Search for neutral MSSM Higgs bosons $h/H/A \rightarrow \mu\mu$ @ 1 fb^{-1}

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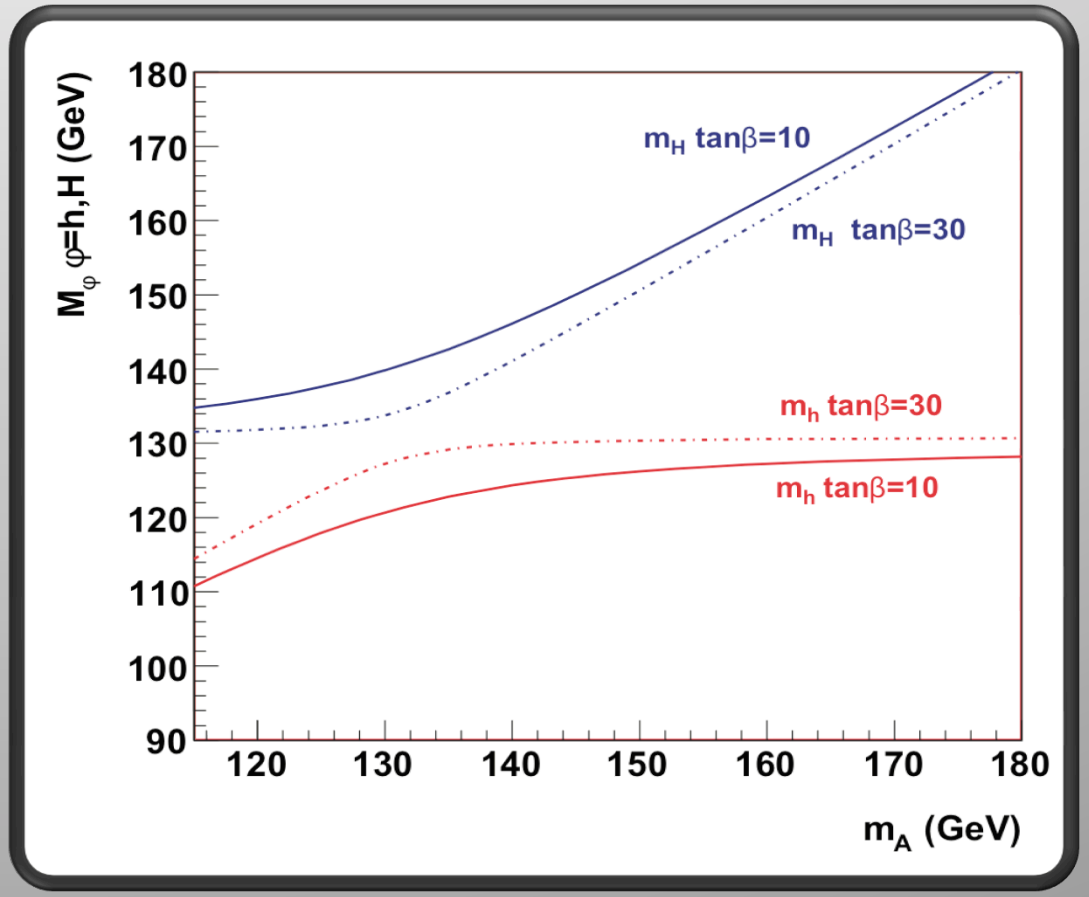
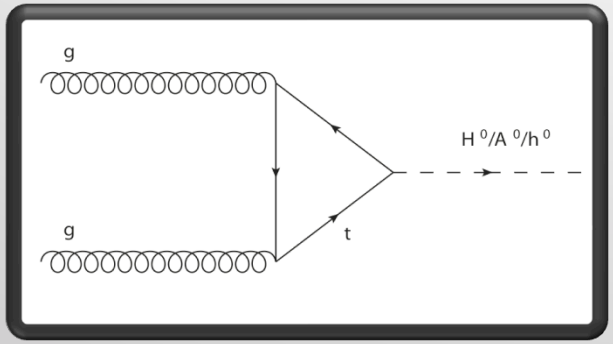
Masses for the MSSM Higgs Bosons

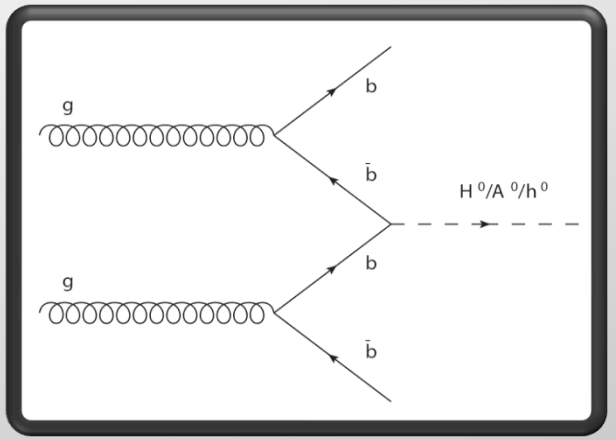
- masses for h/H/A calculated with FeynHiggs 2.6.5
- MSSM parameters are based on m^{h}_{max} scenario
- All three masses are almost degenerated @ 130 GeV



