Inclusive Jet E_T Cross Sections at the LHC

S. Chekanov, S. Magill
Argonne National Laboratory

One of the first physics measurements to come from LHC

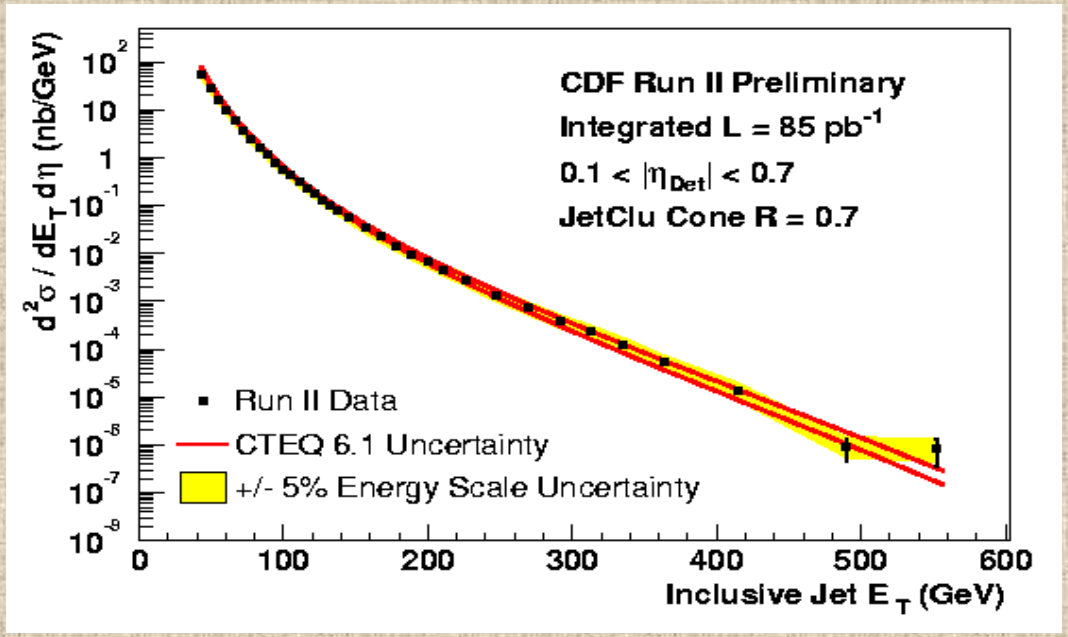
-> evaluation of compositeness limit

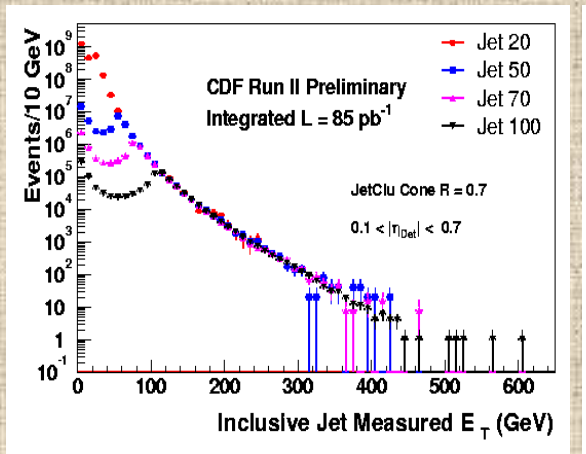
For HERA-LHC Workshop

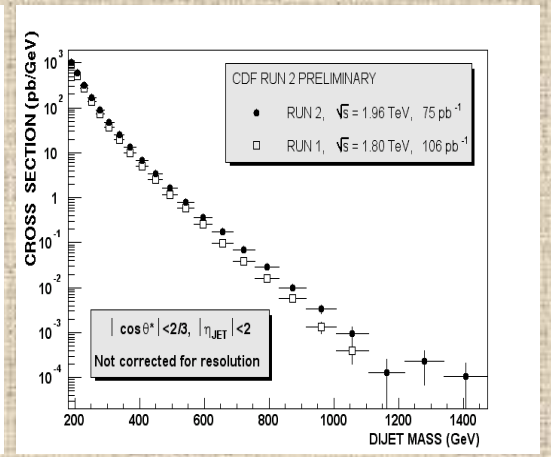
-> study effects of evolution schemes on inclusive jet E_T cross section – PYTHIA vs CASCADE

Jets and Compositeness Limits

- Essentially, the limit on a contact interaction term is set by the highest E_T jet you see, times ~4
- Center-of-mass energy is immensely more valuable than integrated luminosity
  - Even the Tevatron 8.8% increase in energy triples the cross-section for jets above 500 GeV
  - Imagine what a 600% increase buys you!







