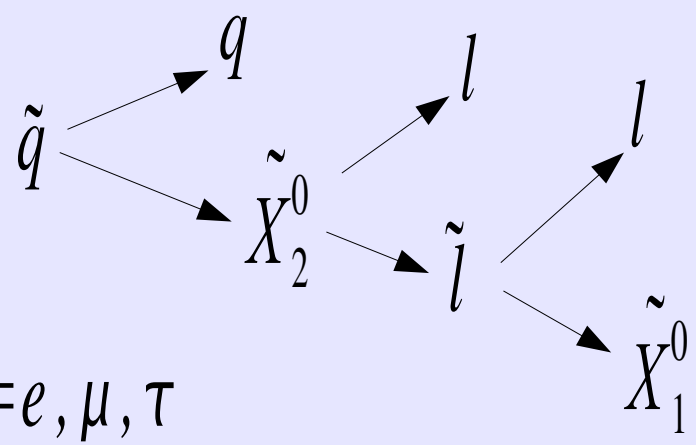
Analyzing SUSY tau final states with Atlfast

Outline:

- introduction
- signal selection
- first attempt of cut optimisation

motivation



SU1:

$$BR(\tilde{X}_2^0 \to \tilde{e}_{1,2} e \to \tilde{X}_1^0 e e) = 6\,\%$$
$$BR(\tilde{X}_2^0 \to \tilde{\mu}_{1,2} \mu \to \tilde{X}_1^0 \mu \mu) = 7\,\%$$
$$BR(\tilde{X}_2^0 \to \tilde{\tau}_{1,2} \tau \to \tilde{X}_1^0 \tau \tau) = 25\,\%$$

SU3:

$$BR(\tilde{X}_2^0 \to \tilde{e}_{1,2} e \to \tilde{X}_1^0 e e) = 6\,\%$$
$$BR(\tilde{X}_2^0 \to \tilde{\mu}_{1,2} \mu \to \tilde{X}_1^0 \mu \mu) = 6\,\%$$
$$BR(\tilde{X}_2^0 \to \tilde{\tau}_{1,2} \tau \to \tilde{X}_1^0 \tau \tau) = 58\,\%$$

mSUGRA Points:

SU1 (coannihilation region), SU3 (bulk region)

	SU1	**SU3**
m0	70 GeV	100 GeV
m½	235 GeV	300 GeV
A0	0	-300 GeV
tanβ	10	6
sgnμ	+	+

note: factor 4 to 10 more taus than electrons/muons

data samples

event generation:

signal:

(*Athena 11.0.42, Herwig 6.5, Atlfast 02*)

	SU1	SU3
σ $[pb]$	7.7	19.5
# events	200000	200000
L $[fb^{-1}]$	25.6	10.3

background:

- Z+Jets, W+Jets, $t\bar{t}$ +Jets, $b\bar{b}$ +Jets, Multijets

(*Athena 11.0.41, Alpgen, Atlfast*)

produced by ATLAS SUSY working group:

/castor/cern.ch/grid/atlas/datafiles/susy/atlfast/2006_b/

copied Luminosity:

	L [fb-1]
Z+Jets	92
W+Jets	2
ttbar+Jets	50
bbbar+Jets	0.1
MultiJets	0.004

- Pythia dijets: in pt-bins (J1-J8)

(*Athena 10.0.4, Pythia 6.2, Atlfast 02*)

