Jet Shapes using MidPoint

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QCD Meeting 23rd April 2004 (blessing)

Outlook

- Motivation
- Event Selection
- Jet Pt corrections using MC
- Jet Shapes Unfolding
- Systematic Uncertainties
- Results
- Gluon/Quark Contributions

CDF-NOTE 6952 (version 2.0, April 21st)

http://www-cdf.fnal.gov/internal/physics/qcd/shapes/shapes.html

Motivation

- Jet shape dictated by multi-gluon emission form primary parton
- Test of parton shower models and their implementations
- Sensitive to underlying event structure
- Sensitive to quark/gluon final state mixture …and running of strong coupling

Event Selection

- Using MidPoint Algorithm (R=0.7) (merging at 75%)

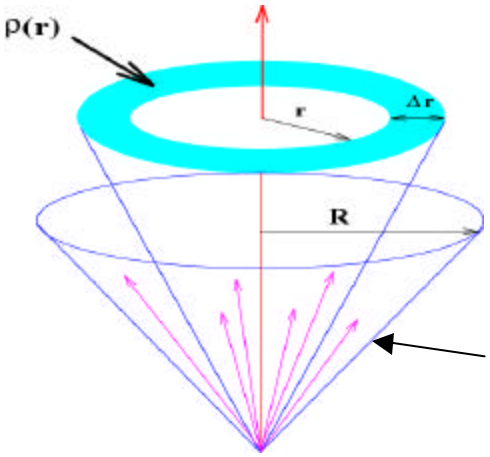
- Using all Jet Data before Shutdown (~170 pb-1)
  - J5 (for Pt > 30 GeV)
  - J20 (for Pt > 45 GeV)
  - J50 (for Pt > 70 GeV)
  - J70 (for Pt > 95 GeV)
  - J100(for Pt > 130 GeV)

  } No trigger bias

- Selection Cuts
  - Good run list 4.0 (QCD no silicon) **run < 166328**
  - At least one central jet (0.1 < |Y| < 0.7) with Pt> 30 GeV
  - MET_significance < 3.5 GeV^-1/2
  - |V_z| < 60 cm
  - N(vxt) = 1

Jet Shape Definition

Differetial Jet Shape



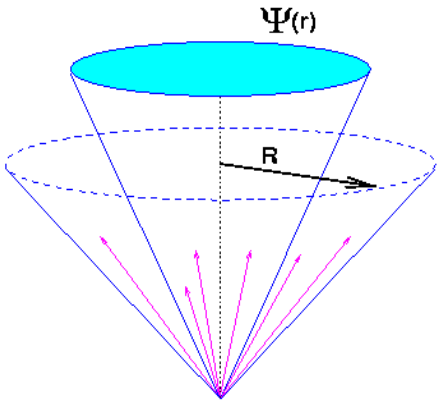
$0.5\,\mathrm{GeV} < P_T^{track} < 100\ GeV$

$|h^{track}| < 1.5$

$|z^{track} - V_z| < 2\,\mathrm{cm}$

$\Delta R(\mathrm{track - jet}) < 0.7$

Integrated Jet Shape Definition



$$r(r) = \frac{1}{\Delta r}\frac{1}{N_{jet}}\sum_{jets}\frac{P_T(r \pm \Delta r/2)}{P_T(0,R)}$$

$$\Psi(r) = \frac{1}{N_{jets}}\sum_{jets}\frac{P_T(0,r)}{P_T(0,R)}$$

$$p(r) = \frac{1}{\Delta r}\frac{1}{N_{jet}}\sum_{jets}\frac{N^{tracks}(r \pm \Delta r/2)}{N^{tracks}(0,R)}$$

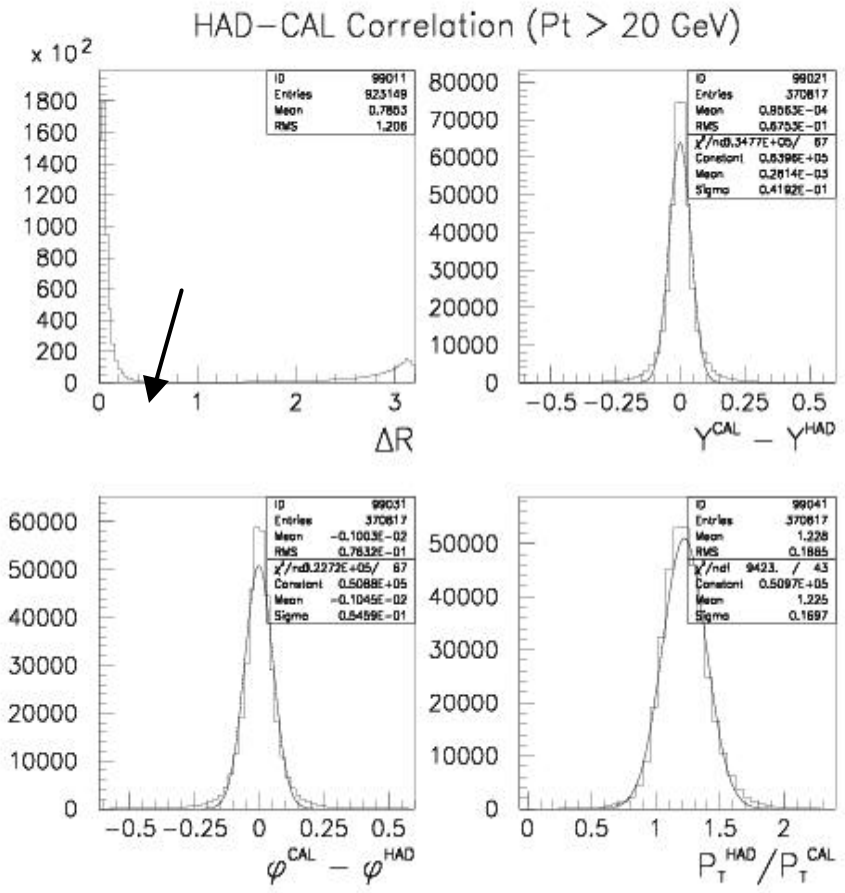
using both CAL and COT

Jet Energy Correction

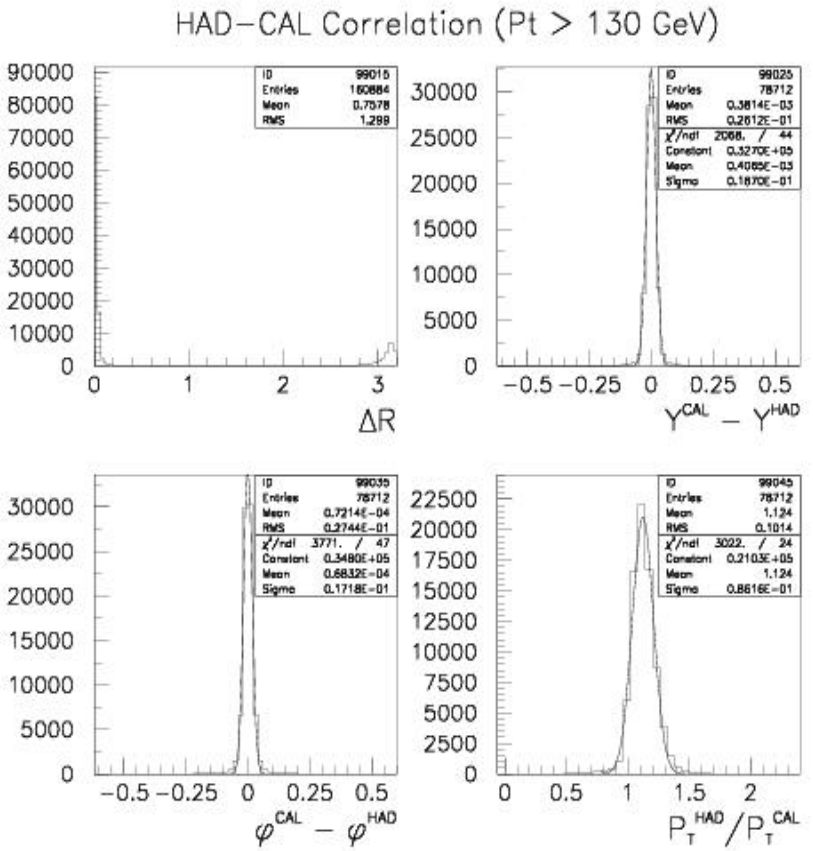
- We intend to use the MC simulation to extract corrections to the hadron level
  - Run MidPoint at CAL and Particle Levels
  - Matching of pairs of leading jets (Y-phi)
  - Fit correlation HAD % CAL
- Be careful with choosing thresholds !
- Apply correction factor to data jet pt's….

…Matching jets….

