Misure all'LHC

IFAE04, Torino, 14-16 Aprile 2004

Michelangelo Mangano
Theory Division
CERN

- Introduction
- SUSY studies
- Higgs studies
- SM measurements
- Conclusions

Large Hadron Collider: pp collisions at √S=14TeV

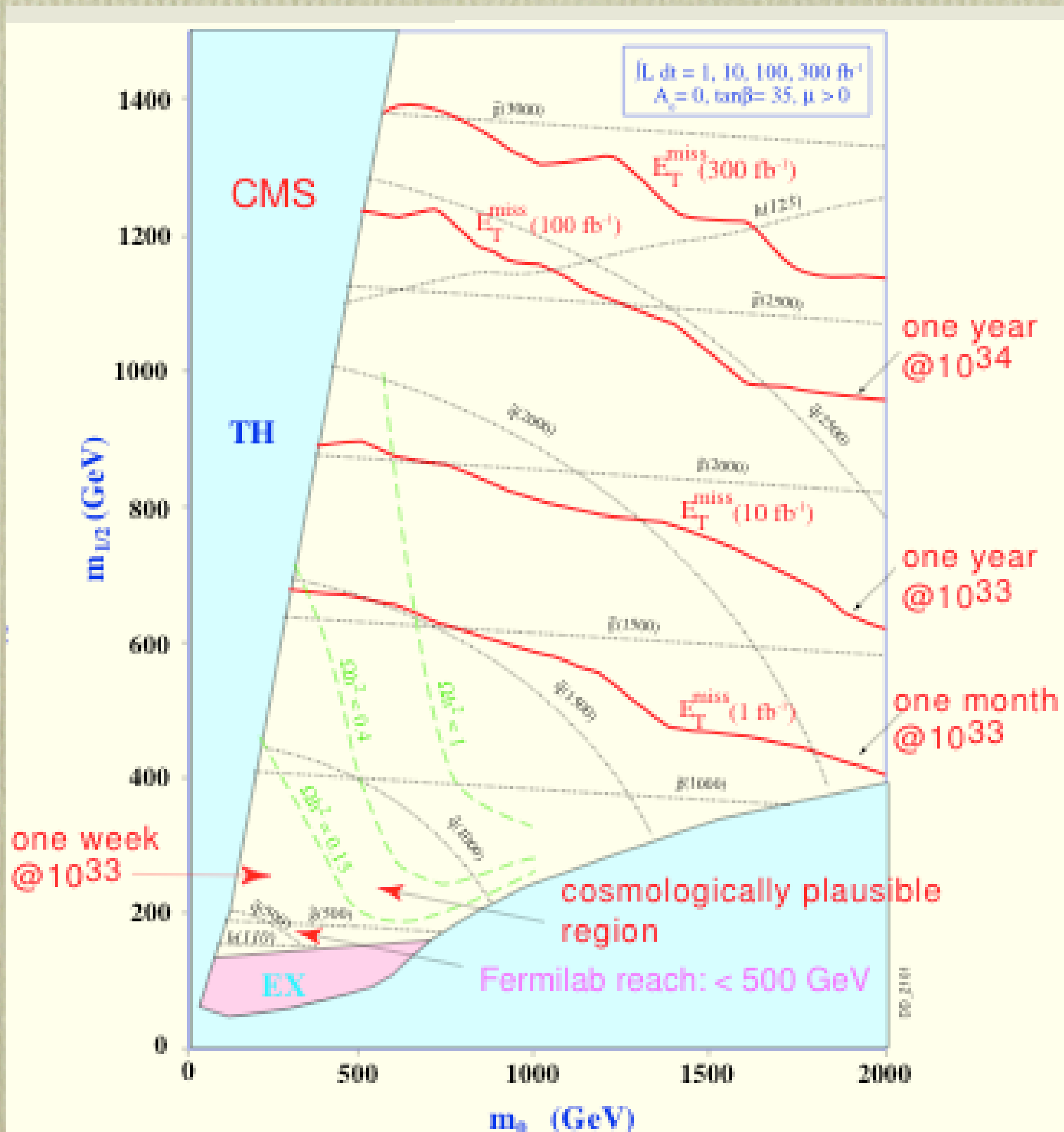
Reference rates for some SM processes

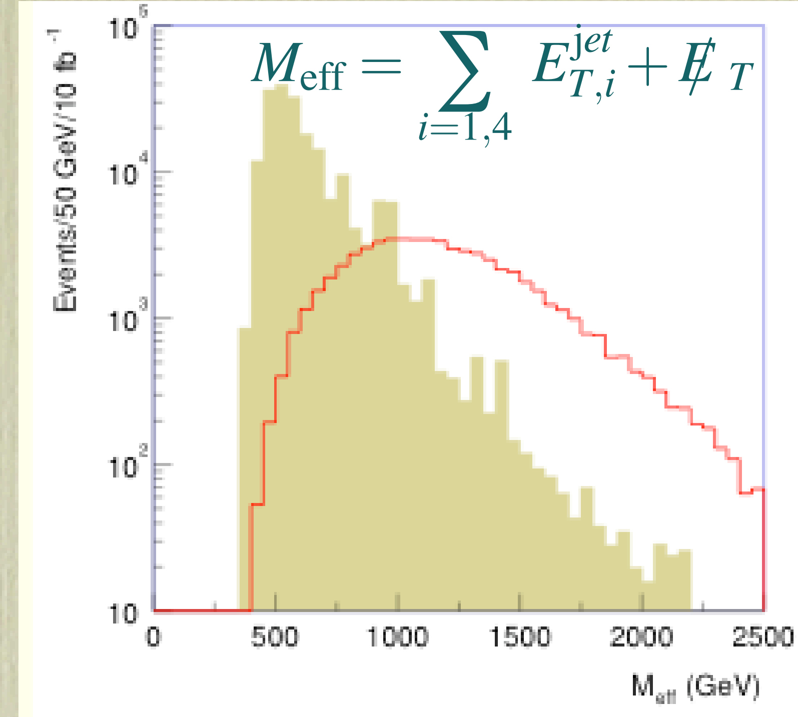
Process	**Evts/s** ($\mathcal{L}=10^{33}$)	**Evts/yr**
Jet, $E_T>0.1$TeV	10^{3}	10^{10}
Jet, $E_T>1$TeV	1.5×10^{-2}	1.5×10^{5}
$W\to\ell\nu$	20	2×10^{7}
bb	5×10^{5}	5×10^{12}
tt	1	10^{7}
$WW\to\ell\nu\ell\nu$	6×10^{-3}	6×10^{4}

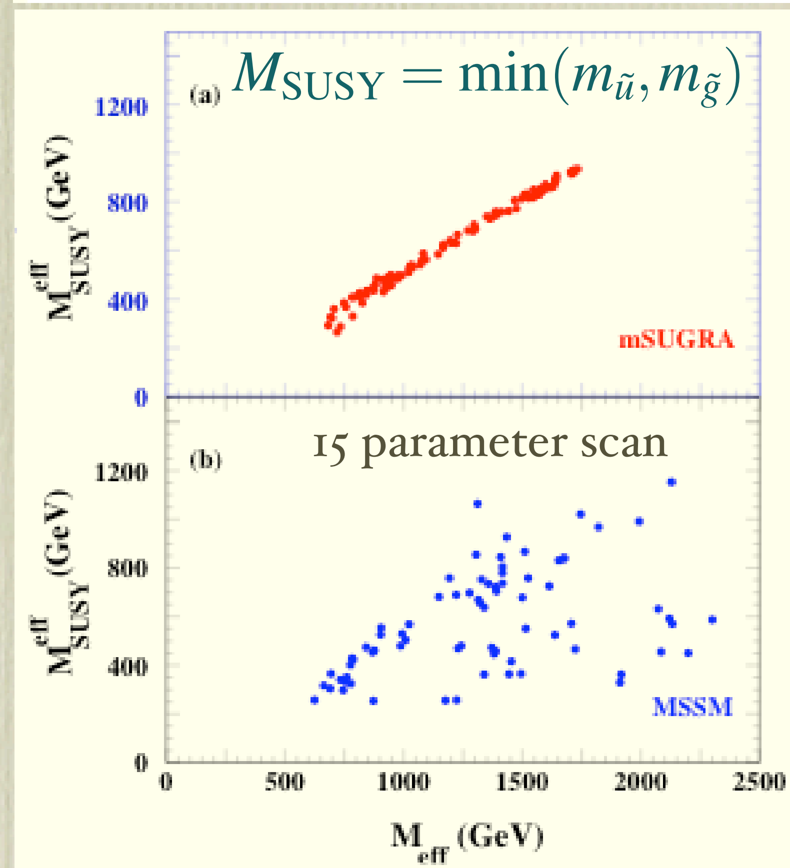
Analogamente, rates visibili in eccesso del pb per molti processi di fisica BSM.

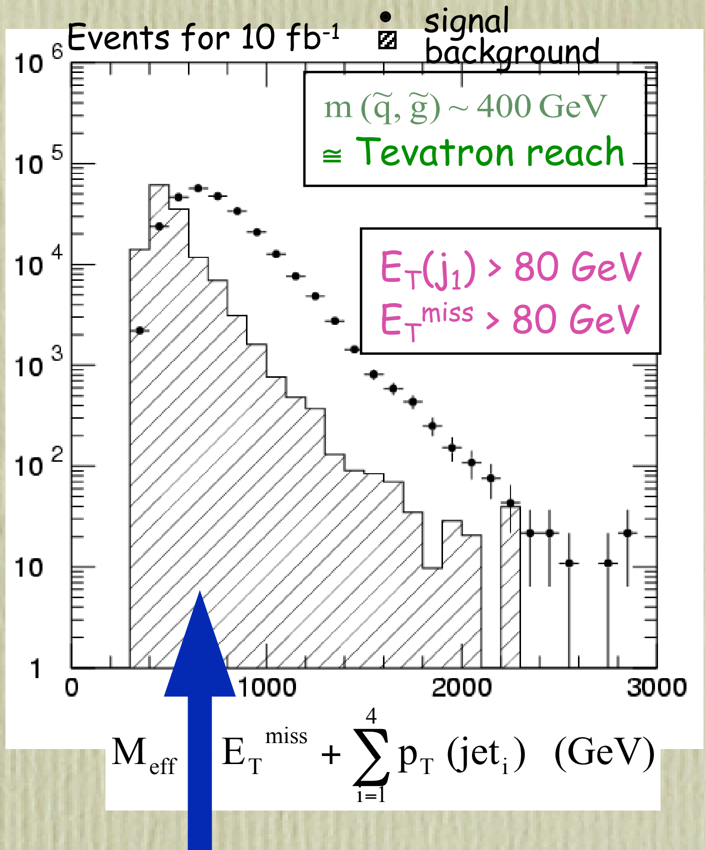
- Immense amount of work done in the past few years to establish the ability of LHC to detect most forms and shapes of BSM models, and to define the ultimate discovery reach
- Many presentations in the parallel sessions, with great detail about the measurements foreseen at the LHC
- The claims of discovery will require a control over backgrounds which will need to be firmly demonstrated using data
- Same comment for the claims of accuracy in the measurement of key quantities
- In the remaining time between now and LHC running, the physics studies should concentrate on formulating concrete and solid strategies of validation for the MC tools used in the analyses (this should include the best possible use of Tevatron and HERA data)
- I will illustrate these points with some examples

SUSY discovery and mass scale determination

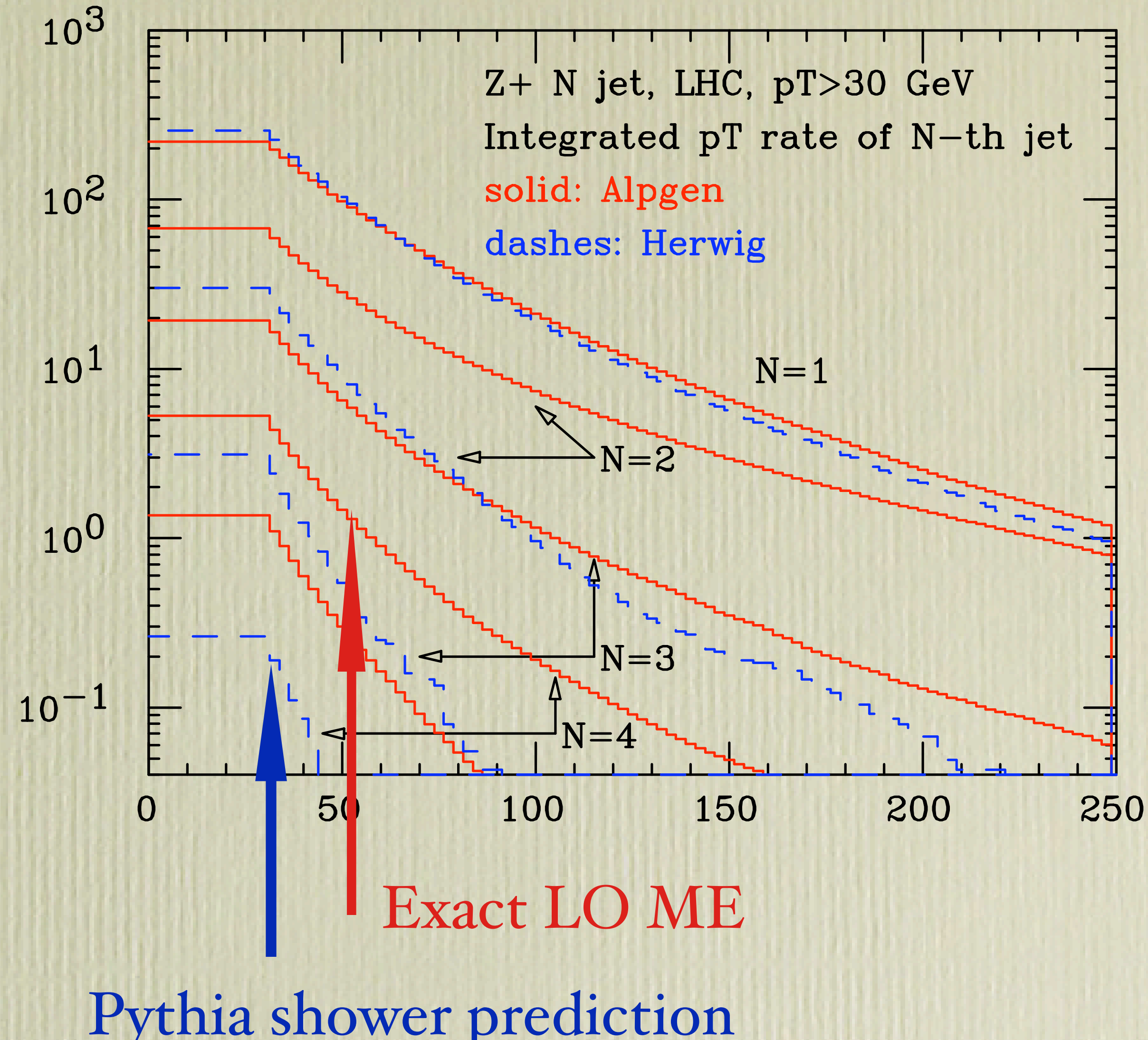








Very good S/B ratio!
..but, how well do we know it?



