Multiple Jet Production at Low Transverse Momenta in Proton-Antiproton Collisions at $\sqrt{s}$=1.96 TeV

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Analysis Goals

- New experimental data on the multiple jet production at low p_T
- Study of the multiple parton interaction (MPI)
- Parameters of the partonic matter distribution

Features of low p_T jet study

- One primary vertex to suppress multiple interactions
- Using of minimum bias and QCD triggers
- Event-by-event trigger efficiencies
- MC smearing of a jet by p_T resolution near the 6 GeV jet threshold
- Big systematic uncertainties of the energy calibration
- Increased MC uncertainty from the p_T resolution

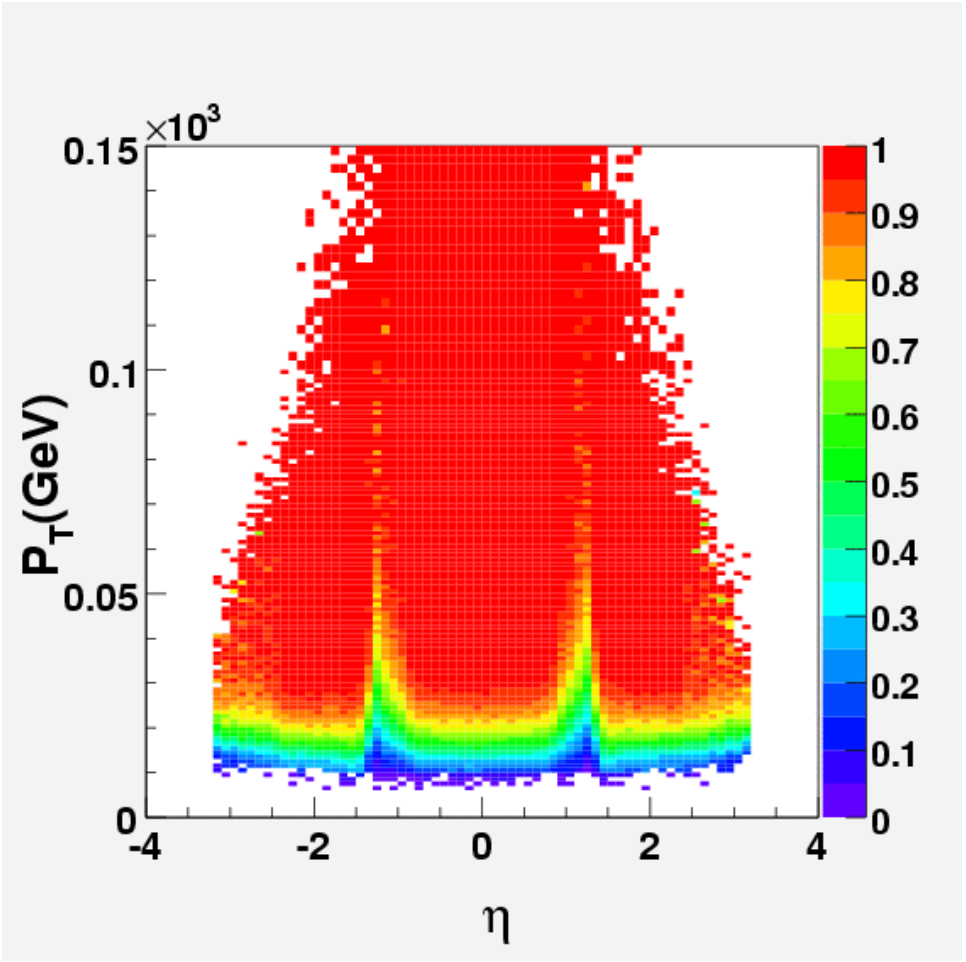
Analysis

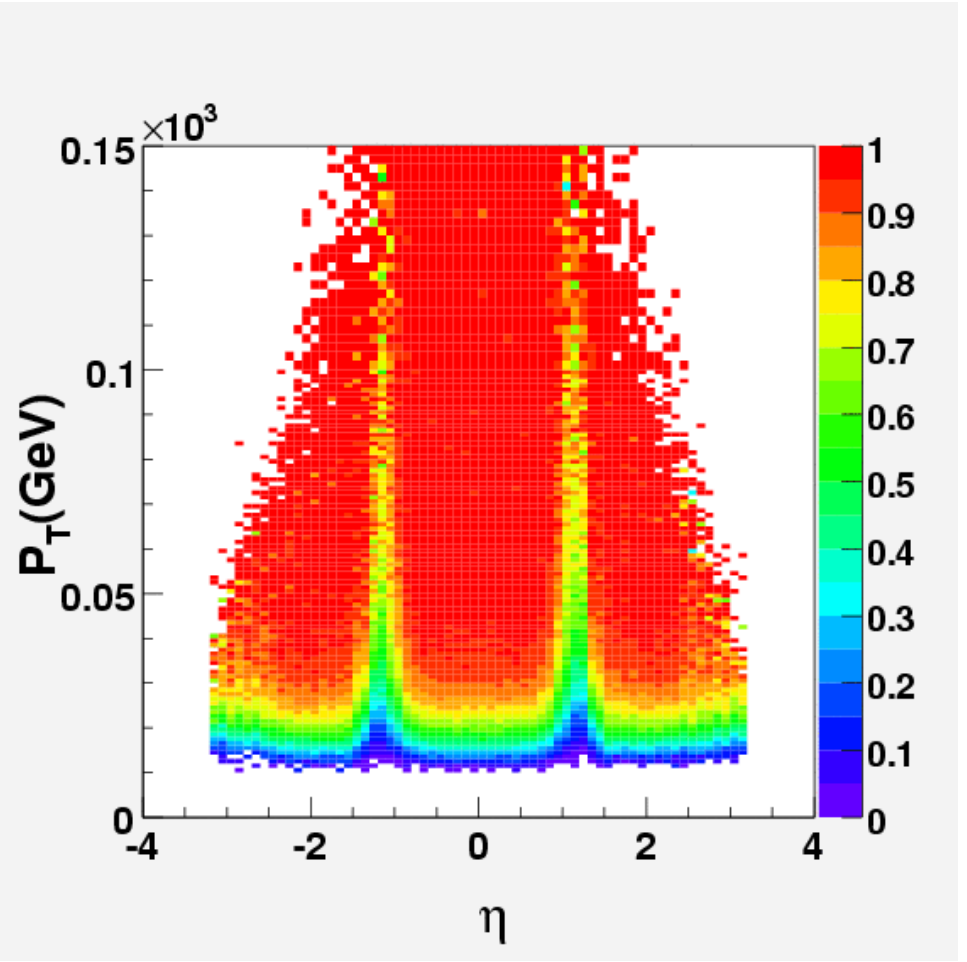
- QCD triggers: JT_8TT, JT_15TT
- MB triggers: min_bias, min_bias_NCU, min_bias_nim_NCU
- QCD ~100M events, MB ~60M events luminosity ~100nb^{-1}(QCD), 0.45nb^{-1}(MB)

Events, Jets, and Vertices

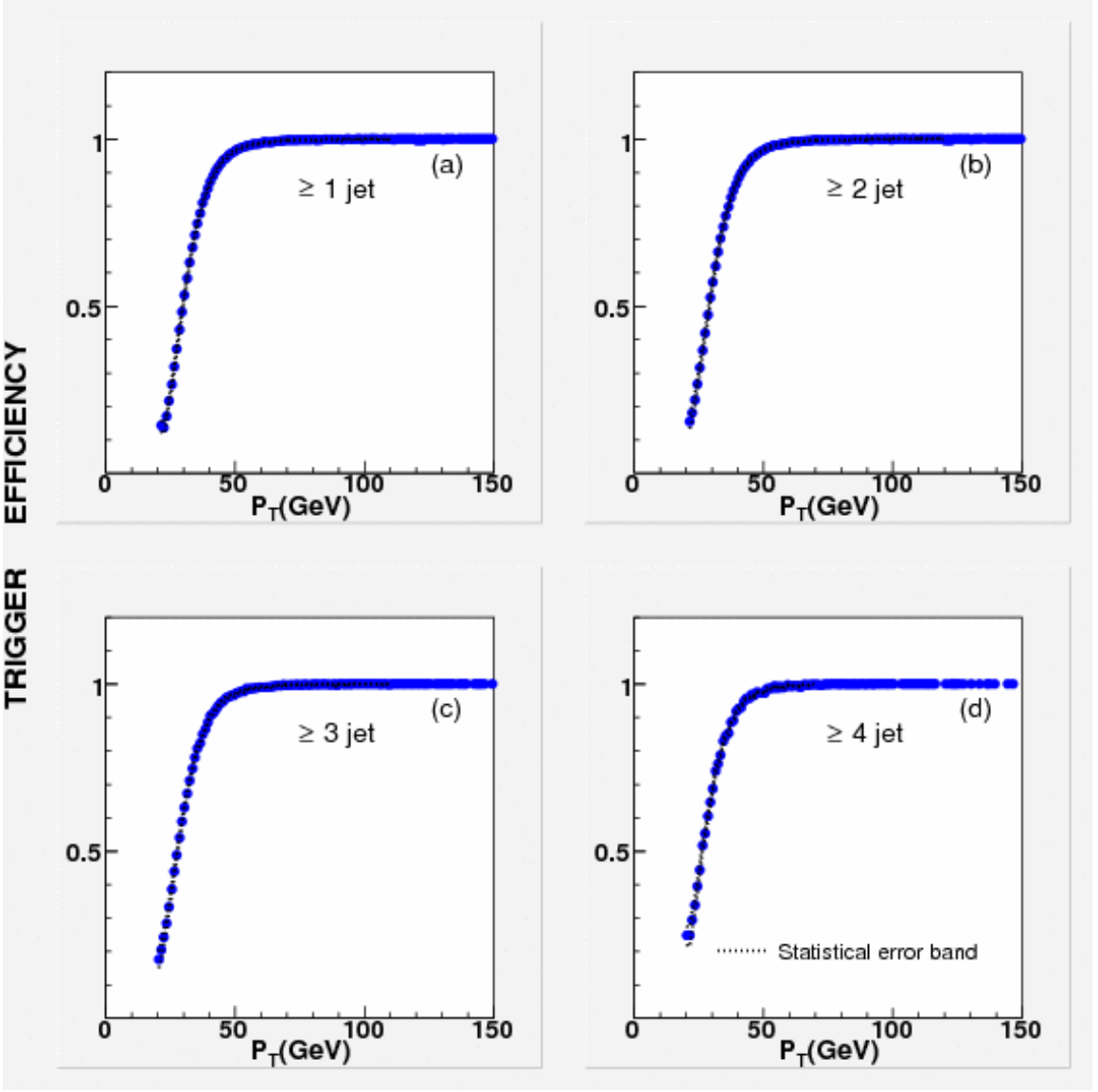
- Events selection:
  $|Z| \leq 50cm$, $N_{PV0}^{tracks} \geq 3$, $MET < 0.7 p_{T1}$
- Jet selection:
  JCCA, Standard Jet ID,
  $p_T > 20GeV$, $|\eta| < 3.0$
- JES:
  jetcorr v07-02-78, Dijet JES(J4S), 4Vector Correction (50-100)%, Uncertainty (2-6)%
- Vertex Efficiency=93.0±0.5%

JT_8TT and JT_15TT ($\eta - p_T$) trigger efficiency

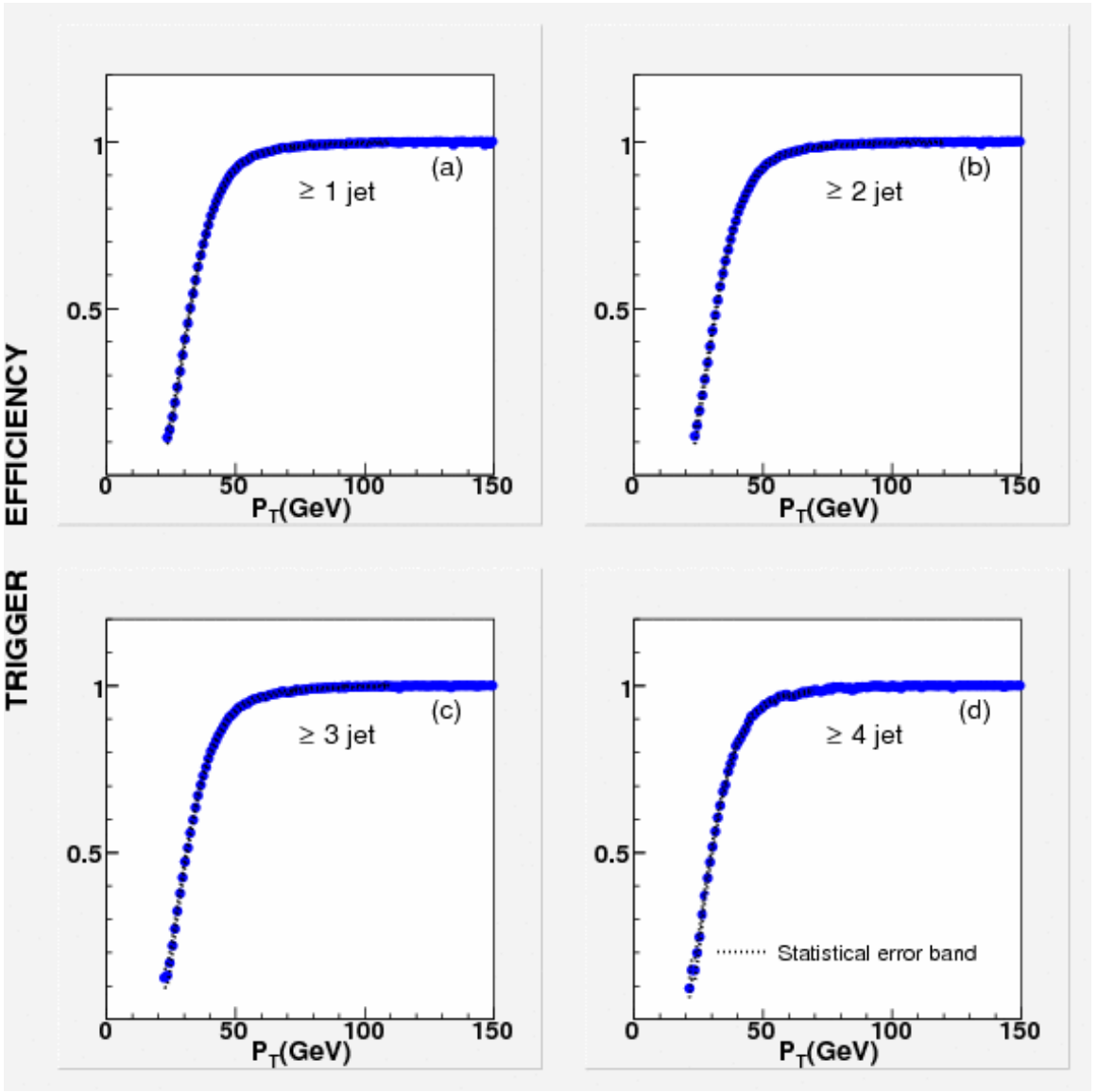




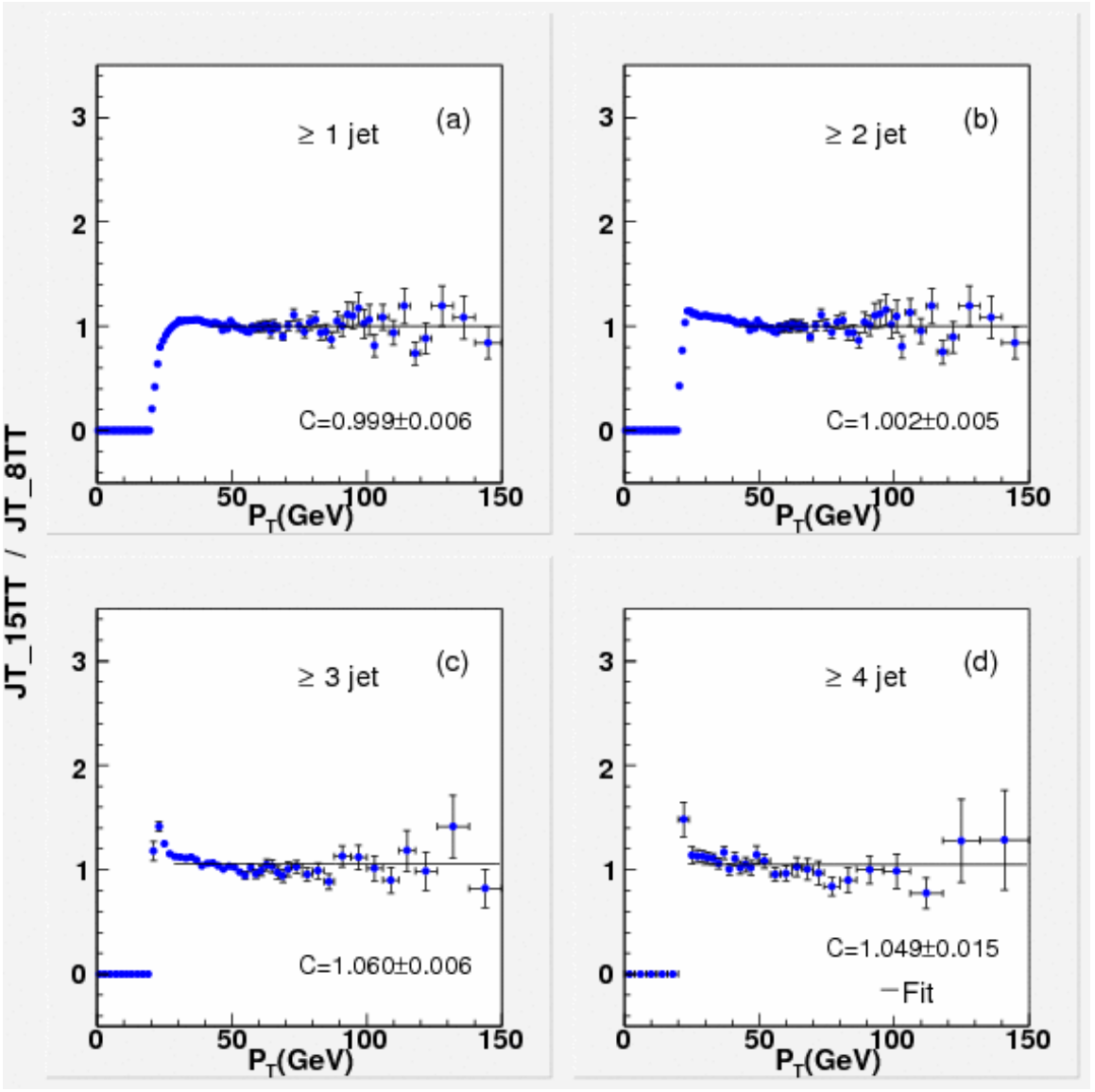
Trigger Efficiency (trigeff_cafe) JT_8TT