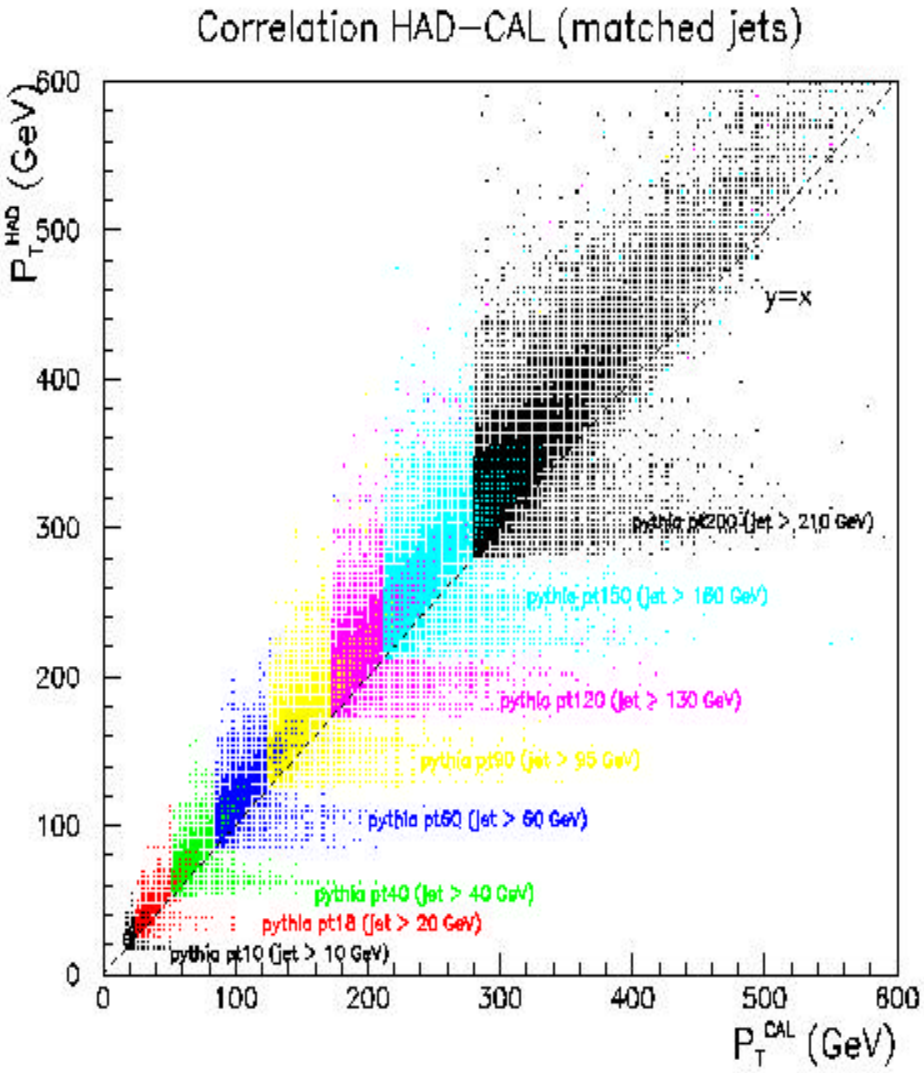
Pythia 18

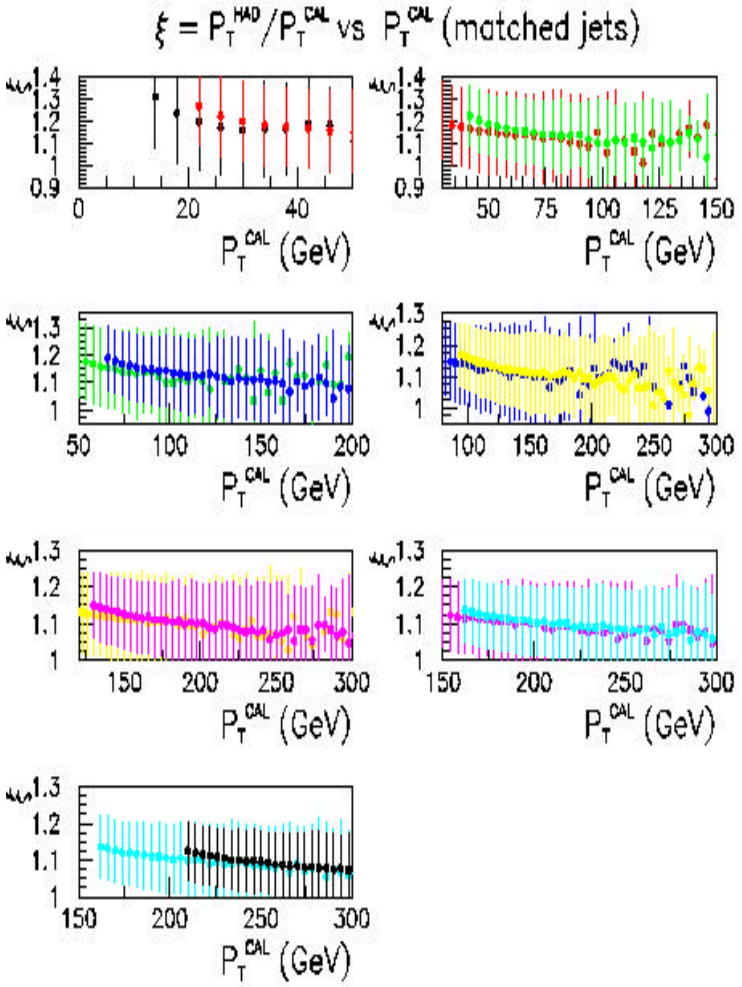


Pythia 120

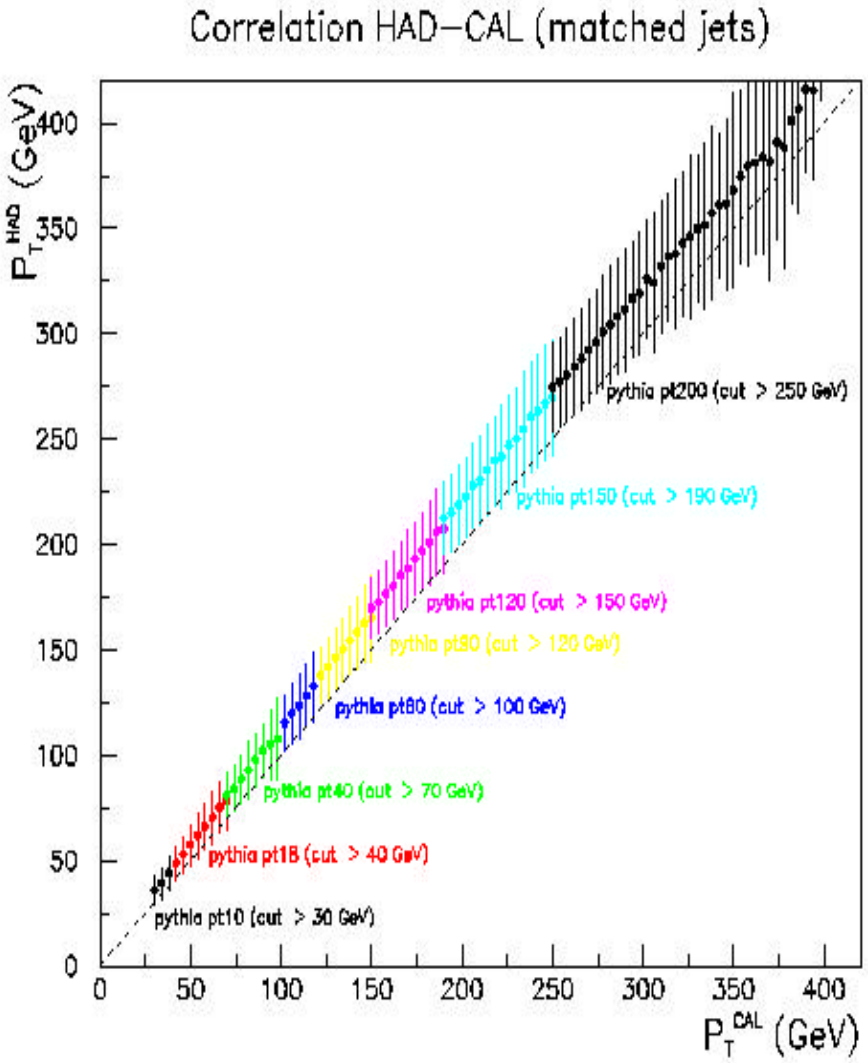


HAD-CAL Correlations (Ia)

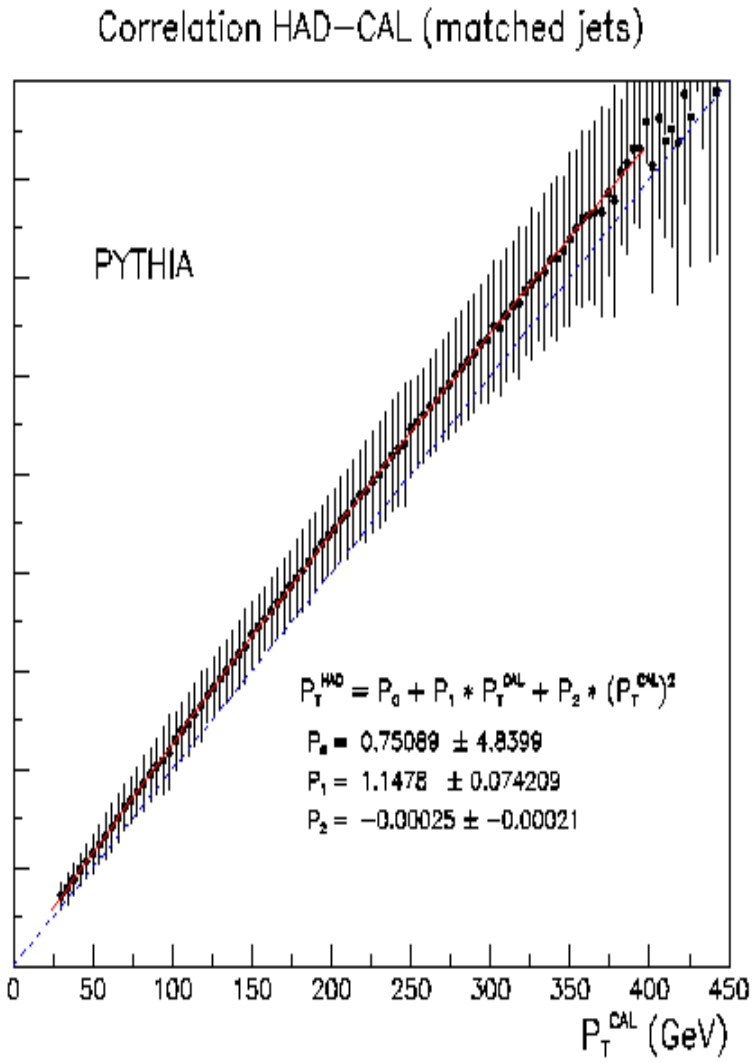




HAD-CAL Correlations (Ib)



pt10 used to validate pt18 GeV



…function applied to data..

Pt - Binning

Jet Pt range (GeV)	Data Sample	MC pt hard (GeV)
37-45	ST5	18
45-55	ST5	18
55-63	J20	18
63-73	J20	18
73-84	J20	18
84-97	J50	40
97-112	J50	40
112-128	J70	60
128-148	J70	60
148-166	J70	90
166-186	J100	90
186-208	J100	120
208-229	J100	120
229-250	J100	150
250-277	J100	150
277-304	J100	200
304-340	J100	200
340-380	J100	200

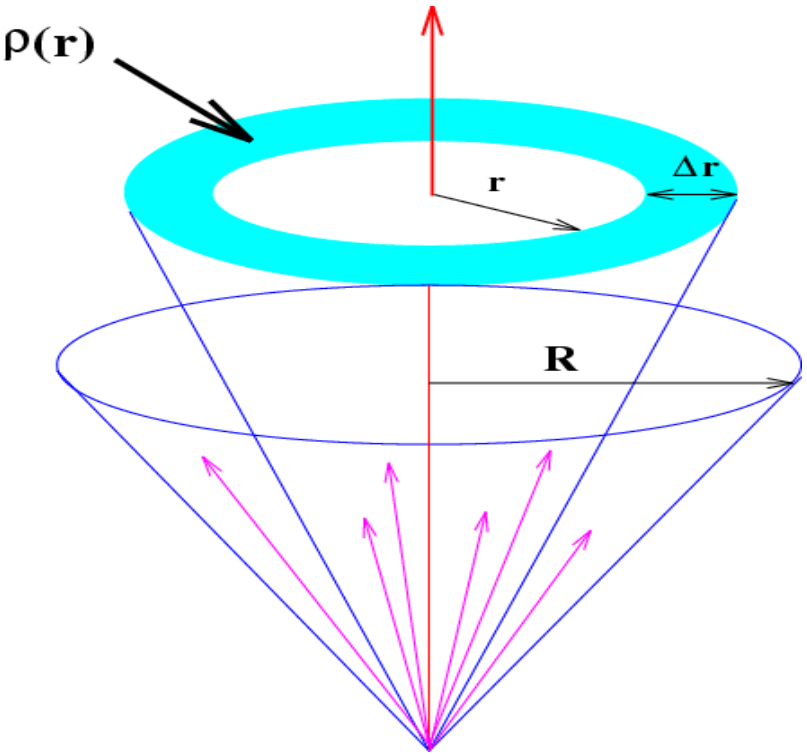
Bin sizes according to resolution....and very safe selection of MC thresholds

Unfolding Procedure

- Bin-by-bin unfolding correction extracted from MC Pythia

$$C(r, P_T^{jet}) = \frac{r^{\,\mathrm{det}ector}(r, P_T^{jet}(cal\ \mathrm{corrected}))}{r^{\,hadrons}(r, P_T^{jet}(hadron\,\mathrm{level}))}$$

