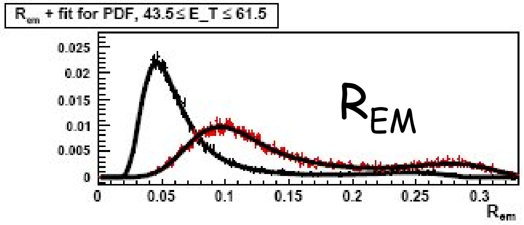
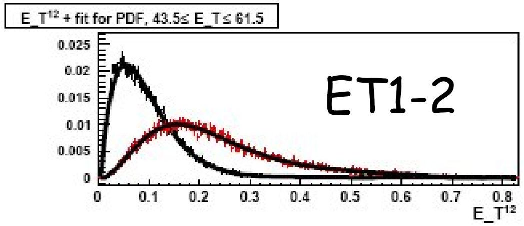
Particle ID for top, Higgs and SUSY

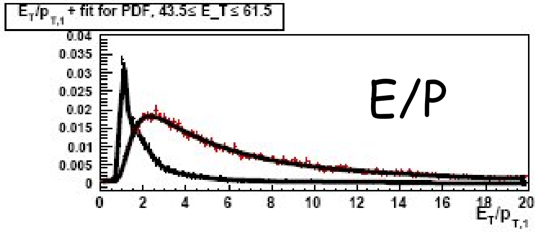
- Tau ID (end of it)
- Jets and Missing E_T,neutrinos
- Trigger strategy and rates
- W and Zs
- B tagging
- Top physics
- Higgs search
- SUSY
- Conclusions

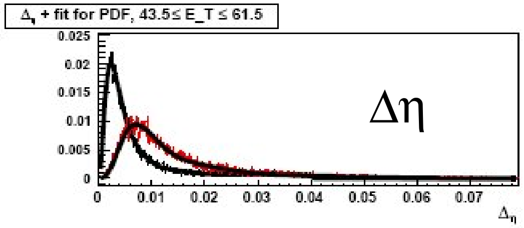
Offline Tau identification in Atlas

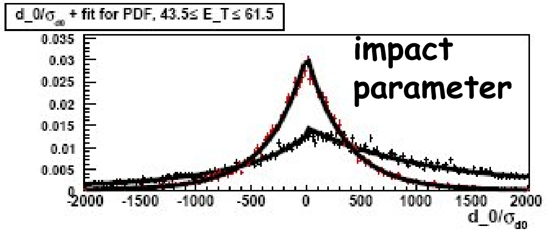


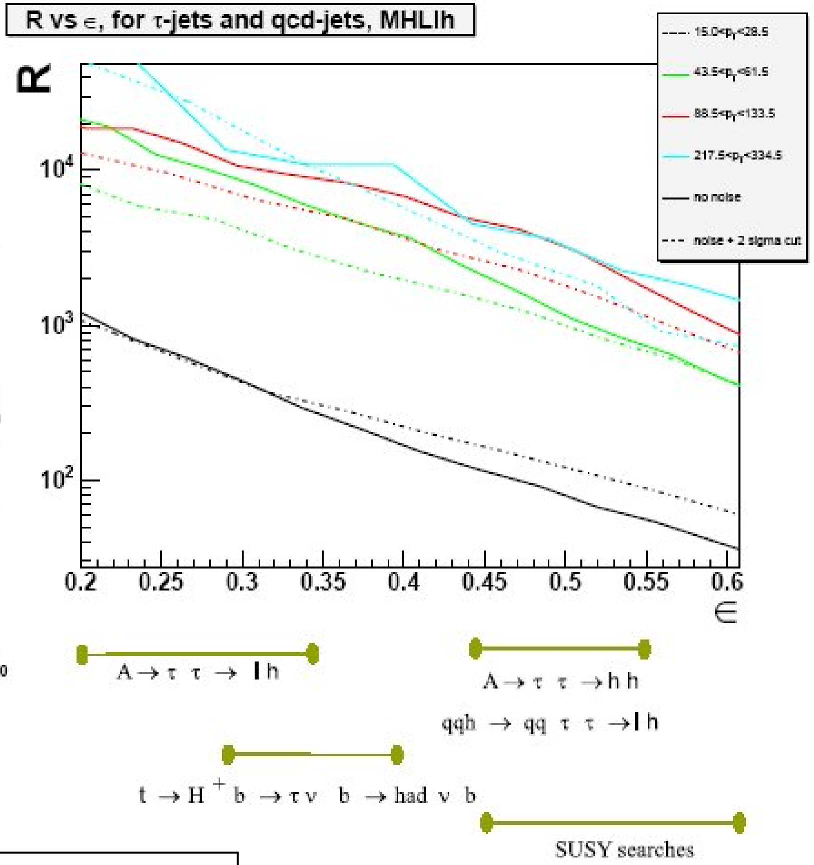
~50 GeV τ−jets











Variables used: Ntr, charge, and from top to bottom

R_{EM} , ET1-2, Δη , E/P, impact parameter

At 50 GeV (green) QCD jet rejection >1000 for τ-jet acceptance=50%

Jets

- Jets are comparatively easier to trigger on and reconstruct.
- Cross-section decreases very fast with E_T
  accurate E_T measurement at trigger level is important
  → large cluster size like 0.8 x 0.8 or more
  →correct weighting of EM and HCAL energies (ATLAS and CMS calorimeters are non-compensating…)
- Ability to separate nearby jets→ smaller cluster size preferred

•ATLAS works with a 4x4 window of 0.2x0.2trigger cells
•A LVL1 internal logic eliminates dble counting and finds core of triggering jet, which defines RoI for HLT
….all that every 25ns for the whole solid angle…

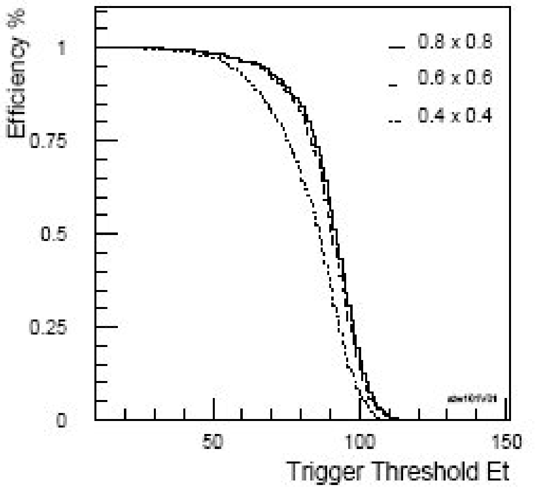


Figure 4-31 Jet trigger efficiency curves for 100 GeV E_T jets, for different cluster sizes, at luminosity 10^{33} $cm^{-2}s^{-1}$.

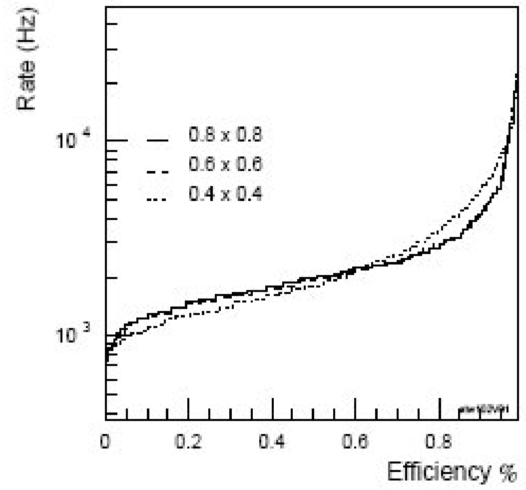


Figure 4-32 Trigger rate vs. efficiency for 100 GeV E_T jets, for different cluster sizes, at luminosity 10^{33} $cm^{-2}s^{-1}$.

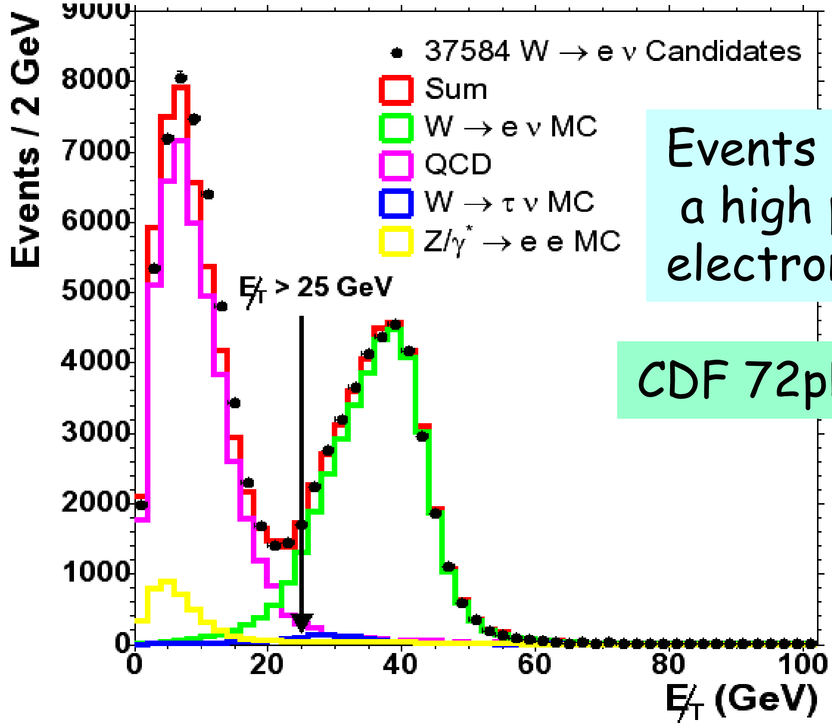
Missing E_T at the trigger/reconstruction level

•From the position and energy of each of the calorimeter cells, are calculated, summing on EM and HCAL sections.
-ΣE_x and ΣE_y a 2-vector in the transverse plane whose modulus is E_T miss
-ΣE_T in the transverse plane, also called "total E_T"

•If there are no missing particles $\Sigma E_x = 0$ and $\Sigma E_y = 0$,ie MET= 0
•Accuracy limited by :
-fluctuations of sampled energies, and noise (option=threshold)
-uncovered solid angle (η>5),(high E, but $*\sin(\theta) \rightarrow 0$=OK)
-cracks,…

•Conversely E_T miss >Eth signs (a) missing particle(s): a neutrino(s) or something more exotic….

LVL1: use calo trigger cells
HLT and offline: use calo cells, apply weighting and zero suppression for better MET resolution



Events with a high p_T electron

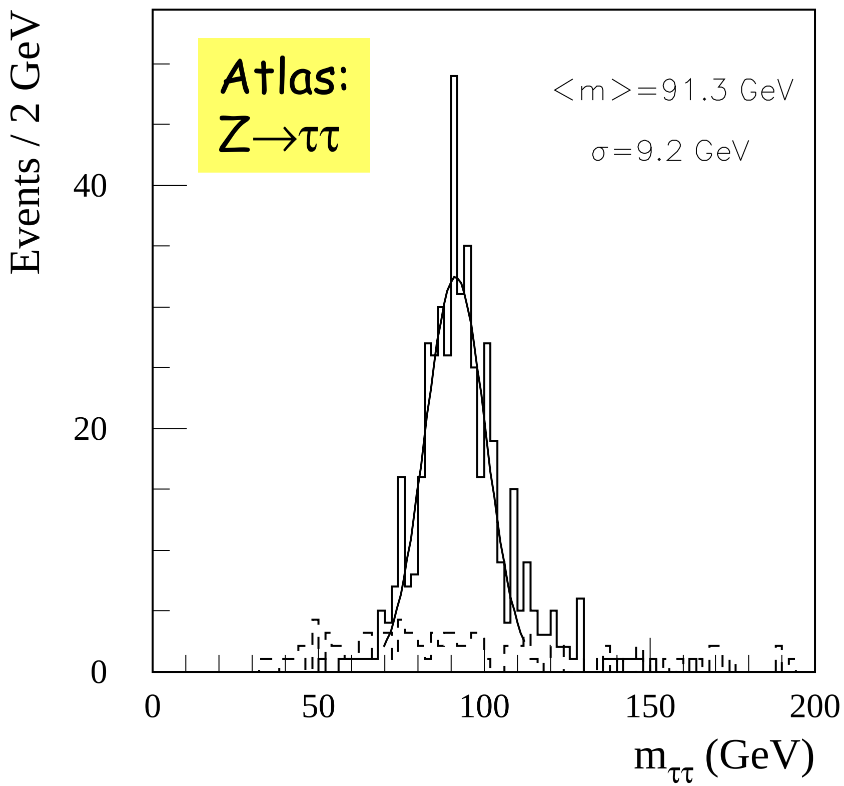
CDF 72pb^{-1}

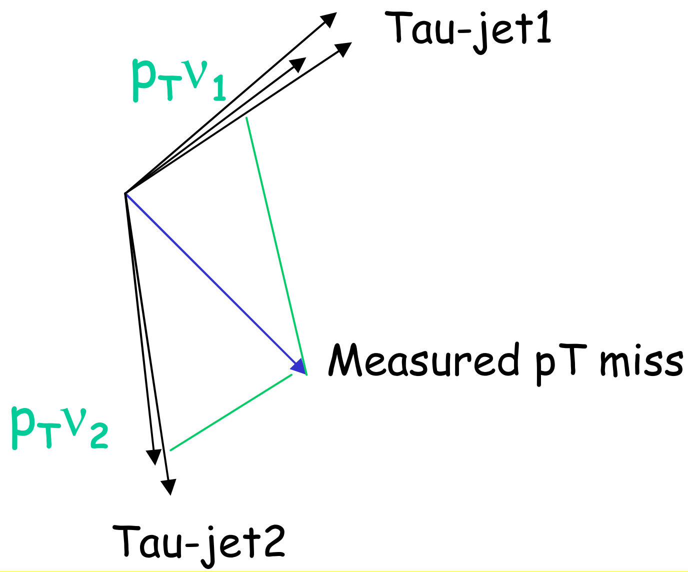
From missing E_T to missing particle(s)

Need hypotheses….to be confirmed by event analysis:

•Single particle missing (ν,neutralino,..) MET = its transverse momentum

•Two particles missing = ambiguous in the transverse plane.
can be solved (transverse and longitudinal) if missing particles are decay products of two "massless" parents, like taus, of which other decay particules are identified (as a narrow jet).



