CKKW MC at CDF

MC4Run2 Workshop

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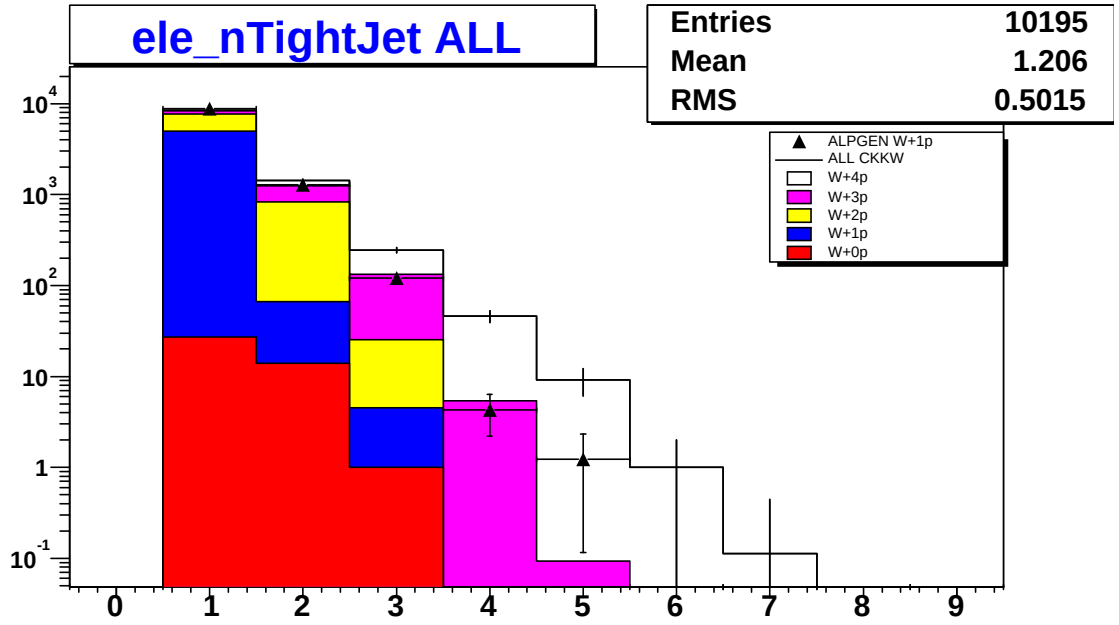
- **How does CKKW help?**
- **How can we validate CKKW?**
- **$W \rightarrow e^{+}\nu$ samples from Steve Mrenna**
  - **Comparison with CDF MC**
- **Future plans**

How does CKKW help?

- **Matrix Element good at hard radiation: ALPGEN, MADGRAPH,GRAPPA**
- **Parton Shower good at soft collinear radiation: PYTHIA, HERWIG**
  - **W+n parton ME+PS good for W+n and (n+1) jets**
  - **W+n parton ME+PS bad for W+(n+2) jets**
  - **Adding samples is bad since double-counts phase space!**
    - **Need complicated (to implement) matching procedure**

- **CKKW cures double-counting problem**
  - **Can simply add different W+np samples**
  - **Cross-section less sensitive to generator cuts**
  - **MC generation much more efficient**



How do we validate CKKW?

- **Compare to MC we used previously**
  - ***We've already compared this MC extensively to data since we've used it for all CDF Run II Top results so far***
  - **Use W+n parton for W+≥n jets *(ET, Ben Cooper)***
  - **Use MLM matching scheme *(Mitch Soderberg)***
- **Apply CDF Top Group W+>=1 jet event selection**
  - ***Even for generator level? Well, yes, since generator level cuts are quite different***
- **Plots so far *(suggestions welcome!)***
  - **W boson MT, PT**
  - **Lepton ET, η and MET**
  - **Jet ET, Jet-Jet invariant mass, ΔR between jets**

MC Generator cuts

- **ALPGEN+HERWIG (without CKKW) – Claudio Ferretti**
  - **$W \rightarrow e^{+}\nu$ and $W \rightarrow e^{-}\nu$**
  - **partons**
    - **PT > 8 GeV, $|\eta|<3.0$, $\Delta R > 0.2$**
  - **Leptons**
    - **PT > 1 GeV, $|\eta|<5.0$**
- **MADGRAPH+PYTHIA (with CKKW) – Steve Mrenna**
  - **$W \rightarrow e^{+}\nu$ only**
  - **Partons**
    - **kT>10 GeV between partons and wrt beam direction**
      - **Partons close together must have rather large ET!**

MC details

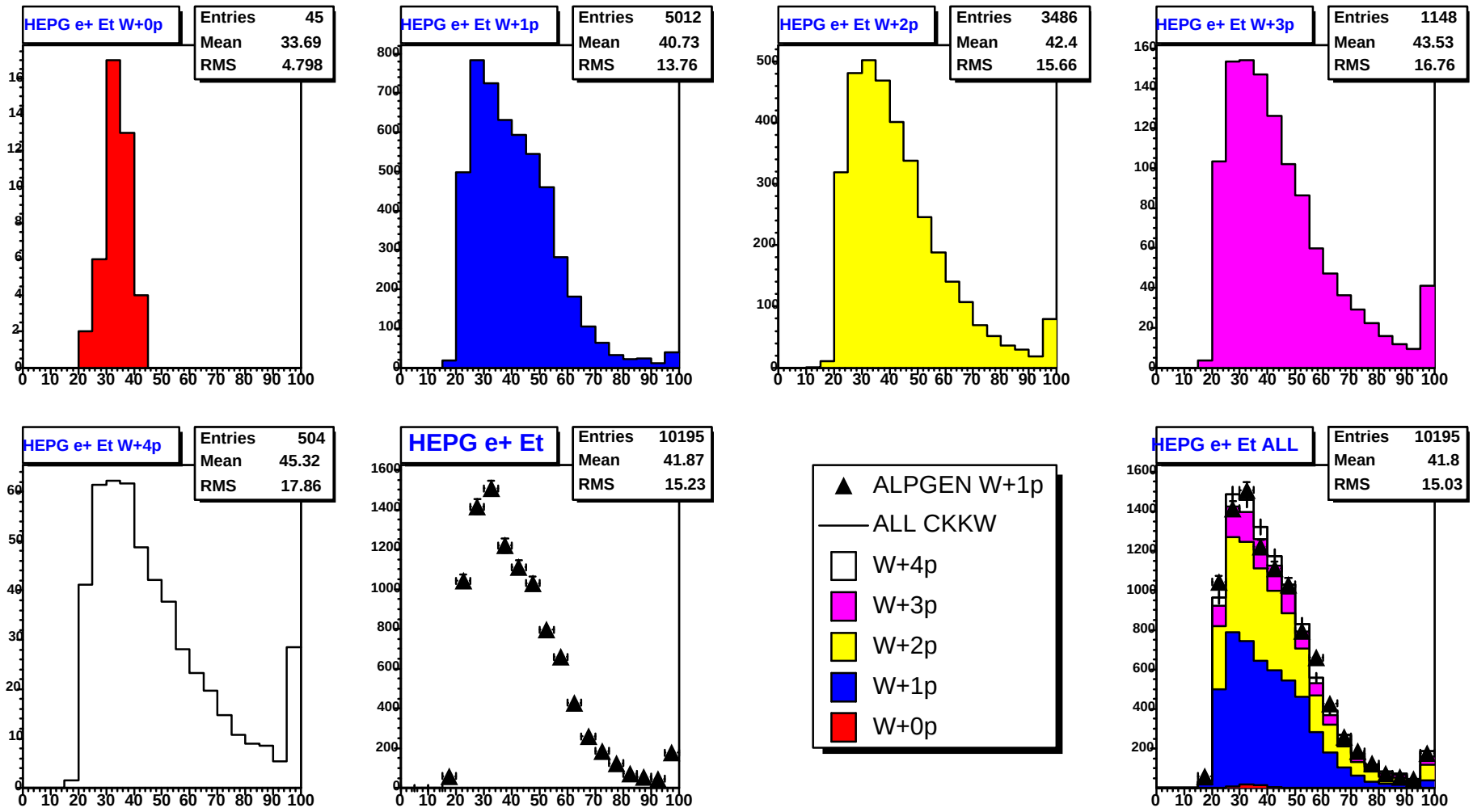
MADGRAPH **$W \rightarrow e^+ \nu$**	Gen xs(pb)	Gen Events	Luminosity (pb-1)
W+0p	733.5	250714	341.8
W+1p	277.2	106677	384.8
W+2p	81.0	101608	1254.4
W+3p	19.4	71605	3691.0
W+4p	7.6	46407	6106.2

ALPGEN **$W \rightarrow e^+ \nu, e^- \nu$**	Gen xs(pb)	Gen Events	Luminosity (pb-1)
W+0p	2038.8	-	-
W+1p	682.4	275000	403.0
W+2p	246.7	189131	766.6
W+3p	89.6	268682	2998.7
W+4p	32.5	292862	9009.3

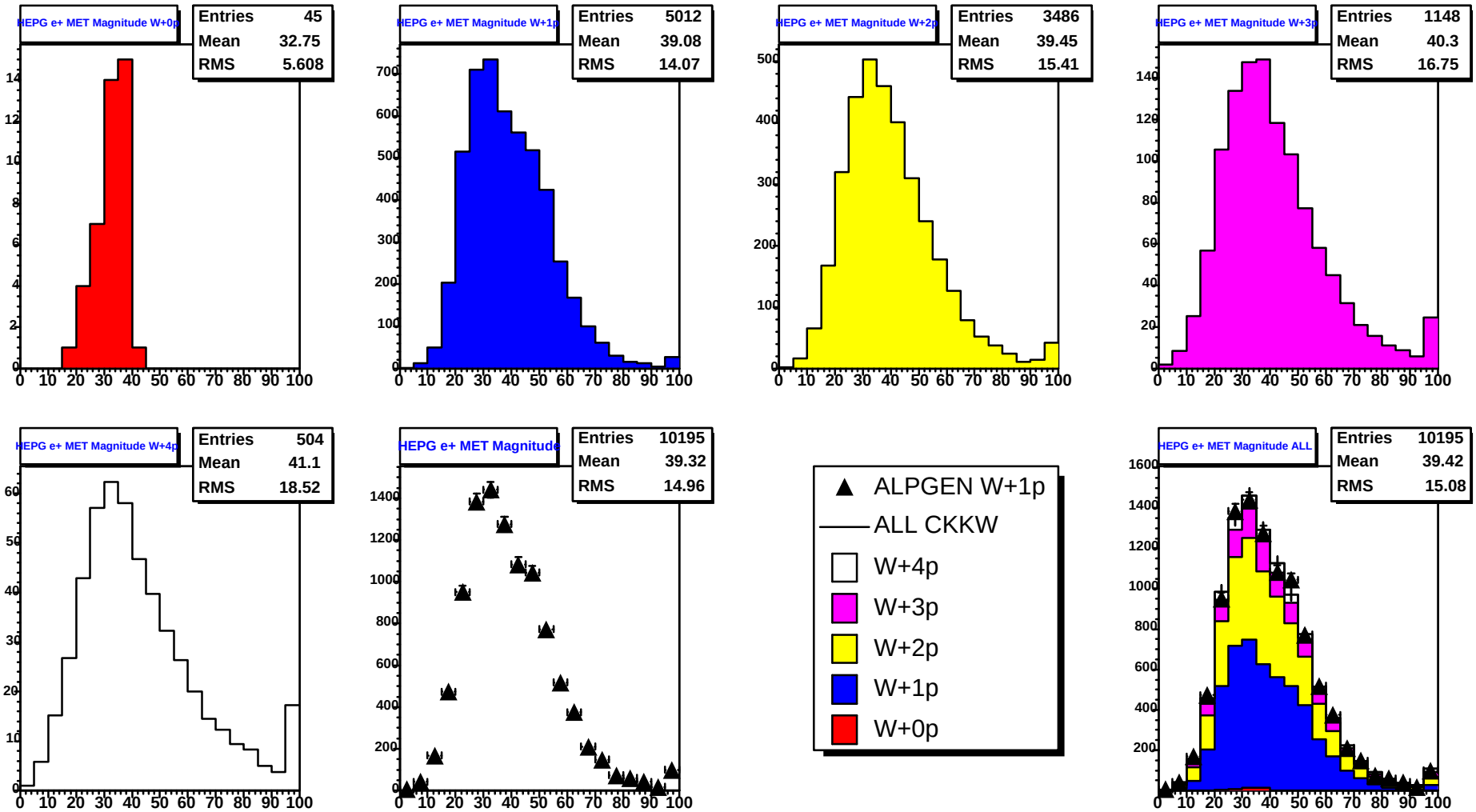
Event Selection

- **Isolated central e+ with ET>20 GeV**
- **MET > 20 GeV**
- **>=1 jet with ET>15 GeV and $|\eta|<2.0$**
  - **JETCLU cone 0.4**
- **Veto**
  - **Z**
  - **conversions**
  - **dileptons**
  - **non-W background**
    - **If MET<30 GeV, veto if $\Delta\varphi$(MET,Leading Jet) outside [0.5,2.5] radians**

