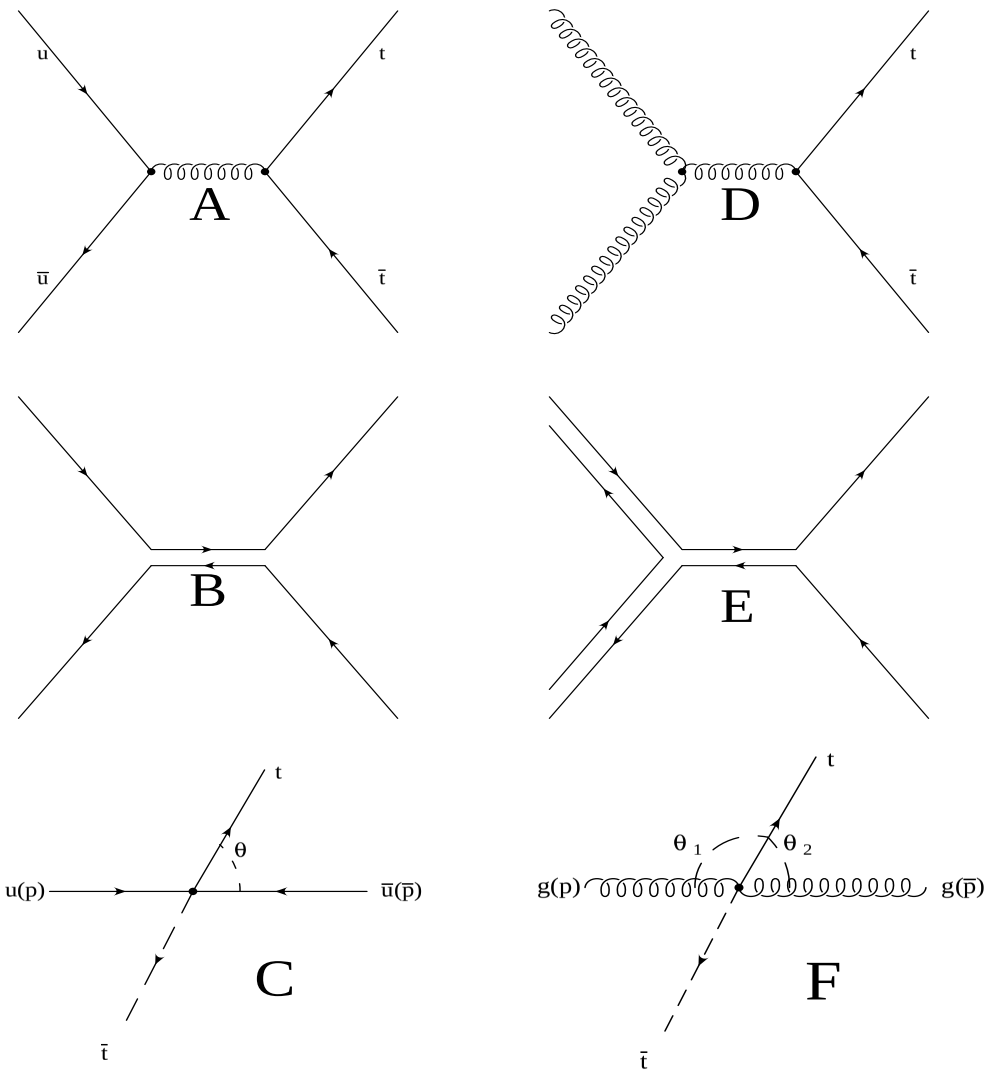
Isolated Tracks in Run 1 Candidate Lepton+Jet $t\bar{t}$ Events.

- Charged Tracks in Top events have sensitivity to QCD induced showers from top quarks.
- With sufficiently large sample (perhaps Run II), study could yield estimate of Top lifetime.
- No sensitivity expected in Run I data.
- Significant issues related to phenomenological description of radiation pattern in top events.
- Assess understanding with Run I candidates.

Documentation

- CDF 5766, 5767,5764
- Presentations:
  - Top Meetings
  - QCD Meetings
- Other less formal documentation/notes:
  - http://ncdf07.fnal.gov/~vejcik/TopQCD.html

Phenomenology



Tevatron top production proceeds through qqbar annihilation.

Shower production rate depends on violence of bending of color lines.

At Lowest order, top showers should be asymmetrically produced at Tevatron.

Observables:

- Charged Track Multiplicity
- Spatial separation of tracks from reconstructed $t\bar{t}$ as measured through distribution of $\frac{1}{R}\frac{dN}{dR}$
- 2 Asymmetries in track multiplicity defined for forward and backward $t\bar{t}$ events.

$$A^0 = \frac{N_f - N_b}{N_f + N_b} \qquad \Delta = n_f - n_b$$

Request for Blessing

- Pretag, tag, double−tag particle multiplicities
- Pretag, tag, double−tag asymmetries
- Pretag, tag, double−tag 1/R dN/dR dists.
- Numbers are quoted for several sets of cuts on:
  - Track Rapidity and P_T (sensitive to amount of ISR/UE)
  - Isolation relative to leading Jet axes (sensitive to description of jet formation)
  - 1 set with variation on track quality requirement.

Procedure

- Reconstruct
- Determine topology
- Count tracks
- Calculate $\frac{1}{R}\frac{dN}{dR}$

Candidate Track Selection

Investigate several definitions.

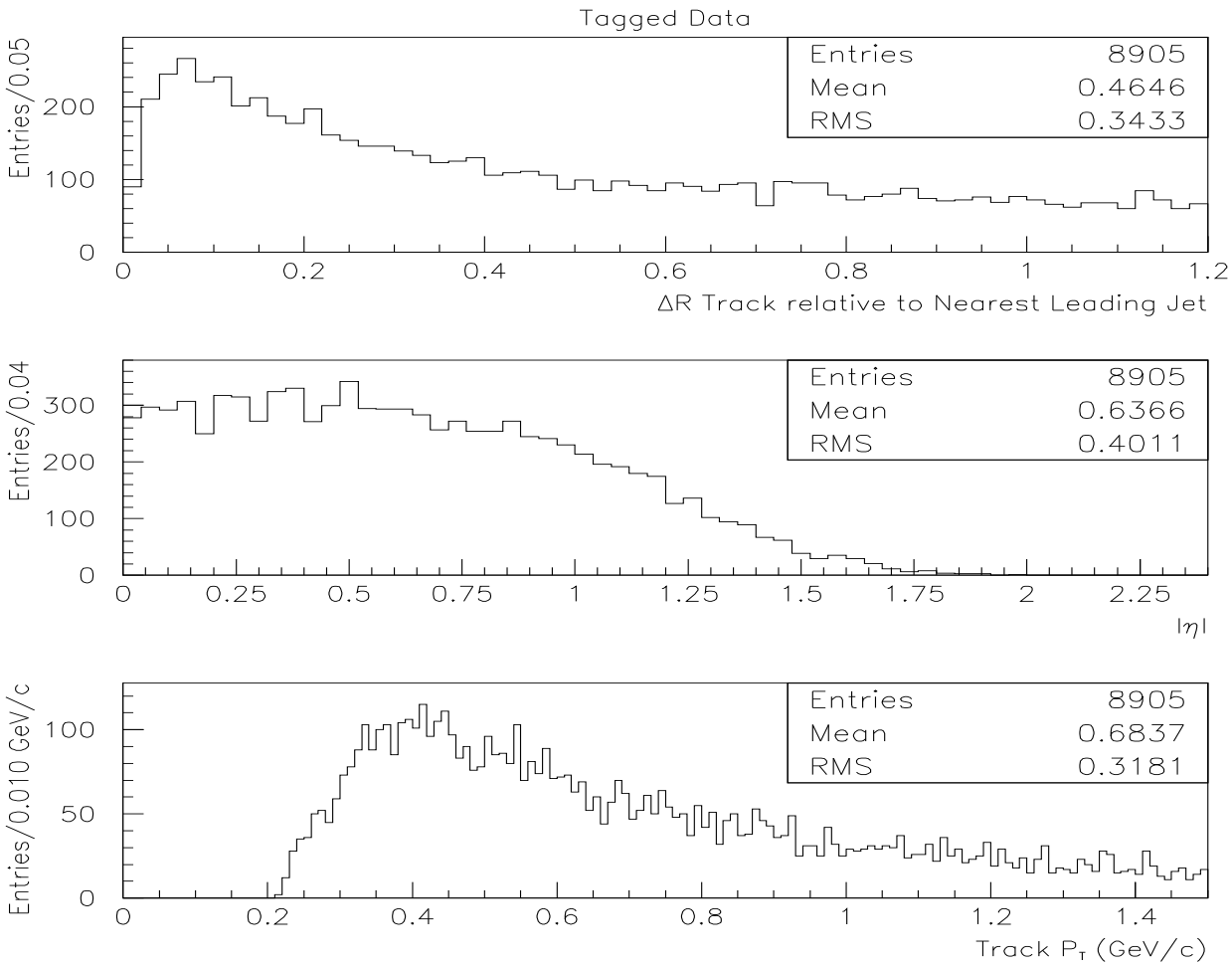
Isolation relative to Leading 4 Jets: $\Delta R > 0.5, 0.7, 1.0$

