Theory Errors and Monte Carlos:
Intro to the Higgs Systematics Meeting

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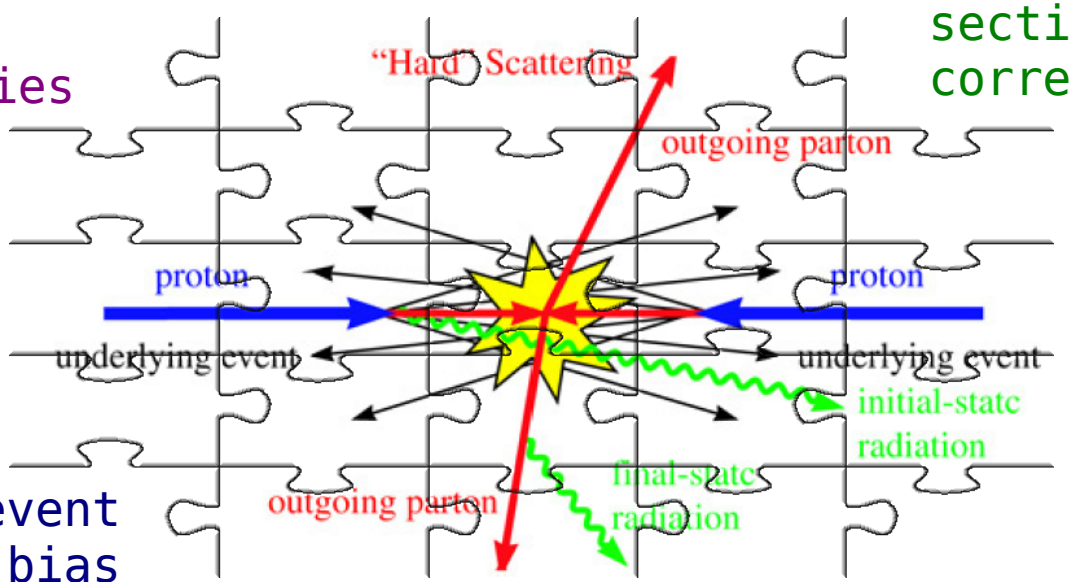
Understanding Cross Sections at hadron colliders: many pieces to the puzzle

LO, NLO and NNLO calculations
K-factors

Benchmark cross sections and pdf correlations

PDFs with uncertainties



Underlying event and minimum bias

Sudakov form factors

Jet algorithms and jet reconstruction

Why a Higgs Systematics Meeting?

- Experimental errors keep shrinking
- Theory calculations more complicated
- Many effects: undercounted, overcounted, missed?
- Communications needs improving
- Want to maximize value of Run2

What are Theory Errors for MCs?

