QCD VBFMET Gridpack Validation

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MadGraph Gridpack v2 characteristics

- A grid pack was generated following the instructions found in the TWiki below:
  - TWiki: QuickGuideMadGraph5aMCatNLO
- Patches to include custom cuts were produced and included in the gridpack generation code
- Include optimizations recommend by Josh Bendavid

Sample characteristics

- Process: $pp \rightarrow jj, jjj, jjjj$
- At least one dijet with:
  - Jets $p_{\perp} > 30$ GeV
  - Dijet $m_{jj} > 800$ GeV

What changed from previous studies:

- Different MAdGraph version: MG5_aMC_v2_3_0 $\rightarrow$ MG5_aMC_v2.3.2.2
- Additional CMS patches and options
  - Physics Model: sm $\rightarrow$ sm-ckm_no_b_mass
  - PDF choice: nn23lo1 $\rightarrow$ lhapdf(263000)
  - Remove jet min $p_{\perp}$ and added auto jet $p_{\perp}$ and m_{jj} optimization option

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Hadronization

Software

- Using CMSSW_7_1_19 (**NEW:** before was CMSSW_7_1_18. Changed to match MG production version.)
- Showering: Pythia8
- Hadronizer: Configuration/Generator/python/Hadronizer_TuneCUETP8M1_13TeV_MLM_5f_max4j_LHE_pythia8_cff.py

Results

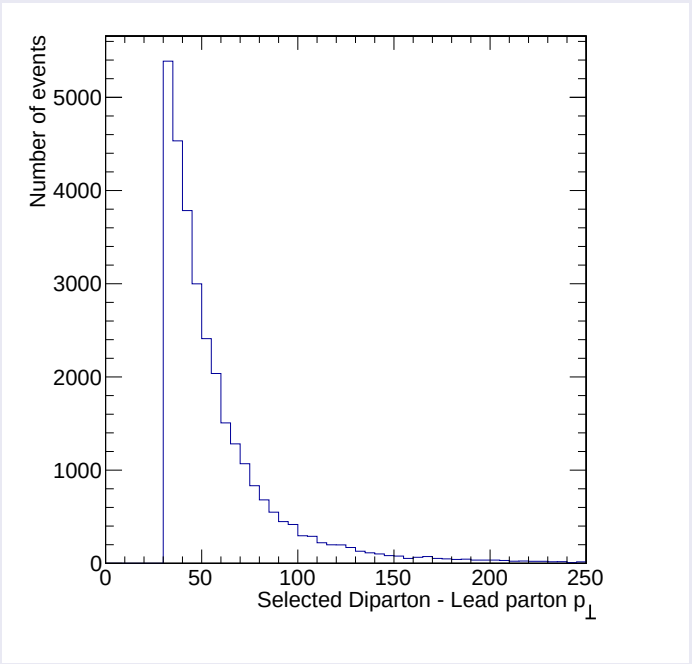
	Events			Cross Section [pb]	
Process	Tried	Passed	accepted [%]	Before	After
$pp \to jj$	53110	12392	23.3 ± 0.2	$1.652 \times 10^6 \pm 9.011 \times 10^3$	$3.854 \times 10^5 \pm 3.689 \times 10^3$
$pp \to jjj$	114701	8253	7.2 ± 0.1	$3.629 \times 10^6 \pm 1.980 \times 10^4$	$2.611 \times 10^5 \pm 3.114 \times 10^3$
$pp \to jjjj$	157189	10054	6.4 ± 0.1	$4.962 \times 10^6 \pm 2.707 \times 10^4$	$3.174 \times 10^5 \pm 3.518 \times 10^3$
Total	325000	30699	9.4 ± 0.1	$1.024 \times 10^7 \pm 3.473 \times 10^4$	$9.638 \times 10^5 \pm 5.973 \times 10^3$

The 3 and 4 jets configurations fail more events since there is no restriction on min(jet $p_\perp$) which fails sometime the imposed hadronizer cut.