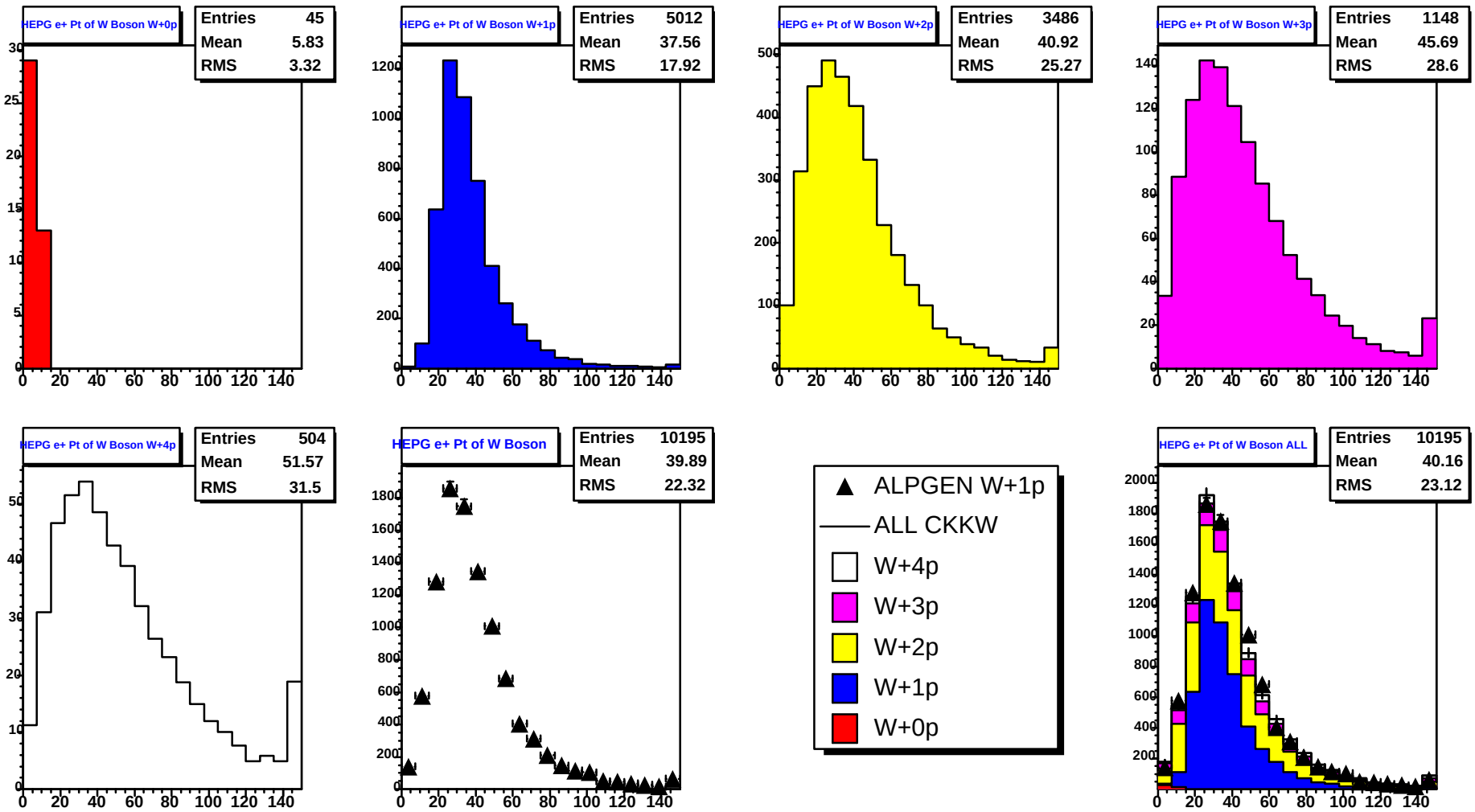
Generator level: positron ET



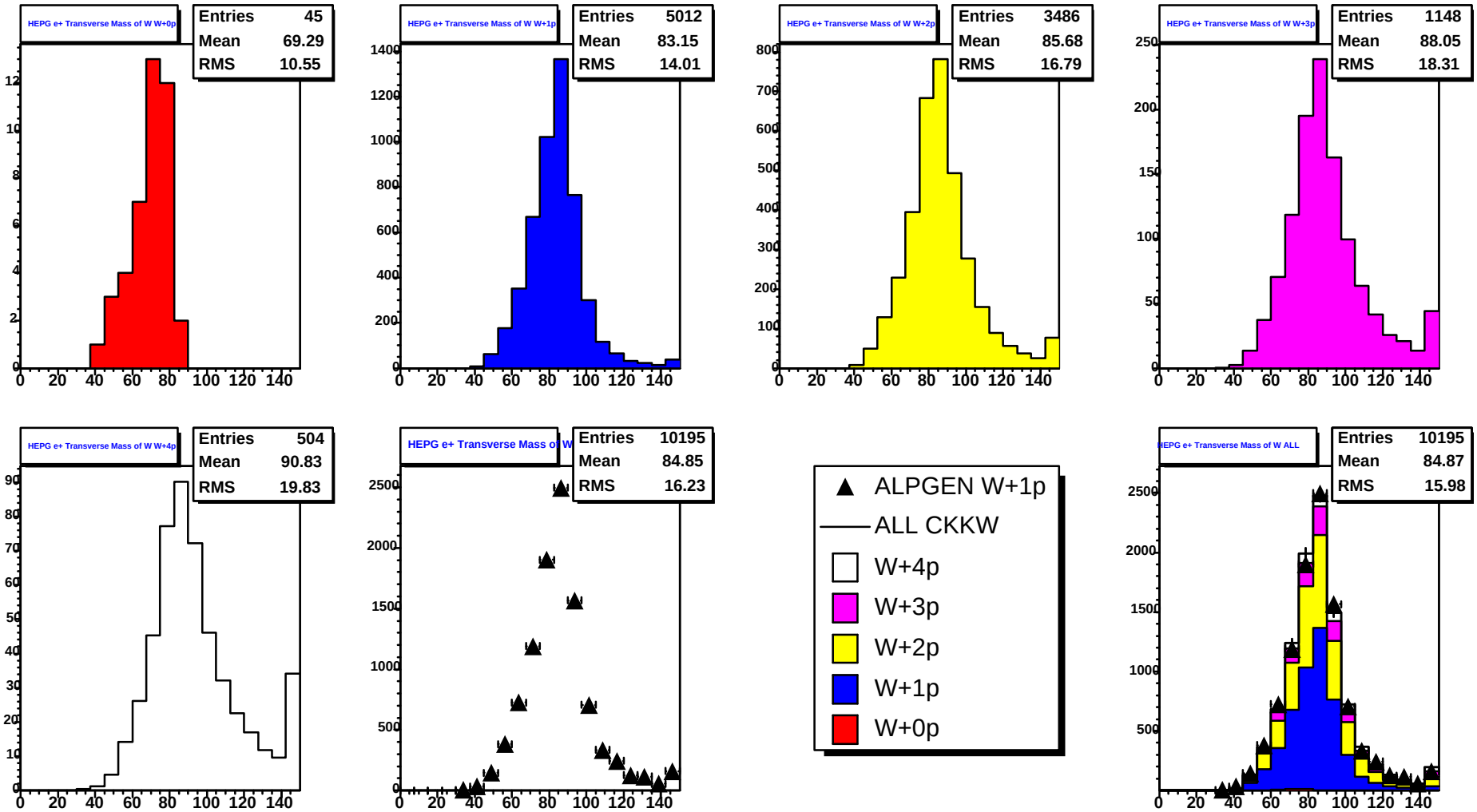
Generator level: ν ET



Generator level: W PT



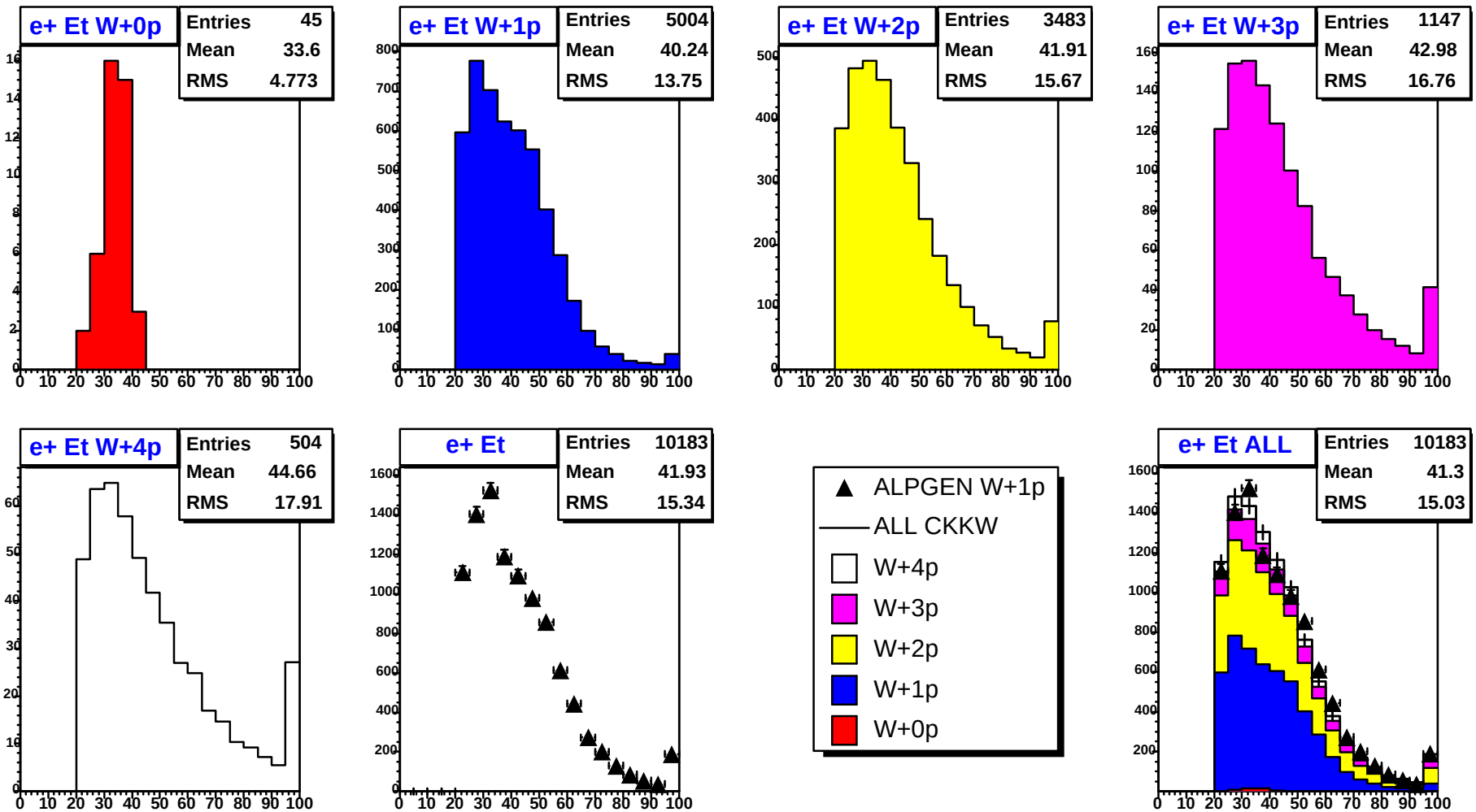
Generator level: W MT



NEXT (MC ONLY):

Full detector simulation and reconstruction

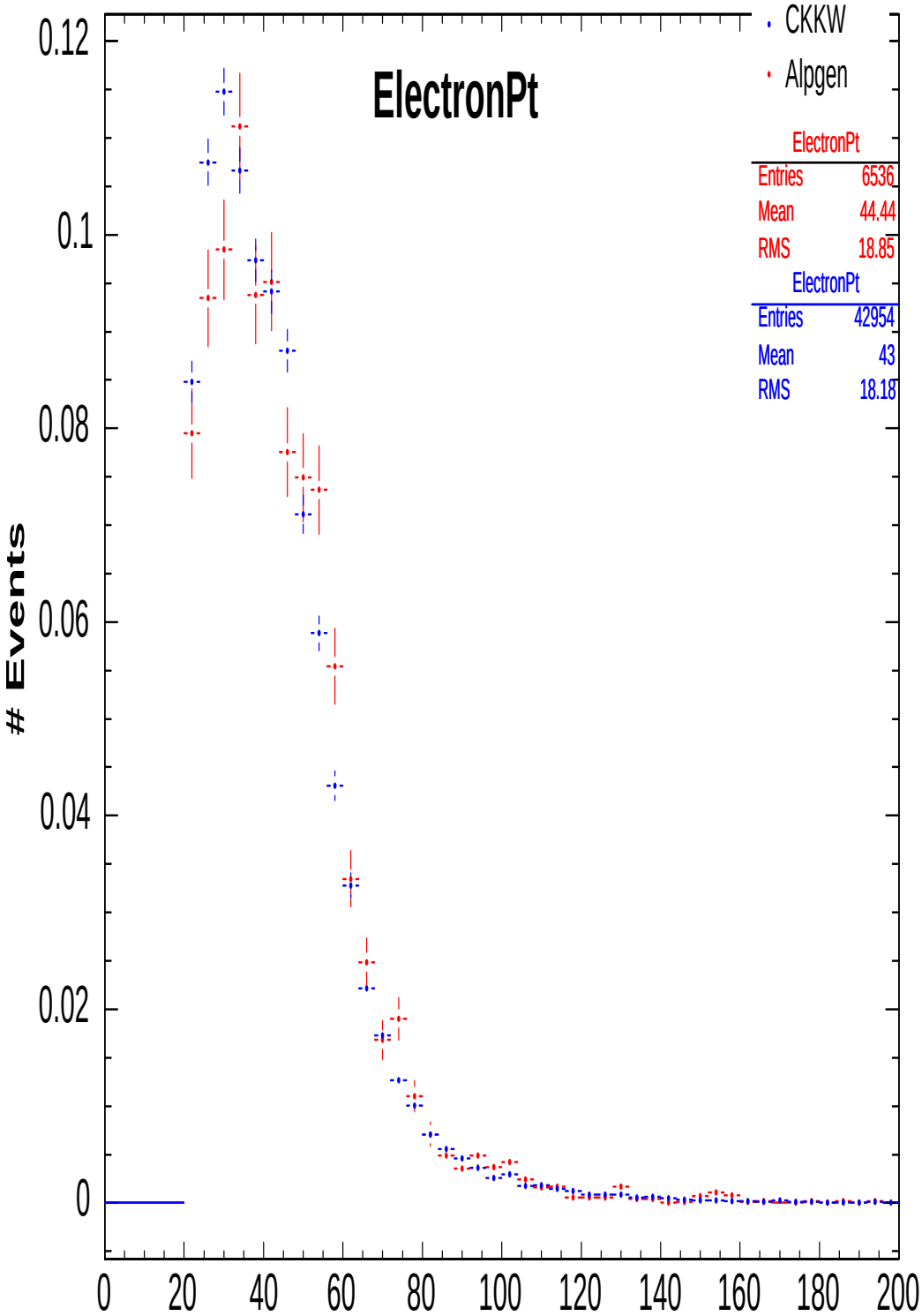
Positron ET


e+ Et W+0p
Entries 45
Mean 33.6
RMS 4.773
e+ Et W+1p
Entries 5004
Mean 40.24
RMS 13.75
e+ Et W+2p
Entries 3483
Mean 41.91
RMS 15.67
e+ Et W+3p
Entries 1147
Mean 42.98
RMS 16.76
e+ Et W+4p
Entries 504
Mean 44.66
RMS 17.91
e+ Et
Entries 10183
Mean 41.93
RMS 15.34
ALPGEN W+1p
ALL CKKW
W+4p
W+3p
W+2p
W+1p
W+0p
e+ Et ALL
Entries 10183
Mean 41.3
RMS 15.03

Mangano Matching Scheme

- **Matching procedure as implemented for CDF by Claudio Ferretti**
  - **Make jets out of final state stable particles**
    - **ie at generator level before simulation or reconstruction**
  - **W+1,2,3p samples**
    - **Each jet matched to a parton (no extra jets)**
  - **W+4p**
    - **Each jet matched to a parton and extra jets allowed**

Positron ET (Matched)



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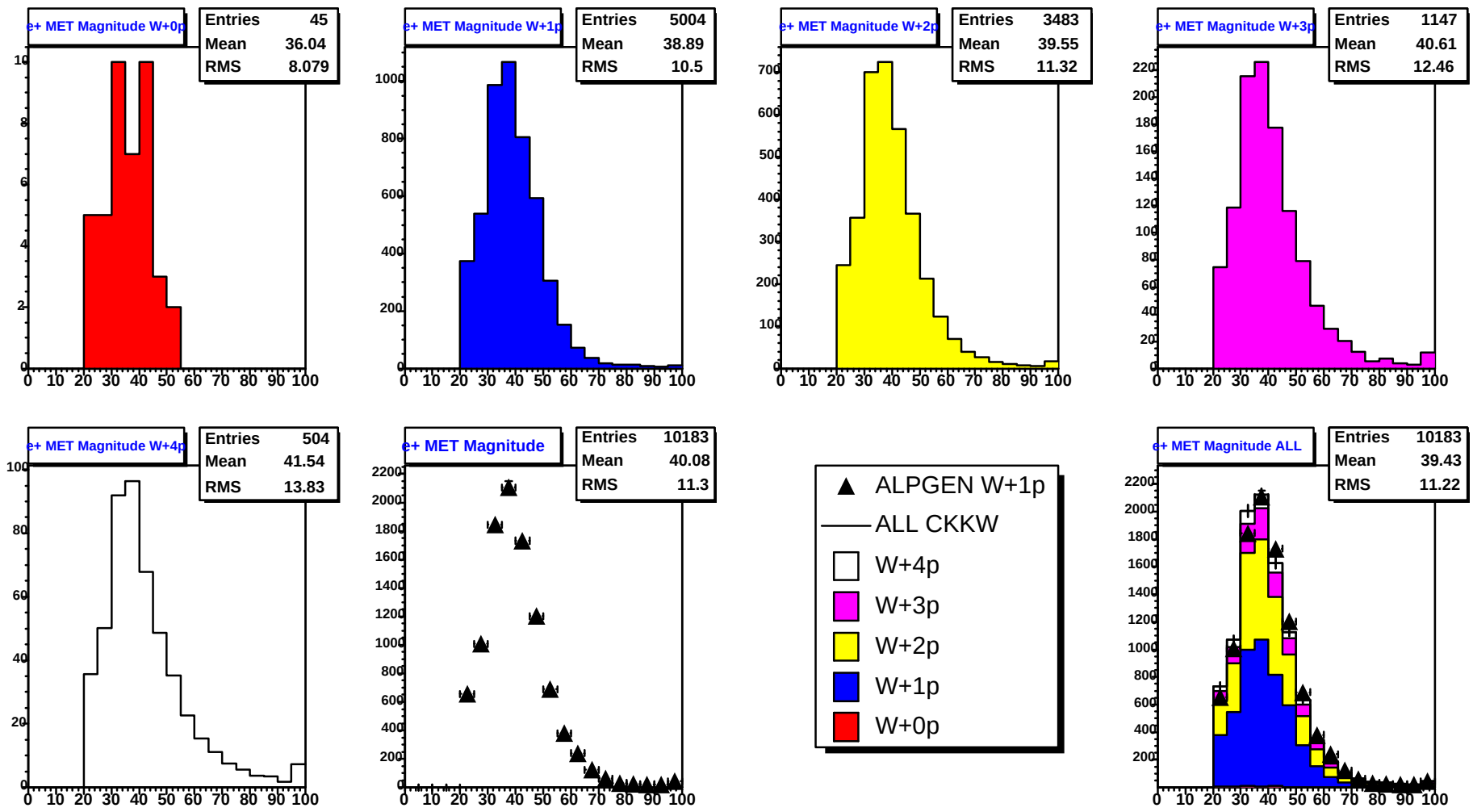
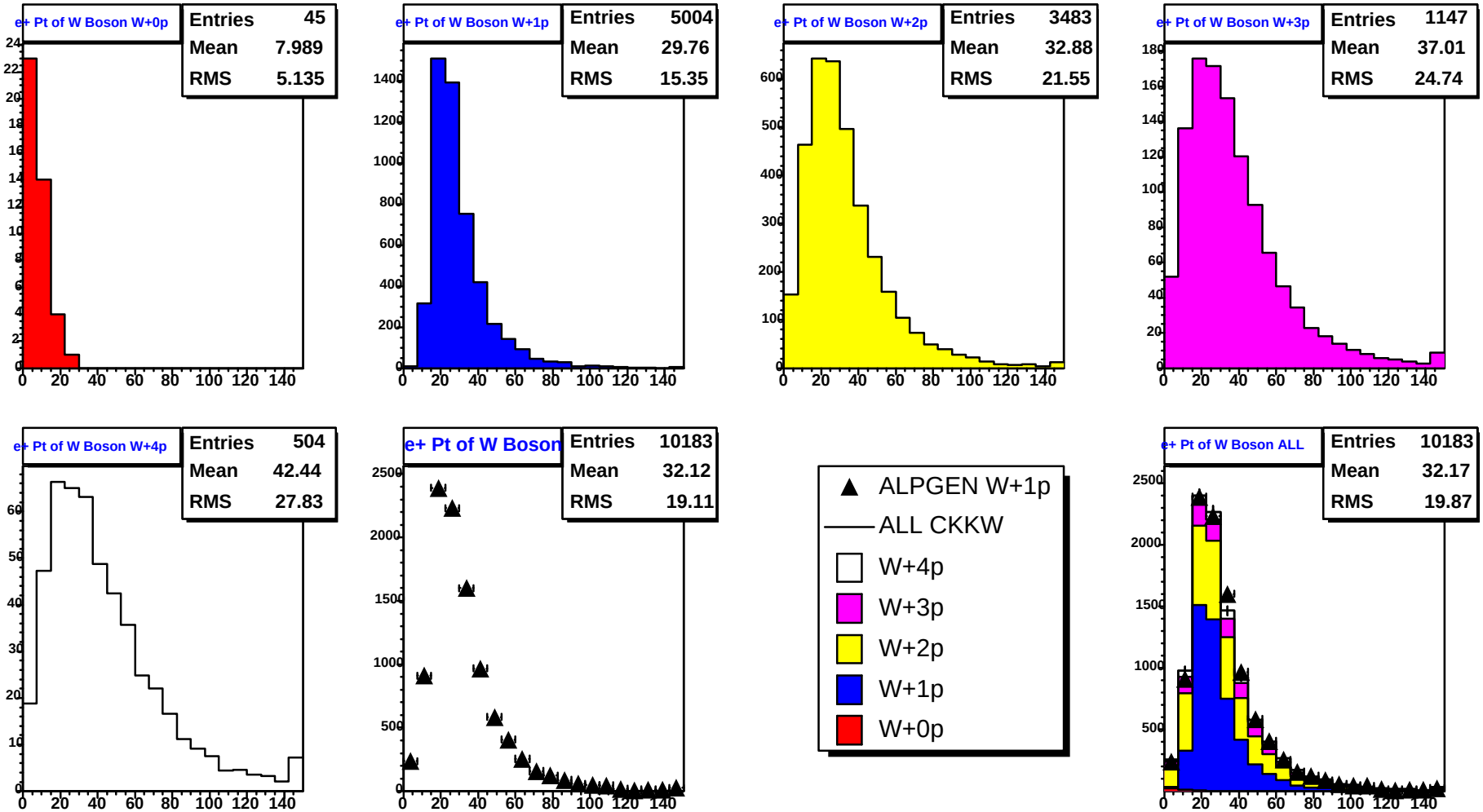
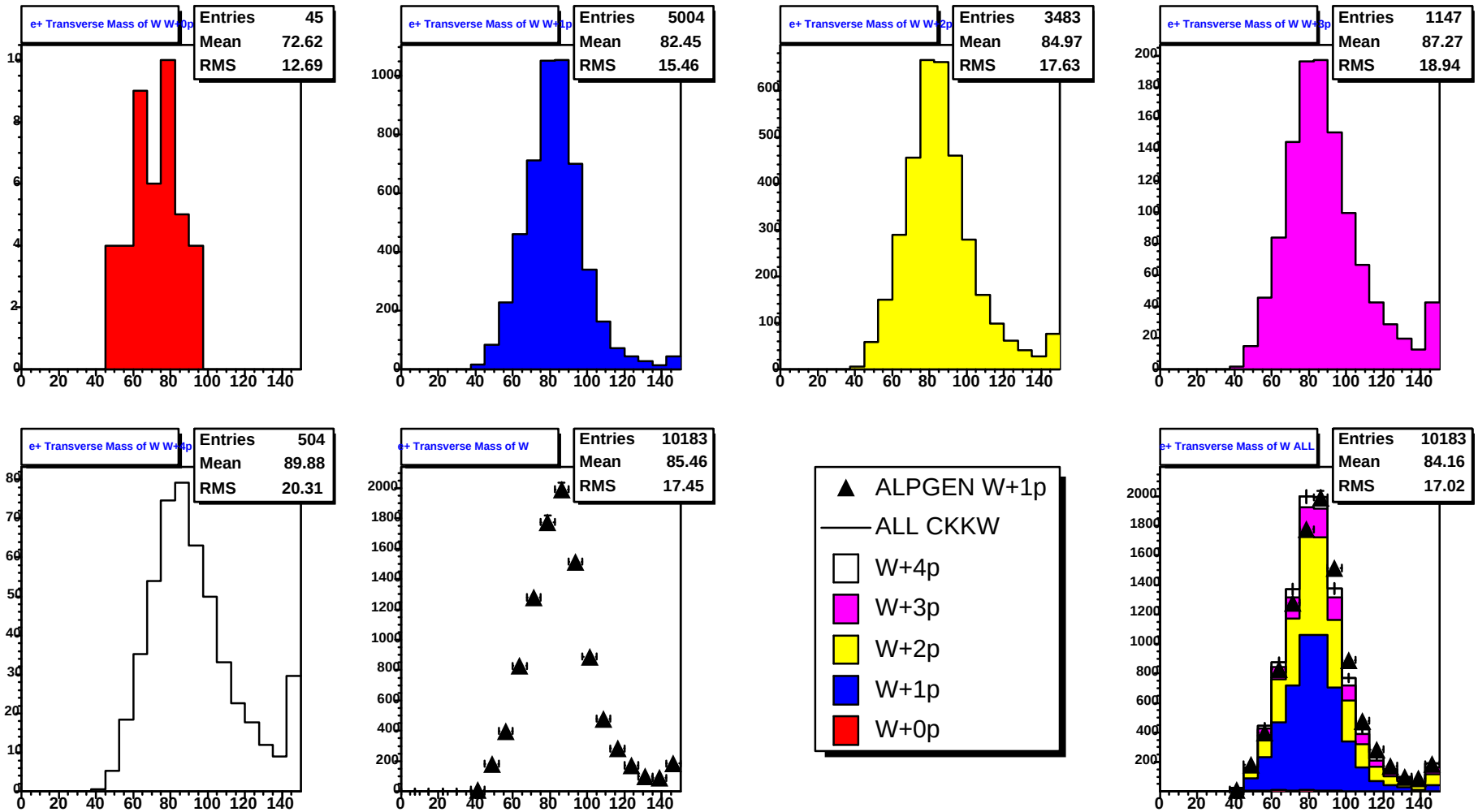
Missing Tranverse Energy



