HLT OPTIMIZATION FOR SUSY : STATUS REPORT

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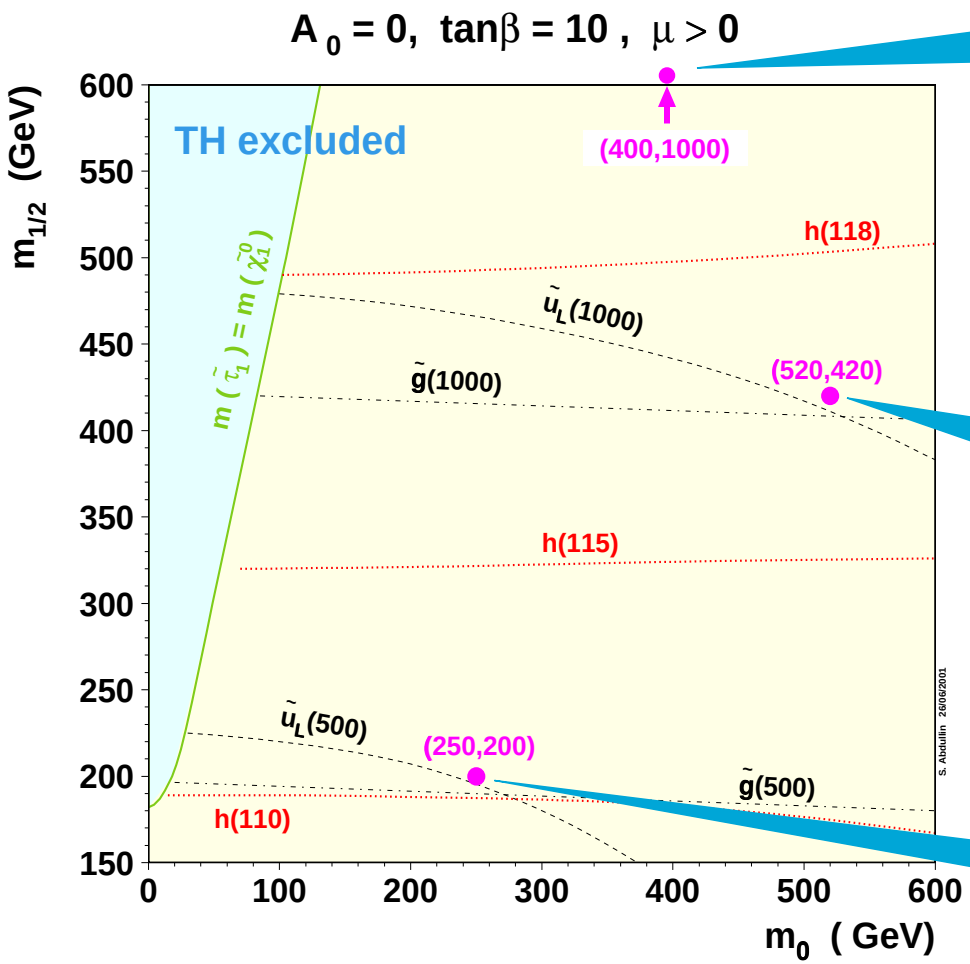
- **Talk at CMS week :**

http://cmsdoc.cern.ch/~abdullin/jetmet/meetings/cmsweek_dec01/SUSY_HLT.pdf

- **6 mSUGRA points analysed**
  - L1 trigger is taken as such from CMS IN 2001/42
  - low L1 jets and MET cuts for 12.5 kHz (optimistic scenario) : j - 120, jj - 90, jjj - 70, jjjj - 50 GeV, auxiliary MET - 100 GeV
  - too optimistic L1 cuts efficiency ...
  - MET cut looks to be important at L2
  - Variety of cuts aren't optimized, just examples are given ...

FIRST 3 POINTS ...