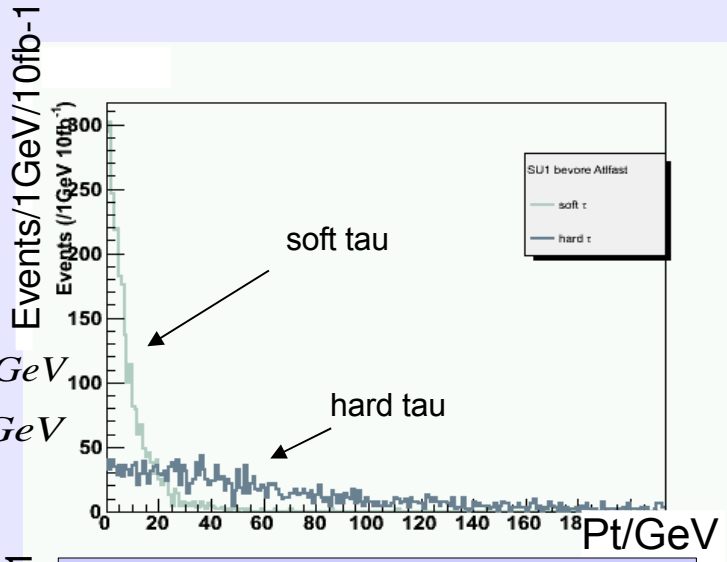
produced by Robindra Prabhu

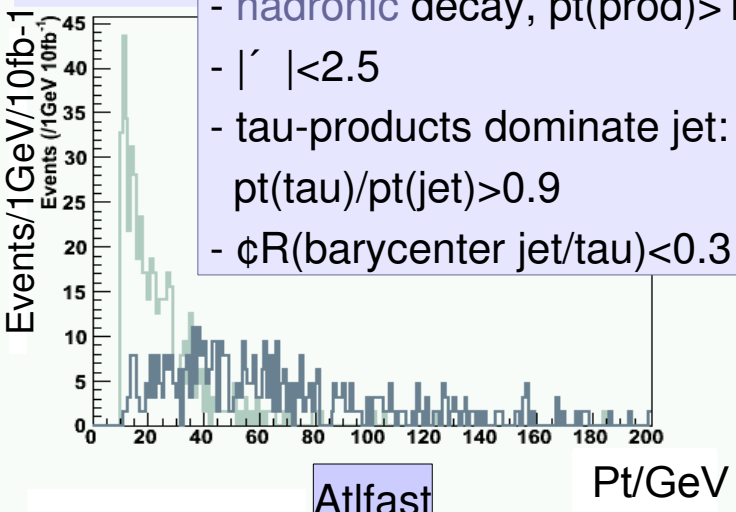
pt of hard/soft tau, generator level and after ATLFAST

SU1

$m(\tilde{X}_2^0 - \tilde{\tau}_1) = 118\,GeV$

$m(\tilde{\tau}_1 - \tilde{X}_1^0) = 9\,GeV$





Jets labelled as taus if:

- hadronic decay, pt(prod)>10GeV
- |´ |<2.5
- tau-products dominate jet: pt(tau)/pt(jet)>0.9
- ¢R(barycenter jet/tau)<0.3

