L1 and HLT Jet/MET Triggers

(Selected Topics)

S. Abdullin

SUSY Trigger : Preamble

Salavat Abdullin

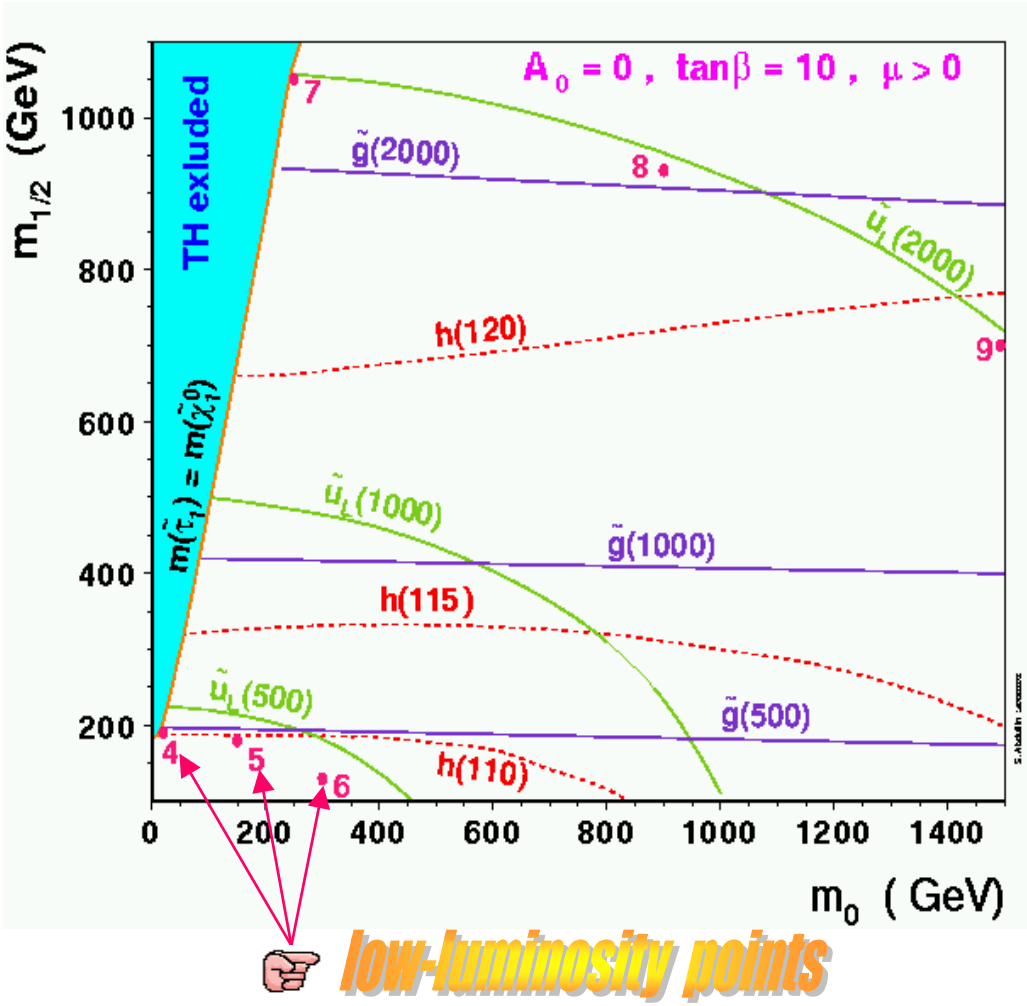
- **Low luminosity study** : CMS IN-2002/036

  http://cmsdoc.cern.ch/~abdullin/events/talks/acat2002.pdf

  - Probing points studied at the Tevatron II reach limit (along squark isomass curve of $\approx$ 400 GeV)
    - Given 2 kHz @ L1 and 3Hz @ L2
    - Hybrid genetic algorithm written for cuts optimization
    - 6 essential combinations of L1 and L2 channels (out of 18)
    - R-parity violation scenario yields marginal efficiency @ L2