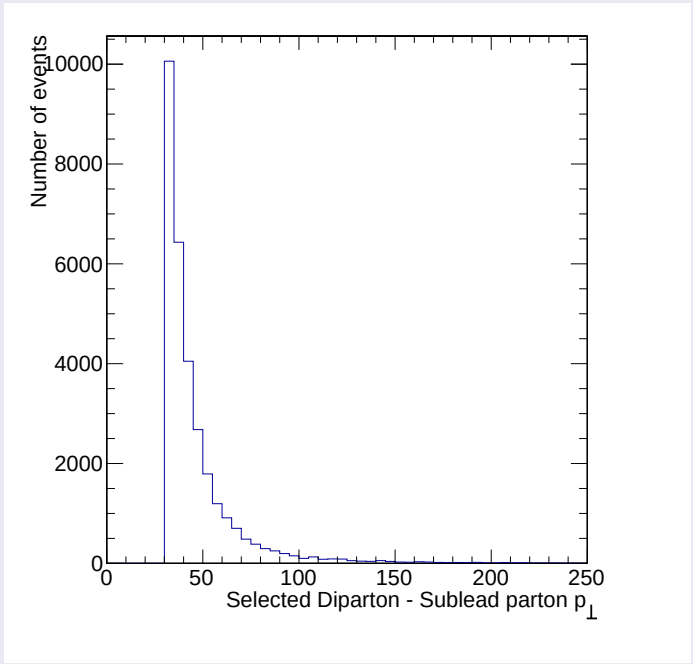
Values are almost the same as gridpack v1 only small changes observed.

Selected Di-parton I

Lead Parton $p_\perp$



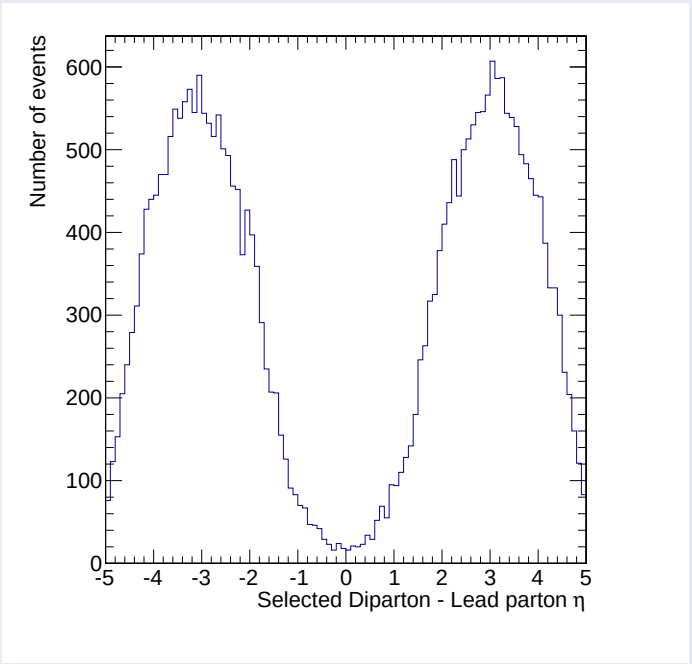
Sublead Parton $p_\perp$



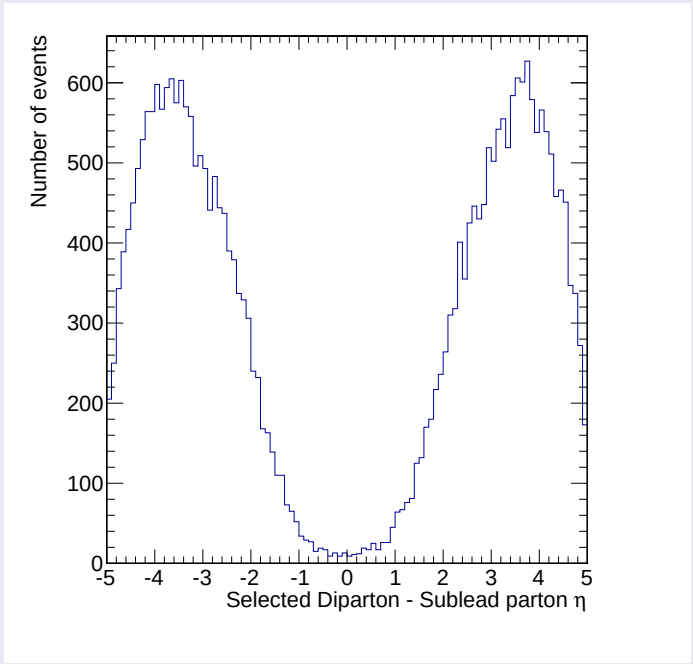
Custom MadGraph cuts on dijet parton $p_\perp$ are implemented correctly.