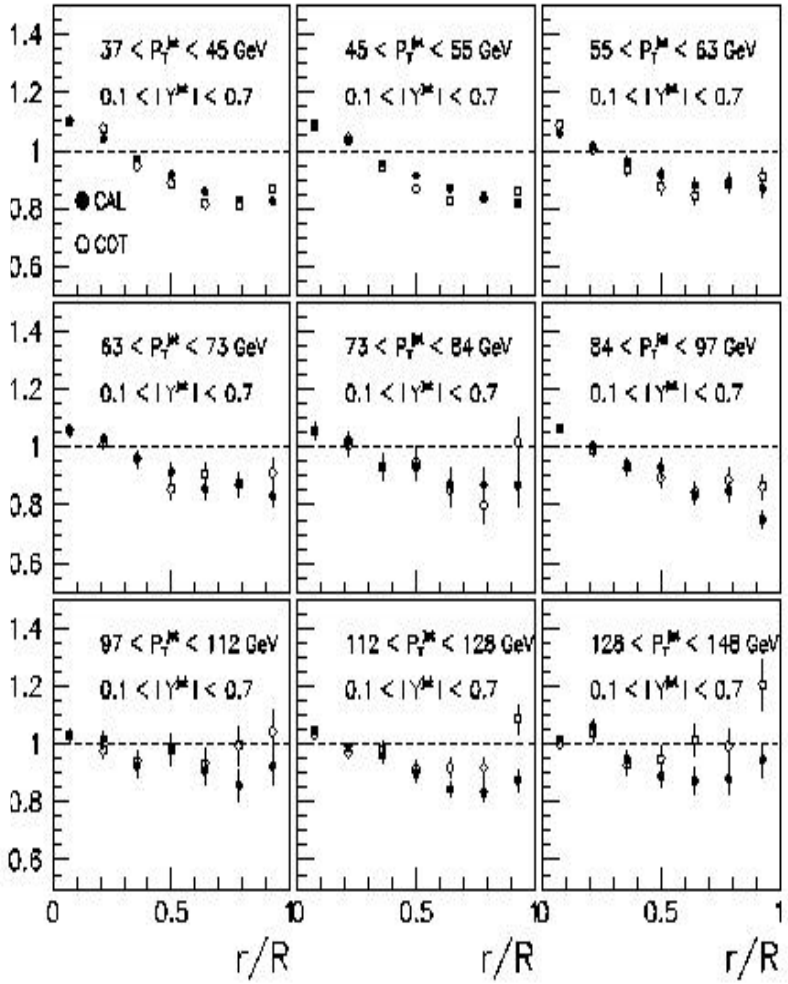
- Jets and jet shapes reconstructed at particle level from HEPG stable particles and using MidPoint Algorithm



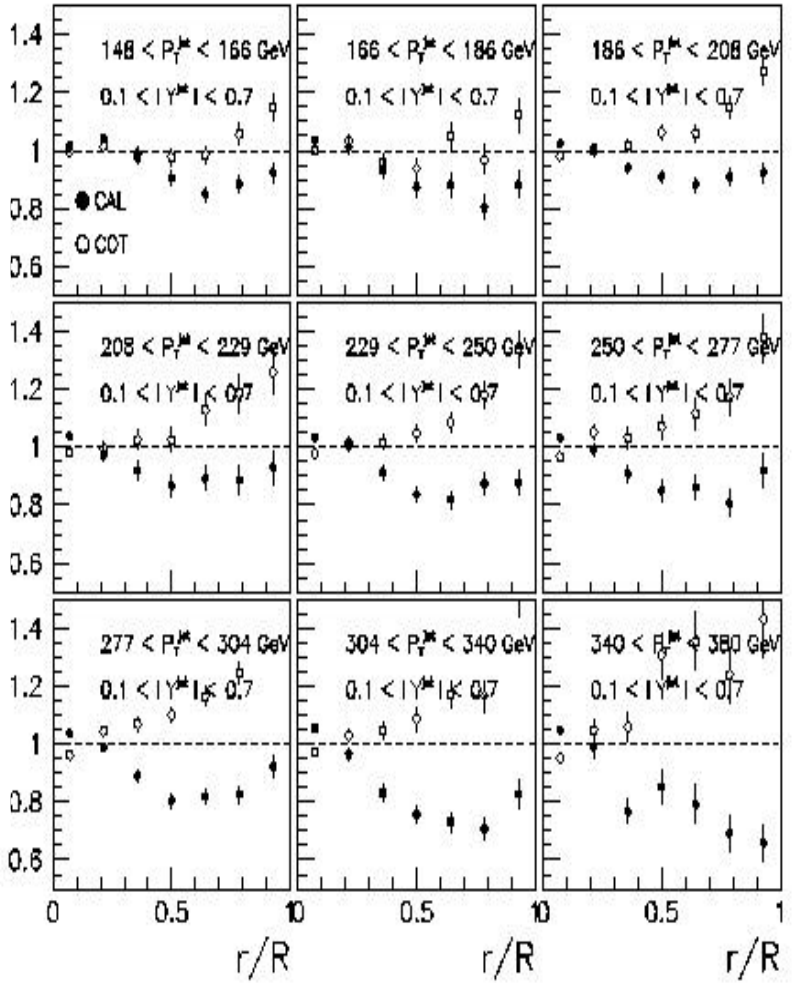
$$r(r) = \frac{1}{\Delta r}\frac{1}{N_{jet}}\sum_{jets}\frac{P_T(r \pm \Delta r/2)}{P_T(0,R)}$$

Corrections to hadron Level (I)

Det/Had correction to hadron level (pythia)



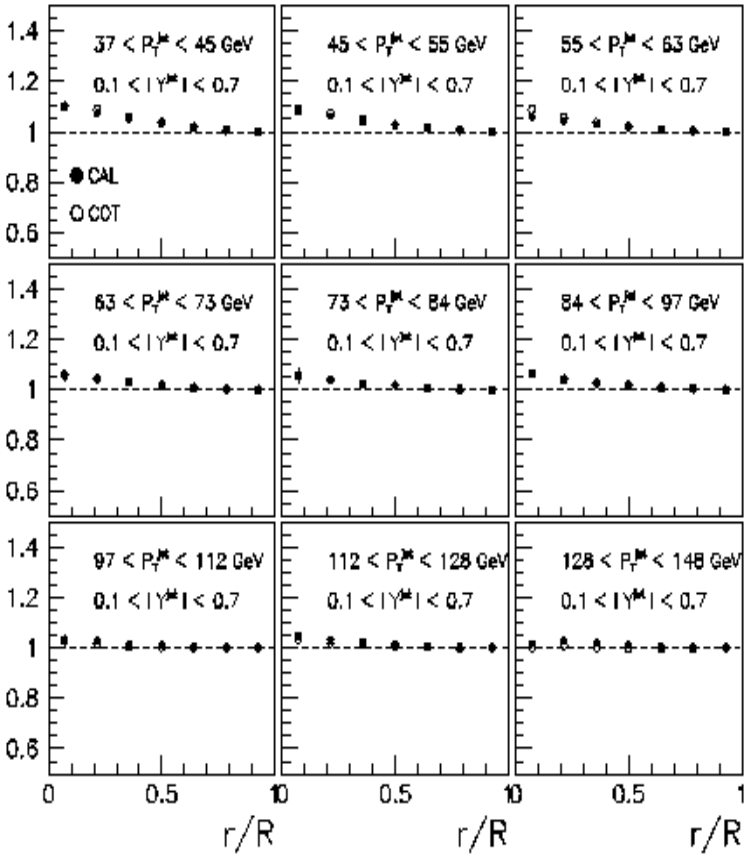
Det/Had correction to hadron level (pythia)



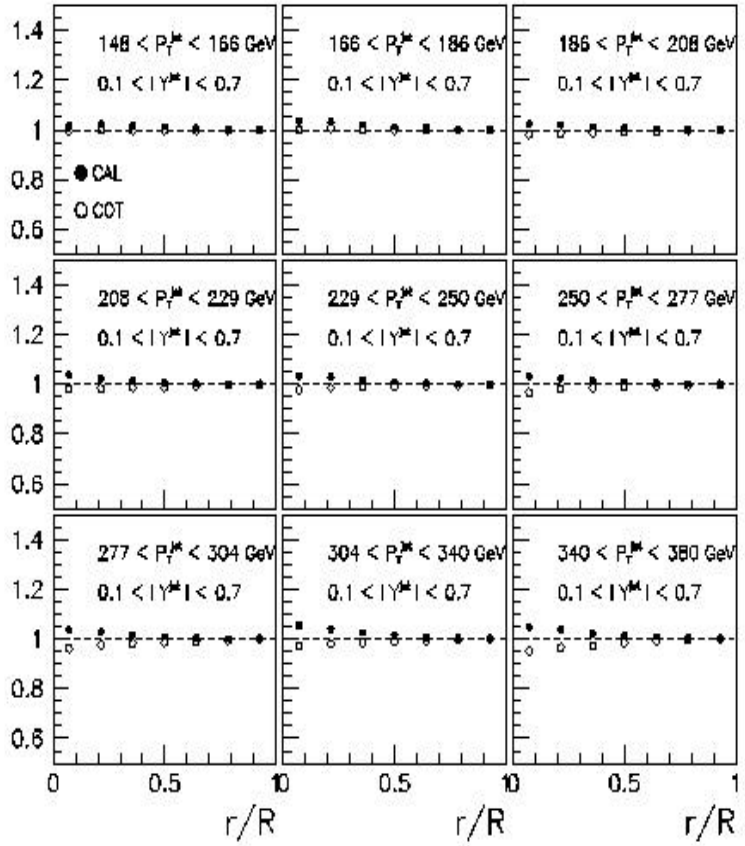
…lost of track efficiency at very high Pt…

Correction to hadron level (II)

Det/Had correction to hadron level (pythia)



Det/Had correction to hadron level (pythia)

