ISR/FSR and Q^2 scale

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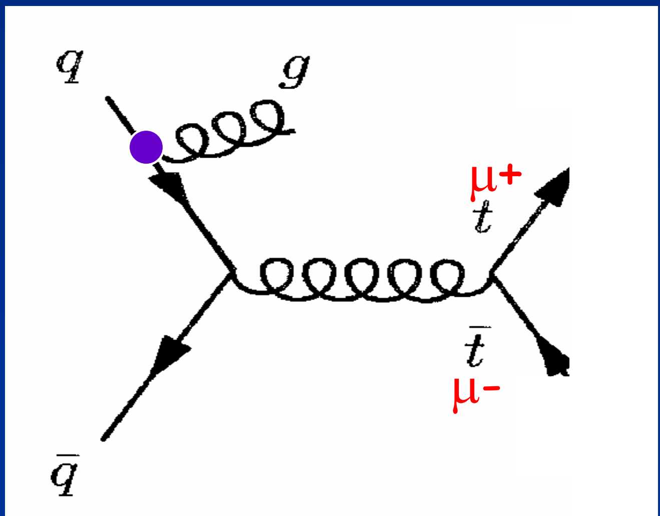
How to control ISR in ttbar system?

- In Run I: switch ISR on/off using PYTHIA
  - Good for understanding size of the effect, but not taking a full QCD knowledge, and not clear for one σ
- In Run II: systematic approach
  - ISR is governed by DGLAP eq.: Q^2, Λ_{QCD}, splitting functions, PDFs
  - Use DY data (no FSR): study Pt of the dilepton, Njets in the DY for different Q^2 region (~different DY(ll) mass region)

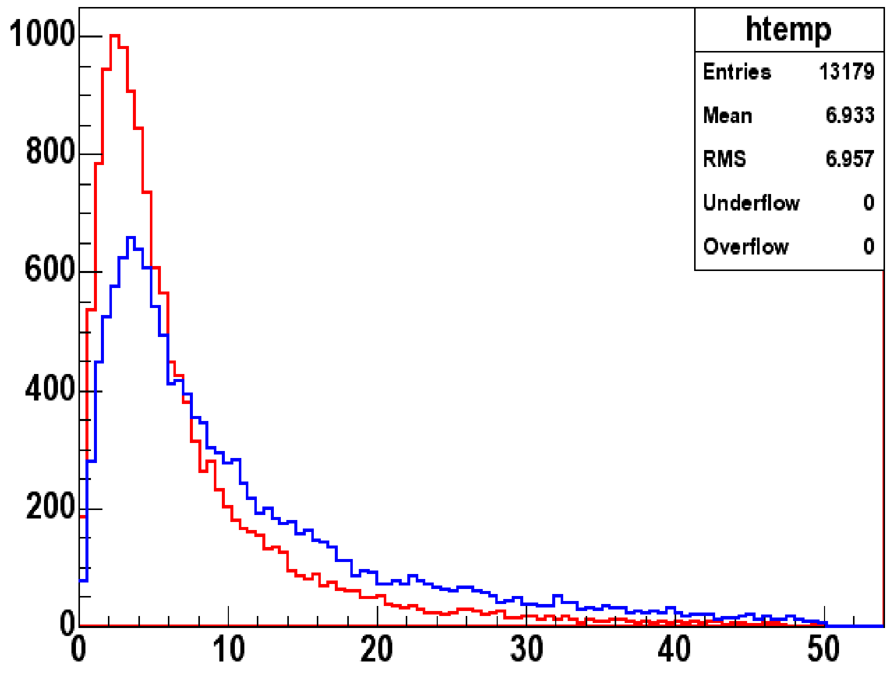


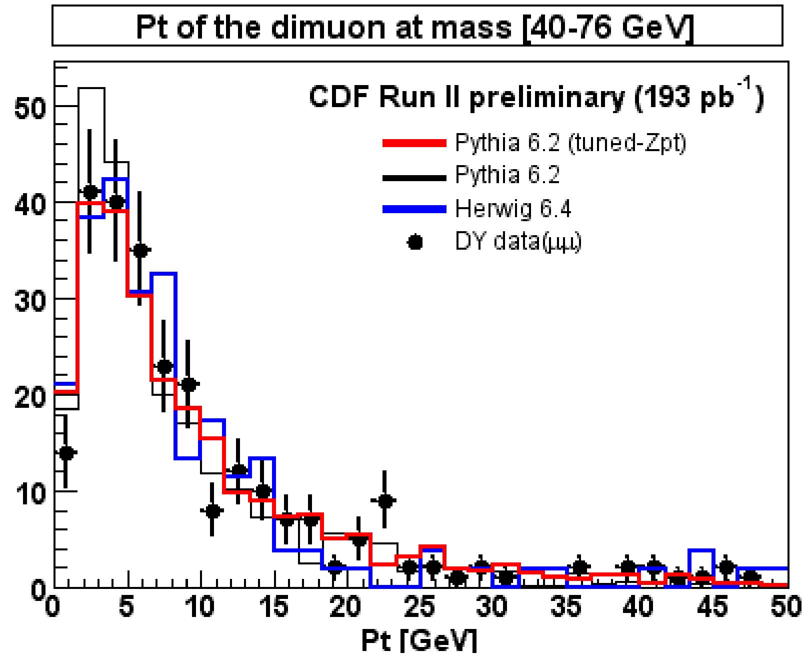
$$\frac{dq(x,Q^2)}{d\ln Q^2} = \int \frac{dy}{y} \alpha_s\left(\frac{Q^2}{\Lambda^2_{QCD}}\right) P_{q\to qg}\left(\frac{x}{y}, Q^2\right) q(y,Q^2)$$