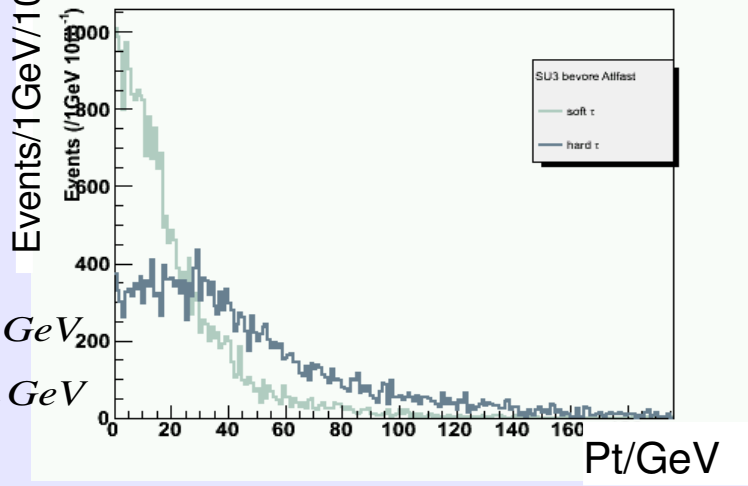
Truth: pt of visible decay products

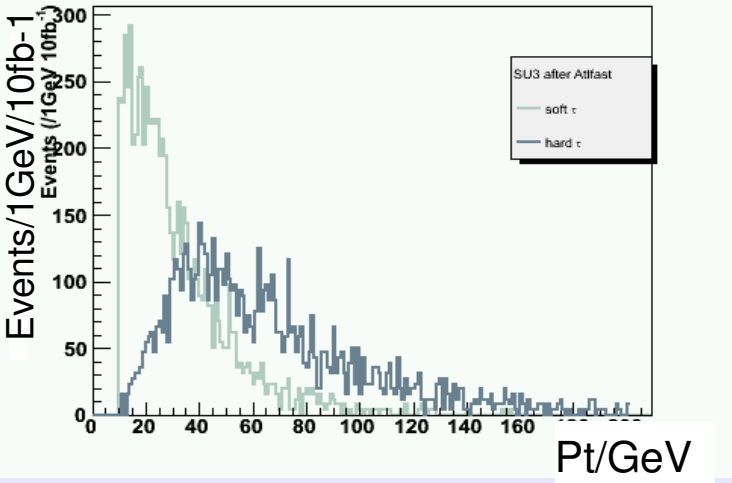
Atlfast

SU3

$m(\tilde{X}_2^0 - \tilde{\tau}_1) = 69\,GeV$

$m(\tilde{\tau}_1 - \tilde{X}_1^0) = 32\,GeV$





Invariant mass

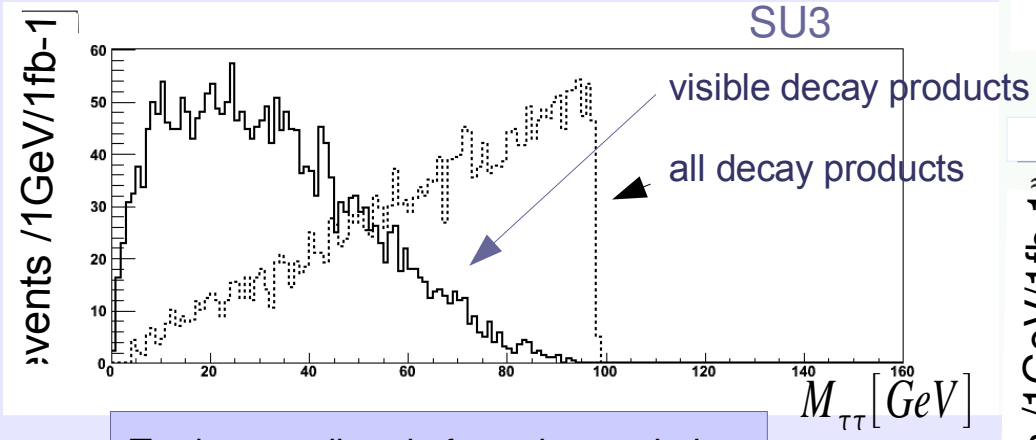
Invariant mass distributions: $\tilde{X}_2^0 \to \tilde{\tau}\,\tau \to \tilde{X}_1^0\,\tau\,\tau$

LSP escapes detection -> no mass peak

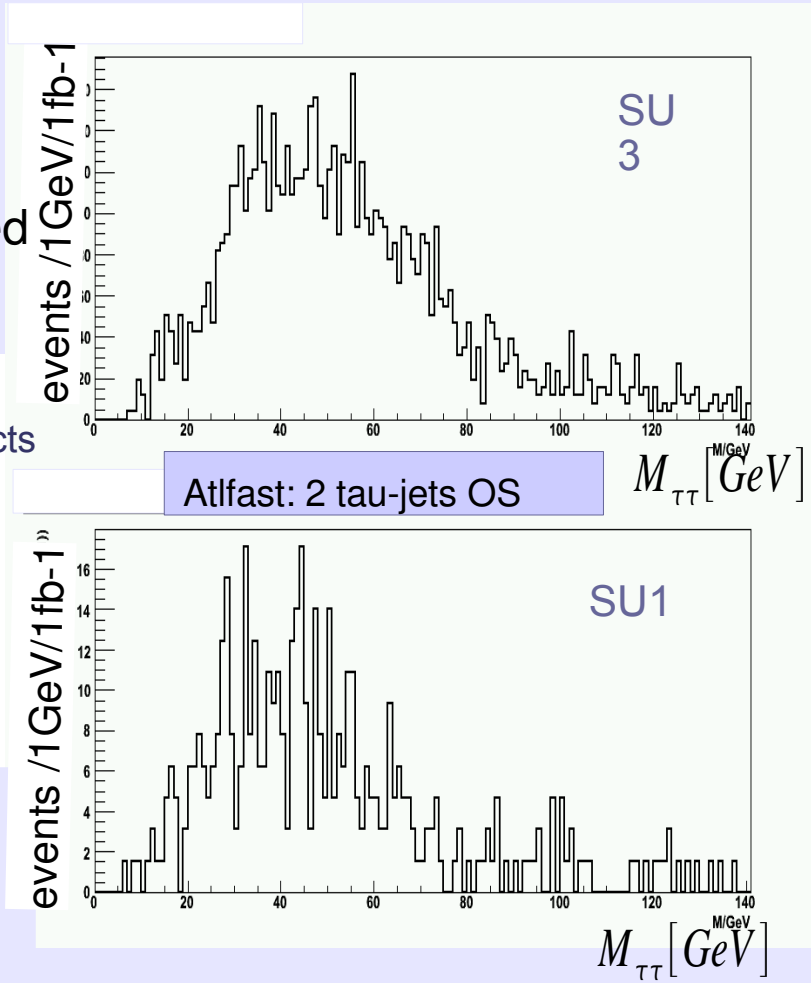
kinematic endpoint at

$$m_{\tau\tau}^{max} = \sqrt{\frac{(m(\tilde{X}_2^0)^2 - m(\tilde{\tau}_1)^2)\cdot(m(\tilde{\tau}_1)^2 - m(\tilde{X}_1^0)^2)}{(m(\tilde{\tau}_1)^2)}}$$