From T. LeCompte, ANL

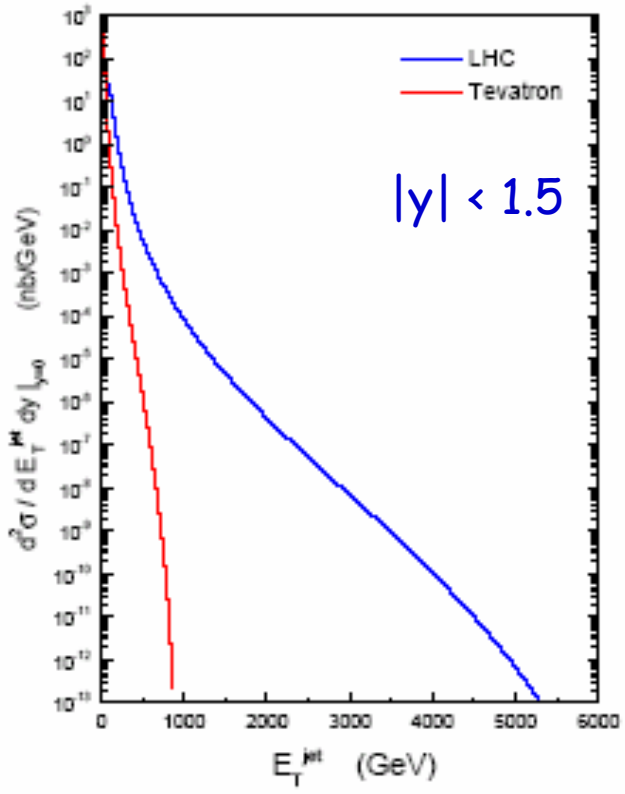
Comparison of LHC/Tevatron

Scenario	Name	Instantaneous Luminosity	Time (s)	Detector Fraction	Integrated Luminosity
1	First store	5×10^{30}	1000	50%	2.5 nb^{-1}
2	First good week	10^{31}	10^5	100%	1 pb^{-1}
3	First good month	2×10^{31}	10^6	100%	20 pb^{-1}
4	Not so good year	10^{32}	10^7	100%	1 fb^{-1}
5	Good 1st year	10^{33}	10^7	100%	10 fb^{-1}

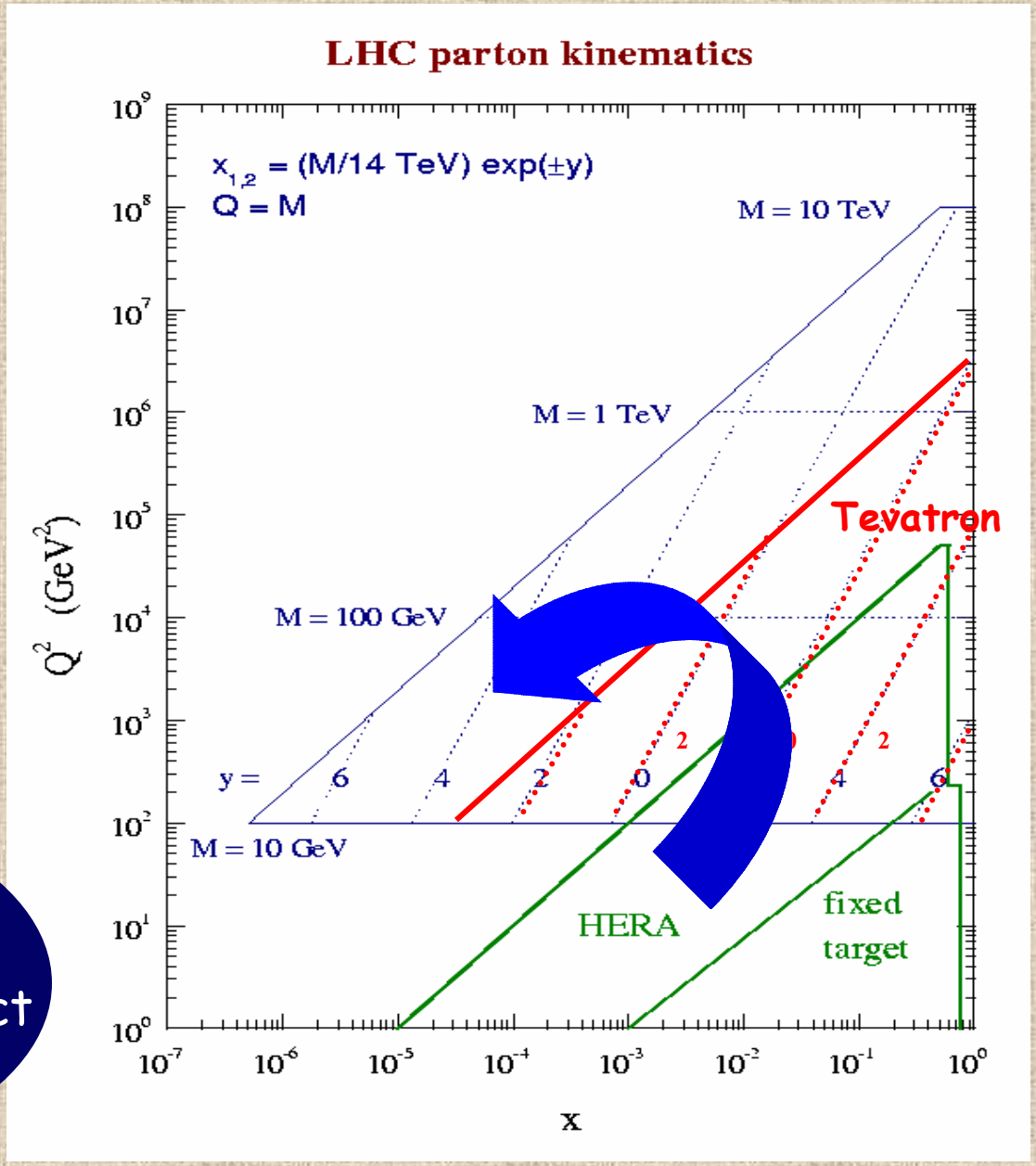
Scenario	Name	Energy Scale	Max Jet E_T	Limit
1	First store	20%	~750 GeV	**~2.4 TeV**
2	First good week	20%	~1600 GeV	~5.1 TeV
3	First good month	10%	~2 TeV	~7.2 TeV
4	Not so good year	5%	~3 TeV	~11.4 TeV
5	Good 1st year	2%	~3.5 TeV	~13.7 TeV