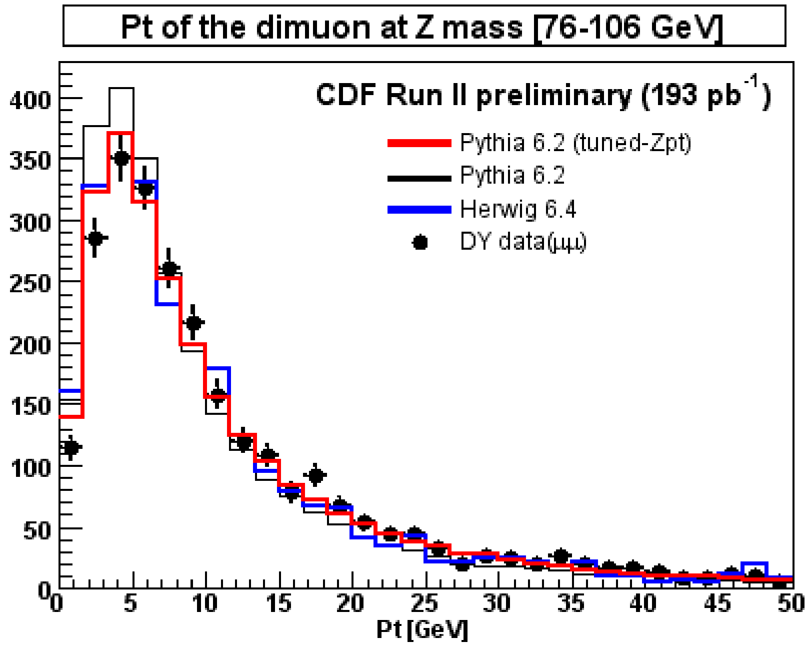
$q\bar{q} \to t\bar{t}$ (85%)

Pt(dilepton) at different mass region

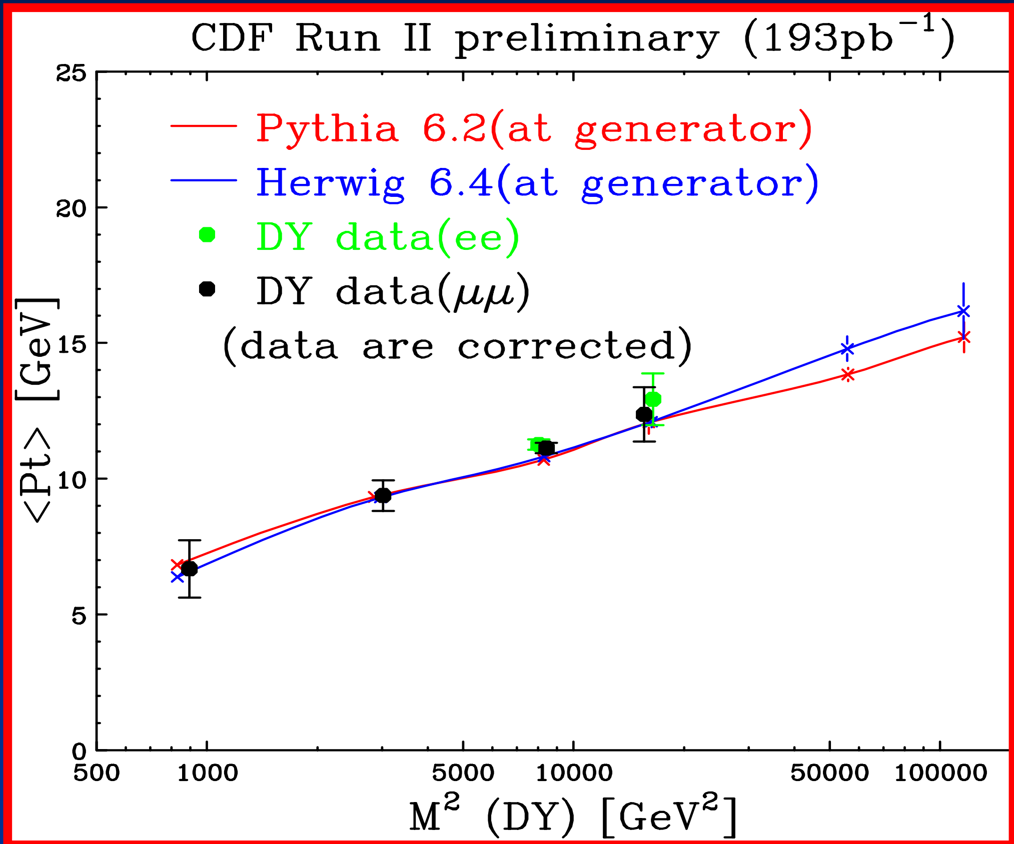
Pt of the dilepton
(M=30 vs 90 GeV)

