



Tau final states in SU_1 & SU_3 with full BG (Atlfast-study)

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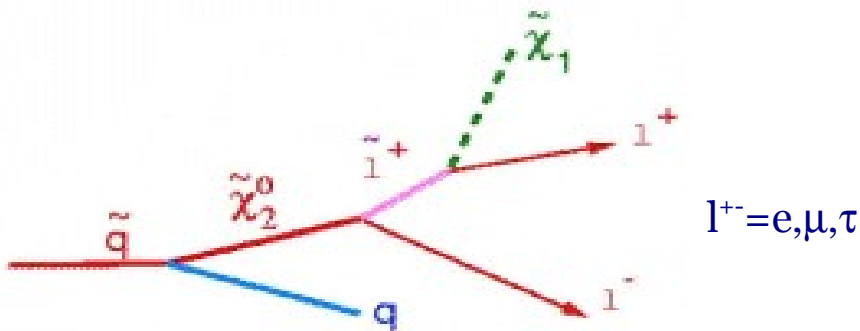
Outline:

- signal channel: $\chi_2^0 \rightarrow \tau\tau \chi_1^0$
- background + cuts
- invariant mass distributions

motivation

considered mSUGRA Points:

- **SU1** (coannihilation region)
- **SU3** (bulk region)



SU1:

$$\text{BR}(\chi_2^0 \rightarrow e^+ e^- \chi_1^0) = 6\%$$

$$\text{BR}(\chi_2^0 \rightarrow \mu^+ \mu^- \chi_1^0) = 7\%$$

$$\text{BR}(\chi_2^0 \rightarrow \tau^+ \tau^- \chi_1^0) = 25\%$$

SU3:

$$\text{BR}(\chi_2^0 \rightarrow e^+ e^- \chi_1^0) = 6\%$$

$$\text{BR}(\chi_2^0 \rightarrow \mu^+ \mu^- \chi_1^0) = 6\%$$

$$\text{BR}(\chi_2^0 \rightarrow \tau^+ \tau^- \chi_1^0) = 58\%$$

	SU1	SU3
σ	7.8pb	19.5pb
$m(\chi_2^0)$	264GeV	219GeV
$m(\tilde{\tau}_2)$	257GeV	232GeV
$m(\tilde{\tau}_1)$	146GeV	150GeV
$m(\chi_1^0)$	137GeV	118GeV
$\Delta m(\tilde{\tau}_1 - \chi_1^0)$	9GeV	32GeV

-> **factor 4 to 10 more taus** than electrons/muons from χ_2^0 -decays

• further sources of taus: $\chi_1^+ \rightarrow \chi_1^0 \tau \nu$, $\tau_{1,2}^- \rightarrow \chi_1^0 \tau$, ...

ATLFAST data samples

- signal:
 - generated with *Athena 11.0.42*, *Herwig 6.5*
 - SU1**: 400K events $\simeq 51 \text{ fb}^{-1}$
 - SU3**: 400K events $\simeq 21 \text{ fb}^{-1}$
- background:
 - subsample of official AtlFast production (*Athena 11.0.41*, *Alpgen*):
(/castor/cern.ch/grid/atlas/datafiles/susy/atlfast/2006_b/)
 - Z+NJets**: $\sim 7 \text{ fb}^{-1}$ per z_1, \dots, z_5
 - W+NJets**: $\sim 3 \text{ fb}^{-1}$ per w_2, \dots, w_5
 - tt+NJets**: $\sim 3 \text{ fb}^{-1}$ per tt_0, \dots, tt_3 for $tt \rightarrow bb + (\ln \ln, \ln qq, qqqq)$
 - bb+NJets**: $\sim 0.05 \text{ fb}^{-1}$ per bb_1, \dots, bb_3
 - MultiNJets**: $\sim 0.0005 \text{ fb}^{-1}$ per m_2, \dots, m_5
 - generated with *Athena 10.0.4*, *Pythia 6.2* (Robindra Prabhu):
 - DiJets (Jn)**: $10\text{K}/J_n$

endpoint

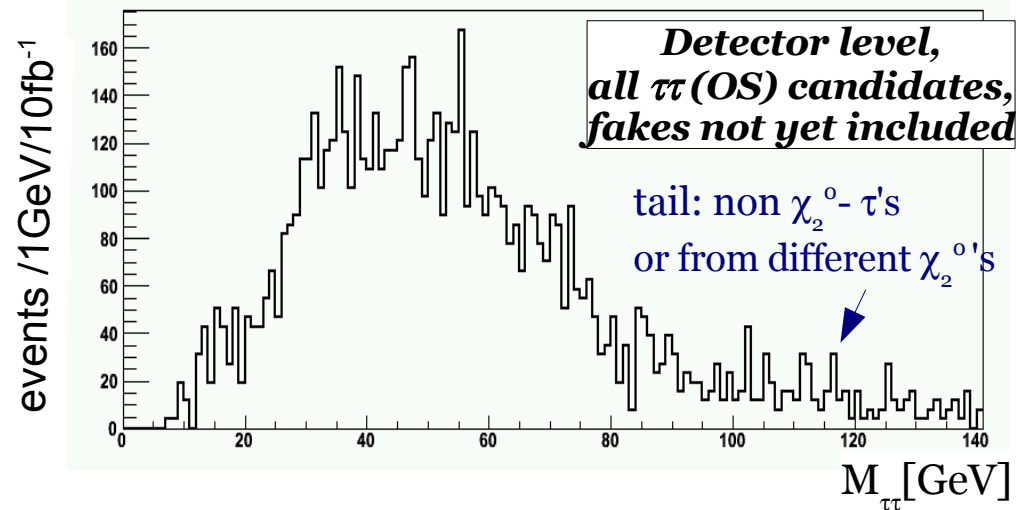
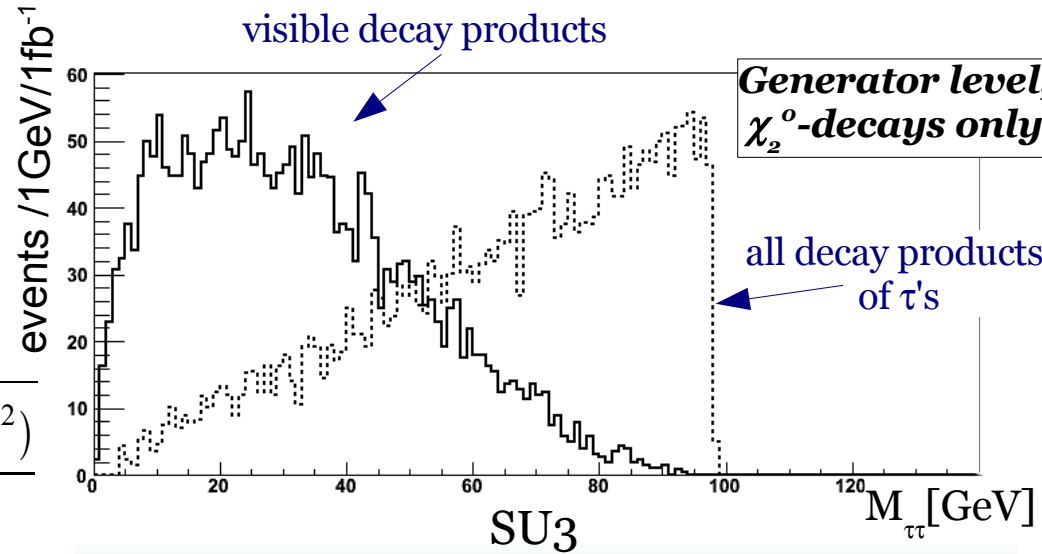
- LSP escapes detection
-> no mass peak