$m(\tilde{\chi}_1^0) = 423$ GeV $m(h) = 121.9$ GeV

$m(\tilde{g}) = 2154$ GeV $m(\tilde{u}_L) = 1993$ GeV

$\sigma \sim 18$ fb, requires $\int Ldt \sim 20\text{-}25\ fb^{-1}$

typical cuts : $\not{E}_T > 800$ GeV, $N_j \geq 2$

3 $E_T^j > 300, 150$ GeV

$m(\tilde{\chi}_1^0) = 177.5$ GeV $m(h) = 116.8$ GeV

$m(\tilde{t}_1) = 726$ GeV

$\sigma = 2.24$ pb, requires $\int Ldt < 100\ pb^{-1}$

typical cuts : $\not{E}_T > 300$ GeV, $N_j \geq 3$

2 $E_T^j > 200, 100, 50$ GeV

$m(\tilde{\chi}_1^0) = 79.0$ GeV $m(h) = 110.7$ GeV

$m(\tilde{t}_1) = 352$ GeV

$\sigma = 115$ pb, requires $\int Ldt < 10\ pb^{-1}$

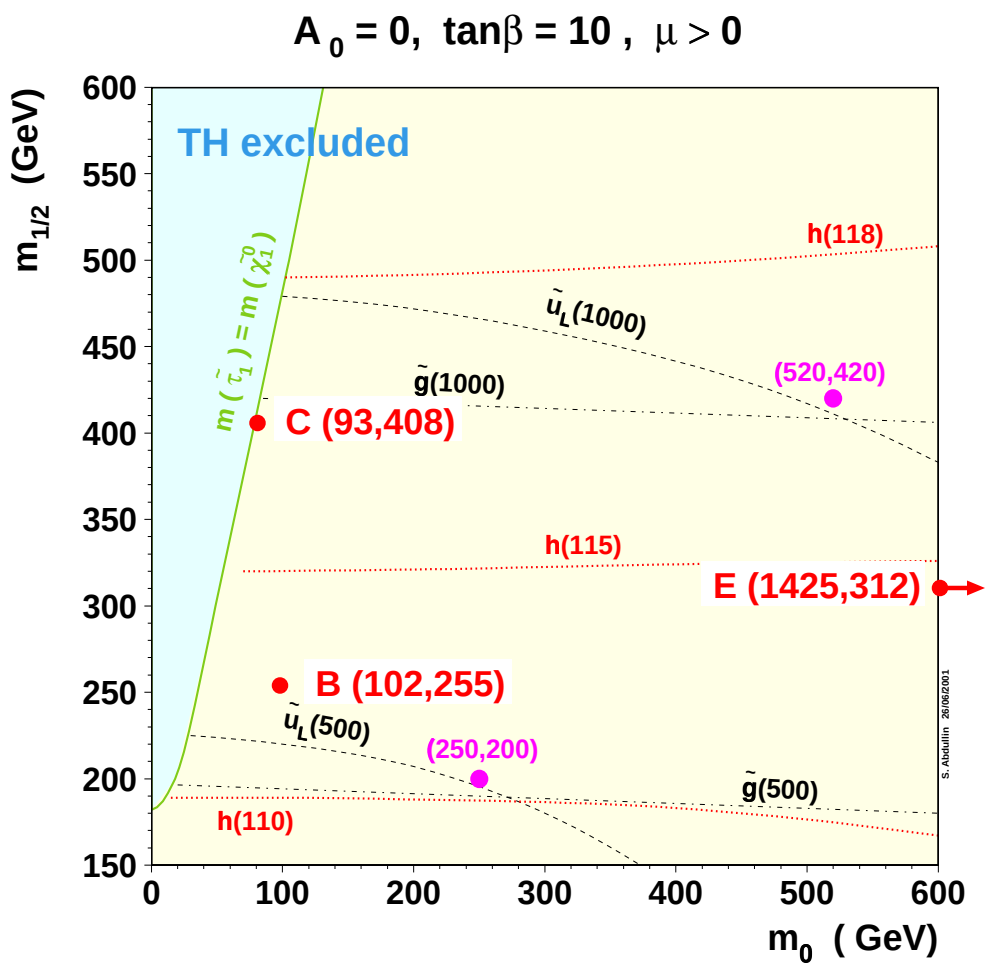
typical cuts : $\not{E}_T > 200$ GeV, $N_j \geq 2$

1 $E_T^j > 100, 50, 50$ GeV

- **Typical off-line signal efficiency : 20 - 70 % (@ 0.5 - 2 TeV)**

3 MORE POINTS ...

taken from paper hep-ph/0106204 by J.Ellis et al.



☞ **All 3 points are within cosmologically interesting region ...**

☞ **Point B :**

m_h = 113 GeV
$m_{\tilde{g}}$ = 606 GeV
$m_{\tilde{q}}$ = 500-550 GeV (400 for $\tilde{t}_1$)
close to g_μ - 2 limit
tau-enriched, quite enough sleptons

☞ **Point C :**

m_h = 117 GeV
$m_{\tilde{g}}$ = 932 GeV
$m_{\tilde{q}}$ = 800-830 GeV (635 for $\tilde{t}_1$)
in the coannihilation "tail"
lower jet multiplicity, higher MET

☞ **Point E (big $\tilde{\chi}\tilde{\chi}$ fraction ~ 40 %) :**

m_h = 116 GeV
$m_{\tilde{g}}$ = 804 GeV, 3-body decays (softer)
$m_{\tilde{q}}$ = ~1500 GeV (987 for $\tilde{t}_1$) → gluino "focused point"
high jet multiplicity (incl. b's), lower MET

AND 6 MORE POINTS IN PRODUCTION ...

