First Look at Flavour Inspired MSSM Points

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Flavour Workshop (WG2)

(Oliver Buchmüller - CERN SUSY/BSM 29.09.2006)

Action Items for LHC/FP benchmark & tool sub-group

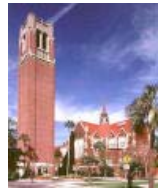
a) identify the models we want to investigate (this of course also depends on our areas of expertise, available codes etc.)

a) collect suggestions for the point(s) in each model
(The points could also be connected to a model line, showing the variation of flavor effects.)
-> can we agree on a certain way of defining the points?

a) test these points, i.e. everyone of us who can check a point against existing experimental data should do this - identify among the "surviving" points the ones that show the potentially most interesting phenomenology

d) Define technical interface to experiment (e.g. common definition, how to generate scenarios, etc)

Target:
Try to exercise a full chain "a) to d)" until Flavour workshop in October



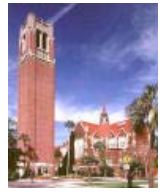
Disclaimer

- **The primary purpose of this talk is to demonstrate the “full chain” of tools in CMS**

- **All Preliminary Results presented in this talk represent work in progress and are not final**

Strategy for Inclusive-Muon SUSY Search CMS Note 2006/134

- Counting experiment
  - Search for excess in number of events over expected from Standard Model
- Require muon triggers
  - Expected to be clean and understood at startup
- Apply quality cuts
  - Pre-select well reconstructed quantities
- Optimise cuts
  - Genetic algorithm used to search space of cuts
  - Systematic effects explicitly included in optimisation metric
- Determine CMS reach in m0 – m1/2 plane
  - Apply cuts to different mSUGRA points generated from Fast Simulation
- Tools used
  - Full Geant-4 based CMS Detector Simulation
    - All SM backgrounds and selected SUSY points
  - Full CMS Reconstruction Framework
  - Pile-up : Low-luminosity (2x10^33) Pile-up included
  - Fast CMS Detector Simulation
    - Used for scans of SUSY parameter space.



Datasets Simulated for CMS Note 2006/134

- **mSUGRA Benchmark point:**

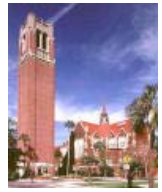
	m_0 (GeV/c^2)	$m_{1/2}$ (GeV/c^2)	$\tan\beta$	A_0	sign(μ)	σ_{LO} (pb)	N_{Gen}	L (fb^{-1})
LM1	60	250	10	0	+	41.9	98250	2.3

- TTBar (3.3 M events, equiv. **L ~7 fb-1**)
- QCD (2.6 M events, equiv. **L ~3 fb-1** for pt_hat > 800 GeV)
- W+jets (2.9 M events, equiv. **L ~2 fb-1** for pt_W > 400 GeV)
- Z+jets (1.5 M events, equiv. **L ~3 fb-1** for pt_Z > 250 GeV)
- WW+jets (483 k events, equiv. **L ~3 fb-1**)
- ZW+jets (276 k events, equiv. **L ~10 fb-1**)
- ZZ+jets (478 k events, equiv. **L ~40 fb-1**)