plots normalized to 1 fb-1



Truth: taus directly from decay chain



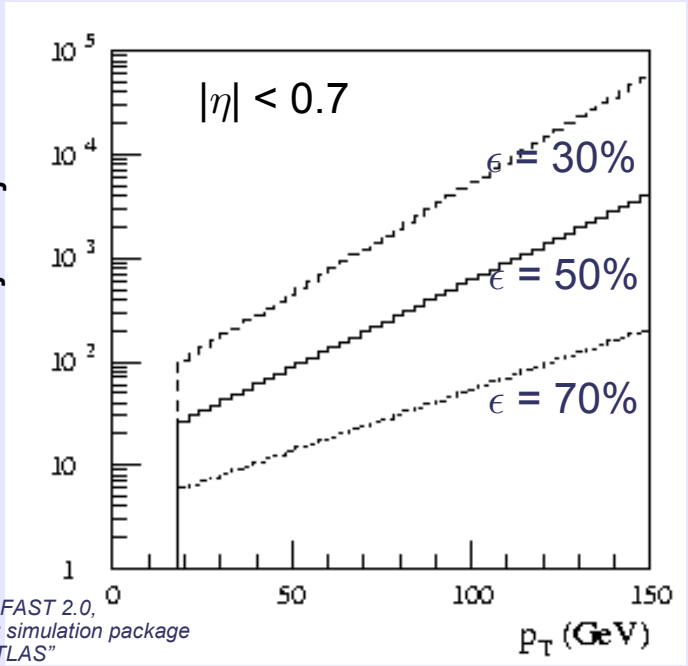
$$m_{\tau\tau}^{max} = \begin{matrix} 76\,GeV\,(SU1) \\ 98\,GeV\,(SU3) \end{matrix}$$

tau ID in Atlfast

Atlfast B package: parameterization based on FullSim results

- constant tau-tagging efficiency: chose 50 %
- fake tau jets: parameterized in pt for three ranges of pseudorapidity

($|\eta|$< 0.7, 0.7<$|\eta|$<1.5, $|\eta|$ >1.5)



[*"ATLFAST 2.0, a fast simulation package for ATLAS" by Elsbieta Richter-Was*]

Number of tau-events at 1fb-1:
(after preselection: ptmiss>80GeV)

	2 taus		2 taus OS	
	Atlfast	**Atlfast B**	**Atlfast**	**Atlfast B**
SU1	329	100	261	76
SU3	150	39	121	32
Z+Jets	578	137	578	137
ttbar	169	44	168	44
W+Jets	0	0	0	0
MultiJets	0	0	0	0
pythia dijets	0	206341	0	0

