Measuring top quarks at the LHC

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❶ Physics : the top quark knowledge within few years

❷ Method : overview of measurements in the pp→tT channels

- ✓ several methods with their individual philosophies and features
- ✓ most of the information from fast simulation studies
- ✓ prospects for extraction of cross-section, mass, spin correlations,…

❸ New ideas : LHC compared to the Tevatron

- ✓ from statistical improvement to detailed systematics studies

❹ Status report on the CMS detector… start-up summer 2007 !!

The top quark at the LHC : simulation studies

Still a few years before real data… hence all based on Monte Carlo simulation

❶ Main generator used : PYTHIA

- ✓ does not include spin correlations
- ☛ fast simulation : the PYTHIA objects are smeared to mimic the detector
  (ATL-PHYS-2002-007 : *less than 200 MeV difference between PYTHIA and HERWIG (m_t)*)
- ☛ the particles interaction not being simulated with GEANT

❷ ATLAS : studies based on fast simulation ('*fastsim*')

- ✓ have published results on the basis of fastsim
- ✓ summarized in the Physics - Technical Design Report (1999)
- ✓ some results cross-checked with full GEANT simulation

❸ CMS : studies based on fast simulation ('*fastsim*')

- ✓ since ~1.5 y policy of not showing fastsim studies ⇨ few publications
- ✓ large efforts have been made to provide GEANT-4 simulation
- ✓ in the process of written a Physics - Technical Design Report with this accurate simulation (expected by early 2006)

The top quark at the LHC : references

Main publications which form the basis of this talk

❶ **In common to ATLAS/CMS :**

- ✔ summary report of the LHC Workshop on Standard Model Physics
- ☛ LHC Yellow Report on Standard Model Physics (1999-2000)

❷ **ATLAS :** studies based on fast simulation ('*fastsim*')

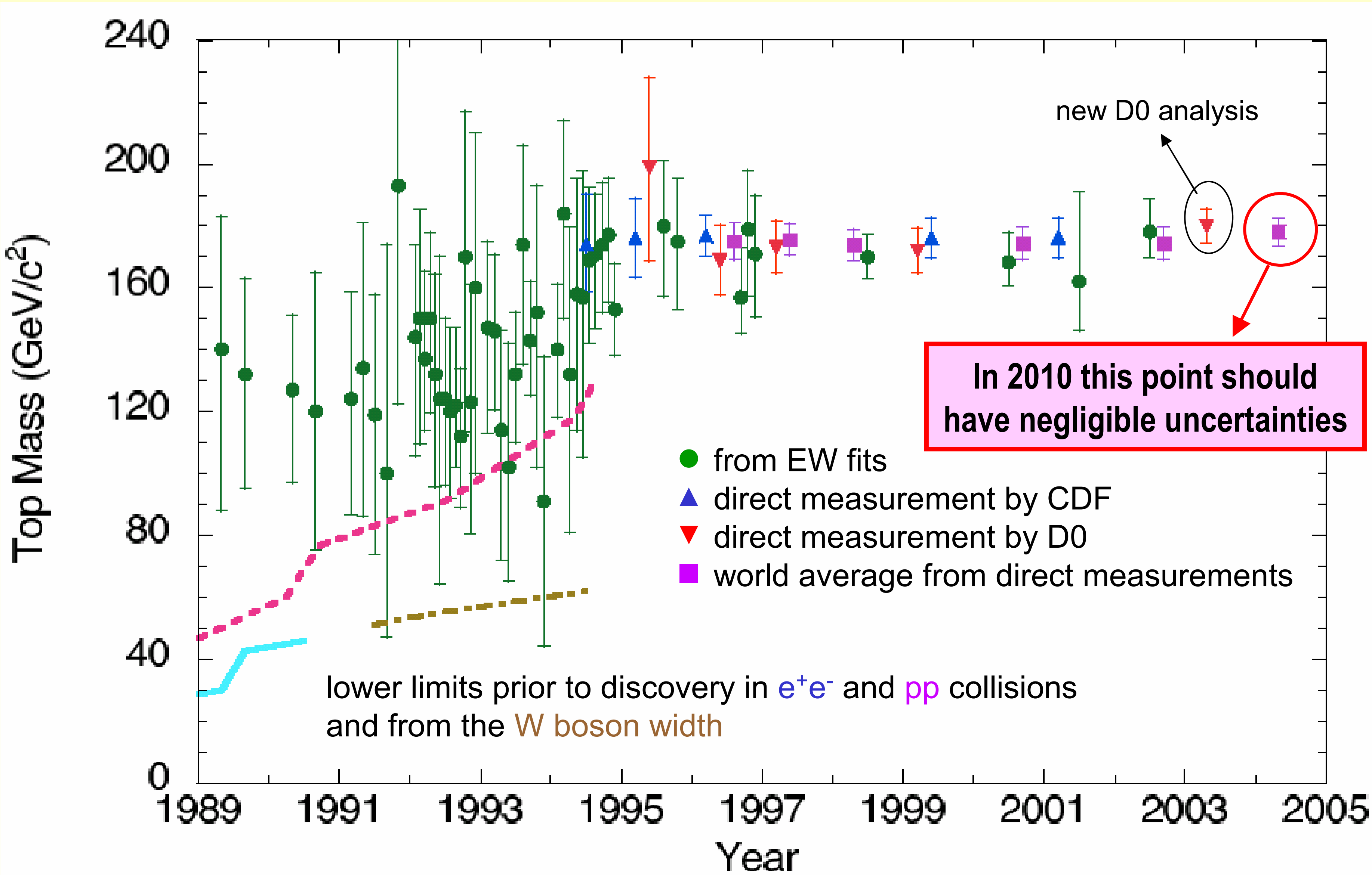
- ✔ Physics – Technical Design Report (P-TDR 1999) – volume 1 & 2
- ✔ hep-ex/0403021
- ✔ Physics notes (ATL-PHYS) : 2001-016, 2002-007, 2003-011, 2003-012

❸ **CMS :** studies based on fast simulation ('*fastsim*')

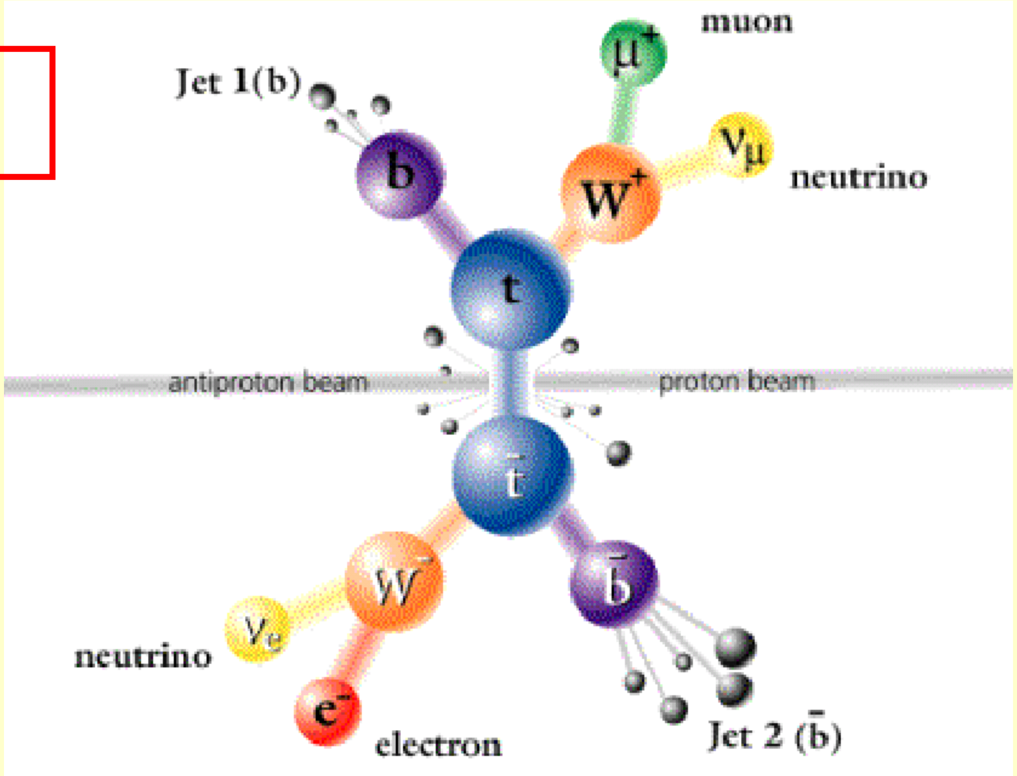
- ✔ CMS-NOTE-1999-065, CMS-NOTE-2001-001

The top quark within the Standard Model : history

A new era for top quark physics starts with the collection of these large event samples



Differentiate our analyses !!!



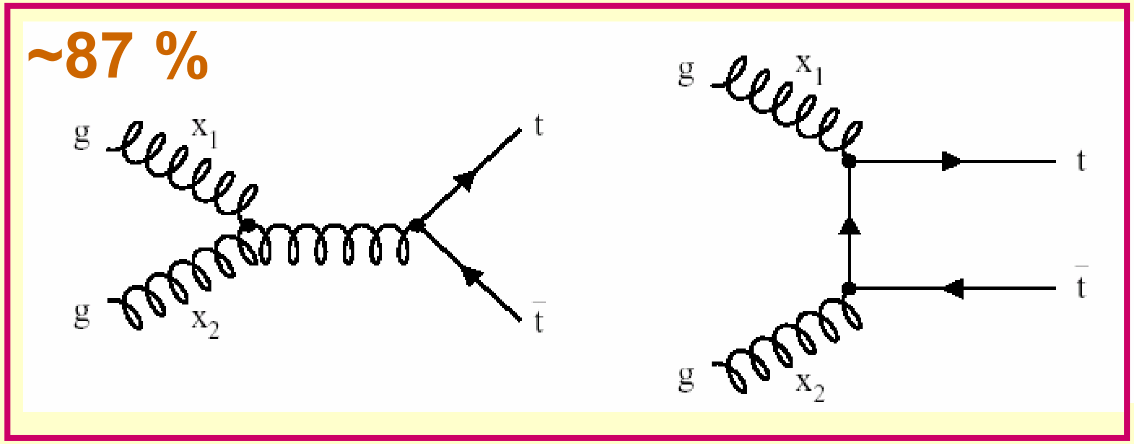
Do not concentrate on few particular analysis tools…

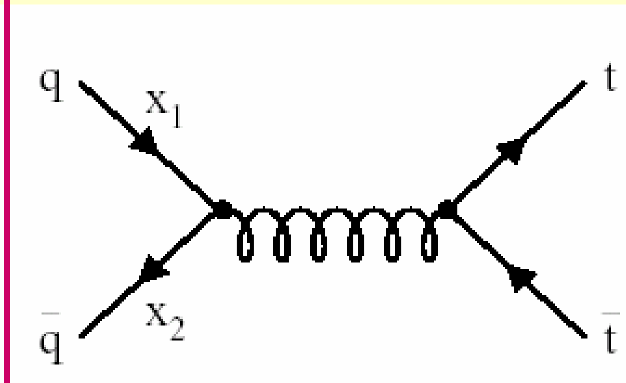
- ✓ study many different tools (for example jet clustering algorithms)
- ✓ identify their positive and negative features in the complex LHC environment