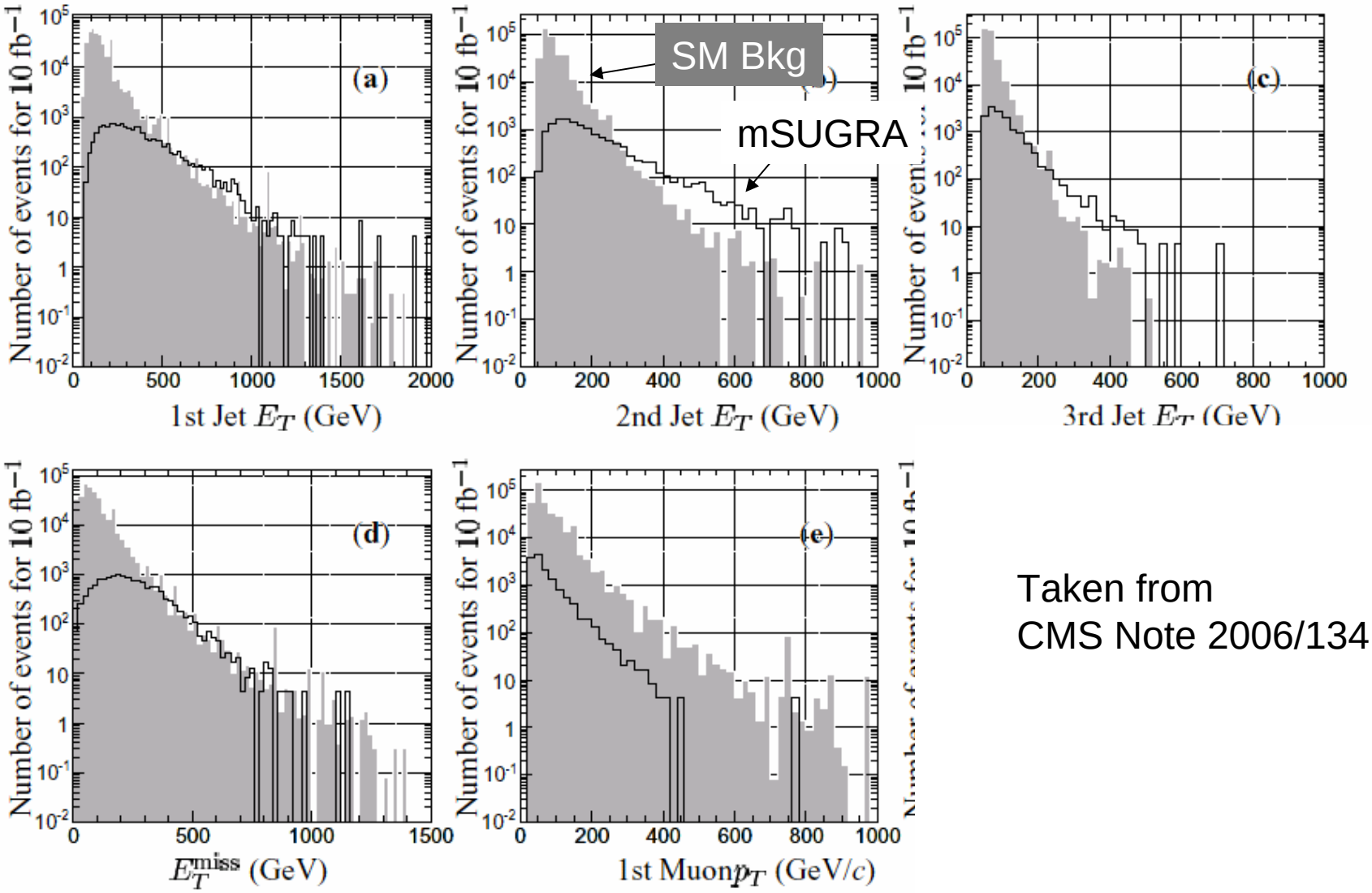
- All samples are reweighed to **L=10 fb-1**

Note:

PS Model used for: TTBar, W+jets, Z+jets
Studied effect of **ME** : ~10% increase in bkg acceptance (applied as syst. Uncert.)



Some Illustrative Distributions SM Backgrounds & mSUGRA



Taken from
CMS Note 2006/134

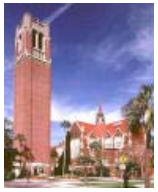
Cuts used in CMS Note 2006/134

CMS Note 2006/134

	Cut Criteria			LM1	SM
Pre-selection	number of muons ≥ 1 "AND" p_T	$>$	30 GeV/c	45450 (10%)	7.383×10^7 (10^{-5}%)
	μ calo. iso. $(R = 0.3)$ E_T	$<$	10 GeV	24260 (53%)	5.26×10^7 (71%)
	number of jets ≥ 3 "AND" E_T	$>$	50 GeV	15660 (64%)	3.769×10^4 (0.07%)
Selection	leading jet (Jet1) E_T^{Jet1}	$>$	440 GeV	4062.0 (25%)	3271.0 (1%)
	next-to-leading jet (Jet2) E_T^{Jet2}	$>$	440 GeV	656.0 (16%)	536.1 (16%)
	$\lvert\eta^{\mathrm{Jet1}}\rvert$	$<$	1.9	639.2 (97%)	500.9 (93%)
	$\lvert\eta^{\mathrm{Jet2}}\rvert$	$<$	1.5	567.7 (88%)	445.9 (89%)
	$\lvert\eta^{\mathrm{Jet3}}\rvert$	$<$	3.0	559.3 (98%)	313.4 (70%)
	$-1 < \cos\left[\Delta\phi(\mathrm{Jet1},\ \mathrm{Jet2})\right]$	$<$	0.2	525.6 (93%)	311.3 (99%)
	$-0.95 < \cos\left[\Delta\phi(E_T^{\mathrm{miss}},\ \mathrm{Jet1})\right]$	$<$	0.3	407.9 (77%)	81.4 (26%)
	$-1 < \cos\left[\Delta\phi(E_T^{\mathrm{miss}},\ \mathrm{Jet2})\right]$	$<$	0.85	386.9 (94%)	34.0 (42%)
	E_T^{miss}	$>$	130 GeV	328.0 (84%)	3.7 (11%)
Trigger	single-μ "OR" di-μ	$=$	"Accept"	311.2 (94%)	2.5 (69%)

