# Tuning with Tevatron data for LHC

**25.05.09**

**MC-Meeting**


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**Albert-Ludwigs Universität Freiburg**


PHYSICS AT THE TERA SCALE

**Helmholtz Alliance**

- **Introduction**
- **Tuning Parameters – a Case Study**
- **Effects at LHC energies**

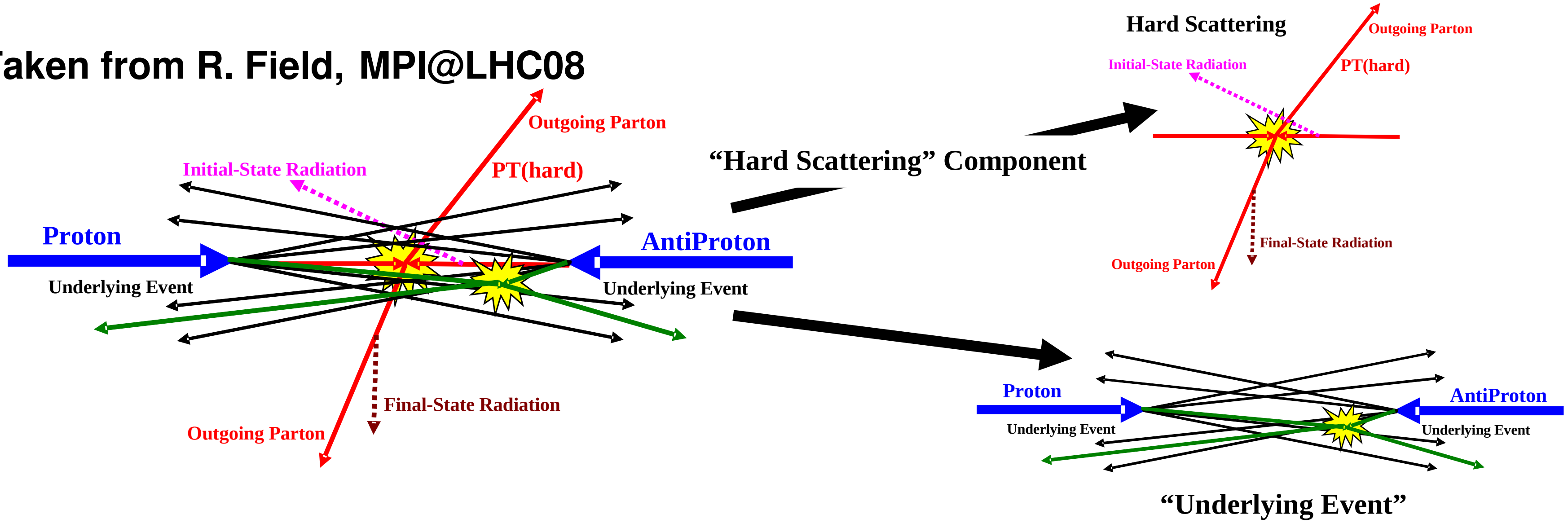
Bookmark

Vorhersage für die Region Freiburg

| Text | Mo, 25.05. | Di, 26.05. | Mi, 27.05. |
|---|---|---|---|
| Tiefst-Temperatur | 14°C | 15°C | 11°C |
| Höchst-Temperatur | 34°C | 24°C | 21°C |
| Vormittag | | | |
| Nachmittag | | | |
| Abend | | | |

# The Underlying Event

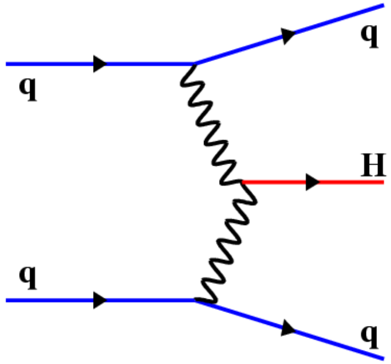
**Taken from R. Field, MPI@LHC08**




- **Can't go into all the detail, but basically:**
  **The underlying event in a hadron-hadron-collision is everything except the hard scattering!**
- **Includes multi-parton-interactions, beam remnants,...**
- **This talk: Only Pythia 6.420, compared different tunes...**

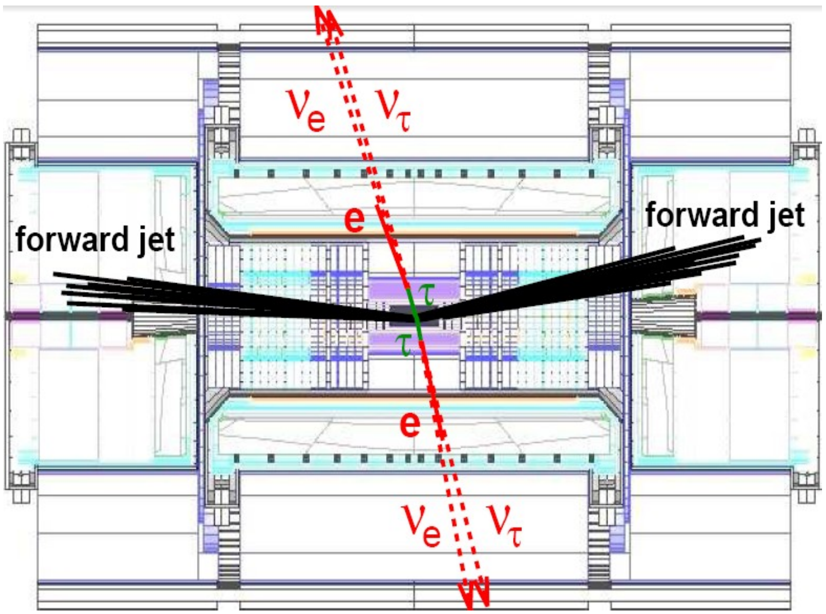
# Why do we need to know it?

- The UE will have a large influence on a lot of physics at the LHC
- One example: Higgs-Boson production via Vector-Boson-Fusion:




- production via fusion of two electroweak gauge bosons
- Very important channel for low $m_H$

- Signature:
  - 2 forward jets
  - Higgs boson decay products in central region
  - color flow: no hadronic activity in central region
  - can be used to reduce backgrounds

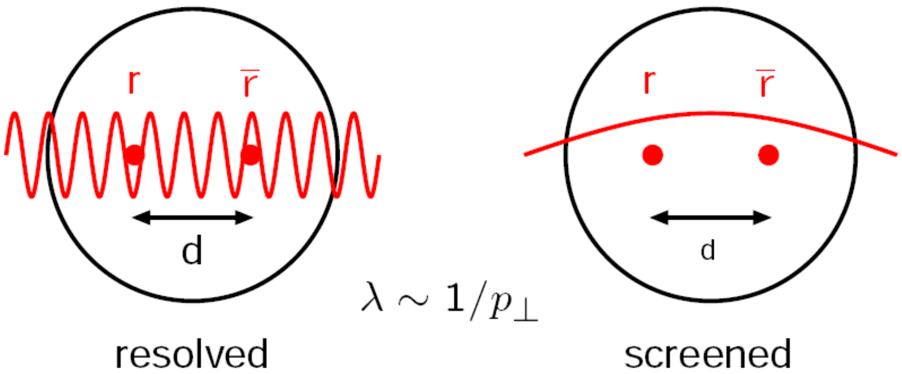



- might be spoiled by Underlying Event!

# Most important Parameters

- **Only Pythia 6.420 in the following (new shower/MPI)**

- **Most important is the regularization parameter for the multi-parton-scatterings (also called screening parameter)**




- **Is fixed at a certain energy (e.g. 1800 GeV) and extrapolated to other CM-energies**

$$p_{T,min}(E) = p_{T,min}(E_{ref}) \cdot \left(\frac{E}{E_{ref}}\right)^{\alpha}$$