Rapidity $|\eta| < 1.0, 2.0$

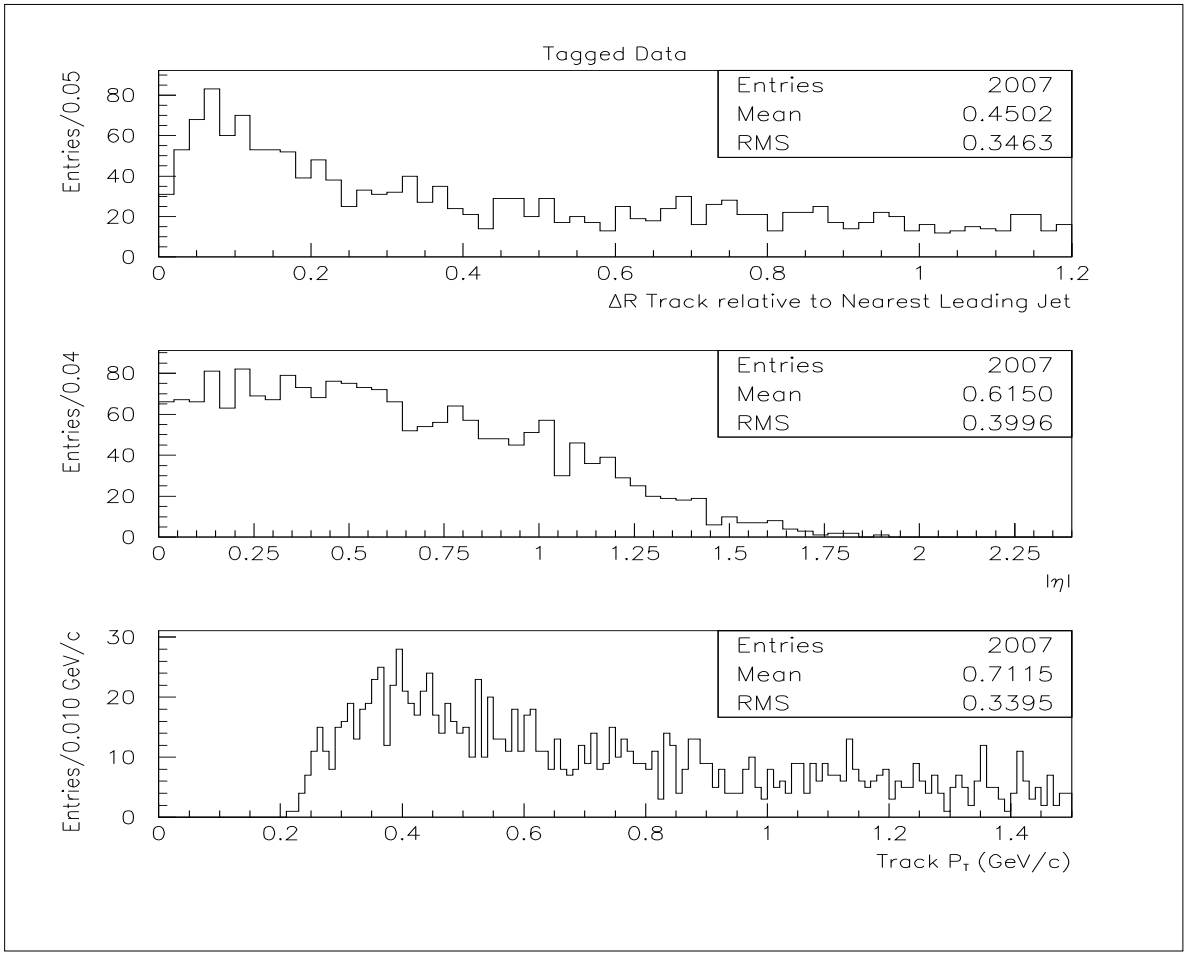
P_T > 0.5 GeV/c and 1.0 GeV/c

- No additional track quality requirements
- Subsequently vary imposition of quality requirements
- In general, each cut singles out one of 3 backgrounds to suppress:
  - ISR (η cut)
  - UE (P_T cut)
  - Hard Jet (Isolation cut)

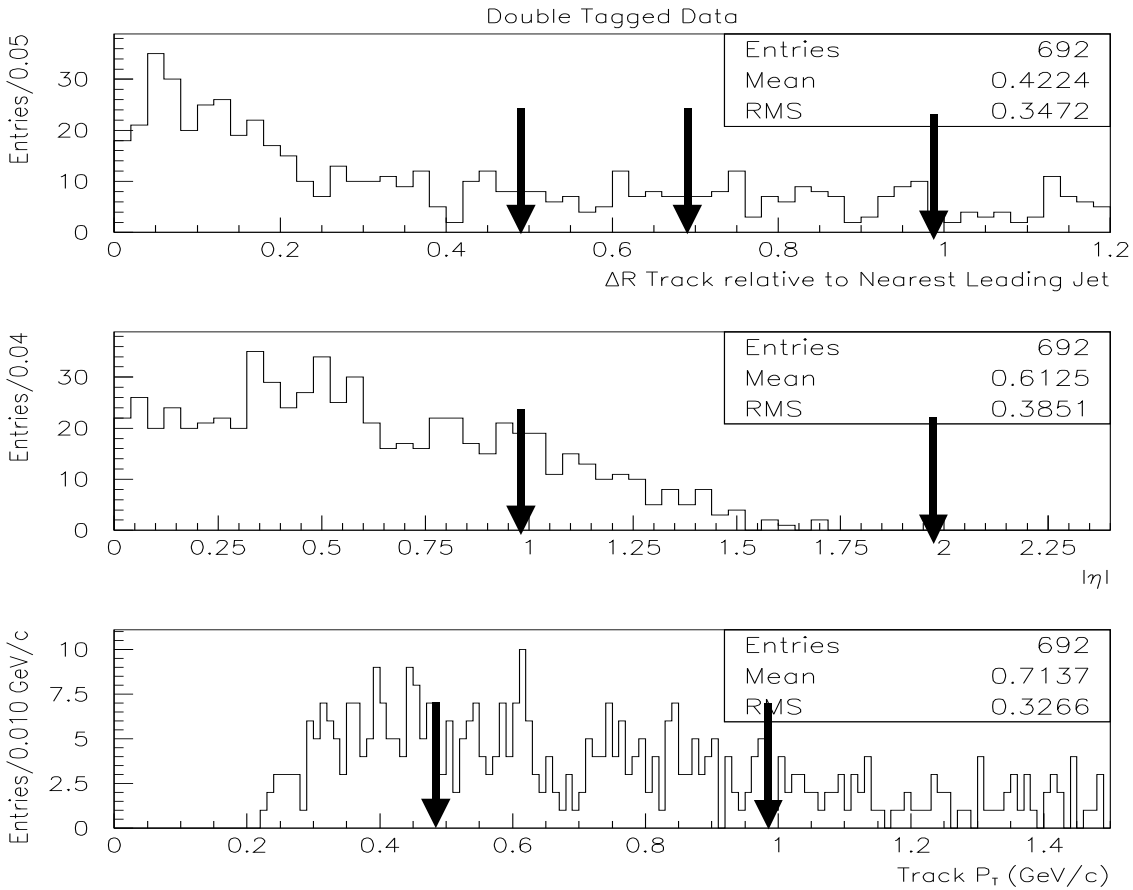
Variables used to select candidate Tracks Pretag