- **High luminosity**
  - Probing points chosen at mass scale of $\approx$ 2 TeV

SUSY Trigger : Probing Points



low-luminosity points

$m(\tilde{\chi}_1^0) = 445$ GeV $m(h) = 122$ GeV

$m(\tilde{g}) = 2235$ GeV $m(\tilde{u}_L) = 1986$ GeV

$\sigma \sim 17$ fb tau and sneutrino – enriched

7 250,1050

$m(\tilde{\chi}_1^0) = 391$ GeV $m(h) = 121$ GeV

$m(\tilde{g}) = 2032$ GeV $m(\tilde{u}_L) = 1962$ GeV

$\sigma \sim 22$ fb "spoiling" dcays of chargino–neutralino

8 900,930

$m(\tilde{\chi}_1^0) = 293$ GeV $m(h) = 120$ GeV

$m(\tilde{g}) = 1625$ GeV $m(\tilde{u}_L) = 1975$ GeV

$\sigma \sim 59$ fb more jets, less MET

9 1500,700

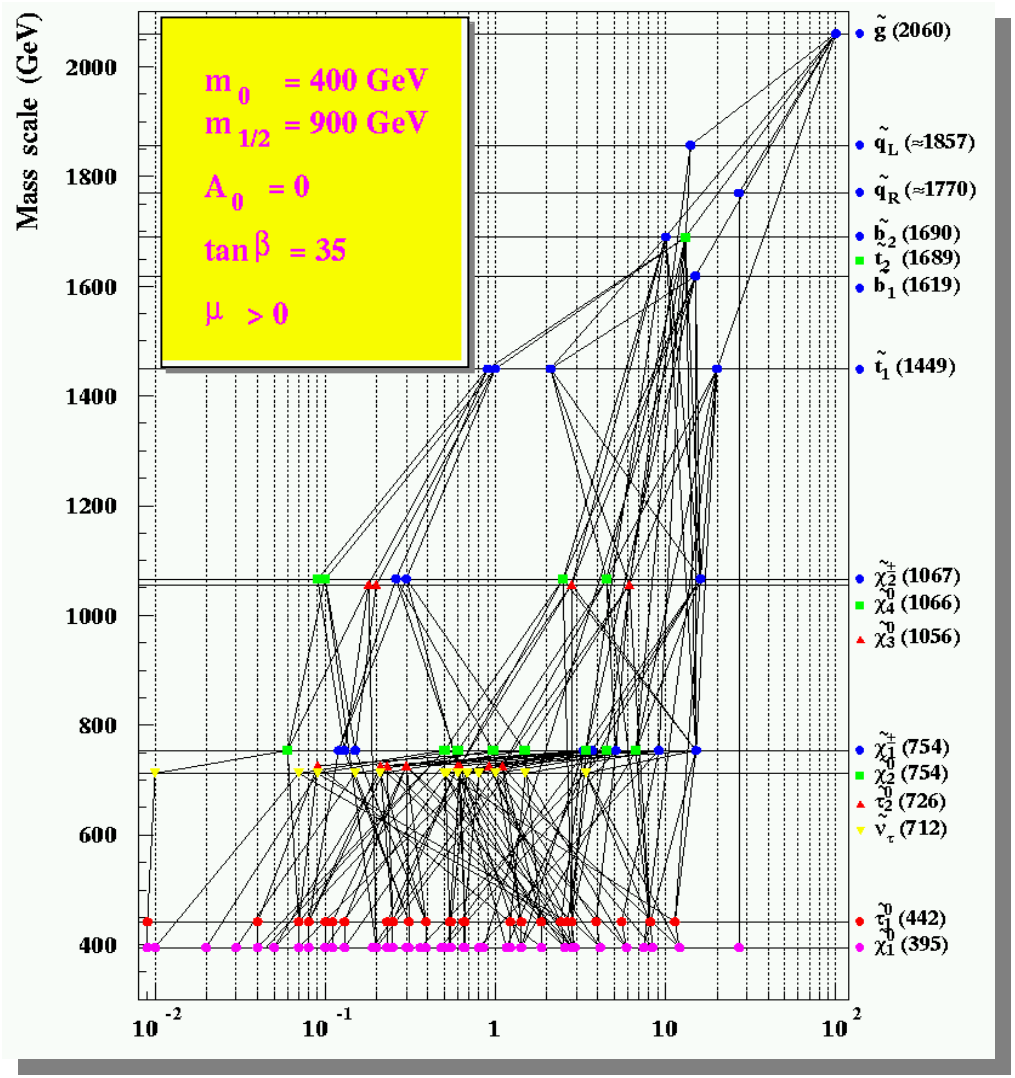
SUSY Trigger : R-Parity Violation

- **Most challenging scenario (?)**
  - $\tilde{\chi}_1^0 \rightarrow$ 3 quarks
  - 6 additional jets, not necessarily soft :
    $\tilde{\chi}_1^0$ mass $\approx$ 300-450 GeV
  - Missing ET shrinks, still some amount remains
    - copious b-jets, W/Z, taus and neutralinos

- **ISAJET 7.58 – ISAWIG 1.104 – HERWIG 6.301**

Points 7R 8R 9R

SUSY Trigger : Many Jets Expected …



gluino branching ratio chart

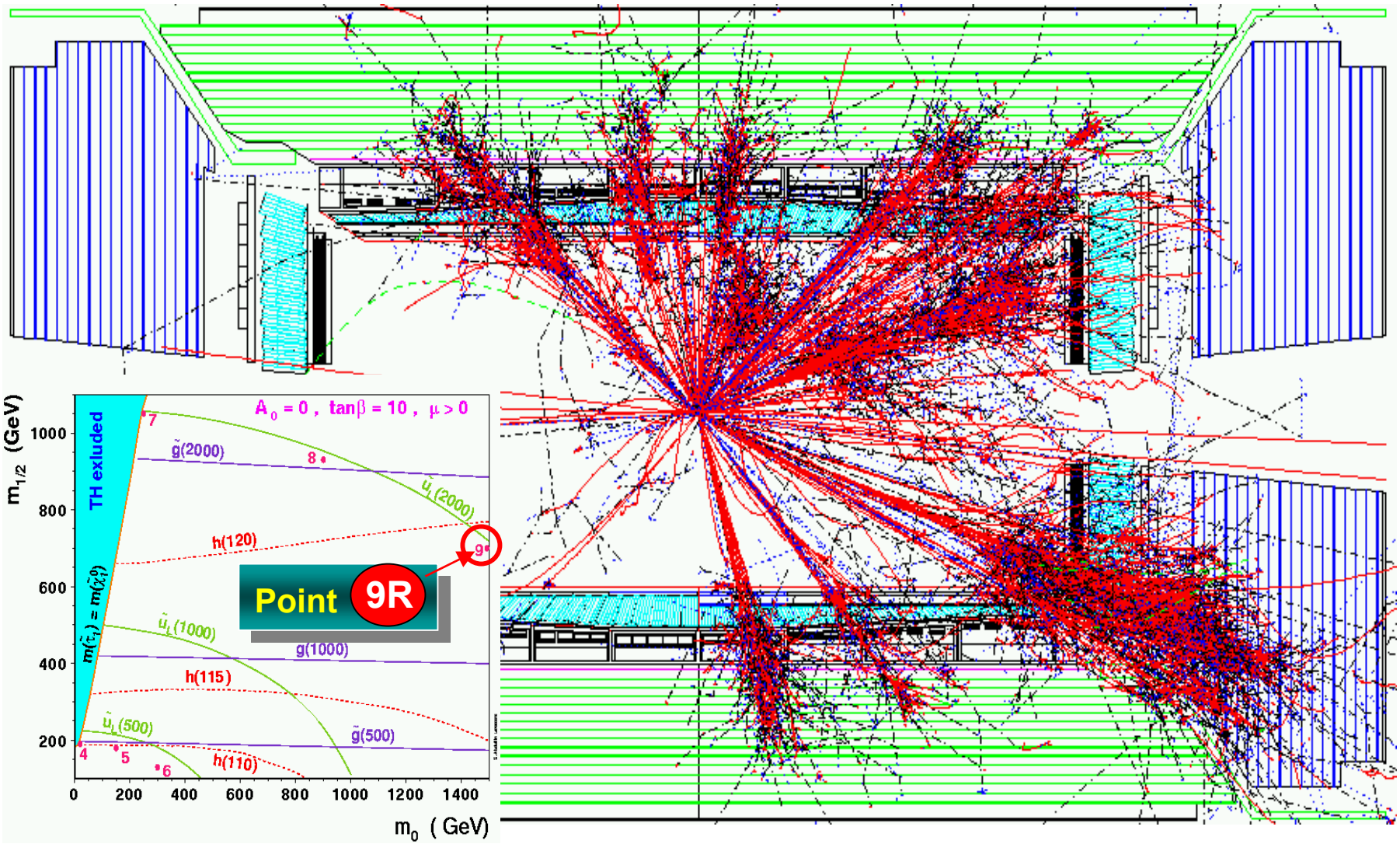
similar to point **7**

$\tilde{\chi}_1^0$ qq	(27.0 %)	$\tilde{\chi}_1^0$ $\tau\nu$WWWbb	(4.1 %)
$\tilde{\chi}_1^0$ $\tau\nu$Wbb	(12.1 %)	$\tilde{\chi}_1^0$ $\tau\tau$bb	(2.9 %)
$\tilde{\chi}_1^0$ $\tau\tau$WWbb	(8.4 %)	$\tilde{\chi}_1^0$ $\tau\tau$qq	(2.9 %)
$\tilde{\chi}_1^0$ WWbb	(7.4 %)	$\tilde{\chi}_1^0$ $\tau\nu$ZWbb	(2.8 %)
$\tilde{\chi}_1^0$ $\tau\nu$qq	(5.9 %)	$\tilde{\chi}_1^0$ $\tau\nu$hWbb	(2.6 %)