Where the Tevatron reach ends ...

- **Point 4 : m_0 = 20 GeV, $m_{1/2}$ = 190 GeV**

m_h = 110 GeV
$m_{\tilde{g}}$ = 466 GeV
$m_{\tilde{q}}$ = 380-470 GeV (296 for $\tilde{t}_1$)
tau-enriched, quite enough sleptons

- **Point 5 : m_0 = 150 GeV, $m_{1/2}$ = 180 GeV**

m_h = 110 GeV
$m_{\tilde{g}}$ = 447 GeV
$m_{\tilde{q}}$ = 380-465 GeV (296 for $\tilde{t}_1$)
nothing special ...

- **Point 6 : m_0 = 150 GeV, $m_{1/2}$ = 180 GeV**

m_h = 106.4 GeV
$m_{\tilde{g}}$ = 349 GeV
$m_{\tilde{q}}$ = 358-425 GeV (281 for $\tilde{t}_1$)
more jets, less MET

ready (yesterday night)
ready (yesterday night)
ready (yesterday night)

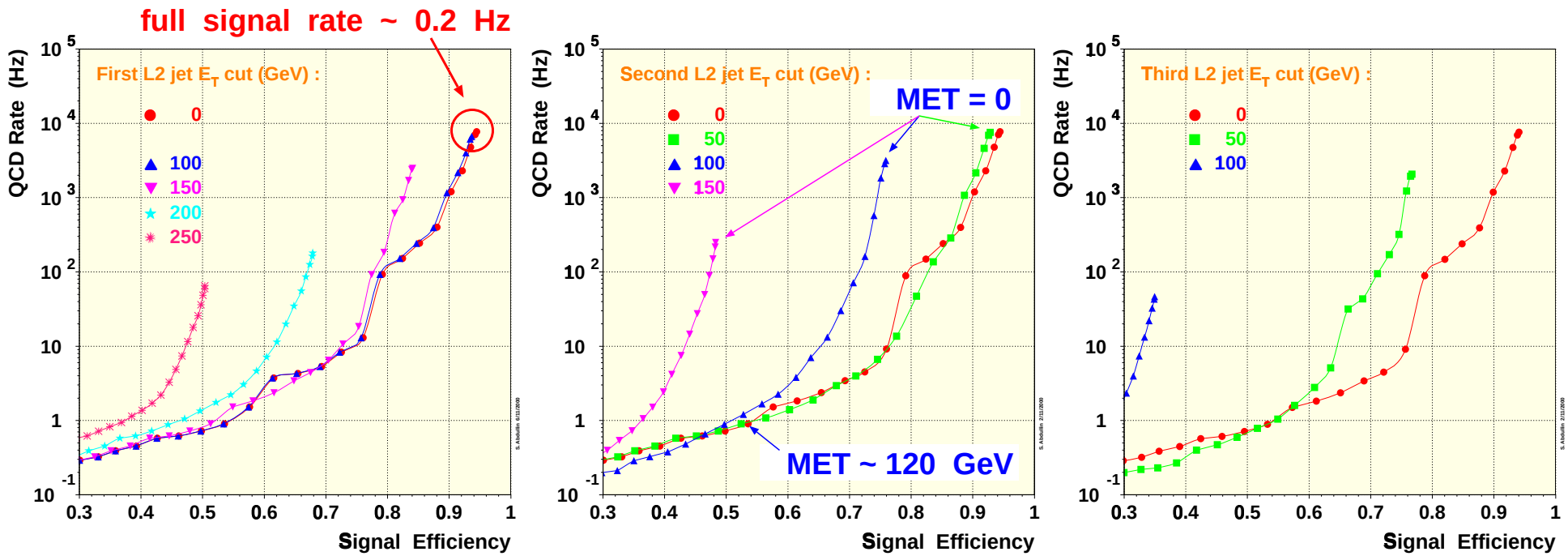
- **The same 3 points were taken and underwent a kind of "surgery" with the help of**

ISAJET 7.51 /
ISAWIG 1.104 /
HERWIG 6.301

chain to acquire R-parity violation (LSB -> 3 jets) :

Points 4R, 5R, 6R

ATTEMPT OF CUTS EVALUATION @ L2



Point 1

- We can preserve > 50 % of the signal, while keeping QCD rate at ~1 Hz by one of the next requirements :
  - 2 jets with E_T > 100 GeV + MET > 120 GeV
  - 3 jets with E_T > 50 GeV + MET > 110 GeV
- MET cut seems to be essential in reducing QCD rate ...