- kinematic endpoint at

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

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

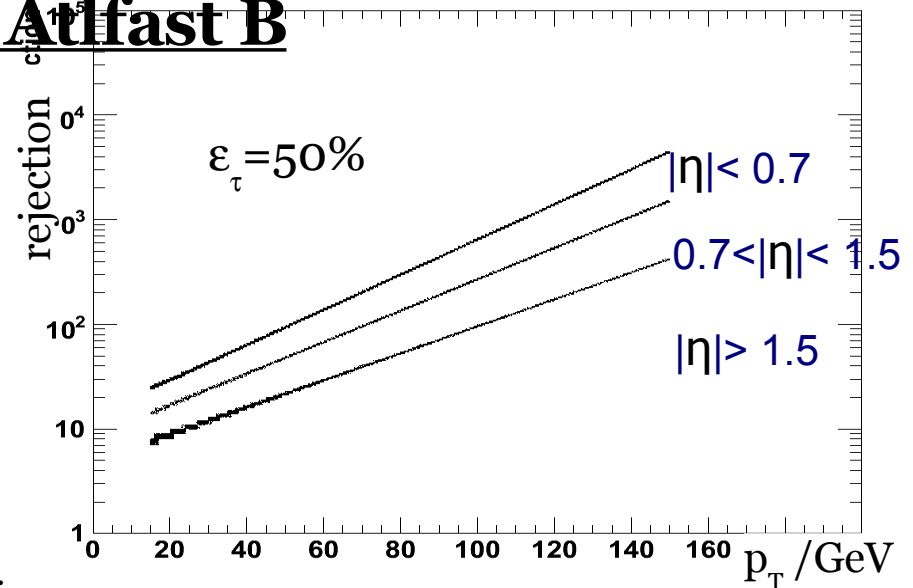
- endpoint smeared out for τ 's due to neutrinos



Tau-ID: Atfast B

τ -ID in Atfast B:

- used 11.0.42
- fake tau jets parameterized in p_T for three ranges of pseudorapidity
 - $|\eta| < 0.7$
 - $0.7 < |\eta| < 1.5$
 - $1.5 < |\eta| < 2.5$
- note: bug in 11.0.4x
 - fake taus are not written as taus but with their original PDG-ID ((*m_it)->setTauTag(pdgid))
 - > used private fix
 - > fixed in 12.0.4x



after pre-selection:
 $p_{T,\text{miss}} > 80\text{GeV}$

10 fb-1 $\epsilon_\tau = 50\%$	2 tau-events		
	0 fake (%)	1 fake (%)	2 fakes (%)
SU1	95 (11)	317 (36)	460 (53)
SU3	2438 (42)	2447 (43)	868 (15)
Z+Jets	1433 (18)	1066 (13)	5413 (68)
W+Jets	0	6559 (47)	7272 (53)
tt+Jets	356 (3)	5338 (46)	5931 (51)
bb+Jets	0	0	2644 (100)
Multijets	0	0	7559 (100)
Jn	0	0	392 (100)

Dependence on τ -efficiency

<i>tau-efficiency</i> 0,5	2 tau-events			
	total (10fb-1)	2 fakes (%)	1 fake (%)	0 fakes (%)
SU1	873	53	36	11
SU3	5753	15	43	42

<i>tau-efficiency</i> 0,3	2 tau-events			
	total (10fb-1)	2 fakes (%)	1 fake (%)	0 fakes (%)
SU1	143	6	44	50
SU3	1529	4	23	73

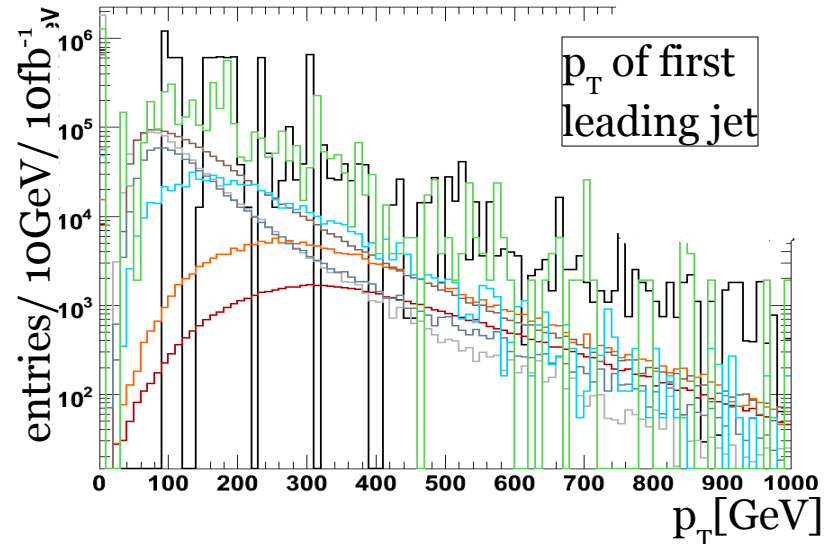
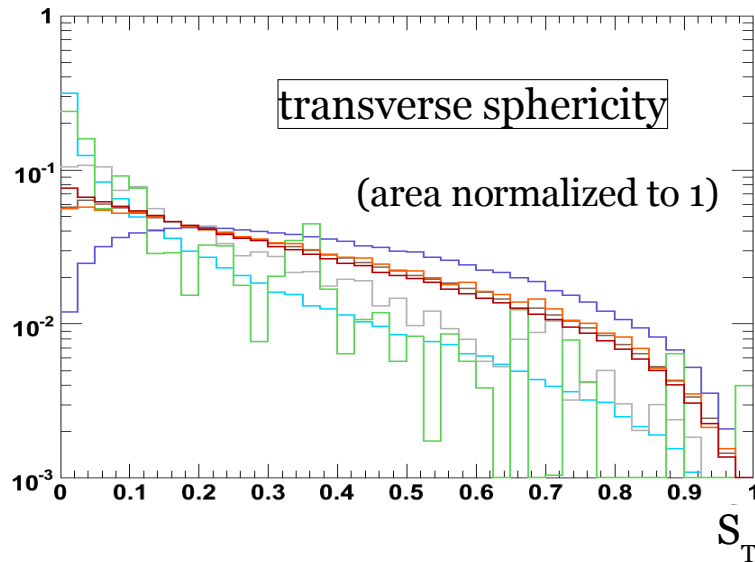
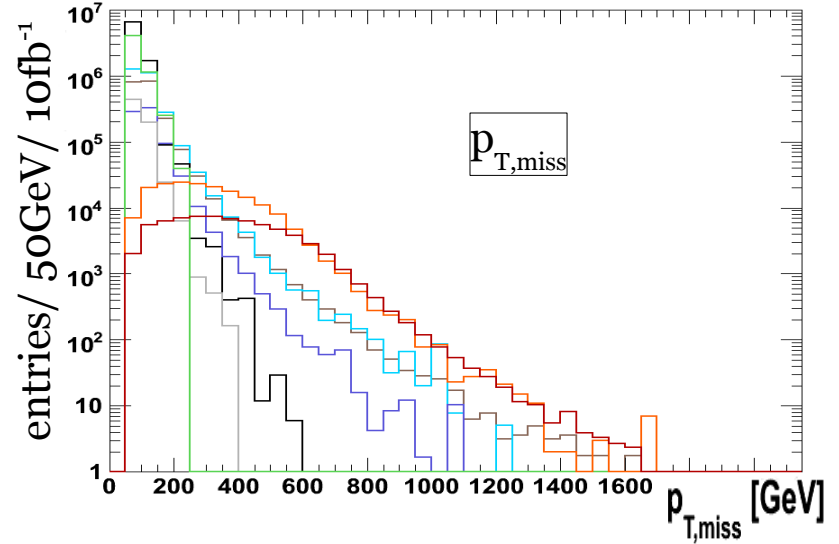
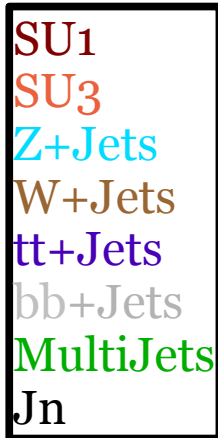
-> poor statistics

