Monte Carlo Tools: Report from CDF

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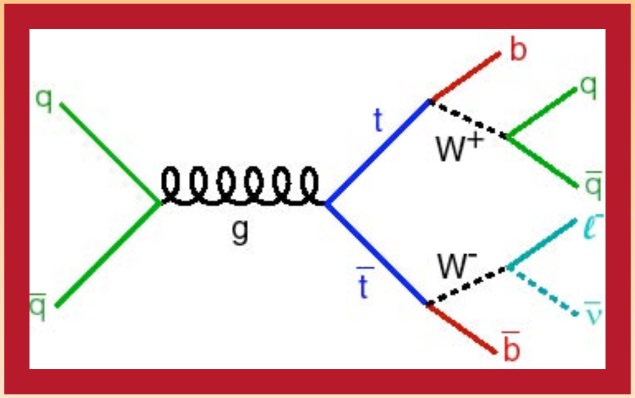
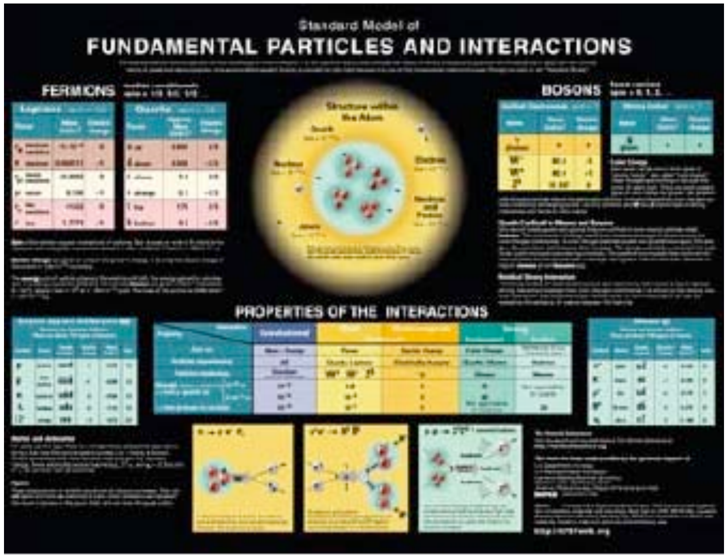


LoopFest V, SLAC -- *Tuesday June 20, 2006*

What People Expect from the Tevatron



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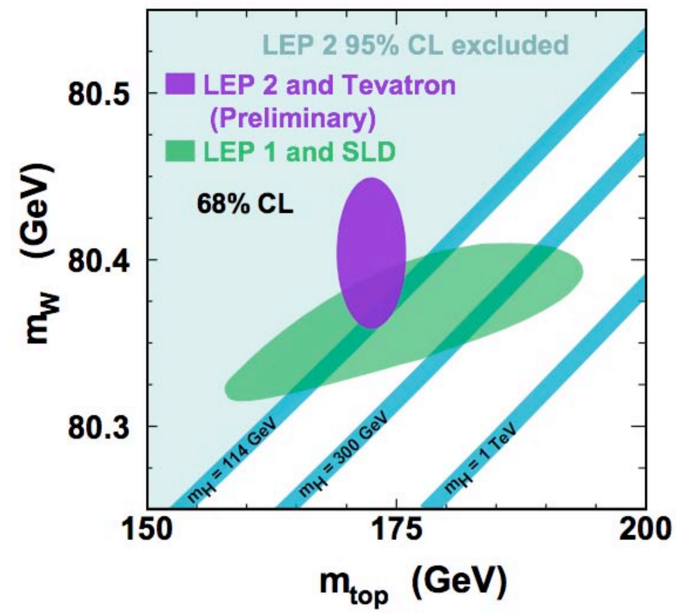

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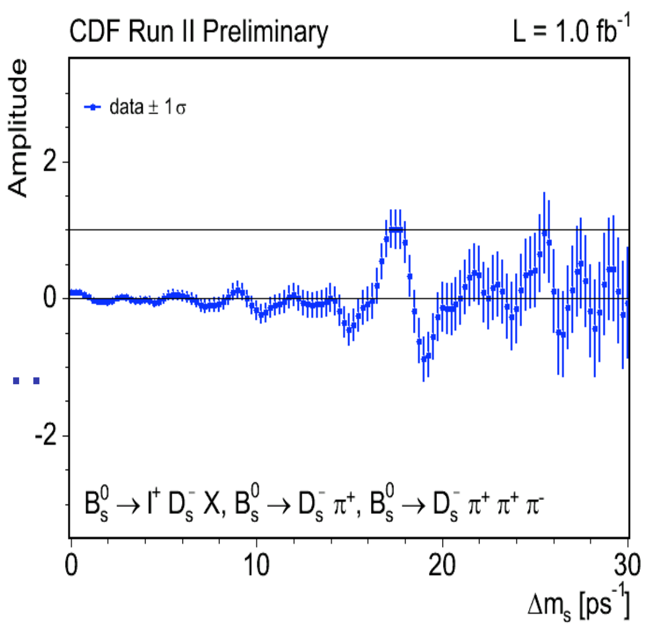
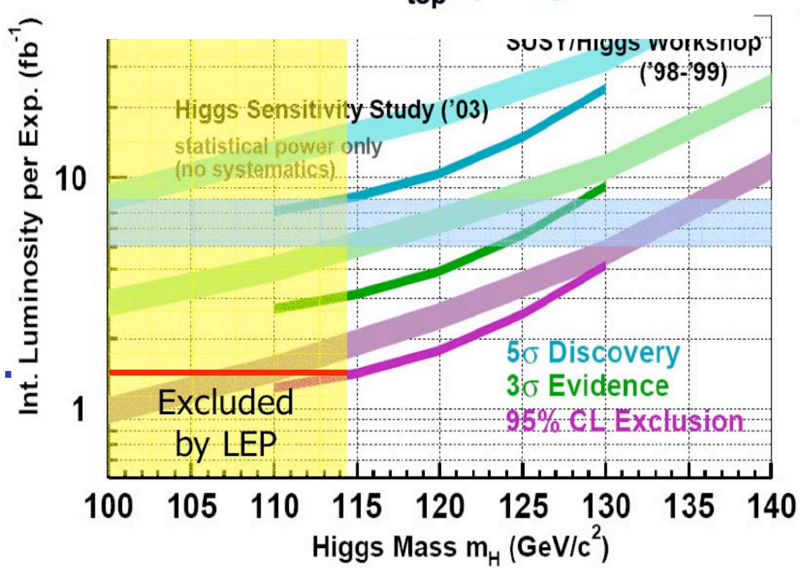


and maybe…



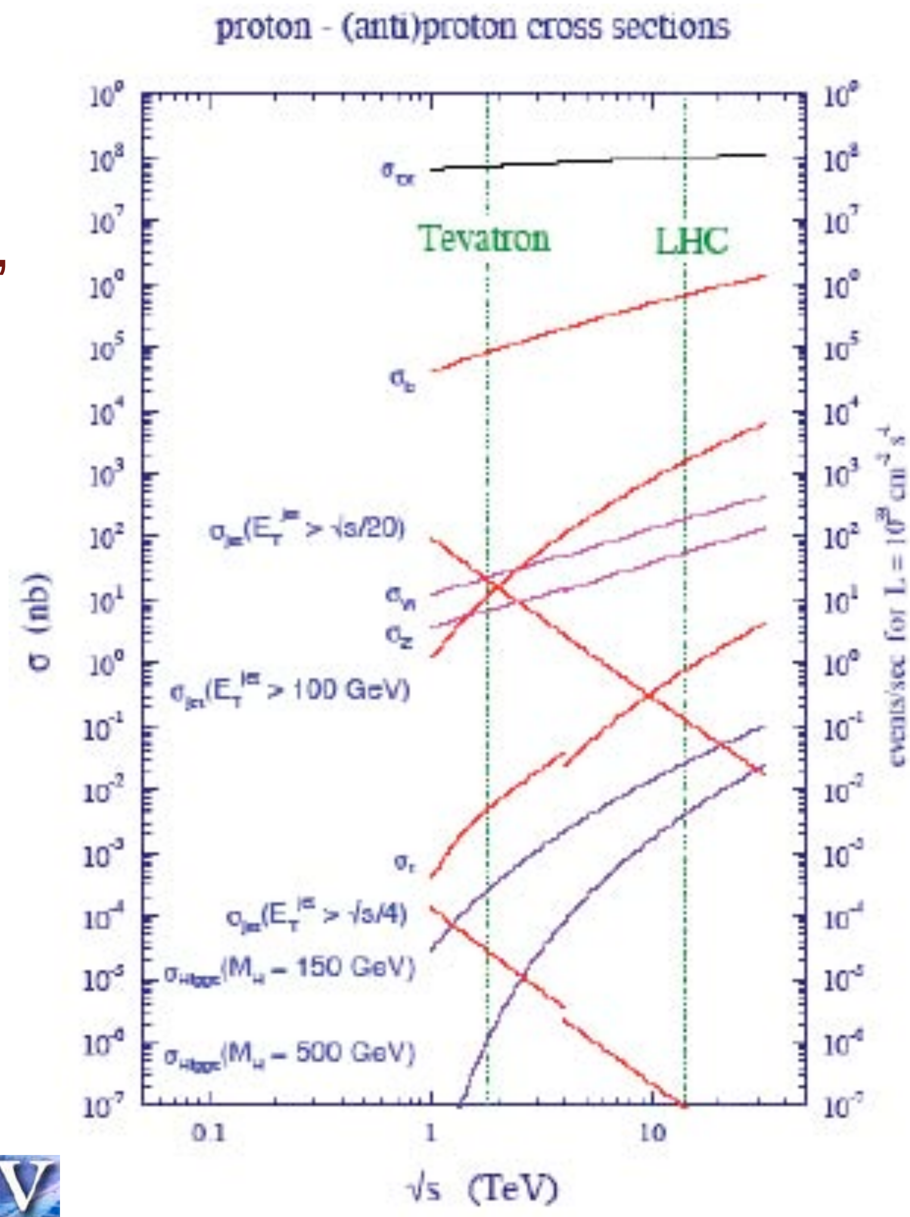
What People Expect at the LHC…

Murayama LP03

“Discovering” the SM at the LHC

Everyone is chanting:
Before we can declare discovery of BSM processes, we’ll need to understand Standard Model processes.
(See T. LeCompte’s talk)

- Detectors calibrated, algorithms well understood
- Backgrounds to BSM need to be certain
- Inclusive jets, W/Z+jets, heavy flavor, …
- Monte carlo tool development, studies, and understanding should happen now… this is understood by many these days...



Startup Strategy: SM Samples

Goal # 1 Understand and calibrate detector and trigger in situ using well-known physics samples

e.g. - $Z \to ee, \mu\mu$ tracker, ECAL, Muon chambers calibration and alignment, etc.

- $tt \to bl\nu\, bjj$ 10^3 evts/day after cuts → jet scale from W→jj, b-tag perf., etc.

Understand basic SM physics at $\sqrt{s}$ = 14 TeV → first checks of Monte Carlos

(hopefully well understood at Tevatron and HERA)

e.g. - measure cross-sections for e.g. minimum bias, W, Z, tt, QCD jets (to ~ 10-20 %), look at basic event features, first constraints of PDFs, etc.

- measure top mass (to 5-7 GeV) → give feedback on detector performance

Note : statistical error negligible after few weeks run

↓ t

Goal # 2 Prepare the road to discovery:

-- measure backgrounds to New Physics : e.g. tt and W/Z+ jets (omnipresent …)

-- look at specific "control samples" for the individual channels:

e.g. ttjj with j ≠ b "calibrates" ttbb irreducible background to ttH → ttbb

↓ t

Goal # 3 Look for New Physics potentially accessible in first year (e.g. Z', SUSY, some Higgs ? …)

…from Mangano and Gianotti talks

Gaining Experience

TeV4LHC successful.
Write-ups in progress or available.

HERA and the LHC also successful.
Writeups available.
Liked it so much, they keep going:
<u>*June 6-9, 2006*</u> (CERN). 2007 (DESY).

J. Huston's plenary very relevant to this talk.
Special thanks to Joey for useful conversations.

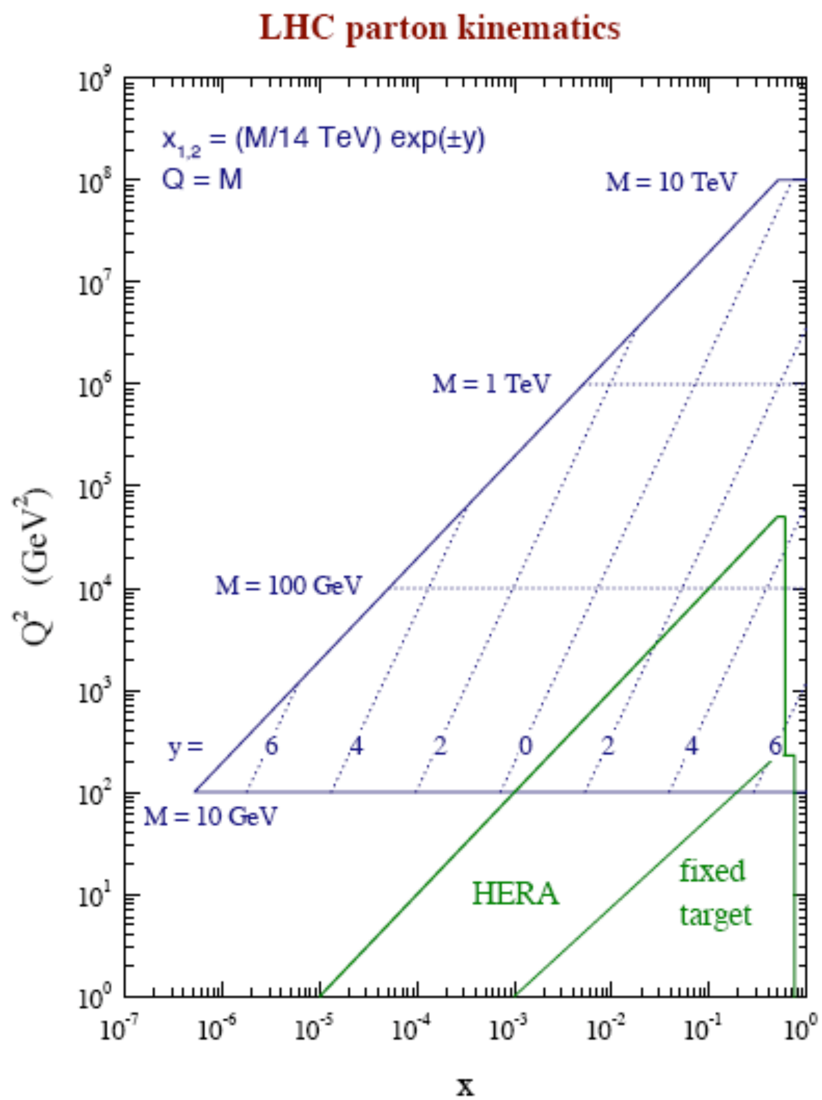
LHC Cross Sections

Comparing to the Tevatron not totally straightforward:
LHC is not necessarily just a rescaling of Tevatron scattering.