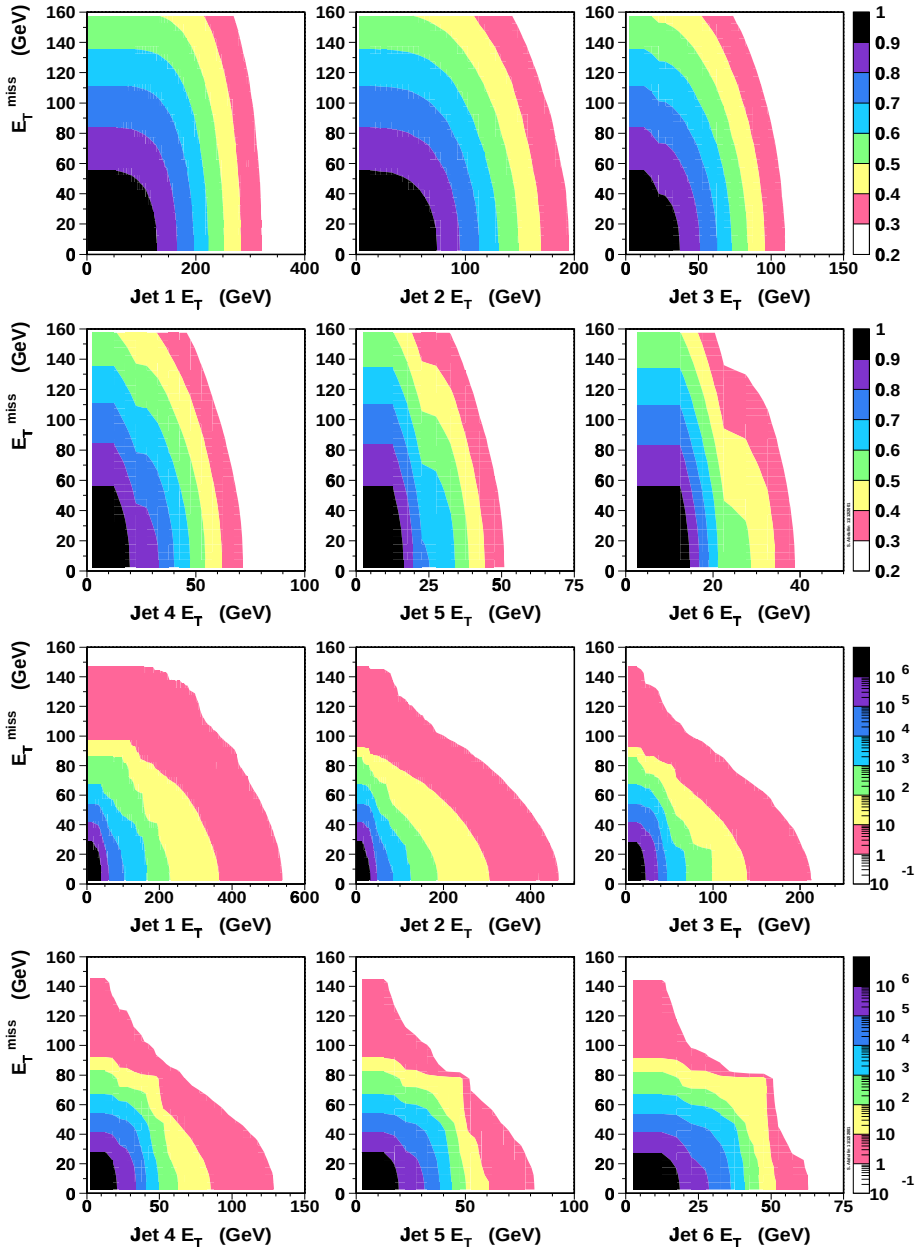
HOW HIGH RATE COULD WE HAVE ?

- **Something like ~ 4 kHz for Jets/MET @ L1 (?)**
  - 2 + 2 for tau physics and other jets/MET channels
- **Something like ~ 6 Hz for Jets/MET @ L2 (?)**
  - 3 + 3 for tau physics and other jets/MET channels
- **Assuming 3 Hz at our disposal :**
  - MET + 1-2 jets — m(gluino) >> m(squark)
  - MET + 3-4 jets — m(gluino) ~ m(squark)
  - 4 or more jets and small MET — m(gluino) < m(squark) or $\not{R}$-parity
- **Discussion with Shuichi at CMS week (2 weeks ago) :**
  - 1 Hz per each case ?
  - from L2 "backwards"
    L2 cuts first, then L1 cuts 100 % efficient ...