<i>tau-efficiency</i> 0,7	2 tau-events			
	total (10fb-1)	2 fakes (%)	1 fake (%)	0 fakes (%)
SU1	6833	78	20	3
SU3	24373	47	40	13

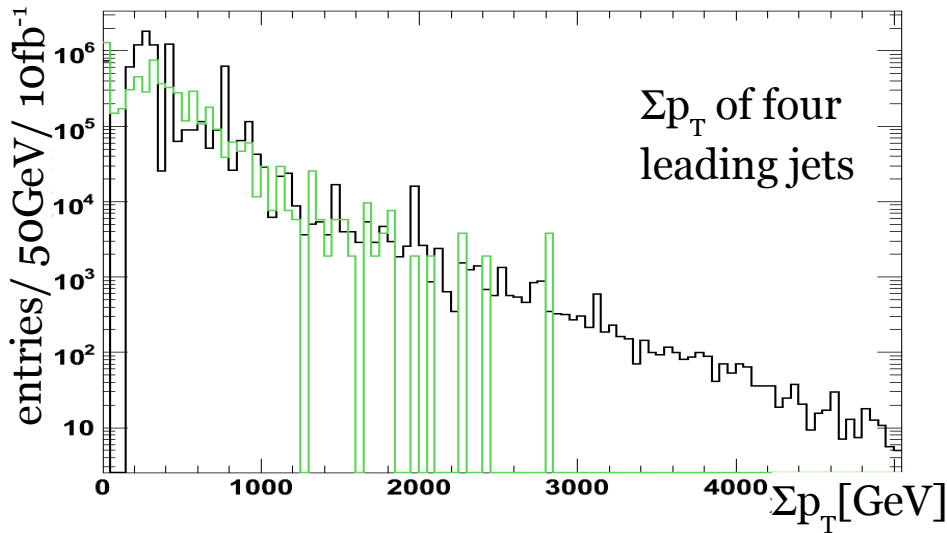
-> too many fakes

standard distributions

All plots with
preselection-cut of
 $p_{T,miss} > 80\text{GeV}$

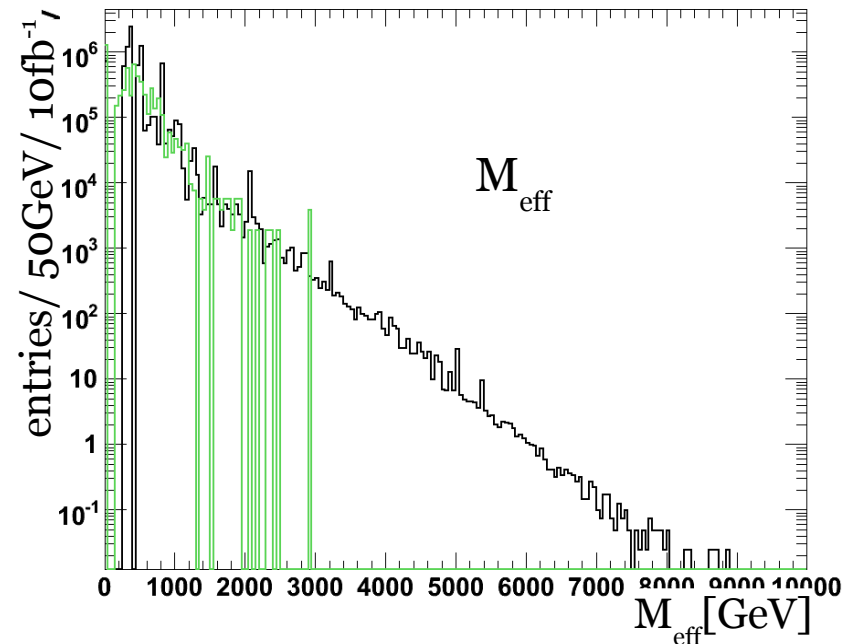
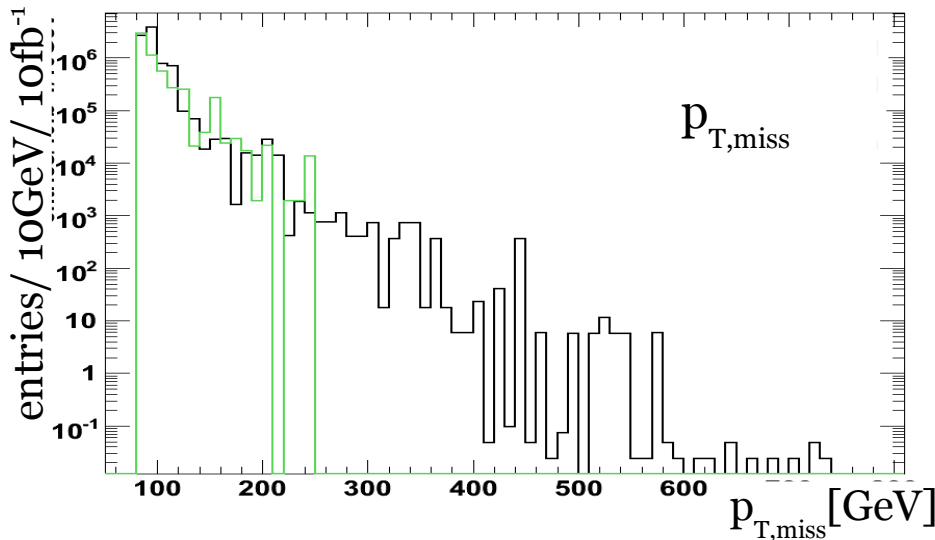


