Search for lonely top quarks at DØ

▶ The DØ RunII detector. Operations. Upgrade
▶ Top quarks at the Tevatron
▶ Sigle top quark production and kinematics
▶ Analysis overview. B-tagging. Background estimation
▶ Final results. Limits
▶ Expectation vs reality
▶ Outlook. Major issues
▶ TeV4LHC workshop advertising
Run I 1992-95
  Top quark discovered!
Run II 2001-09(?)
  $\sqrt{s} = 1.96$ TeV
  $\Delta t = 396$ ns
  36x36 bunches
  Peak Lum $10^{32}$ cm$^{-2}$s$^{-1}$
  Delivered $\sim 500$ pb$^{-1}$
The Run II DØ detector

Tracker: Si+Fiber+Preshower

Solenoid

Fiber Tracker

Silicon Tracker

Preshower

Muon Scintillator

Muon Chamber

Electronics

Shielding

Calorimeter

Toroid

3 layer muon system

protons

Lonely top quarks at DØ

Arán García-Bellido (UW)

Slide 3
New for Run II: Tracking in 2T

Silicon Vertex Detector

- 6 Barrels
- 12 F-disks
- 4 H-disks
- 3m² of Si, 1.2m in length

Central Fiber Tracker

- 8 axial & 8 stereo fiber layers

► Improved momentum resolution and coverage for muons
► New electronics for LAr calorimeter: working on noise and isolation
► Track-based b-quark jet identification
► Will install a Layer 0 for the Si (from RunIIb) in 2005 shutdown
Triggering

Collision rate is huge:

► Every 396 ns at the Tevatron
► Every 25 ns at the LHC

Total cross section is also big ~0.1 barn

► 2-3 interactions per collision at $L=10^{32}$
► 20 interactions per collision at $L=10^{34}$

$W$, $Z$, top, $H$ are relatively rare

Trigger and Luminosity are crucial

$\sigma(W\rightarrow l\nu)$

$\sigma(tt)$

$m_t=175$ GeV
Trigger and DAQ system

- Runs comfortably up to $5 \times 10^{31}$ cm$^{-2}$s$^{-1}$ and will keep pace with luminosity growth as tracking triggers completed, CPUs added.
- **L1**: >100 independent trigger bits
  - Fast trigger pick-offs from all detectors
  - Custom hardware/firmware
  - Trigger on hit patterns in individual detector elements
- **L2**: Combine Level 1 regions and objects
  - Input rate expansion w/ processor replacements
- **L3**: Full detector readout
  - Extensive suite of filters available
- **DAQ**: VME-based PCs and Ethernet switches
  - Working to reduce Front End Busy rate (~4%, mostly tracking)
  - Event reconstruction: Linux commodity farm to make L3 decision
  - Can monitor from a cell phone!
  - Upgrade: Extra 50 Hz to tape
  - Possibly: another extra 50 Hz (for a total of 150 Hz) of B physics triggers

---

Bunch crossing: 396 ns $\Rightarrow$ 2.5 MHz

Table:

<table>
<thead>
<tr>
<th>Spec:</th>
<th>5 kHz</th>
<th>1000 Hz</th>
<th>50 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Level 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tape</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Operating: 1.4 kHz, 800 Hz, 50 Hz

1M channels ~250KB/event
Offline event reconstruction and analysis

DØ Reconstruction Farm
- 240 1.8 GHz dual CPU machines
- 20M event/week capacity
- events processed within days of collection
- 1G events processed in Run II so far

Globally Distributed Resources
11 remote Monte Carlo Farms
- Running full GEANT, DØ reconstruction and trigger simulation
40 SAM stations for remote analysis
- Over 2Pb moved last year
- Up to 200Tb/month
Integrated Luminosity

- ~490 pb\(^{-1}\) on tape: an overall 85% efficiency

- Inefficiency due to:
  - ~ 5% FEB
  - ~ 5% losses in store & run transitions
  - ~ 5% “incidentals”

- Lately recording data with 90% efficiency

- Average 8 pb\(^{-1}\)/week
Latest record: $1.0 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$
Stores last around 20h
We just had a major shutdown:
- Electron cooling installed in the recycler
- Still improving pbar production
- Will aim at $14 \text{ pb}^{-1}/\text{week}$ for FY05

Great performance! Well above expectation!

DØ was taking data after 3 minutes
Top quark physics in Run II

The Tevatron is the world’s only source of top quarks!

Top quark has a special place in the SM: $M_t \sim v/\sqrt{2}$

Window into EWSB?