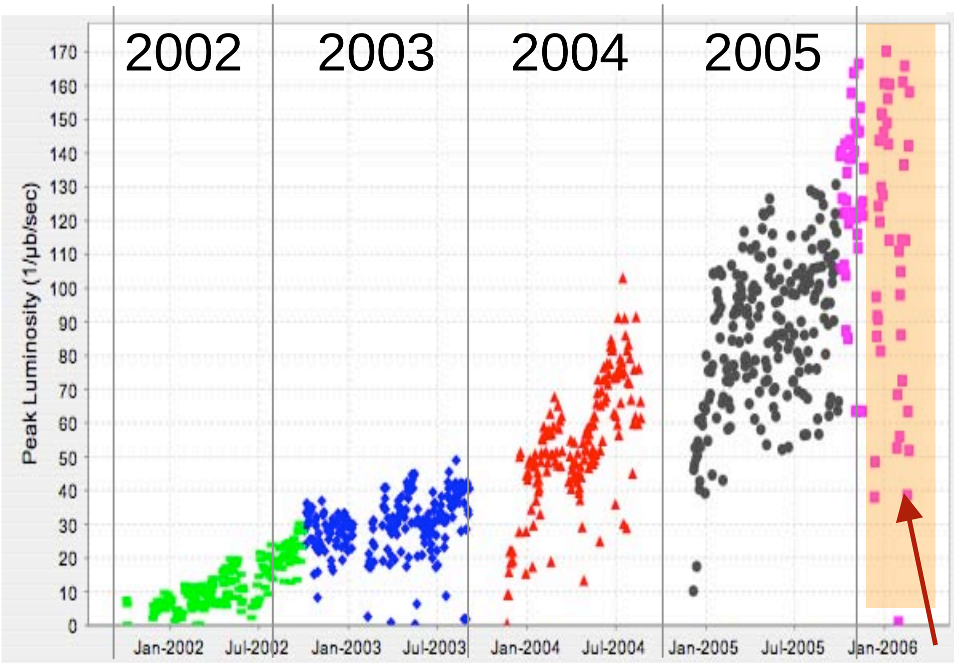
Small x in many searches: gluon and sea quark scattering dominates

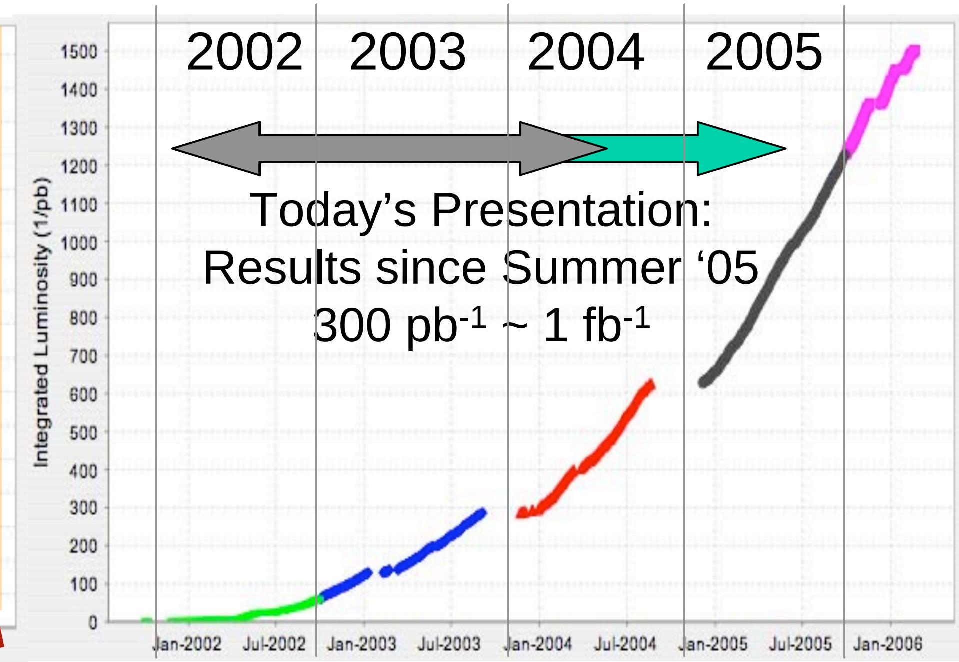
Large gluon emission phase space: big QCD backgrounds

Lots to wade through to get to BSM!



Tevatron Performance

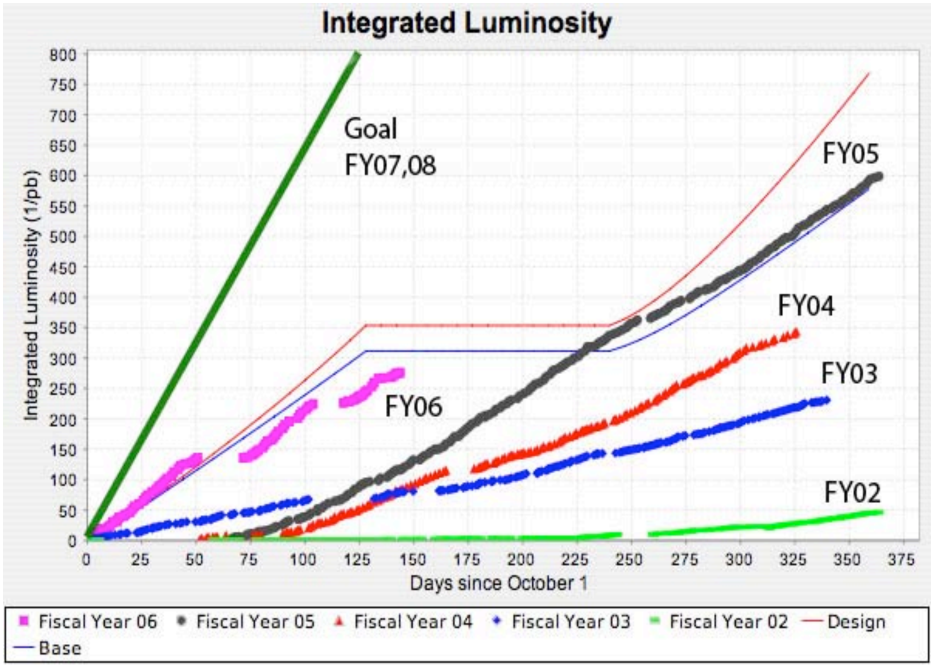




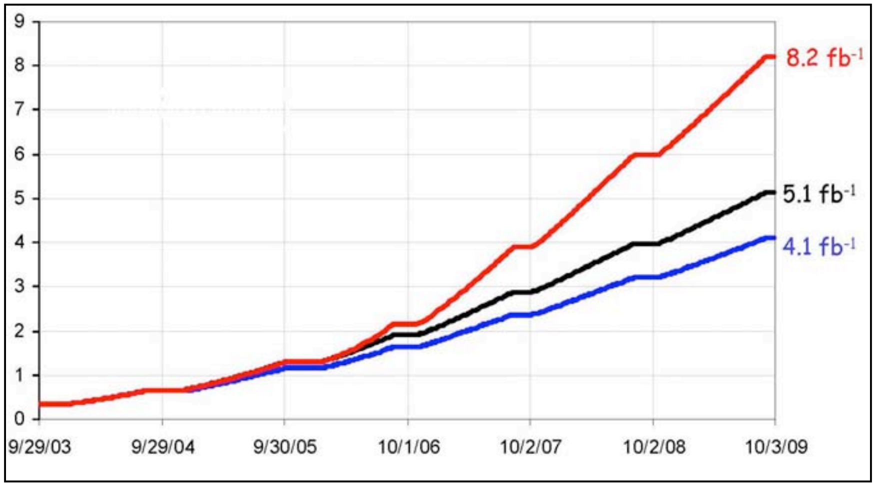
Includes machine studies and diffractive program (low L)

- Peak luminosity record: 1.8 $\times 10^{32}$ $cm^{-2}\ s^{-1}$
- Integrated luminosity
  - Weekly record: 27 pb^{-1} /week/expt
  - Total delivered: 1.5 fb^{-1} /expt. Total recorded: 1.3 fb^{-1} /expt
- Doubling time: ~1 year
- Future: ~2 fb^{-1} by 2006, ~4 fb^{-1} by 2007, ~8 fb^{-1} by 2009

Expectations at the Tevatron



Luminosity history for each fiscal year



Integrated luminosity for different assumptions

Red: 30 mA/hr pbar production
Black: is better base with 20 mA/hr established before shutdown
Blue: Base projection

Some Hadron Collider Math

What are the Tevatron-to-LHC rate increases for interesting processes?

ttbar cross section at LHC:

~ 100x ttbar cross section at Tevatron

$\tilde{\chi}^+\tilde{\chi}^-$ (M(χ)=200 GeV) cross section at LHC:

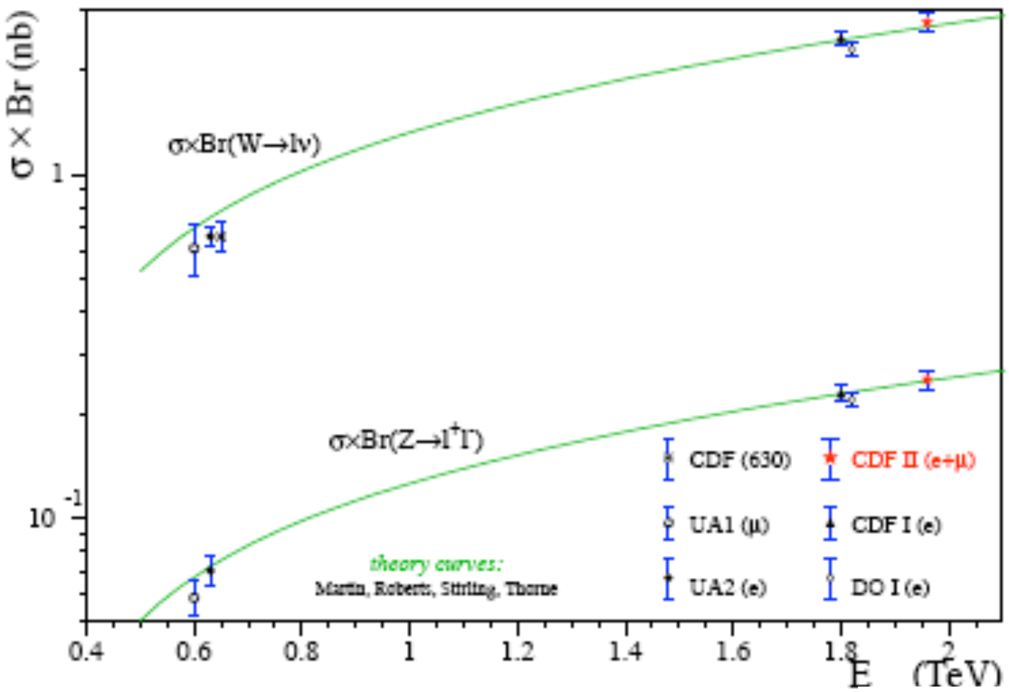
~ 10x $\tilde{\chi}^+\tilde{\chi}^-$ cross section at Tevatron

W+4 parton cross section at LHC:

~ 500x W+4 p cross section at Tevatron

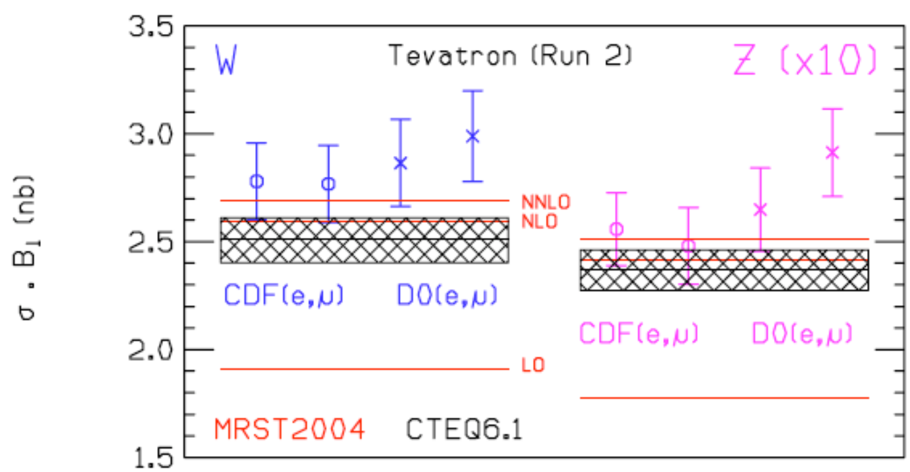
[a la Steve Mrenna. Info from Kidonakis, Pythia, and MadEvent with k_T>20, respectively.]

W and Z Benchmarks



Tevatron: Beginning to use W/Z as luminosity monitors. Cross sections well known, small + NNLO corrections to LO.

LHC: total cross section not well known. Can use W/Z's there until it is measured.



Understanding W+Jets Sample Composition

Understanding W +N partons and W +bb +N partons is very important:

- Current knowledge of samples… since we know SM top is there:

Top = (Data) - (not-top) *-S. Mrenna*

- With our current methods, the jet energy scale is not as big a challenge (see recent CDF Mtop results!), so understanding "not-top" is the key to understanding top.

- Advanced analysis techniques (neural network, likelihood discriminant, matrix element reconstruction) exploit many kinematic variables, as you've seen.

- As our tools improve, we get to more challenging questions.

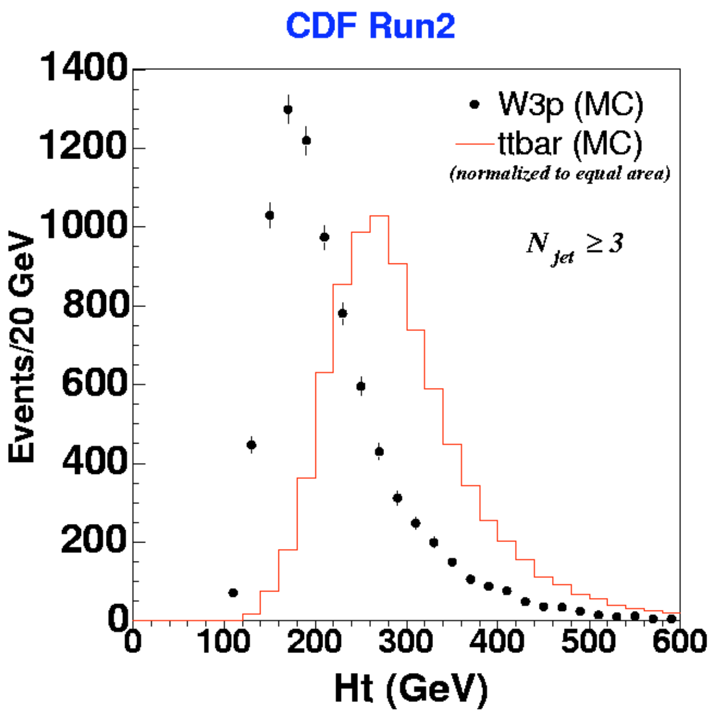
W+Jets: Top Cross Section w/ Event Kinematics

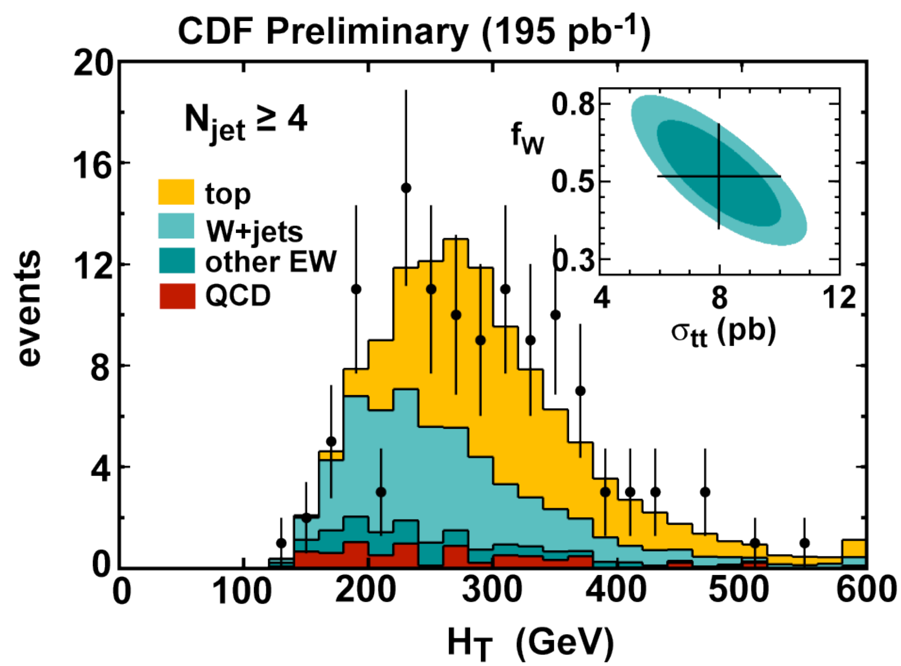
W+ ≥ 4 Jets Sample
Composition:

W+Jets ~ 35% MC
QCD fakes ~ 15% (data)
ttbar ~ 50% MC

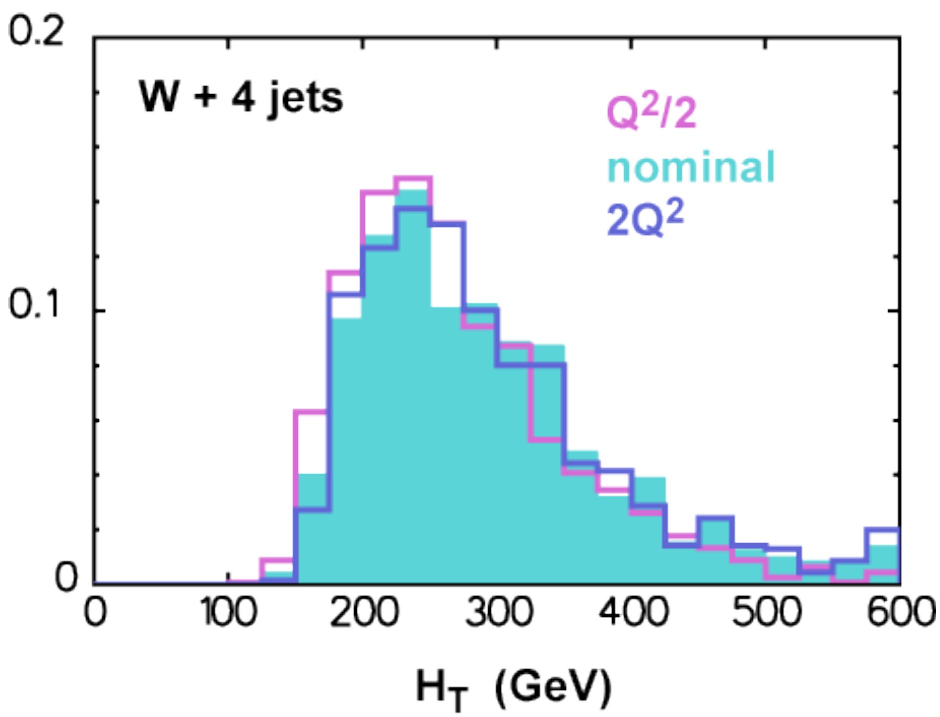
3 component likelihood fit:
- ttbar shape from Pythia
- W+jets shape: AlpGen
- QCD shape from data

QCD from non-iso leptons

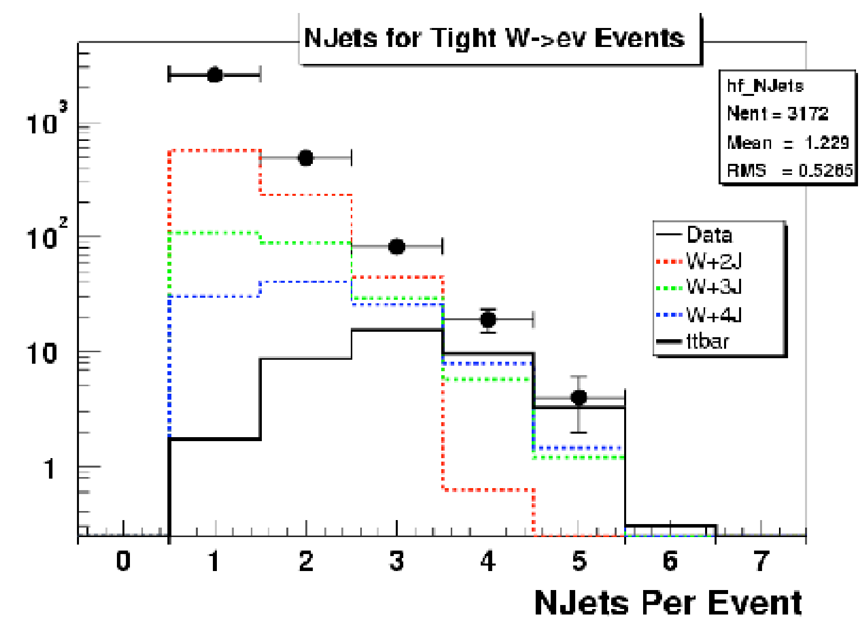




Some Issues in Using Event Kinematics



Cannot add up N parton samples: “double counting”. Need matching to do it. Normalization (cross section) unreliable: W+jets always floats in fit.



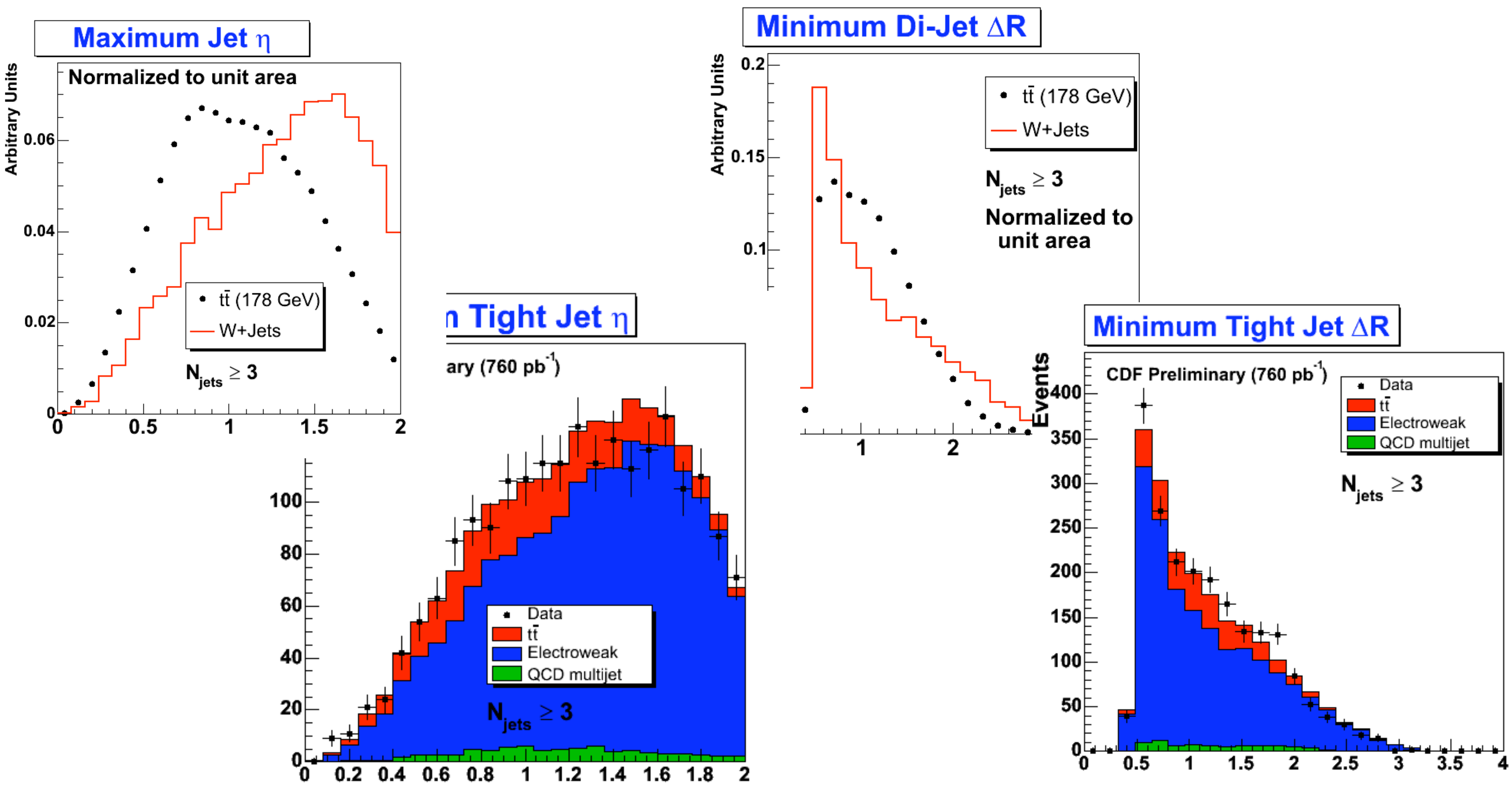
Q^2 assumptions change shape by quite a bit. Largest systematic aside from jet energy scale, where you see shifts above.

Nominal Q^2 scale:

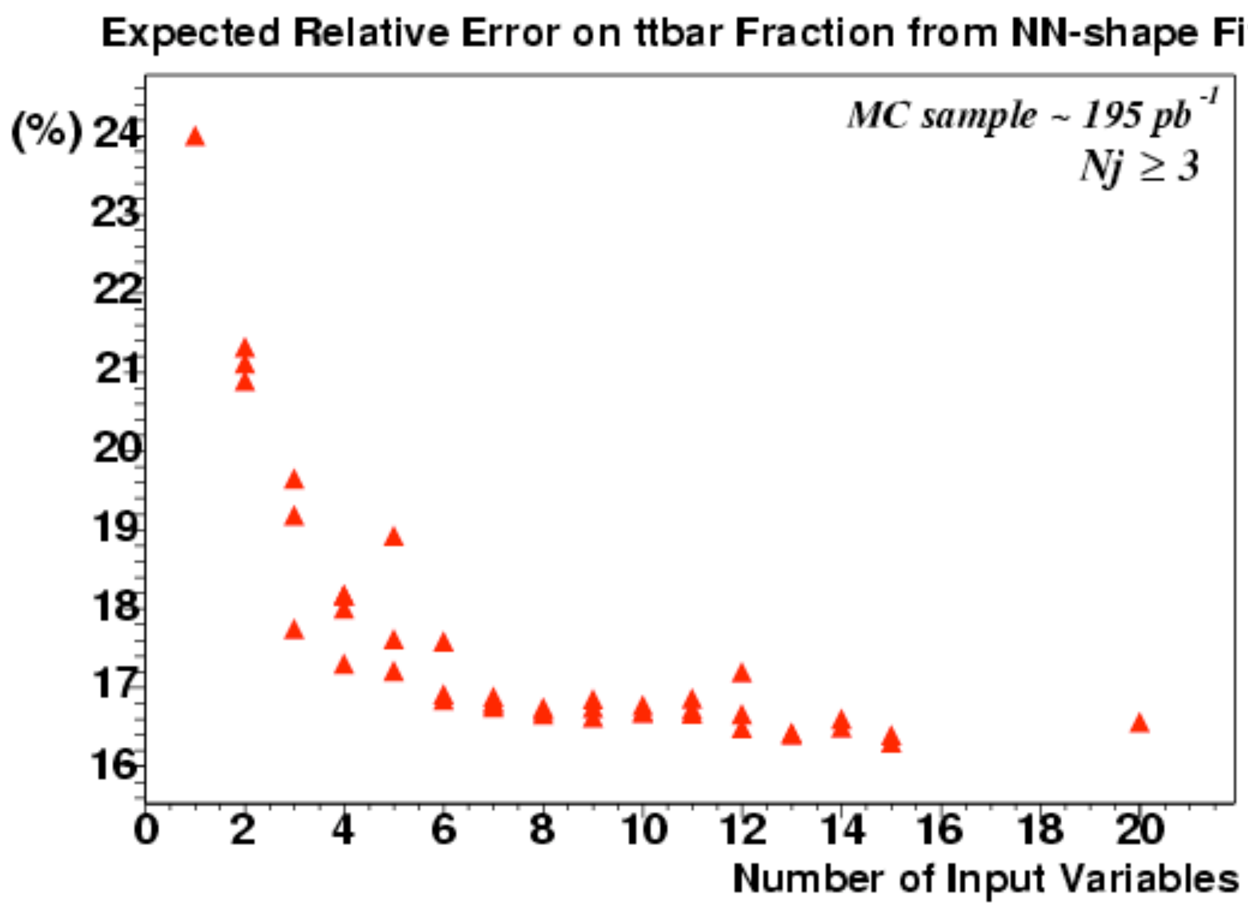
$Q^2 = M_W^2+\Sigma P_T^2$(Jets)

Kinematics in Multivariate Methods

Using many variables (both energy and angular variables) reduces sensitivity to things like jet energy scale, Q2, etc. Neural network version of kinematic top cross section measurement: gain in both statistical and systematic sensitivity. Key: Getting the shapes right with the monte carlo.