Expected number of LM1 mSUGRA Signal

Expected number of total SM Backgrounds



Backgrounds and Systematics

CMS Note 2006/134

	Expected # of Events ($10\,\mathrm{fb}^{-1}$)
QCD	0
$t\bar{t}$	0.7
W + jets	1.6
Z + jets	0.3
WW + jets	0
WZ + jets	0
ZZ + jets	0
Total	2.5

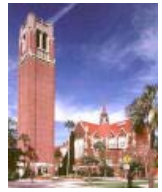
Background Decomposition

Systematic Uncertainties

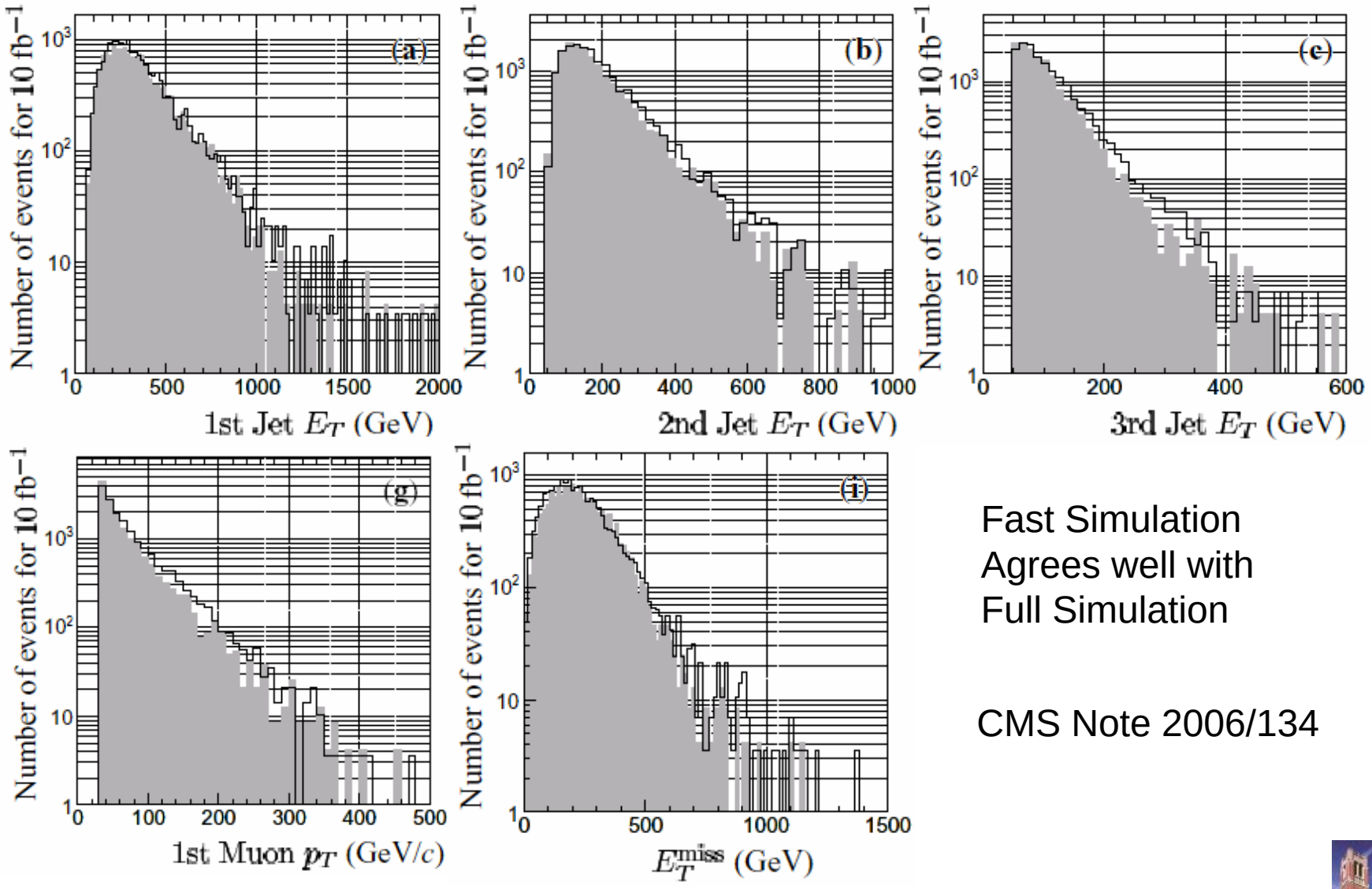
Includes PS/ME effects

Systematic	Uncertainty ($\delta N/N$)	
	single-muon	dimuon
Jet Energy Scale	10%	15%
Jet Energy Resolution	5%	10%
Luminosity	5%	5%
Theory	13%	13%
ORCA vs FAMOS	2%	2%
Background Total	18%	23%

