Status of the "Blind SUSY Analysis" Project

OUTLINE

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I. Reminder

- A project common this group and the Colliders group. A challenge to try to find what SUSY signals are hidden in some pseudo-data samples, the SM and SUSY background being provided

- Main goals:
  - address the issue of the SUSY&Higgs background
  - address the double challenge about a possible SUSY signal:
    1. figure out what is the underlying model (type of SUSY breaking, different hypotheses like Rp conservation, high scale universalities,…)
    2. figure out what are the values of the parameters in this model (may be pseudo-data might fit different model+parameters sets)

- Drawbacks:
  - crude detector simulation
  - and especially not a reliable trigger simulation

II. Production Status

Tools & Method

- Event Generator: Pythia 6.325
- Parton Densities: LHAPDF 4.2
- τ polarization and decay: TAUOLA 2.6
- Detector simulation: ATLFAST 2
- Job Submission:
  - Semi-automatic procedure
  - Shell script to submit in batch for each (sub-)process:
    - the production of 10 x 10k events w/ output in PAW ntuples (atlfast.ntup)
    - those are converted into root-tuples (h2root) and merged (TTree::Merge) if they all have the requested statistics, using ROOT 5.08
    - Normalization: I added an option in Pythia (stat.dat) to make sure the cross section is evaluated w/ at least 50k events whatever the actual number of entries in a single ntuple (the normalization file can be found at ccali.in2p3.fr in HPSS cchpssd0:/hpss/in2p3.fr/home/m/muanza/GDR_SUSY/SUSY_Blind/ANALYSIS/Normalization.tar.gz)
    - the merged root-tuple is copied in HPSS w/ an incremental index in a directory related to its name

II. Production Status

Process List: SM BKGD

- The HPSS sub-directory is given wrt to

cchpssd0:/hpss/in2p3.fr/home/m/muanza/GDR_SUSY/SUSY_Blind/

Process Name HPSS sub-dir	Production Index	Analysis Index
QCD (5<pT*<10)	10	0
QCD (10<pT*<20)	11	1
QCD (20<pT*<40)	12	2
QCD (40<pT*<80)	13	3
QCD (80<pT*<160)	14	4
QCD (160<pT*<320)	15	5
QCD (320<pT*<980)	16	6
QCD (980<pT*<7000)	17	7

Process Name HPSS sub-dir	Production Index	Analysis Index
cc (5<pT*<10)	20	8
cc (10<pT*<20)	21	9
cc (20<pT*<40)	22	10
cc (40<pT*<80)	23	11
cc (80<pT*<160)	24	12
cc (160<pT*<320)	25	13
cc (320<pT*<980)	26	14
cc (980<pT*<7000)	27	15

HPSS sub-dir: BKGD/qcd
Current Stat: 3.0M evts

HPSS sub-dir: BKGD/cc
Current Stat: 3.1M evts

II. Production Status

Process List: SM BKGD

Process Name	Production Index	Analysis Index
bb (5<pT*<10)	30	16
bb (10<pT*<20)	31	17
bb (20<pT*<40)	32	18
bb (40<pT*<80)	33	19
bb (80<pT*<160)	34	20
bb (160<pT*<320)	35	21
bb (320<pT*<980)	36	22
bb (980<pT*<7000)	37	23

Process Name	Production Index	Analysis Index
γ+jets (5<pT*<10)	30	24
γ+jets (10<pT*<20)	31	25
γ+jets (20<pT*<40)	32	26
γ+jets (40<pT*<80)	33	27
γ+jets (80<pT*<160)	34	28
γ+jets (160<pT*<320)	35	29
γ+jets (320<pT*<980)	36	30
γ+jets (980<pT*<7000)	37	31