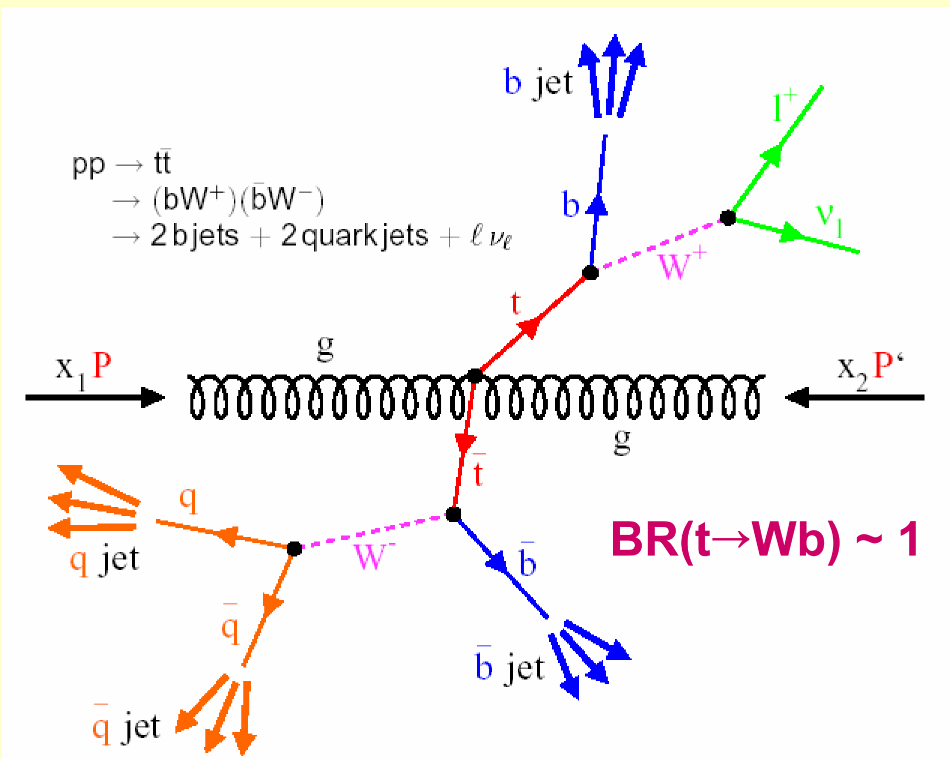
Optimize the analyses for both statistical and systematical uncertainties !!

Jorgen D'Hondt (Brussels)

The pp → tT process at the LHC



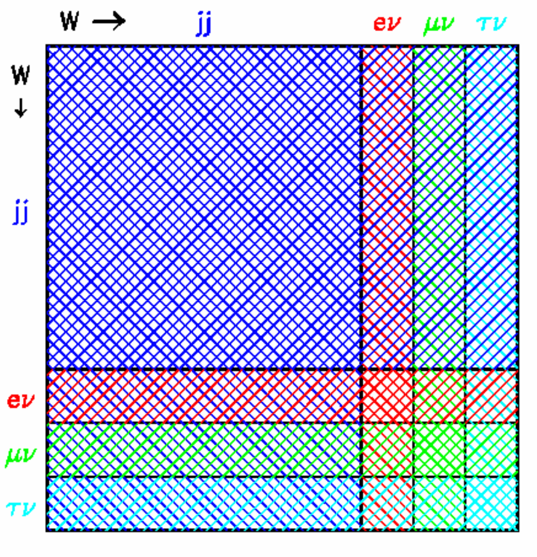




- ✓ Many physics parameters to be measured with these events (hence reconstruct the ***complete*** event !)
- ✓ Also it is the main background for searches beyond the Standard Model at the LHC
- ✓ NLO cross-section for tT production
  σ^{NLO} = 833 pb ⇨ ~8M events for $10 fb^{-1}$

  ($10 fb^{-1}$ = 1 year of LHC running at low luminosity, hence by summer 2008)

The pp → tT process at the LHC : event selection



Main background processes for pp→tT→WbWb :

❶ Fully hadronic channel : 3.7M*evnt*/10fb^{-1}

- ✓ QCD multijet (2→2 parton processes)
- ✓ 6-jets p_T>40GeV, b-tags≥2 : S/B~1/19, ε~2.7%

❷ Lepton + jets channel (lepton = e/μ) : 2.5M*evnt*/10fb^{-1}

- ✓ bb→lv+jets, W+jets→lv+jets, Z+jets→ll+jets, WW→lv+jets, WZ→lv+jets, ZZ→ll+jets
- ✓ before selection we have S/B ~ 10^{-5}
- ✓ p_T^{lepton}>20GeV, E_T^{miss}>20GeV, p_T^{jet}>40GeV, b-tags≥2 : S/B ~ 78, ε~3.5%
- ✓ p_T^{lepton}>20GeV, E_T^{miss}>20GeV, p_T^{jet}>40GeV, b-tags≥1 : S/B ~ 28, ε~14%

❸ Di-lepton channel : 0.4M*evnt*/10fb^{-1}

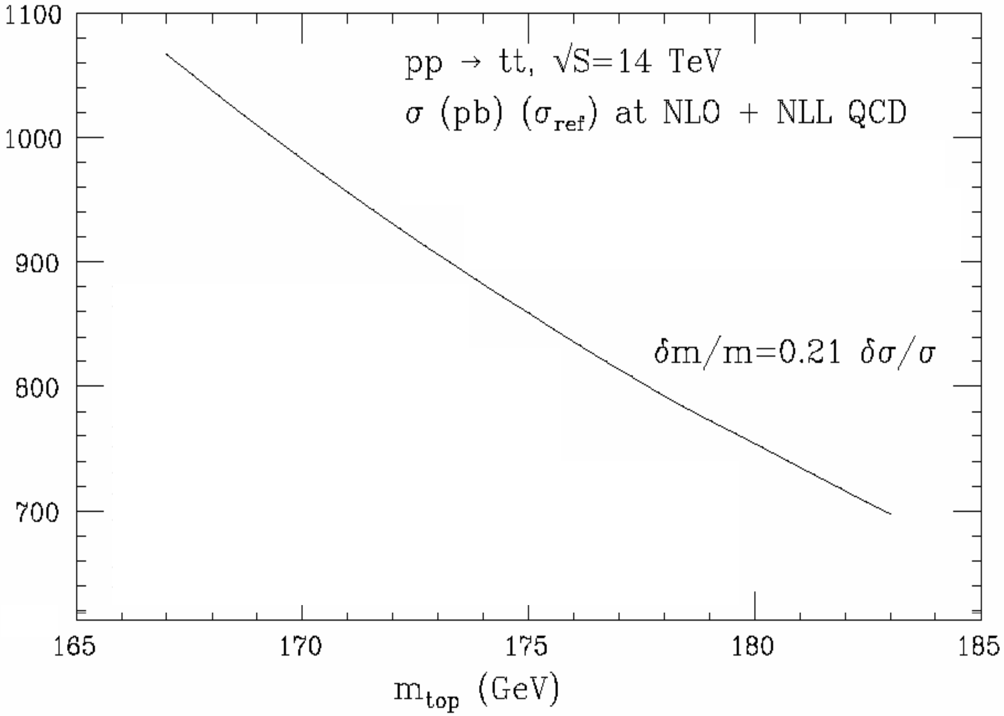
- ✓ Drell-Yan processes, Z+jets→ll+jets, WW+jets, bb
- ✓ p_T^{l+}>35GeV, p_T^{l-}>25GeV, E_T^{miss}>40GeV, p_T^{jets}>25GeV : S/B~10, ε~20%

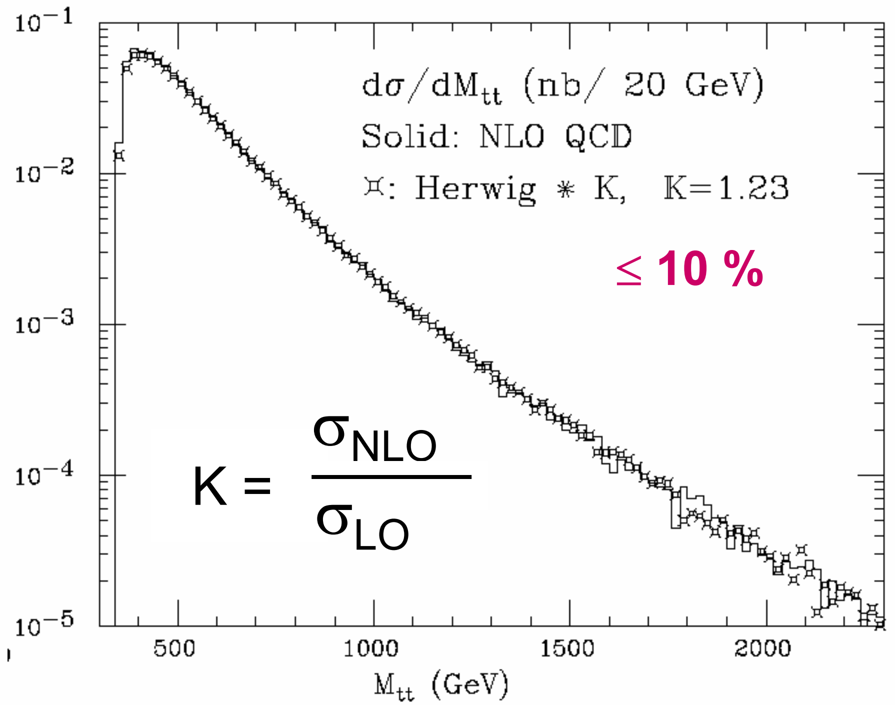
Influence of trigger to be checked, development of b-tag trigger for example.

ATLAS numbers

The pp → tT process at the LHC : cross section

❶ **Sensitive to top mass** : $\Delta\sigma/\sigma \sim 5\ \Delta m_t/m_t$ → 5% on σ gives 2 GeV on m_t





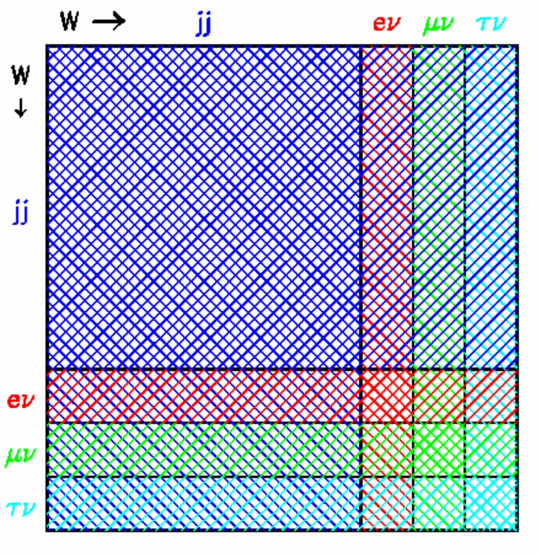
systematics dominated by the uncertainty on the luminosity

ATLAS preliminary

Time	Number of events at 10^{33}	$\Delta\sigma/\sigma$ (stat)
1 "week"	2×10^3	2.5%
1 "month"	7×10^4	0.4%
1 "year"	3×10^5	0.2%

Cross-section sensitive to renormalisation and factorisation scale, and to the choice of PDF (Parton Density Function)

The pp → tT process at the LHC



❶ Fully hadronic channel : 3.7M*evnt*/10fb^{-1}

- ✓ S/B~1/19, ε~2.7%

❷ Lepton + jets channel (lepton = e/μ) : 2.5M*evnt*/10fb^{-1}

- ✓ S/B ~ 28, ε~14%

❸ Di-lepton channel : 0.4M*evnt*/10fb^{-1}

- ✓ S/B~10, ε~20%

Extra cuts can be exploited connected to the kinematics of the complete event

Remember : not all events will be well reconstructed !!