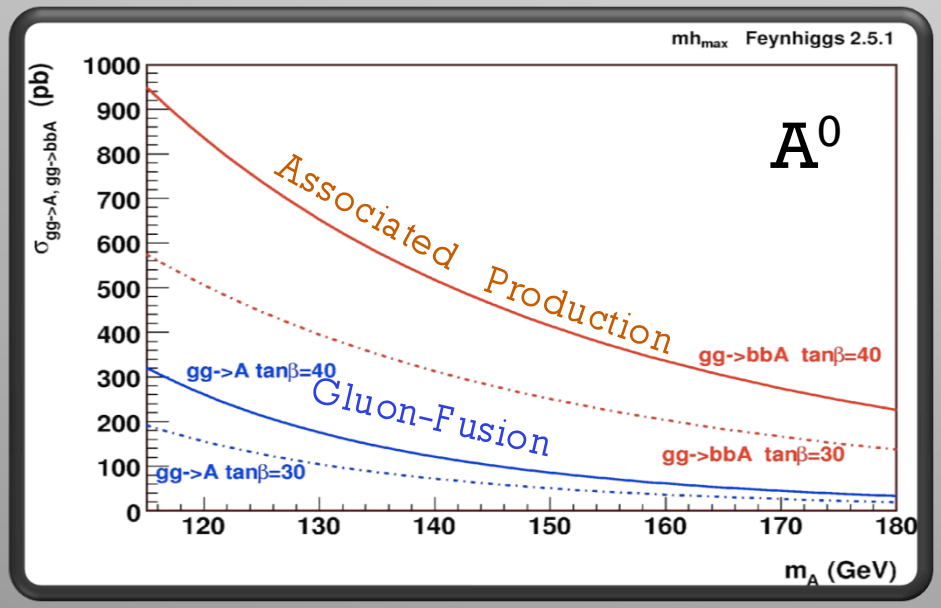
Higgs production @ LHC

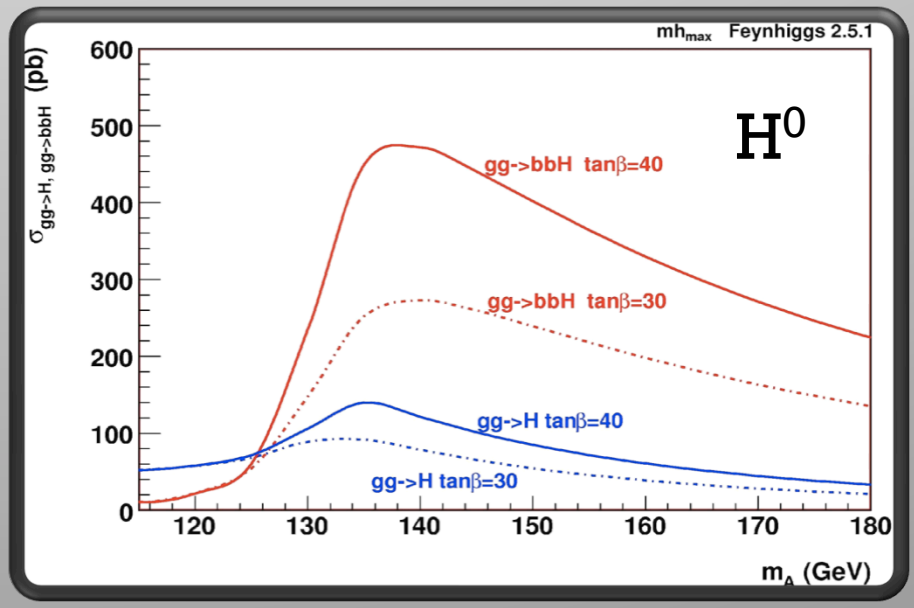


Gluon Fusion



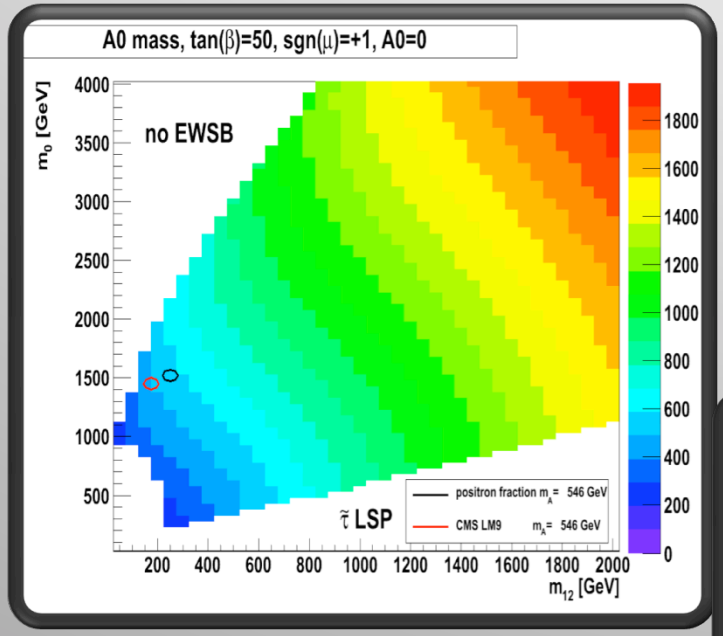
Associated Production

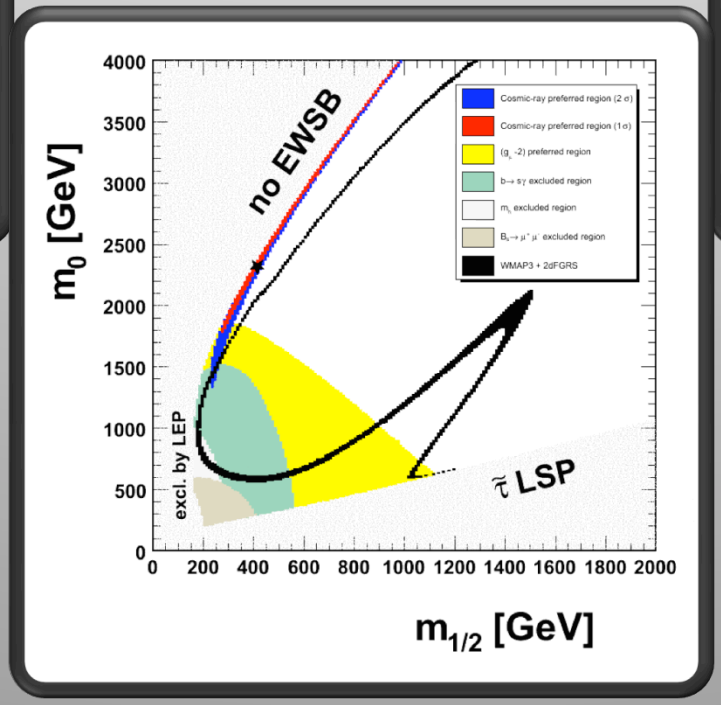


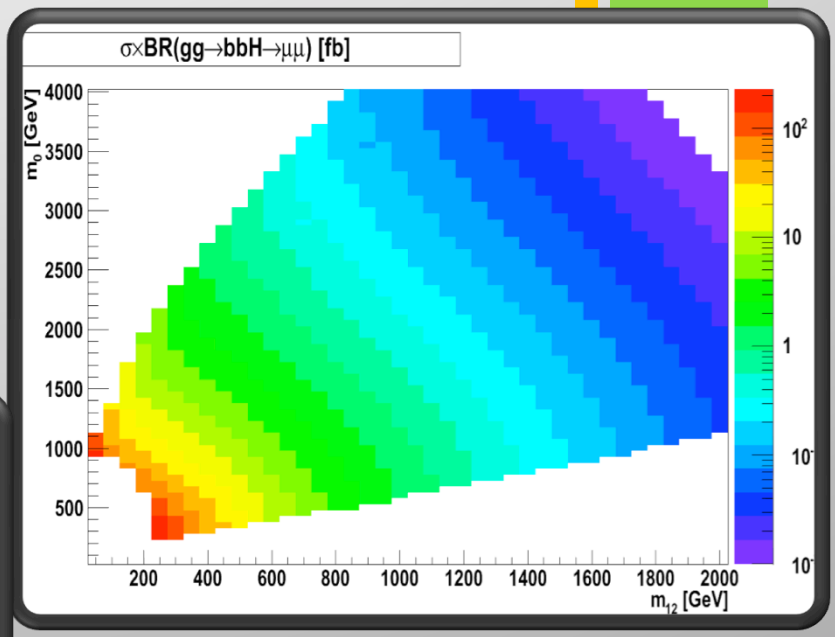


Higgs production @ LHC

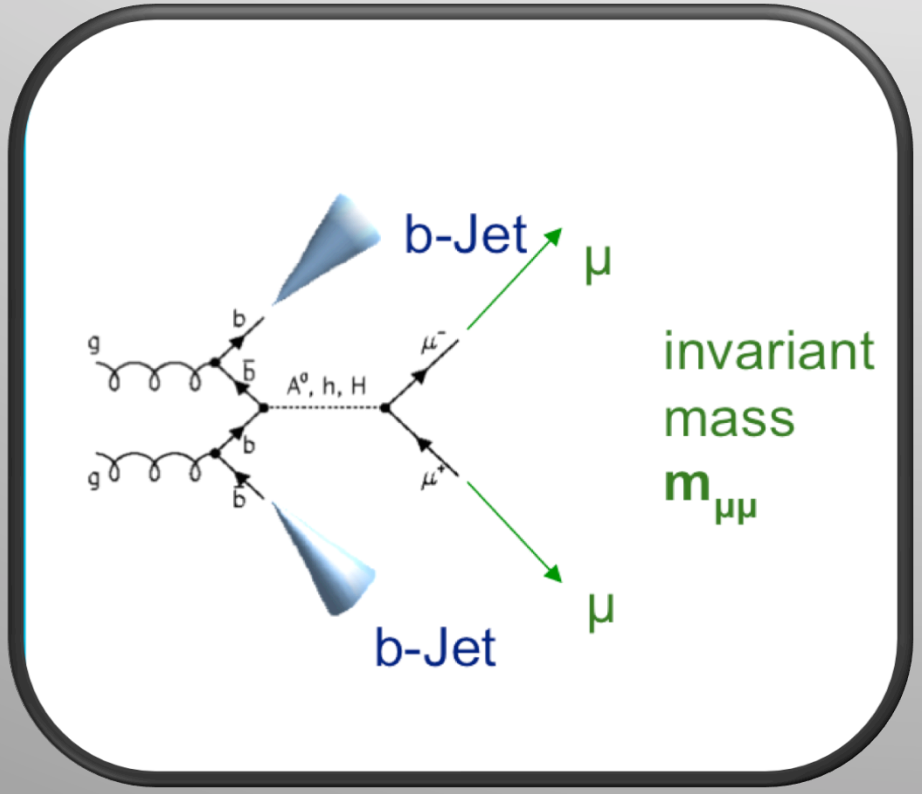
Higgs mass & cross section depend on MSSM parameters m_0 & $m_{1/2}$