Decays before hadronization

Still know very little experimentally about the top quark

Run I:
Identified ~100 top events
Top quark strong production

Pair production through strong interaction

\[ \sigma(tt) \sim 7.5 \text{ pb at } \sqrt{s}=1.96 \text{ TeV} \] (NNLO CTEQ5M, Kidonakis et al.)

- Main production mode at Tevatron
- 30% higher \( \sigma(tt) \) than in Run I
- 0.8 events/hour at recent Luminosities

\[ \sigma(tt) \sim 833 \pm 100 \text{ pb at } \sqrt{s}=14 \text{ TeV} \] (Cacciari et al.)

0.8 events/second at initial (low) luminosities
Top quark Electroweak production

Single top production via EW interaction

\[ \sigma(t) \sim 2.86 \text{ pb at } \sqrt{s}=1.96\text{TeV} \] (NLO Sullivan et al.)

- Flagship measurement at Run II
- Dominant bkgs: Wjj, tt, QCD
- Measure s- and t-channel cross sections separately
- First direct probe of \(|V_{tb}|\)

TeV: \(0.88 \pm 0.11\) pb

LHC: \(10.6 \pm 1.1\) pb

\(\sigma(t) \sim 2.86\) pb at \(\sqrt{s}=1.96\) TeV (NLO Sullivan et al.)

\(\sigma(T) \sim 1.98 \pm 0.25\) pb

\(\sigma(T) \sim 246.6 \pm 0.25\) pb

\(\sigma(T) \sim 62.0^{+16.6}_{-3.6}\) pb

Harris, Laenen, Phaf, Sullivan, Weinzierl, PRD 66 (02) 054024

Tait, PRD 61 (00) 034001
Belyaev, Boos, PRD 63 (01) 034012
Why search for single top?

- Access Wtb
  - measure Vtb directly
  - test unitarity of CKM
- Test V-A structure of SM
- New physics:
  - s-channel sensitive to resonances: \( W' \), top pions, SUSY, etc…
  - t-channel sensitive to FCNCs
- Study top polarization, mass

\[ \text{Slide 13} \]
Signal topology

We are looking for:

► One high $p_T$ isolated lepton (from W)
► MET ($\nu$ from W)
► One b-quark jet (from top)
► A light flavor jet and/or another b-jet
Main backgrounds

► For this analysis, use data as much as possible to estimate backgrounds

► W/Z+jets production (real-\(\ell\))
  – Estimated from data
    • Distributions from untagged sample
    • Normalization from preselected sample
    • Tag probability from QCD sample

► Top-pair production
  – Estimated from Alpgen MC

► Mis-reconstructed multi-jet events (fake-\(\ell\))
  – Estimated from data

► Other (WZ, WW, Ztt, cosmic rays,...)
  – Included in data W/Z+jets estimate
DØ single top search strategy

Goal: Observe electroweak production of single top quarks

1. Select single top events out of large background
   - Loose “Pre-Selection”, reject QCD multi-jet events
   - Maximize acceptance
   - Use b-tagging to enhance signal-to-noise ratio
   - Check modeling of remaining backgrounds

2. Tight selection of single top events
   - Find (or form) sensitive variable for s-channel and t-channel
   - Separate s-channel from backgrounds
   - Separate t-channel from backgrounds

3. Determine cross section
   - Event counting, template fitting, ...
Event selection

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
</tr>
</thead>
<tbody>
<tr>
<td>e</td>
<td>≥1 EM object</td>
<td>—</td>
<td>≥1 EM object</td>
</tr>
<tr>
<td></td>
<td>$p_T &gt; 11\text{GeV}$</td>
<td></td>
<td>$p_T &gt; 15\text{GeV}$</td>
</tr>
<tr>
<td>μ</td>
<td>≥ 1 muon hit</td>
<td>1 muon</td>
<td>—</td>
</tr>
<tr>
<td>jet</td>
<td>≥1 jet</td>
<td>≥1 jet</td>
<td>≥1 jet</td>
</tr>
</tbody>
</table>

Loose preselection to keep data with similar final state objects to signals:

► One good quality isolated $e(\mu)$, $E_T > 15 \text{ GeV}$, $|\eta| < 1.1$ (2.0)
► MET > 15 GeV
► 2 ≤ Njets ≤ 4
  $p_T > 15\text{GeV}$
  $|\eta| < 3.4$
  $p_T$ (jet 1) > 25GeV

Require at least one b-tagged jet
► Reject misreconstructed events
  and regions not well described by backgrounds

Trigger efficiency:
► 85% electron channel
► 89% muon channel
Mis-reconstructed Events?