(*for example the jet clustering algorithm does 'not' take into account the hard gluon radiation from the initial partons, and therefore spoils the reconstructed top mass*)

⇨ cuts needed to minimize these systematic uncertainties

The pp → tT process at the LHC : fully hadronic

❶ Fully hadronic channel : 3.7M*evnt*/10fb^{-1}

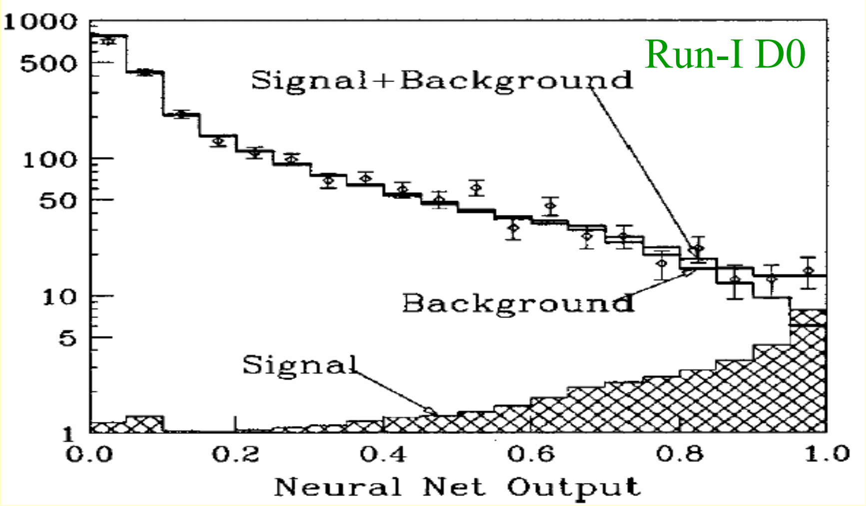
- ✓ 6-jets p_T>40GeV, b-tags≥2 : S/B~1/19, ε~2.7%
- ✓ discriminant variables (energy flow, additional radiation, event shape)

✓ CDF [Phys.Rev.Lett. **79** 1992 (1997)]:

- ➙ relying on high b-tag efficiency (46%)
- ➙ signal significance of 3σ

✓ D0 [hep-ex/9808034] :

- ➙ multi - Neural Network selection
- ➙ complicated analysis !!
- ➙ signal significance of 2.5σ

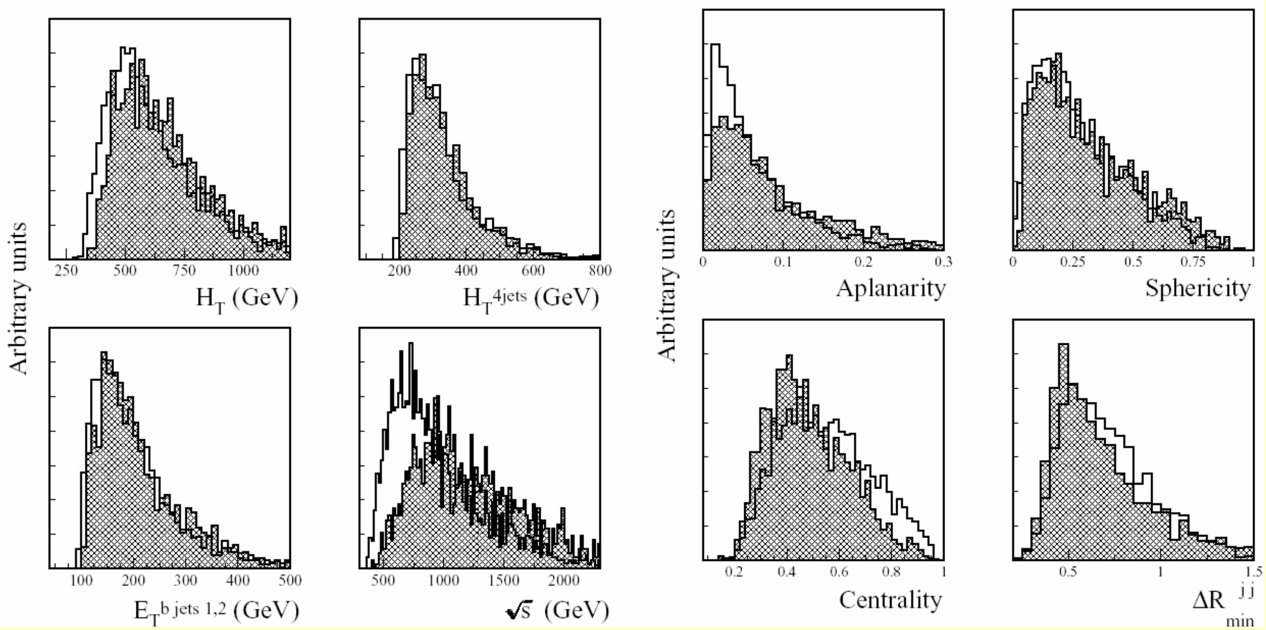


- ✓ try to use the same discriminant variables at the LHC

The pp → tT process at the LHC : fully hadronic

❶ Fully hadronic channel : 3.7M*evnt*/10fb^{-1}

- ✔ 6-jets p_T>40GeV, b-tags≥2 : S/B~1/19, ε~2.7%
- ✔ discriminant variables (energy flow, additional radiation, event shape)



some based on the D0 Neural Network procedure

not as powerful as in D0

ATLAS paper hep-ex/0403021

- *hatched* : tT signal
- *open* : QCD background

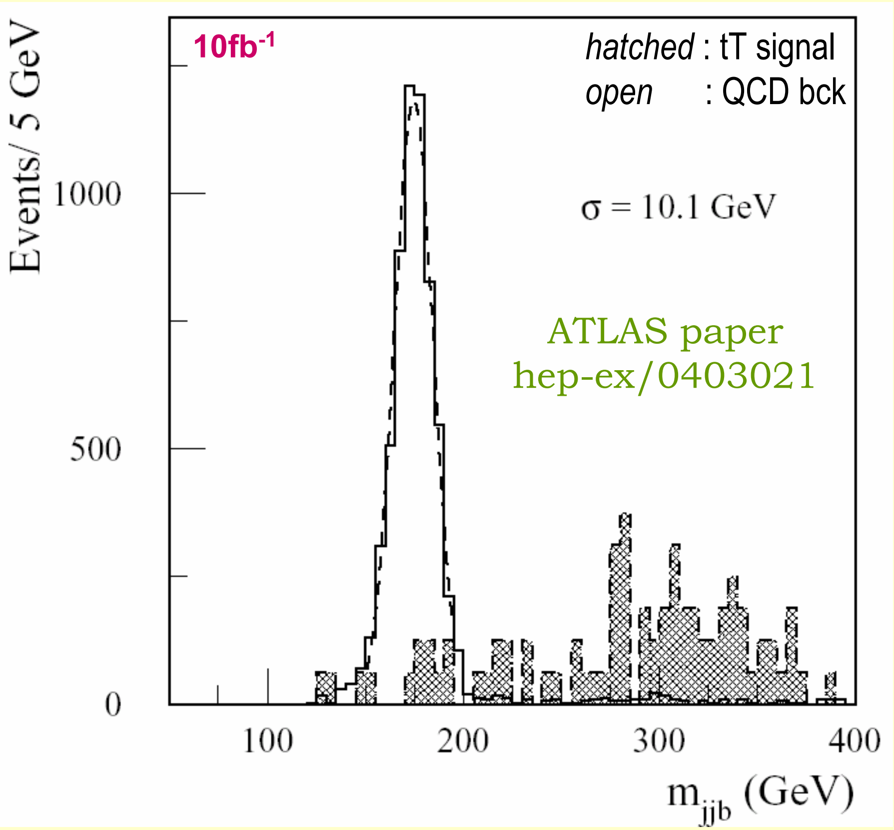
- ✔ kinematic fit (χ^2 on the jet energies) + mass window 130-200 GeV :
  S/B~6, ε~0.18% (uncertainty on remaining background B is ~40%)
- ✔ can be further improved by asking p_T^{top}>200GeV : S/B~18, ε~0.09%

A clean sample of signal events with ~3.3k*evnt*/10fb^{-1} ⇨ *for top mass estimation*

The pp → tT process at the LHC : fully hadronic

❶ <u>Fully hadronic channel :</u> 3.7M*evnt*/10fb^{-1}

- ✓ p_T^{top}>200GeV : S/B~18, ε~0.09% ⇨ ~3.3k*evnt*/year
- ✓ using the kinematic fit and the jet combination with the lowest χ^2



Gaussian fit in the window 130-200 GeV results in a peak width of 10.1 GeV

for 10fb^{-1} ⇨ **δm_t(stat) = 180 MeV**

Systematics	δm_t (GeV)
Light jet energy scale	0.8
b-jet energy scale	0.7
b-quark fragmentation	0.3
Initial state radiation	0.4
Final state radiation	2.8

Total systematic uncertainty ~ 3.0 GeV

➔ This clean sample will also be exploited for differential distributions.

Definition of the systematic uncertainties

❶ **Jet energy scale :**

- ✓ different mis-calibration coefficients were applied to the jets
- ✓ in was assumed that the jet energy scale is known to the 1% level
- ✓ a difference is made between light and heavy quark jets

❷ **Radiation in the initial and final state (ISR/FSR) :**

- ✓ it assumed that our knowledge of ISR/FSR is 10%
- ✓ conservatively 20% of the shift between with-ISR/FSR and no-ISR/FSR was taken (linear rescaling)

❸ **b-quark fragmentation :**

- ✓ described in the fragmentation by the Peterson function (parameter ε_b)
- ✓ PYTHIA default ε_b=-0.006 with an uncertainty of 0.0025
- ✓ the shift between ε_b(default) and ε_b(0.0019) was taken

❹ **Background :**

- ✓ dominated by combinatorial background (S/B is high)
- ✓ estimated by changing the assumed shape in the fit

The pp → tT process at the LHC : lepton+jet channel

❷ Lepton + jets channel (lepton = e/μ) : 2.5Mevtn/10fb^{-1}

- ✔ p_T^{lepton}>20GeV, E_T^{miss}>20GeV, p_T^{jet}>40GeV, b-tags≥2 : S/B ~ 78, ε~3.5%
- ✔ p_T^{lepton}>20GeV, E_T^{miss}>20GeV, p_T^{jet}>40GeV, b-tags≥1 : S/B ~ 28, ε~14%