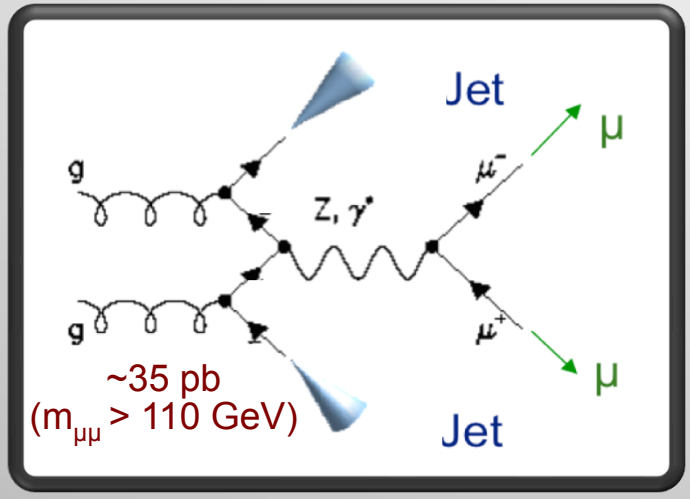


signal for h,H,A→ μμ

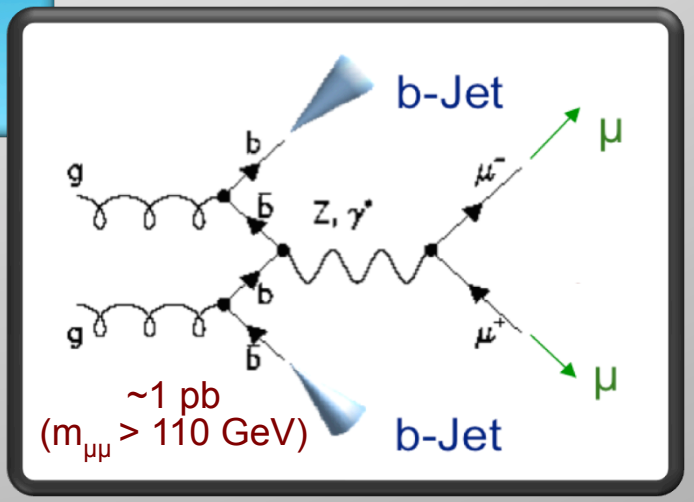


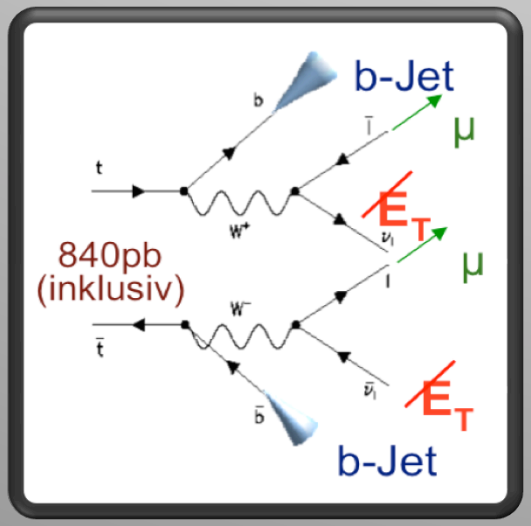
- signature in the detector:
  - 2 isolated muons with high p_T
  - 2 b-jets with low p_T
  - low missing transverse energy

Main backgrounds



- Drell Yan Z/ $\gamma^* \rightarrow \mu\ \mu$
  - no b jets

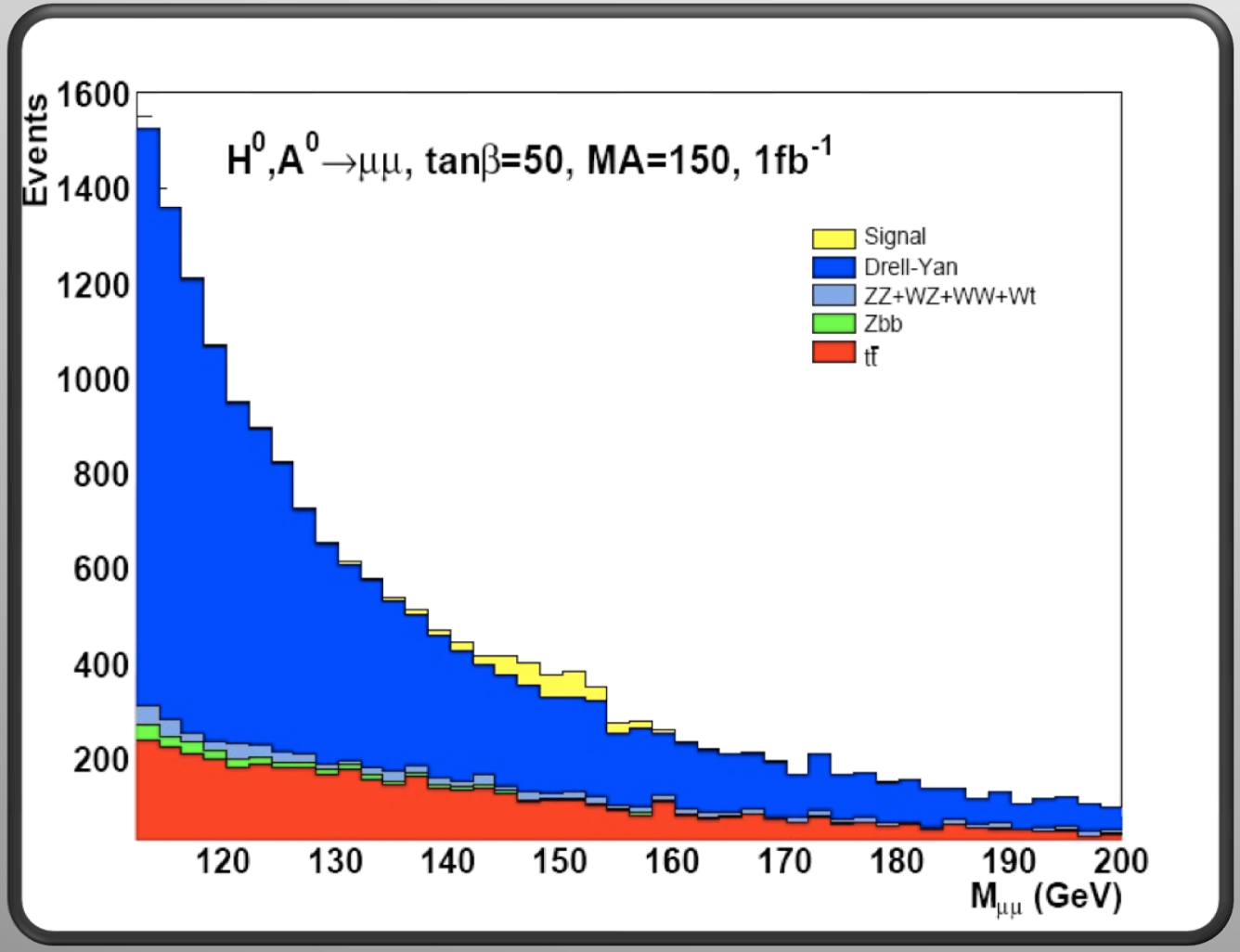




- top pair production
  - high missing energy due to neutrinos

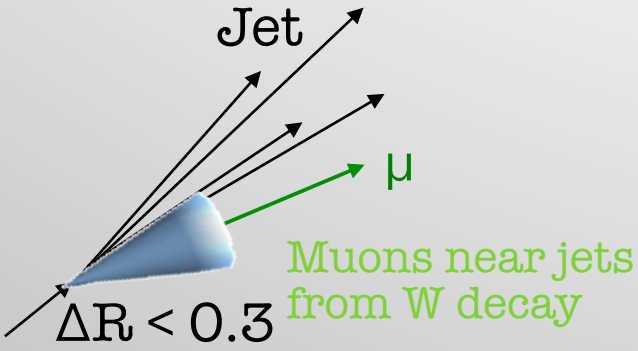
- bbZ/ $\gamma^* \rightarrow$ bb $\mu\ \mu$
  - kinematics similar to signal
  - irreducible subset of Drell Yan (≈2%)

signal & backgroung @ 1 fb^{-1}

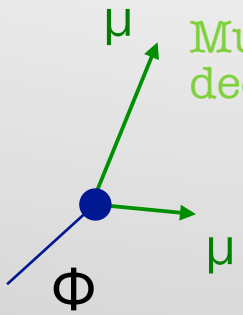


- basic muon identification:
  - Level 1 trigger & HLT passed
  - two muons of opposite charge
  - muons have pT > 20 GeV
- efficiencies:
  - Signal: 99.0 %
  - Zbb: 97.1 %
  - Drell-Yan: 98.0 %
  - top pairs 78.4 %