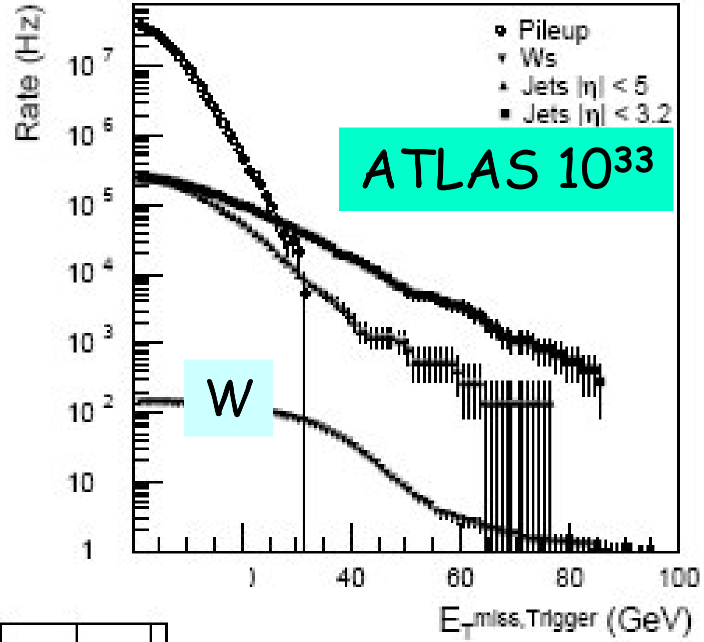


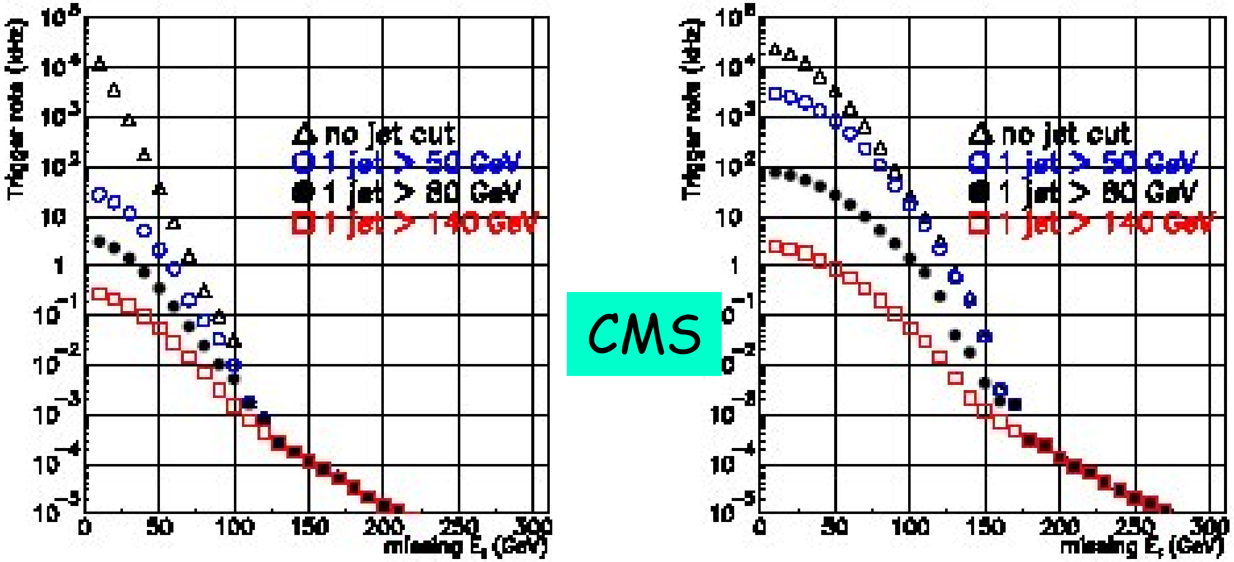
Allows to reconstruct invariant mass of the two particles

Missing E_T in the trigger….

LVL1 MET trigger

→too high rate in stand alone to catch for example $W \rightarrow \tau\nu$
→use it combined with other signatures:
-E_T miss +taus
-E_T miss +jets (SUSY),….





10^{34},MET alone
100 GeV→ 40 kHz

Figure 15-47 Event rates as function of E_T^{miss} when requiring a jet above various thresholds. Left: low luminosity; right: high luminosity.

Expected LVL1 rates at "low" L

Table 15-1 Level-1 Trigger table at low luminosity. Thresholds correspond to values with 95% efficiency.

Trigger (CMS 10^{33})	Threshold (GeV or GeV/c)	Rate (kHz)	Cumulative Rate (kHz)	ATLAS 10^{33}
Inclusive isolated electron/photon	29	3.3	3.3	20GeV/11 kHz
Di-electrons/di-photons	17	1.3	4.3	15GeV/2 kHz
Inclusive isolated muon	14	2.7	7.0	6GeV/23 kHz
Di-muons	3	0.9	7.9	
Single tau-jet trigger	86	2.2	10.1	
Two tau-jets	59	1.0	10.9	20-30/2kHz
1-jet, 3-jets, 4-jets	177, 86, 70	3.0	12.5	180-75-55/0.6 k
Jet * E_T^{miss}	88 * 46	2.3	14.3	50*50/0.4 kHz
Electron * Jet	21 * 45	0.8	15.1	
Minimum-bias (calibration)		0.9	16.0	
TOTAL			**16.0**	40 kHz

HLT reduces to <~200 Hz the rate to "permanent storage", keeping the thresholds energies at or very close to the LVL1

A possible strategy

Selection signature	Examples of physics coverage
e25i	$W \to e\nu$, $Z \to ee$, top production, $H \to WW^{(*)}/ZZ^{(*)}$, W',Z'
2e15i	$Z \to ee$, $H \to WW^{(*)}/ZZ^{(*)}$
μ20i	$W \to \mu\nu$, $Z \to \mu\mu$, top production, $H \to WW^{(*)}/ZZ^{(*)}$, W',Z'
2μ10	$Z \to \mu\mu$, $H \to WW^{(*)}/ZZ^{(*)}$
γ60i	direct photon production, $H \to \gamma\gamma$
2γ20i	$H \to \gamma\gamma$
j400	QCD, SUSY, new resonances
2j350	QCD, SUSY, new resonances
3j165	QCD, SUSY
4j110	QCD, SUSY
τ60i	charged Higgs
μ10 + e15i	$H \to WW^{(*)}/ZZ^{(*)}$, SUSY
τ35i + xE45	$qqH(\tau\tau)$, $W \to \tau\nu$, $Z \to \tau\tau$, SUSY at large tan β
j70 + xE70	SUSY
xE200	new phenomena
E1000	new phenomena
jE1000	new phenomena
2μ6 + $\mu^+\mu^-$ + mass cuts	rare b-hadron decays ($B \to \mu\mu X$) and $B \to J/\psi\ (\psi')X$

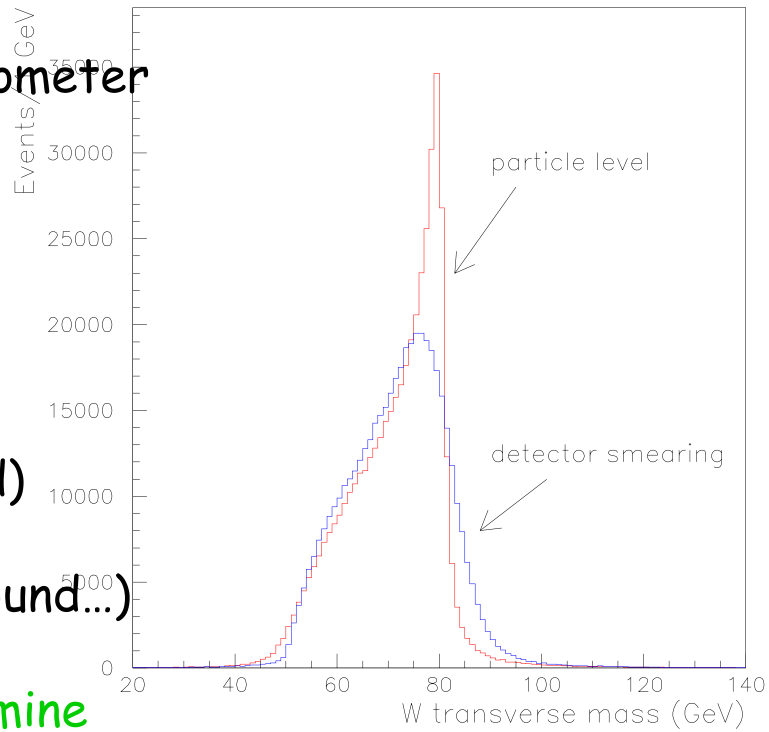
ATLAS 2×10^{33} final selection

W and Zs to calibrate the detector and make important SM measurements

From cross-section, acceptance (η<2.5 and trigger) & luminosity $\Rightarrow$event rate
Assuming 100 days at 2 10^{33} gives:

-5 10^6 $Z \rightarrow ee$ and 5 10^6 $Z \rightarrow \mu\mu$ to mass storage (0.5 Hz each)
-5 10^7 $W \rightarrow e\nu$ and 5 10^7 $W \rightarrow \mu\nu$ "" ""

Using the Z mass constraint (known to 2 10^{-5})
-calibrate the EM calorimeter and muon spectrometer
-calibrate the E_T miss scale
-measure the W mass to ~20 MeV/expt
using lepton + $E_T$miss evts ("transverse mass")
-calibrate the jet scale using Z+jet events
and γ +jet evts (using p_T balance)
Remember that:
-no inclusive $Z \rightarrow$ jet-jet evts (QCD background)
-no inclusive $W \rightarrow$jet-jet evts (but wait/top...)
-barely inclusive $Z \rightarrow \tau\tau$ (threshold,QCD background...)

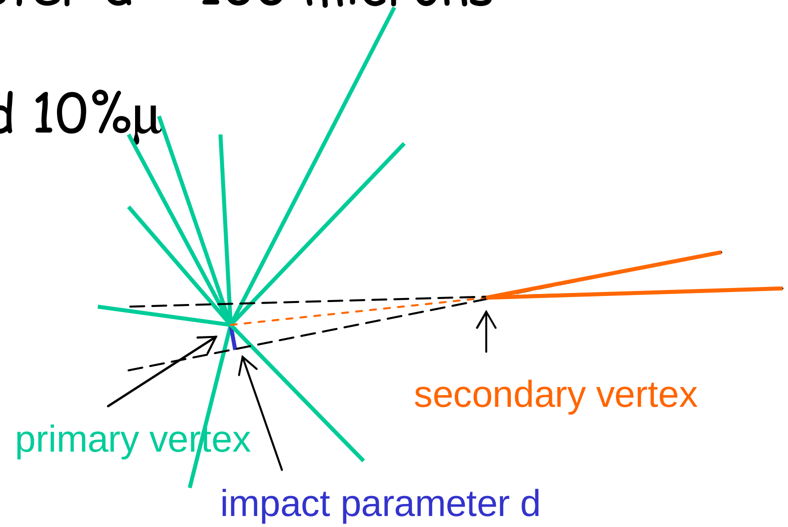


From WW, WZ, Zγ, ZZ,..in the final sate determine Triple Gauge bosons couplings and probe SM.

Vertex detectors and B-tagging

Requirements based on b-jets parameters

- -B hadrons lifetime : average of ~1.6 ps
- -$c\tau$ =470 microns $\rightarrow$impact parameter d ~100 microns
- -need accuracy : < 20 microns on d
- -semi-leptonic fraction ~10%e, and 10%μ



Accuracy limited by

- -lever arm,
- -granularity,
- - number of layers

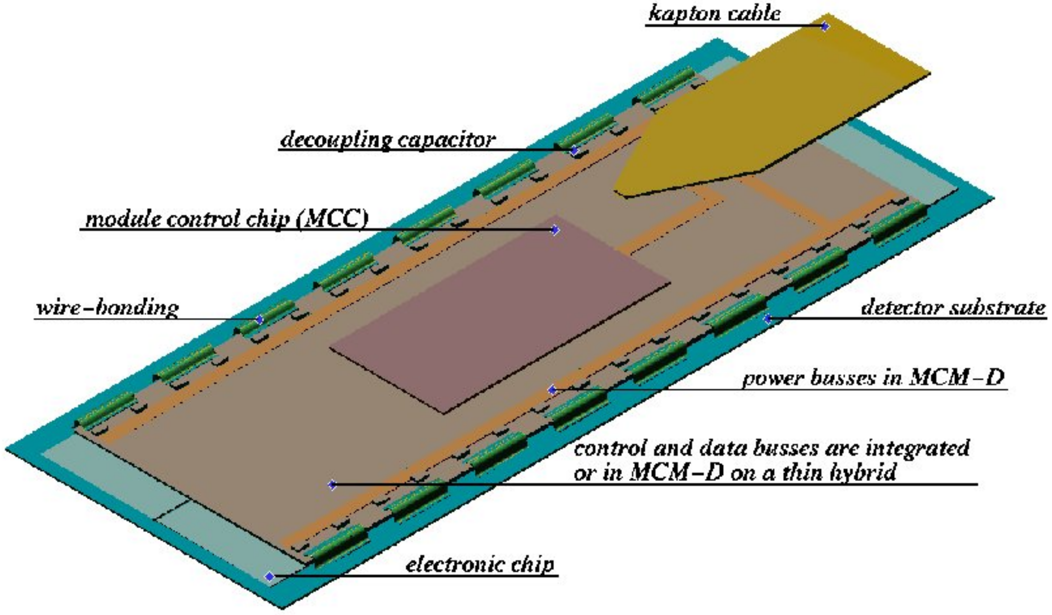
Solution(Atlas and CMS)

- -3 layer pixel detector
- -first layer as close as possible to beam pipe(5cm)
  Can it be reduced later ?(Tevatron=2cm)
- -single hit accuracy < 15 microns in rϕ
- -equipped with fast electronics

Beware of -radiation damage
- -multiple scattering in material
- -power dissipation

Atlas pixels

- 3 cylinders R= 5cm, 10cm, 13cm
- 2 x3 disks
- Sensor: " n + n oxygenated " ,
- FE Electronics IBM 0.25 μm
- 82 M pixels 50 x 400 μm
- 2.8% X_0/layer



Carbon fiber mechanical support
Length about 80cm

Pixels electronics

FE electronics and readout architecture

-80 million channels to be "looked at" every 25 ns !!

-fastpreamp, good S(15ke)/N (200e)for mips $\rightarrow$digital or few bits r/o

-all FE chips proceed in parallel, controlled by local MicroControler

-occupancy small ($<<10^{-2}$) : logic by columns

Schematically:

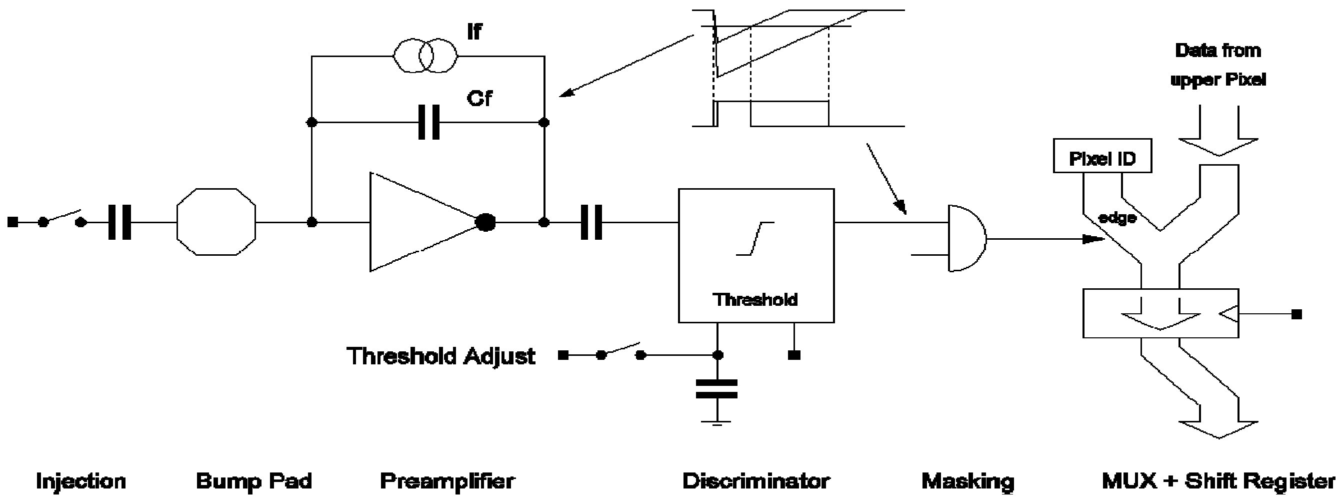
-each FE chip covers 24 columns of 160 cells [400 x 50 μm]=~1cm^2

-at the bump bond pad is connected preamp + discriminator

-the End of Column logic drains data from columns=

address of hit pixel(s) in the column +bunch counter

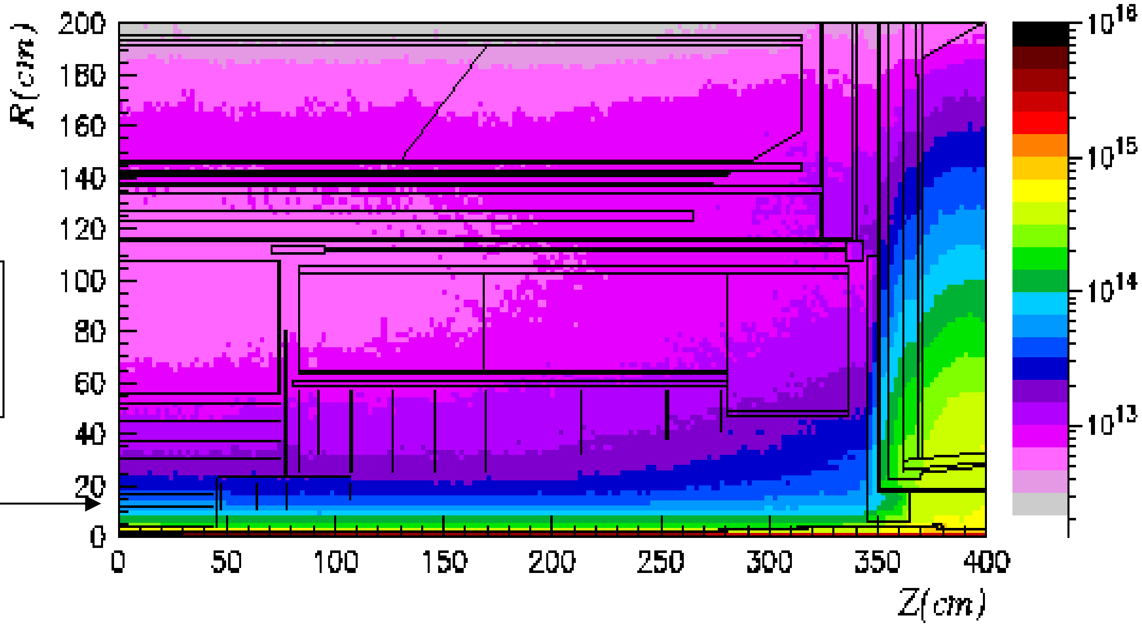
-upon LVL1 signal(<100kHz) the MC scans over its FEchips(~12) gather the hit pixel adresses +bc ,keeps those with proper bc,and clears the buffers.

