# *Experience with Matched Samples*


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# *Outline – A W+Jets MC Study*

- Comparisons at the HEPG level between W + Jet samples produced using 2 different ME-PS matching procedures:
  - CKKW (see Frank's talk) – implemented here by Steve Mrenna.
  - “MLM” matching – explained briefly.
- These samples are combined to produce an inclusive W + Jets sample, and comparisons are between these inclusive samples.
- Comparisons make use of hadron level jets.
- Data comparisons are on there way once the data results are blessed.

# *Problems with ME-PS Interfacing*

- QCD matrix element (ME) calculations are limited to the high energy hard scattering regime.
- Require additional parton showering (PS) programs to simulate the soft QCD processes of final/initial state gluon radiation and hadronization.
- Current ALPGEN(ME) + HERWIG(PS) samples suffer from the following problems related to interfacing the ME and PS components:
  - Overlap in phase space between W+n and W+(n+1) parton samples. Combining these samples results in double counting of events in overlap region.
  - The lack of a full W + n parton spectrum is limiting: W+n parton ALPGEN describes W+n and even W+(n+1) jet samples well but fails at higher multiplicities. Also lacks “feed up” from W +(n-1) samples.

# *MLM Matching Procedure*

- See Micelangelo's recent talk at the June '04 MC meeting.
- Attempts to implement a jet-based ME-PS matching procedure to address double counting and provide “inclusive” samples independent of the generation cuts.
- Generate parton-level configurations for a given hard-parton multiplicity $N_{part}$, with partons constrained by some min $P_T$ and $\Delta R$ cuts.
- Perform parton showering and before hadronization cluster the resulting partons with a cone jet algorithm defined by ($E_T$ min, $R_{cone}$).
- Match partons to jets:
  - for each hard-parton find the min $\Delta R_{part\text{-}jet}$
  - if $\Delta R_{part\text{-}jet} < R_{cone}$ the parton is “matched”
  - a jet can only be matched to one parton
- For the INCLUSIVE prescription, if all partons are matched to jets the event is kept, else it is discarded.
- For the EXCLUSIVE prescription, all partons have to match to jets AND $N_{part} = N_{jets}$, else the event is discarded.
- I apply MLM matching at analysis level, only plotting events which are matched. Exclusive is used for all samples except W+4 parton.

# *The Monte Carlo Samples*

- ALPGEN + HERWIG (A+H) (Claudio Ferreti):
  - W + 1, 2, 3 and 4 parton samples.
  - $W^+$ and $W^-$.
  - ME Parton cuts: $P_T > 8GeV$, $-3.0 < \eta < 3.0$, $\Delta R > 0.2$.
  - Lepton cuts: $P_T > 1GeV$, $-5.0 < \eta < 5.0$.
  - MLM matching is applied to the A+H samples.
- MADGRAPH + PYTHIA (M+P) (Steve Mrenna):
  - W + 0, 1, 2, 3 and 4 parton samples.
  - $W^+$ only.
  - ME parton cuts : $K_T$ = 10, 15 or 20 GeV wrt other partons and beam direction.
  - Steve Mrenna produced CKKW “treated” M+P samples, and also “unmatched” M+P samples to which I have applied MLM matching.

# *Combining the samples*

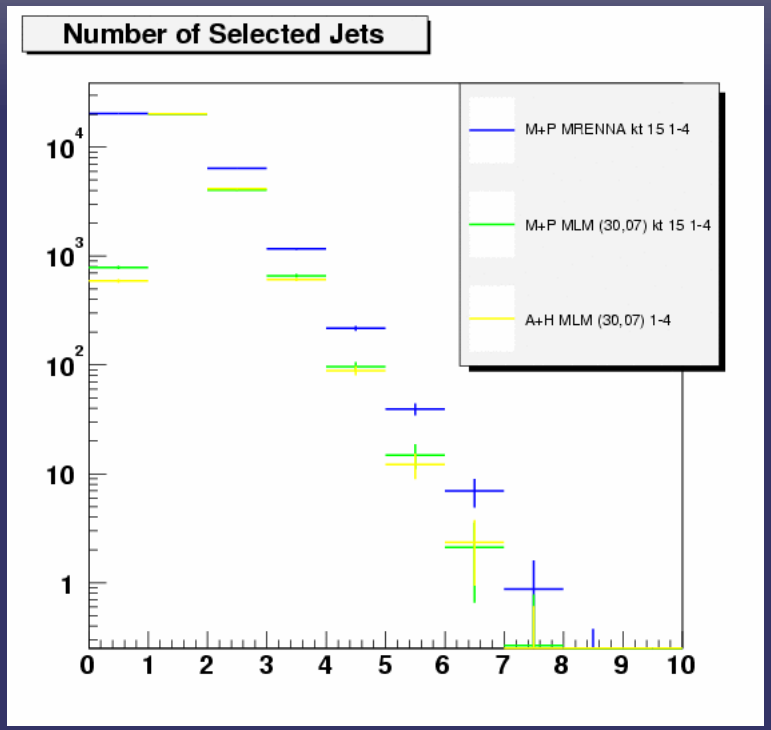
- When combining the samples to form a complete W + ≥ 0 parton spectrum we obviously have to add them in the correct ratio of cross-sections.
- We use:
  - $N_{W+0}$ = All W + 0 events
  - $N_{W+1} = (N_{W+0}) \times ((\sigma_{W+1}) / (\sigma_{W+0}))$
  - $N_{W+2} = (N_{W+0}) \times ((\sigma_{W+2}) / (\sigma_{W+0}))$ and so on...
- As opposed to only using $N_{W+n}$ events, the combining is done at the plotting stage, where the histograms are scaled by $N_{W+n}$ before being summed. Allows one to use the full statistics of each sample.