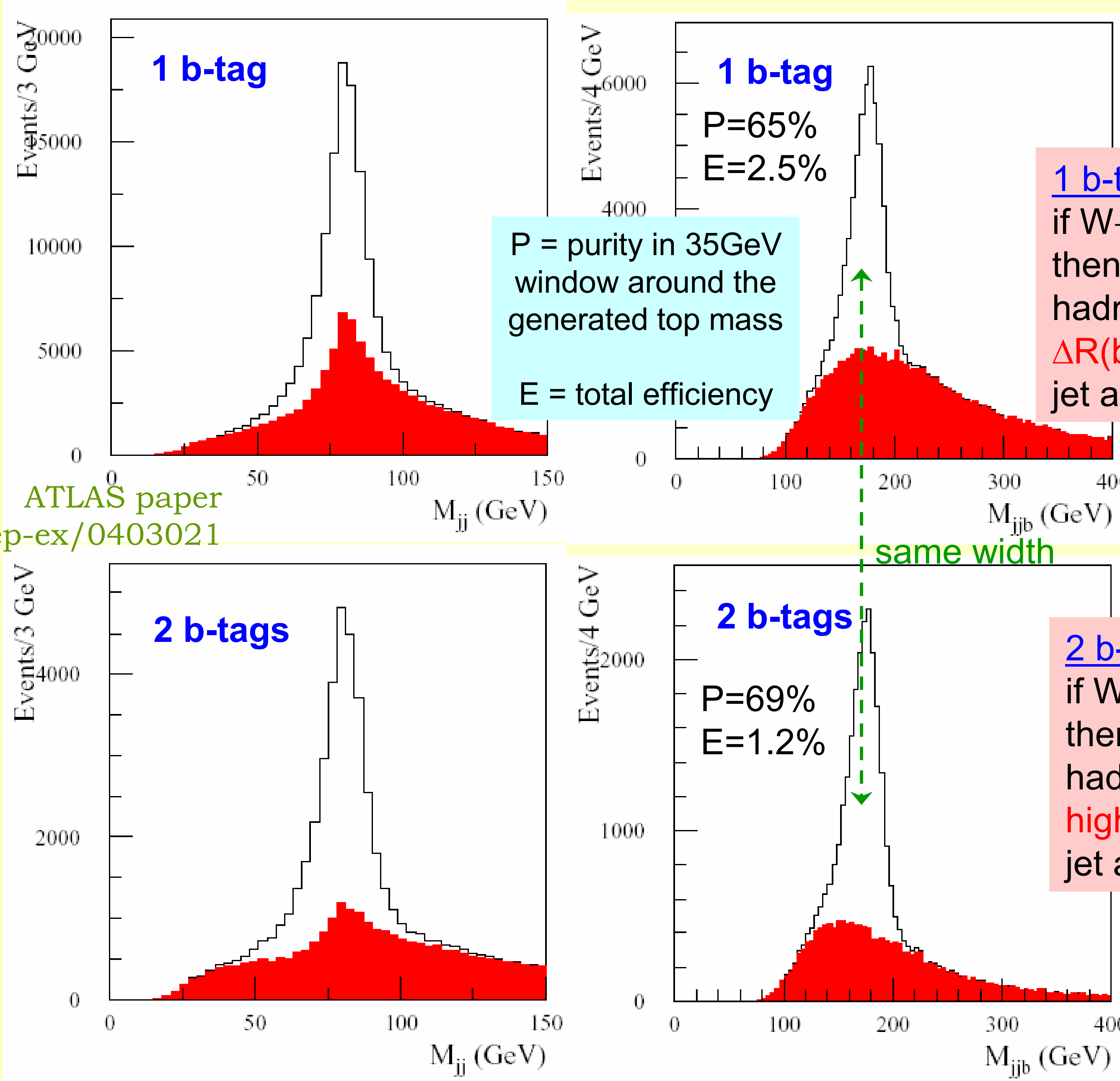
Cut **PYTHIA 5.7 NLO**	Remaining fraction of generated events		
	$\ell = e, \mu$	$\ell = \tau$	$\ell = e, \mu, \tau$
At least 1 lepton with $\vert\eta_\ell\vert < 2.4$	81.0 %	36.9 %	66.3 %
Exactly 1 lepton with $p_\perp(\ell) > 20$ GeV	70.6 %	18.6 %	53.3 %
Lepton isolation $I_{R=0.3} < 0.1$	57.5 %	7.5 %	40.8 %
Missing transverse momentum $\not{p}_\perp > 20$ GeV	51.2 %	6.9 %	36.4 %
At least 4 jets with $E_\perp > 40$ GeV	9.2 %	1.4 %	6.6 %
Exactly 2 b jets with $E_\perp > 50$ GeV	2.5 %	0.4 %	1.8 %
$60 < m_W^{\text{rec.}} < 100$ GeV	0.99 %	0.17 %	0.72 %
Transverse mass $m_\perp(W_{\text{lep.}}) < 100$ GeV	0.94 %	0.16 %	0.68 %
Azimuthal angle between rec. tops: $\cos\phi_{t\bar{t}} \leq$ -0.8	0.70 %	0.13 %	0.51 %
Rec. top mass difference $\vert m_t - m_{\bar{t}}\vert < 25$ GeV	0.19 %	0.03 %	0.14 %

CMS Note 2001/001

→ reconstruction inefficiency of the top

The correct choice of the jet combination into top quarks is important !

The pp → tT process at the LHC : lepton+jet channel



ATLAS paper hep-ex/0403021

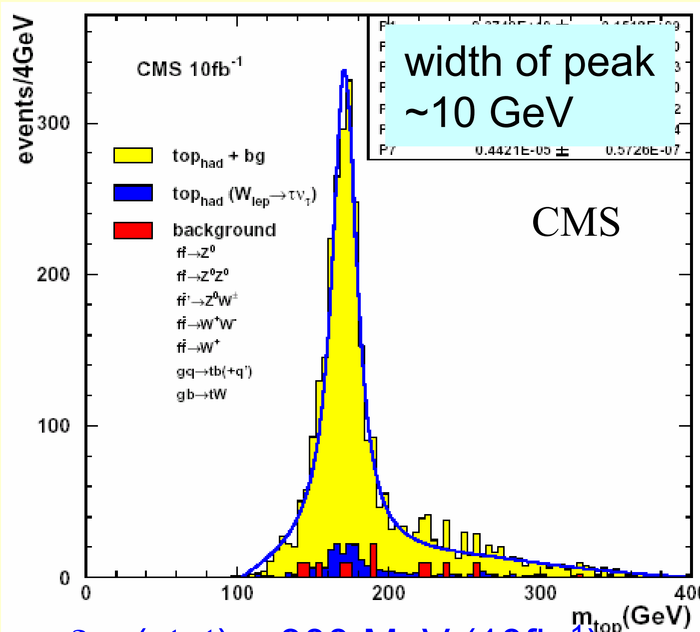
correct combinations
wrong combinations

1 b-tagged sample :
if W→qq is reconstructed then the b jet from the hadronic top decay is
ΔR(b,W) < ΔR(b,lepton)
jet association eff. ~ 82 %

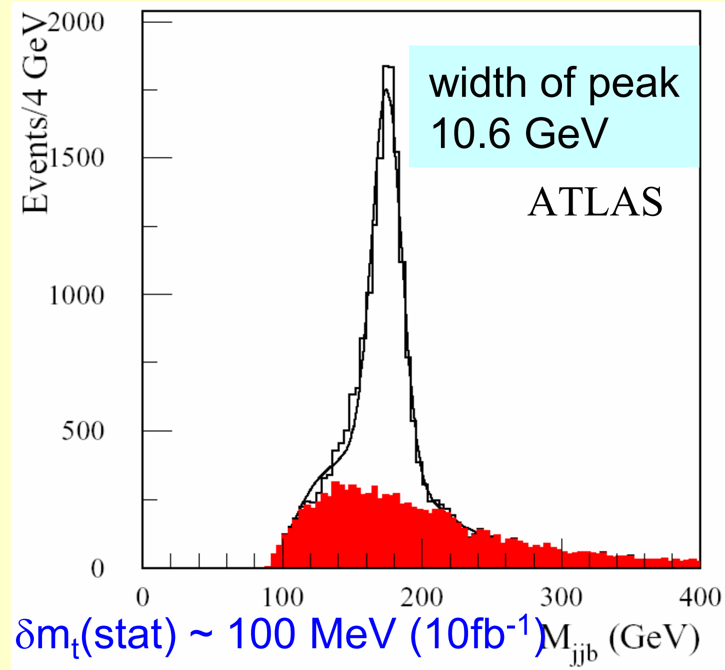
2 b-tagged sample :
if W→qq is reconstructed then the b jet from the hadronic top decay is
highest p_T for top
jet association eff. ~ 81 %

The pp → tT process at the LHC : lepton+jet channel

Preliminary plots of ATLAS/CMS are similar (both on fast simulations):



δm_t(stat) ~ 300 MeV (10fb^{-1})



δm_t(stat) ~ 100 MeV (10fb^{-1})

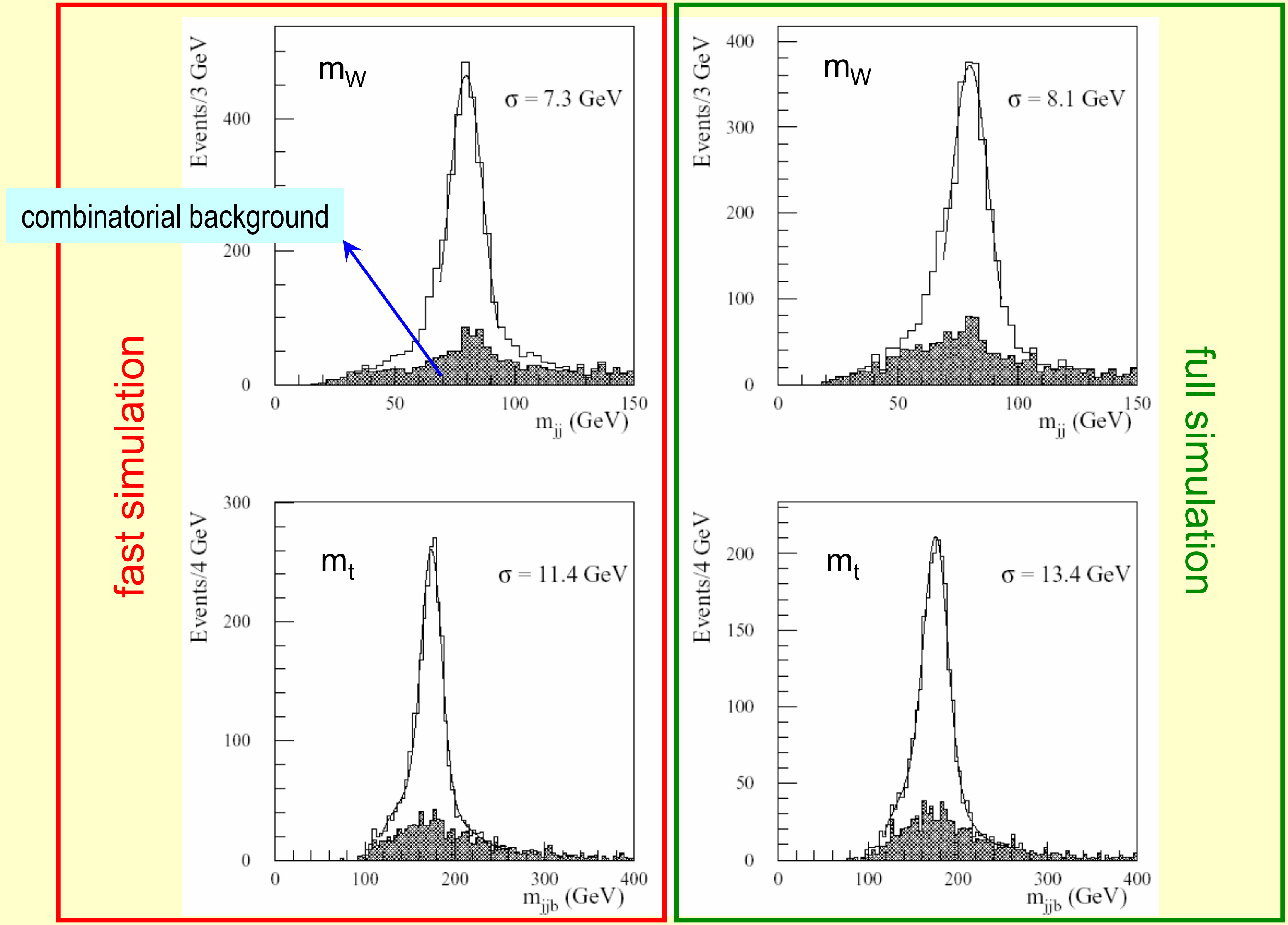
Systematics ATLAS	δm_t (GeV)
Light jet energy scale	0.2
b jet energy scale	$0.7\times x\%$
Initial State Radiation	0.1
Final State Radiation	1
b-quark fragmentation	0.1
Combinatorial background	0.1
Statistical error	0.1

kinematic fit →

Internal Systematics ATLAS	δm_t (GeV)
light jet energy scale	0.2
Initial State Radiation	0.1
Final State Radiation	≤ 0.5
b-quark fragmentation	0.1
Combinatorial background	0.1
Total	≤ 0.6
Statistical error	0.1
b jet energy scale	$0.7\times x\%$