Presumably the study of (Z→ee)+jets will be sufficient to benchmark the MC's. What about data validation of missE_T resolution tails? Validation of tools and bg's might require much higher statistics than collection of signal events!

Dark matter constraints on neutralinos: a CMSSM example

old:

$0.1 < \Omega_\chi h^2 < 0.3$

new WMAP

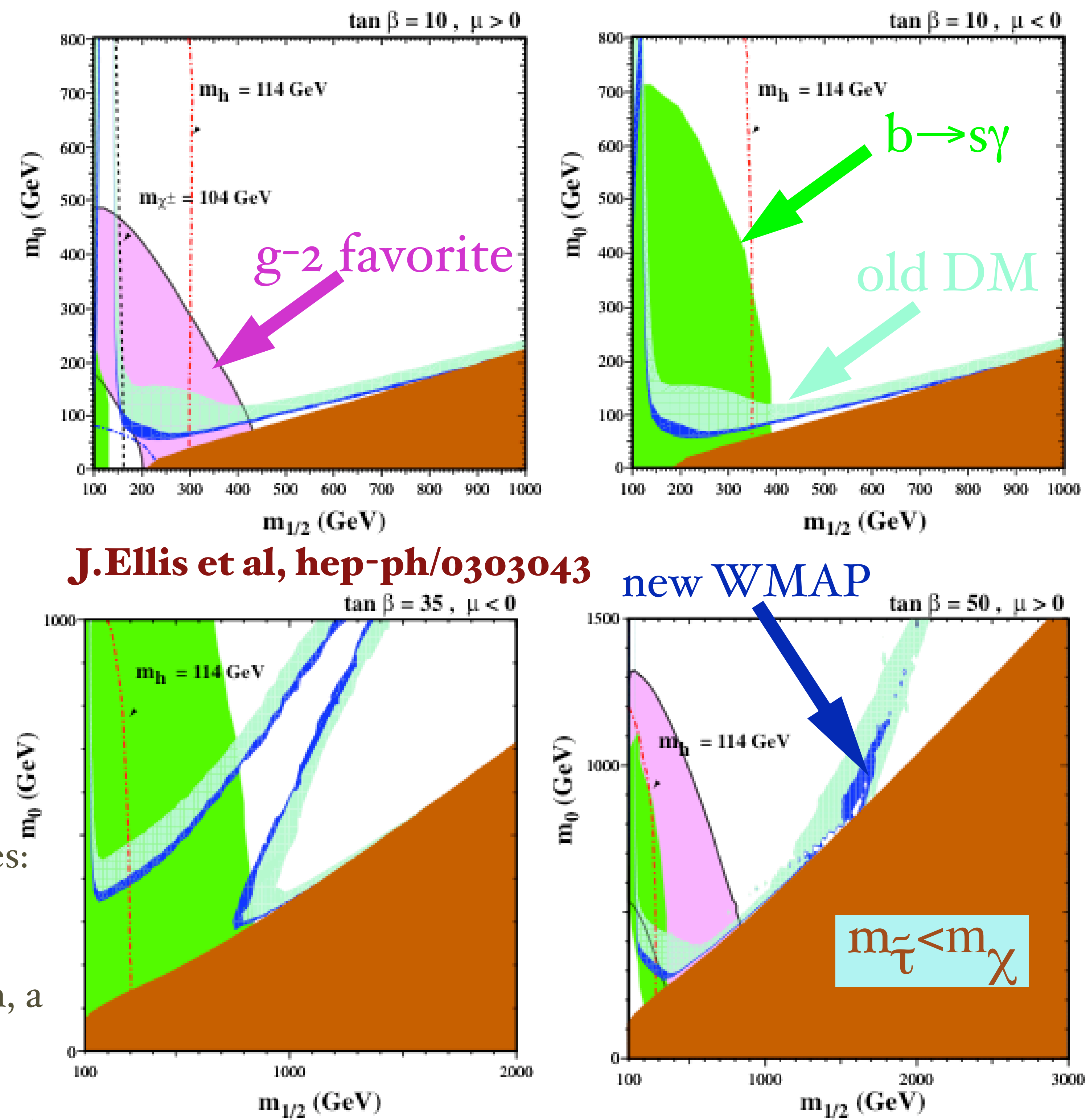
$0.094 < \Omega_\chi h^2 < 0.129$

$\Omega_\chi h^2 \sim m_\chi\, n_\chi \Rightarrow$

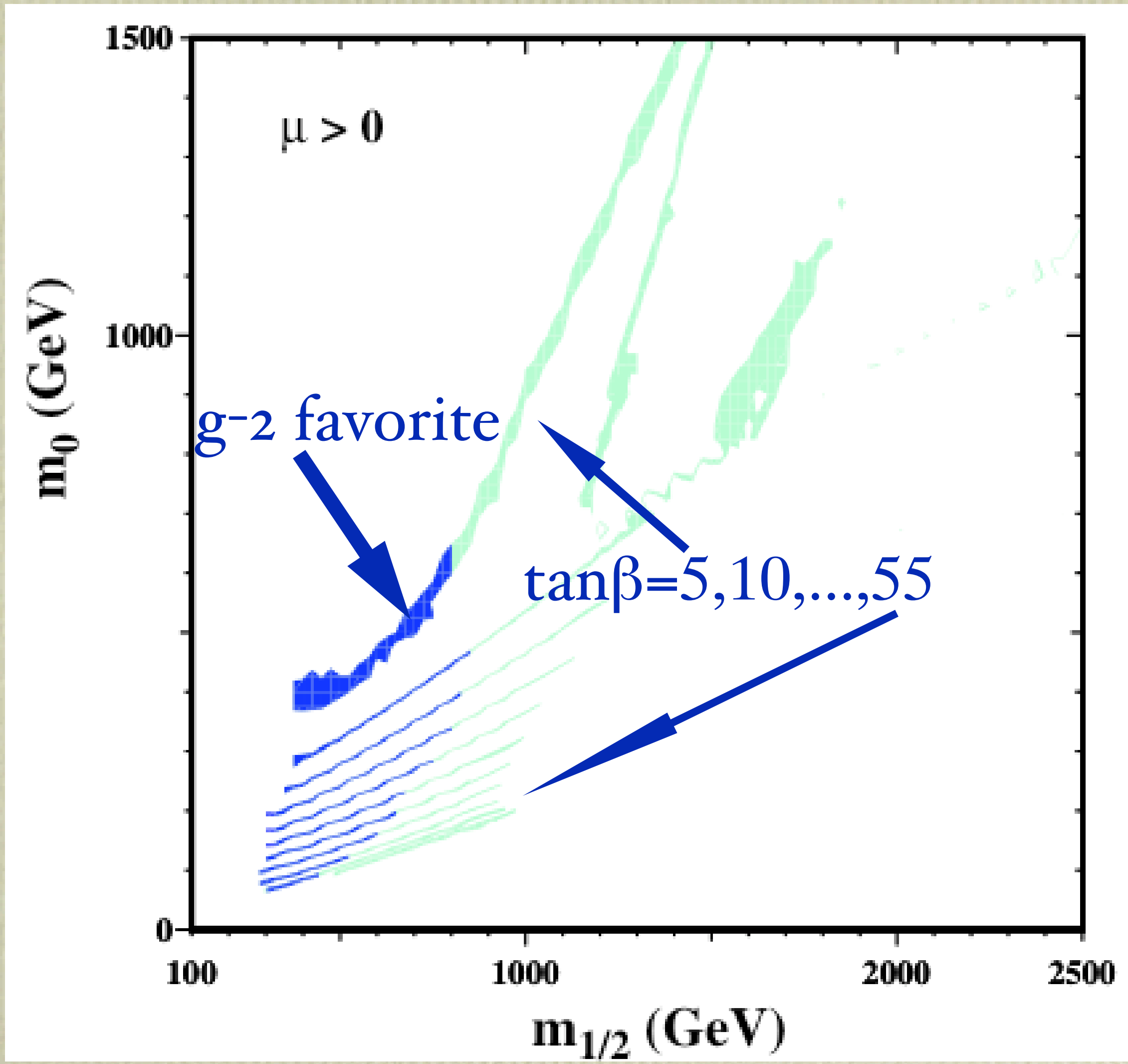
upper limit on Ω_χ requires:

+ small m_χ, or

+ fast/efficient annihilation, a strong constraint on spectrum (to allow, e.g., $\chi\chi \to h$ at threshold or $\chi\tilde{\tau} \to \gamma\tau$)

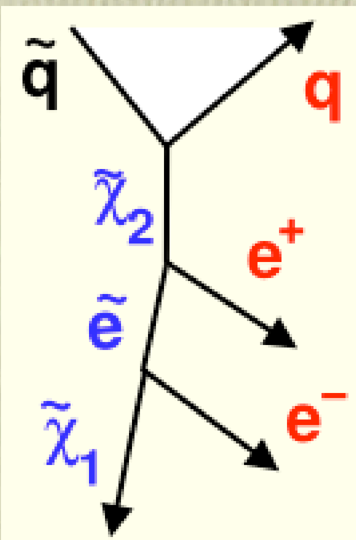


In the CMSSM the measurement of $m_{1/2}$ and m_0 (resp. m_χ and m_{slep}) will fix almost uniquely tanβ



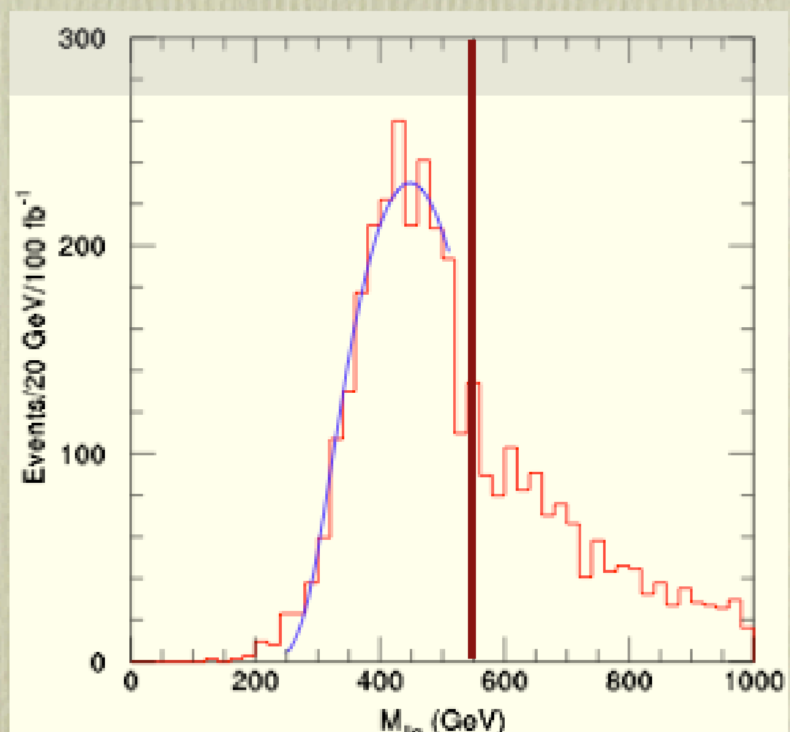
Proving the direct and unambiguous link between cosmology, DM and SUSY would be, perhaps even more than the Higgs discovery, the flagship achievement of the LHC

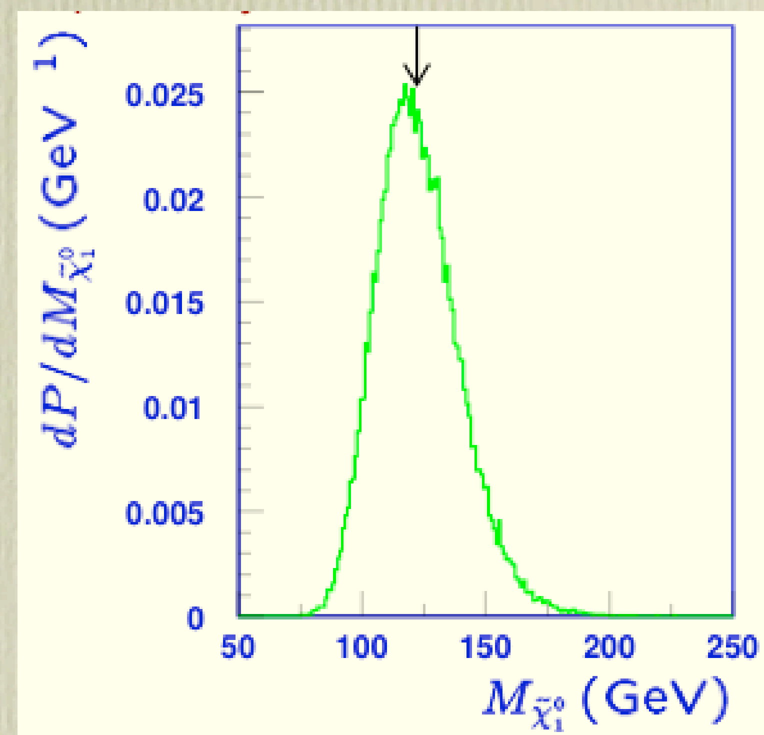
Example of mass reconstruction at the LHC



$$M_{\ell\ell q}^{\max} = \left[\frac{(M^2_{\tilde{q}_L} - M^2_{\tilde{\chi}^0_2})(M^2_{\tilde{\chi}^0_2} - M^2_{\tilde{\chi}^0_1})}{M^2_{\tilde{\chi}^0_2}}\right]^{1/2} = 552.4\,\mathrm{GeV}$$

Fit $\min[M(\ell\ell q)],\ \max[M(\ell\ell q)],\ M(\ell\ell),\ M(\ell q)$ and solve for $m_{\tilde{q}_L},\ m_{\tilde{e}},\ m_{\chi^0_2},\ m_{\chi^0_1}$ with errors of 3%, 9%, 6% and 12% resp.





