

Mini Jets in Deep Inelastic Scattering at HERA.

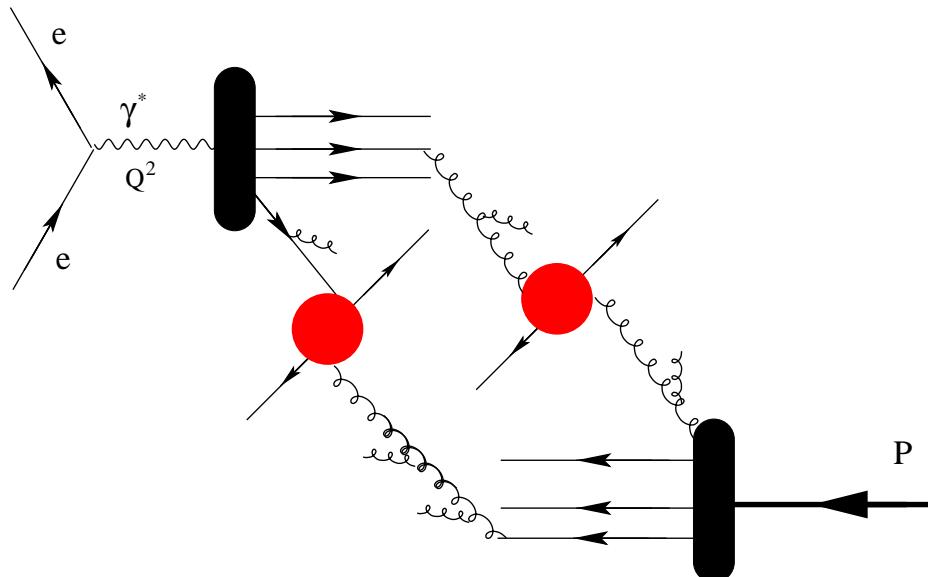
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For the H1 Calibration**

Outline:

- * Underlying Event.
- * Motivation and Strategy.
- * Selections.
- * Result.
- * Summary and Conclusion.

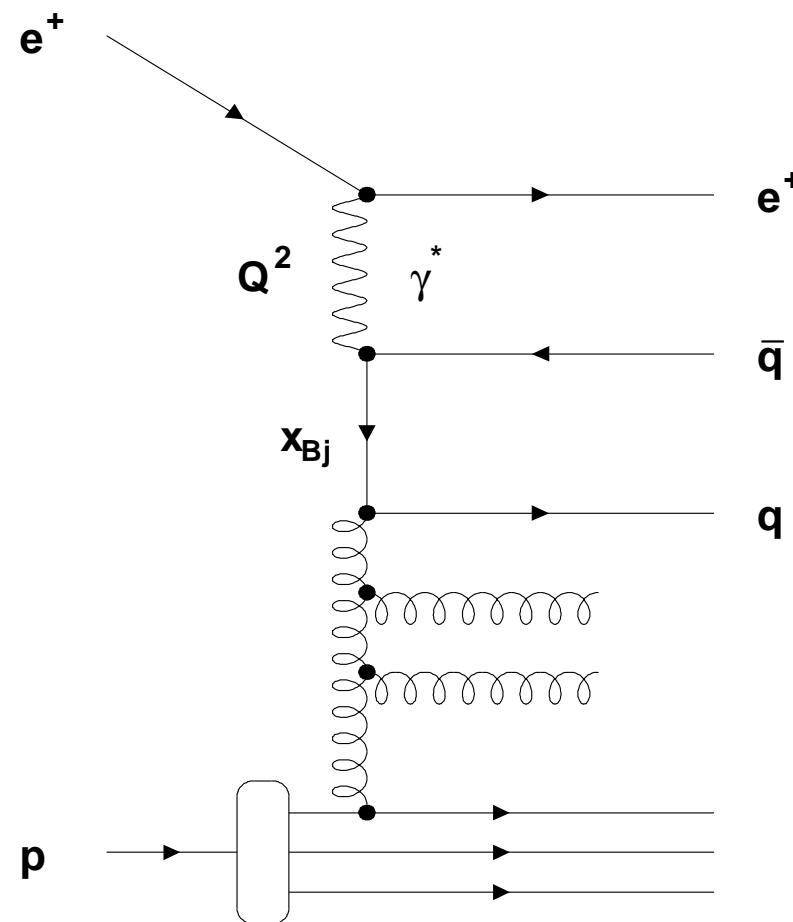
Underlying Event

- * The Underlying Event (UE) consists of particles produced by processes with more than one ladder exchange.
- * Different treatment of UE in Monte Carlo:
 - Soft beam remnant interactions = Soft Underlying Event (SUE).
 - Multiple Interactions (MI).
- * The additional emissions produced by UE may give rise to higher production rate of jets with low transverse momenta (mini jets).



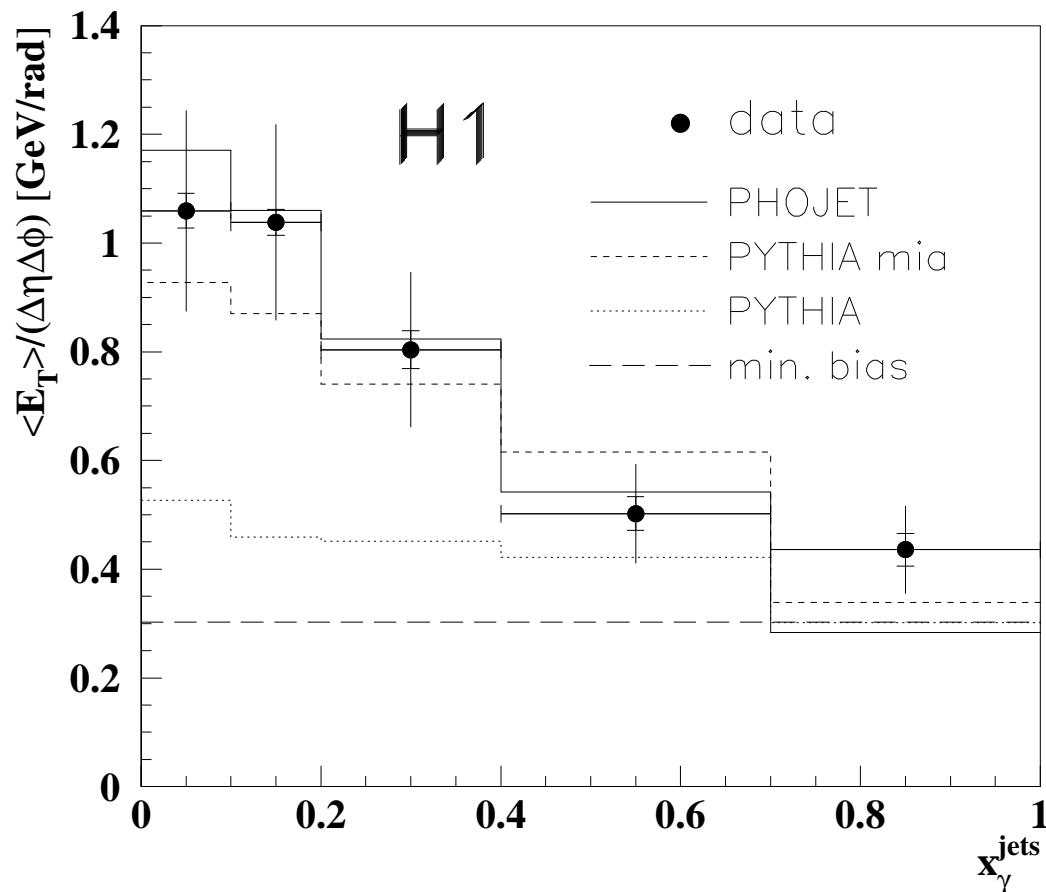
Underlying Event

- * Experimentally it is hard to distinguish between contributions from underlying event and higher order processes from single ladder exchange.