**PARP(82)**

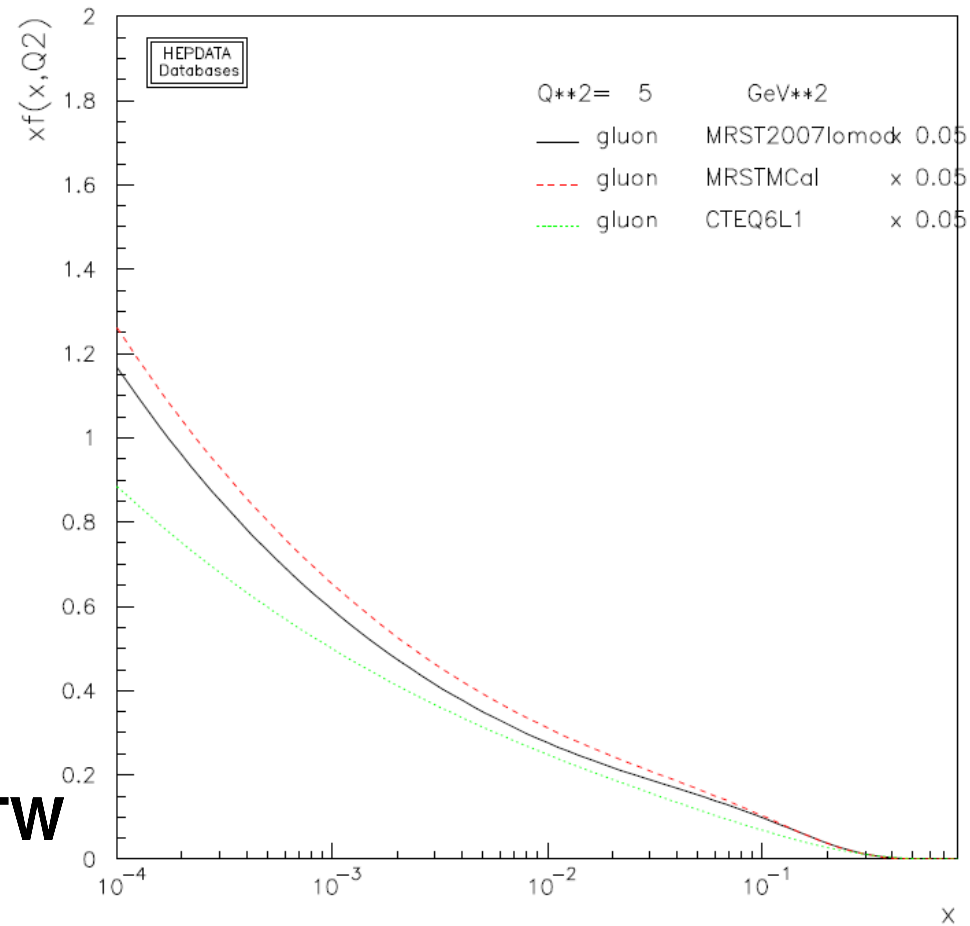
**PARP(90) default: 0.16!**

# A case study

- Did a case study of what can happen to an UE tune

  Started from tune to CTEQ6L1 presented by Arthur Moraes at the MPI@LHC workshop in Perugia

- What happens if one switches the PDF from CTEQ6L1 to the modified LO (or LO*) from MSTW




- Expect larger UE activity, since gluon at small x is enhanced

# Base Tune

PYTHIA6.416 - PYEVNT

CTEQ6ll (LO fit with LO $\alpha_s$) → LHAPDF (set number 10042)

| | Default: | | Tuned: | |
|---|---|---|---|---|
| | MSTP(81)=21 | → | new multiple interaction model & new parton shower selected! | |
| MPI | MSTP(82)=4 | | | |
| ISR | MSTP(84)=1 | → | allowed ISR and FSR after first (hardest) interaction | |
| FSR | MSTP(85)=1 | | | |
| MPI | MSTP(86)=2 | | | |
| colour reconnection | MSTP(87)=4 | | | |
| | MSTP(88)=1 | | | |
| | MSTP(89)=1 | | | |
| | MSTP(90)=0 | | | |
| | MSTP(95)=1 | → | MSTP(95)=2 | minimize the total string length |
| | PARP(78)=0.025 | → | PARP(78)=0.3 | regulates the number of attempted colour reconnections (choose shorter strings) |
| $p_{T0}$ scale | PARP(82)=2.0 | → | PARP(82)=2.1 | |
| matter distribution | PARP(83)=0.5 | → | PARP(83)=0.8 | |
| | PARP(84)=0.4 | → | PARP(84)=0.7 | |
| $p_{T0}$ scale | PARP(89)=1800 | | | |
| | PARP(90)=0.16 | | | |

**Presented by A. Moraes at the MPI@LHC08 workshop in Perugia**

A. Moraes MPI@LHC'08 Workshop Perugia, 28th October 2008

# Tunes for Comparison

- **A. Moraes:**
  - Double gaussian matter distribution,
  - decoupled ISR and MPI regularization
  - PARP(82)=2.1 GeV, PARP(90)=0.16

- **Perugia*:** Tune by P. Skands to mod LO pdf
  - matter distribution: exp($-r^{1.7}$)
  - ISR and MPI regularization scale identical
  - PARP(82)=2.1 GeV, PARP(90)=0.23

- **S0Pro:** Tune by P. Skands to CTEQ5L
  - matter distribution: exp($-r^{1.6}$)
  - ISR and MPI regularization scale identical
  - PARP(82)=1.8 GeV, PARP(90)=0.16

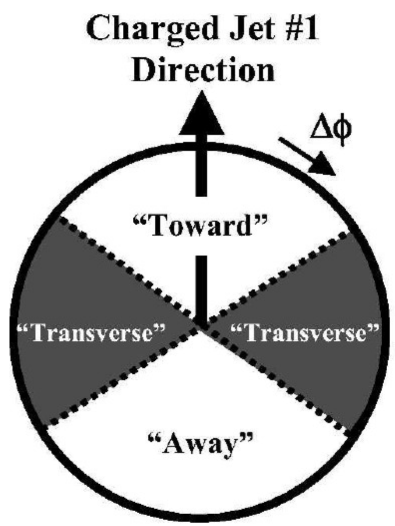
Also some other differences in the shower parameters, don't want to go into too much detail.

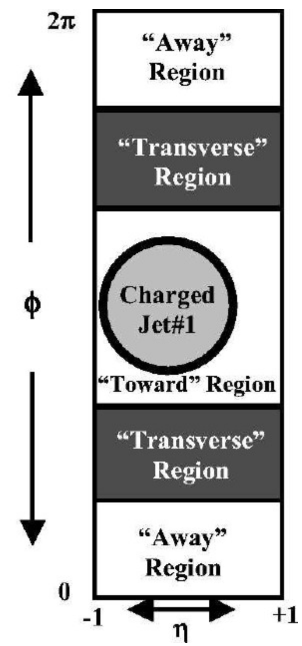
# Some Remarks about tuning

- This talk: Manual tuning “by eye”
- Automatic tools to fit all parameters simultanously to the data also available (e.g. PROFESSOR, Proffit)
- However: Tuning to first LHC data will need to be done manually, since detector understanding limited
- Need step-by-step human interpretation
- Not aiming at very high precision, rather have a quick, robust procedure that is sensible
- Technically: Used Rivet (see discussion days in January)
- Next: Which analyses are there to tune to?

# Leading Jet Analyses

- Select QCD events (mainly dijets)
- Divide into regions
  "toward", "transverse"
  and "away" from leading jet