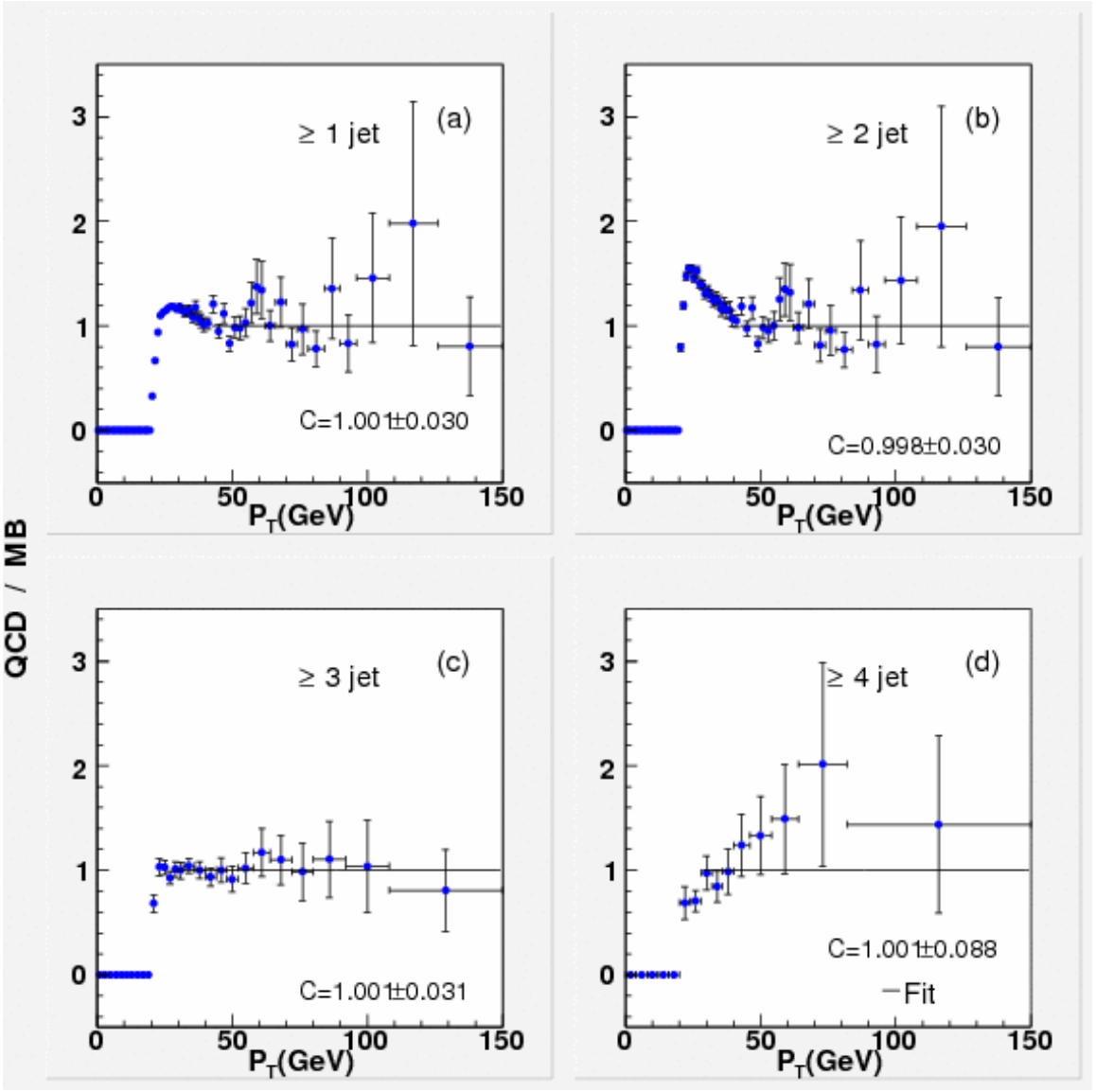
Trigger Efficiency JT_15TT



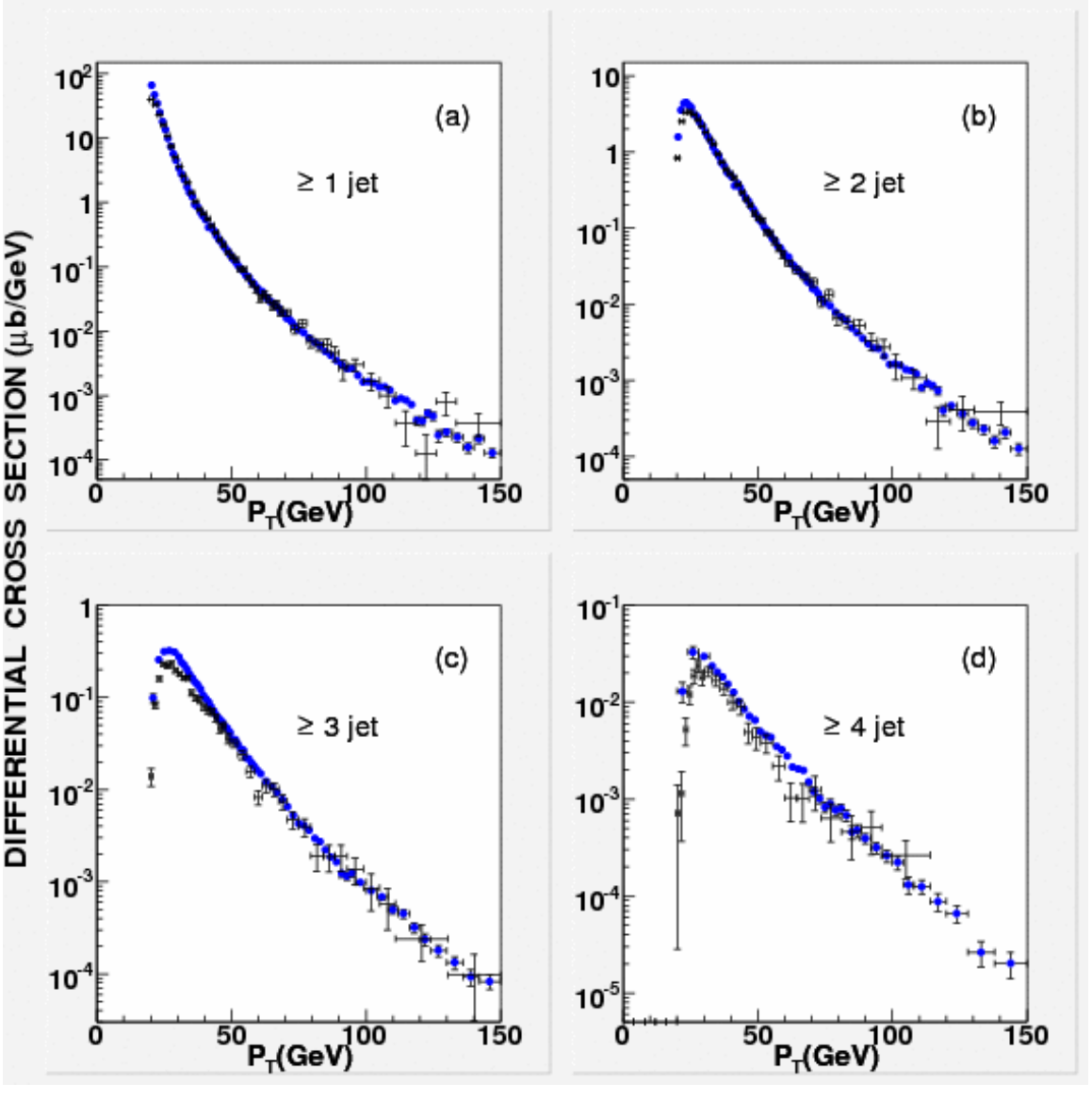
Ratio of the JT_15TT and JT_8TT cross sections



Ratio of the QCD and MB cross sections



Raw data and Run I results



MC

d0_mcpp, d0_mcpp_gen, mcpp_gen ⇒ Standalone MC

⇓

d0_runjob

⇓

Full simulation | Generator level

⇓ | ⇓

Reco MC jets | Particle jets | Particle jets

⇓ | ⇓

smearing | (p_T,η,φ,M) | smearing

⇓ | ⇓

Smeared MC jets | Smeared MC jets GL

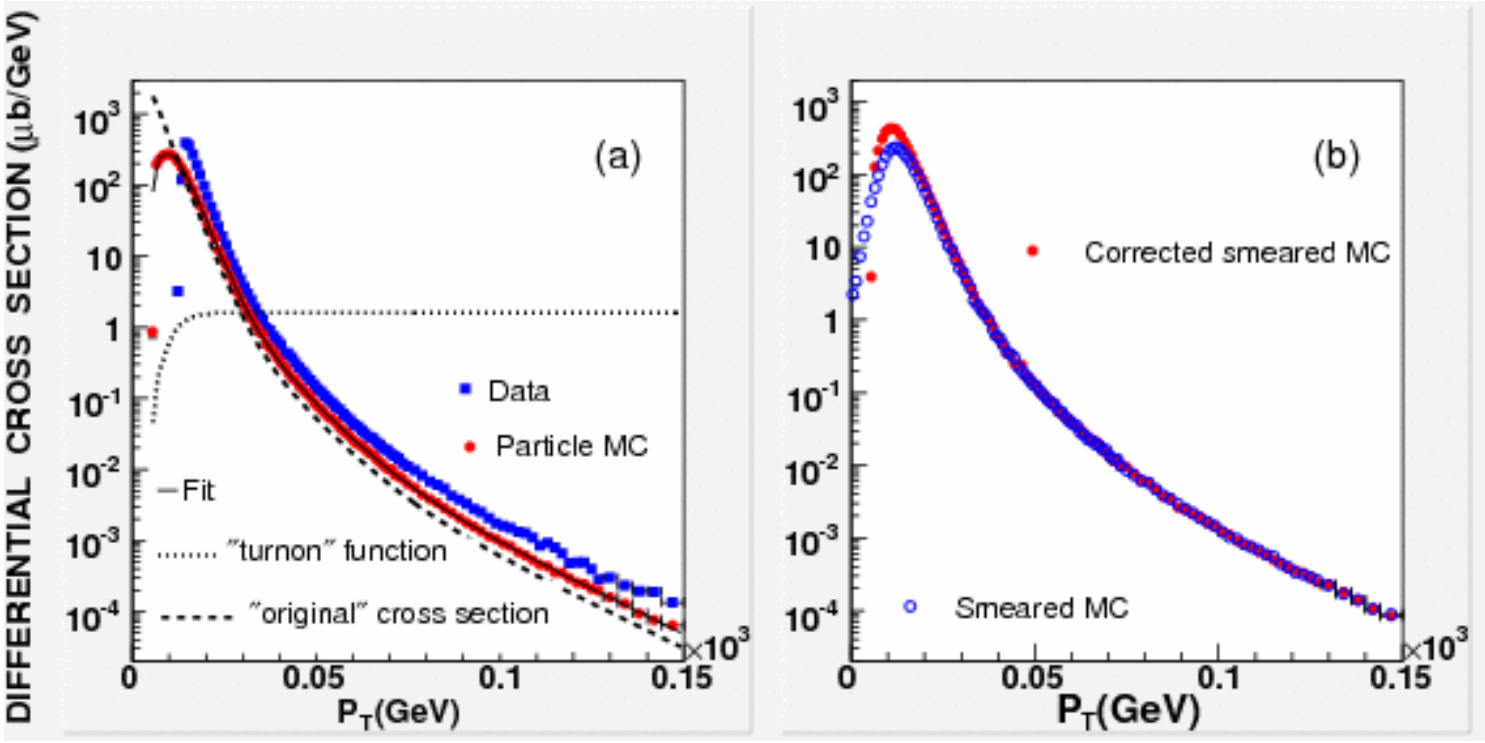
MC

- PYTHIA, PDF CTEQ6L1
- Multiple Parton Interaction (MPI) Tune A
  2 Gaussian partonic matter distribution:
  β=0.32 – core fraction
  a_2/a_1=0.4 – relative size
  p_{T0}=2.0GeV – infrared cut-off
- P_T resolution (dijet data) 20%
  η and φ resolution (MC) 0.07
  mass resolution (MC) 20%
  at p_T= 20GeV

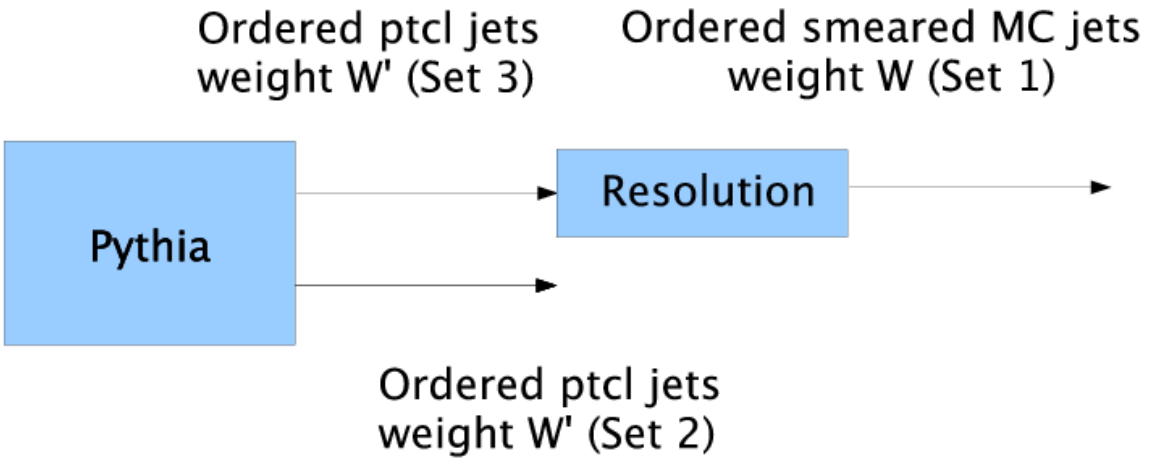
ALPGEN (CTEQ6L1)

- Minimum parton p_T – 6GeV
- Minimum parton–jet p_T in matching – 6GeV
- Parton–parton η–φ distance $\Delta R > 0.9$
- Jet–parton η–φ distance $\Delta R < 0.6$ in matching
- Factorization and renormalization scale $Q = \Sigma_{jets} p_T^2$