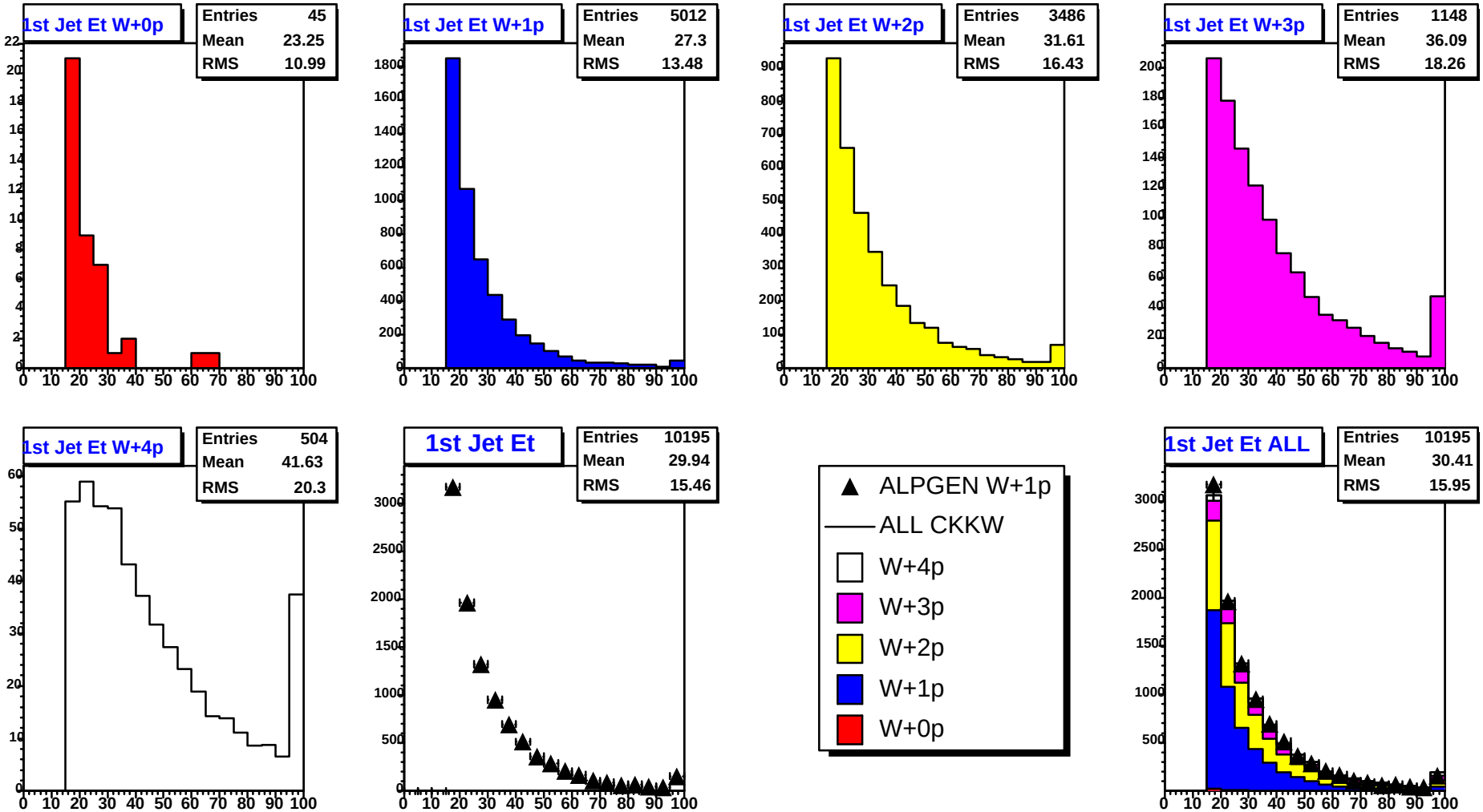
W PT


e+ Pt of W Boson W+0p
Entries 45
Mean 7.989
RMS 5.135
e+ Pt of W Boson W+1p
Entries 5004
Mean 29.76
RMS 15.35
e+ Pt of W Boson W+2p
Entries 3483
Mean 32.88
RMS 21.55
e+ Pt of W Boson W+3p
Entries 1147
Mean 37.01
RMS 24.74
e+ Pt of W Boson W+4p
Entries 504
Mean 42.44
RMS 27.83
e+ Pt of W Boson
Entries 10183
Mean 32.12
RMS 19.11
ALPGEN W+1p
ALL CKKW
W+4p
W+3p
W+2p
W+1p
W+0p
e+ Pt of W Boson ALL
Entries 10183
Mean 32.17
RMS 19.87

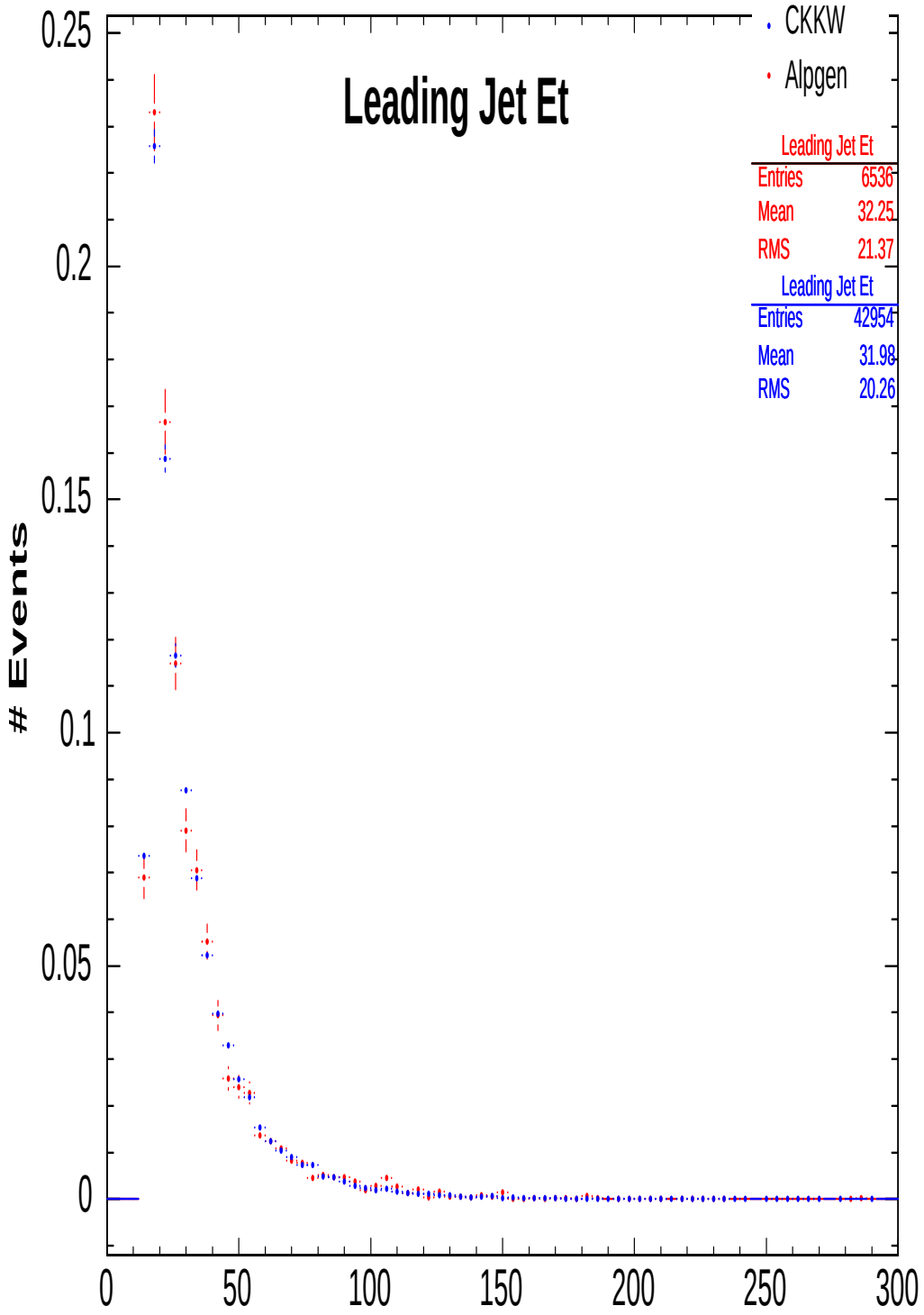
W MT


e+ Transverse Mass of W W+0p
Entries 45
Mean 72.62
RMS 12.69
e+ Transverse Mass of W W+1p
Entries 5004
Mean 82.45
RMS 15.46
e+ Transverse Mass of W W+2p
Entries 3483
Mean 84.97
RMS 17.63
e+ Transverse Mass of W W+3p
Entries 1147
Mean 87.27
RMS 18.94
e+ Transverse Mass of W W+4p
Entries 504
Mean 89.88
RMS 20.31
e+ Transverse Mass of W
Entries 10183
Mean 85.46
RMS 17.45
ALPGEN W+1p
ALL CKKW
W+4p
W+3p
W+2p
W+1p
W+0p
e+ Transverse Mass of W ALL
Entries 10183
Mean 84.16
RMS 17.02

Leading Jet ET



Leading Jet ET (Matched)



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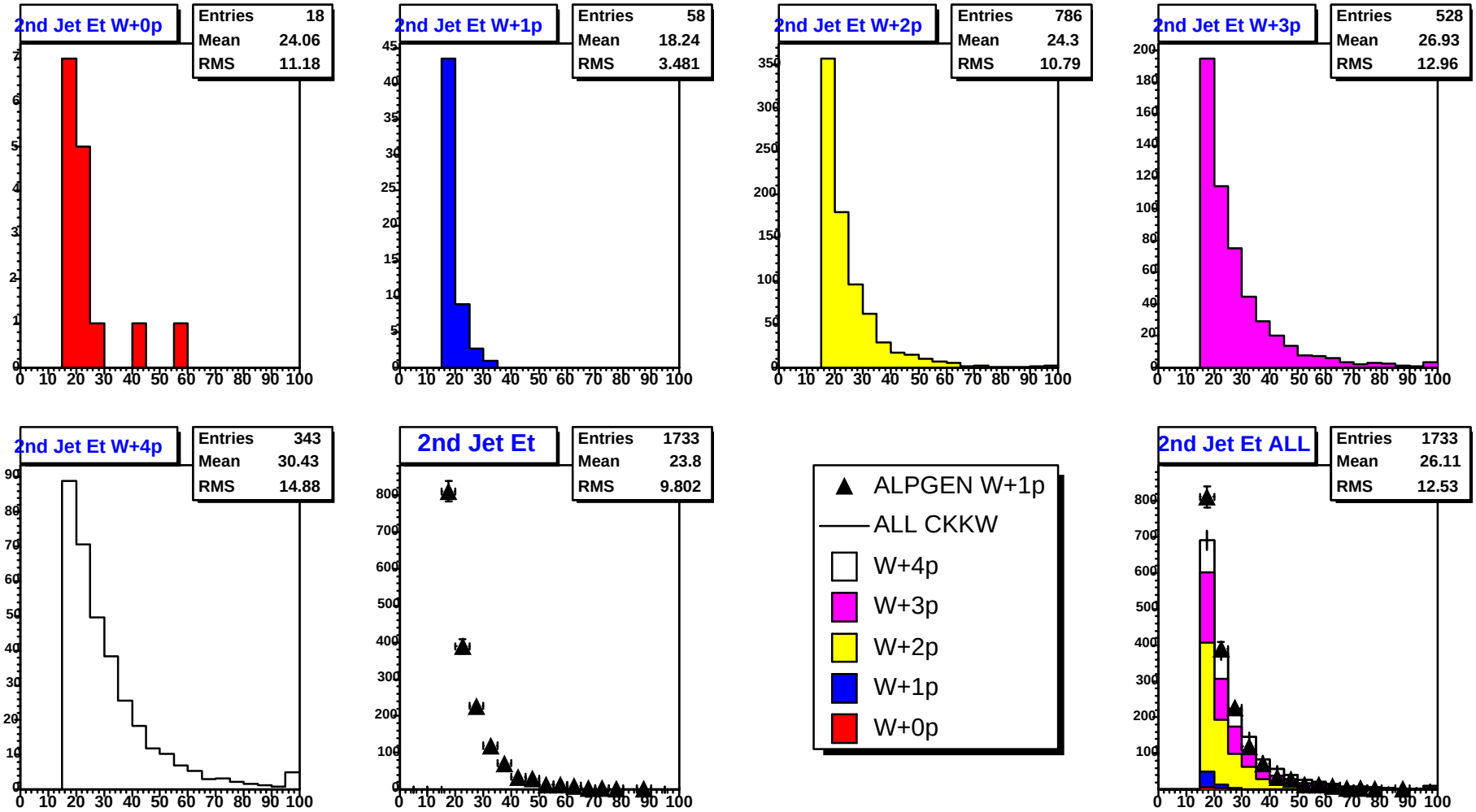
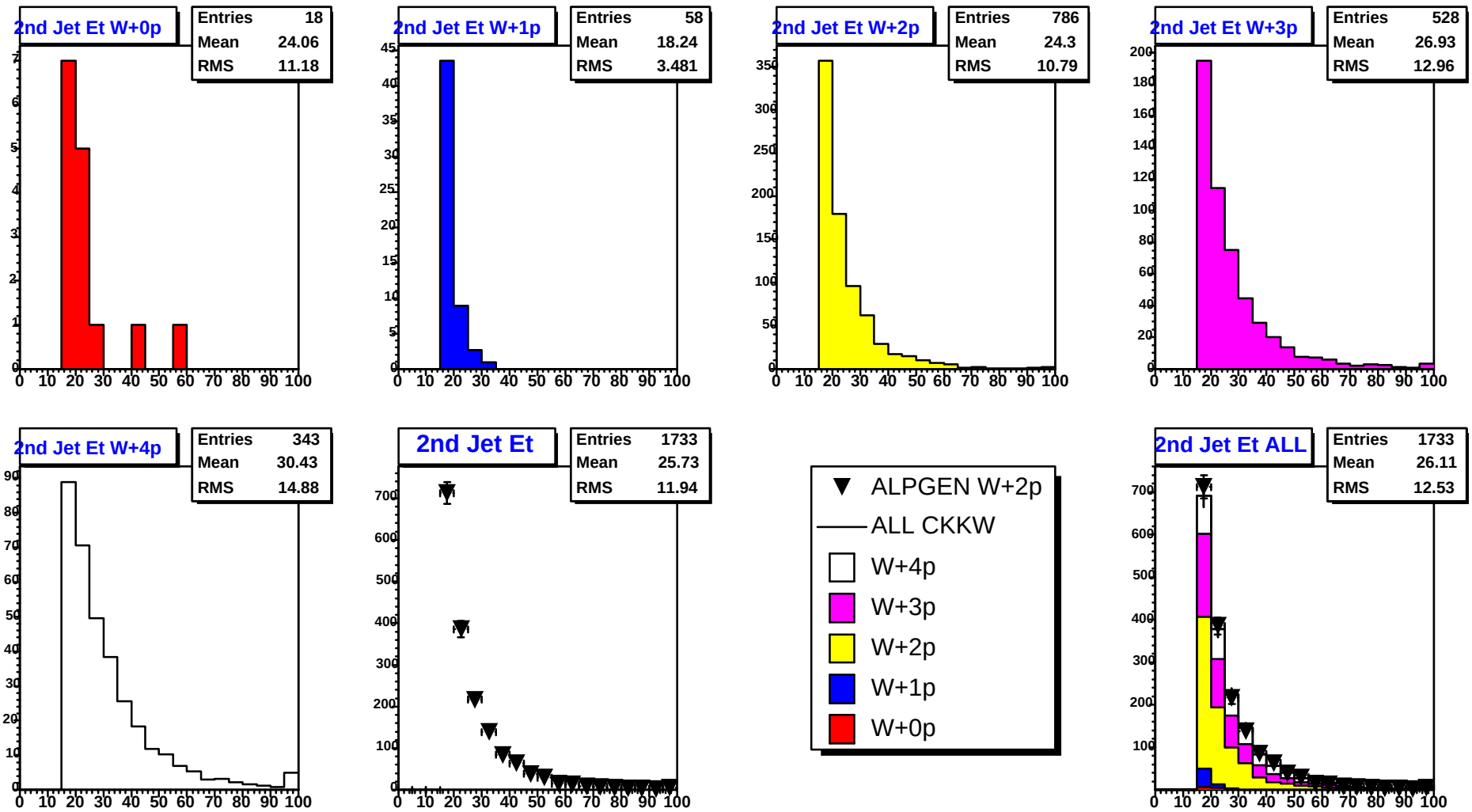
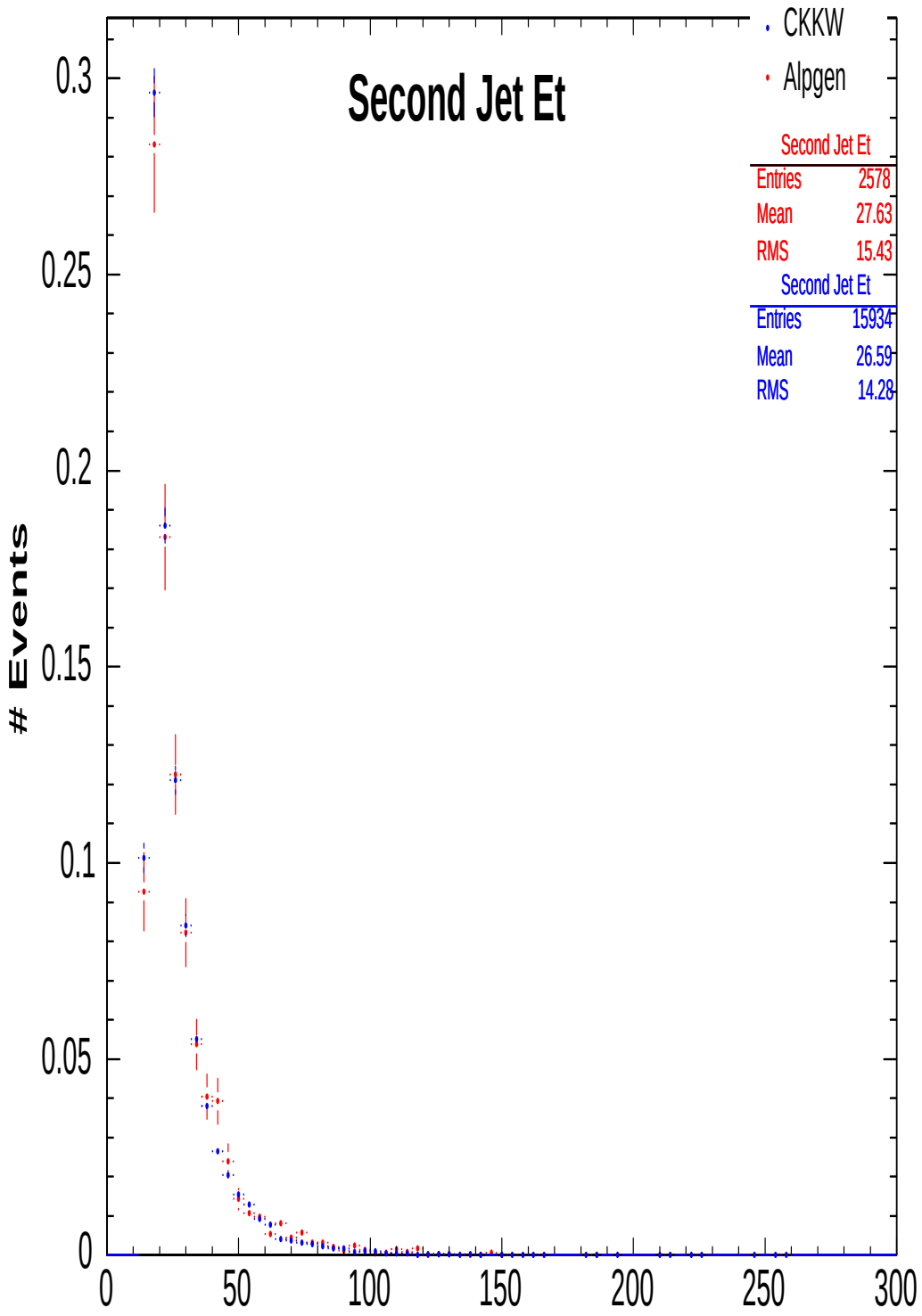
Second Jet ET