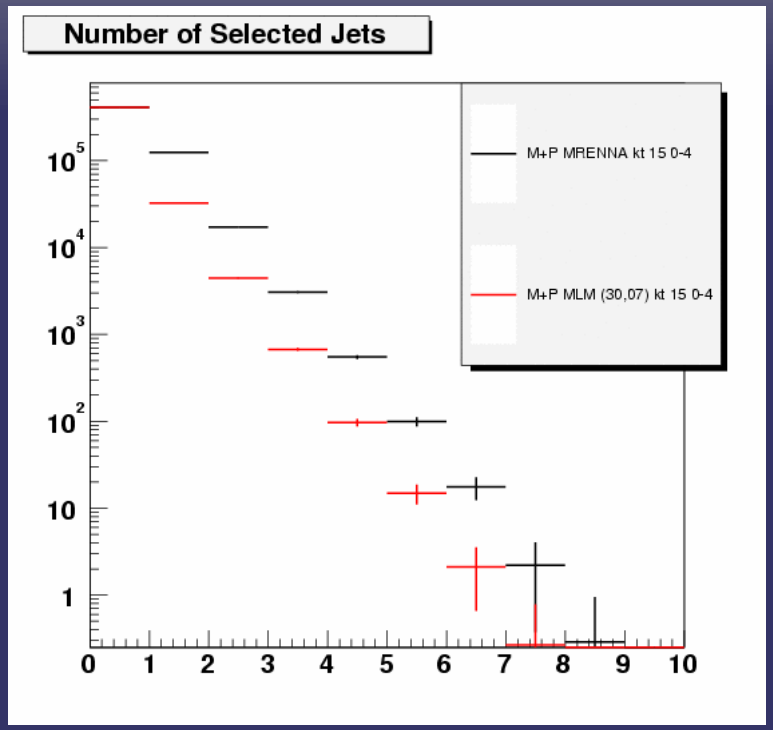
# *Subsequent plots are 5-way comparisons of the following:*

- MLM matched A+H, combined 1p-4p — YELLOW
- MLM matched M+P, combined 1p-4p — GREEN
- CKKW (MRENNA), combined 1p-4p — BLUE
- MLM matched M+P, combined 0p-4p — RED
- CKKW (MRENNA), combined 0p-4p — BLACK
- Consistencies between samples:
  - For “observed” (hadron level) jet plots the analysis cut (20,04) is used for all samples.
  - All MLM samples are matched using (30,07) parton jets
  - All M+P samples (MLM and MRENNA) are kt=15
- Missing Alpgen + Herwig W+0 parton sample – means we have to restrict the combining of samples when comparing to A+H.