Selected Di-parton II

Lead Parton $p\eta$



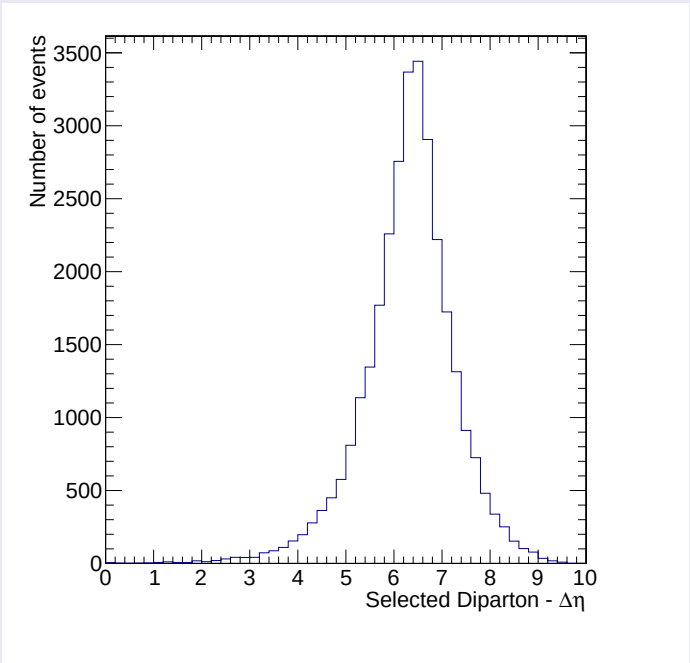
Sublead Parton η



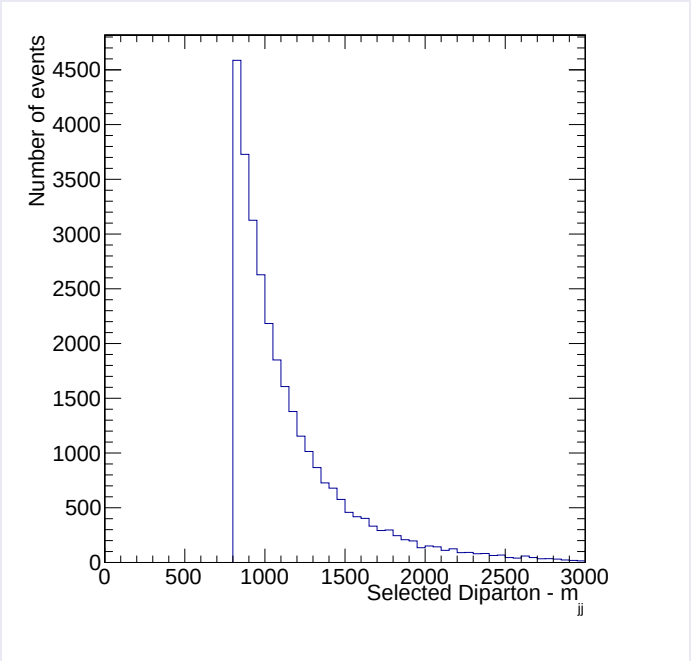
Jet η distribution looks ok. MadGraph cut is at 5.0.

Selected Di-parton III

Di-parton $\Delta\eta$



Di-parton m_{jj}



Custom MadGraph cuts on dijet parton m_{jj} are implemented correctly. $\Delta\eta$ peaks over 6 showing that this variable indeed could not be used to reduce QCD.