HPSS sub-dir: BKGD/bb
Current Stat: 3.1M evts

HPSS sub-dir: BKGD/gam+jets
Current Stat: 3.2M evts

II. Production Status

Process List: SM BKGD

Process Name	Production Index	Analysis Index
tt	50	32
t+b	51	33
t+q	52	34

Process Name	Production Index	Analysis Index
γ+W	60	35
γ+Z	61	36

HPSS sub-dir: BKGD/tt
Current Stat: 0.3M evts

HPSS sub-dir: BKGD/t+b
Current Stat: 0.3M evts

HPSS sub-dir: BKGD/t+q
Current Stat: 0.4M evts

HPSS sub-dir: BKGD/gam+w
Current Stat: 0.4M evts

HPSS sub-dir: BKGD/gam+z
Current Stat: 0.4M evts

Comments: **the flavor excitation single-top process is not available in Pythia 6.3**

II. Production Status

Process List: SM BKGD

Process Name	Production Index	Analysis Index
WW	70	37
WZ	71	38
$\gamma^*/Z+\gamma^*/Z$	72	39

Process Name	Production Index	Analysis Index
W(+jets) → l+ν	100	40
W(+jets) → τ+ν	101	41
W(+jets) → qq'	105	42

Comments: l stands for e or μ

HPSS sub-dir: BKGD/ww
Current Stat: 0.4M evts

HPSS sub-dir: BKGD/wz
Current Stat: 0.4M evts

HPSS sub-dir: BKGD/zz
Current Stat: 0.4M evts

HPSS sub-dir: BKGD/w_lnu
Current Stat: 0.4M evts

HPSS sub-dir: BKGD/w_taunu
Current Stat: 0.4M evts

HPSS sub-dir: BKGD/w_qq
Current Stat: 0.4M evts

Comments: in Pythia 6.3 the WZ process does not include the W+γ* contribution

II. Production Status

Process List: SM BKGD

Process Name	Production Index	Analysis Index
γ*/Z(+jets) → ll (2<m*<60 GeV)	200	43
γ*/Z(+jets) → ττ (2<m*<60 GeV)	**201**	**44**
γ*/Z(+jets) → νν (2<m*<60 GeV)	202	45
γ*/Z(+jets) → ll (60<m*<130 GeV)	210	46
γ*/Z(+jets) → ττ (60<m*<130 GeV)	**211**	**47**
γ*/Z(+jets) → νν (60<m*<130 GeV)	212	48

Process Name	Production Index	Analysis Index
γ*/Z(+jets) → ll (130<m*<250 GeV)	220	49
γ*/Z(+jets) → ττ (130<m*<250 GeV)	**221**	**50**
γ*/Z(+jets) → νν (130<m*<250 GeV)	222	51
γ*/Z(+jets) → ll (250<m*<500 GeV)	230	52
γ*/Z(+jets) → ττ (250<m*<500 GeV)	**231**	**53**
γ*/Z(+jets) → νν (250<m*<500 GeV)	241	54

HPSS sub-dir: BKGD/z_ll
Current Stat: 2.4M evts

HPSS sub-dir: BKGD/z_tautau
Current Stat: 2.4M evts

HPSS sub-dir: BKGD/z_nunu
Current Stat: 2.4M evts

II. Production Status

Process List: SM BKGD

Process Name	Production Index	Analysis Index
γ*/Z(+jets) → ll (500<m*<1960 GeV)	240	55
γ*/Z(+jets) → ττ (500<m*<1960 GeV)	241	56
γ*/Z(+jets) → νν (500<m*<1960 GeV)	242	57
γ*/Z(+jets) → ll (1960<m*<14000 GeV)	250	58
γ*/Z(+jets) → ττ (1960<m*<130 GeV)	251	59
γ*/Z(+jets) → νν (1960<m*<14000 GeV)	252	60

Process Name	Production Index	Analysis Index
γ*/Z(+jets) → qq (2<m*<60 GeV)	205	61
γ*/Z(+jets) → cc (2<m*<60 GeV)	206	62
γ*/Z(+jets) → bb (2<m*<60 GeV)	207	63
γ*/Z(+jets) → qq (60<m*<130 GeV)	215	64
γ*/Z(+jets) → cc (60<m*<130 GeV)	216	65
γ*/Z(+jets) → bb (60<m*<130 GeV)	217	66