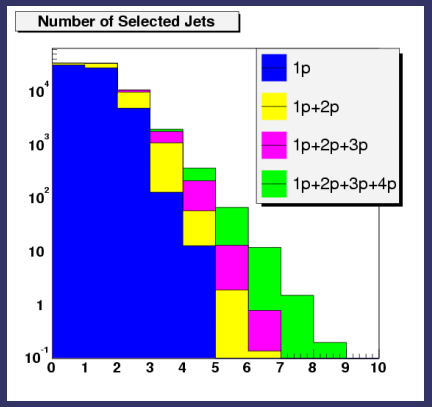
# Number of observed hadron jets

normalised to one jet bin

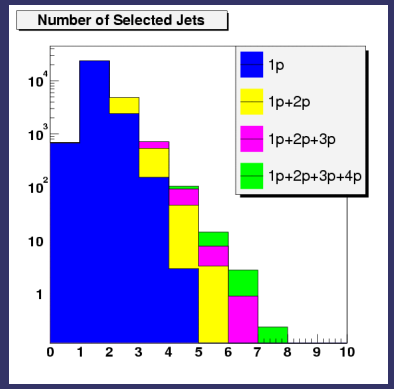


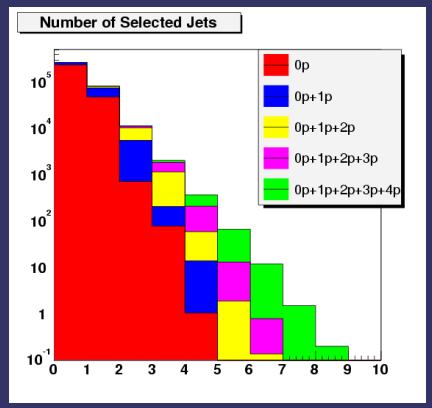

normalised to zero jet bin



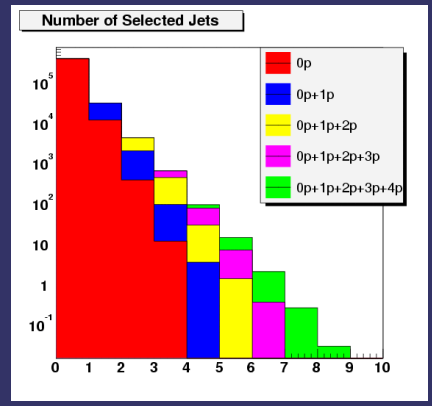

MRENNA M+P
1-4 combined




MLM A+H (30,07)
1-4 combined

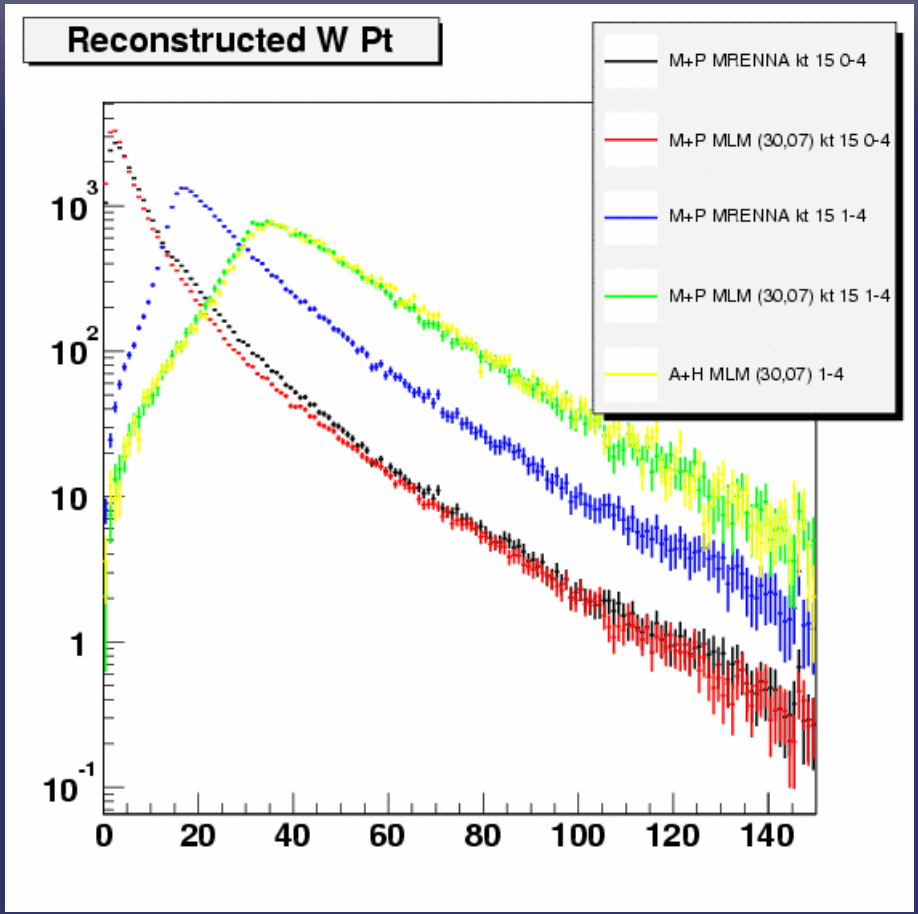


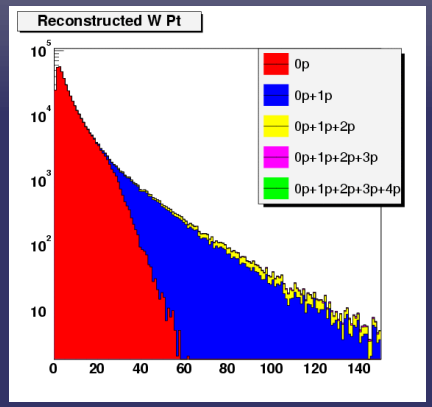

MRENNA M+P
0-4 combined



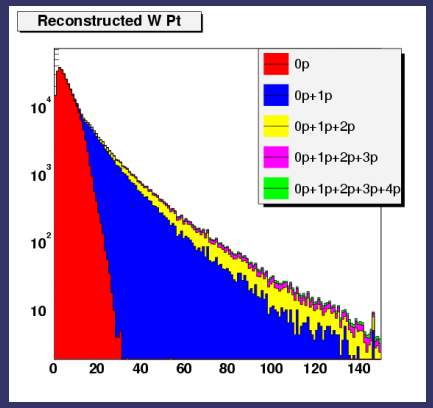

MLM M+P (30,07)
0-4 combined

# Reconstructed W Pt Spectrum



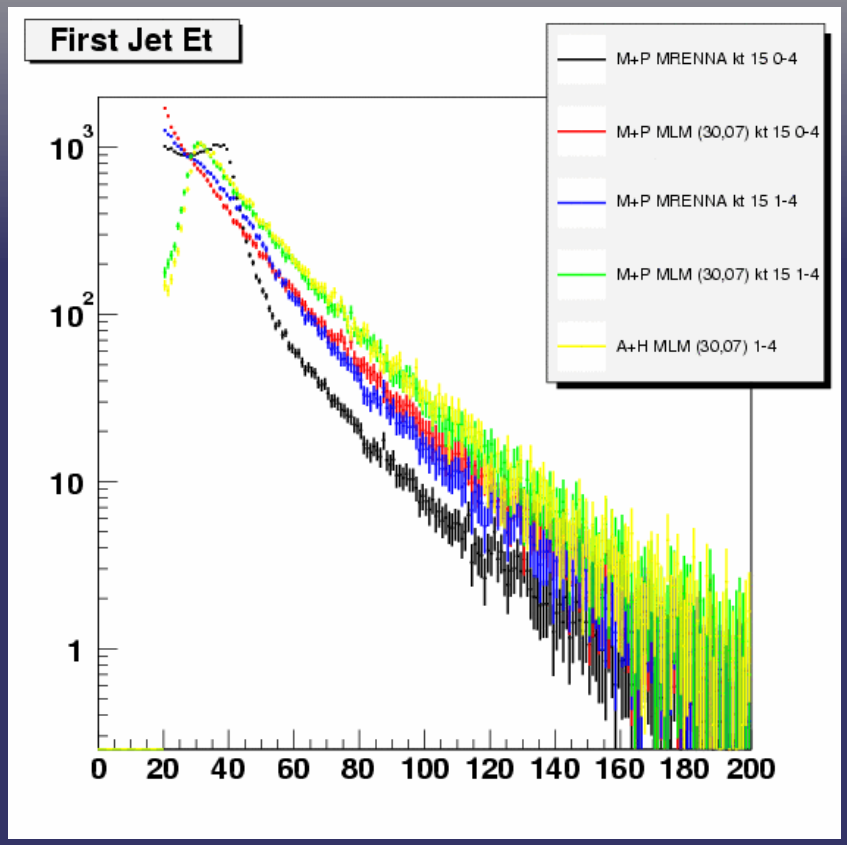