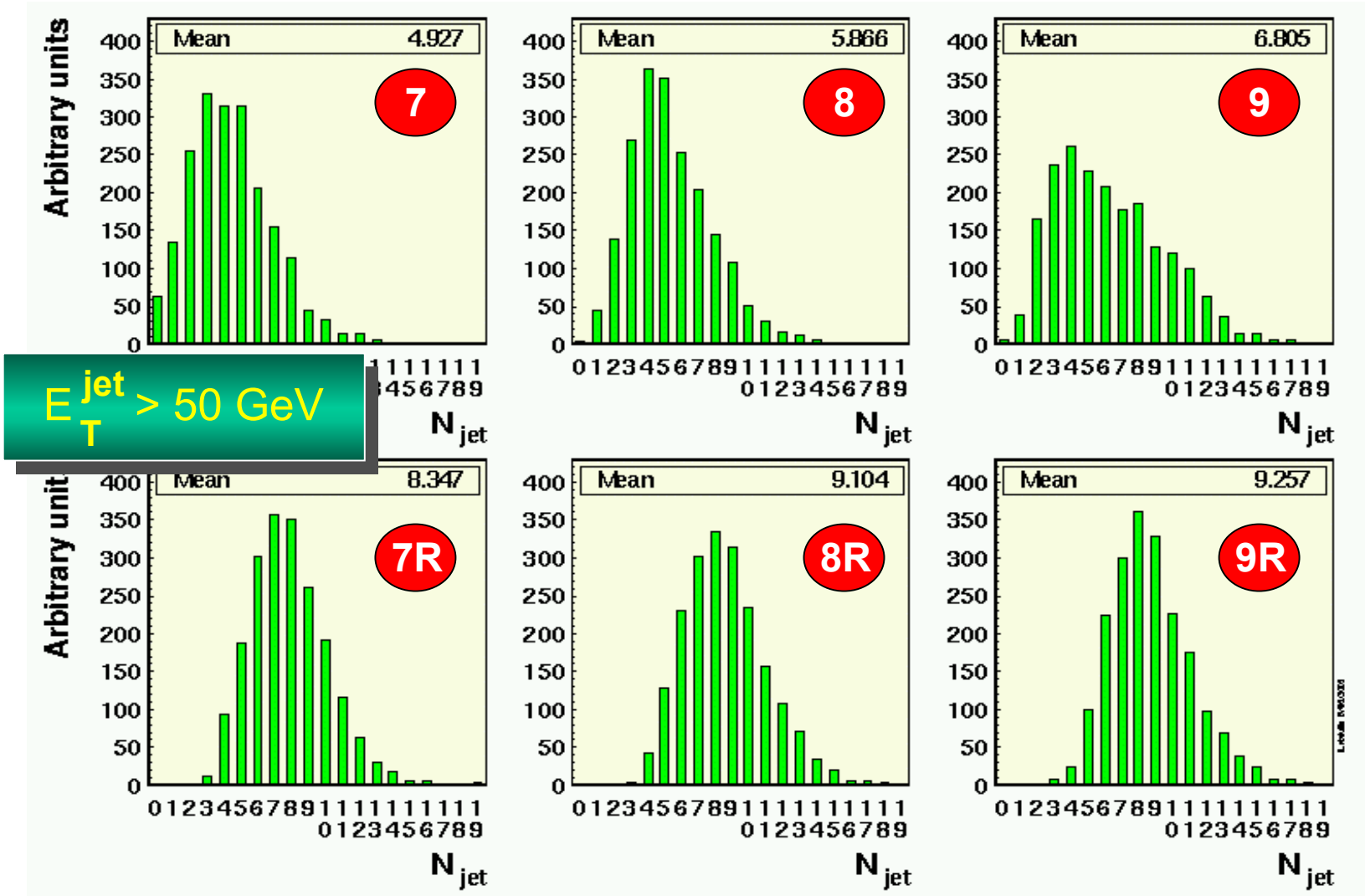
squarks yield less jets

more jets if squarks decay via gluino **9** **9R**

SUSY Trigger : Event Display

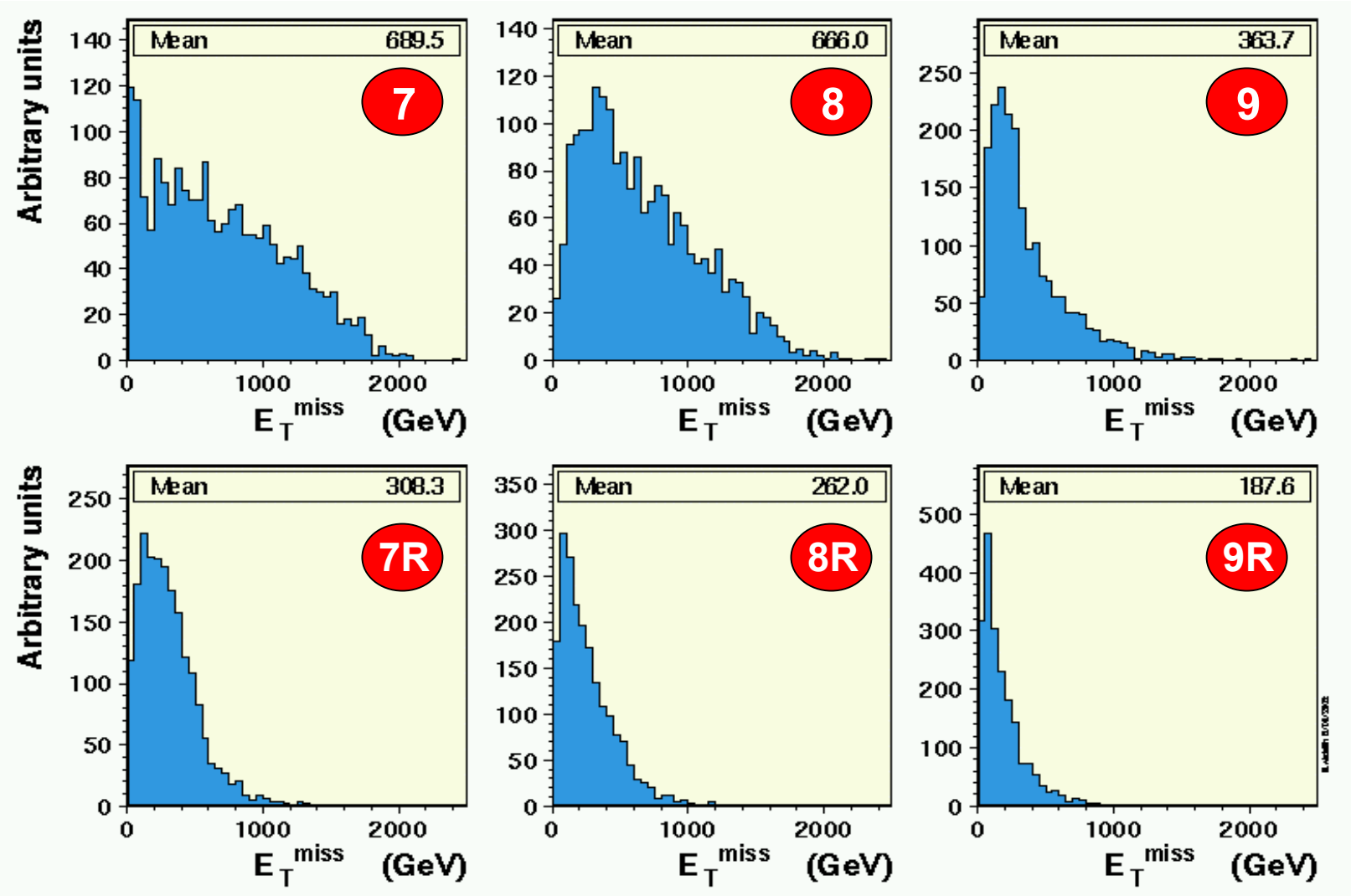


SUSY Trigger : Jet # @ L2



$E_T^{jet} > 50$ GeV

SUSY Trigger : Missing ET @ L2



SUSY Trigger : Data Samples

- **6 mSUGRA samples**
  - spring 2002 production
  - 2000 events each
  - high-lumi energy corrections from Andrei Krokhotine
- **3 SM backgrounds**
  - spring 2002 production (high lumi)
    - QCD (with HF filter) $\approx$ 1,050,000 events
  - autumn 2001 production (low lumi, rescaled)
    - Wj ($W \rightarrow l\,\nu$) $\approx$ 150,000 ev.
    - $t\,\bar{t}$ $\approx$ 46,000 ev.
  - high-lumi jet energy corrections

SUSY Trigger : L1 and L2 cuts

- **L1 cuts :**
  - MET || J1 || J2 || J3 || J4 || (J1 && MET)

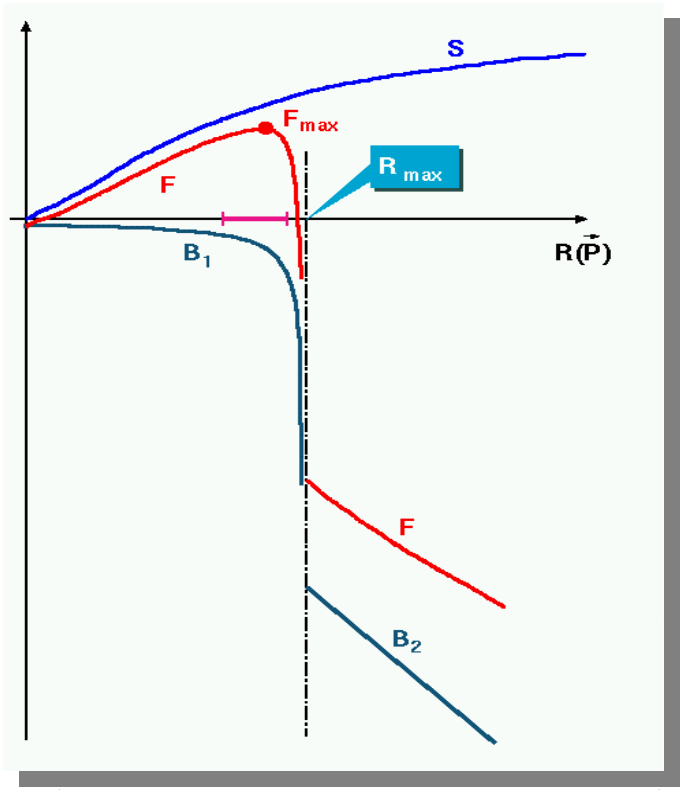
- **L2 cuts :**
  - {(J1 && MET) || (J2 && MET) || (J3 && MET) || (J4 && MET) || Meff || MET } ||

    {
    {(J1 && MET) || (J2 && MET) || (J3 && MET) || (J4 && MET) || Meff || MET } && $\Delta\phi$(J1,J2)
    }

SUSY Trigger : Hybrid GA* (I)

* Genetic Algorithm

- "Society of individuals
  - Fixed-size population (100-1000 individuals)
  - Each individual has a unique combination of genes (cuts) $\vec{P}$
  - Hierarchy is established according to evaluation function $F(\vec{P})$



- Maximal signal efficiency $S(\vec{P})$
- Rate $R(\vec{P})$ is close to R_{max}

SUSY Trigger : Hybrid GA (II)

- **Act of Creation (random)**