Parton-Generator Jet Matching procedure

Pairing Partons and Generator Jets

- Selecting all generator jets within $\Delta R < 0.4$
- From those selecting the generator jet with the lowest $p_\perp$ to the parton as a match.
  - This avoids picking up the wrong jet from just picking lowest ΔR

Results

	Process			
n_{match}	jj	jjj	jjjj	Total
0	3.42%	0.30%	0.08%	1.49%
1	25.27%	4.79%	1.02%	11.82%
2	71.30%	28.29%	8.89%	39.30%
3		66.61%	36.36%	29.82%
4			53.64%	17.57%

- Selected diparton has a match : 73.12%
- Generator jet matched not lowest ΔR : 3.52%

With the current matching procedure we can find matches for the selected di-parton most of the times.

All values are compatible with gridpack v1 (to the 1% level)

Migration study I

A second grid pack was create with reduced thresholds to study migrations.

Sample characteristics

- Process: $pp \rightarrow jj, jjj, jjjj$
- At least one dijet with:
  - Jets $p_{\perp} > 10\ GeV$
  - Dijet $m_{jj} > 600\ GeV$

Key data

- Hard process cross section is $1.095 \times 10^8 \pm 3.924 \times 10^5$ which is 10.7 times more than for our proposed process.
- 1.45M events were produced at parton level to provide enough statistics to study migration of $\approx 1\%$.
- Hadronization was performed the same as for for v2.
  - An event efficiency of 6.7 ± 0.5 was observed which is $\approx 30\%$ less than v2. Probably due to lower jet cuts.
  - The resulting post hadronization cross section of $6.647e+06 \pm 2.380e+04$ which is 6.9 higher than v2.

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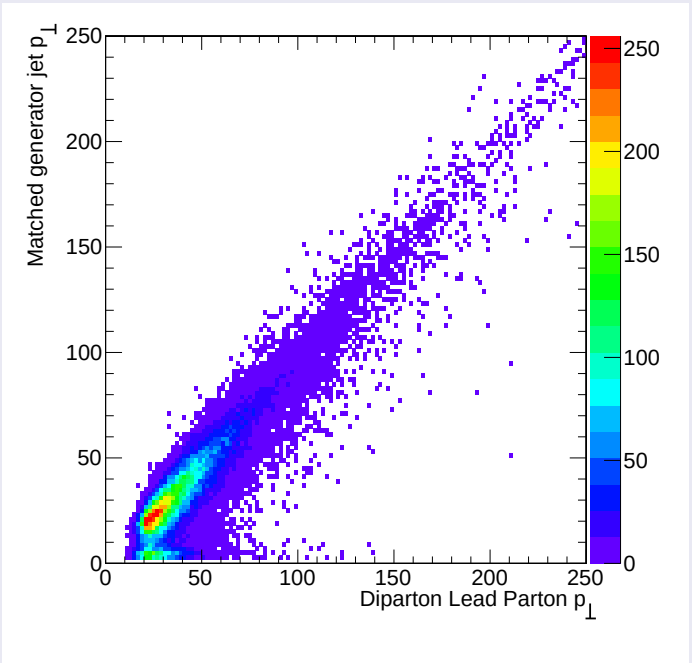
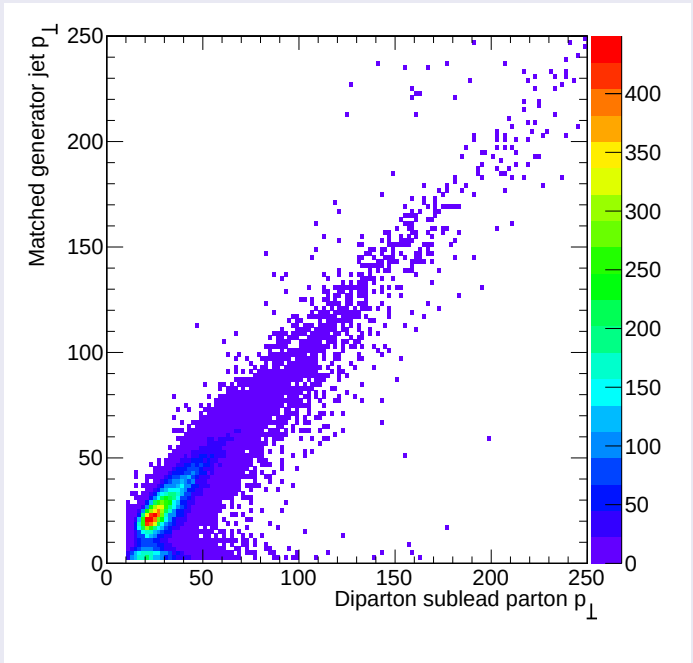
Migration study I