CMS Note 2006/134



Comparison of Full Sim with Fast Sim

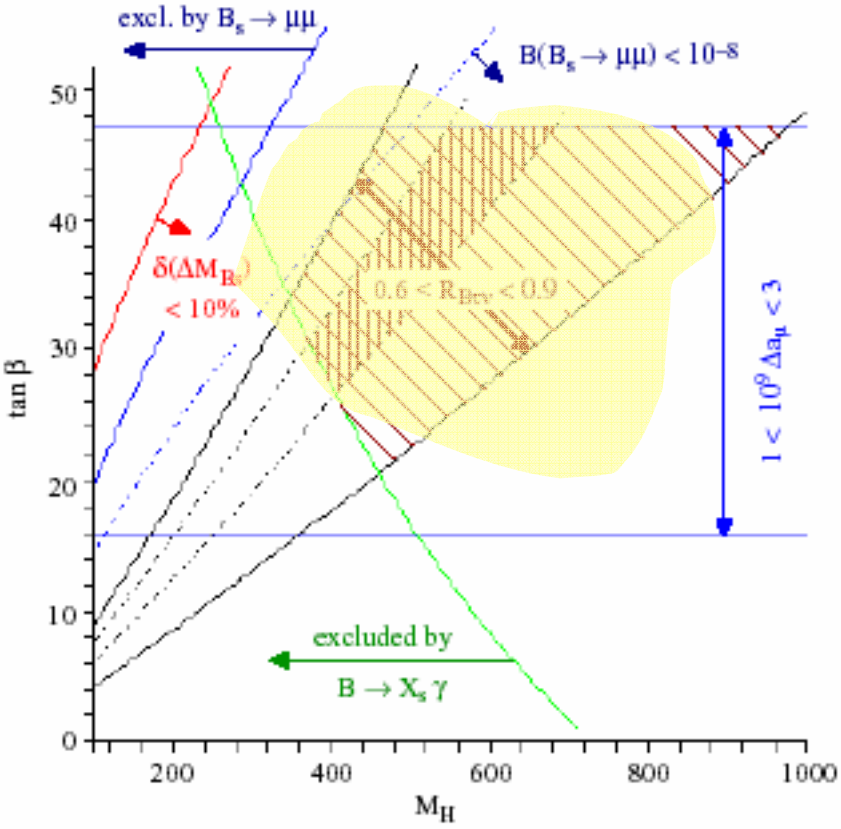


Fast Simulation
Agrees well with
Full Simulation

CMS Note 2006/134

Some Recent Flavour Constraints in MSSM Parameter Space

Example: Search for large $\tan\beta$ within MFV
Isidori, Paradisi, hep-ph/0605012



B-physics observables and $(g-2)_\mu$ in the M_{H^+}–$\tan\beta$ plane:

$$0.76 < \frac{BR(B\to X_s\gamma)^{SUSY}}{BR(B\to X_s\gamma)^{SM}} < 1.15\ [90\%CL]$$

$$\Delta a_\mu = a_\mu^{\rm exp} - a_\mu^{\rm SM} \approx (2 \pm 1) \times 10^{-9}$$

$$BR(B_s \to \mu^+\mu^-) < 8.0 \times 10^{-8}\ \text{CDF}$$

$$\Rightarrow \frac{BR^{SUSY}(B_s\to \ell^+\ell^-)}{BR^{SM}(B_s\to \ell^+\ell^-)} < 23\ [90\%CL]$$

$$R_{B\tau\nu} := \frac{BR^{SUSY}(B_u\to \tau\nu)}{BR^{SM}(B_u\to \tau\nu)}$$

$$R_{B\tau\nu}^{\rm exp} = 0.67^{+0.30}_{-0.27}\ \text{BELLE}$$

$$[\mu, A_U] = [0.5, -1.0]\ \text{TeV}$$

Example: Slide from T. Hurth (presented at Beauty 2006)