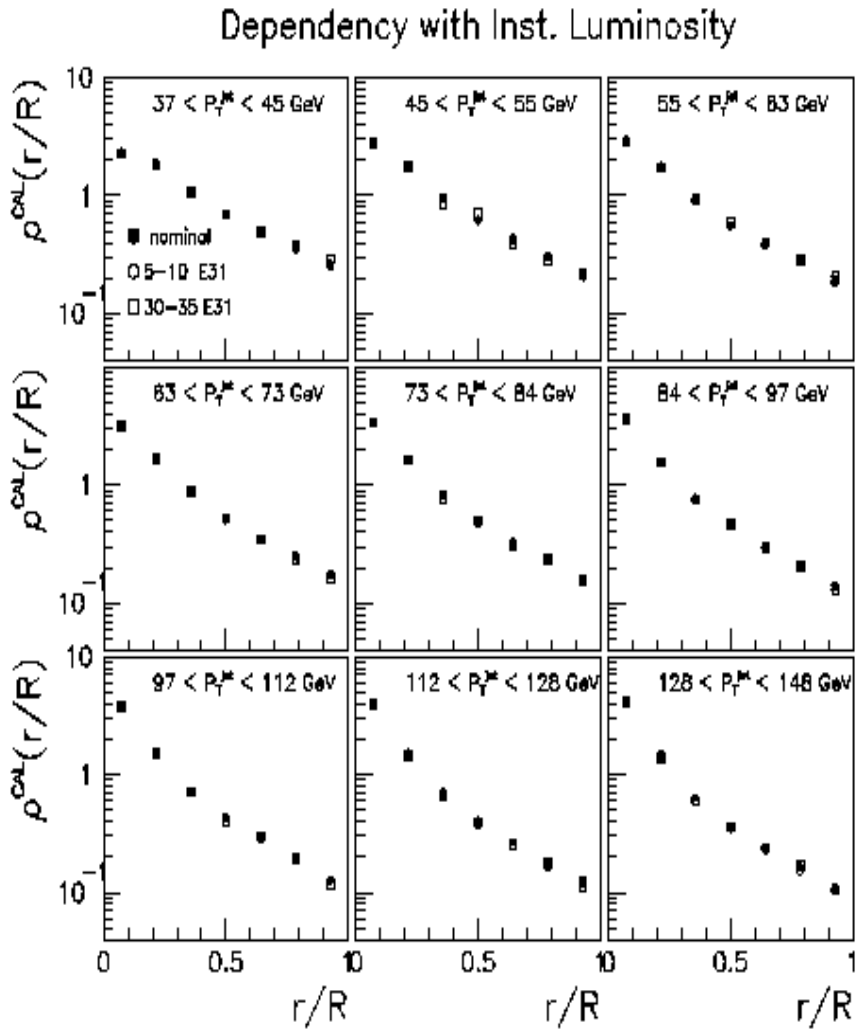


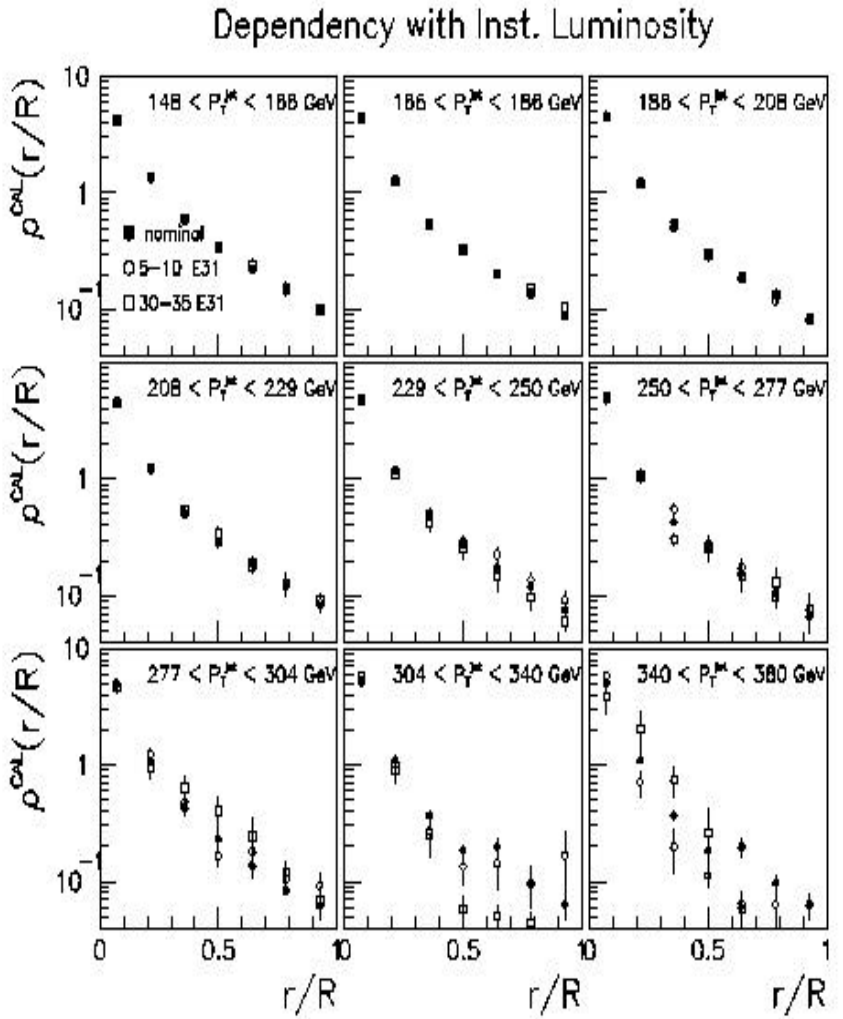
Corrections go to 1 at r=1 by definition….

Systematic Uncertainties

- Instantaneous Luminosity
  - Investigate possible dependence on Inst. Lumi (possible remaining effects on pile-ups ?)
- Jet Energy Scale:
  - 5% variation on measured jet energy
- Parton Shower Modeling
  - Unfolding using Herwig instead of Pythia
- CDF Simulation
  - Compute CAL/COT ratio of raw measurements and compare it with CAL/COT ratio in MC…if double ratio is not = 1 → included in systematics

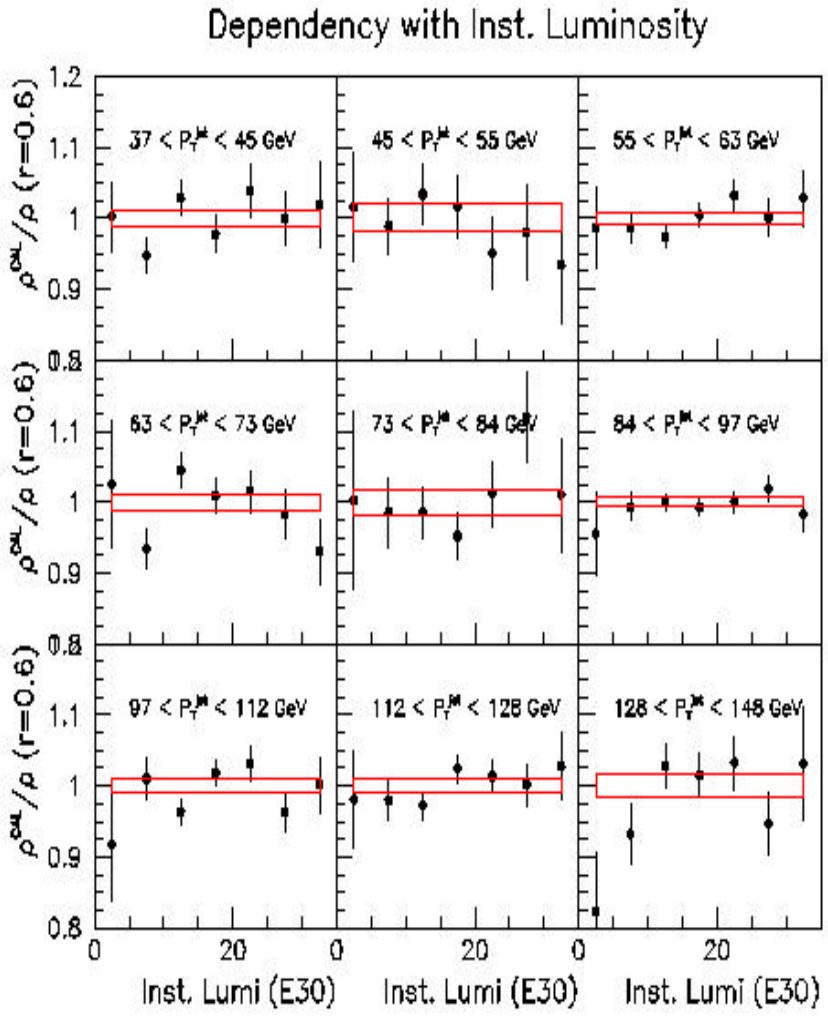
Inst. Luminosity Study (I)

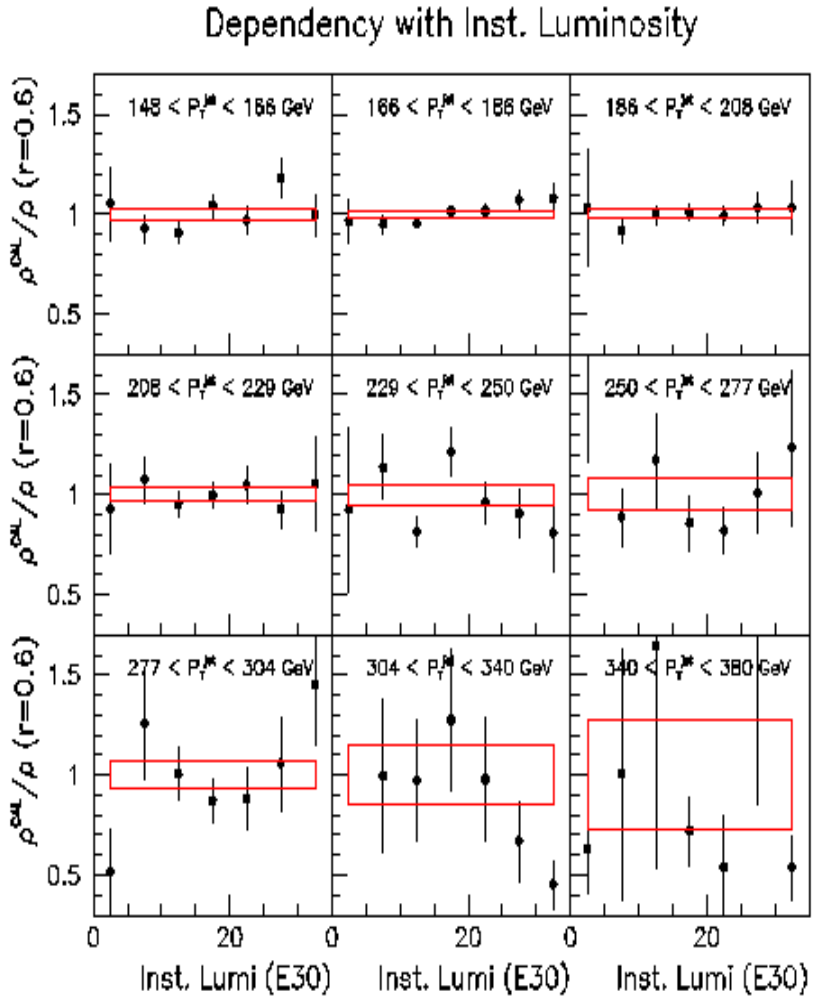




Points at tails …in principal sensitive to pedestals due to pile-ups..