Lead Parton-Generator Jet $p_\perp$



Sublead Parton-Generator Jet $p_\perp$



Single variable migration

- Lead jets: $\frac{p_\perp^{Parton}<30 \text{ AND } p_\perp^{GenJet}\geq 40}{p_\perp^{GenJet}\geq 40} = 0.27\% \pm 0.04\%$
- Sublead jets: $\frac{p_\perp^{Parton}<30 \text{ AND } p_\perp^{GenJet}\geq 40}{p_\perp^{GenJet}\geq 40} = 0.56\% \pm 0.08\%$

Parton to generator jet $p_\perp$ migration are under 0.6%. Much less than the 3.5% majorated last week. This is acceptable.

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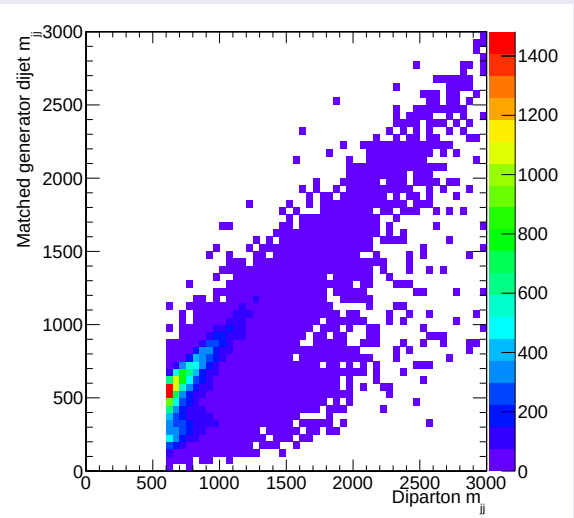
Migration study I

Parton-Generator Jet m_{jj}



Single variable migration

Mjj: $\frac{m_{jj}^{Parton} < 800 \text{ AND } m_{jj}^{GenJet} \geq 1000}{m_{jj}^{GenJet} \geq 800} = 0.13\% \pm 0.04\%$

Double variable migration

- $\frac{(p_{\perp}^{GenJet} > 40 \text{ AND } m_{jj}^{GenJet} > 1000) \text{ AND } (p_{\perp}^{Parton} < 30 \text{ OR } m_{jj}^{Parton} < 800)}{p_{\perp}^{GenJet} > 40 \text{ AND } m_{jj}^{GenJet} > 1000} =$

  $0.23\% \pm 0.13\%$

Parton to generator jet m_{jj} migration are under 0.2% and global migration are under 0.25%. This is also acceptable.

Conclusions

Summary

- A MadGraph gridpack was produce following the CMS Generator Group recommended instructions and now includes Josh Bendavid suggestions
  - A test run was made producing 325k events where it was demonstrated that the custom proposed cuts were correctly implemented.
  - Pythia8 hadronization was performed over the parton level events with an efficiency of 9.4 ± 0.1 and leading to a final sample cross section of $9.638 \times 10^5 \pm 5.973 \times 10^3$.
- A second gridpack with lower thresholds was implemented to study variable migrations
  - A test run was made producing 1.45M events with a post hadronization cross section of $6.647 \times 10^6 \pm 2.380 \times 10^4$ which is 6.9 times more than proposed cuts.
  - A study over the key variable migration was performed showing that global events migration from below selected parton cuts to above selected generator cuts is of $0.23\% \pm 0.13\%$ of the total events that should pass the generator cuts. This is deemed to be acceptable.
- We are ready to pass this gridpack to the generator group and request our new QCD sample production.

The gridpack and the respective cards can be found at:

/afs/cern.ch/work/p/pela/public/qcd_vbf_samples/gridpack_v2/

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