Variables used to select candidate Tracks
1 or more tag



Variables used to select candidate Tracks
2 or more tags
(Not for blessing−internal support for collaboration)



Expectations

- Compare with HERWIG+QFL'
- Cross−check with Pythia+QFL'
- Model additional vertices with Minbias Data
  - Compare observed number of Class 10 Vertices with >20 segments with expected in minbias and top mass sample.
  - Vary Efficiencies of Vertex reconstruction, BBC, mean number of extra vertices, fake rate. Consistent with Top mass sample having 1 ± 0.2 extra vertices.
- Model non−top background with VECBOS

Pretag Results

Loose η cut (ISR sensitive)

Tight P_T Cut (Remove UE)

Set	N Observed	N Expected	Δ Observed	Δ Expected	A^0(%) Observed	A^0(%) Expected
1	7.5±0.2	7.2± 0.5	−1.6±0.4	−0.14±0.01	−10.4±8.4	−0.95±0.08
2	11.4 ± 0.3	11.4 ± 0.8	−1.3±0.5	−0.21±0.02	−5.8±8.2	−0.83±0.07
3	2.7 ± 0.3	2.4 ± 0.2	−0.3±0.3	−0.07±0.01	−5.8±9.2	−1.55±0.13
4	4.1 ± 0.2	3.9 ± 0.3	−0.2±0.3	−0.09±0.01	−2.8±8.8	−1.33±0.11
5	10.6 ± 0.3	12.6 ± 0.7	−1.8±0.5	−0.21±0.02	−8.5±8.2	−0.67±0.06
6	15.4 ± 0.3	18.4 ± 1.2	−1.8±0.6	−0.29±0.03	−5.7±8.1	−0.59±0.05
7	14.7 ± 0.3	14.9 ± 0.9	−1.1±0.6	−0.27±0.03	−3.7±8.1	−0.74±0.06
8	5.4 ± 0.2	5.3 ± 0.2	0.0±0.4	−0.11±0.01	0.0±8.6	−1.21±0.10
9	7.1 ± 0.2	8.2 ± 0.3	−0.1±0.4	−0.17±0.02	−0.4±8.4	−0.90±0.07

Uncertainties:

On observed, uncertainty reflects statistical errors.

On predictions, uncertainty reflects BG fraction and Extra Vertices

ISR maximized for Set 5

UE maximized for Set 1

Hard Jet BG maximized for Set 8

At least one b−tag

Set	N Observed	N Expected	Δ Observed	Δ Expected	A^0(%) Observed	A^0(%) Expected
1	5.5± 0.4	8.0± 0.2	1.5±0.8	−0.29±0.06	41.1±18.3	−2.0±0.5
2	10.2 ± 0.6	12.1 ± 0.3	3.9±1.0	−0.44±0.10	46.4±17.8	−1.7±0.4
3	2.4 ± 0.3	3.5 ± 0.3	0.0±0.5	−0.15±0.03	27.9±19.9	−3.1±0.7
4	4.3 ± 3.2	5.0 ± 0.2	0.8±0.7	−0.19±0.04	36.3±18.5	−2.7±0.6
5	8.6 ± 0.5	13.1 ± 0.3	1.5±1.0	−0.44±0.10	35.9±17.7	−1.4±0.3
6	14.0 ± 0.6	18.9 ± 0.3	4.4±1.2	−0.60±0.14	42.2±17.4	−1.2±0.3
7	13.0 ± 0.6	15.5 ± 0.3	4.8±1.2	−0.55±0.13	44.8±17.6	−1.5±0.3
8	5.8 ± 0.4	6.4 ± 0.2	1.2±0.8	−0.23±0.05	37.5±18.1	−2.4±1.9
9	9.2 ± 0.5	9.2 ± 0.2	1.8±1.0	−0.35±0.07	38.0±17.8	−1.8±1.4

Loose η cut (ISR sensitive)

Tight P_T Cut (Remove UE)

At least 2 b–tags

Set	N Observed	N Expected	Δ Observed	Δ Expected	A^0(%) Observed	A^0(%) Expected
1	4.3± 0.6	6.9± 0.5	3.4±1.0	−0.33±0.03	82.1±32.2	−2.3±0.2
2	8.2 ± 0.8	11.1 ± 0.7	7.6±1.3	−0.49±0.04	86.8±31.3	−2.0±0.2
3	2.0 ± 0.4	2.5 ± 0.1	1.3±0.8	−0.17±0.01	76.9±34.8	−3.6±0.3
4	3.5 ± 0.5	4.1 ± 0.2	2.4±1.0	−0.21±0.02	78.3±32.4	−3.0±0.2
5	7.2 ± 0.7	12.5 ± 0.8	6.3±1.3	−0.50±0.05	85.0±31.3	−1.6±0.1
6	12.5 ± 1.0	18.4 ± 1.2	12.0±1.6	−0.68±0.06	87.7±30.9	−1.4±0.1
7	11.7 ± 1.0	14.7 ± 0.9	9.6±1.7	−0.63±0.05	82.9±30.4	−1.8±0.2
8	5.2 ± 0.6	5.6 ± 0.3	3.2±1.2	−0.26±0.02	76.1±31.2	−2.7±0.2
9	7.3 ± 0.5	8.6 ± 0.5	5.6±1.4	−0.39±0.03	81.1±30.9	−2.0±0.2

Loose η cut (ISR sensitive)

Tight P_T Cut (Remove UE)

2 b–tags with tight track quality cuts

(EXPECTED Calculated with LOOSE cuts correcting for loss of Extra Vertices.)

Set	N Observed	N Expected	Δ Observed	Δ Expected	A^0(%) Observed	A^0(%) Expected
1	3.7±0.5	4.5± 0.5	2.6±1.0	−0.33±0.03	79.2±32.4	−2.3±0.2
2	6.9±0.7	7.6 ± 0.7	6.3±1.2	−0.49±0.04	86.5±31.6	−2.0±0.2
3	1.8±0.4	1.9 ± 0.1	1.1±0.7	−0.17±0.01	75.0±35.1	−3.6±0.3
4	3.2±0.5	3.2 ± 0.2	2.4±0.9	−0.21±0.02	80.5±33.0	−3.0±0.2
5	5.1±0.6	8.5 ± 0.8	4.0±1.1	−0.50±0.05	81.8±31.7	−1.6±0.1
6	9.2±0.8	12.7 ± 1.2	9.0±1.4	−0.68±0.06	88.3±31.3	−1.4±0.1
7	9.8±0.9	10.4 ± 0.8	7.5±1.6	−0.63±0.05	81.1±30.5	−1.8±0.2
8	4.5±0.6	4.5 ± 0.3	2.9±1.1	−0.26±0.02	76.3±31.5	−2.7±0.2
9	6.2±0.7	6.9 ± 0.1	4.5±1.3	−0.39±0.03	80.0±31.1	−2.0±0.2

Loose η cut: Tracks near fiducial edges preferentially lost.

