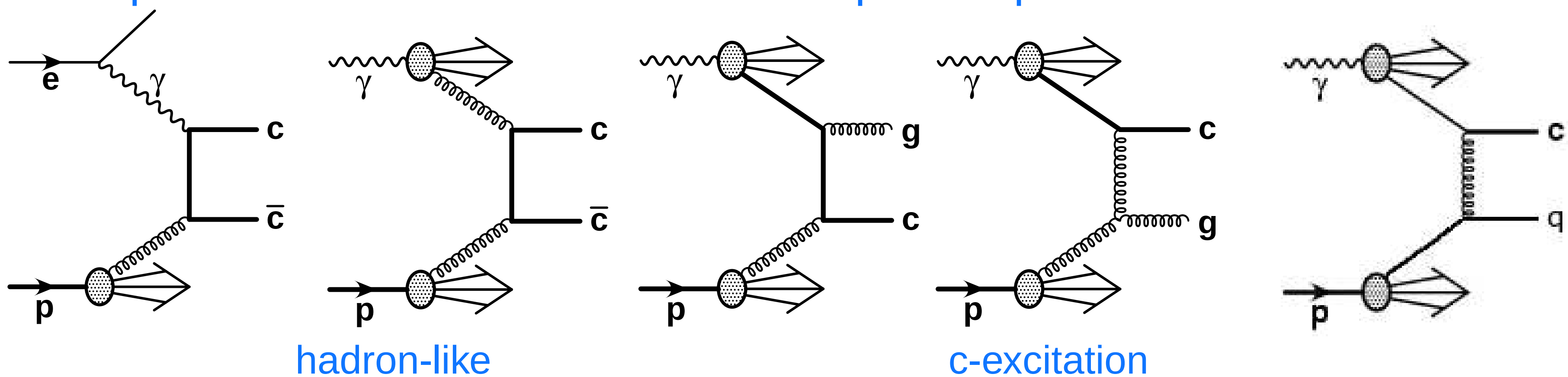
Study of Jet Shapes in Charm Photoproduction at HERA

Mária Martišíková
DESY Hamburg

Motivation

Charm photoproduction: resolved comp. important at low x_γ
excitation comp. needed in many analyses
(LO massless scheme)

direct process: resolved photon processes:



- Select events containing at least 2 jets
- Tag the charm jet by a muon
- Investigate the non-muon jet

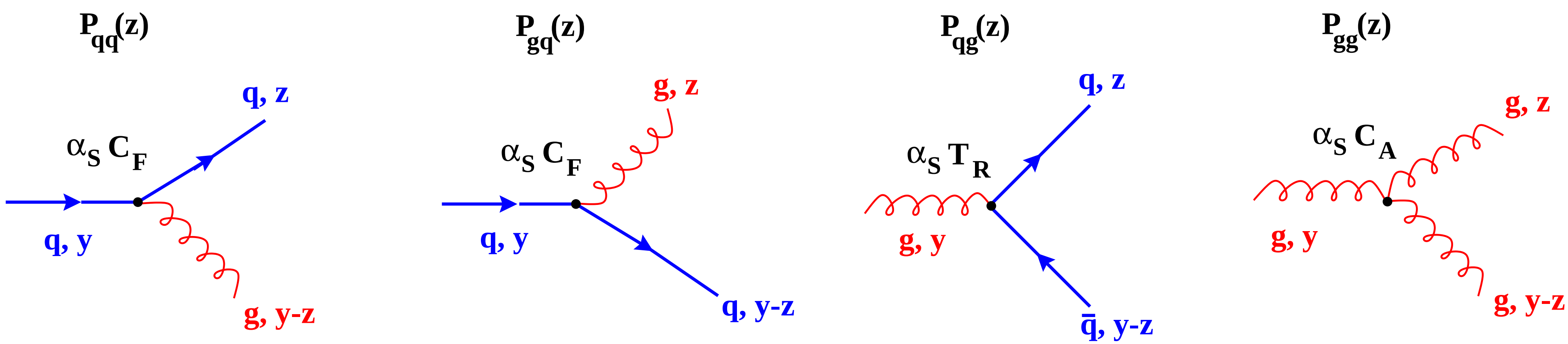
Can we see the large fraction of gluon jets?

Internal Jet Structure

. . . is sensitive to both:

♦ soft part of QCD: nonpertubative part (e.g. fragmentation)

♦ hard part of QCD: Different branching probabilities for a quark and gluon
$\Rightarrow$ different properties of quark and gluon induced jets



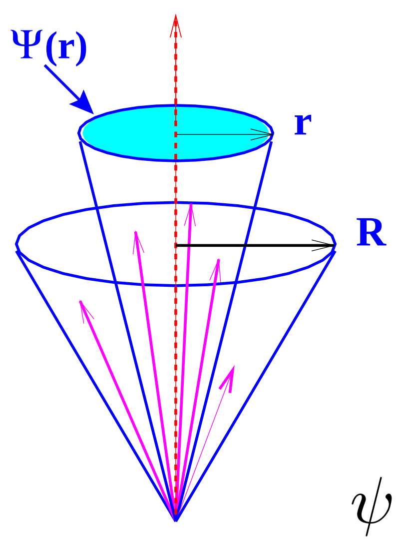
$C_A/C_F = 9/4 \Rightarrow$ more branchings expected for jets originating from gluons

Gluon jets are on average - broader than quark jets (with the same p_t^{jet})
- contain more particles with softer $\mathbf{p_t}$ - spectrum