The pp → tT process at the LHC : lepton+jet channel

Preliminary plots from ATLAS showing the difference between fast/full simulation



Alternative top mass estimators

❶ **Single lepton plus jets : High p_T sample with p_T(jjb)> 200 GeV (Jet-Analysis)**

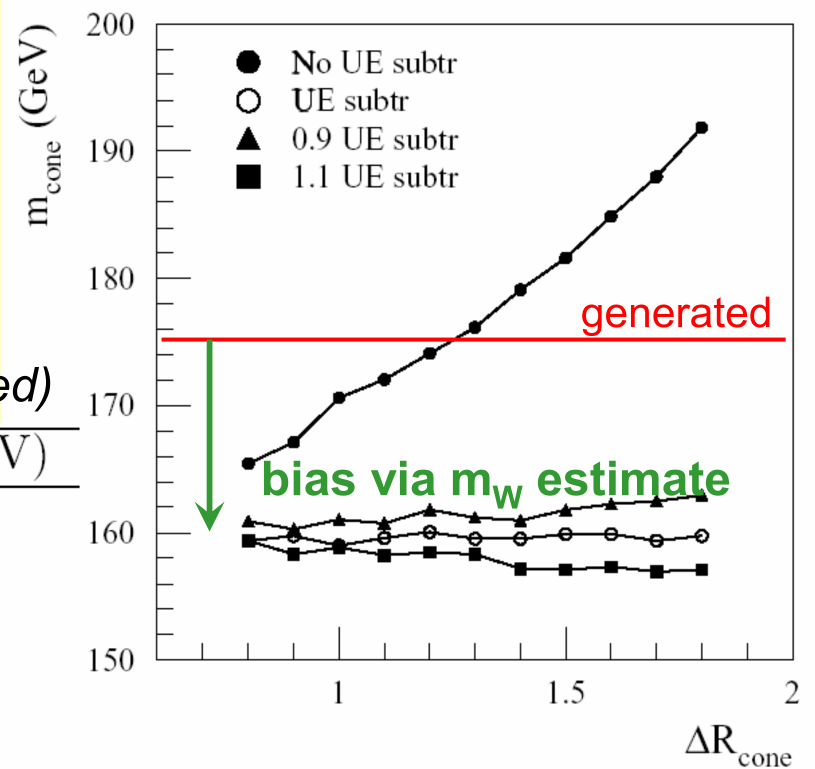
Yellow Report LHC

- ✓ *back-to-back top pair production (lab-frame) : hence different hemi-spheres*
- ✓ *less combinatorial background or other background*
- ✓ *smaller systematics from energy calibration and gluon radiation*
- ✓ *statistical uncertainty $\Delta m_t \sim 250$ MeV/c^2*
- ✖ *jet overlapping probability increases → affects jet calibration*

❷ **Single lepton plus jets : High p_T sample with p_T(jjb)> 200 GeV (Cluster-Analysis)**

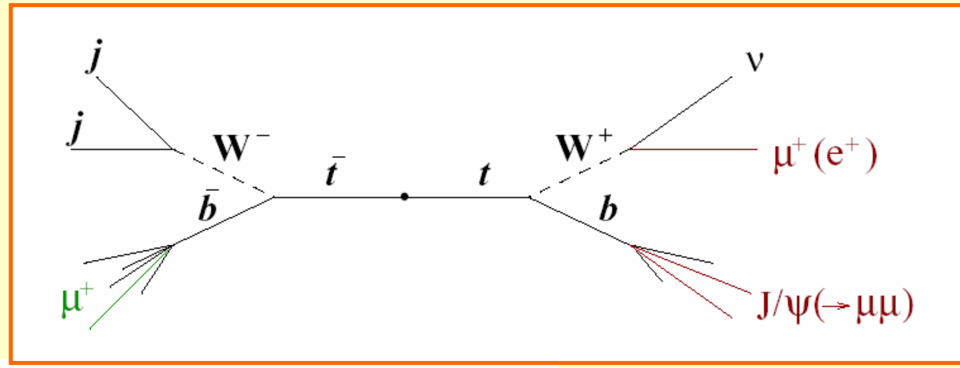
ATLAS-COM-PHYS-99-050

- ✓ *collect all energy in a cone around the top direction*
- ✓ *less sensitive to jet calibration and the jet topology of the event*
- ✖ *large dependence on cone size*
- ✖ *should subtract underlying event energy*
- ✖ *m_W estimate in tT→lepton+jets (data based)*



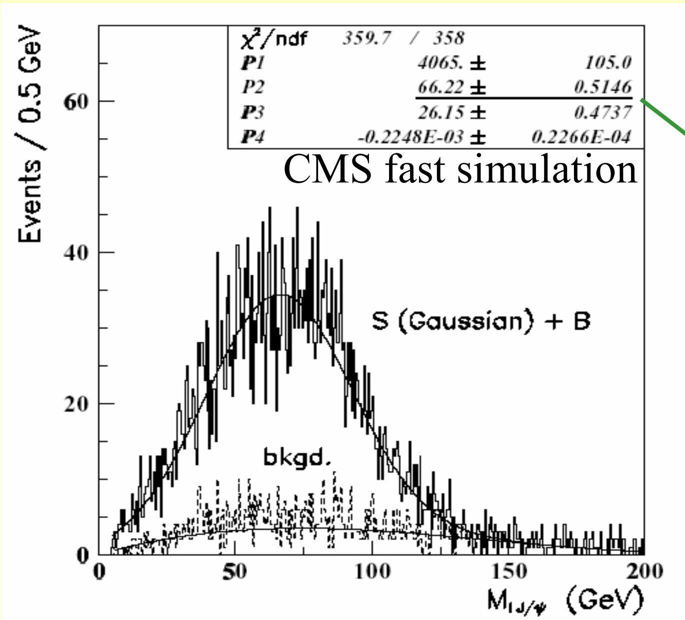
	$\lvert\Delta m_t\rvert$ (GeV)	δm_t (GeV)
Initial state radiation	0.7	0.1
Final state radiation	0.3	0.1
b-quark fragmentation	0.3	0.3
UE estimate (±10%)	1.3	1.3
mass scale calibration	0.9	0.9

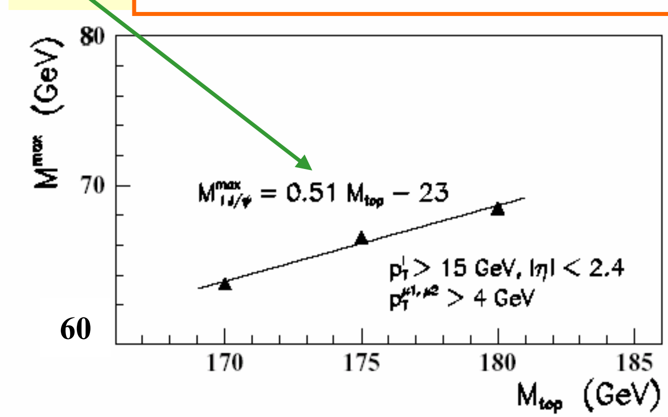
Alternative top mass estimators



❸ From $t \to l + J/\psi + X$ decays :

hep-ph/9912320





slope

- ✑ *100 fb^{-1} gives after selection ~ 1,000 signal events (S/B > 100)*

- ✓ *the large mass of the J/ψ induces a strong correlation with the top mass*
- ✓ *easier to identify (extremely clean sample)*
- ✖ *BR(overall in tT) ~ 5.3 x 10^{-5}*
- ✓ *no jet related systematics !!*

Systematic uncertainties	$\delta M_{\ell\text{-}J/\psi}^{peak}$ (GeV/c²)
Final State Radiation	0.15
PDF	0.1
b-quark fragmentation	0.3
Background	0.1
Statistical error	0.5

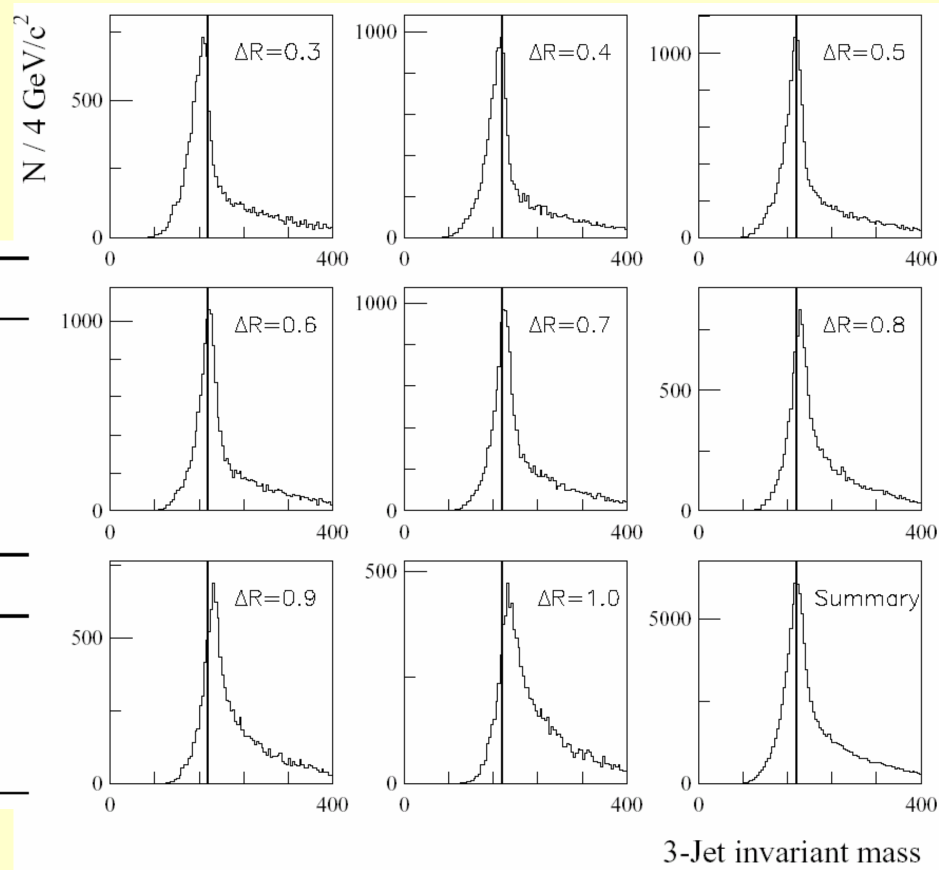
New method : hep-ex/0501043
correlate the b transverse decay length with m_t