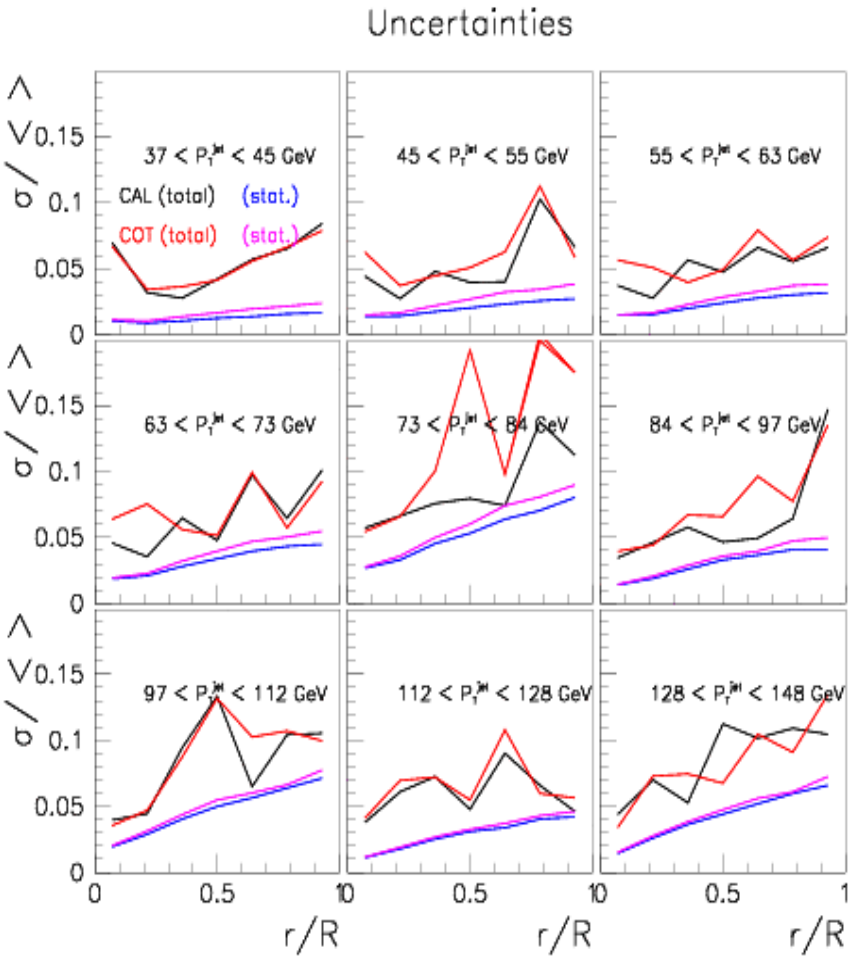
Inst. Luminosity Study (II)

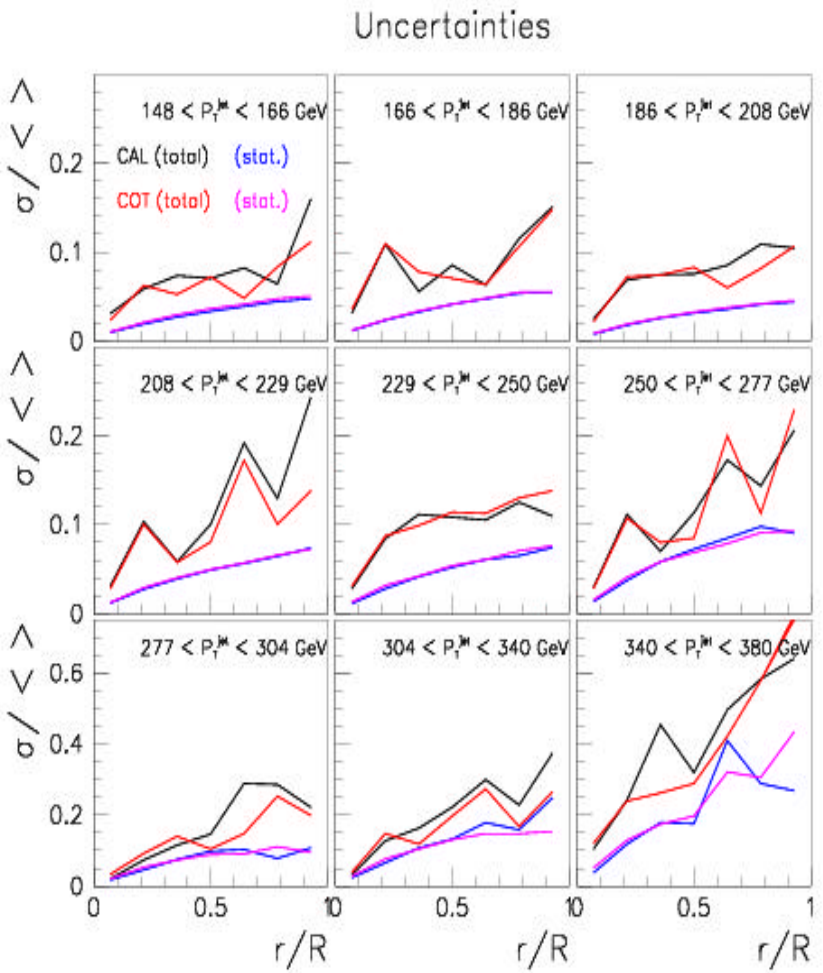




No systematic trend found ….no remaining effects from pile-ups..

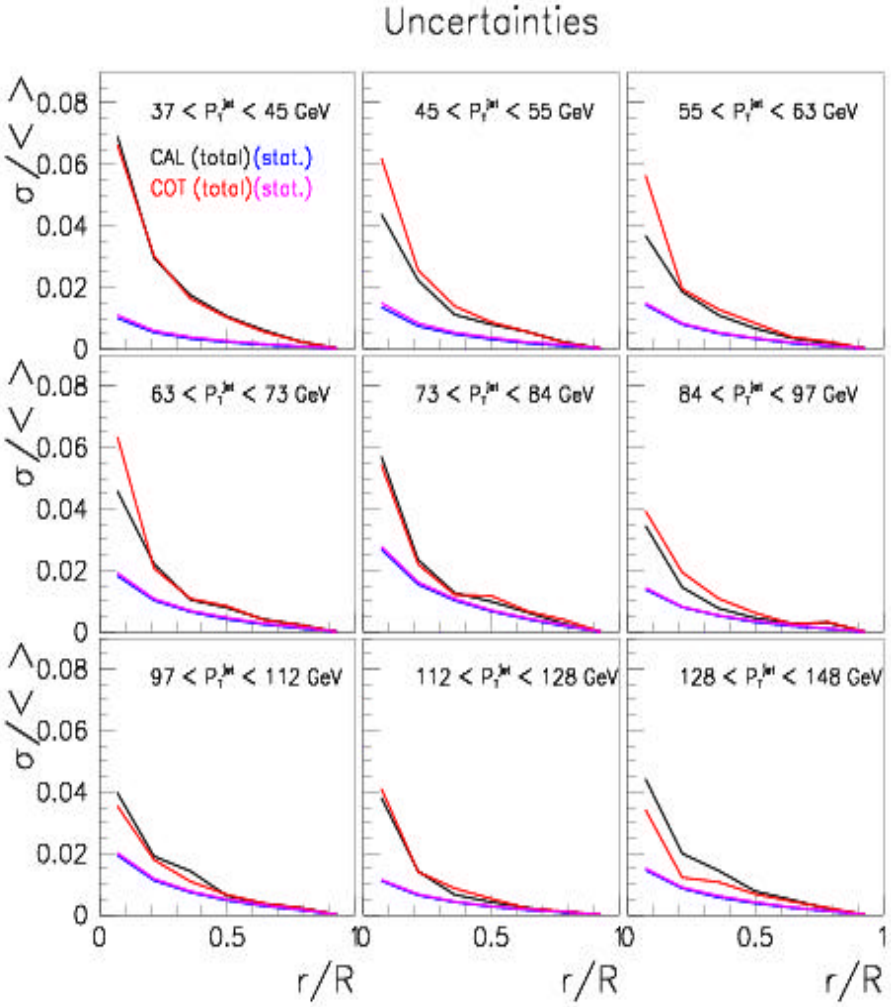
Total Uncertainty on ρ(r)