ATLAS matches TEV limit with first store! – publish new limit after 2 days running

HERA (pdfs) ⇒ Tevatron (DGLAP) ⇒ LHC (+BFKL?)



How do pdf differences/uncertainties and evolution schemes affect this spectrum?



Study Tools

MC Programs	*pdfs*	*Evolution schemes*	*Physics processes*
PYTHIA	✓	DGLAP	quarks, gluons
CASCADE	-	CCFM, DGLAP	gg -> qq

CASCADE process : gg -> qq

-> in DGLAP mode, gg -> qq

-> in CCFM mode, kT factorization on ladder allows

gg -> qq

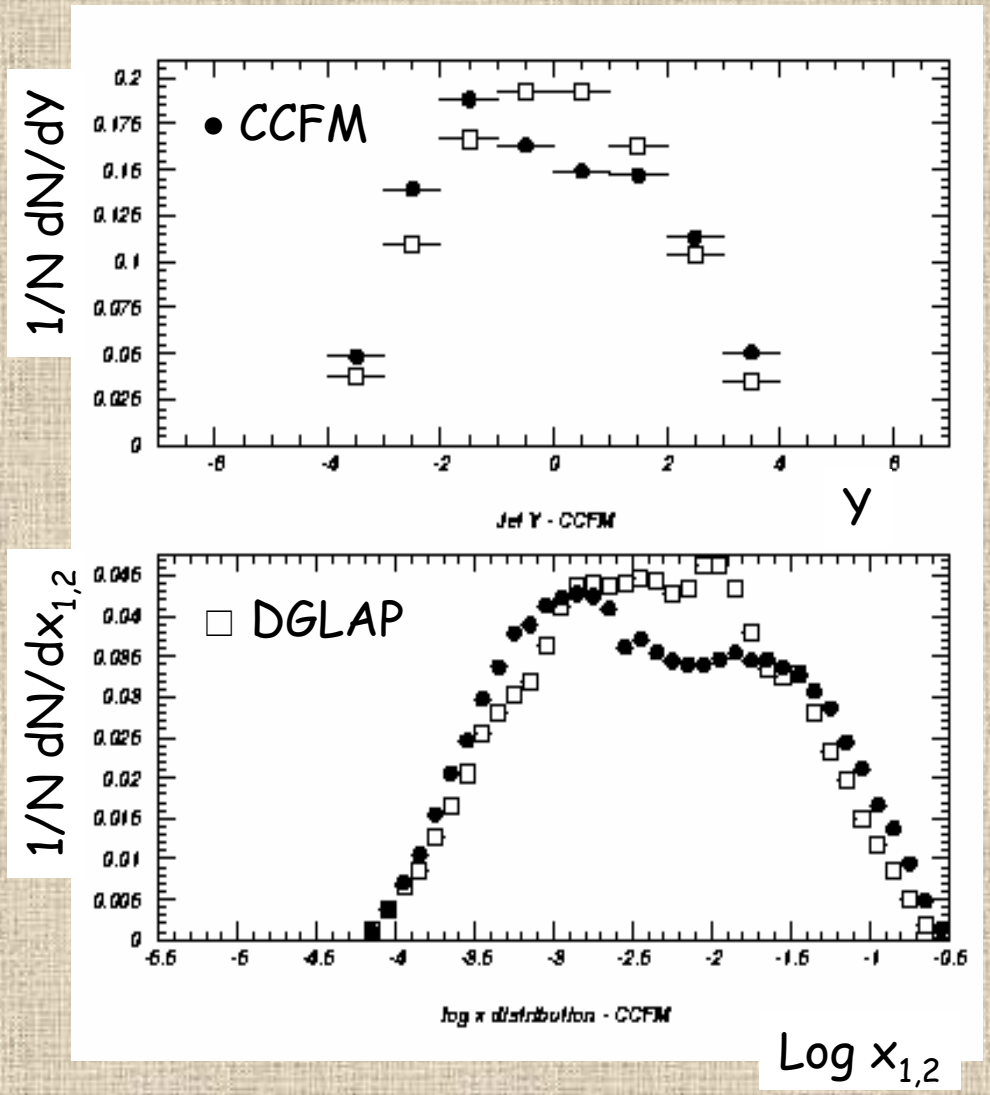
gq -> gq

gg -> gg

PYTHIA processes (DGLAP) for pT_{min} > 40 GeV at $\sqrt{s}$ = 14 TeV:

gg -> qq	1000 nb	
gq -> gq	23000 nb	(1/3 total cross section)
gg -> gg	32000 nb	(1/2 total cross section)
ff' -> ff'	3000 nb	
ff -> f'f'	21 nb	
ff -> gg	32 nb	

Jet Properties



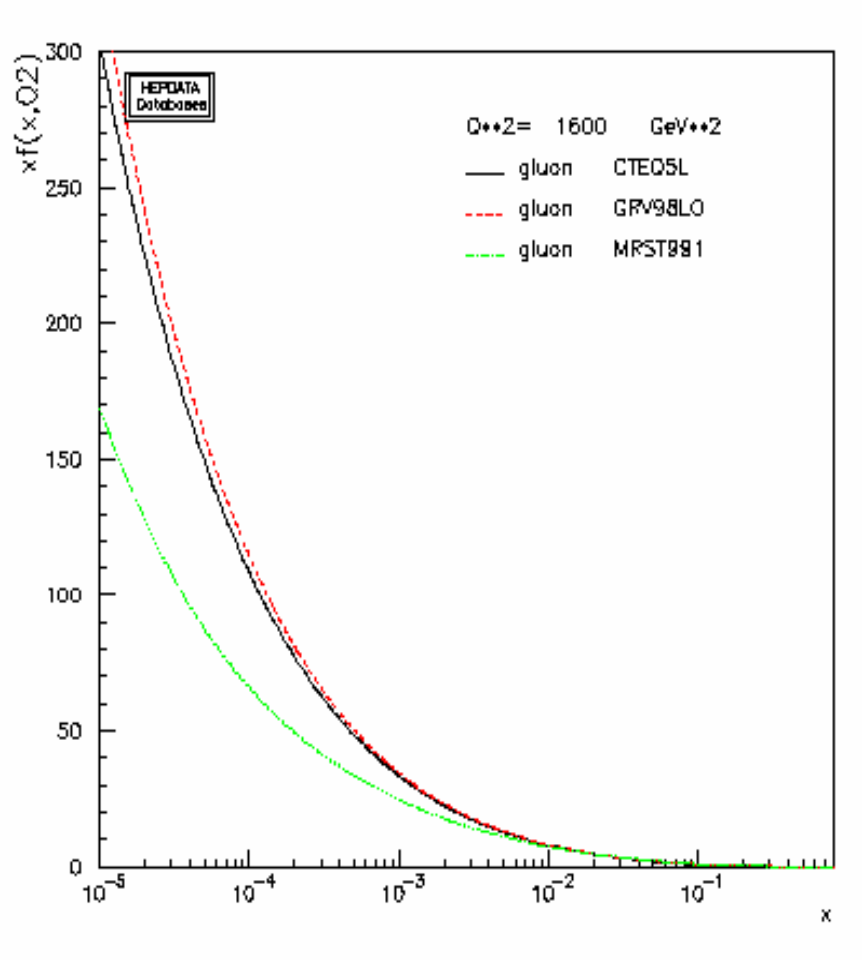
Generated events from CASCADE with DGLAP and CCFM evolution schemes :

Compare shape of rapidity (Y) and $x_{1,2}$ distributions (k_T Algorithm)