- Cosmic rays (muons)
- Primary vertex constraints
  - Primary vertex with ≥3 tracks
  - Lepton originates from the PV
- Mis-reconstructed jets and leptons
  - fake electron
  - fake isolated muon
  - mis-measured jet

The PV position affects the MET

Use triangle cuts to reject mis-reconstructed leptons and jets in $\Delta \Phi(\ell/jet1/jet2,MET)$ vs. MET
Tagging b-jets

B-mesons can decay semileptonically
► Identify low-\(p_T\) muon from decay

- \(b \rightarrow \ell \nu c\) (BR \(\sim 20\%\))
- \(b \rightarrow c \rightarrow \ell \nu s\) (BR \(\sim 20\%\))

B-mesons are long-lived and massive
► Identify vertex of displaced tracks

Both experiments can tag b-jets with up to 55\% efficiency for 0.5\% fake rate tag (SVX)
Lifetime $b$-tagging

Three different algorithms:
- Two based on tracks with large IPs
- One based on secondary vertices

Evidence for displaced vertex

Three different algorithms:
- Two based on tracks with large IPs
- One based on secondary vertices

Run II preliminary!

$\sim 50\%$ $b$-tagging eff at a fake rate of $1\%$, to be compared with $\sim 60\%$ for MC $\Rightarrow$ Improvements to be made by tuning the algorithms
b-tagging performance

\[ p_T^{\text{trk}} > 10 \text{ GeV} \]

- Mean = 0.9 ± 2.2
- Sigma = 36.3 ± 1.8
- Bkgd = 1.1 ± 0.3

Width = 36.3 ± 1.8 \( \mu \text{m} \)

Beam ~ 30 \( \mu \text{m} \)

\( \Rightarrow \) IP resolution ~ 10 \( \mu \text{m} \)
Analysis outline

► Make e and mu channels orthogonal (veto the other lepton)
► Make lifetime taggers orthogonal from SLT (apply soft lepton veto)
► Use several lifetime taggers for cross-check
  but they are not orthogonal: cannot combine
► For this first pass of the analysis with 160 pb⁻¹:
  We do NOT have a separate analysis for s- and t-channel: just count each one in the other’s SM background
  We apply a simple final cut, more refined statistical methods on the pipeline

![Diagram of analysis outline]
Data based background estimation

Normalization and shape from data from preselected sample

The fake-lepton background sample is obtained by:
1. Reversing the lepton isolation cut
2. Scaling it to the size of the pretagged sample
3. Applying the tagger

<table>
<thead>
<tr>
<th>Tight lepton ID</th>
<th>Pass</th>
<th>Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-tagging</td>
<td>signal data</td>
<td>fake-lepton</td>
</tr>
<tr>
<td></td>
<td>W+jets</td>
<td>not used</td>
</tr>
</tbody>
</table>

The W+jets sample is obtained by applying an inclusive Tag Rate Function over the preselected sample with 0 tags:

- Derive inclusive TRF from multijet sample → assume that heavy flavor content is the same in the W+jets and multijets samples for events with the same jet multiplicity: ~20% uncertainty
- Check assumption with clean W+jets samples and Z+jets (free of top quarks)
- The tagger applied directly and the TRF agree within errors
Event Yields after Preselection

Lonely top quarks at DØ

Event Yields after Preselection

DØ Run II Preliminary

- Data
- fake-lepton
- W/Z + jets
- tt
- t-channel
- s-channel

\( e^+ \mu, \text{JLIP} \)

\( e^+ \mu, \text{SVT} \)

\( e^+ \mu, \text{SLT} \)
Lonely top quarks at DØ

W Reconstruction after Preselection

Yield [counts/10GeV]

M_T(W) [GeV]

Data
fake-lepton
W/Z + jets
tt
s-channel

e+\mu, JLIP
e+\mu, SVT
e+\mu, SLT

DØ Run II Preliminary

a-Bellido (UW)

Lonely top quarks at DØ
Transverse Energy after Preselection

Lonely top quarks at DØ

DØ Run II Preliminary

Yield [counts/50GeV]

Hₜ [GeV]

Data
fake-lepton
W/Z + jets
tt
s-channel

a-Bellido (UW)
Sensitive Variable: Transverse Energy

Select simple final variable that shows good signal-background separation
Reject main background from W+jets: $H_T > 150\text{GeV}$
### Final event yields