- **Breeding**
  - random ("uniform") crossover of genes between parents, offspring is added, parents retained;
  - probability to participate ~ place in the hierarchy.
- **Mutation**
  - random change by one bit (up/down) of a random gene; mutation probability is significant (10-20 %) and independent from hierarchy;
  - Initial individual retained, the result of mutation added.
- **Selection**
  - removal of clones (repl. with newly created individ.);
  - descending ordering according to the evaluation func.;
  - removal of redundant individuals;
  - separate "Top 10" list update (if any);
- **Cataclysmic update**
  - complete random renewal of the population, except the best individual; "Top 10" is not affected also.
  - applied in case of stagnation (50-100 generations) a few times.

SUSY Trigger : L1 Results

		J1&&MET 90	J1&&MET 80	J3 90
Signal efficiency (%)	7	89 (89)		**90** (59)
	8	97 (97)		**98** (72)
	9	88 (88)		**92** (62)
	7R	89 (89)		**100** (99)
	8R	84 (84)		**100** (100)
	9R	70 (70)		**99** (97)
Rate (kHz)	QCD	1.53		**1.94** (0.45)
	W j			-
	$t\bar{t}$			-

SUSY Trigger : L2 Results

		MET 170	J4 150	
Signal efficiency w.r.t L1 (%)	7	93 (93)	**95** (20)	
	8	92 (92)	**94** (29)	
	9	79 (79)	**83** (31)	
	7R	70 (70)	**90** (76)	
	8R	58 (58)	**89** (78)	
	9R	42 (42)	**65** (53)	
Rate (Hz)	QCD	1.23	**2.79** (1.60)	**3.12**
	W j		0.11	
	$t\bar{t}$		0.22	

SUSY Trigger : L1+L2 Combined

Table 1: L1+L2 cuts combinations for high lumi SUSY ...