QCD: Alpgen vs. Pythia sample



Alpgen samples not produced in p_T -bins
 -> no statistics in tail

Alpgen MultiJets
 Pythia DiJets



cuts

- Cuts applied before optimization:

- preselection: $p_{T,miss} > 80 \text{ GeV}$

- at least two reconstructed taus

	SU3	Z	W	tt	BG	s
preselection	176K	3M	2M	754K	12M	51
2+ rec τ	5800	7700	14K	12K	42K	28

- fixed τ -efficiency of 0.5
- all numbers normalized to 10fb^{-1}

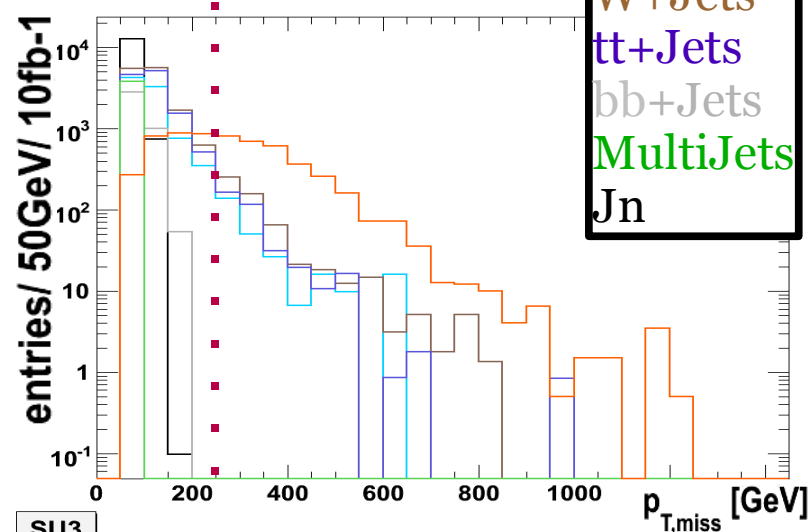
BG: sum of Z+Jets, W+Jets, tt+Jets, bb+Jets, MultiJets
(all Alpgen)

s: significance $s = \frac{\text{signal}}{\sqrt{BG}}$ (signal meaning **all** SUSY-events)

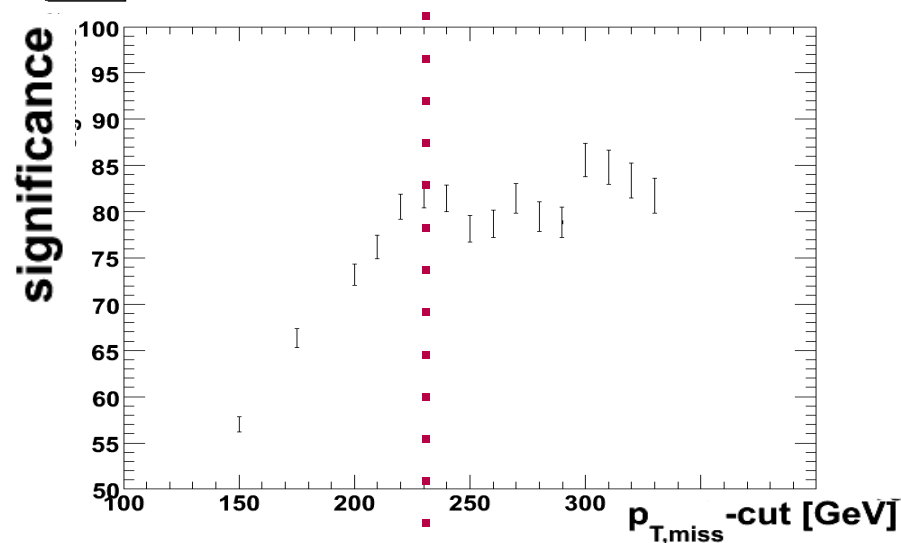
cut flow table

1.) $p_{T,miss}$:

	SU3	Z	W	tt	BG	s
preselection	176K	3M	2M	754K	12M	
2+ rec τ	5800	7700	14K	12K	42K	28
$p_{T,miss} > 230\text{GeV}$	3406	332	704	472	1509	83



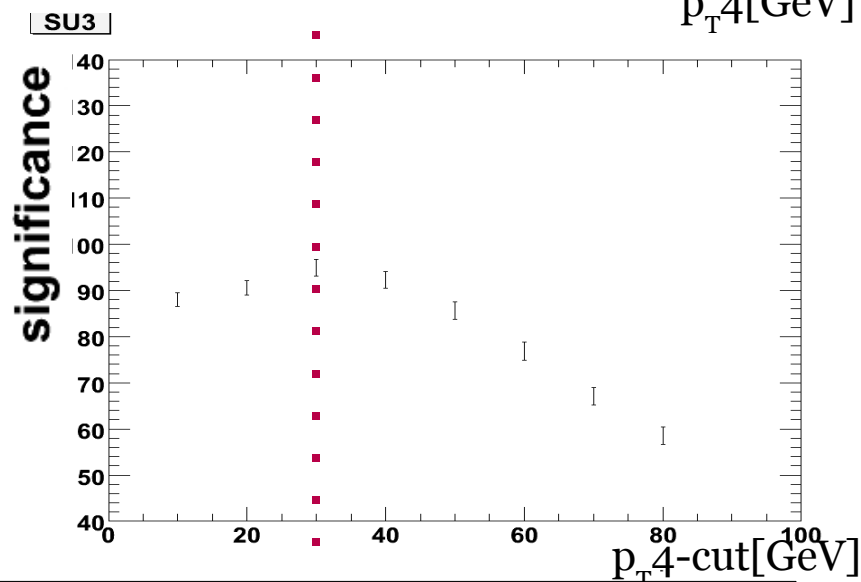
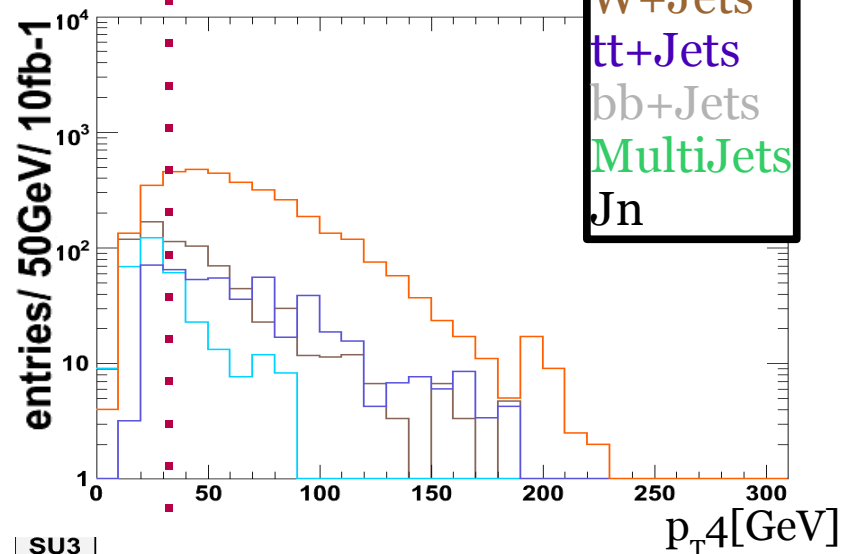
cuts optimized for **SU3** significance
and
tau efficiency **50%**