Second Jet ET (W+2p)



Second Jet ET (Matched)



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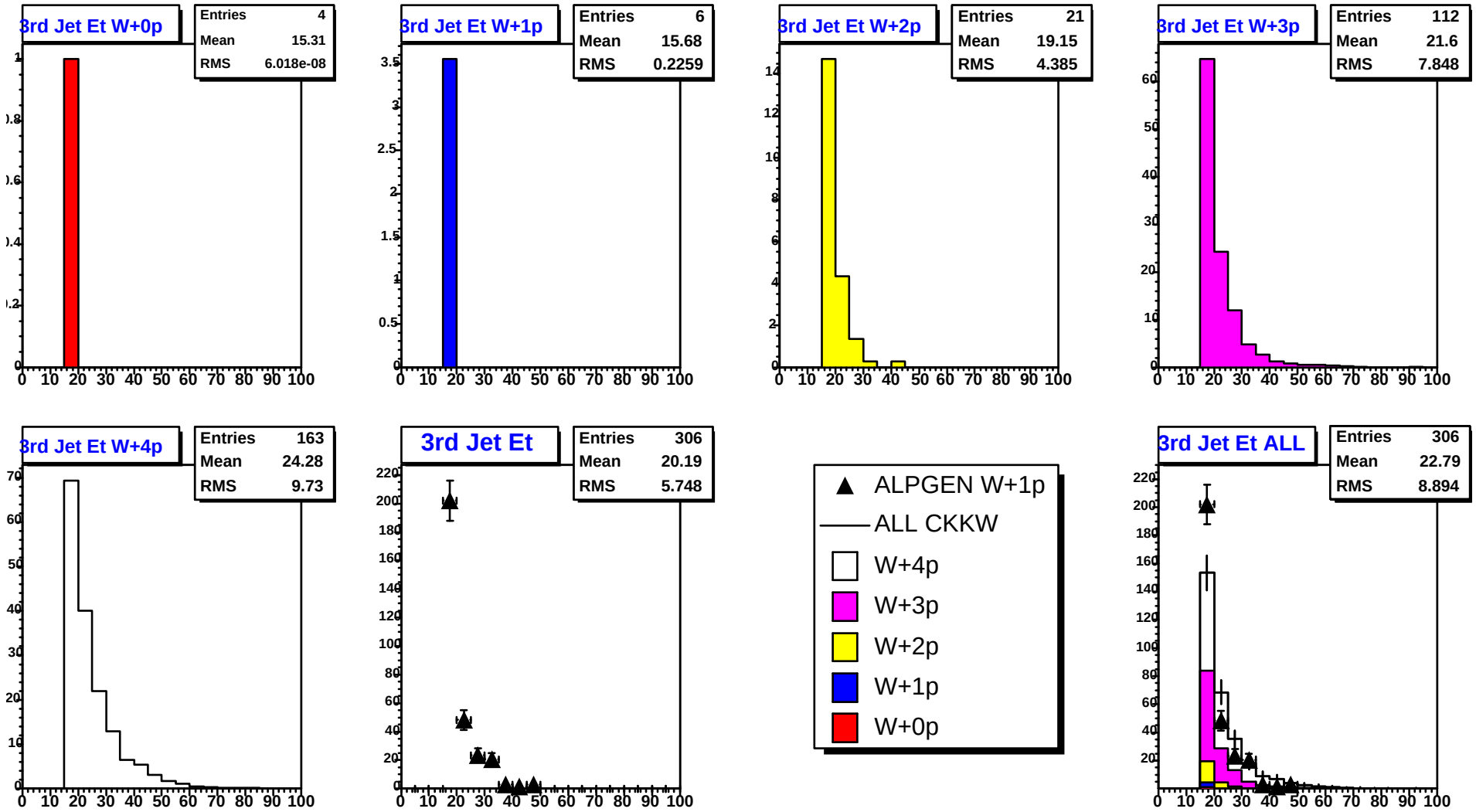
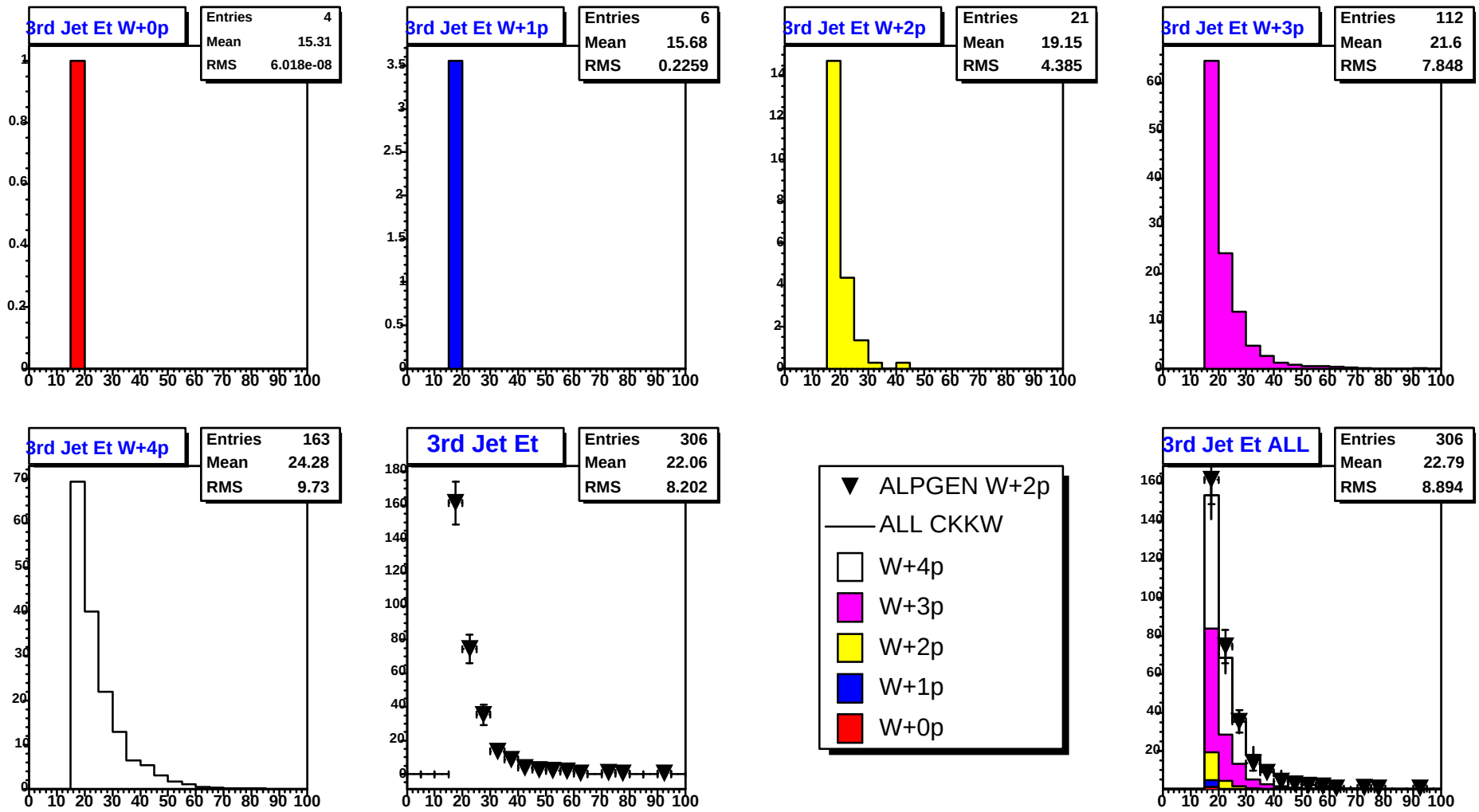
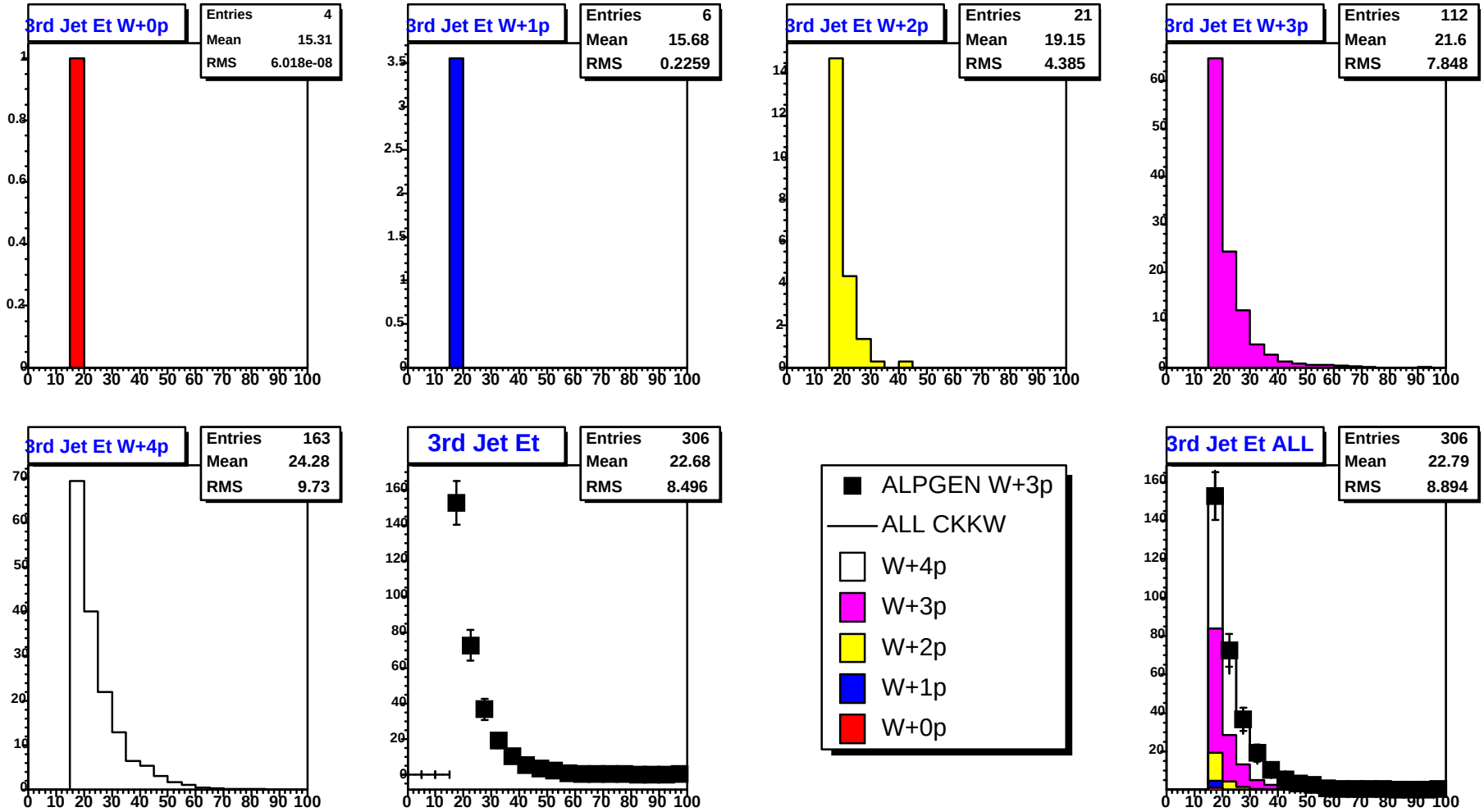
Third Jet ET


3rd Jet Et W+0p
Entries 4
Mean 15.31
RMS 6.018e-08
3rd Jet Et W+1p
Entries 6
Mean 15.68
RMS 0.2259
3rd Jet Et W+2p
Entries 21
Mean 19.15
RMS 4.385
3rd Jet Et W+3p
Entries 112
Mean 21.6
RMS 7.848
3rd Jet Et W+4p
Entries 163
Mean 24.28
RMS 9.73
3rd Jet Et
Entries 306
Mean 20.19
RMS 5.748
ALPGEN W+1p
ALL CKKW
W+4p
W+3p
W+2p
W+1p
W+0p
3rd Jet Et ALL
Entries 306
Mean 22.79
RMS 8.894

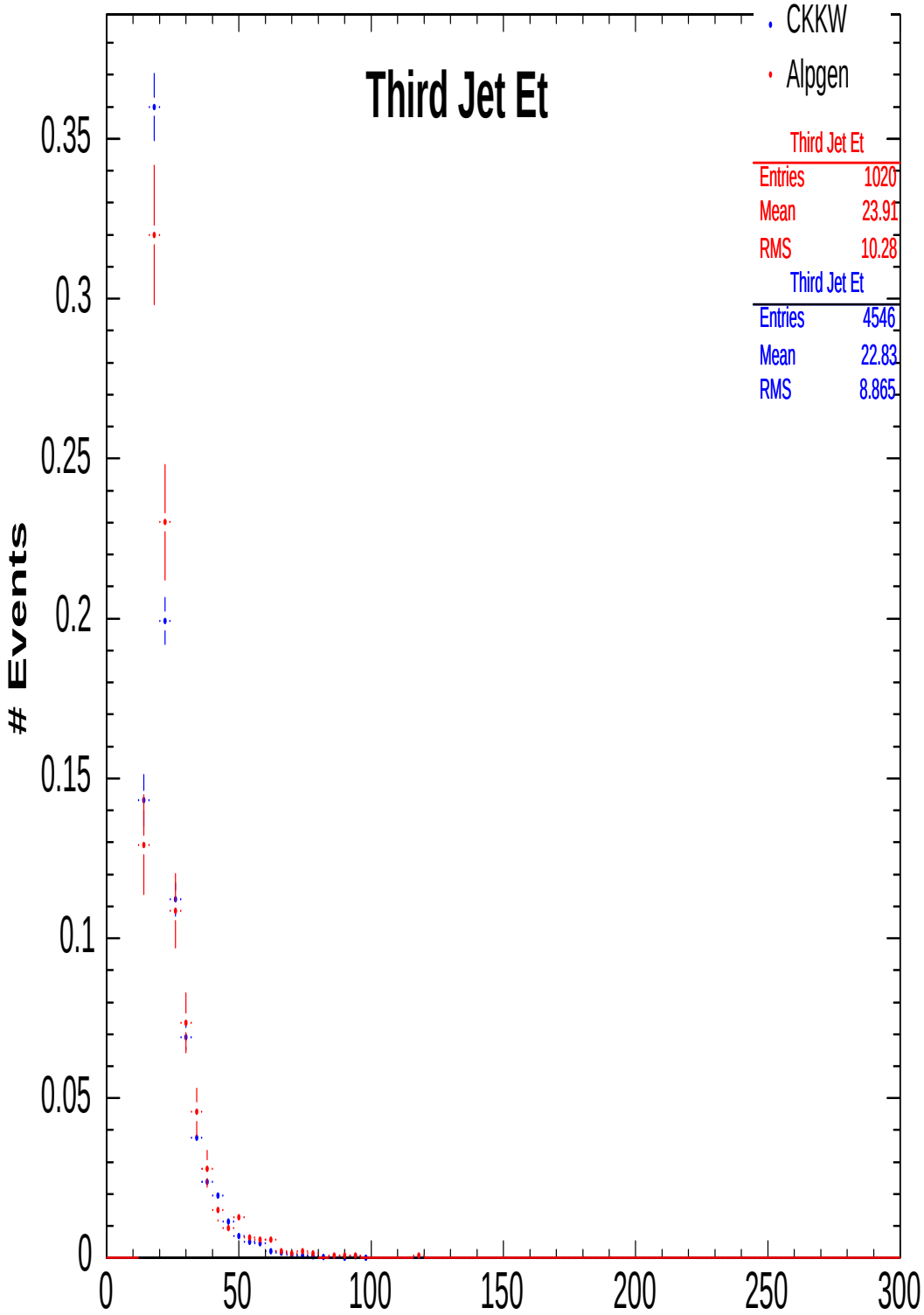
Third Jet ET (W+2p)