HPSS sub-dir: BKGD/z_ll
Current Stat: 2.4M evts

HPSS sub-dir: BKGD/z_tautau
Current Stat: 2.4M evts

HPSS sub-dir: BKGD/z_nunu
Current Stat: 2.4M evts

HPSS sub-dir: BKGD/z_qq
Current Stat: 2.4M evts

HPSS sub-dir: BKGD/z_cc
Current Stat: 2.2M evts

HPSS sub-dir: BKGD/z_bb
Current Stat: 2.4M evts

II. Production Status

Process List: SM BKGD

Process Name	Production Index	Analysis Index
γ*/Z(+jets) → qq (130<m*<250 GeV)	225	67
γ*/Z(+jets) → cc (130<m*<250 GeV)	226	68
γ*/Z(+jets) → bb (130<m*<250 GeV)	227	69
γ*/Z(+jets) → qq (250<m*<500 GeV)	235	70
γ*/Z(+jets) → cc (250<m*<500 GeV)	236	71
γ*/Z(+jets) → bb (250<m*<500 GeV)	237	72

Process Name	Production Index	Analysis Index
γ*/Z(+jets) → qq (500<m*<1960 GeV)	245	73
γ*/Z(+jets) → cc (500<m*<1960 GeV)	246	74
γ*/Z(+jets) → bb (500<m*<1960 GeV)	247	75
γ*/Z(+jets) → qq (1960<m*<14000 GeV)	255	76
γ*/Z(+jets) → cc (1960<m*<14000 GeV)	256	77
γ*/Z(+jets) → bb (1960<m*<14000 GeV)	257	78

HPSS sub-dir: BKGD/z_qq
Current Stat: 2.4M evts

HPSS sub-dir: BKGD/z_cc
Current Stat: 2.2M evts

HPSS sub-dir: BKGD/z_bb
Current Stat: 2.4M evts

Process Name	Production Index	Analysis Index
Total SM BKGD 84=Σ i (i=0 to 78)	-	84

Comments: I chose not to produce the low mass resonance processes like g+J/Ψ or g+Y for the time being

II. Production Status

Process List: Higgs&SUSY

A simulation to search for the following signal illustrates the Blind SUSY Analysis machinery

Process Name	Production Index	Analysis Index
Signal	1000	79
Signal Cplt	2000	80
SUSY Cplt	3000	81
Higgs Cplt	4000	82
Higgs&SUSY BKGD 83=(80–79)+81+82	-	83

HPSS sub-dir: Signal/glss+sq_2l+2b+jets+met
Current Stat: 0.5M evts

HPSS sub-dir: Signal_Cplt/glss+sq_2l+2b+jets+met
Current Stat: 0.4M evts

HPSS sub-dir: SUSY_Cplt/glss+sq_2l+2b+jets+met
Current Stat: 1.0M evts

HPSS sub-dir: HIGGS_Cplt/glss+sq_2l+2b+jets+met
Current Stat: 0.3M evts

Signal:

$$pp \rightarrow \tilde{q} + \tilde{g} \rightarrow \overline{b}\,\tilde{b}_1$$

$$\tilde{q} \rightarrow q\,\tilde{\chi}_1^0 \qquad \tilde{b}_1 \rightarrow b\,\tilde{\chi}_2^0 \rightarrow \ell^+\ell^-\,\tilde{\chi}_1^0$$

Signal Cplt:

$$pp \rightarrow \tilde{q} + \tilde{g} \rightarrow X$$

SUSY Cplt:

- **All available SUSY processes other than** $pp \rightarrow \tilde{q} + \tilde{g}$
- **All available Higgs boson pairs production:**

$$pp \rightarrow h^0A^0 / H^0A^0 / H^\pm h^0 / H^\pm H^0 / H^+H^-$$

HIGGS Cplt:

- **All other available single Higgs boson production processes:**

$$pp \rightarrow h^0 / qh^0 / gh^0 / Wh^0 / Zh^0 / q\bar{q}h^0$$

II. Production Status

Process List

• For more details on the SM and Higgs&SUSY processes, see Pythia 6.3 documentation:
http://cepa.fnal.gov/psm/simulation/mcgen/lund/pythia_manual/pythia6.3/pythia6301/index.html

• Production log files:

- each HPSS sub-directory contains one production log file per sub-process
- Ex:

cchpssd0:/hpss/in2p3.fr/home/m/muanza/GDR_SUSY/SUSY_Blind/BKGD/qcd/demo_16.out
the log file of the **QCD (320<pT*<980)** sub-process

- in it one can find a Pythia event listing, the process cross section, some Atlfast infos,…

•The production index is used in the root-tuple name:
Atlfast_<prod. index>_<prod. iteration>.root
Ex: **cchpssd0:/hpss/in2p3.fr/home/m/muanza/GDR_SUSY/SUSY_Blind/BKGD/z_ll/Atlfast_200_2.root**
corresponds to the 2nd iteration of the $\gamma^*/Z(+jets) \rightarrow l^+l^-$ (2<m*<60 GeV) sub-process
So in order to analyze the full available statistics all the root-tuples w/ the same production index need to be chained or merged

• Current Total Stat: ~33M of produced events

II. Production Status

Detector Fast Simulation: Trigger

L3 Menu	Online Cuts
1 EM 1 e	1 EM particle w/ p_T> 25 GeV, $\|\eta_{EM}\|$<2.5, isolation 1 e, p_T> 25 GeV, $\|\eta_e\|$<2.5, isolation
1 γ	p_T > 40 (60) GeV, $\|\eta_\gamma\|$<2.5, isolation
2 EM 2 e	p_T > 15 (20) GeV, $\|\eta_{EM}\|$<2.5 , isolation 2 e, p_T> 15 GeV, $\|\eta_e\|$<2.5, isolation
1 μ	p_T > 20 GeV, $\|\eta_\mu\|$<2.4, isolation
2 μ	p_T > 10 GeV, $\|\eta_\mu\|$<2.4, isolation
e+μ	p_T^e> 15 GeV, $\|\eta_e\|$<2.5, isolation & p_T^μ> 6 (10) GeV, $\|\eta_\mu\|$<2.4, isolation

Cuts from HLT (ATLAS TDR-016)

- **In red are the Atlfast trigger cuts that are not yet compliant to the HLT TDR**
- **Isolation: see offline reco**

II. Production Status

Detector Fast Simulation: Trigger

L3 Menu	Online Cuts
1 j	**1 jet w/ p_T > 180 (400) GeV, $\|\eta_j\|$<3.2**
2 j	**2 jets w/ p_T >350 GeV , $\|\eta_j\|$<3.2**
3 j	**3 jets w/ p_T > 75 (165) GeV , $\|\eta_j\|$<3.2**
4 j	**4 jets w/ p_T > 55 (110) GeV , $\|\eta_j\|$<3.2**
j70+xE70	**1 jet w/ p_T >70 GeV & E_T^{mis}>70 GeV , $\|\eta_j\|$<3.2**
xE200	**E_T^{mis}>200 GeV**
jE1000	**H_T(jets)>1000 GeV**

Any other terms from the ATLAS HLT TDR-016 can easily be added in the analysis program as cuts are applied on Atlfast reco'd quantities

II. Production Status

Detector Fast Simulation: Offline Reco

ATLFAST Global Parameters	Value
Inst. Lumi. Option	Low
B-field	ON
Smearing	ON
Tracks Reco	ON

Charged Tracks	Cuts
Reco criteria	• $p_T^{track} > 0.5$ GeV, $\|\eta_{track}\| < 2.5$