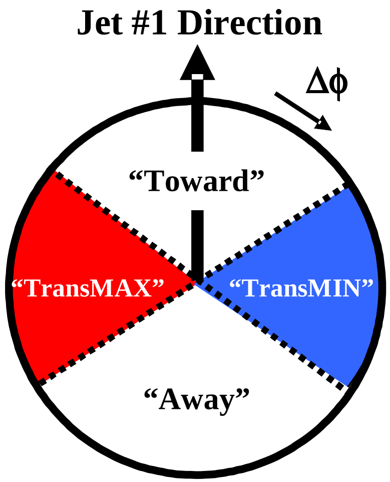



- Run I: Phys. Rev. D65, 092002 (2002), 1.8 TeV

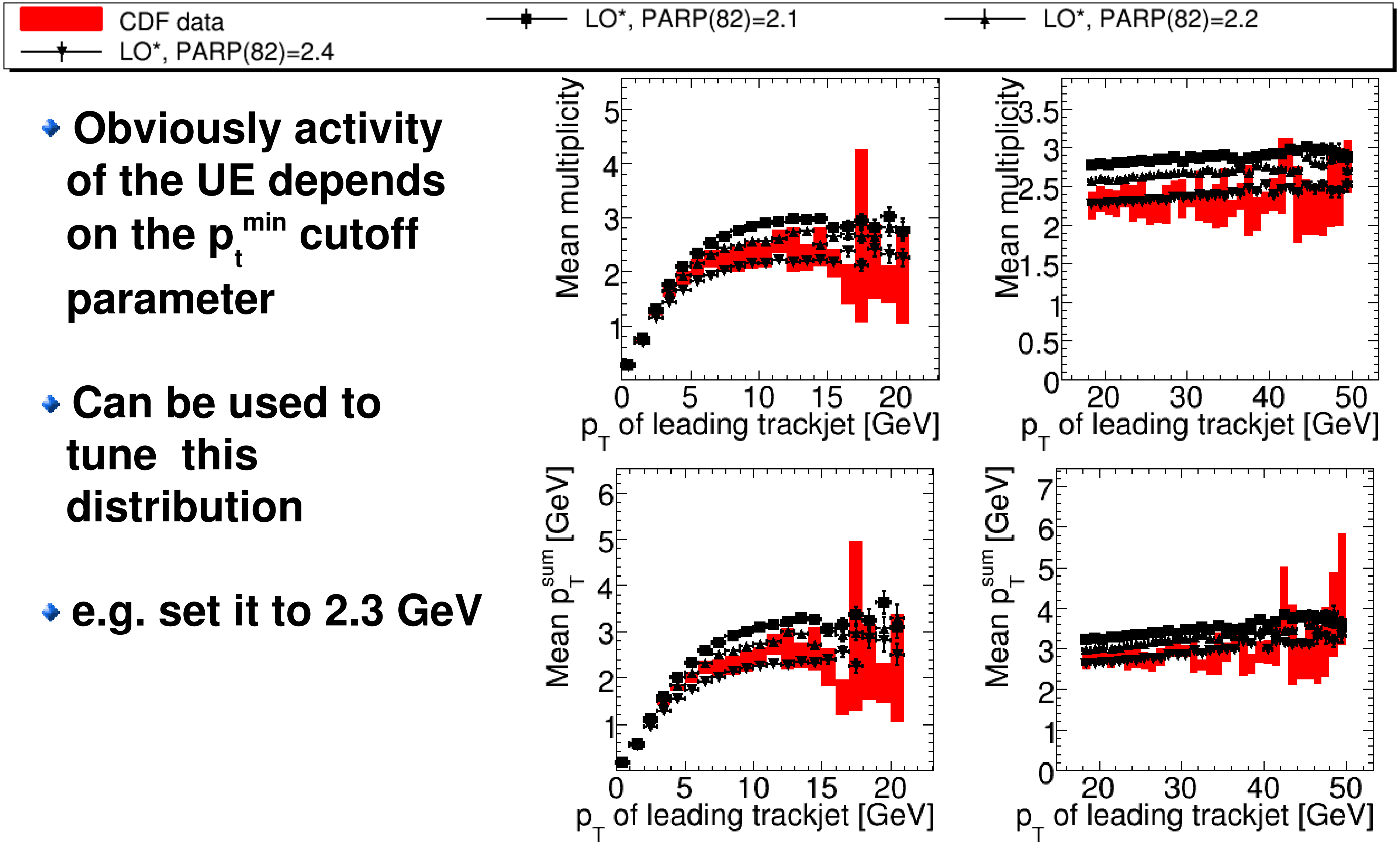
- Preliminary Run II result at 1.96 TeV devides transverse region in subregions with larger (MAX) and smaller (MIN) activity

- "TransMIN": Very sensitive to BBR




Also measured in Drell-Yan (see talk by Deepak Kar in last meeting, not shown here)

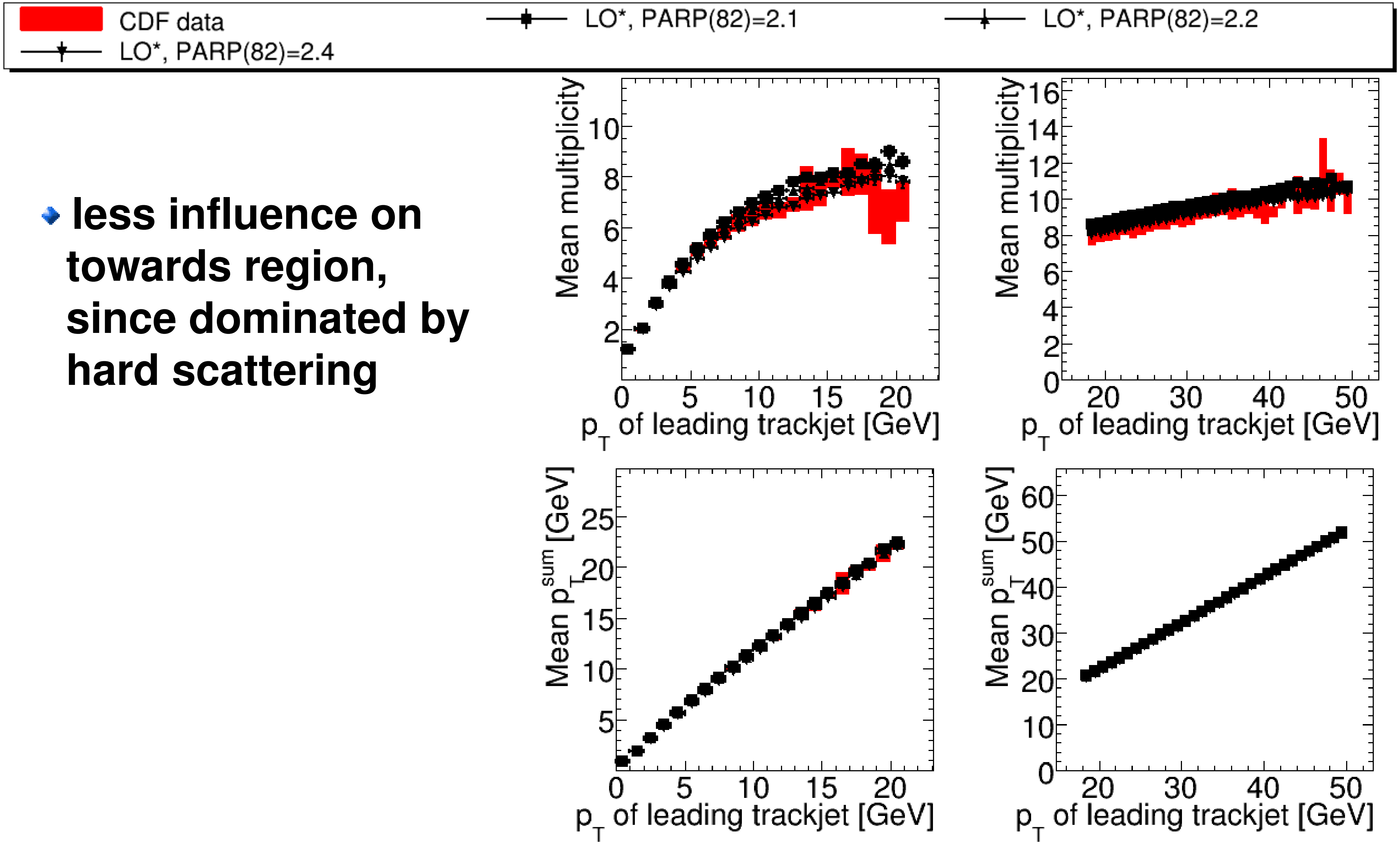
# Leading Jets Run I: transv. region




- Obviously activity of the UE depends on the $p_t^{min}$ cutoff parameter
- Can be used to tune this distribution
- e.g. set it to 2.3 GeV