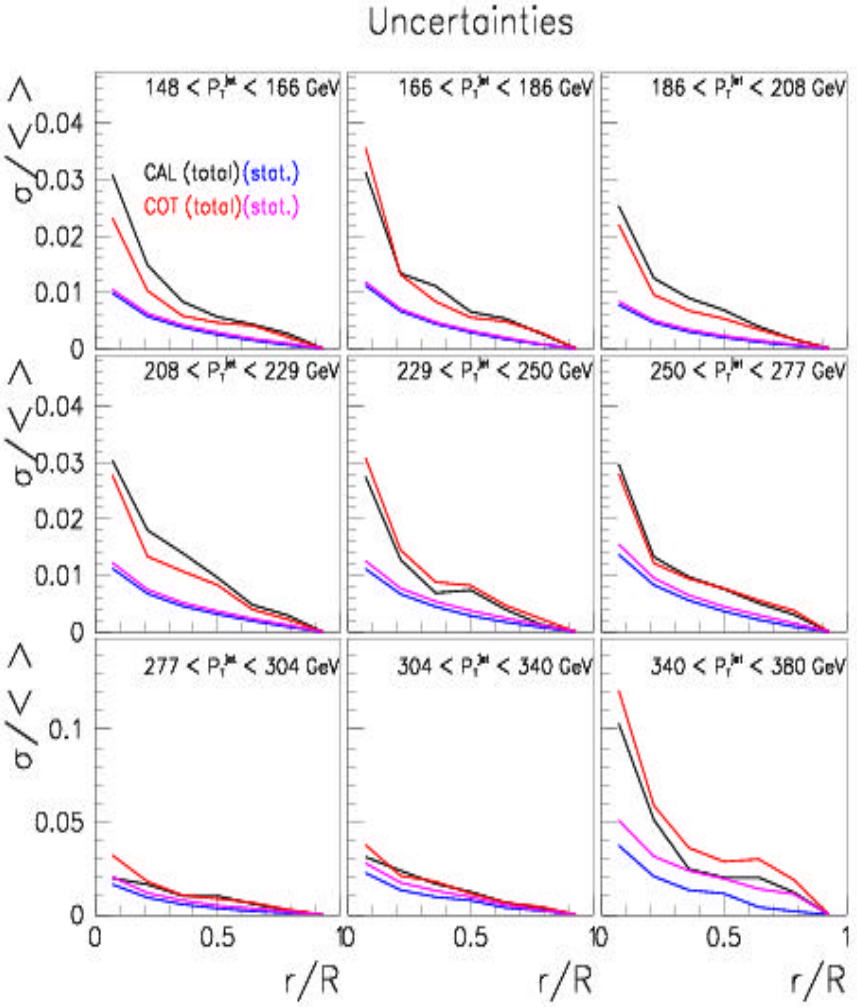




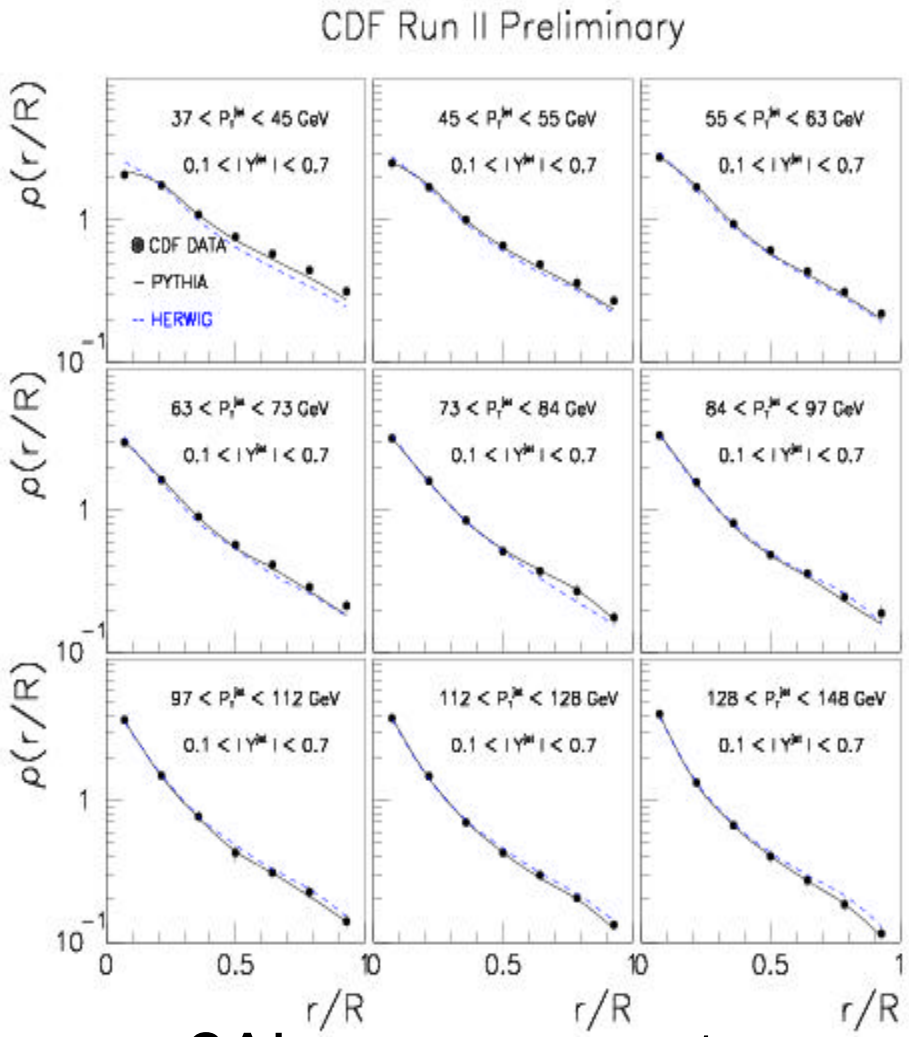
…sensitive to Herwig MC statistics…

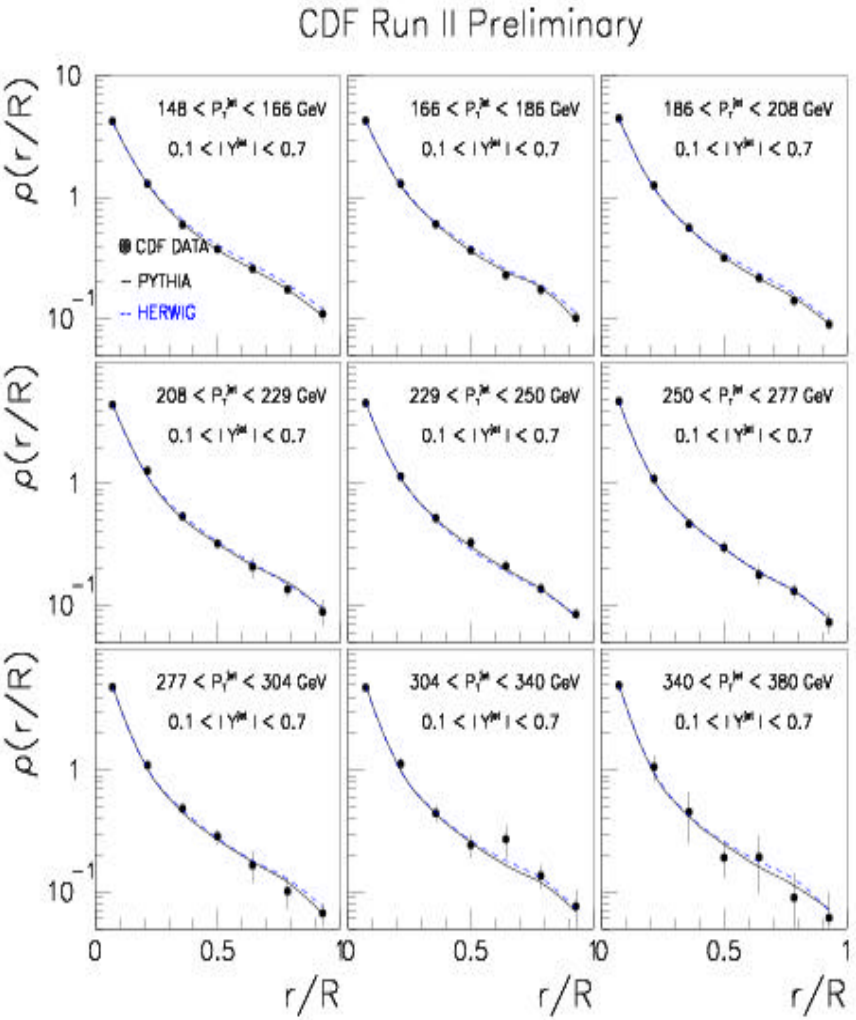
Total Uncertainty for $\Psi(r)$





Results for Blessing (I)



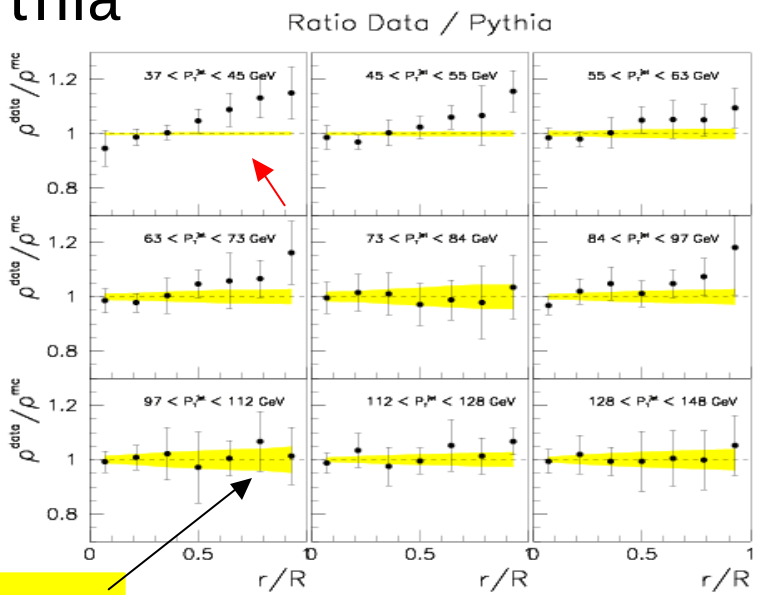


…CAL measurements presented for blessing….