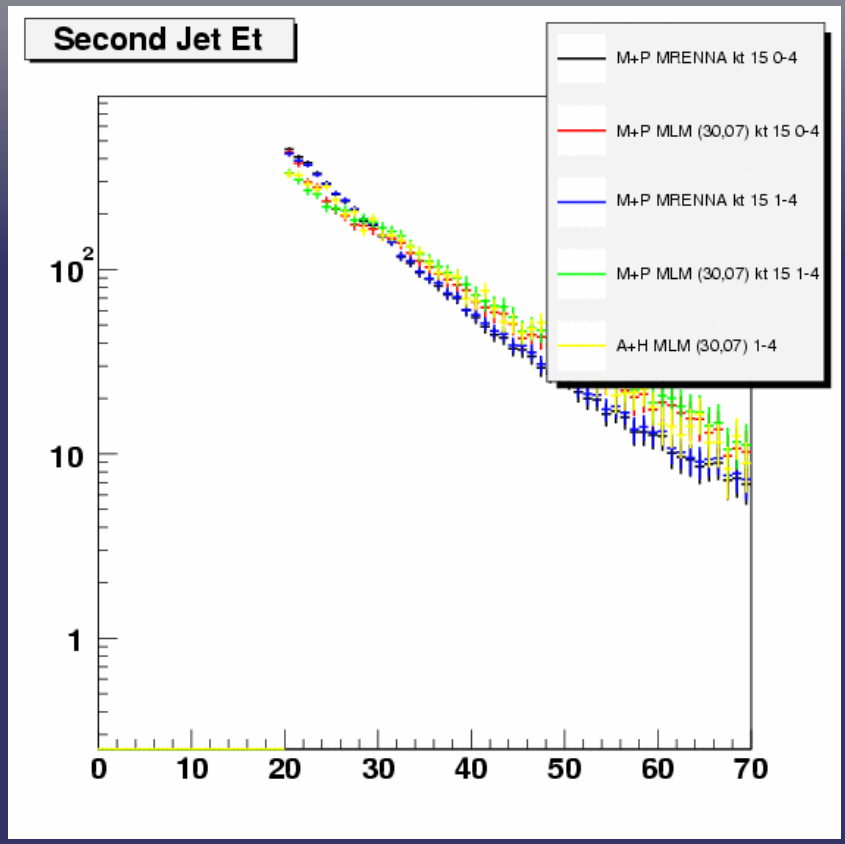

MLM M+P (30,07)
0-4 combined

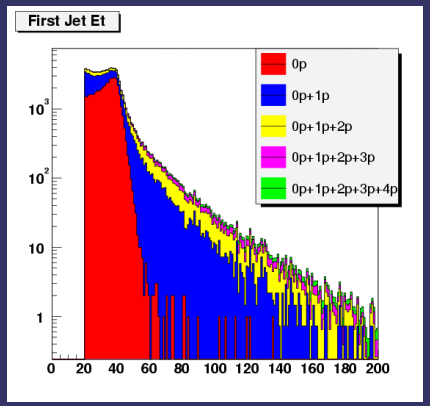



MRENNA M+P
0-4 combined

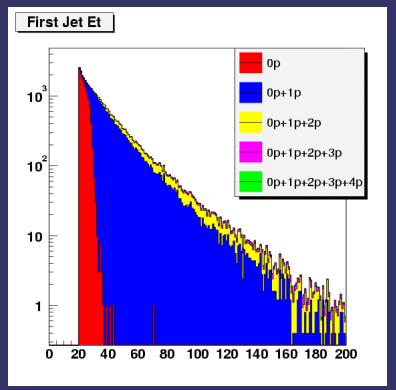
- Green cf Yellow curves – MLM A+H and MLM M+P agree very well – insensitivity to generation cuts...
- Yellow/Green cf Blue curve – when combining only 1p-4p samples, the MLM and CKKW matching prescriptions look quite different.
- Red cf Black curve – when you combine over the full 0p-4p samples, MLM and CKKW prescriptions agree very well.
- Feedup and feeddown relationships are quite different in CKKW and MLM.