cut flow table

2.) 4th leading jet:

	SU3	Z	W	tt	BG	s
preselection	176K	3M	2M	754K	12M	
2+ rec τ	5800	7700	14K	12K	42K	28
$p_{T,miss} > 230\text{GeV}$	3406	332	704	472	1509	83
$p_{T,4^{th}} > 30\text{GeV}$	2942	129	433	398	960	95



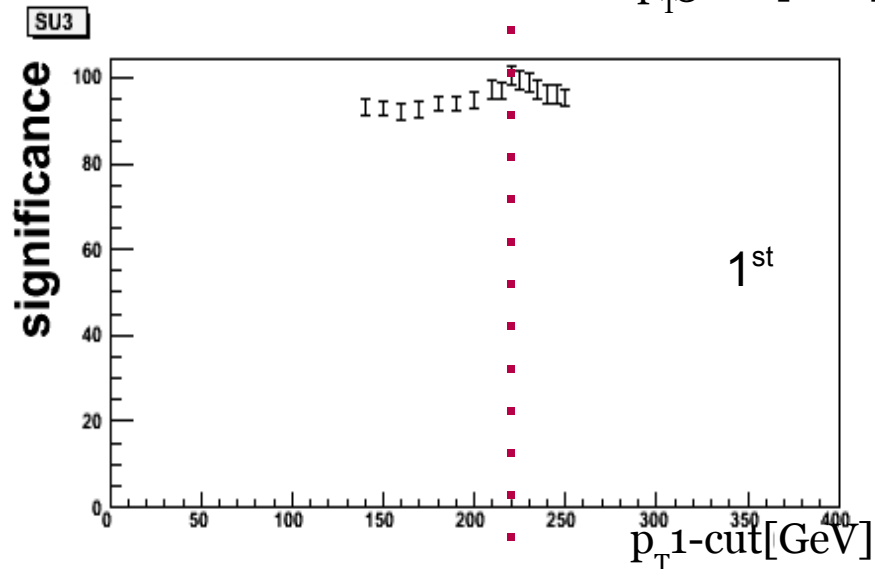
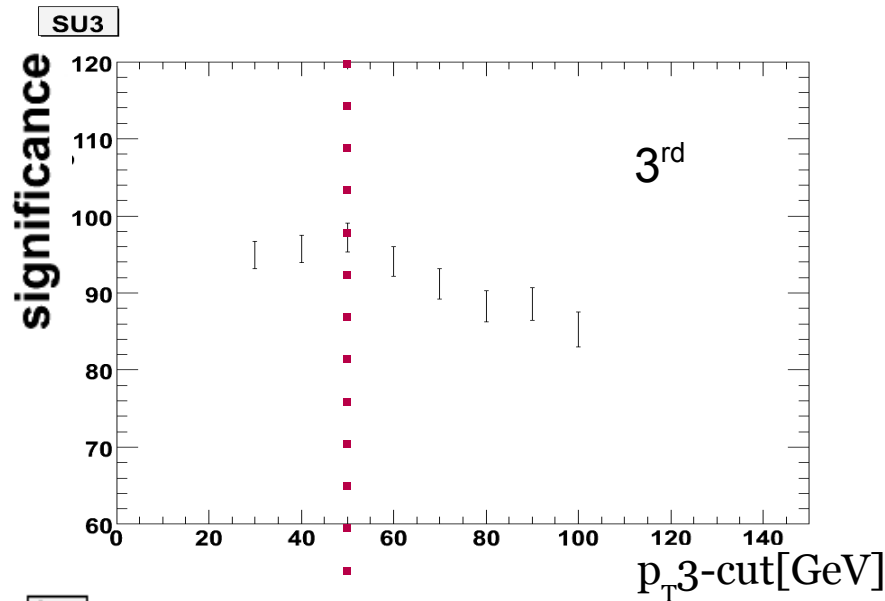
cuts optimized for **SU3** significance
and
tau efficiency **50%**

cut flow table

3.) 3rd and 1st leading jet:

	SU3	Z	W	tt	BG	s
preselection	176K	3M	2M	754K	12M	
2+ rec τ	5800	7700	14K	12K	42K	28
$p_{T,miss} > 230\text{GeV}$	3406	332	704	472	1509	83
$p_T(4^{\text{th}}) > 30\text{GeV}$	2942	129	433	398	960	95
$p_T(3^{\text{rd}}) > 50\text{GeV}$	2731	84	349	356	789	97
$p_T(1^{\text{st}}) > 220\text{GeV}$	2295	49	238	244	531	100

