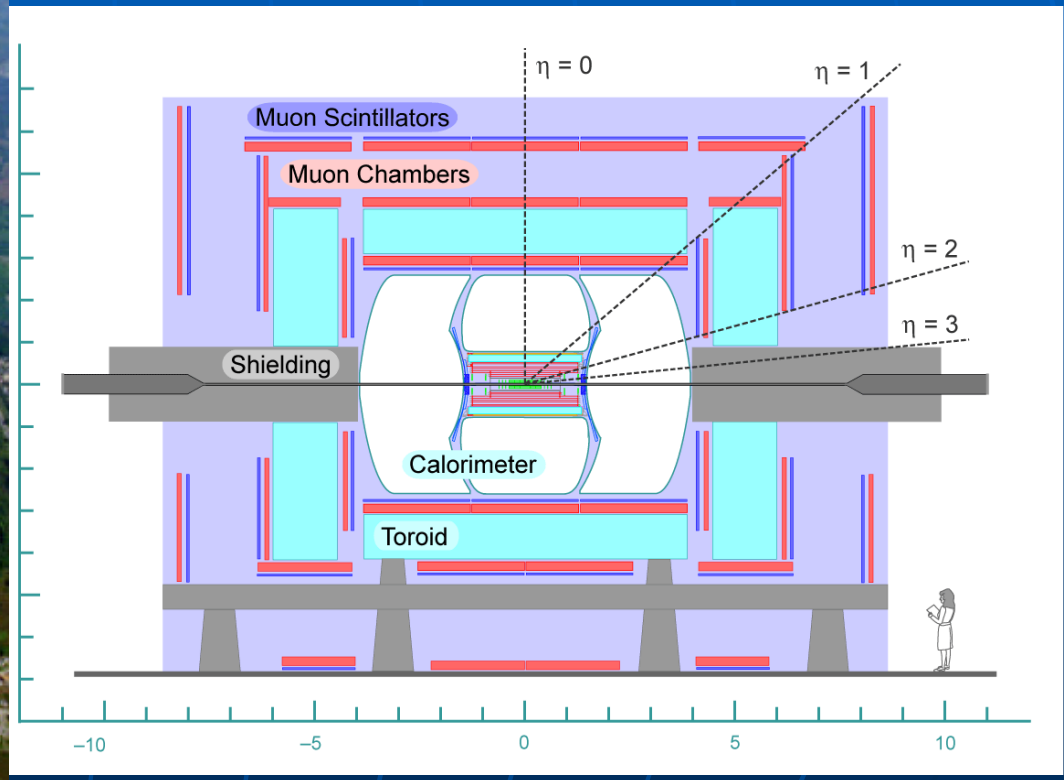
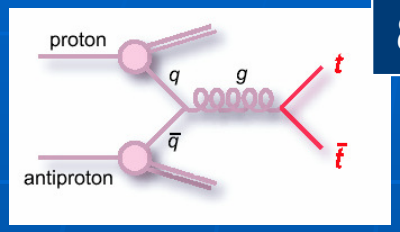
Tevatron / D0


Chicago
p
p̄
1.96 TeV
Booster
CDF
p
DØ
Tevatron
p̄
p̄ source
Main Injector
& Recycler

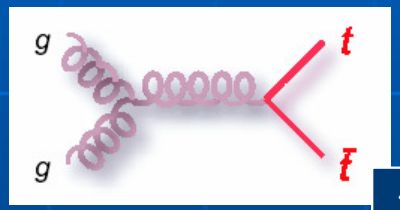

η = 0
η = 1
η = 2
η = 3
Muon Scintillators
Muon Chambers
Shielding
Calorimeter
Toroid
−10
−5
0
5
10