# Leading Jets Run I: tow. region

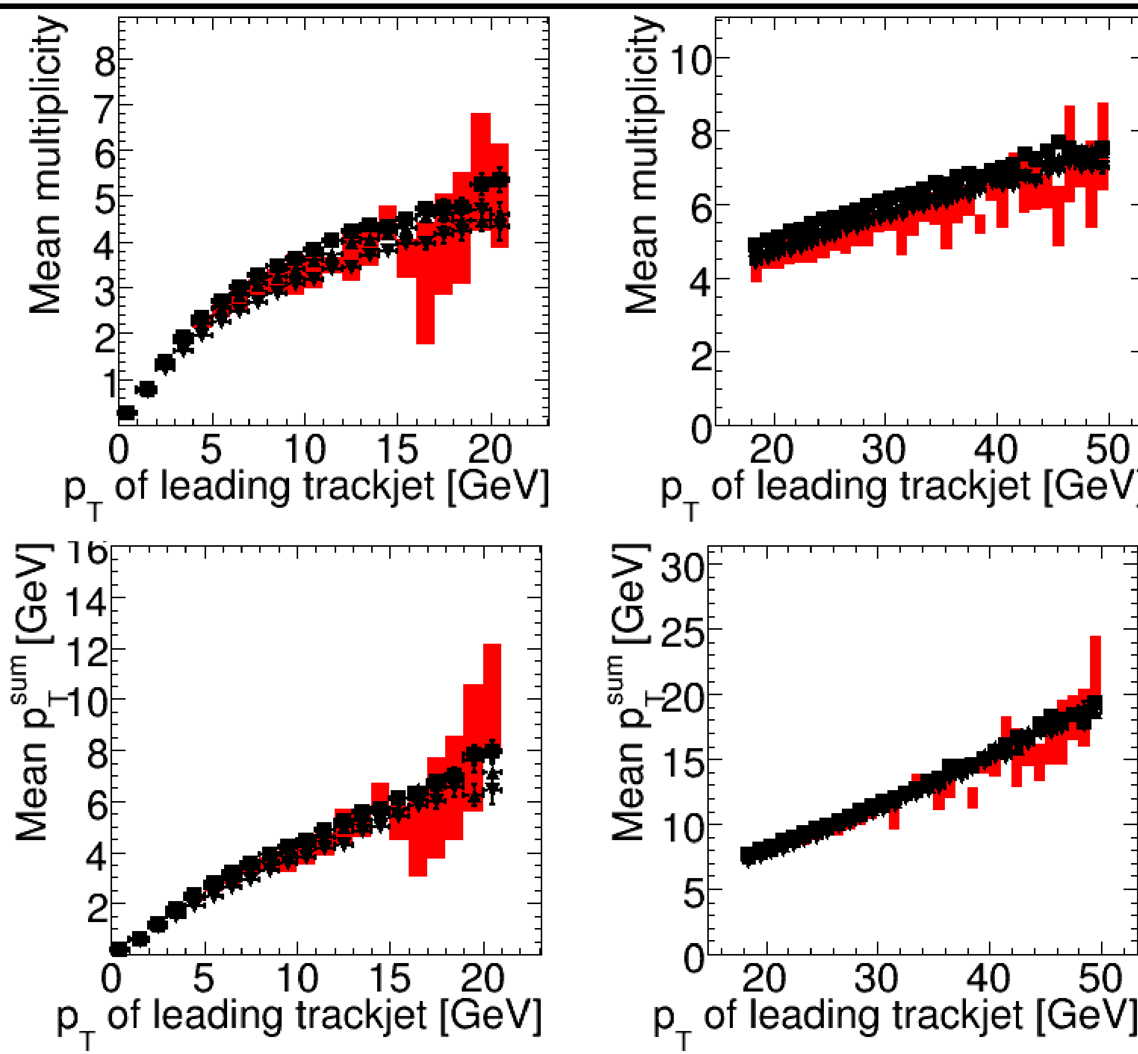
- **less influence on towards region, since dominated by hard scattering**