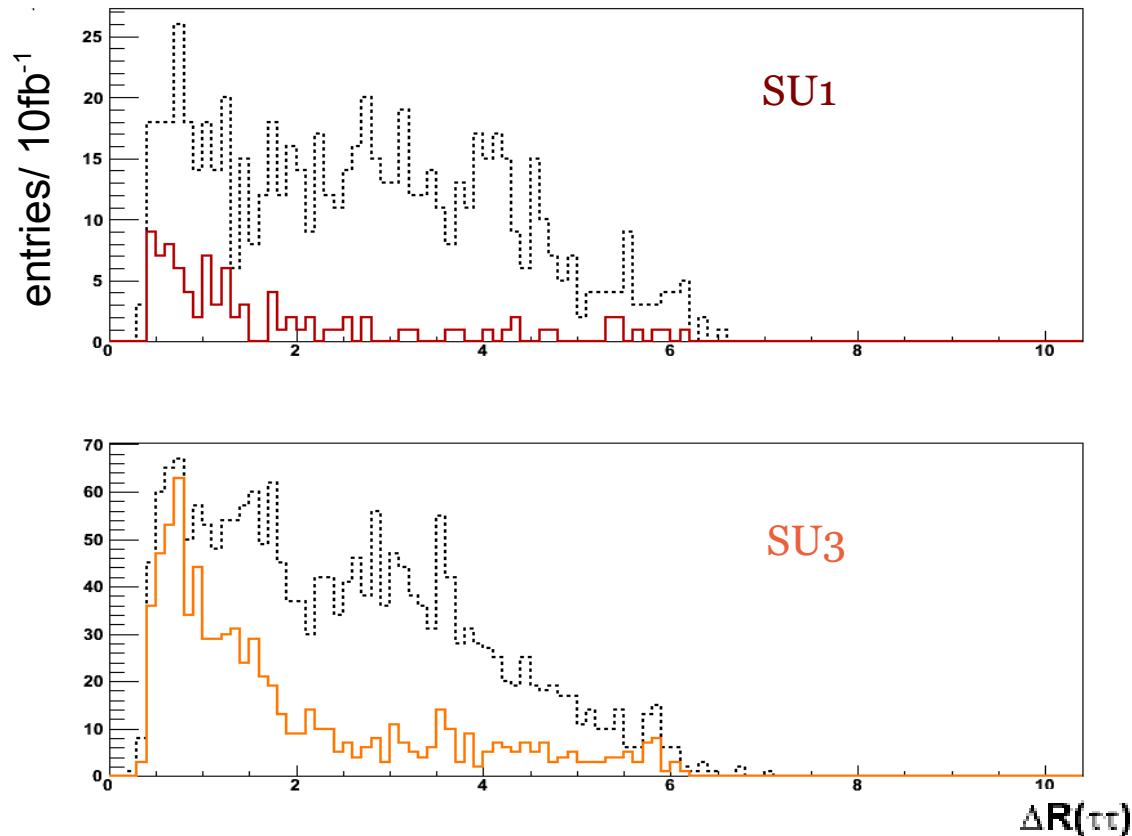
cuts optimized for **SU3** significance
and
tau efficiency **50%**



τ -correlation

- increase fraction of χ_2^0 -decays:

look at distance of the two taus in η - ϕ -plane: $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$



events with 2 τ 's OS:

- dashed line (black):

all

- solid line:

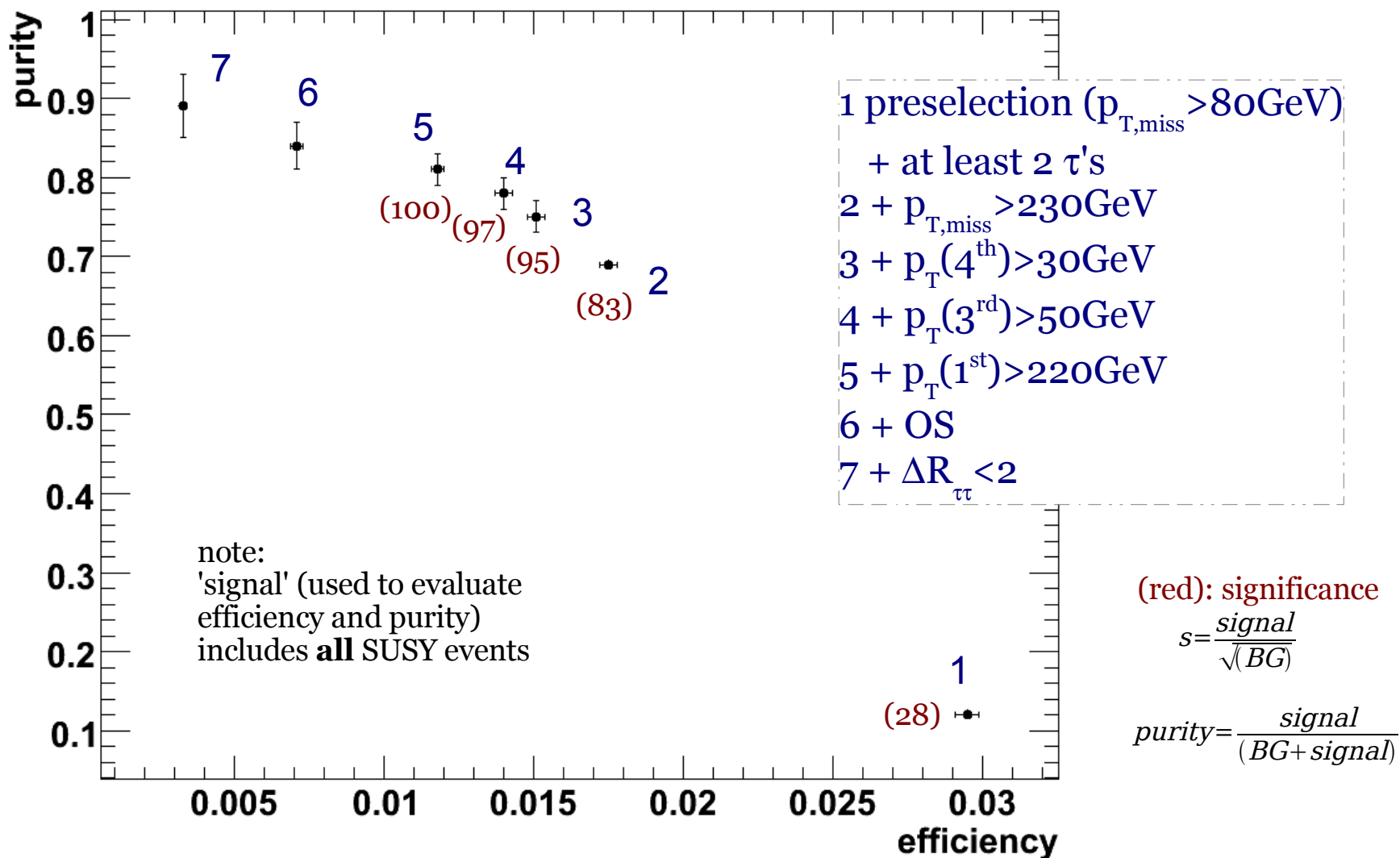
both τ 's in same direction as

τ 's from χ_2^0 -decay ($\Delta R_{\tau\tau} < 0.2$)