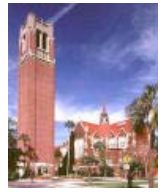
MSSM & MFV

First (crude) estimate of parameter space. Proposal from Isidori et al.

```
tan(beta)  = 30-50
MH         = 300-1000 GeV
-AU        = 1000-2000 GeV
Mu         = 500-1000 GeV
Msquarks >= 1000 GeV

Other soft-breaking parameters

M3 = Msquarks
M2 = 2*M1 = 300-500
```



MSSM Points Studied for this Work

- First Look!!
- Sample only a few of the points of interest from prev. slide
  - Take some combination of parameters' min. & max.
- Only simple generator used : IsaPythia

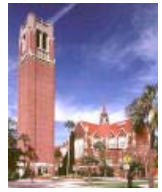
ID	AU	MH	tanβ	μ	m_sq	M2	x-section (pb)
A	-2000	300	40	500	1000	300	1.85 pb
B	-1000	300	40	500	1000	300	1.87 pb
C	-2000	1000	40	500	1000	300	1.90 pb
D	-2000	300	40	1000	1000	300	1.85 pb
E	-2000	300	40	500	2000	300	0.08 pb
F	-2000	300	40	500	1000	500	1.52 pb
G	-1000	1000	40	1000	2000	500	0.06 pb

- Cross-section depends most strongly on m_squark

Example of IsaPythia Cards File

```
C
C Pythia parameters
C ----------------
C
  MRPY 1= 10 ! State of random number generator
C
C mssm
  IMSS 1 = 1 ! general MSSM simulation
C process selection
  MSEL 39 ! inclusive SUSY
C
  RMSS 1  = 150.      ! U(1)  gaugino mass
  RMSS 2  = 300.      ! SU(2) gaugino mass
  RMSS 3  = 1000.     ! SU(3) (gluino) mass parameter
  RMSS 4  = 500.      ! higgsino mass parameter
  RMSS 5  = 40.       ! tanbeta
  RMSS 6  = 500.      ! left slepton mass
  RMSS 7  = 500.      ! right slepton mass
  RMSS 8  = 1000.     ! left squark mass
  RMSS 9  = 1000.     ! right squark mass
  RMSS 10 = 1000.     ! left sq mass for 3th gen/heaviest stop mass
  RMSS 11 = 1000.     ! right sbottom mass/lightest sbotoom mass
  RMSS 12 = 1000.     ! right stop mass/lightest stop mass
  RMSS 13 = 500.      ! left stau mass
  RMSS 14 = 500.      ! right stau mass
  RMSS 15 = -2000.    ! Abottom
  RMSS 16 = -2000.    ! Atop
  RMSS 17 = -2000.    ! Atau
  RMSS 19 =  300.     ! m_A
C
```

(Pythia 6.324)



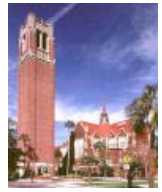
Apply Existing Analysis

Inclusive-Muon SUSY Search (CMS Note 2006/134)

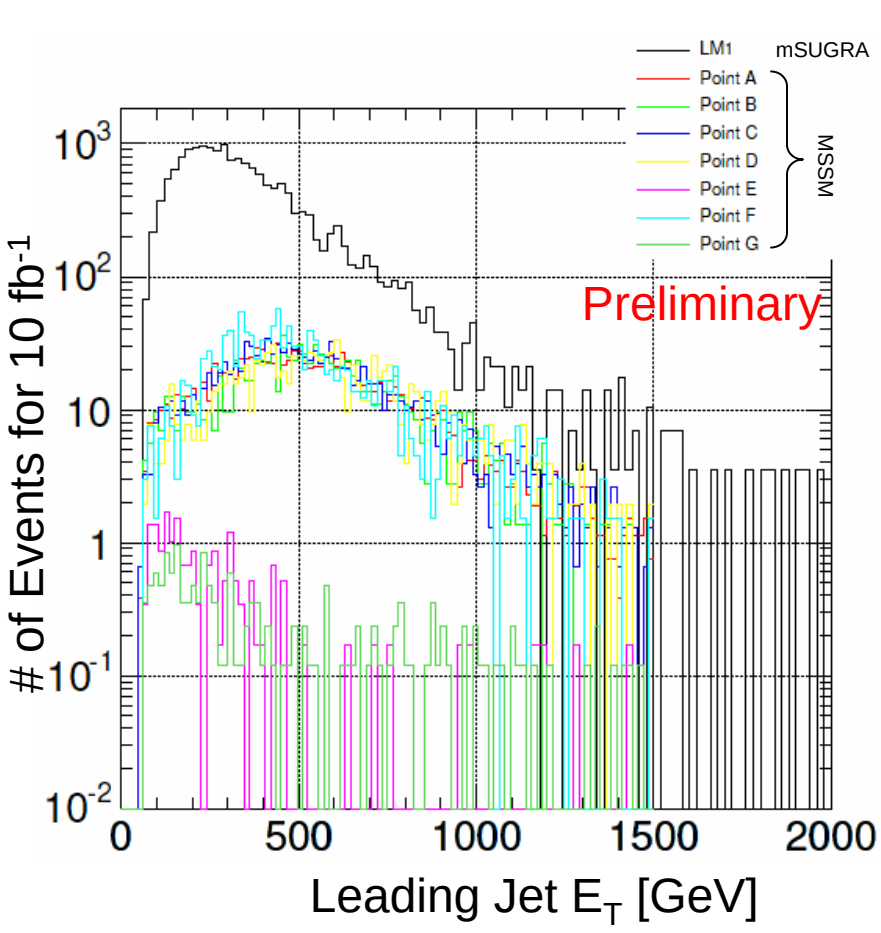
- Counting Experiment
- Require muon triggers
- Apply quality cuts
- Optimise cuts by explicitly including systematics
- Apply cuts to mSUGRA scan