Motivation

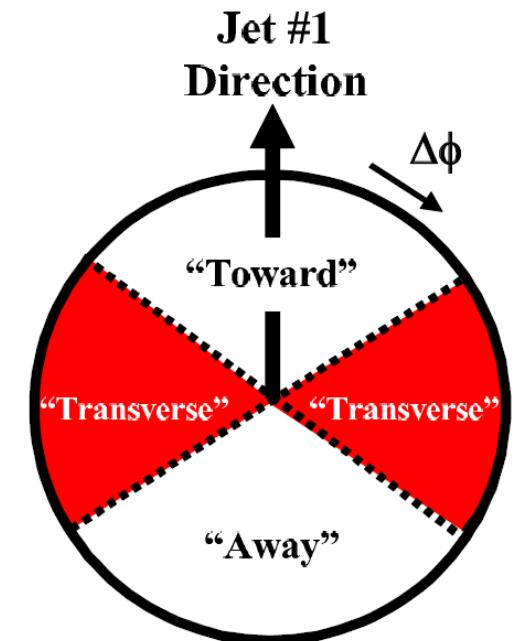
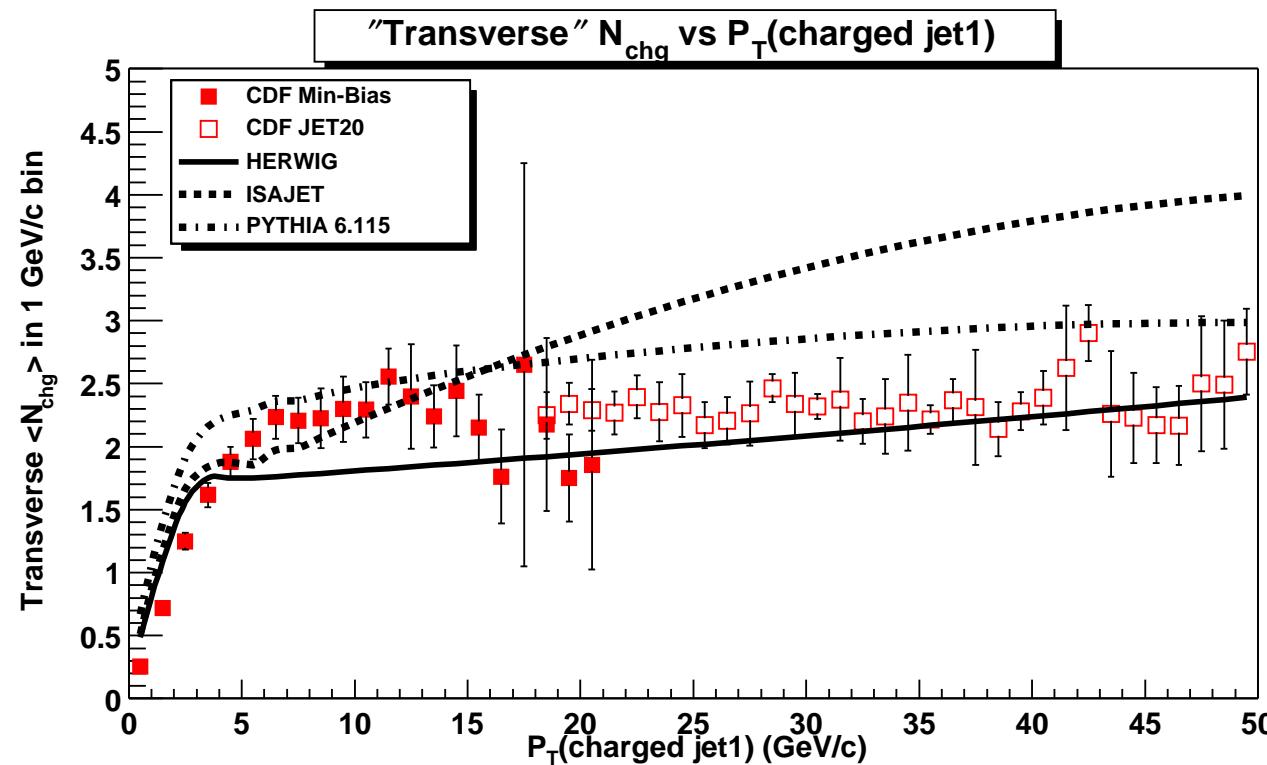
- Multiple interactions needed to describe data in photoproduction at HERA,
Z. Phys. C70 (1996) 17.



$$x_\gamma = \frac{\sum_{i=1}^2 E_{T,i} e^{-\eta_i}}{2E_\gamma}$$

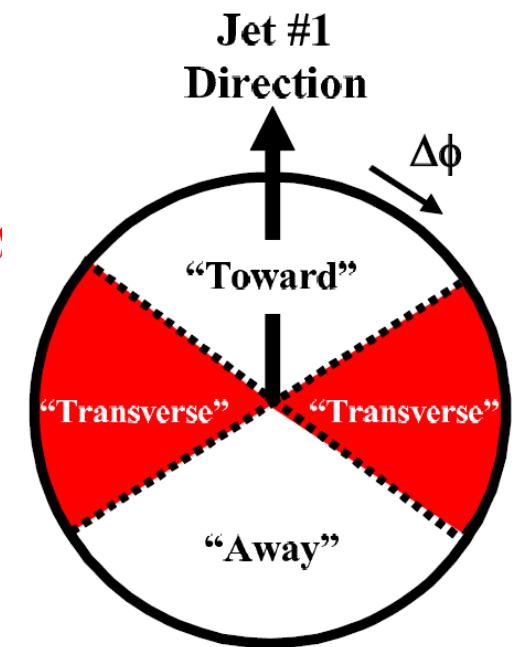
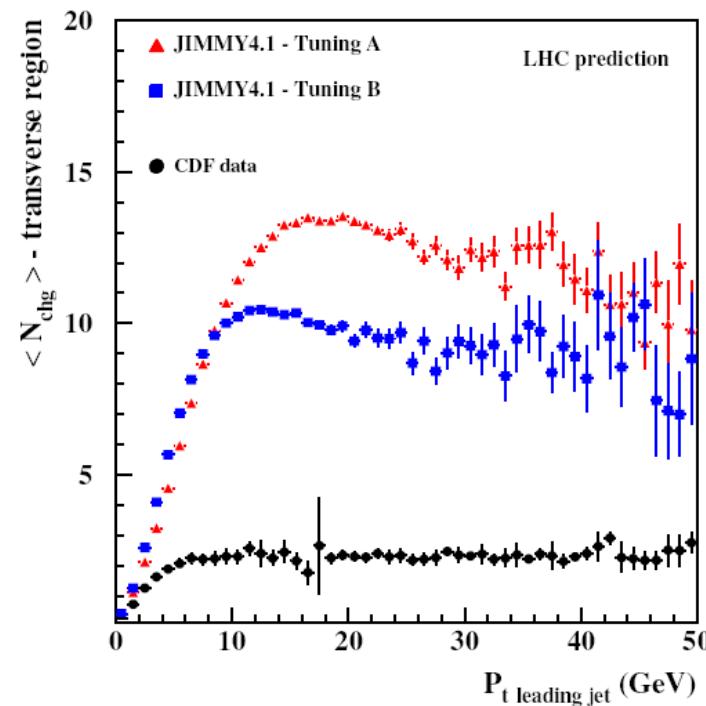
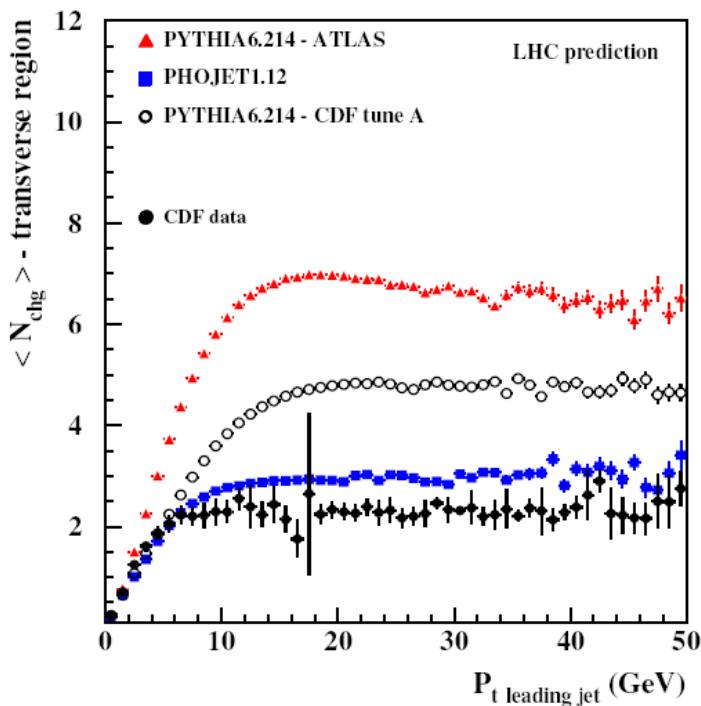
Motivation

- Multiple interactions needed to describe data in photoproduction at HERA, Z. Phys. C70 (1996) 17.
- Multiple interactions needed to describe data at Tevatron, Phys. Rev. D65, 092002, (2002).