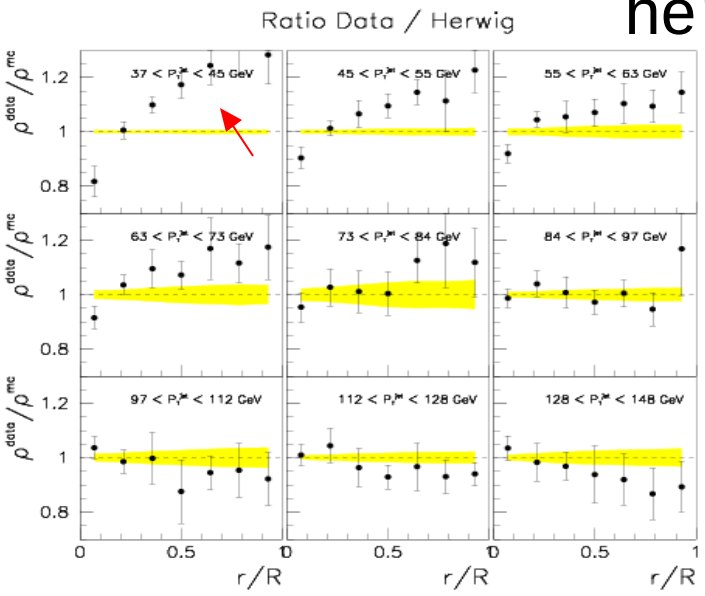
DATA/MC plots

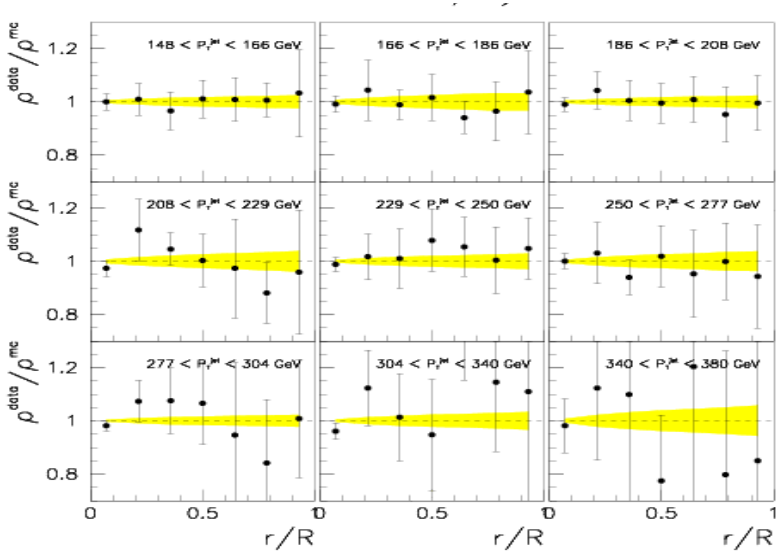
pythia

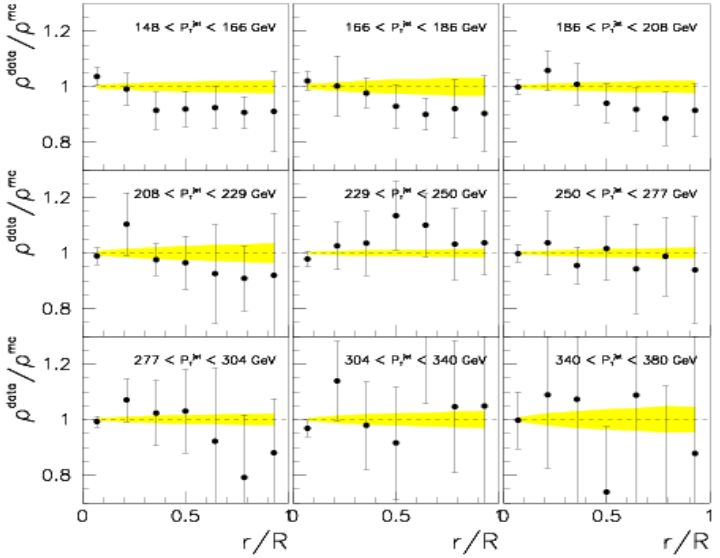
herwig



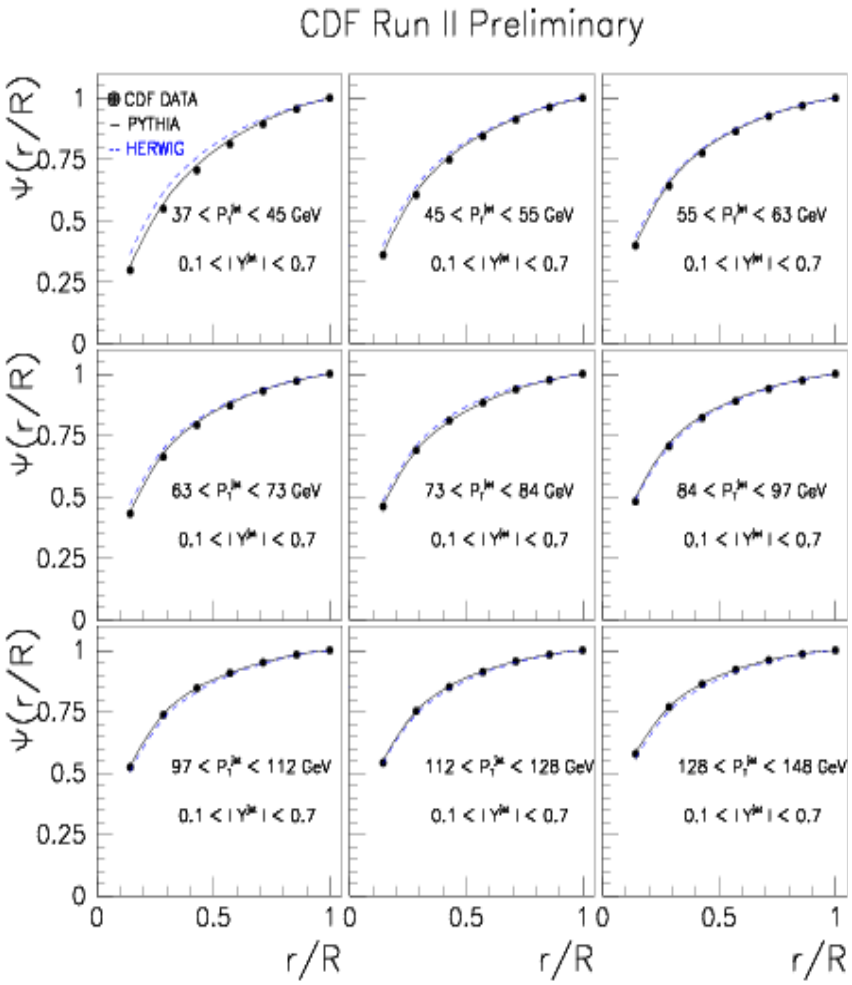
MC error

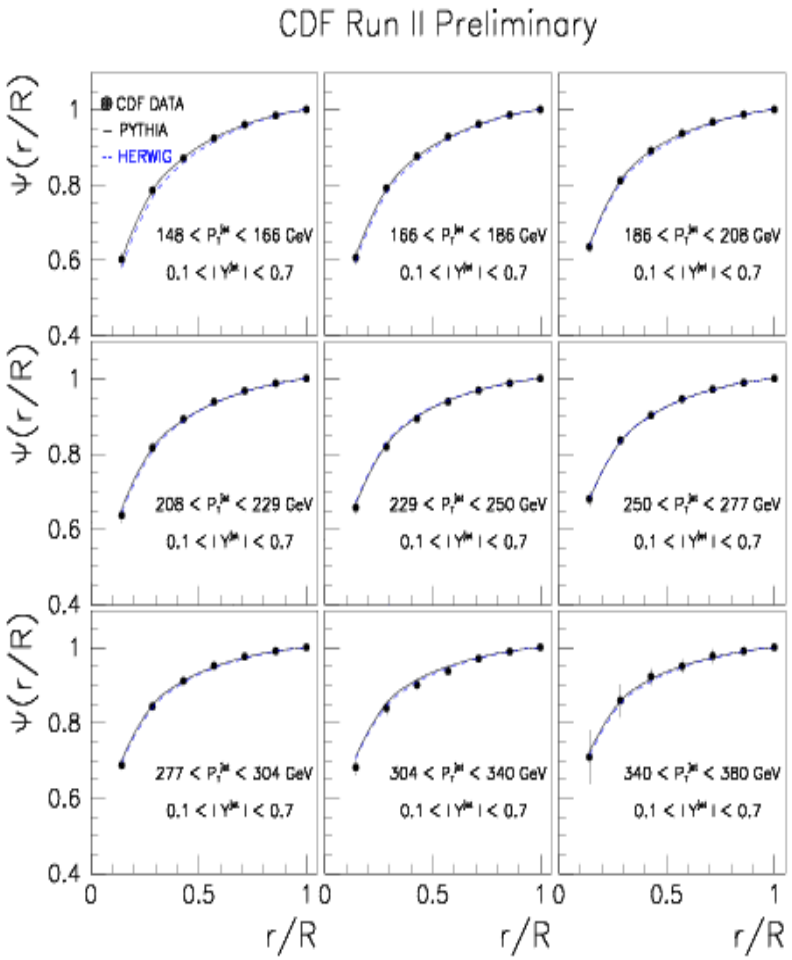






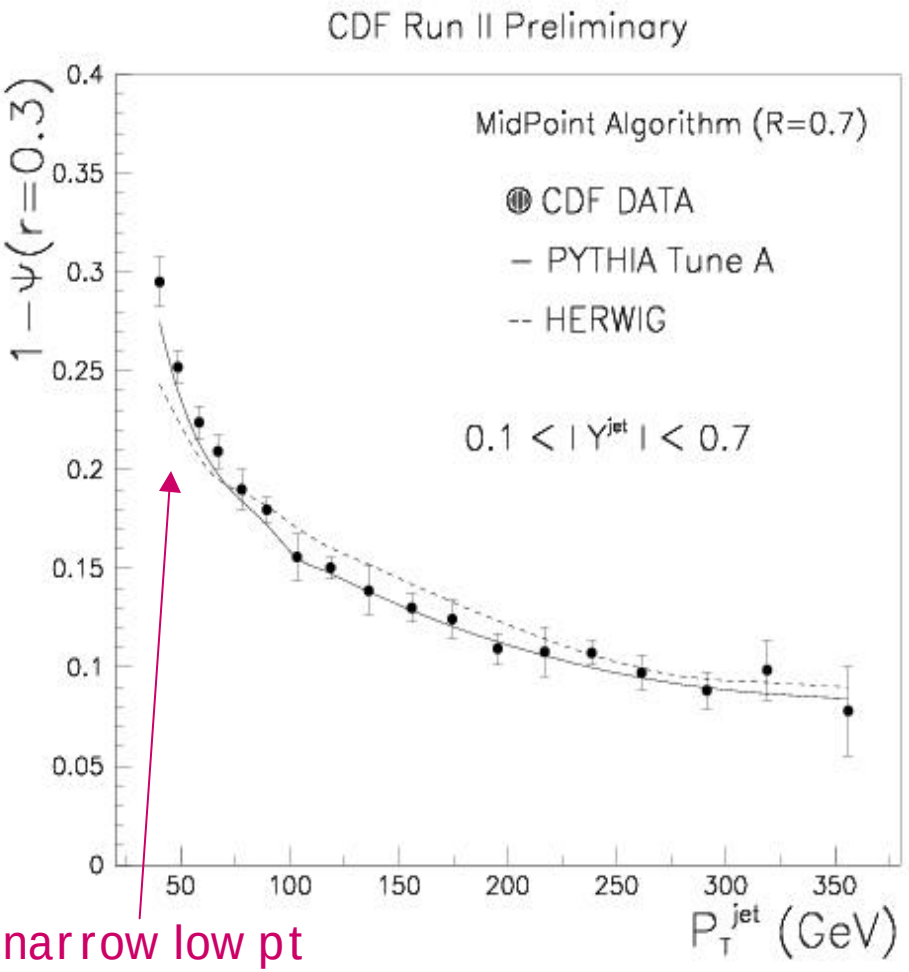
Results for Blessing (II)





Evolution with Pt(jet)

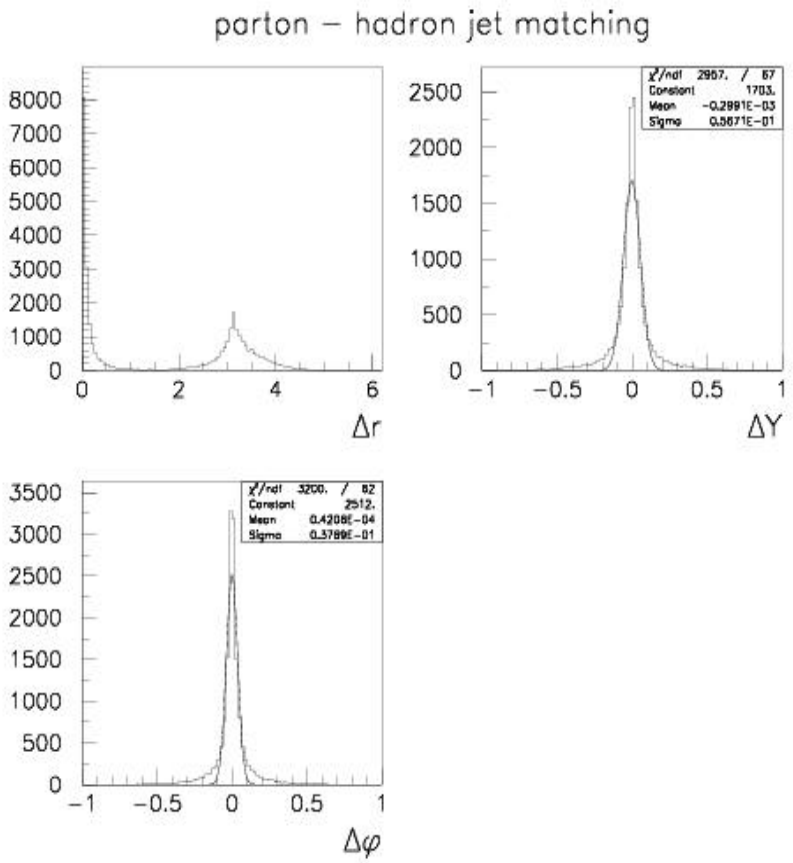
- Evolution with Pt(jet) has information about alpha_s(Pt) and quark/gluon fractions…
- Comparison with NLO will require dedicated studies of
  - Parton -> hadron corrections
  - R_sep dependency
  - Quark/Gluon separation
  - PDF's



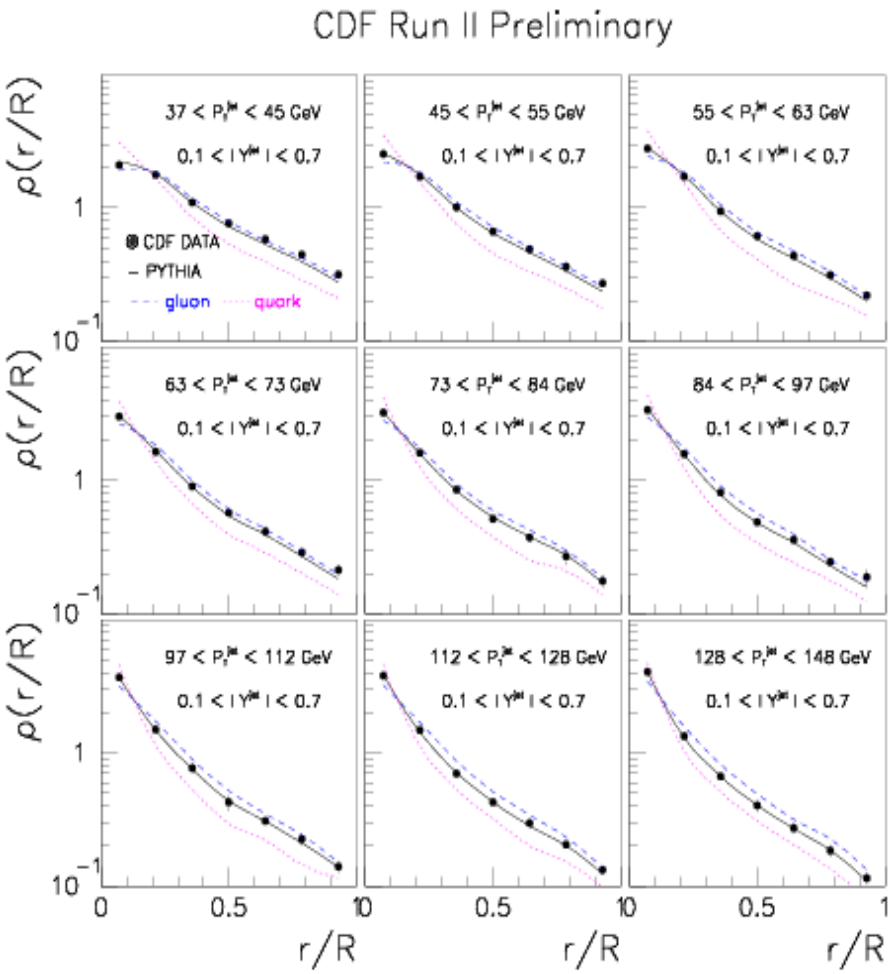
Herwig too narrow low pt (low pt region sensitive to underlying event modeling)