For more studies and new ideas, see the Les Houches BSM report: hep-ph/0402295. See also talk by M.Chiorboli (BSM session)

Sparticle reconstruction

Assuming knowledge of m_{χ^0}

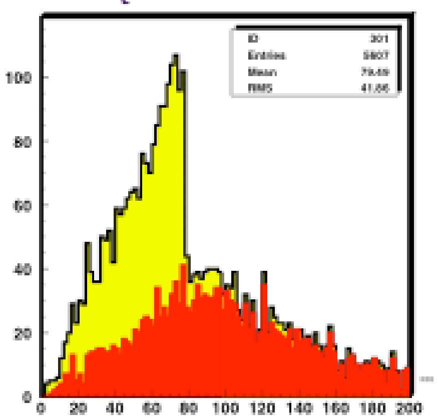
SUSY point B (m_0=100 GeV, $m_{1/2}$=250 GeV, tgβ=30, μ>0)

Studied with fast simulation and parameterizations of b tagging

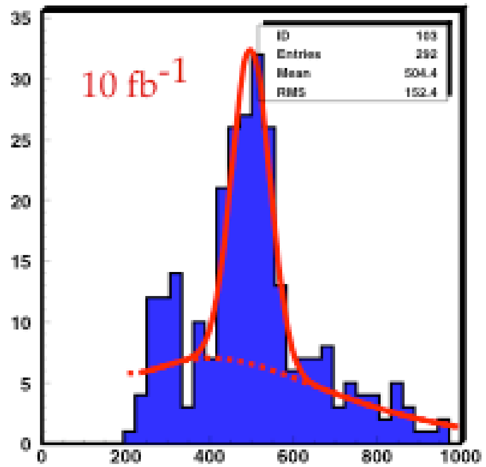
Main cuts: E^t_{miss}, M(ll), E(ll), Eb-jet, b-tagging

Dilepton edge

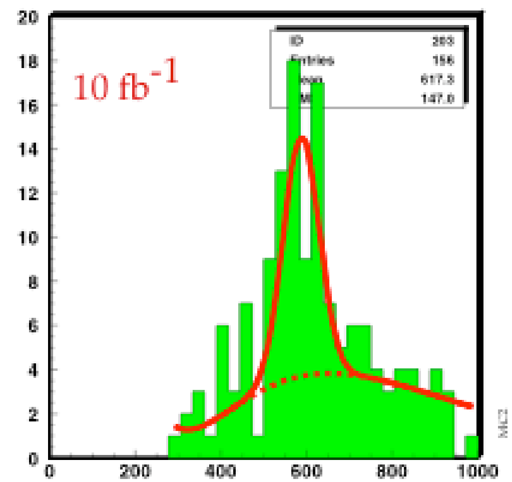
E_t^{miss} > 100 GeV



Sbottom reconstruction

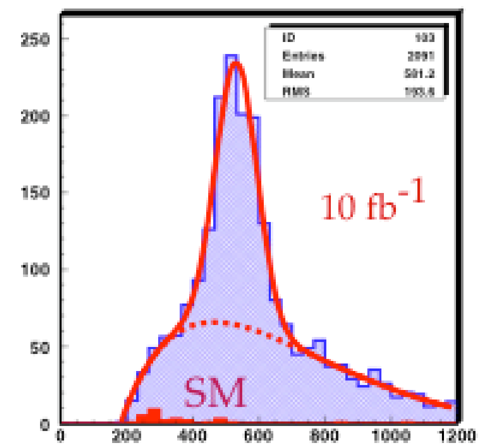


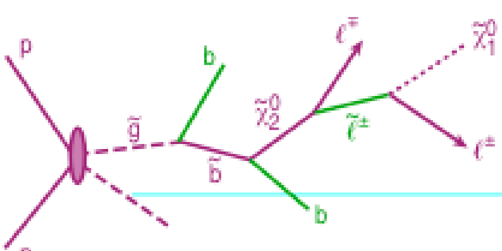
Gluino reconstruction



Squark reconstruction

anti-b-tag: σ < 2, b-veto





fit:

$M(b\tilde{\chi}^0_2)$ GeV = 499 ± 7 GeV

σ = 48 GeV

generated: $M(\tilde{b}_L)$ = 496 GeV

$M(\tilde{b}_R)$ = 524 GeV

fit:

$M(bb\tilde{\chi}^0_2)$ GeV = 587 ± 11 GeV

σ = 41GeV

generated mass: $M(\tilde{g})$ = 595 GeV

fit:

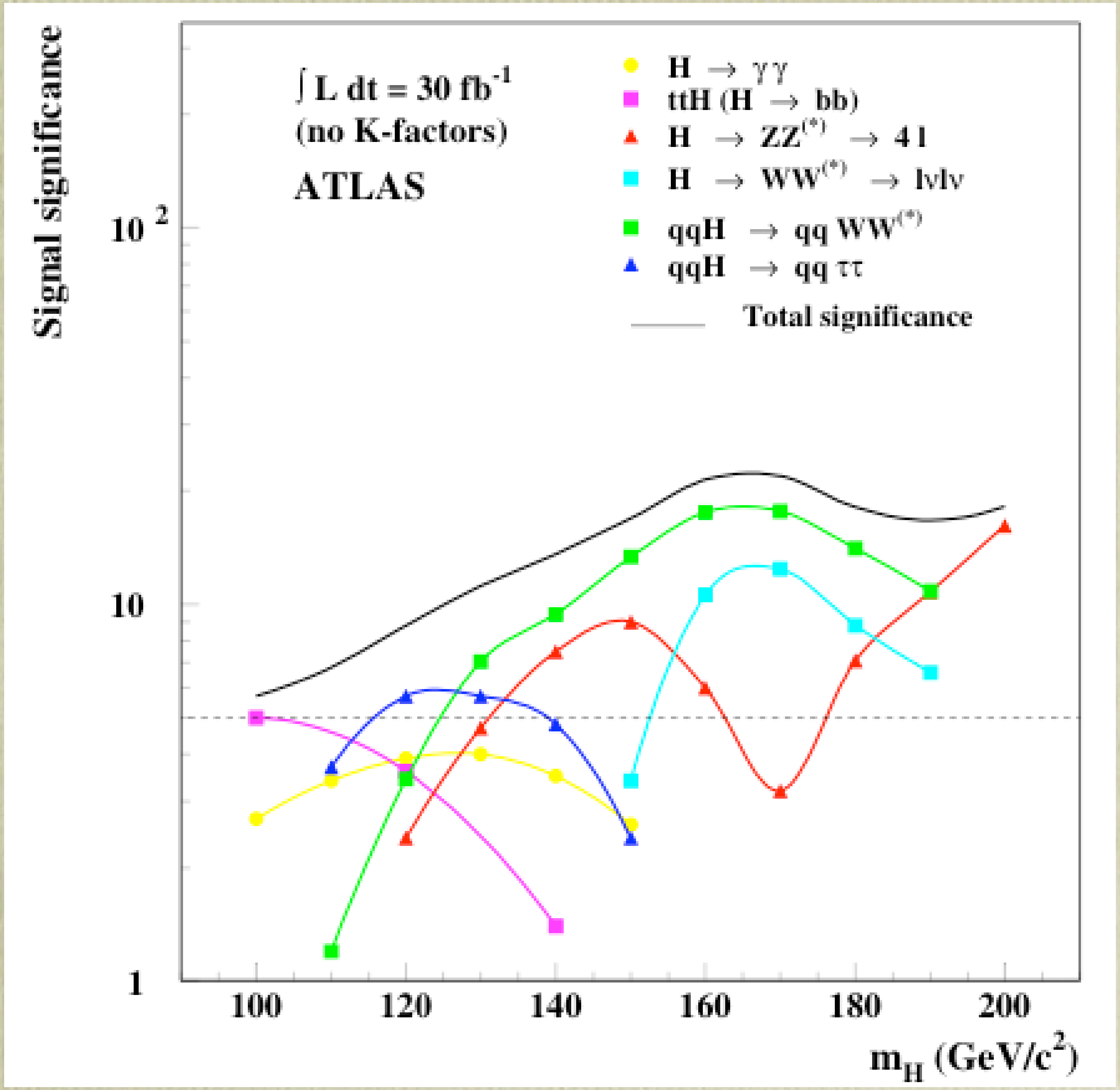
$M(q\tilde{\chi}^0_2)$ = 532 ± 4 GeV

σ = 62 GeV

$M(\tilde{d}_L) = M(\tilde{s}_L)$ = 543 GeV

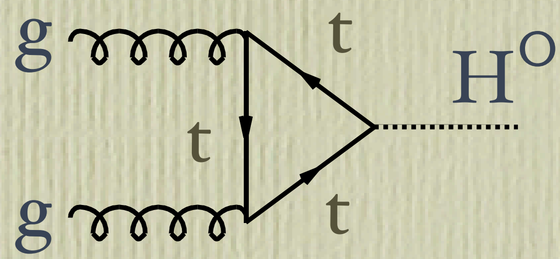
$M(\tilde{u}_L) = M(\tilde{c}_L)$ = 537 GeV

Higgs studies



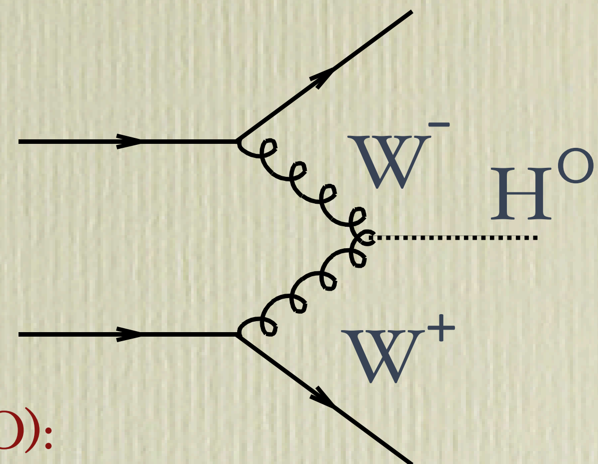
See talk by S.Gennai in the EW session

Four main production mechanisms at the LHC:



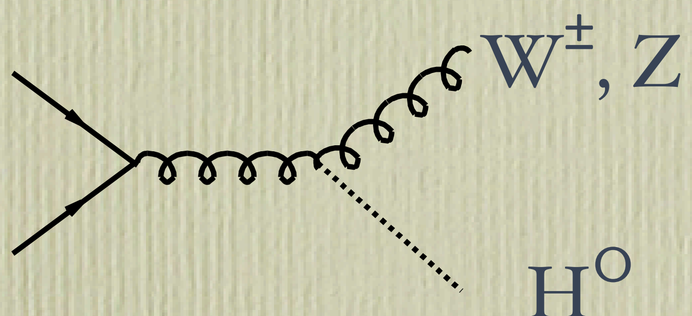
Gluon-gluon fusion (NNLO):

- Largest rate for all m(H).
- Proportional to the top Yukawa coupling, y_t
- gg initial state



Vector-boson (W or Z) fusion (NLO):

- Second largest, and increasing rate at large m(H).
- Proportional to the Higgs EW charge
- mostly ud initial state

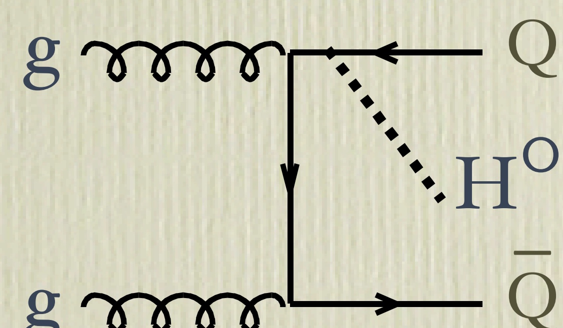


W(Z)-strahlung (NNLO):