Alternative top mass estimators

❹ Continuous jet algorithms :

ATLAS paper hep-ex/0403021

- ✑ *use the same event selection as for the nominal analysis*
- ✓ *use the cone-based jet clustering algorithm, but scan the hole ΔR range*
- ✓ *for each event several m_t are determined depending on ΔR*
- ✓ *let the event itself choose its jet broadness… less sensitive to radiation*
- ✓ *statistical unc. ($10fb^{-1}$) ~ 100 MeV/c^2*
- ✖ *systematics : b-jet energy scale*



Source	δm_t (GeV)
Range of jet cone sizes	0.25
χ^2 dependence	0.2
Signal and background shape	0.1
ISR and FSR	0.2
External b-jet calibration 1%	0.7
Internal b-jet calibration	
Physics effects	0.13
W signal shape	0.1

The pp → tT process at the LHC : di-lepton channel

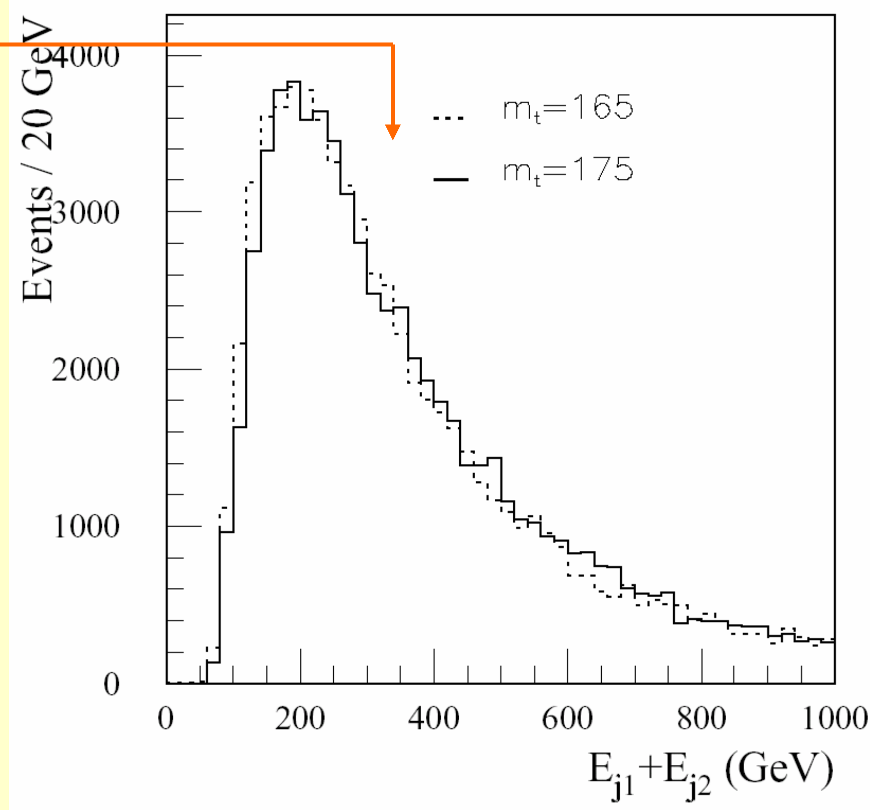
❸ Di-lepton channel : 0.4Mevtn/10fb^{-1}

(Jet-Analysis with m_{lb}, Jet-Energies, Tri-lepton events and Full-reconstruction)

- 10 fb^{-1} gives after selection ~ 80,000 signal events (S/B ~ 10)

i.
- ✓ $m_t^2 = M_W^2 + 2 \langle m_{lb}^2 \rangle / (1 - \langle \cos\theta_{lb} \rangle)$ (high p_T b-tagged jets → 15,000 events)
- ✓ statistical uncertainty ~ 900 MeV/c^2
- ✖ b-quark fragmentation could give large systematics

ii.
- ✓ energy distribution of two leading jets
- ✓ match with correct MC distribution
- ✓ statistical uncertainty ~ 400 MeV/c^2
- ✖ jet energy calibration ~ 1.5 GeV/c^2



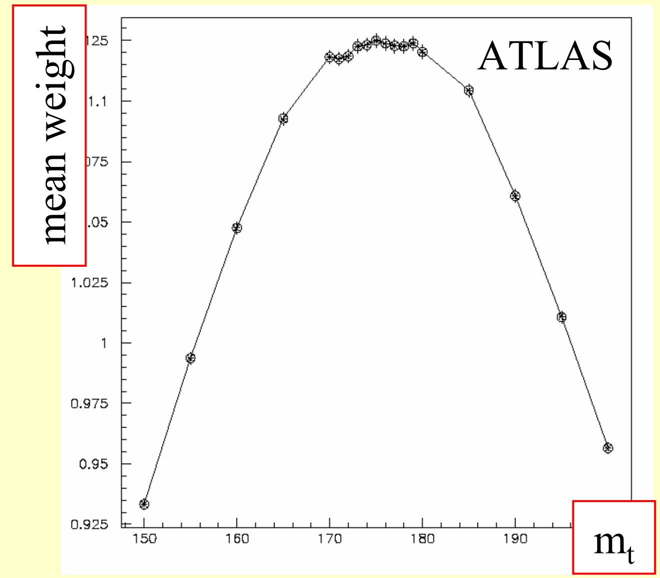
iii.
- ✓ t→lνb followed by b→lνc
- ✓ invariant mass distribution of the two leptons from the same top decay
- ✓ only about 7250 events
- ✓ statistical uncertainty ~ 1000 MeV/c^2
- ✖ systematics from b-quark and ISR and FSR up to 1.5 GeV/c^2

The pp → tT process at the LHC : di-lepton channel

(iv.)
- ✓ *full event reconstruction by assuming a fixed value for the top mass*
- ✓ *a χ^2 can be determined as a function of this value $m_t \rightarrow \chi^2(m_t)$*
- ➔ *based on solving a set of equations (kinematic constraints)*

- ✓ *solution is found in 98% of the selected events*
- ✓ *δm_t(stat) ~ 300 MeV ($10fb^{-1}$)*

- ✓ *small systematics due to radiation (switching on/off ISR/FSR)*



source of uncertainty	$\lvert\Delta m_t\rvert$ (GeV)		δm_t (GeV)
Statistics and reconstruction method			0.3
b-jet energy scale	0.6		0.6
b-quark fragmentation	0.7		0.7
Initial state radiation	0.4	20% →	0.1
Final state radiation	2.7		0.6
Parton distribution function	1.2		1.2

Overview of precision expected for each analysis

CMS notes [1]
ATLAS paper hep-ex/0403021 [2]
LHC Yellow Report on Standard Model Physics [3]

Analysis	Ref.	Stat.Unc. MeV	Syst.Unc. MeV
❶ Single-lepton channel (Full-Analysis)	[1,2]	100	~1000
❷ High p_T single-lepton sample (Jet-Analysis)	[3]	250	~1000 (?)
❸ High p_T single-lepton sample (Cluster-Analysis)	[3]	150	~1500
❹ Single-lepton channel (Continuous jet algorithm)	[2]	100	~1000
❺ Di-lepton channel (Jet-Analysis with m_{lb})	[3]	900	~1300
❻ Di-lepton channel (Energy-Analysis)	[3]	400	~2000
❼ Di-lepton channel (Tri-lepton events)	[3]	1000	~1500
❽ Di-lepton channel (Full-reconstruction)	[2]	300	~1300
❾ From $t \rightarrow l + J/\psi + X$ decays (4 years high lumi)	[1,2,3]	1000	<1000
❿ High p_T fully-hadronic channel	[2]	180	>3500

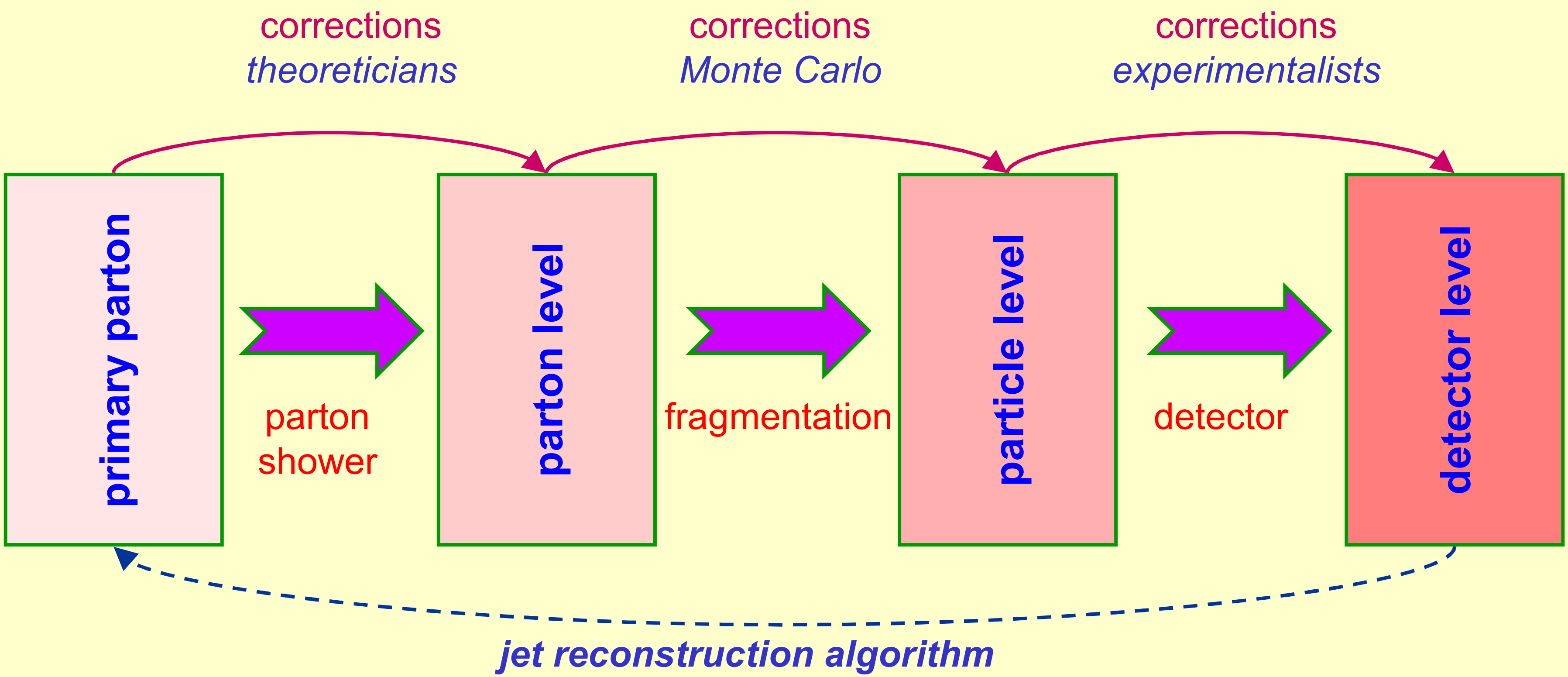
- combining all those results could lead to a more precise measurement *(correlations to be estimated !!)*
- systematic effects do not necessary overlap between analyses

<u>Expectation :</u> top mass determination better than 1 GeV after understanding the detector

Key issue : jet reconstruction

Tevatron paper hep-ex/0005012

❶ A jet of particles is a very complex object !!
- *and we will see many of these particles*
- *jet algorithms can have both theoretical and experimental difficulties*