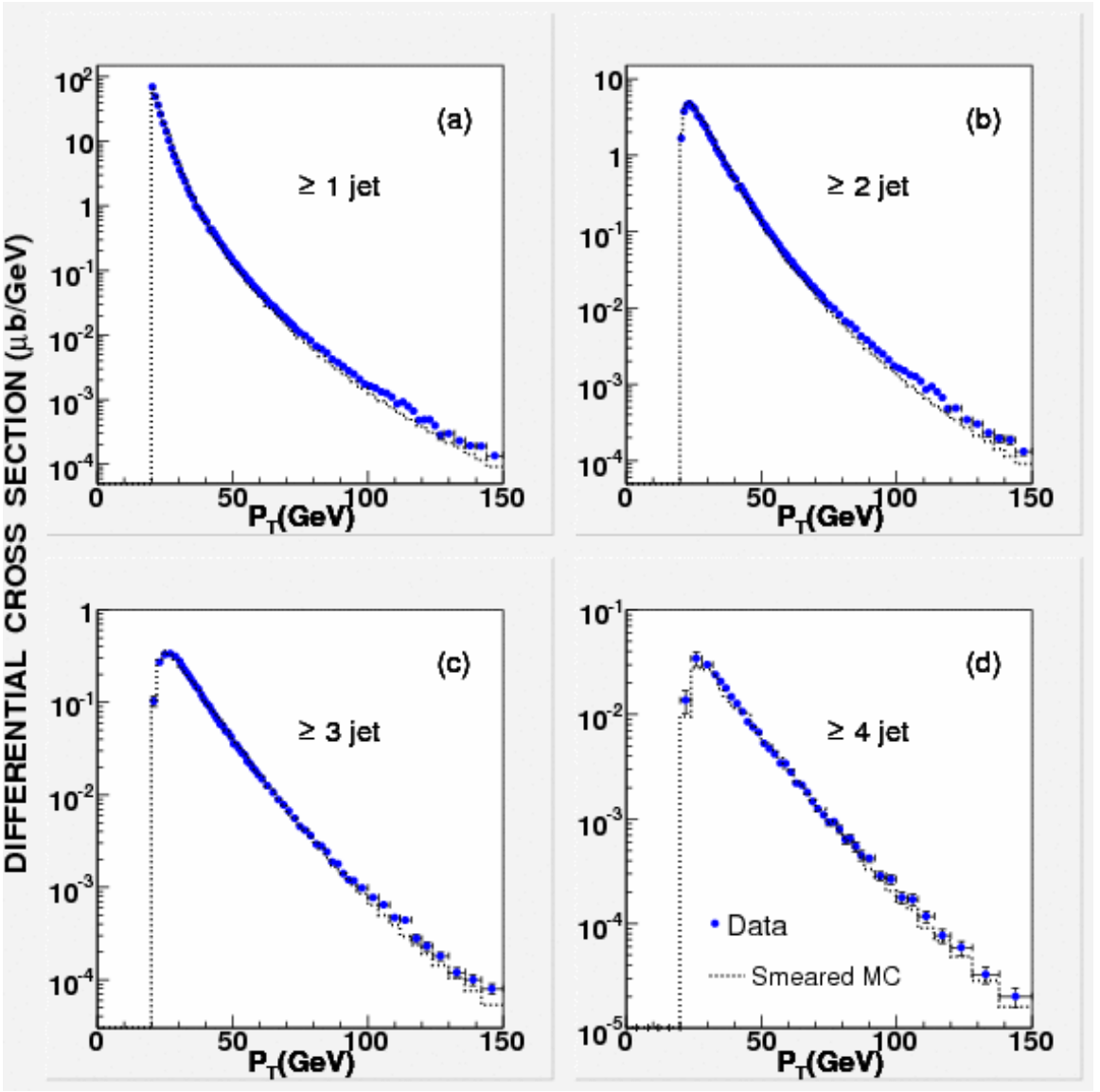
Jet 6GeV threshold correction



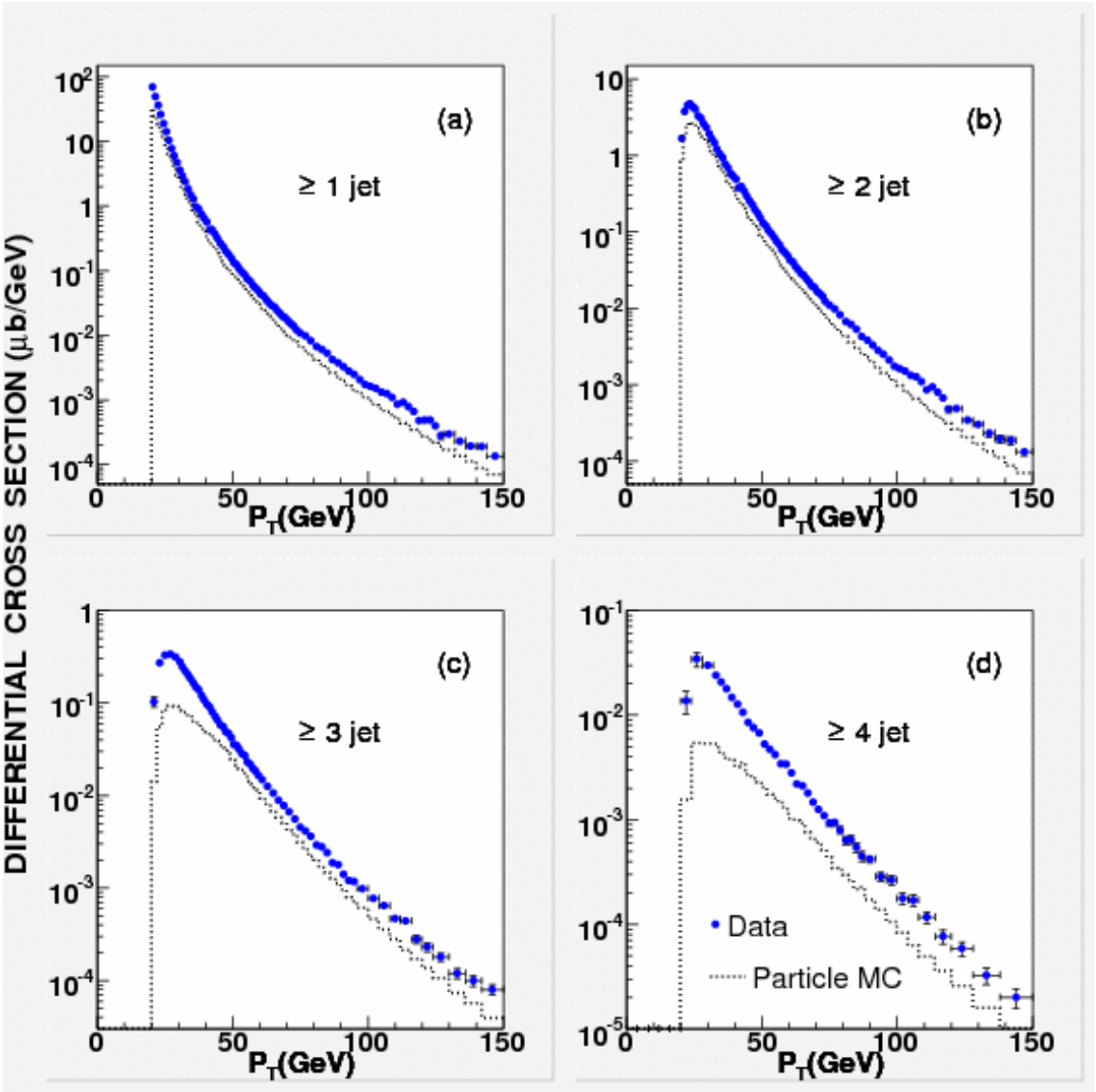
Correction and reweighting in unfolding



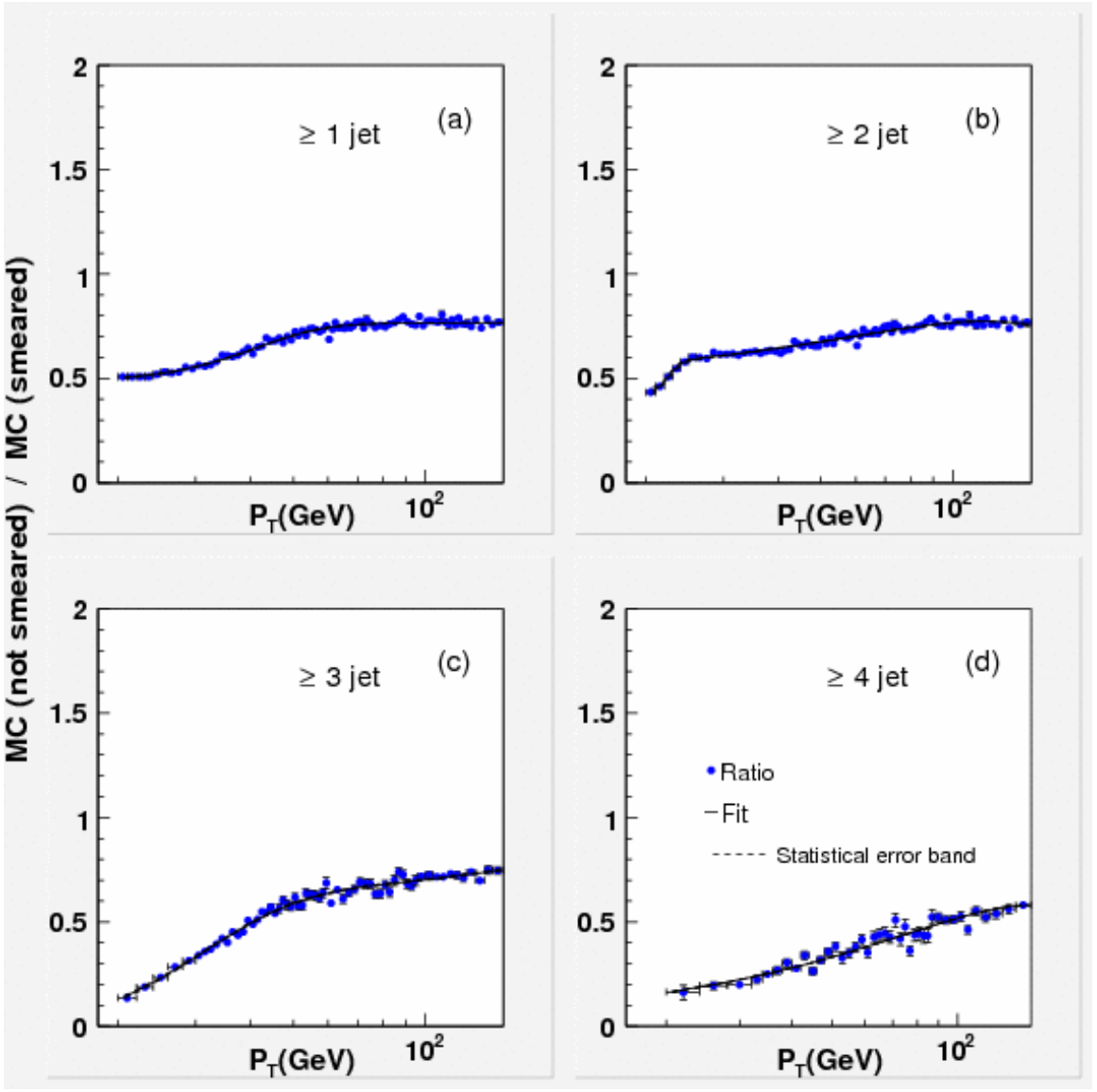
Raw data and smeared MC jets



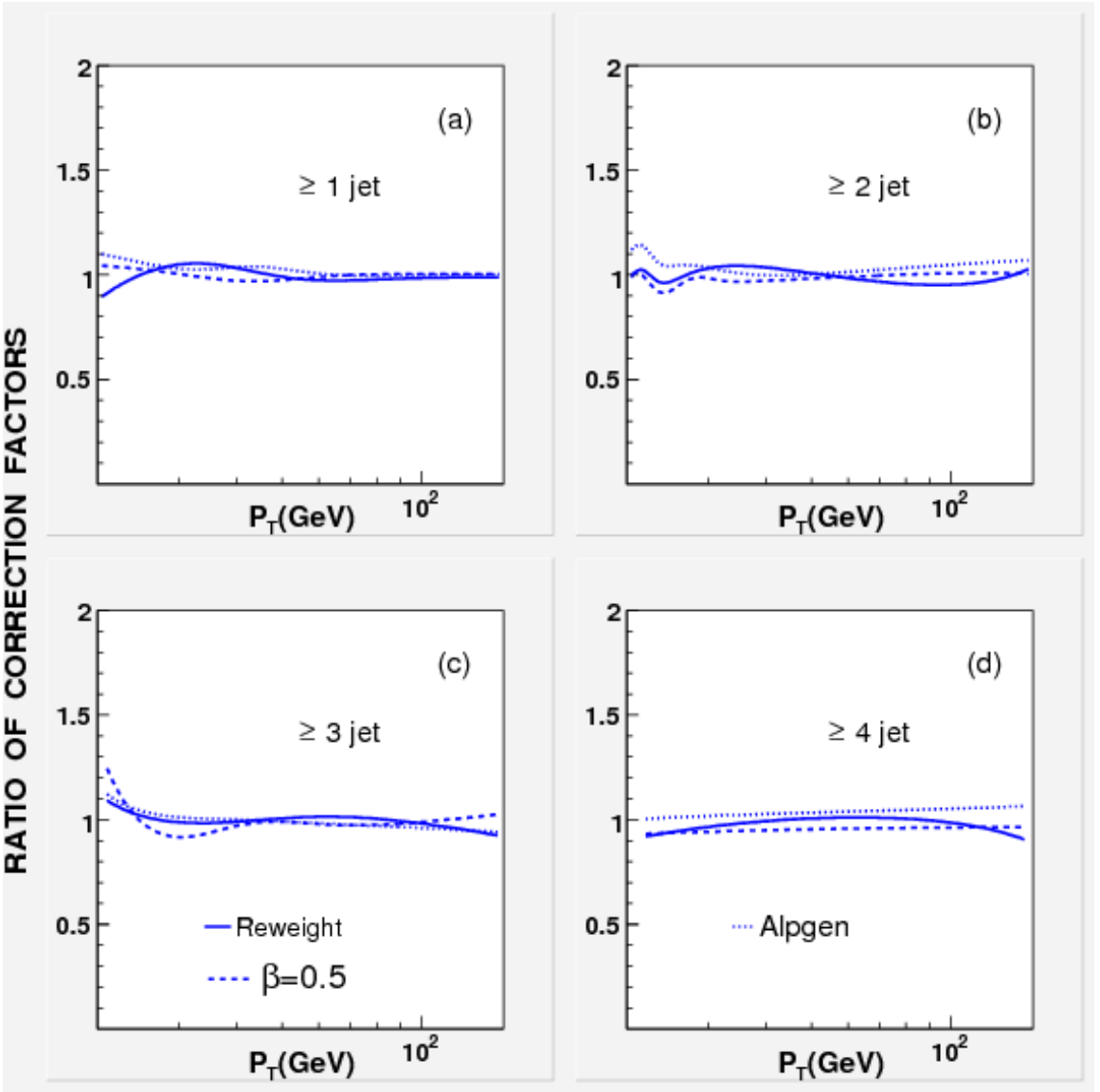
Raw data and particle MC jets



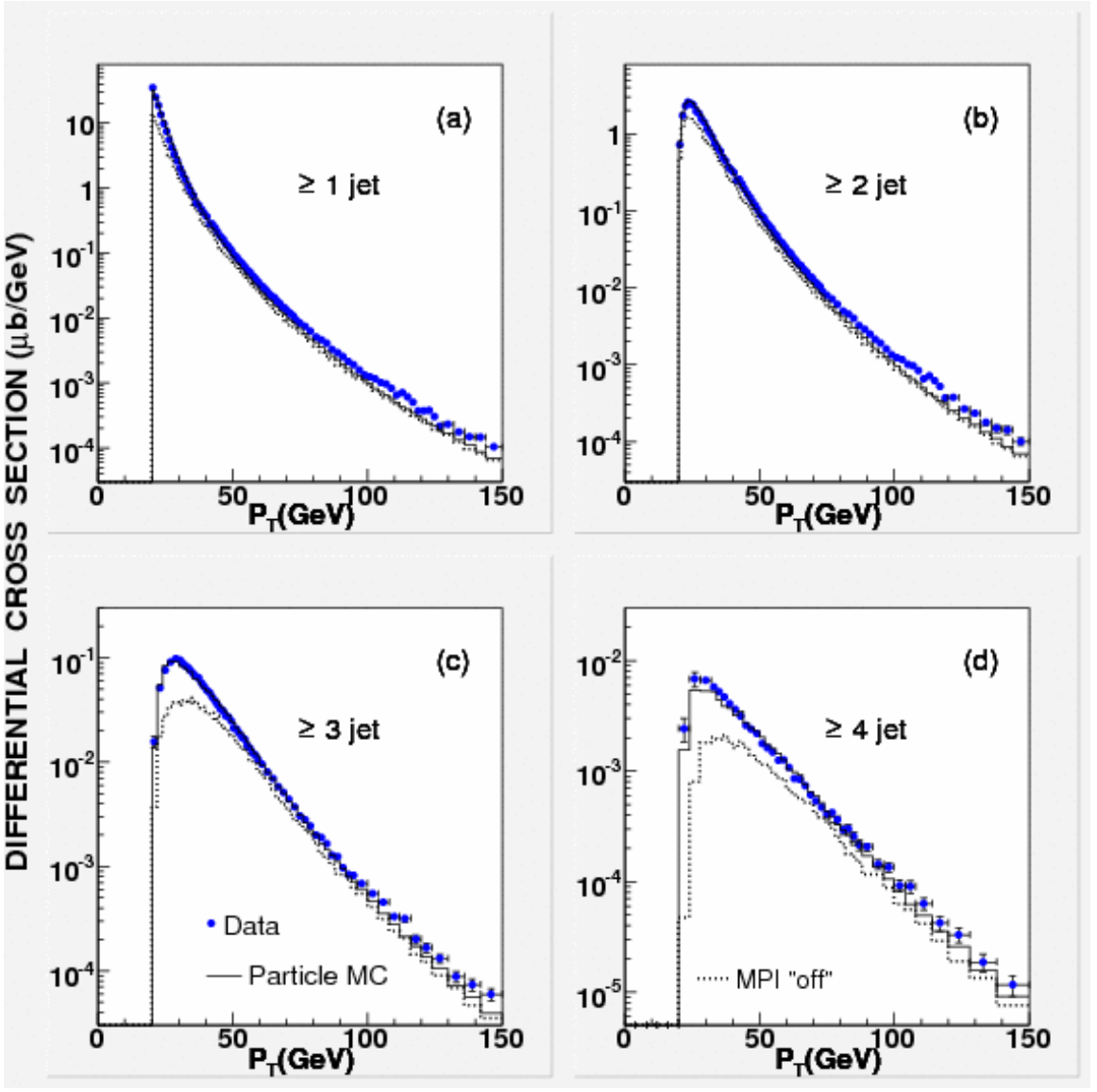
Unsmearing correction factors



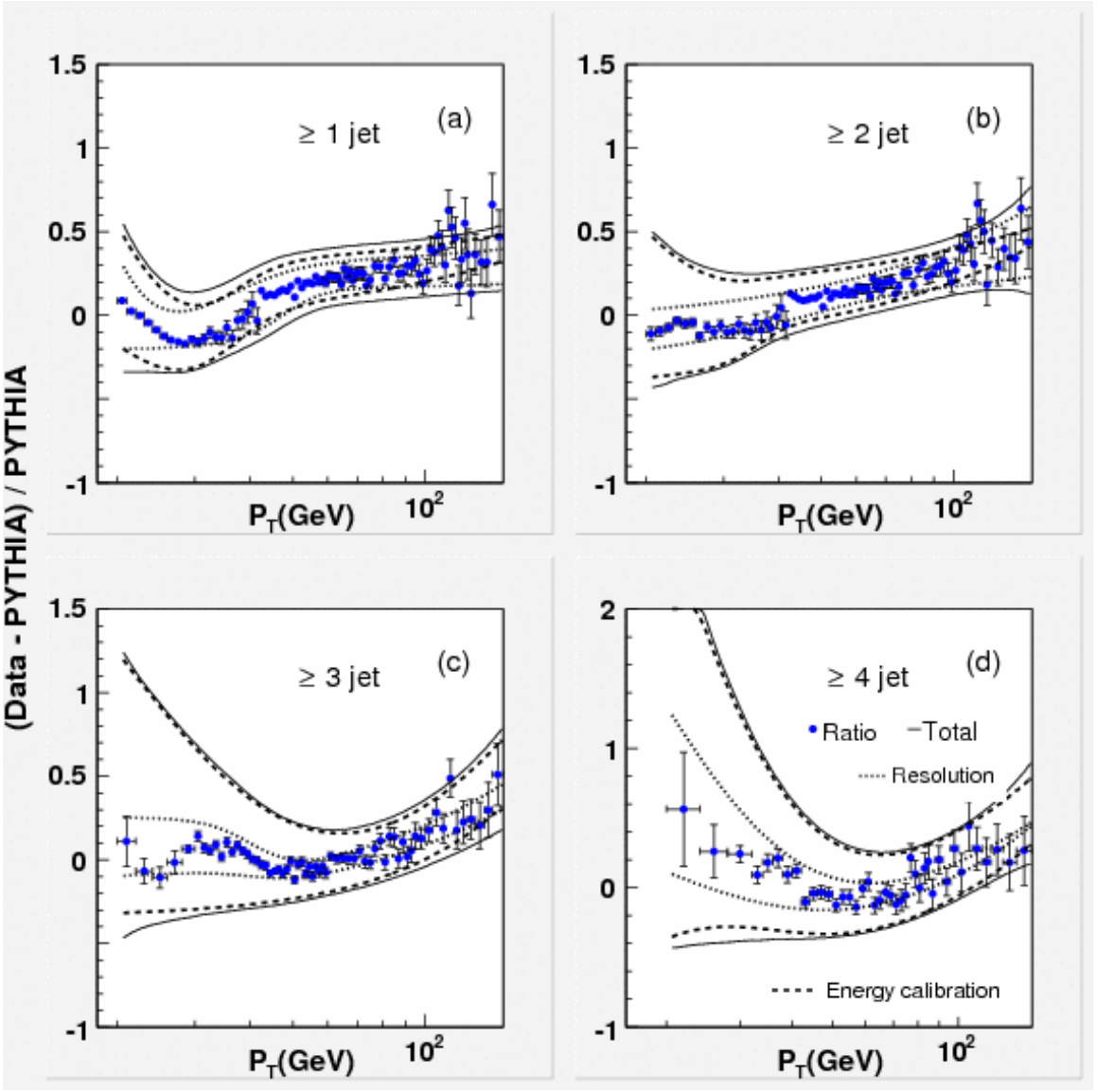
Model dependence of unfolding



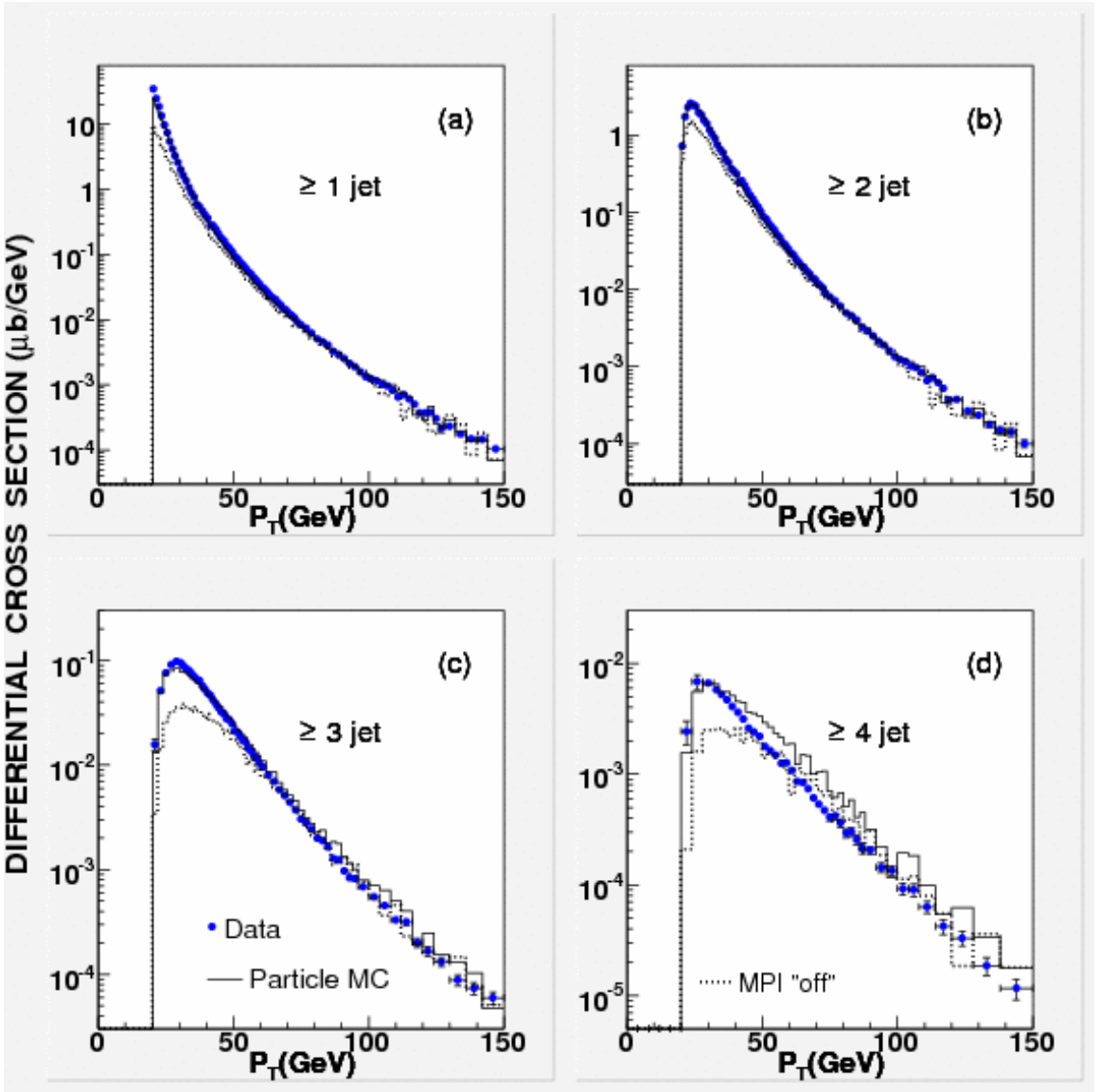
Unfolded data and PYTHIA with CTEQ6L1, β=0.32, a_2/a_1=0.4