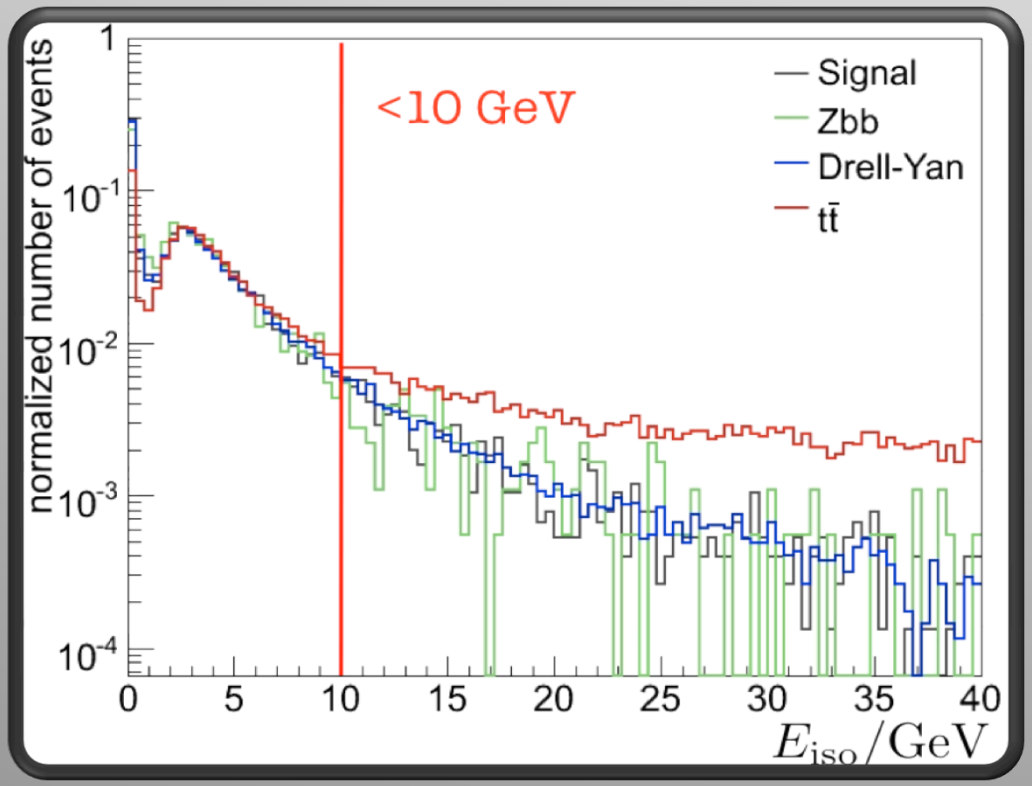
muon isolation



Muons near jets from W decay



Muons from Higgs decay are isolated

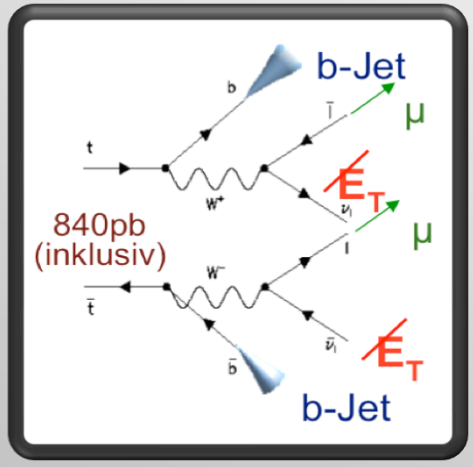


- muon isolation:

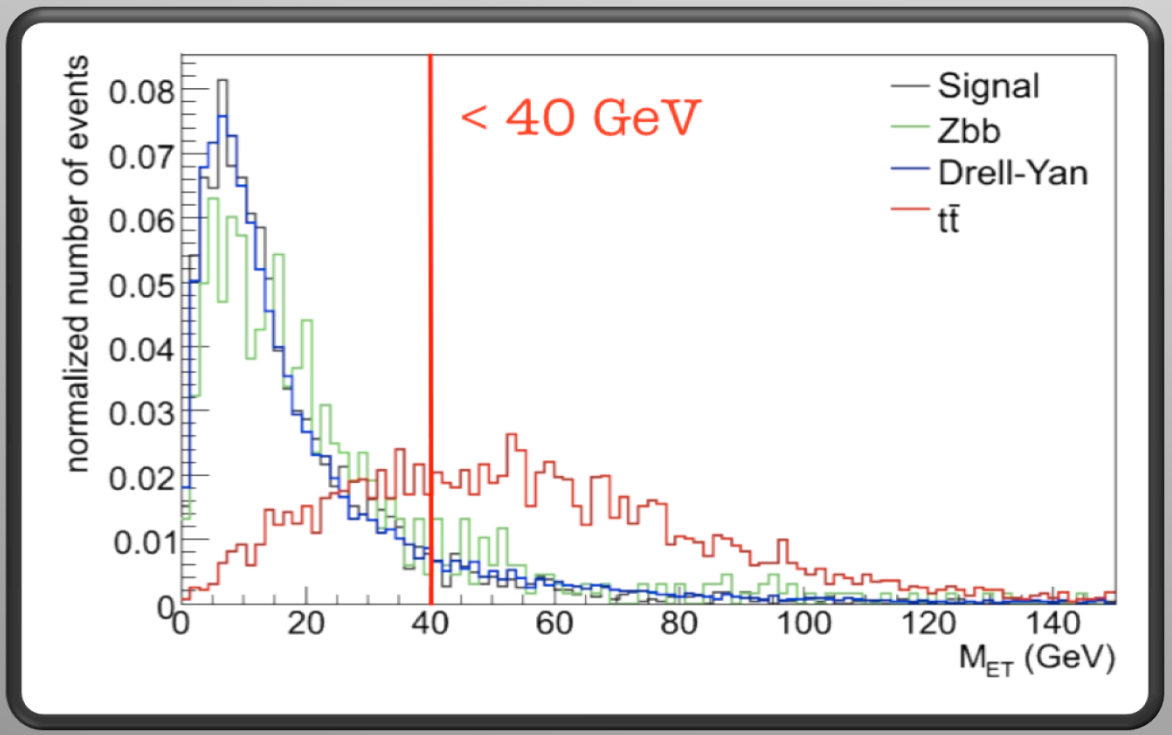
$$\mathbf{E}_{\mathrm{iso}} = \left(\sum_{\Delta \mathbf{R} < 0.3} (\mathbf{P}_{\mathrm{Tracker}} + \mathbf{E}_{\mathrm{ECAL}} + \mathbf{E}_{\mathrm{HCAL}}) \right) - \mathbf{p}_{\mu} < 10 \text{ GeV}$$

- efficiencies:
  - Signal: 76.7 %
  - Zbb: 73.1 %
  - Drell-Yan: 80.3 %
  - top pairs 34.1 %

missing transverse energy



$$\frac{\sigma(\not{E}_T)}{\not{E}_T} \approx 1.0 \frac{\sqrt{\sum E_T}}{\sum E_T} \approx 15.8\ \%$$



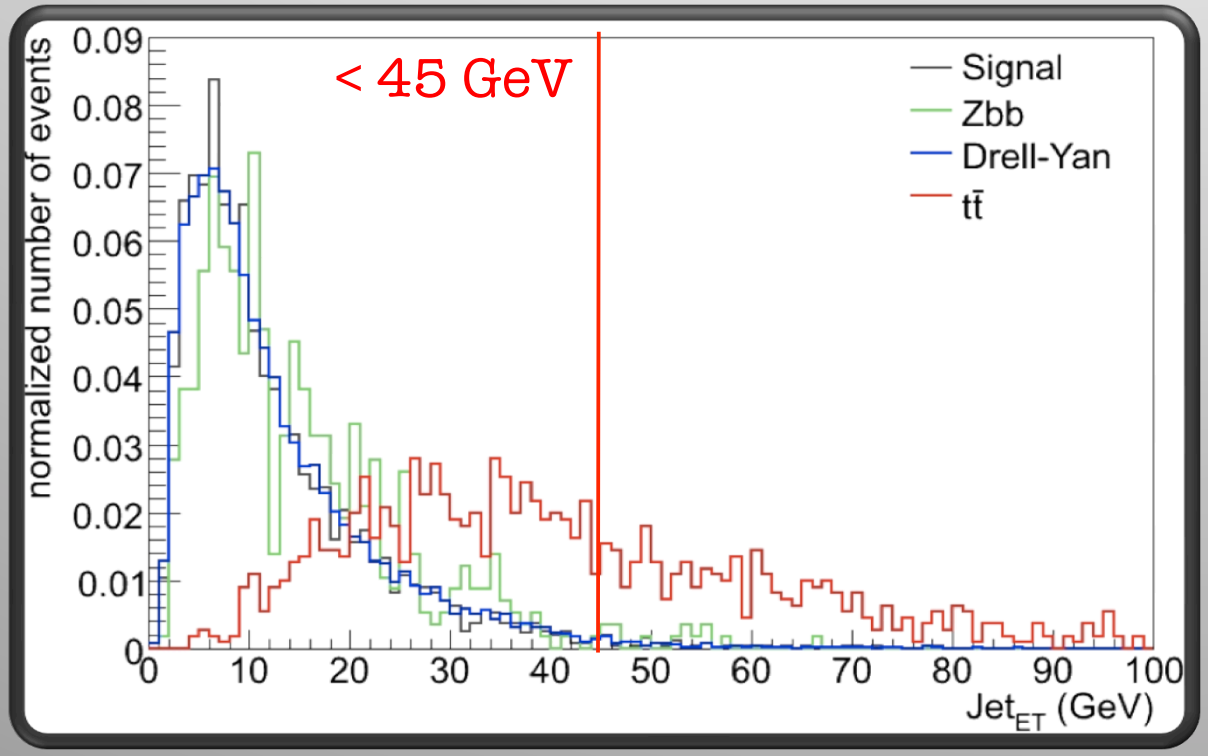
- cut on missing transverse energy to reduce tt-bar background

$$\not{E}_T < 40\ \text{GeV}$$

- efficiencies:
  - Signal: 87.5 %
  - Zbb: 84.3 %
  - Drell-Yan: 83.9 %
  - top pairs 31.6 %