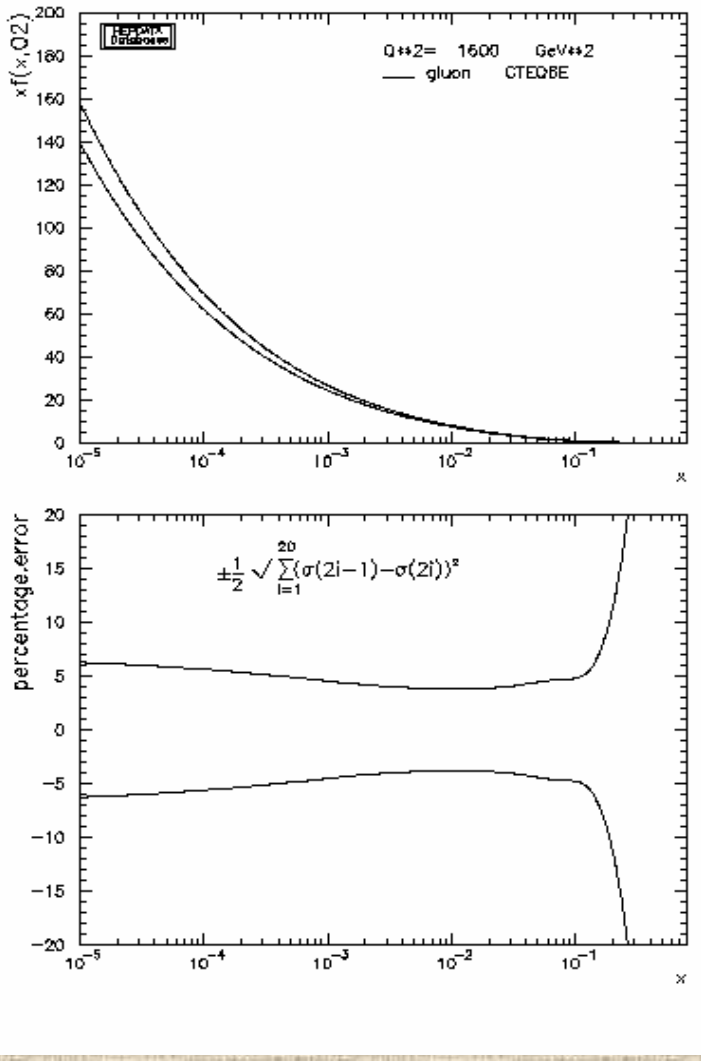
CCFM – slightly more forward and slightly lower x