The Method

Main idea: distinguish processes using c/g jet structure differences

Integrated jet shape

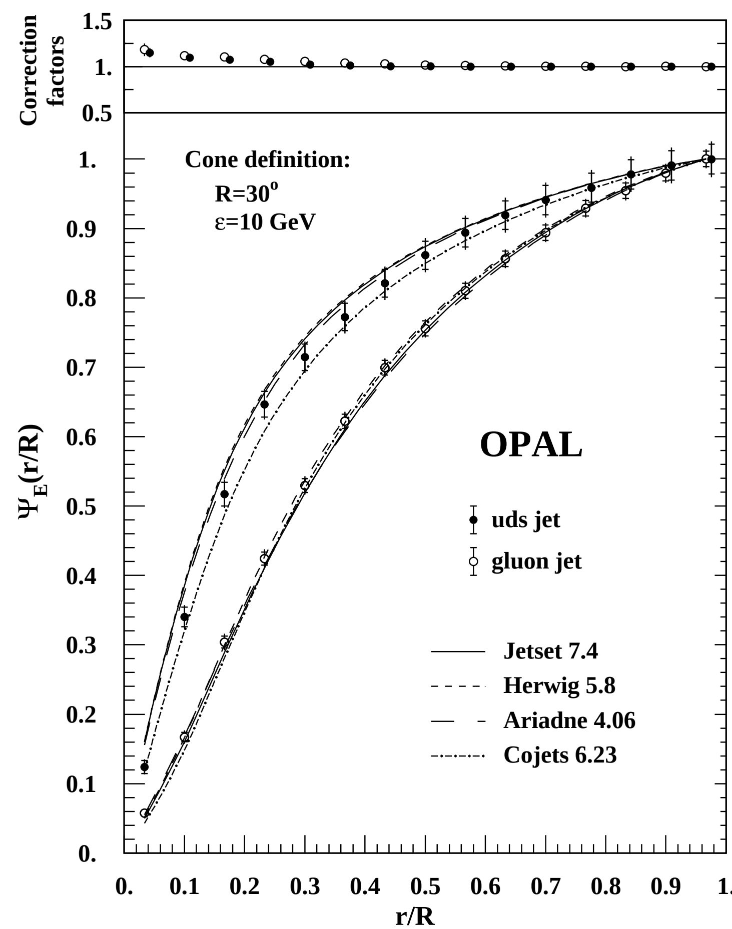


$$\psi(r) = \frac{p_t^{cone}(r)}{p_t^{jet}(r=R)}$$

In the analysis is measured

$$\langle\psi(r)\rangle = \frac{1}{N_{events}} \sum_{events} \psi(r)$$

LEP measurement



Data Selection: Charm

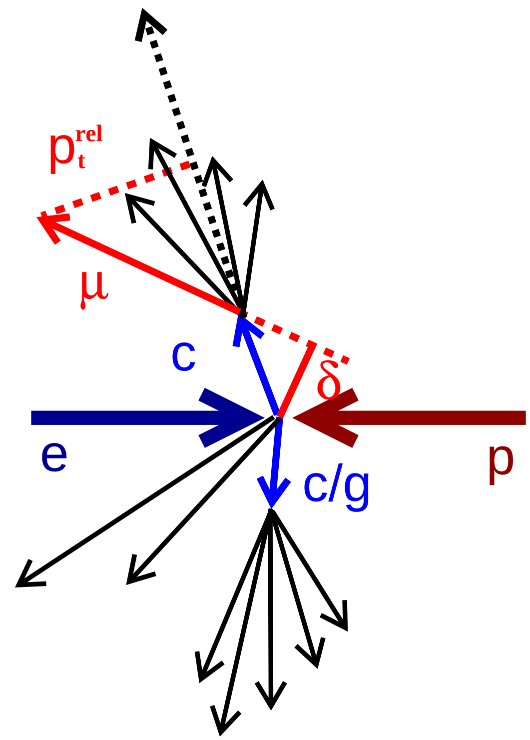
Data: H1 99/00

$\mathcal{L} \sim 48pb^{-1}$

Selection cuts:

- $Q^2 < 1GeV^2$
- $0.2 < y < 0.8$
- muon:
  - $p_t > 2.5$ GeV
  - $35^\circ < \Theta^\mu < 130^\circ$
- 2 jets (inclusive k_t algorithm):
  - $p_t^{jet} >$ 7(6) GeV
  - $20^\circ < \Theta^{jet} < 160^\circ$
  - muon can be in each of them

Tag charm jet by the muon

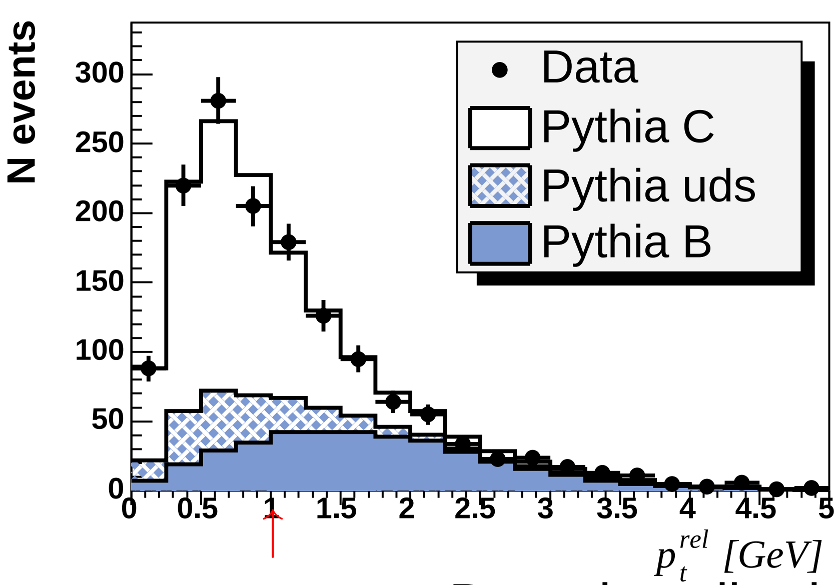


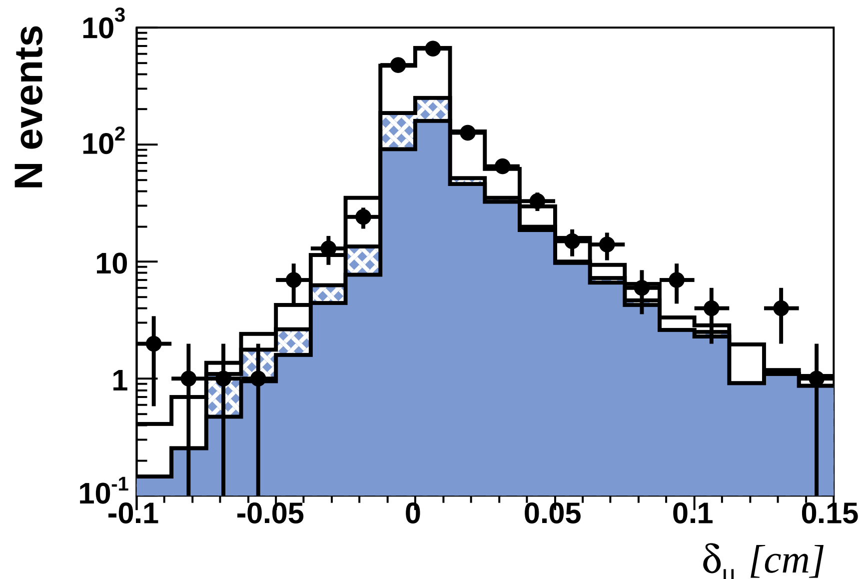
Investigate non-muon jet only:

not biased by the muon cuts

Charm Purity

2D fit to p_t^{rel} und muon impact parameter δ_μ:





Data described by Pythia reasonably well

⇒ enrich charm by $p_t^{rel} < 1$ GeV

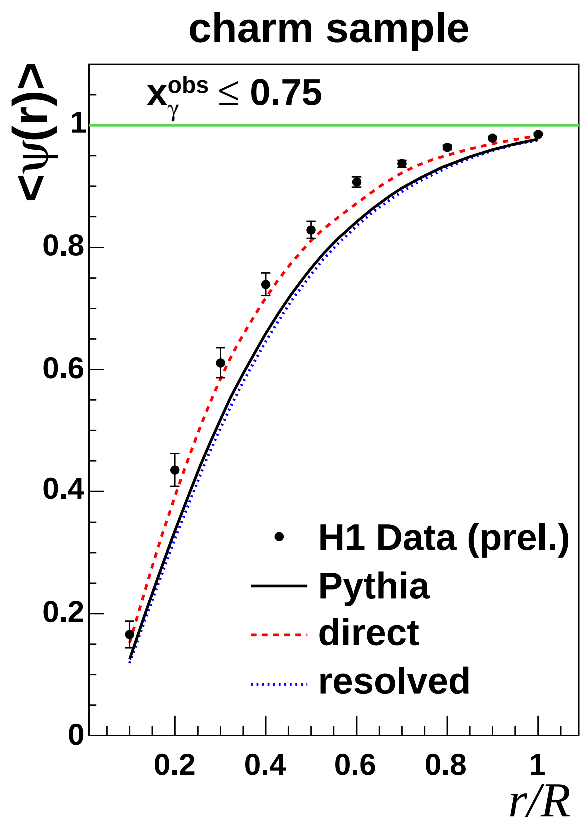
⇒ 800 events with charm purity (for $p_t^{rel} < 1$ GeV):

- $73 \pm 3\%$: 2D fit to p_t^{rel} and δ_μ
- $71 \pm 2\%$: inclusive MC ← used in the analysis