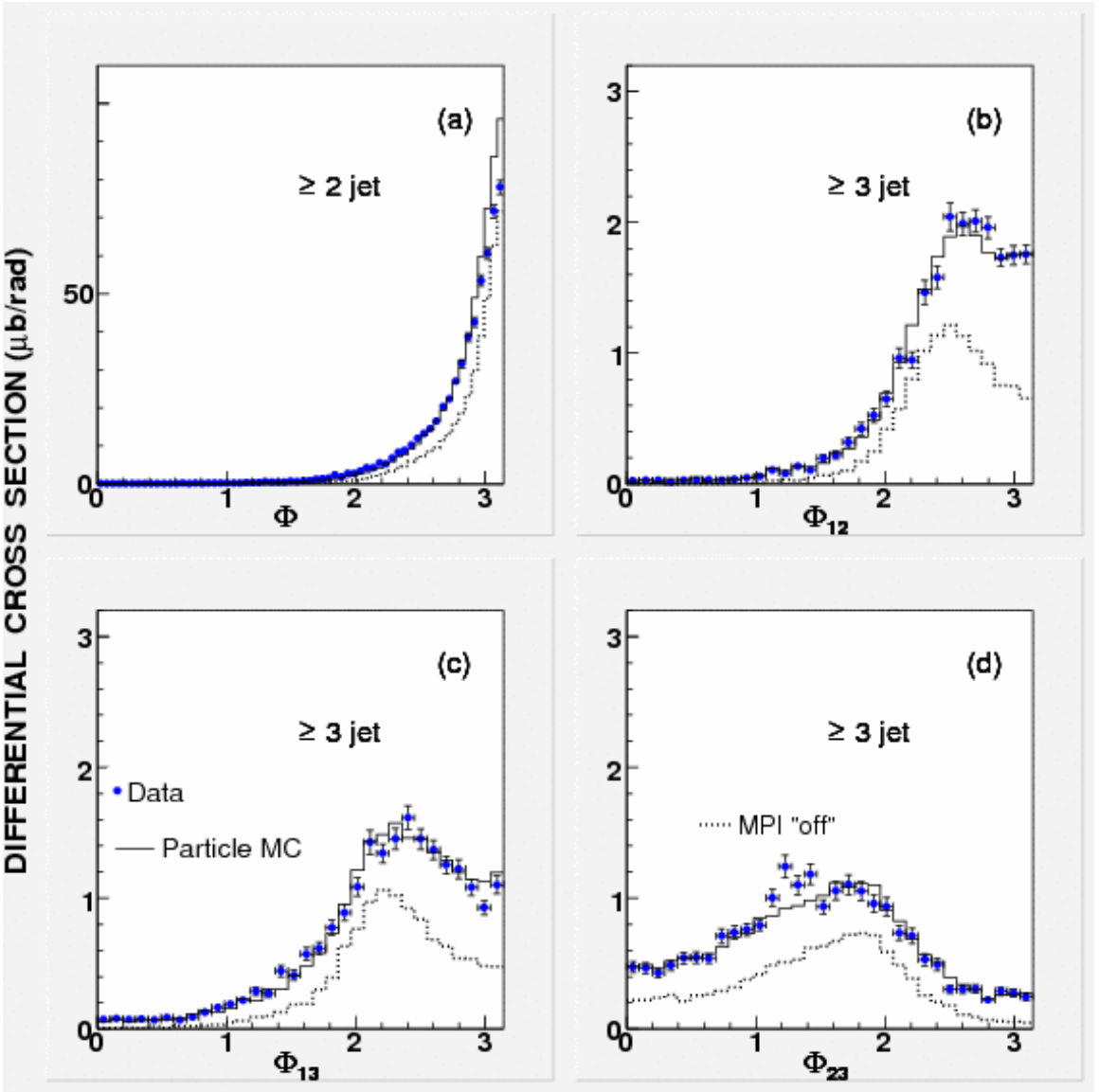
(Data – PYTHIA)/PYTHIA



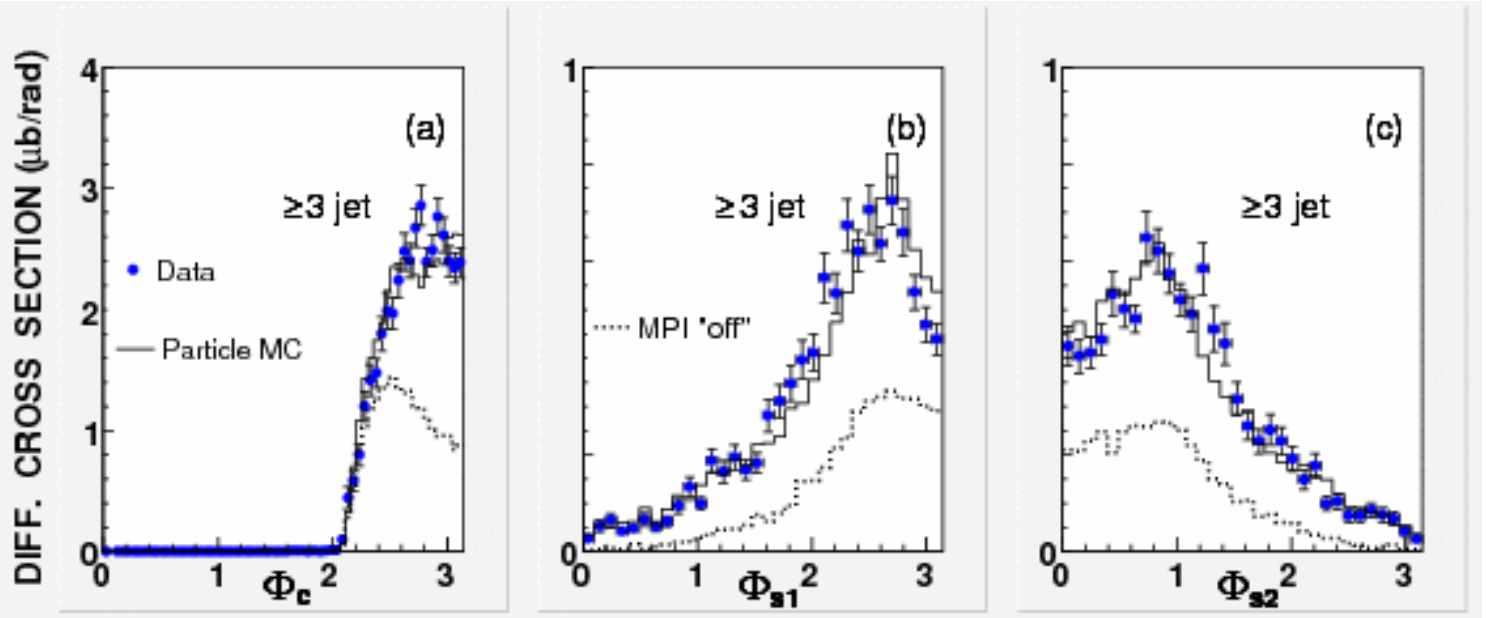
Unfolded data and ALPGEN with CTEQ6L1, β=0.30, a_2/a_1=0.5



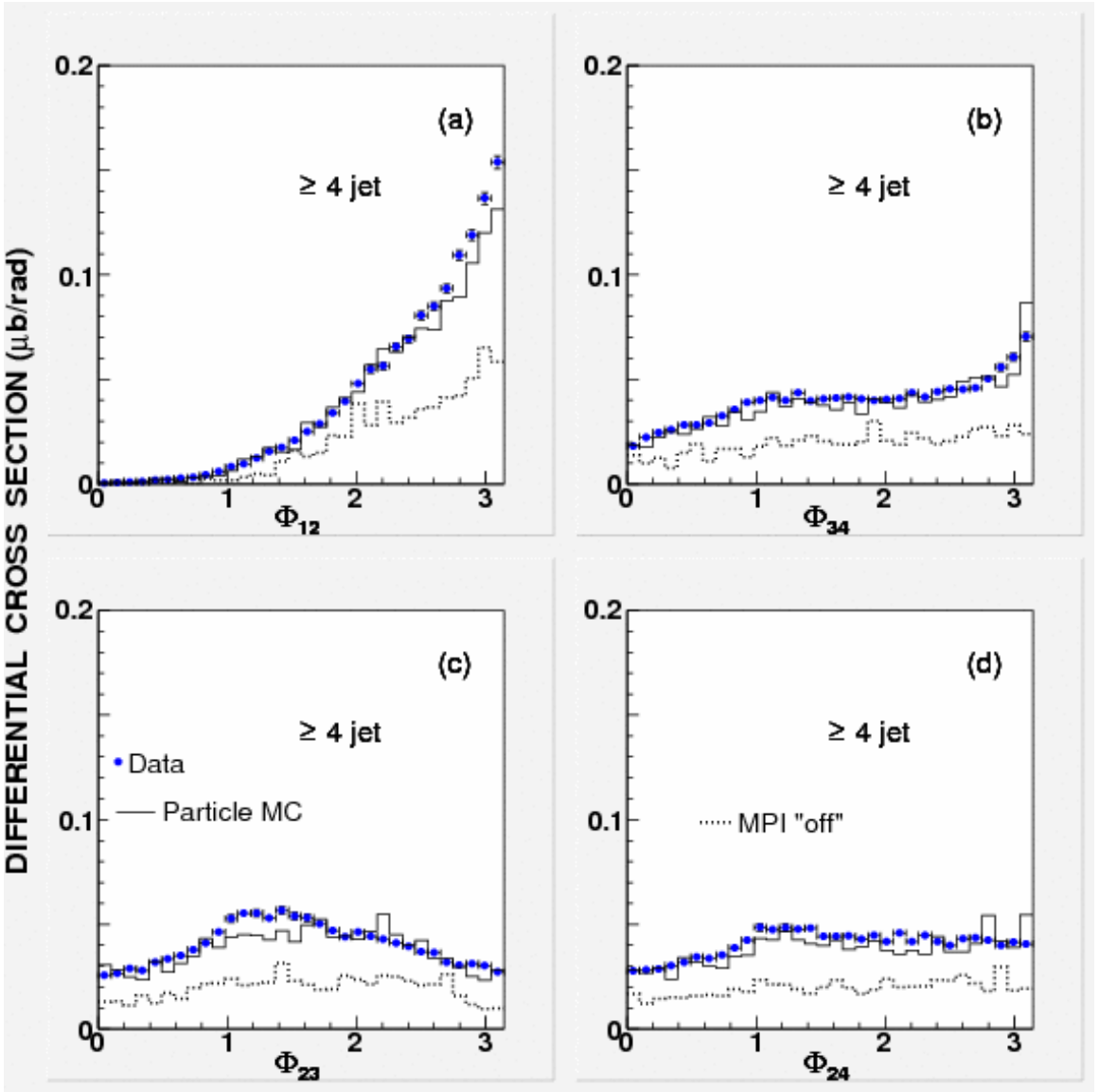
Relative azimuthal angle distributions and PYTHIA



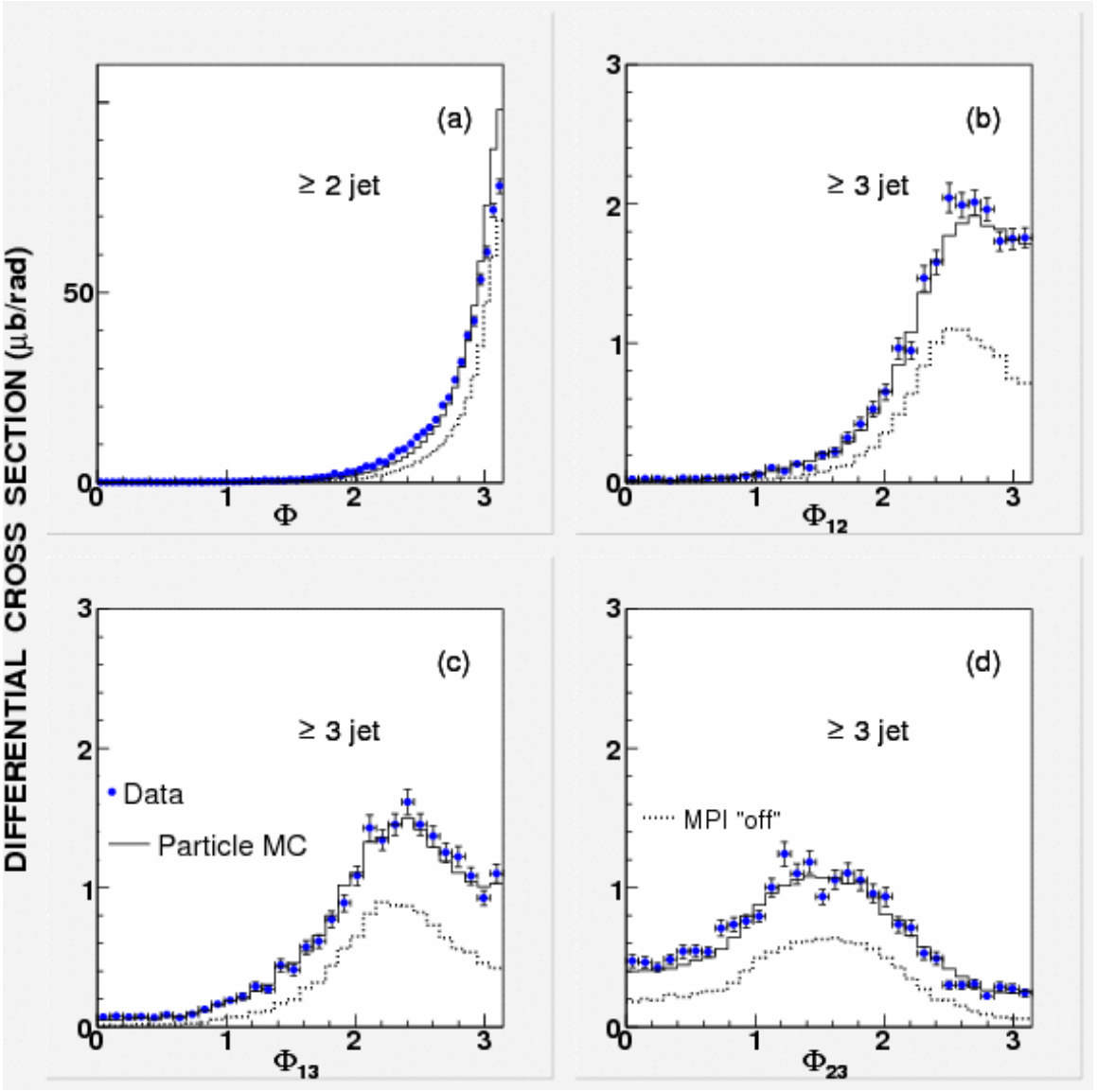
Anglular 3-jet study and PYTHIA



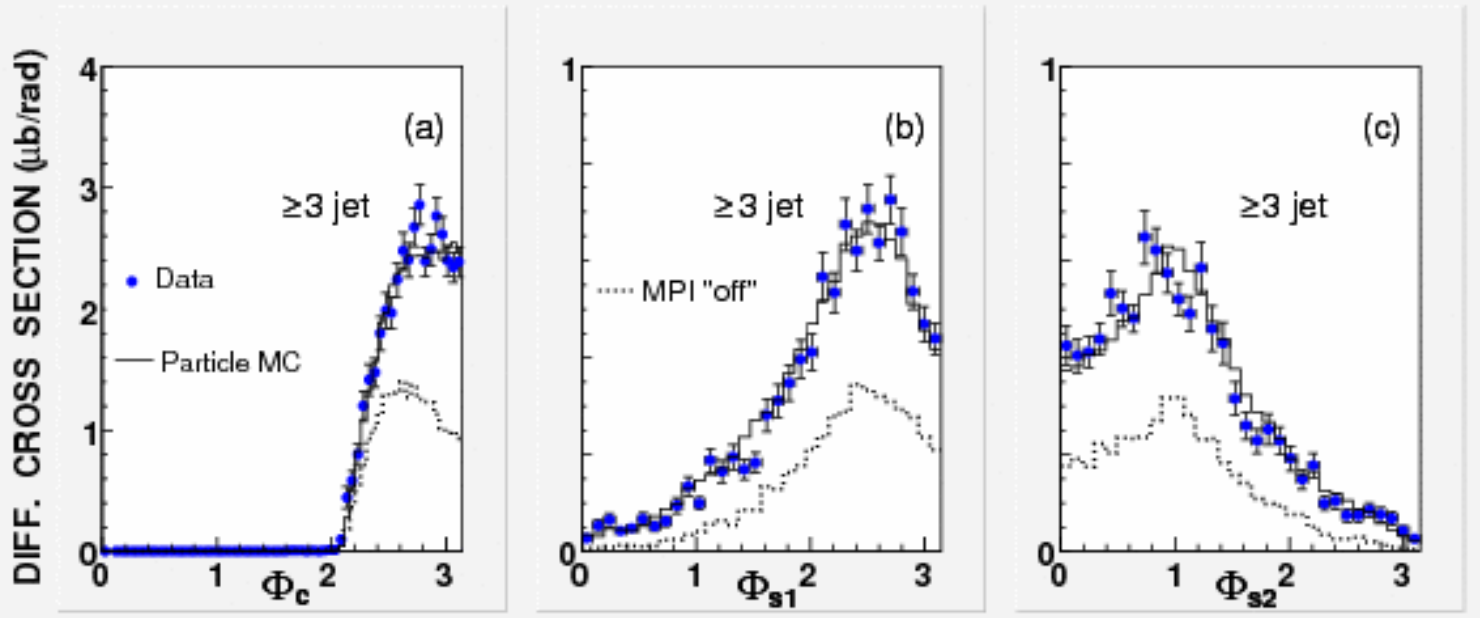
4-jet relative azimuthal angle distributions and PYTHIA



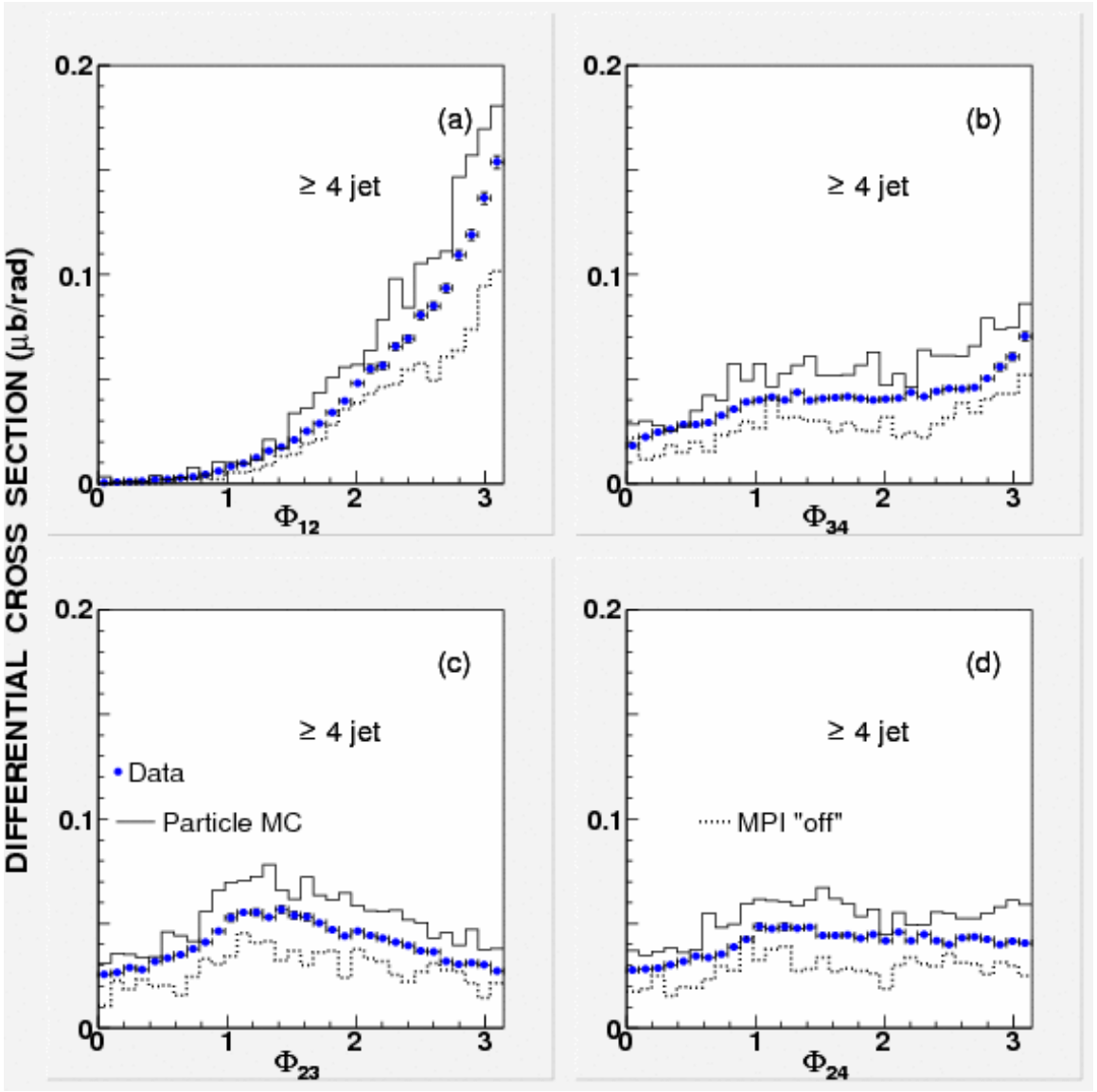
Relative azimuthal angle distributions and ALPGEN