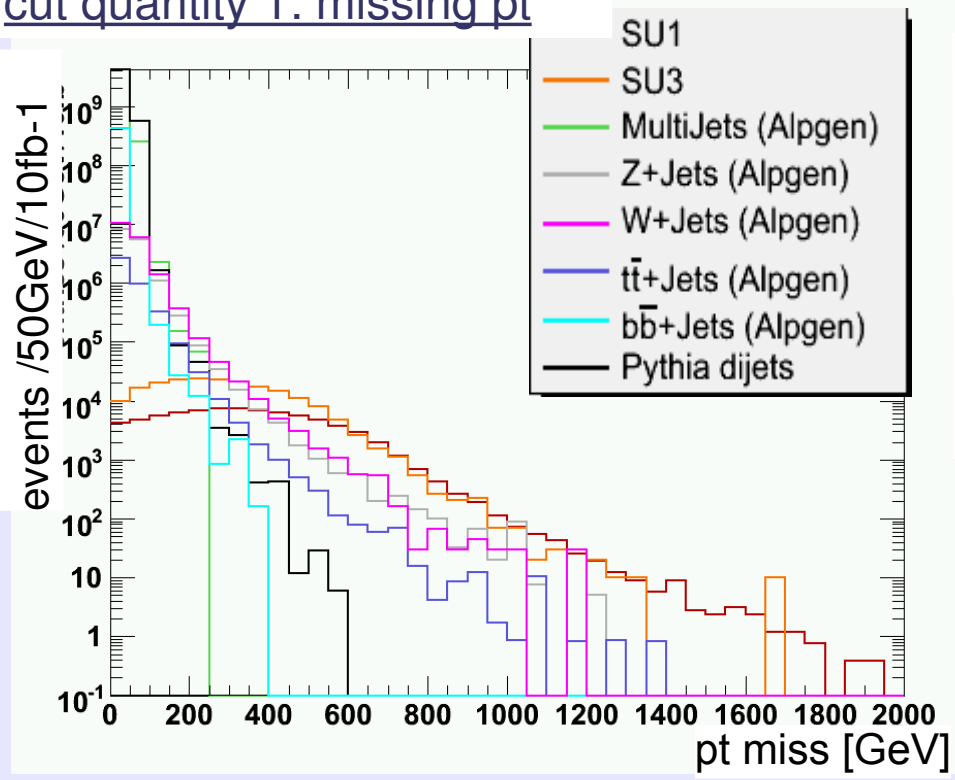
selection

Cut based selection for 2 tau final state:

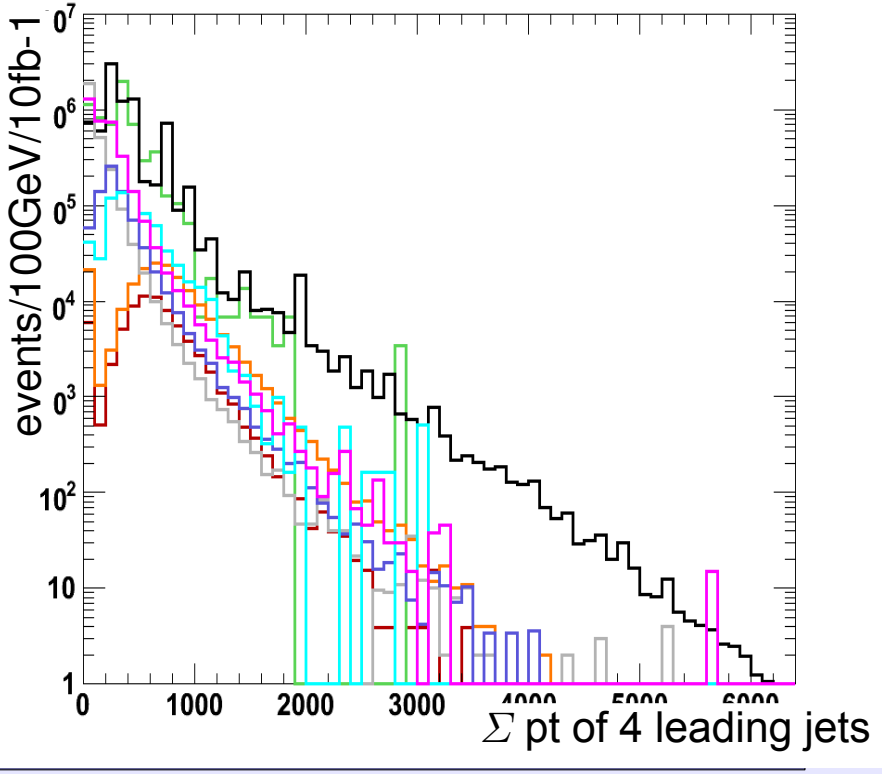
1. general kinematics
2. tau-ID

plots normalized to 10fb-1

cut quantity 1: missing pt



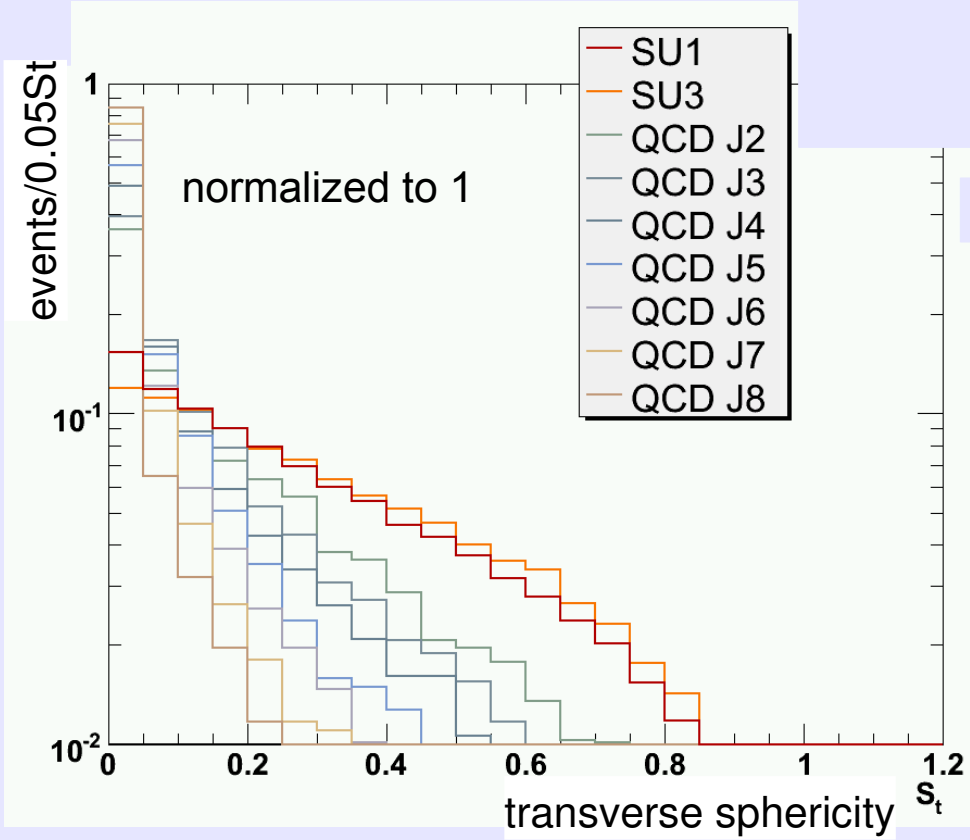
cut quantity 2: hard jets



selection

$$* purity = \frac{(signal\ events\ passing\ all\ cuts)}{(signal + BG\ events\ passing\ all\ cuts)}$$

cut quantity 3: transverse sphericity

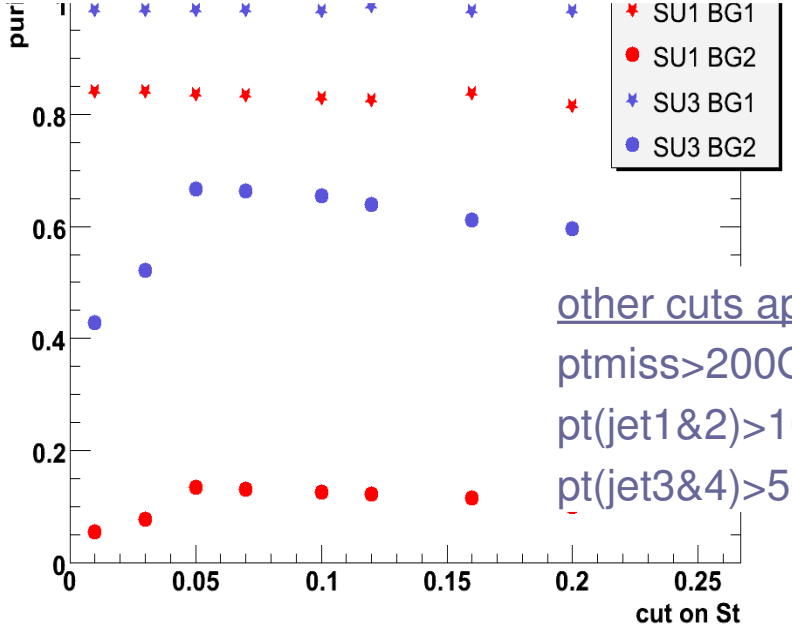


purity* for different St-cuts at 10fb-1:

BG = sum of all background

BG1 includes Alpgen multijets

BG2 includes Pythia dijets



other cuts applied:

ptmiss>200GeV

pt(jet1&2)>100GeV

pt(jet3&4)>50GeV

Cut flow table

Cut flow table for an example of cuts (“cuts 5”):

(numbers are normalized to 10fb-1)