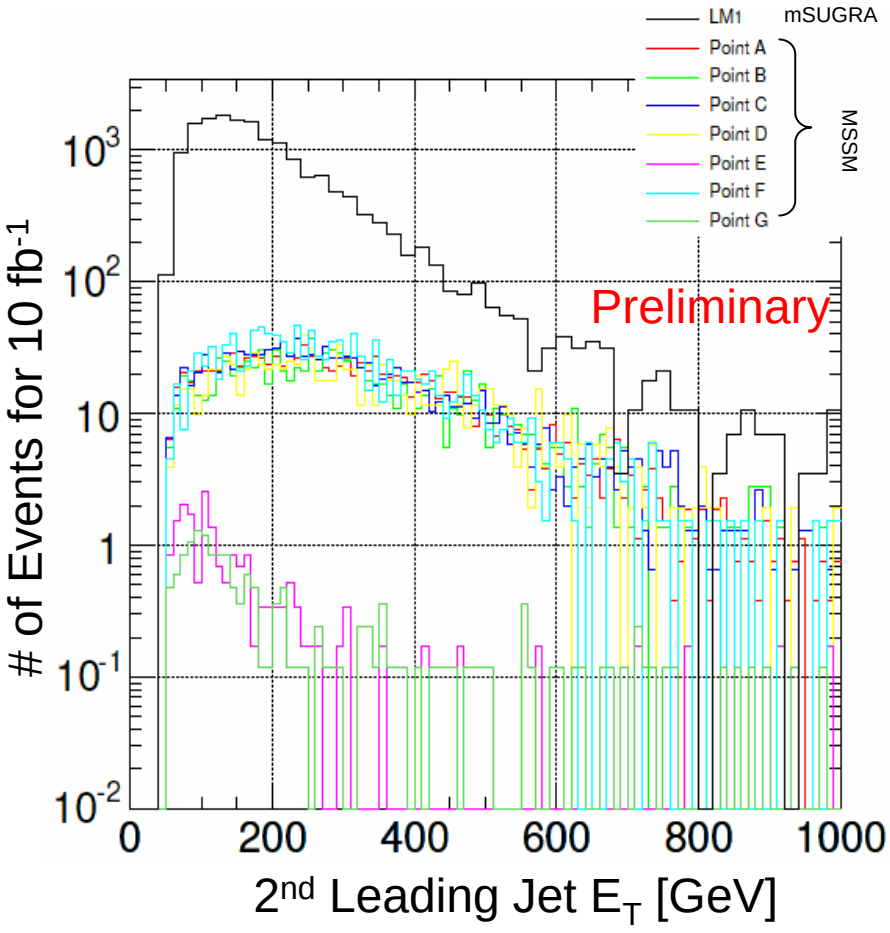
Now (using exact 2006/134 analysis)...

- Apply cuts to new study points, too.