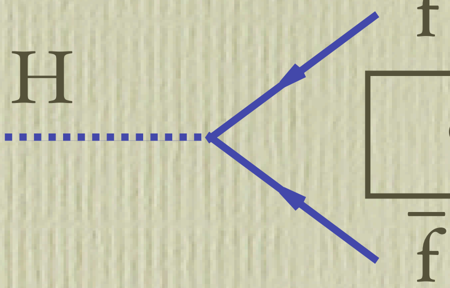
- Same couplings as in VB fusion
- Different partonic luminosity (uniquely qqbar initial state)

ttH/bbH associate production (NLO):

- Proportional to the heavy quark Yukawa coupling, y_Q, dominated by ttH, except in 2-Higgs models, such as SUSY, where b-coupling enhanced by the ratio of the two Higgs expectations values, $\tan\beta^2$
- Same partonic luminosity as in gg-fusion, except for different x-range

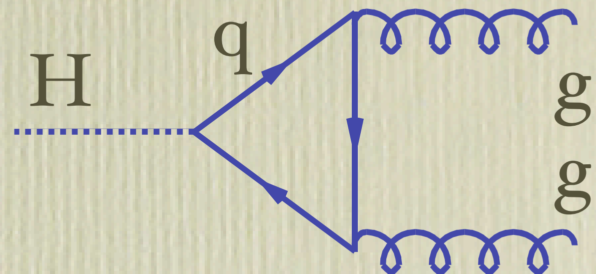


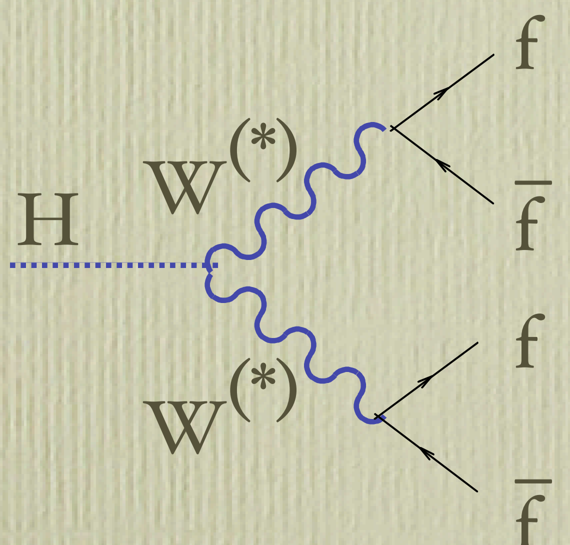
Higgs decays



$\propto m_f^2$ (evaluated at m_H, including QCD running effects)

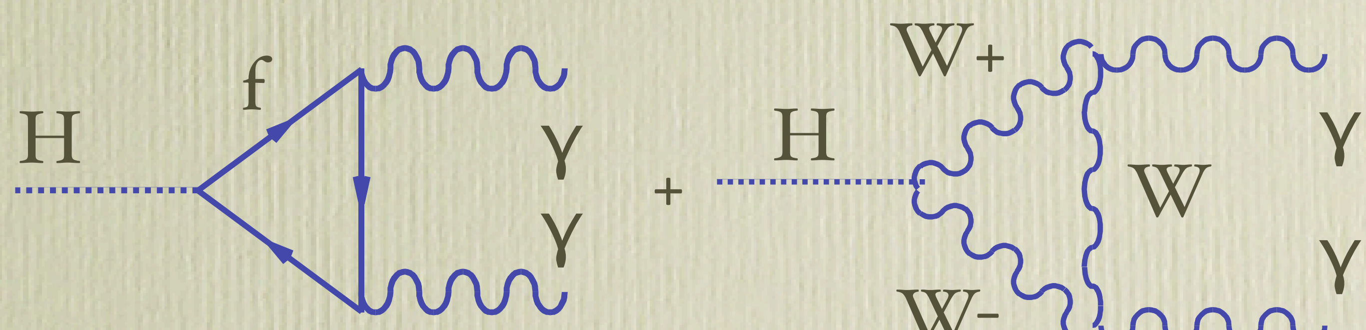
$\propto m_f^2$ (dominated by top-quark loops)





$\propto \alpha_W$ (sharp thereshold at m_H=2m_W , but large BR even down to 130 GeV). Similar processes with W↔Z.

Dominated by the EW couplings, only minor contribution from top loop m ⇒ correlated to H→WW



Direct measurement of Higgs couplings

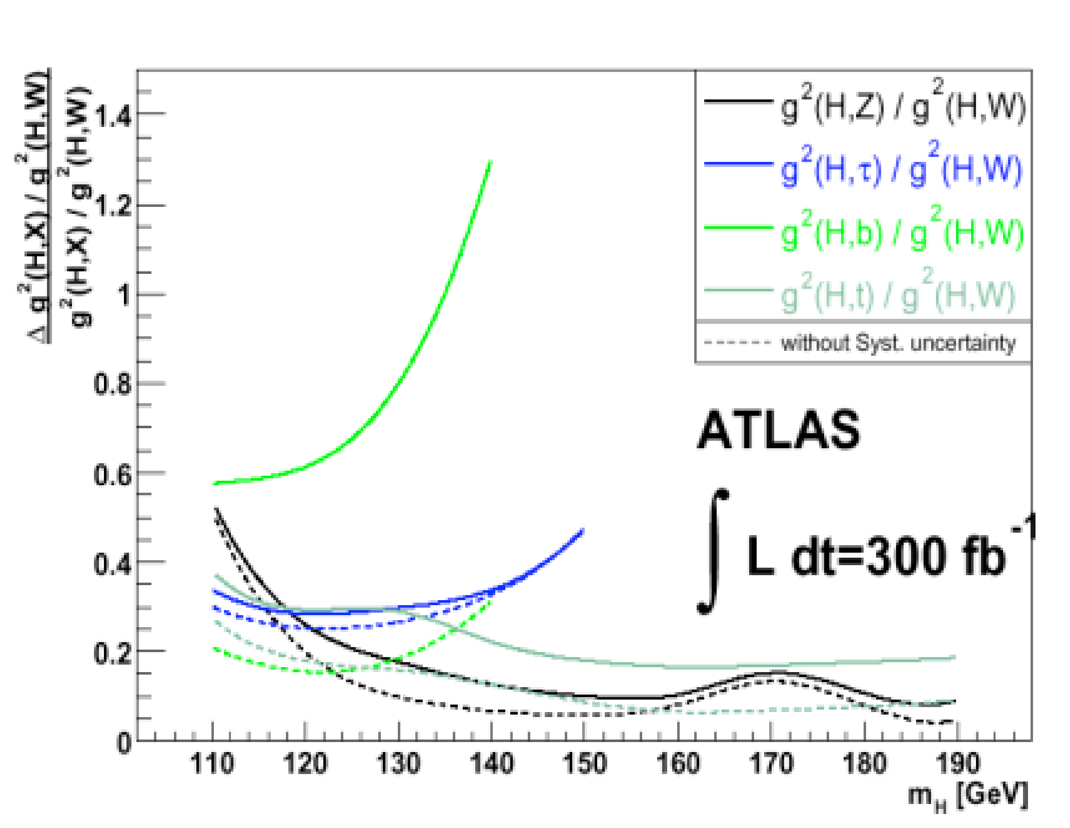
Different production and decay channels provide measurements of the following combinations of partial decay widths

$$X_\gamma = \frac{\Gamma_W \Gamma_\gamma}{\Gamma} \quad from\ \ qq \to qqH,\ H \to \gamma\gamma\,, \qquad Y_\gamma = \frac{\Gamma_g \Gamma_\gamma}{\Gamma} \quad from\ \ gg \to H \to \gamma\gamma\,,$$

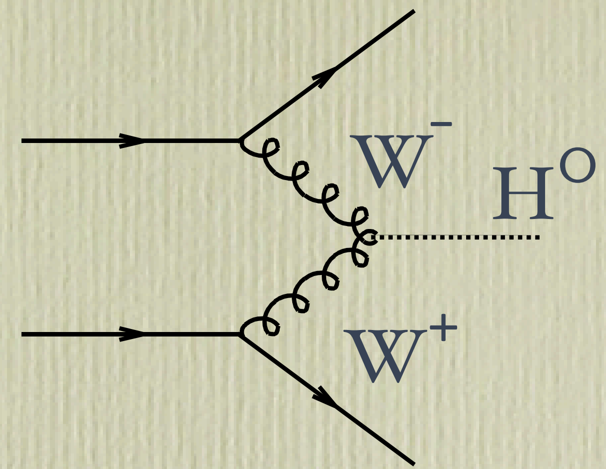
$$X_\tau = \frac{\Gamma_W \Gamma_\tau}{\Gamma} \quad from\ \ qq \to qqH,\ H \to \tau\tau\,, \qquad Y_Z = \frac{\Gamma_g \Gamma_Z}{\Gamma} \quad from\ \ gg \to H \to ZZ^{(*)}\,,$$

$$X_W = \frac{\Gamma_W^2}{\Gamma} \quad from\ \ qq \to qqH,\ H \to WW^{(*)}\,, \qquad Y_W = \frac{\Gamma_g \Gamma_W}{\Gamma} \quad from\ \ gg \to H \to WW^{(*)}$$

Ratios of X or Y quantities factor out not just the partial widths to either W or gluon, but also the overall initial-state parton luminosities and uncertainties on the production cross-sections.



A crucial role in these measurements is played by the vector boson fusion process:



To suppress the bg's, typical analyses require, in addition to the decay products of the H, the following:

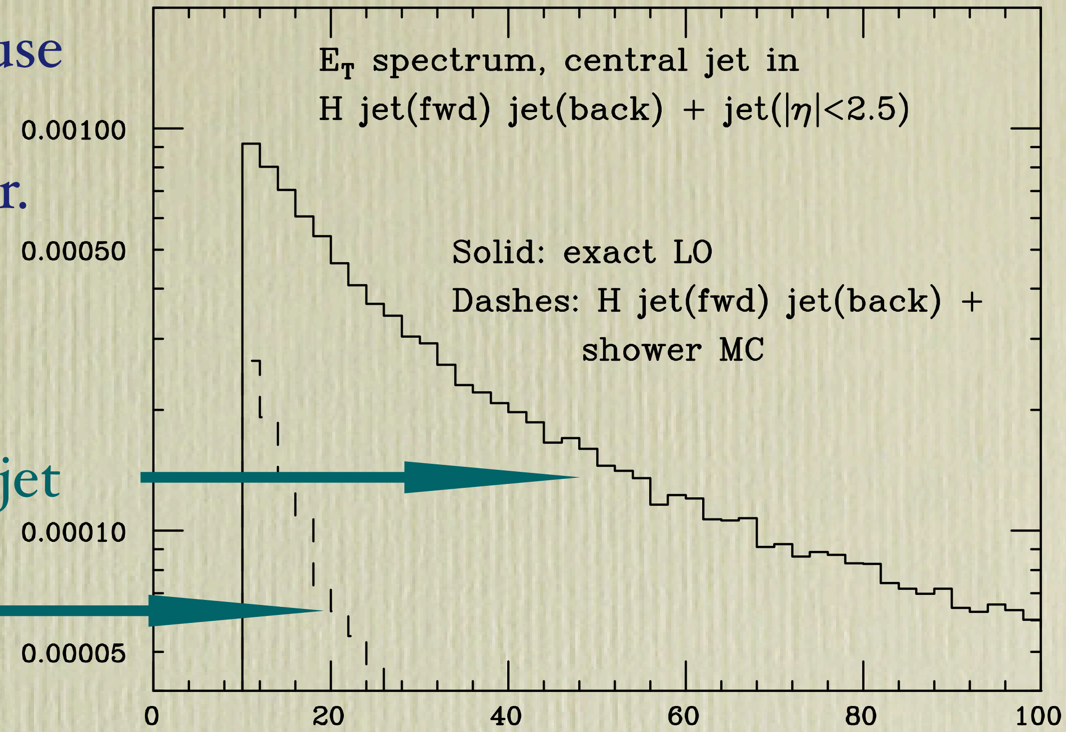
- Two jets with large M(jj), one forward and one backward (typically $|\eta|>2.5$)

- A veto on central jets ($|\eta|<2.5$), justified by the lack of colour exchange between the two hadrons, leading to a rapidity gap

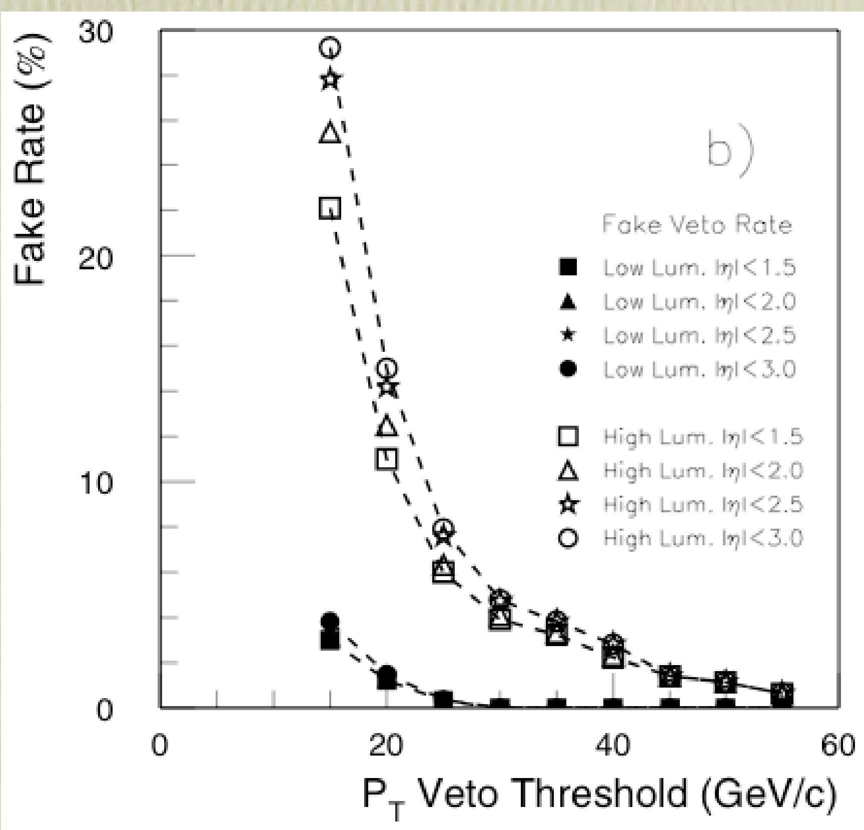
Standard analyses of jet veto efficiency use ME calculations for qq→Hqq, with the central jet generated via a parton shower. Angular ordering in the parton shower prevents emission of central jets, and a bad underestimate of the signal events with a central jet!