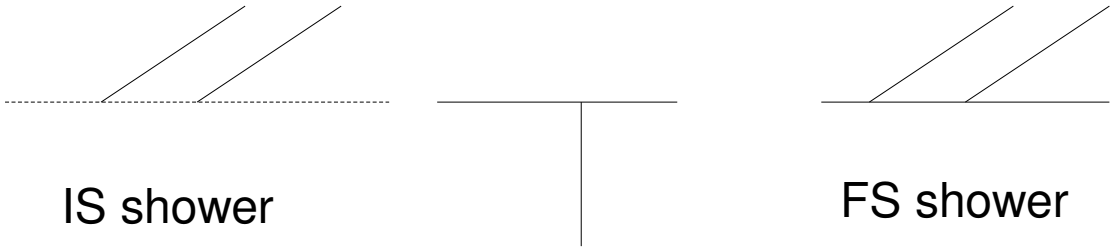
Anglular 3-jet study and ALPGEN



4-jet relative azimuthal angle distributions and ALPGEN

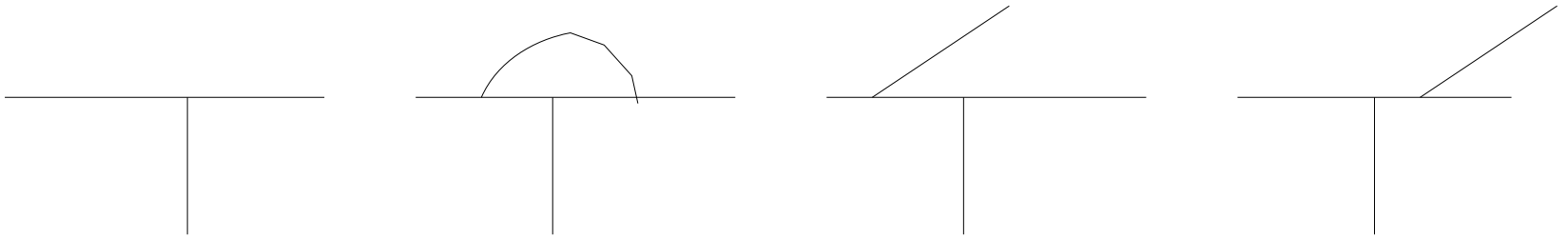


LLO and NLO pdfs



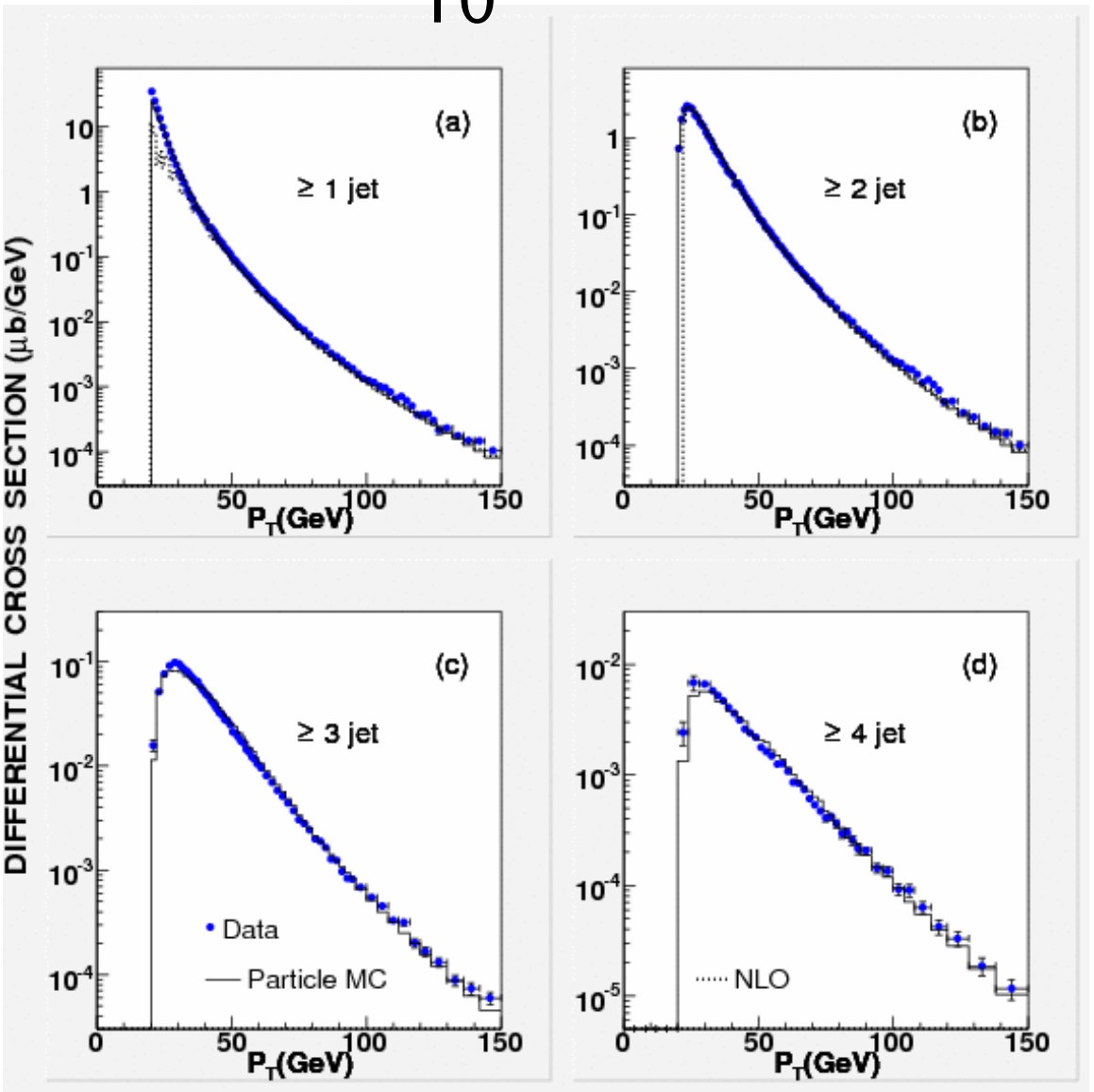
LLO

NLO

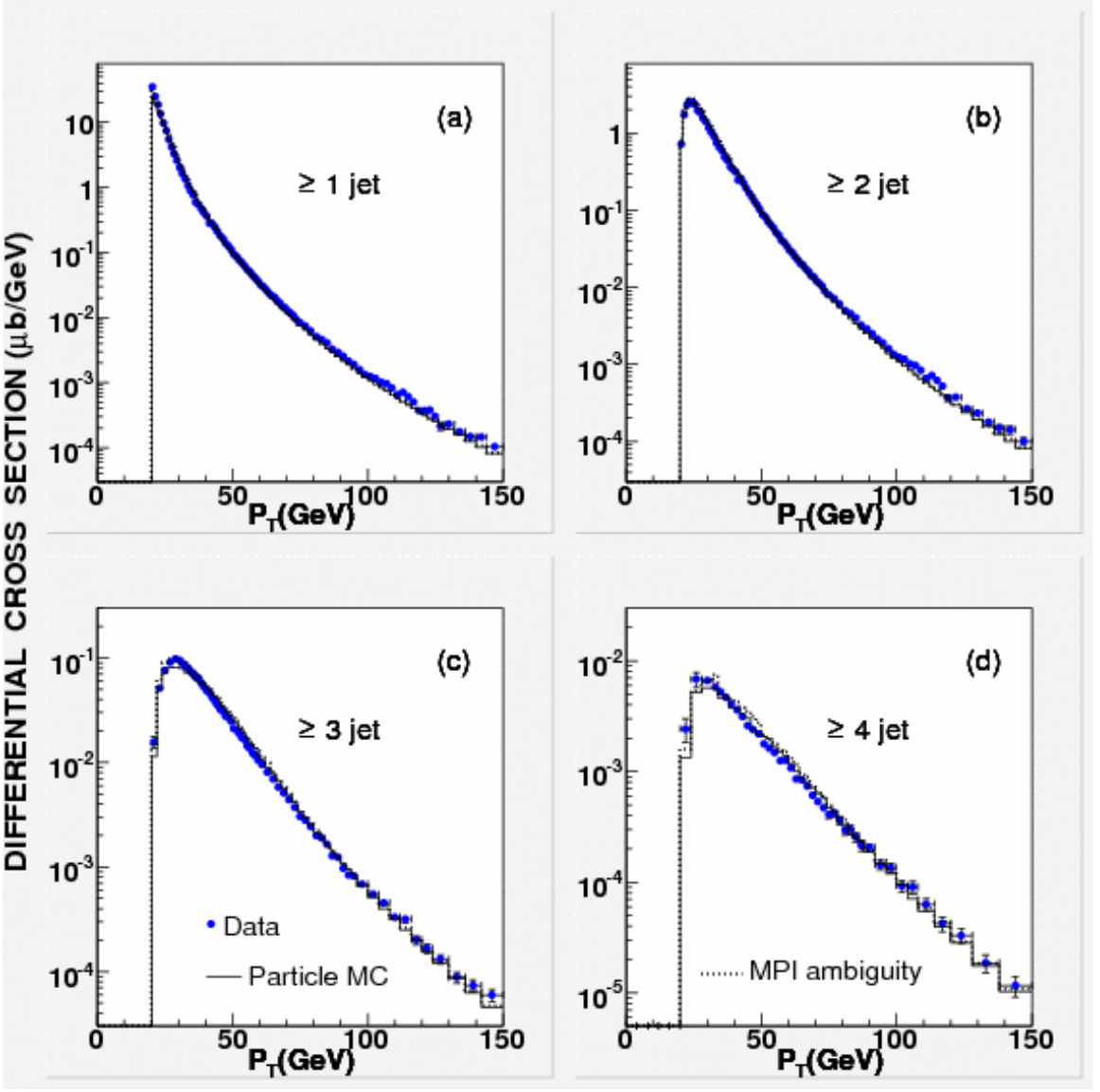


Matrix element

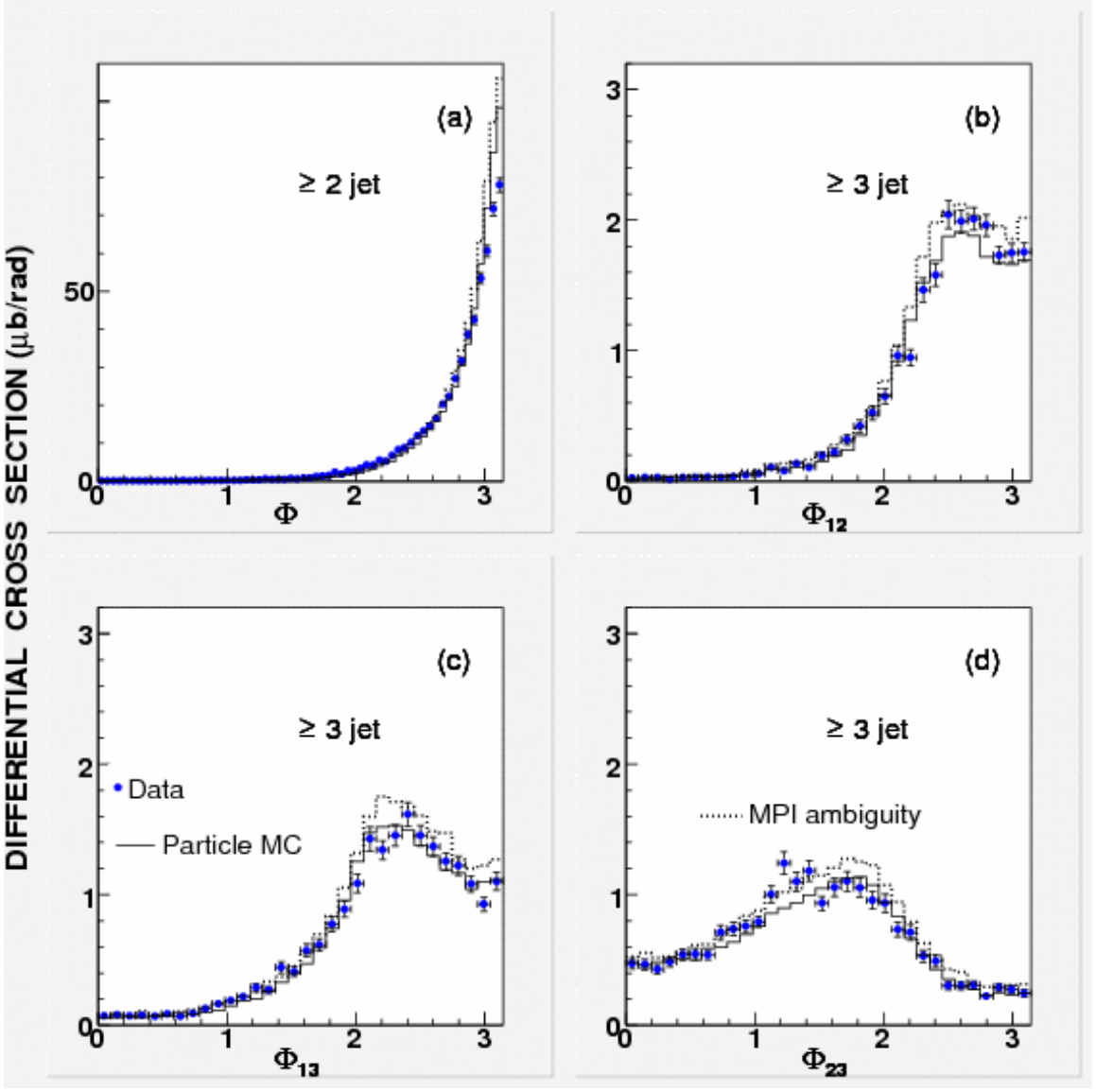
Data with PYTHIA and NLO; MSTW2008, β=0.39, a_2/a_1=0.17, p_{T0}=2.5GeV



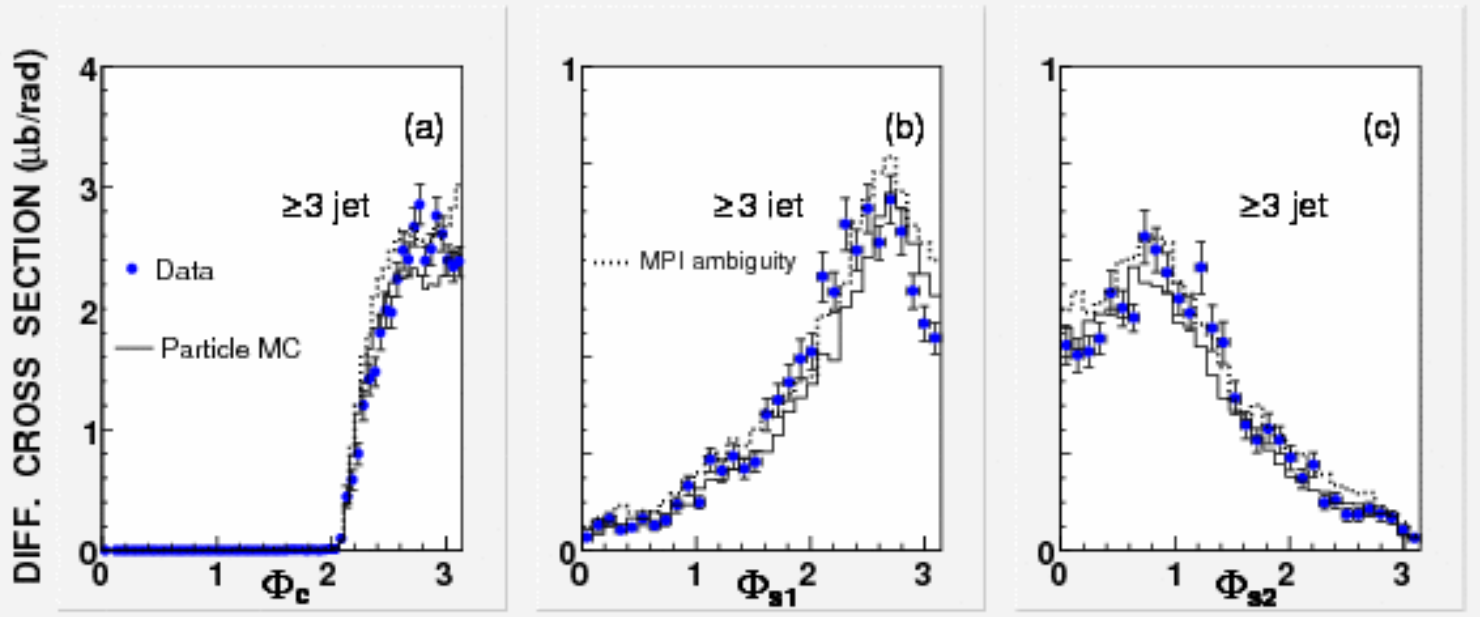
Ambiguous variant with β=0.32, a_2/a_1=0.22, p_{T0}=2.0GeV and basic variant