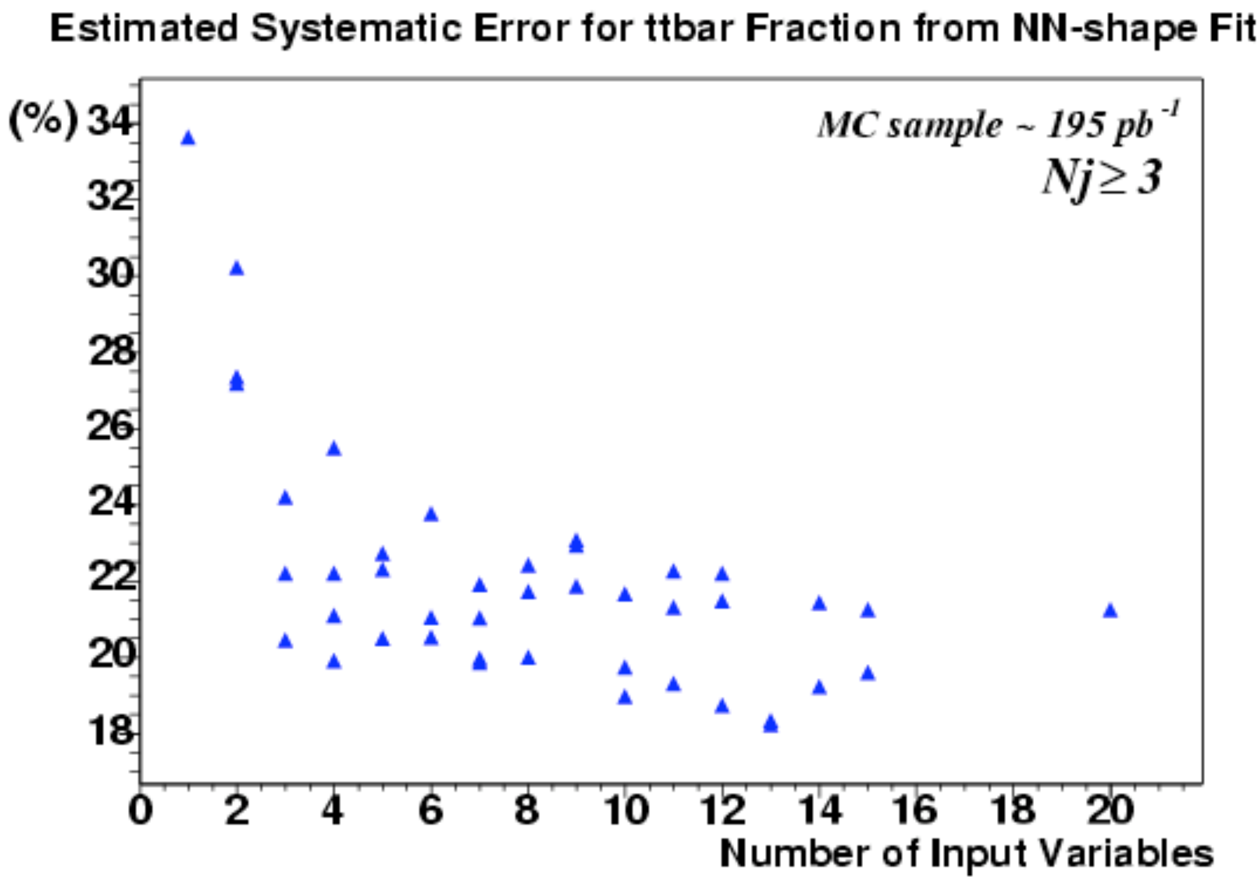


Reduction in Expected Stat Error



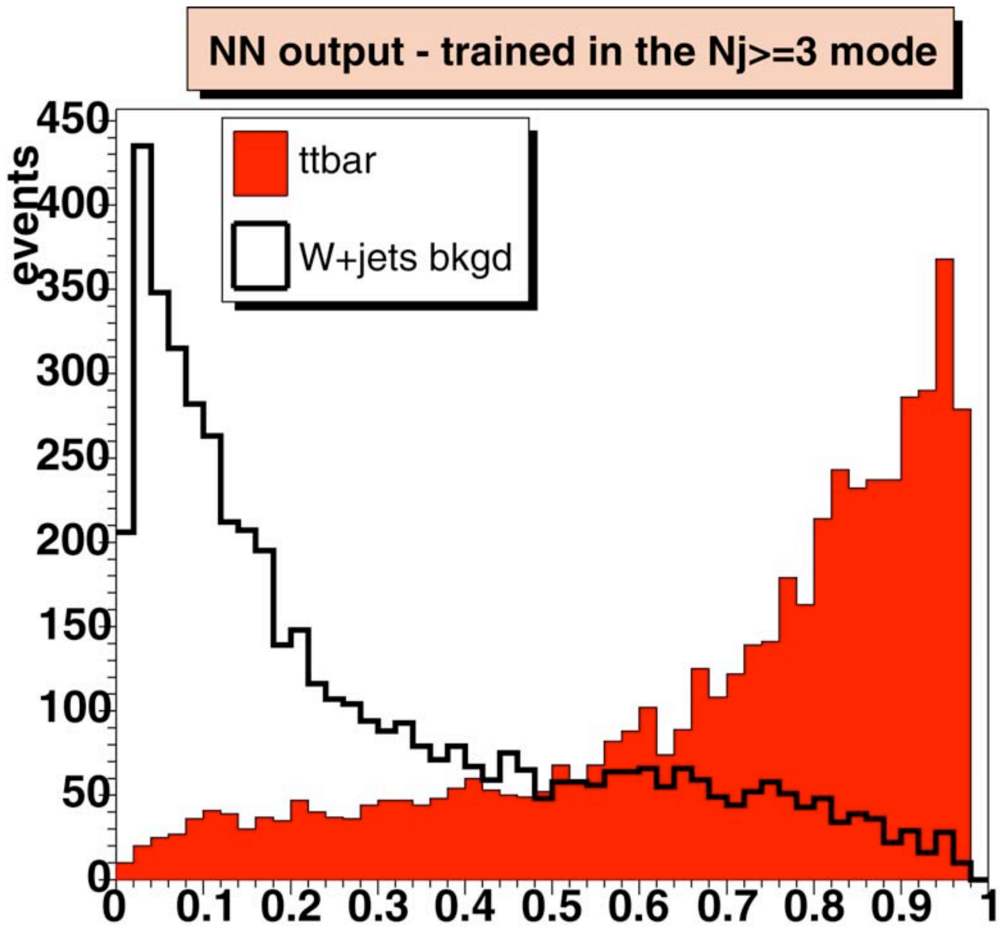
Adding more event event information into the neural network allows better discrimination of top events reduces statistical error.

Reduction in Expected Syst Error



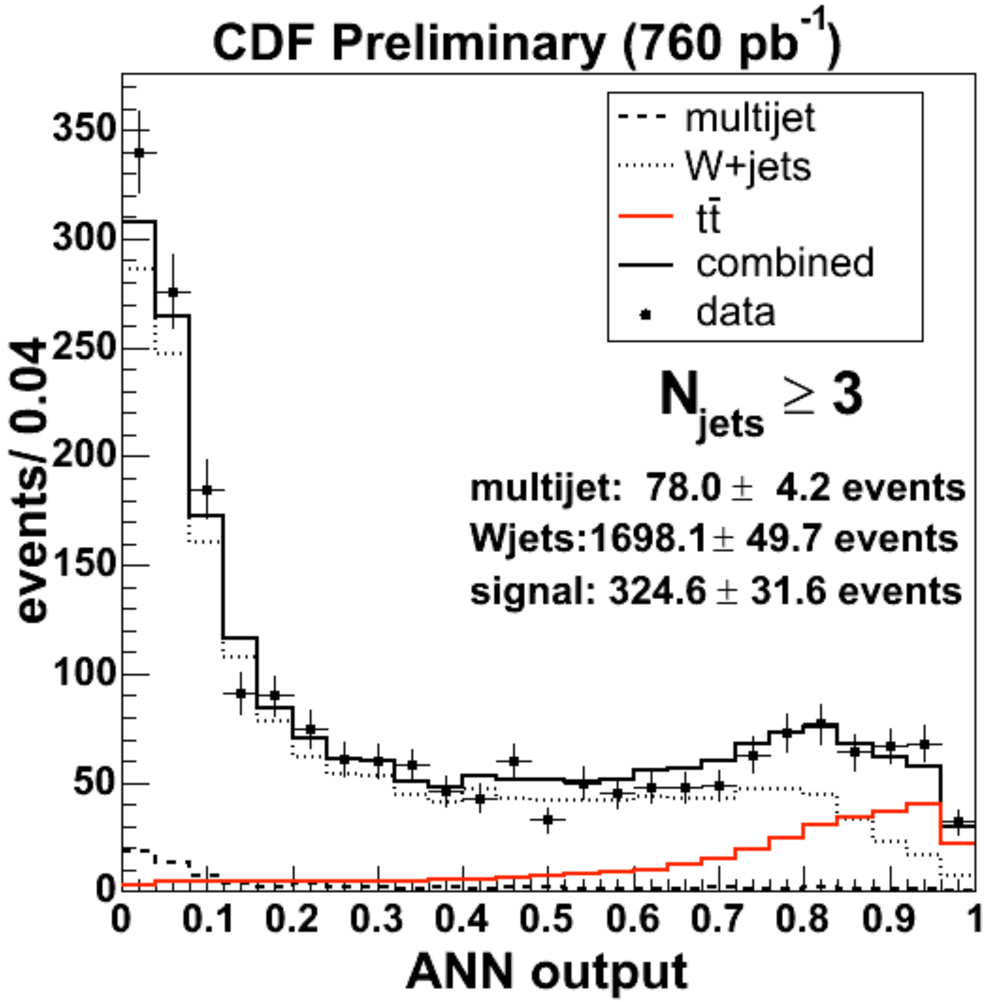
Adding more event event information into the neural network reduces systematics, too, by constraining events from many directions.

Shape Templates: Better S/B Separation



Output of a 7-Input neural network, choosing both shape and energy variables to discriminate top from bkg

Top Cross Section Result, Neural Network

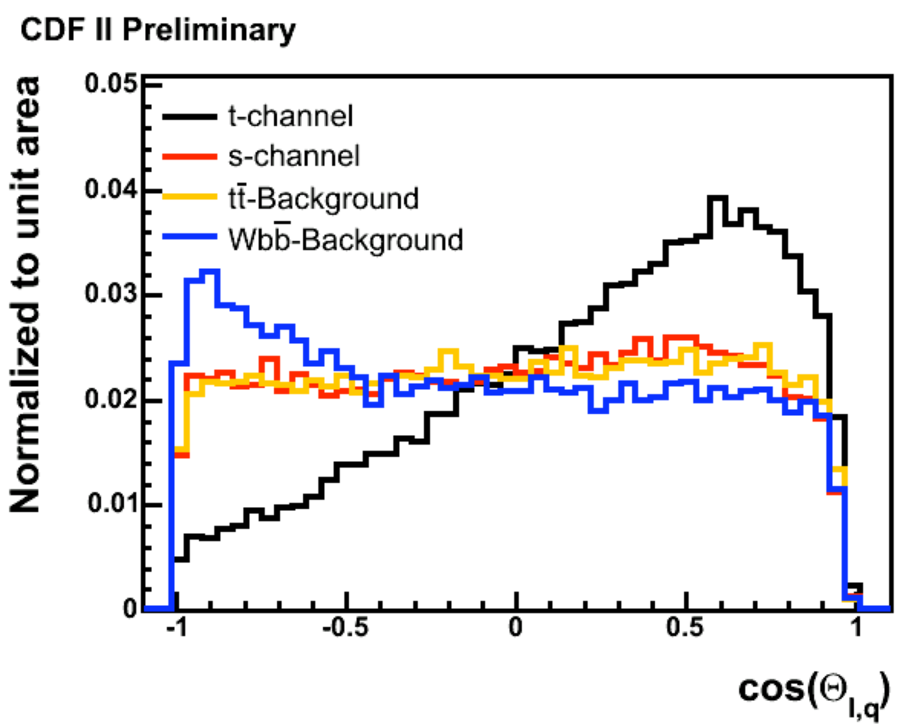


NNLO Theory:
6.8 ± 0.4 pb
Kidonakis, Vogt

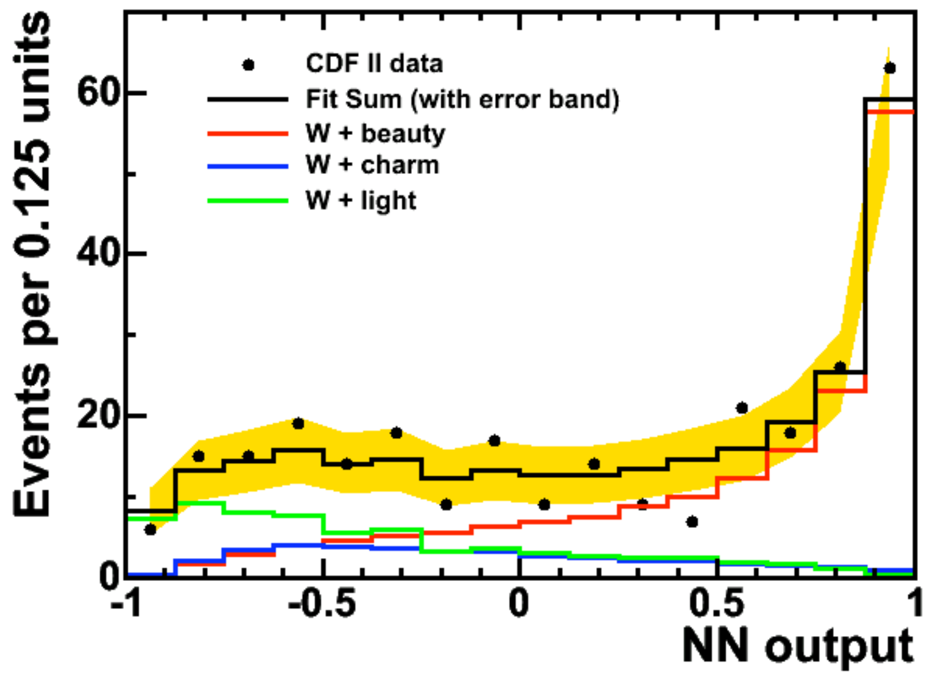
Top pair cross section: 6.0 ± 0.6 ± 0.9 pb
(for Mtop = 175 GeV)

Searches Using Event Kinematics

Kinematics help single top searches



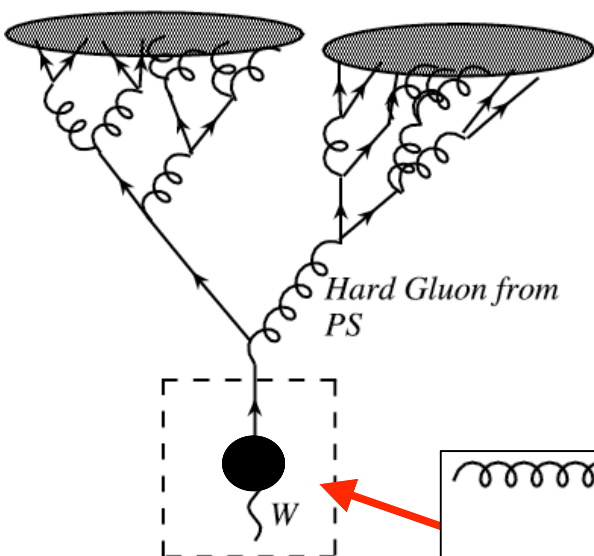
Silicon b-tags purity increased with MC understanding of W+HF



Searches for single top and Higgs both rely on multivariate approaches as well: Neural Network, Likelihood Discriminants, Matrix Element methods, Ideogram. Neural Network b-tagging is providing gains in both acceptance and purity.

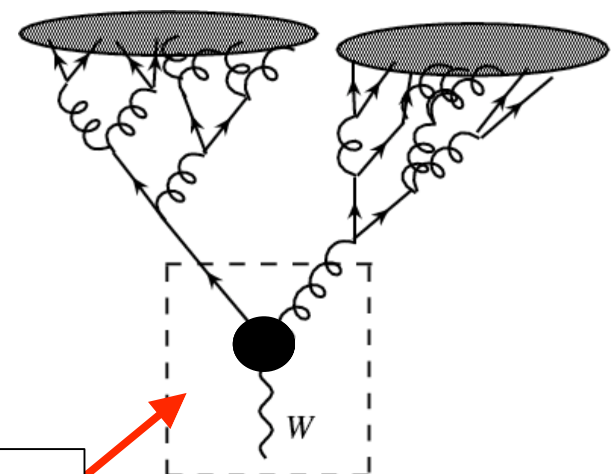
High pT Discovery: ME Tools (LO)

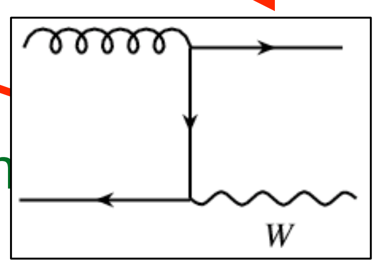
- LO matrix element (ME) perturbative calculations + parton showering (ps) programs to simulate "soft" QCD processes → Enhanced Leading Order approach.
- ELO limitations: W+nparton ELO good for W+n jet sample, worse for W+(n+1) and W+(n+2) samples, etc.
- Why can't we combine all W+n parton samples into a spectrum?



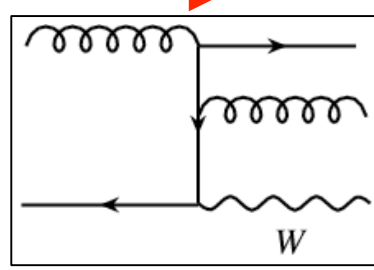
Double counting:

Overlap in phase space between W+1 parton ME + PS, and W+2 parton ME + PS





W+1 parton ME Calc.



W+2 parton ME Calc.

Avoid Double Counting: "MLM Matching"

NOT THIS TYPE OF MATCHING!

Avoid Double Counting: "MLM Matching"

http://mlm.web.cern.ch/mlm/talks/kek-alpgen.pdf

A simple prescription to address this problem

- **Generate parton-level configurations** for a given hard-parton multiplicity N_{part}, with partons constrained by
  - $p_T > p_{T\,min}$ $\Delta R_{jj} > R_{min}$
- **Perform the jet showering**, using the default Herwig/Pythia algorithms
- Process the showered event (before hadronization) with a **cone jet algorithm,** defined by
  - $E_{T\,min}$ and R_{jet}
- **Match partons and jets:**
  - for each hard parton, select the jet with min $\Delta R_{j\text{-}parton}$
  - if $\Delta R_{j\text{-}parton} < R_{jet}$ the parton is "matched"
  - a jet can only be matched to a single parton
  - **if all partons are matched, keep the event, else discard it**
- This prescription defines an **inclusive sample** of $\mathbf{N_{jet}=N_{part}}$ **jets**
- Define an **exclusive N-jet** sample by requiring that the number of reconstructed showered jets $\mathbf{N_{jet}}$ be equal to $\mathbf{N_{part}}$

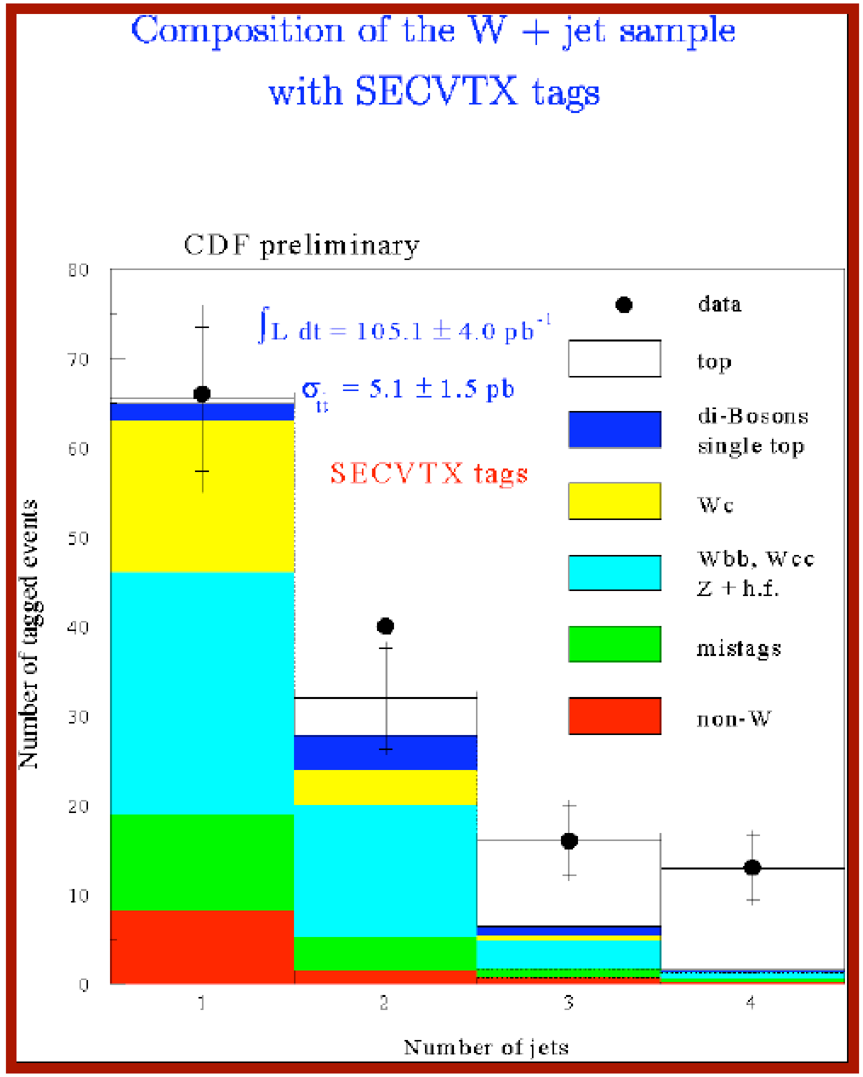
CDF has used this prescription in post- parton shower hand-matched format so far as needed, inclusive samples if possible.
**Needed before AlpGen v2 only!