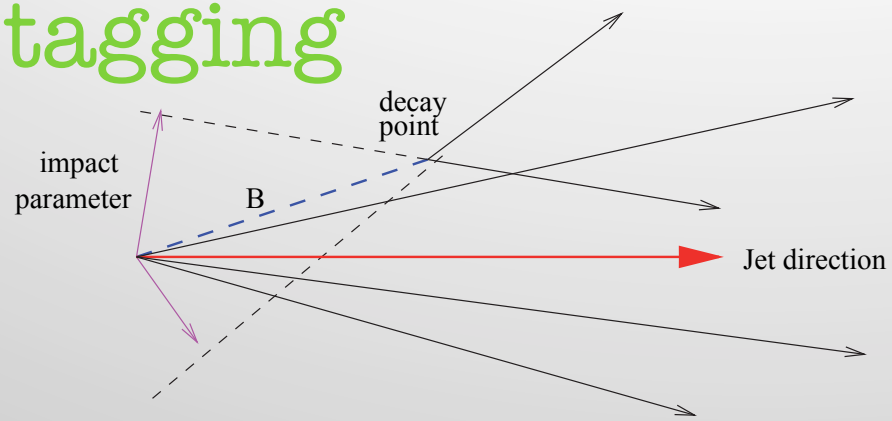
jet veto

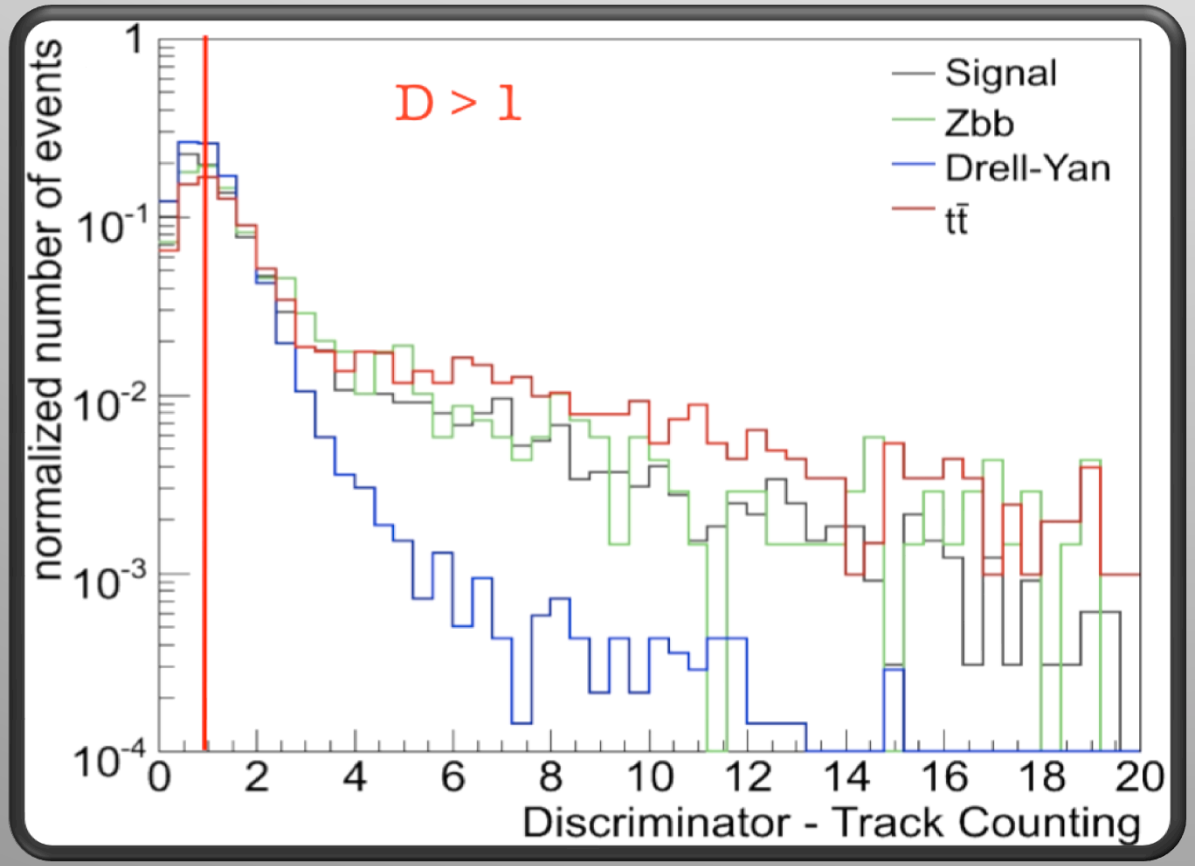
Jet Energy Resolution in this area ≈15 – 20 %



- veto against high E_T jets to further reduce tt-bar background
- no jets with E_T^{jet} > 45 GeV
- efficiencies:
  - Signal: 87.5 %
  - Zbb: 84.3 %
  - Drell-Yan: 83.9 %
  - top pairs 31.6 %

b jet tagging

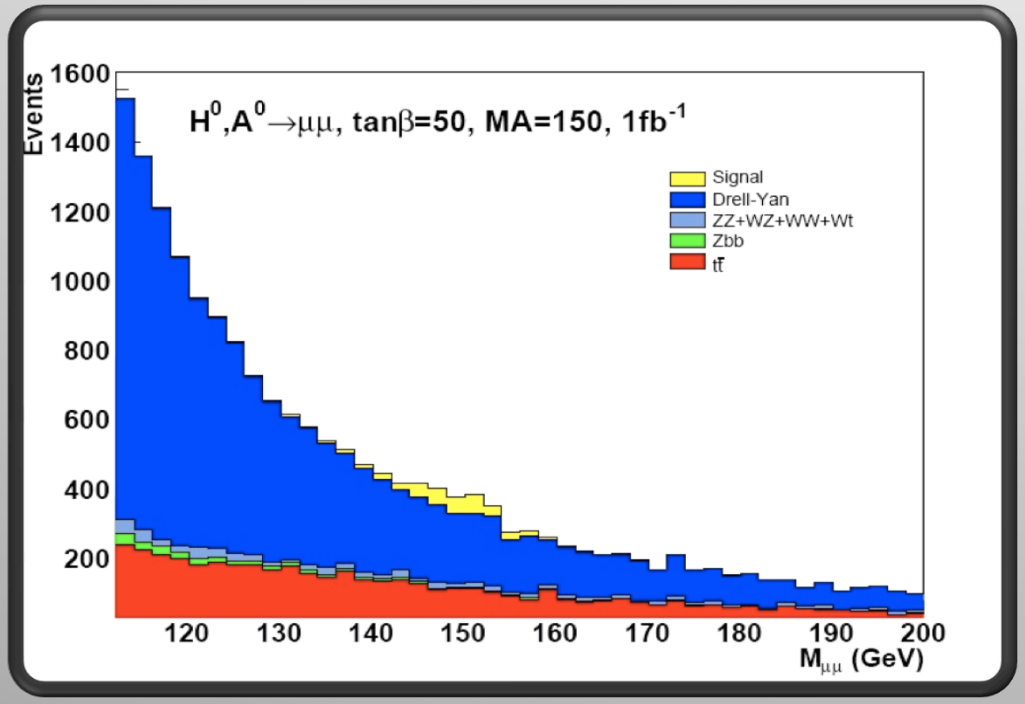


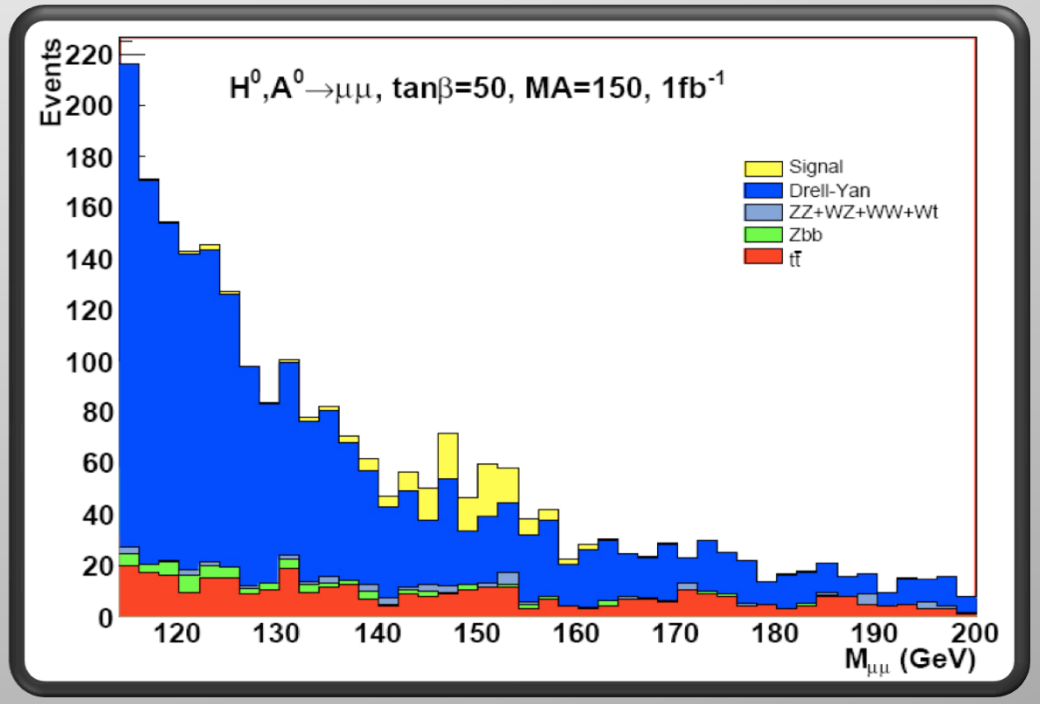


- at least one tagged b-jet demanded to reduce Drell-Yan background
- events with the 2nd highest 3D-impact parameter significance > 1σ are selected
- relatively soft cut to keep enough signal statistics
- efficiencies:
  - Signal: 52.2 %
  - Zbb: 53.1 %
  - Drell-Yan: 25.0 %
  - top pairs 91.8 %

signal & background

The profile likelihood method is used to calculate the probability of a discovery or an exclusion of a signal