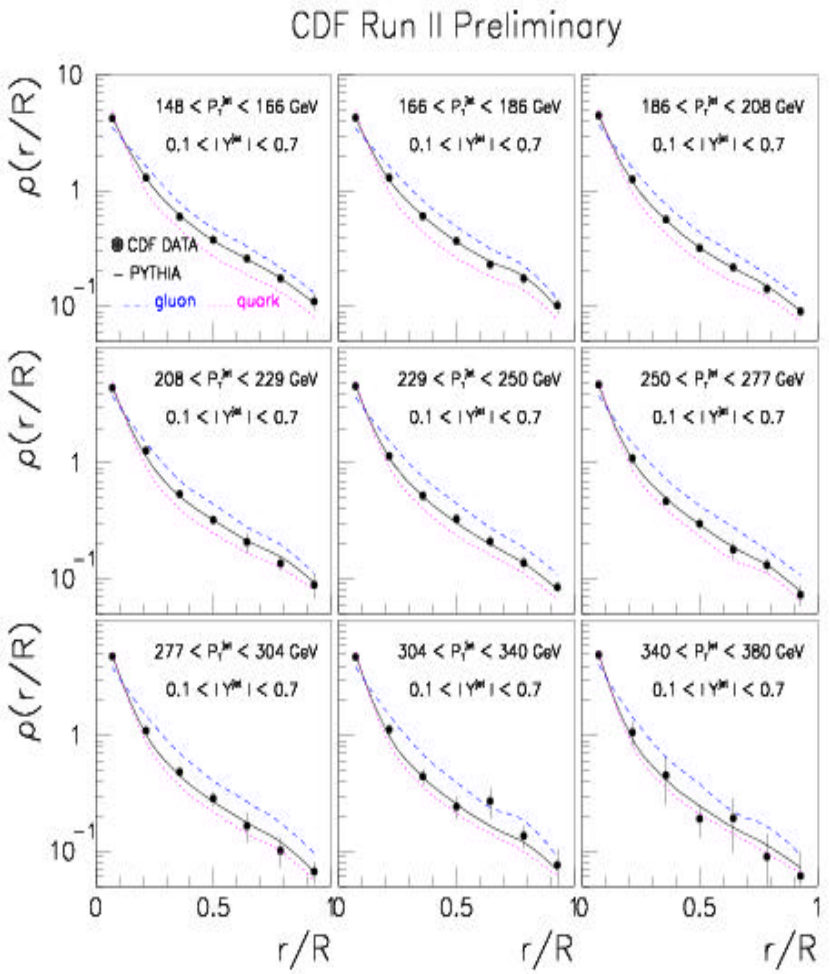
Quark & Gluon Contributions

- The hadron level prediction is a mixture of quark- and gluon-jet contributions.
- Y-ϕ matching between final state partons (qq, qg or gg final states in 2->2 processes) and the jets of hadrons is used to define "quark or gluon" jets
- Jet is defined as "gluon-jet" if gluon is found within the cone of the jet (similar for quarks)
- Jet Shapes are determined separately for quark- and gluon-jets.
- Since t-channel dominates….final states "reflects" PDF contents



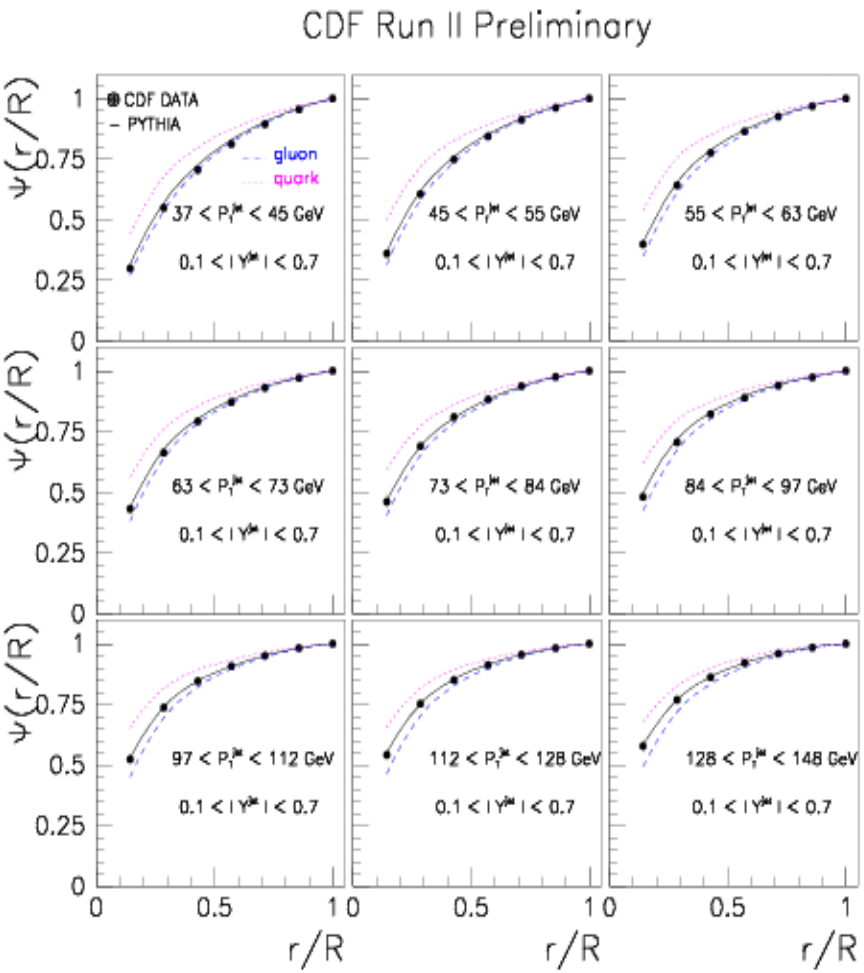
Gluon & Quark Jet Shapes

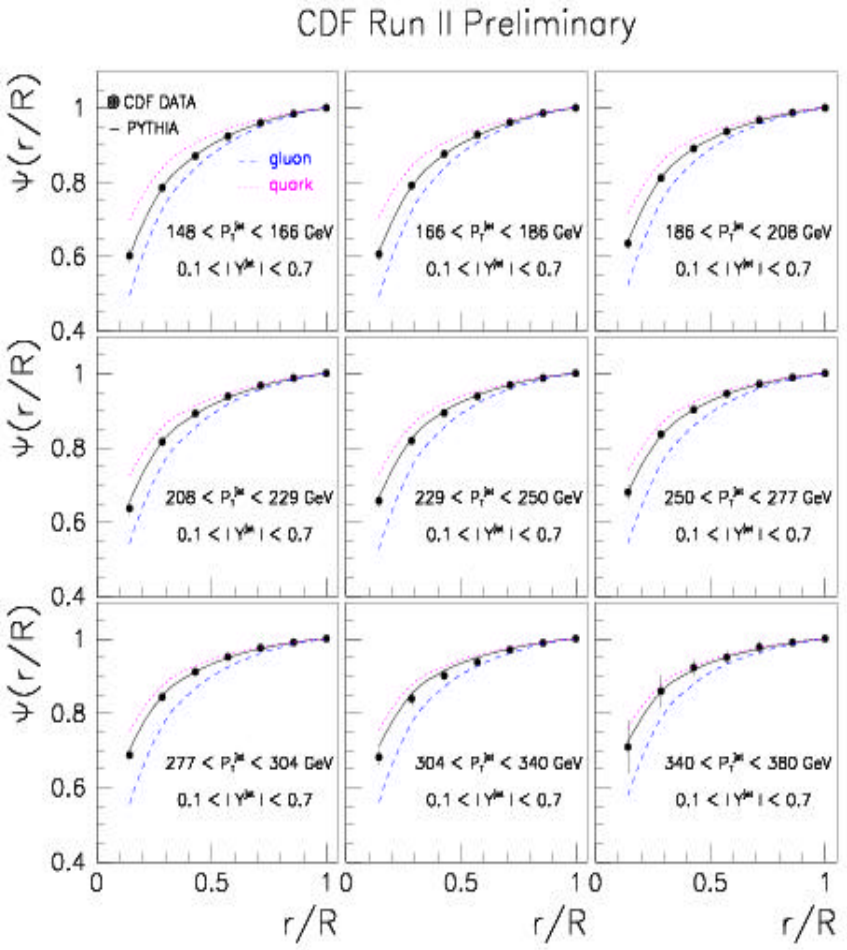




Gluon component dominates at low Pt ……Quarks dominate at high Pt

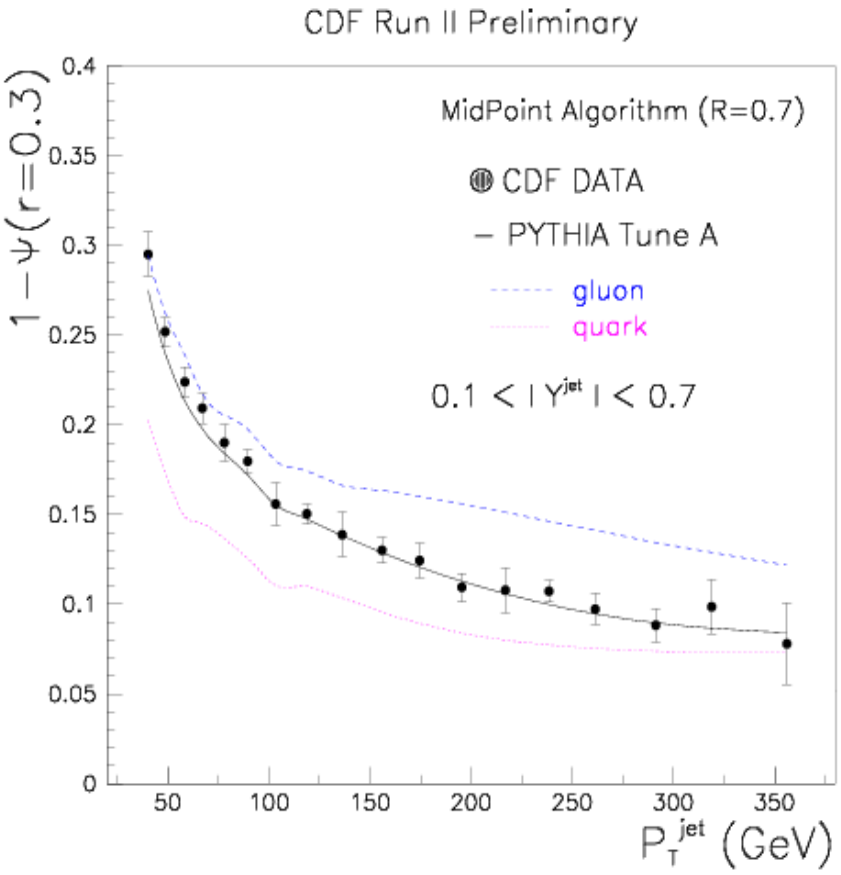
Gluon & Quark Jet Shapes





Gluon component dominates at low Pt .....Quarks dominate at high Pt

Evolution with Pt(jet)



Gluon component dominates at low Pt

Quarks dominate at high Pt….

Average Jet Pt	Gluon Jet Fraction
40 GeV	73 %
136 GeV	50%
356 GeV	20%

Sensitivity to Gluon-Quark contents in the final state..

Plans

- Analysis is now completed
- Next is to finish PRL draft asap

- NLO comparison subject for a second publication (…lots of work involved…)