WHAT TO OPTIMIZE ...

Signal efficiency

QCD rate (Hz)



- MET
- Jet 1 + MET
- Jet 2 + MET
- Jet 3 + MET
- Jet 4 + MET

☞ logical .AND. horizontally

☞ logical .OR. vertically

... AND HOW TO OPTIMIZE ?

- **Direct reading of HLT Ntiples in PAW / FORTRAN is so CPU-waisting (a few hundred seconds ...) that compressing re-writing is inevitable**

- **A simple scan over 9-dim. parameter space (min.min. 10**7 points) looks unfeasible as in each point full QCD rate evaluation is required**

- **MINUIT is CPU-consuming and unstable (local minima, divergency) :**
  - failed to get any reasonable solution (running out of CPU time)

- **PPP (Probable, Promising, Plosible) genetic selection algorithm**

  - the idea to use it and some brief "in-words" description was given by Nikita Stepanov during coffee conversation last Friday ...

THE SIMPLEST GENETIC ALGORITHM (I)

- **"Society of individuals" (fixed-size pipulation ~ 100) with some established hierarhy, e.g. descending ordering of certain function of parameters ("genes") with a few "behaviour" functions defined**
  - breeding
  - mutation
  - "death / birth"
  - selection

  } ***might be a variety of definitions***

- **A generation-by-generation process ...**

- **Breeding (with crossing-over)**
  - probability to participate slightly depends on the hierarhy
  - the simplest exchange of 1 gene (parameter) between each partner, so that 2 "children" are born ...

THE SIMPLEST GENETIC ALGORITHM (II)

- **Mutation**
  - probability to participate independent of the hierarhy
  - the simplest "up / down" change of a randomly chosen gene
  - result of mutation is treated as a new "child"
    (though a direct replacement looks more logical ...)
- **Death / Birth**
  - individuals with the age > max. die ...
  - replaced by new "children" randomly created
- **Selection**
  - ordering according to the hierarhy
  - the best individuals are selected to enter "Top 10" list
    if they are "better" than those already existing in "Top 10" ...
- **End of the Evolution ...**
  - if "Top 10" list isn't updated for a long "time" (10-20 generations)

THE SIMPLEST GENETIC ALGORITHM (III)

- **Simplest**
  - could be much more sophisticated !
  - closer to the natural genetic selection (don't mix with genetic modification ...)

- **Hierarhy is based on the simplest constructed function**

$$H(\vec{P}) = S_{eff}(\vec{P}) - \frac{\text{Weight}}{R_{max} - R(\vec{P})}$$

$\vec{P}$ - vector of cuts ("genes")

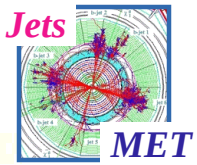
$S_{eff}(\vec{P})$ - signal efficiency

$R(\vec{P})$ - QCD rate (Hz)

R_{max} - maximal "affordable" rate (~ 1.5 Hz)

Weight - tunable parameter (~ 0.01 - 0.02)

FIRST RESULTS



Jets and MET E_T cuts (GeV) for optimal signal effficiency @ L2

	Signal efficiency (%)	QCD rate (Hz)	MET	J1 + MET	J2 + MET	J3 + MET	J4 + MET	
Point 1	64.1 55.8	1.04 0.94	210 145	130 210	140 140	40 160	40 110	yesterday
Point E	42.6	1.02	210	380 290	120 250	40 160	70 80	yesterday
Point 4	60.7	1.05	150	130 250	140 160	60 130	40 140	this morning
Point 5	55.9 51.5	1.05 1.07	200	220 290	60 200	40 140 40 130	50 100 50 100	this morning
Point 6	33.3	1.06	210	190 260	110 190	50 130	50 100	this morning

PROVISIONAL CONCLUSION

- **Genetics algorithm works**
  - fast (a few CPU minutes for a few tens of generations)
- **Idea of "back-propagation" (L2 -> L1) might really work ...**
  - L1 cuts (for 4kHz) from CMS IN 2001/042 :
    j - 150, jj - 110, jjj - 75, jjjj - 70, j+MET - 75+75 GeV
  - to be investigated ...
- **The difference between the points at low mass scale (max. reach of Tevatron) is not very pronounced**
  - optimize all 3 points simultaneously taking the entire granted bandwidth of 3 Hz ?
- **Can't rely on multijets (even if 5-6 jets look favourable for SUSY)**
  - 5-6 jets rate is rather unknown ...
  - jet-counting L1 trigger to use ?