Comparison Between mSUGRA LM1 and MSSM Points





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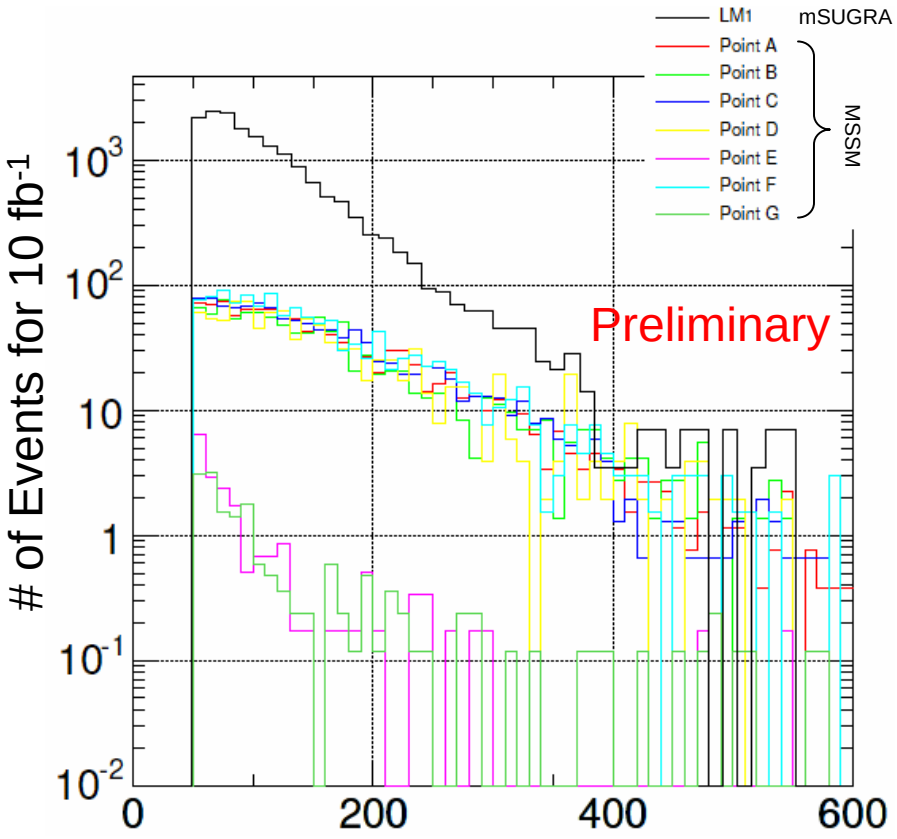