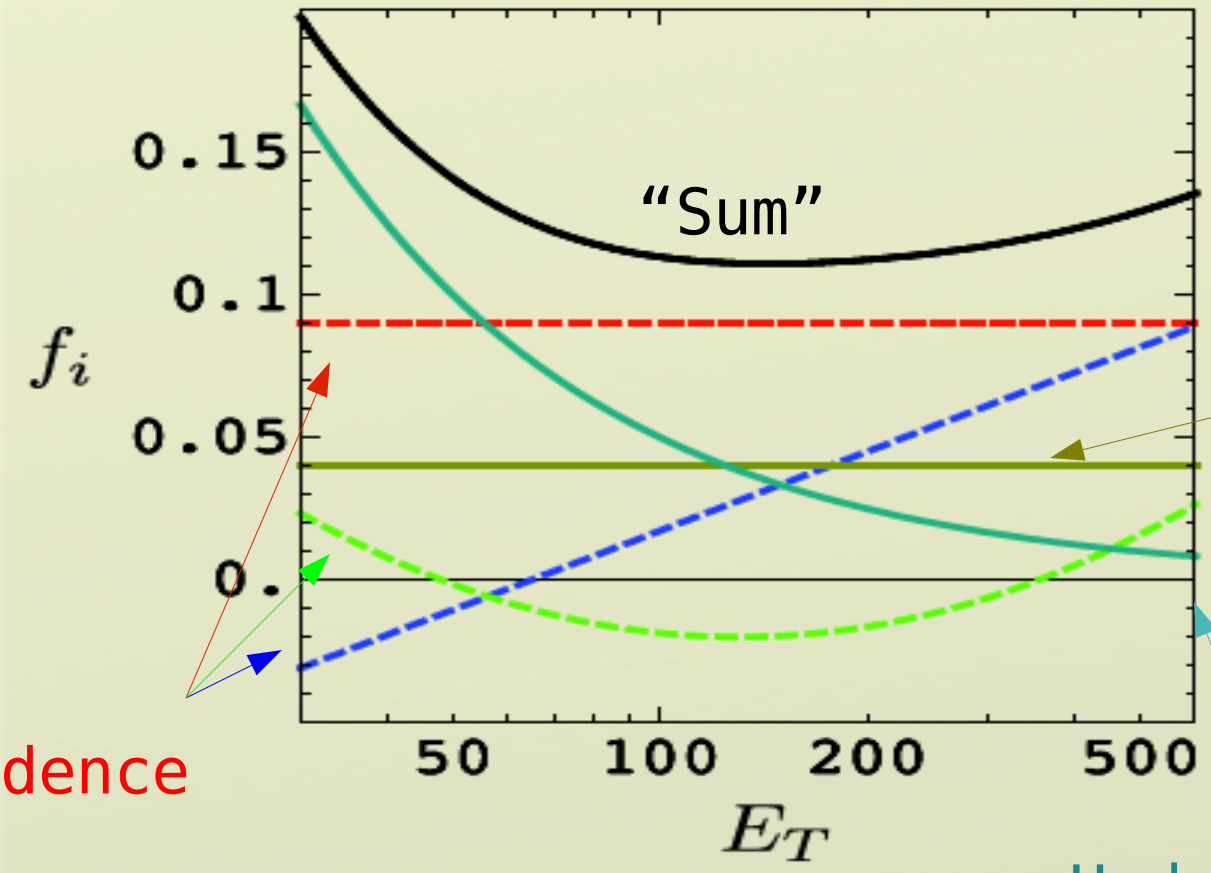
- Ranges for parameters inside MC?
- Uncertainties that can't be accounted for by tuning to data?
- Differences between methodologies?
- Quantified ignorance about all the effects on the 2nd slide?

Theory uncertainties: (educated) guesses about

- Higher orders of perturbation theory (fixed order and resummed) than have been implemented
- Incomplete application of known physics due to approximations
- Simplified models of complex semi-hard or non-perturbative physics
- Unsimulated phenomenon