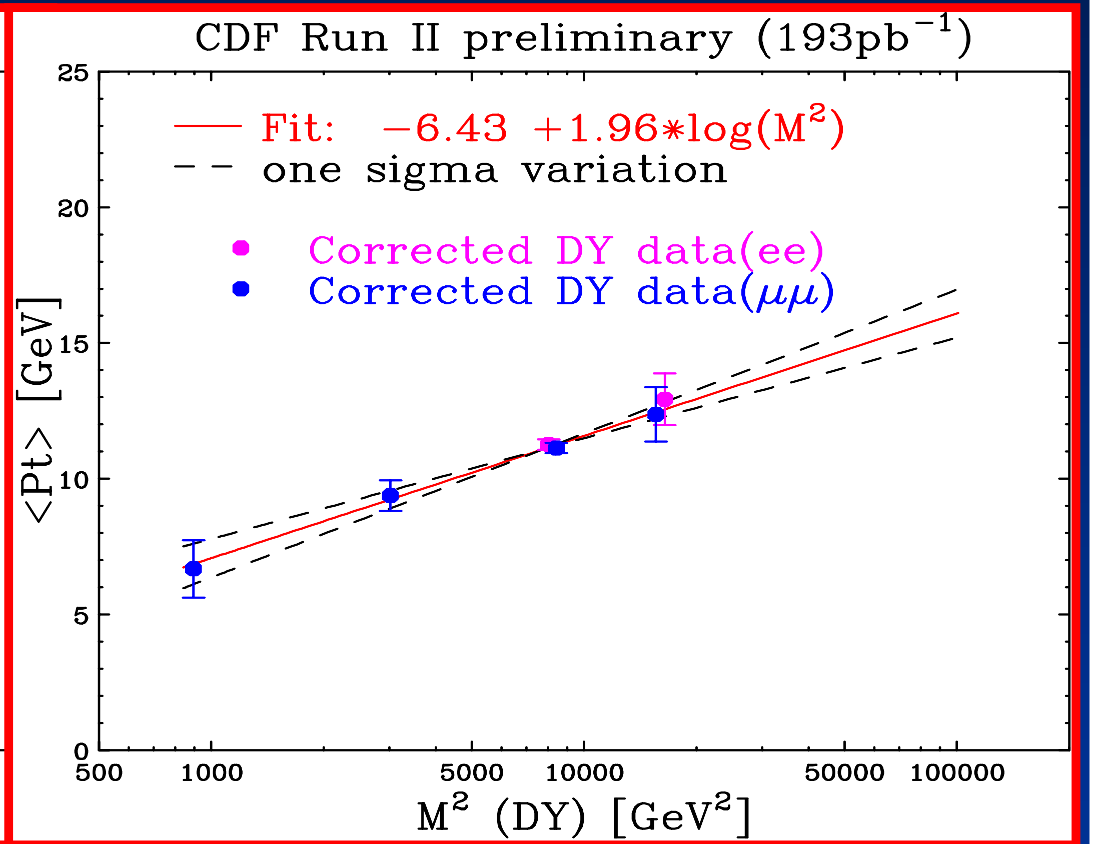






Evolution of the <Pt (dilepton)> as function of the dilepton mass^2





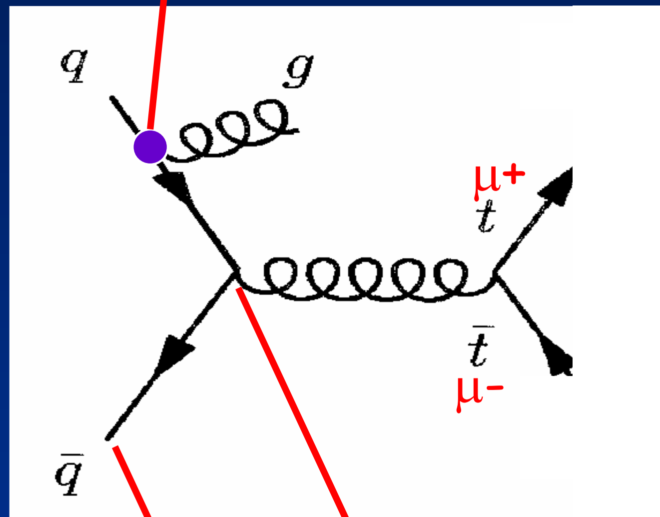
ISR uncertainty

$Kt^2 = PARP(64)(1-z)Q^2 : \alpha_s$,PDF

$\Lambda_{QCD} = PARP(61) : \alpha_s$

- ISR uncertainty is only due to uncertainty in shower processing,
  - PDF, factorization scale uncertainties are not treated as a part of the ISR uncertainty (can be discussed…)

Pythia	ISR more	ISR less
PARP(61) (D=0.192 GeV)	0.384 (4 flavour)	0.100
PARP(64) (D=1.0)	0.25	4.0
PARP(67) (D=1.0)	4.0 (Tune-A)	

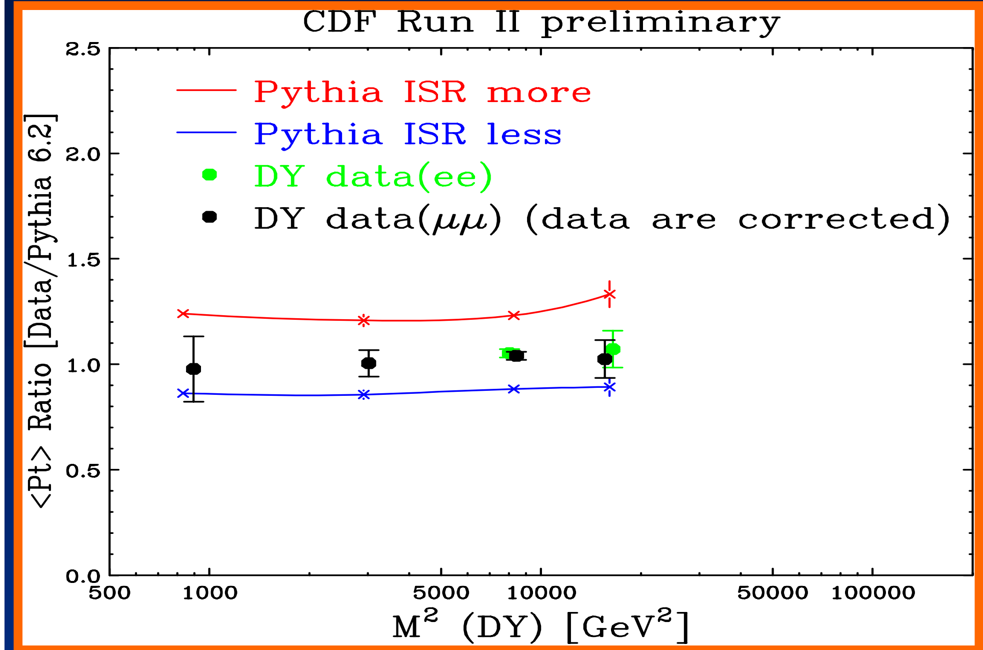


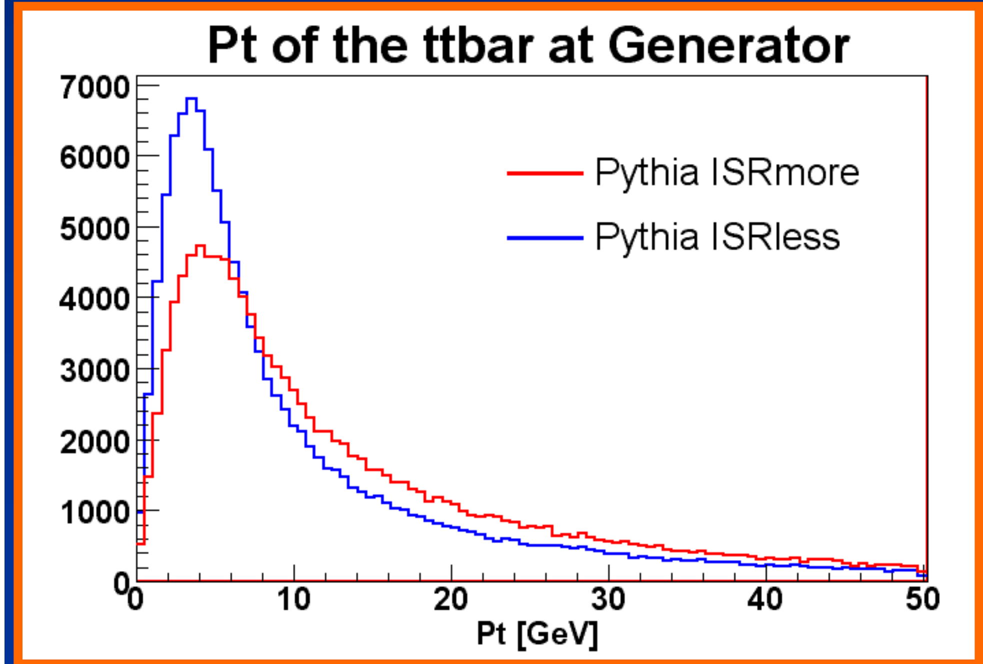
Q^2max: K PARP(67)