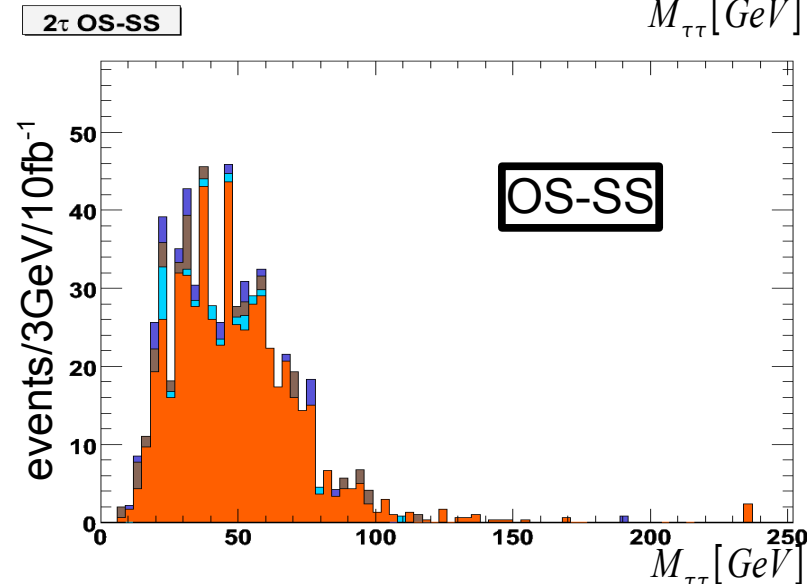
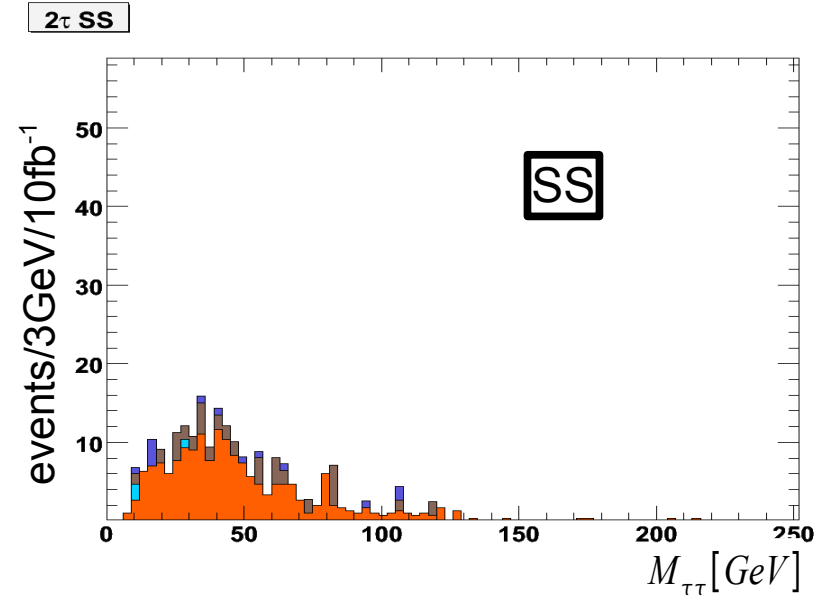
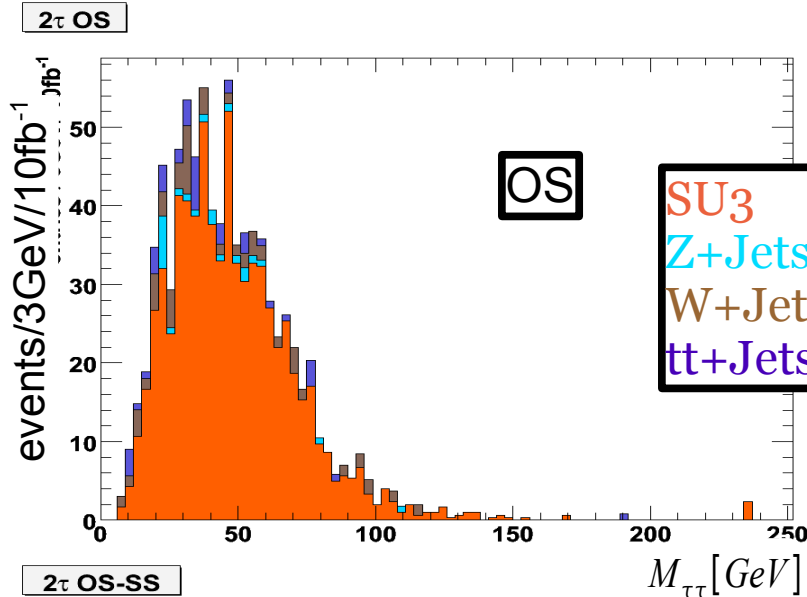
-> **additional cut:**

$$\Delta R_{\tau\tau} < 2$$

cut evolution (SU3)