Tight Cuts on Simulation:

Set	N Expected	Δ Expected	A^0(%) Expected
1	4.3 ± 0.3	−0.33 ± 0.03	−2.3 ± 0.2
5	6.3 ± 0.4	−0.50 ± 0.05	−1.6 ± 0.1
6	10.6 ± 1.2	−0.68 ± 0.06	−1.4 ± 0.1
7	10.2 ± 0.9	−0.63 ± 0.05	−1.8 ± 0.2

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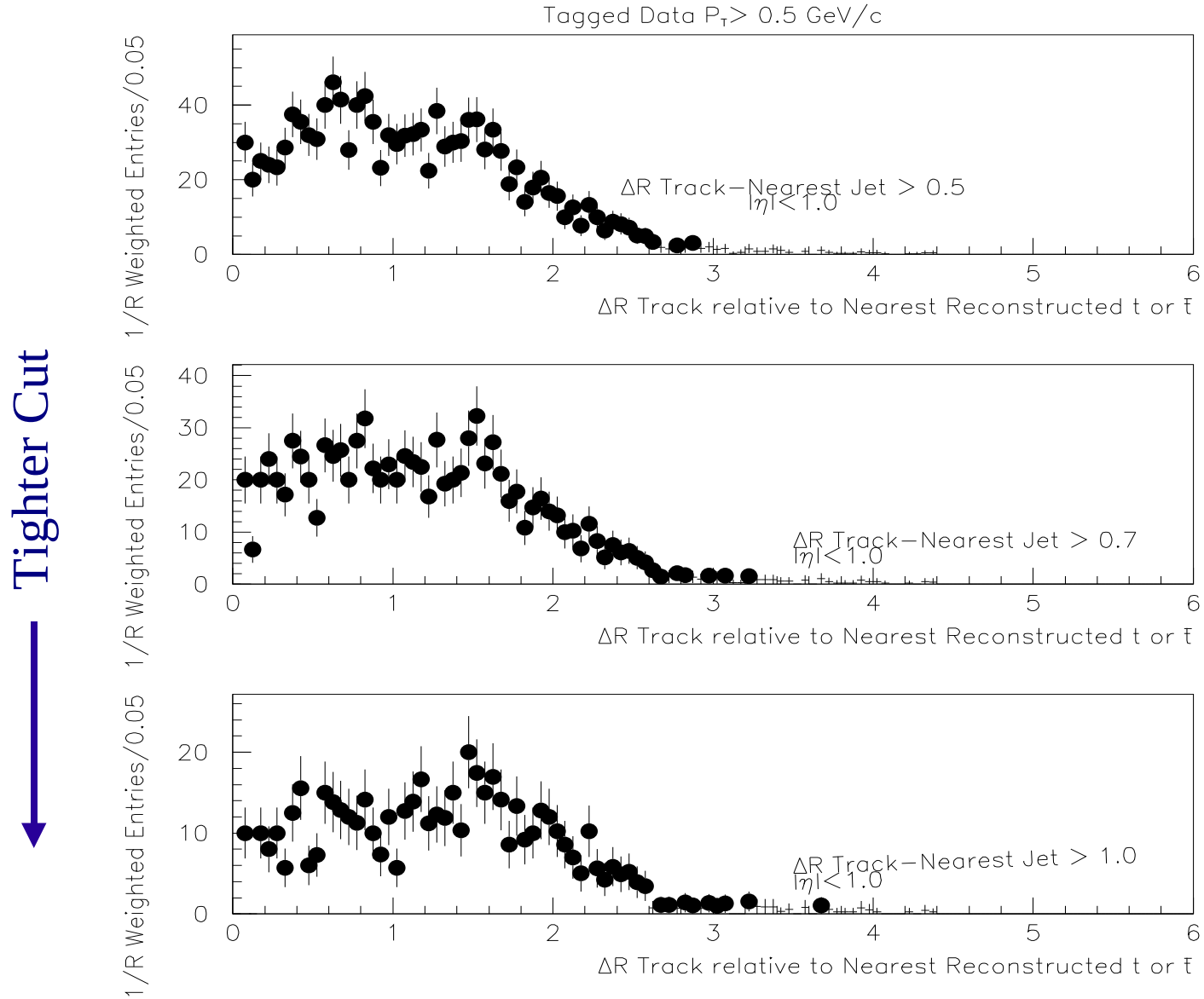
Conclusions

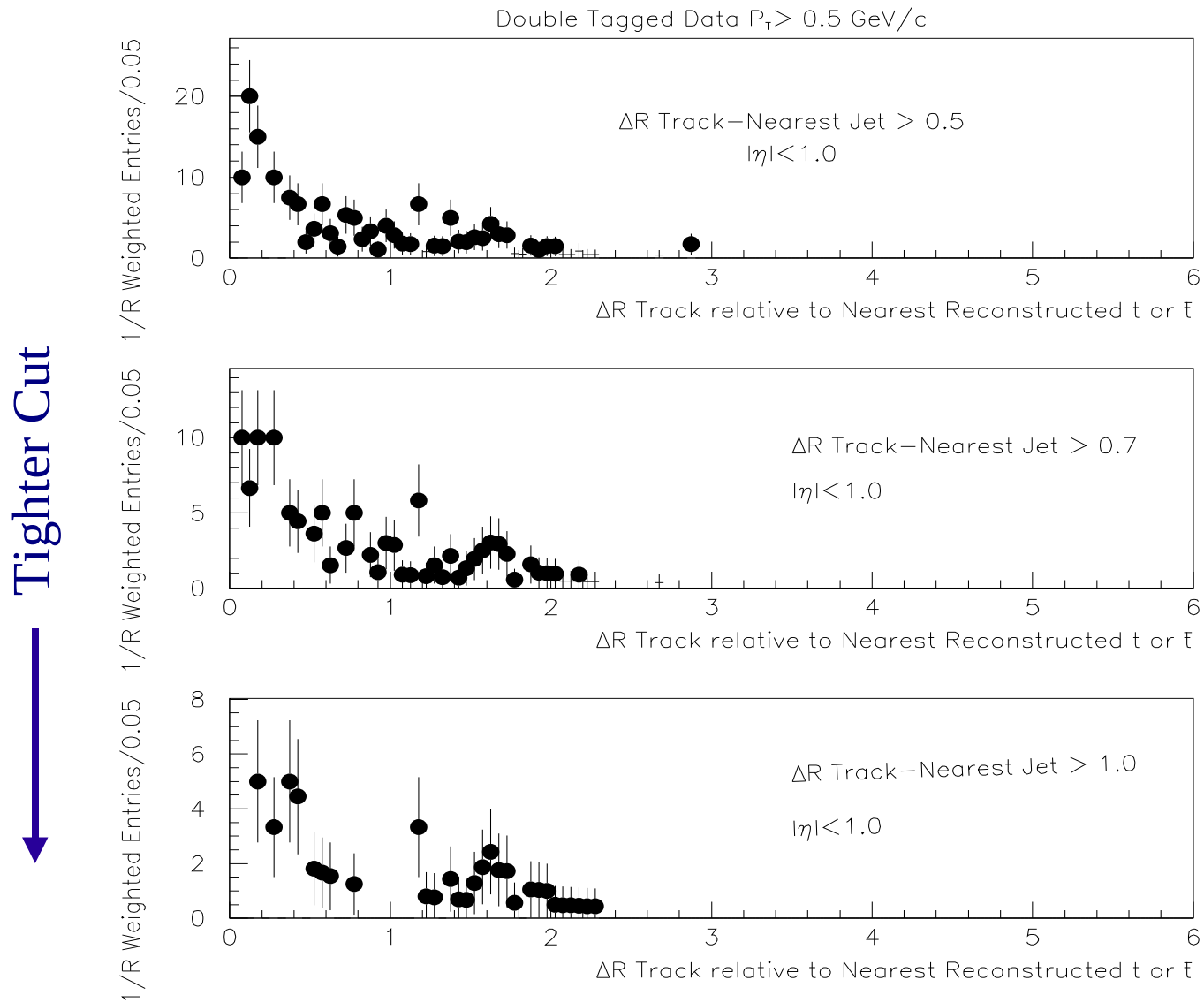
- With *Background Enriched sample* (no b−tagging), measurements of asymmetries, track multiplicities and spatial distribution of tracks is consistent with expectations.
- Variation of cuts shows expected behavior as sensitivity to different backgrounds is changed.
- Demonstrates that systematics are under good control and methodology might work for Run II measurement.
- Tagged and double−tagged samples agree less well
  - Multiplicity is in good agreement but
  - Asymmetries typically requiring a statistical fluctuation of "few" σ in order to be consistent with expectations.
  - Disagreement shows little pattern−maybe less in UE suppressed samples.