II. Production Status

Detector Fast Simulation: Offline Reco

Isolated e and γ	Cuts
Reco criteria	• $p_T^{e/\gamma} > 5$ GeV, $\lvert\eta_{e/\gamma}\rvert < 2.5$
Isolation	• $\Delta R(e/\gamma, j) > 0.15$ • $E_T[\, 0.2 < \Delta R(e/\gamma, \text{clusters}) < 0.4 \,] < 10$ GeV

$$\frac{\sigma_E}{E} = \frac{12\%}{\sqrt{E}} \oplus \frac{0.245}{E_T} \oplus 0.7\%$$ e

$$\frac{\sigma_E}{E} = \frac{10\%}{\sqrt{E}} \oplus \frac{0.245}{E_T} \oplus 0.7\%$$ γ

$$\begin{cases} \sigma_\theta = \dfrac{6.5\%}{\sqrt{E}} \leftrightarrow |\eta| < 0.8 \\ \sigma_\theta = \dfrac{5\%}{\sqrt{E}} \leftrightarrow 0.8 < |\eta| < 1.4 |\eta| < 2.5 \\ \sigma_\theta = \dfrac{40\%}{\sqrt{E}} \leftrightarrow 1.4 < \end{cases}$$ γ

II. Production Status

Detector Fast Simulation: Offline Reco

Isolated μ	Cuts
Reco criteria	• $p_T^{\mu} > 6$ GeV, $\lvert\eta_{\mu}\rvert < 2.5$
Isolation	• $\Delta R(\mu,j) > 0.4$ • $E_T[\,\Delta R(\mu,X) < 0.2\,] < 10$ GeV

$$\frac{\sigma_{p_T}}{p_T} = 0.05\% \times p_T \oplus 1.2\% \leftrightarrow |\eta| < 2.0$$

μ

II. Production Status

Detector Fast Simulation: Offline Reco

Calorimeter clusters	Cuts
Granularity	• **0.1x0.1 ←→ $|\eta|< 3$** • **0.2x0.2 ←→ $|\eta|> 3$**
Acceptance	• **$|\eta|< 5$**
Reco criteria	• **Cluster init.: E_T(init.)> 1.5 GeV** • **Cluster (final): E_T> 5 GeV (D: 10 GeV)** • **Cluster cone: ΔR=0.4**

II. Production Status

Detector Fast Simulation: Offline Reco

τ–jets	Cuts
Reco criteria	• Cone: $\Delta R(had,jet)<0.3$ • $p_T^{\tau} > 10$ GeV, $\lvert\eta_\tau\rvert< 2.5$ • $p_T^{\tau-had} / p_T^{jet} > 90\%$ • No ε or mistag rates are applied so far!!!

Missing E_T	Cuts
Reco criterion	• $E_T(cells)> 0$ GeV • $\lvert\eta(cells)\rvert< 5$ • Vector sum is performed on reco'd objects (e, μ, jets,…) plus on unclustered cells (which E is smeared w/ the jet resolution)

II. Production Status

Detector Fast Simulation: Offline Reco

Jets Reco	Cuts
Algo	• **simple cone** • **$\Delta R=0.4$**
Reco criteria	• **$p_T^{jet} > 10$ GeV (D: 15 GeV)** • **$\lvert\eta_{jet}\rvert < 5$**
• no jet energy calibration is applied so far	

$$\begin{cases} \dfrac{\sigma_E}{E} = \dfrac{50\%}{\sqrt{E}} \oplus 3\% \leftrightarrow |\eta| < 3 \\ \dfrac{\sigma_E}{E} = \dfrac{100\%}{\sqrt{E}} \oplus 3\% \leftrightarrow |\eta| > 3 \end{cases}$$

jets

II. Production Status

Detector Fast Simulation: Offline Reco

Jets Flavor Tagging	Value
• b-jets: from the list of inclusive reco'd jets • equivalent procedure for c-jets	• pT(b)> 5 GeV after FSR • ΔR(b,b-jet)<0.2 • $\lvert\eta_{b\text{-jet}}\rvert < 2.5$
• ε(b-tagging)=60% and mistag rates for c-jets and light flavor jets taken from ATLFAST-B are applied in the analysis program	