Top quark production

Top quark pair production via **strong** interaction



85%

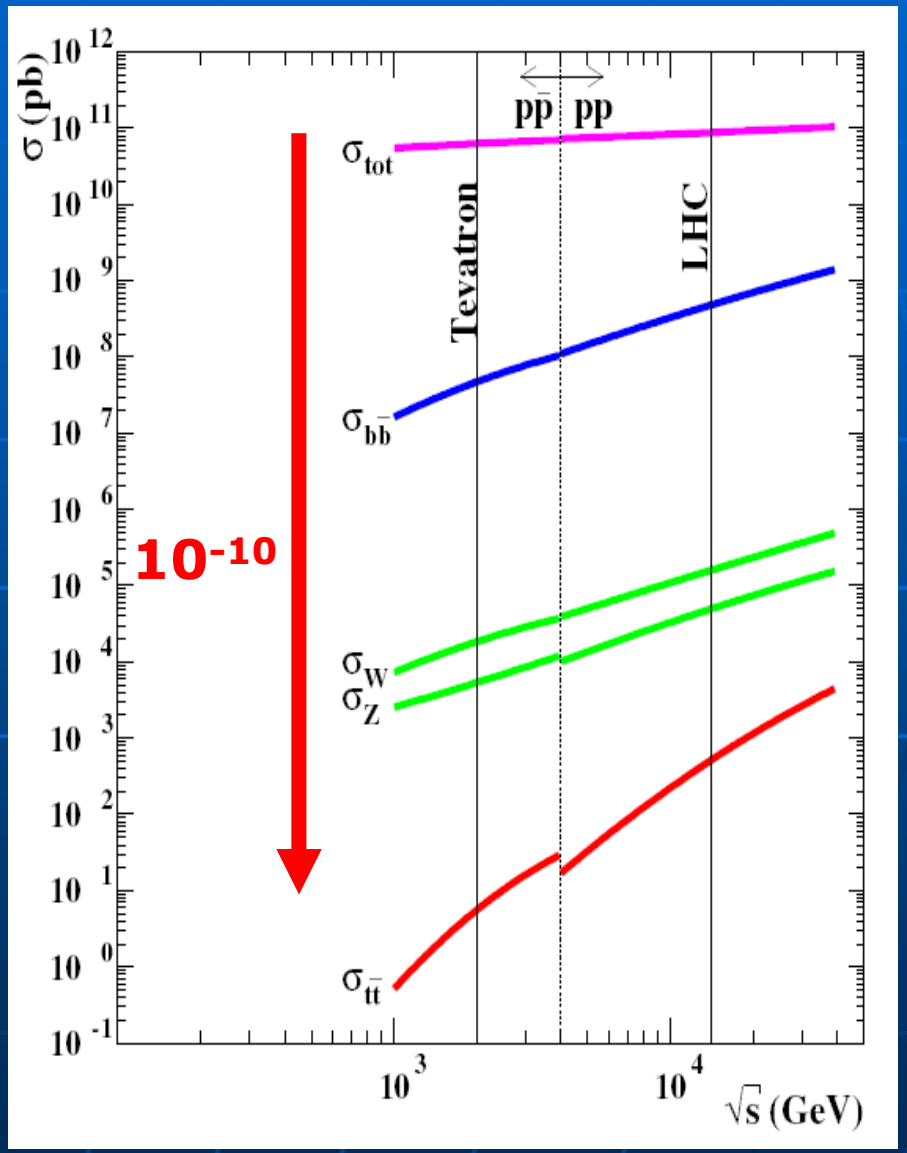


15%

6.7 pb (1.96 TeV, m_t=175GeV/c^2)

N. Kidonakis and R. Vogt, Phys. Rev. D68, 114014 (2003)

Cacciari etal, JHEP 0404, 068 (2004)



Measuring the cross section:

$$\sigma_{t\bar{t}} = \frac{N_{obs} - N_{bkg}}{\int L dt \cdot Br \cdot \varepsilon \cdot A}$$

Goal of this analysis

- Use the lepton + jets sample as defined by the "topological" cross section, i.e. w/o *b* tagging (remember the previous talk ?)
- Use b jet identification to improve the purity