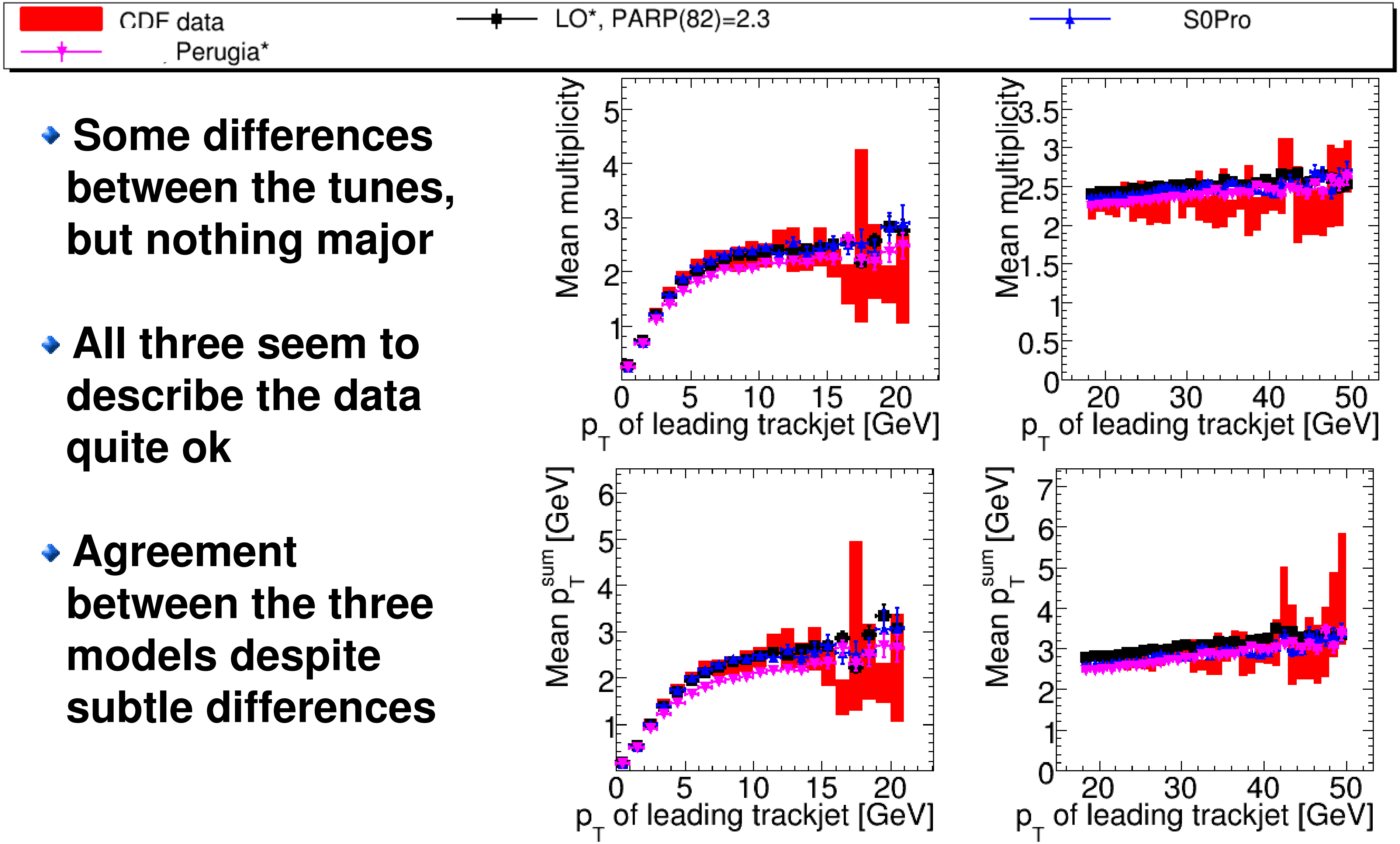
# Leading Jets Run I: away region

- **Away region in between transverse and toward region**

- **Next: compare this tuned result to S0Pro and Perugia* tunes**

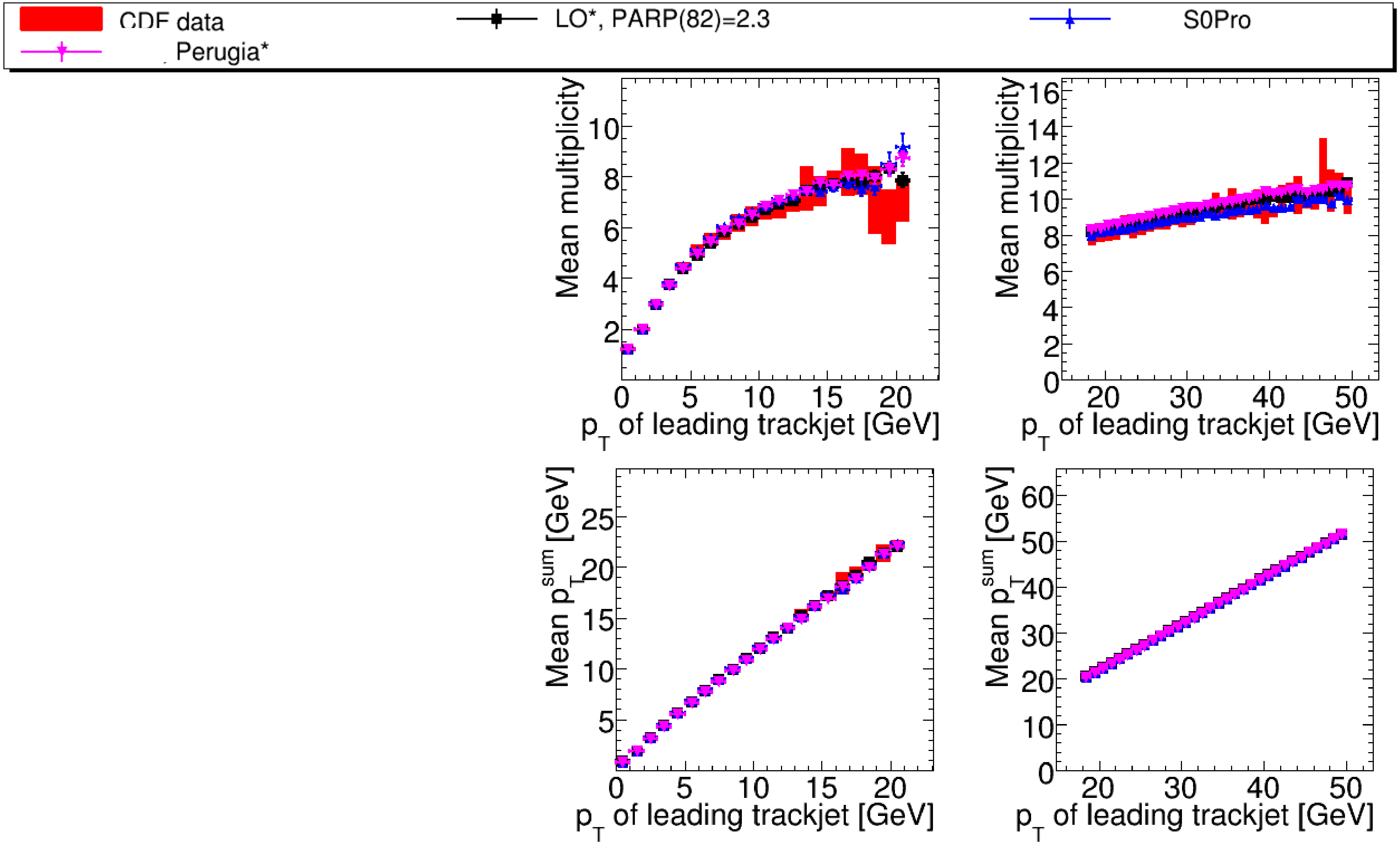


# Leading Jets Run I: transv. region

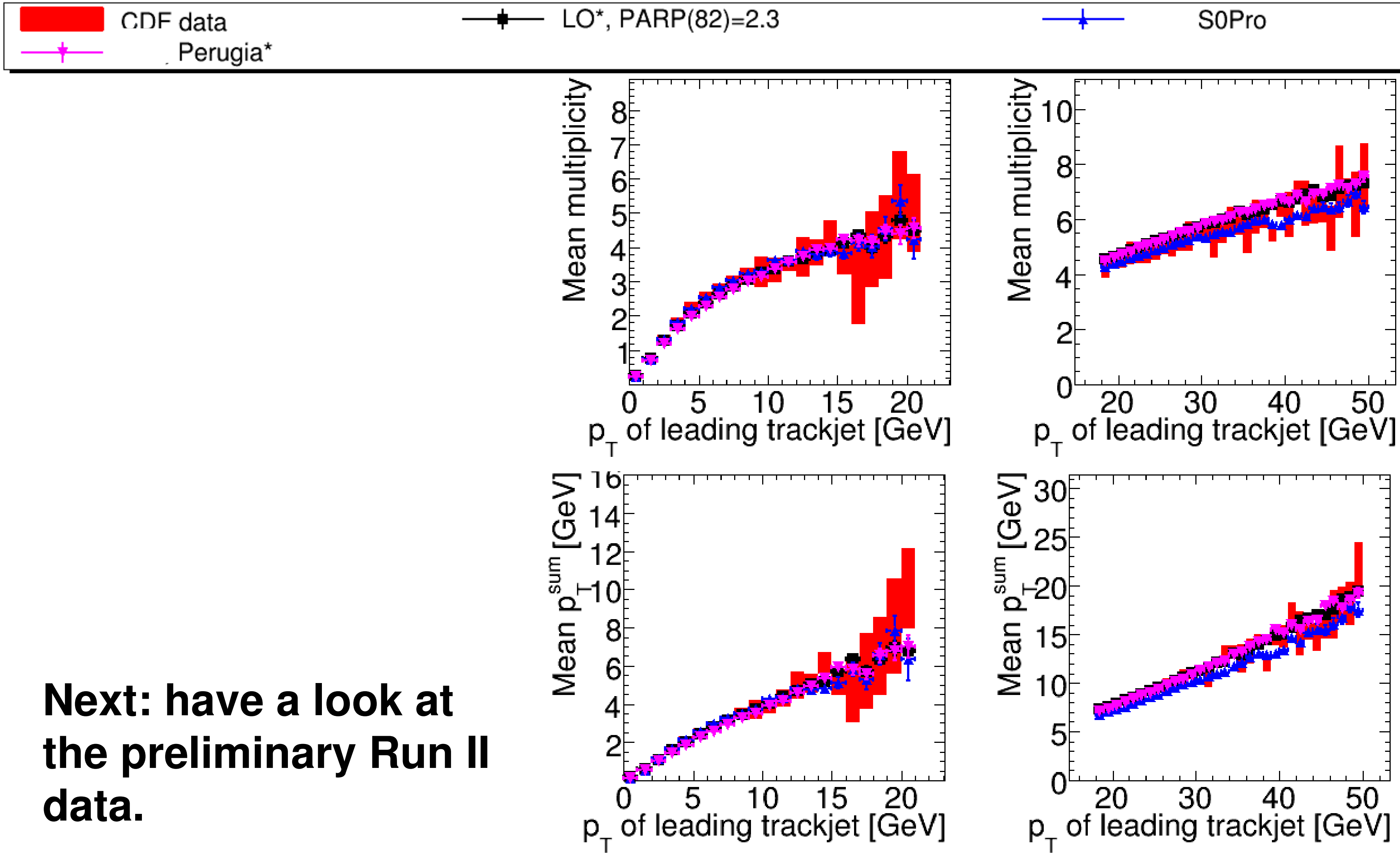



- **Some differences between the tunes, but nothing major**
- **All three seem to describe the data quite ok**
- **Agreement between the three models despite subtle differences**