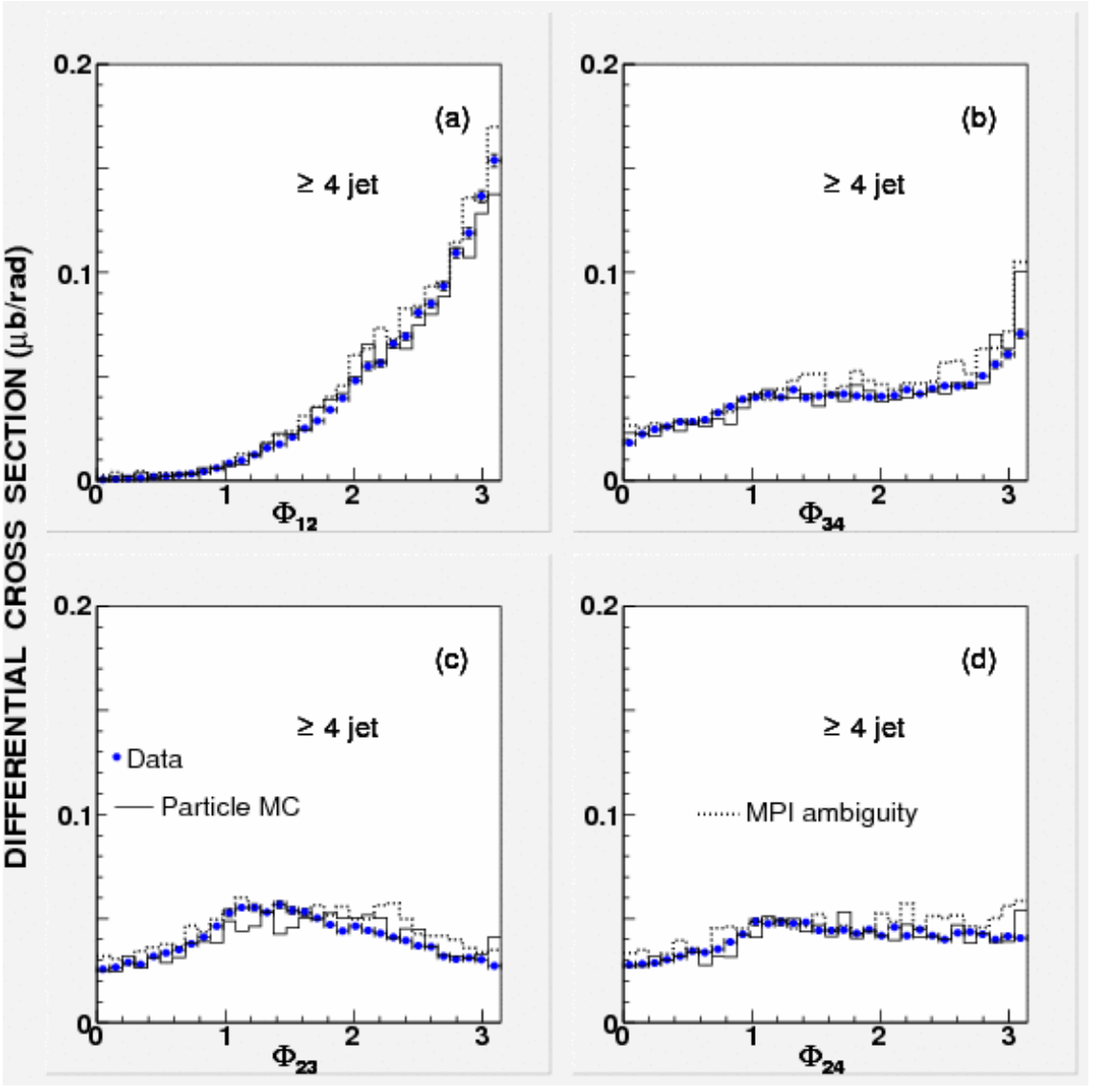
Ambiguous variant with β=0.32, a_2/a_1=0.22, p_{T0}=2.0GeV and basic variant



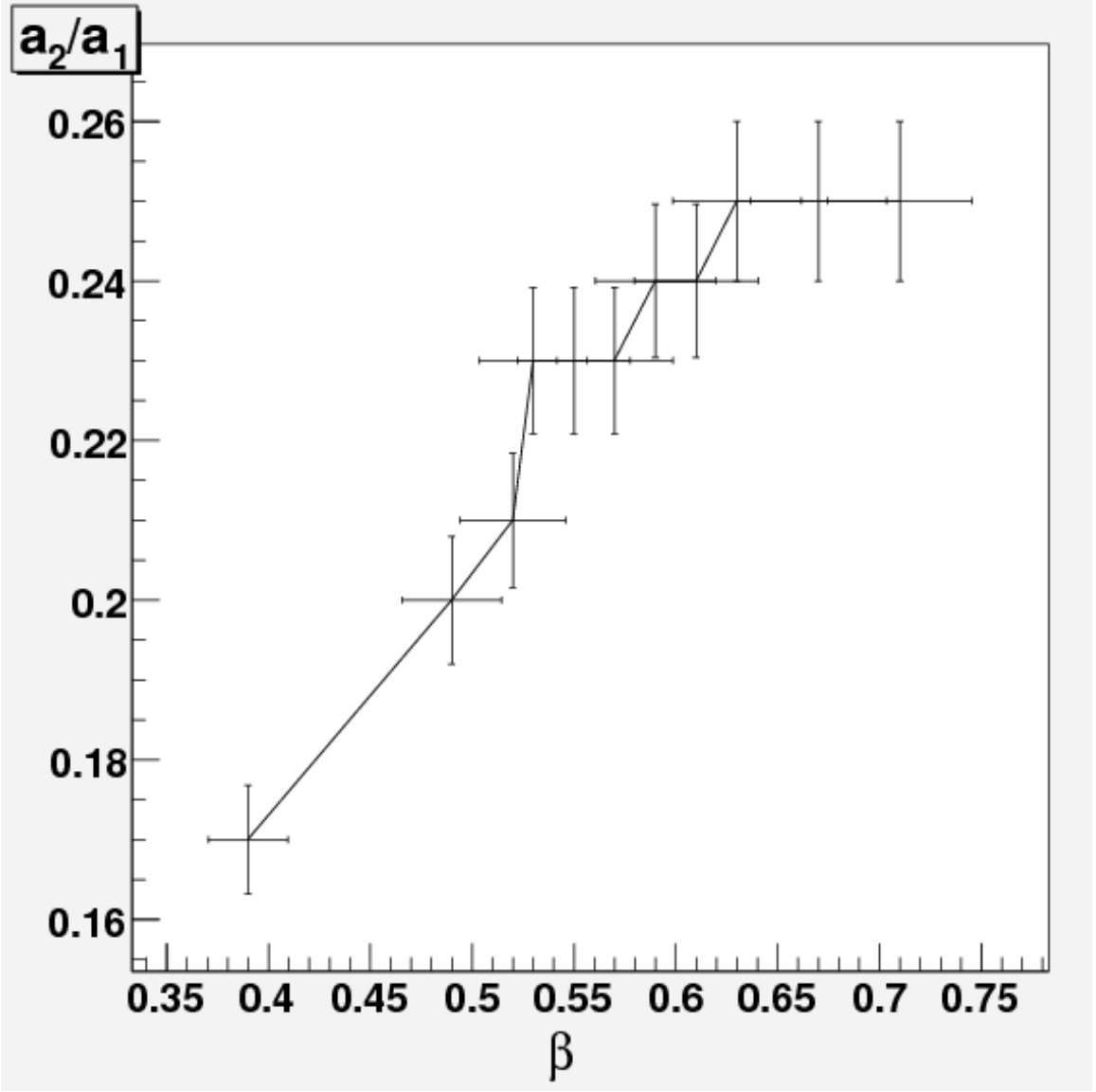
Ambiguous variant with $\beta=0.32$, $a_2/a_1=0.22$, $p_{T0}=2.0$GeV and basic variant



Ambiguous variant with $\beta=0.32$, $a_2/a_1=0.22$, $p_{T0}=2.0$GeV and basic variant

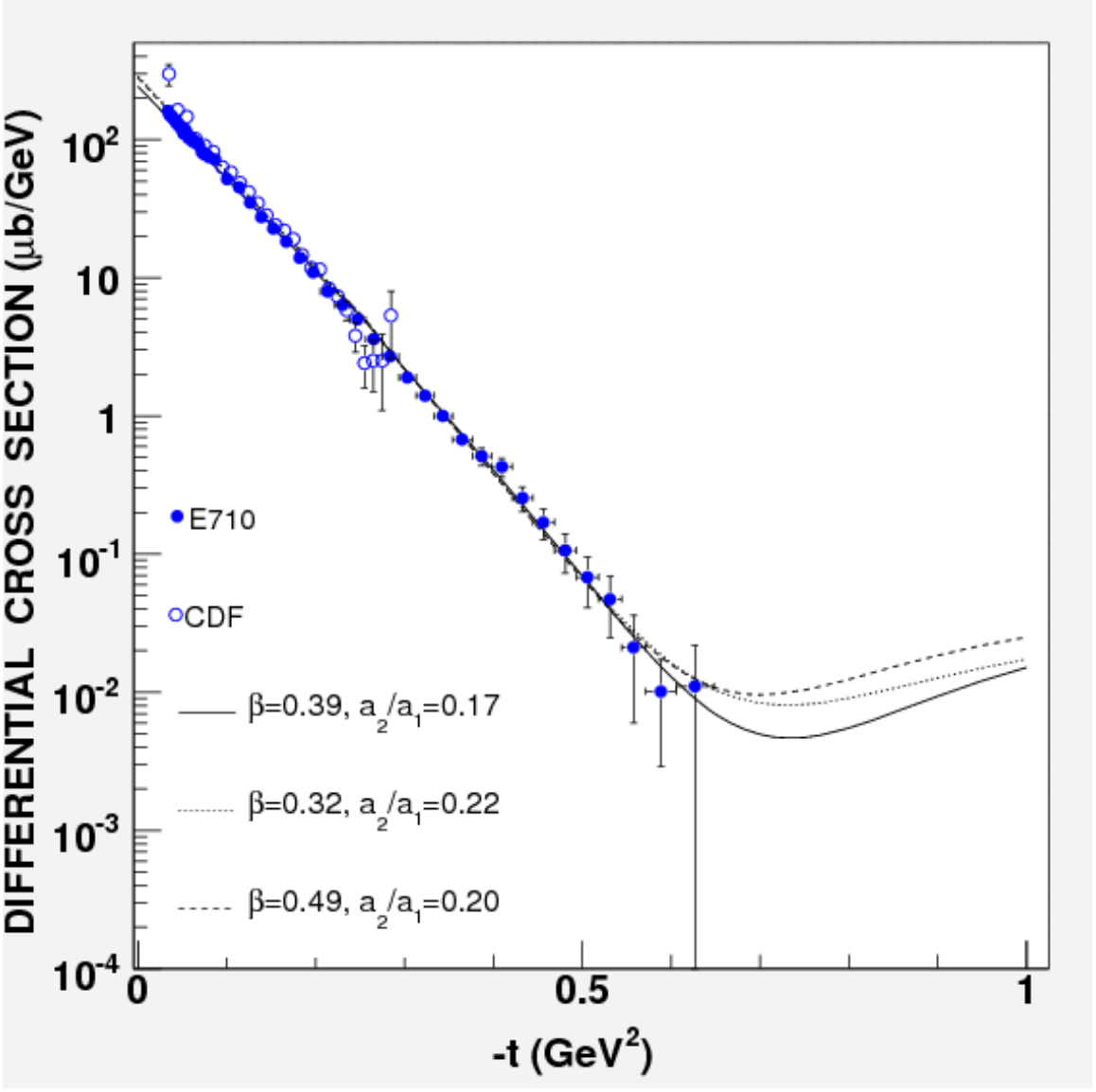


$(a_2/a_1-\beta)$ plot of minimum χ^2



$<r^2>\sim 1-\beta+\beta a_2^2/a_1^2$

Elastic cross section at $\sqrt{s}=1.8$TeV

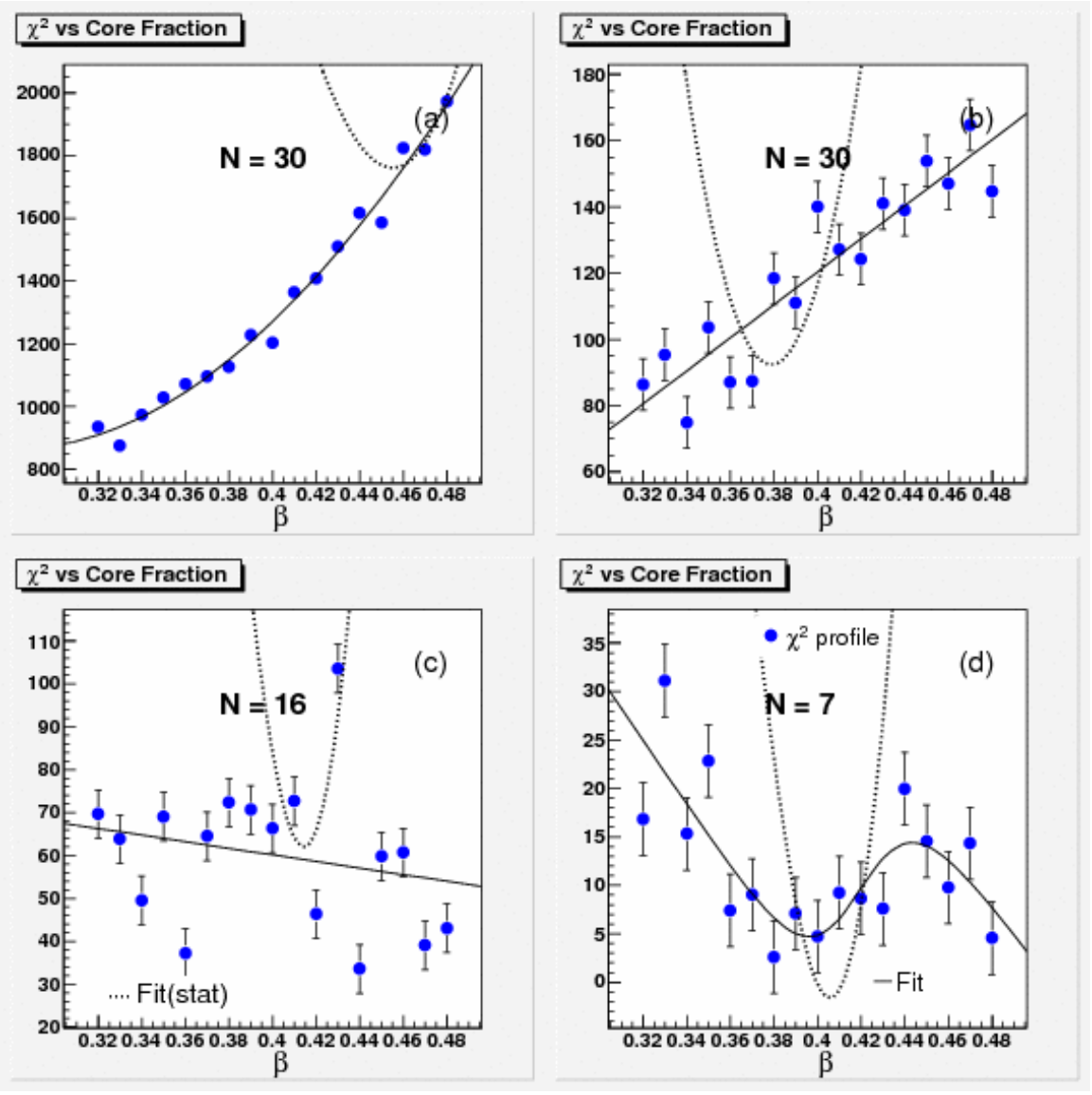


Conclusions

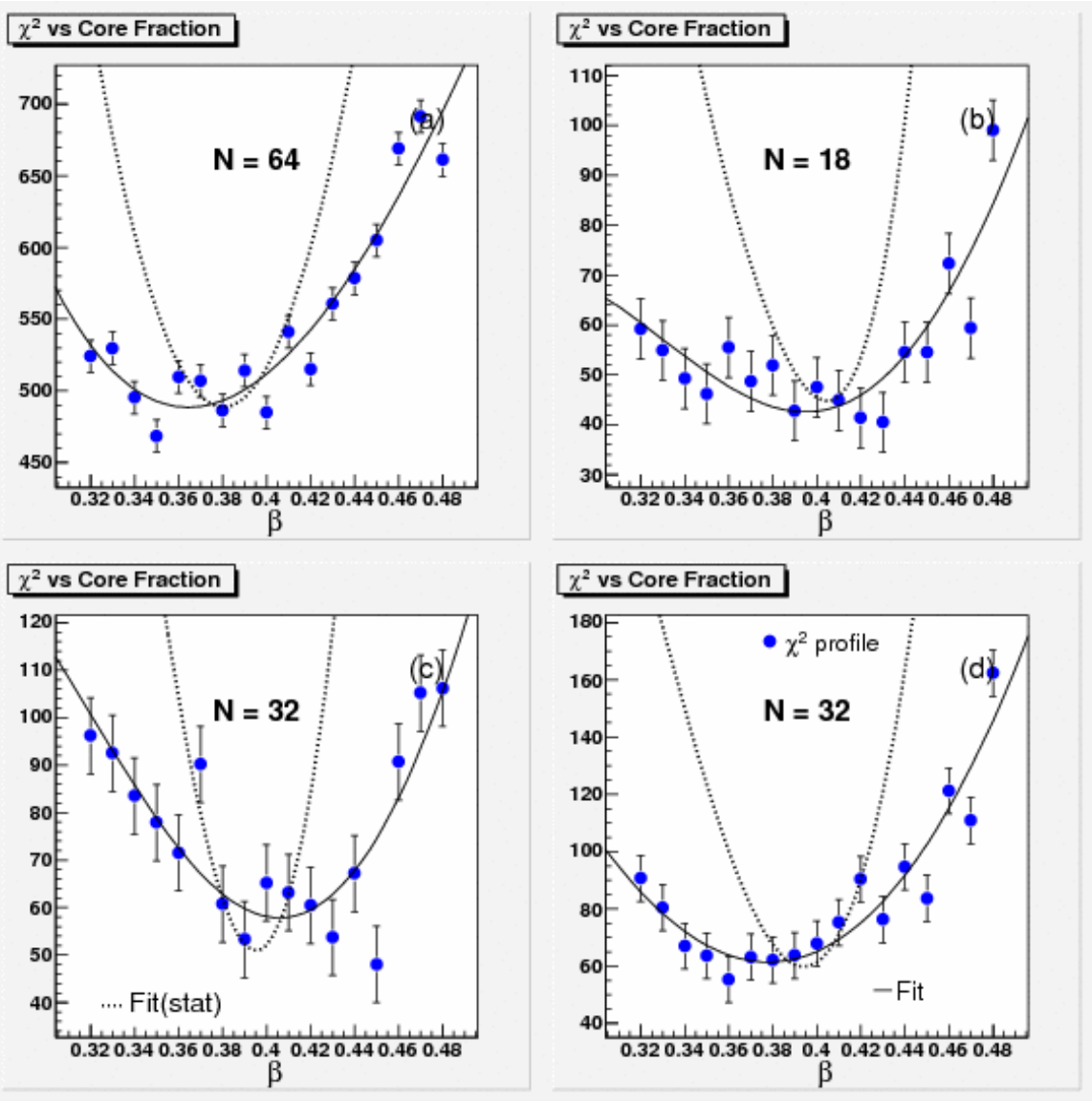
- New data were obtained on the multiple jet production at low p_T
- Data agree with PYTHIA, with ALPGEN for 1, 2, 3-jet, and with NLO for 1, 2-jet at p_T>40GeV. ALPGEN overestimates ~20% 4-jet sample
- Core fraction $\beta=(0.39-0.49)\pm5\%\pm21\%$, relative size $a_2/a_1=(0.17-0.20)\pm4\%\pm14\%$

Appendix:

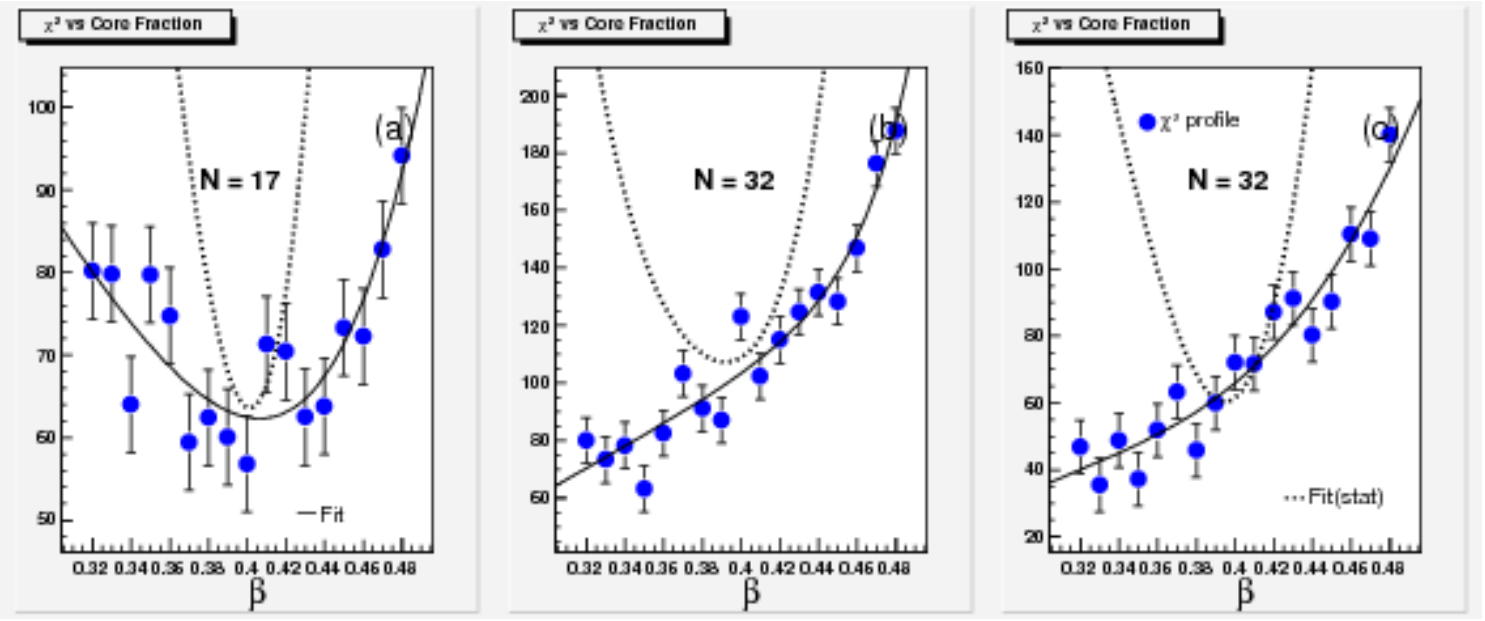
General χ^2 of p_T distributions vs β



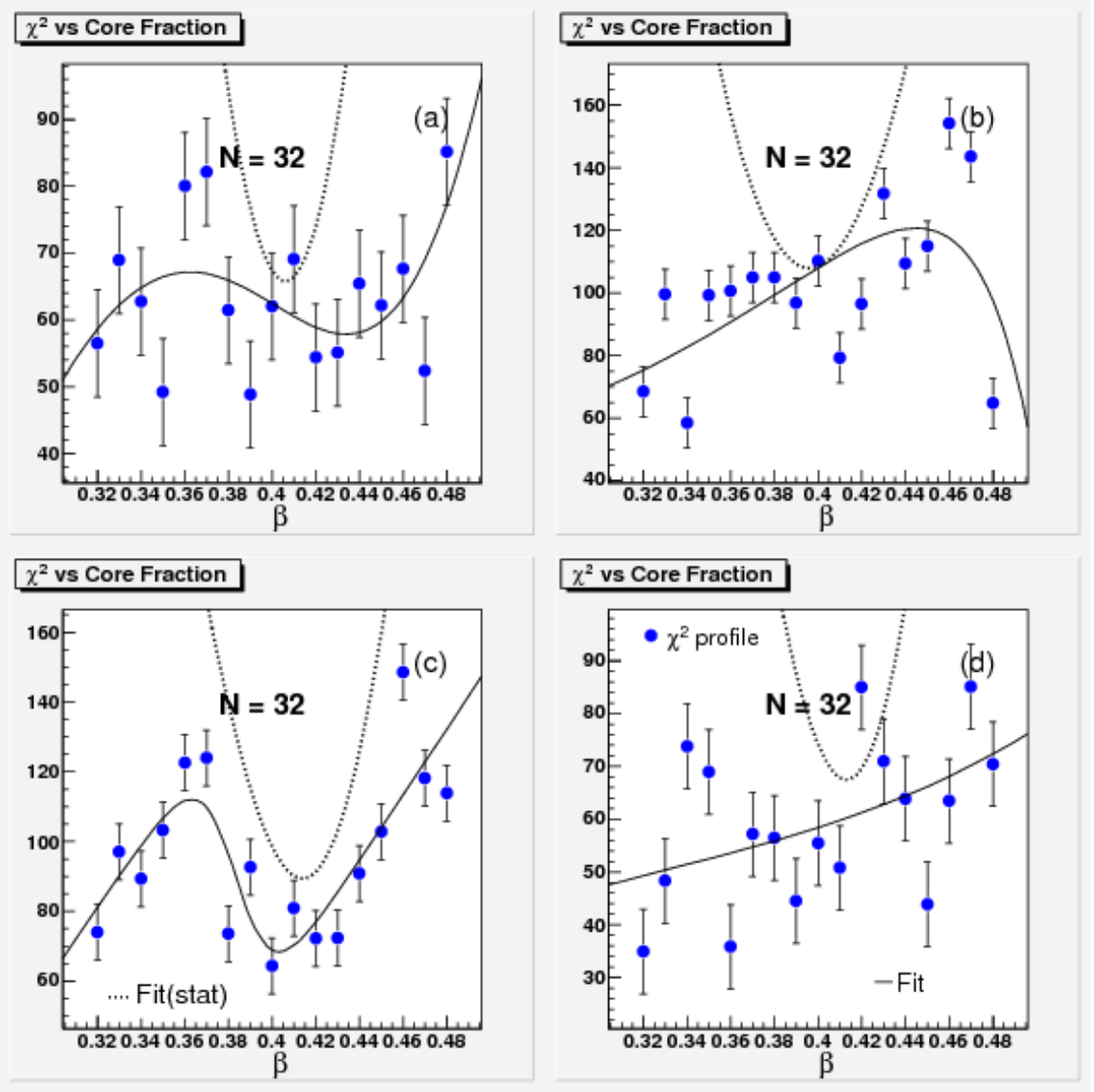
General χ^2 of 2 and 3-jet azimuthal distributions vs β



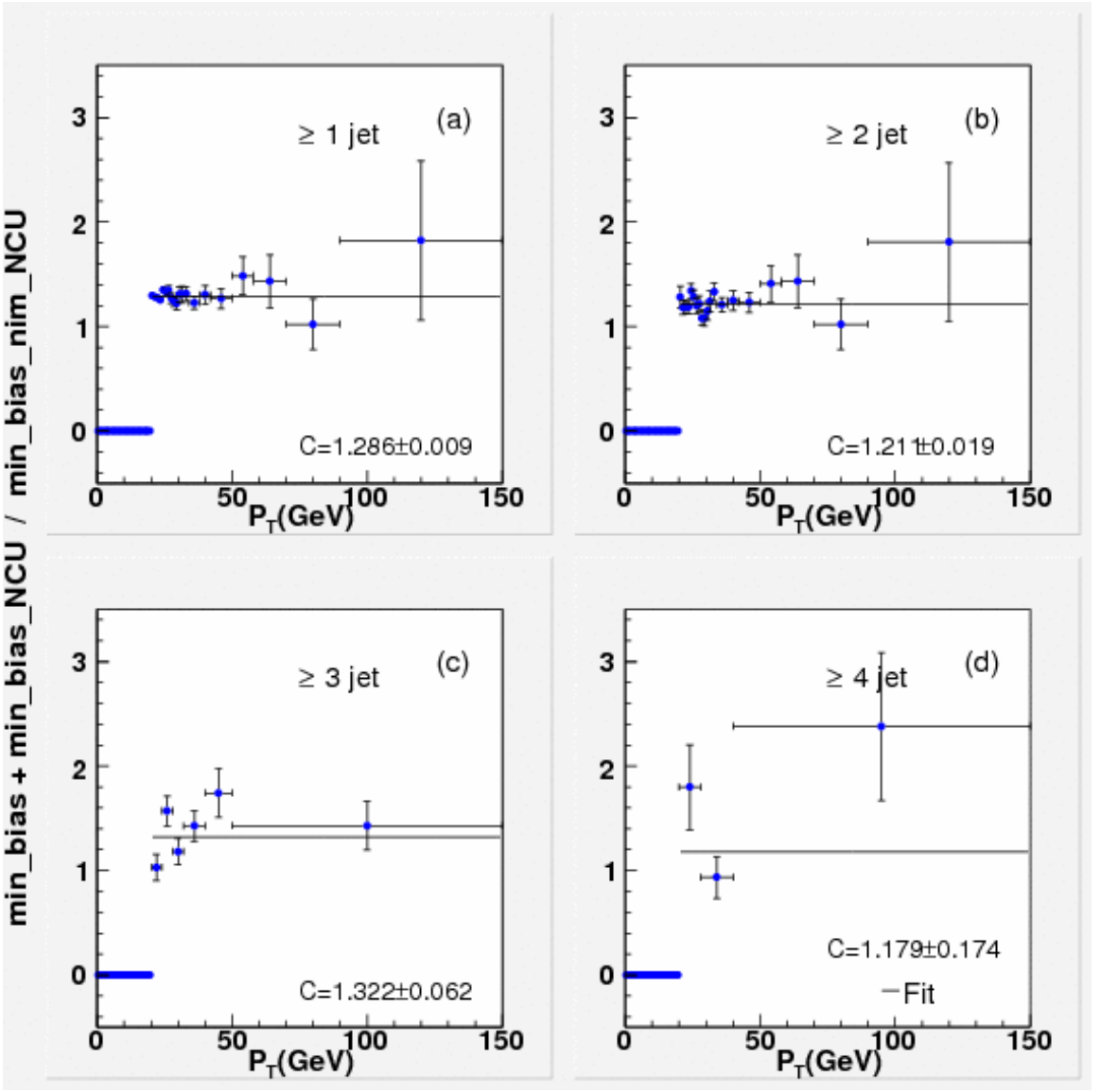
General χ^2 in 3-jet study vs β



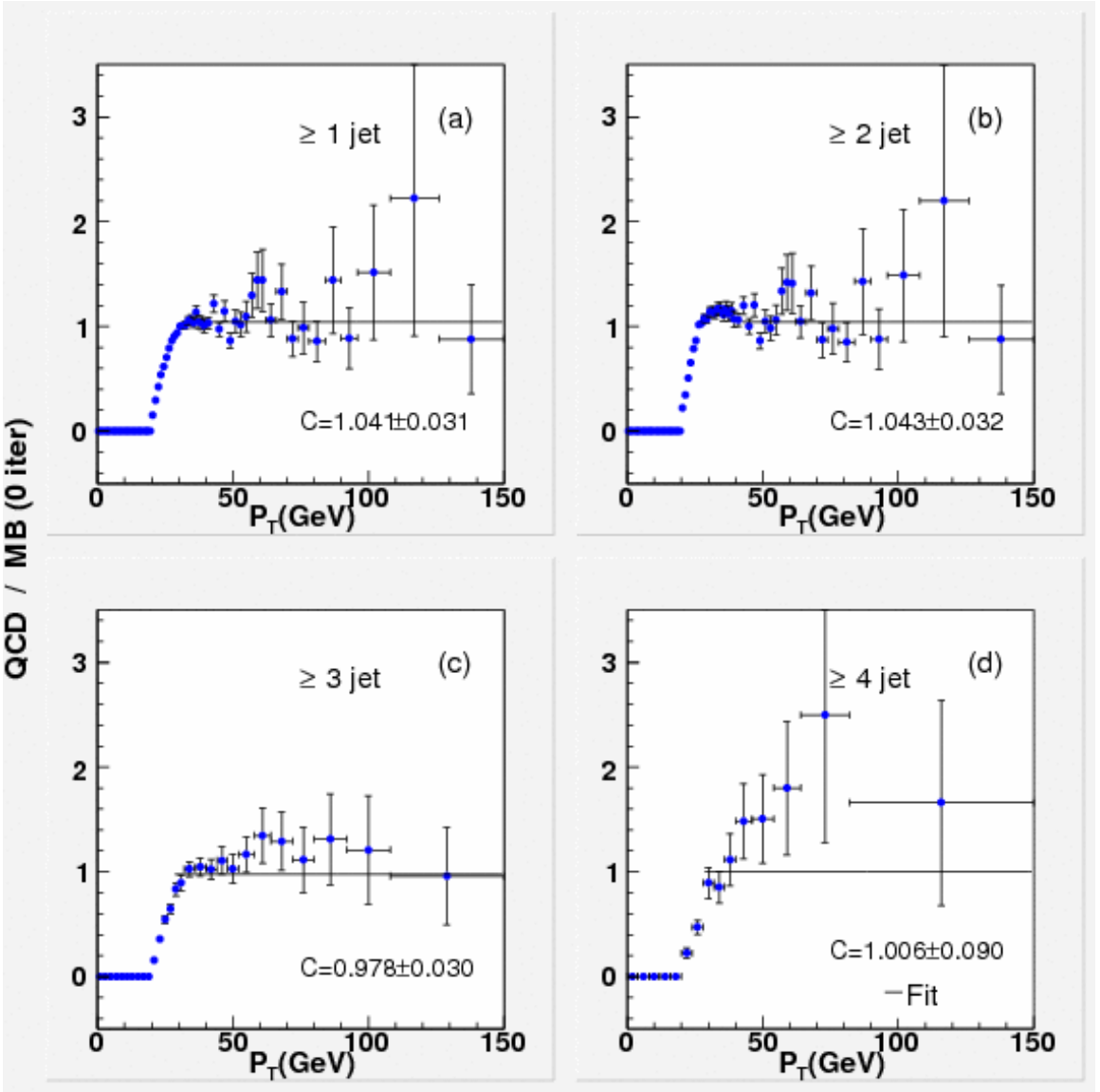
General χ^2 of 4-jet azimuthal distributions vs β



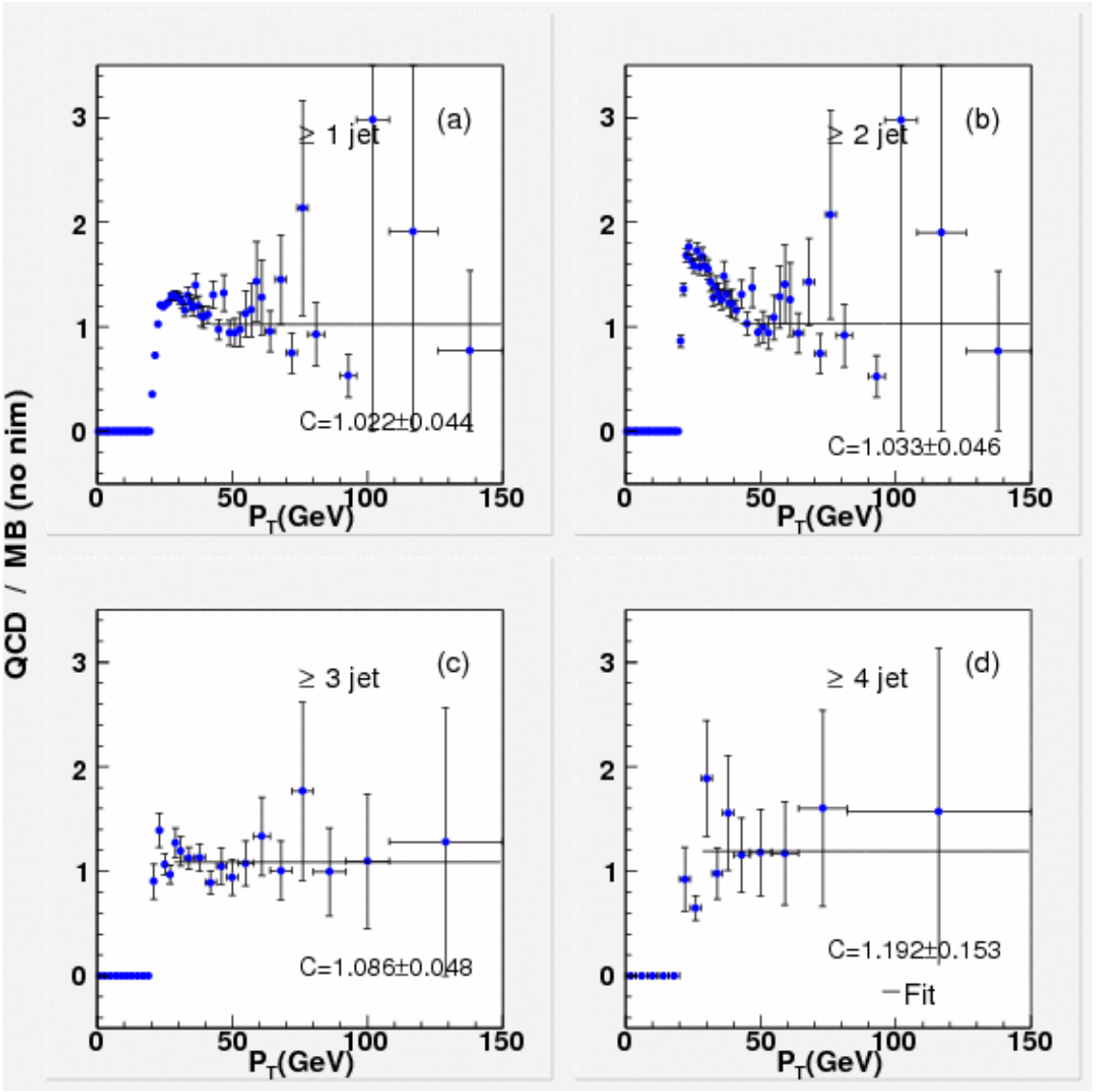
Ratio of the min_bias+min_bias_NCU and min_bias_nim_NCU



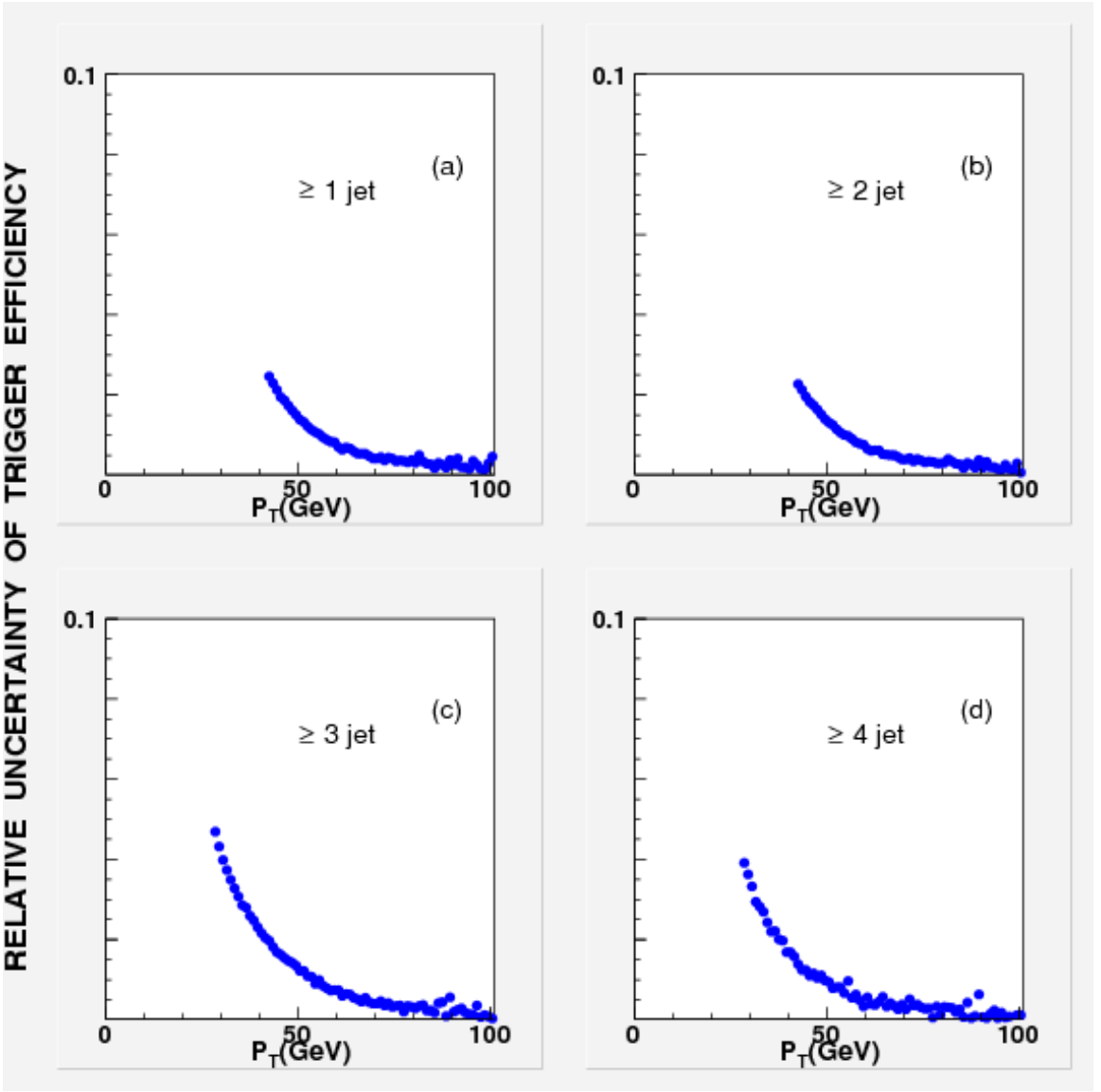
Ratio of the QCD and MB cross sections (systematics Up)