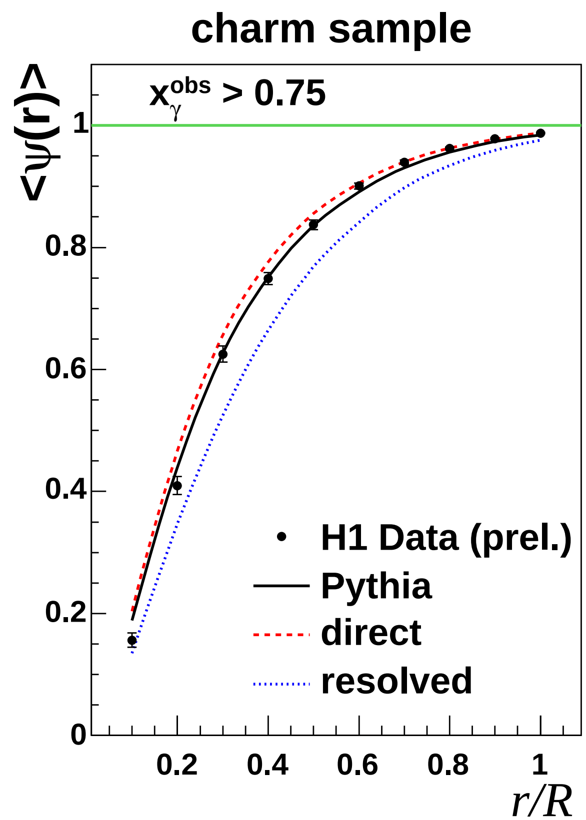
Jet Shape - Detector Level Measurement

Fraction of E_γ entering the hard interaction:

$$x_\gamma^{obs} = \frac{\sum_{jet1,2}(E-p_z)}{\sum_{HFS}(E-p_z)}$$



resolved enhanced



direct enhanced

Pythia: DGLAP evolution

gen. in massles mode (excitation $\sim 35\%$)

Fragm.: lund string and Peterson ($\epsilon = 0.058$)

proton: CTEQ5L
photon: GRV-LO

Data suggest less gluon jets at low x_γ

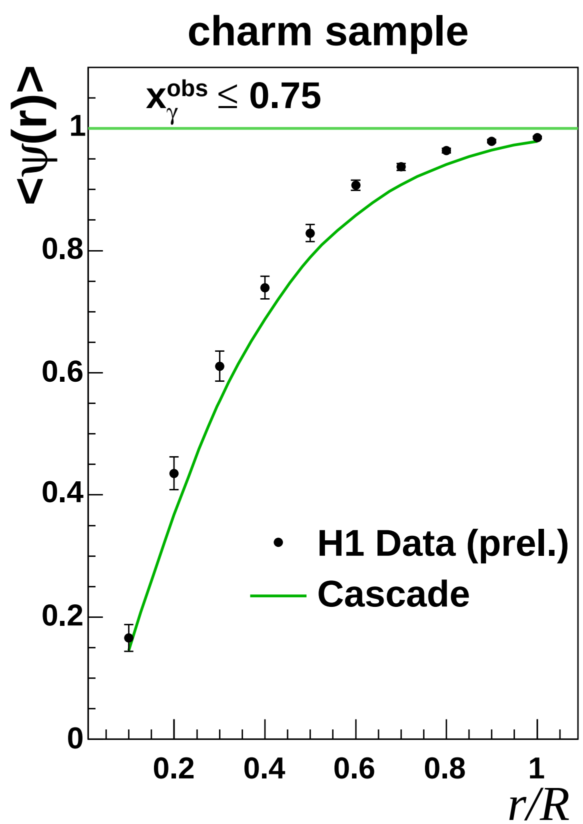
Jet Shape - Comparison to Other Models

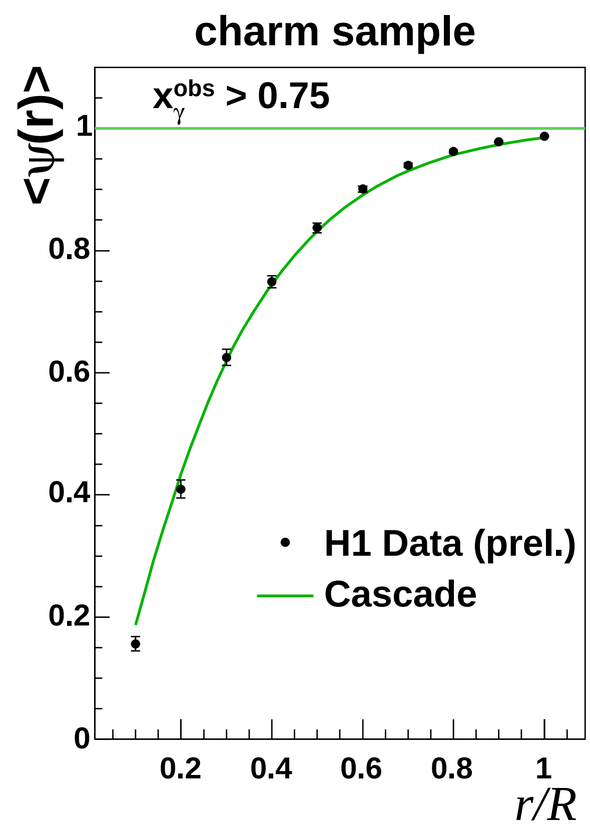
Cascade: version 1.0
- CCFM evolution
- k_t factorization
- unintegrated PDF
- off-shell matrix elemen