# Leading Jets Run I: tow. region

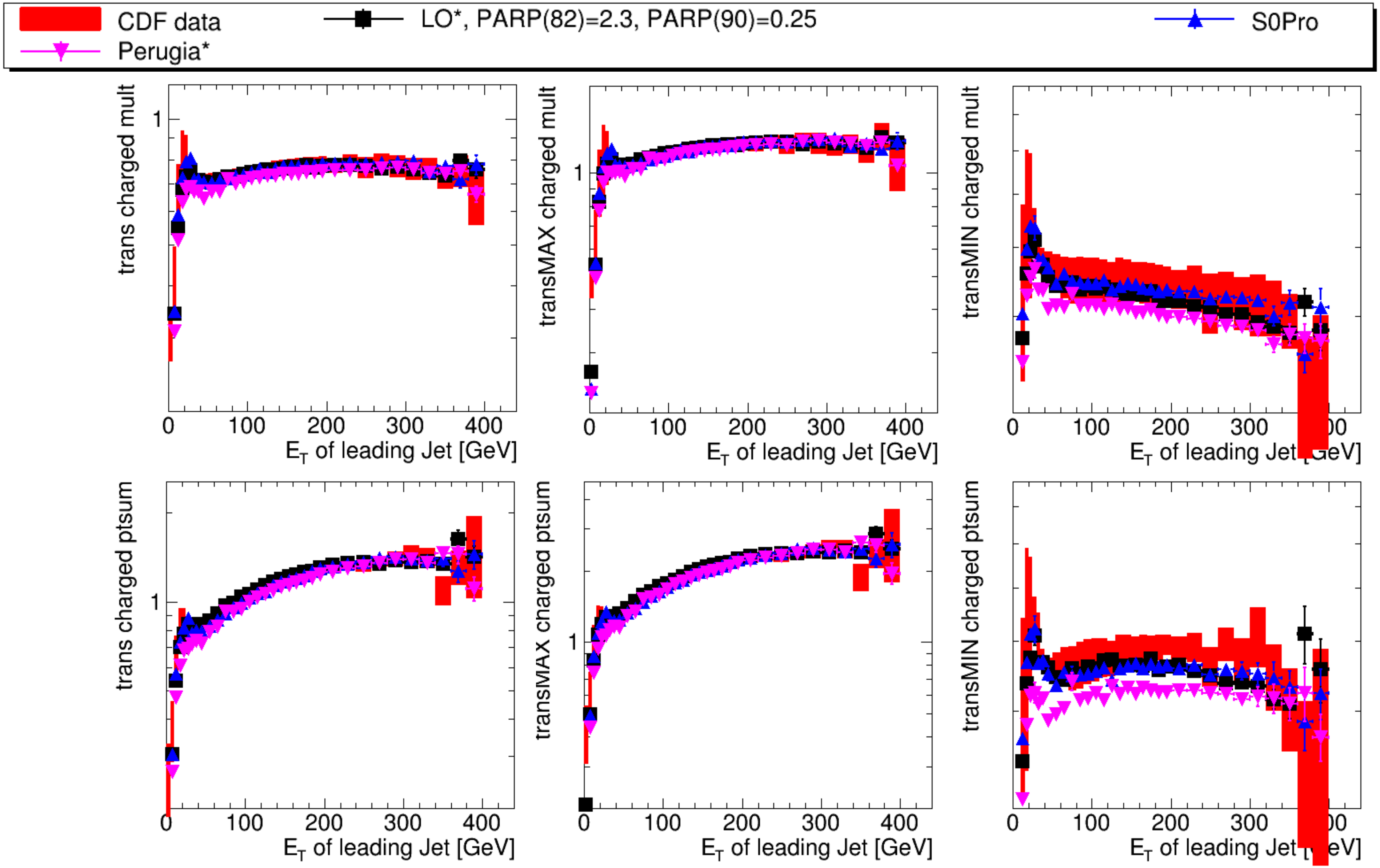


# Leading Jets Run I: away region

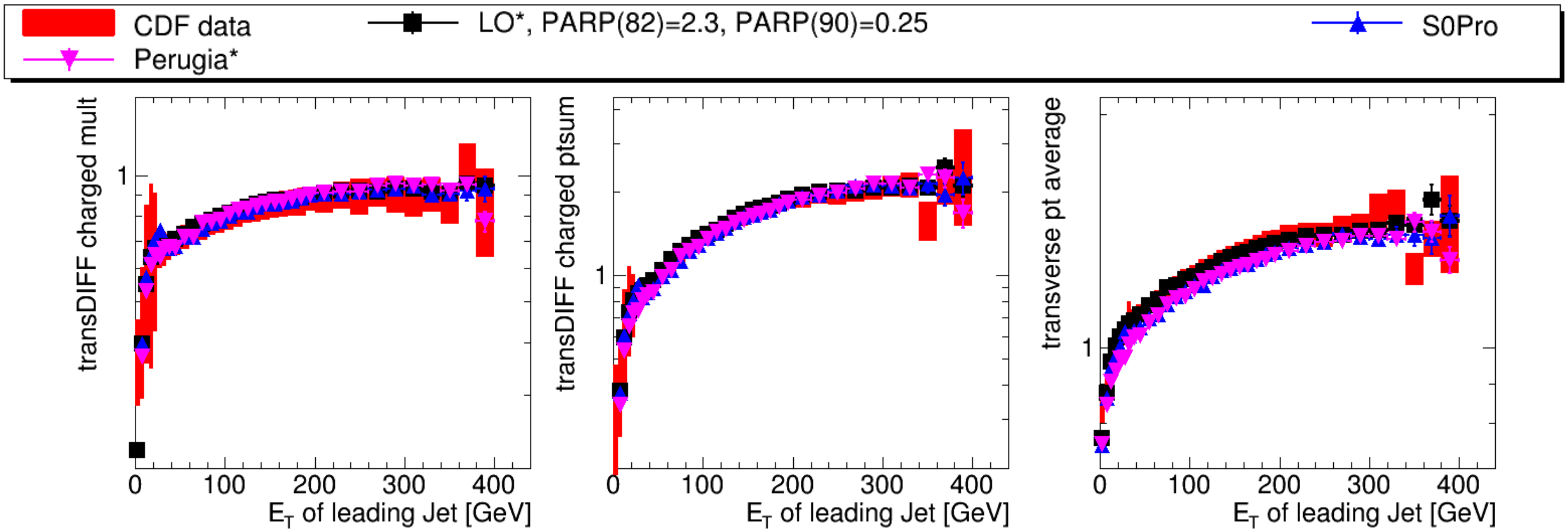



**Next: have a look at the preliminary Run II data.**

# Leading Jets Run II (prelim.)



# Leading Jets Run II (prelim.)




**Overall agreement satisfactory, all three tunes seem to have problems to describe the TransMIN region**
**BUT: 1.96 TeV ≈ 1.8 TeV, so these two datasets cannot distinguish between different rescale exponents**

**Analysis at significantly different CM-energy necessary !**

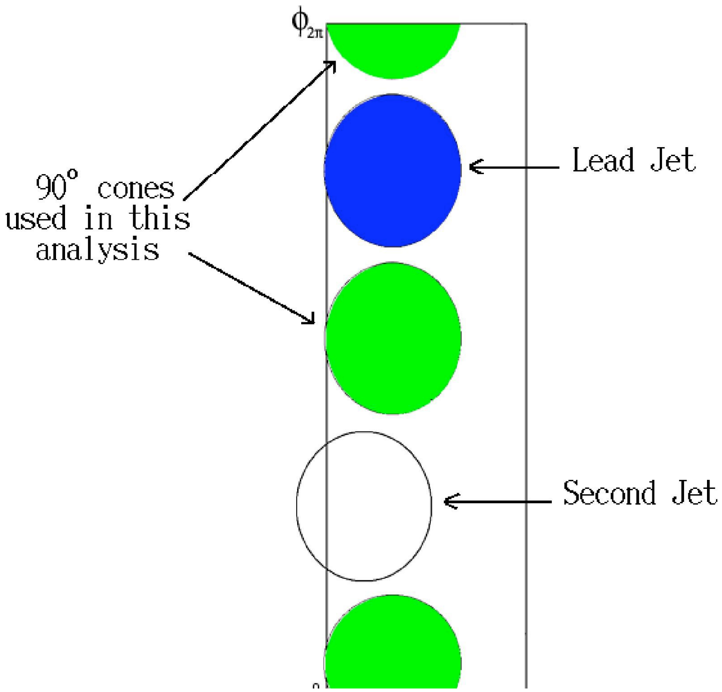
# MIN-MAX-Cone Analysis

- Select QCD events (mainly dijets)
- Cones ($\Delta R=0.7$) perpendicular to leading jet
- Divide into MAX cone and MIN cone
- Also look into difference

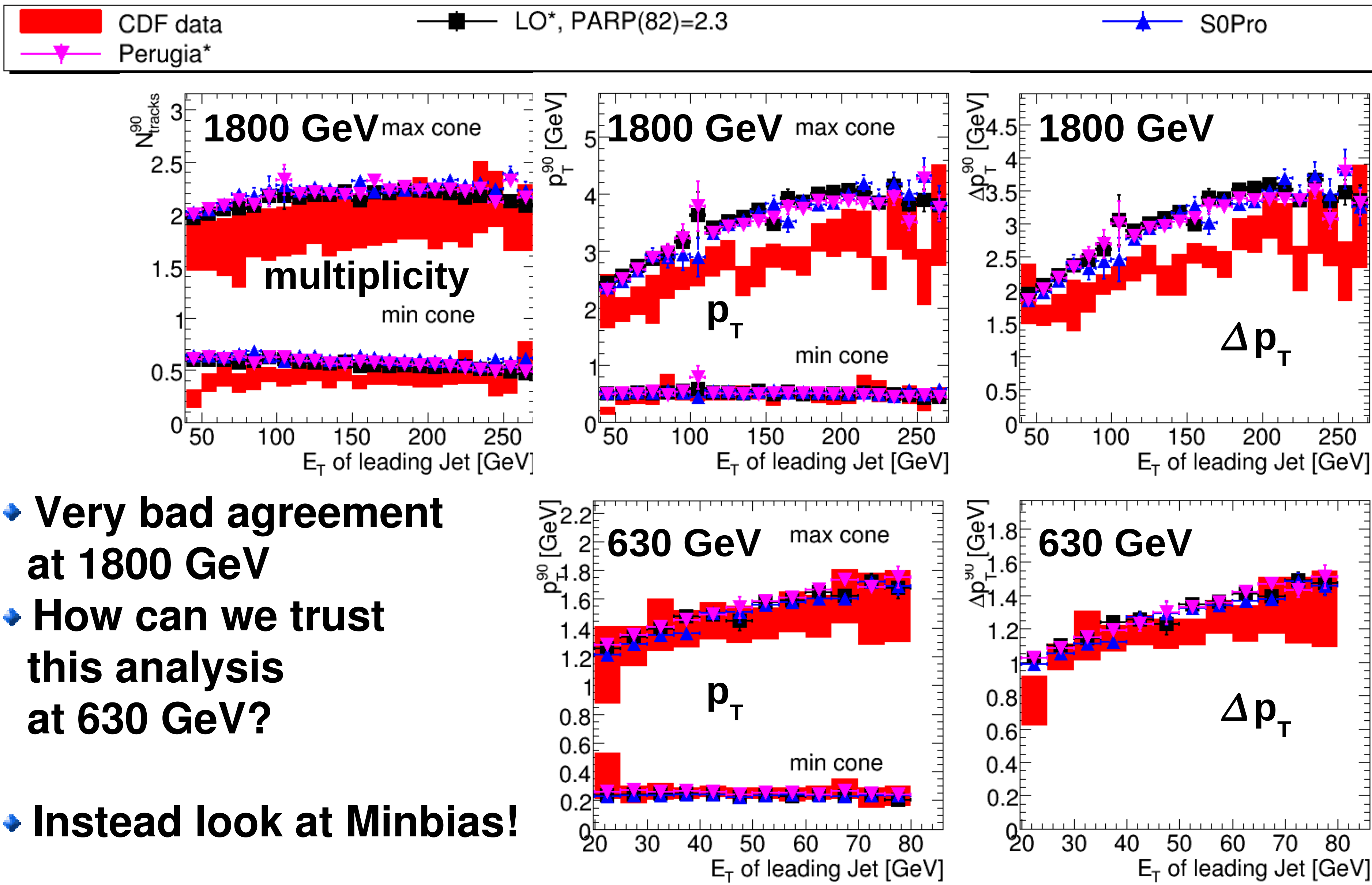
- Phys. Rev. D70, 072002 (2004)