CDF Run 1 “Excess” in W+2 Jet Bin

- Observed excess of b-tags in the 2 jet bin
- Too many SVX double tags (more than one b-tagged jet/event)
- Too many multiple tags (more than one b-tag/jet)

A lot of speculation, but nothing solid.

("superjets")

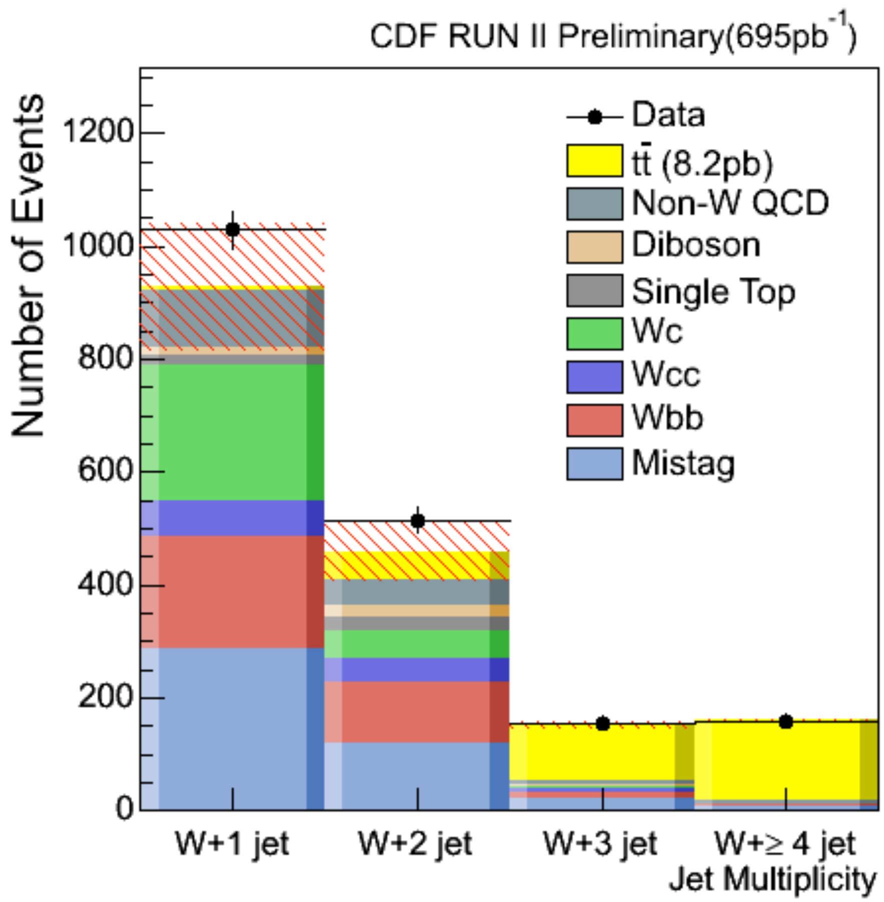


Top Cross Section: Counting Experiment

CDF Method 2: Jargon for MC-based estimation of *b-tagged* top sample composition.

Issue: how do we normalize the W+HF bkgnds in exclusive jet bins?
Answer: Determine HF fraction F_{HF} and normalize to data.

- Monte Carlo (AlpGen) ratio:
  F_{HF} = (W + b-jets) / (W + jets)
- Measure W+jets (no tag)
- W + b-jets = F_{HF} * data(W + jets)
- Wcj / Wbb from MC
- Lots of ratios!

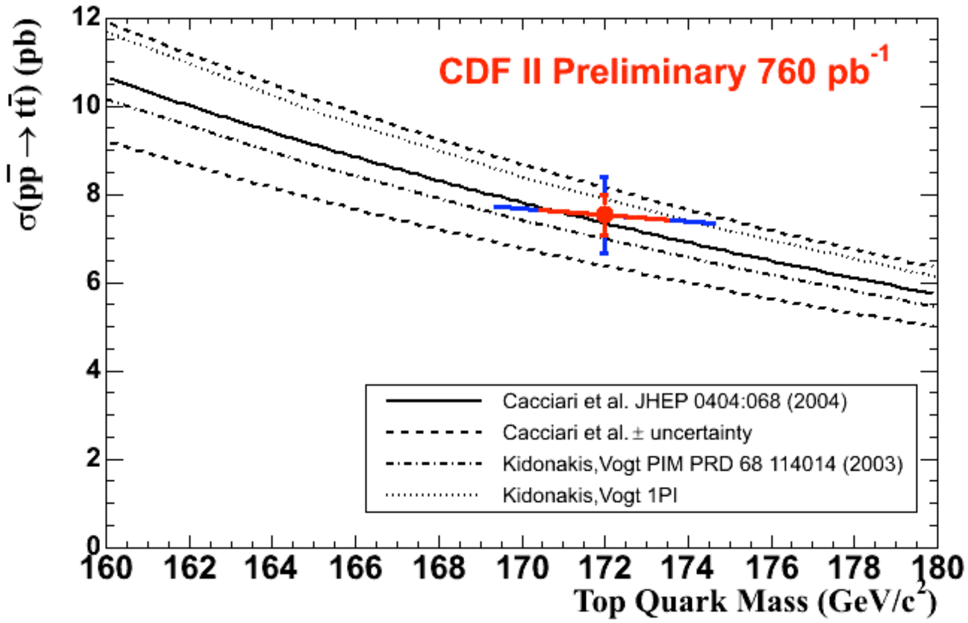


Need to avoid double counting in exclusive jet bins: MLM-style matching employed *by hand*. F_{HF} one of largest systematic errors.

Top Cross Section Combination

7.3 ± 0.5(stat) ± 0.6(syst) ± 0.4(lumi) pb

CDF 8148



NNLO Theory:
6.8 ± 0.4 pb
Kidonakis, Vogt

NLL Resummed:
6.7 ± 0.8 pb
Frixione, MLM, et al

Some things to note:

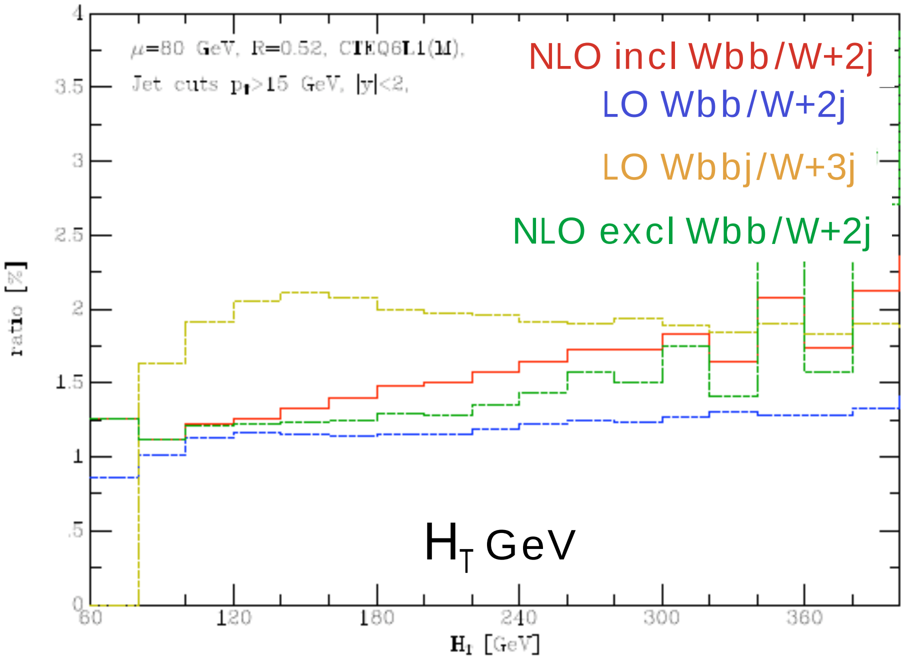
Method 2: 8.2 ± 0.6 ± 1.0 pb | Consistency 7% | ANN: 6.0 ± 0.6 ± 0.9 pb

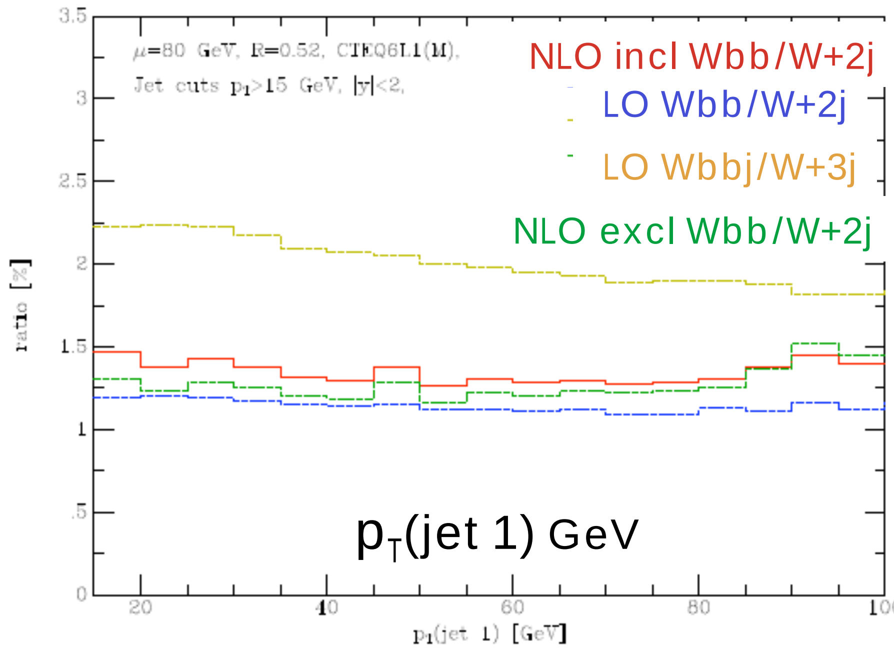
→ SecVtx and ANN: Check/improve systematics to resolve discrepancy

→ Relative error ~10% (~theory). TDR goal:10% with 2 fb^{-1}. Next years will be important in understanding, counting SM backgrounds versus kinematics.

Heavy Flavor Fraction: LO versus NLO

Stand-alone studies by Campbell/Huston (hep-ph/0405276) with MCFM have allowed LO v. NLO comparisons of W+HF versus W+jets.



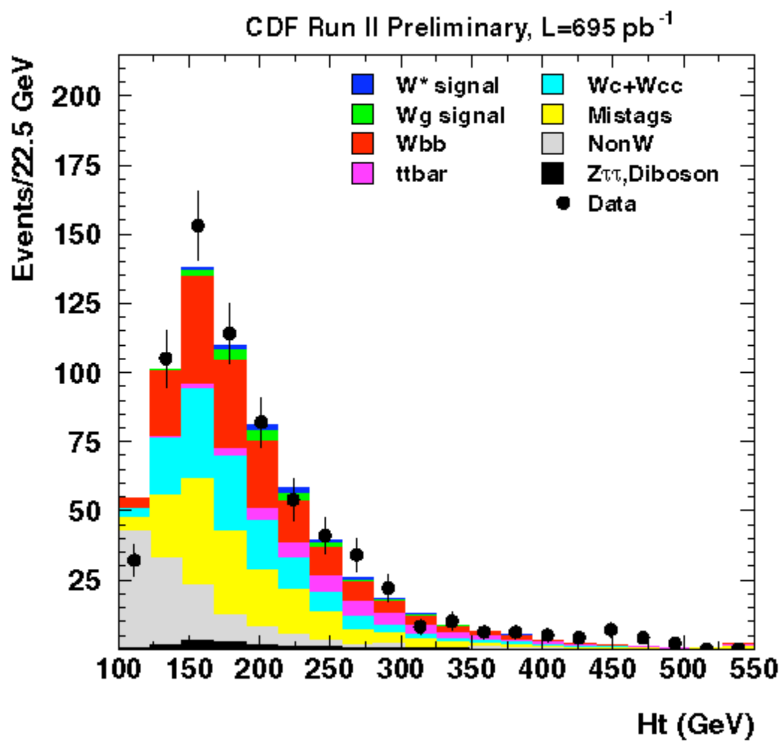


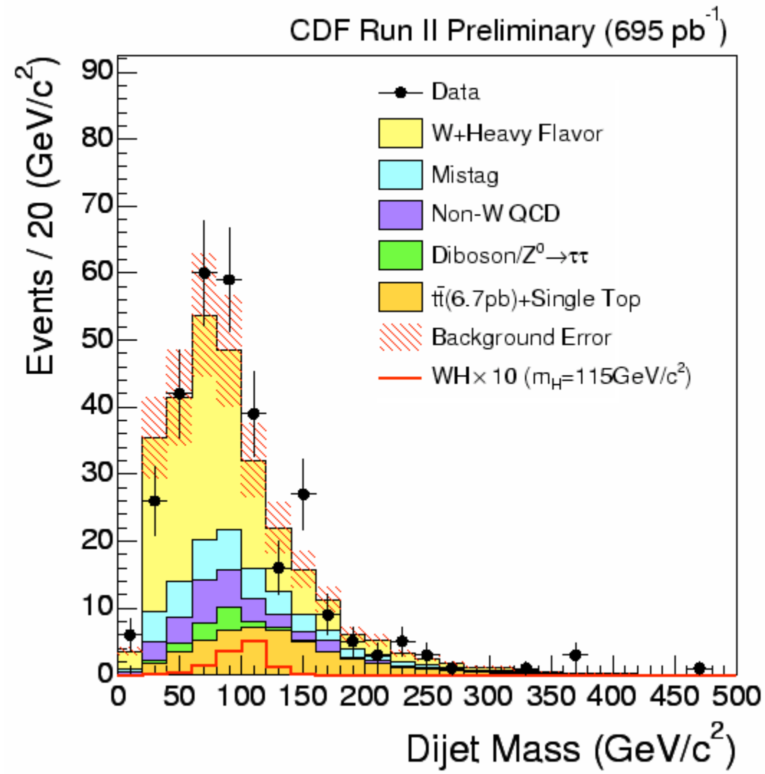
Ratio Wbb/W+2j and Wbbj/W+3j: stable at LO but unstable at NLO (as fn of HT). Stable in both cases as fn of pT.

Conclusion: "exclusive" variables more sensitive than "inclusive". Could affect HF fraction. Predicted by CKKW? List of things needing investigation.