Third Jet Et (W+3p)



Third Jet ET (Matched)



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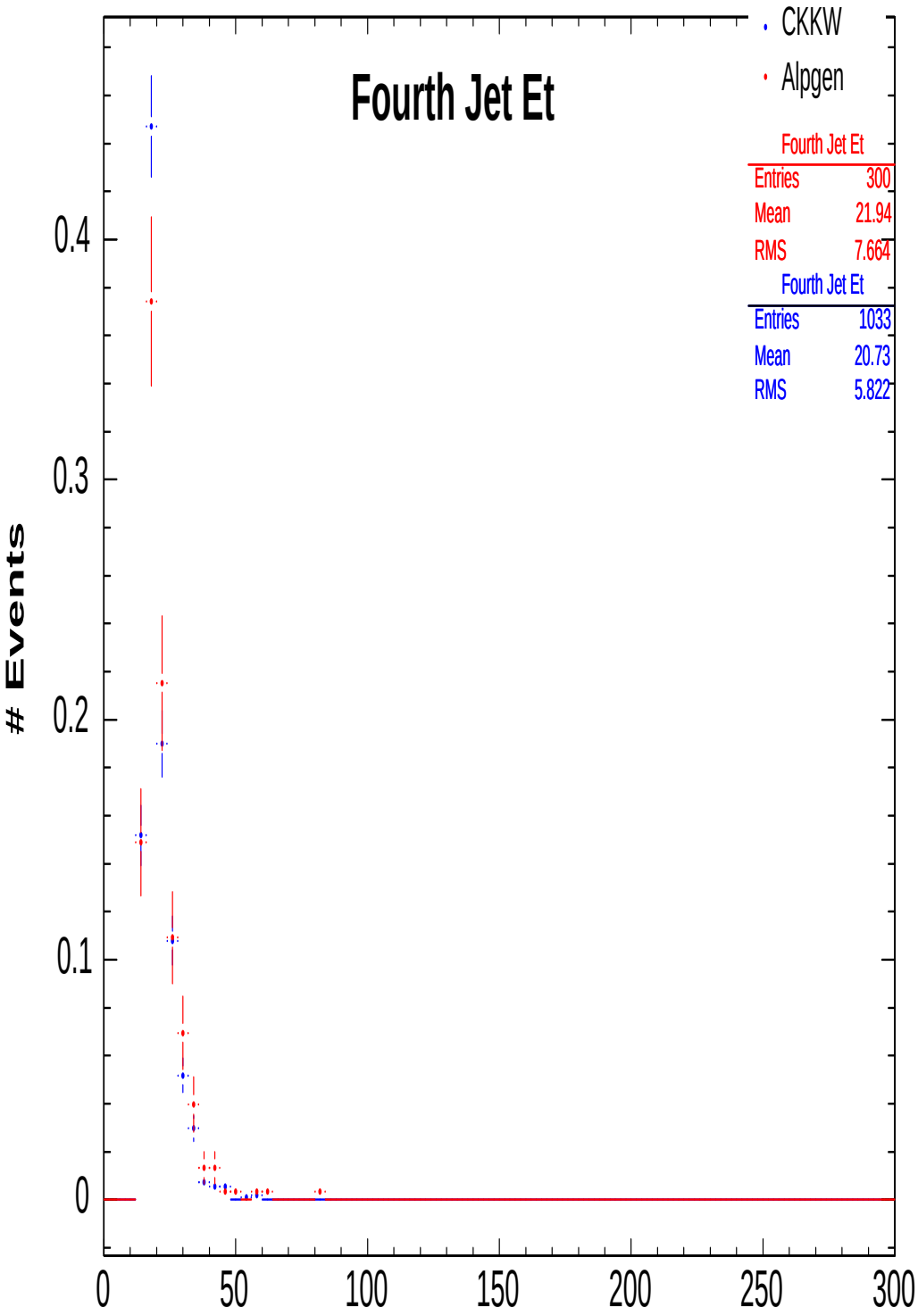
Fourth Jet ET (Matched)



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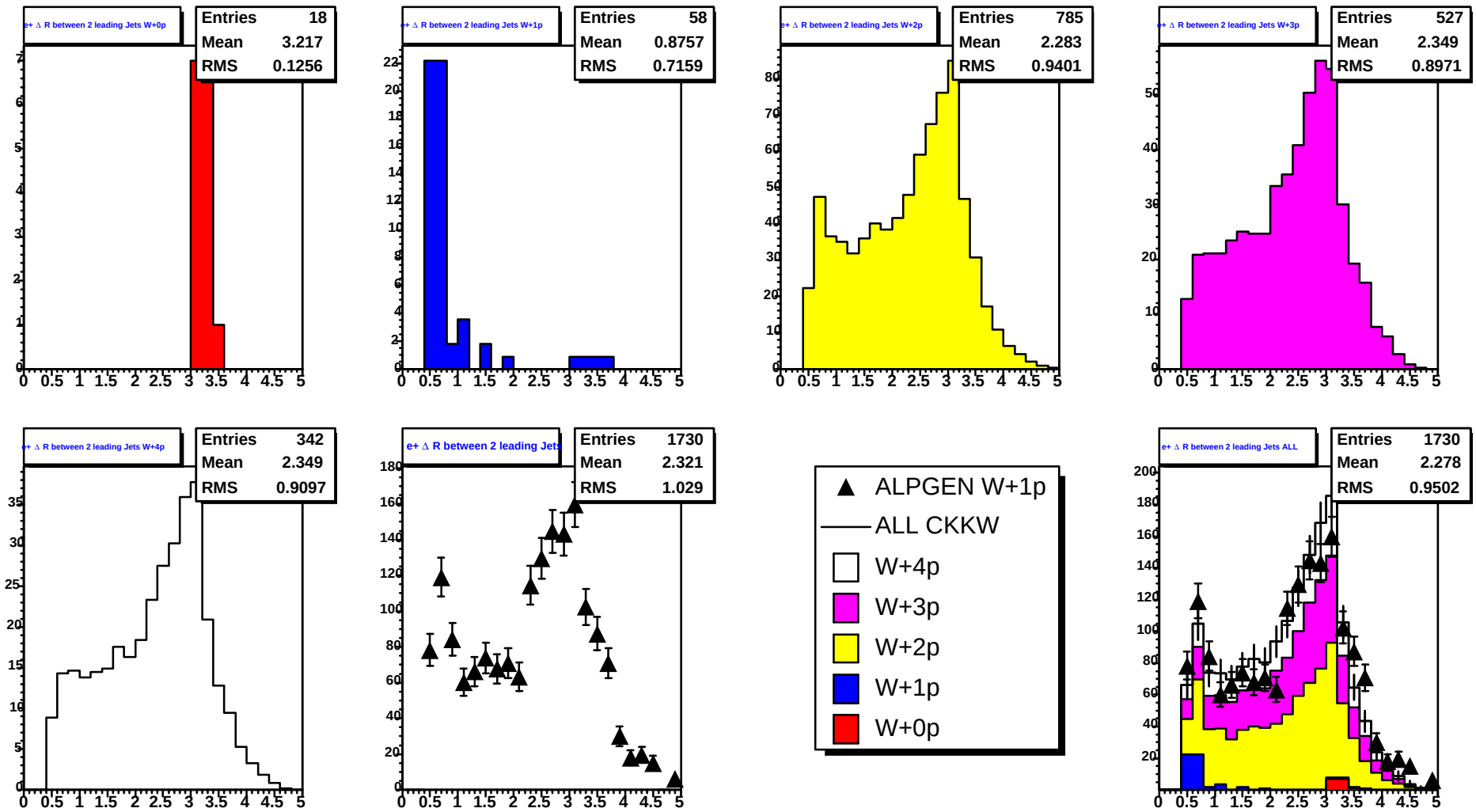
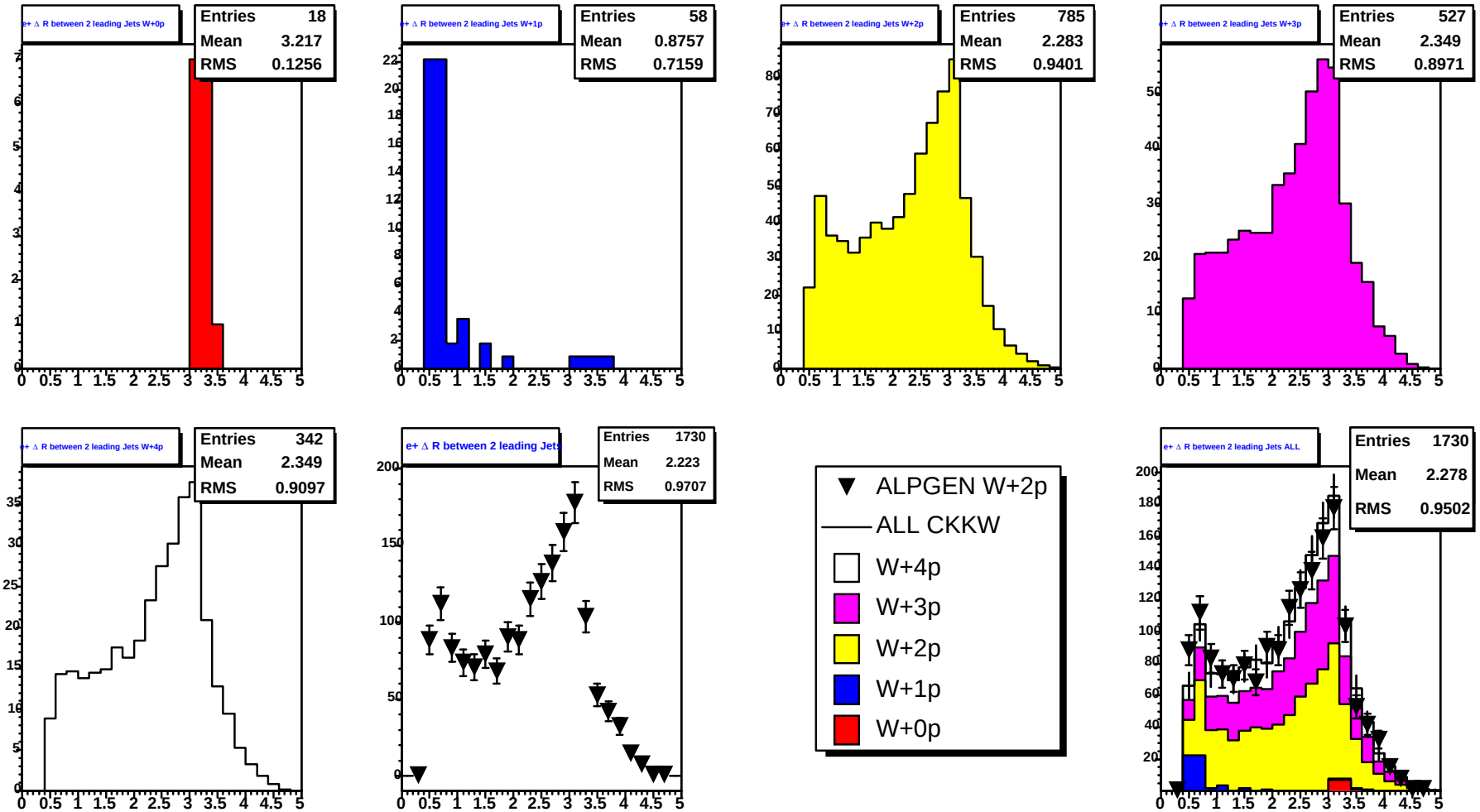
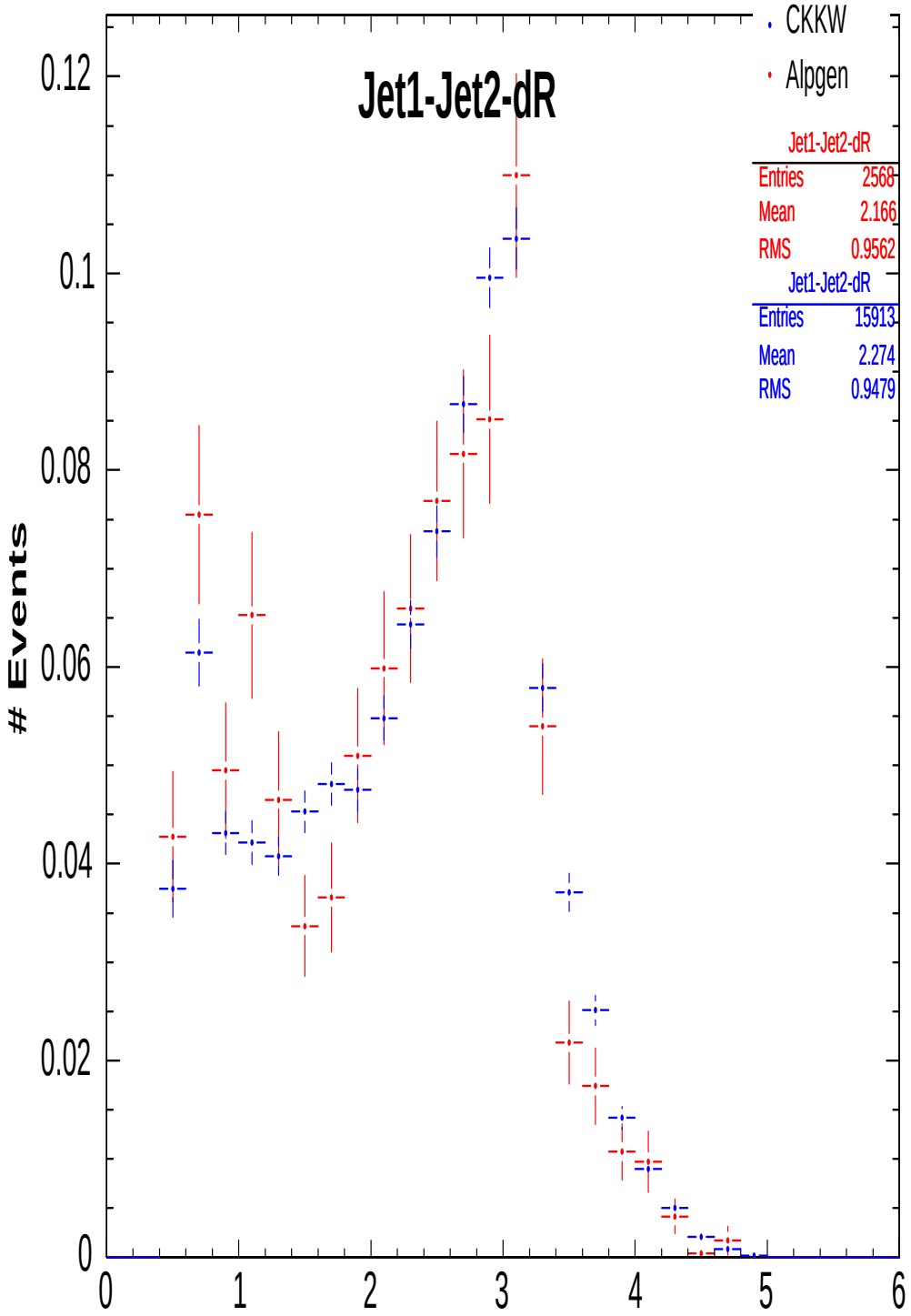
ΔR 2 leading jets



ΔR 2 leading jets (W+2p)



ΔR 2 leading jets (Matched)



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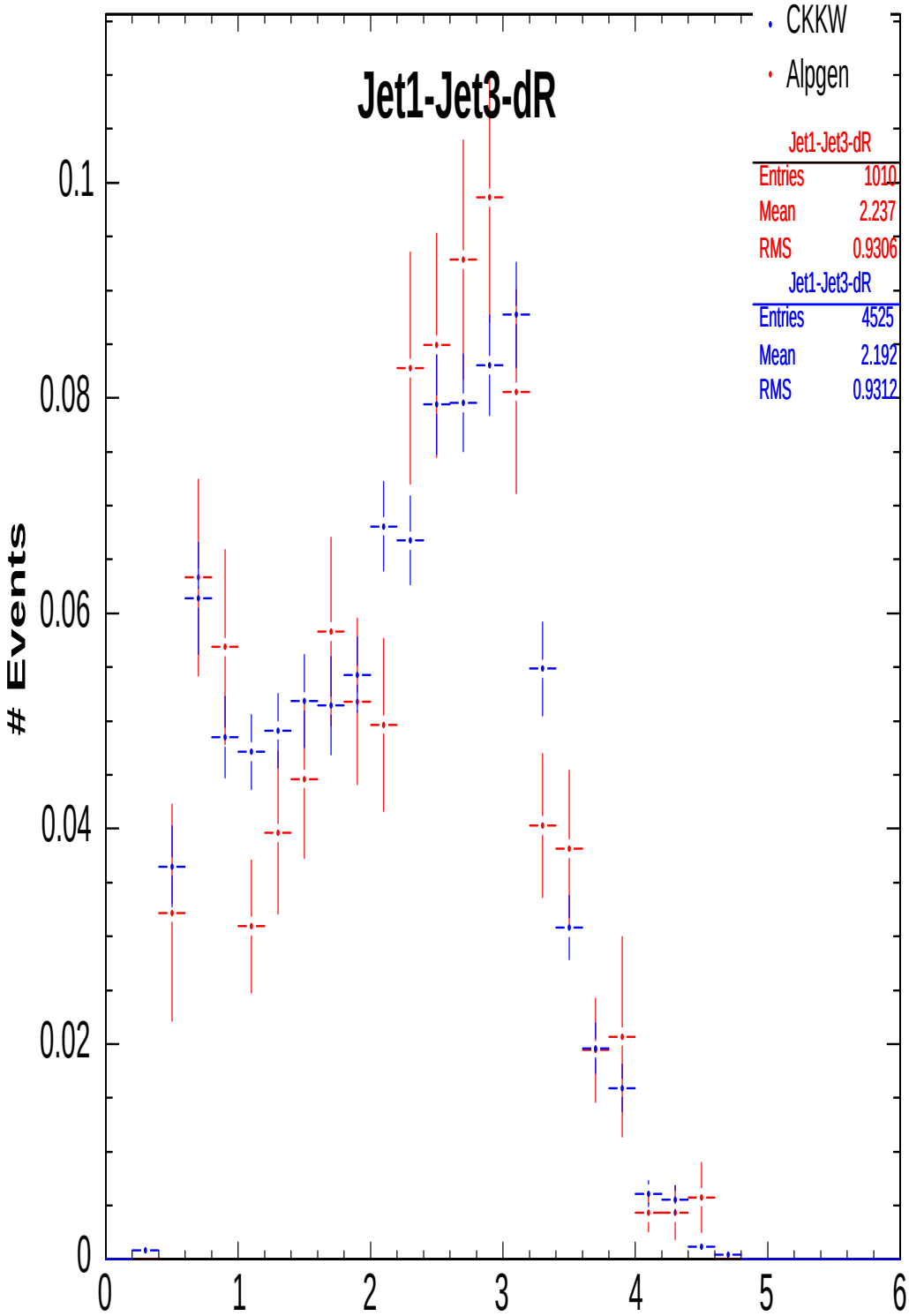
ΔR jets (Matched)