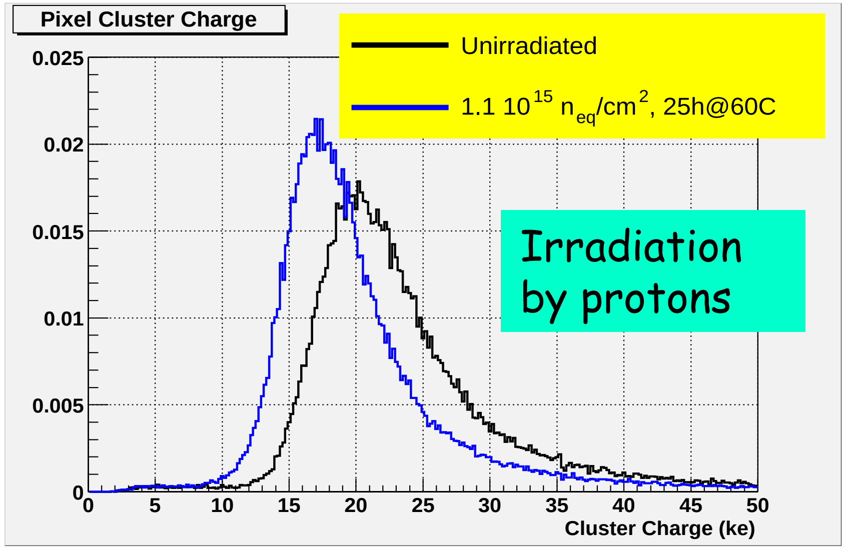


Pixels: radiation damage

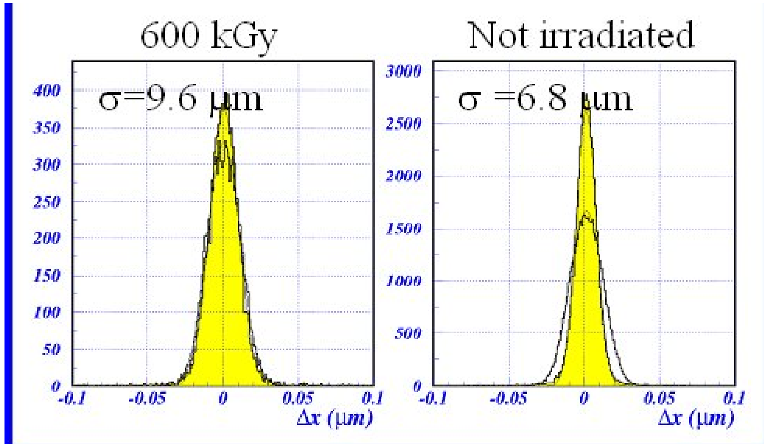
Expected neutron fluence per year at high luminosity⟶

10^{14} n/cm²/year



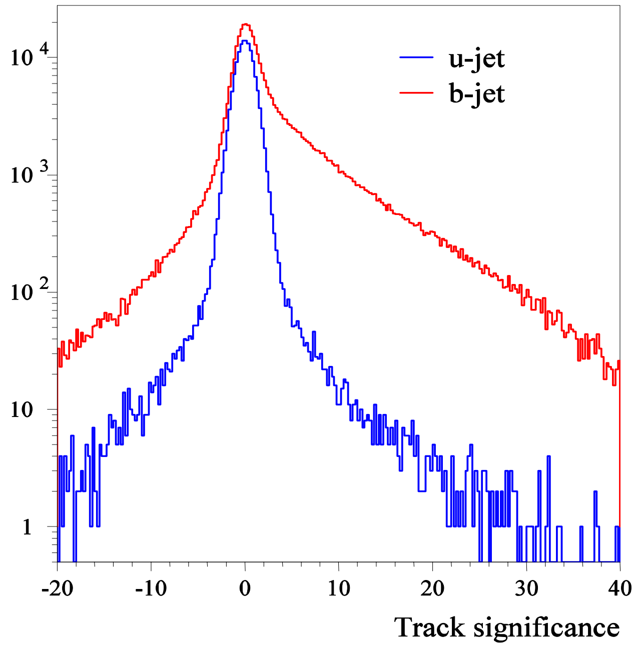


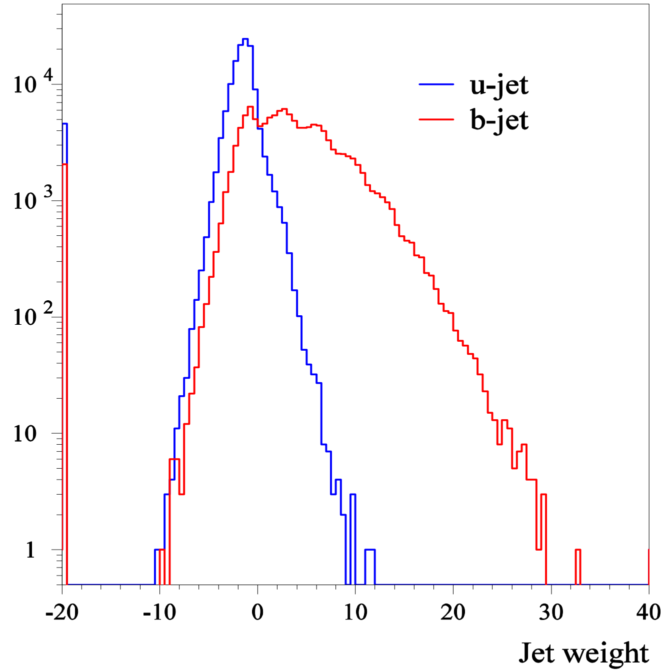
Irradiation by protons



Spatial Residuals (Rϕ direction) with charge interpolation, B off, 10^0 incidence
TDR specifications: 13 μm

B-tagging expected performance



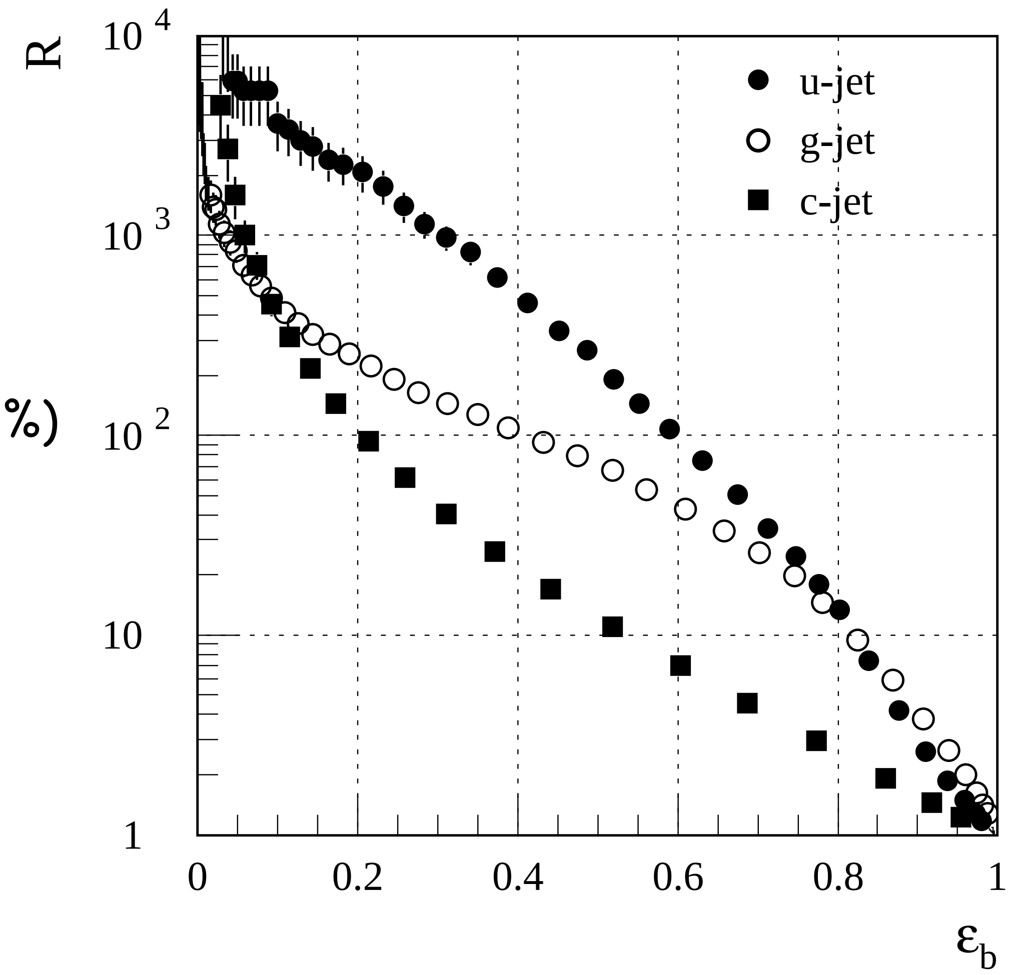


- Start from a calorimeter jet (incl tau-jet..)
- Reconstruct tracks, and select those with p_T>cut (~1 GeV/c) and $\Delta R<0.4$
- Measure d (with a sign), calculate $s=d/\sigma$
- Calculate jet weight as Σlog(signif as b/signif as u)from all its tracks
- Adjust cut position
- Positive tails in u-jets ? secondary interactions,V_0
- Negative tails in b-jets ? Jet direction $\neq$ B direction

B-tagging expected performance

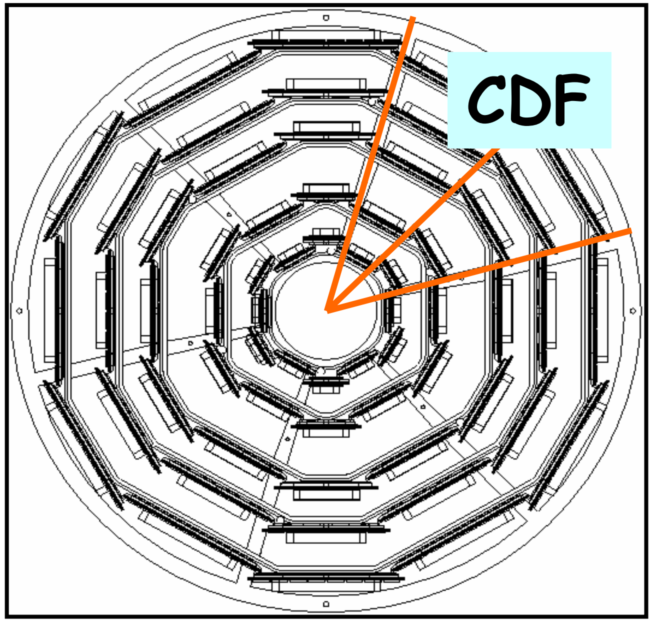
- Full offline reconstruction
- Based on jet weights
- B jet sample from H(100)→bb and H(400)→bb
- Background from jet-jet events same p_T range
- L=2 x 10^{33} (at 10^{34} rejection reduced by ~20%)
- Ru ~100 for 60% efficiency
- Rc more modest because cτ (D+)=300 μm, (D0)=120 μm
- Rg limited by gluon splitting to cc

- Soft lepton tag
  -identification of electrons and muons in cone axis adds a few % efficiency each (BR=10% each)



B-tagging in HLT?

- CDF is using it for selection of "unbiased" B decays
- Starting from LVL1 with 2 tracks >2 GeV/c pT
- Done in a "hardware oriented" way with a processing time of 25 μs/event



> - 12 independent sectors
> - 4 layers(out of 5) of micro-strips grouped to 250 μm pitch
> - 1 point/tracker (ϕ, p_T) + hit pattern compared to 32000 masks

- Interesting approach in LHCb/Velo

- In ATLAS-CMS events to be processed,at LVL2 have in general several jets
Some trial at LVL2-Atlas, not really convincing
- Need "real tracking" to decide if some of the jets are B-jets or not.
Efficient way to do it is at the Event Filter level, with ~full offline performance

B-tagging in HLT:CMS example

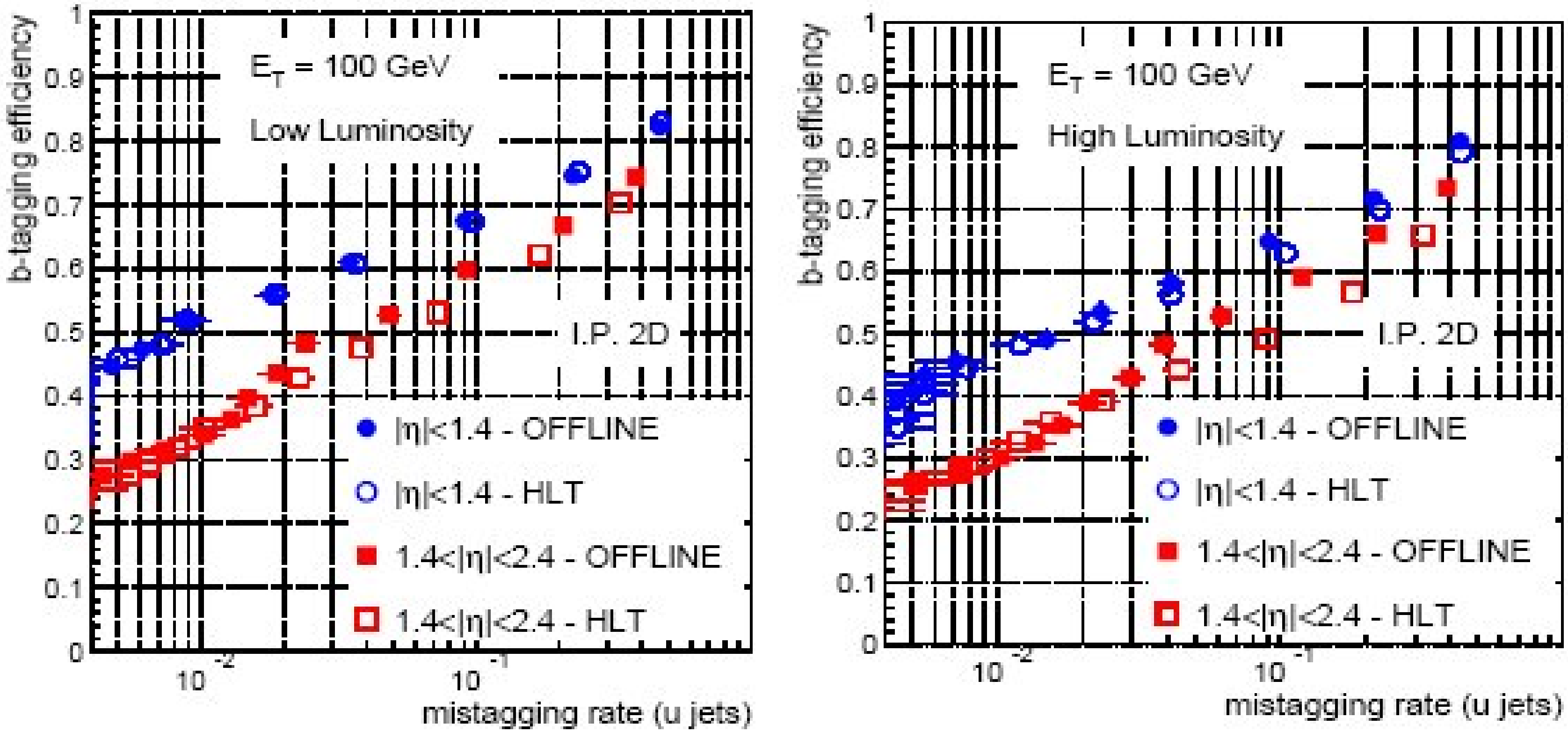


Figure 15-68 Efficiency for the *b*-tag versus mistagging rate for jet with E_T=100 GeV in the low (left) and high (right) luminosity scenarios.