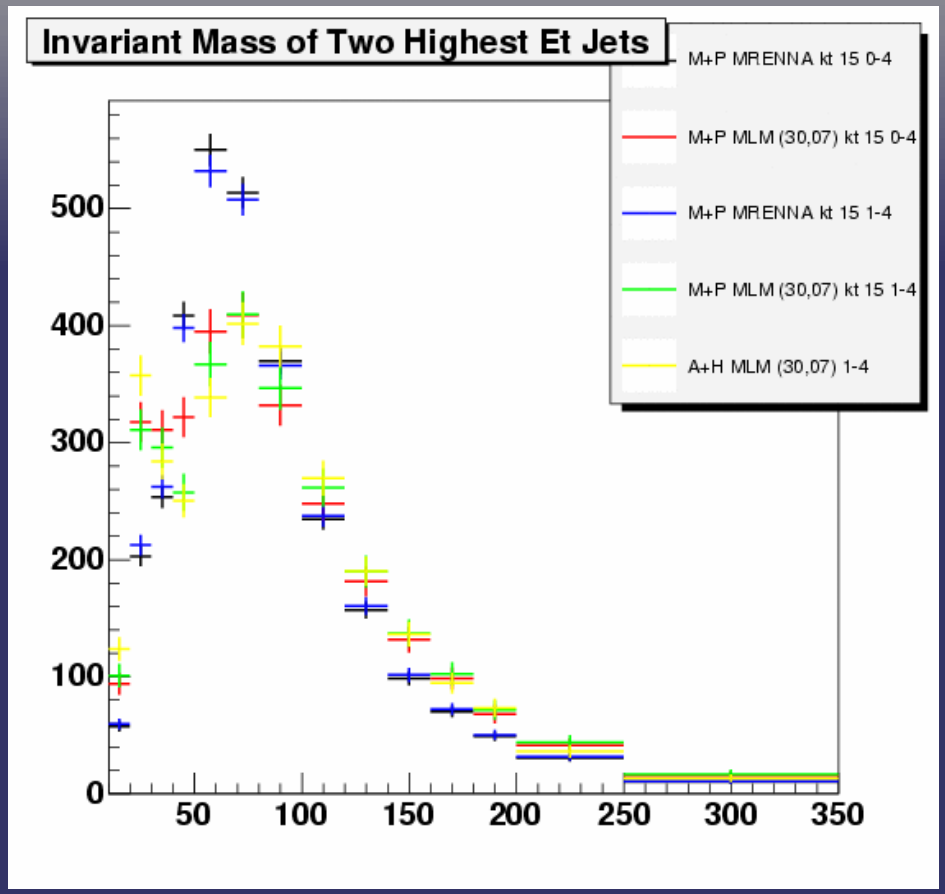



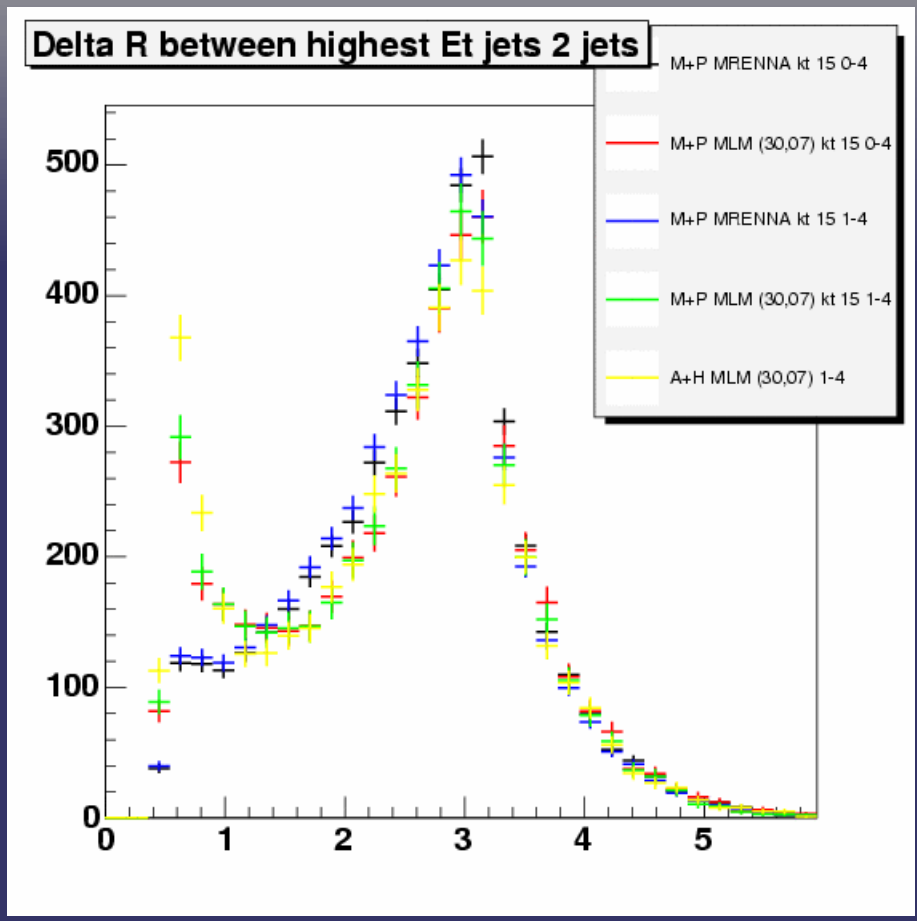

MRENNA M+P
0-4 combined

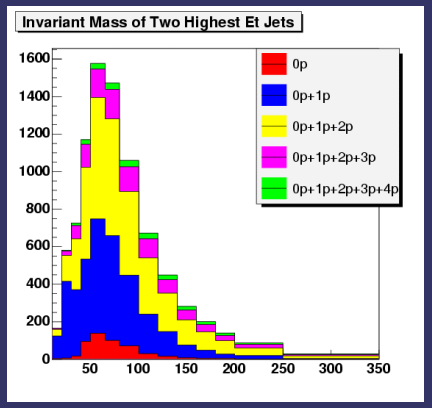



MLM M+P (30,07)
0-4 combined

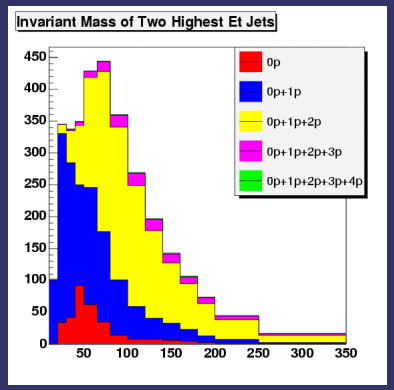
- Difference in shape between MRENNA and MLM leading jet Et is due to the very different shape of the W+0 parton leading jet Et spectrum.