<table>
<thead>
<tr>
<th>e +(\mu) Event Yields</th>
<th>SLT</th>
<th>SVT</th>
<th>JLIP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(s + t) combined</td>
<td>3.0 ± 0.4</td>
<td>8.3 ± 1.4</td>
<td>8.4 ± 1.3</td>
</tr>
<tr>
<td><strong>Backgrounds</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(t\bar{t} \rightarrow l+\text{jets})</td>
<td>13.2 ± 2.2</td>
<td>33.6 ± 5.8</td>
<td>34.1 ± 6.0</td>
</tr>
<tr>
<td>(t\bar{t} \rightarrow ll)</td>
<td>4.7 ± 0.7</td>
<td>9.5 ± 1.7</td>
<td>9.6 ± 1.6</td>
</tr>
<tr>
<td>(Z \rightarrow \mu\mu+\text{jets})</td>
<td>10.3 ± 3.5</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(W+\text{jets &amp; fake-(l)})</td>
<td>48.1 ± 5.7</td>
<td>94.2 ± 12.5</td>
<td>122.2 ± 16.9</td>
</tr>
<tr>
<td><strong>Sum of backgrounds</strong></td>
<td>76.2 ± 7.6</td>
<td>137.4 ± 14.5</td>
<td>165.9 ± 18.6</td>
</tr>
<tr>
<td><strong>Observed events</strong></td>
<td>97</td>
<td>138</td>
<td>148</td>
</tr>
</tbody>
</table>
Event Yield after Final Selection

![Event Yield Graphs]

**Graphs:**
- **Left Graph:** e+μ, JLIP+SLT
- **Right Graph:** e+μ, SVT+SLT

**Legend:**
- **Data**
- **Fake-lepton**
- **W/Z + jets**
- **t̅t̅**
- **t-channel**
- **s-channel**

**Note:**
- Arán García-Bellido (UW)
- Lonely top quarks at DØ
- Slide 29
Systematic Uncertainties

Signal acceptance and Monte Carlo Backgrounds

- Jet Energy Scale ~10%
- Trigger Modeling ~10%
- Tagger Modeling ~10%
- Object ID ~ 5%
- Background normalization ~20%

![Graph showing yield vs jet multiplicity for data, background sum, t-channel, and s-channel with DØ Run II Preliminary e+µ, SVT+SLT labels.](image)
Final result

- With 160 pb$^{-1}$ of Run II data
- No evidence for single top production
- By simple event counting, set a 95% CL on the production cross section
- Using a Bayesian approach and properly including all uncertainties and their correlations

<table>
<thead>
<tr>
<th>95% C.L.</th>
<th>$\sigma_s$</th>
<th>$\sigma_t$</th>
<th>$\sigma_{s+t}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed limit (pb)</td>
<td>19</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>Expected limit (pb)</td>
<td>16</td>
<td>23</td>
<td>20</td>
</tr>
</tbody>
</table>

Reached sensitivity of full Run I analysis
CDF analysis (hep-ex/0410058)

1 Lepton $p_T>20$ GeV
MET>20 GeV
Exactly 2 jets $E_T>15$ GeV $|\eta|<2.8$
$\geq 1$ b-tag
$M_{lvb}$ [140,210] GeV

Maximum likelihood fit to data $H_T$ or $Q \cdot \eta$
distributions using a sum of templates
determined from MC: single top (MadEvent),
$t\bar{t}$ (PYTHIA), non-top: $Wbb$ (ALPGEN)

Background allowed to float but constrained to
expectation.

95% C.L. limits Observed (Expected)

<table>
<thead>
<tr>
<th>Channel</th>
<th>CDF (pb)</th>
<th>DØ (pb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>s+t</td>
<td>&lt;17.8 (13.6)</td>
<td>&lt;23 (20)</td>
</tr>
<tr>
<td>t</td>
<td>&lt;10.1 (11.2)</td>
<td>&lt;25 (23)</td>
</tr>
<tr>
<td>s</td>
<td>&lt;13.6 (12.1)</td>
<td>&lt;19 (16)</td>
</tr>
</tbody>
</table>

Lonely top quarks at DØ
What’s next?

- DØ currently working on significantly improving the final analysis
  - Current focus on multivariate techniques: Neural Networks
  - Reduce background by factor $\sim 20$ and keep $\sim 30\%$ of signal
  - Expected limits below 10pb for 230pb$^{-1}$ dataset → publish soon!