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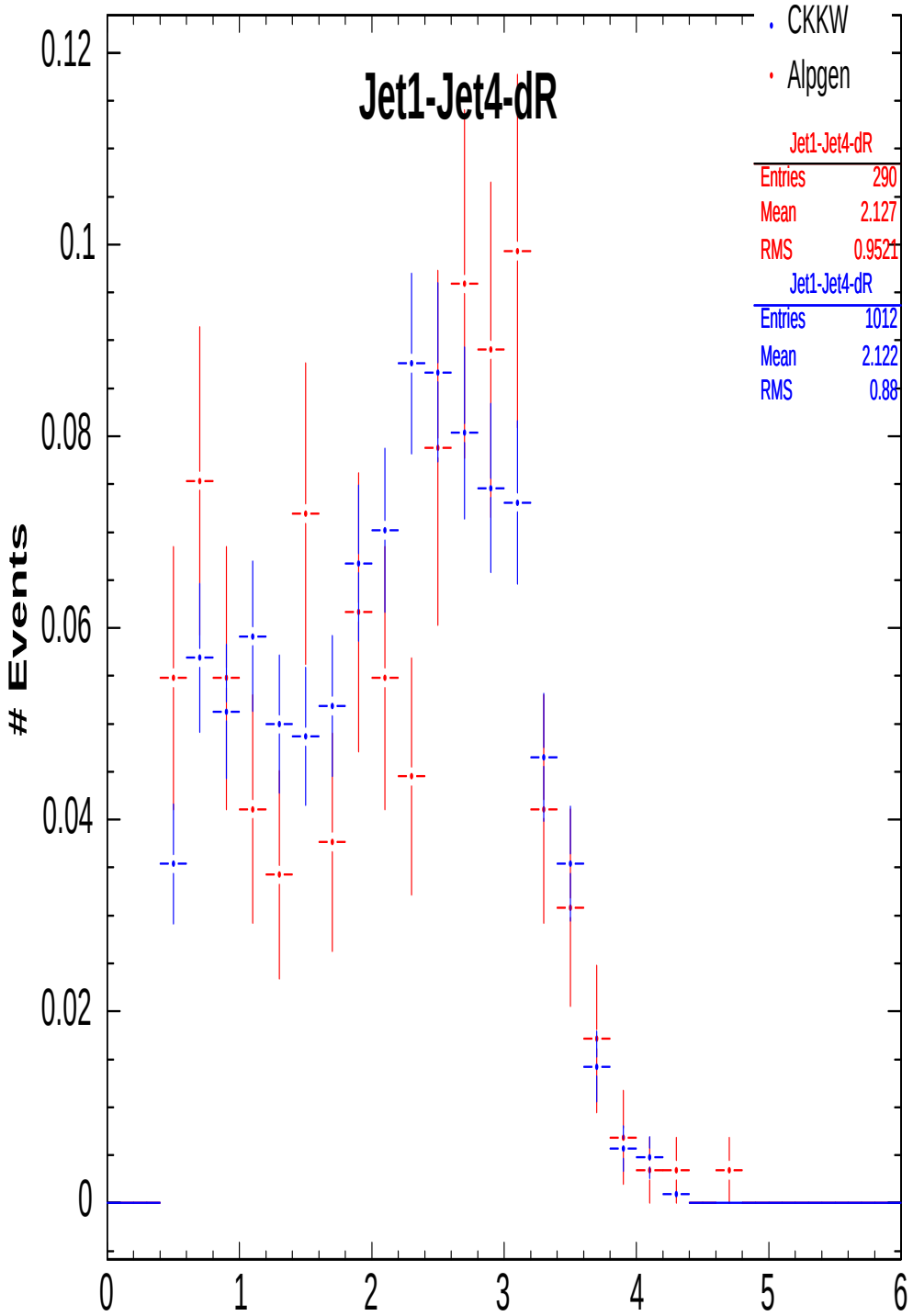
ΔR jets (Matched)



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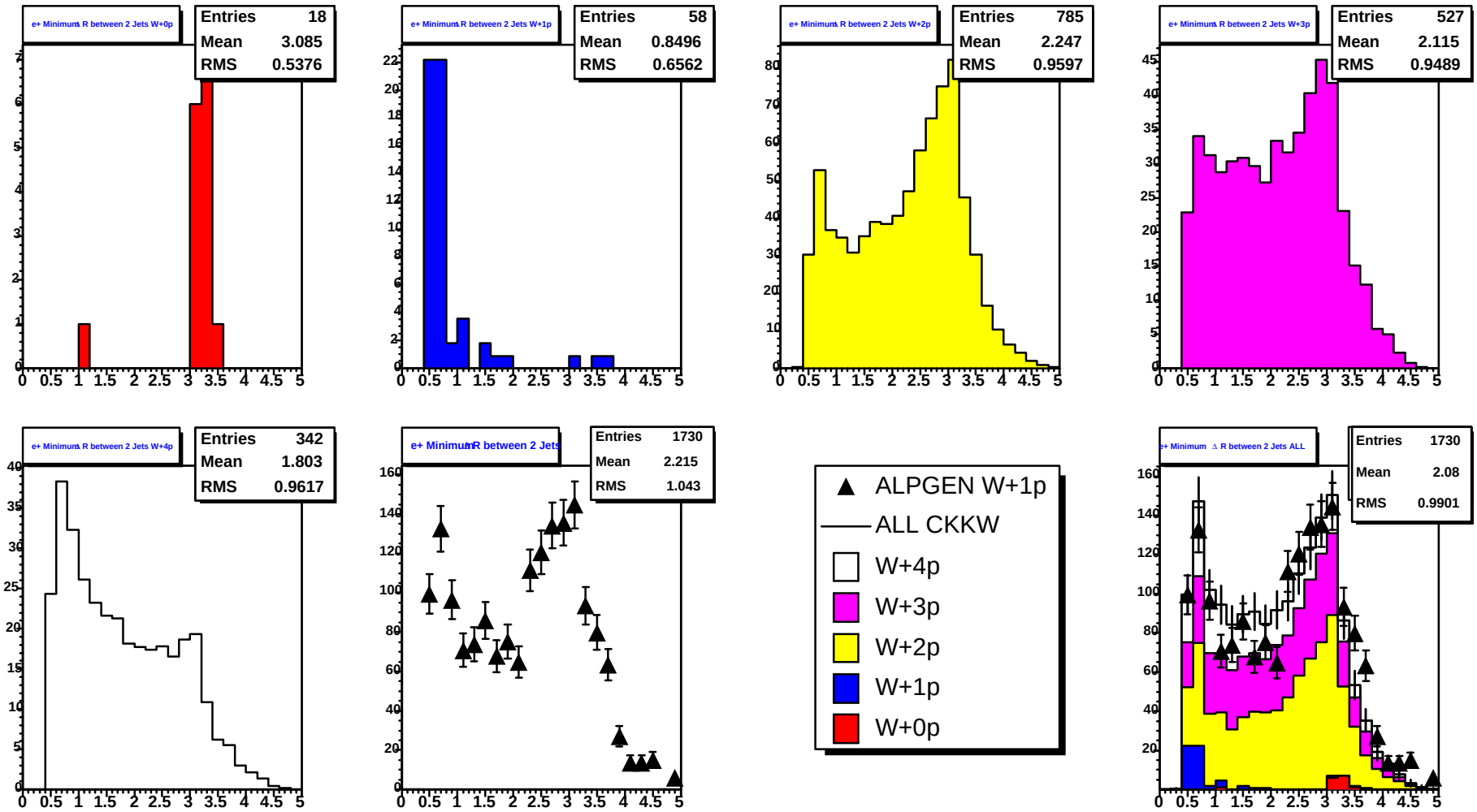
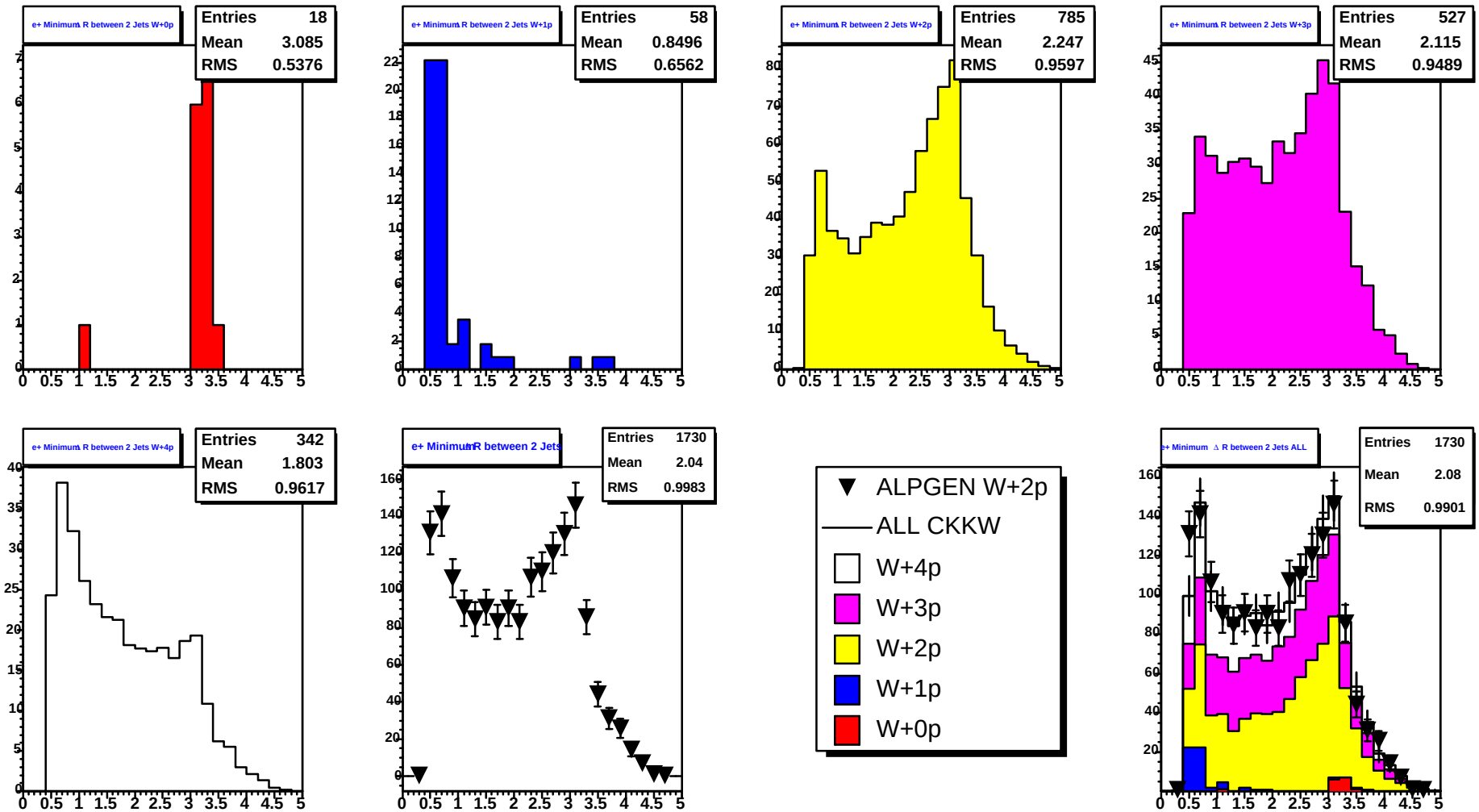
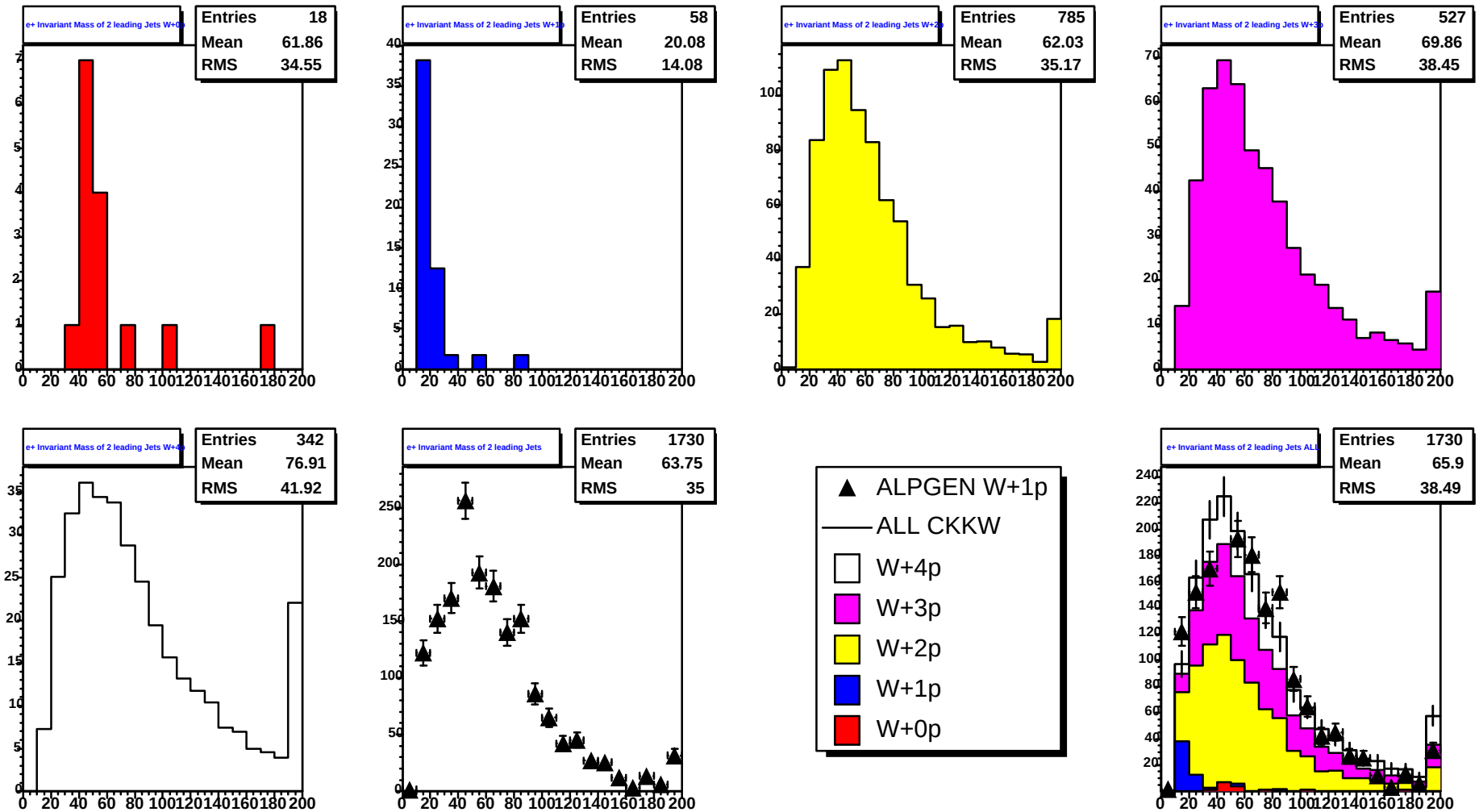
Minimum ΔR 2 jets



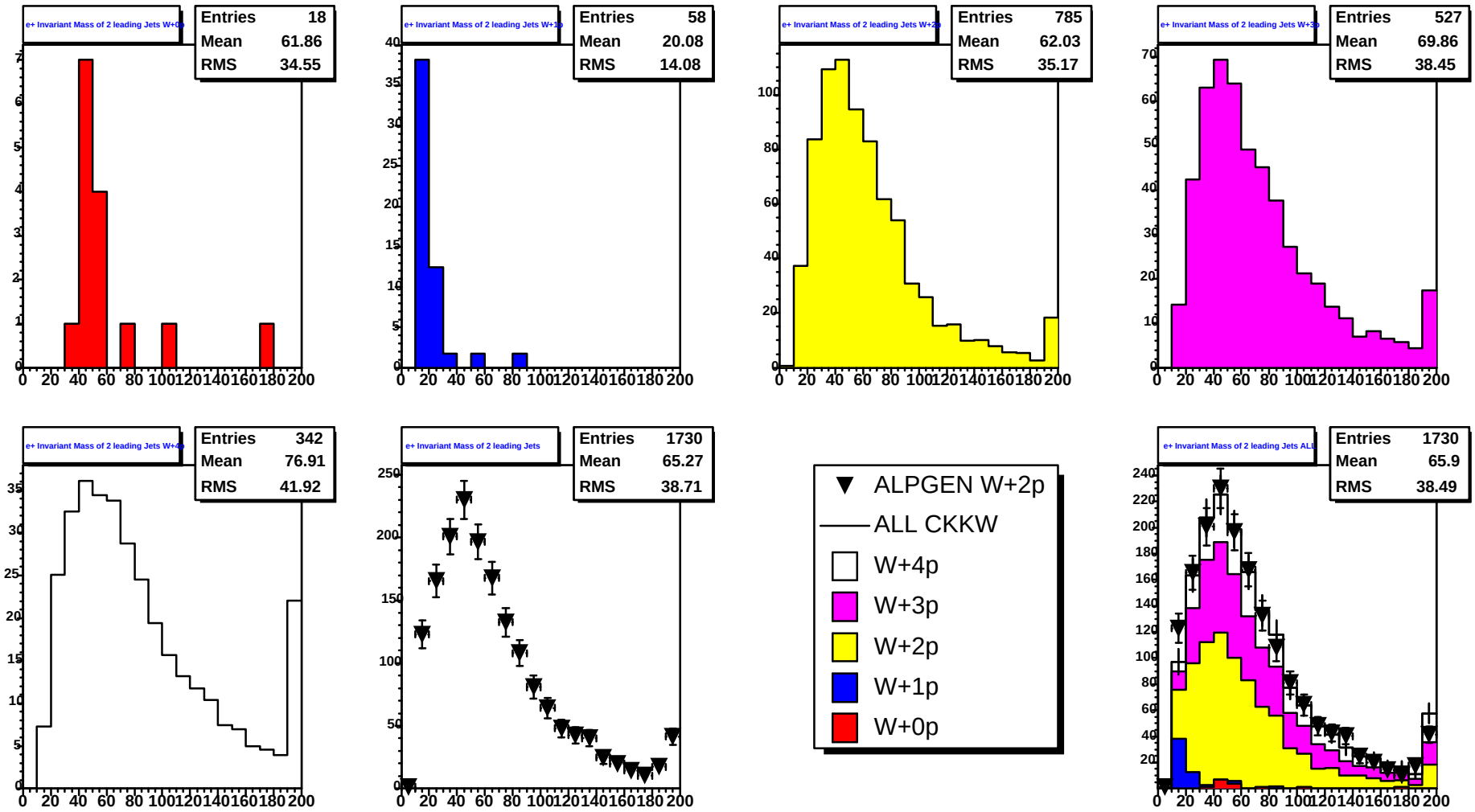
Minimum ΔR 2 jets (W+2p)