III. Analysis Tools Status

Description of the Analysis Program

- The root-tuples to analyze are simple ones without any objects (just converted CWN ntuples)
- The analysis program is a C++ code based on a ROOT MakeClass method
- In fact I'm not programming in C++ yet (I'm not even a C expert), so it's more like a Fortran designed code written in C within a C++ MakeClass (may be this is reassuring to other programming dynosaurs like me… yet it might be frightening for for C++ fans…)!?!?!
- …
- A detailed description of the functionalities are under preparation… Send me a mail (muanza@in2p3.fr or muanza@fnal.gov) in the meantime if you have any comments/questions

III. Analysis Tools Status

« How To »

- How to analyze the available MC samples:

1. Copy the production tar file:
   - **… set ROOT v5.08 (or higher)…**
   - **mkdir analysis_dir**
   - **cd analysis_dir**
   - **rfcp cchpssd0:/hpss/in2p3.fr/home/m/muanza/GDR_SUSY/SUSY_Blind/ANALYSIS/Susy_Blind_Analysis.tar.gz .**
   - **tar xvfz Susy_Blind_Analysis.tar.gz**
   - **gmake clean**
   - **gmake EXE=analysis**
   - **cp param.txt_save param.txt**
   - **…EDIT param.txt: replace all the <XXX_*> with values…**
     - **Ex: VAR=XXX_VARIABLE# → VAR=mET#**
   - **./analysis >& log**
   - **Look at ./log**
   - **root –l <VARIABLE_CUT>.C**
   - **Edit <VARIABLE_CUT>.C if needed**