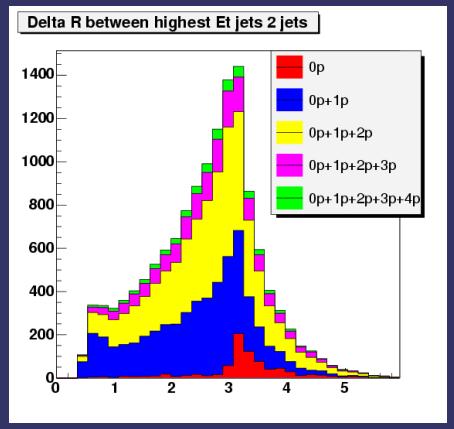



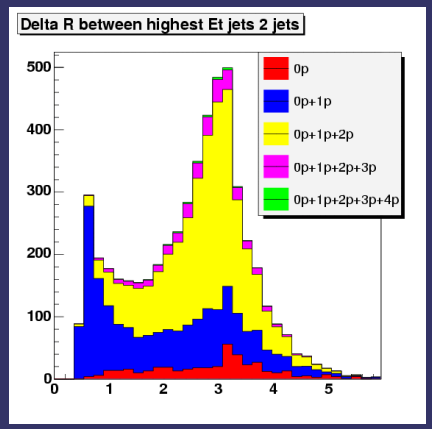

MRENNA M+P
0-4 combined




MLM M+P (30,07)
0-4 combined



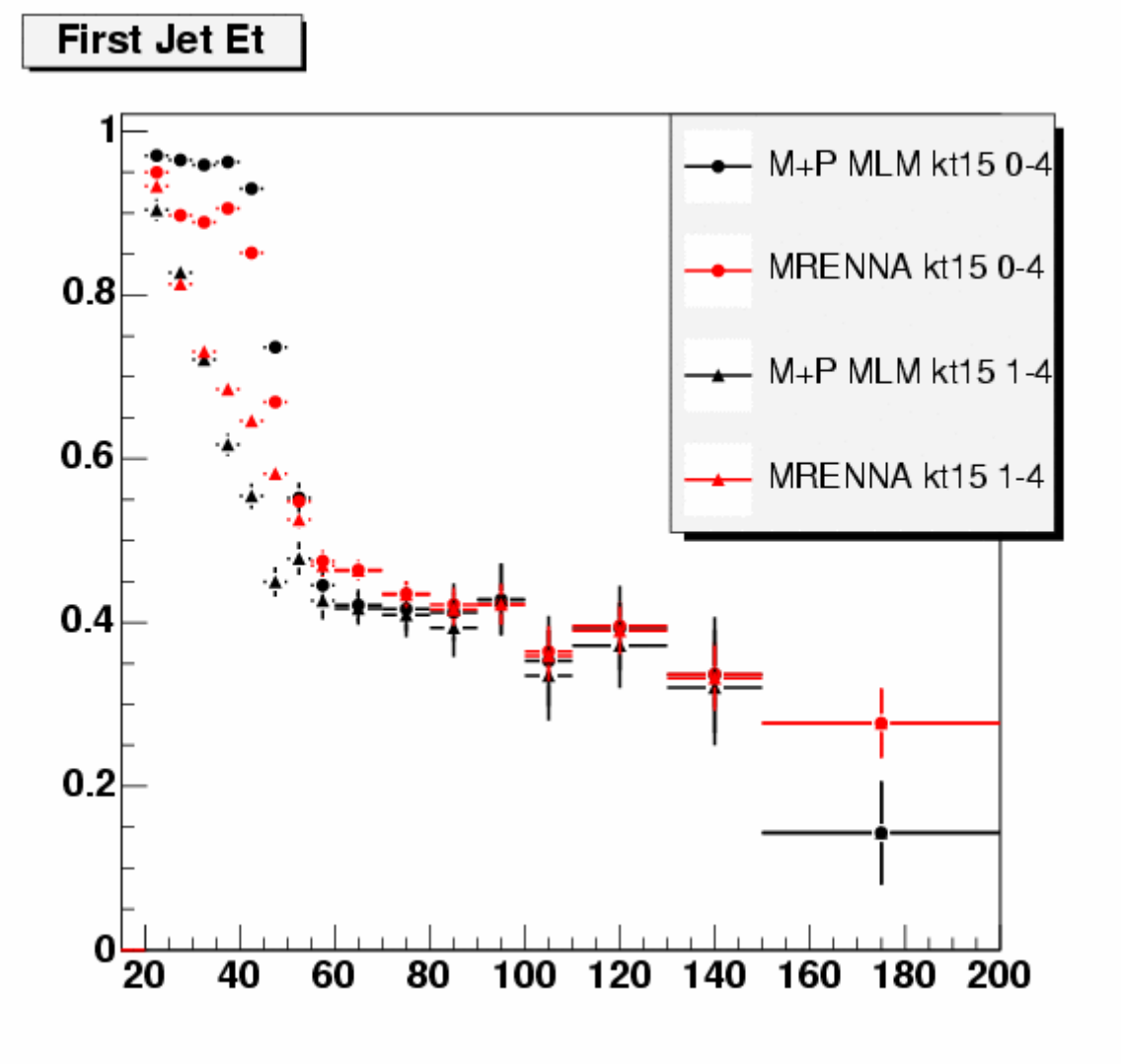

MRENNA M+P
0-4 combined




MLM M+P (30,07)
0-4 combined

# One Jet Fraction

$$\frac{N(1J)}{N(\geq 1J)}$$