Qmin : PARP(62)

Intrinsic Kt: Gaussian Width: PARP(91)

ISR uncertainty





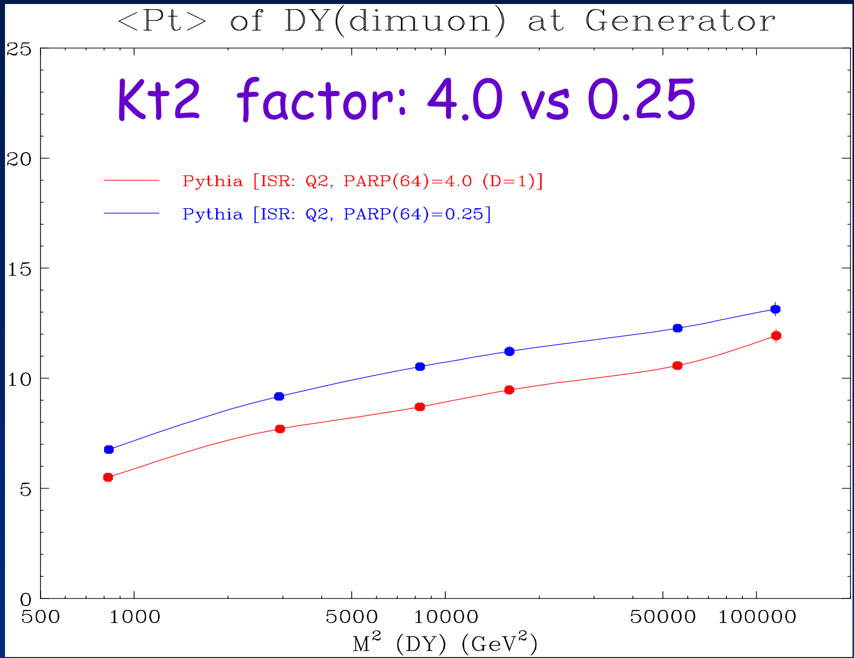
- Non s-channel resonance like ttbar, dijet etc

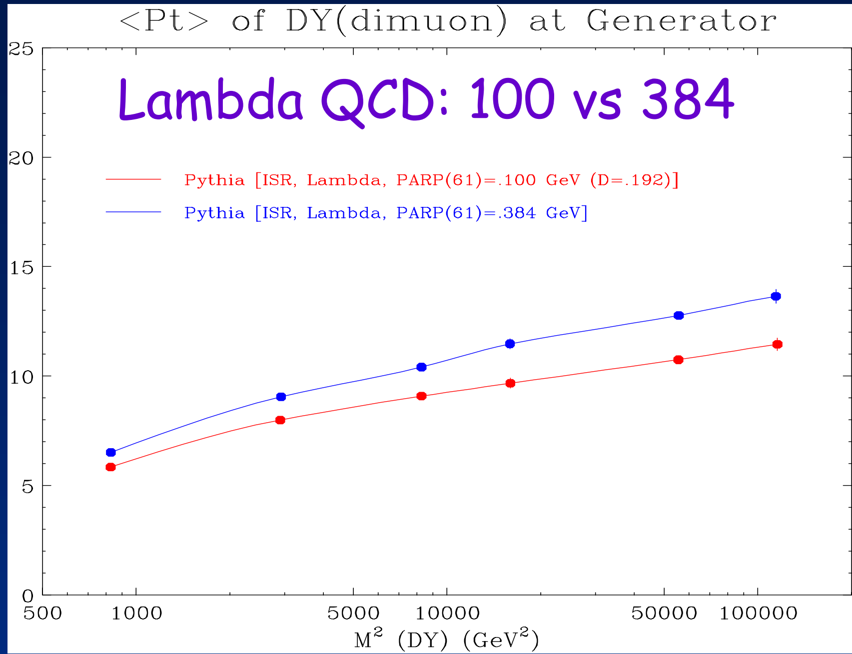
Pythia	ISR more (Top std)	ISR less (Top std)
PARP(61)	0.292(5fl: LO)	0.073
PARP(64)	0.5	2.0
PARP(67) D=1	4.0(tune-A)	4.0

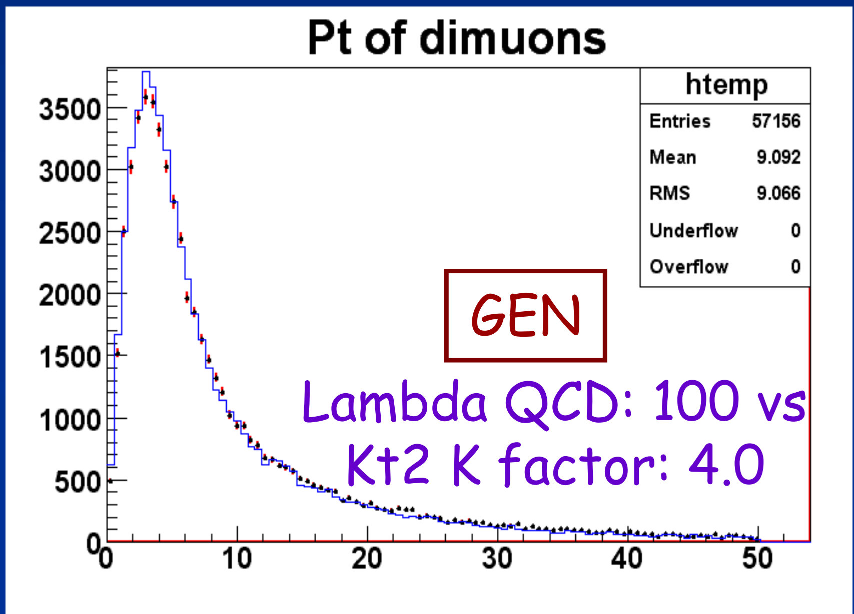
Pythia	ISR more (Top cntrl)	ISR less (Top cntrl)
PARP(61)	0.292(5fl: LO)	0.073
PARP(64)	1.0	1.0
PARP(67)	8.0	2.0