pdf Effects - xG in LHC region

different pdfs



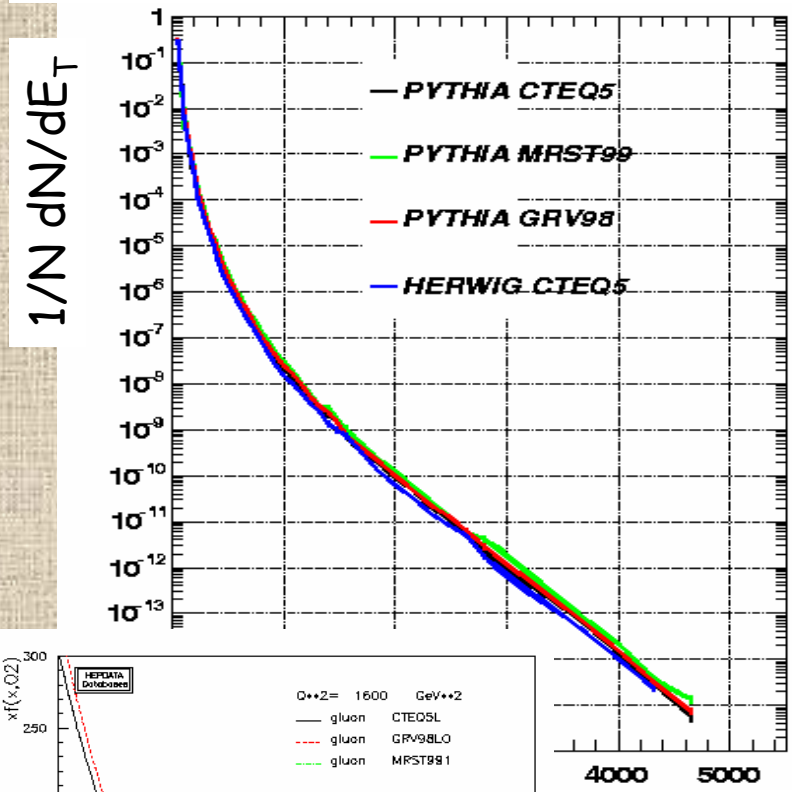
error analysis of pdfs

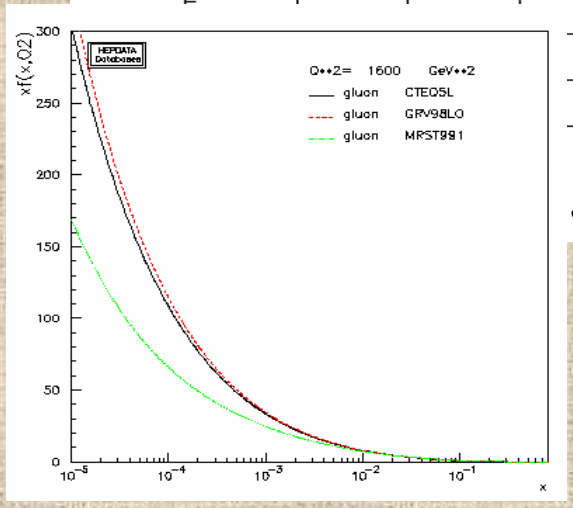


from Durham online pdf generator

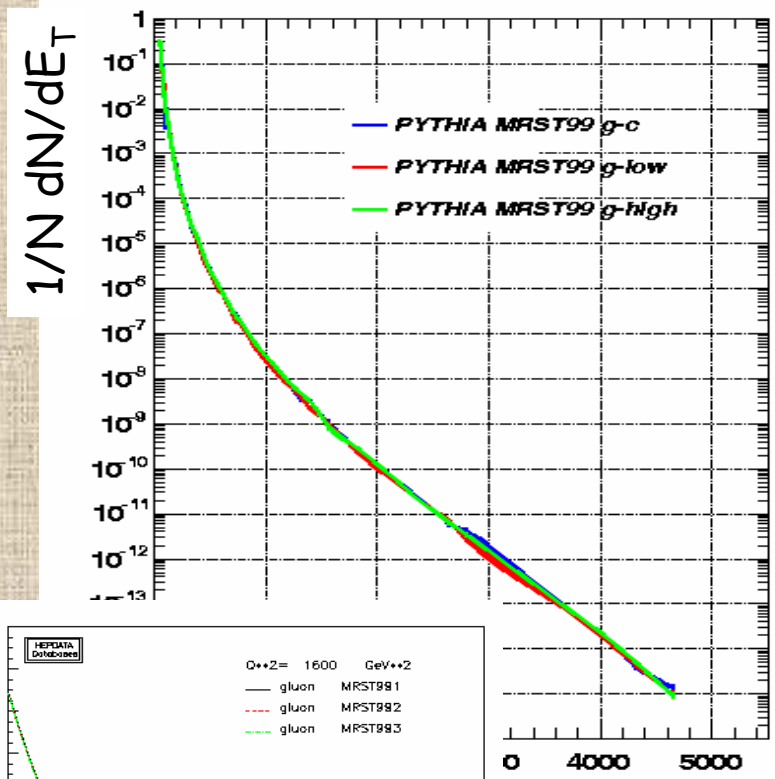
pdf Comparisons

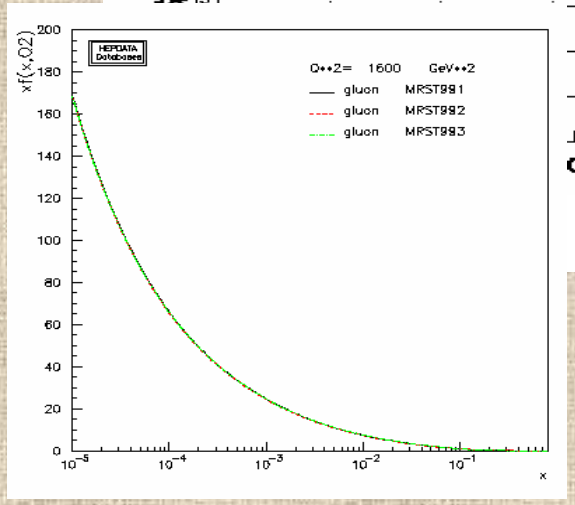
Different pdfs, MC model (HERWIG)