Exact Hqq+jet

Naive Hqq+shower



Central jets in Hqq events are therefore usually assumed to originate from additional multiple collisions. This is quite true at high luminosity, but not at 10^{33}



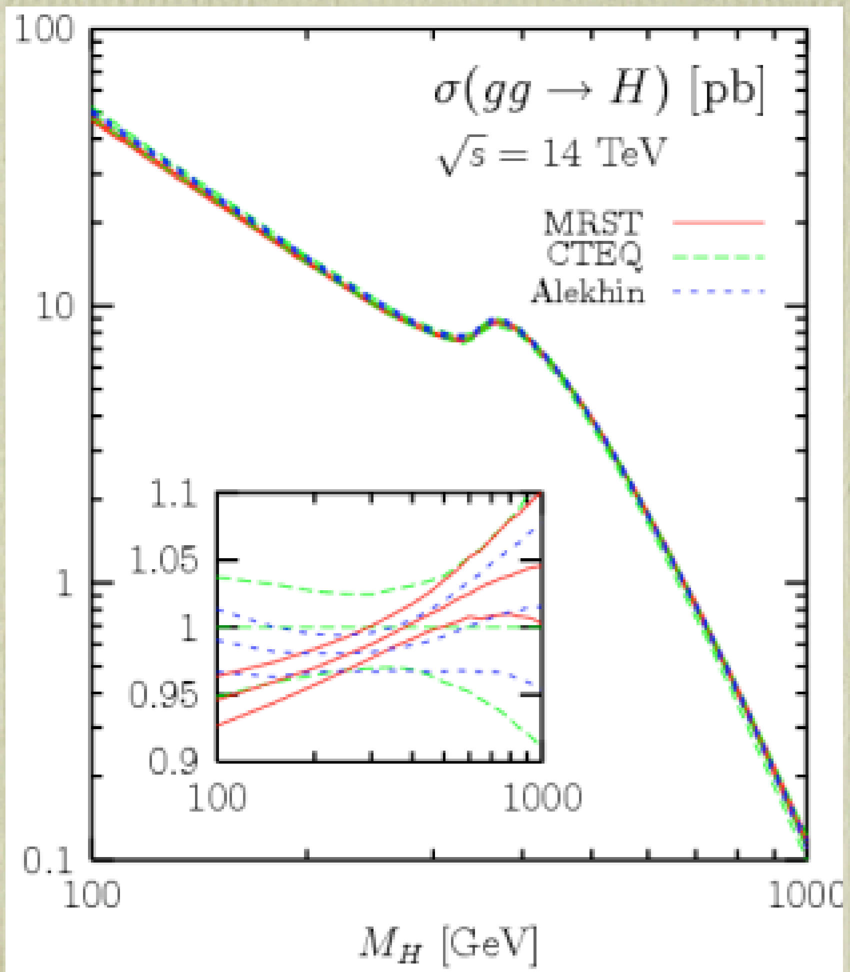
Correct determination of veto efficiency for signal is not just important to establish the best threshold for discovery, but to evaluate the signal cross-section after discovery!

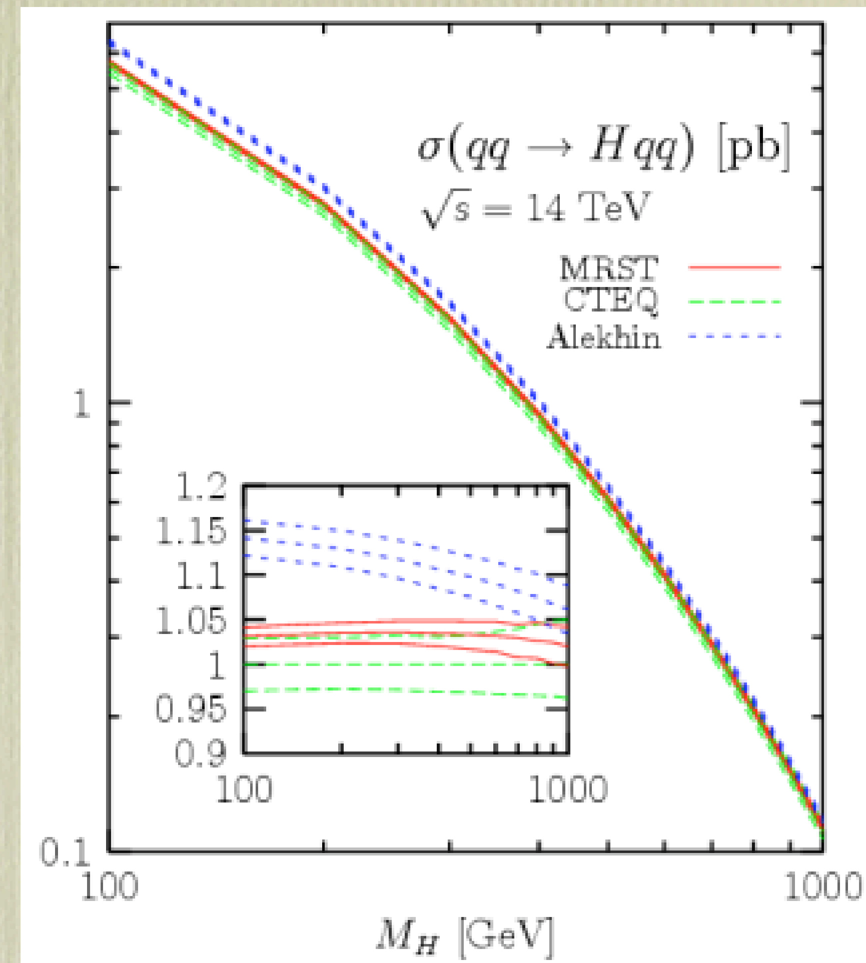
No data from the Tevatron or elsewhere allow today to validate our estimates of central-jet emission in VBF processes. This needs to be done, possibly using the low-luminosity data where fake jets due to multiple interactions are strongly reduced.

Impact of PDF uncertainties on H cross sections

(Djouadi & Ferrag, hep-ph/0310209)

Accurate knowledge of σ(H) is needed to extract H couplings: $\mathbf{N_{ev}} \propto \lambda^2_{\mathbf{H}} \otimes \mathbf{PDF^2}$



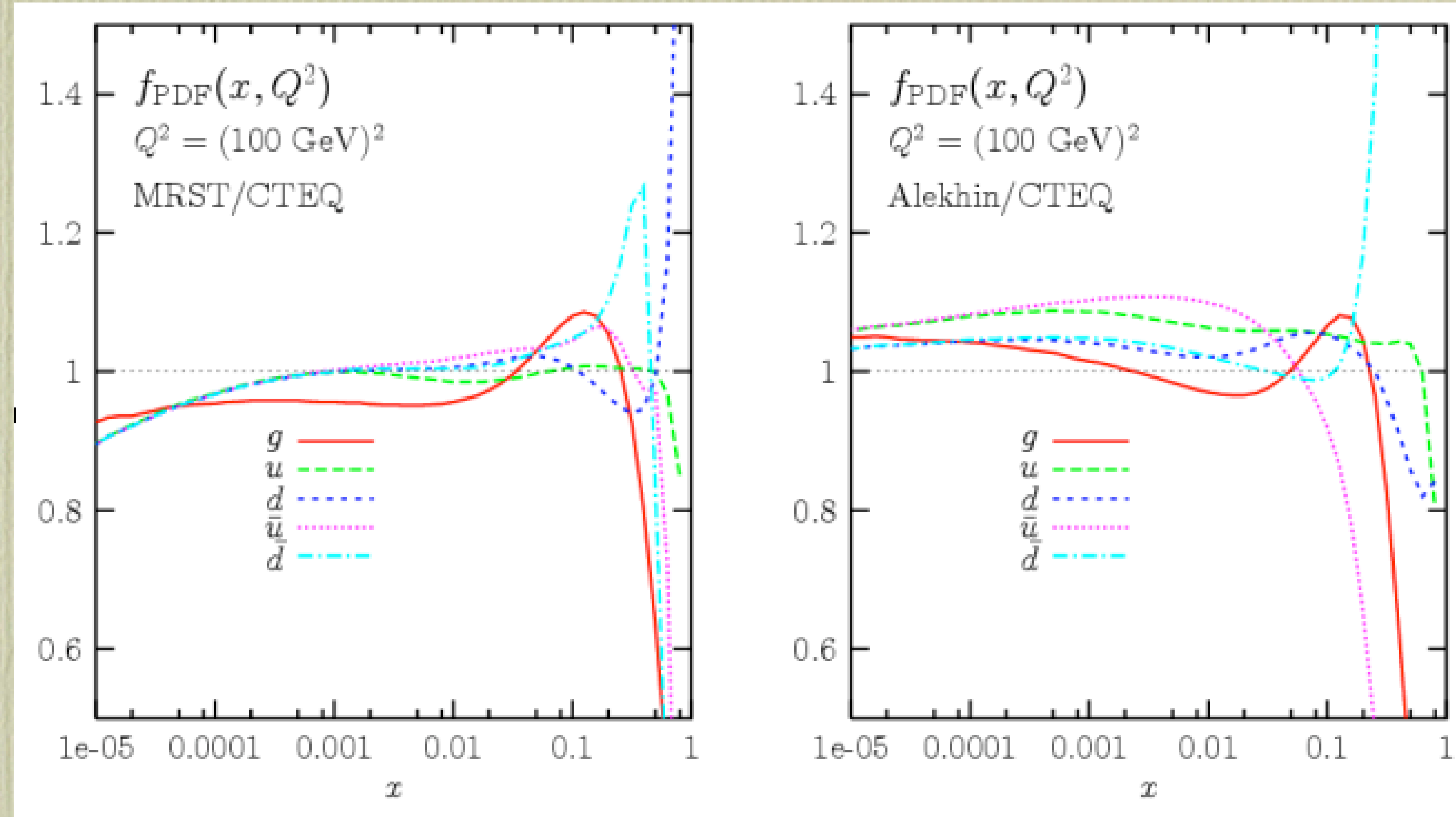


gg→H probes top Yukawa coupling. Good accuracy (<5%) over most m_H range.

Inconsistent estimates of uncert. bands!

qq→Hqq probes H coupling to gauge bosons. Poor accuracy (~10%) over most m_H range.

Inconsistent estimates of uncert. bands!



The problem of inconsistent evaluations of the PDF uncertainties (and central values) is common to several other observables (e.g. top cross-sections, W cross-section, etc). Most of the discrepancies originate in the choice of whether to include or not different sets of data, where to set the minimum Q^2 thresholds, and whether to attempt to describe higher-twist effects at low Q^2.

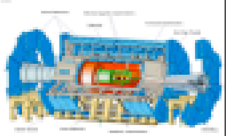
HERA will contribute improving our PDF knowledge in the next few years of run.