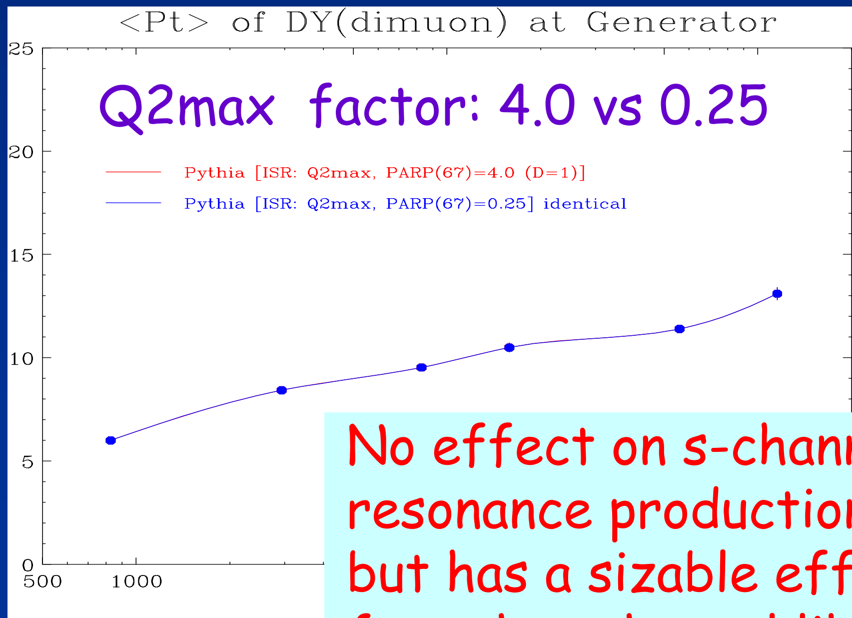
- s-channel resonance like W/Z (no ISR enhancement fromPARP(67)) set PARP(64)=0.2, vary PARP(61)

ISR variation due to Λ_{QCD}, K_t^2 factor









No effect on s-channel resonance production, but has a sizable effect for other channel like ttbar

FSR uncertainty

Pythia	FSR more (Top std)	FSR less (Top std)
PARP(72)	0.292 (5fl: LO)	0.073
PARP(71) D=4	8	2.0

No change in color singlet
Well constrained by LEP data

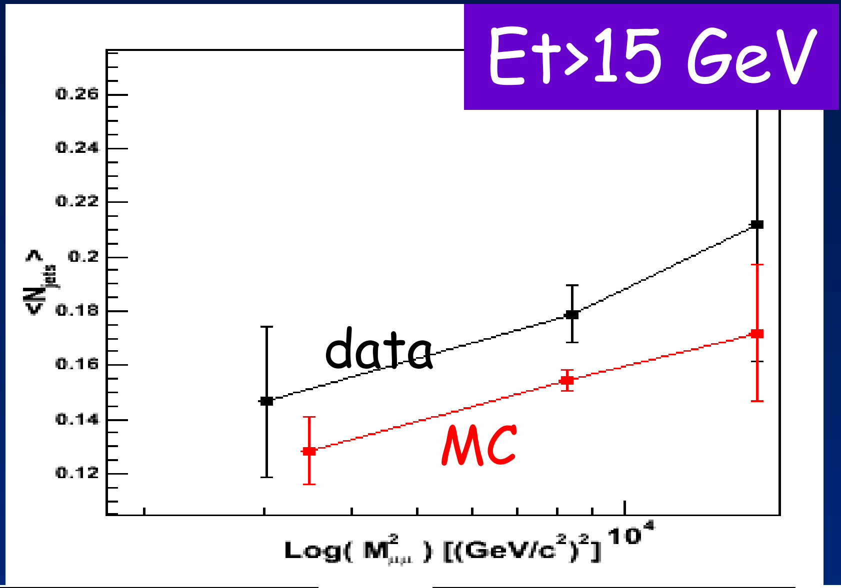
Even allow variation
in color singlet
(conservative)

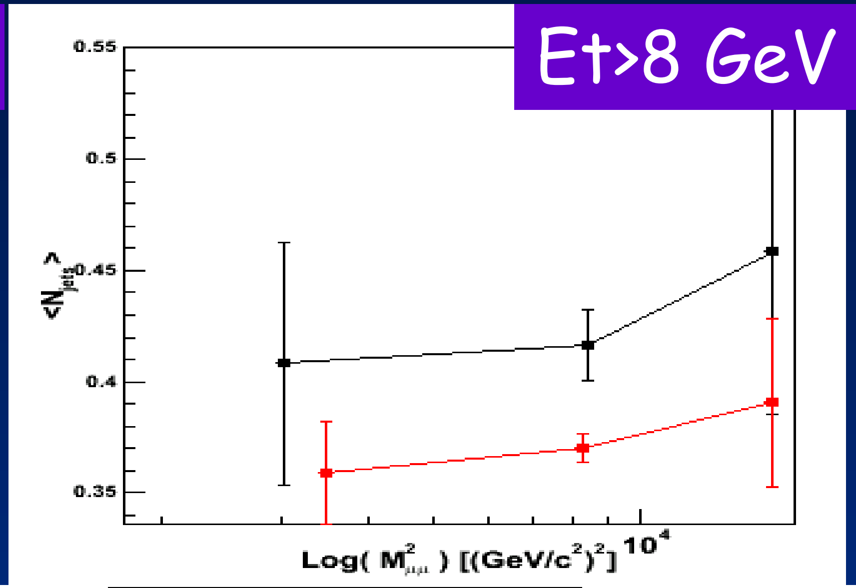
Pythia	FSR more (Top cntrl)	FSR less (Top cntrl)
PARP(72)	0.292 (5fl: LO)	0.073
PARJ(81) D=0.290	0.580 (4fl: LO)	0.145
PARP(71) D=4	8	2.0