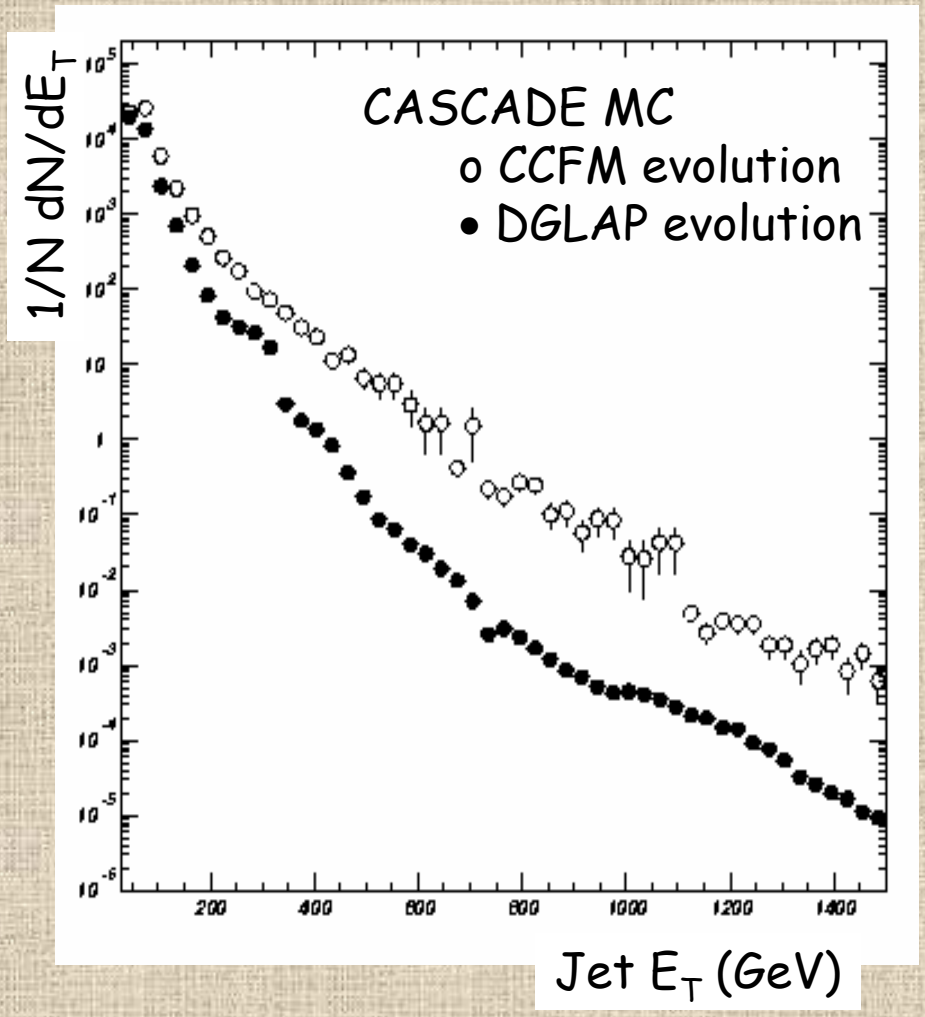
gluon range in MRST





-- little effect on Jet E$_T$ spectrum

Parton Evolution Comparison



Shape :

CCFM (BFKL) harder than DGLAP

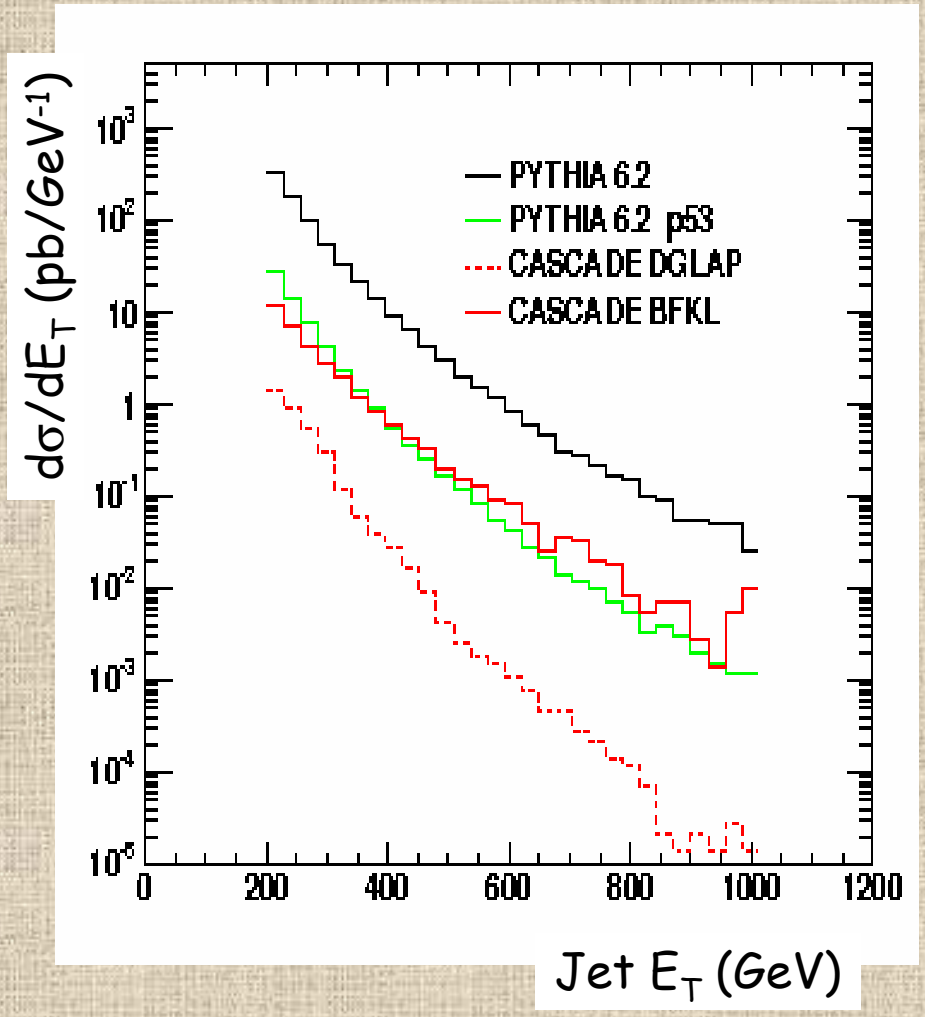
Cross Sections (not shown) :

CCFM ~ 6 X DGLAP

Issues :

1) Is this comparison fair? gg -> qq only in DGLAP?
2) DGLAP CASCADE ≡ gg -> qq in PYTHIA?

PYTHIA Process 53 - $gg \rightarrow q\bar{q}$



Shape :

1) *CCFM (BFKL) still harder than DGLAP*
2) PYTHIA gg -> qq harder than CASCADE DGLAP?