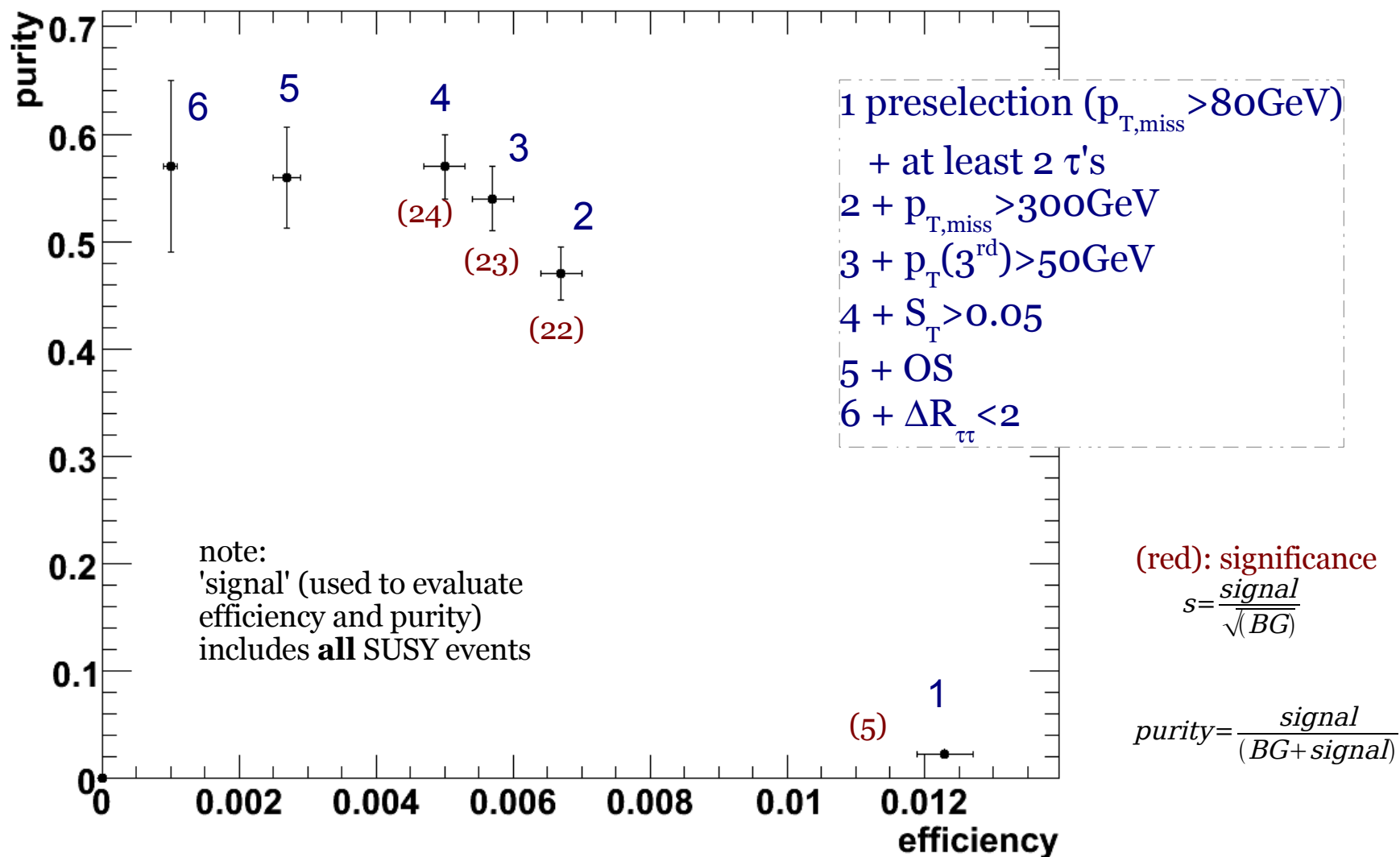
invariant mass: SU3



final cuts:

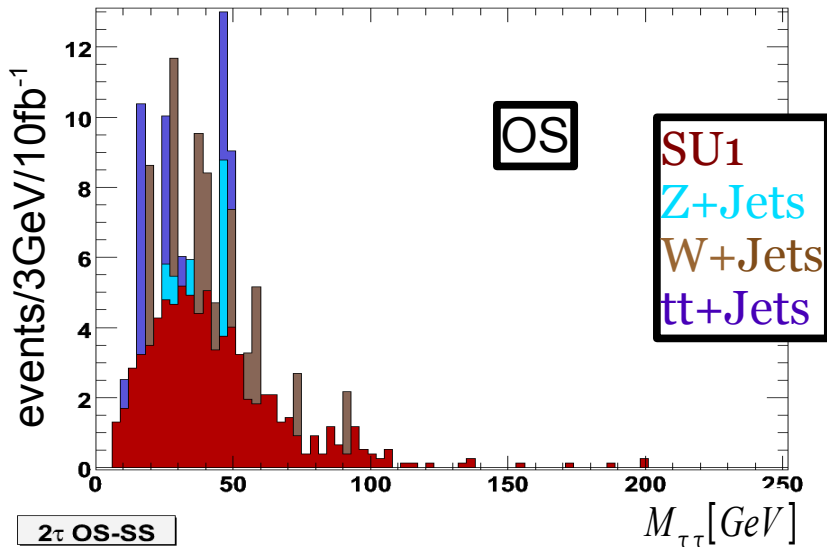
- $p_{T,miss} > 230\text{GeV}$
- 4 jets: $p_T > 30\text{GeV}$
- 3 jets: $p_T > 50\text{GeV}$
- 1 jet: $p_T > 220\text{GeV}$
- $\Delta R_{\tau\tau} < 2$

cut evolution (SU1)

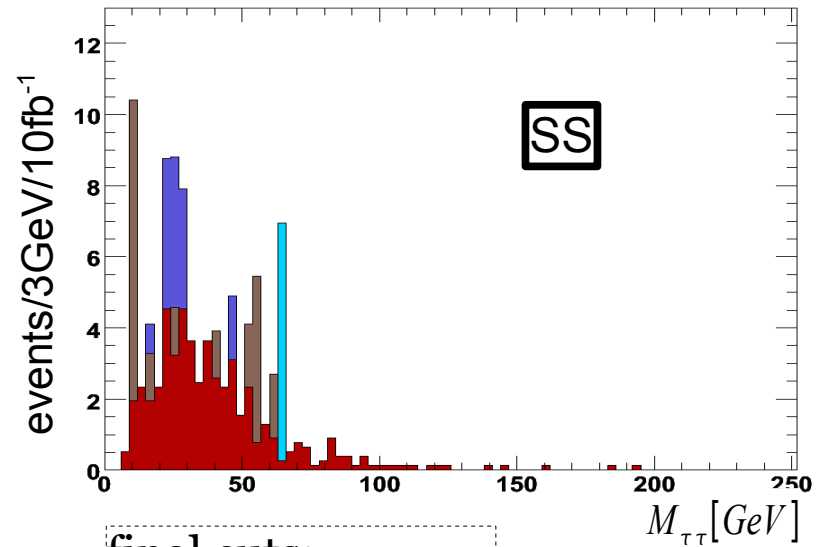


invariant mass: SU1

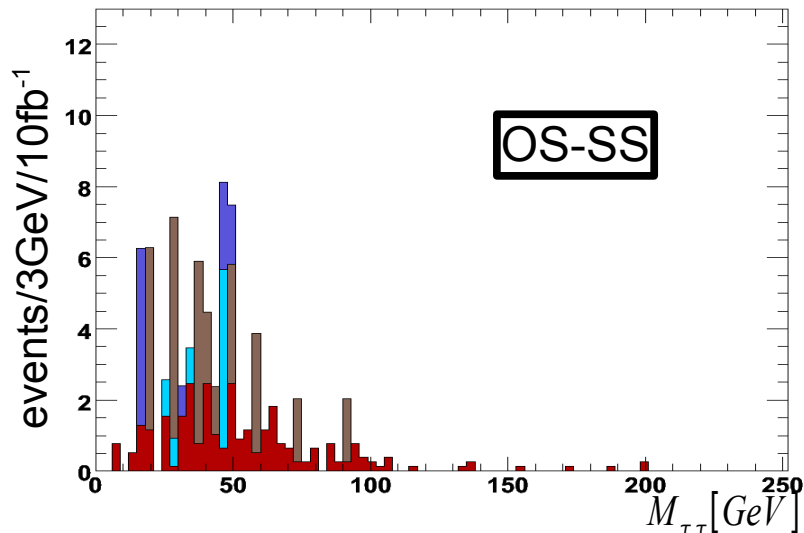
2 τ OS



2 τ SS



2 τ OS-SS



final cuts:

- $p_{T,miss} > 300\text{GeV}$
- 3 jets: $p_T > 50\text{GeV}$
- $S_T > 0.05$
- $\Delta R_{\tau\tau} < 2$

large percentage SS due to bad τ efficiency for very soft τ 's!

-> need for improved τ -ID of low p_T taus

Conclusions

Summary:

- clear signal in SU₃
- worse in SU₁, but still a significance of 10
- improved τ -ID important for SUSY

Future plans:

- prospect of endpoint determination
- include τ -decays to leptons (1 had, 1 lep)
- include other SUSY-points (scan over m_0 - $m_{1/2}$ -plane)
- repeat with 12.0.4

Related projects:

(Peter Wienemann, Robindra Prabhu)

- confirm results with fullsim
- τ -ID for low p_T taus