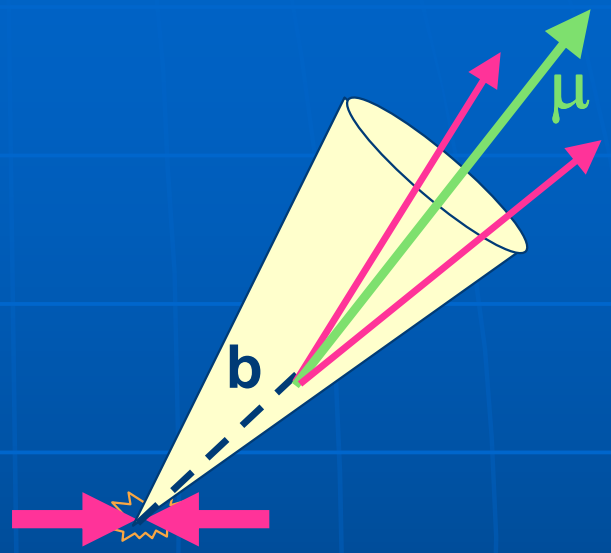
Topological: S/B~1/3

With tagging: S/B~1.4/1

- "Soft Lepton Tagger" mostly independent from other *b* jet taggers
  → independent check ; combination

Tagging *b* jets with muons

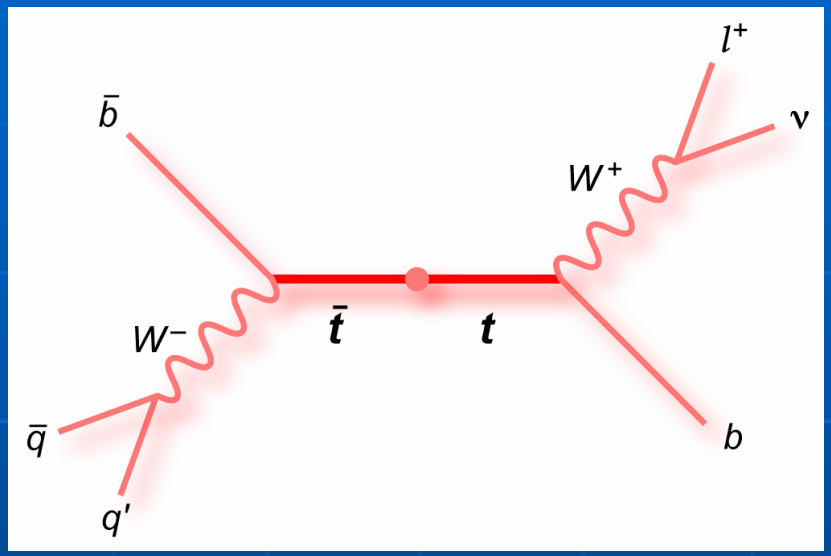
$b \rightarrow \mu$ 11.0%
$b \rightarrow c \rightarrow \mu$ 8.0%



- ~20% *b* jets have a muon in a jet
  (similarly an electron, but this information is not used here)
- Jets from light (u,d,s) quarks rarely have semileptonic decays
- **Soft Lepton Tagging:**
  Identify *b* jets by finding a muon in the jet cone
  (Soft: momentum spectrum of muons from *b* jets is relatively soft)

