MG5 Mass Production Workflow

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Summary

1. Samples are restored & New Cutflow is consistent with old data.
2. Very few missing events will be restored.

Update

Too many root files cause skimming error :

* **Error in <TExMap::Expand>: slot 39186 not empty (should never happen)**

→ Unstable output files and Restrict IMT usage (Implicit Multi Threading).

8. merge.sh (Optional)

If you have toooo many root files (>1000),

skimming procedure based on MT likely suffer from not engough memory.

ROOT provides “hadd” that merge the root files. https://root.cern/manual/root_files/

```
"merge.sh" 44L, 1163B
#!/usr/bin/env bash
set -euo pipefail

# Usage: merge.sh <base_dir> <sub_dir> <prefix> <group_size>

BASE_DIR="$1"      # e.g. TEST
SUB_DIR="$2"       # e.g. ttbb
PREFIX="$3"        # e.g. TTBB_DL
GROUP_SIZE="$4"    # e.g. 100

# move to TARGET_DIR
TARGET_DIR="${BASE_DIR}/${SUB_DIR}"
cd "${TARGET_DIR}" || { echo "Error: Directory not found: ${TARGET_DIR}"; exit 1; }

# create merged/ directory
mkdir -p merged

# 3. collect file list.
files=( ${PREFIX}*.root )
total=${#files[@]}
echo "Found $total files in ${TARGET_DIR}."

# 4. merge files per group.
index=0
group=0
while [ $index -lt $total ]; do
  remaining=$(( total - index ))
  if [ "$remaining" -lt "$GROUP_SIZE" ]; then
    echo "Only $remaining files remaining (< $GROUP_SIZE), skipping merge for these."
    break
  fi

  out_file="${PREFIX}_merged_${group}.root"
  echo "Merging files $index to $(( index + GROUP_SIZE - 1 )) → merged/${out_file}"
  hadd -f "merged/${out_file}" "${files[@]:index:GROUP_SIZE}"

  index=$(( index + GROUP_SIZE ))
  group=$(( group + 1 ))
done

# 5. prompt output result.
echo "Done. Created $group merged file(s) in merged/:"
ls -1 merged/${PREFIX}_merged_*.root
```

$ tmux new –s merge
$ ssh compute-0-4
$ cd /data2/sucho/HL-LHC
$ ./merge.sh TEST ttbb TTBB_DL 100

```
hadd Source file 93: TTBB_SL_P_53_run_01_10.root
hadd Source file 94: TTBB_SL_P_53_run_01_11.root
hadd Source file 95: TTBB_SL_P_53_run_01_8.root
hadd Source file 96: TTBB_SL_P_53_run_01_9.root
hadd Source file 97: TTBB_SL_P_54_run_01_10.root
hadd Source file 98: TTBB_SL_P_54_run_01_11.root
hadd Source file 99: TTBB_SL_P_54_run_01_8.root
hadd Source file 100: TTBB_SL_P_54_run_01_9.root
hadd Target path: merged/TTBB_SL_P_merged_1.root:/
```

Sample Status

Sample Status

Signal : NNPDF40_*nlo*_as_01180_nf_4 _334700, import model loop_sm

Backgrounds : NNPDF40_*lo*_as_01180 _331900, import model sm-no_b_mass

Common : Include tau in lepton.

Statistics : 96M → 110M

```
[stiger97@htop HL-LHC]$ du -sh .
34T     .
[stiger97@htop HL-LHC]$ df -h .
Filesystem      Size  Used Avail Use% Mounted on
/dev/sdd1       107T   66T   42T  62% /data2
[stiger97@htop HL-LHC]$
```

MadSpin_cards

TT decays : DL,

```
# specify the decay for the fi
decay t > w+ b, w+ > l+ vl
decay t~ > w- b~, w- > l- vl~
# running the actual code
launch
```

SL_P,

```
# specify the decay for the final st
define q = u u~ d d~ c c~ s s~ b b~
decay t > w+ b, w+ > l+ vl
decay t~ > w- b~, w- > q q
# running the actual code
launch
```

SL_M

```
# specify the decay for the final st
define q = u u~ d d~ c c~ s s~ b b~
decay t > w+ b, w+ > q q
decay t~ > w- b~, w- > l- vl~
# running the actual code
launch
```

TTHH_SL_P (HH→ bbWW)

```
# specify the decay for the final state particles
set spinmode=none
define q = u u~ d d~ c c~ s s~ b b~
decay t > w+ b, w+ > l+ vl
decay t~ > w- b~, w- > q q
decay h > b b~
decay h > w+ w-, w+ > all all, w- > all all
# running the actual code
launch
```

TTHH_SL_M (HH→ bbWW)

```
# specify the decay for the final state particles
set spinmode=none
define q = u u~ d d~ c c~ s s~ b b~
decay t > w+ b, w+ > q q
decay t~ > w- b~, w- > l- vl~
decay h > b b~
decay h > w+ w-, w+ > all all, w- > all all
# running the actual code
launch
```