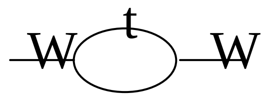
- Reconstruct Tracks in a cone defined by Calo-jet
- Ask for at least 2/3 pixel hits.
- Labelled as b-jet if ≥2 tracks above thresh significance

Particle ID for M(top) measurements

M(W) , M(top) and M(Higgs) are linked in the standard model:

F[M(top),log(M(H)]

$$M(w) = K(\alpha, \sin(\Theta_W), G_F) \,/\mathrm{sqrt}(1-\Delta r)$$



G_F, a_{EM}, $\sin\theta_W$ known with high precision,

precise measurements of M(top) and M(W)

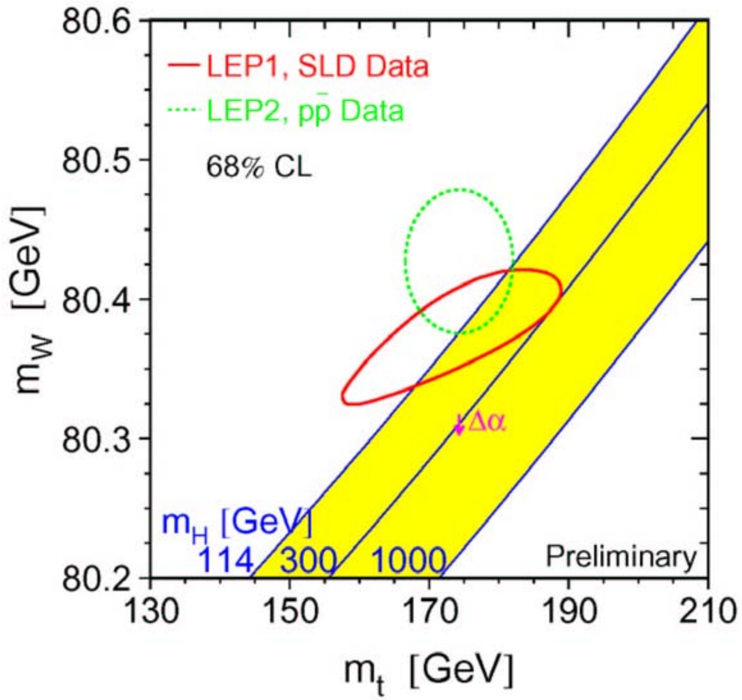
constrain M(H) (weakly because of log term)

10 MeV M(W) $\rightarrow$~1 GeV M(top)

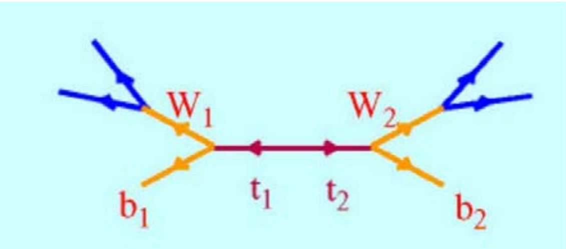
To day (CDF+D0) M(top) = 172.5 $\pm$ 2.3 GeV

Best strategy to measure it at LHC?

[event statistics is not the main problem]



Particle ID for M(top) measurements



Inclusive tt cross-section at LHC~0.7 nb
(100 x Tevatron)

$t \to bW$ 100%
$W \to l\nu$ 11%each , 67% hadronic; no Bs

$W1 \to had, W2 \to had$	: 44% 2 masses fully rec/ huge QCD BG
$W1 \to e/\mu\nu, W2 \to had$ (+ $2 \to 1$)	: 30% 1 mass fully reconstructed
$W1 \to e/\mu, \nu$,$W2 \to e/\mu\nu$	: 5% rate; mass not fully reconstructed
Others: one $W \to \tau$	: not appropriate for precise M meast

Semi-leptonic final sate:
expect 2.5 million evts for $10 fb^{-1}$
- one electron or muon → LVL1 Trigger
- two b jets → Rejection of QCD bckg fact 100/jet
- two non-b-jets Minv=M(W) → Masse scale
- missing E_T → Rejection of QCD bckg, Reconstruction of 2nd top
- in average 2 or 3 g jets/QCD
- underlying event

Particle ID for M(top) measurement

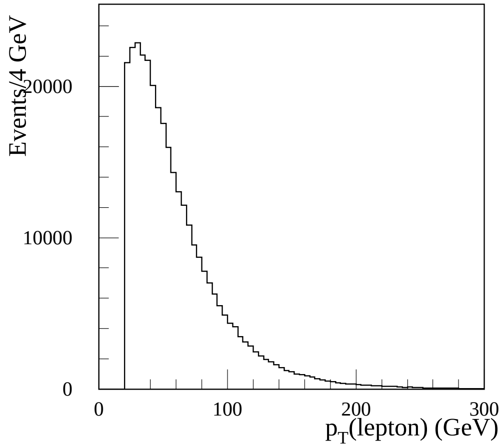
Selection

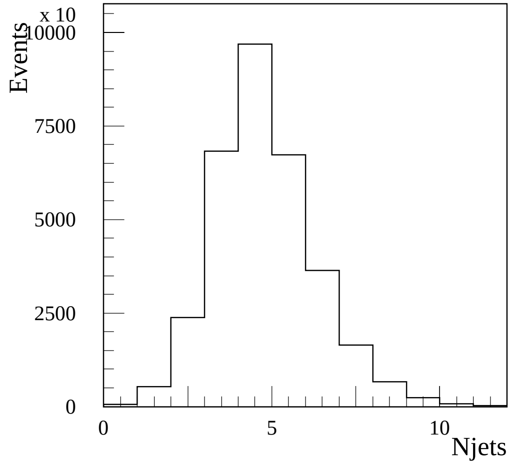
- 1 iso lepton, pT > 20 GeV, |η| < 2.5
- pTmiss > 20 GeV
- ≥ 4 jets with pT > 40 GeV, |η| < 2.5
- ≥ 2 jets with b-tag

Selection efficiency. = 5%
⇒ 126k events, with S/B ~65

Process	$p_T^l > 20$GeV $E_T^{miss} > 20$GeV	As before, plus $N_{jet} \geq 4$	As before, plus $N_{b\text{-}jet} \geq 2$	Events per 10 fb^{-1}
$t\bar{t}$ signal	64.7	21.2	5.0	126 000
W+jets	47.9	0.1	0.002	1658
Z+jets	15.0	0.05	0.002	232
WW	53.6	0.5	0.006	10
WZ	53.8	0.5	0.02	8
ZZ	2.8	0.04	0.008	14
Total background				1922
S/B				65

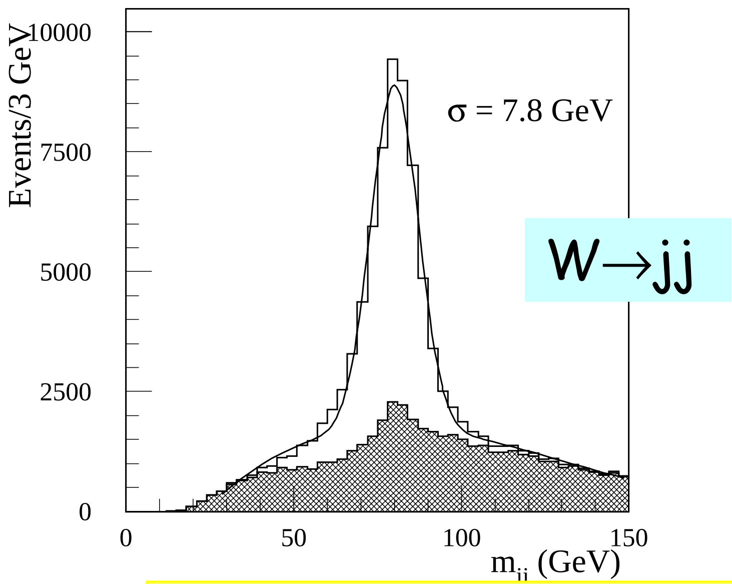
Efficiency of cuts

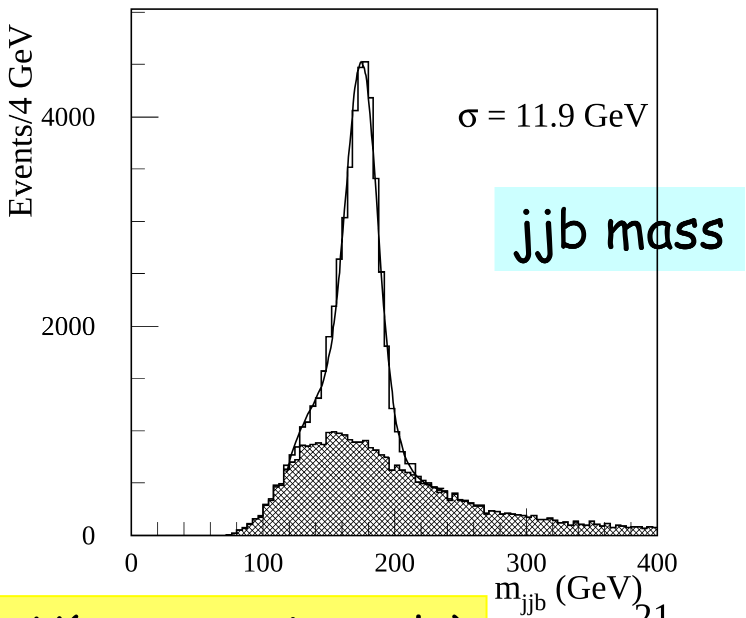




W-ID from "top" sample

- Semi-leptonic ttbar events contain W→jet-jet evts with good S/N
  - ⇒identified hadronic W decays
- This sample of jets is used to adjust the (non-b) jet –scale, starting from jets normalized using photon-jet evts (p_T balance)
- B-jets are normalized from photon(or Z)+ B-id jets (only)
- Remaining uncertainties on jet scales dominate the top mass systematic uncertainty
- Hadronic Ws in jj used in other places (H→WW,..)

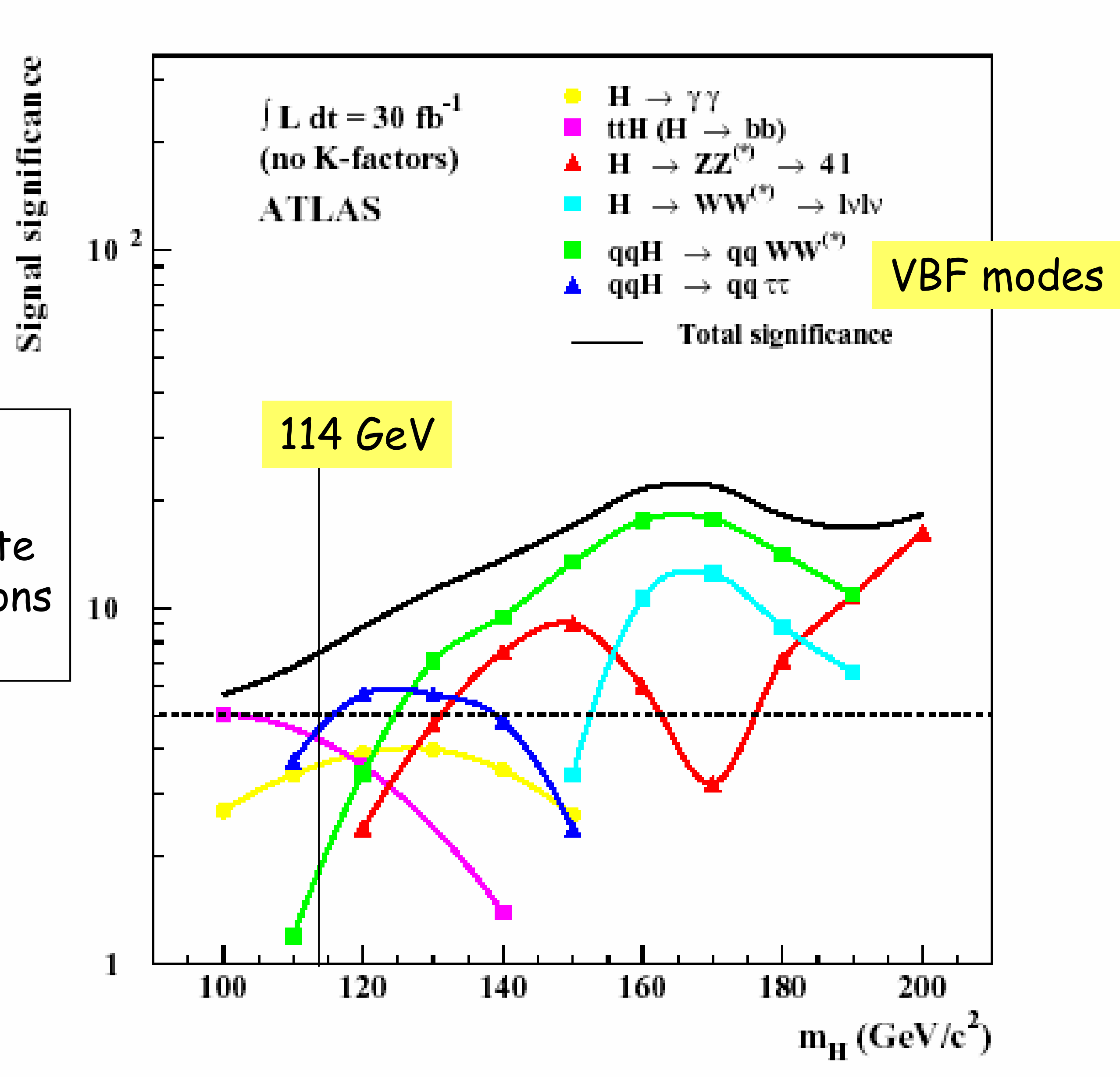




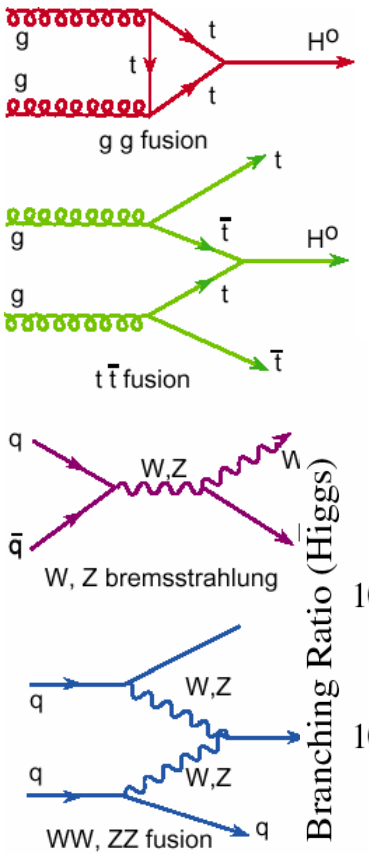
Expected M(top) accuracy : ~1 GeV(systematics only)