Tagging events

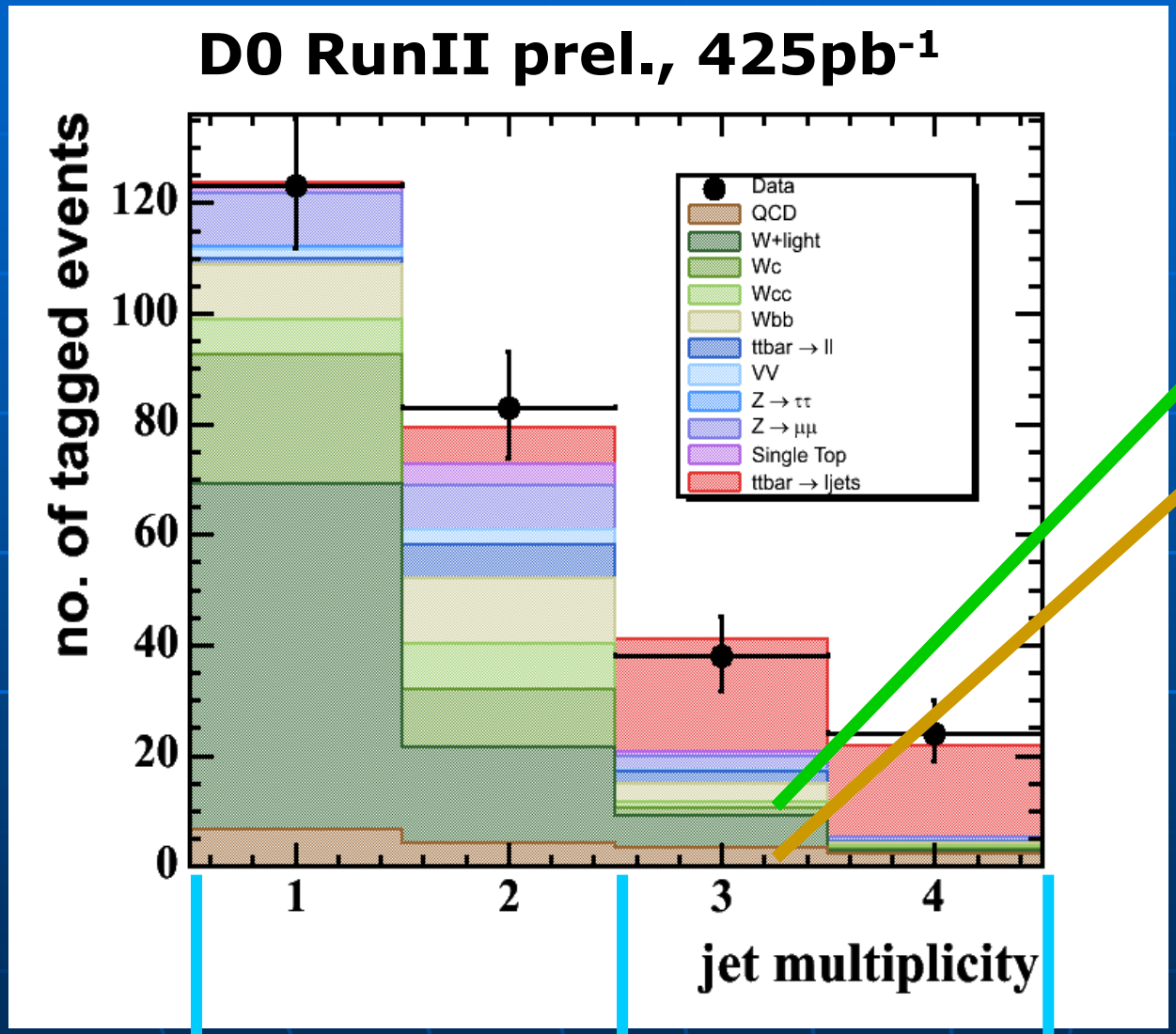
- A 'tagged' event has at least one jet associated with a muon
- ttbar: two *b* jets and 1/2 events have a *c* jet → 40% have a muon in a jet



- Tagging efficiencies:
  16% to 17% for ttbar l+jet events
  <<1% for events with light jets (multijet and V+light)
  Few % for events with *b* or *c* jets
  Up to 18 % for events with multiple *b* and/or *c* jets

Powerful discrimination !

Sample composition after tagging



Cross check | **Measurement**

Expected background:

13 W+jets events

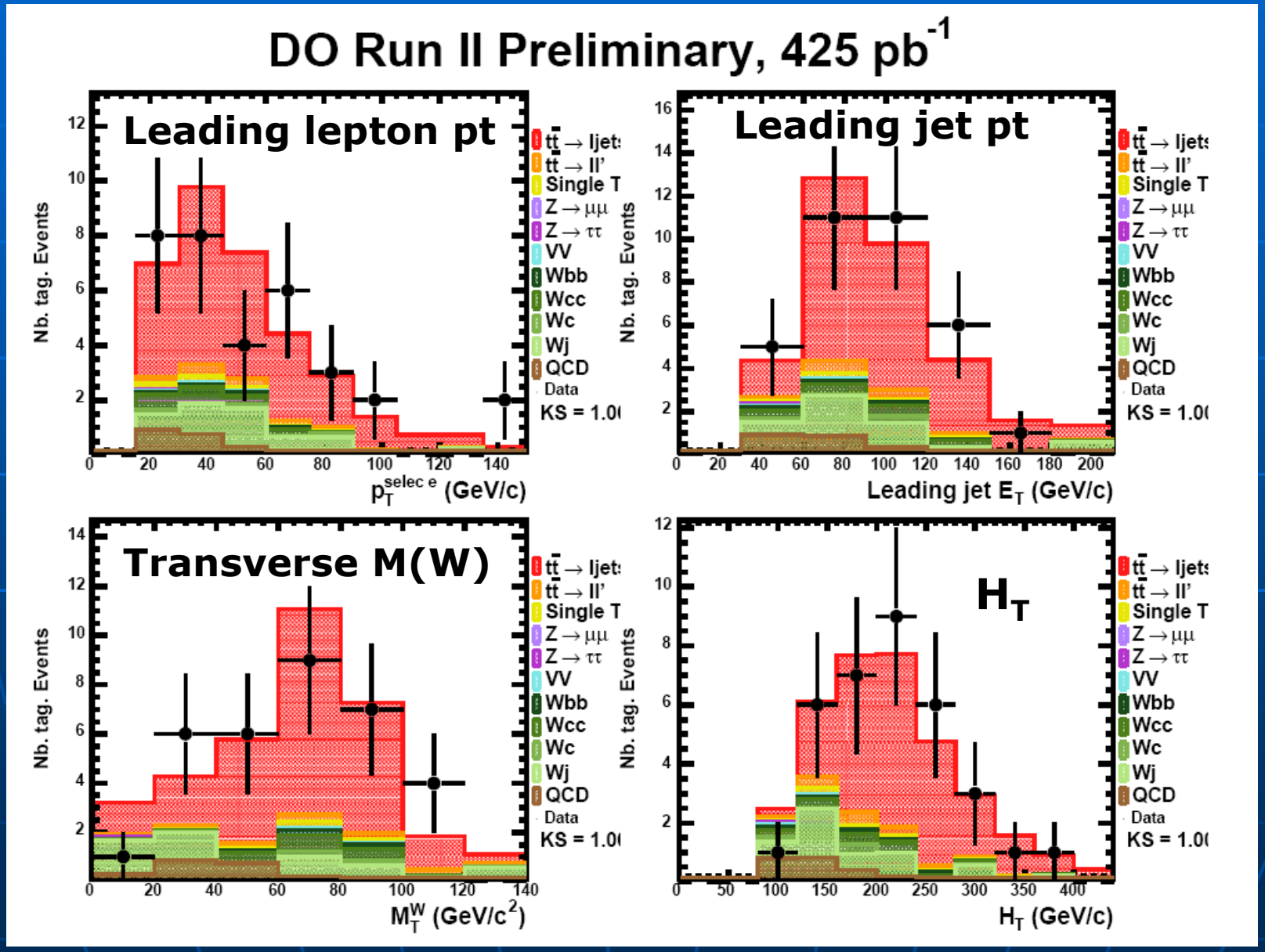
6 multijet events

7 "other" bckg events

(total: 26)