“Theory error”: inclusive jets

Soper&
Olness



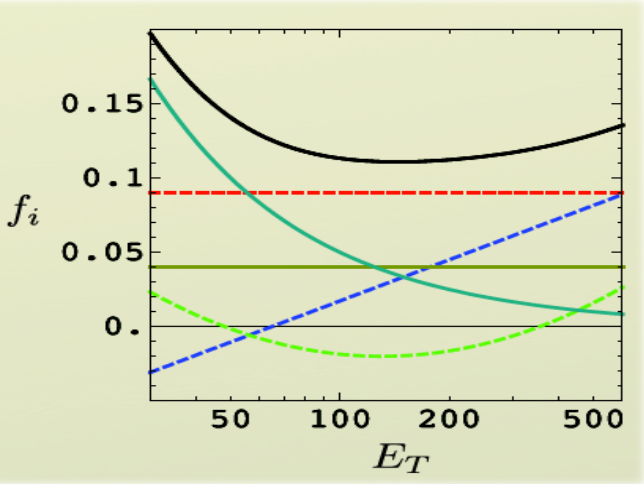
Threshold logs

Scale dependence

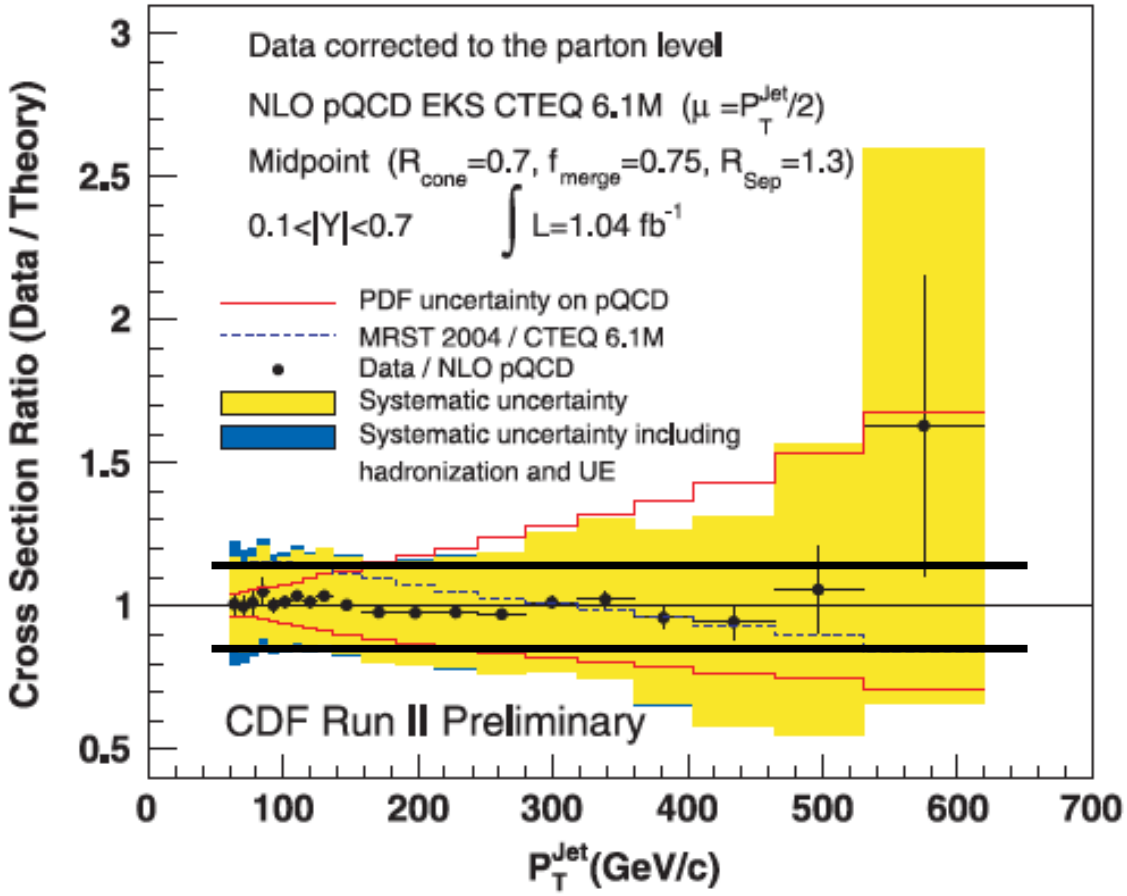
Hadronization
UE (Dasgupta et al)