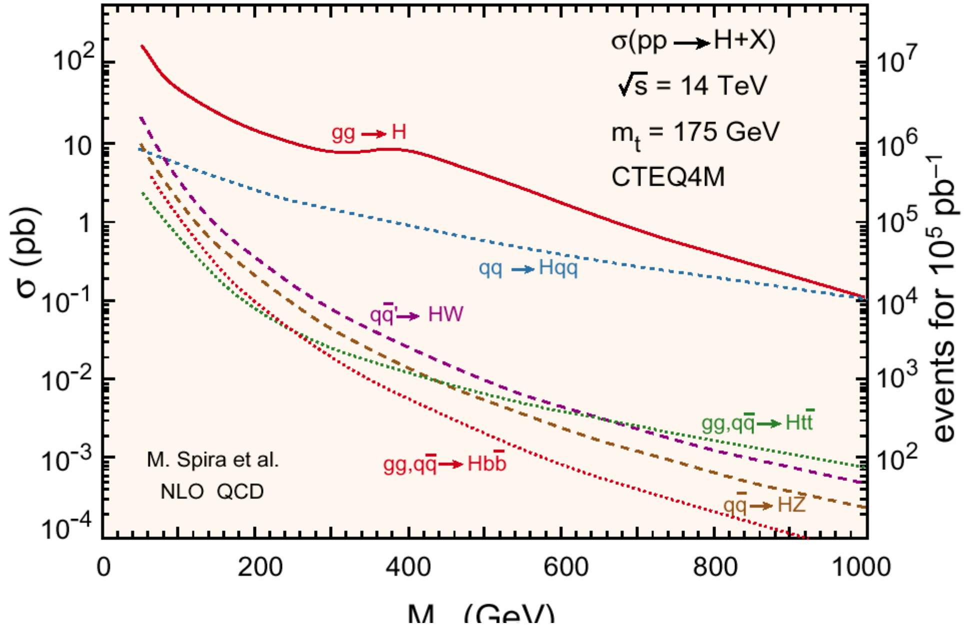
SM-Higgs search global view

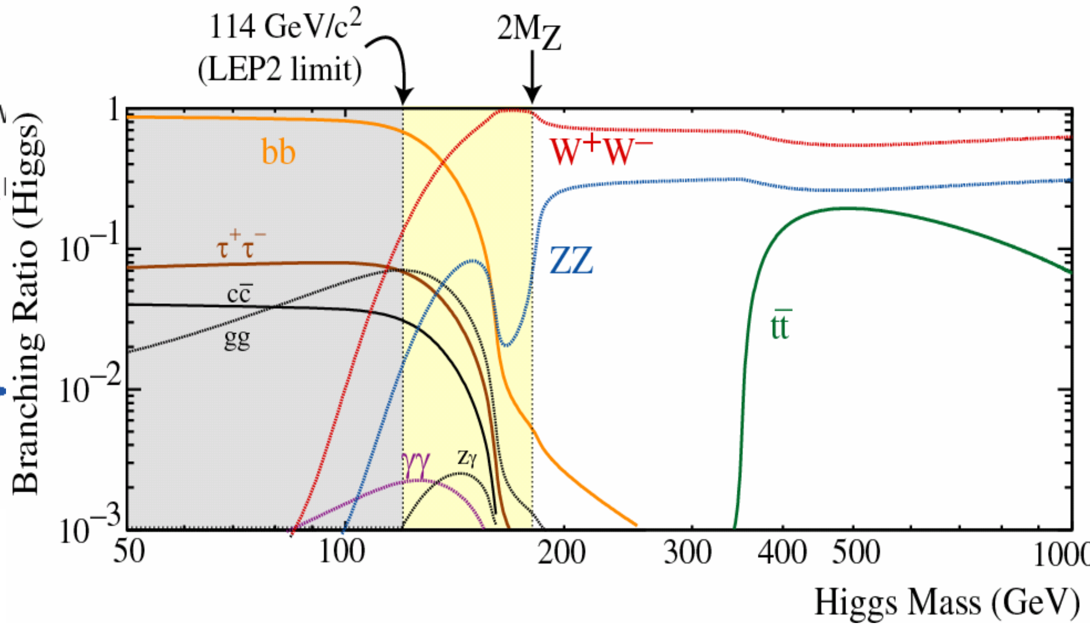
Each channel based
on well identified
particles in the final state
In general containing leptons
and/or gauge bosons

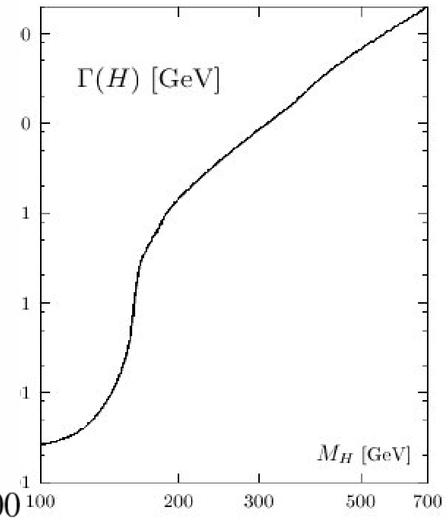


Production and decay





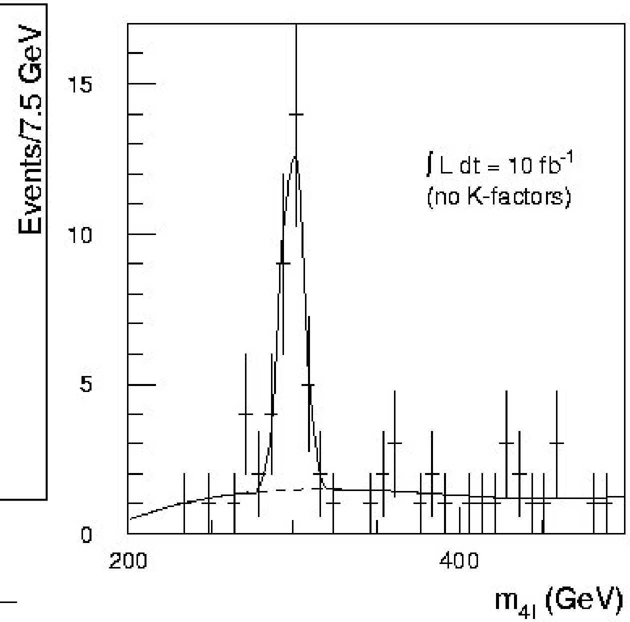




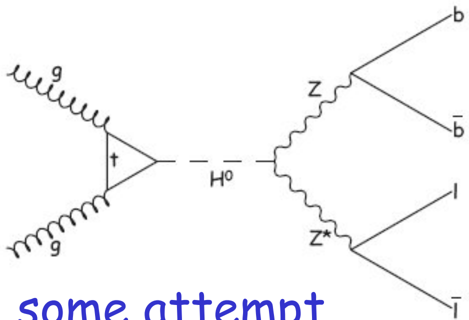
The ZZ "gold plated" mode

M(H)>180 GeV : ZZ mode open

-"Gold plated channel " with each $Z \to ee$ or $\mu\mu$
- Two M(ll)=M(Z) constraints
- Irreducible background (only) = non resonant ZZ
- Main limitation is rate,when M(H) increases
- Adding evts with one $Z \to \tau\tau$ could help (trig/otherZ)
- Using $Z \to \nu\nu$ (*6 ee or $\mu\mu$) allows to extend search up to 700 GeV



Higgs mass (GeV)	200	240	280	320	360	400	500
$BR(H \to ZZ)$	0.26	0.29	0.30	0.31	0.30	0.28	0.27
$\sigma \times$ BR (fb)	12.4	11.2	9.6	8.9	8.7	6.8	3.2
Signal (no p_T cut)	134	127	110	105	105	86	44
Background (no p_T cut)	74	57	43	33	29	29	17
$S/\sqrt{B}$ (no p_T cut) for 30 fb^{-1}	15.6	16.8	16.8	18.2	19.3	15.9	10.7



-what about one Z in jet-jet? BG "Z +2 jets" is large....some attempt with one Z in two b jets ("pedagogical" reaction of the beginning)
In fact,does not bring much....

ZZ* 130<M(H)<180 GeV

- still 4 leptons ee or μμ
- only one M(ll)=M(Z) constraint remaining
- dip in the BR at 2M(W)
-Zbb main reducible background can be reduced applying a veto on displaced vertices
-important issue : acceptance of the lower PT lepton .Analyses require 2 lepons pT>20 GeV (trigger) and 2 leptons with pT>7 GeV (offline)

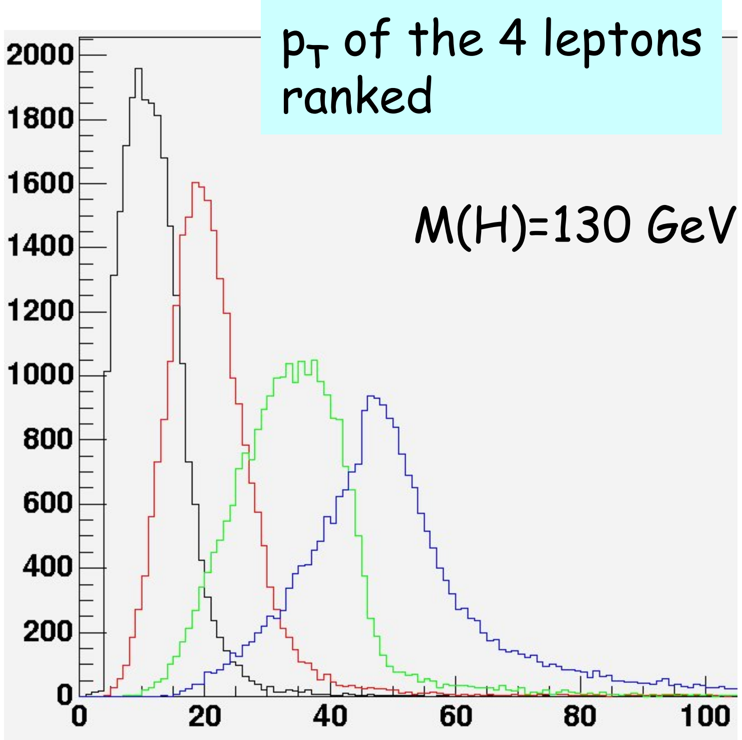


Table 19-14 Signal and background rates after all cuts and signal significances as a function of m_H, for $H \to ZZ^* \to 4l$ events and for an integrated luminosity of 30 fb^{-1} (low luminosity performance).

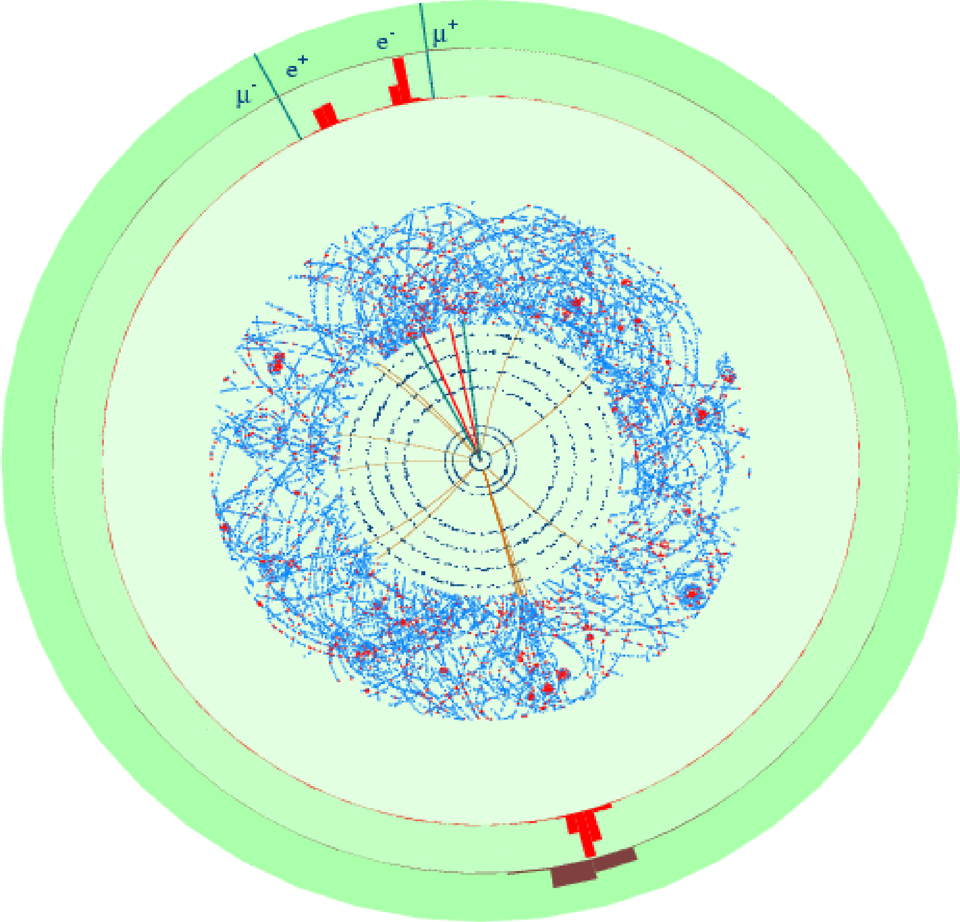
Higgs mass (GeV)	120	130	150	170	180
Signal	4.1	11.4	26.8	7.6	19.7
$t\bar{t}$	0.01	0.02	0.03	0.02	0.02
$Zb\bar{b}$	0.08	0.12	0.19	0.17	0.19
ZZ^*	1.23	2.27	2.51	2.83	2.87
$ZZ \to \tau\tau ll$	0.13	0.20	0.25	0.08	0.02
Significance ($S/\sqrt{B}$)	3.4	7.0	15.5	4.3	11.2
Significance (Poisson)	2.4	4.8	15.5	3.2	11.2

In 50% of cases the softer lepton has Pt < 10 GeV/c (not a trigger problem)

30 fb^{-1}

ATLAS barrel

H → ZZ* → eeμμ (M(H)=130 GeV)



High luminosity

Higgs in 2 photons

For M(H)<150 GeV, most promising channels are:
$H\rightarrow\gamma\gamma$ (inclusive) and $H\rightarrow\tau\tau$ in association with 2 forward jets (VBF)

Distinctive features of the $H\rightarrow\gamma\gamma$ mode are:

- -limited $\sigma \times BR$
- -large irreducible background
- -potentially large instrumental background (jet-jet and γ-jet)
- -clean signature
- -high invariant mass resolution

} defining criteria for EM calorimeters

Ultimate photon energy resolution , when all calibration/normalization problems are solved:
CMS : $3\%/\sqrt{E} \oplus (200\text{MeV} \oplus \text{pile-up})/E \oplus 0.55\%$ (??)
ATLAS : $10\%/\sqrt{E} \oplus (200\text{MeV} \oplus \text{pile-up} /E \oplus 0.70\%$ (?)
Remember converted photons are somewhat worse
$\rightarrow \Delta M(H)/M(H) \sim 1\%$ is the (difficult) target

Jet-jet and γ-jet rejection

Overall jet rejection obtained in ATLAS MC full simulation, confirmed by test beam (using fine strips):

-1050 for quark jets

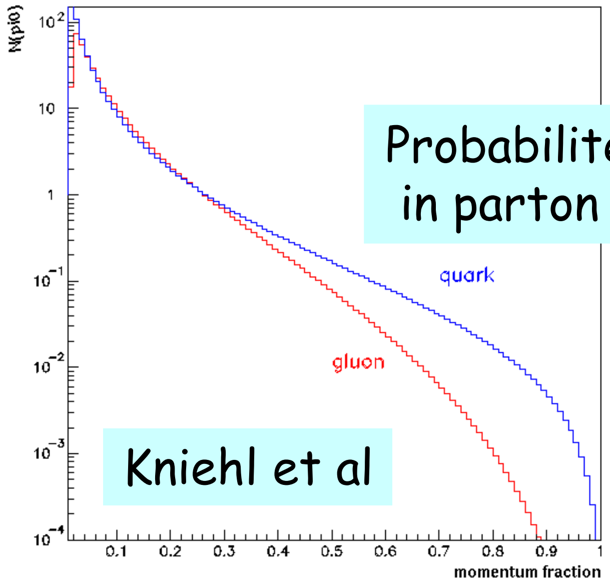
-6000 for gluon jets →Ultimate performance process dependant!