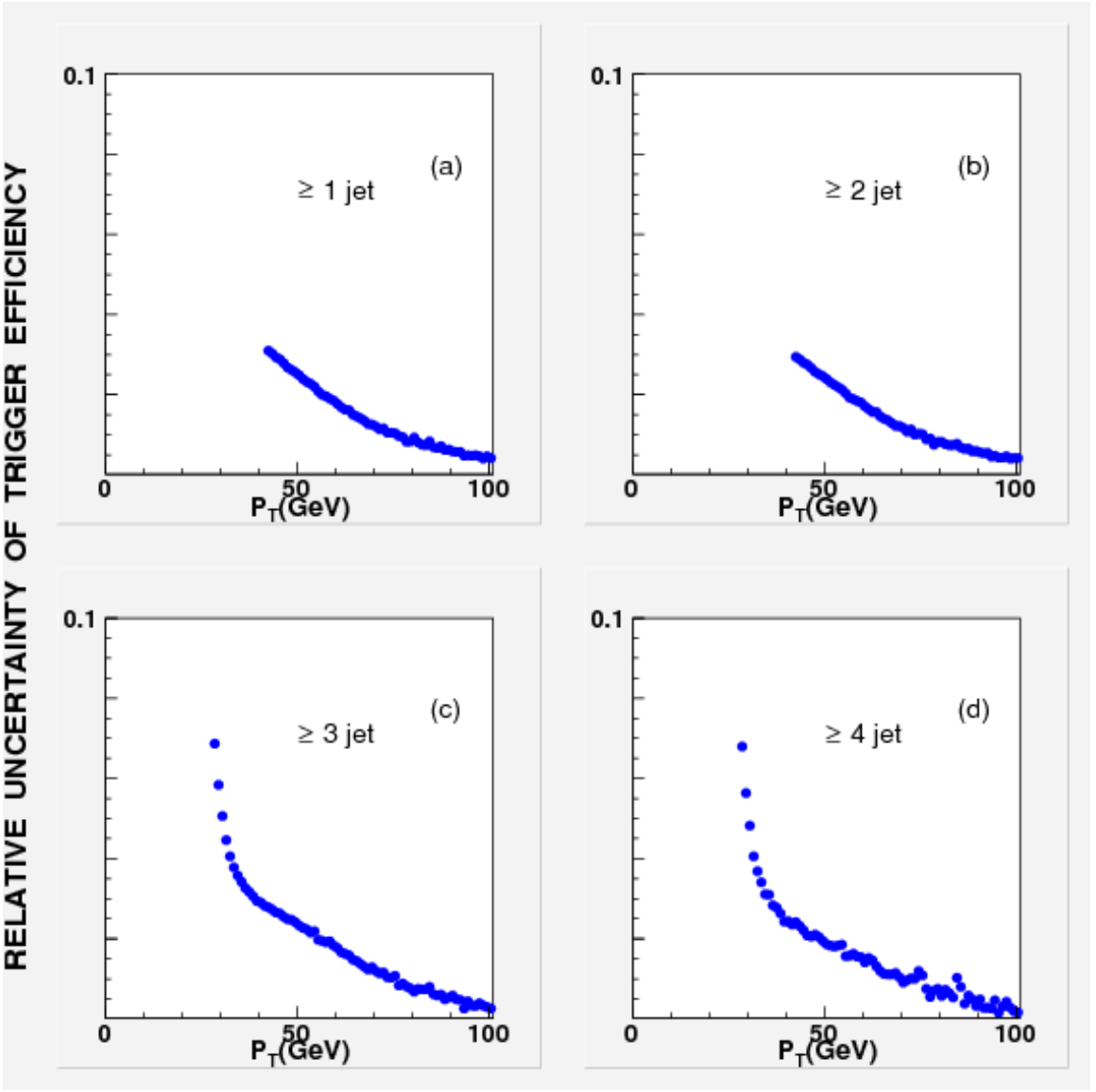
Ratio of the QCD and MB cross sections (no "nim")



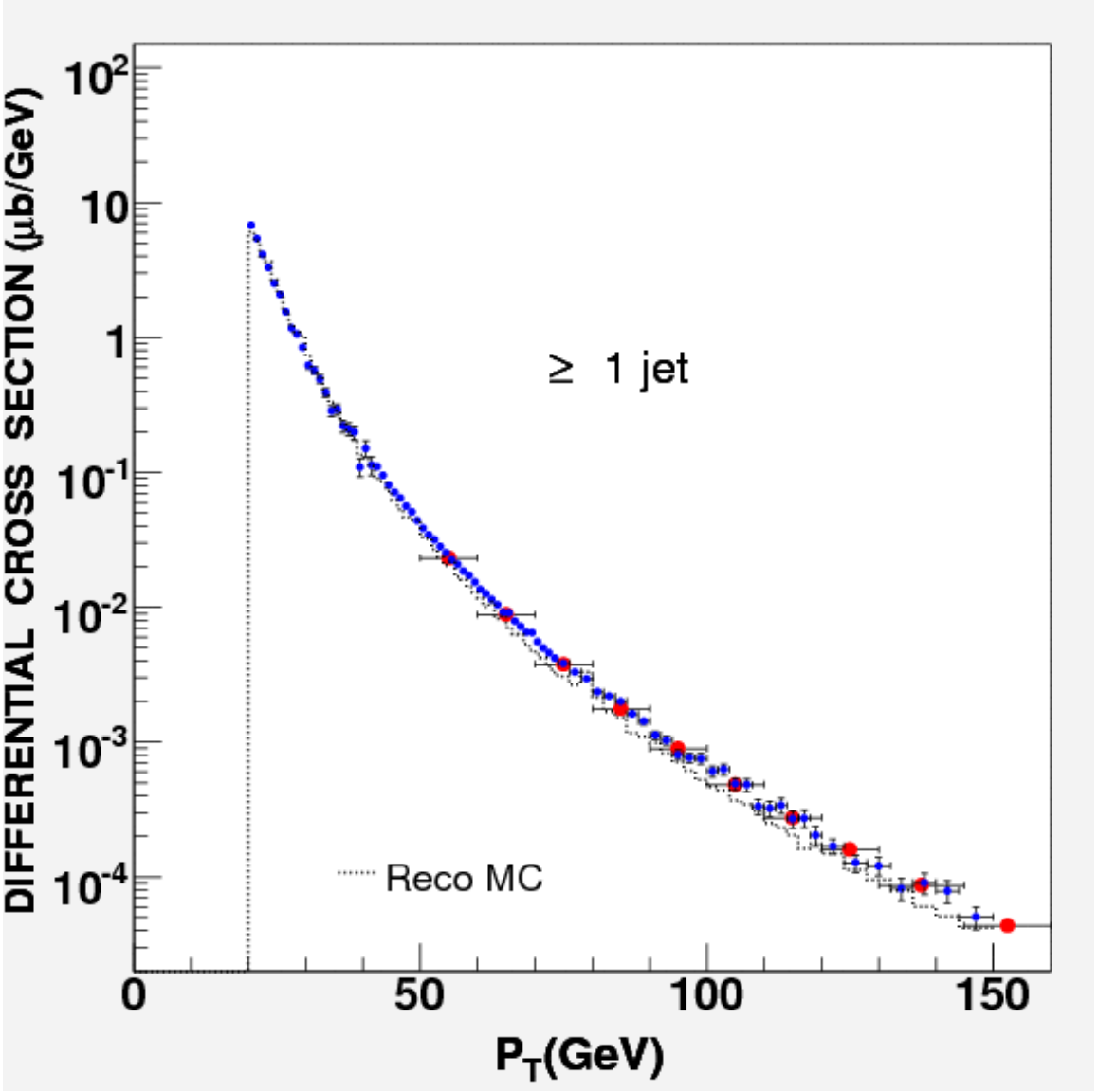
Systematic uncertainty in the JT_8TT trigger efficiency



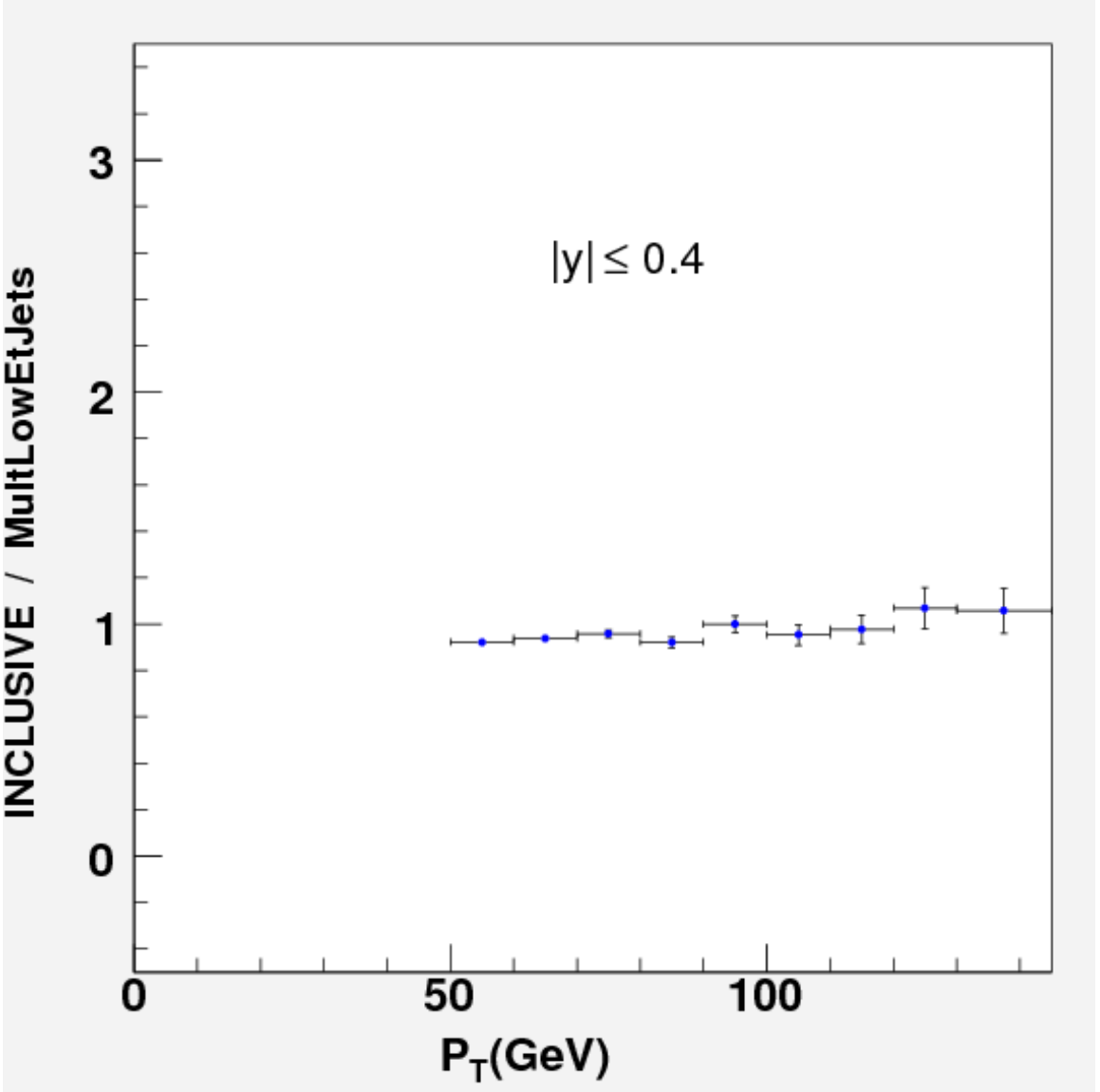
Systematic uncertainty in the JT_15TT trigger efficiency



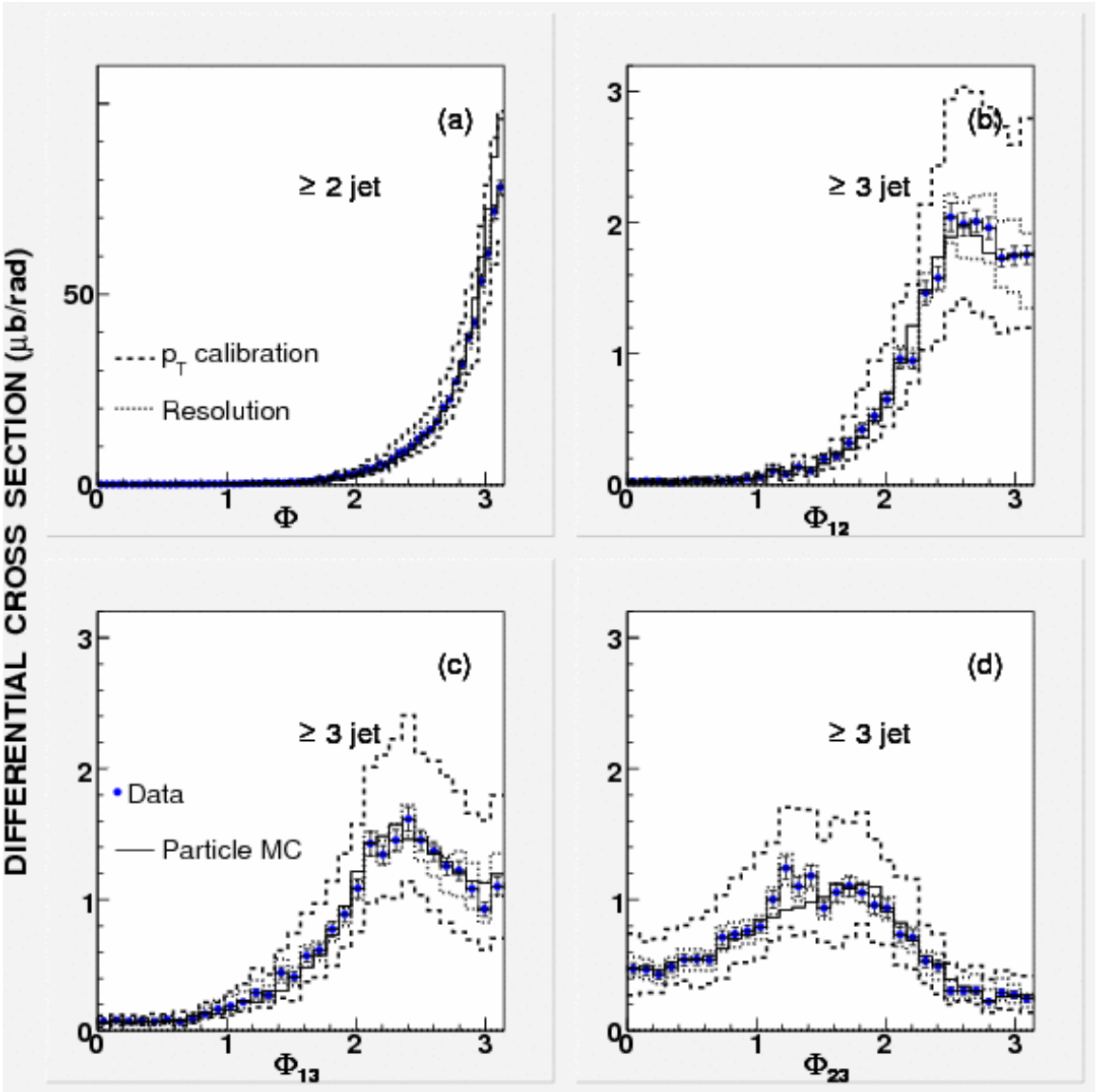
Unfolded inclusive jet cross section and reco MC jets



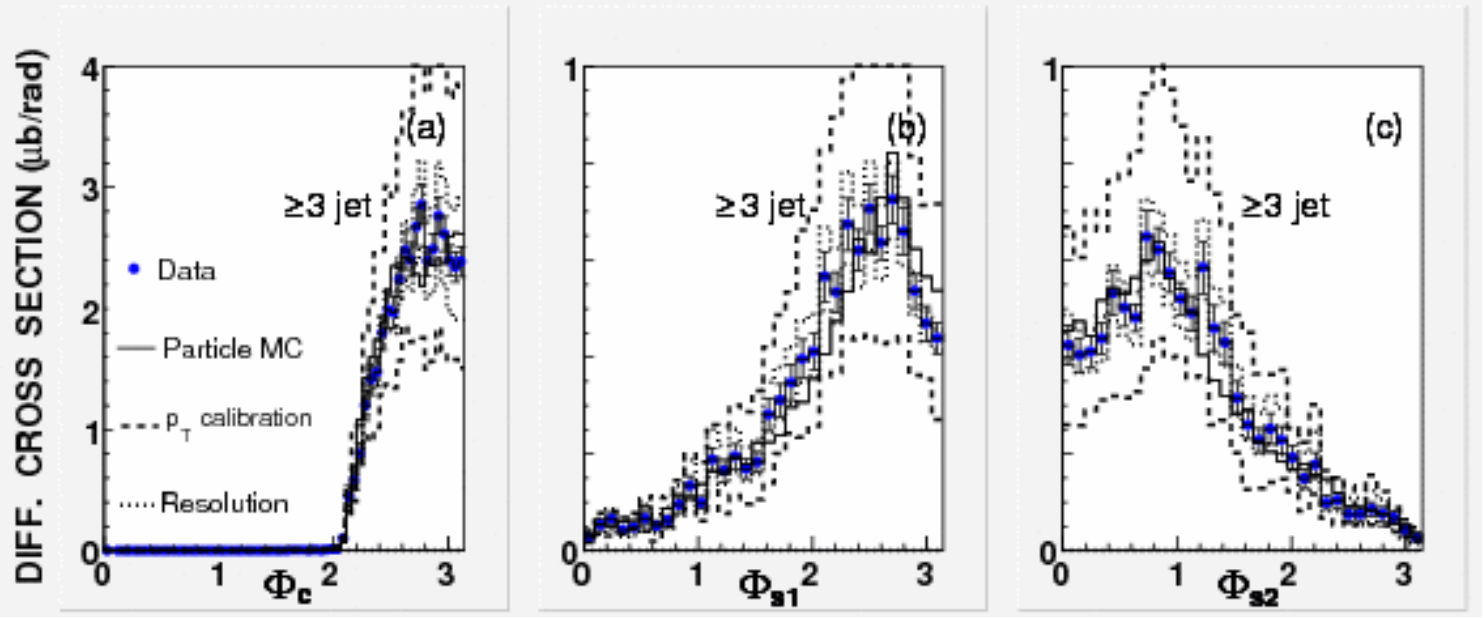
Ratio of unfolded inclusive jet and multiple jet cross section



Main systematic uncertainties



Main systematic uncertainties



Main systematic uncertainties