However a concrete and solid programme of determination/validation of PDF's will have to become an essential part of the physics goals of the LHC

Its possible impact on the trigger and analysis strategies of the early, low-luminosity phase, should be evaluated

See ongoing HERA-LHC Workshop,
http://www.desy.de/~heralhc/

Constraining the pdfs at LHC



How? For an s-channel process (W, Z, W/ZW/Z, tt) $m^2=sx_1x_2$ and $y=1/2\ln(x_1/x_2)$

$$\frac{dN_X}{dy} = \frac{d\sigma_{qq,gg\to X}}{dy} \bullet L \bullet pdf_{qq,gg}(x_1,x_2;Q^2)$$

$\Rightarrow x_{1/2} = e^{\pm y}\, m/\sqrt{s}$

From the shape of y differential cross-sections we can constraint different pdfs

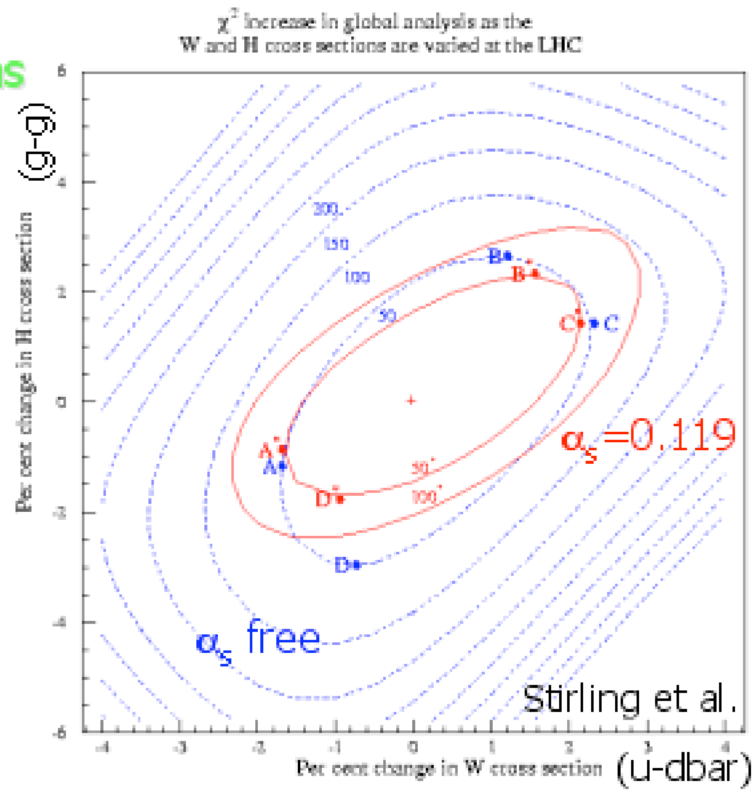
(one can measure L•pdf)

$\Rightarrow$ Single W, Z, W/ZW/Z can bring info on regions of x close to tt production
(q-antiq x range between 3 10^{-4} and 0.1)

$\Rightarrow$ γ or Z+jet can help in the q-g case
(g x range between 5 10^{-4} and 0.2)
($x_{b,c}$ range between 10^{-3} and 0.1)

$\Rightarrow$ W+jet can help for x_s

$\Rightarrow$ $d\sigma/dy(W^-)/d\sigma/dy(W^+) \approx d(x_1)/u(x_1)$ at large y



$\Rightarrow$ **All the high Q^2 region is covered !**
A few % on g and light quarks -syst. » stat.
And 5-10% on s, c, b might be reached

To which extent can we extrapolate from q-q ↔ g-g?

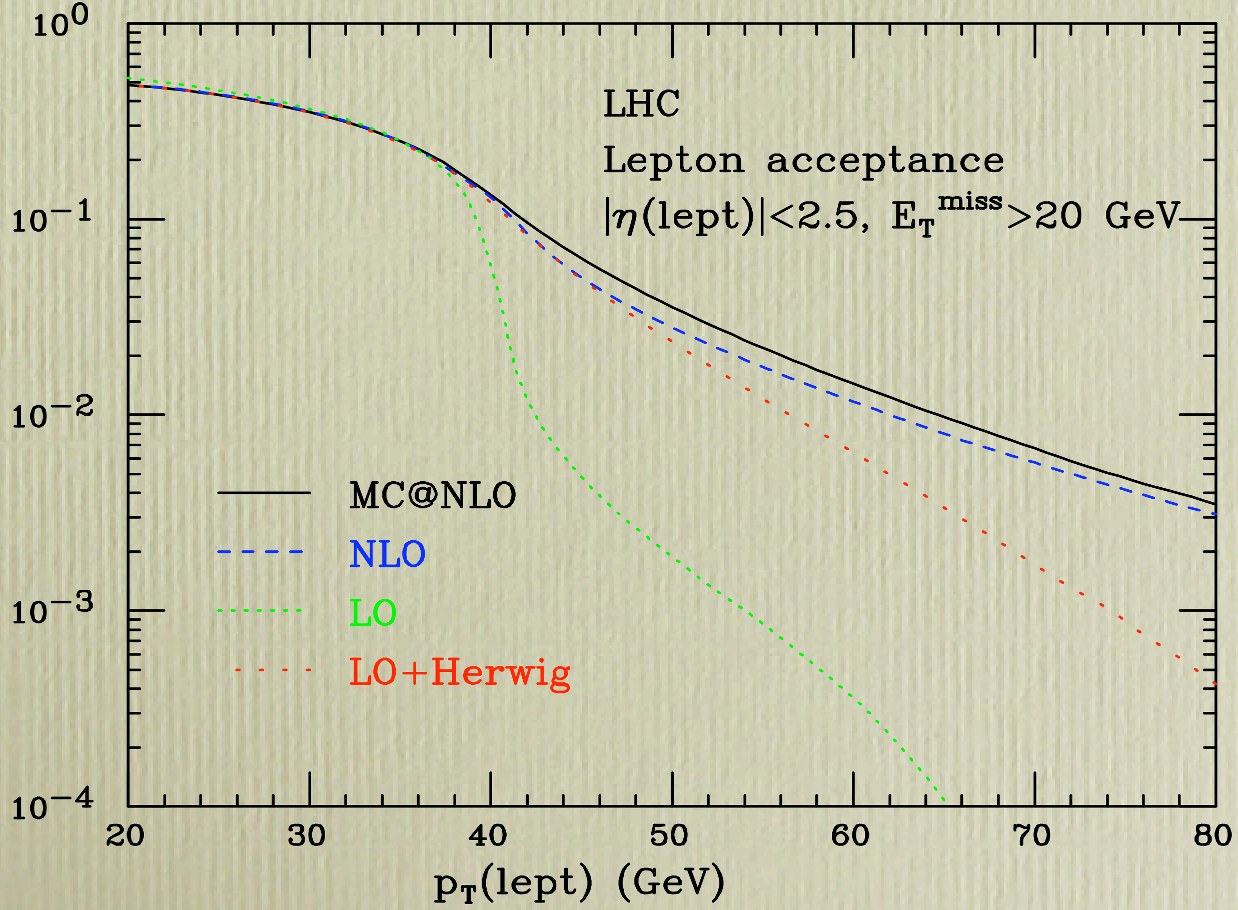
W/Z cross-sections

- Test of QCD to NNLO: potential accuracy ~ 2% on σ_{tot}
- Luminosity monitor
- Probe of PDF's

=> In view of incomplete detector coverage, need to ensure that the potential NNLO accuracy is reflected in the calculation of acceptancies. The realization of a QCD NNLO event generator, however, will still take few years. Is it required?

Example

(MLM and S.Frixione)



LO: leading order ME, parton level

LO+Herwig: leading order ME, plus parton shower

NLO: next-to-leading order ME, parton level

MC@NLO: next-to-leading order ME, plus parton shower

Cuts A $\longrightarrow |\eta^{(e)}| < 2.5,\ p_T^{(e)} > 20$ GeV, $p_T^{(\nu)} > 20$ GeV

Cuts B $\longrightarrow |\eta^{(e)}| < 2.5,\ p_T^{(e)} > 40$ GeV, $p_T^{(\nu)} > 20$ GeV

	LO		LO+HW	NLO		MC@NLO
Cuts A	0.5249	$\xrightarrow{-7.7\%}$	0.4843	0.4771	$\xrightarrow{+1.5\%}$	0.4845
	↓5.4%			↓7.0%		↓6.3%
Cuts A, no spin	0.5535			0.5104		0.5151
Cuts B	0.0585	$\xrightarrow{+208\%}$	0.1218	0.1292	$\xrightarrow{+2.9\%}$	0.1329
	↓29%			↓16%		↓18%
Cuts B, no spin	0.0752			0.1504		0.1570

- Large differences between LO and NLO. In large part absorbed improving LO with the parton shower
- Effect of parton shower strongly reduced after NLO effects are included in ME
- Difference between LO+HW and MC@NLO smaller than between NLO/MC@NLO
- Large impact of spin correlations
- PDF uncert ~ 1%

$\Longrightarrow$ A MC implementation of NNLO corrections is likely not needed with a 1-2% accuracy goal, provided p_T thresholds are loose enough. Before it is of any use, however, spin correlations must be included.

QED effects

With the level of accuracy reached in the QCD part of the W cross-section calculations, EW effects start becoming important. Full inclusion of EW effects will require inclusion of QED effects in the PDF.

Does HERA have any sensitivity to these effects?

How do we validate these calculations with LHC data?

CERN-PH-TH/2004-022
FNT/T 2004/02

Comparisons of the Monte Carlo programs HORACE and WINHAC for single-W-boson production at hadron colliders*

C.M. Carloni Calame[a,b], S. Jadach[c,d], G. Montagna[b,a], O. Nicrosini[a,b] *and* W. Płaczek[e,d]

Program	σ^{tot} [nb]: WITH CUTS		
	Born	$\mathcal{O}(\alpha)$	Best
	$W^- \longrightarrow e^-\bar{\nu}_e$		
HORACE	3.23633 (12)	3.18707 (13)	3.18696 (13)
WINHAC	3.23629 (09)	3.18779 (07)	3.18765 (06)
δ = (W − H)/W	$-1.2\,(4.6)\times10^{-5}$	$2.3\,(0.5)\times10^{-4}$	$2.2\,(0.5)\times10^{-4}$
	$W^- \longrightarrow \mu^-\bar{\nu}_\mu$		
HORACE	3.23632 (12)	3.15990 (12)	3.16013 (13)
WINHAC	3.23630 (07)	3.16418 (06)	3.16409 (05)
δ = (W − H)/W	$-0.6\,(4.3)\times10^{-5}$	$1.35\,(0.05)\times10^{-3}$	$1.25\,(0.05)\times10^{-3}$
	$W^+ \longrightarrow e^+\nu_e$		
HORACE	4.39341 (16)	4.32186 (17)	4.32187 (18)
WINHAC	4.39328 (13)	4.32286 (10)	4.32273 (08)
δ = (W − H)/W	$-3.0\,(4.7)\times10^{-5}$	$2.3\,(0.5)\times10^{-4}$	$2.0\,(0.5)\times10^{-4}$
	$W^+ \longrightarrow \mu^+\nu_\mu$		
HORACE	4.39340 (16)	4.28255 (16)	4.28326 (16)
WINHAC	4.39336 (10)	4.28837 (08)	4.28848 (08)
δ = (W − H)/W	$-0.9\,(4.3)\times10^{-5}$	$1.36\,(0.05)\times10^{-3}$	$1.22\,(0.05)\times10^{-3}$

What is the sequence of steps that will lead to the certification of a W cross-section measurement to the 1-2% level?

These levels of accuracies will be crucial to extract measurements of EW parameters (e.g. $\sin^2\theta_W$).

See talks by Maina and Cobal (EW session)

Once again low luminosity can play an important role, reducing backgrounds, allowing for lower trigger thresholds, better MissE_T resolution, etc.

m(top)

Latest average from Tevatron: **T.Dorigo, EW session**

$$m_t = 178.0 \pm 4.3 \Rightarrow m_H = 117\,^{+45}_{-68}$$

I personally do not believe in this new m_t average, which is mostly driven by the new DO measurement. This is entirely MC driven, and lacks proper validation of the used tools. The impact of the new measurement on the EW fits for m_H is too important to just accept it because we like the outcome.

m_{top} at the LHC: $\Delta m_{top} \sim 1$ GeV

See EWpresentation by **M.Cobal**.
Recent overview of ATLAS strategy and results for m_{top}: hep-ph/0403021

Channels considered:

+ (W→ lν)+4 jets, with 2 b tags
+ high-pT top, t 3 jets
+ (W→ lν) (W→ lν) + bb
+ $m_{l\psi}$ in events with B→ψX

Source of error in GeV	Lepton+jets inclusive sample	Lepton+jets large clusters sample	Dilepton	All jets high pT sample
Energy scale				
Light jet energy scale	0.2	-	-	0.8
b-jet energy scale	0.7	-	0.6	0.7
Mass scale calibration	-	0.9	-	-
UE estimate	-	1.3	-	-
Physics				
Background	0.1	0.1	0.2	0.4
b-quark fragmentation	0.1	0.3	0.7	0.3
Initial state radiation	0.1	0.1	0.1	0.4
Final state radiation	0.5	0.1	0.6	2.8
PDF	-	-	1.2	-

Need a strategy for validation of the MC input models:

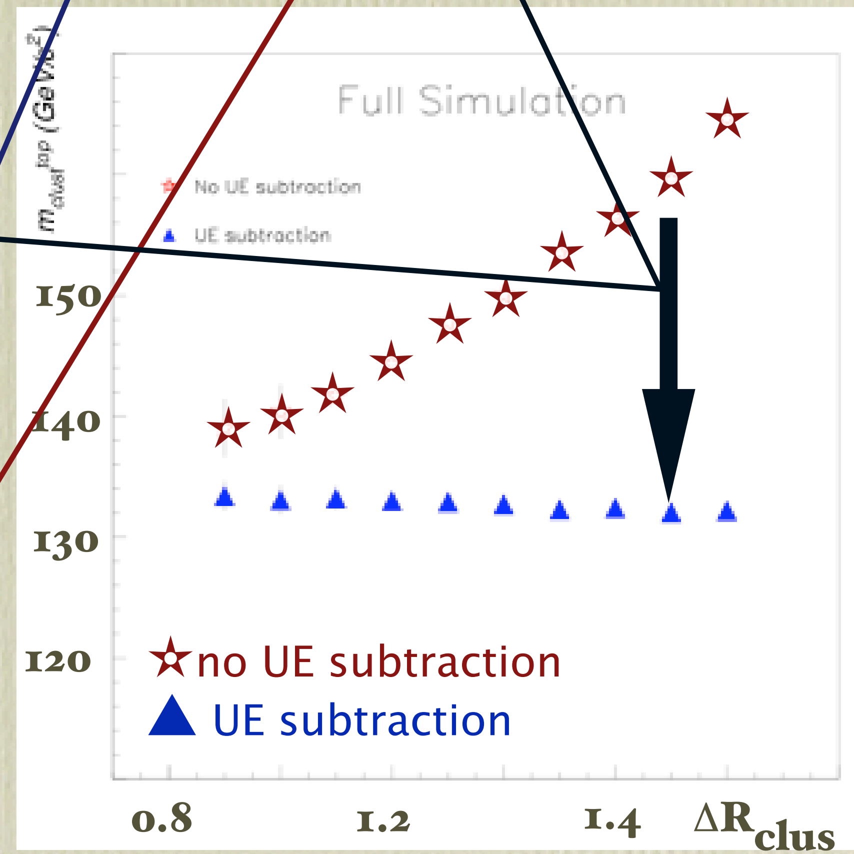
+ UE modeling and subtraction

+ validation of FSR effects:

✶ jet fragmentation properties, jet energy profiles

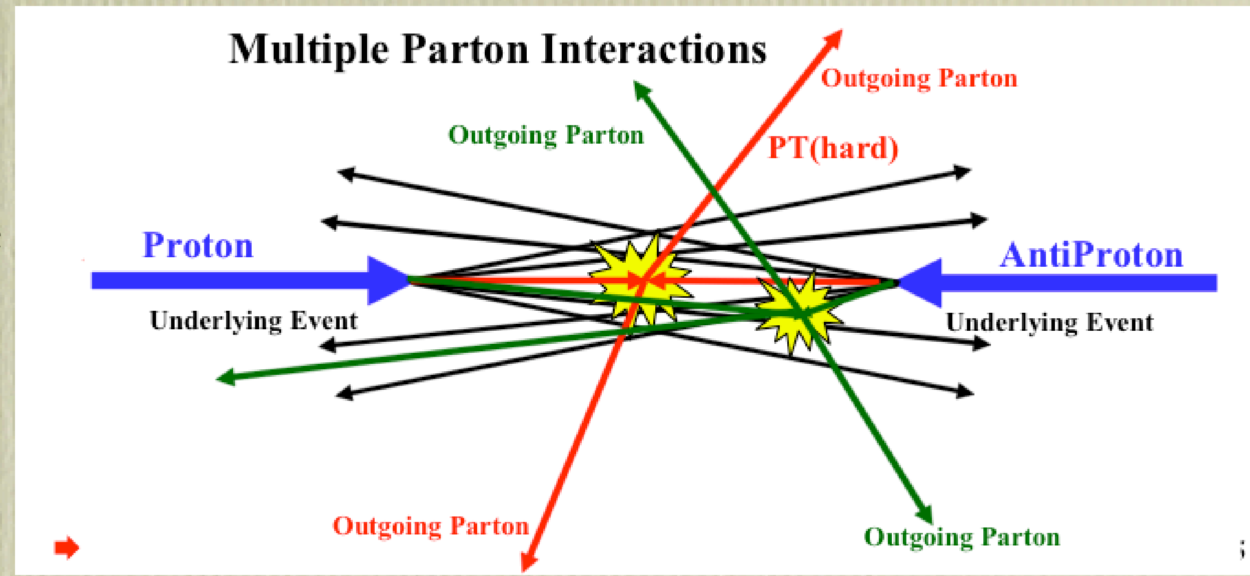
✶ how do we validate emission off the top quark in the high-pt top sample?

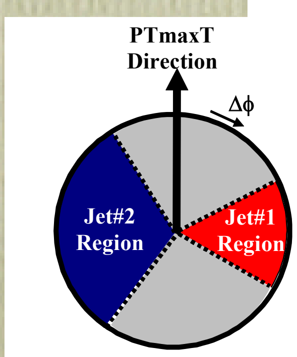
✶ b fragmentation function

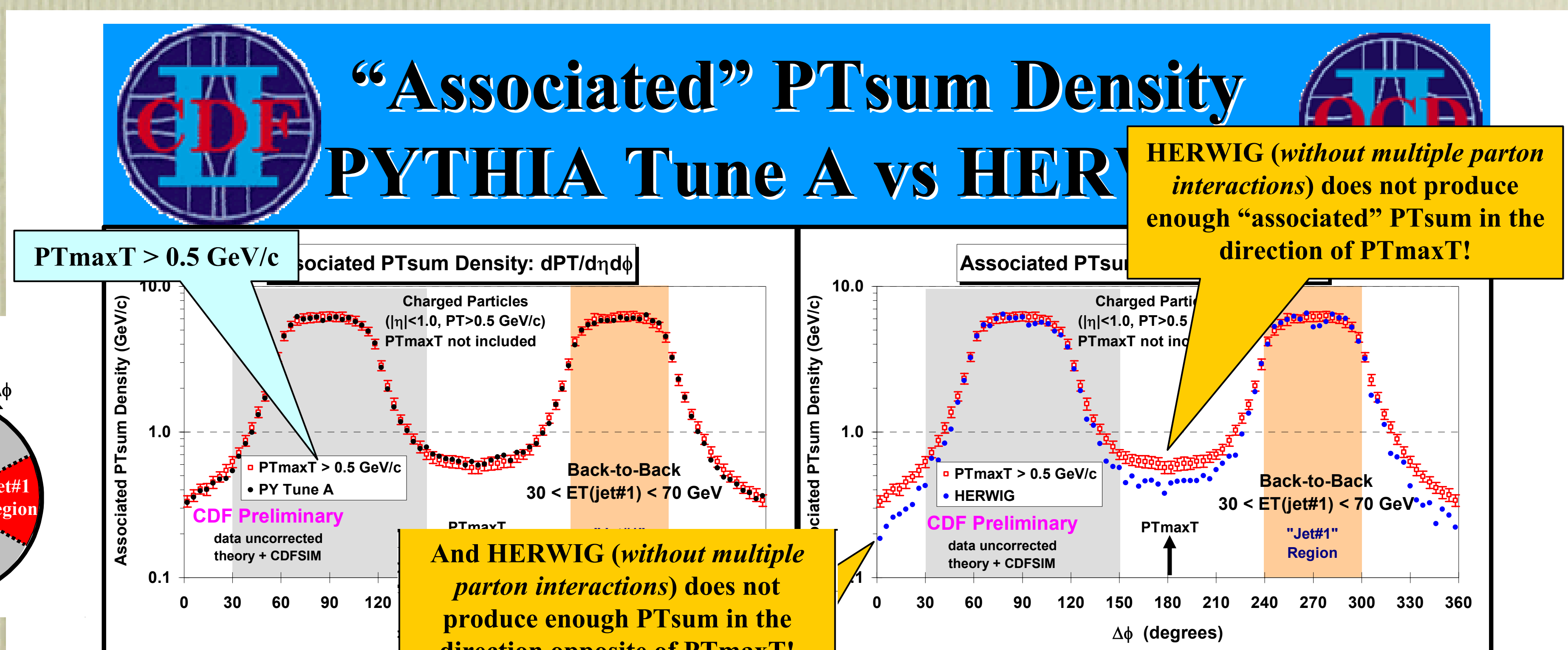


The structure of the underlying event

Mounting experimental evidence (R.Field, CDF) that the UE is the result of **multiple semi-hard (minijet-like) interactions**







- Extrapolation from Tevatron to LHC is hard, as it relies on the understanding of the unitarization of the minijet cross-section
- The mini-jet nature of the UE implies that the particle and energy flows are not uniformly distributed within a given event:
  - can one do better than the standard uniform, constant, UE energy subtraction?
- Studies of MB and UE should be done early on, at very low luminosity, to remove the effect of overlapping pp events:
  - MB triggers
  - low-E_T jet triggers

TRIGGERS

L1 Trigger

Low Luminosity L1 Trigger Table (Prototype)

Trigger type	Threshold (ε=95%) (GeV)	Indiv. Rate (kHz)	Cumul rate (kHz)
1e/γ, 2e/γ	29, 17	4.6	4.3
1μ, 2μ	14, 3	3.6	7.9
1τ, 2τ	86, 59	3.2	10.9
1-jet,3-jets, 4-jets	177,86,70	3.0	12.5
Jet * MissE$_T$	88 * 46	2.3	14.3
e * jet	21 * 45	0.8	15.1
Min-bias		0.9	16.0

Designed to cover the widest possible range of physics for discovery

-Total L1 allocated rate-
50 KHz x 1/3 safety factor

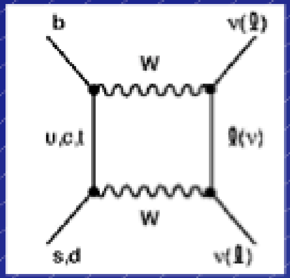
- B Physics selection triggered @ L1 by single or di-muon triggers
- Particles from B decays have relatively soft spectrum
- Important keeping the L1 threshold as low as possible
- Muons are preferred to electron because of the lower trigger threshold

Triggering on secondary vertices?

First examples from CMS DAQ TDR:

Three decay channels chosen as benchmark

- $B_s \to \mu^- \mu^+$



- FCNC b→ s, loop-level process in SM
- Indicator of possible new physics
- Observable before LHC only if drastically enhanced
- Unique signature…….but BR ~ O (10^{-9})

- $B_s \to J/\psi\ \varphi \to \mu^- \mu^+ K^- K^+$

- Gold-plated decay mode for CP-violation
- Sensitive to new physics
- Won't be studied with big accuracy before LHC

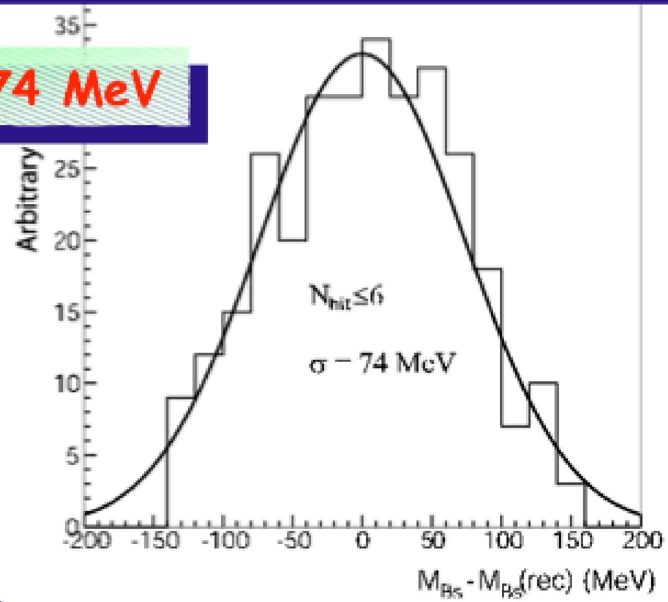
Triggered @ L1 by the presence of 2μ

HLT: require $d_0 > 200\ \mu m$

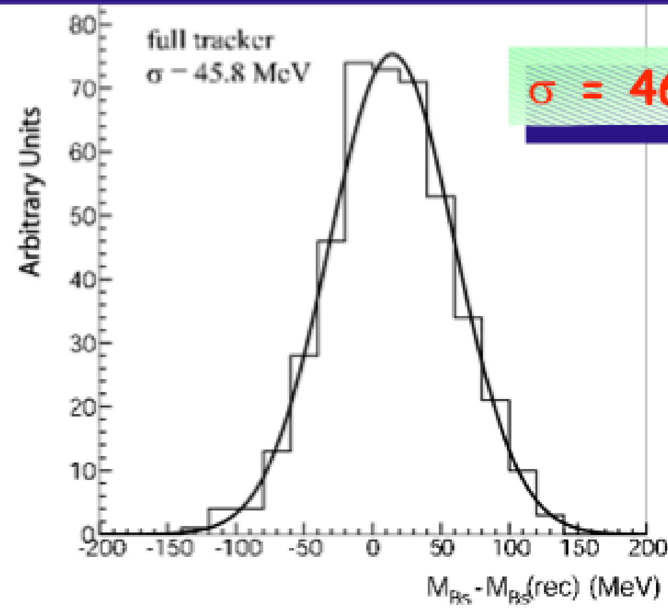
$B_s \rightarrow \mu^- \mu^+$ (BR_{SM}=3.5 10^{-9})

B_s Mass resolution

HLT — σ = 74 MeV



Full Tracking — σ = 46 MeV



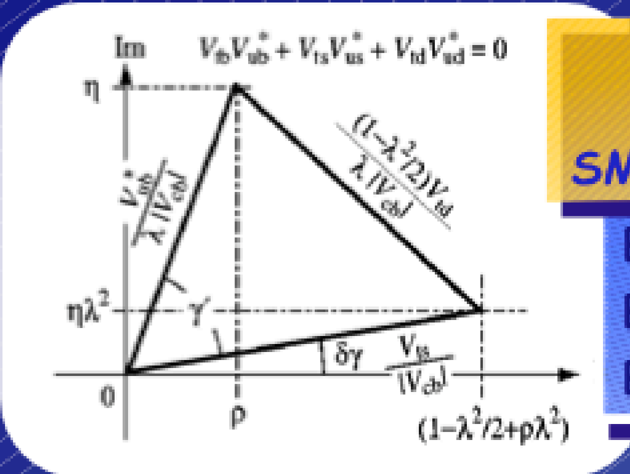
Old offline analysis (hep-ph/9907256 Jul 1999) predicts:

- ✓ 14 evts ± 2 bkg @ 90 C.L. with 20fb^{-1} (1 year @ 2x10^{33} $cm^{-2}s^{-1}$)
- ✓ 5σ observation with 40fb^{-1} and feasibility @ high lumi too