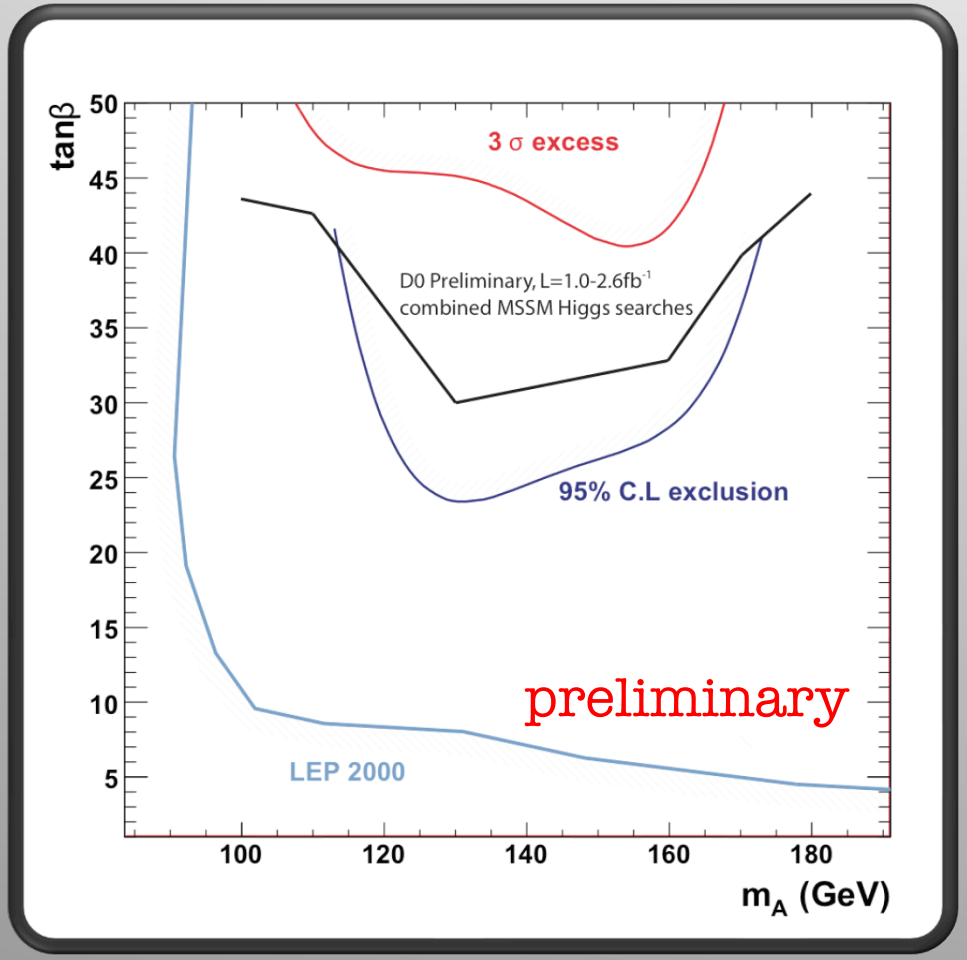




before cuts
8 % ^{sig} / $_{bg}$

after cuts
20 % ^{sig} / $_{bg}$

potential @ 1 fb^{-1}



- simulated for different masses of the Higgs in range of $M_{\mu\mu}$=130 GeV – 180 GeV
- likelihood ratio is used for exclusion
- tevatron exclusion limits can be significantly improved with 1 fb^{-1}
- for discovery higher statistics are necessary

conclusions

- early channel to improve exclusion limits @ 1 fb^{-1} for
  - Higgs masses from $m_{\mu\mu}$=130 GeV up to 180 GeV
  - tan ß > 25
  - higher integrated luminosity will make a discovery possible or will improve the exclusion limits further more
- studied backgrounds
  - Drell-Yan
  - irreducible Drell-Yan Zbb
  - top pairs
- aspects we are currently working on
  - alternatives to b-tagging
  - background shape from data(e.g. di-electron spectrum)