<u>Further checks:</u>

no multiple interactions: small change

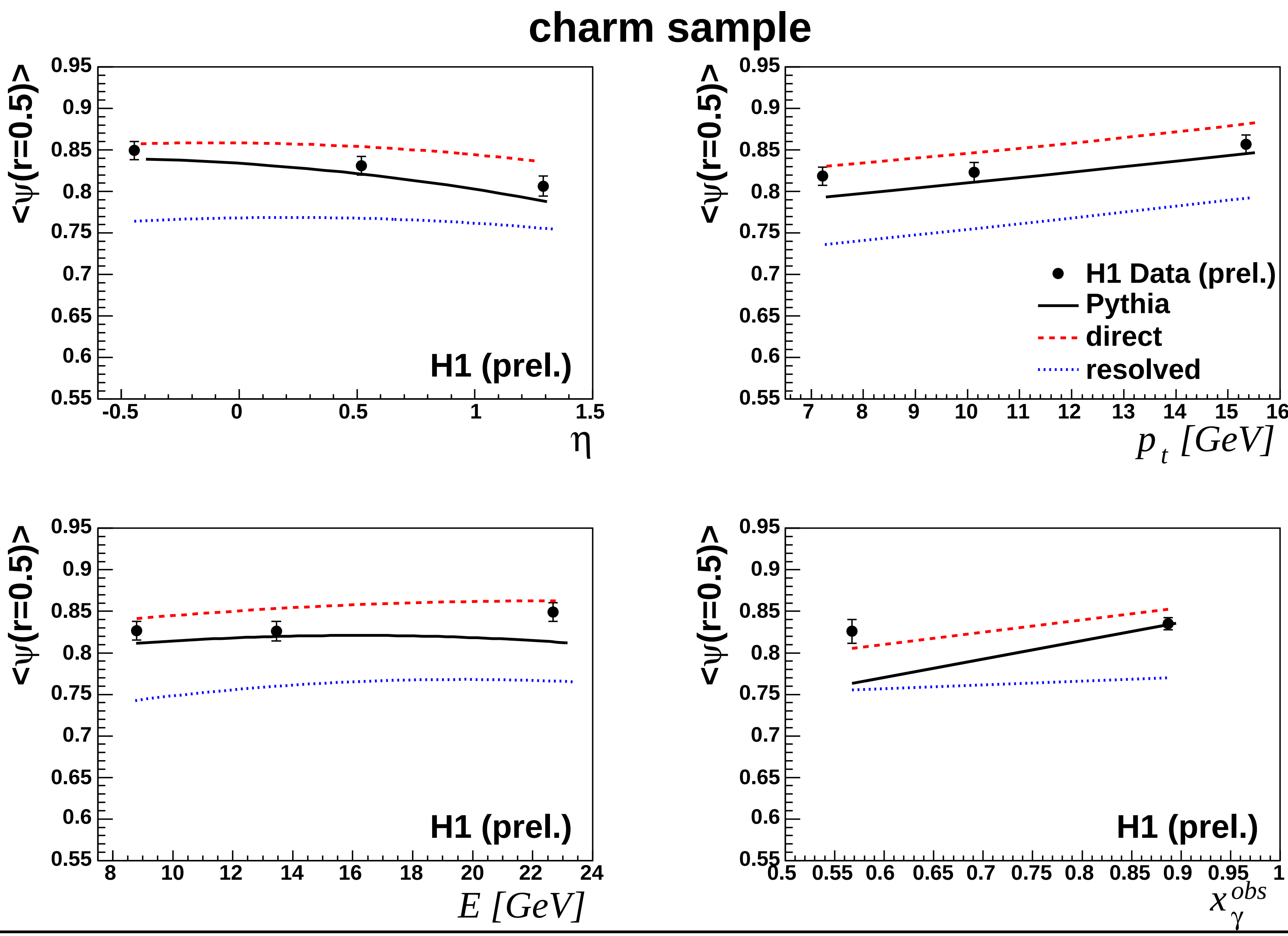
Fragmentation parameter: no change



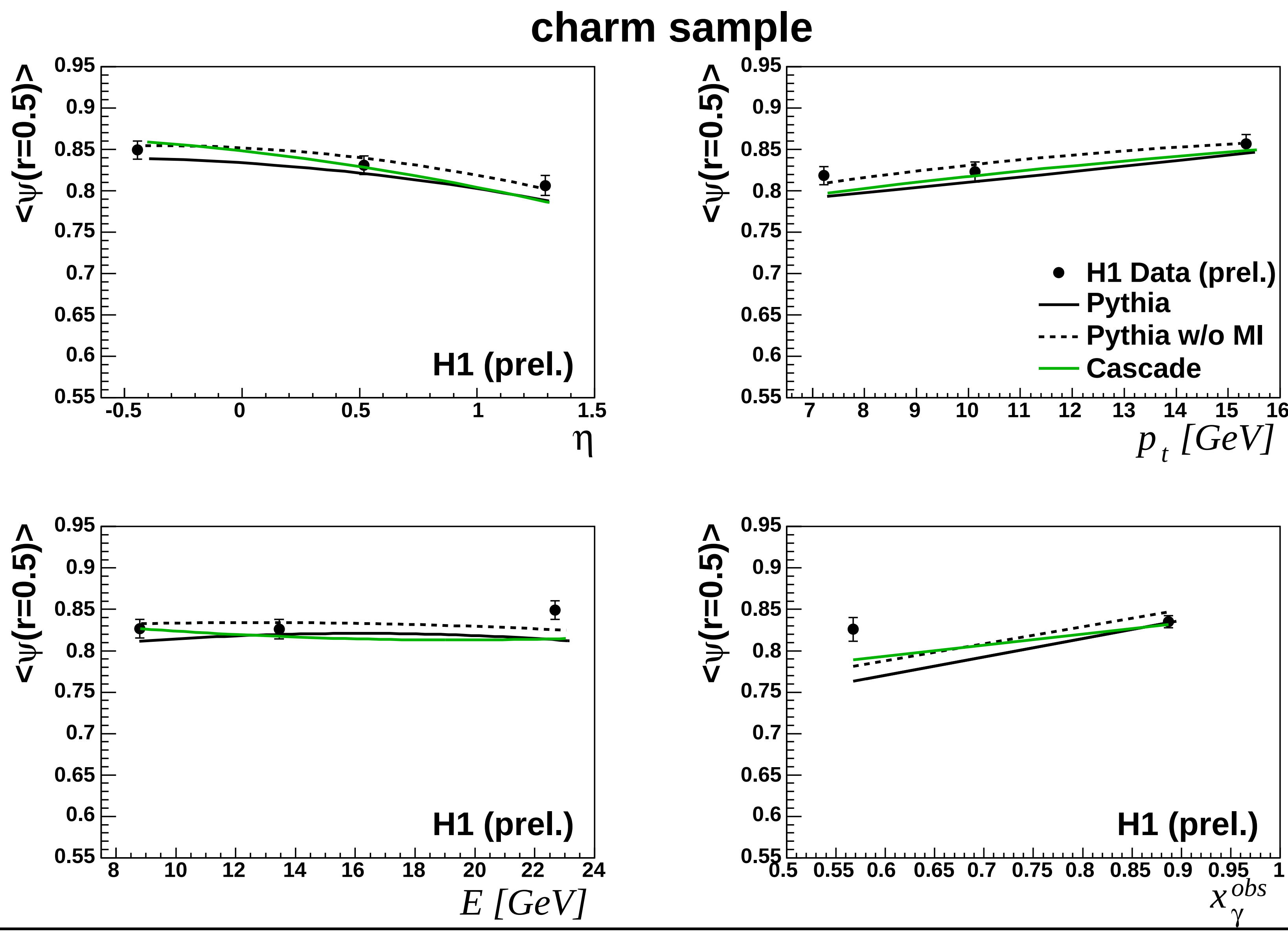


At low x_γ Cascade closer to the data than Pythia
Marginally worse at high x_γ

Charm: Dependences of Jet Shape



Charm: Different models

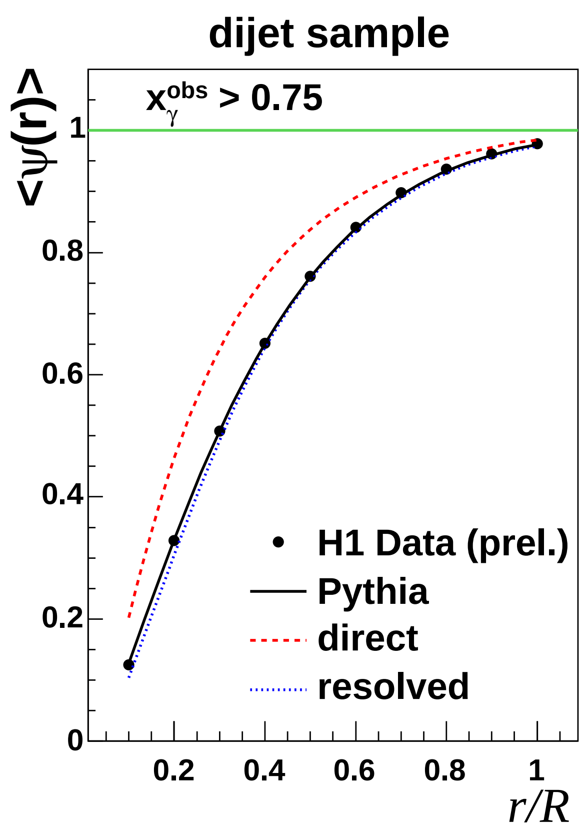


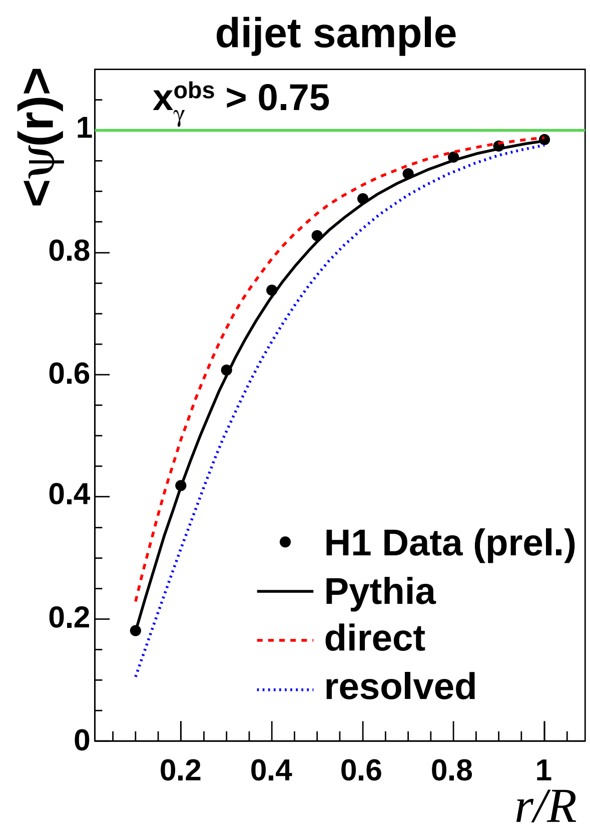
Jet Shapes for Dijets in Photoproduction

Data: H1 e^+ 99/00

Selection cuts:

- $Q^2 < 0.01GeV^2$
- $0.3 < y < 0.65$
- 2 jets (incl. k_t alg.)
- $p_t^{jet} > 7(6)$ GeV
- $20° < \Theta^{jet} < 160°$
- analyse both highest pt jets