(probability of a high x isolated π^0 is much higher in (MC) quark jet

Higgs mass (GeV)	120	130	140	150
Signal events (direct production)	1190	1110	915	617
Signal events (WH, ZH, $t\bar{t}H$ production)	93	76	58	35
$\gamma\gamma$ background	29 000	24 700	20 600	16 900
Jet-jet background	4600	4100	3550	3050
γ-jet background	5800	4900	4100	3400
$Z \rightarrow ee$ background	-	-	-	
Stat. significance for 100 fb^{-1}	6.5	6.5	5.8	4.3
Stat. significance for 30 fb^{-1}	3.9	4.0	3.5	2.6

100fb^{-1}

- Main jet-jet Bkg=gluon-gluon rejection of 6000 x 6000 OK
- Main γ -jet bkg:γ–quark rejection=1000….



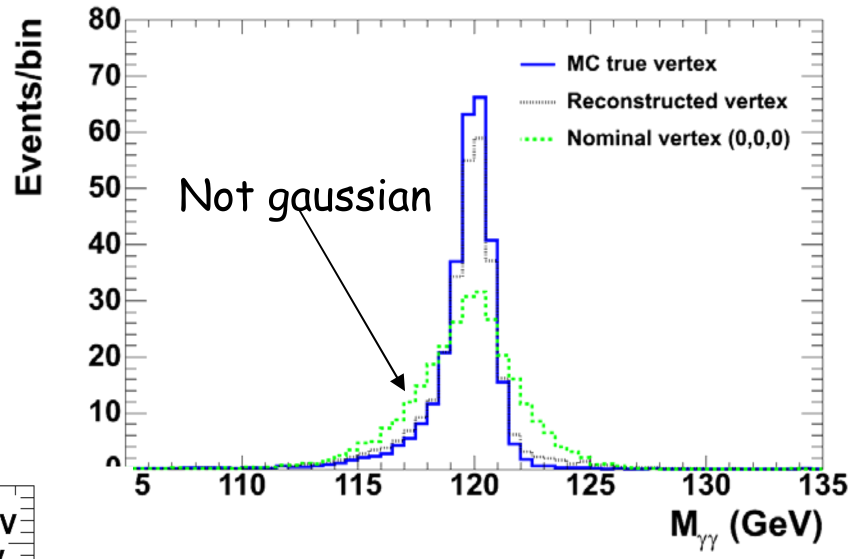
Probabilite of π in parton jet

Kniehl et al

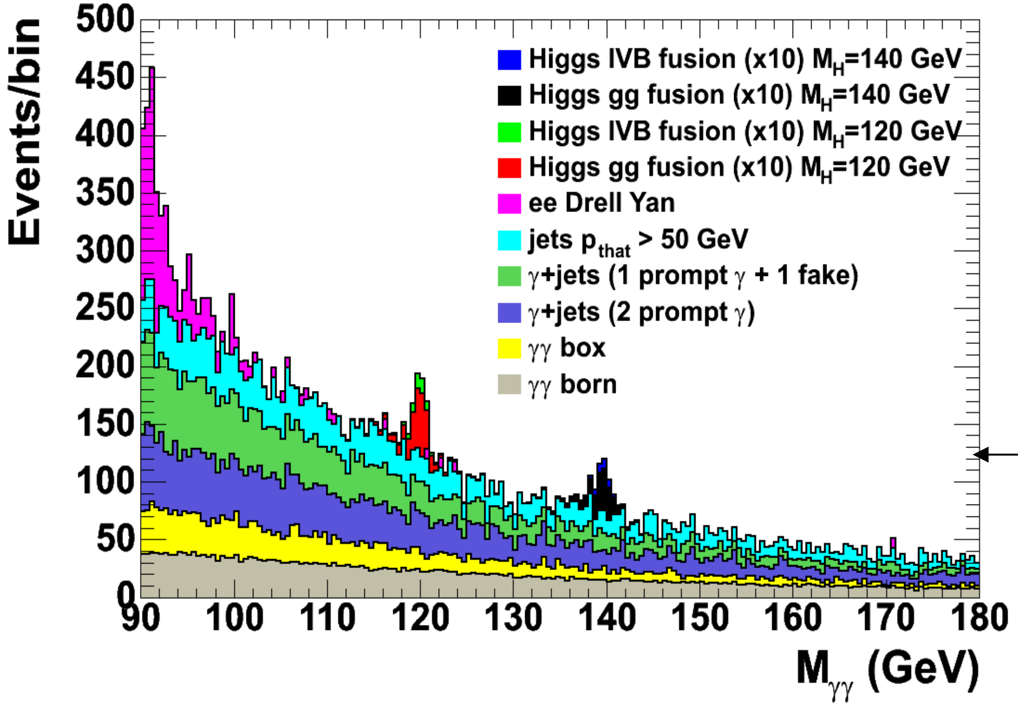
Channel very much dependant on detector Ultimate performance, resolution and photon/ jet identification.

Signal and background in CMS

•Mass resolution degraded by factor~2 if vertex unknown(high luminosity)
•Conversions(at once) do help here



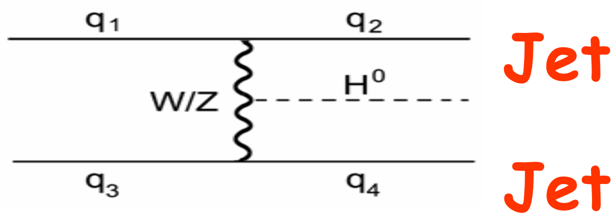
Reducible BG/irreducible = 0.5
Somewhat better in ATLAS which is more granular

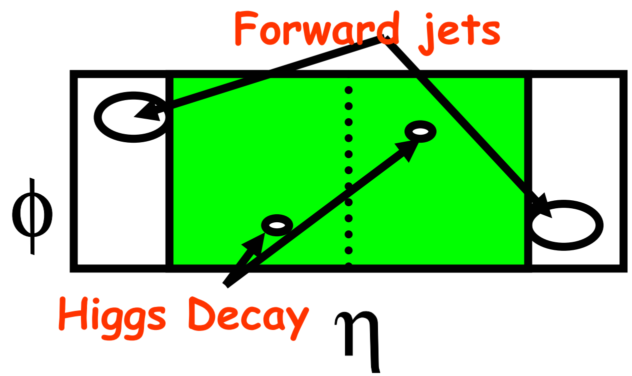


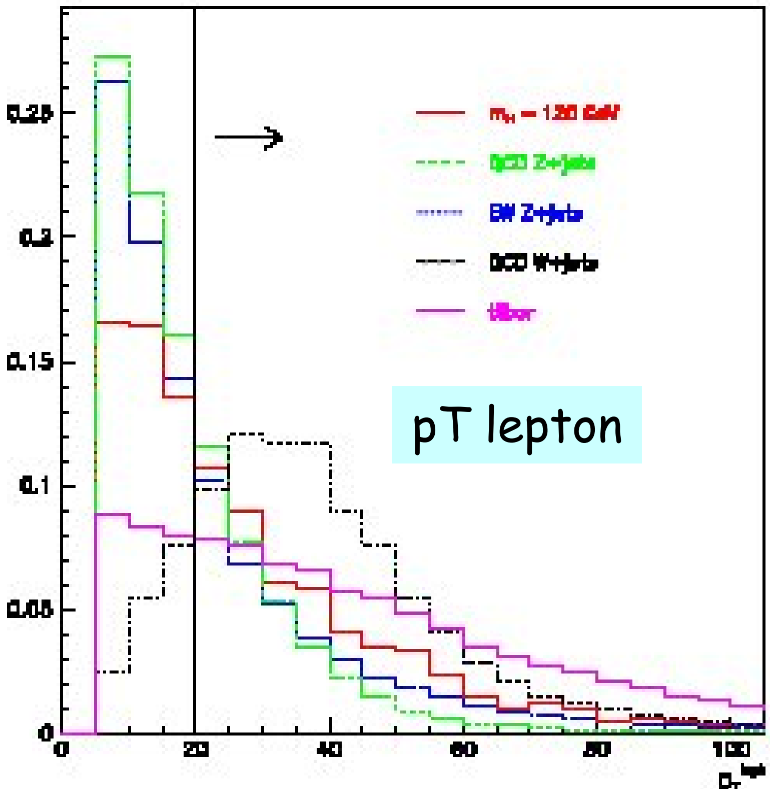
$1 fb^{-1}$
Signal *10
5 σ discovery for 30 fb^{-1}

Higgs → ττ by VBF

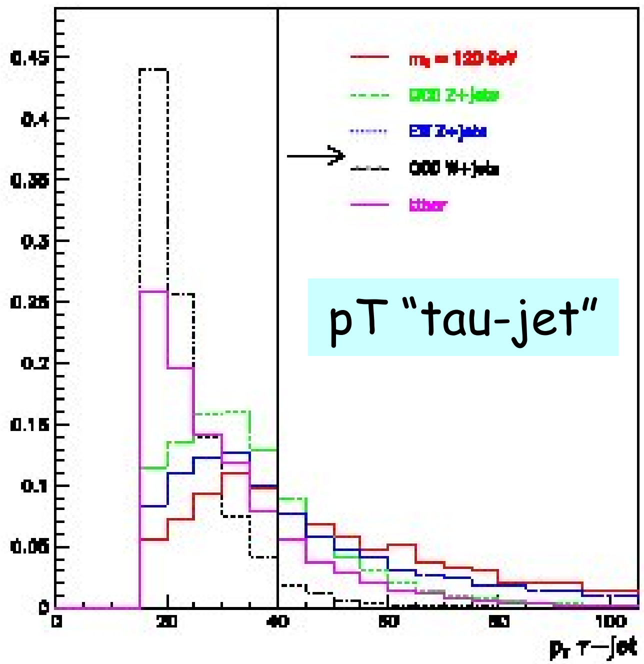
- The ττ mode has a larger BR than γγ but a weaker signature and worse resolution
- Asking 2 forward jets (and no other jet) selects weak process by WW fusion, which has less background







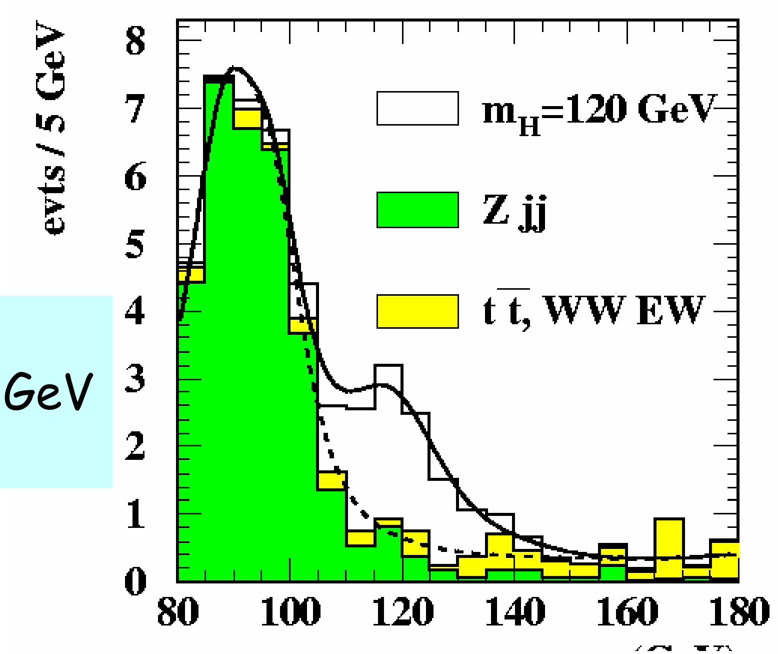
Trigger
- Dilepton: E15mu10
- Lepton-hadron pTlept>20 GeV
  or
  Tau35 xMET45



Higgs →ττ by VBF

Tagging jets:
Δη > 4.4
M(JJ) > 700GeV
Backgrounds:
ttbar, Z+2 jets
Invariant mass:
Calculated using the 2 taus and the missing ET

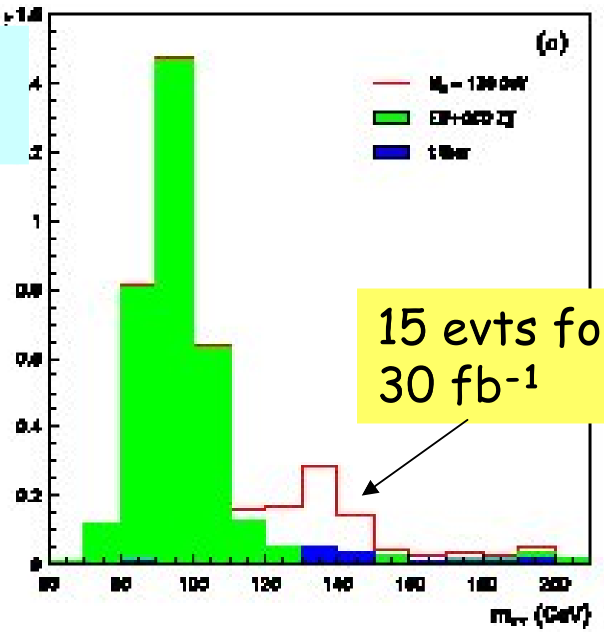
Di-lepton
M(H)=20 GeV
$30fb^{-1}$



σBR in fb

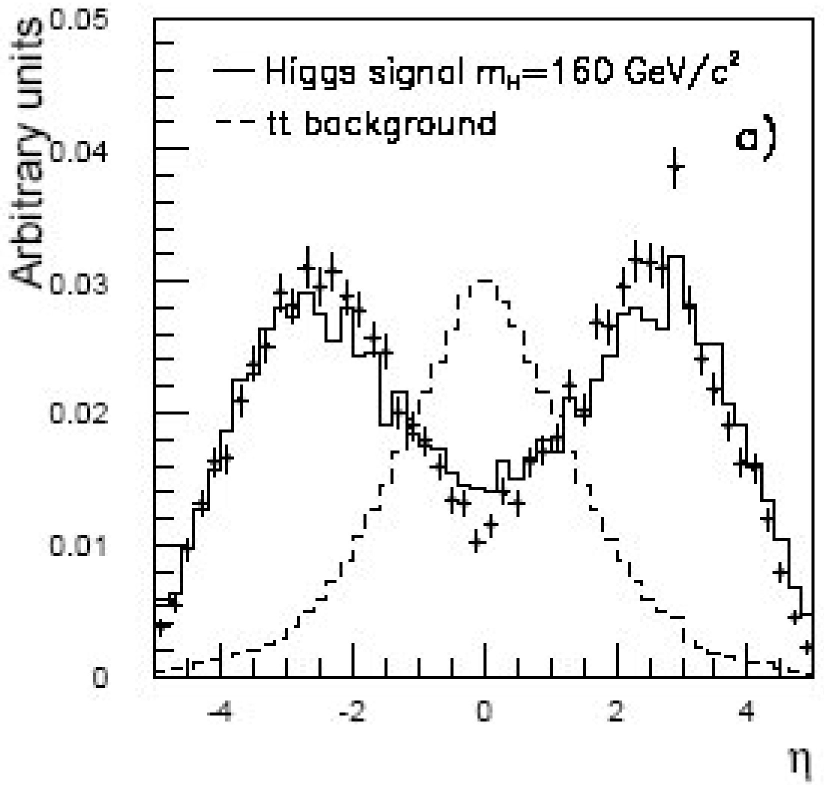
cuts	Hqq	gg fusion	EW Zjj	W+jets	$t\bar{t}$
preselection cuts	28.	101.2	59.3	4.3×10^4	2.07×10^4
lept. trigger	13.7	50.31	22.0	3.4×10^4	1.6×10^4
τ cuts.	6.18	22.65	8.03	3.2×10^3	4.3×10^3
Fwd. tag	1.97	0.176	1.72	30.	29.7
τ decay and reconst.	1.27	0.105	1.09	5.9	6.06
m_T	1.02	0.071	0.92	0.63	1.74
p_T^{miss}	0.81	0.051	0.71	0.58	1.38
m_{jj}	0.71	0.028	0.69	0.37	1.01
Jet veto	0.63	0.014	0.66	0.21	0.14
Mass Window	0.52	0.007	0.06	0.00	0.007