III. Analysis Tools Status

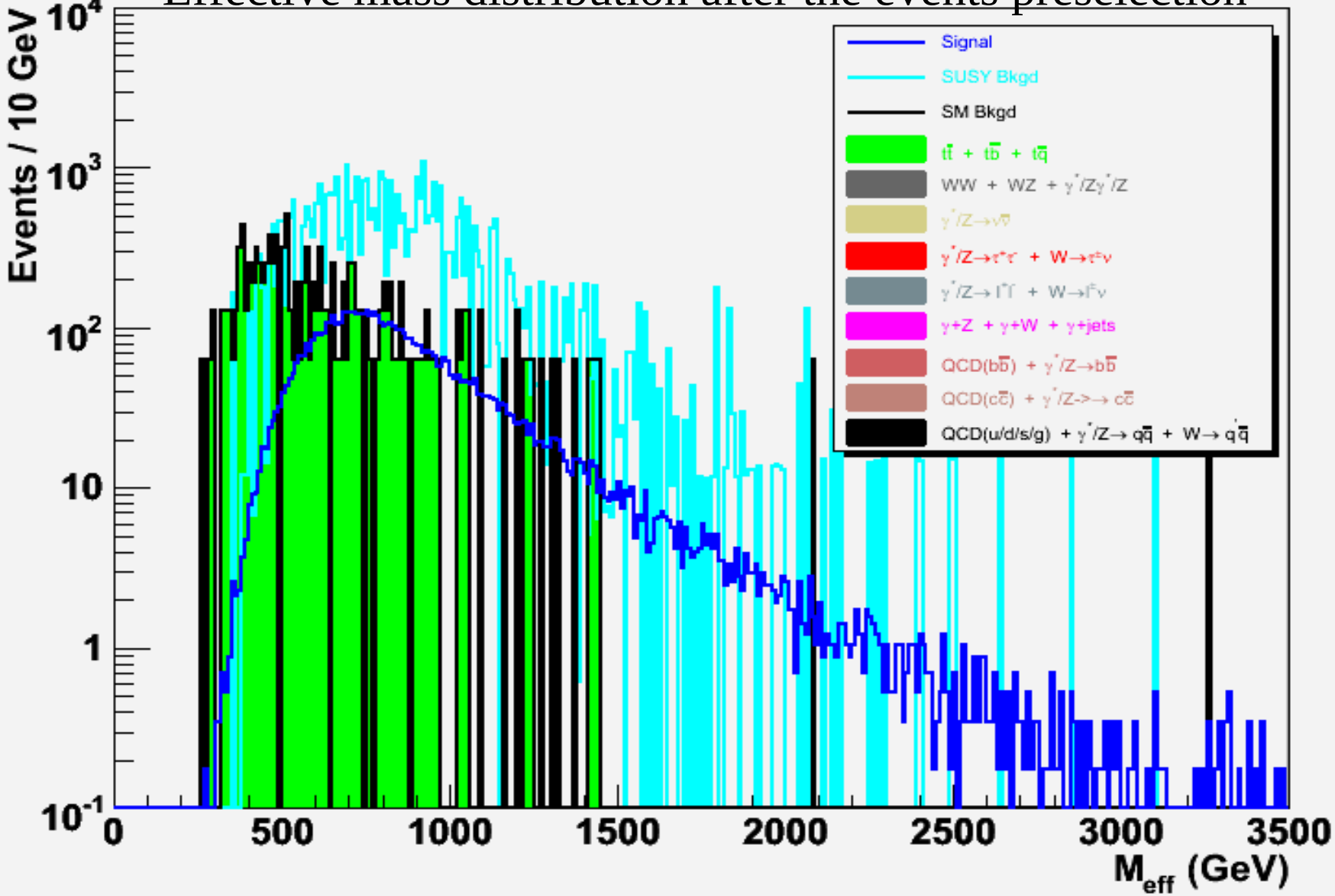
Print Out for Each Sub-Process

Process: tt
Copying: rfcp
cchpssd0:/hpss/in2p3.fr/home/m/muanza/GDR_SUSY/SUSY_Blind/BKGD/tt/Atlfast_50_1.root
/scratch/muanza1013.ccwl0166/
520351911 bytes in 49 seconds through eth0 (in) and local (out) (10370 KB/sec)
Tuple_Name: Atlfast_50_1.root
Processing Chain_32
Root-tuple name: Atlfast_50_1.root
nb of events on file 100000
nb of events to read 100000
Event #: 0
Event #: 10000
…
Event #: 80000
Event #: 90000
Removing: rm Atlfast_50_1.root
Nchain(tt)=100000 Evts
Ngen(tt)=100000 Evts
Nacc(tt)=186 Evts
Eff(tt)=(0.19 +/- 0.01)%
Xsect(tt)=632.00 pb
Max Rate(tt)= 0.00 Hz
Nexp(tt)=(11755.20 +/- 861.13) Evts

III. Analysis Tools Status

Illustration

Effective mass distribution after the events preselection



VI. Conclusions and Prospects

Production

• The pseudo-data samples will be available in HPSS at
cchpssd0:/hpss/in2p3.fr/home/m/muanza/GDR_SUSY/SUSY_Blind/Pseudo_DATA/

• An « How To » produce private signal templates will be available in the coming weeks
• A new production will soon be launched in order to include the event shape variables (circularity, Sphericity, oblateness, thrust) that were commented out by mistake

Analysis

• A working analysis program is provided. It should be easy to run it and get some distributions…
• Comments and feed-back are expected

• Analysis limitation:
  • currently the analysis program is set to read only 1 root-tuple (100k) per sub-process
  • a new version enabling to chain several root-tuples per sub-process will be available soon
  • so for now the analysis runs only on a total statistics ~8M events
  • the HLT method will be modified so as to strictly reflects the L3 trigger cuts as listed in the HLT TDR

Back Up