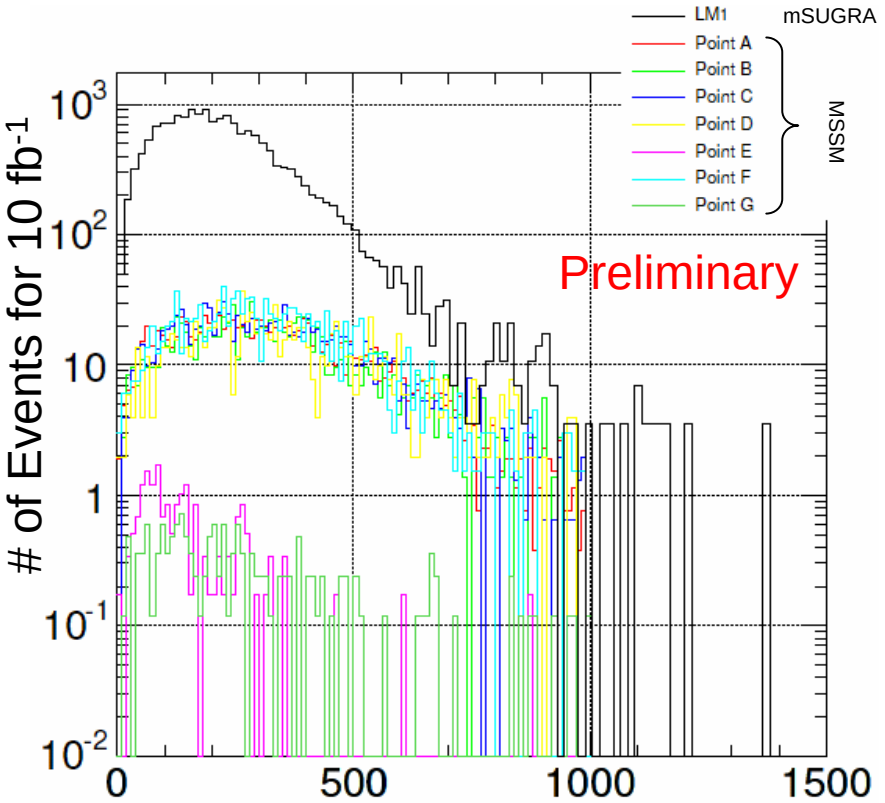

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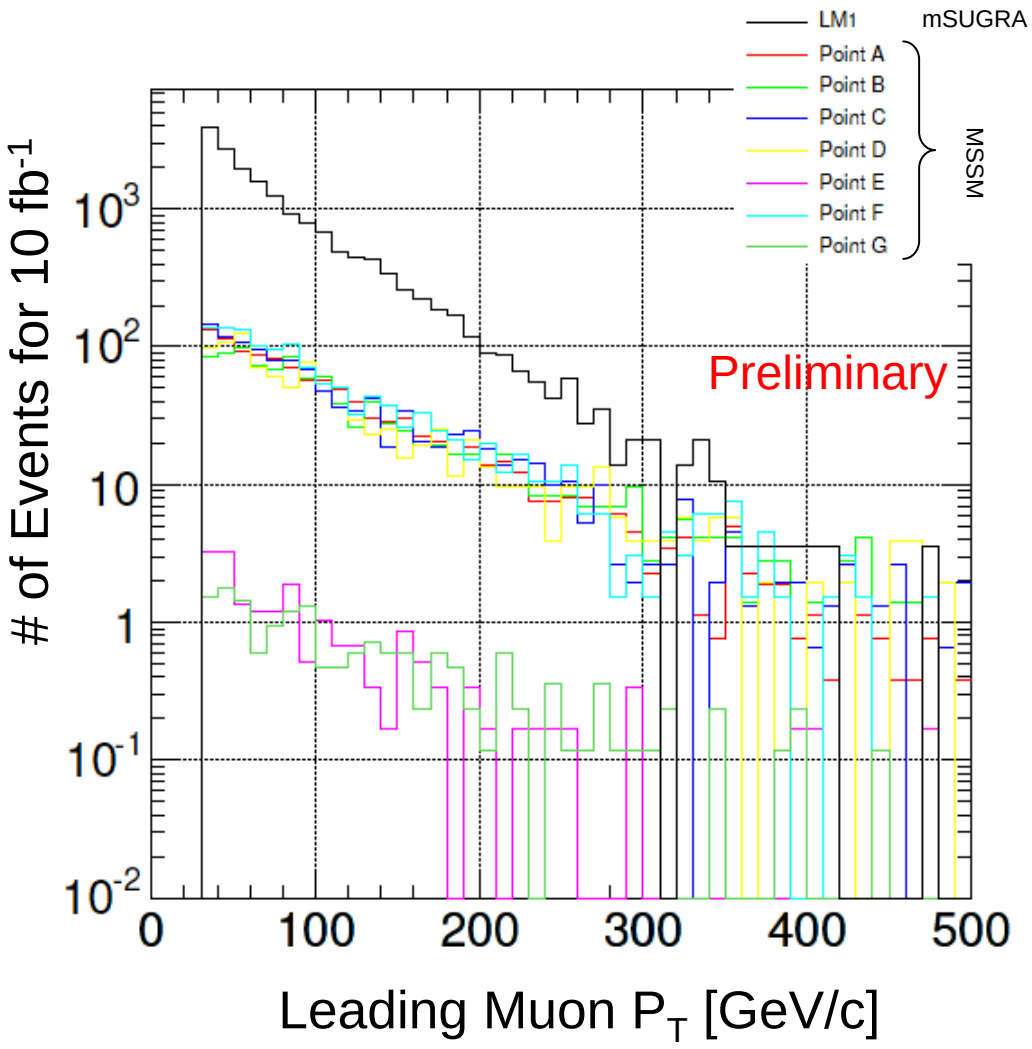
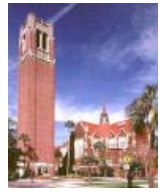


Preliminary Results Extended to MSSM

- First Look!!
  - Application of un-modified inclusive muon analysis
- Analysis optimised to observe low-mass mSUGRA point for 10 fb-1
- Analysis not optimised to observe higher-mass MSSM points
  - Can not yet say, that CMS is able or unable to observe such points!
- Cross section depends most strongly on m_squark

ID	AU	MH	tanβ	μ	m_sq	M2	Discoverable ($10\ fb^{-1}$)
A	-2000	300	40	500	1000	300	
B	-1000	300	40	500	1000	300	
C	-2000	1000	40	500	1000	300	
D	-2000	300	40	1000	1000	300	
E	-2000	300	40	500	2000	300	?
F	-2000	300	40	500	1000	500	
G	-1000	1000	40	1000	2000	500	?

Note: Analysis to be optimised in order to assess discovery of these points



Conclusion

- The CMS Software Tools have been applied to Flavour Inspired MSSM points
  - Full Simulation
  - Fast Simulation
  - Full Reconstruction
  - Preliminary Analysis
    - Not opimised for MSSM points studied
- Many of the points appear promising
- Additional work required to fully establish CMS Reach