- Analysis includes data from 1800 GeV AND 630 GeV

- Need data at second CM-energy to tune rescale exponent



# MIN-MAX-Cone Analysis

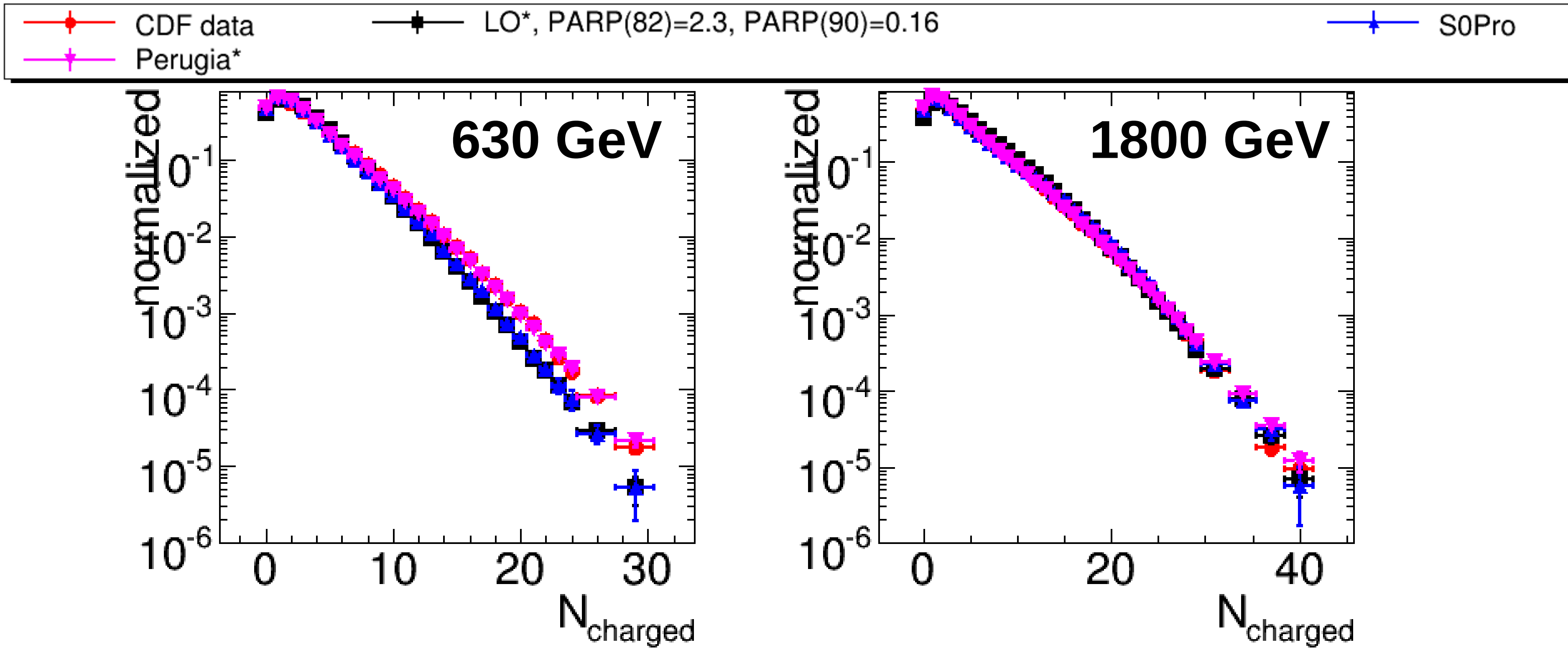



- **Very bad agreement at 1800 GeV**
- **How can we trust this analysis at 630 GeV?**

- **Instead look at Minbias!**

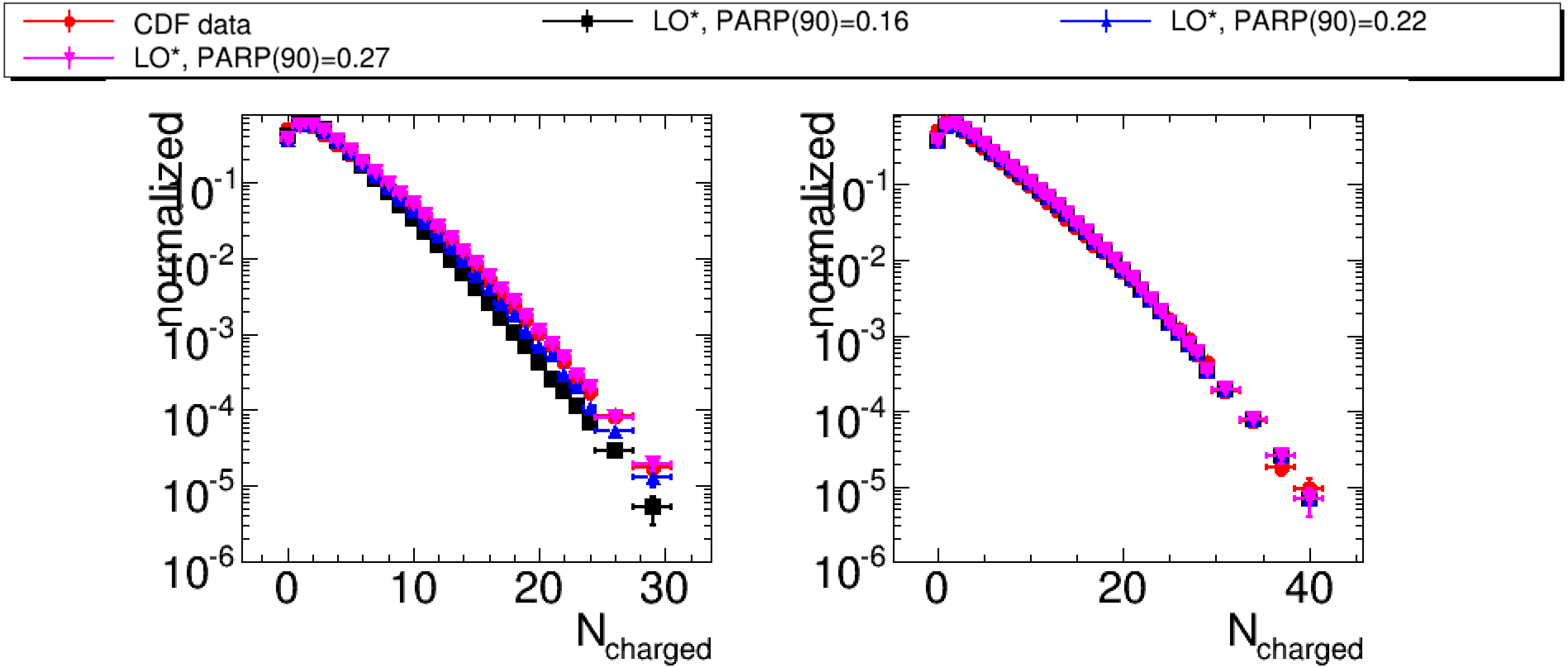
# CDF min. bias

- **CDF minimum bias multiplicity measurement (Phys. Rev. D65:072005, 2002)**




- **All three tunes describe multiplicity at 1800 GeV**
- **630 GeV data strongly disfavors small PARP(90)!**