Motivation

- Multiple interactions needed to describe data in photoproduction at HERA, Z. Phys. C70 (1996) 17.
- Multiple interactions needed to describe data at Tevatron, Phys. Rev. D65, 092002, (2002).
- MC tuned to Tevatron data gives different predictions at LHC



Motivation

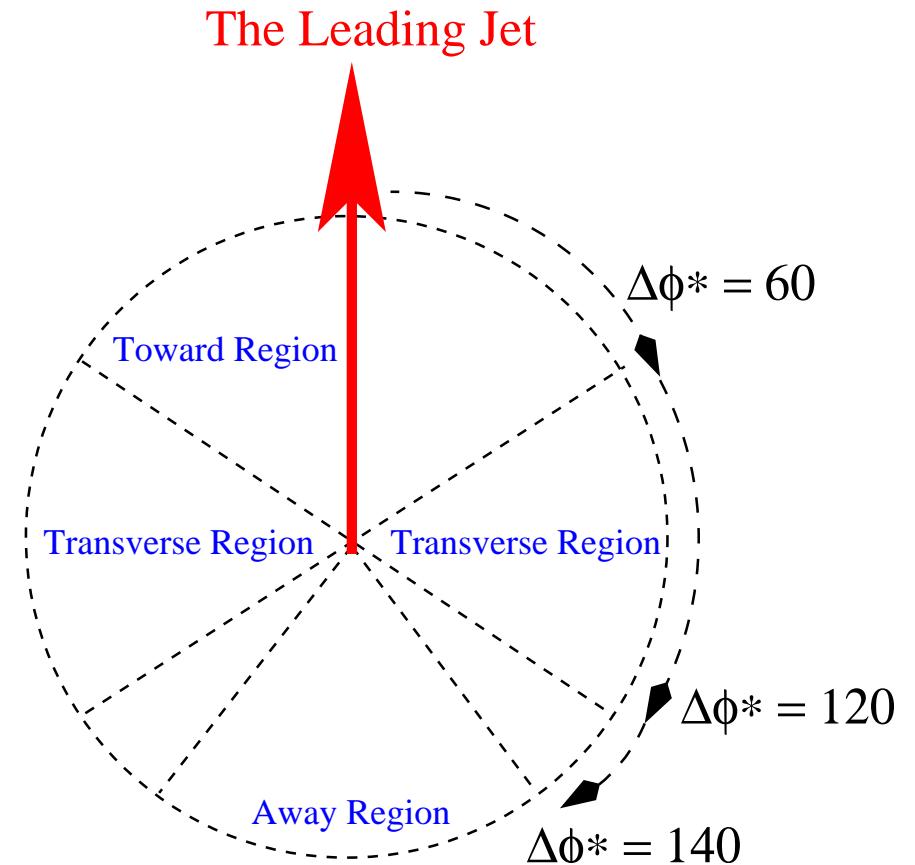
What about DIS? Are we sensitive to UE?

→ Measure regions expected to be sensitive to underlying event.

- Measure jets with low transverse momenta (mini jets).
- Test models commonly used in DIS.
- Test models including MI (and/or SUE) used in photoproduction.

Strategy

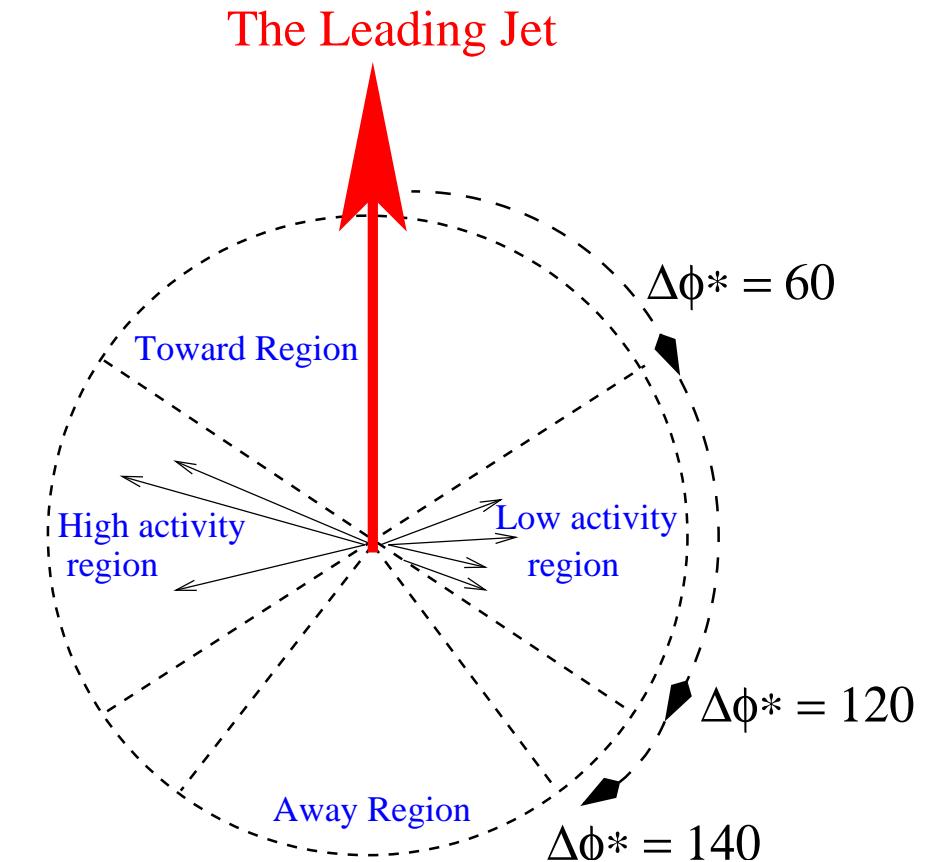
- Select the jet with highest P_T^* in HCM rest frame, the **Leading Jet**.
- Define four regions in azimuthal:
 - **Toward region:**
 $|\Delta\phi^*| < 60^\circ$.
 - **Two Transverse regions:**
 $60^\circ < |\Delta\phi^*| < 120^\circ$.
 - **Away region:**
 $|\Delta\phi^*| > 140^\circ$.



The Toward and Away regions are sensitive to the hard part of the event.