- Other improvements in the future
  - Acceptance, efficiency
  - Resolution
  - Other multivariate techniques
Do we understand our backgrounds?

Especially $W+$jets:
- Normalization and flavor composition
- Flavor composition assumption in data: multijets $\sim W+$jets
- Assign large uncertainty

Single top is kinematically between $W+$jets and top pair production
NLO calculations for rate and shape very important, especially at LHC


$W+$jets with at least one b-tag is the biggest problem facing us today.
$Wqg \rightarrow Wqbb$ is predicted by PYTHIA to be a factor 2 larger than $Wbb$ or $Wjj$ with a mistag
$W+$jets syst errors dominate the measurement

M. Bowen, S. Ellis, M. Strassler, hep-ph/0412223
Do we understand our signal?

Event generators vs. LO t-channel $t\bar{b}$: Pythia and Herwig predict wrong distributions (too soft and too forward) for the non-top $b$-jet

LO MC generators vs NLO shapes

Event generators vs. NLO s-channel:
- Pythia and Herwig have the right shape
- Even after K factor normalization they underestimate the $Wb\bar{b}$ by a factor of 1.4
- Both produce too much additional hard radiation

Corrected LO generators with K factors give reasonable results

Several good solutions on the market with spin correlations:
ZTOP, Singletop (CompHEP), MadEvent, MCFM, new ones being developed
Predictions for Run II were to be sensitive to single top production with $\sim 500 \text{pb}^{-1}$—Where is it?

We have recorded $>470 \text{pb}$ at DØ already

Observation soon?

Stelzer, Sullivan, Willenbrock, PRD58 (98)
Single Top – Expectation vs Reality

Predictions for Run II were to be sensitive to single top production with $\sim 500 \text{pb}^{-1}$ – Where is it?

- Detector performance not (yet) as good as expected
  - b-tagging $\sim 45\%$ per jet
  - Trigger, ID $< 100\%$
  - Jet resolution not (yet) as good as expected
- W+jets background larger than expected
  - NLO calculations: LO $\times 1.5$
  - Gluon splitting, c-contamination
- Top mass, gluon PDF, ...

Many effects, all in the wrong direction!
Single Top – Expectation vs Reality

Predictions for Run II were to be sensitive to single top production with $\sim 500 \text{pb}^{-1}$ – *Where is it?*

► Detector performance not (yet) as good as expected
► W+jets background larger than expected
► Top mass, gluon PDF, ...

Need to significantly improve all aspects of the analysis

► Acceptance, resolution
  ► Object ID, trigger
► Final analysis
  ► Multi-variate analysis techniques (Neural Networks, Decision Trees…)

Observation with $\sim 2 \text{fb}^{-1}$
Starting to be interesting much sooner
Using the data & experience from the Tevatron to prepare for the LHC

Working Groups
QCD, Top & Electroweak Physics, Higgs, and Physics Landscape.

Contacts: Cynthia M. Sazama (FNAL)
sazama@fnal.gov • tev4lhc-org@fnal.gov

Information & Registration: http://conferences.fnal.gov/tev4lhc/
TeV4LHC Workshop

The purpose: Use Tevatron data and experience to prepare for the LHC
Identify areas where further theoretical work is needed

Tevatron $\rightarrow$ LHC
- improved event modelling and theoretical understanding of cross sections for signals and backgrounds
- experience with real experience

LHC $\rightarrow$ Tevatron
- Determine where current LHC prospects are strongly dependent on simulations/extrapolations
- Identify difficult analyses at LHC to investigate them at the Tevatron

The Workshop will combine Talks and Working Sessions, with the idea of initiating specific projects in these areas. Connect TeVatron and LHC people to work on these projects.

- The 1st meeting was held at Fermilab, 16-18 September, 2004.
- The NEXT MEETING will be held at Brookhaven National Lab., 3-5 February, 2005: [www.bnl.gov/tev4lhc](http://www.bnl.gov/tev4lhc)
- A follow-up meeting will be held at CERN, in late April, 2005
- The final meeting will be held at FNAL, in the Fall, 2005
- Would have liked to have more participation from LHC people
From Regina Demina (Rochester) in “Challenges of hadron colliders”:

Why did it take the TeV almost three years (March 2001-December 2003) to publish the first paper?

She asked some Run II physics conveners from CDF and DØ:

What were the limiting factors?