Discussions

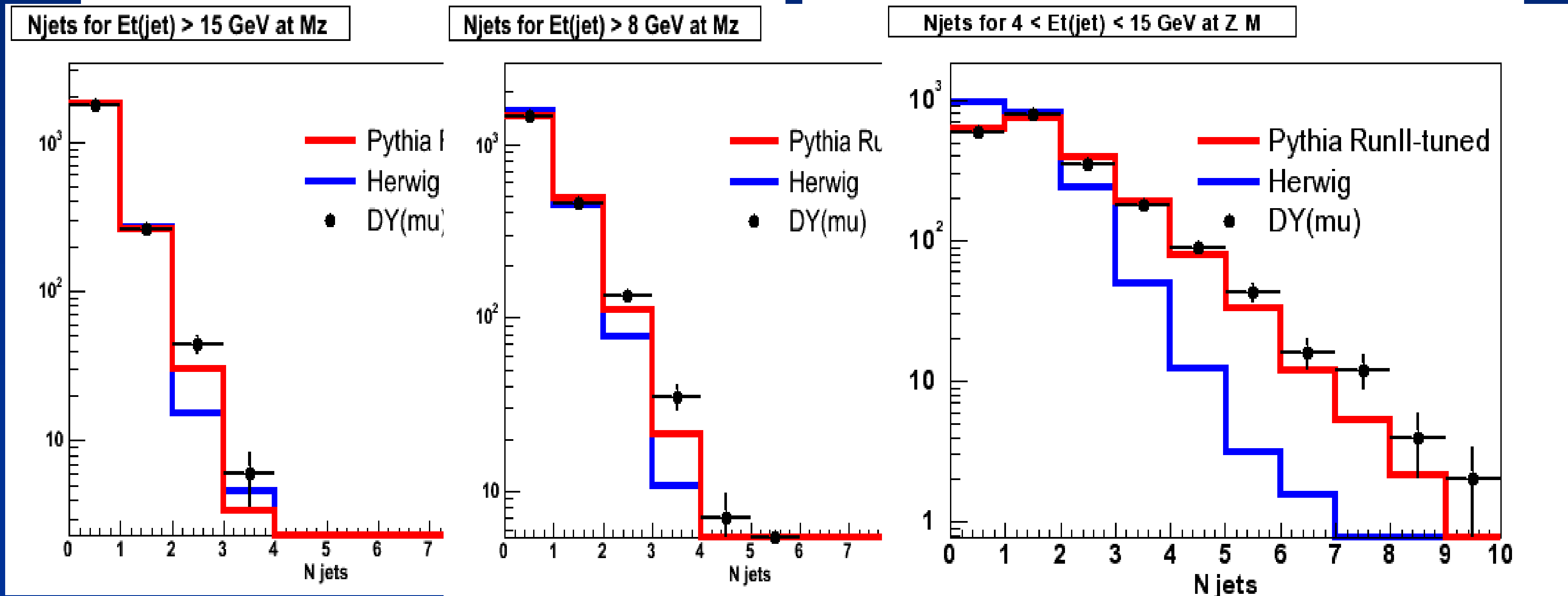
- ISR more/less syst. (based on the pt of the dileton from the DY) and same for FSR
  - How much these syst. covers the NLO effect?
  - Check the difference between LO & MC@NLO is covered by the ISR/FSR syst., the remaining diff will be an additional syst. due to the NLO effect
  - Further constraint using Njet, SumEt(jets), and $\delta\phi(ll)$ dists.
- Possibility to have universal ISR/FSR for non-s vs s-channel resonance productions: PARP(64) vs PARP(67)?
  - Can we tune underlying events using PARP(64) instead of PARP(67)? Rick is looking for a possibility