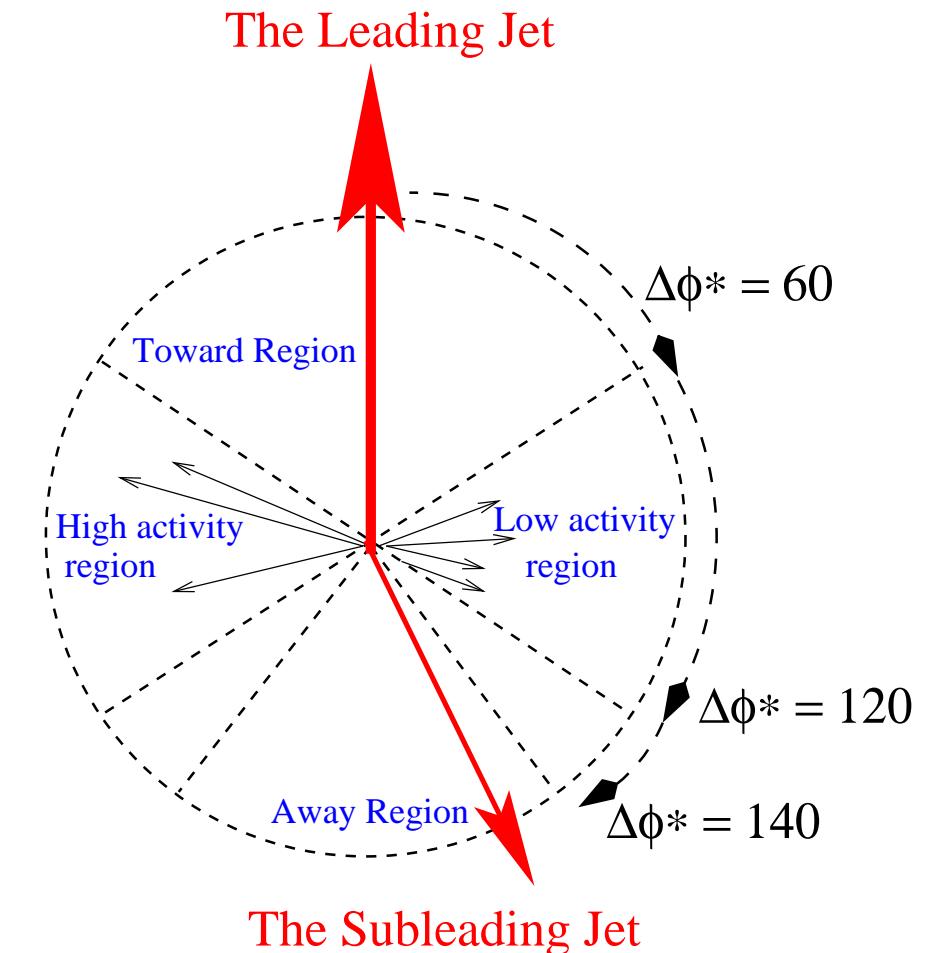
Strategy

- The scalar E_T^* Sum of the particles, E_{TSum}^* , in the **transverse regions** is calculated for each event.
- For each event, split the two Transverse regions into a **low activity** region and a **high activity** region according to E_{TSum}^* .



Strategy

- In addition, select a subsample, Dijet sample, where the second hardest jet, **Subleading Jet**, is restricted to be in the **Away** region.



Strategy

- Measure the average jet multiplicity in the different $\Delta\phi^*$ regions as function of P_T^* of the Leading Jet.

$$\langle N_{\text{MiniJet}} \rangle = \frac{\sum_{i=1}^{N_{ev}} N_{\text{MiniJet},i}}{N_{ev}}$$

- Inclusive sample:
 - In bins of Q^2 .
 - In bins of η^{lab} of the leading jet:
 - * Forward region (close to the proton direction) enhanced contributions from the resolved photon process
 - * Central region less contributions from the resolved photon process
- Dijet sample:
 - In bins of $x_\gamma = \frac{\sum_{i=1}^2 P_{T,i}^* e^{\eta_i^*}}{2E_\gamma^*}$, where i=1 is the leading jet
i=2 is the subleading jet

Selections

Jet samples

DIS sample

$$5 < Q^2 < 100 \text{ GeV}^2$$

$$0.1 < y < 0.7$$

$$W > 200 \text{ GeV}$$

Inclusive sample: jet 1 (Hardest jet)

Dijet sample: jet 1,2 (Two hardest jets)

$$-1.7 < \eta_{1,2}^{lab} < 2.79$$

$$P_{T1,2} > 5 \text{ GeV}$$

$$|\phi_1^* - \phi_2^*| > 140^\circ$$

Mini jets, jets with:

$$-1.7 < \eta^{lab} < 2.79$$

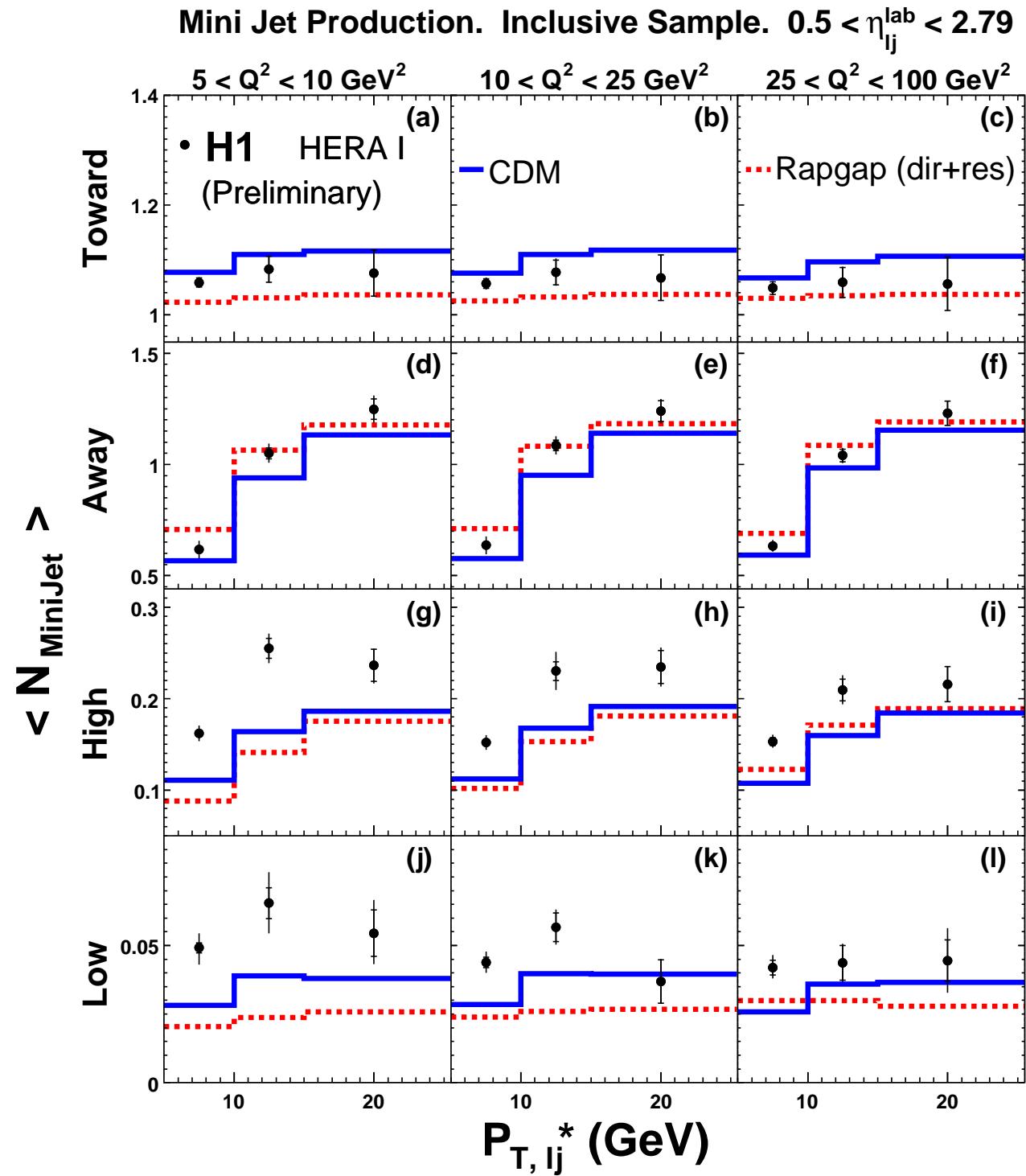
$$P_T > 3 \text{ GeV}$$

The P_T cuts are applied both in HCM and Lab frame.

Jets are defined as inclusive k_t -algorithm jets (HCM).