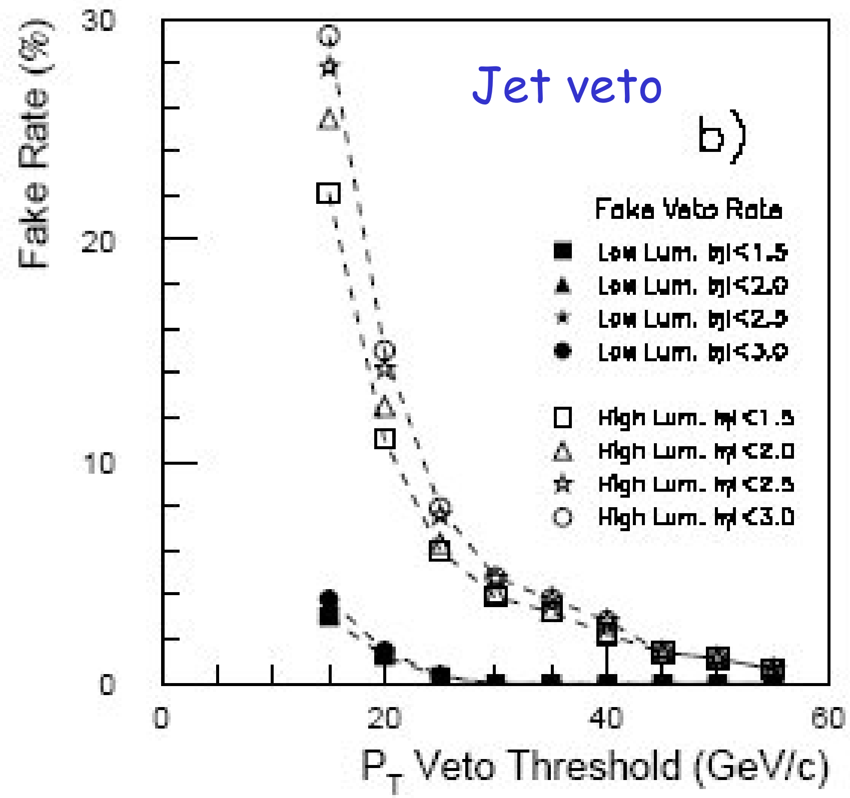
Hadron-lepton
M(H)=130 GeV



15 evts for
$30\ fb^{-1}$

VBF, jet tagging, jet veto





Forward region is a difficult one:
- transition at η=3 between geometries and/or technologies
- Jet tagging sensitive to pile-up noise
- Jet veto problematic at high luminosity

SUSY (just a glance..)

• In the MSSM each fermion $f_{L,R}$ has a scalar partner $sf_{L,R}$, and to each Gauge boson is associated a massless spin ½ gaugino.

• Among other virtues, these states coming with an opposite sign to normal particles in loop corrections, cancel the quadratic divergence of the Higgs mass, which would otherwise run to "infinity".

• None of these particles has been so far observed → heavy !
• sq and sg couple to QCD as usual particles, they should be copiously produced at LHC as soon as threshold is passed.

• In the MSSM R-parity = (-1)**3(B-L)+2S is conserved:
  s-particles are produced in pair
  the lightest one is stable= neutralino χ^0

• Exact signatures depend on the details of the model

• A common feature is large ΣE_T and missing energy (neutralinos)

• The reach of experiments can be evaluated and compared using as parameter m_0 ($m_{1/2}$) the common mass of all scalars (spin ½) at GUT scale

CMS-SUSY reach

- Rates are high:

100 evts /day for
m(sq,sg) = 1 TeV

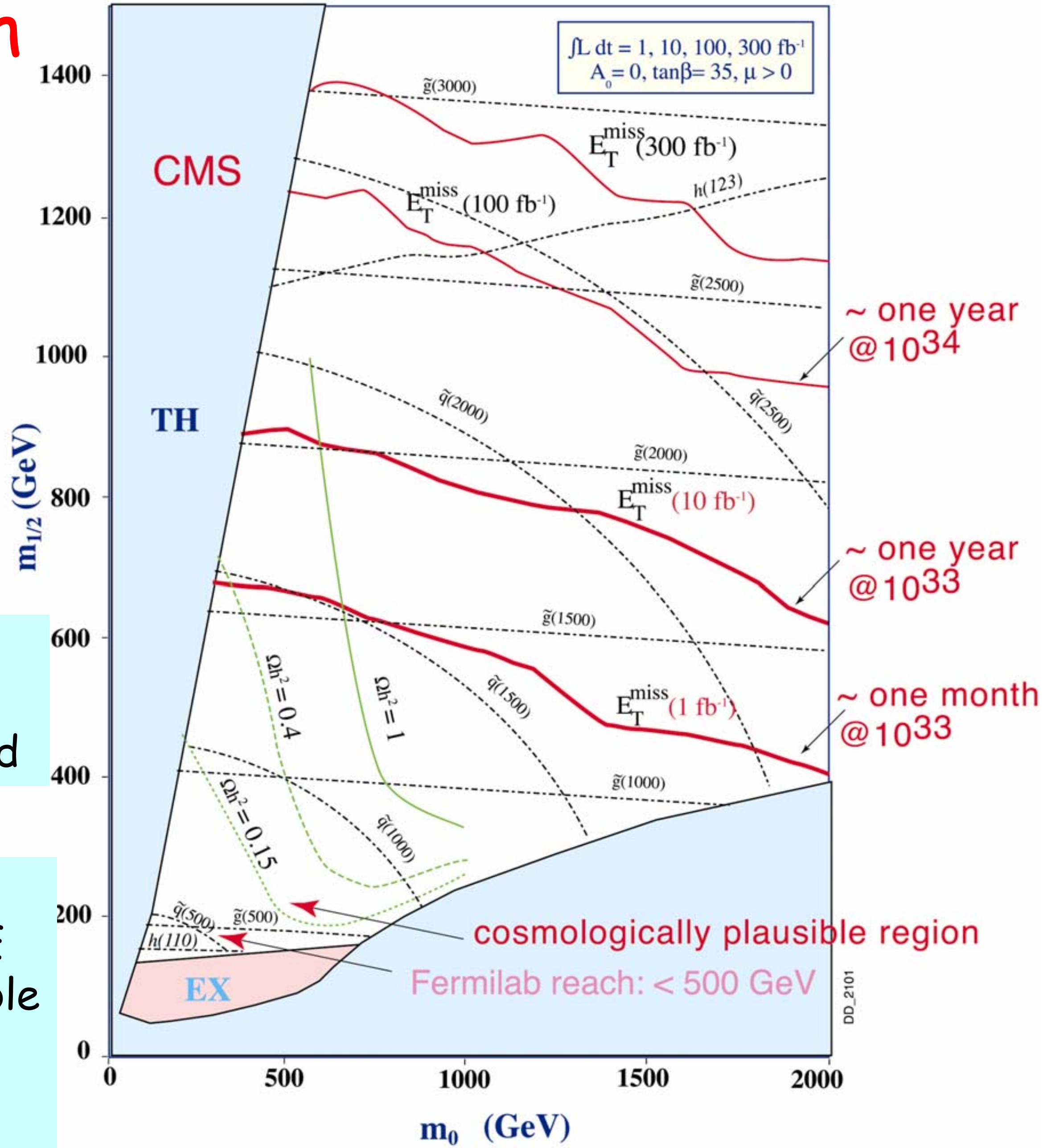
- Trigger is "easy" :

multijets ⊕ MET

Search variable:

$$M_{\text{eff}} = E\!\!\!/_T + \sum |p_{T,\text{jet}}|$$

In principle,…in one month at 10^{33}, s-quarks and gluinos up to ~2 TeV can be discovered

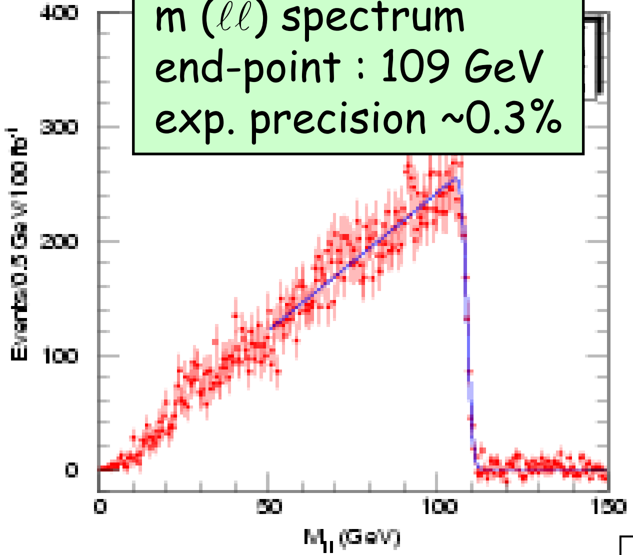


- Background(Z→υυ+N jets,..) reevealuated recently with ME (Alpgen + MLM) is less favorable

- With one lepton in final state, discovery remains "easy"

SUSY parameters from decay chain

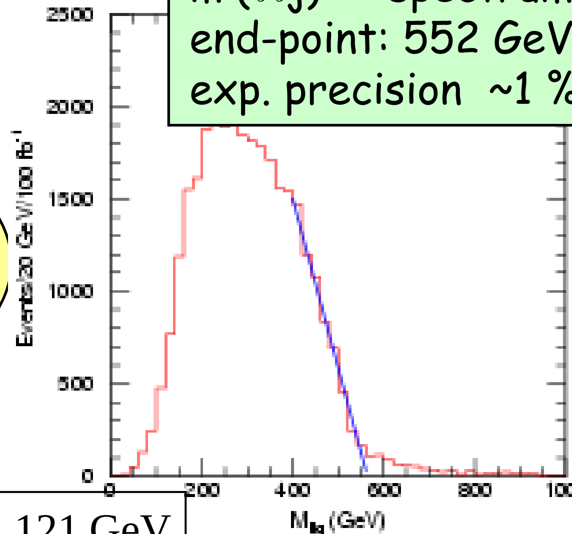
m ($\ell\ell$) spectrum
end-point : 109 GeV
exp. precision ~0.3%



Example: "Point 5"

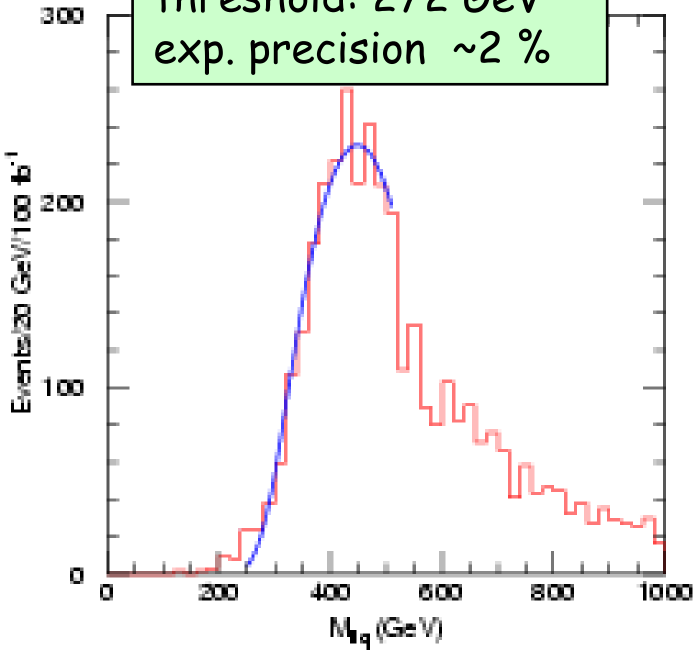
$\tilde{q}_L \to q\, \chi^0_2$
$\quad \hookrightarrow \tilde{\ell}_R\, \ell$
$\quad\quad \hookrightarrow \ell\, \chi^0_1$

m ($\ell\ell$j)^{min} spectrum
end-point: 552 GeV
exp. precision ~1 %



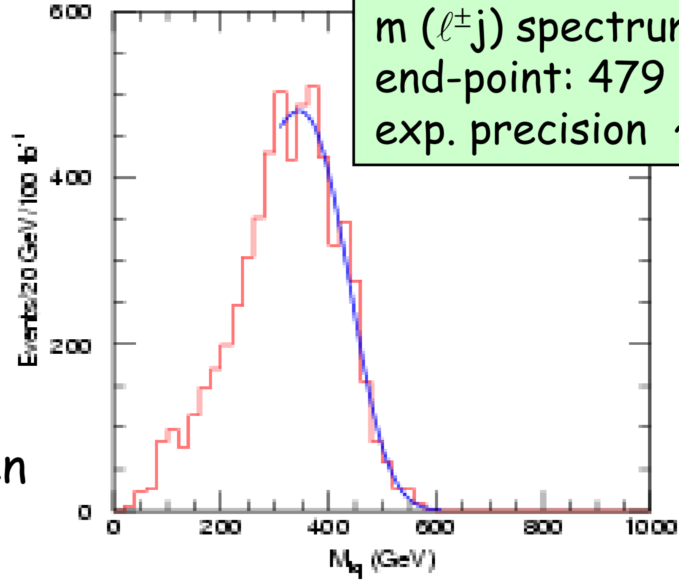
$$m(\tilde{q}_L, \chi^0_2, \tilde{\ell}_R, \chi^0_1) = 690,\ 232,\ 157,\ 121 \text{ GeV}$$

m ($\ell\ell$j)^{max} spectrum
threshold: 272 GeV
exp. precision ~2 %



100 fb^{-1}

m ($\ell^{\pm}$j) spectrum
end-point: 479 GeV
exp. precision ~1 %



End-points
↓
Relation between Masses
↓
All masses → M(χ^0_1) to 12% RMS → DM

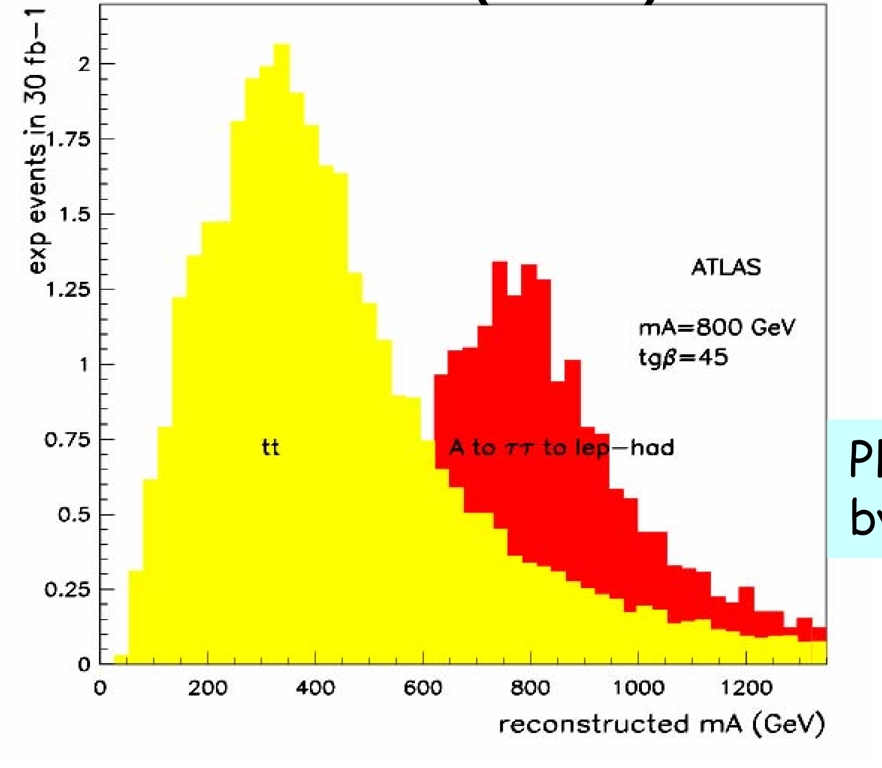
A,H decays in $\tau\tau$

- In the MSSM there are 5 Higgs bosons : h, H, A, H^{+-}
The 5 masses depend on 2 parameters: M(A) and tg(β)