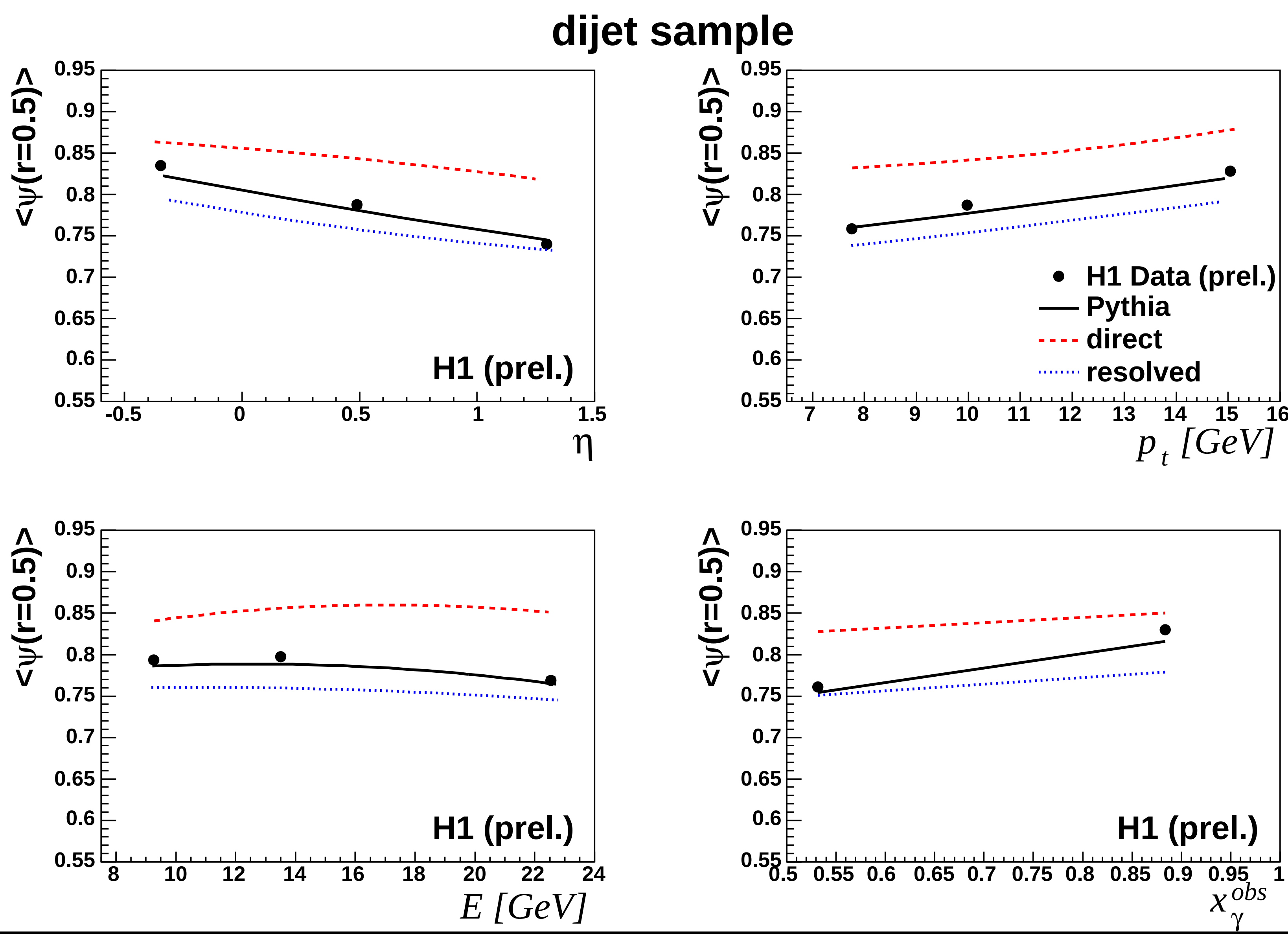


Pythia: incl. γp

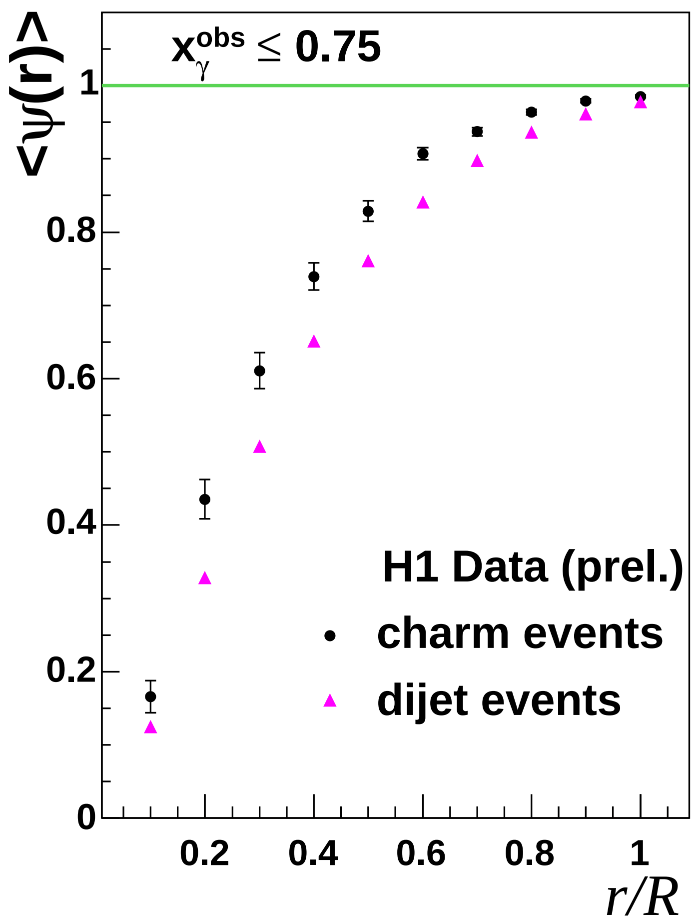
Data described by the MC very well

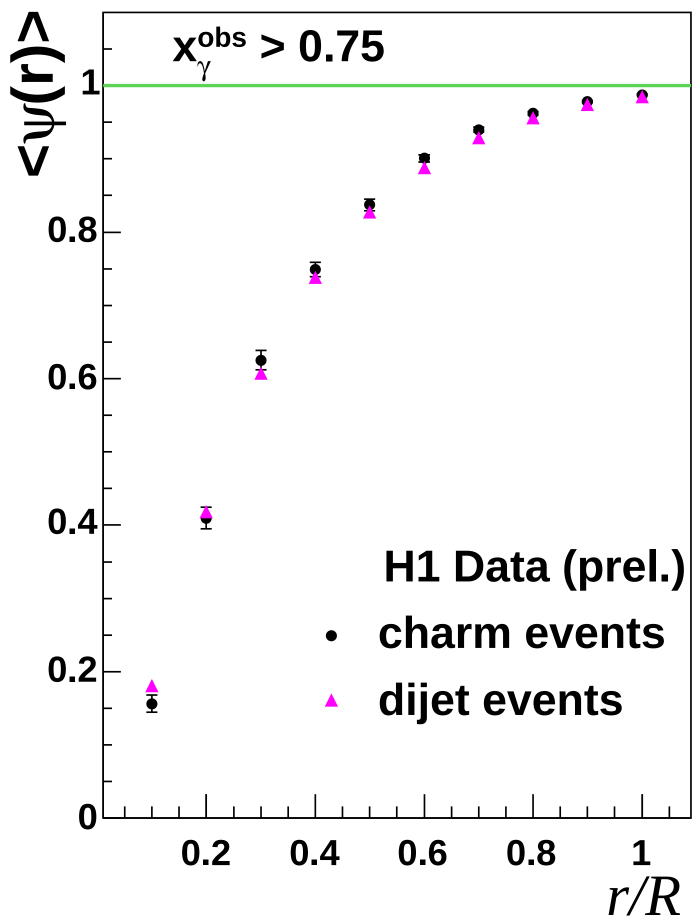
(Detector level)

Dijets: Dependences of Jet Shape



Comparing Charm and Dijet Events





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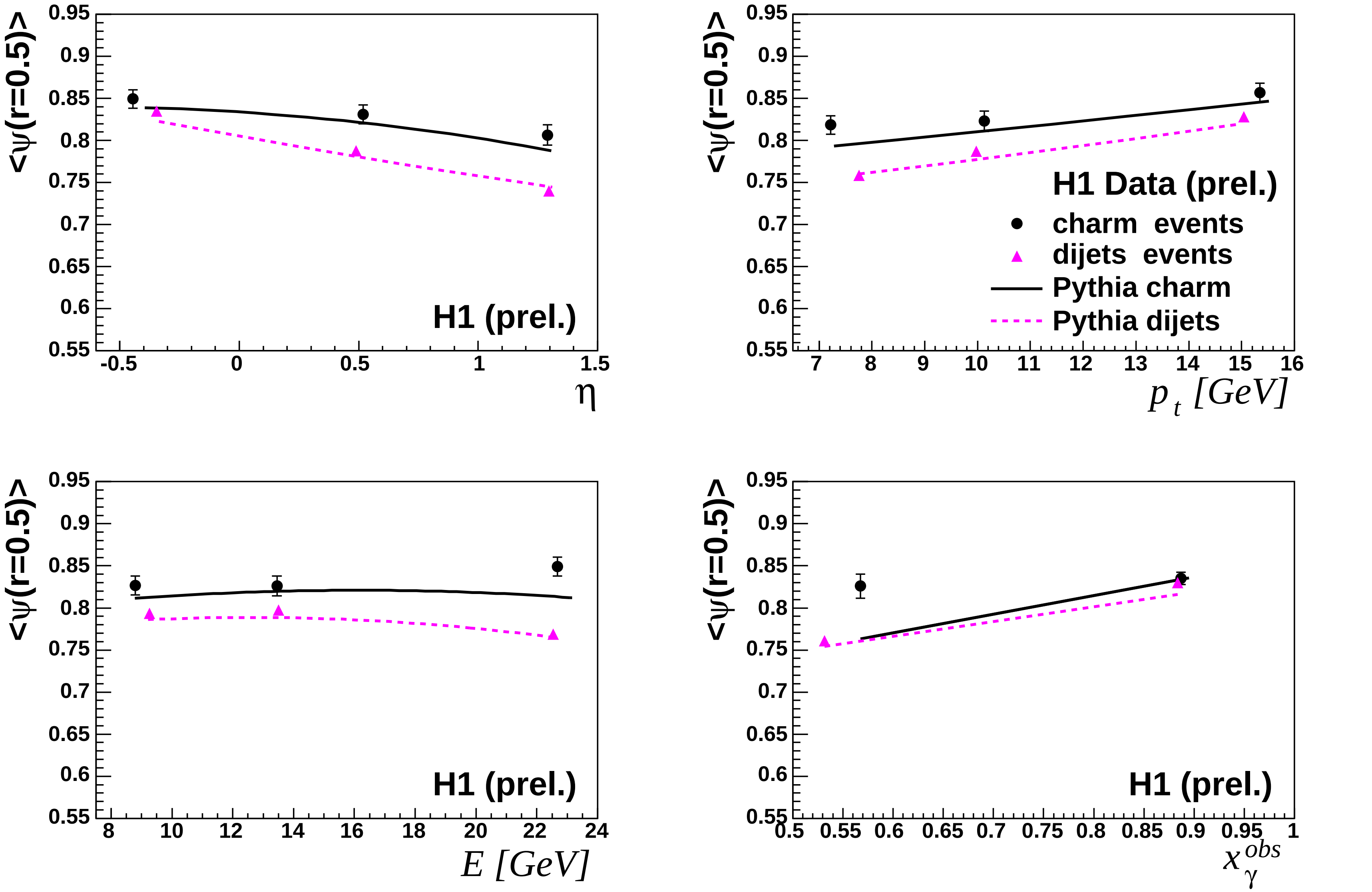


Summary

Jet shapes studied in:

Dijets: ($\sim 75\%$ light quark events)

Charm: ($\sim 70\%$ pure, background corrected)

At high x_γ jet shapes similar $\leftarrow$ direct

At low x_γ jet shapes different $\leftarrow$ resolved

$\rightarrow$ jets from charm events narrower (quark-like)

PYTHIA: Dijets well described everywhere

Charm: deviations at low x_γ (Pythia predicts broader jets)

CASCADE: Somewhat closer to the data

Backup - processes

	Low x_γ^{obs}		Large x_γ^{obs}	
Process	Dijet	Charm	Dijet	Charm
Direct	3	16	43	71
Excit.	57	60	33	17
uds	12	21	7	11
$gg \to gg$	24	–	5	–

Backup - Systematic Studies

CHARM

Source		$\delta\psi_{x_\gamma^{obs}<0.75}$ (%)	$\delta\psi_{total}$ (%)
b fraction	$\pm 20\%$	± 0.35	± 0.20
uds fraction	$\pm 20/50\%$	± 0.9	± 0.30
jet axis	$\phi \pm 2^\circ$, $\theta \pm 0.04$	-0.38	-0.1
Energy scale clusters	$\pm 5\%$	± 0.013	± 0.02
Total sys.		± 1.0	± 0.37
Statist.		± 1.7	± 0.89