1/R dN/dR Distributions varying Isolation Cut, Pretag



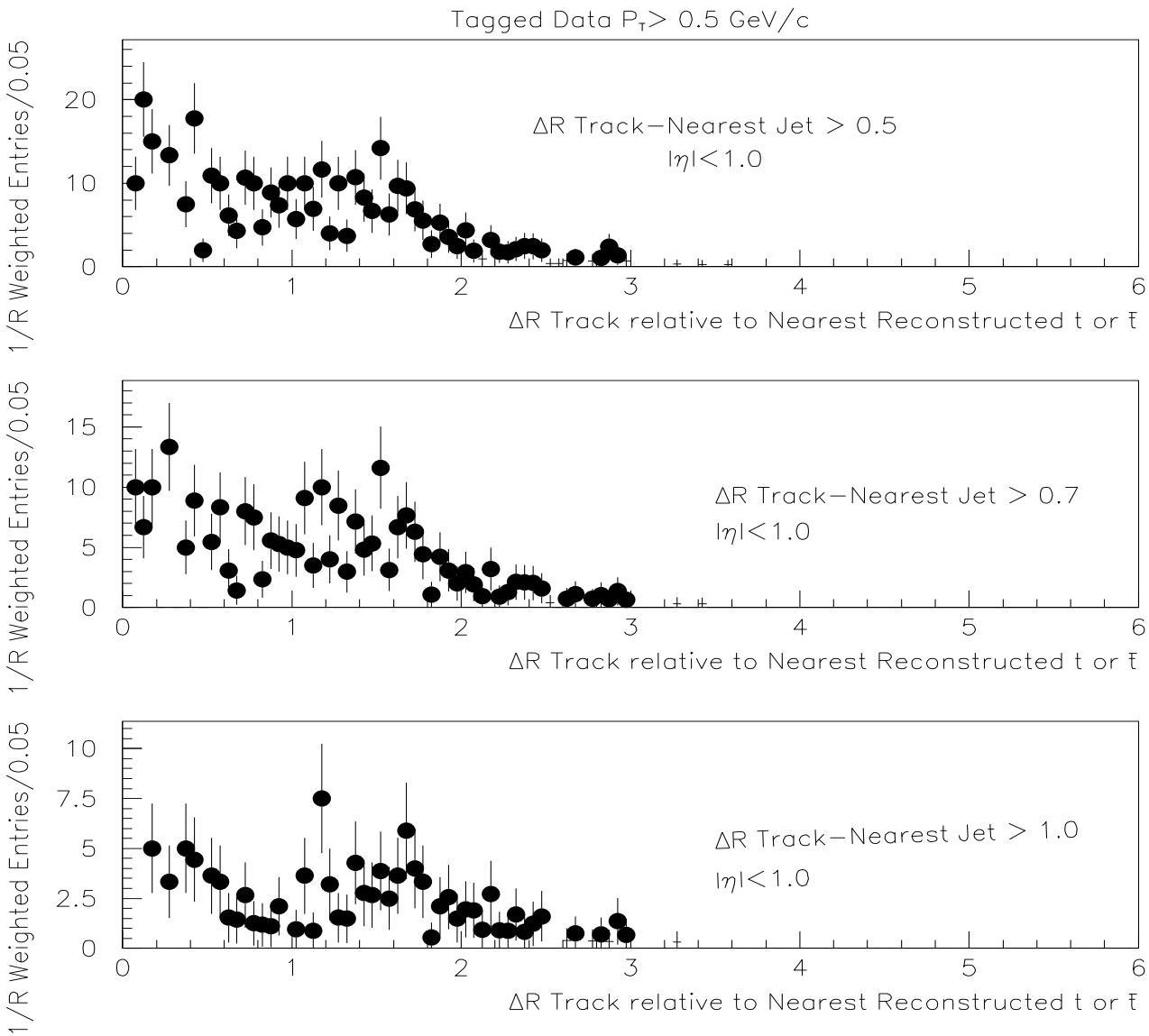
Tighter Cut

1/R dN/dR Distributions varying Isolation Cut, double tag

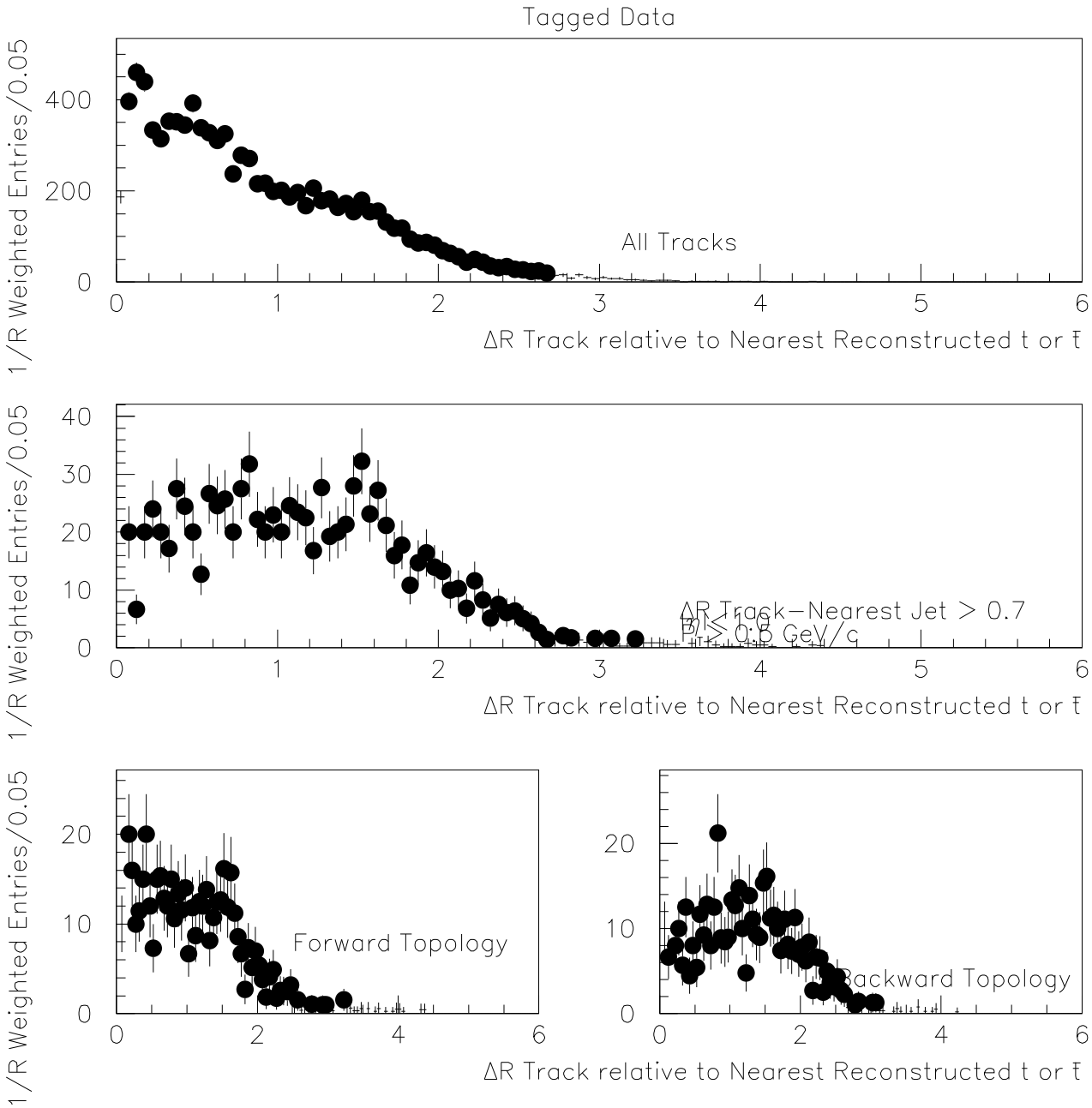