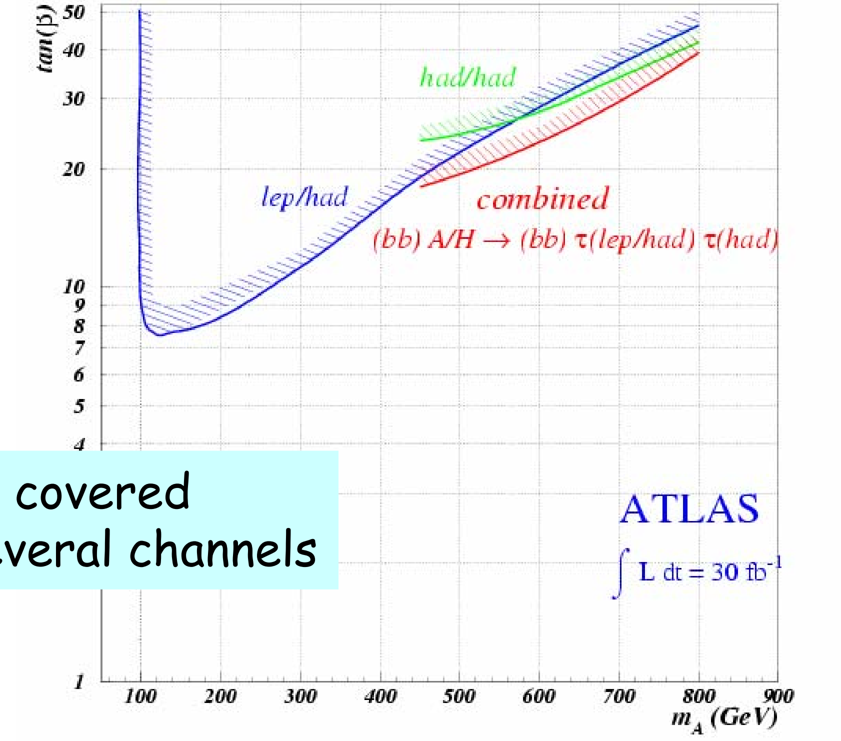
- For large M(A) and tg(β) the H and A couplings to bb and τ τ are enhanced
  bb$\rightarrow$bbA
  $\llcorner\!\rightarrow$ $\tau\tau$ is a favored discovery channel
($\tau\tau$ BR=11%, σ=760 fb for tg(β)=45,M(A)&M(H)=800 GeV)

- LVL1 Triggers = (one tau-jet or lepton)$\oplus$ETmiss

Rec. m$\tau\tau$ (30 fb^{-1})



Plane covered
by several channels

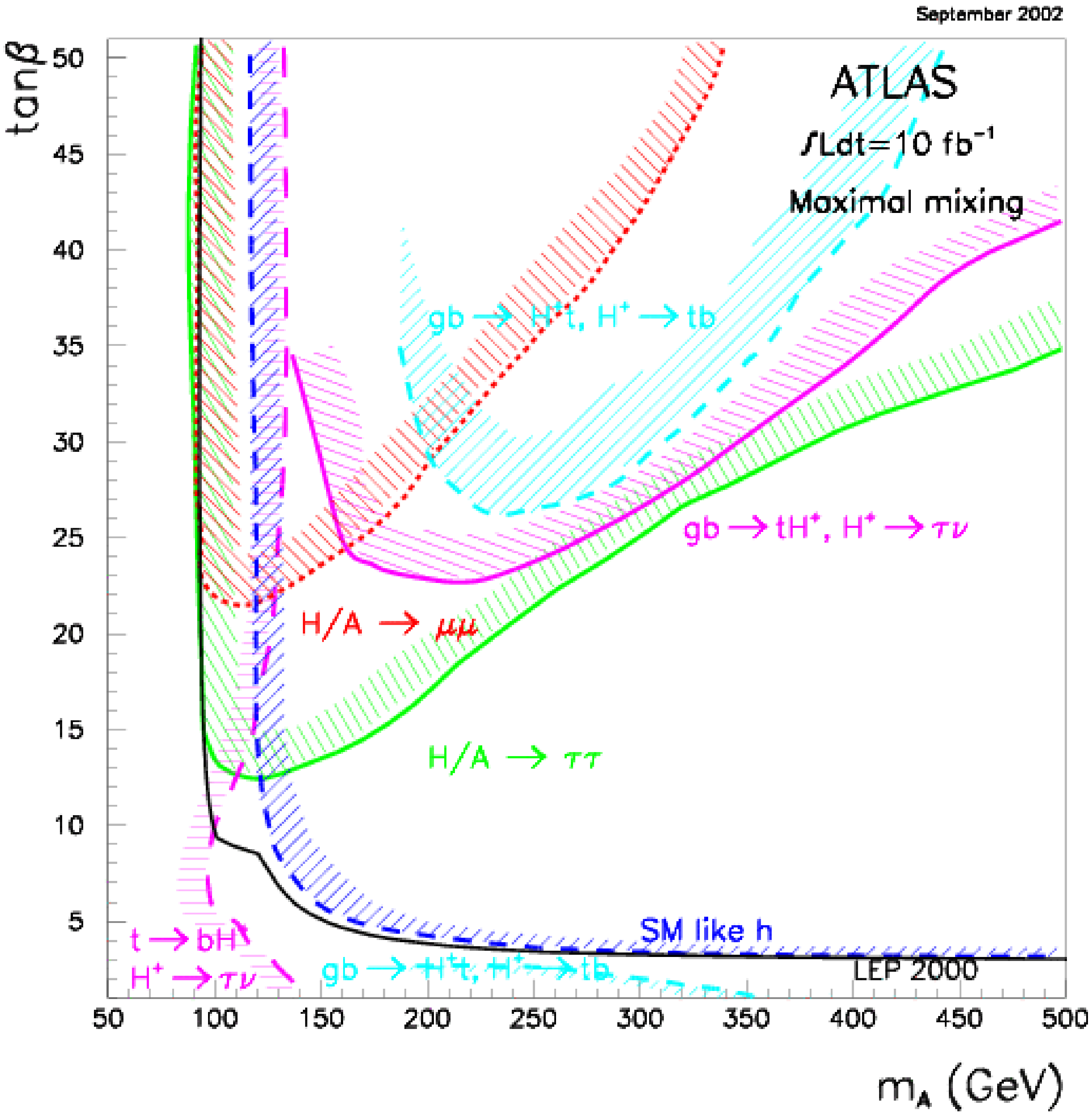


Conclusion-Summary

- Each of the 4 LHC experiment uses technologies at the limit, for ambitious physics program
- Particle identification plays a major role
- Detectors have been carefully designed and are being built, installed and tested with a lot of care.
- Tuning the triggers at start-up will be a crucial step
- A major issue-not discussed here-will be the capacity of the experiments to "digest" the enormous amount of data they will produce, typically 1 Mbyte*200Hz to mass storage
- More in 1.5 years, when LHC gets started

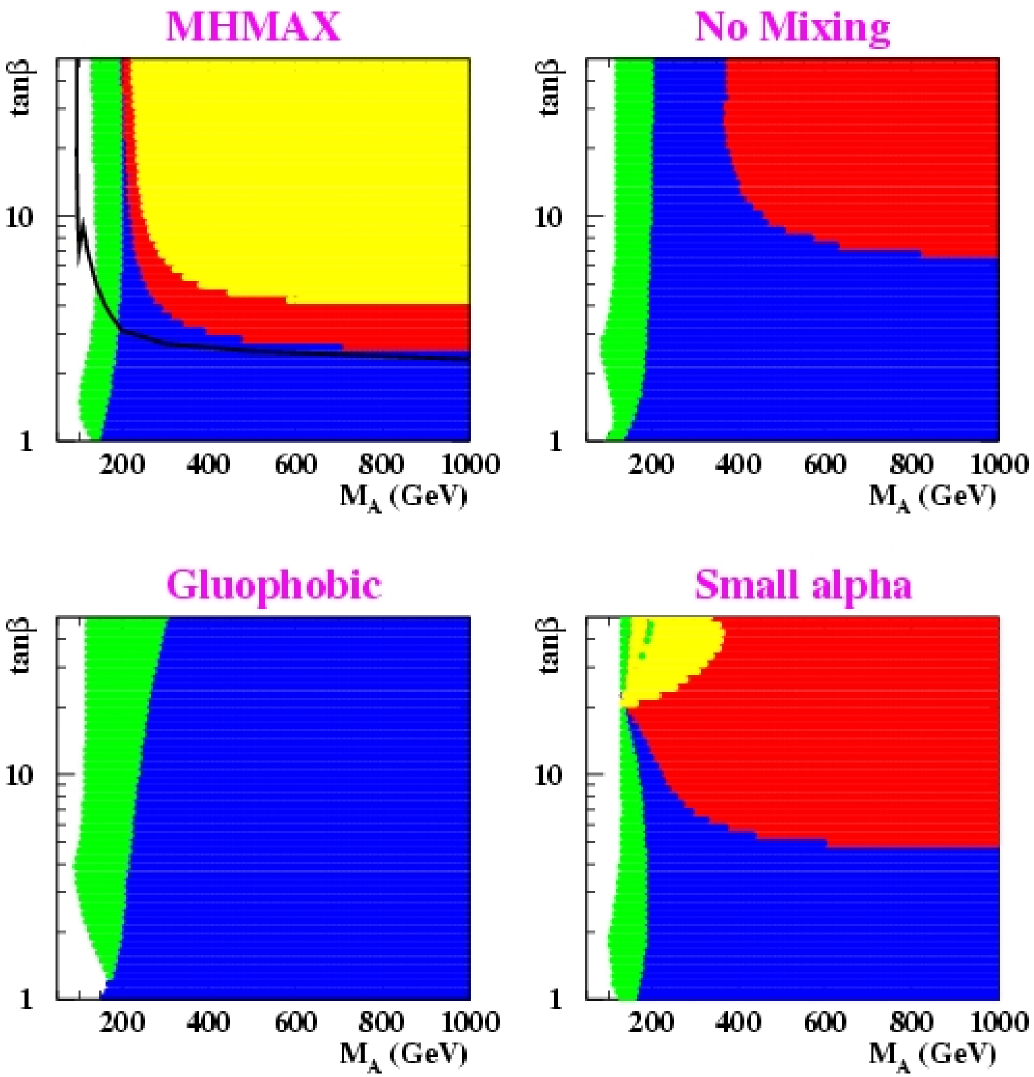
Back-up transparencies

HIGGS-SUSY plane (2003)



MSSM */SM*	t	b/τ	W/Z
h	$\cos\alpha/$ $\sin\beta$	$-\sin\alpha/$ $\cos\beta$	$\sin(\alpha-\beta)$
H	$\sin\alpha/$ $\sin\beta$	$\cos\alpha/$ $\cos\beta$	$\cos(\alpha-\beta)$
A	$\cot\beta$	$\tan\beta$	-----

Light Higgs boson h: 300 fb^{-1}



For high lumi.:
$h \to \gamma\gamma$, $tth \to bb$
$h \to ZZ \to 4l$
contribute

All three

$h \to \gamma\gamma + tth \to bb$

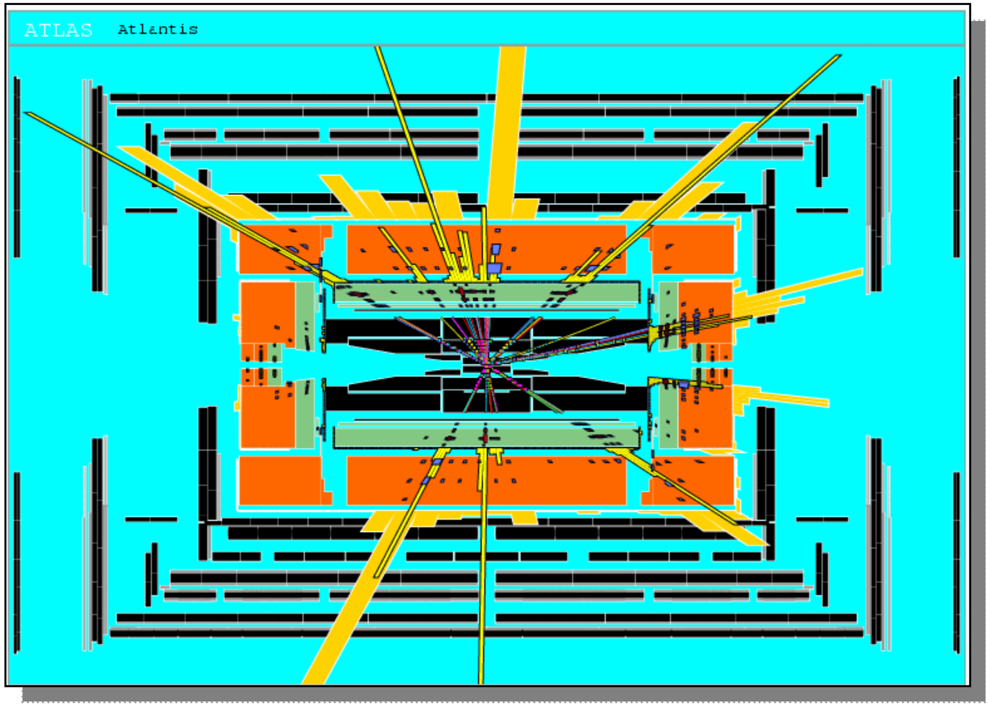
$h \to \gamma\gamma + h \to ZZ \to 4l$

only $tth \to bb$

An example of exotica :Black hole production..

•Another way of stabilizing the Higgs mass is to assume that there are extra space-dimensions, in which case the Planck mass could be as low as a few TeV.

•When $\sqrt{S}$ reaches Mp
Black Holes are produced, which decay "democratically" to quarks, leptons, Gauge bosons.



A typical event (?) could have:
hadrons/leptons/γ,W,Z/Higgs ~ 75%/20%/3%/2%

....a dream for particle identification at the LHC