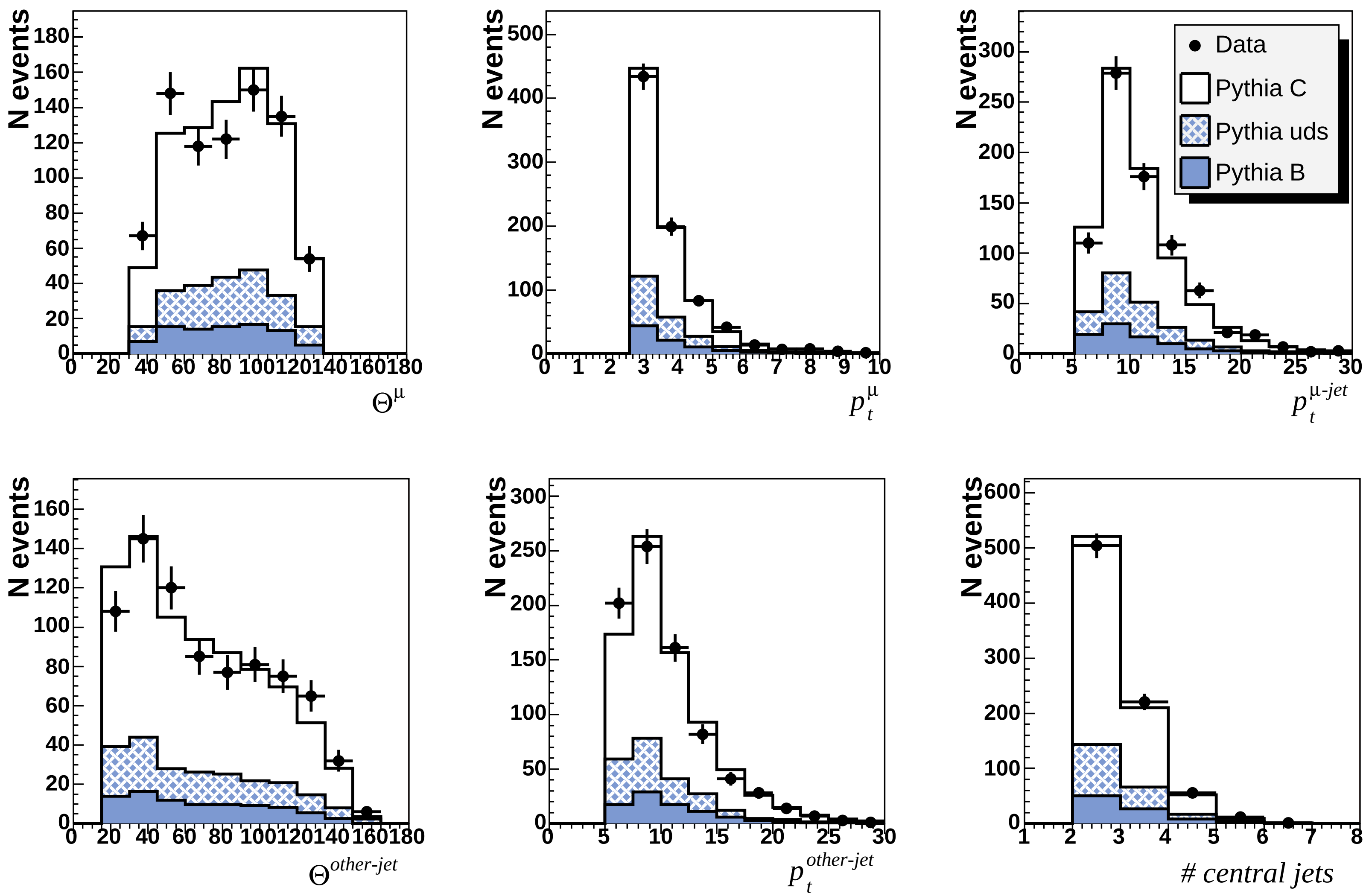
DIJETS

Source		$\delta\psi_{x_\gamma^{obs}<0.75}$ (%)	$\delta\psi_{total}$ (%)
jet axis	$\pm 2^\circ$	-0.53	-0.34
Energy scale clusters	$\pm 5\%$	± 0.02	± 0.02
Total		-0.53	-0.34

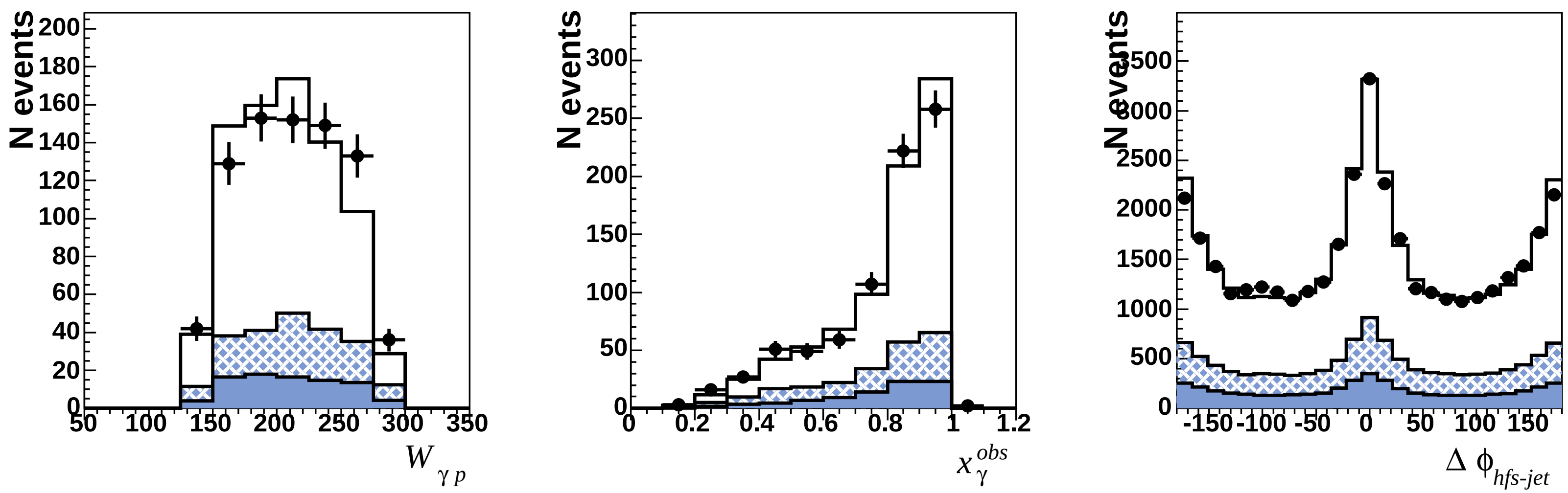
Model Uncertainties:

	$\delta\psi_{x_\gamma^{obs}<0.75}$ (%)	$\delta\psi_{total}$ (%)
PYTHIA no Mult. Int.	$+1.7$	$+1.3$
CASCADE	$+3.3$	~ 0
$\epsilon_{Peters.} \pm \ldots$	~ 0	~ 0