	L2 Trigger cuts (GeV)	
	MET 170	J4 80
L1 J3 (90)	**1 1**	**1 2**
L1 J1&&MET (90&&80)	**2 1**	~~2 2~~

Table 2: Partial and cumulative efficiencies (%) for signal points 7,8,9

7			8			9		
L1 L2	part.	cumul.	L1 L2	part.	cumul.	L1 L2	part.	cumul.
2 1	83.5	83.5	2 1	90.2	90.2	2 1	72.3	72.3
All 4 combinations :		84.6	All 4 combinations :		91.7	All 4 combinations :		76.0

Table 3: Partial and cumulative efficiencies (%) for signal points 7R,8R,9R

7R			8R			9R		
L1 L2	part.	cumul.	L1 L2	part.	cumul.	L1 L2	part.	cumul.
1 2	75.3	75.3	1 2	77.8	77.9	1 2	52.3	52.3
1 1	68.8	88.8	1 1	57.9	88.1	2 1	40.3	64.3
All 4 combinations :		89.6	All 4 combinations :		88.3	All 4 combinations :		64.3

Invisible Higgs

Sasha Nikitenko

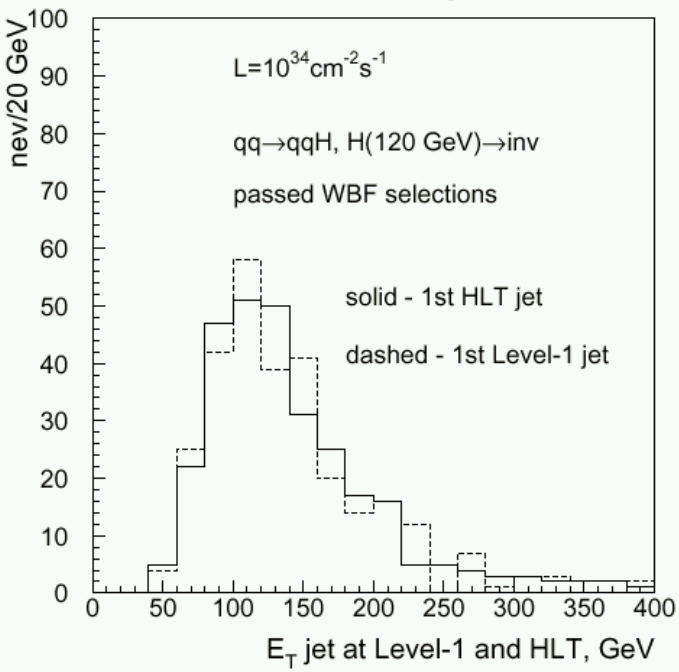
qq->qqH, H->invisible : possible strategy at Level-1 (I)

Level-1 Jet + E_T^{miss} (similar to SUSY triggers , see talk of S. Abdullin)

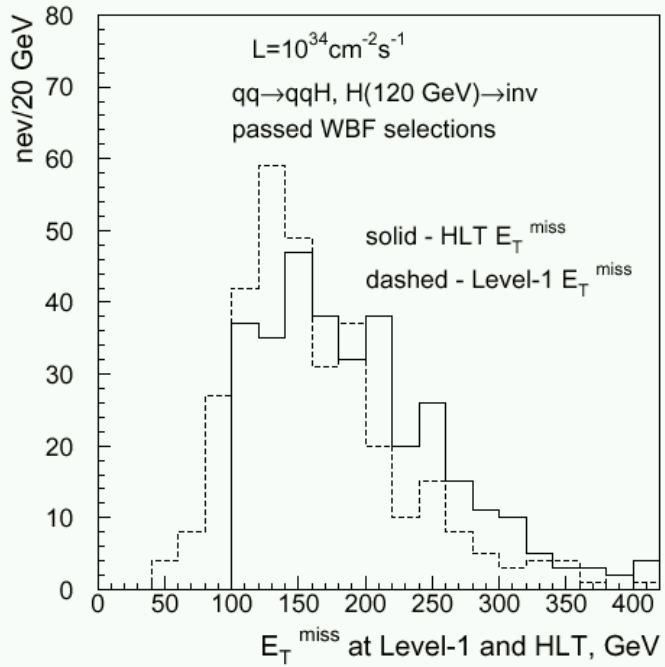
efficiency is defined for Higgs events passed off-line WBF cuts :

$E_T^J > 40$ GeV, $|\eta_{j1} - \eta_{j2}| > 4.4$, $\eta_{j1}\eta_{j2} < 0$, $M_{j1j2} > 1200$ GeV, $\phi_{j1j2} < 1$, $E_T^{miss} > 100$ GeV

1st (highest E_T) Jet



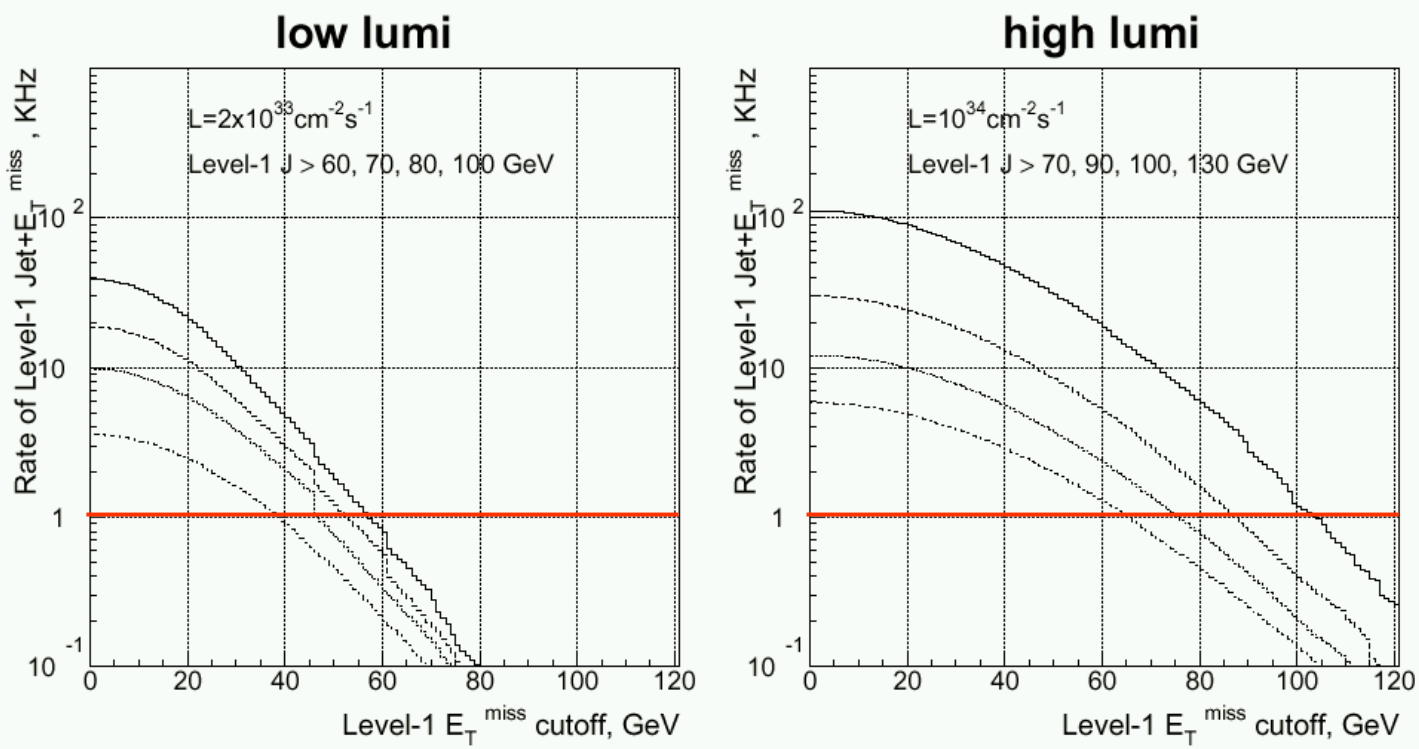
missing E_T



Invisible Higgs

qq->qqH, H->invisible : possible strategy at Level-1 (II)