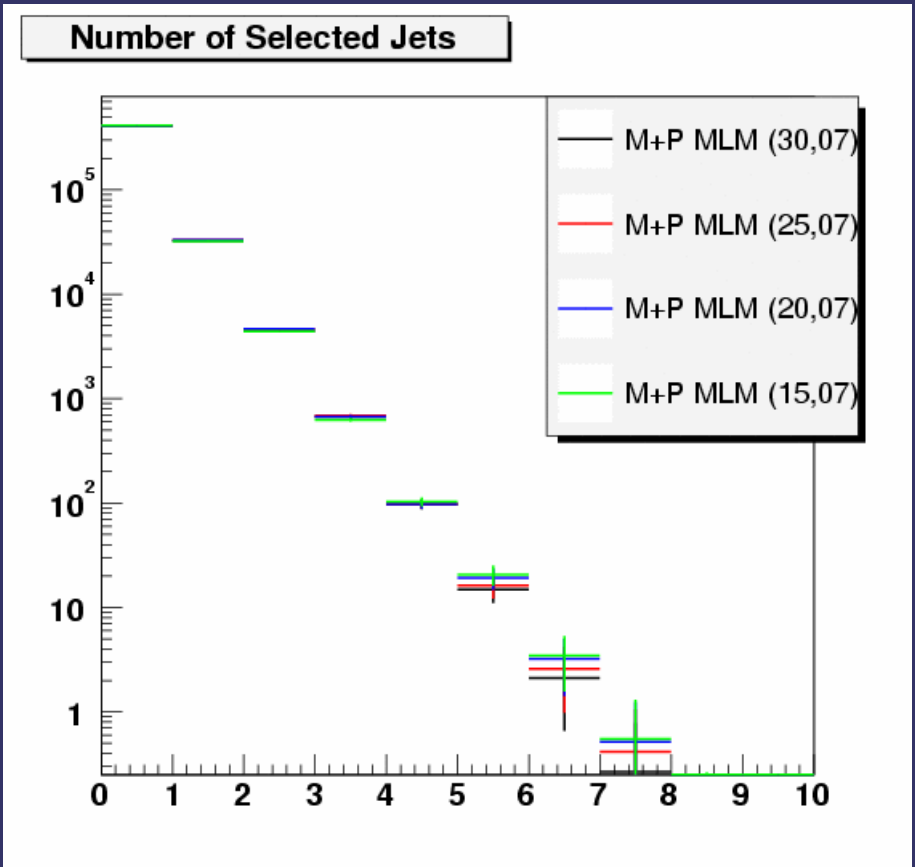


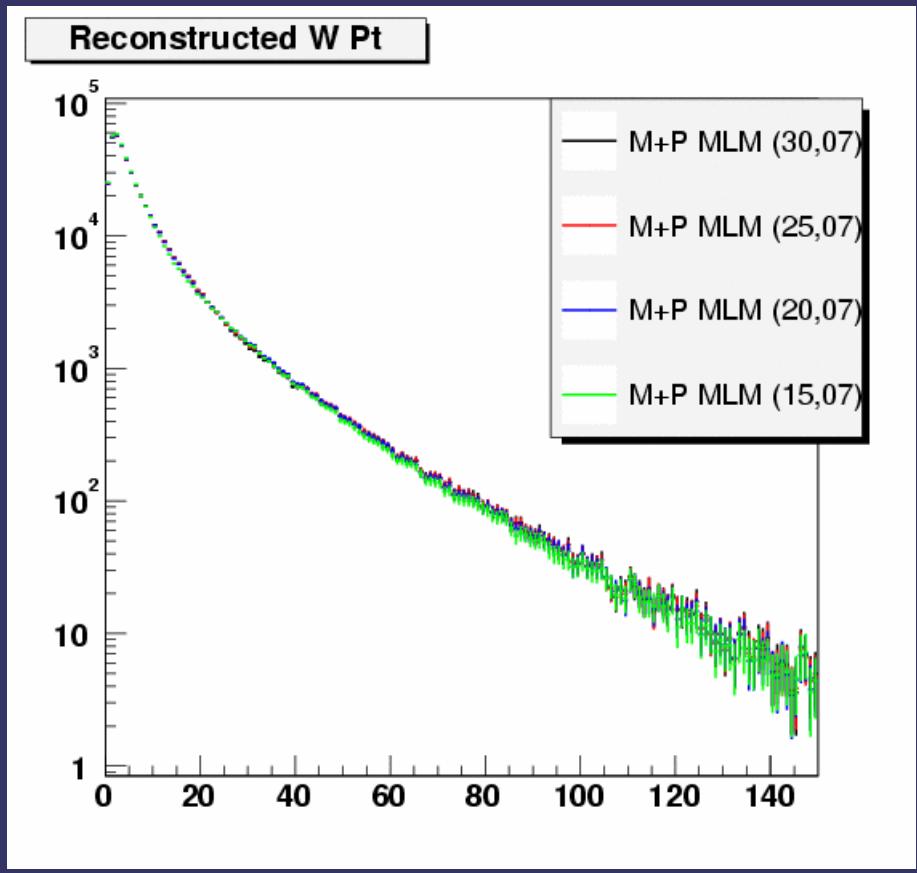

Leading Jet Et

- Essentially the multiplicity of an event as a function of leading jet Et.
- MLM and CKKW prescriptions agree well.
- However, note difference in both cases when you include and exclude the W+0parton sample from the combination.