Observed: 62 Events

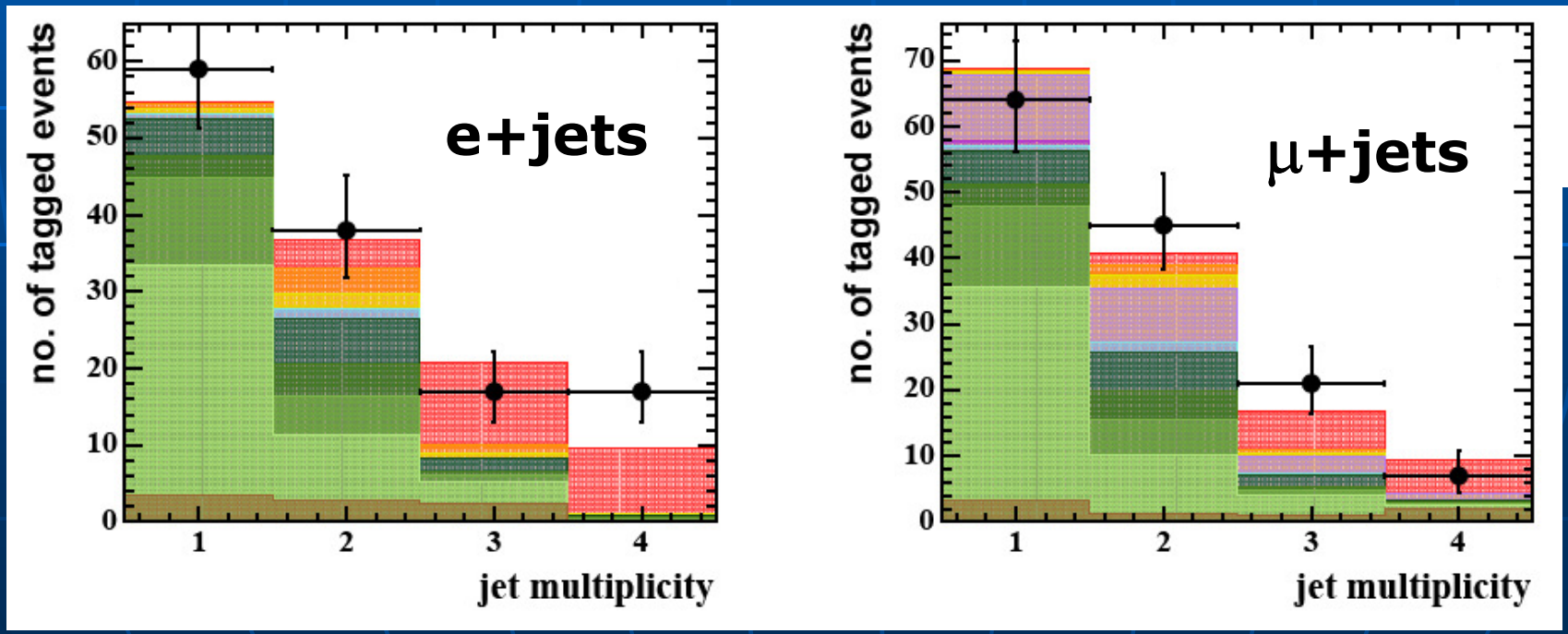
Kinematic distributions



Cross section extraction with a likelihood

$$\mathcal{L}(N_j, \sigma_{t\bar{t}}) = \prod_{j=1}^{4} \mathcal{F}_j(\tilde{N}_j | N_j, \sigma_{t\bar{t}})$$

j: e or μ; 3 or >=4 jets
F: p.d.f. for N
Ňj: number of observed events
Nj: true number of events
σ: tt xsec



D0 RunII Preliminary 425pb^{-1}

Result

Systematic uncertainties included as nuisance parameters in the likelihood

$$\sigma_{pp\to t\bar{t}+X} = 7.3^{+2.0}_{-1.8}\ (\text{stat.} + \text{syst.}) \pm 0.4\ (\text{lumi})\ \text{pb}$$

@m_t=175GeV

425 pb^{-1}

Without integrating over systematic nuisance parameters:
+1.7 -1.6 pb stat.