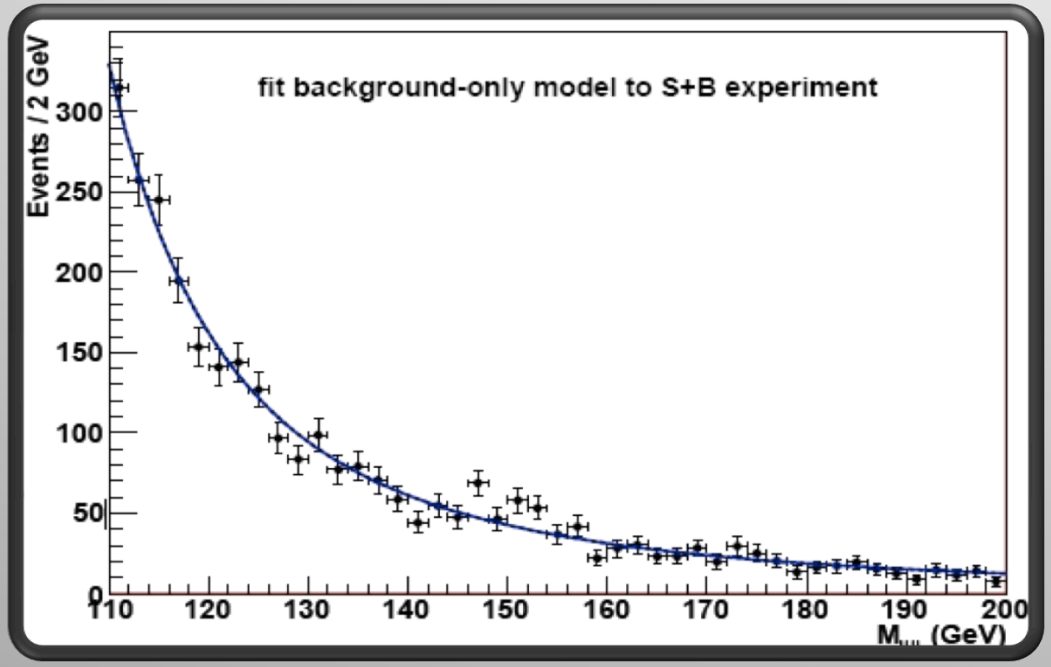
Back up

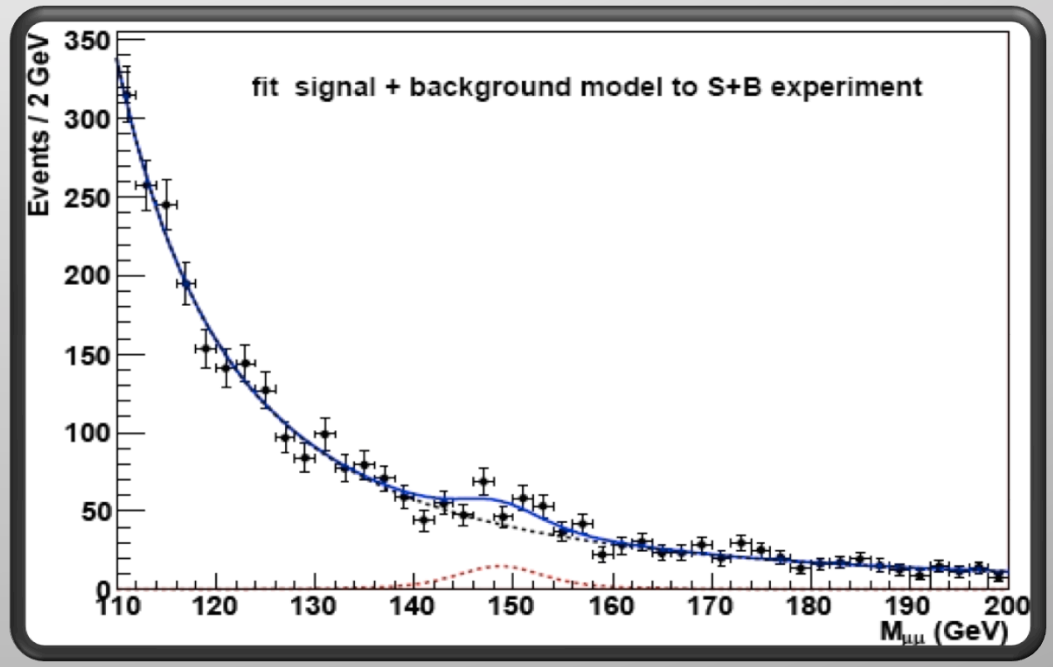
cut flow for 1 fb^{-1}

	H^0		A^0		$Zb\bar{b}$		Drell-Yan		$t\bar{t}$	
	n_{evt}	ϵ [%]	n_{evt}	ϵ [%]	n_{evt}	ϵ [%]	n_{evt}	ϵ [%]	n_{evt}	ϵ [%]
No cuts	265.7	100.0	271.6	100.0	1050.0	100.0	35000	100.0	840000	100.0
L1	253.3	95.3	255.3	94.0	1038.5	98.9	27479	78.5	289629	34.5
HLT	246.6	92.8	244.4	90.0	1020.6	97.2	25711	73.5	139854	16.7
n_μ	203.2	76.5	198.7	73.2	956.0	91.1	16558	47.3	39551	4.7
μ isolation	155.9	58.7	152.5	56.2	698.8	66.6	13290	38.0	13498	1.6
n_{hits}	155.0	58.3	149.8	55.2	694.1	66.1	13126	37.5	13370	1.6
μ p_{T}	151.4	57.0	144.8	53.3	646.3	61.6	12592	36.0	9004	1.1
$\not{E}_T$	132.4	49.8	126.7	46.7	544.9	51.9	10560	30.2	2845	0.3
Jet E_{T}	128.0	48.2	118.1	43.5	528.7	50.4	10024	28.6	1581	0.2
b-tag	64.6	24.3	63.8	23.5	280.9	26.8	2508	7.2	1451	0.2

	ZZ		WW		WZ		Wt	
	n_{evt}	ϵ [%]	n_{evt}	ϵ [%]	n_{evt}	ϵ [%]	n_{evt}	ϵ [%]
No cuts	16100.00	100.00	114300.00	100.00	49900.00	100.00	62000.00	100.00
L1	2023.07	12.57	19257.69	16.85	6995.98	14.02	19468.15	31.40
HLT	1136.72	7.06	14175.78	12.40	4595.79	9.21	11466.27	18.49
n_μ	767.20	4.77	1392.23	1.22	1130.24	2.27	2213.77	3.57
μ isolation	571.58	3.55	836.48	0.73	815.87	1.64	631.94	1.02
n_{hits}	564.33	3.51	830.75	0.73	805.88	1.61	620.01	1.00
μ p_{T}	425.06	2.64	518.50	0.45	618.76	1.24	382.87	0.62
$\not{E}_T$	263.25	1.64	408.21	0.36	391.72	0.79	155.00	0.25
Jet E_{T}	224.61	1.40	389.59	0.34	356.79	0.72	132.48	0.21
b-tag	114.32	0.71	77.35	0.07	124.75	0.25	115.26	0.19

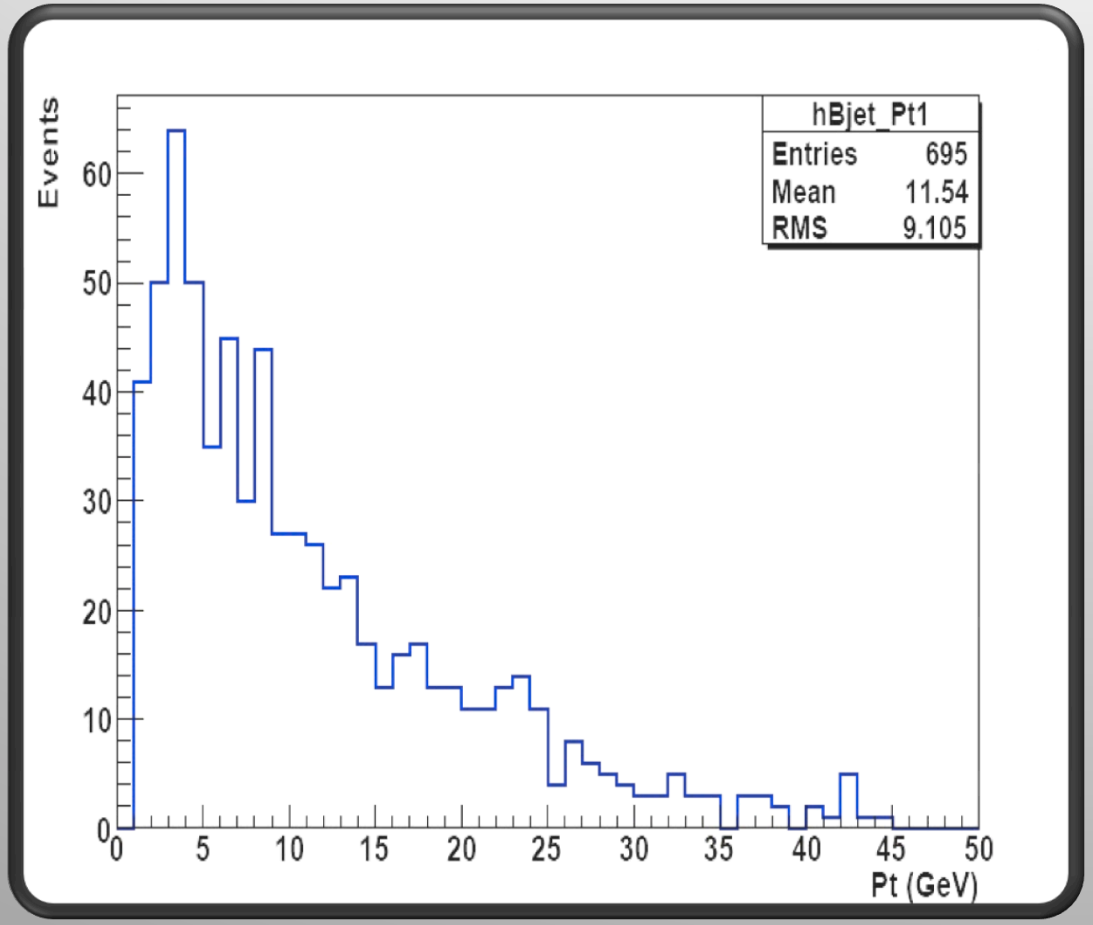
fitting & calculating the significance



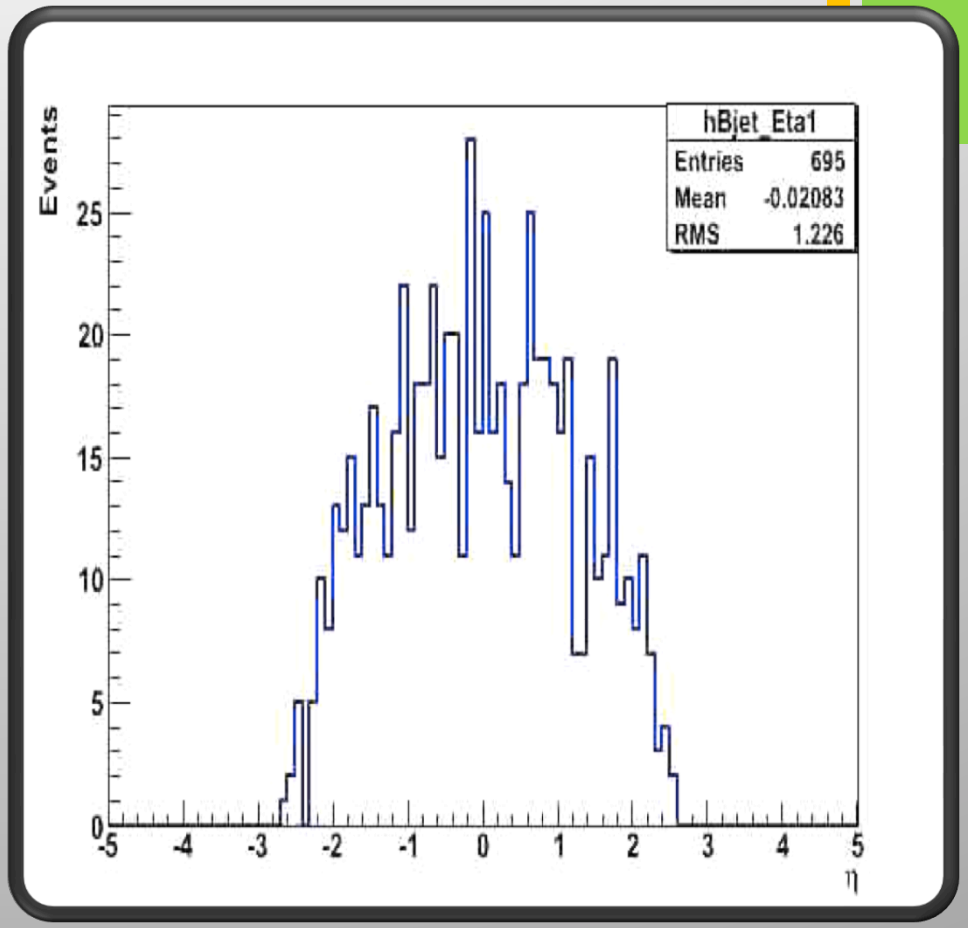


The profile likelihood method is used to calculate the probability of a discovery or an exclusion of a signal