# *Dependance of MLM distributions on Matching Cuts(i)*

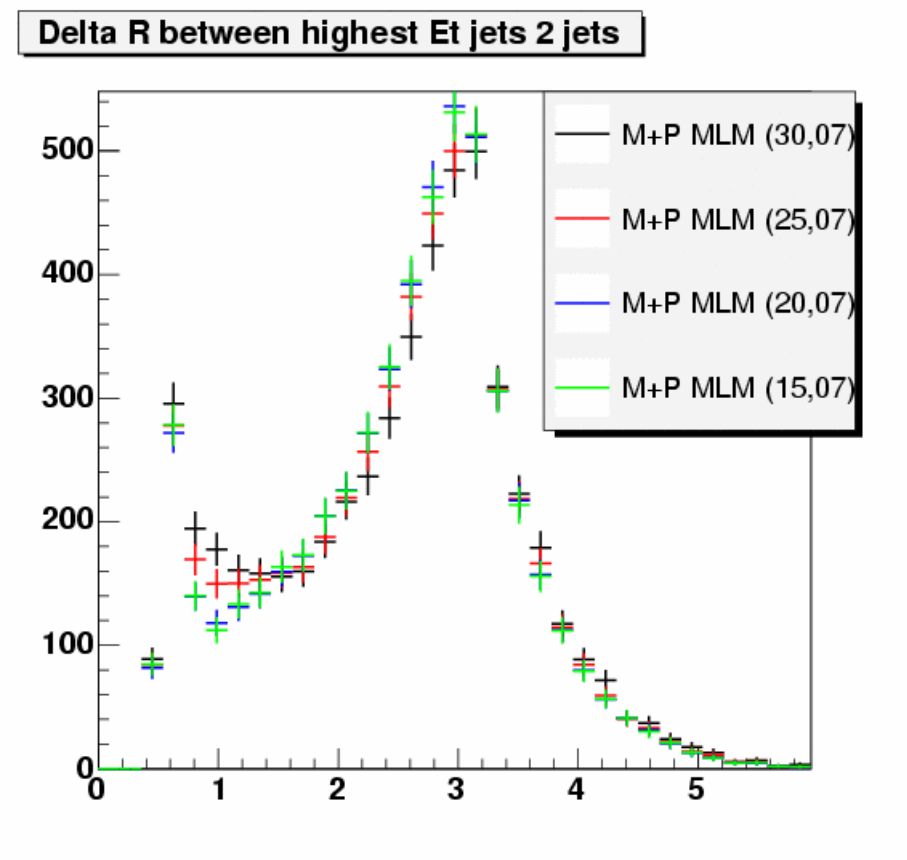
Combined MLM matched Madgraph + Pythia samples, using different matching cuts. All use analysis jet cut (20,04), generation cut kt = 15.

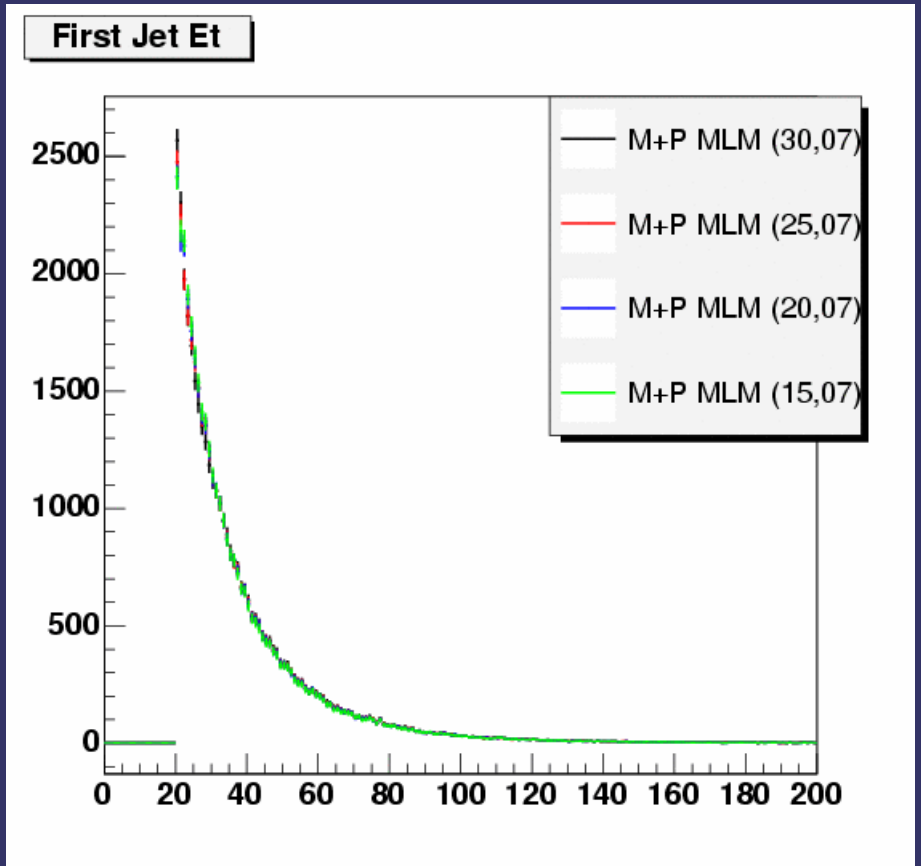



Normalised to zero jet bin.

# Dependance of MLM distributions on Matching Cuts(ii)



# *Conclusions and Future*

- The feed-up and feed-down characteristics of the individual W+n parton samples are quite different for CKKW(MRENNA) vs MLM matching.
- However, agreement between the two prescriptions is generally good, with a few exceptions.
- MLM displays the advertised insensitivity to generation cuts.
- Need to compare CKKW(MRENNA) kt 10 and kt 20 combined samples to establish this for CKKW.
- Both these prescriptions will be compared to data as soon as data is blessed.
- Michelangelo currently working on a version of Alpgen which will have MLM matching built in, and give you an “inclusive” combined sample straight out of the box
- In addition, we (Mitch Soderberg, Joey Huston, John Campbell, Jay Dittmann) are working towards  comparisons with NLO W+1 Jet and W+2 Jet parton level predictions.