There was no clear leading limitation but rather several limiting factors:

1. Detector (and accelerator) performance:
   - Calorimeter calibration (in both experiments)
   - Alignment (tracker and calorimeter)
   - Luminosity delivered by the Tevatron (was too low,… now too high?)
   - Tracking and muons: no major complains both worked fine

2. Maturity of reconstruction algorithms

3. Complexity of the software and reliability of the MC (availability of samples)

4. CPU, speed and ease of data access, data format

5. Social issues and politics
TeV4LHC Workshop: Conclusions

► Lessons of commissioning from Run II:
  4 months of CDF Si cabling WHILE taking physics data
Premature emphasis on physics was counterproductive: it’s hard to commission the detector while taking physics data.

► Common final states should share ID’s and background calculations!

► Build common tools for the physicist (Luminosity calculation, trigger turn on curves, etc.)

► Big complaint: Lack of involvement from senior people

► Too high standards, perfectionism! (Run I, LEP)

► LHC has probably avoided many mistakes made at the Tevatron
► But many others are general and will be worse at the LHC
► This will affect LHC’s ability to do physics
► Tevatron people can give valuable input!
► We all need the LHC to be a success!!
Conclusions

► Single Top is a very exciting opportunity for Run II
  ► A lot of activity, both theoretical and experimental
► The DØ Run II Single Top Search is under way
  ► Detector and trigger working, understood
  ► First pass analysis with 160pb$^{-1}$ completed
  ► Not yet sensitive to single top production
► Expect visible excess at about 1fb$^{-1}$ (in ~1.5 years)
  ► Luminosity required for observation >2fb$^{-1}$
► We are continuing to work on further improvements
► Expect new results with 230pb$^{-1}$ and 370pb$^{-1}$ soon
Conclusions

► There is a lot of physics at the Tevatron
  ► Will go strong with 2-4 fb$^{-1}$ of data before LHC turn on.
  ► Understand now what to measure at TeV to make LHC simpler

► Lots of potential lessons
  ► Tevatron also messy environment
  ► Large collaboration with significant European contributions
  ► Object ID, Algorithms, Data formats, Remote Computing...

► Lots of experience in a hadron - hadron environment
  ► We should have even more at a high luminosity by the time the LHC turns on!
Tevatron luminosity prospects

Integrated luminosity will about double every year for next 4 years

![Graph showing luminosity prospects from FY2004 to FY2009]
Tagged background estimation methods

**Lepton + Jets Data**
- Apply preselection cuts

- **Tagged Sample**
  - Require at least one b-tagged jet

- **Untagged Sample**
  - Require zero b-tagged jets

- Scale to number of W+jets events expected after preselection

- Apply probability to tag each jet given $\eta$ and $E_T$

- **Observed Sample**

- **W+Jets Sample**

**Lepton + Jets Data**
- reverse likelihood (electron)
- reverse isolation (muon)
- Apply preselection cuts

- Scale to number of misID'd lepton events expected after preselection

- Apply b-tagging algorithm

- **MisID'd Lepton Sample**

**tt and Z MC**
- Apply preselection cuts

- Apply data/MC scale factors, trigger thresholds

- Scale to cross section and integrated luminosity or to Z+jets data

- Require a tagging muon or apply probability to tag each jet given $\eta$ and $E_T$

- **tt→ l+jets, ll and Z→ $\mu\mu$ Sample**
Tagged MC estimation methods

For signal, \( t\bar{t} \) and \( Z\to\mu\mu \) MC samples:

* Correct from ID efficiencies (measured in \( Z\to\mu^+\mu^- \) data and MC):
  
  \[
  \text{ID, tracking, matching, isolation scale factor } = \frac{\varepsilon(\text{data})}{\varepsilon(\text{MC})} = 0.86 \pm 0.05
  \]

* Apply trigger response and scale to \( \sigma \mathcal{L} \)

* SVT applies a flavor dependent tag-rate functions after parton matching
  
  - \textbf{b-flavor TRF}: \( f(E_T, \eta) \) from \( \mu+\text{jets} \) sample with \( p_T(\mu) > 8 \text{ GeV/c} \)
    
    Count number of muon-jets with vertex, correct with \( p_T^{\text{fell}} \) templates

  - \textbf{c-flavor TRF}: scale b-TRF by \( c/b \)-tagging ratio from MC

  - \textbf{light-quark TRF}: Use negative side of IP significance

  \[
  \text{Probability(tag event)} = 1 - \text{Probability(no jet tag)}
  \]

* SLT applies directly the tagger (find soft muon close to jet) on the MC