Tighter Cut

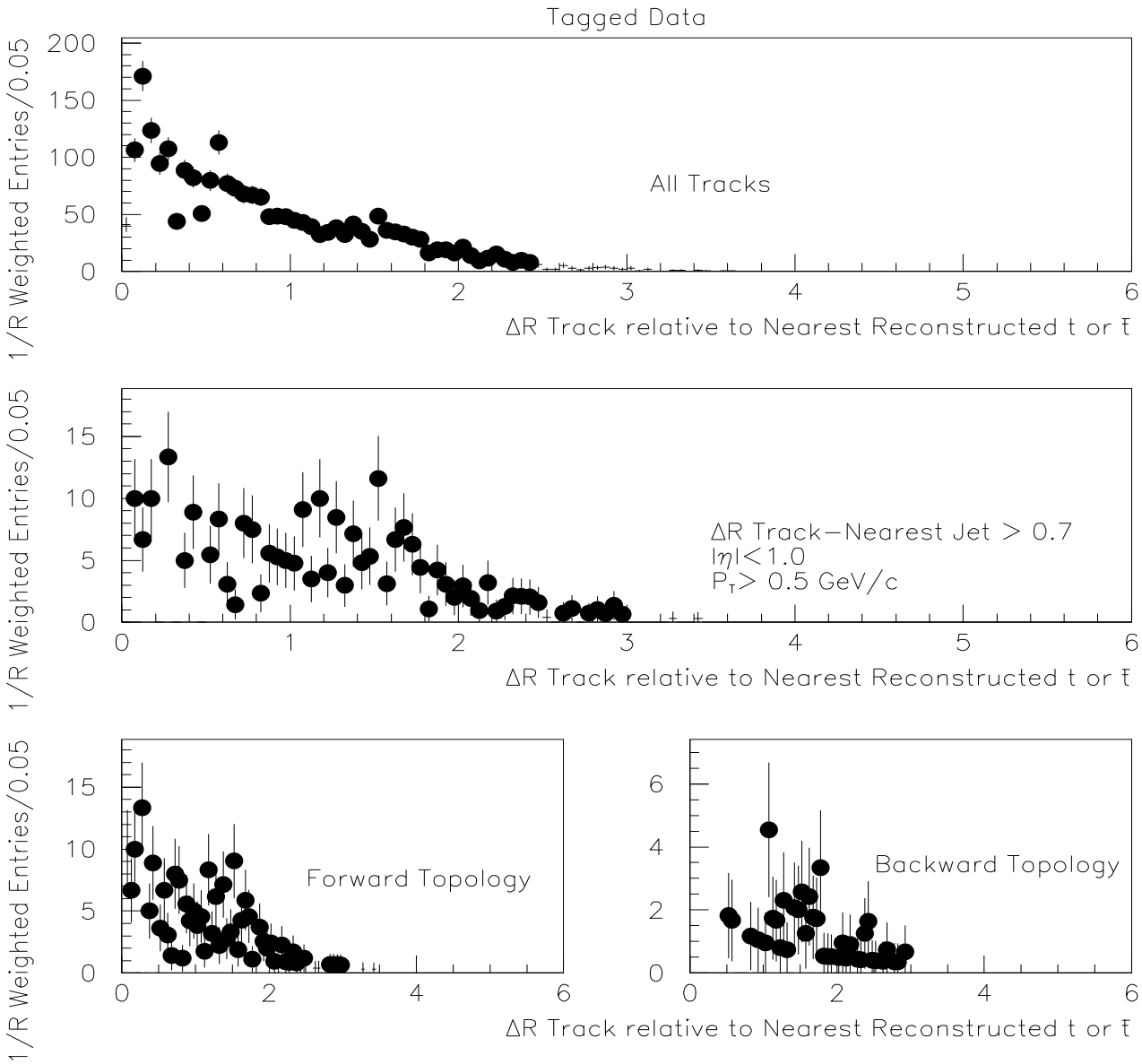
1/R dN/dR Distributions varying Isolation Cut, 1 or more tag



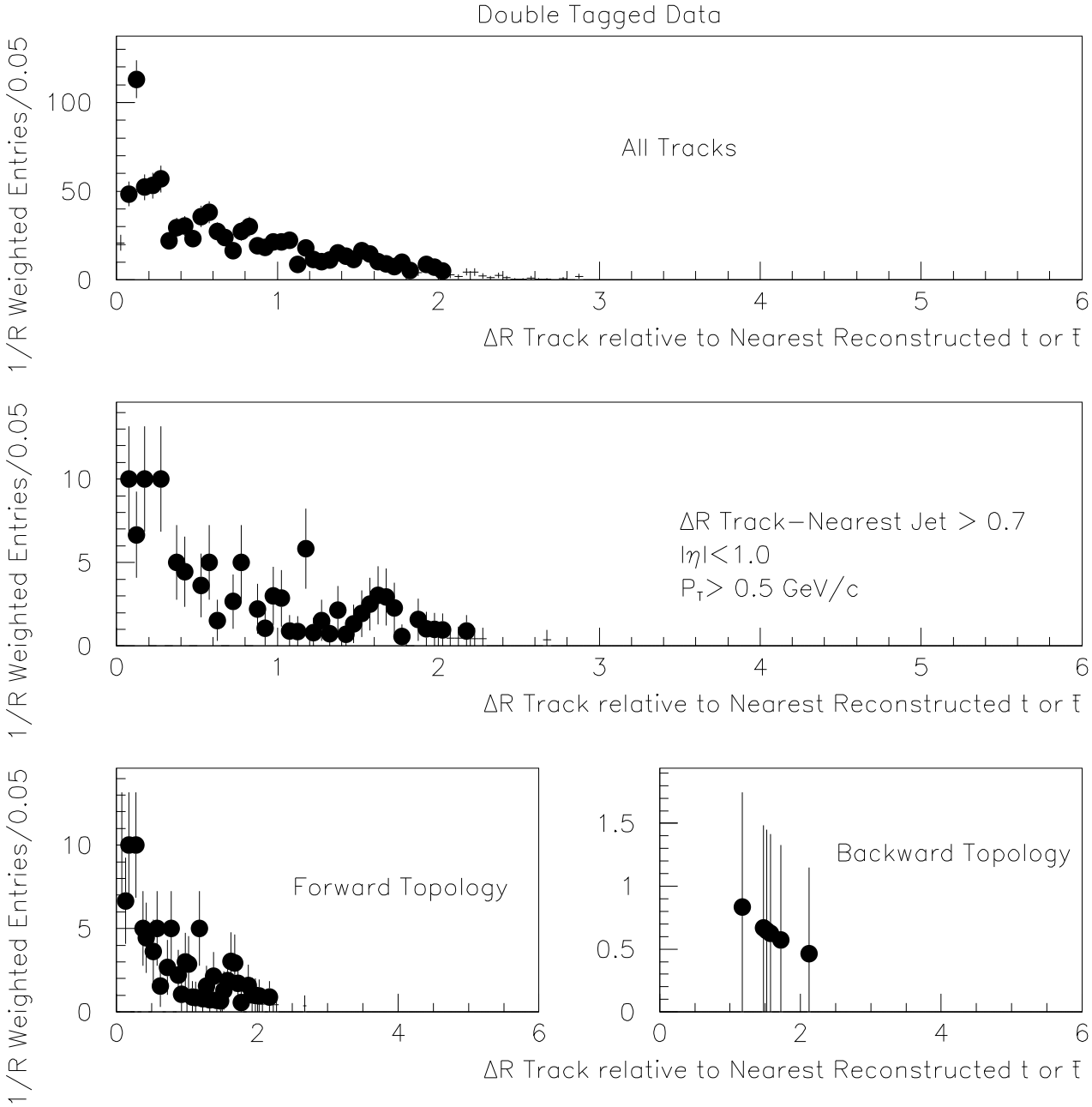
1/R dN/dR Candidate Track Selection Pre−Tagged Data