Njets



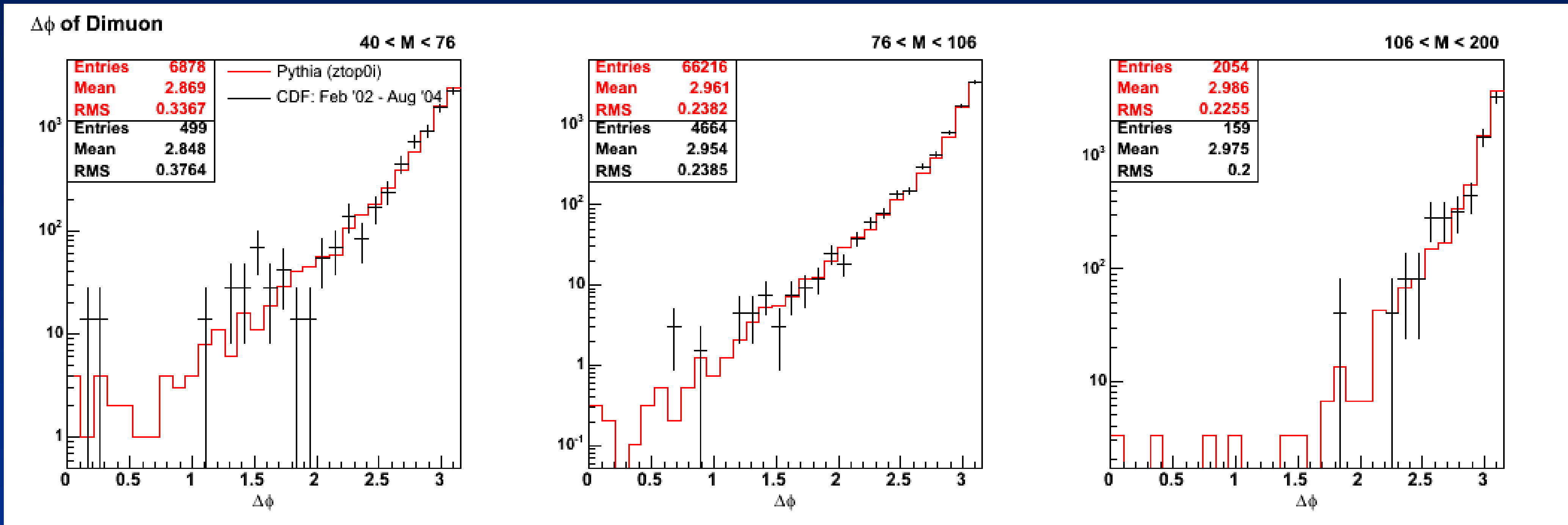


At Zmass



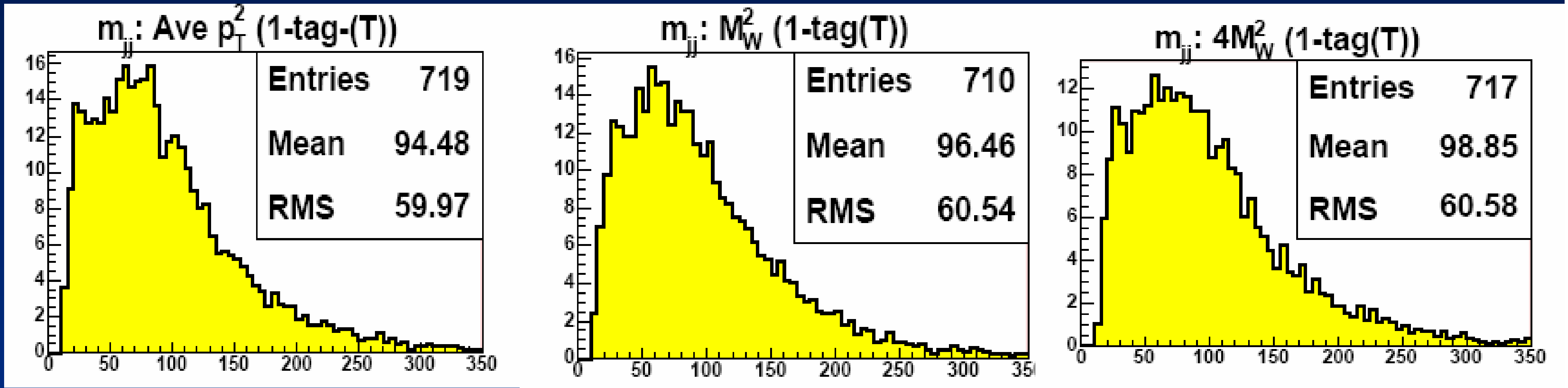
Work in progress with Sasha Rahlin! (no correction on the data yet)

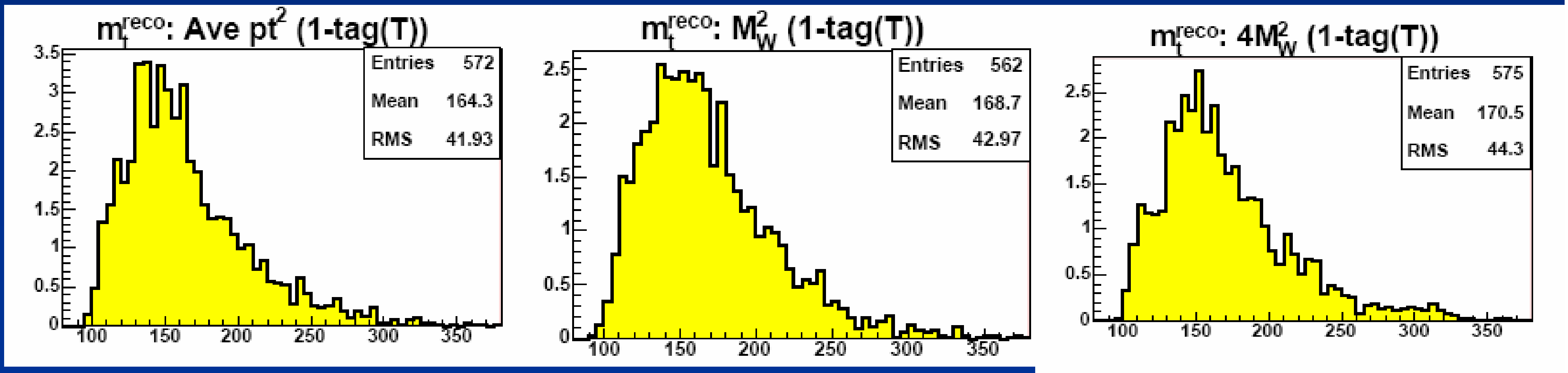
δφ(dimuons)



Δφ of Dimuon
40 < M < 76
Entries 6878
Mean 2.869
RMS 0.3367
Entries 499
Mean 2.848
RMS 0.3764
Pythia (ztop0i)
CDF: Feb '02 - Aug '04
76 < M < 106
Entries 66216
Mean 2.961
RMS 0.2382
Entries 4664
Mean 2.954
RMS 0.2385
106 < M < 200
Entries 2054
Mean 2.986
RMS 0.2255
Entries 159
Mean 2.975
RMS 0.2
Δφ

$Q2$ scale = $A*Mw^2 + b*P^2$(jets)