14TeV (Event/Million)	Calculated (QCD, PDF)	Reference_1 (QCD, PDF)	Reference_2 (QCD, PDF)	BR	Ref * BR
TTHH (20) Take from HWG	8.550e-04 pb +2.0% -6.0%	0.949 fb +1.7% -4.5% ; ±3.1% https://arxiv.org/pdf/1610.07922 (193 page, 2016, NLO)		TT_SL = 0.438 H>bb = 0.58 H>WW = 0.21 **Total = 0.10669**	
TTBB (30) (Take my NLO calculation)	1.555132047181056 pb QCD +57.8% -34.3% PDF : +3.24% -3.24%	Large variance in different scinarios.	1452 +37.6% -27.5% ; ±3.2% (Run2_TTHH_AN own calculation by MG5_v2.)	TT_DL = 0.105 TT_SL = 0.438 **Total = 0.543**	
TTW (20) Take from HWG	0.4238652269546515 pb QCD : +21.8% -16.8% PDF : +4.35% -4.35%	W+ : 474.9 fb +13.2% -11.6% ; ±1.9% W- : 244.5 fb +13.8% -11.8% ; ±2.0% https://arxiv.org/pdf/1610.07922 (160 page, 2016, NLO)	718 fb (W+W-) ~10% https://arxiv.org/pdf/1610.07922 722 fb +70 -78; ±7 moninal. https://arxiv.org/pdf/2301.11670 (35 page, 2023 **HWG**, **Run2**)	TT_DL = 0.105 TT_SL = 0.438 **Total = 0.543**	
TTH (20) (Take from HWG)	0.38571171531386206 pb QCD : +27.1% -20% PDF : +2.38% -2.38%	677.4 fb +6.1% -9.2% https://arxiv.org/pdf/1610.07922 (739 page, 2016, NLO)		TT_DL = 0.105 TT_SL = 0.438 **Total = 0.543**	
TTBBV (4) Take my NLO calculation	0.003049582067173042 pb QCD : +55.3% -33.3% PDF : +3.47% -3.47%	27.6 fb https://arxiv.org/pdf/1905.03772 (5 page, but it's 4FS_LO)		TT_DL = 0.105 TT_SL = 0.438 **Total = 0.543**	
TTTT (4) (Take my NLO or 1.3 times Run2 measured.)	0.0061742099160333064 pb QCD : +6s1.8% -35.7% PDF : +5.06% -5.06%	15.83 fb +18% -21% https://cds.cern.ch/record/2651870/files/ATL-PHYS-PUB-2018-047.pdf (2page, I guess *1.3 projection from Run 2 exp. https://www.mdpi.com/2218-1997/8/12/638)	17 fb ~25% https://indico.cern.ch/event/754958/contributions/3139757/attachments/1729480/2794599/FourtopatLHCandBeyond.pdf + cf) **Run2 measurement = 17 fb.**	**Total = 1.0**	
TTBBH (4) Take my NLO calculation	0.0016201003598561134 pb QCD : +57.8% -34.3% PDF : +3.67% -3.67%	15.6 fb https://arxiv.org/pdf/1905.03772 (5 page, but it's 4FS_LO)		TT_DL = 0.105 TT_SL = 0.438 **Total = 0.543**	
TTVV (5) Take my LO calculation	**0.013492540983606935 pb** QCD : +27.4% -20.1% PDF : +4.09% -4.09%			**Total = 1.0**	
TTZH (3) Take my NLO calculation.	0.0013711348460615275 pb QCD : +27.2% -20% PDF : +3.81% -3.81%	1.55 fb https://arxiv.org/pdf/1905.03772 (5 page, but it's 4FS_LO)		**Total = 1.0**	

Cutflow

- Consistent result compare to old samples (sig = 0.075 -> 0.074)

	Selection	S0	S1	S2	S3	S4
	Description	None	$N_l = 2$	Same sign	$E_T^{Miss} > 30\ GeV$	$N_b \geq 4$
SL & bbWW	$t\bar{t}HH$	304	43	20	18	9
SL + DL	$t\bar{t}b\bar{b}$	2,533,095	176,280	17,036	14,321	5,430
SL + DL	$t\bar{t}W$	1,171,903	165,773	56,317	50,061	2,976
SL + DL	$t\bar{t}H$	1,103,485	111,461	25,437	22,336	3,404
SL + DL	$t\bar{t}b\bar{b}V$	44,960	5,001	1,146	1,032	428
INC	$t\bar{t}t\bar{t}$	51,000	6,930	2,406	2,237	1,254
SL + DL	$t\bar{t}b\bar{b}H$	25,412	2,665	658	588	294
SL + DL → INC	$t\bar{t}VV$	40,470	5,054	1,527	1405	192
SL + DL → INC	$t\bar{t}ZH$	4,650	430	82	74	21
	Acceptance ($t\bar{t}HH$)	1.00	0.14	0.07	0.06	0.03
	$S/\sqrt{B}$					0.074