Level-1 Jet + E_T^{miss} rates

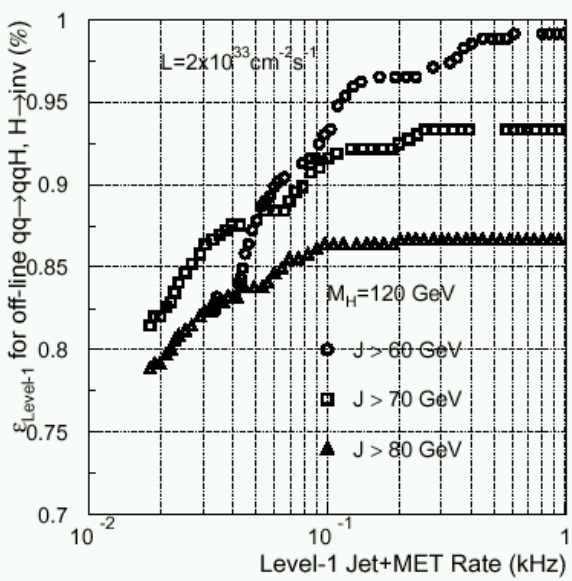


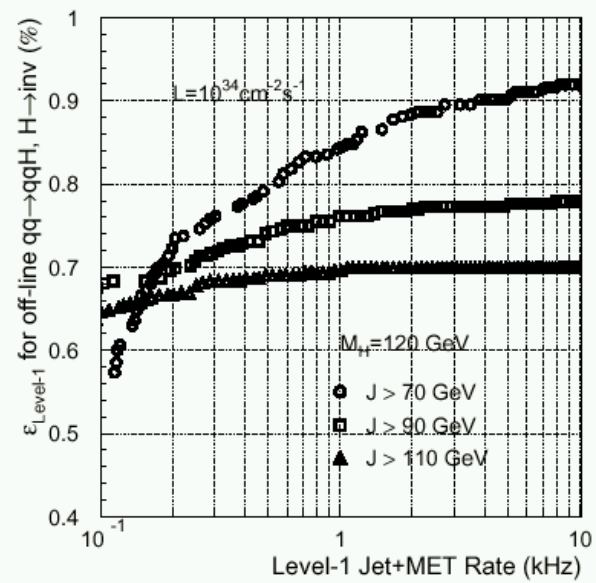
optimization on the next page

Invisible Higgs

qq->qqH, H->invisible : possible strategy at Level-1 (III)

Level-1 Jet + E_T^{miss} optimization: efficiency vs rate



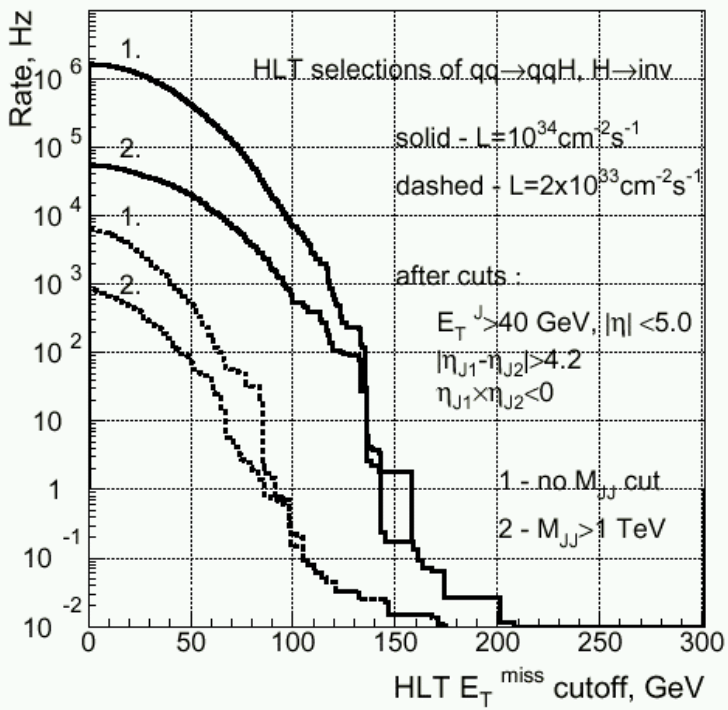


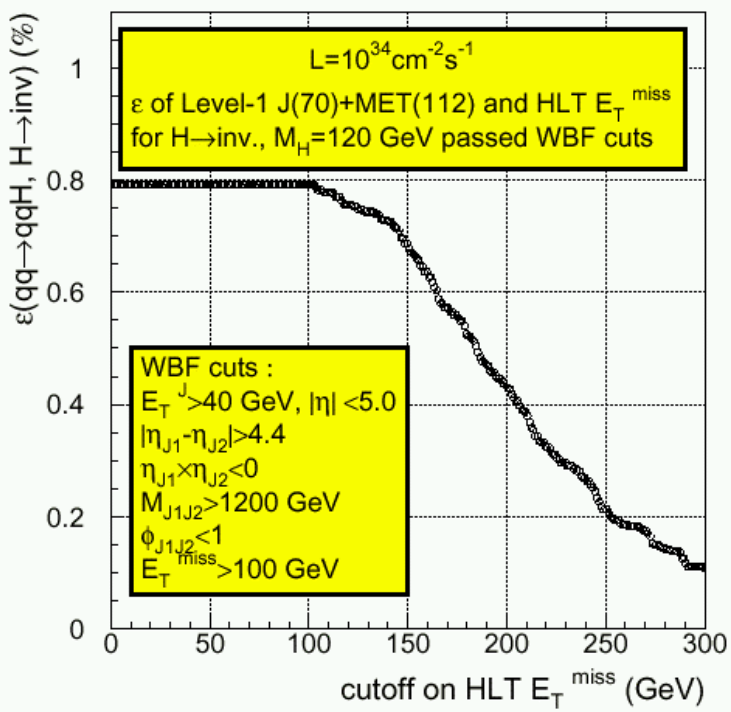
Level-1 Rate of J1+MET, kHz		0.2	0.5	1.0
$L=2x10^{33}cm^{-2}s^{-1}$	L1 J1, MET thresholds, GeV	60, 73	60, 64	60, 56
	L1 efficiency	0.96	0.98	0.99
$L=10^{34}cm^{-2}s^{-1}$	L1 J1, MET thresholds, GeV	70, 122	70, 112	70, 103
	L1 efficiency	0.72	0.79	0.84

Invisible Higgs

qq->qqH, H->invisible : possible strategy at HLT (I)