# Influence of PARP(90)

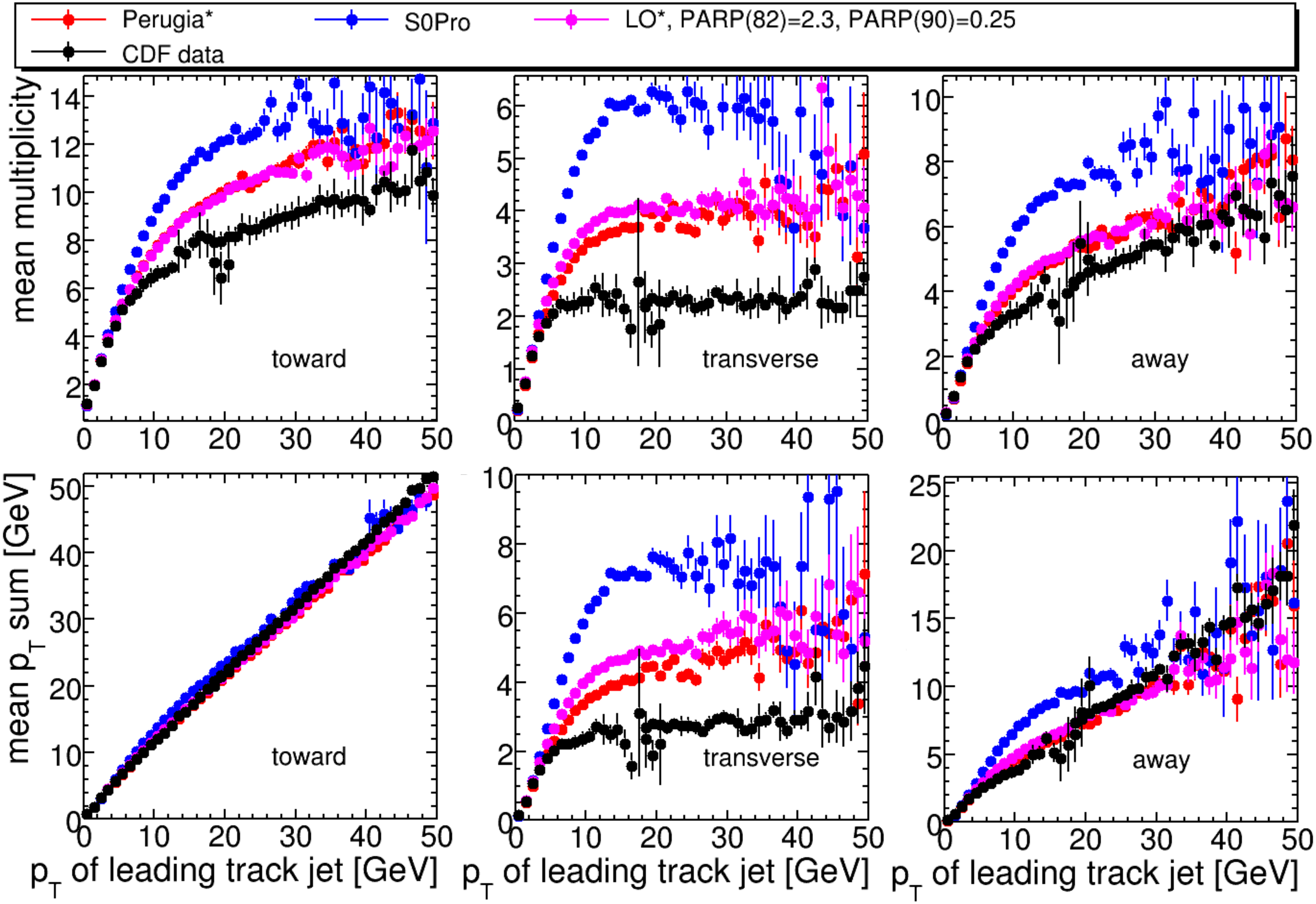



- **Higher PARP(90) ⇒ more activity at smaller CM-energy**
- **If taking the minimum bias data seriously, should switch to PARP(90)=0.25**

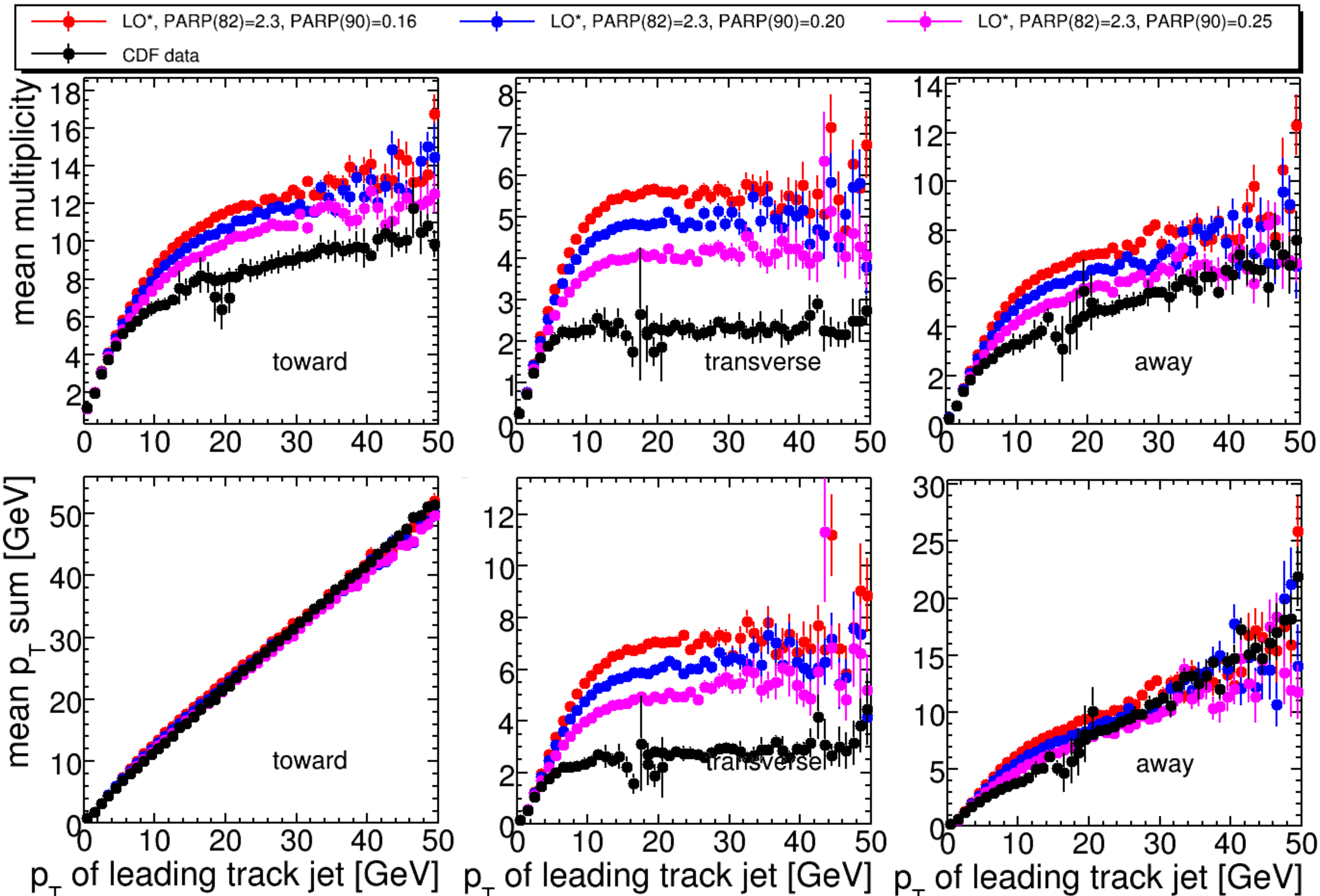
# LHC-predictions

- Clearly the three presented models are able to describe the data at 1800 and 1960 GeV
- Controversial for lower CM-energies:
    - only “jetty” analysis might not be trustworthy?
    - Minimum bias prefers high rescale exponent!
- What are the effects for LHC?
- In the following:
  Run-I-type leading jet analysis for 10 TeV (had to chose one CM-energy, not clear when we will have this)

# LHC-effects


Perugia*
S0Pro
LO*, PARP(82)=2.3, PARP(90)=0.25
CDF data
mean multiplicity
toward
transverse
away
mean $p_T$ sum [GeV]
$p_T$ of leading track jet [GeV]
$p_T$ of leading track jet [GeV]
$p_T$ of leading track jet [GeV]

# Influence of PARP(90)



# Effects at LHC

- Effects at LHC basically dominated by rescale exponent
- high PARP(90)~0.25: about factor of two more activity than for Tevatron energies
- low PARP(90)~0.16: factor of three compared to Tevatron
- Differences between different models with same rescale exponents: ~10%, same as disagreement for Tevatron energies
- Urgently need measurement of the Underlying Event at different CM-energies

# Summary

- Showed tunes of Pythia 6.420 to Tevatron data
- Special emphasis on UE obervables
- Main Problem: Rescale exponent (PARP(90)) can barely be fixed because of sparse data at different CM-energies
- Recent movement in the Tuning-community: Prefer values of PARP(90) higher than Pythia default of 0.16
- Effects for the UE at the LHC are profound
- Only LHC data (possibly at different CM-energies) can tell which models are best