❷ Aim : optimize the resolution on the reconstructed primary parton kinematics
- *use several jet clustering algorithms and study their features*
- *understand the influence of each step in the production of the detected jet*
- *important steps : input object → clustering algorithm → calibration*

Calibration of reconstructed jets

❶ Aim : know the absolute jet energy scale to the level of at least 1% (~1.6 GeV on m_t)

❷ Complex issue :

- *physics : ISR/FSR, fragmentation, underlying event, jet algorithm, …*
- *detector : calorimeter responds, non-linear effects, …*
- *all of them have to be understood at the 0.2% level to reach the 1% global goal*
- *the method has to cover a wide range of jet energies and directions*

❸ Tevatron based method :

$$E = [\, E^{raw} \cdot f_{rel} - MI \,] \cdot f_{abs} - UE + JAC$$

- *f_{rel} : relative energy scale correction (detector related corrections)*
- *MI : multiple interactions in the event*
- *f_{abs} : absolute jet energy scale (to be differentiated in the observable space)*
- *UE : energy of the underlying event*
- *JAC : corrections dependent on the clustering algorithm (eg. out of cone energy)*

❹ All these parameters must be estimated with real data (*control samples*) :

- *$W \rightarrow jj$ ($\delta m_W \sim 30$ MeV) in single-lepton $t\bar{t}$ events*
- *Z + jets ($Z \rightarrow e^+e^-$ or $Z \rightarrow \mu^+\mu^-$) also good for b-jet calibration*
- *γ + jets : large systematics of background from hadronic jets misidentified as photons*
- *…*

Control samples to determine calibration corrections

❶ Aim : know the absolute jet energy to the level of at least 1% directly from data

❷ Light-flavoured jets in **W→jj**

- *use the W decays in single-lepton tT events (large purity of sample)*
- *compare generated parton energy with reconstructed jet energy*
- *apply the constraint $m_W = m_{jj}$*
- *main systematic uncertainty : QCD final state radiation (optimize the jet algorithm)*
- *momentum range : ~50 GeV < p_T < ~200 GeV*
- *take ½ of the events to estimate the jet corrections, and apply them on the other ½*

❸ Flavour dependent measurement in **Z+jets**

- *typical flavour mixture :*
  - ⇨ *28% gluon*
  - ⇨ *54% light-quark jets*
  - ⇨ *12% c-quark jets*
  - ⇨ *6% b-quark jets (between 3000 and 5000 jets after selection depending on $|\eta|$)*
    (decreasing to around 500 for high p_T jets above 120 GeV)
- *calculate the jet corrections as a function of the b-tag probability (using the same b-tag method as in the physics case analysis !!)*
- *momentum range : ~30 GeV < p_T < 200 GeV*

❹ Need both data samples to reduce possible systematic effects !!

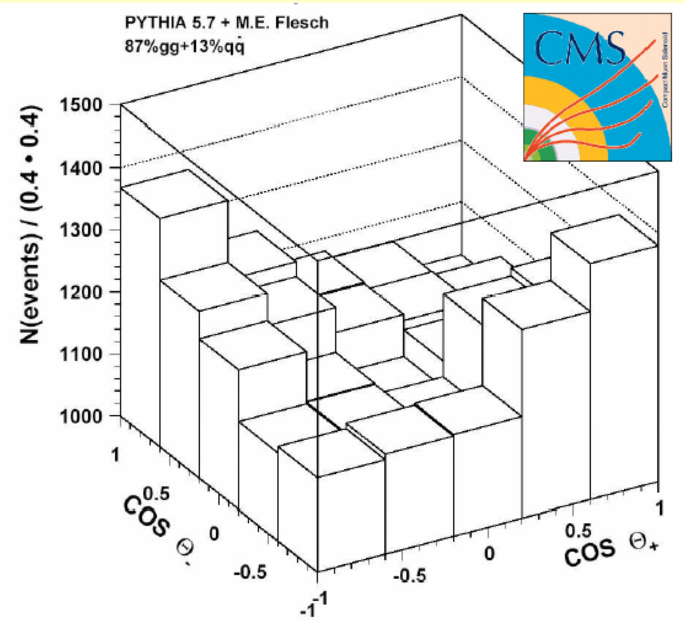
… important work in progress !!

New topics

❶ Spin correlations

⇨ the top quark does not loss its spin information before it is decaying into W and b

⇨ $$\mathcal{A} = \frac{N(t_L\bar{t}_L + t_R\bar{t}_R) - N(t_L\bar{t}_R + t_R\bar{t}_L)}{N(t_L\bar{t}_L + t_R\bar{t}_R) + N(t_L\bar{t}_R + t_R\bar{t}_L)}$$ with $\mathcal{A}$=0.431 (gg) and $\mathcal{A}$=-0.469 (qQ)



⇨ two observables θ+(θ-): angle between t(T) direction in the tT c.m. frame and the ℓ^+(ℓ^-) direction of flight in the t(T) rest frame

⇨ fit to double differential distribution

$$\frac{1}{N}\frac{d^2N}{d\cos\theta^*_{\ell+}\,d\cos\theta^*_{\ell-}} = \frac{1}{4}(1 - \mathcal{A}\cos\theta^*_{\ell+}\cos\theta^*_{\ell-})$$

⇨ result (30fb^{-1}) : $\mathcal{A}$ (stat) = 0.035 and $\mathcal{A}$ (syst) = 0.028

ATL-PHYS-2003-012 : similar results from ATLAS

❷ Measuring the difference between mt and mT

⇨ almost all systematics cancel when taking the difference between both

⇨ after several years the precision could be around 50 MeV

⇨ get theorist to work what we could learn from that ?

⇨ differences between t and T can learn us something about the PDF's (rapidity distributions)

New topics

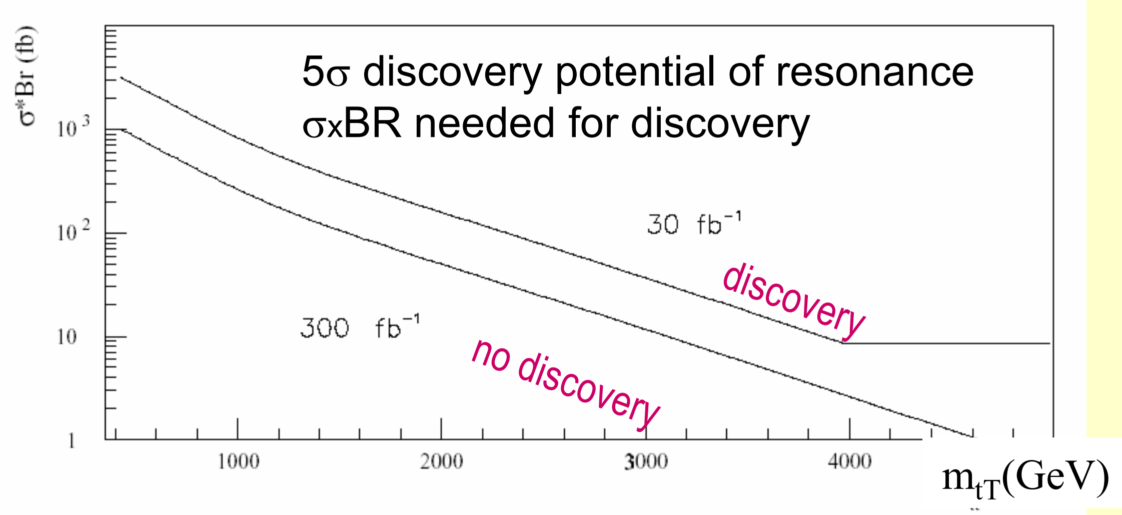
❸ A lot more when we differentiate the selected events in phase-space !!

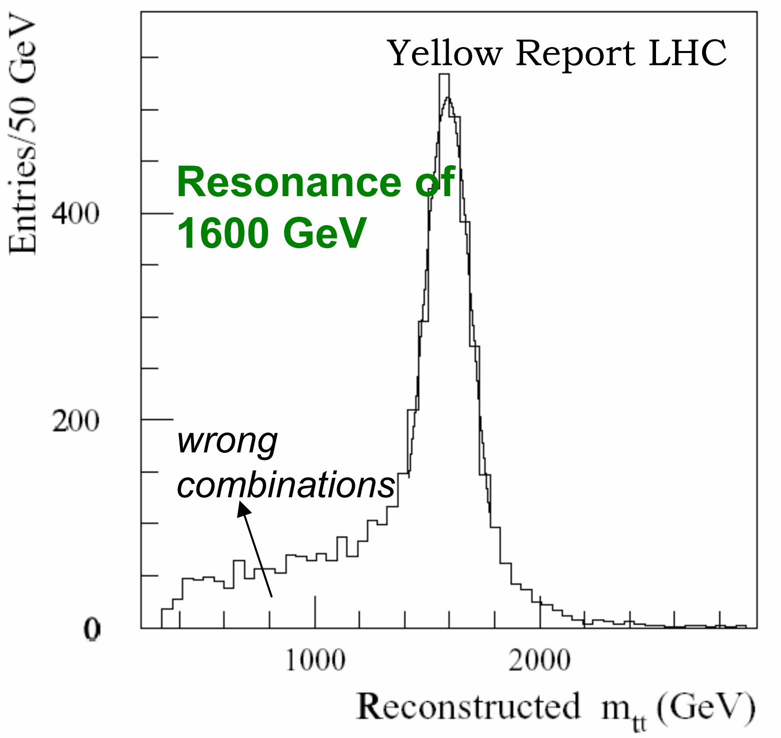
⇨ search for resonances in the $d\sigma_{tT}/dM_{tT}$ spectrum

- SM : BR(H → tT) to small to be visible above continuum tT production (Γ_H too large)
- MSSM : if $M_{H,A} > 2m_t$ then BR(H/A → tT) ≈ 100 % for tanβ ≈ 1
- Technicolor models : in some models heavy particles decaying to tT

- selection of lepton plus jets channel
- precise kinematic reconstruction : $\delta m_{tt}/m_{tt}$ ~ 6.6%

For a random resonance :
(choose jet combination which match best the tT event kinematics)





New topics

❹ Inclusive cross-section σ_{tT} : infuenced by SUSY

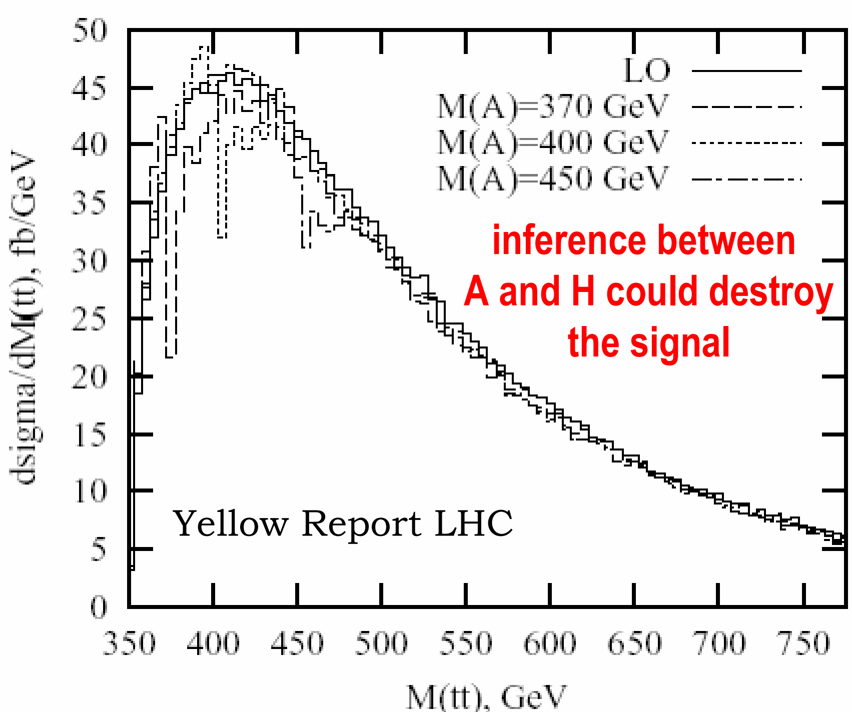
	SM ($M_H = 100$ GeV)	G2HDM	SUSY EW	SUSY QCD
$\lvert\sigma_{t\bar{t}}^{NLO} - \sigma_{t\bar{t}}^{LO}\rvert / \sigma_{t\bar{t}}^{LO}$	2.5%	$\lesssim 4\%$	$\lesssim 10\%$	$\lesssim 4\%$