……… But L1 is in $|\eta|$ < 2.4 + slightly different kinematics cut

Update foreseen for the CMS Physics TDR

$B_s \to J/\psi\varphi \to \mu\mu\ KK$



CP violation weak phase
$\phi_s = 2\delta\gamma = 2\lambda^2\eta$
SM predicts tiny CP asymmetry $\phi_s \sim O(0.03)$

$BR(B_s \to J/\psi\ \phi) = (9.3 \pm 3.3) \times 10^{-4}$
$BR(J/\psi \to \ell^+\ell^-) \approx 6\%$
$BR(\phi \to K^+K^-) \approx 49\%$

- 1st step : J/ψ reconstruction → Retain muon pairs with $|M_{\mu\mu} - M_{J/\psi}| < 100$ MeV & Vertex $\chi^2 < 10$ & $d_0 > 200\ \mu m$

Rate = 15 Hz
<t>~260ms

- 2nd step: φ and B_s reconstruction
Regional/conditional tracking around the J/ψ direction + $|M_{KK} - M_\varphi| < 10$MeV
Then invariant mass $|M_{J/\psi\varphi} - M_{B_s}| < 60$ MeV + B_s vertexing

<t>~800ms

Lvl-1 ε	HLT step 1 ε	HLT step 1 Rate	HLT step 2 ε	HLT step 2 Rate	Events/ $10fb^{-1}$
16.5%	13.7%	14.5 Hz	8.7%	<1.7Hz	83800

$\sigma(\varphi_s) \sim 2^o$ with $40fb^{-1}$

Need for high-lum b-tagging in the trigger

Example: $qq \to qqH$, $H \to bb$

MLM, M.Moretti, Piccinini, Pittau, Polosa

Cuts on b jets: $E_{T,b}>30$ GeV, $|\eta|<2.5$

Cuts on light jets: $E_T>60$ GeV, $M(jj)>1000$ GeV, $|\eta_1-\eta_2|>4.2$, $|\eta_{1,2}|<5$

procs \ m_H	115 GeV		120 GeV		140 GeV	
Signal	1.3×10^4		1.3×10^4		6.2×10^3	
bbjj	6.0×10^6		5.3×10^6		4.7×10^6	
jjj_bj_b	9.5×10^4		9.5×10^4		9.5×10^4	
$jj_b \oplus jj_b$	1.8×10^4		1.9×10^4		2.3×10^4	
$(Z\to bb)_{res}jj$	1.6×10^4		8.3×10^3		7.7×10^2	
$(Z^*\to bb)_{DY}jj$	4.5×10^3		2.8×10^3		1.1×10^3	
$S/\sqrt{B}$; $\delta y/y$	5.1	0.10	5.2	0.10	2.7	0.19

j_b=light jet with $\varepsilon_{fake}=0.01$

⇒ unless there is some b-tag filter at the trigger level, over 10^9 4-jet events to tape ⇒ 100 Hz

Final remarks

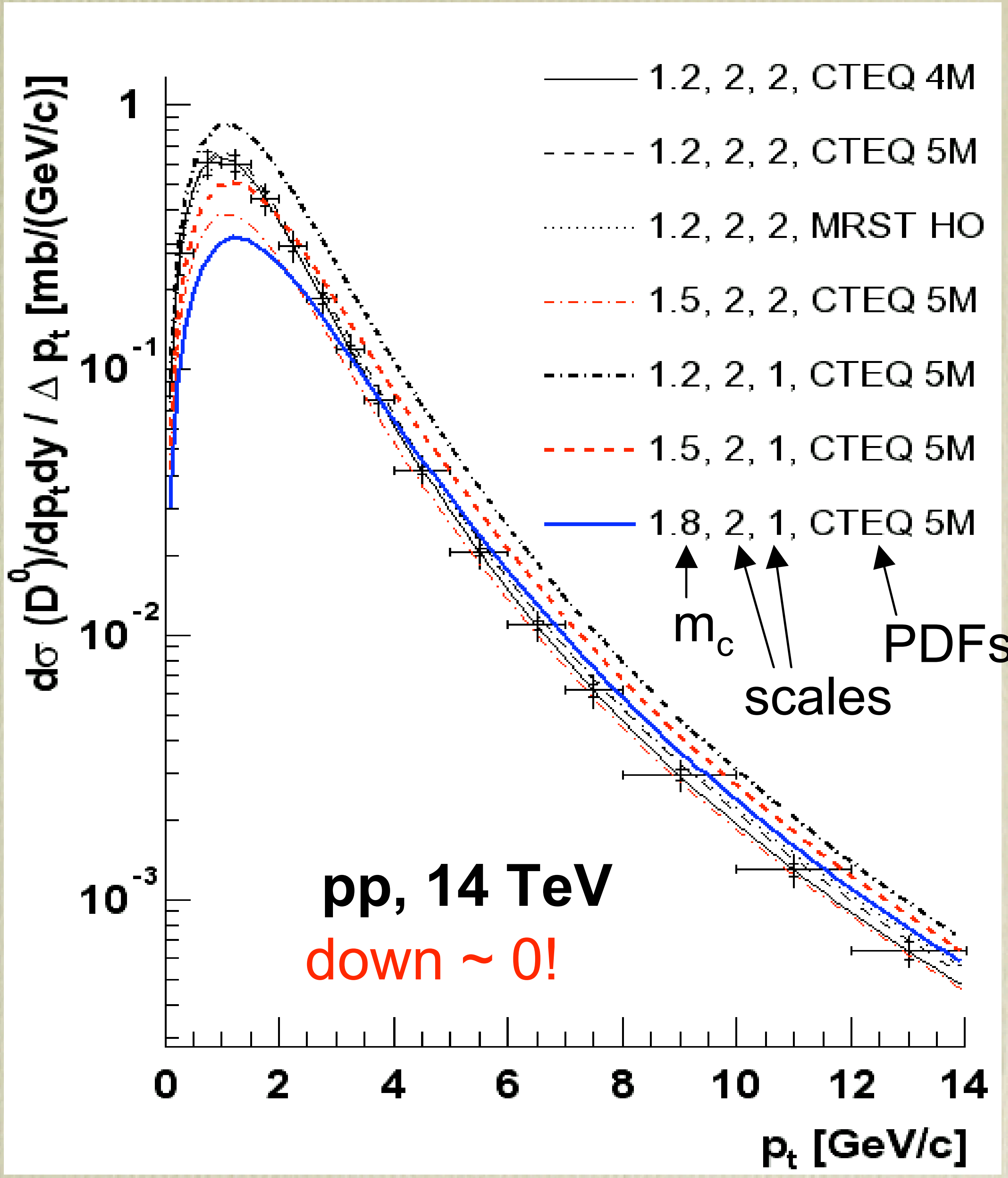
- I personally feel that the most important question the LHC should give an answer to is whether or not SUSY exists. If it does, the Higgs is granted (although it might show up later) and:
  - SUSY will open the door to a very rich domain of measurements, that will keep physicists busy for decades and will ultimately be the single strongest justification for the next generation of accelerators.
  - The understanding of SUSY, pinning down the specific model, will require input from all domains of physics:
    - LC
    - low-energy (g-2, $\mu \to e\gamma$, $K \to \pi\nu\nu$)
    - B decays ($B_s \to \mu\mu$, $B \to s\gamma$, CP phases, etc)
    - Direct DM searches, Cosmology
  - The link with DM and with the evolution of the early Universe, will reposition our field in the spot light of the scientific community, providing a stronger base of requests for the next-generation machines

(cont)

- We'll be "stuck" with the LHC for at least 20 year
- We should keep an open mind to new ideas and new proposals for its full exploitation, even on physics topics away from the main stream. For a long time the LHC will be the only *guaranteed* HEP facility available to our community. Some examples:
  - TOTEM+CMS, ATLAS fwd-physics
  - Atlas/CMS heavy ion programmes
  - Very-Forward photon detectors (cosmic ray physics)
  - Physics potential of beam-gas interactions at LHCb (e.g. $\sigma(b,c)$ at $\sqrt{S} \approx 170$ GeV, prompt γ's and large-x gluon PDF, ???)
  - High-rate charm physics?
- Perhaps the best upgrade path for the LHC is not the luminosity increase, but the construction of much improved detectors, tuned to the needs that will become clear once we find out what new physics is there (more sensitive B detectors, improved tau-tagging, to trigger on $Z \to \tau\tau$ and search for $\tau \to \mu\gamma$, to study $A \to \tau\tau$, etc)

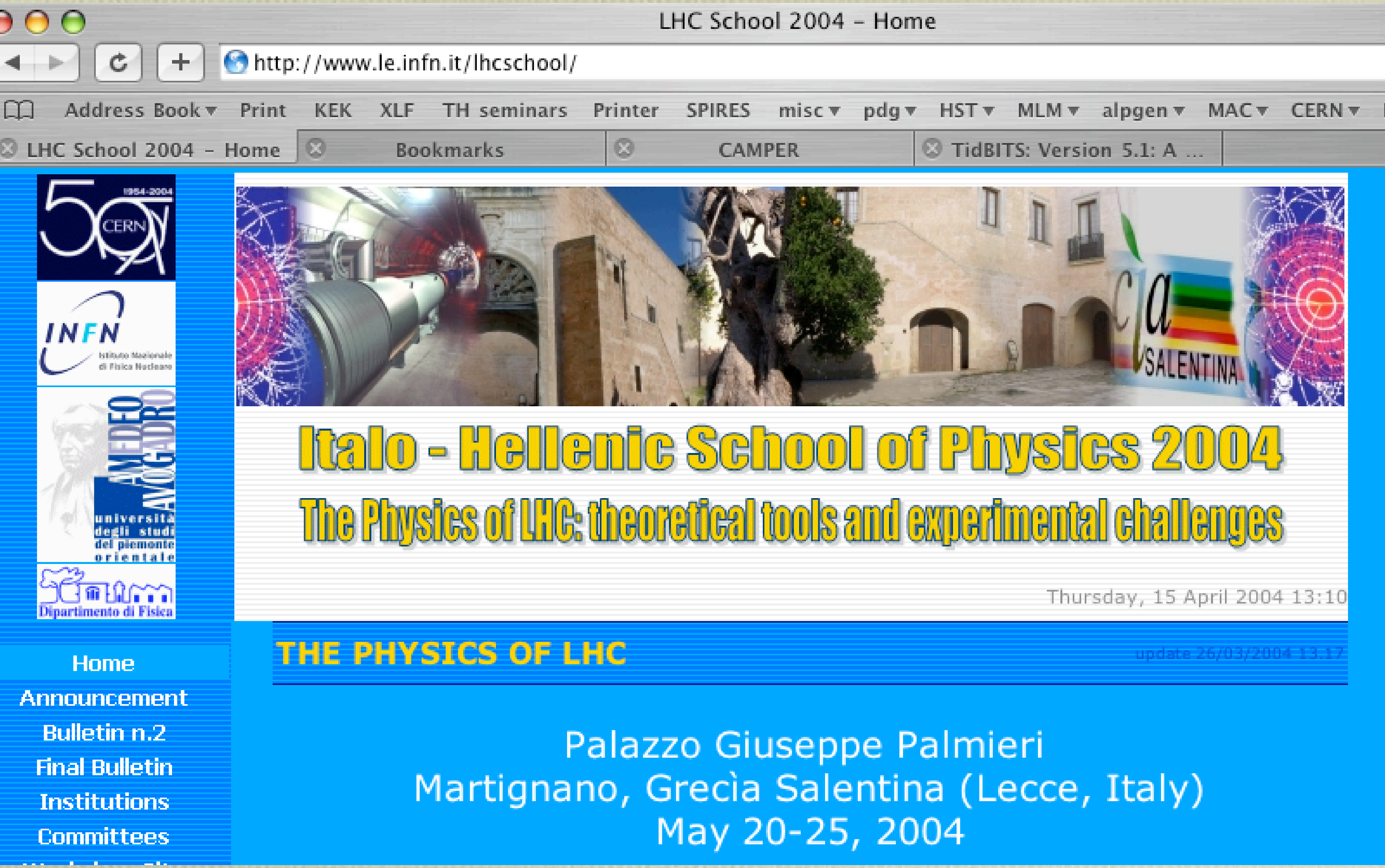
Atlas/CMS can compete with Alice with HIs. Alice is no less versatile, and could itself play a role in pp!

Example: Dainese et al, potential for D meson reconstruction in Alice: efficiency down to pt=0!



cont.

- Our simulation tools have significantly improved over the last 2-3 years:
  - inclusion of higher order matrix elements in shower MC's
  - inclusion of NLO corrections in shower MC's
  - better models for the underlying event, and for hadronization
- Proper use of these tools will require validation and tuning against data. The Tevatron experiments have not yet developed a culture of MC tuning, as has happened instead at LEP and HERA. As a result, I personally **do not feel we have today a solid control over the theoretical systematic uncertainties in several crucial measurements at the LHC:** $\Delta^{th}(m_W)$, $\Delta^{th}(m_{top})$, $\Delta^{th}(\sigma_W)$
- Improvement of our tools, via **theoretical developments** and via strategies for the **validation of the theoretical systematics** is a crucial duty of our community. The collaboration between MC developers and experimentalists will be fundamental!



There are still a few (~ 5) open slots

Dear •••••••

I completed the paper about H -> WW top background extrapolation:
•••••••

I hope you find it useful. Let me know if anything is unclear.
As far as the future is concerned, unfortunately, I have to abandon this direction of research. I have been warned by several senior people that this kind of service work by theorists for experimentalists does not result in career opportunities. I wish CMS and ATLAS the very best for the period of intense Monte Carlo studies that lies ahead in the
final years before the start of the LHC.

All the best,