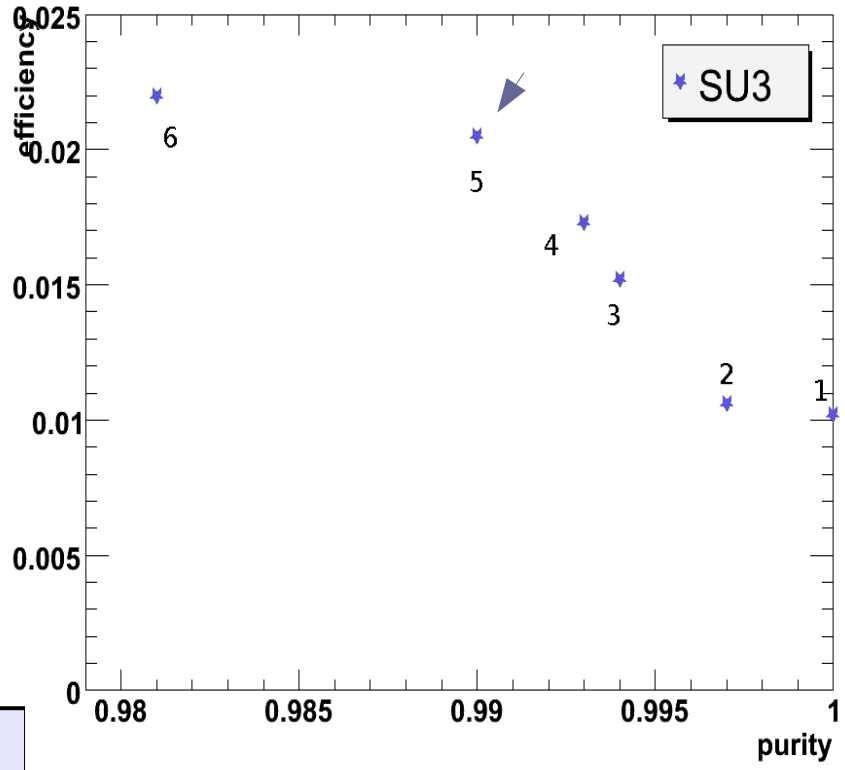
	SU1	SU3	Sum BG without QCD	pythia dijets
all events	77790	194742	$5 \cdot 10^8$	$2 \cdot 10^{13}$
preselection: ptmiss>80GeV	70789	181010	$8 \cdot 10^6$	$9 \cdot 10^6$
2 taus labelled	599	8186	7467	0
2 reconstructed taus	156	2502	1818	$2 \cdot 10^6$
ptmiss > 220 GeV	114	1431	41	1901
pt (1st&2nd jet) > 100 GeV **pt (3rd&4th jet) > 50 GeV**	62	759	6	749
St > 0.05	60	730	6	23
OS	48	565	6	0

first attempt of cut optimization

	missing pt	pt of leading jet	pt of 2nd leading jet	transverse sphericity	sum of four leading jets
1	> 290 GeV	> 100 GeV	> 50 GeV	> 0.1	-
2	> 290 GeV	> 200 GeV	> 100 GeV	> 0.05	-
3	> 200 GeV	> 100 GeV	> 50 GeV	> 0.05	> 600 GeV
4	> 240 GeV	> 100 GeV	> 100 GeV	> 0.05	-
5	> 220 GeV	> 100 GeV	> 100 GeV	> 0.05	-
6	> 200 GeV	> 100 GeV	> 100 GeV	> 0.05	-

(all: pt of 3rd and 4th leading jet > 50 GeV)

purity vs. efficiency at 10fb-1



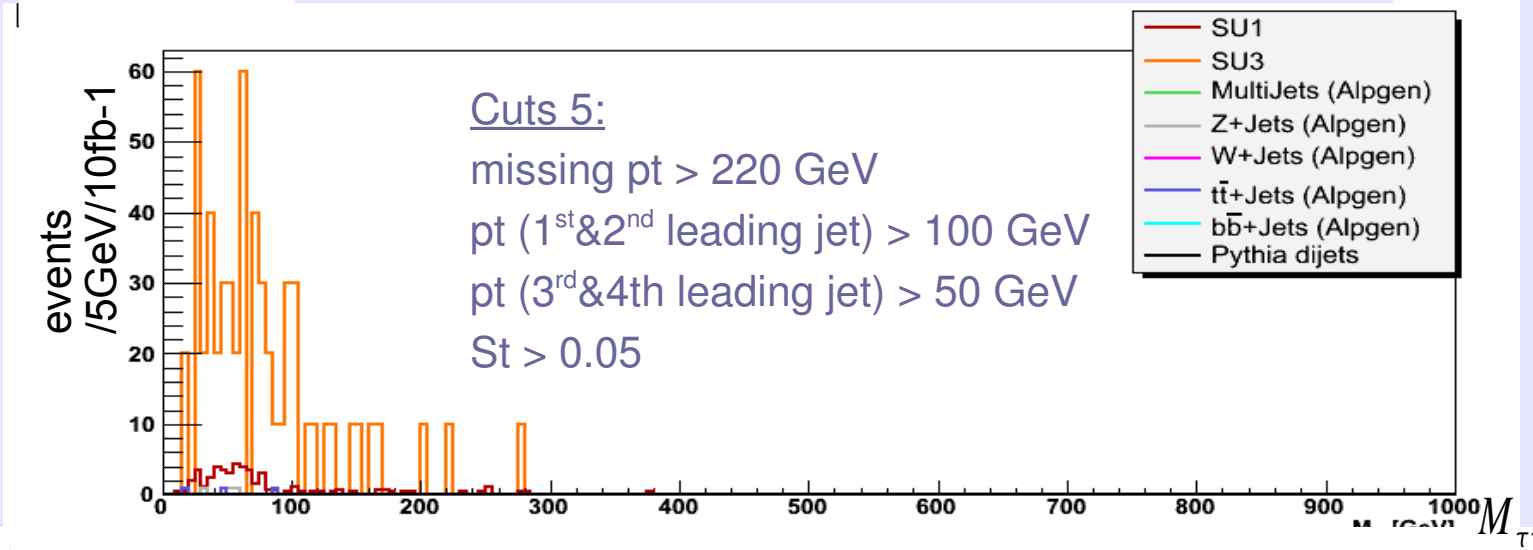
	cuts 1	cuts 2	cuts 3	cuts 4	cuts 5	cuts 6
# signal events SU1	33	33	44	45	48	51
# signal events SU3	282	292	419	477	565	604
# BG events	0	1	3	4	6	12
efficiency SU1	0.007	0.007	0.009	0.009	0.010	0.011
efficiency SU3	0.010	0.011	0.015	0.017	0.021	0.022
purity SU1	1.000	0.975	0.942	0.927	0.897	0.813
purity SU3	1.000	0.997	0.994	0.993	0.990	0.981