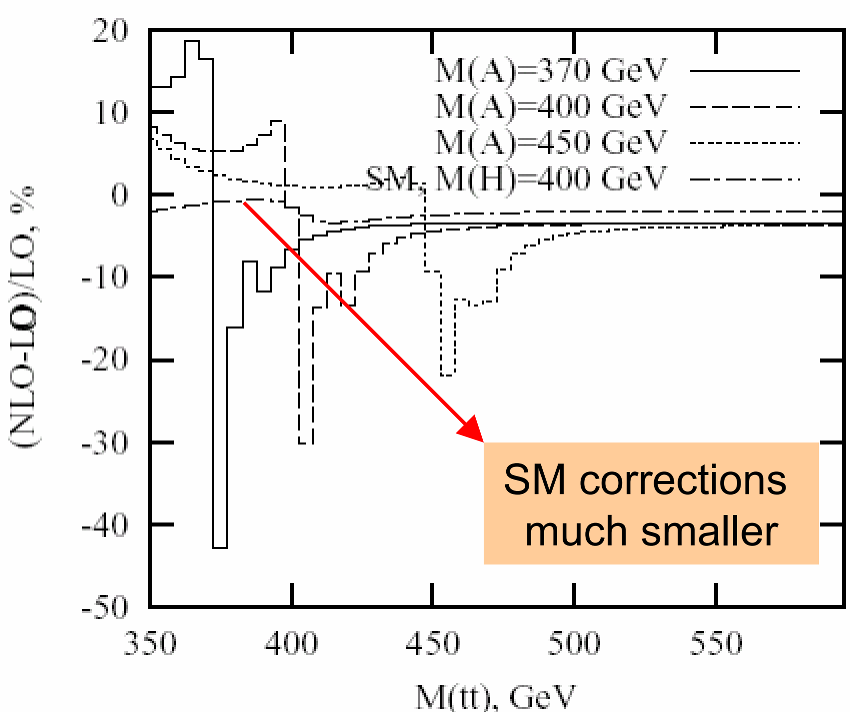
➔ test the consistency of the SUSY model after discovery

❺ Invariant tT-mass distribution : significant distortions of the shape expected

➔ when including MSSM EW corrections (one-loop)

➔ for heavy Higgs A^0 between tT threshold ~350 GeV and ~500 GeV





New topics

❻ If extra-dimensions exist and TeV-scale gravity models are correct

➔ top quarks will be produced from the decay of black holes via Hawking Radiation hep-ph/0205199

➔ Δm_t = 0.28 (stat) ⊕ 0.5 (syst) = 0.57 GeV (LHC using 10 fb^{-1})

➔ Yukawa coupling via single top production
$BR(t \rightarrow tH) = 0.046\ y_t^2 / |V_{tb}|^2$
improvement (30 fb^{-1}) from 16.2% till 2.7%

➔ … but mixing up a lot of unknowns

LHC becoming a reality

LHC becoming a reality

CMS surface hall

LHC becoming a reality

LHC becoming a reality

LHC becoming a reality

magnet

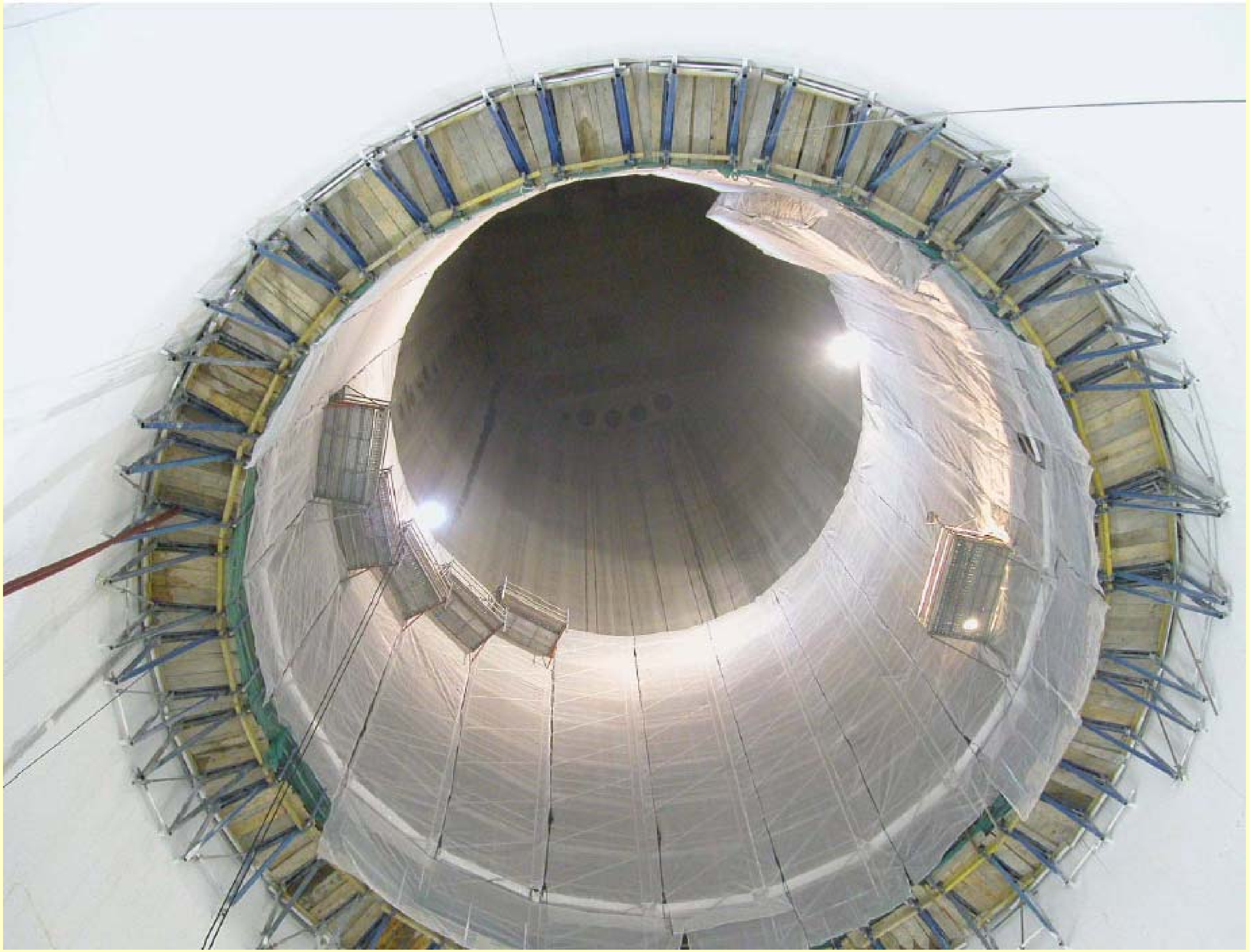
first complete installed muon endcap station

LHC becoming a reality

CMS surface hall

LHC becoming a reality

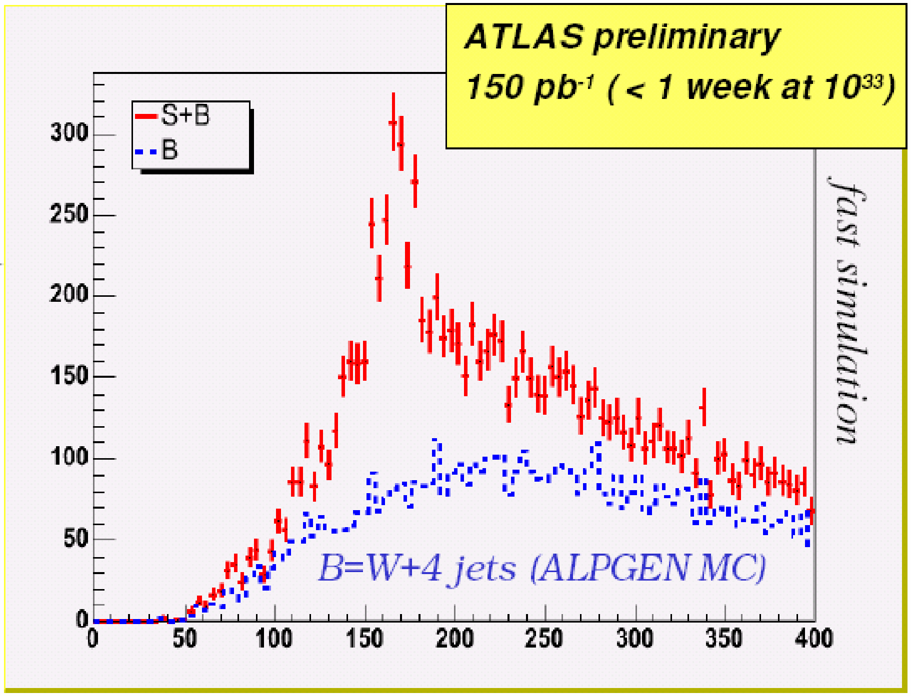
LHC becoming a reality



The top quark : LHC start-up

- In the lepton+jets channel, with a very simple selection
  - one isolated lepton (e,μ) p_T > 20 GeV/c
  - exactly 4 jets E_T > 40 GeV
  - *no kinematic fit*
  - *no b tagging* (several months will be probably necessary to reach an optimal b tagging performance/understanding)

Invariant mass of the most energetic 3 jets



M (jjj) GeV/c^2

- The cross section can be measured
  - 20 % accuracy (10 % luminosity) with 150 pb^{-1}

Summary

- ***the top mass is one of the most important topics of the LHC***
  - ✓ *reconstruction methods are exploited to optimize the m_t analyses*
  - ✓ *dominated by systematics … hence a lot of work to optimize !!*
  - ✓ *if we don't understand 'simple' tt events… who would thrust a new signal*
  - ✓ *new more complex analyses are being performed (for example 'ideogram' tech.)*
- ***most important features for the reconstruction***
  - ✓ *the jet energy calibration (underlying event, pile-up, detector)*
  - ✓ *gluon radiation (initial and final state)*
  - ⇨ *an accurate understanding of the QCD dynamics is required to exploit the data*
- ***what to expect in summer 2007***
  - ✓ *the first signal of the top quark at the LHC… soon !!*
- ***what to expect in summer 2008***
  - ✓ *the top mass measured with a precision of 1 GeV using several methods*
- ***Top@LHC : an interesting domain where many people can interact !!***