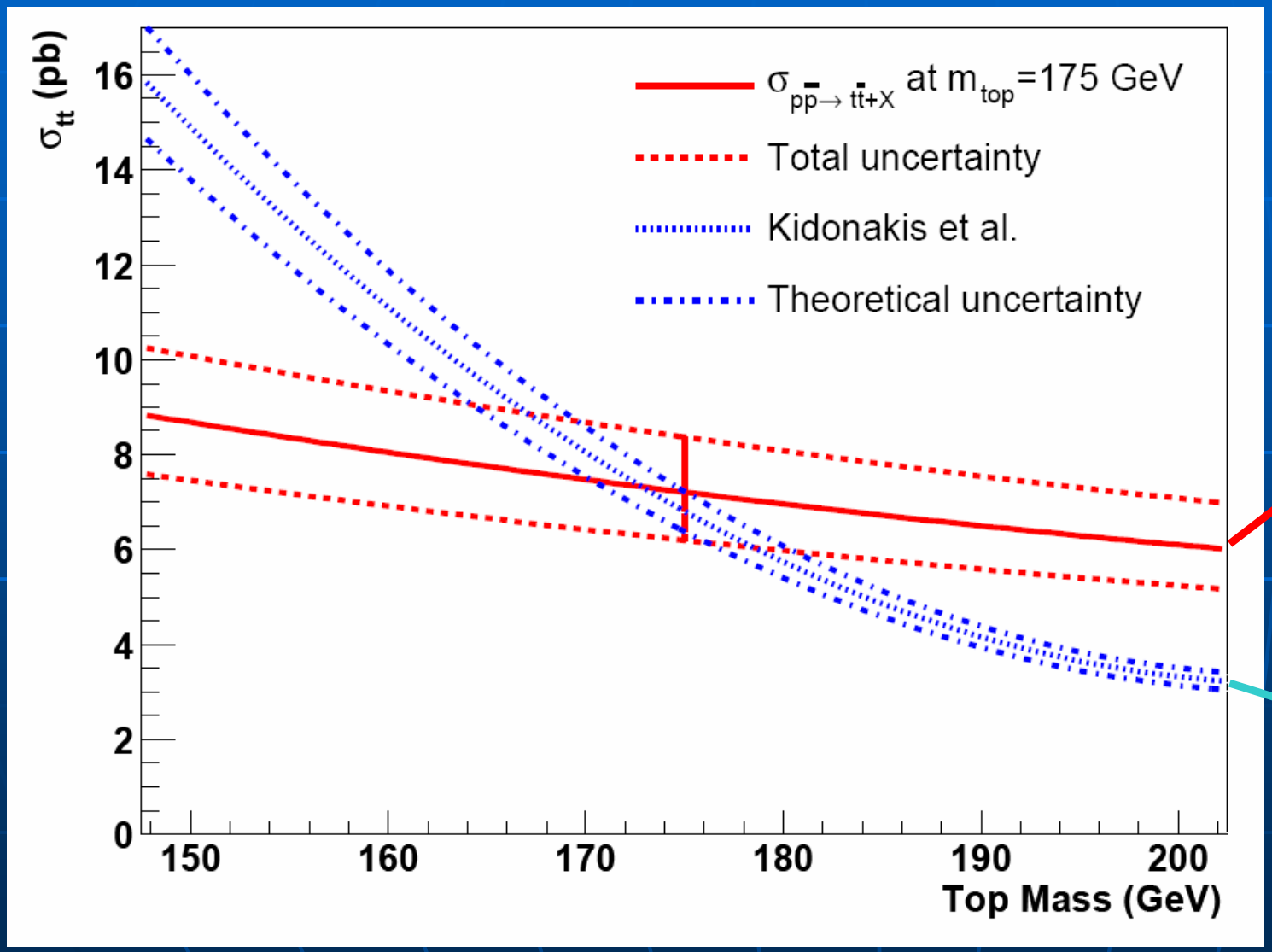
Measurement is Statistics limited

Contributions from systemtics:
±1.0 pb syst.