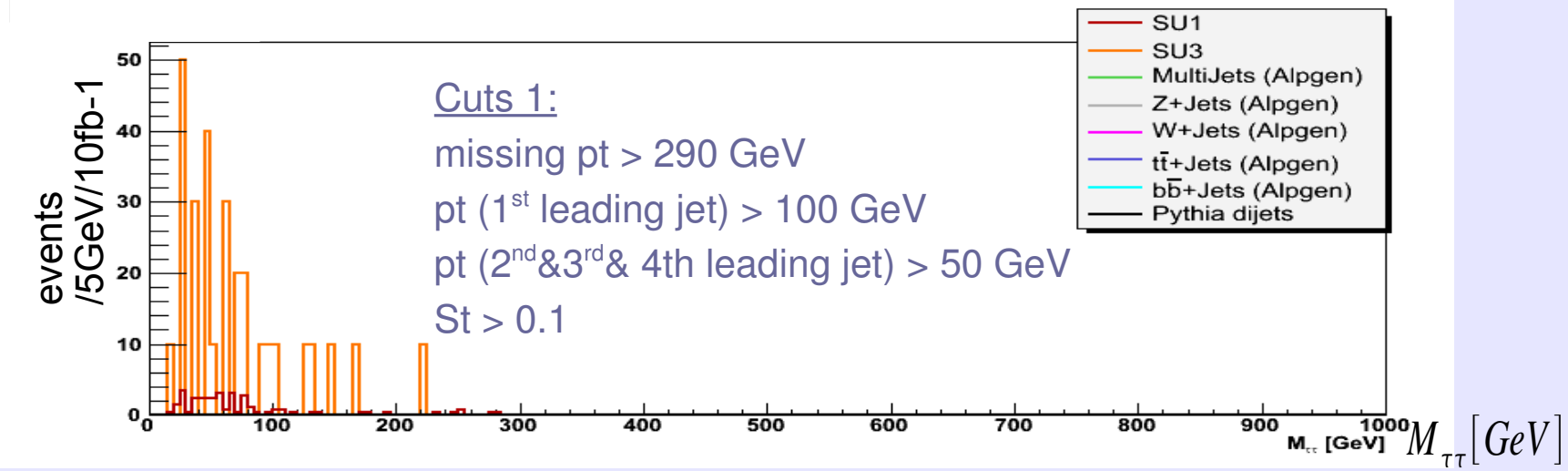
$$efficiency = \frac{(signal\ events\ passing\ all\ cuts)}{(all\ signal\ events)}$$

$$purity = \frac{(signal\ events\ passing\ all\ cuts)}{(signal + BG\ events\ passing\ all\ cuts)}$$

Invariant mass

Invariant mass of two reconstructed taus OS after cuts, at 10fb-1:





Summary and Outlook

Summary:

- tau final states are important for SUSY
- developed cut-based signal selection in Atlfast
- low background but poor efficiency

Future plans:

- give input for improved tau ID
- endpoint determination