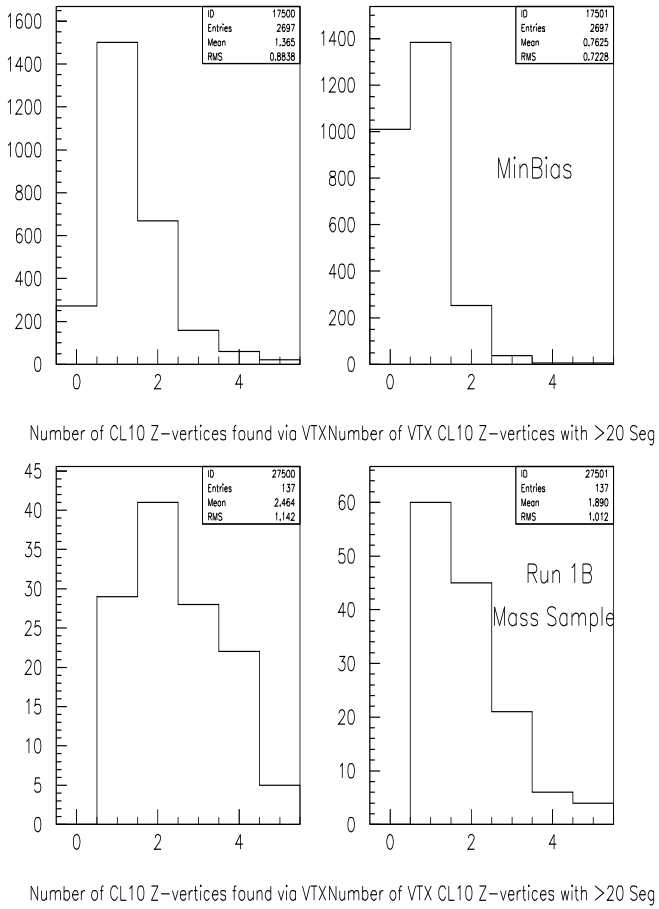
1/R dN/dR Candidate Track Selection Tagged Data

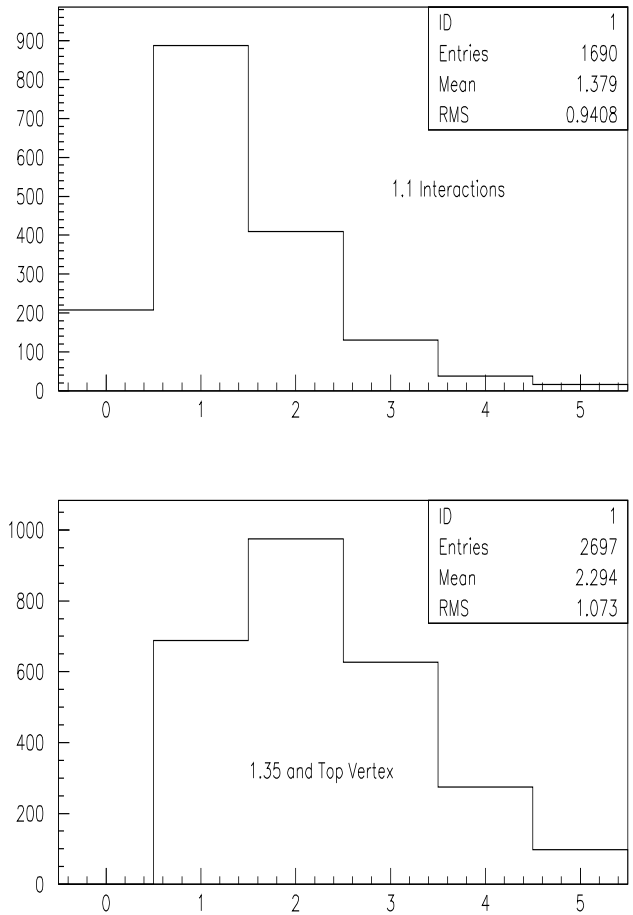


1/R dN/dR Candidate Track Selection Double Tagged Data



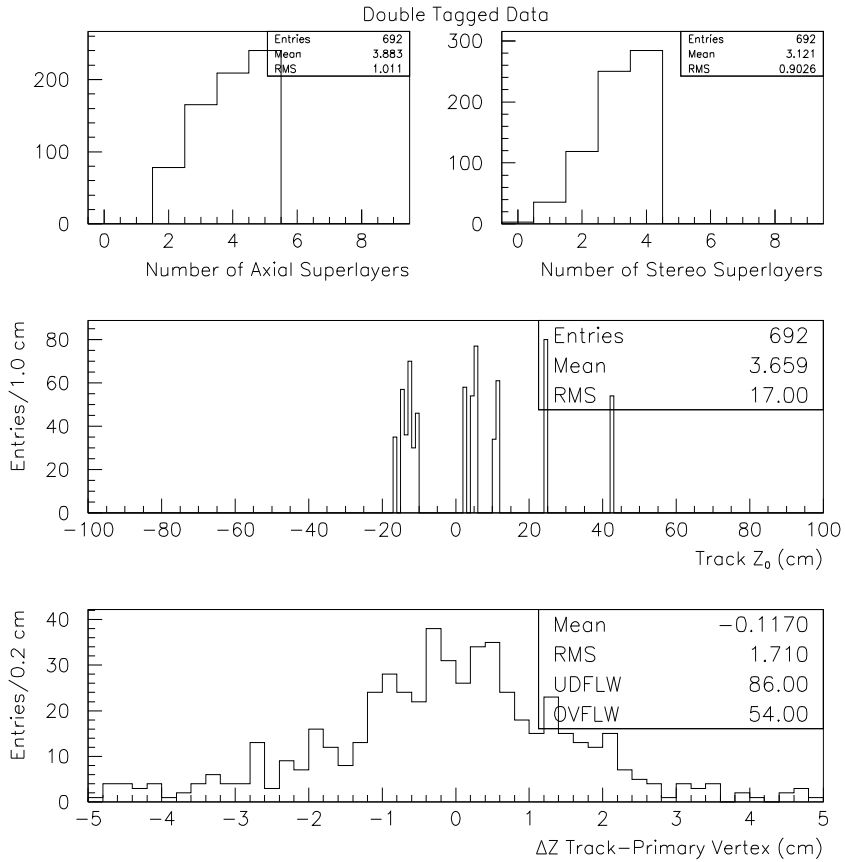
Multiple Vertices in top candidates and min−bias





Rough fit for "Hard" and Minbias Vertex Reconstruction Efficiencies, Number of Minbias events, fake rate. Data consistent with Mass sample having 1 ± 0.2 additional mbias events.