HLT with loose WBF cuts; optimization of E_T^{miss} cutoff

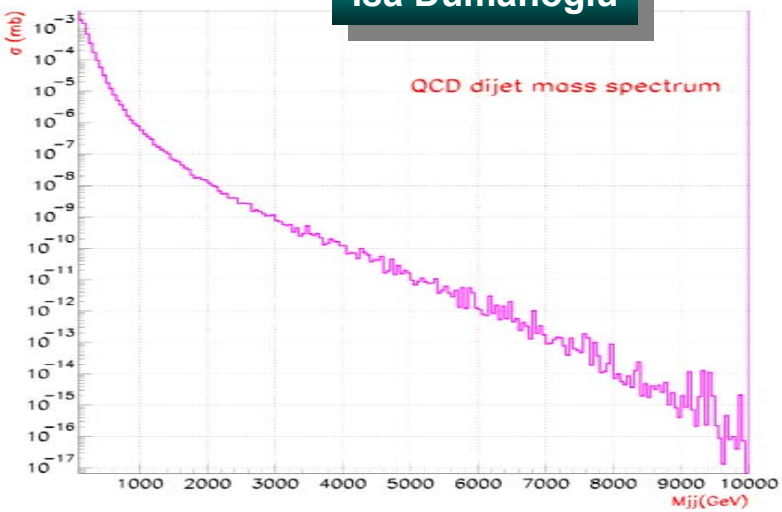


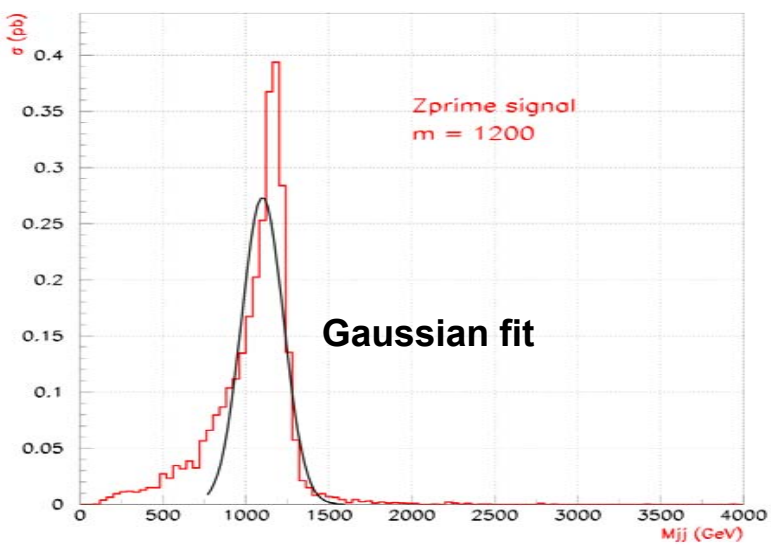


- ϕ_{j1j2} cut is not desirable for H->inv, since prevents physics background estimates from the data (QCD/EW W/Z bkg)

Di-jet Trigger : Calculational details

Isa Dumanoglu

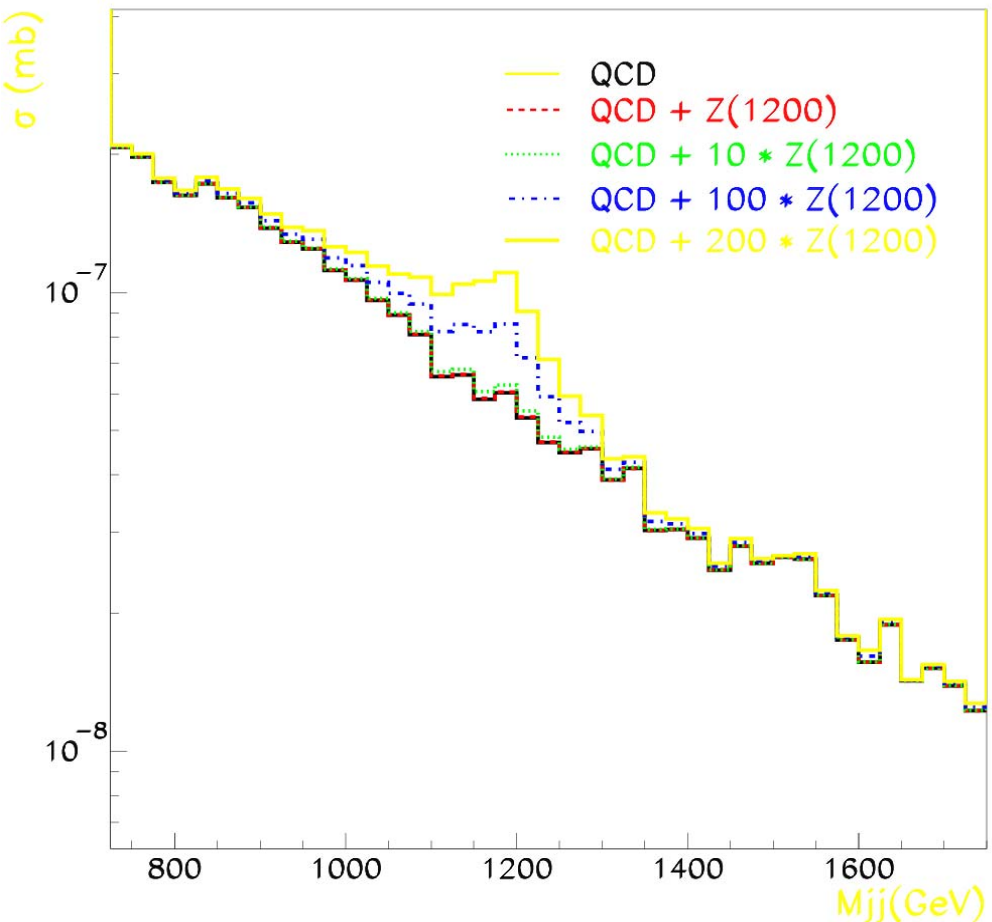




- Events were generated using Pythia 6.158
- Study is done at the generator level
  - Cone jet clustering algorithm is applied on generator particles, cone R=0.5,
  - Jet energy smeared with sigma=1.0 sqrt(E_T).
- QCD bins used for analysis : 20-30, 30-50, 50-80, 80-120, 120-170, 170-230, 230-300, 300-400, 400-500, 500-600, 600-800, 800-1000, 1000-1400, 1400-1800,1800-2200, 2200-2600, 2600-3000, 3000-3500, 3500-4000 .
- 15 K events/bin. 10 K Z' events for each mass.
- Generated particle (Z') masses: 600, 800, 1000, 1200, 1400, 1600, 1800, 2000, 2200, 2400, 2600, 2800, 3000.
- $Mjj=2E_{T1}E_{T2}(\mathrm{Cosh}\Delta\eta-\mathrm{Cos}\Delta\phi)$.
- Applied cuts :

  $\eta\geq 2$ & $E_T \geq 50$ GeV or $E_T \geq m(Z')/4$
- Total cross sections were calculated within $\pm 2\sigma$ mass window for both signal and QCD background.