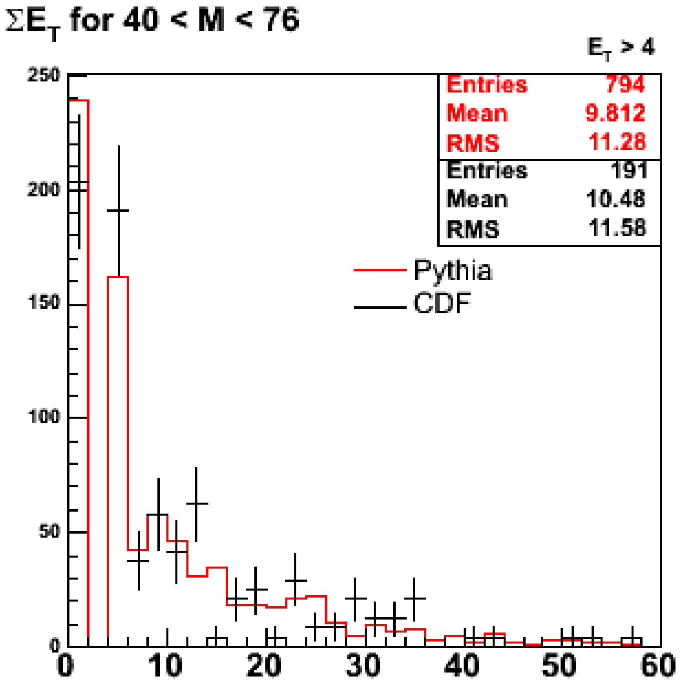


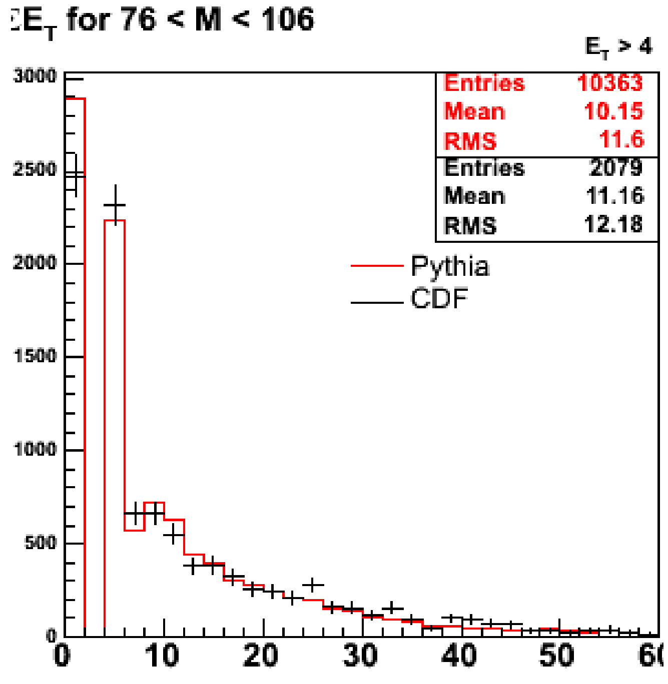
What are values of a & b? => use Z/γ + jets

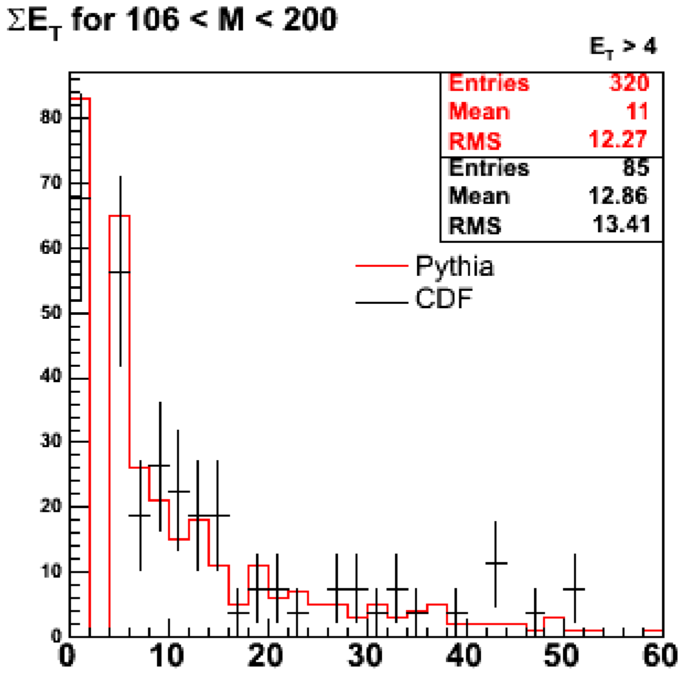
Q^2 scale using Z/γ + jets

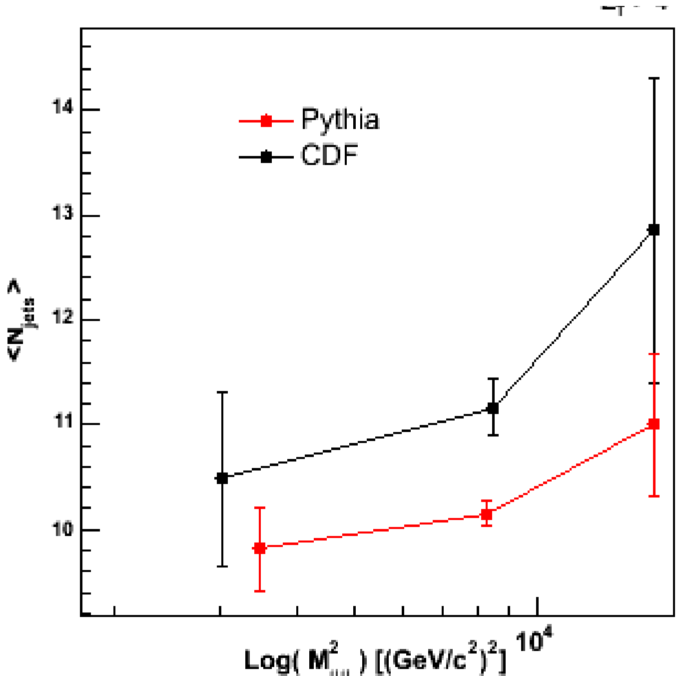
- Q2 scale for W+jets = $a*Mw^2 + b*Pt(jet)^2$?
  $\langle Pt\_jet^2 \rangle$, Mw^2, $Mw^2 + Pt(jet)^2$, $4*Mw^2$
- Using W+jets data, we may get some ideas about Q2 scale, looking at one/two jets bins, but it would be hard to constrain values of a and b parameters.
- Use Z/γ + >=1 jet data, then scan these data as a function of M^2 (dilpeton) and Pt^2(jet)
  - N jets with diff. jet Et thresholds
  - SumEt (jets), leading jet Et
  - Make templates for three diff. mass regions (low, Z, and high mass) with difference choice of a, and b.
  - Then, fit a and b using the data
- Any graduate student for this short project?
  Peter Skands (Pythia 6.3 co-author) is on board too.

SumET(jets)


ΣE_T for 40 < M < 76
E_T > 4
Entries 794
Mean 9.812
RMS 11.28
Entries 191
Mean 10.48
RMS 11.58
Pythia
CDF
0
50
100
150
200
250
0 10 20 30 40 50 60


ΣE_T for 76 < M < 106
E_T > 4
Entries 10363
Mean 10.15
RMS 11.6
Entries 2079
Mean 11.16
RMS 12.18
Pythia
CDF
0
500
1000
1500
2000
2500
3000
0 10 20 30 40 50


ΣE_T for 106 < M < 200
E_T > 4
Entries 320
Mean 11
RMS 12.27
Entries 85
Mean 12.86
RMS 13.41
Pythia
CDF
0
10
20
30
40
50
60
70
80
0 10 20 30 40 50 60


Pythia
CDF
<N_jets >
10
11
12
13
14
10^4