Sample Composition: Method 2 Everywhere

CDF Method 2: Same estimation of backgrounds for b-tagged top cross section used in searches for single top.





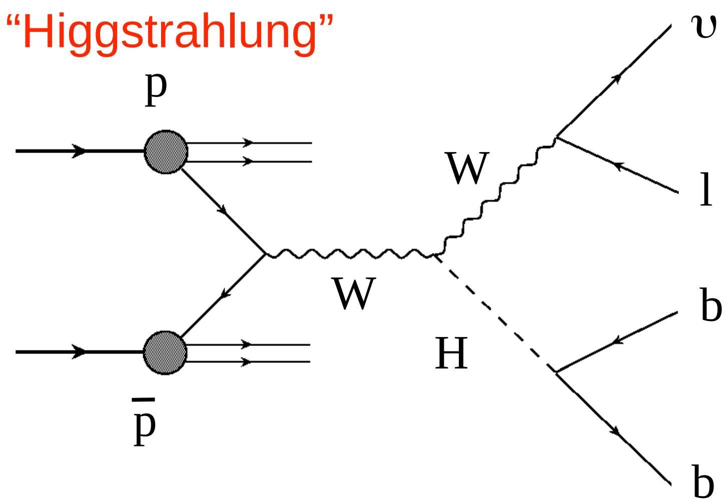
Method 2 Also Used In: CDF search for WH, as well as many top properties (top charge, FCNC, W helicity, top mass.

Multivariate/ME techniques and statistics make these less sensitive to bkgnds than counting experiment. Problems: possible biases and more stats!

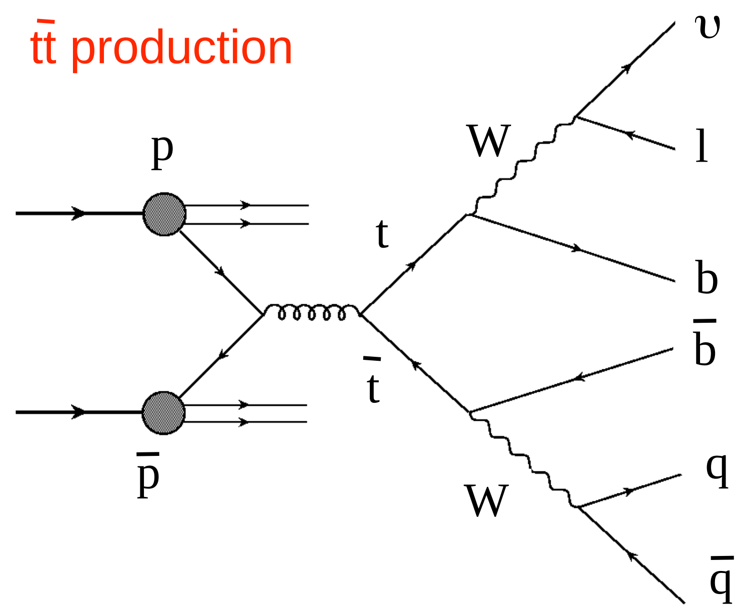
Why So Much About W+Jets?

- Good test ground for QCD: occurs at a scale that should mean perturbative QCD approximations are reasonable.
- Major background to tt , single top, and several potential Higgs discovery channels.
- Accurate prediction of W + Jets background most probably via Monte Carlo.
- Monte Carlo should reproduce data in terms of:
  - Production cross-section
  - Differential cross-section: shape of kinematic variables eg. Jet E_T, angular separation of jets etc.

“Higgstrahlung”



$t\bar{t}$ production



AlpGen v2 with Matching Inside!

Talk by Mauro Moretti

Improvements we are looking for:

•Better interface to ps without user needing to write matching algorithm (matching uncertainty goes down).

•Stability of cross sections and agreement with data: ability for (almost) absolute normalization, at least across multiplicities.

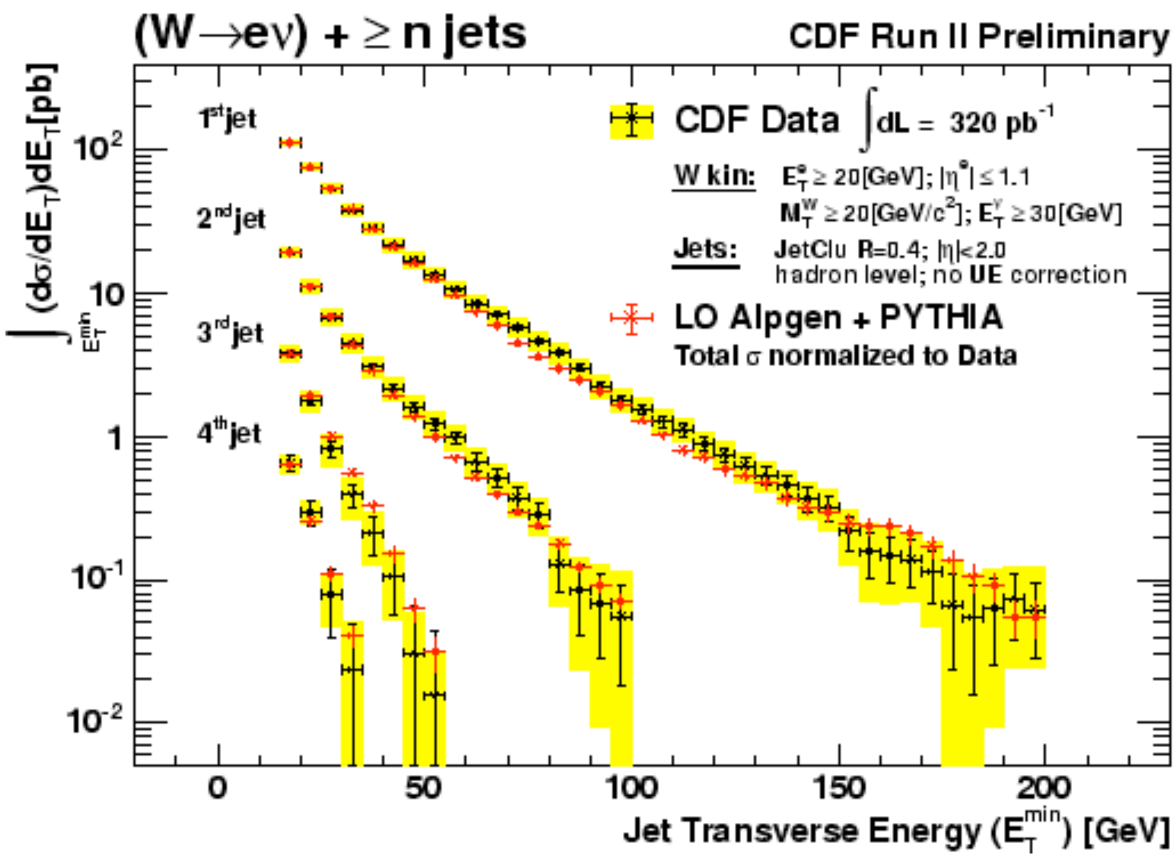
•Vertex-by-vertex scales, reduce uncertainty in Q^2 parameters.

Verdict:

•Still under study. QCD analysis of W+jets (next).

•Top groups (CDF & D0) are in R&D phase with AlpGen 2. Settings, pythia tunes… CDF moving to AlpGen+Pythia

W+Jets at CDF: At the Hadron Level



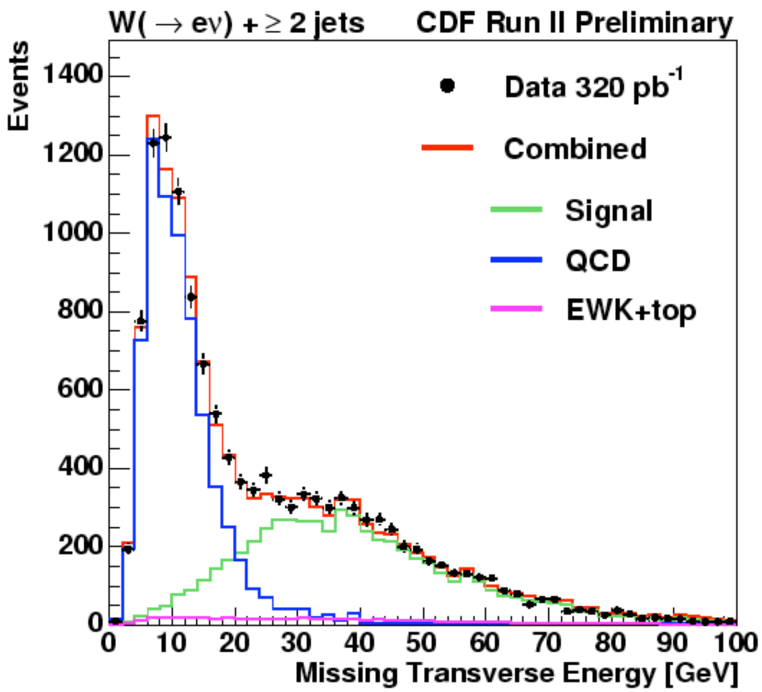
Analysis:

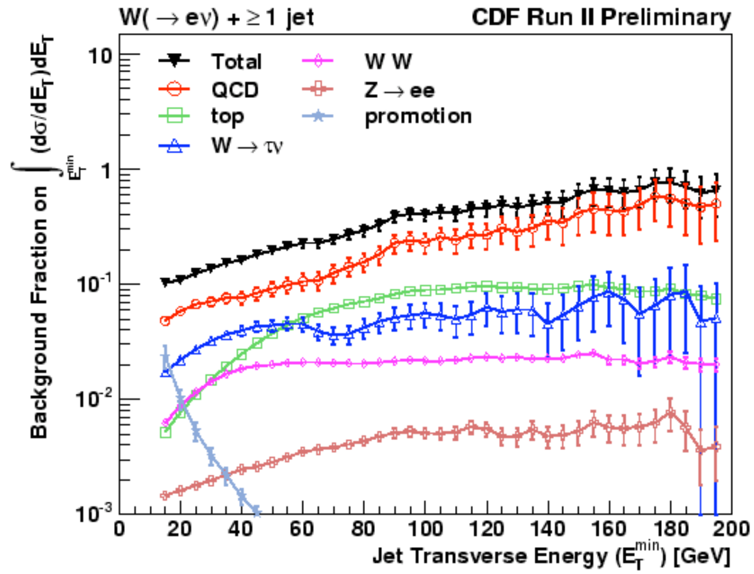
Ben Cooper, Andrea Messina

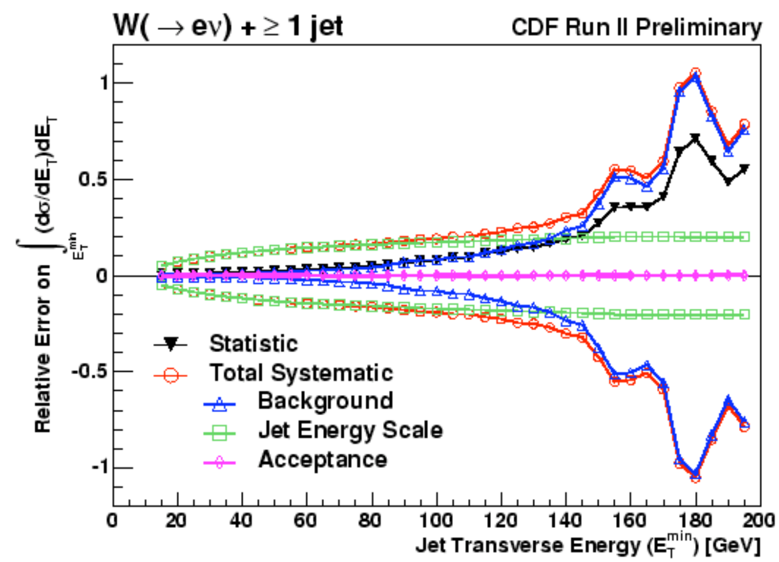
Cooper thesis, pub in the works, find on CDF public results pages, now out of QCD group

Jets are corrected to hadron level and unsmeared (detector). No underlying event UE correction (most 10% and important at low E_T). Differential distribution and other kinematics available. Limited W kinematics. Acceptance model (“theory”): LO AlpGen v2 + Pythia.

W+Jets: AlpGen v2 + Pythia Versus Data







<u>Above</u>: Missing Et in W+≥1 jets: data fit to sample composition: AlpGen + cocktail.

<u>Right</u>: top plot is bkgnd fraction as fn of minimum lead jet Et, W+≥1 jets.

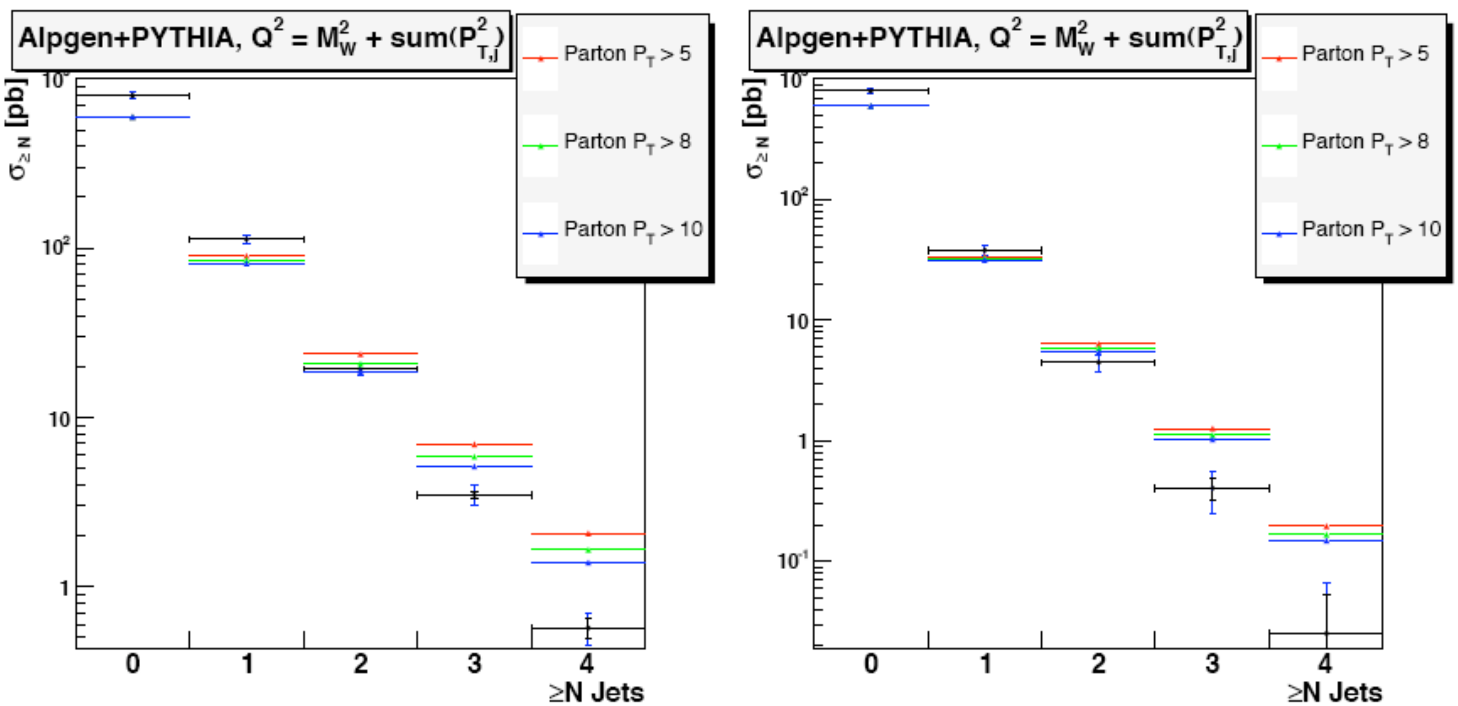
Bottom plot is uncertainty as a fn of minimum lead jet Et.

Things to Watch….

If you're interested in this business and how you can help!

Comparing AlpGen v2 Matched Samples

Ben Cooper's thesis plots: Totally and completely preliminary.