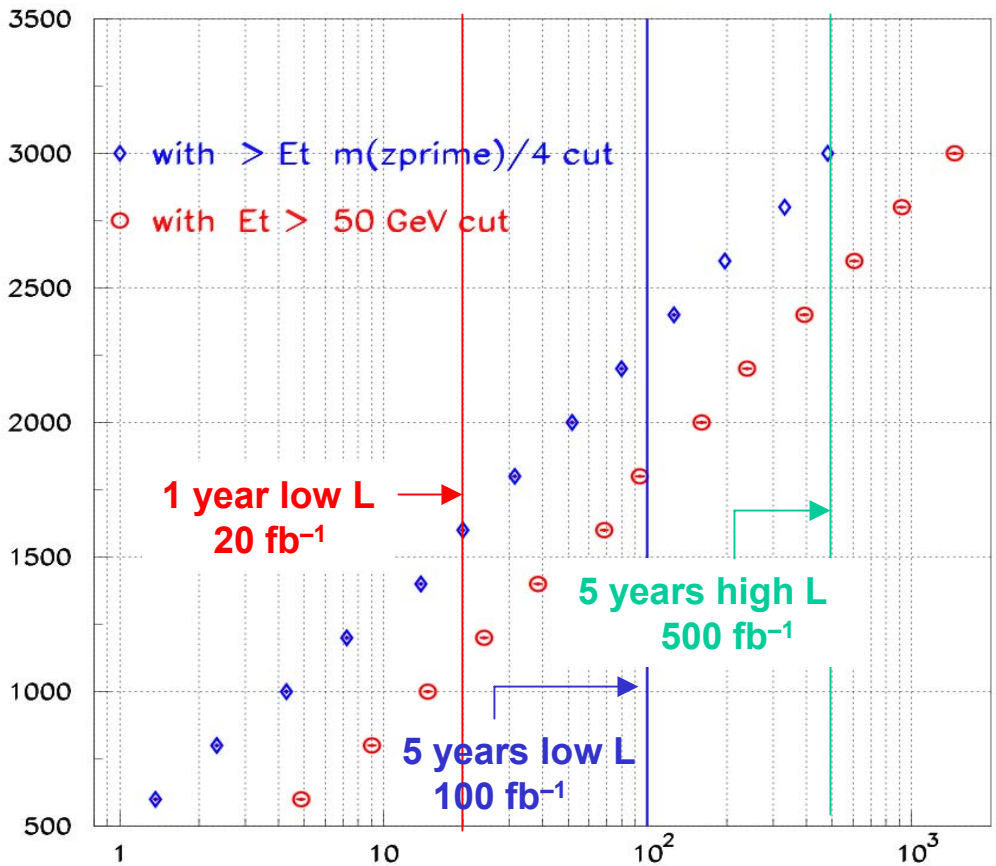
Di-jet Trigger : Signal Cross Section



- QCD + Z′ signal almost equals to QCD
- To observe any difference we need to scale signal cross section with sizeable factor
- With higher scale factor the difference becomes more visible.

Di-jet Trigger

ESTIMATED LUMINOSITIES FOR 5σ DISCOVERY



- Luminosities are given for 5σ discovery.
- Calculated using :

  $L = 25\ \sigma_{QCD}^{\ window} / \sigma^2_{signal}{}^{window}$
- Vertical lines shows 1, 5 years low luminosity & 5 years high luminosity.
- Luminosities are more optimistic for ET ≥ m(Z′)/4 than ET ≥ 50 GeV.
- In first year Low luminosity run Z′ can be discovered up to 1.6 TeV mass (with no prescale)
- Z′ can be discovered up to 3.0 TeV in 5 years high L case.

Di-jet Trigger Table

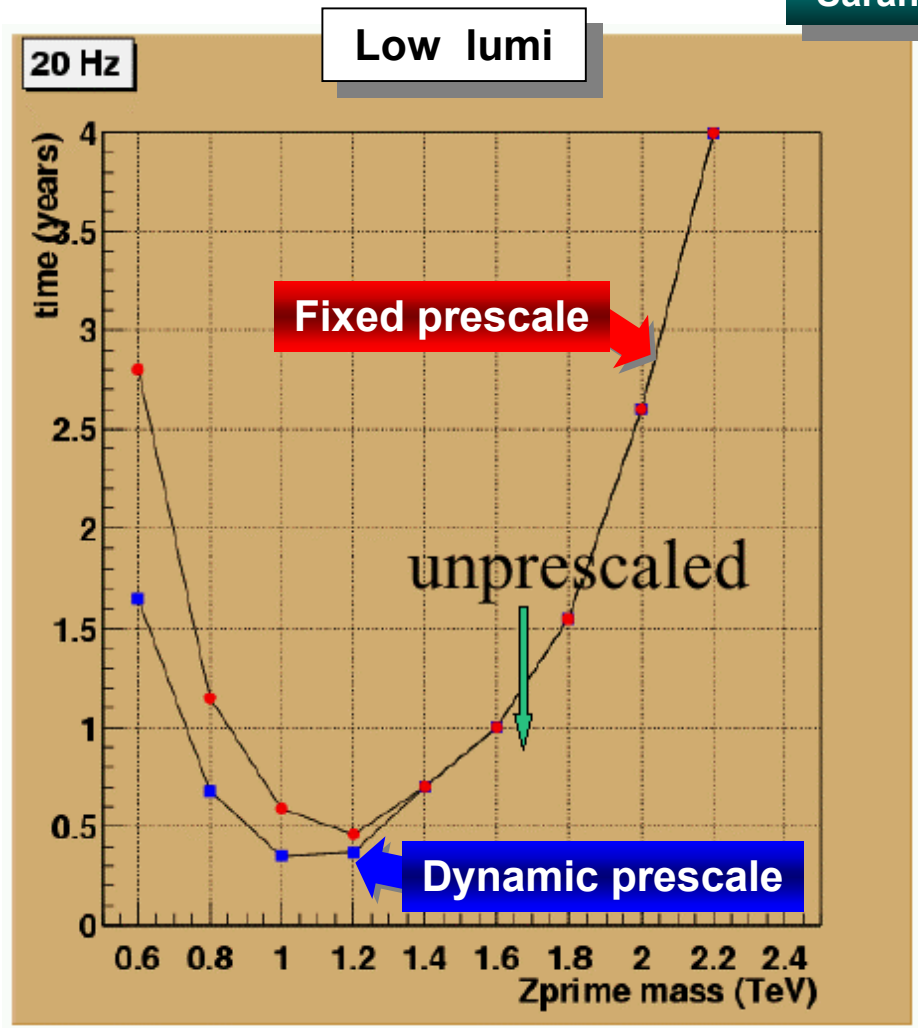
ET(GEV)	RATE (Hz)	PRESCALE	BANDWIDTH(Hz)	L (fb^{-1}/year)
150	800	100	8	0.02
250	80	16	5	1.25
400	8	2	4	10
550	1	1	1	20

M(Z ´)(TeV)	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3
L (fb^{-1})	1.4	2.3	4.3	7.3	14	20	31	52	80	126	197	332	482

With this scenario we could discover Z´ up to 1.6 TeV if it exists.

Di-jet Trigger : Time Required for 5σ

Sarah Eno



- The idea is to keep a constant rate to tape
- Two beam decay models
  - exponential, decay time = 10 h, store time = 10 h, dynamic prescale
  - flat luminosity with fixed prescale
  - 20 Hz fixed rate and 20 fb-1/yr unprescaled assumed for both