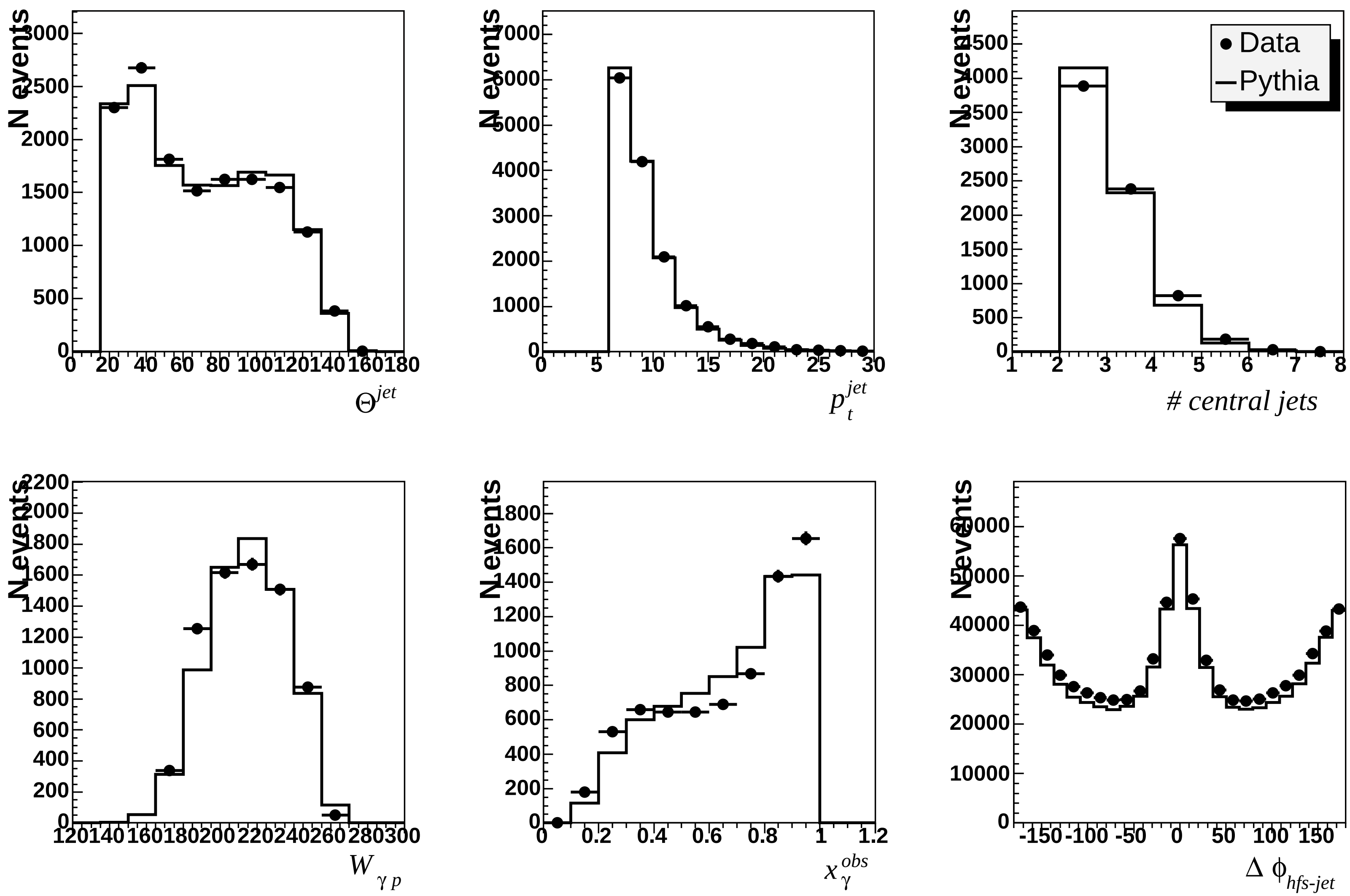
Backup - Charm Control Plots I



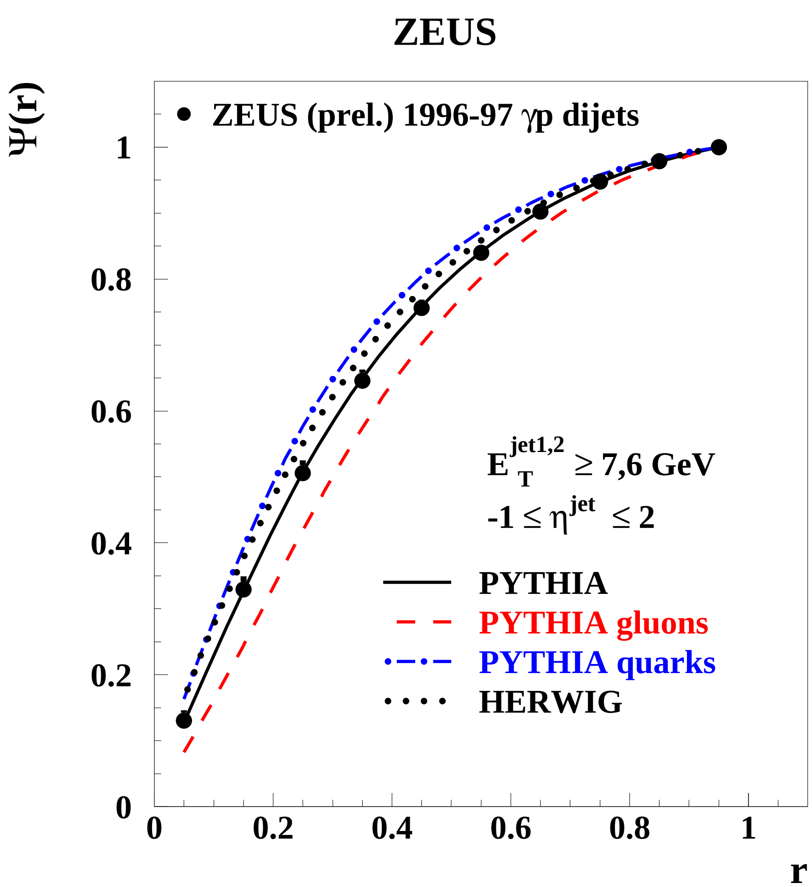
Backup - Charm Control Plots II

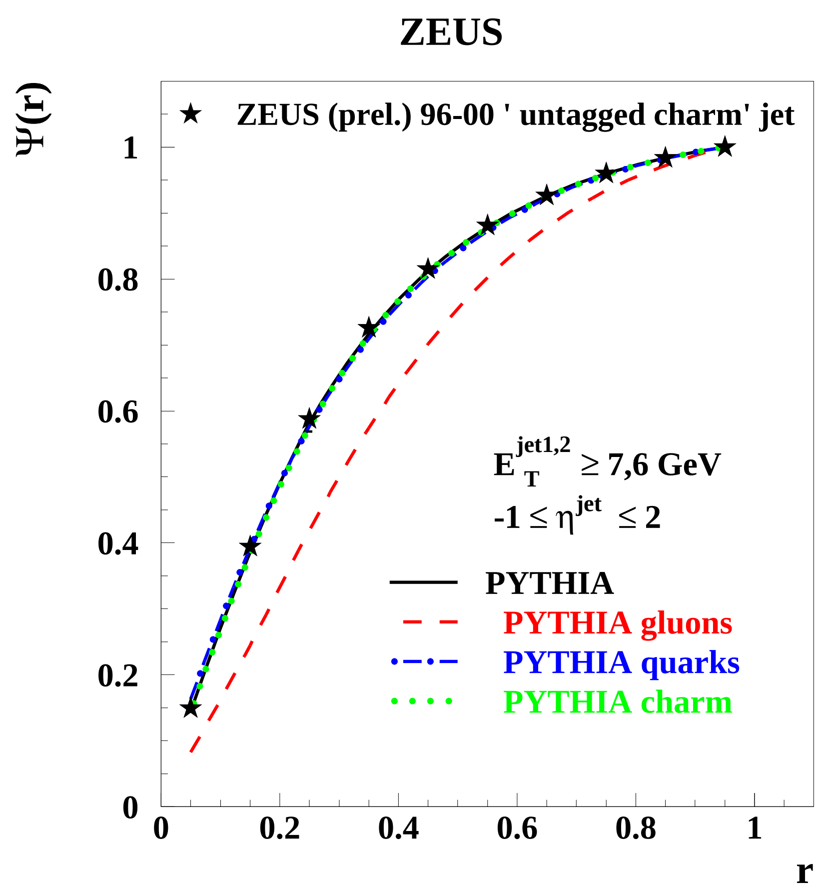


Backup - Control Plots for Dijets



Backup - ZEUS measurement using D^*





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