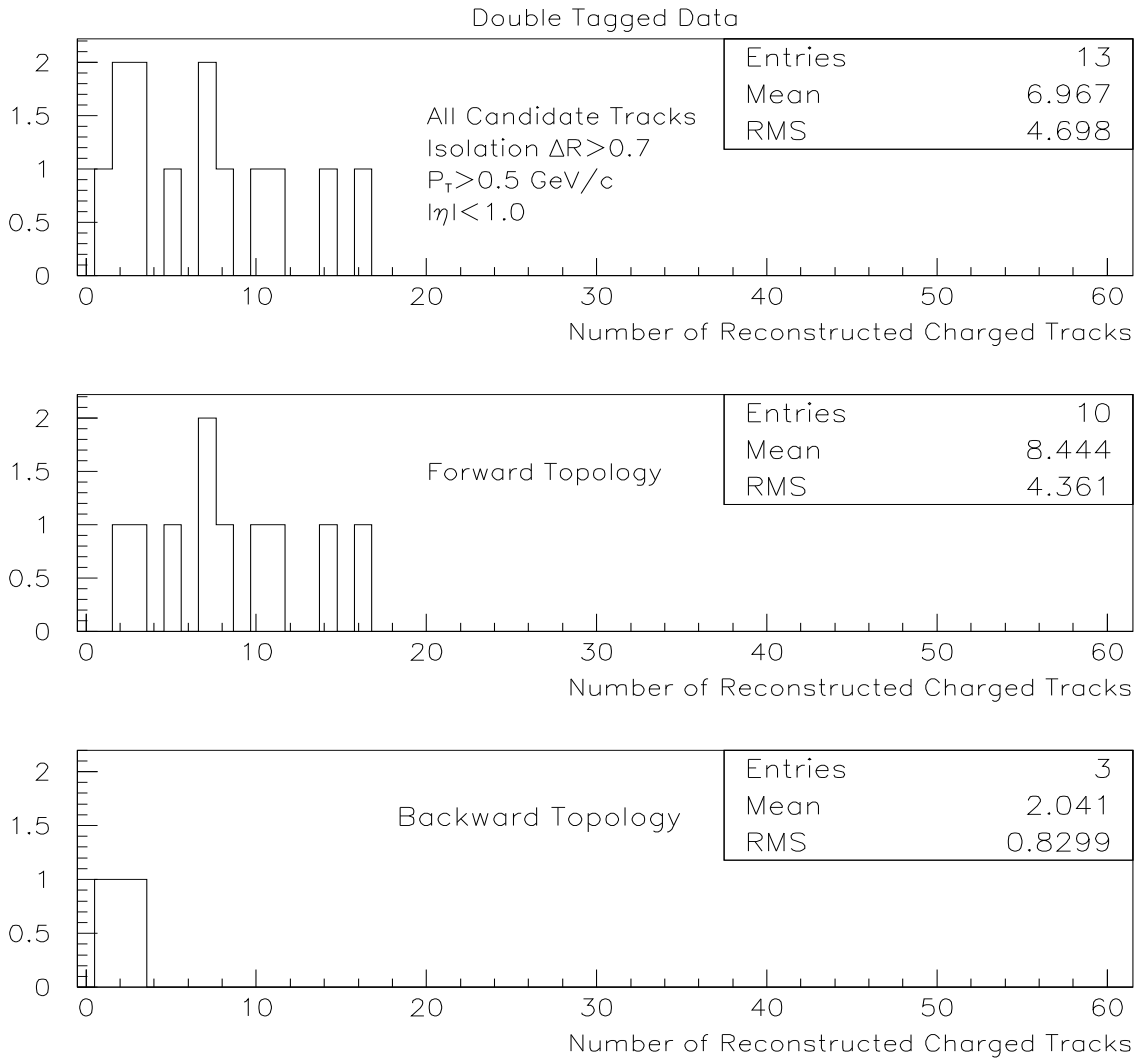
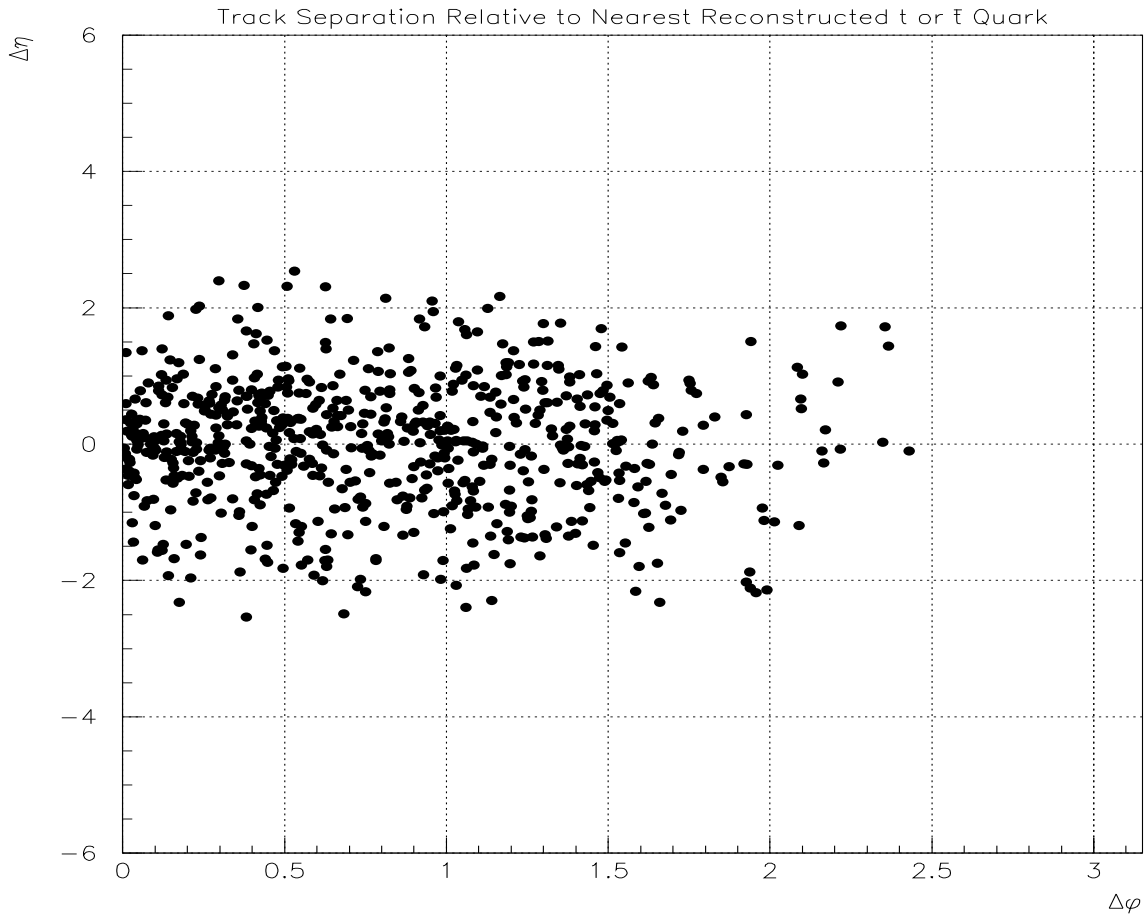
Track Quality Requirements (not for blessing)



Related, Ongoing work

- Analysis of B−samples
- Study of Chris Hill's samples with as ME
- Study of Drell−Yan

Candidate Track Multiplicity Breakdown



All Tracks. Double Tagged Data