Mini Jet Production
 Inclusive Sample
 Forward Region:
 $0.5 < \eta_{lj} < 2.79$

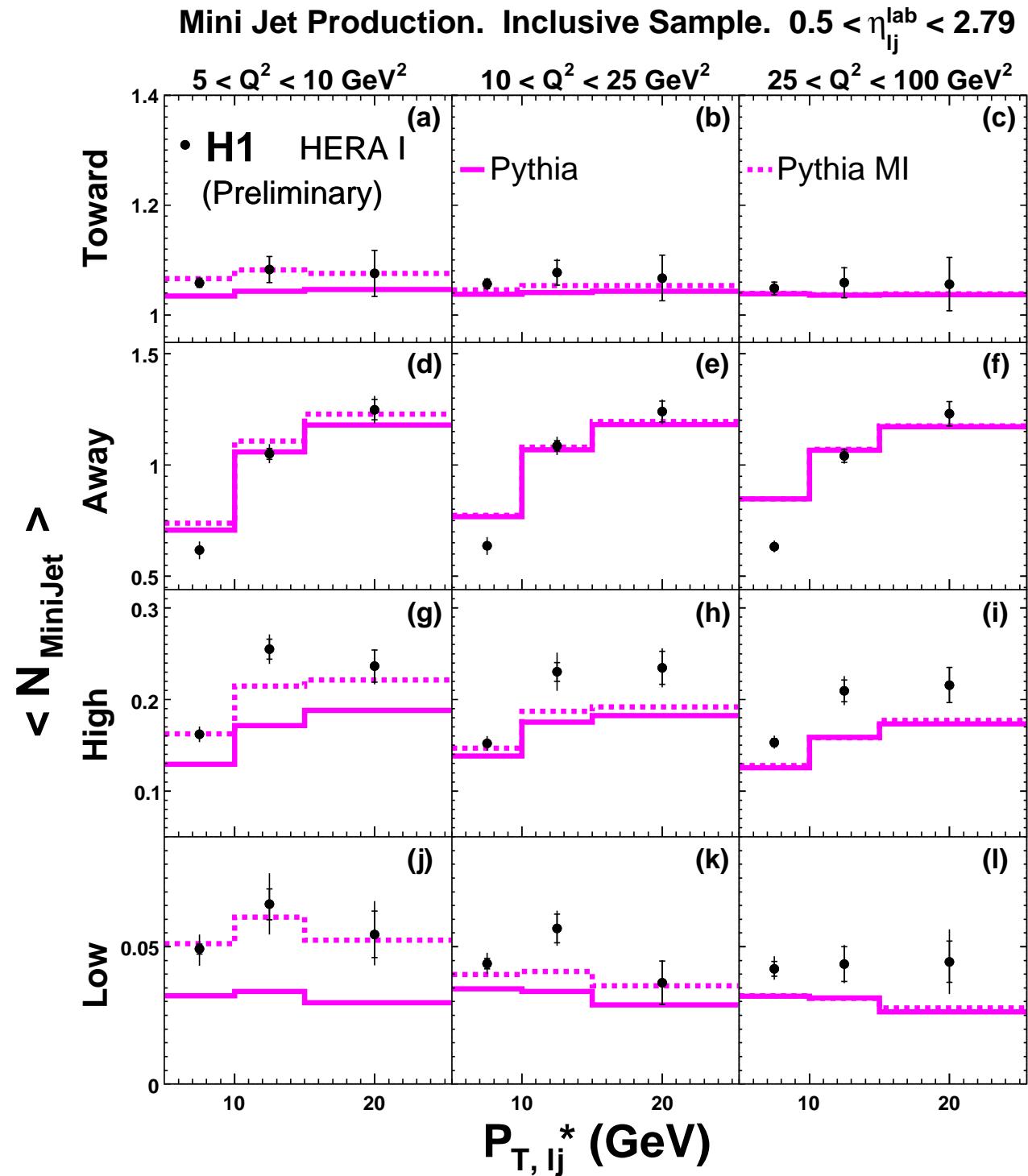
- ✓ Ok in toward and away regions
- ✓ MC's undershoot data in the low and high activity regions



Mini Jet Production
 Inclusive Sample
 Forward Region:
 $0.5 < \eta_{lj} < 2.79$

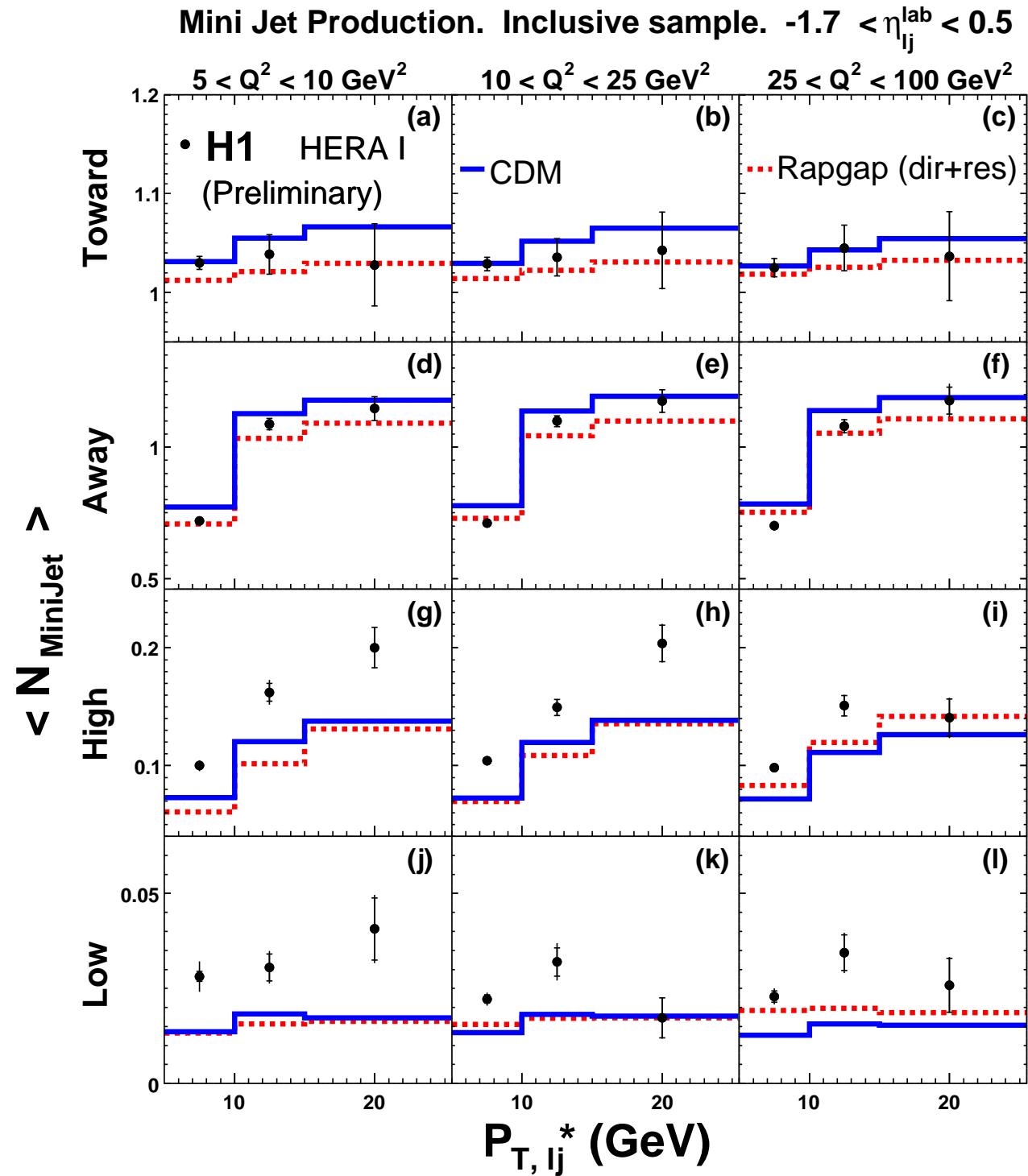
- ✓ Ok in toward and away regions
- ✓ Pythia MI improves the agreement with data at low Q^2