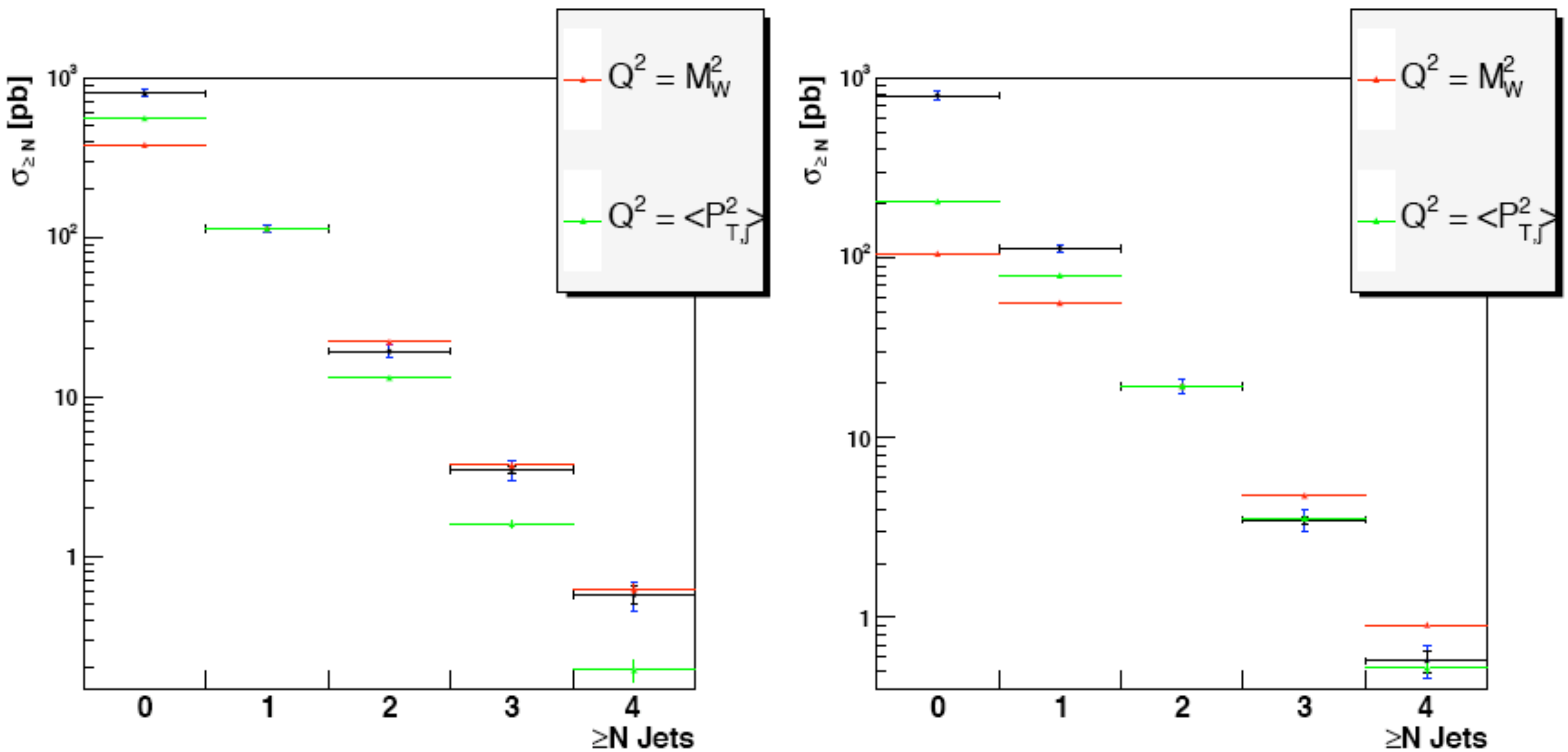


(a) $E_T^{jet} \geq 15$ GeV (b) $E_T^{jet} \geq 30$ GeV

A Look at Njets with different generation Pt cuts.
CDF "nominal" Q^2 value.

Comparing AlpGen v2 Matched Samples

Ben Cooper's thesis plots: Totally and completely preliminary R&D.

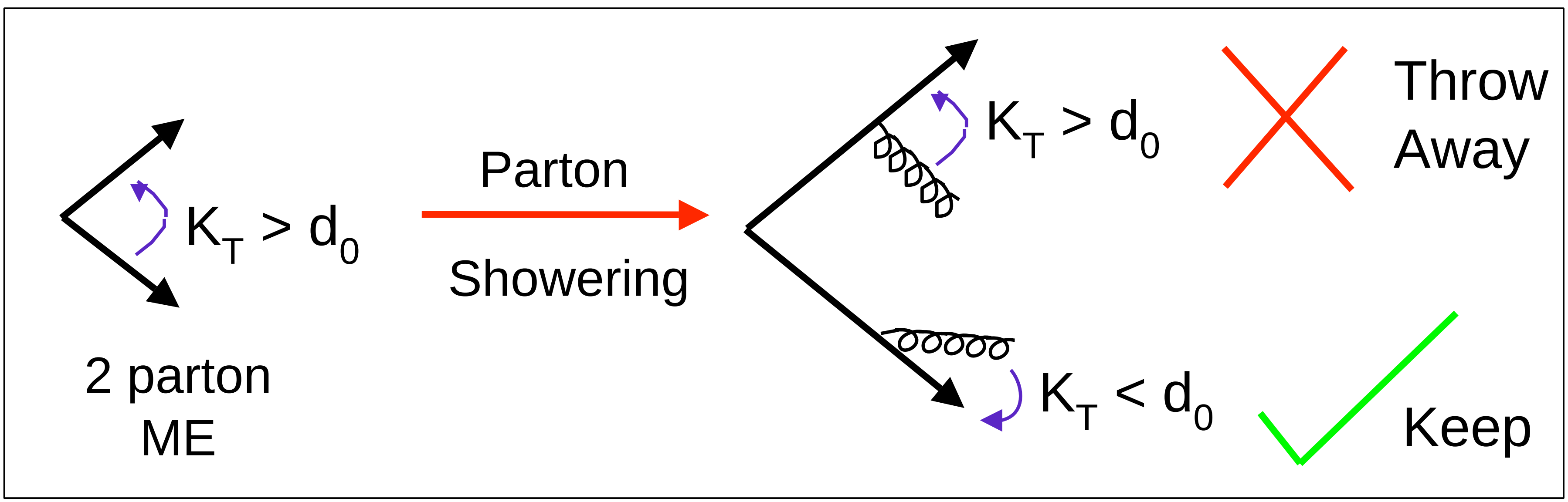


A Look at Njets with different Q^2. Preliminary top group studies also show little change when tweaking parameters. Accidental "feature", user error, or better model?

CKKW Comparisons to W+jets

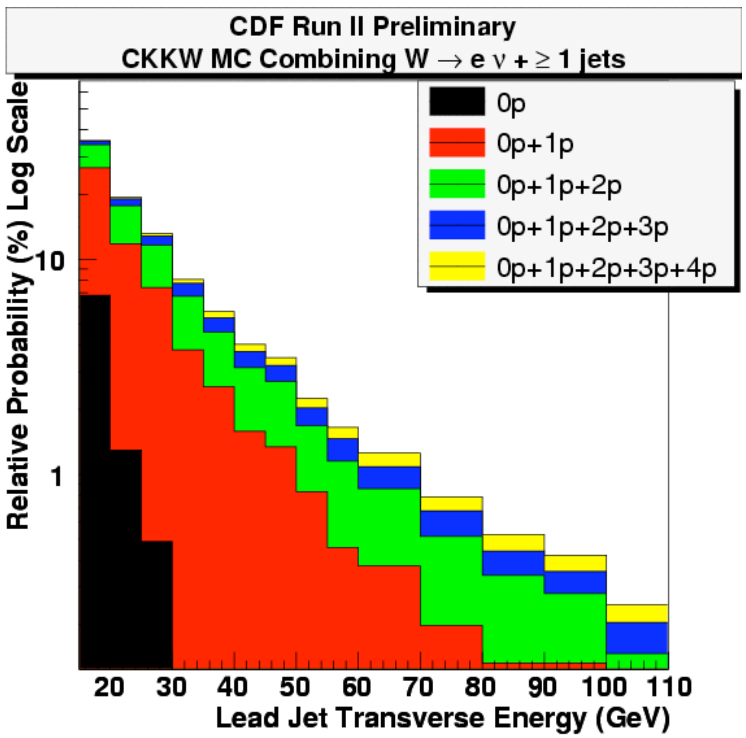
Catani, Krauss, Kunz, Webber hep-ph/0109231

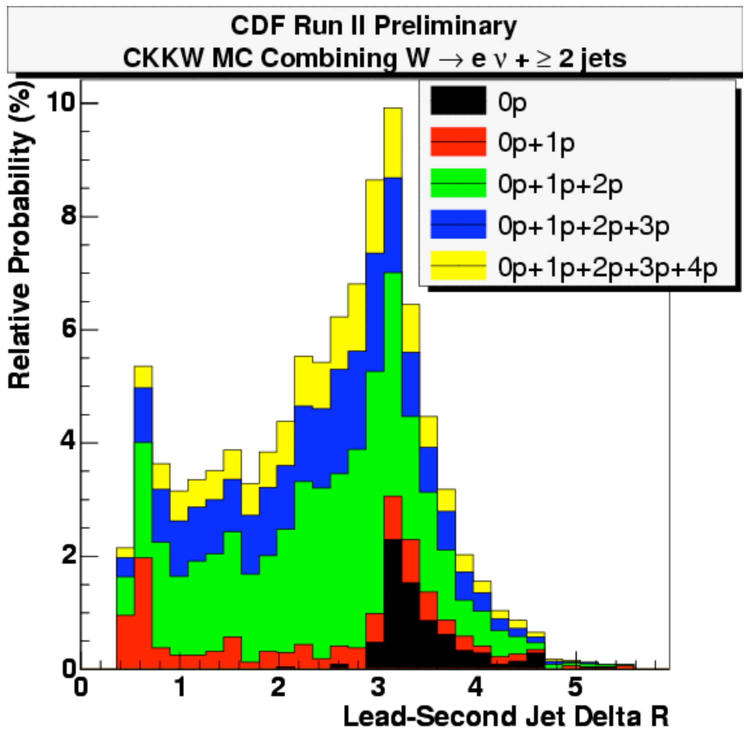
- ME-PS matching scheme: Vetos events at the PS stage that infringe on the phase space already covered by ME.
- W+n parton samples can then be combined without double counting.
- Madgraph + Pythia samples generated by Steve Mrenna.
- CKKW can be implemented with any ME-PS generators.
- Other matching schemes: Mangano's “MLM Matching”



Combining CKKW Samples

After detector simulation: W+0 parton .... W+4 parton CKKW samples combined in ratio of cross-sections → should describe all W + n jet sampes.

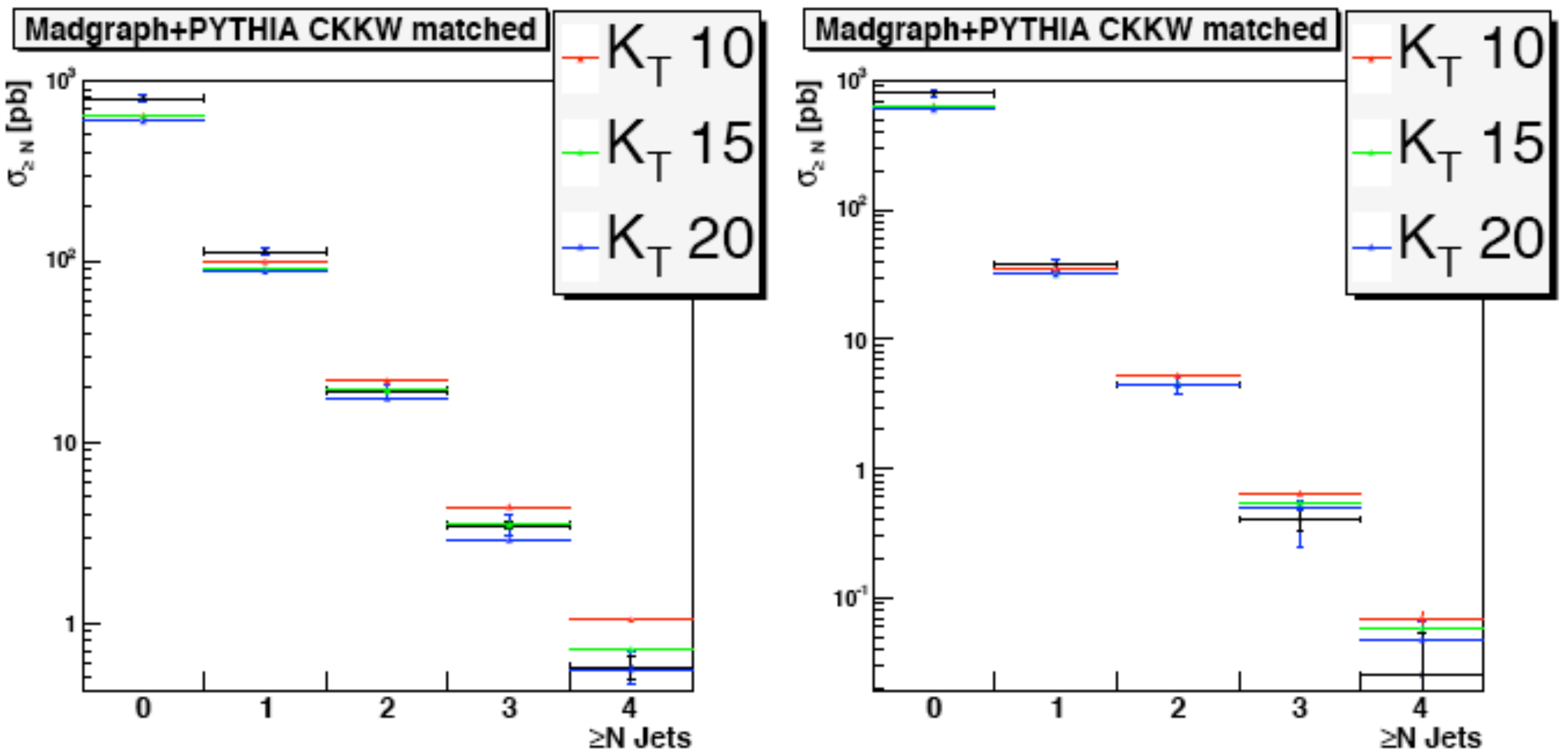




Samples from S. Mrenna (thanks!) a la Mrenna, Richardson hep-ph/0312274

Comparing CKKW Matched Samples

Ben Cooper's thesis plots: Totally and completely preliminary.



(a) $E_T^{jet} \geq 15$ GeV (b) $E_T^{jet} \geq 30$ GeV

A Look at Njets v. data with different generation K_T cuts.
We will work on making studies public, I promise!

More MadGraph CKKW Studies

Some in exotics group doing studies. Henry Frisch standalone MC. Has CDF internal notes comparing W-gamma Z-gamma Madgraph MC and "Baur samples", incorporating models into Madgraph, etc.

Henry's wish:

"Main issue is a common interface- Les Houches isn't a definite spec- has been interpreted differently by Herwig, Alpgen etc. Could you estimate time and money lost to MC interface issues? This would be a really valuable pair of numbers to enter into the discussions."

Vista: Data Comparisons, "Fudge Factors"

Bruce Knuteson instigator. See C. Henderson parallel talk, Pheno '06, and S. Mrenna's FNAL Wine and Cheese talk (on websites).

Vista is an attempt to simultaneously analyze all high p_T data and monitor for discrepancies relative to our implementation of the Standard Model predictions.