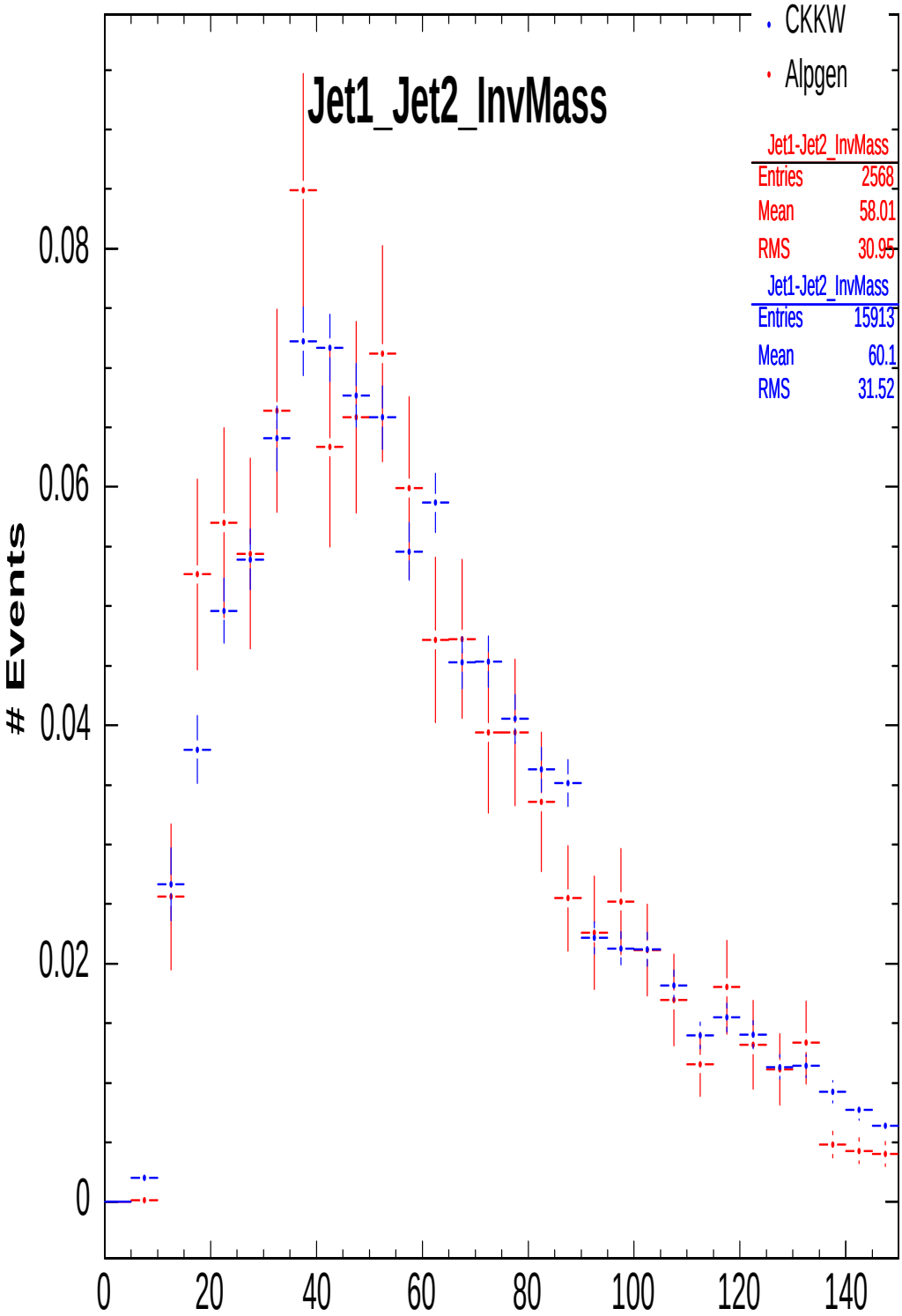
Invariant mass 2 leading jets



Invariant mass 2 leading jets (W+2p)



Invariant mass 2 leading jets (Matched)



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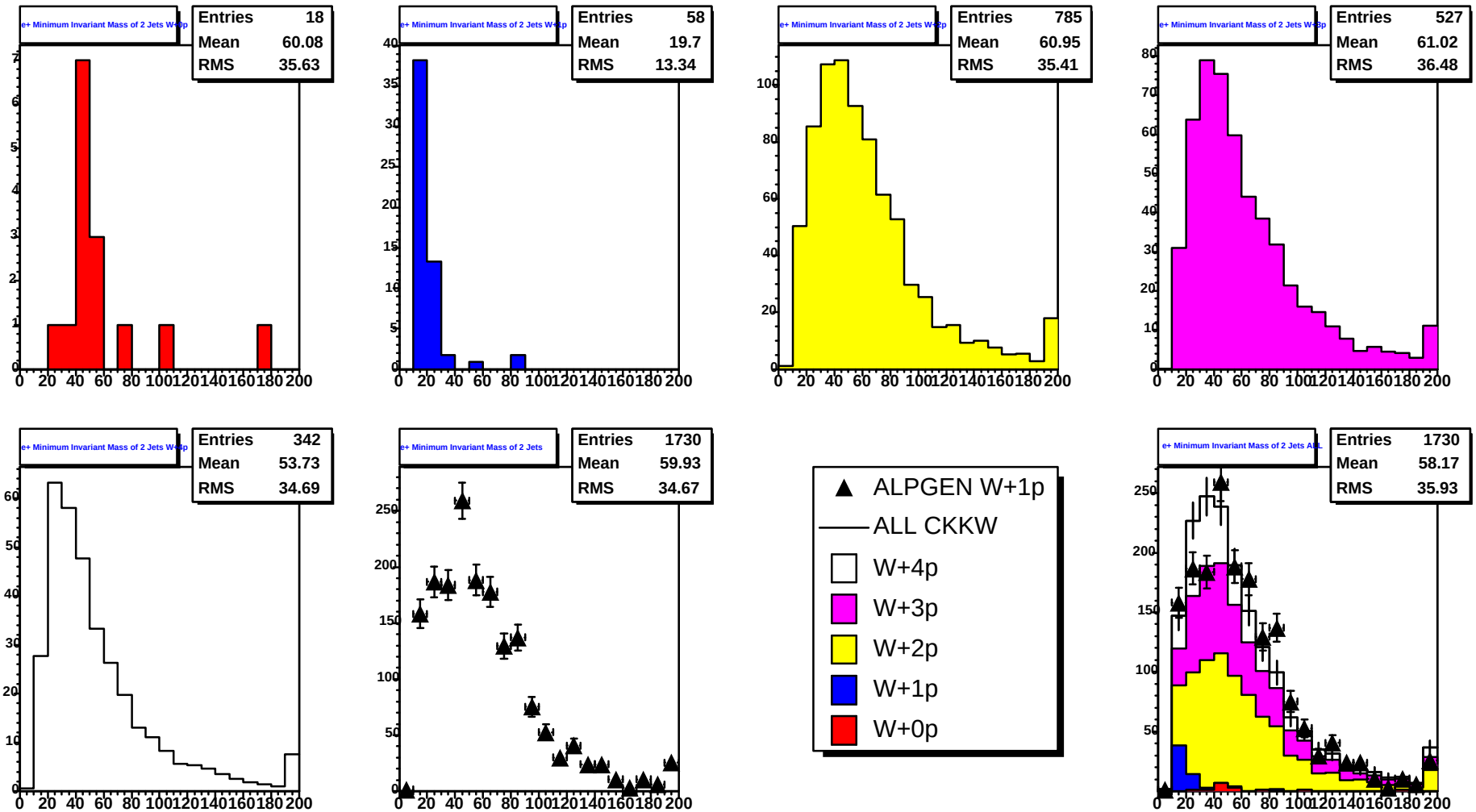
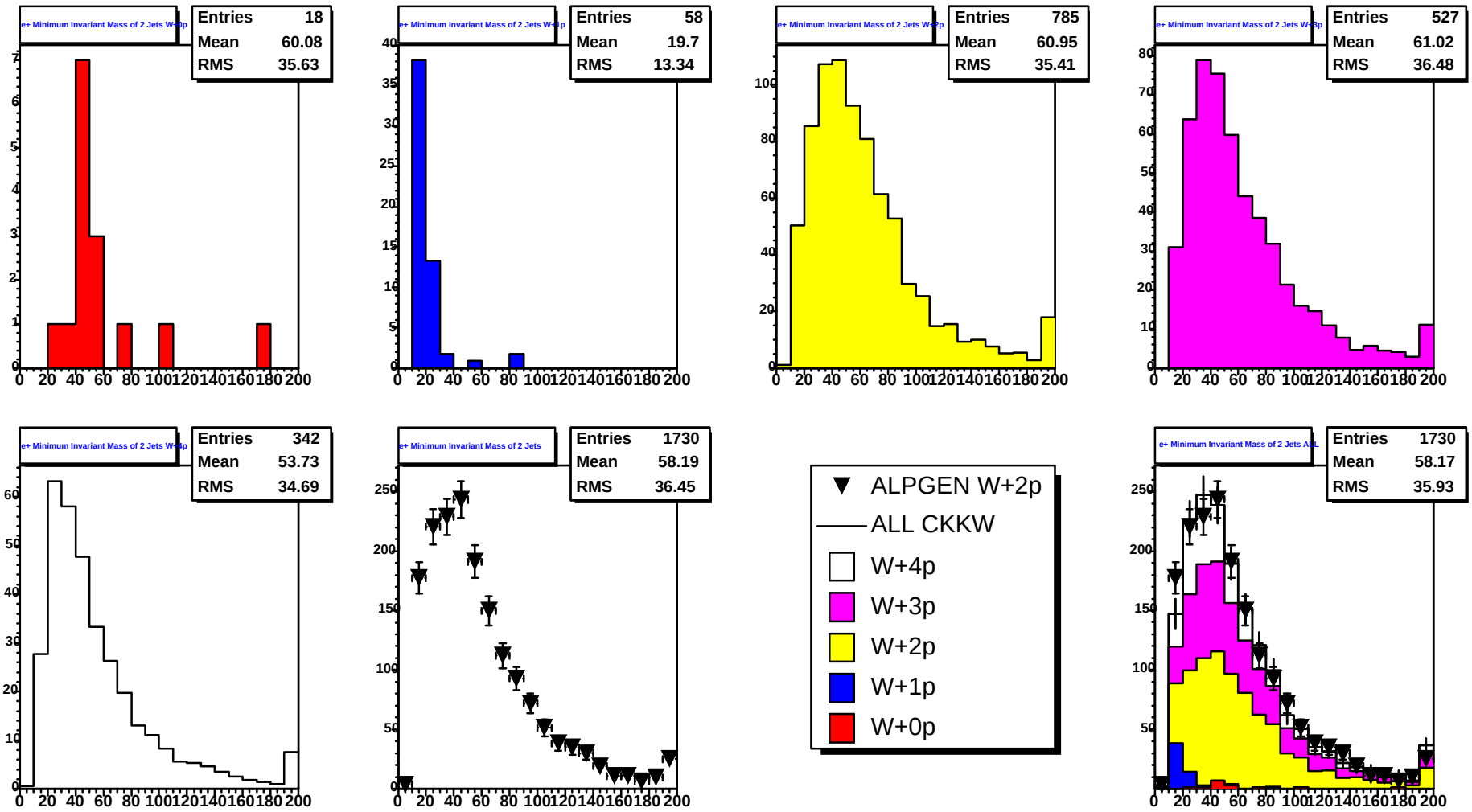
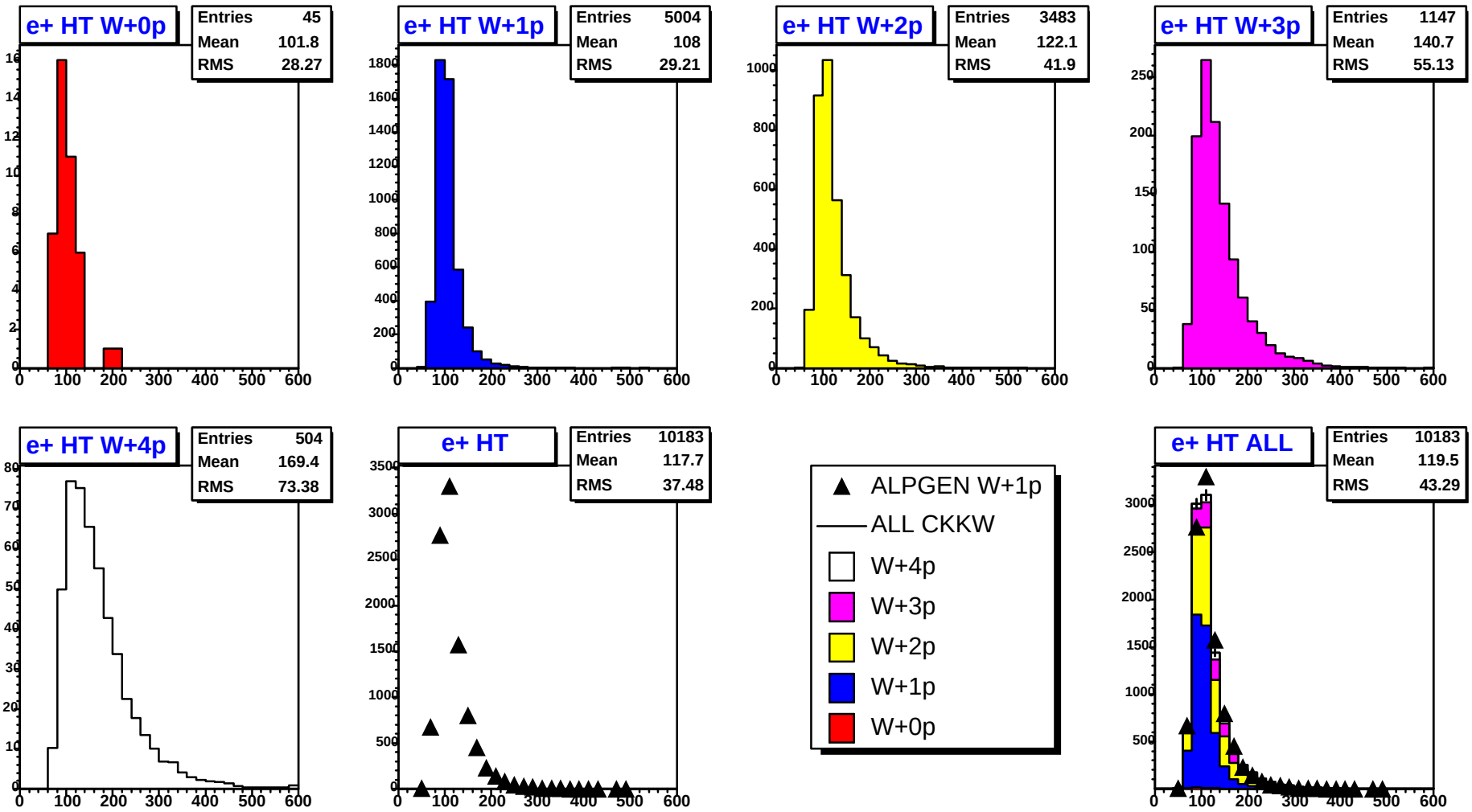
Minimum Invariant mass 2 jets



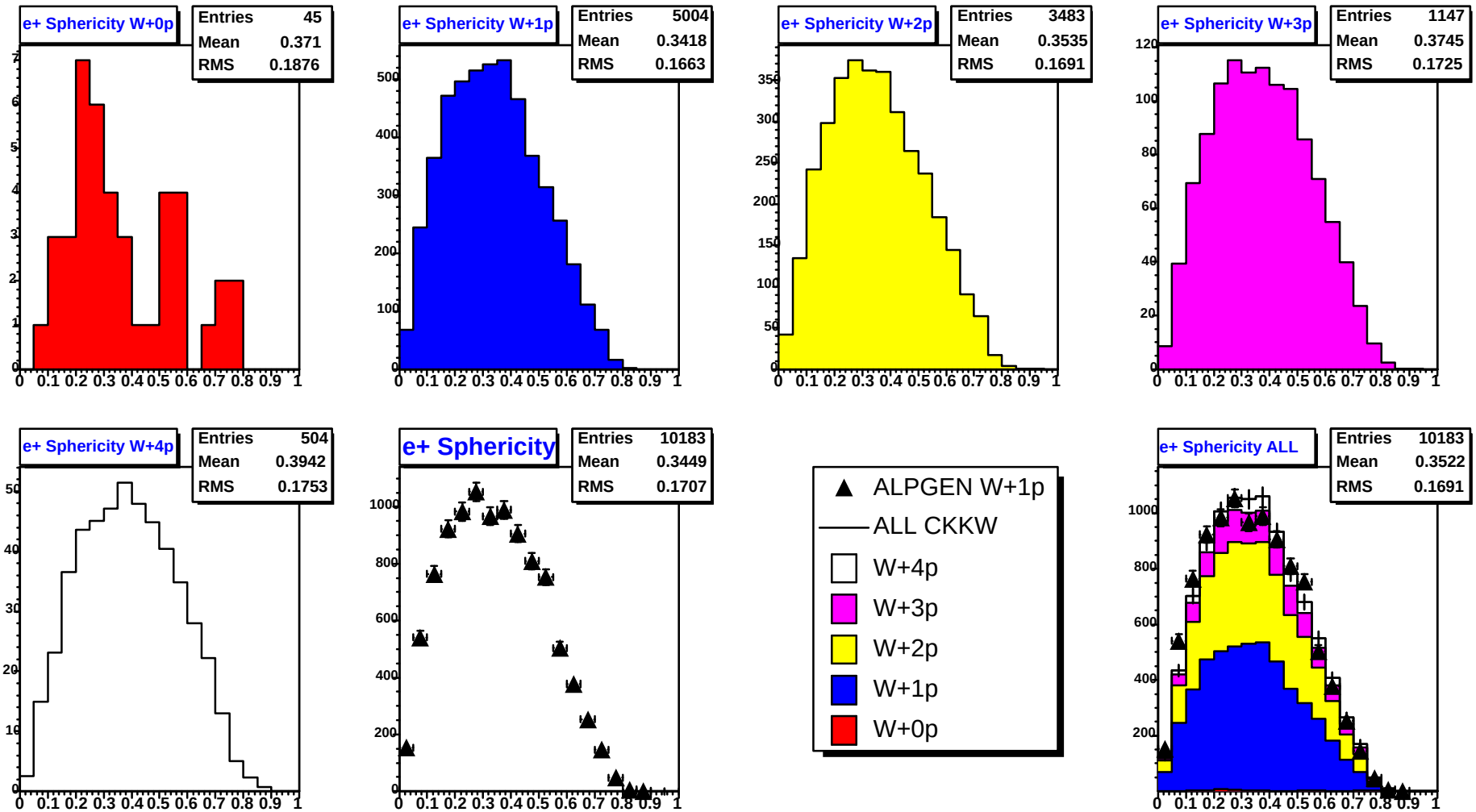
Minimum Invariant mass 2 jets (W+2p)