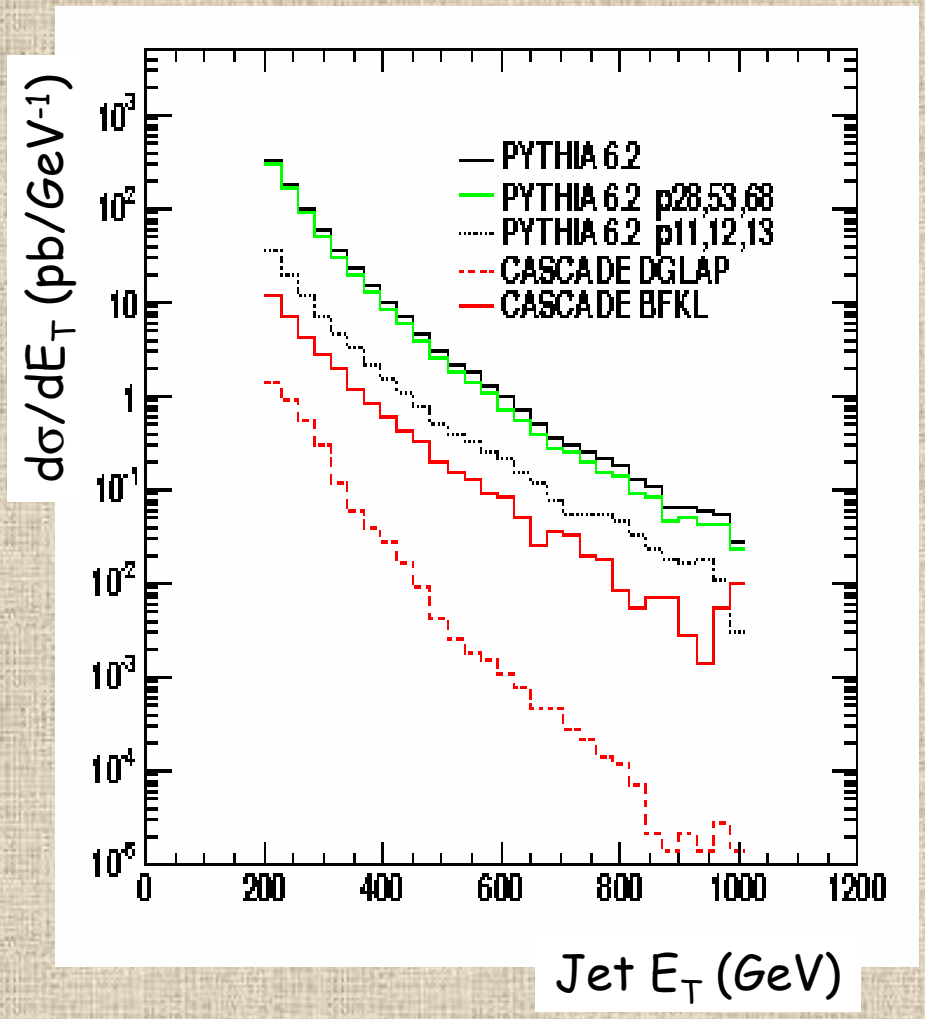
Cross Sections :

PYTHIA gg -> qq > CASCADE DGLAP gg -> qq?

Issues :

1) Our mistake?
2) Require heavy quarks in jets to limit other processes?

Process Comparison – HQ requirement



Shape :

1) *CCFM not harder than DGLAP anymore*
2) *PYTHIA still harder than CASCADE DGLAP*

Cross Sections :

1) PYTHIA 28,53,68 almost total – dominated by 53 (gg -> QQ)
2) Disagreement between PYTHIA gg -> QQ and CASCADE DGLAP even greater than before?
3) PYTHIA quark processes (11,12,13) ≈ CASCADE CCFM (BFKL)

Summary - Issues to Resolve

1) More questions than answers at this mid-workshop point!!

2) Why doesn't the CASCADE DGLAP cross section ≡ PYTHIA process 53 (*gg* -> *qq*)?

3) Does CASCADE CCFM really include all gluon initiated processes (28,53,68 in PYTHIA) with correct cross sections?

4) Do we have any hope of adding CASCADE CCFM to the quark processes of PYTHIA to get a consistent jet E_T spectrum? Only for heavy quarks in the final state?

Summary – Study Goals

BFKL evolution produces a ~harder jet ET spectrum at the LHC for gluon-dominated processes

Understand our issues and how to use the tools we have properly

- consistent process cross sections between MC models
- combining processes from different MC models
- using selection cuts to simplify comparisons, i.e., heavy quarks, Y range

Show LHC jet ET spectrum for all processes assuming DGLAP or BFKL (as implemented in CCFM scheme) evolution of pdfs

- characterize as difference vs E_T
- show enhanced differences for heavy quarks?
- including multiple interactions, 25 bunch crossings, simulated detector effects