b jets

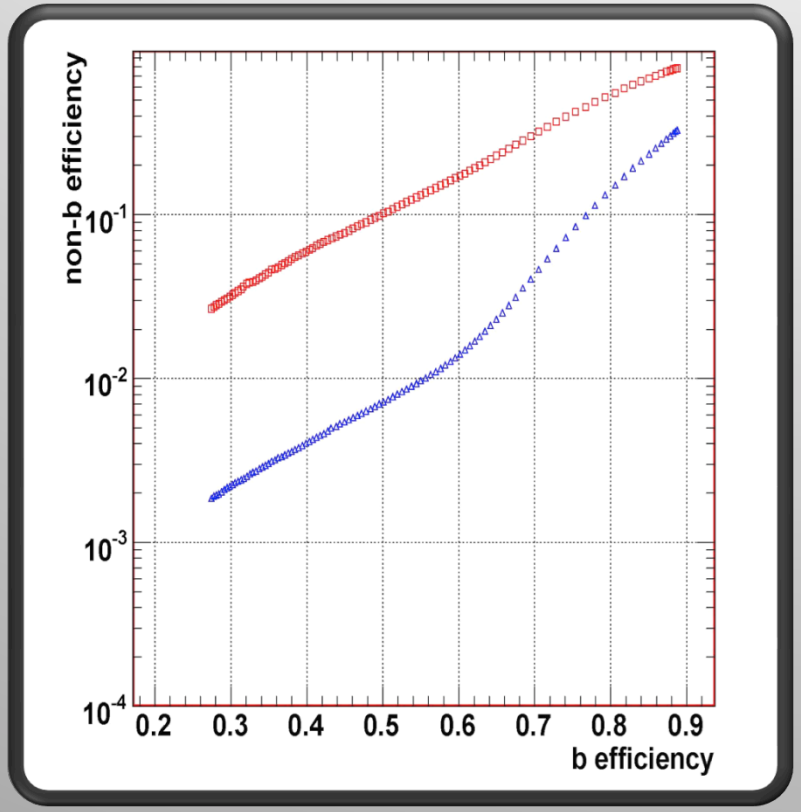


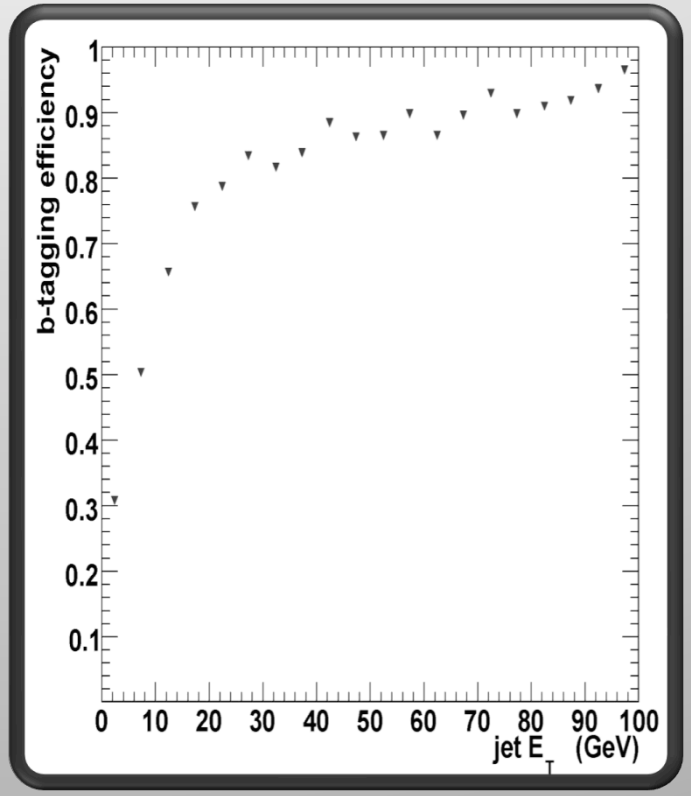
E_T of tagged b jets



η of tagged b jets

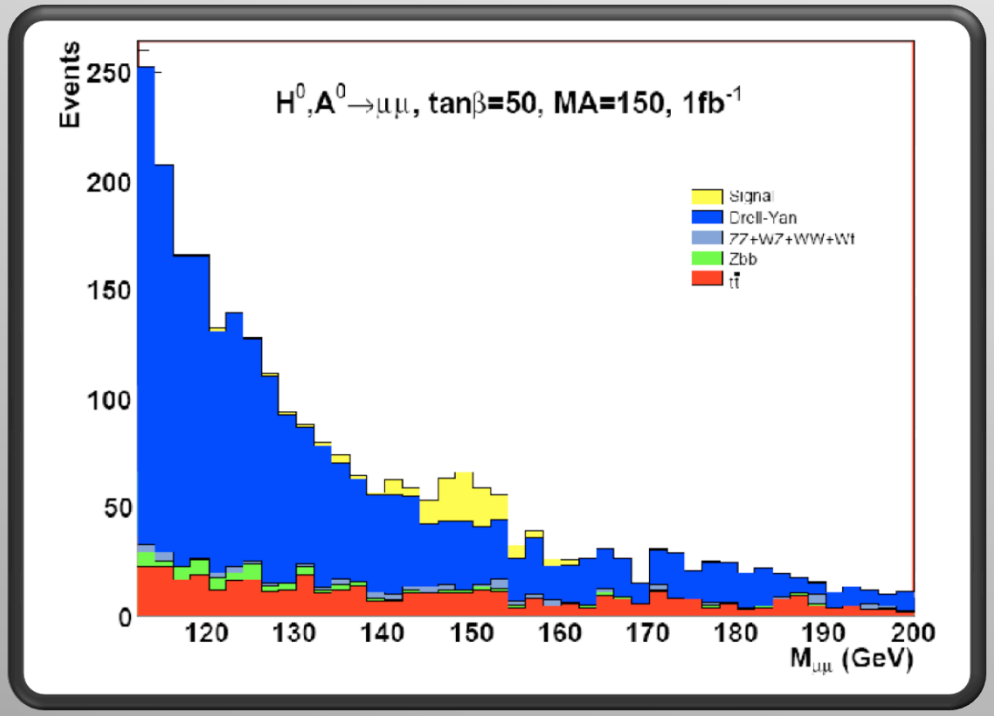
B-Tagging performance (track-counting algorithm)

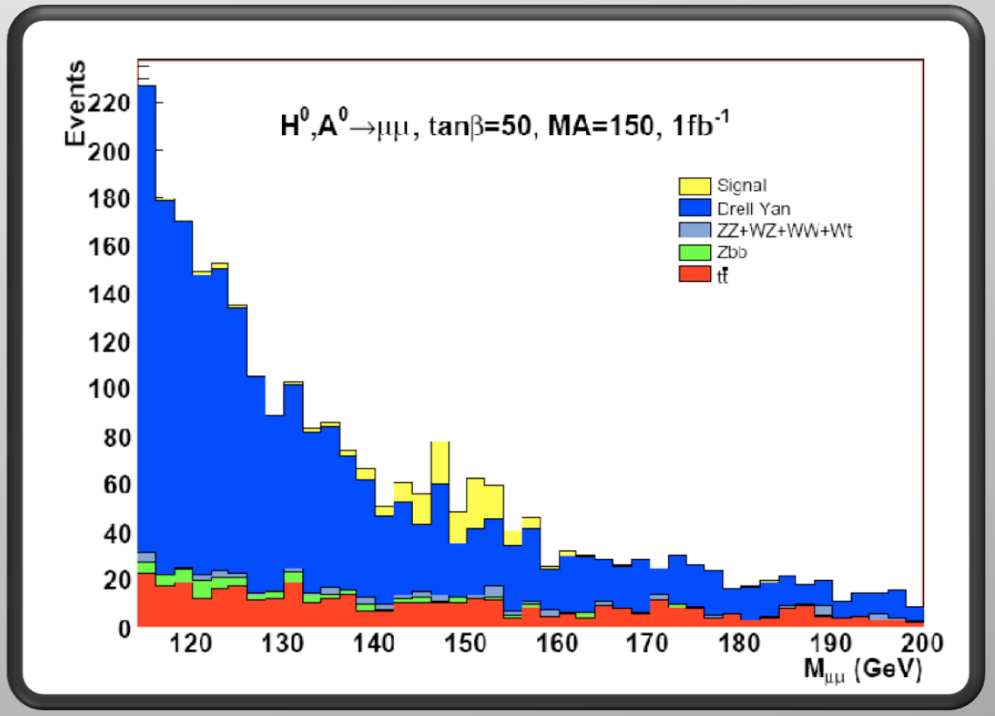




- Very low b-tag efficiencies for low E_T and a mistag efficiency which needs to be considered
- Alternatives should be studied

misalignment





decrease in significance of the O(10%) as a result of misalignment