Similar results are obtained with Herwig



Mini Jet Production
 Inclusive Sample
 Central Region:
 $-1.7 < \eta_{lj} < 0.5$

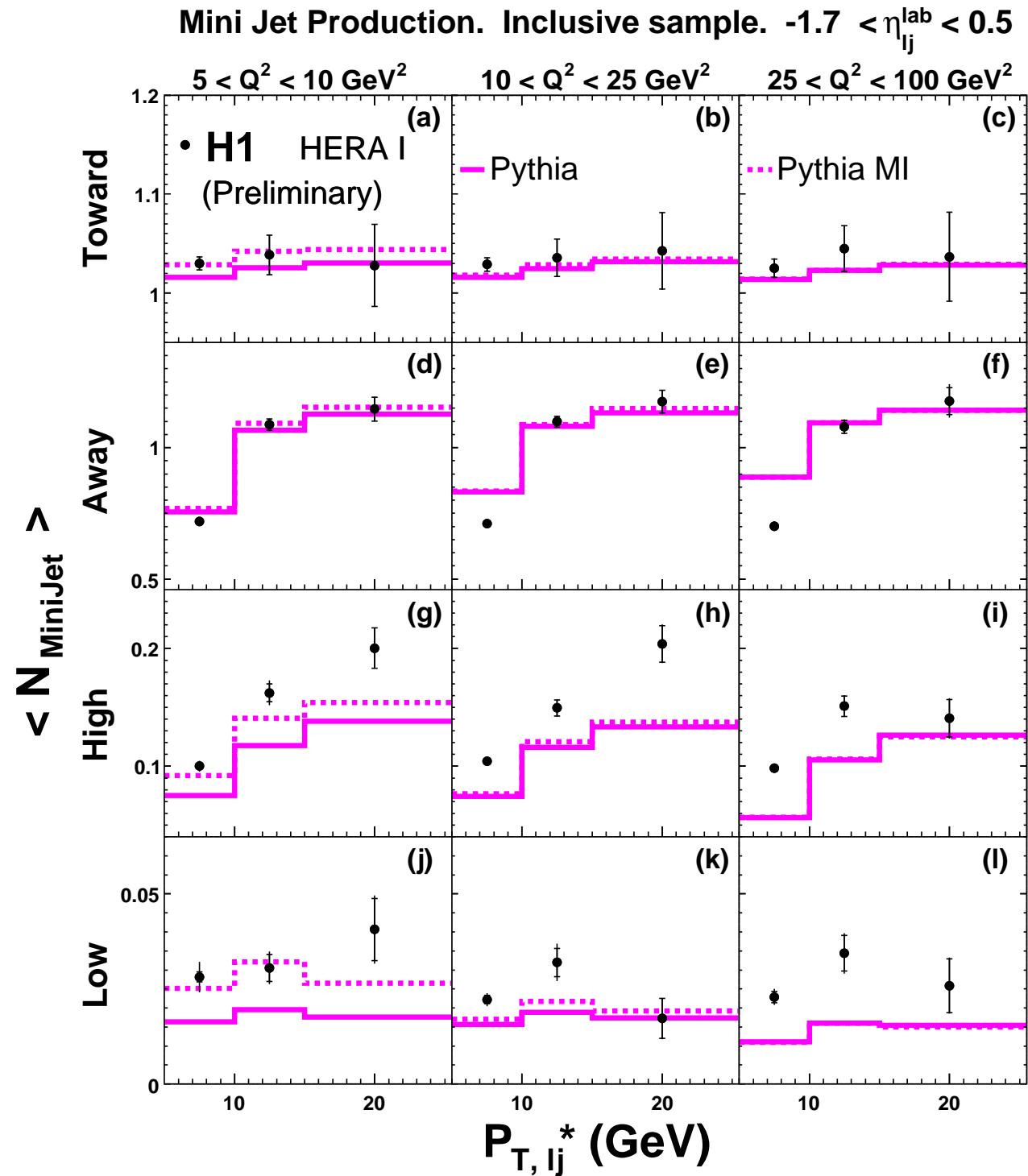
- ✓ Less activity in central region than forward region
- ✓ Ok in toward and away regions
- ✓ MC's undershoot data in the low and high activity regions



Mini Jet Production
Inclusive Sample
Central Region:
 $-1.7 < \eta_{lj} < 0.5$

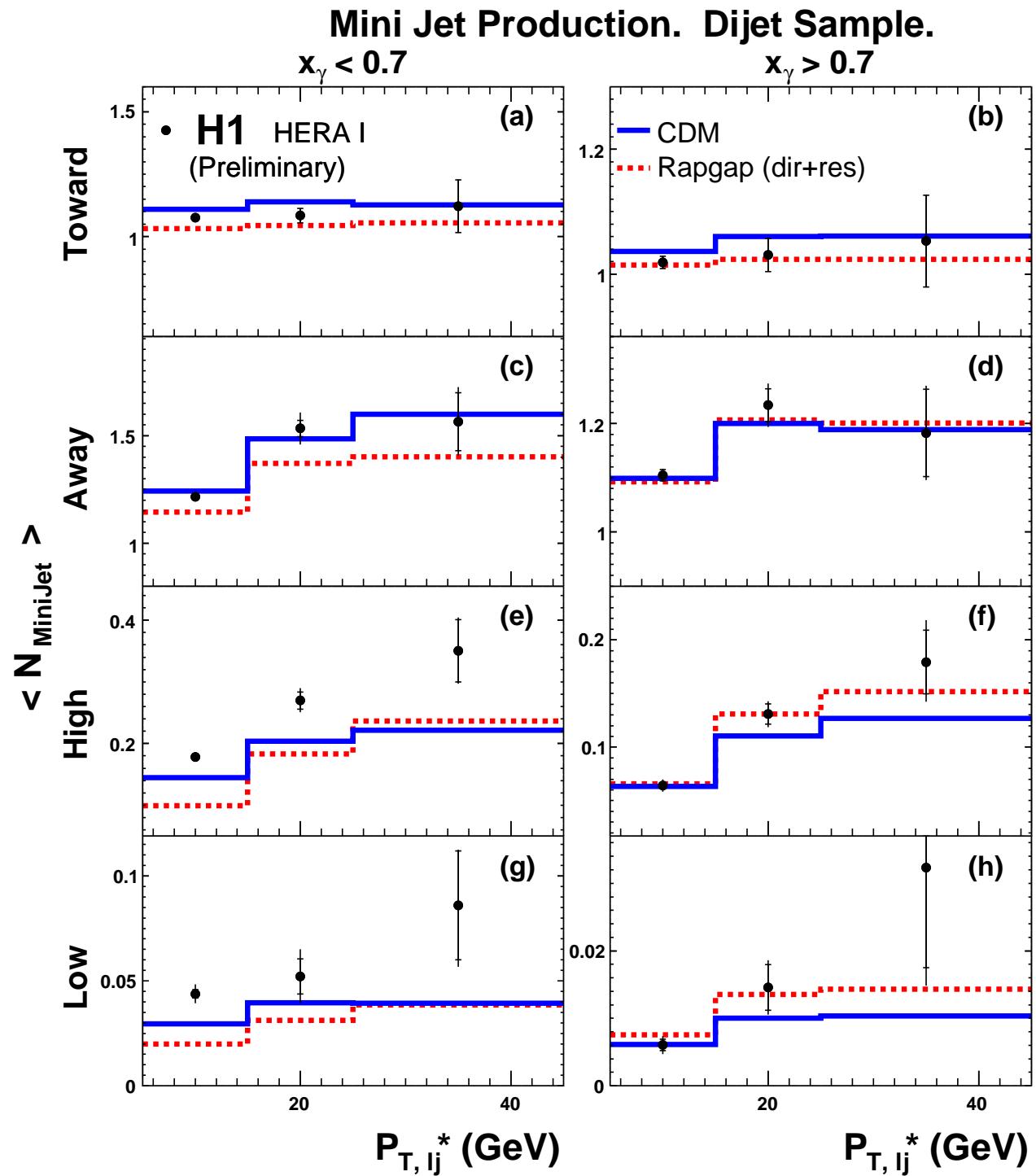
- ✓ Ok in toward and away regions
- ✓ Pythia MI improves the agreement with data at low Q^2