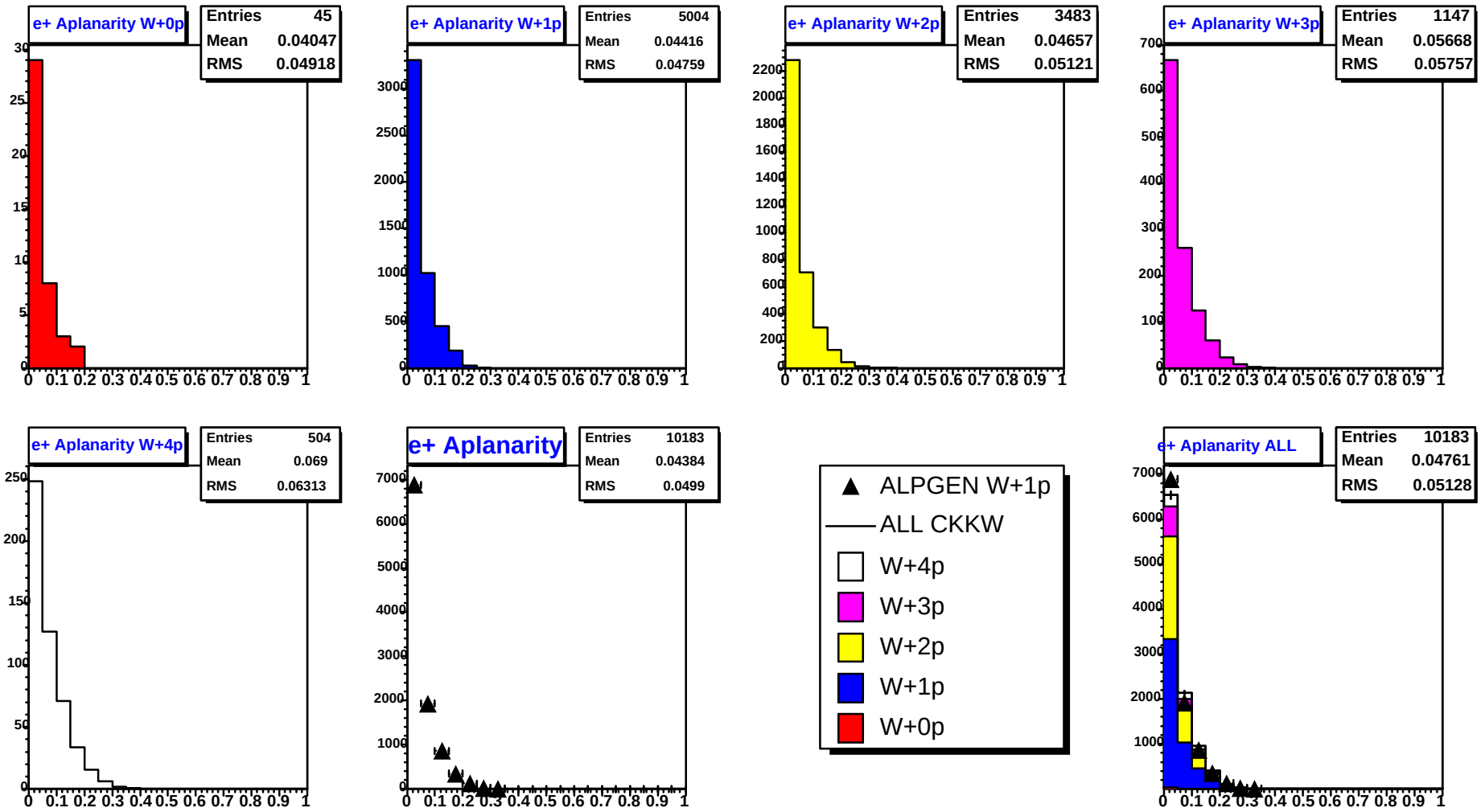
HT (scalar sum of ET jets, ET lepton, MET)



Sphericity

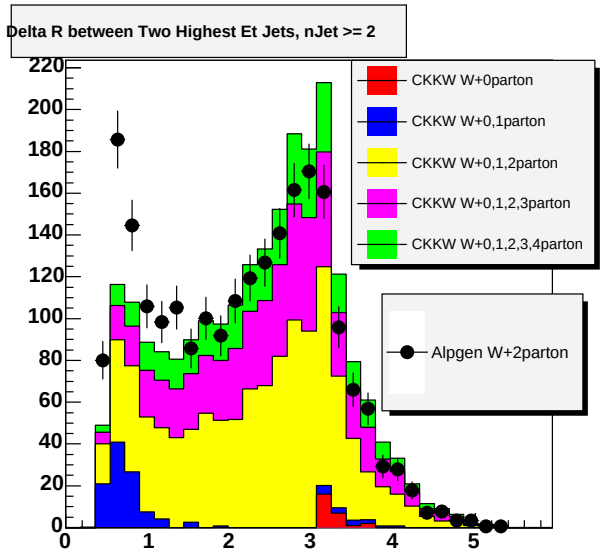

e+ Sphericity W+0p
Entries 45
Mean 0.371
RMS 0.1876
e+ Sphericity W+1p
Entries 5004
Mean 0.3418
RMS 0.1663
e+ Sphericity W+2p
Entries 3483
Mean 0.3535
RMS 0.1691
e+ Sphericity W+3p
Entries 1147
Mean 0.3745
RMS 0.1725
e+ Sphericity W+4p
Entries 504
Mean 0.3942
RMS 0.1753
e+ Sphericity
Entries 10183
Mean 0.3449
RMS 0.1707
ALPGEN W+1p
ALL CKKW
W+4p
W+3p
W+2p
W+1p
W+0p
e+ Sphericity ALL
Entries 10183
Mean 0.3522
RMS 0.1691

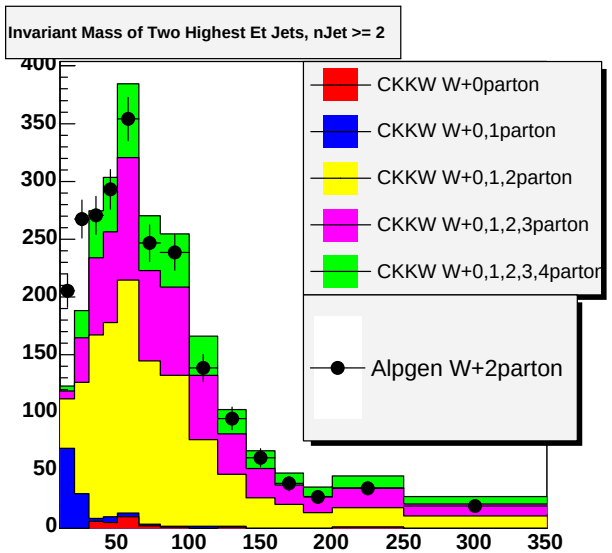
Aplanarity

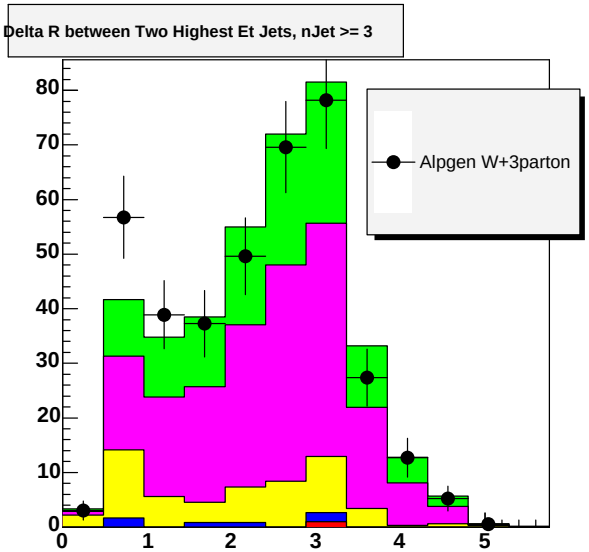

e+ Aplanarity W+0p
Entries 45
Mean 0.04047
RMS 0.04918
e+ Aplanarity W+1p
Entries 5004
Mean 0.04416
RMS 0.04759
e+ Aplanarity W+2p
Entries 3483
Mean 0.04657
RMS 0.05121
e+ Aplanarity W+3p
Entries 1147
Mean 0.05668
RMS 0.05757
e+ Aplanarity W+4p
Entries 504
Mean 0.069
RMS 0.06313
e+ Aplanarity
Entries 10183
Mean 0.04384
RMS 0.0499
ALPGEN W+1p
ALL CKKW
W+4p
W+3p
W+2p
W+1p
W+0p
e+ Aplanarity ALL
Entries 10183
Mean 0.04761
RMS 0.05128

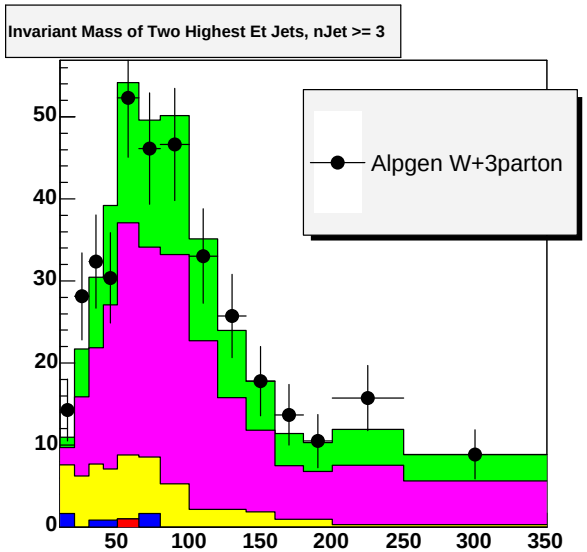
W+≥2 jets and W+≥3 jets

Ben Cooper **sees much bigger effect**
-More sensitive due to lower jet ET threshold???
-Investigating….





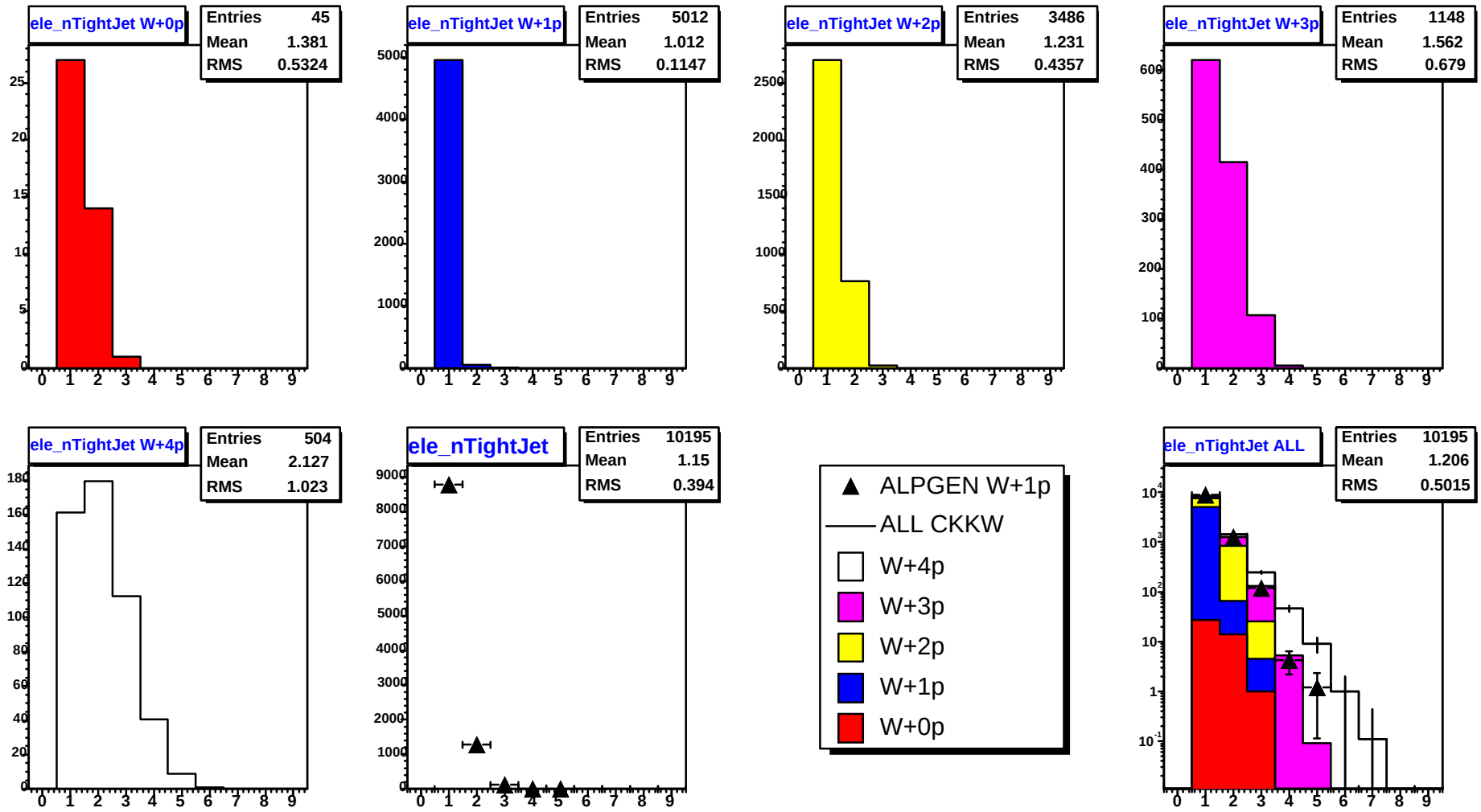
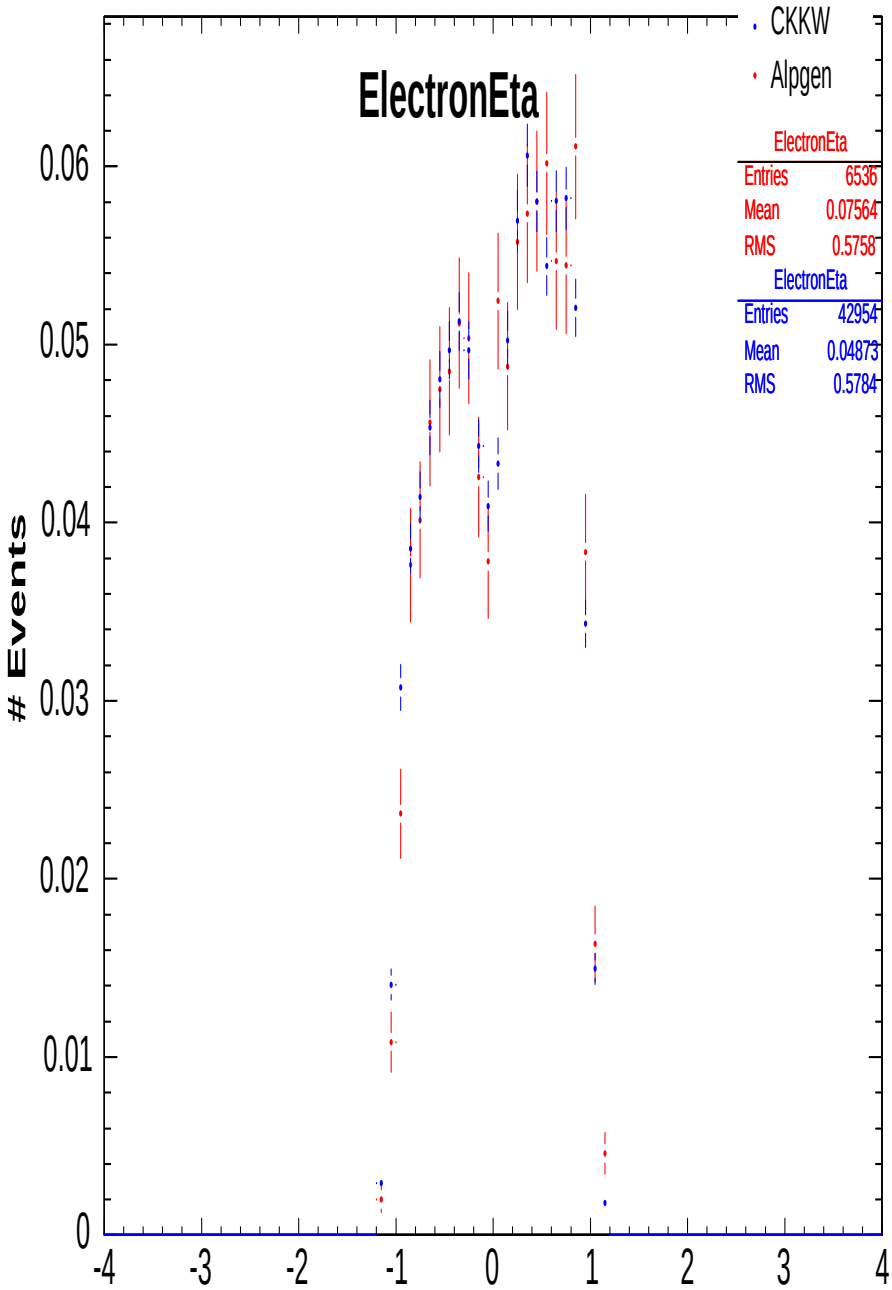




Conclusions and Future Plans

- **CKKW will be very helpful to all Top analyses!**
  - **More robust kinematics**
  - **More stable LO cross-sections (sic)**
  - **More efficient MC generation**
    - **Not throwing away events because of PS**
  - **Easier to use**
- **Validated some for PYTHIA – what about HERWIG?**
- **Next step is to validate CKKW for heavy flavour**
  - **Steve Mrenna tells us it is possible soon…**
  - **Important for b-tag cross-section analyses**
    - **Heavy flavour fractions**
- **Plan to use for next round of CDF Top group MC (February 2004)**

Jet Multiplicity



Positron Eta