Comparable to other errors

$$\frac{d\sigma}{dE_T\,err} = \frac{d\sigma}{dE_T}\left(1+f_i\right)$$



Intention:
add theory
error to
PDF fits

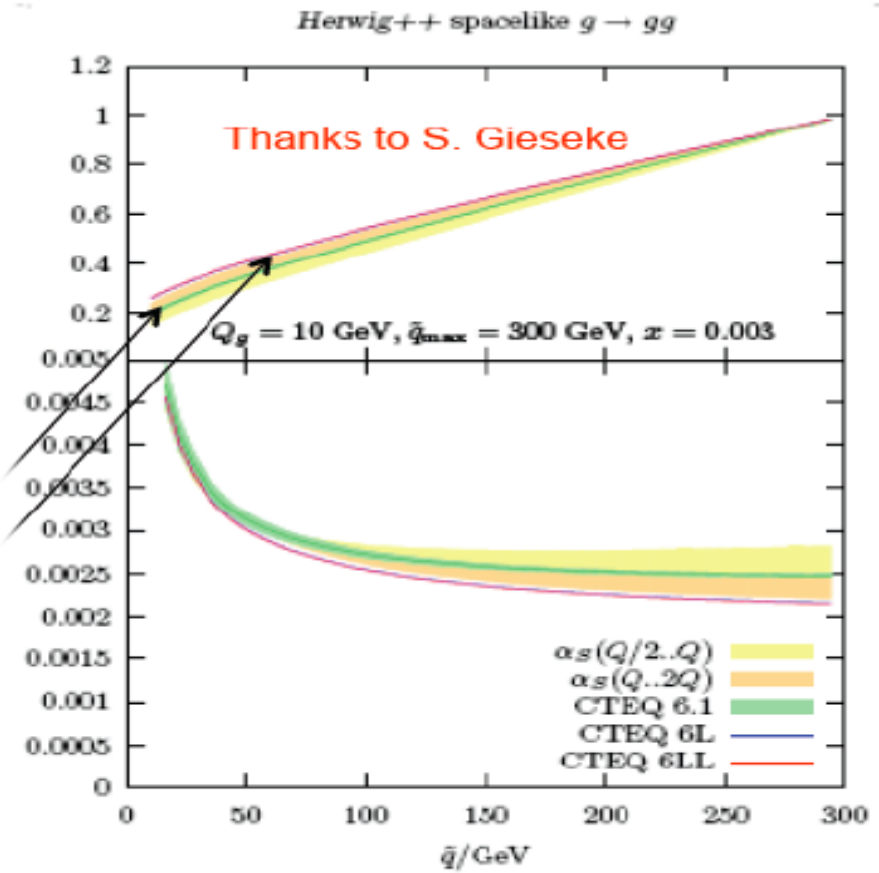


MCs use PDFs for more than just the hard kinematics

Not shown:
UE variation

LO Sudakov variation

NLO PDF band very narrow



What is done in practice? Top Mass Systematics (CDF/D0)

- Radiation (ISR/FSR)
  - Variation of Lambda_QCDs
- PDF
  - Shift in hard kinematics (y_W)
- Generator
  - Different implementations, logs
- UE
  - Ave. of several models
- Jet Energy Corrections
  - Variation of parton->hadron map

Correlation of Parameters

Parameter	Name	Default	ALEPH	DELPHI	L3	OPAL
Fragmentation function	MSTJ(11)	4	3	3	3	3
Baryon model option	MSTJ(12)	2	2	3	2	2
Azimuthal correlations	MSTJ(46)	3	0	3	3	3
$\mathcal{P}(qq)/\mathcal{P}(q)$	PARJ(1)	0.100	0.095	0.099	0.100	0.085
$\mathcal{P}(s)/\mathcal{P}(u)$	PARJ(2)	0.300	0.285	0.308	0.300	0.310
$(\mathcal{P}(us)/\mathcal{P}(ud))/(\mathcal{P}(s)/\mathcal{P}(d))$	PARJ(3)	0.400	0.580	0.650	0.400	0.450
$(1/3)\mathcal{P}(ud_1)/\mathcal{P}(ud_0)$	PARJ(4)	0.050	0.050	0.070	0.050	0.025
$\mathcal{P}(S{=}1)_{d,u}$	PARJ(11)	0.500	0.550	—	0.500	0.600
$\mathcal{P}(S{=}1)_s$	PARJ(12)	0.600	0.470	—	0.600	0.400
$\mathcal{P}(S{=}1)_{c,b}$	PARJ(13)	0.750	0.600	—	0.750	0.720
Axial, $\mathcal{P}(S{=}0,L{=}1;J{=}1)$	PARJ(14)	0.000	0.096	—	0.100	0.430
Scalar, $\mathcal{P}(S{=}1,L{=}1;J{=}0)$	PARJ(15)	0.000	0.032	—	0.100	0.080
Axial, $\mathcal{P}(S{=}1,L{=}1;J{=}1)$	PARJ(16)	0.000	0.096	—	0.100	0.080
Tensor, $\mathcal{P}(S{=}1,L{=}1;J{=}2)$	PARJ(17)	0.000	0.160	—	0.250	0.170
Extra baryon suppression	PARJ(19)	1.000	1.000	0.500	1.000	1.000
σ_q	PARJ(21)	0.360	0.360	0.408	0.399	0.400
extra η suppression	PARJ(25)	1.000	1.000	0.650	0.600	1.000
extra η' suppression	PARJ(26)	0.400	0.400	0.230	0.300	0.400
a	PARJ(41)	0.300	0.400	0.417	0.500	0.110
b	PARJ(42)	0.580	1.030	0.850	0.848	0.520
ϵ_c	PARJ(54)	−0.050	−0.050	−0.038	−0.030	−0.031
ϵ_b	PARJ(55)	−0.0050	−0.0045	−0.00284	−0.0035	−0.0038
Λ_{LLA}	PARJ(81)	0.290	0.320	0.297	0.306	0.250
Q_0	PARJ(82)	1.000	1.220	1.560	1.000	1.900

Effects on other parameters ignored in Lambda_QCD +/- (or other) variation

No unique separation between radiation, hadronization, UE either in data or MC

Tune A == event tune != UE tune

Practicalities of Theory Error Estimation

- ... should be easy to apply (reweighting a must)
- ... should account for correlations in effects
- ... should be backed up with analytic estimates

Higgs Systematics Goals:

- Clear expositions of what theory and experiment are doing
- Consensus on most important effects
- Prescription(s) on how to practically estimate them
- Actions for the near future