Similar results are obtained with Herwig



Mini Jet Production
Dijet Sample
 $5 < Q^2 < 100 \text{ GeV}^2$

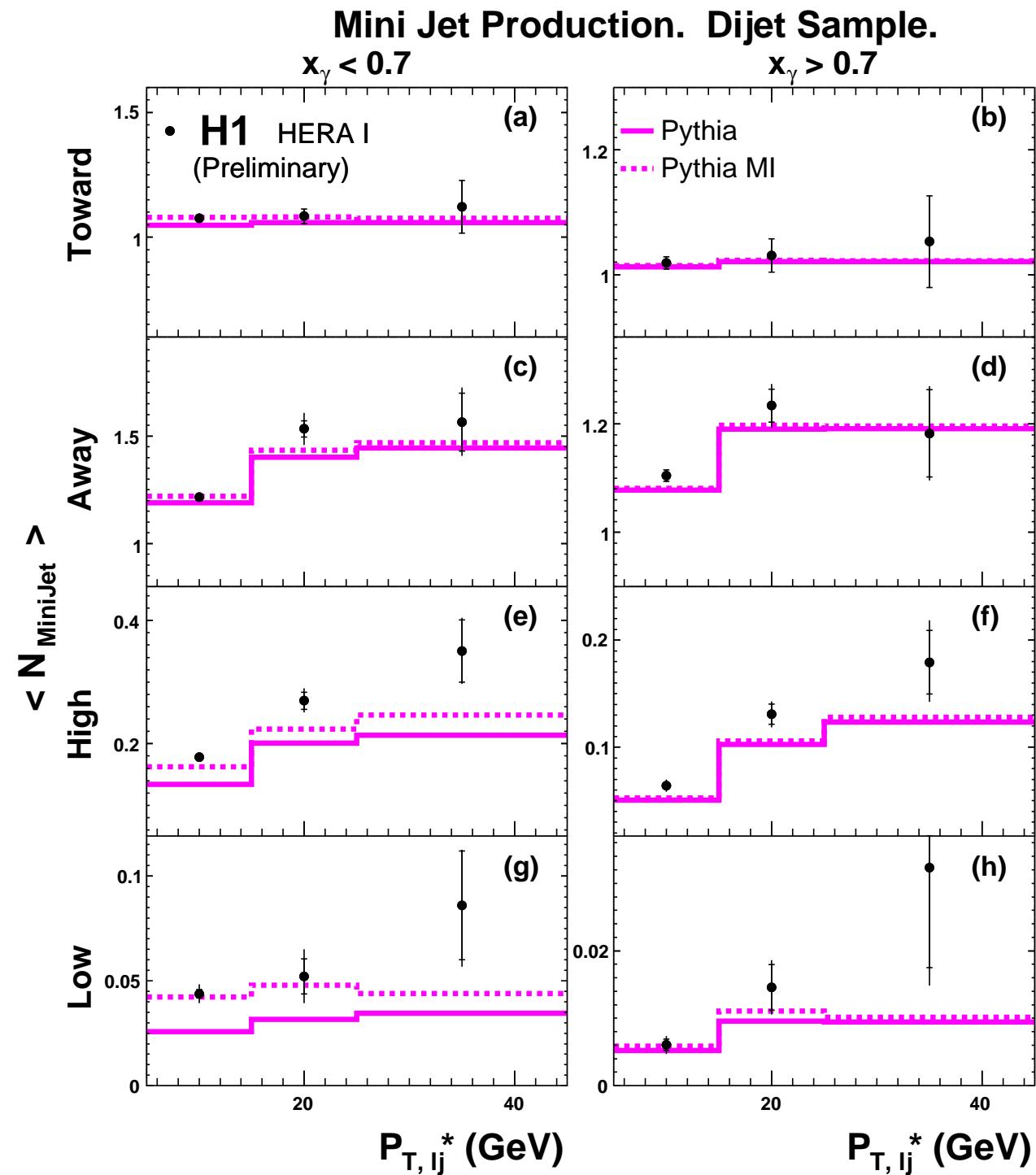
- ✓ higher activity at low x_γ
- ✓ Ok in toward and away regions
- ✓ MC's undershoot data in the low and high activity regions



Mini Jet Production
Dijet Sample
 $5 < Q^2 < 100 \text{ GeV}^2$

- ✓ Ok in toward and away regions
- ✓ Pythia MI improves the agreement with data at low x_γ

Similar results are obtained with Herwig

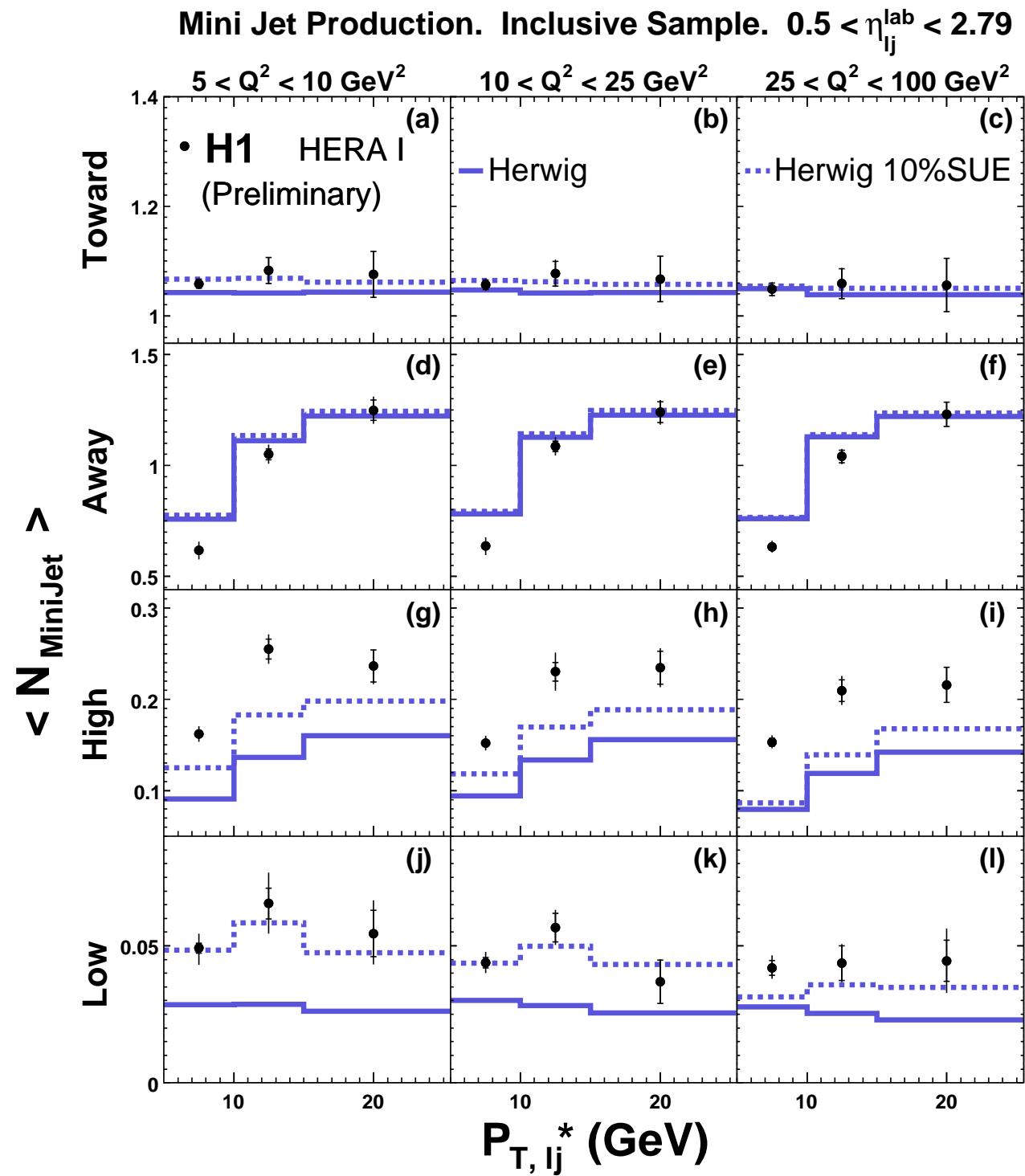


Conclusion:

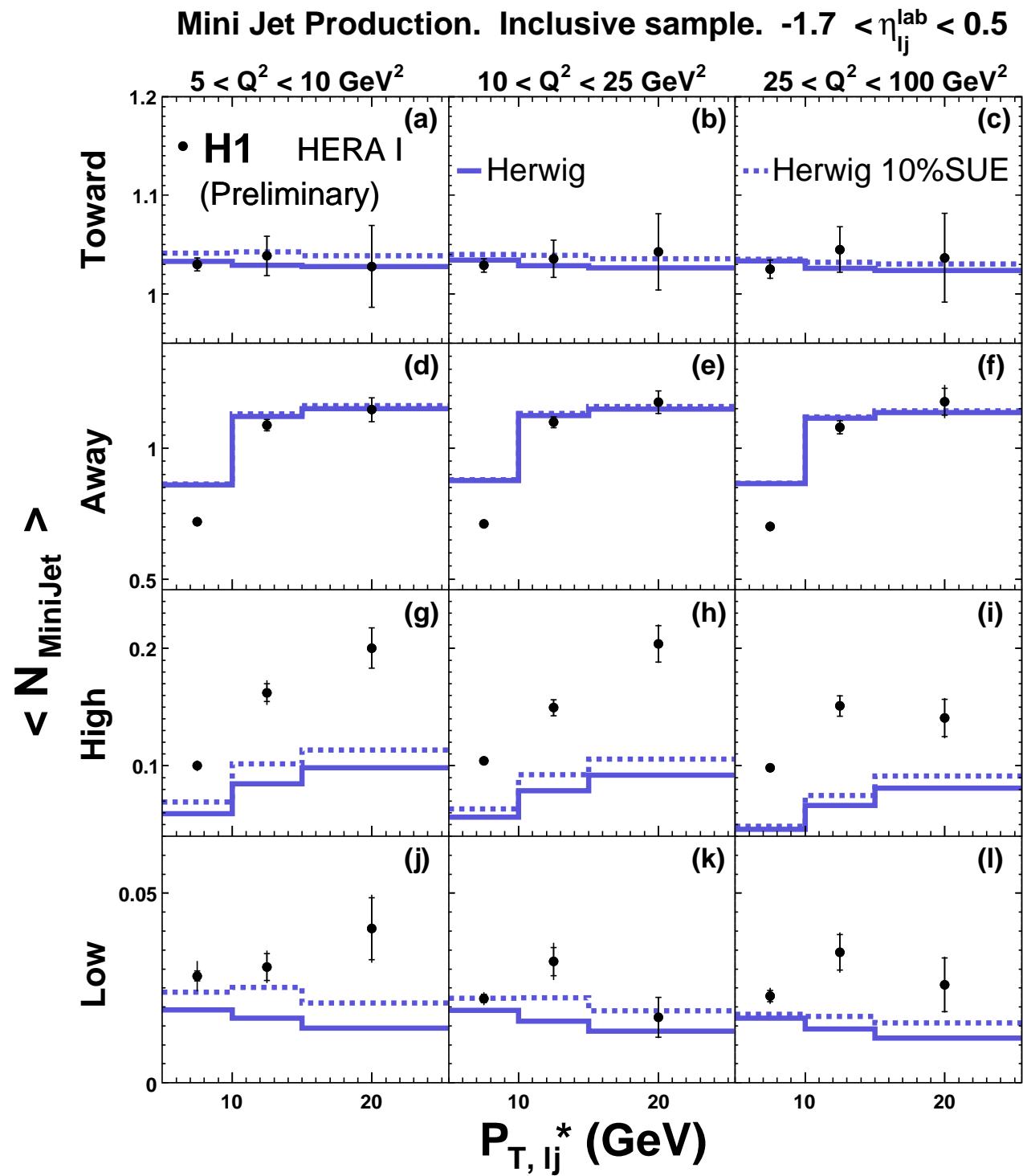
- * Standard QCD Monte Carlo models with LO ME+PS fail to reproduce data in the transverse ϕ -regions —> needs more correct descriptions of higher orders or additional activity to the hadronic final state, like MI.
- * Additional activity like MI (Pythia), successfully used in photoproduction, significantly improve the agreement with data at low Q^2 in the transverse regions, but fails at high Q^2 .
- * Due to the lack of NLO QCD calculations suitable to this analysis no conclusion from higher order contributions can be drawn.

Backup Slides

Mini Jet Production
Inclusive Sample
Forward Region:
 $0.5 < \eta_{lj} < 2.79$

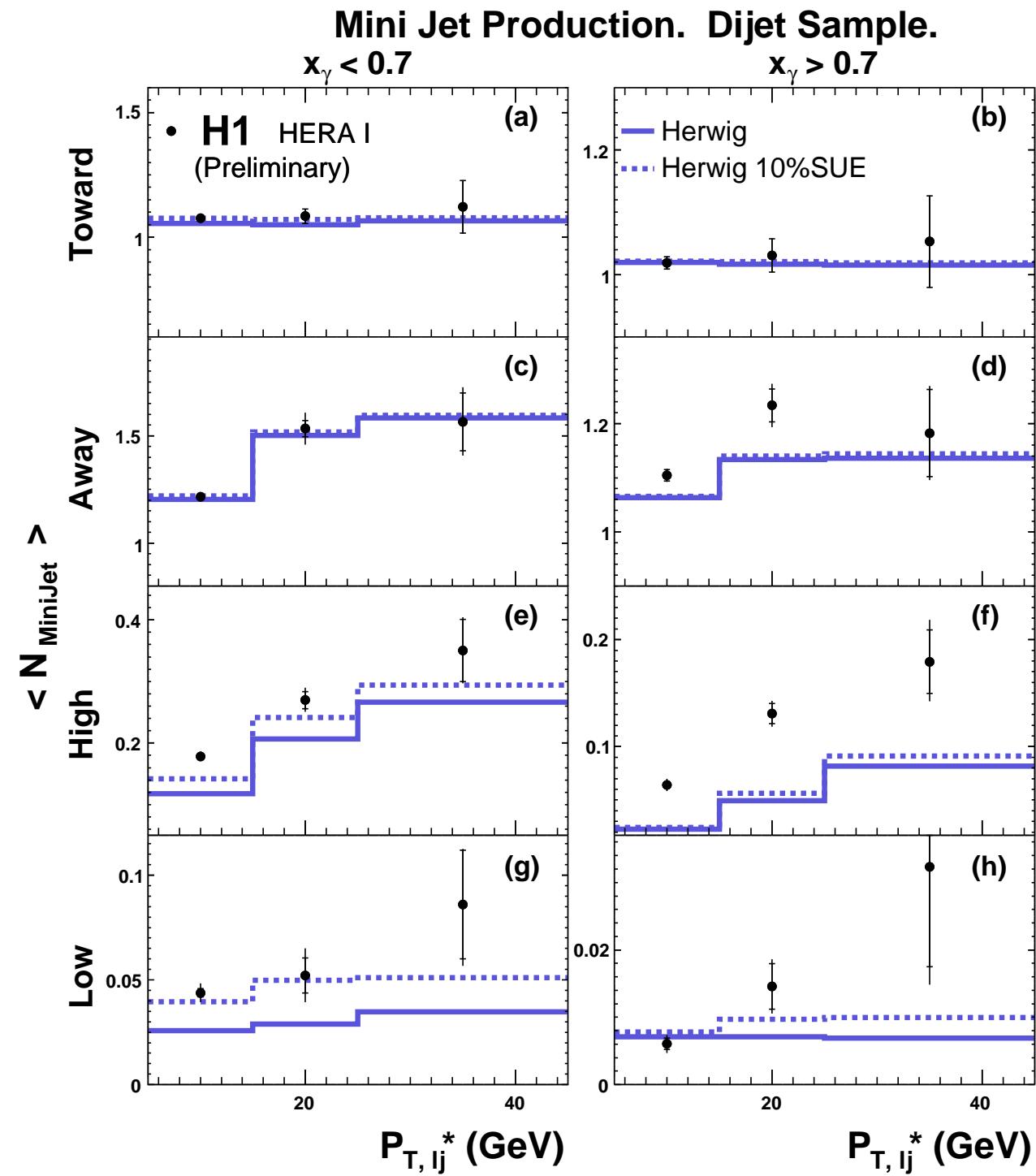


Mini Jet Production
Inclusive Sample
Central Region:
 $-1.7 < \eta_{lj} < 0.5$



Mini Jet Production

Dijet Sample



Summary:

$\langle N_{MiniJet} \rangle$ as function of P_T of the leading jet was presented.

- ✓ $\langle N_{MiniJet} \rangle$ increase with η_{lj}^{lab} (forward jets) in the transverse regions.
- ✓ $\langle N_{MiniJet} \rangle$ tends to decreases with Q^2 (more direct) in the transverse regions.
- ✓ $\langle N_{MiniJet} \rangle$ decreases with x_γ (more direct).

- ✓ Strong correlation between $\langle N_{MiniJet} \rangle$ and the leading jet P_T in the high activity region.
- ✓ Small correlation between $\langle N_{MiniJet} \rangle$ and the leading jet P_T in the low activity region.