Largest contribution is the uncertainty on the fake tagging rate with ± 0.8 pb

Correlation to other l+jets cross section measurements is ~40%

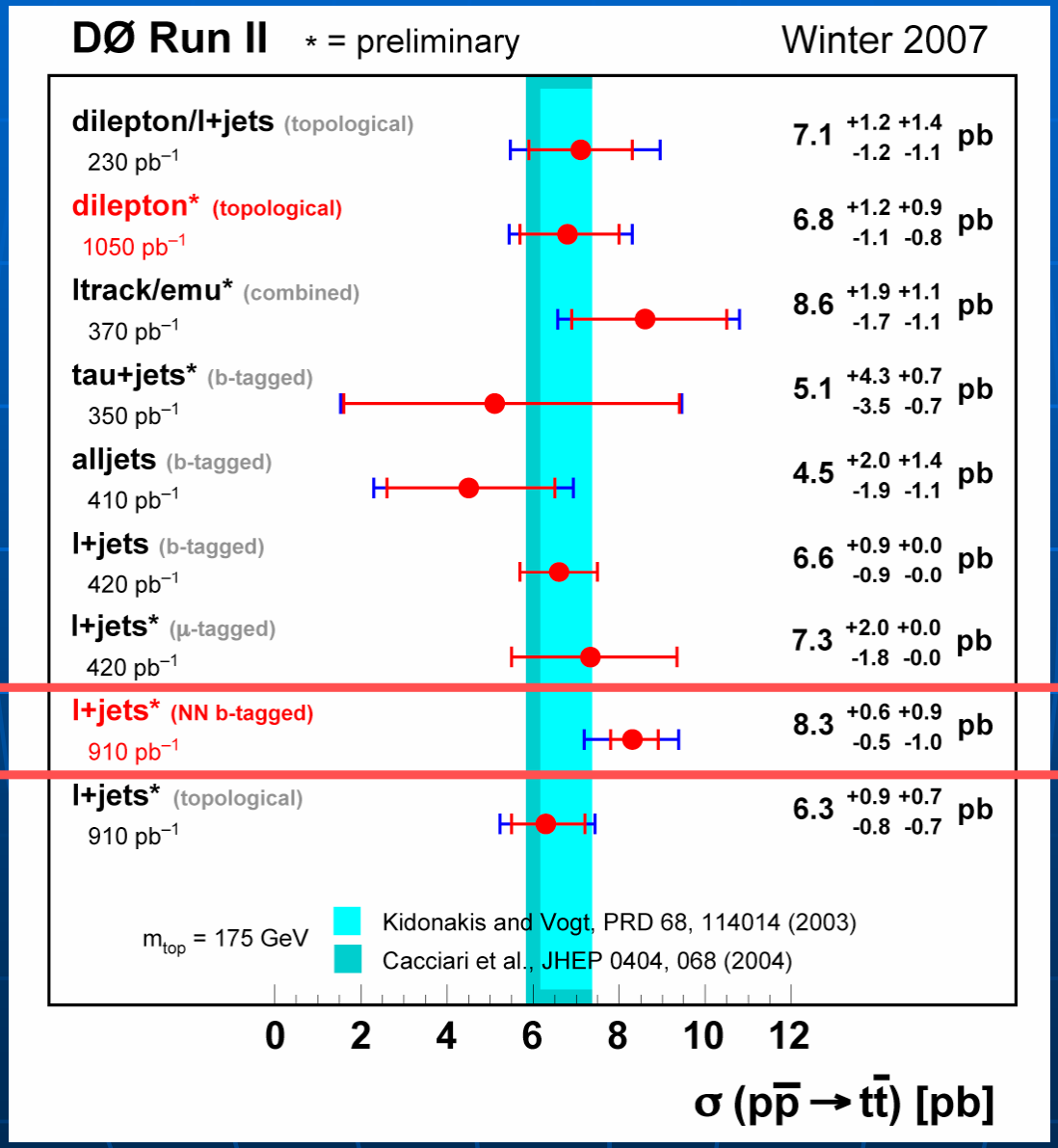
Dependence on the top mass



Measurement
Dependence coming from the selection efficiency

Theory

Comparison to other D0 results



Conclusion

- Shown a measurement of the top production cross section using a soft-muon *b*-jet tagger
- Result: $\sigma_{pp\to t\bar{t}+X} = 7.3^{+2.0}_{-1.8}\ (\text{stat.} + \text{syst.}) \pm 0.4\ (\text{lumi})\ \text{pb}$
- Consistent with other D0 results and standard model expectation
- 23% relative uncertainty
- Will get better with more data !

Systematic uncertainties

Source	σ_+(pb)	σ_-(pb)
Muon preselections	+0.18	−0.13
Electron preselections	+0.19	−0.13
EM triggers	+0.00	−0.03
Muon triggers	+0.12	−0.09
Jet triggers	+0.00	−0.04
Jet energy scale	+0.19	−0.12
Jet energy resolution	+0.02	−0.02
Jet ID	+0.14	-0.12
$Z + jets$ normalization	+0.06	−0.07
Heavy flavor tagging	+0.24	−0.17
Fake tagging rate	+0.84	−0.78
Matrix method	+0.33	−0.35
Monte Carlo statistics	+0.25	−0.27
W fractions	+0.13	−0.19
Total systematics (quad sum of the above)	+1.04	-0.98