<u>Vista Fudge factors</u>

Nature = Generated events $\otimes$ detector simulation/reconstruction $\otimes$ "fudge factors"

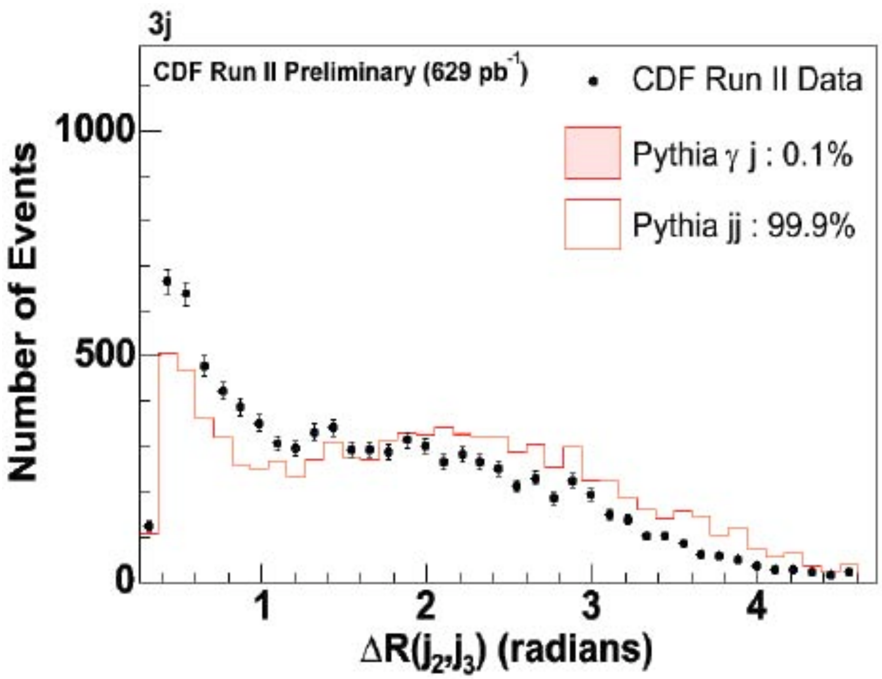
These factors (55!) include:

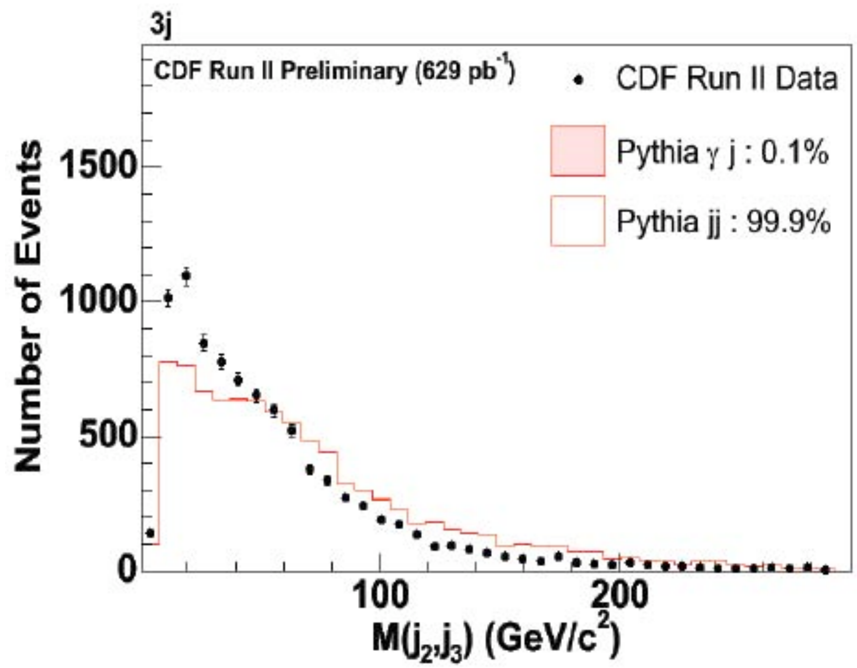
- Trigger efficiencies, luminosity
- Theoretical k-factors
- Reconstruction efficiencies…

[Aside: Hopefully not bugs! Vista at the least is helping us shake out the tools]

Example of Vista Discrepancy: New Tune!

3j final state showed a discrepancy on 2nd and 3rd jet distributions from standard model implemented with Pythia + Rick Field Tune AW.





Vista Crew, Rick Field, and Steve Mrenna worked out a Pythia Tune BW that worked better as a result!

Settings, Tunes, and R&D

What we've seen: differences in ME/MC with different generation settings and tunes for different kinematic comparisons.

Pythia tune A versus AW versus BW: we see varying agreement between data and MC for Z pt (eg) from that for inclusive ttbar MC.

Work is in progress to sort out the best settings, but each time we use new MC, this takes time and effort away from detector and results. Worthy cause: its how we get the physics out!

But knowing this makes it easier for you to understand why we don't have lots of comparisons to every new tool. (and model!)

Admittedly… we should do more to make data public to theorists for comparison, or to make our own comparisons public.

For physics results? Can't afford an industry of different samples: human/computing/disk resources: ….

Top Group MC Samples at a Glance

Estimate of events needed for one round of top analyses using one set of tools (for consistency), not all systematic samples present. Need gen+simulation+det recon.

rough estimation of # of MC events we need for analyses is
b-tagging 30M events
ttbar (incl.syst) 26M events
ALPGEN+PYTHIA 74M events
mass samples 56M events
all hadronic 66M events
tau samples 10-20M events
PYTHIA W/Z 30M events
- ----------------------------
total ~340M events

Followings are list of we want to generate;

(*) For b-tagging scale factor (being generated)
PYTHIA dijet sample filtering Pt>18GeV/c
30M events.

(*) Test samples for top mass (done)
(PYTHIA ttbar, with min. bias, Gen6, 1M each)
165, 170, 180, 185GeV

(*) ttbar signal sample (for main sample; mass=175GeV
PYTHIA + min. bias (done)
tewk1z may be not enough.

(*) single top signal samples
(madEvent+PYTHIA, W decay force to lepton)
with min. bias. (175GeV)

s-channel 0.2M events (done)
t-channel (LO+NLO) 0.2M events (NLO done)

(*) After ALPGEN+PYTHIA was signed off (w/ MB).

(electron, muon, separately)
W + Np (N=0,1,2,3,4) 1M each
W + bb + Np (N=0,1,2) 1.5M each
W + cc + Np (N=0,1,2) 2M each
W + c + NP (N=0,1,2,3) 2M each

(*) After ALPGEN+PYTHIA was signed off (w/ MB).

(electron, muon, separately)
W + Np (N=0,1,2,3,4) 1M each
W + bb + Np (N=0,1,2) 1.5M each
W + cc + Np (N=0,1,2) 2M each
W + c + NP (N=0,1,2,3) 2M each

(electron, muon, Z at peak)
Z + Np (N=0,1,2,3,4) 0.5M each (Z+2p; 5M at Z peak)
Z + bb + Np (N=0,1,2) 0.5M each
Z + cc + Np (N=0,1,2) 0.7M each
Z + c + NP (N=0,1,2,3) 0.7M each

Z + Np (N=0,1,2,3,4) 0.5M each below Z peak (Z+2p; 5M)
Z + Np (N=0,1,2,3,4) 0.5M each above Z peak

(*) After comfirming test samples are OK, mass sample can be generated.

196-200; 2GeV step, 5 samples x 0.5M = 2.5M events
186-195; 1GeV step, 10 samples x 0.5M = 5M events
165-185; 0.5GeV step, 41 samples x 1M = 41M events
155-164; 1GeV step, 10 samples x 0.5M = 5M events
150-154; 2GeV step, 5 samples x 0.5M = 2.5M events

Name should include given mass value.

(*) ALPGEN+PYTHIA dijet samples (for HF k-factor caluculation)
(filter parton with Pt>18GeV/c)
NB: The level of the pt cut on the parton are based on matching the data @L4.

dijet + Np (N=2,3,4) 5M for each
dijet + BB + Np (N=0,1,2) 5M for each
dijet + CC + Np (N=0,1,2) 5M for each

(*) mass sample for single top (0.2M for each)
170 GeV; t-ch and s-ch
180 GeV; t-ch and s-ch

(*) W helicity sample (not sure w/ or w/o min. bias)
GGWIG W+/- left-handed 0.5M
W+/- right-handed 0.5M
W+/- longitudinal 0.5M

(*) systematic mass samples + spin correlation samples
HERWIG + min bias, 170GeV, 175GeV, 180GeV -- 1M for each
MC@NLO 175GeV + min bias -- 1M
MRST72 / MRST75 samples (w/ min. bias) -- 1M for each
ttbar PYTHIA w/o min. bias -- 4M
ttbar HERWIG (including spin correlation, normal) w/o min. bias -- 4M
ttbar HERWIG (spin correlation off) w/o min. bias -- 4M

(*) Systematic samples for HF

(each for Dijets+BB+NP, Dijets+CC+NP, Dijets+NP)
Different matching cuts -- need specify more
Q2 samples -- 2 samples 1M for each
ISR less/more -- 2 samples 1M for each
FSR less/more -- 2 samples 1M for each
Mq (+/- 0.3) -- 2 samples 1M for each

(*) After comfirming Un-Ki's study was done (PYTHIA 175GeV, with MB)

(ttbar)
ISR less 1M
ISR more 1M
FSR less 1M
FSR more 1M

(single top, each for t-ch, s-ch, 0.15M events for each)
ISR less
ISR more
FSR less
FSR more

(*) All hadronic background samples (ALPGEN+PYTHIA+MB)
bb + Np (N=4,5,6) Pt10GeV, 20M for each (1Tb for disk)
cc + Np (N=4,5,6) Pt10GeV, 1M for each?
Np (N=6,7,8) Pt10GeV, 1M for each?

Les Houches 2005: NLO Wish List

- Note have to specify how inclusive final state is
  - what cuts will be made?
  - how important is b mass for the observables?
- How uncertain is the final state?
  - what does scale uncertainty look like at tree level?
  - new processes coming in at NLO?
- Some information may be available from current processes
  - pp->tT j may tell us something about pp->tTbB?
    - j=g->bB
  - CKKW may tell us something about higher multiplicity final states

1. pp->WW jet
2. pp->H + 2 jets now complete
   1. background to VBF production of Higgs
3. pp->tT bB
   1. background to tTH
4. pp->tT + 2 jets
   1. background to tTH
5. pp->WWbB
6. pp->V V + 2 jets
   1. background to WW->H->WW
7. pp->V + 3 jets
   1. beneral background to new physics
8. pp->V V V
   1. background to SUSY trilepton

Are there any other cross sections that should be on this list?

Les Houches 2005 & Benchmarks

Last year's workshop "Physics at TeV Colliders" went well.

→ Proceedings are published: hep-ph/0604120

Benchmark for LHC being collected:

→ Global PDF analysis; to NLO; to NNLO.

→ Inclusive jets at Tevatron, LHC; Progress on Jet Algorithms (Inclusive Kt, new Midpoint).

→ Status of Photon/Diphoton; W/Z/DY; V+jets.

→ ISR/FSR Tevatron studies; parton showers; underlying event tunes.

→ Higher order Calculations, including prioritized list, and a promise:

"Stefan Dittmaer has promised to calculate at least one of these before the LHC turns on."

www.pa.msu.edu/~huston/Les_Houches_2005/Les_Houches_SM.html

2001 NLO Wish List

Campbell, Run II Monte Carlo Workshop, April 2001

- Missing many needed NLO computations   Campbell

An experimenter's wishlist

- Hadron collider cross-sections one would like to know at NLO

Run II Monte Carlo Workshop, April 2001

Single boson	Diboson	Triboson	Heavy flavour
$W+\leq 5j$	$WW+\leq 5j$	$WWW+\leq 3j$	$t\bar{t}+\leq 3j$
$W+b\bar{b}+\leq 3j$	$WW+b\bar{b}+\leq 3j$	$WWW+b\bar{b}+\leq 3j$	$t\bar{t}+\gamma+\leq 2j$
$W+c\bar{c}+\leq 3j$	$WW+c\bar{c}+\leq 3j$	$WWW+\gamma\gamma+\leq 3j$	$t\bar{t}+W+\leq 2j$
$Z+\leq 5j$	$ZZ+\leq 5j$	$Z\gamma\gamma+\leq 3j$	$t\bar{t}+Z+\leq 2j$
$Z+b\bar{b}+\leq 3j$	$ZZ+b\bar{b}+\leq 3j$	$WZZ+\leq 3j$	$t\bar{t}+H+\leq 2j$
$Z+c\bar{c}+\leq 3j$	$ZZ+c\bar{c}+\leq 3j$	$ZZZ+\leq 3j$	$t\bar{b}+\leq 2j$
$\gamma+\leq 5j$	$\gamma\gamma+\leq 5j$		$b\bar{b}+\leq 3j$
$\gamma+b\bar{b}+\leq 3j$	$\gamma\gamma+b\bar{b}+\leq 3j$		
$\gamma+c\bar{c}+\leq 3j$	$\gamma\gamma+c\bar{c}+\leq 3j$		
	$WZ+\leq 5j$		
	$WZ+b\bar{b}+\leq 3j$		
	$WZ+c\bar{c}+\leq 3j$		
	$W\gamma+\leq 3j$		
	$Z\gamma+\leq 3j$		

"Maligned Experimenters Wish List" *-J. Huston*

Current NLO Wish List

Priority Number 1:

VVV+jets

Just kidding!

CDF: What We Know We Have

Similar mentions by Skands, Stephens.., but these are "on our radar":

- AlpGen + Herwig/Pythia using inclusive or matched samples. AlpGen v2 under R&D. CDF/D0 top groups using this predominantly.

- MadGraph + CKKW prescription for PS interface. Steve Mrenna supplies to top & QCD. Exotics (few people) in the business as well.

- Sherpa: Just beginning to get samples and think about comparing (W+jets: its on the immediate to-do list!...after the publication, etc. Hand us some ntuples? We can look at parton/hadron level!)

- MCFM under-utilized for comparisons. Can do hadron level comparisons once we remove detector effects for NLO calculations that exist. Hopefully moving in that direction. (A_{fb} in ttbar-- analysis coming soon! Needs NLO.)

- Grace/Grappa: Soushi Tsuno brought to CDF, but alas- he is leaving. Used for things like ttbar anomalous

- CompHep: User friendly interface, but perhaps under-utilized in CDF.

What We Want in the End…

In general we want to end up with

NLO calculations to be included in MC@NLO (or similar) then use ps plus CKKW (or similar) for extrapolations.

[Note: Here ps = parton shower, not PS=Peter Skands. Though, PS agrees with the above and below, as you've seen in his talk.]

MC@NLO Issues:

- More processes needed, difficult to interface, more manpower!
- Negative weights: would be nice to have only positive weights with values of 1
- Could be a very useful tool if more effort is put into it!

CDF 2006: Wish List

Take these as comments from potential users [and as comments on what might help us get your favorite physics out in the way you want to see it]:

→ NLO monte carlo predictions! Easier to use, more processes, interfaced to ps when needed. Not so many negative weights.

→ User-friendly interfaces for Madgraph/CKKW so we can make them ourselves (not wait for theorists who are over-committed).

→ More manpower (theorists!) working on these tools. European fellowships created, similar ideas here: LHC theory initiative.

→ Help/prescription for uncertainty estimations for when we want to compare with "theory" (= ME/MC output).

→ Common interfaces for all tools.

→ Help incorporating new models (MEs) into MC so we can test models. Already a problem at the Tevatron. Wait until the LHC!

2006 Wish List for CDF

A lot of this work is on us! The first step:
Admit you have a problem. Ok, here goes:

We are not very good at "sharing" (blessing R&D plots for public). Reasons?

1) Takes study and optimization to convince ourselves that we have the best settings, don't have bugs, iterations with theorists so we use tools right and make correct assumptions. Once we get this down, we want an answer and to publish! You see the part we think we have right!

2) Well, you saw the work we do in generating/simulating MC just for our physics measurements. Maybe we could work on diversifying our tools

What do you want to see? What are your priorities? This needs to be a constant conversation...

We've Come a Long Way…

We've come a long way since the Run 1 days of Vecbos

→ Computing power is *much* improved, allows us much better estimations and larger stat samples. More diverse samples, better systematics estimations, etc.

We've come a long way since the Run 2 days of detector problems, JES calibrations, and finally, double counting!

→ Now that we are "comfortable in our shoes" in Run 2, and doing better than physics projections (for a given luminosity), we have time to learn more and more. [eg-- CDF: Top Mass to ~1 GeV mtg!]. D0 top conveners have agreed to meet, perhaps at end of summer.

Invite to Loopfest from M. Peskin: "you might even be able to prod people to do useful work".

<u>My conclusion:</u>

Time to resurrect (rename?) RunII Monte Carlo Workshop?!

Fin